Review of particle properties

Particle Data Group

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This review of the properties of leptons, mesons, and baryons is an updating of the Review of Particle Properties, Particle Data Group [Phys. Lett. **111B** (1982)]. Data are evaluated, listed, averaged, and summarized in tables. Numerous tables, figures, and formulae of interest to particle physicists are also included. A data booklet is available.

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CONTENTS

I. OVERVIEW

This review is an updating through December 1983 of the Review of Particle Properties [Particle Data Group (1982)], a compilation of experimental results on the properties of particles studied in elementary particle physics. These properties include masses, widths or lifetimes, branching ratios, and other experimentally determined properties. Where feasible, we provide a suggested "best" value of each parameter based on our own judgment, using the best available data. A discussion of some of the procedures that we apply, and a brief review of the historical performance of averages of measurements, may be found below (Section V Part D).

The results of this compilation are presented in two sections, the "Tables of Particle Properties" and the "Data Card Listings." The Tables give our estimates of the properties of those states whose existence we consider well established. Our opinion of whether or not a particle's existence is well established can change as new data become available. We attempt to be conservative, so particles whose existence awaits confirmation are not included, even if they may be theoretically well understood. Reported states which have been omitted from the Tables are indicated there by a short arrow (→).

The Listings contain a complete record of our compiled data on all states whose existence is either well established or unconfirmed, but do not include reported states of historical interest only. All data used for the numerical estimates in the Tables are listed here, with references and our comments, if any. Those measurements considered recent enough or important enough to mention, but which for some reason were not used in the averaging, appear in parentheses.

The Listings also contain short reviews, which we call "mini-reviews," about subjects of particular interest or data which have particular problems. These are usually written by the same experts who have assisted with the data compilation itself.

In the past, we have attempted to use the Listings as an archive of all reported data on particles of interest. This is no longer possible because the growth of information would require a 5 to 10% per year expansion in this Review. Therefore we refer interested readers to previous editions [for example, Particle Data Group (1982)] for references to data considered obsolete.

We categorize the particles into types, intended to correspond roughly to the different types of data and problems encountered:

STABLE PARTICLES — All particles stable under the strong interaction. This includes the truly stable particles as well as those which decay weakly or electromagnetically, including the η, D(1865), F, Λ_c, W, Z^0, and so on.

MESONS — All meson resonances, including the ψ, χ, and Υ families.

BARYONS — All baryon resonances, including the resonant N and Δ families, dibaryon candidates, and so on.

This classification scheme is used to organize the Tables and the Listings.

We include a section of "Miscellaneous Tables, Figures, and Formulae." These are designed as a quick reference for the practicing elementary particle physicist. They normally presuppose some understanding of the subject matter, and do not attempt to serve as a textbook. We welcome all suggestions and comments regarding topics for inclusion or deletion, any errors or confusing passages, etc.

A pocket-sized Particle Properties Data Booklet is available. This contains the complete Tables of Particle Properties and the Miscellaneous Section, but not the Listings. For North and South America, Australia, and the Far East, write to Technical Information Department, Lawrence Berkeley Laboratory, Berkeley, CA 94720, USA. For all other areas, write to CERN Scientific Information Service, CH-1211 Geneva 23, Switzerland.

This year we are beginning a multiyear effort aimed at modernization and reorganization. The first fruits are visible immediately in the form of improved readability. We also include, for the first time, an Index at the back. The Miscellaneous Section has been almost completely reorganized. Some new material has been added, and some of the old material is now in different sections. A detailed description of the changes is given in Section III below.

II. AUTHORS AND CONSULTANTS

The primary responsibilities of the authors are as follows:

(1) *Stable particles*: R. Frosch, T. Shimada, R.E. Shrock, T.G. Trippe, W.P. Trower, and C.G. Wohl.

(2) *Meson resonances*: M. Aguilar-Benitez, J.J. Hernandez, M.J. Losty, L. Montanet, F.C. Porter, M. Roos, N.A. Törnqvist, and Ch. Walck

(3) *Baryon resonances*: R.L. Crawford, G.P. Gopal, R.E. Hendrick, G. Höhler, L.D. Roper, and C.G. Wohl.

(4) *General, including Introduction*: All authors.

Of increasing importance to the production of this Review is a world-wide network of consultants, experts in particular topics. We wish to mention the following people with thanks:

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In addition, the Berkeley Particle Data Group has benefited from the advice of the PDG Advisory Committee, which meets annually to discuss matters of importance to the group, including the structure and content of this Review. The members of the 1983 committee are G. Feldman (SLAC) (chair), C.M. Lederer (University of California, Berkeley), J. Rosner (University of Chicago), R. Thun (University of Michigan), and L. Wolfenstein (Carnegie-Mellon University). In addition, G. Gidal (LBL) served in 1982.

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

III. REORGANIZATION

This year we have reorganized the Introduction and Miscellaneous Sections, added an Index (at the back), changed the Appendices to reflect modern interest, and improved the readability of most of the Review. This is the first stage of our modernization of the Review of Particle Properties system. The input of our readership into this process is welcome and encouraged. Many of the planned future changes will be internal, e.g., in the data-handling programs, but we do plan some additional improvements in the appearance and layout of the Review.

The changes in the Introduction Section have been to move the portions with physics discussion to other places. The discussion on the quantum numbers of mesons is now found (condensed) in the new Nonrelativistic Quark Model discussion in the Miscellaneous Section. The discussion of partial-wave amplitudes is partly in the Kinematics, Decays, and Scattering portion of the Miscellaneous Section and partly in some of the baryon mini-reviews, along with the discussion of sign conventions for resonance couplings. The conventions and parameters for weak and electromagnetic decays are now in various mini-reviews in the Stable Particle Section, preceding the appropriate particles.

The changes to the Miscellaneous Section and the Appendices are as follows. Sections which have been substantially revised or which are new appear in italics.

Physical Constants:
General reorganization and updating. Most of the numerical constants have been removed to improve readability.

Clebsch-Gordan Coefficients, Spherical Harmonics, and d Functions:
No change.

SU(3) Isoscalar Factors:
No change.

SU(n) Multiplicities:
Removed; see new SU(n) Multiplets and Young Diagrams Section.

SU(n) Multiplets and Young Diagrams:
New.

Properties of Quarks:
Replaced by Nonrelativistic Quark Model Section.

Tests of Conservation Laws:
New.

Weak Interactions of Quarks and Leptons; Relativistic Kinematics; Lorentz Invariant Phase Space Formulae:
Incorporated into the following five new sections:
Kinematics, Decays, and Scattering
Standard Model of Electroweak Interactions
Cabibbo and Kobayashi-Maskawa Mixing
Quark Parton Model for Deep Inelastic Scattering
Nonrelativistic Quark Model

C.M. Energy and Momentum vs. Beam Momentum:
No change.

Probability and Statistics:
Minor revisions.

Particle Detectors, Absorbers, and Ranges:
Revised. Silicon detectors added. Mean Range in Pb, Cu, Al, C figure revised. Photon Mass Attenuation figures slightly revised. Atomic and Nuclear Properties of Materials revised.

Electromagnetic Relations:
Revised to include motion of charged particles in magnetic and electric fields, conversion of units.

Radioactivity and Radiation Protection:
Revised to include SI units, lethal dose, other changes.

Periodic Table:
No change.

Plots of Cross Sections and Related Quantities:
Revised. New νN figure. Structure Functions expanded. New e^+e^- figures. K_L^0 Regeneration figure deleted. $\pi^+ n$ ($=\pi^- p$) deleted.

Appendices:
Old Appendices [$\Delta I = 1/2$ Rule, SU(3) Classification of Baryon Resonances, Growth of Information] deleted. Portions of the Growth of Information Appendix moved to Introduction, Section V Part D.

Appendix I: *Status of the Standard Model of Electroweak Interactions*:
New.

Appendix II: *The Perturbative QCD Coupling Constant*:
New.

Appendix III: *Kobayashi-Maskawa Mixing Matrix*:
New.

IV. NOMENCLATURE

Our particle name conventions are summarized in Table I.

Stable particles tend to have a well-accepted colloquial name, e.g., e, τ, η, π, K, D, B, Λ, Σ, etc., and we use that name. If a *meson resonance* has such a well-accepted name, we use that. If not, or if there is conflict in the literature, we follow the naming conventions of Table I. For *baryon resonances*, the naming conventions of Table I are regularly followed in the literature. All of the resonances incorporate the mass value in the name, e.g., $\rho(770)$, $\omega(783)$, N(1440), $\Lambda(1520)$, $\Sigma(1385)$, etc. This allows one to distinguish, e.g., the charmed and bottomed mesons, D and B (stable under strong decay), from the meson resonances D(1285) and B(1235). It also distinguishes all of the N, Δ, Λ, etc., baryon resonances from one another.

The meson resonance naming convention of Table I incorporates some information as to the spin-parity J^P into the name. For a few such states believed to have identical quantum numbers, the colloquial names in the literature may incorporate primes into the name, e.g., $\rho(770)$, $\rho'(1600)$, f(1270), f′(1525), etc. However, we discourage this practice except for isosinglets within one SU(3) nonet. Thus $\eta'(958)$ and f′(1525) keep their primes, whereas $\rho'(1600)$ becomes $\rho(1600)$ in analogy with the radial excitations of the $\psi(3100)$ and the $\Upsilon(9460)$. We have taken the liberty of changing some colloquial meson names in accordance with Table I, having been urged for years to standardize the jungle of letters. The old names will still appear next to the new ones, to facilitate this conversion. We have restricted ourselves to relatively minor changes in this edition, but are considering more radical possibilities for the future. For example, it may be argued that, since the D(1285) and the

E(1420) have the same quantum numbers, they should get the same letter in spite of historical considerations. For a second example, there are several possible states whose interpretation is unclear [e.g., $\iota(1440)$, $\theta(1690)$, $\xi(2220)$, $g_S(1240)$, and $g_T(2240)$]. To the extent that some of these may be ordinary $q\bar{q}$ mesons, their exotic names should presumably be changed to more conventional ones. To the extent that some may not be ordinary mesons, it is less clear what naming convention, if any, should be adopted. We hope the reader will understand the rationale for the changes we have made and, in particular, not take any name change as an offense.

Table I. Particle name conventions. These names are used in the absence of a different generally accepted name in the literature.

Name	Isospin	G-Parity	Strangeness	Charm	Bottom
Mesons, $P=(-1)^J$ ("normal" J^P)					
ω, ϕ, ψ, Υ†	0	$-$	0	0	0
ϵ, f	0	+	0	0	0
δ	1	$-$	0	0	0
ρ	1	+	0	0	0
K^*, κ	1/2		± 1	0	0
D^*	1/2		0	± 1	0
F^*	0		± 1	± 1	0
B^*	1/2		0	0	± 1
Mesons, $P=(-1)^{J+1}$ ("abnormal" J^P)					
η, D	0	+	0	0	0
π, A	1	$-$	0	0	0
H	0	$-$	0	0	0
B	1	+	0	0	0
K, Q	1/2		± 1	0	0
D	1/2		0	± 1	0
F	0		± 1	± 1	0
B	1/2		0	0	± 1
Baryons					
N§	1/2		0	0	0
Δ§	3/2		0	0	0
Z_0, Z_1	0, 1		+1	0	0
Λ§	0		-1	0	0
Σ§	1		-1	0	0
Ξ	1/2		-2	0	0
Ω	0		-3	0	0
Λ_c	0		0	+1	0
Σ_c	1		0	+1	0
A	1/2		-1	+1	0
Λ_b	0		0	0	-1

† We use the symbol ω for $I^G = 0^-$ mesons which are mainly $u\bar{u}$ and $d\bar{d}$ quark states, ϕ for those which are mainly $s\bar{s}$ quark states, ψ for mainly $c\bar{c}$ states, and Υ for mainly $b\bar{b}$ states.
§ We occasionally use the symbol N^* to refer to the N and Δ resonances together, and Y^* to refer to the Λ and Σ resonances together.

For baryon resonances, the strangeness, charm, "bottomness," and isospin are incorporated into the name. The J^P is listed separately along with the spectroscopic notation for the partial-wave amplitude in which the particle is produced or decays. Our convention for spectroscopic notation is as follows:

$$L_{2I \cdot 2J}$$

for N, Δ, and Ξ resonances, and

$$L_{I \cdot 2J}$$

for Λ and Σ resonances. Here the orbital angular momentum L is represented by S, P, D, F, $\cdots$ as L = 0, 1, 2, 3, $\cdots$. For example, the $J^P = 7/2^-$ $\Delta(2100)$ is G_{07} and the $J^P = 5/2^+$ $\Delta(1905)$ is F_{35}. Where more than one resonance with the same quantum numbers exists, we add a prime to the lowest mass state, two primes to the second lowest, etc. Thus, for example, the $J^P = 5/2^+$ states $\Lambda(1820)$ and $\Lambda(2100)$ are listed as F'_{05} and F''_{05}, respectively.

Some discussion about quantum numbers is found under the Nonrelativistic Quark Model in the Miscellaneous Section.

V. PROCEDURES

A. Selection and treatment of data

The Listings contain a complete record of all relevant data known to us from the journals listed in the Illustrative Key at the start of the Listings. As a general rule, we do not include results from preprints or conference reports. It is our experience that preprinted results may change before publication. In some cases, such results may be cited but not used in computing the estimates given in the Tables. There are a few exceptions to this exclusion, which we decide on a case-by-case basis after consultation with the experimenters.

As mentioned earlier, we no longer attempt to maintain an archival record of data of historical importance only. Thus, in this edition, results from many early papers on the baryon resonances have been omitted.

If data are included in the Listings but not used in the final average given in the Tables, they are set off by parentheses. We give explanatory comments in some such cases. If no comment is given, the reason the data were excluded is one or more of the following:

- No error was given.
- The data were contained in a preprint or conference report.
- The result involves some assumptions we do not wish to incorporate.
- The measurement has poor signal-to-noise ratio, low statistical significance, or is otherwise of much poorer quality than other data which are available.
- The measurement is clearly inconsistent with other results which appear to be highly reliable (see discussion in Section V Part D below).
- The measurement is not independent of other results, e.g., it is from one of several partial-wave analyses, all of which use the same data, rendering averaging meaningless.

In some cases, none of the measurements pass all these criteria and no statistically meaningful average is quoted. For example, the masses of many of the baryon resonances, obtained from partial-wave analyses, are quoted as a range thought to probably include the true value rather than as an average with error. This is discussed in more detail in some of the Listings mini-reviews in the Baryon Section.

Our treatment of upper limits is normally to quote in the Tables the strongest limit available from a single experiment. We do not average or combine upper limits except in a very few cases where they may be re-expressed as measured numbers with Gaussian errors.

Our treatment of quantum number assignments is to indicate in the Tables those which are either well established or probable. For the Meson Table, we underline those which we consider well established; the others are inferred from whatever experimental evidence is available. In the Stable Particles Section, nearly all quantum numbers are well established and we do not underline; those which are not well established are indicated by a footnote.

As is customary, we assume that antiparticles are the result of operating with CPT on particles, so both share the same spins, masses, and mean lives. There is a new entry in the Miscellaneous Section, Tests of Conservation Laws, which contains tests of CPT and other conservation laws.

B. Criteria for new states

An experimentalist who sees indications of a new state will of course want to know what has been seen in that region in the past. Hence, we include in the Listings all reported states which have not been, in our opinion, disproved by better (e.g., more reliable) data.

For the Tables we are much more conservative in our judgment. We include only those reported states which we feel have a large chance of survival. An arrow (→) at the left of the Tables of Particle Properties indicates that a questionable candidate has been omitted from the Table in that mass region, but that it can be found in the corresponding part of the Data Card Listings. One's betting odds for survival are of course subjective; therefore no precise criteria can be defined. For more detailed discussions, see the mini-reviews in the Listings. In what follows we shall attempt to specify some guidelines.

(a) When energy-independent partial-wave analyses are available (mostly for πN resonances), 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 $Z_0(1780)$ state seen in KN total cross-section experiments and in partial-wave analyses. The partial-wave analyses of Giacomelli (1974) and Martin (1975) find preferred solutions which exhibit a resonance-like loop in the P_{01} wave near 1740 MeV. However, Giacomelli et al. and Martin point out that, despite the resonant-like *appearance* of the loop, the evidence for resonant *energy dependence* is inconclusive. Thus we omit the $Z_0(1780)$ from the Baryon Table. A similar quandary has existed for some time concerning the $Z_1(1900)$, and it too has been omitted from the Tables.

(b) When there are insufficient data to perform energy-independent analyses, one often resorts to energy-dependent partial-wave analyses. 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 ($\bar{K}N \to \bar{K}N$, $\pi\Sigma$, etc.), before putting the claim in the Tables.

(c) Stable particles, most meson resonances, Ξ resonances, and high-mass N* and Y* resonances fall into a category for which no partial-wave analyses exist. In general, we accept such states if they are experimentally reliable, of high statistical significance, or observed in several different production processes.

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

Thus, we enter into the Tables of Particle Properties only states for which there is experimentally convincing evidence, and we expect that nearly all of them will survive.

C. Statistical Procedures

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

1. The unconstrained case, or "simple averaging;" and
2. The constrained case.

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

1. Unconstrained averaging

We use a standard Gaussian procedure with a "scale factor" applied to the errors as our method of averaging the data. The Student's t-distribution, the basis of an earlier experiment of ours in data averaging, would give more conservative (and perhaps more realistic) errors at the two-standard-deviation (2σ) and higher level, but we do not choose to quote such errors. It is worth bearing in mind, however, that a 2σ error might more realistically be somewhat larger than twice a 1σ error, owing to the non-Gaussian character of some sets of real measurements. This is a persistent problem in data averaging arising from the existence of mildly discrepant measurements.

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

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

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

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

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

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

Finally, if $\chi^2/(N-1)$ is greater than 1, but not greatly so, we still average the data, but then also do the following:

(a) We plot an ideogram to display the pattern of the data. Sometimes only one or two data points lie apart from the main body; other times the data split into two or more roughly equal-sized groups. The reader may use this information in deciding upon an alternative average, but caution is urged, as "outlying" data points are sometimes the "correct" ones. An example of such an ideogram is given in Fig. 1 below. Each experiment appearing in the plot is represented by a Gaussian with central value x_i, error δx_i, and area proportional to $1/\delta x_i$. The choice of area is somewhat arbitrary; it assumes that an experimenter will work to reduce the systematic errors until they are slightly smaller (but seldom much smaller) than the statistical errors. Thus, as a physicist collects more events, he or she will use them both to reduce the statistical errors and to study the biases. Our confidence that a significant systematic error has not been made in a given experiment, as compared with other contradictory experiments, then tends to go up as $1/\delta x_i$.

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

We emphasize the difference between least-squares averaging (where the weighting factor is the inverse square of the error) and the ideograms prepared for visual display. The former arithmetic is of course best if one has unbiased data whose errors are well understood. In particular, the error analysis assumes that the true error on each datum is sampled from a Gaussian whose width is correctly reported. Then we obtain a narrow Gaussian distribution centered at the weighted mean for the answer. The ideogram (often multipeaked and certainly not Gaussian) is based on the opposite hypothesis that some of the input is systematically in error. The idea behind least-squares averaging is that experiments 1, 2, 3, etc., are *all* valid (so we should multiply their probabilities). Our *ideograms* are based on the assumption that 1 *or* 2 *or* 3, etc., is valid, "hedged" with $1/\delta x_i$ betting odds; we then add their probabilities. Both approaches cannot simultaneously be right; we allow the reader to choose. However, we quote the least-squares result in the Tables. This is the most precise value if the data satisfy the appropriate assumptions. A glance at the ideogram will show that the difference between the two approaches is usually not severe.

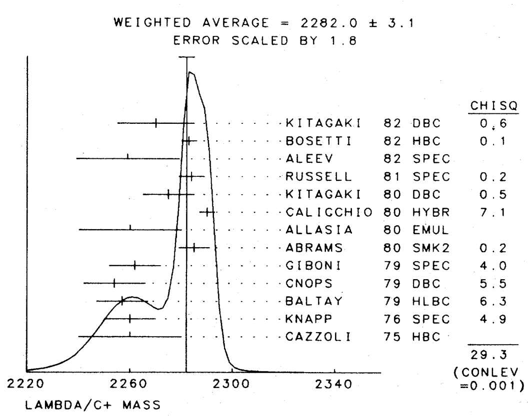

Fig. 1. Ideogram of measurements of the Λ_c^+ mass. The vertical line indicates the position of the weighted average, while the horizontal bar atop the line gives the error in the average after scaling by the SCALE factor. Only those experiments indicated by + error flags were precise enough to be accepted in the calculation of the SCALE factor; the column on the far right gives the χ^2 contribution of each of these experiments. The less precise experiments were included in the calculation of the weighted average, but not SCALE; they have $\perp$ error flags.

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

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

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

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

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

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

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

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

2. Constrained fits

Except for trivial cases, all branching ratios and rate measurements are analyzed by making a simultaneous least-squares fit to all the data and extracting the partial decay fractions P_i, the width Γ, the partial widths Γ_i, and the associated error matrix.

Assume, for a simple example, that a state has only three partial decay fractions, P_1, P_2, and P_3 ($\sum P_i = 1$), which have been measured in four different ratios, $R_1, \cdots, R_4$, where, e.g., $R_1 = P_1/P_2$, $R_2 = P_1/P_3$, etc.‡ Further assume that *each* ratio r has been measured by N_r experiments (we designate each experiment with a subscript x, e.g., R_{1x}). We then find the best values of P_1, P_2, and P_3 by minimizing χ^2:

$$\chi^2 = \sum_{r=1}^{4} \left[\sum_{x=1}^{N_r} \left(\frac{R_{rx} - R_r(P_1,P_2,P_3)}{\delta R_{rx}} \right)^2 \right]. \quad (3)$$

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

Two further comments on the example above:

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

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

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

Inconsistent constrained data. According to Eq. (3), the double sum for χ^2 is first summed over experiments $x = 1$ to N_r, leaving a single sum over ratios

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

We test for SCALE factors after the fit. Knowing the fitted χ_r^2 and its expectation value $\langle \chi_r^2 \rangle$, we form SCALE factors (just as before), i.e.,

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

and if any $(\text{SCALE})_r$ is greater than 1, all N_r of the measurements of that particular ratio are equally penalized by having their errors increased by $(\text{SCALE})_r$. We then recycle the full fit, yielding new values $\delta\overline{P}_i'$ for the errors in the partial decay modes, as well as new central values $\overline{P}_i'$.

Because of the constraint ($\sum P_i = 1$), some of the new SCALE factors may still be greater than 1. If this is so, the whole procedure (i.e., increasing errors by the new SCALE factors and recycling through the fit) is repeated until the process converges.

At the end, we have final estimated errors $\delta\overline{P}_i'$ for the $\overline{P}_i'$. If SCALE factors have been used, they normally will have caused a shift in the central fitted values $\overline{P}_i'$, as well as having given larger errors $\delta\overline{P}_i'$. Often we find that the shift $|\overline{P}_i - \overline{P}_i'|$ due to the SCALE factors is the same size as (or greater than) the $\delta\overline{P}_i'$. We have decided to incorporate this shift into our errors as a reflection of the uncertainty due to the introduction of the SCALE factor; we tabulate an error

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

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

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

However, in line with our policy of not letting SCALE affect the central values, we quote the values of $\overline{P}_i$ obtained from the original (unscaled) fit [which are always less than or equal to one standard deviation from $\overline{P}_i'$, by construction of $(\delta\overline{P}_i)_{\text{tab}}$].

D. Discussion

The entire question of averaging data containing discrepant values is nicely discussed by Taylor (1982). He considers a number of algorithms which attempt to incorporate data which are not completely consistent into a meaningful average. Problems occur because it is very difficult to develop a procedure which handles simultaneously in a reasonable way two basic types of situations: (a) data which seem to lie apart from the main body of the data are incorrect (contain unreported errors); and (b) the opposite (the main body of the data is systematically wrong). Unfortunately, as Taylor shows, case (b) is not infrequent. His conclusion is that the choice of procedure is less significant than the initial choice of data to include or exclude.

We place a great emphasis on the choice of data to include or exclude. Unfortunately, the volume of data precludes spending as much time on the problem as we would like. We address this problem by soliciting the help of as many outside experts (consultants) as possible. In the final analysis, however, it is often impossible to determine which (if either) of two discrepant measurements is correct. Our SCALE factor technique is an attempt to address this ignorance by increasing the error above that suggested by least-squares analysis. In effect, we are saying that present experiments do not allow a precise determination of this constant because of unresolvable discrepancies, and one must await further measurements. The reader is warned of this situation by the size of the SCALE factor; he or she is then able to go back to the literature (via the Listings) and redo the average as desired.

Our situation with regard to discrepant data is easier to handle than most of the cases Taylor considers, such as estimates of the fundamental constants like $\hbar$, etc. Most of the errors in his case are dominated by systematic effects. In

‡ We can handle any R of the form $R = \sum \alpha_i P_i / \sum \beta_i P_i$, where α_i and β_i are constants, usually 1 or 0. The forms $R = P_i \cdot P_j$ and $R = (P_i \cdot P_j)^{1/2}$ are also allowed.

particle properties data, statistical effects are often at least as large as systematic effects, and statistical errors are usually easier to estimate. A notable exception occurs in partial-wave analyses, where different techniques applied to the same data yield different results. In this case, as stated earlier, we often do not attempt an average, but just quote a range of values.

A brief history of Particle Data Group averages is given in Rosenfeld (1975). Updated versions of some of Rosenfeld's figures are shown in Fig. 2. The least-squares error is shown by the thick portion of the error bars; the full error bar exhibits the SCALE factor extension.

Some cases of rather wild fluctuation are shown; this usually represents the introduction of significant new data or the discarding of some older data. Older data are sometimes discarded in favor of more modern data if it is felt that the newer data had fewer systematic errors, had more checks on their systematic errors, made some corrections unknown at the time of the older experiments, or some such reason. Near the time at which a large jump takes place, the SCALE factor sometimes becomes large, reflecting the uncertainty introduced by the new existence of partly inconsistent data.

By and large, a full scan of our history plots shows a rather dull progression toward greater precision at a central value completely consistent with the first data point shown. These plots are available on request from the Berkeley Particle Data Group.

We conclude that the reliability of the combination of experimental data and Particle Data Group averaging procedures is usually good, but it is important to realize that fluctuations outside of the quoted errors can and do occur, perhaps with more frequency than expected for truly Gaussian errors.

ACKNOWLEDGMENTS

The Particle Data Group wishes to acknowledge with appreciation the efforts made over many years by Robert Kelly. Kelly was in charge of the Baryon Section for a number of years and served a term as Berkeley group leader. His contributions will be missed, and we wish him well in his new endeavors.

We thank all those who have assisted in the many phases of preparing this Review. In particular, we acknowledge the usefulness of feedback from the physics community, especially those who have made suggestions or pointed out errors.

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B.N. Taylor, "Numerical Comparisons of Several Algorithms for Treating Inconsistent Data in a Least-Squares Adjustment of the Fundamental Constants," U.S. National Bureau of Standards NBSIR 81-2426 (1982).

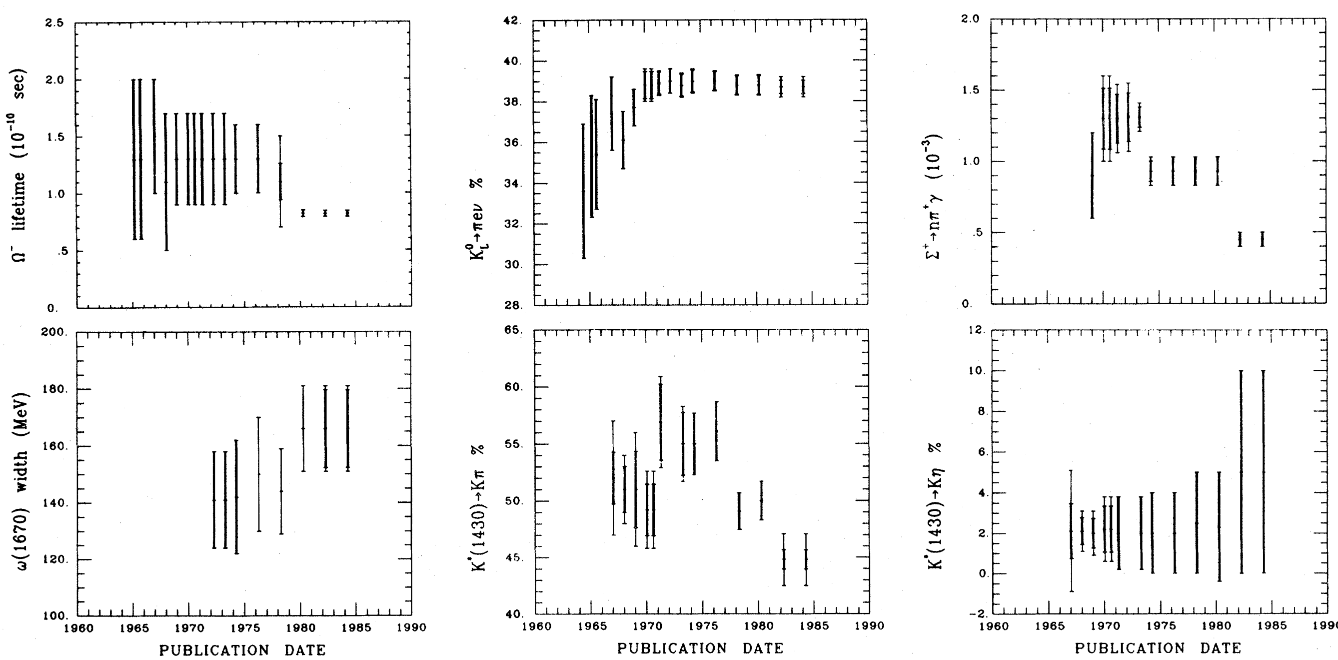


Fig. 2. Historical perspective of a few quantities tabulated in the Review of Particle Properties; abcissa specifies date of publication of the Review. Data measured by a variety of different techniques are included. The general reliability of the averages is good; very few are presently more than two standard deviations from their first tabulated values. Full error bar indicates quoted error; thick-lined portion indicates quoted error with "scale factor" removed (see Section V Part C above).

TABLES OF PARTICLE PROPERTIES

April 1984

M. Aguilar-Benitez, R.N. Cahn, R.L. Crawford, R. Frosch, G.P. Gopal, R.E. Hendrick,
J.J. Hernandez, G. Höhler, M.J. Losty, L. Montanet, F.C. Porter, A. Rittenberg,
M. Roos, L.D. Roper, T. Shimada, R.E. Shrock, N.A. Törnqvist, T.G. Trippe,
W.P. Trower, Ch. Walck, C.G. Wohl, G.P. Yost, and B. Armstrong (Technical Associate)

(Closing date for data: Jan. 1, 1984)

Stable Particle Table

For additional parameters, see Addendum to this table.

Quantities in italics are new or have changed by more than one (old) standard deviation since April 1982.

Particle	$I^G(J^P)C$ [a]	Mass [b] (MeV)	Mean life [b] (sec) $c\tau$ (cm)	Partial decay mode: Mode	Fraction [b]	p or p_{max} [c] (MeV/c)
GAUGE BOSONS						
γ	$0,1(1^-)-$	$(<3\times10^{-33})$	------	stable		
W		*80800* $\pm$*2700*	$\Gamma<$*7* GeV	$e\nu$	(*seen*)	40400
Z		*92900* $\pm$*1600*	$\Gamma<$*8.5* GeV	e^+e^-	(*seen*)	46450
				$\mu^+\mu^-$	(*seen*)	46450
→ weak gauge boson searches						
LEPTONS						
ν_e	$J=\frac{1}{2}$	(<0.000046)[d]	stable $(>3\times10^8 m_{\nu_e}$(MeV))	stable		
e	$J=\frac{1}{2}$	0.5110034 $\pm$0.0000014	stable $(>2\times10^{22}$y)	stable		
ν_μ	$J=\frac{1}{2}$	0(< 0.50)	stable $(>1.1\times10^5 m_{\nu_\mu}$(MeV))	stable		
				μ^- → (or μ^+ →chg. conj.)		
μ	$J=\frac{1}{2}$	105.65932 $\pm$0.00029	2.19709×10^{-6} $\pm$0.00005 $c\tau=6.5867\times10^4$	$e^-\bar{\nu}\nu$	(100)%	53
				†[$e^-\bar{\nu}\nu\gamma$	[e](1.4 ± 0.4)%	53
				$e^-\nu_e\bar{\nu}_\mu$	(<5)%]	53
				$e^-\bar{\nu}\nu e^+e^-$	[e](2.2 ± 1.5)$\times10^{-5}$	53
				$e^-\gamma$	(<1.7)$\times10^{-10}$	53
				$e^-e^+e^-$	(<1.9)$\times10^{-9}$	53
				$e^-\gamma\gamma$	(<8.4)$\times10^{-9}$	53
ν_τ	$J=\frac{1}{2}$	< 164				
				τ^- → (or τ^+ →chg. conj.)		
τ	$J=\frac{1}{2}$	1784.2 $\pm$3.2	$(3.4\pm0.5)\times10^{-13}$ $c\tau=0.010$	$\mu^-\bar{\nu}\nu$	(18.5 ± 1.1)%	889
				$e^-\bar{\nu}\nu$	(16.5 ± 0.9)%	892
				hadron^- neutrals	(*48.1* ± *2.0*)% S=1.1*	
				3($\text{hadron}^\pm$) neutrals	(*17.0* ± *1.3*)% S=1.2*	
				5($\text{hadron}^\pm$) neutrals	(<1.4)%	
				†[3($\text{hadron}^\pm$)ν	(5 ± 4)%	
				3($\text{hadron}^\pm$)ν($\geq1\gamma$)	(12 ± 4)%]	
				†[$\pi^-\nu$	(10.3 ± 1.2)%	887
				$\rho^-\nu$	(22.1 ± 2.4)%	726
				$K^-\nu$	(*1.3* ± *0.5*)%	824
				K^- neutrals	(*small*)%]	

(continued next page)

Stable Particle Table *(cont'd)*

Particle	$I^G(J^P)C$ [a]	Mass [b] (MeV)	Mean life [b] (sec) $c\tau$ (cm)	Mode	Fraction [b]	p or p_{max} [c] (MeV/c)
				τ^- → (or τ^+ → chg. conj.)		
τ (continued)				†[$K^{*-}(892)\nu$	(1.7 ± 0.7)%	669
				$K^{*-}(1430)\nu$	(<0.9)%	323
				$\pi^-\rho^0\nu$	(5.4 ± 1.7)%]	718
				e^- chgd.parts. + μ^- chgd.parts.	(<4)%	
				$\mu^-\gamma$	(<5.5)$\times10^{-4}$	889
				$e^-\gamma$	(<6.4)$\times10^{-4}$	892
				$\mu^-\mu^+\mu^-$	(<4.9)$\times10^{-4}$	876
				$e^-\mu^+\mu^-$	(<3.3)$\times10^{-4}$	886
				$\mu^-e^+e^-$	(<4.4)$\times10^{-4}$	889
				$e^-e^+e^-$	(<4.0)$\times10^{-4}$	892
				$\mu^-\pi^0$	(<8.2)$\times10^{-4}$	884
				$e^-\pi^0$	(<2.1)$\times10^{-3}$	887
				μ^-K^0	(<1.0)$\times10^{-3}$	819
				e^-K^0	(<1.3)$\times10^{-3}$	823
				$\mu^-\rho^0$	(<4.4)$\times10^{-4}$	722
				$e^-\rho^0$	(<3.7)$\times10^{-4}$	726

→ searches for massive neutrinos and lepton mixing
→ ν bounds from astrophysics and cosmology
→ heavy lepton searches

NONSTRANGE MESONS [a]

Particle	$I^G(J^P)C$	Mass (MeV)	Mean life (sec) / $c\tau$ (cm)	Mode	Fraction	p or p_{max} (MeV/c)
				π^+ → (or π^- → chg. conj.)		
$\pi^\pm$	$1^-(0^-)$	139.5673	2.6030×10^{-8}	$\mu^+\nu$	100%	30
		±0.0007	±0.0023	$e^+\nu$	(*1.232±0.024*)$\times10^{-4}$ S=2.0*	70
			$c\tau$=780.4	†[$\mu^+\nu\gamma$	[e](1.24± 0.25)$\times10^{-4}$	30
	$m_{\pi^\pm}-m_{\mu^\pm}$	=33.9080		$e^+\nu\gamma$	[e](5.6 ± 0.7)$\times10^{-8}$]	70
		±0.0008		$e^+\nu\pi^0$	(1.033±0.034)$\times10^{-8}$	5
				$e^+\nu e^+e^-$	(<5)$\times10^{-9}$	70
				$\mu^+\bar{\nu}_e$	(<*1.5*)$\times10^{-3}$	30
				$\mu^+\nu_e$	(<*8*)$\times10^{-3}$	30
π^0	$1^-(0^-)+$	134.9630	0.83×10^{-16}	$\gamma\gamma$	(98.802±0.030)%	67
		±0.0038	±0.06 S=1.8*	γe^+e^-	(1.198)%	67
			$c\tau=2.5\times10^{-6}$	$\gamma\gamma\gamma$	[f](<3.8)$\times10^{-7}$	67
	$m_{\pi^\pm}-m_{\pi^0}$	=4.6043		$e^+e^-e^+e^-$	[f](3.24)$\times10^{-5}$	67
		±0.0037		$\gamma\gamma\gamma\gamma$	(<4)$\times10^{-6}$	67
				e^+e^-	(1.8 ± 0.7)$\times10^{-7}$	67
				$\nu\nu$	(<2.4)$\times10^{-5}$	67
				$\mu^+e^-+\mu^-e^+$	(<*7*)$\times10^{-8}$	26
η	$0^+(0^-)+$	548.8	Γ=(0.88±0.12)keV	$\gamma\gamma$	(39.0 ± 0.8)%	274
		±0.6	Neutral decays	$3\pi^0$	(31.8 ± 0.8)% S=1.1*	180
		S=1.4*	(70.9±0.7)%	$\pi^0\gamma\gamma$	(0.10 ± 0.02)%	258
				$\pi^+\pi^-\pi^0$	(23.7 ± 0.5)%	175
				$\pi^+\pi^-\gamma$	(4.91± 0.13)%	236
				$e^+e^-\gamma$	(0.50± 0.12)%	274
				$\mu^+\mu^-\gamma$	(3.1 ± 0.4)$\times10^{-4}$	253
				e^+e^-	(<3)$\times10^{-4}$	274
				$\mu^+\mu^-$	(6.5 ± 2.1)$\times10^{-6}$	253
			Charged decays	$\pi^+\pi^-e^+e^-$	(0.13± 0.13)%	236
			(29.1±0.7)%	$\pi^+\pi^-\gamma\gamma$	(<0.21)%	236
				$\pi^+\pi^-\pi^0\gamma$	(<6)$\times10^{-4}$	175
				$\pi^+\pi^-$	(<0.15)%	236
				$\pi^0e^+e^-$	(<5)$\times10^{-5}$	258
				$\pi^0\mu^+\mu^-$	(<5)$\times10^{-6}$	211
				$\pi^0\mu^+\mu^-\gamma$	(<3)$\times10^{-6}$	211

Stable Particle Table *(cont'd)*

Particle	$I^G(J^P)$ [a]	Mass [b] (MeV)	Mean life [b] (sec) $c\tau$ (cm)	Partial decay mode: Mode	Fraction [b]		p or p_{max} [c] (MeV/c)
				STRANGE MESONS [a]			
				$K^+ \to$ (or $K^- \to$ chg. conj.)			
$K^\pm$	$\frac{1}{2}(0^-)$	493.667	1.2371×10^{-8}	$\mu^+\nu$	(63.51 ± 0.16)%		236
		±0.015	±0.0026 S=1.9*	$\pi^+\pi^0$	(21.17 ± 0.15)%		205
			$c\tau$=370.9	$\pi^+\pi^+\pi^-$	(5.59 ± 0.03)%	S=1.1*	125
				$\pi^+\pi^0\pi^0$	(1.73 ± 0.05)%	S=1.4*	133
				$\pi^0\mu^+\nu$	(3.18 ± 0.10)%	S=1.9*	215
	$m_{K^\pm}-m_{K^0}$ =	−4.01		$\pi^0e^+\nu$	(4.82 ± 0.05)%	S=1.1*	228
		±0.13		†[$\mu^+\nu\gamma$	[e](5.8 ± 3.5)$\times10^{-3}$		236
		S=1.1*		$\pi^+\pi^0\gamma$	[g,e](2.75 ± 0.16)$\times10^{-4}$		205
				$\pi^+\pi^+\pi^-\gamma$	[e](1.0 ± 0.4)$\times10^{-4}$		125
				$\pi^0\mu^+\nu\gamma$	[e](<6)$\times10^{-5}$		215
				$\pi^0e^+\nu\gamma$	[e](3.7 ± 1.4)$\times10^{-4}$]		228
				$\pi^0\pi^0e^+\nu$	(1.8 $^{+2.4}_{-0.6}$)$\times10^{-5}$		207
				$\pi^+\pi^-e^+\nu$	(3.90 ± 0.15)$\times10^{-5}$		203
				$\pi^+\pi^+e^-\bar{\nu}$	(<1.2)$\times10^{-8}$		203
				$\pi^+\pi^-\mu^+\nu$	(1.4 ± 0.9)$\times10^{-5}$		151
				$\pi^+\pi^+\mu^-\bar{\nu}$	(<3.0)$\times10^{-6}$		151
				$e^+\nu$	(1.54 ± 0.07)$\times10^{-5}$		247
				$e^+\nu\gamma$ (SD+) [h]	(1.52 ± 0.23)$\times10^{-5}$		247
				$e^+\nu\gamma$ (SD−) [h]	(<1.6)$\times10^{-4}$		247
				$\pi^+e^+e^-$	(2.7 ± 0.5)$\times10^{-7}$		227
				$\pi^-e^+e^+$	(<1)$\times10^{-8}$		227
				$\pi^+\mu^+\mu^-$	(<2.4)$\times10^{-6}$		172
				$\pi^+\gamma\gamma$	[e](<8)$\times10^{-6}$		227
				$\pi^+\gamma\gamma\gamma$	[e](<1.0)$\times10^{-4}$		227
				$\pi^+\nu\bar{\nu}$	(<1.4)$\times10^{-7}$		227
				$\pi^\mp e^+\mu^\pm$	(<7)$\times10^{-9}$		214
				$\pi^+e^-\mu^+$	(<5)$\times10^{-9}$		214
				$e^+\nu\nu\bar{\nu}$	(<6)$\times10^{-5}$		247
				$\mu^+\nu\nu\bar{\nu}$	(<6)$\times10^{-6}$		236
				$\mu^+\nu e^+e^-$	(11 ± 3)$\times10^{-7}$		236
				$\mu^-\nu e^+e^+$	(<2.0)$\times10^{-8}$		236
				$e^+\nu e^+e^-$	(2 $^{+2}_{-1}$)$\times10^{-7}$		247
				$\mu^+\nu_e$	(<4)$\times10^{-3}$		236
				$\mu^+\bar{\nu}_e$	(<3.3)$\times10^{-3}$		236
				$\pi^0e^+\bar{\nu}_e$	(<3)$\times10^{-3}$		228
K^0 $\bar{K}^0$	$\frac{1}{2}(0^-)$	497.67 ±0.13 S=1.1*		50 % K_{Short}, 50% K_{Long}			
K^0_S	$\frac{1}{2}(0^-)$		0.8923×10^{-10}	$\pi^+\pi^-$	(68.61 ± 0.24)%	S=1.1*	206
			±0.0022	$\pi^0\pi^0$	(31.39)%		209
			$c\tau$=2.675	†[$\pi^+\pi^-\gamma$	[e](1.85 ± 0.10)$\times10^{-3}$]		206
				$\mu^+\mu^-$	(<3.2)$\times10^{-7}$		225
				e^+e^-	(<3.4)$\times10^{-4}$		249
				$\gamma\gamma$	(<4)$\times10^{-4}$		249
				$\pi^+\pi^-\pi^0$	(<8.5)$\times10^{-5}$		133
				$\pi^0\pi^0\pi^0$	(<3.7)$\times10^{-5}$		139
K^0_L	$\frac{1}{2}(0^-)$		5.183×10^{-8}	$\pi^0\pi^0\pi^0$	(21.5 ± 1.0)%	S=1.7*	139
			±0.040	$\pi^+\pi^-\pi^0$	(12.39 ± 0.20)%	S=1.3*	133
			$c\tau$=1554	$\pi^\pm\mu^\mp\nu$	(27.1 ± 0.4)%	S=1.4*	216
				$\pi^\pm e^\mp\nu$	(38.7 ± 0.5)%	S=1.5*	229
	$m_{K_L}-m_{K_S}$ =	0.5349×10^{10} ℏ sec^{-1}		$\pi^+\pi^-$	[i](0.203 ± 0.005)%	S=1.1*	206
		±0.0022		$\pi^0\pi^0$	[i](0.094 ± 0.018)%	S=1.5*	209
		= 3.521×10^{-12} MeV		†[$\pi e\nu\gamma$	[e](1.3 ± 0.8)%		229
		±0.014		$\pi^+\pi^-\gamma$	[e](4.41 ± 0.32)$\times10^{-5}$]		206
				$\pi^0\gamma\gamma$	(<2.4)$\times10^{-4}$		231
				$\gamma\gamma$	(4.9 ± 0.4)$\times10^{-4}$		249
				$e\mu$	[j](<6)$\times10^{-6}$		238
				$\mu^+\mu^-$	(9.1 ± 1.9)$\times10^{-9}$		225
				$\mu^+\mu^-\gamma$	(2.8 ± 2.8)$\times10^{-7}$		225
				$\pi^0\mu^+\mu^-$	(<1.2)$\times10^{-6}$		177

(continued next page)

Stable Particle Table *(cont'd)*

Particle	$I^G(J^P)$ [a]	Mass [b] (MeV)	Mean life [b] (sec) $c\tau$ (cm)	Partial decay mode: Mode	Fraction [b]		p or p_{max} [c] (MeV/c)
K_L^0 (continued)				e^+e^-	[j] $(<2.0)\times10^{-7}$		249
				$e^+e^-\gamma$	$(1.7 \pm 0.9)\times10^{-5}$		249
				$\pi^0e^+e^-$	$(<2.3)\times10^{-6}$		231
				$\pi^+\pi^-e^+e^-$	$(<9)\times10^{-6}$		206
				$\pi^0\pi^\pm e^\mp\nu$	$(6.2 \pm 2.0)\times10^{-5}$		207
				$(\pi\mu$ atom$)\,\nu$	$(\mathit{1.05} \pm \mathit{0.11})\times10^{-7}$		
CHARMED NONSTRANGE MESONS [a]							
				$D^+ \to$ (or $D^- \to$ chg. conj.)			
$D^\pm$	$\frac{1}{2}(0^-)$	1869.4 ±0.6	$(9.2^{+1.7}_{-1.2})\times10^{-13}$ $c\tau$=0.028	e^+ anything	$(19\ ^{+4}_{-3})$%		
				K^- anything	(16 ± 4)%		
				$\bar{K}^0$ any + K^0 any	(48 ± 15)%		
				K^+ anything	(6.0 ± 3.3)%		
		$m_{D^\pm}-m_{D^0}$= 4.7 ±0.3		η anything	[k] (<13)%		
				$\mu^+\nu$	$(<\mathit{2})$%		932
				†[$K^-\pi^+\pi^+$	(4.6 ± 1.1)%	S=1.3*	845
				$K^-\pi^+\pi^+\pi^0$	$(\mathit{2.6}\ ^{+3.1}_{-1.0})$%		816
				$K^-\pi^+\pi^+\pi^+\pi^-$	(<4)%		772
				$\bar{K}^0\pi^+$	(1.8 ± 0.5)%		862
				$\bar{K}^0\pi^+\pi^0$	(13 ± 8)%		845
				$\bar{K}^0\pi^+\pi^+\pi^-$	(8.4 ± 3.5)%		814
				$\bar{K}^0K^+$	(0.45 ± 0.30)%		792
				$K^+K^-\pi^+$	(<0.6)%		744
				$K^+\pi^+\pi^-$	(<0.23)%		845
				$\pi^+\pi^0$	(<0.5)%		925
				$\pi^+\pi^+\pi^-$	(<0.4)%]		908
				†[$\bar{K}^{*0}\pi^+$	(<3.7)%]		714
				$D^0 \to$ (or $\bar{D}^0 \to$ chg. conj.)			
D^0 $\bar{D}^0$	$\frac{1}{2}(0^-)$	1864.7 ±0.6	$(4.4\ ^{+0.8}_{-0.6})\times10^{-13}$ $c\tau$=0.013	e^+ anything	$(5.3\ ^{+2.9}_{-1.3})$%		
				K^- anything	(44 ± 10)%	S=1.3*	
				$\bar{K}^0$ any+ K^0 any	(33 ± 10)%		
		$\lvert m_{D_1^0}-m_{D_2^0}\rvert$ < *6.5*$\times10^{-10}$ MeV [ℓ]		K^+ anything	(8 ± 3)%		
				η anything	[k] (<13)%		
				†[$K^-\pi^+$	(2.4 ± 0.4)%		861
				$K^-\pi^+\pi^0$	(9.3 ± 2.8)%		844
		$\frac{\lvert\tau_{D_1^0}-\tau_{D_2^0}\rvert}{\text{average}}$ < *0.55* [ℓ]		$K^-\pi^+\pi^+\pi^-$	(4.6 ± 1.4)%	S=1.2*	812
				$K^-\pi^+\pi^0\pi^0$	(seen)		815
				$\bar{K}^0\pi^0$	(2.2 ± 1.1)%		860
				$\bar{K}^0\pi^+\pi^-$	(4.2 ± 0.8)%		842
		$\frac{\Gamma(D^0\to\bar{D}^0\to K^+\pi^-)}{\Gamma(D^0\to K\pi)}$ < 0.16		$\pi^+\pi^-$	$(7.9 \pm 3.8)\times10^{-4}$		922
				$\pi^+\pi^+\pi^-\pi^-$	(<1.0)%		880
				K^+K^-	$(2.7 \pm 0.8)\times10^{-3}$]		791
				†[$K^{*-}\pi^+$	(3.4 ± 1.4)%		711
		$\frac{\Gamma(D^0\to\bar{D}^0\to\mu^-\text{ anything})}{\Gamma(D^0\to\mu^\pm\text{ anything})}$ < *0.044*		$\bar{K}^{*0}\pi^0$	$(1.4\ ^{+2.3}_{-1.4})$%		711
				$K^-\rho^+$	$(7.2\ ^{+3.0}_{-3.1})$%		679
				$\bar{K}^0\rho^0$	$(0.1\ ^{+0.6}_{-0.1})$%		677
				$\bar{K}^{*0}\rho^0$	$(0.7\ ^{+0.8}_{-0.7})$%		423
				$K^-\pi^+\rho^0$	$(3.9\ ^{+1.3}_{-1.6})$%		613
				$\bar{K}^{*0}\pi^+\pi^-$	(<2.3)%		685
				$K^-A_2^+$	(<0.8)%]		198
CHARMED STRANGE MESON [a]							
				$F^+ \to$ (or $F^- \to$ chg. conj.)			
$F^\pm$	$0(0^-)$ [m]	1971 [m] ±6	$(1.9^{+1.3}_{-0.7})\times10^{-13}$ $c\tau$=0.006	$\phi\pi^+$	(*seen*)		713
				$\eta\pi^+$	(*possibly seen*)		903
				$\eta\pi^+\pi^+\pi^-$	(*possibly seen*)		857
				$\eta'\pi^+\pi^+\pi^-$	(*possibly seen*)		679
				$\phi\rho^+$	(*possibly seen*)		411

Stable Particle Table *(cont'd)*

Particle	$I^G(J^P)$ [a]	Mass [b] (MeV)	Mean life [b] (sec) $c\tau$ (cm)	Partial decay mode: Mode	Fraction [b]	p or p_{max} [c] (MeV/c)
BOTTOM MESONS [a]						
				$B^+ \rightarrow$ (or $B^- \rightarrow$ chg. conj.)		
$B^\pm$	$\frac{1}{2}(0^-)$ [n]	5270.8		$\overline{D}^0\pi^+$	(4.2 ± 4.2)%	2303
		±3.0		$D^{*-}\pi^+\pi^+$	(4.8 ± 3.0)%	2243
				$B^0 \rightarrow$ (or $\overline{B}^0 \rightarrow$ chg. conj.)		
B^0 $\overline{B}^0$	$\frac{1}{2}(0^-)$ [n]	5274.2		$\overline{D}^0\pi^+\pi^-$	(13 ± 9)%	2298
		±2.8		$D^{*-}\pi^+$	(2.6 ± 1.9)%	2253
$B^\pm$, B^0, $\overline{B}^0$ (not separated) [p]			$(14\pm4)\times10^{-13}$	$e^\pm\nu$ hadrons	(13.0 ± 1.3)%	
			$c\tau$=0.042	$\mu^\pm\nu$ hadrons	(12.4 ± 3.5)%	
				D^0 anything	(80 ± 28)%	
				K anything	(seen)	
				p anything	(>3.6)%	
				Λ anything	(>2.2)%	
				e^+e^- anything	(<0.8)%	
				$\mu^+\mu^-$ anything	(<0.7)%	
NONSTRANGE BARYONS [a]						
p	$\frac{1}{2}(\frac{1}{2}^+)$	938.2796	stable ($>10^{32}$y) [q]	stable		
		±0.0027		$\lvert q_p\rvert-\lvert q_e\rvert < 10^{-21}\lvert q_e\rvert$ [r]		
n	$\frac{1}{2}(\frac{1}{2}^+)$	939.5731	898±16	$pe^-\overline{\nu}$	100%	1.2
		±0.0027	$c\tau$=2.7×10[13]	$p\nu\overline{\nu}$ (chg.noncons.)	(<9)×10^{-24}	1.3
	m_p-m_n=	*−1.293323*				
		±0.000016		$\lvert q_n\rvert < 10^{-21}\lvert q_e\rvert$ [r]		
STRANGENESS −1 BARYONS [a]						
Λ	$0(\frac{1}{2}^+)$	1115.60	2.632×10^{-10}	$p\pi^-$	(64.2 ± 0.5)%	100
		±0.05	±0.020 S=1.6*	$n\pi^0$	(35.8 ± 0.5)%	104
		S=1.2*	$c\tau$ =7.89	$pe^-\nu$	(8.37± 0.14)×10^{-4}	163
				$p\mu^-\nu$	(1.57± 0.35)×10^{-4}	131
	$m_\Lambda-m_{\Sigma^0}$=	−76.86		†[$p\pi^-\gamma$	[e](8.5 ± 1.4)×10^{-4}]	100
		±0.08				
Σ^+	$1(\frac{1}{2}^+)$	1189.36	0.800×10^{-10}	$p\pi^0$	(51.64 ± 0.30)%	189
		±0.06	±0.004	$n\pi^+$	(48.36 ± 0.30)%	185
		S=1.8*	$c\tau$=2.40	$p\gamma$	(1.20± 0.13)×10^{-3} S=1.2*	225
				†[$n\pi^+\gamma$	[e](4.5 ± 0.5)×10^{-4}]	185
				$\Lambda e^+\nu$	(2.0 ± 0.5)×10^{-5}	71
	$m_{\Sigma^+}-m_{\Sigma^-}$=	−7.97		$n\mu^+\nu$	(<3.0)×10^{-5}	202
		±0.07	$\frac{\Gamma(\Sigma^+\rightarrow\ell^+n\nu)}{\Gamma(\Sigma^-\rightarrow\ell^-n\nu)} < .04$	$ne^+\nu$	(<5)×10^{-6}	224
		S=1.3*		pe^+e^-	(<7)×10^{-6}	225
Σ^0	$1(\frac{1}{2}^+)$ [s]	1192.46	5.8×10^{-20}	$\Lambda\gamma$	100%	74
		±0.08	±1.3	Λe^+e^-	[f](5.45)×10^{-3}	74
			$c\tau$=1.7×10^{-9}	$\Lambda\gamma\gamma$	(<3)%	74
Σ^-	$1(\frac{1}{2}^+)$	1197.34	1.482×10^{-10}	$n\pi^-$	100%	193
		±0.05	±0.011 S=1.3*	$ne^-\nu$	(*1.022±0.034*)×10^{-3}	230
			$c\tau$=4.44	$n\mu^-\nu$	(4.5 ± 0.4)×10^{-4}	210
				$\Lambda e^-\nu$	(5.74± 0.27)×10^{-5}	79
	$m_{\Sigma^0}-m_{\Sigma^-}$=	−4.88		†[$n\pi^-\gamma$	[e](4.6 ± 0.6)×10^{-4}]	193
		±0.06				

Stable Particle Table *(cont'd)*

Particle	$I^G(J^P)$ [a]	Mass [b] (MeV)	Mean life [b] (sec) $c\tau$ (cm)	Mode	Fraction [b]	p or p_{max} [c] (MeV/c)
STRANGENESS −2 BARYONS [a]						
Ξ^0	$\frac{1}{2}(\frac{1}{2}^+)$ [s]	1314.9	2.90×10^{-10}	$\Lambda\pi^0$	100%	135
		±0.6	±0.10	$\Lambda\gamma$	(0.5 ± 0.5)%	184
			$c\tau$=8.69	$\Sigma^0\gamma$	(<7)%	117
				$p\pi^-$	(<3.6)$\times10^{-5}$	299
				$pe^-\nu$	(<1.3)$\times10^{-3}$	323
	$m_{\Xi^0}-m_{\Xi^-}$	=−6.4		$\Sigma^+e^-\nu$	(<1.1)$\times10^{-3}$	120
		±0.6		$\Sigma^-e^+\nu$	(<0.9)$\times10^{-3}$	112
				$\Sigma^+\mu^-\nu$	(<1.1)$\times10^{-3}$	65
				$\Sigma^-\mu^+\nu$	(<0.9)$\times10^{-3}$	49
				$p\mu^-\nu$	(<1.3)$\times10^{-3}$	309
Ξ^-	$\frac{1}{2}(\frac{1}{2}^+)$ [s]	1321.32	1.641×10^{-10}	$\Lambda\pi^-$	100%	139
		±0.13	±0.016	$\Lambda e^-\nu$	(*5.5 ± 0.6*)$\times10^{-4}$ S=2.0*	190
			$c\tau$=4.92	$\Sigma^0e^-\nu$	(8.7 ± 1.7)$\times10^{-5}$	123
				$\Lambda\mu^-\nu$	(3.5 ± 3.5)$\times10^{-4}$	163
				$\Sigma^0\mu^-\nu$	(<8)$\times10^{-4}$	70
				$n\pi^-$	(<1.9)$\times10^{-5}$	303
				$ne^-\nu$	(<3.2)$\times10^{-3}$	327
				$n\mu^-\nu$	(<1.5)%	313
				$\Sigma^-\gamma$	(<1.2)$\times10^{-3}$	118
				$p\pi^-\pi^-$	(<4)$\times10^{-4}$	223
				$p\pi^-e^-\nu$	(<4)$\times10^{-4}$	304
				$p\pi^-\mu^-\nu$	(<4)$\times10^{-4}$	250
				$\Xi^0e^-\nu$	(<2.3)$\times10^{-3}$	6
STRANGENESS −3 BARYON [a]						
Ω^-	$0(\frac{3}{2}^+)$ [s]	1672.45	0.819×10^{-10}	ΛK^-	(68.6 ± 1.3)%	211
		±0.32	±0.027	$\Xi^0\pi^-$	(23.4 ± 1.3)%	294
			$c\tau$=2.46	$\Xi^-\pi^0$	(8.0 ± 0.8)%	290
				$\Xi^0e^-\nu$	(~1)%	319
				$\Xi^0(1530)\pi^-$	(~2)$\times10^{-3}$	
				$\Lambda\pi^-$	(<1.3)$\times10^{-3}$	449
				$\Xi^-\gamma$	(<3.1)$\times10^{-3}$	314
NONSTRANGE CHARMED BARYON [a]						
Λ_c^+	$0(\frac{1}{2}^+)$ [s]	2282.0	$(2.3^{+1.0}_{-0.6})\times10^{-13}$	$pK^-\pi^+$	(2.2 ± 1.0)%	820
		±3.1	$c\tau$=0.007	$p\bar{K}^0$	(1.1 ± 0.7)%	870
		S=1.8*		$p\bar{K}^0\pi^+\pi^-$	(<4, seen)%	751
				Λ anything	(33 ±29)%	
				†[$\Lambda\pi^+$	(0.6 ± 0.5)%	861
				$\Lambda\pi^+\pi^+\pi^-$	(< 3.1, seen)%	804
				$\Sigma^0\pi^+$	(seen)]	822
				†[pK^{*0}	(0.48 ± 0.30)%	681
				$\Delta^{++}K^-$	(0.45 ± 0.27)%	706
				$pK^{*-}\pi^+$	(seen)]	575
				e^+ anything	(4.5 ± 1.7)%	
				†[pe^+ anything	(1.8 ± 0.9)%	
				Λe^+ anything	(1.1 ± 0.8)%]	

→ A^+
→ Λ_b^0
→ top hadron searches
→ free quark searches
→ magnetic monopole searches
→ axion searches
→ other stable particle searches

ADDENDUM TO

Stable Particle Table

e^t — **Magnetic Moment**

$1.001\,159\,652\,209 \pm .000\,000\,000\,031 \ \frac{e\hbar}{2m_e c}$

μ^t — $1.001\,165\,924 \pm .000\,000\,009 \ \frac{e\hbar}{2m_\mu c}$

μ Decay parameters[u]

$\rho = 0.752 \pm 0.003$ $\quad \eta = -0.06 \pm 0.15$ S=1.1*

$\xi \cdot P_\mu > 0.9959^{v}$ $\quad \delta = 0.755 \pm 0.009$ $\quad h = 1.01 \pm 0.06$

$\alpha' = -0.12 \pm 0.10$ $\quad \beta' = 0.029 \pm 0.037$ $\quad \bar{\eta} = 0.006 \pm 0.080$

$|g_A/g_V| = 0.91^{+0.24}_{-0.06}$ $\quad \phi_{AV} = 180° \pm 9°$

$|g_S/g_V| < 0.29$ $\quad |g_T/g_V| < 0.14$ $\quad |g_P/g_V| < 0.25$

τ — **Michel parameter**

$\rho = 0.72 \pm 0.15$

η

Mode	Left-right asymmetry	Sextant asymmetry	Quadrant asymmetry
$\pi^+\pi^-\pi^0$	$(0.12 \pm .17)\%$	$(0.19 \pm 0.16)\%$	$(-0.17 \pm 0.17)\%$
$\pi^+\pi^-\gamma$	$(0.88 \pm .40)\%$		$\beta = 0.047 \pm 0.062$ S=1.5*

K

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

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

See Data Card Listings for quadratic coefficients.

$\Delta S = -\Delta Q$ in $K^0_{\ell 3}$ decay

Re x = $0.009 \pm .020$ S=1.4*

Im x = $-0.004 \pm .026$ S=1.1*

Form factors for $K_{\ell 3}$ decays[x]

K^+_{e3}: $\lambda_+ = 0.029 \pm 0.004$; $|f_S/f_+| = 0.125 \pm 0.044$; $|f_T/f_+| = 0.22 \pm 0.14$

K^0_{e3}: $\lambda_+ = 0.0300 \pm 0.0016$ S=1.2*; $|f_S/f_+| < 0.04$; $|f_T/f_+| < 0.23$

$K^+_{\mu 3}$: $\lambda_+ = 0.032 \pm 0.008$ S=2.3*; $\lambda_0 = 0.004 \pm 0.007$ S=2.3*; $|f_T/f_+| = 0.02 \pm 0.12$

$K^0_{\mu 3}$: $\lambda_+ = 0.034 \pm 0.005$ S=2.3*; $\lambda_0 = 0.025 \pm 0.006$ S=2.3*; $|f_T/f_+| = 0.12 \pm 0.12$

CP-violation parameters[y,i]

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

$\phi_{+-} = (44.6 \pm 1.2)°$ $\quad \phi_{00} = (54 \pm 5)°$ $\quad \mathrm{Re}\ \epsilon = (1.621 \pm 0.088) \times 10^{-3}$

$|\eta_{+-0}|^2 < 0.12$ $\quad |\eta_{000}|^2 < 0.1$ $\quad \delta = (0.330 \pm .012)\%$

	Magnetic moment ($e\hbar/2m_p c$)	Mode	Decay parameters[z] Measured α	Measured ϕ(degree)	Derived γ	Derived Δ(degree)	Coupling Constant Ratios
p^t	$2.7928456 \pm .0000011$						
n^t	$-1.91304184 \pm .00000088$	$pe^-\nu$					$g_A/g_V = -1.254 \pm 0.006$; $\phi_{AV} = (180.11 \pm 0.17)°$
Λ^t	$-0.613 \pm .004$	$p\pi^-$	0.642 ± 0.013	$(-6.5 \pm 3.5)°$	0.76	$(7.7 \pm 4.1)°$	
		$n\pi^0$	0.646 ± 0.044				
		$pe\nu$					$g_A/g_V = -0.694 \pm 0.025$ S=1.3*
Σ^+	$2.379 \pm .020$	$p\pi^0$	-0.979 ± 0.016	$(36 \pm 34)°$	0.17	$(187 \pm 6)°$	
		$n\pi^+$	$+0.068 \pm 0.013$	$(167 \pm 20)°$	-0.97	$(-73^{+134}_{-10})°$	
		$p\gamma$	-0.72 ± 0.29	S=1.1*			
Σ^-	*$-1.10 \pm .05$* S=1.5*	$n\pi^-$	-0.068 ± 0.008	$(10 \pm 15)°$	0.98	$(249^{+12}_{-116})°$	
		$ne^-\nu$					$\lvert g_A/g_V \rvert = 0.372 \pm 0.050$ S=1.9*
		$\Lambda e^-\nu$					$g_V/g_A = 0.01 \pm 0.10$ S=1.5* $\quad g_{WM}/g_A = 2.4 \pm 1.7$
Ξ^0	$-1.250 \pm .014$	$\Lambda\pi^0$	-0.413 ± 0.022 S=2.0*	$(21 \pm 12)°$	0.85	$(218^{+12}_{-18})°$	
Ξ^-	$-1.85 \pm .75$	$\Lambda\pi^-$	-0.434 ± 0.015 S=1.4*	$(2 \pm 6)°$ S=1.1*	0.90	$(184 \pm 12)°$	
		$\Lambda e^-\nu$					$g_A/g_V = -0.25 \pm 0.05$
Ω^-		ΛK^-	-0.10 ± 0.38 S=1.2*				

Stable Particle Table *(cont'd)*

→ Indicates an entry in the Stable Particle Data Card Listings not entered in the Stable Particle Table.

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

† Square brackets indicate subreactions of some previous unbracketed decay mode(s). Reactions in one set of brackets may overlap with reactions in another set of brackets. A radiative mode such as $\pi \to \mu\nu\gamma$ is a subreaction of its parent mode $\pi \to \mu\nu$.

a. The strangeness *S*, charm *C*, and bottomness (beauty) *B* of the hadrons which appear in the Table are as follows:

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

b. Quoted upper limits correspond to a 90% confidence level. Masses, mean lives, and partial rates evaluated assuming equality for particles and antiparticles. See Conservation Laws Section for further details.

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

d. 99% confidence level. See footnote in Stable Particle Data Card Listings.

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

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

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

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

i. The $K_S^0 \to \pi\pi$ and $K_L^0 \to \pi\pi$ branching fractions are from our branching fraction and rate fits and do not include results of $K_L^0-K_S^0$ interference experiments. The $\pi\pi$ rate results are combined with the interference results to obtain the $|\eta_{+-}|$ and $|\eta_{00}|$ values given in the addendum.

j. The stronger limit $<2\times10^{-9}$ of Clark et al., Phys. Rev. Lett. **26**, 1667 (1971) is not listed because of possible (but unknown) systematic errors. See Stable Particle Data Card Listings.

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

ℓ. $D_1^0 - D_2^0$ limits inferred from limit on $D^0 \to \bar{D}^0 \to \mu^-$ anything.

m. F mass determined from $\phi\pi$ mode. See note on conflicting F meson results in Stable Particle Data Card Listings. Quantum numbers shown are favored but not yet established.

n. Quantum numbers not measured. Values shown are quark model predictions.

p. Except for the neutral-current decay modes ($\ell^+\ell^-$ anything), only data from $\Upsilon(10575)$ decays are used. Behrends et al. [Phys. Rev. Lett. **50**, 881 (1983)] estimate the $\Upsilon(10575) \to B^+B^-$ and $\Upsilon(10575) \to B^0\bar{B}^0$ branching fractions to be 60 ± 2 and 40 ± 2%.

q. Partial mean life for $p \to e^+\pi^0$ mode. For antiprotons the best mean life limit, inferred from observation of cosmic ray $\bar{p}$'s, is $\tau_{\bar{p}} > 10^7$ yrs, the cosmic ray storage time.

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

s. P for Ξ, J^P for Ω^- and Σ^0, and J for Λ_c^+ not yet measured. Values shown are quark model predictions.

t. For limits on electric dipole moment, see Conservation Laws Section. Forbidden by P and T invariance.

u. $|g_A/g_V|$ defined by $g_A^2 = |C_A|^2+|C_A'|^2$, $g_V^2 = |C_V|^2+|C_V'|^2$, and $\Sigma[\bar{e}\Gamma_i\mu][\bar{\nu}\Gamma_i(C_i+C_i'\gamma_5)\nu]$; ϕ defined by $\cos\phi = -\mathrm{Re}(C_A^*C_V'+C_A'C_V^*)/g_Ag_V$. For more details, see Data Card Listings.

v. Value assumes $\rho = \delta$. P_μ is muon longitudinal polarization from π decay. In standard V-A theory, $P_\mu = 1$ and $\rho = \delta = 3/4$.

w. The definition of the slope parameter of the Dalitz plot is as follows [see also note in Data Card Listings]:

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

x. For definitions of form factors f_+, f_S, and f_T, and linear t dependences λ_+ and λ_0 of $f_+(t)$ and $f_0(t)$, see note in K^+ section of Data Card Listings.

y. The definition for the CP violation parameters is as follows [see also note in Data Card Listings]:

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

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

z. The definition of these quantities is as follows [for more details and sign convention, see note in Data Card Listings]:

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

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

Meson Table

April 1984

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 at end of this Table.

Quantities in italics are new or have changed by more than one (old) standard deviation since April 1982.

J^P	G \ I	0	1	$\frac{1}{2}$
N	+	ε/f	ρ	K*,κ
	−	ω/φ	δ	
A	+	η/D	B	K,Q
	−	H	π/A	

	$I^G(J^P)C_n$ — *estab.*	Mass M (MeV)	Full Width Γ (MeV)	Partial decay mode: Mode	Fraction(%) [Upper limits (%) are 90% CL]	p or p_{max}[b] (MeV/c)
			NONSTRANGE MESONS			
$\pi^\pm$	$1^-(0^-)+$	139.57	0.0	See Stable Particle Table		
π^0		134.96	7.95 eV ±0.55 eV			
η	$0^+(0^-)+$	548.8 ±0.6	0.83 keV ±0.12 keV	Neutral	70.9	See Stable Particle Table
				Charged	29.1	
ρ(770)	$1^+(1^-)-$	769[‡] ±3[§]	154[‡] ±5[§]	$\pi\pi$	≈ 100	358
				$\pi\gamma$	0.046±0.005	372
				$\mu^+\mu^-$	0.0067±0.0012[d]	370
				e^+e^-	0.0046±0.0002[d]	384
				$\eta\gamma$	seen[‡]	189
M and Γ from neutral mode.				For upper limits, see footnote *e*		
ω(783)	$0^-(1^-)-$	782.6 ±0.2 S=1.1*	9.9 ±0.3	$\pi^+\pi^-\pi^0$	89.9±0.5	327
				$\pi^0\gamma$	8.7±0.5	380
				$\pi^+\pi^-$	1.4±0.2	366
				$\pi^0\mu^+\mu^-$	0.010±0.002	349
				e^+e^-	0.0067±0.0004 S=1.2*	391
				$\eta\gamma$	seen[‡]	199
				For upper limits, see footnote *f*		
η′(958)	$0^+(0^-)+$[‡]	957.57 ±0.25	0.29 ±0.05	$\eta\pi\pi$	65.3±1.6	231
				$\rho^0\gamma$	30.0±1.6	170
				$\omega\gamma$	2.8±0.5	159
				$\gamma\gamma$	1.9±0.2	479
				$\mu^+\mu^-\gamma$	0.009±0.002	467
				For upper limits, see footnote *g*		
S(975) or S*	$0^+(0^+)+$	975[c] ±4 S=1.4*	33[c] ±6	$\pi\pi$	78±3	467
				$K\bar{K}$	22±3	
See note on $\pi\pi$ and $K\bar{K}$ S wave.[‡]						
δ(980)[‡]	$1^-(0^+)+$	983[h] ±2	54[h] ±7	$\eta\pi$	seen	320
				$K\bar{K}$	seen	
φ(1020)	$0^-(1^-)-$	*1019.5* *±0.1* S=1.2*	4.22 ±0.13	K^+K^-	49.3±1.0 S=1.3*	127
				K_LK_S	34.7±1.0 S=1.3*	110
				$\pi^+\pi^-\pi^0$ (incl. $\rho\pi$)	14.8±0.7 S=1.2*	462
				$\eta\gamma$	*1.2±0.2* S=1.4*	362
				$\pi^0\gamma$	0.14±0.05	501
				e^+e^-	0.031±0.001	510
				$\mu^+\mu^-$	0.025±0.003	499
				$\pi^+\pi^-$	0.02±0.01	490
				For upper limits, see footnote *i*		
H(1190)	$0^-(1^+)-$	1190 ±60	320 ±50	$\rho\pi$	seen	327
Seen in one experiment only.						
B(1235)	$1^+(1^+)-$	1234 ±10[§]	*150* *±10*[§]	$\omega\pi$	only mode seen	350
				[D/S amplitude ratio = 0.29±0.05]		
				For upper limits, see footnote *j*		

Meson Table *(cont'd)*

J^P	G \ I	0	1	$\frac{1}{2}$
N	+	ε/f	ρ	K*,κ
	−	ω/φ	δ	
A	+	η/D	B	K,Q
	−	H	π/A	

	$I^G(J^P)C_n$ — *estab.*	Mass M (MeV)	Full Width Γ (MeV)	Partial decay mode: Mode	Fraction(%) [Upper limits (%) are 90% CL]	p or p_{max} [b] (MeV/c)
f(1270)	$0^+(2^+)+$	1274 ± 5§	178 ± 20§	ππ	84.3 ± 1.2	622
				$2\pi^+2\pi^-$	2.9 ± 0.4 S=1.2*	559
				$K\bar{K}$	2.9 ± 0.2	398
				γγ	0.0015 ± 0.0002	637
				$\pi^+\pi^-2\pi^0$	seen	562
				For upper limits, see footnote *k*		
A(1270) or A_1	$1^-(1^+)+$	1275‡ ± 30	315‡ ± 45	ρπ	dominant	389
				$\pi(\pi\pi)_{S-wave}$	*< 0.7*§	599
→ D(1285)	$0^+(1^+)+$	1283 ± 5§	26 ± 5§	$K\bar{K}\pi$	11 ± 3	302
				ηππ	49 ± 6	482
				†[δπ	36 ± 7]	236
				4π (prob. ρππ)‡	40 ± 7	564
ε(1300)	$0^+(0^+)+$	~1300	200−600	ππ	~90	635
				$K\bar{K}$	~10	418
				ηη	*possibly seen*	348
See note on ππ and $K\bar{K}$ S wave.‡						
π(1300)	$1^-(0^-)+$	1300§ ± 100§	200−600	ρπ	seen	407
				$\pi(\pi\pi)_{S-wave}$	seen	612
Not a well-established resonance.						
$A_2(1320)$	$1^-(2^+)+$	1318 ± 5§	110 ± 5§	ρπ	70.1 ± 2.2	419
				ηπ	14.5 ± 1.2	534
				ωππ	10.6 ± 2.5	361
				$K\bar{K}$	4.9 ± 0.8	434
				η′π	< 2 (CL=97%)	286
				πγ	*0.27 ± 0.06*	652
				γγ	0.0007 ± 0.0002	659
E(1420)‡	$0^+(1^+)+$	1418 ± 10§	52 ± 10§	$K\bar{K}\pi$ (incl. $K^*\bar{K}+K\bar{K}^*$)	seen	423
				ηππ	possibly seen	565
				†[δπ	possibly seen]	348
ι(1440)‡	$0^+(0^-)+$	*1440*§ ± *10*§	*76* ± *10*§	$K\bar{K}\pi$ (incl. $K^*\bar{K}+K\bar{K}^*$)	*seen*	441
				ηππ	*seen*	579
				†[δπ	*seen*]	366
f′(1525)	$0^+(2^+)+$	1525 ± 5§	70 ± 10§	$K\bar{K}$	dominant	578
				ππ	possibly seen	750
				γγ	*0.0011 ± 0.0002*	763
→ ρ(1600) or ρ′	$1^+(1^-)-$	1590‡§ ± 20§	260‡§ ± 100§	4π (incl. $\rho\pi^+\pi^-$, A(1270)π)	*60 ± 7*§	733
				ππ	*23 ± 7*§	783
				$K^*\bar{K}+\bar{K}^*K$	*9 ± 2*	377
				ηππ	*7 ± 2*	669
				$K\bar{K}$	*1 ± 0.5*	623
				e^+e^-	*0.003 ± 0.001*	795
ω(1670)	$0^-(3^-)-$	1668 ± 5	166 ± 15§ S=1.1*	3π	seen	806
				†[ρπ	seen]	648
				5π	seen	740
				†[ωππ (prob. Bπ)	seen]	616
A(1680)‡ or A_3	$1^-(2^-)+$	1680§ ± 30§	250§ ± 50§	fπ	53 ± 5	336
				ρπ	34 ± 6	656
				$\pi(\pi\pi)_{S-wave}$	9 ± 5	813
				$K^*\bar{K}+\bar{K}^*K$	*4 ± 1.4*	459
				For upper limits, see footnote *ℓ*		
φ(1680) or φ′	$0^-(1^-)-$	1685 ± 10§	*150*§ ± *30*§	$K^*\bar{K}+\bar{K}^*K$	dominant	466
				ωππ	seen	624
				$K\bar{K}$	seen	683
				e^+e^-	*seen*	842
				$\pi^+\pi^-\pi^0$	*possibly seen*	814

Meson Table *(cont'd)*

J^P	G	I=0	I=1	I=1/2
N	+	ε/f	ρ	K*,κ
	−	ω/φ	δ	
A	+	η/D	B	K,Q
	−	H	π/A	

	$I^G(J^P)C_n$ — *estab.*	Mass M (MeV)	Full Width Γ (MeV)	Mode	Fraction(%) [Upper limits (%) are 90% CL]		p or p_{max} [b] (MeV/c)
g(1690)	$1^+(3^-)-$	1691 ± 5§	200§ ± 20§	2π	23.8 ± 1.3		834
				4π (incl. $\pi\pi\rho$, $\rho\rho$, $A_2\pi$, $\omega\pi$)	70.9 ± 1.9		787
				$K\bar{K}\pi$ (incl. $K^*\bar{K}+K\bar{K}^*$)	*3.8 ± 1.2*		625
				$K\bar{K}$	1.5 ± 0.3	S=1.3*	684
J^P, M, and Γ from the 2π and $K\bar{K}$ modes.							
θ(1690)	$0^+(2^+)+$	*1690 ± 30*	*180 ± 50*	$\eta\eta$	*seen*		643
				$K\bar{K}$	*seen*		683
φ(1850)	$0^-(3^-)-$	*1853 ± 10*	*96 ± 32*	$K\bar{K}$	*seen*		784
				$K^*\bar{K}+\bar{K}^*K$	*seen*		601
h(2030)	$0^+(4^+)+$	2027 ± 12	*220 ± 30*	$\pi\pi$	*17 ± 2*		1004
				$K\bar{K}$	*$0.7^{+0.4}_{-0.2}$*		883
η_c(2980)	$0^+(0^-)\pm$	2981 ± 6	< 20	$\eta\pi^+\pi^-$	seen		1426
				$2(\pi^+\pi^-)$	seen		1458
				$K^+K^-\pi^+\pi^-$	seen		1343
				$p\bar{p}$	seen		1158
J/ψ(3100)	$0^-(1^-)-$	3096.9 ± 0.1	0.063 ± 0.009	e^+e^-	7.4 ± 1.2		1548
				$\mu^+\mu^-$	7.4 ± 1.2		1545
				hadrons + radiative	85 ± 2		

Decay modes into stable hadrons

Mode	Fraction(%)	p (MeV/c)
†[$2(\pi^+\pi^-)\pi^0$	3.7 ± 0.5	1496
$3(\pi^+\pi^-)\pi^0$	2.9 ± 0.7	1433
$\pi^+\pi^-\pi^0K^+K^-$	1.2 ± 0.3	1368
$4(\pi^+\pi^-)\pi^0$	0.9 ± 0.3	1345
$\pi^+\pi^-K^+K^-$	0.72 ± 0.23	1407
$p\bar{p}\pi^+\pi^-$	0.53 ± 0.06	1107
$2(\pi^+\pi^-)$	0.4 ± 0.1	1517
$3(\pi^+\pi^-)$	0.4 ± 0.2	1466
$n\bar{n}\pi^+\pi^-$	0.38 ± 0.36	1106
$\Xi\bar{\Xi}$	0.32 ± 0.08	818
$2(\pi^+\pi^-)K^+K^-$	0.31 ± 0.13	1320
$K^0_SK^\pm\pi^\mp$	0.26 ± 0.07	1440
$\Sigma^+\bar{\Sigma}^-$	0.24 ± 0.26	988
$p\bar{p}\eta$	0.23 ± 0.04	948
$p\bar{p}$	0.22 ± 0.02	1232
$p\bar{n}\pi^-$ or $\bar{p}n\pi^+$	0.21 ± 0.02	1174
$n\bar{n}$	0.18 ± 0.09	1231
$p\bar{p}\pi^+\pi^-\pi^0$	0.16 ± 0.06[m]	1033
$\Sigma^0\bar{\Sigma}^0$	0.13 ± 0.04	988
$\Lambda\bar{\Lambda}$	0.11 ± 0.02	1074
$p\bar{p}\pi^0$	0.11 ± 0.01	1176
$2(K^+K^-)$	0.07 ± 0.03	1131
K^+K^-	0.022 ± 0.008	1468
$\pi^+\pi^-$	0.011 ± 0.005	1542
$\Lambda\bar{\Sigma}$	< 0.015	1032
$K^0_SK^0_L$	< 0.009]	1466

Decay modes into hadronic resonances

Mode	Fraction(%)		p (MeV/c)
†[$\rho\pi$	1.22 ± 0.12		1449
$\omega2\pi^+2\pi^-$	0.85 ± 0.34		1392
ρA_2	0.84 ± 0.45		1126
$\omega\pi\pi$	0.68 ± 0.19		1435
$K^{*0}(892)\bar{K}^{*0}(1430)$+c.c.	0.67 ± 0.26		1009
$K^\pm K^{*\mp}(892)$	0.34 ± 0.05		1373
$B^\pm(1235)\pi^\mp$	0.29 ± 0.07		1298
$K^0\bar{K}^{*0}(892)$+c.c.	0.27 ± 0.06		1370
ωf	0.23 ± 0.08	S=1.2*	1143
$\phi\pi^+\pi^-$	0.21 ± 0.09		1365
$\eta' p\bar{p}$	0.18 ± 0.06		596
$\phi K\bar{K}$	0.18 ± 0.08		1176
$\omega p\bar{p}$	0.16 ± 0.03		768
$\omega K\bar{K}$	0.16 ± 0.10		1265
$\phi\eta$	0.10 ± 0.06		1320
$\phi f'(1525)$	0.037 ± 0.013		871
$\phi S(975)$	*0.026 ± 0.006*		1184
$\pi^\pm A_2^\mp$	< 0.43		1263
$K^{*0}(1430)\bar{K}^{*0}(1430)$	< 0.29		606
$K^0\bar{K}^{*0}(1430)$+c.c.	< 0.2		1158
$K^\pm K^{*\mp}(1430)$	< 0.2		1159
$\phi2\pi^+2\pi^-$	< 0.15		1318
$\phi\eta'$	< 0.13		1192
$K^{*0}(892)\bar{K}^{*0}(892)$	< 0.05		1261
ϕf	< 0.037		1037
$\omega f'(1525)$	< 0.016]		1003

Radiative decay modes

Mode	Fraction(%)	p (MeV/c)
†[$\gamma2(\pi^+\pi^-)$	*0.49 ± 0.17*	1517
$\gamma\rho\rho$	*seen*	1344
$\gamma\iota(1440)\to\gamma K\bar{K}\pi$	0.42 ± 0.12[n]	1214
$\gamma\eta'$	0.36 ± 0.05	1400
γf	0.15 ± 0.04	1286
$\gamma\eta$	0.086 ± 0.009	1500
$\gamma\pi^0$	0.007 ± 0.005	1546

Radiative decay modes (cont'd)

Mode	Fraction(%)	p (MeV/c)
$\gamma\eta_c(2980)$	*seen*	114
$\gamma\theta(1690)$	*seen*	1087
$\gamma\eta\pi\pi$	*seen*	1487
$\gamma D(1285)$	< 0.6	1283
2γ	< 0.05	1548
$\gamma f'(1525)$	< 0.03	1173
$\gamma p\bar{p}$	< 0.01	1232
3γ	< 0.006]	1548

Meson Table *(cont'd)*

J^P \ G \ I		0	1	$\frac{1}{2}$
N	+	ε/f	ρ	K*,κ
	−	ω/φ	δ	
A	+	η/D	B	K,Q
	−	H	π/A	

	$I^G(J^P)C_n$ ___ *estab.*	Mass M (MeV)	Full Width Γ (MeV)	Partial decay mode: Mode	Fraction(%) [Upper limits (%) are 90% CL]	p or p_{max} [b] (MeV/c)
χ(3415)	$0^+(0^+)+$	3415.0 ±1.0		$2(\pi^+\pi^-)$ (incl. $\pi\pi\rho$)	4.3±0.9	1679
				$\pi^+\pi^-K^+K^-$ (incl. $\pi K\bar{K}^*$)	3.4±0.9	1580
				$3(\pi^+\pi^-)$	1.7±0.6	1633
				$\pi^+\pi^-$	0.9±0.2	1702
				$\gamma J/\psi(3100)$	0.8±0.3	303
				K^+K^-	0.8±0.2	1635
				$p\bar{p}\pi^+\pi^-$	0.6±0.2	1320
				For upper limits, see footnote *o*		
χ(3510)	$0^+(1^+)+$	3510.0 ±0.6		$\gamma J/\psi(3100)$	28±3	389
				$3(\pi^+\pi^-)$	2.4±0.9	1683
				$2(\pi^+\pi^-)$ (incl. $\pi\pi\rho$)	1.8±0.5	1727
				$\pi^+\pi^-K^+K^-$ (incl. $\pi K\bar{K}^*$)	1.0±0.4	1632
				$\pi^+\pi^-p\bar{p}$	0.15±0.10	1381
				For upper limits, see footnote *p*		
χ(3555)	$0^+(2^+)+$	3555.8 ±0.6		$\gamma J/\psi(3100)$	15.5±1.8	429
				$2(\pi^+\pi^-)$ (incl. $\pi\pi\rho$)	2.3±0.5	1750
				$\pi^+\pi^-K^+K^-$ (incl. $\pi K\bar{K}^*$)	2.0±0.5	1656
				$3(\pi^+\pi^-)$	1.2±0.8	1706
				$\pi^+\pi^-p\bar{p}$	0.35±0.14	1410
				$\pi^+\pi^-$	0.20±0.11	1772
				K^+K^-	0.16±0.12	1708
				For upper limits, see footnote *q*		
→ ψ(3685)	$0^-(1^-)-$	3686.0 ±0.1	0.215 ±0.040	e^+e^-	0.9±0.1	1843
				$\mu^+\mu^-$	0.8±0.2	1840
				hadrons + radiative	98.1±0.3	
	$m_{\psi(3685)} - m_{\psi(3100)} = 589.06\pm0.13$					

Radiative decay modes			Decay modes into hadrons		
†[$\gamma\chi(3415)$	8.2±1.4	261	†[$J/\psi\pi^+\pi^-$	33±2	477
$\gamma\chi(3510)$	8.0±1.3	172	$J/\psi\pi^0\pi^0$	17±2	481
$\gamma\chi(3555)$	7.4±1.3	128	$J/\psi\eta$	2.8±0.6§	196
$\gamma\eta_c(2980)$	0.43±0.26	638	$2(\pi^+\pi^-)\pi^0$	0.35±0.15	1799
$\gamma\eta_c'(3590)$	0.2 to 1.3	91	$\pi^+\pi^-K^+K^-$	0.16±0.04	1726
$\gamma\pi^0$	<0.5 (CL=95%)	1841	$J/\psi\pi^0$	0.10±0.03	528
$\gamma\eta$	<0.02	1802	$p\bar{p}\pi^+\pi^-$	0.08±0.02	1491
$\gamma\eta'$	<0.02	1719	$K^{*0}(892)K^-\pi^+$ +cc.	0.067±0.025	1674
$\gamma\iota(1440)\rightarrow\gamma K\bar{K}\pi$	<0.012[n]]	1562	$2(\pi^+\pi^-)$	0.05±0.01	1817
			$\rho^0\pi^+\pi^-$	0.042±0.015	1751
			$p\bar{p}$	0.019±0.005	1586
			$3(\pi^+\pi^-)$	0.015±0.010	1774
			K^+K^-	0.010±0.007	1776
			$\pi^+\pi^-$	0.008±0.005	1838
			$\rho\pi$	<0.1	1760
			$\Lambda\bar{\Lambda}$	<0.04]	1467

	$I^G(J^P)C_n$	Mass M (MeV)	Full Width Γ (MeV)	Mode	Fraction(%)	p or p_{max} (MeV/c)
ψ(3770)	$(1^-)-$	3770 ±3	25 ±3	e^+e^-	0.0011±0.0002	1885
				$D\bar{D}$	dominant	242
	$m_{\psi(3770)} - m_{\psi(3685)} = 83.9\pm2.4$ S=1.8*					
ψ(4030)	$(1^-)-$	4030§ ±5§	52 ±10	e^+e^-	0.0014±0.0004	2015
				hadrons	dominant	
				†[$D\bar{D}$	*seen*	752
				$D\bar{D}^* + D^*\bar{D}$	*seen*	559
				$D^*\bar{D}^*$	*seen*]	177
ψ(4160)	$(1^-)-$	4159 ±20	78 ±20	e^+e^-	0.0010±0.0004	2079
				hadrons	dominant	
ψ(4415)	$(1^-)-$	4415 ±6	43 ±20§	e^+e^-	0.0010±0.0003 S=1.4*	2207
				hadrons	dominant	

Meson Table *(cont'd)*

J^P	G \ I	0	1	$\frac{1}{2}$
N	+	ε/f	ρ	K*,κ
N	−	ω/φ	δ	K*,κ
A	+	η/D	B	K,Q
A	−	H	π/A	K,Q

	$I^G(J^P)C_n$ — *estab.*	Mass M (MeV)	Full Width Γ (MeV)	Partial decay mode: Mode	Fraction(%) [Upper limits (%) are 90% CL]	p or p_{max} [b] (MeV/c)
ϒ(9460) or ϒ(1S)	$(1^-)-$	9460.0 ±0.3 S=1.6*	0.0443 ±0.0066	$\mu^+\mu^-$	2.9±0.5	4729
				e^+e^-	2.5±0.5	4730
				$\tau^+\tau^-$	*3.4±0.8*	4381
$\chi_b(9875)$ or $\chi_b(1\,^3P_0)^r$	( )+	*9872.9 ±5.8*		γϒ(9460)	*seen*	404
$\chi_b(9895)$ or $\chi_b(1\,^3P_1)^r$	( )+	*9894.5 ±3.5*		γϒ(9460)	*43±11*	425
$\chi_b(9915)$ or $\chi_b(1\,^3P_2)^r$	( )+	*9914.6 ±2.4*		γϒ(9460)	*20.0±4.4*	444
ϒ(10025) or ϒ(2S)	$(1^-)-$	10023.4 ±0.3	0.0296 ±0.0047	$\mu^+\mu^-$	*1.9±1.8*	5011
				e^+e^-	1.6±0.3	5012
				ϒ(9460)ππ	*19.5±1.7*	476
	$m_{\Upsilon(10025)} - m_{\Upsilon(9460)} = 563.3\pm0.4$			$\gamma\chi_b(9875)$	*3.5±1.4*	149
				$\gamma\chi_b(9895)$	*5.9±1.4*	128
				$\gamma\chi_b(9915)$	*6.1±1.4*	108
→ $\chi_b(10255)$ or $\chi_b(2\,^3P_1)^r$	( )+	*10253.7 ±3.4*		γϒ(9460)	*seen*	763
				γϒ(10025)	*seen*	228
$\chi_b(10270)$ or $\chi_b(2\,^3P_2)^r$	( )+	*10271.0 ±2.4*		γϒ(9460)	*seen*	779
				γϒ(10025)	*seen*	245
ϒ(10355) or ϒ(3S)	$(1^-)-$	10355.5 ±0.5	*0.0177 ±0.0051*	e^+e^-	*2.0±0.7*	5178
				$\mu^+\mu^-$	*3.3±2.0*	5177
				$\Upsilon(9460)\pi^+\pi^-$	*5.1±1.1*	814
	$m_{\Upsilon(10355)} - m_{\Upsilon(9460)} = 895.5\pm.6$			$\Upsilon(10025)\pi^+\pi^-$	*3±3*	177
				$\gamma\chi_b(10235)$	*7.6±3.5*	122
				$\gamma\chi_b(10255)$	*15.6±4.2*	101
				$\gamma\chi_b(10270)$	*12.7±4.1*	84
ϒ(10575) or ϒ(4S)	$(1^-)-$	10573 ±4	14 ±5	e^+e^-	0.0017±0.0007	5286
	$m_{\Upsilon(10575)} - m_{\Upsilon(9460)} = 1113\pm4$					

STRANGE MESONS

	$I^G(J^P)C_n$	Mass M (MeV)	Full Width Γ (MeV)	Mode	Fraction(%)	p or p_{max} (MeV/c)
K^+	$1/2(0^-)$	493.67		See Stable Particle Table		
K^0		497.67				
K*(892)	$1/2(1^-)$	892.1 ±0.4 S=1.4*	51.3 ±1.0 S=1.1*	Kπ	≈ 100	288
				Kγ	0.10±0.01	309
				Kππ	< 0.05	216
M and Γ from charged mode; $m^0 - m^\pm = 6.7\pm1.2$ MeV.						
Q(1280) or Q_1	$1/2(1^+)$	1270§ ±10§	90§ ±20§	Kρ	42±6	45
				κ(1350)π	28±4	
				K*(892)π	16±5	298
				Kω	11±2	
				Kε	3±2	
κ(1350)	$1/2(0^+)$	~1350	~250	Kπ	seen	574
See note on Kπ S wave.‡						
Q(1400) or Q_2	$1/2(1^+)$	1406 ±10	184 ±9	K*(892)π	94±6	403
				Kρ	3±3	299
				Kε	2±2	
				Kω	1±1	285

→

Meson Table *(cont'd)*

J^P	G\I	0	1	1/2
N	+	ε/f	ρ	K*,κ
N	−	ω/φ	δ	
A	+	η/D	B	K,Q
A	−	H	π/A	

	$I^G(J^P)$ ___ *estab.*	Mass M (MeV)	Full Width Γ (MeV)	Mode	Fraction(%) [Upper limits (%) are 90% CL]		p or p_{max} [b] (MeV/c)
K*(1430)	1/2(2⁺)	1425§ ±5§	100§ ±10§	Kπ	44.8±2.3	S=2.7*	618
				K*(892)π	24.5±2.0	S=1.1*	417
				K*(892)ππ	13.0±2.6	S=1.1*	366
				Kρ	8.8±1.0	S=1.2*	324
				Kω	4.2±1.5		310
				Kη	5±5§		485
				Kγ	*0.24±0.05*		627
→ →							
L(1770)‡	1/2(2⁻)	~1770§	~200§	K*(1430)π	dominant		286
				K*(892)π	seen		651
				Kf	seen		
				Kφ	*seen*		816
See note on L(1770).‡							
K*(1780)‡ or K*	1/2(3⁻)	1780 ±10§	160 ±20§	Kππ	large		796
				†[Kρ	large]		620
				†[K*(892)π	large]		657
				Kπ	17±5§		815
See note on K*(1780).‡							
→							
K*(2060)	1/2(4⁺)	*2060§ ±30§*	*210§ ±40§*	Kπ	*7±1*		966
				K*(892)ππ	*seen*		809
				ρKπ	*seen*		751
				ωKπ	*seen*		744
Not a well-established resonance.				K*(892)πππ	*seen*		775
→ → →							
CHARMED, NONSTRANGE MESONS							
D^+	1/2(0⁻)	1869.4		See Stable Particle Table			
D^0		1864.7					
$D^{*+}(2010)$	1/2(1⁻)	2010.1 ±0.7	< 2.0	$D^0\pi^+$	64±11		39
				$D^+\pi^0$	28±9		38
				$D^+\gamma$	8±7		136
	$m_{D^{*+}} - m_{D^0} = 145.4 \pm 0.2$ MeV						
$D^{*0}(2010)$	1/2(1⁻)	2007.2 ±2.1	< 5	$D^0\pi^0$	55±15		44
				$D^0\gamma$	45±15		137
CHARMED, STRANGE MESON							
F^+	0(0⁻)	1971		See Stable Particle Table			
→							
BOTTOM, NONSTRANGE MESON							
B^+	1/2(0⁻)	5271		See Stable Particle Table			
B^0		5274					
→							

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

‡ 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 on the average of the published values. (See the 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 $(M - i\Gamma/2)$.

Meson Table *(cont'd)*

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

e. Empirical limits on fractions for other decay modes of $\rho(770)$ are $\pi^\pm\eta < 0.8\%$ (CL=84%), $\pi^+\pi^+\pi^-\pi^- < 0.15\%$, $\pi^\pm\pi^+\pi^-\pi^0 < 0.2\%$ (CL=84%).

f. Empirical limits on fractions for other decay modes of $\omega(783)$ are $\pi^+\pi^-\gamma < 5\%$, $\pi^0\pi^0\gamma < 1\%$, η + neutral(s) $< 1.5\%$, $\mu^+\mu^- < 0.02\%$.

g. Empirical limits on fractions for other decay modes of $\eta'(958)$ are $\pi^+\pi^- < 2\%$ (CL=84%), $\pi^+\pi^-\pi^0 < 5\%$ (CL=84%), $\pi^+\pi^+\pi^-\pi^- < 1\%$ (CL=95%), $\pi^+\pi^+\pi^-\pi^-\pi^0 < 1\%$ (CL=84%), $6\pi < 1\%$, $\pi^+\pi^-e^+e^- < 0.6\%$, $\pi^0e^+e^- < 1.3\%$ (CL=84%), $\eta e^+e^- < 1.1\%$, $\pi^0\rho^0 < 4\%$, $\eta\mu^+\mu^- < 1.5 \times 10^{-5}$, $\pi^0\mu^+\mu^- < 6 \times 10^{-5}$.

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

i. Empirical limits on fractions for other decay modes of $\phi(1020)$ are $\pi^+\pi^-\gamma < 0.7\%$, $\omega\gamma < 5\%$ (CL=84%), $\rho\gamma < 2\%$ (CL=84%), $2\pi^+2\pi^-\pi^0 < 1\%$ (CL=95%), $2\pi^+2\pi^- < 0.1\%$.

j. Empirical limits on fractions for other decay modes of B(1235) are $\pi\pi < 15\%$, $K\overline{K} < 2\%$ (CL=84%), $4\pi < 50\%$ (CL=84%), $\phi\pi < 1.5\%$ (CL=84%), $\eta\pi < 25\%$, $(K\overline{K})^\pm\pi^0 < 8\%$, $K_SK_S\pi^\pm < 2\%$, $K_SK_L\pi^\pm < 6\%$.

k. Empirical limits (CL=95%) on fractions for other decay modes of f(1270) are $\eta\pi\pi < 1\%$, $K^0K^-\pi^+$ + c.c. $< 0.4\%$, $\eta\eta < 2\%$.

ℓ. Empirical limits on fractions for other decay modes of A(1680) are $\eta\pi < 10\%$, $5\pi < 10\%$.

m. Includes $p\overline{p}\pi^+\pi^-\gamma$ and excludes $p\overline{p}\eta$, $p\overline{p}\omega$, $p\overline{p}\eta'$.

n. See E(1420) mini-review.

o. Empirical limits on fractions for other decay modes of $\chi(3415)$ are $2\gamma < 0.17\%$, $p\overline{p} < 0.11\%$.

p. Empirical limits on fractions for other decay modes of $\chi(3510)$ are ($\pi^+\pi^-$ and K^+K^-) $< 0.2\%$, $\gamma\gamma < 0.16\%$, $p\overline{p} < 0.13\%$.

q. Empirical limits on fractions for other decay modes of $\chi(3555)$ are $2\gamma < 0.06\%$, $p\overline{p} < 0.10\%$, $J/\psi\pi^+\pi^-\pi^0 < 1.5\%$.

r. Spectroscopic labeling for these states is theoretical, pending experimental information.

Contents of Meson Data Card Listings

Non-strange (S = 0; C,B = 0)						Strange (|S| = 1; C,B = 0)	
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	$1^-(0^-)+$	ω (1670)	$0^-(3^-)-$	→ e^+e^- (1100—2200)	(1^-)	K	$1/2(0^-)$
η	$0^+(0^-)+$	A (1680)	$1^-(2^-)+$	→ $\overline{N}N$ (1200—3600)		K* (892)	$1/2(1^-)$
ρ (770)	$1^+(1^-)-$	ϕ (1680)	$0^-(1^-)-$	→ X (1900—3600)		Q (1280)	$1/2(1^+)$
ω (783)	$0^-(1^-)-$	g (1690)	$1^+(3^-)-$	η_c (2980)	$0^+\quad+$	κ (1350)	$1/2(0^+)$
η' (958)	$0^+(0^-)+$	θ (1690)	$0^+(\ ^+)+$	J/ψ (3100)	$0^-(1^-)-$	Q (1400)	$1/2(1^+)$
S (975)	$0^+(0^+)+$	→ η (1700)	$^+$	χ (3415)	$0^+(0^+)+$	→ K (1400)	$1/2(0^-)$
δ (980)	$1^-(0^+)+$	→ S (1730)	$0^+(0^+)+$	χ (3510)	$0^+(1^+)+$	K* (1430)	$1/2(2^+)$
ϕ (1020)	$0^-(1^-)-$	→ π (1770)	$1^-(0^-)+$	χ (3555)	$0^+(2^+)+$	→ L (1580)	$1/2(2^-)$
H (1190)	$0^-(1^+)-$	→ f (1810)	$0^+(2^+)+$	→ η_c (3590)	$+$	→ K* (1650)	$1/2(1^-)$
B (1235)	$1^+(1^+)-$	ϕ (1850)	0	ψ (3685)	$0^-(1^-)-$	L (1770)	$1/2(2^-)$
→ g_S (1240)	$0^+(0^+)+$	→ S (1935)		ψ (3770)	$(1^-)-$	K* (1780)	$1/2(3^-)$
→ ρ (1250)	$1^+(1^-)-$	h (2030)	$0^+(4^+)+$	ψ (4030)	$(1^-)-$	→ K (1830)	$1/2(0^-)$
f (1270)	$0^+(2^+)+$	→ δ (2040)	$1^-(4^+)+$	ψ (4160)	$(1^-)-$	K* (2060)	$1/2(4^+)$
A (1270)	$1^-(1^+)+$	→ A (2050)	$1^-(3^+)+$	ψ (4415)	$(1^-)-$	→ K (2250)	$1/2(2^-)$
→ η (1275)	$0^+(0^-)+$	→ A (2100)	$1^-(2^-)+$	Υ (9460)	$(1^-)-$	→ K (2320)	$1/2(3^+)$
D (1285)	$0^+(1^+)+$	→ ρ (2150)	$1^+(1^-)-$	χ_b (9875)	$(\ \ )+$	→ K (2500)	$1/2(4^-)$
ϵ (1300)	$0^+(0^+)+$	→ ϵ (2150)	$0^+(2^+)+$	χ_b (9895)	$(\ \ )+$	**Charmed (|C| = 1)**	
π (1300)	$1^-(0^-)+$	→ ξ (2220)	$0\ (\ ^+)$	χ_b (9915)	$(\ \ )+$	D	$1/2(0^-)$
A_2 (1320)	$1^-(2^+)+$	→ g_T (2240)	$0^+(2^+)+$	Υ (10025)	$(1^-)-$	D* (2010)	$1/2(1^-)$
E (1420)	$0^+(1^+)+$	→ ρ (2250)	$1^+(3^-)-$	→ χ_b (10235)	$(\ \ )+$	F	$0\ (0^-)$
ι (1440)	$0^+(0^-)+$	→ ϵ (2300)	$0^+(4^+)+$	χ_b (10255)	$(\ \ )+$	→ F* (2140)	
f′ (1525)	$0^+(2^+)+$	→ ρ (2350)	$1^+(5^-)-$	χ_b (10270)	$(\ \ )+$	**Bottom (Beauty) (|B| = 1)**	
→ D (1530)	$0^+(1^+)+$	→ δ (2450)	$1^-(6^+)$	Υ (10355)	$(1^-)-$	B	
ρ (1600)	$1^+(1^-)-$	→ r (2510)	$0^+(6^+)$	Υ (10575)	$(1^-)-$	→ Exotics	

Baryon Table

April 1984

The following short list gives the name, the nominal mass, the quantum numbers (where known), and the status of each of the Baryon States in the Data Card Listings. States with 3- or 4-star status are included in the Baryon Table below; the others are omitted because the evidence for the existence of the effect and/or for its interpretation as a resonance is open to question.

N(939) P11	****	Δ(1232) P33	****	Z0(1780) P01	*	Σ(1193) P11	****	Ξ(1318) P11	****
N(1440) P11	****	Δ(1550) P31	*	Z0(1865) D03	*	Σ(1385) P13	****	Ξ(1530) P13	****
N(1520) D13	****	Δ(1600) P33	**	Z1(1900) P13	*	Σ(1480)	*	Ξ(1630)	*
N(1535) S11	****	Δ(1620) S31	****	Z1(2150)	*	Σ(1560)	**	Ξ(1680)	**
N(1540) P13	*	Δ(1700) D33	****	Z1(2500)	*	Σ(1580) D13	**	Ξ(1820) 13	***
N(1650) S11	****	Δ(1900) S31	***			Σ(1620) S11	**	Ξ(1940)	**
N(1675) D15	****	Δ(1905) F35	****	Λ(1116) P01	****	Σ(1660) P11	***	Ξ(2030) 1	***
N(1680) F15	****	Δ(1910) P31	****	Λ(1405) S01	****	Σ(1670) D13	****	Ξ(2120)	*
N(1700) D13	***	Δ(1920) P33	***	Λ(1520) D03	****	Σ(1690)	**	Ξ(2250)	**
N(1710) P11	***	Δ(1930) D35	***	Λ(1600) P01	***	Σ(1750) S11	***	Ξ(2370) 1	**
N(1720) P13	****	Δ(1940) D33	*	Λ(1670) S01	****	Σ(1770) P11	*	Ξ(2500)	*
N(1990) F17	**	Δ(1950) F37	****	Λ(1690) D03	****	Σ(1775) D15	****		
N(2000) F15	**	Δ(2150) S31	*	Λ(1800) S01	***	Σ(1840) P13	*	Ω(1672) P03	****
N(2080) D13	**	Δ(2200) G37	*	Λ(1800) P01	***	Σ(1880) P11	**	Λ_c(2282)	****
N(2090) S11	*	Δ(2300) H39	**	Λ(1820) F05	****	Σ(1915) F15	****		
N(2100) P11	*	Δ(2350) D35	*	Λ(1830) D05	****	Σ(1940) D13	***	Σ_c(2450)	**
N(2190) G17	****	Δ(2390) F37	*	Λ(1890) P03	****	Σ(2000) S11	*		
N(2200) D15	**	Δ(2400) G39	**	Λ(2000)	*	Σ(2030) F17	****	Λ(2460)	*
N(2220) H19	****	Δ(2420) H311	****	Λ(2020) F07	*	Σ(2070) F15	*		
N(2250) G19	****	Δ(2750) I313	**	Λ(2100) G07	****	Σ(2080) P13	**	Λ_b(5500)	*
N(2600) I111	***	Δ(2950) K315	**	Λ(2110) F05	***	Σ(2100) G17	*	Dibaryons	
N(2700) K113	**	Δ(~3000)		Λ(2325) D03	*	Σ(2250)	***	NN(2170) 1D2	**
N(~3000)				Λ(2350)	***	Σ(2455)	**	NN(2250) 3F3	**
				Λ(2585)	**	Σ(2620)	**	NN(?)	*
						Σ(3000)	*	ΛN(2130) 3S1	**
						Σ(3170)	*	ΞN(?)	*

****	Good, clear, and unmistakable.
***	Good, but in need of clarification or not absolutely certain.
**	Not established; needs confirmation.
*	Evidence weak; could disappear.

Particle[a]	$I(J^P)L^{b}_{2I\cdot 2J}$	P^c_{beam} (GeV/c) $\sigma = 4\pi\lambda\!\!\!^{-2}$ (mb)	Mass[d] M (MeV)	Full[e] width Γ (MeV)	Partial decay modes Mode[f]	Fraction[g] (%)	p^h (MeV/c)
			S=0 I=1/2 NUCLEON RESONANCES (N)				
p	1/2(1/2$^+$)		938.3		See Stable Particle Table		
n			939.6				
N(1440)	1/2(1/2$^+$)P'_{11}	p = 0.61	1400 to	120 to	Nπ	50-70	397
		σ = 31.0	1480	350	Nη	8-18	†
				(200)	Nππ	~30	342
					[Δπ	12-28]*	143
					Nρ	~ 7	†
					Nε]	~ 5	†
N(1520)	1/2(3/2$^-$)D'_{13}	p = 0.74	1510 to	100 to	Nπ	50-60	456
		σ = 23.5	1530	140	Nη	~0.1	149
				(125)	Nππ	35-50	410
					[Δπ	15-25]*	228
					Nρ	15-25	†
					Nε]	< 5	†

Baryon Table *(cont'd)*

Particle[a]	$I(J^P)L^b_{2I \cdot 2J}$	P^c_{beam} (GeV/c) $\sigma = 4\pi\lambda\!\!\!^{-2}$ (mb)	Mass[d] M (MeV)	Full[e] width Γ (MeV)	Partial decay modes Mode[f]	Fraction[g] (%)	p^h (MeV/c)
N(1535)	$1/2(1/2^-)S'_{11}$	p = 0.76	1520 to	100 to	$N\pi$	35-50	467
		σ = 22.5	1560	250	$N\eta$	~35	182
				(150)	$N\pi\pi$	~ 5	422
					[$\Delta\pi$	~ 1]*	242
					$N\rho$	~ 3	†
					$N\epsilon$]	~ 2	†
N(1650)	$1/2(1/2^-)S''_{11}$	p = 0.96	1620 to	100 to	$N\pi$	55-65	547
		σ = 16.4	1680	200	$N\eta$	~1.5	346
				(150)	ΛK	~ 8	161
					ΣK	3-10	†
					$N\pi\pi$	~30	511
					[$\Delta\pi$	4-15]*	344
					$N\rho$	~20	†
					$N\epsilon$]	< 5	†
N(1675)	$1/2(5/2^-)D'_{15}$	p = 1.01	1660 to	120 to	$N\pi$	30-40	563
		σ = 15.4	1690	180	$N\eta$	~ 1	374
				(155)	ΛK	~0.1	209
					$N\pi\pi$	55-70	529
					[$\Delta\pi$	50-65]*	364
					$N\rho$]	~ 5	†
N(1680)	$1/2(5/2^+)F'_{15}$	p = 1.01	1670 to	110 to	$N\pi$	55-65	567
		σ = 15.2	1690	140	$N\eta$	< 1	379
				(125)	ΛK	not seen	218
					$N\pi\pi$	~40	532
					[$\Delta\pi$	~12]*	369
					$N\rho$	~10	†
					$N\epsilon$]	~20	†
N(1700)	$1/2(3/2^-)D''_{13}$	p = 1.05	1670 to	70 to	$N\pi$	8-12	580
		σ = 14.5	1730	120	$N\eta$	~ 4	400
				(100)	ΛK	~0.2	250
					$N\pi\pi$	~85	547
					[$\Delta\pi$	15-40]*	385
					$N\rho$	~ 5	†
					$N\epsilon$]	<40	†
N(1710)	$1/2(1/2^+)P''_{11}$	p = 1.07	1680 to	90 to	$N\pi$	10-20	587
		σ = 14.2	1740	130	$N\eta$	~25	410
				(110)	ΛK	~15	264
					ΣK	2-10	138
					$N\pi\pi$	>50	554
					[$\Delta\pi$	10-25]*	393
					$N\rho$	25-65	48
					$N\epsilon$]	15-40	†
N(1720)	$1/2(3/2^+)P''_{13}$	p = 1.09	1690 to	125 to	$N\pi$	10-20	594
		σ = 13.9	1800	250	$N\eta$	~3.5	420
				(200)	ΛK	~ 5	278
					ΣK	2-5	162
					$N\pi\pi$	~70	561
					[$\Delta\pi$	~20]*	401
					$N\rho$	45-70	104
					$N\epsilon$]	~20	†
N(2190)	$1/2(7/2^-)G_{17}$	p = 2.07	2120 to	200 to	$N\pi$	~14	888
		σ = 6.21	2230	500	$N\eta$	~ 3	790
				(350)	ΛK	~0.3	712

Baryon Table *(cont'd)*

Particle[a]	$I(J^P)L_{2I \cdot 2J}$[b]	P^c_{beam} (GeV/c) $\sigma = 4\pi\lambda^2$ (mb)	Mass[d] M (MeV)	Full[e] width Γ (MeV)	Partial decay modes Mode[f]	Fraction[g] (%)	p^h (MeV/c)
N(2220)	$1/2(9/2^+)H_{19}$	p = 2.14	2150 to	300 to	$N\pi$	~18	905
		σ = 5.97	2300	500	$N\eta$	~0.5	811
				(400)	ΛK	~0.2	732
N(2250)	$1/2(9/2^-)G'_{19}$	p = 2.21	2130 to	200 to	$N\pi$	~10	923
		σ = 5.74	2270	500	$N\eta$	~ 2	831
				(300)	ΛK	~0.3	754
N(2600)	$1/2(11/2^-)I_{111}$	p = 3.12	2580 to	>300	$N\pi$	~ 5	1126
		σ = 3.86	2700	(400)			
S=0 I=3/2 DELTA RESONANCES (Δ)							
Δ(1232)	$3/2(3/2^+)P'_{33}$	p = 0.30	1230 to	110 to	$N\pi$	99.4	227
		σ = 94.8	1234	120	$N\gamma$	0.6	259
				(115)			
Δ(1620)	$3/2(1/2^-)S'_{31}$	p = 0.91	1600 to	120 to	$N\pi$	25-35	526
		σ = 17.7	1650	160	$N\pi\pi$	~70	488
				(140)	[$\Delta\pi$	35-50]*	318
					$N\rho$]	<40	†
Δ(1700)	$3/2(3/2^-)D'_{33}$	p = 1.05	1630 to	190 to	$N\pi$	10-20	580
		σ = 14.5	1740	300	$N\pi\pi$	~85	547
				(250)	[$\Delta\pi$	<50]*	385
					$N\rho$]	~40	†
Δ(1900)	$3/2(1/2^-)S''_{31}$	p = 1.44	1850 to	130 to	$N\pi$	6-12	710
		σ = 9.71	2000	300	ΣK	~10	410
				(150)			
Δ(1905)	$3/2(5/2^+)F_{35}$	p = 1.45	1890 to	250 to	$N\pi$	8-15	713
		σ = 9.62	1920	400	ΣK	< 3	415
				(300)	$N\pi\pi$	~80	687
					[$\Delta\pi$	10-30]*	542
					$N\rho$]	~60	421
Δ(1910)	$3/2(1/2^+)P''_{31}$	p = 1.46	1850 to	200 to	$N\pi$	20-25	716
		σ = 9.54	1950	330	ΣK	2-20	421
				(220)	$N\pi\pi$	>40	691
					[$\Delta\pi$	small]*	545
					$N\rho$]	<40	426
Δ(1920)	$3/2(3/2^+)P'''_{33}$	p = 1.48	1860 to	190 to	$N\pi$	14-20	722
		σ = 9.38	2160	300	ΣK	~ 5	431
				(250)			
Δ(1930)	$3/2(5/2^-)D'_{35}$	p = 1.50	1890 to	150 to	$N\pi$	4-14	729
		σ = 9.21	1960	350	ΣK	<10	441
				(250)			
Δ(1950)	$3/2(7/2^+)F'_{37}$	p = 1.54	1910 to	200 to	$N\pi$	35-45	741
		σ = 8.91	1960	340	ΣK	< 1	460
				(240)	$N\pi\pi$	~60	716
					[$\Delta\pi$	~40]*	574
					$N\rho$]	~20	469
Δ(2420)	$3/2(11/2^+)H_{311}$	p = 2.64	2380 to	300 to	$N\pi$	5-15	1023
		σ = 4.68	2450	500			
				(300)			

Baryon Table *(cont'd)*

Particle[a]	$I(J^P)L_{I\cdot 2J}$[b]	P_{beam}[c] (GeV/c) $\sigma = 4\pi\lambda^2$ (mb)	Mass[d] M (MeV)	Full[e] width Γ (MeV)	Partial decay modes: Mode	Fraction[g] (%)	p[h] (MeV/c)
		S=−1 I=0 LAMBDA RESONANCES (Λ)					
Λ	$0(1/2^+)$		1115.6		See Stable Particle Table		
Λ(1405)	$0(1/2^-)S'_{01}$	Below K^-p threshold	1405 ±5[i]	40±10[i]	$\Sigma\pi$	100	152
Λ(1520)	$0(3/2^-)D'_{03}$	p = 0.395 σ = 82.3	1519.5 ±1.0[i]	15.6±1.0[i]	$N\bar{K}$	45±1	244
					$\Sigma\pi$	42±1	267
					$\Lambda\pi\pi$	10±1	252
					$\Sigma\pi\pi$	0.9±0.1	152
					$\Lambda\gamma$	0.8±0.2	351
Λ(1600)	$0(1/2^+)P'_{01}$	p = 0.58 σ = 41.6	1560 to 1700	50 to 250 (150)	$N\bar{K}$	15-30	343
					$\Sigma\pi$	10-60	336
Λ(1670)	$0(1/2^-)S''_{01}$	p = 0.74 σ = 28.5	1660 to 1680	25 to 50 (35)	$N\bar{K}$	15-25	414
					$\Sigma\pi$	20-60	393
					$\Lambda\eta$	15-35	64
Λ(1690)	$0(3/2^-)D''_{03}$	p = 0.78 σ = 26.1	1685 to 1695	50 to 70 (60)	$N\bar{K}$	20-30	433
					$\Sigma\pi$	20-40	409
					$\Lambda\pi\pi$	~25	415
					$\Sigma\pi\pi$	~20	350
Λ(1800)	$0(1/2^-)S'''_{01}$	p = 1.01 σ = 17.5	1720 to 1850	200 to 400 (300)	$N\bar{K}$	25-40	528
					$\Sigma\pi$	seen	493
					$\Sigma(1385)\pi$	seen	345
					$N\bar{K}^*(892)$	seen	†
Λ(1800)	$0(1/2^+)P''_{01}$	p = 1.01 σ = 17.5	1750 to 1850	50 to 250 (150)	$N\bar{K}$	20-50	528
					$\Sigma\pi$	10-40	493
					$\Sigma(1385)\pi$	seen	345
					$N\bar{K}^*(892)$	30-60	†
Λ(1820)	$0(5/2^+)F'_{05}$	p = 1.06 σ = 16.5	1815 to 1825	70 to 90 (80)	$N\bar{K}$	55-65	545
					$\Sigma\pi$	8-14	508
					$\Sigma(1385)\pi$	5-10	362
Λ(1830)	$0(5/2^-)D_{05}$	p = 1.08 σ = 16.0	1810 to 1830	60 to 110 (95)	$N\bar{K}$	3-10	553
					$\Sigma\pi$	35-75	515
					$\Sigma(1385)\pi$	>15	371
Λ(1890)	$0(3/2^+)P'_{03}$	p = 1.21 σ = 13.6	1850 to 1910	60 to 200 (100)	$N\bar{K}$	20-35	599
					$\Sigma\pi$	3-10	559
					$\Sigma(1385)\pi$	seen	420
					$N\bar{K}^*(892)$	seen	233
Λ(2100)	$0(7/2^-)G_{07}$	p = 1.68 σ = 8.68	2090 to 2110	100 to 250 (200)	$N\bar{K}$	25-35	751
					$\Sigma\pi$	~ 5	704
					$\Lambda\eta$	< 3	617
					ΞK	< 3	483
					$\Lambda\omega$	< 8	443
					$N\bar{K}^*(892)$	10-20	514
Λ(2110)	$0(5/2^+)F''_{05}$	p = 1.70 σ = 8.53	2090 to 2140	150 to 250 (200)	$N\bar{K}$	5-25	757
					$\Sigma\pi$	10-40	711
					$\Lambda\omega$	seen	455
					$\Sigma(1385)\pi$	seen	589
					$N\bar{K}^*(892)$	10-60	524
Λ(2350)	$0(9/2^+)$	p = 2.29 σ = 5.85	2340 to 2370	100 to 250 (150)	$N\bar{K}$	~12	915
					$\Sigma\pi$	~10	867

Baryon Table *(cont'd)*

Particle[a]	$I(J^P)L_{I\cdot 2J}$[b]	P^c_{beam} (GeV/c) $\sigma = 4\pi\lambda^2$ (mb)	Mass[d] M (MeV)	Full[e] width Γ (MeV)	Partial decay modes Mode	Fraction[g] (%)	p[h] (MeV/c)
S=−1 I=1 SIGMA RESONANCES (Σ)							
Σ	1(1/2$^+$)		(+)1189.4 (0)1192.5 (−)1197.3		See Stable Particle Table		
Σ(1385)	1(3/2$^+$)P'_{13}	Below K$^-$p threshold	(+)1382.3±0.4 S=1.6[j] (0)1382.0±2.5 S=1.6[j] (−)1387.4±0.6 S=2.2[j]	35±1 S=1.0[j] ~35 40±2 S=1.9[j]	Λπ Σπ	88±2 12±2	208 127
Σ(1660)	1(1/2$^+$)P'_{11}	p = 0.72 σ = 29.9	1630 to 1690	40 to 200 (100)	N$\bar{K}$ Λπ Σπ	10-30 seen seen	405 439 385
Σ(1670)	1(3/2$^-$)D''_{13}	p = 0.74 σ = 28.5	1665 to 1685	40 to 80 (60)	N$\bar{K}$ Λπ Σπ	7-13 5-15 30-60	414 447 393
Σ(1750)	1(1/2$^-$)S''_{11}	p = 0.91 σ = 20.7	1730 to 1800	60 to 160 (90)	N$\bar{K}$ Λπ Σπ Ση	10-40 seen < 8 15-55	486 507 455 81
Σ(1775)	1(5/2$^-$)D_{15}	p = 0.96 σ = 19.0	1770 to 1780	105 to 135 (120)	N$\bar{K}$ Λπ Σπ Σ(1385)π Λ(1520)π	37-43 14-20 2-5 8-12 17-23	508 525 474 324 198
Σ(1915)	1(5/2$^+$)F'_{15}	p = 1.26 σ = 12.8	1900 to 1935	80 to 160 (120)	N$\bar{K}$ Λπ Σπ Σ(1385)π	5-15 seen seen < 5	618 622 577 440
Σ(1940)	1(3/2$^-$)D'''_{13}	p = 1.32 σ = 12.1	1900 to 1950	150 to 300 (220)	N$\bar{K}$ Λπ Σπ Σ(1385)π Λ(1520)π Δ(1232)$\bar{K}$ N$\bar{K}$*(892)	<20 seen seen seen seen seen seen	637 639 594 460 354 410 320
Σ(2030)	1(7/2$^+$)F_{17}	p = 1.52 σ = 9.93	2025 to 2040	150 to 200 (180)	N$\bar{K}$ Λπ Σπ ΞK Σ(1385)π Λ(1520)π Δ(1232)$\bar{K}$ N$\bar{K}$*(892)	17-23 17-23 5-10 < 2 5-15 10-20 10-20 < 5	702 700 657 412 529 430 498 438
Σ(2250)	1(?)	p = 2.04 σ = 6.76	2210 to 2280	60 to 150 (100)	N$\bar{K}$ Λπ Σπ	<10 seen seen	851 842 803

Baryon Table *(cont'd)*

Particle[a]	$I(J^P)L^b_{2I \cdot 2J}$	Mass[d] M (MeV)	Full[e] width Γ (MeV)	Partial decay modes: Mode	Fraction (%)	p^h (MeV/c)
		S=−2 I=1/2 CASCADE RESONANCES (Ξ)				
Ξ	1/2(1/2$^+$)	(0)1314.9 (−)1321.3		See Stable Particle Table		
Ξ(1530)	1/2(3/2$^+$)P_{13}	(0)1531.8±0.3 S = 1.3[j] (−)1535.0±0.6	9.1±0.5 10.1±1.9	Ξπ	100	148
→→						
Ξ(1820)	1/2(3/2)	1823 ±6[i]	20^{+15}_{-10}[i]	Λ$\bar{K}$ Σ$\bar{K}$ Ξπ Ξ(1530)π	~45 ~10 small ~45	396 306 413 231
→						
Ξ(2030)	1/2(?)	2024 ±6[i]	16^{+15}_{-5}[i]	Λ$\bar{K}$ Σ$\bar{K}$ Ξπ Ξ(1530)π	~20 ~80 small small	587 524 573 418
→→→→						
		OTHER BARYONS				
Ω^-	0(3/2$^+$)	1672.4		See Stable Particle Table		
→→ Λ_c^+	0(1/2$^+$)	2282		See Stable Particle Table		
→→→→→→→						

→ Each arrow in the left-hand margin indicates there is an entry in the Data Card Listings for a baryon that is not well enough established (status less than 3 stars) to be included here. There is a short list of *all* the baryons in the Listings, whatever their status, at the front of this Table.

†. This mode is energetically forbidden when the nominal mass of the decaying resonance (and of any resonance in the final state) is used, but is in fact allowed due to the nonzero widths of the resonance(s).

*. The modes in brackets are subreactions of the Nππ mode.

a. The nominal mass here (in MeV) is used for identification. See column 4 for the actual mass.

b. When there is more than one baryon with the same quantum numbers, one prime is attached to the spectroscopic symbol for the first of them (e.g., S'_{11}), two primes to the second, etc.

c. The quantities here are calculated using the nominal mass of column 1.

d. Usually a conservatively large range of masses rather than a statistical average of the various determinations of the mass is given. In these cases, the mass determinations are nearly entirely from various phase-shift analyses of more or less the same data. It is thus not appropriate to treat the determinations as independent measurements or to average them together. The masses, widths, and branching fractions in this Table are Breit-Wigner parameters. The Data Card Listings also include pole parameters where they are available.

e. Usually a conservatively large range of widths rather than a statistical average of the various determinations of the width is given (see note *d* for the reason). The nominal value in parentheses is then simply a best guess.

f. For information on the Nγ decay modes, see the Note on N and Δ Resonances in the Listings.

g. Most of the inelastic branching fractions come from partial-wave analyses, and these determine $\sqrt{xx'}$, where x and x′ are the elastic and inelastic branching fractions, not x′ directly. Thus any uncertainty (and it is often considerable) in x carries over into x′. When x′ so determined is really poorly known, we here simply note that the mode is seen. The values of $\sqrt{xx'}$ are given in the Data Card Listings.

h. For a 2-body decay mode, this is the momentum of the decay products in the rest frame of the decaying particle. For a mode with more than two decay products, this is the maximum momentum any of the products can have in this frame. The nominal mass of column 1 is used, as is the nominal mass of any resonance in the final state.

i. The error given here is only an educated guess. It is larger than the error on the weighted average of the published values (the error on this average is given in the Listings).

j. The error given here has been scaled up by the "S factor" (see the * footnote to the Stable Particle Table for how S is defined) because the various measurements disagree more seriously than one would expect from statistics.

PHYSICAL CONSTANTS*

Quantity	Symbol, equation	Value	Uncert. (ppm)
speed of light	c	$2.997\,924\,58(1.2)\times10^{10}$ cm s^{-1} (see note**)	0.004
Planck constant	h	$6.626\,176(36)\times10^{-27}$ erg s	5.4
Planck constant, reduced	$\hbar = h/2\pi$	$1.054\,588\,7(57)\times10^{-27}$ erg s	5.4
		$= 6.582\,173(17)\times10^{-22}$ MeV s	2.6
electron charge magnitude	e	$4.803\,242(14)\times10^{-10}$ esu	2.9
		$= 1.602\,189\,2(46)\times10^{-19}$ coulomb	2.9
conversion constant	$\hbar c$	197.328 58(51) MeV fm	2.6
conversion constant	$(\hbar c)^2$	0.389 385 7(20) GeV^2 mbarn	5.2
electron mass	m_e	0.511 003 4(14) MeV/c^2 = $9.109\,534(47)\times10^{-28}$ g	2.8, 5.1
proton mass	m_p	938.279 6(27) MeV/c^2 = $1.672\,648\,5(86)\times10^{-24}$ g	2.8, 5.1
		= 1.007 276 470(11) amu = 1836.151 52(70) m_e	0.011, 0.38
deuteron mass	m_d	1875.628 0(53) MeV/c^2	2.8
atomic mass unit (amu)	(mass C^{12} atom)/12 = (1 g)/N_A	931.501 6(26) MeV/c^2 = $1.660\,565\,5(86)\times10^{-24}$ g	2.8, 5.1
fine structure constant	$\alpha = e^2/\hbar c$	1/137.036 04(11)	0.82
classical electron radius	$r_e = e^2/m_ec^2$	2.817 938 0(70) fm	2.5
electron Compton wavelength	$\lambda\!\!\!^{-}_e = \hbar/m_ec = r_e\alpha^{-1}$	$3.861\,590\,5(64)\times10^{-11}$ cm	1.6
Bohr radius ($m_{nucleus} = \infty$)	$a_\infty = \hbar^2/cm_ee^2 = r_e\alpha^{-2}$	$0.529\,177\,06(44)\times10^{-8}$ cm	0.82
Rydberg energy	$hcR_\infty = m_ee^4/2\hbar^2 = m_ec^2\alpha^2/2$	13.605 804(36) eV	2.6
Thomson cross section	$\sigma_T = 8\pi r_e^2/3$	0.665 244 8(33) barn	4.9
Bohr magneton	$\mu_B = e\hbar/2m_ec$	$5.788\,378\,5(95)\times10^{-15}$ MeV gauss^{-1}	1.6
nuclear magneton	$\mu_N = e\hbar/2m_pc$	$3.152\,451\,5(53)\times10^{-18}$ MeV gauss^{-1}	1.7
electron cyclotron frequency/field	$\omega^e_{cycl}/B = e/m_ec$	$1.758\,804\,7(49)\times10^{7}$ rad s^{-1} gauss^{-1}	2.8
proton cyclotron frequency/field	$\omega^p_{cycl}/B = e/m_pc$	$9.578\,756(28)\times10^{3}$ rad s^{-1} gauss^{-1}	2.8
gravitational constant	G_N	$6.672\,0(41)\times10^{-8}$ cm^3 g^{-1} s^{-2}	615
grav. acceleration, sea level, 45° lat.	g	980.62 cm s^{-2}	—
Fermi coupling constant	$G_F/(\hbar c)^3$	$1.166\,37(2)\times10^{-5}$ GeV^{-2}	17
Avogadro number	N_A	$6.022\,045(31)\times10^{23}$ mol^{-1}	5.1
Boltzmann constant	k	$1.380\,662(44)\times10^{-16}$ erg K^{-1}	32
		$= 8.617\,35(28)\times10^{-5}$ eV K^{-1}	32
molar volume, ideal gas at STP	$N_Ak(273.15\text{ K})/(1\text{ atmosphere})$	22 413.83(70) cm^3 mol^{-1}	31
Stefan-Boltzmann constant	$\sigma = \pi^2k^4/60\hbar^3c^2$	$5.670\,32(71)\times10^{-5}$ erg s^{-1} cm^{-2} K^{-4}	125

π = 3.141 592 653 589 793 238 $\qquad$ e = 2.718 281 828 459 045 235 $\qquad$ γ = 0.577 215 664 901 532 861

1 in = 2.54 cm	1 newton = 10^5 dyne	1 coulomb = $2.997\,924\,58\times10^9$ esu	1 tropical year ≃ $3.155\,69\times10^7$ s
1 Å = 10^{-8} cm	1 joule = 10^7 erg	1 tesla = 10^4 gauss	1 light year = $9.460\,528\times10^{17}$ cm
1 fm = 10^{-13} cm	1 eV = $1.602\,189\,2\times10^{-12}$ erg	1 atm. = $1.013\,25\times10^6$ dyne/cm^2	1 parsec = 3.261 633 light year
1 barn = 10^{-24} cm^2	1 eV/c^2 = $1.782\,676\times10^{-33}$ g	0°C = 273.15 K	1 astro. unit = $1.495\,979\times10^{13}$ cm

* Revised 1984 by Barry N. Taylor, based mainly on the "1973 Least-Squares Adjustment of the Fundamental Constants," by E.R. Cohen and B.N. Taylor, J. Phys. Chem. Ref. Data **2**, 663 (1973). The figures in parentheses give the 1-standard-deviation uncertainties in the last digits of the main numbers; the uncertainties in parts per million (ppm) are given in the last column. The uncertainties of the output values of a least-squares adjustment are in general correlated, and the laws of error propagation must be used in calculating additional quantities.

The set of constants resulting from the 1973 adjustment of Cohen and Taylor has been recommended for international use by CODATA (Committee on Data for Science and Technology), and is the most up-to-date, generally accepted set currently available. Since the publication of the 1973 adjustment, new experiments have yielded better values for some of the constants: $N_A = 6.022\,097\,8(63)\times10^{23}$ mol^{-1} (1.04 ppm); α^{-1} = 137.035 963(15) (0.11 ppm); and m_p/m_e = 1836.152 470(79) (0.043 ppm). However, since a change in the measured value of one constant usually leads to changes in the adjusted values of others, one must be cautious in using together the values from the 1973 adjustment and the results of more recent experiments.

A new adjustment of the fundamental constants is planned for completion in 1984.

** In October 1983, the Conférence Générale des Poids et Mesures adopted a new definition of the meter. The meter is the length of the path traveled by light in vacuum during a time interval of 1/299 792 458 s. Thus the speed of light is *defined* to be 299 792 458 m/s. For a discussion of this change, see B.W. Petley, Nature **303**, 373 (1983).

CLEBSCH-GORDAN COEFFICIENTS, SPHERICAL HARMONICS, AND D FUNCTIONS

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

Notation:

m_1 m_2 \ J, M	J J ... / M M ...
m_1 m_2 ⋮	Coefficients

1/2 × 1/2

m_1 m_2	J=1, M=+1
+1/2 +1/2	1

m_1 m_2	J=1, M=0	J=0, M=0
+1/2 -1/2	1/2	1/2
-1/2 +1/2	1/2	-1/2

m_1 m_2	J=1, M=-1
-1/2 -1/2	1

1 × 1/2

m_1 m_2	J=3/2, M=+3/2
+1 +1/2	1

m_1 m_2	J=3/2, M=+1/2	J=1/2, M=+1/2
+1 -1/2	1/3	2/3
0 +1/2	2/3	-1/3

m_1 m_2	J=3/2, M=-1/2	J=1/2, M=-1/2
0 -1/2	2/3	1/3
-1 +1/2	1/3	-2/3

m_1 m_2	J=3/2, M=-3/2
-1 -1/2	1

2 × 1

m_1 m_2	J=3, M=+3
+2 +1	1

m_1 m_2	J=3, M=+2	J=2, M=+2
+2 0	1/3	2/3
+1 +1	2/3	-1/3

m_1 m_2	J=3, M=+1	J=2, M=+1	J=1, M=+1
+2 -1	1/15	1/3	3/5
+1 0	8/15	1/6	-3/10
0 +1	6/15	-1/2	1/10

m_1 m_2	J=3, M=0	J=2, M=0	J=1, M=0
+1 -1	1/5	1/2	3/10
0 0	3/5	0	-2/5
-1 +1	1/5	-1/2	3/10

m_1 m_2	J=3, M=-1	J=2, M=-1	J=1, M=-1
0 -1	6/15	1/2	1/10
-1 0	8/15	-1/6	-3/10
-2 +1	1/15	-1/3	3/5

m_1 m_2	J=3, M=-2	J=2, M=-2
-1 -1	2/3	1/3
-2 0	1/3	-2/3

m_1 m_2	J=3, M=-3
-2 -1	1

1 × 1

m_1 m_2	J=2, M=+2
+1 +1	1

m_1 m_2	J=2, M=+1	J=1, M=+1
+1 0	1/2	1/2
0 +1	1/2	-1/2

m_1 m_2	J=2, M=0	J=1, M=0	J=0, M=0
+1 -1	1/6	1/2	1/3
0 0	2/3	0	-1/3
-1 +1	1/6	-1/2	1/3

m_1 m_2	J=2, M=-1	J=1, M=-1
0 -1	1/2	1/2
-1 0	1/2	-1/2

m_1 m_2	J=2, M=-2
-1 -1	1

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

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

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

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

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

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

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

2 × 1/2

m_1 m_2	J=5/2, M=+5/2
+2 1/2	1

m_1 m_2	J=5/2, M=+3/2	J=3/2, M=+3/2
+2 -1/2	1/5	4/5
+1 +1/2	4/5	-1/5

m_1 m_2	J=5/2, M=+1/2	J=3/2, M=+1/2
+1 -1/2	2/5	3/5
0 +1/2	3/5	-2/5

m_1 m_2	J=5/2, M=-1/2	J=3/2, M=-1/2
0 -1/2	3/5	2/5
-1 +1/2	2/5	-3/5

m_1 m_2	J=5/2, M=-3/2	J=3/2, M=-3/2
-1 -1/2	4/5	1/5
-2 +1/2	1/5	-4/5

m_1 m_2	J=5/2, M=-5/2
-2 -1/2	1

3/2 × 1/2

m_1 m_2	J=2, M=+2
+3/2 +1/2	1

m_1 m_2	J=2, M=+1	J=1, M=+1
+3/2 -1/2	1/4	3/4
+1/2 +1/2	3/4	-1/4

m_1 m_2	J=2, M=0	J=1, M=0
+1/2 -1/2	1/2	1/2
-1/2 +1/2	1/2	-1/2

m_1 m_2	J=2, M=-1	J=1, M=-1
-1/2 -1/2	3/4	1/4
-3/2 +1/2	1/4	-3/4

m_1 m_2	J=2, M=-2
-3/2 -1/2	1

3/2 × 1

m_1 m_2	J=5/2, M=+5/2
+3/2 +1	1

m_1 m_2	J=5/2, M=+3/2	J=3/2, M=+3/2
+3/2 0	2/5	3/5
+1/2 +1	3/5	-2/5

m_1 m_2	J=5/2, M=+1/2	J=3/2, M=+1/2	J=1/2, M=+1/2
+3/2 -1	1/10	2/5	1/2
+1/2 0	3/5	1/15	-1/3
-1/2 +1	3/10	-8/15	1/6

m_1 m_2	J=5/2, M=-1/2	J=3/2, M=-1/2	J=1/2, M=-1/2
+1/2 -1	3/10	8/15	1/6
-1/2 0	3/5	-1/15	-1/3
-3/2 +1	1/10	-2/5	1/2

m_1 m_2	J=5/2, M=-3/2	J=3/2, M=-3/2
-1/2 -1	3/5	2/5
-3/2 0	2/5	-3/5

m_1 m_2	J=5/2, M=-5/2
-3/2 -1	1

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

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

3/2 × 3/2

m_1 m_2	J=3, M=+3
+3/2 +3/2	1

m_1 m_2	J=3, M=+2	J=2, M=+2
+3/2 +1/2	1/2	1/2
+1/2 +3/2	1/2	-1/2

m_1 m_2	J=3, M=+1	J=2, M=+1	J=1, M=+1
+3/2 -1/2	1/5	1/2	3/10
+1/2 +1/2	3/5	0	-2/5
-1/2 +3/2	1/5	-1/2	3/10

m_1 m_2	J=3, M=0	J=2, M=0	J=1, M=0	J=0, M=0
+3/2 -3/2	1/20	1/4	9/20	1/4
+1/2 -1/2	9/20	1/4	-1/20	-1/4
-1/2 +1/2	9/20	-1/4	-1/20	1/4
-3/2 +3/2	1/20	-1/4	9/20	-1/4

m_1 m_2	J=3, M=-1	J=2, M=-1	J=1, M=-1
+1/2 -3/2	1/5	1/2	3/10
-1/2 -1/2	3/5	0	-2/5
-3/2 +1/2	1/5	-1/2	3/10

m_1 m_2	J=3, M=-2	J=2, M=-2
-1/2 -3/2	1/2	1/2
-3/2 -1/2	1/2	-1/2

m_1 m_2	J=3, M=-3
-3/2 -3/2	1

2 × 3/2

m_1 m_2	J=7/2, M=+7/2
+2 +3/2	1

m_1 m_2	J=7/2, M=+5/2	J=5/2, M=+5/2
+2 +1/2	3/7	4/7
+1 +3/2	4/7	-3/7

m_1 m_2	J=7/2, M=+3/2	J=5/2, M=+3/2	J=3/2, M=+3/2
+2 -1/2	1/7	16/35	2/5
+1 1/2	4/7	1/35	-2/5
0 3/2	2/7	-18/35	1/5

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

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

m_1 m_2	J=7/2, M=-3/2	J=5/2, M=-3/2	J=3/2, M=-3/2
0 -3/2	2/7	18/35	1/5
-1 -1/2	4/7	-1/35	-2/5
-2 1/2	1/7	-16/35	2/5

m_1 m_2	J=7/2, M=-5/2	J=5/2, M=-5/2
-1 -3/2	4/7	3/7
-2 -1/2	3/7	-4/7

m_1 m_2	J=7/2, M=-7/2
-2 -3/2	1

2 × 2

m_1 m_2	J=4, M=+4
+2 +2	1

m_1 m_2	J=4, M=+3	J=3, M=+3
+2 +1	1/2	1/2
+1 +2	1/2	-1/2

m_1 m_2	J=4, M=+2	J=3, M=+2	J=2, M=+2
+2 0	3/14	1/2	2/7
+1 1	4/7	0	-3/7
0 2	3/14	-1/2	2/7

m_1 m_2	J=4, M=+1	J=3, M=+1	J=2, M=+1	J=1, M=+1
+2 -1	1/14	3/10	3/7	1/5
+1 0	3/7	1/5	-1/14	-3/10
0 1	3/7	-1/5	-1/14	3/10
-1 2	1/14	-3/10	3/7	-1/5

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

m_1 m_2	J=4, M=-1	J=3, M=-1	J=2, M=-1	J=1, M=-1
+1 -2	1/14	3/10	3/7	1/5
0 -1	3/7	1/5	-1/14	-3/10
-1 0	3/7	-1/5	-1/14	3/10
-2 1	1/14	-3/10	3/7	-1/5

m_1 m_2	J=4, M=-2	J=3, M=-2	J=2, M=-2
0 -2	3/14	1/2	2/7
-1 -1	4/7	0	-3/7
-2 0	3/14	-1/2	2/7

m_1 m_2	J=4, M=-3	J=3, M=-3
-1 -2	1/2	1/2
-2 -1	1/2	-1/2

m_1 m_2	J=4, M=-4
-2 -2	1

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

SU(3) ISOSCALAR FACTORS

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

A $\sqrt{\ }$ is understood over every integer in the matrices; the exponent ½ is a reminder of this. For example, in de Swart's notation the $\Xi \to \Omega K$ element of our $10 \to 10 \otimes 8$ matrix reads

$$\left[\begin{matrix} 10 \\ 0\ -2 \end{matrix}\ \begin{matrix} 8 \\ ½\ 1 \end{matrix}\ \middle|\ \begin{matrix} 10 \\ ½\ -1 \end{matrix}\right] = \frac{-\sqrt{6}}{\sqrt{24}}\,.$$

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

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

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

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

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

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

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

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

is

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

Thus,

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

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

$1 \to 8 \otimes 8$

$$(\Lambda)_1 \to (N\bar{K}\ \ \Sigma\pi\ \ \Lambda\eta\ \ \Xi K)_{8\otimes 8} = \frac{1}{\sqrt{8}}(2\ \ 3\ \ -1\ \ -2)^{½}$$

$8_1 \to 8 \otimes 8$

$$\begin{pmatrix} N \\ \Sigma \\ \Lambda \\ \Xi \end{pmatrix}_{8_1} \to \begin{pmatrix} N\pi & N\eta & \Sigma K & \Lambda K & \\ N\bar{K} & \Sigma\pi & \Lambda\pi & \Sigma\eta & \Xi K \\ N\bar{K} & \Sigma\pi & \Lambda\eta & \Xi K & \\ \Sigma\bar{K} & \Lambda\bar{K} & \Xi\pi & \Xi\eta & \end{pmatrix}_{8\otimes 8} = \frac{1}{\sqrt{20}}\begin{pmatrix} 9 & -1 & -9 & -1 & \\ -6 & 0 & 4 & 4 & -6 \\ 2 & -12 & -4 & -2 & \\ 9 & -1 & -9 & -1 & \end{pmatrix}^{½}$$

$8_2 \to 8 \otimes 8$

$$\begin{pmatrix} N \\ \Sigma \\ \Lambda \\ \Xi \end{pmatrix}_{8_2} \to \begin{pmatrix} N\pi & N\eta & \Sigma K & \Lambda K & \\ N\bar{K} & \Sigma\pi & \Lambda\pi & \Sigma\eta & \Xi K \\ N\bar{K} & \Sigma\pi & \Lambda\eta & \Xi K & \\ \Sigma\bar{K} & \Lambda\bar{K} & \Xi\pi & \Xi\eta & \end{pmatrix}_{8\otimes 8} = \frac{1}{\sqrt{12}}\begin{pmatrix} 3 & 3 & 3 & -3 & \\ 2 & 8 & 0 & 0 & -2 \\ 6 & 0 & 0 & 6 & \\ 3 & 3 & 3 & -3 & \end{pmatrix}^{½}$$

$10 \to 8 \otimes 8$

$$\begin{pmatrix} \Delta \\ \Sigma \\ \Xi \\ \Omega \end{pmatrix}_{10} \to \begin{pmatrix} N\pi & \Sigma K & & & \\ N\bar{K} & \Sigma\pi & \Lambda\pi & \Sigma\eta & \Xi K \\ \Sigma\bar{K} & \Lambda\bar{K} & \Xi\pi & \Xi\eta & \\ \Xi\bar{K} & & & & \end{pmatrix}_{8\otimes 8} = \frac{1}{\sqrt{12}}\begin{pmatrix} -6 & 6 & & & \\ -2 & 2 & -3 & 3 & 2 \\ 3 & -3 & 3 & 3 & \\ 12 & & & & \end{pmatrix}^{½}$$

$8 \to 10 \otimes 8$

$$\begin{pmatrix} N \\ \Sigma \\ \Lambda \\ \Xi \end{pmatrix}_{8} \to \begin{pmatrix} \Delta\pi & \Sigma K & & \\ \Delta\bar{K} & \Sigma\pi & \Sigma\eta & \Xi K \\ \Sigma\pi & \Xi K & & \\ \Sigma\bar{K} & \Xi\pi & \Xi\eta & \Omega K \end{pmatrix}_{10\otimes 8} = \frac{1}{\sqrt{15}}\begin{pmatrix} -12 & 3 & & \\ 8 & -2 & -3 & 2 \\ -9 & 6 & & \\ 3 & -3 & -3 & 6 \end{pmatrix}^{½}$$

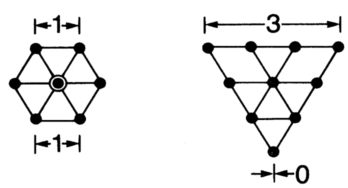
$10 \to 10 \otimes 8$

$$\begin{pmatrix} \Delta \\ \Sigma \\ \Xi \\ \Omega \end{pmatrix}_{10} \to \begin{pmatrix} \Delta\pi & \Delta\eta & \Sigma K & \\ \Delta\bar{K} & \Sigma\pi & \Sigma\eta & \Xi K \\ \Sigma\bar{K} & \Xi\pi & \Xi\eta & \Omega K \\ \Xi\bar{K} & \Omega\eta & & \end{pmatrix}_{10\otimes 8} = \frac{1}{\sqrt{24}}\begin{pmatrix} 15 & 3 & -6 & \\ 8 & 8 & 0 & -8 \\ 12 & 3 & -3 & -6 \\ 12 & -12 & & \end{pmatrix}^{½}$$

SU(N) MULTIPLETS AND YOUNG DIAGRAMS

This note tells how SU(n) particle multiplets are identified or labeled, how to find the number of particles in a multiplet from its label, how to draw the Young diagram for a multiplet, and how to use Young diagrams to determine the overall multiplet structure of a composite system, such as a 3-quark or a meson-baryon system.

(1) **Multiplet labels** — An SU(n) multiplet is uniquely identified by a string of (n−1) nonnegative integers: $(\alpha,\beta,\gamma,\cdots)$. Any such set of integers specifies a multiplet. For an SU(2) multiplet such as an isospin multiplet, the single integer α is the number of *steps* from one end of the multiplet to the other (i.e., it is one fewer than the number of particles in the multiplet). In SU(3), the two integers α and β are the numbers of steps across the top and bottom levels of the multiplet diagram. Thus the labels for the SU(3) octet and decuplet



are (1,1) and (3,0). For larger n, the interpretation of the integers in terms of the geometry of the multiplets, which exist in an (n−1)-dimensional space, is not so readily apparent.

The label for the SU(n) singlet is (0,0,...,0). In a flavor SU(n), the n quarks together form a (1,0,...,0) multiplet, and the n antiquarks belong to a (0,...,0,1) multiplet. These two multiplets are *conjugate* to one another, which means their labels are related by $(\alpha,\beta,...) \longleftrightarrow (...,\beta,\alpha)$.

(2) **Number of particles** — The number of particles in a multiplet, $N = N(\alpha,\beta,...)$, is given as follows (note the pattern of the equations). In SU(2), $N = N(\alpha)$ is

$$N = \frac{(\alpha+1)}{1} .$$

In SU(3), $N = N(\alpha,\beta)$ is

$$N = \frac{(\alpha+1)}{1} \cdot \frac{(\beta+1)}{1} \cdot \frac{(\alpha+\beta+2)}{2} .$$

In SU(4), $N = N(\alpha,\beta,\gamma)$ is

$$N = \frac{(\alpha+1)}{1} \cdot \frac{(\beta+1)}{1} \cdot \frac{(\gamma+1)}{1} \cdot \frac{(\alpha+\beta+2)}{2} \cdot \frac{(\beta+\gamma+2)}{2} \cdot \frac{(\alpha+\beta+\gamma+3)}{3} .$$

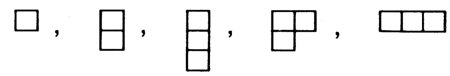
Note that there is no factor with $(\alpha+\gamma+2)$: only a *consecutive* sequence of the label integers appears in any factor. One more example should make the pattern clear for any SU(n). In SU(5), $N = N(\alpha,\beta,\gamma,\delta)$ is

$$N = \frac{(\alpha+1)}{1} \cdot \frac{(\beta+1)}{1} \cdot \frac{(\gamma+1)}{1} \cdot \frac{(\delta+1)}{1} \cdot \frac{(\alpha+\beta+2)}{2} \cdot \frac{(\beta+\gamma+2)}{2} \times$$

$$\frac{(\gamma+\delta+2)}{2} \cdot \frac{(\alpha+\beta+\gamma+3)}{3} \cdot \frac{(\beta+\gamma+\delta+3)}{3} \cdot \frac{(\alpha+\beta+\gamma+\delta+4)}{4} .$$

Multiplets that are conjugate to one another obviously have the same number of particles, but so can other multiplets. For example, the SU(4) multiplets (3,0,0) and (1,1,0) each have 20 particles.

(3) **Young diagrams** — A Young diagram consists of an array of boxes (or some other symbol) arranged in one or more *left-justified* rows, with each row being *at least as long* as the row beneath. The correspondence between a diagram and a multiplet label is: The top row juts out α boxes to the right past the end of the second row, the second row juts out β boxes to the right past the end of the third row, etc. A diagram in SU(n) has at most n rows. There can be any number of "completed" columns of n boxes buttressing the left of a diagram; these don't affect the label. Thus in SU(3) the diagrams



represent the multiplets (1,0), (0,1), (0,0), (1,1), and (3,0). In any SU(n), the quark multiplet is represented by a single box, the antiquark multiplet by a column of (n−1) boxes, and a singlet by a completed column of n boxes.

(4) **Coupling multiplets together** — The following recipe tells how to find the multiplets that occur in coupling two multiplets together. To couple together more than two multiplets, first couple two, then couple the third with each of the multiplets obtained from the first two, etc.

First a definition: A sequence of the letters *a,b,c,...* is *admissible* if at any point in the sequence at least as many *a*'s have been reached as *b*'s, at least as many *b*'s have been reached as *c*'s, etc. Thus *abcd* and *aabcb* are admissible sequences and *abb* and *acb* are not. Now the recipe:

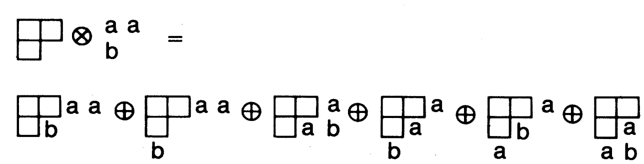
(a) Draw the Young diagrams for the two multiplets, but in one of the diagrams replace the boxes in the first row with *a*'s, the boxes in the second row with *b*'s, etc. The unlettered diagram forms the *upper left-hand corner* of all the enlarged diagrams constructed below.

(b) Add the *a*'s from the lettered diagram to the unlettered diagram to form all possible legitimate Young diagrams that have no more than one *a* per column. (All the *a*'s appear in each new diagram.)

(c) Use the *b*'s to further enlarge the diagrams already obtained, subject to the same rules. Throw away any diagram in which the sequence of letters formed by reading *right to left* in the first row, then the second row, etc., is not admissible.

(d) Proceed as in (c) with the *c*'s, etc.

Thus, for example, the calculation to find the multiplets that can occur in a system made up of two SU(3) octets (one might be the π-meson octet, the other the N-baryon octet) is as follows:



where only the diagrams with admissible sequences and with fewer than four rows (since n = 3) have been kept. In terms of multiplet labels, the above may be written

$$(1,1) \otimes (1,1) = (2,2) \oplus (3,0) \oplus (0,3) \oplus (1,1) \oplus (1,1) \oplus (0,0) ,$$

or in terms of numbers of particles,

$$\mathbf{8} \otimes \mathbf{8} = \mathbf{27} \oplus \mathbf{10} \oplus \overline{\mathbf{10}} \oplus \mathbf{8} \oplus \mathbf{8} \oplus \mathbf{1} .$$

The product of the numbers of the left is equal to the sum on the right. (See the section on the Nonrelativistic Quark Model for results for 3-quark systems.)

TESTS OF CONSERVATION LAWS*

INTRODUCTION

In response to the current interest in tests of conservation laws, we have made a list of experimental limits on all weak and electromagnetic decays, mass differences, and moments, whose observation would violate conservation laws. The list is in two parts, "Number Conservation Laws," i.e., lepton, baryon, hadronic flavor, and charge conservation, and "Discrete Space Time Symmetries," i.e. C, P, T, CP, and CPT. The references for these data can be found in the Stable Particle Section of the Data Card Listings in this Review. A discussion of these tests follows.

CONSERVATION OF LEPTON NUMBERS

Present experimental evidence and the standard electroweak theory are consistent with the absolute conservation of three separate lepton numbers: electron number L_e, muon number L_μ, and τ-number L_τ. Searches for violations are of the following types:

a) $\Delta L = 2$ for one type of lepton. The best limit comes from the search for neutrinoless double beta decay $(Z,A) \rightarrow (Z+2,A) + e^- + e^-$. The best laboratory limit is $t_{1/2} > 2\times10^{22}$ yr for ^{76}Ge [E. Bellotti et al., Phys. Lett. **121B**, 72 (1983)].

b) Conversion of one lepton type to another. For purely leptonic processes, the best limit is on $\mu \rightarrow e\gamma$. For semileptonic processes, the best limit comes from the coherent conversion process in a muonic atom $\mu^- + (Z,A) \rightarrow e^- + (Z,A)$. Of special interest is the case in which the hadronic flavor also changes, as in $K_L \rightarrow \mu^\pm e^\mp$. Limits on the conversion of τ into e or μ are found in τ decay and are much less stringent that those for $\mu \rightarrow e$ conversion.

c) Conversion of one type of lepton into another type of antilepton. The case most studied is $\mu^- + (Z,A) \rightarrow e^+ + (Z-2,A)$.

d) Relation to neutrino mass. If neutrinos have masses then it is expected even in the standard electroweak theory that separate lepton numbers are not conserved. With small neutrino masses this would be observed first in neutrino oscillations which have been the subject of extensive experimental searches. If the $\Delta L = 2$ type of violation occurs, it is expected that neutrinos will have a nonzero mass of the Majorana type.

CONSERVATION OF HADRONIC FLAVORS

The conversion of quarks of a given charge, (d,s,b) or (u,c,t), into one another is forbidden in strong and electromagnetic interactions by the conservation of hadron flavors: S (strangeness), C (charm), B (bottomness), and T (topness). The weak interactions violate these conservation laws as a result of the Cabibbo or Kobayashi-Maskawa mixing (see Appendix III in the complete Review of Particle Properties). The way in which these conservation laws are violated is tested as follows:

a) $\Delta S = \Delta Q$ rule. In the semileptonic decay of strange particles, the strangeness change equals the change in charge of the hadrons. Tests come from limits on decay rates such as $\Sigma^+ \rightarrow ne^+\nu$ and from a detailed analysis of $K_L \rightarrow \pi e\nu$, which yields the parameter x. A corresponding rule for charm decays is $\Delta C = \Delta Q$.

b) Change of flavor by 2 units. In the standard model this occurs only in second-order weak interactions. The one example for which this has been measured is the $\Delta S = 2$ $K^0 - \overline{K}^0$ mixing, which is directly measured by $m(K_S) - m(K_L)$. A limit on the $\Delta C = 2$ $D^0 - \overline{D}^0$ mixing provides a limit on $|m(D^0_1) - m(D^0_2)|$.

c) Flavor-changing neutral-currents. In the standard model the neutral-current interactions do not change flavor. The low rate of $K_L \rightarrow \mu^+\mu^-$ puts limits on such interactions; the nonzero value for this rate is attributed to a combination of the weak and electromagnetic interactions. The best test should come from a limit on $K^+ \rightarrow \pi^+\nu\overline{\nu}$, which occurs in the standard model only as a second-order weak process with a branching fraction of 10^{-10} to 10^{-11}. Limits for charm-changing or bottom-changing neutral currents are much less stringent.

CPT INVARIANCE

General principles of relativistic field theory require invariance under the combined transformation CPT. The simplest tests of CPT invariance are the equality of the masses and lifetimes of a particle and its antiparticle. The best test comes from a limit on the mass difference between K^0 and $\overline{K}^0$. Any such mass difference contributes to the CP-violating parameter ϵ. In fact ϵ can be explained by a CPT-conserving but CP-violating mixing of K^0 and $\overline{K}^0$, which yields a prediction that $\phi_{+-} \approx 44°$, while a $K^0 - \overline{K}^0$ mass difference would yield $\phi_{+-} \approx 44° + 90°$. It is thus possible to deduce that $|m(K^0) - m(\overline{K}^0)| < 10^{-4}|m(K_S) - m(K_L)| < 3\times10^{-10}$ eV. Also, an upper limit on $|m(D^0) - m(\overline{D}^0)|$ can be derived from the bound $|m(D^0_1) - m(D^0_2)| < 0.65\times10^{-9}$ MeV (inferred from bound on $D^0 \rightarrow \overline{D}^0 \rightarrow \mu^-$ anything), given an input value of, or bound on, the CP-violation parameter ϵ for $D^0 - \overline{D}^0$ mixing.

CP AND T INVARIANCE

Given CPT invariance, CP violation and T violation are equivalent. So far the only evidence for CP or T violation comes from the measurements of η_{+-}, η_{00}, and the semileptonic decay charge asymmetry for K_L. Other searches for CP or T violation should be divided into (a) those that involve weak interactions or parity violation, and (b) those that involve processes allowed by the strong or electromagnetic interactions. In class (a) the most sensitive is probably the search for an electric dipole moment of the neutron, which requires both P and T violation to be nonzero. Class (b) searches involve looking for C or T violation in strong or electromagnetic processes. Examples are the search for C violation in η decay, believed to be an electromagnetic process, and the search for T violation in a number of nuclear and electromagnetic reactions.

* Prepared April 1984 by R.E. Shrock, T.G. Trippe, and L. Wolfenstein.

TESTS OF CONSERVATION LAWS (Cont'd)

Number Conservation Laws

Quantity[a]	Value[b]	Conservation Law Tested
$\mu^+ \to e^+\overline{\nu}_e\nu_\mu$ / all	$< 5 \times 10^{-2}$	Lepton family number[c,d]
$\to e^+\gamma$ / all	$< 1.7 \times 10^{-10}$	Lepton family number[d]
$\to e^+e^+e^-$ / all	$< 1.9 \times 10^{-9}$	" " "
$\to e^+\gamma\gamma$ / all	$< 8.4 \times 10^{-9}$	" " "
$\mu^-\ S_{32} \to e^-\ S_{32}$ / all	$< 7 \times 10^{-11}$	" " "
coupling for $(\mu^+e^- \to \mu^-e^+)_{bound}$	$< 42\ G_F$	" " "
$\tau^+ \to \mu^+\gamma$ / all	$< 5.5 \times 10^{-4}$	" " "
$\to e^+\gamma$ / all	$< 6.4 \times 10^{-4}$	" " "
$\to \mu^+\mu^+\mu^-$ / all	$< 4.9 \times 10^{-4}$	" " "
$\to e^+\mu^+\mu^-$ / all	$< 3.3 \times 10^{-4}$	" " "
$\to \mu^+e^+e^-$ / all	$< 4.4 \times 10^{-4}$	" " "
$\to e^+e^+e^-$ / all	$< 4.0 \times 10^{-4}$	" " "
$\to \mu^+\pi^0$ / all	$< 8.2 \times 10^{-4}$	" " "
$\to e^+\pi^0$ / all	$< 2.1 \times 10^{-3}$	" " "
$\to \mu^+K^0$ / all	$< 1.0 \times 10^{-3}$	" " "
$\to e^+K^0$ / all	$< 1.3 \times 10^{-3}$	" " "
$\to \mu^+\rho^0$ / all	$< 4.4 \times 10^{-4}$	" " "
$\to e^+\rho^0$ / all	$< 3.7 \times 10^{-4}$	" " "
$\pi^+ \to \mu^+\nu_e$ / all	$< 8.0 \times 10^{-3}$ (e)	" " "
$K^+ \to \pi^+e^+\mu^-$ / all	$< 7 \times 10^{-9}$	" " "
$\to \pi^+e^-\mu^+$ / all	$< 5 \times 10^{-9}$	" " "
$\to \mu^+\nu_e$ / all	$< 4 \times 10^{-3}$ (e)	" " "
$\to \mu^-\nu e^+e^+$ / all	$< 2 \times 10^{-8}$	" " "
$K^0_L \to e\mu$ / charged	$< 8 \times 10^{-6}$	" " "
ν oscillations and lepton mixing effects in particle decays	See Data Card Listings	" " "
$\mu^-\ S_{32} \to e^+\ Si^*_{32}$ / all	$< 9 \times 10^{-10}$	Total lepton number[f]
$\mu^-\ I_{127} \to e^+\ Sb^{stable}_{127}$ / all	$< 3 \times 10^{-10}$	" " "
$\pi^+ \to \mu^+\overline{\nu}_e$ / all	$< 1.5 \times 10^{-3}$ (e)	" " "
$K^+ \to \pi^-e^+e^+$ / all	$< 1 \times 10^{-8}$	" " "
$\to \pi^-e^+\mu^+$ / all	$< 7 \times 10^{-9}$	" " "
$\to \mu^+\overline{\nu}_e$ / all	$< 3.3 \times 10^{-3}$ (e)	" " "
$\to e^+\pi^0\overline{\nu}_e$ / all	$< 3 \times 10^{-3}$ (e)	" " "
neutrinoless double beta decay	See Data Card Listings	" " "
$\tau_p / BR(p \to e^+\pi^0)$	$< 1 \times 10^{32}$ years	Baryon number
mean time for $n \to \overline{n}$ trans.	> 1.0 year	" "
e mean life	$> 2 \times 10^{22}$ years	Charge
$n \to p\nu\overline{\nu} / pe^-\overline{\nu}$	$< 9 \times 10^{-24}$	"
Re x from $K^0 \to \pi e\nu$	0.009 ± 0.020	$\Delta S = \Delta Q$ (g)
Im x from $K^0 \to \pi e\nu$	-0.004 ± 0.026	"
$K^+ \to \pi^+\pi^+e^-\nu$ / all	$< 1.2 \times 10^{-8}$	"
$\to \pi^+\pi^+\mu^-\nu$ / all	$< 3 \times 10^{-6}$	"
$\Sigma^+ \to ne^+\nu$ / all	$< 5 \times 10^{-6}$	"
$\to n\mu^+\nu$ / all	$< 3 \times 10^{-5}$	"
$(\Sigma^+ \to n\ell^+\nu)/(\Sigma^- \to n\ell^-\overline{\nu})$	< 0.04	"
$\Xi^0 \to \Sigma^-e^+\nu$ / all	$< 9 \times 10^{-4}$	"
$\to \Sigma^-\mu^+\nu$ / all	$< 9 \times 10^{-4}$	"
$\to pe^-\nu$ / all	$< 1.3 \times 10^{-3}$	$\Delta S = 2$ forbidden[g]
$\to p\mu^-\nu$ / all	$< 1.3 \times 10^{-3}$	" "
$\Xi^- \to ne^-\nu$ / all	$< 3.2 \times 10^{-3}$	" "
$\to n\mu^-\nu$ / all	$< 1.5 \times 10^{-2}$	" "
$\to p\pi^-e^-\nu$ / all	$< 4 \times 10^{-4}$	" "
$\to p\pi^-\mu^-\nu$ / all	$< 4 \times 10^{-4}$	" "
$\Xi^0 \to p\pi^-$ / all	$< 3.6 \times 10^{-5}$	" "
$\Xi^- \to n\pi^-$ / all	$< 1.9 \times 10^{-5}$	" "
$\to p\pi^-\pi^-$ / all	$< 4 \times 10^{-4}$	" "
$\Omega^- \to \Lambda\pi^-$ / all	$< 3.1 \times 10^{-3}$	" "
$m_{K_L} - m_{K_S}$	$(3.521 \pm 0.014) \times 10^{-12}$ MeV	" "
$(D^0 \to \overline{D}^0 \to K^+\pi^-)/(D^0 \to K\pi)$	< 0.16	$\Delta C = 2$ forbidden[g]
$(D^0 \to \overline{D}^0 \to \mu^-$ anything$)/(D^0 \to \mu^+$ anything$)$	< 0.044	" "
$\lvert m_{D^0_1} - m_{D^0_2}\rvert$ (from previous limit)	$< 6.5 \times 10^{-10}$ MeV	" "
$K^0_L \to \mu^+\mu^-$ / all	$(9.1 \pm 1.9) \times 10^{-9}$	no flav. chng. neut. curr.
$\to e^+e^-$ / all	$< 2.0 \times 10^{-7}$	" " " " "
$\to \mu^+\mu^-\gamma$ / all	$(2.8 \pm 2.8) \times 10^{-7}$	" " " " "
$\to e^+e^-\gamma$ / all	$(1.7 \pm 0.9) \times 10^{-5}$	" " " " "
$\to \pi^0\mu^+\mu^-$ / all	$< 1.2 \times 10^{-6}$	" " " " "
$\to \pi^0e^+e^-$ / all	$< 2.3 \times 10^{-6}$	" " " " "
$\to \pi^+\pi^-e^+e^-$ / all	$< 9 \times 10^{-6}$	" " " " "
$K^0_S \to \mu^+\mu^-$ / all	$< 3.2 \times 10^{-7}$	" " " " "
$\to e^+e^-$ / all	$< 3.4 \times 10^{-4}$	" " " " "
$K^+ \to \pi^+e^+e^-$ / all	$(2.7 \pm 0.5) \times 10^{-7}$	" " " " "
$\to \pi^+\mu^+\mu^-$ / all	$< 2.4 \times 10^{-6}$	" " " " "
$\to \pi^+\nu\overline{\nu}$ / all	$< 1.4 \times 10^{-7}$	" " " " "
$B \to e^+e^-$ anything / all	$< 8 \times 10^{-3}$	" " " " "
$\to \mu^+\mu^-$ anything / all	$< 7 \times 10^{-3}$	" " " " "

TESTS OF CONSERVATION LAWS (Cont'd)

Discrete Space Time Symmetries

Quantity[a]	Value[b]	Symmetry Tested or Violated
$\pi^0 \to \gamma\gamma\gamma$ / all	$< 3.8 \times 10^{-7}$	C
$(e^+e^-)_{J=1} \to \gamma\gamma\gamma$ / all	$(5 \pm 3) \times 10^{-4}$[h]	C
$\eta \to e^+e^-\pi^0$ / all	$< 5 \times 10^{-5}$	C (single photon process)
$\eta \to \mu^+\mu^-\pi^0$ / all	$< 5 \times 10^{-6}$	C (single photon process)
$\eta \to \pi^+\pi^-\pi^0$ parameters:		
left-right asymmetry	$(1.2 \pm 1.7) \times 10^{-3}$	C
sextant asymmetry	$(1.9 \pm 1.6) \times 10^{-3}$	C
quadrant asymmetry	$(-1.7 \pm 1.7) \times 10^{-3}$	C
$\eta \to \pi^+\pi^-\gamma$ parameters:		
left-right asymmetry	$(8.8 \pm 4.0) \times 10^{-3}$	C
beta (D-wave)	0.047 ± 0.062	C
$\eta \to \pi^+\pi^-$ / all	$< 1.5 \times 10^{-3}$	P and CP
e electric dipole moment	$< 3 \times 10^{-24}$ e cm	T and P
μ electric dipole moment	$(3.7 \pm 3.4) \times 10^{-19}$ e cm	T and P
p electric dipole moment	$< 4 \times 10^{-21}$ e cm	T and P
n electric dipole moment	$(2.3 \pm 2.3) \times 10^{-25}$ e cm	T and P
Λ electric dipole moment	$< 1.5 \times 10^{-16}$ e cm	T and P
α' / a from $\mu \to e\bar{\nu}\nu$	-0.12 ± 0.10	T
β' / a from $\mu \to e\bar{\nu}\nu$	-0.029 ± 0.037	T
Im ξ in $K^{\pm}_{\mu 3}$ decay (from transverse μ pol.)	-0.017 ± 0.025	T
Im ξ in $K^0_{\mu 3}$ decay (from transverse μ pol.)	-0.020 ± 0.022	T
$\phi(g_A) - \phi(g_V)$ for n	$(180.11 \pm 0.17)°$	T (0° or 180°)
n 3-vector corr. coeff.	-0.0007 ± 0.0014	T
$K^{\pm} \to \pi^{\pm}\pi^+\pi^-$ rate difference / average	$(0.07 \pm 0.12)\%$	CP
$K^{\pm} \to \pi^{\pm}2\pi^0$ rate difference / average	$(-0.03 \pm 0.55)\%$	CP
$K^{\pm} \to \pi^{\pm}\pi^0\gamma$ rate difference / average	$(0.9 \pm 3.3)\%$	CP
$K \to 3\pi^{\pm}$ slope $(g^+ - g^-)$ / sum	$(-0.7 \pm 0.5)\%$	CP
$\|\eta_{+-0}\|^2 = \Gamma(K^0_S \to \pi^+\pi^-\pi^0) / \Gamma(K^0_L \to \pi^+\pi^-\pi^0)$	< 0.12	CP
$\|\eta_{000}\|^2 = \Gamma(K^0_S \to 3\pi^0) / \Gamma(K^0_L \to 3\pi^0)$	< 0.1	CP
Charge asymm. j in $K^0_L \to \pi^+\pi^-\pi^0$	0.0011 ± 0.0008	CP
$K^0_L \to (\mu^+\pi^-\nu - \mu^-\pi^+\nu)$ / sum	$(0.319 \pm 0.038)\%$	CP (violated)
$K^0_L \to (e^+\pi^-\nu - e^-\pi^+\nu)$ / sum	$(0.333 \pm 0.014)\%$	CP (violated)
$\|\eta_{00}\| = \|A(K^0_L \to \pi^0\pi^0)/A(K^0_S \to \pi^0\pi^0)\|$	$(2.33 \pm 0.08) \times 10^{-3}$	CP (violated)
$\|\eta_{+-}\| = \|A(K^0_L \to \pi^+\pi^-)/A(K^0_S \to \pi^+\pi^-)\|$	$(2.274 \pm 0.022) \times 10^{-3}$	CP (violated)
ϕ_{+-}: phase of η_{+-}	$(44.6 \pm 1.2)°$	CP (violated)
ϕ_{00}: phase of η_{00}	$(54 \pm 5)°$	CP (violated)
Re ϵ	$(1.621 \pm 0.088) \times 10^{-3}$	CP (violated)
$(g_{e^+} - g_{e^-})$ / average	$(2.2 \pm 6.4) \times 10^{-11}$	CPT
$(g_{\mu^+} - g_{\mu^-})$ / average	$(-2.6 \pm 1.6) \times 10^{-8}$	CPT
$(\mu_p - \mu_{\bar{p}})$ / average	$(-1 \pm 7) \times 10^{-3}$	CPT
$\pi^+ - \pi^-$ mass difference / average	$(2 \pm 5) \times 10^{-4}$	CPT
$K^+ - K^-$ mass difference / average	$(-0.6 \pm 1.8) \times 10^{-4}$	CPT
$\|K^0 - \bar{K}^0\|$ mass difference / average	$< 6 \times 10^{-19}$	CPT
$p - \bar{p}$ mass difference / average	$(7 \pm 4) \times 10^{-5}$	CPT
$\Lambda - \bar{\Lambda}$ mass difference / average	$(7 \pm 7) \times 10^{-6}$	CPT
$\Xi^- - \bar{\Xi}^+$ mass difference / average	$(1.1 \pm 2.7) \times 10^{-4}$	CPT
$\Omega^- - \bar{\Omega}^+$ mass difference / average	$(-4 \pm 6) \times 10^{-4}$	CPT
$\mu^+ - \mu^-$ mean life difference / average	$(3 \pm 8) \times 10^{-5}$	CPT
$\pi^+ - \pi^-$ mean life difference / average	$(5 \pm 7) \times 10^{-4}$	CPT
$K^+ - K^-$ mean life difference / average	$(1.1 \pm 0.9) \times 10^{-3}$	CPT
$\Lambda - \bar{\Lambda}$ mean life difference / average	$(4.4 \pm 8.5) \times 10^{-2}$	CPT
$\Xi^- - \bar{\Xi}^+$ mean life difference / average	(0.02 ± 0.18)	CPT
$K^{\pm} \to \mu^{\pm}\nu$ rate difference / average	$(-0.54 \pm 0.41)\%$	CPT
$K^{\pm} \to \pi^{\pm}\pi^0$ rate difference / average	$(0.8 \pm 1.2)\%$	CPT[i]

a. Branching fractions are described by a shorthand notation, e.g., "$\mu^+ \to e^+\gamma$/all" means $\Gamma(\mu^+ \to e^+\gamma)/\Gamma(\mu^+ \to \text{all})$.
b. Limits are given at 90% confidence level while errors are given as ±1 standard deviation.
c. Test of additive vs. multiplicative lepton family number conservation.
d. Lepton family number conservation means separate conservation of e-number, μ-number, and τ-number.
e. These limits are derived from the analysis of neutrino oscillation experiments.
f. Violation of total lepton number conservation also implies violation of lepton family number conservation.
g. Can be violated in second-order weak interactions.
h. Orthopositronium data are from Liu and Roberts, Phys. Rev. Lett. **16**, 67 (1966).
i. Neglecting photon channels. See, e.g., A. Pais and S.B. Treiman, Phys. Rev. **D12**, 2744 (1975).

KINEMATICS, DECAYS, AND SCATTERING

A. LORENTZ TRANSFORMATIONS

The energy E and three-momentum $\vec{p}$ of a particle form a four-vector $p = (E, \vec{p})$. Viewed from a second frame with velocity $\vec{v} = \beta c\hat{z}$ relative to the original frame, the components of p are $(E', \vec{p}')$, where

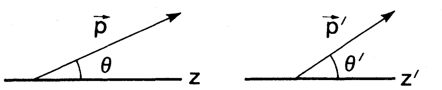
$$E' = \gamma E - \beta\gamma p_z\,,$$

$$p_z' = \gamma p_z - \beta\gamma E\,,$$

$$p_x' = p_x;\; p_y' = p_y\,,$$

and where $\gamma = (1-\beta^2)^{-1/2}$. It follows that the scalar product of two momenta, $p_1 \cdot p_2 = E_1E_2 - \vec{p}_1\cdot\vec{p}_2$, is invariant, that is, frame independent.

If $\vec{p}$ makes an angle θ with the z-axis, then $\vec{p}'$ makes an angle θ' with the z-axis,



where

$$\tan\theta' = \frac{|\vec{p}|\sin\theta}{\gamma|\vec{p}|\cos\theta - \beta\gamma E}\,.$$

In particular, if the unprimed frame is the center of mass and the primed frame is the lab, and if the velocity of the center of mass in the lab frame is $\beta^*\hat{z}$, we use $\beta = -\beta^*$ above to find (denoting $p_{cm} = |\vec{p}_{cm}|$)

$$\tan\theta_{lab} = \frac{p_{cm}\sin\theta_{cm}}{\gamma^* p_{cm}\cos\theta_{cm} + \beta^*\gamma^* E_{cm}}\,.$$

If $\beta^* > p_{cm}/E_{cm}$, the particle is necessarily moving forward in the lab and

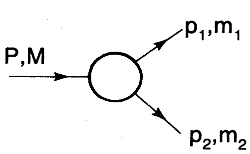
$$(\tan\theta_{lab})_{max} = \frac{p_{cm}}{\gamma^* E_{cm}}\,\frac{1}{\sqrt{\beta^{*2} - p_{cm}^2/E_{cm}^2}}\,.$$

We denote $p_\perp = p_\perp' = |\vec{p}|\sin\theta_{cm}$. Then given a fixed p_{cm} and E_{cm}, as, for example, in a two-to-two scattering process, as θ_{cm} varies from 0 to 2π the lab momentum describes an ellipse:

$$\frac{(p_z' - \beta^*\gamma^* E_{cm})^2}{\gamma^{*2}p_{cm}^2} + \frac{p_\perp'^2}{p_{cm}^2} = 1\,.$$

B. DECAYS

B.1.a Two-body kinematics:



In the rest frame of the decaying particle,

$$E_1 = \frac{M^2 + m_1^2 - m_2^2}{2M}\,,$$

$$|\vec{p}_1| = \left[\frac{[M^2 - (m_1+m_2)^2][M^2 - (m_1-m_2)^2]}{4M^2}\right]^{1/2}\,.$$

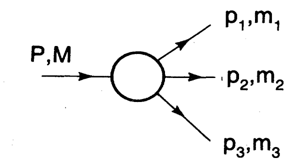
B.1.b Two-body partial decay rate:

If $\mathscr{M}$ is the Lorentz invariant matrix element (see Section D below), the partial decay rate in the rest frame of the decaying particle is

$$d\Gamma = \frac{1}{32\pi^2}\,|\mathscr{M}|^2\,\frac{|\vec{p}_1|\,d\Omega}{M^2}\,,$$

where $d\Omega$ is the differential solid angle in the rest frame of the decaying particle.

B.2.a Three-body kinematics:



We denote

$$p_{12} = p_1 + p_2\,,\; m_{12}^2 = p_{12}^2\,,\ \text{etc.}$$

Then

$$m_{12}^2 + m_{23}^2 + m_{13}^2 = M^2 + m_1^2 + m_2^2 + m_3^2\,.$$

The invariant mass of the pair 1-2 is related to the energy of particle 3 in the rest frame of M,

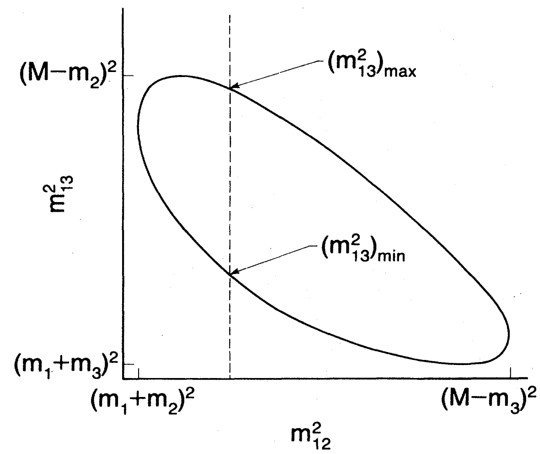
$$m_{12}^2 = (P - p_3)^2 = M^2 + m_3^2 - 2ME_3\,.$$

B.2.b Dalitz plot:

If the orientation of the decaying particle is ignored, there are two kinematic variables, which may be chosen to be m_{12}^2 and m_{13}^2. For fixed m_{12}^2, the range of m_{13}^2 is determined by letting $\vec{p}_1$ be parallel or antiparallel to $\vec{p}_3$. In the rest frame of $(p_1 + p_2)$, the energy of particle 3 is $E_3^* = (M^2 - m_{12}^2 - m_3^2)/(2m_{12})$, and that of particle 1 is $E_1^* = (m_{12}^2 + m_1^2 - m_2^2)/(2m_{12})$. Thus for a given m_{12}^2,

$$(m_{13}^2)_{max} = (E_1^* + E_3^*)^2 - \left(\sqrt{E_1^{*2} - m_1^2} - \sqrt{E_3^{*2} - m_3^2}\right)^2$$

$$(m_{13}^2)_{min} = (E_1^* + E_3^*)^2 - \left(\sqrt{E_1^{*2} - m_1^2} + \sqrt{E_3^{*2} - m_3^2}\right)^2\,.$$



The scatter plot in m_{12}^2 and m_{13}^2 is called a Dalitz plot. Phase space density is uniform across the plot. See below.

KINEMATICS, DECAYS, AND SCATTERING (Cont'd)

B.2.c Three-body phase space: Fixing the energies E_1 and E_2 of two of the final state particles in the M rest frame determines the relative orientation of the three outgoing particles. Their momenta may then be regarded as a rigid body whose orientation with respect to the initial particle is specified by the Euler angles α, β, and γ. The partial decay rate in the M rest frame is

$$d\Gamma = \frac{(2\pi)^{-5}}{16M} |\mathcal{M}|^2 \, dE_1 \, dE_2 \, d\alpha \, d\cos\beta \, d\gamma \, .$$

If the angles are integrated out, we have the Dalitz plot form,

$$d\Gamma = \frac{(2\pi)^{-3}}{8M} |\mathcal{M}|^2 \, dE_1 \, dE_2 = \frac{(2\pi)^{-3}}{32M^3} |\mathcal{M}|^2 \, dm_{12}^2 dm_{23}^2 \, .$$

An alternative expression is

$$d\Gamma = \frac{(2\pi)^{-5}}{16M^2} |\mathcal{M}|^2 \, |\vec{p}_1^{\,*}| \, |\vec{p}_3| \, dm_{12} \, d\Omega_1^* \, d\Omega_3 \, ,$$

where

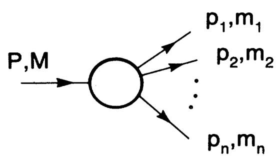
$$|\vec{p}_1^{\,*}| = \left[\frac{[m_{12}^2 - (m_1 + m_2)^2][m_{12}^2 - (m_1 - m_2)^2]}{4m_{12}^2} \right]^{1/2}$$

is the momentum of particle 1 in the rest frame of m_{12},

$$|\vec{p}_3| = \left[\frac{[M^2 - (m_{12} + m_3)^2][M^2 - (m_{12} - m_3)^2]}{4M^2} \right]^{1/2}$$

is the momentum of particle 3 in the M rest frame, $d\Omega_1^*$ is the solid angle element for particle 1 in the 1-2 rest frame, and $d\Omega_3$ is the solid angle element for particle 3 in the M rest frame.

B.3 n-body phase space:



The partial decay rate in the M rest frame is

$$d\Gamma = \frac{(2\pi)^4}{2M} |\mathcal{M}|^2 \, d\Phi_n(P; p_1, \cdots, p_n) \, ,$$

where

$$d\Phi_n(P; p_1, \cdots, p_n) = \delta^4(P - \sum_{i=1}^{n} p_i) \prod_{i=1}^{n} \frac{d^3 p_i}{(2\pi)^3 2E_i} \, .$$

In particular,

$$d\Phi_2(P; p_1, p_2) = (2\pi)^{-6} \frac{|\vec{p}_1^{\,*}|}{4M} d\Omega_1^* \, ,$$

where $|\vec{p}_1^{\,*}|$ is the momentum of particle 1 in the M rest frame and $d\Omega_1^*$ is the solid angle element in the same frame.

Phase space for n particles can be related to that for n−1 by treating particles 1 and 2 as a single system of momentum $p_{12} = p_1 + p_2$ and mass squared $m_{12}^2 = p_{12}^2$. Thus

$$d\Phi_n(P; p_1, p_2, \cdots, p_n) = d\Phi_{n-1}(P; p_{12}, p_3, \cdots, p_n)$$

$$\times d\Phi_2(p_{12}; p_1, p_2) \, (2\pi)^3 \, dm_{12}^2 \, .$$

C. SCATTERING

Throughout Section C, we set $\hbar = 1$, $c = 1$. Use $\hbar c = 197.3$ MeV fermi, and $(\hbar c)^2 = 0.3894$ GeV^2 mb for conversions.

C.1 Partial waves: The amplitude in the center of mass for elastic scattering of spinless particles may be written in a partial wave expansion

$$f(k,\theta) = \frac{1}{k} \sum_\ell (2\ell+1) \, a_\ell \, P_\ell(\cos\theta) \, ,$$

where k is the c.m. momentum, θ is the c.m. scattering angle, $a_\ell = (\eta_\ell e^{2i\delta_\ell} - 1)/2i$, $0 \leq \eta_\ell \leq 1$, and δ_ℓ is the phase shift of the ℓ^{th} partial wave. For purely elastic scattering, $\eta_\ell = 1$. The differential cross section is

$$\frac{d\sigma}{d\Omega} = |f(k,\theta)|^2 \, .$$

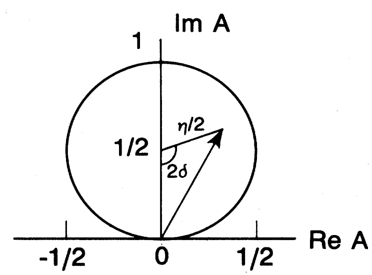
The optical theorem is

$$\sigma_{tot} = \frac{4\pi}{k} \, \mathrm{Im} \, f(k,0) \, ,$$

and the cross section in the ℓ^{th} partial wave is

$$\sigma_\ell = \frac{4\pi}{k^2} (2\ell + 1) \, |a_\ell|^2 \leq \frac{4\pi \, (2\ell + 1)}{k^2}$$

The partial-wave amplitude a_ℓ can be displayed in an Argand plot.



The usual Lorentz invariant matrix element $\mathcal{M}$ (see Section D below) for the elastic process is related to $f(k,\theta)$ by

$$\mathcal{M} = -8\pi\sqrt{s} \, f(k,\theta) \, ,$$

so

$$\sigma_{tot} = -\frac{1}{2k\sqrt{s}} \, \mathrm{Im}\mathcal{M}(t=0) \, ,$$

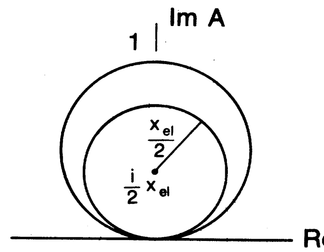
where s and t are the center-of-mass energy squared and momentum transfer squared, respectively (see Section C.3.a).

C.2 Resonances: The Breit-Wigner form for a_ℓ with a resonance at c.m. energy E_R, elastic width Γ_{el}, and total width Γ_{tot} is

$$a_\ell = \frac{\frac{1}{2}\Gamma_{el}}{E_R - E - \frac{i}{2}\Gamma_{tot}} \, ,$$

where E is the c.m. energy. This gives a circle in the Argand plot with center $ix_{el}/2$ and radius $x_{el}/2$, where $x_{el} = \Gamma_{el}/\Gamma_{tot}$. The quantity x_{el} is called the elasticity. The amplitude has a pole at $E = E_R - i\Gamma_{tot}/2$.

KINEMATICS, DECAYS, AND SCATTERING (Cont'd)

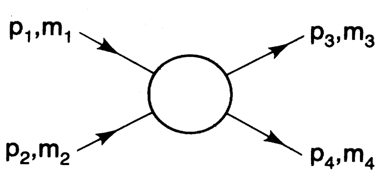


The Breit-Wigner cross section for a spin-J resonance produced in the collision of particles of spin S_1 and S_2 is

$$\sigma_{BW}(E) = \frac{(2J+1)}{(2S_1+1)(2S_2+1)} \frac{\pi}{k^2} \frac{B_{in}B_{out}\Gamma^2_{tot}}{(E-E_R)^2+\Gamma^2_{tot}/4},$$

where k is the c.m. momentum, E is the c.m. energy, and B_{in} and B_{out} are the branching fractions of the resonance into the entrance and exit channels. The $2S+1$ factors are the multiplicities of the incident spin states, so they are replaced by 2 for photons, etc.

C.3.a Two-body scattering kinematics:



In the center of mass,

$$E_{1cm} = \frac{s+m_1^2-m_2^2}{2\sqrt{s}},$$

$$p_{1cm} = \left[\frac{[s-(m_1+m_2)^2][s-(m_1-m_2)^2]}{4s}\right]^{1/2}$$

$$= \frac{p_{1lab}m_2}{\sqrt{s}},$$

where $\sqrt{s}$ is the total c.m. energy. The Lorentz invariant Mandelstam variables are

$$s = (p_1+p_2)^2 = (p_3+p_4)^2$$
$$= m_1^2 + 2E_1E_2 - 2\vec{p}_1\cdot\vec{p}_2 + m_2^2,$$
$$t = (p_1-p_3)^2 = (p_2-p_4)^2$$
$$= m_1^2 - 2E_1E_3 + 2\vec{p}_1\cdot\vec{p}_3 + m_3^2,$$
$$u = (p_1-p_4)^2 = (p_2-p_3)^2$$
$$= m_1^2 - 2E_1E_4 + 2\vec{p}_1\cdot\vec{p}_4 + m_4^2,$$

and they satisfy

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

If θ_{cm} is the c.m. scattering angle between particles 1 and 3, then (denoting $p_{1cm} = |\vec{p}_{1cm}|$, $p_{3cm} = |\vec{p}_{3cm}|$)

$$t = (E_{1cm}-E_{3cm})^2 - (p_{1cm}-p_{3cm})^2 - 4p_{1cm}p_{3cm}\sin^2(\theta_{cm}/2).$$

For $\theta_{cm} = 0$, $-t$ is a minimum.

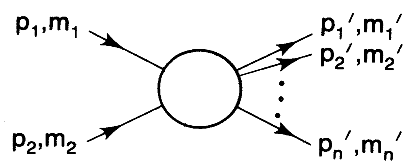
C.3.b Two-body differential cross sections: In the center of mass or lab,

$$\frac{d\sigma}{dt} = \frac{1}{64\pi s}\frac{1}{p^2_{1cm}}|\mathcal{M}|^2.$$

In the center of mass,

$$\frac{d\sigma}{d\Omega_{cm}} = \frac{p_{1cm}p_{3cm}}{\pi}\frac{d\sigma}{dt}.$$

C.4 n-body differential cross sections:

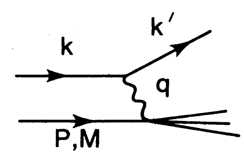


In the c.m. or lab

$$d\sigma = \frac{(2\pi)^4|\mathcal{M}|^2}{4\sqrt{(p_1\cdot p_2)^2-m_1^2m_2^2}}\,d\Phi_n(p_1+p_2;p_1',p_2',\cdots,p_n'),$$

where n-body phase space, $d\Phi_n$, is described in Section B.3 above. Note that $\sqrt{(p_1\cdot p_2)^2-m_1^2m_2^2} = p_{1lab}m_2 = p_{1cm}\sqrt{s}$.

C.5.a Leptoproduction kinematics:



$q = k - k'$ is the four-momentum transferred to the target.

Invariant quantities:

$\nu = \dfrac{q\cdot P}{M} = E - E'$ is the lepton's energy loss in the lab (in earlier literature sometimes $\nu = q\cdot P$). Here, E and E′ are the initial and final lepton energies in the lab.

$Q^2 = -q^2 = 2(EE' - \vec{k}\cdot\vec{k}') - m_\ell^2 - m_{\ell'}^2$ where $m_\ell(m_{\ell'})$ is the initial (final) lepton mass. If $EE'\sin^2(\theta/2) \gg m_\ell^2$, $m_{\ell'}^2$, then

$\simeq 4EE'\sin^2(\theta/2)$, where θ is the lepton's scattering angle in the lab.

$x = \dfrac{Q^2}{2M\nu}$ In the parton model, x is the fraction of the target nucleon's momentum carried by the struck quark. See section on Quark Parton Model.

$y = \dfrac{q\cdot P}{k\cdot P} = \dfrac{\nu}{E}$ is the fraction of the lepton's energy lost in the lab.

$W^2 = (P+q)^2 = M^2 + 2M\nu - Q^2$ is the mass squared of the system recoiling against the lepton.

C.5.b Leptoproduction cross sections:

$$\frac{d^2\sigma}{dx\,dy} = 2M\nu E\frac{d^2\sigma}{d\nu\,dQ^2} = \frac{2\pi M\nu}{E'}\frac{d^2\sigma}{d\Omega_{lab}dE'} = 2xME\frac{d^2\sigma}{dx\,dQ^2}.$$

KINEMATICS, DECAYS, AND SCATTERING (Cont'd)

C.5.b.i Electroproduction structure functions:

$$\frac{d^2\sigma}{dx\,dy} = \frac{8\pi\alpha^2 ME}{Q^4}\left[\frac{1+(1-y)^2}{2}\,2xF_1^{em} + (1-y)(F_2^{em} - 2xF_1^{em}) - \frac{M}{2E}xyF_2^{em}\right].$$

$F_1^{em}(x, Q^2)$ and $F_2^{em}(x, Q^2)$ are the (unpolarized) structure functions, which are, in the naive parton model, independent of Q^2.

C.5.b.ii Neutrino production structure functions:

$$\frac{d^2\sigma^\nu}{dx\,dy} = \frac{G_F^2 ME}{\pi}\left[(1-y-\frac{M}{2E}xy)\,F_2^\nu + \frac{y^2}{2}2xF_1^\nu + (y-\frac{y^2}{2})xF_3^\nu\right],$$

$$\frac{d^2\sigma^{\bar\nu}}{dx\,dy} = \frac{G_F^2 ME}{\pi}\left[(1-y-\frac{M}{2E}xy)\,F_2^{\bar\nu} + \frac{y^2}{2}2xF_1^{\bar\nu} - (y-\frac{y^2}{2})xF_3^{\bar\nu}\right].$$

The structure functions $F_i^{\nu,\bar\nu}$ are related to quark distributions in the parton model (see section on Quark Parton Model). There are separate F_i's for neutral- and charged-current processes.

C.6.a e^+e^- annihilation: For pointlike spin-1/2 fermions in the c.m., the differential cross section for $e^+e^- \to f\bar f$ via single photon annihilation is

$$\frac{d\sigma}{d\Omega} = \frac{\alpha^2}{4s}\beta\left[1+\cos^2\theta + (1-\beta^2)\sin^2\theta\right]e_Q^2,$$

where β is the velocity of the final state fermion in the center of mass, and where e_Q is the charge of the fermion in units of the proton charge. For $\beta \to 1$,

$$\sigma = \frac{4\pi\alpha^2}{3s}e_Q^2 = \frac{86.8\,e_Q^2\text{ nb}}{s(\text{GeV}^2)}.$$

C.6.b e^+e^- two-photon process: In the equivalent photon approximation, the cross section for $e^+e^- \to e^+e^-X$ is related to the cross section for $\gamma\gamma \to X$ by

$$d\sigma_{e^+e^-\to e^+e^-X}(s) = \eta^2\int d\omega\, f(\omega)\, d\sigma_{\gamma\gamma\to X}(\omega s),$$

where

$$\eta \approx \frac{\alpha}{2\pi}\ell n\left[\frac{s}{4m_e^2}\right]$$

and

$$f(\omega) = \frac{1}{\omega}\left[(2+\omega)^2\ell n\frac{1}{\omega} - 2(1-\omega)(3+\omega)\right].$$

For the production of a resonance of mass m_R and spin J,

$$\sigma(e^+e^- \to e^+e^-R) = \eta^2\frac{(2J+1)\,8\pi^2\Gamma(R\to\gamma\gamma)}{m_R s}\,f(\frac{m_R^2}{s}).$$

C.7 Inclusive hadronic reactions: A particle's momentum can be parametrized by selecting a particular direction for the z-axis and writing

$$(E = m_\perp \cosh y,\ p_z = m_\perp \sinh y,\ p_x,\ p_y),$$

where

$$m_\perp^2 = m^2 + p_x^2 + p_y^2,$$

$$y = \frac{1}{2}\ell n\left(\frac{E+p_z}{E-p_z}\right) = \ell n\left(\frac{E+p_z}{m_\perp}\right) = \tanh^{-1}\left(\frac{p_z}{E}\right).$$

The variable y is called the rapidity. A boost in the z-direction then modifies y by $y \to y + \Delta$, where $\gamma = \cosh\Delta$, $\beta = \tanh\Delta$. Thus the shape of the distribution dN/dy is invariant under such a boost, and

$$E\frac{d^3\sigma}{d^3p} = \frac{d^3\sigma}{dy\,d^2p_\perp}.$$

Feynman's x variable is defined to be

$$x = \left(\frac{p_z}{p_{z\,max}}\right)_{cm} \approx \frac{2p_{z\,cm}}{\sqrt{s}} \approx \frac{2m_\perp \sinh y_{cm}}{\sqrt{s}}.$$

For y_{cm} not small ($e^{-2y_{cm}} \ll 1$)

$$x \approx \frac{m_\perp}{\sqrt{s}}e^{y_{cm}}$$

and

$$(y_{cm})_{max} = \ell n\frac{\sqrt{s}}{m}.$$

D. LORENTZ INVARIANT AMPLITUDES

The quantity $-i\mathscr{M}$ is determined in perturbation theory by the Feynman rules. Our convention above is consistent with the Appendices of Bjorken and Drell except that fermion spinors are normalized so that $\bar u u = 2m$, etc. In particular, the S-matrix for two-body scattering is

$$\langle p_1'p_2'|S|p_1p_2\rangle = I - i(2\pi)^4\delta^4(p_1+p_2-p_1'-p_2') \times \frac{\mathscr{M}(p_1,p_2;p_1',p_2')}{(2E_1)^{1/2}(2E_2)^{1/2}(2E_1')^{1/2}(2E_2')^{1/2}},$$

where the states are normalized so

$$\langle p'|p\rangle = (2\pi)^3\delta^3(\vec p - \vec p').$$

C.M. ENERGY AND MOMENTUM VS. BEAM MOMENTUM
(for scattering on a proton target)

$$E_{cm}dE_{cm} = m_p dT_{beam} = m_p v_{beam} dP_{beam} \approx m_p dP_{beam}$$

PBEAM (GEV/C)	C. M. ENERGY (GEV)				MOMENTUM IN C. M. (GEV/C)			
	γp, νp, ep	πp	Kp	pp	γp, νp, ep	πp	Kp	pp
0.00	.938	1.078	1.432	1.877	.000	.000	.000	.000
0.02	.958	1.079	1.432	1.877	.020	.017	.013	.010
0.04	.977	1.083	1.433	1.877	.038	.035	.026	.020
0.06	.996	1.089	1.434	1.878	.056	.052	.039	.030
0.08	1.015	1.096	1.436	1.878	.074	.068	.052	.040
0.10	1.033	1.105	1.439	1.879	.091	.085	.065	.050
0.12	1.051	1.116	1.441	1.880	.107	.101	.078	.060
0.14	1.069	1.127	1.445	1.882	.123	.117	.091	.070
0.16	1.087	1.139	1.448	1.883	.138	.132	.104	.080
0.18	1.104	1.152	1.453	1.885	.153	.147	.116	.090
0.20	1.121	1.165	1.457	1.887	.167	.161	.129	.099
0.22	1.137	1.178	1.462	1.889	.182	.175	.141	.109
0.24	1.154	1.192	1.468	1.892	.195	.189	.153	.119
0.26	1.170	1.206	1.473	1.894	.209	.202	.166	.129
0.28	1.186	1.219	1.480	1.897	.222	.215	.178	.138
0.30	1.201	1.233	1.486	1.900	.234	.228	.189	.148
0.32	1.217	1.247	1.493	1.903	.247	.241	.201	.158
0.34	1.232	1.261	1.500	1.906	.259	.253	.213	.167
0.36	1.247	1.275	1.507	1.910	.271	.265	.224	.177
0.38	1.262	1.288	1.514	1.913	.282	.277	.235	.186
0.40	1.277	1.302	1.522	1.917	.294	.288	.247	.196
0.42	1.292	1.315	1.530	1.921	.305	.300	.258	.205
0.44	1.306	1.329	1.538	1.925	.316	.311	.268	.214
0.46	1.320	1.342	1.546	1.929	.327	.322	.279	.224
0.48	1.335	1.356	1.554	1.934	.337	.332	.290	.233
0.50	1.349	1.369	1.563	1.938	.348	.343	.300	.242
0.52	1.362	1.382	1.571	1.943	.358	.353	.310	.251
0.54	1.376	1.395	1.580	1.947	.368	.363	.321	.260
0.56	1.390	1.408	1.589	1.952	.378	.373	.331	.269
0.58	1.403	1.421	1.598	1.957	.388	.383	.341	.278
0.60	1.416	1.434	1.607	1.962	.397	.393	.350	.287
0.62	1.430	1.447	1.616	1.968	.407	.402	.360	.296
0.64	1.443	1.459	1.625	1.973	.416	.412	.370	.304
0.66	1.456	1.472	1.634	1.978	.425	.421	.379	.313
0.68	1.468	1.484	1.643	1.984	.434	.430	.388	.322
0.70	1.481	1.496	1.653	1.989	.443	.439	.397	.330
0.72	1.494	1.509	1.662	1.995	.452	.448	.406	.339
0.74	1.506	1.521	1.671	2.001	.461	.457	.415	.347
0.76	1.519	1.533	1.681	2.007	.470	.465	.424	.355
0.78	1.531	1.545	1.690	2.013	.478	.474	.433	.364
0.80	1.543	1.557	1.699	2.019	.486	.482	.442	.372
0.82	1.555	1.569	1.709	2.025	.495	.490	.450	.380
0.84	1.567	1.580	1.718	2.031	.503	.499	.459	.388
0.86	1.579	1.592	1.728	2.037	.511	.507	.467	.396
0.88	1.591	1.604	1.737	2.043	.519	.515	.475	.404
0.90	1.603	1.615	1.747	2.050	.527	.523	.484	.412
0.92	1.615	1.627	1.756	2.056	.535	.531	.492	.420
0.94	1.626	1.638	1.765	2.062	.542	.538	.500	.428
0.96	1.638	1.649	1.775	2.069	.550	.546	.508	.435
0.98	1.649	1.661	1.784	2.075	.558	.554	.515	.443
1.00	1.660	1.672	1.794	2.082	.565	.561	.523	.451
1.02	1.672	1.683	1.803	2.088	.573	.569	.531	.458
1.04	1.683	1.694	1.812	2.095	.580	.576	.538	.466
1.06	1.694	1.705	1.822	2.102	.587	.583	.546	.473
1.08	1.705	1.716	1.831	2.108	.594	.591	.553	.481
1.10	1.716	1.726	1.840	2.115	.601	.598	.561	.488
1.12	1.727	1.737	1.850	2.122	.609	.605	.568	.495
1.14	1.738	1.748	1.859	2.129	.616	.612	.575	.502
1.16	1.748	1.759	1.868	2.136	.622	.619	.583	.510
1.18	1.759	1.769	1.877	2.142	.629	.626	.590	.517
1.20	1.770	1.780	1.887	2.149	.636	.633	.597	.524
1.22	1.780	1.790	1.896	2.156	.643	.639	.604	.531
1.24	1.791	1.800	1.905	2.163	.650	.646	.611	.538
1.26	1.801	1.811	1.914	2.170	.656	.653	.618	.545
1.28	1.812	1.821	1.923	2.177	.663	.660	.624	.552
1.30	1.822	1.831	1.932	2.184	.669	.666	.631	.559
1.32	1.832	1.841	1.941	2.191	.676	.673	.638	.565
1.34	1.843	1.851	1.950	2.198	.682	.679	.645	.572
1.36	1.853	1.862	1.959	2.205	.689	.685	.651	.579
1.38	1.863	1.872	1.968	2.212	.695	.692	.658	.585
1.40	1.873	1.882	1.977	2.219	.701	.698	.664	.592
1.42	1.883	1.891	1.986	2.226	.708	.704	.671	.599
1.44	1.893	1.901	1.995	2.233	.714	.711	.677	.605
1.46	1.903	1.911	2.004	2.240	.720	.717	.684	.612
1.48	1.913	1.921	2.013	2.247	.726	.723	.690	.618
1.50	1.922	1.931	2.022	2.254	.732	.729	.696	.624
1.52	1.932	1.940	2.031	2.261	.738	.735	.702	.631
1.54	1.942	1.950	2.039	2.268	.744	.741	.709	.637
1.56	1.951	1.959	2.048	2.275	.750	.747	.715	.643
1.58	1.961	1.969	2.057	2.282	.756	.753	.721	.650
1.60	1.970	1.978	2.065	2.289	.762	.759	.727	.656
1.62	1.980	1.988	2.074	2.296	.768	.765	.733	.662
1.64	1.989	1.997	2.083	2.304	.773	.770	.739	.668
1.66	1.999	2.006	2.091	2.311	.779	.776	.745	.674
1.68	2.008	2.016	2.100	2.318	.785	.782	.751	.680
1.70	2.018	2.025	2.109	2.325	.791	.788	.756	.686
1.72	2.027	2.034	2.117	2.332	.796	.793	.762	.692
1.74	2.036	2.043	2.126	2.339	.802	.799	.768	.698
1.76	2.045	2.053	2.134	2.346	.807	.805	.774	.704
1.78	2.054	2.062	2.143	2.353	.813	.810	.780	.710
1.80	2.064	2.071	2.151	2.360	.818	.816	.785	.716
1.82	2.073	2.080	2.159	2.367	.824	.821	.791	.721
1.84	2.082	2.089	2.168	2.374	.829	.827	.796	.727
1.86	2.091	2.098	2.176	2.381	.835	.832	.802	.733
1.88	2.100	2.107	2.184	2.388	.840	.837	.808	.739
1.90	2.109	2.115	2.193	2.395	.845	.843	.813	.744
1.92	2.117	2.124	2.201	2.402	.851	.848	.819	.750
1.94	2.126	2.133	2.209	2.409	.856	.853	.824	.756
1.96	2.135	2.142	2.217	2.416	.861	.859	.829	.761
1.98	2.144	2.151	2.226	2.423	.867	.864	.835	.767
2.0	2.153	2.159	2.234	2.430	.872	.869	.840	.772
2.1	2.196	2.202	2.274	2.465	.897	.895	.866	.799
2.2	2.238	2.244	2.314	2.500	.922	.920	.892	.826
2.3	2.280	2.286	2.353	2.534	.947	.944	.917	.852
2.4	2.320	2.326	2.392	2.568	.970	.968	.941	.877
2.5	2.360	2.366	2.430	2.602	.994	.991	.965	.901
2.6	2.400	2.405	2.468	2.636	1.02	1.01	.989	.926
2.7	2.439	2.444	2.505	2.669	1.04	1.04	1.01	.949
2.8	2.477	2.482	2.542	2.702	1.06	1.06	1.03	.972
2.9	2.514	2.520	2.578	2.735	1.08	1.08	1.06	.995
3.0	2.551	2.556	2.613	2.768	1.10	1.10	1.08	1.02
3.1	2.588	2.593	2.649	2.800	1.12	1.12	1.10	1.04
3.2	2.624	2.629	2.683	2.832	1.14	1.14	1.12	1.06
3.3	2.660	2.664	2.718	2.863	1.16	1.16	1.14	1.08
3.4	2.695	2.699	2.752	2.895	1.18	1.18	1.16	1.10
3.5	2.729	2.734	2.785	2.926	1.20	1.20	1.18	1.12
3.6	2.763	2.768	2.818	2.957	1.22	1.22	1.20	1.14
3.7	2.797	2.801	2.851	2.987	1.24	1.24	1.22	1.16
3.8	2.830	2.835	2.884	3.018	1.26	1.26	1.24	1.18
3.9	2.863	2.868	2.916	3.048	1.28	1.28	1.26	1.20
4.0	2.896	2.900	2.947	3.077	1.30	1.29	1.27	1.22
4.1	2.928	2.932	2.979	3.107	1.31	1.31	1.29	1.24
4.2	2.960	2.964	3.010	3.136	1.33	1.33	1.31	1.26
4.3	2.992	2.996	3.041	3.165	1.35	1.35	1.33	1.27
4.4	3.023	3.027	3.071	3.194	1.37	1.36	1.34	1.29
4.5	3.054	3.058	3.101	3.223	1.38	1.38	1.36	1.31
4.6	3.084	3.088	3.131	3.251	1.40	1.40	1.38	1.33
4.7	3.115	3.118	3.161	3.279	1.42	1.41	1.40	1.34
4.8	3.144	3.148	3.190	3.307	1.43	1.43	1.41	1.36
4.9	3.174	3.178	3.220	3.335	1.45	1.45	1.43	1.38
5.0	3.204	3.207	3.248	3.363	1.46	1.46	1.44	1.40
5.2	3.262	3.265	3.305	3.417	1.50	1.49	1.48	1.43
5.4	3.319	3.322	3.362	3.471	1.53	1.53	1.51	1.46
5.6	3.375	3.378	3.417	3.524	1.56	1.56	1.54	1.49
5.8	3.430	3.433	3.471	3.576	1.59	1.59	1.57	1.52
6.0	3.484	3.487	3.524	3.627	1.62	1.61	1.60	1.55
6.2	3.538	3.541	3.577	3.678	1.64	1.64	1.63	1.58
6.4	3.590	3.593	3.629	3.728	1.67	1.67	1.65	1.61
6.6	3.642	3.645	3.680	3.778	1.70	1.70	1.68	1.64
6.8	3.693	3.696	3.731	3.827	1.73	1.73	1.71	1.67
7.0	3.744	3.747	3.781	3.875	1.75	1.75	1.74	1.70
7.2	3.794	3.797	3.830	3.923	1.78	1.78	1.76	1.72
7.4	3.843	3.846	3.878	3.970	1.81	1.81	1.79	1.75
7.6	3.891	3.894	3.926	4.016	1.83	1.83	1.82	1.78
7.8	3.939	3.942	3.974	4.062	1.86	1.86	1.84	1.80
8.0	3.987	3.989	4.021	4.108	1.88	1.88	1.87	1.83
8.2	4.033	4.036	4.067	4.153	1.91	1.91	1.89	1.85
8.4	4.080	4.082	4.113	4.198	1.93	1.93	1.92	1.88
8.6	4.125	4.128	4.158	4.242	1.96	1.95	1.94	1.90
8.8	4.171	4.173	4.203	4.286	1.98	1.98	1.96	1.93
9.0	4.215	4.218	4.247	4.329	2.00	2.00	1.99	1.95
9.2	4.260	4.262	4.291	4.372	2.03	2.03	2.01	1.97
9.4	4.303	4.306	4.335	4.415	2.05	2.05	2.03	2.00
9.6	4.347	4.349	4.378	4.457	2.07	2.07	2.06	2.02
9.8	4.390	4.392	4.420	4.498	2.09	2.09	2.08	2.04
10.0	4.432	4.435	4.462	4.540	2.12	2.12	2.10	2.07
10.5	4.537	4.539	4.566	4.641	2.17	2.17	2.16	2.12
11.0	4.639	4.642	4.668	4.741	2.22	2.22	2.21	2.18
11.5	4.739	4.742	4.767	4.839	2.28	2.28	2.26	2.23
12.0	4.837	4.839	4.864	4.934	2.33	2.33	2.31	2.28
12.5	4.933	4.935	4.960	5.028	2.38	2.38	2.36	2.33
13.0	5.027	5.030	5.053	5.120	2.43	2.43	2.41	2.38
13.5	5.120	5.122	5.145	5.211	2.47	2.47	2.46	2.43
14.0	5.211	5.213	5.236	5.300	2.52	2.52	2.51	2.48
14.5	5.300	5.302	5.324	5.388	2.57	2.57	2.56	2.53
15.0	5.388	5.390	5.412	5.474	2.61	2.61	2.60	2.57
15.5	5.474	5.476	5.498	5.559	2.66	2.66	2.65	2.62
16.0	5.559	5.561	5.582	5.642	2.70	2.70	2.69	2.66
16.5	5.643	5.645	5.666	5.725	2.74	2.74	2.73	2.70
17.0	5.726	5.727	5.748	5.806	2.79	2.79	2.78	2.75
17.5	5.807	5.809	5.829	5.886	2.83	2.83	2.82	2.79
18.0	5.887	5.889	5.909	5.965	2.87	2.87	2.86	2.83
18.5	5.966	5.968	5.988	6.043	2.91	2.91	2.90	2.87
19.0	6.044	6.046	6.066	6.120	2.95	2.95	2.94	2.91
19.5	6.122	6.123	6.142	6.196	2.99	2.99	2.98	2.95
20	6.198	6.199	6.218	6.272	3.03	3.03	3.02	2.99
21	6.347	6.349	6.367	6.419	3.10	3.10	3.09	3.07
22	6.493	6.495	6.513	6.564	3.18	3.18	3.17	3.14
23	6.636	6.638	6.655	6.705	3.25	3.25	3.24	3.22
24	6.776	6.778	6.795	6.843	3.32	3.32	3.31	3.29
25	6.913	6.915	6.932	6.979	3.39	3.39	3.38	3.36
26	7.048	7.049	7.066	7.112	3.46	3.46	3.45	3.43
27	7.180	7.181	7.197	7.243	3.53	3.53	3.52	3.50
28	7.309	7.311	7.326	7.371	3.59	3.59	3.59	3.56
29	7.436	7.438	7.453	7.497	3.66	3.66	3.65	3.63
30	7.562	7.563	7.578	7.621	3.72	3.72	3.71	3.69
31	7.685	7.686	7.701	7.743	3.79	3.78	3.78	3.76
32	7.806	7.807	7.822	7.864	3.85	3.85	3.84	3.82
33	7.925	7.926	7.941	7.982	3.91	3.91	3.90	3.88
34	8.043	8.044	8.058	8.099	3.97	3.97	3.96	3.94
35	8.158	8.160	8.174	8.214	4.03	4.02	4.02	4.00
36	8.273	8.274	8.288	8.327	4.08	4.08	4.08	4.06
37	8.385	8.386	8.400	8.439	4.14	4.14	4.13	4.11
38	8.496	8.498	8.511	8.549	4.20	4.20	4.19	4.17
39	8.606	8.607	8.621	8.658	4.25	4.25	4.24	4.23
40	8.715	8.716	8.729	8.766	4.31	4.31	4.30	4.28
41	8.822	8.823	8.836	8.872	4.36	4.36	4.35	4.34
42	8.927	8.928	8.941	8.978	4.41	4.41	4.41	4.39
43	9.032	9.033	9.046	9.081	4.47	4.47	4.46	4.44
44	9.135	9.136	9.149	9.184	4.52	4.52	4.51	4.50
45	9.237	9.238	9.251	9.286	4.57	4.57	4.56	4.55
46	9.338	9.339	9.352	9.386	4.62	4.62	4.62	4.60
47	9.438	9.439	9.451	9.486	4.67	4.67	4.67	4.65
48	9.537	9.538	9.550	9.584	4.72	4.72	4.72	4.70
49	9.635	9.636	9.648	9.681	4.77	4.77	4.77	4.75
50	9.732	9.733	9.745	9.778	4.82	4.82	4.81	4.80
52	9.923	9.924	9.935	9.968	4.92	4.92	4.91	4.89
54	10.11	10.11	10.12	10.15	5.01	5.01	5.01	4.99
56	10.29	10.30	10.31	10.34	5.10	5.10	5.10	5.08
58	10.47	10.48	10.49	10.52	5.20	5.19	5.19	5.17
60	10.65	10.65	10.66	10.69	5.28	5.28	5.28	5.26
62	10.83	10.83	10.84	10.87	5.37	5.37	5.37	5.35
64	11.00	11.00	11.01	11.04	5.46	5.46	5.45	5.44
66	11.17	11.17	11.18	11.21	5.54	5.54	5.54	5.53
68	11.34	11.34	11.35	11.37	5.63	5.63	5.62	5.61
70	11.50	11.50	11.51	11.54	5.71	5.71	5.71	5.69
72	11.66	11.66	11.67	11.70	5.79	5.79	5.79	5.77
74	11.82	11.82	11.83	11.86	5.87	5.87	5.87	5.85
76	11.98	11.98	11.99	12.02	5.95	5.95	5.95	5.93
78	12.13	12.14	12.14	12.17	6.03	6.03	6.03	6.01
80	12.29	12.29	12.30	12.32	6.11	6.11	6.10	6.09
82	12.44	12.44	12.45	12.48	6.18	6.18	6.18	6.17
84	12.59	12.59	12.60	12.63	6.26	6.26	6.26	6.24
86	12.74	12.74	12.75	12.77	6.33	6.33	6.33	6.32
88	12.88	12.89	12.89	12.92	6.41	6.41	6.40	6.39
90	13.03	13.03	13.04	13.06	6.48	6.48	6.48	6.46
92	13.17	13.17	13.18	13.21	6.55	6.55	6.55	6.54
94	13.31	13.32	13.32	13.35	6.62	6.62	6.62	6.61
96	13.45	13.46	13.46	13.49	6.69	6.69	6.69	6.68
98	13.59	13.59	13.60	13.63	6.76	6.76	6.76	6.75
100	13.73	13.73	13.74	13.76	6.83	6.83	6.83	6.82
150	16.80	16.80	16.81	16.83	8.38	8.38	8.37	8.36
200	19.40	19.40	19.40	19.42	9.68	9.67	9.67	9.66
250	21.68	21.68	21.69	21.70	10.8	10.8	10.8	10.8
300	23.75	23.75	23.75	23.76	11.9	11.9	11.9	11.8
350	25.65	25.65	25.65	25.66	12.8	12.8	12.8	12.8
400	27.41	27.41	27.42	27.43	13.7	13.7	13.7	13.7
450	29.07	29.07	29.08	29.09	14.5	14.5	14.5	14.5
500	30.65	30.65	30.65	30.66	15.3	15.3	15.3	15.3
550	32.14	32.14	32.14	32.15	16.1	16.1	16.1	16.0
600	33.57	33.57	33.57	33.58	16.8	16.8	16.8	16.8
650	34.94	34.94	34.94	34.95	17.5	17.5	17.5	17.4
700	36.26	36.26	36.26	36.27	18.1	18.1	18.1	18.1
750	37.53	37.53	37.53	37.54	18.8	18.8	18.8	18.7
800	38.76	38.76	38.76	38.77	19.4	19.4	19.4	19.4
850	39.95	39.95	39.95	39.96	20.0	20.0	20.0	20.0
900	41.11	41.11	41.11	41.12	20.5	20.5	20.5	20.5
950	42.23	42.23	42.24	42.24	21.1	21.1	21.1	21.1
1000	43.33	43.33	43.33	43.34	21.7	21.7	21.7	21.6
2000	61.27	61.27	61.27	61.28	30.6	30.6	30.6	30.6
5000	96.87	96.87	96.87	96.87	48.4	48.4	48.4	48.4
10000	137.0	137.0	137.0	137.0	68.5	68.5	68.5	68.5
20000	193.7	193.7	193.7	193.7	96.9	96.9	96.9	96.9
50000	306.3	306.3	306.3	306.3	153	153	153	153
100000	433.2	433.2	433.2	433.2	217	217	217	217
200000	612.6	612.6	612.6	612.6	306	306	306	306
500000	968.6	968.6	968.6	968.6	484	484	484	484
1000000	1370	1370	1370	1370	685	685	685	685

STANDARD MODEL OF ELECTROWEAK INTERACTIONS

The couplings of the photon, $W^{\pm}$, and Z to fundamental fermions are

$$\bar{\psi}\gamma^{\mu}\left[eQA_{\mu} + \frac{e}{\sqrt{2}\sin\theta_W}\left(T^{+}W_{\mu}^{+} + T^{-}W_{\mu}^{-}\right) + \frac{e}{\sin\theta_W\cos\theta_W}\left(T_3 - \sin^2\theta_W Q\right)Z_{\mu}\right]\psi ,$$

where

ψ = $\begin{pmatrix}u\\d'\end{pmatrix}, \begin{pmatrix}c\\s'\end{pmatrix}, \begin{pmatrix}t\\b'\end{pmatrix}, \begin{pmatrix}\nu_e\\e^-\end{pmatrix}, \begin{pmatrix}\nu_\mu\\\mu^-\end{pmatrix}, \begin{pmatrix}\nu_\tau\\\tau^-\end{pmatrix}$;

for mixing effects defining d′, s′, and b′ see the section on Cabibbo and Kobayashi-Maskawa Mixing;

T^+ = $\frac{1}{2}(1-\gamma_5)\times$ weak isospin raising operator ($T^{\pm}$ act on left-handed fermions);

T_3 = $\frac{1}{2}(1-\gamma_5)\times$ third component of weak isospin, (i.e., 1/2 for ν_e, ν_μ, ν_τ, u, c, t; −1/2 for e^-, μ^-, τ^-, d, s, b);

Q = electric charge operator, in units of proton charge;

θ_W = weak mixing angle;

A = electromagnetic vector potential.

Thus, for example, the Weν coupling is

$$\left(\frac{e}{\sqrt{2}\sin\theta_W}\right)\left[W_{\mu}^{-}\bar{e}\gamma^{\mu}\tfrac{1}{2}(1-\gamma_5)\nu + W_{\mu}^{+}\bar{\nu}\gamma^{\mu}\tfrac{1}{2}(1-\gamma_5)e\right]$$

and the $Zu\bar{u}$ coupling is

$$\left(\frac{e}{\sin\theta_W\cos\theta_W}\right)Z_{\mu}\bar{u}\gamma^{\mu}\left[\tfrac{1}{4}(1-\gamma_5)-\tfrac{2}{3}\sin^2\theta_W\right]u .$$

The physical neutral fields A and Z are mixtures of W_3, the partner of $W^{\pm}$, and another field B:

$$A = W_3\sin\theta_W + B\cos\theta_W ,\quad Z = W_3\cos\theta_W - B\sin\theta_W .$$

The SU(2) × U(1) gauge couplings g and g′ appear as

$$gW_{\mu}\cdot T + g'B_{\mu}\frac{Y}{2} ,$$

where electric charge Q, T_3, and Y/2 are connected by $Q = T_3 + Y/2$. The couplings and mixing angle are related by $\tan\theta_W = g'/g$, $\sin\theta_W = e/g$.

In lowest order

$$M_W^2 = \frac{\pi\alpha}{\sqrt{2}\sin^2\theta_W G_F} \simeq \left(\frac{37.3\ \text{GeV}}{\sin\theta_W}\right)^2 ,$$

$$M_Z^2 = M_W^2/\cos^2\theta_W .$$

See Appendix I of this Review (found only in complete version, not in booklet) for more details.

Branching fractions of the $W^{\pm}$ and Z are predicted to be roughly

$BR(W^+ \to e^+\nu_e)$ = 0.08 ,	$BR(W^+ \to u\bar{d})$ = 0.24 ,
$BR(Z \to \nu_e\bar{\nu}_e)$ = 0.06 ,	$BR(Z \to e^+e^-)$ = 0.03 ,
$BR(Z \to u\bar{u})$ = 0.10 ,	$BR(Z \to d\bar{d})$ = 0.13 , etc.

and similarly for the other generations, assuming there is no suppression for phase space even for the t quark. The total widths are expected to be (with $\sin^2\theta_W \simeq 0.21$): $\Gamma(W) \simeq 2.8$ GeV and $\Gamma(Z) \simeq 2.8$ GeV.

CABIBBO AND KOBAYASHI-MASKAWA MIXING

The quark mass eigenstates are not the weak eigenstates. The unitary matrix connecting them is known as the Kobayashi-Maskawa matrix. It generalizes to three generations the Cabibbo mixing which includes only the first two generations. The K-M matrix can be parametrized by three angles θ_1, θ_2, and θ_3 and a phase $e^{i\delta}$, as described in Appendix II (found in the full Review of Particle Properties, not in the data booklet). Independent of such a parametrization we can write

$$\begin{pmatrix}d'\\s'\\b'\end{pmatrix} = \begin{pmatrix}V_{ud} & V_{us} & V_{ub}\\ V_{cd} & V_{cs} & V_{cb}\\ V_{td} & V_{ts} & V_{tb}\end{pmatrix}\begin{pmatrix}d\\s\\b\end{pmatrix} .$$

The primed quarks are the weak eigenstates, while the unprimed ones are the mass eigenstates. The analysis in Appendix II leads to an estimate of the K-M matrix:

$$\begin{pmatrix} 0.9705 \text{ to } 0.9770 & 0.21 \text{ to } 0.24 & 0. \text{ to } 0.014\\ 0.21 \text{ to } 0.24 & 0.971 \text{ to } 0.973 & 0.036 \text{ to } 0.070\\ 0. \text{ to } 0.024 & 0.036 \text{ to } 0.069 & 0.997 \text{ to } 0.999 \end{pmatrix} .$$

QUARK PARTON MODEL FOR DEEP INELASTIC SCATTERING

In the naive parton model, the number of quarks, q(x)dx, of type q carrying a fraction between x and x+dx of the proton's momentum (in a frame in which it is large) is independent of the Q^2 of the scattering. (In more complete QCD models there is a logarithmic dependence on Q^2.) Thus deep inelastic leptoproduction probes u(x), d(x), $\bar{u}$(x), etc. In particular, the structure functions for scattering from a proton (see section on Kinematics, Decays, and Scattering) are determined by these:

$$F_2^{\nu CC} = 2x\left[d(x) + s(x) + \bar{u}(x) + \bar{c}(x)\right]$$

$$xF_3^{\nu CC} = 2x\left[d(x) + s(x) - \bar{u}(x) - \bar{c}(x)\right]$$

$$F_2^{\bar{\nu} CC} = 2x\left[u(x) + c(x) + \bar{d}(x) + \bar{s}(x)\right]$$

$$xF_3^{\bar{\nu} CC} = 2x\left[u(x) + c(x) - \bar{d}(x) - \bar{s}(x)\right]$$

$$F_2^{em} = x\left[\tfrac{4}{9}\left(u(x)+\bar{u}(x)\right) + \tfrac{1}{9}\left(d(x)+\bar{d}(x)\right) + \cdots\right]$$

$$F_2^{\nu NC} = 2\rho^2 x\left\{\left[\tfrac{1}{4} - \tfrac{2}{3}\sin^2\theta_W + \tfrac{8}{9}\sin^4\theta_W\right]\left[u(x)+\bar{u}(x)\right] + \left[\tfrac{1}{4} - \tfrac{1}{3}\sin^2\theta_W + \tfrac{2}{9}\sin^4\theta_W\right]\left[d(x)+\bar{d}(x)\right]\right\}$$

$$xF_3^{\nu NC} = 2\rho^2 x\left\{\left[\tfrac{1}{4} - \tfrac{2}{3}\sin^2\theta_W\right]\left[u(x)-\bar{u}(x)\right] + \left[\tfrac{1}{4} - \tfrac{1}{3}\sin^2\theta_W\right]\left[d(x)-\bar{d}(x)\right]\right\}$$

$F_2 = 2xF_1$ (in all cases. This is the Callan-Gross relation, and ignores parton transverse momentum.)

$$F_i^{\bar{\nu} NC} = F_i^{\nu NC} .$$

Here $\rho = M_W^2/(M_Z^2\cos^2\theta_W)$. See section on the Standard Model of Electroweak Interactions and Appendix I of this Review (found only in complete version, not in booklet).

NONRELATIVISTIC QUARK MODEL

A. QUANTUM NUMBERS

Each quark has spin 1/2. The additive quantum numbers (other than baryon number = 1/3) of the known (and presumed) quarks are shown in the table.

Quantum number	Quark type (flavor) d	u	s	c	b	t
$\mathscr{Q}$— electric charge	$-\frac{1}{3}$	$+\frac{2}{3}$	$-\frac{1}{3}$	$+\frac{2}{3}$	$-\frac{1}{3}$	$+\frac{2}{3}$
$\mathscr{I}_z$ — z-component of isospin	$-\frac{1}{2}$	$+\frac{1}{2}$	0	0	0	0
$\mathscr{S}$— strangeness	0	0	−1	0	0	0
$\mathscr{C}$— charm	0	0	0	+1	0	0
$\mathscr{B}$— bottomness	0	0	0	0	−1	0
$\mathscr{T}$— topness	0	0	0	0	0	+1

With these conventions the strangeness $\mathscr{S}$ of the K^+ is +1 and the bottomness $\mathscr{B}$ of the B^+ is +1.

The G-parity operator is defined to be $G = Ce^{-i\pi I_y}$, where C is the charge conjugation operator. The mesons with $\mathscr{S} = \mathscr{C} = \mathscr{B} = \mathscr{T} = 0$ are eigenstates of G. If a meson is also an eigenstate of the charge conjugation operator with charge conjugation C, then $G = C(-1)^I$, where I is its isospin; all the other particles in the same isomultiplet have the same value of G: $G(\pi^\pm) = G(\pi^0) = -1$, $G(\rho^\pm) = G(\rho^0) = +1$, etc.

B. MESONS

Nearly all known mesons can be understood as bound states of a quark q and an antiquark $\overline{q}'$ (the flavors of q and q′ may be different). If the orbital angular momentum of the $q\overline{q}'$ state is L, then the parity $P = (-1)^{L+1}$. A state $q\overline{q}$ of a quark and its own antiquark is also an eigenstate of charge conjugation with $C = (-1)^{L+S}$, where the spin S = 0 or 1. The L = 0 states are the pseudoscalars, $J^P = 0^-$, and the vectors, $J^P = 1^-$. See table below.

States in the "normal" spin-parity series, $P = (-1)^J$, must, according to the above, have S = 1 and hence CP = +1. Thus mesons with normal spin-parity and CP = −1 are forbidden in the $q\overline{q}'$ quark model. The $J^{PC} = 0^{--}$ state is forbidden as well. Mesons with such J^{PC} could exist, but would lie outside the $q\overline{q}'$ model.

States with the same J^P and additive quantum numbers can mix (if they are eigenstates of charge conjugation, they must also have the same value of C). Thus the physical $J^P = 1^+$, strangeness $\mathscr{S} = 1$ states, Q(1280) and Q(1400), are mixtures of Q_A and Q_B. The $\psi(3770)$ is a mixture of $^3S_1$ and $^3D_1$. The η and η' are mixtures of the SU(3) octet and singlet states.

For the pseudoscalar mesons, the Gell-Mann-Okubo formula is

$$m_\eta^2 = \frac{1}{3}(4m_K^2 - m_\pi^2),$$

assuming no octet-singlet mixing. However, the octet η_8 and singlet η_1 mix because of SU(3) breaking. The physical states η and η' are given by

$$\eta = \eta_8 \cos\theta_P - \eta_1 \sin\theta_P$$

$$\eta' = \eta_8 \sin\theta_P + \eta_1 \cos\theta_P .$$

These combinations diagonalize the mass-squared matrix

$$M^2 = \begin{pmatrix} M_{11}^2 & M_{18}^2 \\ M_{18}^2 & M_{88}^2 \end{pmatrix},$$

where $M_{88}^2 = \frac{1}{3}(4m_K^2 - m_\pi^2)$. It follows that

$$\tan^2\theta_P = \frac{M_{88}^2 - m_\eta^2}{m_{\eta'}^2 - M_{88}^2}.$$

The sign of θ_P is meaningful in the quark model. If

$$\eta_1 = (u\overline{u} + d\overline{d} + s\overline{s})/\sqrt{3}$$

$$\eta_8 = (u\overline{u} + d\overline{d} - 2s\overline{s})/\sqrt{6},$$

then the matrix element M_{18}^2, which is due mostly to the strange

Standard quark model assignments for some of the known mesons. Some assignments, especially for 0^{++}, are controversial. Note that only the states in the $u\overline{u}$, $d\overline{d}$, $s\overline{s}$, $c\overline{c}$, and $b\overline{b}$ columns and the neutral states in the I = 1 column are eigenstates of charge conjugation C.

$^{2S+1}L_J$	J^{PC}	$u\overline{u}, d\overline{d}, s\overline{s}$ I = 0	$u\overline{d}, u\overline{u}, d\overline{d}$ I = 1	$\overline{s}u, \overline{s}d$ I = 1/2	$c\overline{u}, c\overline{d}$ I = 1/2	$c\overline{s}$ I = 0	$c\overline{c}$ I = 0	$\overline{b}u, \overline{b}d$ I = 1/2	$b\overline{b}$ I = 0
$^1S_0$	0^{-+}	η, η'	π	K	D	F	η_c	B	
$^3S_1$	1^{--}	ϕ, ω	ρ	K*(892)	D*(2010)		J/ψ		Υ
$^1P_1$	1^{+-}	H	B(1235)	Q_B					
$^3P_0$	0^{++}	S(975), ϵ	δ	κ			χ(3415)		χ_b(9875)
$^3P_1$	1^{++}	D(1285), E	A(1270)	Q_A			χ(3510)		χ_b(9895)
$^3P_2$	2^{++}	f′, f	A_2	K*(1430)			χ(3555)		χ_b(9915)
$^1D_2$	2^{-+}		A(1680)						
$^3D_1$	1^{--}						ψ(3770)		
$^3D_2$	2^{--}			L(1770)					
$^3D_3$	3^{--}	ω(1670)	g	K*(1780)					

NONRELATIVISTIC QUARK MODEL (Cont'd)

quark mass, is negative. From the relation

$$\tan\theta_P = \frac{M_{88}^2 - m_\eta^2}{M_{18}^2} ,$$

we find $\theta_P < 0$.

For the vector mesons we replace $\pi \to \rho$, $K \to K^*$, $\eta \to \phi$, and $\eta' \to \omega$, so

$$\phi = \omega_8 \cos\theta_V - \omega_1 \sin\theta_V$$

$$\omega = \omega_8 \sin\theta_V + \omega_1 \cos\theta_V .$$

For "ideal mixing," $\phi = s\bar{s}$, $\tan\theta_V = 1/\sqrt{2}$, so $\theta_V \approx 35.3°$. Experimentally, θ_V is near 35°, the sign being determined by a formula analogous to that for $\tan\theta_P$. Following this procedure we find the mixing angles below. There are uncertainties of a few degrees arising from electromagnetic mass splittings and uncertainties in resonance masses.

Singlet-octet mixing for the pseudoscalar, vector, and tensor mesons. The sign conventions are as above. The value of θ_{quad} is obtained from the equations above, and θ_{lin} is obtained by replacing $m^2 \to m$ throughout. Of the two isosinglets, the mostly octet one is listed first.

J^{PC}	Nonet Members	θ_{quad}	θ_{lin}
0^{-+}	π, K, η, η'	−10°	−23°
1^{--}	ρ, K*(892), ϕ, ω	39°	36°
2^{++}	A_2, K*(1430), f′, f	28°	26°
3^{--}	g(1690), K*(1780), ϕ(1850), ω(1670)	29°	28°

C. BARYONS

All the established baryons are apparently 3-quark (qqq) states, and each such state is an SU(3) color singlet, a completely antisymmetric state of the three possible colors. Since the quarks are fermions, the state function for any baryon must be antisymmetric under interchange of any two of its quarks. Thus the state is *symmetric* under interchange of the quantum labels other than color:

$$|qqq\rangle_A = |\text{color}\rangle_A \times |\text{space, spin, flavor}\rangle_S ,$$

where the subscripts S and A indicate symmetry or antisymmetry under interchange of any two of the quarks. Note the contrast with the state function for the three nucleons in ^{3}H or ^{3}He:

$$|NNN\rangle_A = |\text{space, spin, isospin}\rangle_A .$$

This difference has major implications for internal structure, magnetic moments, etc. (For a nice discussion, see Ref. 1.)

Few of the baryons containing c or heavier quarks have yet been discovered, so we restrict further attention to baryons made up of just d, u, and s quarks. The three flavors imply a flavor SU(3), which requires that baryons made of these quarks belong to the multiplets on the right side of

$$\mathbf{3} \otimes \mathbf{3} \otimes \mathbf{3} = \mathbf{10}_S \oplus \mathbf{8}_M \oplus \mathbf{8}_M \oplus \mathbf{1}_A$$

(see the section on SU(n) Multiplets and Young Diagrams). Here the subscripts indicate symmetric, mixed-symmetric, or antisymmetric states under interchange of any two quarks. The figure shows particle assignments in these multiplets. States Λ_8 and Λ_1 that have the same spin and parity can mix; an example is the mainly octet D_{03} $\Lambda(1690)$ and mainly singlet D_{03} $\Lambda(1520)$. The formalism is the same as for $\eta-\eta'$ or $\phi-\omega$ mixing (see above), except that for baryons the mass M instead of M^2 is used. The section SU(3) Isoscalar Factors shows how relative decay rates in, say, $\mathbf{10} \to \mathbf{8} \otimes \mathbf{8}$ decays may be calculated. A summary of results of fits to the observed baryon masses and decay rates for the best-known SU(3) multiplets is given in Appendix II of our 1982 edition.[2]

Flavor and spin may be combined in a flavor-spin SU(6) in which the six basic states are d↑, d↓, · · · , s↓ (↑, ↓ = spin up, down). Then the baryons belong to the multiplets on the right side of

$$\mathbf{6} \otimes \mathbf{6} \otimes \mathbf{6} = \mathbf{56}_S \oplus \mathbf{70}_M \oplus \mathbf{70}_M \oplus \mathbf{20}_A .$$

These SU(6) multiplets decompose into flavor SU(3) multiplets as follows:

$$\mathbf{56} = {}^4\mathbf{10} \oplus {}^2\mathbf{8}$$

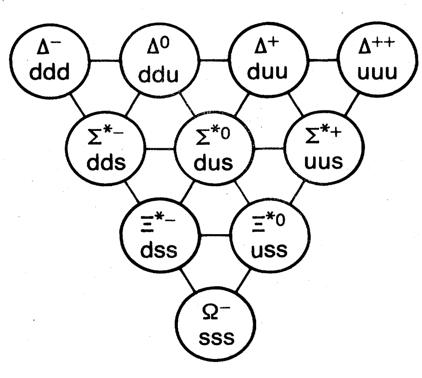
$$\mathbf{70} = {}^2\mathbf{10} \oplus {}^4\mathbf{8} \oplus {}^2\mathbf{8} \oplus {}^2\mathbf{1}$$

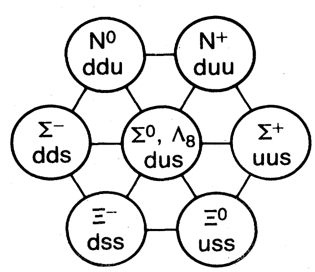
$$\mathbf{20} = {}^2\mathbf{8} \oplus {}^4\mathbf{1} ,$$

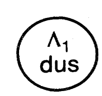
where the superscript (2S+1) gives the net spin S of the quarks for each particle in the SU(3) multiplet. The $J^P = 1/2^+$ octet containing the nucleon and the $J^P = 3/2^+$ decuplet containing the $\Delta(1232)$ together make up the "ground-state" 56-plet in which the orbital angular momenta between the quarks are zero (so that the spatial part of the state function is trivially symmetric). The **70** and **20** require some excitation of the spatial part of the state function in order to make the overall state function symmetric.

The quark model for baryons is extensively reviewed in Ref. 3.

1. F.E. Close, in *Quarks and Nuclear Forces* (Springer-Verlag, 1982), p. 56.
2. Particle Data Group, Phys. Lett. **111B** (1982).
3. A.J.G. Hey and R.L. Kelly, Phys. Reports **96**, 71 (1983).



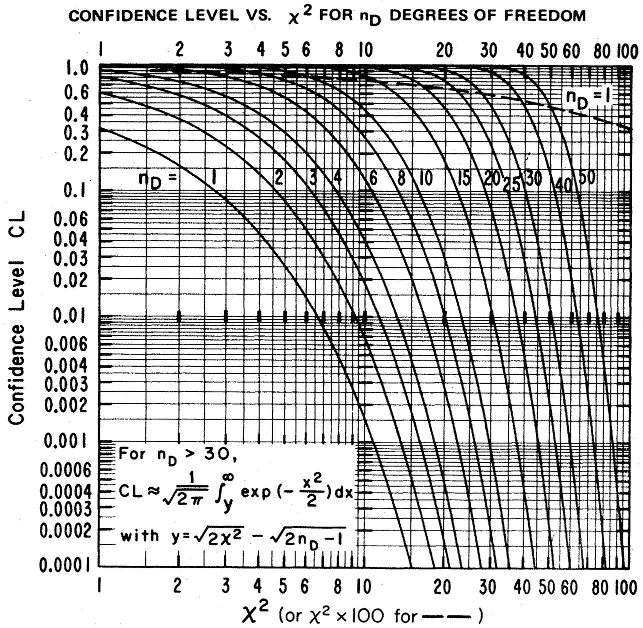




PROBABILITY AND STATISTICS

A. PROBABILITY DISTRIBUTIONS AND CONFIDENCE LEVELS

We give here properties of the three probability distributions most commonly used in high energy physics: normal (or Gaussian), chi-squared (χ^2), and Poisson. We *warn* the reader that there is no universal convention for the term "confidence level"; thus, explicit definitions that correspond to common usage are given for each distribution. It is explained below how confidence levels for all three distributions may be extracted from the following figure.



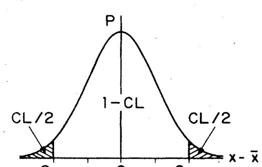
A.1 Normal distribution

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

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

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

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



since the distribution is symmetric about $\bar{x}$. The small figure in Eq. (2) is drawn with $\delta = 2\sigma$. CL is given by the ordinate of the $n_D = 1$ curve in the large figure at $\chi^2 = (\delta/\sigma)^2$. The confidence level for $\delta = 1\sigma$ is 31.7%; 2σ, 4.6%; 3σ, 0.3%. The *odds* against exceeding δ, $(1-CL)/CL$, for $\delta = 1\sigma$ are 2.15:1; 2σ, 21:1; 3σ, 370:1; 4σ, 16,000:1; 5σ, 1,700,000:1. Relations between σ and other measures of the *width*: probable error (CL = 0.5) = 0.67σ; mean absolute deviation = 0.80σ; RMS deviation = σ; half width at half maximum = 1.18σ.

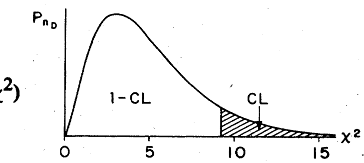
A.2 χ^2 distribution

The χ^2 distribution for n_D degrees of freedom is:

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

where h (for "half") = $n_D/2$. The mean and variance are n_D and $2n_D$ respectively. In evaluating Eq. (3) one may use *Stirling's approximation*: $\Gamma(h) \simeq 2.507\, e^{-h}\, h^{(h-1/2)}(1 + 0.0833/h)$, which is accurate to $\pm$ 0.1% for all $h \geq 1/2$. The *confidence level* associated with a given value of n_D and an observed value of χ_0^2 is the probability of the χ^2 exceeding the observed value, i.e.,

$$CL = \int_{\chi_0^2}^{\infty} d\chi^2\, P_{n_D}(\chi^2) \qquad (4)$$



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

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

becomes normally distributed with unit standard deviation and mean zero. A *better* approximation is that χ, not χ^2, becomes normally distributed; specifically

$$y_2 = \sqrt{2\chi^2} - \sqrt{2n_D - 1} \qquad (6)$$

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

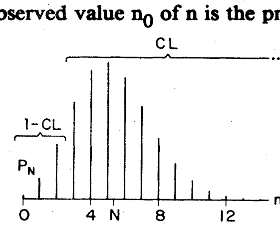
A.3 Poisson distribution

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

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

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

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



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

Tables of confidence levels for all three of these distributions, the relation between Poisson and χ^2 confidence levels, and numerous other useful tables and relations may be found in Ref. 1.

PROBABILITY AND STATISTICS (Cont'd)

B. STATISTICS

Suppose one is presented with N independent data, $y_n \pm \sigma_n$, and it is desired to make some *inference* about the "true" value of the quantity represented by these data. For this purpose we interpret each datum y_n as a single sample point drawn randomly (and independently of the other data) from a distribution having true mean $\overline{y}_n$ (which we wish to estimate) and variance σ_n^2. We do not require that they be normally distributed. (Identification of the true σ_n with the σ_n datum is often an *approximation* which may become seriously inaccurate when σ_n is an appreciable fraction of y_n.) Some methods of estimation commonly used in high energy physics are given below; see Ref. 2 for numerous applications. Section B.1 deals with the case in which all $\overline{y}_n$ are the same, e.g., several different measurements of the same quantity; Sec. B.2 deals with the case in which $\overline{y}_n = \overline{y}(x_n)$, where x_n represents some set of independent variables, e.g., cross-section measurements at various values of energy and angle, $x_n = \{E_n, \theta_n\}$.

B.1 Single mean and variance estimates

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

$$\hat{y} = \frac{1}{N}\sum_{n=1}^{N} y_n \quad \text{and} \tag{9}$$

$$\hat{\sigma}^2 = \frac{1}{N-1}\sum_{n=1}^{N}(y_n - \hat{y})^2 = \frac{N}{N-1}\left[\langle (y^2)\rangle - (\hat{y})^2\right] \tag{10}$$

are unbiased estimates of $\overline{y}$ and σ^2; the angular brackets denote an average over the data. The variance of $\hat{y}$ is σ^2/N. If the parent distribution is normal and N is large, the variance of $\hat{\sigma}^2$ is $2\sigma^4/N$.

(2) If the y_n are independent estimates of the same $\overline{y}$, and the σ_n are known, then the weighted average

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

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

B.2 Linear least-squares fit

We wish to determine the best fit of independent unbiased data $y_n \pm \sigma_n$, measured at points x_n, to the form $y(x) = \Sigma a_i f_i(x)$, where the f_i are known, linearly independent functions (e.g., Legendre polynomials) one-to-one over the allowed range of x. The estimates for the linear coefficients a_i which minimize the sum of the squared deviations are

$$\hat{a}_i = \sum_{j,n} V_{ij}\, f_j(x_n) y_n/\sigma_n^2 . \tag{12}$$

Here V is the covariance matrix of the fitted parameters

$$V_{ij} = \overline{(\hat{a}_i - \overline{a}_i)(\hat{a}_j - \overline{a}_j)}, \tag{13}$$

where the overbar denotes the unknown true value; V is estimated by

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

The estimated variance of an interpolated or extrapolated value of y at point x, $\hat{y} = \Sigma\, \hat{a}_i f_i(x)$, is:

$$(\hat{y}-\overline{y})^2\big|_{est} = \sum_{ij} V_{ij} f_i(x) f_j(x) . \tag{15}$$

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

$$\hat{a} = (S_y S_{xx} - S_x S_{xy})/D, \tag{16}$$

$$\hat{b} = (S_1 S_{xy} - S_x S_y)/D,$$

where

$$S_1, S_x, S_y, S_{xx}, S_{xy} = \sum (1, x_n, y_n, x_n^2, x_n y_n)/\sigma_n^2 , \tag{17}$$

respectively, and

$$D = S_1 S_{xx} - S_x^2 .$$

The covariance matrix of the fitted parameters is:

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

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

$$(\hat{y} - \overline{y})^2\big|_{est} = \frac{1}{S_1} + \frac{S_1}{D}\left[x - \frac{S_x}{S_1}\right]^2 . \tag{19}$$

A least-squares fit gives estimates for the a_i [Eq.(12)] with the smallest variance, under the conditions that the expansion of y in terms of $a_i f_i$ is the correct model and that the y_n are independent, unbiased measurements whose variances σ_n^2 are known.

C. ERROR PROPAGATION

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

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

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

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

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

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

Note that these equations will usually be applied by substituting measured quantities, $\{\tilde{y}\}$ say, for the true means, $\{\overline{y}\}$. If, as is often the case, $\tilde{y}_n - \overline{y}_n$ is of order $\sqrt{V_{nn}}$, then the second-order terms in Eqs. (20) and (22) may be small compared with the first-order errors introduced by the substitution.

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1. M. Abramowitz and I. Stegun, eds., *Handbook of Mathematical Functions* (Dover, New York, 1972).
2. W.T. Eadie, D. Drijard, F.E. James, M. Roos, and B. Sadoulet, *Statistical Methods in Experimental Physics* (North Holland, Amsterdam and London, 1971); S.L. Meyer, *Data Analysis for Scientists and Engineers* (John Wiley and Sons, Inc., New York, 1975); A.G. Frodesen, O. Skjeggestad, and H. Tøfte, *Probability and Statistics in Particle Physics* (Universitetsforlaget, Oslo, Norway, 1979).

PARTICLE DETECTORS, ABSORBERS, AND RANGES*

A. DETECTOR PARAMETERS

In this section we give various parameters for common detectors. The quoted numbers are usually based on some typical apparatus, and obviously should be regarded as rough approximations, valid only for preliminary design when applied to other cases. A more detailed introduction to detectors can be found in "A Consumer's Guide to Particle Detectors," by D.J. Miller, Rutherford Lab Report RL-76-072, July 1976.

A.1 Scintillators: The photon yield in the frequency range of practical photomultiplier tubes is $\simeq 1\gamma$ per 100 eV of charged particle ionization energy loss in plastic scintillator[1] and $\simeq 1\gamma/25$ eV in NaI.[1,2]

A.2 Cerenkov:[3] The half-angle θ_c of the Cerenkov cone aperture in terms of the velocity β and the index of refraction n is:

$$\theta_c = \arc\cos\left(\frac{1}{\beta n}\right) \simeq \left[2\left(1-\frac{1}{\beta n}\right)\right]^{1/2}.$$

The threshold velocity is: $\beta_t = 1/n$; $\gamma_t = 1/\sqrt{1-\beta_t^2}$. Therefore, $\beta_t\gamma_t = 1/\sqrt{2\delta+\delta^2}$, where $\delta = n-1$. Values of δ for various commonly used gases are given as a function of pressure and wavelength in Ref. 4; for values at atmospheric pressure, see the Table of Atomic and Nuclear Properties, following.

The number of photons N per cm of path length is given by:

$$N = \frac{\alpha}{c}\int\left(1-\frac{1}{\beta^2 n^2}\right)2\pi d\nu = \frac{\alpha}{c}\beta_t^2\int\left(\frac{1}{\beta_t^2\gamma_t^2}-\frac{1}{\beta^2\gamma^2}\right)2\pi d\nu$$

$$\simeq 500\sin^2\theta_c/\text{cm (visible spectrum)}\ .$$

A.3 Photon collection: In addition to the photon yield, one should take into account the light collection efficiency ($\lesssim 10\%$ for typical 1-cm-thick scintillator), the attenuation length ($\simeq 1$ to 4 m for typical scintillators[5]), and the quantum efficiency of the photomultiplier cathode ($\lesssim 25\%$).

A.4 Typical detector characteristics:

Detector Type	Accuracy (rms)	Resolution Time	Dead Time
Bubble chamber	$\simeq \pm 10$ to $\simeq \pm 150\mu$	$\simeq$ 1 ms	$\simeq 1/20$ s[a]
Streamer chamber	$\pm 300\mu$	$\simeq$ 2 μs	$\simeq$ 100 ms
Proportional chamber	$> \pm 300\mu$[b,c]	$\simeq$ 50 ns	$\simeq$ 200 ns
Drift chamber	± 50 to 300μ	$\simeq$ 2 ns[d]	$\simeq$ 100 ns
Scintillator	—	$\simeq$ 150 ps	$\simeq$ 10 ns
Emulsion	$\pm 1\mu$	—[e]	—[e]
Silicon strip	$\pm 5\mu$		

[a] Multiple pulsing time.
[b] 300μ is for 1 mm pitch.
[c] Delay line cathode readout can give $\pm 150\mu$ parallel to anode wire.
[d] For two chambers.
[e] Limited at present by noise and readout time of attached electronics.

A.5 Shower detectors: We give below typical energy resolutions (FWHM) for an incident electron in the 1 GeV range; E is in GeV. For a fixed number of radiation lengths, FWHM in the last three detectors would be expected to be proportional to $\sqrt{t}$ for t (= plate thickness) > 0.2 radiation lengths.[6] For all detectors, operational resolution may be up to 50% worse due to dead areas, non-normally incident tracks, and other effects.

NaI (20 rad. lengths):[7] $\dfrac{2\%}{E^{1/4}}$

Lead glass (14 rad. lengths):[8] $\dfrac{10-12\%}{\sqrt{E}}$

Lead-liquid argon (15.75 rad. lengths):[6] $\dfrac{16\%}{\sqrt{E}}$
(42 cells: 1.1 mm lead, 2 mm liquid argon, 2.3 mm lead-G10, 2 mm liquid argon)

Lead-scintillator sandwich (12.5 rad. lengths):[9] $\dfrac{17\%}{\sqrt{E}}$
(66 cells: 1 mm lead, 5 mm scintillator)

Proportional wire shower chamber (17 rad. lengths):[10] $\dfrac{40\%}{\sqrt{E}}$
(36 cells: 0.474 rad. length type-metal + Al, 9.5 mm 80% Ar - 20% CH_4 gas)

A.6 dE/dx resolution in Argon: Particle identification (relativistic, Q = 1 incident particles) by dE/dx is dependent on the width of the distribution:

Multiple-sample Ar gas counters (no lead):[11]

$$\frac{\text{FWHM}\left(\left.\frac{dE}{dx}\right|_{\text{most probable}}\right)}{\left.\frac{dE}{dx}\right|_{\text{most probable}}} = 0.96N^{-0.46}(tp)^{-0.32}\ ;$$

N = no. samples, t = thickness per sample (cm), p = pressure (atm.); most commonly used chamber gases (except Xe) give approximately the same resolution.

A.7. Proportional chamber wire instability: The limit on the voltage V for a wire tension T, due to mechanical effects when the electrostatic repulsion of adjacent wires exceeds the restoring force of wire tension, is given by (MSKA)[12]

$$V < \frac{s}{\ell C}\sqrt{4\pi\epsilon_0 T}\ ,$$

where s, ℓ, and C are the wire spacing, length, and capacitance per unit length. An approximation to C for chamber half-gap t and wire diameter d (good for s $\lesssim$ t) gives[13]

$$V \lesssim 59T^{1/2}\left[\frac{t}{\ell}+\frac{s}{\pi\ell}\ell n\left(\frac{s}{\pi d}\right)\right],$$

where V is in kV, and T is in grams-weight equivalent.

A.8 Proportional and drift chamber potentials: The potential distributions and fields in a proportional or drift chamber can usually be calculated with good accuracy from the exact formula for the potential around an array of parallel line charges q (coul/m) along z and located at y = 0, x = 0, ±s, ±2s,...,

$$V(x,y) = -\frac{q}{4\pi\epsilon_0}\ell n\left\{4\left[\sin^2\left(\frac{\pi x}{s}\right)+\sinh^2\left(\frac{\pi y}{s}\right)\right]\right\}.$$

Errors from the presence of cathodes, mechanical defects, TPC-type edge effects, etc., are usually small and are beyond the scope of this review.

A.9 Silicon strip detectors: These are silicon diodes operated with a reverse bias voltage V (typically 30-300 volts) sufficient to deplete the sensitive volume of most mobile charge carriers (electrons and holes). The active (depletion layer) thickness t is given in a simple model by (MKSA)

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$$t = \sqrt{\frac{2\epsilon V}{ne}} = \sqrt{2\rho\mu\epsilon V}\,,$$

where

n = number of impurity centers/m^3
e = electron charge
ϵ = dielectric constant $\simeq$ 105 pF/m $\simeq 11.9\,\epsilon_0$
ρ = resistivity $\simeq$ 10-200 Ω-m
μ = majority charge carrier mobility
$\simeq$ 0.13-0.15 m^2/volt-sec (electrons)
$\simeq$ 0.045-0.06 m^2/volt-sec (holes).

A minimum-ionizing particle has a Landau energy-loss distribution with average energy loss 39 keV/100 μm and full width at half-maximum of $0.071t/\beta^2$ keV, where t is the detector thickness in microns and $\beta = v_{inc}/c$. The width is usually increased further by electronic noise ($\sigma \sim$1-10 keV) and for thin layers by a Gaussian contribution due to atomic effects $[\sigma \sim (0.3\text{-}0.4)\sqrt{t}\text{ keV}]$. The average energy required to produce an electron-hole pair is 3.62 eV, from which one can estimate total charge of either sign released. Silicon detectors can tolerate integrated charged-particle fluxes of up to $\sim 10^{14}\text{-}10^{18}/m^2$ and still operate as efficient detectors.

B. COSMIC RAY FLUXES

The fluxes of particles of different types depend on the latitude, their energy, and the conditions of measurement. Some typical sea-level values[14] for charged particles are given below:

I_v flux per unit solid angle about vertical direction crossing unit horizontal area
J_1 perpendicular component of total flux crossing unit horizontal area from above
J_2 total flux crossing unit horizontal area

	Total Intensity	Hard Component	Soft Component	
I_v	1.1×10^2	0.8×10^2	0.3×10^2	$m^{-2}\,sec^{-1}\,sterad^{-1}$
J_1	1.8×10^2	1.3×10^2	0.5×10^2	$m^{-2}\,sec^{-1}$
J_2	2.4×10^2	1.7×10^2	0.7×10^2	$m^{-2}\,sec^{-1}$

Very approximately, about 75% of all particles at sea level are penetrating, and are muons. The sea-level vertical flux ratio for protons to muons (both charges together) is about 3½% at 1 GeV/c, decreasing to about ½% at 10 GeV/c.

The muon flux at sea level has a mean energy of 2 GeV and a differential spectrum falling as E^{-2}, steepening smoothly to $E^{-3.6}$ above a few TeV. The angular distribution is $\cos^2\theta$, changing to $\sec\theta$ at energies above a TeV, where θ is the zenith angle at production. The $+-$ charge ratio is 1.25-1.30. The mean energy of muons originating in the atmosphere is roughly 300 GeV at slant depths $\gtrsim$ a few hundred meters. Beyond slant depths of $\sim$10 km water-equivalent, the muons are due primarily to in-the-earth neutrino interactions (roughly 1/8 interaction $ton^{-1}\,year^{-1}$ for $E_\nu >$ 300 MeV, $\sim$ constant throughout the earth).[15] Muons from this source arrive with a mean energy of 20 GeV, and have a flux of $2\times10^{-9}\,m^{-2}\,sec^{-1}\,sterad^{-1}$ in the vertical direction and about twice that in the horizontal,[16] down at least as far as the deepest mines.

C. PASSAGE OF PARTICLES THROUGH MATTER

C.1 Energy loss rates for heavy charged projectiles: A heavy projectile (much more massive than an electron) of charge $Z_{inc}e$, incident at speed βc ($\beta >> 1/137$) through a slowing medium, dissipates energy principally via interactions with the electrons of the medium. The mean rate of such energy loss per unit path length x, called the stopping power, is given by the Bethe-Bloch equation:[17]

$$\left(\frac{dE}{dx}\right)_{inc} = \frac{D\,Z_{med}\,\rho_{med}}{A_{med}}\left(\frac{Z_{inc}}{\beta}\right)^2$$
$$\times\left[\ell n\left(\frac{2m_e\gamma^2\beta^2c^2}{I}\right) - \beta^2 - \frac{\delta}{2} - \frac{C}{Z_{med}}\right]\left\{1+\nu\right\},$$

where $D = 4\pi N_A r_e^2 m_e c^2 = 0.3070$ MeV cm^2/g (see Physical Constants Table). Mean range and energy loss figures appear at the end of this section.

Here, Z_{med} and A_{med} are the charge and mass numbers of the medium and ρ_{med} is the mass density of the medium; I, δ, C, and ν are phenomenological functions. Frequently, the values of δ, C, and ν are negligibly small; the parameter I characterizes the binding of the electrons of the medium. As a rule of thumb, we may estimate I for an idealized medium as $I \simeq 16\,(Z_{med})^{0.9}$ eV when $Z_{med} > 1$. For realistic media the value of I will vary at the 10% level from this estimate. Variations of this order occur due to atomic effects such as completion of a shell, also due to chemical binding, and even due to the phase of the substance. Hydrogen, perhaps the most sensitive, has I of about 15 eV in the atomic mode, rising to about 19.2 eV as H_2 gas and to 21.8 eV as H_2 liquid.[18] For many substances, the transition from gas to solid is accompanied by a 20-30% increase in I.[18] We may *approximately* treat media which are chemical mixtures or compounds by computing

$$\frac{dE}{dx} \simeq \sum_{n=1}^{N}\left(\frac{dE}{dx}\right)_n,$$

with $(dE/dx)_n$ appropriate to the n^{th} chemical constituent (using $\rho_{med}^{(n)}$ as the partial density in the formula for dE/dx).[19] For many chemical compounds, small corrections to this additivity rule may be found in Ref. 18.

The function δ represents the density effect upon the energy loss rate; it is non-negligible only for highly relativistic projectiles in denser media.[20] For ultra-relativistic projectiles, δ approaches $2\ell n\gamma$ + constant, where the value of the constant depends upon the density of the medium as well as its chemical composition.

The function C represents shell corrections to the energy loss rate.[17] These effects are non-negligible only for projectiles with speeds not much faster than the speeds of the fastest electrons bound in the medium.

The function ν represents corrections due to higher order electrodynamics.[21] These effects become important when $|Z_{inc}/\beta|$ is comparable to 137. For relativistic unit-charge projectiles, $|\nu|$ is of the order of 1%; positively charged projectiles lose energy more rapidly than do their charge conjugates.[21,22]

For nonrelativistic projectiles, our formulae above are inapplicable. At the very slowest speeds, total energy loss rates are believed to be proportional to β, rising through a peak at projectile speeds comparable to atomic speeds (β on the order of αc), after having passed through a smaller peak (due to elastic Coulomb collisions with the *nuclei* of the slowing medium[23]) at intermediate speeds. For example, for protons in Si, dE/dx = 61.23 β GeV/(gm cm^{-2}) for β <0.005; the peak occurs at β = 0.0126 where dE/dx = 522 MeV/(gm cm^{-2}). In some cases, energy loss rates depend significantly upon the relation of the projectile trajectory to the crystalline structure of the slowing medium.[24]

For relativistic projectiles, $(dE/dx)_{inc}$ falls rapidly with increasing β until reaching a minimum around β = 0.96 (almost independent of medium), followed by a slow rise. Because of the density

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effect, the quantity in square brackets approaches $\ell n\gamma$ + constant for large γ.

The quantity $(dE/dx)_{inc}\delta x$ is the *mean* total energy loss via interactions with electrons of the medium in a layer of thickness δx. For any finite δx, Poisson fluctuations can cause the actual energy loss to deviate from the mean. For thin layers, the distribution is broad and skewed, being peaked below $(dE/dx)\delta x$, and having a long tail toward large energy losses.[25] Only for a very thick layer $[(dE/dx)\delta x >> 2m_e\beta^2\gamma^2c^2]$ will the distribution of energy losses become nearly Gaussian. The large fluctuations of the total energy loss rate from the mean are due to a small number of collisions involving large energy transfers. The fluctuations are greatly reduced for the so-called restricted energy loss rate, described in Section C.4.

C.2 Ionization yields: Physicists frequently relate total energy loss to the number of ion pairs produced near the projectile's track. This relation becomes complicated for relativistic projectiles due to the wandering of energetic knock-on electrons whose ranges exceed the dimensions of the fiducial volume. For a qualitative appraisal of the nonlocality of energy deposition by such modestly energetic knock-on electrons in various media, see Ref. 26. Furthermore, the mean local energy dissipation per local ion pair produced, W, while essentially constant for relativistic projectiles, increases at slow projectile speeds.[27] The numerical value of W for gases can be surprisingly sensitive to trace amounts of various contaminants.[27] Of course, in addition to the preceding effects, practical ionization yields may be greatly influenced by subsequent recombinations and other factors.[28]

C.3 Energetic knock-on electrons: For a relativistic point-charge projectile, the production of high energy (kinetic energy $T >> I$) electrons is given by:[29]

$$\frac{d^2N}{dTdx} = \frac{1}{2}D\left(\frac{Z_{med}}{A_{med}}\right)\left(\frac{Z_{inc}}{\beta}\right)^2 \rho_{med}\frac{1}{T^2}F\,,$$

for $I << T < T_{max}$, where

$$T_{max} = \frac{2m_e\beta^2\gamma^2c^2}{1 + 2\gamma\dfrac{m_e}{M_{inc}} + \left(\dfrac{m_e}{M_{inc}}\right)^2}\,,$$

M_{inc} is the mass of the incident projectile, and all other quantities except F are as in Sec. C.1. F ($\simeq 1$ for $T << T_{max}$) is a factor dependent upon the spin of the projectile.

For spin-0 projectiles,

$$F = 1 - \beta^2\frac{T}{T_{max}}\,;$$

for spin-1/2 projectiles,

$$F = 1 - \beta^2\frac{T}{T_{max}} + \frac{1}{2}\left(\frac{T}{T_{inc} + M_{inc}c^2}\right)^2,$$

where T_{inc} is the kinetic energy of the projectile; for electrons incident,

$$F = \beta^2T^2\left[\frac{T_{inc}}{T(T_{inc} - T)} - \frac{1}{T_{inc}}\right]^2;$$

and for positrons incident,

$$F = \beta^2\left[1 - \frac{T}{T_{inc}} + \left(\frac{T}{T_{inc}}\right)^2\right]^2.$$

For incident electrons, the indistinguishability of projectile and target means that the range of T is only up to $T_{inc}/2$. For additional formulas see Ref. 30. Our formula is inaccurate for T close to I; for $2I \lesssim T \lesssim 10I$, the $1/T^2$ dependence above becomes $\simeq T^{-\eta}$ with $3 \lesssim \eta \lesssim 5$.[31]

C.4 Rates of restricted energy loss for relativistic charged projectiles: The variability of energy loss for heavy projectiles is due primarily to the variability in the production of energetic knock-on electrons. Bremsstrahlung and pair-production processes make this variability even greater for electrons than for heavy particles as projectiles (see, e.g., the figure "Fractional Energy Loss for Electrons and Positrons in Lead," following). If an instrument, such as a bubble chamber, is capable of isolating these high-energy-loss interactions, then it is appropriate to consider the rate of energy loss excluding them, i.e., a restricted energy loss rate. The mean energy loss rate via all collisions which have energy transfer T such that $T < E_{max} << T_{max}$ is:[17]

$$\left(\frac{dE}{dx}\right)_{<E_{max}} = \frac{1}{2}D\frac{Z_{med}\rho_{med}}{A_{med}}\left(\frac{Z_{inc}}{\beta}\right)^2 \times\left[\ell n\left(\frac{E_{max}T_{max}}{I^2}\right) - \beta^2 - \delta - \frac{2C}{Z_{med}}\right].$$

Notice the overall factor of 1/2. See Sec. C.1 above for definitions of the quantities in this equation.

The density effect causes the restricted energy loss rate to approach a constant, the Fermi plateau value, for the fastest projectiles.

C.5 Multiple scattering through small angles: As a charged particle traverses a medium it is deflected by many small-angle elastic scatterings. The bulk of this deflection is due to elastic Coulomb scattering from the nuclei within the medium, hence the usual identification as multiple Coulomb scattering (note, however, that strong interactions do contribute to the total multiple scattering for hadronic projectiles). For both Coulomb and strong interactions, the Central Limit Theorem provides little useful guidance in establishing the precise nature of the distribution of the total deflections resulting from multiple scattering. The true distribution is roughly Gaussian only for small deflection angles, while it shows much greater probability for large-angle scatterings ($\gtrsim$ a few θ_0, see below, depending on absorber) than the Gaussian would suggest. These tails on the distribution (a few per cent of peak height in the region where the Gaussian part becomes negligible) are more pronounced for hadrons than for muons as projectiles. The large-angle behavior of these distributions is best estimated by computing the exact distribution for the vectorial sum of the largest deflections based upon the true elastic scattering cross section of the projectile against the medium,[32] or, when applicable, by interpolation from tabular data.[33] An easier alternative which may suffice for noncritical applications would be to use a Gaussian approximation with the following width:[34]

$$\theta_0 = \frac{14.1\ \text{MeV/c}}{p\beta} Z_{inc}\sqrt{L/L_R}\left[1 + \frac{1}{9}\log_{10}\left(L/L_R\right)\right]\text{(radians)},$$

where p, β, and Z_{inc} are the momentum (in MeV/c), velocity, and charge number of the incident particle, and L/L_R is the thickness, in radiation lengths, of the scattering medium. L_R for certain

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materials is given in the Table of Atomic and Nuclear Properties of Materials, following. See also Sec. C.7 below. The angle, θ_0, is a fit to Moliere[32] theory, accurate to about 5% for $10^{-3} < L/L_R < 10$ except for very light elements or low velocity where the error is about 10 to 20%. In this Gaussian approximation, θ_0 has the meaning

$$\theta_0 = \theta_{\text{plane}}^{\text{rms}} = \frac{1}{\sqrt{2}}\,\theta_{\text{space}}^{\text{rms}}\,.$$

The nonprojected (space) and projected (plane) angular distributions are given approximately[32] by the Gaussian forms:

$$\frac{1}{2\pi\theta_0^2}\exp\left[-\frac{\theta_{\text{space}}^2}{2\theta_0^2}\right]d\Omega,$$

$$\frac{1}{\sqrt{2\pi}\,\theta_0}\exp\left[-\frac{\theta_{\text{plane}}^2}{2\theta_0^2}\right]d\theta_{\text{plane}},$$

where θ is the deflection angle.

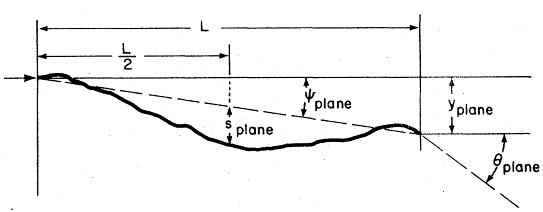
Other quantities are sometimes used to describe the amount of multiple Coulomb scattering: the auxiliary quantities ψ_{plane}, y_{plane}, and s_{plane} (see the figure) obey:

$$\psi_{\text{plane}}^{\text{rms}} = \frac{1}{\sqrt{3}}\,\theta_{\text{plane}}^{\text{rms}} = \frac{1}{\sqrt{3}}\theta_0\,,$$

$$y_{\text{plane}}^{\text{rms}} = \frac{1}{\sqrt{3}}\,L\,\theta_{\text{plane}}^{\text{rms}} = \frac{1}{\sqrt{3}}L\theta_0\,,$$

and

$$s_{\text{plane}}^{\text{rms}} = \frac{1}{4\sqrt{3}}\,L\,\theta_{\text{plane}}^{\text{rms}} = \frac{1}{4\sqrt{3}}L\theta_0\,.$$



All the quantitative estimates in this section apply only in the limit of small $\theta_{\text{plane}}^{\text{rms}}$ and in the absence of large-angle scatters.

C.6 Longitudinal distribution of electromagnetic showers: A photon of energy $E \gg 0.1$ GeV converting in a semi-infinite medium produces an electromagnetic cascade whose intensity initially increases with depth and then falls off. The average number of $e^\pm$ with kinetic energy above 1.5 MeV, crossing a plane at a depth of L radiation lengths from the beginning of the medium, in a material of atomic number Z, calculated using the Monte Carlo program EGS,[35] can be fit by the empirical formula[36]

$$N = N_0 L^a e^{-bL}\,,$$

where $N_0 = 5.51\ E(\text{GeV})\ \sqrt{Z}\ b^{a+1}/\Gamma(a+1)$ and $b = 0.634 - 0.0021\ Z$. For $Z \geq 26$, $a = 2.0 - Z/340 + (0.664 - Z/340)\ell n\ E$. For $Z = 13$, $a = 1.77 - 0.52\ell n\ E$. The maximum intensity, N_{max}, occurs at the depth $L = a/b$. The maximum error of the fit occurs in the vicinity of this depth and is less than $0.15\ N_{max}$. The integral of the tail, $\int_{1.5a/b}^{\infty} N\,dL$ is fit to better than 2.5%. The total longitudinally projected $e^\pm$ path length, $\int_0^\infty N\,dL = 5.51\ E\ \sqrt{Z}$, is less than the total $e^\pm$ path length due primarily to multiple Coulomb scattering.

C.7 Radiation length: For the passage of electromagnetically interacting particles through a medium it is convenient to measure thickness in terms of radiation length.[37] For most electromagnetic processes (Bremsstrahlung, Coulomb scattering, showering, pair production, etc.), over large energy intervals, some or all of the dependence upon the medium is contained in the radiation length.

The radiation length may be defined as the distance L_R over which a high energy electron ($\gtrsim 1$ GeV for most materials) loses all but a fraction 1/e of its energy to Bremsstrahlung, on average. For a homogeneous monoatomic medium, $Z \geq 5$,

$$\frac{1}{L_R} = \frac{4\alpha r_e^2 N_A Z^2}{A}\left\{\ell n\left[\frac{184.15}{Z^{1/3}}\right] + \frac{1}{Z}\ell n\left[\frac{1194}{Z^{2/3}}\right] - 1.202\alpha^2 Z^2 + 1.0369\alpha^4 Z^4 - \frac{1.008\alpha^6 Z^6}{1+\alpha^2 Z^2}\right\} = \frac{Z^2\{\ \}}{716.405A}\,,$$

where α, r_e, and N_A are found in the Physical Constants Table, and Z and A are the atomic number and weight of the medium. For $Z < 5$, a more complex numerical calculation is required. Radiation lengths for many substances are tabulated in the Table of Atomic and Nuclear Properties of Materials, following. For media which are chemical mixtures or compounds,

$$\frac{1}{L_R} \simeq \sum_i \frac{f_i}{L_R^i}\,,$$

where f_i is the fraction by mass of atoms of type i, radiation length L_R^i. Chemical binding can lower L_R from this, typically by a few per cent.

For electrons of energy below about one GeV, the average fractional energy loss per unit length decreases as the energy decreases (see Fractional Energy Loss for Electrons and Positrons in Lead figure, following). With distances measured in units of L_R, dependence of the Bremsstrahlung fractional energy loss upon Z of the medium in the low energy region ($\gtrsim 10$ MeV) is of order a few percent or less.

For photons of infinite energy, the total pair-production cross section is

$$\sigma = \tfrac{7}{9}(A/L_R N_A)\,.$$

This is accurate to within a few per cent down to ~ 1 GeV for most materials. For energies below about 1 GeV, the cross section varies in a manner which may be determined from the Photon Mass Attenuation figures, following. See also Contributions to Photon Cross Section in Carbon and Lead figure, following.

C.8 Electron practical range: The electron "practical range" — a common measure of straight-line penetration distance — is shorter than the total path length because of multiple Coulomb scattering, which becomes increasingly important as the electron slows down. E.g., for a fast electron the rms projected angle due to multiple Coulomb scattering reaches 1 radian by the time the electron has slowed to 0.4 MeV in hydrogen, 1.5 MeV in carbon, 9 MeV in copper, and 24 MeV in lead. Electrons which have energy less than

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0.2 MeV in Ar, 1.5 MeV in Cu, 3.5 MeV in Sn, and 5 MeV in Pb are likely to deposit 10% of their energy *behind* their starting plane. The practical range, R_p, is defined as that absorber thickness obtained by extrapolating to zero the linearly decreasing part of the curve of penetration probability vs. absorber thickness. Data for Al in the T range up to about 10 MeV are available, and fit (to $\sim\pm 10\%$) $R_p = AT[1\text{-}B/(1+CT)]$ mg cm^{-2}, a form suggested in Ref. 38, with A=0.55 mg cm^{-2} keV^{-1}, B = 0.9841, and C = 0.0030 keV^{-1}. At this penetration depth, 90 - 95% of the incident electrons have stopped. Data for other elements are sketchy, but suggest that higher-Z ($\lesssim 50$) elements have $1 \lesssim R_p/R_p(\mathrm{Al}) \lesssim 1.4$ below ~10 keV, and $0.6 \lesssim R_p/R_p(\mathrm{Al}) \lesssim 1$ above ~ 100 keV. The "critical energy" (above which the energy loss due to bremsstrahlung exceeds that due to ionization, and showering becomes important) is 400 MeV for hydrogen, 100 MeV for carbon, 25 MeV for copper, and 10 MeV for lead. The mean positron range may differ from the mean electron range by several percent. See Refs. 39 and 40. Electron energy deposition and penetration probability vs. range are discussed in Refs. 26, 41, and 42.

C.9 Atomic and nuclear properties of matter: See table following.

C.10 Range and energy loss for heavy projectiles in lead, copper, aluminum, and carbon: See figure following.

C.11 Range and energy loss for heavy projectiles in liquid hydrogen: See figure following.

C.12 Photon mass attenuation coefficients, energy deposition: See figures following.

C.13 Fractional energy loss for electrons and positrons in lead: See figure following.

C.14 Contributions to photon cross section in lead and carbon: See figures following.

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PARTICLE DETECTORS, ABSORBERS, AND RANGES (Cont'd)

Atomic and Nuclear Properties of Materials*

Material	Z	A	Nuclear[a] total cross section σ_T [barn]	Nuclear[b] inelastic cross section σ_I [barn]	Nuclear[c] collision length λ_T [g/cm^2]	Nuclear[c] interaction length λ_I [g/cm^2]	dE/dx min[d] $\overline{\Delta E}$ [MeV/g/cm^2]	dE/dx min[d] E_{mp}, 1 cm [MeV] () is for gas [keV]	Radiation length[e] L_{rad} [g/cm^2]	Radiation length[e] L_{rad} [cm] () is for gas	Density[f] [g/cm^3] () is for gas [g/ℓ]	Refractive index n[f] () is $(n-1)\times10^6$ for gas
H_2	1	1.01	0.0387	0.033	43.3	50.8	4.12	(0.19)	61.28	865	0.0708(0.090)	1.112(140)
D_2	1	2.01	0.073	0.061	45.7	53.7	2.07	(0.17)	122.6	757	0.162(0.177)	1.128
He	2	4.00	0.133	0.102	49.9	65.1	1.94	(0.16)	94.32	755	0.125(0.178)	1.024(35)
Li	3	6.94	0.211	0.157	54.6	73.4	1.58	0.70	82.76	155	0.534	—
Be	4	9.01	0.268	0.199	55.8	75.2	1.61	2.61	65.19	35.3	1.848	—
C	6	12.01	0.331	0.231	60.2	86.3	1.78	3.57	42.70	18.8	2.265[g]	—
N_2	7	14.01	0.379	0.265	61.4	87.8	1.82	(0.93)	37.99	44.5	0.808(1.25)	1.205(300)
O_2	8	16.00	0.420	0.292	63.2	91.0	1.82	(1.31)	34.24	28.7	1.14(1.43)	1.22(266)
Ne	10	20.18	0.507	0.347	66.1	96.6	1.73	(0.75)	28.94	24.0	1.207(0.90)	1.092(67)
Al	13	26.98	0.634	0.421	70.6	106.4	1.62	3.81	24.01	8.9	2.70	—
Si	14	28.09	0.660	0.440	70.6	106.0	1.66	3.36	21.82	9.36	2.33	—
Ar	18	39.95	0.868	0.566	76.4	117.2	1.51	(1.30)	19.55	14.0	1.40(1.78)	1.233(283)
Fe	26	55.85	1.120	0.703	82.8	131.9	1.48	10.7	13.84	1.76	7.87	—
Cu	29	63.54	1.232	0.782	85.6	134.9	1.44	11.85	12.86	1.43	8.96	—
Sn	50	118.69	1.967	1.21	100.2	163	1.26	8.3	8.82	1.21	7.31	—
Xe	54	131.30	2.120	1.29	102.8	169	1.24	(3.57)	8.48	2.77	3.057(5.89)	(705)
W	74	183.85	2.767	1.65	110.3	185	1.16	21.1	6.76	0.35	19.3	—
Pb	82	207.19	2.960	1.77	116.2	194	1.13	11.7	6.37	0.56	11.35	—
U	92	238.03	3.378	1.98	117.0	199	1.09	19.3	6.00	≈0.32	≈18.95	—
Air, 20°C, 1 atm. (STP in paren.)					62.0	90.0	1.82	(1.12)	36.66	(30420)	0.001205(1.29)	1.000273(293)
H_2O					60.1	84.9	2.03	1.72	36.08	36.1	1.00	1.33
Shielding concrete[h]					67.4	99.9	1.70	3.68	26.7	10.7	2.5	—
SiO_2 (quartz)					67.0	99.2	1.72	3.28	27.05	12.3	2.2	1.458
H_2 (bubble chamber 26°K)					43.3	50.8	4.12	0.20	61.28	≈1000	≈0.063[i]	1.100
D_2 (bubble chamber 31°K)					45.7	53.7	2.07	0.22	122.6	≈900	≈0.140[i]	1.110
H-Ne mixture (50 mole percent)[j]					65.0	94.5	1.84	0.59	29.70	73.0	0.407	1.092
Ilford emulsion G5					82.0	134	1.44	4.79	11.0	2.89	3.815	—
NaI					94.8	152	1.32	4.13	9.49	2.59	3.67	1.775
BaF_2					92.1	146	1.35	3.78	9.91	2.05	4.83	1.56
BGO ($Bi_4Ge_3O_{12}$)					97.4	156	1.27	8.07	7.98	1.12	7.1	2.15
Polystyrene, scintillator (CH)[k]					58.4	82.0	1.95	1.72	43.8	42.4	1.032	1.581
Lucite, Plexiglas ($C_5H_8O_2$)					59.2	83.6	1.95	1.98	40.55	≈34.4	1.16-1.20	≈1.49
Polyethylene (CH_2)					56.9	78.8	2.09	1.68	44.8	≈47.9	0.92-0.95	—
Mylar ($C_5H_4O_2$)					60.2	85.7	1.86	2.24	39.95	28.7	1.39	—
Borosilicate glass (Pyrex)[ℓ]					66.2	97.6	1.72	3.32	28.3	12.7	2.23	1.474
CO_2					62.4	90.5	1.82	(1.92)	36.2	(18310)	(1.977)	(410)
Methane CH_4					54.7	74.0	2.41	(0.91)	46.5	(64850)	0.423(0.717)	(444)
Isobutane C_4H_{10}					56.3	77.4	2.22	(3.43)	45.2	(16930)	(2.67)	(1270)
Freon 12 (CCl_2F_2) gas, 26°C, 1 atm.[m]					70.6	106	1.62	4.49	23.7	4810	4.93	1.001080
Silica Aerogel[n]					65.5	95.7	1.83	0.28	29.85	≈150	0.1-0.3	$1.0+0.25\rho$
G10 plate[o]					62.6	90.2	1.87	2.7	33.0	19.4	1.7	—

* Table revised April 1984 by Joachim Engler. For details, see Report KfK 3386B, Kernforschungzentrum, D 7500 Karlsruhe, P.O. Box 3640, FRG.

a. σ_{total} at 80-240 GeV for neutrons (≈ σ for protons) from Murthy et al., Nucl. Phys. **B92**, 269 (1975).

b. $\sigma_{inelastic} = \sigma_{total} - \sigma_{elastic} - \sigma_{quasielastic}$; for neutrons at 60-375 GeV from Roberts et al., Nucl. Phys., **B159**, 56 (1979). For protons and other particles, see Carroll et al., Phys. Lett. **80B**, 319 (1979); note that $\sigma_I(p) \approx \sigma_I(n)$.

c. Mean free path between collisions (λ_T) or inelastic interactions (λ_I), calculated from $\lambda = A/(N\times\sigma)$.

d. For minimum-ionizing protons and pions. $\overline{\Delta E}$ is energy loss per g/cm^2 from Barkas and Berger, *Tables of Energy Losses and Ranges of Heavy Charged Particles*, NASA-SP-3013 (1964). For electrons and positrons see: M.J. Berger and S.M. Seltzer, *Stopping Powers and Ranges of Electrons and Positrons* (2nd Ed.), U.S. National Bureau of Standards report NBSIR 82-2550-A (1982). E_{mp} is the most probable deposited energy in one cm, in MeV for solids and liquids, in keV for gases. E_{mp} varies with depth in a nonproportional manner. (See Sec. C.1 preceding.) Parentheses refer to gaseous form at STP (0°C, 1 atm.).

e. From Y.S. Tsai, Rev. Mod. Phys. **46**, 815 (1974). Corrections for molecular binding applied for H_2, and D_2. Parentheses refer to gaseous form at STP (0°C, 1 atm.).

f. Values for solids, or the liquid phase at boiling point, except as noted. Values in parentheses for gaseous phase at STP (0°C, 1 atm.). Refractive index given for sodium D line.

g. For pure graphite; industrial graphite density may vary 2.1 - 2.3 g/cm^3.

h. Standard shielding blocks, typical composition O_2 52%, Si 32.5%, Ca 6%, Na 1.5%, Fe 2%, Al 4%, plus reinforcing iron bars. The attenuation length, ℓ = 115 ± 5 g/cm^2, is also valid for earth (typical ρ = 2.15), from CERN-LRL-RHEL Shielding exp., UCRL-17841 (1968).

i. Density may vary about ±3%, depending on operating conditions.

j. Values for typical working conditions with H_2 target: 50 mole percent, 29°K, 7 atm.

k. Typical scintillator; e.g., PILOT B and NE 102A have an atomic ratio H/C = 1.10.

ℓ. Main components: 80% SiO_2 + 12% B_2O_3 + 5% Na_2O.

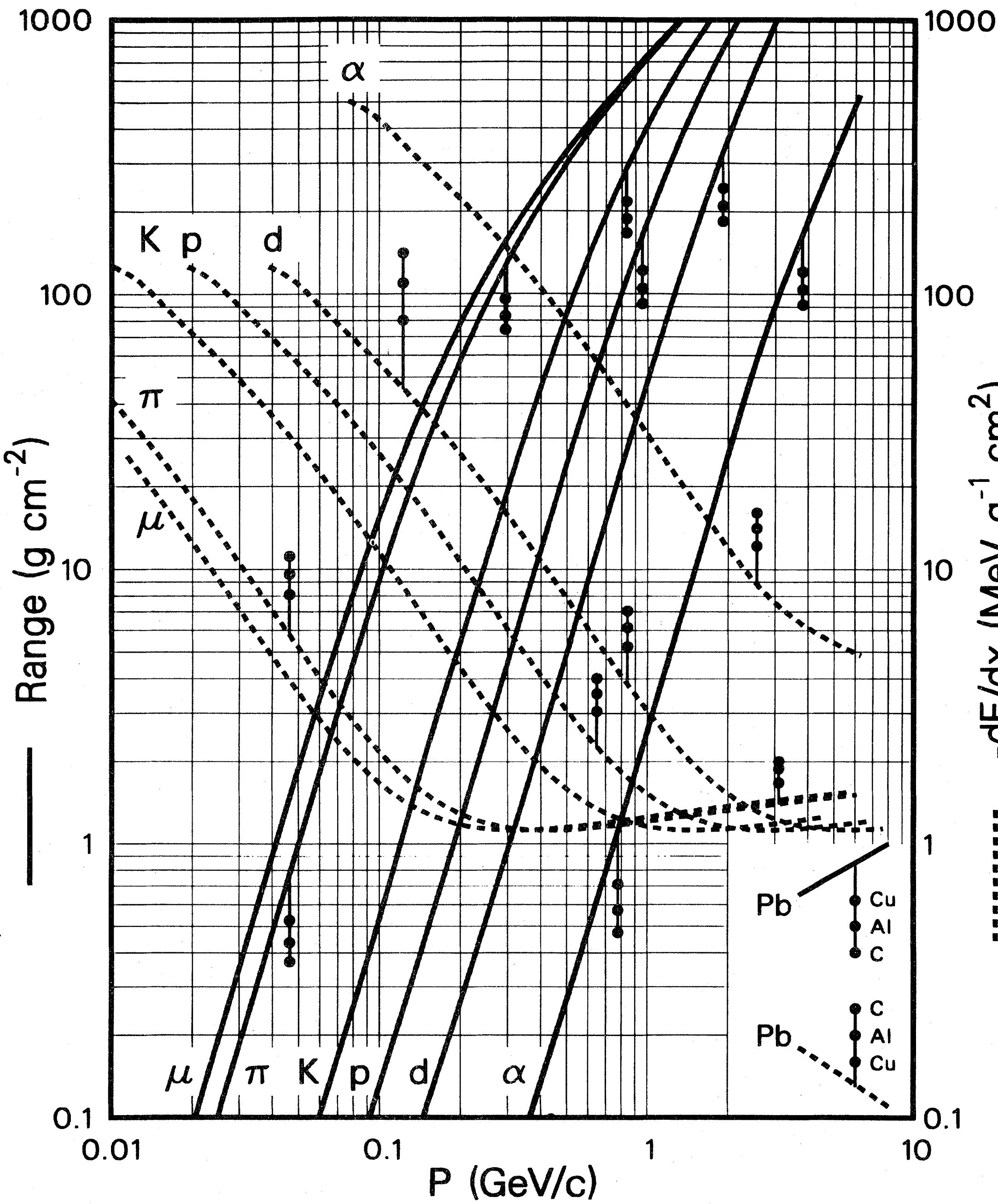
m. Used in Cerenkov counters. Values at 26°C and 1 atm. Indices of refraction from E.R. Hayes, R.A. Schluter, and A. Tamosaitis, ANL-6916 (1964).

n. $n(SiO_2) + 2n(H_2O)$ used in Cerenkov counters, ρ = density in g/cm^3. From M. Cantin et al., Nucl. Instr. Meth. **118**, 177 (1974).

o. G10-plate, typical 60% SiO_2 and 40% Epoxy.

PARTICLE DETECTORS, ABSORBERS, AND RANGES (Cont'd)

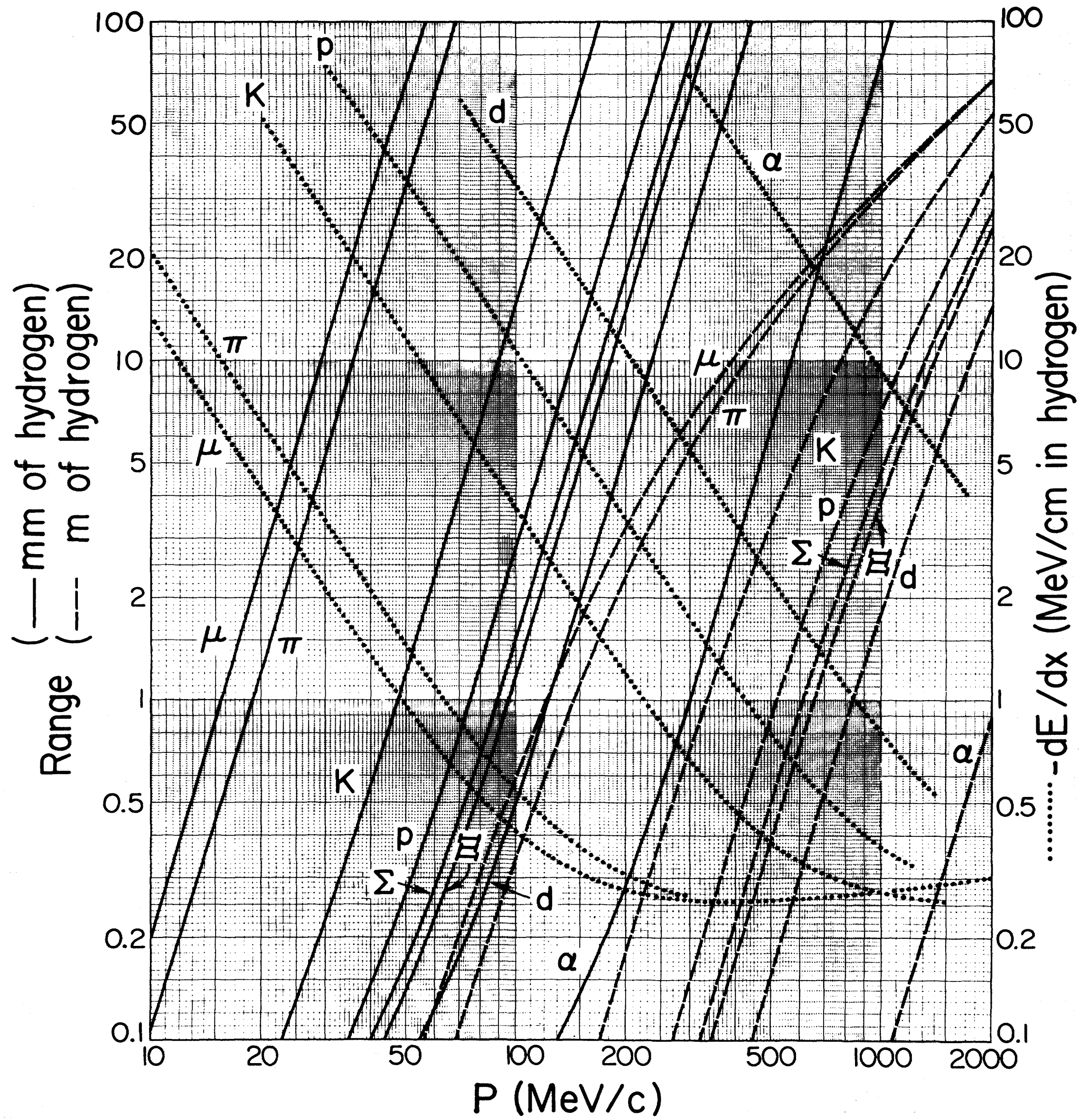
Mean Range and Energy Loss in Lead, Copper, Aluminum, and Carbon



Mean range and energy loss due to ionization for the indicated particles in Pb, with scaling to Cu, Al, and C indicated, using Bethe-Bloch equation (Section C.1 above) with corrections. Calculated by M.J. Berger, using ionization potentials and density effect corrections as discussed in M.J. Berger and S.M. Seltzer, "Stopping Powers and Ranges of Electrons and Positrons," (2nd ed.), U.S. National Bureau of Standards Report NBSIR 82-2550-A (1982). The average ionization potentials (I) assumed were: Pb (823 eV), Cu (322 eV), Al (166 eV), and C (78.0 eV). Figure indicates total path length; observed range may be smaller (by ~ 1 % - 2% in heavy elements) due to multiple scattering, primarily from small energy-loss collisions with nuclei. The functional forms have not been experimentally verified to better than roughly ±1%. For higher energies refer to discussion by Cobb ["A Study of Some Electromagnetic Interactions of High Velocity Particles with Matter," University of Oxford Report HEP/T/55 (1973)] and by Turner ["Penetration of Charged Particles in Matter: A Symposium," National Academy of Sciences, Washington D.C. (1970), p. 48]. Scaling to other beam particles is, to a good approximation, described by the expression on the next page.

PARTICLE DETECTORS, ABSORBERS, AND RANGES (Cont'd)

Mean Range and Energy Loss in Liquid Hydrogen

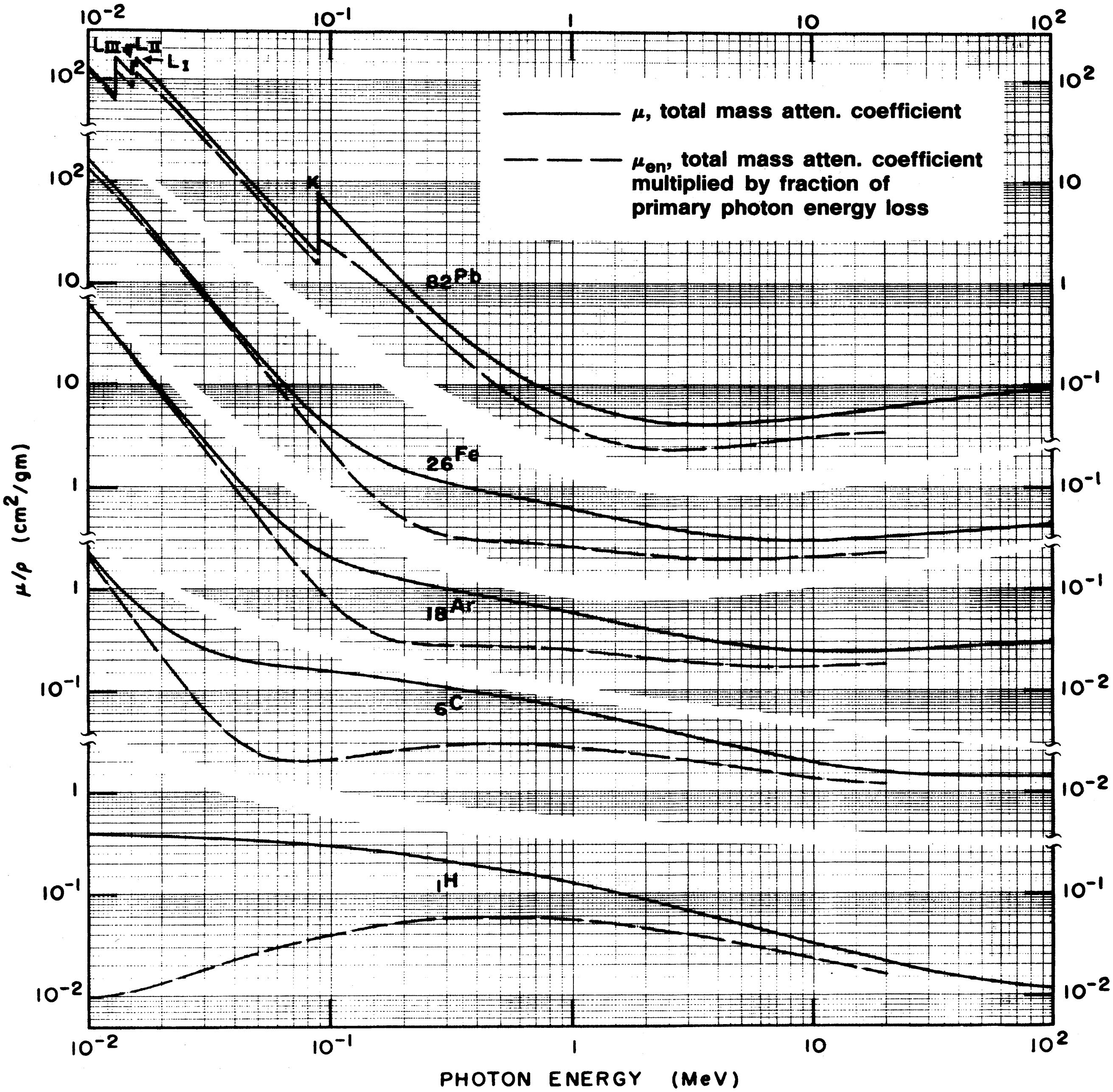


Range and energy loss in liquid hydrogen bubble chamber, based on Bethe-Bloch equation (Section C.1 above), using an average ionization potential for H_2 of I = 20.0 eV, which is an approximate average of the experimental result of Garbincius and Hyman [Phys. Rev. A2, 1834 (1970)] and the theoretical result of Ford and Browne [Phys. Rev. A7, 418 (1973)]. Bubble chamber conditions are chosen to be those of Garbincius and Hyman: parahydrogen of density = 0.0625 g/cm^3 (note: range $\propto$ 1/density), with vapor-pressure 60.8 lb/in^2 (absolute) and temperature 26.2°K. The functional dependence of the Bethe-Bloch equation is not experimentally verified to better than about ± 1% over large momentum ranges. It should be noted that the number of bubbles per cm of a track in a bubble chamber is nearly proportional to $1/\beta^2$, not dE/dx. For the linear portions of the range curves, R $\propto$ p$^{3.6}$. *Scaling law for particles of other mass or charge (except electrons):* for a given medium, the range R_b of any beam particle with mass M_b, charge z_b, and momentum p_b is given in terms of the range R_a of any other particle with mass M_a, charge z_a, and momentum $p_a = p_b M_a/M_b$ (i.e., having the same velocity) by the expression:

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

PARTICLE DETECTORS, ABSORBERS, AND RANGES (Cont'd)

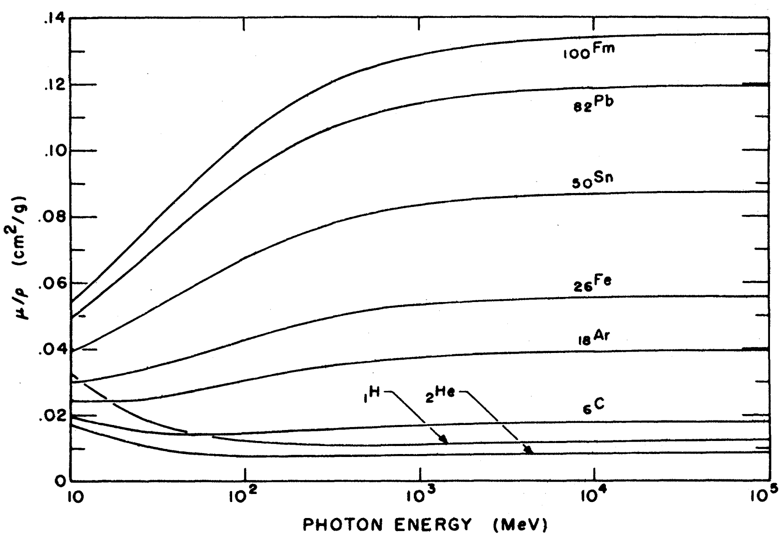
Photon Mass Attenuation Coefficients, Energy Deposition



The photon mass attenuation coefficient μ for various absorbers as a function of photon energy (***solid curves***). For a homogeneous medium of density ρ, the intensity I remaining after traversal of thickness t is given by $I = I_0 \exp(-\mu t)$. The accuracy is a few percent. Interpolation to other Z should be done in the cross section $\sigma = (\mu/\rho)\, A/N_A$ cm^2/atom, where A is the atomic weight of the absorber material and N_A is Avogadro's number. For a chemical compound or mixture, use $(\mu/\rho)_{\rm eff} \simeq \sum w_i(\mu/\rho)_i$, accurate to a few percent, where w_i is the proportion by weight of the $i^{\rm th}$ constituent. See next page for high energy range. The ***dashed curves*** give the mass energy-absorption coefficient μ_{en}, which is μ multiplied by the fraction of photon energy deposited in a small volume (assumed large enough to contain the ranges of most secondary electrons) about the interaction. This fraction is smaller than 1.0 because such processes as Compton scattering and electron bremsstrahlung imply radiation of some of the energy away from the immediate area. The absorption coefficient is an approximation to the energy available for chemical, biological, and other effects associated with exposure to ionizing radiation. At high energies, the range of secondary electrons tends to become comparable to the photon mean free path, and μ_{en} is not a useful approximation. From Hubbell, Gimm, and Øverbø, J. Phys. Chem. Ref. Data 9, 1023 (1980). See also J.H. Hubbell, Int. J. of Applied Rad. and Isotopes 33, 1269 (1982). Figures courtesy J.H. Hubbell.

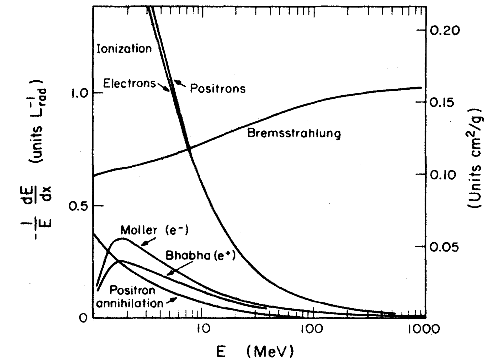
PARTICLE DETECTORS, ABSORBERS, AND RANGES (Cont'd)

Photon Mass Attenuation Coefficients (High Energy)



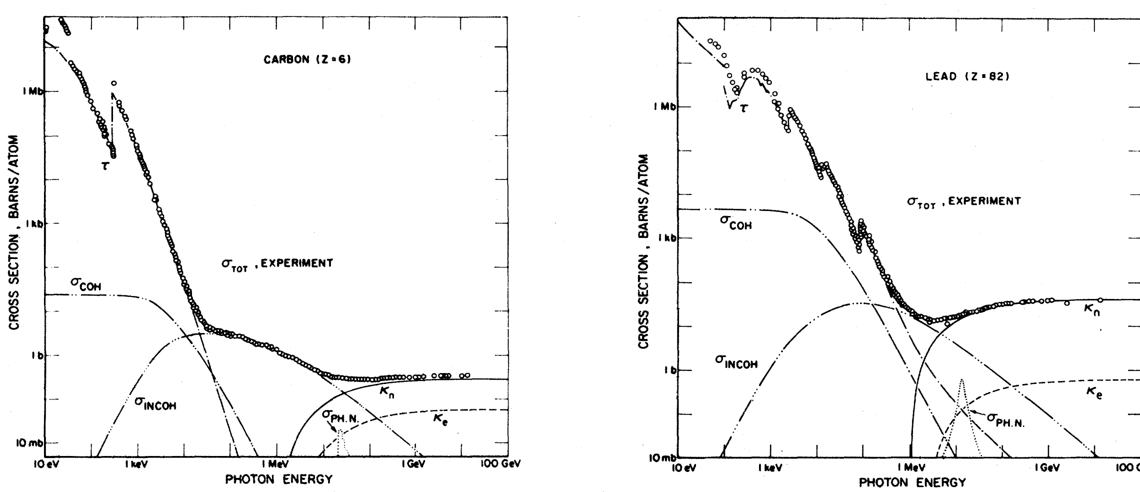
The photon mass attenuation coefficient, high energy range (note that ordinate is linear scale). See caption on previous page for details.

Fractional Energy Loss for Electrons and Positrons in Lead



Fractional energy loss per radiation length in lead as a function of electron or positron energy. Electron (positron) scattering is considered as ionization when the energy loss per collision is below 0.255 MeV, and as Moller (Bhabha) scattering when it is above. Adapted from Fig. 3.2 from Messel and Crawford, *Electron-Photon Shower Distribution Function Tables for Lead, Copper, and Air Absorbers*, Pergamon Press, 1970. Messel and Crawford use $L_r(Pb) = 5.82$ g/cm², but we have modified the figures to reflect the value given in the Table of Atomic and Nuclear Properties of Materials (following), namely $L_r(Pb) = 6.4$ g/cm². The development of electron-photon cascades is approximately independent of absorber when the results are expressed in terms of inverse radiation lengths (i.e., scale on left of plot).

Contributions to Photon Cross Section in Carbon and Lead



Photon total cross sections as a function of energy in carbon and lead, showing the contributions of different processes.

τ	= Atomic photo-effect (electron ejection, photon absorption)
σ_{COH}	= Coherent scattering (Rayleigh scattering — atom neither ionized nor excited)
σ_{INCOH}	= Incoherent scattering (Compton scattering off an electron)
κ_n	= Pair production, nuclear field
κ_e	= Pair production, electron field
$\sigma_{PH.N.}$	= Photonuclear absorption (nuclear absorption, usually followed by emission of a neutron or other particle)

From Hubbell, Gimm, and Øverbø, J. Phys. Chem. Ref. Data 9, 1023 (1980). Figures courtesy J.H. Hubbell.

ELECTROMAGNETIC RELATIONS

Quantity	Gaussian CGS	MKSA
Units and conversions:		
Charge:	2.99792×10^9 esu	$= 1$ coul $= 1$ amp-sec
Potential:	(1/299.792) statvolt $= (1/299.792)$ erg/esu	$= 1$ volt $= 1$ joule/coul
Magnetic field:	10^4 gauss $= 10^4$ dyne/esu	$= 1$ tesla $= 1$ nt/amp-m
Electron charge:	$e = 4.803\,242 \times 10^{-10}$ esu	$= 1.602\,189\,2 \times 10^{-19}$ coul
Lorentz force:	$\mathbf{F} = q(\mathbf{E} + \frac{\mathbf{v}}{c} \times \mathbf{B})$	$\mathbf{F} = q(\mathbf{E} + \mathbf{v} \times \mathbf{B})$
Maxwell equations:	$\nabla \cdot \mathbf{D} = 4\pi\rho$ $\nabla \times \mathbf{E} = -\frac{1}{c}\frac{\partial \mathbf{B}}{\partial t}$ $\nabla \cdot \mathbf{B} = 0$ $\nabla \times \mathbf{H} = \frac{4\pi \mathbf{j}}{c} + \frac{1}{c}\frac{\partial \mathbf{D}}{\partial t}$	$\nabla \cdot \mathbf{D} = \rho$ $\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$ $\nabla \cdot \mathbf{B} = 0$ $\nabla \times \mathbf{H} = \mathbf{j} + \frac{\partial \mathbf{D}}{\partial t}$
Materials:	$\mathbf{D} = \epsilon \mathbf{E}$, $\mathbf{B} = \mu \mathbf{H}$	$\mathbf{D} = \epsilon \mathbf{E}$, $\mathbf{B} = \mu \mathbf{H}$
Dielectric constant:	$\epsilon_{vac} = 1$	$\epsilon_{vac} = \epsilon_0$
Magnetic susceptibility:	$\mu_{vac} = 1$	$\mu_{vac} = \mu_0$
Fields:	$\mathbf{E} = -\nabla V - \frac{1}{c}\frac{\partial \mathbf{A}}{\partial t}$ $\mathbf{B} = \nabla \times \mathbf{A}$	$\mathbf{E} = -\nabla V - \frac{\partial \mathbf{A}}{\partial t}$ $\mathbf{B} = \nabla \times \mathbf{A}$
Static potentials: (coulomb gauge)	$V = \sum_{\text{charges}} \frac{q}{r}$ $\mathbf{A} = \frac{1}{c} \sum_{\text{currents}} \frac{\mathbf{I}}{r}$	$V = \frac{1}{4\pi\epsilon_0} \sum_{\text{charges}} \frac{q}{r}$ $\mathbf{A} = \frac{\mu_0}{4\pi} \sum_{\text{currents}} \frac{\mathbf{I}}{r}$
Relativistic transformations: (v is the velocity of primed system as seen in unprimed system)	$\mathbf{E}'_{\parallel} = \mathbf{E}_{\parallel}$ $\mathbf{E}'_{\perp} = \gamma(\mathbf{E}_{\perp} + \frac{1}{c}\mathbf{v} \times \mathbf{B})$ $\mathbf{B}'_{\parallel} = \mathbf{B}_{\parallel}$ $\mathbf{B}'_{\perp} = \gamma(\mathbf{B}_{\perp} - \frac{1}{c}\mathbf{v} \times \mathbf{E})$	$\mathbf{E}'_{\parallel} = \mathbf{E}_{\parallel}$ $\mathbf{E}'_{\perp} = \gamma(\mathbf{E}_{\perp} + \mathbf{v} \times \mathbf{B})$ $\mathbf{B}'_{\parallel} = \mathbf{B}_{\parallel}$ $\mathbf{B}'_{\perp} = \gamma(\mathbf{B}_{\perp} - \frac{1}{c^2}\mathbf{v} \times \mathbf{E})$
	$4\pi\epsilon_0 = \frac{1}{c^2} 10^7 \frac{\text{coul}^2}{\text{nt sec}^2} = \frac{1}{8.987} 55 \times 10^{-9} \frac{\text{coul}^2}{\text{nt m}^2}$ $\frac{\mu_0}{4\pi} = 10^{-7} \frac{\text{nt sec}^2}{\text{coul}^2}$; $c = 2.997\,924\,58 \times 10^8$ m sec^{-1}	

Impedances (MKSA)

ρ = resistivity in 10^{-8} Ωm:

~ 1.7 for Cu	~ 5.5 for W
~ 2.4 for Au	~ 73 for SS 304
~ 2.8 for Al	~ 100 for Nichrome
(Al alloys may have double this value.)	

For alternating currents, instantaneous current I, voltage V, angular frequency ω:

$$V = V_0 e^{i\omega t} = ZI\,.$$

Impedance of self-inductance L: $Z = i\omega L$.

Impedance of capacitance C: $Z = 1/i\omega C$.

Impedance of free space: $Z = \sqrt{\mu_0/\epsilon_0} = 376.7\ \Omega$.

Impedance per unit length of a flat conductor of width w (high frequency, ν):

$$Z = \frac{(1+i)\rho}{w\delta}\text{ , where } \delta = \text{effective skin depth ;}$$

$$\delta = \sqrt{\frac{\rho}{\pi\nu\mu}} \approx \frac{6.6\text{ cm}}{\sqrt{\nu(\text{sec}^{-1})}} \text{ for Cu .}$$

Capacitance $\hat{C}$ and inductance $\hat{L}$ per unit length (MKSA)

Flat rectangular plates of width w, separated by d << w:

$$\hat{C} = \epsilon\frac{w}{d}\ ;\ \hat{L} = \mu\frac{d}{w}\ ;$$

$$\frac{\epsilon}{\epsilon_0} = 2 \text{ to } 6 \text{ for plastics; } 4 \text{ to } 8 \text{ for porcelain, glasses.}$$

Coaxial cable of inner radius r_1, outer radius r_2:

$$\hat{C} = \frac{2\pi\epsilon}{\ell n(r_2/r_1)}\ ;\ \hat{L} = \frac{\mu}{2\pi}\ell n(r_2/r_1)\,.$$

Transmission lines (no loss):

Impedance: $Z = \sqrt{\hat{L}/\hat{C}}$.

Velocity: $v = 1/\sqrt{\hat{L}\hat{C}} = 1/\sqrt{\mu\epsilon}$.

Motion of charged particles in a uniform, static, magnetic field

The path of motion of a charged particle of momentum p is a helix of constant radius R and constant pitch angle λ, with the axis of the helix along **B**:

$$p(\text{GeV}/c)\cos\lambda = 0.29979\ q\ B(\text{tesla})\ R(\text{m})\,,$$

where the charge q is in units of the electronic charge. The angular velocity about the axis of the helix is

$$\omega(\text{rad sec}^{-1}) = 8.98755 \times 10^7\ q\ B(\text{tesla})/E(\text{GeV})\,,$$

where E is the energy of the particle.

ELECTROMAGNETIC RELATIONS (Cont'd)

Synchrotron radiation (CGS)

For a relativistic particle of charge e, velocity β, γ, energy E, traveling in a circular orbit of radius R:

$$\text{Energy loss/revolution (MeV)} = \frac{4\pi}{3}\frac{e^2}{R}\beta^3\gamma^4$$

$$\simeq 0.0885\ [E(\text{GeV})]^4/R(\text{m}) \text{ for } e^{\pm} \text{ if } \beta \simeq 1.$$

Energy spectrum: The energy radiated into the photon energy interval $d(\hbar\omega)$ is

$$dI = \alpha\gamma F(\omega/\omega_c) d(\hbar\omega)\,,$$

where $\alpha = e^2/(\hbar c)$ is the fine-structure constant,

$F(y) = 2\sqrt{3}y\int_{2y}^{\infty} dx\, K_{5/3}(x)$, with $K_{5/3}(x)$ a modified spherical Bessel function of the third kind, and $\omega_c = 3\gamma^3 c/R$ is a critical frequency;

$$\hbar\omega_c\ (\text{keV}) \simeq 4.44\ [E(\text{GeV})]^3/R(\text{m}) \text{ for } e^{\pm} \text{ if } \beta \simeq 1.$$

In the limit $\gamma >> 1$,

for $\omega << \omega_c$:

$$\frac{dI}{d(\hbar\omega)} \simeq 3.3\alpha\left[\frac{\omega R}{c}\right]^{1/3};$$

for $\frac{\omega}{\omega_c} = (0.01, 0.1, 0.2, 1.0, 2.0)$:

$$\frac{dI}{d(\hbar\omega)} \simeq (1.0, 1.6, 1.6, 0.5, 0.08)\alpha\gamma \text{, respectively;}$$

for $\omega \gtrsim 2\omega_c$:

$$\frac{dI}{d(\hbar\omega)} \simeq \sqrt{3\pi}\alpha\gamma\left[\frac{\omega}{\omega_c}\right]^{1/2} e^{-2\omega/\omega_c}.$$

The radiation is confined to angles $\lesssim 1/\gamma$ relative to the instantaneous direction of motion.

See J.D. Jackson, *Classical Electrodynamics*, 2nd edition (John Wiley & Sons, New York, 1975) for more formulae and details. (Prepared April 1974; revised April 1984.)

RADIOACTIVITY AND RADIATION PROTECTION

The International Commission on Radiation Units and Measurements (ICRU) recommends the use of SI units. Therefore we list SI units first, followed by cgs (or other common) units in parentheses, where they differ.

Unit of activity = becquerel (curie):
1 Bq = 1 disintegration/sec [= $1/(3.7\times10^{10})$ Ci].

Unit of exposure, the quantity of X- or γ- radiation at a point in space integrated over time, in terms of charge of either sign produced by showering electrons in a small volume of air about the point:
= 1 coul/kg of air (roentgen; 1 R = 2.58×10^{-4} coul/kg
= 1 esu/cm^3 = 87.8 erg released energy per g of air); implicit in the definition is the assumption that the small test volume is embedded in a sufficiently large uniformly irradiated volume that the number of secondary electrons entering the volume equals the number leaving.

Unit of absorbed dose = gray (rad):
1 Gy = 1 joule/kg (= 10^4 erg/g = 10^2 rad)
= 6.24×10^{12} MeV/kg deposited energy.

Unit of dose equivalent (for biological damage) = sievert [= 10^2 rem (roentgen equivalent for man)]:
Dose equivalent in Sv = grays × Q, where Q (quality factor) expresses long-term risk (primarily cancer and leukemia) from low-level chronic exposure; it depends upon the type of radiation and other factors. For γ rays and β particles, Q $\simeq$ 1; for protons, Q $\simeq$ 1 at $\sim$10 MeV, rising gradually to $\simeq$ 2 at $\sim$1 GeV; for thermal neutrons, Q $\simeq$ 3; for fast neutrons, Q ranges up to 10; and for α particles and heavy ions (assuming internal deposition — skin and clothing are usually sufficient protection against external sources), Q $\simeq$ 20.

Natural annual background, all sources: Most world areas, whole-body dose equivalent rate $\simeq$ (0.4-4) mSv (40-400 millirems). Can range up to 50 mSv (5 rems) in certain areas. U.S. average $\simeq$ 0.8 mSv. The lungs receive an additional $\simeq$ 0.1 mSv ($\simeq$ 10 mrem) from inhaled natural radioactivity, mostly radon and radon daughters (good to $\simeq$ factor of 2 in open areas; can range an order of magnitude higher in buildings and up to 1000× in poorly ventilated mines).

Cosmic ray background in counters (Earth's surface):
$\sim10^4$/min/m^2/ster. For more accurate estimates and more details, see Sec. B of Particle Detectors, Absorbers, and Ranges.

Fluxes (per m^2) to deposit one Gy in one kg of matter, assuming uniform irradiation:
$\simeq$ **(charged particles)** 6.24×10^{12}/(dE/dx), where dE/dx (MeV m^2/kg), the energy loss per unit length, may be obtained (after conversion of units) from the Mean Range and Energy Loss figures.
$\simeq$ 3.5×10^{13} minimum-ionizing singly charged particles in carbon.
$\simeq$ **(photons)** $6.24\times10^{12}/[E(\text{MeV})(\mu_{en}/\rho)(\text{m}^2/\text{kg})]$, for photons of energy E, mass energy absorption coefficient μ_{en}, and density ρ (see Photon Mass Attenuation Coefficients, Energy Deposition figure), for samples of thickness enough to contain the secondary electrons but $<< 1/\mu_{en}$.
$\simeq$ 2×10^{15} photons of 1 MeV energy on carbon.
(Quoted fluxes good to about a factor of 2 for all materials.)

U.S. maximum permissible occupational dose for the whole body:
50 mSv/year (5 rem/year).

Lethal dose: Whole-body dose from penetrating ionizing radiation resulting in 50% mortality in 30 days (assuming no medical treatment), 2.5-3.0 Gy (250-300 rads) as measured internally on body longitudinal center line; surface dose varies due to variable body attenuation and may be a strong function of energy.

For a recent review, see E. Pochin, *Nuclear Radiation: Risks and Benefits* (Clarendon Press, Oxford, 1983).

PERIODIC TABLE OF THE ELEMENTS

IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIII	VIII	VIII	IB	IIB	IIIA	IVA	VA	VIA	VIIA	
								1 H 1.0079									2 He 4.00260
3 Li 6.94	4 Be 9.01218											5 B 10.81	6 C 12.011	7 N 14.0067	8 O 15.9994	9 F 18.998403	10 Ne 20.17
11 Na 22.98977	12 Mg 24.305											13 Al 26.98154	14 Si 28.0855	15 P 30.97376	16 S 32.06	17 Cl 35.453	18 Ar 39.948
19 K 39.0983	20 Ca 40.08	21 Sc 44.9559	22 Ti 47.90	23 V 50.9415	24 Cr 51.996	25 Mn 54.9380	26 Fe 55.847	27 Co 58.9332	28 Ni 58.71	29 Cu 63.546	30 Zn 65.38	31 Ga 69.735	32 Ge 72.59	33 As 74.9216	34 Se 78.96	35 Br 79.904	36 Kr 83.80
37 Rb 85.467	38 Sr 87.62	39 Y 88.9059	40 Zr 91.22	41 Nb 92.9064	42 Mo 95.94	43 Tc 98.9062	44 Ru 101.07	45 Rh 102.9055	46 Pd 106.4	47 Ag 107.868	48 Cd 112.41	49 In 114.82	50 Sn 118.69	51 Sb 121.75	52 Te 127.60	53 I 126.9045	54 Xe 131.30
55 Cs 132.9054	56 Ba 137.33	57–71 Rare Earths	72 Hf 178.49	73 Ta 180.947	74 W 183.85	75 Re 186.207	76 Os 190.2	77 Ir 192.22	78 Pt 195.09	79 Au 196.9665	80 Hg 200.59	81 Tl 204.37	82 Pb 207.2	83 Bi 208.9804	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra 226.0254	89– Acti- nides	104 (260)	105 (260)	106 (263)												

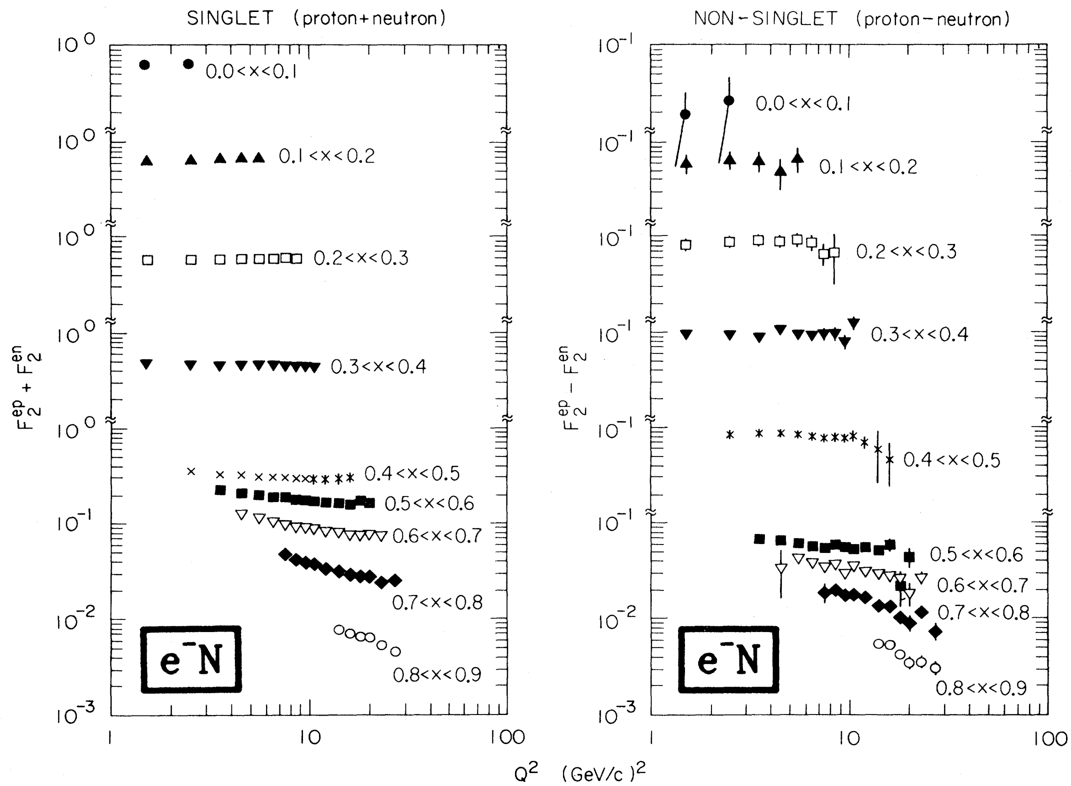
57 La 138.9055	58 Ce 140.12	59 Pr 140.9077	60 Nd 144.24	61 Pm (145)	62 Sm 150.4	63 Eu 151.96	64 Gd 157.25	65 Tb 158.9254	66 Dy 162.50	67 Ho 164.9304	68 Er 167.26	69 Tm 168.9342	70 Yb 173.04	71 Lu 174.967	Rare earths (Lanthanide series)
89 Ac (227)	90 Th 232.0381	91 Pa 231.0359	92 U 238.029	93 Np 237.0482	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (254)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (260)	Actinide series

Upper number is atomic number, expressing the positive charge of the nucleus in multiples of the electronic charge e. Lower number is atomic mass weighted by isotopic abundance in earth's surface, relative to the mass of the carbon 12 isotope, which has been arbitrarily assigned a mass of 12.00000 atomic mass units (amu). Numbers in parentheses are mass numbers (the whole number nearest the value of the atomic mass, in amu) of most stable isotope of that element. Adapted from the *Handbook of Chemistry and Physics, 64th Ed., 1983-1984.* (Particle Data Group update, April 1984.)

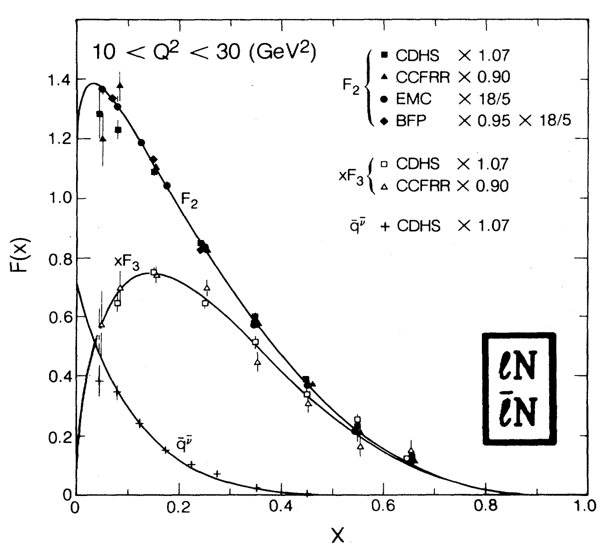
PLOTS OF CROSS SECTIONS AND RELATED QUANTITIES

NOTE: THE FIGURES IN THIS SECTION ARE INTENDED TO SHOW THE "BEST" OR "MOST REPRESENTATIVE" DATA IN THE OPINION OF THE COMPILER. THEY ARE NOT NECESSARILY COMPLETE COMPILATIONS OF ALL THE WORLD'S RELIABLE DATA.

Structure Functions



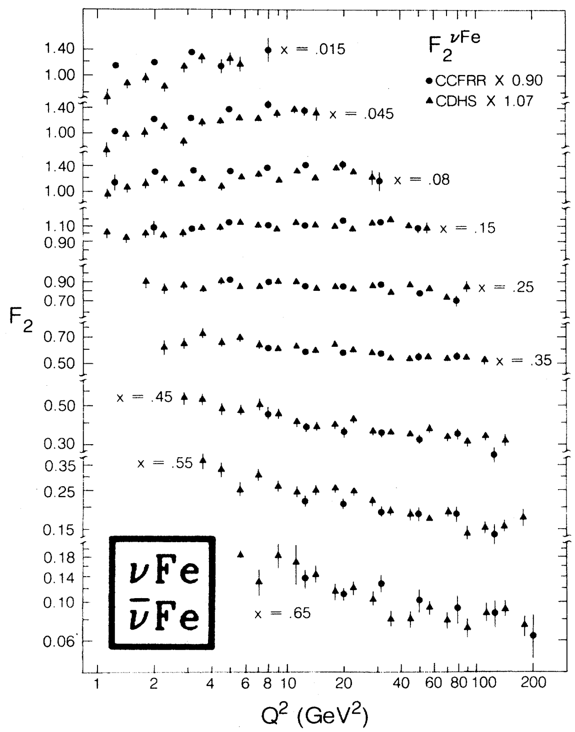
F_2 structure functions derived from inelastic electron-nucleon data taken at SLAC[1-4] with recoil mass > 2 GeV and four-momentum transfer squared $Q^2 > 1$ (GeV/c)^2 are shown. For definitions of F_2, x, and Q^2, see the Kinematics, Decays, and Scattering Section. $R = \sigma_L/\sigma_T = 0.21$ [3] was assumed. Systematic errors are comparable in size to the data point symbols. Corrections for nucleon motion in deuterium have been made. These corrections are small except for x > 0.7. No error was included to account for uncertainties in this correction. References: 1) A. Bodek et al., Phys. Rev. D20, 1471 (1979); 2) W.B. Atwood et al., SLAC Report No. 185 (1975); 3) M.D. Mestayer, SLAC Report No. 214 (1978); 4) S. Stein et al., Phys. Rev. D12, 1884 (1975). Courtesy W.B. Atwood, SLAC.

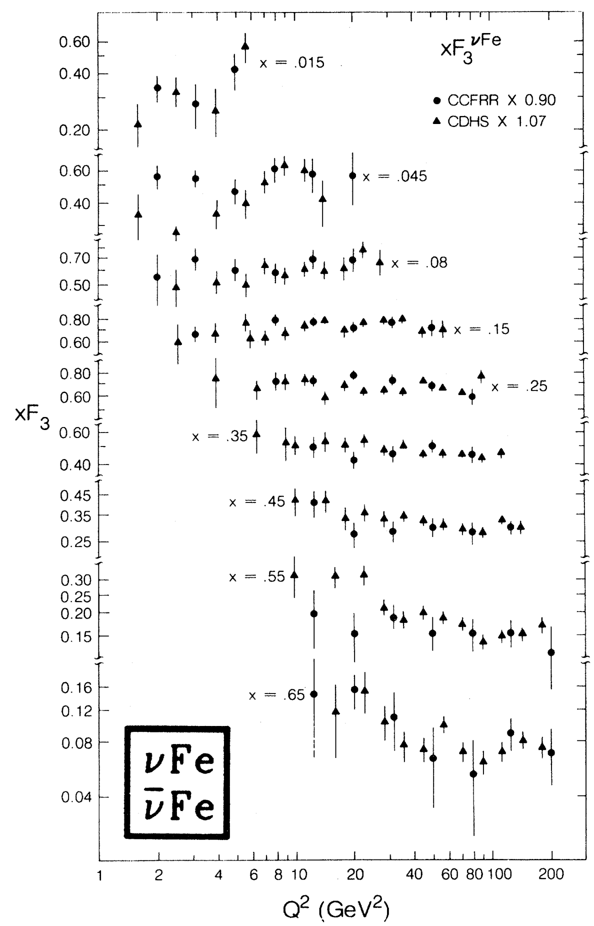


Structure functions F_2, xF_3, and $\overline{q}^\nu$, measured in different experiments, for fixed Q^2 versus x, plotted assuming $R = \sigma_L/\sigma_T = 0$. The electromagnetic structure function $F_2^{\mu N}$ measured by EMC and BFP is compared with the charged-current structure function $F_2^{\nu N}$ using the 18/5 factor from the average charge squared of the quarks. No correction has been applied for the difference between the strange and charm sea quarks so the interpretation is $F_2 = x[q + \overline{q} - \frac{3}{5}(s + \overline{s} - c - \overline{c})]$. (In this Q^2 range, $F_2^{\nu N}$ is depleted by a similar amount due to charm threshold effects in the transition $s \to c$.) The antiquark distribution measured from antineutrino scattering is $\overline{q}^\nu = x(\overline{u} + \overline{d} + 2\overline{s})$. The solid lines have the forms: $F_2 = 3.9x^{0.55}(1-x)^{3.2} + 1.1(1-x)^8$, $xF_3 = 3.6x^{0.55}(1-x)^{3.2}$, $\overline{q}^\nu = 0.7(1-x)^8$. Relative normalization factors have been fitted to optimize agreement between the different data sets, and absolute changes have been arbitrarily chosen as indicated. References: CDHS — H. Abramowicz et al., Zeit. Phys. C17, 283 (1983); CCFRR — F. Sciulli, private communication; EMC — J.J. Aubert et al., Phys. Lett. 105B, 322 (1981); and A. Edwards, private communication; BFP — A.R. Clark et al., Phys. Rev. Lett. 51, 1826 (1983); and P. Meyers, Ph.D. Thesis, LBL-17108 (1983), Univ. of Calif., Berkeley. Courtesy J. Carr, LBL.

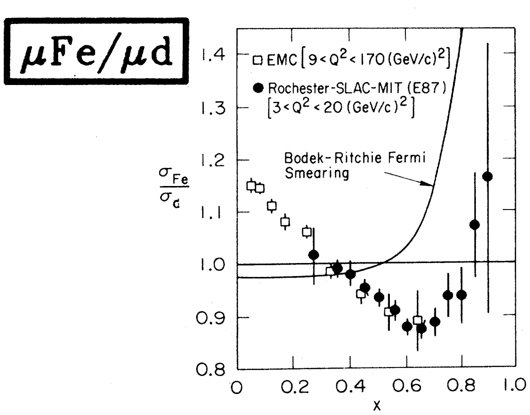
PLOTS OF CROSS SECTIONS AND RELATED QUANTITIES (Cont'd)

Structure Functions





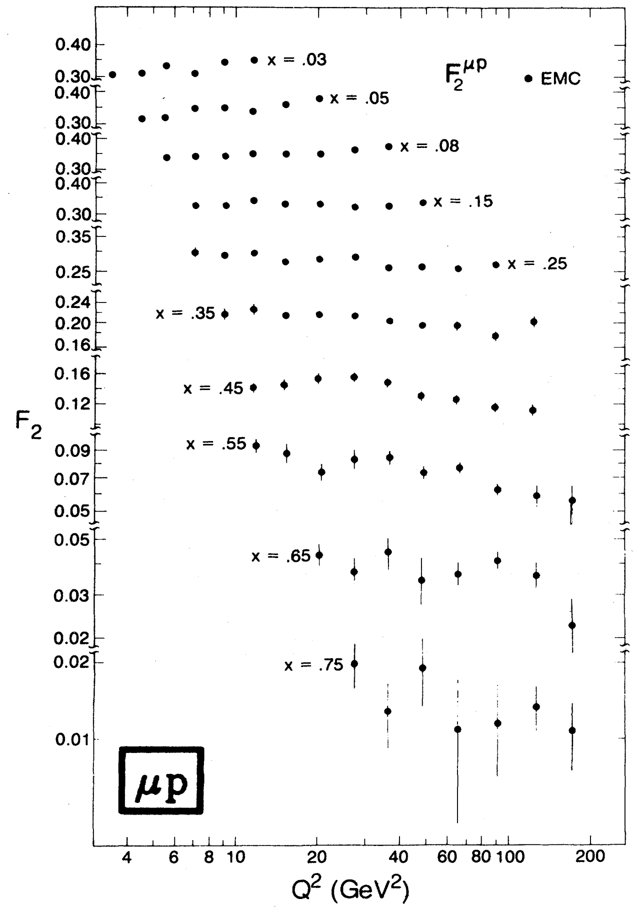
Structure functions F_2 and xF_3 for nucleons, measured in charged-current neutrino and antineutrino scattering from iron targets with $20 < E_\nu < 300$ GeV, versus Q^2 for fixed bins of x, plotted assuming $R = \sigma_L/\sigma_T = 0.1$. A relative normalization factor has been fitted to optimize the agreement between the different data sets, and absolute changes to the published data have been arbitrarily chosen as indicated. The point-to-point systematic errors for both experiments are generally smaller or of the same order as the statistical errors. In addition, CDHS quote an overall scale error of ±6% for F_2 and ±8% for xF_3, while for the CCFRR data the scale error is estimated to be ±4%. References: CDHS — H. Abramowicz et al., Zeit. Phys. C17, 283 (1983); CCFRR — F. Sciulli, private communication. Courtesy J. Carr, LBL.



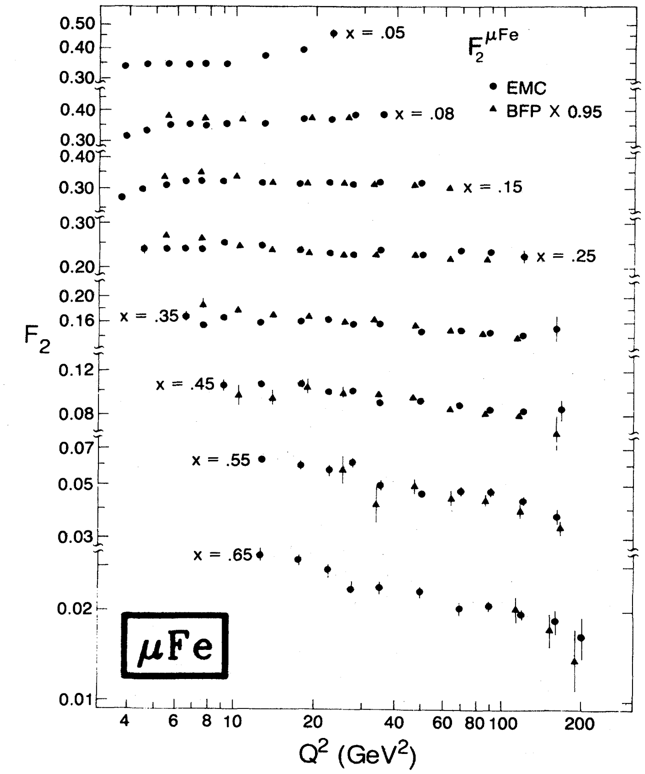
The "EMC" effect: the ratio of the differential cross section per nucleon, σ_{Fe}/σ_d, measured in electromagnetic deep inelastic scattering on iron and deuterium targets. (For equal values of $R = \sigma_L/\sigma_T$ on each target, $\sigma_{Fe}/\sigma_d = F_2^{Fe}/F_2^d$). The curve indicates the contribution to the ratio from Fermi motion in the nucleus [Phys. Rev. D23, 1070 (1981) and D24, 1400 (1981)]. The errors plotted are statistical only. The systematic errors are estimated as ±0.011 for the Rochester-SLAC-MIT data, and ±0.015 at x = 0.35 and ±0.06 at x = 0.05 and x = 0.65 for the EMC data. References: Rochester-SLAC-MIT (electrons) — Phys. Rev. Lett. 50, 1431 (1983); and EMC (muons) — Phys. Lett. 123B, 275 (1983). Courtesy D. Coward, SLAC.

PLOTS OF CROSS SECTIONS AND RELATED QUANTITIES (Cont'd)

Structure Functions

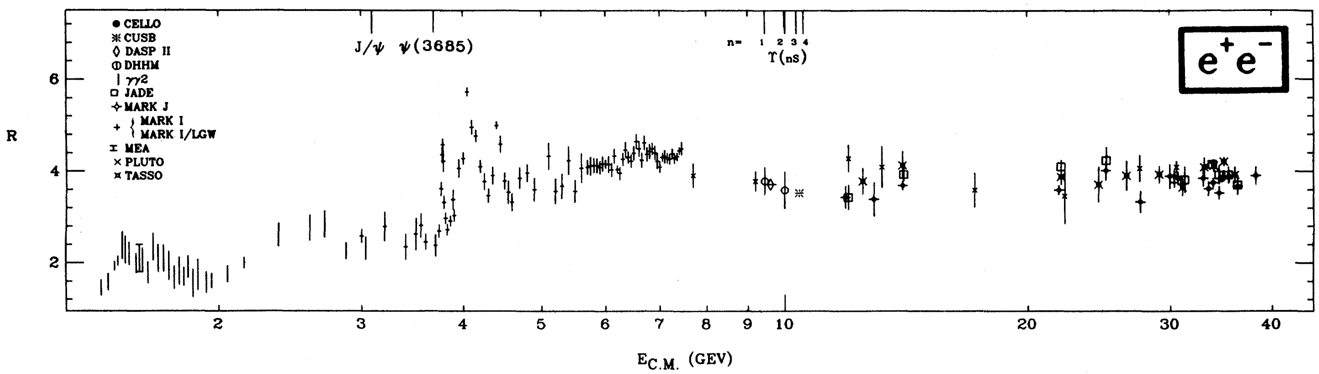


Structure function F_2^p, measured in electromagnetic muon scattering from a hydrogen target with beam energies 120, 200, 240, 280 GeV, versus Q^2 for fixed bins of x, plotted assuming $R = \sigma_L/\sigma_T = 0$. References: J.J. Aubert et al., Phys. Lett. **105B**, 315 (1981); and A. Edwards, private communication. Courtesy J. Carr, LBL.

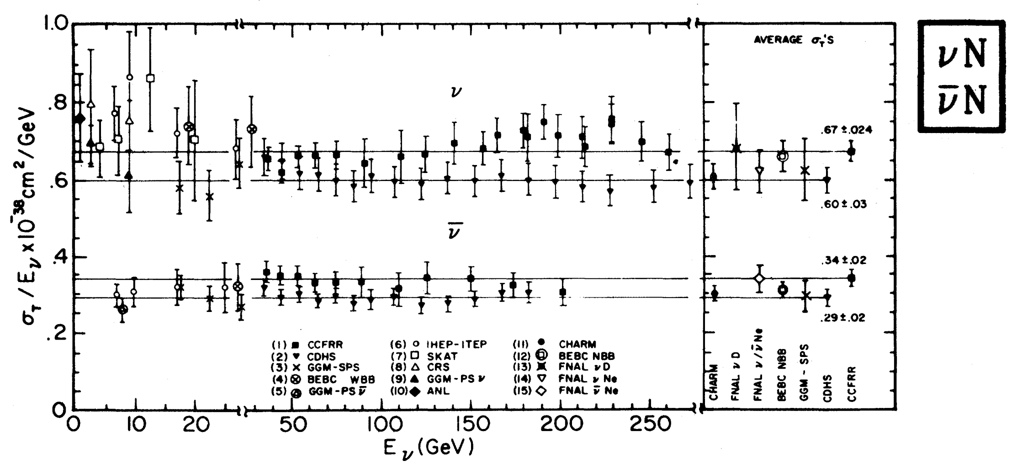


Structure function F_2 per nucleon, measured in electromagnetic muon scattering from iron targets with beam energies 120, 200, 250, 280 GeV (EMC) and 93, 215 GeV (BFP), versus Q^2 for fixed bins of x, plotted assuming $R = \sigma_L/\sigma_T = 0$. A relative normalization factor has been fitted to optimize agreement between the different data sets and has been arbitrarily applied to one data set as indicated. References: **EMC** — J.J. Aubert et al., Phys. Lett. **105B**, 322 (1981); and A. Edwards, private communication; **BFP** — A.R. Clark et al., Phys. Rev. Lett. **51**, 1826 (1983); and P. Meyers, Ph.D. Thesis, LBL-17108 (1983), Univ. of Calif., Berkeley. Courtesy J. Carr, LBL.

PLOTS OF CROSS SECTIONS AND RELATED QUANTITIES (Cont'd)

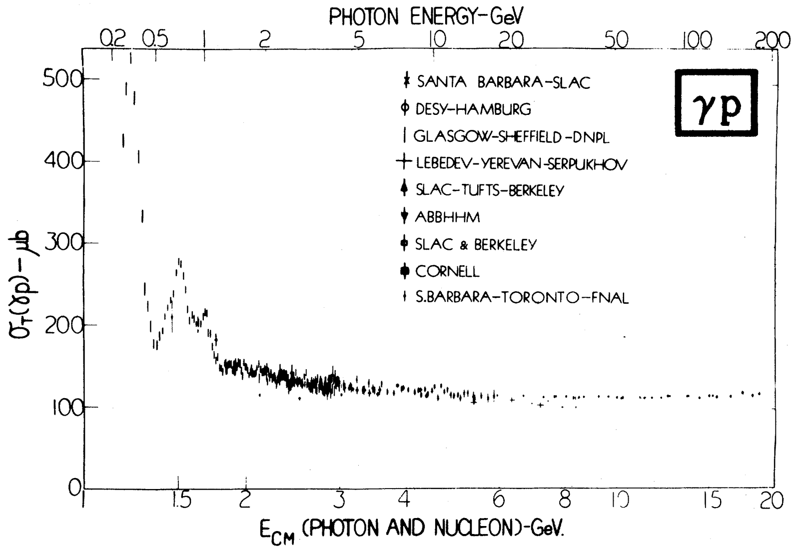


Measurements of R $\equiv \sigma(e^+e^- \rightarrow \text{hadrons})/\sigma(e^+e^- \rightarrow \mu^+\mu^-)$, where the annihilation proceeds via one photon. The denominator is a calculated quantity; see the section on Kinematics, Decays, and Scattering. Radiative corrections and, where important, corrections for two-photon processes and τ production have been made. Note that the ADONE data ($\gamma\gamma2$ and MEA) is for $\geqslant$3 hadrons. The points in the ψ(3770) region are from the MARK I - Lead Glass Wall experiment. The DASP [R. Brandelik et al., Phys. Lett. **76B**, 361 (1978)] and PLUTO (see references below) measurements have been omitted in the charm threshold region for clarity. Also for clarity, some points have been combined or shifted slightly (<4%) in $E_{c.m.}$, and some points with low statistical significance have been omitted. Systematic normalization errors are not included; they range from ~5 - 20%, depending on experiment. Note the suppressed zero. The horizontal extent of the plot symbols has no significance. The positions of the J/ψ(3100), ψ(3685), and the four known Υ vector-meson resonances are indicated at the top of the figure. References: **CELLO** — H.-J. Behrend et al., Phys. Lett. **B**, to be published (preprint DESY 81-029); **CUSB** — E. Rice et al., Phys. Rev. Lett. **48**, 906 (1982); **DASP II** — Phys. Lett. **116B**, 383 (1982); **DHHM** — P. Bock et al. (DESY-Hamburg-Heidelberg-MPI München Collab.), Zeit. fur Physik **C6**, 125 (1980); **$\gamma\gamma$2** — C. Bacci et al., Phys. Lett. **86B**, 234 (1979); **JADE** — W. Bartel et al., Phys. Lett. **129B**, 145 (1983); **MARK J** — B. Adeva et al., Phys. Rev. Lett. **50**, 799 (1983); and H. Newman, private communication; **MARK I** — J.L. Siegrist et al., Phys. Rev. **D26**, 969 (1982); **MARK I + Lead Glass Wall** — P.A. Rapidis et al., Phys. Rev. Lett. **39**, 526 (1977); and P.A. Rapidis, thesis, SLAC-Report-220 (1979); **MEA** — B. Esposito et al., Lett. Nuovo Cimento **19**, 21 (1977); **PLUTO** — A. Bäcker, thesis Gesamthochschule Siegen, DESY F33-77/03 (1977); C. Gerke, thesis, Hamburg Univ. (1979); Ch. Berger et al., Phys. Lett. **81B**, 410 (1979); and W. Lackas, thesis, RWTH Aachen, DESY PLUTO-81/11 (1981); **TASSO** — R. Brandelik et al., Phys. Lett. **113B**, 499 (1982).

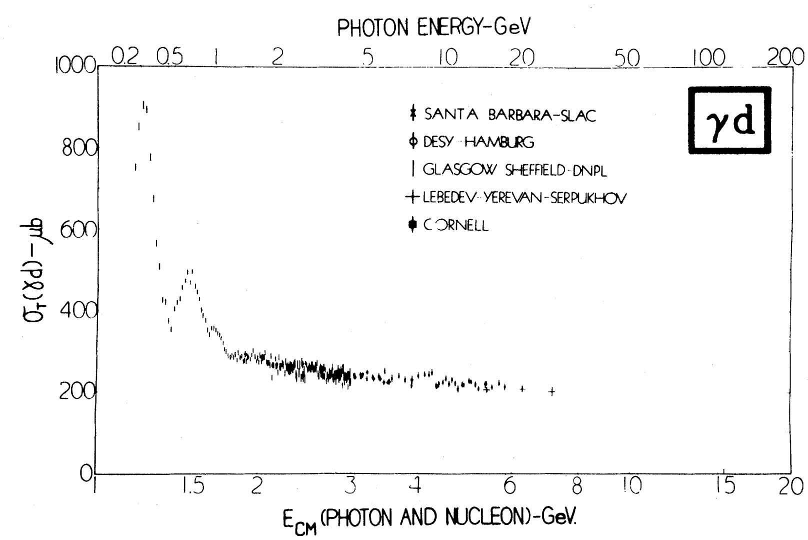


σ_T/E_ν for the muon neutrino and antineutrino charged-current total cross section as a function of neutrino energy. The error bars include both statistical and systematic errors. The straight lines are averages for the CCFRR and CDHS measurements. Note the change in the energy scale between 20 and 50 GeV. The data points on the right give averages for other high energy measurements. References: (1) R. Blair et al., Phys. Rev. Lett. **51**, 343 (1983), and J.R. Lee, Ph.D. Thesis, Caltech (1981), "Measurements of νN Charged Current Cross Sections from E_ν = 25 GeV to E_ν = 260 GeV;" (2) H. Abramowicz et al., Zeit. fur Physik **C17**, 283 (1983); (3) J. Morfin et al., Phys. Lett. **104B**, 235 (1981); (4) D.C. Colley et al., Zeit. fur Physik **C2**, 187 (1979); (5) O. Erriquez et al., Phys. Lett. **80B**, 309 (1979); (6) A.S. Vovenko et al., Sov. J. Nucl. Phys. **30**, 527 (1979); (7) D.S. Baranov et al., Phys. Lett. **81B**, 255 (1979); (8) C. Baltay et al., Phys. Rev. Lett. **44**, 916 (1980); (9) S. Ciampolillo et al., Phys. Lett. **84B**, 281 (1979); (10) S.J. Barish et al., Phys. Rev. **D19**, 2521 (1979); (11) M. Jonker et al., Phys. Lett. **99B**, 265 (1981), E_ν = 20-200 GeV; (12) P. Bosetti et al., Phys. Lett. **110B**, 167 (1982), E_ν = 20-200 GeV; (13) T. Kitagaki et al., Phys. Rev. Lett. **49**, 98 (1982), E_ν = 10-200 GeV; (14) N.J. Baker et al., Phys. Rev. Lett. **51**, 735 (1983), E_ν = 10-240 GeV; (15) G.N. Taylor et al., Phys. Rev. Lett. **51**, 739 (1983), E_ν = 5-250 GeV. Courtesy M.H. Shaevitz, Columbia University (Nevis Laboratory).

PLOTS OF CROSS SECTIONS AND RELATED QUANTITIES (Cont'd)

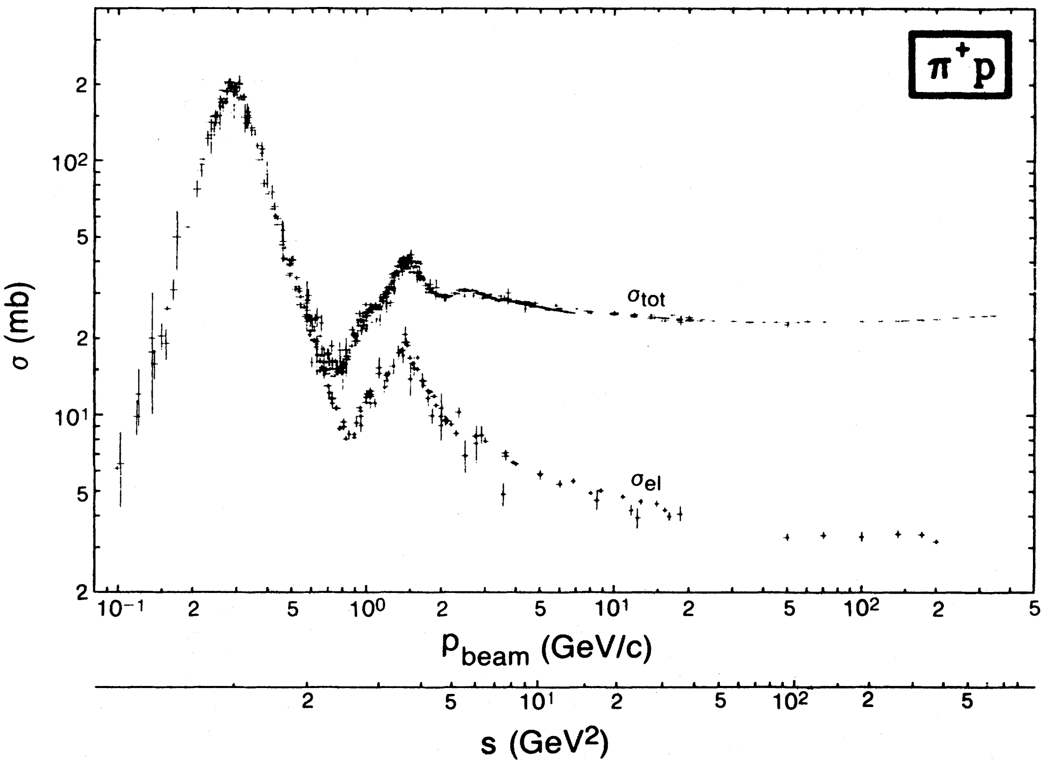


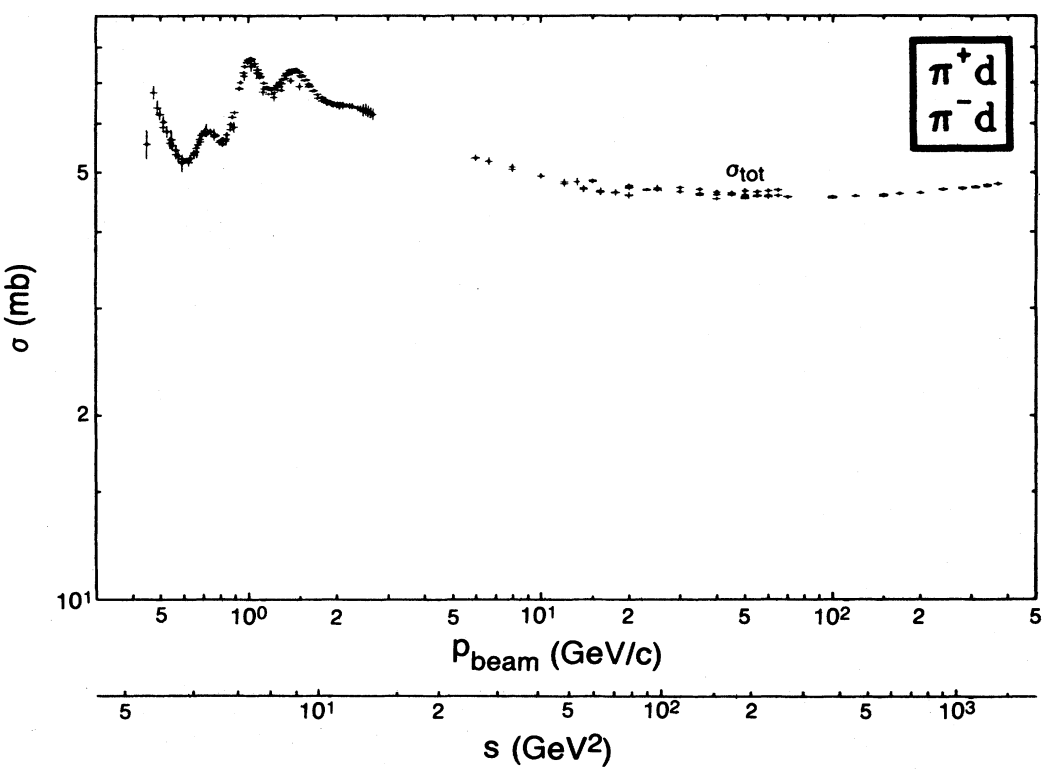
γp total cross section versus photon energy (top scale) and photon-plus-nucleon total center-of-mass energy (lower scale). References: **SANTA BARBARA-SLAC** — D.O. Caldwell et al., Phys. Rev. **D7**, 1362 (1973); **DESY-HAMBURG** — H. Meyer et al., Phys. Lett. **33B**, 189 (1970); **GLASGOW-SHEFFIELD-DNPL** — T.A. Armstrong et al., Phys. Rev. **D5**, 1640 (1972); **LEBEDEV-YEREVAN-SERPUKHOV** — A.S. Belousov et al., Preprint 19, Moscow, (1970); A. S. Belousov et al., Sov. Phys. Doklady **19**, 123 (1974); and A. S. Belousov et al., Sov. J. Nucl. Phys. **21**(3), 289 (1975); **SLAC-BERKELEY-TUFTS** — J. Ballam et al., Phys. Rev. **D5**, 545 (1972); **ABBHHM** — H.G. Hilpert et al., Phys. Lett. **27B**, 474 (1968); **SLAC** and **BERKELEY** — J. Ballam et al., Phys. Rev. Lett. **21**, 1544 (1968), and H.H. Bingham et al., Phys. Rev. **D8**, 1277 (1973); **CORNELL** — S. Michalowski et al., Phys. Rev. Lett. **39**, 737 (1977); **SANTA BARBARA-TORONTO-FNAL** — D.O. Caldwell et al., Phys. Rev. Lett. **40**, 1222 (1978). See, also, the ep data of E.D. Bloom et al., SLAC-PUB-653 (1969). Courtesy Gething M. Lewis, Glasgow.



γd total cross section versus photon energy (top scale) and photon-plus-single-nucleon total center-of-mass energy (lower scale). References: **SANTA BARBARA-SLAC** — D.O. Caldwell et al., Phys. Rev. **D7**, 1362 (1973); **DESY-HAMBURG** — H. Meyer et al., Phys. Lett. **33B**, 189 (1970); **GLASGOW-SHEFFIELD-DNPL** — T.A. Armstrong et al., Nucl. Phys. **B41**, 445 (1972); **LEBEDEV-YEREVAN-SERPUKHOV** — A.S. Belousov et al., Sov. J. Nucl. Phys. **21**(3), 289 (1975); **CORNELL** — S. Michalowski et al., Phys. Rev. Lett. **39**, 737 (1977). Courtesy Gething M. Lewis, Glasgow.

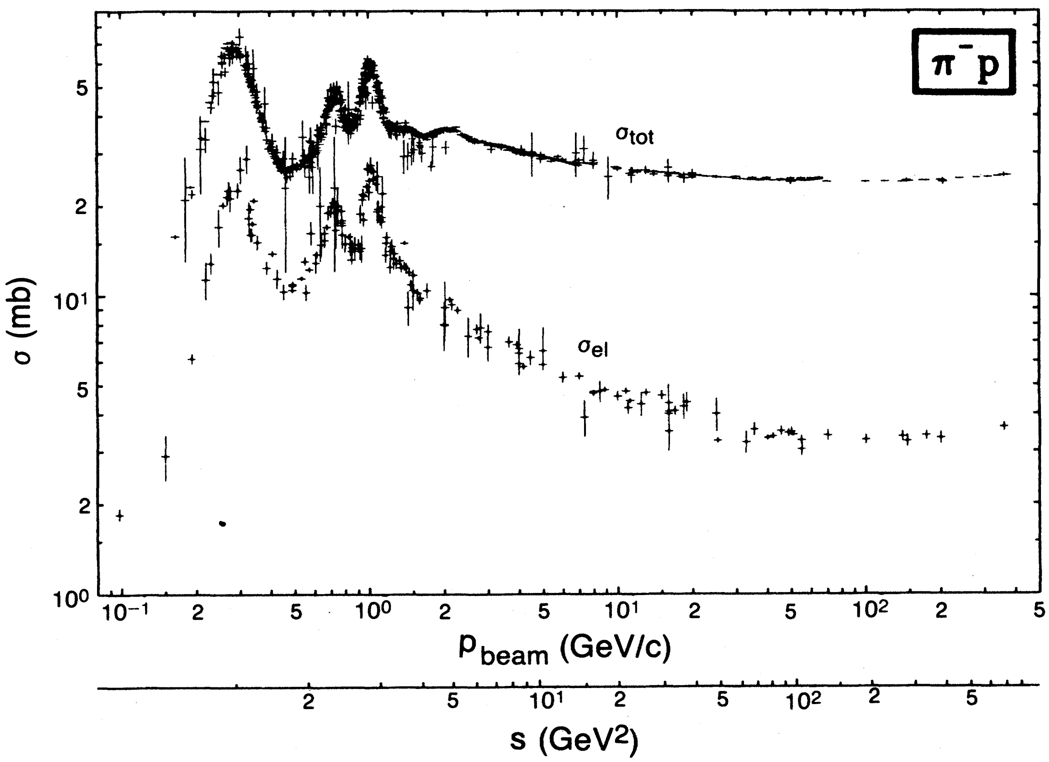
PLOTS OF CROSS SECTIONS AND RELATED QUANTITIES (Cont'd)

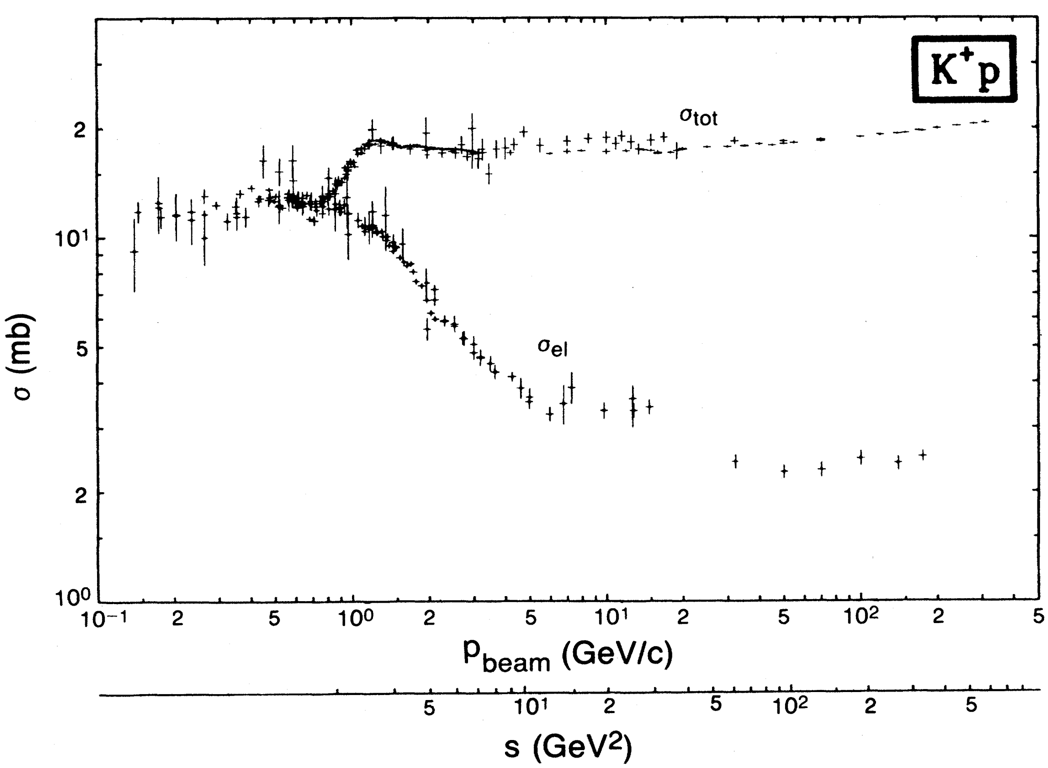




Hadronic total and elastic cross sections vs. laboratory beam momentum p_{beam} and center-of-mass energy squared s. Figures courtesy V. Flaminio, W.G. Moorhead, D.R.O. Morrison, and N. Rivoire, CERN.

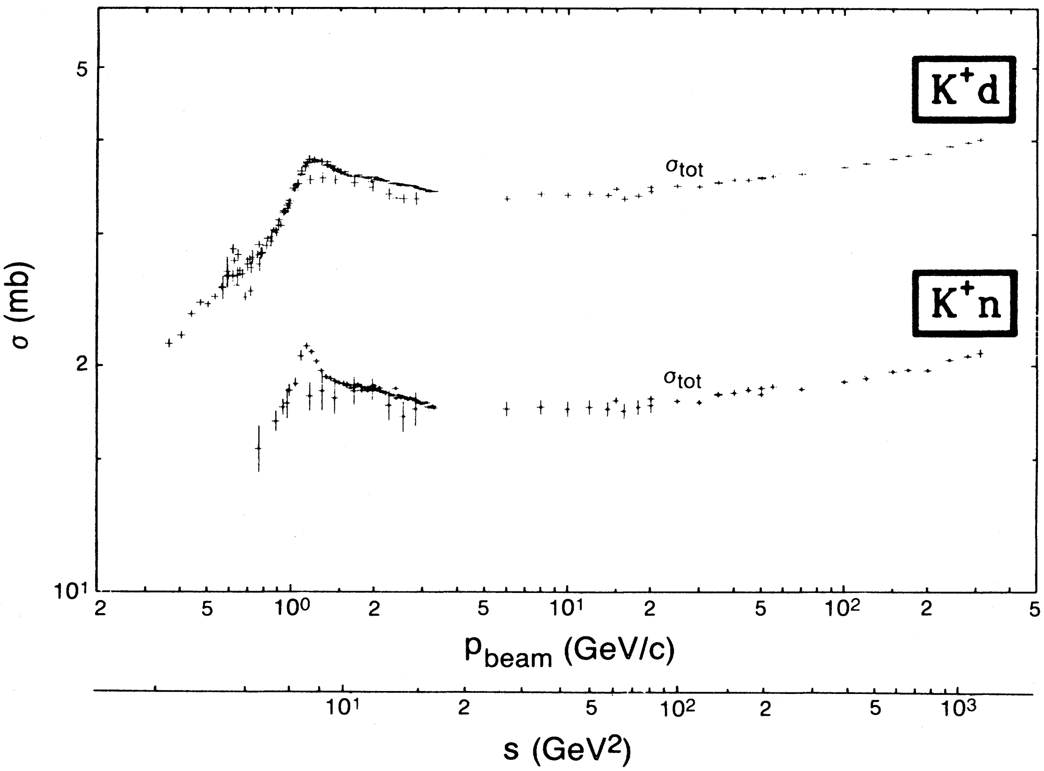
PLOTS OF CROSS SECTIONS AND RELATED QUANTITIES (Cont'd)

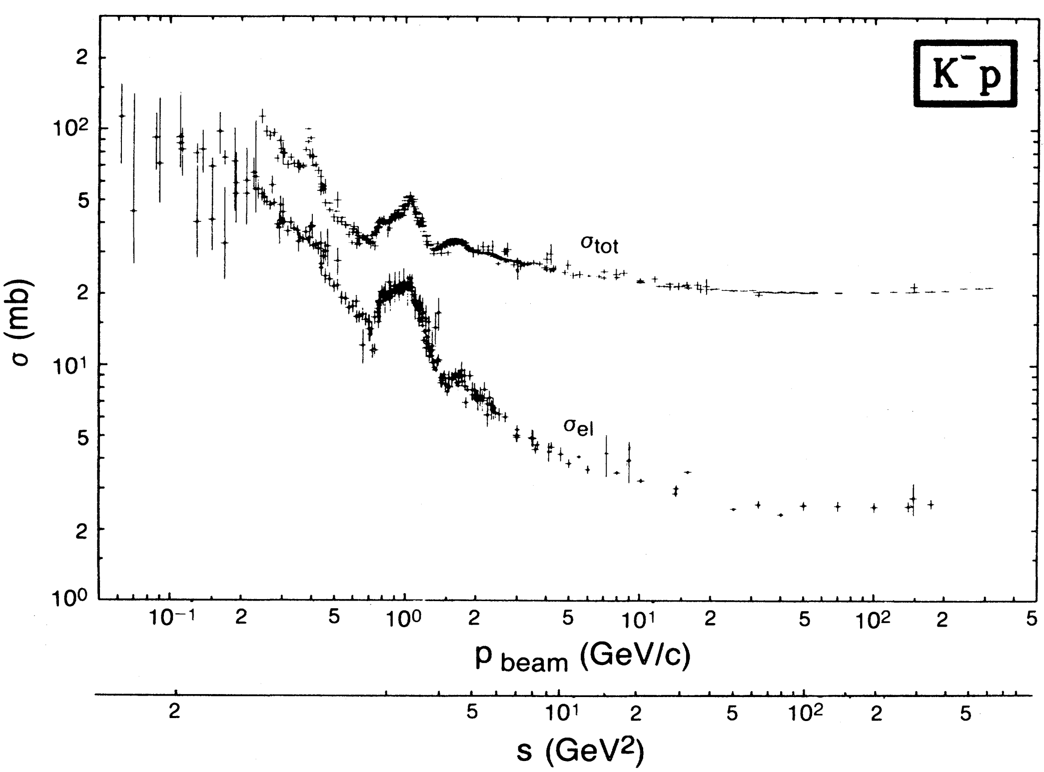




Hadronic total and elastic cross sections vs. laboratory beam momentum p_{beam} and center-of-mass energy squared s. Figures courtesy V. Flaminio, W.G. Moorhead, D.R.O. Morrison, and N. Rivoire, CERN.

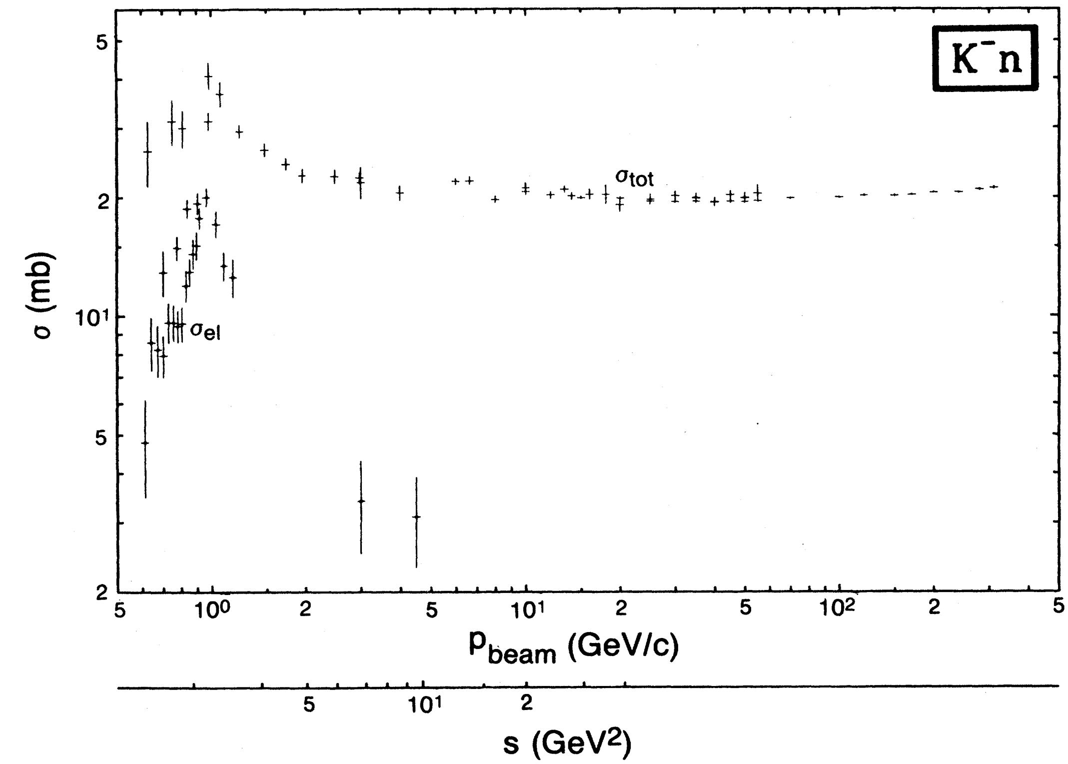
PLOTS OF CROSS SECTIONS AND RELATED QUANTITIES (Cont'd)

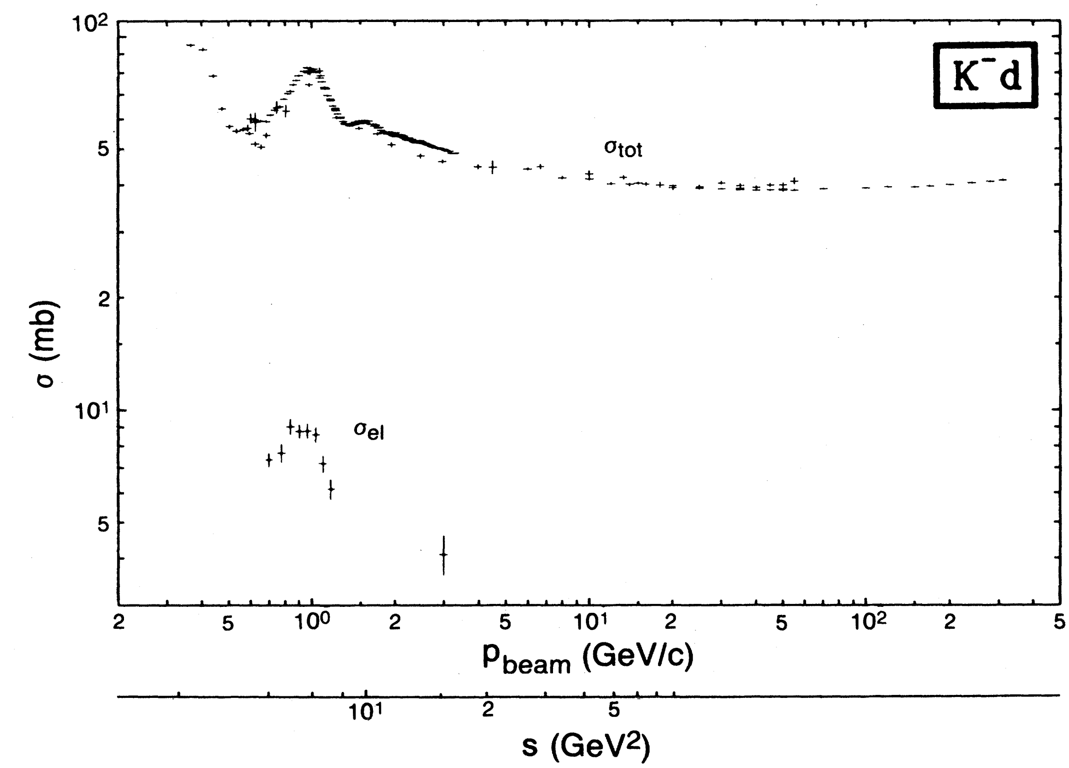




Hadronic total and elastic cross sections vs. laboratory beam momentum p_{beam} and center-of-mass energy squared s. Figures courtesy V. Flaminio, W.G. Moorhead, D.R.O. Morrison, and N. Rivoire, CERN.

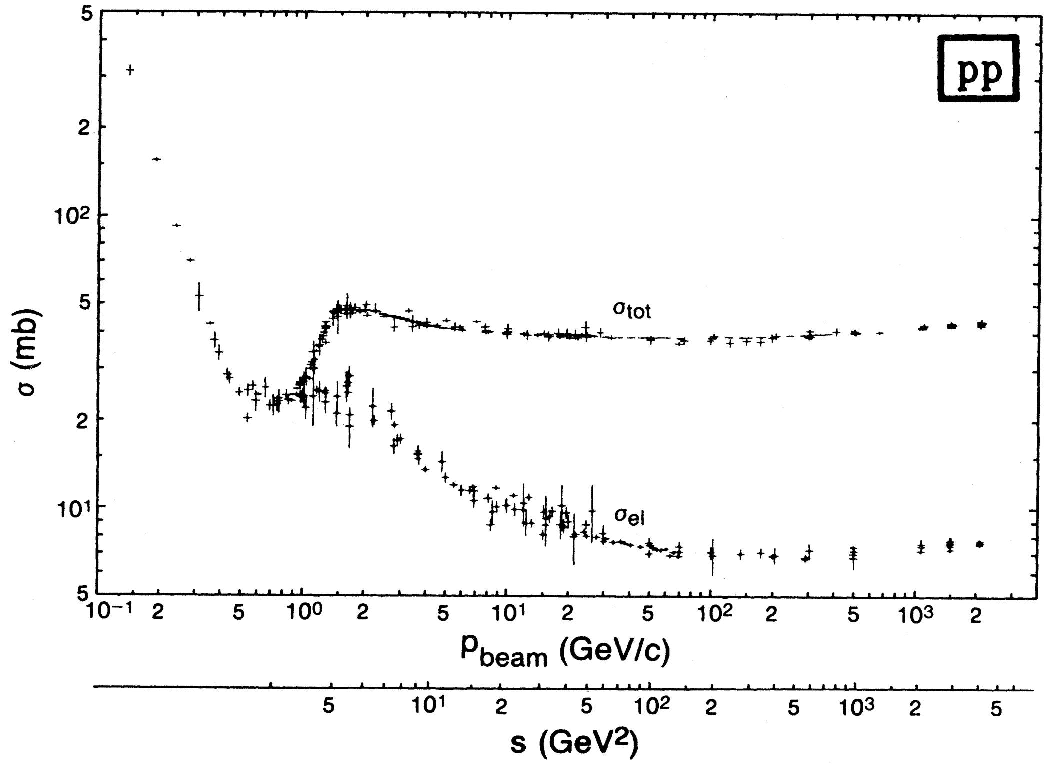
PLOTS OF CROSS SECTIONS AND RELATED QUANTITIES (Cont'd)

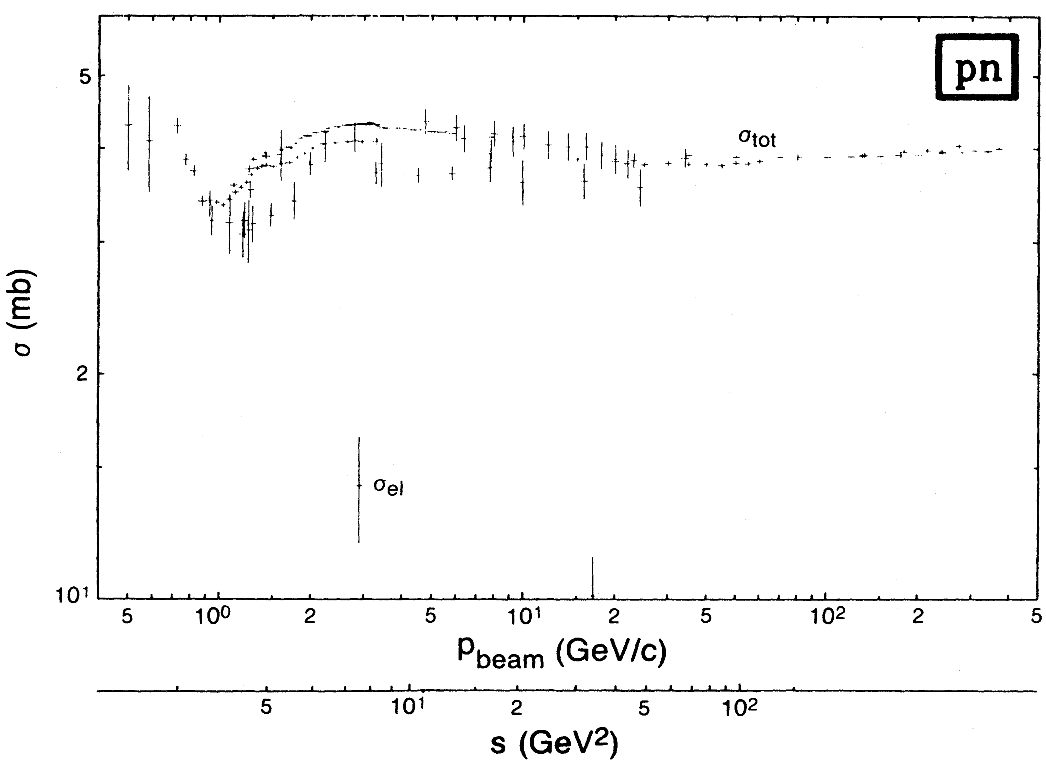




Hadronic total and elastic cross sections vs. laboratory beam momentum p_{beam} and center-of-mass energy squared s. Figures courtesy V. Flaminio, W.G. Moorhead, D.R.O. Morrison, and N. Rivoire, CERN.

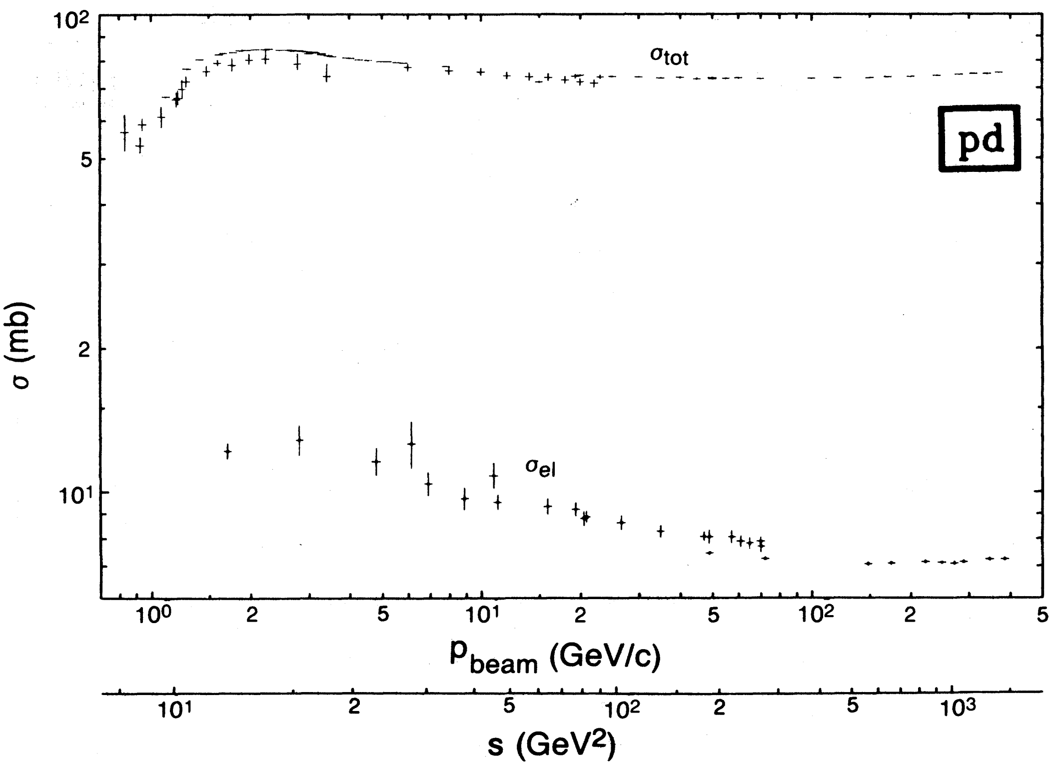
PLOTS OF CROSS SECTIONS AND RELATED QUANTITIES (Cont'd)

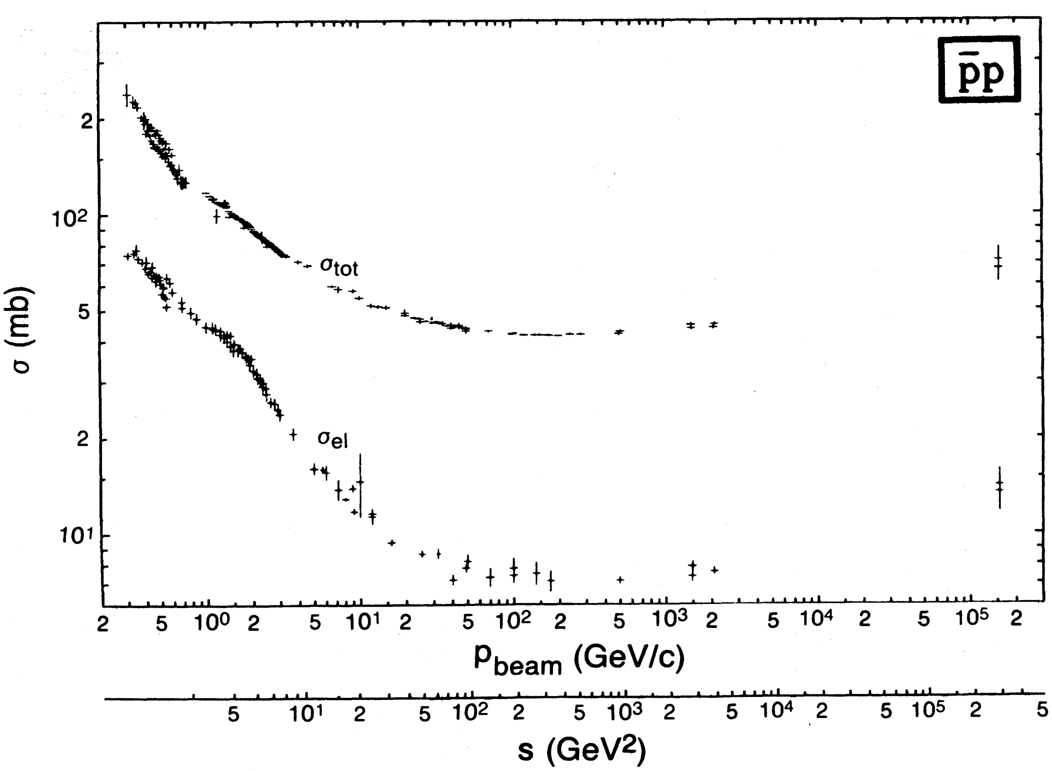




Hadronic total and elastic cross sections vs. laboratory beam momentum p_{beam} and center-of-mass energy squared s. Figures courtesy V. Flaminio, W.G. Moorhead, D.R.O. Morrison, and N. Rivoire, CERN.

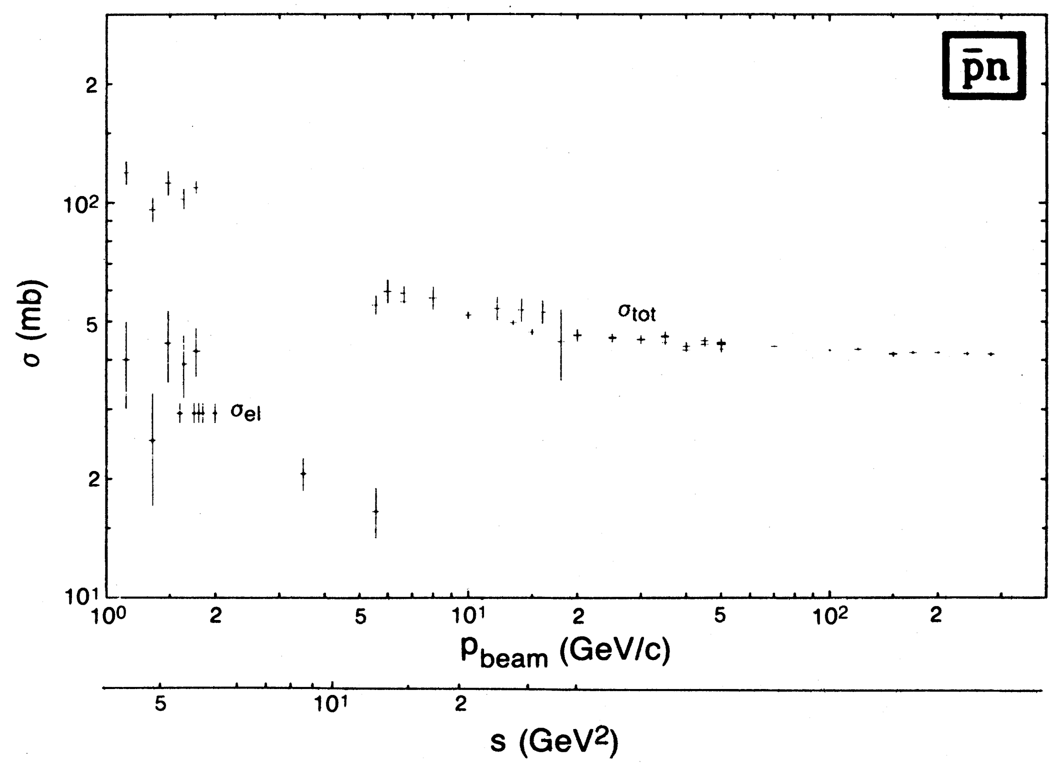
PLOTS OF CROSS SECTIONS AND RELATED QUANTITIES (Cont'd)

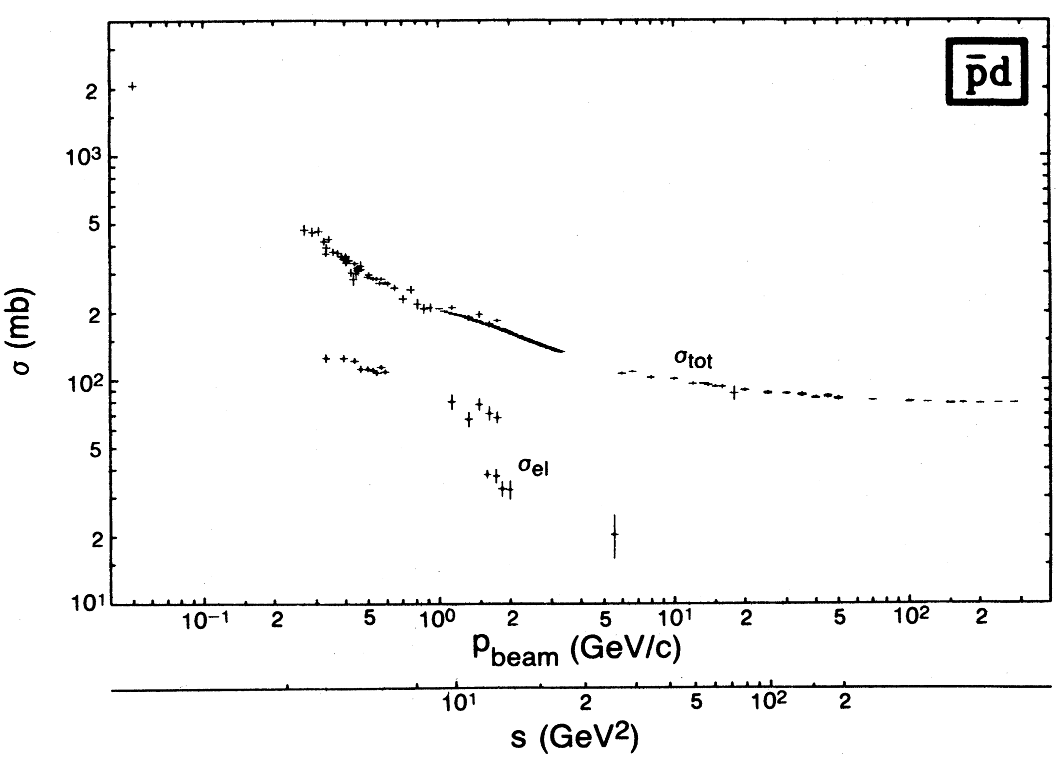




Hadronic total and elastic cross sections vs. laboratory beam momentum p_{beam} and center-of-mass energy squared s. Figures courtesy V. Flaminio, W.G. Moorhead, D.R.O. Morrison, and N. Rivoire, CERN.

PLOTS OF CROSS SECTIONS AND RELATED QUANTITIES (Cont'd)



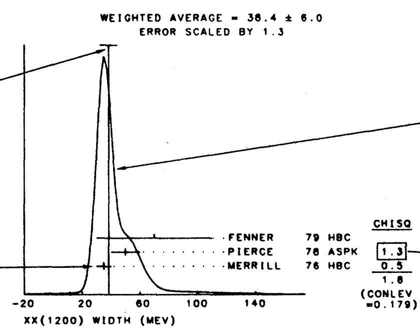


Hadronic total and elastic cross sections vs. laboratory beam momentum p_{beam} and center-of-mass energy squared s. Figures courtesy V. Flaminio, W.G. Moorhead, D.R.O. Morrison, and N. Rivoire, CERN.

DATA CARD LISTINGS

Illustrative Key

```
                XX(1200)   74  XX MESON (1200,JPG= -) I=1
                               ORIGINALLY CALLED XXX
                ------->       OMITTED FROM TABLE
------ --------- --------- --------- --------- --------- --------- --------
                          74  XX(1200) MASS (MEV)
M               1216.       11.          MERRILL   76 HBC   0 3.2 K-P        7/76
M  L       150 (1192.)     (16.)         LYNCH     77 HBC  +- 2.7 PI-P       6/77
M  L       LYNCH DATA HAS QUESTIONABLE BACKGROUND SUBTRACTION
M               1198.       10.     7.   PIERCE    78 ASPK +  2.1 K-P        9/78
M              (1208.)                   FENNER    79 HBC   0 4.2 PI+P       9/79
M     S     80  1210.       8.           SMITH     83 MMS   - 3.5 PI-P       1/84*
M     S    SUPERSEDES EARLIER RESULT
M
M     AVG       1206.9      5.1     AVERAGE
------ --------- --------- --------- --------- --------- --------- --------
                          74  XX(1200) WIDTH (MEV)
W                 35.       5.           MERRILL   76 HBC   0 3.2 K-P        7/76
W                 50.      10.           PIERCE    78 ASPK +  2.1 K-P        9/78
W                 70.      40.           FENNER    79 HBC   0 4.2 PI+P       9/79
W                (60.)     OR LESS       SMITH     83 MMS   - 3.5 PI-P       1/84*
W
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   76 HBC   0 3.2 K-P        7/76
R1    L           (.68)     (.03)        LYNCH     77 HBC  +- 2.7 PI-P       6/77
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    78 ASPK +  2.1 K-P        9/78
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    79 HBC   0 4.2 PI+P       9/79
R3                 .41       .04         SMITH     83 MMS   - 3.5 PI-P       1/84*
R3
R3    AVG        0.468     0.043    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.8)
R3    FIT        0.480     0.027    FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)

****** ********* ********* ********* ********* ********* ********* ********
                          REFERENCES FOR XX(1200)

MERRILL  76 PRL 16 143       A. MERRILL                   (SACLAY+CERN) IJP
LYNCH    77 PR 155 610       B. LYNCH                            (BNL)
PIERCE   78 PL 27B 230       N. PIERCE                           (LRL)
FENNER   79 NC 61B 372       D. FENNER,B. BEANE            (NYSE+AMEX)
SMITH    83 PRL 46 14        J. SMITH                           (SLAC)
****** ********* ********* ********* ********* ********* ********* ********
****** ********* ********* ********* ********* ********* ********* ********
```

- 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.).
- Symbol used to key together data card and related comments.
- Number of events above background.
- Measured value (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 tabulated.
- Vertical bar indicates average; width of horizontal bar on top is (scaled) error on 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 tabulated, as determined from constrained fit (using all measured branching ratios for this particle).
- References, listed by year, then author.
- Abbreviated reference form used on data cards above.
- Journal, report, preprint, etc. (see abbreviations on next page).

- Particle name, and quantum numbers (if known).
- Particle code (for internal use only).
- General comments on particle.
- Abbreviated reference for this result; full reference given below.
- Measurement technique (see abbreviations on next page).
- Charge(s) of particle(s) detected.
- Reaction producing particle, or comments.
- Date this result entered (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 very large error).
- Representative masses of decay products (used for calculating last column of Particle Property Tables).
- Branching ratio R_j in terms of partial decay mode fractions P_i above.
- Author(s).
- Quantum number determinations in this reference.
- Institution(s) of author(s) (see abbreviations on next page).

Illustrative Key *(cont'd)*

Abbreviations

Journals

APAH	Acta Phys. Acad. Hungarica
ADVP	Advances in Physics
ANP	Annals of Physics
APJ	Astrophysical Journal
APP	Acta Physica Polonica
ARNS	Annual Review of Nuclear Science
BAPS	Bulletin of the Amer. Phys. Soc.
CJP	Canadian Journal of Physics
JAP	Journal of Applied Physics
JETP	English Transl. of Soviet Physics JETP
JETPL	Letters of Soviet Physics JETP
JPA	Journal of Physics A
JPG	Journal of Physics G
JPSJ	Journal of the Phys. Soc. of Japan
LNC	Letters to Nuovo Cimento
NAT	Nature
NC	Nuovo Cimento
NIM	Nuclear Instruments and Methods
NP	Nuclear Physics
PL	Physics Letters
PN	Particles and Nuclei
PPSL	Proc. of the Phys. Soc. of London
PR	Physical Review
PRAM	Pramana
PRL	Physical Review Letters
PRPL	Physics Reports (Physics Letters C)
PRSE	Proc. of the Royal Soc. of Edinburgh
PRSL	Proc. of the Royal Soc. of London
PS	Physica Scripta
PTP	Progress of Theoretical Physics
RA	Radiochimica Acta
RMP	Reviews of Modern Physics
RRP	Revue Romaine de Physique
SCI	Science
SJNP	Soviet Journal of Nuclear Physics
SPU	Soviet Physics - Uspekhi
ZNAT	Zeitschrift fur Naturforschung
ZPHY	Zeitschrift fur Physik

Conferences

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

Measurement Techniques (i.e., Detectors and Methods of Analysis)

AEMS	Argonne effective mass spectrometer
ARG	ARGUS detector at DORIS
ASPK	Automatic spark chambers
BEBC	Big European bubble chamber at CERN
BONA	Bonanza nonmagnetic detector at DORIS
BPWA	Barrelet-zero partial-wave analysis
CALO	Calorimeter
CBAL	SLAC-SPEAR Crystal Ball detector
CC	Cloud chamber
CELL	CELLO detector at DESY
CHRM	CHARM neutrino detector at CERN
CIBS	CERN-IHEP boson spectrometer
CLEO	Cornell magnetic detector at CESR
CNTR	Counters
COSM	Cosmology and astrophysics
CUSB	Columbia U. - Stony Brook segmented NAI detector at CESR
DASP	DESY double-arm spectrometer
DBC	Deuterium bubble chamber
DLCO	SLAC-SPEAR DELCO detector
DM1	Detector at Orsay DM1 collider
DPWA	Energy-dependent partial-wave analysis
ELEC	Electronic combination
EMUL	Emulsions
FBC	Freon bubble chamber
FIT	Fit to previously existing data
FRAB	ADONE $B\bar{B}$ Group detector
FRAG	ADONE $\gamma\gamma$ Group detector
FRAM	ADONE MEA Group detector
FRBC	Freon bubble chamber
GOLI	CERN Goliath spectrometer
HBC	Hydrogen bubble chamber
HEBC	Helium bubble chamber
HDBC	Hydrogen and deuterium bubble chambers
HLBC	Heavy-liquid bubble chamber
HRS	SLAC high-resolution spectrometer
HYBR	Hybrid: bubble chamber + electronics
INDU	Magnetic induction
IPWA	Energy-independent partial-wave analysis
JADE	JADE detector at DESY
LASS	Large-angle superconducting solenoid spectrometer at SLAC
LENA	Non-magnetic lead-glass NaI detector at DORIS
MAC	MAC detector at PEP/SLAC
MBR	Molecular beam resonance technique
MMS	Missing mass spectrometer
MPS	Multiparticle spectrometer at BNL
MPWA	Model-dependent partial-wave analysis
MRKJ	Mark-J detector at DESY
MRS	Magnetic resonance spectrometer
NEUL	Neuland large-angle neutrino spectrometer
OLYA	Detector at VEPP-4, Novosibirsk
OMEG	CERN OMEGA spectrometer
OSPK	Optical spark chamber
PBC	Propane bubble chamber
PLAS	Plastic detector
PLUT	DESY PLUTO detector
PWA	Partial-wave analysis
REDE	Resonance depolarization
RVUE	Review of previous data
SFM	CERN split-field magnet
SILI	Silicon detector
SMAG	SPEAR magnetic detector
SMK2	SLAC Mark-II detector
SMK3	SLAC Mark-III detector
SPEC	Spectrometer
SPRK	Spark chamber
STRC	Streamer chamber
TASS	DESY TASSO detector
THEO	Theoretical or heavily model-dependent result
TPC	TPC detector at PEP/SLAC
UA1	UA1 detector at CERN
UA2	UA2 detector at CERN
UA5	UA5 detector at CERN
WIRE	Wire chamber
XEBC	Xenon bubble chamber

Institutions

AACH	Technische Univ. Aachen	Aachen, West Germany
AARH	Univ. of Aarhus	Aarhus, Denmark
ABO	Abo Akademi	Abo, Finland
ADEL	Adelphi Univ.	Garden City, NY, USA
AERE	Atomic Energy Res. Estab.	Harwell, Berks., England
AGDR	Acad. of Sci. of the German Demo. Rep.	Berlin-Zeuthen, East Germany
AICH	Aichi Univ. of Education	Kariya, Aichi Pref., Japan
AIKO	Inst. Kernphys. Onderzoek	Amsterdam, Netherlands
ALAH	Univ. of Alabama at Huntsville	Huntsville, AL, USA
ALBA	State Univ. of New York at Albany	Albany, NY, USA
ALBE	Alberta Univ., NRC	Edmonton, Alta., Canada
AMST	Univ. of Amsterdam	Amsterdam, Netherlands
ANIK	Amsterdam NIKHEF	Amsterdam, Netherlands
ANKA	Middle East Technical Univ.	Ankara, Turkey
ANL	Argonne National Lab.	Argonne, IL, USA
ARIZ	Univ. of Arizona	Tucson, AZ, USA
ARZS	Arizona State Univ.	Tempe, AZ, USA
ATEN	Nuclear Res. Centre Demokritos	Athens, Greece
ATHU	Univ. of Athens	Athens, Greece
AUCK	Univ. of Auckland	Auckland, New Zealand
BARC	Univ. de Barcelona	Barcelona, Spain
BARI	Univ. di Bari	Bari, Italy
BART	Bartol Research Foundation	Swarthmore, PA, USA
BASL	Univ. of Basel	Basel, Switzerland
BAYR	Univ. Bayreuth	Bayreuth, West Germany
BEDF	Bedford College	London, England
BELG	Inst. Interuniv. des Sci. Nuc.	Bruxelles, Belgium
BELL	Bell Labs.	Murray Hill, NJ, USA
BERG	Univ. of Bergen	Bergen, Norway
BERL	Inst. Hochenergiephys. DAW	Berlin-Zeuthen, East Germany
BERN	Univ. Bern	Bern, Switzerland
BGNA	Univ. di Bologna	Bologna, Italy
BHAB	Bhabha Atomic Research Center	Bombay, India
BHEP	Inst. of High Energy Physics	Beijing, China
BIEL	Univ. Bielefeld	Bielefeld, West Germany
BING	State Univ. of New York at Binghamton	Binghamton, NY, USA
BIRM	Birmingham Univ.	Birmingham, England
BNL	Brookhaven National Lab.	Upton, L.I., NY, USA
BOHR	Niels Bohr Inst.	Copenhagen, Denmark
BOIS	Boise State Univ.	Boise, ID, USA
BOMB	Univ. of Bombay	Bombay, India
BONN	Univ. Bonn	Bonn, West Germany
BORD	Univ. de Bordeaux	Bordeaux, France
BOST	Boston Univ.	Boston, MA, USA
BRAN	Brandeis Univ.	Waltham, MA, USA
BRCO	Univ. of British Columbia	Vancouver, B.C., Canada
BRIS	H. H. Wills Phys. Lab., U. of Bristol	Bristol, England
BROW	Brown Univ.	Providence, RI, USA
BRUX	Univ. Libre de Bruxelles	Bruxelles, Belgium
BUCH	Bucharest State Univ.	Bucharest, Romania
BUDA	Central Research Inst. of Physics	Budapest, Hungary
BUFF	State Univ. of New York at Buffalo	Buffalo, NY, USA
BURE	Inst. des Hautes Etutes Sci.	Bures-sur-Yvette, France
CAEN	Lab. de Phys. Corpusculaire	Caen, France
CAIW	Carnegie Inst. of Washington	Washington, DC, USA
CAMB	Cambridge Univ.	Cambridge, England
CANB	Australian National Univ.	Canberra, Australia
CARL	Carleton Univ.	Ottawa, Ont., Canada
CARN	Carnegie-Mellon Univ.	Pittsburgh, PA, USA
CASE	Case Western Reserve Univ.	Cleveland, OH, USA
CATH	Catholic Univ. of America	Washington, DC, USA
CAVE	Cavendish Lab., Cambridge Univ.	Cambridge, England
CCAC	Community College of Allegheny County	Pittsburgh, PA, USA
CDEF	College de France	Paris, France
CEA	Cambridge Electron Accel.	Cambridge, MA, USA
CENG	CEN, Grenoble	Grenoble, France
CERN	European Org. for Nuclear Research	Geneva, Switzerland
CHIC	Univ. of Chicago	Chicago, IL, USA
CINC	Univ. of Cincinnati	Cincinnati, OH, USA
CIT	Calif. Inst. of Technology	Pasadena, CA, USA
CLEV	Cleveland State Univ.	Cleveland, OH, USA
CNRC	Canadian National Research Council	Ottawa, Ont., Canada
COLO	Univ. of Colorado	Boulder, CO, USA
COLU	Columbia Univ.	New York, NY, USA
CORN	Cornell Univ.	Ithaca, NY, USA
COSU	Colorado State Univ.	Fort Collins, CO, USA
CRAC	Inst. for Nuclear Research	Cracow, Poland
CUNY	City Univ. of New York	New York, NY, USA
CURI	Laboratoire Joliot-Curie	Paris, France
DARE	Daresbury Nuclear Physics Lab.	Daresbury, England
DART	Dartmouth College	Hanover, NH, USA
DELF	Univ. of Technology	Delft, Netherlands
DELH	Univ. of Delhi	Delhi, India
DESY	Deutsches Elektronen-Synchrotron	Hamburg, West Germany
DOE	U.S. Department of Energy	Washington, DC, USA
DORT	Univ. Dortmund	Dortmund, West Germany
DUKE	Duke Univ.	Durham, NC, 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, IL, USA
ELMT	Elmhurst College	Elmhurst, IL, USA
EPOL	Ecole Polytechnique	Palaiseau, France
ERLA	Univ. Erlangen-Nurnberg	Erlangen, West Germany
ETH	Swiss Federal Inst. of Technology	Zurich, Switzerland
FIRZ	Univ. di Firenze	Firenze, Italy
FISK	Fisk Univ.	Nashville, TN, USA
FLOR	Univ. of Florida	Gainsville, FL, USA
FNAL	Fermi National Accelerator Lab.	Batavia, IL, USA
FOM	Found. for Fundamental Res. on Matter	Utrecht, Netherlands
FRAS	Lab. Nazionali del C.N.E.N.	Frascati, Italy
FREI	Univ. of Freiburg	Freiburg, West Germany
FSU	Florida State Univ.	Tallahassee, FL, USA
GENO	Univ. di Genova	Genova, Italy
GESC	General Electric Res. and Dev. Center	Schenectady, NY, USA
GEVA	Univ. de Geneve	Geneva, Switzerland
GLAS	Univ. of Glasgow	Glasgow, Scotland
GMAS	George Mason Univ.	Fairfax, VA, USA
GRAZ	Univ. Graz	Graz, Austria
GREN	Inst. des Sci. Nuc., Univ. de Grenoble	Grenoble, France
GSCO	Geological Survey of Canada	Ottawa, Ont., Canada
GUEL	Guelph Univ.	Guelph, Ont., Canada
HAIF	Technion - Israel Inst. of Technology	Haifa, Israel
HAMB	Univ. Hamburg	Hamburg, West Germany
HARV	Harvard Univ.	Cambridge, MA, USA
HAWA	Univ. of Hawaii	Honolulu, HI, USA
HEBR	Hebrew Univ.	Jerusalem, Israel
HEID	Univ. Heidelberg	Heidelberg, West Germany
HELS	Helsingin Yliopisto	Helsinki, Finland
HIRO	Hiroshima Univ.	Hiroshima, Japan
HOUS	Univ. of Houston	Houston, TX, USA
HPC	Hewlett-Packard Corp.	Cupertino, CA, USA
IAS	Inst. for Advanced Study	Princeton, NJ, USA
IBM	International Business Machines	Palo Alto, CA, USA

Illustrative Key *(cont'd)*

Institutions (cont'd)

IFRJ	Inst. de Fisica, Rio de Janeiro	Rio de Janeiro, Brazil
IIT	Illinois Inst. of Tech.	Chicago, IL, USA
ILL	Univ. of Illinois	Urbana, IL, USA
ILLC	Univ. of Illinois at Chicago	Chicago, IL, USA
ILLG	Inst. Laue-Langevin	Grenoble, France
IND	Univ. of Indiana	Bloomington, IN, USA
INEL	Idaho National Engineering Lab.	Idaho Falls, ID, USA
INFN	Ist. Nazionale di Fisica Nuclear	Roma, Italy
INNS	Phys. Inst., Univ. Innsbruck	Innsbruck, Austria
INRM	Inst. for Nuclear Research	Moscow, USSR
INUS	Inst. for Nuclear Study at Tokyo Univ.	Tokyo, Japan
IOFF	Ioffe Inst. of Physics and Tech.	Leningrad, USSR
IOWA	Univ. of Iowa	Iowa City, IA, USA
IPCR	Inst. of Physical and Chemical Research	Saitama-ken, Japan
IPN	Inst. de Phys. Nucleaire	Orsay, France
IPNP	Inst. de Physique Nucleaire	Paris, France
IPPC	Inst. for Particle Physics of Canada	Montreal, Que., Canada
IRAD	Inst. du Radium	Paris, France
ISU	Iowa State Univ.	Ames, IA, USA
ITEP	Inst. for Theor. and Exp. Phys.	Moscow, USSR
ITHA	Ithaca College	Ithaca, NY, USA
ITPU	Inst. for Theoretical Physics	Utrecht, Netherlands
IUPU	Indiana U. - Purdue U. at Indianapolis	Indianapolis, IN, USA
JAGL	Jagellonian Univ.	Cracow, Poland
JHU	Johns Hopkins Univ.	Baltimore, MD, USA
JINR	Joint Inst. for Nucl. Research	Dubna, USSR
KAGO	Kagoshima Univ.	Kagoshima, Japan
KANS	Univ. of Kansas	Lawrence, KS, USA
KARL	Univ. Karlsruhe	Karlsruhe, West Germany
KAZA	Kazakh Academy of Science	Alma-Ata, USSR
KEK	Nat. Lab for High Energy Phys., Japan	Tsukuba-gun, Japan
KENT	Kent Univ. at Cantebury, Kent	Cantebury, England
KEYN	Open Univ.	Milton Keynes, England
KHAR	Phys.-Tech. Inst., Acad. Sci., Ukr.SSR	Kharkov, USSR
KIAE	Kurchatov Inst. of Atomic Energy	Moscow, USSR
KIEL	Kiel Univ.	Kiel, West Germany
KIEV	Physical-Technical Inst.	Kiev, USSR
KINK	Kinki Univ.	Osaka, Japan
KNTY	Univ. of Kentucky	Lexington, KY, USA
KOBE	Kobe Univ.	Kobe, Japan
KONA	Konan Univ.	Kobe, Japan
KONS	B. P. Konstantinov Inst. of Nucl. Phys.	USSR
KYOT	Kyoto Univ.	Kyoto, Japan
LALO	Linear Accelerator Lab, Orsay	Orsay, France
LANC	Lancaster Univ.	Lancaster, England
LANL	U.C. Los Alamos National Lab.	Los Alamos, NM, USA
LAPP	Lab. d'Annecy de Phys. des Particules	Annecy, France
LASL	U.C. Los Alamos Scientific Lab.	Los Alamos, NM, USA
LAUS	Univ. of Lausanne	Lausanne, Switzerland
LBL	U.C. Lawrence Berkeley Lab.	Berkeley, CA, USA
LCGT	Lab. di Cosmo-Geofisica del CNR	Torino, Italy
LEBD	Lebedev Physics Inst.	Moscow, USSR
LEED	Univ. of Leeds	Leeds, England
LEHI	Lehigh Univ.	Bethlehem, PA, USA
LEHM	Herbert H. Lehman College	Bronx, NY, USA
LEID	Inst. Lorentz	Leiden, Netherlands
LEMO	Le Moyne College	Syracuse, NY, USA
LENI	Inst. of Nucl. Phys., USSR Acad. Sci.	Leningrad, USSR
LIBH	Lab. Interuniv. Belge High Eng.	Bruxelles, Belgium
LINZ	Linz Inst. fur Physik, Kepler Hoch.	Linz, Austria
LISB	Univ. de Lisboa	Lisboa, Codex, Portugal
LIVP	Liverpool Univ.	Liverpool, England
LLL	Lawrence Livermore Lab.	Livermore, CA, USA
LOIC	Imperial Col. of Sci. and Tech.	London, England
LOQM	Queen Mary College	London, England
LOUC	University College	London, England
LOWC	Westfield College	London, England
LPNP	Lab. de Phys. Nucl. et Hautes Energies	Paris, France
LPTP	Lab. de Phys. Theor. et Hautes Energies	Paris, France
LRL	U.C. Lawrence Berkeley Lab.	Berkeley, CA, USA
LSU	Louisiana State Univ.	Baton Rouge, LA, USA
LUND	Univ. I Lund	Lund, Sweden
LVLN	Univ. Catholique de Louvain	Louvain-La-Neuve, Belgium
LYON	Univ. de Lyon	Villeurbanne, France
MADR	Junta de Energia Nuclear	Madrid, Spain
MADU	Univ. Autonome de Madrid	Madrid, Spain
MANH	Manhattan College	New York, NY, USA
MANI	Univ. of Manitoba	Winnipeg, Man., Canada
MANZ	Univ. Mainz	Mainz, West Germany
MARS	Center National de la Recherche Sci.	Marseille, France
MASA	Univ. of Massachusetts	Amherst, MA, USA
MASB	Univ. of Massachusetts	Boston, MA, USA
MCGI	McGill Univ.	Montreal, Que., Canada
MCHS	Univ. Manchester	Manchester, England
MEIS	Meisei Univ.	Hino, Tokyo, Japan
MELB	Univ. of Melbourne	Parkville, Australia
MHCO	Mount Holyoke College	South Hadley, MA, USA
MICH	Univ. of Michigan	Ann Arbor, MI, USA
MILA	Univ. di Milano	Milano, Italy
MINN	Univ. of Minnesota	Minneapolis, MN, USA
MINR	Inst. for Nuclear Research	Moscow, USSR
MIOH	Miami Univ.	Oxford, OH, USA
MIT	Massachusetts Inst. of Technology	Cambridge, MA, USA
MODE	Ist. di Fisica dell Univ.	Modena, Italy
MONP	Univ. de Montpellier	Montpellier, France
MONS	Univ. de l'Etat, Mons	Mons, Belgium
MONT	Univ. de Montreal	Montreal, Que., Canada
MOSU	Moscow State Univ.	Moscow, USSR
MPEI	Moscow Phys. Eng. Inst.	Moscow, USSR
MPIH	Max Planck Inst. fur Kernphysik	Heidelberg, West Germany
MPIM	Max Planck Inst. fur Phys.-Astrophys.	Munich, West Germany
MSNA	Ist. di Fisica dell Univ.	Messina, Italy
MSU	Michigan State Univ.	East Lansing, MI, USA
MTHO	Mt. Holyoke College	South Hadley, MA, USA
MULH	Centre Univ. du Haut-Rhin	Mulhouse, France
MUNI	Univ. of Munich	Munich, West Germany
MURA	Midwestern Univ. Research Assoc.	Stroughton, WI, USA
NAGO	Nagoya Univ.	Nagoya, Japan
NAPL	Univ. di Napoli	Napoli, Italy
NARA	Nara Women's Univ.	Nara, Japan
NASA	NASA, Goddard Space Flight Center	Greenbelt, MD, USA
NBS	U.S. National Bureau of Standards	Washington, DC, USA
NDAM	Univ. of Notre Dame	Notre Dame, IN, USA
NEAS	Northeastern Univ.	Boston, MA, USA
NEUC	Univ. de Neuchatel	Neuchatel, Switzerland
NEVI	Nevis Lab.	Irvington-on-Hudson, NY, USA
NIJM	R. K. Univ. Nijmegen	Nijmegen, Netherlands
NIU	Northern Illinois Univ.	De Kalb, IL, USA
NORD	Nordisk Inst. for Teor. Atomfys.	Copenhagen, Denmark
NOVO	Inst. of Nucl. Phys.	Novosibirsk, USSR
NPOL	Northern Polytechnic	London, England
NRL	Naval Research Laboratory	Washington, DC, USA
NSF	U.S. National Science Foundation	Washington, DC, USA
NTUA	National Technical Univ.	Athens, Greece
NWES	Northwestern Univ.	Evanston, IL, USA
NYU	New York Univ.	New York, NY, USA
OHIO	Ohio Univ.	Athens, OH, USA
OKAY	Okayama Univ.	Okayama, Japan
OREG	Univ. of Oregon	Eugene, OR, USA
ORNL	Oak Ridge National Lab.	Oak Ridge, TN, USA
ORSA	Univ. de Paris, Fac. des Sci.	Orsay, France
OSAK	Osaka Univ.	Osaka, Japan
OSKC	Osaka City Univ.	Osaka, Japan

Institutions (cont'd)

OSLO	Oslo Univ.	Oslo, Norway
OSU	Ohio State Univ.	Columbus, OH, USA
OTTA	Univ. of Ottawa	Ottawa, Ont., Canada
OXF	Oxford Univ.	Oxford, England
PADO	Univ. di Padova	Padova, Italy
PATR	Univ. of Patras	Patras, Greece
PAVI	Univ. di Pavia	Pavia, Italy
PENN	Univ. of Pennsylvania	Philadelphia, PA, USA
PGIA	Univ. di Perugia	Perugia, Italy
PHIL	Philipps Univ.	Marburg, West Germany
PISA	Univ. di Pisa	Pisa, Italy
PITT	Univ. of Pittsburgh	Pittsburgh, PA, USA
PNL	Pacific Northwest Lab.	Richland, WA, USA
PPA	Princeton-Penn. Proton Accel.	Princeton, NJ, USA
PRAG	Inst. of Physics, CSAV	Prague, Czechoslovakia
PRIN	Princeton Univ.	Princeton, NJ, USA
PSLL	Physical Science Lab.	Las Cruces, NM, USA
PURD	Purdue Univ.	Lafayette, IN, USA
QUKI	Queens Univ.	Kingston, Ont., Canada
RAL	Rutherford Appleton Lab. (formerly RL)	Chilton, Did., Berks., England
REGE	Univ. Regensburg	Regensburg, West Germany
REHO	Weizmann Inst. of Sci.	Rehovoth, Israel
RHEL	Rutherford High Energy Lab.	Chilton, Did., Berks., England
RICE	William Marsh Rice Univ.	Houston, TX, USA
RISO	Research Estab. Riso	Roskilde, Denmark
RL	Rutherford Lab. (formerly RHEL)	Chilton, Did., Berks., England
RMCS	Royal Military College of Science	Shrivenham, England
ROCH	Univ. of Rochester	Rochester, NY, USA
ROCK	Rockefeller Univ.	New York, NY, USA
ROMA	Univ. di Roma	Roma, Italy
ROSE	Rose Polytechnic Inst.	Terre Haute, IN, USA
RUTG	Rutgers Univ.	New Brunswick, NJ, USA
SACL	Cntr. d'Etudes Nucl. Saclay	Gif-sur-Yvette, France
SAGA	Saga Univ.	Saga, Japan
SANI	Ist. Superiore di Sanita	Roma, Italy
SBER	San Bernardino State College	San Bernardino, CA, USA
SCUC	Univ. of South Carolina	Columbia, SC, USA
SEAT	Seattle Pacific College	Seattle, WA, USA
SEIB	Research Center Seibersdorf	Vienna, Austria
SEOU	Korea Univ.	Seoul, Korea
SERP	Inst. of High Energy Physics	Serpukov, USSR
SETO	Seton Hall Univ.	South Orange, NJ, USA
SFLA	Univ. of South Florida	Tampa, FL, USA
SFSU	San Francisco State Univ.	San Francisco, CA, USA
SHEF	Univ. of Sheffield	Sheffield, England
SHMP	Univ. of Southampton	Southampton, England
SIBE	Inst. of Nucl. Phys., USSR Acad. Sci.	Siberia, USSR
SIEG	Gesamthochschule Siegen	Huttental, West Germany
SIN	Swiss Inst. of Nuclear Research	Villigen, Switzerland
SLAC	Stanford Linear Accel. Center	Stanford, CA, USA
SMAS	Southeastern Massachusetts Univ.	North Dartmouth, MA, USA
SOFI	Bulgarian Acad. of Sci.	Sofia, Bulgaria
STAN	Stanford Univ.	Stanford, CA, USA
STEV	Stevens Inst. of Tech.	Hoboken, NJ, 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., NY, USA
STRB	Centre des Res. Nucleaires	Strasbourg, France
SURR	Univ. of Surrey	Surrey, England
SUSS	Univ. of Sussex	Falmer, Brighton, England
SYDN	Univ. of Sydney	Sydney, Australia
SYRA	Syracuse Univ.	Syracuse, NY, USA
TAMU	Texas A and M Univ.	College Station, TX, USA
TBLI	Tbilisi State Univ.	Tbilisi, USSR
TELA	Univ. of Tel-Aviv	Tel-Aviv, Israel
TEMP	Temple Univ.	Philadelphia, PA, USA
TENN	Univ. of Tennessee	Knoxville, TN, USA
TEXA	Univ. of Texas	Austin, TX, USA
THES	Univ. of Thessaloniki	Thessaloniki, Greece
TIFR	Tata Inst. of Fundamental Research	Bombay, India
TIT	Tokyo Inst. of Technology	Tokyo, Japan
TMSK	Nucl. Phys. Inst., Tomsk Polytech Inst.	Tomsk, USSR
TMU	Tokyo Metropolitan Univ.	Tokyo, Japan
TNTO	Univ. of Toronto	Toronto, Ont., Canada
TOHO	Tohoku Univ.	Sendai, Japan
TOIN	Tokyo Inst. of Technology	Tokyo, Japan
TOKY	Univ. of Tokyo	Tokyo, Japan
TORI	Univ. di Torino	Torino, Italy
TRIK	Rikkyo Univ.	Tokyo, Japan
TRIN	Trinity College	Dublin, Ireland
TRIU	TRIUMF, Univ. of British Columbia	Vancouver, B.C., Canada
TRST	Univ. di Trieste	Trieste, Italy
TSUK	Univ. of Tsukuba	Tsukuba, Japan
TTAM	Tamagawa Univ.	Tokyo, Japan
TUFT	Tufts Univ.	Medford, MA, USA
TWAS	Waseda Univ.	Tokyo, Japan
UBEL	Univ. of Belgrade	Belgrade, Yugoslavia
UCB	Univ. of Calif. at Berkeley	Berkeley, CA, USA
UCD	Univ. of Calif. at Davis	Davis, CA, USA
UCI	Univ. of Calif. at Irvine	Irvine, CA, USA
UCLA	Univ. of Calif. at Los Angeles	Los Angeles, CA, USA
UCND	Union Carbide Nuclear Division	Oak Ridge, TN, USA
UCR	Univ. of Calif. at Riverside	Riverside, CA, USA
UCSB	Univ. of Calif. at Santa Barbara	Santa Barbara, CA, USA
UCSC	Univ. of Calif. at Santa Cruz	Santa Cruz, CA, USA
UCSD	Univ. of Calif. at San Diego	La Jolla, CA, USA
UMD	Univ. of Maryland	College Park, MD, USA
UNCS	Union College	Schenectady, NY, USA
UNH	Univ. of New Hampshire	Durham, NH, USA
UNM	Univ. of New Mexico	Albuquerque, NM, USA
UOEH	Univ. of Occup. and Environ. Health	Kitakyushu, Japan
UPNJ	Upsala College	East Orange, NJ, USA
UPPS	Gustaf Werner Inst.	Uppsala, Sweden
USC	Univ. of Southern California	Los Angeles, CA, USA
USTL	Univ. Sci. et Tech. du Languedoc	Montpellier, France
UTAH	Univ. of Utah	Salt Lake City, UT, USA
UTRE	Univ. of Utrecht	Utrecht, Netherlands
VAND	Vanderbilt Univ.	Nashville, TN, USA
VICT	Univ. of Victoria	Victoria, B.C., Canada
VIEN	Inst. for High Energy Physics, A. A. S.	Vienna, Austria
VIRG	Univ. of Virginia	Charlottesville, VA, USA
VPI	Virginia Polytechnic Inst.	Blacksburg, VA, USA
WARS	Univ. of Warsaw	Warsaw, Poland
WASH	Univ. of Washington	Seattle, WA, USA
WIEN	Univ. Wien	Wien, Austria
WILL	College of William and Mary	Williamsburg, VA, USA
WINR	Warsaw Inst. of Nuclear Research	Warsaw, Poland
WISC	Univ. of Wisconsin	Madison, WI, USA
WITW	Univ. of the Witwatersrand	Johannesburg, S. Africa
WMIU	Western Michigan Univ.	Kalamazoo, MI, USA
WOOD	Woodstock College	Woodstock, MD, USA
WUPG	Gesamthochschule Wuppertal	Wuppertal, West Germany
WUPP	Univ. Wuppertal	Wuppertal, West Germany
WURZ	Univ. Wurzburg	Wurzburg, West Germany
WUSL	Washington Univ.	St. Louis, MO, USA
WYOM	Univ. of Wyoming	Laramie, WY, USA
YALE	Yale Univ.	New Haven, CT, USA
YERE	Yerevan Physics Inst.	Yerevan, Armenia, USSR
YOKO	Yokohama Univ.	Yokohama, Japan
YORK	York Univ.	Toronto, Ont., Canada
ZAGR	Inst. Rudjer Boskovic	Zagreb, Yugoslavia
ZEEM	Zeeman Lab., Univ. of Amsterdam	Amsterdam, Netherlands
ZURI	Univ. Zurich	Zurich, Switzerland

Stable Particles

Data Card Listings

γ, W, Z, WEAK GAUGE BOSON SEARCHES

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γ

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                    0   GAMMA(0,J=1)
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                    0   GAMMA MASS (MEV)

M    F      (6. E-21)OR LESS              PATEL     65          SATELLITE DATA    10/69
M           (6. E-21)OR LESS              GINTSBURG 64          SATELLITE DATA    10/69
M           (2.3E-21)OR LESS              GOLDHABER 68          SATELLITE DATA    10/69
M    F      (6. E-23)OR LESS              FRANKEN   71          LOW FREQ RES CIR   3/72
M           (1. E-20)OR LESS              WILLIAMS  71 CNTR     TESTS GAUSS LAW    3/71
M           (4. E-13)OR LESS              LOWENTHAL 73          GENL RELATIVITY    8/77
M           (7.3E-22)OR LESS              HOLLWEG   74          ALFVEN WAVES       7/74
M           (6. E-22)OR LESS   CL=.997    DAVIS     75          JUPITER MAGFIELD   1/78
M            3. E-33 OR LESS              CHIBISOV  76          GALACTIC MAG FLD   2/84*
M    F   VALIDITY QUESTIONABLE. SEE CRITICISM IN KROLL 71 AND GOLDHABER 71.        3/78
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                              REFERENCES FOR GAMMA

GINTSBUR 64 SOV. ASTR.AJ7 536 M. A. GINTSBURG                (ACAD SCI,USSR)
PATEL    65 PL     14  105    V. L. PATEL                          (DURHAM)
GOLDHABE 68 PRL    21  567    A. GOLDHABER,M. NIETO          (STONY BROOK)
FRANKEN  71 PRL 26 115        P A FRANKEN, G W AMPULSKI              (MICH)
WILLIAMS 71 PRL 26 721        +FALLER,HILL                       (WESLEYAN)

LOWENTHA 73 PR D8 2349        D.D.LOWENTHAL                           (UCI)
HOLLWEG  74 PRL 32 961        J V HOLLWEG  (NATL CENTER FOR ATMOS RESRCH)
DAVIS    75 PRL 35 1402       +GOLDHABER,NIETO              (CIT+STON+LASL)
CHIBISOV 76 SPU 19 624        G.B.CHIBISOV                           (LEBD)

                              PAPERS NOT REFERRED TO IN DATA CARDS

GOLDHABE 71 RMP 43 277        A S GOLDHABER, M M NIETO   (STON+BOHR+UCSB)
KROLL    71 PRL 26 1395       N M KROLL                              (SLAC)
BYRNE    77 AST.SP.SCI.46 115 J.C.BYRNE                              (LOIC)
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W

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                    43  W(80000,JP=  )

       MEASUREMENTS OF CHARGED WEAK GAUGE BOSON PARAMETERS
       ARE LISTED HERE.  SEE ALSO WEAK GAUGE BOSON SEARCHES SECTION BELOW.

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                    43  W MASS (GEV)

M          6  (81.)     (5.)               ARNISON   83 UA1  REPL.BY ARNISON2 83  3/83*
M         27   80.9      2.9               ARNISON2  83 UA1  P AP, ECM=540 GEV.  11/83*
M    B        (81.0)    (2.8)              BAGNAIA   83 UA2  P AP, ECM=550 GEV.  11/83*
M          4  80.       10.       6.       BANNER    83 UA2  P AP, ECM=550 GEV.   3/83*
M    B   BAGNAIA 83 MASS IS PRELIMINARY VALUE OBTAINED IN ZO EXPERIMENT .        11/83*
M             . . . . . . . . . .
M    AVG       80.8      2.7     AVERAGE

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                    43  W WIDTH  (GEV)

W         27    7.    OR LESS  CL=.90    ARNISON2  83 UA1   P AP, ECM=540 GEV.  11/83*

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                    43  W PARTIAL DECAY MODES                                  10/83*

                                                             DECAY MASSES
P1      W+- INTO E+- NEU                                   .511+   0

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                    43  W BRANCHING RATIOS                                     10/83*

R1      W+- INTO (E+- NEU)/TOTAL                          (P1)                 10/83*
R1        6    SEEN                  ARNISON   83 UA1  REPL.BY ARNISON2 83 10/83*
R1       52    SEEN                  ARNISON2  83 UA1  P AP ECM=540 GEV    11/83*
R1   B    4    SEEN                  BANNER    83 UA2  P AP ECM=540 GEV    10/83*

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                              REFERENCES FOR W

ARNISON  83 PL 122B 103       UA1 COLLAB.(AACH+LAPP+BIRM+CERN+HELS+LOQM+)
ARNISON2 83 PL 129B 273       UA1 COLLAB.(AACH+LAPP+BIRM+CERN+HELS+LOQM+)
BAGNAIA  83 PL 129B 130       UA2 COLLAB. (BERN+CERN+BOHR+LALO+PAVI+SACL)
BANNER   83 PL 122B 476       UA2 COLLAB. (BERN+CERN+BOHR+LALO+PAVI+SACL)
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Z

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                    44  Z(95000,JP=  )

       MEASUREMENTS OF NEUTRAL WEAK GAUGE BOSON PARAMETERS
       ARE LISTED HERE.  SEE ALSO WEAK GAUGE BOSON SEARCHES SECTION BELOW.

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                    44  Z MASS (GEV)

M          5  (95.2)    (2.5)              ARNISON   83 UA1  REPL.BY ARNISON2 83 11/83*
M          5   95.6      3.2               ARNISON2  83 UA1  P AP, ECM=540 GEV.  11/83*
M          4   91.9      1.9               BAGNAIA   83 UA2  P AP, ECM=550 GEV.  11/83*
M             . . . . . . . . . . .
M    AVG       92.9      1.6     AVERAGE

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                    44  Z WIDTH  (GEV)

W    A     4  (10.2)  OR LESS  CL=.90    ARNISON   83 UA1  REPL.BY ARNISON2 83 11/83*
W          4    8.5   OR LESS  CL=.90    ARNISON2  83 UA1  P AP, ECM=550 GEV.  11/83*
W          4  (11.)   OR LESS  CL=.90    BAGNAIA   83 UA2  P AP, ECM=550 GEV.  11/83*
W    A   ARNISON 83 GIVE A MOST PROBABLE VALUE OF 6.2 GEV AND AN UPPER LIMIT 11/83*
W    A   OF 10.2 GEV FOR THE WIDTH.  THIS IS CONSISTENT WITH THEIR           11/83*
W    A   EXPERIMENTAL RESOLUTION AND A NATURAL Z WIDTH OF 3.0 GEV.           11/83*

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                    44  Z PARTIAL DECAY MODES

                                                             DECAY MASSES
P1      Z INTO E+ E-                                       .511+.511
P2      Z INTO MU+ MU-                                      106+ 106

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                    44  Z BRANCHING RATIOS

R1      Z INTO (E+ E-)/TOTAL                              (P1)                 11/83*
R1        4    SEEN                  ARNISON   83 UA1  P AP, ECM=540 GEV.  11/83*
R1   B    8    SEEN                  BAGNAIA   83 UA2  P AP, ECM=550 GEV.  11/83*
R1   B  BAGNAIA 83 INTERPRET THEIR EVENTS AS EITHER (Z-->E+ E-) OR           11/83*
R1   B  (Z-->E+ E- GAMMA) .                                                  11/83*

R2      Z INTO (MU+ MU-)/TOTAL                            (P2)
R2        1    SEEN                  ARNISON   83 UA1  P AP, ECM=540 GEV.  11/83*

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                              REFERENCES FOR Z(95000)

ARNISON  83 PL 126B 398       UA1 COLLAB.(AACH+LAPP+BIRM+CERN+HELS+LOQM+)
ARNISON2 83 PL 129B 273       UA1 COLLAB.(AACH+LAPP+BIRM+CERN+HELS+LOQM+)
BAGNAIA  83 PL 129B 130       UA2 COLLAB. (BERN+CERN+BOHR+LALO+PAVI+SACL)
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WEAK GAUGE BOSON SEARCHES

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       MEASUREMENTS OF PARAMETERS OF THE W AND Z ARE LISTED IN
       SEPARATE SECTIONS ABOVE.

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M       W BOSON MASS LIMITS (GEV)
M    A   0     1.7    OR MORE  CL=.99   BERNARDIN 65 HYBR +  NEU N, CERN          2/74
M    A   0     2.0    OR MORE  CL=.90   BURNS     65 OSPK +  NEU N, BNL           2/74
M    B   0     3.8    OR MORE  CL=.90   BARISH    73 ASPK +  W+ TO LEP+NEU=.2     2/74
M    B   0     4.5    OR MORE  CL=.90   BARISH    73 ASPK +  W+ TO LEP+NEU=.5     2/74
M    B   0     4.7    OR MORE  CL=.90   BARISH    73 ASPK +  W+ TO LEP+NEU=.8     2/74
M    C   0     5.0    OR MORE  CL=.95   BERGESON  73 ELEC                         1/76
M    D   0 NONE WITH MASS 10-20 GEV     BUSSER    74 WIRE +-0 P-P,52.7 GEV CM     8/76
M    E   0 NONE WITH MASS 5.5-8.5 GEV ABRAMOV     77 CNTR +-                     12/77
M
M    A  LOOKED FOR (NEU N) TO (W+ MU- N), W+ TO (MU+ NEU, E+ NEU, OR HDRNS)  2/74
M
M    B  BARISH 73 LOOKED FOR (NEU N) TO (W+ MU- N), W+ TO (MU+ NEU) AT NAL.  2/74
M    B  RESULT GIVEN FOR THREE ASSUMED BR.FRACS. W+ TO (LEPTON NEU)/ALL.     2/74
M
M    C  BERGESON 73 LOOKED AT ENERGY DISTR OF NEU-INDUCED MUON FLUX UNDER-   1/76
M    C  GROUND. SCALE INVARIANCE OF THE INELASTIC STRUCT FN ASSUMED.         1/76
M
M    D  BUSSER 74 IS CERN ISR EXPT. LOOKED FOR ELECTRONS OF LARGE            8/76
M    D  TRANSVERSE MOMENTUM. RESULT QUOTED ABOVE IS MODEL DEPENDENT.         8/76
M
M    E  ABRAMOV 77 IS 70 GEV P-CU EXPT AT SERP LOOKING AT DIRECT MUONS OF   12/77
M    E  HIGH TRANSVERSE MOM. RESULT IS MODEL DEPENDENT.                     12/77

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MR        RIGHT-HANDED W BOSON MASS LIMITS (GEV)                              11/83*
MR   A                                  BERGSMA   83 CHRM +  NUMU E -->MU NUE  1/84*
MR   B      380.     OR MORE  CL=.90    CARR      83 ELEC +  MU+ DECAY        11/83*
MR
MR   A  BERGSMA 83 SET LIMIT M(W2)/M(W1) > 1.9 AT CL=.90.                     1/84*
MR
MR   B  CARR 83 IS TRIUMF EXPERIMENT WITH A HIGHLY POLARIZED MU+ BEAM.       11/83*
MR   B  LOOKED FOR DEVIATION FROM V-A AT THE HIGH MOMENTUM END OF THE DECAY 11/83*
MR   B  E+ ENERGY SPECTRUM. LIMIT FROM PREVIOUS WORLD-AV.MUON POLALIZATION  11/83*
MR   B  PARAMETER IS M(WR)> 240 GEV.                                        11/83*

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C       W BOSON PRODUCTION CROSS SECTION (10**-36 CM**2)
C    A   0     6.0    OR LESS              ANKENBRAN 71 CNTR +- W TO(MU NEU)=1.0  2/74
C
C    A  ANKENBRANDT 71 LOOKED FOR (P N)TO(W HADRONS), W TO (MU NEU) AT BNL.  2/74
C    A  THIS ASSUMES BR OF W TO MU NEU IS 1.  IN GENERAL THIS VALUE IS       2/74
C    A  6.0/BR, WHERE BR=(W TO MU NEU)/(W TO ALL).                           2/74

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ZOA     CHARGE ASYMMETRY IN E+ E- --> MU+ MU-                                  1/83*
ZOA  A                                  BARTEL    82 JADE WCM=25.-36.8GEV      1/83*
ZOA  B                                  FERNANDEZ 83 MAC  WCM=29 GEV          11/83*
ZOA  C                                  ALTHOFF   84 TASS WCM=34.4 GEV        11/83*
ZOA
ZOA  A  BARTEL 82 OBTAINED A=-0.118+-.038 AFTER RAD. COR. AND FOR             1/83*
ZOA  A  COS(THETA) WITHIN (+-0.8).  CONSISTENT WITH STANDARD MODEL            1/83*
ZOA  A  PREDICTION A=-0.078).                                                 1/83*
ZOA
ZOA  B  FERNANDEZ 83 GOT A=-.076+.018-.003.ST.MODEL(INCL.RC) GIVES A=-.060. 11/83*
ZOA
ZOA  C  ALTHOFF 84 OBTAINED A=-.098+-.023+-.005, SIN(THETA/W)**2=.27+-.07.  11/83*

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ZOM     ZO BOSON MASS LIMITS IN E+ E- ANNIHILATION (GEV)                      2/82
ZOM  A   0    51.     OR MORE  CL=.95   BARTEL    81 JADE                     2/82
ZOM  B   0    40.     OR MORE  CL=.95   BERGER    81 PLUT                     2/82
ZOM  C        45.0    OR MORE  CL=.95   BRANDELIK 82 TASS                    10/83*
ZOM  D     BETWEEN 43.1-81.8 CL=.95     BRANDEL2  82 TASS                    11/83*
ZOM  E        50.     OR MORE  CL=.95   FERNANDEZ 83 MAC                     11/83*
ZOM
ZOM     ABOVE LIMITS ARE IN STANDARD SU(2)XU(1) MODEL. FOR BOUND-PLOTS IN    2/82
ZOM     EXTENDED MODELS WITH TWO OR MORE ZO'S, SEE INDIVIDUAL PAPERS.        2/82
ZOM
ZOM  A  BARTEL 81 AT DESY-PETRA STUDIED E+E- -->E+E-,MU+MU- UP TO WCM=36GEV  2/82
ZOM  A  IN STANDARD MODEL WITH FREE ZO MASS AND WITH COUPLINGS FIXED AT LOW  2/82
ZOM  A  Q2 VALUES(SIN(THETA/W)**2=.23).                                      2/82
ZOM
ZOM  B  BERGER 81 AT DESY-PETRA ANALYZED E+E- -->E+E-,MU+MU-,TAU+TAU- DATA   2/82
ZOM  B  AT WCM=27.5-31.6 GEV IN STANDARD MODEL. CL=.95 CONTOUR IN GV**2 AND  2/82
ZOM  B  GA**2 PLANE IS INCONSISTENT W. NU E RESULT IF MZ BELOW ABOVE LIMIT.  2/82
ZOM
ZOM  C  BRANDELIK 82 AT DESY-PETRA FITTED TO TOTAL E+E- CROSS SECTION WITH   1/83*
ZOM  C  WCM=14-36.7 GEV INCLUDING QCD CORRECTION WITH ALPHAS=0.17. ABOVE     1/83*
ZOM  C  LIMIT ASSUMES SIN(THETA/W)**2=.228.                                  1/83*
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For notation, see key at front of Listings.


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ZOM  D  BRANDELIK2 82 STUDIED E+E- -->E+E-,MU+MU- AT WCM=34.4 GEV. LIMIT    11/83*
ZOM  D  ASSUMES LOW-ENERGY NU E SCATTERING RESULT GV**2=.0016,GA**2=.25 .   11/83*
ZOM
ZOM  E  FERNANDEZ 83 ANALYZED E+E- -->MU+MU- AT WCM=29 GEV WITH PEP-MAC.     11/83*
ZOM  E  ABOVE LIMIT IS FROM FIT TO THE ENERGY-DEPENDENCE OF ASYMMETRY DATA  11/83*
ZOM  E  INCLUDING THIS DATA AND ASSUMES GA(E)*GA(MU)=0.25.                  11/83*

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S       SCALAR BOSON MASS LIMITS (GEV)
S    A   0   10.0   OR MORE  CL=.90   CONVERSI  73 ASPK  0 E+E- FRASCATI     3/74
S
S    A  CONVERSI 73 LOOKED FOR QED VIOLATION IN E+E- SCATTERING AT 2.8 GEV   3/74
S    A  AND ASSUMED W BOSON MASS=10 GEV.  FOR MW=15 GEV, MS LIMIT= 6.5 GEV   3/74

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                              REFERENCES FOR WEAK GAUGE BOSON SEARCHES

BERNARDI 65 NC 38 608         BERNARDINI,BIENLEIN,BOHM,DARDEL,+     (CERN)
BURNS    65 PRL 15 42         +GOULIANOS,HYMAN,LEDERMAN,LEE +  (COLU+BNL)
ANKENBRA 71 PR D3 2582        ANKENBRANDT,LARSEN,LEIPUNER+     (BNL+YALE)

BARISH   73 PRL 31 180        +BARTLETT,BUCHHOLZ,HUMPHREY+     (CIT+FNAL)
BERGESON 73 PRL 31 66         +CASSIDAY,HENDRICKS                  (UTAH)
CONVERSI 73 PL 46B 269        +D'ANGELO,GATTO,PAOLUZI              (ROMA)
BUSSER   74 PL 48B 371        +CAMILLERI,DI LELLA +      (CERN+COLU+ROCK)
ABRAMOV  77 SJNP 25 41        +ANISIMOVA,BONDARENKO,GRIDASOV +     (SERP)

BARTEL   81 PL 99B 281        JADE C.  (DESY+HAMB+HEID+LANC+MCHS+RL+TOKY)
BERGER   81 ZPHY C7 289       PLUTO C.(AACH+BERG+DESY+HAMB+UMD+SIEG+WUPP)
BARTEL   82 PL 108B 140       JADE C.  (DESY+HAMB+HEID+LANC+MCHS+RL+TOKY)
BRANDELI 82 PL 113B 499       TASSO C.  (AACH+BONN+DESY+HAMB+LOIC+OXF+RL)
BRANDEL2 82 PL 117B 365       BRANDELIK+ TASSO C.  (AACH+BONN+DESY+HAMB+)

BERGSMA  83 PL 122B 465       CHARM C.         (ANIK+CERN+HAMB+ITEP+ROMA)
CARR     83 PRL 51 627        +GIDAL,GOBBI,JODIDIO,ORAM+  (LBL+NWES+TRIU)
FERNANDE 83 PRL 50 1238       + (COLO+FRAS+HOUS+NEAS+STAN+SLAC+UTAH+WISC)
ALTHOFF  84 ZPHY (TO BE PUBL.)TASSO C. (AACH+BONN+DESY+HAMB+LOIC+OXF+RL+)
    ALSO 82 BRANDELIK2

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NOTE ON NEUTRINOS

(by R.E. Shrock, State Univ. of New York, Stony Brook)

With the 1982 edition of this Review, the section on neutrino properties was expanded and reorganized. As before, there are listings which deal specifically with ν_e, ν_μ, and ν_τ. In addition, in the category of searches near the end of the Stable Particle Listings, we include sections which deal with correlated bounds on neutrino masses and lepton mixing but which do not pertain to any one weak eigenstate individually. Furthermore, we include constraints from cosmological and astrophysical data. (Since this Review is a compendium of data traditionally derived more or less directly from particle and nuclear physics, we have been somewhat less comprehensive in our coverage of astrophysical data.)

In contrast to the other particles in this Review, the neutrinos ν_e, ν_μ, and ν_τ are defined as weak eigenstates (that is, states which couple weakly with unit strength to e, ν, and τ) and are not, in general, states of definite mass. In the conventional case, where all neutrinos were assumed to be massless and hence degenerate, it was possible to define the weak eigenstates to be simultaneously mass eigenstates. However, in the general case of massive (nondegenerate) neutrinos, the weak eigenstates have no well-defined masses, but instead are linear combinations of mass eigenstates. Let us denote the charged leptons as the set $\{\ell_a\}$, a = 1, $\cdots$,n, where $n \geqslant 3$ is the number of generations, with $\ell_1 \equiv e$, $\ell_2 \equiv \mu$, $\ell_3 \equiv \tau$. In the standard $SU(2)_L \times U(1)$ electroweak theory[1] the mixing of the left-handed components of the mass eigenstates $(\nu_j)_L$ to form the weak gauge-group eigenstates $(\nu_{\ell_a})_L$ is specified by the transformation

$$(\nu_{\ell_a})_L = \sum_{j=1}^{n} U_{aj} (\nu_j)_L \,,$$

where $U^\dagger = U^{-1}$. (In the case of Dirac neutrinos there are right-handed components of the ν_j, but they are singlets under the gauge group; in the case of Majorana neutrinos in the standard theory there are no right-handed components.) The ordering of the mass eigenbasis is defined such that U is as nearly diagonal as possible, i.e., $|U_{jj}|$ (no sum on j) $\geqslant |U_{jk}|$, $k \neq j$. This does not imply that $m(\nu_j) > m(\nu_k)$ if $j > k$, although this ordering might be regarded as natural in view of the similar one that obtains in the quark sector. The virtue of this convention is that a mass limit on "$m(\nu_{\ell_a})$" can be used as a definite limit on ν_j, j = a, the dominantly coupled mass eigenstate in ν_{ℓ_a}.

Thus, in this general case of n massive (Dirac or Majorana) neutrinos, decays such as $H^3 \rightarrow He^3 + e^- + \overline{\nu}_e$ and $\pi^+ \rightarrow \mu^+ + \nu_\mu$, which have been used to set the best bounds on the respective neutrino masses, really consist of incoherent sums of the separate decay modes $H^3 \rightarrow He^3 + e^- + \overline{\nu}_j$ and $\pi^+ \rightarrow \mu^+ + \nu_k$, where the ν_j, ν_k are mass eigenstates, and the indices j and k range over the subset $\{1, \cdots, n\}$ allowed by phase space in these two respective decays.[2] The coupling strengths for the j^{th} modes are given for the two decays by the factors $|U_{1j}|^2$ and $|U_{2j}|^2$, respectively. There are, in addition, certain kinematic factors depending on the $m(\nu_j)$ which enter in determining the branching ratio for the j^{th} decay mode. Assuming that the off-diagonal elements of the lepton mixing matrix U are small relative to the diagonal elements, the dominantly coupled decays are the ones with coupling strength $|U_{aj}|^2$, a = j, i.e., $H^3 \rightarrow He^3 + e^- + \overline{\nu}_1$ and $\pi^+ \rightarrow \mu^+ + \nu_2$.

It follows that the old neutrino mass limits quoted in the literature for "$m(\nu_e)$", "$m(\nu_\mu)$" and "$m(\nu_\tau)$" are meaningful only insofar as they are reinterpreted as limits on the corresponding mass eigenstates. Specifically, a bound such as the Bergkvist limit,[3] "$m(\nu_e)$" < 60 eV (90% CL), really constitutes a weighted limit on each of the mass eigenstates ν_j in the weak eigenstate ν_e which are kinematically allowed to occur in tritium decay and which are coupled with strength $|U_{1j}|^2$ sufficiently

Stable Particles

Data Card Listings

Neutrinos

large to make a significant contribution to the observed spectrum. It is thus certainly a limit on ν_1. If leptonic mixing is hierarchical as quark mixing is known to be (at least for the first three generations), i.e., $|U_{jj}|^2 \gg |U_{jk}|^2$, $j \neq k$, then ν_1 is the only mass eigenstate significantly constrained by a bound on "$m(\nu_e)$." Furthermore, a neutrino mass limit cannot be stated in isolation; it always contains some implicit dependence on the relevant lepton mixing angles. Fortunately, this dependence is relatively unimportant for the dominantly coupled decay modes, i.e., $e\bar{\nu}_1$, $\mu\bar{\nu}_2$, and $\tau\bar{\nu}_3$. Since these modes were the ones responsible for the mass limits given previously, the latter can be reinterpreted without significant complication as proper limits on $m(\nu_j)$, j = 1, 2, and 3, respectively.

In addition to mass and lifetime limits, we have added data on neutrino magnetic dipole moments. These are of interest because a massless, purely chiral (empirically, left-handed) Dirac neutrino cannot have a magnetic (or electric) dipole moment. The same is true for a Majorana neutrino, whether massless or massive, because of its defining property of being self-conjugate.

If one considers the possibility of nonzero masses for neutrinos, for consistency one must also consider the leptonic mixing which would in general occur concomitantly. Accordingly we have devoted one category in the searches section to correlated bounds on neutrino masses and lepton mixing angles. These can be divided into two types. First, there are those due to decays involving neutrinos in the final state, which must be recognized to have the general multimode structure pointed out above. In the two most sensitive cases suggested as tests for neutrino masses and mixing,[2] one obtains a limit on $m(\nu_j)$ and $|U_{aj}|^2$ individually for each j. Second, there are those due to processes involving the propagation and subsequent interaction of neutrinos. The latter are often called neutrino "oscillation"[3] limits, although this term is correct only if the differences in neutrino masses are sufficiently small relative to their momenta that the propagation is effectively coherent in a quantum mechanical sense; otherwise, the individual ν_j from a given decay such as $\pi_{\mu 2}$ or $k_{\mu 2}$ propagate in a measurably incoherent manner and there is no "oscillation." Experimentalists usually present their results in terms of a simplifying model in which mixing is assumed to occur only between two neutrino species. Then the transformation equation becomes

$$\begin{pmatrix} \nu_{\ell_a} \\ \nu_{\ell_b} \end{pmatrix} = \begin{pmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{pmatrix} \begin{pmatrix} \nu_i \\ \nu_j \end{pmatrix} .$$

Let the distance between the source of the neutrinos and their point of interaction be labeled as x, and their energy as E. Assume furthermore that the $m(\nu_j)$ are such that the coherence assumption is valid. Then, the probability of an initial ν_{ℓ_a} being equal to ν_{ℓ_b} at time t, or equivalently (given the above assumption) at distance x = t, is

$$|\langle \nu_{\ell_b}(0) | \nu_{\ell_a}(t) \rangle|^2 = \sin^2 2\theta \sin^2 \left(\frac{\Delta m^2 x}{4E} \right) ,$$

where

$$\Delta m^2 = m(\nu_i)^2 - m(\nu_j)^2 .$$

Thus, neutrino oscillation experiments cannot measure individual neutrino masses, but only differences of masses squared, and indeed these are generally weighted in a more complicated way by mixing-matrix coefficients than in the two-species model. Experimental results are presented as allowed regions on a plot, the axes of which are $|\Delta m^2|$ and $\sin^2 2\theta$. These are often summarized in terms of the asymptotic limits $|\Delta m^2|_{max}$ for $\sin^2 2\theta = 1$, and $\sin^2 2\theta$ for "large" $|\Delta m^2|$, i.e., sufficiently large $|\Delta m^2|$ that the detector averages over many cycles of oscillation (or there ceases to be any coherence). We refer the reader to the original papers for the two-dimensional plots; for the purpose of these Listings, we shall give only the asymptotic limits.

An important question has to do with whether neutrinos are Dirac or Majorana (self-conjugate) particles. In the former case neutrinoless double beta decay, (Z,A) → (Z+2,A) + e^- + e^-, is forbidden from occurring.[4] In the Majorana case it may occur if (a) neutrinos are massive and/or (b) there are right-handed leptonic currents. In the light-neutrino case an upper limit on neutrinoless double beta decay yields a correlated upper bound on the quantity

$$\overline{m} \equiv \left| \sum_{j=1}^{n} U_{1j}^2 \, m(\nu_j) \right|$$

and η, the fractional admixture of right-handed leptonic current.

The correlated limits given in the section on Massive Neutrinos and Lepton Mixing are in digital form. For recent compendia of limits in convenient graphical form, see Refs. 5 and 6, and Figs. 1 and 2 (pp. 332-333) of Ref. 7.

Further explanatory notes are included in the Listings.

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5. M.H. Shaevitz, in *Proceedings of the 1983 International Symposium on Lepton and Photon Interactions at High Energies*, Cornell, eds. D.G. Cassel and D.L. Kreinich (Cornell University, 1983), p. 132.
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7. R.E. Shrock, in *Proceedings of the Third LAMPF II Workshop*, eds. J.C. Allred et al. (Los Alamos National Laboratory, 1983), p. 316.

ν_e

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                     1  NU-E(J=1/2)
        NOT IN GENERAL A MASS EIGENSTATE

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                     1  NU-E ''MASS'' (EV)

        APPLIES TO NU-1, THE PRIMARY MASS EIGENSTATE IN NU-E.  WOULD ALSO
        APPLY TO ANY OTHER NU-J WHICH MIXES STRONGLY IN NU-E AND HAS
        SUFFICIENTLY SMALL MASS THAT IT CAN OCCUR IN THE RESPECTIVE DECAYS.
        THE NEUTRINO MASS MAY BE OF DIRAC OR MAJORANA TYPE; THE FORMER
        CONSERVES TOTAL LEPTON NUMBER WHILE THE LATTER VIOLATES IT.
        IN GENERAL, EITHER WOULD VIOLATE LEPTON FAMILY NUMBER, SINCE
        NOTHING FORCES THE NEUTRINO MASS EIGENSTATES TO COINCIDE WITH THE
        NEUTRINO INTERACTION EIGENSTATES.  FOR LIMITS ON MAJORANA NU-E
        MASS, SEE THE SECTION ON MASSIVE NEUTRINOS AND LEPTON MIXING,
        PART 5(C), ENTITLED SEARCHES FOR NEUTRINOLESS DOUBLE BETA DECAY.

        NOTE -- THE ABBREVIATION ANU IS USED BELOW FOR ANTINU

M           (250.)   OR LESS            LANGER    52 CNTR    ANU-E, TRITIUM
M           (500.)   OR LESS            HAMILTON  53 CNTR    ANU-E, TRITIUM    11/73
M           (550.)   (280.)             FRIEDMAN  58 CNTR    ANU-E, TRITIUM
M          (4100.)   OR LESS  CL=.67    BECK      68 CNTR    NU, SODIUM 22     11/73
M   D       (500.)   OR LESS  CL=.90    DARIS     69 CNTR    ANU-E, TRITIUM    11/73
M           (320.)   OR LESS  CL=.90    SALGO     69 CNTR    ANU-E, TRITIUM    11/73
M            (60.)   OR LESS  CL=.90    BERGKVIS  72 CNTR    ANU-E, TRITIUM    11/73
M            (86.)   OR LESS  CL=.90    RODE      72 CNTR    ANU-E, TRITIUM    11/73
M           (100.)   OR LESS            PIEL      73 CNTR    ANU-E, TRITIUM     1/81
M            (4.5E5)OR LESS   CL=.90    CLARK     74 ASPK    KE3 DECAY         11/75
M     L      (35.)   OR LESS  CL=.90    TRETYAKOV 76 SPEC    ANU-E, TRITIUM     4/82
M     L      (14.)  TO 46.    CL=.99    LUBIMOV   80 SPEC    ANU-E, TRITIUM     9/81
M            (65.)   OR LESS  CL=.95    SIMPSON   81 CNTR    ANU-E, TRITIUM     1/82
M          (1300.)   OR LESS            ANDERSEN  82 CNTR    NU, HOLMIUM 163   11/82*
M           (500.)   OR LESS  CL=.90    JONSON    83 CNTR    NU, PLATINUM 193   2/84*
M    P       (20.)   OR MORE  CL=.95    LUBIMOV   83 CNTR    ANU-E, TRITIUM     3/84*
M    Y     (1250.)   OR LESS            YASUMI    83 CNTR    NU, HOLMIUM 163   11/83*
M   D     DARIS 69 VALUE 75EV(CL=.67) DISAGREES WITH THEIR FIG.6. WE USE       11/73
M   D     FIG.6.                                                               11/73
M     L   TRETYAKOV 76 DATA INCLUDED, AT LEAST IN PART, IN LUBIMOV 80.          4/82
M     L   NOTE THAT LUBIMOV 83 REMARKS THAT THE 14 EV LOWER LIMIT GOES TO       3/84*
M     L   ZERO IF THE INTRINSIC RESOLUTION OF THE CONVERSION LINES USED FOR     3/84*
M     L   CALIBRATION ARE TAKEN INTO ACCOUNT.  A DETAILED DISCUSSION IS GIVEN   3/84*
M     L   BY SIMPSON 84.  SEE ALSO THE DISCUSSION OF THE LUBIMOV 80 RESULT      3/84*
M     L   BY BERGKVIST 80.  WE CONTINUE TO USE UPPER LIMIT FROM LUBIMOV 80      3/84*
M     L   IN THE STABLE PARTICLE TABLE.                                         3/84*
M    Y    LIMIT OBTAINED BY YASUMI 83 ASSUMES UPPER LIMIT ON Q-VALUE           11/83*
M    Y    REPORTED BY ANDERSEN 82.                                             11/83*
M    P  PRELIMINARY RESULT FROM BRIGHTON CONF.                                  3/84*

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                  1  (NU-1) - (ANU-1) MASS DIFF. (EV)

        TEST OF CPT FOR A DIRAC NEUTRINO

DM         (4100.)   OR LESS  CL=.67    BECK      68 CNTR    NU, SODIUM 22     11/73
DM           (4.5E5)OR LESS   CL=.90    CLARK     74 ASPK    KE3 DECAY         11/75
DM         (1300.)   OR LESS            ANDERSEN  82 CNTR    NU, HOLMIUM 163   11/82*
DM     Y    1250.    OR LESS            YASUMI    83 CNTR    NU, HOLMIUM 163   11/83*
DM     Y  ASSUMES UPPER LIMIT ON Q-VALUE REPORTED BY ANDERSEN 82.              11/83*

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                  1  NU-1 MEAN LIFE/MASS  (UNITS SEC/EV)

T     R      3. E 2  OR MORE            REINES    74 CNTR    ANTI-NEUTRINO      3/78
T     R  REINES 74 LOOKED FOR NU-E OF NON-ZERO MASS DECAYING TO A NEUTRAL       3/78
T     R  OF LESSER MASS + GAMMA.  USED LIQUID SCINT. DETECTOR NEAR FISSION      3/78
T     R  REACTOR.  FINDS LAB LIFETIME 6.E7 SEC OR MORE.  ABOVE VALUE OF         3/78
T     R  MEAN LIFE/MASS ASSUMES AVG. EFFECTIVE NEUTRINO ENERGY OF 0.2MEV.       3/78
T     R  TO OBTAIN THE LIMIT 6.E7 SEC REINES 74 ASSUMED THAT THE FULL           2/84*
T     R  ANTI-NUE REACTOR FLUX COULD BE RESPONSIBLE FOR YIELDING DECAYS         2/84*
T     R  WITH PHOTON ENERGIES IN THE INTERVAL 0.1 MEV TO 0.5 MEV.  THIS         2/84*
T     R  REPRESENTS SOME OVERESTIMATE SO THEIR LOWER LIMIT IS AN OVER-          2/84*
T     R  ESTIMATE OF THE LAB LIFETIME (P. VOGEL, PRIV. COMM., 1984).            2/84*

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                  1  NU-1 MAGNETIC MOMENT  (UNITS EV/GAUSS)

        MUST VANISH FOR MAJORANA NEUTRINO OR PURELY CHIRAL MASSLESS
        DIRAC NEUTRINO

MM   B     (1.1E-17)OR LESS             BERNSTEIN 63                            1/82
MM   B   BERNSTEIN 63 IS A THEORETICAL ANALYSIS OF REACTOR ANTINU-E             1/82
MM   B   SCATTERING DATA.                                                       1/82
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                          REFERENCES FOR NU-E

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)
BERNSTEI  63 PR  132 1227        BERNSTEIN,RUDERMAN,FEINBERG         (NYU+COLU)
BECK      68 ZPHY 216 229        E BECK,H DANIEL                         (MPIH)
DARIS     69 NP A138 545         R DARIS,C ST-PIERRE             (LAVAL-QUEBEC)
SALGO     69 NP A138 417         R C SALGO,H H STAUB                   (ZURICH)

BERGKVIS  72 NP B39 317          KARL-ERIK BERGKVIST         (UNIV STOCKHOLM)
RODE      72 LNC 5 139           B RODE,H DANIEL                  (MUNICH+MPIH)
PIEL      73 NP A203 369         WILLIAM F. PIEL, JR.                      (IND)
CLARK     74 PR D9 533           +ELIOFF,FRISCH,JOHNSON,KERTH,SHEN+        (LBL)
REINES    74 PRL 32 180          +SOBEL,GURR                               (UCI)
    ALSO  78  PRIVATE COMM.      V. BARNES                                (PURD)

TRETYAKO  76 BASUP 40 10-1       TRETYAKOV+ (BULL.ACAD.SCI.USSR,PHY.) (ITEP)
    ALSO  76 NU CONF. AACHEN     TRETYAKOV,MYASOEDOV,APALIKOV,KONYAEV+(ITEP)
BERGKVIS  80 NEUTRINO 80,ERICE K.E.BERGKVIST                            (STOH)
LUBIMOV   80 PL 94B 266          +NOVIKOV,NOZIK,TRETYAKOV,KOSIK           (ITEP)
    ALSO  80 SJNP 32 154         (YF 32 301) KOZIK,LUBIMOV,NOVIKOV,+  (ITEP)
    ALSO  81 JETP 54 616         (ZETF 81 1158) LUBIMOV,NOVIKOV,NOZIK+(ITEP)
SIMPSON   81 PR D23 649          J.J.SIMPSON                              (GUEL)

ANDERSEN  82 PL 113B 72          +BEYER,CHARPAK,DERUJULA +  (AARH+CERN+RISO)
JONSON    83 NP A396 479C        +ANDERSEN,BEYER+       (CERN+AARH+BOHR+LUND)
LUBIMOV   83 BRIGHTON CONF.      PROC. OF HEP 83, P. 386                  (ITEP)
YASUMI    83 PL 122B 461         +RAJASEKARAN,ANDO+ (KEK+OSAK+TIT+TOHO+TSUK)
SIMPSON   84 PREPRNT SUB.TO PL   J.J. SIMPSON                             (GUEL)

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Stable Particles — Data Card Listings

e, ν_μ

e

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                         3  ELECTRON(0.5,J=1/2)
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                         3  ELECTRON MASS (MEV)

M          (0.511006 0.00002)        COHEN      65 RVUE
M          (0.5110041 .0000016)      TAYLOR     69 RVUE     USING NEW E/H      7/70
M           0.5110034 .0000014       COHEN      73 RVUE                        3/74

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                         3  ELECTRON MEAN LIFE / BRANCHING FRACTION (UNITS YRS)

                            TEST OF CHARGE CONSERVATION

T   MS     (2. E21) OR MORE          MOE        65 CNTR     SEE NOTE S BELOW   6/66
T          (4. E22) OR MORE          MOE        65 CNTR     E- --> NEU GAMMA   6/66
T    S     (5.3E21) OR MORE          STEINBERG 75 CNTR     SEE NOTE S BELOW   2/76
T    S      2. E22  OR MORE  CL=.68  KOVALCHUK 79 CNTR     SEE NOTE S BELOW   1/81
T          (3.5E23) OR MORE  CL=.68  KOVALCHUK 79 CNTR     E- --> NEU GAMMA   1/81
T          (3. E23) OR MORE  CL=.68  BELLOTTI   83 CNTR     E- --> NEU GAMMA  11/83*
T    B      2. E22  OR MORE  CL=.68  BELLOTTI   83 CNTR     SEE NOTE B BELOW  11/83*
T    M   SEE MOE 65 FOR DISCUSSION OF EARLIER EXPERIMENTS.                      1/81
T    M   MOE 65 LIMIT REESTIMATED BY STEINBERG 75 TO BE (1. E20).               1/81
T    S   THESE LIMITS ARE FOR ALL MODES IN WHICH DECAY PARTICLES ESCAPE         1/81
T    S   FROM THE DETECTOR WITHOUT DEPOSITING ENERGY.                           1/81
T    B   SECOND LIMIT OF BELLOTTI 83 IS FOR DISAPPEARANCE OF K-ELECTRONS IN   11/83*
T    B   GE-ATOMS. THIS WOULD PRODUCE A PEAK IN THE GE(LI) COUNTER SPECTRUM.  11/83*

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                         3  ELECTRON MAGNETIC MOMENT(E/2ME)

MM       ELECTRON OR POSITRON G/2-VALUE
MM        THIS IS MAGNETIC MOMENT IN UNITS (E/2ME-) FOR E-, (E/2ME+) FOR E+.
MM        FOR REVIEWS OF THEORY AND EXPERIMENTS, SEE KINOSHIA 78, LAUTRUP 72,
MM        AND RICH 72.
MM        FOR MOST ACCURATE THEORETICAL CALCULATION, SEE KINOSHITA 81.
MM          (1.0011609)    +-(24)E-7     SCHUPP     61 CNTR -
MM          (1.001159622) +-(27)E-9      WILKINSON 63 CNTR -                       8/66
MM          (1.001168)     +-(22)E-6     RICH       66 CNTR +  POSITRON            8/66
MM R        (1.001159557) +-(30)E-9      RICH       68 CNTR -                      6/68
MM          (1.0011596389)+-(31)E-10     TAYLOR     69 RVUE                        2/71
MM          (1.001159644) +-(7)E-9       WESLEY     70 CNTR                        6/70
MM          (1.0011596577)+-(35)E-10     WESLEY     71 CNTR -                      2/72
MM          (1.0011603)    +-(12)E-7     GILLELAND 72 CNTR +                      2/72
MM          (1.0011596567)+-(35)E-10     COHEN      73 RVUE                        3/74
MM          (1.001159667) +-(24)E-9      WALLS      73 CNTR -  BOLOMETRIC TECHN  11/77
MM          (1.00115965241)+-(20)E-11    VANDYCK    77 CNTR -  RPL.BY VANDYCK79  12/77
MM V         1.001159652200+-(40)E-12    VANDYCK    79 CNTR -  PENNING TRAP       1/82
MM           1.001159652222+-(50)E-12    SCHWINBER 81 CNTR +  PENNING TRAP       1/82
MM R     RICH 68 IS REEVALUATION OF WILKINSON 63.
MM V     VANDYCK 79 CONFIRMED FINAL BY H. DEHMELT, PRIV. COMM.                     1/82
MM
MM  AVG     1.001159652209+-(31)E-12 AVERAGE (ERROR INCL. SCALE FACTOR 1.0)     1/82
MM       AVERAGE ASSUMING EQUAL G/2-VALUES FOR E+ AND E- BY CPT.

MMR      POSITRON TO ELECTRON G-FACTOR RATIO MINUS ONE, (G+/G-)-1
MMR       TEST OF CPT
MMR         (1.6E-8) OR LESS  CL=.95     SEREDNYAK 77 CNTR ME+=ME- ASSUMED       4/82
MMR          2.2E-11  6.4E-11            SCHWINBER 81 ELEC    PENNING TRAP       4/82

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                         3  ELECTRON ELECTRIC DIPOLE MOMENT(UNITS 10**-23 E-CM)

                  FORBIDDEN BY BOTH T INVARIANCE AND P INVARIANCE

EDM          0.3   OR LESS  CL=.90   WEISSKOPF 68 MRS     CESIUM             12/79
EDM         (0.07)   (0.22) CL=.90   PLAYER     70 MRS     XENON               4/82
EDM         (0.19)   (0.34) CL=.90   SANDARS    75 MRS     THALLIUM            4/82
EDM         (8.1)    (11.6)          VASILEV    78                            12/79
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REFERENCES FOR ELECTRON


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SCHUPP   61 PR  121    1        A A SCHUPP,R W PIDD,H R CRANE              (MICH)
WILKINSO 63 PR 130 852          D T WILKINSON,H R CRANE                    (MICH)
COHEN    65 RMP 37 537          COHEN,DUMOND  (N.A.AVIATION SCI.CENTER+CIT)
MOE      65 PR 140 B 992        M K MOE,F REINES       (CASE INST TECHNOLOGY)

RICH     66 PRL  17  271        A RICH, H R CRANE                          (MICH)
RICH     68 PRL 20 967          A RICH                                     (MICH)
WEISSKOP 68 PRL 21 1645         WEISSKOPF,CARRICO,GOULD,LIPWORTH+          (BRAN)
TAYLOR   69 RMP 41 375          +PARKER,LANGENBERG                (PRIN+UCI+PENN)

PLAYER   70 JP B3 1620          M.A.PLAYER,P.G.H.SANDARS                    (OXF)
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)
LAUTRUP  72 PRPL 3 193          B.LAUTRUP,A.PETERMAN,E.DE RAFAEL(CERN+BURE)
RICH     72 RMP 44 250          A RICH,J C WESLEY                          (MICH)
COHEN    73 J.PHYS.CHEM.REF.DATA 2, P.663, E.R.COHEN,B.N.TAYLOR
WALLS    73 PRL 31 975          F.L.WALLS,T.S.STEIN                        (WASH)
SANDARS  75 PR A11 473          P.G.H.SANDARS,R.M.STERNHEIMER          (OXF+BNL)
STEINBER 75 PR D12 2582         R.I.STEINBERG,KWIATKOWSKI,MAENHAUT+         (UMD)
SEREDNYA 77 PL 66B 102          SEREDNYAKOV,SIDOROV,SKRINSKY+              (NOVO)
VANDYCK  77 PRL 38 310          +SCHWINBERG,DEHMELT                        (WASH)
KINOSHIT 78  TOKYO HEP P.571    T. KINOSHITA                               (CORN)

VASILEV  78 JETP 47 243         +KOLYCHEVA                                 (JINR)
KOVALCHU 79 JETPL 29 145        KOVALCHUK,POMANSKY,SMOLNIKOV               (INRM)
VANDYCK  79 BULL. APS 24 758    +SCHWINBERG,DEHMELT                        (WASH)
   ALSO  81 AT.PHYS. 7, P.337 H.DEHMELT(EDS.KLEPPNER+,PLENUM,NY,81)(WASH)
KINOSHIT 81 PRL 47 1573         T.KINOSHITA, W.B.LINDQUIST                 (CORN)
SCHWINBE 81 PRL 47 1679         SCHWINBERG,VAN DYCK,DEHMELT                (WASH)
BELLOTTI 83 PL 124B 435         +CORTI,FIORINI,LIGUORI,PULLIA+             (MILA)
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ν_μ

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                         2  NU-MU(J=1/2)
         NOT IN GENERAL A MASS EIGENSTATE.  SEE NOTE ON NEUTRINOS
         IN THE ELECTRON NEUTRINO SECTION ABOVE.

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                         2  NU-MU ''MASS'' (MEV)

          APPLIES TO NU-2, THE PRIMARY MASS EIGENSTATE IN NU-MU.  WOULD ALSO
          APPLY TO ANY OTHER NU-J WHICH MIXES STRONGLY IN NU-MU AND HAS
          SUFFICIENTLY SMALL MASS THAT IT CAN OCCUR IN THE RESPECTIVE DECAYS.
          (THIS WOULD BE NONTRIVIAL ONLY FOR J .GE. 3, GIVEN THE NU-E ''MASS''
          LIMIT ABOVE.)

M           (3.5)  OR LESS            BARKAS     56 EMUL
M           (4.0)  OR LESS            DUDZIAK    59 CNTR
M           (3.6)  OR LESS            FEINBERG   63 RVUE                       7/66
M           (3.0)  OR LESS            ALLCOCK    65 RVUE                       7/66
M           (2.5)  OR LESS            BARDON     65 ASPK
M           (2.8)  OR LESS  CL=.90    SHAFER     65 CNTR                       5/71
M           (1.6)  OR LESS  CL=.90    BOOTH      67 CNTR                       3/68
M           (2.2)  OR LESS  CL=.90    HYMAN      67 HEBC     0. K- HE         11/67
M   B M     (1.2)  OR LESS  CL=.90    BACKENSTO 71 CNTR     M**2=-1.28+-1.24 10/71
M   S       (1.15) OR LESS  CL=.90    SHRUM      71 CNTR     M**2=-1.55+-1.14 12/71
M   B M     (1.15) OR LESS  CL=.90    BACKENSTO 73 CNTR     M**2=-0.29+-0.90  1/73
M           (0.65) OR LESS  CL=.90    CLARK      74 ASPK     KMU3 DECAY        7/74
M           (0.57) OR LESS  CL=.90    DAUM       79 SPEC     M**2= 0.13+-0.14 10/81
M     L     (0.52) OR LESS  CL=.90    LU         80 CNTR     M**2=0.102+-.119  1/81
M            0.50  OR LESS  CL=.90    ANDERHUB   82 SPEC     M**2=-0.14+-0.20 11/82*
M     M  WE CALCULATE UPPER LIMIT AT CL=.90 FROM M**2.                          1/76
M   B    BACKENSTOSS 73 REPLACES BACKENSTOSS 71 AND USES THEIR NEW PI- MASS.   1/73
M   S    SHRUM 71 USES SHAFER 67 PI- MASS VALUE AND CRANE 71 MU MASS VALUE.    1/73
M     L  LU 80 COMBINES DAUM 79 PI+ --> MU+ NUMU MEASUREMENT WITH NEW LU 80    1/82
M     L  PI- MASS AND REPLACES DAUM 79.                                         1/82

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                         2  (NU-2) - (ANU-2) MASS DIFF. (MEV)

          TEST OF CPT FOR A DIRAC NEUTRINO

DM          (0.45) OR LESS  CL=.90    CLARK      74 ASPK KMU3 DECAY           11/75

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                         2  NU-2 MEAN LIFE/MASS  (UNITS SEC/EV)

T     B   0 (3. E-3) OR MORE  CL=.90   BELLOTTI  76 HLBC NU, CERN GGM          1/78
T     B   1 (1.3E-2) OR MORE  CL=.90   BELLOTTI  76 HLBC ANTINU, CERN GGM      1/78
T     B   0 (2.2E-3) OR MORE  CL=.90   BARNES    77 DBC  NU, ANL 12FT.         1/78
T     B   0 (1.0E-2) OR MORE  CL=.90   BLIETSCHA 78 HLBC NU-MU CERN GGM        1/82
T     B   0 (1.7E-2) OR MORE  CL=.90   BLIETSCHA 78 HLBC ANU-MU CERN GGM       1/82
T     B   0     0.11  OR MORE  CL=.90   FRANK     81 CNTR NU, ANU LAMPF         1/82
T     B  THESE EXPERIMENTS LOOK FOR NU(MU) --> NU(E)+GAMMA OR ANU(MU) -->      1/78
T     B  ANU(E)+GAMMA.                                                          1/78

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                         2  C - (NU-2 VELOCITY) -- ABS((V-C)/C) (UNITS 10**-4)
                              EXPECTED TO BE ZERO FOR MASSLESS NEUTRINO

V        77   (2.0)  OR LESS  CL=.99   ALSPECTOR 76 SPEC >50GEV NU             1/78
V        26   (4.0)  OR LESS  CL=.99   ALSPECTOR 76 SPEC <50GEV NU             1/78
V      9800   (0.4)  OR LESS  CL=.95   KALBFLEIS 79 SPEC                      12/79

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                         2  NU-2 MAGNETIC MOMENT  (UNITS EV/GAUSS)

          MUST VANISH FOR MAJORANA NEUTRINO OR PURELY CHIRAL MASSLESS
          DIRAC NEUTRINO

MM  K      (4.7 E-17)OR LESS              KIM        74                         1/82
MM  K    KIM 74 IS A THEORETICAL ANALYSIS OF ANTINU-MU REACTION DATA.           1/82
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REFERENCES FOR NU-MU


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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)
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 PL 43B 539          BACKENSTOSS,DANIEL,KOCH+ (CERN+KARL+MUNICH)

CLARK    74 PR D9 533           +ELIOFF,FRISCH,JOHNSON,KERTH,SHEN +      (LBL)
KIM      74 PR D9 3050          J.E.KIM,V.S.MATHER,S.OKUBO                (ROCH)
ALSPECTO 76 PRL 36 837          ALSPECTOR +          (BNL+PURD+CIT+FNAL+ROCK)
BELLOTTI 76 LNC 17 553          +CAVALLI,FIORINI,ROLLIER                  (MILA)
BARNES   77 PRL 38 1049         +CARMONY,DAUWE,FERNANDEZ +           (PURD+ANL)
BLIETSCH 78 NP B133 205         BLIETSCHAU+(AACH+LIBH+CERN+EPOL+MILA+ORSA+)

KALBFLEI 79 PRL 43 1361         KALBFLEISCH,BAGGETT,FOWLER+(FNAL+PURD+BELL)
DAUM     79 PR D20 2692         +EATON,FROSCH,HIRSCHMANN,MCCULLOCH+      (SIN)
    ALSO 76 PL 60B 380          DAUM,DUBAL,EATON,FROSCH,MCCULLOCH+(SIN+ETH)
    ALSO 78 PL 74B 126          DAUM,EATON,FROSCH,HIRSCHMANN,+             (SIN)
LU       80 PRL 45 1066         +DELKER,DUGAN,WU,CAFFREY+     (YALE+COLU+JHU)
FRANK    81 PRD 24 2001         +BURMAN+ (LASL+YALE+MIT+SACL+SIN+CNRC+BERN)
ANDERHUB 82 PL 114B 76          +BOECKLIN,HOFER,KOTTMANN+             (ETH+SIN)
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                      4  MUON(106,J=1/2)
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                      4  MUON MASS (MEV)

M          (105.659)  (0.002)          FEINBERG  63 RVUE
M          (105.6599) (0.0014)         TAYLOR    69 RVUE    USING NEW E/H     7/70
M     C    (105.6597) (0.0005)         CRANE     71 CNTR INCLUDED IN COHEN73  1/73
M     D    (105.6594) (0.0004)         CROWE     72 CNTR INCLUDED IN COHEN73  2/72
M          (105.65948)(0.00035)        COHEN     73 RVUE                      3/74
M     A    (105.65945)(0.00033)        CASPERSON 77 CNTR +                   12/77
M     K    (105.65933)(0.00029)        KLEMPT    82 CNTR + INCL IN MARIAM 82  2/82
M     M     105.65928  0.00029         MARIAM    82 CNTR +                    1/83*
M     C  CRANE 71 GIVES MU/ME=206.76878(85).  WE USE ME=.5110041(16)MEV.     1/73
M     D  CROWE 72 GIVES MU/ME=206.7682(5) AND USES ME=.5110041(16)MEV.       1/73
M     A  CASPERSON 77 GIVES MU/ME=206.76859(29).  WE USE ME=.5110034(14)MEV. 12/77
M     K  KLEMPT 82 GIVES MU/ME=206.76835(11).  WE USE ME=.5110034(14)MEV.    2/82
M     M  MARIAM 82 GIVES MMU/ME=206.768259(62). WE USE ME=.5110034(14)MEV.   1/83*
M             . . . . . . . . . .
M    FIT      105.65932  0.00029 FROM FIT                                     3/84*

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                      4  MUON MEAN LIFE (UNITS 10**-6 SEC)

T             2.198     0.001     0.001    FARLEY    62 CNTR
T             2.203     0.004              LUNDY     62 CNTR    CONLEV=.98   11/67
T             2.202     0.003     0.003    ECKHAUSE  63 CNTR
T             2.197     0.005     0.002    MEYER     63 CNTR +
T             2.198     0.002     0.002    MEYER     63 CNTR -               7/66
T     W      (2.20026)(0.00081)            WILLIAMS  72 CNTR +               2/76
T             2.1973    0.0003             DUCLOS    73 CNTR +               1/76
T             2.19711   0.00008            BALANDIN  74 CNTR +               1/76
T             2.1948    0.0010             BAILEY2   77 CNTR -  STORAGE RINGS 2/79
T             2.1966    0.0020             BAILEY2   77 CNTR +  STORAGE RINGS 2/79
T            (2.197182 0.000121)           BARDIN    81 CNTR REPL. BY BARDIN 84 1/82
T             2.197078 0.000073            BARDIN    84 CNTR +               2/84*
T             2.197025 0.000155            BARDIN    84 CNTR -               2/84*
T     W  WILLIAMS 72 MEAN LIFE MEASUREMENT WAS NOT THE PRIMARY PURPOSE OF    1/76
T     W  THEIR EXPERIMENT AND DISAGREES STRONGLY WITH LATER EXPTS. NOT AVGD. 1/76
T             . . . . . . . . . .
T    AVG      2.197090 0.000050 0.000050 AVERAGE

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                      4  MU+/MU- MEAN LIFE RATIO

DT       TEST OF CPT
DT            1.000     0.001              MEYER     63 CNTR  MEAN LIFE MU+/MU-  7/66
DT            1.0008    0.0010             BAILEY    79 CNTR    STORAGE RING     7/79
DT            1.000024 0.000078            BARDIN    84 CNTR                     2/84*
DT            . . . . . . . . . .
DT   AVG      1.000029 0.000078  AVERAGE

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

MM       FOR REVIEWS OF THEORY AND EXPERIMENTS, SEE COMBLEY 81, FARLEY 79,
MM       KINOSHITA 78, CALMET 77, COMBLEY 74, LAUTRUP 72, AND RICH 72.
MM          (1162.0)     (5.0)             CHARPAK   62 CNTR +
MM   B      (1165.75)    (0.71)            BAILEY    68 CNTR +  STOR. RINGS     5/69
MM   B      (1166.25)    (0.24)            BAILEY    68 CNTR  - STOR. RINGS     5/69
MM   B        ERRORS STATISTICAL. VALUES COMBINED TO GIVE MU+- VALUE BELOW     5/69
MM            1166.16      0.31            BAILEY    68 CNTR +- STOR. RINGS     5/69
MM            1060.       67.              HENRY     69 CNTR +                  1/77
MM   IA     (1165.895)   (0.027)           BAILEY    75 CNTR +  STORAGE RING   11/75
MM   IA     (1165.922)   (0.009)           BAILEY    77 CNTR +- STORAGE RING   11/77
MM   I      (1165.911)   (0.011)           BAILEY    79 CNTR +  STORAGE RING    7/79
MM   I      (1165.937)   (0.012)           BAILEY    79 CNTR -  STORAGE RING    7/79
MM    I      1165.924     0.0085           BAILEY    79 CNTR +- STORAGE RING    7/79
MM    A  BAILEY 77 INCLUDES RESULTS OF BAILEY 75.                             11/77
MM    I  BAILEY 79 IS FINAL RESULT. INCLUDES BAILEY 75 AND 77 DATA.            7/79
MM    I  THIRD BAILEY 79 RESULT IS FIRST TWO COMBINED.                         7/79
MM            . . . . . . . . . .
MM   AVG     1165.9242    0.0085  AVERAGE

MMR     MU+ TO MU- G-FACTOR RATIO MINUS ONE, (G+/G-)-1
MMR      TEST OF CPT
MMR         -2.6E-8   1.6E-8               BAILEY    79                         2/84*

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                      4  MUON ELECTRIC DIPOLE MOMENT (UNITS 10**-19 E-CM)

             FORBIDDEN BY BOTH T INVARIANCE AND P INVARIANCE

EDM B         (8.6)     (4.5)              BAILEY    78 CNTR +  STORAGE RINGS   2/79
EDM B         (0.8)     (4.3)              BAILEY    78 CNTR -  STORAGE RINGS   2/79
EDM  B         3.7       3.4               BAILEY    78 CNTR +- STORAGE RING    2/79
EDM  B   BAILEY 78 YIELDS EDM < 1.05*10**-18 WITH CL=.95.  THIRD RESULT IS      2/79
EDM  B   FIRST TWO COMBINED ASSUMING CPT.                                       2/79

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                      4  MUON TO PROTON MAGNETIC MOMENT RATIO

MPR      THIS RATIO IS USED TO OBTAIN A PRECISE VALUE OF THE MUON MASS.
MPR        (3.1865) (0.0022)               COFFIN    58 CNTR +  SPIN RESONANCE     2/72
MPR        (3.1830) (0.0011)               LUNDY     58 CNTR +  PRECESSION STROB   2/72
MPR        (3.176)  (0.013)                LUNDY     58 CNTR -  PRECESSION STROB   2/72
MPR        (3.1834) (0.0002)               GARWIN    60 CNTR +  PRECESSION PHASE   2/72
MPR        (3.18336)(0.00007)              BINGHAM   63 CNTR +  PRECESSION STROB   2/72
MPR        (3.1808) (0.0004)               BINGHAM   63 CNTR -  PRECESSION STROB   2/72
MPR        (3.18338)(0.00004)              HUTCHINS  63 CNTR +  PRECESSION PHASE   2/72
MPR D      (3.183351 0.000016)             EHRLICH   69 CNTR    HFS SPLITTING      2/72
MPR C      (3.183314 0.000034)             THOMPSON  69 CNTR    HFS SPLITTING      2/72
MPR        (3.183330 0.000044)             HUTCHINS  70 CNTR +  PRECESSION PHASE   2/72
MPR H      (3.183347 0.000009)             HAGUE     70 CNTR +  PRECESSION PHASE   2/72
MPR  C     (3.183336 0.000013)             CRANE     71 CNTR    HFS SPLITTING      2/72
MPR  D     (3.183349 0.000015)             DEVOE     71 CNTR    HFS SPLITTING      1/73
MPR F      (3.183326 0.000013)             FAVART    71 CNTR    HFS SPLITTING      2/72
MPR  H     (3.1833467 .0000082)            CROWE     72 CNTR +  PRECESSION PHASE   2/72
MPR  R   THE RESULTS THROUGH 1972 ARE INCLUDED IN COHEN 73.                        3/74
MPR  R      3.1833402 .0000072             COHEN     73 RVUE                       3/74
MPR E      (3.1833299 .0000025)            CASPERSON 75 CNTR                       2/76
MPR         3.1833403 .0000044             CASPERSON 77 CNTR +  HFS SPLITTING     12/77
MPR        (3.1833448 .0000029)            CAMANI    78 CNTR +  REPL.BY KLEMPT82   7/79
MPR         3.1833441 .0000017             KLEMPT    82 CNTR +  PRECESSION STROB   2/82
MPR         3.1833461 .0000011             MARIAM    82 CNTR +  HFS SPLITTING      1/83*
MPR  D   DEVOE 71 SUPERCEDES EHRLICH 69.  THIS IS NOT A DIRECT MEASUREMENT.        1/73
MPR  D   WE GIVE A NEW VALUE WHICH CONTAINS A THEORETICAL CORRECTION OF            1/73
MPR  D   -7.8+-2.3 PPM, AS DISCUSSED IN FOOTNOTE 35A OF CROWE 72.                  1/73
MPR C    CRANE 71 SUPERSEDES THOMPSON 69. THIS IS NOT A DIRECT MEASUREMENT.        1/73
MPR H    CROWE 72 SUPERSEDES HAGUE 70.
MPR F    FAVART 71 ASSUMES A ZERO VALUE FOR THE PROTON POLARIZABILITY.             1/73
MPR  E   USES INCORRECT THEO. EXPRESSION FOR NU(HFS). SEE KLEMPT 82, TBL.XI.       2/82
MPR           . . . . . . . . . .
MPR AVG     3.1833452 .0000010  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)

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                      4  MUON PARTIAL DECAY MODES
                                                               DECAY MASSES
P1       MUON INTO E ANUE NUMU                               .511+   0+   0
P2       MUON INTO E ANUE NUMU GAMMA                         .511+   0+   0+   0
P3       MUON INTO E NUE ANUMU                               .511+   0+   0
P4       MUON INTO E GAMMA                                   .511+   0
P5       MUON INTO 3ELECTRONS                                .511+.511+.511
P6       MUON INTO E 2GAMMA                                  .511+   0+   0
P7       MUON INTO E- E+ E- ANUE NUMU                        .511+.511+.511+   0+

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                      4  MUON BRANCHING RATIOS

R1       MUON INTO (E ANUE NUMU GAMMA)/TOTAL                    (P2)
R1        27 EVENTS SEEN                   ASHKIN    59 CNTR                       1/78
R1            1.4E-2   0.4E-2              CRITTENDE 61 CNTR T(GAM) GT 10 MEV      1/78
R1           (3.3E-3) (1.3E-3)             CRITTENDE 61 CNTR T(GAM) GT 20 MEV      1/78
R1       862 EVENTS SEEN                   BOGART    67 CNTR T(GAM) GT 14.5 MEV    1/78

R2       MUON+ INTO (E+ ANUE NUMU)/TOTAL                        (P3)
R2        FORBIDDEN BY ADDITIVE CONSERVATION LAW FOR LEPTON FAMILY NUMBER.
R2        MULTIPLICATIVE LAW PREDICTS THIS BRANCHING RATIO TO BE 1/2.
R2        FOR A RECENT REVIEW SEE NEMETHY 81.
R2            (0.25) OR LESS  CL=.90   EICHTEN   73 HLBC +                        11/75
R2            (0.13)    (0.15)         BLIETSCHA 78 HLBC +- AVG. OF 4 VALUES       1/82
R2            (0.09) OR LESS  CL=.90   JONKER    80 CALO REPL. BY BERGSMA 83       2/82
R2           (-0.001)  (0.061)         WILLIS    80 CNTR +                         8/81
R2    A        0.05  OR LESS  CL=.90   BERGSMA   83 CALO ANUMU E -->MU- ANUE      11/83*
R2    A   BERGSMA 83 GIVES LIMIT ON INVERSE MUON DECAY CROSS SECTION RATIO         2/82
R2    A   SIGMA(ANUMU E- --> MU- ANUE) / SIGMA(NUMU E- --> MU- NUE), WHICH         2/82
R2    A   IS ESSENTIALLY EQUIVALENT TO R2 FOR SMALL VALUES LIKE THAT QUOTED.       2/82

R3       MUON INTO (E GAMMA)/TOTAL (UNITS 10**-8)               (P4)
R3        FORBIDDEN BY LEPTON FAMILY NUMBER CONSERVATION
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 +  DUBNA                 10/71
R3            (0.36) OR LESS  CL=.90   DEPOMMIER 77 CNTR REPL. BY AZUELOS 83      12/77
R3            (0.11) OR LESS  CL=.90   POVEL     77 ELEC REPL. BY SCHAAF 80        1/79
R3            (0.019)OR LESS  CL=.90   BOWMAN    79 SPEC REPL.BY KINNISON 82       7/79
R3            (0.10) OR LESS  CL=.90   SCHAAF    80 ELEC +  SIN                    3/82
R3             0.017 OR LESS  CL=.90   KINNISON  82 SPEC +  LAMPF                 11/82*
R3            (0.10) OR LESS  CL=.90   AZUELOS   83 CNTR +                        10/83*

R4       MUON INTO (3ELECTRONS)/TOTAL (UNITS 10**-7)            (P5)
R4        FORBIDDEN BY LEPTON FAMILY NUMBER CONSERVATION
R4 F          (5.0)  OR LESS  CL=.90   PARKER    62 CNTR
R4 F          (1.3)  OR LESS  CL=.90   ALIKHANOV 62 OSPK
R4 F          (1.5)  OR LESS  CL=.90   FRANKEL2  63 CNTR
R4 F          (1.2)  OR LESS  CL=.90   BABAEV    63 OSPK
R4 K          (0.062)OR LESS  CL=.90   KORENCH2  71 OSPK    DUBNA                  2/72
R4 K           0.019 OR LESS  CL=.90   KORENCHEN 76 SPEC +  DUBNA                  6/77
R4 F      FOUR ABOVE EXPERIMENTS EVALUATED UPPER LIMITS ASSUMING A SECOND
R4 F      ORDER V-A NEUTRINO LOOP DIAGRAM. LIMITS NOT SIGNIFICANTLY CHANGED
R4 F      BY ASSUMING A CONSTANT MATRIX ELEMENT.
R4 K      THESE EXPERIMENTS ASSUME A CONSTANT MATRIX ELEMENT.                     10/77

R5       MUON INTO (E 2GAMMA)/TOTAL (UNITS 10**-7)              (P6)
R5        FORBIDDEN BY LEPTON FAMILY NUMBER CONSERVATION
R5          (160.)   OR LESS  CL=.90   FRANKEL1  63 OSPK +
R5 P         (40.)   OR LESS  CL=.90   POUTISSOU 74 CNTR +  LBL                   12/75
R5   A        (0.5)  OR LESS  CL=.90   BOWMAN    78 CNTR DEPOMMIER 77 DATA         4/82
R5   B         0.084 OR LESS  CL=.90   AZUELOS   83 CNTR +                        10/83*
R5 P      POUTISSOU 74 LIMIT APPLIES TO SUM OF ALL NEUTRINOLESS MU+ DECAYS.        1/76
R5   A    BOWMAN 78 ASSUMES INT. LAGRANG. LOCAL ON SCALE OF INVERSE MU MASS.       4/82
R5   B    AZUELOS 83 USES PHASE SPACE DISTRIBUTION OF BOWMAN 78. SEE ABOVE.       10/83*
R6       MUON INTO (E- E+ E- ANUE NUMU)/TOT.(UNITS 10**-5)(P7)
R6  L     3    (1.5)      (1.0)        LEE       59 HBC  +                        11/83*
R6  G     1    (2.)                    GUREVICH  60 EMUL +                        11/83*
R6   C    7     2.2        1.5         CRITTENDE 61 HLBC +      E(E+E-)>10MEV     11/83*
R6  L     IN THE THREE LEE 59 EVENTS, THE SUM OF ENERGIES S=E(E+)+E(E-)+E(E+)     11/83*
R6  L     WAS S=51 MEV, 55 MEV, AND 33 MEV .                                      11/83*
R6  G     GUREVICH 60 INTERPRET THEIR EVENT AS EITHER VIRTUAL OR REAL PHOTON      11/83*
R6  G     CONVERSION.  E+ AND E- ENERGIES NOT MEASURED .                          11/83*
R6   C    CRITTENDEN 61 COUNT ONLY THOSE DECAYS WHERE TOTAL ENERGY OF EITHER      11/83*
R6   C    (E+,E-) COMBINATION IS >10 MEV )                                        11/83*

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                      4  LIMIT ON MUON --> ELECTRON CONVERSION

          FORBIDDEN BY LEPTON FAMILY NUMBER CONSERVATION

RE       (MU- SULFUR32 --> E- SULFUR32)/(MU-SULFUR32 --> NUMU PHOSPHORUS32*)
RE       CROSS SECTION RATIO
RE           (4. E-10)OR LESS  CL=.90   BADERTSCH 77 STRC    SIN                   1/82
RE             0.7E-10 OR LESS  CL=.90   BADERTSCH 80 STRC    SIN                   1/82

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                      4  LIMIT ON MUON --> POSITRON CONVERSION

          FORBIDDEN BY TOTAL LEPTON NUMBER CONSERVATION

RP1      (MU- SULFUR32 --> E+ SILICON32*)/(MU-SULF32 --> NUMU PHOSPHORUS32*)
RP1          (1.5E-9) OR LESS  CL=.90   BADERTSCH 78 STRC    SIN                   1/82
RP1            0.9E-9  OR LESS  CL=.90   BADERTSCH 80 STRC    SIN                   1/82

RP2      (MU- IODINE127 --> E+ ANTIMONY127*)/(MU- IODINE127 --> ANYTHING)         4/82
RP2  A          0.3E-9  OR LESS  CL=.90   ABELA     80 CNTR RADIOCHEMICAL TECH.    4/82
RP2  A    ABELA 80 IS UPPER LIMIT FOR MU- E+ CONVERSION LEADING TO PARTICLE-      4/82
RP2  A    STABLE STATES OF SB127. LIMIT FOR TOTAL CONVERSION RATE IS HIGHER       4/82
RP2  A    BY A FACTOR LESS THAN 4 (G. BACKENSTOSS, PRIVATE COMM.)                 4/82

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                      4  LIMIT ON (MU+,E-) BND. STATE CONVERSION TO (MU-,E+)

             FORBIDDEN BY LEPTON FAMILY NUMBER CONSERVATION

MC           RG = GC/GF
MC           WHERE GF = 1.16637E-5 GEV**(-2) IS THE FERMI CONSTANT AND
MC           GC IS AN EFFECTIVE COUPLING (DIMENSIONS GEV**(-2)) FOR A
MC           FOUR-FERMION INTERACTION ASSUMED TO BE RESPONSIBLE FOR THE
MC           CONVERSION OF THE (MU+,E-) BOUND STATE TO (MU-,E+).
MC
MC               42    OR LESS  CL=.95   MARSHALL  82 CNTR                        12/83*
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Stable Particles

Data Card Listings

μ

NOTE ON 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 $\mu^- \rightarrow e^- + \nu_\mu + \overline{\nu}_e$. Assuming a local and lepton-conserving interaction, the matrix element in the charge-retention form may be written as

$$\sum_i [\overline{e}\Gamma_i\mu]\,[\overline{\nu}_\mu\Gamma_i(C_i + C_i'\gamma_5)\nu_e]\,,$$

where the summation is taken over i = S, V, T, A, P. Using the definitions and sign conventions of Sachs and Sirlin[1] and Scheck[2] for the Lorentz-covariant operators, we have for the momentum parameters:

$$\rho = (3g_A^2 + 3g_V^2 + 6g_T^2)/D\,,$$

$$\eta = (g_S^2 - g_P^2 + 2g_A^2 - 2g_V^2)/D\,;$$

for the asymmetry parameters:

$$\xi = \frac{-6g_Sg_P\cos\phi_{SP} - 8g_Ag_V\cos\phi_{AV} + 14g_T^2\cos\phi_{TT}}{D}\,,$$

$$\delta = (-6g_Ag_V\cos\phi_{AV} + 6g_T^2\cos\phi_{TT})/D\xi\,;$$

and for the parameter describing the helicity of the electron:

$$h = \frac{2g_Sg_P\cos\phi_{SP} + 8g_Ag_V\cos\phi_{AV} + 6g_T^2\cos\phi_{TT}}{D}\,.$$

Here

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

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

and

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

The quantities g_i are defined to be real non-negative numbers, and the ϕ_{ij} are phase angles between the i-type and j-type interactions. Under the assumption of two-component neutrinos, $C_V' = -C_V$ and $C_A' = -C_A$, 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 $\eta = 0$ and η for $\rho = 3/4$. 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.

References

1. A.M. Sachs and A. Sirlin, in *Muon Physics II*, eds. C.S. Wu and V. Hughes (Academic Press, New York, 1975), p. 49.
2. F. Scheck, Phys. Rep. **44**, 187 (1978).

4 MUON DECAY PARAMETERS

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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

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
ETA  A1.2M    0.19       0.18           CORRIVEAU 83 CNTR +  10-53 MEV E+     11/83*
ETA  A  CORRIVEAU 83 MEASURE TRANSVERSE POLARIZATION OF E+ VERSUS ENERGY OF 11/83*
ETA  A  E+. THEY DERIVE (ALPHA/A)=0.11+-0.11 , (BETA/A)=-0.038+-0.037 , AND 11/83*
ETA  A  ETA=(ALPHA-2*BETA)/A. ALPHA,BETA AND A ARE DEFINED IN SECTION 3 OF  11/83*
ETA  A  SCHECK 78 . RESULTS ON T-VIOLATION SEE SECTIONS ALP, BTP BELOW .    11/83*
ETA          . . . . . . . . .
ETA AVG       0.06       0.15    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)

XSI    (XSI PARAMETER)*(MUON LONGITUDINAL POLARIZATION)
XSI                                    (V-A THEORY PREDICTS XSI=1, LONG.POL.=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    66K  (0.975)     (0.030)         GUREVICH  64 EMUL REPL.BY AKHMANOV 68 10/69
XSI         (0.975)     (0.015)         AKHMANOV  68 EMUL    140 KGAUSS        9/81
XSI  C        0.9959 OR MORE  CL=.90    CARR      83 SPEC +  11 KGAUSS        10/83*
XSI  C  CARR 83 FIND (XSI*PMU*DELTA/RHO) > 0.9959. WE USE (DELTA/RHO) = 1.0 10/83*
XSI  C  FROM V-A THEORY TO DERIVE ABOVE LIMIT FOR (XSI*PMU) .                 10/83*

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
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For notation, see key at front of Listings.

Stable Particles

μ, ν_τ

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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  500K   1.010     0.064          CORRIVEAU  81 CNTR +  BHABHA + ANNIHIL   1/82
HEL        . . . . . . . . .
HEL AVG     1.008     0.057    AVERAGE

ALP      (ALPHA-PRIME)/A
ALP      ALPHA-PRIME AND BETA-PRIME (SEE BELOW) AFFECT DEPENDENCE OF DIFFER- 11/83*
ALP      ENTIAL DECAY PROBABILITY ON ELECTRON SPIN DIRECTION , AND ARE ZERO  11/83*
ALP      IF TIME-REVERSAL INVARIANCE HOLDS. ALPHA-PRIME, BETA-PRIME AND A    11/83*
ALP      ARE DEFINED IN SECTION 3 OF SCHECK 78 .                             11/83*
ALP  C1.2M   -0.12     0.10          CORRIVEAU  83 CNTR +   10-53 MEV E+     11/83*
ALP  C   CORRIVEAU 83 MEASURE TRANSVERSE E+ POLARIZATION VERSUS E+ ENERGY .  11/83*

BTP      (BETA-PRIME)/A                                                      11/83*
BTP      SEE COMMENT IN SECTION ALP ABOVE .                                  11/83*
BTP  C1.2M    0.029    0.037         CORRIVEAU  83 CNTR +   10-53 MEV E+     11/83*
BTP  C   CORRIVEAU 83 MEASURE TRANSVERSE E+ POLARIZATION VERSUS E+ ENERGY .  11/83*

ETB      ETA-BAR PARAMETER                  (V-A THEORY PREDICTS ETA-BAR=0)
ETB      ETA-BAR AFFECTS SPECTRUM OF RADIATIVE MUON DECAY.                    2/84*
ETB         +0.09      0.14          BOGART     67 CNTR +                     2/84*
ETB        (-0.014)  (0.090)         EICHENBER  84 ELEC +   RHO FREE          2/84*
ETB         -0.035     0.098         EICHENBER  84 ELEC +   RHO=0.75 ASSUMED  2/84*
ETB        . . . . . . . . .
ETB AVG      0.006     0.080   AVERAGE

GS       SCALAR BOSON COUPLING CONSTANT IN MUON DECAY (IN UNITS OF GV)
GS          0.29  OR LESS            MURSULA    83 RVUE                       3/83*
GS   A     (0.16) OR LESS            MURSULA    83 RVUE                       3/83*
GS   A   ASSUMING EQUAL S AND PS COUPLINGS, AND NO TENSOR COUPLING.           3/83*

GA       AXIAL BOSON COUPLING CONSTANT IN MUON DECAY (IN UNITS OF GV)
GA          0.91      0.24      0.06 MURSULA    83 RVUE                       3/83*
GA   A     (0.94)    (0.19)    (0.07) MURSULA   83 RVUE                       3/83*
GA   B     (0.97)    (0.16)    (0.10) MURSULA   83 RVUE                       3/83*
GA   B   ASSUMING NO SCALAR OR PSEUDOSCALAR COUPLINGS.                        3/83*
GA   A   ASSUMING EQUAL S AND PS COUPLINGS, AND NO TENSOR COUPLING.           3/83*

FAV      PHASE BETWEEN VECTOR AND AXIAL VECTOR COUPLINGS  (DEGREES)
FAV        180.        9.            MURSULA    83 RVUE                       3/83*
FAV A     (182.)      (5.)      (9.)  MURSULA   83 RVUE                       3/83*
FAV B     (184.)      (4.)     (10.)  MURSULA   83 RVUE                       3/83*
FAV B    ASSUMING NO SCALAR OR PSEUDOSCALAR COUPLINGS.                        3/83*
FAV A    ASSUMING EQUAL S AND PS COUPLINGS, AND NO TENSOR COUPLING.           3/83*

GT       TENSOR BOSON COUPLING CONSTANT IN MUON DECAY (IN UNITS OF GV)
GT          0.14  OR LESS            MURSULA    83 RVUE                       3/83*

GP       PS.SCALAR BOSON COUPLING CONSTANT IN MUON DECAY (IN UNITS OF GV)
GP          0.25  OR LESS            MURSULA    83 RVUE                       3/83*

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REFERENCES FOR MUON


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COFFIN   58 PR 109 973           +GARWIN,PENMAN,LEDERMAN,SACHS    (COLUMBIA)
LUNDY    58 PRL 1 38             +SENS,SWANSON,TELEGDI,YOVANOVITCH (CHICAGO)
ASHKIN   59 NC 14 1266           +FAZZINI,FIDECARO,LIPMAN,MERRISON +  (CERN)
BARDON   59 PRL   2   56         M BARDON, D BERLEY, L LEDERMAN   (COLUMBIA)
DUDZIAK  59 PR  114  336         W DUDZIAK,R SAGANE, J VEDDER          (LRL)
LEE      59 PRL 3 55             JULIET LEE, N. P. SAMIOS             (COLU)
GARWIN   60 PR 118 271           GARWIN,HUTCHINSON,PENMAN,SHAPIRO (COLUMBIA)
GUREVICH 60 JETP 10 225          GUREVICH,NIKOLSKII,SURKOVA           (ITEP)
PLANO    60 PR  119 1400         R J PLANO                        (COLUMBIA)

ALI-ZADE 61 JETP  13  313        ALI-ZADE,GUREVICH,NIKOLSKI           (USSR)
CRITTEND 61 PR 121 1823          CRITTENDEN,WALKER,BALLAM         (WISC+MSU)
KRUGER   61 UCRL-9322 (UNPUB) H KRUGER                                 (LRL)
ALIKHANO 62 CERN CONF 423        A I ALIKHANOV,A BABAEV +     (ITEP MOSCOW)
BLOCK    62 NC   23  1114        BLOCK,FIORINI,KIKUCHI+(DUKE,BOLOGNA,MILANO)
CHARPAK  62 PL    1  16          G CHARPAK,F J M FARLEY,R L GARWIN +  (CERN)
FARLEY   62 CERN CONF 415        FARLEY,MASSAM,MULLER,ZICHICHI        (CERN)

LUNDY    62 PR 125 1686          RICHARD A LUNDY                       (EFI)
PARKER   62 NC  23  485          S PARKER,S PENMAN                     (EFI)
BABAEV   63 JETP 16 1397         BABAEV,BALATS,KAFTANOV,LANDSBERG +   (ITEP)
BINGHAM  63 NC 27 1352           G.MCD.BINGHAM                         (LRL)
BUHLER   63 PL    7  368         +CABIBBO,FIDECARO,MASSAM,MULLER+     (CERN)
DICK     63 PL    7  150         DICK,FEUVRAIS,SPIGHEL                (CERN)

ECKHAUSE 63 PR 132  422          M ECKHAUSE,T A FILIPPAS +        (CARNEGIE)
FEINBERG 63 ARNS 13 431          GERALD FEINBERG, L M LEDERMAN    (COLUMBIA)
FRANKEL1 63 NC  27  894          S FRANKEL,W FRATI,J HALPERN +        (PENN)
FRANKEL2 63 PR 130  351          S FRANKEL,W FRATI,J HALPERN +        (PENN)
HUTCHINS 63 PR 131 1351          HUTCHINSON,MENES,PATLACH,SHAPIRO (COLUMBIA)
MEYER    63 PR  132  2693        S L MEYER,ANDERSON,BLESER,LEDERMAN+  (COLU)

BARLOW   64 PPS   84  239        +BOOTH,CARROL,COURT,DAVIES,EDWARDS+  (LIVP)
BLOOM    64 PL    8   87         +DICK,FEUVRAIS,HENRY,MACQ,SPIGHEL    (CERN)
DUCLOS   64 PL    9   62         +HEINTZE,DE RUJULA,SOERGEL           (CERN)
GUREVICH 64 PL   11  185         GUREVICH,MAKARIYNA+                  (KIAE)
PONTECOR 64 DUBNA CONF           PONTECORVO,SULYAEV                 (MOSCOW)
PARKER   64 PR 133B 768          S PARKER,H L ANDERSON,C REY           (EFI)

PEOPLES  66 NEVIS-147 (UNPUB) J PEOPLES                           (COLUMBIA)
BOGART   67 PR 156 1405          +DICAPUA,NEMETHY,STRELZOFF           (COLU)
SCHWARTZ 67 PR  162 1306         D M SCHWARTZ                          (EFI)
SHERWOOD 67 PR  156 1475         B A SHERWOOD                          (EFI)
AKHMANOV 68 SJNP 6 230           +GUREVICH,DOBRETSOV,MAKARINA+        (KIAE)
BAILEY   68 PL   28B  287        +BARTL,VON BOCHMANN,BROWN,FARLEY+    (CERN)
    ALSO 72 NC 9A 369            +BARTL,VON BOCHMANN,BROWN,FARLEY+    (CERN)
FRYBERGE 68 PR  166 1379         D FRYBERGER                           (EFI)

DERENZO  69 PR  181 1854         S DERENZO                             (EFI)
EHRLICH  69 PRL 23 513           +HOFER,MAGNON,STOWELL,SWANSON+    (CHICAGO)
HENRY    69 NC 63A 995           +SCHRANK,SWANSON           (STAN+UCSB+UCSD)
TAYLOR   69 RMP 41 375           +PARKER,LANGENBERG           (PRIN+UCI+PENN)
THOMPSON 69 PRL 22 163           +AMATO,CRANE,HUGHES,MOBLEY+          (YALE)
HAGUE    70 PRL 25 628           +ROTHBERG,SCHENCK,WILLIAMS+      (WASH+LRL)
HUTCHINS 70 PRL 24 1254          HUTCHINSON,LARSON,SCHOEN,SOBER,+      (PPA)

CRANE    71 PRL 27 474           +CASPERSON,CRANE,EGAN,HUGHES+        (YALE)
DEVOE    71 PRL 25 1779(ER)      +MCINTGRE,MAGNON,STOWELL,SWANSON+ (CHICAGO)
    ALSO 71 PRL 26 213           DEVOE,MCINTGRE,MAGNON,STOWELL+    (CHICAGO)
FAVART   71 PRL 27 1336          +MCINTYRE,STOWELL,TELEGDI,DEVOE+  (CHICAGO)
KORENCH1 71 SJNP 13 190          KORENCHENKO,KOSTIN,MICELMACHER+      (JINR)
KORENCH2 71 SJNP 13 728          KORENCHENKO,KOSTIN,MICELMACHER+      (JINR)

CROWE    72 PR D5 2145           +HAGUE,ROTHBERG,SCHENCK+         (LBL+WASH)
WILLIAMS 72 PR D6 737            R W WILLIAMS,D L WILLIAMS      (WASHINGTON)
COHEN    73 J.PHYS.CHEM.REF.DATA 2, P.663, E.R.COHEN,B.N.TAYLOR
DUCLOS   73 PL 47B 491           +MAGNON,PICARD                       (SACL)
EICHTEN  73 PL 46B 281           +DEDEN+(AACH+BELG+CERN+EPOL+MILA+LALO+LOUC)

BALANDIN 74 JETP 40 811          +GREBENYUK,ZINOV,KONIN,PONOMAREV     (JINR)
POUTISSO 74 NP B80 221           POUTISSOU,FELAWKA,INGRAM +      (MONT+BRCO)
BAILEY   75 PL 55B 420           +BORER+(CERN+DARE+BERN+SHEF+MANZ+RMCS+BIRM)
CASPERSO 75 PL 59B 397           CASPERSON,CRANE+ (YALE+LASL+HEID+BERN+WYOM)
KORENCHE 76 JETP 43 1            KORENCHENKO,KOSTIN,MITSELMAKHER+     (JINR)
BADERTSC 77 PRL 39 1385          BADERTSCHER,BORER,CZAPEK,FLUECKIGER+ (BERN)

BAILEY   77 PL 67B 225           +BORER+(CERN+DARE+BERN+SHEF+MANZ+RMCS+BIRM)
      OR 77 PL 68B 191           +BORER+/CERN+DARE+BERN+SHEF+MANZ+RMCS+BIRM
BAILEY2  77 NATURE 268 301             (DARE+BERN+SHEF+CERN+MANZ+RMCS+BIRM)
    ALSO 79 BAILEY
CASPERSO 77 PRL 38 956           CASPERSON,CRANE+ (BERN+HEID+LASL+WYOM+YALE)
DEPOMMIE 77 PRL 39 1113          DEPOMMIER,MARTIN+(MONT+BRCO+TRIU+VICT+MELB)
POVEL    77 PL 72B 183           +DEY,WALTER,PFEIFFER +         (ZURI+ETH+SIN)

BADERTSC 78 PL 79B 371           BADERTSCHER,BORER,CZAPEK,FLUECKIGER+ (BERN)
BAILEY   78 JPG 4 345                  (DARE+BERN+SHEF+MANZ+RMCS+CERN+BIRM)
    ALSO 79 BAILEY
BLIETSCH 78 NP B133 205          BLIETSCHAU+(AACH+LIBH+CERN+EPOL+MILA+ORSA+)
BOWMAN   78 PRL 41 442           +CHENG,LI,MATIS           (LASL+IAS+CARN+EFI)
CAMANI   78 PL 77B 326           +GYGAX,KLEMPT,SCHENCK,SCHULZE+   (ETH+MANZ)
BAILEY   79 NP B150 1             (DARE+BERN+SHEF+MANZ+RMCS+CERN+BIRM+LBL+)
BOWMAN   79 PRL 42 556           +COOPER,HAMM,HOFFMAN +        (LASL+EFI+STAN)

ABELA    80 PL 95B 318           +BACKENSTOSS,SIMONS,WUEST +     (BASL+KARL)
BADERTSC 80 LNC 28 401           BADERTSCHER,BORER,CZAPEK,FLUECKIGER+ (BERN)
JONKER   80 PL 93B 203           CHARM COLLAB.    (ANIK+CERN+HAMB+ITEP+ROMA)
SCHAAF   80 NP A340 249          +ENGFER,POVEL,DEY+             (ZURI+ETH+SIN)
WILLIS   80 PRL 44 522           +HUGHES+ (YALE+LBL+LASL+SACL+SIN+CNRC+BERN)
    ALSO 80 PRL 45 1370          WILLIS+  (YALE+LBL+LASL+SACL+SIN+CNRC+BERN)

BARDIN   81 NP A352 365          +DUCLOS,MAGNON+        (SACL+CERN+BGNA+TRIU)
CORRIVEA 81 PR D24 2004          CORRIVEAU,EGGER,FETSCHER +    (ETH+SIN+MANZ)
NEMETHY  81 CNPP 10 147          P.NEMETHY,V.W.HUGHES             (LBL+YALE)
KINNISON 82 PR D25 2846          +ANDERSON,MATIS,WRIGHT +     (EFI+STAN+LANL)
KLEMPT   82 PR D25 652           +SCHULZE,WOLF,CAMANI,GYGAX+      (MANZ+ETH)
MARIAM   82 PRL 49 993           +BEER,BOLTON,EGAN,GARDNER+ (YALE+HEID+BERN)
MARSHALL 82 PR D25 1174          +WARREN,ORAM,KIEFL                   (BRCO)

AZUELOS  83 PRL 51 164           +DEPOMMIER,LEROY,MARTIN+   (MONT+TRIU+BRCO)
BERGSMA  83 PL 122B 465          CHARM COLLAB.    (ANIK+CERN+HAMB+ITEP+ROMA)
CARR     83 PRL 51 627           +GIDAL,GOBBI,JODIDIO,ORAM+  (LBL+NWES+TRIU)
CORRIVEA 83 PL 129B 260          CORRIVEAU,EGGER,FETSCHER+     (ETH+SIN+MANZ)
MURSULA  83 NP B219 321          K.MURSULA,M.ROOS,F.SCHECK        (HELS+MANZ)
BARDIN   84 SACLAY PREPRINT      +DUCLOS,MAGNON+        (SACL+CERN+BGNA+FIRZ)
    ALSO 82 THESIS 2567          J. MARTINO                           (ORSA)
EICHENBE 84 NP A412 523          EICHENBERGER,ENGFER,VAN DER SCHAFF   (ZURI)

                                 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)

LAUTRUP  72 PRPL 3 193           B.LAUTRUP,A.PETERMAN,E.DE RAFAEL(CERN+BURE)
RICH     72 RMP 44 250           A RICH,J C WESLEY                    (MICH)
COMBLEY  74 PRPL 14 1            F.COMBLEY,E.PICASSO                  (CERN)
CALMET   77 RMP 49 21            J.CALMET,S.NARISON,M.PERROTTET+      (MARS)
KINOSHIT 78  TOKYO HEP P.571     T. KINOSHITA                         (CORN)
SCHECK   78 PRPL 44C 187         F. SCHECK                            (MANZ)
FARLEY   79 ARNPS 29 243         F.J.M.FARLEY,E.PICASSO          (RMCS+CERN)
DEPOMMIE 80 NP A335 97           P.DEPOMMIER                          (MONT)
COMBLEY  81 PRPL 68 93           COMBELY,FARLEY,PICASSO     (SHEF+RMCS+CERN)

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                36  NU-TAU(J=1/2)

                EXISTENCE INDIRECTLY ESTABLISHED FROM TAU DECAY DATA
                COMBINED WITH NU REACTION DATA.  SEE FOR EXAMPLE
                FELDMAN 81.  KIRKBY 79 RULES OUT J=3/2 USING
                TAU --> PI NUTAU BRANCHING RATIO.

        NOT IN GENERAL A MASS EIGENSTATE.  SEE NOTE ON NEUTRINOS
        IN THE ELECTRON NEUTRINO SECTION ABOVE.
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                36  NU-TAU ''MASS'' (MEV)

        APPLIES TO NU-3, THE PRIMARY MASS EIGENSTATE IN NU-TAU.  WOULD ALSO
        APPLY TO ANY OTHER NU-J WHICH MIXES STRONGLY IN NU-TAU AND HAS
        SUFFICIENTLY SMALL MASS THAT IT CAN OCCUR IN THE RESPECTIVE DECAYS.
        (THIS WOULD BE NONTRIVIAL ONLY FOR A HYPOTHETICAL J .GE. 4, GIVEN
        THE NU-E AND NU-MU ''MASS'' LIMITS ABOVE.)

M    P 144 (600.)   OR LESS  CL=.95   PERL       77 SMAG E+E-3.8-7.8GEV ECM  12/77
M          (740.)   OR LESS  CL=.90   BRANDELIK 78 DASP ASSUMES V-A DECAY    3/78
M    B 594 (250.)   OR LESS  CL=.95   BACINO     79 DLCO E+E- ECM=3.5-7.4GEV  7/79
M          (250.)   OR LESS  CL=.95   BLOCKER    82 SMK2 E+E- ECM=5.2 GEV     2/82
M           164.    OR LESS  CL=.95   MATTEUZZI 84 SMK2 E+E- ECM=29 GEV      2/84*
M    P  PERL 77 IS E+E- TO TAU+ TAU- EXPT. VALUE QUOTED ASSUMES V-A DECAY   12/77
M    P  AND TAU MASS=1900 MEV.                                              12/77
M    B  BACINO 79 EXPT RULES OUT V+A DECAY, DISFAVORS PURE V OR A, AND IS    7/79
M    B  IN GOOD AGREEMENT WITH V-A.                                          1/82

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REFERENCES FOR NU-TAU


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PERL     77 PL 70B 487          +FELDMAN,ABRAMS,ALAM,BOYARSKI+   (SLAC+LBL)
BRANDELI 78 PL 73B 109          BRANDELIK +      (AACH+DESY+HAMB+MPIM+TOKY)
ALLES    79 NCL 25 404          W.ALLES                              (BGNA)J
BACINO   79 PRL 42 749          +FERGUSON,NODULMAN+    (UCLA+SLAC+UCI+STON)
KIRKBY   79  SLAC-PUB-2419      J.KIRKBY(LEPTON PHOTON SYMP. BATAVIA)(SLAC)J
FELDMAN  81  SLAC-PUB-2839      G.J.FELDMAN(SANTA CRUZ APS 1981)(SLAC+STAN)
BLOCKER  82 PL 109B 119         +DORFAN,ABRAMS,ALAM,BLONDEL+     (LBL+SLAC)
MATTEUZZ 84  SLAC-PUB-3291      MATTEUZZI,ABRAMS+           (SLAC+LBL+HARV)

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Stable Particles

Data Card Listings

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35  TAU+-(1785,J=1/2) HEAVY LEPTON

E+E- --> TAU+TAU- CROSS SECTION THRESHOLD BEHAVIOR
AND MAGNITUDE CONSISTENT WITH POINTLIKE SPIN 1/2
DIRAC PARTICLE.  BRANDELIK 78 RULES OUT POINTLIKE
SPIN 0 OR SPIN 1 PARTICLE.  FELDMAN 78 RULES OUT
J=3/2.  KIRKBY 79 ALSO RULES OUT J=INTEGER, J=3/2.
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35  TAU MASS (MEV)

M   P   64(1800.)   (200.)              PERL       75 SMAG    INCL. IN PERL 77  2/78
M    B 220(1910.)    (30.)              BURMEST1   77 PLUT ASSUMES V-A DECAY   12/77
M    P 144(1900.)   (100.)              PERL       77 SMAG E+E- 3.8-7.8GEV ECM 12/77
M    A 692 1783.       3.        4.     BACINO     78 DLCO E+E- 3.1-7.4GEV ECM  2/82
M    R 299 1787.      10.       18.     BARTEL     78 SPEC E+E- 3.6-4.4GEV ECM  7/79
M          1807.      20.               BRANDELIK  78 DASP E+E- 3.1-5.2GEV ECM  3/78
M          1787.      10.               BLOCKER    80 SMK2 E+E- 3.5-6.7GEV ECM  2/82
M      1138(1803.)   (16.)              BLOCKER1   82 SMK2 INCL. IN BLOCKER 80  2/82
M
M    B  BURMESTER 77 MASS VALUE ARE FROM EVENTS CONTAINING MU+- PLUS ONE       12/77
M    B  OTHER PRONG, ORIGINATING FROM E+ E- --> TAU+ TAU-. THE MASS            12/77
M    B  VALUES COME FROM A FIT TO THE SHAPE AND ECM DEPENDENCE OF THE          12/77
M    B  MU+- SPECTRA, ASSUMING THAT THE TAU SPIN IS 1/2 AND ITS ASSOC          12/77
M    B  NEUTRINO HAS M=0.                                                       12/77
M
M    P  PERL 77 VALUE COMES FROM E+ E- TO E+- MU-+ AND NO OTHER DETECTED       12/77
M    P  PARTICLES. ASSUMES V-A COUPLING AND ZERO MASS FOR ASSOC NEUTRINO.     12/77
M
M    A  BACINO 78 VALUE COMES FROM E+- X-+ THRESHOLD. PUBLISHED MASS 1782       2/82
M    A  MEV INCREASED BY 1 MEV USING THE HIGH PRECISION PSI-PRIME MASS          2/82
M    A  MEASUREMENT OF ZHOLENTZ 80 TO ELIMINATE THE ABSOLUTE SPEAR ENERGY       2/82
M    A  CALIBRATION UNCERTAINTY.                                                2/82
M
M    R  BARTEL 78 FITS ENERGY DEPENDENCE OF CS FOR E+- AND MU+- EVENTS.         7/79
M    R  MASS VALUE NOT DEPENDENT ON WHETHER V-A OR V+A DECAY ASSUMED.           7/79
M          . . . . . . . . . .
M   AVG    1784.2      3.2     AVERAGE
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35  TAU MEAN LIFE  (UNITS 10**-13 SEC)

T        77  (90.)   OR LESS  CL=.95   ALEXANDER 79 PLUT E+E- 3.9-5 GEV ECM    7/79
T       594  (23.)   OR LESS  CL=.95   BACINO2   79 DLCO E+E- ECM=3.5-7.4GEV   7/79
T        38  (14.)   OR LESS  CL=.95   BRANDELIK 80 TASS E+E- ECM=30GEV        8/81
T       102    4.6     1.9             FELDMAN   82 SMK2 E+E- ECM=29 GEV       1/82
T       131    4.9     2.0             FORD      82 MAC  E+E- ECM=28,29 GEV   11/82*
T       143    4.7     3.9      2.9    BEHREND2  83 CELL E+E- ECM=22,34 GEV   11/83*
T       156    3.20    0.54            JAROS     83 SMK2 E+E- ECM=29 GEV      10/83*
T          . . . . . . . . . .
T   AVG        3.43    0.50    AVERAGE                                         3/84*
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35  TAU PARTIAL DECAY MODES

                                                              DECAY MASSES
P1      TAU+- INTO MU+- NUMU NUTAU                          106+   0+   0
P2      TAU+- INTO E+- NUE NUTAU                           .511+   0+   0
P7      TAU+- INTO HADRON+- NEUTRAL(S)
P8      TAU+- INTO 3 HADRONS+- NEUTRAL(S)
P9      TAU+- INTO NUTAU RHO0 PI+-                             0+ 769+ 140
P10     TAU+- INTO NUTAU A1(1100)+-                            0+1275
P11     TAU+- INTO K+- NEUTRAL(S)
P12     TAU+- INTO NUTAU PI+-                                  0+ 140
P13     TAU+- INTO NUTAU 2PI+- PI-+ (INCL. P9, P10)            0+ 140+ 140+ 140
P14     TAU+- INTO NUTAU 2PI+- PI-+ (PI0S) (INCL. P13)         0+ 140+ 140+ 140
P15     TAU+- INTO NUTAU .GE.3HADRONS+- NEUTRAL(S)
P16     TAU+- INTO NUTAU RHO+-                                 0+ 769
P17     TAU+- INTO 3 HADRONS+- NUTAU
P18     TAU+- INTO 3 HADRONS+- NUTAU GAMMA(S)
P19     TAU+- INTO HADRON+- (NOT RHO+-, PI+-) NEUTRAL(S)
P20     TAU+- INTO 5 HADRONS+- NEUTRAL(S)
P21     TAU+- INTO NUTAU K*(892)                               0+ 892
P22     TAU+- INTO NUTAU K*(1430)                              0+1425
P23     TAU+- INTO NUTAU K+-                                   0+ 494

         LEPTON FAMILY NUMBER VIOLATING MODES.
         ------------------------------

P31     TAU+- INTO MU+- GAMMA                               106+   0
P32     TAU+- INTO E+- GAMMA                               .511+   0
P33     TAU+- INTO MU+- CHARGED PARTICLES
P34     TAU+- INTO E+- CHARGED PARTICLES
P35     TAU+- INTO MU+- MU+ MU-                             106+ 106+ 106
P36     TAU+- INTO E+- MU+ MU-                             .511+ 106+ 106
P37     TAU+- INTO MU+- E+ E-                               106+.511+.511
P38     TAU+- INTO E+- E+ E-                               .511+.511+.511
P39     TAU+- INTO MU+- PI0                                 106+ 135
P40     TAU+- INTO E+- PI0                                 .511+ 135
P41     TAU+- INTO MU+- K0                                  106+ 498
P42     TAU+- INTO E+- K0                                  .511+ 498
P43     TAU+- INTO MU+- RHO0                                106+ 769
P44     TAU+- INTO E+- RHO0                                .511+ 769
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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	P12	P16	P17	P18	P19
P 1	.1845+-.0114						
P 2	-.1141	.1646+-.0094					
P12	.0145	-.1273	.1034+-.0125				
P16	-.1190	-.1179	.0150	.2215+-.0242			
P17	.0029	.0023	-.0003	-.0007	.0532+-.0409		
P18	.0056	.0044	-.0006	-.0013	-.9476	.1171+-.0416	
P19	-.2544	-.1233	-.3746	-.6963	-.0481	-.0927	.1557+-.0314

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35  TAU BRANCHING RATIOS

R1      TAU+- INTO (MU+- NUMU NUTAU)/TOTAL                 (P1)
R1      220    0.15      0.03              BURMEST1  77 PLUT ASSUMES V-A DECAY    12/77
R1             0.175     0.040             PERL      77 SMAG    E+E- TO MU+- X-+  12/77
R1             0.22      0.10      0.07    CAVALLISF 77 SPEC    E+E- TO MU+- X-+   1/78
R1       11    0.22      0.07      0.08    SMITH     78 SPEC    E+E- TO MU+MU-X0   7/79
R1             0.35      0.14              BRANDELIK 80 TASS    E+E- ECM=30GEV     8/81
R1             0.178     0.027             BERGER    81 PLUT    E+E- 9-32GEV ECM   1/82
R1     E 47    0.176     0.033             BEHREND   83 CELL    E+E- ECM=34 GEV.  11/83*
R1     E  STATISTICAL AND SYSTEMATIC ERRORS COMBINED IN QUADRATURE.               11/83*
R1          . . . . . . . . . .
R1    AVG      0.175     0.015   AVERAGE
R1    FIT      0.185     0.011   FROM FIT

R2      TAU+- INTO (E+- NUE NUTAU)/TOTAL                   (P2)
R2     B 459   0.160     0.013             BACINO    78 DLCO E+E- ECM=3.1-7.4GEV   1/79
R2             0.19      0.09              BRANDELIK 80 TASS E+E- ECM=30GEV         8/81
R2     E  60   0.183     0.031             BEHREND   83 CELL E+E- ECM=34 GEV.     11/83*
R2     B  BACINO 78 VALUE COMES FROM FIT TO EVENTS WITH E+- AND 1 OTHER             1/79
R2     B  NONELECTRON CHARGED PRONG.                                                1/79
R2     E  STATISTICAL AND SYSTEMATIC ERRORS COMBINED IN QUADRATURE.               11/83*
R2          . . . . . . . . . .
R2    AVG      0.164     0.012   AVERAGE
R2    FIT      0.1646    0.0094 FROM FIT

R3      TAU+- INTO (L+- NUL NUTAU)/TOTAL                   SQRT(P1*P2)
R3       WHERE L MEANS E OR MU.  EQUALITY OF E AND MU MODES IS ASSUMED.
R3     P 105   0.17      0.06      0.03    PERL      76 SMAG                        3/77
R3     B 144   0.186     0.030             PERL      77 SMAG                       12/77
R3     B  21   0.224     0.055             BARBARO-G 77 SMAG                       11/77
R3     B  13   0.182     0.031             BRANDELIK 78 DASP ASSUMES V-A DECAY      3/78
R3     B  WE HAVE COMBINED STATISTICAL AND SYSTEMATIC ERRORS QUADRATICALLY.         3/78
R3     P  ASSUMES V-A COUPLING, TAU MASS=1.8 GEV, TAU NEUTRINO MASS=0.
R3     B  ASSUMES V-A COUPLING, TAU MASS=1.9 GEV, TAU NEUTRINO MASS=0.
R3          . . . . . . . . . .
R3    AVG      0.186     0.018   AVERAGE
R3    FIT      0.1743    0.0069 FROM FIT

R4      TAU+- INTO E+- NUE NUTAU/MU+- NUMU NUTAU           (P2)/(P1)
R4       PREDICTED TO BE 1 FOR SEQUENTIAL LEPTON, 2 FOR PARAELECTRON,
R4       AND 1/2 FOR PARAMUON. PARAELECTRON ALSO RULED OUT BY HEILE 78.
R4       21    0.92      0.37              BURMEST2  77 PLUT ASSUMES V-A DECAY     12/77
R4     B 18    1.09      0.38              BRANDELIK 78 DASP E+E- 3.1-5.2GEV ECM   12/78
R4     L 154   0.75      0.23              BLOCKER1  82 SMK2 E+E- ECM=3.5-6.7GEV    2/82
R4     B  BRANDELIK 78 QUOTES THE INVERSE OF THIS RATIO AS .92+-.32 .             12/78
R4     L  BLOCKER 82 GIVES THE INVERSE OF THIS RATIO AS 1.33+-.18+-.36 .           2/82
R4          . . . . . . . . . .
R4    AVG      0.86      0.17    AVERAGE
R4    FIT      0.892     0.079   FROM FIT

R5      TAU+- INTO (MU+- NUMU NUTAU)*(E+- NUE NUTAU)       (P1)*(P2)
R5            (0.034)   (0.006)            ABRAMS    79 SMK2 REPL BY BLOCKER 82    12/79
R5     B 20    0.034     0.009             BACINO1   79 DLCO E+E- ECM=3.6-7.4GEV    1/79
R5      257    0.030     0.005             BLOCKER1  82 SMK2 E+E- ECM=3.5-6.7GEV    2/82
R5     B  BACINO1 79 QUOTES BR(MU)=0.21+-0.058(STAT.+SYST. ERRORS COMBINED IN       1/79
R5     B  QUADRATURE) ASSUMING BR(E)=0.16.  WE MPY. BY 0.16 TO GET ABOVE VAL.      1/79
R5          . . . . . . . . . .
R5    AVG      0.0309    0.0044  AVERAGE
R5    FIT      0.0304    0.0024 FROM FIT

R8      TAU+- INTO (HADRON+- NEUTRAL(S))/(TOTAL)           (P12+P16+P19)          11/77
R8       19    0.45      0.19              BARBARO-G 77 SMAG                       11/77
R8             0.29      0.11              BRANDELIK 78 DASP ASSUMES V-A DECAY      3/78
R8    B       (0.22)    (0.14)             BRANDELIK 80 TASS E+E- ECM=30GEV         8/81
R8    B  NOT INDEPENDENT OF BRANDELIK 80 R1, R2 AND R21 VALUES.                     8/81
R8          . . . . . . . . . .
R8    AVG      0.330     0.095   AVERAGE
R8    FIT      0.481     0.020   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R9      TAU+- INTO (K+- NEUTRAL(S))/TOTAL                  (P11)
R9     B     SMALL                         BRANDELIK 77 DASP   3.6-5.2ECM E+E-      1/78
R9     B  BRANDELIK 77 FINDS 0.07+-0.06 K+- PER EVT IN E+E- --> E+- PRONG-+.        1/78

R10     TAU+- INTO (3 HADRONS+- NEUTRAL(S))/TOTAL          (P17+P18)
R10            0.35      0.11              BRANDELIK 78 DASP ASSUMES V-A DECAY      3/78
R10      35    0.24      0.06              BRANDELIK 80 TASS E+E- ECM=30 GEV        8/81
R10     186    0.150     0.020             BEHREND   82 CELL E+E- 32-36.8GEV ECM  10/83*
R10 B   152   (0.14)    (0.02)             BLOCKER3  82 SMK2 E+ E- ECM = 29 GEV   10/83*
R10 B    NOT INDEPENDENT OF BLOCKER3 82 ONE-PRONG VALUE (R21).                     10/83*
R10         . . . . . . . . . .
R10 AVG        0.165     0.027   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
R10 FIT        0.170     0.013  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)
                         (SEE IDEOGRAM BELOW)
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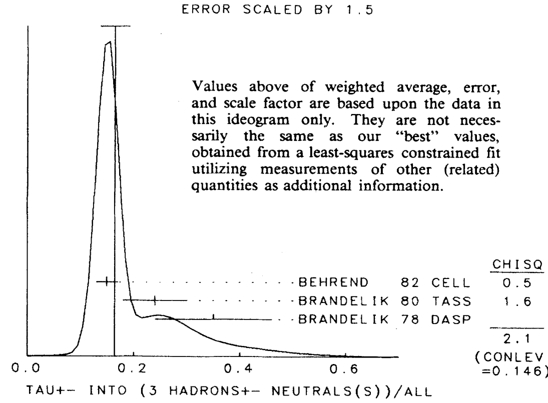
WEIGHTED AVERAGE = 0.165 ± 0.027
ERROR SCALED BY 1.5



For notation, see key at front of Listings.

Stable Particles

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R11     TAU+- INTO (NUTAU RHO0 PI+-)/TOTAL                   (P9)
R11      21   (0.0045) (0.0013)         ALEXAND1  78 PLUT REPL. BY WAGNER 80   3/78
R11      27    0.0054   0.0017          WAGNER    80 PLUT E+E- 4-5 GEV ECM     2/82

R12     TAU+- INTO (NUTAU A1(1100)+-)/TOTAL                  (P10)
R12      21   (0.10)   (0.03)           ALEXAND1  78 PLUT REPL. BY WAGNER 80  12/78
R12 W    27   (0.108)  (0.034)          WAGNER    80 PLUT E+E- 4-5 GEV ECM     2/82
R12 W    NOT INDEPENDENT OF WAGNER 80 R11 VALUE ABOVE.  ASSUMES THAT ALL       2/82
R12 W    (NU RHO0 PI+-) EVENTS ARE (NU A1+-) AND BR(L+- NU NU)=                2/82
R12 W    .173+-.013 .                                                          2/82

R13     TAU+- INTO (NUTAU 2PI+- PI-+ (PI0S))/TOTAL           (P17+P18)
R13      ASSUMED EQUAL TO (3 HADRONS+- NEUTRAL(S)) FOR FIT SINCE DECAY
R13      MODES CONTAINING KAONS ARE EXPECTED TO BE CABIBBO SUPPRESSED.
R13      33    0.18     0.065           JAROS     78 SMAG E+E- ECM > 6 GEV     1/79
R13              . . . . . . . . . .
R13 FIT        0.170    0.013  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

R14     TAU+- INTO (NUTAU 2PI+- PI-+)/TOTAL                  (P17)
R14     ASSUMED EQUAL TO (3 HADRONS+- NUTAU) FOR FIT SINCE DECAY MODES
R14     CONTAINING KAONS ARE EXPECTED TO BE CABIBBO SUPPRESSED.
R14  J  13     0.07     0.05            JAROS     78 SMAG E+E- ECM > 6 GEV     1/79
R14  J  JAROS 78 EVENTS CONSISTENT WITH BEING RHO PI OR A1.                    1/79
R14              . . . . . . . . . .
R14 FIT        0.053    0.041  FROM FIT

R15     TAU+- INTO (NUTAU .GE.3HADRONS+- NEUTRAL(S))         (P17+P18)
R15     692    0.32     0.05            BACINO    78 DLCO E+E- ECM=3.1-7.4GEV  1/79
R15      FOR THE FIT WE ASSUME THAT THIS EQUALS THE BRANCHING FRACTION FOR
R15      (3HADRONS+- NEUTRALS), I.E. THAT THE BRANCHING FRACTION FOR 5 OR
R15      MORE CHARGED HADRONS IS ZERO.
R15              . . . . . . . . . .
R15 FIT        0.170    0.013  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

R16     TAU+- INTO (NUTAU PI+-)*(E+- NUE NUTAU)              (P12)*(P2)
R16  A  23     0.015    0.006           ALEXAND2  78 PLUT E+E- ECM=3.6-5 GEV   2/79
R16  B  10     0.013    0.006           BACINO1   79 DLCO E+E- ECM=3.6-7.4GEV  1/79
R16  A  ALEXANDER2 78 QUOTE BR(PI)=.090+-.038(STAT.+SYST.ERRORS COMBINED IN    2/79
R16  A  QUADRATURE) USING BR(E)=.167+-.010. WE MPY. BY .167 TO GET ABV.VAL.    2/79
R16  B  BACINO1 79 QUOTES BR(PI)=0.080+-0.035(STAT.+SYST.ERRORS COMBINED IN    1/79
R16  B  QUADRATURE) ASSUMING BR(E)=0.16.  WE MPY. BY 0.16 TO GET ABOVE VAL.    1/79
R16              . . . . . . . . . .
R16 AVG        0.0140   0.0042  AVERAGE
R16 FIT        0.0170   0.0022 FROM FIT

R17     TAU+- INTO (NUTAU RHO+-)*(E+- NUTAU NUE)             (P16)*(P2)       12/79
R17           (0.0421) (0.0090)         ABRAMS    79 SMK2 REPL. BY BLOCKER 80 12/79
R17     139    0.034    0.008           BLOCKER   80 SMK2 E+E- ECM=3.5-6.7GEV  2/82
R17              . . . . . . . . . .
R17 FIT        0.0365   0.0043 FROM FIT

R18     TAU+- INTO (NUTAU RHO+-)*(MU+- NUTAU NUMU)           (P16)*(P1)       12/79
R18           (0.0329) (0.0100)         ABRAMS    79 SMK2 REPL. BY BLOCKER 80 12/79
R18     103    0.041    0.009           BLOCKER   80 SMK2 E+E- ECM=3.5-6.7GEV  2/82
R18              . . . . . . . . . .
R18 FIT        0.0409   0.0049 FROM FIT

R19     TAU+- INTO (3 HADRONS+- NUTAU)/TOTAL                 (P17)             8/81
R19 B         (0.09)   (0.06)           BRANDELIK 80 TASS E+E- ECM=30GEV       8/81
R19 B   NOT INDEPENDENT OF BRANDELIK 80 R10 AND R20 VALUES.                    8/81
R19              . . . . . . . . . .
R19 FIT        0.053    0.041  FROM FIT

R20     TAU+- INTO (3 HADRONS+- NUTAU GAMMA(S))/TOTAL        (P18)
R20            0.15     0.07            BRANDELIK 80 TASS E+E- ECM=30GEV       8/81
R20              . . . . . . . . . .
R20 FIT        0.117    0.042  FROM FIT

R21     TAU+- INTO (1 CHARGED NEUTRAL(S))/TOTAL              (P1+P2+P12+P16+P19)  8/81
R21      37    0.76     0.06            BRANDELIK 80 TASS E+E- ECM=30GEV       8/81
R21     672    0.840    0.020           BEHREND   82 CELL E+E- 32-36.8GEV ECM 10/83*
R21  B 764     0.86     0.022           BLOCKER3  82 SMK2 E+ E- ECM = 29 GEV  10/83*
R21  B  SYSTEMATIC AND STATISTICAL ERRORS COMBINED IN QUADRATURE.             10/83*
R21              . . . . . . . . . .
R21 AVG        0.844    0.016   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
R21 FIT        0.830    0.013  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

R22     TAU+- INTO (5 HADRONS+- NEUTRAL(S))/TOTAL            (P20)             8/81
R22           (0.06) OR LESS  CL=.95    BRANDELIK 80 TASS E+E- ECM=30GEV       8/81
R22  B  10     0.010    0.004           BEHREND   82 CELL E+E- 32-36.8GEV ECM 10/83*
R22  B   2     0.005 OR LESS  CL=.95    BLOCKER3  82 SMK2 E+ E- ECM = 29 GEV  10/83*
R22  B  IN THE STABLE PARTICLE TABLES WE QUOTE AN UPPER LIMIT 0.014 OR LESS   3/84*

R23     TAU+- INTO (NUTAU K*(892)+-)/TOTAL                   (P21)            12/81
R23      11    0.017    0.007           DORFAN    81 SMK2 E+E- 4.2-6.7GEV ECM 12/81

R24     TAU+- INTO (NUTAU K*(1430)+-)/TOTAL                  (P22)            12/81
R24       0    0.009 OR LESS  CL=.95    DORFAN    81 SMK2 E+E- 4.2-6.7GEV ECM 12/81

R25     TAU+- INTO (NUTAU PI+-)/TOTAL                        (P12)
R25    1138    0.117    0.019           BLOCKER1  82 SMK2 E+E- ECM=3.5-6.7GEV  2/82
R25  E  34     0.099    0.021           BEHREND   83 CELL E+E- ECM=34 GEV.    11/83*
R25  E  STATISTICAL AND SYSTEMATIC ERRORS COMBINED IN QUADRATURE.             11/83*
R25              . . . . . . . . . .
R25 AVG        0.109    0.014   AVERAGE
R25 FIT        0.103    0.012  FROM FIT

R26     TAU+- INTO (NUTAU 2PI+- PI-+ NON-RES.)/TOTAL         (P13-P9)
R26           (0.014)OR LESS  CL=.95    WAGNER    80 PLUT E+E- 4-5 GEV ECM     2/82

R27     TAU+- INTO (NUTAU K+-)/TOTAL                         (P23)            11/82*
R27      15    0.013    0.005           BLOCKER2  82 SMK2 E+E- ECM=3.9-6.7GEV 11/82*

R28     TAU+- INTO (NUTAU RHO+-)/TOTAL                       (P16)
R28  E 101     0.228    0.033           BEHREND   83 CELL E+E- ECM=34 GEV.    11/83*
R28  E  STATISTICAL AND SYSTEMATIC ERRORS COMBINED IN QUADRATURE.             11/83*
R28              . . . . . . . . . .
R28 FIT        0.221    0.024  FROM FIT

R51     TAU+- INTO(MU+- GAMMA(S) + E+- GAMMA(S))/TOTAL       (P31+P32)
R51      TEST OF LEPTON FAMILY NUMBER CONSERVATION
R51  B        (0.12) OR LESS  CL=.90    BURMEST2  77 PLUT E+E- 4-5 GEV ECM    12/77
R51  B  ASSUMES SAME MU,E MOM. SPEC. AS (MU E + NOTHING DETECTED).            12/77

R52     TAU+- INTO(MU+- CHGD. PARTS. + E+- CHGD. PARTS.)/TOTAL (P33+P34)
R52      TEST OF LEPTON FAMILY NUMBER CONSERVATION
R52  B         0.04  OR LESS  CL=.90    BURMEST2  77 PLUT E+E- 4-5 GEV ECM    12/77
R52  B  ASSUMES SAME MU,E MOM. SPEC. AS (MU E + NOTHING DETECTED).            12/77

R53     TAU+- INTO (MU+- GAMMA)/TOTAL                        (P31)
R53      TEST OF LEPTON FAMILY NUMBER CONSERVATION
R53        5.5E-4  OR LESS  CL=.90   HAYES      82 SMK2 E+E- 3.8-6.8GEV ECM  4/82

R54     TAU+- INTO (E+- GAMMA)/TOTAL                         (P32)
R54      TEST OF LEPTON FAMILY NUMBER CONSERVATION
R54        6.4E-4  OR LESS  CL=.90   HAYES      82 SMK2 E+E- 3.8-6.8GEV ECM  4/82

R55     TAU+- INTO (MU+- MU+ MU-)/TOTAL                      (P35)
R55      TEST OF LEPTON FAMILY NUMBER CONSERVATION
R55        4.9E-4  OR LESS  CL=.90   HAYES      82 SMK2 E+E- 3.8-6.8GEV ECM  4/82

R56     TAU+- INTO (E+- MU+ MU-)/TOTAL                       (P36)
R56      TEST OF LEPTON FAMILY NUMBER CONSERVATION
R56        3.3E-4  OR LESS  CL=.90   HAYES      82 SMK2 E+E- 3.8-6.8GEV ECM  4/82

R57     TAU+- INTO (MU+- E+ E-)/TOTAL                        (P37)
R57      TEST OF LEPTON FAMILY NUMBER CONSERVATION
R57        4.4E-4  OR LESS  CL=.90   HAYES      82 SMK2 E+E- 3.8-6.8GEV ECM  4/82

R58     TAU+- INTO (E+- E+ E-)/TOTAL                         (P38)
R58      TEST OF LEPTON FAMILY NUMBER CONSERVATION
R58        4.0E-4  OR LESS  CL=.90   HAYES      82 SMK2 E+E- 3.8-6.8GEV ECM  4/82

R59     TAU+- INTO (MU+- PI0)/TOTAL                          (P39)
R59      TEST OF LEPTON FAMILY NUMBER CONSERVATION
R59        8.2E-4  OR LESS  CL=.90   HAYES      82 SMK2 E+E- 3.8-6.8GEV ECM  4/82

R60     TAU+- INTO (E+- PI0)/TOTAL                           (P40)
R60      TEST OF LEPTON FAMILY NUMBER CONSERVATION
R60        2.1E-3  OR LESS  CL=.90   HAYES      82 SMK2 E+E- 3.8-6.8GEV ECM  4/82

R61     TAU+- INTO (MU+- K0)/TOTAL                           (P41)
R61      TEST OF LEPTON FAMILY NUMBER CONSERVATION
R61        1.0E-3  OR LESS  CL=.90   HAYES      82 SMK2 E+E- 3.8-6.8GEV ECM  4/82

R62     TAU+- INTO (E+- K0)/TOTAL                            (P42)
R62      TEST OF LEPTON FAMILY NUMBER CONSERVATION
R62        1.3E-3  OR LESS  CL=.90   HAYES      82 SMK2 E+E- 3.8-6.8GEV ECM  4/82

R63     TAU+- INTO (MU+- RHO0)/TOTAL                         (P43)
R63      TEST OF LEPTON FAMILY NUMBER CONSERVATION
R63        4.4E-4  OR LESS  CL=.90   HAYES      82 SMK2 E+E- 3.8-6.8GEV ECM  4/82

R64     TAU+- INTO (E+- RHO0)/TOTAL                          (P44)
R64      TEST OF LEPTON FAMILY NUMBER CONSERVATION
R64        3.7E-4  OR LESS  CL=.90   HAYES      82 SMK2 E+E- 3.8-6.8GEV ECM  4/82

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                       35  TAU DECAY PARAMETERS

RHO     RHO (MICHEL) PARAMETER        (V-A THEORY PREDICTS RHO=0.75)
RHO     594    0.72      0.15            BACINO2   79 DLCO E+E- ECM=3.5-7.4GEV  3/83*

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REFERENCES FOR TAU(1785) HEAVY LEPTON


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PERL      75 PRL 35 1489        +ABRAMS,BOYARSKI,BREIDENBACH +   (LBL+SLAC)
PERL      76 PL 63B 466         +FELDMAN,ABRAMS,ALAM,BOYARSKI +  (SLAC+LBL)

BARBARO-  77 PRL 39 1058        BARBARO-GALTIERI+       (LBL+NWES+SLAC+HAWA)
BRANDELI  77 PL 70B 125         BRANDELIK +        (AACH+DESY+HAMB+MPIM+TOKY)
BURMEST1  77 PL 68B 297         BURMESTER,CRIEGEE +   (DESY+HAMB+SIEG+WUPG)
BURMEST2  77 PL 68B 301         BURMESTER,CRIEGEE +   (DESY+HAMB+SIEG+WUPG)
CAVALLIS  77 LNC 20 337         CAVALLI-SFORZA,GOGGI +       (PAVI+PRIN+UMD)
PERL      77 PL 70B 487         +FELDMAN,ABRAMS,ALAM,BOYARSKI+   (SLAC+LBL)

ALEXAND1  78 PL 73B 99          ALEXANDER,CRIEGEE+     (DESY+AACH+SIEG+WUPG)
ALEXAND2  78 PL 78B 162         ALEXANDER+        (DESY+AACH+HAMB+SIEG+WUPG)
BACINO    78 PRL 41 13          +FERGUSON,NODULMAN +    (UCLA+SLAC+UCI+STON)J
    ALSO  78 TOKYO CONF. P.249  J.KIRZ(19TH INTL.CONF. ON HEP)          (STON)
    ALSO  80 PL 96B 214         ZHOLENTZ,KURDADZE,LELCHUK,MISHNEV+      (NOVO)
BARTEL    78 PL 77B 331         +DITTMANN,DUINKER,OLSSON,ONEILL+(DESY+HEID)

BRANDELI  78 PL 73B 109         BRANDELIK +     (AACH+DESY+HAMB+ MPIM+TOKY)J
HEILE     78 NP B138 189        +PERL,ABRAMS,ALAM,BOYARSKI+         (SLAC+LBL)
JAROS     78 PRL 40 1120        +ABRAMS,ALAM+             (SLAC+LBL+NWES+HAWA)
SMITH     78 PR D18 1           +FORD,MORSE,MANN,RESVANIS+ (COLO+PENN+WISC)

ABRAMS    79 PRL 43 1555        +ALAM,BLOCKER,BOYARSKI+             (SLAC+LBL)
ALEXANDE  79 PL 81B 84          ALEXANDER +       (DESY+AACH+HAMB+SIEG+WUPP)
ALLES     79 NCL 25 404         W.ALLES                                 (BGNA)J
BACINO1   79 PRL 42 6           +FERGUSON,NODULMAN +    (UCLA+SLAC+UCI+STON)
BACINO2   79 PRL 42 749         +FERGUSON,NODULMAN+     (UCLA+SLAC+UCI+STON)

BLOCKER   80  LBL-10801,THESIS  C.A.BLOCKER                              (LBL)
BRANDELI  80 PL 92B 199         BRANDELIK + (AACH+BONN+DESY+HAMB+LOIC+OXF+)
WAGNER    80 ZPHY C3 193        +ALEXANDER+          (AACH+DESY+HAMB+SIEG+WUPG)
ZHOLENTZ  80 PL 96B 214         +KURDADZE,LELCHUK,MISHNEV,NIKITIN+      (NOVO)
    ALSO  81 YAD.PHYS.34 1471   ZHOLENTZ +                              (NOVO)
BERGER    81 PL 99B 489         +GENZEL+(AACH+BERG+DESY+HAMB+UMD+SIEG+WUPG)
DORFAN    81 PRL 46 215         +BLOCKER,ABRAMS,ALAM +              (SLAC+LBL)

BEHREND   82 PL 114B 282        +CHEN+       (DESY+KARL+MPIM+LALO+LPNP+SACL)
BLOCKER1  82 PL 109B 119        +DORFAN,ABRAMS,ALAM,BLONDEL+       (LBL+SLAC)J
BLOCKER2  82 PRL 48 1586        +ABRAMS,ALAM,BLONDEL,BOYARSKI +  (SLAC+LBL)
BLOCKER3  82 PRL 49 1369        +LEVI,ABRAMS,AMIDEI,BACKER+ (HARV+LBL+SLAC)
FELDMAN   82 PRL 48 66          +TRILLING,ABRAMS,AMIDEI+     (SLAC+LBL+HARV)
FORD      82 PRL 49 106         +SMITH+(COLO+FRAS+NEAS+STAN+SLAC+UTAH+WISC)
HAYES     82 PR D25 2869        +PERL,ALAM,BOYARSKI,BREIDENBACH+ (SLAC+LBL)

BEHREND   83 PL 127B 270        +CHEN+       (DESY+KARL+MPIM+LALO+LPNP+SACL)
BEHREND2  83 NP B211 369        +CHEN+       (DESY+KARL+MPIM+LALO+LPNP+SACL)
JAROS     83 PRL 51 955         +AMIDEI,TRILLING+            (SLAC+LBL+HARV)

                                REVIEWS

PERL2     77 HAMBURG SYMP.      ALSO ISSUED AS SLAC-PUB-2022, M.PERL (SLAC)
FLUGGE    77 MESON CONF.BOSTON  ALSO ISSUED AS DESY 77-35, G.FLUGGE  (DESY)

AZIMOV    78 SPU 21 225         +FRANKFURT,KHOZE                        (LENI)
FELDMAN   78 TOKYO CONF.,P.777  G.J.FELDMAN (19TH INTL. CONF. ON HEP)(SLAC)J
PERL      78 SLAC-PUB-2219      M.L.PERL (KARLSRUHE SUMMER INST.1978)(SLAC)

FLUGGE    79 ZPHY C1 121        G.FLUGGE                                (DESY)
KIRKBY    79  SLAC-PUB-2419     J.KIRKBY(LEPTON PHOTON SYMP. BATAVIA)(SLAC)J
PERL      80 ARNPS 30 299       M.L.PERL                                (SLAC)

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SEARCHES FOR MASSIVE NEUTRINOS AND LEPTON MIXING

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SEE THE NOTE ON NEUTRINOS BY R.E. SHROCK IN THE ELECTRON NEUTRINO
SECTION NEAR THE BEGINNING OF THESE DATA CARD LISTINGS.

SEARCHES FOR INDIRECT EFFECTS OF NEUTRINO MASSES AND LEPTON MIXING
ARE LISTED HERE.  DIRECT SEARCHES FOR MASSES OF DOMINANTLY COUPLED
NEUTRINOS ARE LISTED IN THE APPROPRIATE SECTION ON NU-MU, NU-E,
OR NU-TAU.  RESULTS OF THESE INDIRECT SEARCHES ARE CORRELATED
UPPER BOUNDS ON MIXING MATRIX COEFFICIENTS U(A,J) VERSUS
NEUTRINO MASS.  THESE RESULTS ARE DIVIDED INTO THREE SECTIONS--
        (A) BOUNDS FROM PARTICLE AND NUCLEAR DECAYS
        (B) BOUNDS FROM NEUTRINO REACTIONS
        (C) SEARCHES FOR NEUTRINOLESS DOUBLE BETA DECAY

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                5  (A).  BOUNDS FROM PARTICLE AND NUCLEAR DECAYS

U1J      LIMITS ON CABS(U(1,J))**2 AS FUNCTION OF MASS(NU-J)
U1J
U1J      APPLICATION OF PEAK SEARCH TEST TO EXISTING DATA.
U1J  D        1.     OR LESS  CL=.95   SIMPSON    81        M(NU-J)=0.1 KEV     1/82
U1J  D        4. E-3 OR LESS  CL=.95   SIMPSON    81               =10 KEV      1/82
U1J  A        0.1    OR LESS  CL=.68   SHROCK     80        M(NU-J)=0.1-3 MEV   1/82
U1J  B        1. E-4 OR LESS  CL=.68   SHROCK1    81        M(NU-J)=10 MEV      1/82
U1J  B        5. E-6 OR LESS  CL=.68   SHROCK1    81               =60 MEV      1/82
U1J  C        1. E-5 OR LESS  CL=.68   SHROCK     80        M(NU-J)=80 MEV      1/82
U1J  C        3. E-6 OR LESS  CL=.68   SHROCK     80               =160 MEV     1/82
U1J  D   APPLICATION OF KINK SEARCH TEST TO TRITIUM BETA DECAY KURIE PLOT.      1/82
U1J  A   APPLICATION OF TEST TO SEARCH FOR KINKS IN BETA DECAY KURIE PLOTS.     1/82
U1J  B   ANALYSIS OF (PI+ --> E+ NU-E)/(PI+ --> MU+ NUMU) AND                   1/82
U1J  B   (K+ --> E+ NUE)/(K+ --> MU+ NUMU) DECAY RATIOS.                        1/82
U1J  C   ANALYSIS OF (K+ --> E+ NUE) SPECTRUM.                                  1/82
U1J
U1J      NEW EXPERIMENTS TO APPLY PEAK AND KINK SEARCH TESTS.
U1J           1. E-4 OR LESS  CL=.90   BRYMAN     83 CNTR M(NU-J)=5 MEV        12/83*
U1J           1.5E-6 OR LESS  CL=.90   BRYMAN     83 CNTR        =53 MEV       12/83*
U1J           1. E-5 OR LESS  CL=.90   BRYMAN     83 CNTR        =70 MEV       12/83*
U1J           1. E-4 OR LESS  CL=.90   BRYMAN     83 CNTR        =130 MEV      12/83*
U1J
U1J      SEARCHES FOR DECAYS OF MASSIVE NEUTRINOS
U1J  B        1. E-2 OR LESS  CL=.90   BERGSMA    83 CNTR M(NU-J)=10 MEV       12/83*
U1J  B        1. E-5 OR LESS  CL=.90   BERGSMA    83 CNTR        =110 MEV      12/83*
U1J  B        6. E-7 OR LESS  CL=.90   BERGSMA    83 CNTR        =410 MEV      12/83*
U1J           1. E-5 OR LESS  CL=.90   GRONAU     83        M(NU-J)=160 MEV     2/84*
U1J           1. E-6 OR LESS  CL=.90   GRONAU     83        M(NU-J)=480 MEV     2/84*
U1J  B   BERGSMA 83 ALSO QUOTE LIMITS ON CABS(U(1,3))**2 WHERE THE INDEX 3      2/84*
U1J  B   REFERS TO THE MASS EIGENSTATE DOMINANTLY COUPLED TO THE TAU.  THOSE    2/84*
U1J  B   LIMITS ARE SENSITIVE TO ASSUMPTIONS ABOUT F PRODUCTION AND F MASS.     2/84*
U1J  B   A 1970 MEV F MASS WOULD WEAKEN THESE LIMITS AND WOULD GIVE NO          2/84*
U1J  B   LIMIT FOR NU-TAU MASS ABOVE 190 MEV.                                   2/84*
U1J
U1J      KINK SEARCH IN NUCLEAR BETA DECAY
U1J           2.5E-2 OR LESS  CL=.90   SCHRECKEN  83 CNTR M(NU-J)=30 KEV        2/84*
U1J           0.4E-2 OR LESS  CL=.90   SCHRECKEN  83 CNTR        =140 KEV       2/84*
U1J           0.8E-2 OR LESS  CL=.90   SCHRECKEN  83 CNTR        =440 KEV       2/84*

U2J      LIMITS ON CABS(U(2,J))**2 AS FUNCTION OF MASS(NU-J)
U2J
U2J      APPLICATION OF PEAK SEARCH TEST TO EXISTING DATA.
U2J  A        5. E-2 OR LESS  CL=.95   SHROCK     80        M(NU-J)=4-6 MEV     1/82
U2J  A        3. E-2 OR LESS  CL=.95   SHROCK1    81        M(NU-J)=7 MEV       1/82
U2J  A        1. E-2 OR LESS  CL=.95   SHROCK1    81               =13 MEV      1/82
U2J  A        1. E-4 OR LESS  CL=.68   SHROCK1    81        M(NU-J)=13 MEV      1/82
U2J  A        3. E-5 OR LESS  CL=.68   SHROCK1    81               =33 MEV      1/82
U2J  B        6. E-3 OR LESS  CL=.68   SHROCK1    81        M(NU-J)=80 MEV      1/82
U2J  B        5. E-3 OR LESS  CL=.68   SHROCK1    81               =120 MEV     1/82
U2J  C        6. E-6 OR LESS  CL=.95   ASANO      81        M(NU-J)=240 MEV     1/82
U2J  C        5. E-7 OR LESS  CL=.95   ASANO      81               =280 MEV     1/82
U2J  C        6. E-6 OR LESS  CL=.95   ASANO      81               =300 MEV     1/82
U2J
U2J      NEW EXPERIMENTS TO APPLY PEAK SEARCH TEST.
U2J  D        1. E-1 OR LESS  CL=.90   ABELA      81        M(NU-J)=4 MEV       1/82
U2J  D        7. E-5 OR LESS  CL=.90   ABELA      81               =11 MEV      1/82
U2J  D        2. E-4 OR LESS  CL=.90   ABELA      81        M(NU-J)=11 MEV      1/82
U2J  D        2. E-5 OR LESS  CL=.90   ABELA      81               =16 MEV      1/82
U2J  D        2. E-5 OR LESS  CL=.90   ABELA      81        M(NU-J)=16-30 MEV   1/82
U2J  D        1. E-2 OR LESS  CL=.95   CALAPRICE  81        M(NU-J)=7 MEV       1/82
U2J  D        3. E-3 OR LESS  CL=.95   CALAPRICE  81               =33 MEV      1/82
U2J  E        2. E-5 OR LESS  CL=.95   ASANO      81        M(NU-J)=170 MEV     1/82
U2J  E        3. E-6 OR LESS  CL=.95   ASANO      81               =210 MEV     1/82
U2J  E        3. E-6 OR LESS  CL=.95   ASANO      81               =230 MEV     1/82
U2J  E        1. E-4 OR LESS  CL=.90   HAYANO     82        M(NU-J)=70 MEV     11/82*
U2J  E        9. E-7 OR LESS  CL=.90   HAYANO     82               =250 MEV    11/82*
U2J  E        5. E-6 OR LESS  CL=.90   HAYANO     82               =330 MEV    11/82*
U2J  A   ANALYSIS OF MAG. SPEC. EXP., BC EXP. AND EMUL. EXP. ON PI+ --> MU+     1/82
U2J  A   NU-MU DECAY.                                                           1/82
U2J  B   ANALYSIS OF MAG. SPEC. EXP. ON K-->MU,NUMU DECAY.                      1/82
U2J  C   ANALYSIS OF EXP. ON K+ --> MU+ NU-MU NU-X ANU-X DECAY.                 1/82
U2J  D   PI+ --> MU+ NU-MU  PEAK SEARCH EXP.                                    1/82
U2J  E   K+ --> MU+ NU-MU  PEAK SEARCH EXP.                                     1/82
U2J
U2J      PEAK SEARCH IN MUON-CAPTURE
U2J      LIMIT ON CABS(U(2,J))**2 AS FUNCTION OF MASS(NU-J)
U2J         (1.E-1)  OR LESS           DEUTSCH    83        M(NU-J)=45 MEV     12/83*
U2J         (7.E-3)  OR LESS           DEUTSCH    83               =70 MEV     12/83*
U2J         (1.E-1)  OR LESS           DEUTSCH    83               =85 MEV     12/83*

UAJ      LIMITS ON CABS(U(A,J))**2, WHERE A=1,2, FROM RHO PARAM. IN MU DECAY.
UAJ           1. E-2 OR LESS  CL=.68   SHROCK2    81        M(NU-J)=10 MEV      1/82
UAJ           2. E-3 OR LESS  CL=.68   SHROCK2    81               =40 MEV      1/82
UAJ           4. E-2 OR LESS  CL=.68   SHROCK2    81               =70 MEV      1/82

PRO      LIMITS ON CABS(U(1,J)*U(2,J)) AS FUNCTION OF MASS(NU-J)
PRO
PRO           1. E-2 OR LESS  CL=.90   BERGSMA    83 CNTR M(NU-J)=10 MEV       12/83*
PRO           1. E-5 OR LESS  CL=.90   BERGSMA    83 CNTR        =140 MEV      12/83*
PRO           7. E-7 OR LESS  CL=.90   BERGSMA    83 CNTR        =370 MEV      12/83*

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                5  (B).  BOUNDS FROM NEUTRINO REACTIONS

------ --------- --  5  SOLAR NEUTRINO EXPERIMENTS  ---- --------- --------

S        SOLAR NU FLUX (UNITS, SNU)
S        (1 SOLAR NEUTRINO UNIT, SNU, =1.E-36 CAPTURES/SEC/TARGET ATOM)
S             (7.3)      (1.5)           BAHCALL    80          THEOR.CALC.FLUX    1/82
S              2.1        0.3            DAVIS      81          MEAS. FLUX         1/82
S             (7.0)      (3.0)           FILIPPONE  82          THEOR.CALC.FLUX    1/82
S        SEE ALSO THE REVIEW BY BAHCALL 82 AND THE ANALYSIS BY EHRLICH 82.        12/83*

------ --------- --  5  DEEP MINE EXPERIMENTS  ---- --------- --------

DM       R= (MEASURED FLUX OF NU-MU)/(EXPECTED FLUX OF NU-MU)
DM             0.62       0.17           CROUCH     78          CASE WEST/UCI      1/82
DM   B         0.95       0.22           BOLIEV     81          BAKSAN            12/83*
DM   B   FROM THIS DATA BOLIEV 81 OBTAIN THE LIMIT DELTA(M**2) .LE. 6.E-3         12/83*
DM   B   EV**2 FOR MAXIMAL MIXING, NU(MU) -/-> NU(MU) TYPE OSCILLATION.           12/83*
DM             . . . . . . . .
DM   AVERAGE MEANINGLESS (SCALE FACTOR = 1.2)

------ --------- --  5  REACTOR ANTINEUTRINO EXPERIMENTS  -------- --------

RD       (EVENTS OBSERVED)/(EVENTS EXPECTED) FROM REACTOR ANU-E EXPTS.
RD  B         (0.89)     (0.15)          BOEHM      80          ANU-E P --> E+ N   1/82
RD A R         0.38       0.21           REINES     80          SEE NOTE A         1/82
RD A R         0.40       0.22           REINES     80          SEE NOTE A         1/82
RD   B         0.955      0.12           KWON       81          ANU-E P --> E+ N   1/82
RD   V         1.05       0.054          VUILLEUMI  82          ANU-E P --> E+ N  11/82*
RD   B   KWON 81 REPRESENTS AN ANALYSIS OF A LARGER SET OF DATA FROM THE           1/82
RD   B   SAME EXPERIMENT AS BOEHM 80. SYST.+STAT. ERRORS COMBINED IN               1/82
RD   B   QUADRATURE.                                                               1/82
RD   A   REINES 80 INVOLVES COMPARISON OF NEUTRAL- AND CHARGED-CURRENT             1/82
RD   A   REACTIONS ANU-E D --> N P ANU-E AND ANU-E D --> N N E+ RSPECTIVELY.       1/82
RD   A   COMBINED ANALYSIS OF REACTOR ANU-E EXPTS. WAS PERFORMED BY                1/82
RD   A   SILVERMAN 81.                                                             1/82
RD   R   THE TWO REINES 80 VALUES CORRESPOND TO THE CALCULATED ANU-E FLUXES        1/82
RD   R   OF AVIGNONE-GREENWOOD AND DAVIS ET AL RESPECTIVELY.                       1/82
RD   V   STATISTICAL AND SYSTEMATIC ERRORS COMBINED IN QUADRATURE.                11/82*

------ --------- --  5  ACCELERATOR EXPERIMENTS  ------- --------- --------

         BOUNDS ON DELTA(M**2) VS. SIN(2*THETA)**2
         WHERE DELTA(M**2) IS MAGNITUDE OF ( MASS(NU-I)**2 - MASS(NU-J)**2)
         AND THETA IS THE MIXING ANGLE FOR THE SIMPLIFYING ASSUMPTION OF
         MIXING BETWEEN TWO NEUTRINO FAMILIES ONLY.

         EACH EXPERIMENTAL RESULT IS A PLOT GIVING ALLOWED AND EXCLUDED
         REGIONS AS FUNCTIONS OF DELTA(M**2) AND SIN(2*THETA)**2.  WE QUOTE
         TWO REPRESENTATIVE LIMITS FROM EACH PLOT --
            1)  DELTA(M**2) FOR SIN(2*THETA)**2=1.
            2)  SIN(2*THETA)**2 FOR ''LARGE'' DELTA(M**2), I.E. SUFFICIENTLY
                LARGE DELTA(M**2) THAT THE DETECTOR WOULD MEASURE ONLY AN
                EFFECT AVERAGED OVER MANY OSCILLATIONS.
         EXPERIMENTS ARE OF TWO GENERAL TYPES --
            (A) THOSE WHICH SEARCH FOR NU(A)-->NU(B) (B NOT EQUAL A), I.E.
                THE APPEARANCE OF L(B) FROM CHARGED CURRENT REACTION OF A
                NU(A) BEAM.
            (B) THOSE WHICH SEARCH FOR THE 'DISAPPEARANCE' OF PART OF THE
                INITITAL NU(A) BEAM BY COMPARING THE NUMBER OF OBSERVED L(A)
                EVENTS WITH THE NUMBER EXPECTED FROM FLUX CALCULATIONS.
                THESE EXPERIMENTS DO NOT TRY TO OBSERVE THE ANOMALOUS
                L(B)'S.  WE LABEL SUCH EXPERIMENTS AS NU-A -/-> NU-A

NU-MU --> NU-E
D1       DELTA(M**2) FOR SIN(2*THETA)**2=1   (UNITS EV**2)   NU-MU --> NU-E
D1            1.2        OR LESS  CL=.95  BELLOTTI  76 HLBC GGM CERN PS          1/82
D1            1.2        OR LESS  CL=.95  BLIETSCHA 78 HLBC GGM CERN PS          1/82
D1            1.7        OR LESS  CL=.90  ARMENISE  81 HLBC GGM CERN SPS         1/82
D1            0.6        OR LESS  CL=.90  BAKER     81 HLBC 15FT FNAL            1/82
D1            1.7        OR LESS  CL=.90  ERRIQUEZ  81 HLBC BEBC CERN SPS        1/82

S1       SIN(2*THETA)**2 FOR ''LARGE'' DELTA(M**2)           NU-MU --> NU-E
S1            1. E-2     OR LESS  CL=.95  BELLOTTI  76 HLBC GGM CERN PS          1/82
S1            6. E-2     OR LESS  CL=.95  BLIETSCHA 78 HLBC GGM CERN PS          1/82
S1            1. E-2     OR LESS  CL=.90  ARMENISE  81 HLBC GGM CERN SPS         1/82
S1            6. E-3     OR LESS  CL=.90  BAKER     81 HLBC 15FT FNAL            1/82
S1            1. E-2     OR LESS  CL=.90  ERRIQUEZ  81 HLBC BEBC CERN SPS        1/82

ANU-MU --> ANU-E

D2       DELTA(M**2) FOR SIN(2*THETA)**2=1   (UNITS EV**2)   ANU-MU --> ANU-E
D2            1.         OR LESS  CL=.95  BLIETSCHA 78 HLBC GGM CERN PS          1/82
D2            0.91       OR LESS  CL=.90  NEMETHY   81 CNTR LAMPF                1/82
D2            2.4        OR LESS  CL=.90  TAYLOR    83 HLBC    15 FT FNAL        2/84*

S2       SIN(2*THETA)**2 FOR ''LARGE'' DELTA(M**2)           ANU-MU --> ANU-E
S2            6. E-2     OR LESS  CL=.95  BLIETSCHA 78 HLBC GGM CERN PS          1/82
S2            0.2        OR LESS  CL=.90  NEMETHY   81 CNTR LAMPF                1/82
S2            1.3E-2     OR LESS  CL=.90  TAYLOR    83 HLBC    15 FT FNAL        2/84*

NU-MU --> NU-TAU

D3       DELTA(M**2) FOR SIN(2*THETA)**2=1   (UNITS EV**2)   NU-MU --> NU-TAU
D3            4.6        OR LESS  CL=.90  ARMENISE  81 HLBC GGM CERN SPS         1/82
D3            3.         OR LESS  CL=.90  BAKER     81 HLBC 15FT FNAL            1/82
D3            6.         OR LESS  CL=.90  ERRIQUEZ  81 HLBC BEBC CERN SPS        1/82
D3            3.         OR LESS  CL=.90  USHIDA    81 EMUL FNAL                 1/82

S3       SIN(2*THETA)**2 FOR ''LARGE'' DELTA(M**2)           NU-MU --> NU-TAU
S3            1.7E-2     OR LESS  CL=.90  ARMENISE  81 HLBC GGM CERN SPS         1/82
S3            6. E-2     OR LESS  CL=.90  BAKER     81 HLBC 15FT FNAL            1/82
S3            5. E-2     OR LESS  CL=.90  ERRIQUEZ  81 HLBC BEBC CERN SPS        1/82
S3            1.3E-2     OR LESS  CL=.90  USHIDA    81 EMUL FNAL                 1/82

ANU-MU --> ANU-TAU

D4       DELTA(M**2) FOR SIN(2*THETA)**2=1  (UNITS EV**2)  ANU-MU --> ANU-TAU
D4            2.2        OR LESS  CL=.90  ASRATYAN  81 HLBC FNAL                 1/82
D4            7.4        OR LESS  CL=.90  TAYLOR    83 HLBC    15 FT FNAL        2/84*

S4       SIN(2*THETA)**2 FOR ''LARGE'' DELTA(M**2)           ANU-MU --> ANU-TAU
S4            4.4E-2     OR LESS  CL=.90  ASRATYAN  81 HLBC FNAL                 1/82
S4            8.8E-2     OR LESS  CL=.90  TAYLOR    83 HLBC    15 FT FNAL        2/84*
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For notation, see key at front of Listings. **Stable Particles**

MASSIVE ν'S & LEPTON MIXING, ν BOUNDS FROM ASTROPHYSICS & COSMOLOGY

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NU-E -/-> NU-E

D6      DELTA(M**2) FOR SIN(2*THETA)**2=1   (UNITS EV**2)   NU-E -/-> NU-E
D6          8.       OR LESS  CL=.90   BAKER      81 HLBC 15FT FNAL           1/82
D6         56.       OR LESS  CL=.90   DEDEN      81 HLBC BEBC CERN SPS       1/82
D6         10.       OR LESS  CL=.90   ERRIQUEZ   81 HLBC BEBC CERN SPS       1/82
D6         2.3 TO 8 EXCLUDED  CL=.90   NEMETHY    81 CNTR LAMPF               1/82

S6      SIN(2*THETA)**2 FOR ''LARGE'' DELTA(M**2)          NU-E -/-> NU-E
S6          0.6      OR LESS  CL=.90   BAKER      81 HLBC 15FT FNAL           1/82
S6          0.3      OR LESS  CL=.90   DEDEN      81 HLBC BEBC CERN SPS       1/82
S6          7.E-2    OR LESS  CL=.90   ERRIQUEZ   81 HLBC BEBC CERN SPS       1/82

ANU-E --> ANU-TAU

S7      SIN(2*THETA)**2 FOR ''LARGE'' DELTA(M**2)         ANU-E --> ANU-TAU
S7   F      0.7      OR LESS  CL=.90   FRITZE     80 HYBR BEBC CERN SPS       1/82
S7   F   AUTHORS GIVE P(NUE-->NUTAU)< .35, EQUIVALENT TO ABOVE LIMIT.         1/82

NU-MU --> (ANU-E)-L

        THIS IS A LIMIT ON LEPTON FAMILY-NUMBER VIOLATION AND TOTAL LETPON-  12/83*
        NUMBER VIOLATION.  (ANU-E)-L DENOTES A HYPOTHETICAL LEFT-HANDED      12/83*
        ANTI-ELECTRON NEUTRINO.  THE BOUND IS QUOTED IN TERMS OF DELTA       12/83*
        (M**2), SIN(2*THETA), AND ALPHA, WHERE ALPHA DENOTES THE FRACTIONAL  12/83*
        ADMIXTURE OF (V+A) CHARGED CURRENT.                                  12/83*

AD1     ALPHA*DELTA(M**2) FOR SIN(2*THETA)**2=1 (UNITS EV**2)                12/83*
AD1  C       7.E-1  OR LESS  CL=.90   COOPER     82 HLBC                     12/83*
AD1  C  EXISTING BOUNDS ON V+A CURRENTS REQUIRE ALPHA SMALL - SEE COOPER82.  12/83*

AS1     ALPHA**2*SIN(2*THETA)**2 FOR ''LARGE'' DELTA(M**2)                   12/83*
AS1  C       1.E-3  OR LESS  CL=.90   COOPER     82 HLBC                     12/83*
AS1  C  EXISTING BOUNDS ON V+A CURRENTS REQUIRE ALPHA SMALL - SEE COOPER82.  12/83*

NU-E --> (ANU-E)-L                                                           12/83*

       SEE NOTE FOR NU-MU --> (ANU-E)-L LIMIT                                12/83*
AD2     ALPHA*DELTA(M**2) FOR SIN(2*THETA)=1 (UNITS EV**2)                   12/83*
AD2  C       7.     OR LESS  CL=.90   COOPER     82 HLBC                     12/83*
AD2  C  EXISTING BOUNDS ON V+A CURRENTS REQUIRE ALPHA SMALL - SEE COOPER82.  12/83*

AS2     ALPHA**2*SIN(2*THETA)**2 FOR ''LARGE'' DELTA(M**2)                   12/83*
AS2  C       5.E-2  OR LESS  CL=.90   COOPER     82 HLBC                     12/83*
AS2  C  EXISTING BOUNDS ON V+A CURRENTS REQUIRE ALPHA SMALL - SEE COOPER82.  12/83*

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                      5 (C).  SEARCHES FOR NEUTRINOLESS DOUBLE BETA DECAY

        THE DECAY (Z,A) --> (Z+2,A) + E- + E-, I.E. NEUTRINOLESS DOUBLE
        BETA DECAY, VIOLATES TOTAL LEPTON NUMBER BY TWO UNITS.  IT IS
        FORBIDDEN IF NEUTRINOS ARE DIRAC PARTICLES BUT CAN OCCUR IF
        NEUTRINOS ARE MAJORANA PARTICLES AND (A) THEY ARE MASSIVE OR
        (B) THEY HAVE NON (V-A) COUPLINGS.  PRIMAKOFF 81, ROSEN 81, AND
        HAXTON 83 DISCUSS CORRELATED BOUNDS ON MNUW AND RIGHT-HANDED
        COUPLINGS.  FURTHER THEORETICAL DISCUSSIONS INCLUDE DOI 81,
        HAXTON 82, AND GROTZ 83.

MW      MNUW, THE EFFECTIVE WEIGHTED SUM OF NEUTRINO MASSES CONTRIBUTING TO
MW      NEUTRINOLESS DOUBLE BETA DECAY   (UNITS EV)
MW        MNUW= CABS(SUM FROM 1 TO N OF U(1,J)**2*M(NU-J)), WHERE N= NUMBER
MW        OF NEUTRINO GENERATIONS, AND NU-J IS A MAJORANA NEUTRINO.  NOTE
MW        THAT U(1,J)**2, NOT CABS(U(1,J))**2, OCCURS IN THE SUM; THE
MW        POSSIBILITY OF CANCELLATIONS HAS BEEN STRESSED IN WOLFENSTEIN 81.
MW
MW   D      (30.)   APPROX.            DOI        81
MW   H       12.    OR LESS            HAXTON     81                          1/82
MW   M       (.8)   OR MORE            MINKOWSKI  82          CAUTION-SEE NOTE 12/83*
MW           40     OR LESS            VERGADOS   82          CA-48           12/83*
MW           10     OR LESS  CL=.90    AVIGNONE   83 CNTR+THY GE-76           12/83*
MW   B       22     OR LESS  CL=.68    BELLOTTI   83 CNTR+THY1  GE-76         12/83*
MW   B        8.3   OR LESS  CL=.68    BELLOTTI   83 CNTR+THY2  GE-76         12/83*
MW            5.6   OR LESS  CL=.95    KIRSTEN    83 SPEC+THY TE-128/TE-130   12/83*
MW   D  DOI 80 IS THEORETICAL ANALYSIS OF LIFETIME RATIO FOR                   1/82
MW   D  TELLURIUM-128/TELLURIUM-130 AND USES NUCLEAR MATRIX ELEMENTS           1/82
MW   D  CALCULATED BY VERGADOS.                                                1/82
MW   H  HAXTON 81 IS THEORETICAL ANALYSIS OF LIFETIMES OF GERMANIUM-76 AND     1/82
MW   H  SELENIUM-82, THE FORMER OF WHICH YIELDS MNUW.LT.12 EV AND THE          1/82
MW   H  LATER OF WHICH YIELDS MNUW.LT.15 EV.  WE LIST THE MORE RESTRICTIVE     1/82
MW   H  UPPER LIMIT ABOVE. THE DOI 81 VALUE OF MNUW AND THE HAXTON 81 LIMIT    1/82
MW   H  ON MNUW BOTH ASSUME V-A COUPLINGS.                                     1/82
MW   M  THE DEFINITION OF WEIGHTED NEUTRINO MASS GIVEN IN MINKOWSKI 82        12/83*
MW   M  IS WRONG; IT SHOULD INVOLVE U(1,J)**2, NOT CABS(U(1,J))**2. THE       12/83*
MW   M  CONCLUSION OF THIS PAPER, THAT 'EXPERIMENTAL RATES DO IMPLY A         12/83*
MW   M  VIOLATION OF LEPTON NUMBER', IS IN DISAGREEMENT WITH THE              12/83*
MW   M  CONCLUSIONS OF HAXTON 81, ROSEN 81, HAXTON 83, AVIGNONE 83,           12/83*
MW   M  KIRSTEN 83, AND BELLOTTI 83.                                          12/83*
MW   B  LIMITS ARE OBTAINED FROM ANALYSIS OF DATA USING THEORETICAL           12/83*
MW   B  CALCULATIONS BY DOI-83 (=THY1) AND ROSEN 81 (=THY2).                  12/83*

ETA     LIMITS ON LEPTON-NUMBER VIOLATING (V+A) CURRENT ADMIXTURE
ETA       ETA IS DEFINED AS THE FRACTIONAL ADMIXTURE OF (V+A)
ETA       CHARGED CURRENT, RELATIVE TO (V-A) IN ELECTRON-TYPE
ETA       LEPTON SECTOR.
ETA
ETA          2.4E-5  OR LESS            AVIGNONE   83 CNTR+THY GE-76          12/83*
ETA  B       4. E-5  OR LESS  CL=.68    BELLOTTI   83 CNTR+THY1  GE-76        12/83*
ETA  B       1.5E-5  OR LESS  CL=.68    BELLOTTI   83 CNTR+THY2  GE-76        12/83*
ETA          2.4E-5  OR LESS  CL=.95    KIRSTEN    83 SPEC+THY TE-128/TE-130  12/83*
ETA  B  LIMITS ARE OBTAINED FROM ANALYSIS OF DATA USING THEORETICAL           12/83*
ETA  B  CALCULATIONS BY DOI-83 (=THY1) AND ROSEN 81 (=THY2).                  12/83*

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                      REFERENCES FOR COR. BOUNDS ON NU MASS, MIXING.

BELLOTTI 76 LNC 17 553          +CAVALLI,FIORINI,ROLLIER                  (MILA)
BLIETSCH 78 NP B133 205         BLIETSCHAU+(AACH+LIBH+CERN+EPOL+MILA+ORSA+)
CROUCH   78 PR D18 2239         +LANDECKER,LATHROP,REINES+  (CASE+UCI+WITW)

BAHCALL  80 PRL 45 945          +LUBOW,HUEBNER+     (IAS+LASL+YALE+LLL+UCLA)
    ALSO 76 SCIENCE 191 264     J.N.BAHCALL,R.DAVIS                 (IAS+BNL)
BOEHM    80 PL 97B 310          +CAVAIGNAC,FEILITZSCH+ (ILLG+CIT+GREN+MUNI)
FRITZE   80 PL 96B 427          +GRASSLER+    (AACH+BONN+CERN+LOIC+OXF+SACL)

REINES   80 PRL 45 1307         F.REINES,H.W.SOBEL,E.PASIERB               (UCI)
    ALSO 59 PR 113 273          F.REINES,C.L.COWAN                        (LASL)
    ALSO 66 PR 142 852          F.A.NEZRICK,F.REINES                      (CASE)
    ALSO 76 PRL 37 315          F.REINES,H.S.GURR,H.W.SOBEL                (UCI)
SHROCK   80 PL 96B 159          R.E.SHROCK                                (STON)

ABELA    81 PL 105B 263         +DAUM,EATON,FROSCH,JOST,KETTLE,STEINER(SIN)
ARMENISE 81 PL 100B 182         +FOGLI-MUCIACCIA+       (BARI+CERN+MILA+LALO)
ASANO    81 PL 104B 84          +HAYANO,KIKUTANI,KUROKAWA+  (KEK+TOKY+OSAK)
    ALSO 81 SHROCK1
ASRATYAN 81 PL 105B 301         +EFREMENKO,FEDOTOV +  (ITEP+FNAL+SERP+MICH)
BAKER    81 PRL 47 1576         +CONNOLLY,KAHN,KIRK,MURTAGH+      (BNL+COLU)
    ALSO 78 PRL 40 144          CNOPS,CONNOLLY,KAHN,KIRK+         (BNL+COLU)

BALTAY   81 NU 81 CONF HAWAII C.BALTAY                                 (COLU)
BOLIEV   81 SJNP 34 787         +BUTKEVICH,ZAKIDYSHEV,MAKOEV,MIKHEEV+(INRM)
CALAPRIC 81 PL 106B 175         CALAPRICE,SCHREIBER,SCHNEIDER +  (PRIN+IND)
DAVIS    81  BNL NU WKSHP       B.T.CLEVELAND,R.DAVIS JR., J.K.ROWLEY (BNL)
DEDEN    81 PL 98B 310          +        (AACH+BONN+CERN+ATEN+LOIC+OXF+SACL)
DOI      81 PL 103B 219         +KOTANI,NISHIURA,OKUDA,TAKASUGI          (OSAK)
    ALSO 81 PTP 66 1739         DOI,KOTANI,NISHIURA,OKUDA,TAKASUGI      (OSAK)
    ALSO 81 PTP 66 1765         DOI,KOTANI,NISHIURA,OKUDA,TAKASUGI      (OSAK)

ERRIQUEZ 81 PL 102B 73          +NATALI+    (BARI+BIRM+LIBH+EPOL+RHEL+SACL+)
HAXTON   81 PRL 47 153          +G.J.STEPHENSON,D.STROTTMAN      (PURD,LASL)
KWON     81 PR D24 1097         +BOEHM,HAHN,HENRIKSON+       (CIT+GREN+MUNI)
NEMETHY  81 PR D23 262          +     (YALE+LBL+LASL+MIT+SACL+SIN+CNRC+BERN)

PRIMAKOF 81 ARNS 31 145         H.PRIMAKOFF,S.P.ROSEN                    (PURD)
ROSEN    81 NU 81 CONF HAWAII S.P.ROSEN                                (PURD)
    ALSO 78 RMP 50 11           D.BRYMAN,C.PICCIOTTO               (TRIU,VICT)
SHROCK1  81 PR D24 1232         R.E.SHROCK                               (STON)
SHROCK2  81 PR D24 1275         R.E.SHROCK                               (STON)

SILVERMA 81 PRL 46 467          D.SILVERMAN,A.SONI                  (UCI+UCLA)
SIMPSON  81 PR D24 2971         J.SIMPSON                                (GUEL)
USHIDA   81 PRL 47 1694           (AICH+FNAL+KOBE+SEOU+MCGI+NAGO+OSU+OKAY+)
WOLFENST 81 PL 107B 77          L.WOLFENSTEIN                            (CARN)

BAHCALL  82 RMP (TO BE PUBL.) +HUEBNER,LUBOW+    (IAS+LANL+HPC+YALE+UCLA)
COOPER   82 PL 112B 97          +GUY,MICHETTE,TYNDEL,VENUS                 (RL)
EHRLICH  82 PR D25 2282         R.EHRLICH                                (GMAS)
FILIPPON 82 APJ 253 393         B.W.FILIPPONE,D.N.SCHRAMM            (ANL+EFI)
HAXTON   82 PR D25 2360         +STEPHENSON,STROTTMAN               (LANL+PURD)
HAYANO   82 PRL 49 1305         +TANIGUCHI,YAMANAKA +          (TOKY+KEK+TSUK)
MINKOWSK 82 NP B201 269         P.MINKOWSKI                              (BERN)
VERGADOS 82 PL 109B 96          J.D.VERGADOS                             (CERN)
    ALSO 82 PL 113B 513         J.D.VERGADOS                             (CERN)
    ALSO 83 NP 218B 109         J.D.VERGADOS                             (CERN)
VUILLEUM 82 PL 114B 298         VUILLEUMIER,BOEHM,EGGER +      (CIT+SIN+MUNI)

AVIGNONE 83 PRL 50 721          +BRODZINSKI,BROWN,EVANS,HENSLEY+ (SCUC+PNL)
BELLOTTI 83 PL 121B 72          +FIORINI,LIGURORI,PULLIA,SARRACINO+  (MILA)
BERGSMA  83 PL 128B 361         CHARM COLLAB.     (ANIK+CERN+HAMB+ITEP+INFN)
BRYMAN   83 PRL 50 1546         +DUBOIS,NUMAO,OLANIYI,OLIN+       (TRIU+CNRC)
    ALSO 83 PRL 50 7            BRYMAN,DUBOIS,NUMAO,OLANIYA+      (TRIU+CNRC)
DEUTSCH  83 PR D27 1644         J.P.DEUTSCH,M.LEBRUN,R.PRIEELS          (LVLN)
DOI      83 PTP 69 602          +KOTANI,NISHIURA,TAKASUGI          (OSAK+KYOT)
GRONAU   83 PR D28 2762         GRONAU                                   (HAIF)
GROTZ    83 JPG 9 L169          K.GROTZ,H.V.KLAPDOR,J.METZINGER          (MPIH)
HAXTON   83 CNPP 11 41          W.C.HAXTON                          (LASL+PURD)
KIRSTEN  83 PRL 50 474          T.KIRSTEN,H.RICHTER,E.JESSBERGER         (MPIH)
    ALSO 83 ZPHY 16 189         T.KIRSTEN,H.RICHTER,E.JESSBERGER         (MPIH)
SCHRECKE 83 PL 129B 265         SCHRECKENBACH,COLVIN+               (GREN+ILLG)
TAYLOR   83 PR D28 2705         +CENCE,HARRIS,JONES+            (HAWA+LBL+FNAL)

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NEUTRINO BOUNDS FROM ASTROPHYSICS AND COSMOLOGY

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        SEE THE NOTE ON NEUTRINOS BY R.E. SHROCK IN THE ELECTRON NEUTRINO
        SECTION NEAR THE BEGINNING OF THESE DATA CARD LISTINGS.  FOR
        INFORMATION ON NEUTRINOS DERIVED FROM MORE CONVENTIONAL
        (TERRESTRIAL) EXPERIMENTS, SEE THE NUE, NUMU, NUTAU, AND
        HEAVY-NU SECTIONS ABOVE.
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NOTE ON ν MASS LIMITS

These limits apply to m_{tot} given by

$$m_{tot} = \sum_{j=1,n} \left(\frac{g_{\nu_j}}{2}\right) m_{\nu_j} ,$$

where n is the number of neutrino species and g_{ν_j} is the number of independent components in the neutrino field: $g_{\nu_j} = 4$ for Dirac neutrinos; $g_{\nu_j} = 2$ for chiral Majorana neutrinos.

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                      6  NU MASS (EV)

M       LIMIT ON TOTAL NEUTRINO MASS, SUMMED OVER ALL SPIN COMPONENTS,
M       OF EFFECTIVELY STABLE NEUTRINOS (I.E. THOSE WITH MEAN LIVES ROUGHLY
M       EQUAL TO OR GREATER THAN THE AGE OF THE UNIVERSE)  (UNITS EV)
M    A     (132.)   OR LESS            COWSIK     72 COSM
M    A      (80.)   OR LESS            LEE        77 COSM                    9/81
M          (100.)   OR LESS            OLIVE      81 COSM                    1/82
M    A  COWSIK 72 AND LEE 77 HAVE BEEN GENERALIZED TO APPLY TO M(TOT) AS     4/82
M    A  DEFINED ABOVE, WHERE ONE ALLOWS EITHER DIRAC OR MAJORANA NEUTRINOS.  4/82
M    A  THESE PAPERS ASSUMED DIRAC NEUTRINOS.                                4/82
M       FOR OTHER LIMITS, SEE SATO 77, VYSOTSKY 77, DICUS 78, HUT 79,        2/82
M       AND ZELDOVICH 80.                                                    2/82
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Stable Particles

Data Card Listings

ν BOUNDS FROM ASTROPHYSICS & COSMOLOGY, HEAVY LEPTON SEARCHES

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ML      ASTROPHYSICAL AND COSMOLOGICAL LIMITS ON NEUTRINO MASSES. (UNITS EV)
ML      ANALYSES OF MASS/LIGHT RATIOS AND DYNAMICS OF GALAXIES AND
ML      CLUSTERS ARE CONSISTENT WITH PRESENCE OF DARK MATTER.  TREMAINE 79
ML      STATED THAT THE DARK MATTER COULD NOT BE MUON OR ELECTRON NEUTRINOS
ML      OF NONZERO REST MASS OR ANY NEUTRAL LEPTON LESS MASSIVE THAN 1 MEV.
ML      AUTHORS BOND 81, DAVIS 81, AND SCHRAMM 81 CLAIMED THAT THIS DARK
ML      MATTER COULD CONSISTENTLY BE ASCRIBED TO MASSIVE NEUTRINOS
ML      WITH SUFFICIENTLY LONG LIFETIMES.  SUBSEQUENT ANALYSES HAVE
ML      CHALLENGED THIS CLAIM; SEE PRIMACK 83.  FOR DEGENERATE NEUTRINOS,
ML      SEE FREESE 83.
ML
ML                                         TREMAINE  79 COSM  ISOTHERMAL          1/82
ML       ORDER 30                          BOND      81 COSM  ADIABATIC           2/82
ML         50-100                          DAVIS     81 COSM  ADIA.+DECAYING NUS  1/82
ML          4-20                           SCHRAMM   81 COSM  ISOTHERMAL          1/82
ML          NO CONSISTENT VALUE            PRIMACK   83 COSM                     12/83*

MSW     LIMITS ON MASSES OF STABLE RIGHT-HANDED NEUTRINOS
MSW     (WITH NECESSARILY SUPPRESSED INTERACTION STRENGTHS)
MSW  O                                     OLIVE     82                          12/83*
MSW  O  ALLOWED VALUES OF MASS ARE STRONGLY CORRELATED WITH INTERACTION          12/83*
MSW  O  STRENGTH.  SEE FIG. 1 OF OLIVE 82.                                       12/83*

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                         6  NU RADIATIVE MEAN LIFE VERSUS MASS

T                                          COWSIK    77 COSM                      1/82
T                                          DICUS     77 COSM                      1/82
T                                          GOLDMAN   77 COSM                      4/82
T                                          FALK      78 COSM                      1/82
T                 STRONGLY CORRELATED      COWSIK    79 COSM                      1/82
T                 LIMITS. SEE REFERENCES   GOLDMAN   79 COSM                      1/82
T                                          DERUJULA  80 COSM                      1/82
T                                          STECKER   80 COSM                      1/82
T                                          HENRY     81 COSM                      1/82
T                                          KIMBLE    81 COSM                      1/82
T                                          REPHAELI  81 COSM                     12/83*
T                                          TURNER    81 COSM                      1/82
T                                          KRAUSS    83 COSM                     12/83*

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                         6  POSSIBLE LIMITS ON NUMBER OF LIGHT (< ABOUT 1 MEV)
                            TWO-COMPONENT NU TYPES

N       NUMBER COUPLING WITH FULL WEAK STRENGTH
N                                          SHVARTSMA 69 COSM                      1/82
N             (7)    OR LESS               STEIGMAN  77 COSM                      1/82
N             (4)    OR LESS               YANG      79 COSM                      1/82
N    S      CRITICISM OF BOUND             STECKER2  80 COSM                      1/82
N           MAYBE NO FIRM BOUND            OLIVE     81 COSM                      1/82
N             (4)    OR LESS               TURNER    81 COSM                      1/82
N           CRITICISM OF BOUND             RANA      82 COSM                      1/82
N             (4)    OR LESS               SCHRAMM   82 COSM                      1/84*
N            (FROM 10 TO 1000) OR LESS     ELLIS     83      ASTROPHYS MODEL-DEP 12/83*
N             (4)    OR LESS               YANG      84 COSM                      1/84*
N    S  SEE, HOWEVER OLIVE2 81 CRITIQUE AND STECKER 81 REPLY.                     1/82
N       UNCERTAINTIES AND CRITICISMS COME FROM DIFFERING ESTIMATES OF LOWER       4/82
N       LIMIT ON BARYON DENSITY OF THE UNIVERSE AND UPPER LIMIT ON THE            4/82
N       PRIMORDIAL HELIUM-4 ABUNDANCE.  SEE ALSO BERNSTEIN 82.                    4/82

NSW     NUMBER COUPLING WITH LESS THAN FULL WEAK STRENGTH
NSW  A       (20)    OR LESS               STEIGMAN  79 COSM                      1/82
NSW  A  LIMIT VARIES WITH STRENGTH OF COUPLING.                                   4/82

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                         6  MAGNETIC MOMENT OF SUFFICIENTLY LIGHT NU
                                                        (UNITS EV/GAUSS)

MM   S      (4.9E-19)OR LESS               SUTHERLAN 76 COSM FOR M(NU)<10 KEV.    1/82
MM   S  USES SUTHERLAND 76 EQ.3 WITH F<1/3 FROM THEIR TABLE AS MODIFIED TO        1/82
MM   S  APPLY AS A LIMIT ON ANY ONE NEUTRINO SPECIES INDIVIDUALLY.                1/82

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                                   REFERENCES FOR NU BOUNDS FROM ASTRO. AND COSM.

SHVARTSM 69 JETPL 9 184        V. F. SHVARTSMAN                          (MOSU)
COWSIK   72 PRL 29 669         R.COWSIK,J.MC CLELLAND                     (UCB)
SUTHERLA 76 PR D13 2700        SUTHERLAND,NG,FLOWERS,+         (PENN+COLU+NYU)

COWSIK   77 PRL 39 784         R. COWSIK                            (MPIM+TIFR)
    ALSO 79 COWSIK
DICUS    77 PRL 39 168         D.A.DICUS,E.W.KOLB,V.L.TEPLITZ       (TEXA+VPI)
GOLDMAN  77 PR D16 2256        T.GOLDMAN, G.J.STEPHENSON                 (LASL)
LEE      77 PRL 39 165         B. W. LEE, S. WEINBERG               (FNAL+STAN)
SATO     77 PTP 58 1775        K.SATO,M.KOBAYASHI                        (KYOT)
STEIGMAN 77 PL 66B 202         G.STEIGMAN,D.SCHRAMM,J.GUNN (YALE,CHIC,CIT)
VYSOTSKY 77 JETPL 26 188       VYSOTSKY,DOLGOV,ZELDOVICH                 (ITEP)

DICUS    78 PR D17 1529        +KOLB,TEPLITZ,WAGONER           (TEXA+VPI+STAN)
FALK     78 PL 79B 511         S. FALK, D. SCHRAMM                       (CHIC)
    ALSO 78 APJ 223 1015       GUNN,LEE+             (CIT+CAMB+FNAL+CHIC+YALE)

COWSIK   79 PR D19 2219        R. COWSIK                                 (TIFR)
GOLDMAN  79 PR D19 2215        T.GOLDMAN,G.J.STEPHENSON                  (LASL)
HUT      79 PL 87B 144         P.HUT,K.A.OLIVE                 (AMSTERDAM+EFI)
STEIGMAN 79 PRL 43 239         G.STEIGMAN,K.OLIVE,D.SCHRAMM         (BART+EFI)
TREMAINE 79 PRL 42 407         S. TREMAINE, J. E. GUNN         (CIT+CAMB+CAIW)
YANG     79 APJ 227 697        YANG,SCHRAMM,STEIGMAN,ROOD (CHIC+YALE+VIRG)
    ALSO 79 STEIGMAN           FOOTNOTE 4

DERUJULA 80 PRL 45 942         A.DE RUJULA,S.L.GLASHOW              (MIT+HARV)
STECKER  80 PRL 45 1460        F.W.STECKER                               (NASA)
    ALSO 81 NU 81 CONF HAWAII  F.W.STECKER (PROC. V.1, P. 124)           (NASA)
STECKER2 80 PRL 44 1237        F.W.STECKER                               (NASA)
ZELDOVIC 80 SJNP 31 664        ZELDOVICH,KLYPIN,KHLOPOV,CHECHETKIN

BOND     81 NU 81 CONF HAWAII  J.R.BOND, A.S.SZALAY                 (UCB+CHIC)
DAVIS    81 APJ 250 423        M.DAVIS,M.LECAR,C.PRYOR,E.WITTEN(HARV+PRIN)
HENRY    81 PRL 47 618         R.C.HENRY, P.D.FELDMAN                     (JHU)
KIMBLE   81 PRL 46 80          R.KIMBLE,S.BOWYER,P.JAKOBSEN               (UCB)

OLIVE    81 APJ 246 557        +SCHRAMM,STEIGMAN,TURNER,YANG+  (CHIC+BART)
OLIVE2   81 PRL 46 516         K.A.OLIVE,M.S.TURNER                       (EFI)
REPHAELI 81 PL 106B 73         Y.REPHAELI,A.S.SZALAY                (UCSB+CHIC)
SCHRAMM  81 APJ 243 1          D. N. SCHRAMM, G. STEIGMAN           (CHIC+BART)
STECKER  81 PRL 46 517         F.W.STECKER                               (NASA)
TURNER   81 NU 81 CONF HAWAII  M.S.TURNER                           (UCSB+CHIC)

BERNSTEI 82 PRL 48 774         J.BERNSTEIN                               (STEV)
OLIVE    82 PR D25 213         K.A.OLIVE,M.S.TURNER                 (CHIC+UCSB)
RANA     82 PRL 48 209         N.C.RANA                                  (TIFR)
SCHRAMM  82 PRSL A307 43       D.N. SCHRAMM                              (CHIC)

ELLIS    83 NP B223 256        J.ELLIS,K.A.OLIVE                         (CERN)
FREESE   83 PR D27 1689        K.FREESE,E.W.KOLB,M.S.TURNER         (CHIC+LANL)
KRAUSS   83 PL 128B 37         L.M.KRAUSS                                (HARV)
PRIMACK  83 PHILADELPHIA       J.PRIMACK (4TH WKSHP. ON GRAND.UNIF.)(UCSC)
    ALSO 82 NAT 299 37         BLUMENTHAL,PAGELS,PRIMACK            (UCSC+ROCK)
YANG     84  APJ (TO BE PUBL)  +TURNER,STEIGMAN,SCHRAMM,OLIVE       (CHIC+BART)
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HEAVY LEPTON SEARCHES

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Data on the $\tau^{\pm}$ are listed in a separate section above, following the e and μ listings.

The following section contains information on searches for heavy leptons of other types and searches for the $\tau^{\pm}$ in collisions other than e^+e^-.

Several types of heavy leptons (that is, non-strongly-interacting fermions other than e and μ) have been proposed. In the Data Card Listings we distinguish four types.[1,2] Each has a corresponding antiparticle with opposite charge and lepton number. For convenience we omit writing the antiparticles in the following descriptions. The four types are:

Sequential leptons (L^-, ν_L). Such a pair is assumed to have its own separately strictly conserved lepton number $n_L = +1$. This means that the radiative decays

$$\left.\begin{array}{l} L^- \to e^-\gamma \\ L^- \to \mu^-\gamma \end{array}\right\} \text{ are forbidden },$$

while the weak decays (assuming m_{L^-} sufficiently large)

$$\left.\begin{array}{l} L^- \to \nu_L\, e^- \bar{\nu}_e \\ L^- \to \nu_L\, \mu^- \bar{\nu}_\mu \\ L^- \to \nu_L \text{ hadrons} \end{array}\right\} \text{ are allowed }.$$

There could be an increasing mass sequence of such pairs. It is frequently assumed that the neutrinos are massless.

Decay rates are assumed calculable from conventional weak interaction theory. For an L^- mass between 1 and 3 GeV, the branching fraction to each of the two leptonic modes above should be roughly 10 to 20%. For an L^- mass above 1 GeV, the mean life should be $\lesssim 10^{-12}$ seconds.

Paraleptons (E^+, E^0) *and* (M^+, M^0). These pairs have the same lepton numbers as the opposite-charge ordinary leptons, i.e., e^- and μ^-, respectively. Radiative decays are again forbidden and decays similar to those allowed for L^- are allowed here, e.g.,

$$M^+ \to \nu_\mu\, e^+ \nu_e$$

or

Stable Particles
HEAVY LEPTON SEARCHES

$$M^+ \rightarrow \nu_\mu \mu^+ \nu_\mu .$$

However, the lightest member is not stable as is the case for sequential leptons, so that bizarre decay schemes such as (assuming $m_{E^0} < m_{E^+}$)

$$E^+ \rightarrow E^0 \mu^+ \nu_\mu$$
$$\quad\ \ \llcorner\!\!\rightarrow e^- e^+ \nu_e$$

are allowed.

Heavy leptons of this type (and/or a neutral intermediate boson Z^0) are desired in unified gauge theories of weak and electromagnetic interactions to cancel unphysical high energy behavior in such processes as $e^+e^- \rightarrow W^+W^-$.[3]

Ortholeptons (F^- *and* N^-). These have the same lepton numbers as e^- and μ^-, respectively. They may or may not have associated neutral leptons. Radiative decays are allowed in addition to weak modes similar to those of sequential leptons. The radiative mode can dominate or can be relatively unimportant depending on the model.[4] Decays such as

$$F^- \rightarrow e^- + \text{hadrons}$$

are also allowed.

Long-lived penetrating particles. Heavy leptons could have long mean lives under certain circumstances. For example, if $m_{\nu_L} > m_{L^-}$, then L^-, the sequential lepton, is completely stable since its lepton number is conserved.

Experimental results. The results are summarized in the Data Card Listings below. Mass limits for sequential leptons are listed in subsection MS, while all other types are listed together in subsection M.

The Listings also contain cross-section upper limits reported as results of unsuccessful searches. We no longer list cross sections for anomalous $e\mu$ events in e^+e^- collisions. These cross sections are consistent with coming from $e^+e^- \rightarrow \tau^+\tau^-$ where the $\tau^\pm$ is assumed to be a spin-1/2 Dirac point particle with a mass about 1785 MeV.

References

1. M.L. Perl and P. Rapidis, SLAC-PUB-1496 (October 1974).
2. C.H. Llewellyn Smith, Invited paper presented at the Royal Society Meeting on New Particles and New Quantum Numbers, 11 March 1976, Oxford Ref. 33/76.
3. J.D. Bjorken and C.H. Llewellyn Smith, Phys. Rev. **D7**, 887 (1973).
4. F. Wilczek and A. Zee, Nucl. Phys. **B106**, 461 (1976).


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SEE PERL 81 FOR A REVIEW

PROPERTIES OF THE TAU+-(1785) HEAVY LEPTON AND ITS ASSOCIATED
NEUTRINO ARE LISTED SEPARATELY ABOVE FOLLOWING THE E AND MU
LISTINGS.  THE FOLLOWING SECTION CONTAINS INFORMATION ON SEARCHES
FOR HEAVY LEPTONS OF OTHER TYPES AND SEARCHES FOR TAU+- IN
COLLISIONS OTHER THAN E+E-.  WE LIST MASS LIMITS AND CROSS SECTION
UPPER LIMITS REPORTED AS NEGATIVE SEARCH RESULTS.  WE NO LONGER
LIST CROSS SECTIONS FOR THE ESTABLISHED PROCESS E+ E- --> TAU+ TAU-
AS WAS DONE IN OUR 1977 SUPPLEMENT.

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                  25  HEAVY LEPTON MASS LIMITS

       LIMITS APPLY ONLY TO HEAVY LEPTON TYPE GIVEN IN COMMENT AT RIGHT ON  3/77
       DATA CARD.  SEE REVIEW ABOVE FOR DESCRIPTION OF TYPES.               3/77
       IN COMMENTS BELOW, ALL BEAMS ARE MU TYPE NEUTRINO OR ANTINEUTRINO.   3/77
       L,E,M,F,N STAND FOR SEQUENTIAL LEPTON,PARA-ELECTRON,PARA-MUON,       3/77
       ORTHO-ELECTRON,ORTHO-MUON RESPECTIVELY.                              3/77

MS    SEQUENTIAL HEAVY LEPTON MASS LIMITS (GEV)
MS  A     (13.)   OR MORE            AZIMOV    80      +- SEQUENTIAL (L)   2/82
MS  B      16.    OR MORE  CL=.95    BARBER    80 CNTR +- SEQUENTIAL (L)   9/81
MS  C  NONE 4GEV TO 14.5GEV CL=.95   BERGER    81 PLUT +- SEQUENTIAL (L)   1/82
MS  D  NONE BELOW 15.5 GEV  CL=.95   BRANDELIK 81 TASS +- SEQUENTIAL (L)   1/82
MS     NONE BELOW 14 GEV    CL=.95   ADEVA     82 MRKJ +- SEQUENTIAL (L)   1/84*
MS  E  NONE BELOW 18 GEV             ADEVA     83 MRKJ +- SEQUENTIAL (L)  11/83*
MS  F  NONE BELOW 18.0 GEV  CL=.95   BARTEL    83 JADE +- SEQUENTIAL (L)  11/83*
MS
MS  A  AZIMOV 80 ESTIMATED PROBABILITIES FOR M+N TYPE EVENTS IN E+ E- -->  2/82
MS  A  L+ L- DEDUCING SEMI-HADRONIC DECAY MULTIPLICITIES OF L FROM E+ E-   2/82
MS  A  ANNIHILATION DATA AT WCM=(2/3)*ML. OBTAINED ABOVE LIMIT COMPARING   2/82
MS  A  THESE WITH E+E- DATA (BRANDELIK 80,PL 92B 199).                     2/82
MS
MS  B  BARBER 80 LOOKED FOR E+ E- --> L+ L-, L-->NEU(L)+X WITH MARK-J AT   9/81
MS  B  DESY-PETRA.                                                         9/81
MS
MS  C  BERGER 81 IS DESY DORIS AND PETRA EXPT. LOOKING FOR E+E- --> L+L-.  1/82
MS
MS  D  BRANDELIK 81 IS DESY PETRA EXPT. LOOKING FOR E+E- --> L+L-.         1/82
MS
MS  E  ADEVA 83 LOOKED FOR MUON OPPOSITE AGAINST A HADRON JET.            11/83*
MS
MS  F  BARTEL 83 LIMIT IS FROM PETRA E+E- EXP WITH AVERAGE WCM=34.2 GEV.  11/83*


M     HEAVY LEPTON MASS LIMITS (GEV)
M   A   0     1.0    OR MORE            BEHREND   65 SPEC -  ORTHOELECTRON(F)  6/77
M   B  NONE BETWEEN 0.12 AND 0.57       BETOURNE  65 SPEC -  ORTHOELECTRON(F)  6/77
M   C  NONE BETWEEN 0.3  AND 0.7        BUDNITZ   66 SPEC -  ORTHOELECTRON(F)  6/77
M   D  NONE BETWEEN 0.2  AND 0.92       BARNA     68 CNTR -  LONG-LIVED        6/77
M   D  NONE BETWEEN 0.97 AND 1.03       BARNA     68 CNTR -  LONG-LIVED        6/77
M   E  NONE BETWEEN 0.1  AND 1.3        BOLEY     68 SPEC -  ORTHOELECTRON(F)  6/77
M   F  NONE BETWEEN 0.2  AND 0.6        LIBERMAN  69 OSPK -  ORTHOMUON(N)      6/77
M   G        0.490 OR MORE              ROTHE     69 RVUE                      6/77
M   H  NONE BETWEEN 0.26 AND 1.32       LICHTENST 70 SPEC -  ORTHOELECTRON(F)  6/77
M   I  20    (0.424)  (0.013)  (0.002)RAMM      70 HLBC 0                      6/77
M   I  22    (0.431)  (0.004)           RAMM      71 HLBC -  ORTHOMUON(N)      6/77
M   J   0     0.1    OR MORE            ANSORGE   73 HBC  -  LONG-LIVED        6/77
M   K   0     0.6    OR MORE            BACCI     73 ELEC +- ORTHOELECTRON(F)  1/76
M   K   0     2.2    OR MORE            BACCI     73 ELEC +- ORTHOELECTRON(F)  1/76
M   L   0     2.0    OR MORE  CL=.90    BARISH    73 ASPK +  PARAMUON (M)      2/74
M   M   0     1.4    OR MORE  CL=.95    BERNARDIN 73 ASPK +- ANY NON-RAD TYPE  2/74
M   M   0     1.0    OR MORE  CL=.95    BERNARDIN 73 ASPK +- ANY NON-RAD TYPE  2/74
M   N  NONE BETWEEN 0.55 AND 4.5        BUSHNIN   73 CNTR -  LONG-LIVED        2/74
M   O   0     2.4    OR MORE  CL=.90    EICHTEN   73 HLBC +  PARAMUON (M)      3/74
M   P         7.8    OR MORE  CL=.95    HANSON    73 WIRE    ORTHOELECTRON(F)  6/77
M   Q         1.8    OR MORE  CL=.90    ASRATYAN  74 HLBC +- ORTHOMUON (N)    11/75
M   R         8.4    OR MORE  CL=.90    BARISH    74 SPEC +  PARAMUON (M)      7/74
M   S   NONE BETWEEN 0 AND 2.0          GITTLESON 74 SPEC    ORTHOMUON (N)    12/77
M   T   0     1.15   OR MORE  CL=.95    ORITO     74 ASPK +- ANY NON-RAD TYPE 11/75
M   U   NONE BETWEEN 0.25 AND 2.3       BACCI     77 SPEC +- ORTHOELECTRON(F) 12/77
M   V         1.2    OR MORE            MEYER     77 SMAG 0  NEUTRAL          12/77
M   W        10.3    OR MORE  CL=.98    ASRATYAN  78      -  ORTHOMUON (N)     1/79
M   X   0     7.5    OR MORE            CNOPS     78 HLBC -  ORTHOMUON (N)     8/78
M   X   0     9.0    OR MORE            CNOPS     78 HLBC +  PARAMUON (M)      8/78
M   Y        10.0    OR MORE            ERRIQUEZ  78 BEBC                      1/79
M   Z        12.     OR MORE  CL=.90    HOLDER    78 CNTR +  PARAMUON (M)      6/78
M   1  NONE 1 GEV TO 9 GEV    CL=.90    CLARK     81 SPEC 0  PARAMUON(MOBAR)   1/82
M   1  NONE 1 GEV TO 9 GEV    CL=.90    CLARK     81 SPEC ++                   1/82
M   2  NONE BETWEEN 0.6 AND 3.3         HAYES     82 SMK2 +- ORTHOMUON (N)     4/82
M   2  NONE BETWEEN 0.5 AND 3.3         HAYES     82 SMK2 +- ORTHOELECTRON(F)  4/82
M   3        24.5    OR MORE  CL=.95    BARTEL    83 JADE 0  PARAELECTRON(E0) 11/83*
M   3        22.5    OR MORE  CL=.95    BARTEL    83 JADE 0  PARAELECTRON(E0) 11/83*
M
M   A  BEHREND 65 IS DESY EXPT. LOOKS FOR E P-->F P, F--> E GAMMA.          6/77
M   A  THIS MASS LIMIT CORRESPONDS TO A LIMIT ON LAMBDA**2 OF 6.25*10**-4.  6/77
M
M   B  BETOURNE 65 IS ORSAY EXPT. LOOKS FOR E P -->F P. MASS OF .12         6/77
M   B  CORRESPONDS TO COUPLING CONSTANT LAMBDA**2 GT .0016, MASS OF .57     6/77
M   B  TO LAMBDA**2 GT .22.                                                 6/77
M
M   C  BUDNITZ 66 IS CEA EXPT. LOOKS FOR E P-->F P.                         6/77
M
M   D  BARNA 68 IS SLAC PHOTOPRODUCTION EXPT.                               6/77
M
M   E  BOLEY 68 IS CEA EXPT. LOOKS FOR E P-->F P. MASS OF .1 CORRESPONDS    6/77
M   E  TO COUPLING CONSTANT LAMBDA**2 GT 3*10**-4, MASS LIMIT OF 1.3 TO     6/77
M   E  LAMBDA**2 GT .01.                                                    6/77
M
M   F  LIBERMAN 69 IS A BNL EXPT MEASURING MUON BREMSSTRAHLUNG.             6/77
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Stable Particles

Data Card Listings

HEAVY LEPTON SEARCHES

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M    G  ROTHE 69 EXAMINES PREVIOUS DATA ON MU PAIR PROD AND PI AND K DECAYS  6/77
M
M    H  LICHTENSTEIN 70 IS CORNELL EXPT MEASURING E BREMSSTRAHLUNG.         6/77
M    H  MASS LIMIT DEPENDS ON COUPLING CONSTANT. FIRST VALUE ABOVE IS FOR   6/77
M    H  LAMBDA**2 GT .17, SECOND IS FOR LAMBDA**2 GT .42.                   6/77
M
M    I  RAMM 70 FINDS PEAK IN MU PI COMBINED MASS PRODUCED BY NEUTRINO      6/77
M    I  INTERACTIONS. HE ALSO CLAIMS EVIDENCE FOR THIS IN KOMU3 DECAYS IN   6/77
M    I  HBC WHERE PI MU COMBINED MASS PEAKS IN SAME REGION. CLARK 72 FINDS  6/77
M    I  NO EVIDENCE FOR PI MU PEAK IN HIGH STATISTICS KL3 EXPT.             6/77
M    I  RAMM 71 SEES PEAK IN MU GAMMA COMBINED MASS PRODUCED BY NEUTRINOS.  6/77
M
M    J  ANSORGE 73 LOOKS FOR ELECTRON PAIR PROD AND ELECTRON-LIKE BREMSS.   6/77
M
M    K  BACCI 73 IS FRASCATI E+E- EXPT. LOOKS FOR F --> E GAMMA.            1/76
M    K  MASS LIMIT DEPENDS ON COUPLING CONSTANT LAMBDA FOR THIS DECAY.      1/76
M    K  FIRST VALUE ABOVE IS FOR LAMBDA**2 GT 9*10**-5, 2ND IS FOR          1/76
M    K  LAMBDA**2 GT 10**-3.                                                1/76
M
M    L  BARISH 73 IS FNAL 50,145 GEV NEU EXPT.  LOOKS FOR (NEU NUCLEON -->  3/77
M    L  M+ ANYTHING). ASSUMES (M+ --> MU+ NEU NEU) WITH BR=.3.              3/77
M
M    M  BERNARDINI 73 IS FRASCATI E+E- EXPT. FIRST VALUE ASSUMES UNIVERSAL  2/74
M    M  COUPLING TO ORDINARY LEPTONS.  SECOND VALUE ALSO ASSUMES COUPLING   2/74
M    M  TO HADRONS.                                                         2/74
M
M    N  BUSHNIN 73 IS SERPUKOV 70 GEV P EXPT. MASSES ASSUME MEAN LIFE ABOVE 2/74
M    N  7E-10 AND 3E-8 RESPECTIVELY. CALCULATED FROM CROSS SEC(DC BELOW)    2/74
M    N  AND 30 GEV MUON PAIR PRODUCTION DATA.                               2/74
M
M    O  EICHTEN 73 IS CERN 1-10GEV NEU EXPT. LOOKS FOR M+ PRODUCED IN       2/76
M    O  NEU NUCL --> M+ HADRONS ASSUMING 15 PERCENT DECAY TO E+ NEU NEU.    2/76
M
M    P  HANSON 73 LOOK FOR DEVIATIONS FROM QED IN E+ E- -->2 GAMMA. THEY    6/77
M    P  MEASURE THE PRODUCT OF THE F MASS * THE COUPLING CONSTANT LAMBDA,   6/77
M    P  WHICH IS THE VALUE QUOTED ABOVE.                                    6/77
M
M    Q  ASRATYAN 74 USES EICHTEN 73 DATA ON NEU NUCL --> E- HADRONS AND     2/76
M    Q  ANTINEU NUCL --> E+ HADRONS TO SET LIMITS ON ORTHOMUON PRODUCTION.  2/76
M
M    R  BARISH 74 IS FNAL 50,135 GEV NEU EXPT.  LOOKS FOR (NEU NUCLEON -->  7/74
M    R  M+ ANYTHING).  ASSUMES (M+ -->MU+ NEU NEU) WITH BR=.3.              7/74
M
M    S  GITTLESON 74 IS MU P --> P ORTHOMUON SEARCH. COUPLING CONSTANT     12/77
M    S  LAMBDA**2 IS <.01 FOR MASS UP TO .7 GEV, LIMIT ON LAMBDA**2 RISES  12/77
M    S  TO <.1 FOR MASS OF 2.0 GEV.                                        12/77
M
M    T  ORITO 74 LOOKED FOR H+H- PAIRS GIVING MU-E PAIRS. MASS LIMIT REFERS 3/74
M    T  TO ANY NON-RADIATIVE TYPE HEAVY LEPTON -- L, E, M, F, N.            3/74
M    T  COUPLING TO HADRON ASSUMED FROM THEORETICAL MODELS.                 3/74
M
M    U  BACCI 77 IS SAME TYPE AS BACCI 73. LOWER MASS LIMIT CORRESPONDS TO 12/77
M    U  LAMBDA**2 LIMIT OF 4*10**-5, UPPER VALUE IS FOR LAMBDA**2 LIMIT OF 12/77
M    U  1.5*10**-3.                                                        12/77
M
M    V  MEYER 77 LOOKS FOR NARROW NEUTRAL RESONANCE IN(E PI)AND(MU PI)     12/77
M    V  CHANNELS PRODUCED BY E+E- AT 6.8 GEV (ECM). ASSUMED TO BE DECAY    12/77
M    V  PRODUCT OF THE TAU. SEE SECTION NE BELOW.
M
M    W  ASRATYAN 78 ANALYZES DEPENDENCE OF N.C./C.C. ON ENERGY OF ASSOC.    1/79
M    W  HADRONS. USES DATA OF HOLDER 77 (PL 72B, 254)--NUMU INTERACTIONS    1/79
M    W  AT CERN-SPS.                                                        1/79
M
M    X  CNOPS 78 IS FNAL EXPT LOOKING FOR NEUMU NE --> L+(-), FOLLOWD BY    8/78
M    X  L+(-) --> E+(-) NEU NEU.                                            3/78
M
M    Y  ERRIQUEZ 78 IS CERN SPS EXPT. LOOKS FOR NUMU NUCLEON-->MU- E+ X.    1/79
M    Y  FINDS CS FOR PRODUCING HVY LEPT--> E+ <.7*10**-3 *C.C. CS.          1/79
M
M    Z  HOLDER 78 IS A CERN NEU EXPT LOOKING FOR NEUMU NUCLEON --> MU+ ANY  6/78
M    Z  THING. ASSUMES M+ --> MU+ 2NEUMU WITH BR=0.2 .                      6/78
M
M    1  CLARK 81 IS FNAL EXP WITH 209 GEV MUONS. BOUNDS APPLY TO MO WHICH   1/82
M    1  COUPLES WITH FULL WEAK STRENGTH TO MUON. SEE ALSO SECTION MU.       1/82
M
M    2  HAYES 82 IS SLAC SPEAR EXPT.  THEIR TBL.5,6 GIVES CROSS SEC. LIMITS 4/82
M    2  FOR ORTHOMUON AND ORTHOELECTRON FOR MASSES IN ABOVE RANGE.          4/82
M
M    3  BARTEL 83 IS PETRA E+E- EXP WITH AVERAGE WCM=34.2 GEV.FIRST(SECOND) 11/83*
M    3  LIMIT IS FOR V+A(V-A) TYPE W-EO-E COUPLING.                        11/83*
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NEU     HEAVY LEPTON LIMITS (NEUTRINO NUCLEON)
NEU     SEE ALSO SECTION 'T' IN 'OTHER NEW PARTICLE SEARCHES'.
NEU  A   6 TRIMUON EVENTS               BENVENU1  77 NEUL      5/6NEU,1/6NEUBAR  1/78
NEU  A  10 MU+ MU-, 3 MU- MU- EVENTS    BENVENU2  77 NEUL                        1/78
NEU  B                                  BOSETTI   78 HYBR                        6/78
NEU
NEU  A  BENVENUT1 77 IS FNAL EXPT.AND CLAIMS TRIMUON EVTS. INDICATE BY PROD  7/77
NEU  A  OF A NEW HEAVY LEPTON -->MU- NEUBAR NEW LIGHTER LEPTON --> MU+ MU-   7/77
NEU  A  NEUTRINO. SEE ALSO BENVENUT2 77, ALBRIGHT 77 AND BARGER 77 FOR       7/77
NEU  A  FURTHER ANALYSIS.  THIS CLAIM WAS REFUTED BY LATER EXPS. AT CERN     7/77
NEU  A  (HOLDER 78)  AND FNAL (CNOPS 78), AND BY THEORETICAL ANALYSIS OF     7/77
NEU  A  OF COMBINED DATA - SEE SMITH 78.                                     7/77
NEU
NEU  B  BOSETTI 78 ANALYSES MOMENTA OF MUONS FROM DIMUON EVENTS USING        6/78
NEU  B  200 GEV NARROW BAND NEU BEAM AT CERN. FINDS (NEUMU P --> HVY-LEPT)/  6/78
NEU  B  (NEUMU P --> MU) < 0.06 (90 PCNT CL) WHERE HVY-LEPT --> E- NU(E)     6/78
NEU  B  NU(HVY-LEPT) 15 PCNT OF THE TIME.                                    6/78
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MU      HEAVY LEPTON PRODUCTION CROSS SECTION (MU NUCLEON) (CM**2)           10/81
MU      SEE ALSO SECT 'MU' IN CHARM SEARCHES AND OTHER NEW PARTICLE SEARCHES 10/81
MU   A     1.22E-34 OR LESS             LEBRITTON 80 SPEC    MO-->MU+ MU- NU 12/81
MU   B   0  4. E-38 OR LESS             CLARK     81 SPEC 0  PARAMUON(MOBAR)  1/82
MU   B   0  6. E-38 OR LESS             CLARK     81 SPEC ++                  1/82
MU
MU   A  LEBRITTON 80 IS BNL EXP WITH 10.5GEV MUONS. TRIMUONS ARE CONSISTENT 12/81
MU   A  WITH QED TRIDENT AND DIFFRACTIVELY PRODUCED RHO DECAY.              12/81
MU
MU   B  CLARK 81 IS FNAL EXP WITH 209 GEV MUON. LOOKED FOR MU+ N-->MOBAR X,  1/82
MU   B  MOBAR-->MU+ MU- ANTINEU(MU) AND MU+ N-->M++ X,M++-->2MU+ NEU(MU).    1/82
MU   B  ABOVE LIMITS ARE FOR CS*BR TAKEN FROM THEIR MASS-DEP PLOT FIG.2.     1/82
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DC      HEAVY LEPTON PRODUCTION DIFF. CROSS SEC. (P NUCLEON) (CM**2/SR-GEV)
DC   A   0  1.6E-37 OR LESS  CL=.90   GOLOVKIN  72 CNTR- 70GEV P, SERPUKHOV  1/76
DC   B   0  4. E-38 OR LESS  CL=.90   BUSHNIN   73 CNTR- 70GEV P, SERPUKHOV  2/74
DC
DC   A  MASS RANGE 1 TO 4.5 GEV,THETA=0,P=25 GEV/C.                          1/76
DC
DC   B  BUSHNIN 73 HEAVY LEPTON PATH TRAVERSES 6800 GM/CM**2 ABSORBER.       2/74
DC   B  DIFFERENTIAL CROSS-SECTION MEASURED AT P=30 GEV/C THETA= 2 MRAD.     3/74
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TBD     TAU LEPTON PRODUCTION CROSS SECTIONS IN HADRONIC COLLISIONS (CM**2)  2/82
TBD  A       1.8E-30 OR LESS  CL=.90   AGAKISHIE 80 SPRK 70GEV P FE BM DUMP  2/82
TBD
TBD  A  AGAKISHIEV 80 REANALYZED BEAM DUMP DATA (ASRATYAN 78 PL 79B 497).    2/82
TBD  A  FOUND NO EXCESS OF MUONLESS EVENT IN NEUTRINO DETECTOR. ABOVE LIMIT  2/82
TBD  A  IS FOR CS(P NUC-->F X)*BR(F-->TAU NUTAU X) ASSUMING LINEAR A DEP     2/82
TBD  A  AND THAT SOLE SOURCE OF TAU LEPTON IS DECAY OF F-MESON.              2/82
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BD      PRODUCTION OF HEAVY LEPTON IN BEAM DUMP                              1/83*
BD   A                                 LOSECCO   81 CALO     28 GEV PROTONS  1/83*
BD   A  LOSECCO 81 AT BNL AGS SET LIMIT FOR CS(PROD)*CS(INT) RATIO OF        1/83*
BD   A  SLOW (BETA<0.89) HEAVY LEPTONS TO PROMPT NEUS AS 2.2E-2(CL=.90).     1/83*
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IC      INVARIANT HEAVY LEPTON PROD. CROSS SEC. (P NUCLEON) (CM**2/GEV**2)
IC   A   0  5.4E-39 OR LESS  CL=.90   CRONIN    74 SPEC -  M=1-6.8 GEV       1/76
IC   B   0  6.4E-35 OR LESS  CL=.90   BINTINGER 75 SPEC +- M=1-5 GEV         2/76
IC   C   0  1.8E-33 OR LESS  CL=.90   ARMITAGE  79 SPEC    M=1.87 GEV        7/79
IC
IC   A  CRONIN 74 IS AN FNAL 300 GEV P CU EXPT.  LOOKED FOR LONG LIVED       2/76
IC   A  PENETRATING PARTICLES.  ABOVE LIMIT ASSUMES STABLE.  MULTIPLY IT BY  2/76
IC   A  EXP(1.22E-8*M/TAU) FOR MASS M(GEV) AND LIFETIME TAU(SEC). LIMIT      2/76
IC   A  OBTAINED AT THETA(LAB) = 77 MRAD, PT = 2.38 GEV/C.                   4/77
IC
IC   B  BINTINGER 75 IS A 30-300 GEV P C EXPT.  LOOKED FOR LONG LIVED        2/76
IC   B  PENETRATING PARTICLES.  ABOVE LIMIT ASSUMES STABLE.  MULTIPLY IT BY  2/76
IC   B  EXP(3.5E-8*M/TAU/P) FOR MASS M(GEV), LIFETIME TAU(SEC), MOM.P(GEV).  2/76
IC   B  OBTAINED AT THETA(LAB) = 91 MRAD, PT = 1-2.25 GEV/C.                 4/77
IC
IC   C  ARMITAGE 79 IS CERN-ISR EXPT AT ECM=53 GEV.  VALUE IS FOR X=0.1 AND  7/79
IC   C  PT=.15.                                                              7/79
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RPI     HEAVY LEPTON PROD. CROSS SECTION ( CS(HVY LEP) / CS(PION) )         12/81
RPI  A   0  7. E-12 OR LESS  CL=.95   BUSSIERE  80 CNTR Q= -1   M=4-4.5 GEV 12/81
RPI  A   0  2.5E-12 OR LESS  CL=.95   BUSSIERE  80 CNTR Q= -2   M=5-7.5 GEV 12/81
RPI
RPI  A  BUSSIERE 80 IS CERN-SPS EXPT WITH 200-240 GEV PROTONS ON BE AND AL  12/81
RPI  A  TARGET SEARCHING FOR LONG-LIVED PARTICLES.  FOR LIMITS AT OTHER     12/81
RPI  A  MASS RANGES SEE THEIR FIG. 7.                                       12/81
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CN      NEUTRAL HEAVY LEPTON PRODUCTION CROSS SECTION  (CM**2)
CN   A   5 (1. E-37 OR MORE)          KRISHNASW 75 CNTR +0-  M=2-5 GEV       2/76
CN   B   0                            BENVENUTI 75 SPEC  0                   2/76
CN
CN   A  KRISHNASWAMY 75 IS KOLAR GOLD MINE COSMIC RAY EXPT.  TYPICAL EVENT   2/76
CN   A  HAS VERTEX IN AIR 70 CM FROM WALL WITH THREE OBSERVED CHARGED        2/76
CN   A  TRACKS.  AUTHORS SUGGEST NEU+ROCK GIVES NEW PARTICLE WITH MEAN LIFE  2/76
CN   A  10E-9 SEC OR LONGER.  DE RUJULA 75 GIVES ANOTHER INTERPRETATION.     2/76
CN   A  SEE ALSO RAJASEKARAN 75.                                             8/76
CN
CN   B  BENVENUTI 75 IS AN FNAL EXPERIMENT WHICH ROUGHLY SIMULATES THE       2/76
CN   B  KRISHNASWAMY 75 EXPT. BUT APPARENTLY CONTRADICTS IT, FINDING NO      2/76
CN   B  EVENTS. SENSITIVE TO DECAYS OF NEUTRAL PENETRATING PARTICLES         3/77
CN   B  PRODUCED BY THE PRIMARY PROTONS OR BY SECONDARY NEUTRINO             3/77
CN   B  INTERACTIONS IN THE 1 KM. NEUTRINO BEAM EARTH SHIELD.                3/77
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N       NEUTRAL HEAVY LEPTON PRODUCED IN NEUTRINO INTERACTIONS
N    A   1      POSSIBLY SEEN         BARANOV   77 HLBC  0 SERPUKHOV        12/77
N    A   2      POSSIBLY SEEN         BARANOV   79 HLBC  0 SERPUKHOV         1/82
N
N    A  BARANOV HEAVY LEPTON CLAIM REFUTED BY BALTAY 78.                     1/82
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MM      UNEXPLAINED MISSING NEUTRAL (HEAVY LEPTON?) MOMENTUM /TOTAL MOMENTUM
MM   A        0.05       0.03          ELLIOT    77 CALO                     1/78
MM
MM   A  ELLIOT 77 IS SLAC 10.5 GEV PI+ P --> P NPI+- NEUTRALS.  FINDS THAT   1/78
MM   A  NEUTRAL SPECTRUM CAN BE EXPLAINED BY GAMMA, KO, LAMBDA, NEUTRON.     1/78
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CP      NEUTRAL HEAVY LEPTON PROD. CROSS SEC. (PROTON NUCLEON) (CM**2)
CP   A   0  1. E-29 OR LESS           FAISSNER  76 HLBC 0                    1/77
CP   B   0  2.8E-35 OR LESS  CL=.90   BECHIS    78 SPEC  0                   8/78
CP   C   0  8.2E-40 OR LESS  CL=.90   AGAKISHIE 80 SPRK 0 M=4GEV,TAU=E-7 S   2/82
CP
CP   A  FAISSNER 76 LIMIT ASSUMES STABLE NEUTRAL WEAKLY INTERACTING LEPTON.  1/77
CP   A  ALSO RULES OUT DE RUJULA 75 INTERP. OF 5 KRISHNASWAMY 75 EVENTS AS   1/77
CP   A  (P NUCLEON --> L+ X, L+ --> LO X) UNLESS L+ MASS IS ABOVE 3 GEV.     1/77
CP
CP   B  BECHIS 78 IS 400 GEV FNAL EXPT. LOOKS FOR P NUCLEON --> L+,          8/78
CP   B  L+ --> LO X, LO --> MU PI OR E PI. RESULT IS CL=.90 FOR MASS OF LO   8/78
CP   B  < 1 GEV, LIFETIME BETW 10**-10 AND 10**-8 SEC.(VALID ONLY FOR CASES  8/78
CP   B  WHEN LO UNACCOMPANIED BY MUON OF P>10 GEV.)                          8/78
CP
CP   C  AGAKISHIEV 80 REANALYZED BEAM DUMP DATA FROM 70 GEV PROTON ON IRON   2/82
CP   C  (ASRATYAN 78 PL 79B,497). ASSUMED DRELL-YAN PROD OF CHGD HVY LEPTON  2/82
CP   C  PAIR FOLLOWED BY DECAY INTO NEUTRAL HVY LEPTON. ABOVE VALUE IS WHEN  2/82
CP   C  LIMIT IS MOST STRINGENT. FOR OTHER MASS AND LIFE,SEE THEIR TABLE 1,  2/82
CP   C  AND FOR LIMIT DEDUCED FOR PI NUCLEON INTERACTION,SEE THEIR TABLE 2.  2/82
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NE      NEUTRAL HEAVY LEPTON PROD. CROSS SECTION (E+ E-)  (CM**2)           12/77
NE   A       4.5E-36 OR LESS  CL=.90   MEYER     77 SMAG E+E- 6.8 GEV (ECM) 12/77
NE
NE   A  MEYER 77 EXPT LOOKS FOR NARROW NEUTRAL RESONANCE IN E-PI AND MU-PI  12/77
NE   A  CHANNELS. VALUE GIVEN IS FOR MASS OF .5 GEV, AND IS PRODUCT OF CS*  12/77
NE   A  BR(TAU--> NEW NEUTRAL LEPTON)*BR(NEUTRAL LEPTON--> E OR MU PI). IF  12/77
NE   A  MASS OF NEUTRAL LEPTON IS 1.5 GEV, LIMIT BECOMES 2.5E-36. SEE S25M. 12/77
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TNU     LIMIT ON NU(TAU) PRODUCTION IN BEAM DUMP EXPERIMENT                  1/82
TNU  A                                 FRITZE    80 HYBR                     1/82
TNU
TNU  A  FRITZE 80 IS CERN SPS EXP WITH BEBC. NC/CC RATIO CORRESPONDS TO      1/82
TNU  A  R=(PROMPT-NU(TAU)-INDUCED EVENTS)/(ALL PROMPT-NU EVENTS) <0.1.       1/82
TNU  A  MIXING PROBABILITY P(NU(E)-->NU(TAU)) < 0.35 AT CL=.90.              1/82
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EXC     LIMITS ON EXCITED ELECTRONS(E*) AND MUONS(MU*)
EXC  A  NONE BELOW 58 GEV    CL=.95   ADEVA     82 MRKJ    E* PROD IN E+E-    1/84*
EXC  A  NONE BELOW 10 GEV    CL=.95   ADEVA     82 MRKJ    MU* PROD IN E+E-   1/84*
EXC  B                                BUKIN     82         E* PROD IN E+E-    1/84*
EXC  C                                RENARD    82         G-2 OF E*,MU*     11/83*
EXC  D                                FORD      83 MAC     MU* PROD IN E+E-  11/83*
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For notation, see key at front of Listings.

Stable Particles

HEAVY LEPTON SEARCHES, $\pi^{\pm}$

EXC	A	BERGSMA 83 M(E*) LIMIT ASSUMES E* COUPLING EQUALS TO THAT OF E.	1/84*
EXC	A	SEE THEIR FIG.2 FOR DEPENDENCE ON THE COUPLING.	1/84*
EXC			
EXC	B	BUKIN 82 IS VEPP-2M RING EXP FOR E+E- -->E+ E- GAMMA WITH WCM=0.64-	1/84*
EXC	B	1.4 GEV. OBSERVED NO PEAK IN M(E GAM) SPECTRUM. SET CL=.95 LIMIT	1/84*
EXC	B	CS(E*+E-)/CS(E+E-) < (0.2-6)*10**-4 FOR M(E*)=0.2-1.0 GEV.	1/84*
EXC			
EXC	C	RENARD 82 DERIVED FROM G-2 DATA LIMITS ON MASS AND COUPLINGS OF E*	11/83*
EXC	C	AND MU*. SEE FIGS.2 AND 3 OF THE PAPER.	11/83*
EXC			
EXC	D	FORD 83 AT PEP-MAC (WCM=29 GEV) SET CL=.90 LIMITS	11/83*
EXC	D	CS(MU*MU*)/CS(MU+MU-) < (1-2)*10**-3 FOR M(MU*)=2-14 GEV, AND	11/83*
EXC	D	CS(MU* MU)/CS(MU+MU-) < (1-2)*10**-3 FOR M(MU*)=2.5-27 GEV.	11/83*

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REFERENCES FOR HEAVY LEPTON SEARCHES

BEHREND 65 PRL 15 900 +BRASSE,ENGLER,GANSSAUGE+ (DESY+KARL)
BETOURNE 65 PL 17 70 +NGUYEN NGOC,PEREZ Y JORBA+ (ORSA)
BUDNITZ 66 PR 141 1313 +DUNNING,GOITEIN,RAMSEY,WALKER,WILSON(HARV)
BARNA 68 PR 173 1391 +COX,MARTIN,PERL,TAN,TONER,ZIPF+(SLAC+STAN)
BOLEY 68 PR 167 1275 +ELIAS,FRIEDMAN,HARTMANN,KENDALL+ (MIT+CEA)

LIBERMAN 69 PRL 22 663 +HOFFMAN,ENGELS,IMRIE+(HARV+CASE+MCGI+SLAC)
ROTHE 69 NP B10 241 K.W.ROTHE,A.M.WOLSKY (PENN)
LICHTENS 70 PR D1 825 LICHTENSTEIN,ASH,BERKELMAN,HARTILL+ (CORN)
RAMM 70 NATURE 227 1323 C.A.RAMM (CERN)
ALSO 72 NATURE 237 388 CLARK,ELIOFF,FIELD,FRISCH,JOHNSON+ (LBL)

RAMM 71 NAT.PH.SC.230 145 C.A.RAMM (CERN)
GOLOVKIN 72 PL 42B 136 +GRACHEV,KHODYREV,KUBAROVSKY+ (SERP)
ANSORGE 73 PR D7 26 +BAKER,KRZESINSKI,NEALE,RUSHBROOKE+ (CAVE)
BACCI 73 PL 44B 530 +PARISI,PENSO,SALVINI,STELLA+ (ROMA+FRAS)
BARISH 73 PRL 31 410 +BARTLETT,BUCHHOLZ,HUMPHREY+ (CIT+FNAL)

BERNARDI 73 NC 17A 383 BERNARDINI,BOLLINI,BRUNINI+(CERN+BGNA+FRAS)
ALSO 70 LNC 4 1156 ALLES-BORELLI,BERNARDINI,BOLLINI+ (CERN)
BUSHNIN 73 NP B58 476 +DUNAYTZEV,GOLOVKIN,KUBAROVSKY + (SERP)
ALSO 72 PL 42B 136 GOLOVKIN,GRACHEV,SHODYREV + (SERP)
EICHTEN 73 PL 46B 281 +DEDEN+(AACH+BELG+CERN+EPOL+MILA+LALO+LOUC)
HANSON 73 NCL 7 587 +LEONG,NEWMAN,LAW,LITKE+(MIT+HARV+CEA+HAIF)

ASRATYAN 74 PL 49B 488 +GERSHTEIN,KAFTANOV,KUBANTZEV,LAPIN+ (SERP)
BARISH 74 PRL 32 1387 +BARTLETT,BUCHHOLZ,MERRITT + (CIT+FNAL)
CRONIN 74 PR D10 3093 +FRISCH,SHOCHET,BOYMOND,MERMOD + (EFI+PRIN)
GITTLESO 74 PR D10 1379 GITTLESON,KIRK+ (HARV+ROCH+COLU+FNAL)
ORITO 74 PL 48B 165 +VISENTIN,CERADINI,CONVERSI + (FRAS+ROMA)

BENVENUT 75 PRL 35 1486 BENVENUTI,CLINE,FORD+ (HARV+PENN+WISC+FNAL)
BINTINGE 75 PRL 34 982 BINTINGER,CURRY+ (EFI+HARV+PENN+WISC)
BACCI 77 PL 71B 227 +DEZORZI,PENSO,STELLA+ (ROMA+FRAS)
KRISHNAS 75 PL 57B 105 KRISHNASWAMY,MENON+ (BOMBAY+OSAKA)
ALSO 75 PRL 35 628 DE RUJULA,GEORGI,GLASHOW (HARV)
ALSO 75 PRAMANA 5 78 RAJASEKARAN,SARMA (TIFR)

FAISSNER 76 PL 60B 401 +HASERT+(AACH+BELG+CERN+EPOL+MILA+OXF+LOUC)
BARANOV 77 PL 70B 269 +VOLKOV,GERSHTEIN,IVANILOV + (SERP)
ALSO 77 SJNP 26 57 BARANOV,VOLKOV,GERSHTEIN,IVANILOV +(SERP)
BENVENU1 77 PRL 38 1110 BENVENUTI,CLINE+ (FNAL+HARV+PENN+RUTG+WISC)
ALSO 77 PRL 38 1187 ALBRIGHT,SMITH,VERMASEREN (FNAL+STON)
ALSO 77 PRL 38 1190 BARGER,GOTTSCHALK+ (WISC+ZARAGOZA+RHEL)
BENVENU2 77 PRL 38 1183 BENVENUTI,CLINE+ (FNAL+HARV+PENN+RUTG+WISC)

ELLIOT 77 PR D15 1851 +FORTNEY,GOSHAW,LAMSA,LOOS+ (DUKE+ALBA)
MEYER 77 PL 70B 469 +NGUYEN,ABRAMS,ALAM+ (SLAC+LBL+NWES+HAWA)
ASRATYAN 78 PL 76B 237 ASRATYAN,KUBANTSEV (ITEP)
BALTAY 78 TOKYO CONF. C.BALTAY (19TH INTL. CONF. ON HEP) (COLU)

BECHIS 78 PRL 40 602 +CHANG,DOMBECK,ELLSWORTH,GLASSER,LAU+ (UMD)
BOSETTI 78 PL 73B 380 +DEDEN + (AACH+BONN+CERN+LOIC+OXF+SACL)
CNOPS 78 PRL 40 144 +CONNOLLY,KAHN,KIRK,MURTAGH + (BNL+COLU)
ERRIQUEZ 78 PL 77B 227 BARI+BIRM+BRUX+EPOL+RHEL+SACL+LOUC
HOLDER 78 PL 74B 277 +KNOBLOCH,MAY + (CERN+DORT+HEID+SACL+BGNA)
SMITH 78 NU 78 CONF J.SMITH (COLU)

ARMITAGE 79 NP B150 87 +BENZ,BOBBINK+ (CERN+DARE+FOM+MCHS+UTRECHT)
BARANOV 79 PL 81B 261 +IVANILOV,KONYUSHKO,KORABLEV+ (SERP)
ALSO 79 SJNP 29 622 BARANOV,+VOLKOV,IVANILOV,KONYUSHKO,+ (SERP)

AGAKISHI 80 SJNP 32 345 AGAKISHIEV,VOVENKO,GORYACHEV,MUKHIN (SERP)
AZIMOV 80 JETPL 32 665 YA.I.AZIMOV,V.A.KHOZE (KONS)
BARBER 80 PRL 45 1904 +BECKER,BEI+ (AACH+DESY+MIT+AIKO+BHEP)
BUSSIERE 80 NP B174 1 +GIACOMELLI,LESQUOY+ (BGNA+SACL+LAPP)
FRITZE 80 PL 96B 427 AACH+BONN+CERN+LOIC+OXF+SACL COLLABORATION
LEBRITTO 80 PL 89B 271 LEBRITTON,MCCAL,MELISSINOS+ (ROCH+BNL+NSF)

BERGER 81 PL 99B 489 +GENZEL+(AACH+BERG+DESY+HAMB+UMD+SIEG+WUPP)
BRANDELI 81 PL 99B 163 BRANDELIK+ (AACH+BONN+DESY+HAMB+LOIC+OXF+)
CLARK 81 PRL 46 299 +JOHNSON,KERTH,LOKEN+ (UCB+LBL+FNAL+PRIN)
ALSO 82 PR D25 2762 SMITH,CLARK,JOHNSON+ (UCB+LBL+FNAL+PRIN)
LOSECCO 81 PL 102B 209 +SULAK,GALIK,HORSTKOTTE+ (MICH+PENN+BNL)

ADEVA 82 PRL 15 967 MARK-J C (AACH+DESY+MIT+MADR+ANIK+CIT+BHEP)
BUKIN 82 SJNP 35 844 +KURDADZE,LELCHUK,PANIN,SIDOROV+ (SIBE)
HAYES 82 PR D25 2869 +PERL,ALAM,BOYARSKI,BREIDENBACH+ (SLAC+LBL)
RENARD 82 PL 116B 264 F.M.RENARD (CERN)

ADEVA 83 PRL 51 443 MARKJ C. (AACH+DESY+MIT+MADR+AIKO+BHEP+CIT)
BARTEL 83 PL 123B 353 +CORDS+(DESY+HAMB+HEID+LANC+MCHS+RHEL+TOKY)
FORD 83 PRL 51 257 +READ,SMITH+(COLO+FRAS+NEAS+SLAC+UTAH+WISC)

REVIEWS

PERL 81 SLAC-PUB-2752 M.L.PERL, PHYS. IN COLL. CONF, V.P.I.(SLAC)

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$\pi^{\pm}$

8 CHARGED PION(140,JPG=0--) I=1

8 CHARGED PION MASS (MEV)

M		139.37	0.20	CROWE	54 CNTR	-	
M		139.68	0.15	BARKAS	56 EMUL	+	
M	S	(139.577)	(0.013)	SHAFER	67 CNTR	- MESONIC ATOMS	6/68
M	B	(139.549)	(0.008)	BACKENSTO	71 CNTR	- MESONIC ATOMS	10/71
M	S	139.566	0.013	SHAFER	72 CNTR	- MESONIC ATOMS	1/73
M	B	139.569	0.008	BACKENSTO	73 CNTR	- MESONIC ATOMS	1/73
M		139.571	0.010	BRANDAODO	76 CNTR	- MESONIC ATOMS	1/78
M		139.5686	0.0020	CARTER	76 CNTR	- MESONIC ATOMS	6/77
M	M	139.5667	0.0024	MARUSHENK	76 CNTR	- MESONIC ATOMS	12/77
M	D	(139.5658)	(0.0018)	DAUM	79 SPEC	+ PI+ --> MU+ NEU	10/81
M		139.5675	0.0009	LU	80 CNTR	- MESONIC ATOMS	1/81

M	S	SHAFER 72 UPDATES SHAFER67 WITH NEW ALPHA AND NEW CALIB. LINE ENER.	1/73
M	B	BACKENSTOSS 73 CORRECTS BACKENSTOSS 71 WITH NEW VACUUM POL. CALC.	1/73
M	M	THIS MARUSHENKO 76 VALUE USED AT AUTHORS REQUEST BECAUSE IT USES	3/78
M	M	ACCEPTED SET OF CALIBRATION GAMMA ENERGIES. ERROR INCREASED FROM	3/78
M	M	.0017 TO INCLUDE QED CALC. ERROR OF .0017 (12 PPM).	3/78
M	D	DAUM 79 VALUE DEPENDS ON ASSUMED MU+ MASS M(MU)=105.65948+-.00035 .	2/78
M	D	ENTERS OUR FIT VIA PI-MU MASS DIFF. BELOW WHICH IS INDEP. OF M(MU).	2/78
M		. . . .	
M	AVG	139.56761 0.00077 AVERAGE	
M	FIT	139.5673 0.0007 FROM FIT	3/84*

8 (PI+) - (MU+) MASS DIFFERENCE (MEV)

D		34.00	0.076	BARKAS	56 EMUL		
D		33.89	0.076	BARKAS	56 EMUL		
D	145	33.881	0.035	HYMAN	67 HEBC	+ K-HE	2/71
D		33.925	0.025	BOOTH	70 CNTR	+ MAGNETIC SPECT.	2/71
D		33.9063	0.0018	DAUM	79 SPEC	+ SEE NOTE D ABOVE	10/81
D		. . . . . .	. . . .				
D	AVG	33.9064	0.0018	AVERAGE			
D	FIT	33.9080	0.0008	FROM FIT			3/82

8 ((PI+) - (PI-))/AVG., MASS DIFFERENCE (PERCENT)

DM	TEST OF CPT				
DM	0.02	0.05	AYRES	71 CNTR	3/71

8 CHARGED PION MEAN LIFE (UNITS 10**-9 SEC)

T			25.6	0.5	0.5	CROWE	57 RVUE	
T			25.6	0.8	0.8	ANDERSON	60 CNTR	
T		8000	25.46	0.32	0.32	ASHKIN	60 CNTR +	
T			26.02	0.04		ECKHAUSE	65 CNTR +	9/66
T			25.6	0.3		BARDON	66 CNTR	6/66
T			25.9	0.3		DUNAITSEV	66 CNTR	6/68
T	N		(26.40)	(0.08)		KINSEY	66 CNTR +	6/66
T	N	SYSTEMATIC ERRORS IN CALIBR.IN THIS EXP.DISCUSSED BY NORDBERG 67						8/67
T			26.67	0.24		LOBKOWICZ	66 CNTR	9/66
T			26.04	0.05		NORDBERG	67 CNTR +	8/67
T			26.02	0.04		AYRES	71 CNTR +-	3/71
T			26.09	0.08		DUNAITSEV	73 CNTR +	3/74
T			. . . . . .	. . . .				
T	AVG		26.030	0.023	0.023	AVERAGE		

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

DT	N	THIS QUANTITY IS A MEASURE OF CPT INVARIANCE IN W.I.				
DT		0.23	0.40	LOBKOWICZ 66 CNTR	SEE NOTE L	9/66
DT	L	ABOVE IS THE MOST CONSERVATIVE VALUE QUOTED BY AUTHORS				9/66
DT		0.4	0.7	BARDON 66 CNTR		7/66
DT		-0.14	0.29	PETRUKHIN 68 CNTR		8/68
DT		0.055	0.071	AYRES 71 CNTR		3/71
DT		. . . . . .	. . . .			
DT	AVG	0.053	0.068	AVERAGE		

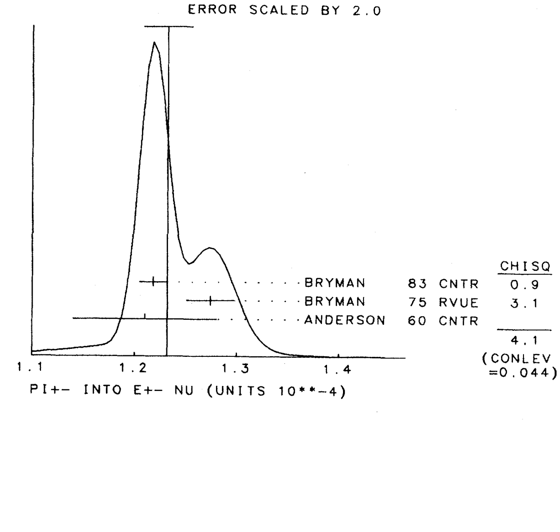
8 CHARGED PION PARTIAL DECAY MODES

		DECAY MASSES
P1	CHAR. PION INTO MU (MU-NEU)	106+ 0
P2	CHAR. PION INTO E (E-NEU)	.511+ 0
P3	CHAR. PION INTO MU (MU-NEU) GAMMA	106+ 0+ 0
P4	CHAR. PION INTO PIO E (E-NEU)	135+.511+ 0
P5	CHAR. PION INTO E NEU GAMMA	.511+ 0+ 0
P6	CHAR. PION INTO E NEU E+ E-	.511+ 0+.511+.511
P7	PI+ INTO MU+ NEUBAR(E)	106+ 0
P8	PI+ INTO MU+ NEU(E)	106+ 0

8 CHARGED PION BRANCHING RATIOS

R1		CHAR. PION INTO MU NEU GAMMA (UNITS 10**-4)				(P3)/(P1)		
R1		26	1.24	0.25	CASTAGNOL	58 EMUL	E(MU).LT.3.38 MV	
R2		CHAR. PION INTO E NEU (UNITS 10**-4)				(P2)/(P1)		
R2			1.21	0.07	ANDERSON	60 CNTR		
R2	D	11K	(1.247)	(0.028)	DI CAPUA	64 CNTR		11/75
R2	D	11K	1.274	0.024	BRYMAN	75 RVUE		9/75
R2		32K	1.218	0.014	BRYMAN	83 CNTR +		10/83*
R2	D	BRYMAN 75 IS A RECALC. OF DICAPUA 64 EXPT USING LATEST PI LIFETIME.						9/75
R2			. . . . . .	. . . .				
R2	AVG		1.232	0.024	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.0)			
					(SEE IDEOGRAM BELOW)			

WEIGHTED AVERAGE = 1.232 ± 0.024
ERROR SCALED BY 2.0



Stable Particles

Data Card Listings

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R3      CHAR. PION INTO PIO E NEU (UNITS 10**-8)          (P4)/(P1)
R3  D   52   (1.15)   (0.22)         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 M  1235    1.036    0.039         MCFARLANE 83 CNTR +  DECAY IN FLIGHT  10/83*
R3  D   DEPOMMIER 68 STATES THAT THE RESULT OF DEPOMMIER 63 IS AT LEAST    2/72
R3  D   10 PERCENT TOO LARGE BECAUSE OF A SYSTEMATIC ERROR IN THE PIO      2/72
R3  D   DETECTION EFFICIENCY.  THIS MAY BE TRUE OF ALL THE PREVIOUS        2/72
R3  D   MEASUREMENTS ACCORDING TO DEPOMMIER 68 AND V.SOERGEL, PRIVATE      2/72
R3  D   COMMUNICATION, 1972.
R3 M    COMBINES MEASURED RATE(.398+-.015)/SEC WITH 1982 PDG MEAN LIFE.    10/83*
R3           . . . . . . . . . .
R3  AVG       1.033    0.034   AVERAGE

R4      CHAR. PION INTO E NEU GAMMA (UNITS 10**-8)        (P5)/(P1)
R4      143   (3.0)                  DEPOMMI2  63 CNTR + E+, GAM KE >48MEV  3/82
R4    S 226    5.6     0.7           STETZ     78 SPEC + E MOM >56 MEV/C.  12/79
R4    S  STETZ 78 IS FOR E-GAMMA OPENING ANGLE >132DEG.  OBTAINS 3.7 WHEN  12/79
R4    S  USING SAME CUTOFFS AS DEPOMMIER.                                   12/79

R5      CHAR. PION INTO E NEU E+ E- (UNITS 10**-8)        (P6)/(P1)
R5           (3.4)  OR LESS  CL=.90  KORENCHEN 71 OSPK +                   10/71
R5            0.48  OR LESS  CL=.90  KORENCHEN 76 SPEC +                    1/78

R6      PI+ INTO MU+ NEUBAR(E) (UNITS 10**-3)             (P7)/(P1)
R6       FORBIDDEN BY TOTAL LEPTON NUMBER CONSERVATION.
R6            1.5   OR LESS  CL=.90  COOPER    82 HLBC WIDEBAND NEU BEAM    1/83*

R7      PI+ INTO MU+ NEU(E) (UNITS 10**-3)                (P8)/(P1)
R7       FORBIDDEN BY LEPTON FAMILY NUMBER CONSERVATION.
R7            8.0   OR LESS  CL=.90  COOPER    82 HLBC WIDEBAND NEU BEAM    1/83*

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REFERENCES FOR CHARGED PION


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CROWE    54 PR  96  470         K M CROWE,R H PHILLIPS                     (LRL)
BARKAS   56 PR 101  778         W H BARKAS,W BIRNBAUM,F M SMITH            (LRL)
CROWE    57 NC   5  541         K M CROWE                       (STANFORD HEPL)
CASTAGNO 58 PR 112 1779         C CASTAGNOLI,M MUCHNIK                    (ROMA)

ANDERSON 60 PR 119 2050         H L ANDERSON,T FUJII,R H MILLER +          (EFI)
ASHKIN   60 NC  16  490         ASHKIN,FAZZINI,FIDECARO,LIPMAN +          (CERN)
DEPOMMI1 63 PL 5 61             DEPOMMIER,HEINTZE,RUBBIA,SOERGEL          (CERN)
DEPOMMI2 63 PL 7 285            P DEPOMMIER,HEINTZE,RUBBIA,SOERGEL        (CERN)
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)
BOOTH    70 PL 32B 723          +JOHNSON,WILLIAMS,WORMALD                 (LIVP)
AYRES    71 PR 3D 1051          +CORMACK,GREENBERG,KENNEY +          (LRL,UCSB)
   ALSO  67 PR  157  1288       AYRES,CALDWELL,GREENBERG,KENNEY,KURZ+ (LRL)
   ALSO  68 PRL 21 261          AYRES,CORMACK,GREENBERG,KENNEY+  (LRL,UCSB)
   ALSO  69 UCRL-18369          DAVID S AYRES (THESIS)                     (LRL)
   ALSO  69 PRL 23 1267         GREENBERG,AYRES,CORMACK,KENNEY+  (LRL,UCSB)

BACKENST 71 PL 36B 403          BACKENSTOSS,DANIEL,KOCH+   (CERN,KARL,HEID)
   ALSO  70 THESIS              C. VON DER MALSBURG              (HEIDELBERG)
KORENCHE 71 SJNP 13 189         KORENCHENKO,KOSTIN,MICELMACHER+          (JINR)
SHAFER   72 PRIVATE COMM.       R. SHAFER, 1972                           (FNAL)
BACKENST 73 PL 43B 539          BACKENSTOSS,DANIEL,KOCH+ (CERN+KARL+MUNICH)
   ALSO  73 SUBMITTED TO NP     L. TAUSCHER
DUNAITSE 73 SJNP 16 292         DUNAITSEV,PROKOSHKIN,RAZUVAEV+            (SERP)

BRYMAN   75 PR D11 1337         +PICCIOTTO                 (UNIV OF VICTORIA)
BRANDAOD 76 ZNAT 31A 1150       BRANDAO D'OLIVERA,DANIEL,VON EGIDY+  (MUNI)
CARTER   76 PRL 37 1380         +DIXIT,SUNDARESAN+     (CARL+CNRC+CHIC+CIT)
KORENCHE 76 JETP 44 35          KORENCHENKO,KOSTIN,MICELMACHER+          (JINR)
MARUSHEN 76 JETPL 23 72         MARUSHENKO,MEZENTSEV,PETRUNIN+           (LENI)
   ALSO  76  PRIVATE COMM.      R. SHAFER                                 (FNAL)
   ALSO  78  PRIVATE COMM.      A. I. SMIRNOV                             (LENI)

STETZ    78 NP B138 285         +CARROLL,ORTENDAHL,PEREZ-MENDEZ+ (LBL+UCLA)
DAUM     79 PR D20 2692         +EATON,FROSCH,HIRSCHMANN,MCCULLOCH+     (SIN)
   ALSO  78 PL 74B 126          DAUM,EATON,FROSCH,HIRSCHMANN,+            (SIN)
LU       80 PRL 45 1066         +DELKER,DUGAN,WU,CAFFREY+   (YALE+COLU+JHU)
COOPER   82 PL 112B 97          +GUY,MICHETTE,TYNDEL,VENUS                 (RL)
BRYMAN   83 PRL 50 7            +DUBOIS,NUMAO+   (TRIU+VICT+CNRC+BRCO+QUKI)
MCFARLAN 83 PRL 51 249          MCFARLANE,AUERBACH,GAILLE+       (TEMP+LANL)

                                PAPERS NOT REFERRED TO IN DATA CARDS

CARTWRIG 53 PR 91 677           CARTWRIGHT,RICHMAN,WHITEHEAD,WILCOX   (LRL)J
MERRISON 62 ADVP 11 1           A W MERRISON                       (LIVERPOOL)
SHAPIRO  62 PR 125 1022         G SHAPIRO,L M LEDERMAN              (COLUMBIA)
CZIRR    63 PR 130 341          JOHN B CZIRR                               (LRL)
CARRIGAN 68 NP B6 662           R.A.CARRIGAN JR.                         (CARN)J
DEPOMMIE 80 NP A335 97          P.DEPOMMIER                               (MONT)
WILKIN   80 JPG 6 L5            C. WILKIN                                (LOUC)P
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9 NEUTRAL PION(135,JPG=0--) I=1

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              9  (PI+-) - (PIO) MASS DIFFERENCE (MEV)

D             (5.37)   (1.0)          PANOFSKY  51 CNTR  -
D              4.50     0.31          CHINOWSKY 54 CNTR  -
D              4.62     0.05          HADDOCK   59 CNTR  -
D              4.60     0.04          HILLMAN   59 CNTR
D              4.55     0.07          CASSELS   59 CNTR
D              4.69     0.07          SAMIOS    60 HBC                    2/72
D              4.6056   0.0055        CZIRR     63 CNTR
D              4.59     0.03          PETRUKHIN 63 CNTR  -
D              4.6034   0.0052        VASILEVSK 66 CNTR  -                  9/66
D           . . . . . . . . . .
D    AVG       4.6043   0.0037  AVERAGE

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              9  NEUTRAL PION MEAN LIFE (UNITS 10**-16 SEC)

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  B          0.82     0.04            BROWMAN   74 CNTR   PRIMAKOFF EFFECT  7/75
T   N   OLD EMULSION MEASUREMENTS NOT USED BECAUSE OF POSSIBLE SYSTEMATIC
T   N   SHIFT TO LARGER MEAN LIFE VALUES.
T  K    INCLUDES EVENTS OF KOLLER 63.                                        8/67
T  B    BROWMAN GIVES PIO WIDTH=8.02+-.42EV.  MEAN LIFE IS HBAR/WIDTH.      11/75
T           . . . . . . . . . .
T   AVG       0.828    0.057     0.053  AVERAGE (ERROR INCL. SCALE FACTOR OF 1.8)
                    (SEE IDEOGRAM BELOW)
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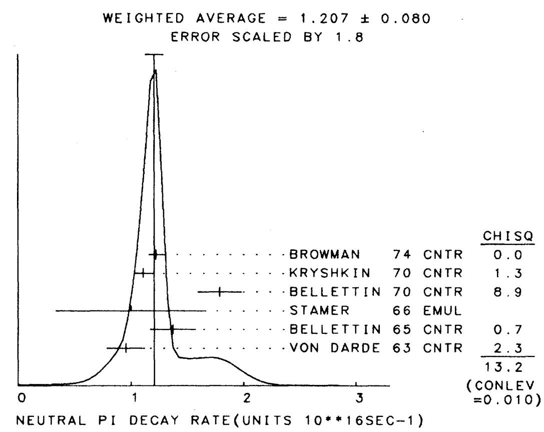


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              9  NEUTRAL PION PARTIAL DECAY MODES

                                                        DECAY MASSES
P1      PIO INTO 2GAMMA                                   0+   0
P2      PIO INTO E+ E- GAMMA                           .511+.511+   0
P3      PIO INTO 4ELECTRONS                            .511+.511+.511+.511
P4      PIO INTO 3 GAMMA                                  0+   0+   0
P5      PIO INTO 4 GAMMA                                  0+   0+   0+   0
P6      PIO INTO E+ E-                                 .511+.511
P7      PIO INTO 2 NEUTRINOS                              0+   0
P8      PIO INTO MU+ E- + MU- E+                        106+.511

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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 --> PIO N
R1            1.25     0.04           SCHARDT   81 SPEC     PI- P --> PIO N   1/82
R1  S   SAMIOS VALUE USES PANOFSKY RATIO = 1.62
R1          . . . . . . . . . .
R1  AVG       1.213    0.030   AVERAGE

R2      PIO INTO (3 GAMMA)/TOTAL      (UNITS 10**-6)      (P4)
R2       FORBIDDEN BY C INVARIANCE.
R2   D   0    (4.9)   OR LESS  CL=.90   DUCLOS    65 CNTR                     6/66
R2   D        (4.9)   OR LESS  CL=.90   KUTIN     65 CNTR                     3/68
R2   D  THESE EXPTS. GIVE BR(3GAMMA/2GAMMA)<5.0*10**-6.
R2       0    (1.5)   OR LESS  CL=.90   AUERBAC1  78 CNTR                     1/79
R2       0     0.38   OR LESS  CL=.90   HIGHLAND  80 CNTR                     1/81

R3      PIO INTO (E+E+E-E-)/(2 GAMMA) (UNITS 10**-5)      (P3)/(P1)
R3  N  146    (3.18)   (0.30)           SAMIOS    62 HBC      SEE NOTE N BELOW  6/66
R3             3.28    THEORET. CALC.   MIYAZAKI  73          QUANTUM ELECT.    2/76
R3  N   ABOVE VALUE USES PANOFSKY RATIO = 1.62

R4      PIO INTO (4 GAMMA)/TOTAL        (UNITS 10**-5)    (P5)                8/73
R4   A   0    (6.0)   OR LESS  CL=.90   ABRAMS    73 ASPK                     8/73
R4   A  ABRAMS 73 GIVES BR(4GAMMA/2GAMMA)<6.1*10**-5.
R4       0    (3.8)   OR LESS  CL=.90   AUERBAC2  78 CNTR                     2/79
R4       0     0.44   OR LESS  CL=.90   AUERBACH  80 CNTR                     8/81

R5      PIO INTO (E+ E-)/TOTAL  (UNITS 10**-6)            (P6)/(P1)          12/75
R5   D        (2.0)   OR LESS  CL=.90   DAVIES    74 RVUE                    12/75
R5            (4.0)   OR LESS  CL=.90   SCHACHER  77 STRC     PI- P --> PIO N  11/82*
R5       8     0.223    0.240    0.110 FISCHER2  78 SPRK     K+ EXPT. CL=.90   6/78
R5      58    (0.18)   (0.06)           MISCHKE   82 SPEC     REPL.BY FRANK 83 11/82*
R5      59     0.17     0.07            FRANK     83 SPEC     PI- P --> PIO N  11/83*
R5   D  DAVIES 74 EXTRACTS THIS INFORMATION FROM BLOCH 75 K+ EXPERIMENT.     12/75
R5          . . . . . . . . . .
R5  AVG        0.177    0.065   AVERAGE

R6      PIO INTO (2 NEU)/TOTAL    (UNITS 10**-5)          (P7)                2/82
R6       0     2.4    OR LESS  CL=.90   HERCZEG   81 RVUE                     2/82
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For notation, see key at front of Listings.


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R7      PIO INTO (MU+ E- + MU- E+)/TOTAL                    (P8)
R7       FORBIDDEN BY LEPTON FAMILY NUMBER CONSERVATION
R7              7E-8  OR LESS            BRYMAN    82 RVUE    K+ --> PI+ MU E  11/83*
R7           (14E-8) OR LESS             HERCZEG   84 RVUE    K+ --> PI+ MU E   2/84*
R7            (2E-15)OR LESS             HERCZEG   84 THEO    MU- --> E- CONV   2/84*

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9 NEUTRAL PION ELECTROMAGNETIC FORM FACTOR

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      THE AMPLITUDE FOR THE PROCESS PIO --> E+ E- GAMMA CONTAINS A
      FORM FACTOR GAMMA(X**2) AT THE (PIO GAMMA GAMMA) VERTEX
      WHERE X=MASS(E+E-)/MASS(PIO).  THE PARAMETER  A  IN THE LINEAR
      EXPANSION  GAMMA(X**2)=1+A*(X**2) IS LISTED BELOW.

A       LINEAR COEFFICIENT OF PIO ELECTROMAGNETIC FORM FACTOR
A            (-0.15)   (0.10)            KOBRAK    61 HBC     NO RAD. CORR.     2/80
A       3071 (-0.24)   (0.16)            SAMIOS    61 HBC     NO RAD. CORR.     2/80
A       2200 (+0.01)   (0.11)            DEVONS    69 OSPK    NO RAD. CORR.     2/80
A     F 30K   +0.10     0.03             FISCHER1  78 SPEC    RAD. CORR.        2/80
A     F  ERROR STATISTICAL ONLY.  RESULT WITHOUT RAD. CORR.=+0.05+-0.03.        2/80

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REFERENCES FOR NEUTRAL PION


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PANOFSKY 51 PR    81  565      W K H PANOFSKY,R L AAMODT,J HADLEY    (LRL)
CHINOWSK 54 PR    93  586      W CHINOWSKY,J STEINBERGER        (COLUMBIA)
CASSELS  59 PPS  74   92       CASSELS,JONES,MURPHY,O.NEILL    (LIVERPOOL)
HADDOCK  59 PRL    3  478      HADDOCK,ABASHIAN,CROWE,CZIRR          (LRL)
HILLMAN  59 NC    14  887      HILLMAN,MIDDELKOOP,YAMAGATA,ZAVATTINI(CERN)

BUDAGOV  60 JETP 11  755       BUDAGOV,VIKTOR,DZHELEPOV,ERMOLOV +   (JINR)
JOSEPH   60 NC 16 997          D W JOSEPH                            (EFI)
SAMIOS   60 NC 18 154          N P SAMIOS                       (COLUMBIA)
GLASSER  61 PR   123 1014      R G GLASSER,N SEEMAN,B STILLER        (NRL)
KOBRAK   61 NC 20 1115         H.KOBRAK                              (EFI)
SAMIOS   61 PR   121  275      N P SAMIOS                   (COLUMBIA+BNL)
SAMIOS   62 PR 126 1844        SAMIOS,PLANO,PRODELL +       (COLUMBIA+BNL)
TIETGE   62 PR   127 1324      J TIETGE,W PUESCHEL      (MAX PLANCK INST)

CZIRR    63 PR   130  341      JOHN B CZIRR                          (LRL)
KOLLER   63 NC    27 1405      E L KOLLER,S TAYLOR,T HUETTER     (STEVENS)
    ALSO 66 STAMER
PETRUKHI 63 SIENA CONF 208     V I PETRUKHIN,YU D PROKOSHKIN        (JINR)
VON DARD 63 PL     4   51      VON DARDEL,DEKKERS,MERMOD,VAN PUTTEN+(CERN)

SHWE     64 PR   136B 1839     H SHWE,F M SMITH,W H BARKAS           (LRL)
BELLETTI 65 NC 40 A 1139       BELLETTINI,BEMPORAD,BRACCINI+(PISA+FIRENZE)
DUCLOS   65 PL 19 253          DUCLOS,FREYTAG,HEINTZE +  (CERN+HEIDELBERG)
EVANS    65 PR 139 B 982       D A EVANS                          (OXFORD)
KUTIN    65 JETP LETT 2 243    KUTIN,PETRUKHIN,PROKOSHKIN           (JINR)

STAMER   66 PR 151  1108       STAMER,TAYLOR,KOLLER,HUETTER+     (STEVENS)
VASILEVS 66 PL  23  281        VASILEVSKY,VISHNYAKOV,DUNAITSEV +   (DUBNA)
DEVONS   69 PR 184 1356        +NEMENTHY,NISSIM-SABAT,DI CAPUA+(COLU+ROMA)
BELLETTI 70 NC 66A 243         BELLETTINI,BEMPORAD,LUBELSMEY+  (PISA+BONN)
KRYSHKIN 70 JETP 30 1037       +STERLIGOV,USOV      (TOMSK POLYTECH.INST.)
ABRAMS   73 PL 45B 66          +CARROLL,KYCIA,LI,MICHAEL,MOCKETT +   (BNL)
MIYAZAKI 73 PR D8 2051         T.MIYAZAKI,E.TAKASUGI                (TOKY)
BROWMAN  74 PRL 33 1400        +DEWIRE,GITTELMAN,HANSON+       (CORN+BING)
DAVIES   74 NC 24A 324         +GUY,ZIA                   (BIRM+RHEL+SHMP)

SCHACHER 77 LNC 20 177         +CZAPEK,HAHN,MARTI                   (BERN)
AUERBAC1 78 PRL 41 275         AUERBACH,HIGHLAND,JOHNSON,  +   (TEMP+LASL)
AUERBAC2 78 PL 78B 353         AUERBACH,HIGHLAND,JOHNSON,  +   (TEMP+LASL)
FISCHER1 78 PL 73B 359         +EXTERMANN,GUISAN,MERMOD,+      (GEVA+SACL)
FISCHER2 78 PL 73B 364         +EXTERMANN,GUISAN,MERMOD,MOREL+ (GEVA+SACL)

AUERBACH 80 PL 90B 317         +HAIK,HIGHLAND,MCFARLANE,MACEK+ (TEMP+LASL)
HIGHLAND 80 PRL 44 628         +AUERBACH,HAIK,MCFARLANE,MACEK+ (TEMP+LASL)
HERCZEG  81 PL 100B 347        P. HERCZEG, C. M. HOFFMAN            (LANL)
SCHARDT  81 PRD 23 639         +FRANK,HOFFMANN,MISCHKE,MOIR +  (ARZS+LANL)
BRYMAN   82 PR D26 2538        D. BRYMAN                            (TRIU)
MISCHKE  82 PRL 48 1153        +FRANK,HOFFMAN,MOIR,SARRACINO + (LANL+ARZS)
FRANK    83 PR D28 423         +HOFFMAN,MISCHKE,MOIR+          (LANL+ARZS)
HERCZEG  84 PR D TO BE PUBL.   P.HERCZEG,C.M.HOFFMAN                (LANL)
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14 ETA(549,JPG=0-+) I=0

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14 ETA MASS (MEV)

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M        53  549.0       1.2            BASTIEN   62 HBC
M        35  546.0       4.0            PICKUP    62 HBC
M        91  548.0       1.0            ALFF      62 HBC
M            549.3       2.9            DELCOURT  63 CNTR
M       148  549.0       0.7            FOELSCHE  64 HBC
M       325  552.0       3.0            KRAEMER   64 DBC
M            548.2       0.65           FOSTER3   65 HBC                    7/66
M       250  555.0       2.0            JAMES     66 HBC                    6/66
M            . . . . . . . . .
M   AVG      548.82      0.56    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
                         (SEE IDEOGRAM BELOW)

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14 ETA WIDTH

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W       ETA WIDTH DETERMINED FROM MASS SPECTRUM (UNITS MEV)
W        91  (10.0)  OR LESS            ALFF      62 HBC
W       148  (10.0)  OR LESS            FOELSCHE  64 HBC
W        31  (12.0)  OR LESS            JAMES     66 HBC                    6/66
W             (4.0)  OR LESS            BALTAY    66 DBC                    7/66
W             (0.9)  OR LESS  CL=.95    JONES     66 CNTR                   8/67

W       ETA WIDTH DETERMINED FROM DECAY RATE (UNITS KEV)
W        THIS IS THE PARTIAL DECAY RATE (W1) FOR THE MODE (ETA INTO 2GAMMA)
W        DIVIDED BY THE FITTED BRANCHING FRACTION (P1) FOR THAT MODE.
W            . . . . . . . . .
W   FIT        0.88      0.12    FROM FIT

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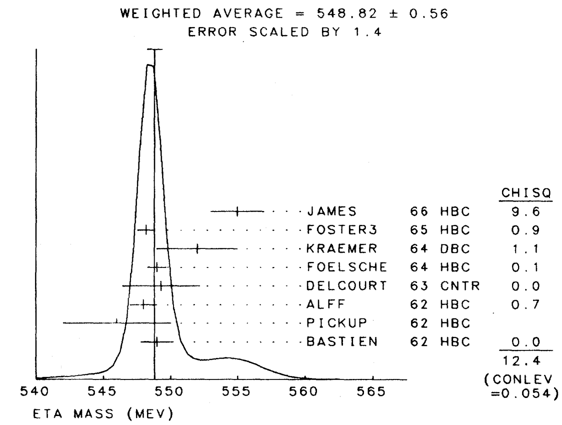


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14 ETA PARTIAL DECAY MODES

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                                                     DECAY MASSES
P1      ETA INTO 2GAMMA                               0+   0
P2      ETA INTO 3PIO                               135+ 135+ 135
P3      ETA INTO PI+ PI- PIO                        140+ 140+ 135
P4      ETA INTO PI+ PI- GAMMA                      140+ 140+   0
P5      ETA INTO E+ E- PIO                          135+.511+.511
P6      ETA INTO E+ E- PI+ PI-                      140+ 140+.511+.511
P7      ETA INTO PIO 2GAMMA                         135+   0+   0
P8      ETA INTO E+ E- GAMMA                       .511+.511+   0
P10     ETA INTO PI+ PI- PIO GAMMA                  140+ 140+ 135+   0
P11     ETA INTO PI+ PI- 2GAMMA                     140+ 140+   0+   0
P12     ETA INTO MU+ MU-                            106+ 106
P13     ETA INTO MU+ MU- GAMMA                      106+ 106+   0
P14     ETA INTO MU+ MU- PIO                        106+ 106+ 135
P15     ETA INTO PI+ PI-                            140+ 140
P16     ETA INTO E+ E-                             .511+.511
P17     ETA INTO MU+ MU- PIO GAMMA                  106+ 106+ 135+   0

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FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions, P_i, as follows: The diagonal elements are $P_i \pm \delta P_i$, where $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$, while the off-diagonal elements are the normalized correlation coefficients $\langle \delta P_i \delta P_j \rangle / (\delta P_i \cdot \delta P_j)$. For the definitions of the individual P_i, see the listings above; only those P_i appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

	P 1	P 2	P 3	P 4	P 7	P 8
P 1	.3902+-.0084					
P 2	-.6885	.3179+-.0080				
P 3	-.4327	-.3366	.2368+-.0054			
P 4	-.3764	-.2950	.8016	.0491+-.0013		
P 7	-.0107	-.0162	-.0016	-.0013	.0010+-.0002	
P 8	-.0521	-.0462	-.0546	-.0540	-.0000	.0050+-.0012

FITTED PARTIAL DECAY MODE RATES

The matrix below is the branching fraction matrix above, transformed into rate space; i.e., $G_i \equiv \Gamma_i = \Gamma_{total} P_i$, in appropriate units. In analogy to the matrix above, the diagonal elements are $G_i \pm \delta G_i$, where $\delta G_i = \sqrt{\langle \delta G_i \delta G_i \rangle}$, while the off-diagonal elements are the normalized correlation coefficients $\langle \delta G_i \delta G_j \rangle / (\delta G_i \cdot \delta G_j)$. Note that, because of the error in Γ_{total}, the errors and correlations here are not directly derivable from those above.

	G 1	G 2	G 3	G 4	G 7	G 8
G 1	.3420+-.0443					
G 2	.9475	.2787+-.0381				
G 3	.9634	.9584	.2076+-.0279			
G 4	.9584	.9535	.9974	.0431+-.0058		
G 7	.4709	.4669	.4727	.4704	.0008+-.0002	
G 8	.4809	.4777	.4808	.4772	.2368	.0044+-.0012

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14 ETA DECAY RATES

```
W1      ETA INTO 2GAMMA (UNITS KEV)                          (G1)
W1   B        (1.00)    (0.22)          BEMPORAD  67 CNTR    PRIMAKOFF EFFECT 11/75
W1             0.324     0.046          BROWMAN   74 CNTR    PRIMAKOFF EFFECT  7/74
W1        56   0.56      0.16           WEINSTEIN 83 CNTR    E+E- -> E+E- ETA  2/84*
W1   B    BEMPORAD 67 GIVES W1=1.21+-.26 KEV ASSUMING THAT W1/TOTAL=0.314.    11/75
W1   B    BEMPORAD PRIVATE COMMUNICATION GIVES MORE GENERAL RESULT AS         11/75
W1   B    W1*W1/TOTAL=.380+-.083.  WE EVALUATE THIS USING W1/TOTAL=.38+-.01.  11/75
W1   B    NOT INCLUDED IN AVERAGE BECAUSE THE UNCERTIANTY RESULTING FROM THE   2/76
W1   B    SEPARATION OF THE COULOMB AND NUCLEAR AMPLITUDES HAS APPARENTLY      2/76
W1   B    BEEN UNDERESTIMATED.                                                 2/76
W1            . . . . . . . . .
W1   AVG       0.342     0.063   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
W1   FIT       0.342     0.044  FROM FIT

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Stable Particles

Data Card Listings

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              14  ETA BRANCHING RATIOS

R1       ETA INTO NEUTRALS/CHARGED
R1                                                  (P1+P2+P7)/(P3+P4+P8)
R1  N    10   (2.5)    (1.0)          PICKUP    62 HBC
R1  N    53   (3.20)   (1.26)         BASTIEN   62 HBC
R1  N   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  FIT       2.437    0.076  FROM FIT

R2       ETA INTO 2GAMMA/CHARGED                               (P1)/(P3+P4+P8)
R2            0.99     0.48           CRAWFORD  63 HBC
R2      75    1.51     0.93           KENDALL   74 OSPK                      12/75
R2          . . . . . . . . . . .
R2  AVG       1.10     0.43    AVERAGE
R2  FIT       1.341    0.050  FROM FIT
```

NOTE ON $\eta \to \pi^0\gamma\gamma$

It appears that earlier problems with the $\eta \to \pi^0\gamma\gamma$ branching fraction have been resolved by the excellent new measurement of BINON 82. Interested readers are referred to their paper and to the note in our 1982 edition.[1]

Reference

1. Particle Data Group, Phys. Lett. **111B** (1982).

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R3       ETA INTO (PIO 2GAMMA)/NEUTRALS                       (P7)/(P1+P2+P7)
R3        OTHER RESULTS ARE IN SECTIONS R14, R22(DAVYDOV 81), AND R26.
R3            (0.375)  (0.072)            DIGIUGNO  66 CNTR   ERROR DOUBLED      6/66
R3            (0.27)   (0.10)             GRUNHAUS  66 OSPK                      8/67
R3            (0.028)  (0.044)            BUNIATOV  67 OSPK REPL. BY SCHMITT 70 11/67
R3            (0.244)  (0.05)             FELDMAN   67 OSPK                      8/67
R3            (0.026)  (0.019)            BUTTRAM   70 OSPK                     12/70
R3            (0.122)  (0.052)  (0.044)COX      70 HBC                       6/70
R3            (0.07) OR LESS  CL=.90      DEVONS    70 OSPK                     12/70
R3      16    (0.016)  (0.047)            SCHMITT   70 OSPK REANAL. BUNIATOV 67 12/70
R3            (0.11)   (0.03)             STRUGALSK 71 HLBC                      5/71
R3            (0.04) OR LESS  CL=.90      ABROSIMOV 80 HLBC                     10/81
R3          . . . . . . . . . . .
R3  FIT       0.00134  0.00032 FROM FIT

R4       ETA INTO (PI+ PI- GAMMA)/(PI+ PI- PIO)               (P4)/(P3)
R4            0.14     0.08               FOELSCHE  64 HBC
R4      24    (0.73)   (0.25)             PAULI     64 DBC
R4            0.30     0.06               CRAWFORD  66 HBC                       6/66
R4            0.10     0.10               KRAEMER   64 DBC                       7/66
R4            0.196    0.041              FOSTER3   65 HBC                       7/66
R4            0.25     0.035              LITCHFIEL 67 DBC                       8/67
R4            0.28     0.04               BALTAY2   67 DBC                      11/67
R4    7250    0.201    0.006              GORMLEY   70 ASPK                      6/70
R4     18K    0.209    0.004              THALER    73 ASPK                      6/73
R4          . . . . . . . . . . .
R4  AVG       0.2074   0.0037  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
R4  FIT       0.2074   0.0033 FROM FIT

R6       ETA INTO 3PIO/2GAMMA                                 (P2)/(P1)
R6            (0.90) OR MORE              CHRETIEN  62 PBC
R6            (1.25)   (0.39)             BACCI     63 CNTR INVERSE BR REPORTED  7/66
R6            0.88     0.16               BALTAY1   67 DBC                      11/67
R6            1.1      0.2                CENCE     67 OSPK                      1/68
R6            0.91     0.14               COX       70 HBC                       6/70
R6            0.75     0.09               DEVONS    70 OSPK                     12/70
R6          . . . . . . . . . . .
R6  AVG       0.842    0.065   AVERAGE
R6  FIT       0.815    0.035  FROM FIT

R7       ETA INTO 2GAMMA/(PI+ PI- P0)                         (P1)/(P3)
R7            1.61     0.39               FOSTER1   65 HBC
R7     401    1.72     0.25               BAGLIN    69 HLBC                      7/69
R7          . . . . . . . . . . .
R7  AVG       1.69     0.21    AVERAGE
R7  FIT       1.647    0.061  FROM FIT

R8       ETA INTO NEUTRAL/(PI+ PI- PIO)                       (P1+P2+P7)/(P3)
R8      50    3.6      0.8                KRAEMER   64 DBC
R8            3.8      1.1                PAULI     64 DBC                       7/66
R8            2.89     0.56               ALFF-STEI 66 HBC                       9/66
R8     244    3.6      0.6                FLATTE2   67 HBC                       1/68
R8      29    3.4      1.1                AGUILAR-B 72 HBC                      11/72
R8 B    70    2.83     0.80               BLOODWORT 72 HBC                      11/72
R8      74    2.54     1.89               KENDALL   74 OSPK                     12/75
R8 B    ERROR INCREASED FROM PUBLISHED VALUE 0.5 BY BLOODWORTH, PRIV. COMM.   1/73
R8          . . . . . . . . . . .
R8  AVG       3.26     0.30    AVERAGE
R8  FIT       2.994    0.095  FROM FIT

R9       ETA INTO (E+E-PIO)/(PI+PI-PIO) (UNITS 10**-4)    (P5)/(P3)
R9        SINGLE PHOTON PROCESS FORBIDDEN BY C-PARITY
R9          (110.)    OR LESS             PRICE     65 HBC
R9       0  (77.)     OR LESS             FOSTER2   65 HBC
R9           (42.)    OR LESS  CL=.90     BAGLIN1   67 HLBC                      8/67
R9       0  (16.)     OR LESS  CL=.90     BILLING   67 HLBC                     11/67
R9            1.9     OR LESS  CL=.90     JANE1     75 OSPK                     12/75

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          (0.416)  (0.044)             DIGIUGNO  66 CNTR   ERROR DOUBLED      6/66
R12          (0.44)   (0.07)              GRUNHAUS  66 OSPK                      8/67
R12          (0.579)  (0.052)             FELDMAN   67 OSPK                      8/67
R12 T        (0.39)   (0.06)              JONES     66 CNTR                      8/67
R12 T     THIS RESULT FROM COMBINING CROSS SECTIONS FROM TWO DIFFERENT EXPTS.
R12           0.59     0.033              BUNIATOV  67 OSPK                     11/67
R12           0.535    0.018              BUTTRAM   70 OSPK                     12/70
R12          (0.57)   (0.09)              STRUGALSK 71 HLBC                      5/71
R12     113   0.60     0.14               KENDALL   74 OSPK                     12/75
R12      88   0.52     0.09               ABROSIMOV 80 HLBC                     10/81
R12         . . . . . . . . . . .
R12 AVG       0.547    0.016   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
R12 FIT       0.550    0.011  FROM FIT

R13      ETA INTO 3PIO/NEUTRALS                               (P2)/(P1+P2+P7)
R13          (0.209)  (0.054)             DIGIUGNO  66 CNTR   ERROR DOUBLED      6/66
R13          (0.29)   (0.10)              GRUNHAUS  66 OSPK                      8/67
R13          (0.177)  (0.035)             FELDMAN   67 OSPK                      8/67
R13          (0.41)   (0.033)             BUNIATOV  67 OSPK NOT INDEP. OF R12   11/67
R13           0.439    0.024              BUTTRAM   70 OSPK                     12/70
R13          (0.32)   (0.09)              STRUGALSK 71 HLBC                      5/71
R13      75   0.44     0.08               ABROSIMOV 80 HLBC                     10/81
R13         . . . . . . . . . . .
R13 AVG       0.439    0.023   AVERAGE
R13 FIT       0.448    0.011  FROM FIT

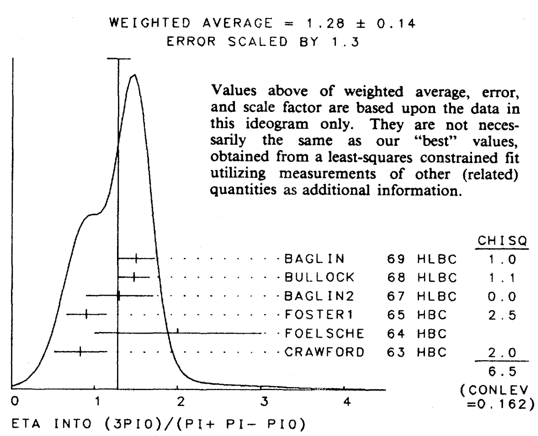
R14      ETA INTO (PIO 2GAMMA)/2GAMMA                         (P7)/(P1)
R14          (0.5)  OR LESS  CL=.90   WAHLIG    66 SPRK                          7/66
R14          (0.28) OR LESS  CL=.95   BALTAY1   67 DBC                          11/67
R14         . . . . . . . . . . .
R14 FIT       0.00244  0.00059 FROM FIT

R15      ETA INTO (E+E-PIO)/TOTAL (UNITS 10**-2)             (P5)
R15       SINGLE PHOTON PROCESS FORBIDDEN BY C-PARITY
R15          (0.7)  OR LESS               RITTENBER 65 HBC                       6/66
R15          (0.084)OR LESS  CL=.90   BAZIN     68 DBC                           6/68
R15       0  (0.016)OR LESS  CL=.90   MARTYNOV  76 HLBC                          6/77

R17      ETA INTO (PI+PI-PIO GAMMA)/(PI+PI-PIO) (UNITS 10**-2)
R17                                                           (P10)/(P3)
R17          (7.0)  OR LESS               FLATTE    67 HBC                       8/67
R17          (0.9)  OR LESS               PRICE     67 HBC                       8/67
R17          (1.6)  OR LESS  CL=.95   BALTAY2   67 DBC                          11/67
R17          (1.7)  OR LESS  CL=.90   ARNOLD    68 HLBC                          9/68
R17       0   0.24  OR LESS  CL=.90   THALER    73 ASPK                          6/73

R18      ETA INTO (PI+PI- 2GAMMA)/(PI+PI-PIO)                 (P11)/(P3)
R18           0.009 OR LESS               PRICE     67 HBC                       8/67
R18          (0.016)OR LESS  CL=.95   BALTAY2   67 DBC                          11/67

R19      ETA INTO 3PIO/(PI+ PI- PIO)                          (P2)/(P3)
R19           0.83     0.32               CRAWFORD  63 HBC                       7/66
R19           2.0      1.0                FOELSCHE  64 HBC                       7/66
R19           0.90     0.24               FOSTER1   65 HBC                       7/66
R19           1.3      0.4                BAGLIN2   67 HLBC                      8/67
R19           1.47     0.20     0.17  BULLOCK   68 HLBC                          9/68
R19     199   1.50     0.15     0.29  BAGLIN    69 HLBC                          7/69
R19         . . . . . . . . . . .
R19 AVG       1.28     0.14    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
R19 FIT       1.342    0.052  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)
                             (SEE IDEOGRAM BELOW)
```

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R21      ETA INTO NEUTRALS/TOTAL                              (P1+P2+P7)
R21           0.79     0.08               BUNIATOV  67 OSPK                     11/67
R21     16K   0.705    0.008              BASILE    71 CNTR MM SPECTROMETER      8/71
R21         . . . . . . . . . . .
R21 AVG       0.7058   0.0080  AVERAGE
R21 FIT       0.7091   0.0065 FROM FIT

R22      ETA INTO (PIO 2GAMMA)/TOTAL                          (P7)
R22          (0.12) OR LESS  CL=.95   JACQUET   69 HLBC                          6/70
R22       0  (0.003)OR LESS  CL=.90   DAVYDOV   81 CNTR PI- P-->ETA N            1/82
R22      70  0.00095  0.00023             BINON     82 CNTR PI- P-->ETA N       11/83*
R22         . . . . . . . . . . .
R22 FIT       0.00095  0.00023 FROM FIT

R23      ETA INTO MU+MU-/TOTAL (UNITS 10**-5)                (P12)
R23       0  (2.)   OR LESS  CL=.95   WEHMANN   68 OSPK                          4/68
R23      27   0.65     0.21               DZHELYA2  80 SPEC PI- P-->ETA N        9/81
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```
R24     ETA INTO MU+MU-PIO/TOTAL (UNITS 10**-4)                (P14)
R24      SINGLE PHOTON PROCESS FORBIDDEN BY C-PARITY
R24          (5.)    OR LESS              WEHMANN   68 OSPK                        4/68
R24           0.05   OR LESS  CL=.90      DZHELYADI 81 SPEC PI- P-->ETA N          1/82

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          (0.1)    (0.3)               KANOFSKY  70 OSPK                        2/71
R26          . . . . . . . . . . .
R26 FIT      0.00298  0.00072 FROM FIT

R27     ETA INTO (PI+ PI-)/TOTAL (UNITS 10**-2)                (P15)               6/73
R27      VIOLATES P AND T INVARIANCE
R27      0    0.15   OR LESS              THALER    73 ASPK CON. LEV. NOT GIVEN    6/73

R28     ETA INTO (E+E-GAMMA)/(PI+PI-PIO) (UNITS 10**-2)  (P8)/(P3)
R28  J  80    2.1       0.5               JANE2     75 OSPK                        2/76
R28  J  VALUE CHANGED BY ERRATUM.                                                  2/76
R28          . . . . . . . . . . .
R28 FIT       2.11      0.50   FROM FIT

R29     ETA INTO (E+ E-)/TOTAL  (UNITS 10**-4)                 (P16)
R29  D        3.     OR LESS  CL=.90      DAVIES    74 RVUE                        2/78
R29  D  DAVIES 74 EXTRACTS THIS INFORMATION FROM ESTEN 67.                         2/78

R30     ETA INTO (MU+ MU- GAMMA)/TOTAL   (UNITS 10**-4)  (P13)                     2/79
R30     100   (1.5)     (0.75)            BUSHNIN   78 SPEC REPL.BY DZHELYA1 80    2/79
R30     600    3.1       0.4              DZHELYA1  80 SPEC PI- P-->ETA N          9/81

R31     ETA INTO (MU+ MU- PIO GAMMA)/TOT (UNITS 10**-6)  (P17)                     1/82
R31           3.     OR LESS  CL=.90      DZHELYADI 81 SPEC PI- P-->ETA N          1/82
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NOTE ON η DECAY PARAMETERS

C violation in η decays

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

(a) The left-right asymmetry

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

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

(b) The sextant asymmetry

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

for the decay $\eta \to \pi^+\pi^-\pi^0$. The numbers refer to sextants of the Dalitz plot (see, for example, Layter et al.[1]). A_s is sensitive to an I = 0 C-violating asymmetry.

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

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

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

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

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

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

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

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

Here,

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

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

Dalitz plot for $\eta \to \pi^0\pi^0\pi^0$

The Dalitz plot for the decay $\eta \to \pi^0\pi^0\pi^0$ may be fit to the expression

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

where

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

Here E_i is the energy of the i^{th} pion in the η rest frame, and ρ is the distance to the center of the Dalitz plot. We list the parameter α in section A0 below.

Reference

1. J.G. Layter et al., Phys. Rev. Lett. **29**, 316 (1972).

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                    14  ETA C-NONCONSERVING DECAY PARAMETERS

A1      LEFT-RIGHT ASYMMETRY PARAMETER FOR PI+ PI- PIO  (UNITS 10**-2)
A1     1351     7.2       2.8             BALTAY    66 DBC                          8/66
A1     1300     5.8       3.4             CLPWY     66 HBC                          8/66
A1    10665    (0.3)     (1.0)            CNOPS     66 OSPK REPL BY MULLER 69       8/67
A1      705    -6.1       4.0             LARRIBE   66 HBC                          8/67
A1   G36800    (1.5)     (0.5)            GORMLEY3  68 ASPK                         6/68
A1    10709     0.3       1.1             MULLER    69 OSPK                         9/69
A1     1138    -1.4       3.              CARPENTR  70 HBC                          6/70
A1      349     3.2       5.4             DANBURG   70 DBC                          2/71
A1     220K    -0.05      0.22            LAYTER    72 ASPK                         8/72
A1     165K     0.28      0.26            JANE1     74 OSPK                         3/74
A1   G   GORMLEY3 68 ASYMMETRY PROBABLY DUE TO UNMEASURED (E X B) SPK. CH.         3/74
A1   G   EFFECTS.  NEW EXPTS. WITH (E X B) CONTROLS DONT OBSERVE ASYMMETRY.        3/74
A1           . . . . . . . . . . .
A1   AVG        0.12      0.17    AVERAGE

A2      LEFT-RIGHT ASYMMETRY PARAMETER FOR PI+ PI- GAMMA (UNITS 10**-2)
A2       33    -2.       17.              CRAWFORD  66 HBC                         11/66
A2             -4.        8.              LITCHFIEL 67 DBC                          8/67
A2 N   1620     1.5       2.5             MULLER    69 OSPK                         9/69
A2     7257     1.22      1.56            GORMLEY   70 ASPK                         6/70
A2      36K     0.5       0.6             THALER    72 ASPK                         8/72
A2      35K     1.2       0.6             JANE2     74 OSPK                         3/74
A2 N  MULLER 69 IS SENSITIVE ONLY TO UPPER .4 OF GAMMA-RAY SPECTRUM.
A2           . . . . . . . . . . .
A2   AVG        0.88      0.40    AVERAGE
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Stable Particles
η, $K^{\pm}$

Data Card Listings

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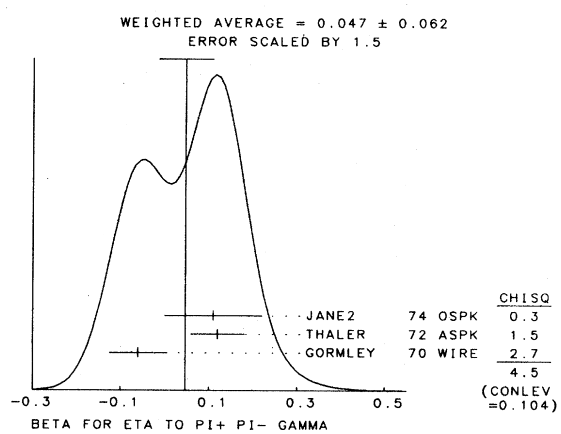
AS       SEXTANT ASYMMETRY PARAMETER FOR PI+ PI- PIO  (UNITS 10**-2)
AS     1300     6.8       3.3               CLPWY       66 HBC                    12/75
AS      705    -2.4       4.0               LARRIBE     66 HBC                    12/75
AS      37K     0.5       0.5               GORMLEY3    68 WIRE                   12/75
AS     220K     0.10      0.22              LAYTER      72 ASPK                   12/75
AS     165K     0.20      0.25              JANE1       74 OSPK                   12/75
AS
AS  AVG         0.19      0.16      AVERAGE

AQ       QUADRANT ASYMMETRY PARAMETER FOR PI+ PI- PIO (UNITS 10**-2)
AQ     220K    -0.07      0.22              LAYTER      72 ASPK                   12/75
AQ     165K    -0.30      0.25              JANE1       74 OSPK                   12/75
AQ
AQ  AVG        -0.17      0.17      AVERAGE

BET      BETA FOR ETA TO PI+ PI- GAMMA. SENSITIVE TO D-WAVE CONTRIBUTION.
BET      DN/DCOS THETA = SIN**2 THETA * (1 + BETA * COS**2 THETA)
BET    7250    -0.060     0.065             GORMLEY     70 WIRE                   12/75
BET  L          0.12      0.06              THALER      72 ASPK                   12/75
BET     35K     0.11      0.11              JANE2       74 OSPK                   12/75
BET  L   AUTHORS DONT BELIEVE THIS TO INDICATE D-WAVE BECAUSE DEPENDENCE OF       12/75
BET  L   BETA ON GAMMA ENERGY INCONSISTENT WITH THEOR. PREDICTION.                12/75
BET  L   COS**2 DEPENDENCE MAY ALSO COME FROM P AND F-WAVE INTERFERENCE.          12/75
BET
BET AVG         0.047     0.062     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
                                    (SEE IDEOGRAM BELOW)
```

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                14 ENERGY DEPENDENCE OF ETA DALITZ PLOT

DP       SEE NOTE ON ETA DECAY PARAMETERS ABOVE.
DP       THE FOLLOWING EXPTS FIT TO ONE OR MORE OF THE COEFFICIENTS
DP       A,B,C,D, OR E FOR ETA TO PI+ PI- PIO
DP       MATRIX ELEMENT**2=1 + A*Y + B*(Y**2) + C*X + D*(X**2) + E*X*Y
DP     1300 SEE NOTE ABOVE                  CLPWY       66 HBC                    12/75
DP      705 SEE NOTE ABOVE                  LARRIBE     66 HBC                    12/75
DP     7170 SEE NOTE ABOVE                  CNOPS       68 OSPK                   12/75
DP      37K SEE NOTE ABOVE                  GORMLEY3    68 WIRE                   12/75
DP      526 SEE NOTE ABOVE                  BAGLIN      69 HLBC                   12/75
DP     1138 SEE NOTE ABOVE                  CARPENTR    70 HBC                    12/75
DP      349 SEE NOTE ABOVE                  DANBURG     70 DBC                    12/75
DP     7250 SEE NOTE ABOVE                  GORMLEY     70 WIRE                   12/75
DP     220K SEE NOTE ABOVE                  LAYTER      72 ASPK                   12/75
DP      81K SEE NOTE ABOVE                  LAYTER      73 ASPK                   12/75

AO       ALPHA PARAMETER FOR ETA TO 3 PIO
AO       MATRIX ELEMENT **2 = 1 + 2*ALPHA*Z (SEE NOTE ABOVE)                      12/75
AO      192    -0.32      0.37              BAGLIN      70 HLBC                   12/75
****** ********* ********* ********* ********* ********* ********* ********
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REFERENCES FOR ETA

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PEVSNER  61 PRL 7 421           PEVSNER,KRAEMER,NUSSBAUM,RICHARDSON + (JHU)

ALFF     62 PRL 9 322           ALFF,BERLEY,COLLEY,BRUGGER + (COLU+RUTGERS)
BASTIEN  62 PRL 8 114           BASTIEN,BERGE,DAHL,FERRO-LUZZI +        (LRL)
CHRETIEN 62 PRL  9  127         CHRETIEN+     (BRAN+BROWN+HARVARD+MIT+PADOVA)
PICKUP   62 PRL 8 329           E PICKUP,ROBINSON,SALANT           (CNRC+BNL)

BACCI    63 PRL 11 37           BACCI,PENSO,SALVINI +              (ROMA+FRAS)
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)

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)
FOSTER3  65 THESIS              M.C.FOSTER                       (WISCONSIN)
PRICE    65 PRL  15   123       L.R.PRICE,F.S.CRAWFORD                 (LRL)
RITTENBE 65 PRL 15 556          RITTENBERG,KALBFLEISCH             (LRL+BNL)

ALFF-STE 66 PR 145 1072         ALFF-STEINBERGER,BERLEY+ (COLUMBIA+RUTGERS)
BALTAY   66 PRL 16 1224         +FRANZINI,KIM,KIRSCH+(COLUMBIA+STONY BROOK)
CLPWY    66 PR 149   1044       COLUMBIA,LRL,PURDUE,WISCONSIN,YALE
CNOPS    66 PL 22 546           CNOPS,FINOCCHIARS,LASSALLE,+(CERN,ETH,SACL)
CRAWFORD 66 PRL   16   333      F.S.CRAWFORD,L.R.PRICE                 (LRL)

DIGIUGNO 66 PRL 16 767          DIGIUGNO,GIORGI,SILVESTRI+ (NAPL,TRST,FRAS)
GROSSMAN 66 PR 146   993        R GROSSMAN,L PRICE,F CRAWFORD          (LRL)
GRUNHAUS 66 THESIS              J.GRUNHAUS                        (COLUMBIA)

JAMES    66 PR 142    896       F E JAMES,H L KRAYBILL           (YALE+BNL)
JONES    66 PL 23  597          JONES,BINNIE,DUANE,HORSEY,MASON,(LOIC,RHEL)
LARRIBE  66 PL 23 600           LARRIBE,LEVEQUE,MULLER,PAULI,+ (SACL+RHEL)
WAHLIG   66 PRL  17  221        WAHLIG,SHIBATA,MANNELLI          (MIT+PISA)

BAGLIN1  67 PL 24B 637          BAGLIN,BEZAGUET,DEGRANGE,+        (EPOL+UCB)
BAGLIN2  67 BAPS 12 567         BAGLIN,BEZAGUET,DEGRANGE,+        (EPOL+UCB)
BALTAY1  67 PRL 19 1495         BALTAY,FRANZINI,KIM,NEWMAN+      (COLU+BRAN)
BALTAY2  67 PRL 19 1498         BALTAY,FRANZINI,KIM,NEWMAN+      (COLU+STON)
BEMPORAD 67 PL 25B 380          BEMPORAD,BRACCINI,FOA,LUBELSMEY+(PISA,BONN)
   ALSO     PRIVATE COMMUNICATION

BILLING  67 PL 25B 435          BILLING,BULLOCK,ESTEN,GOVAN,+     (LOUC,OXF)
BOWEN    67 PL 24B 206          BOWEN,CNOPS ,FINOCCHIARO,+  (CERN+ETH+SACL)
BUNIATOV 67 PL 25B 560          BUNIATOV,ZAVATTINI,DEINET,+      (CERN+KARL)
CENCE    67 PRL 19 1393         CENCE,PETERSON,STENGER,CHIU+   (HAWAII+LRL)
ESTEN    67 PL 24B 115          +GOVAN,KNIGHT,MILLER,TOVEY+       (LOUC+OXF)

FELDMAN  67 PRL 18 868          FELDMAN,FRATI,GLEESON,HALPERN,+       (PENN)
FLATTE   67 PRL 18 976          S.M.FLATTE                             (LRL)
FLATTE2  67 PR 163 1441         S.M.FLATTE AND C.G.WOHL                (LRL)
LITCHFIE 67 PL 24B 486          LITCHFIELD,RANGAN,SEGAR,SMITH+(RHEL+SACLAY)
PRICE    67 PRL 18 1207         L.R.PRICE,F.S.CRAWFORD                 (LRL)

ARNOLD   68 PL 27B 466          +PATY,BAGLIN,BINGHAM+  (STRB+MADR+EPOL+UCB)
BAZIN    68 PRL 20 895          BAZIN,GOSHAW,ZACHER,+    (PRINCETON,QUEENS)
BULLOCK  68 PL 27B 402          +ESTEN,FLEMING,GOVAN,HENDERSON,OWEN+ (LOUC)
GORMLEY3 68 PRL 21 402          GORMLEY,HYMAN,LEE,NASH,PEOPLES+  (COLU+BNL)
WEHMANN  68 PRL 20 748          WEHMANN,ENGELS,+ (HARV+CASE+SLAC+CORN+MCGI)

BAGLIN   69 PL 29B 445          BAGLIN,BEZAGUET,+        (EPOL,UCB,MADR,STRB)
   ALSO  70 NP B22 66           +BEZAGUET,DEGRANGE,MUSSET +(EPOL,MADR,STRB)
HYAMS    69 PL 29B 128          HYAMS,KOCH,POTTER,VON LINDERN,+ (CERN,MPIM)
JACQUET  69 NC 58 743           JACQUET,NGUYEN-KHAC,HAATUFT+     (EPOL,BERG)
MULLER   69 THESIS              ARMAND MULLER                         (STRB)

BAGLIN   70 NP B22 66           +BEZAGUET,DEGRANGE,MUSSET+ (EPOL+MADR+STRB)
BUTTRAM  70 PRL 25 1358         +KREISLER,MISCHKE                     (PRIN)
CARPENTR 70 PR D1 1303          CARPENTER,BINKLEY,CHAPMAN,COX,DAGAN+ (DUKE)
COX      70 PRL 24 534          COX,FORTNEY,GOLSON                    (DUKE)

DANBURG  70 PR D2 2564          +ABOLINS,DAHL,DAVIES,HOCH,KIRZ,+       (LRL)
DEVONS   70 PR D1 1936          +GRUNHAUS,KOZLOWSKI,NEMETHY +    (COLU,SYRA)
GORMLEY  70 PR D2 501           GORMLEY,HYMAN,LEE,NASH,PEOPLES+  (COLU+BNL)
   ALSO  70 NEVIS 181(THESIS)   MICHAEL GORMLEY                       (COLU)
KANOFSKY 70 NC 68 413           A. KANOFSKY                           (LEHI)
SCHMITT  70 PL 32B 638          +BUNIATOV,ZAVATTINI,DEINET+      (CERN,KARL)

BASILE   71 NC 3A 796           +BOLLINI,DALPIAZ,FRABETTI+ (CERN,BGNA,STRB)
STRUGALS 71 NP B27 429          +CHUVILO,GEMESY,IVANOVSKAYA+          (JINR)
AGUILAR- 72 PR D6 29            AGUILAR-BENITEZ,CHUNG,EISNER,SAMIOS    (BNL)
BLOODWOR 72 NP B39 525          BLOODWORTH,JACKSON,PRENTICE,YOON  (TORONTO)
LAYTER   72 PRL 29 316          +APPEL,KOTLEWSKI,LEE,STEIN,THALER     (COLU)
THALER   72 PRL 29 313          +APPEL,KOTLEWSKI,LAYTER,LEE,STEIN     (COLU)

LAYTER   73 PR D7 2565          +APPEL,KOTLEWSKI,LEE,STEIN,THALER     (COLU)
THALER   73 PR D7 2569          +APPEL,KOTLEWSKI,LAYTER,LEE,STEIN     (COLU)
BROWMAN  74 PRL 32 1067         +DEWIRE,GITTELMAN,HANSON,LOH +  (CORN+BING)
DAVIES   74 NC 24A 324          +GUY,ZIA                   (BIRM+RHEL+SHMP)
JANE1    74 PL 48B 260          +JONES,LIPMAN,OWEN,PENNEY+ (RHEL+LOWC+SUSS)
JANE2    74 PL 48B 265          +JONES,LIPMAN,OWEN,PENNEY+ (RHEL+LOWC+SUSS)
KENDALL  74 NC 21A 387          +LANOU,MASSIMO,SHAPIRO +    (BROW+BARI+MIT)

JANE1    75 PL 59B 99           +GRANNIS,JONES,LIPMAN,OWEN +     (RHEL+LOWC)
JANE2    75 PL 59B 103          +GRANNIS,JONES,LIPMAN,OWEN +     (RHEL+LOWC)
   ALSO  76 PL (TO BE PUBL.)    ERRATUM, M.R.JANE, PRIVATE COMMUNICATION.
MARTYNOV 76 SJNP 23 48          +SALTYKOV,TARASOV,UZHINSKII           (JINR)
BUSHNIN  78 PL 79B 147          +DZHELYADIN,GOLOVKIN,GRITSUCK +       (SERP)
   ALSO  78 SJNP 28 775         BUSHNIN,GOLOVKIN,GRITSUK,DZHELYADIN+  (SERP)

ABROSIMO 80 SJNP 31 195         ABROSIMOV,ILINA,NISZCZ,OKHRIMENKO+    (JINR)
DZHELYA1 80 PL 94B 548          DZHELYADIN,GOLOVKIN,KACHANOV +        (SERP)
   ALSO  80 SJNP 32 516 (YF 32 998) VIKTOROV, GOLOVKIN +              (SERP)
DZHELYA2 80 PL 97B 471          DZHELYADIN,GOLOVKIN,KACHANOF +        (SERP)
   ALSO  80 SJNP 32 518 (YF 32 1002) VIKTOROV, GOLOVKIN +             (SERP)

DAVYDOV  81 LNC 32 45           +DONSKOV,INYAKIN +     (SERP+BELG+LAPP+CERN)
   ALSO  81 SJNP 33 825 (YF 33 1534) BINON,BRICMAN+ (SERP+BELG+LAPP+CERN)
DZHELYAD 81 PL 105B 239         DZHELYADIN,GOLOVKIN,KONSTANTINOV +    (SERP)
   ALSO  81 SJNP 33 822 (YF 33 1529) VIKTOROV,GOLOVKIN+               (SERP)
BINON    82 SJNP 36 391         +BRICMAN,GOUANERE+     (SERP+BELG+LAPP+CERN)
   ALSO  82 NC 71A 497          BINON,BRICMAN,DAVYDOV+(SERP+BELG+LAPP+CERN)
WEINSTEI 83 PR D28 2896         WEINSTEIN+         (HARV+CIT+PRIN+STAN+SLAC)

       QUANTUM NUMBER DETERMINATIONS NOT REFERRED TO IN THE DATA CARDS

BASTIEN  62 PRL 8 114           BASTIEN,BERGE,DAHL,FERRO-LUZZI,MILLER+(LRL)
CARMONY  62 PRL 8 117           D CARMONY,A ROSENFELD,VAN DE WALLE    (LRL)
ROSENFEL 62 PRL 8 293           A ROSENFELD,D CARMONY,VAN DE WALLE    (LRL)
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$K^{\pm}$

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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 REPL.BY KUNSELMAN74  10/71
M          493.691     0.040           BACKENSTO 73 CNTR  - KAONIC ATOMS        1/73
M          493.662     0.19            KUNSELMAN 74 CNTR  - KAONIC ATOMS        3/74
M          493.657     0.020           CHENG     75 CNTR -  KAONIC ATOMS        6/77
M          493.670     0.029           BARKOV    79 EMUL +- E+E- --> K+ K-      7/79
M          493.640     0.054           LUM       81 CNTR -  KAONIC ATOMS        1/82
M
M   AVG    493.666     0.015     AVERAGE
M   FIT    493.667     0.015     FROM FIT                                      3/84*
------ --------- --------- --------- --------- --------- --------- --------

                10  (K+) - (K-) MASS DIFFERENCE (MEV)

DM       TEST OF CPT
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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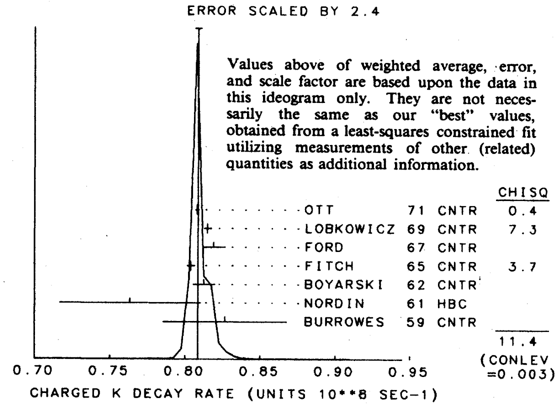
                10  CHARGED K MEAN LIFE (UNITS 10**-8 SEC)

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)
```

WEIGHTED AVERAGE = 0.8084 ± 0.0021
ERROR SCALED BY 2.4

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          10  ((K+) - (K-))/AVG., MEAN LIFE DIFFERENCE (PERCENT)

DT   N    THIS QUANTITY IS A MEASURE OF CPT INVARIANCE IN W.I.

DT           0.47      0.30          FORD       67 CNTR                        8/67
DT           0.090     0.078         LOBKOWICZ 69 CNTR                       12/70
DT         . . . . . . . . .
DT   AVG     0.114     0.093    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
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                 10  CHARGED K PARTIAL DECAY MODES

                                                              DECAY MASSES
P1       CHAR. K INTO MU NEU                  K MU2          106+   0
P2       CHAR. K INTO PI PIO                  K PI2          140+ 135
P3       CHAR. K INTO PI PI+ PI-              TAU            140+ 140+ 140
P4       CHAR. K INTO PI 2PIO                 TAU PRIME      140+ 135+ 135
P5       CHAR. K INTO MU PIO NEU              K MU3          106+ 135+   0
P6       CHAR. K INTO E PIO NEU               K E3          .511+ 135+   0
P7       K+ INTO PI+ PI- E+ NEU               K E+ 4         140+ 140+.511+   0
P8       K+ INTO PI+ PI+ E- NEU               K E- 4         140+ 140+.511+   0
P9       K+ INTO PI+ PI- MU+ NEU              K+MU+ 4        140+ 140+ 106+   0
P10      K+ INTO PI+ PI+ MU- NEU              K+MU- 4        140+ 140+ 106+   0
P11      CHAR. K INTO E NEU                   K E2          .511+   0
P12      CHAR. K INTO MU NEU GAMMA            K MU RAD       106+   0+   0
P13      CHAR. K INTO PI PIO GAMMA            K PI RAD       140+ 135+   0
P14      CHAR. K INTO PI PI+ PI- GAMMA        TAU RAD        140+ 140+ 140+   0
P15      CHAR. K INTO PI E+ E-                PI E E         140+.511+.511
P16      CHAR. K INTO PI MU+ MU-              PI MU MU       140+ 106+ 106
P17      CHAR. K INTO PI GAMMA GAMMA          PI GAM GAM     140+   0+   0
P18      CHAR. K INTO PIO E NEU GAMMA         PI E NEU GAM   135+.511+   0+   0
P19      K+- INTO PI-+ E+- E+-                PI-+E+-E+-     140+.511+.511
P20      CHAR. K INTO PI NEU NEU              PI NEU NEU     140+   0+   0
P21      CHAR. K INTO E NEU GAMMA             K E2 RAD      .511+   0+   0
P22      CHAR. K INTO PI GAMMA                K PI GAM       140+   0
P23      CHAR. K INTO PI 3GAMMA               PI 3GAM        140+   0+   0+   0
P24      CHAR. K INTO PIO PIO E NEU           K E4 2PIO      135+ 135+.511+   0
P25      K+ INTO PI- E+ MU+                   PI-E+MU+       140+.511+ 106
P26      K+ INTO PI+ E+ MU-                   PI+E+MU-       140+.511+ 106
P27      CHAR. K INTO MU NEU NEU NEUBAR       MU 3NEU        106+   0+   0+   0
P28      CHAR. K INTO PIO MU NEU GAMMA        PI MU NEU GAM  135+ 106+   0+   0
P29      K+ INTO PI+ MU+ E-                   PI+MU+E-       140+ 106+.511
P30      CHAR. K INTO MU NEU E+ E-            MU NEU E+E-    106+   0+.511+.511
P31      K+- INTO MU-+ NEU E+- E+-            MU-+ NEU 2E+-  106+   0+.511+.511
P32      CHAR. K INTO NEU E E E               NEU 3E           0+.511+.511+.511
P33      CHAR. K INTO E NEU NEU NEUBAR        E 3NEU        .511+   0+   0+   0
P34      K+ INTO MU+ NEU(E)                                  106+   0
P35      K+ INTO MU+ NEUBAR(E)                               106+   0
P36      K+ INTO PIO E+ NEUBAR(E)                            135+.511+   0
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                   CHARGED K CONSTRAINED FIT
             OVERALL FIT OF MEAN LIFE, WIDTHS AND BRANCHING
             RATIOS USES 59 DATA POINTS TO DETERMINE SIX
             QUANTITIES.  OVERALL FIT HAS CHISQ=78.0.  MAIN                4/82
             CONTRIBUTION (13.2) COMES FROM R19 OF HAIDT                   4/82
             71 (WE SEE NO REASON TO REJECT THIS EXPERIMENT                4/82
             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 $\delta P_i = \sqrt{(\delta P_i \delta P_i)}$, while the off-diagonal elements are the normalized correlation coefficients $(\delta P_i \delta P_j)/(\delta P_i \cdot \delta P_j)$. For the definitions of the individual P_i, see the listings above; only those P_i appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

```
          P 1        P 2        P 3        P 4        P 5        P 6
P 1  .6351+-.0016
P 2   -.7202   .2117+-.0015
P 3   -.1749     -.0208   .0559+-.0003
P 4   -.1578      .0502      .2232   .0173+-.0005
P 5   -.2912     -.2519     -.1649     -.3566   .0318+-.0010
P 6   -.3397     -.1448      .1407      .0043      .2208   .0482+-.0005
```

FITTED PARTIAL DECAY MODE RATES

The matrix below is the branching fraction matrix above, transformed into rate space; i.e., $G_i \equiv \Gamma_i = \Gamma_{total} P_i$, in appropriate units. In analogy to the matrix above, the diagonal elements are $G_i \pm \delta G_i$, where $\delta G_i = \sqrt{(\delta G_i \delta G_i)}$, while the off-diagonal elements are the normalized correlation coefficients $(\delta G_i \delta G_j)/(\delta G_i \cdot \delta G_j)$. 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  .5134+-.0017
G 2   -.3170   .1711+-.0013
G 3   -.0862      .0116   .0452+-.0002
G 4   -.0904      .0629      .2263   .0140+-.0004
G 5   -.1815     -.2190     -.1725     -.3534   .0257+-.0008
G 6   -.1566     -.0868      .1432      .0095      .2270   .0390+-.0004
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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     51.34     0.17    FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

W2      CHAR. K INTO PI PI+ PI- (UNITS 10**6 SEC-1)       (G3)
W2   F      (4.496)  (0.030)           FORD       67 CNTR +- SEE NOTE F      8/67
W2   F 3.2M (4.529)  (0.032)           FORD       70 ASPK    SEE NOTE F     11/70
W2           4.511    0.024            FORD       70 ASPK    SEE NOTE F     11/70
W2   F   THE LAST IS THE COMBINED RESULT OF FORD 67 AND FORD 70
W2         . . . . . . . . .
W2   FIT     4.518    0.023    FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)
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          10  ((K+) - (K-))/AVG., DECAY RATE DIFFERENCE (PERCENT)

D1      DIFFERENCE IN K MU2 RATES      ((G1+)-(G1-))/G1        (PERCENT)
D1           -0.54     0.41            FORD       67 CNTR                    8/67

D2      DIFFERENCE IN TAU RATES        ((G3+)-(G3-))/G3        (PERCENT)
D2           -0.50     0.90            FLETCHER   67 OSPK                    8/67
D2   F      (-0.04)   (0.21)           FORD       67 CNTR    SEE NOTE F      8/67
D2   F 3.2M  (0.10)   (0.14)           FORD       70 ASPK    SEE NOTE F     11/70
D2 F          0.08     0.12            FORD       70 ASPK    SEE NOTE F     11/70
D2   S      (-0.02)   (0.16)           SMITH      73 ASPK +-                11/73
D2   F   SECOND FORD 70 VALUE IS FIRST FORD 70 COMBINED WITH FORD 67.
D2   S   SMITH 73 VALUE OF D2 IS DERIVED FROM SMITH 73 VALUE OF D3.         11/73
D2         . . . . . . . . .
D2   AVG      0.07     0.12    AVERAGE

D3      DIFFERENCE IN TAU PRIME RATES ((G4+)-(G4-))/AVERAGE   (PERCENT)
D3    1802   -1.1      1.8             HERZO      69 OSPK                    5/70
D3            0.08     0.58            SMITH      73 ASPK +-                11/73
D3         . . . . . . . . .
D3   AVG     -0.03     0.55    AVERAGE

D4      DIFFERENCE IN K PI2 RATES      ((G2+)-(G2-))/AVERAGE   (PERCENT)
D4            0.8      1.2             HERZO      69 OSPK                    5/70

D5      DIFFERENCE IN K PI RAD RATES  ((G13+)-(G13-))/AVERAGE (PERCENT)
D5      24    0.0     24.0             EDWARDS    72 OSPK    PI KE 58-90 MEV   8/72
D5    4000    1.0      4.0             ABRAMS     73 ASPK +- PI KE 51-100 MEV  3/74
D5    2461    0.8      5.8             SMITH      76 WIRE +- PI+-KE 55-90 MEV 11/76
D5         . . . . . . . . .
D5   AVG      0.9      3.3     AVERAGE
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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     63.51     0.16    FROM FIT

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     21.17     0.15    FROM FIT
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Stable Particles

Data Card Listings

$K^{\pm}$

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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       5.589    0.030  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)
                       (SEE IDEOGRAM BELOW)
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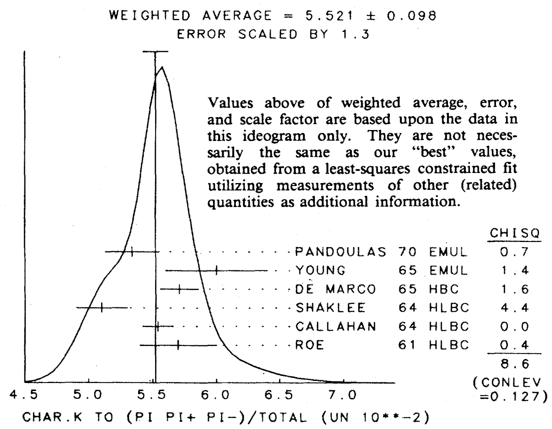


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R4      CHAR. K INTO (PI 2PIO)/TOTAL (UNITS 10**-2)       (P4)
R4  O        (2.1)    (0.5)              BIRGE      56 EMUL +
R4  O        (2.2)    (0.4)              ALEXANDER  57 EMUL +
R4  O        (1.5)    (0.2)              TAYLOR     59 EMUL +
R4  O   EARLIER EXPERIMENTS NOT AVERAGED
R4            1.7      0.2               ROE        61 HLBC +                 11/67
R4      108   1.8      0.2               SHAKLEE    64 HLBC +                 11/67
R4 P    198   1.53     0.11              PANDOULAS  70 EMUL +                 10/70
R4     1307   1.84     0.06              CHIANG     72 OSPK +  1.84 GEV/C K+   9/72
R4 P    INCLUDES EVENTS OF TAYLOR 59.
R4          . . . . . . . . .
R4  AVG       1.767    0.071   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
R4  FIT       1.733    0.046  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.4)
                       (SEE IDEOGRAM BELOW)
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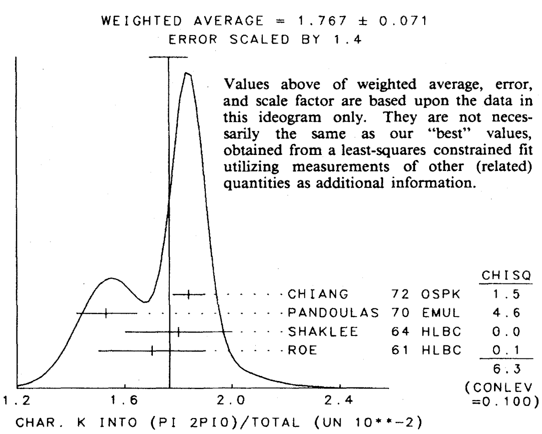


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R5      CHAR. K INTO (MU PIO NEU)/TOTAL (UNITS 10**-2)    (P5)
R5  O        (2.8)    (1.0)              BIRGE      56 EMUL +
R5  O        (5.9)    (1.3)              ALEXANDER  57 EMUL +
R5  O        (2.8)    (0.4)              TAYLOR     59 EMUL +
R5  O   EARLIER EXPERIMENTS NOT AVERAGED
R5     2345   3.33     0.16              CHIANG     72 OSPK +  1.84 GEV/C K+   9/72
R5          . . . . . . . . .
R5  FIT       3.180    0.095  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
R6  FIT       4.819    0.052  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)
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```
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     24.35     0.15  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R8      K+ INTO (PI+ PI+ E- NEU)/TOTAL (UNITS 10**-7)    (P8)
R8       TEST OF DELTA-S = DELTA-Q RULE
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      TEST OF DELTA-S = DELTA-Q RULE
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

R12     CHAR. K INTO (PI GAMMA GAMMA)/TOTAL (UNITS 10**-4)
R12                                                   (P17)
R12      ALL VALUES GIVEN HERE ASSUME A PHASE SPACE PION ENERGY SPECTRUM      2/72
R12       (-0.1)      (0.6)             CHEN       68 OSPK +  T(PI) 60-90 MEV   9/73
R12   0   (0.5)   OR LESS  CL=.90   KLEMS      71 OSPK +  T(PI)GT 117 MEV   8/71
R12   0   (0.35)  OR LESS  CL=.90   LJUNG      73 HLBC +  6-102,114-127MEV  9/73
R12   0  (-0.42)     (0.52)            ABRAMS     77 SPEC +  T(PI)LT 92 MEV   12/77
R12   0    0.084  OR LESS  CL=.90   ASANO      82 CNTR +  TPI=117-127 MEV  11/82*

R13     CHAR. K INTO (PI PIO GAMMA)/TOTAL (UNITS 10**-4) (P13)
R13 O   18   (2.2)      (0.7)              CLINE      64 FBC  +  PI+ KE 55-80 MEV  8/66
R13      0   (1.9)   OR LESS  CL=.90   EMMERSON   69 OSPK    PI+ KE 55-80 MEV 10/69
R13  M   0   (1.0)   OR LESS              MALTSEV    70 HLBC +  PI+ KE LT 55 MEV 12/75
R13  A2100    2.71      0.19              ABRAMS     72 ASPK +- PI+ KE 55-90 MEV  1/73
R13 O   24   (2.4)      (0.8)              EDWARDS    72 OSPK    PI+ KE 58-90 MEV  8/72
R13 L        (1.5)      (1.1)     (0.6)   LJUNG      73 HLBC +  PI+ KE 55-80 MEV  9/73
R13 L        (2.6)      (1.5)     (1.1)   LJUNG      73 HLBC +  PI+ KE 55-90 MEV  9/73
R13 OL  17   (6.8)      (3.7)     (2.1)   LJUNG      73 HLBC +  PI+ KE 55-102MEV  9/73
R13   2461    2.87      0.32              SMITH      76 WIRE +- PI+-KE 55-90 MEV 11/76
R13 O   ONLY HIGH STATISTICS EXPERIMENTS ARE AVERAGED.                           3/78
R13  M  MALTSEV 70 SELECTS LOW PI+ ENERGY TO ENHANCE DIRECT EMISSION CONTR.   1/76
R13  L  THE LJUNG 73 VALUES ARE NOT INDEPENDENT.                                9/73
R13  A  ABRAMS 72 OBSERVES DIRECT EMISSION BR. RATIO OF (1.56+-0.35)*10**-5   1/73
R13  A  +-0.5*10**-5 ADDNL. SYST. ERROR  AND INNER BREMSSTRAHLUNG BR. RATIO   1/73
R13  A  OF (2.55+-0.18)*10**-4.  WE QUOTE THE SUM OF THESE BR. RATIOS.        1/73
R13          . . . . . . . . .
R13 AVG       2.75      0.16    AVERAGE

R14     CHAR. K INTO (PI PI+ PI- GAMMA)/TOTAL (UNITS 10**-4)
R14                                                   (P14)
R14           1.0       0.4               STAMER     65 EMUL +  EGAM GT 11MEV      8/66

R15     CHAR. K INTO (PI E+ E-)/TOTAL (UNITS 10**-6)      (P15)
R15     1   (2.45) OR LESS  CL=.90   CAMERINI   64 FBC  +                     8/66
R15         (4.4)  OR LESS  CL=.90   BISI       67 DBC  +                    11/67
R15  C      (0.4)  OR LESS            CLINE1     67 FBC  +                    11/67
R15  C      (0.88) OR LESS  CL=.90   CLINE2     67 FBC  +                     2/74
R15        (32.0)  OR LESS  CL=.90   BEIER      72 OSPK +-                    9/72
R15         (1.7)  OR LESS  CL=.90   CENCE      74 ASPK +  THREE TRACK EVTS 10/74
R15         (0.27) OR LESS  CL=.90   CENCE      74 ASPK +  TWO TRACK EVENTS 10/74
R15  C  CLINE2 REPLACES CLINE1.  CLINE1 IS NOT FOR CL=.90 .                     2/74

R16     CHAR. K INTO (PI MU+ MU-)/TOTAL (UNITS 10**-6)    (P16)
R16         (3.0)  OR LESS  CL=.90   CAMERINI   65 FBC  +                     8/66
R16          2.4   OR LESS  CL=.90   BISI       67 DBC  +                    11/67

R17     CHAR. K INTO (PI PIO)/TAU                         (P2)/(P3)
R17    134   3.24      0.34              YOUNG      65 EMUL +                  8/66
R17   1045   3.96      0.15              CALLAHAN   66 FBC  +                  9/66
R17        . . . . . . . . .
R17 AVG      3.84      0.27    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.9)
R17 FIT      3.787     0.034  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R18     CHAR. K INTO (PI 2PIO)/TAU                        (P4)/(P3)
R18   2027   0.303     0.009             BISI       65 H+HL +                  8/66
R18     17   0.393     0.099             YOUNG      65 EMUL +                  8/66
R18        . . . . . . . . .
R18 AVG      0.3037    0.0090  AVERAGE
R18 FIT      0.3100    0.0079 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)

R19     CHAR. K INTO (MU PIO NEU)/TAU                     (P5)/(P3)
R19  B2845   0.63      0.07              BISI 1     65 H+HL +                  8/66
R19     38   0.90      0.16              YOUNG      65 EMUL +                  8/66
R19 H 1505  (0.510)   (0.017)            EICHTEN    68 HLBC +                 11/68
R19  H1505   0.503     0.019             HAIDT      71 HLBC +                 12/70
R19  B  ERROR ENLARGED FOR BACKGROUND PROBLEMS.  SEE GAILLARD 70.             11/83*
R19  H  HAIDT 71 IS A REANALYSIS OF EICHTEN 68.
R19        . . . . . . . . .
R19 AVG      0.517     0.032   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.8)
R19 FIT      0.569     0.018  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.9)
                       (SEE IDEOGRAM BELOW)

R20     CHAR. K INTO (E PIO NEU)/TAU                      (P6)/(P3)
R20    230   0.90      0.06              BORREANI   64 HBC  +                  8/66
R20     37   0.90      0.16              YOUNG      65 EMUL +                  8/66
R20    854   0.94      0.09              BELLOTT2   67 HLBC                   11/67
R20 H 4385  (0.846)   (0.021)            EICHTEN    68 HLBC +                 11/68
R20  H4385   0.850     0.019             HAIDT      71 HLBC +                 12/70
R20   2827   0.856     0.040             BRAUN      75 HLBC +                 12/75
R20  H  HAIDT 71 IS A REANALYSIS OF EICHTEN 68.
R20        . . . . . . . . .
R20 AVG      0.858     0.016   AVERAGE
R20 FIT      0.8622    0.0098 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R21     K+ INTO (PI+ PI- E+ NEU)/TAU (UNITS 10**-4)       (P7)/(P3)
R21     69   6.7       1.5               BIRGE      65 FBC  +                  8/66
R21    269   5.83      0.63              ELY        69 HLBC +                 11/68
R21    500   7.36      0.68              BOURQUIN   71 ASPK                   12/71
R21    106   7.0       0.9               SCHWEINBE  71 HLBC +                  9/71
R21    30K   7.21      0.32              ROSSELET   77 SPEC +                 11/77
R21        . . . . . . . . .
R21 AVG      6.98      0.26    AVERAGE

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
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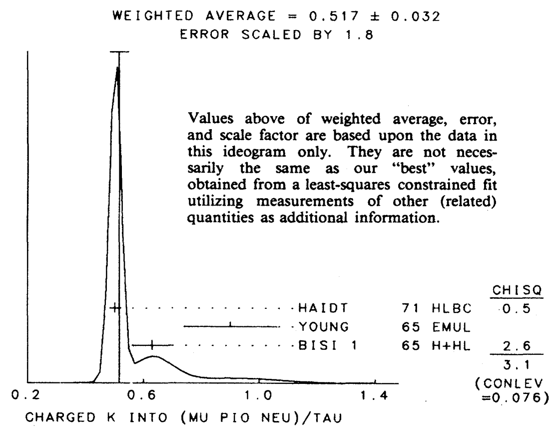
For notation, see key at front of Listings.

Stable Particles
$K^{\pm}$

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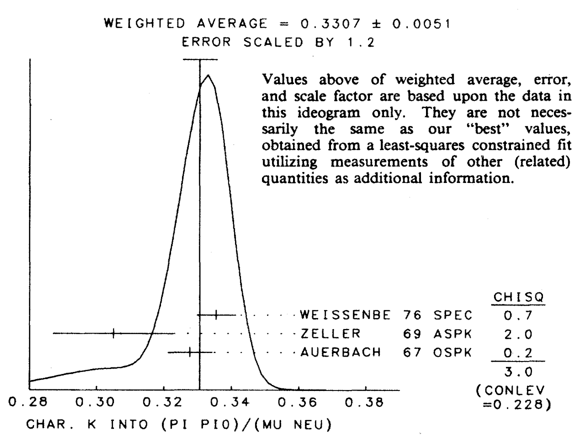
R23    CHAR. K INTO (E PIO NEU)/(MU2+PI2) (UNITS 10**-2)(P6)/(P1+P2)
R23   1679    5.89     0.21           CESTER    66 OSPK +               8/67
R23   5110    6.16     0.22           ESCHSTRUT 68 OSPK +               3/68
R23 W         5.92     0.65           WEISSENBE 76 SPEC +               1/78
R23 W  VALUE CALCULATED FROM WEISSENBERG 76 KE3, KMU2, KPI2 VALUES      1/78
R23 W  TO ELIMINATE DEPENDENCE ON OUR 1974 TAU AND TAU-PRIME FRACTIONS. 1/78
R23
R23 AVG       6.01     0.15    AVERAGE
R23 FIT       5.691    0.067  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)
R24    CHAR. K INTO (PI PIO)/(MU NEU)               (P2)/(P1)
R24  A4517    0.3277   0.0065         AUERBACH  67 OSPK +               1/74
R24   1600    0.305    0.018          ZELLER    69 ASPK +              10/69
R24 W  25K   (0.328)  (0.005)         WEISSENBE 74 STRC +               7/74
R24 W         0.3355   0.0057         WEISSENBE 76 SPEC +               1/78
R24 A  AUERBACH 67 CHANGED FROM .3253+-.0065.  SEE COMMENT WITH RATIO R26. 1/74
R24 W  WEISSENBERG 76 REVISES WEISSENBERG 74.                           1/78
R24
R24 AVG       0.3307   0.0051  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
R24 FIT       0.3333   0.0030 FROM FIT
                               (SEE IDEOGRAM BELOW)
```

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R25    CHAR. K INTO (E PIO NEU)/(MU NEU)               (P6)/(P1)
R25  A 295    0.0791   0.0054         AUERBACH  67 OSPK +               1/74
R25    960    0.0775   0.0033         BOTTERI1  68 ASPK +               5/68
R25    561    0.069    0.006          GARLAND   68 OSPK +               4/68
R25    350    0.069    0.006          ZELLER    69 ASPK +              10/69
R25 A  AUERBACH 67 CHANGED FROM .0797+-.0054.  SEE COMMENT WITH RATIO R26. 1/74
R25 A  THE VALUE .0785+-.0025 GIVEN IN AUERBACH 67 IS AN AVERAGE OF     3/74
R25 A  AUERBACH 67 R25 AND CESTER 66 R23.                               3/74
R25
R25 AVG       0.0752   0.0024  AVERAGE
R25 FIT       0.07588  0.00091 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R26    CHAR. K INTO (MU PIO NEU)/(MU NEU)              (P5)/(P1)
R26  A 307    0.0486   0.0040         AUERBACH  67 OSPK +               1/74
R26  G 424    0.0480   0.0037         GARLAND   68 OSPK +               1/74
R26    240    0.054    0.009          ZELLER    69 ASPK +              10/69
R26 A  AUERBACH 67 CHANGED FROM .0602+-.0046 BY ERRATUM WHICH BRINGS THE 1/76
R26 A  MU-SPECTRUM CALCULATION INTO AGREEMENT WITH GAILLARD 70 APPENDIX B. 1/74
R26 G  GARLAND 68 CHANGED FROM .055+-.004 IN AGREEMENT WITH MU-SPECTRUM  1/74
R26 G  CALCULATION OF GAILLARD 70 APPENDIX B.  L.G.PONDROM, PRIV.COMM.(73) 1/74
R26
R26 AVG       0.0488   0.0026  AVERAGE
R26 FIT       0.0501   0.0015 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.8)

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      11.363    0.072  FROM FIT

R28    CHAR. K INTO (E NEU)/(MU NEU) (UNITS 10**-5)      (P11)/(P1)
R28     10    1.9      0.7      0.5   BOTTERILL 67 ASPK +              11/67
R28      8    1.8      0.8      0.6   MACEK     69 ASPK +               4/69
R28    112    2.42     0.42           CLARK     72 OSPK +               1/73
R28    534    2.37     0.17           HEARD2    75 SPEC +              11/75
R28    404    2.51     0.15           HEINTZE   76 SPEC +               2/76
R28
R28 AVG       2.42     0.11    AVERAGE

R29    CHAR. K INTO (MU PIO NEU)/(E PIO NEU)            (P5)/(P6)
R29  C1509    0.703    0.056          CALLAHA1  66 HLBC                 6/68
R29   5601    0.667    0.017          BOTTERI2  68 ASPK +               6/68
R29 H 1398   (0.604)  (0.022)         EICHTEN   68 HLBC                10/68
R29 H        (0.596)  (0.025)         HAIDT     71 HLBC +              12/70
R29  D3480    0.698    0.025          CHIANG    72 OSPK +  1.84 GEV/C K+  9/72
R29  L 554    0.705    0.063          LUCAS2    73 HBC  -  DALITZ PRS ONLY 11/73
R29 B 1585   (0.608)  (0.014)         BRAUN     75 HLBC +               1/76
R29           0.67     0.12           WEISSENBE 76 SPEC +               1/78
R29 E        (0.670)  (0.014)         HEINTZE   77 SPEC +              12/77
R29                COMMENTS
R29  C  FROM CALLAHAN1 66 WE USE ONLY THE MU3/E3 RATIO AND DO NOT
R29  C  INCLUDE IN THE FIT THE RATIOS MU3/TAU AND E3/TAU, SINCE THEY SHOW
R29  C  LARGE DISAGREEMENTS WITH THE REST OF THE DATA.
R29 H   HAIDT 71 IS A REANALYSIS OF EICHTEN 68.
R29 H   ONLY INDIVIDUAL RATIOS INCLUDED IN FIT (SEE R19 AND R20).      11/68
R29  D  CHIANG 72 R29 IS STATISTICALLY INDEPENDENT OF CHIANG 72 R5 AND R6.  9/72
R29  L  LUCAS 73 GIVES N(MU3)=554+-7.6PCT, N(E3)=786+-3.1PCT.  WE DIVIDE. 11/73
R29 B   BRAUN 75 VALUE IS FROM FORM FACTOR FIT.  ASSUMES MU-E UNIVERSALITY. 1/76
R29 E   HEINTZE 77 VALUE FROM FIT TO LAMBDAO. ASSUMES MU-E UNIVERSALITY. 12/77
R29
R29 AVG       0.679    0.013   AVERAGE
R29 FIT       0.660    0.019  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.8)

R30    CHAR. K INTO (PIO E NEU GAMMA)/(PIO E NEU) (UNITS 10**-2)
R30                                                    (P18)/(P6)
R30          (1.2)    (0.8)           BELLOTT1  67 HLBC +  EGAM GT 30MEV  11/67
R30  R  13    0.76     0.28           ROMANO    71 HLBC    EGAM GT 10MEV  10/71
R30 R        (0.53)   (0.22)          ROMANO    71 HLBC +  EGAM GT 30 MEV  9/73
R30 L   16   (0.48)   (0.20)          LJUNG     73 HLBC +  EGAM GT 30 MEV  9/73
R30 L        (0.22)   (0.15)  (0.10)  LJUNG     73 HLBC +  EGAM GT 30 MEV  9/73
R30 L   FIRST LJUNG VALUE IS FOR COS(ELECT-GAMMA)L.T. 0.9, SECOND VALUE IS  9/73
R30 L   FOR COS(ELECT-GAMMA) BETW 0.6 AND 0.9 FOR COMPARISON WITH ROMANO.  9/73
R30 R   BOTH ROMANO VALUES ARE FOR COS(ELECT-GAMMA) BETW 0.6 AND 0.9.      9/73
R30 R   SECOND VALUE IS FOR COMPARISON WITH SECOND LJUNG VALUE.            9/73
R30 R   WE USE LOWEST EGAM CUT FOR TABLE VALUE. SEE ROMANO FOR EGAM DEPEND. 9/73

R31    K- INTO (PI+ E- E-)/TOTAL (UNITS 10**-5)        (P19)
R31    TEST OF TOTAL 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 C        (1.4)  OR LESS  CL=.90   KLEMS     71 OSPK +  T(PI) 117-127MEV  3/74
R32 C        (0.94) OR LESS  CL=.90   CABLE     73 CNTR +  T(PI) 60-105 MEV  2/74
R32  C       (0.56) OR LESS  CL=.90   CABLE     73 CNTR +  T(PI) 60-127 MEV  2/74
R32  L   0  (57.0)  OR LESS  CL=.90   LJUNG     73 HLBC +                    9/73
R32           0.14  OR LESS  CL=.90   ASANO     81 CNTR +  T(PI) 116-127MEV  1/82
R32  C  KLEMS 71 AND CABLE 73 ASSUME PI SPECTRUM SAME AS KE3 DECAY.         3/74
R32  C  SECOND CABLE LIMIT COMBINES CABLE AND KLEMS DATA FOR VECTOR INT.    2/74
R32  L  LJUNG 73 ASSUMES VECTOR INTERACTION.                                9/73

R33    CHAR. K INTO (E NEU GAMMA)/TOTAL  (UNITS 10**-5) (P21)
R33  M       (7.1)  OR LESS               MACEK     70 OSPK +  P(E) 234 TO 247  12/70
R33  M  ABOVE IS MEASUREMENT OF STRUCTURE-DEPENDENT DECAY ONLY.

R34    CHAR. K INTO (PI GAMMA)/TOTAL (UNITS 10**-6)     (P22)
R34    VIOLATES ANGULAR MOMENTUM CONSERVATION.  NOT LISTED IN TABLES.
R34  K       (4.0)  OR LESS  CL=.90   KLEMS     71 OSPK +               8/71
R34          (1.4)  OR LESS  CL=.90   ASANO     82 CNTR +              11/82*
R34  K  TEST OF MODEL OF SELLERI, NC 60A, 291(1969).

R36    CHAR. K INTO (PI 3GAMMA)/TOTAL (UNITS 10**-4)    (P23)
R36    VALUES GIVEN HERE ASSUME A PHASE SPACE PION ENERGY SPECTRUM.
R36          (3.0)  OR LESS  CL=.90   KLEMS     71 OSPK +  T(PI) GT 117MEV   8/71
R36           1.0   OR LESS  CL=.90   ASANO     82 CNTR +  TPI=117-127 MEV  11/82*

R37    K+ INTO (PI+ PI+ E- NEU)/(PI+ PI- E+ NEU) (UNITS 10**-4)
R37                                                    (P8)/(P7)
R37    TEST OF DELTA-S = DELTA-Q RULE
R37     0 (130.)    OR LESS  CL=.95   BOURQUIN  71 ASPK                 8/76
R37  B  3    3.6    OR LESS  CL=.95   BLOCH     76 SPEC                 8/76
R37  B  CORRESPONDS TO 3E10-4 AT CL=.90.                                2/80

R38    CHAR. K INTO (PIO PIO E NEU)/KE3 (UNITS 10**-4)  (P24)/(P6)
R38     0  (37.0)   OR LESS  CL=.90   ROMANO    71 HLBC +              12/71
R38     2    3.8      5.0      1.2    LJUNG     73 HLBC +               9/73

R39    K+ INTO (PI- E+ MU+)/TOTAL (UNITS 10**-8)       (P25)
R39    K- INTO (PI+ E- MU-)/TOTAL IS ALSO INCLUDED HERE
R39          (2.8)  OR LESS  CL=.90   BEIER     72 OSPK +-              9/72

R40    K+ INTO (PI+ E+ MU-)/TOTAL (UNITS 10**-8)       (P26)
R40    K- INTO (PI- E- MU+)/TOTAL IS ALSO INCLUDED HERE
R40          (1.4)  OR LESS  CL=.90   BEIER     72 OSPK +-              9/72

R41    CHAR. K INTO (MU 3NEU)/TOTAL (UNITS 10**-6)      (P27)
R41  P   0    6.0   OR LESS  CL=.90   PANG      73 CNTR +              11/73
R41  P  PANG 73 ASSUMES MU SPECTRUM FROM NEU-NEU INTERACTION OF BARDIN 70.  3/74

R42    CHAR. K INTO (PIO MU NEU GAM)/TOTAL(UNITS 10**-5)(P28)               9/73
R42      0    6.1   OR LESS  CL=.90   LJUNG     73 HLBC +  EGAM GT 30 MEV   9/73

R43    CHAR. K INTO (E PIO NEU)/(PI PIO)               (P6)/(P2)
R43  L 786    0.221    0.012          LUCAS2    73 HBC  -  DALITZ PRS ONLY 11/73
R43  L  LUCAS 73 GIVES N(E3)=786+-3.1PCT, N(PI2)=3564+-3.1PCT.  WE DIVIDE. 11/73
R43
R43 FIT       0.2277   0.0031 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R44    CHAR. K INTO (PI 2PIO)/(PI PIO)                 (P4)/(P2)
R44  L 574    0.081    0.005          LUCAS2    73 HBC  -  DALITZ PRS ONLY 11/73
R44  L  LUCAS 73 GIVES N(PI 2PIO)=574+-5.9 PCT, N(PI2)=3564+-3.1 PCT.      11/73
R44  L  WE QUOTE 0.5*N(PI 2PIO)/N(PI2) WHERE 0.5 IS BECAUSE ONLY DALITZ    11/73
R44  L  PAIR PIO'S WERE USED.                                             11/73
R44
R44 FIT       0.0819   0.0022 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)

R45    CHAR. K INTO(MU NEU GAMMA)/TOTAL   (UNITS 10**-3) (P12)              7/74
R45     12    5.8      3.5            WEISSENBE 74 STRC +  E-GAMMA GT 9 MEV  7/74

R46    CHAR. K INTO (PI E+ E-)/(PI+ PI- E NEU) (UNITS 10**-3)  (P15)/(P7)
R46    TEST FOR DELTA-S = 1 WEAK NEUTRAL CURRENT.  ALLOWED BY COMBINED
R46    FIRST ORDER WEAK AND E.M. INTERACTIONS.
R46  B  41    7.0      1.3            BLOCH     75 SPEC +              11/75
R46  B  BLOCH 75 QUOTES THIS RESULT MULTIPLIED BY OUR 1974 KE4 BR.FRAC.  11/75

R47    CHAR. K INTO (E NEU GAM)/(E NEU)                (P21)/(P11)
R47    STRUCTURE DEPENDENT PART WITH + GAMMA HELICITY.
R47 H   56   (1.05)   (0.25)  (0.30)  HEARD1    75 SPEC +  P(E) 236 TO 247  11/75
R47 H   THIS VALUE IS INCLUDED IN THE SECOND HEINTZE 79 VALUE IN SEC.R54  11/75
R47 H   BELOW.                                                            11/75
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Stable Particles

Data Card Listings

$K^{\pm}$

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R48     K+ INTO (PI+-MU-+E+)/(PI+PI-E NEU) (UNITS 10**-4) (P25+P26)/(P7)     11/76
R48      TEST OF LEPTON FAMILY NUMBER OR TOTAL LEPTON NUMBER CONSERVATION.
R48  D   0    1.9   OR LESS  CL=.90   DIAMANTBE 76 SPEC +                    11/76
R48  D  DIAMANTBE 76 QUOTES THIS RESULT TIMES OUR 1975 KE4 BR. RATIO.        11/76

R49     K+ INTO (PI+ MU+ E-)/(PI+PI- E NEU) (UNITS 10**-4)  (P29)/(P7)       11/76
R48      TEST OF LEPTON FAMILY NUMBER CONSERVATION.
R49  D   0    1.3   OR LESS  CL=.90   DIAMANTBE 76 SPEC +                    11/76
R49  D  DIAMANTBE 76 QUOTES THIS RESULT TIMES OUR 1975 KE4 BR RATIO.         11/76

R50     CHAR. K INTO (MU NEU E+E-)/(PI+PI-ENEU) (UNITS 10**-3) (P30)/(P7)    11/76
R50 D   14   (3.3)    (0.9)           DIAMANTBE 76 SPEC +  M(EE) GT 140     11/76
R50  D  14   27.       8.             DIAMANTBE 76 SPEC +  EXTRAPOLATED BR  11/76
R50  D  DIAMANTBE 76 QUOTES THESE RESULTS TIMES OUR 1975 KE4 BR RATIO.       11/76
R50  D  THE SECOND DIAMANTBE 76 VALUE IS THE FIRST VALUE EXTRAPOLATED TO 0  11/76
R50  D  TO INCLUDE LOW MASS E PAIRS.                                         11/76

R51     K+ INTO(PI- E+ E+ )/(PI+ PI- E NEU) UNITS(10**-4) (P19)/(P7)         11/76
R51      TEST OF TOTAL LEPTON NUMBER CONSERVATION
R51  D   0    2.5   OR LESS  CL=.90   DIAMANTBE 76 SPEC +                    11/76
R51  D  DIAMANTBE 76 QUOTES THIS RESULT TIMES OUR 1975 BR RATIO.             11/76

R52     K+ INTO(MU- NEU E+ E+)/(PI+ PI- E NEU)  (UNITS 10**-3) (P31)/(P7)    11/76
R52      TEST OF LEPTON FAMILY NUMBER CONSERVATION.
R52  D   0    0.5   OR LESS  CL=.90   DIAMANTBE 76 SPEC +                    11/76
R52  D  DIAMANTBE 76 QUOTES THIS RESULT TIMES OUR 1975 KE4 BR RATIO.         11/76

R53     K+ INTO (NEU E+ E+ E-)/(PI+PI- E NEU) (UNITS 10**-2) (P32)/(P7)      11/76
R53      4    0.54     0.54     0.27  DIAMANTBE 76 SPEC +                    11/76
R53  D  DIAMANTBE 76 QUOTES THIS RESULT TIMES OUR 1975 KE4 BR RATIO.         11/76

R54     CHAR. K INTO (E NEU GAM)/(MU NEU)  (UNITS 10**-5)(P21)/(P1)
R54      STRUCTURE DEPENDENT PART WITH + GAMMA HELICITY
R54 H   51   (2.33)   (0.42)          HEINTZE   79 SPEC +                     7/79
R54  H 107    2.40     0.36           HEINTZE   79 SPEC +                     7/79
R54  H  SECOND HEINTZE 79 RESULT IS FIRST COMBINED WITH HEARD1 75 RESULT      7/79
R54  H  FROM SECTION R47 ABOVE.                                               7/79

R55     CHAR. K INTO (E NEU GAM)/TOTAL (UNITS 10**-4)    (P21)
R55      STRUCTURE DEPENDENT PART WITH - GAMMA HELICITY
R55  H        1.6   OR LESS  CL=.90   HEINTZE   79 SPEC +                     2/82
R55  H  IMPLIES (AXIAL VEC./VECTOR) AMPL. RATIO OUTSIDE RANGE -1.8 TO -.54.   2/82

R56     CHAR. K INTO (E NEU NEU NEUBAR)/(E NEU)          (P33)/(P11)          7/79
R56      0    3.8   OR LESS  CL=.90   HEINTZE   79 SPEC +                     7/79

R57     K+ INTO (MU+ NEU(E))/TOTAL                       (P34)
R57      FORBIDDEN BY LEPTON FAMILY NUMBER CONSERVATION.
R57      0    0.004 OR LESS  CL=.90   LYONS     81 HLBC 200GEV K+ N.B. BEAM  2/82
R57          (0.012)OR LESS  CL=.90   COOPER    82 HLBC WIDEBAND NEU BEAM    1/83*

R58     K+ INTO MU+ NEUBAR(E)/TOTAL (UNITS 10**-3)       (P35)
R58      FORBIDDEN BY TOTAL LEPTON NUMBER CONSERVATION.
R58           3.3   OR LESS  CL=.90   COOPER    82 HLBC WIDEBAND NEU BEAM    1/83*

R59     K+ INTO PIO E+ NEUBAR(E)/TOTAL                   (P36)
R59      FORBIDDEN BY TOTAL LEPTON NUMBER CONSERVATION.
R59           0.003 OR LESS  CL=.90   COOPER    82 HLBC WIDEBAND NEU BEAM    1/83*
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NOTE ON DALITZ PLOT PARAMETERS FOR $K \to 3\pi$ DECAYS

The Dalitz plot distribution for $K^{\pm} \to \pi^{\pm}\pi^{\pm}\pi^{\mp}$, $K^{\pm} \to \pi^0\pi^0\pi^{\pm}$, and $K_L^0 \to \pi^+\pi^-\pi^0$ can be parametrized by a series expansion such as that introduced by Weinberg.[1] We use the form

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

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

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

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

Here the P_i are four-vectors, m_i and T_i are the mass and kinetic energy of the i^{th} pion, and the index 3 is used for the odd pion.

The coefficient g is a measure of the slope in the variable s_3 (or T_3) of the Dalitz plot, while h and k measure the quadratic dependence on s_3 and $(s_2 - s_1)$, respectively. The coefficient j is related to the asymmetry of the plot and must be zero if CP invariance holds. Note also that if CP is good, g, h, and k must be the same for $K^+ \to \pi^+\pi^+\pi^-$ as for $K^- \to \pi^-\pi^-\pi^+$.

Since different experiments use different forms for $|M|^2$, in order to compare the experiments we have converted to g, h, j, and k whatever coefficients have been measured. For details of this conversion and discussion of the data, see the April 1982 version of this note.[2]

See also the review of Devlin and Dickey,[3] which contains an analysis of $K \to 2\pi$ and $K \to 3\pi$ data in terms of transition amplitudes with appropriate energy dependence.

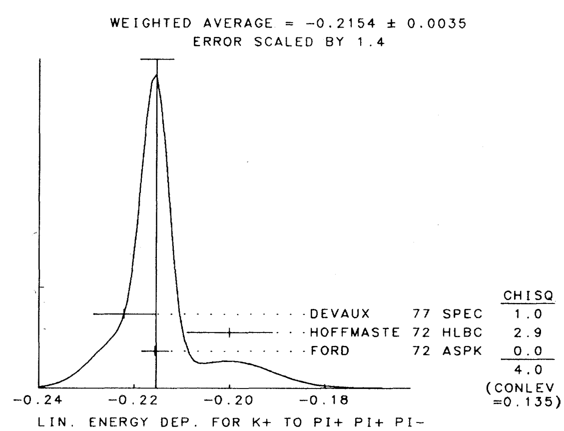
References

1. S. Weinberg, Phys. Rev. Lett. **4**, 87 (1960).
2. Particle Data Group, Phys. Lett. **111B**, 69 (1982).
3. T.J. Devlin and J.O. Dickey, Rev. Mod. Phys. **51**, 237 (1979).

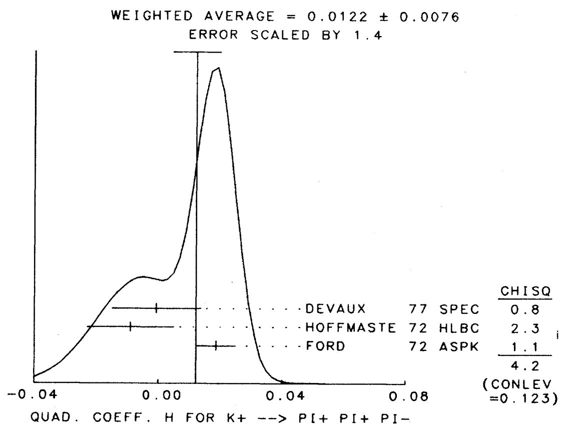

```
                10  CHARGED K ENERGY DEPENDENCE OF DALITZ PLOT

     MATRIX ELEMENT SQUARED = 1 + G*U + H*U**2 + K*V**2                      1/79
     WHERE U=(S3-S0)/(MPI**2) AND V=(S1-S2)/(MPI**2)                         1/79

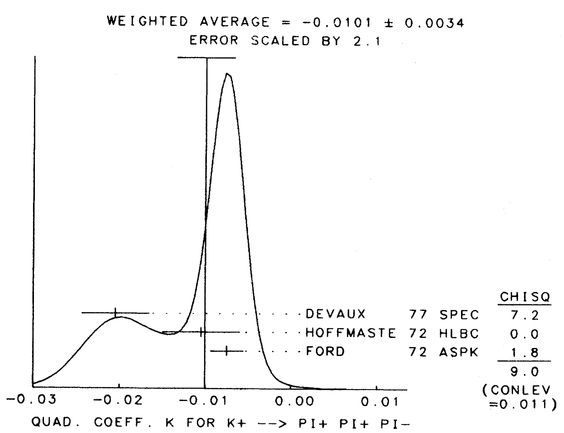
GT+     LINEAR COEFFICIENT G FOR TAU DECAYS K+ --> PI+ PI+ PI-               1/79
GT+        SOME  EXPTS USE DALITZ VARIABLES X AND Y. WE GIVE AY=COEFF OF Y   1/79
GT+        TERM AT RIGHT. SEE MINI-REVIEW ABOVE.                             1/79
GT+ZL 5428  (-0.22)   (0.024)          ZINCHENKO 67 HBC  +  AY=0.28+-.03    10/69
GT+ L 9994  (-0.218)  (0.016)          BUTLER    68 HBC  +  AY=0.277+-.020  10/69
GT+ G17898  (-0.196)  (0.012)          GRAUMAN   70 HLBC +  AY=0.228+-.030   8/70
GT+   750K   -0.2157   0.0028          FORD      72 ASPK +  AY=0.2734+-.0035 1/79
GT+H 39819   -0.200    0.009           HOFFMASTE 72 HLBC +                   1/79
GT+   225K   -0.2221   0.0065          DEVAUX    77 SPEC +  AY=0.2814+-.0082 1/79
GT+ L   EXPERIMENTS WITH LARGE ERRORS NOT INCLUDED IN AVERAGE.               3/78
GT+ Z   ALSO INCLUDES DBC EVENTS
GT+ G   EMULS. DATA ADDED - ALL EVENTS INCLUDED BY HOFFMASTER 72             1/71
GT+H    HOFFMASTER 72 INCLUDES GRAUMAN 70 DATA.                              1/79
GT+        . . . . . . . . . .
GT+ AVG      -0.2154   0.0035  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
                       (SEE IDEOGRAM BELOW)
```



```
HT+     QUADRATIC COEFF. H FOR K+ --> PI+ PI+ PI-                         1/79
HT+   750K    0.0187   0.0062           FORD       72 ASPK +              1/79
HT+  39819   -0.009    0.014            HOFFMASTE 72 HLBC +              1/79
HT+   225K   -0.0006   0.0143           DEVAUX     77 SPEC +              1/79
HT+           . . . . . . . . .
HT+ AVG       0.0122   0.0076  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
                       (SEE IDEOGRAM BELOW)
```




```
KT+     QUADRATIC COEFF. K FOR K+ --> PI+ PI+ PI-                         1/79
KT+   750K   -0.0075   0.0019           FORD       72 ASPK +              1/79
KT+  39819   -0.0105   0.0045           HOFFMASTE 72 HLBC +              1/79
KT+   225K   -0.0205   0.0039           DEVAUX     77 SPEC +              1/79
KT+           . . . . . . . . .
KT+ AVG      -0.0101   0.0034  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.1)
                       (SEE IDEOGRAM BELOW)
```



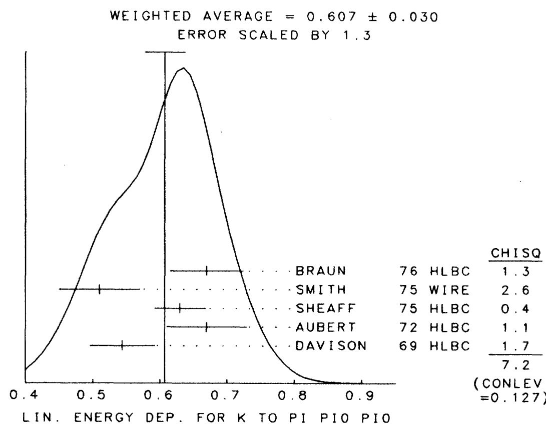

```
GT-     LINEAR COEFFICIENT G FOR TAU DECAYS K- --> PI- PI- PI+
GT-        FOR DEFINITION OF AY SEE NOTE IN SECTION GT+ ABOVE.
GT- F 1347  (-0.220)  (0.035)           FERRO-LUZ 61 HBC   - AY=0.28+-.045     10/69
GT-ML 5778  (-0.190)  (0.023)           MOSCOSO   68 HBC   - AY=0.242+-.029    10/69
GT-  50919   -0.193    0.010            MAST      69 HBC  -  AY=0.244 +-.013    1/79
GT-   750K   -0.2186   0.0028           FORD      72 ASPK -  AY=0.2770+-.0035   1/79
GT- Q  81K  (-0.199)  (0.008)           LUCAS1    73 HBC   - AY=0.252+-.011    10/72
GT- F   NO RADIATIVE CORRECTIONS INCLUDED.
GT- L   EXPERIMENTS WITH LARGE ERRORS NOT INCLUDED IN AVERAGE.                 3/78
GT- M   ALSO INCLUDES DBC EVENTS.
GT- Q  QUADRATIC DEPENDENCE IS REQUIRED BY KL EXPTS.  FOR COMPARISON WE        1/79
GT- Q  AVERAGE ONLY THOSE K+- EXPERIMENTS WHICH QUOTE QUADRATIC FIT VALUES.    1/79
GT-           . . . . . . . . .
GT- AVG      -0.2167   0.0066  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.5)

HT-     QUADRATIC COEFF H FOR K- --> PI- PI- PI+                          1/79
HT-  50919   -0.001    0.012            MAST       69 HBC  -              1/79
HT-   750K    0.0125   0.0062           FORD       72 ASPK -              1/79
HT-           . . . . . . . . .
HT- AVG       0.0097   0.0055  AVERAGE

KT-     QUADRATIC COEFF K FOR K- --> PI- PI- PI+                          1/79
KT-  50919   -0.014    0.012            MAST       69 HBC  -              1/79
KT-   750K   -0.0083   0.0019           FORD       72 ASPK -              1/79
KT-           . . . . . . . . .
KT- AVG      -0.0084   0.0019  AVERAGE

DG  ((GT+)-(GT-))/((GT+)+(GT-)) IN PERCENT
DG       A NON-ZERO VALUE FOR THIS QUANTITY INDICATES CP VIOLATION
DG    3.2M   -0.70     0.53             FORD       70 ASPK               11/70
```

```
GTP     LINEAR COEFFICIENT G FOR TAU PRIME DECAYS CHAR. K --> PI PIO PIO.
GTP     UNLESS OTHERWISE STATED, ALL EXPTS INCLUDE TERMS QUADRATIC IN
GTP     (S3-SO)/(MPI**2). SEE MINI-REVIEW ABOVE.
GTP K 1792    (0.48)    (0.04)          KALMUS     64 HLBC +                     1/79
GTP K 1874    (0.586)   (0.098)         BISI       65 HLBC +  ALSO HBC           1/79
GTP   4048     0.544     0.048          DAVISON    69 HLBC +  ALSO EMUL          1/79
GTP L  198    (0.527)   (0.102)         PANDOULAS 70 EMUL +                     1/79
GTP   1365     0.67      0.06           AUBERT     72 HLBC +                     1/79
GTP K  574    (0.484)   (0.084)         LUCAS2     73 HBC  -  DALITZ PRS ONLY    1/79
GTP   5635     0.630     0.038          SHEAFF     75 HLBC +                     1/79
GTP    27K     0.510     0.060          SMITH      75 WIRE +                     1/79
GTP L 4639    (0.806)   (0.220)         BERTRAND   76 EMUL +                     1/79
GTP   3263     0.670     0.054          BRAUN      76 HLBC +                     1/79
GTP K   AUTHORS GIVE LINEAR FIT ONLY.
GTP L   EXPERIMENTS WITH LARGE ERRORS NOT INCLUDED IN AVERAGE.
GTP           . . . . . . . . .
GTP AVG        0.607     0.030   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
                         (SEE IDEOGRAM BELOW)
```




```
HTP     QUADRATIC COEFF H FOR CHAR K --> PI PIO PIO. SEE MINI-REVIEW ABOVE.
HTP   4048     0.026     0.050          DAVISON    69 HLBC +  ALSO EMUL          1/79
HTP L  198    (0.018)   (0.124)         PANDOULAS 70 EMUL +                     1/79
HTP   1365    -0.01      0.08           AUBERT     72 HLBC +                     1/79
HTP   5635     0.041     0.030          SHEAFF     75 HLBC +                     1/79
HTP    27K     0.009     0.040          SMITH      75 WIRE +                     1/79
HTP L 4639    (0.164)   (0.121)         BERTRAND   76 EMUL +                     1/79
HTP   3263     0.152     0.082          BRAUN      76 HLBC +                     1/79
HTP L   EXPERIMENTS WITH LARGE ERRORS NOT INCLUDED IN AVERAGE.                   1/79
HTP           . . . . . . . . .
HTP AVG        0.034     0.020   AVERAGE
```

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NOTE ON $K^{\pm}_{\ell 3}$ AND $K^{0}_{\ell 3}$ FORM FACTORS

Assuming that only the vector current contributes to $K \to \pi \ell \nu$ decays, we write the matrix element as

$$M \propto f_+(t)[(P_K + P_\pi)_\mu \bar{\ell}\gamma_\mu(1+\gamma_5)\nu]$$

$$+ f_-(t)[m_\ell \bar{\ell}(1+\gamma_5)\nu] \,, \qquad (1)$$

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

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

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

Most $K_{\mu 3}$ data are adequately described by Eq. (2) for f_+ and a constant f_- (i.e., $\lambda_- = 0$). There are two equivalent parametrizations commonly used in these analyses:

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

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

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

Method A. By studying the Dalitz plot or the pion spectrum of $K_{\mu 3}$ decay. The Dalitz plot density is (see, e.g., Chounet et al.[4]):

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

where

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

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

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

$$E'_\pi = E_\pi^{\max} - E_\pi = (m_K^2 + m_\pi^2 - m_\mu^2)/2m_K - E_\pi \,.$$

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

Method B. By measuring the $K_{\mu 3}/K_{e3}$ branching ratio and comparing it with the theoretical ratio (see, e.g., Fearing et al.[5]) as given in terms of λ_+ and $\xi(0)$, assuming μ-e universality:

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

$$\Gamma(K_{\mu 3}^{0})/\Gamma(K_{e3}^{0}) = 0.6452 + 1.3162\lambda_+ + 0.1264\xi(0)$$
$$+ 0.0186\xi(0)^2 + 0.0064\lambda_+\xi(0) \,.$$

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

Method C. By measuring the muon polarization in $K_{\mu 3}$ decay. In the rest frame of the K, the μ is expected to be polarized in the direction **A** with $\mathbf{P} = \mathbf{A}/|\mathbf{A}|$, where **A** is given (Cabibbo and Maksymowicz[6]) by

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

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

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

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

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

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

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

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

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

For notation, see key at front of Listings.

See the 1982 version of this note[4] for additional discussion of the $K^0_{\mu 3}$ parameters, correlations, and conversion between parametrizations, and also for a comparison of the experimental results.

(b) K_{e3} experiments. Analysis of K_{e3} data is simpler than that of $K_{\mu 3}$ because the second term of the matrix element assuming a pure vector current [Eq. (1) above] can be neglected. Here f_+ is usually assumed to be linear in t, and the linear coefficient λ_+ of Eq. (2) is determined.

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

$$+ 2m_K f_S \bar{\ell}(1+\gamma_5)\nu$$

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

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

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

References

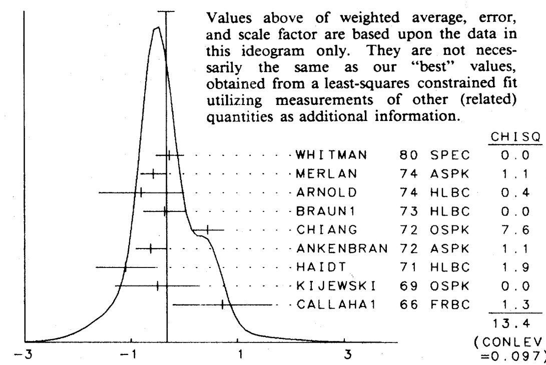
1. L.M. Chounet, J.M. Gaillard, and M.K. Gaillard, Phys. Rep. **4C**, 199 (1972).
2. H.W. Fearing, E. Fischbach, and J. Smith, Phys. Rev. **D2**, 542 (1970).
3. N. Cabibbo and A. Maksymowicz, Phys. Lett. **9**, 352 (1964).
4. Particle Data Group, Phys. Lett. **111B**, 73 (1982).

10 CHARGED K FORM FACTORS

```
IN THE FORM FACTOR COMMENTS, THE FOLLOWING ABBREVIATIONS ARE USED.
F+ AND F- ARE FORM FACTORS FOR THE VECTOR MATRIX ELEMENT.
FS AND FT REFER TO THE SCALAR AND TENSOR TERM.
F0 = (F+) + (F-)*T/(MK**2-MPI**2)
L+, L- AND L0 ARE THE LINEAR EXPANSION COEFFS. OF F+, F- AND F0.
L+ REFERS TO THE KMU3 VALUE EXCEPT IN THE KE3 SECTIONS.
DXI/DL IS THE CORRELATION BETWEEN XI(0) AND L+ IN KMU3.
DL0/DL+ IS THE CORRELATION BETWEEN L0 AND L+ IN KMU3.
T   = MOMENTUM TRANSFER TO THE PI IN UNITS OF MPI**2.
DP  = DALITZ PLOT ANALYSIS
PI  = PI SPECTRUM ANALYSIS
MU  = MU SPECTRUM ANALYSIS
POL= MU POLARIZATION ANALYSIS
BR  = KMU3/KE3 BRANCHING RATIO ANALYSIS
E   = POSITRON OR ELECTRON SPECTRUM ANALYSIS
RC  = RADIATIVE CORRECTIONS
```

```
XIA     XIA = F-/F+ (DETERMINED FROM SPECTRA)   ----------------------------
XIA     76  (+1.8)    (0.6)           BROWN     62 XEBC +  DP+BR, L+=0         1/74
XIA     87  (+0.7)    (0.5)           GIACOMELL 64 EMUL +  MU+BR RVUE, L+=0    1/74
XIA J       (-0.08)   (0.7)           JENSEN    64 XEBC +  DP+BR(KMU3,KE3)     1/74
XIA   2648  (0.0)     (1.1)   (0.9)   CALLAHA1  66 FRBC +  MU, L+=0, T UNKN    1/74
XIA  C 444  +0.72      0.93           CALLAHA1  66 FRBC +  PI, DXI/DL=-17      1/74
XIA     78  (-0.5)    (0.9)           EISLER    68 HLBC +  PI,L+=0,NO DX/DL    1/74
XIA  K2041  -0.5       0.8            KIJEWSKI  69 OSPK +  PI, DXI/DL=-26      1/74
XIA  H3240  -1.1       0.56           HAIDT     71 HLBC +  DP, DXI/DL=-29      1/74
XIA  A4025  -0.62      0.28           ANKENBRAN 72 ASPK +  PI, DXI/DL=-12      1/74
XIA  B3480  +0.45      0.28           CHIANG    72 OSPK +  DP, DXI/DL=-15      1/74
XIA  D1897  -0.36      0.40           BRAUN1    73 HLBC +  DP, DXI/DL=-19      3/74
XIA  N 490  -0.8       0.8            ARNOLD    74 HLBC +  DP, DXI/DL=-20     11/75
XIA  M6527  -0.57      0.24           MERLAN    74 ASPK +  DP, DXI/DL= -9      3/74
XIA   3973  -0.27      0.25           WHITMAN   80 SPEC +  DP, DXI/DL=-17      4/82
XIA         . . . . . . . . . . .
XIA AVG     -0.32      0.15    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
XIA FIT     -0.35      0.15   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 2.3)  3/84*
                      (SEE IDEOGRAM BELOW)
```

WEIGHTED AVERAGE = -0.32 ± 0.15
ERROR SCALED BY 1.3



XIA = F-/F+ FOR K+MU3 DECAY SPECTRA

```
XIA      FIT DISCUSSED IN NOTE ON KL3 FORM FACTORS IN 1982 EDITION.
XIA J    JENSEN 64 GIVES L+M=L+E=-.020+-.027. DXI/DL UNKNOWN. INCLUDES         1/74
XIA J    SHAKLEE 64 XIB(KMU3/KE3).                                              1/74
XIA  C   CALLAHAN 66 TABLE 1 (PI ANAL) GIVES DXI/DL=(.72-.05)/(0-.04)=-17,     1/74
XIA  C   ERROR RAISED FROM .80 TO AGREE WITH DXI0=.37 FOR FIXED L+.            1/74
XIA  K   KIJEWSKI 69 FIG. 17 WAS USED TO OBTAIN DXI/DL AND ERRORS.             1/74
XIA  H   HAIDT 71 TABLE 8 (DP ANAL) GIVES DXI/DL=(-1.1+0.5)/(.050-.029)=-29,  1/74
XIA  H   ERROR RAISED FROM .50 TO AGREE WITH DXI0=.20 FOR FIXED L+.            1/74
XIA  A   ANKENBRANDT 72 FIG. 3 WAS USED TO OBTAIN DXI/DL.                      1/74
XIA  B   CHIANG 72 FIG. 10 WAS USED TO OBTAIN DXI/DL.                          1/74
XIA  B   FIT HAD L-=L+ BUT WOULD NOT CHANGE FOR L-=0.  L.PONDROM,PRIV.COM.74   1/74
XIA  D   BRAUN1 73 GIVES XI(T)=-.34+-.20, DXI(T)/DL+=-14 FOR L+=.027, T=6.6.  3/74
XIA  D   WE CALCULATE ABOVE XI(0) AND DXI(0)/DL+ FOR THEIR L+=.025+-.017 .     3/74
XIA  N   ARNOLD 74 FIG. 4 WAS USED TO OBTAIN XIA AND DXI/DL.                  11/75
XIA  M   MERLAN 74 FIG.5 WAS USED TO OBTAIN DXI/DL.                            3/74

XIB     XIB = F-/F+ (DETERMINED FROM KMU3/KE3)  -------------------------
XIB      THE KMU3/KE3 BRANCHING RATIO FIXES A RELATIONSHIP BETWEEN XI(0)       1/74
XIB      AND L+.  WE QUOTE THE AUTHORS XI(0) AND ASSOCIATED L+ BUT DO NOT      1/74
XIB      AVERAGE BECAUSE THE L+ VALUES DIFFER.  THE FIT RESULT AND SCALE       1/74
XIB      FACTOR GIVEN IN THE ABOVE NOTE ON KL3 FORM FACTORS ARE NOT OBTAINED   2/76
XIB      FROM THESE XIB VALUES.  INSTEAD THEY ARE OBTAINED DIRECTLY FROM THE   2/76
XIB      FITTED KMU3/KE3 RATIO (R29), WITH THE EXCEPTION OF HEINTZE 77.        4/82
XIB         (-0.17)   (0.75)   (0.99) SHAKLEE   64 XEBC +  BR, L+=0            1/74
XIB         (+0.6)    (0.5)           BISI 1    65 HBC  +  BR, L+=0            1/74
XIB     500 (+0.8)    (0.6)           CUTTS     65 OSPK +  BR, L+=0            1/74
XIB     636 (+0.4)    (0.4)           CALLAHA1  66 FRBC +  BR, L+=0            1/74
XIB     306 (+0.75)   (0.50)          AUERBACH  67 OSPK +  BR, L+=0            1/74
XIB B 5601  (-0.08)   (0.15)          BOTTERIL2 68 ASPK +  BR,L+=.023+-.008    1/74
XIB E 1398  (-0.60)   (0.20)          EICHTEN   68 HLBC +  BR, SEE NOTE E      1/74
XIB     986 (+1.0)    (0.6)           GARLAND   68 OSPK +  BR, L+=0            1/74
XIB         (+0.91)   (0.82)          ZELLER    69 ASPK +  BR, L+=.023         1/74
XIB  B      (-0.35)   (0.22)          BOTTERIL  70 OSPK +  BR,L+=.045+-.015    1/74
XIB  E1505  (-0.81)   (0.27)          HAIDT     71 HLBC +  BR,L+=.028,FIG.8    1/74
XIB   5825  (0.0)     (0.15)          CHIANG    72 OSPK +  BR,L+=.03,FIG.10    1/74
XIB  H 55K  -0.12      0.12           HEINTZE   77 CNTR +  BR,L+=.029          3/78
XIB         . . . . . . . . . . .
XIB FIT     -0.35      0.15   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 2.3)  3/84*

XIB      FIT DISCUSSED IN NOTE ON KL3 FORM FACTORS IN 1982 EDITION.
XIB  B   BOTTERIL 70 IS REEVALUATION OF BOTTERIL 2 68 WITH DIFFERENT L+.       1/74
XIB E    EICHTEN 68 HAS L+=.023+-.008, T=4, INDEP. OF L-. REPL. BY HAIDT 71.   1/74
XIB  H   CALCULATED BY US FROM L0 AND L+ GIVEN BELOW.                          3/78

XIC     XIC = F-/F+ (DETERMINED FROM MU POLARIZATION IN KMU3)  ------------
XIC      THE MU POLARIZATION IS A MEASURE OF XI(T). NO ASSUMPTIONS ON L+-
XIC      NECESSARY, T (WEIGHTED BY SENSITIVITY TO XI0) SHOULD BE SPECIFIED.
XIC     IN L+,XI(0) PARAMETERIZATION THIS IS XI(0) FOR L+=0.  DXI/DL=XI*T.
XIC      FOR RAD. CORR. TO MUON POLARIZATION IN KMU3 SEE GINSBERG 71.
XIC T 2100  (+1.2)    (2.4)   (1.8)   BORREANI  65 HLBC +  POLARIZATION        8/67
XIC T  500 BTWN -4.0 AND +1.7         CUTTS     65 OSPK +  LONG. POL.          1/74
XIC T  397  (-1.4)    (1.8)           CALLAHA1  66 FRBC +  TOTAL POL.          8/67
XIC T 2950  (-0.7)    (0.9)   (3.3)   CALLAHA1  66 FRBC +  LONG. POL.          8/67
XIC  B6000  -1.0       0.3            BETTELS   68 HLBC +  TOTAL POL. T=4.9    1/74
XIC  C3133  -0.95      0.3            CUTTS     69 OSPK +  TOTAL POL. T=4.0    1/74
XIC M  40K  (-0.64)   (0.27)          MERLAN    74 ASPK +  POL,DXI/DL=+1.7     3/74
XIC  D1585  -0.25      1.20           BRAUN     75 HLBC +  POL. T=4.2          1/76
XIC         . . . . . . . . . . .
XIC AVG     -0.95      0.21    AVERAGE
XIC FIT     -0.35      0.15   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 2.3)  3/84*

XIC      FIT DISCUSSED IN NOTE ON KL3 FORM FACTORS IN 1982 EDITION.
XIC T    T VALUE NOT GIVEN.
XIC  B   BETTELS 68 DXI/DL=XI*T=-1.0*4.9=-4.9 .
XIC  C   CUTTS 69 T=4.0 WAS CALCULATED FROM FIG.8. DXI/DL=XI*T=-.95*4=-3.8 .   1/74
XIC M    MERLAN 74 POLARIZATION RESULT (FIG.5) NOT POSSIBLE.  SEE DISCUSSION   1/76
XIC M    OF POLARIZATION EXPERIMENTS IN NOTE ON KL3 FORM FACTORS ABOVE.        1/76
XIC  D   BRAUN 75 DXI/DL=XI*T=-.25*4.2=-1.0 .                                  1/76
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Stable Particles

Data Card Listings

K±

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IXI          IMAGINARY PART OF XI (TEST OF T REVERSAL)   --------------------
IXI    2648    0.0        1.0                CALLAHA1  66 FRBC +  MU                 1/74
IXI     397   +1.6        1.3                CALLAHA1  66 FRBC +  TOTAL POL.         1/74
IXI    2950    0.5        1.4        0.5     CALLAHA1  66 FRBC +  LONG. POL.         1/74
IXI    6000   -0.1        0.3                BETTELS   68 HLBC +  TOTAL POL.         1/74
IXI    3133   -0.3        0.3        0.4     CUTTS     69 OSPK +  TOTAL POL. FIG.7   1/74
IXI     20M   -0.016      0.025              CAMPBELL  81 CNTR +  POL.               1/82
IXI B   32M  (-0.010)    (0.019)             BLATT     83 CNTR    POLARIZATION       2/84*
IXI B    COMBINED RESULT OF MORSE 80 (K0MU3) AND CAMPBELL 81 (K+MU3).                2/84*
IXI           . . . . . . . . .
IXI AVG       -0.017      0.025    AVERAGE

L+M      LAMBDA +  (LINEAR ENERGY DEPENDENCE OF F+ IN KMU3 DECAY)   ---------
L+M       SEE ALSO THE CORRESPONDING ENTRIES AND FOOTNOTES IN SECTIONS XIA,
L+M       XIC, AND L0.
L+M       FOR RAD.COR. OF KMU3 DP SEE GINSBURG 70 AND BECHERRAWY 70.                 3/74
L+M     444    0.0        0.05               CALLAHA1  66 FRBC +  PI                 1/74
L+M    2041    0.009      0.026              KIJEWSKI  69 OSPK +  PI                 1/74
L+M    3240    0.050      0.018              HAIDT     71 HLBC +  DP                 1/74
L+M   A4025    0.024      0.019              ANKENBRAN 72 ASPK +  PI                 1/74
L+M    3480   -0.006      0.015              CHIANG    72 OSPK +  DP                 1/74
L+M    1897    0.025      0.017              BRAUN1    73 HLBC +  DP                 3/74
L+M     490    0.025      0.030              ARNOLD    74 HLBC +  DP                 7/74
L+M    6527    0.027      0.019              MERLAN    74 ASPK +  DP                 3/74
L+M    3973   +0.050      0.013              WHITMAN   80 SPEC +  DP                10/81
L+M           . . . . . . . . .
L+M AVG        0.0272     0.0072  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
L+M FIT        0.032      0.008  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 2.3)   3/84*

L+M       FIT DISCUSSED IN NOTE ON KL3 FORM FACTORS IN 1982 EDITION.
L+M  A    ANKENBRANDT 72 L+ FROM FIG.3 TO MATCH DXI/DL. TEXT GIVES .024+-.022   1/74

L0       LAMBDA 0 (LINEAR ENERGY DEPENDENCE OF F0 IN KMU3 DECAY)   ----------
L0        WHEREVER POSSIBLE, WE HAVE CONVERTED THE ABOVE VALUES OF XI(0) INTO
L0        VALUES OF L0 USING THE ASSOCIATED L+M AND DXI/DL.
L0 W    444   +0.058      0.036              CALLAHA1  66 FRBC +  PI,DL0/DL+=-0.37   1/74
L0 L   6000   -0.063     (0.024)             BETTELS   68 HLBC +  POL,DL0/DL+=+.60   1/74
L0 L   3133   -0.056     (0.024)             CUTTS     69 OSPK +  POL,DL0/DL+=+.69   1/74
L0 W   2041   -0.031      0.045              KIJEWSKI  69 OSPK +  PI,DL0/DL+=-1.10   1/74
L0 W   3240   -0.039      0.029              HAIDT     71 HLBC +  DP,DL0/DL+=-1.34   1/74
L0 W   4025   -0.026      0.013              ANKENBRAN 72 ASPK +  PI,DL0/DL+=+0.03   1/74
L0 W   3480   +0.030      0.014              CHIANG    72 OSPK +  DP,DL0/DL+=-0.21   1/74
L0      D1897 -0.008      0.020              BRAUN1    73 HLBC +  DP,DL0/DL+=-0.53   1/76
L0       490  -0.040      0.040              ARNOLD    74 HLBC +  DP,DL0/DL+=-0.62   7/74
L0   B       (-0.017)    (0.011)             BRAUN     74 HLBC +  KMU3/KE3 VS. T    11/75
L0 M   6527   -0.019      0.015              MERLAN    74 ASPK +  DP,DL0/DL+=+0.27   3/74
L0 L   1585   +0.008      0.097              BRAUN     75 HLBC +  POL,DL0/DL+=+.92   1/76
L0      H 55K +0.019     (0.010)             HEINTZE   77 SPEC +  BR,DL0/DL+=+0.03  12/77
L0     3973   +0.029      0.011              WHITMAN   80 SPEC +  DP,DL0/DL+=-0.37  10/81
L0            . . . . . . . . .
L0  AVG        0.0032     0.0099  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)
L0  FIT       +0.004      0.007  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 2.3)   3/84*
                          (SEE IDEOGRAM BELOW)
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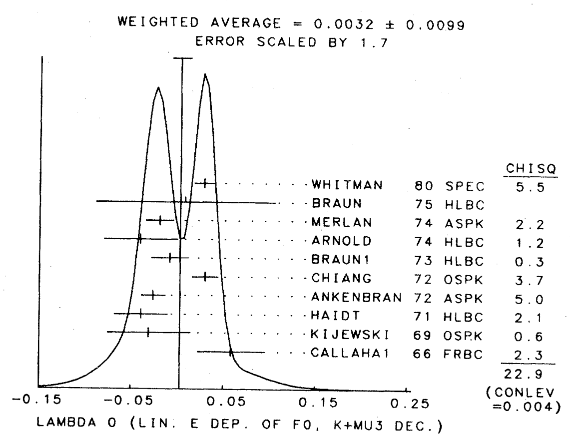


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L0        FIT DISCUSSED IN NOTE ON KL3 FORM FACTORS IN 1982 EDITION.
L0 W      L0 CALCULATED BY US FROM XI0, L+M, AND DXI/DL.                           1/74
L0 L      L0 VALUE IS FOR L+=0.03  CALCULATED BY US FROM XI0 AND DXI/DL.           1/74
L0    D   THIS VALUE AND ERROR ARE TAKEN FROM BRAUN 75 BUT CORRESPOND TO THE       1/76
L0    D   BRAUN1 73 L+M RESULT.  DL0/DL+ IS FROM BRAUN1 73 DXI/DL IN XIA ABV.      1/76
L0   B    BRAUN 74 IS A COMBINED KMU3-KE3 RESULT.  IT IS NOT INDEPENDENT OF       11/75
L0   B    BRAUN1 73 (KMU3) AND BRAUN2 73 (KE3) FORM FACTOR RESULTS.               11/75
L0 M      MERLAN 74 L0 AND DL0/DL+ WERE CALCULATED BY US FROM XIA, L+M, AND        3/74
L0 M      DXI/DL.  THEIR FIG.6 GIVES L0=-0.025+-0.012 AND NO DL0/DL+.              3/74
L0    H   HEINTZE 77 USES L+=0.029+-0.003.  DL0/DL+ ESTIMATED BY US.              12/77

L+E       LAMBDA +  (LINEAR ENERGY DEPENDENCE OF F+ IN KE3 DECAY)   ---------
L+E       FOR RAD.COR. OF KE3 DP SEE GINSBURG 67 AND BECHERRAWY 70.                3/74
L+E     217   +0.036      0.045              BROWN     62 XEBC +  PI, NO RC
L+E     407   -0.010      0.029              JENSEN    64 XEBC +  PI, NO RC          8/67
L+E     230   -0.04       0.05               BORREANI  64 HBC  +  E+, NO RC          8/67
L+E     854    0.045      0.017      0.018   BELLOTT2  67 FBC  +  DP, USES RC       11/67
L+E    1393   +0.016      0.016              IMLAY     67 OSPK +  DP, NO RC          8/67
L+E     515   +0.028      0.013      0.014   KALMUS    67 FBC  +  E+, PI, NO RC      8/67
L+E     960    0.08       0.04               BOTTERIL1 68 ASPK +  E+, USES RC        6/68
L+E      90   -0.02       0.08       0.12    EISLER    68 HLBC +  PI, USES RC        6/68
L+E    1458    0.045      0.015              BOTTERIL  70 OSPK    PI, USES RC       10/69
L+E    2707    0.027      0.010              STEINER   71 HLBC +  DP, USES RC       11/71
L+E    4017    0.029      0.011              CHIANG    72 OSPK +  DP, RC NEGLIGBLE   9/72
L+E  A         0.027      0.008              BRAUN2    73 HLBC +  DP, NO RC          3/74
L+E B         (0.025)    (0.007)             BRAUN     74 HLBC +  KMU3/KE3 VS. T    11/75
L+E  A    BRAUN2 73 STATES THAT RC OF GINSBERG 67 WOULD LOWER L+E BY .002 BUT      3/74
L+E  A    THAT RC OF BECHERRAWY DISAGREES AND WOULD RAISE L+E BY .005 .            1/76
L+E B     BRAUN 74 IS A COMBINED KMU3-KE3 RESULT.  IT IS NOT INDEPENDENT OF       11/75
L+E B     BRAUN1 73 (KMU3) AND BRAUN2 73 (KE3) FORM FACTOR RESULTS.               11/75
L+E           . . . . . . . . .
L+E AVG        0.0285     0.0043   AVERAGE

FS      FS/F+  RATIO OF SCALAR TO F+ COUPLINGS FOR KE3 DECAY(ABS. VALUE)----
FS             (0.18) OR LESS  CL=.90    BELLOTT2  67 HLBC                          10/69
FS             (0.30) OR LESS  CL=.95    KALMUS    67 HLBC +                        10/69
FS             (0.23) OR LESS  CL=.90    BOTTERIL1 68 ASPK                           8/66
FS     2707     0.14      0.03      0.04 STEINER   71 HLBC +  L+,FS,FT,PHI FIT       2/72
FS     4017    (0.13) OR LESS  CL=.90    CHIANG    72 OSPK +                         9/72
FS     2827     0.00      0.10           BRAUN     75 HLBC +                        12/75
FS            . . . . . . . . .
FS  AVG         0.125     0.044   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)

FT      FT/F+  RATIO OF TENSOR TO F+ COUPLINGS FOR KE3 DECAY(ABS. VALUE)----
FT             (0.58) OR LESS  CL=.90    BELLOTT2  67 HLBC                          10/69
FT             (1.1)  OR LESS  CL=.95    KALMUS    67 HLBC +                        10/69
FT             (0.58) OR LESS  CL=.90    BOTTERIL1 68 ASPK                           8/66
FT     2707     0.24      0.16      0.14 STEINER   71 HLBC +  L+,FS,FT,PHI FIT       2/72
FT     4017    (0.75) OR LESS  CL=.90    CHIANG    72 OSPK +                         9/72
FT     2827     0.07      0.37           BRAUN     75 HLBC +                        12/75
FT            . . . . . . . . .
FT  AVG         0.22      0.14    AVERAGE

FTM     FT/F+  RATIO OF TENSOR TO F+ COUPLINGS FOR KMU3 DECAY   ------------
FTM    1585     0.02      0.12           BRAUN     75 HLBC                           1/76

KE4     KE4 DECAY FORM FACTORS ARE GIVEN IN THE FOLLOWING PAPERS
KE4                                      BASILE    71 ASPK +                        11/75
KE4                                      BEIER     73 OSPK +-                       11/75
KE4                                      ROSSELET  77 SPEC +                         2/80

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REFERENCES FOR CHARGED K


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BIRGE    56 NC    4   834       BIRGE,PERKINS,PETERSON,STORK,WHITEHEA (LRL)
ILOFF    56 PR 102   927        ILOFF,GOLDHABER,LANNUTTI,GILBERT +    (LRL)
ALEXANDE 57 NC    6   478       ALEXANDER,JOHNSTON,OCEALLAIGH (DUBLIN INST)
COHEN    57 FUND.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       BORREANI,MARZARI-CHIESA,RINAUDO+   (TORINO)
BORREANI 65 PR 140 B1686        BORREANI,GIDAL,RINAUDO,CAFORIO+ (BARI,TORI)
CALLAHAN 65 PRL   15   129      A CALLAHAN,D CLINE              (WISCONSIN)
CAMERINI 65 NC 37 1795          +CLINE,GIDAL,KALMUS,KERNAN       (WISC+LRL)
CLINE    65 PL    15   293      A CLINE,W F FRY                 (WISCONSIN)
CUTTS    65 PR 138 B969         CUTTS,ELIOFF,STIENING                 (LRL)

DE MARCO 65 PR 140 B 1430       DE MARCO,GROSSO,RINAUDO       (TORINO+CERN)
FITCH    65 PR 140 B 1088       FITCH,QUARLES,WILKINS(PRINCETON+MT HOLYOKE)
GREINER  65 ARNS  15   67       QUOTED BY BARKAS                      (LRL)
STAMER   65 PR   138 B 440      STAMER,HUETTER,KOLLER,TAYLOR,GRAUMAN (STEV)
TRILLING 65 UCRL 16473          GEORGE H TRILLING                     (LRL)
   UPDATED FROM 1965 ARGONNE CONF., PAGE 5.
YOUNG    65 UCRL 16362          POH-SHIEN YOUNG (THESIS,BERKELEY)     (LRL)
   ALSO  67 PR 156 1464         P-S YOUNG,W.Z.OSBORNE,W.H.BARKAS      (LRL)

CALLAHA1 66 PR 150 1153         CALLAHAN,CAMERINI+(WISC,LRL,RIVERSIDE,BARI)
CALLAHAN 66 NC   44A 90         A C CALLAHAN                    (WISCONSIN)
CESTER   66 PL 21 343           CESTER,ESCHSTRUTH,ONEILL+  (PRINCETON-PENN)
   ALSO  67 AUERBACH, FOOTNOTE 1.

AUERBACH 67 PR 155  1505        +DOBBS,MANN,MCFARLANE,WHITE+    (PENN,PRIN)
   ALSO  74 PR D9 3216          ERRATUM
BELLOTT1 67 HEIDELBERG CONF     BELLOTTI,PULLIA                     (MILAN)
BELLOTT2 67 NC 52A  1287        BELLOTTI,FIORINI,PULLIA             (MILAN)
   ALSO  66 PL  20  690         BELLOTTI,FIORINI,PULLIA+            (MILAN)
BISI     67 PL 25B  572         BISI,CESTER,CHIESA,VIGONE          (TORINO)

BOTTERIL 67 PRL  19  982        BOTTERILL,BROWN,CORBETT,CULLIGAN + (OXFORD)
   ALSO  68 BOTTERIL
BOWEN    67 PR 154 1314         BOWEN,MANN,MCFARLANE,HUGHES+(PENN-PRINCETO)
CLINE1   67 HEIDELBERG CONF     CLINE,HAGGERTY,SINGLETON,FRY+   (WISCONSIN)
CLINE2   67 HERCEG NOVI TBL.4 D.CLINE,PROC.INTL.SCH.ON ELEM.PART.PHYSICS

FLETCHER 67 PRL  19  98         FLETCHER,BEIER,EDWRADS,+         (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+
   ALSO  71 HAIDT
BOTTERIL 68 PR 171 1402         BOTTERILL,BROWN,CLEGG,CORBETT +    (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)
EICHTEN  68 PL 27B 586          AACHEN-BARI-CERN-EP-ORSAY-PADOVA-VALENCIA
EISLER   68 PR  169  1090       EISLER,FUNG,MARATECK,MEYER,PLANO (RUTGERS)
ESCHSTRU 68 PR  165  1487       ESCHSTRUTH,FRANKLIN,HUGHES+(PRINCETON,PENN)
GARLAND  68 PR  167  1225       +TSIPIS,DEVONS,ROSEN+  (COLUMBIA,RUTG,WISC)
MOSCOSO  68  THESIS             M L MOSCOSO               (UNIV PARIS ORSAY)

CUTTS    69 PR 184 1380         +STIENING,WIEGAND,DEUTSCH         (LRL,MIT)
   ALSO  68 PRL 20 955          CUTTS,STIENING,WIEGAND,DEUTSCH    (LRL,MIT)
DAVISON  69 PR   180 1333       +BACASTOW,BARKAS,EVANS,FUNG,PORTER+   (UCR)
ELY      69 PR   180 1319       ELY,GIDAL,HAGOPIAN,KALMUS+  (LOUC+WISC+LRL)
EMMERSON 69 PRL 23 393          EMMERSON,QUIRK                     (OXFORD)

HERZO    69 PR 186 1403         +BANNER,BEIER,BERTRAM,EDWARDS +       (ILL)
KIJEWSKI 69 UCRL-18433 THESIS P K KIJEWSKI                            (LBL)
LOBKOWIC 69 PR 185 1676         +MELISSINOS,NAGASHIMA,TEWKSBURY+ (ROCH,BNL)
   ALSO  66 PRL 17 548          LOBKOWICZ,MELISSINOS,NAGASHIM+   (ROCH+BNL)
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For notation, see key at front of Listings.

Stable Particles

$K^{\pm}$, K^0, K^0_S

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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)
MALTSEV  70 SJNP 10 678         +PESTOVA,SOLODOVNIKOVA,FADEEV +      (JINR)
PANDOULA 70 PR D2 1205          +TAYLOR,KOLLER,GRAUMAN +        (STEV,SETO)

BASILE   71 PL 36B 619          +BREHIN,DIAMANT-BERGER,KUNZ+    (SACL+GEVA)
BOURQUIN 71 PL 36B 615          +BOYMOND,EXTERMANN,MARASCO+     (GEVA,SACL)
HAIDT    71 PR D3 10            AACHEN+BARI+CERN+EP+NIJMEGEN+ORSAY+PADOVA+
    ALSO 69 PL  29B 691         +(AACH,BARI,CERN,EPOL,NIJM,ORSAY,PADO,TORI)
KLEMS    71 PR D4 66            +HILDEBRAND,STIENING            (CHIC,LRL)
    ALSO 70 PRL 24 1086         KLEMS,HILDEBRAND,STIENING       (LRL,CHIC)
    ALSO 70 PRL 25 473          KLEMS,HILDEBRAND,STIENING       (LRL,CHIC)

KUNSELMA 71 PL 34B 485          R. KUNSELMAN                      (WYOMING)
OTT      71 PR D3 52            OTT,PRITCHARD                        (LOQM)
ROMANO   71 PL 36B 525          +RENTON,AUBERT,BURBAN-LUTZ (BARI,CERN,ORSA)
SCHWEINB 71 PL 36B 246          AACHEN+BELGIUM+CERN+NIJMEGEN+PADOVA COLLAB
STEINER  71 PL 36B 521          AACHEN+BARI+CERN+EPOL+ORSA+NIJM+PADO+TORIN

ABRAMS   72 PRL 29 1118         +CARROLL,KYCIA,LI,MENES,MICHAEL +     (BNL)
ANKENBRA 72 PRL 28 1472         ANKENBRANDT,LARSEN+   (BNL+LASL+FNAL+YALE)
AUBERT   72 NC 12A 509          +HEUSSE,PASCAUD,VIALLE+    (ORSA+BRUX+EPOL)
BEIER    72 PRL 29 678          +BUCHHOLZ,MANN,PARKER        (PENNSYLVANIA)
CHIANG   72 PR D6 1254          +ROSEN,SHAPIRO,HANDLER,OLSEN+   (ROCH+WISC)

CLARK    72 PRL 29 1274         +CORK,ELIOFF,KERTH,MCREYNOLDS,NEWTON+ (LBL)
EDWARDS  72 PR D5 2720          +BEIER,BERTRAM,HERZO,KOESTER +        (ILL)
FORD     72 PL 38B 335          +PIROUE,REMMEL,SMITH,SOUDER     (PRINCETON)
HOFFMAST 72 NP B36 1            HOFFMASTER,KOLLER,TAYLOR+  (STEV+SETO+LEHI)

ABRAMS   73 PRL 30 500          +CARROLL,KYCIA,LI,MENES,MICHAEL +     (BNL)
BACKENST 73 PL 43B 431          BACKENSTOSS,BAMBERGER+(CERN+KARL+HEID+STOH)
BEIER    73 PRL 30 399          +BUCHHOLZ,MANN,PARKER,ROBERTS        (PENN)
BRAUN1   73 PL 47B 182          AACHEN+BARI+BRUSSELS+CERN COLLABORATION
    ALSO 75 BRAUN
BRAUN2   73 PL 47B 185          AACHEN+BARI+BRUSSELS+CERN COLLABORATION
    ALSO 75 BRAUN
CABLE    73 PR D8 3807          +HILDEBRAND,PANG,STIENING         (EFI+LBL)

LJUNG    73 PR D8 1307          D.LJUNG,D.CLINE                      (WISC)
    ALSO 72 PRL 28 523          D.LJUNG                              (WISC)
    ALSO 72 PRL 28 1287         D.CLINE,D.LJUNG                      (WISC)
    ALSO 69 PRL 23 326          CAMERINI,LJUNG,SHEAFF,CLINE          (WISC)
LUCAS1   73 PR D8 719           LUCAS,TAFT,WILLIS                    (YALE)
LUCAS2   73 PR D8 727           LUCAS,TAFT,WILLIS                    (YALE)
PANG     73 PR D8 1989          +HILDEBRAND,CABLE,STIENING   (EFI+ARIZ+LBL)
    ALSO 72 PL 40B 699          CABLE,HILDEBRAND,PANG,STIENING    (EFI+LBL)
SMITH    73 NP B60 411          +BOOTH,RENSHALL,JONES+ (GLAS+LIVP+OXF+RHEL)

ARNOLD   74 PR D9 1221          C L ARNOLD,B P ROE,D SINCLAIR        (MICH)
BRAUN    74 PL 51B 393          +CORNELSSEN,MARTYN +  (AACH+BARI+BRUX+CERN)
CENCE    74 PR D10 776          +HARRIS,JONES,MORGADO +     (HAWA+LBL+WISC)
    ALSO 73 THESIS (UNPUBL.)    D B CLARKE                           (WISC)
KUNSELMA 74 PR C9 2469          R.KUNSELMAN                          (WYOM)
MERLAN   74 PR D9 107           +KASHA,WANDERER,ADAIR+      (YALE+BNL+LASL)
WEISSENB 74 PL 48B 474          WEISSENBERG,EGOROV,MINERVINA +  (ITEP+LEBD)

BLOCH    75 PL 56B 201          +BREHIN,BUNCE,DEVAUX+           (SACL+GEVA)
BRAUN    75 NP B89 210          +CORNELSSEN,MARTYN+   (AACH+BARI+BRUX+CERN)
CHENG    75 NP A254 381         +ASANO,CHEN,DUGAN,HU,WU,HUGHES+ (COLU+YALE)
HEARD1   75 PL 55B 324          +HEINTZE,HEINZELMANN+           (CERN+HEID)
HEARD2   75 PL 55B 327          +HEINTZE,HEINZELMANN+           (CERN+HEID)
SHEAFF   75 PR D12 2570         M. SHEAFF                            (WISC)
SMITH    75 NP B91 45           +BOOTH,RENSHALL,JONES+ (GLAS+LIVP+OXF+RHEL)

BERTRAND 76 NP B114 387         +SACTON +         (BRUX+UBEL+DUUC+LOUC+WARS)
BLOCH    76 PL 60B 393          +BUNCE,DEVAUX,DIAMANT-BERGER+   (GEVA+SACL)
BRAUN    76 LNC 17 521          +MARTYN,ERRIQUEZ +    (AACH+BARI+BELG+CERN)
DIAMANTB 76 PL 62B 485          DIAMANT-BERGER,BLOCH,DEVAUX +   (SACL+GEVA)
HEINTZE  76 PL 60B 302          +HEINZELMANN,IGO-KEMENES,MUNDHENKE+  (HEID)
SMITH    76 NP B109 173         +BOOTH,RENSHALL,JONES+ (GLAS+LIVP+OXF+RHEL)
WEISSENB 76 NP B115 55          WEISSENBERG,EGOROV,MINERVINA+   (ITEP+LEBD)

ABRAMS   77 PR D15 22           +CARROLL,KYCIA,LI,MICHAEL,MOCKETT +   (BNL)
DEVAUX   77 NP B126 11          +BLOCH,DIAMANT-BERGER,MAILLARD+ (SACL+GEVA)
HEINTZE  77 PL 70B 482          +HEINZELMANN,IGO-KEMENES,+      (HEID+CERN)
ROSSELET 77 PR D15 574          +EXTERMANN,FISCHER,GUISAN +     (GEVA+SACL)
BARKOV   79 NP B148 53          +VASSERMAN,ZOLOTOREV,KRUPIN+    (NOVO+KIAE)
HEINTZE  79 NP B149 365         +HEINZELMANN,IGO-KEMENES+       (HEID+CERN)

WHITMAN  80 PR D21 652          +ABRAMS,CARROLL,KYCIA,LI+    (ILLC+BNL+ILL)
ASANO    81 PL 107B 159         +KIKUTANI,KUROKAWA,MIYACHI+ (KEK+TOKY+OSAK)
CAMPBELL 81 PRL 47 1032         +BLACK,BLATT,KASHA,SCHMIDT +     (YALE+BNL)
    ALSO 83 BLATT
LUM      81 PR D23 2522         +WIEGAND,KESSLER,DESLATTES,SEKI+ (LBL+NBS+)
LYONS    81 ZPHY C10 215        +ALBAJAR,MYATT                        (OXF)
ASANO    82 PL 113B 195         +KIKUTANI,KUROKAWA,MIYACHI+ (KEK+TOKY+OSAK)
COOPER   82 PL 112B 97          +GUY,MICHETTE,TYNDEL,VENUS             (RL)
BLATT    83 PR D27 1056         +ADAIR,BLACK,CAMPBELL,KASHA+     (YALE+BNL)

         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)

BARDIN   70 PL 32B 121          BARDIN,BILENKY,PONTECORVO            (JINR)
BECHERRA 70 PR D1 1452          T.BECHERRAWY                         (ROCH)
FEARING  70 PR D3 542           +FISCHBACK,SMITH                (STON+BOHR)
GAILLARD 70 CERN 70-14          M K GAILLARD, L M CHOUNET       (CERN+ORSA)
GINSBERG 70 PR D1 229           E S GINSBERG                    (IIT HAIFA)

GINSBERG 71 PR D4 2893          E S GINSBERG                          (MIT)
CHOUNET  72 PL 4C 199           (PHYS. REPTS.)CHOUNET,2*GAILLARD(ORSA+CERN)

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K^0

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                    11  NEUTRAL K(498,JP=0-) I=1/2

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                    11  NEUTRAL K MASS (MEV)

M          498.1      0.4               CHRISTENS 64 OSPK
M     2223 497.44     0.33              KIM       65 HBC    K0 FROM PBAR P    6/66
M     4500 498.9      0.5               BALTAY    66 HBC    K0 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    497.67     0.13  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)  3/84*
                      (SEE IDEOGRAM BELOW)
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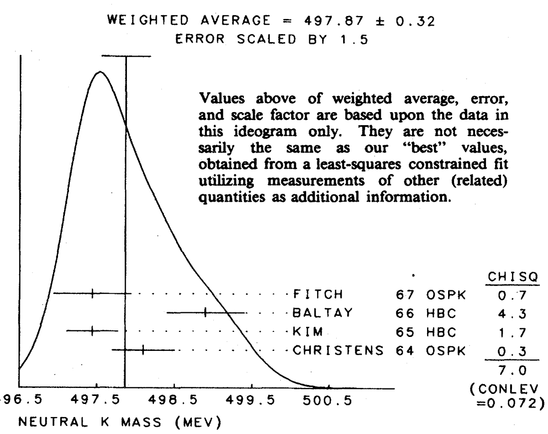

Values above of weighted average, error, and scale factor are based upon the data in this ideogram only. They are not necessarily the same as our "best" values, obtained from a least-squares constrained fit utilizing measurements of other (related) quantities as additional information.

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                    11  (K0) - (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 K0 N    6/68
D     417   3.95      0.21              HILL      68 DBC   +  K+D TO K0PP     3/68
D         . . . . . . . . . .
D   AVG     3.92      0.14    AVERAGE
D   FIT     4.01      0.13  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)  3/84*

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                    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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                    12  KS MEAN LIFE (UNITS 10**-10 SEC)

T      KS MEAN LIFE (PRE-1971 EXPERIMENTS)
T   O   90   (1.07)   (0.13)   (0.13) BOLDT     58 CC
T      512    0.94     0.05     0.05  CRAWFORD  59 HBC
T   O   63   (1.09)   (0.18)   (0.15) BOWEN     60 CC
T   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          . . . . . . . . . .
T   AVG       0.8641   0.0065   0.0065 AVERAGE (ERROR INCL. SCALE FACTOR OF 1.3)

T      KS MEAN LIFE (POST-1971 EXPERIMENTS)
T       THESE VALUES ARE USED TO DETERMINE THE STABLE PARTICLE TABLE
T       VALUES OF THE KS MEAN LIFE AND RATES.
T  H   50K    0.8958   0.0045         SKJEGGEST 72 HBC                     1/73
T   F 2173   (0.867)  (0.024)         FACKLER   73 OSPK                   11/73
T       6M    0.8937   0.0048         GEWENIGER 74 ASPK                    3/74
T  C          0.8913   0.0032         CARITHERS 75 SPEC                    7/75
T      26K    0.881    0.009          ARONSON   76 SPEC                   11/76
T   A        (0.905)  (0.007)         ARONSON   82 SPEC   E=30-110 GEV    1/83*
T          . . . . . . . . . .
T   AVG       0.8923   0.0022   0.0022 AVERAGE
T   FIT       0.8923   0.0022 FROM FIT
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Stable Particles

Data Card Listings

K^0_S

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                    COMMENTS
T  H    HILL 68 HAS BEEN CHANGED BY THE AUTHORS FROM THE PUBLISHED VALUE    11/72
T  H    (0.865+-0.009) BECAUSE OF A CORRECTION IN THE SHIFT DUE TO ETA+-.   11/72
T  H    SKJEGGESTAD 72 AND HILL 68 GIVE DETAILED DISCUSSIONS OF SYSTEMATICS
T  H    ENCOUNTERED IN THIS TYPE OF EXPERIMENT.
T   B   KS MEAN LIFE NOT THE PRIMARY QUANTITY MEASURED IN THIS EXPT.         6/68
T   F   FACKLER 73 DOES NOT INCLUDE SYSTEMATIC ERRORS.                      11/73
T  C    CARITHERS 75 VALUE IS FOR KL-KS MASS DIFFERENCE DM=.5348+-.0021.    11/75
T  C    THE DM DEPENDENCE OF THE TOTAL DECAY RATE (INVERSE MEAN LIFE) IS    11/75
T  C    GAMMA(KS)=((1.122+-.004)+.16*(DM-.5348)/DM)*10**10 /SEC.            11/75
T  C    VALUE WOULD NOT CHANGE WITH OUR CURRENT DM=.5349+-.0022.             2/76
T   A   ARONSON 82 FIND THAT KS MEAN LIFE MAY DEPEND ON THE KAON ENERGY.     1/83*

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                    12  KS PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      KS INTO PI+ PI-                                  140+ 140
P2      KS INTO PIO PIO                                  135+ 135
P3      KS INTO MU+ MU-                                  106+ 106
P4      KS INTO E+ E-                                   .511+.511
P5      KS INTO PI+ PI- GAMMA                            140+ 140+   0
P6      KS INTO GAMMA GAMMA                                0+   0
P7      KS INTO 3PIO                                     135+ 135+ 135
P8      KS INTO PI+ PI- PIO                              140+ 140+ 135

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                    12  KS BRANCHING RATIOS

R1      KS INTO (PI+ PI-)/TOTAL                                  (P1)
R1              0.68      0.04          CRAWFORD  59 HBC
R1              0.70      0.08          COLUMBIA  60 HBC
R1   U         (0.740)   (0.024)        ANDERSON  62 HBC
R1 U  3447      0.670     0.010         DOYLE     69 HBC     PI- P TO LAM K0   1/76
R1   U   ANDERSON RESULT NOT PUBLISHED, EVENTS ADDED TO DOYLE SAMPLE            2/71
R1           . . . . . . . . . . .
R1   AVG        0.6710    0.0096  AVERAGE
R1   FIT        0.6861    0.0024 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R2      KS 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        0.3139    0.0024 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)
                          (SEE IDEOGRAM BELOW)
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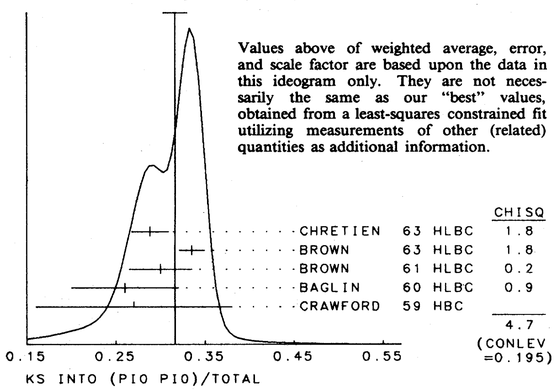
WEIGHTED AVERAGE = 0.316 ± 0.014
ERROR SCALED BY 1.3

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R3      KS INTO (PI+ PI-)/(PIO PIO)                              (P1)/(P2)
R3  N  267    (2.12)    (0.17)          BOZOKI    69 HLBC                      5/70
R3  G 3016    (2.285)   (0.055)         GOBBI     69 OSPK    K+N TO K0P        5/69
R3    3700     2.10      0.06           MORFIN    69 HLBC    K+N TO K0P       10/69
R3 G  7944     2.282     0.043          MOFFETT   70 OSPK    K+N TO K0P        2/72
R3 B  6150     2.22      0.095          BALTAY    71 HBC  K-P TO K0 +NEUTRALS 12/71
R3 A  3068     2.22      0.10           ALITTI    72 HBC     K+P TO PI+ P K0   6/72
R3    6380     2.22      0.08           MORSE     72 DBC     K+N TO K0P        2/72
R3 N   701     2.10      0.11           NAGY      72 HLBC    K+N TO K0P        1/73
R3    4799     2.16      0.08           HILL      73 DBC     K+D TO K0 P P     9/73
R3     16K     2.169     0.094          COWELL    74 OSPK    PI- P TO LAM K0   7/75
R3    1315     2.11      0.09           EVERHART  76 WIRE    PI- P TO LAM K0  11/76
R3 N    NAGY 72 IS A FINAL RESULT WHICH INCLUDES BOZOKI 69.                    11/73
R3 G    MOFFETT 70 IS A FINAL RESULT WHICH INCLUDES GOBBI 69.                   2/72
R3 B    THE DIRECTLY MEASURED QUANTITY IS KS TO PI+PI-/ALL K0BAR=.345+-.005 12/71
R3 A    THE DIRECTLY MEASURED QUANTITY IS KS TO PI+ PI-/ALL K0=.345+-.005     6/72
R3           . . . . . . . . . . .
R3  AVG        2.197     0.026   AVERAGE
R3  FIT        2.186     0.025   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R4      KS INTO (MU+ MU-)/CHARGED (UNITS 10**-5)           (P3)/(P1)
R4          (10.0)   OR LESS  CL=.90   BOTT-BODE 67 OSPK                        8/67
R4          (20.0)   OR LESS  CL=.90   BOHM      69 OSPK                        2/71
R4           (1.07)  OR LESS  CL=.90   HYAMS     69 OSPK                       10/69
R4   S      (32.6)   OR LESS  CL=.90   STUTZKE   69 OSPK                        5/69
R4             0.047 OR LESS  CL=.90   GJESDAL   73 ASPK                        7/73
R4   S  VALUE CALCULATED BY US, USING 2.3 INSTEAD OF 1 EVENT, 90 PERC.CL

R5      KS INTO (PI+ PI- GAMMA)/(PI+ PI-) (UN.10**-3)     (P5)/(P1)
R5       27        NO RATIO GIVEN       BELLOTTI  66 HBC     PG GT 50 MEV/C   10/69
R5       10    3.3        1.2           WEBBER    70 HBC     PG GT 50 MEV/C   10/69
R5 B           2.8        0.6           BURGUN    73 HBC     PG GT 50 MEV/C   11/73
R5 C     29   (3.0)      (0.6)          BOBISUT   74 HLBC    PG GT 40 MEV/C   12/75
R5    T        2.68       0.15          TAUREG    76 SPEC    PG GT 50 MEV/C    6/77
R5 B    BURGUN 73 ESTIMATES THAT DIRECT EMISSION CONTRIBUTION IS .3+-.6 .     11/73
R5 C    BOBISUT 74 NOT INCLUDED IN AVERAGE BECAUSE P(GAMMA) CUT DIFFERS.       1/76
R5 C    ESTIMATES DIRECT EMISSION CONTRIBUTION TO BE 0.5 OR LESS, CL=.95.      1/76
R5    T TAUREG 76 FIND DIRECT EMISSION CONTRIB LT .06,CL=.90.                  6/77
R5           . . . . . . . . . . .
R5  AVG        2.70       0.14    AVERAGE

R6      KS INTO (E+ E-)/CHARGED (UNITS 10**-5)            (P4)/(P1)
R6           50.0   OR LESS  CL=.90   BOHM      69 OSPK                        2/71

R7      KS INTO 2 GAMMA/TOTAL (UNITS 10**-3)              (P6)
R7 R     0  (21.0)  OR LESS  CL=.90   BANNER    69 OSPK                       12/71
R7 R     0   (2.2)  OR LESS  CL=.90   REPELLIN  71 OSPK                       12/71
R7 R     0   (0.71) OR LESS  CL=.90   BANNER    72 OSPK                        8/72
R7       0   (2.0)  OR LESS  CL=.90   MORSE     72 DBC                         2/72
R7       0    0.4   OR LESS  CL=.90   BARMIN2   73 HLBC                        2/74
R7 R     THESE LIMITS ARE FOR MAXIMUM INTERFERENCE IN KS-KL TO 2 GAMMAS       12/71

R8      KS INTO (PI+ PI- PIO)/TOTAL (UNITS 10**-4)        (P8)
R8            0.85  OR LESS  CL=.90   METCALF   72 ASPK                        1/84*

R9      KS INTO (PIO PIO PIO)/TOTAL (UNITS 10**-4)        (P7)
R9           (4.3)  OR LESS  CL=.90   BARMIN1   73 HLBC                        2/84*
R9            0.37  OR LESS  CL=.90   BARMIN    83 HLBC                        1/84*

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NOTE ON CP VIOLATION IN $K^0_S \to 3\pi$

For $K^0_S \to 3\pi$, the quantities which measure CP violation are the ratios of amplitudes

$$\eta_{+-0} = \frac{A_S(K_S \to \pi^+\pi^-\pi^0)}{A_L(K_L \to \pi^+\pi^-\pi^0)} ,$$

$$\eta_{000} = \frac{A_S(K_S \to \pi^0\pi^0\pi^0)}{A_L(K_L \to \pi^0\pi^0\pi^0)} .$$

If one assumes that CPT invariance holds and that there are no transitions to I = 3 states, then $\mathrm{Re}(\eta_{+-0})$ and $\mathrm{Re}(\eta_{000})$ can be neglected, and CP violation would be observed as nonzero values of $\mathrm{Im}(\eta_{+-0})$ and $\mathrm{Im}(\eta_{000})$. Sections ET+ and ET0 list the relative rates

$$(\mathrm{Im}\eta_{+-0})^2 = \frac{\Gamma(K_S \to \pi^+\pi^-\pi^0)}{\Gamma(K_L \to \pi^+\pi^-\pi^0)}$$

$$(\mathrm{Im}\eta_{000})^2 = \frac{\Gamma(K_S \to \pi^0\pi^0\pi^0)}{\Gamma(K_L \to \pi^0\pi^0\pi^0)}$$

obtained under the above assumptions.

In the above expressions the three pions are restricted to the dominant symmetric I = 1 state, a CP = −1 state which couples to K_S only if CP is violated. The decay $K_S \to \pi^+\pi^-\pi^0$ also has CP-allowed amplitudes to I = 0 and I = 2 states of the three pions. The angular momenta in these states cannot be S wave so they are strongly suppressed by centrifugal barrier effects, and, for the I = 2 state, by the $\Delta I = 1/2$ rule as well. For comparison with the CP-violating rate, we list in section RSQ the CP-conserving rate relative to $K_L \to \pi^+\pi^-\pi^0$ decay. The CP-conserving limit is large and thus determines the branching ratio limit $\Gamma(K_S \to \pi^+\pi^-\pi^0)/\Gamma(K_S \to \pi^+\pi^-)$ given in section R8.

12 CP VIOLATION PARAMETERS IN KS DECAY

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ET+      IM(ETA+-0)**2
ET+      WHERE ETA+-0 = A(KS -> PI+ PI- PI0, CP VIOL.)/A(KL -> PI+ PI- PI0).
ET+      CPT ASSUMED VALID - (I.E. RE(ETA+-0)=0)
ET+       18   (3.8)  OR LESS  CL=.90   ANDERSON  65 HBC  INCL. IN WEBBER 70  10/69
ET+            (0.45) OR LESS  CL=.90   BEHR      66 HLBC                      8/66
ET+       71   (0.8)  OR LESS  CL=.90   WEBBER    70 HBC                       8/70
ET+       99   (1.2)  OR LESS  CL=.90   CHO       71 DBC                       4/71
ET+       98   (1.0)  OR LESS  CL=.90   JAMES     71 HBC  INCL. IN JAMES 72    6/71
ET+ M     50   (1.2)  OR LESS  CL=.95   MEISNER   71 HBC      CL=.9 NOT AVAIL. 2/71
ET+      180   (0.66) OR LESS  CL=.90   JAMES     72 HBC                       1/73
ET+       99   (1.2)  OR LESS  CL=.90   JONES     72 OSPK                     10/72
ET+      384    0.12  OR LESS  CL=.90   METCALF   72 ASPK                      2/74
ET+      148   (0.71) OR LESS  CL=.90   MALLARY   73 OSPK    RE(A)=-.05+-.17   8/73
ET+      192   (1.2)  OR LESS  CL=.90   BALDOCEOL 75 HLBC                     12/75
ET+ M     THESE AUTHORS FIND REAL(A)= 2.75+-.65, ABOVE VALUE AT RE(A)=0        2/71

RSQ      RHO**2
RSQ      WHERE RHO=CABS(A(KS -> PI+ PI- PI0, CP CONS.)/A(KL -> PI+ PI- PI0)).
RSQ      CONSERVES CP BUT LISTED HERE FOR COMPARISON WITH SECTION ET+ ABOVE.
RSQ      THIS LIMIT DETERMINES BRANCHING RATIO R8 ABOVE.
RSQ      384    0.42  OR LESS  CL=.90   METCALF   72 ASPK                     11/72

ETO      IM(ETA000)**2
ETO      WHERE ETA000 = A(KS INTO 3PI0, CP VIOLATING)/A(KL INTO 3PI0)
ETO      SEE COMMENTS IN SECTION ET+ ABOVE.
ETO      THIS LIMIT DETERMINES BRANCHING RATIO R9 ABOVE.
ETO       22   (1.2)  OR LESS  CL=.90   BARMIN1   73 HLBC                     11/73
ETO   G        (0.28) OR LESS  CL=.90   GJESDAL   74 SPEC    INDIRECT MEAS.   11/75
ETO   B 632     0.1   OR LESS  CL=.90   BARMIN    83 HLBC                      2/84*
ETO   G  GJESDAL 74 USES K2PI, KMU3 AND KE3 DECAY RESULTS, UNITARITY, AND     11/75
ETO   G  CPT.  CALCULATES ABS(ETA000)=.26+-.20.  WE CONVERT TO UPPER LIMIT.   11/75
ETO   B  BARMIN 83 FIND RE(ETA000)=(-.08+-.18) AND IM(ETA000)=(-.05+-.27) .   11/83*
ETO   B  ASSUMING CPT INVARIANCE THEY OBTAIN THE LIMIT QUOTED ABOVE .         11/83*

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REFERENCES FOR KS


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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)
BOZOKI   69 PL 30B 498           +FENYVES,GOMBOSI,NAGY,SURANYI+   (BUDAPEST)
DOYLE    69 UCRL 18139-THESIS J.C. DOYLE                               (LRL)
GOBBI    69 PRL 22 682           GOBBI,GREEN,HAKEL,MOFFETT,ROSEN+(ROCHESTER)
HYAMS    69 PL   29B 521         +KOCH,POTTER,VON LINDERN,LORENZ+ CERN(MPIM)
MORFIN   69 PRL   23  660        MORFIN,SINCLAIR                          (MICH)
STUTZKE  69 PR   177  2009       +ABASHIAN,JONES,MANTSCH,ORR,SMITH(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)
JAMES    71 PL 35B 265           +MONTANET,PAUL,PAULI+       (CERN+SACL+OSLO)
MEISNER  71 PR D3 59             +MANN,HERTZBACH,KOFLER +    (MASA+BNL+YALE)
REPELLIN 71 PL 36B 603           +WOLFF,CHOLLET,GAILLARD,JANE+   (ORSA+CERN)

ALITTI   72 PL 39B 568           J ALITTI,E LESQUOY,A MULLER          (SACLAY)
BANNER   72 PRL 29 237           +CRONIN,HOFFMAN,KNAPP,SHOCHET   (PRINCETON)
JAMES    72 NP B49 1             +MONTANET,PAUL,SAETRE+      (CERN+SACL+OSLO)
JONES    72 NC 9A 151            +ABASHIAN,GRAHAM,MANTSCH,ORR,SMITH+   (ILL)

METCALF  72 PL 40B 703           +NEUHOFER,NIEBERGALL+        (CERN+IPN+WIEN)
MORSE    72 PRL 28 388           +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)

BARMIN1  73 PL 46B 465           +BARYLOV,DAVIDENKO,DEMIDOV+              (ITEP)
BARMIN2  73 PL 47B 463           +BARYLOV,DAVIDENKO,DEMIDOV+              (ITEP)
BURGUN   73 PL 46B 481           +BERTRANET,LESQUOY,MULLER,PAULI+(SACL+CERN)
FACKLER  73 PRL 31 847           +FRISCH,MARTIN,SMOOT,SOMPAYRAC            (MIT)
GJESDAL  73 PL 44B 217           +PRESSER,STEFFEN,STEINBERGER+   (CERN+HEID)
HILL     73 PR D8 1290           +SAKITT,SAMIOS,BURRIS,ENGLER+    (BNL+CARN)
MALLARY  73 PR D7 1953           +BINNIE,GALLIVAN,GOMEZ,PECK,SCIULLI+  (CIT)

BOBISUT  74 LNC 11 646           +HUZITA,MATTIOLI,PUGLIERIN               (PADO)
COWELL   74 PR D10 2083          +LEE-FRANZINI,ORCUTT,FRANZINI + (STON+COLU)
GEWENIGE 74 PL 48B 487           GEWENIGER,GJESDAL,PRESSER+      (CERN+HEID)
GJESDAL  74 PL 52B 119           +PRESSER,STEFFEN,STEINBERGER +  (CERN+HEID)

BALDOCEO 75 NC 25A 688           BALDO-CEOLIN,BOBISUT,CALIMANI+  (PADO+WISC)
CARITHER 75 PRL 34 1244          CARITHERS,MODIS,NYGREN,PUN +      (COLU+NYU)
ARONSON  76 NC 32A 236           +MCINTYRE,ROEHRIG +    (WISC+EFI+UCSD+ILLC)
EVERHART 76 PR D14 661           +KRAUS,LANDE,LONG,LOWENSTEIN +           (PENN)
TAUREG   76 PL 65B 92            +ZECH,DYDAK,NAVARRIA+       (HEID+CERN+DORT)
ARONSON  82 PRL 48 1306          +BOCK,CHENG,FISCHBACH         (BNL+CHIC+PURD)
    ALSO 82 PL 116B 73           FISCHBACH,CHENG,ARONSON,BOCK(PURD+BNL+CHIC)
    ALSO 83 PR D28 476           ARONSON,BOCK,CHENG,FISCHBACH(BNL+CHIC+PURD)
    ALSO 83 PR D28 495           ARONSON,BOCK,CHENG,FISCHBACH(BNL+CHIC+PURD)
BARMIN   83 PL 128B 129          +BARYLOV,CHISTYAKOVA,CHUVILO+   (ITEP+PADO)
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PAPERS NOT REFERRED TO IN DATA

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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^0_L — 13 LONG-LIVED NEUTRAL K(498, JP=0-) I=1/2

13 (KL) - (KS) MASS DIFFERENCE

WE GIVE (KL-KS MASS DIFFERENCE / HBAR) IN UNITS OF 10**10 SEC-1

```
D  TX          (2.20)   (0.35)          FITCH     61 CNTR
D   X          (0.84)   (0.29)    (0.22)GOOD      61 HLBC
D  TXC         (1.02)   (0.23)          CAMERINI  62 HLBC                     8/67
D  TX          (0.55)   (0.24)          AUBERT    65 HLBC                     6/66
D   X          (0.26)   (0.36)    (0.26)BALDO-CEO 65 HLBC   ASSUMES CP CONS.
D  TXA         (0.64)   (0.12)          CHRISTENS 65 OSPK                     6/66
D  TX          (0.70) OR LESS           FITCH     65 OSPK   CF. MEISNER 66    7/66
D   V   130    (0.89)   (0.15)          VISHNEVSK 65 OSPK   CU AND AL REGEN   8/67
D   X          (0.514)  (0.039)         ALFF-STEI 66 OSPK                     6/66
D   X    84    (0.42)   (0.24)   (0.36) BALDO-CEO 66 HLBC   KO+N INTO HYPER.  8/67
D   B          (0.531)  (0.027)         BOTT-BODE 66 OSPK   C REGEN           9/66
D  TX    77    (0.58)   (0.17)          CAMERINI  66 HBC, DBC KO+N INTO HYPER 8/67
D   N    72   (+0.64)   (0.18)          CANTER    66 DBC    KO SCATTER IN D2 11/66
D   X    95    (0.62)   (0.10)   (0.16) CHANG     66 HBC    KO+P INTO HYPER.  8/67
D   X          (0.81)   (0.17)          FUJII     66 OSPK   IRON REGENERATOR  9/66
D   X    59    (0.74)   (0.34)          MEISNER1  66 HBC                      6/66
D            + SIGN FAVORED             MEISNER2  66 HBC                      9/66
D   X          (0.38)   (0.16)          JOVANOVIC 66 OSPK   C+URANIUM REGEN. 11/66
D  TX   136   (+0.64)   (0.19)          CANTER    67 DBC    KO+D INTO HYPER. 11/67
D   X          (0.65)   (0.11)          MISCHKE   67 OSPK                    11/67
D   X   590    (0.59)   (0.13)          BALATZ    68 OSPK   AL REGENERATOR    3/68
D   X          (0.520)  (0.044)         CARNEGIE  68 HBC    GAP METHOD        3/68
D  TX         (+0.487)  (0.046)         MELHOP    68 OSPK   ST.STEEL REGEN    6/68
D  BX          (0.547)  (0.024)         BOTT-BODE 69 OSPK   C REGEN           1/71
D  FX          (0.555)  (0.020)         FAISSNER  69 ASPK   REGEN IN CU      10/69
D               0.542    0.006          CULLEN    70 CNTR                     1/71
D   R          (0.542)  (0.006)         ARONSON   70 ASPK   GAP METHOD        1/71
D   X          (0.481)  (0.052) (0.075)BALATS     71 OSPK                     9/71
D   R          (0.534)  (0.007)         CARNEGIE  71 ASPK   GAP METHOD        8/71
D  TH   119   (+0.67)   (0.14)          HILL      71 DBC                     10/71
D   S 1757     (0.557)  (0.038)         FACKLER   73 OSPK                    11/73
D               0.5340   0.0030         GEWENIG3  74 SPEC   GAP METHOD       11/75
D               0.5334   0.0040         GJESDAL   74 SPEC   CHG ASYMMETRY    11/75
D   Z          (0.482)  (0.014)         ARONSON2  82 SPEC   E=30-110 GEV      1/83*
D             . . . . . . . . .
D  AVG          0.5349   0.0022  AVERAGE
                     COMMENTS
D   X   NO ATTEMPT HAS BEEN MADE TO CORRECT OLDER EXPERIMENTS WITH LARGE      11/75
D   X   ERRORS FOR THE SUBSEQUENT CHANGES IN THE KS MEAN LIFE OR IN ETA+-.     2/76
D  T    A KS MEAN LIFE OF 0.862 10**-10 SEC WAS USED IN CONVERTING THE         1/71
D  T    MASS DIFFERENCE FROM UNITS OF INVERSE KS 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    KS MEAN LIFE.                                                          1/71
D    C  CAMERINI 62 VALUE CHANGED FROM 1.7 (SEE TABLE 1 OF CAMERINI 66)        8/67
D    A  CHRISTENSON 65 CORRECTED FOR INTERFERENCE BY FITCH 65 FOOTNOTE.        1/71
D   V   VISHNEVSKY 65 NOT CORRECTED FOR INTERFERENCE EFFECTS.                  3/68
D   N   CANTER 66 ERROR IGNORES UNCERTAINTY OF PHASE SHIFTS.  THESE EVENTS    10/71
D   N   ARE USED IN HILL 71.                                                  10/71
D  B    BOTT-BODENHAUSEN 69 IS A REEVALUATION OF BOTT-BODENHAUSEN 66.          1/71
D  F    FAISSNER 69 HAS ADDNL. SYSTEMATIC ERROR LESS THAN TWO PERCENT.         1/71
D   R   ARONSON 70 AND CARNEGIE 71 USE KS MEAN LIFE=.862+-.006 E-10 SEC.      11/75
D   R   WE HAVE NOT ATTEMPTED TO ADJUST THESE VALUES FOR THE SUBSEQUENT        2/76
D   R   CHANGE IN THE KS MEAN LIFE OR IN ETA+-.                                2/76
D   H   HILL 71 PRIMARY RESULT IS THAT DM IS POSITIVE.                        10/71
D   H   THE MAGNITUDE MAY HAVE AN ADDITIONAL SYSTEMATIC ERROR OF ABOUT 0.12   10/71
D   S   NOT AVERAGED BECAUSE ERROR IS LARGE AND SYSTEMATICS NOT DISCUSSED.     2/76
D   Z   ARONSON 82 FIND THAT DELTA-M MAY DEPEND ON THE KAON ENERGY .           1/83*
```

13 KL MEAN LIFE (UNITS 10**-8 SEC)

```
T        KL 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     0.4M     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
T    FIT       5.183    0.040   FROM FIT
```

13 KL PARTIAL DECAY MODES

```
                                                         DECAY MASSES
P1    KL INTO 3PI0                    TAU 0 PRIME     135+ 135+ 135
P2    KL INTO PI+ PI- PI0             TAU 0           140+ 140+ 135
P3    KL INTO PI MU NEUTRINO          KL MU3          140+ 106+   0
P4    KL INTO PI E NEUTRINO           KL E3           140+.511+   0
P5    KL INTO PI+ PI-                 KL PI+ PI-      140+ 140
P6    KL INTO MU+ MU-                 KL 2MU          106+ 106
P7    KL INTO E+ E-                   KL 2E          .511+.511
P8    KL INTO E MU                    KL EMU         .511+ 106
P9    KL INTO TWO GAMMAS              KL 2GAMMA         0+   0
P10   KL INTO PI+ PI- GAMMA           KL PI+-G        140+ 140+   0
P11   KL INTO PI0 PI0                 KL 2PI0         135+ 135
P12   KL INTO PI E NEU GAMMA          KL E3GAM        140+.511+   0+   0
P13   KL INTO PI0 TWO GAMMAS          KL PI2GAMMA     135+   0+   0
P14   KL INTO E+ E- GAMMA             KL 2EGAM       .511+.511+   0
P15   KL INTO MU+ MU- GAMMA           KL 2MUGAM       106+ 106+   0
P16   KL INTO MU+ MU- PI0             KL 2MUPI0       106+ 106+ 135
P17   KL INTO PI+ PI- E+ E-           KL 2PI2E        140+ 140+.511+.511
P18   KL INTO PI0 PI+- E-+ NEU        KL 2PIENEU      135+ 140+.511+   0
P19   KL INTO (PI MU ATOM) NEU        KL (PIMU)NEU
P20   KL INTO E+ E- PI0               KL 2EPI0       .511+.511+ 135
```

Stable Particles

Data Card Listings

K_L^0

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                NEUTRAL K CONSTRAINED FIT
        OVERALL FIT OF MEAN LIFE, WIDTHS AND BRANCHING
        RATIOS USES 65 DATA POINTS TO DETERMINE SIX                  3/78
        QUANTITIES.  OVERALL FIT HAS CHI-SQUARED=69.9                3/78

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FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions, P_i, as follows: The diagonal elements are $P_i \pm \delta P_i$, where $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$, while the off-diagonal elements are the normalized correlation coefficients $\langle \delta P_i \delta P_j \rangle / (\delta P_i \cdot \delta P_j)$. For the definitions of the individual P_i, see the listings above; only those P_i appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

```
        P 1       P 2       P 3       P 4       P 5       P11
P 1  .2147+-.0099
P 2   -.6525   .1239+-.0020
P 3   -.8540     .4407  .2711+-.0042
P 4   -.9098     .4699     .6132  .3873+-.0055
P 5   -.4358     .5469     .3154     .3362  .0020+-.0001
P11    .2287    -.1620    -.2102    -.2241    -.1080  .0009+-.0002
```

FITTED PARTIAL DECAY MODE RATES

The matrix below is the branching fraction matrix above, transformed into rate space; i.e., $G_i \equiv \Gamma_i = \Gamma_{total} P_i$, in appropriate units. In analogy to the matrix above, the diagonal elements are $G_i \pm \delta G_i$, where $\delta G_i = \sqrt{\langle \delta G_i \delta G_i \rangle}$, while the off-diagonal elements are the normalized correlation coefficients $\langle \delta G_i \delta G_j \rangle / (\delta G_i \cdot \delta G_j)$. Note that, because of the error in Γ_{total}, the errors and correlations here are not directly derivable from those above.

```
        G 1       G 2       G 3       G 4       G 5       G11
G 1  .0414+-.0020
G 2   -.4747   .0239+-.0004
G 3   -.6405     .4950  .0523+-.0009
G 4   -.6736     .5241     .6596  .0747+-.0011
G 5   -.3287     .5695     .3562     .3770  .0004+-.0000
G11    .2375    -.1236    -.1648    -.1734    -.0853  .0002+-.0000

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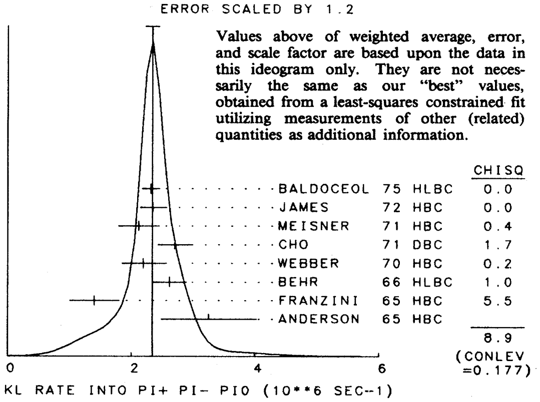
13 KL DECAY RATES

```
W1      KL INTO PIO PIO PIO (UNITS 10**6 SEC-1)          (G1)
W1       54    5.22     1.03     0.84  BEHR      66 HLBC   ASSUMES CP       8/66
W1              . . . . . . . . .
W1   FIT        4.14     0.20   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.7)

W2      KL INTO PI+ PI- PO (UNITS 10**6 SEC-1)           (G2)
W2       18    3.26     0.77           ANDERSON  65 HBC                     8/66
W2       14    1.4      0.4            FRANZINI  65 HBC                     6/66
W2      136    2.62     0.28     0.27  BEHR      66 HLBC   ASSUMES CP       8/66
W2       53    2.20     0.35           WEBBER    70 HBC    ASSUMES CP      10/71
W2       99    2.71     0.28           CHO       71 DBC    ASSUMES CP       4/71
W2   J   98   (2.5)    (0.3)           JAMES     71 HBC    ASSUMES CP       6/71
W2       50    2.12     0.33           MEISNER   71 HBC    ASSUMES CP      10/71
W2  J   180    2.35     0.20           JAMES     72 HBC    ASSUMES CP       1/73
W2      192    2.32     0.13     0.15  BALDOCEOL 75 HLBC   ASSUMES CP       1/76
W2       IN THE OVERALL FIT THIS RATE IS WELL DETERMINED BY THE MEAN LIFE AN
W2       THE BRANCHING RATIO R2. FOR THIS REASON THE DISCREPANCY BETWEEN THE
W2       W2 MEASUREMENTS DOES NOT AFFECT THE SCALE FACTOR OF THE OVERALL FIT
W2  J    JAMES 72 IS A FINAL MEASUREMENT AND INCLUDES JAMES 71.            11/73
W2              . . . . . . . . .
W2   AVG        2.34     0.11    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
W2   FIT        2.391    0.041  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)
                         (SEE IDEOGRAM BELOW)
```

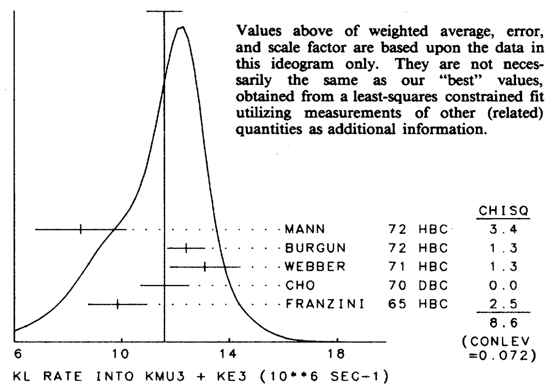
WEIGHTED AVERAGE = 2.34 ± 0.11
ERROR SCALED BY 1.2




```
W3      KL 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
W3   FIT        7.47     0.11   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)
W4      KL 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     0.21   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.4)
```

```
W5      KL 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       12.70     0.18   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.4)
                         (SEE IDEOGRAM BELOW)
```

WEIGHTED AVERAGE = 11.60 ± 0.65
ERROR SCALED BY 1.5

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W6      KL 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        5.232    0.086  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)

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13 KL BRANCHING RATIOS

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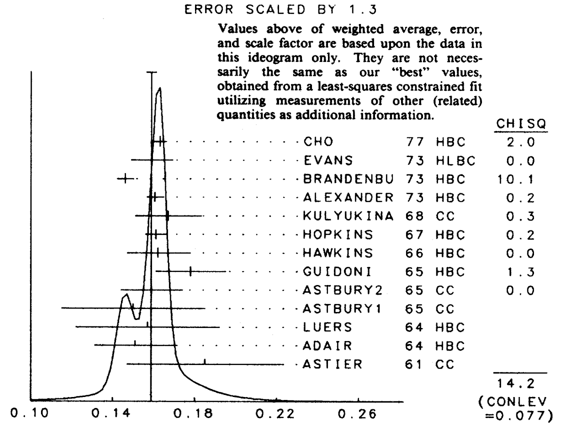
R1      KL INTO (PIO PIO PIO)/CHARGED                     (P1)/(P2+P3+P4)
R1       24    0.24     0.08           ANIKINA   64 CC                      6/66
R1      549    0.251    0.014          BUDAGOV   68 HLBC   ORSAY MEASUR.   10/68
R1      444    0.277    0.021          BUDAGOV   68 HLBC   EC. POLYTEC.MEAS 10/68
R1       29    0.31     0.07     0.06  KULYUKINA 68 CC                      2/71
R1              . . . . . . . . .
R1   AVG        0.260    0.011   AVERAGE
R1   FIT        0.274    0.016  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.7)

R2      KL INTO (PI+ PI- PIO)/CHARGED                     (P2)/(P2+P3+P4)
R2       59    0.185    0.038          ASTIER    61 CC                      8/66
R2       79    0.151    0.020          ADAIR     64 HBC                     8/66
R2       75    0.157    0.03     0.04  LUERS     64 HBC                     8/66
R2       66    0.15     0.03     0.04  ASTBURY1  65 CC                      8/66
R2      326    0.159    0.015          ASTBURY2  65 CC                      6/66
R2      566    0.178    0.017          GUIDONI   65 HBC                     6/66
R2     1729   (0.144)  (0.004)         HOPKINS   65 HBC    SEE HOPKINS 67   6/66
R2      126    0.162    0.015          HAWKINS   66 HBC                     6/66
R2             0.161    0.005          HOPKINS   67 HBC                     8/67
R2     1402    0.167    0.016          KULYUKINA 68 CC                      2/71
R2     1590    0.1605   0.0038         ALEXANDER 73 HBC                     1/74
R2     3200    0.146    0.004          BRANDENBU 73 HBC                     1/74
R2      558    0.159    0.010          EVANS     73 HLBC                    1/73
R2     6499    0.163    0.003          CHO       77 HBC                    11/77
R2              . . . . . . . . .
R2   AVG        0.1587   0.0024  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
R2   FIT        0.1584   0.0020 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)
                         (SEE IDEOGRAM BELOW)
```

WEIGHTED AVERAGE = 0.1587 ± 0.0024
ERROR SCALED BY 1.3



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R3      KL 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      0.3466   0.0028 FROM FIT

R4      KL INTO (PI E NEUTRINO)/CHARGED                     (P4)/(P2+P3+P4)
R4      24    0.46     0.11            NEAGU      61 CC                        2/76
R4     153    0.487    0.05            LUERS      64 HBC
R4     202    0.46     0.08    0.10    ASTBURY1   65 CC                        7/66
R4     500    0.498    0.052           KULYUKINA  68 CC                        2/71
R4
R4  AVG       0.485    0.032   AVERAGE
R4  FIT       0.4951   0.0029 FROM FIT

R5      KL 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       0.5882   0.0032 FROM FIT

R6      KL INTO (PI+ PI- PIO)/TOTAL                         (P2)
R6
R6
R6  FIT       0.1239   0.0020 FROM FIT

R7      KL INTO (LEPTON PI NEUTRINO)/TOTAL                  (P3+P4)
R7
R7
R7  FIT       0.6585   0.0087 FROM FIT

R8      KL 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   KL 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
R8        R21 BELOW GIVES (4.82+-.52)E-4. COMBINED AVG (4.85+-.37)E-4.        4/82

R9      KL INTO (PI+ PI-)/CHARGED (UNIT 10**-3)             (P5)/(P2+P3+P4)
R9  O   45   (2.0)    (0.4)            CHRISTENS 64 OSPK ETA +- = 1.95+-0.20  2/76
R9  O   54   (2.08)   (0.35)           GALBRAITH 65 OSPK ETA +- = 1.99+-0.16  2/76
R9  O        (1.93)   (0.26)           BASILE    66 OSPK ETA +- = 1.92+-0.13  2/76
R9  O        (1.993)  (0.080)          BOTT-BODE 66 OSPK ETA +- = 1.95+-0.04  2/76
R9  M 4200   (2.60)   (0.07)           MESSNER   73 ASPK ETA +- = 2.23+-0.05  6/73
R9  O   OLD EXPERIMENTS EXCLUDED FROM FIT.  SEE SUBSECTION E+- BELOW FOR       2/76
R9  O   AVERAGE ETA+- OF THESE EXPERIMENTS AND FOR NOTE ON DISCREPANCY.        2/76
R9  M   FROM SAME DATA AS R27 MESSNER 73,BUT WITH DIFFERENT NORMALIZATION.     6/73
R9
R9  FIT       2.589    0.060   FROM FIT

R10     KL INTO (PI MU NEU)/(PI E NEU)                      (P3)/(P4)
R10           0.81     0.19            ADAIR      64 HBC                       6/66
R10           0.82     0.10            DEBOUARD   67 OSPK                     11/67
R10     273   0.7      0.2             HAWKINS    67 HBC                       8/67
R10           0.81     0.08            HOPKINS    67 HBC                       8/67
R10     770   0.71     0.05            BUDAGOV    68 HLBC                     10/68
R10 K        (0.67)   (0.13)           KULYUKINA  68 CC                        3/74
R10 B   569  (0.71)   (0.04)           BEILLIERE  69 HLBC                     10/69
R10    1309  (0.648)  (0.030)          EVANS      69 HLBC REPL. BY EVANS 73    1/73
R10    3548   0.68     0.08            BASILE     70 OSPK                     10/70
R10    6700   0.741    0.044           BRANDENBU  73 HBC                       1/74
R10    1309   0.662    0.030           EVANS      73 HLBC                      1/73
R10     10K   0.662    0.037           WILLIAMS   74 ASPK                     10/74
R10     33K   0.702    0.011           CHO        80 HBC                       2/82
R10 K   KULYUKINA 68 R10 IS NOT MEASURED INDEPENDENTLY FROM R2 AND R4.         1/74
R10 B  BEILLIERE 69 IS A SCANNING EXPT USING SAME EXPOSURE AS BUDAGOV 68
R10
R10 AVG       0.7001   0.0093  AVERAGE
R10 FIT       0.7001   0.0092 FROM FIT

R11     KL 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     KL INTO (PI+ PI- GAMMA)/TOTAL (UNITS 10**-3)    (P10)
R12          (15.0)  OR LESS           ANIKINA    65 CC                        6/66
R12     0     (5.0)  OR LESS           BELLOTTI   66 HLBC    GAM KE 40-130 MV  8/67
R12     1     (3.0)  OR LESS           NEFKENS    66 OSPK    GAM KE 120 MEV    6/66
R12           (0.4)  OR LESS  CL=.90   THATCHER   68 OSPK    GAM KE 20-170 MV  2/71
R12           (3.2)  OR LESS  CL=.90   BOBISUT    74 HLBC    GAM KE GT 40 MEV 12/75
R12  D  24   (0.062)  (0.021)          DONALDS1   74 SPEC                     10/74
R12          (0.46)  OR LESS  CL=.90   WOO        74 SPEC                     12/75
R12 H  516   (0.0152) (0.0016)         CARROLL2   80 SPEC +-OGAM KE GT 20 MEV 12/80
R12 J  546   (0.0289) (0.0028)         CARROLL2   80 SPEC +-O                 12/80
R12  K1062    0.0441   0.0032          CARROLL2   80 SPEC +-OGAM KE GT 20 MEV 12/80
R12   D   USES KL TO PI+PI-PIO/ALL KL DECAYS = 0.126                          10/74
R12 H    INTERNAL BREMSSTRAHLUNG COMPONENT ONLY.                              12/80
R12 J    DIRECT GAMMA EMISSION COMPONENT ONLY.                                12/80
R12   K   BOTH COMPONENTS. USES KL TO PI+PI-PIO/ALL KL DECAYS = 0.1239 .      12/80

R13     KL 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     KL INTO (E MU)/CHARGED (UNITS 10**-4)               (P8)/(P2+P3+P4)
R14       TEST OF LEPTON FAMILY NUMBER CONSERVATION.
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     KL 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 IN THE CP VIOLATION SECTION BELOW.

R16     KL 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 BELOW.            2/71
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R17     KL 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     KL INTO (3PIO)/(PI+PI-PIO)                    (P1)/(P2)
R18     188     2.0       0.6             ALEKSANYA  64 FBC                    9/66
R18    1010     1.80      0.13            BUDAGOV    68 HLBC                  10/68
R18     883    (1.65)    (0.07)           BARMIN2    72 HLBC   ERROR STAT. ONLY 3/74
R18
R18 AVG         1.81      0.13    AVERAGE
R18 FIT         1.73      0.10    FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.7)

R19     KL INTO (2PIO)/(3PIO) (UNITS 10**-2)          (P11)/(P1)
R19 C   109    (1.89)    (0.31)           CRONIN 1   67 OSPK   ETA00=4.9+-0.5   8/67
R19 C          (1.36)    (0.18)           CRONIN 2   67 OSPK   ETA00=3.92+-0.3 11/67
R19 C      CRONIN2 IS FURTHER ANALYSIS OF CRONIN1, NOW BOTH WITHDRAWN         11/68
R19      NO EVENTS SEEN                   BARTLETT   68 OSPK   SEE E00 BELOW   11/68
R19      57     0.46      0.11            BANNER     69 OSPK   ETA00=2.2+-0.3   2/72
R19 R   133    (1.31)    (0.31)           CENCE      69 OSPK   ETA00=3.7+-0.5  10/69
R19      29     0.37      0.08            BARMIN     70 HLBC   ETA00=2.02+-0.23 12/70
R19      30     0.32      0.15            BUDAGOV    70 HLBC   ETA00=1.9+-0.5  10/70
R19   F 172     0.90      0.30            FAISSNER   70 OSPK   ETA00=3.2+-0.5  12/70
R19   R 150     1.21      0.30            REY        76 OSPK   ETA00=3.8+-0.5   8/76
R19   F FAISSNER 70 CONTAINS SAME 2PIO EVENTS AS GAILLARD 69 R17
R19   R  CENCE 69 EVENTS ARE INCLUDED IN REY 76.                                1/77
R19
R19 AVG         0.437     0.092   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)
R19 FIT         0.437     0.085   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.5)
                                  (SEE IDEOGRAM BELOW)
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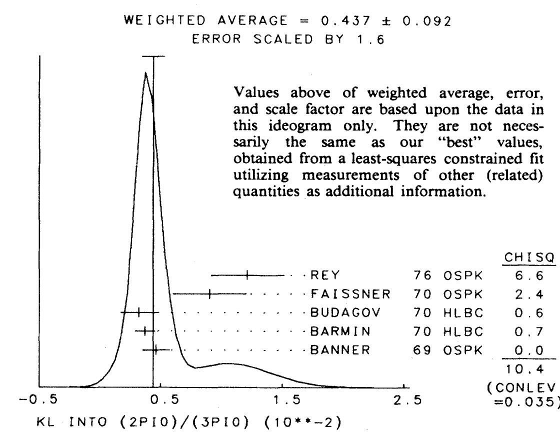


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R20     KL INTO (PI+ PI-)/(KE3 + KMU3) (UNITS 10**-3)      (P5)/(P3+P4)
R20 O  309    (2.51)    (0.23)            DEBOUARD   67 OSPK   ETA+-=2.00+-0.09  2/76
R20 O  525    (2.35)    (0.19)            FITCH      67 OSPK   ETA+-=1.94+-0.08  2/76
R20   2703     3.04      0.14             DEVOE      77 SPEC   ETA+-=2.25+-0.05 11/77
R20 O   OLD EXPERIMENTS EXCLUDED FROM FIT.  SEE SUBSECTION E+- BELOW FOR        2/76
R20 O   AVERAGE ETA+- OF THESE EXPERIMENTS AND FOR NOTE ON DISCREPANCY.         2/76
R20
R20 FIT        3.076     0.075    FROM FIT

R21     KL INTO (2GAMMA)/(3 PIO) (UNITS 10**-3)            (P9)/(P1)
R21      16    2.5       0.7              ARNOLD     68 HLBC   VACUUM DECAY    11/68
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

R22     KL INTO (MU+MU-)/(PI+PI-) (UNITS 10**-6)           (P6)/(P5)
R22      TEST FOR DELTA-S = 1 WEAK NEUTRAL CURRENT.  ALLOWED BY FIRST ORDER
R22      WEAK INTERACTION COMBINED WITH ELECTROMAGNETIC INTERACTION.
R22        0 (140.)  OR LESS  CL=.90   FOETH      69 SPEC                      5/70
R22        0  (18.)  OR LESS  CL=.90   DARRIULAT  70 SPEC                     11/70
R22 A      0  (1.53) OR LESS  CL=.90   CLARK      71 SPEC                      2/76
R22   C    9    5.8       2.3     1.5  CARITHERS  73 SPEC                      2/76
R22   F    3    4.2       5.1     2.6  FUKUSHIMA  76 SPEC                      2/76
R22       15    4.0       1.4     0.9  SHOCHET    79 SPEC                      7/79
R22 A    CLARK 71 LIMIT RAISED FROM 1.2 E-06 BY FIELD 74 REANALYSIS.           2/76
R22 A    NOT IN AGREEMENT WITH SUBSEQUENT EXPTS. SO NOT AVERAGED.              2/76
R22   C  CARITHERS 73 ERRORS ARE AT CL=0.68, W.CARITHERS, PRIV.COMM. 1979.     2/76
R22   F  FUKUSHIMA 76 ERRORS ARE AT CL=90 PERCENT.                             2/76
R22
R22 AVG        4.47      0.95     AVERAGE

R23     KL INTO (E+ E- )/(PI+PI-) (UNITS 10**-5)           (P7)/(P5)
R23      TEST FOR DELTA-S = 1 WEAK NEUTRAL CURRENT.  ALLOWED BY FIRST ORDER
R23      WEAK INTERACTION COMBINED WITH ELECTROMAGNETIC INTERACTION.
R23        0   10.0    OR LESS  CL=.90   FOETH      69 ASPK                    5/70
R23 A         (0.10) OR LESS  CL=.90   CLARK      71 ASPK                      6/71
R23 A    POSSIBLE (BUT UNKNOWN) SYSTEMATIC ERRORS.  SEE NOTE A IN R22 ABOVE.   5/82*

R24     KL INTO (E MU)/(PI+PI-) (UNITS 10**-5)             (P8)/(P5)
R24   A       (0.10) OR LESS  CL=.90   CLARK      71 ASPK                      6/71
R24   A  POSSIBLE (BUT UNKNOWN) SYSTEMATIC ERRORS.  SEE NOTE A IN R22 ABOVE.   4/82

R25     KL 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     KL INTO (PIO TWO GAMMAS)/(3PIO) (UNITS 10**-3)    (P13)/(P1)
R26       0    1.1    OR LESS  CL=.90   BANNER     69 OSPK                     2/72

R27     KL INTO (PI+ PI-)/TAU (UNITS 10**-2)               (P5)/(P2)        6/73
R27    4200    1.64      0.04             MESSNER    73 ASPK    ETA +- = 2.23   6/73
R27
R27 FIT        1.635     0.035    FROM FIT
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Stable Particles

Data Card Listings

K^0_L

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R28    KL INTO (E+ E- GAMMA)/TOTAL  (UNITS 10**-5)       (P14)
R28     TEST FOR DELTA-S = 1 WEAK NEUTRAL CURRENT.  ALLOWED BY FIRST ORDER
R28     WEAK INTERACTION COMBINED WITH ELECTROMAGNETIC INTERACTION.
R28  B   0   (2.7)  OR LESS  CL=.90   BARMIN1   72 HLBC                     3/74
R28  C   4    1.74     0.87           CARROLL1  80 SPEC +-0                12/80
R28  B  USES KL TO 3PI0/TOTAL=0.214 .
R28  C  USES KL TO PI+PI-PI0/ALL KL DECAYS = 0.1239 .                      12/80

R29    KL INTO (MU+ MU- GAMMA)/TOTAL (UNITS 10**-6)      (P15)             12/75
R29     TEST FOR DELTA-S = 1 WEAK NEUTRAL CURRENT.  ALLOWED BY FIRST ORDER
R29     WEAK INTERACTION COMBINED WITH ELECTROMAGNETIC INTERACTION.
R29  D       (7.81) OR LESS  CL=.90   DONALDS3  74 SPEC                     6/77
R29  C   1    0.28     0.28           CARROLL1  80 SPEC +-0                12/80
R29  D  USES KL TO PI+PI-PI0/ALL KL DECAYS = 0.126 .                        6/77
R29  C  USES KL TO PI+PI-PI0/ALL KL DECAYS = 0.1239 .                      12/80

R30    KL INTO (MU+ MU- PI0)/TOTAL   (UNITS 10**-5)      (P16)             12/75
R30     TEST FOR DELTA-S = 1 WEAK NEUTRAL CURRENT.  ALLOWED BY FIRST ORDER
R30     WEAK INTERACTION COMBINED WITH ELECTROMAGNETIC INTERACTION.
R30  D       (5.66) OR LESS  CL=.90   DONALDS3  74 SPEC                     6/77
R30  C   0    0.12  OR LESS  CL=.90   CARROLL1  80 SPEC                    12/80
R30  D  USES KL TO PI+PI-PI0/ALL KL DECAYS = 0.126 .                        6/77
R30  C  USES KL TO PI+PI-PI0/ALL KL DECAYS = 0.1239 .                      12/80

R31    KL INTO (PI+PI-E+E-) /TOTAL   (UNITS 10**-6)      (P17)             12/75
R31        (30.)    OR LESS           ANIKINA   73 STRC                     3/78
R31  D        8.81  OR LESS  CL=.90   DONALDSON 76 SPEC                     6/77
R31  D  USES KL TO PI+PI-PI0/ALL KL DECAYS = 0.126 .                        6/77

R32    KL INTO (PI0 PI+- E-+ NEU)/TOTAL (UNITS 10**-3)  (P18)              12/75
R32  D       (2.2)  OR LESS  CL=.90   DONALDS3  74 SPEC                     6/77
R32     16    0.062    0.020          CARROLL3  80 SPEC                     9/81
R32  D  DONALDSON3 74 USES KL TO PI+PI-PI0/ALL KL DECAYS = 0.126 .          6/77

R33    KL INTO ((PI MU ATOM)NEU)/(PI MU NEU) (10**-7)   (P19)/(P3)        11/82*
R33     18  SEEN                      COOMBES   76 WIRE                     6/77
R33    155    3.88     0.41           ARONSON   82 SPEC                    11/82*

R34    KL INTO (E+ E- PI0)/TOTAL (UNITS 10**-6)          (P20)
R34     TEST FOR DELTA-S = 1 WEAK NEUTRAL CURRENT.  ALLOWED BY FIRST ORDER
R34     WEAK INTERACTION COMBINED WITH ELECTROMAGNETIC INTERACTION.
R34  C   0    2.3   OR LESS  CL=.90   CARROLL1  80 SPEC                    12/80
R34  C  USES KL TO PI+PI-PI0/ALL KL DECAYS = 0.1239 .                      12/80

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13 KL ENERGY DEPENDENCE OF DALITZ PLOT

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      FOR DISCUSSION, SEE NOTE ON SLOPE PARAMETERS IN THE CHARGED K
      SECTION OF THE DATA CARD LISTINGS ABOVE.

     MATRIX ELEMENT SQUARED = 1 + G*U + H*U**2 + J*V + K*V**2
     WHERE U=(S3-S0)/(MPI**2) AND V=(S1-S2)/(MPI+**2)

GTO      LINEAR COEFFICIENT G FOR KL --> PI+ PI- PI0 MATRIX ELEMENT SQUARED
GTO Q   79   (0.55)   (0.23)          ADAIR     64 HBC  AV=-7.6 +- 1.7       3/71
GTO Q   77   (0.51)   (0.20)          LUERS     64 HBC  AV=-7.3 +- 1.6       3/71
GTO Q   66   (0.32)   (0.13)          ASTBURY1  65 CC   AV=-5.5 +- 1.5       3/71
GTO Q  310   (0.51)   (0.09)          ASTBURY2  65 CC   AV=-(7.3 +.6 -.8)    3/71
GTO Q  280   (0.64)   (0.17)          ANIKINA   66 CC   AV=-(8.2 +.9 -1.3)   3/71
GTO Q  126   (0.70)   (0.12)          HAWKINS   66 HBC  AV=-8.6 +- 0.7       3/71
GTO Q 1350   (0.649)  (0.044)         HOPKINS   67 HBC  AT=-0.294 +- .018   10/69
GTO Q 1198   (0.428)  (0.055)         NEFKENS   67 OSPK AU=-0.204 +- .025    3/71
GTO Q 2446   (0.400)  (0.045)         BASILE2   68 OSPK AT=-0.188 +- .020    3/71
GTO Q  29K   (0.650)  (0.012)         ALBROW    70 ASPK AY=-0.858+-.015      1/79
GTO QB 36K   (0.593)  (0.022)         BUCHANAN  70 SPEC AU=-0.278 +- .010    2/76
GTO Q 4400   (0.664)  (0.056)         SMITH     70 OSPK AT=-0.306 +-0.024    1/79
GTO Q  180   (0.50)   (0.11)          JAMES     72 HBC                       1/73
GTO Q 1486   (0.608)  (0.043)         KRENZ     72 HLBC AT=-0.277 +- .018   11/72
GTO Q  384   (0.688)  (0.074)         METCALF   72 ASPK AT=-0.31  +- .03    11/72
GTO Q        (0.612)  (0.032)         ALEXANDER 73 HBC                       2/76
GTO Q 3200   (0.73)   (0.04)          BRANDENBU 73 HBC                       1/74
GTO QC 20K   (0.619)  (0.027)         BISI      74 ASPK AT=-0.282 +- .011   10/74
GTO   509K    0.677    0.010          MESSNER   74 ASPK AY=-0.917+-.013      7/75
GTO Q  192   (0.69)   (0.07)          BALDOCEOL 75 HLBC                     12/75
GTO Q  56K   (0.590)  (0.022)         BUCHANAN  75 SPEC AU=-0.277 +- .010    7/75
GTO  H6499    0.681    0.024          CHO       77 HBC                      11/77
GTO   4709    0.620    0.023          PEACH     77 HBC                      11/77
GTO Q   QUADRATIC DEPENDENCE REQUIRED BY SOME EXPERIMENTS (SEE SECTIONS
GTO Q   HTO AND KTO BELOW).  CORRELATIONS PREVENT US FROM AVERAGING RESULTS
GTO Q   OF FITS NOT INCLUDING G, H, AND K TERMS.
GTO  B  BUCHANAN 70 RESULT REVISED BY BUCHANAN 75 TO INCLUDE RADIATIVE COR.  2/76
GTO  B  AND TO USE MORE RELIABLE KL MOM.SPECT. OF 2ND EXPT.(HAD SAME BEAM).  2/76
GTO  C  BISI 74 VALUE COMES FROM QUADRATIC FIT WITH QUAD. TERM CONSISTENT   11/75
GTO  C  WITH ZERO.  GTO ERROR IS THUS LARGER THAN IF LINEAR FIT WERE USED.  11/75
GTO         . . . . . . . . . .
GTO AVG       0.670    0.014   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)
                      (SEE IDEOGRAM BELOW)
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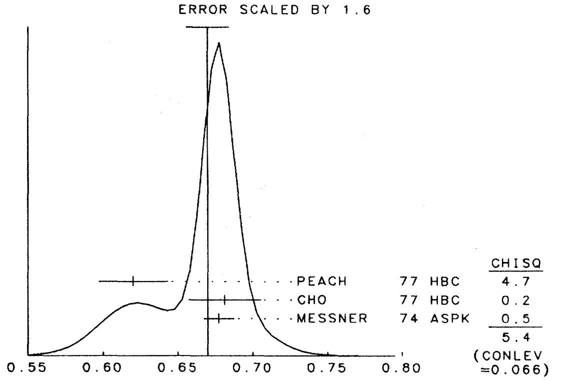
WEIGHTED AVERAGE = 0.670 ± 0.014
ERROR SCALED BY 1.6



TAU 0 SLOPE PARAMETER FOR KL

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HTO      QUADRATIC COEFF. H FOR KL --> PI+ PI- PI0 MATRIX ELEMENT SQUARED
HTO Q  29K  (-0.011)  (0.018)          ALBROW    70 ASPK                     1/79
HTO Q 4400   (0.043)  (0.052)          SMITH     70 OSPK                     1/79
HTO   509K    0.079    0.007           MESSNER   74 ASPK                     3/78
HTO   6499    0.095    0.032           CHO       77 HBC                      3/78
HTO   4709    0.048    0.036           PEACH     77 HBC                      3/78
HTO     SEE NOTES IN SECTION GTO ABOVE.                                      1/79
HTO         . . . . . . . . . .
HTO AVG      0.0786   0.0067  AVERAGE

KTO      QUADRATIC COEFF. K FOR KL --> PI+ PI- PI0 MATRIX ELEMENT SQUARED
KTO   509K    0.0097   0.0018          MESSNER   74 ASPK                     3/78
KTO   6499    0.024    0.010           CHO       77 HBC                      3/78
KTO   4709   -0.008    0.012           PEACH     77 HBC                      3/78
KTO         . . . . . . . . . .
KTO AVG      0.0098   0.0018  AVERAGE

JTO      LINEAR COEFF. J FOR KL --> PI+ PI- PI0 CP VIOLATING TERM            1/79
JTO      LISTED IN CP VIOLATION SECTION BELOW.                               1/79

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13 KL FORM FACTORS

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      FOR DISCUSSION, SEE NOTE ON FORM FACTORS IN THE CHARGED K
      SECTION OF THE DATA CARD LISTINGS ABOVE.

      IN THE FORM FACTOR COMMENTS, THE FOLLOWING ABBREVIATIONS ARE USED.
      F+ AND F- ARE FORM FACTORS FOR THE VECTOR MATRIX ELEMENT.
      FS AND FT REFER TO THE SCALAR AND TENSOR TERM.
      F0 = (F+) + (F-)*T/(MK**2-MPI**2)
      L+, L- AND L0 ARE THE LINEAR EXPANSION COEFFS. OF F+, F- AND F0.
      L+ REFERS TO THE KMU3 VALUE EXCEPT IN THE KE3 SECTIONS.
      DXI/DL IS THE CORRELATION BETWEEN XI(0) AND L+ IN KMU3.
      DL0/DL+ IS THE CORRELATION BETWEEN L0 AND L+ IN KMU3.
      T  = MOMENTUM TRANSFER TO THE PI IN UNITS OF MPI**2.
      DP = DALITZ PLOT ANALYSIS
      PI = PI SPECTRUM ANALYSIS
      MU = MU SPECTRUM ANALYSIS
      POL= MU POLARIZATION ANALYSIS
      BR = KMU3/KE3 BRANCHING RATIO ANALYSIS
      E  = POSITRON OR ELECTRON SPECTRUM ANALYSIS
      RC = RADIATIVE CORRECTIONS

XIA    XIA = F-/F+ (DETERMINED FROM SPECTRA)  ---------------------------
XIA  A1341   +1.2     (0.8)           CARPENTER 66 OSPK   DP, DXI/DL=-18     1/74
XIA B 3140  (-3.9)    (0.4)           BASILE    70 OSPK   DP, INDEP OF L+    1/74
XIA C  16K  (-0.68)   (0.12)   (0.20) CHIEN     70 ASPK   DP, DXI/DL=-26     1/74
XIA  D9086   -1.5      0.7            ALBROW    72 ASPK   DP, DXI/DL=-28     1/74
XIA C  16K  (+0.50)   (0.61)          DALLY     72 ASPK   DP, DXI/DL UNKN.   1/74
XIA  E1385   -1.00    (0.45)          PEACH     73 HLBC   DP, DXI/DL=-20     1/74
XIA  F1.6M   -0.11     0.07           DONALDS2  74 SPEC   DP, DXI/DL=-17    11/75
XIA  G 32K   -0.25     0.22           BUCHANAN  75 SPEC   DP, DXI/DL=-5.9    2/76
XIA  H 16K   +0.13     0.23           HILL      79 STRC   DP, DXI/DL=-20     4/82
XIA  H 14K   +0.26     0.16           CHO       80 HBC    DP, DXI/DL=-13     4/82
XIA  I150K   -0.10     0.09           BIRULEV   81 SPEC   DP, DXI/DL=-12     4/82
XIA         . . . . . . . . . .
XIA AVG      -0.074    0.061   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
XIA FIT      -0.11     0.09   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 2.3)  3/84*
                      (SEE IDEOGRAM BELOW)

XIA       FIT DISCUSSED IN NOTE ON KL3 FORM FACTORS IN 1982 EDITION.
XIA  A    CARPENTER 66 XI(0) IS FOR L+=0.  DXI/DL IS FROM FIG. 9.            1/74
XIA B     BASILE 70 IS INCOMPATIBLE WITH ALL OTHER RESULTS.  AUTHORS SUGGEST 1/74
XIA B     THAT EFFICIENCY ESTIMATES MIGHT BE RESPONSIBLE.                    1/74
XIA C     CHIEN 70 ERRORS ARE STATISTICAL ONLY.  DXI/DL FROM FIG.4.          1/74
XIA  C    DALLY 72 IS A REANALYSIS OF CHIEN 70.  THE DALLY 72 RESULT IS      1/74
XIA  C    NOT COMPATIBLE WITH ASSUMPTION L-=0 SO NOT INCLUDED IN OUR FIT.    2/76
XIA  C    THE NON-ZERO L- VALUE AND THE RELATIVELY LARGE L+ VALUE FOUND BY   1/74
XIA  C    DALLY 72 COME MAINLY FROM A SINGLE LOW T BIN (FIGS.1,2).           1/74
XIA  C    THE (F+,XI) CORRELATION WAS IGNORED.                               1/74
XIA  C    WE ESTIMATE FROM FIG. 2 THAT FIXING L-=0 WOULD GIVE XI(0)=-1.4+-0.3 1/74
XIA  C    AND WOULD ADD 10 TO CHI SQUARED.  DXI/DL IS NOT GIVEN.             1/74
XIA  D    ALBROW 72 FIT HAS L- FREE, GETS L-=-.030+-.060 OR LAM=+.15+.17-.11. 1/74
XIA  E    PEACH 73 GIVES XI0=-.95+-.45 FOR L+=L-=.025 .  THE ABOVE VALUE IS  1/74
XIA  E    FOR L-=0.  K.PEACH, PRIVATE COMMUNICATION(1974).                   1/74
XIA  F    DONALDSON2 74 GIVES XI=-.11+-.02 NOT INCLUDING SYSTEMATICS.  ABOVE 11/75
XIA  F    ERROR AND DXI/DL WERE CALCULATED BY US FROM L0 AND L+ ERRORS (WHICH 11/75
XIA  F    INCLUDE SYSTEMATICS) AND DL0/DL+.                                 11/75
XIA  G    BUCHANAN 75 IS CALCULATED BY US FROM L0, L+ AND DL0/DL+ BECAUSE    2/76
XIA  G    THEIR APPENDIX A VALUE -.20+-22 ASSUMES XI(T) CONSTANT, I.E. L-=L+. 2/76
XIA  H    HILL 79 AND CHO 80 CALCULATED BY US FROM L0, L+, AND DL0/DL+.      4/82
XIA  I    BIRULEV 81 ERROR, DXI/DL CALC. BY US FROM L0, L+.  DL0/DL+=0 USED. 4/82
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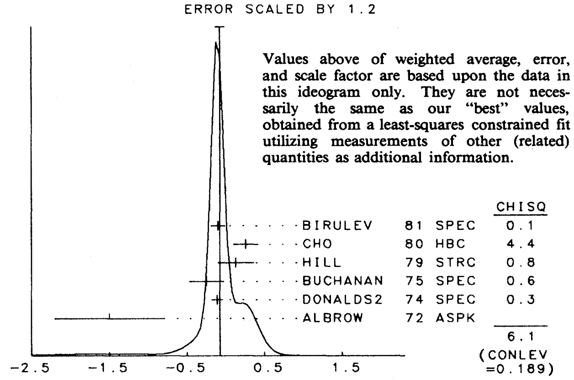
WEIGHTED AVERAGE = −0.074 ± 0.061
ERROR SCALED BY 1.2



XIA = F−/F+ FOR K0MU3 DECAY SPECTRA

For notation, see key at front of Listings.

Stable Particles

K^0_L

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XIB     XIB = F-/F+ (DETERMINED FROM KMU3/KE3)  ---------------------------
XIB       THE KMU3/KE3 BRANCHING RATIO FIXES A RELATIONSHIP BETWEEN XI(0)       1/74
XIB       AND L+.  WE QUOTE THE AUTHORS XI(0) AND ASSOCIATED L+ BUT DO NOT      1/74
XIB       AVERAGE BECAUSE THE L+ VALUES DIFFER.  THE FIT RESULT AND SCALE       1/74
XIB       FACTOR GIVEN IN THE NOTE ON KL3 FORM FACTORS IN THE K+- SECTION OF    2/76
XIB       THE DATA CARDS ARE NOT OBTAINED FROM THESE XIB VALUES.  INSTEAD       2/76
XIB       THEY ARE OBTAINED DIRECTLY FROM THE AUTHORS KMU3/KE3 BRANCHING        2/76
XIB       RATIO VIA THE FITTED KMU3/KE3 RATIO (R10).                            2/76
XIB     389  (+1.1)     (1.1)           ADAIR      64 HBC      BR, L+=0         1/74
XIB          (+0.66)    (0.9)    (1.3)  LUERS      64 HBC      BR, L+=0         1/74
XIB          (+0.2)     (0.8)    (1.2)  KULYUKINA  68 CC       BR, L+=0         1/74
XIB     569  (+0.45)    (0.28)          BEILLIERE  69 HLBC     BR, L+=0         1/74
XIB E  1309  (-0.22)    (0.30)          EVANS      69 HLBC                      1/74
XIB    3548  (-0.5)     (0.5)           BASILE     70 OSPK     BR, L+=.02       1/74
XIB    6700   (0.5)     (0.4)           BRANDENBU  73 HBC      BR,L+=.019+-.013 1/74
XIB   E1309  (-0.08)    (0.25)          EVANS      73 HLBC     BR, L+=.02       1/74
XIB          . . . . . . . . . .
XIB FIT       -0.11      0.09    FROM FIT (ERROR INCLUDES SCALE FACTOR OF 2.3)  3/84*

XIB       FIT DISCUSSED IN NOTE ON KL3 FORM FACTORS IN 1982 EDITION.
XIB  E    EVANS 73 REPLACES EVANS 69.                                           1/74

XIC     XIC = F-/F+ (DETERMINED FROM MU POLARIZATION IN KMU3)  ------------
XIC     THE MU POLARIZATION IS A MEASURE OF XI(T). NO ASSUMPTIONS ON L+-
XIC     NECESSARY, T (WEIGHTED BY SENSITIVITY TO XIO) SHOULD BE SPECIFIED.
XIC     IN L+,XI(0) PARAMETERIZATION THIS IS XI(0) FOR L+=0.  DXI/DL=XI*T.
XIC       FOR RAD. CORR. TO MUON POLARIZATION IN KMU3, SEE GINSBERG 73.         2/72
XIC T 2608  (-1.2)      (0.5)           AUERBACH   66 OSPK     POLARIZATION     8/67
XIC T  638  (-1.6)      (0.5)           ABRAMS     68 OSPK     POLARIZATION     5/69
XIC  L        -1.81      0.50     0.26  LONGO      69 CNTR     POL. T=3.3       1/74
XIC  S2.2M    -0.385     0.105          SANDWEISS  73 CNTR     POL,DXI/DL=-6    1/74
XIC  H207K    +0.178     0.105          CLARK      77 SPEC     POL,DXI/DL=+.68 11/77
XIC          . . . . . . . . . .
XIC AVG       -0.17      0.28     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 3.9)
XIC FIT       -0.11      0.09    FROM FIT (ERROR INCLUDES SCALE FACTOR OF 2.3)  3/84*
                        (SEE IDEOGRAM BELOW)

XIC       FIT DISCUSSED IN NOTE ON KL3 FORM FACTORS IN 1982 EDITION.
XIC T     T VALUE NOT GIVEN.                                                    1/74
XIC  L    LONGO 69 T=3.3 CALC. FROM DXI/DL=-6.0 (TABLE 1) DIVIDED BY XI=-1.81   1/74
XIC  S    SANDWEISS 73 IS FOR L+=0 AND T=0.                                     1/74
XIC  H    CLARK 77 T=+3.80, DXI/DL=XI(T)*T=.178*3.80=+.68 .                    11/77
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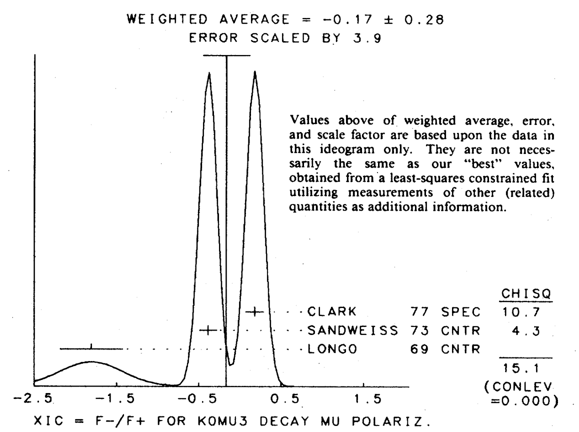


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IXI         IMAGINARY PART OF XI  (TEST OF T REVERSAL)  ---------------------
IXI           -0.2       0.6            ABRAMS     68 OSPK     POLARIZATION      10/69
IXI           -0.02      0.08           LONGO      69 CNTR     POL. T=3.3        11/69
IXI   2.2M    -0.060     0.045          SANDWEISS  73 CNTR     POL, T=0           1/74
IXI  S2.2M    -0.085     0.064          SANDWEISS  73 CNTR     POL,T=0           12/79
IXI  C207K     0.35      0.30           CLARK      77 SPEC     POL, T=0          11/77
IXI           (0.012)   (0.026)         SCHMIDT    79 CNTR     REPL.BY MORSE 80  12/79
IXI    12M     0.009     0.030          MORSE      80 CNTR     POLARIZATION      10/81
IXI  S  SANDWEISS 73 VALUE CORRECTED FROM VALUE QUOTED IN THEIR PAPER DUE        12/79
IXI  S  TO NEW VALUE OF RE(XI). SEE FTNOTE 4 OF SCHMIDT 79.                      12/79
IXI  C  CLARK 77 VALUE HAS ADDITIONAL XIO DEPENDENCE +0.21*RE(XIO).              11/77
IXI          . . . . . . . . . .
IXI AVG       -0.020     0.022   AVERAGE

L+M     LAMBDA +  (LINEAR ENERGY DEPENDENCE OF F+ IN KMU3 DECAY)  ---------
L+M       SEE ALSO THE CORRESPONDING ENTRIES AND NOTES IN SECTION XIA AND LO.
L+M       FOR RAD.COR. OF KMU3 DP SEE GINSBURG 70 AND BECHERRAWY 70.              3/74
L+M     16K   (0.07)    (0.02)          CHIEN      70 ASPK REPL. BY DALLY 72      1/74
L+M   A9086    0.085     0.015          ALBROW     72 ASPK    DP                  1/74
L+M     16K   (0.11)    (0.04)          DALLY      72 ASPK    DP                  1/74
L+M     82K   (0.046)   (0.008)         ALBRECHT   74 WIRE REPL. BY BIRULEV 81 11/75
L+M    1.6M    0.030     0.003          DONALDS2   74 SPEC    DP                 10/74
L+M     32K    0.046     0.030          BUCHANAN   75 SPEC    DP                  9/75
L+M    129K   (0.0337)  (0.0033)        DZHORDZHA  77 SPEC REPL. BY BIRULEV 81 12/79
L+M     16K    0.028     0.011          HILL       79 STRC    DP                 12/79
L+M     14K    0.028     0.010          CHO        80 HBC     DP                  2/82
L+M    150K    0.0427    0.0044         BIRULEV    81 SPEC    DP                  1/82
L+M          . . . . . . . . . .
L+M AVG        0.0347    0.0049  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.1)
L+M FIT        0.034     0.005  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 2.3)   3/84*
                        (SEE IDEOGRAM BELOW)

L+M       FIT DISCUSSED IN NOTE ON KL3 FORM FACTORS IN 1982 EDITION.
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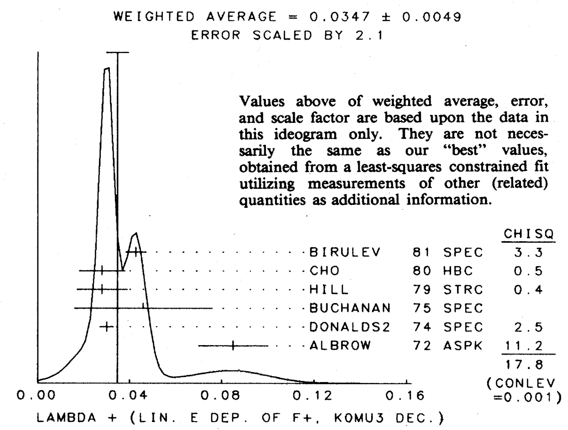


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LO      LAMBDA O (LINEAR ENERGY DEPENDENCE OF FO IN KMU3 DECAY)  ----------
LO        WHEREVER POSSIBLE, WE HAVE CONVERTED THE ABOVE VALUES OF XI(0) INTO
LO        VALUES OF LO USING THE ASSOCIATED L+M AND DXI/DL.
LO L  1371    +0.08     (0.07)           CARPENTER 66 OSPK    DP,DLO/DL+=-0.54  1/74
LO L          -0.140    (0.043)  (0.022)LONGO      69 CNTR    POL,DLO/DL+=+.49  1/74
LO  B 3140   (-0.333)   (0.034)          BASILE    70 OSPK    DP,DLO/DL+=+1.    1/74
LO A  9086    -0.043     0.052           ALBROW    72 ASPK    DP,DLO/DL+=-1.39  1/74
LO  C  16K   (-0.067)   (0.227)          DALLY     72 ASPK    DP,DLO/DL+ UNKN.  1/74
LO  R 6700   (+0.06)    (0.03)           BRANDENBU 73 HBC     BR,L+=.019+-.013  1/74
LO P  1385    -0.060    (0.038)          PEACH     73 HLBC    DP,DLO/DL+=-0.71  1/74
LO L  2.2M    -0.018    (0.009)          SANDWEISS 73 CNTR    POL,DLO/DL+=+.49  1/74
LO      82K  (+0.024)   (0.011)          ALBRECHT  74 WIRE REPL. BY BIRULEV 81 11/75
LO E  1.6M    +0.019     0.004           DONALDS2  74 SPEC    DP,DLO/DL+=-0.47 10/74
LO    F 32K   +0.025     0.019           BUCHANAN  75 SPEC    DP,DLO/DL+=+0.5   2/76
LO L  207K    +0.047    (0.009)          CLARK     77 SPEC    POL,DLO/DL+=1.06 11/77
LO      47K  (+0.0485)  (0.0076)         DZHORDZHA 77 SPEC REPL. BY BIRULEV 81 12/79
LO      16K   +0.039     0.010           HILL      79 STRC    DP,DLO/DL+=-0.67 12/79
LO      14K   +0.050     0.008           CHO       80 HBC     DP,DLO/DL+=-0.11  2/82
LO  G   14K   (0.041)   (0.008)          CHO       80 HBC     BR, L+=0.028      2/82
LO H  150K     0.0341    0.0067          BIRULEV   81 SPEC    DP,DLO/DL+=?      4/82
LO           . . . . . . . . . .
LO  AVG        0.0279    0.0057  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.9)
LO  FIT        0.025     0.006  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 2.3)   3/84*
                        (SEE IDEOGRAM BELOW)

LO        FIT DISCUSSED IN NOTE ON KL3 FORM FACTORS IN 1982 EDITION.
LO L      LO VALUE IS FOR L+=0.03  CALCULATED BY US FROM XIO AND DXI/DL.        1/74
LO  B     BASILE 70 LO IS FOR L+=0.  CALCULATED BY US FROM XIA WITH DXI/DL=0.   1/74
LO  B     BASILE 70 IS INCOMPATIBLE WITH ALL OTHER RESULTS.  AUTHORS SUGGEST    1/74
LO  B     THAT EFFICIENCY ESTIMATES MIGHT BE RESPONSIBLE.                       1/74
LO A      ALBROW 72 LO IS CALCULATED BY US FROM XIA,L+ AND DXI/DL.  THEY GIVE   1/74
LO A      LO=-.043+-.039 FOR L-=0.  WE USE OUR LARGER CALCULATED ERROR.         1/74
LO  C     DALLY 72 GIVES FO=1.20+-.35, LO=-.080+-.272, LOPRIME=-.006+-.045,     1/74
LO  C     BUT WITH A DIFFERENT DEFINITION OF LO.  OUR QUOTED LO IS HIS LO/FO.   1/74
LO  C     WE CANNOT CALCULATE TRUE LO ERROR WITHOUT HIS (LO,FO) CORRELATIONS.   1/74
LO  C     SEE ALSO NOTE C IN SECTION XIA.                                       1/74
LO P      PEACH 73 ASSUMES L+=0.025.  CALCULATED BY US FROM XIO AND DXIO/DL+.   1/74
LO  R     FIT FOR LO DOES NOT INCLUDE THIS VALUE BUT INSTEAD INCLUDES THE       2/76
LO  R     KMU3/KE3 RESULT FROM THIS EXPERIMENT.                                 2/76
LO E      DONALDSON2 74 DLO/DL+ OBTAINED FROM FIG. 18.                         11/75
LO   F    BUCHANAN 75 VALUE IS FROM THEIR APPENDIX A AND USES ONLY KMU3 DATA.   2/76
LO   F    DLO/DL+ WAS OBTAINED BY PRIVATE COMMUNICATION, C.BUCHANAN, 1976.      2/76
LO   G    CHO 80 BR RESULT NOT INDEPENDENT OF THEIR DP RESULT.                  4/82
LO   H    BIRULEV 81 GIVES DLO/DL+=-1.5, GIVING AN UNREASONABLY NARROW ERROR    4/82
LO   H    ELLIPSE WHICH DOMINATES ALL OTHER RESULTS.  WE USE DLO/DL+=0.         4/82
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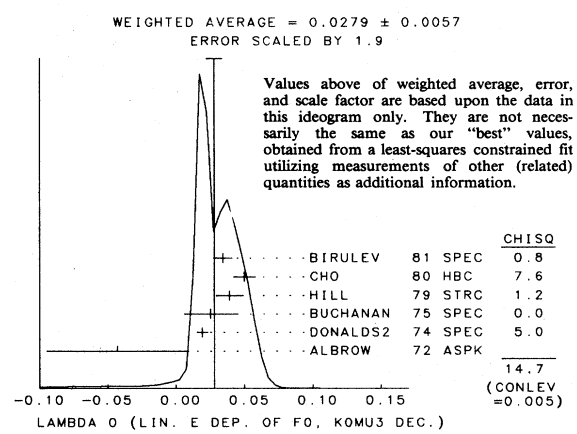

Stable Particles

Data Card Listings

K^0_L

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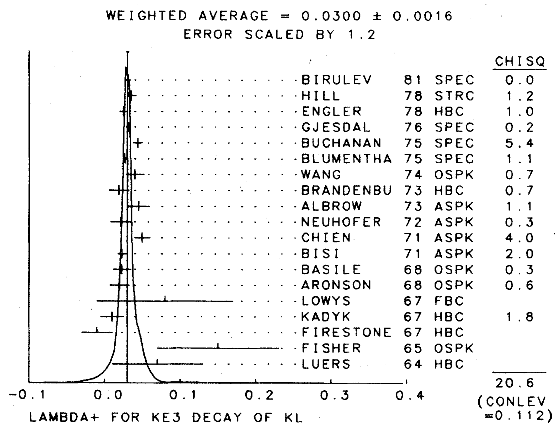
L+E      LAMBDA +  (LINEAR ENERGY DEPENDENCE OF F+ IN K0 E3 DECAY)    ------
L+E      FOR RAD.COR. OF KE3 DP SEE GINSBURG 67 AND BECHERRAWY 70.             3/74
L+E     153   +0.07      0.06                LUERS     64 HBC     DP, NO RC
L+E     577   +0.15      0.08                FISHER    65 OSPK    DP, NO RC    8/67
L+E     762   -0.01      0.02                FIRESTONE 67 HBC     DP, NO RC    8/67
L+E     531   +0.01      0.015               KADYK     67 HBC     E,PI, NO RC  8/67
L+E     240   +0.08      0.10       0.08     LOWYS     67 FBC     PI           8/67
L+E    1000    0.02      0.013               ARONSON   68 OSPK    PI           5/69
L+E    4800   +0.023     0.012               BASILE    68 OSPK    DP, NO RC    3/68
L+E     42K    0.023     0.005               BISI      71 ASPK    DP          12/71
L+E     16K    0.05      0.01                CHIEN     71 ASPK    DP, NO RC    6/71
L+E    1910    0.022     0.014               NEUHOFER  72 ASPK    PI           1/73
L+E    5600    0.045     0.014               ALBROW    73 ASPK    DP           9/73
L+E    1871    0.019     0.013               BRANDENBU 73 HBC     PI TRANSV.   1/74
L+E    2171    0.040     0.012               WANG      74 OSPK    DP           7/74
L+E     25K    0.0270    0.0028              BLUMENTHA 75 SPEC    DP           7/75
L+E     24K    0.044     0.006               BUCHANAN  75 SPEC    DP           7/75
L+E     48K   (0.032)   (0.0042)             BIRULEV   76 SPEC REPL. BY BIRULEV 81  1/78
L+E    500K    0.0312    0.0025              GJESDAL   76 SPEC    DP           1/77
L+E   E 12K    0.025     0.005               ENGLER    78 HBC     DP           7/79
L+E     18K    0.0348    0.0044              HILL      78 STRC    DP           6/78
L+E     26K   (0.0286)  (0.0049)             BIRULEV   79 SPEC REPL. BY BIRULEV 81 10/81
L+E E   19K   (0.029)   (0.005)              CHO       80 HBC     DP           2/82
L+E     74K    0.0306    0.0034              BIRULEV   81 SPEC    DP           1/82
L+E E    ENGLER 78 USES UNIQUE KE3 SUBSET OF CHO 80 EVENTS AND IS LESS         2/82
L+E E    SUBJECT TO SYSTEMATIC EFFECTS.                                        2/82
L+E
L+E AVG        0.0300    0.0016  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
                         (SEE IDEOGRAM BELOW)
```




```
FS       FS/F+  RATIO OF SCALAR TO F+ COUPLINGS FOR KE3 DECAY(ABS. VALUE)----
FS             (0.15) OR LESS  CL=.68   KULYUKINA 67 CC                      10/69
FS     5600    (0.19) OR LESS  CL=.95   ALBROW    73 ASPK                     9/73
FS      25K    (0.04) OR LESS  CL=.68   BLUMENTHA 75 SPEC                     7/75
FS      48K    (0.07) OR LESS  CL=.68   BIRULEV   76 SPEC SEE ALSO BIRULEV 81 1/78
FS      18K    (0.095)OR LESS  CL=.95   HILL      78 STRC                     6/78

FT       FT/F+  RATIO OF TENSOR TO F+ COUPLINGS FOR KE3 DECAY(ABS. VALUE)----
FT             (1.0)  OR LESS  CL=.68   KULYUKINA 67 CC                      10/69
FT     5600    (1.0)  OR LESS  CL=.95   ALBROW    73 ASPK                     9/73
FT      25K    (0.23) OR LESS  CL=.68   BLUMENTHA 75 SPEC                     7/75
FT      48K    (0.34) OR LESS  CL=.68   BIRULEV   76 SPEC SEE ALSO BIRULEV 81 1/78
FT      18K    (0.40) OR LESS  CL=.95   HILL      78 STRC                     6/78

FTM      FT/F+  RATIO OF TENSOR TO F+ COUPLINGS FOR KMU3 DECAY(ABS. VALUE)---
FTM            (0.12)   (0.12)          BIRULEV   81 SPEC                     2/82
------ --------- --------- --------- --------- --------- --------- --------
```

NOTE ON CP VIOLATION IN K^0_L DECAY

We list the parameters which measure CP violation in K^0_L decays and compare them with superweak model predictions.

Parameters

There are three different K^0_L decays in which CP can be tested (for details, see Okun and Rubbia[1], Steinberger[2], and Wolfenstein[3]).

(a) Charge asymmetry in $K_L \to \pi^+\pi^-\pi^0$ decays. As was discussed in the note on $K \to 3\pi$ decay in the $K^\pm$ section of the Data Card Listings, the Dalitz plot distribution for this decay contains a charge asymmetry term with coefficient j, the presence of which would indicate CP violation. Experimenters have used several forms for this CP-violation term. As described in the "Note on Slope Parameters for $K \to 3\pi$ Decays" in the 1982 edition of this Review,[4] we have converted all results to coefficient j and have listed the results in section JT0 below. The coefficient j is consistent with zero, i.e., absence of CP violation.

(b) Asymmetry in the $K_L \to \pi^\mp \ell^\pm \nu$ decays. The quantity measured and compiled here is

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

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

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

where x is defined below in the "Note on the $\Delta S = \Delta Q$ Rule in K^0 Decay," and ϵ is the parameter of the expansion

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

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

We list δ separately for $K^0_L \to \pi\mu\nu$ and $K^0_L \to \pi e\nu$ in sections A1 and A2 respectively, and list the combined values in section AL.

(c) $K_L \to 2\pi$ decay. The relevant parameters are

$$\eta_{+-} = A(K_L \to \pi^+\pi^-)/A(K_S \to \pi^+\pi^-)$$

$$= |\eta_{+-}| \exp(i\phi_{+-}) ,$$

$$\eta_{00} = A(K_L \to \pi^0\pi^0)/A(K_S \to \pi^0\pi^0)$$

$$= |\eta_{00}| \exp(i\phi_{00}) ,$$

ϵ, defined in Eqs. (1) above, and

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

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

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

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

Wu and Yang[5] have derived the relationships

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

For notation, see key at front of Listings.

Stable Particles

K^0_L

Measurements of $|\eta_{+-}|$, $|\eta_{00}|^2$, ϕ_{+-}, and ϕ_{00} are listed in sections E+−, E0S, F+−, and F00. The FIT values given in these sections come from constrained fits which include the $|\eta_{00}|/|\eta_{+-}|$ and $\phi_{00} - \phi_{+-}$ measurements from sections ER and DF, respectively.

Superweak model predictions for $|\eta_{00}/\eta_{+-}|$, ϕ_{+-}, and Re ϵ

The superweak model[6] predicts that[7]

$$|\eta_{00}/\eta_{+-}| = 1 ,$$

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

and

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

The latter two expressions and the values of the $K^0_L - K^0_S$ mass difference $\Delta m = (0.5349 \pm 0.0022)\times 10^{10}\,\hbar\ \mathrm{sec}^{-1}$, the K^0_S mean life $\tau_S = (0.8923 \pm 0.0022)\times 10^{-10}$ sec, and the magnitude of the $(K^0_L \to \pi^+\pi^-)/(K^0_S \to \pi^+\pi^-)$ amplitude ratio $|\eta_{+-}| = (2.274 \pm 0.022)\times 10^{-3}$, all from the current edition, result in the predictions that

$$\phi_{+-} = \phi_{00} = (43.67 \pm 0.14)^\circ$$

and

$$\mathrm{Re}\,\epsilon = (1.645 \pm 0.016)\times 10^{-3} .$$

The above predictions can be compared with the experimental values

$$|\eta_{00}/\eta_{+-}| = 1.023 \pm 0.036 ,$$

$$\phi_{+-} = (44.6 \pm 1.2)^\circ ,$$

$$\phi_{00} = (54.5 \pm 5.3)^\circ ,$$

$$\mathrm{Re}\,\epsilon = (1.621 \pm 0.088)\times 10^{-3} ,$$

where Re ϵ has been computed using the relation

$$\mathrm{Re}\,\epsilon = \frac{\delta}{2}\left(\frac{|1-x|^2}{1-|x|^2}\right) ,$$

and our current values of the charge asymmetry parameter for leptonic K^0_L decay $\delta = (0.330 \pm 0.012)\%$ and the $\Delta S = -\Delta Q$ amplitude (Rex, Imx) = (0.009 ± 0.020, −0.004 ± 0.026).

The superweak predictions are within one standard deviation of the data except for the measured value of ϕ_{00}, which is two standard deviations above the prediction. This results primarily from the CHRISTENSON1 79 measurement $\phi_{00} = (55.7 \pm 5.8)^\circ$.

References

1. L.B. Okun and C. Rubbia, in *Proceedings Heidelberg Conference on Elementary Particles*, p. 301 (1967).
2. J. Steinberger, in *CERN Topical Conference on Weak Interactions*, CERN 69-7, p. 291 (1969).
3. L. Wolfenstein, in *Theory and Phenomenology in Particle Physics*, ed. A. Zichichi (Academic Press, New York, 1969) p. 218.
4. Particle Data Group, Phys. Lett. **111B**, 69 (1982).
5. T.T. Wu and C.N. Yang, Phys. Rev. Lett. **13**, 380 (1964).
6. L. Wolfenstein, Phys. Lett. **13**, 562 (1964).
7. T.D. Lee and L. Wolfenstein, Phys. Rev. **138B**, 1490 (1965).

13 CP VIOLATION PARAMETERS IN KL DECAYS

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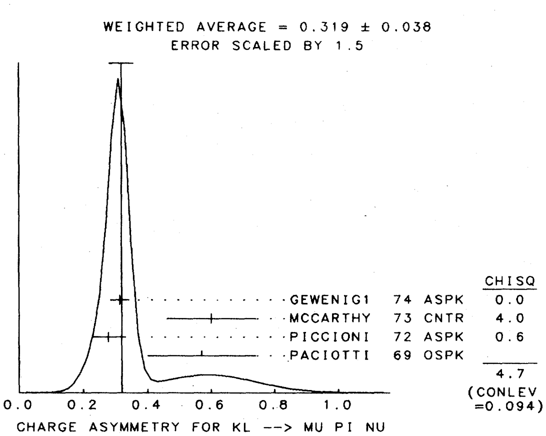
--------------------13 CHARGE ASYMMETRY IN TAU DECAYS----------------------

JTO    CP VIOL. COEFF. J FOR KL --> PI+ PI- PI0 MATRIX ELEMENT SQUARED.
JTO    DEFINED AT BEGINNING OF SECTION GTO ABOVE. SEE ALSO NOTE ON SLOPE
JTO    PARAMETERS IN CHARGED K SECTION AND NOTE ON CP VIOLATION IN KL
JTO    DECAY ABOVE.
JTO   238K    0.001    0.004          BLANPIED  68                       1/79
JTO     3M    0.0013   0.0009         SCRIBANO  70                       1/79
JTO   4400    0.0      0.017          SMITH     70 OSPK                  1/79
JTO   6499    0.001    0.011          CHO       77                       1/79
JTO   4709   -0.001    0.003          PEACH     77                       1/79
JTO
JTO AVG      0.00110  0.00084  AVERAGE
--------------------13  CHARGE ASYMMETRY IN LEPTONIC DECAYS (PERCENT)------

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

A1    KL INTO (MU+PI-NU)-(MU-PI+NU)/(MU+PI-NU)+(MU-PI+NU)    (PERCENT)
A1  D    1M   (0.403)  (0.134)        DORFAN    67 OSPK   DERIVED FROM R16 11/67
A1 D     1M    0.57     0.17          PACIOTTI  69 OSPK                  1/73
A1     7.7M    0.278    0.051         PICCIONI  72 ASPK                  1/73
A1     4.1M    0.60     0.14          MCCARTHY  73 CNTR                  6/73
A1      15M    0.313    0.029         GEWENIG1  74 ASPK                  7/74
A1 D    PACIOTTI 69 IS A REANALYSIS OF DORFAN 67 AND IS CORRECTED FOR    1/73
A1 D    MU+ MU- RANGE DIFFERENCE IN MC CARTHY 72.                        1/73
A1
A1  AVG        0.319    0.038   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
                               (SEE IDEOGRAM BELOW)
```



Stable Particles

Data Card Listings

K^0_L

```
A2      KL INTO (E+PI-NU)-(E-PI+NU)/(E+PI-NU)+(E-PI+NU)          (PERCENT)
A2  B  10M   (0.224)  (0.036)         BENNETT   67 CNTR                   11/67
A2 B   10M    0.246    0.059          SAAL      69 CNTR                   10/70
A2     10M    0.346    0.033          MARX      70 CNTR                   10/70
A2    600K    0.36     0.18           ASHFORD   72 ASPK                    2/72
A2     40M    0.318    0.038          FITCH     73 ASPK                   12/73
A2     34M    0.341    0.018          GEWENIG1  74 ASPK                    7/74
A2  B SAAL 69 IS A REANALYSIS OF BENNETT 67
A2           . . . . . . . . . . .
A2  AVG       0.333    0.014   AVERAGE

AL      KL INTO ((L+)-(L-))/((L+)+(L-))  (COMBINED A1 AND A2) (PERCENT)
AL B   10M    0.246    0.059          SAAL      69 CNTR   KE3              2/71
AL D    1M    0.57     0.17           PACIOTTI  69 OSPK   KMU3             1/73
AL     10M    0.346    0.033          MARX      70 CNTR   KE3              2/71
AL    600K    0.36     0.18           ASHFORD   72 ASPK   KE3              2/72
AL    7.7M    0.278    0.051          PICCIONI  72 ASPK   KMU3             1/73
AL     40M    0.318    0.038          FITCH     73 ASPK   KE3             12/73
AL    4.1M    0.60     0.14           MCCARTHY  73 CNTR   KMU3             6/73
AL     33M    0.333    0.050          WILLIAMS  73 ASPK   KMU3+KE3        12/73
AL     15M    0.313    0.029          GEWENIG1  74 ASPK   KMU3             7/74
AL     34M    0.341    0.018          GEWENIG1  74 ASPK   KE3              7/74
AL      SEE FOOTNOTES IN SECTIONS A1 AND A2 ABOVE.                         1/73
AL           . . . . . . . . . . .
AL  AVG       0.330    0.012   AVERAGE

--------------------13  PARAMETERS FOR KL INTO 2PI DECAY-------------------

     ETA+- = A(KL TO PI+PI-)/A(KS TO PI+PI-)
     ETA00 = A(KL TO PI0PI0)/A(KS TO PI0PI0)

     THE FITTED VALUES OF ETA+- AND ETA00 GIVEN BELOW ARE THE RESULTS
     OF A FIT TO ETA+-, ETA00 AND ETA00/ETA+- RESULTS.  THE VALUES LISTED
     BELOW WHICH ARE NOT PARENTHESIZED ENTER THE FIT AS SHOWN.  THE
     VALUES WHICH ARE PARENTHESIZED AND BEAR THE FOOTNOTE X DO NOT ENTER
     THE FIT AS SHOWN.  THESE EXPERIMENTS GIVE BRANCHING RATIOS AND ENTER
     THE FIT VIA THE QUANTITY ACTUALLY MEASURED -- BRANCHING RATIOS
     R9, R20 AND R27 (ETA+-) AND R17 AND R19 (ETA00).  THESE BRANCHING
     RATIOS ARE COMBINED WITH CURRENT NORMALIZATIONS AND CURRENT KL AND KS
     MEAN LIVES TO OBTAIN PI PI RATES.  THE ETA+- AND ETA00 VALUES OBTAINED
     FROM THESE RATES ARE ENTERED BELOW WITH THE NAME 'GKL/GKS'.

E0S     (ETA00)**2 = (A(KL TO 2PI0)/A(KS TO 2PI0))**2  (UNITS 10**-6)   ----
E0S X    0  (-2.)      (7.0)          BARTLETT  68 OSPK                   10/69
E0S X   57   (4.9)     (1.2)          BANNER    69 OSPK                    2/72
E0S XR 133  (14.1)     (3.4)          CENCE     69 OSPK                   10/69
E0S XF 180  (13.)      (4.)           GAILLARD  69 OSPK                   10/69
E0S X   29   (4.08)    (0.9)          BARMIN    70 HLBC                   12/70
E0S X   30   (3.61)    (1.9)          BUDAGOV   70 HLBC                   10/70
E0S  C        8.7       3.7           CHOLLET   70 OSPK   CU REG.,4 GAMMAS  2/72
E0S XF 172   (9.9)     (3.4)          FAISSNER  70 OSPK                   12/70
E0S  C  56    7.4       2.0           WOLFF     71 OSPK   CU REG.,4GAMMAS  12/71
E0S XR 150  (14.1)     (3.4)          REY       76 OSPK                    8/76
E0S           5.43      0.84          CHRISTE1  79 ASPK                   12/79
E0S  X        5.1       1.0           GKL/GKS   84 RVUE BR SCALE FACTOR=1.5  3/84*
E0S X   SEE NOTE ABOVE REGARDING FITTED VALUES OF ETA+- AND ETA00.
E0S  R  CENCE 69 EVENTS ARE INCLUDED IN REY 76.                            1/77
E0S  F  FAISSNER 70 CONTAINS SAME 2PI0 EVENTS AS GAILLARD 69
E0S  C  CHOLLET 70 GIVES ETA00=(1.23+-0.24)*(REGEN AMPL,2GEV/C CU)/10000MB  2/72
E0S  C  WOLFF 71   GIVES ETA00=(1.13+-0.12)*(REGEN AMPL,2GEV/C CU)/10000MB  2/72
E0S  C  WE COMPUTE BOTH ETA00**2 VALUES FOR (REGEN AMPL,2GEV/C CU)=24+-2MB.  2/72
E0S  C  THIS REGEN AMPL RESULTS FROM AVERAGING OVER FAISSNER 69,           2/72
E0S  C  EXTRAPOLATED USING OPTICAL MODEL CALCULTIONS OF BOHM ET AL.         2/72
E0S  C  PL 27B 594 (1968) AND THE DATA OF BALATS 71. (FROM H. FAISSNER,    2/72
E0S  C  PRIVATE COMMUNICATION)                                             2/72
E0S  F  FAISSNER 70 CONTAINS SAME 2PI0 EVENTS AS GAILLARD 69
E0S          . . . . . . . . . . .
E0S AVG       5.58      0.60    AVERAGE
E0S FIT       5.41      0.38   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)  3/84*

E00     ETA00 = A(KL TO 2PI0)/A(KS TO 2PI0)  (UNITS 10**-3)  --------------
E00      THE FIT VALUE ABOVE FOR ETA00**2 CORRESPONDS TO ETA00=2.325+-0.082  3/84*

E+-     ETA+-  = A(KL TO PI+PI-)/A(KS TO PI+PI-) UNITS 10**-3  ------------
E+- X   45   (1.95)    (0.20)         CHRISTENS 64 OSPK                    2/76
E+- X   54   (1.99)    (0.16)         GALBRAITH 65 OSPK                    2/76
E+- X        (1.92)    (0.13)         BASILE    66 OSPK                    2/76
E+- X        (1.95)    (0.04)         BOTT-BODE 66 OSPK                    2/76
E+- X        (2.00)    (0.09)         DEBOUARD  67 OSPK                    2/76
E+- X        (1.94)    (0.08)         FITCH     67 OSPK                    2/76
E+- AX       (1.95)    (0.03)         GKL/GKS   71 RVUE   EXPTS. BEFORE 71  2/76
E+- A   AVERAGE OF ABOVE EXPERIMENTS.  THESE ARE EXCLUDED FROM THE GKL/GKS,  1/80
E+- A   AVERAGE, AND FIT VALUES BELOW SINCE THEY DO NOT AGREE WITH MORE      1/80
E+- A   RECENT PRECISE AND IN PRINCIPLE SUPERIOR EXPERIMENTS.              1/80
E+- X 4200   (2.23)    (0.05)         MESSNER   73 ASPK                   11/75
E+-           2.30      0.035         GEWENIG2  74 ASPK                    3/74
E+- X 2703   (2.25)    (0.05)         DEVOE     77 SPEC                   11/77
E+-           2.27      0.12          CHRISTE2  79 ASPK                   12/79
E+-  X        2.255     0.029         GKL/GKS   84 RVUE   BR EXP. AFTER 71  3/84*
E+- Z        (2.09)    (0.02)         ARONSON2  82 SPEC   E=30-110 GEV     1/83*
E+- Z   ARONSON 82 FIND THAT ETA+- MAY DEPEND ON THE KAON ENERGY .          1/83*
E+- X   SEE NOTE ABOVE REGARDING FITTED VALUES OF ETA+- AND ETA00.
E+-          . . . . . . . . . . .
E+- AVG       2.273     0.022   AVERAGE
E+- FIT       2.274     0.022  FROM FIT                                   3/84*

ER      RATIO OF ETA00 OVER ETA+-
ER      124   1.03      0.07          BANNER1   72 OSPK                    8/72
ER      167   1.00      0.06          HOLDER    72 ASPK                    8/72
ER  C        (1.00)    (0.09)         CHRISTE1  79 ASPK                    2/80
ER  C   NOT INDEPENDENT OF E+- AND E0S VALUES WHICH ARE INCLUDED IN FIT.    2/80
ER           . . . . . . . . . . .
ER  AVG       1.013     0.046   AVERAGE
ER  FIT       1.023     0.036  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)  3/84*

F+-     PHI+-, THE PHASE OF ETA +-    (DEGREES)   -------------------------
F+-      THE DEPENDENCE OF THE PHASE ON THE KL-KS MASS DIFFERENCE
F+-      IS GIVEN FOR EACH EXPERIMENT IN THE COMMENTS BELOW, WHERE DM IS
F+-      (MASS DIFF./HBAR) IN UNITS 10**10 SEC-1.  WE HAVE EVALUATED THESE
F+-      MASS DEPENDENCES USING OUR APRIL 1982 VALUE, DM=0.5349+-0.0022
F+-      TO OBTAIN THE VALUES AND AVERAGE QUOTED BELOW. WE ALSO GIVE THE
F+-      REGENERATOR PHASE FR IN THE COMMENTS BELOW.
F+- O        (45.0)    (50.0)         FITCH     65 OSPK   BE REGEN        11/67
F+- O        (30.0)    (45.0)         FIRESTONE 66 HBC                    11/67
F+- O        (70.0)    (21.0)         BOTT-BODE 67 OSPK   C REGEN         11/67
F+- O        (25.0)    (35.0)         MISCHKE   67 OSPK   CU REGEN         7/68
F+- O   OLD EXPERIMENTS WITH LARGE ERRORS NOT INCLUDED IN AVERAGE.          2/76
F+- N        (51.0)    (11.0)         BENNETT2  68 CNTR   CU REG. USES     8/68
F+-  C        34.2      10.0          BENNETT   69 CNTR   CU REGEN         2/71
F+-  B        45.3      12.0          BOHM      69 OSPK   VACUUM REGEN     2/71
F+-  F        45.2       7.4          FAISSNER  69 ASPK   CU REGEN         2/71
F+-  J        40.6       4.2          JENSEN    70 ASPK   VACUUM REGEN     2/71
F+-  D        37.2      12.0          BALATS    71 OSPK   CU REGEN         9/71
F+-  P        36.2       6.1          CARNEGIE  72 ASPK   CU REGEN         1/73
F+-  G        46.5       1.6          GEWENIG2  74 ASPK   VACUUM REGEN     3/74
F+-  H        45.5       2.8          CARITHERS 75 SPEC   C REGEN          7/75
F+-           41.7       3.5          CHRISTE2  79 ASPK                   12/79
F+- A        (35.3)     (3.9)         ARONSON2  82 SPEC   E=30-110 GEV     1/83*
F+-          . . . . . . . . . . .
F+- AVG       44.6       1.2    AVERAGE
F+- FIT       44.6       1.2   FROM FIT                                   3/84*
                           COMMENTS
F+-  N  BENNETT 69 IS A REEVALUATION OF BENNETT2 68.                      11/69
F+-  C  BENNETT 69 USES MEASUREMENT OF (F+-)-(PHIF) OF ALFF-STEINBERGER 66.  2/71
F+-  C  BENNETT 69  F+-=(34.9+-10.0)+ 69*(DM-.545) DEG.  FR=-49.9+-5.4 DEG.  2/71
F+-  B  BOHM 69     F+-=(41.0+-12.0)+479*(DM-.526) DEG.                    2/71
F+-  F  FAISSNER 69 ERROR ENLARGED TO INCLUDE ERROR IN REGENERATOR PHASE.  11/69
F+-  F  FAISSNER 69 F+-=(49.3+-7.4)+205*(DM-.555) DEG.   FR=-42.7+-5.0 DEG.  2/71
F+-  J  JENSEN 70   F+-=(42.4+-4.0)+576*(DM-.538) DEG.                     2/71
F+-  D  BALATS 71   F+-=(39.0+-12.0)+198*(DM-.544) DEG.  FR=-43.0+-4.0 DEG.  9/71
F+-  P  CARNEGIE 72 F+- IS INSENSITIVE TO DM.            FR=-56.2+-5.2 DEG.  1/73
F+-  G  GEWENIG2 74 F+-=(49.4+-1.0)+565*(DM-.540) DEG.                     3/74
F+-  H  CARITHER 75 F+-=(45.5+-2.8)+224*(DM-.5348) DEG.  FR=-40.9+-2.6 DEG. 11/75
F+- A   ARONSON 82 FIND THAT PHI+- MAY DEPEND ON THE KAON ENERGY .          1/83*

F00     PHI00, THE PHASE OF ETA 00    (DEGREES)   ---------------------
F00          FIRST QUADRANT PREFERRED   GOBBI     69 OSPK                 11/69
F00  C        51.0      30.0          CHOLLET   70 OSPK   CU REG.,4 GAMMAS 10/70
F00  W  56    38.0      25.0          WOLFF     71 OSPK   CU REG.,4 GAMMAS 12/71
F00           55.7       5.8          CHRISTE1  79 ASPK                   12/79
F00  C  CHOLLET 70 USES REGENERATOR PHASE FR=-46.5+-4.4 DEG.               1/73
F00  W  WOLFF 71   USES REGENERATOR PHASE FR=-48.2+-3.5 DEG.               1/73
F00          . . . . . . . . . . .
F00 AVG       54.7       5.6    AVERAGE
F00 FIT       54.5       5.3   FROM FIT                                   3/84*

DF      PHASE DIFFERENCE PHI00 - PHI+-       (DEGREES)---------------------
DF B          7.6       18.0          BARBIELLI 73 ASPK                    7/73
DF  C       (12.6)      (6.2)         CHRISTE1  79 ASPK                    2/80
DF B    INDEPENDENT OF REGENERATOR MECHANISM,DM,AND LIFETIMES.             7/73
DF  C   NOT INDEPENDENT OF PHI+- AND PHI00 VALUES WHICH ARE INCLUDED IN FIT  2/80
DF           . . . . . . . . . . .
DF  FIT        9.8       5.4   FROM FIT                                   3/84*
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NOTE ON ΔS = ΔQ RULE IN K^0 DECAYS

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

$$x = A(\overline{K}^0 \to \pi^- \ell^+ \nu)/A(K^0 \to \pi^- \ell^+ \nu)\,.$$

We list Re{x} and Im{x} for K_{e3} and $K_{\mu 3}$ combined.

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

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 K0 LMBDA 11/67
REX N   335  (0.17)   (0.10)          HILL      67 DBC    K+D YIELDS K0PP  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 K0P        4/69
REX   N 215   0.12     0.09           CHO       70 DBC    K+D TO K0PP      10/70
REX U   222  (0.04)   (0.07)   (0.08) BURGUN    71 HBC    K+P TO K0PPI+     2/72
REX     252   0.25     0.07     0.09  WEBBER    71 HBC    K-P TO KBAR N    10/69
REX   U 410   0.03     0.06     0.06  BURGUN    72 HBC    K+P TO K0PPI+     1/73
REX     126   0.26     0.10     0.14  MANN      72 HBC    K-P TO K0BAR N    9/72
REX G   342 (-0.13)   (0.11)          MANTSCH   72 OSPK   KE3  FROM K0 LMB  2/72
REX G   100  (0.04)   (0.10)   (0.13) GRAHAM    72 OSPK   KMU3 FROM K0 LMB  2/72
REX   G 442  -0.05     0.09           GRAHAM    72 OSPK   PI-P TO K0 LMBDA  2/72
REX    1757  -0.008    0.044          FACKLER   73 OSPK   KE3 FROM K0       9/73
REX    1367  -0.03     0.07           HART      73 OSPK   KE3 FROM K0 LMB   2/74
REX    1079  -0.070    0.036          MALLARY   73 OSPK   KE3 FROM K0 LM +  6/73
REX    4724   0.04     0.03           NIEBERGA  74 ASPK   K+P TO K0PPI+     7/74
REX      79   0.10     0.18     0.19  SMITH     75 WIRE   PI-P TO K0 LMBDA  8/76
REX   C  BALDO-CE 65 GIVES X AND THETA.CONVERTED BY US TO REX AND IMX.     11/67
REX   F  FRANZINI 65 GIVES X AND THETA.FOR REX AND IMX SEE SCHMIDT 67.     11/67
REX N    CHO 70 IS ANALYSIS OF UNAMBIGUOUS EVENTS IN NEW DATA AND HILL 67.  10/70
REX  U   BURGUN 72 IS A FINAL RESULT WHICH INCLUDES BURGUN 71.            11/73
REX  B   BENNETT 69 IS A REANALYSIS OF BENNETT1 68.                       10/69
REX G    SECOND GRAHAM 72 VALUE IS FIRST GRAHAM 72 VALUE COMBINED WITH      2/72
REX G    MANTSCH 72.                                                        2/72
REX          . . . . . . . . . . .
REX AVG       0.009    0.020   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
                          (SEE IDEOGRAM BELOW)

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 K0 LMBDA 11/67
IMX N   335 (-0.20)   (0.10)          HILL      67 DBC    K+D YIELDS K0PP  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 K0P        4/69
IMX   N 215  -0.08     0.07           CHO       70 DBC    K+D TO K0PP      10/70
IMX U   222  (0.12)   (0.08)   (0.09) BURGUN    71 HBC    K+P TO K0PPI+     2/72
IMX     252   0.0      0.08           WEBBER    71 HBC    K-P TO KBAR N    10/69
IMX   U 410   0.07     0.06     0.07  BURGUN    72 HBC    K+P TO K0PPI+     1/73
IMX     126   0.21     0.15     0.12  MANN      72 HBC    K-P TO K0BAR N    9/72
IMX G   342 (-0.04)   (0.16)          MANTSCH   72 OSPK   KE3  FROM K0 LMB  2/72
IMX G   100  (0.12)   (0.17)   (0.16) GRAHAM    72 OSPK   KMU3 FROM K0 LMB  2/72
IMX   G 442   0.05     0.13           GRAHAM    72 OSPK   PI-P TO K0 LMBDA  2/72
IMX    1757  -0.017    0.060          FACKLER   73 OSPK   KE3 FROM K0       9/73
IMX    1367   0.09     0.07           HART      73 OSPK   KE3 FROM K0 LMB   2/74
IMX    1079   0.107    0.092   0.074  MALLARY   73 OSPK   KE3 FROM K0 LM +  6/73
IMX    4724  -0.06     0.05           NIEBERGA  74 ASPK   K+P TO K0PPI+     7/74
IMX      79  -0.10     0.16     0.19  SMITH     75 WIRE   PI-P TO K0 LMBDA  8/76
IMX   C  BALDO-CE 65 GIVES X AND THETA.CONVERTED BY US TO REX AND IMX.     11/67
IMX   F  FRANZINI 65 GIVES X AND THETA.FOR REX AND IMX SEE SCHMIDT 67.     11/67
IMX N    FTNOTE 10 OF HILL 67 SHOULD READ +0.58, NOT -0.58 (PRIV.COMM.).    3/68
IMX N    CHO 70 IS ANALYSIS OF UNAMBIGUOUS EVENTS IN NEW DATA AND HILL 67.  10/70
IMX  U   BURGUN 72 IS A FINAL RESULT WHICH INCLUDES BURGUN 71.            11/73
IMX G    SECOND GRAHAM 72 VALUE IS FIRST GRAHAM 72 VALUE COMBINED WITH      2/72
IMX G    MANTSCH 72.                                                        2/72
IMX          . . . . . . . . . . .
IMX AVG      -0.004    0.026   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
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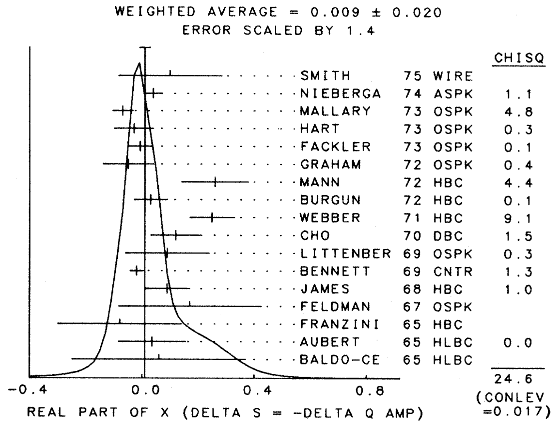
For notation, see key at front of Listings.

Stable Particles

K^0_L



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REFERENCES FOR KL

BARDON 58 ANP 5 156 M BARDON,K LANDE,L LEDERMAN (COLUMBIA+BNL)
CRAWFORD 59 PRL 2 361 CRAWFORD,CRESTI,DOUGLASS,GOOD + (LRL)
ASTIER 61 AIX CONF 1 227 ASTIER,BLASKOVIC,RIVET,SIAUD + (EPOL)
FITCH 61 NC 22 1160 V FITCH,P PIROUE,R PERKINS (PRINCETON)
GOOD 61 PR 124 1223 GOOD,MATSEN,MULLER,PICCIONI,POWELL + (LRL)
NEAGU 61 PRL 6 552 NEAGU,OKONOV,PETROV,ROSANOVA,RUSAKOV (JINR)
ALSO 61 JETP 13 1138 NYAGU,OKONOV,PETROV,ROZANOVA,RUSAKOV (JINR)

CAMERINI 62 PR 128 362 CAMERINI,FRY,GAIDOS,BIRGE,ELY + (WISC+LRL)
DARMON 62 PL 3 57 J DARMON,A ROUSSET,J SIX (EPOL)

ADAIR 64 PL 12 67 R K ADAIR,L B LEIPUNER (YALE+BNL)
ALEKSANY 64 DUBNA 2 102 ALEKSANYAN,ALIKHANYAN,VARTAZARYAN+ (EREVAN)
ALSO 64 JETP 19 1019 ALEKSANYAN+ (LEBEDEV+MOS ENG PHYS+EREVAN)
ANIKINA 64 JETP 19 42 ANIKINA,ZHURAVLEVA+ (GEORG ACAD SCI+ DUBNA)
CHRISTEN 64 PRL 13 138 CHRISTENSON,CRONIN,FITCH,TURLAY (PRINCETON)
FUJII 64 DUBNA 2 146 FUJII,JOVANOVICH,TURKOT+ (BNL,MARYLAND,MIT)
LUERS 64 PR 133 B 1276 LUERS,MITTRA,WILLIS,YAMAMOTO (BNL)

ANIKINA 65 JINR P 2488 ANIKINA,VARDENGA,ZHURAVLEVA,KOTLYA+ (DUBNA)
ANDERSON 65 PRL 14 475 ANDERSON,CRAWFORD,GOLDEN,STERN + (LRL+WISC)
ASTBURY1 65 PL 16 80 ASTBURY,FINOCCHIARO,BEUSCH + (CERN+ZURICH)
ALSO 65 HELV.PH.AC.39 523 M PEPIN
ASTBURY2 65 PL 18 175 ASTBURY,MICHELINI,BEUSCH + (CERN+ZURICH)
ASTBURY3 65 PL 18 178 ASTBURY,MICHELINI,BEUSCH + (CERN+ZURICH)

AUBERT 65 PL 17 59 AUBERT,BEHR,CANAVAN,CHOUNET+ (EPOL+ORSAY)
ALSO 67 LOWYS
BALDO-CE 65 NC 38 684 BALDO-CEOLIN,CALIMANI,CIAMPOLILLO + (PADO)
CHRISTEN 65 PR 140 B 74 CHRISTENSON,CRONIN,FITCH,TURLAY (PRINCETON)
FISHER 65 ANL 7130 83 FISHER,ABASHIAN,ABRAMS,CARPENTER+ (ILL)
FITCH 65 PRL 15 73 FITCH,ROTH,RUSS,VERNON (PRINCETON)

FRANZINI 65 PR 140 B 127 FRANZINI,KIRSCH,PLANO + (COLUMBIA+RUTGERS)
GALBRAIT 65 PRL 14 383 GALBRAITH,MANNING,JONES + (AERE+BRIS+RHEL)
GUIDONI 65 ARGONNE CONF 49 +BARNES,FOELSCHE,FERBEL,FIRESTO+ (BNL+YALE)
HOPKINS 65 ARGONNE CONF 67 H W K HOPKINS,BACON,EISLER (VAND+RUTGERS)
VISHNEVS 65 PL 18 339 VISHNEVSKY,GALANINA,SEMENOV + (ITEP)

ALFF-STE 66 PL 21 595 ALFF-STEINBERGER,HEUER,RUBBIA + (CERN)
ANIKINA 66 SJNP 2 339 ANIKINA, VARDENGA, ZHURAVLEVA+ (JINR)
AUERBACH 66 PRL 17 980 AUERBACH,MANN,MCFARLANE,SCIULLI (PENN)
AUERBACH 66 PR 149 1052 AUERBACH,DOBBS,LANDE,MANN,SCIULLI+ (PENN)
ALSO 65 PRL 14 192 +LANDE,MANN,SCIULLI,UTO,WHITE,YOUNG (PENN)
BALDO-CE 66 NC 45A 733 BALDO-CEOLIN,CALIMANI,CIAMPOLILLO+ (PADUA)
BASILE 66 BALATON CONF BASILE,CRONIN,THEVENET + (SACLAY)

BEHR 66 PL 22 540 +BRISSON,BALDO-CEOLIN,AUBERT+ (PADO,EPOL)
BELLOTTI 66 NC 45A 737 BELLOTTI,PULLIA,BALDO-CEOLIN+ (MILAN,PADUA)
BOTT-BOD 66 PL 23 277 BOTT-BODENHAUSEN,DE BOUARD,CASSEL+ (CERN)
CAMERINI 66 PR 150 1148 CAMERINI,CLINE,ENGLISH,FISCHBEIN+WISCONSIN
CANTER 66 PRL 17 942 +CHO,ENGLER,FISK,HILL + (CARNEGIE+BNL)
CARPENTE 66 PR 142 871 CARPENTER,ABASHAN,ABRAMS,FISHER (ILLINOIS)
CHANG 66 PL 23 702 CHANG,BASSANO,KIKUCHI,DODD+ (SYRACUSE,BNL)

CRIEGEE 66 PRL 17 150 +FOX,FRAUENFELDER,HANSON,MOSCAT+ (ILLINOIS)
FIRESTON 66 PRL 16 556 FIRESTONE,KIM,LACH,SANDWEISS+ (YALE,BNL)
FIRESTON 66 PRL 17 116 FIRESTONE,KIM,LACH,SANDWEISS+ (YALE,BNL)
FUJII 66 PRL 13 253 FUJII,JOVANOVICH,TURKOT,ZORN (BNL+MARYLAND)
FUJII 66 IS THE CORRECTED VALUE GIVEN BY JOVANOVICH+ 66
HAWKINS 66 PL 21 238 C J B HAWKINS (YALE)
ALSO 67 PR 156 1444 C J B HAWKINS (YALE)

JOVANOVI 66 PRL 17 1075 JOVANOVICH,FUJII,TURKOT,ZORN +(BNL+UMD+MIT)
KULYUKIN 66 BERKELEY 2B KULYUKINA,MESTVIRISHVILI,NEAGU,PETR+ (JINR)
MEISNER1 66 PRL 16 278 G W MEISNER,B B CRAWFORD,F CRAWFORD (LRL)
MEISNER2 66 PRL 17 492 G MEISNER,B CRAWFORD,F CRAWFORD (LRL)
NEFKENS 66 PL 19 706 NEFKENS,ABASHIAN,ABRAMS,CARPENTER+ (ILL)
VERHEY 66 PRL 17 669 VERHEY,NEFKENS,ABASHIAN+ (ILL)

BENNETT 67 PRL 19 993 BENNETT,NYGREN,SAAL,STEINBERGER +(COLUMBIA)
BOTT-BOD 67 PL 24B 194 BOTT-BODENHAUSEN,DEBOUARD,CASSEL + (CERN)
BOTT-BOD 67 PL 24B 438 BOTT-BODENHAUSEN,DEBOUARD,DEKKERS+ (CERN)
ALSO 66 PL 20 212 BOTT-BODENHAUSEN,DEBOUARD,CASSEL+ (CERN)
ALSO 66 PL 23 277 BOTT-BODENHAUSEN,DEBOUARD,CASSEL+ (CERN)
CANTER 67 THESIS J.M. CANTER (CARNEGIE)

CRONIN 1 67 PRL 18 25 +KUNZ,RISK,WHEELER (PRINCETON)
CRONIN 2 67 PRINC CONF(11/67) +KUNZ,RISK,WHEELER (PRINCETON)
DEBOUARD 67 NC 52A 662 DEBOUARD,DEKKERS,JORDAN,MERMOD + (CERN)
ALSO 65 PL 15 58 DE BOUARD,DEKKERS,SCHARFF+ (CERN+ORSA+MPIM)
DEVLIN 67 PRL 18 54 DEVLIN,SOLOMON,SHEPARD,BEALL+ (PRIN+UMD)
ALSO 68 PR 169 1045 SAYER,BEALL,DEVLIN,SHEPHARD+ (UMD+PPA+PRIN)

DORFAN 67 PRL 19 987 DORFAN,ENSTROM,RAYMOND,SCHWARTZ +(SLAC+LRL)
FELDMAN 67 PR 155 1611 FELDMAN,FRANKEL,HIGHLAND,SLOAN (PENN)
FIRESTON 67 PRL 18 176 FIRESTONE,KIM,LACH,SANDWEISS,+ (YALE,BNL)
FITCH 67 PR 164 1711 FITCH,ROTH,RUSS,VERNON (PRINCETON)
HAWKINS 67 PR 156 1444 C J B HAWKINS (YALE)
HILL 67 PRL 19 668 HILL,LUERS,ROBINSON,CANTER+ (BNL,CARNEGIE)

HOPKINS 67 PRL 19 185 HOPKINS,BACON,EISLER (BNL)
KADYK 67 PRL 19 597 KADYK,CHAN,DRIJARD,OREN,SHELDON (LRL)
KULYUKIN 67 PREPRINT KULYUKINA+MESTVIRISHVILI+NEAGU + (JINR)
LOWYS 67 PL 24B 75 LOWYS,AUBERT,CHOUNET,PASCAUD+ (EPOL,ORSA)
MISCHKE 67 PRL 18 138 MISCHKE,ABASHIAN,ABRAMS+ (ILLINOIS)
NEFKENS 67 PR 157 1233 +ABASHIAN,ABRAMS,CARPENTER,FISHER+ (ILL)
TODOROFF 67 THESIS JOHN A TODOROFF (ILLINOIS)

ABRAMS 68 PR 176 1603 +ABASHIAN,MISCHKE,NEFKENS,SMITH+ (ILLINOIS)
ARNOLD 68 PL 28B 56 ARNOLD,BUDAGOV,CUNDY,AUBERT+ (CERN+ORSAY)
ARONSON 68 PRL 20 287 S.H.ARONSON, K.W.CHEN (PRINCETON)
ALSO 69 PR 175 1708 S H ARONSON, K W CHEN (PRINCETON)
BALATZ 68 PL 26B 320 BALATZ,BEREZIN,VISHNEVSKY,GALANINA+ (ITEP)
BARTLETT 68 PRL 21 558 BARTLETT,CARNEGIE,FITCH+ (PRINCETON)

BASILE 68 PL 26B 542 BASILE,CRONIN,THEVENET,TURLAY+ (SACLAY)
BASILE2 68 PL 28B 58 +CRONIN,THEVENET,TURLAY,ZYLBERAJCH+(SACLAY)
BENNETT1 68 PL 27B 244 BENNETT,NYGREN,STEINBERGER+ (COLUMBIA+CERN)
BENNETT2 68 PL 27B 248 BENNETT,NYGREN,STEINBERGER+ (COLUMBIA+CERN)
BLANPIED 68 PRL 21 1650 BLANPIED,LEVIT,ENGELS+ (CASE+HARV+MCGI)
BUDAGOV 68 NC 57A 182 BUDAGOV,BURMEISTER,CUNDY+ (CERN,ORSA,IPNP)
ALSO 68 PL 28B 215 +CUNDY,MYATT,NEZRICK+ (CERN,ORSA,EPOL)

CARNEGIE 68 PRINC TR44 THESIS R.K.CARNEGIE (PRINCETON)
JAMES 68 NP B8 365 F JAMES, H BRIAND (IPNP,CERN)
ALSO 68 PRL 21 257 HELLAND,LONGO,YOUNG (UCLA,MICH)
KULYUKIN 68 JETP 26 20 KULYUKINA,MESTVIRISHVILI,NEAGU+ (JINR)
KUNZ 68 THESIS (PU 46) P F KUNZ (PRINCETON)
MELHOP 68 PR 172 1613 MELHOP MURTY BOWLES,BURNETT+ (LA JOLLA)
THATCHER 68 PR 174 1674 THATCHER,ABASHIAN,ABRAMS,CARPENTER + (ILL)

BANNER 69 PR 188 2033 +CRONIN,LIU,PILCHER (PRINCETON)
ALSO 68 PRL 21 1103 BANNER,CRONIN,LIU,PILCHER (PRINCETON)
ALSO 68 PRL 21 1107 BANNER CRONIN,LIU,PILCHER (PRINCETON)
BEILLIER 69 PL 30B 202 BEILLIERE,BOUTANG,LIMON (EPOL)
BENNETT 69 PL 29B 317 +NYGREN,SAAL,STEINBERGER+ (COLU,BNL)
BOHM 69 NP B9 605 +DARRIULAT,GROSSO,KAFTANOV+ (CERN)
ALSO 68 PL 27B 321 BOHM,DARRIULAT,GROSSO,KAFTANOV (CERN)

BOTT-BOD 69 CERN 69-7 329 BOTT-BODENHAUSEN,DE BOUARD,CASSEL+ (CERN)
CENCE 69 PRL 22 1210 CENCE,JONES,PETERSON,STENGER+ (HAWAII,LRL)
EVANS 69 PRL 23 427 EVANS,GOLDEN,MUIR,PEACH+ (EDINBURGH,CERN)
FAISSNER 69 PL 30B 204 +FOETH,STAUDE,TITTEL+ (AACH,CERN,TORI)
FOETH 69 PL 30B 282 +HOLDER,RADERMACHER + (AACHEN,CERN,TORINO)

GAILLARD 69 NC 59A 453 +GALBRAITH,HUSSRI,JANE+ (CERN,RHEL,AACHEN)
ALSO 67 PRL 18 20 +KRIENEN,GALBRAITH,HUSSRI+ (CERN+RHEL+AACH)
GOBBI 69 PRL 22 685 +GREEN,HAKEL,MOFFETT,ROSEN,GOZ+ (ROCH+RUTG)
LITTENBE 69 PRL 22 654 LITTENBERG,FIELD,PICCIONI,MEHLHOP+ (UCSD)
LONGO 69 PR 181 1808 M J LONGO,K K YOUNG,J A HELLAND (MICH,UCLA)
PACIOTTI 69 THESIS,UCRL 19446 M A PACIOTTI (LRL)
SAAL 69 THESIS H J SAAL (COLUMBIA)

ALBROW 70 PL 33B 516 +ASTON,BARBER,BIRD,ELLISON + (MCHS+DARE)
ARONSON 70 PRL 25 1057 +EHRLICH,HOFER,JENSEN+ (EFI,ILLC,SLAC)
BARMIN 70 PL 33B 377 +BARYLON,BORISOV,BYSHEVA+ (ITEP,JINR)
BASILE 70 PR D2 78 +CRONIN,THEVENT,TURLAY,ZYLBERAJCH + (SACL)
BUCHANAN 70 PL 33B 623 +DRICKEY,RUDNICK,SHEPARD+ (SLAC,JHU,UCLA)
ALSO PRIVATE COMMUNICATION, B. COX, FEB. 71

BUDAGOV 70 PR D2 815 +CUNDY,MYATT,NEZRICK+ (CERN, ORSA,EPOL)
ALSO 68 PL 28B 215 +CUNDY,MYATT,NEZRICK+ (CERN,ORSA,EPOL)
CHIEN 70 PL 33B 627 C-Y.CHIEN,COX,ETTLINGER + (JHU+SLAC+UCLA)
ALSO PRIVATE COMMUNICATION, B. COX, FEB. 71.
CHO 70 PR D1 3031 +DRALLE,CANTER,ENGLER,FISK+ (CARN,BNL,CASE)
ALSO 67 PRL 19 668 HILL,LUERS,ROBINSON,SAKITT + (BNL,CARN)

CHOLLET 70 PL 31B 658 +GAILLARD,JANE,RATCLIFFE,REPELLIN + (CERN)
CULLEN 70 PL 32B 523 +DARRIULAT,DEUTSCH,FOETH + (AACH,CERN,TORI)
DARRIULA 70 PL 33B 249 +FERRERO,GROSSO,HOLDER + (AACH,CERN,TORI)
FAISSNER 70 NC 70A 57 +REITHLER,THOME,GAILLARD+ (AACH,CERN,RHEL)
JENSEN 70 THESIS D.A. JENSEN (EFI)
ALSO 69 PRL 23 615 JENSEN,ARONSON,EHRLICH,FRYBERGER+ (EFI,ILL)

MARX 70 PL 32B 219 +NYGREN,PEOPLES,STEINBERGE+(COLU,HARV,CERN)
ALSO 70 THESIS,NEVIS 179 JAY MARX (COLUMBIA)
SCRIBANO 70 PL 32B 224 +MANNELLI,PIERAZZINI,MARX+ (PISA,COLU,HARV)
SMITH 70 PL 32B 133 +WANG,WHATLEY,ZORN,HORNBOSTEL (UMD,BNL)
WEBBER 70 PR D1 1967 +SOLMITZ,CRAWFORD,ALSTON-GARNJOST (LRL)
ALSO 69 UCRL 19226 THESIS B R WEBBER (LRL)
BALATS 71 SJNP 13 53 +BEREZIN,VISHNEVSKII,GALANINA+ (ITEP)
BARMIN 71 PL 35B 604 +BARYLOV,VESELOVSKY,DAVIDENKO+ (ITEP)
BISI 71 PL 36B 533 +DARRIULAT,FERRERO,RUBBIA+ (AACH,CERN,TORI)
BURGUN 71 LNC 2 1169 +LESQUOY,MULLER,PAULI+ (SACL+CERN+OSLO)
CARNEGIE 71 PR D4 1 +CESTER,FITCH,STROVINK,SULAK (PRIN)
CHAN 71 LBL-350 THESIS J.HIONG-SING CHAN (LBL)

CHIEN 71 PL 35B 261 +COX,ETTLINGER,RESVANIS+ (JHU,SLAC,UCLA)
ALSO 72 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)
ALSO 74 SLAC-PUB-1498 R.C.FIELD (SLAC)

ENSTROM 71 PR D4 2629 +AKAVIA,COOMBES,DORFAN+ (SLAC,STAN)
ALSO 70 THESIS (SLAC 125) J E ENSTROM (STANFORD)
HILL 71 PR D4 7 +SAKITT,SKJEGGESTAD,CANTER+ (BNL,CARN,CASE)
JAMES 71 PL 35B 265 +MONTANET,PAUL,PAULI+ (CERN+SACL+OSLO)
MEISNER 71 PR D3 59 +MANN,HERTZBACH,KOFLER + (MASA+BNL+YALE)
PEACH 71 PL 35B 351 +EVANS,MUIR,BUDAGOV,HOPKINS+ (EDIN,CERN)

REPELLIN 71 PL 36B 603 +WOLFF,CHOLLET,GAILLARD,JANE+ (ORSA,CERN)
WEBBER 71 PR D3 64 +SOLMITZ,CRAWFORD,ALSTON-GARNJOST (LRL)
ALSO 68 PRL 21 498 WEBBER,SOLMITZ,CRAWFORD,ALSTONGARNJOST(LRL)
ALSO 69 UCRL 19266-THESIS B R WEBBER (LRL)
WOLFF 71 PL 36B 517 +CHOLLET,REPELLIN,GAILLARD+ (ORSA,CERN)

ALBROW 72 NP B44 1 +ASTON,BARBER,BIRD,ELLISON+ (MCHS+DARE)
ASHFORD 72 PL 38B 47 +BROWN,MASEK,MAUNG,MILLER,RUDERMAN+ (UCSD)
BANNER1 72 PRL 28 1597 +CRONIN,HOFFMAN,KNAPP,SHOCHET (PRINCETON)
BANNER2 72 PRL 29 237 +CRONIN,HOFFMAN,KNAPP,SHOCHET (PRINCETON)
BARMIN1 72 SJNP 15 636 +DAVIDENKO,DEMIDOV,DOLGOLENKO+ (ITEP)
BARMIN2 72 SJNP 15 638 +BARYLOV,DAVIDENKO,DEMIDOV+ (ITEP)
BURGUN 72 NP B50 194 +LESQUOY,MULLER,PAULI,+ (SACL+CERN+OSLO)
CARNEGIE 72 PR D6 2335 +CESTER,FITCH,STROVINK,SULAK (PRINCETON)

DALLY 72 PL 41B 647 +INNOCENTI,SEPPI,CHIEN,COX+ (SLAC+JHU+UCLA)
ALSO 70 CHIEN
ALSO 71 CHIEN

Stable Particles

Data Card Listings

K^0_L, $D^{\pm}$


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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)
KRENZ    72 LNC 4 213            +HOPKINS,EVANS,MUIR,PEACH   (AACH+CERN+EDIN)

MANN     72 PR D6 137            +KOFLER,MEISNER,HERTZBACH+  (MASA+BNL+YALE)
MANTSCH  72 NC 9A 160            +ABASHIAN,GRAHAM,JONES,ORR+      (ILL+NEAS)
METCALF  72 PL 40B 703           +NEUHOFER,NIEBERGALL+        (CERN+IPN+WIEN)
NEUHOFER 72 PL 41B 642           +NIEBERGALL,REGLER,STIER+  (CERN+ORSA+VIEN)
PICCIONI 72 PRL 29 1412          +COOMBES,DONALDSON,DORFAN,FRYBERGER+ (SLAC)
    ALSO 74 PR D9 2939           PICCIONI,DONALDSON +        (SLAC+UCSC+COLO)
VOSBURGH 72 PR D6 1834           +DEVLIN,ESTERLING,GOZ,BRYMAN +  (RUTG,MASA)
    ALSO 71 PRL 26 866           VOSBURGH,DEVLIN,ESTERLING,GOZ + (RUTG,MASA)

ALBROW   73 NP B58 22            +ASTON,BARBER,BIRD,ELLISON+      (MCHS+DARE)
ALEXANDE 73 NP B65 301           ALEXANDER,BENARY,BOROWITZ,LANDE+(TELA+HEID)
ANIKINA  73  P1-7539 COM.JINR    +BALASHOV,BANNIK +                    (JINR)
BARBIELL 73 PL 43B 529           BARBIELLINI,DARRIULAT,FAINBERG+       (CERN)
BRANDENB 73 PR D8 1978           BRANDENBURG,JOHNSON,LEITH,LOOS+       (SLAC)
CARITHER 73 PRL 31 1025          CARITHERS,NYGREN,GORDON+     (COLU+BNL+CERN)
    ALSO 73 PRL 30 1336          CARITHERS,MODIS,NYGREN,PUN+ (COLU+CERN+NYU)
EVANS    73 PR D7 36             +MUIR,PEACH,BUDAGOV+          (EDINBURGH+CERN)
    ALSO 69 PRL 23 427           EVANS,GOLDEN,MUIR,PEACH+     (EDINBURGH+CERN)

FACKLER  73 PRL 31 847           +FRISCH,MARTIN,SMOOT,SOMPAYRAC          (MIT)
FITCH    73 PRL 31 1524          +HEPP,JENSEN,STROVINK,WEBB        (PRINCETON)
    ALSO 72 COO-3072-13          R.C.WEBB (THESIS)                 (PRINCETON)
HART     73 NP B66 317           +HUTTON,FIELD,SHARP,BLACKMORE+  (CAVE+RHEL)
MALLARY  73 PR D7 1953           +BINNIE,GALLIVAN,GOMEZ,PECK,SCIULLI + (CIT)
    ALSO 70 PRL 25 1214          SCIULLI,GALLIVAN,BINNIE,GOMEZ +        (CIT)

MCCARTHY 73 PR D7 687            +BREWER,BUDNITZ,ENTIS,GRAVEN,MILLER+  (LBL)
    ALSO 72 PL 42B 291           MCCARTHY,BREWER,BUDNITZ,ENTIS,GRAVEN+ (LBL)
    ALSO 71 THESIS LBL-550       R.L.MCCARTHY                           (LBL)
MESSNER  73 PRL 30 876           +MORSE,NAUENBERG,HITLIN +  (COLO+SLAC+UCSC)
PEACH    73 PL 43B 441           +EVANS,MUIR,HOPKINS,KRENZ  (EDIN+CERN+AACH)
SANDWEIS 73 PRL 30 1002          +SUNDERLAND,TURNER,WILLIS,KELLER (YALE+ANL)
WILLIAMS 73 PRL 31 1521          +LARSEN,LEIPUNER,SAPP,SESSOMS+   (BNL+YALE)

ALBRECHT 74 PL 48B 393           DUBNA+BERLIN+BUDAPEST+PRAGUE+SERPUKH+SOFIA
BISI     74 PL 50B 504           BISI,FERRERO                          (TORI)
BOBISUT  74 LNC 11 646           +HUZITA,MATTIOLI,PUGLIERIN            (PADO)
DONALDS1 74 PRL 33 554           DONALDSON,HITLIN,KENNELLY,KIRKBY +    (SLAC)
    ALSO 74 DONALDSON 3
    ALSO 76 DONALDSON
DONALDS2 74 PR D9 2960           DONALDSON,FRYBERGER,HITLIN,LIU+ (SLAC+UCSC)
    ALSO 73 PRL 31 337           DONALDSON,FRYBERGER,HITLIN,LIU+ (SLAC+UCSC)
DONALDS3 74 SLAC 184-THESIS      GREGORY J. DONALDSON                  (SLAC)
    ALSO 76 DONALDSON

GEWENIG1 74 PL 48B 483           GEWENIGER,GJESDAL,KAMAE,PRESSER+(CERN+HEID)
    ALSO 74 CERN INT. REPT.      VERA LUTH (THESIS-INT. REPT. 74-4)  (HEID)
GEWENIG2 74 PL 48B 487           GEWENIGER,GJESDAL,PRESSER +     (CERN+HEID)
    ALSO 74 PL 52B 119           GJESDAL,PRESSER,STEFFEN +       (CERN+HEID)
GEWENIG3 74 PL 52B 108           GEWENIGER,GJESDAL,PRESSER +     (CERN+HEID)
GJESDAL  74 PL 52B 113           +PRESSER,KAMAE,STEFFEN+         (CERN+HEID)

MESSNER  74 PRL 33 1458          +FRANKLIN,MORSE,NAUENBERG+ (COLO+SLAC+UCSC)
NIEBERGA 74 PL 49B 103           NIEBERGALL,REGLER,STIER +  (CERN+ORSA+VIEN)
WANG     74 PR D9 540            +SMITH,WHATLEY,ZORN,HORNBOSTEL    (UMD+BNL)
WILLIAMS 74 PRL 33 240           +LARSEN,LEIPUNER,SAPP,SESSOMS +  (BNL+YALE)
WOO      74 LNC 10 38            +BUCHANAN,PEPPER                      (UCLA)

BALDOCEO 75 NC 25A 688           BALDO-CEOLIN,BOBISUT,CALIMANI+  (PADO+WISC)
BLUMENTH 75 PRL 34 164           BLUMENTHAL,FRANKEL,NAGY +  (PENN+CHIC+TEMP)
BUCHANAN 75 PR D11 457           +DRICKEY,PEPPER,RUDNICK +   (UCLA+SLAC+JHU)
CARITHER 75 PRL 34 1244          CARITHERS,MODIS,NYGREN,PUN +     (COLU+NYU)
SMITH    75 UCSD THESIS-UNPUB    JAMES G. SMITH                        (UCSD)

BIRULEV  76 SJNP 24, 178         +VESTERGOMBI,VOVENKO,VOTRUBA,GENCHEV+(JINR)
COOMBES  76 PRL 37 249           +FLEXER,HALL,KENNELLY,KIRKBY +   (STAN+NYU)
DONALDSO 76 PR D14 2839          DONALDSON,HITLIN,KENNELLY,KIRKBY,LIU+(SLAC)
    ALSO 74 SLAC 184-THESIS      GREGORY J. DONALDSON                  (SLAC)
FUKUSHIM 76 PRL 36 348           FUKUSHIMA,JENSEN,SURKO,THALER+  (PRIN+MASA)
GJESDAL  76 NP B109 118          +KAMAE,PRESSER,STEFFEN +        (CERN+HEID)
REY      76 PR D13 1161          +CENCE,JONES,PARKER +       (NDAM+HAWA+LBL)
    ALSO 69 CENCE

CHO      77 PR D15 587           +DERRICK,LISSAUER,MILLER,ENGLER+ (ANL+CARN)
CLARK    77 PR D15 553           +FIELD,HOLLEY,JOHNSON,KERTH,SAH,SHEN  (LBL)
    ALSO 75 LBL-4275 THESIS      GILBERT SHEN                           (LBL)
DEVOE    77 PR D16 565           +CRONIN,FRISCH,GROSSO-PILCHER+    (EFI+ANL)
DZHORDZH 77 SJNP 26 478          DZHORDZHADZE,KEKELIDZE,KRIVOKHIZHIN+ (JINR)
PEACH    77 NP B127 399          +CAMERON +       (BGNA+EDIN+GLAS+PISA+RHEL)

ENGLER   78 PR D18 623           +KEYES,KRAEMER,TANAKA,CHO+       (CARN+ANL)
HILL     78 PL 73B 483           +SAKITT,SNAPE,STEVENS+      (BNL+SLAC+SBER)
BIRULEV  79 SJNP 29 778          +VESTERGOMBI,GVAKHARIYA,GENCHEV+      (JINR)
CHRISTE1 79 PRL 43 1209          CHRISTENSON,GOLDMAN,HUMMEL,ROTH+       (NYU)
CHRISTE2 79 PRL 43 1212          CHRISTENSON,GOLDMAN,HUMMEL,ROTH+       (NYU)
HILL     79 NP B153 39           +SAKITT,SNAPE,STEVENS+      (BNL+SLAC+SBER)
SCHMIDT  79 PRL 43 556           +BLATT,CAMPBELL,GRANNAN+          (YALE+BNL)
SHOCHET  79 PR D19 1965          +LINSAY,GROSSO-PILCHER,FRISCH+    (EFI+ANL)
    ALSO 77 PRL 39 59            SHOCHET,LINSAY,GROSSO-PILCHER,+   (EFI+ANL)

CARROLL1 80 PRL 44 525           +CHIANG,KYCIA,LI,LITTENBERG,MARX+(BNL+ROCH)
CARROLL2 80 PRL 44 529           +CHIANG,KYCIA,LI,LITTENBERG,MARX+(BNL+ROCH)
CARROLL3 80 PL 96B 407           +CHIANG,KYCIA,LI,LITTENBERG,MARX+(BNL+ROCH)
CHO      80 PR D22 2688          +DERRICK,MILLER,SCHLERETH,ENGLER+(ANL+CARN)
MORSE    80 PR D21 1750          +LEIPUNER,LARSEN,SCHMIDT,BLATT+  (BNL+YALE)
BIRULEV  81 NP B182 1            +DZHORDZHADZE,GENCHEV,GRIGALASHVILI+ (JINR)
    ALSO 80 SJNP 31 622          BIRULEV,VESTERGOMBI,GENCHEV +         (JINR)
ARONSON  82 PRL 48 1078          +BERNSTEIN,BOCK +      (BNL+CHIC+STAN+WISC)
ARONSON2 82 PRL 48 1306          +BOCK,CHENG,FISCHBACH       (BNL+CHIC+PURD)
    ALSO 82 PL 116B 73           FISCHBACH,CHENG,ARONSON,BOCK(PURD+BNL+CHIC)
    ALSO 83 PR D28 476           ARONSON,BOCK,CHENG,FISCHBACH(BNL+CHIC+PURD)
    ALSO 83 PR D28 495           ARONSON,BOCK,CHENG,FISCHBACH(BNL+CHIC+PURD)

                                 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)
BECHERRA 70 PR D1 1452           T BECHERRAWY                          (ROCH)

GINSBERG 70 PR D1 229         E S GINSBERG                     (IIT HAIFA)
HEUSSE   70 LNC  3 449        +AUBERT,PASCAUD,VIALLE              (ORSAY)
GINSBERG 73 PR D8 3887        E S GINSBERG, J SMITH            (MIT+STON)
KLEINKNE 76 ARNS 26 1         K. KLEINKNECHT                       (DORT)
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                 31  CHARGED D(1869,JP=0-)  I=1/2

     FOR A RECENT REVIEW SEE TRILLING 81

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                 31  CHARGED D MASS (MEV)

M       50(1876.)    (15.)          PERUZZI   76 SMAG +- K-+PI+-PI+-       1/77
M         (1874.)     (5.)          GOLDHABER 77 SMAG +- DO,D+ RECOIL SPC 12/77
M   P     (1868.3)    (0.9)         PERUZZI   77 SMAG +- E+E- 3.77GEV ECM 12/77
M         (1874.)    (11.)          PICCOLO   77 SMAG +- E+E-4.03,4.41ECM  1/78
M   P     (1868.4)    (0.5)         SCHINDLER 81 SMK2 +- E+E- 3.77GEV ECM  1/82
M    P     1869.4      0.6          TRILLING  81 RVUE +- E+E- 3.77GEV ECM  1/82
M    P  PERUZZI 77 AND SCHINDLER 81 ERRORS DO NOT INCLUDE THE 0.13 PERCENT 1/82
M    P  UNCERTAINTY IN THE ABSOLUTE SPEAR ENERGY CALIBRATION.  TRILLING 81 1/82
M    P  USES THE HIGH PRECISION PSI AND PSI-PRIME MEASUREMENTS OF          1/82
M    P  ZHOLENTZ 80 TO DETERMINE THIS UNCERTAINTY AND COMBINES THE         1/82
M    P  PERUZZI 77 AND SCHINDLER 81 RESULTS TO OBTAIN THE VALUE QUOTED.    1/82

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                 31  CHARGED D MEAN LIFE   (UNITS 10**-13 SEC)

T           (8.)     OR LESS  CL=.90  ARMENISE  79 HYBR NEU P -->DIMUONS +   1/80
T       4    2.5       2.2     1.1    ALLASIA   80 EMUL NEU WIDEBAND        12/81
T   A       (10.4)    (3.9)   (2.9)   BACINO    80 DLCO E+E- 3.77 GEV ECM    1/81
T       5   (10.3)   (10.5)   (4.1)   USHIDA    80 EMUL NEU WIDEBAND        12/81
T   B   8   (4.4)                     ADAMOVICH 81 EMUL GAM NUC-->           1/82
T   C   1   (2.2)     (2.3)   (1.1)   BALLAGH   81 HYBR FNAL 15FT, NU HE-H2  1/82
T    D  9    8.2       4.5     2.5    ABE       82 HYBR SLAC GAM P 19.5 GEV  2/82
T    E 70    9.5       3.1     1.9    ALBINI    82 SILI CERN GAM SI          2/82
T      15    8.4       3.5     2.2    AGUILAR   83 HYBR PI- P, P P          11/83*
T       7    6.3       5.0     2.7    BADERTSCH 83 HYBR CERN PI- NUCL.      11/83*
T      11   11.5       7.5     3.5    USHIDA    83 EMUL REPL. USHIDA 80      2/84*
T   A   USES THEORETICAL RATE D TO (K E NEU)=1.4*10**11 SEC**-1 .            1/81
T   B   ADAMOVICH 81 VALUE ESTIMATED WITHOUT INFORMATION ON D MOMENTUM .     1/82
T   C   BALLAGH 81 VALUE QUOTED HERE ASSUMES THAT ALL DILEPTON EVENTS        1/82
T   C   CONTAIN DO OR D+, EACH WITH EQUAL NUMBERS OF SEMILEPTONIC DECAYS.    1/82
T    D  ABE 82 CANNOT RULE OUT F+- INTERP., OR ON 2 EVTS. LAMBDA/C+ INTERP.  2/82
T    E  ALBINI 82 ASSUMES D MOMENTUM IS 1/2 BEAM MOMENTUM.                   2/82
T   F   CERN NA16 (LEBC-EHS) EXPT.  PRESENTED AT MORIOND CONF. 82.           4/82
T          . . . . . . . . . .
T   AVG      9.2       1.7     1.2     AVERAGE

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                 31  CHARGED D PARTIAL DECAY MODES

                                                        DECAY MASSES
P1      D+ INTO K- PI+ PI+                             494+ 140+ 140
P2      D+ INTO KOBAR PI+                              498+ 140
P3      D+ INTO PI+ PI+ PI-                            140+ 140+ 140
P4      D+ INTO PI+ K+ K-                              140+ 494+ 494
P5      D+ INTO K+ PI+ PI-                             494+ 140+ 140
P6      D+ INTO E+ NUE                                .511+   0
P7      D+ INTO E+ ANYTHING
P8      D+ INTO K- ANYTHING
P9      D+ INTO KOBAR ANYTHING + KO ANYTHING
P10     D+ INTO K+ ANYTHING
P11     D+ INTO K*(892)OBAR PI+                        892+ 140
P12     D+ INTO KOBAR PI+ PIO                          498+ 140+ 135
P13     D+ INTO KOBAR PI+ PI+ PI-                      498+ 140+ 140+ 140
P14     D+ INTO K- PI+ PI+ PI+ PI-                     494+ 140+ 140+ 140+
P15     D+ INTO PI+ PIO                                140+ 135
P16     D+ INTO KOBAR K+                               498+ 494
P18     D+ INTO KOBAR RHO+                             498+ 769
P19     D+ INTO ETA ANYTHING
P20     D+ INTO MU+ NUMU                               106+   0
P21     D+ INTO K- PI+ PI+ PIO                         494+ 140+ 140+ 135

        D- MODES ARE CHARGE CONJUGATES OF THE ABOVE MODES

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                 31  CHARGED D BRANCHING RATIOS

R1      D+ INTO (K- PI+ PI+)/TOTAL                       (P1)
R1      85     0.039     0.010       PERUZZI   77 SMAG    E+E- 3.77GEV ECM 12/77
R1     239     0.063     0.015       SCHINDLER 81 SMK2 E+E- 3.771 GEV ECM   1/82
R1          . . . . . . . . . .
R1  AVG        0.046     0.011   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)

R2      D+ INTO (KOBAR PI+)/TOTAL                        (P2)
R2      17     0.015     0.006       PERUZZI   77 SMAG    E+E- 3.77GEV ECM 12/77
R2      36     0.023     0.007       SCHINDLER 81 SMK2 E+E- 3.771 GEV ECM   1/82
R2          . . . . . . . . . .
R2  AVG        0.0184    0.0046  AVERAGE

R3      D+ INTO (KOBAR PI+)/(K- PI+ PI+)                 (P2)/(P1)
R3   P       (0.45) OR LESS  CL=.90   PICCOLO   77 SMAG +- E+E- 4.03GEV ECM 12/77
R3   P  OBTAINED FROM SIGMA*BR VALUES OF TABLE I.                          12/77

R4      D+ INTO (PI+ PI+ PI-)/(K- PI+ PI+)               (P3)/(P1)
R4   P         0.08  OR LESS  CL=.90   PICCOLO   77 SMAG +- E+E- 4.03GEV ECM 12/77
R4           (0.084)OR LESS  CL=.90   SCHINDLER 81 SMK2 E+E- 3.771 GEV ECM   1/82
R4   P  OBTAINED FROM SIGMA*BR VALUES OF TABLE I.                          12/77

R5      D+ INTO (PI+ K+ K-)/(K- PI+ PI+)                 (P4)/(P1)
R5   P       (0.15) OR LESS  CL=.90   PICCOLO   77 SMAG +- E+E- 4.03GEV ECM 12/77
R5             0.14  OR LESS  CL=.90   SCHINDLER 81 SMK2 E+E- 3.771 GEV ECM   1/82
R5   P  OBTAINED FROM SIGMA*BR VALUES OF TABLE I.                          12/77

R6      D+ INTO (K+ PI+ PI-)/(K- PI+ PI+)                (P5)/(P1)
R6   P         0.05  OR LESS  CL=.90   PICCOLO   77 SMAG +- E+E- 4.03GEV ECM 12/77
R6   P  OBTAINED FROM SIGMA*BR VALUES OF TABLE I.                          12/77

R7      (D+ INTO E+ NUE)/(D+ INTO E+ ANYTHING + DO INTO E+ ANYTHING)
R7             0.10  OR LESS  CL=.90   BRANDELIK 77 DASP E+E- 3.99-4.08 GEV  12/77

R8      D+ AND DO INTO (E+ ANYTHING)/(TOTAL D+ AND DO)
R8       MEASURED AT THE PSI(3772).  THIS GIVES A WEIGHTED AVERAGE OF         2/82
R8       D+ (44 PCT.) AND DO (56 PCT.) BRANCHING FRACTIONS.                   2/82
R8             0.072     0.028         FELLER    78 SMAG E+E- 3.772 GEV ECM   2/78
R8            (0.11)    (0.02)         BACINO    78 DLCO REPL. BY BACINO 79   3/78
R8   A        (0.08)    (0.015)        BACINO    79 DLCO E+E- 3.772 GEV ECM   4/82
R8   A   NOT INDEPENDENT OF BACINO 80 R13(D+) AND R13(DO).                    4/82
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For notation, see key at front of Listings.

Stable Particles

$D^{\pm}$, D^0

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R9      D+ INTO (K- ANYTHING)                                   (P8)             1/79
R9       3    0.10      0.07            VUILLEMIN 78 SMAG E+E- 3.772 GEV ECM     1/79
R9      26    0.19      0.05            SCHINDLER 81 SMK2 E+E- 3.771 GEV ECM     1/82
R9              . . . . . . . . . .
R9  AVG       0.160     0.043    AVERAGE

R10     D+ INTO (K0BAR ANYTHING + K0 ANYTHING)/TOTAL            (P9)             1/79
R10      3    0.39      0.29            VUILLEMIN 78 SMAG E+E- 3.772 GEV ECM     1/79
R10     15    0.52      0.18            SCHINDLER 81 SMK2 E+E- 3.771 GEV ECM     1/82
R10             . . . . . . . . . .
R10 AVG       0.48      0.15     AVERAGE

R11     D+ INTO (K+ ANYTHING)/TOTAL                             (P10)
R11      2    0.06      0.06            VUILLEMIN 78 SMAG E+E- 3.772 GEV ECM     1/79
R11     12    0.06      0.04            SCHINDLER 81 SMK2 E+E- 3.771 GEV ECM     1/82
R11             . . . . . . . . . .
R11 AVG       0.060     0.033    AVERAGE

R12     D+ INTO (K*(892)0BAR PI+)/TOTAL                         (P11)
R12      92 EVENTS SEEN                 DRIJARD   79 SFM  +  P P,ECM=53 GEV      7/79
R12           0.037 OR LESS  CL=.90     SCHINDLER 81 SMK2 E+E- 3.771 GEV ECM     1/82

R13     D+ INTO (E+ ANYTHING)/TOTAL                             (P7)
R13         (0.220)  (0.044)  (0.022)BACINO    80 DLCO E+E- 3.77 GEV ECM      4/82
R13      23  (0.168)  (0.064)           SCHINDLER 81 SMK2 E+E- 3.771 GEV ECM     4/82
R13           0.19      0.04      0.03  TRILLING  81 RVUE BEST ESTIMATE          4/82

R14     D+ INTO (K0BAR PI+ PI0)/TOTAL                           (P12)            1/82
R14      10   0.129     0.084           SCHINDLER 81 SMK2 E+E- 3.771 GEV ECM     1/82

R15     D+ INTO (K0BAR PI+ PI+ PI-)/TOTAL                       (P13)            1/82
R15      21   0.084     0.035           SCHINDLER 81 SMK2 E+E- 3.771 GEV ECM     1/82

R16     D+ INTO (K- PI+ PI+ PI+ PI-)/TOTAL                      (P14)            1/82
R16           0.041 OR LESS  CL=.90     SCHINDLER 81 SMK2 E+E- 3.771 GEV ECM     1/82

R17     D+ INTO (K0BAR RHO+)/TOTAL                              (P18)            1/82
R17 S        (0.016)OR MORE  CL=.90     SCHINDLER 81 SMK2 E+E- 3.771 GEV ECM     1/82
R17 S   SCHINDLER 81 USE TRIANGLE RELATION FOR AMPLITUDES D0 -->K0BAR RHO0,      1/82
R17 S   D0 -->K- RHO+ AND D+ -->K0BAR RHO+, AND THEIR D+/D0 LIFETIME RATIO.      1/82
R18     D+ INTO (PI+ PI0)/(K0BAR PI+)                           (P15)/(P2)       1/82
R18           0.30  OR LESS  CL=.90     SCHINDLER 81 SMK2 E+E- 3.771 GEV ECM     1/82

R19     D+ INTO (K0BAR K+)/(K0BAR PI+)                          (P16)/(P2)       1/82
R19      6    0.25      0.15            SCHINDLER 81 SMK2 E+E- 3.771 GEV ECM     1/82

R21     D+ AND D0 INTO (ETA ANYTHING)/(TOTAL D+ AND D0)
R21  B       (0.02) OR LESS             BRANDELIK 79 DASP    E+E- ECM=4.03GEV    1/82
R21           0.13  OR LESS             PARTRIDGE 81 CBAL    E+E- ECM=3.77GEV    1/82
R21  B BRANDELIK 79 RESULT BASED ON ABSENCE OF ETA SIGNAL AT 4.03 GEV.           1/82
R21  B PARTRIDGE 81 OBSERVE SUBSTANTIALLY HIGHER ETA CROSS SECTION AT 4.03.      1/82

R22     D+ INTO (MU+ NUMU)/TOTAL                                (P20)           11/83*
R22  A   0    0.02  OR LESS  CL=.90     AUBERT    83 SPEC    MU+ FE, 250 GEV    11/83*
R22  A  AUBERT 83 OBTAIN UPPER LIMIT 0.014 ASSUMING THAT FINAL STATE            11/83*
R22  A  CONTAINS EQUAL MIXTURE OF (D+,D-),(D+,AD0),(D-,D0) AND (D0,AD0) .       11/83*
R22  A  WE QUOTE THE LIMIT WHICH THEY GET UNDER MORE GENERAL ASSUMPTIONS .      11/83*

R23     D+ INTO (K- PI+ PI+ PI0)/(K- PI+ PI+)                   (P21)/(P1)
R23      1    0.57      0.65      0.17  AGUILAR2  83 HYBR    PI- P,360GEV        2/84*

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REFERENCES FOR CHARGED D


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GOLDHABE 76 PRL 37 255          GOLDHABER,PIERRE,ABRAMS,ALAM+     (LBL+SLAC)
PERUZZI  76 PRL 37 569          +PICCOLO,FELDMAN,NGUYEN,WISS+     (SLAC+LBL)
WISS     76 PRL 37 1531         +GOLDHABER,ABRAMS,ALAM,BOYARSKI+ (LBL+SLAC)

BRANDELI 77 PL 70B 387          BRANDELIK +       (AACH+DESY+HAMB+MPIM+TOKY)
GOLDHABE 77 PL 69B 503          GOLDHABER,WISS,ABRAMS,ALAM +      (LBL+SLAC)
PERUZZI  77 PRL 39 1301         +PICCOLO,FELDMAN+       (SLAC+LBL+NWES+HAWA)
PICCOLO  77 PL 70B 260          +PERUZZI,LUTH,NGUYEN,WISS,ABRAMS+(SLAC+LBL)

BACINO   78 PRL 40 671          +BAUMGARTEN,BIRKWOOD +       (SLAC+UCLA+UCI)
FELLER   78 PRL 40 274          +LITKE,MADARAS,RONAN+  (LBL+SLAC+NWES+HAWA)
VUILLEMI 78 PRL 41 1149         VUILLEMIN,FELDMAN +    (LBL+SLAC+NWES+HAWA)

ARMENISE 79 PL 86B 115          +ERRIQUEZ+         (BARI+CERN+EPOL+MILA+ORSA)
BACINO   79 PRL 43 1073         +FERGUSON,NODULMAN+     (UCLA+SLAC+UCI+STON)
BRANDELI 79 PL 80B 412          BRANDELIK+         (AACH+DESY+HAMB+MPIM+TOKY)
DRIJARD  79 PL 81B 250          +FISCHER,GEIST+        (CERN+CDEF+HEID+KARL)

ALLASIA  80 NP B176 13           (ANKA+LIBH+CERN+DUUC+LOUC+KEYN+PISA+ROMA+)
BACINO   80 PRL 45 329          +FERGUSON+          (UCLA+SLAC+STAN+UCI+STON)
USHIDA   80 PRL 45 1053           (AICH+FNAL+KOBE+SEOU+MCGI+NAGO+OSU+OKAY+)
ZHOLENTZ 80 PL 96B 214          +KURDADZE,LELCHUK,MISHNEV,NIKITIN+    (NOVO)
    ALSO 81 YAD.PHYS.34 1471    ZHOLENTZ +                            (NOVO)

ADAMOVIC 81 PL 99B 271          ADAMOVICH+(PHOTON-EMUL,OMEGA-PHOTON COLLS.)
BALLAGH  81 PR D24 7            +BINGHAM+      (LBL+UCB+FNAL+HAWA+WASH+WISC)
    ALSO 80 PL 89B 423          BALLAGH +      (LBL+UCB+FNAL+HAWA+WASH+WISC)
PARTRIDG 81 PRL 47 760          PARTRIDGE,PECK+   (CIT+HARV+PRIN+STAN+SLAC)
SCHINDLE 81 PR D24 78           SCHINDLER,ALAM,BOYARSKY +         (SLAC+LBL)

ABE      82 PRL 48 1526         (SLAC HYBRID FACILITY PHOTON COLLABORATION)
ALBINI   82 PL 110B 339         ALBINI+      (FRAS+MILA+PISA+ROMA+TORI+TRST)
AGUILAR  83 PL 122B 312         AGUILAR-BENITEZ+    LEBC-EHS COLLAB (CERN+)
AGUILAR2 83 PL 123B 98          AGUILAR-BENITEZ+    LEBC-EHS COLLAB (CERN+)
AUBERT   83 NP B213 31          EUROPEAN MUON COLLAB.      (CERN+DESY+FREI+)
BADERTSC 83 PL 123B 471         BADERTSCHER,HAHN,HUGENTOBLER+    (BERN+MPIM)
USHIDA   83 PRL 51 2362           (AICH+FNAL+KOBE+SEOU+MCGI+NAGO+OSU+OKAY+)
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REVIEWS

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BARBAROG 78 LBL-8537            A.BARBARO-GALTIERI (ERICE 1978)          (LBL)
WOJCICKI 78 SLAC-PUB-2232       S.WOJCICKI (SLAC SUMMER INST.1978)      (SLAC)
KIRKBY   79 SLAC-PUB-2419       J.KIRKBY (LEPTON CONF. BATAVIA, 1979)(SLAC)
TRILLING 81 PRPL 75 57          G.H.TRILLING                        (LBL+UCB)J
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D^0

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                32  NEUTRAL D(1865,JP=0-)  I=1/2

      FOR A RECENT REVIEW SEE TRILLING 81

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                32  NEUTRAL D MASS (MEV)

M       234(1865.)    (15.)            GOLDHABER 76 SMAG    K PI AND K 3PI     1/77
M          (1863.)     (3.)            GOLDHABER 77 SMAG    D0,D+ RECOIL SPC  12/77
M    P     (1863.3)    (0.9)           PERUZZI   77 SMAG    E+E- 3.77GEV ECM  12/77
M          (1868.)    (11.)            PICCOLO   77 SMAG    E+E-4.03,4.41ECM   1/78
M        64(1850.)    (15.)            BALTAY    78 HBC     NEU NUCL,K0PIPI    1/79
M    A   94(1854.)     (6.)            ATIYA     79 SPEC GAM NUC-->D0 D0BAR  12/79
M         1(1866.)     (8.)            ADAMOVICH 80 EMUL GAMMA NUC-->D0BAR +  2/80
M       238(1863.0)    (2.5)           ASTON     80 OMEG GAMMA P-->D0BAR     12/81
M    A  143(1860.)     (2.)            AVERY     80 SPEC    GAMMA NUC-->D*+  12/81
M    A   35(1869.)     (4.)            AVERY     80 SPEC    GAMMA NUC-->D*+  12/81
M         1(1847.)     (7.)            FIORINO   81 EMUL GAMMA NUC-->D0BAR +  1/82
M    P    (1863.8)     (0.5)           SCHINDLER 81 SMK2    E+E- 3.77GEV ECM  1/82
M     P    1864.7      0.6             TRILLING  81 RVUE +- E+E- 3.77GEV ECM  1/82
M     P  PERUZZI 77 AND SCHINDLER 81 ERRORS DO NOT INCLUDE THE 0.13 PERCENT   1/82
M     P  UNCERTAINTY IN THE ABSOLUTE SPEAR ENERGY CALIBRATION.  TRILLING 81   1/82
M     P  USES THE HIGH PRECISION PSI AND PSI-PRIME MEASUREMENTS OF            1/82
M     P  ZHOLENTZ 80 TO DETERMINE THIS UNCERTAINTY AND COMBINES THE           1/82
M     P  PERUZZI 77 AND SCHINDLER 81 RESULTS TO OBTAIN THE VALUE QUOTED.      1/82
M     A  ERROR DOES NOT INCLUDE POSSIBLE SYSTEMATIC MASS SCALE SHIFT,         1/81
M     A  ESTIMATED TO BE LESS THAN 5 MEV.                                     1/81

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                32  (D01) - (D02) MASS DIFFERENCE (UNITS 10**-4 EV)

D      D01 AND D02 ARE THE CP EIGENSTATES OF THE NEUTRAL D MESON.
D        MEASURE OF DELTA-C = 2 D0-D0BAR MIXING.
D     B        6.5    OR LESS  CL=.90   BODEK      82 SPEC    PI-,P FE-->D0      2/84*
D     B  BODEK 82 LIMIT IS FOR THE ABSOLUTE VALUE OF THE MASS DIFFERENCE.        2/84*

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                32  (D+-) - (D0) MASS DIFFERENCE (MEV)

DM    A       5.0       0.8            PERUZZI   77 SMAG +- E+E- 3.77GEV ECM  3/78
DM    A       4.7       0.3            SCHINDLER 81 SMK2 +- E+E- 3.77GEV ECM  1/82
DM    A  NOT INDEPENDENT OF D+- AND D0 MASS MEASUREMENTS.                     3/78
DM          . . . . . . . . . .
DM   AVG      4.74      0.28     AVERAGE

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                32  NEUTRAL D MEAN LIFE   (UNITS 10**-13 SEC)

T              (8.0)  OR LESS  CL=.90   ARMENISE  79 HYBR NEU P -->DIMUONS +   1/80
T          1   (0.226)                  ADAMOVICH 80 EMUL INCL IN ADAMOVICH81  2/80
T     E    3   (0.53)   (0.57)   (0.25) ALLASIA   80 EMUL NEU WIDEBAND        12/81
T     C        (2.1)  OR LESS  CL=.95   BACINO    80 DLCO E+E- 3.77 GEV ECM    1/81
T     G    7   (1.00)   (0.52)   (0.31) USHIDA    80 EMUL INCL. IN USHIDA 82  12/81
T     F    3   (0.58)   (0.8)    (0.2)  ADAMOVICH 81 EMUL CERN-SPS GAMMA NUCL  1/82
T     H    1   (0.14)                   ADAMOVI2  81 EMUL CERN-SPS GAMMA NUCL  4/82
T     H    1   (3.4)  OR  (7.5)         ADAMOVI2  81 EMUL CERN-SPS GAMMA NUCL  4/82
T     B    2   (2.8)    (2.2)    (1.3)  BALLAGH   81 HYBR FNAL 15FT, NU NE-H2  1/82
T     A    1   (2.1)                    ADEVA     81 HYBR LEBC CERN-SPS PI- P  1/82
T     A    1   (5.9)                    ADEVA     81 HYBR LEBC CERN-SPS PI- P  1/82
T          5    3.1      2.0      1.6   FUCHI     81 EMUL CERN-SPS PI- NUC     1/82
T         11    6.7      3.5      2.0   ABE       82 HYBR SLAC GAM P 19.5 GEV  2/82
T      G  16    2.3      0.8      0.5   USHIDA    82 EMUL FNAL NU,ANU WIDEBND  2/82
T         16    4.1      1.3      0.9   AGUILAR   83 HYBR PI- P, P P          11/83*
T          9    4.1      2.6      1.4   BADERTSCH 83 HYBR CERN PI- NUCL.      11/83*
T         27    4.2      1.6      1.4   YELTON    84 SMK2 E+E- ECM=29 GEV      2/84*
T     E  ALLASIA 80 ASSUMES NO LONG-LENGTH LOSSES.  VISIBILITY PROBLEMS IN     4/82
T     E  THE EMUL.                                                             4/82
T     C  USES THEORETICAL RATE D TO (K E NEU)=1.4*10**11 SEC**-1 .             1/81
T     F  ADAMOVICH 81 ASSUMES NO LONG-LENGTH LOSSES.                           4/82
T     H  ADAMOVICH2 81 HAS NO CORRECTION FOR DETECTION EFFICIENCY.             4/82
T     B  BALLAGH 81 VALUE QUOTED HERE ASSUMES THAT ALL DILEPTON EVENTS         1/82
T     B  CONTAIN D0 OR D+, EACH WITH EQUAL NUMBERS OF SEMILEPTONIC DECAYS.     1/82
T     A  ADEVA 81 FIRST AND SECOND VALUES ARE PROPER LIFETIMES OF D0 AND AD0   1/82
T     A  FROM SINGLE EVENT.  DETECTION EFFICIENCY LOW FOR LIFETIMES 10**-13    1/82
T     A  SEC OR LESS.                                                          1/82
T     D  CERN NA16 (LEBC-EHS) EXPT.  PRESENTED AT MORIOND CONF. 82.            4/82
T      G USHIDA 82 HAVE 3 SEMI-LEPTONIC DECAYS NOT INCLUDED IN THIS NUMBER,    4/82
T      G BUT BELIEVED TO HAVE MUCH LONGER LIFETIMES.  SUPERCEDES USHIDA 80.    4/82
T           . . . . . . . . . .
T    AVG       4.40     0.81      0.60   AVERAGE

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                32  ((D01) - (D02))/AVG., MEAN LIFE DIFFERENCE

DT     D01 AND D02 ARE THE CP EIGENSTATES OF THE NEUTRAL D MESON.
DT    B       0.55   OR LESS  CL=.90   BODEK      82 SPEC    PI-,P FE-->D0      2/84*
DT    B  BODEK 82 LIMIT IS FOR THE ABSOLUTE VALUE OF THE MEAN LIFE              2/84*
DT    B  DIFFERENCE.                                                            2/84*

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                32  (CHARGED D)/(NEUTRAL D) MEAN LIFE RATIO

TR       FROM RATIO OF D+ TO D0 SEMILEPTONIC BRANCHING FRACTIONS.
TR        NOT USED BY US TO CONSTRAIN BEST VALUES OF D LIFETIMES FOR TABLE.
TR            (4.3)  OR MORE  CL=.95   BACINO    80 DLCO E+E- 3.77 GEV ECM     1/82
TR            (3.1)     (4.6)     (1.4) SCHINDLER 81 SMK2 E+E- 3.77 GEV ECM     1/82

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                32  NEUTRAL D PARTIAL DECAY MODES

                                                           DECAY MASSES
P1       D0 INTO K- PI+                                  494+ 140
P2       D0 INTO K- PI+ PI+ PI-                          494+ 140+ 140+ 140
P3       D0 INTO K0BAR PI+ PI-                           498+ 140+ 140
P4       D0 INTO K0BAR PI+ PI- PI+ PI-                   498+ 140+ 140+ 140+
P5       D0 INTO PI+ PI-                                 140+ 140
P6       D0 INTO K+ PI- (VIA D0BAR)                      494+ 140
P7       D0 INTO K+ K-                                   494+ 494
P8       D0 INTO K- PI+ PI0                              494+ 140+ 135
P9       D0 INTO K0BAR PI0                               498+ 135
P10      D0 INTO E+ ANYTHING
P11      D0 INTO K- ANYTHING
P12      D0 INTO K+ ANYTHING
P13      D0 INTO K0BAR ANYTHING + K0 ANYTHING
P14      D0 INTO K*(892)- PI+                            892+ 140
P15      D0 INTO K*(892)0 PI0                            892+ 135
P16      D0 INTO K- RHO+                                 494+ 769
P17      D0 INTO K0BAR RHO0                              498+ 769
P18      D0 INTO PI- PI- PI+ PI+                         140+ 140+ 140+ 140
P19      D0 INTO UNFITTED MODES (KEEPS FIT PGM. HAPPY)
P20      D0 INTO K- PI+ PI0 PI0                          494+ 140+ 135+ 135
P21      D0 INTO ETA ANYTHING (SEE CHARGED D SECTION R21)
P22      D0 INTO K*(892)0 RHO0                           892+ 769
P23      D0 INTO K- PI+ RHO0                             494+ 140+ 769
P24      D0 INTO K*(892)0 PI+ PI-                        892+ 140+ 140
P25      D0 INTO K- A2(1320)+                            494+1318
P26      D0 INTO MU- ANYTHING (VIA D0BAR)
P27      D0 INTO MU+ ANYTHING

         D0BAR MODES ARE CHARGE CONJUGATES OF ABOVE MODES

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Stable Particles

Data Card Listings

D^0, $F^\pm$

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 5	P 7	P19
P 1	.0239+-.0038					
P 2	.3191	.0456+-.0116				
P 3	.1725	.0550	.0420+-.0077			
P 5	.3308	.1056	.0571	.0008+-.0004		
P 7	.5146	.1642	.0888	.1702	.0027+-.0008	
P19	-.5761	-.8195	-.5569	-.2114	-.3343	.8849+-.0164

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32 NEUTRAL D BRANCHING RATIOS

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R1      DO INTO (K- PI+)/TOTAL                             (P1)
R1       130    0.022    0.006          PERUZZI   77 SMAG    E+E- 3.77GEV ECM 12/77
R1       263    0.030    0.006          SCHINDLER 81 SMK2 E+E- 3.771 GEV ECM   1/82
R1               . . . . . . . . .
R1   AVG        0.0260   0.0042  AVERAGE
R1   FIT        0.0239   0.0038 FROM FIT

R2      DO INTO (K- PI+ PI+ PI-)/TOTAL                     (P2)
R2        44    0.032    0.011          PERUZZI   77 SMAG    E+E- 3.77GEV ECM 12/77
R2       185    0.085    0.021          SCHINDLER 81 SMK2 E+E- 3.771 GEV ECM   1/82
R2               . . . . . . . . .
R2   AVG        0.043    0.022   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.2)
R2   FIT        0.046    0.012   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.4)

R3      DO INTO (K0BAR PI+ PI-)/TOTAL                      (P3)
R3        28    0.040    0.013          PERUZZI   77 SMAG    E+E- 3.77GEV ECM 12/77
R3        32    0.038    0.012          SCHINDLER 81 SMK2 E+E- 3.771 GEV ECM   1/82
R3               . . . . . . . . .
R3   AVG        0.0389   0.0088  AVERAGE
R3   FIT        0.0420   0.0077 FROM FIT

R4      DO INTO (K- PI+ PI+ PI-)/(K- PI+)                  (P2)/(P1)
R4     P 214    2.2      0.8            PICCOLO   77 SMAG    E+E-4.03,4.41ECM 12/77
R4        10    2.0      1.0            BAILEY    83 SPEC    PI- BE--> D0      2/84*
R4     P THIS CHANNEL DOMINATED BY K- PI+ RHO0 (85+-15 PERCENT).              12/77
R4     P K* PI+ PI- AND K- A2+ CONSISTENT WITH 0, K* RHO0 FRAC IS 0.1+-0.1 .  12/77
R4               . . . . . . . . .
R4   AVG        2.12     0.62    AVERAGE
R4   FIT        1.91     0.48    FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

R5      DO INTO (K0BAR PI+ PI-)/(K- PI+)                   (P3)/(P1)
R5       116    2.8      1.0            PICCOLO   77 SMAG    E+E-4.03,4.41ECM 12/77
R5        35    1.7      0.8            AVERY     80 SPEC    GAMMA NUC-->D*+  12/81
R5               . . . . . . . . .
R5   AVG        2.13     0.62    AVERAGE
R5   FIT        1.76     0.39    FROM FIT

R6      DO INTO (PI+ PI-)/(K- PI+)                         (P5)/(P1)
R6              0.07  OR LESS  CL=.90   PICCOLO   77 SMAG    E+E- 4.03 GEVECM 12/77
R6              0.033    0.015          ABRAMS    79 SMK2    E+E- 3.77GEV ECM 12/79
R6               . . . . . . . . .
R6   FIT        0.033    0.015   FROM FIT

R7      DO INTO (K+ K-)/(K- PI+)                           (P7)/(P1)
R7              0.07  OR LESS  CL=.90   PICCOLO   77 SMAG    E+E- 4.03GEV ECM 12/77
R7              0.113    0.030          ABRAMS    79 SMK2    E+E- 3.77GEV ECM 12/79
R7               . . . . . . . . .
R7   FIT        0.113    0.030   FROM FIT

R8      DO INTO (K+ PI-, VIA D0BAR)/(K- PI+ + K+ PI-)      (P6)/(P1+P6)
R8       THIS IS THE D0-D0BAR MIXING LIMIT
R8              0.16  OR LESS  CL=.90   FELDMAN   77 SMAG    D*+ TO D0 PI+     3/77
R8             (0.18) OR LESS  CL=.90   GOLDHABER 77 SMAG                     12/77

R9      DO INTO (K- PI+ PI0)/TOTAL                         (P8)
R9         7    0.12     0.06           SCHARRE   78 SMAG    E+E- 3.77 GEV     1/78
R9        37    0.085    0.032          SCHINDLER 81 SMK2 E+E- 3.771 GEV ECM   1/82

R10     DO INTO (K0BAR PI0)/TOTAL                          (P9)
R10            (0.06) OR LESS  CL=.90   SCHARRE   78 SMAG    E+E- 3.77 GEV     1/78
R10        8    0.022    0.011          SCHINDLER 81 SMK2 E+E- 3.771 GEV ECM   1/82

R12     DO INTO (K0BAR ANYTHING + K0 ANYTHING)/TOTAL       (P13)
R12        6    0.57     0.26           VUILLEMIN 78 SMAG E+E- 3.772 GEV ECM   1/79
R12       13    0.29     0.11           SCHINDLER 81 SMK2 E+E- 3.771 GEV ECM   1/82
R12              . . . . . . . . .
R12 AVG         0.33     0.10    AVERAGE

R13     DO INTO (E+ ANYTHING)/TOTAL                        (P10)
R13        0   (0.04) OR LESS  CL=.95   BACINO    80 DLCO E+E- 3.77 GEV ECM    4/82
R13       12    0.055    0.037          SCHINDLER 81 SMK2 E+E- 3.771 GEV ECM   4/82
R13        3    0.051    0.048    0.014 AGUILAR   83 HYBR PI- P, P P          11/83*
R13              . . . . . . . . .
R13             0.053    0.029    0.013 AVERAGE                                3/84*

R14     DO INTO (K*(892)- PI+)/TOTAL                       (P14)               1/82
R14       25    0.034    0.014          SCHINDLER 81 SMK2 E+E- 3.771 GEV ECM   1/82

R15     DO INTO (K*(892)0 PI0)/TOTAL                       (P15)               1/82
R15        4    0.014    0.023    0.014 SCHINDLER 81 SMK2 E+E- 3.771 GEV ECM   1/82

R16     DO INTO (K- RHO+)/TOTAL                            (P16)               1/82
R16       31    0.072    0.030    0.031 SCHINDLER 81 SMK2 E+E- 3.771 GEV ECM   1/82

R17     DO INTO (K0BAR RHO0)/TOTAL                         (P17)               1/82
R17        1    0.001    0.006    0.001 SCHINDLER 81 SMK2 E+E- 3.771 GEV ECM   1/82

R18     DO INTO (PI- PI- PI+ PI+)/(K- PI+ PI+ PI-)         (P18)/(P2)          1/82
R18             0.21  OR LESS  CL=.90   SCHINDLER 81 SMK2 E+E- 3.771 GEV ECM   1/82

R19     DO INTO (K- ANYTHING)/TOTAL                        (P11)               1/82
R19       19    0.35     0.10           VUILLEMIN 78 SMAG E+E- 3.772 GEV ECM   1/79
R19      121    0.55     0.11           SCHINDLER 81 SMK2 E+E- 3.771 GEV ECM   1/82
R19              . . . . . . . . .
R19 AVG         0.440    0.100   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)

R20     DO INTO (K+ ANYTHING)/TOTAL                        (P12)               1/82
R20       25    0.08     0.03           SCHINDLER 81 SMK2 E+E- 3.771 GEV ECM   1/82

R21     DO INTO (K- PI+ PI0 PI0)/TOTAL                     (P20)               1/82
R21        1 SEEN                       ADEVA     81 HYBR   PI- P-->D0 D0BAR   1/82

R22     DO INTO (K*(892)0 RHO0)/(K- PI+ PI+ PI-)           (P22)/(P4)
R22      FOLLOWED BY DECAY K*(892)0 --> K- PI+
R22      20     0.10      0.11      0.10  PICCOLO   77 SMAG    E+E-4.03,4.41ECM  2/84*
R22       5    (0.5)     (0.2)  CL=.90    BAILEY    83 SPEC    PI BE --> D0      2/84*

R23     DO INTO (K- PI+ RHO0)/(K- PI+ PI+ PI-)             (P23)/(P4)
R23     180     0.85      0.11      0.22  PICCOLO   77 SMAG    E+E-4.03,4.41ECM  2/84*
R23       2    (0.2)     (0.2)  CL=.90    BAILEY    83 SPEC    PI BE --> D0      2/84*

R24     DO INTO (K*(892)0 PI+ PI-)/(K- PI+ PI+ PI-)        (P24)/(P4)
R24      FOLLOWED BY DECAY K*(892)0 --> K- PI+
R24   P   0     0.0       0.2       0.0   PICCOLO   77 SMAG    E+E-4.03,4.41ECM  2/84*
R24       0    (0.18) OR LESS  CL=.90    BAILEY    83 SPEC    PI BE --> D0      2/84*
R24   P  CORRESPONDS TO 0.33 AT CL=.90.                                          2/82

R25     DO INTO (K- A2(1320)+)/(K- PI+ PI+ PI-)            (P25)/(P4)
R25      FOLLOWED BY DECAY A2+ --> PI+ PI+ PI- (B.R.=0.35)                        2/84*
R25             0.06  OR LESS             PICCOLO   77 SMAG    E+E-4.03,4.41ECM  2/84*
R26     DO INTO (MU- ANYTHING,VIA D0BAR)/(MU+ ANY + MU- ANY)
R26                                                        (P26)/(P26+P27)
R26             0.044 OR LESS  CL=.90    BODEK     82 SPEC    PI-,P FE-->D0     2/84*
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REFERENCES FOR NEUTRAL D


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GOLDHABE 76 PRL 37 255         GOLDHABER,PIERRE,ABRAMS,ALAM+    (LBL+SLAC)
FELDMAN  77 PRL 38 1313        +PERUZZI,PICCOLO,ABRAMS,ALAM +   (SLAC+LBL)
GOLDHABE 77 PL 69B 503         GOLDHABER,WISS,ABRAMS,ALAM +     (LBL+SLAC)
PERUZZI  77 PRL 39 1301        +PICCOLO,FELDMAN+       (SLAC+LBL+NWES+HAWA)
PICCOLO  77 PL 70B 260         +PERUZZI,LUTH,NGUYEN,WISS,ABRAMS+(SLAC+LBL)

BALTAY   78 PRL 41 73          +CAROUMBALIS,FRENCH,HIBBS,HYLTON+(COLU+BNL)
SCHARRE  78 PRL 40 74          +BARBARO-GALTIERI +     (SLAC+LBL+NWES+HAWA)
VUILLEMI 78 PRL 41 1149        VUILLEMIN,FELDMAN +     (LBL+SLAC+NWES+HAWA)
ABRAMS   79 PRL 43 481         +ALAM,BLOCKER,BOYARSKI+          (SLAC+LBL)
ARMENISE 79 PL 86B 115         +ERRIQUEZ+         (BARI+CERN+EPOL+MILA+ORSA)
ATIYA    79 PRL 43 414         +HOLMES,KNAPP,LEE+           (COLU+ILL+FNAL)

ADAMOVIC 80 PL 89B 427         ADAMOVICH+(PHOTON-EMUL,OMEGA-PHOTON COLLS.)
ALLASIA  80 NP B176 13          (ANKA+LIBH+CERN+DUUC+LOUC+KEYN+PISA+ROMA+)
ASTON    80 PL 94B 113         +(BONN+CERN+EPOL+GLAS+LANC+MCHS+LALO+LPNP+)
AVERY    80 PRL 44 1309        +WISS,BUTLER,GLADDING+       (ILL+FNAL+COLU)
BACINO   80 PRL 45 329         +FERGUSON+         (UCLA+SLAC+STAN+UCI+STON)
USHIDA   80 PRL 45 1049          (AICH+FNAL+KOBE+SEOU+MCGI+NAGO+OSU+OKAY+)
ZHOLENTZ 80 PL 96B 214         +KURDADZE,LELCHUK,MISHNEV,NIKITIN+    (NOVO)
    ALSO 81 YAD.PHYS.34 1471   ZHOLENTZ +                            (NOVO)

ADAMOVIC 81 PL 99B 271         ADAMOVICH+(PHOTON-EMUL,OMEGA-PHOTON COLLS.)
ADAMOVI2 81 JETPL 34 456       (PISMA JETF 34 477)(PHOT.EMUL.,OMEGA-PHOT.)
    ALSO 80 ADAMOVICH
    ALSO 81 FIORINO
ADEVA    81 PL 102B 285        +AGUILAR-BENITEZ + (LEBC-EHS COLLABORATION)
BALLAGH  81 PR D24 7           +BINGHAM+      (LBL+UCB+FNAL+HAWA+WASH+WISC)
    ALSO 80 PL 89B 423         BALLAGH +      (LBL+UCB+FNAL+HAWA+WASH+WISC)
FIORINO  81 LNC 30 166         FIORINO+ (PHOTON-EMUL, OMEGA-PHOTON COLLS.)
FUCHI    81 LNC 31 199         +HOSHINO,MIYANISHI+   (NAGO+AICH+TOKY+YOKO)
SCHINDLE 81 PRD 24 78          SCHINDLER,ALAM,BOYARSKY +         (SLAC+LBL)
ABE      82 PRL 48 1526        (SLAC HYBRID FACILITY PHOTON COLLABORATION)
BODEK    82 PL 113B 82         +BREEDON,COLEMAN+ (ROCH+CIT+CHIC+FNAL+STAN)
USHIDA   82 PRL 48 844           (AICH+FNAL+KOBE+SEOU+MCGI+NAGO+OSU+OKAY+)
AGUILAR  83 PL 122B 312        AGUILAR-BENITEZ+    LEBC-EHS COLLAB (CERN+)
BADERTSC 83 PL 123B 471        BADERTSCHER,HAHN,HUGENTOBLER+   (BERN+MPIM)
BAILEY   83 PL 132B 237        +BARDSLEY,BECKER+    ACCMOR COLLAB. (CERN+)
YELTON   84  SLAC-PUB-3274     +GLADNEY,GOLDHABER,ABRAMS+  (SLAC+LBL+HARV)

         QUANTUM NUMBER DETERMINATIONS NOT REFERRED TO IN THE DATA CARDS

NGUYEN   77 PRL 39 262         +WISS,ABRAMS,ALAM,BOYARSKI+      (LBL+SLAC)J

                               REVIEWS

BARBAROG 78 LBL-8537           A.BARBARO-GALTIERI (ERICE 1978)        (LBL)
WOJCICKI 78 SLAC-PUB-2232      S.WOJCICKI (SLAC SUMMER INST.1978)    (SLAC)
KIRKBY   79 SLAC-PUB-2419      J.KIRKBY (LEPTON CONF. BATAVIA, 1979)(SLAC)
TRILLING 81 PRPL 75 57         G.H.TRILLING                       (LBL+UCB)J
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$F^\pm$

34 F+-(1970,JP=0-) I=0

QUANTUM NUMBERS NOT MEASURED. VALUES ARE ASSIGNED HERE ASSUMING CHARMED-STRANGE GROUND STATE F-MESON. CHEN 83 OBSERVATIONS ARE CONSISTENT WITH J=0.

NOTE ON THE F MESON

The strongest evidence for the F meson comes from the CLEO observation (CHEN 83) of a $\phi\pi^\pm$ signal of 104 ± 19 events above background with mass $(1970 \pm 5 \pm 5)$ MeV and width consistent with resolution. The decay angular distributions are consistent with a spin-0 F decaying to $\phi\pi$ followed by $\phi \to K^+K^-$. The observation of a $\phi\pi^\pm$ state at this mass has been confirmed by TASSO (ALTHOFF 84) and supported in a preliminary report from ARGUS (ARGUS 83).

The 1970-MeV mass is inconsistent with that found by the OMEGA Spectrometer photoproduction experiment, while the earlier DASP mass (BRANDELIK 77,79) is consistent with both the CLEO and OMEGA

For notation, see key at front of Listings.

Stable Particles

$F^{\pm}$, $B^{\pm}$

results. DASP (BRANDELIK 77,79) observed an $\eta\pi^{\pm}$ signal of 6 events with negligible background at (2030 ± 60) MeV. OMEGA reported signals in $\eta\pi^{\pm}$, $\eta\pi^{\pm}\pi^{+}\pi^{-}$, and $\eta'\pi^{\pm}\pi^{+}\pi^{-}$ at an average mass of $(2020\pm10\pm20)$ MeV (ASTON 81), in $\phi\rho^{\pm}$ at (2049 ± 15) MeV (ASTON2 81), and later in $\eta\pi^{\pm}$ at (2017 ± 13) MeV (ATKINSON 83). The disagreement between OMEGA and CLEO masses cannot be accounted for by any known systematic errors.

Another apparent disagreement involves the $F\to\phi\pi^{\pm}$ branching fraction. OMEGA sets a limit $\sigma\cdot B<4$ nb for the $F\overline{F}$ photoproduction cross section times the branching fraction to this mode (ASTON2 81), compared with $\sigma\cdot B=(140\pm20)$ nb for the sum of the four modes they reported, i.e., a branching ratio $\Gamma(F^{\pm}\to\phi\pi^{\pm})/\Gamma(F^{\pm}\to\eta\pi^{\pm}+\eta\pi^{\pm}\pi^{+}\pi^{-}+\eta'\pi^{\pm}\pi^{+}\pi^{-}+\phi\rho^{\pm})<3\%$. This suggests a much smaller branching ratio to all possible modes: $B(F\to\phi\pi)\equiv\Gamma(F\to\phi\pi)/\Gamma(F\to\text{all})\ll3\%$. In contrast CLEO (CHEN 83), using a crude estimate of the level of $F^{\pm}$ production, obtains $B(F\to\phi\pi)\sim4.4\%$, while TASSO (ALTHOFF 84) finds a somewhat higher value. Theoretical estimates for this branching fraction are 2%-3%.[1]

The hybrid-emulsion spectrometer wide-band neutrino beam experiment at Fermilab (USHIDA 83) cannot be used to establish an F mass because their cuts to eliminate D background effectively require their F candidates to have a mass greater than 2000 MeV. In a second run this group has reduced the mass bias by improved mass resolution and by including ϕ decay modes. Preliminary results for this run reported at Cornell[2] give a mass for 8 $F^{\pm}$ candidates which is in agreement with both the CLEO and the OMEGA results.

The situation is thus by no means clear. In the Stable Particle Table we give the mass determined from $e^{+}e^{-}$ observations of the $\phi\pi^{\pm}$ mode, $m_F=(1971\pm6)$ MeV, to which we attach a cautionary footnote pointing out the conflicting results. We list decay modes of the F other than $\phi\pi$ as "possibly seen" because the conflicting mass values suggest that these other modes may not be observations of the 1971-MeV state adopted here as the F.

References

1. L. Maiani, J. Phys. (Paris), Colloq. **43**, C3-631 (1982); and D. Fakirov and B. Stech, Nucl. Phys. **B133**, 315 (1978).
2. N.W. Reay, *Proceedings 1983 International Lepton/Photon Symposium* (Cornell, 1983), eds. D.G. Cassel and D.L. Kreinick, p. 244.


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                     34  F+-(1970) MASS (MEV)

M        4(2030.)    (60.)            BRANDELIK 77 DASP +- IN BRANDELIK 79  12/77
M        6(2030.)    (60.)            BRANDELIK 79 DASP +- E+E- ECM=4.42GEV  1/80
M        1(2017.)    (25.)            AMMAR     80 HYBR +  NEU WIDEBAND      9/81
M        1(2026.)    (56.)            USHIDA    80 EMUL -  FNAL NU WIDEBAND  2/82
M        1(2089.)   (121.)            USHIDA    80 EMUL +  FNAL NU WIDEBAND  2/82
M   A  460(2020.)    (22.)            ASTON     81 OMEG +- GAMMA P-->F +     1/82
M       30(2049.)    (15.)            ASTON2    81 OMEG +- GAMMA P-->F +     2/84*
M         (1970.)    (10.)            ARGUS     83 ARG     PRELIMINARY       2/84*
M   C   17(2017.)    (13.)            ATKINSON  83 OMEG +- GAMMA P-->F +    11/83*
M    S 104 1970.       7.             CHEN      83 CLEO +- E+E- ECM=10.5GEV 10/83*
M    S  49 1975.      14.             ALTHOFF   84 TASS +- E+E- ECM14-25GEV  2/84*
M   A   ERROR QUOTED BY ASTON 81 IS 10 MEV STAT AND <20 MEV SYST.            1/82
M   A   AVERAGE OF THREE MODES LISTED IN SECTIONS R2, R3, AND R4 BELOW.      2/84*
M   C   ATKINSON 83 MASS ERROR INCLUDES SYSTEMATIC UNCERTAINTIES.           11/83*
M    S  STATISTICAL AND SYSTEMATIC ERRORS COMBINED IN QUADRATURE.            2/84*
M          . . . . . . . . . .
M   AVG    1971.0      6.3     AVERAGE

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                     34  F+-(1970) MEAN LIFE     (UNITS 10**-13 SEC)

T        2   (2.24)   (2.78)   (1.05) USHIDA    80 EMUL    NEU WIDEBAND     12/81
T        1   (1.4)                    AMMAR     80 HYBR +  NEU WIDEBAND      1/82
T   A    2   (2.1)    (3.6)    (0.8)  AGUILAR   83 HYBR PI- P, P P           2/84*
T        4    1.9      1.3      0.7   USHIDA    83 EMUL REPL. USHIDA 80      2/84*
T   A   WITHDRAWN BY AUTHORS.  D INTERPRETATION CANNOT BE RULED OUT WITHOUT  2/84*
T   A   PARTICLE ID.  S.REUCROFT (PRIVATE COMMUNICATION, 1984).              2/84*

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                     34  F+-(1970) PARTIAL DECAY MODES

                                                              DECAY MASSES
P1      F+- INTO ETA PI+-                                     549+ 140
P2      F+- INTO ETA ANYTHING                                 549+   0
P3      F+- INTO ETA PI+- PI+ PI-                             549+ 140+ 140+ 140
P4      F+- INTO ETA PRIME PI+- PI+ PI-                       958+ 140+ 140+ 140
P5      F+- INTO PHI RHO+-                                   1020+ 769
P6      F+- INTO PHI PI+-                                    1020+ 140
P7      F+- INTO MU+- NU                                      106+   0
P8      F+- INTO PHI PI+- PI+ PI-                            1020+ 140+ 140+ 140

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                     34  F+-(1970) BRANCHING RATIOS

R1      F+- INTO (ETA PI+-)/(ETA ANYTHING)              (P1)/(P2)
R1  A    6   (0.09)   (0.06)          BRANDELIK 79 DASP    E+E- ECM=4.42GEV  4/82
R1  A   DENOMINATOR INCONSISTENT WITH PARTRIDGE 81 (CRYSTAL BALL)            4/82

R2      F+- INTO ETA PI+-                               (P1)
R2       40 +- 9 EVENTS SEEN          ASTON     81 OMEG    GAMMA P-->F +     2/84*
R2       17 +- 6 EVENTS SEEN          ATKINSON  83 OMEG    GAMMA P-->F +     2/84*

R3      F+- INTO ETA PI+- PI+ PI-                       (P3)                 1/82
R3      360 +- 90 EVENTS SEEN         ASTON     81 OMEG    GAMMA P-->F +     1/82

R4      F+- INTO ETA PRIME PI+- PI+ PI-                 (P4)                 1/82
R4       60 +- 20 EVENTS SEEN         ASTON     81 OMEG    GAMMA P-->F +     1/82

R5      F+- INTO PHI RHO+-                              (P5)                 1/82
R5       83 +- 26 EVENTS SEEN         ASTON2    81 OMEG    GAMMA P-->F +     1/82

R6      F+- INTO PHI PI+-                               (P6)                10/83*
R6          (SEEN)                    ARGUS     83 ARG     PRELIMINARY       2/84*
R6  A   104   (0.044)                 CHEN      83 CLEO +- E+E- ECM=10.5GEV 10/83*
R6  A    49   (0.13)   (0.05)  (0.08) ALTHOFF   84 TASS +- E+E- ECM14-25GEV  2/84*
R6  A   BOTH VALUES BASED ON SAME CRUDE ESTIMATE OF F+- PRODUCTION LEVEL.    2/84*
R6  A   ALTHOFF 84 ERRORS ARE STATISTICAL AND SYSTEMATIC COMBINED IN         2/84*
R6  A   QUADRATURE WITH ADDITIONAL NEGATIVE ERROR FOR F+- FROM PRIMARY B.    2/84*

R7      F+- INTO (MU+- NU)/TOTAL                        (P7)
R7  A    0   (0.03) OR LESS           AUBERT    83 SPEC    MU+ FE, 250 GEV  11/83*
R7  A   AUBERT 83 OBTAIN THIS LIMIT ASSUMING THAT F+- PRODUCTION RATE IS    11/83*
R7  A   20 PERCENT OF TOTAL CHARM PRODUCTION RATE .                         11/83*

R8      F+- INTO PHI PI+- PI+ PI-                       (P8)
R8          (SEEN)                    ARGUS     83 ARG     PRELIMINARY       2/84*

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                         REFERENCES FOR F+-(1970)

BRANDELI 77 PL 70B 132         BRANDELIK +       (AACH+DESY+HAMB+MPIM+TOKY)
BRANDELI 79 PL 80B 412         BRANDELIK+        (AACH+DESY+HAMB+MPIM+TOKY)
AMMAR    80 PL 94B 118         +     (KANS+FNAL+SERP+ITEP+CRAC+JINR+WASH+)
USHIDA   80 PRL 45 1053          (AICH+FNAL+KOBE+SEOU+MCGI+NAGO+OSU+OKAY+)

ASTON    81 PL 100B 91          (BONN+CERN+EPOL+GLAS+LANC+MCHS+LALO+LPNP+)
ASTON2   81 NP B189 205         (BONN+CERN+EPOL+GLAS+LANC+MCHS+LALO+LPNP+)
PARTRIDG 81 PRL 47 760         PARTRIDGE,PECK+    (CIT+HARV+PRIN+STAN+SLAC)

AGUILAR  83 PL 122B 312        AGUILAR-BENITEZ+    LEBC-EHS COLLAB  (CERN)
ARGUS    83 CERN COUR. 23 423 ARGUS COLLABORATION (PRELIMINARY)
ATKINSON 83 ZP C17 1           +   (BONN+CERN+GLAS+LANC+MCHS+LPNP+RL+SHEF)
AUBERT   83 NP B213 31         EUROPEAN MUON COLLAB.      (CERN+DESY+FREI+)
CHEN     83 PRL 51 634         +  (SYRA+VAND+HARV+OSU+CORN+ITHA+ROCH+RUTG)
USHIDA   83 PRL 51 2362          (AICH+FNAL+KOBE+SEOU+MCGI+NAGO+OSU+OKAY+)
ALTHOFF  84 PL 141B TO BE PUB TASSO C.     (AACH+BONN+DESY+HAMB+LOIC+OXF+)

                               REVIEWS

TRILLING 81 PRPL 75 57         G.H.TRILLING                       (LBL+UCB)

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B±

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                 41  CHARGED B(5271, JP=  )  I=

                 SEE ALSO THE LISTING FOR THE B (FOLLOWING THE ENTRY
                 FOR THE NEUTRAL B) FOR MEASUREMENTS WHICH DO NOT
                 IDENTIFY THE CHARGE STATE.


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                 41  CHARGED B MASS  (MEV)

M    A  6  5270.8      3.0         BEHRENDS  83 CLEO +- D*- PI+ PI+ + CC  4/83*
M    A  STATISTICAL (2.3 MEV) AND SYSTEMATICAL (2.0 MEV) ERRORS COMBINED.  4/83*

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Stable Particles

$B^{\pm}$, B^0, B, p


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                    41  CHARGED B PARTIAL DECAY MODES

                                                        DECAY MASSES
P1      B+ INTO DOBAR PI+                            1865+ 140
P2      B+ INTO D*(2010)- PI+ PI+                    2007+ 140+ 140

        B- MODES ARE CHARGE CONJUGATES OF THE ABOVE MODES.

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                    41  CHARGED B BRANCHING RATIOS

R1      B+ INTO DOBAR PI+                          (P1)
R1      2     0.042    0.042       BEHRENDS  83 CLEO +- E+ E-, UPSIL(4S)  4/83*

R2      B+ INTO D*(2010)- PI+ PI+                  (P2)
R2      6     0.048    0.030       BEHRENDS  83 CLEO +- E+ E-, UPSIL(4S)  4/83*

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                         REFERENCES FOR CHARGED B

BEHRENDS 83 PRL 50 881        +  (ROCH+RUTG+SYRA+VAND+CORN+ITHA+HARV+OSU)

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B0

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                    42  NEUTRAL B(5274, JP-  )  I-

                    SEE ALSO THE LISTING FOR THE B (FOLLOWING THIS ENTRY)
                    FOR MEASUREMENTS WHICH DO NOT IDENTIFY THE CHARGE
                    STATE.

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                    42  NEUTRAL B MASS  (MEV)

M    A  5  5274.2      2.8         BEHRENDS  83 CLEO 0  D*- PI+ + CC     4/83*
M    A  STATISTICAL (1.9 MEV) AND SYSTEMATICAL (2.0 MEV) ERRORS COMBINED.  4/83*

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                    42  (B0) - (B+) MASS DIFFERENCE (MEV)

DM   A        3.4      3.6         BEHRENDS  83 CLEO    E+E-, UPSIL(4S)   3/84*
DM   A  STATISTICAL (3.0) AND SYSTEMATICAL (2.0) ERRORS COMBINED.         3/84*

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                    42  NEUTRAL B PARTIAL DECAY MODES

                                                        DECAY MASSES
P1      B0 INTO DOBAR PI+ PI-                        1865+ 140+ 140
P2      B0 INTO D*(2010)- PI+                        2007+ 140

        B0BAR MODES ARE CHARGE CONJUGATES OF THE ABOVE MODES.

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                    42  NEUTRAL B BRANCHING RATIOS

R1      B0 INTO DOBAR PI+ PI-                      (P1)
R1      5     0.13     0.09        BEHRENDS  83 CLEO 0  E+ E-, UPSIL(4S)  4/83*

R2      B0 INTO D*(2010)- PI+                      (P2)
R2      5     0.026    0.019       BEHRENDS  83 CLEO 0  E+ E-, UPSIL(4S)  4/83*

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                         REFERENCES FOR NEUTRAL B

BEHRENDS 83 PRL 50 881        +  (ROCH+RUTG+SYRA+VAND+CORN+ITHA+HARV+OSU)

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B

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                    39  BOTTOM MESON B(5271, JP-  )

                    THIS ENTRY LISTS MEASUREMENTS OF B MESON PARAMETERS
                    FOR WHICH THE CHARGE STATES ARE NOT SEPARATED.
                    MEASUREMENTS IN WHICH THE CHARGE STATE IS CLEARLY
                    IDENTIFIED ARE LISTED IN THE PRECEDING CHARGED B
                    AND NEUTRAL B ENTRIES.

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                    39  B MASS  (MEV)

M    A         5180 TO 5290         ANDREWS   80 CLEO UPSIL(4S) THRESHOLD 12/83*
M    A         5289  OR LESS        FINOCCHIA 80 CUSB UPSIL(4S) THRESHOLD 12/83*
M    AB        5263 TO 5278         SCHAMBERG 82 CUSB UPSIL(4S) THRESHOLD 12/83*
M    A  REDETERMINATION OF THE CESR ENERGY SCALE CHANGED THE ANDREWS 80,  12/83*
M    A  FINOCCHIARO 80, AND SCHAMBERGER 82 LIMITS FROM THEIR PUBLISHED    12/83*
M    A  VALUES TO THOSE GIVEN ABOVE.                                      12/83*
M    AB SCHAMBERGER 82 DEDUCED ABOVE LIMITS FROM NON-OBSERVATION OF 50 MEV 12/83*
M    AB GAMMAS FROM B* --> B GAMMA AND UPSIL(4S) --> B B*.                12/83*

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                    39  B MEAN LIFE  (UNITS 10**-13 SEC)                  1/83*

T          (14.)   OR LESS  CL=.95   BARTEL    82 JADE E+E-,AVG ECM 34 GEV  1/83*
T    A      18.      7.2             FERNAND2  83 MAC  E+E- AT ECM=29 GEV 12/83*
T    B      12.0     5.4      4.7    LOCKYER   83 SMK2 E+E- AT ECM=29 GEV 12/83*
T    A  THE STATISTICAL AND SYSTEMATIC ERRORS ARE 6 AND 4.                12/83*
T    B  THE STATISTICAL ERRORS ARE +4.5 AND -3.6, THE SYSTEMATIC ERROR IS 12/83*
T    B  3.0.  THE LIFETIME IS AN AVERAGE OVER BOTTOM PARTICLES PRODUCED.  12/83*
T          . . . . . . . . .                                               3/84*
T   AVG     14.       4.       AVERAGE                                     3/84*

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                    39  B PARTIAL DECAY MODES

                                                        DECAY MASSES
P1      B INTO ELECTRON NEUTRINO HADRONS
P2      B INTO MUON NEUTRINO HADRONS
P3      B INTO E+ E- ANYTHING
P4      B INTO MU+ MU- ANYTHING
P5      B INTO KAON ANYTHING
P6      B INTO J/PSI ANYTHING
P7      B INTO DO ANYTHING
P8      B INTO PROTON ANYTHING
P9      B INTO LAMBDA ANYTHING
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                    39  B BRANCHING RATIOS

R1      B INTO (ELECTRON NEUTRINO HADRONS)/TOTAL       (P1)
R1   A      (0.13)   (0.042)        BEBEK     81 CLEO DIRECT E AT UPS(4S)  4/82
R1   B      (0.136)  (0.039)        SPENCER   81 CUSB DIRECT E AT UPS(4S)  4/82
R1   C       0.127    0.021         CHADWICK  83 CLEO DIRECT E AT UPS(4S) 11/83*
R1   D       0.132    0.016         KLOPFENST 83 CUSB DIRECT E AT UPS(4S)  1/84*
R1   E      (0.116)  (0.027)        NELSON    83 SMK2 E+E-,ECM=29 GEV     11/83*
R1   A  THE STATISTICAL AND SYSTEMATIC ERRORS ARE EACH 0.03.               4/82
R1   B  THE STATISTICAL AND SYSTEMATIC ERRORS ARE 0.025 AND 0.03.          4/82
R1   AB THE ELECTRON ENERGY SPECTRA IN BOTH BEBEK 81 AND SPENCER 81 FAVOR  4/82
R1   AB B-TO-C OVER B-TO-U QUARK TRANSITIONS.                              4/82
R1   C  THE STATISTICAL AND SYSTEMATIC ERRORS ARE 0.017 AND 0.013.        11/83*
R1   D  STATISTICAL AND SYSTEMATIC ERRORS ARE 0.008 AND 0.014.             1/84*
R1   D  RATIO CS(B-->E NU UP)/CS(B-->E NU CHARM) < 0.055 AT CL=.90.        1/84*
R1   E  THE STATISTICAL AND SYSTEMATIC ERRORS ARE 0.021 AND 0.017.        11/83*
R1
R1      ONLY THE EXPERIMENTS AT THE UPSILON(4S) ARE USED IN THE AVERAGE.
R1
R1          . . . . . . . . . .
R1   AVG     0.130    0.013    AVERAGE

R2      B INTO (MUON NEUTRINO HADRONS)/TOTAL           (P2)
R2          (0.094)  (0.036)        CHADWICK  81 CLEO DIRECT MU AT UP(4S)  4/82
R2   A      (0.105)  (0.020)        ADEVA2    83 MRKJ E+E- ECM=33-38.5GEV 11/83*
R2   B       0.124    0.035         CHADWICK  83 CLEO DIRECT MU AT UP(4S) 11/83*
R2          (0.155)  (0.054) (0.029) FERNAND1 83 MAC  E+E- AT ECM=29 GEV  12/83*
R2          (0.117)  (0.028)        ALTHOFF   84 TASS E+E-, ECM=34.5 GEV   3/84*
R2   A  THE STATISTICAL AND SYSTEMATIC ERRORS ARE 0.015 AND 0.013.        11/83*
R2   B  THE STATISTICAL AND SYSTEMATIC ERRORS ARE 0.017 AND 0.031.        11/83*
R2
R2      THE AVERAGE OF THE THREE HIGH-ENERGY RESULTS IS 0.113+-0.016.
R2      THESE EXPERIMENTS PRODUCE OTHER BOTTOM PARTICLES IN ADDITION TO
R2      THE B MESON.

R3      B INTO (E+ E- ANYTHING)/TOTAL                  (P3)
R3          (0.05) OR LESS  CL=.90   BEBEK     81 CLEO E+ E- AT UPSIL(4S)   4/82

R4      B INTO (MU+ MU- ANYTHING)/TOTAL                (P4)
R4          (0.017)OR LESS  CL=.90   CHADWICK  81 CLEO E+ E- AT UPSIL(4S)   4/82
R4           0.007 OR LESS  CL=.95   ADEVA1    83 MRKJ E+E- 30<WCM<38 GEV  11/83*
R4           0.007 OR LESS  CL=.95   BARTEL    83 JADE E+E- 33<WCM<36.7GEV  1/84*
R4          (0.02)  OR LESS  CL=.95  ALTHOFF   84 TASS E+E-, ECM=34.5 GEV   3/84*

R5      B INTO (DILEPTON ANYTHING)                     (P3+P4)
R5           0.008 OR LESS  CL=.90   MATTEUZZI 83 SMK2 E+ E- AT ECM=29 GEV 11/83*

R6      B INTO (KAON ANYTHING)/TOTAL                   (P5)
R6   C       SEEN                    BRODY     82 CLEO KAONS AT UPSIL(4S)   4/82
R6   D       SEEN                    GIANNINI  82 CUSB KAONS AT UPSIL(4S)   2/84*
R6   C  ASSUMING UPSILON(4S) --> B BBAR, A TOTAL OF 3.38+-0.34+-0.68 KAONS  4/82
R6   C  PER UPSILON(4S) DECAY IS FOUND (THE SECOND ERROR IS SYSTEMATIC). IN 4/82
R6   C  THE CONTEXT OF THE STANDARD B-DECAY MODEL, THIS LEADS TO A VALUE    4/82
R6   C  FOR (B-QUARK --> C-QUARK)/(B-QUARK --> ALL) OF 1.09+-0.33+-0.13.    4/82
R6   D  GIANNINI 82 AT CESR-CUSB OBSERVED 1.58+-.35 K0 PER HADRONIC EVENT   2/84*
R6   D  MUCH HIGHER THAN 0.82+-0.10 BELOW THRESHOLD. CONSISTENT WITH        2/84*
R6   D  PREDOMINANT B-->C X DECAY.                                          2/84*

R7      B INTO (J/PSI ANYTHING)/TOTAL                  (P6)
R7          (0.049)OR LESS  CL=.90   MATTEUZZI 83 SMK2 E+ E- AT ECM=29 GEV 11/83*

R8      B INTO (DO ANYTHING)/TOTAL                     (P7)
R8   A       0.8       0.28          GREEN     83 CLEO E+ E- AT UPSIL(4S)  12/83*
R8   A  OBSERVED 0.8+-0.2(STAT.)+-0.2(SYST.) DO PER B DECAY.               12/83*
R9      B INTO (PROTON ANYTHING)/TOTAL                 (P8)
R9   A       0.036 OR MORE           ALAM      83 CLEO PROTONS AT UPSI(4S) 11/83*
R9   A  THE STATISTICAL AND SYSTEMATIC ERRORS ARE 0.006 AND 0.009. VALUES  11/83*
R9   A  ARE FOR (BR(B-->P X)+BR(B-->ANTI-P X)/2. DATA ARE CONSISTENT WITH  11/83*
R9   A  EQUAL YIELDS OF BARYONS AND ANTIBARYONS. USING ASSUMED YIELDS      11/83*
R9   A  BELOW CUT, BR(B-->P+X)=0.03 NOT INCLUDING PROTONS FROM LAM.DECAYS. 11/83*

R10     B INTO (LAMBDA ANYTHING)/TOTAL                 (P9)
R10  A       0.022 OR MORE           ALAM      83 CLEO LAMBDAS AT UPSI(4S) 11/83*
R10  A  THE STATISTICAL AND SYSTEMATIC ERRORS ARE 0.007 AND 0.004. VALUES  11/83*
R10  A  ARE FOR (BR(LAMBDA X)+BR(ANTI-LAMBDA X)/2. DATA ARE CONSISTENT WITH 11/83*
R10  A  EQUAL YIELDS OF BARYONS AND ANTIBARYONS. USING ASSUMED YIELDS      11/83*
R10  A  BELOW CUT, BR(B-->LAMBDA X)=0.03.                                  11/83*

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REFERENCES FOR BOTTOM MESON B(5271)


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ANDREWS  80 PRL 45 219        +       (CORN+HARV+ITHA+SYRA+ROCH+RUTG+VAND)
FINOCCHI 80 PRL 45 222        FINOCCHIARO,GIANNINI,+       (STON+COLU+LSU)
BEBEK    81 PRL 46 84         +       (HARV+ITHA+SYRA+ROCH+RUTG+VAND+CORN)
CHADWICK 81 PRL 46 88         +GANCI+(ROCH+RUTG+SYRA+VAND+CORN+HARV+ITHA)
SPENCER  81 PRL 47 771        +FINOCCHIARO,+          (STON+COLU+LSU+MPIM)

BARTEL   82 PL 114B 71        JADE C.(DESY+HAMB+HEID+LANC+MCHS+RHEL+TOKY)
BRODY    82 PRL 48 1070       +CHEN,+(SYRA+VAND+CORN+ITHA+HARV+ROCH+RUTG)
GIANNINI 82 NP B206 1         +FINOCCHIARO,FRANZINI+ (STON+COLU+LSU+MPIM)
SCHAMBER 82 PR D26 720        SCHAMBERGER+            (STON+COLU+LSU+MPIM)

ADEVA1   83 PRL 50 799        MARKJ C. (AACH+DESY+MIT+MADR+AIKO+BHEP+CIT)
ADEVA2   83 PRL 51 443        MARKJ C. (AACH+DESY+MIT+MADR+AIKO+BHEP+CIT)
ALAM     83 PRL 51 1143       + (VAND+HARV+OHIO+CORN+ITHA+ROCH+RUTG+SYRA)
BARTEL   83 PL 132B 241       JADE C.(DESY+HAMB+HEID+LANC+MCHS+RHEL+TOKY)
CHADWICK 83 PR D27 475        + (ROCH+RUTG+SYRA+VAND+CORN+HARV+ITHA+OHIO)
FERNAND1 83 PRL 50 2054       +MAC.C.(COLO+FRAS+HOUS+NEAS+SLAC+UTAH+WISC)
FERNAND2 83 PRL 51 1022       +MAC.C.(COLO+FRAS+HOUS+NEAS+SLAC+UTAH+WISC)
GREEN    83 PRL 51 347        + (RUTG+SYRA+VAND+HARV+OHIO+CORN+ITHA+ROCH)
KLOPFENS 83 PL 130B 444       KLOPFENSTEIN+      (STON+COLU+CORN+LSU+MPIM)
LOCKYER  83 PRL 51 1316       +JAROS,NELSON,ABRAMS,+  (SLAC+LBL+UCB+HARV)
MATTEUZZ 83 PL 129B 141       MATTEUZZI,ABRAMS,AMIDEI+(SLAC+LBL+UCB+HARV)
NELSON   83 PRL 50 1542       +BLONDEL,TRILLING+      (LBL+UCB+SLAC+HARV)
ALTHOFF  84 ZPHY C (SUBMITTED)+   (AACH+BONN+DESY+HAMB+LOIC+OXF+RL+SIEG+)
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                    16  PROTON(938,J=1/2) I=1/2
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                    16  PROTON MASS (MEV)

M        (938.256)  (0.005)        COHEN     65 RVUE                     7/66
M        (938.2592) (0.0052)       TAYLOR    69 RVUE    USING NEW E/H    7/70
M         938.2796   0.0027        COHEN     73 RVUE                     3/74

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For notation, see key at front of Listings. **Stable Particles**

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                    16  ANTIPROTON MASS  (MEV)

M1          938.3     0.5               BAMBERGER 70 CNTR                     12/79
M1          938.179   0.058             HU        75 CNTR  EXOTIC ATOMS       12/79
M1          938.229   0.049             ROBERSON  77 CNTR                     12/79
M1          938.30    0.13              ROBERTS   78 CNTR                      6/78
M1          . . . . . . . . . .
M1   AVG    938.216   0.036   AVERAGE
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NOTE ON PROTON MEAN LIFE LIMITS

(by M. Goldhaber, Brookhaven National Laboratory, and F. Reines, University of California, Irvine)

Current ideas on the unification of the weak, electromagnetic, and strong forces suggest that baryon number might not be strictly conserved, so that the proton could decay. In the Particle Properties Tables there are nearly thirty particles listed with a mass smaller than that of the proton (if we count both particles and antiparticles and different members of multiplets separately). Ten of these particles are fermions and the remainder bosons. There are then a great many possible two-body decay modes of the proton and an even larger number of three-body, etc., decay modes which satisfy charge, energy, momentum, and angular momentum conservation. Each decay mode has to contain at least one fermion to satisfy angular momentum conservation.

The "decay signature" distributions as well as the backgrounds depend on detector characteristics (the material from which the detector is made, the method of detection, timing information, time resolution, etc.). The background, due chiefly to atmospheric neutrinos, depends also on the geomagnetic latitude and on the phase of the solar cycle with which the magnetic field of the sun is associated. The depth-dependent cosmic ray background is due to cosmic ray muons and their progeny. For each possible proton decay signature there is a finite probability of a background event with a similar signature, where the probability depends on the detector characteristics.

The Data Card Listings following this note show only published results. The lower limits quoted are partial mean life (mean life divided by branching fraction) for the proton or bound neutron decay mode listed at the right.

Since there are many new unpublished results, we also show a table of the latest (preliminary) results as reported at the ICOBAN '84 Conference at Park City, Utah, Jan. 4-8. This table is based on the summary talk given at the conference by W. Allison, Oxford. The table shows the 90% confidence level lower limits on the partial mean life for decay to the mode shown. The units are 10^{30} years.

The number of candidate events is shown in brackets. A particular event may be listed as a candidate for several modes. The IMB collaboration considers their candidate events to be qualitatively compatible with neutrino background. An initial report on their neutrino background is given in Bionta et al., Phys. Rev. Lett. **51**, 27 (1983). The Kamiokande background estimates are given after the slash (/). The Kolar-Goldfield experiment (KRISHNASWAMY 82, Data Card Listings) has a total of 6 candidates for nucleon decay. Until the above results can be reproduced consistently and above neutrino background, it is too early to draw any conclusions about proton instability.

The simplest grand unified theory, minimal SU(5), predicts $e^+\pi^0$ to be the predominant proton decay mode. The IMB lower limit on the partial mean life for this mode, 2×10^{32} years, is at least a factor of 10 higher

Lower limits on partial mean life (τ/B) for proton or bound neutron decay. (Adapted from W. Allison, summary talk at ICOBAN '84.)

	NUSEX	IMB*	Kamiokande†
Sensitivity (ton-years)	180	2300	324
Mode	τ/B limit, CL=90%, units 10^{30} yr		
$p \rightarrow e^+\pi^0$	>10	>200	>26
$\mu^+\pi^0$	>7	>120	>18
$e^+\gamma$		>220	
$\mu^+\gamma$		>160	
$e^+\eta$		>130	>18
$\mu^+\eta$		>40 [2 ev]	>8 [1 ev/0]
e^+K^0		>31	>18
μ^+K^0	>13 1 ev	>26 [2 ev]	>8 [1 ev/0]
$e^+\omega$		>41 [1 ev]	>6 [1 ev/0.2]
$\mu^+\omega$		>51 [2 ev]	
νK^+	>5	>12 [3 ev]	>7 [3 ev/1]
$\nu\pi^+$	>4	—	>3 [5 ev/5.5]
$n \rightarrow e^+\pi^-$	>19	—	>9
$\mu^+\pi^-$	>4	—	>11
$\nu\pi^0$	>10	—	>15
νK^0	>6	>8 [3 ev]	>8

*No events observed unless listed in brackets. Background subtraction not made.

†Brackets contain the number of candidates observed followed by estimated background in listed mode.

than predicted by minimal SU(5) theory.

See also the reviews by Reines and Schultz, Surveys in High Energy Physics **1**, 89 (1980); Goldhaber, Langacker, and Slansky, Science **210**, 851 (1980); and Goldhaber and Sulak, Comments Nucl. Part. Phys. **10**, 215 (1981).

See also the neutron-antineutron oscillations section NAN in the neutron Data Card Listings below for another test of baryon conservation.

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                     16  PROTON MEAN LIFE / BRANCHING FRACTION (UNITS YEARS)

T        TEST OF BARYON CONSERVATION.
T   H       (1.4E20) OR MORE              GOLDHABER 54 TH232   NUC-->ANYTHING
T   H       (1.4E22) OR MORE              REINES    54 CNTR    NUC-->CHGD ANY    9/81
T   H       (6. E23) OR MORE              REINES    57 CNTR    P --> CHGD ANY    9/81
T   H       (3. E23) OR MORE              FLEROV    58 TH232   NUC-->ANYTHING
T   H M     (4. E26) OR MORE              BACKENSTO 60 CNTR    NUC-->MU ANY
T   H M     (9. E27) OR MORE              GIAMATI   62 CNTR    P --> MU GAMMA    9/81
T   H M     (6. E28) OR MORE              KROPP     65 CNTR    P --> MU GAMMA
T   H M     (1.2E30) OR MORE              GURR      67 CNTR    P --> MU GAMMA
T           (3. E23) OR MORE              DIX       70 CNTR    P --> ANYTHING    9/81
T           (1.3E29) OR MORE              BERGAMASC 74 CNTR    P --> CHGD ANY   12/75
T    L      (2. E30) OR MORE              REINES    74 CNTR    NUC-->MU ANY     12/75
T           (1.6E25) OR MORE              EVANS     77 TE130   NUC-->ANYTHING    9/81
T   L M     (6. E30) OR MORE              LEARNED   79 CNTR    NUC-->MU ANY      9/81
T   L       (1. E30) OR MORE              LEARNED   79 CNTR    NUC-->ANYTHING   12/79
T           (1.8E30) OR MORE  CL=.90      COWSIK    80 CNTR    NUC-->MU ANY      4/82
T         0 (1.25E30)OR MORE              ALEKSEEV  81 CNTR    NUC-->ANYTHING    2/82
T   C     2 (3. E31) OR MORE              CHERRY    81 CNTR    NUC-->MU ANY      1/82
T   C       (1.5E30) OR MORE              CHERRY    81 CNTR    NUC-->ANYTHING    1/82
T   K     2 (8. E30) OR MORE              KRISHNASW 81 CNTR REPL.BY KRISHNASW82  1/82
T   B     1 (8. E30) OR MORE              BATTISTON 82 CNTR    SEE COMMENT B    10/83*
T   K     6 (7. E30) OR MORE              KRISHNASW 82 CNTR    NUC-->ANYTHING   11/82*
T         1 (1. E30) OR MORE  CL=.90      BARTELT   83 CNTR    NUC-->ANYTHING   10/83*
T         0  1. E32  OR MORE  CL=.90      BIONTA    83 CNTR    P-->E+ PIO       10/83*
T   H    CONVERTED TO MEAN LIFE BY DIVIDING HALF-LIFE BY LN(2)=.693 .
T     M  REFERENCE ALSO GIVES LIMITS FOR OTHER MODES. WE GIVE HIGHEST LIMIT.
T   L    FIRST LEARNED 79 VALUE SUPERCEDES REINES 74.  SECOND LEARNED 79
T   L    VALUE IS FIRST TIMES B.F.=.15, A GRAND UNIF. GAUGE THEORY ESTIMATE.
T   C    CHERRY 81 SEE (2+-2) EVENTS ABOVE BACKGROUND. SECOND CHERRY 81      1/82
T   C    VALUE IS FIRST TIMES B.F.=.05, A GRAND UNIF. GAUGE THEORY ESTIMATE. 1/82
T   K    KRISHNASWAMY 82 SEE 3 EVENTS IN FIDUCIAL VOLUME OF DETECTOR.        1/82
T   K    TENTATIVE MEAN LIFE ASSUMES B.F. * EFF. =0.5 (FROM GUT) .           1/82
T   K    WE QUOTE THEIR TENTATIVE MEAN LIFE AS A LOWER LIMIT.                1/82
T   B    BATTISTONI 82 EVENT CAN BE INTERPRETED AS EITHER P --> KO MU+ , OR 10/83*
T   B    P --> K* NU , WITH K* --> KO PI , OR P --> 3 MU .                  10/83*

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                     16  ANTIPROTON MEAN LIFE / BR. FRACTION  (UNITS HOURS)

         LIMITS SHOWN ARE PARTIAL MEAN LIFE FOR MODE SHOWN AT RIGHT.

T1          (3.3E-8)  OR MORE  CL=.95   GANGULI   78 HBC     PBAR-->ANYTHING   6/78
T1    B     (32.)     OR MORE           BREGMAN   78 CNTR    PBAR-->ANYTHING   7/79
T1    E     (1700.)   OR MORE  CL=.90   BELL      79 CNTR    PBAR-->E- PIO     1/80
T1    G      1. E11   OR MORE           GOLDEN    79 SPEC    PBAR-->ANYTHING  12/79
T1    B  BREGMAN 78 STORED ANTIPROTONS IN ICE STORAGE RING AT CERN 85 HOURS.  7/79
T1    E  BELL 79 STORED ANTIPROTONS IN ICE STORAGE RING FOR 10 DAYS.          1/80
T1    G  GOLDEN 79 VALUE INFERRED FROM PBAR/P RATIO IN COSMIC RAYS.          12/79

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                     16  PROTON MAGNET. MOMENT(E/2MP)

MM          (2.79276)(0.00002)          COHEN     65 RVUE
MM          (2.792782 0.000017)         TAYLOR    69 RVUE    USING NEW E/H     7/70
MM           2.7928456 .0000011         COHEN     73 RVUE                      3/74
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                     16  ANTIPROTON MAGNETIC MOMENT (E/2MP)

MM1 O        (-1.8)     (1.2)           BUTTON    62 CNTR
MM1 R        (-2.83)    (0.10)          FOX       72 CNTR                     11/75
MM1 R        (-2.819)   (0.056)         ROBERTS   74 CNTR                      7/75
MM1           -2.791     0.021          HU        75 CNTR    EXOTIC ATOMS     12/79
MM1   R       -2.817     0.048          ROBERTS   78 CNTR                      6/78
MM1 O    OLD EXPERIMENT WITH LARGE ERROR.  NOT AVERAGED.
MM1   R  ROBERTS 74 IS REANALYSIS OF FOX 72 DATA.  REPLACES OLD FOX VALUE.     7/75
MM1   R  ROBERTS 78 IS A REANALYSIS OF ROBERTS 74.                             6/78
MM1           . . . . . . . . . .
MM1 AVG       -2.795     0.019     AVERAGE

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                     16  PROTON ELECTRIC DIPOLE MOMENT (UNITS 10**-23 E CM)

               FORBIDDEN BY BOTH T INVARIANCE AND P INVARIANCE

EDM      1G  (700.)    (900.)           HARRISON  69 MBR                      10/69
EDM         (55000.)   OR LESS          KHRIPLOVI 76                           1/78
EDM            400.    OR LESS          RAMSEY    82 RVUE                      2/84*

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                     16  PROTON ELECTRON CHARGE DIFFERENCE (UNITS E)

        SEE ALSO SECTION Q IN THE NEUTRON DATA CARDS LISTINGS BELOW.

DQ    D       1.0E-21 OR LESS           DYLLA     73       NEUTRALITY OF SF6   2/80
DQ    D    ASSUMES THAT Q(NEUTRON)=Q(PROTON)-Q(E-).  SEE DYLLA 73 FOR A        2/80
DQ    D    SUMMARY OF EXPERIMENTS ON THE NEUTRALITY OF MATTER.                 2/80

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                              REFERENCES FOR PROTON

GOLDHABE 54 PR 96 1157 FNOTE2 REINES,COWAN,GOLDHABER             (LASL+BNL)
REINES   54 PR 96 1157        REINES,COWAN,GOLDHABER             (LASL+BNL)
FLEROV   58 SOV PHYS DOK 3 79 FLEROV,KLOCHKOV,SKOBKIN,TERENTEV       (USSR)
REINES   57 PR 109 609        REINES,COWAN,KRUSE                     (LASL)
BACKENST 60 NC 16 749         BACKENSTOSS,FRAUENFELDER,HYAMS +       (CERN)

BUTTON   62 PR 127 1297       J BUTTON,B MAGLIC                       (LBL)
GIAMATI  62 PR 126 2178       GIAMATI,REINES                         (CASE)
COHEN    65 RMP 37 537        +DUMOND (N.AMER.AVIATION SCIENCE CENT.,CIT)
KROPP    65 PR 137B 740       W R KROPP,F REINES                     (CASE)
GURR     67 PR 158 1321       GURR,KROPP,REINES,MEYER (CASE,JOHANNESBURG)

HARRISON 69 PRL 22 1263       HARRISON,SANDARS,WRIGHT  (CLARENDON OXFORD)
TAYLOR   69 RMP 41 375        +PARKER,LANGENBERG           (PRIN+UCI+PENN)
BAMBERGE 70 PL 33B 233        BAMBERGER,LYNEN,PIEKARZ+   (MPIH+CERN+KARL)
DIX      70 THESIS CASE       F E DIX                                (CASE)
FOX      72 PRL 29 193        +BARNES,EISENSTEIN+(BNL+CARN+VPI+WILL+WYOM)
COHEN    73 J.PHYS.CHEM.REF.DATA 2, P.663, E.R.COHEN,B.N.TAYLOR
DYLLA    73 PR A7 1224        H.F.DYLLA, J.G.KING                     (MIT)

BERGAMAS 74 LNC 11 636        BERGAMASCO,PICCHI                 (TORI+FRAS)
REINES   74 PRL 32 493        +CROUCH                            (UCI+CASE)
ROBERTS  74 PRL 33 1181       +COX,ECKHAUSE+ (WILL+VPI+CARN+WYOM+CIT+BNL)
    ALSO 75 PR D12 1232       ROBERTS,COX +  (WILL+VPI+CARN+WYOM+CIT+BNL)
HU       75 NP A254 403       +ASANO,CHEN,CHENG,DUGAN+          (COLU+YALE)

KHRIPLOV 76 JETP 44 25        I.B.KHRIPLOVICH    (NUC.PHYS.INST.,SIBERIA)
EVANS    77 SCIENCE 197 989   +STEINBERG                         (BNL+PENN)
ROBERSON 77 PR C16 1945       +KING,KUNSELMAN+    (WYOM+CIT+CARN+VPI+WILL)
BREGMAN  78 PL 78B 174        +CALVETTI,CARRON,CITTOLIN,HAUER,HERR+(CERN)
GANGULI  78 PL 74B 130        +MALHOTRA,RAGHAVAN,SUBRAMANIAN +       (TIFR)
ROBERTS  78 PR D17 358        B. L. ROBERTS                     (WILL+RHEL)

BELL     79 PL 86B 215        +CALVETTI,CARRON,CHANEY,CITTOLIN+      (CERN)
GOLDEN   79 PRL 43 1196       +HORAN,MAUGER,BADHWAR,LACY+       (NASA+PSLL)
LEARNED  79 PRL 43 907        +REINES,SONI                            (UCI)
COWSIK   80 PR D22 2204       R.COWSIK,V.S.NARASIMHAN                (TIFR)

ALEKSEEV 81 JETPL 33 651      +BAKATANOV,BUTKEVICH,VOEVODSKII +      (LENI)
CHERRY   81 PRL 47 1507       +DEAKYNE,LANDE,LEE,STEINBERG +    (PENN+BNL)
KRISHNAS 81 PL 106B 339       KRISHNASWAMY,MENON,MONDAL+ (TIFR+OSKC+TOKY)
BATTISTO 82 PL 118B 461       BATTISTONI,BELLOTTI+  (FRAS+MILA+LCGT+CERN)
KRISHNAS 82 PL 115B 349       KRISHNASWAMY,MENON,MONDAL+ (TIFR+OSKC+TOKY)
RAMSEY   82 ARNS 32 211       N.F.RAMSEY                        (MHCO+HARV)
BARTELT  83 PRL 50 651        +COURANT,HELLER,JOYCE,MARSHAK+    (MINN+ANL)
BIONTA   83 PRL 51 27         +BLEWITT+ (UCI+MICH+BNL+CIT+CLEV+HAWA+LOUC)

        QUANTUM NUMBER DETERMINATIONS NOT REFERRED TO IN THE DATA CARDS

KALOGERO 76 PRL 37 1037       KALOGEROPOULOS,CHIU,SUDARSHAN   (SYRA+TEXA)P
FRANKLIN 77 PR D16 910        JERROLD FRANKLIN                      (HAIF)P
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                     17  NEUTRON(939,J=1/2) I=1/2

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                     17  NEUTRON MASS (MEV)

M    T     (939.5527) (0.0052)         TAYLOR    69 RVUE    USING NEW E/H      7/70
M   T       939.5731   0.0027          COHEN     73 RVUE                       3/74
M    T     (939.5730) (0.0026)         GREENWOOD 80 CNTR    N P --> D GAMMA    2/84*
M   T    THESE DETERMINATIONS OF NEUTRON MASS NOT INDEPENDENT OF               7/70
M   T    NEUTRON-PROTON MASS DIFFERENCE MEASUREMENTS BELOW.                    7/70

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                     17  (NEUTRON) - (PROTON) MASS DIFFERENCE (MEV)

D   M     (1.29344) (0.00007)          MATTAUCH  65 RVUE                       3/71
D         (1.293429)(0.000036)         COHEN     73 RVUE                       3/74
D   M      1.293330  0.000040          VYLOV     78 CNTR    N P --> D GAMMA    2/84*
D   M      1.293322  0.000017          GREENWOOD 80 CNTR    N P --> D GAMMA    2/84*
D   M    WE HAVE CONVERTED MEASURED 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
D          . . . . . . . . . .
D    AVG     1.293323 0.000016  AVERAGE

------ --------- --------- --------- --------- --------- --------- --------

                     17  NEUTRON MEAN LIFE (UNITS 10**3 SEC)

         THE ORIGIN OF THE DISCREPANCIES BETWEEN MEASUREMENTS OF THE
         NEUTRON MEAN LIFE IS NOT KNOWN.  WE AVERAGE THE HIGHEST PRECISION
         MODERN EXPERIMENTS AND INCLUDE THE RESULTING SCALE FACTOR IN THE
         ERROR, AS USUAL.  THE IDEOGRAM SHOWS THE INVERSE MEAN LIFE, THE
         QUANTITY ACTUALLY USED IN CALCULATING OUR AVERAGE VALUE.

T           (1.013)  (0.026)           SOSNOVSKI 59 CNTR                       7/68
T           (0.935)  (0.014)           CHRISTENS 67 CNTR REPL BY CHRISTENS72   3/68
T            0.918    0.014            CHRISTENS 72 CNTR                       6/72
T     A      0.881    0.008            BONDARENK 78 CNTR                       8/81
T            0.937    0.018            BYRNE     80 CNTR                       2/82
T           (0.875)  (0.095)           KOSVINTSE 80 CNTR                      10/81
T    B      (0.902)  (0.010)           WILKINSON 82 RVUE    INFERRED VALUE    11/83*
T     A  INCLUDES CORRECTION FOR RECOIL PROTON SCATTERING SEE BONDARENKO 82.  10/83*
T    B   WILKINSON 82 VALUE INFERRED FROM N DECAY CORRELATIONS.               11/83*
T          . . . . . . . . . .
T    AVG     0.898    0.016     0.016  AVERAGE (ERROR INCL. SCALE FACTOR OF 2.4)
                              (SEE IDEOGRAM BELOW)

------ --------- --------- --------- --------- --------- --------- --------

                     17  NEUTRON MAGNETIC MOMENT (MAGNETONS,938.2 MEV)

MM      (-1.913148   0.000066)         COHEN     56 RVUE                       7/66
MM      (-1.91304211 0.00000088)       GREENE    77 MRS  REPL. BY GREENE 79    3/78
MM       -1.91304184 0.00000088        GREENE    79 MRS                       12/79

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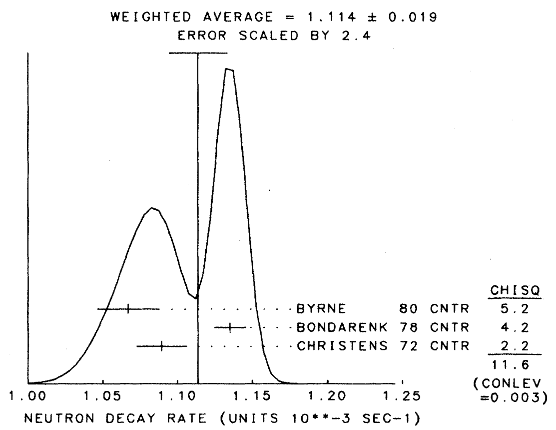
```

For notation, see key at front of Listings.



17 NEUTRON ELECTRIC DIPOLE MOMENT (UNITS 10-23 E CM)**

FORBIDDEN BY BOTH T INVARIANCE AND P INVARIANCE

```
EDM M     (-20.)    (30.)           MILLER     67 MRS                          1/78
EDM        +24.      39.            SHULL      67 CNTR                         1/78
EDM  M     (30.)   OR LESS          DRESS      68 MRS  ABSOLUTE VALUE          1/78
EDM         (5.)   OR LESS          BAIRD      69 MRS  INCLUDED IN DRESS73    10/69
EDM        - 2.      39.            APOSTOLES  70 MRS                          1/78
EDM          0.32      0.75         DRESS      73 MRS  < 10**-23 (CL=.80)      6/73
EDM          0.04      0.15         DRESS      77 MRS  < 3  E-24 (CL=.90)      6/77
EDM  A       0.040     0.075        ALTAREV    79 MRS  < 1.6E-24 (CL=.90)     10/81
EDM  A       0.021     0.024        ALTAREV    81 MRS  < 6  E-25 (CL=.90)      2/82
EDM  M  DRESS 68 INCLUDES DATA OF MILLER 67.                                   1/78
EDM  A  ALTAREV 79 AND 81 USE ULTRACOLD NEUTRONS.                              4/82
EDM
EDM AVG      0.023     0.023   AVERAGE
```

17 NEUTRON CHARGE

SEE ALSO SECTION DQ IN THE PROTON DATA CARD LISTINGS ABOVE

```
Q                 17  NEUTRON CHARGE (UNITS 10**-20 E)                         11/82*
Q          (-1.5)    (2.2)  CL=.90   GAHLER     82 CNTR    REACTOR N BEAM      11/82*
```

17 LIMIT ON NEUTRON-ANTINEUTRON OSCILLATIONS

```
NAN    MEAN TIME FOR N-ANTIN TRANSITION IN VACUUM  (UNITS SEC.)
NAN     TEST OF BARYON CONSERVATION.
NAN     LIMITS ARE DERIVED FROM EXPERIMENTAL LIMITS ON DELTA-B = 2 NUCLEAR    3/84*
NAN     DECAY PROCESSES, USING THEORETICAL ASSUMPTIONS FOR NUCLEAR PHYSICS    3/84*
NAN     EFFECTS.  SEE ALSO THE THEORETICAL ANALYSIS OF DOVER, GAL, AND        3/84*
NAN     RICHARDS, PR D27, 1090 (1983).  SEE THE REVIEWS OF H.L. ANDERSON,     3/84*
NAN     PROC. LASL CONF. ON NUCLEAR PARTICLE PHYSICS AT ENERGIES UP TO 31     3/84*
NAN     GEV, 1981.                                                            3/84*
NAN          (1.E8) OR MORE             CHETYRKIN 81 THEO                     1/82
NAN          (3.E7) OR MORE             ALBERICO  82 THEO                     9/83*
NAN          (2.E7) OR MORE             CHERRY    83 CNTR+THY                12/83*
NAN          (1.E6) OR MORE  CL=.90     PUGLIERIN 83 CNTR REACTOR N, PRELIM.  1/84*
NAN           2.7E7 TO 1.1E8  OR MORE   JONES     84 CNTR+THY                 3/84*
```

17 NEUTRON PARTIAL DECAY MODES

```
                                                          DECAY MASSES
                                                          DECAY MASSES
P1     NEUTRON INTO PROTON E- ANTI(NUE)                   938+.511+   0
P2     NEUTRON INTO PROTON NUE ANTI(NUE)                  938+   0+   0
```

17 NEUTRON BRANCHING RATIOS

```
R1      NEUTRON INTO (PROTON NUE ANTI(NUE))/(PROTON E- ANTI(NUE)  (P2)/(P1)
R1       FORBIDDEN BY CHARGE CONSERVATION
R1    S      (3. E-17)OR LESS          SUNYAR    60 CNTR RB87-->SR87M+NEUTRL  2/80
R1           (3. E-19)OR LESS          NORMAN    79 CNTR RB87-->SR87M+NEUTRL  2/80
R1            9. E-24 OR LESS          BARABANOV 80 CNTR GA71-->GE71 + ANY    2/82
R1           (7.9E-21)OR LESS          VAIDYA    83 CNTR RB87-->SR87M+NEUTRL 11/83*
R1    S  WE HAVE CONVERTED SUNYAR 60 MEAN LIFE LIMIT FOR (N --> P + NEUTRLS)  2/80
R1    S  AS DESCRIBED IN NORMAN 79.                                           2/80
```

NOTE ON BARYON DECAY PARAMETERS

A/V ratio for baryon leptonic decays

Consider the decay

$$B_i \rightarrow B_f + \ell + \nu \, .$$

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 as[1]

$$\overline{B}_f[\gamma_\lambda(g_V - g_A\gamma_5) + (g_W/m_{B_i})\sigma^{\lambda\nu}q_\nu]B_i \, .$$

Here B_i and $\overline{B}_f$ are spinors which represent initial and final baryons, g_A and g_V are the axial and vector coupling constants, g_W is the weak magnetism coupling constant, and q_ν is the sum of the lepton momenta. The Pauli representation is used for the γ matrices. The ratio g_A/g_V may be written as

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

where ϕ is 0 plus $n\pi$ if time reversal holds.[2]

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

Due to statistical limitations, the weak magnetism form factor g_W is usually assumed from CVC and SU(3), so that usually 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[3]).

(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[3]).

(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 et al.[4]). The lepton spectrum also provides a measure of g_W/g_A if the CVC-SU(3) assumption is relaxed.

(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[5]).

(e) The presence of a triple correlation term proportional to

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

where the initial baryon is polarized or

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

where the polarization of the decay baryon is observed provides a measure of the deviation of ϕ from 0 or π, and is thus a test of time-reversal invariance (see, e.g., Willis and Thompson[5]).

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

All the coupling constants and decay rates for baryon leptonic decays are related by Cabibbo's theory,[6] extended to six quarks (and three mixing angles) by Kobayashi and Maskawa.[7] A discussion of the Kobayashi-Maskawa mixing matrix is given in Appendix III to this edition.

Asymmetry parameters in nonleptonic hyperon decays

The transition matrix for hyperon decay may be written as

$$M = s + p(\boldsymbol{\sigma} \cdot \mathbf{q}) , \qquad (1)$$

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

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

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

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

With the transition matrix M given by Eq. (1) above, the angular distribution of the decay baryon, in the hyperon rest system, is of the form

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

where $\mathbf{P}_Y = \langle Y | \boldsymbol{\sigma} | Y \rangle$ is the hyperon polarization. In the notation of Lee and Yang,[8] the polarization P_B of the decay baryons is

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

modulo π, where δ_s and δ_p are the pion-baryon scattering phase shifts at the appropriate energy and for the appropriate isospin state. For Λ decay, assuming the validity of the $|\Delta I| = ½$ rule,

$$\Delta = \delta_s - \delta_p = (7.0 \pm 1.0)\ \mathrm{deg.}$$ [9]

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.

For notation, see key at front of Listings.

Stable Particles

n, Λ

References

1. M.L. Goldberger and S.B. Treiman, Phys. Rev. **11**, 354 (1958).
2. J.D. Jackson, S.B. Treiman, and H.W. Wyld Jr., Phys. Rev. **106**, 517 (1957).
3. C.H. Albright, Phys. Rev. **115**, 750 (1959).
4. I. Bender, V. Linke, and H.J. Rothe, Z. Physik **212**, 190 (1968).

17 NEUTRON BETA DECAY PARAMETERS

```
AV       GA/GV  (SEE NOTE ABOVE 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 REPL.BY EROZOLIMS79 10/71
AV EP       (-1.239)  (0.011)          CHRISTENS 72 CNTR    N DEC.+ FT VALUE  1/73
AV  P       (-1.263)  (0.016)          KROPF     73 RVUE    N DECAY ALONE     1/73
AV   P       -1.250    0.009           KROPF     73 RVUE    N DEC.+ FT VALUE  1/73
AV E        (-1.250)  (0.036)          DOBROZEMS 75 CNTR REPL.BY STRATOWA 78 12/75
AV   K       -1.253    0.021           KROHN     75 CNTR PE,NEUT SPIN CORREL  1/77
AV          (-1.263)  (0.015)          EROZOLIMS 77 CNTR REPL.BY EROZOLIMS79  1/78
AV E         -1.259    0.017           STRATOWA  78 CNTR PROTON RECOIL SPECT  2/82
AV E         -1.261    0.012           EROZOLIMS 79 CNTR PE,NEUT SPIN CORREL 10/81
AV           -1.226    0.042           MOSTOVOY  83 RVUE                      2/84*
AV  C    CONFORTO 67 COMBINES FREE NEUTRON DATA TO 1967.  REPL. BY KROPF 73.  1/73
AV E     THESE EXPERIMENTS MEASURE THE ABSOLUTE VALUE OF GA/GV ONLY          10/71
AV   P   KROPF 73 VALUE OBTAINED BY FITTING ALL DATA THROUGH 1972.            1/73
AV   K   KROHN 75 PAPER GIVES -1.258+-.015 INCLUDING EVENTS OF CHRISTENS 70.  1/78
AV   K   THE VALUE QUOTED ABOVE IS DERIVED FROM HIS A,BASED ON NEW EXPT ONLY  1/77
AV           . . . . . . . . . .
AV  AVG      -1.2539   0.0063  AVERAGE

F        PHASE ANGLE OF GA RELATIVE TO GV  (DEGREES)
F         TIME REVERSAL INVARIANCE WOULD REQUIRE THIS TO BE 0 OR 180 DEGREES
F   P      (175.)     (10.)            BURGY     60 CNTR    POLAR. NEUTRONS   6/77
F   P      (198.)     (27.)            CLARK     60 CNTR    POLAR. NEUTRONS   6/77
F   C      (176.1)     (6.4)           CONFORTO  67 RVUE                     11/68
F   P      (181.3)     (1.3)           EROZOLIMS 70 CNTR   POLAR. NEUTRON    10/69
F    P      181.1       1.3            KROPF     73 RVUE    N DECAY           1/73
F           180.35      0.43           EROZOLIMS 74 CNTR    POLAR. NEUTRONS   6/77
F           180.14      0.22           STEINBERG 74 CNTR    POLAR. NEUTRONS   6/77
F           179.71      0.39           EROZOLIMS 78 CNTR    POLAR. NEUTRONS   7/79
F   C    CONFORTO 67 COMBINES FREE NEUTRON DATA TO 1967.  REPL. BY KROPF 73.  1/73
F    P   KROPF 73 VALUE OBTAINED BY FITTING ALL DATA THROUGH 1972.            1/73
F           . . . . . . . . . .
F   AVG     180.11      0.17   AVERAGE
D1      TRIPLE CORRELATION COEFFICIENT                                        7/76
D1      D1 MEASURES COMPONENT OF NEUTRON SPIN PERPENDICULAR TO THE DECAY      7/76
D1      PLANE IN BETA DECAY. SHOULD BE ZERO IF T-INVARIANCE NOT               7/76
D1      VIOLATED.  SEE NOTE ON BARYON DECAY PARAMETERS ABOVE.                 7/76
D1           -0.01      0.01           EROZOLIMS 70 CNTR    POLAR. NEUTRONS   7/76
D1    E      -0.0027    0.0050         EROZOLIMS 74 CNTR    POLAR. NEUTRONS  12/81
D1    E      -0.0011    0.0017         STEINBERG 74 CNTR    POLAR. NEUTRONS  12/81
D1           +0.0022    0.0030         EROZOLIMS 78 CNTR    POLAR. NEUTRONS   7/79
D1    E  EROZOLIMSKII 78 SAYS ASYMMETRIC PROTON LOSSES AND NON-UNIFORM BEAM  12/81
D1    E  POLARIZATION MAY GIVE SYSTEMATIC ERROR UP TO 0.003, THUS INCREASING 12/81
D1    E  THE EROZOLIMSKII 74 ERROR TO 0.005 .  STEINBERG 74, 76 ESTIMATES    12/81
D1    E  THESE SYSTEMATIC ERRORS TO BE INSIGNIFICANT IN THEIR EXPERIMENT.    12/81
D1           . . . . . . . . . .
D1  AVG      -0.0007    0.0014  AVERAGE

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REFERENCES FOR NEUTRON


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COHEN    56 PR 104 283          V W COHEN, CORNGOLD, RAMSEY   (BNL+HARVARD)
SOSNOVSK 59 JETP  9  717        SOSNOVSKII,SPIVAK,PROKOFEV +   (IAE MOSCOW)
BURGY    60 PR 120 1829         +KROHN,NOVEY,RINGO                (ANL+CHIC)
CLARK    60 CJP 38 693          +ROBSON
SUNYAR   60 PR 120 871          A.W.SUNYAR, M.GOLDHABER                (BNL)

MATTAUCH 65 NP 67 1             +THIELE,WAPSTRA     (MAX PLANCK INST.CHEM.)
CHRISTEN 67 PL 26B 11           CHRISTENSEN,NIELSON,BAHNSEN,BROWN+    (RISO)
CONFORTO 67 APAH 22 15          G. CONFORTO                           (CERN)
MILLER   67 PRL 19 381          +DRESS,BAIRD,RAMSEY              (ORNL+HARV)
SHULL    67 PRL 19 384          C.G.SHULL, R.NATHANS              (MIT+BNL)
DRESS    68 PR 170 1200         +BAIRD,MILLER,RAMSEY             (ORNL+HARV)
GRIGOREV 68 SJNP 6 239          +GRISHIN,VLADIMIRSKII,NIKOLAEVSKII + (ITEP)

BAIRD    69 PR  179  1285       +MILLER,DRESS,RAMSEY             (ORNL,HARV)
TAYLOR   69 RMP 41 375          +PARKER,LANGENBERG          (PRIN+UCI+PENN)
APOSTOLE 70 RRP 15 343          APOSTOLESCU,IONESCU,IONESCU-BUJOR +  (BUCH)
CHRISTEN 70 PR C1 1693          CHRISTENSEN,KROHN,RINGO                (ANL)
EROZOLIM 70 SJNP 11 583         EROZOLIMSKI,BONDARENKO,  +            (KIAE)
    ALSO    PL 27B 557          EROZOLIMSKY,BONDARENKO  +             (KIAE)

EROZOLIM 71 JETPL 13 252        EROZOLIMSKII,BONDARENKO               (KIAE)
CHRISTEN 72 PR D5 1628          CHRISTENSEN,NIELSON,BAHNSEN,BROWN+    (RISO)
COHEN    73 J.PHYS.CHEM.REF.DATA 2, P.663, E.R.COHEN,B.N.TAYLOR
DRESS    73 PR D7 3147          DRESS,MILLER,RAMSEY              (ORNL+HARV)
KROPF    73 ZPHY TO BE PUBL.    A KROPF,H PAUL                        (LINZ)
    ALSO 70 NP A154 160         H PAUL                                (VIEN)

EROZOLIM 74 JETPL 20 345        EROZOLIMSKII,MOSTOVOI,FEDUNIN,FRANK+
STEINBER 74 PRL 33 41           STEINBERG,LIAUD,VIGNON,HUGHES   (YALE+GREN)
    ALSO 76 PR D13 2469         STEINBERG,LIAUD,VIGNON,HUGHES   (YALE+GREN)
DOBROZEM 75 PR D11 510          DOBROZEMSKY,KERSCHBAUM,MORAW,PAUL +  (SEIB)
KROHN    75 PL 55B 175          KROHN,RINGO                            (ANL)

DRESS    77 PR D15 9            +MILLER,PENDLEBURY,PERRIN+ (ORNL+GREN+HARV)
EROZOLIM 77 JETPL 23 663        EROZOLIMSKII,FRANK,MOSTOVOI+          (KIAE)
GREENE   77 PL 71B 297          +RAMSEY,MAMPE+   (HARV+ILLG+SUSS+ORNL+CENG)
EROZOLIM 78 SJNP 28 48          EROZOLIMSKII,MOSTOVOI,FEDUNIN,FRANK+ (KIAE)
STRATOWA 78 PR D18 3970         +DOBROZEMSKY,WEINZIERL                (SEIB)
BONDAREN 78 JETPL 28 303        BONDARENKO,KURGUZOV,PROKOFEV+         (KIAE)
    ALSO 82 SMOLENICE CONF.     L.N.BONDARENKO                        (KIAE)
VYLOV    78 SJNP 28 585         +GROMOV,IVANOV,OSIPENKO,FROLOV        (JINR)

ALTAREV  79 JETPL 29 730        +BORISOV,BRANDIN,EGOROV,EZHOV,IVANOV+(LENI)
EROZOLIM 79 SJNP 30 356         EROZOLIMSKII,FRANK,MOSTOVOI+          (KIAE)
GREENE   79 PR D20 2139         +RAMSEY,MAMPE+   (HARV+ILLG+SUSS+ORNL+CENG)
NORMAN   79 PRL 43 1226         E.B.NORMAN, A.G.SEAMSTER              (WASH)
BARABANO 80 JETPL 32 359        BARABANOV,VERETENKIN,GAVRIN +         (LENI)
BYRNE    80 PL 92B 274          +MORSE,SMITH,SHAIKH,GREEN,GREENE  (SUSS+RL)
GREENWOO 80 PR C21 498          R.C.GREENWOOD,R.C.CHRIEN          (INEL+BNL)
KOSVINTS 80 JETPL 31 236        KOSVINTSEV,KUSHNIR,MOROZOV,TEREKHOV  (JINR)

ALTAREV  81 PL 102B 13          +BORISOV,BOROVIKOVA,BRANDIN,EGOROV + (LENI)
CHETYRKI 81 PL 99B 358          CHETYRKIN,KAZARNOVSKY,KUZMIN+         (INRM)
ALBERICO 82 PL 114B 266         +BOTTINO,MOLINARI                (CERN+TORI)
GAHLER   82 PR D25 2887         +KALUS,MAMPE                     (BAYR+ILLG)
WILKINSO 82 NP A377 474         D.H.WILKINSON                     (SUSS+BNL)
CHERRY   83 PRL 50 1354         +LANDE,LEE,STEINBERG,CLEVELAND   (PENN+BNL)
MOSTOVOY 83 JETPL 37 196        YU.A.MOSTOVOY                         (KIAE)
PUGLIERI 83 BRIGHTON CONF.      PUGLIERIN           (CERN+ILL+PADO+RL+SUSS)
VAIDYA   83 PR D27 486          +ROY,EPHRAIM,DATAR,BHATTACHERJEE      (TIFR)
JONES    84 PRL 52 720          IMB COLLAB(ICI+MICH+BNL+CIT+CLEV+HAWA+LOUC)

                                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)
BYRNE    82 RPP 45 115          J.BYRNE                               (SUSS)
FRANK    82 SPU 25 280          A.I.FRANK                             (KIAE)
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Λ 18 LAMBDA(1116,JP=1/2+) I=0

18 LAMBDA MASS (MEV)

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M   N   SINCE OUR FINAL VALUES FOR THE SIGMA AND LAMBDA MASSES COME FROM
M   N   DOING AN OVERALL FIT TO ALL MEASURED MASSES AND MASS DIFFERENCES,
M   N   WE HAVE USED THE UNCORRELATED MEASUREMENTS FROM SCHMIDT 65 RATHER
M   N   THAN THE ONES COMING FROM THE OVERALL FIT REPORTED IN THAT PAPER.
M   N   SINCE THERE SEEMS TO BE NO CONVINCING ARGUMENT AS TO WHY ONE SHOULD
M   N   IGNORE DATA USING RANGE MEASUREMENTS, WE HAVE INCLUDED HERE VALUES
M   N   DEPENDING ON PROTON AND PION RANGES.  THE SCHMIDT 65 MASSES HAVE
M   N   BEEN REEVALUATED USING OUR APRIL 1973 PROTON AND CHARGED K AND PI
M   N   MASSES.  P. SCHMIDT, PRIVATE COMMUNICATION, (1974).

M          1115.44     0.12          BHOWMIK   63 RVUE +  SEE NOTE L BELOW
M   L   ABOVE LAMBDA MASS HAS BEEN RAISED 35 KEV TO ACCOUNT FOR 46 KEV
M   L   INCREASE IN PROTON MASS AND 11 KEV DECREASE IN CHARGED PION MASS.
M   S  635(1115.86)   (0.09)         BALTAY    65 HBC    ERROR IS STATIS.   6/66
M      488 1115.65     0.07          SCHMIDT   65 HBC  SEE NOTE N           3/74
M   S 1147(1115.74)   (0.04)         CHIEN     66 HBC     6.9 PBAR P        9/67
M   S  972(1115.69)   (0.05)         CHIEN     66 HBC     6.9 PBAR PANTIL   9/67
M          1115.6      0.4           LONDON    66 HBC                       6/66
M         (1116.0)    (0.2)          BADIER    67 HBC     2.4 PBAR P,LLBAR  8/67
M      195 1115.39     0.12          MAYEUR    67 EMUL                     11/67
M   B 1524(1115.52)   (0.03)         BOHM      70 EMUL                      3/72
M      935 1115.59     0.08          HYMAN     72 HEBC                     11/71
M   B   AVERAGE OF VERY INCONSISTENT DATA. ERROR STATISTICAL ONLY. AUTHORS  3/72
M   B   DETECT SYSTEMATIC EFFECT OF ABOUT .15 MEV, WHICH THEY ATTRIBUTE     3/72
M   B   TO ERROR IN RANGE-ENERGY RELATIONS, IN REGION BETA=0.6-0.7.         3/72
M   B   THIS EFFECT, IF CONFIRMED, WOULD AFFECT VERY LITTLE THE VALUES OF   3/72
M   B   BHOWMICK 63 AND MAYEUR 67.
M   S   ERROR PURELY STATISTICAL.
M          . . . . . . . . . .
M   AVG    1115.566    0.056   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
M   FIT    1115.596    0.046  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)  3/84*
                      (SEE IDEOGRAM BELOW)
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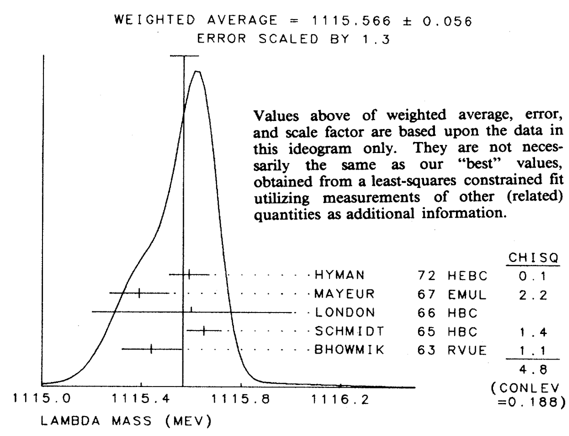

18 LAMBDA - ANTILAMBDA MASS DIFFERENCE (MEV)

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DM       TEST OF CPT
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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Stable Particles — Data Card Listings

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

T    O  188   (2.63)    (0.21)    (0.21) BOLDT      58 CC
T    O  825   (2.72)    (0.16)    (0.16) CRAWFORD   59 HBC
T    O  140   (2.72)    (0.29)    (0.27) BOWEN      60 CC
T    O  186   (2.60)    (0.28)    (0.20) CHANG      62 HBC
T    O  799   (2.69)    (0.11)    (0.11) HUMPHREY   62 HBC
T    O 2239   (2.36)    (0.06)    (0.06) BLOCK      63 HEBC
T    O  706   (2.76)    (0.20)           CHRETIEN   63 HLBC
T    O  794   (2.59)    (0.09)           HUBBARD    64 HBC
T    O 2260   (2.31)    (0.10)           KREISLER   64 OSPK
T    O 1378   (2.59)    (0.07)           SCHWARTZ   64 HBC
T    O  635   (2.51)    (0.16)           BALTAY     65 HBC                        6/66
T    O 2534   (2.6)     (0.1)            HILL       65 OSPK
T    O  916   (2.35)    (0.09)           BURAN      66 HLBC                       6/66
T    S 1147   (2.50)    (0.14)           CHIEN      66 HBC      6.9 PBAR P        9/67
T    S  972   (2.70)    (0.20)           CHIEN      66 HBC      6.9 PBAR P,ANTI   9/67
T    O 2213   (2.452)   (0.056)   (0.054)ENGELMANN  66 HBC                        9/66
T    O  585   (2.68)    (0.13)    (0.11) AUERBACH   67 OSPK                       8/67
T    O        (2.44)    (0.15)           BADIER     67 HBC     2.4 PBAR P         6/68
T    O        (2.55)    (0.15)           BADIER     67 HBC     2.4 PBAR P,ANTIL   6/68
T    O 8342   (2.535)   (0.035)          GRIMM      68 HBC                        6/68
T    O 2600   (2.47)    (0.08)           HEPP       68 HBC                        8/68
T    O 1059   (2.39)    (0.10)           DEMIDOV    70 HLBC PI-P, 3.86 GEV/C     12/70
T    O 4572   (2.54)    (0.04)           BALTAY     71 HBC     K-P AT REST        6/71
T    O 6582   (2.69)    (0.05)           ALTHOFF2   73 OSPK    PI+N TO K+LAMBDA   2/74
T        36K   2.626     0.020           POULARD    73 HBC     K-P,KMOM .4TO2.3   9/73
T        34K   2.611     0.020           CLAYTON    75 HBC     K-P,KMOM .96-1.4   1/77
T        53K   2.69      0.03            ZECH       77 SPEC NEUTRAL HYP. BEAM    12/77
T    O   OLD LOWER STATISTICS EXPERIMENTS NOT INCLUDED IN AVERAGE.                1/78
T    S   ERROR PURELY STATISTICAL.
T           . . . . . . . . . . .
T    AVG       2.632     0.020     0.020  AVERAGE (ERROR INCL. SCALE FACTOR OF 1.6)
                         (SEE IDEOGRAM BELOW)
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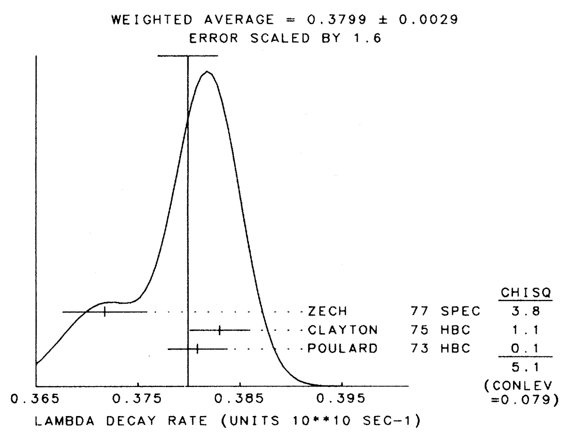


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            18  (LAMBDA - ANTILAMBDA)/AVG., MEAN LIFE DIFFERENCE

DT       TEST OF CPT
DT           0.044     0.085            BADIER    67 HBC      2.4 PBAR P        8/67

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            18  LAMBDA MAGNETIC MOMENT (MAGNETONS,938.26 MEV)

MM            -1.5       0.5             COOL       62 OSPK
MM             0.0       0.6             KERNAN     63 CC
MM     8553   -1.39      0.72            ANDERSON   64 HBC
MM      151   -0.5       0.28            CHARRIERE  65 EMUL
MM       49  (-0.67)    (0.31)   (0.37)  BARKOV     71 EMUL   PRELIM. RESULT    2/72
MM     1300   -0.66      0.07            DAHLJENSE  71 EMUL   MAG FIELD=200KG   6/71
MM     3868   -0.73      0.18            HILL       71 OSPK                    10/71
MM       57   -0.65      0.28            BARKOV     72 EMUL INCLUDES BARKOV 71  3/78
MM     1.2M   -0.57      0.05            BUNCE      76 SPEC                     1/78
MM     350K   -0.59      0.07            HELLER     77 SPEC                     1/78
MM       3M   -0.6138    0.0047          SCHACHING  78 SPEC                     1/79
MM     200K   -0.606     0.015           COX        81 SPEC                    12/81
MM           . . . . . . . . . .
MM   AVG      -0.6130    0.0044   AVERAGE

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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   P       0.015 OR LESS  CL=.95   PONDROM    81 SPEC                       1/82
EDM   B  BARONI MEASURES (-5.9+-2.9)*10**-15 E CM                              2/72
EDM   P  PONDROM 81 MEASURE (-3.0+-7.4)*10**-17 E CM .                         1/82

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            18  LAMBDA PARTIAL DECAY MODES

                                                      DECAY MASSES
P1       LAMBDA INTO PROTON PI-                      938+ 140
P2       LAMBDA INTO NEUTRON PIO                     940+ 135
P3       LAMBDA INTO PROTON MU- NEUTRINO             938+ 106+    0
P4       LAMBDA INTO PROTON E- NEUTRINO              938+.511+    0
P5       LAMBDA INTO PROTON PI- GAMMA                938+ 140+    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
R1   FIT      0.6419    0.0049 FROM FIT

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
R2   FIT      0.3581    0.0049 FROM FIT

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

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   LC 218   (1.32)   (0.15)           LINDQUIST 71 OSPK    PI-P TO KO LAM     3/72
R5    L 544    1.23     0.11            LINDQUIST 77 SPEC    PI-P TO KO LAM    12/77
R5      10K    1.313    0.024           WISE      80 SPEC                       8/81
R5     7111    1.335    0.056           BOURQUIN  83 SPEC SPS HYPERON BEAM      2/84*
R5    C  CALCULATED BY US FROM R3 ASSUMING THE AUTHORS USED (P PI-)/TOT=2/3     3/72
R5    L  LINDQUIST 77 INCLUDES DATA OF LINDQUIST 71.                           12/77
R5          . . . . . . . . . .
R5   AVG       1.304    0.020   AVERAGE

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

     SEE NOTE ON BARYON DECAY PARAMETERS IN NEUTRON SECTION ABOVE.

A-      ALPHA LAMBDA- (LAMBDA INTO PI- PROTON)
A-     1156    0.62     0.07            CRONIN    63 CNTR    LAMBDA FROM PI-P   8/67
A-            (0.663)  (0.022)          BERGE     66 RVUE  INCLUDES ABOVE       9/66
A-    10130    0.645    0.017           OVERSETH  67 OSPK    LAMBDA FROM PI-P   8/67
A-  M  2529   (0.747)  (0.086)          MERRILL   68 HBC  REPL BY DAUBER 68     6/68
A-     3520    0.67     0.06            DAUBER    69 HBC  FROM XI DECAY         6/68
A-    10325    0.649    0.023           CLELAND   72 OSPK    LAMBDA FROM PI-P   5/72
A-     8500    0.584    0.046           ASTBURY   75 SPEC    LAMBDA FROM PI-P   2/78
A-          . . . . . . . . . .
A-   AVG       0.642    0.013   AVERAGE

A0      ALPHAO /ALPHA- FOR LAMBDA (L INTO PIO N/L INTO PI- P)
A0             1.10     0.27            CORK      60 CNTR
A0 O   4760    1.000    0.068           OLSEN     70 OSPK PI+N TO K+ LAMBDA     5/70
A0 O     DONE BY COMPARING PROTON DISTR.WITH N DISTR. FROM LAMBDA DECAY.
A0          . . . . . . . . . .
A0   AVG       1.006    0.066   AVERAGE

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

AV      GA/GV FOR LAMBDA BETA DECAY
AV      (FOR SIGN CONVENTION, SEE NOTE ON BARYON DECAY PARAMETERS IN
AV      NEUTRON SECTION ABOVE.)
AV   C   22  (-1.03)                    LIND      64 HBC                        6/68
AV   C  102    (0.6)  OR MORE           BAGLIN    65 HLBC    NO SIGN GIVEN      1/71
AV   C        BETW 0. AND -1.1          BARLOW    65 OSPK                       6/68
AV   C  102    (0.7)  OR MORE  CL=.95   ELY       65 HLBC     ABS. VALUE        1/71
AV   C   EXPERIMENTS INCLUDED IN CONFORTO 65, RVUE                              6/68
AV            -1.14     0.23      0.33  CONFORTO  65 RVUE                      11/67
AV M    148   -0.72     0.14      0.19  MALONEY   69 HBC                       10/69
AV  A  1078  (-0.62)   (0.08)    (0.09) ALTHOFF2  71 OSPK    POLARIZED LAMBDA   7/73
AV M    141   -0.75     0.15      0.18  CANTER    71 HBC                        4/71
AV  L   173  (-0.40)   (0.13)    (0.17) LINDQUIST 71 OSPK  E-NEU AND UP-DOWN    9/71
AV M    352   -0.74     0.09      0.12  BAGGETT1  72 HBC     STOP.K-            2/72
AV A    817   -0.63     0.06            ALTHOFF1  73 OSPK    POLARIZED LAMBDA   7/73
AV      405   -0.47     0.09            BURNETT   76 SPEC    E-NEU AND SPIN     2/78
AV    L 441   -0.53     0.09      0.11  LINDQUIST 77 SPEC POL LAMBDA, 3 ASYMM  12/77
AV M    10K   -0.734    0.031           WISE      81 SPEC E-NEU ANG. CORREL.    1/82
AV     7111   -0.70     0.03            BOURQUIN  83 SPEC XI- --> LAMBDA PI-    2/84*
AV   A   ALTHOFF1 73 INCLUDES DATA OF ALTHOFF2 71.  USES PROT SPECTRUM AND      7/73
AV   A   THREE SPIN ASYMMETRIES.                                                7/73
AV M     EXPT MEASURES ONLY THE ABSOLUTE VALUE OF A/V                           7/73
AV    L  LINDQUIST 77 INCLUDES DATA OF LINDQUIST 71.                           12/77
AV          . . . . . . . . . .
AV   AVG      -0.694    0.025   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
                                (SEE IDEOGRAM BELOW)
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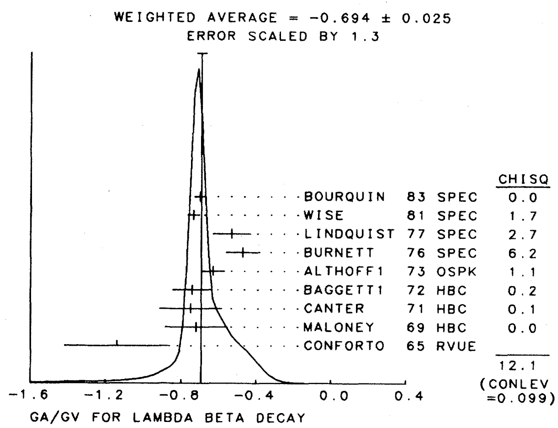
For notation, see key at front of Listings.

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REFERENCES FOR LAMBDA


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EISLER   57 NC      5 1700        EISLER,PLANO,SAMIOS,SCHWARTZ +   (COLU+BNL)
BOLDT    58 PRL     1  148        E BOLDT,D O CALDWELL,Y PAL             (MIT)
CRAWFORD 59 PRL     2  266        CRAWFORD,CRESTI,DOUGLASS,GOOD +        (LRL)

BAGLIN   60 NC     18 1043        BAGLIN,BLOCH,BRISSON,HENNESSY +       (EPOL)
BOWEN    60 PR    119 2030        BOWEN,HARDY,REYNOLDS,SUN +       (PRINCETON)
CORK     60 PR    120 1000        CORK,KERTH,WENZEL,CRONIN+     (LRL+PRIN+BNL)
COLUMBIA 60 ROCH CONF 726         M SCHWARTZ +                      (COLUMBIA)
HUMPHREY 61 PRL     6  478        HUMPHREY,KIRZ,ROSENFELD,RHEE +   (LRL+SYRA)

ANDERSON 62 CERN CONF 832         ANDERSON,CRAWFORD,GOLDEN,LLOYD +       (LRL)
AUBERT   62 NC     25  479        AUBERT,BRISSON,HENNESSY,SIX +         (EPOL)
CHANG    62 THESIS DUKE           CHUEN CHUEN CHANG                     (DUKE)
COOL     62 PR    127 2223        COOL,HILL,MARSHALL +      (BNL+MIT+NYU+ANL)
GOOD     62 PRL     9  518        M L GOOD,V G LIND                (WISCONSIN)
HUMPHREY 62 PR    127 1305        W E HUMPHREY,R R ROSS                  (LRL)

ALSTON   63 UCRL 10926            ALSTON,KIRZ,NEUFELD,SOLMITZ,WOHLMUT    (LRL)
BHOWMIK  63 NC     28 1494        B BHOWMIK,D P GOYAL                  (DELHI)
BLOCK    63 PR    130  766        BLOCK,GESSAROLI,RATTI+(NWES+BGNA+SYRA+ORNL)
BROWN    63 PR    130  769        BROWN,KADYK,TRILLING,ROE +        (LRL+MICH)
CHRETIEN 63 PR    131  2208       CHRETIEN,CROUCH+   (BRAN+BROWN+HARVARD+MIT)
CRONIN   63 PR    129 1795        J W CRONIN,O E OVERSETH          (PRINCETON)
ELY      63 PR    131  868        ELY,GIDAL,KALMUS,OSWALD,POWELL +       (LRL)
KERNAN   63 PR    129  870        KERNAN,NOVEY,WARSHAW,WATTENBERG    (ANL+ILL)

ANDERSON 64 PRL    13  167        J A ANDERSON,F S CRAWFORD              (LRL)
BAGLIN   64 NC     35  977        BAGLIN,BINGHAM+  (EPOL+CERN+LOUC+RHEL+BERG)
HUBBARD  64 PR    135 B 183       HUBBARD,BERGE,KALBFLEISCH,SHAFER +     (LRL)
KERNAN   64 PR    133 B 1271      KERNAN,POWELL,SANDLER +           (LRL+LOUC)
KREISLER 64 PR 136 B 1074         M N KREISLER,O OVERSETH,J CRONIN      (PRIN)
LIND     64 PR    135 B 1483      LIND,BINFORD,GOOD,STERN          (WISCONSIN)
RONNE    64 PL     11   357       RONNE+          (CERN+EPOL+LOUC++UNIV.BERGEN)
SCHWARTZ 64 UCRL 11360 THESIS     JOSEPH ADAM SCHWARTZ                   (LRL)

BAGLIN   65 NC 35 977             BAGLIN +        (EPOL,CERN,LOUC,RHEL,BERGEN)
BALTAY   65 PR 140 B 1027         BALTAY,SANDWEISS,CULWICK,KOPP +  (YALE+BNL)
BARLOW   65 PL    18   64         J BARLOW,BLAIR,CONFORTO+   (CERN+RHEL+PENN)
CHARRIER 65 PL    15     66       CHARRIERE,GIBSON+      (EPOL+BRIS+CERN+MPIM)
    ALSO 66 NC    46A  205        CHARRIERE,GIBSON +     (EPOL,BRIS,CERN,MPIM)
CONFORTO 65 EC INT HERZEGNOVI     G CONFORTO                            (CERN)
ELY      65 PR 137 B1302          ELY,GIDAL,KALMUS,POWELL +        (LRL,LOUC)
HILL     65 PRL 15 85             HILL,LI,JENKINS,KYCIA,RUDERMAN    (MIT,BNL)
SCHMIDT  65 PR 140 B 1328         P SCHMIDT                         (COLUMBIA)

BERGE    66  BERKELEY 46          BERGE,CABIBBO              ((RVUE) LRL,CERN)
BURAN    66 PL 20 318             BURAN,EIVINDSON,SKJEGGESTAD,TOFTE +  (OSLO)
CHIEN    66 PR   152  1171        +LACH,SANDWEISS,TAFT,YEH,OREN +  (YALE+BNL)
ENGELMAN 66 NC 45A  1038          ENGELMANN,FILTHUTH,ALEXANDER+    (HEID,REHO)
GIBSON   66 NC 45A 882            W M GIBSON,K GREEN                    (BRIS)
LONDON   66 PR 143 1034           LONDON,RAU,GOLDBERG,LICHTMAN+    (BNL,SYRA)

AUERBACH 67 NC   47A  19          AUERBACH,BOWEN,DOBBS,LANDE,MANN+      (PENN)
BADIER   67 PL 25B 152            +BONNET,BRIANDET,SADOULET             (EPOL)
CLELAND  67 PL 26B 45             CLELAND,BIENLEIN,CONFORTO+ (CERN+GEVA+LUND)
MAYEUR   67 U.LIBR.BRUX.BUL32     C.MAYEUR,E.TOMPA,J.WICKENS       (BELG,LOUC)
OVERSETH 67 PRL   19  391         O E OVERSETH, R F ROTH           (MICH+PRIN)
GRIMM    68 NC 54A 187            H.-J.GRIMM                      (HEIDELBERG)
HEPP     68 ZPHYS 214 71          V.HEPP,H. SCHLEICH              (HEIDELBERG)
MERRILL  68 PR 167 1202           MERRILL,SHAFER                         (LRL)

DAUBER   69 PR   179 1262         +BERGE,HUBBARD,MERRILL,MILLER          (LRL)
DOYLE    69 UCRL 18139-THESIS     J.C. DOYLE                             (LRL)
MALONEY  69 PRL 23 425            MALONEY,SECHI-ZORN          (UNIV MARYLAND)
BOHM     70 NC 70A 384            + KRECKER + (BERL+BRUX+DUUC+LOUC+LOWC+WARS)
DEMIDOV  70 SJNP 10 681           +KIRILLOV-UGRYUMOV,PONOSOV,PROTASOV+ (ITEP)
OLSEN    70 PRL 24 843            +PONDROM,HANDLER,LIMON,SMITH +   (WISC,MICH)

ALTHOFF1 71 PL 37B 531            +BROWN,FREYTAG,HEARD,HEINTZE +   (CERN,HEID)
ALTHOFF2 71 PL 37B 535            +BROWN,FREYTAG,HEARD,HEINTZE +   (CERN,HEID)
BALTAY   71 PR D4 670             +BRIDGEWATER,COOPER,HABIBI+      (COLU+BING)
BARKOV   71 JETPL 14 60           +GUREVICH,MAKARINA,MARTEMYANOV+       (ITEP)
BARONI   71 LNC 2 1256            G BARONI,S PETRERA,G ROMANO           (ROMA)
CANTER   71 PRL 26 868            +COLE,LEE-FRANZINI,LOVELESS +    (STON+COLU)

CANTER1  71 PRL 27 59             +COLE,LEE-FRANZINI,LOVELESS+     (STON+COLU)
DAHLJENS 71 NC 3A 1               DAHL-JENSEN +    (CERN+ANKA+LAUS+MPIM+ROMA)
HILL     71 PR D4 1979            +LI,JENKINS,KYCIA,RUDERMAN        (MIT,BNL)
    ALSO 65 PRL 15 85             HILL,LI,JENKINS,KYCIA,RUDERMAN    (MIT,BNL)
LINDQUIS 71 PRL 27 612            LINDQUIST,SUMNER+         (EFI,WUSL,OSU,ANL)

BAGGETT1 72 ZPHY 249 279          +BAGGETT,EISELE,FILTHUTH,FREHSE+      (HEID)
BAGGETT2 72 ZPHY 252 362          +BAGGETT,EISELE,FILTHUTH,FREHSE+      (HEID)
BAGGETT3 72 PL 42B 379            +BAGGETT,EISELE,FILTHUTH,FREHSE,HEPP+(HEID)
BARKOV   72 JETPL 16 104          +GUREVICH,MAKARINA,MARTEMYANOV +      (ITEP)
CLELAND  72 NP B40 221            +CONFORTO,EATON,GERBER+    (CERN+GEVA+LUND)
HYMAN    72 PR D5 1063            +BUNNELL,DERRICK,FIELDS,KATZ+    (ANL+CARN)

ALTHOFF1 73 PL 43B 237            +BROWN,FREYTAG,HEARD,HEINTZE+    (CERN+HEID)
ALTHOFF2 73 NP B66 29             +BROWN,FREYTAG,HEARD,HEINTZE+    (CERN+HEID)
POULARD  73 PL 46B 135            +GIVERNAUD,BORG                       (SACL)

ASTBURY  75 NP B99 30             +GALLIVAN,JAFAR +      (LOIC+CERN+ETH+SACL)
CLAYTON  75 NP B95 130            +BACON,BUTTERWORTH,WATERS +      (LOIC+RHEL)
BUNCE    76 PRL 36 1113           +HANDLER,MARCH,MARTIN +     (WISC+MICH+RUTG)
BURNETT  76 NC 34A 14             +INNES,MASEK,MAUNG,MILLER,RUDERMAN+  (UCSC)

HELLER   77 PL 68B 480            +OVERSETH,BUNCE,DYDAK +     (MICH+WISC+HEID)
LINDQUIS 77 PR D16 2104           LINDQUIST,SWALLOW,SUMNER +     (EFI+OSU+ANL)
    ALSO 76 JPG 2 L211            LINDQUIST,SWALLOW,SUMNER+(EFI+WUSL+OSU+ANL)
ZECH     77 NP B124 413           +DYDAK,NAVARRIA+        (SIEG+CERN+DORT+HEID)
SCHACHIN 78 PRL 41 1348           SCHACHINGER,BUNCE,COX +     (MICH+RUTG+WISC)

WISE     80 PL 91B 165            +JENSEN,KREISLER,LOMANNO,POSTER+ (MASA+BNL)
COX      81 PRL 46 877            +DWORKIN +           (MICH+WISC+RUTG+MINN+BNL)
PONDROM  81 PRD 23 814            +HANDLER,SHEAFF,COX + (WISC+MICH+RUTG+MINN)
WISE     81 PL 98B 123            +JENSEN,KREISLER,LOMANNO,POSTER+ (MASA+BNL)
BOURQUIN 83 ZPHY C21 1            +BROWN+          (BRIS+GEVA+HEID+LALO+RL+STRB)

                                  PAPERS NOT REFERRED TO IN DATA CARDS

ARMENTER 62 CERN CONF 236         ARMENTEROS+ (CERN+EPOL+LOIC+BIRM+CEN-SACLAY)
BALTAY   62 CERN CONF 233         BALTAY,FOWLER,SANDWEISS,CULWICK+ (YALE+BNL)
BERGE    63 THESIS (BERKELEY)     J PETER BERGE                          (LRL)
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19 SIGMA+(1189,JP=1/2+) I=1

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19 SIGMA+ MASS (MEV)

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M   N SEE NOTE PRECEDING LAMBDA MASS LISTINGS

M      144 1189.38     0.15            BARKAS    63 EMUL +  SEE NOTE S BELOW
M       58 1189.48     0.22            BHOWMIK   64 EMUL +  SEE NOTE S BELOW
M   S  ABOVE SIGMA+ MASSES HAVE BEEN RAISED 30  KEV TO ACCOUNT FOR 46 KEV
M   S  INCREASE IN PROTON MASS AND 21 KEV DECREASE IN PION MASS
M     4205 1189.61     0.08            SCHMIDT   65 HBC  SEE NOTE N              3/74
M          1189.16     0.12            HYMAN     67 HEBC                         6/68
M    B 607 1189.33     0.04            BOHM      72 EMUL                        12/73
M    B  BOHM 72 UPDATED WITH PDG APR. 73 K-, PI- AND PIO MASSES.                12/73
M          . . . . . . . . . . .
M   AVG    1189.371    0.060   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.8)
M   FIT    1189.365    0.058  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.8)    3/84*
                       (SEE IDEOGRAM BELOW)
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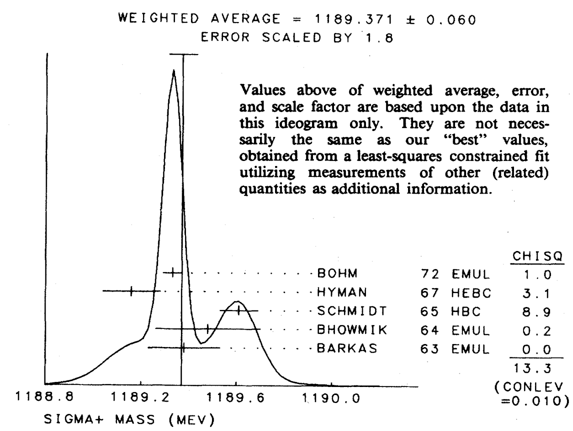


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19 SIGMA+ MEAN LIFE (UNITS 10-10 SEC)**

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T                                             GLASER    58 RVUE
T        127     0.98      0.16      0.12     PUSCHEL   60 EMUL
T         41     0.82      0.34      0.20     EVANS     60 EMUL
T        117     0.85      0.14      0.11     FREDEN    60 EMUL
T         54     0.80      0.10      0.067    KAPLON    60 EMUL
T         23     0.76      0.22      0.14     CHIESA    61 EMUL
T         49     0.75      0.13      0.09     BERTHELOT 61 HLBC
T        140     0.82      0.10      0.08     BARKAS    61 EMUL
T        192     0.749     0.056     0.052    GRARD     62 HBC
T        456     0.765     0.04               HUMPHREY  62 HBC
T        203     0.84      0.12      0.08     BHOWMIK   64 EMUL
T        181     0.84      0.09               BALTAY    65 HBC                          6/66
T        900     0.76      0.03               CARAYAN   65 HBC                          6/66
T   C   1300     0.83      0.032              CHANG     66 HBC                          6/66
T    S   125    (0.86)    (0.15)              CHIEN     66 HBC   +   6.9 PBAR P         9/67
T    S   117    (1.10)    (0.24)              CHIEN     66 HBC   -   6.9 PBAR P,ANTI    9/67
T        381     0.80      0.07               COOK      66 OSPK                         7/66
T      10664     0.803     0.008              BARLOUTAU 69 HBC     K-P .4-1.2 GEV/C  11/69
T        20K     0.795     0.010              EISELE    70 HBC     K-P AT REST        2/71
T        526     0.83      0.04               BAKKER    71 DBC     K-N TO SIG+ 2PI-  10/71
T       5719     0.807     0.013              CONFORTO  76 HBC     K-P 1-1.4 GEV/C   11/77
T        30K     0.798     0.005              MARRAFFIN 80 HBC     K- P TO SIG+ PI-   2/80
T   C     CHANG ERROR 0.018 RAISED BY US.  SEE 1970 EDITION, RMP 42,123(1970)  1/73
T    S    ERROR PURELY STATISTICAL
T             . . . . . . . . . . .
T    AVG         0.7997    0.0036    0.0036 AVERAGE

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Stable Particles

Data Card Listings

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               19  SIGMA+ MAGNETIC MOMENT (MAGNETONS,938.26 MEV)

MM     381    1.5      1.1            COOK      66 OSPK                      7/66
MM      52    3.5      1.5            KOTELCHUC 67 EMUL   K-P AT 1.15BEV/C   8/67
MM      51    3.0      1.2            SULLIVAN  67 EMUL   PHOTOPRODUCTION    8/67
MM      69    3.5      1.2            COMBE     68 EMUL                     10/68
MM   29333    2.1      1.0            MAST      68 HBC    K-P AT .4 GEV/C    6/68
MM     955    2.67     0.97           ALLEY     71 OSPK   1.28 GEV/C PI+P   10/70
MM    2651    2.7      0.9            SAHA      73 HLBC   K-P.25TO.55GEV/C   6/73
MM  S 8503   (2.95)   (0.31)          DOBLE     77 HBC    K-P .46 GEV/C     12/77
MM   S 14K    2.30     0.14           SETTLES   79 HBC    K-P.42TO.50GEV/C  12/79
MM     44K    2.38     0.02           ANKENBRAN 83 CNTR   210GEV HYP.BEAM   10/83*
MM   S  SETTLES 79 INCLUDES DOBLE 77 DATA.                                  12/79
MM          . . . . . . . . . . .
MM  AVG      2.379     0.020   AVERAGE

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               19  SIGMA+ PARTIAL DECAY MODES

                                                            DECAY MASSES
P1      SIGMA+ INTO PROTON PIO                            938+ 135
P2      SIGMA+ INTO NEUTRON PI+                           940+ 140
P3      SIGMA+ INTO NEUTRON PI+ GAMMA                     940+ 140+   0
P4      SIGMA+ INTO LAMBDA E+ NEU                        1116+.511+   0
P5      SIGMA+ INTO PROTON GAMMA                          938+   0
P6      SIGMA+ INTO NEUTRON MU+ NEUTRINO                  940+ 106+   0
P7      SIGMA+ INTO NEUTRON E+ NEUTRINO                   940+.511+   0
P8      SIGMA+ INTO PROTON E+ E-                          938+.511+.511

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               19  SIGMA+ BRANCHING RATIOS

R1      SIGMA+ INTO (NEUTRON PI+)/(NUCLEON PI)           (P2)/(P1+P2)
R1      308    0.490     0.024        HUMPHREY  62 HBC
R1      534    0.46      0.02         CHANG     66 HBC                       6/66
R1     1331    0.488     0.010        BARLOUTAU 69 HBC    K-P .4-1.2 GEV/C 11/69
R1      537    0.484     0.015        TOVEE     71 EMUL                     12/71
R1     1861    0.488     0.008        NOWAK     78 HBC  BRITISH 1.5M (TST)  7/79
R1    M 10K    0.4828    0.0036       MARRAFFIN 80 HBC    K-P 420-500MEV/C  2/80
R1    M  MARRAFFINO 80 GIVES BR TO (P PIO)/ALL.  WE QUOTE 1-BR.             2/80
R1          . . . . . . . . . . .
R1   AVG       0.4836    0.0030   AVERAGE

R2      SIGMA+ INTO (NEUT PI+ GAM)/(PI+N) (UNITS 10**-3) (P3)/P2)
R2            (1.8)      ABOUT        BAZIN2    65 HBC    PI+ LT 116 MEV/C  8/67
R2       29   (0.27)    (0.05)        ANG       69 HBC    PI+ LT 110 MEV/C 11/68
R2      180    0.93      0.10         EBENHOH   73 HBC    PI+ LT 150 MEV/C  3/74
R2       PI+ MOMENTUM CUTS DIFFER, NOT AVERAGED. LATEST VALUE USED IN TABLE.  4/82

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

R4      SIGMA+ INTO (P GAMMA)/(P PIO) (UNITS 10**-2)     (P5)/(P1)
R4        1   (0.068)OR LESS          CARRARA   64 HBC
R4       24    0.37      0.08         BAZIN     65 HBC
R4        4   (0.17)                  QUARENI   65 EMUL                      6/66
R4       45    0.21      0.03         ANG       69 HBC    STOP K-           10/69
R4       31    0.276     0.051        GERSHWIN  69 HBC                      10/69
R4       46    0.211     0.038        MANZ      80 HBC  K- P-->SIGMA+ PI-    9/81
R4          . . . . . . . . . . .
R4   AVG       0.232     0.025    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
                        (SEE IDEOGRAM BELOW)
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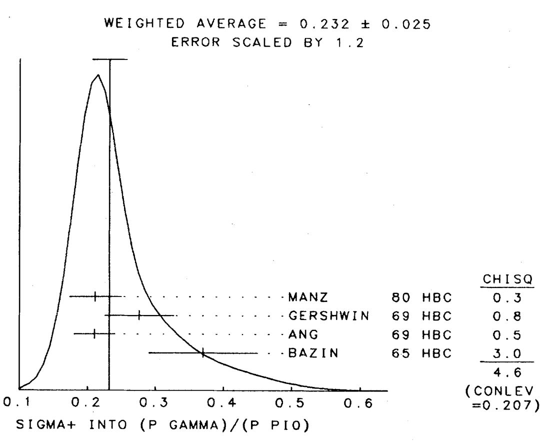


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R5      SIGMA+ INTO (N E+ NEU)/(N PI+) (UNITS 10**-5)    (P7)/(P2)
R5       TEST OF DELTA-S = DELTA-Q RULE
R5 EO    0    (16220)EFFECTIVE DENOM.  COURANT   64 HBC    SEE NOTE E      11/67
R5 EO    0     (2720)EFFECTIVE DENOM.  MURPHY    64 HBC    SEE NOTE E      11/67
R5 EO    1     (9690)EFFECTIVE DENOM.  NAUENBERG 64 HBC    SEE NOTE E       6/68
R5  O    0    (32406)EFFECTIVE DENOM.  BIERMAN   68 HBC                     6/68
R5 UA    0    (80400)EFFECTIVE DENOM.  EISELE2   69 HBC    STOP K-          6/68
R5 UO    1    (30000)EFFECTIVE DENOM.  NORTON    69 HBC                    11/69
R5  O    OLDER LOWER STATISTICS EXPTS. NOT INCLUDED IN AVERAGE.             2/76
R5 U     0    105000 EFFECTIVE DENOM.  SECHIZORN 73 HBC    STOP K-          2/76
R5 U A   0    111000 EFFECTIVE DENOM.  EBENHOH   74 HBC    STOP K-          1/76
R5 U                 EFFECTIVE DENOM.  CALCULATED BY US
R5 E                 EFFECTIVE DENOM.  TAKEN FROM EISELE 67                11/67
R5    A  EISELE2 69 REPLACED BY BY EBENHOH 74.                              1/76
R5          . . . . . . . . .
R5            1.1   OR LESS  CL=.90   OUR AVERAGE (2.3 EVTS)/(EFF.DNOM.SUM)  2/76
R5       NUMBER OF EVENTS INCREASED TO 2.3 FOR 90PC CONFIDENCE LEVEL         2/76
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R6      SIGMA+ INTO (N MU+ NEU)/(PI+N) (UNITS 10**-5)    (P6)/(P2)
R6       TEST OF DELTA-S = DELTA-Q RULE
R6       1      (120)ANALYSED EVENTS   GALTIERI  62 EMUL   NO RATIO QUOTED  11/67
R6 E     0     10150 EFFECTIVE DENOM.  COURANT   64 HBC    SEE NOTE E       11/67
R6 E     0      1710 EFFECTIVE DENOM.  NAUENBERG 64 HBC    SEE NOTE E       11/67
R6 U     2     62000 EFFECTIVE DENOM.  EISELE2   69 HBC                      6/68
R6       0     33800 EFFECTIVE DENOM.  BAGGETT   69 HBC                     11/68
R6 E                 EFFECTIVE DENOM.  TAKEN FROM EISELE 67                 11/67
R6 U                 EFFECTIVE DENOM.  CALCULATED BY US
R6          . . . . . . . . . . .
R6             6.2   OR LESS  CL=.90   OUR AVERAGE (6.7 EVTS)/(EFF.DNOM.SUM)  2/76
R6       NUMBER OF EVENTS INCREASED TO 6.7 FOR 90PC CONFIDENCE LEVEL          2/76

R7      (SIGMA+ INTO LEPTONS)/(SIGMA- INTO LEPTONS)
R7       TEST OF DELTA-S = DELTA-Q RULE.
R7       0    (0.034)OR LESS           BAGGETT   67 HBC                      6/68
R7       1    (0.08) OR LESS           NORTON    69 HBC                     10/69
R7          . . . . . . . . . . .
R7             0.043 OR LESS  CL=.90   OUR AVERAGE  USING R5 AND R6          2/76

R8      SIGMA+ INTO (PROTON E+ E-)/TOTAL (UNITS 10**-6)  (P8)
R8             7.0   OR LESS           ANG       69 HBC    STOP K-          10/69
R8    A   ANG 69 FOUND 3 E+E- EVENTS IN AGREEMENT WITH GAMMA CONVERSION OF
R8    A   PROTON GAMMA DECAY -LIMIT GIVEN HERE IS FOR NEUTRAL CURRENT

R9      (SIGMA+ INTO N MU+ NEU)/(SIGMA- INTO N MU- NEU)
R9       2  0.06        0.045     0.03   EISELE2   69 HBC  +- STOP K-       10/69
R9          . . . . . . . . . . .
R9             0.12  OR LESS  CL=.90   OUR AVERAGE  USING R6                 2/71

R10     (SIGMA+ INTO N E+ NEU)/(SIGMA- INTO N E- NEU)
R10 E    0    (0.03) OR LESS  CL=.90   EISELE2   69 HBC  +- STOP K-         10/69
R10      0    (0.12) OR LESS  CL=.95   COLE      71 HBC  +- STOP K-         10/71
R10      0    (0.018)OR LESS  CL=.90   SECHIZORN 73 HBC  +- STOP K-,POISSON  8/73
R10  E   0    (0.019)OR LESS  CL=.90   EBENHOH   74 HBC  +- STOP K-         12/75
R10  E  EISELE2 69 REPLACED BY EBENHOH 74.                                  12/75
R10         . . . . . . . . . . .
R10            0.009 OR LESS  CL=.90   OUR AVERAGE  USING R5                 2/76

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               19  SIGMA+ DECAY PARAMETERS

      SEE NOTE ON BARYON DECAY PARAMETERS IN NEUTRON SECTION ABOVE.

A+0     ALPHA+/ALPHAO FOR SIGMA+ (SIG+ TO PI+ N)/(SIG+ TO PIO P)
A+0          (+0.04)    (0.11)          CORK      60 CNTR   SIG+ FROM PI+P
A+0          (+0.20)    (0.24)          TRIPP     62 HBC    REPLAC.BY BANGER
A+0 O 3500   (-.014)    (0.052)         BANGERTER 66 HBC    SIG+ FROM K-P     9/66
A+0 O 2600   (-.047)    (0.07)          BERLEY    66 HBC    SIG+ FROM K-P     9/66
A+0    20K   (-0.104)   (0.028)         REUCROFT  77 HBC REPL.BY MARRAFFINO80  6/77
A+0    23K    -0.073     0.021          MARRAFFIN 80 HBC    K- P TO SIG+ PI-  2/80
A+0 O        OLD RESULTS, HAVE BEEN REPLACED. SEE BELOW.
A+0         . . . . . . . . . . .
A+0 FIT       -0.069     0.013   FROM FIT                                    4/82

A+      ALPHA+ FOR SIGMA+ (SIG+ TO PI+ N)
A+   35000     0.069     0.017          BANGERTER 69 HBC    K-P AT 400 MEV/C 11/69
A+    4101     0.037     0.049          BERLEY    70 HBC                     12/70
A+          . . . . . . . . . . .
A+   AVG       0.066     0.016    AVERAGE
A+   FIT       0.068     0.013   FROM FIT                                    4/82

AO      ALPHAO FOR SIGMA+ (SIG+ INTO PIO PROTON)
AO            -0.80      0.16           BEALL     62 CNTR
AO           (-0.90)    (0.25)          TRIPP     62 HBC    REPLAC. BY BANGE
AO   O 5200  (-0.986)   (0.072)         BANGERTER 66 HBC    K-P TO SIG+ PI-   7/66
AO    32000   -0.999     0.022          BANGERTER 69 HBC                     10/69
AO H  1335    -0.98      0.05      0.02 HARRIS    70 OSPK   PI+P TO SIG+ K+   5/70
AO      16K   -0.940     0.045          BELLAMY   72 ASPK   PI+P TO SIG+ K+  11/72
AO L  1259    -0.945     0.055     0.042 LIPMAN   73 OSPK   PI+P TO SIG +     7/73
AO L    DECAY PROTONS SCATTERED OFF ALUMINUM.                                 7/73
AO H    DECAY PROTONS SCATTERED OFF CARBON.
AO          . . . . . . . . . . .
AO   AVG      -0.979     0.016    AVERAGE
AO   FIT      -0.979     0.016   FROM FIT                                    4/82

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      ALPHAG FOR SIGMA+ (SIG+ INTO PROTON GAMMA)
AG       61   -1.03      0.52      0.42  GERSHWIN  69 HBC    K-P TO SIG PI   11/69
AG       46   -0.53      0.38      0.36  MANZ      80 HBC  K- P-->SIGMA+ PI-  9/81
AG          . . . . . . . . . . .
AG   AVG      -0.72      0.29      AVERAGE

FO      PHIO ANGLE (SIG+ INTO PIO PROTON) SIN(PHI)/COS(PHI)=BETA/GAMMA (DEG)
FO H          22.0       90.0           HARRIS    70 OSPK PI+P TO SIG+ K+     5/70
FO L  1259    38.1       35.7      37.1  LIPMAN    73 OSPK   PI+P TO SIG+K+    7/73
FO L    DECAY PROTON SCATTERED OFF ALUMINUM.                                  7/73
FO H    DECAY PROTONS SCATTERED OFF CARBON.
FO          . . . . . . . . . .
FO   AVG      35.8       33.7      AVERAGE

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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)
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For notation, see key at front of Listings.

Stable Particles
Σ^+, Σ^-


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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)
EISELE   70 ZPHY 238 372        +FILTHUTH,HEPP,PRESSER,ZECH    (HEIDELBERG)
HARRIS   70 PRL 24 165          +OVERSETH,PONDROM,DETTMANN      (MICH,WISC)

ALLEY    71 PR  D3  75          +BENBROOK,COOK,GLASS,GREEN,HAGUE +   (WASH)
BAKKER   71 LNC 1 37            +,SABRE COLLAB.  (ZEEM+SACL+BGNA+REHO+EPOL)
COLE     71 PR D4 631           +LEE-FRANZINI,LOVELESS,BALTAY+  (STON,COLU)
TOVEE    71 NP B33 493          LOUC,BELGRADE,BERL,BRUX,DUBLIN,WARS COLLAB
BELLAMY  72 PL 39B 299          +ANDERSON,CRAWFORD,OSMON+  (LOWC+RHEL+SUSS)
BOHM     72 NP B48 1            BERLIN+BELGRADE+BRUX+DUBLIN+LOUC+WARSAW
    ALSO 73 IIHE-73.2 NOV       BRUSSELS BULLETIN, SAME COLLABORATION

EBENHOH  73 ZPHY 264 413        +E1SELE,FILTHUTH,HEPP,LEITNER,THOUW+ (HEID)
LIPMAN   73 PL 43B 89           +UTO,WALKER,MONTGOMERY+    (RHEL+SUSS+LOWC)
SAHA     73 PR D7 3295          +FETKOVICH,HEINTZELMAN,MELTZER +     (CARN)
SECHIZOR 73 PR D8 12            B.SECHI-ZORN,G.SNOW                   (UMD)

EBENHOH  74 ZPHY 266 367        +EISELE,ENGELMANN,FILTHUTH,HEPP +    (HEID)
CONFORTO 76 NP B105 189         +GOPAL,KALMUS,LITCHFIELD,ROSS + (RHEL+LOIC)
DOBLE    77 PL 67B 483          +GOTTSTEIN,HANSL,HERYNEK+  (MPIM+BOHR+VAND)
REUCROFT 77 PR D15 5            +ROOS,WATERS,WEBSTER,HANSL +    (VAND+MPIM)
NOWAK    78 NP B139 61          +ARMSTRONG,DAVIS+     (LOUC+BELG+DURH+WARS)

SETTLES  79 PR D20 2154         +MANZ,MATT,HANSL,HERYNEK,DOBLE+ (MPIM+VAND)
MANZ     80 PL 96B 217          +REUCROFT,SETTLES,WOLF +        (MPIM+VAND)
MARRAFFI 80 PR D21 2501         MARRAFFINO,REUCROFT,ROOS,WATERS+(VAND+MPIM)
ANKENBRA 83 PRL 51 863          ANKENBRANDT,BERGE+     (FNAL+IOWA+ISU+YALE)

                                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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Σ^-

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                   20  SIGMA-(1197,JP=1/2+) I=1

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                   20  SIGMA- MASS (MEV)

M   N   SEE NOTE PRECEDING LAMBDA MASS LISTINGS

M     3000 1197.43     0.08            SCHMIDT   65 HBC  SEE NOTE N          3/74
M          1197.24     0.15            DUGAN     75 CNTR    EXOTIC ATOMS    12/79
M          . . . . . . . . . .
M   AVG    1197.388    0.079   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
M   FIT    1197.34     0.05   FROM FIT                                      3/84*

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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
D   FIT       7.97     0.07   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)  3/84*

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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     0.13            SCHMIDT   65 HBC  SEE NOTE N          3/74
DL    2279   81.64     0.09            HEPP      68 HBC                     8/68
DL         . . . . . . . . . .
DL  AVG      81.693    0.069   AVERAGE
DL  FIT      81.740    0.052  FROM FIT                                      3/84*

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               20  SIGMA- MEAN LIFE (UNITS 10**-10 SEC)

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      0.1M    1.485    0.022          EISELE    70 HBC     K-P AT REST           2/71
T      1383    1.42     0.05           BAKKER    71 DBC     K-N TO SIG- 2PI     10/71
T              1.41     0.09     0.08  TOVEE     71 EMUL                        12/71
T      2400    1.463    0.039          ROBERTSON 72 HBC     K-P .25 GEV/C         3/74
T      8437    1.49     0.03           CONFORTO  76 HBC     K-P 1-1.4 GEV/C     11/77
T       16K    1.480    0.014          MARRAFFIN 80 HBC     K- P TO SIG- PI+      2/80
T  C    CHANG ERROR 0.018 RAISED BY US.  SEE 1970 EDITION, RMP 42,123(1970)    1/73
T   S   ERROR PURELY STATISTICAL.
T          . . . . . . . . . .
T   AVG        1.482    0.011    0.011  AVERAGE (ERROR INCL. SCALE FACTOR OF 1.3)
                        (SEE IDEOGRAM BELOW)
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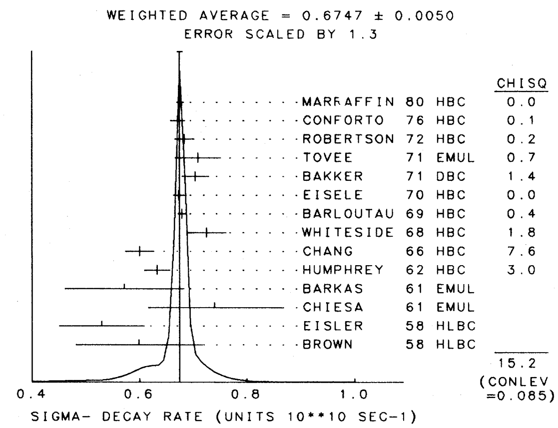


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               20  SIGMA- MAGNETIC MOMENT (MAGNETONS,938.26 MEV)

MM  R      BTWN -1.6 AND +0.8           FOX       73 CNTR   SIG-ATOM FINE ST  3/74
MM   R        -1.48      0.37           ROBERTS   74 CNTR   SIG-ATOM FINE ST 12/75
MM   D        -1.40      0.41     0.28  DUGAN     75 CNTR   SIG-ATOM FINE ST 12/79
MM  D         (0.65)    (0.28)   (0.40) DUGAN     75 CNTR   SIG-ATOM FINE ST 12/79
MM      28K   -0.71      1.25           HANSL     78 HBC    K-P-->SIG- PI+    7/79
MM     516K   -0.89      0.14           DECK      83 SPEC   P BE-->SIGMA- X  11/83*
MM            -1.111     0.033          HERTZOG   83 CNTR   SIG-ATOM FINE ST 10/83*
MM   R  ROBERTS 74 INCLUDES DATA FROM FOX 73.                               12/75
MM   D  DUGAN 75 NEGATIVE VALUE AVERAGED SINCE IT AGREES WITH ROBERTS 74.   12/79
MM          . . . . . . . . . .
MM  AVG       -1.104     0.049   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
                         (SEE IDEOGRAM BELOW)
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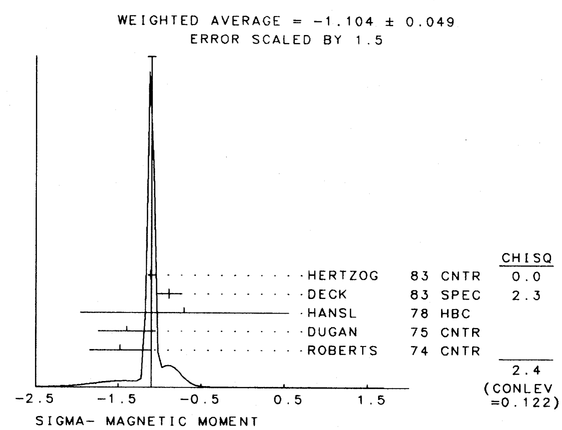


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               20  SIGMA- PARTIAL DECAY MODES

                                                     DECAY MASSES
P1     SIGMA- INTO NEUTRON PI-                        940+ 140
P2     SIGMA- INTO NEUTRON PI- GAMMA                  940+ 140+    0
P3     SIGMA- INTO NEUTRON MU- NEUTRINO               940+ 106+    0
P4     SIGMA- INTO NEUTRON E- NEUTRINO                940+.511+    0
P5     SIGMA- INTO LAMBDA E- NEUTRINO                1116+.511+    0

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Stable Particles

Data Card Listings

Σ^-

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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

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      331   (1.02)    (0.08)           ANG 1     69 HBC  REPL. BY EBENHOH 74 10/69
R2       57    0.97      0.15            COLE      71 HBC     STOP K-          10/71
R2    A 455    1.05      0.07      0.13  SECHIZORN 73 HBC     STOP K-           8/73
R2    A 601    1.09      0.06      0.08  EBENHOH   74 HBC     STOP K-           1/76
R2     2847    0.96      0.05            BOURQUI1  83 SPEC SPS HYPERON BEAM   2/84*
R2    A  ADDITIONAL NEGATIVE SYSTEMATIC ERROR INCLUDED FOR INTERNAL          2/84*
R2    A  RADIATIVE CORRECTIONS AND LATEST FORM FACTORS.  SEE BOURQUIN1 83.   2/84*
R2           . . . . . . . . .
R2  AVG        1.022     0.034   AVERAGE

R3      SIGMA- INTO (LAMBDA E- NEU)/(N PI-) (UNITS 10**-4)
R3                                                        (P5)/(P1)
R3       11    0.75      0.28            COURANT   64 HBC     STOP. K-
R3       35    0.64      0.12            BARASH    67 HBC     STOP K-           8/67
R3       31    0.69      0.12            EISELE1   69 HBC     STOP K-          10/69
R3       31    0.52      0.09            BALTAY    69 HBC     STOP K-           4/69
R3   H  122   (0.60)    (0.11)           HERBERT   78 ASPK    HYPERON BEAM      6/78
R3    H 114    0.63      0.11            THOMPSON  80 ASPK    HYPERON BEAM      9/81
R3 B  1620     0.561     0.031           BOURQUIN  82 SPEC    SPS HYPERON BEAM 11/83*
R3   H   HERBERT 78 REPLACED BY THOMPSON 80.
R3 B     VALUE IS FROM BOURQUIN2 83. INCLUDES RAD. CORR. AND NEW ACCEPTANCE. 11/83*
R3           . . . . . . . . .
R3  AVG        0.574     0.027   AVERAGE

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)    (0.02)           ANG 2     69 HBC     PI- LT 110 MEV/C 10/69
R4      292    0.46      0.06            EBENHOH   73 HBC     PI+ LT 150 MEV/C  3/74
R4       PI+ MOMENTUM CUTS DIFFER, NOT AVERAGED. LATEST VALUE USED IN TABLE.  4/82

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                    20  SIGMA- DECAY PARAMETERS

        SEE NOTE ON BARYON DECAY PARAMETERS IN NEUTRON SECTION ABOVE.

A-      ALPHA SIGMA-
A-           (-0.16)    (0.21)           TRIPP     62 HBC     REPL.BY BANGERTE
A-   O 6500  (-0.010)   (0.043)          BANGERTER 66 HBC     K-P TO SIG- PI+   7/66
A-   O 6068  (-0.104)   (0.04)           BERLEY    67 HBC     K-P TO SIG- PI+  11/67
A-    51000   -0.071     0.012           BANGERTER 69 HBC                      10/69
A-   B 5978  (-0.134)   (0.034)          BERLEY    70 HBC     K-P AT 400 MEV/C  2/71
A-    60000   -0.067     0.011           BOGERT    70 HBC     K-P AT 400 MEV/C 12/70
A-      28K   -0.062     0.024           HANSL     78 HBC     K-P-->SIG- PI+    7/79
A-   O   OLD RESULTS.  HAVE BEEN REPLACED.
A-   B   BERLEY 70 REPLACED BY BOGERT 70                                        2/71
A-           . . . . . . . . .
A-  AVG       -0.0681    0.0077  AVERAGE

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
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NOTE ON $\Sigma^- \to \Lambda e^- \nu$

(by J.A. Thompson, University of Pittsburgh)

The decay $\Sigma^- \to \Lambda e^- \nu$ is of special interest because its form is predicted by the strong form of CVC and is not sensitive to the current octet assumptions or SU(3) structure constants which enter into Cabibbo's predictions for the other hyperon decays. For $\Delta S = 0$ transitions, the weak interaction vector current is related to the electromagnetic current through a multiplicative constant, set by neutron beta decay, and an isospin rotation.

The decay $\Sigma^0 \to \Lambda\gamma$ (the isospin-rotation analogue of $\Sigma^- \to \Lambda e^- \nu$) is mediated predominantly through the magnetic interaction, assuming there are no inhomogeneities in the Σ^0, Λ charge distributions. Thus we expect the g_{WM} term,

$$g_{WM} \sim \frac{\mu_{\Sigma\Lambda}}{\sqrt{2}} \sim -\frac{\sqrt{3}}{2}\mu_n \text{ [by SU(3)]} ,$$

to dominate the vector part of the weak current. The strong CVC predictions are thus: $g_V/g_A = 0$ and $g_{WM} \sim 1.6$.

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AV      GV/GA FOR SIGMA TO LAMBDA BETA DECAY
AV       (FOR SIGN CONVENTION, SEE NOTE ON BARYON DECAY PARAMETERS IN
AV       NEUTRON SECTION ABOVE.)
AV       PREDICTED TO BE ZERO BY CONSERVED VECTOR CURRENT THEORY.
AV       VALUES AVERAGED ASSUME CVC-SU3 WEAK MAGNETISM TERM.
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    0.45     0.20             FRANZINI  72 HBC    USING SIG+-        1/73
AV       55  -0.17     0.35             TANENBAUM 75 SPEC   BNL HYPERON BEAM 12/75
AV      114  -0.29     0.29             THOMPSON  80 ASPK   BNL HYPERON BEAM  1/82
AV S  1620   -0.034    0.080            BOURQUIN  82 SPEC   SPS HYPERON BEAM 11/82*
AV   B  BARASH 67 MEASURED ABSOLUTE VALUE.
AV   S  SIGN CHANGED TO AGREE WITH OUR CONVENTION.
AV F    FRANZINI 72 INCLUDES EVENTS OF BARASH 67, EISELE1 69, BALTAY 69.     1/73
AV          . . . . . . . . .
AV  AVG       0.01     0.10   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
                             (SEE IDEOGRAM BELOW)
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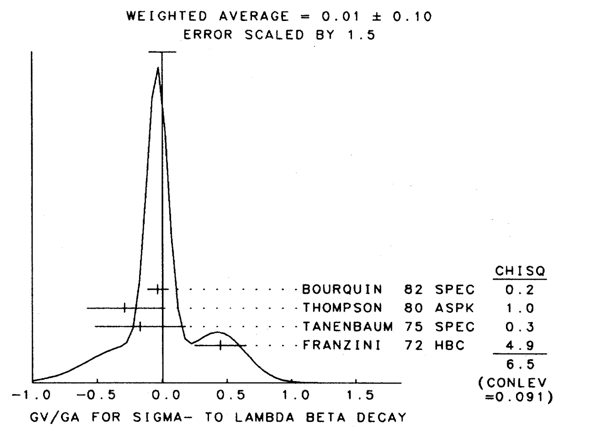


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WM      GWM/GA FOR SIGMA TO LAMBDA BETA DECAY
WM       VALUES QUOTED ASSUME THE CVC PREDICTION GV=0.
WM      186    2.4      2.1             FRANZINI  72 HBC    USING SIG+-        1/82
WM       55    3.5      4.5             TANENBAUM 75 SPEC   BNL HYPERON BEAM  1/82
WM      114    1.75     3.5             THOMPSON  80 ASPK   BNL HYPERON BEAM  1/82
WM          . . . . . . . . .
WM  AVG        2.4      1.7    AVERAGE

AV1     GA/GV FOR SIGMA TO NEUTRON BETA DECAY
AV1      (FOR SIGN CONVENTION, SEE NOTE ON BARYON DECAY PARAMETERS IN
AV1      NEUTRON SECTION ABOVE.)
AV1      57   (0.05)   (0.23)   (0.32) GERSHWIN  68 HBC  REPLACED BY GER.69   6/68
AV1      61   +0.19     0.20     0.17  GERSHWIN  69 HBC  POLARIZED SIGMAS    10/69
AV1      63   -0.33     0.30     0.85  BOGERT    70 HBC  K-P AT 400 MEV/C    10/70
AV1      43   -0.4      0.52     1.5   ELLIS     72 ASPK    POLARIZED SIGMAS 10/71
AV1   S 193    0.15  OR LESS  CL=.95   KELLER    82 SPEC    POLARIZED SIGMAS 11/82*
AV1   S4456   +.33 PREF. BY 2.6STD.DEV BOURQUI1  83 SPEC SPS HYPERON BEAM     2/84*
AV1   S  SIGN CHANGED TO AGREE WITH OUR CONVENTION.                          11/82*

AV2     ABSOLUTE VALUE OF GA/GV FOR SIGMA TO NEUTRON BETA DECAY
AV2      49    0.23     0.16           COLLERAIN 69 HBC     NEUTRON SCATTER  10/69
AV2      33    0.37     0.26     0.19  EISELE2   69 HBC     NEUTRON SCATTER  10/69
AV2      36    0.29     0.28     0.29  BALTAY    72 HBC     NEUTRON SCATTER   6/72
AV2    3507    0.435    0.035          TANENBAU  74 ASPK                     10/74
AV2     519    0.17     0.07     0.09  DECAMP    77 ELEC    H.E.HYPERON BEAM 11/77
AV2    4456    0.34     0.05           BOURQUI1  83 SPEC SPS HYPERON BEAM     2/84*
AV2          . . . . . . . . .
AV2 AVG        0.372    0.050   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.9)
                               (SEE IDEOGRAM BELOW)
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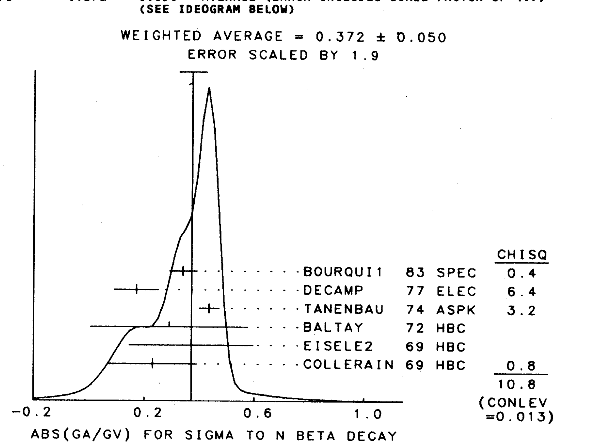

REFERENCES FOR SIGMA-

BROWN 58 CERN CONF 270 BROWN,GLASER,GRAVES,PERL,CRONIN + (MICH)
EISLER 58 NC SER10 10 150 EISLER,BASSI,CONVERSI+ (COLU,BNL,BGNA,PISA)

BARKAS 61 PR 124 1209 BARKAS,DYER,MASON,NICKOLS,SMITH (LRL)
CHIESA 61 NC 19 1171 A M CHIESA,B QUASSIATI,G RINAUDO (TURIN)
HUMPHREY 62 PR 127 1305 W E HUMPHREY,R R ROSS (LRL)
TRIPP 62 PRL 9 66 R D TRIPP,M WATSON,M FERRO-LUZZI (LRL)

BARKAS 63 PRL 11 26 W H BARKAS,J N DYER,H H HECKMAN (LRL)
BURNSTEI 64 PRL 13 66 BURNSTEIN,DAY,KEHOE,SECHI ZORN,SNOW (UMD)
COURANT 64 PR 136 B 1791 COURANT,FILTHUTH+ (CERN+HEID+UMD+NRL+BNL)
MILLER 64 PL 11 262 MILLER,STANNARD,BEZAGUET+ (LOUC,EPOL+BERG)
MURPHY 64 PR 134 B 188 C THORNTON MURPHY (WISCONSIN)
NAUENBER 64 PRL 12 679 NAUENBERG,SCHMIDT,MARATECK+(COLU+RUTG+PRIN)

BAZIN 65 PR 140 B 1358 BAZIN,PLANO,SCHMIDT + (PRIN+RUTG+COLU)
DOSCH 65 PL 14 239 DOSCH,ENGELMANN,FILTHUTH,HEPP,KLUGE+ (HEID)
ALSO 66 PR 151 1081 CHUNG YUN CHANG (COLUMBIA)
SCHMIDT 65 PR 140 B 1328 P SCHMIDT (COLUMBIA)
BANGERTE 66 PRL 17 495 BANGERTER,GALTIERI,BERGE,MURRAY+ (LRL)
CHANG 66 PR 151 1081 CHUNG YUN CHANG (COLUMBIA)
CHIEN 66 PR 152 1171 +LACH,SANDWEISS,TAFT,YEH,OREN + (YALE+BNL)

BARASH 67 PRL 19 181 BARASH,DAY,GLASSER,KEHOE,KNOP + (MARYLAND)
BERLEY 67 PRL 19 979 BERLEY,HERTZBACH,KOFLER + (BNL,MASA,YALE)
BIERMAN 68 PRL 20 1459 BIERMAN,KOUNOSU,NAUENBERG + (PRINCETON)
GERSHWIN 68 PRL 20 1270 GERSHWIN,ALSTON-GARNJOST,BANGERTER+ (LRL)
HEPP 68 ZPHY 214 71 V.HEPP,H. SCHLEICH (HEIDELBERG)
WHITESID 68 NC 54A 537 H. WHITESIDE,J. 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)
EISELE 70 ZPHY 238 372 +FILTHUTH,HEPP,PRESSER,ZECH (HEIDELBERG)

BAKKER 71 LNC 1 37 +,SABRE COLLAB. (ZEEM+SACL+BGNA+REHO+EPOL)
COLE 71 PR D4 631 +LEE-FRANZINI,LOVELESS,BALTAY+ (STON,COLU)
ALSO 69 NEVIS-175 THESIS HERBERT NORTON (COLUMBIA)
TOVEE 71 NP B33 493 LOUC,BELGRADE,BERL,BRUX,DUBLIN,WARS COLLAB

BALTAY 72 PR D5 1569 +FEINMAN,FRANZINI,NEWMAN,YEH+ (COLU+STON)
BOHM 72 NP B48 1 BERLIN+BELGRADE+BRUX+DUBLIN+LOUC+WARSAW
ELLIS 72 NP B39 77 OXF+AERE+RHEL+LOQM+LYON+NWES+ITEP COLLABOR
FRANZINI 72 PR D6 2417 COLUMBIA+HEIDELBERG+MARYLAND+STONY BROOK
ROBERTSO 72 THESIS R.M.ROBERTSON (IIT)

EBENHOH 73 ZPHY 264 413 +EISELE,FILTHUTH,HEPP,LEITNER,THOUW+ (HEID)
FOX 73 PRL 31 1084 +LAM,BARNES,EISENSTEIN+ (BNL+VPI+WILL+WYOM)
SECHIZOR 73 PR D8 12 B.SECHI-ZORN,G.SNOW (UMD)

EBENHOH 74 ZPHY 266 367 +EISELE,ENGELMANN,FILTHUTH,HEPP + (HEID)
ROBERTS 74 PRL 32 1265 WILL+VPI+CARN+WYOM+CIT COLLABORATION
ALSO 74 PRL 33 122 ERRATUM TO ROBERTS 74
ALSO 75 PR D12 1232 ROBERTS,COX + (WILL+VPI+CARN+WYOM+CIT+BNL)
TANENBAU 74 PRL 33 175 TANENBAUM,HUNGERBUEHLER + (YALE+FNAL+BNL)
ALSO 75 TANENBAUM

DUGAN 75 NP A254 396 +ASANO,CHEN,CHENG,HU,LIDOFSKY+ (COLU+YALE)
TANENBAU 75 PR D12 1871 TANENBAUM,HUNGERBUEHLER + (YALE+FNAL+BNL)
CONFORTO 76 NP B105 189 +GOPAL,KALMUS,LITCHFIELD,ROSS + (RHEL+LOIC)
DECAMP 77 PL 66B 295 +BADIER,BLAND,CHOLLET,GAILLARD+ (LALO+EPOL)

HANSL 78 NP B132 45 +MANZ,MATT,REUCROFT,SETTLES + (MPIM+VAND)
HERBERT 78 PRL 40 1230 +CLELAND,COOPER,DRIS,ENGELS + (PITT+BNL)
MARRAFFI 80 PR D21 2501 MARRAFFINO,REUCROFT,ROOS,WATERS+(VAND+MPIM)
THOMPSON 80 PR D21 25 +CLELAND,COOPER,DRIS,ENGELS+ (PITT+BNL)

BOURQUIN 82 ZPHY C12 307 +BROWN + (BRIS+GEVA+HEID+LALO+RL+STRB)
ALSO 83 BOURQUIZ
KELLER 82 PRL 48 971 +LESNIK,ROMANOWSKI,KEIG + (OSU+CHIC+ANL)
BOURQUI1 83 ZPHY C21 17 BOURQUIN+ (BRIS+GEVA+HEID+LALO+RL+STRB)
BOURQUI2 83 ZPHY C21 27 BOURQUIN+ (BRIS+GEVA+HEID+LALO+RL+STRB)
DECK 83 PR D28 1 +BERETVAS,DEVLIN,LUK+ (RUTG+WISC+MICH+MINN)
HERTZOG 83 PRL 51 1131 +ECKHAUSE+ (WILL+BOST+CIT+CARN+WYOM)

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 SIGMAO(1193,JP=1/2+) I=1

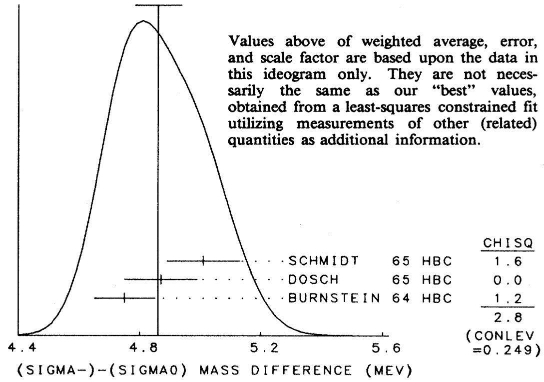
JP NOT MEASURED FOR SIGMAO. ASSUMED SAME AS SIGMA+ AND SIGMA- TO ALLOW ISOTRIPLET ASSOCIATION.

21 (SIGMA-) - (SIGMAO) MASS DIFFERENCE (MEV)

D1 N SEE NOTE PRECEDING LAMBDA MASS LISTINGS.

D1	18	4.75	0.1	BURNSTEIN 64 HBC			
D1	37	4.87	0.12	DOSCH 65 HBC			
D1	12	5.01	0.12	SCHMIDT 65 HBC	SEE NOTE N		3/74
D1		. . . . . .	. . . . . .				
D1	AVG	4.860	0.076	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)			
D1	FIT	4.881	0.063	FROM FIT			3/84*
			(SEE IDEOGRAM BELOW)				

WEIGHTED AVERAGE = 4.860 ± 0.076
ERROR SCALED BY 1.2



Values above of weighted average, error, and scale factor are based upon the data in this ideogram only. They are not necessarily the same as our "best" values, obtained from a least-squares constrained fit utilizing measurements of other (related) quantities as additional information.

21 (SIGMAO) - (LAMBDA) MASS DIFFERENCE (MEV)

DL N SEE NOTE PRECEDING LAMBDA MASS LISTINGS.

DL	208	76.63	0.28	SCHMIDT 65 HBC	SEE NOTE N	6/68
DL	109	76.23	0.55	COLAS 75 HLBC	LAMBDA-GAMMA DEC	12/75
DL		. . . . . .	. . . . . .			
DL	AVG	76.55	0.25	AVERAGE		
DL	FIT	76.86	0.08	FROM FIT		3/84*

21 SIGMAO MEAN LIFE (UNITS 10**-19 SEC)

T	(E-14 OR LESS)		DAVIS 62 EMUL		6/77
T	0.58	0.13	DYDAK 77 SPEC	PRIMAKOFF EFFECT	6/77

21 SIGMAO PARTIAL DECAY MODES

		DECAY MASSES
P1	SIGMAO INTO LAMBDA GAMMA	1116+ 0
P2	SIGMAO INTO LAMBDA E+ E-	1116+.511+.511
P3	SIGMAO INTO LAMBDA GAMMA GAMMA	1116+ 0+ 0

21 SIGMAO BRANCHING RATIOS

R1	SIGMAO INTO(LAMBDA E+ E-)/TOTAL	(P2)/(P1+P2)		
R1	0.00545 THEORET. CAL. FEINBERG 58		QUANTUM ELECT.	9/66
R2	SIGMAO INTO (LAMBDA GAMMA GAMMA)/(LAMBDA GAMMA)	(P3)/(P1)		12/75
R2	0.03 OR LESS CL=.90 COLAS 75 HLBC			12/75

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REFERENCES FOR SIGMAO

FEINBERG 58 PR 109 1019 G.FEINBERG (BNL)
DAVIS 62 PR 127 605 D DAVIS,R SETTI,M RAYMOND,G TOMASIN (EFI)
BURNSTEI 64 PRL 13 66 BURNSTEIN,DAY,KEHOE,SECHI ZORN,SNOW (UMD)
DOSCH 65 PL 14 239 DOSCH,ENGELMANN,FILTHUTH,HEPP,KLUGE+ (HEID)
SCHMIDT 65 PR 140 B 1328 P SCHMIDT (COLUMBIA)

COLAS 75 NP B91 253 +FARWELL,FERRER,SIX (ORSA)
DYDAK 77 NP B118 1 +NAVARRIA,OVERSETH,STEFFEN+(CERN+DORT+HEID)

PAPERS NOT REFERRED TO IN DATA CARDS

COURANT 63 PRL 10 409 COURANT,FILTHUTH,FRANZINI+ (CERN+UMD+NRL)

QUANTUM NUMBER DETERMINATIONS NOT REFERRED TO IN THE DATA CARDS

ALFF 65 PR 137 B1105 ALFF,GELFAND,NAUENBERG+ (COLUMBIA+RUTG+BNL)P

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22 XI-(1321,JP=1/2) I=1/2

22 XI- MASS (MEV)

M H	11(1317.0)	(2.2)	WANG 61 HLBC			
M H	18(1317.9)	(1.9)	FOWLER 61 HLBC			
M H	(OLD DATA AND LOW STATISTICS DROPPED ON SUGGESTION OF J R HUBBARD)					
M	517 1321.4	0.4	JAUNEAU 63 FBC			
M	62 1321.1	0.65	SCHNEIDER 63 HBC			
M	241 1321.1	0.3	BADIER1 64 HBC			
M	ALL MASSES ABOVE WERE RAISED 0.09 MEV BECAUSE LAMBDA MASS RAISED					
M	149 1321.3	0.4	PJERROU 65 HBC			11/67
M	6 1321.67	0.52	CHIEN 66 HBC	-	6.9 PBAR P	9/67
M	299 1321.4	1.1	LONDON 66 HBC			6/66
M G	195 1321.87	0.51	GOLDWASSE 70 HBC		5.5 K-P	8/70
M G	USES LAMBDA MASS OF 1115.58-M(XI) IS 1322.18 IF M(LAMBDA)=1115.84					8/70
M	268 1321.12	0.41	WILQUET 72 HLBC			1/73
M	632 1321.46	0.34	DIBIANCA 75 DBC		4.9 GEV/C K-D	1/77
M	. . . . . .	. . . . . .				
M AVG	1321.34	0.14	AVERAGE			
M FIT	1321.32	0.13	FROM FIT			3/84*

THE FIT ASSUMES XI AND ANTI-XI MASSES EQUAL.

Stable Particles

Data Card Listings

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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
M1   FIT    1321.32     0.13   FROM FIT                                           3/84*
         THE FIT ASSUMES XI AND ANTI-XI MASSES EQUAL.

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                    22  (XI-) - (ANTI-XI+) MASS DIFFERENCE (MEV)

DM           1.0        1.1              CHIEN      66 HBC       6.9 PBAR P       9/67
DM       MASS DIFFERENCE FROM SECTIONS M-M1 IS +0.14+-0.36 MEV.                   3/84*

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                    22  XI- MAGNETIC MOMENT (MAGNETONS,938.26 MEV)

MM    2724   -0.1       2.1              BINGHAM    70 OSPK  - 1.8 GEV/C K-P      2/71
MM    2436   -2.1       0.8              COOL       74 OSPK -  1.8 GEV/C K-P     10/74
MM         . . . . . . . . . . .
MM   AVG     -1.85      0.75    AVERAGE

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                    22  XI- MEAN LIFE (UNITS 10**-10 SEC)

T    H    11   (3.5)    (3.4)    (1.23) WANG      61 HLBC
T    H    18   (1.28)   (0.41)   (0.25) FOWLER    61 HLBC
T    H    (OLD DATA AND LOW STATISTICS DROPPED ON SUGGESTION OF J R HUBBARD)
T        517    1.86     0.15     0.14  JAUNEAU   63 FBC
T         62    1.55     0.31     0.31  SCHNEIDER 63 HBC
T        356   (1.77)   (0.12)          CARMONY   64 HBC     REP BY PJERROU 65
T        794    1.69     0.07           HUBBARD   64 HBC
T        246    1.70     0.12           PJERROU   65 HBC                         11/67
T    S     6   (1.37)   (0.51)          CHIEN     66 HBC   -  6.9 PBAR P          9/67
T        299    1.80     0.16           LONDON    66 HBC                          6/66
T    S         (1.67)   (0.07)          BURGUN    68 HBC      K-P AT 1.3-1.8      2/71
T       2610    1.61     0.04           DAUBER    69 HBC                          6/68
T        680    1.73     0.08     0.07  MAYEUR    72 HLBC     2.1 GEV/C K-        1/73
T       4303    1.63     0.03           BALTAY    74 HBC      1.75 GEV/C K-       3/74
T    S 2436    (1.637)  (0.050)         COOL      74 OSPK -   1.8 GEV/C K-P      10/74
T               1.67     0.08           DIBIANCA  75 DBC      4.9 GEV/C K-D       1/77
T       4286    1.609    0.028          HEMINGWAY 78 HBC      4.2 GEV/C K- P      7/79
T        41K    1.665    0.065          BOURQUIN  79 SPEC     HYPERON BEAM       12/79
T    S   THE ERROR IS STATISTICAL ONLY
T          . . . . . . . . . . .
T    AVG        1.641    0.016    0.016  AVERAGE

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                    22  ANTI-XI+ MEAN LIFE (UNITS 10**-10 SEC)

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-                            1116+ 140
P2      XI- INTO LAMBDA E- NEUTRINO                    1116+.511+    0
P3      XI- INTO NEUTRON PI-                            940+ 140
P4      XI- INTO LAMBDA MU- NEUTRINO                   1116+ 106+    0
P5      XI- INTO SIGMAO E- NEUTRINO                    1192+.511+    0
P6      XI- INTO SIGMAO MU- NEUTRINO                   1192+ 106+    0
P7      XI- INTO NEUTRON E- NEUTRINO                    940+.511+    0
P8      XI- INTO NEUTRON MU- NEUTRINO                   940+ 106+    0
P9      XI- INTO SIGMA- GAMMA                          1197+   0
P10     XI- INTO PROTON PI- PI-                         938+ 140+ 140
P11     XI- INTO PROTON PI- E- NEUTRINO                 938+ 140+.511+    0
P12     XI- INTO PROTON PI- MU- NEUTRINO                938+ 140+ 106+    0
P13     XI- INTO XIO E- NEUTRINO                       1315+.511+    0

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                    22  XI- BRANCHING RATIOS

R1      XI- INTO (LAMBDA E- NEU)/(LAMBDA PI-) (UNITS 10**-3)
R1                                                     (P2)/(P1)
R1        1        155 EFFECTIVE DENOM.  CARMONY   63 HBC                         11/67
R1        0        260 EFFECTIVE DENOM.  JAUNEAU   63 HBC                         11/67
R1        0        220 EFFECTIVE DENOM.  BERGE     66 HBC                         11/67
R1        1        155 EFFECTIVE DENOM.  LONDON    66 HBC                         11/67
R1        0        717 EFFECTIVE DENOM.  TRIPPE    67 HBC                         11/67
R1        2       1976 EFFECTIVE DENOM.  HUBBARD   68 HBC                          6/68
R1   H    4    (1.15)   (0.90)   (0.55) HUBBARD   68 RVUE                          6/68
R1   H    HUBBARD 68 (RVUE) INCLUDES ALL ABOVE EVENTS                              6/68
R1        1     0.24     0.24           YEH       74 HBC                           7/75
R1       11    (0.31)   (0.11)          HERBERT   78 ASPK REPL.BY THOMPSON 80      9/81
R1       11     0.30     0.13           THOMPSON  80 ASPK    HYPERON BEAM          9/81
R1     2857     0.564    0.031          BOURQUIN  83 SPEC SPS HYPERON BEAM         2/84*
R1          . . . . . . . . . . .
R1   AVG        0.545    0.059   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.0)
                        (SEE IDEOGRAM BELOW)

R2      XI- INTO (NEUTRON PI-)/(LAMBDA PI-) (UNITS 10**-3)
R2                                                     (P3)/(P1)
R2             (5.0)   OR LESS          FERRO-LUZ 63 HBC                           6/68
R2             (1.1)   OR LESS          DAUBER    69 HBC                           6/68
R2        0    (3.0)   OR LESS  CL=.90  YEH       74 HBC        760 EFF.DENOM.    7/75
R2              0.019 OR LESS  CL=.90   BIAGI2    82 SPEC CERN-SPS HYPERON BM    11/82*

R3      XI- INTO (LAMBDA MU- NEUTRINO)/TOTAL (UNITS 10**-3)
R3                                                     (P4)
R3            (12.0)   OR LESS          BERGE     66 HBC                           6/68
R3             (1.3)   OR LESS          DAUBER    69 HBC                           6/68
R3        1     0.35      0.35          YEH       74 HBC       2859 EFF.DENOM.    7/75
R3        0    (2.3)   OR LESS   CL=.90 THOMPSON  80 ASPK      1017 EFF.DENOM.    9/81

R4      XI- INTO (SIGMAO E- NEUTRINO)/TOTAL (UNITS 10**-3)
R4                                                     (P5)
R4             (3.0)   OR LESS          BERGE     66 HBC                           6/68
R4             (0.5)   OR LESS          DAUBER    69 HBC                           6/68
R4        0    (0.53)  OR LESS  CL=.90  YEH       74 HBC       4363 EFF.DENOM.    7/75
R4        0    (0.14)  OR LESS  CL=.90  THOMPSON  80 ASPK     16000 EFF.DENOM.    9/81
R4      154     0.087    0.017          BOURQUIN  83 SPEC SPS HYPERON BEAM         2/84*
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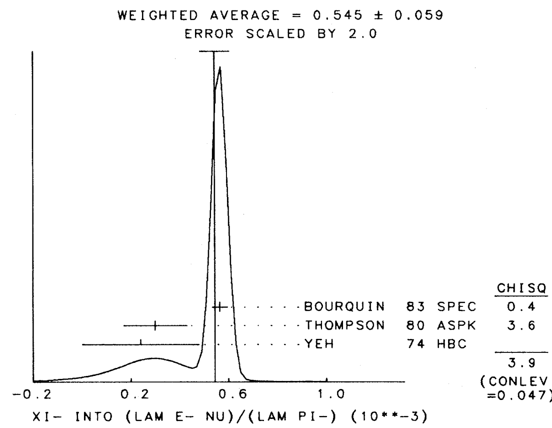


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R5      XI- INTO (SIGO MU- NEU)/(LAM PI-) (UNITS 10**-3) (P6)/(P1)
R5           (5.0)   OR LESS          BERGE     66 HBC                           7/66
R5      0     0.76   OR LESS  CL=.90  YEH       74 HBC       3026 EFF.DENOM.    7/75

R6      XI- INTO (N E- NEU)/(LAMBDA PI-) (UNITS 10**-3)  (P7)/(P1)
R6       TEST OF DELTA-S = DELTA-Q RULE
R6          (10.0)   OR LESS  CL=.90  BINGHAM   65 RVUE                          9/66
R6      0     3.2    OR LESS  CL=.90  YEH       74 HBC        715 EFF.DENOM.    7/75

R7      XI- INTO (SIGMAO E- NEU + LAMBDA E- NEU)/TOTAL (10**-3)
R7                                                   (P2+P5)
R7   D   17    (0.68)    (0.22)       DUCLOS    71 OSPK    SEE NOTE D         10/71
R7   B 3011    (0.651)   (0.031)      BOURQUIN  83 SPEC SPS HYPERON BEAM      2/84*
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.
R7   B   BOURQUIN 83 VALUE IS CORRELATED WITH THEIR RESULT FOR R1 AND R4.    2/84*

R8      XI- INTO (N MU- NEU)/(LAMBDA PI-) (UNITS 10**-3) (P8)/(P1)
R8       TEST OF DELTA-S = DELTA-Q RULE
R8      0    15.3    OR LESS  CL=.90  YEH       74 HBC        150 EFF.DENOM. 11/75

R9      XI- INTO (SIGMA- GAMMA)/(LAM PI-) (UNITS 10**-4) (P9)/(P1)
R9      0    11.5    OR LESS  CL=.90  YEH       74 HBC       2000 EFF.DENOM. 11/75

R10     XI- INTO (P PI- PI-)/(LAMBDA PI-) (UNITS 10**-4) (P10)/(P1)
R10     0     3.7    OR LESS  CL=.90  YEH       74 HBC       6200 EFF.DENOM. 11/75

R11     XI- INTO (P PI- E- NEU)/(LAM PI-) (UNITS 10**-4) (P11)/(P1)
R11      TEST OF DELTA-S = DELTA-Q RULE
R11     0     3.7    OR LESS  CL=.90  YEH       74 HBC       6200 EFF.DENOM. 11/75

R12     XI- INTO (P PI- MU- NEU)/(LAM PI-) (UNITS 10**-4) (P12)/(P1)
R12      TEST OF DELTA-S = DELTA-Q RULE
R12     0     3.7    OR LESS  CL=.90  YEH       74 HBC       6200 EFF.DENOM. 11/75

R13     XI- INTO (XIO E- NEU)/(LAM PI-) (UNITS 10**-3)   (P13)/(P1)
R13     0     2.3    OR LESS  CL=.90  YEH       74 HBC       1000 EFF.DENOM. 11/75

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                    22  XI- DECAY PARAMETERS

         SEE NOTE ON BARYON DECAY PARAMETERS IN NEUTRON SECTION ABOVE.

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      2529   (-0.375)   (0.051)       MERRILL   68 HBC   REPL. BY DAUBER 69  6/68
A      2781    -0.391     0.045        DAUBER    69 HBC     SEE NOTE A BELOW
A      2724    -0.383     0.065        BINGHAM   70 OSPK                     10/70
A       820    -0.42      0.11         MAYEUR    72 HLBC    2.1 GEV/C K-      1/73
A      4303    -0.376     0.038        BALTAY    74 HBC     1.75 GEV/C K-     3/74
A      2436    -0.39      0.05         COOL      74 OSPK -  1.8 GEV/C K-P    10/74
A     B 414    -0.40      0.19         DIBIANCA  75 DBC     4.9 GEV/C K-D     1/77
A      6599    -0.370     0.032        HEMINGWAY 78 HBC     4.2 GEV/C K- P    7/79
A      9046    -0.49      0.04         CLELAND   80 ASPK    BNL HYPERON BEAM  9/81
A    C 150K    -0.462     0.015        BIAGI     82 SPEC CERN-SPS HYPERON BM  4/82
A     O   OLD DATA NOT INCLUDED IN AVERAGE.
A     D   ERRORS MULTIPLIED BY 1.1 DUE TO APPROXIMATIONS USED FOR XI
A     D   POLARIZATION. (SEE DAUBER 69 FOR DETAILED DISCUSSION)              6/68
A    L    LONDON 66 USES ALPHA-LAMBDA = 0.62
A     A   USED ALPHA LAMBDA = 0.647 +- 0.020.
A      B  DIBIANCA 75 USES ALPHA LAMBDA = 0.647.                              1/77
A    C    BIAGI 82 USES ALPHA LAMBDA = -0.647+-0.014                          4/82
A           . . . . . . . . . . .
A     AVG      -0.434     0.015   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
                         (SEE IDEOGRAM BELOW)

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      2529    (9.8)     (11.6)        MERRILL   68 HBC   REPL. BY DAUBER 69  6/68
F      2781   -14.        11.          DAUBER    69 HBC     SEE NOTE A BELOW
F      2724   -26.0       30.0         BINGHAM   70 OSPK                     10/70
F      4303    11.0        9.0         BALTAY    74 HBC     1.75 GEV/C K-     3/74
F      2436     5.0       16.0         COOL      74 OSPK -  1.8 GEV/C K-P    10/74
F     O   OLD DATA NOT INCLUDED IN AVERAGE.
F     D   ERRORS MULTIPLIED BY 1.2 DUE TO APPROXIMATIONS USED FOR XI
F     D   POLARIZATION. (SEE DAUBER 68 FOR DETAILED DISCUSSION)
F    L    LONDON 66 USES ALPHA-LAMBDA = 0.62
F     A   USED ALPHA LAMBDA = 0.647 +- 0.020.
F           . . . . . . . . . .
F     AVG       2.0        5.7    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
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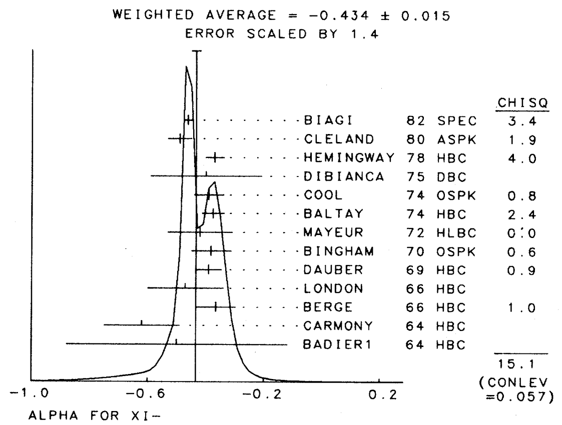


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AV      GA/GV FOR XI- TO LAMBDA BETA DECAY
AV        (FOR SIGN CONVENTION, SEE NOTE ON BARYON DECAY PARAMETERS IN
AV        NEUTRON SECTION ABOVE.)
AV     1992   -0.25      0.05             BOURQUIN  83 SPEC SPS HYPERON BEAM     2/84*

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REFERENCES FOR XI-


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FOWLER   61 PRL 6 134            FOWLER,BIRGE,EBERHARD,ELY,GOOD,POWELL+(LRL)
WANG     61 JETP 13 512          K WANG,T WANG,VIRYASOV,TING,SOLOVEV+ (JINR)
BROWN    62 PRL 8 255            BROWN,CULWICK,FOWLER,GAILLOUD +  (BNL+YALE)

CARMONY  63 PRL  10  381         CARMONY,PJERROU                      (UCLA)
FERRO-LU 63 PR 130 1568          FERRO-LUZZI,ALSTON,ROSENFELD,WOJCICKI (LRL)
JAUNEAU  63 SIENA CONF 4         JAUNEAU+       (EPOL+CERN+LOUC+RHEL+BERGEN)
    ALSO 63 PL  5  261           JAUNEAU,+      (EPOL,CERN,LOUC,RHEL,BERGEN)
SCHNEIDE 63 PL 4 360             H SCHNEIDER                          (CERN)

CARMONY  64 PRL 12 482           CARMONY,PJERROU,SCHLEIN,SLATER,STORK+(UCLA) J
BADIER1  64 DUBNA CONF I 593     BADIER,DEMOULIN,BARLOUTAUD+(EPOL,SACL,ZEEM)
HUBBARD  64 PR 135 B 183         HUBBARD,BERGE,KALBFLEISCH,SHAFER +    (LRL)
BINGHAM  65 PRSL  285  202       H H BINGHAM                          (CERN)
PJERROU  65 PRL 14 275           + SCHLEIN,SLATER,SMITH,STORK,TICHO   (UCLA)
PJERROU  65 THESIS               G M PJERROU                          (UCLA)

BERGE    66 PR  147  945         BERGE,EBERHARD,HUBBARD,MERRILL +      (LRL)
BERGE 2  66 BERKELEY CONF 46     BERGE,CABIBBO                (LRL,CERN(RVUE))
LONDON   66 PR 143 1034          LONDON,RAU,GOLDBERG,LICHTMAN+(BNL+SYRACUSE)
CHIEN    66 PR  152  1171        +LACH,SANDWEISS,TAFT,YEH,OREN +  (YALE+BNL)
SHEN     67 PL 25 B 443          B.C.SHEN,A.FIRESTONE,G.GOLDHABER  (UCB+LRL)
TRIPPE   67 PRIV. COMM.          T. TRIPPE                            (UCLA)

BURGUN   68 NP 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 1262         +BERGE,HUBBARD,MERRILL,MILLER         (LRL)J
BINGHAM  70 PR D1 3010           +COOK,HUMPHREY,SANDER,WILLIAMS+ (UCSD,WASH)
GOLDWASS 70 PR D1 1960           GOLDWASSER, SCHULTZ                   (ILL)
STONE    70 PL 32B 515           +BERLINGHIERI,BROMBERG,COHEN,FERBEL +(ROCH)

DUCLOS   71 NP B32 493           +FREYTAG,HEINTZE,HEINZELMAN,JONES+   (CERN)
MAYEUR   72 NP B47 333           +VAN BINST,WILQUET+   (BRUX+CERN+TUFT+LOUC)
VOTRUBA  72 NP B45 77            VOTRUBA,SAFDER,RATCLIFFE          (BIRM+EDIN)
WILQUET  72 PL 42B 372           +FLIAGINE,GUY,KNIGHT+ (BRUX+CERN+TUFT+LOUC)
BALTAY   74 PR D9 49             +BRIDGEWATER,COOPER,GERSHWIN+   (COLU+BING)J
COOL     74 PR D10 792           +GIACOMELLI,JENKINS,KYCIA,LEONTIC,LI+ (BNL)
    ALSO 72 PRL 29 1630          COOL,GIACOMELLI,JENKINS,KYCIA,LEONTIC+(BNL)
YEH      74 PR D10 3545          +GAIGALAS,SMITH,ZENDLE,BALTAY + (BING+COLU)
DIBIANCA 75 NP B98 137           F.A.DIBIANCA, R.J.ENDORF             (CARN)

HEMINGWA 78 NP B142 205          HEMINGWAY,ARMENTEROS+  (CERN+ZEEM+NIJM+OXF)
HERBERT  78 PRL 40 1230          +CLELAND,COOPER,DRIS,ENGELS +     (PITT+BNL)
BOURQUIN 79 PL 87B 297             (BRIS+GEVA+HEID+ORSA+RHEL+STRB+CERN+MELB)
CLELAND  80 PR D21 12            +COOPER,DRIS,ENGELS,HERBERT+      (PITT+BNL)
THOMPSON 80 PR D21 25            +CLELAND,COOPER,DRIS,ENGELS+      (PITT+BNL)
BIAGI    82 PL 112B 265          +          (BRIS+CAMB+GEVA+HEID+LAUS+LOQM+RL)
BIAGI2   82 PL 112B 277          +          (LOQM+GEVA+RL+HEID+CAMB+LAUS+BRIS)
BOURQUIN 83 ZPHY C21 1           +BROWN+         (BRIS+GEVA+HEID+LALO+RL+STRB)
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23 XIO(1315,JP=1/2) I=1/2

23 XIO MASS (MEV)

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M         1 1313.4        1.8               PALMER    68 HBC                    3/68
M        49 1315.2        0.92              WILQUET   72 HLBC                   1/73
M           . . . . . . . . .
M    AVG    1314.83       0.82    AVERAGE
M    FIT    1314.91       0.55   FROM FIT                                       3/84*
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23 (XI-) - (XIO) MASS DIFFERENCE (MEV)

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D        23    6.8        1.6               JAUNEAU   63 FBC
D        45   (6.1)      (1.6)              CARMONY   64 HBC    REP BY PJERROU 65
D        88    6.1        0.9               PJERROU   65 HBC                   11/67
D        29    6.9        2.2               LONDON    66 HBC                    6/66
D           . . . . . . . . .
D    AVG       6.34       0.74    AVERAGE
D    FIT       6.41       0.55   FROM FIT                                       3/84*
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23 XIO MEAN LIFE (UNITS 10-10 SEC)**

```
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   M    157    2.90      0.32       0.27  MAYEUR    72 HLBC    2.1 GEV/C K-     1/74
T        652    2.88      0.21       0.19  BALTAY    74 HBC     1.75 GEV/C K-    3/74
T   Z   6300    2.77      0.16             ZECH      77 SPEC NEUTRAL HYP. BEAM  12/77
T   M     MAYEUR 72 VALUE MODIFIED BY ERRATUM.                                   1/74
T   Z     ZECH 77 VALUE IS FOR LAMBDA LIFETIME=2.69E-10. FOR LAM LIFETIME       12/77
T   Z     DIFFERENT FROM THIS, TAUXIO=(2.77-(TAULAMBDA-2.69))E-10.              12/77
T             . . . . . . . . .
T    AVG        2.903     0.099      0.093  AVERAGE
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23 XIO MAGNETIC MOMENT (MAGNETONS,938.26 MEV)

```
MM       42K  -1.20       0.06              BUNCE     79 SPEC                    1/80
MM      270K  -1.253      0.014             COX       81 SPEC                   12/81
MM            . . . . . . . . .
MM   AVG      -1.250      0.014    AVERAGE
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23 XIO PARTIAL DECAY MODES

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                                                           DECAY MASSES
P1      XIO INTO LAMBDA PIO                               1116+ 135
P2      XIO INTO PROTON PI-                                938+ 140
P3      XIO INTO PROTON E- NEU                             938+.511+   0
P4      XIO INTO SIGMA+ E- NEU                            1189+.511+   0
P5      XIO INTO SIGMA- E+ NEU                            1197+.511+   0
P6      XIO INTO SIGMA+ MU- NEU                           1189+ 106+   0
P7      XIO INTO SIGMA- MU+ NEU                           1197+ 106+   0
P8      XIO INTO PROTON MU- NEU                            938+ 106+   0
P9      XIO INTO LAMBDA GAMMA                             1116+   0
P10     XIO INTO SIGMAO GAMMA                             1192+   0
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23 XIO BRANCHING RATIOS

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R1      XIO INTO (PROTON PI-)/(LAMBDA PIO)  (UNITS 10**-5)
R1                                                     (P2)/(P1)
R1         (2700.)   OR LESS             TICHO      63 HBC                     6/68
R1          (500.)   OR LESS             HUBBARD    66 HBC                     6/68
R1           (90.)   OR LESS             DAUBER     69 HBC                     6/68
R1       0 (180.)    OR LESS   CL=.90    YEH        74 HBC      1300 EFF.DENOM. 11/75
R1            3.6    OR LESS   CL=.90    GEWENIGER  75 SPEC                    11/75

R2      XIO INTO (PROTON E- NEU)/(LAMBDA PIO) (UNITS 10**-3)
R2                                                     (P3)/(P1)
R2       TEST OF DELTA-S = DELTA-Q RULE
R2          (27.0)   OR LESS             TICHO      63 HBC                     6/68
R2           (6.0)   OR LESS             HUBBARD    66 HBC                     6/68
R2            1.3    OR LESS             DAUBER     69 HBC                     6/68
R2       0   (3.4)   OR LESS   CL=.90    YEH        74 HBC       670 EFF.DENOM. 11/75

R3      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
R3       0    1.1    OR LESS   CL=.90    YEH        74 HBC      2100 EFF.DENOM. 11/75

R4      XIO INTO (SIGMA- E+ NEU)/(LAMBDA PIO) (UNITS 10**-3)
R4                                                     (P5)/(P1)
R4       TEST OF DELTA-S = DELTA-Q RULE
R4           (6.0)   OR LESS             HUBBARD    66 HBC                     6/68
R4           (1.5)   OR LESS             DAUBER     69 HBC                     6/68
R4       0    0.9    OR LESS   CL=.90    YEH        74 HBC      2500 EFF.DENOM. 11/75

R5      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
R5       0    1.1    OR LESS   CL=.90    YEH        74 HBC      2100 EFF.DENOM. 11/75

R6      XIO INTO (SIGMA- MU+ NEU)/TOTAL (UNITS 10**-3)   (P7)
R6       TEST OF DELTA-S = DELTA-Q RULE
R6           (6.0)   OR LESS             HUBBARD    66 HBC                     6/68
R6           (1.5)   OR LESS             DAUBER     69 HBC                     6/68
R6       0    0.9    OR LESS   CL=.90    YEH        74 HBC      2500 EFF.DENOM. 11/75

R7      XIO INTO (PROTON MU- NEU)/TOTAL (UNITS 10**-3)   (P8)
R7       TEST OF DELTA-S = DELTA-Q RULE
R7           (6.0)   OR LESS             HUBBARD    66 HBC                     6/68
R7            1.3    OR LESS             DAUBER     69 HBC                     6/68
R7       0   (3.5)   OR LESS   CL=.90    YEH        74 HBC       664 EFF.DENOM. 11/75

R8      XIO INTO (LAMBDA GAMMA)/(LAM PIO) (UNITS 10**-3) (P9)/(P1)
R8       1    5.         5.              YEH        74 HBC       200 EFF.DENOM. 11/75

R9      XIO INTO (SIGMAO GAMMA)/(LAM PIO) (UNITS 10**-2) (P10)/(P1)
R9      0-1   6.5    OR LESS   CL=.90    YEH        74 HBC        60 EFF.DENOM. 11/75
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23 XIO DECAY PARAMETERS

SEE NOTE ON BARYON DECAY PARAMETERS IN NEUTRON SECTION ABOVE.

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A       ALPHA XI 0
A   X        (-0.09)    (0.46)              PJERROU   65 HBC     SEE NOTE D BELOW  6/68
A   X   146  (-0.13)    (0.17)              BERGE     66 HBC     SEE NOTE D BELOW  6/68
A   X    46  (-0.2)     (0.4)               LONDON    66 HBC     SEE NOTE D BELOW  6/68
A  A    739   -0.43      0.09               DAUBER    69 HBC     1.7-2.6 GEV/C K-
A   X   130  (-0.84)    (0.27)              MAYEUR    72 HLBC    2.1 GEV/C K-      1/73
A  B    652   -0.54      0.10               BALTAY    74 HBC     1.75 GEV/C K-     3/74
A  U   6075   -0.490     0.042              BUNCE     78 SPEC FNAL HYPERON BEAM    7/79
A  H   300K   -0.405     0.012              HANDLER   82 SPEC FNAL HYPERON BEAM    1/82
A   X    LOW STATISTICS EXPERIMENTS EXCLUDED FROM AVERAGE.                         1/82
A   D    ERRORS MULTIPLIED BY 1.1 DUE TO APPROXIMATIONS USED FOR XI
A   D    POLARIZATION. (SEE DAUBER 69 FOR DETAILED DISCUSSION)
A  A     DAUBER 69 USES ALPHA LAMBDA = 0.650 +- 0.019.
A  B     BALTAY 74 USES ALPHA-LAMBDA = 0.645
A  U     BUNCE 78 USES ALPHA-LAMBDA = 0.647                                        7/79
A  H     HANDLER 82 USES ALPHA-LAMBDA=0.642+-0.013                                 1/82
A            . . . . . . . . .
A   AVG       -0.413     0.022   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.0)
                         (SEE IDEOGRAM BELOW)
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Stable Particles — Data Card Listings

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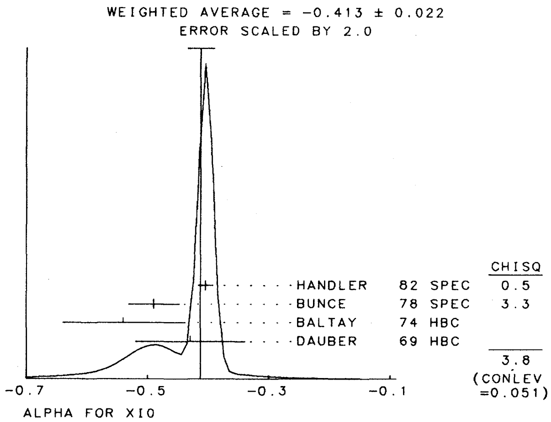


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F        PHI ANGLE  (SIN(PHI)/COS(PHI)=BETA/GAMMA)  (DEGREES)
F        146   -8.       30.               BERGE      66 HBC      SEE NOTE D BELOW   6/68
F   A    739   38.       19.               DAUBER     69 HBC      SEE NOTE A BELOW
F        652   16.0      17.0              BALTAY     74 HBC      1.75 GEV/C K-      3/74
F   A    USED ALPHA LAMBDA = 0.647 +- 0.020.
F   D    ERRORS MULTIPLIED BY 1.2 DUE TO APPROXIMATIONS USED FOR XI
F   D    POLARIZATION. (SEE DAUBER 69 FOR DETAILED DISCUSSION)
F
F   AVG        20.7      11.7       AVERAGE
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REFERENCES FOR XIO

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ALVAREZ  59 PRL 2 215          ALVAREZ,EBERHARD,GOOD,GRAZIANO,TICHO+ (LRL)
JAUNEAU  63 SIENA CONF 1 1     JAUNEAU+         (EPOL+CERN+LOUC+RHEL+BERGEN)
    ALSO 63 PL 4 49            JAUNEAU+         (EPOL+CERN+LOUC+RHEL+BERGEN)
TICHO    63 BNL CONF 410       HAROLD K TICHO                         (UCLA)

CARMONY  64 PRL 12 482         CARMONY,PJERROU,SCHLEIN,SLATER,STORK+(UCLA)
HUBBARD  64 PR 135 B 183       HUBBARD,BERGE,KALBFLEISCH,SHAFER +      (LRL)
PJERROU  65 PRL 14 275         + SCHLEIN,SLATER,SMITH,STORK,TICHO     (UCLA)
PJERROU  65 THESIS             G M PJERROU                            (UCLA)

BERGE    66 PR  147  945       BERGE,EBERHARD,HUBBARD,MERRILL +        (LRL)
HUBBARD  66 UCRL 11510         J RICHARD HUBBARD (THESIS,BERKELEY)     (LRL)
LONDON   66 PR 143 1034        LONDON,RAU,GOLDBERG,LICHTMAN+(BNL+SYRACUSE)

PALMER   68 PL 26B  323        PALMER,RADOJICIC,RAU,RICHARDSON+ (BNL,SYRA)
DAUBER   69 PR   179 1262      +BERGE,HUBBARD,MERRILL,MILLER           (LRL)
MAYEUR   72 NP B47 333         +VAN BINST,WILQUET+     (BRUX+CERN+TUFT+LOUC)
    ALSO 73 NP B53 268         ERRATUM TO MAYEUR 72
WILQUET  72 PL 42B 372         +FLIAGINE,GUY,KNIGHT+ (BRUX+CERN+TUFT+LOUC)

BALTAY   74 PR D9 49           +BRIDGEWATER,COOPER,GERSHWIN+    (COLU+BING)J
YEH      74 PR D10 3545        +GAIGALAS,SMITH,ZENDLE,BALTAY + (BING+COLU)
GEWENIGE 75 PL 57B 193         GEWENIGER,GJESDAL,PRESSER +      (CERN+HEID)
ZECH     77 NP B124 413        +DYDAK,NAVARRIA+            (SIEG+CERN+DORT+HEID)

BUNCE    78 PR D18 633         +HANDLER,MARCH,MARTIN+      (WISC+MICH+RUTG)
BUNCE    79 PL 86B 386         +OVERSETH,COX,DWORKIN+ (BNL+MICH+RUTG+WISC)
COX      81 PRL 46 877         +DWORKIN +             (MICH+WISC+RUTG+MINN+BNL)
HANDLER  82 PR D25 639         +GROBEL,PONDROM+       (WISC+MICH+MINN+RUTG)
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24 OMEGA-(1672,JP=3/2+) I=0

QUANTUM NUMBERS ASSIGNED FROM SU3

24 OMEGA- MASS (MEV)

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M   E     1(1615.)                       EISENBERG 54 EMUL                       9/73
M    F    1 1672.1     1.                FRY1      55 EMUL                       9/73
M    F    1 1670.6     (1.)              FRY2      55 EMUL                       9/73
M         1 1673.0     8.0               ABRAMS    64 HBC    INTO XI- PIO
M         3 1673.3     1.0               PALMER    68 HBC    K-P 4.6,5. GEV/C   11/69
M         3 1671.8     0.8               SCHULTZ   68 HBC    K-P 5.5 GEV/C      11/69
M         5 1674.2     1.6               SCOTTER   68 HBC    K-P 6.  GEV/C      11/69
M   B     6(1671.9)    (1.2)             SPETH     69 HBC    K-P 10. GEV/C      11/69
M   B    13(1671.43)   (0.78)            ABCLV     73 HBC    K-P 10. GEV/C      12/73
M     D   4 1673.4     1.7               DIBIANCA  75 DBC    4.9 GEV/C K-D       1/77
M        41 1673.0     0.8               BAUBILLIE 78 HBC    8.25 GEV/C K-P      2/79
M        27 1671.7     0.6               HEMINGWAY 78 HBC    4.2 GEV/C K-P       2/79
M
M   AVG     1672.37    0.34     AVERAGE
M   FIT     1672.45    0.32     FROM FIT                                        3/84*
       THE FIT COMBINES OMEGA- AND ANTI-OMEGA- VALUES ASSUMING CPT
M
M   E    EISENBERG 54 MASS CALCULATED FOR DECAY IN FLIGHT. ALVAREZ 73 HAS       9/73
M   E    SHOWN THAT THE OMEGA INTERACTED WITH AG NUCLEUS TO GIVE K- XI AG.      9/73
M    F   BOTH FRY EVENTS IDENTIFIED AS OMEGA- BY ALVAREZ 73.                     9/73
M    F   FRY MASSES ASSUME DECAY TO LAMBDA K- AT REST.  DECAY FROM ATOMIC       3/74
M    F   ORBIT COULD DOPPLER SHIFT THE K- ENERGY AND RESULTING OMEGA- MASS      3/74
M    F   BY SEVERAL MEV FOR FRY 2.  THIS SHIFT IS NEGLIGIBLE FOR FRY 1          3/74
M    F   BECAUSE THE OMEGA DECAY IS APPROXIMATELY PERPENDICULAR TO ITS          3/74
M    F   ORBITAL VELOCITY, AS IS KNOWN BECAUSE THE LAMBDA STRIKES THE           3/74
M    F   NUCLEUS (L.ALVAREZ, PRIVATE COMM. 1973).  WE HAVE CALCULATED THE       3/74
M    F   ERROR ASSUMING THAT ORBITAL N IS 4 OR LARGER.                          3/74
M   B    ABCLV VALUE INCLUDES THE SPETH 69 EVENTS. EXCLUDED FROM AVERAGE.     12/73
M   B    SEE NOTE D IN THE OMEGA- MEAN LIFE SECTION BELOW.                      2/82
M     D  DIBIANCA 75 GIVES MASS FOR EACH EVENT.  WE QUOTE AVERAGE.              1/77
```

24 ANTI-OMEGA+ MASS (MEV)

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MB        1 1673.1       1.0              FIRESTONE 71 HBC      12 GEV/C K+D      3/71
MB
MB   FIT    1672.45      0.32   FROM FIT                                         3/84*
       THE FIT COMBINES OMEGA- AND ANTI-OMEGA- VALUES ASSUMING CPT
```

24 OMEGA- MEAN LIFE (UNITS 10**-10 SEC)

```
T          1   (1.63)                         ABRAMS    64 HBC                        7/66
T          1   (0.7)                          BARNES 1  64 HBC                        7/66
T          1   (1.4)                          BARNES 2  64 HBC                        7/66
T          1   (1.85)                         COLLEY    65 HBC                        7/66
T          1   (1.5)                          RICHARDSO 65 HBC                        7/66
T          1   (1.20)                         SCHULTZ   68 HBC                       11/67
T          1   (0.06)                         SCHULTZ   68 HBC                       11/67
T          1   (0.63)                         SCHULTZ   68 HBC                       11/67
T          1   (0.25)                         SCOTTER   68 HBC                        6/68
T          1   (0.30)                         SCOTTER   68 HBC                        6/68
T          1   (0.71)                         SCOTTER   68 HBC                        6/68
T          1   (0.08)                         SCOTTER   68 HBC                        6/68
T          1   (1.04)                         SCOTTER   68 HBC                        6/68
T          1   (2.38)                         SCOTTER   68 HBC                        6/68
T    D    16   (1.39)    (0.45)    (0.31)     ABCLV     73 HBC     K-P 10. GEV/C     12/73
T          1   (0.135)                        DIBIANCA  75 DBC     4.9 GEV/C K-D      1/77
T          1   (0.482)                        DIBIANCA  75 DBC     4.9 GEV/C K-D      1/77
T          1   (0.702)                        DIBIANCA  75 DBC     4.9 GEV/C K-D      1/77
T          1   (0.228)                        DIBIANCA  75 DBC     4.9 GEV/C K-D      1/77
T         40    0.80      0.16      0.12      BAUBILLIE 78 HBC     8.25 GEV/C K-P     2/79
T    D   101   (1.41)    (0.15)    (0.24)     DEUTSCHMA 78 HBC     10,16 GEV/C K- P   6/78
T         39    0.75      0.14      0.11      HEMINGWAY 78 HBC     4.2 GEV/C K-P      2/79
T       2437    0.822     0.028               BOURQUIN  79 SPEC CERN SPS HYPERON BM 12/79
T    D   DEUTSCHMANN 78 INCLUDES EVENTS OF ABCLV 73. EXCLUDED FROM AVERAGE          2/80
T    D   BECAUSE OF SIGNIFICANT DISAGREEMENT WITH OTHER RECENT EXPERIMENTS,         2/80
T    D   POSSIBLY DUE TO XI- CONTAMINATION.                                         2/82
T
T    AVG        0.819     0.028     0.026  AVERAGE
```

24 OMEGA- PARTIAL DECAY MODES

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                                                         DECAY MASSES
P1      OMEGA- INTO LAMBDA K-                            1116+ 494
P2      OMEGA- INTO XIO PI-                              1315+ 140
P3      OMEGA- INTO XI- PIO                              1321+ 135
P4      OMEGA- INTO LAMBDA PI-                           1116+ 140
P5      OMEGA- INTO XI- GAMMA                            1321+   0
P6      OMEGA- INTO XI*(1530)0 PI-                       1533+ 140
P7      OMEGA- INTO XIO E- NEU                           1315+.511+    0
```

24 OMEGA- BRANCHING RATIOS

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R1      OMEGA- INTO LAMBDA K-                                      (P1)
R1   F   1  EVENT                        FRY1      55 EMUL                       11/73
R1   F   1  EVENT                        FRY2      55 EMUL                       11/73
R1   F   BOTH FRY EVENTS IDENTIFIED BY ALVAREZ 73.                               11/73
R1       2  EVENTS                       PALMER    68 HBC                        11/69
R1       3  EVENTS                       SCHULTZ   68 HBC                        11/69
R1       5  EVENTS 1 XI PI DECAY AMB.SCOTTER       68 HBC                        11/69
R1      13  EVENTS +2 AMBIG. WITH XI-ABCLV         73 HBC    K-P 10. GEV/C       12/73
R1       2  EVENTS                       DIBIANCA  75 DBC    4.9 GEV/C K-D        1/77
R1    1920    0.686     0.013            BOURQUI2  79 SPEC CERN SPS HYPERON BM    1/80

R2      OMEGA- INTO XIO PI-                                        (P2)
R2       5  EVENTS                       PALMER    68 HBC                        11/69
R2       3  EVENTS                       SCOTTER   68 HBC                        11/69
R2       3  EVENTS +1 AMBIG.WITH SIG-ABCLV         73 HBC    K-P 10. GEV/C       12/73
R2       2  EVENTS                       DIBIANCA  75 DBC    4.9 GEV/C K-D        1/77
R2     317    0.234     0.013            BOURQUI2  79 SPEC CERN SPS HYPERON BM    1/80

R3      OMEGA- INTO XI- PIO                                        (P3)
R3       1  EVENT                        ABRAMS    64 HBC                        11/69
R3       1  EVENT                        PALMER    68 HBC                        11/69
R3       1  EVENT                        SCOTTER   68 HBC                        11/69
R3       1  EVENT                        ABCLV     73 HBC    K-P 10. GEV/C       12/73
R3     145    0.080     0.008            BOURQUI2  79 SPEC CERN SPS HYPERON BM    1/80

R4      OMEGA- INTO (LAMBDA PI-)/TOTAL    (UNITS 10**-3)  (P4)
R4       0    1.3    OR LESS  CL=.90     BOURQUI2  79 SPEC CERN SPS HYPERON BM    1/80

R5      OMEGA- INTO (XI- GAMMA)/TOTAL     (UNITS 10**-3)  (P5)
R5       0    3.1    OR LESS  CL=.90     BOURQUI2  79 SPEC CERN SPS HYPERON BM    1/80

R6      OMEGA- INTO (XI(1530)0 PI-)/TOTAL  (UNITS 10**-3)(P6)
R6       1    2.     APPROX              BOURQUI2  79 SPEC CERN SPS HYPERON BM    1/80

R7      OMEGA- INTO (XIO E- NEU)/TOTAL    (UNITS 10**-2)  (P7)
R7       3    1.     APPROX              BOURQUI2  79 SPEC CERN SPS HYPERON BM    1/80
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24 OMEGA- DECAY PARAMETERS

SEE NOTE ON BARYON DECAY PARAMETERS IN NEUTRON SECTION ABOVE.

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AL      ALPHA FOR OMEGA- TO K- LAMBDA
AL  K    15   (-0.66)    (0.36)    (0.30)  KOCHER     74 HBC     10 GEV/C K-P      10/74
AL       40    0.58       0.50             BAUBILLIE  78 HBC     8.25 GEV/C K-P     2/79
AL       40   -0.2        0.4              HEMINGWAY  78 HBC     4.2 GEV/C K-P      2/79
AL  S  1400   (0.06)     (0.14)            SAUVAGE    78 SPEC CERN SPS HYPERON BM   4/82
AL  K    SEE NOTE D IN THE OMEGA- MEAN LIFE SECTION ABOVE.                          2/82
AL  S    SAUVAGE 78 IS PRELIMINARY.                                                 4/82
AL
AL  AVG        0.10       0.38     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
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REFERENCES FOR OMEGA-

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EISENBER 54 PR 96 541          Y EISENBERG                            (CORNELL)
FRY1     55 PR 97 1189         FRY,SCHNEPS,SWAMI                         (WISC)
FRY2     55 NC 2 346           FRY,SCHNEPS,SWAMI                         (WISC)

ABRAMS   64 PRL 13 670         + BURNSTEIN,GLASSER +                  (UMD+NRL)
BARNES 1 64 PRL  12  204       V E BARNES,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)
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PALMER   68 PL 26B 323        PALMER,RADOJICIC,RAU,RICHARDSON+ (BNL,SYRA)
SCHULTZ  68 PR  168  1509     SCHULTZ+     (ILL,ARGONNE,NORTHWESTERN,WISC)
SCOTTER  68 PL 26B 474        SCOTTER+       (BIRM,GLASGOW,LOIC,MUNICH,OXF)
SPETH    69 PL  29B 252       SPETH+         (AACHEN,BERLIN,CERN,LOIC,VIEN)

FIRESTON 71 PRL 26 410        +GOLDHABER,LISSAUER,SHELDON,TRILLING  (LRL)
ABCLV    73 NP B61 102        AACHEN+BERLIN+CERN+LONDON+VIENNA COLLABOR.
ALVAREZ  73 PR D8 702         LUIS W. ALVAREZ                       (LBL)
KOCHER   74 PL 51B 193        KOCHER,WERNHARD                 (INNS+VIEN)
DIBIANCA 75 NP B98 137        F.A.DIBIANCA, R.J.ENDORF             (CARN)

BAUBILLI 78 PL 78B 342        BAUBILLIER +       (BIRM+CERN+GLAS+MSU+LPNP)
DEUTSCHM 78 PL 73B 96         DEUTSCHMANN+(AACH+BERL+CERN+INNS+LOIC+VIEN)
HEMINGWA 78 NP B142 205       HEMINGWAY,ARMENTEROS+  (CERN+ZEEM+NIJM+OXF)
SAUVAGE  78  TOKYO CONF P 427 G.SAUVAGE, PROC. 19TH INTL. HEP CONF (ORSA)
BOURQUIN 79 PL 87B 297           (BRIS+GEVA+HEID+ORSA+RHEL+STRB+CERN+MELB)
BOURQUI2 79 PL 88B 192           (BRIS+GEVA+HEID+ORSA+RHEL+STRB+CERN+MELB)
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Λ_c^+

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33  LAMBDA/C+(2282,JP-  )

FOR THE (SIGMA/C)-(LAMBDA/C) MASS DIFFERENCE SEE THE
SIGMA/C SECTION OF THE BARYON DATA CARD LISTINGS.
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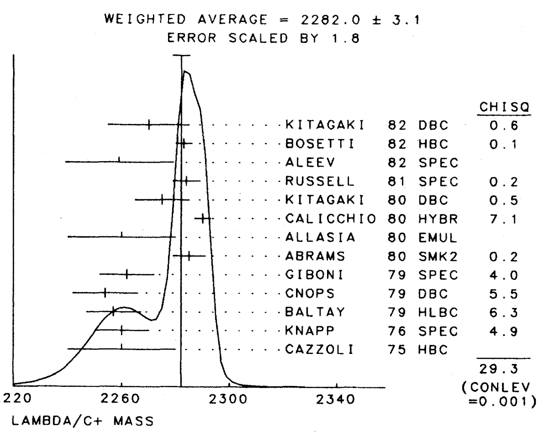
33  LAMBDA/C+ MASS (MEV)

M       1  2260.      20.          CAZZOLI    75 HBC  +  LAMBDA 2PI+ PI-     3/77
M      60  2260.      10.          KNAPP      76 SPEC -  ANTILAM 2PI- PI+    3/77
M       1 (2248.)   OR MORE        BARISH     77 DBC     MODE P15 BELOW      3/77
M       1 (2295.)    (15.)         ANGELINI   79 HYBR REPL. BY ALLASIA 80  12/79
M       6  2257.      10.          BALTAY     79 HLBC +  LAMBDA PI+          7/79
M       1  2254.      12.          CNOPS      79 DBC     P K*(892)- PI+     12/79
M   A  30  2262.      10.          GIBONI     79 SPEC    K- P PI+            2/80
M   A  GIBONI 79 RESULT CHANGED FROM 2255+-4 BY AUTHORS.  SEE KERNAN 79.     2/80
M      39  2285.       6.          ABRAMS     80 SMK2 +- K- P PI+ + C.C.     1/80
M       1  2260.      20.          ALLASIA    80 EMUL    P K- PI+           12/81
M       1  2290.       3.          CALICCHIO 80 HYBR     P K- PI+           12/81
M      19  2275.      10.          KITAGAKI   80 DBC     LAM PI+, KOBAR P  12/81
M       1 (2330.)    (50.)         ADAMOVICH 81 EMUL  +  LAMBDA PI+          1/82
M   B   1 (2285.)     (5.)         GRAESSLER 81 HBC   +  P K- PI+            1/82
M   B   1 (2280.)     (3.)         GRAESSLER 81 HBC   +  P K- PI+            1/82
M      55  2284.0      5.0         RUSSELL    81 SPEC +- KOBAR P + C.C.    12/81
M      76  2259.      20.          ALEEV      82 SPEC    P KS PI+ PI-     11/83*
M   B   3  2283.0      3.0         BOSETTI    82 HBC  +  P K- PI+            3/82
M   B  BOSETTI 82 COMBINE ONE NEW EVENT AT 2288+-5 MEV WITH THEIR EARLIER   3/82
M   B  TWO (GRAESSLER 81 ABOVE).                                            3/82
M       3  2270.0     15.0         KITAGAKI   82 DBC     SIGMAO PI+          2/82
M
M  AVG     2282.0      3.1     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.8)
                               (SEE IDEOGRAM BELOW)
```

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33  LAMBDA/C+ MEAN LIFE (UNITS 10**-13 SEC)

T       1  (7.3)                    ANGELINI  79 HYBR P K- PI+              12/79
T       4  (1.14)   (0.90)   (0.44) USHIDA    80 EMUL LAM 3PI, P KBAR 2PI  12/81
T       1  (0.57)                   ADAMOVICH 81 EMUL LAMBDA PI+             2/82
T       8   2.3      1.0      0.6   USHIDA    83 EMUL REPL. USHIDA 80       2/84*
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33  LAMBDA/C+ PARTIAL DECAY MODES

                                                         DECAY MASSES
P1     LAMBDA/C+ INTO LAMBDA PI+ PI+ PI-                 1116+ 140+ 140+ 140
P2     LAMBDA/C+ INTO LAMBDA PI+                         1116+ 140
P3     LAMBDA/C+ INTO P KOBAR                             938+ 498
P4     LAMBDA/C+ INTO P K- PI+                            938+ 494+ 140
P5     LAMBDA/C+ INTO K*(892)0 P                          892+ 938
P6     LAMBDA/C+ INTO DEL(1232)++ K-                     1232+ 494
P7     LAMBDA/C+ INTO P KOBAR PI- PI+                     938+ 498+ 140+ 140
P8     LAMBDA/C+ INTO P K*(892)- PI+                      938+ 892+ 140
P9     LAMBDA/C+ INTO SIGMA+ PIO                         1189+ 135
P10    LAMBDA/C+ INTO SIGMAO PI+                         1192+ 140
P11    LAMBDA/C+ INTO SIGMA+ ETA                         1189+ 549
P12    LAMBDA/C+ INTO E+ ANYTHING
P13    LAMBDA/C+ INTO P E+ ANYTHING
P14    LAMBDA/C+ INTO LAMBDA E+ ANYTHING
P15    LAMBDA/C+ INTO P PI- PIO KO E+ NEU                 938+ 140+ 135+ 498+
P16    LAMBDA/C+ INTO LAMBDA ANYTHING
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33  LAMBDA/C+ BRANCHING RATIOS

R1    LAMBDA/C+ INTO (P K- PI+)/TOTAL                       (P4)
R1     90   (SEEN)                   DRIJARD   79 SFM  P P AT 62.8 GEV ECM 12/79
R1     98   (SEEN)                   GIBONI    79 SPEC P P AT 63 GEV ECM   12/79
R1     18   (SEEN)                   LOCKMAN   79 SPEC P P 53, 62 GEV ECM  12/79
R1     39    0.022     0.010         ABRAMS    80 SMK2 E+E- 5.2 GEV ECM     1/80
R1      1   (SEEN)                   CALICCHIO 80 HBC  NU P IN BEBC-TST    12/81
R1     74   (SEEN)                   IRION     81 SPEC P P AT 63 GEV ECM    2/82

R2    LAMBDA/C+ INTO (P K*(892)0)/(P K- PI+)                (P5)/(P4)
R2      1   (SEEN)                   ANGELINI  79 HYBR NU EMUL WITH BEBC   12/79
R2     47   (SEEN)                   DRIJARD   79 SFM  P P AT 52.5 GEV ECM 12/79
R2           0.18      0.10          WEISS     80 SMK2 E+ E- 5.2 GEV ECM    4/82
R2     12    0.42      0.24          BASILE    81 CNTR P P -> LAM/C+ E- X   2/82
R2     THE ABOVE RATIOS INCLUDE THE KOBAR PIO MODE OF THE K*O.              4/82
R2
R2  AVG      0.216     0.092    AVERAGE

R3    LAMBDA/C+ INTO (DEL(1232)++ K-)/(P K- PI+)            (P6)/(P4)       1/82
R3     40   (SEEN)                   DRIJARD   79 SFM  P P AT 52.5 GEV ECM 12/79
R3           0.17      0.07          WEISS     80 SMK2 E+ E- 5.2 GEV ECM    4/82
R3     17    0.40      0.17          BASILE    81 CNTR P P -> LAM/C+ E- X   1/82
R3
R3  AVG      0.203     0.081    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)

R4    LAMBDA/C+ INTO P KOBAR                                (P3)
R4      5   (SEEN)                   BALTAY    79 HLBC NU NE-H2 IN 15-FT    2/80
R4     10   (SEEN)                   KITAGAKI  80 DBC  NU D IN FNAL 15-FT  12/81
R4     55   (SEEN)             55/75 RUSSELL   81 SPEC PHOTOPRODUCTION      2/82

R5    LAMBDA/C+ INTO (P KOBAR)/(P K- PI+)                   (P3)/(P4)
R5     12    0.5       0.25          WEISS     80 SMK2 E+ E- 5.2 GEV ECM    4/82

R6    LAMBDA/C+ INTO (P K- PI+)/(P KOBAR)                   (P4)/(P3)      12/81
R6     50   (1.5)  OR LESS  CL=.90   RUSSELL   81 SPEC PHOTOPRODUCTION     12/81

R7    LAMBDA/C+ INTO LAMBDA PI+                             (P2)
R7      6   (SEEN)                   BALTAY    79 HLBC NU NE-H2 IN 15-FT    2/80
R7      9   (SEEN)                   KITAGAKI  80 DBC  NU D IN FNAL 15-FT  12/81

R8    LAMBDA/C+ INTO (LAMBDA PI+)/(P K- PI+)                (P2)/(P4)
R8          (0.8)  OR LESS  CL=0.9   WEISS     80 SMK2 E+ E- 5.2 GEV ECM    4/82

R9    LAMBDA/C+ INTO (LAMBDA PI+)/(P KOBAR)                 (P2)/(P3)
R9   K  5    0.67      0.78    0.35  BALTAY    79 HLBC NU NE-H2 IN 15-FT   12/81
R9      9    0.51      0.62    0.27  KITAGAKI  80 DBC  NU D IN FNAL 15-FT  12/81
R9     40   (0.4)  OR LESS  CL=.90   RUSSELL   81 SPEC PHOTOPRODUCTION     12/81
R9   K  CALCULATED BY KITAGAKI 80 FROM BALTAY 79 RESULTS.                  12/81
R9
R9  AVG      0.57      0.35     AVERAGE

R10   LAMBDA/C+ INTO LAMBDA PI+ PI+ PI-                     (P1)
R10     1    SEEN                    CAZZOLI   75 HBC  NU P IN BNL 7-FT     2/80
R10    60    SEEN                    KNAPP     76 SPEC GAMMA BE             2/80
R10     2    SEEN                    BALTAY    79 HLBC NU NE-H2 IN 15-FT    2/80
R10    12    SEEN                    GIBONI    79 SPEC P P AT 63 GEV ECM   12/79
R10    18    SEEN                    LOCKMAN   79 SPEC P P 53, 62 GEV ECM  12/79

R11   LAMBDA/C+ INTO (LAMBDA PI+ PI+ PI-)/(P K- PI+)        (P1)/(P4)
R11          1.4   OR LESS  CL=0.9   WEISS     80 SMK2 E+ E- 5.2 GEV ECM    4/82

R12   LAMBDA/C+ INTO (LAMBDA PI+ PI+ PI-)/ (P KOBAR)        (P1)/(P3)      12/81
R12   220   (3.1)  OR LESS  CL=.90   RUSSELL   81 SPEC PHOTOPRODUCTION     12/81

R13   LAMBDA/C+ INTO P KOBAR PI- PI+                        (P7)
R13    76    SEEN                    ALEEV     82 SPEC N CARBON 40 GEV    12/83*

R14   LAMBDA/C+ INTO (P KOBAR PI- PI+)/(P KOBAR)            (P7)/(P3)      12/81
R14    45    3.3   OR LESS  CL=.90   RUSSELL   81 SPEC PHOTOPRODUCTION     12/81

R15   LAMBDA/C+ INTO SIGMAO PI+                             (P10)
R15     3    SEEN                    KITAGAKI  82 DBC  NU D IN FNAL 15-FT   2/82

R16   LAMBDA/C+ INTO P K*(892)- PI+                         (P8)
R16     1    SEEN                    CNOPS     79 DBC  NU N IN BNL 7-FT     2/80

R17   LAMBDA/C+ INTO (E+ ANYTHING)/TOTAL                    (P12)           3/82
R17          0.045     0.017         VELLA     82 SMK2 E+ E- 4.5-6.8 GEV    3/82

R18   LAMBDA/C+ INTO (P E+ ANYTHING)/TOTAL                  (P13)           3/82
R18  M       0.018     0.009         VELLA     82 SMK2 E+ E- 4.5-6.8 GEV    3/82
R18  M  THIS INCLUDES PROTONS FROM LAMBDA DECAY.                            3/82

R19   LAMBDA/C+ INTO (LAMBDA E+ ANYTHING)/TOTAL             (P14)           2/82
R19     1   (0.022)OR LESS  CL=.90   BALLAGH   81 HYBR NU NE-H2 IN 15-FT    2/82
R19  N       0.011     0.008         VELLA     82 SMK2 E+ E- 4.5-6.8 GEV    3/82
R19  N  THIS INCLUDES LAMBDAS FROM SIGMAO DECAY.                            3/82

R20   LAMBDA/C+ INTO (LAMBDA E+ ANY.)/(LAMBDA ANY.)         (P14)/(P16)
R20  S       0.027     0.017         SON       82 DBC  NU D IN FNAL 15-FT 12/83*
R20  V       0.065     0.041         VELLA     82 SMK2 E+E- 4.5-6.8 GEV   12/83*
R20  S  SON 82 USES OWN DATA AND MU- E+ LAMBDA EVENTS OF MURTAGH 79 .      12/83*
R20  V  THIS VALUE DEDUCED BY SON 82 FROM DATA OF VELLA 82.                12/83*
R20
R20 AVG      0.033     0.016    AVERAGE

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REFERENCES FOR LAMBDA/C+


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CAZZOLI  75 PRL 34 1125       +CNOPS,CONNOLY,LOUTTIT,MURTAGH, +      (BNL)
KNAPP    76 PRL 37 882        +LEE,LEUNG,SMITH +     (COLU+HAWA+ILL+FNAL)
BARISH   77 PR D15 1          +DERRICK,DOMBECK,MUSGRAVE +       (ANL+PURD)

ANGELINI 79 PL 84B 150        (ANKA+LIBH+CERN+DUUC+LOUC+KEYN+PISA+ROMA+)
BALTAY   79 PRL 42 1721       +CAROUMBALIS,FRENCH,HIBBS, +      (COLU+BNL)
CNOPS    79 PRL 42 197        +CONNOLLY,KAHN,KIRK,MURTAGH,PALMER+    (BNL)
DRIJARD  79 PL 85B 452        +FISCHER+     (CERN+CDEF+DORT+HEID+LAPP+WARS)
GIBONI   79 PL 85B 437        +DIBITONTO+  (AACH+CERN+HARV+MUNI+NWES+UCR)
KERNAN   79   LEPTON CONF.FNAL A. KERNAN                             (UCR)
LOCKMAN  79 PL 85B 443        +MEYER,RANDER,SCHLEIN,WEBB+      (UCLA+SACL)
MURTAGH  79 FERMILAB.SYMP.277 M.J. MURTAGH                          (FNAL)

ABRAMS   80 PRL 44 10         +ALAM,BLOCKER,BOYARSKI, +        (SLAC+LBL)
ALLASIA  80 NP B176 13        (ANKA+LIBH+CERN+DUUC+LOUC+KEYN+PISA+ROMA+)
CALICCHI 80 PL 93B 521        + (BARI+BIRM+BRUX+CERN+EPOL+RHEL+SACL+LOUC)
KITAGAKI 80 PRL 45 955        +TANAKA,YUTA,ABE, +(TOHO+IIT+UMD+STON+TUFT)
USHIDA   80 PRL 45 1053         (FNAL+MCGI+NAGO+OSU+OSKC+OTTA+TOKY+TNTO+)
WEISS    80 TORONTO CONF 319  J M WEISS                             (SLAC)

ADAMOVIC 81 PL 99B 271        ADAMOVICH+(PHOTON-EMUL,OMEGA-PHOTON COLLS.)
BALLAGH  81 PR D24 7          +BINGHAM +      (LBL+UCB+FNAL+HAWA+WASH+WISC)
BASILE   81 NC 62A 14         +CARA ROMEO +         (CERN+BGNA+PGIA+FRAS)
FIORINO  81 LNC 30 166        (PHOTON-EMUL COLLAB.+OMEGA-PHOTON COLLAB.)
  -- THE EVENT IN FIORINO 81 IS ALSO IN ADAMOVICH 81.
GRAESSLE 81 PL 99B 159        GRAESSLER,LANSKE+ (AACH+BONN+CERN+MPIM+OXF)
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Stable Particles

Data Card Listings

Λ_c^+, A^+, Λ_b^0, TOP HADRON SEARCHES, FREE QUARK SEARCHES


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IRION    81 PL 99B 495          +SEEBRUNNER, +   (AACH+CERN+HARV+MUNI+NWES)
RUSSELL  81 PRL 46 799          +AVERY,BUTLER,GLADDING +    (ILL+FNAL+COLU)
ALEEV    82 SJNP 35 687         + (JINR+AGDR+BUDA+LEBD+MOSU+PRAG+SOFI+TBLI)
BOSETTI  82 PL 109B 234         +GRAESSLER, +     (AACH+BONN+CERN+MPIM+OXF)
KITAGAKI 82 PRL 48 299          +TANAKA,YUTA,ABE,+ (TOHO+IIT+UMD+STON+TUFT)
SON      82 PRL 49 1128         +SNOW,CHANG,KUNORI+(UMD+IIT+STON+TOHO+TUFT)
VELLA    82 PRL 48 1515         +TRILLING,ABRAMS,ALAM,+      (SLAC+LBL+UCB)
USHIDA   83 PRL 51 2362           (AICH+FNAL+KOBE+SEOU+MCGI+NAGO+OSU+OKAY+)

                                THEORY AND REVIEW

DERUJULA 75 PR D12 147          +GEORGI,GLASHOW                      (HARV)
GAISSER  76 PR D14 3153         T.K.GAISSER,F.HALZEN            (BART+WISC)
LEE      77 PR D15 157          +QUIGG,ROSNER                        (FNAL)
MULLER   79 CERN/EP 79-148      F.MULLER (CARGESE LEC.1979)          (CERN)
DIBITONT 81 MADISON CONF.       D.DIBITONTO                          (CERN)
TRILLING 81 PRPL 75 57          G H TRILLING                          (LBL)
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A^+

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                 45  A+(2460,JP=  )

                 A NARROW SIGNAL (WIDTH COMPATIBLE WITH THE 23-MEV
                 RESOLUTION) INTERPRETED AS A STABLE CHARMED STRANGE
                 BARYON (QUARK CONTENT CSU).

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                 45  A+ MASS (MEV)

M        82 2460.      25.          BIAGI      83 SPEC    SIGMA- BE-->A+ X 11/83*

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                 45  A+ PARTIAL DECAY MODES

                                                              DECAY MASSES
P1      A+ INTO LAMBDA K- PI+ PI+                        1116+ 494+ 140+ 140

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                 45  A+ BRANCHING RATIOS

R1      A+ INTO LAMBDA K- PI+ PI+                        (P1)
R1        82     SEEN               BIAGI      83 SPEC    SIGMA- BE-->A+ X 11/83*

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                         REFERENCES FOR A+(2460)
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BIAGI    83 PL 122B 455         +   (BRIS+CERN+GEVA+HEID+LAUS+LOQM+MELB+RL)
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Λ_b^0

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                 40  LAMBDA/B0(5500, JP=  )

                 THE CLAIM BY BASILE 81 IS HOTLY DISPUTED BY DRIJARD 82.
                 BASILE 82 IS THE REPLY, AND DRIJARD1 82 IS THE REPLY TO
                 THAT.

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                 40  LAMBDA/B0 MASS  (MEV)

M          5425.0     175.0      75.0   BASILE     81 SFM  0  P P 62 GEV ECM     4/82

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                 40  LAMBDA/B0 PARTIAL DECAY MODES

                                                              DECAY MASSES
P1      LAMBDA/B0 INTO P D0 PI-                            938+1865+ 140

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                 40  LAMBDA/B0 BRANCHING RATIOS

R1      LAMBDA/B0 INTO (P D0 PI-)/TOTAL                  (P1)
R1           SEEN                   BASILE     81 SFM  D0 TO K- PI+          4/82

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                         REFERENCES FOR LAMBDA/B0
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BASILE   81 LNC 31 97           +BONVICINI,CARA ROMEO+(CERN+BGNA+FRAS+PGIA)
BASILE   82 NC 68A 289          +BONVICINI,CARA ROMEO+      (CERN+BGNA+FRAS)
DRIJARD  82 PL 108B 361         +FISCHER,+  (CERN+CDEF+DORT+HEID+LAPP+WARS)
DRIJARD1 82 CERN/EP 82-31       +FISCHER,+  (CERN+CDEF+DORT+HEID+LAPP+WARS)
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TOP HADRON SEARCHES

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TE      SEARCH FOR TOP HADRON PRODUCTION IN (E+ E-) COLLISONS
TE   A   NONE ECM=22-31.6 GEV          BARTEL1   79 JADE R                      8/81
TE   B   NONE ECM=22-31.6 GEV          BARTEL2   79 JADE <S>                    8/81
TE   C   NONE ECM=31.6 GEV             BARBER    79 MRKJ R,<S>,<T>              6/82*
TE   D   NONE ECM=22-31.6 GEV          BERGER    79 PLUT R,<S>,<T>,MU           8/81
TE   E   NONE ECM=30-36 GEV            BARBER    80 MRKJ R,<T>,MU               8/81
TE   F   NONE ECM=12-31.6 GEV          BERGER    80 PLUT MU                     8/81
TE   G   NONE ECM=33-35.8 GEV          BARTEL    81 JADE MU                     2/82
TE   H   NONE ECM=14-36.7 GEV          BRANDELIK 82 TASS R                     10/83*
TE   I   NONE ECM < 38.54 GEV CL=.99   ADEVA1    83 MRKJ    R,<T>,(MU+MU-X)   11/83*
TE   J   NONE ECM < 38 GEV             ADEVA2    83 MRKJ    PT(MU),<T>        11/83*
TE
TE                                     COMMENTS
TE       ALL ABOVE MEASUREMENTS ARE DONE AT DESY-PETRA. THE LAST COLUMN         8/81
TE       SPECIFIES MEASURED QUANTITIES.                                         8/81

TE   A  BARTEL1 79 SAW NO EVIDENCE OF NEW Q=2/3 QUARK PROD. IN R-RATIO.      6/82*
TE
TE   B  BARTEL2 79 OBSERVE NO SIGNIFICANT ACCUMULATION OF SPHERICAL EVENTS.  8/81
TE
TE   C  BARBER 79 R,THRUST,SPHEROCITY INDICATE TOP-PRODUCTION UNLIKELY.      6/82*
TE
TE   D  BERGER 79 FIND R=3.88+0.22 WHICH ALONG WITH SPHERICITY AND THRUST    8/81
TE   D  BEHAVIORS IS AGAINST OPEN TOP ANTI-TOP CHANNEL BELOW 30GEV. FINAL    8/81
TE   D  MUONS ARE ALSO CONSISTENT WITH EXPECTATION WITHOUT TOP QUARK STATE.  8/81
TE
TE   E  BARBER 80 FIND NO EVIDENCE FOR AN OPEN TOP ANTI-TOP THRESHOLD IN R,  8/81
TE   E  THRUST DIST. AND INCLUSIVE MUONS. ENERGY SCAN IN THE RANGE 29.9<ECM  8/81
TE   E  <31.6GEV REVEALS NO HADRON RESONANCE CORRESPONDING TO A (TOP-QUARK   8/81
TE   E  ANTI-TOP-QUARK) BOUND STATE.                                         8/81
TE
TE   F  BERGER 80  MEASURES INCLUSIVE MUONS WITH MOMENTUM >2 GEV/C. AGREE    8/81
TE   F  WITH EXPECTED SEMILEPTONIC DECAYS FROM CHARMED AND BOTTOM MESONS.    8/81
TE
TE   G  BARTEL 81 MEASURES INCLUSIVE MUONS WITH MOMENTUM  >1.4 GEV/C. AGREE  2/82
TE   G  WITH EXPECTED SEMILEPTONIC DECAYS FROM CHARMED AND BOTTOM MESONS.    2/82
TE
TE   H  BRANDELIK 82 GOT R=4.01+-0.03+-0.2 WITH NO STEP FOR W>14GEV. NARROW 10/83*
TE   H  STATE SEARCH FOR W=33-36.7GEV SETS EE-WIDTH*BR(HAD)<1.5KEV(CL=.95). 10/83*
TE
TE   I  ADEVA1 ENERGY SCAN EXCLUDES OPEN TOP CONTINUUM BELOW 38.54 GEV AND  11/83*
TE   I  TOPONIUM BETWEEN 29.90 AND 38.63 GEV (HAD.BR*E-WIDTH < 2.0 KEV AT   11/83*
TE   I  CL=.95). ALSO SET LIMIT BR(B-->MU+MU-X) < 0.007 (CL=.95) WHICH      11/83*
TE   I  EXCLUDES FLAVOR-CHANGING NEUTRAL CURRENT IN TOPLESS MODELS.         11/83*
TE
TE                                 COMMENT
TE
TE      RECENT UPPER LIMITS ON THE FLAVOR CHANGING NEUTRAL CURRENT DECAY     1/84*
TE      OF BOTTOM MESON ARE IN CONFLICT WITH THE EXPECTED RATE IN THE        1/84*
TE      TOPLESS MODEL AND SERVE AS INDIRECT SUPPORT FOR THE TOP QUARK.       1/84*
TE      SEE PARTIAL DECAY MODE B-->MU+ MU- X OF THE BOTTOM MESON SECTION.    1/84*

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TP     SEARCH FOR TOP HADRON PRODUCTION IN (P PBAR) COLLISIONS
TP   A                               ARNISON   83 CALO   UA1 COLLAB.       11/83*
TP   B                               BARGER    83 RVUE                     11/83*
TP   C                               BASILE    83 RVUE                     11/83*
TP   D                               GODBOLE   83 RVUE                     11/83*
TP
TP   A  ARNISON 83 OBSERVED  11 LARGE-PT ELECTRON EVENTS WITH A JET OPPO-   11/83*
TP   A  SITE TO THE TRACK WITHIN A 30 DEGREE AZIMUTHAL ANGLE.               11/83*
TP   A  INTERPRETATION OF THESE AS T-->E NU JET IS GIVEN BY 3 RVUES BELOW.  11/83*
TP
TP   B  BARGER 83 FIND  MT(E NUE) DISTRIBUTION IS CONSISTENT WITH TOP.      11/83*
TP   B  FIT GIVES M(TOP)=34+-6 GEV.                                         11/83*
TP
TP   C  BASILE 83 MONTE-CARLO ANALYSIS FINDS EVENT-RATE IS CONSISTENT WITH  11/83*
TP   C  BOTH SUPERBEAUTY(M ABOUT 55 GEV) AND TOP (M ABOUT 35 GEV).          11/83*
TP
TP   D  GODBOLE 83 STUDIED EVENT-TOPOLOGY OF TOP DECAY.  ASSOCIATED HADRON  11/83*
TP   D  (B) MAKES A LARGE RELATIVE AZIM.ANGLE TO E AS SEEN BY ARNISON 83.   11/83*
TP
TP                    NOTE
TP      BULK OF UA1 ELECTRON PLUS JET EVENTS DO NOT APPEAR TO HAVE ADDI-
TP      TIONAL SIGNATURES FROM THE ASSOCIATED TOP DECAY (T-AND BBAR-JET).
TP      SEE E.G. POSTSCRIPT IN BARGER 83.

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                         REFERENCES FOR TOP HADRON SEARCHES
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BARTEL1  79 PL 88B 171          JADE C.(DESY+HAMB+HEID+MCHS+LANC+RHEL+TOKY)
BARTEL2  79 PL 89B 136          JADE C.(DESY+HAMB+HEID+MCHS+LANC+RHEL+TOKY)
BARBER   79 PL 85B 463          MARK-J COLLAB.     (AACH+DESY+MIT+AIKO+BHEP)
BERGER   79 PL 86B 413          PLUTO C.(AACH+BERG+DESY+HAMB+UMD+SIEG+WUPP)
BARBER   80 PRL 44 1722         MARK-J COLLAB.     (AACH+DESY+MIT+AIKO+BHEP)
BERGER   80 PRL 45 1533         PLUTO C.(AACH+BERG+DESY+HAMB+UMD+SIEG+WUPP)
BARTEL   81 PL 99B 277          +CORDS+(DESY+HAMB+HEID+LANC+MCHS+RHEL+TOKY)
BRANDELI 82 PL 113B 499         TASSO C.   (AACH+BONN+DESY+HAMB+LOIC+OXF+RL)

ADEVA1   83 PRL 50 799          MARKJ C. (AACH+DESY+MIT+MADR+AIKO+BHEP+CIT)
ADEVA2   83 PRL 51 443          MARKJ C. (AACH+DESY+MIT+MADR+AIKO+BHEP+CIT)
ARNISON  83 PL 122B 103         UA1-C.(AACH+LAPP+BIRM+CERN+HELS+LOQM+CDEF+)
BARGER   83 PL 125B 339         +MARTIN,PHILLIPS             (DURH+WISC+RHEL)
BASILE   83 LNC 37 255          +BERBIERS,BONVICINI,CARA+  (CERN+BGNA+FRAS)
GODBOLE  83 PRL 50 1539         R.M.GODBOLE,S.PAKVASA,D.P.ROY   (BOMB+TIFR)
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FREE QUARK SEARCHES

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(by W.P. Trower, Virginia Polytechnic Institute and State University)

The idea that all hadrons are constructed from a set of fractionally charged constituents (quarks) is central to the quantum-chromodynamics description of particle scattering and hadron spectroscopy. Quantum-chromodynamics in its usual form contains the as-yet-unproven restriction that quarks must forever be confined to the mesons and baryons they make up.

Experiments support the conclusion that it is at best difficult to "unglue" quarks. Accelerator searches at increasing energies have produced no evidence for free quarks. Of the several candidate cosmic ray events, one still enjoys the active advocacy of its discoverer.[1] The only positive searches in matter, those of LARUE, have published no new data since November 1980.

This compilation should be used as a directory to the literature since the quoted experimental limits are often only indicative.

Reference

1. C.B.A. McCusker, Aust. J. Phys. **36**, 717 (1983).

C QUARK PRODUCTION CROSS SECTION -- ACCELERATOR SEARCHES

		QUARK EVENTS	X-SECT CM2	CHARGE 1/3E	MASS GEV	REFERENCE		DET	BEAM GEV	
C	G	0	<5E-3	-4	1-8	AIHARA	84	TPC	29E+E-	2/84*
C		0	<1E-36	+-1,2	<9	AUBERT	83	SPEC	200MU	2/84*
C	I	0	<3E-3	+-1,2	<2	BANNER	83	CNTR	540P AP	10/83*
C	H	0	<1E-4	+-1,2	-	LINDGREN	83	CNTR	106FE56	2/84*
C	HI	0	<3E-3	>+-1/6	-	PRICE	83	PLAS	74AR40	10/83*
C	G	0	<1E-2	+-1,2	<14	MARINI1	82	CNTR	29E+E-	10/83*
C	G	0	<8E-2	+-1,2	<12	ROSS	82	CNTR	29E+E-	10/83*
C	C	0	<2E-10	+-2,4	1-3	BUSSIERE	80	CNTR	200PROT	12/81
C	EF	0	<5E-38	+1,2	>5	STEVENSON	79	CNTR	300PROT	12/79
C		0	<1E-33	+-1	<20	BASILE1	78	SPEC	52P P	2/79
C	E	0	<9E-39	+-1,2	<6	ANTREASYA	77	SPEC	400PROT	11/77
C	D	0	<8E-35	+1,2	<20	FABJAN	75	CNTR	52P P	1/77
C		0	<5E-38	-1,2	4-9	NASH	74	CNTR	200PROT	2/77
C		0	<1E-32	+2,4	4-24	ALPER	73	SPEC	52P P	1/76
C		0	<5E-31	+1,2,4	<12	LEIPUNER	73	CNTR	300PROT	2/74
C		0	<6E-34	+-1,2	<13	BOTT	72	CNTR	52P P	2/74
C		0	<1E-36	-4	4	ANTIPOV	71	CNTR	70PROT	1/76
C	B	0	<1E-35	+-1,2	2	ALLABY	69	CNTR	28PROT	1/76
C	C	0	<4E-37	-2	<5	ANTIPOV1	69	CNTR	70PROT	2/74
C	B	0	<3E-37	-1,2	2-5	ANTIPOV2	69	CNTR	70PROT	1/76
C		0	<1E-35	+1,2	<7	DORFAN	65	CNTR	30PROT	2/74
C	A	0	<2E-35	-2	<2.5-5	FRANZINI	65	CNTR	30PROT	3/77
C		0	<5E-35	+1,2	<2.2	BINGHAM	64	HLBC	21PROT	3/77
C		0	<1E-32	+1,+2	<4.0	BLUM	64	HBC	28PROT	3/77
C	A	0	<1E-35	+1,+2	<2.5	HAGOPIAN	64	HBC	31PROT	3/77
C		0	<1E-34	+1	<2	LEIPUNER	64	CNTR	28PROT	3/77
C		0	<1E-33	+1,2	<2.4	MORRISON	64	HBC	24PROT	3/77

C I - BOUND TO NUCLEI.
C H - FOR X-SECT READ FRACTION OF FRAGMENTS.
C G - FOR X-SECTION READ X-SECT(Q-Q X)/X-SECT(MU-MU)
C F - 3E-5 < LIFETIME < 1E-3 S.
C E - X-SECTION CM2/GEV2.
C D - INCLUDES BOTT 72 RESULTS.
C C - HADRONIC OR LEPTONIC QUARKS.
C B - ASSUMES ISOTROPIC CM PRODUCTION.
C A - CROSS SECTION INFERRED FROM FLUX.

D QUARK DIFFERENTIAL PRODUCTION CROSS SECTION -- ACCELERATOR SEARCHES

		QUARK EVENTS	X-SECT CM2/SR/GEV	CHARGE 1/3E	MASS GEV	REFERENCE		DET	BEAM GEV	
D		0	<4E-36	-2,4	1.5-6	BALDIN	76	CNTR	70PROT	1/77
D		0	<2E-33	+-4	5-20	ALBROW	75	SPEC	52P P	1/77
D		0	<5E-34	<7	7-15	JOVANOVIC	75	CNTR	44P P	11/75
D	A	0	<5E-35	-	-	GALIK	74	CNTR	20GAMMA	7/76
D		0	<9E-35	-1,2	-	NASH	74	CNTR	200PROT	2/77
D		0	<4E-36	-4	2.3-2.7	ANTIPOV	71	CNTR	70PROT	1/76
D		0	<3E-35	+-1,2	<2.7	ALLABY	69	CNTR	27PROT	1/76
D		0	<7E-38	-1,2	<2.5	ANTIPOV2	69	CNTR	70PROT	1/76

D A - X-SECTION IN CM**2/SR/EQUIV. QUANTA .

FR QUARK FLUX -- ACCELERATOR SEARCHES

		QUARK EVENTS	FLUX/ NUEVENT	CHARGE 1/3E	MASS GEV	REFERENCE		DET	BEAM GEV	
FR	E	0	<3E-4	+-2	1.8-2	WEISS	81	SMK2	7E+E-	1/82
FR	E	0	<5E-2	+1,2,4,5	2-12	BARTEL	80	JADE	27E+E-	2/82
FR	AB	0	<2E-5	+1,2	-	BASILE	80	CNTR	NU	12/81
FR	D*	0	<3E-10	+-2,4	1-3	BOZZOLI	79	CNTR	200PROT	12/79
FR	*	0	<6E-11	+-1	<21	BASILE1	78	SPEC	52P P	2/79
FR		0	<5E-3	-	-	BASILE2	78	CNTR	NUMU	7/79
FR	*	0	<2E-9	+-1	<26	BASILE	77	SPEC	62P P	1/78
FR	C*	0	<7E-10	+1,2	<20	FABJAN	75	CNTR	52PROT	1/77
FR	AB	0	-	+1,2	>4.5	GALIK	74	CNTR	GAMMA	7/76
FR	AB	0	-	+1,2	>1.5	BELLAMY	68	CNTR	12E-	3/77
FR	A	0	-	+1,2	>0.9	BATHOW	67	CNTR	GAMMA	3/77
FR	A	0	-	+1,2	>0.9	FOSS	67	CNTR	6GAMMA	3/77

FR E - FOR FLUX READ QUARK PROD. X-SECTION RATIO TO CSE+E->MU+MU .
FR D - QUARK LIFETIMES >1.E-8 S.
FR C - ONE CANDIDATE M <.17 GEV.
FR B - HADRONIC QUARK.
FR A - LEPTONIC QUARK.
FR * - QUARK FLUX PER CHARGED PARTICLE.

F QUARK FLUX -- COSMIC RAY SEARCHES

		QUARK EVENTS	FLUX /CM2/S/SR	CHARGE 1/3E	MASS GEV	REFERENCE		DET	SHIELDING KG/CM2	
F		0	<2E-12	+-1,2,3	-	MASHIMO	83	CNTR	-0.3*	10/83*
F		0	<3E-10	+-1,2	-	MARINI2	82	CNTR	0.3	10/83*
F	C	0	<8E-10	+-1,2	-	NAPOLITAN	82	CNTR	0.3	10/83*
F	F	3	-	-	-	YOCK	78	CNTR	-	2/79
F	A	0	<1E-9	-	-	BRIATORE	76	ELEC	-	1/77
F	B	0	<2E-11	+1	-	HAZEN	75	CC	-	7/76
F		0	<2E-10	+1,2	-	KRISOR	75	CNTR	-	3/77
F	BE	0	<1E-7	+1,2	-	CLARK	74	CC	-	1/77
F		0	<3E-10	+1	>20	KIFUNE	74	CNTR	-	7/76
F	B	0	<8E-11	+1	-	ASHTON	73	CNTR	-	3/77
F		0	<2E-8	+1,2	-	HICKS	73	CNTR	-	1/76
F		0	<5E-10	+4	-	BEUCHAMP	72	CNTR	2.8*	3/77
F	B	0	<1E-10	+1,2	-	BOHM	72	CNTR	-	2/74
F		0	<1E-10	+1,2	-	COX	72	ELEC	2.8*	3/77
F		0	<3E-10	+2	-	CROUCH	72	CNTR	-	3/77
F	A	0	<3E-8	-	-	DARDO	72	CNTR	7	3/77
F	B	0	<4E-9	+1	-	EVANS	72	CC	-	1/77
F	A	0	<2E-9	-	>10	TONWAR	72	CNTR	-	3/77
F		0	<2E-10	+1	-	CHIN	71	CNTR	2.8*	3/77
F	B	0	<3E-10	+1,2	-	CLARK	71	CC	-	3/77
F	B	0	<1E-10	+1,2	-	HAZEN	71	CC	-	2/77
F		0	<5E-10	+1,2	-	BOSIA	70	CNTR	3.5*	1/78
F	B	1	(-)	+1,2	<6.5	CHU	70	HLBC	-	5/76
F		0	<2E-9	+1	-	FAISSNER	70	CNTR	-	3/77
F		0	<2E-10	+1,2	-	KRIDER	70	CNTR	0.8*	3/77
F		4	<5E-11	+2	-	CAIRNS	69	CC	-	3/77
F		0	<8E-10	+1,2	<10	FUKUSHIMA	69	CNTR	-	2/74
F	BD	1	-	+2	-	MCCUSKER	69	CC	-	2/74
F	A	0	<1E-10	-	>5	BJORNBOE	68	CNTR	1.7,3.6	2/74
F	C	0	<1E-8	+-1,2,4	-	BRIATORE	68	CNTR	6.3,.2*	5/76
F		0	<3E-8	-	>2	FRANZINI	68	CNTR	-	2/74
F		0	<9E-11	+-1,2	-	GARMIRE	68	CNTR	-	3/77
F		0	<4E-10	+-1	-	HANAYAMA	68	CNTR	-	3/77
F		0	<3E-8	-	>15	KASHA1	68	OSPK	-	2/74
F		0	<2E-10	+2	-	KASHA2	68	CNTR	-	3/77
F		0	<2E-10	+4	-	KASHA3	68	CNTR	-	3/77
F		0	<2E-10	+2	-	BARTON	67	CNTR	6	3/77
F		0	<2E-7	+4	-	BUHLER1	67	CNTR	0.008,0.5*	3/77
F		0	<5E-10	1,2	-	BUHLER2	67	CNTR	0.008,0.5*	3/77
F		0	<4E-10	+1,2	-	GOMEZ	67	CNTR	-	3/77
F		0	<2E-9	+2	-	KASHA	67	CNTR	-	3/77
F		0	<2E-10	+2	-	BARTON	66	CNTR	220	3/77
F		0	<2E-9	+1,2	-	BUHLER	66	CNTR	0.5*	3/77
F		0	<3E-9	+1,2	-	KASHA	66	CNTR	-	3/77
F		0	<2E-9	+1,2	-	LAMB	66	CNTR	-	3/77
F		0	<2E-8	+1,2	>7	DELISE	65	CNTR	2.8*	3/77
F		0	<5E-8	+2	>2.5	MASSAM	65	CNTR	0.5*	3/77
F		0	<2E-8	+1	-	BOWEN	64	CNTR	2.5*	3/77
F		0	<2E-7	+1	-	SUNYAR	64	CNTR	0.8	3/77

F F - LIFETIME >10**-8 S; CHARGE +-.70,.68,.42; AND MASS
F F >4.4, 4.8, AND 20 GEV, RESPECTIVELY.
F E - ALSO 1/4 AND 1/6E CHARGES.
F D - NO EVENTS IN SUBSEQUENT EXPTS.
F C - LEPTONIC QUARKS.
F B - PROMPT AIR SHOWER SEARCH.
F A - TIME DELAYED AIR SHOWER SEARCH.
F * - ALTITUDE IN KM. ALL OTHERS SEALEVEL.

RHO QUARK DENSITY -- MATTER SEARCHES

		QUARK EVENTS	QUARKS/ NUCLEON	CHARGE 1/3E	MASS GEV	REFERENCE		MATERIAL/METHOD	
RHO		0	<9E-20	+-<13	-	JOYCE	83	WATER/OIL DROP	10/83*
RHO		0	<2E-21	+->1/2	-	LIEBOWITZ	83	LEVITATED STEEL	10/83*
RHO		0	<1E-19	+-1,2	-	VANDESTEE	83	PHOTO ION SPEC	10/83*
RHO	B	0	<2E-20	-	-	HODGES	81	MERCURY/OIL DROP	2/82
RHO		4	<2E-20	-1	-	LARUE	81	LEVITATED NIOBIUM	1/82
RHO		4	<2E-20	+1	-	LARUE	81	LEVITATED NIOBIUM	1/82
RHO		0	<1E-21	-	-	MARINELLI	80	LEVITATED STEEL	12/81
RHO		0	<6E-16	-	-	BOYD	79	HELIUM/MASS SPEC	12/79
RHO		3	<5E-21	+1	-	LARUE	79	LEVITATED NIOBIUM	7/79
RHO		0	<4E-28	-	-	OGORODNIK	79	EARTH+/ION BEAM	10/81
RHO		0	<5E-15	+1	-	BOYD1	78	TUNGSTEN/MASS SPEC	8/78
RHO		0	<5E-16	+3	<1.7	BOYD2	78	HYDROGEN/MASS SPEC	1/79
RHO		0	<1E-21	+-2,4	-	LUND	78	WATER/ION BEAM	12/81
RHO		0	<6E-15	>1/2	-	PUTT	78	LEVITATED TUNGSTEN	2/79
RHO		0	<1E-22	-	-	SCHIFFER	78	METALS/MASS SPEC	2/79
RHO		0	<5E-15	-	-	BLAND	77	LEVITATED TUNGSTEN OX	8/77
RHO		0	<3E-21	-	-	GALLINARO	77	LEVITATED IRON	7/77
RHO		1	(1E-2)	-1	-	LARUE	77	LEVITATED NIOBIUM	7/77
RHO		2	(1E-2)	+1	-	LARUE	77	LEVITATED NIOBIUM	7/77
RHO		0	<1E-13	+3	<7.7	MULLER	77	HYDROGEN/MASS SPECTRA	12/79
RHO		0	<5E-27	-	-	OGORODNIK	77	WATER+/ION BEAM	12/79
RHO		0	<1E-21	-	-	STEVENS	76	LUNAR+/ION SPEC	3/77
RHO		0	<1E-15	+1	<60	ELBERT	70	OXYGEN+/ION SPEC	3/77
RHO		0	<5E-19	-	-	MORPURGO	70	LEVITATED GRAPHITE	3/77
RHO		0	<5E-23	-	-	COOK	69	WATER+/ATOM BEAM	3/77
RHO		0	<1E-17	+-1,2	-	BRAGINSKI	68	LEVITATED GRAPHITE	3/77
RHO		0	<1E-17	-	-	RANK	68	WATER+/UV SPEC	3/77
RHO		0	<3E-19	+-1	-	STOVER	67	LEVITATED IRON	2/74
RHO	A	0	<1E-10	-	-	BENNETT	66	SUN/UV SPEC	3/77
RHO		0	<1E-17	+1,2	-	CHUPKA	66	METORITES+/ION BEAM	3/77
RHO		0	<1E-16	+-1	-	GALLINARO	66	LEVITATED GRAPHITE	3/77
RHO		0	<1E-22	-	-	HILLAS	59	ARGON/ELECTROMETER	3/77

RHO B - ALSO SET LIMITS FOR Q=+-1/6E.
RHO A - LIMIT INFERRED BY JONES 76.

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REFERENCES FOR QUARK SEARCHES

AIHARA 84 PRL 52 168 + (LBL+UCLA+UCR+JHU+MASA+TOKY+YALE)
AUBERT 83 PL 133B 461 (CERN+DESY+FREI+KIEL+LANC+LAPP+LIVP+MARS+)
BANNER 83 PL 121B 187 UA2 (BERN+CERN+BOHR+LALO+PAVI+SACL)
JOYCE 83 PRL 51 731 +ABRAMS,BLAND,JOHNSON,LINDGREN+ (SFSU)
LIEBOWIT 83 PRL 50 1640 LIEBOWITZ,BINDER,ZIOCK (VIRG)
LINDGREN 83 PRL 51 1621 +JOYCE,ABRAMS+ (SFSU+UCR+UCI+SLAC+LBL+LANL)
MASHIMO 83 PL 128B 327 +ORITO,KAWAGOE,NAKAMURA,NOZAKI (TOKY)
PRICE 83 PRL 50 566 +TINCKNELL,TARLE,AHLEN,FRANKEL+ (UCB)
VANDESTE 83 PRL 50 1234 VANDESTEEG,JONGBLOETS,WYDER (NIJM)

Stable Particles

FREE QUARK SEARCHES, MAGNETIC MONOPOLE SEARCHES


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MARINI1  82 PRL 48 1649        +PERUZZI,PICCLO+  (FRAS+LBL+NWES+STAN+HAWA)
MARINI2  82 PR D26 1777        +PERUZZI,PICCLO+  (FRAS+LBL+NWES+STAN+HAWA)
NAPOLITA 82 PR D25 2837        NAPOLITANO,BESSET+(STAN+FRAS+LBL+NWES+HAWA)
ROSS     82 PL 118B 199        +RONGA,BESSET+    (FRAS+LBL+NWES+STAN+HAWA)
HODGES   81 PRL 47 1651        +ABRAMS,BADEN,BLAND,JOYCE,ROYER+ (UCR+SFSU)
LARUE    81 PRL 46 967         +PHILLIPS,FAIRBANK                   (STAN)
WEISS    81 PL 101B 439        +ABRAMS,ALAM,BLOCKER,BLONDEL+(SLAC+LBL+UCB)
BARTEL   80 ZPHY C6 295         JADE  (DESY+HAMB+HEID+LANC+MCHS+RHEL+TOKY)
BASILE   80 LNC 29 251         +BERBIERS,CONTIN+(BGNA+CERN+FRAS+ROMA+BARI)
BUSSIERE 80 NP B174 1          +GIACOMELLI,LESQUOY+       (BGNA+SACL+LAPP)
MARINELL 80 PL 94B 433         MARINELLI,MORPURGO                   (GENO)
    ALSO 80 PL 94B 427         MARINELLI,MORPURGO                   (GENO)
BOYD     79 PRL 43 1288        +BLATT,DONOGHUE,DRIES,HAUSMAN,SUITER  (OSU)
BOZZOLI  79 NP B159 363        +BUSSIERE,GIACOMELLI+ (BGNA+LAPP+SACL+CERN)
LARUE    79 PRL 42 142         +FAIRBANK,PHILLIPS                   (STAN)
  ERRATA 79 PRL 42 1019        LARUE,FAIRBANK,PHILLIPS
OGORODNI 79 JETP 49 953        OGORODNIKOV,SAMOILOV,SOLNTSEV        (KIAE)
STEVENSO 79 PR D20 82          STEVENSON                             (LBL)
YOCK     78 PR D18 641         YOCK                                 (AUCK)
BASILE1  78 NC 45A 171         +CARAROMEO,CIFARELLI,CONTIN+    (CERN+BGNA)
BASILE2  78 NC 45A 281         +CARAROMEO,CIFARELLI,CONTIN+    (CERN+BGNA)
BOYD1    78 PRL 40 216         +ELMORE,MELISSINOS,SUGARBAKER        (ROCH)
BOYD2    78 PL 72B 484         +ELMORE,NITZ,OLSEN,SUGARBAKER,WARREN+(ROCH)
LUND     78 RAD. ACTA 25 75    +BRANDT,FARES                        (PHIL)
PUTT     78 PR D17 1466        +YOCK                                (AUCK)
SCHIFFER 78 PR D17 2241        +RENNER,GEMMELL,MOORING          (CHIC+ANL)
ANTREASY 77 PRL 39 513         ANTREASYAN,COCCONI,CRONIN,FRISCH+(EFI+PRIN)
BASILE   77 NC 40A 41          +CARA ROMEO,CIFARELLI,GIUSTI+   (CERN+BGNA)
BLAND    77 PRL 39 369         +BOCOBO,EUBANK,ROYER                 (SFSU)
GALLINAR 77 PRL 38 1255        GALLINARO,MARINELLI,MORPURGO         (GENO)
LARUE    77 PRL 38 1011        +FAIRBANK,HEBARD                     (STAN)
MULLER   77 SCI 196 521        +ALVAREZ,HOLLEY+STEPHENSON            (LBL)
OGORODNI 77 JETP 45 857        OGORODNIKOV,SAMOILOV,SOLNTSEV        (KIAE)
BALDIN   76 SJNP 22 264        +VERTOGRADOV,VISHNEVSKII,GRISHKEVICH+(JINR)
BRIATORE 76 NC 31A 553         +DARDO,PIAZZOLI,MANNOCCHI+ (LCGT+FRAS+FREI)
STEVENS  76 PR D14 716         +SCHIFFER,CHUPKA                      (ANL)
ALBROW   75 NP B97 189         +BARBER,BENZ+(CERN+DARE+FOM+LANC+MCHS+UTRE)
FABJAN   75 NP B101 349        +GRUHN,PEAK,SAULI,CALDWELL+     (CERN+MPIM)
HAZEN    75 NP B95 189         +HODSON,WINTERSTEIN,GREEN,KASS+ (MICH+LEED)
JOVANOVI 75 PL 56B 105         JOVANOVICH+ (MANI+AACH+CERN+GENO+HARV+TORI)
KRISOR   75 NC 27A 132         KRISOR                               (AACH)
CLARK    74 PR D10 2721        +FINN,HANSEN,SMITH                    (LLL)
GALIK    74 PR D9 1856         +JORDAN,RICHTER,SEPPI,SIEMANN+  (SLAC+FNAL)
KIFUNE   74 JPSJ 36 629        +HIEDA,KUROKAWA,TSUNEMOTO,KIMURA+(TOKY+KEK)
NASH     74 PRL 32 858         +YAMANOUCHI,NEASE,SCULLI    (FNAL+CORN+NYU)
ALPER    73 PL 46B 265         + (CERN+LIVP+LUND+BOHR+RHEL+STOH+BERG+LOUC)
ASHTON   73 JPA 6 577          +COOPER,PARVARESH,SALEH              (DURH)
HICKS    73 NC 14A 65          +FLINT,STANDIL                       (MANI)
LEIPUNER 73 PRL 31 1226        +LARSEN,SESSOMS,SMITH,WILLIAMS+  (BNL+YALE)
BEUCHAMP 72 PR D6 1211         +BOWEN,COX,KALBACH                   (ARIZ)
BOHM     72 PRL 28 326         +DIEMONT,FAISSNER,FASOLD,KRISOR+     (AACH)
BOTT     72 PL 40B 693         +CALDWELL,FABJAN,GRUHN,PEAK+    (CERN+MPIM)
COX      72 PR D6 1203         +BEUCHAMP,BOWEN,KALBACH              (ARIZ)
CROUCH   72 PR D5 2667         +MORI,SMITH                          (CASE)
DARDO    72 NC 9A 319          +NAVARRA,PENENGO,SITTE               (TORI)
EVANS    72 PRSE A70 143       +FANCEY,MUIR,WATSON             (EDIN+LEED)
TONWAR   72 JPA 5 569          +NARANAN,SREEKANTAN                  (TIFR)
ANTIPOV  71 NP B27 374         +KACHANOV,KUTJIN,LANDSBERG,LEBEDEV+  (SERP)
CHIN     71 NC 2A 419          +HANAYAMA,HARA,HIGASHI,TSUJI         (OSAK)
CLARK    71 PRL 27 51          +ERNST,FINN,GRIFFIN,HANSEN,SMITH+ (LLL+LBL)
HAZEN    71 PRL 26 582         HAZEN                                (MICH)
BOSIA    70 NC 66A 167         +BRIATORE                            (TORI)
CHU      70 PRL 24 917         +KIM,BEAM,KWAK             (OSU+ROSE+KANS)
    ALSO 70 PRL 25 550         ALLISON,DERRICK,HUNT,SIMPSON,VOYVODIC (ANL)
ELBERT   70 NP B20 217         +ERWIN,HERB,NIELSEN,PETRILAK,WEINBERG(WISC)
FAISSNER 70 PRL 24 1357        +HOLDER,KRISOR,MASON,SAWAF,UMBACH    (AACH)
KRIDER   70 PR D1 835          +BOWEN,KALBACH                       (ARIZ)
MORPURGO 70 NIM 79 95          +GALLINARO,PALMIERI                  (GENO)
ALLABY   69 NC 64A 75          +BIANCHINI,DIDDENS,DOBINSON,HARTUNG+ (CERN)
ANTIPOV1 69 PL 29B 245         +KARPOV,KHROMOV,LANDSBERG,LAPSHIN+   (SERP)
ANTIPOV2 69 PL 30B 576         +BOLOTOV,DEVISHEV,DEVISHEVA,ISAKOV+  (SERP)
CAIRNS   69 PR 186 1394        +MCCKUSKER,PEAK,WOOLCOTT             (SYDN)
COOK     69 PR 188 2092        +DEPASQUALI,FRAUENFELDER,PEACOCK +    (ILL)
FUKUSHIM 69 PR 178 2058        FUKUSHIMA,KIFUNE,KONDO,KOSHIBA+      (TOKY)
MCCUSKER 69 PRL 23 658         +CAIRNS                              (SYDN)
BELLAMY  68 PR 166 1391        +HOFSTADTER,LAKIN,PERL,TONER    (STAN+SLAC)
BJORNBOE 68 NC B53 241         +DAMGARD,HANSEN+      (BOHR+TIFR+BERN+BERG)
BRIATORE 68 NC 57A 850         +CASTAGNOLI,BOLLINI,MASSAM+(TORI+CERN+BGNA)
FRANZINI 68 PRL 21 1013        +SHULMAN                             (COLU)
GARMIRE  68 PR 166 166         +LEONG,SREEKATAN                      (MIT)
HANAYAMA 68 CJP 46 S734        +HARA,HIGASHI,KITAMURA,MIONO+        (OSAK)
KASHA1   68 PR 172 1297        +STEFANSKI                       (BNL+YALE)
KASHA2   68 PRL 20 217         +LARSEN,LEIPUNER,ADAIR           (BNL+YALE)
KASHA3   68 CJP 46 S730        +LARSEN,LEIPUNER,ADAIR           (BNL+YALE)
MRAGINSK 68 JEPT 27 51         MRAGINSKII,ZELDOVICH,MARTYNOV,MIGULIN(MOSU)
RANK     68 PR 176 1635        RANK                                 (MICH)
BARTON   67 PRSL 90 87         BARTON                               (NPOL)
BATHOW   67 PL 25B 163         +FREYTAG,SCHULZ,TESCH                (DESY)
BUHLER1  67 NC 49A 209         +FORTUNATO,MASSAM+ZICHICHI      (CERN+BGNA)
BUHLER2  67 NC 51A 837         +DALPIAZ,MASSAM,ZICHICHI   (CERN+BGNA+STRB)
FOSS     67 PL 25B 166         +GARELICK,HOMMA,LOBAR,OSBORNE,UGLUM   (MIT)
GOMEZ    67 PRL 18 1022        +KOBRAK,MOLINE,MULLINS,ORTH,VANPUTTEN+(CIT)
KASHA    67 PR 154 1263        +LEIPUNER,WANGLER,ALSPECTOR,ADAIR(BNL+YALE)
STOVER   67 PR 164 1599        +MORAN,TRISCHKA                      (SYRA)
BARTON   66 PL 21 360          +STOCKEL                             (NPOL)
BENNETT  66 PRL 17 1196        BENNETT                              (YALE)
BUHLER   66 NC 45A 520         +FORTUNATO,MASSAM,MULLER+  (CERN+BGNA+STRB)
CHUPKA   66 PRL 17 60          +SCHIFFER,STEVENS                     (ANL)
GALLINAR 66 PL 23 609          GALLINARO,MORPURGO                   (GENO)
KASHA    66 PR 150 1140        +LEIPUNER,ADAIR                  (BNL+YALE)
LAMB     66 PRL 17 1068        +LUNDY,NOVEY,YOVANOVITCH              (ANL)
MASSAM   65 NC 40A 589         +MULLER,ZICHICHI                     (CERN)
FRANZINI 65 PRL 14 196         +LEONTIC,RAHM,SAMIOS,SCHWARTZ    (BNL+COLU)
DORFAN   65 PRL 14 999         +EADES,LEDERMAN,LEE,TING             (COLU)
DELISE   65 PR 140B 458        +BOWEN                               (ARIZ)
BINGHAM  64 PL 9 201           +DICKINSON,DIEBOLD,KOCH,LEITH+  (CERN+EPOL)
BLUM     64 PRL 13 353A        +BRANDT,COCCONI,CZYZEWSKI,DANYSZ+    (CERN)
BOWEN    64 PRL 13 728         +DELISE,KALBACH,MORTARA              (ARIZ)
HAGOPIAN 64 PRL 13 280         +SELOVE,EHRLICH,LEBOY,LANZA,RAHM+(PENN+BNL)
LEIPUNER 64 PRL 12 423         +CHU,LARSEN,ADAIR                (BNL+YALE)
MORRISON 64 PL 9 199           MORRISON                             (CERN)
SUNYAR   64 PR 136B 1157       +SCHWARZSCHILD,CONNORS                (BNL)
HILLAS   59 NAT 184 892        +CRANSHAW                            (AERE)

                              REVIEWS

LYONS    81 PPNP 7 157         LYONS                                 (OXF)
JONES    76 RMP 69 717         JONES                                (MICH)

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MAGNETIC MONOPOLE SEARCHES

(by W.P. Trower, Virginia Polytechnic Institute and State University)

Although the usual formulation of Maxwell's equations suggests magnetic monopoles, no observed phenomenon requires them for its explanation.[1] From the assertion that a monopole anywhere in the universe would result in electric charge quantization everywhere followed the prediction of a least magnetic charge $G = e/2\alpha$, the Dirac charge.[2] Observed pure multiphoton events have been attributed to virtual monopole production and annihilation.[3] Monopoles have recently become indispensable to many gauge theories, which endow them with a variety of extraordinarily large masses.

Monopole detectors have predominantly used either induction or ionization. Induction experiments measure the monopole magnetic charge by detecting a change in current when a monopole passes through a loop.[4] These measurements, which are independent of monopole electric charge, mass, and velocity, have produced a solitary monopole candidate event (CABRERA 82), uncorroborated by later searches (e.g., CABRERA 83).

Ionization experiments rely on a magnetic charge producing more ionization than an electrical charge with the same velocity. However, the ability to distinguish a monopole by ionization diminishes with velocity. The theory of monopole energy loss for $\beta \leqslant 10^{-3}$ is still unsettled.

Cosmic rays are the most likely source of large-mass monopoles, as accelerator energies are insufficient to produce them. Evidence for such monopoles may also be obtained from astrophysical observations.

This compilation should be used as a directory to the literature since the quoted experimental limits are often only indicative.

References

1. J.D. Jackson, CERN-77-17 (1977).
2. P.A.M. Dirac, Proc. Royal Soc. London **A133**, 60 (1931).
3. M.A. Ruderman and D. Zwanziger, Phys. Rev. Lett. **22**, 146 (1969).
4. L.W. Alvarez, LRL Physics Note 470 (1963).

For notation, see key at front of Listings.

Stable Particles

MAGNETIC MONOPOLE SEARCHES, AXION SEARCHES

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C       MONOPOLE PRODUCTION CROSS SECTION  --  ACCELERATOR SEARCHES
C
C      MONOPOLE X-SECT       MASS   G       REFERENCE   DET           BEAM
C       EVENTS  CM**2        GEV                                   GEV
C
C         0      <1E-31        - 1,3     AUBERT     83 PLAS      540P AP       10/83*
C         0      <4E-38      <10  <6     MUSSET     83 PLAS       34E+E-       10/83*
C    A    0      <8E-36      <20   -     DELL       82 CNTR       52P P         3/83*
C         0      <9E-37      <30  <3     KINOSHITA  82 PLAS       29E+E-        2/82
C         0      <1E-37      <20 <24     CARRIGAN   78 CNTR       63P P         2/79
C         0      <1E-37      <30  <3     HOFFMANN   78 PLAS       56P P         2/79
C    A    0        -           -   -     DELL       76 SPRK       62P P         4/82
C    A    0      <4E-33        -   -     STEVENS    76 SPRK      300PROT        4/82
C    C    0      <1E-40       <5  <2     ZRELOV     76 CNTR       70PROT        1/80
C    A    0      <2E-30        -   -     BURKE      75 OSPK      300NEUT        1/78
C    B    0      <1E-38        -   -     CARRIGAN   75 HLBC        8NU          1/76
C         0      <5E-43      <12 <10     EBERHARD   75 INDU      400PROT        1/75
C         0      <2E-36      <30  <3     GIACOMELL  75 PLAS       60P P         2/76
C         0      <5E-42      <13 <24     CARRIGAN   74 CNTR      400PROT       12/75
C         0      <6E-42      <12 <24     CARRIGAN   73 CNTR      300PROT        3/74
C         0      <1E-41       <5   -     GUREVICH   72 EMUL       70PROT        3/74
C         0      <1E-40       <3  <2     AMALDI     63 EMUL       28PROT       12/75
C         0      <2E-40       <3  <2     PURCELL    63 CNTR       30PROT       12/75
C         0      <1E-35       <3  <4     FIDECARO   61 CNTR       28PROT        4/82
C         0      <2E-35       <1   1     BRADNER    59 EMUL        6PROT        4/82
C
C    C - CHERENKOV RADIATION POLARIZATION.
C    B - RE-EXAMINES CERN NEUTRINO EXPTS.
C    A - MULTIPHOTON EVENTS.

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F       MONOPOLE FLUX  --  COSMIC RAY SEARCHES
F
F      MONOPOLE  FLUX        MASS    G      REFERENCE   DET     COMMENTS
F       EVENTS /CM2/S/SR     GEV
F
F         0      <4E-13        -     1     TARLE      84 CNTR   6E-4<B<2E-3        2/84*
F    D    7        -           -     -     ANDERSON   83 EMUL                      2/84*
F         0      <4E-13        -     1     BARTELT    83 CNTR   E-2<B<E-3          3/83*
F         0      <1E-12        -     1     BARWICK    83 PLAS   7E-3<B<1           2/84*
F         0      <5E-12        -     1     BATTISTON  83 CNTR   1E-4<B<1           2/84*
F         0      <3E-13        -     1     BONARELLI  83 CNTR   1E-3<B<4E-1       10/83*
F    C    0      <3E-12        -     -     BOSETTI    83 CNTR   5E-4<B<5E-2        2/84*
F         0      <4E-11        -     1     CABRERA    83 INDU                      2/84*
F         0      <5E-15        -     1     DOKE       83 PLAS   1E-2<B<1          10/83*
F    C    0      <8E-15        -     -     ERREDE     83 CNTR   1E-4<B<1E-1       10/83*
F    C    0      <7E-22        -     -     FREESE     83 COSM   PULSARS            2/84*
F         0      <5E-12        -     1     GROOM      83 CNTR   1E-4<B<3E-2        3/83*
F         0      <2E-12        -     -     MASHIMO    83 CNTR   6E-4<B<1          10/83*
F    C    0      <1E-18     <1E18    1     REPHAELI   83 COSM   INTERGLAC. FIELD   2/84*
F         0      <1E-13        -     1     ALEXEYEV   82 CNTR   B=3E-3             1/83*
F         0      <2E-12        -     1     BONARELLI  82 CNTR   7E-3<B<6E-1        3/83*
F         1       6E-10        -     1     CABRERA    82 INDU   DG=+-.06           4/82
F    C    0      <1E-23        -     -     DIMOPOULO  82 COSM   NEUT STARS         2/84*
F    C    0      <5E-22        -     -     KOLB       82 COSM   NEUT STARS        10/83*
F         0      <2E-11        -     -     MASHIMO    82 CNTR   7E-3<B<3           3/83*
F    B    0      <1E-12        -     1     TURNER     82 COSM   B=3E-3             1/83*
F         0      <2E-15        -     -     BARTLETT   81 PLAS   CONCENTRATOR       2/82
F         0      <2E-40        -     -     BONNARDEA  81 COSM   NEUT STARS         2/82
F         0      <1E-13       >1     -     KINOSHITA  81 PLAS   1E-3<B             2/82
F         0      <5E-11     <1E17    -     ULLMAN     81 CNTR   3E-4<B<1E-3        2/82
F         0      <2E-11        -     -     BARTLETT   78 PLAS   CONCENTRATOR       2/82
F    A    1      (1E-1)     >200     2     PRICE      75 PLAS   -                 12/75
F         0      <2E-13        -    >2     FLEISCHER  71 PLAS   -                  1/83*
F         0      <1E-16        -     1     PARKER     70 COSM   GALACTIC FIELD     1/83*
F         0      <1E-19        -    >2     FLEISCHER369 PLAS    OBSIDIAN, MICA     2/76
F         0      <5E-15      <15    <3     CARITHERS  66 ELEC   CONCENTRATOR      12/75
F         0      <2E-11        -  <1-3     MALKUS     51 EMUL   CONCENTRATOR       4/82

F    D - ANOMALOUS LONG-RANGE ALPHA TRACKS.
F    C - CATALYSIS OF NUCLEON DECAY.
F    B - REEVALUATES PARKER 80 LIMIT FOR GUT MONOPOLES.
F    A - ALVAREZ 75, FLEISCHER 75, FRIEDLANDER 75, ROSS 76EXPLAIN AS
F        FRAGMENTING NUCLEUS. EBERHARD 75 DISCUSSES CONFLICT WITH OTHER
F        EXPTS. HAGSTROM REINTERPRETS AS ANTINUCLEUS. PRICE 78 REASSESSES.

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D       MONOPOLE DENSITY  --  MATTER SEARCHES
D
D      MONOPOLE    DENSITY            G       REFERENCE   DET   MATERIAL
D       EVENTS
D
D        >1      >1E-14/GRAM        >1/3    MIKHAILOV 83 SPEC  IRON AEROSOLS        2/84*
D         0      <6E-33/NUCL           1    SCHATTEN  83 ELEC  MOON WAKE           10/83*
D         0      <2E-R/GRAM            -    CARRIGAN  80 COSM  EARTH HEAT          10/83*
D         0      <2E-4/PROT            -    BRODERICK 79 COSM  42-CM ABSORPTION    12/81
D         0      <6E-4/GRAM            -    CARRIGAN  76 CNTR  AIR, SEAWATER        1/77
D         0      <5E-1/GRAM         >.04    CABRERA   75 INDU  11 MATERIALS         5/82*
D         0      <2E-4/GRAM         >.05    ROSS      73 INDU  MOON ROCK            2/76
D         0      <6E-7/GRAM         <140    KOLM      71 CNTR  SEAWATER            12/75
D         0      <2E-13/M**3           -    SCHATTEN  70 ELEC  MOON WAKE            4/77
D         0      <1E-4/GRAM           >0    FLEISCH2  69 PLAS  MANGANESE           12/75
D         0      <1E-2/GRAM         <120    FLEISCH1  69 PLAS  MANGANESE NODULES    4/82
D         0      <2E-3/GRAM         <1-3    GOTO      63 EMUL  MAGNETITE, METEOR   12/75
D         0      <2E-2/GRAM            -    PETUKHOV  63 CNTR  METEORITE           12/75
D

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REFERENCES FOR MAGNETIC MONOPOLE SEARCHES


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TARLE    84 PRL 52 90         +AHLEN,LISS                      (UCB+MICH+IND)
ANDERSON 83 PR D28 2308       +LORD,STRAUSZ,WILKES                    (WASH)
AUBERT   83 PL 120B 465       +MUSSET,PRICE,VIALLE               (CERN+LAPP)
BARWICK  83 PR D28 2338       +KINOSHITA,PRICE                         (UCB)
BARTELT  83 PRL 50 655        +COURANT,HELLER,JOYCE,MARSHAK+    (MINN+ANL)
BATTISTO 83 PL 133B 454       BATTISTONI,BELLOTTI+  (FRAS+MILA+TORI+CERN)
BONARELL 83 PL 126B 137       BONARELLI,CAPILUPPI,DANTONE             (BGNA)
BOSETTI  83 PL 133B 265       +GORHAM,HARRIS,LEARNED+     (AACH+HAWA+TOKY)
CABRERA  83 PRL 51 1933       +TABER,GARDNER,BOURG                    (STAN)
DOKE     83 PL 129B 370       +HAYAHSI,HAMASAKI+     (TWAS+TRIK+TTAM+IPCR)
ERREDE   83 PRL 51 245        +STONE+    (UCI+MICH+BNL+CIT+CLEV+HAWA+LOUC)
FREESE   83 PRL 51 1625       +TURNER,SCHRAMM                         (CHIC)
GROOM    83 PRL 50 573        +LOH,NELSON,RITSON                 (UTAH+STAN)
MASHIMO  83 PL 128B 327       +ORITO,KAWAGOE,NAKAMURA,NOZAKI          (TOKY)
MIKHAILO 83 PL 130B 331       MIKHAILOV                               (KAZA)
MUSSET   83 PL 128B 333       +PRICE,LOHRMANN                    (CERN+HAMB)
REPHAELI 83 PL 121B 115       +TURNER                                 (CHIC)
SCHATTEN 83 PR D27 1525       SCHATTEN                                (NASA)
ALEXEYEV 82 LNC 35 413        +BOLIEV,CHUDAKOV,MAKOEV,MIKHEYEV+       (INRM)
BONARELL 82 PL 112B 100       BONARELLI,CAPILUPPI,DANTONE,+           (BGNA)
CABRERA  82 PRL 48 1378       CABRERA                                 (STAN)
DIMOPOUL 82 PL 119B 320       DIMOPOULOS,PRESKILL,WILCZEK        (HARV+UCSB)
DELL     82 NP B209 45        +YUAN,ROBERTS,DOOHER+AMALDI+(BNL+ADEL+ROMA)
KINOSHIT 82 PRL 48 77         KINOSHITA,PRICE,FRYBERGER          (UCB+SLAC)
KOLB     82 PRL 49 1373       +COLGATE,HARVEY                    (LASL+PRIN)
MASHIMO  82 JPSJ 51 3067      +KAWAGOE,KOSHIBA                        (TOKY)
TURNER   82 PR D26 1296       +PARKER,BOGDAN                          (CHIC)
BARTLETT 81 PR D24 612        +SOO,FLEISCHER,HART,MOGROCAMPERO(COLO+GESC)
BONNARDE 81 PR D23 323        BONNARDEAU                              (MPIM)
KINOSHIT 81 PR D24 1707       KINOSHITA,PRICE                          (UCB)
ULLMAN   81 PRL 47 289        ULLMAN                              (LEHM+BNL)
CARRIGAN 80 NAT 288 348       CARRIGAN                                (FNAL)
BRODERIC 79 PR D19 1046       BRODERICK,FICENEC,TEPLITZ,TEPLITZ        (VPI)
BARTLETT 78 PR D18 2253       +SOO,WHITE                         (COLO+PRIN)
CARRIGAN 78 PR D17 1754       +STRAUSS,GIACOMELLI                (FNAL+BGNA)
HOFFMANN 78 LNC 23 357        +KANTARDJIAN,DILIBERTO,MEDDI+      (CERN+ROMA)
PRICE    78 PR D18 1382     + SHIRK,OSBORNE,PINSKY                (UCB+HOUS)
HAGSTROM 77 PRL 38 729        HAGSTROM                                 (LBL)
CARRIGAN 76 PR D13 1823       +NEZRICK,STRAUSS                        (FNAL)
DELL     76 LNC 15 269        +UTO,YUAN,AMALDI+        (CERN+BNL+ROMA+ADEL)
ROSS     76  LBL-4665         ROSS                                     (LBL)
STEVENS  76 PR D14 2207       +COLLINS,FICENEC,TROWER,FISCHER+   (VPI+BNL)
ZRELOV   76 CZJP B26 1306     +KOLLAROVA,KOLLAR,LUPILTSEV,PAVLOVIC+(JINR)
ALVAREZ  75  LBL-4260         ALVAREZ                                  (LBL)
BURKE    75 PL 60B 113        +GUSTAFSON,JONES,LONGO                  (MICH)
CABRERA  75 PH D THESIS       CABRERA                                 (STAN)
CARRIGAN 75 NP B91 279        +NEZRICK                                (FNAL)
    ALSO 71 PR D3 56          +NEZRICK                                (FNAL)
EBERHARD 75  LBL-4289         EBERHARD                                 (LBL)
EBERHARD 75 PR D11 3099       +ROSS,TAYLOR,ALVAREZ,OBERLACK       (LBL+MPIM)
FLEISCHE 75 PRL 35 1412       FLEISCHER,WALKER                   (GESC+WUSL)
FRIEDLAN 75 PRL 35 1167       FRIEDLANDER                             (WUSL)
GIACOMEL 75 NC 28A 21         GIACOMELLI,ROSSI,+     (BGNA+CERN+SACL+ROMA)
PRICE    75 PRL 35 487        +SHIRK,OSBORNE,PINSKY               (UCB+HOUS)
CARRIGAN 74 PR D10 3867       +NEZRICK,STRAUSS                        (FNAL)
CARRIGAN 73 PR D8 3717        +NEZRICK,STRAUSS                        (FNAL)
ROSS     73 PR D8 698         +EBERHARD,ALVAREZ,WATT              (LBL+SLAC)
    ALSO 71 PR D4 3260        EBERHARD,ROSS,ALVAREZ,WATT          (LBL+SLAC)
    ALSO 70 SCI 167 701       ALVAREZ,EBERHARD,ROSS,WATT          (LBL+SLAC)
GUREVICH 72 PL 38B 549        +KHAKIMOV,MARTEMIANOV+       (KIAE+NOVO+SERP)
    ALSO 72 JETP 34 917       BARKOV,GUREVICH,ZOLOTAREV    (KIAE+NOVO+SERP)
    ALSO 70 PL 31B 394        +KHAKIMOV,MARTEMIANOV        (KIAE+NOVO+SERP)
FLEISCHE 71 PR D4 24          FLEISCHER,HART,NICHOLS,PRICE            (GESC)
KOLM     71 PR D4 1285        +VILLA,ODIAN                        (MIT+SLAC)
PARKER   70 APJ 160 383       PARKER                                  (CHIC)
SCHATTEN 70 PR D1 2245        SCHATTEN                                (NASA)
FLEISCH1 69 PR 177 2029       FLEISCHER,JACOBS,SCHWARTZ,PRICE   (GESC+FSU)
FLEISCH2 69 PR 184 1393       FLEISCHER,HART,JACOBS,+      (GESC+UNCS+GSCO)
FLEISCH3 69 PR 184 1398       FLEISCHER,PRICE,WOODS                   (GESC)
    ALSO 70 JAP 41 958        +HART,JACOBS,PRICE,SCHWARTZ,WOODS       (GESC)
CARITHER 66 PR 149 1070       CARITHERS,STEFANSKI,ADAIR           (YALE+BNL)
AMALDI   63 NC 28 773         +BARONI,MANFREDINI,BRADNER+(ROMA+UCSD+CERN)
GOTO     63 PR 132 387        +KOLM,FORD                     (TOKY+MIT+BRAN)
PETUKHOV 63 NP 49 87          +YAKIMENKO                              (LEBD)
PURCELL  63 PR 129 2326       +COLLINS,FUJII,HORNBOSTEL,TURKOT (HARV+BNL)
FIDECARO 61 NC 22 657         +FINOCCHIARO,GIACOMELLI                 (CERN)
BRADNER  59 PR 114 603        +ISBELL                                  (LBL)
MALKUS   51 PR 83 899         MALKUS                                  (CHIC)
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BIBLIOGRAPHIES

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CRAVEN   82  FERMILAB-82/96   +TROWER                             (FNAL+VPI)
RUZICKA  80  JINR 2-80-850    +ZRELOV                                 (JINR)
CRAVEN   81  FERMILAB-81/37   +TROWER,CARRIGAN                    (VPI+FNAL)
CARRIGAN 77  FERMILAB-77/42   CARRIGAN                                (FNAL)
STEVENS  73  VPI-EPP-73-5     STEVENS                                  (VPI)
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REVIEWS

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CARRIGAN 83 NAT 305 673       +TROWER                             (FNAL+VPI)
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AXION SEARCHES

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AX      VARIOUS AXION SEARCHES IN PRODUCTION OR DECAY                       1/83*
AX      (VALUES QUOTED ARE AXION PRODUCTION RATIO TO PIO PROD CROSS SEC.)   1/83*
AX       FOR THEORY AND REVIEW SEE WEINBERG PRL 40, 223 (1978); WILCZEK
AX       PRL 40, 279 (1978); DONNELLY PR D18, 1607 (1978); BARSHAY ET AL.,
AX       PRL 46, 1361 (1981); BARROSO+MUKHOPADHYAY PL 106, 91 (1981); AND
AX       PECCEI, PROC. INTL. NEUTRINO CONF., MAUI(1981), ED. CENCE (HAWAII).
AX       FOR INVISIBLE-AXION THEORY SEE E.G. WISE, GEORGI AND GLASHOW
AX       PRL 47, 402 (1981), AND FOR VERY HEAVY AXION THEORY SEE E.G. TYE
AX       PRL 47, 1035 (1981).  FOR K --> PI A0 SEE ALSO E.G., GOLDMAN
AX       AND HOFFMAN, PRL 40, 220 (1978), FRERE ET AL., PL 103B, 129 (1981).
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AX

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AXP     AXION PRODUCTION IN HADRONIC COLLISIONS AND VARIOUS BEAM DUMP EXPTS.
AXP     LIMITS ARE FOR CS(A0)/CS(PI0).
AXP        1. E-8   OR LESS  CL=.90   ALIBRAN   78 HYBR    BEAM DUMP           6/78
AXP        6. E-9   OR LESS  CL=.95   ASRATYAN  78 CALO    BEAM DUMP          12/79
AXP   A    5.4E-14  OR LESS  CL=.90   BELLOTTI  78 HLBC    FOR MASS=1.5 MEV    1/79
AXP   A    4.1E- 9  OR LESS  CL=.90   BELLOTTI  78 HLBC    FOR MASS=1 MEV      1/79
AXP   A    1.5E- 8  OR LESS  CL=.90   BELLOTTI  78 HLBC    BEAM DUMP           1/79
AXP   B    1. E-8   OR LESS  CL=.90   BOSETTI   78 HYBR    BEAM DUMP           6/78
AXP   C                               DONNELLY  78                            12/79
AXP        0.5E-8   OR LESS  CL=.90   HANSL1    78 WIRE    BEAM DUMP           6/78
AXP   D                               MICELMACH 78                            12/79
AXP   E                               VYSOTSSKI 78                             1/80
AXP   F                               BECHIS    79 CNTR                       12/79
AXP   G    1. E-8   OR LESS  CL=.90   COTEUS    79 OSPK    BEAM DUMP           7/79
AXP   H    1. E-3   OR LESS  CL=.95   DISHAW    79 CALO    400 GEV P P        12/79
AXP   I   0                           FAISSNER  80 OSPK BEAM DUMP,A0-->E+E-    1/82
AXP   J    1. E-8   OR LESS  CL=.90   JACQUES   80 HLBC    28 GEV PROTONS      9/81
AXP   J    1. E-14  OR LESS  CL=.90   JACQUES   80 HLBC    BEAM DUMP           9/81
AXP   K                               SOUKAS    80 CALO    28GEV P   B.DUMP    9/81
AXP   L  12                           FAISSNE1  81 OSPK CERN PS NU WIDEBAND    6/82*
AXP   M  15                           FAISSNE2  81 OSPK BEAM DUMP,A0-->2GAM    2/82
AXP   N   8                           KIM       81 OSPK 26 GEV P NUC-->A0 X    1/82
AXP   O                               FETSCHER  82 RVUE    CF.FAISSNER2 81    11/83*
AXP   P  24                           FAISSNER  83 OSPK BEAM-DUMP,A0-->2GAM   11/83*
AXP   Q                               FAISSNER2 83 RVUE LAMPF BEAM DUMP        1/84*
AXP   R                               HOFFMAN   83 CNTR PI-P-->N(A0-->E+E-)  11/83*
AXP
AXP   A  BELLOTTI 78 FIRST VALUE COMES FROM SEARCH FOR A-->E+E-. SECOND        1/79
AXP   A  VALUE COMES FROM SEARCH FOR A-->2GAMMA, ASSUMING MASS<2*MASS(E-).     1/79
AXP   A  FOR ANY MASS SATISFYING THIS,LIMIT IS ABOVE VALUE*(MASS**-4).         1/79
AXP   A  THIRD VALUE USES DATA OF PL 60B 401 AND QUOTES CS(PROD)*CS(INTER-     1/79
AXP   A  ACTION)<10**-67 CM**4.                                                1/79
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Stable Particles

Data Card Listings

AXION SEARCHES, OTHER STABLE PARTICLE SEARCHES

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AXP  B  BOSETTI 78 QUOTES CS(PROD)*CS(INTERACT)< 2.E-67 CM**4                6/78
AXP
AXP  C  DONNELLY 78 EXAMINES DATA FROM REACTOR NEUTRINO EXPTS OF REINES 76  12/79
AXP  C  AND GURR 74 AS WELL AS SLAC BEAM DUMP EXPT. EVIDENCE IS NEGATIVE.   12/79
AXP
AXP  D  MICELMACHER 78 FINDS NO EVIDENCE OF AXION EXISTENCE IN REACTOR      12/79
AXP  D  EXPTS OF REINES 76 AND GURR 74. (SEE REF UNDER DONNELLY 78 BELOW).  12/79
AXP
AXP  E  VYSOTSSKII 78 DERIVED LOWER LIMIT FOR THE AXION MASS. 25 KEV FROM    1/80
AXP  E  LUMINOSITY OF THE SUN AND 200 KEV FROM RED SUPERGIANTS.              1/80
AXP
AXP  F  BECHIS 79 LOOKED FOR THE AXION PRODUCTION IN LOW ENERGY ELECTRON    12/79
AXP  F  BREMSSTRAHLUNG AND THE SUBSEQUENT DECAY INTO EITHER 2 GAMMAS OR     12/79
AXP  F  E+ E-. NO SIGNAL FOUND. C.L.=0.90 LIMITS FOR MODEL PARAMETER(S)     12/79
AXP  F  ARE GIVEN.                                                          12/79
AXP
AXP  G  COTEUS 79 IS A BEAM DUMP EXPERIMENT AT BNL.                         12/79
AXP
AXP  H  DISHAW 79 IS A CALORIMETRIC EXPERIMENT AND LOOKS FOR LOW ENERGY     12/79
AXP  H  TAIL OF ENERGY DISTRIBUTUIONS DUE TO ENERGY LOST TO WEAKLY          12/79
AXP  H  INTERACTING PARTICLES.                                              12/79
AXP
AXP  I  FAISSNER 80 IS SIN BEAM DUMP EXPT WITH 590 MEV PROTONS LOOKING FOR   1/82
AXP  I  A0-->E+ E- DECAY. ASSUMING A0/PI0=5.5E-7,OBTAINED DECAY RATE LIMIT   1/82
AXP  I  20/(A0 MASS) MEV/SEC (CL=.90),WHICH IS ABOUT 10**-7 BELOW THEORY     1/82
AXP  I  AND INTERPRETED AS UPPER LIMIT TO MASS(A0) < 2* MASS(E-).            1/82
AXP
AXP  J  JACQUES 80 IS A BNL BEAM DUMP EXP.  FIRST LIMIT ABOVE COMES FROM     9/81
AXP  J  NON-OBSERVATION OF EXCESS NC-TYPE EVENTS (CS(PROD)*CS(INTERACT) <    9/81
AXP  J  7.E-68 CM**4,CL=0.90).  SECOND LIMIT IS FROM NON-OBSERVATION OF      9/81
AXP  J  AXION DECAYS INTO TWO GAMMAS OR E+E-, AND FOR AXION MASS A FEW MEV.  9/81
AXP
AXP  K  SOUKAS 80 AT BNL OBSERVED NO EXCESS OF NC-TYPE EVENTS IN BEAM DUMP.  9/81
AXP
AXP  L  FAISSNER1 81 SEE EXCESS MU E EVENTS. SUGGEST AXION INTERACTIONS.     6/82*
AXP
AXP  M  FAISSNER2 81 IS SIN 590MEV PROTON BEAM DUMP. OBSERVED 14.5+-5.0 EVS  2/82
AXP  M  OF 2 GAMMA DECAY OF LONG-LIVED NEUTRAL PENETRATING PARTICLE WITH     2/82
AXP  M  M(2 GAMMA) < APPROX. 1 MEV. AXION INTERPR. WITH ETA-A0 MIXING GIVES  2/82
AXP  M  M(A0)=(250+-25)KEV, TAU(2 GAMMA)=(7.3+-3.7)E-3 SEC FROM ABOVE RATE.  2/82
AXP
AXP  N  KIM 81 ANALYZED 8 CANDIDATES FOR A0-->2 GAMMA OBTAINED BY AACHEN-    1/82
AXP  N  PADOVA EXPT AT CERN WITH 26 GEV PROTONS ON BE. ESTIMATED AXION MASS  1/82
AXP  N  IS ABOUT 300 KEV AND LIFE IS (0.86 TO 5.6)E-3 S DEPENDING MODELS.    1/82
AXP  N  FAISSNER, PRIV. COMM, SAYS AXION PROD. UNDERESTIMATED AND MASS       4/82
AXP  N  OVERESTIMATED.  CORRECT VALUE AROUND 200 KEV.                        4/82
AXP
AXP  O  FETSCHER 82 RE-ANALYZES SIN BEAM-DUMP DATA OF FAISSNER 81. CLAIMS   11/83*
AXP  O  NO EVIDENCE FOR AXION SINCE 2-GAMMA PEAK RATE REMARKABLY DECREASES  11/83*
AXP  O  IF IRON WALL IS SET IN FRONT OF THE DECAY REGION.                   11/83*
AXP
AXP  P  FAISSNER 83 OBSERVED 19 1-GAMMA AND 12 2-GAMMA EVENTS WHERE A BKGD  11/83*
AXP  P  OF 4.8 AND 2.3 RESPECTIVELY IS EXPECTED. A SMALL-ANGLE PEAK IS      11/83*
AXP  P  OBSERVED EVEN IF IRON WALL IS SET IN FRONT OF THE DECAY REGION.     11/83*
AXP
AXP  Q  FAISSNER2 83 EXTRAPOLATE SIN GAM SIGNAL TO LAMPF NEU EXP CONDITION.  1/84*
AXP  Q  RESULTING 370 GAMMAS ARE NOT AT VARIANCE WITH LAMPF UPPER LIMIT      1/84*
AXP  Q  OF 450 GAMMAS. DERIVED FROM LAMPF LIMIT THAT (DSIGMA(A0)/DOMEGA AT   1/84*
AXP  Q  90 DEG)*M(A0)/TAU(A0) < 14*10**-35 CM**2*SR**-1*MEV*MILLISEC**-1.    1/84*
AXP
AXP  R  HOFFMAN 83 SET CL=.90 LIMIT DSIGMA/DT*BR(E+E-)<3.5E-32 CM**2/GEV**2 11/83*
AXP  R  FOR 140 <M(A0)<160 MEV. LIMIT ASSUMES TAU(A0) < 10**-9 SEC.         11/83*

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AXD    AXION SEARCHES IN THE DECAY OR TRANSITION OF POSITRONIUM,QUARKONIUM,
AXD    KAON,NUCLEON,AND RADIOACTIVE NUCLEUS. LIMITS ARE FOR BRANCHING RATIO
AXD  A                                CALAPRICE 79         CARBON           9/81
AXD  B                                ZHITNITSK 79         HEAVY AXION      9/81
AXD  C   0                            ASANO     81 CNTR STOPPED K+-->PI+ A0  2/82
AXD  D                                VUILLEUMI 81 CNTR REACTOR,A0--> 2 GAM  1/84*
AXD  E   0                            ZEHNDER   81 CNTR BA*-->(A0-->2GAM)BA  1/82
AXD  F                                ALEKSEEV  82 CNTR LI*,D* TR. A0->2GAM 11/83*
AXD  G   0                            ASANO     82 CNTR STOPPED K+-->PI+ A0  1/83*
AXD  H                                BARROSO   82      PHOTO-PROD.IN STARS 11/83*
AXD  I                                DATAR     82 CNTR LIGHT WATER REACTOR  1/83*
AXD  J     1.4 E-5  OR LESS  CL=.90   EDWARDS   82 CBAL J/PSI-->A0 GAMMA    11/83*
AXD  K                                LEHMANN   82 CNTR CU*-->(A0-->2GAM)CU  1/83*
AXD  L     3.5 E-4  OR LESS  CL=.90   SIVERTZ   82 CUSB UPSI(1S)-->A0 GAMMA 11/83*
AXD  L     1.2 E-4  OR LESS  CL=.90   SIVERTZ   82 CUSB UPSI(3S)-->A0 GAMMA 11/83*
AXD  M   0                            ZEHNDER   82 CNTR LI*,NB*DECAY,N-CAPT  1/83*
AXD  N     3.  E-4  OR LESS  CL=.90   ALAM      83 CLEO UPSI(1S)-->A0 GAMMA 11/83*
AXD  O                                CARBONI   83 CNTR ORTHO-POSITRONIUM   11/83*
AXD  P                                CAVAIGNAC 83 CNTR NB97*,D*TR.A0->2GAM 11/83*
AXD  Q     9.1 E-4  OR LESS  CL=.90   NICZYPORU 83 LENA UPSI(1S)-->A0 GAMMA 11/83*
AXD
AXD  A  CALAPRICE 79 SAW NO AXION EMISSION FROM EXCITED STATES OF CARBON.    9/81
AXD  A  SENSITIVE TO AXION MASS BETWEEN 1 AND 15 MEV.                        9/81
AXD
AXD  B  ZHITNITSKII 79 ARGUE THAT A HEAVY AXION BY YANG (3<M<40 MEV)         9/81
AXD  B  CONTRADICTS EXPERIMENTAL MUON ANOM. MAGNETIC MOMENTS.                9/81
AXD
AXD  C  ASANO 81 IS KEK EXPT. SET BR(K+ -->PI+ A0) < 3.8E-8 AT CL=.90.       2/82
AXD
AXD
AXD  D  VUILLEUMIER 81 IS AT GRENOBLE REACTOR. SET LIMIT M(A0)<280 KEV.      1/84*

AXD  E  ZEHNDER 81 LOOKED FOR BA*-->A0 BA TRANSITION WITH A0-->2 GAMMA.      1/82
AXD  E  OBTAINED 2GAMMA COINCIDENCE RATE < 2.2E-5 /SEC(CL=.95) EXCLUDING     1/82
AXD  E  MASS(A0)>160 KEV(OR 200 KEV DEPENDING ON HIGGS MIXING).              1/82
AXD  E  HOWEVER, SEE BARROSO + MUKHOPADHYAY, REF. ABOVE.                     4/82
AXD
AXD  F  ALEKSEEV 82 WITH IBR-2 PULSED REACTOR EXCLUDE STANDARD A0 AT CL=.95 11/83*
AXD  F  MASS-RANGES M(A0)<400 KEV (LI* DECAY) AND 330 KEV<M(A0)<2.2MEV      11/83*
AXD  F  (DEUT* DECAY).                                                      11/83*
AXD
AXD  G  ASANO 82 AT KEK SET LIMITS FOR BR(K+-->PI+ A0) FOR M(A0)<100 MEV AS  1/83*
AXD  G  BR <4.E-8 FOR TAU(A0-->N-GAMMAS)>1.E-9S, BR<1.4E-6 FOR TAU<1.E-9S.   1/83*
AXD                                                                          1/83*
AXD  H  BARROSO 82 DERIVE IN DFS-MODEL(PL104B,199)  A0 MASS LIMITS FROM     11/83*
AXD  H  STELLER-ENERGY-LOSS BOUND. ALLOWED MASS REGIONS ARE                 11/83*
AXD  H  M(A0)<10 EV (AXION INVISIBLE DUE TO VERY SMALL COUPLING), AND       11/83*
AXD  H  M(A0) AROUND 200 KEV (CORRESPONDING DFS-A0 PARAM IS HARDLY          11/83*
AXD  H  COMPATIBLE WITH REACTOR DATA OF ZEHNDER 81).                        11/83*
AXD
AXD  I  DATAR 82 LOOKED FOR A0-->2 GAMMA IN NEUTRON CAPTURE (N P-->D A0) AT  1/83*
AXD  I  TARAPUR 500 MW REACTOR. SENSITIVE TO SUM OF I=0 AND I=1 AMPLITUDES.  1/83*
AXD  I  WITH ZEHNDER 81((I=0)-(I=1)) RESULT, ASSERT NON-EX OF STANDARD A0.   1/83*
AXD
AXD  J  EDWARDS 82 LOOKED FOR J/PSI-->GAMMA+AXION DECAYS BY LOOKING FOR      4/82
AXD  J  EVENTS WITH A SINGLE GAMMA (OF ENERGY APPROX. 1/2 THE J/PSI MASS),   4/82
AXD  J  PLUS NOTHING ELSE IN THE DETECTOR. THE LIMIT IS INCONSISTENT WITH   11/83*
AXD  J  THE AXION INTERPRETATION OF THE FAISSNER2 81 RESULT.                11/83*
AXD                                                                          1/83*
AXD  K  LEHMANN 82 OBTAINED A0-->2GAM RATE<6.2E-5 /SEC (CL=.95) EXCLUDING    1/83*
AXD  K  MASS(AXION) BETWEEN 100 AND 1000 KEV.                                1/83*
AXD  L  SIVERTZ 82 IS CESR EXPT. LOOKED FOR UPSI-->GAMMA A0, A0 UNDETECTED. 11/83*
AXD  L  LIMIT FOR 1S(3S) IS VALID FOR M(A0)<7 GEV (4 GEV).                  11/83*
AXD                                                                          1/83*
AXD  M  ZEHNDER 82 USED GOESGEN 2.8GW LIGHT-WATER REACTOR TO CHECK A0 PROD.  1/83*
AXD  M  NO TWO GAMMA PEAK IN LI*,NB* DECAY(BOTH SINGLE P TRANSITION) NOR IN  1/83*
AXD  M  N CAPTURE(COMB WITH PREVIOUS BA* NEG RESULT) RULES OUT STANDARD A0.  1/83*
AXD  M  SET LIMIT M(A0)<60KEV FOR ANY A0.                                    1/83*
AXD
AXD  N  ALAM 83 IS AT CESR. THIS LIMIT COMBINED WITH LIMIT FOR BR(J/PSI-->  11/83*
AXD  N  A0 GAMMA) (EDWARDS 82) EXCLUDES STANDARD AXION.                     11/83*
AXD
AXD  O  CARBONI 83 LOOKED FOR ORTHOPOSITRONIUM-->A0 GAMMA. SET LIMIT FOR A0 11/83*
AXD  O  ELECTRON COUPLING SQUARED, G(EEA0)**2/(4*PI) < 6.E-10 TO 7.E-9 FOR  11/83*
AXD  O  M(A0)FROM 150 TO 900 KEV(CL=.997). THIS IS ABOUT 1/10 OF G-2 BOUND. 11/83*
AXD
AXD  P  CAVAIGNAC 83 AT BUGEY REACTOR EXCLUDE AXION AT ANY MASS(NB97*DECAY) 11/83*
AXD  P  AND AXION WITH M(A0) BETWEEN 275 AND 288 KEV (DEUTERON* DECAY).     11/83*
AXD
AXD  Q  NICZYPORUK 83 IS DESY-DORIS EXPERIMENT. THIS LIMIT TOGETHER WITH    11/83*
AXD  Q  LOWER LIMIT 9.2 E-4 OF BR(UPSI-->A0 GAMMA)   DERIVED FROM BR(J/PSI  11/83*
AXD  Q  -->A0 GAMMA) LIMIT (EDWARDS 82) EXCLUDES STANDARD AXION.            11/83*

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REFERENCES FOR AXION SEARCHES


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ALIBRAN  78 PL 74B 134        AACH+BARI+BERG+BRUX+CERN+EPOL+MILA+ORSA+
ASRATYAN 78 PL 79B 497        +EPSTEIN,FAKHRUTDINOV+           (ITEP+SERP)
BELLOTTI 78 PL 76B 223        +FIORINI,ZANOTTI                      (MILA)
BOSETTI  78 PL 74B 143        +DEDEN+      (AACH+BONN+CERN+LOIC+OXF+SACL)

DONNELLY 78 PR D18 1607       +FREEDMAN,LYTEL,PECCEI,SCHWARTZ       (STAN)
    ALSO 76 PRL 37 315        REINES,GURR,SOBEL
    ALSO 74 PRL 33 179        GURR,REINES,SOBEL
HANSL1   78 PL 74B 139        +HOLDER,KNOBLOCH+(CERN+DORT+HEID+SACL+BGNA)
MICELMAC 78 LNC 21 441        MICELMACHER,PONTECORVO                (JINR)
VYSOTSSK 78 JETPL 27 502      VYSOTSSKII+(INST.APPL.MATH.,USSR ACA. SCI.)

BECHIS   79 PRL 42 1511       +DOMBECK+    (UMD+COLU+A.F.R.R.I.-BETHESDA)
CALAPRIC 79 PR D20 2708       CALAPRICE,DUNFORD,KOUZES,MILLER+      (PRIN)
COTEUS   79 PRL 42 1438       +DIESBURG,FINE,LEE,SOKOLSKY+ (COLU+ILL+BNL)
DISHAW   79 PL 85B 142        +DIAMANT-BERGER,FAESSLER,LIU+     (SLAC+CIT)
ZHITNITS 79 SJNP 29 517       ZHITNITSKII,SKOVPEN                   (NOVO)

FAISSNER 80 PL 96B 201        +FRENZEL,HEINRIGS,PREUSSGER,SAMM,SAMM(AACH)
JACQUES  80 PR D21 1206       +KALELKAR,MILLER,PLANO+     (RUTG+STEV+COLU)
SOUKAS   80 PRL 44 564        +WANDERER,WENG,BREGMAN+(BNL+HARV+ORNL+PENN)

ASANO    81 PL 107B 159       +KIKUTANI,KUROKAWA+          (KEK+TOKY+OSAK)
FAISSNE1 81 ZPHY C10 95       FAISSNER,FRENZEL,GRIMM,HANSL,HOFFMAN+(AACH)
FAISSNE2 81 PL 103B 234       FAISSNER,FRENZEL,HEINRIGS,PREUSSGER+ (AACH)
KIM      81 PL 105B 55        B.R.KIM,CH.STAMM                      (AACH)
VUILLEUM 81 PL 101B 341       VUILLEUMIER,BOEHM,HAHN,KWON+      (CIT+MUNI)
ZEHNDER  81 PL 104B 494       A.ZEHNDER                              (ETH)

ALEKSEEV 82 JETPL 36 116      +KALININA,KRUGLOV,KULIKOV +      (MOSU+JINR)
ASANO    82 PL 113B 195       +KIKUTANI,KUROKAWA+          (KEK+TOKY+OSAK)
BARROSO  82 PL 116B 247       A.BARROSO,C.BRANCO                    (LISB)
DATAR    82 PL 114B 63        +BABA,BETIGERI,SINGH                  (BHAB)
EDWARDS  82 PRL 48 903        +PARTRIDGE,PECK+  (CIT+HARV+PRIN+STAN+SLAC)

FETSCHER 82 JPG 8 L147        W.FETSCHER                             (ETH)
LEHMANN  82 PL 115B 270       +LESQUOY,MULLER,ZYLBERAJCH            (SACL)
SIVERTZ  82 PR D26 717        +LEE-FRANZINI+         (STON+COLU+LSU+MPIM)
ZEHNDER  82 PL 110B 419       +GABATHULER,VUILLEUMIER       (ETH+SIN+CIT)

ALAM     83 PRD 27 1665       + (VAND+CORN+ITHA+HARV+OHIO+ROCH+RUTG+SYRA)
CARBONI  83 PL 123B 349       G.CARBONI,W.DAHME                (CERN+MUNI)
CAVAIGNA 83 PL 121B 193       CAVAIGNAC,HOUMMADA,KOANG,OST+    (GREN+LAPP)
FAISSNER 83 PRD 28 1198       +HEINRIGS,PREUSSGER,SAMM              (AACH)
FAISSNE2 83 PRD 28 1787       FAISSNER,FRENZEL,HEINRIGS,PRESSGER,+ (AACH)
HOFFMAN  83 PRD 28 660        +FRANK,MISCHKE,MOIR,SCHARDT      (LANL+ARZS)
NICZYPOR 83 ZPHY C17 197      NICZYPORUK+ LENA COLLAB.  (CRAC+ERLA+DESY+)
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OTHER STABLE PARTICLE SEARCHES

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We collect here those searches which do not fit neatly into one of the above search categories. These include searches for higgs bosons, technipions, gluinos, photinos, squarks, shadrons, and sleptons (sections H, HGC, EGT, EGP, SLP), trimuon and four-lepton production in neutrino and antineutrino reactions (T, FL), di- and trimuon production in muon interactions (MU), and heavy particle searches in accelerator experiments (EE, CH, CS, D, ICH, RPI, CA, CEN), in cosmic rays (F), and in matter (CON). Searches are also listed for light particles (C), highly-ionizing particles (ION), penetrating non-neutrino-like particles (BD), and tachyons (TCF, TCM, TCD). Note that axion searches now appear in a separate section above.

OTHER STABLE PARTICLE SEARCHES

BD **PRODUCTION OF NEW PENETRATING NON-NEUTRINO LIKE STATES IN BEAM DUMP**
BD A LOSECCO 81 CALO 28 GEV PROTONS 1/82
BD A NO EXCESS N.C.EVS LEADS TO CSP*CSI*ACCEPTANCE<2.26E-71 CM**4/NUC**2 1/82
BD A (CL=.90)FOR LIGHT NEUTRALS. ACC. DEPENDS ON MODELS (0.1 TO 4.E-4). 1/82

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T **TRIMUON PRODUCTION IN NEUTRINO NUCLEON INTERACTIONS**
T SEE ALSO SECTION 'NEU' IN 'HEAVY LEPTON SEARCHES'.
T FOR EXTENSIVE DISCUSSION, SEE ALBRIGHT 78 (PR D18, 108), HANSL 78
T (NP B142, 381), AND KANE 79 (PR D19, 1978).
T
T A 2 EVENTS MU- MU MU BARISH 77 SPEC NEU BEAM 7/77
T A BARISH 77 EVENTS CONTAIN FAST MU- AND 2 ADDITIONAL MUONS WITH LOW 7/77
T A ENGERY IN DIMUON REST FRAME. SLOW MUONS COULD COME FROM EITHER 7/77
T A VIRTUAL PHOTON OR VECTOR MESON OR FROM ASSOC PROD OF CHARMED 7/77
T A PARTICLES WHICH DECAY LEPTONICALLY. 7/77
T
T B 6 SEEN BENVENUTI 77 NEUL 5/6NEU,1/6NEUBAR 12/77
T B BENVENUTI 77 IS FNAL EXPT. CAN BE EXPLAINED BY PROD OF NEW HEAVY 12/77
T B LEPTON --> MU- NEUBAR NEW LIGHTER LEPTON --> MU+ MU- NEU. 12/77
T
T C BLETZACKE 77 RVUE 12/77
T C BLETZACKER 77 EXPLAINS TRIMUON AND LIKE SIGN DIMUON PROD AS ASSOC 12/77
T C PROD OF CHARM. 12/77
T
T D 3 SEEN HOLDER 77 SPEC 12/77
T D HOLDER 77 EVENTS ARE MU-MU-M+ AND MU-MU+MU+ WITH NEU BEAM, AND 12/77
T D MU+MU-MU- WITH NEUBAR BEAM. RATE RELATIVE TO CHARGED CURRENT EVENTS 12/77
T D IS 4*10**-5. 12/77
T
T E ALBRIGHT 78 RVUE 12/79
T E ALBRIGHT 78 COMPARES DATA OF TRIMUON AND FOUR-MUON EVENTS LISTED 12/79
T E ABOVE WITH SIX MODELS. 12/79
T
T F 7 SEEN BENVENUTI 78 NEUL 8/78
T F BENVENUTI 78 IS FNAL EXPT. 6 OF THE EVENTS ARE SEEN USING A 95 PCNT 8/78
T F NEU BEAM, 1 USING AN 83 PCNT NEUBAR BEAM. SEE MORI 78 FOR LIMITS 8/78
T F OF THE PROB THAT THE TRIMUONS ARE PRODUCED BY A NEW SHORT-LIVED 8/78
T F SOURCE OF NEUTRINOS. 8/78
T
T G 76 EVENTS MU- MU- MU+ HANSL2 78 SPEC NEU BEAM 1/79
T G HANSL2 78 IS CERN SPS EXPT. RATE RELATIVE TO SINGLE MUON EVENTS IS 1/79
T G (3.0+-.4)*10**-5 FOR E(NEU)>30 GEV. CAN BE EXPLAINED AS C.C. 1/79
T G INTERACTIONS WITH ADDITIONAL LOW MASS MU PAIRS. NO EVIDENCE FOR NEW 1/79
T G HEAVY LEPTON. 1/79
T
T H 39 MU-MU-MU+ SEEN BENVENUTI 79 NEUL NEU BEAM 7/79
T H BENVENUTI 79 INCLUDES 9 EVENTS FROM BENVENUTI 77 AND 78. RATE 7/79
T H RELATIVE TO SINGLE MUON EVENTS IS (1.1+-.5)*10**-4 FOR E(NEU)>100 7/79
T H GEV. CONSISTENT WITH E.M. AND DIRECT PRODUCTION OF MU PAIRS. 7/79
T H CHARM ASSOC PROD MAY ACCOUNT FOR 20 PERCENT OF PRODUCTION. NO 7/79
T H EVIDENCE FOR NEW HEAVY LEPTONS OR HEAVY QUARKS. 7/79
T
T I 8 MU+MU+MU- DEGROOT 79 SPEC NEUBAR BEAM 12/79
T I DEGROOT 79 IS CERN SPS EXPT. RATE RELATIVE TO SINGLE MUON EVENTS 12/79
T I IS (1.8+-0.6)E-5 FOR E(NEU)>=30 GEV AND P(MU)>=4.5 GEV/C. COULD BE 12/79
T I EXPLAINED AS C.C. INTERACTION ACCOMPANIED BY A MUON PAIR OF EITHER 12/79
T I HADRONIC OR E.M. ORIGIN AS IN NEU CASE. NEGATIVE SIGNAL FOR HEAVY 12/79
T I LEPTON. 12/79

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FL **FOUR-LEPTON PRODUCTION IN NEUTRINO-NUCLEON INTERACTIONS** 2/79
FL A 1 2MU+ 2MU- HOLDER 78 SPEC 2/79
FL B 1 2E- E+ MU+ LOVELESS 78 HBC 2/79
FL
FL A HOLDER 78 EVENT IS FROM CERN-SPS EXPT. RATE RELATIVE TO MU+MU- 2/79
FL A EVENTS IS 1.4E-4. 2/79
FL
FL B LOVELESS 78 EVENT IS FROM FNAL EXPT. EVENT ALSO HAS 1 KS AND 7 2/79
FL B GAMMAS. 2/79

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MU **DI- AND TRI-MUON PRODUCTION IN MU NUCLEON INTERACTIONS**
MU SEE ALSO SECTION 'MU' IN HEAVY LEPTON SEARCHES AND CHARM SEARCHES 10/81
MU A 11 TRIMUON EVENTS CHANG 77 SPEC 12/77
MU A 32 DIMUON EVENTS CHANG 77 SPEC 12/77
MU B 450 MU+MU- 223 MU-MU- EVENTS LEBRITTON 80 SPEC WCM(VIRTUAL PHOTON- 12/81
MU B 158 MU-MU-MU+ EVENTS LEBRITTON 80 SPEC NUCLEON) < 4.5 GEV 12/81
MU
MU A CHANG 77 DIMUON RATE IS GT 5*10**-4 THAT OF INCLUSIVE MUON RATE. 12/77
MU A CROSS SECTION UNCORRECTED FOR ACCEPTANCE IS 5*10**-36 CM**2/NUCLEON 12/77
MU
MU B LEBRITION 80 IS BNL EXP. LOOKED FOR MUOPRODUCTION OF SHORT- 12/81
MU B LIVED PARTICLES BELOW CHARM THRESHOLD. TRIMUONS ARE CONSISTENT WITH 12/81
MU B QED TRIDENT PLUS RHO DECAY AND DIMUONS ALSO WITH KNOWN SOURCES. AT 12/81
MU B CL=.90 CS(MU-N-->M+ X)*BR(M+ -->MU+ X) < 1.64 E-34 CM**2 AND CS(MU- 12/81
MU B N-->M- X)*BR(M- -->MU- X)<.81E-34 CM**2 WITH M+- SHORT-LIVED MESON. 12/81

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EE **HEAVY PARTICLE PRODUCTION CROSS-SECTION IN E+ E- REACTION** 2/82
EE (RATIO TO CS(E+E- -->MU+MU-)). SEE ALSO SECTION EE IN QUARK SEARCHES 2/82
EE AND SECTION EE IN MAGNETIC MONOPOLE SEARCHES. 2/82
EE A 0 5.0 E-2 OR LESS CL=.90 BARTEL 80 JADE Q=(3,4,5)/3 2-12GEV 2/82
EE B 0 1.6 E-2 OR LESS CL=.95 KINOSHITA 82 PLAS Q=3-180,M<14.5GEV 2/82
EE
EE A BARTEL 80 IS DESY PETRA EXPT WITH WCM=27-35 GEV. ABOVE LIMIT IS FOR 2/82
EE A INCLUSIVE PAIR PROD AND RANGES BETWEEN 1.E-1 - 1.E-2 DEPENDING ON 2/82
EE A MASS AND PROD MOMENTUM DIST. (SEE THEIR FIGS.9,10,11). 2/82
EE
EE B KINOSHITA 82 IS SLAC PEP EXPT AT WCM=29 GEV USING LEXAN AND CR-39 2/82
EE B PLASTIC SHEETS SENSITIVE TO HIGHLY IONIZING PARTICLES. 2/82

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CH **HEAVY PARTICLE PRODUCTION CROSS SECTION (CM**2)**
CH A 0 1. E-31 OR LESS LEIPUNER 73 CNTR +- M=3-11 GEV 5/76
CH B 0.3-1.3E-31 OR LESS CARROLL 78 SPEC M=2.-2.5 GEV 1/79
CH
CH A LEIPUNER 73 IS AN NAL 300 GEV P EXPT. WOULD HAVE DETECTED PARTICLES 4/76
CH A WITH LIFETIME GREATER THAN 200 NSEC. 4/76
CH
CH B CARROLL 78 LOOK FOR NEUTRAL, S=-2 DIHYPERON RESONANCE IN 1/79
CH B P P --> 2K+ X. CS VARIES WITHIN ABOVE LIMITS OVER MASS RANGE AND 1/79
CH B PLAB=5.1-5.9 GEV/C. 1/79

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CS **HEAVY PARTICLE PRODUCTION CROSS-SECTION (CM**2/NUCLEON)**
CS A 0 2.5E-35 OR LESS GUSTAFSON 76 CNTR 0 TAU GT 10**-7 1/77
CS
CS A GUSTAFSON 76 IS A 300 GEV FNAL EXPT LOOKING FOR HEAVY (M GT 2 GEV) 1/77
CS A LONGLIVED NEUTRAL HADRONS IN THE M4 NEUTRAL BEAM. THE ABOVE TYPICAL 1/77
CS A VALUE IS FOR M=3 GEV AND ASSUMES AN INTERACTION CROSS SECTION OF 1/77
CS A 1 MB. VALUES AS A FUNCTION OF MASS AND INTERACTION CROSS SECTION 1/77
CS A ARE GIVEN IN FIG. 2. 1/77

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D **HEAVY PARTICLE PRODUCTION DIFFERENTIAL CROSS SECTION (CM**2/SR-GEV)**
D A 0 1.5E-36 OR LESS DORFAN 65 CNTR BE TARGET M=3-7GEV 5/76
D A 0 3.0E-36 OR LESS DORFAN 65 CNTR FE TARGET M=3-7GEV 5/76
D 0 2.4E-35 OR LESS CL=.90 BINON 69 CNTR Q=- M=1-1.8 GEV 3/77
D B 0 2.4E-35 OR LESS CL=.90 ANTIPOV1 71 CNTR Q=- M=1.2-1.7,2.1-4 3/77
D C 0 1.2E-35 OR LESS CL=.90 ANTIPOV2 71 CNTR Q=- M=2.2-2.8 3/77
D D 0 5.8E-34 OR LESS CL=.90 ALPER 73 SPEC +- M=1.5-24 GEV 5/76
D E 0 1. E-31 OR LESS CL=.90 APPEL 74 CNTR +- M=3.2-7.2 GEV 2/76
D F 0 2.2E-33 OR LESS CL=.90 ALBROW 75 SPEC Q=+-1 M=4-15 GEV 1/77
D F 0 1.1E-33 OR LESS CL=.90 ALBROW 75 SPEC Q=+-2 M=6-27 GEV 1/77
D G 0 8. E-35 OR LESS CL=.90 JOVANOVIC 75 CNTR +- M=15-26 GEV 2/76
D G 0 1.5E-34 OR LESS CL=.90 JOVANOVIC 75 CNTR Q=+-2, M=3-10 GEV 2/76
D G 0 6. E-35 OR LESS CL=.90 JOVANOVIC 75 CNTR Q=+-2, M=10-26 GEV 2/76
D H 0 2.6E-36 OR LESS CL=.90 BALDIN 76 CNTR Q=-1, M=2.1-9.4 GEV 1/77
D
D A DORFAN 65 IS A 30 GEV/C P EXPT AT BNL. UNITS ARE PER GEV MOMENTUM 5/76
D A PER NUCLEUS. 5/76
D
D B ANTIPOV1 71 LIMIT INFERRED FROM FLUX RATIO. 70 GEV P EXPERIMENT. 3/77
D
D C ANTIPOV2 71 IS FROM SAME 70 GEV P EXP. AS ANTIPOV1 71 AND BINON 69. 3/77
D
D D ALPER 73 IS CERN ISR 26+26 GEV P+P EXPT. P>.9 GEV, .2< BETA <.65. 5/76
D
D E APPEL 74 IS NAL 300 GEV P+W EXPERIMENT. STUDIES FORWARD PRODUCTION 2/76
D E OF HEAVY (UP TO 24 GEV) CHARGED PARTICLES WITH MOMENTA 24-200GEV(-) 2/76
D E AND 40-150GEV (+CHG). ABOVE TYPICAL VALUE IS FOR 75 GEV AND IS 5/76
D E PER GEV MOMENTUM PER NUCLEON. 5/76
D
D F ALBROW 75 IS A CERN ISR EXPT WITH ECM=53 GEV. THETA=40 MR. SEE 1/77
D F FIG. 5 FOR MASS RANGES UP TO 35 GEV. 1/77
D
D G JOVANOVICH 75 IS A CERN ISR 26+26 AND 15+15 GEV P+P EXPERIMENT. 2/76
D G FIG.4 COVERS RANGES Q=1/3 TO 2 AND M=3 TO 26 GEV. 2/76
D G VALUE IS PER GEV MOMENTUM. 5/76
D
D H BALDIN 76 IS A 70 GEV SERP EXP. VALUE IS PER AL NUCLEUS AT 1/77
D H THETA=0. FOR OTHER CHARGES IN RANGE -0.5 TO -3.0, CL=.90 LIMIT IS 1/77
D H (2.6E-36)/ABS(CHARGE) FOR MASS RANGE (2.1 TO 9.4GEV)*ABS(CHARGE). 1/77
D H ASSUMES STABLE PARTICLE INTERACTING WITH MATTER AS DO ANTIPROTONS. 1/77

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ICH **LONGLIVED HEAVY PARTICLE INVARIANT C.S. (CM**2/GEV**2/NUCLEON)** 1/79
ICH A 0 1.1E-37 OR LESS CL=.90 CUTTS 78 CNTR MASS=4-10 GEV 1/79
ICH B 0 3.0E-37 OR LESS CL=.90 VIDAL 78 CNTR MASS=4.5-6 GEV 12/79
ICH C 0 6. E-33 OR LESS CL=.90 ARMITAGE 79 SPEC M=1.87 GEV 7/79
ICH C 0 1.5E-33 OR LESS CL=.90 ARMITAGE 79 SPEC M=1.5-3.0 GEV 7/79
ICH D 0 BOZZOLI 79 CNTR Q=+-(2/3,1,4/3,2) 1/80
ICH
ICH A CUTTS 78 IS P BE EXPT AT FNAL SENSITIVE TO PARTICLES OF TAU>5E-8SEC 1/79
ICH A VALUE IS FOR -.3<X<0 AND PT=0.175.
ICH
ICH B VIDAL 78 IS FNAL 400 GEV PROTON EXPT. VALUE IS FOR X=0 AND PT=0. 2/79
ICH B PUTS LIFETIME LIMIT OF <5*10**-8 SEC ON PARTICLE IN THIS MASS RANGE 2/79
ICH
ICH C ARMITAGE 79 IS CERN-ISR EXPT AT ECM=53 GEV. VALUE IS FOR X=0.1 AND 7/79
ICH C PT=0.15. OBSERVED PARTICLES AT M=1.87 GEV ARE FOUND ALL CONSISTENT 7/79
ICH C WITH BEING ANTIDEUTERONS. 7/79
ICH
ICH D BOZZOLI 79 IS CERN-SPS 200 GEV P N EXPERIMENT. LOOKS FOR PARTICLE 1/80
ICH D WITH TAU LARGER THAN 10**-8 SEC. SEE THEIR FIG.11-18 FOR PRODUCTION 1/80
ICH D CROSS SECTION UPPER LIMITS VS MASS. 1/80

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RPI **LONGLIVED HEAVY PARTICLE PRODUCTION (CS(HEAVY PARTICLE)/CS(PION))** 12/81
RPI A 0 BUSSIERE 80 CNTR Q=+-(2/3,1,4/3,2) 12/81
RPI
RPI A BUSSIERE 80 IS CERN-SPS EXPT WITH 200-240 GEV PROTONS ON BE AND AL 12/81
RPI A TARGET. SEE THEIR FIG.6-7 FOR CS RATIO VS MASS. 12/81

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CA **CROSS-SEC FOR PROD AND CAPT OF LONG-LIVED MASSIVE PARTICLES (CM**2)**
CA A 0 0.1-9E-36 OR LESS FRANKEL 74 CNTR TAU=1 TO 1000 HRS 7/76
CA B 0 1.4-9E-36 OR LESS FRANKEL 75 CNTR TAU=50 MS TO 10 HRS 2/77
CA C 0 2-20E-34 OR LESS ALEKSEEV1 76 ELEC TAU=100 MS TO 1 DAY 4/77
CA C 0 0.2-8E-34 OR LESS ALEKSEEV2 76 ELEC TAU=5 MS TO 1 DAY 3/77
CA
CA A FRANKEL 74 LOOKS FOR PARTICLES PRODUCED IN THICK AL TARGETS BY 7/76
CA A 300-400 GEV/C PROTONS. 7/76
CA
CA B FRANKEL 75 IS EXTENSION OF FRANKEL 74. 2/77
CA
CA C ALEKSEEV(1,2) 76 ARE 61-70 GEV P SERP EXPT. CS IS PER PB NUCLEUS. 3/77

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CEN **CENTAURO PROD. CROSS SECTION IN ACCELARATOR EXPERIMENT (CM**2)**
CEN A 0 ALPGARD 82 UA5 P PBAR COLLIDER 11/83*
CEN B 0 (1. E-30)OR LESS ARNISON 83 UA1 P PBAR COLLIDER 11/83*
CEN A ALPGARD 82 IS CERN COLLIDER EXPERIMENT WITH WCM=540 GEV(155 TEV LAB 11/83*
CEN A EQUIVALENT). OBSERVED NO LARGE CHGD MULTIPLICITY EVENTS WITH PHOTON 11/83*
CEN A MULTIPLICITY CONSISTENT WITH ZERO IN 3600 INELASTIC EVENTS. 11/83*
CEN B ARNISON 83 IS CERN COLLIDER EXPT WITH WCM=540GEV. LOOKED FOR EVENTS 11/83*
CEN B WITH LARGE HAD. AND LOW EM CONTENT. NONE IN 48000 LOW BIAS EVENTS. 11/83*

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F **HEAVY PARTICLE FLUX IN COSMIC RAYS (NUMBER/CM**2-SEC-SR)**
F 0 5.0E-11 OR LESS CL=.90 JONES 67 ELEC M=5 TO 15 GEV 3/77
F 0 3.0E-10 OR LESS BJORNBOE 68 CNTR M ABOVE 5 GEV 4/77
F 0 3.0E-8 OR LESS DARDO 72 CNTR 4/77
F 0 1.5E-9 OR LESS TONWAR 72 CNTR M GT 10 GEV 4/77
F A 5 6. E-9 OR MORE YOCK 74 CNTR M GT 6 GEV 1/76
F 0 7. E-10 OR LESS CL=.90 YOCK 75 ELEC +- Q GT 7 OR LT -7E 9/76
F 0 1.0E-9 OR LESS BRIATORE 76 ELEC 4/77
F B 1.3E-9 OR LESS CL=.90 BHAT 78 CNTR +- M GT 1 GEV 1/80

Stable Particles

OTHER STABLE PARTICLE SEARCHES

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F          3  4.3+-1.3 E-11                  GOODMAN   79 ELEC    M>= 5 GEV          7/79
F     C    3  3.0E-9                         YOCK      80 SPRK    M APPROX.=4.5 MP  10/81
F     D    0  3.5E-11 OR LESS  CL=.90        ULLMAN    81 CNTR PLANCK-MASS E+19GEV   2/82
F     D    0  7. E-11 OR LESS  CL=.90        ULLMAN    81 CNTR M=1.E-16GEV OR LESS   2/82
F     E    3  2. E-9                         YOCK      81 SPRK Q=+-1 M ABOUT 4.5MP   1/82
F     E    3                                 YOCK      81 SPRK FRACTIONALLY CHGD     1/82
F     F    0  1.7E-11 OR LESS  CL=.99        BHAT      82 CC                         1/83*
F     G    0  1. E-9  OR LESS  CL=.90        MARINI    82 CNTR Q=+-1 M ABOUT 4.5MP  10/83*
F     H                                      SAKUYAMA  83 PLAS    M ABOUT 1 TEV     11/83*
F
F     A  YOCK 74 EVENTS COULD BE TRITONS.                                            1/76
F
F     B  BHAT 78 IS AT KOLAR GOLD FIELDS. LIMIT IS FOR TAU > 10**-6 SEC.             1/80
F
F     C  YOCK 80 EVENTS ARE WITH CHARGE EXACTLY OR APPROX. EQUAL TO UNITY.          10/81
F
F     D  ULLMAN 81 IS SENSITIVE FOR HEAVY SLOW SINGLY CHARGE PARTICLE                2/82
F     D  REACHING EARTH WITH VERTICAL VELOCITY 100-350 KM/S.                         2/82
F
F     E  YOCK 81 SAW ANOTHER 3 EVENTS WITH Q=+-1 AND M ABOUT 4.5MP AS WELL           1/82
F     E  AS 2 EVS WITH M>5.3MP,Q=+-.75+-.05 AND M>2.8MP,Q=+-.70+-.05 AND 1           1/82
F     E  EVENT WITH M=(9.3+-3.)MP,Q=+-.89+-.06 AS POSSIBLE HEAVY CANDIDATES.         1/82
F
F     F  BHAT 82 OBSERVED 12 EVENTS WITH DELAY>2.E-8 SEC AND WITH MORE THAN          1/83*
F     F  40 PARTICLES. 1 EV HAS GOOD HADRON SHOWER. HOWEVER ALL EVENTS ARE           1/83*
F     F  DELAYED IN ONLY ONE OF TWO DETECTORS IN CLOUD C.,AND COULD NOT BE           1/83*
F     F  DUE TO STRONGLY INTERACTING MASSIVE PARTICLE.                               1/83*
F
F     G  MARINI 82 APPLIED PEP-CNTR FOR TOF. ABOVE LIMIT IS FOR VELOCITY=.54 10/83*
F     G  OF LIGHT. LIMIT IS INCONSISTENT WITH YOCK 80,81 EVENTS IF ISOTROPIC 10/83*
F     G  DEPENDENCE ON ZENITH ANGLE IS ASSUMED.                              10/83*
F
F     H  SAKUYAMA 83  ANALYZED 6000 EXTENDED AIR SHOWER EVENTS. INCREASE OF  11/83*
F     H  DELAYED PARTICLES AND CHANGE OF LATERAL DISTRIBUTION ABOVE 10**17EV 11/83*
F     H  MAY INDICATE PRODUCTION OF VERY HEAVY PARENT AT TOP OF ATOMOSPHERE. 11/83*

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CON     CONCENTRATION OF HEAVY (CHARGE+1) STABLE PARTICLES IN MATTER
CON    2.E-22 TO 1.E-21 OR LESS        SMITH     79 SPEC WATER,M=6-350 MPROT   7/79

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C       LIGHT (BETWEEN MU AND E MASSES) PARTICLE MASS(UNITS-ELECTRON MASSES)
C          0    NONE BETWEEN 6 AND 25     BELOUSOV  60 CNTR   SPINOR,TAU>1 E-8     5/76
C          0    NONE BETWEEN 2 AND 25     GORBUNOV  60 CC     SPINOR,TAU>1 E-9     5/76
C          0    NONE BETWEEN 5 AND 175    COWARD    63 CNTR   SPINOR,TAU>22 E-10   5/76
C          0    NONE BETWEEN 5 AND 175    COWARD    63 CNTR   SCALAR,TAU>68 E-10   5/76
C     A    0    NONE BETWEEN 2 AND 13     BLAGOV    75 CNTR SPINOR,TAU>2E-10SEC    2/76
C     A    0    NONE BETWEEN 2 AND 10.6   BLAGOV    75 CNTR SCALAR,TAU>2E-10SEC    2/76
C     B    0    NONE BETWEEN 110 AND 180 VIERTEL    78 CNTR TAU >2.E-5 SEC         1/80
C
C     A  BLAGOV 75 BOUNDS ON LIFETIME DEPEND ON MASS AND IMPROVE AS MASS           4/77
C     A  DECREASES.  AT 2 GEV THE EXPERIMENT IS SENSITIVE TO TAU>3E-11 SEC         4/77
C     A  FOR SPINOR, TAU>5E-11 SEC FOR SCALAR.                                     4/77
C
C     B  VIERTEL 78 SEARCHES FOR MU+ -->X+ NEU. FINDS BR<8.5E-6 IN MASS            1/80
C     B  RANGE GIVEN ABOVE (CL=.90). BEST LIMIT BR<5.E-7 (CL=.90) IS  FOUND        1/80
C     B  AT MASS=80 MEV.                                                           1/80

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H       HIGGS BOSON MASS LIMIT (GEV)                                               1/82
H     A   0  0.409    OR MORE             DZHELYADI 81      ETAPRIM-->ETA HIGGS  1/82
H     B   0  0.325    OR MORE             WILLEY    82 RVUE K+-->DILEPTON+PI+   11/83*
H     C                                   HOFFMAN   83 CNTR PI-P-->N(HO-->E+E-) 11/83*
H
H     A  DZHELYADIN 81 OBTAINED BR(ETA PRIM-->ETA MU+MU-)<1.5E-5 (CL=.90)          1/82
H     A  WHICH EXCLUDES A LIGHT HIGGS BOSON IN MU+MU- CHANNEL.                     1/82
H
H     B  WILLEY 82 CALCULATED BR(K+-->HO+PI+) BY ONE-LOOP S-->D HO AND QUARK 11/83*
H     B  MODEL. EXCLUDE M(HO) < M(K)-M(PI).                                  11/83*
H
H     C  HOFFMAN 83 LOOKED FOR E+E- PEAK FROM HIGGS PRODUCED IN PI-P CEX AT  11/83*
H     C  300MEV/C. SET CL=.90 LIM. DSIGMA/DT*BR(E+E-)<3.5 E-32 CM**2/GEV**2  11/83*
H     C  FOR  140 < M(HO) < 160 MEV.                                         11/83*

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HGC     CHARGED HIGGS(OR TECHNI-PION) MASS LIMIT IN E+ E- REACTION            1/83*
HGC      SINCE HIGGS COUPLES TO HEAVY PARTICLES, DOMINANT EXPECTED MODES      1/83*
HGC      ARE (TAU NEU) AND (CHARM ANTI-S). EXCLUDED MASS REGION DEPENDS ON    1/83*
HGC      BRANCHING RATIO. SEE GRAPHS IN INDIVIDUAL PAPERS. WE QUOTE ONLY A    1/83*
HGC      SAMPLE LIMIT FOR BR(TAU NEU) SPECIFIED.                              1/83*
HGC   A  NONE 5GEV TO 13GEV   CL=.95   ADEVA     82 MRKJ BR(TAU NEU)=.25      1/83*
HGC   A  NONE 3GEV TO 13GEV   CL=.95   BARTEL    82 JADE BR(TAU NEU)=0.2-1.0  1/83*
HGC   B  NONE 7GEV TO 14GEV   CL=.95   BEHREND   82 CELL BR(TAU NEU)=.80      1/83*
HGC   A  NONE 4GEV TO  9GEV   CL=.90   BLOCKER   82 SMK2 BR(TAU NEU)=.10-.90  1/83*
HGC   C  NONE 5GEV TO 13GEV   CL=.95   ALTHOFF   83 TASS H+ -->C S (C B)     11/83*
HGC   D  NONE BELOW 14 GEV             ADEVA     83 MRKJ H+H- -->MU HAD.JET  11/83*
HGC   E  NONE BELOW M(B-MESON)         CHEN      83 RVUE B DECAY AT UPSI(4S) 11/83*
HGC
HGC   A  STUDIED H+ H- -->(TAU NEU)+(TAU NEU),(TAU NEU)+HADRONS.               1/83*
HGC
HGC   B  BEHREND 82 STUDIED H+ H- -->(TAU NEU)+(TAU NEU). SEE THEIR FIG.3.    1/83*
HGC
HGC   C  ALTHOFF 83 ANALYZED 4-JETS. LIMIT IS FOR H+ DECAYING PREDOMINANTLY  11/83*
HGC   C  INTO HADRONS. COMBINING WITH (TAU NU)RESULTS LIMIT APPLIES TO H+    11/83*
HGC   C  WITH ANY HADRONIC BRANCHING RATIOS.                                 11/83*
HGC
HGC   E  CHEN 83 EXCLUDE A MODEL WHERE B-->H+ LIGHT-QUARK AT BR=1. OBSERVED  11/83*
HGC   E  BR(B-->E X) WOULD REQUIRE BR(H+-->TAU X)=1 BUT THEN CHARGED ENERGY  11/83*
HGC   E  FRACTION WOULD BE SMALLER THAN EXPT VALUE(.60+-.03).(CLEO DATA)     11/83*

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EGT     MASS BOUNDS DERIVED FOR PARTICLES IN EXTENDED GAUGE THEORIES          1/83*
EGT   A  NONE BELOW 2-3GEV             KANE      82 RVUE GLUINO               1/83*
EGT   B  NONE BELOW 0.5TEV(MTOP=20GEV) SHANKER   82 RVUE CHGD-HIGGS           1/83*
EGT   B  NONE BELOW 1. TEV             SHANKER   82 RVUE PS-LEPTOQUARK        1/83*
EGT   B  NONE BELOW 125TEV             SHANKER   82 RVUE VECTOR-LEPTOQUARK    1/83*
EGT   B  NONE BELOW 0.1-1 TEV          SHANKER   82 RVUE SUSY-PARTNER         1/83*
EGT   C  NONE BETWEEN 100MEV AND 13GEV BEHREND   83 CELL E-E+-->PHOTINO PAIR 11/83*
EGT   D                                BERGSMA   83 RVUE GLUINO,SQUARK       11/83*
EGT   B  NONE BELOW 350 GEV            BRYMAN    83 CNTR CHGD-HIGGS          10/83*
EGT   E                                CHANOWITZ 83 RVUE CHARGED SHADRON     11/83*
EGT   F  NONE BELOW 350 TEV            DESHPANDE 83 RVUE PATI-SALAM X-BOSON   1/84*
EGT
EGT   A  KANE 82 INFERED ABOVE GLUINO MASS LIMIT FROM RETROACTIVE ANALYSIS    1/83*
EGT   A  OF  HADRONIC COLLISION AND BEAM DUMP EXPERIMENTS.                    1/83*
EGT
EGT   B  FROM (PI-->E NU)/(PI-->MU NU) RATIO.  BRYMAN 83 BASED ON SHANKER 82  1/83*
EGT   B  MODEL WITH HIGGS-FERMION COUPLINGS PROPORTIONAL TO HEAVY FERMION     1/83*
EGT   B  MASSES.                                                              1/83*
EGT
EGT   C  BEHREND 83 AT DESY-PETRA LOOKED FOR 2 GAM EVTS WITH MISSING ENERGY. 11/83*
EGT   C  LIMITS QUOTED ARE FOR SCALE BREAKING PARAMETER D=(100GEV**2).       11/83*
EGT   D  BERGSMA 83 IS REANALYSIS OF CERN-SPS BEAM-DUMP DATA. DISFAVOURS      11/83*
EGT   D  M(GLUINO)<2 GEV AND M(SQUARK)<100 GEV. SEE THEIR FIG.1.              11/83*
EGT
EGT   E  CHANOWITZ 83 FIND IN BAG-MODEL THAT CHARGED SHADRON (Q QBAR GLUINO  11/83*
EGT   E  -BOUND STATE) IS STABLE AGAINST STRONG DECAY IF M(GLUINO)> 1 GEV.   11/83*
EGT   E  A POSSIBILITY IS OF VERY LIGHT GLUINO WITH LIFE 1.E-11 TO 2.E-8 SEC 11/83*
EGT   E  TOO LONG(SHORT) LIVED TO BE EXCLUDED BY BEAM-DUMP(CONTAM.) EXPTS.   11/83*
EGT
EGT   F  DESHPANDE 83 USED UPPER LIMIT ON KL -->MU E DECAY WITH R.G.EQUATION  1/84*
EGT   F  TO ESTIMATE COUPLING AT THE HEAVY BOSON MASS.                        1/84*
EGT   F  SEE ALSO DIMOPOULOS ET AL., NP B182, 77 (1981).                      1/84*

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EGP     PRODUCTION OF PARTICLES IN EXTENDED GAUGE THEORIES
EGP   A                                    BEHREND   83 CELL E-E+-->PHOTINO PAIR 11/83*
EGP   B                                    HOFFMAN   83 CNTR PI-P-->N(E+E-)      11/83*
EGP   C                                    VERGADOS  82 CNTR 2BETA DECAY, SCALAR 12/83*
EGP
EGP   A  BEHREND 83 AT DESY-PETRA SET CL=.95 LIMIT OF 1.1 PB FOR PHOTINO-     11/83*
EGP   A  ANTIPHOTINO PRODUCTION (M(PHOTINO)<2GEV) AT WCM AROUND 34GEV.        11/83*
EGP
EGP   B  HOFFMAN 83 SET CL=.90 LIMIT DSIGMA/DT*BR(E+E-)<3.5E-32 CM**2/GEV**2 11/83*
EGP   B  FOR SPIN-1 PARTNER OF GOLDSTONE FERMIONS WITH 140<M<160 MEV          11/83*
EGP   B  DECAYING INTO E+E- PAIR.                                             11/83*
EGP
EGP   C  VERGADOS 82 SETS LIMIT GH.LT.4E-3 FOR (DIMENSIONLESS) LEPTON-NUMBER 12/83*
EGP   C  VIOLATING COUPLING, GH, OF SCALAR BOSON TO NEUTRINOS, FROM ANALYSIS 12/83*
EGP   C  OF DATA ON DOUBLE BETA DECAY OF CA48.                               12/83*

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SLP     SCALAR LEPTON MASS LIMIT IN E+ E- REACTIONS                           1/83*
SLP      SCALAR-TAU-->TAU PHOTINO LOOKS IDENTICAL TO CHGD-HIGGS-->TAU NEU IN  1/83*
SLP      SECTION HGC ABOVE. LIMITS BELOW CORRESPOND TO BR(TAU NEU)=1.0 LINE   1/83*
SLP      IN MASS-LIMIT GRAPH FOR CGHD-HIGGS-->(TAU NEU)+(TAU NEU) AND WE      1/83*
SLP      DERIVE LIMIT IN THIS WAY IF NECESSARY.                               1/83*
SLP      NONE 3GEV TO 15GEV     CL=.95   BARBER    80 MRKJ SCALAR MU         10/81
SLP           14GEV  OR MORE    CL=.95   ADEVA     82 MRKJ SCALAR TAU         1/83*
SLP      NONE 4GEV TO 14GEV     CL=.95   BARTEL    82 JADE SCALAR TAU         1/83*
SLP      NONE 2GEV TO 16.8GEV   CL=.95   BEHREND   82 CELL SCALAR E           1/83*
SLP      NONE 3.3GEV TO 16GEV   CL=.95   BEHREND   82 CELL SCALAR MU          1/83*
SLP   A  NONE 6GEV TO 15.3GEV   CL=.95   BEHREND   82 CELL SCALAR TAU         1/83*
SLP   A  NONE M(TAU) TO 3.8GEV  CL=.95   BEHREND   82 CELL SCALAR TAU         1/83*
SLP      NONE M(TAU) TO 9.9GEV  CL=.90   BLOCKER   82 SMK2 SCALAR TAU         1/83*
SLP   B     NONE BELOW 16.6GEV  CL=.95   BRANDELIK 82 TASS SCALAR E          11/83*
SLP   B     NONE BELOW 16.4GEV  CL=.95   BRANDELIK 82 TASS SCALAR MU         11/83*
SLP   C     NONE BELOW 13.8GEV  CL=.95   FERNANDEZ 83 MAC  SCALAR MU          1/84*
SLP   D     NONE BELOW 22.2GEV  CL=.95   GLADNEY   83 SMK2 SCALAR E           1/84*
SLP
SLP   A  BEHREND 82 FIRST LIMIT FOR SCALAR TAU IS FROM PT-CUT TAU-PAIR        1/83*
SLP   A  ANALYSIS, SECOND LIMIT FROM NO EXCESS TAU PAIR EVENTS.               1/83*
SLP
SLP   B  BRANDELIK 82 LIMITS ARE FROM NO ENHANCEMENT IN EVENTS WITH THETA    11/83*
SLP   B  NEAR 90 DEG(LIGHT SCALAR) AND WITH LARGE ACOPLANARITY(HVY SCALAR).  11/83*
SLP
SLP   C  FERNANDEZ 83 OBSERVED NO EXCESS ACOPLANAR MU+MU- EVENTS.             1/84*
SLP
SLP   D  GLADNEY 83 LOOKED FOR LARGE PT E FROM SINGLY PRODUCED S-ELECTRONS.   1/84*

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ION     HIGHLY IONIZING PARTICLE FLUX  (UNITS NUMBER/M**2-YR)
ION       0     0.4   OR LESS  CL=.95   KINOSHITA 81 PLAS Z/BETA 30-100        2/82

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TCF     TACHYON FLUX IN COSMIC RAYS (NUMBER/CM**2-SEC-SR)
TCF      SEE SMITH 77 FOR A REVIEW OF EARLIER COSMIC RAY AND ACCELERATOR
TCF      EXPERIMENTS.
TCF   A     NONE                         PRESCOTT  76 CNTR                    6/82*
TCF   B     NONE                         SMITH     77 CNTR                    6/82*
TCF   C   0  2.3E-10 OR LESS  CL=.95     BHAT      79 CNTR                   10/81
TCF   D   0  2.4E-9  OR LESS  CL=.90     MARINI    82 CNTR V/C>1.2           10/83*
TCF
TCF   A  PRESCOTT 76 REANALYZED CLAY AND CROUCH(C.C.)74 DATA(NATURE 248,28).  6/82*
TCF   A  FOUND APPARATUS EFFECT,CORRECTION FOR WHICH MUCH REDUCES THE STAT.   6/82*
TCF   A  SIGNIFICANCE OF POSITIVE C.C.RESULT. ALSO PERFORMED TWO NEW EXPTS    6/82*
TCF   A  ONE USING C.C.APPARATUS,ANOTHER WITH NEW APPARATUS. SET UPPER LIMIT  6/82*
TCF   A  AT CL=.95 OF ABOUT 30 TACHYONS PER SHOWER WITH AVERAGE SIZE N=6E+5.  6/82*
TCF
TCF   B  SMITH 77 ANALYZED MORE THAN 200000 SHOWERS(223 DAYS) WITH E>1.E+14   6/82*
TCF   B  EV SCANNING 290 E-6 SEC PERIOD BEFORE EACH SHOWER. OBSERVED EXCESS   6/82*
TCF   B  46+-40 EVS DOES NOT CONSTITUTE STATISTICALLY SIGNIFICANT EVIDENCE.   6/82*
TCF
TCF   C  BHAT 79 IS AT OOTACAMUND(2200M ABOVE SEA). NO SIGNAL IN 3621 HOURS. 10/81
TCF
TCF   D  MARINI 82 IS TOF MEASUREMENT USING PEP-CNTR AT SEA LEVEL.           10/83*

TCM     TACHYON SEARCHES IN E+ E- ANNIHILATION
TCM   A   0  1. E-6  OR LESS  CL=.90   PEREPELIT 77 CNTR V*U(EQ) < 1          6/82*
TCM   A   0  1. E-5  OR LESS  CL=.90   PEREPELIT 77 CNTR 1 < V*U(EQ) < 15     6/82*
TCM
TCM   A  PEREPELITSA 77 IS MICHELSON-TYPE EXPT FOR PAIR-PRODUCED TACHYONS     6/82*
TCM   A  IN E+ E- ANNIHILATION (E+ FROM CU ISOTOPE). ABOVE LIMITS ARE FOR     6/82*
TCM   A  CS(E+E- -->TACHYON PAIR)/CS(E+E- -->2 GAMMA) AND V*U(EQ) IS TACHYON  6/82*
TCM   A  VELOCITIES TIMES EARTH EQUATOR COMPONENT OF VELOCITY OF PREFERRED    6/82*
TCM   A  REFERENCE FRAME.

TCD     SEARCHES FOR TACHYONIC DECAY (LOWER LIMIT FOR MEAN LIFE IN YEARS)
TCD      SEE LJUBICIC 75 FIG. 1 FOR REVIEW OF EARLIER EXPERIMENTS.
TCD   A      4.6E+13 OR MORE              LJUBICIC  75 ELEC M(TACHYON)> 1.1 KEV  6/82*
TCD
TCD   A  LJUBICIC 75 USED LEAD OXIDE CATHODE AND ELECTRON MULTIPLIER LOOKING  6/82*
TCD   A  FOR IONIZATION DUE TO TACHYONIC DECAY (SPONTANEOUS ACQUISITION OF    6/82*
TCD   A  ENERGY) OF BOUND-STATE E-. SENSITIVE TO PROPER TACHYON MASS>1.1KEV.  6/82*
TCD   A  ABOVE LIMIT IS OBTAINED FROM OBSERVED E- EMISSION RATE 3/HOUR.       6/82*

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REFERENCES FOR OTHER NEW PARTICLE SEARCHES


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BELOUSOV 60 JETP 11 1143      +RUSAKOV,TAMM,CERENKOV                 (LEBD)
GORBUNOV 60 JETP 11 51        +SPIRIDONOV,CERENKOV                   (LEBD)
COWARD   63 PR 131 1782       +GITTELMAN,LYNCH,RITSON                (STAN)
DORFAN   65 PRL 14 999        +EADES,LEDERMAN,LEE,TING               (COLU)
JONES    67 PR 164 1584         (MICH+WISC+LBL+UCLA+MINN+COSU+COLO+MURA)

BJORNBOE 68 NC B53 241        +DAMGARD,HANSEN,CHATTERGEE+     (BOHR+BERN)
BINON    69 PL 30B 510        DUTEIL,KACHANOV,KHROMOV,KUTYIN+        (SERP)
ANTIPOV1 71 PL 34B 164        +DENISOV,DONSKOV,GORIN,KACHANOV+       (SERP)
ANTIPOV2 71 NP B31 235        +DENISOV,DONSKOV,GORIN,KACHANOV+       (SERP)
DARDO    72 NC 9A 319         DARDO,NAVARRA,PENENGO,SITTE            (TORI)
TONWAR   72 JPA 5 569         TONWAR,NARANAN,SREEKANTAN              (TIFR)
ALPER    73 PL 46B 265         (CERN+LIVP+LUND+BOHR+RHEL+STOH+BERG+LOUC)
LEIPUNER 73 PRL 31 1226       +LARSEN,SESSOMS,SMITH,WILLIAMS+  (BNL+YALE)
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For notation, see key at front of Listings.

Stable Particles

OTHER STABLE PARTICLE SEARCHES

APPEL 74 PRL 32 428 +BOURQUIN,GAINES,LEDERMAN,PAAR+ (COLU+FNAL)
FRANKEL 74 PR D9 1932 +FRATI,RESVANIS,YANG,NEZRICK (PENN+FNAL)
YOCK 74 NP B76 175 P.C.M.YOCK (UNIV OF AUCKLAND)

ALBROW 75 NP B97 189 +BARBER,BENZ+(CERN+DARE+FOM+LANC+MCHS+UTRE)
BLAGOV 75 YAD.FIZ. 21,300 +KOMAR,MURASHOVA,SYREISHCHIKOVA+ (LEBD)
FRANKEL 75 PR D12 2561 +FRATI,RESVANIS,YANG,NEZRICK (PENN+FNAL)
JOVANOVI 75 PL 56B 105 JOVANOVICH+ (MANI+AACH+CERN+GENO+HARV+TORI)
LJUBICIC 75 PR D11 696 +PAVLOVIC,PISK,LOGAN (ZAGR+OTTA)
YOCK 75 NP B86 216 P.C.M. YOCK (UNIV OF AUCKLAND+SLAC)

ALEKSEE1 76 SJNP 22 531 ALEKSEEV,ZAITSEV,KALININA,KRUGLOV+ (JINR)
ALEKSEE2 76 SJNP 23 633 ALEKSEEV,ZAITSEV,KALININA,KRUGLOV+ (JINR)
BALDIN 76 SJNP 22 264 +VERTOGRADOV,VISHNEVSKII,GRISHKEVICH+(JINR)
BRIATORE 76 NC 31A 553 +DARDO,PIAZZOLI,MANNOCCHI+ (LCGT+FRAS+FREI)
GUSTAFSO 76 PRL 37 474 GUSTAFSON,AYRE,JONES,LONGO,MURTHY (MICH)
PRESCOTT 76 JPG 2 261 J.R.PRESCOTT (ADELAIDE)

BARISH 77 PRL 38 577 +BARTLETT,BODEK,BROWN + (CIT+FNAL+ROCK)
BENVENUT 77 PRL 38 1110 BENVENUTI,CLINE+ (FNAL+HARV+PENN+RUTG+WISC)
BLETZACK 77 PRL 38 1241 BLETZACKER,NIEH,SONI (STON+UCSB)
CHANG 77 PRL 39 519 +CHEN,VAN GINNEKEN (MSU+FNAL)
HOLDER 77 PL 70B 393 +KNOBLOCH,MAY+ (CERN+DORT+HEID+SACL+BGNA)
PEREPELI 77 PL 67B 471 V.P.PEREPELITSA (ITEP)
SMITH 77 CJP 55 1280 G.R.SMITH,S.STANDIL (MANI)

ALBRIGHT 78 PR D18 108 +SMITH,VERMASEREN (FNAL+STON+PURD)
BENVENUT 78 PRL 40 488 BENVENUTI+ (FNAL+HARV+PENN+RUTG+WISC)
BHAT 78 PRAM 10 115 +RAMANA MURTY (TIFR)
BOSETTI 78 PL 74B 143 +DEDEN+ (AACH+BONN+CERN+LOIC+OXF+SACL)

CARROLL 78 PRL 41 777 +CHIANG,JOHNSON,KYCIA,KI + (BNL+PRIN)
CUTTS 78 PRL 41 363 +DULUDE + (BROW+FNAL+ILL+BARI+MIT+WARS)
HANSL2 78 PL 77B 114 +HOLDER,KNOBLOCH+(CERN+DORT+HEID+SACL+BGNA)
ALSO 78 NP B142 381 HANSL,HOLDER+ (CERN+DORT+HEID+SACL+BGNA)

HOLDER 78 PL 73B 105 +KNOBLOCH,MAY+ (CERN+DORT+HEID+SACL+BGNA)
LOVELESS 78 PL 78B 505 +BENADA+ (WISC+LBL+UCB+FNAL+HAWA+WASH)
MORI 78 PRL 40 432 +BENVENUTI+ (FNAL+HARV+PENN+RUTG+WISC)
VIDAL 78 PL 77B 344 +HERB,LEDERMAN,SNYDER+ (COLU+FNAL+STON+UCB)
VIERTEL 78 LNC 22 235 +HAHN,SCHACHER (BERN)

ARMITAGE 79 NP B150 87 +BENZ,BOBBINK+ (CERN+DARE+FOM+MCHS+UTRECHT)
BHAT 79 JPG 5 L13 BHAT,GOPALAKRISHNAN,GUPTA,TONWAR (TIFR)
BENVENUT 79 PRL 42 1024 BENVENUTI+ (FNAL+HARV+OSU+PENN+RUTG+WISC)
BOZZOLI 79 NP B159 363 +BUSSIERE,GIACOMELLI (BGNA+CERN+LAPP+SACL)

DEGROOT 79 PL 85B 131 +HANSL,HOLDER+ (CERN+DORT+HEID+SACL+BGNA)
GOODMAN 79 PR D19 2572 +ELLSWORTH,ITO,MACFALL,SIOHAN + (UMD)
SMITH 79 NP B149 525 +BENNETT (RHEL)

BARBER 80 PRL 45 1904 +BECKER,BEI+ (AACH+DESY+MIT+AIKO+BHEP)
BARTEL 80 ZPHY C6 295 JADE C.(DESY+HAMB+HEID+LANC+MCHS+RHEL+TOKY)
BUSSIERE 80 NP B174 1 +GIACOMELLI,LESQUOY+ (BGNA+SACL+LAPP)
LEBRITTO 80 PL 89B 271 LEBRITTON,MCCAL,MELISSINOS+ (ROCH+BNL+NSF)
YOCK 80 PR D22 61 YOCK (AUCK)

DZHELYAD 81 PL 105B 239 +GOLOVKIN,KONSTANTINOV,KONSTANTINOV+ (SERP)
ALSO 81 SJNP 33 822 (YF 33 1529) VIKTOROV,GOLOVKIN+ (SERP)
KINOSHIT 81 PR D24 1707 K.KINOSHITA,P.B.PRICE (UCB)
LOSECCO 81 PL 102B 209 +SULAK,GALIK,HORSTKOTTE+ (MICH+PENN+BNL)
ULLMAN 81 PRL 47 289 J.D.ULLMAN (LEHM+BNL)
YOCK 81 PR D23 1207 P.C.M.YOCK (AUCK)

ADEVA 82 PL 115B 345 MARK-J COLLAB(AACH+DESY+MIT+MADR+ANIK+BHEP)
ALPGARD 82 PL 115B 71 + UA5 COLLAB. (BONN+BRUX+CAVE+CERN+STOH)
BARTEL 82 PL 114B 211 JADE C. (DESY+HAMB+HEID+LANC+MCHS+RL+TOKY)
BEHREND 82 PL 114B 287 CELLO C. (DESY+KARL+MPIM+ORSA+LPNP+SACL)
BHAT 82 PR D25 2820 +GUPTA,RAMANA MURTHY,SREEKANTAN+ (TIFR)
BLOCKER 82 PRL 49 517 +MATTEUZZI,ABRAMS+ (HARV+SLAC+LBL)

BRANDELI 82 PL 117B 365 BLANDELIK+ TASSO C. (AACH+BONN+DESY+HAMB+)
KANE 82 PL 112B 227 G.L.KANE,J.P.LEVEILLE (MICH)
KINOSHIT 82 PRL 48 77 KINOSHITA,PRICE,FRYBERGER (UCB+SLAC)
MARINI 82 PR D26 1777 +PERUZZI,PICCOLO+ (FRAS+LBL+NWES+STAN+HAWA)
SHANKER 82 NP B204 375 O.SHANKER (TRIU)
VERGADOS 82 PL 109B 96 J.D.VERGADOS (CERN)
ALSO 82 PL 113B 513 J.D.VERGADOS (CERN)
ALSO 83 NP 218B 109 J.D.VERGADOS (CERN)
WILLEY 82 PR D26 3287 R.S.WILLEY,H.L.YU (PITT)

ADEVA 83 PRL 51 443 MARKJ C. (AACH+DESY+MIT+MADR+AIKO+BHEP+CIT)
ALTHOFF 83 PL 122B 95 TASSO C. (AACH+BONN+DESY+HAMB+LOIC+OXF+)
ARNISON 83 PL 122B 189 + UA1 COLLAB. (AACH+LAPP+BIRM+CERN+HELS+)
BEHREND 83 PL 123B 127 + CELLO COL.(DESY+KARL+MPIM+ORSA+LPNP+SACL)
BERGSMA 83 PL 121B 429 + CHARM COLLAB. (ANIK+CERN+HAMB+MOSU+ROMA)
BRYMAN 83 PRL 50 7 +DUBOIS,NUMAO+ (TRIU+VICT+CNRC+BRCO+QUKI)

CHANOWIT 83 PL 126B 225 M.CHANOWITZ,S.SHARPE (UCB+LBL)
CHEN 83 PL 122B 317 + (SYRA+VAND+CORN+ITHA+HARV+OHIO+ROCH+RUTG)
DESHPAND 83 PR D27 1193 DESHPANDE,JOHNSON (OREG)
FERNANDE 83 PR D28 2721 FERNANDEZ+ (COLO+FRAS+HOUS+NEAS+SLAC+UTAH+)
GLADNEY 83 PRL 51 2253 +HOLLEBEEK,LECLAIRE,ABRAMS+ (SLAC+LBL+HARV)
HOFFMAN 83 PR D28 660 +FRANK,MISCHKE,MOIR,SCHARDT (LANL+ARZS)
SAKUYAMA 83 NCL 37 17 H.SAKUYAMA,N.NUZUKI (MEIS)
ALSO 83 NCL 36 389 H.SAKUYAMA,K.WATANABE (MEIS)
ALSO 83 NC 78A 147 H.SAKUYAMA,K.WATANABE (MEIS)
ALSO 83 NC 6C 371 H.SAKUYAMA,K.WATANABE (MEIS)

****** ********* ********* ********* ********* ********* ********* ********
****** ********* ********* ********* ********* ********* ********* ********

Mesons

Data Card Listings

$\pi^{\pm}$, π^{0}, η, $\rho(770)$

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****** ********* ********* ********* ********* ********* ********* ********
****** ********* ********* ********* ********* ********* ********* ********
      S=0,  C=0,  B=0  MESON  STATES
****** ********* ********* ********* ********* ********* ********* ********
****** ********* ********* ********* ********* ********* ********* ********
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$\pi^{\pm}$

```
8  CHARGED PION(140,JPG=0--) I=1
   SEE STABLE PARTICLE DATA CARD LISTINGS
****** ********* ********* ********* ********* ********* ********* ********
****** ********* ********* ********* ********* ********* ********* ********
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π^{0}

```
9  NEUTRAL PION(135,JPG=0--) I=1
   SEE STABLE PARTICLE DATA CARD LISTINGS
****** ********* ********* ********* ********* ********* ********* ********
****** ********* ********* ********* ********* ********* ********* ********
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η

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14  ETA(549,JPG=0-+) I=0
    SEE STABLE PARTICLE DATA CARD LISTINGS
****** ********* ********* ********* ********* ********* ********* ********
****** ********* ********* ********* ********* ********* ********* ********
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$\rho(770)$

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9  RHO(770,JPG = 1-+) I=1
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NOTE ON THE ρ^0 MASS AND WIDTH

Because of the broadness of the ρ meson, its shape is not very well described by a Breit-Wigner formula, which is a narrow-resonance approximation. Although most experimental distributions can be well described by a relativistic Breit-Wigner formula with a P-wave width and an additional shape parameter (PISUT 68), the resulting resonance parameters will clearly depend on this model. A consistent set of such determinations (PISUT 68, ESTABROOKS 74, BARTALUCCI 78, WICKLUND 78, HEYN 80) yields $m_{\rho^0} = (769 \pm 3)$ MeV, $\Gamma_{\rho^0} = (154 \pm 3)$ MeV.

Attempts have been made to determine the ρ pole position in a more model-independent way (LANG 79, BOHACIK 80). It is comforting that these determinations agree with the above mass average (LANG 79, however, finds a somewhat smaller width).

A phenomenological estimate of the ρ mass can be obtained with an SU(4) generalization of the Gell-Mann-Okubo mass formula, which in the limit of ideal mixing can be written (MONTONEN 75)

$$\rho = \frac{2[\psi K^*(892) - \phi D^*] + \omega[D^* - K^*(892)]}{2[\psi - \phi] - [D^* - K^*(892)]}.$$

The masses of the vector mesons on the right-hand side have all been determined to a much better precision than that of the ρ and can be used to predict the mass of the $\rho = (768 \pm 2)$ MeV. The theoretical error due to nonideal mixing is expected to be of the order of $\pm$ 1.5 MeV. The result is consistent with the measured value (769 ± 3) MeV given above.

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                        9  RHO MASS (MEV)

M       WE NO LONGER LIST S-WAVE BREIT-WIGNER FITS, PBAR P DATA WITH HIGH
M       COMBINATORIAL BACKGROUND, AND INSIGNIFICANT OR DOUBTFUL DATA.
M       SEE ALSO THE MINI-REVIEW ABOVE.

M    CHARGED ONLY
M    R      (760.0)    (9.0)            CARMONY   64 HBC  +  3.5 PI+P,TCUT 4
M    R      (768.0)    (5.0)            BLIEDEN   65 MMS  -  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    R      (768.0)    (5.0)            MILLER    67 HBC  -  2.7 PI-,T CUT20    9/66
M    R      (773.0)    (2.0)            BATON     68 HBC  -  2.8 PI-,T CUT13    7/69
M
M   Z  900  767.       6.               EISNER    67 HBC  -  4.2 PI-,T CUT10    1/73
M   A 9650  766.8      1.5              PISUT     68 RVUE -  1.7-3.2PI-,CT10    6/68
M   X 6500  766.       7.               BYERLY    73 OSPK -  5. PI- P           2/74
M           . . . . . . . . .
M    AVG    766.8      1.4      AVERAGE

MO   NEUTRAL ONLY
MO   R  300 (760.0)   (10.0)            ABOLINS   63 HBC   0 3.5 PI+P
MO   R  500 (770.0)   (10.0)            GOLDHABER 64 HBC   0 3.7 PI+P
MO   R      (750.0)    (5.0)            ALFF-STEI 66 HBC   0 2-3 PI+ P          6/66
MO   R      (775.0)    (5.0)            HAGOPIAN1 66 HBC   0 3.0 PI- P          6/66
MO   R      (770.)     (5.)             HAGOPIAN2 66 HBC   0 2.1 PI-,TCUT 12    2/67
MO   R 4207 (758.0)    (7.5)            JACOBS    66 HBC   0 2-3PI-,T CUT 20    6/68
MO   R      (765.0)    (8.0)            JAMES     66 HBC   0 2.1 PI+ P          6/66
MO   R      (760.0)    (3.0)            WEST      66 HBC   0 2.1 PI- P         10/66
MO   P 4000 (765.)     (5.0)            ASBURY 2  67 CNTR  0 GAMMA + PB         1/73
MO   R      (768.0)    (2.0)            BACON     67 HBC   0 1.7 PI-P           9/67
MO   R      (761.)     (3.)             HUWE      67 HBC   0 2.4 PI- P          7/67
MO   R      (770.0)    (4.0)            MILLER    67 HBC   0 2.7 PI-,T CUT20    9/66
MO   R      (775.0)    (2.0)            ARMENISE  68 DBC   0 5.1 PI+D           6/68
MO   R      (768.4)    (2.4)            MALAMUD   69 RVUE  0 2-4 PI-P           1/73
MO   P      (765.0)   (10.0)            ALVENSLEB 70 CNTR  0 GAMMA A,TCUT.01    1/73
MO   P      (775.)     (5.)             GLADDING  73 CNTR  0 2.9-4.7 GAMMA P    2/74
MO   H      (778.)     (2.)             HYAMS     73 ASPK  0 17.PI-P,PI+PI-N    1/74
MO   H      (770.)     (9.)             ESTABROOK 74 RVUE  0 17 PI-P,PI+PI-N   12/75
MO   G      (775.)     (2.)             GRAYER    74 ASPK  0 17.PI-P,PI+PI-N    2/74
MO   D      (776.3)    (0.4)            ROOS      75 RVUE  0 PHASE SHIFTS      12/75
MO EG       (776.1)    (2.6)            BECKER    79 ASPK  0 17.PI-P POLARIZ   12/79
MO  CH      (769.5)    (0.7)            LANG      79 RVUE  0                    1/82
MO
MO     2250  775.0     3.0              HYAMS     68 OSPK  0  11.2 PI- P        9/68
MO A 13300   769.2     1.5              PISUT     68 RVUE  0 1.7-3.2PI-,CT10    1/73
MO     1700  774.0     3.0              REYNOLDS  69 HBC   0 2.26 PI- P        12/78
MO     140K  767.7     1.9              BIGGS     70 CNTR  0 PHOTOPROD.         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 Z 11200   773.5     1.7              JACOBS    72 HBC   0 2.8 PI- P          1/73
MO     6800  764.0     3.0              RATCLIFF  72 ASPK  0 15. PI-P,TCUT.3    2/74
MO C 32000   775.0     4.0              PROTOPOPE 73 HBC   0 7.1 PI+P,TCUT.4    2/74
MO     4100  767.      4.               ENGLER    74 DBC   0 6. PI+N,PI+PI-P   12/75
MO    76000  768.0     1.0              DEUTSCHMA 76 HBC   0 16. PI+ P          4/78
MO E         767.6     2.7              BARTALUCC 78 CNTR  0 BREMS,E+E-P       12/77
MO X         769.0     3.0              WICKLUND  78 ASPK  0 3,4,6 PI+-PN       4/78
MO C H       768.0     4.0              BOHACIK   80 RVUE  0                    1/82
MO E B       770.      2.               HEYN      80 RVUE    PION FORM FACTOR   9/81
MO G         777.4     2.0              CHABAUD   83 ASPK  0 17 PI-P POLARIZ   12/83*
MO K         775.9     2.0              KURDADZE  83 OLYA      E+E-             1/84*
MO           . . . . . . . . .
MO  AVG      770.34    0.86     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)
                               (SEE IDEOGRAM BELOW)

M        ----------NOTES----------

M    A   FROM FIT OF 3-PARAMETER RELATIVISTIC P-WAVE BREIT WIGNER TO TOTAL
M    A   MASS DISTRIBUTION.
M    B   HEYN 80 INCLUDES ALL SPACELIKE AND TIMELIKE F(PI)
M    B   VALUES UNTIL 1978.
M    C   FROM POLE EXTRAPOLATION
M    D   ENERGY-DEPENDENT ANALYSIS OF BATON 70, HYAMS 73,
M    D   PROTOPOPESCU 73 PHASE SHIFTS.
M    E   PURE P-WAVE SYSTEM.
M    G   FROM FIT OF 3-PARAMETER RELATIVISTIC BREIT-WIGNER TO
M    G   HELICITY ZERO PART OF P-WAVE INTENSITY. CHABAUD 83 AND BECKER 79
M    G   INCLUDE DATA OF GRAYER 74.
M    H   FROM PHASE SHIFT ANALYSIS OF GRAYER 74 DATA.
M    P   FROM PHOTOPRODUCTION, MODEL DEPENDENT.
M    R   INCLUDED IN PISUT 68 RVUE
M   X    PHASE SHIFT ANALYSIS. SYSTEMATIC ERRORS ADDED CORRESPONDING
M   X    TO SPREAD OF DIFFERENT FITS.
M   Z    MASS ERRORS ENLARGED BY US TO WIDTH/SQRT(N),SEE K* TYPED NOTE
M   K    FROM THE GOUNARIS-SAKURAI PARAMETRIZATION OF THE PION FORM FACTOR
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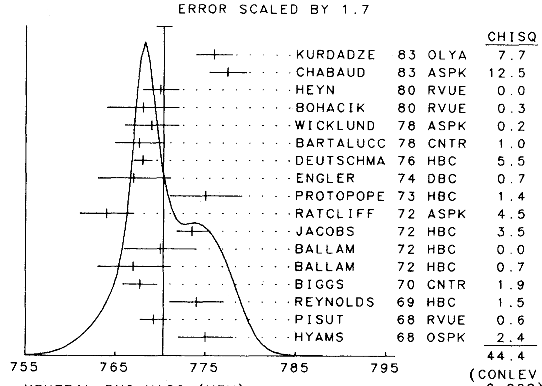
WEIGHTED AVERAGE = 770.34 ± 0.86
ERROR SCALED BY 1.7

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                    9  (RHO0) - (RHO+-) MASS DIFFERENCE (MEV)

D  A  3600   -5.       5.              FOSTER     68 HBC  +-0 PBAR P AT REST   12/78
D    22950    2.4      2.1             PISUT      68 RVUE     PI N TO RHO N     6/68
D  A  3000   -4.0      4.0             REYNOLDS   69 HBC   -0 2.26 PI- P       12/78
D          . . . . . . . . . .
D   AVG       0.3      2.2     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)

D  A    FROM QUOTED MASSES OF CHARGED AND NEUTRAL MODES

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                    9  RHO RANGE PARAMETER (GEV-1)

R             5.3      0.9       0.7   CHABAUD    83 ASPK  0 17 PI-P POLARIZ  12/83*

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                    9  RHO WIDTH (MEV)

W       WE NO LONGER LIST S-WAVE BREIT-WIGNER FITS, PBAR P DATA WITH HIGH
W       COMBINATORIAL BACKGROUND, AND INSIGNIFICANT OR DOUBTFUL DATA.
W       SEE FURTHER MINI-REVIEW ABOVE.

W   CHARGED ONLY
W   R        (77.0)   (20.0)           CARMONY    64 HBC  +   3.5 PI+P,TCUT 4
W   R       (100.0)                    ALFF-STEI  66 HBC  +   2-3 PI+ P         6/66
W   R       (127.0)    (5.0)           BLIEDEN    66 MMS  -   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   R       (153.0)   (13.0)           MILLER     67 HBC  -   2.7 PI-,T CUT20   9/66
W   R       (150.0)    (5.0)           BATON      68 HBC  -   2.8 PI- P         7/69
W
W      900  146.       13.             EISNER     67 HBC  -   4.2 PI-,T CUT10   9/67
W  A  9650  148.2       4.1            PISUT      68 RVUE -   1.7-3.2PI-,CT10   6/68
W  X  6500  146.       12.             BYERLY     73 OSPK -   5. PI- P          2/74
W           . . . . . . . . . .
W   AVG     147.8       3.7     AVERAGE

WO  NEUTRAL ONLY
WO  R  300  (90.0)    (10.0)           ABOLINS    63 HBC   0 3.5 PI+P
WO  R  500 (130.0)                     GOLDHABER  64 HBC   0 3.7 PI+P
WO  R      (100.0)                     ALFF-STEI  66 HBC   0 2-3 PI+ P          6/66
WO  R      (120.0)    (10.0)           HAGOPIAN1  66 HBC   0 3.0 PI- P          6/66
WO  R      (135.0)    (20.0)           HAGOPIAN2  66 HBC   0 2.14 PI-P,LOW T    9/67
WO  R 4207 (122.2)    (15.0)           JACOBS     66 HBC   0 2-3PI-,T CUT 20    6/68
WO  R      (103.0)    (13.0)           JAMES      66 HBC   0 2.1 PI+ P          6/66
WO  R      (173.0)    (13.0)           WEST       66 HBC   0 2.1 PI- P         10/66
WO  P 4000 (130.)      (5.)            ASBURY 2   67 CNTR  0 GAMMA + PB         1/73
WO  R      (148.0)     (8.0)           BACON      67 HBC   0 1.7 PI-P           9/67
WO  R      (152.)     (15.)            HUWE       67 HBC   0 2.4 PI- P          7/67
WO  R      (160.0)    (15.0)           MILLER     67 HBC   0 2.7 PI-,T CUT20    9/66
WO  R      (167.0)     (6.0)           ARMENISE   68 DBC   0 5.1 PI+D           6/68
WO  P      (160.0)    (10.0)           LANZEROTT  68 CNTR  0 GAMMA P            1/73
WO  R      (132.0)    (13.0)           MALAMUD    69 RVUE  0 2-4 PI-P           1/73
WO  P      (140.0)     (5.0)           ALVENSLEB  70 CNTR  0 GAMMA A,TCUT.01    1/73
WO  P      (147.)     (11.)            GLADDING   73 CNTR  0 BREMS.             2/74
WO  H      (152.)      (2.)            HYAMS      73 ASPK  0 17.PI-P,PI+PI-N    1/74
WO  H      (143.)     (13.)            ESTABROOK  74 RVUE  0 17 PI-P,PI+PI-N   12/75
WO  G      (163.)      (4.)            GRAYER     74 ASPK  0 17.PI-P,PI+PI-N    2/74
WO  D      (154.5)     (1.0)           ROOS       75 RVUE  0 PHASE SHIFTS      12/75
WO  G      (161.8)     (7.6)    (7.2)  BECKER     79 ASPK  0 17.PI-P POLARIZ   12/79

WO Z  2250  145.0      12.0            HYAMS      68 OSPK  0 11.2 PI- P         1/73
WO A 13300  163.0      15.0            PISUT      68 RVUE  0 1.7-3.2PI-,CT10    1/73
WO    1700  143.0       8.0            REYNOLDS   69 HBC   0 2.26 PI- P        12/78
WO    140K  146.1       2.9            BIGGS      70 CNTR  0 PHOTOPROD.         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    6800  157.0       8.0            RATCLIFF   72 ASPK  0 15. PI-P,TCUT.3    2/74
WO C 32000  160.0      10.0            PROTOPOPE  73 HBC   0 7.1 PI+P,TCUT.4    2/74
WO    4100  146.       14.             ENGLER     74 DBC   0 6. PI+N,PI+PI-P   12/75
WO   76000  154.0       2.0            DEUTSCHMA  76 HBC   0 16. PI+ P          4/78
WO E        150.9       3.0            BARTALUCC  78 CNTR  0 BREMS,E+E-P       12/77
WO X        152.0       9.0            WICKLUND   78 ASPK  0 3,4,6 PI+-PN       4/78
WO  CH     (148.0)     (1.3)           LANG       79 RVUE  0                    1/82
WO C H      148.0       6.0            BOHACIK    80 RVUE  0                    1/82
WO E B      155.        1.             HEYN       80 RVUE  0 PION FORM FACT.    9/81
WO G        160.0       4.1      4.0   CHABAUD    83 ASPK  0 17 PI-P POLARIZ   12/83*
WO K        148.8       4.3            KURDADZE   83 OLYA    E+E-               1/84*
WO          . . . . . . . . . .
WO  AVG     153.7       1.0     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
                        (SEE IDEOGRAM BELOW)

W       ----------NOTES----------

W    A   FROM FIT OF 3-PARAMETER RELATIVISTIC P-WAVE BREIT WIGNER TO TOTAL
W    A   MASS DISTRIBUTION.
W    B   HEYN 80 INCLUDES ALL SPACELIKE AND TIMELIKE F(PI)
W    B   VALUES UNTIL 1978.
W    C   FROM POLE EXTRAPOLATION
W    D   ENERGY-DEPENDENT ANALYSIS OF BATON 70, HYAMS 73,
W    D   PROTOPOPESCU 73 PHASE SHIFTS.
W    E   PURE P-WAVE SYSTEM.
W    G   FROM FIT OF 3-PARAMETER RELATIVISTIC BREIT-WIGNER TO
W    G   HELICITY ZERO PART OF P-WAVE INTENSITY. CHABAUD 83 AND BECKER 79
W    G   INCLUDE DATA OF GRAYER 74.
W    H   FROM PHASE SHIFT ANALYSIS OF GRAYER 74 DATA.
W    P   FROM PHOTOPRODUCTION, MODEL DEPENDENT.
W    R   INCLUDED IN PISUT 68 RVUE
W   X    PHASE SHIFT ANALYSIS. SYSTEMATIC ERRORS ADDED CORRESPONDING
W   X    TO SPREAD OF DIFFERENT FITS.
W   Z    WIDTH ERRORS ENLARGED BY US TO 4*WIDTH/SQRT(N),SEE K* TYPED NOTE
W   K    FROM THE GOUNARIS-SAKURAI PARAMETRIZATION OF THE PION FORM FACTOR

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                    9  RHO PARTIAL DECAY MODES

                                                          DECAY MASSES
P1     RHO INTO 2PI                                      140+ 140
P2     RHO INTO 4PI                                      140+ 140+ 140+ 140
P3     RHO INTO PI GAMMA                                 140+   0
P4     RHO INTO E+ E-                                   .511+.511
P5     RHO INTO PI ETA (VIOLATES G)                      140+ 549
P6     RHO INTO MU+ MU-                                  106+ 106
P7     RHO INTO PI+ PI- PIO (VIOLATES G)                 140+ 140+ 135
P8     RHO INTO ETA GAMMA                                549+   0

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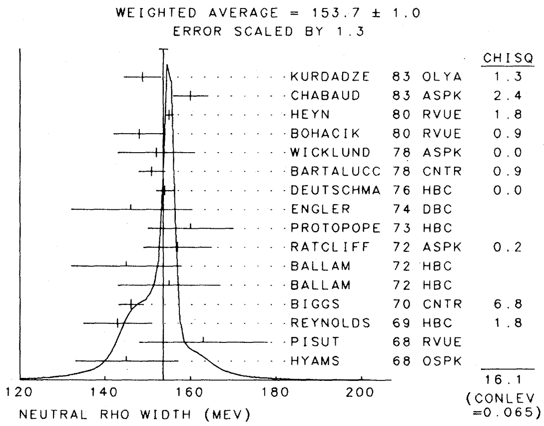


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                    9  RHO PARTIAL WIDTHS (KEV)

W3     RHO INTO (PI GAMMA)                                   (G3)
W3        (35.0)    (10.0)             GOBBI      74 OSPK  - 23. PI-A,PI-PIOA 12/75
W3         71.0       7.0              JENSEN     83 SPEC  - PI-A,PI- PIO A    9/83*
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                    9  RHO BRANCHING RATIOS

R1     RHO INTO 4PI/2PI                                      (P2)/(P1)

R1     RHO+- INTO (PI+- PI+ PI- PIO) / (PI+- PIO)
R1          (0.002)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)R LESS  CL=.90     ERBE       69 HBC    0 2.5-5.8 GAMMA P  10/67
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NOTE ON THE e^+e^- AND $\mu^+\mu^-$ DECAYS

Extraction of a ratio for $\rho^0 \to e^+e^-$ is complicated by interference with ω decay. In photoproduction, $\gamma A \to e^+e^- A$, there is substantial interference between the allowed $(\rho^0, \omega) \to e^+e^-$ decays. The interference in the colliding-beam reaction $e^+e^- \to \pi^+\pi^-$ is due to G-parity-violating mixing of the overlapping ρ^0 and ω resonances; it alters the results for the rate $\Gamma(\rho^0 \to e^+e^-)$ only by a small amount. Therefore at present we average only the values from the $e^+e^- \to \pi^+\pi^-$ experiments.

The same comment applies to the decay $\rho^0 \to \mu^+\mu^-$.

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R3     RHO INTO(E+ E-)/(PI+PI-) (UNITS 10**-4)             (P4)/(P1)
R3
R3       SEE MINI-REVIEW ABOVE.
R3
R3   P   94   (0.65)    (0.14)            ASBURY 1  67 CNTR     PHOTOPRODUCTION  9/67
R3   H        (0.65)    (1.1)    (0.5)    HERTZBACH 67 OSPK ASSUME SU(3)+MIXING 10/66
R3   A   33   (0.53)    (0.11)            ASTVACATU 68 OSPK ASSUME SU(3)+MIXING  6/68
R3             0.50      0.10             AUSLENDER 69 OSPK   E+E- COLLID.BEAM   9/68
R3   F        (0.49)    (0.12)   (0.15)   BIGGS     70 CNTR   PHOTOPRODUCTION    6/70
R3             0.41      0.05             BENAKSAS  72 OSPK    E+E- COLL.BEAMS  12/72
R3             0.462     0.018            KURDADZE  83 OLYA    E+E-              1/84*
R3           . . . . . . . . . .
R3   AVG       0.457     0.017   AVERAGE

R3   A         NOT SEPARATED FROM OMEGA DECAY. ERROR STATISTICAL ONLY.
R3   F         ASSUMING RHO WIDTH 140 MEV. ERROR STATISTICAL ONLY.
R3   H         NOT SEPARATED FROM OMEGA DECAY.
R3   P         POSSIBLY LARGE RHO-OMEGA INTERFERENCE
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R4       RHO INTO (PI ETA)/(2PI)                              (P5)/(P1)
R4             (0.008)OR LESS            FERBEL     66 HBC  +- PI+- P ABOVE 2.5 11/66

R5       RHO INTO (MU+ MU-)/(PI+ PI-) (UNITS 10**-4)          (P6)/(P1)
R5
R5        SEE MINI-REVIEW ABOVE.
R5
R5    H          0.97       0.31      0.33  HYAMS      67 OSPK     11 PI- LI H       6/67
R5    R          0.82       0.16      0.36  ROTHWELL   69 CNTR    PHOTOPRODUCTION    4/70
R5    W          0.56       0.15            WEHMANN    69 OSPK     12 PI- ON C,FE    7/69
R5            . . . . . . . . .
R5   AVG         0.67       0.12    AVERAGE

R5    H          HYAMS MASS RESOL. IS 20 MEV. THE OMEGA REGION WAS EXCLUDED.
R5    R          POSSIBLY LARGE RHO-OMEGA INTERFERENCE LEADS US TO INCREASE
R5    R          THE MINUS ERROR
R5    W          RESULT CONTAINS (11 +- 11) PER CENT CORRECTION USING SU(3)
R5    W          FOR CENTRAL VALUE. THE ERROR ON THE CORRECTION TAKES ACCOUNT
R5    W          OF POSSIBLE RHO-OMEGA INTERFERENCE AND THE UPPER LIMIT AGREES
R5    W          WITH THE UPPER LIMIT OF (OMEGA INTO MU+ MU-) FROM THIS EXPT.

R6       RHO  INTO (PI+ PI- 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

R7       RHO INTO (ETA GAMMA)/TOTAL (UNITS 10**-4)            (P8)
R7    A         (3.6)     (0.9)          ANDREWS    77 CNTR  0 6.7-10 GAMMA CU  12/77
R7    B         (5.4)     (1.1)          ANDREWS    77 CNTR  0 6.7-10 GAMMA CU  12/77
R7    A   SOLUTION CORRESPONDING TO CONSTRUCTIVE OMEGA-RHO INTERFERENCE
R7    A   THE QUARK MODEL PREDICTS A RELATIVE DECAY PHASE OF ZERO.
R7    B   SOLUTION CORRESPONDING TO DESTRUCTIVE OMEGA-RHO INTERFERENCE

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REFERENCES FOR RHO


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ANDERSON 61 PRL 6 365          ANDERSON,BANG,BURKE,CARMONY,SCHMITZ   (LRL)
ERWIN    61 PRL 6 628          A.R.,R.MARCH,W.D.WALKER,E.WEST        (WISC)

KENNEY   62 PR 126 736         V P KENNEY,W D SHEPHARD,C D GALL (KENTUCKY)
SAMIOS   62 PRL 9 139          SAMIOS,BACHMAN,LEA+    (BNL+CUNY+COLU+KNTY)
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+CDEF+IRAD+LIVP)
BATON    67 PL 25 B 419        J.BATON,G.LAURENS,J.REIGNIER       (SACLAY)
    ALSO 67 NP B 3  349        J.BATON,G.LAURENS,J.REIGNIER       (SACLAY)
CLEAR    67 NC 49A 399         +JOHNSTON+COOPER+MANNER+   (TNTO+ANL+WISC)
DANYSZ   67 NC 51 A 801        DANYSZ+FRENCH+SIMAK                  (CERN)
EISNER   67 PR 164 1699        +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)
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+CDEF)
HUSON    68 PL 28B 208         +LUBATTI,SIX,VEILLET,+     (ORSA+MILA+UCLA)
HYAMS    68 NP B 7 1           +KOCH,POTTER,WILSON,VON LINDERN+(CERN+MPIM)
JONES    68 PR 166 1405        +BLEULER,CALDWELL,ELSNER,HARTING+    (CERN)
JOHNSON  68 PR 176 1651        +POIRIER,BISWAS,GUTAY+     (NDAM+PURD+SLAC)
KEY      68 PR 166 1430        +PRENTICE+COOPER+MANNER+   (TNTO+ANL+WISC)
LAMSA    68 PR 166 1395        +CASON+BISWAS+DERADO+GROVES+    (NOTREDAME)
LANZEROT 68 PR 166 1365        LANZEROTTI,BLUMENTHAL,EHN,FAISSLER + (HARV)
MARATECK 68 PRL 21 1613        +HAGOPIAN,+  (PENN+LRL+COLO+PURD+TNTO+WISC)
PISUT    68 NP B 6 325         J.PISUT,M.ROOS                       (CERN)

AUGUSTI1 69 PL 28 B 508        +BIZOT+BUON+HAISSINSKI+LALANNE+     (ORSAY)
AUGUSTI2 69 LNC 2 214          +LEFRANCOIS,LEHMANN,MARIN,+         (ORSAY)
AUSLENDE 69 SJNP 9  69         AUSLENDER,BUDKER,PANTUSOVA,PESTOV+   (NOVO)
ERBE     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 NP B 35 133        BLOODWORTH,JACKSON,PRENTICE,YOON  (TORONTO)
DEERY    71 PR D 3 635         +BISWAS,CASON,GROVES,JOHNSON,+ (NOTRE DAME)

BAILLON  72 PL 38 B 555        +CARNEGIE,KLUGE,LEITH,LYNCH,RATCLIFF+(SLAC)
BALLAM   72 PR D 5 545         +CHADWICK,BINGHAM,MILBURN,+ (SLAC+LBL+TUFT)
BASDEVAN 72 PL 41 B 178        BASDEVANT,FROGGATT,PETERSEN          (CERN)
BENAKSAS 72 PL 39 B 289        +COSME,JEAN-MARIE,JULLIAN,LAPLANCHE,+(ORSA)
DRIVER   72 NP B 38 1          +HEINLOTH,HOHNE,HOFMANN,RATHJE,+(DESY+HAMB)
EISENBER 72 PR D 5 15          EISENBERG,BALLAM,DAGAN,+   (REHO+SLAC+TELA)
GRAYER   72 PHIL.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)
TAKAHASH 72 PR D 6 1266        TAKAHASHI,BARISH,+      (TOHO+PENN+NDAM+ANL)

BYERLY   73 PR D 7 637         +ANTHONY,COFFIN,MEANLEY,MEYER,RICE,+ (MICH)
CHARLESW 73 NP B 65 253        CHARLESWORTH,EMMS,BELL,+    (RHEL+BIRM+DURH)
GLADDING 73 PR D 8 3721        +RUSSEL,TANNENBAUM,WEISS,THOMSON     (HARV)
HYAMS    73 NP B 64 134        +JONES,WEILHAMMER,BLUM,DIETL,+  (CERN+MPIM)
PROTOPOP 73 PR D 7 1280        PROTOPOPESCU,GARNJOST,GALTIERI,FLATTE+(LBL)

CARROLL  74 PR D 10 1430       +MATTHEWS,WALKER+      (SLAC+DUKE+WISC+TNTO)
ENGLER   74 PR D 10 2070       +KRAEMER,TOAFF,WEISSER,DIAZ+    (CARN+CASE)
ESTABROO 74 NP B 79 301        P.ESTABROOKS,A.D.MARTIN              (DURH)
GOBBI    74 PRL 33 1450        +ROSEN,SCOTT,SHAPIRO+      (NWES+ROCH+CARN)
GRAYER   74 NP B 75 189        G.GRAYER,HYAMS,BLUM,DIETL,+     (CERN+MPIM)
HABER    74 PR D10 1387        +HODOUS,HULSIZER,KISTIAKOWSKY,LEVY+   (MIT)
NORDBERG 74 PL 51 B 106        +ABRAMSON,ANDREWS,HARVEY,+      (CORN+ROCH)
SPITAL   74 PR D 9 126         R.SPITAL,D.R.YENNIE                  (CORN)

MONTONEN 75 LNC 12 627         C.MONTONEN,M.ROOS,N.TORNQVIST        (HELS)
ROOS     75 NP B 97 165        M.ROOS                               (HELS)

DEUTSCHM 76 NP B 103 426       +KIRK,+(AACH+BERL+BONN+CERN+CRAC+HEID+WARS)

ANDREWS  77 PRL 38 198         +FUKUSHIMA,HARVEY,LOBKOWICZ,MAY,+    (ROCH)

BALTAY   78 PR D 17 62         +CAUTIS,COHEN,CSORNA,SMITH,YEH,+(COLU+BING)
BARTALUC 78 NC 44 A 587        BARTALUCCI,BASINI,BERTOLUCCI,   (DESY+FRAS)
QUENZER  78 PL 76 B 512        +RIBES,RUMPF,BERTRAND,BIZOT,CHASE,+  (LALO)
WICKLUND 78 PRD 17 1197        +AYRES,DIEBOLD,GREENE,KRAMER,PAWLICKI (ANL)

BECKER   79 NP B 151  46       +BLANAR,BLUM,CERRADA+ (MPIM+CERN+ZEEM+CRAC)
LANG     79 PR D 19 956        C.B.LANG,A.MAS-PARAREDA              (GRAZ)

BERG     80 PRL 44 706         +CHANDLEE,BIEL,HEPPELMANN,+(ROCH+FNAL+MINN)
BOHACIK  80 PR D 21 1342       J.BOHACIK,H.KUHNELT      (BRATISLAVA+WIEN)
HEYN     80 ZPHY C 7 169       M.F.HEYN,C.B.LANG                    (GRAZ)

ALEKSEEV 82 JETP 55 591        ALEKSEEVA,KARTAMYSHEV,MAKARIN+       (KIAE)

CHABAUD  83 NP B 223 1         +GORLICH,CERRADA+          (CERN+CRAC+MPIM)
JENSEN   83 PR D 27 26         +BERG,BIEL,COLLICK+        (ROCH+FNAL+MINN)
KURDADZE 83 JETPL 37 613       +LELCHUK,PAKHTUSOVA+                 (NOVO)
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ω(783)

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1  OMEGA(783,JPG=1--) I=0

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                       1  OMEGA MASS (MEV)

M   R 2198 (783.4)    (0.7)           BALTAY     67 HBC     0.0 PBAR P          2/74
M   R      (784.0)    (0.7)           ATHERTON   70 HBC     3.6 PBAR P, 7 PI    2/74
M  SR 4800 (782.0)    (0.8)           OREN       74 HBC     2.3 PBAR P,5PI     12/75
M
M     2400  782.4      0.5            BIZZARRI   69 HBC      0 PBAR P           9/69
M      750  784.1      1.2            ABRAMOVIC  70 HBC      3.9 PI- P          2/74
M    F      783.2      1.6            BIGGS      70 CNTR    PHOTOPRODUCTION     2/74
M      248  783.4      1.0            BIZZARRI   71 HBC      0.0 P PBAR K+K-  11/71
M      510  781.0      0.6            BIZZARRI   71 HBC      0.0 P PBAR K1K1  11/71
M  D        783.7      1.0            COYNE      71 HBC     3.7 PI+ P          11/71
M      418  782.5      0.8            AGUILAR    72 HBC     3.9,4.6 K- P       12/72
M  B  7000  782.4      0.5            KEYNE      76 CNTR    PI-P, OMEGA N      12/75
M     2100  783.5      0.8            GESSAROLI  77 HBC     11 PI-P,OMEGA PI   12/77
M      535  782.7      0.9            APELDOORN  78 HBC     7.2 PB P,PB P OM    4/78
M     1430  781.8      0.6            COOPER     78 HBC     .7-.8 PB P,5 PI     4/78
M     3000  782.6      0.8            BENKHEIRI  79 OMEG    9-12 PI+- P        12/79
M           783.3      0.4            CORDIER    80 WIRE    E+E-,PI+PI-PI0      9/81
M    33260  782.5      0.8            ROOS       80 RVUE    0-3.6 PBAR P       12/79
M           782.4      0.4            KURDADZ2   83 OLYA     E+E-               1/84*
M
M   AVG     782.58     0.18    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)

M  B    OBSERVED BY THRESHOLD-CROSSING TECHNIQUE. MASS RESOL.=4.8 MEV FWHM
M  D    FROM BEST-RESOLUTION SAMPLE OF COYNE 71
M   F   FROM OMEGA-RHO INTERFERENCE IN THE PI+PI- MASS SPECTRUM
M   F   ASSUMING OMEGA WIDTH 12.6 MEV.
M   R   INCLUDED IN ROOS 77,79 RVUE
M  S    ERROR INCLUDES 0.5 MEV MASS SCALE ERROR
M

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                       1  OMEGA FULL WIDTH (MEV)

W      750    8.8       3.0               ABRAMOVIC 70 HBC     3.9 PI- P          6/70
W            11.2       2.7               ATHERTON  70 HBC    3.6 PBAR P, 7 PI    5/70
W      510   10.3       1.4               BIZZARRI  71 HBC     0.0 P PBAR K1K1  11/71
W      248   12.8       3.0               BIZZARRI  71 HBC     0.0 P PBAR K+K-  11/71
W     4270    9.5       1.0               COYNE     71 HBC    3.7 PI+ P          11/71
W      418   13.3       2.                AGUILAR   72 HBC    3.9,4.6 K- P       12/72
W             9.1       0.8               BENAKSAS1 72 OSPK   E+E- COLL.BEAMS     2/73
W            10.5       1.5               BORENSTEI 72 HBC    2.18 K-P            7/77
W  E   940    7.70      1.65              BROWN     72 MMS    2.5 PI- P,N MMS    12/72
W  B 20000   10.22      0.43              KEYNE     76 CNTR   PI-P, OMEGA N      12/75
W     2100    9.4       2.5               GESSAROLI 77 HBC    11 PI-P,OMEGA PI   12/77
W     1430   12.0       2.0               COOPER    78 HBC    .7-.8 PB P,5 PI     4/78
W             9.0       0.8               CORDIER   80 WIRE   E+E-,PI+PI-PI0      9/81
W             9.8       0.9               KURDADZ2  83 OLYA    E+E-               1/84*
W
W   AVG       9.89      0.28     AVERAGE

W  B    OBSERVED BY THRESHOLD-CROSSING TECHNIQUE. MASS RESOL.=4.8 MEV FWHM
W  E    ERROR TAKES ACCOUNT OF SYSTEMATICS ADDED LINEARLY

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For notation, see key at front of Listings.


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                    1  OMEGA PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      OMEGA INTO PI+ PI- PIO                            140+ 140+ 135
P2      OMEGA INTO PI+ PI- (VIOLATES G)                   140+ 140
P3      OMEGA INTO PIO GAMMA                              135+   0
P4      OMEGA INTO PI+ PI- GAMMA                          140+ 140+   0
P5      OMEGA INTO 2PIO GAMMA                             135+ 135+   0
P6      OMEGA INTO ETA GAMMA                              549+   0
P7      OMEGA INTO E+ E-                                 .511+.511
P8      OMEGA INTO MU+ MU-                                106+ 106
P9      OMEGA INTO ETA PIO (VIOLATES C)                   549+ 135
P10     OMEGA INTO 3 GAMMA                                  0+   0+   0
P11     OMEGA INTO PIO MU+ MU-                            135+ 106+ 106

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FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions, P_i, as follows: The diagonal elements are $P_i \pm \delta P_i$, where $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$, while the off-diagonal elements are the normalized correlation coefficients $\langle \delta P_i \delta P_j \rangle / (\delta P_i \cdot \delta P_j)$. For the definitions of the individual P_i, see the listings above; only those P_i appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

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       P 1         P 2        P 3
P 1 .8990+-.0051
P 2   -.3762  .0140+-.0021
P 3   -.9107     -.0400  .0870+-.0047

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                    1  OMEGA BRANCHING RATIOS

R1      OMEGA INTO NEUTRAL/(PI+ PI- PIO)                    (P3+...)/(P1)
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         0.1033    0.0091  AVERAGE
R1  FIT         0.0968    0.0057 FROM FIT

R2      OMEGA INTO (PI+ PI-)/(PI+ PI- PIO). SEE ALSO R15 (P2)/(P1)
R2 R          (0.011)OR MORE  CL=.95    ABRAMOVIC 70 HBC       3.9 PI- P        6/70
R2 B            0.014     0.005   0.004 BIGGS     70 CNTR    PHOTOPRODUCTION   12/78
R2 R          (0.035)OR LESS  CL=.95    BIZZARRI  70 DBC      PBAR N AT REST   11/71
R2            (0.019)OR MORE  CL=.95    CHAPMAN   70 HBC     1.6-2.2 P PBAR     6/70
R2 R            0.022     0.009    0.01 ROOS      70 RVUE                       6/70
R2 S            0.021     0.028   0.009 RATCLIFF  72 ASPK    15.PI- P,N 2PI    12/72
R2            (0.0115)OR MORE           BURNS     73 HBC     .6-1.1 PBAR P     12/75
R2  C         (0.04)    (0.02)          LYONS     77 HBC     3-4 K-P,LAM OMEG  12/77
R2            . . . . . . . . . .
R2  AVG         0.0157    0.0040  AVERAGE
R2  FIT         0.0155    0.0024 FROM FIT

R2 B    RE-EVALUATED UNDER R2 BY BEHREND 71 USING MORE ACCURATE OMEGA
R2 B    TO RHO PHOTOPRODUCTION CROSS-SECTION RATIO.
R2  C   ASSUMING COMPLETE RHO-OMEGA COHERENCE
R2 R    ROOS 70 COMBINES ABRAMOVICH 70 AND BIZZARRI 70
R2 S    SIGNIFICANT INTERFERENCE EFFECT OBSERVED.NB OF OMEGA INTO 3PI
R2 S    COMES FROM AN EXTRAPOLATION.

R3      OMEGA INTO (PIO GAMMA) / (PI+ PI- PIO)              (P3)/(P1)
R3              0.13      0.04          JACQUET   69 HLBC                      10/67
R3              0.081     0.020         BALDIN    71 HLBC    2.9 PI+ P         11/71
R3              0.109     0.025         BENAKSAS2 72 OSPK    E+E- COLL.BEAMS    2/73
R3              0.084     0.013         KEYNE     76 CNTR    PI-P, OMEGA N     12/75
R3            . . . . . . . . . .
R3  AVG         0.0898    0.0097  AVERAGE
R3  FIT         0.0968    0.0057 FROM FIT

R4      OMEGA INTO (PI+ PI- GAMMA)/(PI+ PI- PIO)            (P4)/(P1)
R4            (0.05) OR LESS  CL=.90    FLATTE    66 HBC       1.8 K-P          9/66
R4             (.066)OR LESS  CL=.90    KALBFLEI  75 HBC     2.2 K- P,GAMMA + 12/75

R6      OMEGA INTO (MU+ MU-)/(PI+ PI- PIO)(UNITS 10**-3) (P8)/(P1)
R6            (1.2)  OR LESS            GALTIERI  65 HBC       2.7 K-P
R6            (1.7)  OR LESS  CL=.74    FLATTE    66 HBC       1.8 K-P          9/66
R6            (0.2)  OR LESS            WILSON    69 OSPK    12 PI- ON C,FE     9/69

R7      OMEGA INTO (2PIO GAMM)/(PIO GAMMA)                  (P5)/(P3)
R7            (0.1)  OR LESS            BARMIN    64 HLBC     1.3-2.8 PI-P
R7            (0.14) OR LESS            BALDIN    71 HLBC    2.9 PI+ P         11/71
R7            (0.15) OR LESS  CL=.90    BENAKSAS2 72 OSPK    E+E- COLL. BEAMS   2/73
R7            (0.18) OR LESS  CL=0.95   KEYNE     76 CNTR    PI-P,OMEGA N       7/77

R8      OMEGA INTO (ETA PIO + ETA GAMMA)/(PI+ PI- PIO)   (P9+P6)/(P1)
R8            (0.017)OR LESS  CL=.90    FLATTE    66 HBC      1.8 K-P           9/66
R8            (0.045)OR LESS  CL=.95    JACQUET   69 HLBC                       4/70

R9      OMEGA INTO (NEUTRALS) / (CHARGED)                   (P3+...)/(P1+P2...)
R9              0.124     0.021         FELDMAN   67 OSPK     1.2 PI- P         3/67
R9            . . . . . . . . . .
R9  FIT         0.0953    0.0056 FROM FIT

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             0.010     0.045         APEL      72 OSPK    4-8 PI- P,N 3GAM   2/73

R12     OMEGA INTO (PIO MU+ MU-) / TOTAL (UNITS 10**-3)  (P11)
R12             0.096     0.023         DZHELYADI 81 CNTR    25-33 PI-P,OME N   1/82

R13     OMEGA INTO (E+ E-)/TOTAL (UNITS 10**-4)             (P7)
R13 A    33   (0.65)    (0.13)          ASTVACATU 68 OSPK ASSUME SU(3)+MIXING   6/68
R13 Z         (0.40)    (0.21)          BOLLINI1  68 CNTR     1.7 PI-P          9/68
R13 E         (0.92)    (0.07)          AUGUSTI1  69 OSPK    E+E-, 2PI          2/72
R13             0.83      0.10          BENAKSAS1 72 OSPK    E+E-, 3PI          2/73
R13             0.675     0.069         CORDIER   80 WIRE    E+ E-,3PI         12/79
R13             0.64      0.04          KURDADZ2  83 OLYA     E+E-              1/84*
R13           . . . . . . . . . .
R13 AVG         0.668     0.041   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)

R13 A        NOT RESOLVED  FROM  RHO  DECAY. ERROR STATISTICAL ONLY.
R13 E        RESCALED BY US TO CORRESPOND TO OMEGA WIDTH 10.1 MEV.
R13 Z        MASS RESOLUTION OF BOLLINI 1 IS +-10 MEV.HIS ERROR IS +-.15
R13 Z        WITHOUT RHO-OMEGA INTERFERENCE. COMPLETE INTERFERENCE WOULD
R13 Z        CHANGE VALUE BY +-35 PER CENT. THEREFORE WE INCREASED ERROR.

R14     OMEGA INTO NEUTRALS / TOTAL                         (P3+...)
R14             0.084     0.015         BOLLINI   68 CNTR    2.1 PI- P          6/68
R14             0.079     0.019         DEINET    69 OSPK    1.5 PI- P          9/69
R14             0.075     0.025         BIZZARRI  71 HBC      0.0 P PBAR       11/71
R14      42     0.073     0.018         BASILE    72 CNTR    1.67 PI- P         2/73
R14           . . . . . . . . . .
R14 AVG         0.0788    0.0092  AVERAGE
R14 FIT         0.0870    0.0047 FROM FIT

R15     OMEGA INTO (PI PI)/(TOTAL). SEE ALSO R2             (P2)
R15             0.032     0.028   0.019 AUGUSTI2  69 OSPK      E+E- COLL.BEAMS  8/69
R15           (0.003)OR MORE  CL=.95    GOLDHABER 69 HBC         3.7-4.0 PI+P  11/69
R15           (0.014)OR MORE  CL=.95    ALLISON   70 HBC     1.3-1.7 PBAR P     6/70
R15 B         (0.0080) (0.0028) (0.0022)IGGS      70 CNTR    PHOTOPRODUCTION   12/78
R15             0.0122    0.0030        ALVENSLEB 71 CNTR    PHOTOPRODUCTION   11/71
R15             0.013     0.012   0.009 MOFFEIT   71 HBC     2.8,4.7 GAMMA P   11/71
R15             0.036     0.024   0.018 BENAKSAS  72 OSPK     E+E- COLL.BEAMS  12/72
R15 F         (0.035)   (0.018)         BRANDENBU 76 ASPK    13.K-P,PI+PI-     12/79
R15 F         (0.04)    (0.03)   (0.02) HOLMGREN  77 HBC     4.2 K-P,PI+PI-    12/79
R15             0.016     0.009   0.007 QUENZER   78 CNTR    E+E- COLL.BEAMS    4/78
R15 F         (0.010)   (0.001)         WICKLUND  78 ASPK    3,4,6 PI+-PN      12/79
R15             0.020     0.06          KURDADZ1  83 OLYA     E+E-              1/84*
R15           . . . . . . . . . .
R15 AVG         0.0133    0.0027  AVERAGE
R15 FIT         0.0140    0.0021 FROM FIT

R15 B   RE-EVALUATED UNDER R2 BY BEHREND 71 USING MORE ACCURATE OMEGA
R15 B   TO RHO PHOTOPRODUCTION CROSS-SECTION RATIO.
R15 F   FROM A MODEL DEPENDENT ANALYSIS ASSUMING COMPLETE COHERENCE.

R17     OMEGA INTO (2 PIO GAMMA) / (ALL NEUTRALS)           (P5)/(P3+...)
R17           (0.19) OR LESS  CL=.90    DEINET    69 OSPK                       9/69
R17 D         (0.22)    (0.07)          DAKIN     72 OSPK    1.4 PI- P,N MMO   12/72
R17 D       SEE R18

R18     OMEGA INTO (PIO GAMMA) / (ALL NEUTRALS)             (P3)/(P3+...)
R18           (0.81) OR MORE  CL=.90    DEINET    69 OSPK                       9/69
R18 D         (0.78)    (0.07)          DAKIN     72 OSPK    1.4 PI- P,N MMO   12/72
R18 D       ERROR STATISTICAL ONLY.AUTHORS OBTAIN GOOD FIT ALSO ASSUMING
R18 D       PIO GAMMA AS THE ONLY NEUTRAL DECAY.

R19     OMEGA INTO (ETA GAMMA)/TOTAL (UNITS 10**-4)         (P6)
R19 A         (3.0)     (2.5)     (1.8) ANDREWS   77 CNTR    6.7-10 GAMMA CU   12/77
R19 B        (29.0)     (7.0)           ANDREWS   77 CNTR    6.7-10 GAMMA CU   12/77
R19 A   SOLUTION CORRESPONDING TO CONSTRUCTIVE OMEGA-RHO INTERFERENCE
R19 A   THE QUARK MODEL PREDICTS A RELATIVE DECAY PHASE OF ZERO
R19 B   SOLUTION CORRESPONDING TO DESTRUCTIVE OMEGA-RHO INTERFERENCE

R20     OMEGA INTO (PIO MU+ MU-) / ( MU+ MU-)               (P11)/(P8)         12/78
R20 S   30   (1.2)     (0.6)            DZHELYADI 79 CNTR    25-33 PI- P       12/79
R20 S   SUPERSEDED BY DZHELYADIN 81 RESULT ABOVE.

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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)
ZDANIS   65 PRL 14 721         ZDANIS,MADANSKY,KRAEMER,HERTZBACH+(JHU+BNL)

ALFF-STE 66 PR 145 1072        ALFF-STEINBERGER,BERLEY,BRUGGER+(COLU+RUTG)
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)

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)
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)
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Mesons

Data Card Listings

$\omega(783)$, $\eta'(958)$

ABRAMS 71 PR D 4 653 +BARNHAM,BUTLER,COYNE,GOLDHABER,HALL,+(LBL)
ALVENSLE 71 PRL 27 888 ALVENSLEBEN,BECKER,BUSZA,CHEN,COHEN,+(DESY)
ANGELOW 71 SJNP 12 427 +GRAMENITSKY,KANASIRSKY,KERATSCHEW,+ (JINR)
BALDIN 71 SJNP 13 758 +YERGAKOV,TREBUKHOVSKY,SHISHOV (ITEP)
BARDADIN 71 PR D4 2711 BARDADIN-OTWINOWSKA,HOFMOKL,MICHEJDA+(WARS)
BEHREND 71 PRL 27 61 +LEE,NORDBERG,WEHMAN,+ (ROCH+CORN+FNAL)
BIZZARRI 71 NP B 27 140 +MONTANET,NILSSON,D-ANDLAU,+ (CERN+CDEF)
BLOODWOR 71 NP B 35 133 BLOODWORTH,JACKSON,PRENTICE,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)
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)
BORENSTE 72 PR D 5 1559 BORENSTEIN,DANBURG,KALBFLEISCH,+ (BNL+MICH)

BINNIE 73 PR D 8 2789 +CARR,DEBENHAM,DUANE,GARBUTT,+ (LOIC+SHMP)
BURNS 73 PR D 7 1310 +CONDON,KIM,MANDELKERN,PRICE,SCHULTZ (UCI)

ESTABROO 74 NP B 81 70 ESTABROOKS,HYAMS,JONES,BLUM, (CERN+MPIM)
GREGORIO 74 NC 20 A 437 M.A.GREGORIO (ICTP-TRIESTE)
KRAMER 74 PRL 33 505 +AYRES,DIEBOLD,GREENE,PAWLICKI+ (ANL)
OREN 74 NP B 71 189 +COOPER,FIELDS,RHINES,ALLISON+ (ANL+OXF)

EMMS 75 NP B98 1 +KINSON,STACEY,BELL,DALE+ (BIRM+DURH+RHEL)
KALBFLEI 75 PR D 11 987 KALBFLEISCH,STRAND,CHAPMAN (BNL+MICH)
ROOS 75 NP B 97 165 M.ROOS (HELS)

BRANDENB 76 NP B 104 413 BRANDENBURG,CARNEGIE,CASHMORE,DAVIER+(SLAC)
KEYNE 76 PR D 14 28 +BINNIE,CARR,DEBENHAM,GARBUTT,+ (LOIC+SHMP)
ALSO 73 BINNIE

ANDREWS 77 PRL 38 198 +FUKUSHIMA,HARVEY,LOBKOWICZ,MAY,+ (ROCH)
BARTKE 77 NP B 118 360 + (AACH+BERL+BONN+CERN+CRAC+LOIC+WIEN+WARS)
GESSAROL 77 NP B 126 382 GESSAROLI,+ (BGNA+FIRZ+GENO+MILA+OXF+PAVI)
HOLMGREN 77 PL 66 B 191 +JONGEJANS,ENGELEN,+ (CERN+AMST+NIJM+OXF)
LYONS 77 NP B 125 207 +COOPER,CLARK (OXF)
ROOS 77 LNC 19 419 M.ROOS (HELSINKI)

APELDOOR 78 NP B 133 245 VAN APELDOORN,GRUNDEMAN,HARTING,+ (ZEEM)
COOPER 78 NP B 146 1 +GURTU,MONTANET,+ (TIFR+CERN+CDEF+MADR)
QUENZER 78 PL 76 B 512 +RIBES,RUMPF,BERTRAND,BIZOT,CHASE,+ (LALO)
WICKLUND 78 PRD 17 1197 +AYRES,DIEBOLD,GREENE,KRAMER,PAWLICKI (ANL)

BENKHEIR 79 NP B 150 268 BENKHEIRI,EISENSTEIN,+(EPOL+CERN+CDEF+LALO)
DZHELYAD 79 PL 84 B 143 DZHELYADIN,GOLOVKIN,GRITSUK,+ (SERP)

CORDIER 80 NP B 172 13 +DELCOURT,ESCHSTRUTH,FULDA,+ (LALO)
ROOS 80 LNC 27 321 +PELLINEN (HELS)

DZHELYAD 81 PL 102 B 296 DZHELYADIN,GOLOVKIN,KONSTANTINOV,+ (SERP)

KURDADZ1 83 JETPL 37 613 +LELCHUK,PAKHTUSOVA+ (NOVO)
KURDADZ2 83 JETPL 36 274 +PAKHTUSOVA,SIDOROV+ (NOVO)

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$\eta'(958)$

2 ETA PRIME(958,JPG=0-+) I=0

NOTE ON THE J^P ASSIGNMENT OF $\eta'(958)$

From the Dalitz plot analyses of the $\eta' \to \pi\pi\eta$ and $\eta' \to \pi^+\pi^-\gamma$ decays and from the observation of an $\eta' \to \gamma\gamma$ decay mode, all assignments except $J^{PC} = 0^{-+}$ and 2^{-+} are excluded. The Dalitz plot analyses favor spin 0, but cannot rule out spin 2. The indication of anisotropy in the decay of very forward-produced η' (KALBFLEISCH 73) has not been confirmed by BALTAY 74, thus again favoring spin 0, but still not ruling out spin 2 (LEDNICKY 77).

Two analyses, however, seem to have established the spin 0 assignment of the η'.

CERRADA 77 perform a partial-wave analysis of the $\eta\pi\pi$ system produced in the reaction $K^-p \to \eta'\Lambda$, taking into account the η' and Λ joint decay angular correlations. They conclude that J^P is unambiguously 0^- (see also DELAGUILA 77).

ROUSSARIE 77 analyze a large sample of events from the reaction $\pi^-p \to \eta'n$ at beam momenta just above threshold. They verify that the η' is produced in a relative S-wave state, and thus the Adair condition is satisfied by their total sample of some 1800 events. The decay angular distribution of the η' is consistent with isotropy, and thus ROUSSARIE 77 conclude that the spin cannot be 2.

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2 ETA PRIME MASS (MEV)

M		957.	1.		RITTENBER	69	HBC	1.7-2.7 K- P	9/69
M	3415	956.1	1.1		BASILE1	71	CNTR	1.6 PI- P,N X0	11/71
M	535	957.4	1.4		BASILE1	71	CNTR	1.6 PI- P,N X0	11/71
M	1414	958.2	0.5		DANBURG	73	HBC	2.2 K-P,LAM X0	2/74
M	400	958.	1.		JACOBS	73	HBC	2.9 K-P,LAM X0	1/74
M		957.46	0.33		DUANE	74	MMS	PI- P,N MM	1/74
M		. . . .	. . . .						
M	AVG	957.57	0.25	AVERAGE					

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2 ETA PRIME WIDTH (MEV)

WE INCLUDE DIRECT MEASUREMENTS OF THE ETA PRIME TOTAL WIDTH AND GAMMA GAMMA PARTIAL WIDTH TOGETHER WITH THE MEASURED BRANCHING RATIOS IN THE FIT FOR THE PARTIAL DECAY RATES.

W	1000	0.28	0.10		BINNIE	79	MMS	0 PI- P,N MM	12/79
W		. . . .	. . . .						
W	FIT	0.291	0.051	FROM FIT					

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2 ETA PRIME PARTIAL DECAY MODES

		DECAY MASSES
P1	ETA PRIME INTO PI+ PI- ETA P1(N) ETAS DECAY INTO ALL NEUTRALS P1(C) ETAS DECAY CHARGED	140+ 140+ 549
P2	ETA PRIME INTO PI0 PI0 ETA P2(N) ETAS DECAY INTO ALL NEUTRALS P2(C) ETAS DECAY CHARGED	135+ 135+ 549
P3	ETA PRIME INTO PI+ PI- GAMMA (INCLUDING RHO GAMMA)	140+ 140+ 0
P4	ETA PRIME INTO GAMMA GAMMA	0+ 0
P5	ETA PRIME INTO OMEGA GAMMA	783+ 0
P6	ETA PRIME INTO RHO0 GAMMA	769+ 0
P10	ETA PRIME INTO PI+ PI- E+ E-	140+ 140+.511+.511
P11	ETA PRIME INTO 2 PI	140+ 140
P12	ETA PRIME INTO 3 PI	140+ 140+ 135
P13	ETA PRIME INTO 4 PI	140+ 140+ 140+ 140
P14	ETA PRIME INTO 5 PI	
P15	ETA PRIME INTO 6 PI	
P16	ETA PRIME INTO PI0 E+ E- (VIOLATES C IN BORN APPROX.)	135+.511+.511
P17	ETA PRIME INTO ETA E+ E- (VIOLATES C IN BORN APPROX.)	549+.511+.511
P18	ETA PRIME INTO PI0 RHO 0 (VIOLATES C)	135+ 769
P19	ETA PRIME INTO PI0 OMEGA (VIOLATES C)	135+ 783
P20	ETA PRIME INTO MU+ MU- GAMMA	106+ 106+ 0
P21	ETA PRIME INTO ETA MU+ MU-	549+ 106+ 106
P22	ETA PRIME INTO PI0 MU+ MU-	135+ 106+ 106

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FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions, P_i, as follows: The diagonal elements are $P_i \pm \delta P_i$, where $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$, while the off-diagonal elements are the normalized correlation coefficients $\langle \delta P_i \delta P_j \rangle / (\delta P_i \cdot \delta P_j)$. For the definitions of the individual P_i, see the listings above; only those P_i appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

	P 1	P 2	P 3	P 4	P 5
P 1	.4266+-.0174				
P 2	-.6480	.2268+-.0206			
P 3	-.2784	-.5030	.3004+-.0160		
P 4	.0323	-.1057	.0043	.0187+-.0016	
P 5	.0672	-.2090	-.1437	-.0029	.0275+-.0054

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 1	.1240+-.0223				
G 2	.8000	.0659+-.0135			
G 3	.9224	.7796	.0873+-.0161		
G 4	.8768	.7630	.8526	.0054+-.0009	
G 5	.6601	.5137	.6024	.5868	.0080+-.0021

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NOTE ON η'(958) BRANCHING FRACTIONS

In our calculation of the branching fractions of the $\eta'(958)$, we use the decay modes $\eta\pi\pi$ (including $\eta\pi^0\pi^0$), $\rho^0\gamma$, $\omega\gamma$, and $\gamma\gamma$. It is assumed that the rate $\eta \rightarrow$ neutrals is 70.9%.

In the fit we do not use the constraint

$$R = \frac{\Gamma(\eta' \rightarrow \eta\pi^+\pi^-)}{\Gamma(\eta' \rightarrow \eta\pi^0\pi^0)} = 2$$

from isospin conservation. The result of the fit is in agreement with it: R = 1.9 ± 0.2.

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                     2  ETA PRIME PARTIAL WIDTHS (KEV)

W4      ETA PRIME INTO (GAMMA GAMMA)                              (G4)
W4    B  23    (5.8)     (2.3)           ABRAMS     79 SMK2    E+E-,E+E- RHO GA 12/79
W4    C 213     5.0       1.4            BARTEL     82 JADE    E+E-,E+E- RHO GA  8/83*
W4    C  43     6.2       1.9            BEHREND    83 CELL    E+E-,E+E- RHO GA  8/83*
W4    C        (4.1)     (1.9)           FRAZER     83 TASS    E+E-,E+E- RHO GA  9/83*
W4    C  95     5.8       2.3            JENNI      83 SMK2    E+E-,E+E- RHO GA  9/83*
W4           . . . . . . . . . . .
W4   AVG        5.5       1.0      AVERAGE
W4   FIT        5.44      0.90    FROM FIT

W4    C THE SYSTEMATIC ERROR HAS BEEN ADDED LINEARLY.
W4    B ABRAMS 79 IS INCLUDED IN JENNI 83.

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                     2  ETA PRIME BRANCHING RATIOS

                  SEE MINI-REVIEW ABOVE.

R1      ETA PRIME INTO (PI+ PI-ETA (NEUTRAL DEC.))/TOTAL (P1N)
R1      281     0.314     0.026          RITTENBER 69 HBC      1.7-2.7 K-P        9/69
R1           . . . . . . . . . . .
R1   FIT        0.302     0.012   FROM FIT

R2      ETA PRIME INTO (PI+ PI- NEUTRALS) / TOTAL         (P1N+P2C+P5)
R2       33     0.35      0.06           BADIER     65 HBC      3.0 K-P          10/66
R2       39     0.4       0.1            LONDON     66 HBC      2.2 K-P          10/66
R2           . . . . . . . . . . .
R2   AVG        0.363     0.051    AVERAGE
R2   FIT        0.393     0.011   FROM FIT

R3      ETA PRIME INTO (PI+ PI- ETA (CHRGD.DECAY))/TOTAL (P1C)
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
R3   FIT        0.1241    0.0051 FROM FIT

R4      ETA PRIME INTO (PI+ PI- NEUTRALS (EXCLUDING       (P2C+P5)
R4          PI+ PI- ETA (NEUTR.DEC.))) / TOTAL
R4       42     0.045     0.029          RITTENBER 69 HBC      1.7-2.7 K-P        9/69
R4           . . . . . . . . . . .
R4   FIT        0.0908    0.0069 FROM FIT

R5      ETA PRIME INTO (NEUTRALS) / TOTAL                 (P2N+P4)
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        0.187     0.017    AVERAGE
R5   FIT        0.182     0.014   FROM FIT

R6      ETA PRIME INTO (PI+ PI- GAMMA (INCLUDING RHO GAMMA))/TOTAL
R6                                                         (P3)
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        0.319     0.030    AVERAGE
R6   FIT        0.300     0.016   FROM FIT

R7      ETA PRIME INTO (PI+ PI- GAMMA (INCLUDING RHO GAMMA))/(PI PI ETA)
R7                                                         (P3)/(P1+P2)
R7              0.31      0.15           DAVIS      68 HBC      5.5 K- P          9/68
R7           . . . . . . . . . . .
R7   FIT        0.460     0.035   FROM FIT

R8      ETA PRIME INTO (PIO E+ E-)/TOTAL                   (P16)
R8          (0.013)OR LESS               RITTENBER 65 HBC               2.7 K-P   10/66

R9      ETA PRIME INTO (ETA E+ E-)/TOTAL                   (P17)
R9          (0.011)OR LESS               RITTENBER 65 HBC               2.7 K-P   10/66

R10     ETA PRIME INTO (PIO RHOO)/TOTAL                    (P18)
R10         (0.04) OR LESS               RITTENBER 65 HBC               2.7 K-P   10/66

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

R17     ETA PRIME INTO (OMEGA GAMMA)/(PI+PI-ETA)            (P5)/(P1)
R17      68     0.068     0.013          ZANFINO    77 ASPK    8.4 PI-P          12/77
R17          . . . . . . . . . . .
R17 FIT         0.065     0.013   FROM FIT

R18     ETA PRIME INTO (PI+ PI- GAM(INCL.RHO GAM))/(PI PI ETA + OMEGA GAM)
R18                                                        (P3)/(P1+P2+P5)
R18             0.25      0.14           DAUBER     64 HBC      1.95 K-P         10/66
R18          . . . . . . . . . . .
R18 FIT         0.441     0.034   FROM FIT

R19     ETA PRIME INTO (2 GAMMA)/TOTAL                     (P4)
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             0.025     0.007          DUANE      74 MMS     PI-P,N MM        12/75
R19    6000     0.018     0.002          APEL       79 CNTR    15-40 PI- P      12/79
R19          . . . . . . . . . . .
R19 AVG         0.0183    0.0016  AVERAGE
R19 FIT         0.0187    0.0016 FROM FIT

R20     ETA PRIME INTO (PI+PI-)/TOTAL                      (P11)
R20         (0.02) OR LESS               RITTENBER 69 HBC      1.7-2.7 K-P        9/69
R20         (0.08) OR LESS  CL=.95       DANBURG    73 HBC     2.2 K-P,LAM X0     2/74

R21     ETA PRIME INTO (PI+PI-PIO)/TOTAL                   (P12)
R21         (0.05) OR LESS               RITTENBER 69 HBC      1.7-2.7 K-P        9/69
R21         (0.09) OR LESS  CL=.95       DANBURG    73 HBC     2.2 K-P,LAM X0     2/74

R22     ETA PRIME INTO (PI+PI+PI-PI-)/TOTAL                (P13)
R22         (0.01) OR LESS               RITTENBER 69 HBC      1.7-2.7 K-P        9/69
R22         (0.01) OR LESS  CL=.95       DANBURG    73 HBC     2.2 K-P,LAM X0     2/74

R23     ETA PRIME INTO (PI+PI+PI-PI-PIO)/TOTAL             (P14)
R23         (0.01) OR LESS               RITTENBER 69 HBC      1.7-2.7 K-P

R24     ETA PRIME INTO (PI+PI+PI-PI- NEUTRALS)/TOTAL       (P15+...)
R24         (0.01) OR LESS               RITTENBER 69 HBC      1.7-2.7 K-P        9/69

R25     ETA PRIME INTO (RHOO GAMMA)/(ALL PI+ PI- GAMMA)    (P6)/(P3)
R25             0.94      0.20           AGUILAR    70 HBC     3.9-4.6K-P         1/71
R25  E 473      1.15      0.10           DANBURG    73 HBC     2.2 K-P,LAM X0     2/74
R25  E 473     (0.95) OR MORE  CL=.95    DANBURG    73 HBC     2.2 K-P,LAM X0     2/74
R25    137      1.01      0.15           JACOBS     73 HBC     2.9 K-P,LAM X0     1/74
R25          . . . . . . . . . . .
R25 AVG         1.082     0.077    AVERAGE

R25  E  EQUIVALENT STATEMENTS

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         0.0680    0.0062 FROM FIT

R27     ETA PRIME INTO (PI+ PI- GAMMA)/(PI+ PI- ETA(NEUTRAL DEC.))
R27                                                        (P3)/(P1N)
R27 K          (0.54)    (0.10)          AGUILAR    72 HBC     3.9,4.6 K- P      12/72
R27 K    NOT AVERAGED DUE TO COMPLICATION WITH M(953).SEE KALBFLEI 74.
R27     473     0.92      0.14           DANBURG    73 HBC     2.2 K-P,LAM X0     2/74
R27     192     1.11      0.18           JACOBS     73 HBC     2.9 K-P,LAM X0     1/74
R27          . . . . . . . . . . .
R27 AVG         0.99      0.11     AVERAGE
R27 FIT         0.993     0.075    FROM FIT

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         0.116     0.015   FROM FIT

R29     ETA PRIME INTO (GAMMA 2MU)/(2GAMMA)(UNITS 10**-3)(P20)/(P4)             12/78
R29      33     4.9       1.2            VIKTOROV  80 CNTR    25,33 PI-P,2MU G  9/81

R30     ETA PRIME INTO (ETA MU+ MU-)/TOTAL (UNITS 10**-5)(P21)                  1/82
R30         (1.5)  OR LESS  CL=.90       DZHELYAD  81 CNTR     30 PI-P,ETAP N     1/82

R31     ETA PRIME INTO (PIO MU+ MU-)/TOTAL (UNITS 10**-5)(P22)                  1/82
R31         (6.0)  OR LESS  CL=.90       DZHELYAD  81 CNTR     30 PI-P,ETAP N     1/82

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                2  ETA PRIME C-NONCONSERVING DECAY PARAMETER

        SEE THE NOTE ON ETA DECAY PARAMETERS IN THE STABLE PARTICLE
        LISTINGS FOR DEFINITION OF THIS PARAMETER

A   DECAY ASYMMETRY PARAMETER FOR PI+ PI- GAMMA
A      152      .07       .08            RITTENBE  65 HBC     2.1-2.7 K-P        12/75
A      103      .00       .10            KALBFLEI  75 HBC     2.2 K-P            12/75
A      295     -.069      .078           GRIGORIA  75 STRC    2.1 PI-P           12/75
A            . . . . . . . . . . .
A   AVG        -0.001     0.049    AVERAGE

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REFERENCES FOR ETA PRIME


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DAUBER   64 PRL 13 449            DAUBER,SLATER,SMITH,STORK,TICHO       (UCLA)JP
   ALSO  64 DUBNA CONF 1 418      DAUBER,SLATER,L T SMITH,STORK,TICHO  (UCLA)
GOLDBERG 64 PRL 12 546            +GUNDZIK,LICHTMAN,CONNOLLY,HART,+(SYRA+BNL)
GOLDBERG 64 PRL 13 249            +GUNDZIK,LEITNER,CONNOLLY,HART,+ (SYRA+BNL)
KALBFLE1 64 PRL 12 527            KALBFLEISCH,ALVAREZ,BARBARO-GALTIERI,+(LRL)JP
KALBFLE2 64 PRL 13 349            G.R.KALBFLEISCH,O.DAHL,A.RITTENBERG   (LRL)JP

BADIER   65 PL 17 337             BADIER,DEMOULIN,BARLOUTAUD+(EPOL+SACL+AMST)
KIENZLE  65 PL 19 438             KIENZLE,MAGLIC,LEVRAT,LEFEBVRES +    (CERN)
RITTENBE 65 PRL 15 556            RITTENBERG,KALBFLEISCH             (LRL+BNL)
TRILLING 65 PL 19 427             +BROWN,GOLDHABERS,KADYK,SCANIO          (LRL)

COHN     66 PL 21 347             COHN,MCCULLOCH,BUGG,CONDO  (ORNL+TENN+UCND)
LONDON   66 PR 143 1034           LONDON,RAU,SAMIOS,GOLDBERG + (BNL+SYRACUSE)IJP
MARTIN   66 PL 22,352             MARTIN,CRITTENDEN,SCHROEDER     (INDIANA U)I

BARBARO- 68 PRL 20 349            BARBARO-GALTIERI,MATISON,RITTENBERG+  (LRL)I=0
BARLOUTA 68 PL 26 B  674          BARLOUTAUD+    (SACLAY+AMST+BGNA+REHO+EPOL)I=0
BOLLINI  68 NC 58 A  289          +BUHLER,DALPIAZ,MASSAM+    (CERN+BGNA+STRB)
DAVIS    68 PL 27 B 532           +AMMAR,MOTT,DAGAN,DERRICK,FIELDS (NWES+ANL)

DUFEY    69 PL 29 B 605           +GOBBI,POUCHON,CNOPS,+      (ETH+CERN+SACL)IJP
MOTT     69 PR 177 1966           +AMMAR,DAVIS,KROPAC,SLATE,DAGAN+ (NWES+ANL)
RITTENBE 69  UCRL-18863           ALAN RITTENBERG (THESIS)              (LRL)I=0
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AGUILAR 70 PRL 25 1635 AGUILAR-BENITEZ,BASSANO,SAMIOS,BARNES+(BNL)
BENSINGE 70 PL 33 B 505 BENSINGER,ERWIN,THOMPSON,W.D.WALKER (WISC)

BARDADIN 71 PR D4 2711 BARDADIN-OTWINOWSKA,HOFMOKL,MICHEJDA+(WARS)
BASILE1 71 NC 3 A 371 +BOLLINI,DALPIAZ,FRABETTI,+(CERN+BGNA+STRB)
BASILE2 71 NP B 33 29 +BOLLINI,DALPIAZ,FRABETTI,+(CERN+BGNA+STRB)
HARVEY 71 PRL 27 885 +MARQUIT,PETERSON,RHOADES,+ (MINN+MICH)
OGIEVETS 71 PL 35 B 69 OGIEVETSKY,TYBOR,ZASLAVSKY (DUBNA)

AGUILAR 72 PR D 6 29 AGUILAR-BENITEZ,CHUNG,EISNER,SAMIOS (BNL)
APEL 72 PL 40 B 680 +AUSLANDER,MULLER,BERTOLUCCI,+ (KARL+PISA)
BINNIE 72 PL 39 B 275 +CAMILLERI,DUANE,GARBUTT,BURTON+(LOIC+SHMP)
BLOODWOR 72 NP B 39 525 BLOODWORTH,JACKSON,PRENTICE,YOON (TORONTO)
DALPIAZ 72 PL 42 B 377 +FRABETTI,MASSAM,NAVARRIA,ZICHICHI (CERN)
RADER 72 PR D 6 3059 +ABOLINS,DAHL,DANBURG,DAVIES,HOCH,+ (LBL)

DANBURG 73 PR D 8 3744 +KALBFLEISCH,BORENSTEIN,CHAPMAN,+(BNL+MICH) JP
JACOBS 73 PR D 8 18 +CHANG,GAUTHIER,+ (BRAN+UMD+SYRA+TUFT) JP
KALBFLEI 73 PRL 31 333 KALBFLEISCH,CHAPMAN,+ (BNL+MICH+LBL) JP

BALTAY 74 PR D9 2999 +COHEN,CSORNA,HABIBI,KALELKAR,+ (COLU+BING) JP
DUANE 74 PRL 32 425 +BINNIE,CAMILLERI,CARR,DEBENHAM+(LOIC+SHMP)
GAULT 74 NC 24 A 259 +JONES,SCADRON,THEWS (DURH+LOIC+ARIZ)
KALBFLEI 74 PR D10 916 G.R.KALBFLEISCH (BNL)

GRIGORIA 75 NP B91 232 GRIGORIAN,LADAGE,MELLEMA,RUDNICK,+ (UCLA)
KALBFLEI 75 PR D11 987 KALBFLEISCH,STRAND,CHAPMAN (BNL+MICH)

CERRADA 77 NP B 126 189 +WAGNER,BLOCKZIJL,+ (CERN+AMST+NIJM+OXF) JP
DELAGUIL 77 PR D16 2833 F.DEL AGUILA AND M.G.DONCEL (BARCELONA) JP
GESSAROL 77 NP B 126 382 GESSAROLI,+ (BGNA+FIRZ+GENO+MILA+OXF+PAVI)
LEDNICKY 77 E2-10521,22,23 R.LEDNICKY (JINR) JP
ROUSSARI 77 PREPRINT +ERNWEIN,FELTESSE,BORGEAUD,ROUSSARIE+(SACL) JP
ALSO 77 BUDAPEST CONF. HEMINGWAY REVIEW TALK (CERN)
ZANFINO 77 PRL 38 930 +BROCKMAN,DANKOWYCH,+ (CARL+MCGI+OHIO+TNTO)

ABRAMS 79 PRL 43 477 +ALAM,BLOCKER,BOYARSKI,+ (SLAC+LBL)
APEL 79 PL 83 B 131 +AUGENSTEIN,BERTOLUCCI(KARL+PISA+SERP+WIEN)
BINNIE 79 PL 83 B 141 +CARR,DEBENHAM,JONES,KARAMI,KEYNE+ (LOIC)
DZHELYAD 79 PL B 88 379 DZHELYADIN,GOLOVKIN,GRITZUK,KACHANOV+(SERP)

VIKTOROV 80 SJNP 32 520 +GOLOVKIN,DZHELYADIN,ZAITSEV,MUKHIN,+(NOVO)

DZHELYAD 81 PL 105 B 239 DZHELYADIN,GOLOVKIN,KONSTANTINOV,+ (SERP)

BARTEL 82 PL 113 B 190 +CORDS+(DESY+HAMB+HEID+LANC+MCHS+RHEL+TOKY)
BICKERST 82 ZPHY C 16 171 BICKERSTAFF,MCKELLAR (MELB)

BEHREND 83 PL 125 B 518 +D-AGOSTINI+(DESY+KARL+MPIM+LALO+LPNP+SACL)
ALSO 82 PL 114 B 378 BEHREND+ (DESY+KARL+MPIM+LALO+LPNP+SACL)
FRAZER 83 AACHEN CONF. RAPPORTEUR TALK (UCSD)
JENNI 83 PR D 27 1031 +BURKE,TELNOV,ABRAMS,BLOCKER+ (SLAC+LBL)

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S(975) or S^*

3 S(975,JPG=0++) I=0

FORMERLY CALLED S*
UNDER THIS ENTRY WE LIST PARAMETERS OF THE POLE IN THE ISOSCALAR S WAVE. FOR A MINI-REVIEW SEE UNDER EPSILON.

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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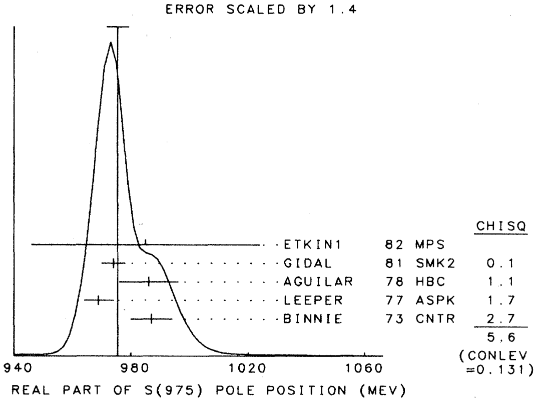
3 MASS OR REAL PART OF THE S(975) POLE POSITION (MEV)

M POLE POSITION DETERMINATIONS

M	R	(997.)	(6.)	PROTOPOPE	73	HBC	PI+ P		12/77
M	A	(997.)		ESTABROOK	73	ASPK	17 PI-P,PI+PI-N		12/75
M	R	(1012.)	(6.)	GRAYER	73	ASPK	17 PI-P,PI+PI-N		12/77
M	R	(1007.)	(20.)	HYAMS	73	ASPK	17 PI-P,N PI+PI-		12/77
M	A	(986.)	(5.)	FUJII	75	RVUE	17 PI-P,PI+PI-N		12/75
M	AD	(998.0)	(7.0)	BOHACIK	80	RVUE			9/81
M	E	(988.)		IRVING	81	RVUE			3/82
M	F	(966.)		IRVING	81	RVUE			3/82
M		987.	7.	BINNIE	73	CNTR	PI- P,MM N		12/77
M		969.0	5.0	LEEPER	77	ASPK	2-2.4 PI-P		12/77
M	C	986.	10.	AGUILAR	78	HBC	.7 PBAR P, KS KS		12/77
M		(986.)		MARTIN	79	RVUE			9/81
M		974.0	4.0	GIDAL	81	SMK2	J/PSI DECAY		1/82
M	G	985.0	39.0	ETKIN1	82	MPS	23 PI-P,2KOS N		9/83*
M		. . . .							
M	AVG	975.4	3.7	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4) (SEE IDEOGRAM BELOW)					

WEIGHTED AVERAGE = 975.4 ± 3.7
ERROR SCALED BY 1.4



M MASS DETERMINATIONS (REAL PART OF MASS MATRIX EIGENVALUE)

M	B	(975.)	ACHASOV	80	RVUE	9/81
M	B	(985.)	TORNQVIST	82	RVUE	1/82

M A FROM SINGLE CHANNEL FIT TO HYAMS 73 DATA.
M B COUPLED CHANNEL ANALYSIS WITH FINITE WIDTH CORRECTIONS,SEE MINIREV.
M D POLE POSITIONS FROM ALMOST MODEL-INDEPENDENT PARAMETRIZATION
M C FROM COUPLED CHANNEL FIT TO HYAMS 73 AND PROTOPOPESCU 73 DATA.
M C WITH A SIMULTANEOUS FIT TO THE PI PI PHASE-SHIFTS,
M C INELASTICITY AND TO THE KS KS INVARIANT MASS.
M E FROM COUPLED CHANNEL ANALYSIS OF PI N --> PI PI N OR K KBAR N DATA
M E FROM GRAYER 73 AND COHEN 80
M F SIMILAR TO (E), BUT OMIT PI N --> PI PI N MOMENTS, AND INCLUDE
M F K- P --> PI+ PI- Y DATA
M R INCLUDED IN AGUILAR 78 FIT
M G ETKIN1 82 QUOTES ERRORS +9/-39 MEV. WE USE +-39 MEV IN THE AVERAGE.

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3 WIDTH OR IMAG. PART OF THE S(975) POLE POSITION (ME

W POLE POSITION DETERMINATIONS (CORRESPONDS TO HALF-WIDTH,NOT FULL WIDTH)

W	R	(27.)	(8.)		PROTOPOPE	73	HBC	7. PI+ P	12/77
W	A	(5.)			ESTABROOK	73	ASPK	17 PI-P,PI+PI-N	12/75
W	R	(16.)	(5.)		GRAYER	73	ASPK	17 PI-P,PI+PI-N	12/77
W	R	(15.)	(5.)		HYAMS	73	ASPK	17 PI-P,N PI+PI-	12/77
W	A	(19.)	(3.)		FUJII	75	RVUE	17 PI-P,PI+PI-N	12/75
W	AD	(19.0)	(6.0)		BOHACIK	80	RVUE		9/81
W	E	(8.)			IRVING	81	RVUE		3/82
W	F	(24.)			IRVING	81	RVUE		3/82
W		24.	7.		BINNIE	73	CNTR	PI- P,MM N	12/77
W		15.0	4.0		LEEPER	77	ASPK	2-2.4 PI-P	12/77
W	C	50.	40.		AGUILAR	78	HBC	.7 PBAR P, KS KS	12/77
W		(7.)			MARTIN	79	RVUE		9/81
W		14.0	5.0		GIDAL	81	SMK2	J/PSI DECAY	1/82
W		60.0	141.0	10.0	ETKIN1	82	MPS	23 PI-P,2KOS N	9/83*
W		. . . .							
W	AVG	16.4	2.8		AVERAGE				

W FULL WIDTH DETERMINATIONS (FROM IMAG PART OF MASS MATRIX EIGENVALUE)

W	B	70 TO 300		ACHASOV	80	RVUE	9/81
W	B	(400.)	APPROX.	TORNQVIST	82	RVUE	1/82

W ACR SEE NOTES UNDER REAL PART
W EF SEE NOTES UNDER REAL PART
W B COUPLED CHANNEL ANALYSIS WITH FINITE WIDTH CORRECTIONS,SEE MINIREV.
W D POLE POSITIONS FROM ALMOST MODEL-INDEPENDENT PARAMETRIZATION

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3 S(975) PARTIAL DECAY MODES

		DECAY MASSES
P1	S(975) INTO K KBAR	498+ 498
P2	S(975) INTO PI PI	140+ 140
P3	S(975) INTO ETA ETA	549+ 549

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3 S(975) BRANCHING RATIOS

R1 S(975) INTO (PI PI)/TOTAL (P2)

R1		(0.71)			HYAMS	75	ASPK	17.2 PI-P,PI+PI-	9/81
R1		0.78	0.03		WETZEL	76	OSPK	8.9 PI-P,KS KS N	9/81
R1		0.81	0.09	0.04	CASON	78	STRC	7. PI- P,KS KS N	9/81
R1		0.67	0.09		LOVERRE	80	HBC	4. PI- P,K K N	9/81
R1		. . . .							
R1	AVG	0.776	0.026		AVERAGE				

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REFERENCES FOR S(975)

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+ (ETH+CERN)
DAHL 67 PR 163 1377 +HARDY+HESS+KIRZ+MILLER (LRL)

ALITTI 68 PRL 21 1705 +BARNES,CRENNELL,FLAMINIO,GOLDBERG,+ (BNL)
LAI 68 PHILAD.CONF.P.303 KWAN WU LAI (BNL)
PHELAN 68 THESIS JAMES J. PHELAN (ANL+ST.LOUIS UNIV)
ALSO 68 PRL 21 316 HOANG,EARTLY,PHELAN,ROBERTS+(ANL+CHIC+NDAM)

AGUILAR- 69 PL 29 B 241 M.AGUILAR-BENITEZ,J.BARLOW,+ (CERN+CDEF)
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 (ETH+CERN)
HYAMS 70 PHILA.CONF.P.41 +KOCH,BEUSCH,+ (CERN+MPIM+ETH+LOIC+HAWA)
ALSO 70 NP B 22 189 HYAMS,KOCH,POTTER,VON LINDERN,+ (CERN+MPIM)
OH 70 PR D 1 2494 +GARFINKEL,MORSE,WALKER,PRENTICE(WISC+TNTO)

ALSTON-G 71 PL 36 B 152 ALSTON-GARNJOST,BARBARO-GALTIERI,+ (LBL)

BASDEVAN 72 PL 41 B 178 BASDEVANT,FROGGATT,PETERSEN (CERN)
DAMERI 72 NC 9 A 1 +BORZATTA,GOUSSU,+ (GENO+MILA+SACL)
DUBOC 72 NP B 46 429 +GOLDBERG,MAKOWSKI,DONALD,+ (LPNP+LIVP)
FLATTE 72 PL 38 B 232 +ALSTON-GARNJOST,BARBARO-GALTIERI,+ (LBL)
GRAYER 72 PHIL.CONF.PROC. 5 +HYAMS,JONES,SCHLEIN,BLUM,DIETL+(CERN+MPIM)
WILLIAMS 72 PR D 6 3178 P.K.WILLIAMS (FSU)

BINNIE 73 PRL 31 1534 +CARR,DEBENHAM,DUANE,GARBUTT,+ (LOIC+SHMP)
DIAMOND 73 PR D 7 1977 +BINKLEY,+ (WISC+DUKE+COLO+TNTO+OHIO)
ESTABROO 73 TALLAHASSEE ESTABROOKS,MARTIN,GRAYER,HYAMS+ (CERN+MPIM)
FUJII 73 NC 13 A 311 Y.FUJII,M.KATO (TOKYO)
GRAYER 73 TALLAHASSEE +HYAMS,JONES,BLUM,DIETL,KOCH+ (CERN+MPIM)
HYAMS 73 NP B 64 134 +JONES,WEILHAMMER,BLUM,DIETL,+ (CERN+MPIM)
OCHS 73 THESIS W.OCHS (MPIM)
PROTOPOP 73 PR D 7 1280 PROTOPOPESCU,GARNJOST,GALTIERI,FLATTE+(LBL)

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GRAYER    74 NP B 75 189           +HYAMS,JONES,BLUM,DIETL,KOCH+   (CERN+MPIM)
GRAYER    74 NP B 76 375           +HYAMS,JONES,BLUM,DIETL         (CERN+MPIM)
MORGAN    74 PL 51B 71             D.MORGAN                             (RHEL)

FUJII     75 NP B85 179            Y.FUJII,M.FUKUGITA                   (TOKY)
HYAMS     75 NP B 100 205          +JONES,WEILHAMMER,BLUM,DIETL+   (CERN+MPIM)
MORGAN    75 ARGONNE CONF. 45      D. MORGAN                            (RHEL)
PAWLICKI  75 PR D12 631            +AYRES,DIEBOLD,GREENE,KRAMER,WICKLUND (ANL)

BRANDEB   76 NP B 104 413          +CARNEGIE,CASHMORE,DAVIER,LASINSKI,+ (SLAC)
BUTTRAM   76 PR D 13 1153          +CRAWLEY,DUKE,LAMB,LEEPER,PETERSON    (ISU)
CERRADA   76 PL 62 B 353           +GONZALEZ-ARROYO,RUBIO,YNDURAIN (CERN+MADR)
FLATTE    76 PL 63 B 228           S.M.FLATTE                           (CERN)
WETZEL    76 NP B 115 208          +FREUDENREICH,BEUSCH,+       (ETH+CERN+LOIC)
WILKINS   76 PR D 13 1831          +ALBRIGHT,S+V HAGOPIAN,LANNUTTI       (FSU)

FROGATT   77 NP B 129 89           +PETERSEN             (GLASGOW+COPENHAGEN)
LEEPER    77 PR D 16 2054          +BUTTRAM,CRAWLEY,DUKE,LAMB,PETERSON   (ISU)
MARTIN    77 NP B 121 514          +OZMUTLU,SQUIRES                   (DURHAM)
PAWLICKI  77 PR D 15 3196          +AYRES,COHEN,DIEBOLD,KRAMER,WICKLUND  (ANL)I J

AGUILAR   78 NP B 140 73           +CERRADA,+         (MADRID+BOMBAY+CERN+PARIS)
BALAND    78 NP B 140 220          +GRARD,JOHNSON,+ (MONS+BELG+CERN+LOIC+LALO)
CASON     78 PRL 41 271            +BAUMBAUGH,BISHOP,BISWAS,KENNEY,+(NDAM+ANL)

ACHASOV   79 PL 88 B 367           +DEVYANIN,SHESTAKOV                  (NOVO)
APEL      79 NP B 160 42           +AUSLANDER,MULLER,REHAK+        (KARL+PISA)
BECKER    79 NP B 151  46          +BLANAR,BLUM,CERRADA+ (MPIM+CERN+ZEEM+CRAC)
CORDEN    79 NP B 157 250          +DOWELL,GARVEY,JOBES,+(BIRM+RHEL+TELA+LOWC)  JP
ESTABROO  79 PR D 19 2678          P.ESTABROOKS                         (CARL)
GREENHUT  79 PR D 20 2326          +INTEMANN                            (SETO)
MARTIN    79 NP B 158 520          +OZMUTLU                             (DURH)I,JP
POLYCHRO  79 PR D 19 1317          POLYCHRONAKOS,CASON,BISHOP+      (NDAM+ANL)

ACHASOV   80 SJNP 32 566           +DEVYANIN,SHESTAKOV                  (NOVO)
BOHACIK   80 PR D 21 1342          J.BOHACIK,H.KUHNELT        (BRATISLAVA+WIEN)
COHEN     80 PR D 22 2595          +AYRES,DIEBOLD,KRAMER,PAWLICKI+      (ANL)I,JP
LOVERRE   80 ZPHY C 6 187          +ARMENTEROS,DIONISI+  (CERN+CDEF+MADR+STOH)I,JP
WICKLUND  80 PRL 45 1469           +AYRES,COHEN,DIEBOLD,PAWLICKI         (ANL)

ACHASOV   81 PL 102 B 196          +DEVYANIN,SHESTAKOV                  (NOVO)
AGUILAR   81 ZPHY C 10 299         AGUILAR-BENITEZ,DONE,MARTIN     (MADR+DURH)
GIDAL     81 PL 107 B 153          +GOLDHABER,GUY,MILLIKAN,ABRAMS,+ (SLAC+LBL)
IRVING    81 ZPHY C 10 45          +MARTIN,DONE                    (LIVP+DURH)
ROUSSARI  81 PL 105 B 304          ROUSSARIE,BURKE,ABRAMS,ALAM,+    (SLAC+LBL)

BARBER    82 ZPHY C 12 1           +DAINTON,BRODBECK,BROOKES,+(DARE+LANC+SHEF)
ETKIN1    82 PR D 25 1786          +FOLEY,LAI,LINDENBAUM+ (BNL+CUNY+TUFT+VAND)
ETKIN2    82 PR D 25 2446          +FOLEY,LAI,LINDENBAUM+ (BNL+CUNY+TUFT+VAND)
TORNQVIS  82 PRL 49 624            N.A.TORNQVIST                        (HELS)

MENNESSI  83 ZPHY C 16 241         G.MENNESSIER                         (MONP)
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δ(980)

36 DELTA(980,JPG=0+-) I=1

The quantum numbers of the δ(980) resonance are: $I^G = 1^-$, deduced from its production in $D^0 \rightarrow \delta\pi$, from its $\eta\pi$ decay, and from the absence of a $\pi\pi$ decay; and $J^P = 0^+$, deduced from the absence of a 3π or $\rho\pi$ decay (LIPKIN 69, GRASSLER 77) and from the decay distributions of the $\eta\pi$ decay. With these quantum numbers, the δ(980) is expected to couple to the I = 1 $K\overline{K}$ system, too, and to explain the nearby $K\overline{K}$ threshold enhancement (ASTIER 67).

The SU(3) and quark-model classification of the δ(980) has been somewhat controversial. The naive quark model would suggest that the lightest 0^{++} states should belong to a 1P $q\overline{q}$ nonet. This conclusion is also supported by models with very general spin-dependent terms (SCHNITZER 82). The unconventional mass spectrum, in particular the near-degeneracy of δ(980) and S(975), has on the other hand led to suggestions for a 4-quark assignment of the δ(980) (JAFFE 79). A 4-quark assignment would predict a very large ("superallowed") coupling to $\eta\pi$ and $K\overline{K}$ (ACHASOV 79,80). A comparatively large coupling is not incompatible with a narrow δ peak width (FLATTE 76), since the $K\overline{K}$ threshold distorts drastically the δ(980) shape.

However, a $q\overline{q}$ interpretation also requires by SU(3) a large $\delta\eta\pi$ coupling, and it has been shown (TORNQVIST 82) that it is possible to understand within the unitarized quark model the unconventional features of the lightest scalar mesons. In this framework, the mass shifts, mixings, and distortions of resonance shapes induced by the nearest SU(3)-related thresholds are crucial for the light 0^{++} states. Thus the δ(980) mass is shifted considerably by the nearby $\pi\eta$, $K\overline{K}$, and $\pi\eta'$ thresholds, whereas, e.g., the κ(1350) is shifted much less by $K\pi$ and $K\eta'$, which lie relatively far from the resonance mass. Possible weaknesses of this approach have been discussed (ACHASOV 83).

A conventional $q\overline{q}$ assignment is also favored by the D(1285)/E(1420) $\rightarrow \rho\pi$ branching ratio, the decay $\eta' \rightarrow \delta\pi \rightarrow \eta\pi\pi$, and the tadpole contributions to e.m. mass differences and mixings (BRAMON 80,83), although some of these arguments might turn out to be inadequate (ACHASOV 83). Thus it seems plausible (TORNQVIST 82,83) that the δ(980) is a $q\overline{q}$ state with large Fock-space components of $q\overline{q}q\overline{q}$ in the form of virtual $\eta\pi$, $K\overline{K}$, and $\eta'\pi$ pairs. See also the mini-reviews under ϵ(1300) and κ(1350).

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                    36  DELTA(980) MASS  (MEV)

M  ETA PI FINAL STATE ONLY.
M       10 (960.)     APPROX.          CHUNG S    68 HBC   -  3.2 PI-P          5/70
M       80 (975.0)                     DEFOIX     68 HBC  +-  1.2 PB P,ETA PI  11/77
M       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 D0 PI    11/77
M
M       30  980.0     10.0             AMMAR      68 HBC  +-     ,5.5K-,ETA PI  2/73
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      150  972.      10.              DEFOIX     72 HBC  +- 0.7 PBAR P,7 PI    1/73
M  C    70  989.0     10.0             WELLS      75 HBC   - 3.1-6 K-P,ETA PI  11/77
M       80  981.0      6.0             GAY        76 HBC   - 4.2 K-P,ETA PI    11/77
M           977.0      7.0             GRASSLER   77 HBC   - 16 PI-+P,ETA PI   11/77
M       47  980.      11.              CONFORTO   78 OSPK -  4.5 PI-P,P X-      4/78
M       50  978.0     16.0             CORDEN     78 OMEG +- 12-15PI-P,ETA PI   4/78
M     R 145 990.0      7.0             GURTU      79 HBC  +- 4.2 K- P,ETA PI   12/79
M     R 500 986.       3.              EVANGELIS 81 OMEG     12 PI-P,ETA3PIP    1/82
M
M   REVUE ARTICLES
M   B       (982.)                     ACHASOV1   80 RVUE                       9/81
M           (970.)                     TORNQVIST  82 RVUE                       8/83*
M           . . . . . . . . .
M   AVG     983.4      2.1     AVERAGE

M  C    SYSTEMATIC ERROR 6 MEV DUE TO ENERGY CALIBRATION ADDED
M   B   COUPLED CHANNEL ANALYSIS WITH FINITE WIDTH CORRECTIONS,SEE MINIREV.
M    R  FROM D(1285) DECAY

M  K KBAR ONLY, SEE THE TYPED NOTE ABOVE
M      143(1003.3)     7.0+SYSTEMATIC ROSENFELD 65 RVUE +-                      8/66
M  A   100(1016.)    (10.)             ASTIER     67 HBC  +-  0 PBAR P         12/77
M      316  976.       6.              DE BILLY   80 HBC  +- 1.2-2 PB P,D OMG   6/81
M  A    ASTIER 67 INCLUDES DATA OF BARLOW 67,CONFORTO 67,ARMENTEROS 65.
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                    36  DELTA(980) WIDTH  (MEV)

W  ETA PI  FINAL STATE ONLY
W       80  (25.0)                     DEFOIX     68 HBC  +-  1.2 PB P,ETA PI  11/77
W       20  (50.0)  OR LESS            BARNES     69 HBC   -  4-5 K-P,PI-ETA   11/77
W      150  (30.)     (5.)             DEFOIX     72 HBC  +- 0.7 PBAR P,7 PI    2/74
W       70  (16.0)   (25.0)   (16.0)   WELLS      75 HBC   - 3.1-6 K-P,ETA PI

W       30   80.0     30.0             AMMAR      68 HBC  +-     ,5.5K-,ETA PI  2/73
W            40.      15.              CAMPBELL   69 DBC  +- 2.7 PI+ D          1/73
W       15   60.0     30.0             MILLER     69 HBC   -  4.5 K-N,ETA PI    2/74
W       21   31.0     28.0             BARDADIN   71 HBC  +- 8 PI+P,P D0 PI     2/74
W    N       55.0     15.0             GAY        76 HBC   - 4.2 K-P  ETA PI   11/77
W            44.0     22.0             GRASSLER   77 HBC   - 16 PI-+P,ETA PI   11/77
W       47   60.      50.      30.     CONFORTO   78 OSPK -  4.5 PI-P,P X-      4/78
W    D  50   86.0     60.0     50.0    CORDEN     78 OMEG +- 12-15PI-P,ETA PI   4/78
W    R 145   60.0     20.0             GURTU      79 HBC  +- 4.2 K- P,ETA PI   12/79
W    R 500   62.      15.              EVANGELIS 81 OMEG     12 PI-P,ETA3PIP    1/82
W
W   REVUE ARTICLES
W    F       80 TO 300                 FLATTE     76 RVUE -  4.2 K-P,ETA PI    11/77
W    B      103 TO 262                 ACHASOV1   80 RVUE                       9/81
W    B     (500.)  APPROX.             TORNQVIST  82 RVUE                       1/82
W           . . . . . . . . .
W   AVG      53.7      6.7     AVERAGE
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Mesons

Data Card Listings

δ(980), φ(1020)

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W    B  COUPLED CHANNEL ANALYSIS WITH FINITE WIDTH CORRECTIONS,SEE MINIREV.
W   F   USING A TWO CHANNEL RESONANCE PARAMETRIZATION OF GAY 76 DATA.
W    N  THE ERROR IN THE PAPER IS WRONGLY QUOTED AT ONE POINT
W    R  FROM D(1285) DECAY

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
W   M      (120.) APPROX.             MORGAN    75 RVUE    1.2 PBAR P       12/75

W  A    ASTIER 67 INCLUDES DATA OF BARLOW 67,CONFORTO 67,ARMENTEROS 65.
W   M   FROM COUPLED CHANNEL FIT TO DUBOC 72 DATA
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36 DELTA(980) PARTIAL DECAY MODES

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                                                     DECAY MASSES
P1     DELTA(980)   INTO ETA PI                     549+ 135
P2     DELTA(980)   INTO RHO PI                     769+ 135
P3     DELTA(980)   INTO K KBAR                     498+ 498
P4     DELTA(980)   INTO PI ETA PRIME               140+ 958
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36 DELTA(980) BRANCHING RATIOS

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R1     DELTA(980)   INTO (RHO PI)/(ETA PI)                 (P2)/(P1)
R1           (0.25) OR LESS  CL=.70   AMMAR     70 HBC  +- 4.1,5.5K-,ETA PI  5/70

R2     DELTA(980)   INTO (K KBAR)/(ETA PI)                 (P3)/(P1)
R2  L        (0.25)   (0.08)          DEFOIX    72 HBC  +-  0.7 PBAR P     11/77
R2          SEEN                      GAY       76 HBC   - 4.2 K-P  ETA PI 11/77
R2   L       (0.7)    (0.3)           CORDEN    78 OMEG    12-15PI-P        4/78
R2  B        (0.75)TO 4.2             ACHASOV1  80 RVUE                     9/81
R2  B   COUPLED CHANNEL ANALYSIS WITH FINITE WIDTH CORRECTIONS,SEE MINIREV.
R2  L   FROM THE DECAY OF D(1285).
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REFERENCES FOR DELTA(980)

TURKOT   63 SIENNA CONF 1 661 +COLLINS,FUJII,KEMP+   (BNL+PITTSBURGH)

ARMENTER 65 PL 17 344   ARMENTEROS,EDWARDS, JACOBSEN + (CERN+CDEF)
BARASH   65 PR 139 B 1659   +FRANZINI,KIRSCH,MILLER,STEINBERGER+ (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)
LIPKIN   69 PRL 22 212   +MESHKOV   (REHO+NBS) JP
MILLER   69 PL 29 B 255   D.H.MILLER,S.L.KRAMER,D.D.CARMONY,+(PURDUE)
    ALSO 69 PR 188 2011   YEN,AMMANN,CARMONY,ELSNER,+   (PURDUE)
SCHROEDE 69 PR 188 2081   SCHROEDER,KERNAN,FISHER,LIBBY,+ (ISU+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)

BINNIE   72 PL 39 B 275   +CAMILLERI,DUANE,GARBUTT,BURTON+(LOIC+SHMP)
CHESHIRE 72 PRL 28 520   +HOFFMAN,GARFINKEL,+   (IOWA+ANL+PURD)
DEFOIX   72 NP B 44 125   +NASCIMENTO,BIZZARRI,+   (CDEF+CERN)
DUBOC   72 NP B 46 429   +GOLDBERG,MAKOWSKI,DONALD,+   (LPNP+LIVP)
HOLLOWAY 72 PHIL.CONF.PROC.133+HULD,KOETZ,KRUSE,BERNSTEIN,+   (ILL+ILLC)

ATHERTON 73 PL 43 B 249   +FRANEK,FRENCH,GHIDINI,HILPERT,+   (CERN)

BINNIE   74 PRL 32 392   +CAMILLERI,CARR,DEBENHAM,+   (LOIC+SHMP)
KALBFLEI 74 NP B69 279   KALBFLEISCH,VANDERBURG,+   (BNL+RUTG+IND)
MORGAN   74 PL 51B 71   D.MORGAN   (RHEL)

BUTTRAM 75 PRL 35 970   +CRAWLEY,DUKE,LAMB,LEEPER,PETERSON   (ISU)
MORGAN   75 ARGONNE CONF. 45 D.MORGAN   (RHEL)
WELLS   75 NP B 101 333   +RADOJICIC,ROSCOE,LYONS   (OXF)

GAY   76 PL 63 B 220   +CHALOUPKA,BLOKZIJL,HEINEN+(CERN+AMST+NIJM) JP
FLATTE   76 PL 63 B 224   S.M.FLATTE   (CERN)

GRASSLER 77 NP B 121 189   +   (AACH+BERL+BONN+CERN+CRAC+HEID+WARS)
IRVING   77 PL 70 B 217   A.C.IRVING   (LIVERPOOL)
MARTIN   77 NP B 121 514   +OZMUTLU,SQUIRES   (DURHAM)
MAY   77 PR D 16 1983   +ABRAMSON,ANDREWS,BUSNELLO,+   (ROCH+CORN)

CONFORTO 78 LNC 23 419   B+G CONFORTO,KEY+(RHEL+TNTO+CHIC+FNAL+WISC)
CORDEN   78 NP B 144 253   +CORBETT,ALEXANDER,+ (BIRM+RHEL+TELA+LOWC)
MARTIN   78 ANP 114 1   A.D.MARTIN,M.R.PENNINGTON   (CERN)

ACHASOV 79 PL 88 B 367   +DEVYANIN,SHESTAKOV   (NOVO)
ESTABROO 79 PR D 19 2678   P.ESTABROOKS   (CARL)
GURTU   79 NP B 151 181   +GAVILLET,BLOKZIJL,+   (CERN+ZEEM+NIJM+OXF)
MARTIN   79 NP B 158 520   +OZMUTLU   (DURH)

ACHASOV1 80 SJNP 32 566   +DEVYANIN,SHESTAKOV   (NOVO)
ACHASOV2 80 PL 96 B 168   +DEVYANIN,SHESTAKOV   (NOVO)
BRAMON   80 PL 93 B 65   +MASSO   (BARC)
DE BILLY 80 NP B 176 1   +BRIAND,DUBOC,LEVY+   (CURI+LAUS+NEUC+GLAS)

EVANGELI 81 NP B 178 197   EVANGELISTA+(BARI+BONN+CERN+DARE+LIVP+MILA)

ACHASOV 82 TP-20-130   +DEVYANIN,SHESTAKOV   (NOVO)
BICKERST 82 ZPHY C 16 171   BICKERSTAFF,MCKELLAR   (MELB)
TORNQVIS 82 PRL 49 624   N.A.TORNQVIST   (HELS)

BRAMON   83 PL 120 B 240   +MASSO   (BARC)

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φ(1020)

4 PHI(1020,JPG=1--) I=0

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4 PHI MASS (MEV)

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M                  WE ONLY AVERAGE MASS AND WIDTH VALUES WHEN THE
M                  SYSTEMATIC ERRORS HAVE BEEN EVALUATED.

M      410 1019.9      0.3            STOTTLEMY 71 HBC    2.9 K-P,Y K KBAR 11/71
M    D 120 1019.6      0.5            AGUILAR   72 HBC    3.9,4.6 K- P     12/75
M    D 100 1019.9      0.5            AGUILAR   72 HBC    3.9,4.6 K- P     12/75
M      131 1020.4      0.5            COLLEY    72 HBC    10.K+ P,K+ P PHI 12/72
M      100 1020.3      0.4            BALLAM    73 HBC    2.8 - 9.3 G P     1/74
M          1019.4      0.7            BINNIE    73 CNTR   PI-P,PHI N        4/78
M   AR 500(1019.5)    (0.6)           AYRES     74 ASPK   3-6PI/K-P,K+K-   12/77
M      984 1019.4      0.8            BESCH     74 CNTR   2 GAMMA P,PK+K-  12/75
M   AR 170(1020.3)    (0.4)           DE GROOT  74 HBC    4.2 K-P,L K+K-   12/77
M      454 1019.7      0.5            KALBFLEIS 76 HBC    2.18 K-P,K KBAR   7/77
M   AR1300(1019.7)    (0.2)           AKERLOF   77 SPEC   400 P+A,K+K-     12/77
M   AR 905(1020.4)    (0.3)           BALDI     77 CNTR   10 K-P,K-PHI P   12/77
M   A  383(1020.0)    (1.0)           BALDI     77 CNTR   10 PI-P,PI-PHI P 12/77
M   AR2504(1020.0)    (0.2)           BALDI     77 CNTR   10 K+P,K+PHI P   12/77
M   AR 721(1022.0)    (1.0)           BALDI     77 CNTR   10 P P,P PHI P   12/77
M      800 1018.9      0.6            COHEN     77 ASPK   6 PI- PN,K+K-PN  12/77
M          1019.52     0.13           BUKIN 1   78 OLYA   E+E- COLL.BEAMS   9/81
M      337 1019.4      0.5            COOPER    78 HBC    .7-.8 PB P,KS K0  4/78
M     1100 1019.54     0.12           BARKOV    79 EMUL   E+E- COLL.BEAMS   3/82
M   R 6730(1019.7)    (0.1)           DAUM      81 SPEC   P BE,K+ K- X      9/81
M  C   766 1019.8      0.7            IVANOV    81 OLYA   1-1.4 E+E-,K+K-   1/82
M     1500 1019.3      0.1            ARENTON   82 AEMS   11.8 POL.P P,KK   9/83*
M    25080 1019.67     0.17           PELLINEN  82 RVUE                     1/82
M   A     (1021.0)    (0.2)           ARMSTRONG 83 OMEG   18.5 K-P,K-K+LAM 12/83*
M   A     (1020.0)    (0.5)           ARMSTRONG 83 OMEG   18.5 K-P,K-K+LAM 12/83*
M   A     (1019.7)    (0.3)           BARATE    83 GOLI   190 PI-BE,2MU     9/83*
M          . . . . . . . . . .
M   AVG    1019.513    0.069   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
                       (SEE IDEOGRAM BELOW)

M   A   SYSTEMATIC ERRORS NOT EVALUATED.
M  C    SYSTEMATIC ERROR ADDED LINEARLY BY US.
M    D  MASS ERRORS ENLARGED BY US TO WIDTH/SQRT(N),SEE K* TYPED NOTE
M    R  INCLUDED IN PELLINEN 82 RVUE
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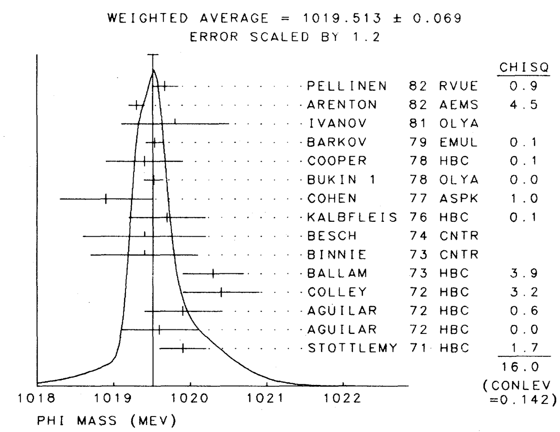

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4 PHI WIDTH (MEV)

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W                  WE ONLY AVERAGE MASS AND WIDTH VALUES WHEN THE
W                  SYSTEMATIC ERORRS HAVE BEEN EVALUATED.

W    D 150     4.2      1.4           AUGUSTIN  69 OSPK   E+ E- COLL.BEAMS 12/72
W              4.09     0.29          BIZOT     70 OSPK   E+ E- COLL.BEAMS 12/72
W    D 681     4.67     0.72          BALAKIN   71 OSPK    E+ E- COLL.BEAM 12/75
W    D 120     4.6      1.7           AGUILAR   72 HBC    3.9,4.6 K- P     12/75
W    D 100     4.7      1.9           AGUILAR   72 HBC    3.9,4.6 K- P     12/75
W    D 131     5.0      1.8           COLLEY    72 HBC    10.K+ P,K+ P PHI 12/75
W    D 454     3.8      0.7           BORENSTEI 72 HBC    2.18 K-P,K KBAR   7/77
W    D 100     3.8      1.5           BALLAM    73 HBC    2.8 - 9.3 G P    12/75
W              4.5      1.1           BINNIE    73 CNTR   PI-P,PHI N        4/78
W   AD 500    (4.5)    (0.8)          AYRES     74 ASPK   3-6PI/K-P,K+K-   12/75
W    D 984     4.4      0.6           BESCH     74 CNTR   2 GAMMA P,PK+K-  12/75
W              3.81     0.37          COSME 2   74 OSPK   E+E- COLL.BEAMS   2/74
W   AD 170    (4.2)    (1.3)          DE GROOT  74 HBC    4.2 K-P,L K+K-   12/75
W  A D1300     4.5      0.50          AKERLOF   77 SPEC   400 P+A,K+K-     12/77
W  B D3681     4.36     0.29          BUKIN 1   78 OLYA   E+E- COLL.BEAMS   9/81
W    D 337     3.6      0.8           COOPER    78 HBC    .7-.8 PB P,KS K0  4/78
W    D1100     4.58     0.55          BARKOV    79 EMUL   E+E- COLL.BEAMS   3/82
W    D         4.3      0.6           CORDIER   80 WIRE   E+E-,PI+PI-PI0    9/81
W    D 766     4.2      0.6           IVANOV    81 OLYA   1-1.4 E+E-,K+K-   1/82
W     1500     4.5      0.7           ARENTON   82 AEMS   11.8 POL.P P,KK   9/83*
W          . . . . . . . . . .
W   AVG        4.22     0.13    AVERAGE

W   A   SYSTEMATIC ERRORS NOT EVALUATED.
W  B    NUMBER OF EVENTS INCLUDES A SMALL BACKGROUND CONTRIBUTION.
W    D  WIDTH ERRORS ENLARGED BY US TO 4*WIDTH/SQRT(N), SEE K* TYPED NOTE
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For notation, see key at front of Listings.

Mesons
$\phi(1020)$

4 PHI PARTIAL DECAY MODES

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                                                       DECAY MASSES
P1    PHI INTO K+ K-                                   494+ 494
P2    PHI INTO KL KS                                   498+ 498
P3    PHI INTO PI+ PI- PIO (INCLUDING RHO PI)          140+ 140+ 135
P4    PHI INTO ETA GAMMA                               549+   0
P5    PHI INTO E+ E-                                   .511+.511
P6    PHI INTO MU+ MU-                                 106+ 106
P7    PHI INTO PIO GAMMA                               135+   0
P8    PHI INTO PI+ PI- (VIOLATES G)                    140+ 140
P9    PHI INTO PI+PI-GAMMA                             140+ 140+   0
P10   PHI INTO OMEGA GAMMA (VIOLATES C)                783+   0
P11   PHI INTO ETA PIO (VIOLATES C)                    549+ 135
P12   PHI INTO RHO GAMMA (VIOLATES C)                  769+   0
P13   PHI INTO ETA NEUTRALS
P14   PHI INTO 5PI                                     140+ 140+ 140+ 140+
P15   PHI INTO PI+ PI- PI+ PI- (VIOLATES G)            140+ 140+ 140+ 140
P16   PHI INTO RHO PI                                  769+ 140
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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 .4928+-.0102
P 2   -.7182    .3475+-.0099
P 3   -.3905      -.3328    .1479+-.0073
P 4   -.1109      -.0800      -.0117    .0117+-.0020

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4 PHI BRANCHING RATIOS

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R1       PHI INTO (K+ K-)/(K KBAR + PI+ PI- PIO)          (P1)/(P1+P2+P3)
R1      252   0.48     0.04       LINDSEY    66 HBC      2.7 K-P         10/66
R1            0.540    0.034      BALAKIN    71 OSPK     E+ E- COLL.BEAM 11/71
R1            0.486    0.044      CHATELUS   71 OSPK   E+ E- COLL.BEAMS 11/71
R1      270   0.49     0.06       DE GROOT   74 HBC    4.2 K-P,L PHI    12/75
R1      321   0.45     0.05       KALBFLEIS  76 HBC      2.18 K-P         7/77
R1
R1  AVG       0.497    0.019   AVERAGE
R1  FIT       0.499    0.010   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)

R2       PHI INTO (KL KS)/(K KBAR + PI+ PI- PIO)          (P2)/(P1+P2+P3)
R2      167   0.40     0.04       LINDSEY    66 HBC      2.7 K-P         10/66
R2            0.257    0.038      BALAKIN    71 OSPK   E+ E- COLL.BEAMS  1/73
R2      133   0.27     0.03       KALBFLEIS  76 HBC    2.18 K-P           7/77
R2  A   270  (0.37)   (0.05)      DE GROOT   74 HBC    4.2 K-P,L PHI    12/77
R2  A   SUPERSEDED BY LOSTY 78 UNDER R19.
R2
R2  AVG       0.300    0.042   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.1)
R2  FIT       0.352    0.010   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)
                               (SEE IDEOGRAM BELOW)
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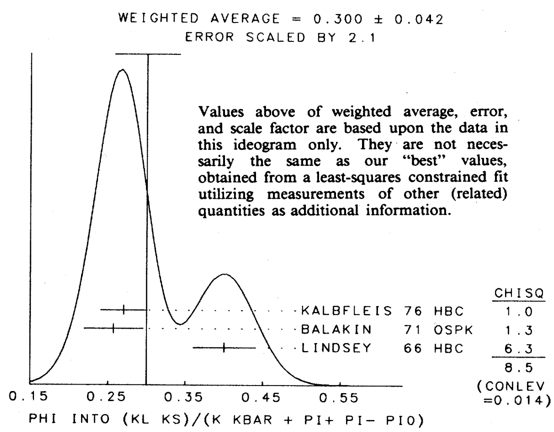


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R3       PHI INTO (PI+ PI- PIO (INCL.RHO PI))/TOTAL       (P3)
R3 E          0.139    0.007      PARROUR2   76 OSPK   E+E- COLL.BEAMS    7/77
R3 E     USING TOTAL WIDTH 4.1 MEV. THE 3 PI MODE IS MORE THAN 80 PER CENT
R3 E     RHO PI AT THE 90 PER CENT C.L.
R3
R3  FIT       0.1479   0.0073  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

R5       PHI INTO (KL KS)/(K KBAR)                        (P2)/(P1+P2)
R5       10   0.40     0.10       SCHLEIN    63 HBC      2.0 K-P         10/66
R5       52   0.48     0.07       BADIER     65 HBC      3.0 K-P         11/67
R5            0.44     0.07       LONDON     66 HBC      2.2 K-P         10/66
R5
R5  AVG       0.448    0.044   AVERAGE
R5  FIT       0.414    0.011   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)

R6       PHI INTO (PI+ PI- PIO (INCL.RHO PI))/(K KBAR)    (P3)/(P1+P2)
R6            0.30     0.15       LONDON     66 HBC      2.2 K-P         10/66
R6            0.237    0.039      CERRADA    77 HBC    4.2 K-P,LAM 3PI   12/77
R6
R6  AVG       0.241    0.038   AVERAGE
R6  FIT       0.176    0.010   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

R7       PHI INTO (PI+ PI- PIO (INCL.RHO PI))/(KL KS)     (P3)/(P2)
R7            0.47     0.06       COSME 1    74 OSPK    E+E- COLL.BEAMS   2/74
R7            0.56     0.13       BUKIN 1    78 OLYA    E+ E- COLL.BEAMS  9/81
R7
R7  AVG       0.486    0.054   AVERAGE
R7  FIT       0.426    0.028   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)

R10      PHI INTO (MU+ MU-)/TOTAL (UNITS 10**-4)          (P6)
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       2.48     0.34    AVERAGE

R11      PHI INTO (ETA GAMMA)/TOTAL                       (P4)
R11A     25   0.026    0.007      BENAKSAS   72 OSPK   E+E- COLL.BEAMS    2/73
R11A     54   0.015    0.004      COSME      76 OSPK   E+E- COLL.BEAMS   12/75
R11B         (0.024)OR LESS  CL=0.95  COSME  76 OSPK   E+E- COLL.BEAMS    7/77
R11           0.0135   0.0029     ANDREWS    77 CNTR   6.7-10 GAMMA CU   12/77
R11     290   0.0088   0.0020     KURDADZE   83 OLYA     E+E-,3 GAMMA     1/84*
R11
R11 AVG       0.0117   0.0023  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)
R11 FIT       0.0117   0.0020  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.4)

R11A     FROM 2 GAMMA    DECAY MODE OF ETA                                7/77
R11B     FROM PI+PI-PIO DECAY MODE OF ETA                                 7/77

R12      PHI INTO (PI+ PI- GAMMA)/TOTAL                   (P9)
R12          (0.04) OR LESS           LINDSEY    65 HBC      2.7 K-P          2/74
R12          (0.007)OR LESS  CL=.90   COSME 1    74 OSPK   E+E- COLL.BEAMS    2/74
R12          (.06) OR LESS   CL=.90   KALBFLEI   75 HBC    2.2 K- P,GAMMA +  12/75

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           2.81     0.25       BALAKIN    71 OSPK   E+ E- COLL.BEAMS 11/71
R16           3.50     0.27       CHATELUS   71 OSPK   E+ E- COLL.BEAMS 11/71
R16           3.3      0.3        COSME 1    74 OSPK   E+ E- COLL.BEAMS  2/74
R16  E        3.10     0.14       PARROUR1   76 OSPK   E+ E- COLL.BEAMS  7/77
R16           3.00     0.21       BUKIN 1    78 OLYA   E+ E- COLL.BEAMS  9/81
R16
R16 AVG       3.107    0.096   AVERAGE

R16  E   USING TOTAL WIDTH 4.2 MEV. THEY DETECT 3 PI MODE AND OBSERVE
R16  E   SIGNIFICANT INTERFERENCE WITH OMEGA TAIL. THIS IS ACCOUNTED FOR
R16  E   IN THE RESULT QUOTED ABOVE

R17      PHI INTO (PIO GAMMA)/(TOTAL)                     (P7)
R17       7  (0.0025) (0.0012)        BENAKSAS   72 OSPK    E+E- COLL. BEAMS  2/73
R17      32   0.0014   0.0005         COSME      76 OSPK    E+ E- COLL.BEAMS 12/77

R18      PHI INTO (PI+ PI-)/(TOTAL) (UNITS 10**-4)        (P8)
R18          (2.7)  OR LESS  CL=.95   ALVENSLE   72 OSPK    GAMMA+C           1/72
R18          (4.0)  OR LESS  CL=.95   JULLIAN    76 OSPK    E+ E- COLL.BEAMS  9/81
R18          (6.6)  OR LESS  CL=.95   BUKIN 2    78 OLYA    E+ E- COLL.BEAMS  9/81
R18A          1.94     1.03     0.81  VASSERMAN  81 OLYA    E+ E- COLL.BEAMS  9/81
R18A     USING PHI INTO (E+ E-)/TOTAL = 3.1

R19      PHI INTO (KL KS)/(K+ K-)                         (P2)/(P1)
R19     144   0.89     0.10       AGUILAR    72 HBC      3.9,4.6 K- P     12/72
R19     125  (1.15)   (0.15)      COLLEY     72 HBC      10.K+ P,K+ P PHI 12/72
R19           0.71     0.05       LAVEN      77 HBC      10 K-P,K+K-LAMBD 12/77
R19           0.71     0.08       LYONS      77 HBC      3-4 K-P,LAMB PHI 12/77
R19           0.70     0.05       BUKIN 1    78 OLYA     E+ E- COLL.BEAMS  9/81
R19           0.82     0.08       LOSTY      78 HBC      4.2 K-P,PHI HYP   4/78
R19
R19 AVG       0.736    0.030   AVERAGE
R19 FIT       0.705    0.032   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)

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       0.300    0.018   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

R21      PHI INTO (2PI+ 2PI- PIO)/(K+ K-)                 (P14)/(P1)
R21          (0.02) OR LESS  CL=0.95  AGUILAR    72 HBC      3.9,4.6 K- P     12/72

R22      PHI INTO (PI+ PI- PI+ PI-)/TOTAL (UNITS 10**-4)  (P15)
R22          (8.7)  OR LESS  CL=.90   CORDIER    79 WIRE     E+ E-,4PI        12/79

R23      PHI INTO (RHO PI)/(PI+ PI- PIO)                  (P16)/(P3)
R23          (0.8)  OR MORE  CL=.90   JULLIAN    76 OSPK     E+ E- COLL.BEAM

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REFERENCES FOR PHI


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BERTANZA 62 PRL 9 180          BERTANZA,BRISSON,CONNOLLY,HART + (BNL+SYRA)

ARMENTER 63 SIENA CONF 2 70    ARMENTEROS,EDWARDS,ASTIER+       (CERN+CDEF)
GELFAND  63 PRL 11 438         GELFAND,MILLER,NUSSBAUM,KIRSCH+  (COLU+RUTG)
SCHLEIN  63 PRL 10 368         SCHLEIN,SLATER,SMITH,STORK,TICHO      (UCLA)

BADIER   65 PL 17 337          BADIER,DEMOULIN,BARLOUTAUD+      (SACL+AMST)
BERLEY   65 PR 139 B 1097      D BERLEY,N GELFAND            (BNL+COLUMBIA)
GALTIERI 65 PRL 14 279         A BARBARO GALTIERI,R D TRIPP           (LRL)
LINDSEY  65 PRL 15 221         JAMES S LINDSEY,GERALD A SMITH         (LRL)
  LINDSEY 65 DATA INCLUDED IN LINDSEY 66 BELOW
MILLER D 65 CU-237(NEVIS 131)  DAVID C MILLER  (THESIS)          (COLUMBIA)

GRAY, L  66 PRL  17  501       +HAGERTY,BIZZARRI,CIAPETTI +    (SYRA+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)
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)
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Mesons

ϕ(1020), H(1190), B(1235)


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AUGUSTIN 69 PL 28 B 517          +BIZOT,BUON,DELCOURT,HAISSINSKI,+   (ORSAY)
MOY      69  THESIS              KEN MIN MOY      (NORTHEASTERN UNIVERSITY)
SCOTTER  69 NC 62 A 1057         +ERSKINE,PALER,+  (BIRM+GLAS+LOIC+MPIM+OXF)

BIZOT    70 PL 32 416            +BUON,CHATELUS,JEANJEAN,LALANNE,+    (ORSA)
    ALSO 69 PEREZ-Y-JORBA, LIVERPOOL SYMP.69
BIZOT2   70 LNC 4 1273           +DELCOURT,JEANJEAN,LALANNE,+        (ORSAY)
EARLES   70 PRL 25 1312          +FAISSLER,GETTNER,LUTZ,MOY,TANG,+    (NEAS)
HYAMS    70 NP B 22 189          +KOCH,POTTER,V.LINDERN,LORENZ,LUTJENS(CERN)

ALVENSLE 71 PRL 27 441           ALVENSLEBEN,BECKER,BUSZA,CHEN,+  (MIT+DESY)
BALAKIN  71 PL 34 B 328          +BUDKER,PAKHTUSOVA,SIDOROV,SKRINSKY,+(NOVO)
CHATELUS 71  LAL 1247(THESIS)    Y.CHATELUS                     (STRASBOURG)
    ALSO 70 BIZOT
DIBIANCA 71 NP B 35 13           +EINSCHLAG,ENDORF,ENGLER,FISK,+      (CORN)
HAYES    71 PR D 4 899           +IMLAY,JOSEPH,KEIZER,STEIN           (CORN)
STOTTLEM 71  ORO 2504 170        A.R.STOTTLEMYER,THESIS           (MARYLAND)

AGUILAR  72 PR D 6 29            AGUILAR-BENITEZ,CHUNG,EISNER,SAMIOS   (BNL)
ALVENSLE 72 PRL 28 66            ALVENSLEBEN,BECKER,BIGGS,BINKLEY+(MIT+DESY)
BALAKIN  72 PL 40 B 431          +BOKIN,PAKHTUSOVA,SIDOROV,+   (NOVOSIBIRSK)
BASILE   72 NP B 44 605          +DALPIAZ,FRABETTI,ZICHICHI+(CERN+BGNA+STRB)
BENAKSAS 72 PL 42 B 511          +COSME,JEAN-MARIE,JULLIAN,LAPLANCHE+(ORSAY)
BORENSTE 72 PR D 5 1559          BORENSTEIN,DANBURG,KALBFLEISCH,+ (BNL+MICH)
COLLEY   72 NP B 50 1            +JOBES,RIDDIFORD,GRIFFITHS,+    (BIRM+GLAS)

BALLAM   73 PR D 7 3150          +CHADWICK,EISENBERG,BINGHAM,+    (SLAC+LBL)
BINNIE   73 PR D 8 2789          +CARR,DEBENHAM,DUANE,GARBUTT,+  (LOIC+SHMP)

AYRES    74 PRL 32 1463          +DIEBOLD,GREENE,KRAMER,LEVINE,+       (ANL)
BESCH    74 NP B70 257           +HARTMANN,KOSE,KRAUTSCHNEIDER,PAUL,+ (BONN)
BIZZARRI 74 NC 20A 393           +CIAPETTI,DIONISI,DORE,GASPERO+      (ROMA)
COSME 1  74 PL 48 B 155          +JEAN-MARIE,JULLIAN,LAPLANCHE,+     (ORSAY)
COSME 2  74 PL 48 B 159          +JEAN-MARIE,JULLIAN,LAPLANCHE,+     (ORSAY)
DE GROOT 74 NP B74 77            +HOOGLAND,JONGEJANS,METZGER+    (AMST+NIJM)

KALBFLEI 75 PR D11 987           KALBFLEISCH,STRAND,CHAPMAN       (BNL+MICH)

COSME    76 PL 63 B 352          +COURAU,DUDELZAK,GRELAUD,JEAN-MARIE+(ORSAY)
JULLIAN  76 TBLISI VOL.2 R19     S.JULLIAN                           (ORSAY)
KALBFLEI 76 PR D 13 22           KALBFLEISCH,STRAND,CHAPMAN       (BNL+MICH)
PARROUR1 76 PL 63 B 357          +GRELAUD,COSME,COURAU,DUDELZAK,+    (ORSAY)
PARROUR2 76 PL 63 B 362          +GRELAUD,COSME,COURAU,DUDELZAK,+    (ORSAY)

AKERLOF  77 PRL 39 861           +ALLEY,BINTINGER,DITZLER,+ (FNAL+MICH+PURD)
ANDREWS  77 PRL 38 198           +FUKUSHIMA,HARVEY,LOBKOWICZ,MAY,+    (ROCH)
BALDI    77 PL 68 B 381          +BOHRINGER,DORSAZ,HUNGERBUHLER,+   (GENEVA)
CERRADA  77 NP B 126 241         +BLOCKZIJL,HEINEN,+    (AMST+CERN+NIJM+OXF)
COHEN    77 PRL 38 269          +AYRES,DIEBOLD,KRAMER,PAWLICKI,WICKLUND(ANL)
COURANT  77 PR D 16 1            +MAKDISI,MARSHAK,PETERSON,RUDDICK,+  (MINN)
EVANGEL  77 NP B 127 384         EVANGELISTA,+    (BARI+BONN+CERN+DARE+GLAS+)
LAVEN    77 NP B 127 43          +OTTER,KLEIN,+    (AACH+BERL+CERN+LOIC+WIEN)
LYONS    77 NP B 125 207         +COOPER,CLARK                         (OXF)

BARTALUC 78 NC 44 A 587          BARTALUCCI,BASINI,BERTOLUCCI+   (DESY+FRAS)
BUKIN 1  78 SJNP 27 516          +KURDADZE,SEREDNYAKOV,SIDOROV+       (NOVO)
BUKIN 2  78 SJNP 27 521          +KURDADZE,SIDOROV,SKRINSKII+         (NOVO)
COOPER   78 NP B 146 1           +GURTU,MONTANET,+      (TIFR+CERN+CDEF+MADR)
LOSTY    78 NP B 133 38          +HOLMGREN,BLOKZIJL,+   (CERN+AMST+NIJM+OXF)

BARKOV   79  IYAF 79-93          +ZOLOTOREV,MAKARINA,MISHAKOVA,+      (NOVO)
CORDIER  79 PL B 81 389          +DELCOURT,ESCHSTRUTH,FULDA,+         (LALO)

CORDIER  80 NP B172 13           +DELCOURT,ESCHSTRUTH,FULDA+         (ORSAY)
ROOS     80 LNC 27 321           +PELLINEN                            (HELS)

DAUM     81 PL 100 B 439         +BARDSLEY+  (AMST+BRIS+CERN+CRAC+MPIM+RHEL)
IVANOV   81 PL 107 B 297         +KURDADZE,LELCHUK,SIDOROV,SKRINSKY,+ (NOVO)
    ALSO 82  PRIVATE COMM.       S.I.EIDELMAN                         (NOVO)
VASSERMA 81 PL 99 B 62           VASSERMAN,KURDADZE,SIDOROV,SKRINSKY+ (NOVO)

ARENTON  82 PR D 25 2241         +AYRES,DIEBOLD,MAY,SWALLOW+       (ANL+ILL)
PELLINEN 82 PS 25 599            A.PELLINEN, M.ROOS                   (HELS)

ARMSTRON 83 NP B 224 193         ARMSTRONG+  (BARI+BIRM+CERN+MILA+LPNP+PAVI)
BARATE   83 PL 121 B 449         +BAREYRE,ASTBURY,MCEWEN(SACL+LOIC+SHMP+IND)
KURDADZE 83 JETPL 38 306         +LELCHUK,ROOT+                       (NOVO)
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H(1190)

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30  H(1190,JPG=1+-) I=0

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                  30  H(1190) MASS (MEV)

M    C      1190.      60.              DANKOWYCH 81 SPEC   08 PI P,3 PI N     6/81
M   T     (1175.0)  APPROX              TORNQVIST 82 RVUE                      9/83*

M    C  USES THE MODEL OF BOWLER 75
M   T   FROM A UNITARIZED QUARK MODEL CALCULATION

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                  30  H(1190) WIDTH (MEV)

W    C       320.      50.              DANKOWYCH 81 SPEC   08 PI P,3 PI N     6/81
W   T      (365.0)  APPROX              TORNQVIST 82 RVUE                      9/83*

W    C  USES THE MODEL OF BOWLER 75
W   T   FROM A UNITARIZED QUARK MODEL CALCULATION

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                  30  H(1190) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      H(1190) INTO RHO PI                             769+ 135

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REFERENCES FOR H(1190)


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BOWLER   75 NP B97 227          +GAME,ATTCHISON,DAINTON          (OXF+DARE)

DANKOWYC 81 PRL 46 580          +BROCKMAN,EDWARDS+(TNTO+BNL+CARL+MCGI+OHIO)

TORNQVIS 82 NP B 203 268        TORNQVIST.                            (HELS)
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B(1235)

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11  B(1235,JPG=1++) I=1

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                  11  B MASS (MEV)

M   W     (1228.)     (5.)          FRENKIEL  72 HBC  +- 0. PBAR PI,5 PI  12/72
M      360(1208.0)   (18.0)         GAVILLET  78 HBC  +  4.2 K-P,BACKWARD  4/78
M   T     (1243.0)  APPROX          TORNQVIST 82 RVUE                      9/83*

M           1220.      20.          CHUNG     68 HBC   - 3.2,4.2 PI- P     9/67
M           1240.0     20.0         ANDERSON  70 CNTR   0 5-18 GAMMA P    11/70
M           1236.0     15.0         HOOGLAND  70 DBC   -  3.0 K- D         2/71
M  O  1163 1243.        6.          OTT       72 HBC  +  7.1 PI+ P,P B+    2/73
M           1235.      15.          AFZAL     73 HBC  +  11.7 PI+ P        2/73
M           1268.      16.          AFZAL     73 HBC  -  11.2 PI- P        2/73
M     1400 1222.        4.          CHALOUPKA 74 HBC   - 3.9 PI-P,P B-    12/75
M      600 1220.        7.          KARSHON   74 HBC  +  4.9 PI+P,P B+    12/75
M      890 1245.0      11.0         FLATTE    76 HBC   - 4.2 K-P,PI-OMEGA  7/77
M      450 1251.0       8.0         GESSAROLI 77 HBC   - 11 PI-P,PI- OME  12/77
M      225 1240.0      15.0         BALTAY    78 HBC  +  15 PI+P,P 4PI     4/78
M      105 1234.0      15.0         BLOODWORT 80 HBC   - 8.2 K- P,Y*+ B-  12/79
M           1239.       5.          EVANGELIS 81 OMEG  - 12 PI-P,OME PI P  1/82
M           . . . . . . . . . . .
M   AVG     1233.6      3.3     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
                              (SEE IDEOGRAM BELOW)

M  O    FROM FIT OF THE MASS SPECTRUM
M   W   FIT REQUIRES AN ADDITIONAL JP=1- RESONANCE
M   W   AT 1256 MEV, WIDTH 129 MEV.
M   T   FROM A UNITARIZED QUARK MODEL CALCULATION
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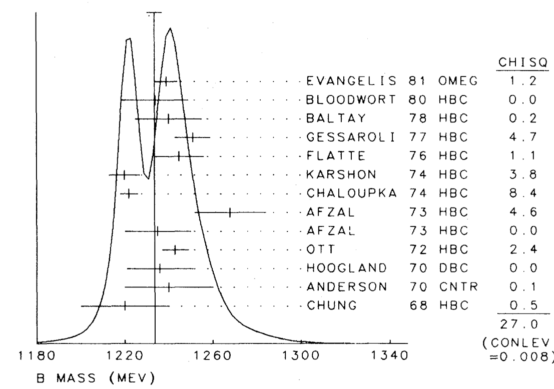
WEIGHTED AVERAGE = 1233.6 ± 3.3
ERROR SCALED BY 1.5

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                  11  B WIDTH (MEV)

W   W      (126.)     (10.)              FRENKIEL  72 HBC  +- 0. PBAR PI,5 PI  12/72
W      360 (163.0)    (50.8)             GAVILLET  78 HBC  +  4.2 K-P,BACKWARD  4/78
W   T      (118.0)   APPROX              TORNQVIST 82 RVUE                      9/83*

W           150.       20.               CHUNG     68 HBC   - 3.2,4.2 PI- P     9/67
W           132.0      20.0              HOOGLAND  70 DBC   -  3.0 K- D         2/71
W  O  1163  134.       23.        26.    OTT       72 HBC  +  7.1 PI+ P,P B+    2/73
W           120.       50.               AFZAL     73 HBC  +  11.7 PI+ P        2/73
W           130.       50.               AFZAL     73 HBC  -  11.2 PI- P        2/73
W     1400  135.       20.               CHALOUPKA 74 HBC   - 3.9 PI-P,P B-    12/75
W      600  156.       22.               KARSHON   74 HBC  +  4.9 PI+P,P B+    12/75
W      890  182.0      45.0              FLATTE    76 HBC   - 4.2 K-P,PI-OMEGA  7/77
W      450  155.0      32.0              GESSAROLI 77 HBC   - 11 PI-P,PI- OME  12/77
W      225  170.0      50.0              BALTAY    78 HBC  +  15 PI+P,P 4PI     4/78
W      105  150.0      50.0              BLOODWORT 80 HBC   - 8.2 K- P,Y*+ B-  12/79
W           170.       15.               EVANGELIS 81 OMEG  - 12 PI-P,OME PI P  1/82
W           . . . . . . . . . . .
W   AVG     150.0       7.3     AVERAGE

W  O    FROM FIT OF THE MASS SPECTRUM
W   W   SEE NOTE UNDER THE MASS ABOVE.
W   T   FROM A UNITARIZED QUARK MODEL CALCULATION

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                  11  B PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      B INTO OMEGA+PI                                 783+ 140
P2      B INTO 2PI+ 2PI-                                140+ 140+ 140+ 140
P3      B INTO K KBAR                                   494+ 494
P4      B INTO PI PI                                    140+ 140
P5      B INTO PI PHI                                   135+1020
P6      B INTO ETA PI (FORBIDDEN BY G)                  549+ 140
P7      B INTO K KBAR PI                                494+ 494+ 140

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                  11  B BRANCHING RATIOS

R10     D/S RATIO FOR B(1235) INTO OMEGA PI
R10
R10           0.3       0.1               CHALOUPKA 74 HBC  -  3.9-7.5 PI-P       1/74
R10     600   0.35      0.25              KARSHON   74 HBC  +  4.9 PI+P,P B+     12/75
R10           0.21      0.08              CHUNG     75 HBC  +  7.1 PI+P          12/75
R10           0.4       0.1        0.1    GESSAROLI 77  HBC  - 11 PI-P,PI- OME   12/77
R10           . . . . . . . . . .
R10 AVG       0.291     0.052     AVERAGE
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For notation, see key at front of Listings.

Mesons
B(1235), g_S(1240), ρ(1250), f(1270)

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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

R7      B+- INTO (KS KS PI+-) / (PI OMEGA)
R7           (0.02) OR LESS  CL=.90    BALTAY    67 HBC  +-  0.0 PBA- P       2/67

R8      B+- INTO (KS KL PI+-) / (PI OMEGA)
R8           (0.06) OR LESS  CL=.90    BALTAY    67 HBC  +-  0.0 PBAR P       2/67

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REFERENCES FOR B


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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.  (AMST+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 15 A 61        +BASSLER,+        (DURH+GENO+DESY+MILA+SACL)   JP
ARMENISE  73 NC 17 A 707        +FORINO,CARTACCI,+             (BARI+BGNA+FIRZ)
ARMENISE  73 LNC 8 425          +FORINO,CARTACCI,+             (BARI+BGNA+FIRZ)
ARNOLD    73 LNC 6 707          +ENGEL,ESCOUBES,KURTZ,LLORET,PATY,+  (STRB)
CASON     73 PR D 7 1971        +BISWAS,KENNEY,MADDEN,SANDER,SHEPHARD(NDAM)
CASON 1   73 NP B 64 14         +MADDEN,BISHOP,BISWAS,KENNEY,+       (NDAM)
CHUNG     73 PL 47 B 526        +PROTOPOPESCU,LYNCH,FLATTE,+ (BNL+LBL+UCSC)   JP
COHEN     73 PR D 8 23          +FERBEL,SLATTERY                (ROCHESTER)

BALLAM    74 NP B76 375         +CHADWICK,BINGHAM,FRETTER+  (SLAC+LBL+MPIM)
CHALOUPK  74 PL 51B 407         CHALOUPKA,FERRANDO,LOSTY,MONTANET    (CERN)   JP
KARSHON   74 PR D10 3608        +MIKENBERG,EISENBERG,PITLUCK,RONAT+  (REHO)   JP

CHUNG     75 PR D11 2426        +PROTOPOPESCU,LYNCH,FLATTE,+ (BNL+LBL+UCSC)   JP
DUBOVIKO  75 SJNP 20 229        M.S.DUBOVIKOV,I.A.EROFEEV            (ITEP)   JP

FLATTE    76 PL 64 B 225        +GAY,BLOKZIJL,METZGER,+(CERN+AMST+NIJM+OXF)   JP

GESSAROL  77 NP B 126 382       GESSAROLI,+  (BGNA+FIRZ+GENO+MILA+OXF+PAVI)   JP

BALTAY    78 PR D 17 62         +CAUTIS,COHEN,CSORNA,SMITH,YEH,+(COLU+BING)
GAVILLET  78 PL 78 B 158        +DIONISI,GURTU,+        (CERN+AMST,NIJM+OXF)   JP

BLOODWOR  80 LNC 27 555         BLOODWORTH,+       (BIRM+CERN+GLAS+MSU+LPNP)

EVANGELI  81 NP B 178 197       EVANGELISTA+(BARI+BONN+CERN+DARE+LIVP+MILA)
WONG      81 PRL 46 974         +KEY,FRISKEN,CLINE,DEBONTE+(TNTO+YORK+PURD)

TORNQVIS  82 NP B 203 268       TORNQVIST                            (HELS)

ATKINSON  83  CERN-EP/83-179    + (BONN+CERN+GLAS+LANC+MCHS+LPNP+RHEL+SHEF)
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g_S(1240)

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87  G/S(1240,JPG=0++) I=0

SEEN IN PHASE SHIFT ANALYSIS OF KOS KOS SYSTEM.
NAMED G/S BY ETKIN 82.
NEEDS CONFIRMATION. OMITTED FROM TABLE.
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                    87  G/S(1240) MASS (MEV)

M  A      1240.0     30.0             ETKIN     82 MPS   0 23 PI-P,2KOS N    9/83*

M  A    FROM AN AMPLITUDE ANALYSIS OF THE KOS KOS SYSTEM. SYSTEMATIC
M  A    ERROR ADDED LINEARLY BY US.
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                    87  G/S(1240) WIDTH (MEV)

W  A       140.0     30.0             ETKIN     82 MPS   0 23 PI-P,2KOS N    9/83*

W  A    FROM AN AMPLITUDE ANALYSIS OF THE KOS KOS SYSTEM. SYSTEMATIC
W  A    ERROR ADDED LINEARLY BY US.
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                    87  G/S(1240) PARTIAL DECAY MODES

                                                           DECAY MASSES
P1     G/S(1240) INTO K KBAR                               498+ 498

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REFERENCES FOR G/S(1240)


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BAUBILLI 83 ZPHY C 17 309     BAUBILLIER+        (BIRM+CERN+GLAS+MSU+LPNP)
ETKIN    82 PR D 25 2446      +FOLEY,LAI,LINDENBAUM+ (BNL+CUNY+TUFT+VAND)   JP
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ρ(1250)

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69  RHO(1250,JPG=1-+) I=1

FORMERLY CALLED RHO PRIME
EVIDENCE NOT COMPELLING. OMITTED FROM TABLE.
SEE ALSO THE RHO(1600) MINI-REVIEW.
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                    69  RHO(1250) MASS  (MEV)

M          1256.      10.              FRENKIEL  72 HBC  +- 0.PBARP,OMEGA PI 12/77
M          1266.0      5.0             BARTALUCC 79 DASP   07 GAM P,E+E- P   12/79
M    A    (1250.)                      ASTON     80 OMEG    20-70G P,OME PI0  9/81
M    A    (1290.)    (40.)             BARBER    80 SPEC    3-5 G P,OMEG PI0  9/81
M          . . . . . . . . . .
M    AVG   1264.0      4.5    AVERAGE

M    A   NOT SEPARATED FROM B(1235),NOT PURE JP=1- EFFECT
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                    69  RHO(1250) WIDTH  (MEV)

W           130.      20.              FRENKIEL  72 HBC  +- 0.PBARP,OMEGA PI 12/77
W           110.0     35.0             BARTALUCC 79 DASP   07 GAM P,E+E- P   12/79
W    A     (300.)                      ASTON     80 OMEG    20-70G P,OME PI0  9/81
W    A     (320.)   (100.)             BARBER    80 SPEC    3-5 G P,OMEG PI0  9/81
W          . . . . . . . . . .
W    AVG    125.1     17.4    AVERAGE

W    A   NOT SEPARATED FROM B(1235),NOT PURE JP=1- EFFECT

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REFERENCES FOR RHO(1250)


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ANDERSON 70 PR D 1 27          +GUSTAVSON,JOHNSON,+   (SLAC+CIT+UCSB+NEAS)

PODOLSKY 71  UCRL 20128        W.J.PODOLSKY,PH.D. THESIS              (LBL)

FRENKIEL 72 NP B 47 61         +GHESQUIERE,LILLESTOL,CHUNG,+   (CDEF+CERN)JP
WOLF     72 ITHACA N.Y. CONF.  G.WOLF,P.213                          (SLAC)

CHUNG    73 PL 47 B 526        +PROTOPOPESCU,LYNCH,FLATTE,+ (BNL+LBL+UCSC)
BRAMON   73 LNC 8 659          A.BRAMON                          (FRASCATI)

BALLAM   74 NP B76 375         +CHADWICK,BINGHAM,FRETTER+  (SLAC+LBL+MPIM)
CHALOUPK 74 PL 51B 407         CHALOUPKA,FERRANDO,LOSTY,MONTANET    (CERN)
CONVERSI 74 PL 52B 493         +PAOLUZI,CERADINI,GRILLI+         (ROMA+FRAS)
ESTABROO 74 NP B79 301         P.ESTABROOKS,A.D.MARTIN              (DURH)
KARSHON  74 PR D10 3608        +MIKENBERG,EISENBERG,PITLUCK,RONAT+  (REHO)   JP

ALLES    75 NC 30A 136         ALLES-BORELLI,BERNARDINI+  (CERN+BGNA+FRAS)
CHUNG    75 PR D11 2426        +PROTOPOPESCU,LYNCH,FLATTE,+ (BNL+LBL+UCSC)
ESTABROO 75 NP B95 322         P.ESTABROOKS,A.D.MARTIN              (DURH)
FROGGATT 75 NP B91 454         C.D.FROGGATT,J.L.PETERSEN       (GLAS+NORD)
HYAMS    75 NP B100 205        +JONES,WEILHAMMER,BLUM,DIETL+   (CERN+MPIM)

BASSOMPI 76 PL 65 B 397        BASSOMPIERRE,BINDER,+       (MULH+STRB+TORI)

BUDNEV   77 PL 70 B 365        N.M.BUDNEV,V.M.BUDNEV,V.V.SEREBRYAKOV(NOVO)
COSTA    77 PL 67 B 213        COSTA DE BEAUREGARD,PHAM,PIRE,TRUONG (EPOL)
GESSAROL 77 NP B 126 382       GESSAROLI,+  (BGNA+FIRZ+GENO+MILA+OXF+PAVI)

BUKIN    78 PL  73 B 226       +VASSERMAN,KOOP,KURDADZE,SIDOROV,+    (NOVO)

BACCI    79 PL B 86 234        +DE ZORZI,PENSO,STELLA,+   (ROMA+BGNA+FRAS)
BARTALUC 79 NC 49 A 207        BARTALUCCI,BASINI,BERTOLUCCI+   (DESY+FRAS)

ASTON    80 PL 92 B 211        (BONN+CERN+EPOL+GLAS+LANC+MCHS+ORSA+PARIS+)
BARBER   80 ZPHY C 4 169       +DAINTON,BRODBECK,BROOKES,+(DARE+LANC+SHEF)
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f(1270)

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5  F(1270,JPG=2++) I=0
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                    5  F MASS (MEV)

M          (1273.0)    (7.0)            ARMENISE  70 HBC     9 PI+ N -- MM P  1/71
M       600(1275.0)   (10.0)            OH        70 HBC    1.26 PI- P,P F    1/71
M    E     (1273.0)    (6.0)            STUNTEBEC 70 HBC    8.PI-P,5.4 PI+D  11/71
M      2000(1261.0)   (10.0)            JACOBS    72 HBC     2.8 PI- P        1/73
M   IH     (1269.)     (4.)             ESTABROOK 75 RVUE   17 PI-P,PI+PI-N  12/75
M   IG     (1275.)     (4.)             HYAMS     75 ASPK    17 PI-P,PI+PI-N 12/75
M    G     (1273.8)    (2.8)     (2.7)  BECKER    79 ASPK   17 PI- P POLARIZ 12/79

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 PI0 0  1/73
M           1265.       8.              BOESEBECK 68 HBC    8 PI+ P           6/68
M     J     1268.0      6.0             JOHNSON   68 HBC     3.7-4.2 PI- P    7/69
M           1275.0     13.0             ARMENISE  70 HBC     9 PI+ N -- F P   1/71
M      5300 1277.0      4.0             FLATTE    71 HBC     7.0 PI+ P        6/71
M       600 1258.0     10.0             TAKAHASHI 72 HBC    8. PI- P,N 2PI    1/73
M      4600 1272.       4.              ENGLER    74 DBC     6. PI+N,PI+PI-P 12/75
M     16000 1284.0     10.0             DEUTSCHMA 76 HBC    16 PI+P           4/78
M           1282.0      5.0             CORDEN    79 OMEG   12-15PI-P, N 2PI 12/79
M           1281.0      7.0             GIDAL     81 SMK2   J/PSI DECAY       1/82
M           1280.0      4.0             CASON     82 STRC   8 PI+P,PI+2PI0 P  8/83*
M           1273.3      2.3             CHABAUD   83 ASPK   17 PI-P POLARIZ  12/83*
M           . . . . . . . . . . .
M    AVG    1273.8      1.6    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)

M    G   INCLUDED IN CHABAUD 83 ANALYSIS
M    H   USES SAME DATA AS HYAMS 75
M   I    ERROR TAKES ACCOUNT OF SPREAD OF DIFFERENT PHASE-SHIFT SOLUTIONS
M     J  JOHNSON 68 INCLUDES BONDAR 63, LEE 64, DERADO 65, EISNER 67.
M   T    MASS ERRORS ENLARGED BY US TO WIDTH/SQRT(N),SEE K*(892) TYPED NOTE
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Mesons

Data Card Listings

f(1270)

5 F WIDTH (MEV)

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W             (131.0)   (25.0)              ARMENISE  70 HBC     9 PI+ N -- MM P  1/71
W    T   600  (120.0)   (20.0)              OH        70 HBC    1.26 PI- P,P F    2/74
W       2000  (130.0)   (25.0)              JACOBS    72 HBC     2.8 PI- P        1/73
W    IH       (209.)    (10.)               ESTABROOK 75 RVUE   17 PI-P,PI+PI-N  12/75
W    IG       (188.)     (4.)               HYAMS     75 ASPK    17 PI-P,PI+PI-N 12/75
W    G        (183.2)    (8.3)     (7.9)    BECKER    79 ASPK   17 PI- P POLARIZ 12/79

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              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    T         173.0     25.0               ARMENISE  70 HBC     9 PI+ N -- F P   2/74
W              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    T   600   166.0     28.0               TAKAHASHI 72 HBC    8. PI- P,N 2PI    1/73
W       4600   192.      16.                ENGLER    74 DBC    6. PI+N,PI+P+-P  12/75
W      16000   225.0     38.0               DEUTSCHMA 76 HBC    16 PI+P           4/78
W    T   650   187.0     30.0               ANTIPOV   77 CIBS   25 PI-P,P 3PI     1/82
W              216.0     13.0               CORDEN    79 OMEG   12-15PI-P, N 2PI 12/79
W              186.0     27.0               GIDAL     81 SMK2   J/PSI DECAY       1/82
W              152.0      9.0               CASON     82 STRC   8 PI+P,PI+2PI0 P  8/83*
W              179.2      6.9       6.6     CHABAUD   83 ASPK   17 PI- P POLARIZ 12/83*
W              . . . . . . . . . . .
W    AVG       178.0      5.6     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
                         (SEE IDEOGRAM BELOW)

W    G   INCLUDED IN CHABAUD 83 ANALYSIS
W    H   USES SAME DATA AS HYAMS 75
W    I   ERROR TAKES ACCOUNT OF SPREAD OF DIFFERENT PHASE-SHIFT SOLUTIONS
W     J  JOHNSON 68 INCLUDES BONDAR 63, LEE 64, DERADO 65, EISNER 67.
W    T   WIDTH ERRORS ENLARGED BY US TO 4*WIDTH/SQRT(N),SEE K*(892) NOTE
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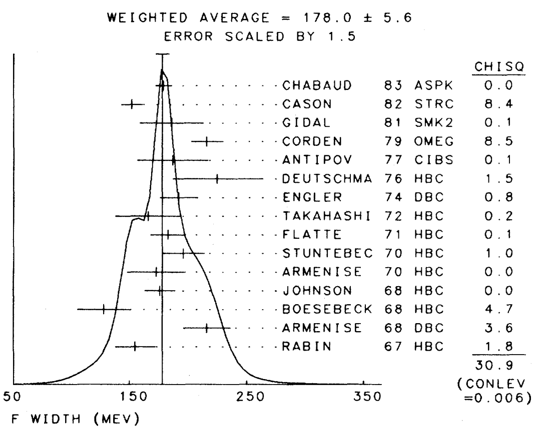

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5 F PARTIAL DECAY MODES

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                                                     DECAY MASSES
P1     F INTO PI PI                                140+ 140
P2     F INTO 2PI+ 2PI-                            140+ 140+ 140+ 140
P3     F INTO PI+ PI- 2PI0                         140+ 140+ 135+ 135
P4     F INTO K KBAR                               498+ 498
P5     F INTO K KBAR PI                            498+ 498+ 140
P6     F INTO ETA PI PI                            549+ 140+ 140
P7     F INTO ETA ETA                              549+ 549
P8     F INTO GAMMA GAMMA                            0+   0
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5 F PARTIAL WIDTHS

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W8     F INTO GAMMA GAMMA (KEV)                           (G8)                   12/78
W8   A        2.3      0.8            BERGER     80 PLUT    E+ E-               9/81
W8 D          3.2      0.8            BRANDELIK 81 TASS     GAM GAM,2PI         1/82
W8 D          3.6      0.8            ROUSSARIE 81 SMK2     GAM GAM,2PI         1/82
W8 D          2.7      0.8            EDWARDS    82 CBAL    GAM GAM,2PI0        2/82
W8 DH        (2.9)    (1.2)    (1.0)  EDWARDS    82 CBAL    GAM GAM,2PI0        2/82
W8 D          2.7      0.4            FRAZER     83 CELL    E+E-,E+E- PI+PI-    9/83*
W8 D          2.3      0.7            FRAZER     83 JADE    E+E-,E+E- PI+PI-    9/83*
W8          . . . . . . . . . . .
W8  AVG       2.75     0.26    AVERAGE

W8   A  USING MASS, WIDTH AND BR(F TO 2PI) FROM PDG 1978
W8 D    SYSTEMATIC ERROR ADDED LINEARLY BY US.
W8  H   IF HELICITY=2 ASSUMPTION IS NOT MADE
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5 F BRANCHING RATIOS

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R1     F INTO (2PI+ 2PI-)/(PI PI)                          (P2)/(P1)
R1            0.047     0.013            OH         70 HBC    1.26 PI- P,P F     2/73
R1     154    0.037     0.007            ANDERSON   73 DBC    6. PI+N,P F0       1/74
R1           (0.033)OR LESS  C.L.=.90    BUGG       73 DBC    8. PI+N,P F0       1/74
R1      70    0.051     0.025            EISENBERG 74 HBC     4.9 PI+P,DEL++F0  11/75
R1     285    0.043     0.007     .011   LOUIE      74 HBC    3.9 PI- P,N F0    11/75
R1     160    0.024     0.006            EMMS       75 DBC    4.  PI+N,P F0     11/75
R1          . . . . . . . . . . .
R1  AVG       0.0340    0.0045  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)

R2     F INTO (PI+ PI- 2PI0)/(PI PI)                       (P3)/(P1)
R2    SHOULD BE TWICE R1 IF DECAY IS RHO-RHO (SEE ASCOLI 68)
R2     600    0.15      0.06             EISENBERG 74 HBC     4.9 PI+P,DEL++F0  11/75
R2           (0.07)                      EMMS       75 DBC    4.  PI+N,P F0     11/75

R3     F INTO (K KBAR)/(PI PI)                             (P4)/(P1)
R3         WE ONLY AVERAGE EXPERIMENTS WHICH EITHER TAKE INTO ACCOUNT F-A2
R3         INTERFERENCE EXPLICITLY OR DEMONSTRATE THAT A2 PRODUCTION IS
R3         NEGLIGIBLE.
R3  W        (0.029)  (0.006)            WETZEL     76 OSPK   8.9 PI-P,KS KS     7/77
R3  BC       (0.047)  (0.005)            PAWLICKI   77 SPEC   6. PI N,K+ K- N   12/77
R3  AN       (0.028)  (0.005)            CASON      78 STRC   7. PI-P,KS KS N   12/78
R3           (0.047)  (0.012)+ SYST.     BEUSCH     67 OSPK   5,7,12 PI-P        9/67
R3      20    0.031    0.012             ADERHOLZ   69 HBC     8 PI+ P,K+K-PI-  12/75
R3            0.025    0.015             EMMS       75 DBC    4.  PI+N,P F0     11/75
R3            0.030    0.005             MARTIN     79 RVUE                     12/79
R3   M        0.027    0.009             POLYCHRON 79 STRC    7. PI-P,KS KS N   12/79
R3   D        0.036    0.005             COSTA      80 OMEG   1-2.2 PI-P,K+K-N   9/81
R3            0.039    0.008             LOVERRE    80 HBC    4. PI-P,K K N     12/79
R3           (0.03) OR LESS  CL=.95      AGUILAR    81 HBC    4.2 K-P,LAM 2K     1/82
R3            0.045    0.009             CHABAUD    81 ASPK   17 PI-P POLARIZ   12/83*
R3            0.037    0.008     0.021   ETKIN      82 MPS    23 PI-P,2K0S N     9/83*
R3          . . . . . . . . . . .
R3  AVG       0.0340   0.0027   AVERAGE

R3   C  THIS DETERMINATION HAS QUANTITATIVELY ACCOUNTED FOR BOTH F-PRIME
R3   C  AND A2 INTERFERENCE EFFECTS.
R3   M  TAKES INTO ACCOUNT THE F-F PRIME INTERFERENCE
R3   N  BY EXTRAPOLATION TO THE PION POLE
R3  W   USING F PRIME WIDTH = 40 MEV
R3  A   INCLUDED IN POLYCHRONAKOS 79.
R3  B   INCLUDED IN MARTIN 79 REVIEW.
R3   D  RE-EVALUATED BY CHABAUD 83.W.

R4     F INTO (K0 K- PI+ AND C.C.)/(PI PI)                 (P5)/(P1)
R4           (.004)OR LESS  CL=.95   EMMS       75 DBC    4.  PI+N,P F0     11/75

R5     F INTO (ETA PI PI)/(PI PI)                          (P6)/(P1)
R5           (.010)OR LESS  CL=.95   EMMS       75 DBC    4.  PI+N,P F0     11/75

R6     F INTO (ETA ETA)/(PI PI)                            (P7)/(P1)
R6           (.09) OR LESS  CL=.95   EISENBERG 74 HBC     4.9 PI+P,DEL++F0  11/75
R6           (.016)OR LESS  CL=.95   EMMS       75 DBC    4.  PI+N,P F0     11/75
R6           (.05) OR LESS  CL=.95   EDWARDS    82 CBAL   GAM GAM,4GAMMA     2/82

R10    F INTO (PI PI)/TOTAL                                (P1)
R10    600    0.8       0.04             OH         70 HBC    01.26 PI- P,P F    1/71
R10    250    0.85      0.05             BEAUPRE    71 HBC    08 PI+ P,DELTA++F  1/71
R10IH        (0.82)    (0.01)            ESTABROOK 75 RVUE     17 PI-P,PI+PI-N  12/75
R10IG        (0.803)   (0.003)           HYAMS      75 ASPK     17 PI-P,PI+PI-N 12/75
R10           0.847     0.016            BECKER     79 ASPK    17 PI- P POLARIZ 12/79
R10           0.849     0.025            CHABAUD    83 ASPK    17 PI-P POLARIZ  12/83*
R10         . . . . . . . . . . .
R10 AVG       0.843     0.012   AVERAGE

R10 G   INCLUDED IN BECKER 79 ANALYSIS
R10 H   USES SAME DATA AS HYAMS 75
R10I    ERROR TAKES ACCOUNT OF SPREAD OF DIFFERENT PHASE-SHIFT SOLUTIONS
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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+          (ETH+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)
LAMSA    68 PR 166 1395        +CASON+BISWAS+DERADO+GROVES+    (NOTREDAME)
WHITEHEA 68 NC 53A 817         +MCEWEN,OTT,AITKEN+        (AERE+SHMP+LOUC)

ADERHOLZ 69 NP B 11 259        +BARTSCH,+          (AACH+BERL+CERN+JAGL+WARS)
AGUILAR  69 PL 29 B  241       M.AGUILAR-BENITEZ,J.BARLOW,+    (CERN+CDEF)
ARMENISE 69 LNC 2 501          +GHIDINI,FORINO,CARTACCI+  (BARI+BGNA+FIRZ)
CASO     69 NC 62 A 755        +CONTE,BENZ,+    (GENO+DESY+HAMB+MILA+SACL)
DONALD   69 NP B 11 551        +EDWARDS,BURAN,BETTINI,+   (LIVP+OSLO+PADO)

AGUILAR  70 PRL 25 58          AGUILAR-BENITEZ,BARNES,BASSANO,+ (BNL+SYRA)
ARMENISE 70 LNC 4  199         +GHIDINI,FORING,CARTACCI,+ (BARI+BGNA+FIRZ)
BADIER   70 NP B 22 512        +BONNET,DREVILLON,BAUBILLIER,+  (EPOL+IPNP)
OH       70 PR D 1 2494        +GARFINKEL,MORSE,WALKER,PRENTICE(WISC+TNTOJ)
STUNTEBE 70 PL 32 B 391        STUNTEBECK,KENNEY,DEERY,BISWAS,CASON+(NDAM)

BARDADIN 71 PR D4 2711         BARDANIN-OTWINOWSKA,HOFMOKL,+        (WARS)
BEAUPRE  71 NP B 28 77         +DEUTSCHMANN,GRAESSLER,+   (AACH+BERL+CERN)
FARBER   71 NP B 29 237        +DE PINTO,BISWAS,CASON,DEERY,KENNEY,+(NDAM)
FLATTE   71 PL 34 B 551        +ALSTON-GARNJOST,BARBARO-GALTIERI,+   (LBL)

AGUILAR  72 PR D 6 29          AGUILAR-BENITEZ,CHUNG,EISNER,SAMIOS   (BNL)
BISWAS   72 PR D 5 1564        +CASON,HARRINGTON,KENNEY,SHEPHARD    (NDAM)
FOGLI    72 NC 8 A 670         FOGLI-MUCIACCIA,PICCIARELLI          (BARI)
GRAYER   72 PHIL.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)

ANDERSON 73 PRL 31 562         +ENGLER,KRAEMER,TOAF,DIAZ,+     (CARN+CASE)
BUGG     73 PR D 7 3264        +CONDO,HART,COHN,ENDORF,+  (TENN+ORNL+CINC)
CHARLESW 73 NP B 65 253        CHARLESWORTH,EMMS,BELL,+   (RHEL+BIRM+DURH)
HYAMS    73 NP B 64 134        +JONES,WEILHAMMER,BLUM,DIETL,+  (CERN+MPIM)
TOET     73 NP B 63 248        +THUAN,MAJOR,RINAUDO,+(NIJM+BONN+DURH+TORI)

EISENBER 74 PL 52B 239         EISENBERG,ENGLER,HABER,KARSHON+      (REHO)
ENGLER   74 PR D10 2070        +KRAEMER,TOAFF,WEISSER,DIAZ+    (CARN+CASE)
GRAYER   74 NP B 75 189        G.GRAYER,HYAMS,BLUM,DIETL,+     (CERN+MPIM)
HOLLOWAY 74 PR D9 1161         +HULD,JORDAN,KOETZ,BERNSTEIN+    (ILL+ILLC)
LOUIE    74 PL 48B 385         +ALITTI,GANDOIS,CHALOUPKA+      (SACL+CERN)
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EMMS     75 NP B96 155          +KINSON,STACEY,VOTRUBA+     (BIRM+DURH+RHEL)
ESTABROO 75 NP B95 322          P.ESTABROOKS,A.D.MARTIN               (DURH)
HYAMS    75 NP B100 205         +JONES,WEILHAMMER,BLUM,DIETL+    (CERN+MPIM)
PAWLICKI 75 PR D12 631          +AYRES,DIEBOLD,GREENE,KRAMER,WICKLUND (ANL)

DEUTSCHM 76 NP B 103 426        +KIRK,+(AACH+BERL+BONN+CERN+CRAC+HEID+WARS)
WETZEL   76 NP B 115 208        +FREUDENREICH,BEUSCH,+       (ETH+CERN+LOIC)

ALEXANDE 77 NP B 131 365        ALEXANDER,CORDEN,+     (TELA+BIRM+RHEL+LOWC)
ANTIPOV  77 NP B 119 45         +BUSNELLO,DAMGAARD,KIENZLE,+     (SERP+GEVA)
PAWLICKI 77 PR D 15 3196        +AYRES,COHEN,DIEBOLD,KRAMER,WICKLUND  (ANL)

BALTAY   78 PR D 17 62          +CAUTIS,COHEN,CSORNA,SMITH,YEH,+(COLU+BING)
CASON    78 PRL 41 271          +BAUMBAUGH,BISHOP,BISWAS,KENNEY,+(NDAM+ANL)

BECKER   79 NP B 151  46        +BLANAR,BLUM,CERRADA+ (MPIM+CERN+ZEEM+CRAC)
CORDEN   79 NP B 157 250        +DOWELL,GARVEY,JOBES,+(BIRM+RHEL+TELA+LOWC)
MARTIN   79 NP B 158 520        +OZMUTLU                              (DURH)
POLYCHRO 79 PR D 19 1317        POLYCHRONAKOS,CASON,BISHOP+       (NDAM+ANL)

BERGER   80  DESY 80/34         +GENZER+(AACH+BERG+DESY+HAMB+UMD+SIEG+WUPG)
COSTA    80 NP B 175 402        +        (BARI+BONN+CERN+GLAS+LIVP+MILA+WIEN)
GORLICH  80 NP B 174 16         +NICZYPORUK,ROZANSKA+ (CRAC+MPIM+CERN+ZEEM)
LOVERRE  80 ZPHY C 6 187        +ARMENTEROS,DIONISI+  (CERN+CDEF+MADR+STOH)

AGUILAR  81 ZPHY C 8 313        +ALBAJAR,ARMENTEROS,+ (CERN+CDEF+MADR+STOH)
BRANDELI 81 ZPHY C 10 117       BRANDELIK,BOERNER,+    (TASSO COLLABORATION)
CHABAUD  81 APP B 12 575        +NICZYPORUK,BECKER+         (CERN+CRAC+MPIM)
GIDAL    81 PL 107 B 153        +GOLDHABER,GUY,MILLIKAN,ABRAMS,+ (SLAC+LBL)
ROUSSARI 81 PL 105 B 304        ROUSSARIE,BURKE,ABRAMS,ALAM,+     (SLAC+LBL)

CASON    82 PRL 48 1316         +BISWAS,BAUMBAUGH,BISHOP,CANNATA+(NDAM+ANL)
EDWARDS  82 PL 110 B 82         +PARTRIDGE,PECK,+ (CIT+HARV+PRIN+STAN+SLAC)
ETKIN    82 PR D 25 1786        +FOLEY,LAI,LINDENBAUM+ (BNL+CUNY+TUFT+VAND)

ARMSTRON 83 NP B 224 193        ARMSTRONG+  (BARI+BIRM+CERN+MILA+LPNP+PAVI)
CASON    83 PR D 28 1586        +CANNATA,BAUMBAUGH,BISHOP,WATSON+(NDAM+ANL)
CHABAUD  83 NP B 223 1          +GORLICH,CERRADA+           (CERN+CRAC+MPIM)
FRAZER   83 AACHEN CONF.        RAPPORTEUR TALK                       (UCSD)
JENNI    83 PR D 27 1031        +BURKE,TELNOV,ABRAMS,BLOCKER+     (SLAC+LBL)
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A(1270) or A_1

10 A(1270,JPG=1+-) I=1

We no longer use the subscript 1 to specify this resonance.

The long-standing question concerning the resonance interpretation of the A(1270) was considerably clarified at the time of our 1982 edition.

The results of the partial-wave analyses obtained in two high-statistics experiments dealing with the diffractive (DAUM 80,81) and charge-exchange (DANKOWYCH 81) production of the 3π system in πp interactions clearly show that the behavior of the 1^+S0^+ intensity with the 3π mass and the phase variation of the 1^+S0^+ $(\rho\pi)$ amplitude with respect to other waves [already reported in a study of diffractive production from nuclei (PERNEGR 78)] require the presence of both Deck background and a resonance.

The resonance parameters of the A(1270) are obtained by fitting the data (intensity and relative phases) to a phenomenological amplitude containing direct resonance production and a coherent Deck background which is rescattered through the resonance (BOWLER 75, BASDEVANT 77). In the context of this model-dependent analysis, the Deck background is responsible for making the peak of the 1^+S0^+ intensity occur some 110 MeV below the most-likely resonance mass.

We take the mass values for the A(1270) from the above reactions (1240 ± 80 MeV, DANKOWYCH 81; 1280 ± 30 MeV, DAUM 81). Note, however, the result reported in a study of a backwardly produced 3π system in the reaction $K^-p \to \Sigma^-\pi^+\pi^+\pi^-$ (1041 ± 13 MeV, GAVILLET 77). Based on a small statistical sample, GAVILLET 77 fitted the 3π mass distribution with a relativistic S-wave Breit-Wigner and a background including reflections from all the competing channels.

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                 10  A(1270) MASS (MEV)

M    A      1270. TO 1350.             BOWLER     75 RVUE +- 7-40 PI+- P       6/81
M     B    (1382.)                     BASDEVANT  77 RVUE  - 25,40 PI- P       6/81
M   F      (1041.0)   (13.0)           GAVILLET   77 HBC  + 4.2 K- P,S 3PI    12/77
M     D     1240.0     80.0            DANKOWYCH  81 SPEC   08.45 PI-P,3PI N   6/81
M     D     1280.0     30.0            DAUM       81 CNTR    63,94 PI- P      12/79
M    E     (1230.0)   (30.0)           LONGACRE   82 RVUE                     8/83*
M    T     (1250.0)  APPROX            TORNQVIST  82 RVUE                     9/83*
M
M    AVG    1275.1     28.1      AVERAGE

M    A   USES DATA OF ANTIPOV 73,ASCOLI 74,OTTER 74,TABAK 74,THOMPSON 74.
M     B  USES ANTIPOV 73 DATA. WE SELECT SOLUTION B OF BASDEVANT 77.
M     D  USES THE MODEL OF BOWLER 75.
M    E   USES MULTICHANNEL AITCHISON-BOWLER MODEL.
M    E   USES DATA FROM GAVILLET 77, DAUM 80 AND DANKOWYCH 81.
M    F   PRODUCED IN K- BACKWARD SCATTERING.
M    T   FROM A UNITARIZED QUARK MODEL CALCULATION

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                 10  A(1270) WIDTH (MEV)

W    A       240. TO  280.             BOWLER     75 RVUE +- 7-40 PI+- P       6/81
W     B     (470.)                     BASDEVANT  77 RVUE  - 25,40 PI- P       6/81
W   F       (230.0)   (50.0)           GAVILLET   77 HBC  + 4.2 K- P,S 3PI    12/77
W     D      380.0    100.0            DANKOWYCH  81 SPEC   08.45 PI-P,3PI N   6/81
W     D      300.0     50.0            DAUM       81 CNTR    63,94 PI- P       1/82
W    E      (330.0)   (60.0)           LONGACRE   82 RVUE                     8/83*
W    T      (234.0)  APPROX            TORNQVIST  82 RVUE                     9/83*
W
W    AVG     316.0     44.7      AVERAGE

M    A   USES DATA OF ANTIPOV 73,ASCOLI 74,OTTER 74,TABAK 74,THOMPSON 74.
W     B  USES ANTIPOV 73 DATA. WE SELECT SOLUTION B OF BASDEVANT 77.
W     D  USES THE MODEL OF BOWLER 75.
W    E   USES MULTICHANNEL AITCHISON-BOWLER MODEL.
W    E   USES DATA FROM GAVILLET 77, DAUM 80 AND DANKOWYCH 81.
W    F   PRODUCED IN K- BACKWARD SCATTERING.
W    T   FROM A UNITARIZED QUARK MODEL CALCULATION

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                 10  A(1270) PARTIAL DECAY MODES

                                                         DECAY MASSES
P1        A(1270) INTO RHO PI                            769+ 140
P2        A(1270) INTO KBAR K                            494+ 498
P3        A(1270) INTO PI (PI PI) S WAVE                 140+ 140+ 140

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                 10  A(1270) BRANCHING RATIOS

R4        A(1270) INTO (PI (PI PI) S WAVE)/(RHO PI)        (P3)/(P1)
R4 E          0.003     0.003          LONGACRE  82 RVUE                      8/83*
R4 E      USES MULTICHANNEL AITCHISON-BOWLER MODEL.
R4 E      USES DATA FROM GAVILLET 77, DAUM 80 AND DANKOWYCH 81.

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REFERENCES FOR A(1270)


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BELLINI  63 NC 29 896           BELLINI,FIORINI,HERZ,NEGRI,RATTI     (MILAN)

ADERHOLZ 64 PL 10 226           AACH+BERL+BIRM+BONN+DESY+HAMBURG+LOIC+MPIM
GOLDHABE 64 PRL 12 336          GOLDHABER,BROWN,KADYK,SHEN+        (LRL+UCB)
LANDER   64 PRL 13 346 A        LANDER,ABOLINS,CARMONY,HENDRICKS +  (UCSD)  JP

ABOLINS  65 ATHENS(OHIO)CONF.   +CARMONY,LANDER,XUONG,YAGER     (LA JOLLA)I=1
ALITTI   65 PL 15 69            ALITTI,BATON,DELER,CRUSSARD+     (SACL+BGNA)

ALLARD   66 NC 46A 737          +DRIJARD+HENNESSY+   (ORSAY+MILAN+SACL+UCB)
DEUTSCHM 66 PL 20 82            DEUTSCHMANN,STEINBERG +  (AACH+BERLIN+CERN)
HESS     66 UCRL-16832          R I HESS (THESIS, BERKELEY)              (LRL)

ALLISON  67 PL 25B 619          +CRUZ+          (OXF+MPIM+BIRM+RHEL+GLAS+LOIC)
DAHL     67 PR 163 1377         +HARDY+HESS+KIRZ+MILLER                  (LRL)
DANYSZ   67 NC 51 A 801         DANYSZ+FRENCH+SIMAK                     (CERN)
JUHALA   67 PRL 19 1355         +LEACOCK+RHODE+KOPELMAN+           (IOWA+COLO)
SLATTERY 67 NC 50A 377          +KRAYBILL+FORMAN+FERBEL            (YALE+ROCH)  JP

ARMENISE 68 PL 26 B  336        +FORINO+CARTACCI+     (BARI+BGNA+FIRZ+ORSAY)
ASCOLI   68 PRL 21 113          +CRAWLEY,KRUSE,MORTARA,SCHAFER,+ (ILLINOIS)
BALLAM   68 PRL 21 934          +BRODY,CHADWICK,FRIES,GUIRAGOSSIAN+  (SLAC)JP
BOESEBEC 68 NP B 4 501          BOESEBECK,DEUTSCHMANN,+(AACHEN+BERLIN+CERN)
CASO     68 NC 54 A 983         +CONTE+CORDS+DIAZ+  (GENOVA+HAMB+MILA+SACL)
CHUNG    68 PR 165 1491         S.U.CHUNG,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)
ASCOLI   70 PRL 25 962          +BROCKWAY,CRAWLEY,EISENSTEIN,HANFT,+  (ILL)  JP
BRANDENB 70 NP B16 369          +BRENNER,IOFFREDO,JOHNSON,KIM+     (HARVARD)
CASO     70 LNC 3  707          +CORDS,COSTA+     (GENO+DESY+HAMB+MILA+SACL)
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Mesons

Data Card Listings

A(1270) [A_1], η(1275), D(1285)

CRENNELL 70 PRL 24 781 +KARSHON,LAI,SCARR,SIMS (BNL)
GARELICK 70 PHILAD.CONF.P.205 D.A.GARELICK,REVIEW (NORTHEASTERN)
RABIN 70 PRL 24 925 +GALTIERI,DERENZO,FLATTE,FRIEDMAN+ (LRL)

ASCOLI 71 PRL 26 929 ILLINOIS+GENO+HAMB+MIL+SACL+HARV+TNTO+WISC
BEMPORAD 71 NP B 33 397 +BEUSCH,MELISSINOS,+ (CERN+ETH+LOIC+MILA)
BERGER 71 PHENOMENOLOGY IN PARTICLE PHYSICS, CALTECH 1971 (LRL)
RINAUDO 71 NC 5 A 239 +BOECKMANN,MAJOR+(TORI+BONN+DURH+NIJM+EPOL) JP

BERENYI 72 NP B 37 621 +PRENTICE,STEENBERG,YOON,WALKER (TNTO+WISC)
BLOODWOR 72 NP B 46 402 BLOODWORTH,JACKSON,PRENTICE,YOON (TORONTO)
DIEBOLD 72 BATAV.CONF.3P.17 R.DIEBOLD RAPPORTEUR TALK (ANL)
LAMSA 72 NP B 41 388 +EZELL,GAIDOS,WILLMANN (PURDUE)
MORSE 72 NP B 43 77 +OH,WALKER,JOHNSTON,YOON (WISC+TNTO)

ANTIPOV1 73 NP B 63 153 +ASCOLI,BUSNELLO,FOCACCI,+ (CERN+SERP) JP
ANTIPOV2 73 NP B 63 141 +ASCOLI,BUSNELLO,FOCACCI,+ (CERN+SERP) JP
ARNOLD 73 NC 17 A 393 +ENGEL,ESCOUBES,GEMESY,JANOSSY,+(STRB+BUDA)
ASCOLI 1 73 PR D 8 3894 +JONES,WEINSTEIN,WYLD (ILL)
ASCOLI 2 73 PRL 31 795 +CHAPIN,CUTLER,HOLLOWAY,KOESTER,KRUSE+(ILL) JP
ATHERTON 73 PL 43 B 249 +FRANEK,FRENCH,GHIDINI,HILPERT,+ (CERN)
READ 73 NP B 64 511 B.J.READ (DESY)

ASCOLI 74 PR D9 1963 +CUTLER,JONES,KRUSE,ROBERTS,WEINSTEIN+(ILL)
BOWLER 74 NP B74 493 +DAINTON,KADDOURA,AITCHISON (OXF)
KRUSE 74 PRL 32 1328 +ROBERTS,EDELSTEIN+ (ILL+CARN+NWES+ROCH) JP
LICHTMAN 74 NP B81 31 +BISWAS,CASON,KENNEY,MCGAHAN,+ (NDAM) JP
OTTER 74 NP B80 1 +RUDOLPH+ (AACH+BERL+BONN+CERN+HEID) JP
TABAK 74 BOSTON CONF. P.46 +RONAT,ROSENFELD,LASINSKI+ (LBL+SLAC) JP
THOMPSO1 74 PR D9 560 THOMPSON,GAIDOS,MCILWAIN,WILLMANN (PURD) JP
THOMPSO2 74 NP B69 381 THOMPSON,BADEWITZ,GAIDOS,MCILWAIN+ (PURD) JP

ABASHIAN 75 PRL 34 691 +BEAMER,BROSS,EISENSTEIN,+ (ILL+ANL+ISU)
AITCHISO 75 PL 59 B 288 I.J.R.AITCHISON, R.J.GOLDING (OXFORD)
ASCOLI 75 PR D 12 43 G.ASCOLI, H.W.WYLD (ILLINOIS)
BEUSCH 75 PL 55B 97 +POLGAR,FREUDENREICH+ (CERN+ETH+LOIC+MILA)
BOSETTI 75 NP B 101 304 +OTTER+(AACH+BERL+BONN+CERN+HEID+LOIC+WIEN)
BOWLER 75 NP B97 227 +GAME,AITCHISON,DAINTON (OXF+DARE)
DIAZ 75 PR 12 D 1272 +DIBIANCA,FICKINGER,DADO,ENGLER+(CASE+CARN) JP
EMMS 1 75 NP B93 1 +JONES,KINSON,BELL,DALE+ (BIRM+DURH+RHEL) JP
EMMS 2 75 PL 60 B 109 +JONES,KINSON,BELL,DALE+ (BIRM+DURH+RHEL) JP
HORNE 75 PR D11 996 +S.HAGOPIAN,V.HAGOPIAN,BENSINGER+(FSU+BRAN)
KANE 75 TENTH RENCONTRE DE MORIOND (MICH)
WAGNER 75 PL 58B 201 +TABAK,CHEW (LBL) JP

BAUBILLI 76 NP B 115 237 BAUBILLIER,RIVOAL,ARMENISE + (BARI+LPNP) JP
BENZ 76 NP B 115 385 +BRAUN +(AACHEN+BONN+HAMBURG+HEIDBERG+MPIM)
BRAYSHAW 76 PRL 36 73 D.BRAYSHAW (SLAC)

BALTAY 77 PRL 39 591 +CAUTIS,KALELKAR (COLUMBIA) JP
BASDEVAN 77 PR D 16 657 BASDEVANT,BERGER (FNAL+ANL) JP
CAUTIS 77 THESIS NEVIS 221 C.V.CAUTIS (COLUMBIA) JP
CERRADA 77 NP B 126 241 +BLOCKZIJL,HEINEN+ (AMST+CERN+NIJM+OXF) JP
FERRER 77 THESIS,LAL 1295 A.FERRER SORIA (ORSAY)
GAVILLET 77 PL 69 B 119 +BLOCKZIJL,ENGELEN+ (AMST+CERN+NIJM+OXF) JP
HABER 77 NP B 129 429 H.E.HABER,G.L.KANE (UNIV. OF MICHIGAN)
LONGACRE 77 PRL 38 1509 +AARON (NORTHEASTERN,BOSTON) JP
SCHULT 77 PR D 16 62 + WYLD (ILLINOIS) JP

ALEXANDE 78 PL 73 B 99 ALEXANDER,KNIES,+(DESY+AACH+HAMB+SIEG+WUPG)
BALTAY 78 PR D 17 62 +CAUTIS,COHEN,CSORNA,KALELKAR+ (COLU+BING)
BASDEVAN 78 PRL 40 994 BASDEVANT,BERGER (FNAL+ANL) JP
CORDEN 78 NP B 136 77 DOWELL,GARVEY,JOBES+ (BIRM+RHEL+TELA+LOWC) JP
FERRER 1 78 PL 74 B 287 +TREILLE,RIVET + (ORSAY+CERN+CDEF+LPNP)
FERRER 2 78 NPB 142 77 +TREILLE,RIVET + (ORSAY+CERN+CDEF+LPNP)
JAROS 78 PRL 40 1120 +ABRAMS,ALAM+ (SLAC+LBL+NWES+HAWA)
PERNEGR 78 NP B 134 436 +AEBISCHER+ (ETH+CERN+LOIC+MILA) JP
ROBERTS 78 PR D 18 59 +KRUSE,EDELSTEIN+ (ILL+CARN+NWES+ROCH) JP

CORDIER 79 PL B 81 389 +DELCOURT,ESCHSTRUTH,FULDA,+ (LALO)
KASPER 79 NP B 156 207 +CHAPMAN,DEROACH,GOLD,KLEIN,MARTIN+ (MELB)
MAZZUCAT 79 NP B 156 532 MAZZUCATO,PENNINGTON+ (CERN+ZEEM+NIJM+OXF)

DAUM 80 PL 89 B 281 +HERTZBERGER+(AMST+CERN+CRAC+MPIM+OXF+RHEL) JP
WAGNER 80 ZPHY C 3 193 +ALEXANDER+ (AACH+DESY+HAMB+SIEG+WUPP)

AARON 81 PR D 24 1207 +LONGACRE (NEAS+BNL)
DANKOWYC 81 PRL 46 580 +BROCKMAN,EDWARDS+(TNTO+BNL+CARL+MCGI+OHIO)
DAUM 81 NP B 182 269 +HERTZBERGER+(AMST+CERN+CRAC+MPIM+OXF+RHEL)
FOSTER 81 NP B 187 231 +BLOKZIJL,ARMENTEROS,+ (OXF+ZEEM+CERN+NIJM)

ARMSTRON 82 NP B 202 1 +BACCAR(AACH+BARI+BONN+CERN+GLAS+LIVP+MILA)
BELLINI 82 NP B 199 1 + (CERN+MILA+JINR+BGNA+HELS+PAVI+WARS+VIEN)
ETKIN 82 PR D 25 1786 +FOLEY,LAI,LINDENBAUM+ (BNL+CUNY+TUFT+VAND)
GAVILLET 82 ZPHY C 16 119 +ARMENTEROS,AGUILAR+ (CERN+CDEF+PADO+ROMA)
LONGACRE 82 PR D 26 83 R.S.LONGACRE (BNL)
TORNQVIS 82 NP B 203 268 TORNQVIST (HELS)

LEEDOM 83 PR D 27 1426 +DE BONTE,GAIDOS,KEY,WONG+ (PURD+TNTO)

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η(1275) →

37 ETA(1275,JPG=0-+) I=0

SEEN IN PHASE SHIFTS ANALYSIS OF THE ETA PI+ PI-
SYSTEM WITH PI+ PI- IN AN S-WAVE (STANTON 79).
WAIT CONFIRMATION. OMITTED FROM TABLE.

37 ETA(1275) MASS (MEV)

M	(1275.)	APPROX.	STANTON	79	CNTR	0	8.4PI-P,ETA 2PI	12/79

37 ETA(1275) WIDTH (MEV)

W	(70.)	APPROX.	STANTON	79	CNTR	0	8.4PI-P,ETA 2PI	12/79

37 ETA(1275) PARTIAL DECAY MODES

		DECAY MASSES
P1	ETA(1275) INTO DELTA PI	983+ 140
P2	ETA(1275) INTO ETA PI+ PI-	549+ 140+ 140

37 ETA(1275) BRANCHING RATIOS.

R1	**ETA(1275) INTO DELTA PI**		**(P1)**				
R1	LARGE	STANTON	79	CNTR	0	8.4PI-P,ETA 2PI	12/79

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REFERENCES FOR ETA(1275)

STANTON 79 PRL 42 346 +BROCKMAN,DANKOWYCH,+ (OSU+CARL+MCGI+TNTO) JP

BARNES 82 PL 116 B 365 T.BARNES AND F.E.CLOSE (RHEL)
TANIMOTO 82 PL 116 B 198 M.TANIMOTO (BIEL)

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D(1285)

8 D(1285,JPG=1++) I=0

8 D(1285) MASS (MEV)

M	S	500(1280.)	(3.)	THUN	72	MMS	13.4 PI- P	12/72
M		34(1271.0)	(10.0)	CORDEN	78	OMEG	12-15PI-P,K+K-PI	4/78
M	P	46(1275.0)	APPROX.	STANTON	79	CNTR	8.5PI-P,2GAM 2PI	12/79
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		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		210 1279.0	5.0	GRASSLER	77	HBC	16. PI-+ P	11/77
M		85 1295.0	12.0	CORDEN	78	OMEG	12-15PI-P, N 5PI	4/78
M		320 1282.0	2.0	NACASCH	78	HBC	.7+.76 PB P,KKBP	4/78
M		200 1288.0	9.0	GURTU	79	HBC	4.2 K- P,ETA 2PI	12/79
M		31 1275.0	6.0	BROMBERG	80	SPEC	100 PI-P,2KPIX	1/82
M		103 1283.0	3.0	DIONISI	80	HBC	4. PI- P,K KB PI	12/79
M		1278.	4.	EVANGELIS	81	OMEG	12 PI-P,ETA3PIP	1/82
M	T	(1279.)	APPROX	TORNQVIST	82	RVUE		9/83*
M		1285.0	2.0	PALANO	83	OMEG	85 PP PI+P,2KPIX	12/83*
M								
M	AVG	1283.5	1.1	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)				

M P FROM PHASE SHIFT ANALYSIS OF ETA PI+PI- SYSTEM.
M S SEEN IN THE MISSING MASS SPECTRUM
M T FROM A UNITARIZED QUARK MODEL CALCULATION

8 D(1285) WIDTH (MEV)

W	R	(35.0)	(10.0)	DAHL	67	HBC	1.6-4.2 PI- P	11/71
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	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	D	34 (55.0)	(38.0)	CORDEN	78	OMEG	12-15PI-P,K+K-PI	4/78
W	P	(10.0)	APPROX.	STANTON	79	CNTR	8.5PI-P,2GAM 2PI	12/79
W	U	46.	20.	D-ANDLAU	68	HBC	1.2 PBAR P, 5-6 PFS	2/72
W		30.0	15.0	CAMPBELL	69	DBC	2.7 PI+ D	8/69
W		10.0	10.0	BOESEBECK	71	HBC	16.0 PI P,5 PI	6/71
W		210 24.0	18.0	GRASSLER	77	HBC	16. PI-+ P	12/77
W	D	85 70.0	30.0	CORDEN	78	OMEG	12-15PI-P, N 5PI	4/78
W		320 28.3	6.7	NACASCH	78	HBC	.7+.76 PB P,KKBP	4/78
W		200 25.0	15.0	GURTU	79	HBC	4.2 K- P,ETA 2PI	12/79
W		31 22.0	21.0	BROMBERG	80	SPEC	100 PI-P,2KPIX	1/82
W		103 29.0	10.0	DIONISI	80	HBC	4. PI- P,K KB PI	12/79
W		26.	12.	EVANGELIS	81	OMEG	12 PI-P,ETA3PIP	1/82
W		26.	5.	PALANO	83	OMEG	85 PP PI+P,2KPIX	12/83*
W								
W	AVG	26.2	3.1	AVERAGE				

W D WIDTH ERRORS ENLARGED BY US TO 4*WIDTH/SQRT(N),SEE K*(892) NOTE
W P FROM PHASE SHIFT ANALYSIS OF ETA PI+PI- SYSTEM.
W R RESOLUTION NOT UNFOLDED
W S SEEN IN THE MISSING MASS SPECTRUM
W U UNFOLDED BY DOBRZYNSKI 71

8 D(1285) PARTIAL DECAY MODES

		DECAY MASSES
P1	D(1285) INTO K KBAR PI	498+ 498+ 135
P2	D(1285) INTO PI PI RHO	135+ 135+ 769
P3	D(1285) INTO ETA PI PI	549+ 135+ 135
P4	D(1285) INTO DELTA PI	983+ 135
P5	D(1285) INTO 2PI+ 2PI-	140+ 140+ 140+ 140
P6	D(1285) INTO K*(892) KBAR	892+ 498
P7	D(1285) INTO 4PI	140+ 140+ 140+ 140

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 3	P 7
P 1	.1117+-.0266		
P 3	.2931	.4883+-.0586	
P 7	-.6152	-.9341	.4000+-.0711

8 D(1285) BRANCHING RATIOS

THE D(1285) BRANCHING RATIOS FIT IS MADE WITH THE ASSUMPTION THAT
THE D(1285) INTO 4PI DECAY IS ALWAYS VIA DECAY INTO I=1 PI PI
PAIRS (E.G., RHO PI PI).

R1		**D(1285) 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 (RHO0 PI+ PI-)/(K KBAR PI0)						

```
R2      D(1285) INTO (K KBAR PI)/(ETA PI PI)                  (P1)/(P3)
R2             0.16      0.08             CAMPBELL  69 DBC    2.7 PI+ D          1/73
R2 K           0.20      0.08             DEFOIX    72 HBC    0.7 PBAR P,7 PI    1/73
R2             0.5       0.2              CORDEN    78 OMEG   12-15PI-P          4/78
R2             0.42      0.15             GURTU     79 HBC    4.2 K- P          12/79
R2          . . . . . . . . .
R2  AVG        0.229     0.061   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
R2  FIT        0.229     0.053  FROM FIT
                         (SEE IDEOGRAM BELOW)

R2 K    K KBAR SYSTEM CHARACTERIZED BY THE I=1 THRESHOLD
R2 K    ENHANCEMENT (SEE UNDER DELTA(980)).
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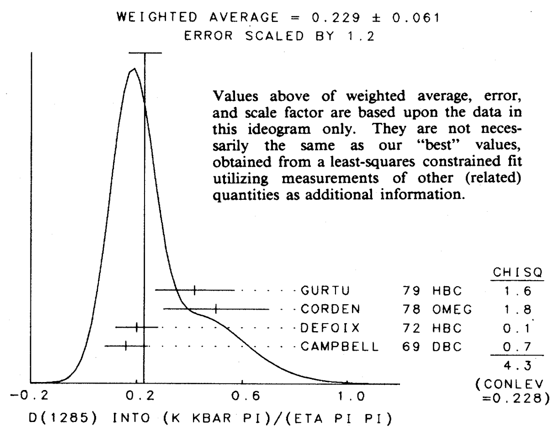


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R3      D(1285) INTO (DELTA PI)/(ETA PI PI)                   (P4)/(P3)
R3           SEEN                       DEFOIX    68 HBC      PBAR P            1/80
R3             1.0       0.3            GRASSLER  77 HBC    0 16. PI-+ P       11/77
R3             0.6       0.3      0.2   CORDEN    78 OMEG     12-15PI-P         4/78
R3             0.72      0.15           GURTU     79 HBC      4.2 K- P         12/79
R3          . . . . . . . . .
R3  AVG        0.74      0.12    AVERAGE

R4      D INTO (2PI+ 2PI- (INCL. RHO PI PI))/(ETA PI+PI-)(P5)/(2/3P3)
R4             0.46      0.15           GRASSLER  77 HBC      16. PI-+ P       11/77
R4             0.32      0.20           GURTU     79 HBC      4.2 K- P         12/79
R4          . . . . . . . . .
R4  AVG        0.41      0.12    AVERAGE
R4  FIT        0.41      0.12   FROM FIT
R5      D(1285) INTO (K*(892) KBAR)/TOTAL                     (P6)
R5           NOT SEEN                   NACASCH   77 HBC      .7+.76 PB P,KKBP 12/77

R6      D(1285) INTO (RHO0 PI+ PI-)/(2PI+ 2PI-)               (1/3P2)/(P5)
R6             1.0       0.4            GRASSLER  77 HBC      16 GEV PI+- P    11/77

R7      D(1285) INTO (RHO PI PI)/(ETA PI PI)                        (P2)/(P3)
R7 C          (0.4)  OR LESS  CL=.95    CORDEN    78 OMEG     12-15PI-P         4/78
R7 C     NOTE THAT CORDEN 78 AND GRASSLER 77 ARE IN DISAGREEMENT.
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REFERENCES FOR D(1285)


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D-ANDLAU 65 PL 17 347          +BARLOW,ADAMSON,+      (CDEF+CERN+IRAD+LIVP)
MILLER   65 PRL 14 1074        +CHUNG,DAHL,HESS,HARDY,KIRZ,+      (LRL+UCB)

BARLOW   67 NC  50 A  701      +MONTANET,D-ANDLAU+    (CERN+CDEF+IRAD+LIVP)
DAHL     67 PR 163 1377        +HARDY+HESS+KIRZ+MILLER              (LRL)I JP

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)
GOLDBERG 71 LNC 1 627          +MAKOWSKI,TOUCHARD,DONALD,+      (IPN+LIVP)  JP

BERENYI  72 NP B 37 621        +PRENTICE,STEENBERG,YOON,WALKER (TNTO+WISC)
CHAPMAN  72 NP B 42 1          +CHURCH,LYS,MURPHY,RING,VANDER VELDE (MICH)
DEFOIX   72 NP B 44 125        +NASCIMENTO,BIZZARRI,+          (CDEF+CERN)
DUBOC    72 NP B 46 429        +GOLDBERG,MAKOWSKI,DONALD,+     (LPNP+LIVP)
THUN     72 PRL 28 1733        +BLIEDEN,FINOCCHIARO,BOWEN,+    (STON+NEAS)

VUILLEMI 75 LNC 14 165         VUILLEMIN,+      (LAUS+NEUC+LPNP+LIVP+GLAS)  JP
WELLS    75 NP B 101 333       +RADOJICIC,ROSCOE,LYONS,+                (OXF)

HANDLER  76 NP B 110 173       +PLANO,BRUCKER,KOLLER+      (RUTG+STEV+SETO)
VUILLEMI 76 NC 33A 133         VUILLEMIN+       (LAUS+NEUC+LPNP+LIVP+GLAS)

GRASSLER 77 NP B 121 189       +(AACHEN+BERLIN+BONN+CERN+CRACOW+HEID+WARS)

CORDEN   78 NP B 144 253       +CORBETT,ALEXANDER,+  (BIRM+RHEL+TELA+LOWC)  JP
IRVING   78 NP B 139 327       A.C.IRVING,H.R.SEPANGI                  (LIVP)
NACASCH  78 NP B 135 203       +DEFOIX,DOBRZYNSKI,+     (PARIS+MADRID+CERN)

GURTU    79 NP B 151 181       +GAVILLET,BLOKZIJL,+    (CERN+ZEEM+NIJM+OXF)
STANTON  79 PRL 42 346         +BROCKMAN,DANKOWYCH,+  (OSU+CARL+MCGI+TNTO)  JP

BROMBERG 80 PR D 22 1513       +HAGGERTY,ABRAMS,DZIERBA(CIT+FNAL+ILLC+IND)
DE BILLY 80 NP B 176 1         +BRIAND,DUBOC,LEVY+    (CURI+LAUS+NEUC+GLAS)  JP
DIONISI  80 NP B 169 1         +GAVILLET,ARMENTEROS+ (CERN+MADR+CDEF+STOH)

EVANGELI 81 NP B 178 197       EVANGELISTA+(BARI+BONN+CERN+DARE+LIVP+MILA)

GAVILLET 82 ZPHY C 16 119      +ARMENTEROS,AGUILAR+  (CERN+CDEF+PADO+ROMA)
TORNQVIS 82 NP B 203 268       TORNQVIST                              (HELS)

PALANO   83  CERN/EP 83-107    +ARMSTRONG,APOSTOLAKIS(ATEN+BARI+BIRM+CERN)
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ϵ(1300) 14 EPSILON(1300,JPG=0++) I=0

NOTE ON S-WAVE $\pi\pi$ AND $K\bar{K}$ INTERACTIONS

In this note we discuss information on the non-strange $I^G J^{PC} = 0^+ 0^{++}$ partial wave (S wave) coupled to the $\pi\pi$ and $K\bar{K}$ systems.

The threshold behavior of elastic $\pi^+\pi^-$ scattering involves S, P, and D waves which can be sufficiently well described by the scattering lengths a_0^0, a_0^2, a_1^1, a_2^0, and a_2^2. The determination of these parameters has in the past met with great difficulties (see our 1978 edition). A consistent set of parameters has been proposed (see ALEKSEEVA 82 and references therein).

Up to the ρ meson mass region, the phase shift δ_0^0 is (qualitatively) uniquely determined: it rises monotonically and reaches 60° to 70° near 700 MeV (SONDEREGGER 69, BATON 70, BAILLON 72, CARROL 72, FRENKIEL 72, GAIDOS 72, PROTOPOPESCU 73, HYAMS 73, OCHS 73, ENGLER 74, ESTABROOKS 74,75, GRAYER 74).

In the early phase-shift analyses two solutions for δ_0^0 were found (the "up-down ambiguity") in the 700-900-MeV region. The "up" solution corresponds to an ϵ resonance under the ρ meson with mass and width similar to the ρ meson, the ϵ(800). The "down" solution is characterized by an approximately energy-independent phase shift of almost 90°, showing no resonant behavior. This ambiguity was considered resolved in favor of the "down" solution by the observation of a very rapid decrease in the modulus of the S-wave amplitude between 900 MeV and the $K\bar{K}$ threshold, followed by a sharp drop in the elasticity. δ_0^0 is ~90° at about 900 MeV and reaches ~180° around 990 MeV (FLATTE 72, GAIDOS 72, HYAMS 73, BINNIE 73, ENGLER 74). However, the region is complicated by the simultaneous presence of the S(975) resonance and the opening of the $K\bar{K}$ channel, permitting almost discontinuous jumps from one solution to another.

Without polarization information, the reaction $\pi N \rightarrow \pi\pi N$ cannot be analyzed unambiguously due to the fact that there are more helicity amplitudes than observables (see, e.g., DONOHUE 75). Thus one is obliged to make some supplementary assumptions.

An amplitude analysis (ESTABROOKS 74) of the largest $\pi^- p$ (unpolarized) $\rightarrow \pi^+\pi^- n$ experiment (HYAMS 73, GRAYER 74) still finds both the "up" and "down" solutions. This analysis assumes both spin coherence (the unnatural-parity-exchange, s-channel helicity amplitudes are nucleon spin-flip, i.e., no A(1270)-like exchange) and phase coherence (the S-wave amplitude and the unnatural-parity-exchange, meson helicity-zero P-wave amplitude have the same phase). These assumptions may tend to bias the results (MORGAN 74, DONOHUE 75,79).

The advent of $\pi^- p$ (polarized) $\rightarrow \pi^+\pi^- n$ data (BECKER 79) has made both the spin coherence and phase coherence assumptions unnecessary. Analyzing their data in a model-independent way, BECKER2 79 also find both the "up" and the "down" solutions.

The reaction $\pi^+ p \rightarrow \pi^+\pi^-\Delta^{++}$ has been analyzed in the region 660 to 860 MeV (OWENS 76, DONOHUE 79) and in the region 600 to 920 MeV (GELFAND 78), using all the information carried by the Δ^{++} decay. The conclusion from both analyses is that the $\epsilon(800)$ of the "up" solution cannot be ruled out.

The only way to rule out a narrow ϵ under the ρ meson (the "up" solution) is to study the $\pi^0\pi^0$ system. Many experiments agree that no such narrow resonance is present and that the "down" solution describes the data well (DEINET 69, SONDEREGGER 69, SHIBATA 70, BENSINGER 71, APEL 72,79, BRAUN 73, RIESTER 75, GRIVAZ 76, DAVID 77, BORREANI 79,81). The phase shifts of BISWAS 81 lie much lower than all others in the 300-700-MeV region, thus requiring a sudden phase motion in the ρ region to match the "down" solution above the ρ.

A recent amplitude analysis of the reaction $\pi^+\pi^- \rightarrow \pi^0\pi^0$ (CASON 83) has selected the so-called "down-down" solution as the only one making the $\pi^+\pi^- \rightarrow \pi^0\pi^0$ and $\pi^+\pi^- \rightarrow \pi^+\pi^-$ data consistent (as already noted by SKUJA 73). This solution "leads to a rather rapid phase variation at approximately 750 MeV and a phase shift which goes through 90° at about 800 MeV" (CASON 83) (see Fig. 1).

Additional information on the $\pi\pi$ scalar states is emerging from the study of meson pair production in $\gamma\gamma$ scattering. A recent analysis of available data (MENESSIER 83) argues in favor of a very broad low-mass scalar in the 500-700-MeV region.

The region of elastic $\pi\pi$ scattering is known to extend to about 990 MeV, near the $K\bar{K}$ threshold (BATON 70, CARROLL 72, PROTOPOPESCU 73,

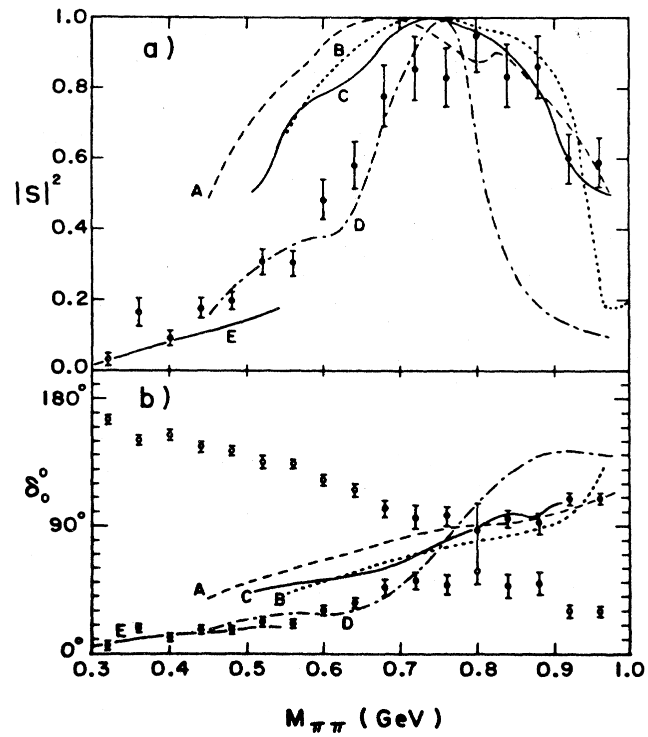

Fig. 1. (a) Extrapolated S-wave intensity as a function of the $\pi^0\pi^0$ mass. (b) I = 0, S-wave phase shifts. From CASON 83.

HYAMS 73, OCHS 73). Beyond 1 GeV we therefore have to consider the two channels $\pi\pi$ and $K\bar{K}$, and beyond 1100 MeV the $\eta\eta$ channel also opens up. In addition, the solutions have inherent ambiguities related to the Barrelet zeros of the amplitudes. Thus HYAMS 75 find four solutions in the region 1.0 to 1.8 GeV, ESTABROOKS 74 find eight solutions, and CORDEN 79, extending the $\pi\pi$ analysis to 2.08 GeV, find another eight solutions.

In the past many of these solutions have been ruled out by imposing continuity in various ways, as well as analyticity and unitarity (FROGGATT 75,77, COMMON 76, MARTIN 78).

One notes that a model-independent partial-wave analysis (BECKER2 79 on polarized target) agrees qualitatively with solutions β and β' (of MARTIN 78).

The β and β' amplitudes describe the experimental moments in each bin without any explicit smoothing; they are analytic in s and approximately analytic in $\cos\theta$. They take into account all waves up to $\ell = 4$. The β solution has a highly elastic S wave, whereas the

For notation, see key at front of Listings.

Mesons

$\epsilon(1300)$

S wave of solution β' is somewhat inelastic (MARTIN 78). The unique solution of FROGGATT 77, which has explicit smoothness built in and which takes account only of $\ell \leq 3$ waves, is rather similar to β. However, it has problems with unitarity, apparently because of the neglected G wave (MARTIN 78).

The S wave is clearly resonant in the data of BECKER2 79. In the 1150-1400-MeV region both the S-P and S-D phase differences show the presence of a broad resonance, and the intensity of the S wave confirms this by exhibiting a peak at about 1300 MeV with a width of about 300 MeV.

The amplitude analysis of the $\pi^- p \to \pi^+\pi^- n$ experiment of CORDEN 79 has two preferred solutions which are close to β and β', giving some support for an $\epsilon(1300)$. Also the S wave in the $\pi^0\pi^0$ system tends to confirm the $\epsilon(1300)$ by staying near its unitarity limit around 1200 MeV (APEL 79).

The new results on $\pi^+\pi^- \to \pi^0\pi^0$ (CASON 83) establish that the only solutions consistent with the data are the β and β', in agreement with BECKER2 79. That implies a significant $\pi\pi$ coupling of the $\rho(1600)$.

Independent evidence for the $\epsilon(1300)$ comes from studies of the $K\bar{K}$ systems. In the reaction $\pi^- p \to K^0_S K^0_S n$, the S wave exhibits a large intensity in the 1300-MeV region (WETZEL 76, LOVERRE 80, ETKIN 82) with evidence for a bump. Moreover, the Y^2_0 moment shows a large negative excursion indicating S-D interference (CASON 76, WETZEL 76, POLYCHRONAKOS 79, GOTTESMAN 80, LOVERRE 80, ETKIN 82). The main problem was the isospin of the bump: if OPE were the only mechanism, I = 0 would be assured. The new high-statistics data (ETKIN 82), in the restricted t′ region smaller than 0.1 GeV^2, strongly argues in favor of OPE dominance and assigns the observed effects to the $I^G = 0^+$ state.

An enhancement in the intensity of the S wave around 1300 MeV has also been observed in the K^+K^- system produced in $\pi^- p$, $\pi^+ n$, and $\pi^- p$ (polarized) scattering. Again contributions from the I = 0 and I = 1 states may be present (PAWLICKI 77, MARTIN 79, COHEN 80, COSTA 80, GORLICH 80, WICKLUND 80).

To get from the mass-independent S-wave amplitudes and S-D relative phase to resonance parameters and $q\bar{q}$ composition several assumptions have to be made. Various analyses (PAWLICKI 80, ETKIN2 83) reach contradictory results concerning the number and properties of the resonance states coupled to the $I^G = 0^+$ system.

Recently, two fully unitarized coupled-channel analyses have been performed (ACHASOV 79,80,81, TORNQVIST 82) giving fairly consistent results.

The picture emerging (TORNQVIST 82) is that of a dominantly $q\bar{q}$ system with large $q\bar{q}q\bar{q}$ components in the form of virtual two-meson bound states. At the SU(3) level, two isoscalar resonances are needed, a narrow S(975) superimposed on a broad ϵ. The position and width of the S(975) are well determined by the interference with the ϵ, visible as a dip in the $\pi\pi \to \pi\pi$ cross section.

The interpretation of the S(975) as a $q\bar{q}q\bar{q}$ system is another possiblity.

The mass and width of the ϵ, however, are difficult to define in any simple way, its Breit-Wigner shape being completely distorted by hadronic mass-renormalization effects (cusps) from the $\pi\pi$, $K\bar{K}$, and $\eta\eta$ channels (MORGAN 74, ACHASOV 79,80,81, IRVING 81, TORNQVIST 82).

For further discussion of the scalar nonet, see the mini-reviews under $\delta(980)$ and $\kappa(1350)$.

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                  14  EPSILON(1300) MASS (MEV)

M        (1256.0)                    FROGGATT  77 RVUE   PI+PI- CHANNEL     12/77
M        (1270.)  APPROX.            MARTIN    78 RVUE   PI+PI- CHANNEL     12/77
M        (1300.)  APPROX.            POLYCHRON 79 STRC   7. PI-P,KS KS N    12/79
M         1425.      15.             WICKLUND  80 SPEC   6. PI N,K+ K- N     9/81
M        (1394.)                     IRVING    81 RVUE   PI+PI-,K KBAR CH    3/82
M         1463.0      9.0            ETKIN1    82 MPS    23 PI-P,2K0S N      9/83*
M   C     1470.0     30.0            ETKIN2    82 MPS    23 PI-P,2K0S N      9/83*
M        (1237.)   APPROX            TORNQVIST 82 RVUE                       1/82
M         . . . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 1.6)

M   C    FIT INCLUDES INTERFERING G/S(1240) RESONANCE. SYSTEMATIC
M   C    ERROR ADDED LINEARLY BY US.

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                  14  EPSILON(1300) WIDTH (MEV)

W   E     (400.)  APPROX.            FROGGATT  77 RVUE   PI+PI- CHANNEL     12/77
W         (150.)  APPROX.            POLYCHRON 79 STRC   7. PI-P,KS KS N    12/79
W          160.      30.             WICKLUND  80 SPEC   6. PI N,K+ K- N     9/81
W P       (220.)                     IRVING    81 RVUE   PI+PI-,K KBAR CH    3/82
W          118.0    138.0     16.0   ETKIN1    82 MPS    23 PI-P,2K0S N      9/83*
W   C      140.0     30.0            ETKIN2    82 MPS    23 PI-P,2K0S N      9/83*
W        (1400.)   APPROX.           TORNQVIST 82 RVUE                       1/82
W   AVERAGE MEANINGLESS

W   C    FIT INCLUDES INTERFERING G/S(1240) RESONANCE. SYSTEMATIC
W   C    ERROR ADDED LINEARLY BY US.
W    E   WIDTH DEFINED AS DISTANCE BETWEEN 45 AND 135 DEGREES PHASE SHIFT.
W P      FROM POLE POSITION

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                  14  EPSILON(1300) PARTIAL DECAY MODES

                                                            DECAY MASSES
P1      EPSILON(1300) INTO PI PI                           140+ 140
P2      EPSILON(1300) INTO K KBAR                          498+ 498
P3      EPSILON(1300) INTO ETA ETA                         549+ 549

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                  14  EPSILON(1300) BRANCHING RATIOS

R1      EPSILON(1300) INTO (PI PI)/TOTAL                  (P1)
R1           (0.73)                  HYAMS     75 ASPK     17.2 PI-P,PI+PI-   9/81
R1            0.936     0.019  0.015 GORLICH   80 ASPK     17,18 PI-P POLAR   9/81
R1           (0.93)                  LOVERRE   80 HBC      4. PI- P,K K N     9/81
R1           (0.93) APPROX.          TORNQVIST 82 RVUE                        1/82

R2      EPSILON(1300) INTO (K KBAR)/(PI PI )              (P2)/(P1)
R2            0.08      0.01         COSTA     80 OMEG   0 10 PI-P,K+ K- N    1/82
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Mesons

Data Card Listings

ϵ(1300), π(1300)

REFERENCES FOR EPSILON(1300)

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)

BETTINI 66 NC 42A 695 +CRESTI,LIMENTANI,LORIA,PERUZZO+(PADO+PISA)
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)
BEUSCH 67 PL 25 B 357 +FISCHER,GOBBI,ASTBURY+ (ETH+CERN)
CLEGG 67 PR 163 1664 A.B.CLEGG (LANCASTER)
CORBETT 67 PR 156 1451 +DAMERELL+MIDDLEMAS+NEWTON (OXF+RHEL)
GUTAY 67 PRL 18 142 +JOHNSON+LOEFFLER+MCILWAIN+ (PURDUE+LRL)
JOHNSON 67 PR 163 1497 +GUTAY,EISNER,KLEIN,PETERS,SAHNI,YEN+(PURD)
MALAMUD 67 PRL 19 1056 E.MALAMUD + P.E.SCHLEIN (UCLA)
WALKER 67 RMP 39 695 W.D.WALKER (WISCONSIN)
WALKER 67 PRL 18 630 +CARROLL,GARFINKEL,OH (WISCONSIN)

BANDER 68 PR 168 1679 +SHAW,FULCO (UC IRVINE+S.BARBARA)
BISWAS 68 PL 27 B 513 +CASON,JOHNSON,KENNEY,POIRIER+ (NDAM)
BRAUN 68 PRL 21 1275 BRAUN,CLINE,SCHERER (WISCONSIN)
DUTTA-RO 68 PR 169 1357 B. DUTTA-ROY, I.R. LAPIDUS (STEV)
EISENHAN 68 PRL 20 758 EISENHANDLER,MISTRY,MOSTEK + (CORNELL)
FOSTER 68 NP B 6 107 +GAVILLET+LABROSSE+MONTANET+ (CERN+CDEF)
HYAMS 68 NP B7 1 +KOCH,POTTER,..VON LINDERN,LOREN(CERN+MPIM)
JONES 68 PR 166 1405 +CALDWELL+ZACHAROV+HARTING+BLEULER+ (CERN)
JOHNSON 68 PR 176 1651 +POIRIER,BISWAS,GUTAY+ (NDAM+PURD+SLAC)
LOVELACE 68 PL 28 B 264 C.LOVELACE (CERN)
MARATECK 68 PRL 21 1613 +HAGOPIAN,+ (PENN+LRL+COLO+PURD+TNTO+WISC)

BIZZARRI 69 NP B14 169(SEE P.190)+FOSTER,GAVILLET,GHESQUIERE+ (CERN+CDEF)
DAVISON 69 PR 180 1333 +BACASTOW,BARKAS,+ (UCR+UCB)
DEINET 69 PL 30 B 359 +MENZIONE,MULLER,STAUDENMAIER,+ (KARL+CERN)
ELY 69 PR 180 1319 +GIDAL,HAGOPIAN,+ (UCB+LOUC+WISC)
FELDMAN 69 PRL 22 316 +FRATI,GLEESON,HALPERN,NUSSBAUM,+ (PENN)
GUTAY 69 NP B 12 31 +CARMONY,CSONKA,LOEFFLER,MEIERE (PURDUE)
HALL 69 NP B 12 573 +MURRAY,RIDDIFORD (BIRMINGHAM)
HOPKINSO 69 NC 59 A 181 J.HOPKINSON,R.G.ROBERTS (CERN)
MALAMUD 69 ARGONNE CONF.P.93 E.MALAMUD, P.SCHLEIN (UCLA)
MORGAN 69 NP B 10 261 D.MORGAN,G.SHAW (RHEL)
ROBERTS 69 PL 29 B 368 R.G. ROBERTS, F. WAGNER (CERN)
SCHAREN1 69 ARGONNE CONF.306 SCHARENGUIVEL (PURDUE)
SCHAREN2 69 PR 186 1387 SCHARENGUIVEL(PURD+LRL+CERN+COLO+PENN+TNTO)
SMITH 69 PRL 23 335 G.A.SMITH, R.J.MANNING (MSU+LRL)
SONDEREG 69 SEE BASDEVANT 72 SONDEREGGER,BONAMY (SACL)
STRUGALS 69 PL 29 B 518 +CHUVILO,FENYVES,+ (WARS+JINR+BUDA)
ALSO 70 NP B 24 358 STRUGALSKI,CHUVILO,FENYVES,GEMESY,+ (DUBNA)
WAGNER 69 NC 64 A 189 F.WAGNER (CERN)

BARTSCH 70 NP B 22 1 +KEPPEL,GENSCH,MORRISON,+ (AACH+BERL+CERN)
BATON 70 PL 33 B 528 +LAURENS,REIGNIER (SACLAY)
BRODY 70 PRL 24 948 +GROVES,VANBERG,MAGLIC+(PENN+RUTG+UPNJ+ANL)
DIAZ 70 NP B 16 239 +GAVILLET,LABROSSE,MONTANET+ (CERN+CDEF)
HYAMS 70 PHILAD.CONF.P.41 +SCHLEIN,BEUSCH,+ (CERN+MPIM+ETH+LOIC+HAWA)
MAUNG 70 PL 33 B 521 +MASEK,MILLER,RUDERMAN,VERNON,+ (UCSD+LRL)
MORGAN 1 70 SPRINGER TRACTS MOD.PHYS.,VOL.55,P.1. MORGAN,PISUT(RHEL+CERN)
MORGAN 2 70 PR D 2 520 D.MORGAN,G.SHAW (RHEL)
NIELSEN 70 NP B 22 525 +LYNG-PETERSEN,PIETARINEN (NORDITA)
OH 70 PR D 1 2494 +GARFINKEL,MORSE,WALKER,PRENTICE(WISC+TNTO)
SCHARENG 70 NP B 22 16 SCHARENGUIVEL,GUTAY,MILLER,+ (PURD+PENN)
SHIBATA 70 PRL 25 1227 +FRISCH,WAHLIG (MIT)

ALSTON-G 71 PL 36 B 152 ALSTON-GARNJOST,BARBARO-GALTIERI,+ (LBL)
BANAIGS 71 NP B 28 509 +BERGER,DUFLO,GOLDZAHL,COTTEREA+(SACL+CAEN)
BEAUPRE 71 NP B 28 77 +DEUTSCHMANN,GRAESSLER,+ (AACH+BERL+CERN)
BENSINGE 71 PL 36 B 134 BENSINGER,ERWIN,THOMPSON,W.D.WALKER (WISC)
DUBAL 71 NP B 32 535 L.DUBAL,D.J.BROWN (CNRC+CARL)
GUILLOU 71 NC 5 A 659 LE GUILLOU,MOREL,NAVELET (CERN)
GUTAY 71 NP B 27 486 +SCHARENGUIVEL,FUCHS,GAIDOS,MILLER,+ (PURD)
HAMILTON 71 SPRINGER TRACTS MOD.PHYS.,VOL. 57,P.41 J.HAMILTON (NORDITA)
KIM 71 PR D 4 265 +BANDER (UCI)
LYNG PET 71 PHYS.REPRTS 2 155 J.LYNG PETERSEN (REVIEW) (CERN)

APEL 72 PL 41 B 542 +AUSLANDER,MULLER,BERTOLUCCI,+ (KARL+PISA)
BAILLON 72 PL 38 B 555 +CARNEGIE,KLUGE,LEITH,LYNCH,RATCLIFF+(SLAC)
BASDEVAN 72 PL 41 B 178 BASDEVANT,FROGGATT,PETERSEN (CERN)
BRODY 1 72 PRL 28 1215 +GROVES,MAGLICH,NOREM,+ (PENN+RUTG+UPNJ)
BRODY 2 72 PRL 28 1217 H.BRODY (PENNSYLVANIA)
CARROLL 72 PRL 28 318 +DIAMOND,FIREBAUGH,MATTHEWS,+ (WISC+TNTO)
ELVEKJAE 72 NP B 43 445 F.ELVEKJAER (AARHUS)
FLATTE 72 PL 38 B 232 +ALSTON-GARNJOST,BARBARO-GALTIERI, (LBL)
FRENKIEL 72 NP B 47 61 +GHESQUIERE,LILLESTOL,CHUNG,+ (CDEF+CERN)
GAIDOS 72 NP B 46 449 +MCILWAIN,THOMPSON,WILLMANN (PURDUE)
PRASAD 72 PR D 6 3216 +BREHM (UNIV.OF MASSACHUSETTS)
NIELSEN 72 NP B 49 586 H.NIELSEN,G.OADES (NORD+AARHUS)
WHITEHEA 72 NP B 48 365 WHITEHEAD,AULD,+ (AERE+RHEL+SHMP+LOUC)
WILLIAMS 72 PR D 6 3178 P.K.WILLIAMS (FSU)
ZYLBERSZ 72 PL 38 B 457 ZYLBERSZTEJN,BASILE,BOURQUIN,+ (GEVA+SACL)

ANJOS 73 NP B 67 37 +D.LEVY,A.SANTORO (SACLAY)
BANAIGS1 73 PL 43 B 535 +COTTEREAU,FABBRI,+ (SACL+CAEN+FRAS)
BANAIGS2 73 NP B 67 1 +BERGER,GOLDZAHL,COTTEREAU,+ (SACL+CAEN)
BASDEVAN 73 AIX CONF.P.220 J.L.BASDEVANT RAPPORTEUR TALK (PARIS VI)
BEIER 73 PRL 30 399 +BUCHHOLZ,MANN,PARKER,ROBERTS (PENN)
BINNIE 73 PRL 31 1534 +CARR,DEBENHAM,DUANE,GARBUTT,+ (LOIC+SHMP)
BRAUN 73 PR D 8 3794 +D.CLINE (WISC)
HYAMS 73 NP B 64 134 +JONES,WEILHAMMER,BLUM,DIETL,+ (CERN+MPIM)
FOR OTHER RESULTS ON SAME EXPERIMENT SEE GRAYER 74
OCHS 73 THESIS THESIS (MPIM)
PILKUHN 73 NP B 65 460 +SCHMIDT,MARTIN,+ (KARL+CERN+LOUC+NIJM)
PROTOPOP 73 PR D 7 1280 PROTOPOPESCU,GARNJOST,GALTIERI,FLATTE+(LBL)
RISSER 73 PL 43 B 68 T.RISSER,M.D.SHUSTER (SACL)
SKUJA 73 PRL 31 653 +WAHLIG,RISSER,PRIPSTEIN,NELSON,+ (LBL)

BASDEVAN 74 NP B 72 413 BASDEVANT,FROGGATT,PETERSEN (LPTP+NORD)
BONNIER 74 NP B 83 440 B.BONNIER,N.JOHANNESSON (CERN)
CARROLL 74 PR D 10 1430 +MATTHEWS,WALKER+ (SLAC+DUKE+WISC+TNTO)
ENGLER 74 PR D 10 2070 +KRAEMER,TOAFF,WEISSER,DIAZ+ (CARN+CASE)
ESTABROO 74 NP B 79 301 P.ESTABROOKS,A.D.MARTIN (DURH)
GRAYER 74 NP B 75 189 +HYAMS,JONES,BLUM,DIETL (CERN+MPIM)
JONES 74 NP B 83 93 +ALLISON,SAXON (OXF)
MORGAN 74 PL 51 B 71 D.MORGAN (RHEL)
ORITO 74 PL 48 B 380 +FERRER,PAOLUZI,SANTONICO (FRAS+ROMA)
PASCUAL 74 NP B 83 362 P.PASCUAL,F.J.YNDURAIN (BARC+MADU)

BAR-NIR 75 NP B 87 109 +RISSER,SHUSTER (CERN+UCSB+TELA)
BARRY 75 NP B 85 239 G.W.BARRY (PURD)
BASDEVAN 75 NP B 98 285 BASDEVANT,CHAPELLE,LOPEZ,SIGELLE (LPTP)
DONOHUE 75 NC 25 A 409 J.T.DONOHUE,Y.LEROYER (BORD)
ESTABROO 75 NP B 95 322 P.ESTABROOKS,A.D.MARTIN (DURH)
FROGGATT 75 NP B 91 454 C.D.FROGGATT,J.L.PETERSEN (GLAS+NORD)
FUJII 75 NP B 85 179 Y.FUJII,M.FUKUGITA (TOKY)
HYAMS 75 NP B 100 205 +JONES,WEILHAMMER,BLUM,DIETL+ (CERN+MPIM)
MORGAN 75 ARGONNE CONF. 45 D.MORGAN (RHEL)
RIESTER 75 NP B 96 407 +ARNOLD,ENGEL,PATY (STRB)
SHIMADA 75 NP B 100 225 T.SHIMADA (TOKY)
SRINIVAS 75 PR D 12 681 SRINIVASAN,HELLAND,LENNOX,KLEM+ (NDAM+ANL)

BANAIGS 76 NP B 105 52 +BERGER,GOLDZAHL,COTTEREAU+(SACL+CAEN+FRAS)I,JP
CASON 76 PRL 36 1485 +POLYCHRONAKOS,BISHOP,BISWAS,+ (NDAM+ANL)I J
CERRADA 76 PL 62 B 353 +GONZALEZ-ARROYO,RUBIO,YNDURAIN (CERN+MADR)
COMMON 76 NP B 103 109 A.K.COMMON (KENT) JP
FLATTE 76 PL 63 B 228 S.M.FLATTE (CERN)
GRIVAZ 76 PL 61 B 400 +DAVIS,HALSTEINSLID,IRWIN,+(LALO+BERG+EPOL)
OWENS 76 NP B 112 514 +EISNER,CHUNG,PROTOPOPESCU (CASE+BNL)
PAWLICKI 76 PRL 37 1666 +AYRES,COHEN,DIEBOLD,KRAMER,WICKLUND (ANL)I,JP
WETZEL 76 NP B 115 208 +FREUDENREICH,BEUSCH,+ (ETH+CERN+LOIC)

FROGGATT 77 NP B 129 89 +PETERSEN (GLASGOW+COPENHAGEN)
DAVID 77 PR D 16 2027 +VILLET,AYED,BAREYRE,BORGEAUD,+ (SACL)
MARTIN 77 NP B 121 514 +OZMUTLU,SQUIRES (DURHAM)
PAWLICKI 77 PR D 15 3196 +AYRES,COHEN,DIEBOLD,KRAMER,WICKLUND (ANL)I J
ROSSELET 77 PR D 15 574 +EXTERMANN,FISHER,BERGER,BLOCH,+(GEVA+SACL)

AGUILAR 78 NP B 140 73 +CERRADA,+ (MADRID+BOMBAY+CERN+PARIS)
GELFAND 78 NP B 138 365 +DAGAN,LISSAUER,OREN,ABRAMS+ (TELA+UCB)
HOLMGREN 78 PL 77 B 304 +PENNINGTON (STOH+CERN)
MARTIN 78 ANP 114 1 A.D.MARTIN,M.R.PENNINGTON (CERN)

ACHASOV 79 PL B 88 367 +DEVYANIN,SHESTAKOV (NOVO)
APEL 79 NP B 160 42 +AUSLANDER,MULLER,REHAK+ (KARL+PISA)
BECKER 1 79 NP B 150 301 +BLANAR,BLUM,CERRADA+ (MPIM+CERN+ZEEM+CRAC)
BECKER 2 79 NP B 151 46 +BLANAR,BLUM,CERRADA+ (MPIM+CERN+ZEEM+CRAC)
BORREANI 79 NP B 147 28 +FISHER,GUY,ELY,LEUTZ,+(TORI+RHEL+LBL+CERN)
CORDEN 79 NP B 157 250 +DOWELL,GARVEY,JOBES,+(BIRM+RHEL+TELA+LOWC) JP
DONOHUE 79 NP B 158 123 +LEROYER (BORD+ANL+OXF)
ESTABROO 79 PR D 19 2678 P.ESTABROOKS (CARL)
GREENHUT 79 PR D 20 2326 +INTEMANN (SETO)
JAFFE T 79 PR D 19 2105 R.L.JAFFE,F.E.LOW (MIT)
MARTIN 79 NP B 158 520 +OZMUTLU (DURH)I,JP
POLYCHRO 79 PR D 19 1317 POLYCHRONAKOS,CASON,BISHOP+ (NDAM+ANL)I,JP

ACHASOV 80 SJNP 32 566 +DEVYANIN,SHESTAKOV (NOVO)
BOHACIK 80 PR D 21 1342 J.BOHACIK,H.KUHNELT (BRATISLAVA+WIEN)
COHEN 80 PR D 22 2595 +AYRES,DIEBOLD,KRAMER,PAWLICKI+ (ANL)I,JP
COSTA 80 NP B 175 402 + (BARI+BONN+CERN+GLAS+LIVP+MILA+WIEN)
DE BILLY 80 NP B 176 1 +BRIAND,DUBOC,LEVY+ (CURI+LAUS+NEUC+GLAS) JP
GORLICH 80 NP B 174 16 +NICZYPORUK,ROZANSKA+ (CRAC+MPIM+CERN+ZEEM)
GOTTESMA 80 PR D 22 1503 GOTTESMAN,JACOBS,+ (SYRA+BRAN+BNL+CINC)
LOVERRE 80 ZPHY C 6 187 +ARMENTEROS,DIONISI+ (CERN+CDEF+MADR+STOH)I,JP
WICKLUND 80 PRL 45 1469 +AYRES,COHEN,DIEBOLD,PAWLICKI (ANL)

ACHASOV 81 PL 102 B 196 +DEVYANIN,SHESTAKOV (NOVO)
AGUILAR 81 ZPHY C 10 299 AGUILAR-BENITEZ,DONE,MARTIN (MADR+DURH)
AGUILAR2 81 ZPHY C 8 313 +ALBAJAR,ARMENTEROS,+ (CERN+CDEF+MADR+STOH)
BOREANI 81 NP B 187 42 +GUY,MARCHETTO,MAURIZIO,+ (TORI+RHEL+CERN)
BISWAS 81 PRL 47 1378 +CASON,BAUMBAUGH,BISHOP,CANNATA,+(NDAM+ANL)
BRANDELI 81 ZPHY C 10 117 BRANDELIK+ (AACH+BONN+DESY+HAMB+LOIC+OXF+)
GIDAL 81 PL 107 B 153 +GOLDHABER,GUY,MILLIKAN,ABRAMS,+ (SLAC+LBL)
IRVING 81 ZPHY C 10 45 +MARTIN,DONE (LIVP+DURH)

ACHASOV 82 TP 20(130) +DEVYANIN,SHESTAKOV (NOVO)
ALEKSEEV 82 JETP 55 591 ALEKSEEVA,KARTAMYSHEV,MAKARIN+ (KIAE)
CASON 82 PRL 48 1316 +BISWAS,BAUMBAUGH,BISHOP,CANNATA+(NDAM+ANL)
ETKIN1 82 PR D 25 1786 +FOLEY,LAI,LINDENBAUM+ (BNL+CUNY+TUFT+VAND)
ETKIN2 82 PR D 25 2446 +FOLEY,LAI,LINDENBAUM+ (BNL+CUNY+TUFT+VAND)
SCHNITZE 82 PR B 117 96 H.SCHNITZER (BRAN)
TORNQVIS 82 PRL 49 624 N.A.TORNQVIST (HELS)

BAUBILLI 83 ZPHY C 17 309 BAUBILLIER+ (BIRM+CERN+GLAS+MSU+LPNP)
CASON 83 PR D 28 1586 +CANNATA,BAUMBAUGH,BISHOP,WATSON+(NDAM+ANL)
HITLIN 83 CORNELL CONF. 746 DAVID HITLIN, RAPPORTEUR'S TALK (CIT)
MENNESSI 83 ZPHY C 16 241 G.MENNESSIER (MONP)
TORNQVIS 83 EMS CONFERENCE N.A.TORNQVIST (HELS)

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π(1300) 58 PI(1300,JPG=0--) I=1

SEEN IN PARTIAL WAVE ANALYSIS OF THE
DIFFRACTIVELY PRODUCED 3 PI SYSTEM.

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58 PI(1300) MASS (MEV)

M	E	1273.0	50.0	AARON	81 RVUE			1/82
M		1342.	20.	BONESINI	81 OMEG	12 PI-P,3PI P		1/82
M		(1400.)	APPROX.	DAUM	81 SPEC	63,94 PI- P		1/82
M		1240.	30.	BELLINI	82 SPEC	40 PI-A,3PI A		8/83*
M		. . . .						
M	AVERAGE MEANINGLESS (SCALE FACTOR = 2.1)							

M E USES MULTICHANNEL AITCHISON-BOWLER MODEL.
M E USES DATA FROM DAUM 80 AND DANKOWYCH 81.

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58 PI(1300) WIDTH (MEV)

W	E	580.0	100.0	AARON	81 RVUE		1/82
W		220.	70.	BONESINI	81 OMEG	12 PI-P,3PI P	1/82
W		(600.)	APPROX.	DAUM	81 SPEC	63,94 PI- P	1/82
W		360.	120.	BELLINI	82 SPEC	40 PI-A,3PI A	8/83*
W		. . . .					
W	AVERAGE MEANINGLESS (SCALE FACTOR = 2.1)						

W E USES MULTICHANNEL AITCHISON-BOWLER MODEL.
W E USES DATA FROM DAUM 80 AND DANKOWYCH 81.

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58 PI(1300) PARTIAL DECAY MODES

		DECAY MASSES
P1	PI(1300) INTO RHO PI	769+ 140
P2	PI(1300) INTO EPSILON(1300) PI	1300+ 140
P3	PI(1300) INTO PI (PI PI) S WAVE	140+ 140+ 140

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For notation, see key at front of Listings.

Mesons

π(1300), A_2(1320)

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                      58  PI(1300) BRANCHING RATIOS

R1     PI(1300) INTO (PI (PI PI) S WAVE/(RHO PI)          (P3)/(P1)
R1 E          (2.12)                  AARON      81 RVUE                       3/82
R1 E    USES MULTICHANNEL AITCHISON-BOWLER MODEL.
R1 E    USES DATA FROM DAUM 80 AND DANKOWYCH 81.

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                                 REFERENCES FOR PI(1300)

DAUM      80 PL 80 B 281          +HERTZBERGER+(AMST+CERN+CRAC+MPIM+OXF+RHEL)

AARON     81 PR D 24 1207         +LONGACRE                        (NEAS+BNL)
BELLINI   81 LISBON CONF. 413     +IVANSHIN,FRABETTI,+        (MILA+JINR+BGNA)
BONESINI  81 PL 103 B 75          +DONALD,+    (MILA+LIVP+DARE+CERN+BARI+BONN)
DANKOWYC  81 PRL 46 580           +BROCKMAN,EDWARDS+(TNTO+BNL+CARL+MCGI+OHIO)
DAUM      81 NP B 182 269         +HERTZBERGER+(AMST+CERN+CRAC+MPIM+OXF+RHEL)
EVANGELI  81 NP B 178 197         EVANGELISTA+(BARI+BONN+CERN+DARE+LIVP+MILA)

BELLINI   82 PRL 48 1697          +FRABETTI,IVANSHIN,LITKIN+ (MILA+BGNA+JINR)

LEEDOM    83 PR D 27 1426         +DE BONTE,GAIDOS,KEY,WONG+       (PURD+TNTO)

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A_2(1320)

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                12  A2(1320,JPG=2+-) I=1

                ONLY EXPERIMENTS GIVING MASS ERROR LESS THAN 15 MEV
                ARE KEPT FOR AVERAGING.

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                12  A2 MASS (MEV),  3PI MODE

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           1310.0     14.0              EISENBERG 69 HBC  +  4.3,5.3 GAMMA P  12/69
M       941 1306.0      4.0              ALSTON    70 HBC  +  7.0 PI+P,3PI P    1/71
M       280 1313.0      7.0              BOCKMANN  70 HBC     05. PI+P          5/70
M       360 1304.0      4.5              BARNHAM   71 HBC  +  3.7 PI+ P,(3PI)+ 11/71
M     10000 1307.       5.               BINNIE1   71 MMS   - PI-P NEAR A2 THR 11/71
M      5000 1309.       5.               BINNIE1   71 MMS   - PI-P NEAR A2 THR 11/71
M     28000 1299.0      6.0              BOWEN     71 MMS   - 5. PI- P         11/71
M     24000 1300.       6.0              BOWEN     71 MMS  +  5. PI+ P         11/71
M     17000 1309.0      4.0              BOWEN     71 MMS   - 7. PI- P         11/71
M       160 1307.       7.               BLOODWORT 72 HBC  +  5.45 PI+ P,P 3PI  1/73
M  P        1315.       5.               ANTIPOV1  73 CNTR -  25.,40. PI- P     1/74
M      1580 1306.       9.               CHALOUPKA 73 HBC  -  3.9 PI- P,P A2    2/73
M  P   1600 1318.       7.               EMMS      75 DBC     04.  PI+N,P A20  11/75
M  P   1200 1298.       8.               WAGNER    75 HBC     07.  PI+P,DEL++A2 11/75
M      1097 1320.0     10.0              BALTAY 1  78 HBC  +0 15 PI+P,P 4PI     4/78
M   P   490(1343.0)   (11.0)             BALTAY 1  78 HBC   0 15 PI+P,DEL 3PI   4/78
M          (1285.0)    (9.0)             CORDEN 2  78 OMEG  - 12-15 PI-P,3PI N  4/78
M           1306.0      8.0              FERRER    78 OMEG  - 9 PI-P,P 3PI      4/78
M  P 25000 1317.0      2.0              DAUM      80 SPEC  - 63,94 PI- P= 3PI 12/79
M  P        1310.       2.               EVANGELIS 81 OMEG  - 12 PI-P,3PI P     1/82
M           . . . . . . . . . . .
M   AVG     1310.7      1.3     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
                       (SEE IDEOGRAM BELOW)

M  P     FROM A FIT TO JP=2+ RHO PI PARTIAL WAVE
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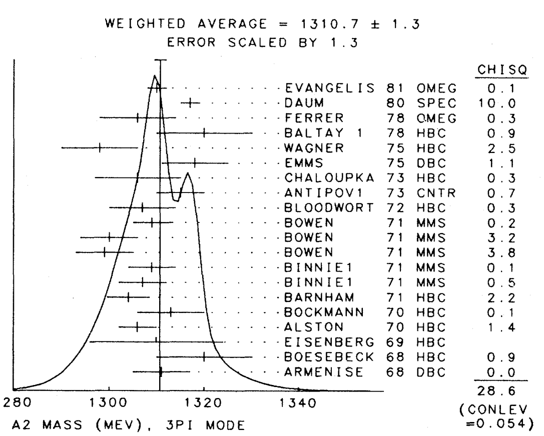


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                12  A2 MASS (MEV), CHARGED K KBAR MODE

MK S  1500 1319.0      3.0               GRAYER    71 ASPK  - 17.2 PI-P,K-KS P  2/72
MK     730 1313.0      4.0               FOLEY     72 CNTR  - 20.3 PI- P,K- KS 12/72
MK    2724 1320.0      2.0               MARGULIES 76 SPEC  - 23.PI-P,K-KS     12/77
MK   11000 1312.0      4.0               CHABAUD   78 SPEC   -9.8 PI-P,K- KS P  4/78
MK    4730 1316.0      2.0               CHABAUD   78 SPEC  - 18.8PI-P,K- KS P  4/78
MK     350 1324.0      5.0               HYAMS     78 ASPK +  12.7 PI+P,K+KS P  4/78
MK P S     1318.       1.                MARTIN 1  78 SPEC   -10 PI P,KS K- P   4/78
MK    4000 1320.0      2.0               CHABAUD   80 SPEC  - 17PI-NUCLEI,KSK- 12/79
MK P W1000 1330.0     11.0               CLELAND   82 SPEC +  30 PI+P,KS K+ P   8/83*
MK P W4700 1319.0      5.0               CLELAND   82 SPEC +  50 PI+P,KS K+ P   8/83*
MK P W5200 1324.0      6.0               CLELAND   82 SPEC -  50 PI-P,KS K- P   8/83*
MK         . . . . . . . . . . .
MK  AVG    1318.22     0.70    AVERAGE

MK S     SYSTEMATIC ERROR IN MASS SCALE SUBTRACTED
MK   W   NUMBER OF EVENTS EVALUATED BY US.

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                12  A2 MASS (MEV),  ETA PI MODE

M  E  1000 1323.        8.               KEY       73 OSPK -  6.PI-P,P PI-ETA   1/74
M  EM 6200(1324.)      (8.)              CONFORTO  73 OSPK -  6.PI-P,P MMS-     1/74
M     2561 1336.2       1.7              DELFOSSE  81 SPEC +  PI+-P,PI+-ETA P   1/82
M     1653 1330.7       2.4              DELFOSSE  81 SPEC -  PI+-P,PI+-ETA P   1/82
M          . . . . . . . . . . .
M   AVG    1334.0       2.6     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.9)

M  E    ERROR INCLUDES 5 MEV SYSTEMATIC MASS-SCALE ERROR
M   M   MISSING MASS WITH ENRICHED MMS=ETA PI-, ETA = 2 GAMMA

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                12  A2 WIDTH (MEV), 3PI MODE

W      260   96.0      16.0              ARMENISE  68 DBC    0 5.1 PI+D         9/67
W      941   79.0      12.0              ALSTON    70 HBC  +  7.0 PI+P,3PI P    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        115.       15.               ANTIPOV1  73 CNTR -  25.,40. PI- P     1/74
W     1580   99.       15.               CHALOUPKA 73 HBC  -  3.9 PI- P,P A2    2/73
W  P  1600  112.       18.               EMMS      75 DBC     04.  PI+N,P A20  11/75
W  P S1200  122.       14.               WAGNER    75 HBC     07.  PI+P,DEL++A2 11/75
W     1097  110.0      15.0              BALTAY 1  78 HBC  +0 15 PI+P,P 4PI     4/78
W   P  490 (115.0)    (14.0)             BALTAY 1  78 HBC   0 15 PI+P,DEL 3PI   4/78
W          (150.0)    (20.0)             CORDEN 2  78 OMEG  - 12-15 PI-P,3PI N  4/78
W  P 25000   96.0       9.0              DAUM      80 SPEC  - 63,94 PI- P= 3PI 12/79
W  P         97.        5.               EVANGELIS 81 OMEG  - 12 PI-P,3PI P     1/82
W          . . . . . . . . . . .
W   AVG     100.6       2.2     AVERAGE

W    S  WIDTH ERRORS ENLARGED BY US TO 4*WIDTH/SQRT(N),SEE K*(892) NOTE
W  P     FROM A FIT TO JP=2+ RHO PI PARTIAL WAVE

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                12  A2 WIDTH (MEV), CHARGED K KBAR MODE

WK   S1500  123.0      13.0              GRAYER    71 ASPK  - 17.2 PI-P,K-KS P 11/71
WK     730  113.0      19.0              FOLEY     72 CNTR  - 20.3 PI- P,K- KS 12/72
WK   S2724  105.0       8.0              MARGULIES 76 SPEC  - 23.PI-P,K-KS     12/77
WK     350  110.0      18.0              HYAMS     78 ASPK +  12.7 PI+P,K+KS P  4/78
WK   11000  126.0      11.0              CHABAUD   78 SPEC   -9.8 PI-P,K- KS P  4/78
WK    4730  101.0       8.0              CHABAUD   78 SPEC  - 18.8PI-P,K- KS P  4/78
WK P S      113.        4.               MARTIN 1  78 SPEC   -10 PI P,KS K- P   4/78
WK    4000  106.0       4.0              CHABAUD   80 SPEC  - 17PI-NUCLEI,KSK- 12/79
WK P W1000  121.0      51.0              CLELAND   82 SPEC +  30 PI+P,KS K+ P   8/83*
WK P W4700  112.0      20.0              CLELAND   82 SPEC +  50 PI+P,KS K+ P   8/83*
WK P W5200  120.0      25.0              CLELAND   82 SPEC -  50 PI-P,KS K- P   8/83*
WK         . . . . . . . . . . .
WK  AVG     109.8       2.4     AVERAGE

WK  P     FROM A FIT TO JP=2+ PARTIAL WAVE.
WK   S  WIDTH ERRORS ENLARGED BY US TO 4*WIDTH/SQRT(N),SEE K* TYPED NOTE
WK   W  NUMBER OF EVENTS EVALUATED BY US.

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                12  A2 WIDTH (MEV), ETA PI MODE

W     1000  108.        9.               KEY       73 OSPK -  6.PI-P,P PI-ETA   1/74
W   M 6200 (104.)      (9.)              CONFORTO  73 OSPK -  6.PI-P,P MMS-     1/74
W     2561  112.2       5.7              DELFOSSE  81 SPEC +  PI+-P,PI+-ETA P   1/82
W     1653  116.6       7.7              DELFOSSE  81 SPEC -  PI+-P,PI+-ETA P   1/82
W          . . . . . . . . . . .
W   AVG     112.6       4.1     AVERAGE

W   M   MISSING MASS WITH ENRICHED MMS=ETA PI-, ETA = 2 GAMMA

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                12  A2 PARTIAL DECAY MODES

                                                      DECAY MASSES
P1      A2 INTO RHO PI                               769+ 140
P2      A2 INTO K KBAR                               494+ 498
P3      A2 INTO ETA PI                               549+ 140
P4      A2 INTO OMEGA PI PI                          140+ 140+ 783
P5 S    A2 INTO PI+ PI- PIO EXCL.RHO PI              140+ 140+ 135
P6 S    A2 INTO PI+ PI- PI- EXCL.RHO PI              140+ 140+ 140
P7 S    A2 INTO PI GAMMA                             140+   0
P8 S    A2 INTO ETA PRIME PI                         958+ 140
P9 S    A2 INTO GAMMA GAMMA                            0+   0

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 .7006+-.0225
P 2   -.1065   .0487+-.0080
P 3   -.0680      -.0451   .1448+-.0117
P 4   -.8336      -.2037      -.3936  .1058+-.0250

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                12  A2 PARTIAL WIDTHS

W7      A2 INTO PI+- GAMMA (KEV)                               (G7)
W7  M       (461.)   (110.)          MAY       77 SPEC +- 9.7 GAM N,A2 X     9/83*
W7           295.      60.           CIHANGIR  82 SPEC +  200 PI+Z,Z A2      9/83*
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Mesons

Data Card Listings

$A_2(1320)$

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W9      A2 INTO GAMMA GAMMA (KEV)                           (G9)
W9 E G  22     0.77     0.45               EDWARDS   82 CBAL   E+ E-,PIO ETA     2/82
W9 F E  35     0.81     0.61      0.30     BEHREND   83 CELL   E+E-,E+E- 3 PI    9/83*
W9 F E         0.84     0.22               FRAZER    83 JADE   E+E-,E+E- 3 PI    9/83*
W9          . . . . . . . . . . .
W9  AVG        0.82     0.18     AVERAGE

W   E    SYSTEMATIC ERROR ADDED LINEARLY BY US
W   F    FROM RHO PI DECAY MODE
W    M   MODEL DEPENDENT
W    G   FROM ETA PIO DECAY MODE.

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12 A2 BRANCHING RATIOS

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R1      A2 (CHARGED ONLY) INTO (K KBAR)/(RHO PI)            (P2)/(P1)
R1  C        (0.054)  (0.022)          CHUNG     68 HBC  -  3.2 PI-P          1/67
R1  C        (0.06)   (0.03)           ABRAMOVIC 70 HBC  -  3.93 PI- P        1/71
R1  C        (0.07)   (0.03)           NEF       70 MMS  -  7.0 PI- P         6/70
R1  C  113   (0.097)  (0.018)          ALSTON    71 HBC  +  7.0 PI+ P         1/71
R1  C   50   (0.056)  (0.014)          CHALOUPKA 73 HBC  - 3.9 PI- P,P A2     2/73
R1            0.078    0.017           CHABAUD   78 RVUE                     12/78
R1  C   INCLUDED IN CHABAUD 78 RVUE.
R1          . . . . . . . . . . .
R1  FIT        0.070    0.012  FROM FIT

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
R2  FIT        0.162    0.012  FROM FIT

R3      A2 INTO (ETA PI) / (RHO PI)                         (P3)/(P1)
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      15     0.25     0.09           BOCKMANN  70 HBC  +  5.0 PI+P          9/69
R3     167     0.246    0.042          ALSTON    71 HBC  +  7.0 PI+ P         1/71
R3     149     0.211    0.044          CHALOUPKA 73 HBC  - 3.9 PI- P,P A2     2/73
R3      52     0.22     0.05           ANTIPOV   73 CNTR - 40. PI-P,P A2-     1/74
R3             0.18     0.05           FORINO    76 HBC    11 PI- P,ETA PI   12/77
R3          . . . . . . . . . . .
R3  AVG        0.213    0.020   AVERAGE
R3  FIT        0.207    0.018  FROM FIT

R4      A2 INTO (ETA PRIME PI) / TOTAL                      (P8)
R4           (0.02) OR LESS  CL=.97   BARNHAM    71 HBC  + 3.7 PI+ P          2/72

R5      A2 INTO (ETA PRIME PI)/(RHO PI)                     (P8)/(P1)
R5             0.04     0.03     0.04  BOCKMANN  70 HBC   0 5.0 PI+ P         9/69
R5           (0.04) OR LESS            ALSTON    71 HBC  +  7.0 PI+ P         1/71
R5           (0.011)OR LESS  CL=.90    EISENSTEI 73 HBC  - 5.PI- P,P 6PI      1/74

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       8     0.03     0.02           DAMERI    72 HBC  - 11. PI- P         12/72
R8             0.05     0.02           TOET      73 HBC  + 5. PI+ P,P K+ KO  12/75
R8             0.09     0.04           TOET      73 HBC   0 5.PI+P,PI+P K KB 12/75
R8  A   NOT AVERAGED BECAUSE OF DISCREPANCY BETWEEN MASSES
R8  A   FROM  (K KBAR)  AND  (RHO PI)  MODES
R8          . . . . . . . . . . .
R8  AVG        0.048    0.012   AVERAGE
R8  FIT        0.0545   0.0088 FROM FIT

R9      A2 INTO (PI+ PI- PI-)/(RHOO 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)
R11R           0.005    0.005     0.003 EISENBERG 72 HBC     PHOTOPRODUCTION  11/71
R11R    PION EXCHANGE MODEL USED IN THIS ESTIMATION

R12     A2 INTO (OMEGA PI PI)/(RHO PI)                      (P4)/(P1)
R12          (0.19)   (0.08)           DEFOIX    73 HBC   0 0.7 PBAR P,7 PI  12/77
R12    279     0.10     0.05           CHALOUPKA 73 HBC  - 3.9 PI- P,P A2     2/73
R12     60     0.28     0.09           DIAZ      74 DBC   0 6.PI+N,P(5PI)0    1/74
R12  K 140   (0.29)   (0.08)           KARSHON   74 HBC   0 4.9 PI+P,DEL++A2 12/77
R12  K  60   (0.10)   (0.04)           KARSHON   74 HBC  + 4.9 PI+P,P A2+    12/77
R12  K         0.18     0.08           KARSHON   74 HBC   AVG OF ABOVE TWO   12/77
R12         . . . . . . . . . . .
R12 AVG        0.151    0.049   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
R12 FIT        0.151    0.040  FROM FIT

R12  K  KARSHON 74 SUGGEST AN ADDITIONAL I=0 STATE, STRONGLY COUPLED
R12  K  TO OMEGA PI PI  COULD EXPLAIN DISCREPANCIES IN BRANCHING RATIOS
R12  K  AND MASSES. WE USE A CENTRAL VALUE AND A SYST. SPREAD.

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REFERENCES FOR A2


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ADERHOLZ 64 PL 10 226            (AACHEN+BERLIN+BIRM+BONN+HAMBURG+LOIC+MPIM)
CHUNG    64 PRL 12 621           +DAHL,HARDY,HESS,KALBFLEISCH,KIRZ      (LRL)
GOLDHABE 64 DUBNA CONF   1 480 G GOLDHABER,S GOLDHABER,OHALLORAN,SHEN(LRL)
    ALSO 64 PRL 12 336           G+S.GOLDHABER,BROWN,KADYK,TRILLING,+  (LBL)
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+           (ETH+CERN)
CASON    67 PRL 18 880           +LAMSA,BISWAS,DERADO,GROVES,+   (NOTREDAME)
CHIKOVAN 67 PL 25B 44            CERN MISSING MASS SPECTROMETER GROUP (CERN)
CHUNG    67 PRL 18 100           +DAHL,HARDY,HESS,KIRZ,MILLER           (LRL)
    ALSO 66 UCRL-16832           RICHARD I HESS--THESIS,BERKELEY        (LRL)
COHN     67 NP B1 57             +MCCULLOCH+BUGG+CONDO       (ORNL+UNIV.TENN.)
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)
VETLITSK 69 SJNP 9 596           VETLITSKY,GRIGOREYEV,GRISHIN,+        (ITEP)

ABRAMOVI 70 NP B 29 466          ABRAMOVICH,BLUMENFELD,BRUYANT,+      (CERN)  JP
ALSTON   70 PL 33 B 607          +BARBARO,BUHL,DERENZO,EPPERSON,FLATTE+(LRL)
ASCOLI   70 PRL 25 962           +BROCKWAY,CRAWLEY,EISENSTEIN,HANFT,+  (ILL)  JP
BASILE   70 LNC 4 838            +DALPIAZ,FRABETTI,MASSAM,+ (CERN+BGNA+STRB)
BAUD1    70 PL 31B  397          CERN BOSON SPECTROMETER GROUP         (CERN)
BAUD2    70 PHILAD.CONF.P.311 CERN BOSON SPECTROMETER GROUP            (CERN)
BAUD3    70 PL 31 B 401          CERN BOSON SPECTROMETER GROUP         (CERN)
BOCKMANN 70 NP B 16 221          +MAJOR,POLS,+    (BONN+DURH+NIJM+EPOL+TORI)
BUTLER   70  UCRL 19845          THESIS                                 (LRL)
CAROLL   70 PRL 25 1393          +FIREBAUGH,GARFINKEL,MORSE,OH,+ (WISC+TNTO)
CASO     70 LNC 3 707            +CONTE,TOMASINI,CORDS+(GENO+HAMB+MILA+SACL)
DIAZ     70 NP B 16 239          +GAVILLET,LABROSSE,MONTANET+    (CERN+CDEF)JP
DZIERBA  70 PR D 2 2544          +SHEPHARD,BISWAS,CASON,JOHNSON,KENNEY(NDAM)
GARFINKE 70 PL 33 B 536          GARFINKEL,AMMANN,CARMONY,YEN          (PURD)JPC
JOHNSTON 70 NP B 24 253          +KEY,PRENTICE,YOON,GARFINKEL,+  (TNTO+WISC)
KRUSE    70 PHILAD.CONF.P.359 U.KRUSE, PARTIAL WAVE ANALYSIS           (ILL)  JP
NEF      70  THESIS+PRIV.COMM.CERN 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   71 PL 34 B 156          +BARBARO,BUHL,DERENZO,EPPERSON,FLATTE+(LRL)
BARNHAM  71 PRL 26 1494          +ABRAMS,BUTLER,COYNE,GOLDHABER,HALL,+ (LBL)
BEKETOV  71 SJNP 4 765           +SOMBKOWSKY,KONOWALOV,KRUTSCHININ,+  (ITEP)  JP
BINNIE1  71 PL 36 B 257          +CAMILLERI,DUANE,FARUQI,BURTON,+(LOIC+SHMP)
BINNIE2  71 PL 36 B 537          +CAMILLERI,DUANE,FARUQI,BURTON,+(LOIC+SHMP)
BOWEN    71 PRL 26 1663          +FARLES,FAISSLER,BLIEDEN,+      (NEAS+STON)
CRENNEL  71 PL 35 B 185          +GORDON,KWAN-WU LAI,SCARR              (BNL)
FARBER   71 NP B 29 237          +DE PINTO,BISWAS,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)
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)
DIEBOLD  72 BATAVIA CONF.        R.DIEBOLD  RAPPORTEUR TALK             (ANL)
EISENBER 72 PR D 5 15            EISENBERG,BALLAM,DAGAN,+   (REHO+SLAC+TELA)
ESPIGAT  72 NP B 36 93           +GHESQUIERE,LILLESTOL,MONTANET  (CERN+CDEF)
FOLEY    72 PR D 6 747           +LOVE,OZAKI,PLATNER,LINDENBAUM,+ (BNL+CUNY)
LASSILA  72 PRL 28 1491          LASSILA,YOUNG                         (IOWA)
MORSE    72 NP B 43 77           +OH,WALKER,JOHNSTON,YOON         (WISC+TNTO)

AMMANN   73 PR D 7 1345          +CARMONY,GARFINKEL,GUTAY,MILLER+(PURD+IUPU)
ANKEBRAN 73 PR D 8 2785          ANKEBRANDT,BRABSON,CRITTENDEN,HEINZ,+ (IND)
ANTIPOV  73 NP B 63 175          +ASCOLI,BUSNELLO,FOCACCI,+      (CERN+SERP)  JP
ANTIPOV1 73 NP B 63 153          +ASCOLI,BUSNELLO,FOCACCI,+      (CERN+SERP)  JP
ANTIPOV2 73 NP B 63 141          +ASCOLI,BUSNELLO,FOCACCI,+      (CERN+SERP)  JP
CASON    73 NP B 64 14           +MADDEN,BISHOP,BISWAS,KENNEY,+        (NDAM)
CHALOUPK 73 PL 44 B 211          CHALOUPKA,DOBRZYNSKI,FERRANDO,LOSTY,+(CERN)
CONFORTO 73 PL 45 B 154          +MOBLEY,KEY,PERPOST,+  (EFI+FNAL+TNTO+WISC)
DEFOIX   73 PL 43 B 141          +DOBRZYNSKI,ESPIGAT,NASCIMENTO,+      (CDEF)
EISENSTE 73 PR D 7 278           EISENSTEIN,SCHULTZ,ASCOLI,IOFFREDO,+  (ILL)
KEY      73 PRL 30 503           +CONFORTO,MOBLEY,+     (TNTO+EFI+FNAL+WISC)
TOET     73 NP B 63 248          +THUAN,MAJOR,RINAUDO,+(NIJM+BONN+DURH+TORI)

DIAZ     74 PRL 32 260           +DIBIANCA,FICKINGER,ANDERSON,+  (CASE+CARN)
KARSHON  74 PRL 32 852           +MIKENBERG,PITLUCK,EISENBERG,RONAT+  (REHO)
OTTER    74 NP B80 1             +RUDOLPH+        (AACH+BERL+BONN+CERN+HEID)  JP
TABAK    74  BOSTON P. 46        +RONAT,ROSENFELD,LASINSKI+      (LBL+SLAC)  JP
THOMPSO1 74 PR D9 560            THOMPSON,GAIDOS,MCILWAIN,WILLMANN    (PURD)  JP
THOMPSO2 74 NP B69 381           THOMPSON,BADEWITZ,GAIDOS,MCILWAIN+   (PURD)  JP

ABASHIAN 75 PRL 34 691           +BEAMER,BROSS,EISENSTEIN,+    (ILL+ANL+ISU)
EMMS     75 PL 58B 117           +JONES,KINSON,STACEY,BELL+ (BIRM+DURH+RHEL)  JP
LOSTY    75 PL 56B 96            +CHALOUPKA,MONTANET,GANDOIS+    (CERN+SACL)  JP
UNDERWOO 75 PR D11 2345          UNDERWOOD,CONFORTO,KEY+(EFI+FNAL+TNTO+WISC)
    ALSO 73 CONFORTO, 73 KEY
WAGNER   75 PL 58B 201           +TABAK,CHEW                            (LBL)  JP

FORINO   76 NC A 35 465          +GESSAROLI,+  BGNA+FIRZ+GENO+MILA+OXF+PAV
HANDLER  76 NP B 110 173         +PLANO,BRUCKNER,KOLLER,,+  (RUTG,STEV,SETO)
MARGULIE 76 PR D 14 667          +KRAMER,FOLEY,LOVE,LINDENBAUM,+  (BNL+CUNY)

CERRADA  77 NP B 126 241         +BLOCKZIJL,HEINEN,+    (AMST+CERN+NIJM+OXF)
MAY      77 PR D 16 1983         +ABRAMSON,ANDREWS,BUSNELLO,+    (ROCH+CORN)
PAWLICKI 77 PR D 15 3196         +AYRES,COHEN,DIEBOLD,KRAMER,WICKLUND  (ANL)I J

BALTAY 1 78 PR D 17 62           +CAUTIS,COHEN,CSORNA,SMITH,YEH,+(COLU+BING)
BALTAY 2 78 PRL 40 87            +CAUTIS,KALELKAR                      (COLU)  JP
CHABAUD  78 NP B 145 349         +HYAMS,JONES,WEILHAMMER,BLUM,+  (CERN+MPIM)
CORDEN 1 78 NP B 136 77          DOWELL,GARVEY,JOBES+  (BIRM+RHEL+TELA+LOWC)  JP
CORDEN 2 78 NP B 138 235         +CORBETT,ALEXANDER,+  (BIRM+RHEL+TELA+LOWC)
FERRER   78 PL 74 B 287          +TREILLE,RIVET +      (ORSAY+CERN+CDEF+LPNP)
HYAMS    78 NP B 146 303         +JONES,WEILHAMMER,BLUM,+   (CERN+MPIM+ATEN)
MARTIN 1 78 PL 74 B 417          +OZMUTLU+BALDI,BOHRINGER,DORSAZ+(DURH+GEVA)  JP
MARTIN 2 78 NP B 140 158         +OZMUTLU,BALDI,BOHRINGER,DORSAZ+(DURH+GEVA)

CHABAUD  80 NP B 175 189         +HYAMS,PAPADOPOULOU,+      (CERN+MPIM+AMST)
DAUM     80 PL 89 B 276          +HERTZBERGER+(AMST+CERN+CRAC+MPIM+OXF+RHEL)  JP

DAUM     81 NP B 182 269         +HERTZBERGER+(AMST+CERN+CRAC+MPIM+OXF+RHEL)
DELFOSSE 81 NP B 183 349         +GUISAN,MARTIN,MUHLEMANN,WEILL,+(GEVA+LAUS)
EVANGELI 81 NP B 178 197         EVANGELISTA+(BARI+BONN+CERN+DARE+LIVP+MILA)
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BEHREND  82 PL 114 B 378      +D-AGOSTINI+(DESY+KARL+MPIM+LALO+LPNP+SACL)
CIHANGIR 82 PL 117 B 123      +BERG,BIEL,CHANDLEE,FERBEL+(FNAL+MINN+ROCH)
CLELAND  82 NP B 208 228      +DELFOSSE,DORSAZ,GLOOR(DURH+GEVA+LAUS+PITT)
EDWARDS  82 PL 110 B 82       +PARTRIDGE,PECK,+ (CIT+HARV+PRIN+STAN+SLAC)

BEHREND  83 PL 125 B 518      +D-AGOSTINI+(DESY+KARL+MPIM+LALO+LPNP+SACL)
FRAZER   83 AACHEN CONF.      RAPPORTEUR TALK                      (UCSD)
JENNI    83 PR D 27 1031      +BURKE,TELNOV,ABRAMS,BLOCKER+    (SLAC+LBL)
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E(1420)

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6  E(1420,JPG=1++) I=0
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NOTE ON THE E(1420) AND ι(1440)

We are tentatively splitting the data on the E(1420)/ι(1440) into two entries according to the proposed J^{PC} assignments.

The $J^{PC} = 1^{++}$ state (DIONISI 80), E(1420), appears to have a dominant decay mode into the $K^*(892)K$ system.

The state with $J^{PC} = 0^{-+}$ is named ι(1440). Under this entry we group the results obtained in the early $\bar{p}p$ annihilation experiment at rest (BAILLON 67) and in the radiative decays of the J/ψ resonance (SCHARRE 80,81, EDWARDS 82). The ι(1440) is largely coupled to the $\delta(980)\pi$ decay channel, although the lack of a signal in the $\eta\pi\pi$ system (EDWARDS 83) is a source of concern.

Note that the experimental situation in this mass region is still confused and that forthcoming results may drastically change present views on the subject (HITLIN 83).

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                    6  E(1420) MASS (MEV)

M          1420.      20.           DAHL      67 HBC   1.6-4.2 PI- P    9/66
M          1423.0     10.0          FRENCH    67 HBC    3-4 PBAR P      6/67
M      310 1420.       7.           LORSTAD   69 HBC   .7PB P,4,5-BODY  9/69
M      170 1398.      10.           DEFOIX    72 HBC   0.7 PBAR P,7 PI  1/73
M      280 1406.       7.           DUBOC     72 HBC   1.2 PBAR P,2K4PI 12/72
M       36(1397.0)   (10.0)         CORDEN    78 OMEG  12-15PI-P,K+K-PI  4/78
M          1417.5      4.           NACASCH   78 HBC    .7,.76 PBAR P    4/78
M  A       1440.0     10.0          BROMBERG  80 SPEC  100 PI-P,2KPIX    1/82
M      221 1426.0      6.0          DIONISI   80 HBC   4. PI-P,K K PI N 12/79
M   T     (1431.0)  APPROX          TORNQVIST 82 RVUE                    9/83*
M         (1432.0)    (3.0)         PALANO    83 OMEG  85 PP PI+P,2KPIX 12/83*
M          . . . . . . . . . . .
M   AVG    1418.4      3.5    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
                             (SEE IDEOGRAM BELOW)

M  A    MASS ERROR INCREASED TO ACCOUNT FOR DELTA(980) MASS CUT UNCERTAINTIES
M   T   FROM A UNITARIZED QUARK MODEL CALCULATION
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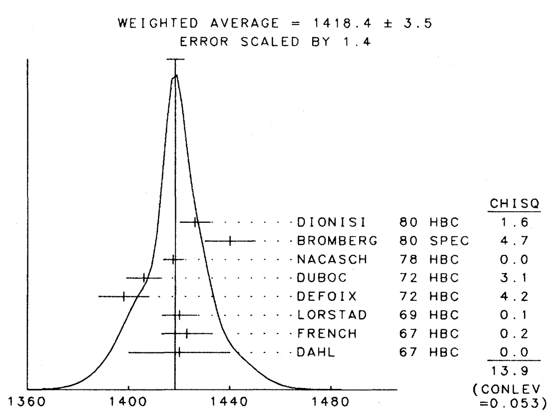


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                    6  E(1420) WIDTH (MEV)

W            60.0      20.0        DAHL      67 HBC    1.6-4.2 PI- P   10/66
W            45.       20.         FRENCH    67 HBC    3-4 PBAR P       6/67
W      310   60.       20.         LORSTAD   69 HBC   .7PB P,4,5-BODY   9/69
W      170   50.       10.         DEFOIX    72 HBC   0.7 PBAR P,7 PI   1/73
W      280   50.       12.         DUBOC     72 HBC   1.2 PBAR P,2K4PI 12/72
W       36  (45.0)    (30.0)       CORDEN    78 OMEG  12-15PI-P,K+K-PI  4/78
W            53.       20.0        NACASCH   78 HBC    .7,.76 PBAR P    4/78
W            62.0      14.0        BROMBERG  80 SPEC  100 PI-P,2KPIX    1/82
W      221   40.0      15.0        DIONISI   80 HBC   4. PI-P,K K PI N 12/79
W           (58.0)     (9.0)       PALANO    83 OMEG  85 PP PI+P,2KPIX 12/83*
W            . . . . . . . . . . .
W   AVG      51.7       5.2    AVERAGE

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                    6  E(1420) PARTIAL DECAY MODES

                                                        DECAY MASSES
P1      E(1420) INTO K K*(892)                         498+ 892
P2      E(1420) INTO K KBAR PI                         498+ 498+ 140
P3      E(1420) INTO PI PI RHO                         140+ 140+ 769
P4      E(1420) INTO DELTA(980) PI                     983+ 140
P5      E(1420) INTO ETA PI PI                         549+ 140+ 140
P6      E(1420) INTO 4 PI                              140+ 140+ 140+ 140
P7      E(1420) INTO GAMMA GAMMA                         0+   0
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                    6  E(1420) PARTIAL WIDTHS (KEV)

W7      E(1420) INTO (GAMMA GAMMA)*(P2)                (G7)*(P2)
W7    A        8.0   OR LESS  CL=0.95  JENNI     83 SMK2    GAM GAM,KKBAR PI  1/84*
W7    A  THIS IS THE PARTIAL WIDTH TIMES THE E(1420) BRANCHING FRACTION
W7    A  INTO K KBAR PI. SEE ALSO IOTA(1440).

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                    6  E(1420) BRANCHING RATIOS

R1      E(1420) INTO (KBAR K*(892) + C.C.)/(K KBAR PI)   (P1)/(P2)
R1           0.76      0.06           BROMBERG  80 SPEC    100 PI-P,2KPIX    1/82
R1           0.86      0.12           DIONISI   80 HBC     4. PI-P,K K PI N 12/79
R1    AVERAGE MEANINGLESS

R2      E(1420) INTO (PI PI RHO) / (K KBAR PI)           (P3)/(P2)
R2          (2.0)  OR LESS            DAHL      67 HBC     0  1.6-4.2 PI- P  10/66
R2          (0.3)  OR LESS  CL=.95    CORDEN    78 OMEG    12-15PI-P         4/78

R3      E(1420) INTO (ETA 2 PI)/(K KBAR PI)              (P5)/(P2)
R3          (1.5)  OR LESS  CL=.95    FOSTER    68 HBC   - 0.0 PBAR P        9/69
R3           1.5      0.8             DEFOIX    72 HBC     0.7 PBAR P        1/73
R3          (0.5)  OR LESS  CL=.95    CORDEN    78 OMEG    12-15PI-P         4/78

R4      E(1420) INTO (DELTA(980) PI)/(ETA PI PI)         (P4)/(P5)
R4           0.4      0.2             DEFOIX    72 HBC     0.7 PBAR P,7 PI   1/73
R4           NOT SEEN IN EITHER MODE  CORDEN    78 OMEG    12-15PI-P         4/78

R5      E(1420) INTO (4PI)/(KBAR K*(892) +C.C.)          (P6)/(P1)
R5          (0.90)OR LESS CL=.95      DIONISI   80 HBC     4. PI-P,K K PI N 12/79

R6      E(1420) INTO                                     (P2)/(P1+P4)
R6              (K KBAR PI)/(DELTA PI + KBAR K*(892) +C.C)
R6    C      0.65      0.27           DIONISI   80 HBC     4. PI-P           2/81
R6    C  CALCULATED USING,
R6    C  (DELTA(980) INTO K KB)/(DELTA(980) INTO ETA PI)=0.24+-0.07

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REFERENCES FOR E(1420)


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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,BERTANZA,BIGI+(PADO+PISA)IC
LORSTAD  69 NP B 14 63        B.LORSTAD,D-ANDLAU,ASTIER,+     (CDEF+CERN)  JP

DEVONS   71 PRL 27 1614       +KOZLOWSKI,HORWITZ,+            (COLU+SYRA)

CHAPMAN  72 NP B 42 1         +CHURCH,LYS,MURPHY,RING,VANDER VELDE (MICH)
DEFOIX   72 NP B 44 125       +NASCIMENTO,BIZZARRI,+          (CDEF+CERN)
DUBOC    72 NP B 46 429       +GOLDBERG,MAKOWSKI,DONALD,+     (LPNP+LIVP)

VUILLEMI 75 LNC 14 165        VUILLEMIN,+      (LAUS+NEUC+LPNP+LIVP+GLAS)  JP

HANDLER  76 NP B 110 173      +PLANO,BRUCKER,KOLLER+     (RUTG+STEV+SETO)
VUILLEMI 76 NC 33A 133        +VUILLEMIN,+     (LAUS+NEUC+LPNP+LIVP+GLAS)

GRASSLER 77 NP B 121 189      +(AACHEN+BERLIN+BONN+CERN+CRACOW+HEID+WARS)
CORDEN   78 NP B 144 253      +CORBETT,ALEXANDER,+  (BIRM+RHEL+TELA+LOWC)
IRVING   78 NP B 139 327      A.C.IRVING,H.R.SEPANGI                (LIVP)
NACASCH  78 NP B 135 203      +DEFOIX,DOBRZYNSKI,+    (PARIS+MADRID+CERN)

STANTON  79 PRL 42 346        +BROCKMAN,DANKOWYCH,+  (OSU+CARL+MCGI+TNTO)  JP

BROMBERG 80 PR D 22 1513      +HAGGERTY,ABRAMS,DZIERBA(CIT+FNAL+ILLC+IND)
   ALSO  82  PRIVATE COMM.    C.BROMBERG                             (MSU)
DIONISI  80 NP B 169 1        +GAVILLET,ARMENTEROS+ (CERN+MADR+CDEF+STOH)I,JP
LACAZE   81 NP B 186 247      +NAVELET                              (SACL)

BAILLON  82 PARIS CONFERENCE  P.BAILLON                             (CERN)
GAVILLET 82 ZPHY C 16 119     +ARMENTEROS,AGUILAR+  (CERN+CDEF+PADO+ROMA)
EDWARDS  82 PRL 49 259        +PARTRIDGE,PECK+  (CIT+HARV+PRIN+STAN+SLAC)
   ALSO  83 PRL 50 219        EDWARDS+PARTRIDGE+(CIT+HARV+PRIN+STAN+SLAC)
TORNQVIS 82 NP B 203 268      TORNQVIST                             (HELS)

BAILLON  83  CERN/EP 83-82    P.BAILLON                             (CERN)
EDWARDS  83 PRL 51 859        +PARTRIDGE,PECK+  (CIT+HARV+PRIN+STAN+SLAC)
HITLIN   83 CORNELL CONF. 746 DAVID HITLIN, RAPPORTEUR'S TALK        (CIT)
JENNI    83 PR D 27 1031      +BURKE,TELNOV,ALAM,BOYARSKI+     (SLAC+LBL)
MENNESSI 83 ZPHY C 16 241     G.MENNESSIER                          (MONP)
PALANO   83  CERN/EP 83-107   +ARMSTRONG,APOSTOLAKIS(ATEN+BARI+BIRM+CERN)
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Mesons

Data Card Listings

ι(1440), f′(1525)

ι(1440)

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27  IOTA(1440,JPG=0-+) I=0

    CALLED E BY BAILLON 67
    AND IOTA BY SCHARRE 80.
    SEE MINIREVIEW UNDER E(1420)

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                    27  IOTA(1440) MASS (MEV)

M          1425.      7.             BAILLON    67 HBC     0. PBAR P           11/66
M          1440.0    10.0    15.0    SCHARRE    80 SMK2    E+E-,J/PSI,E GAM     6/81
M      174 1440.0    20.0    15.0    EDWARDS    82 CBAL    J/PSI,ETA GAM       12/83*
M          1460.     10.             EINSWEILE  83 SMK3    E+E-,HADRONS GAM    12/83*
M          . . . . . . . . . .
M   AVG    1437.4     8.3     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)

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                    27  IOTA(1440) WIDTH (MEV)

W            80.     10.             BAILLON    67 HBC     0. PBAR P           11/66
W            50.0    30.0    20.0    SCHARRE    80 SMK2    E+E-,J/PSI,E GAM     6/81
W      174   55.0    20.0    30.0    EDWARDS    82 CBAL    J/PSI,ETA GAM       12/83*
W            97.     25.             EINSWEILE  83 SMK3    E+E-,HADRONS GAM    12/83*
W          . . . . . . . . . .
W   AVG      75.9     8.2     AVERAGE

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                    27  IOTA(1440) DECAY MODES

                                                          DECAY MASSES
P1      IOTA(1440) INTO K K*(892)                       498+ 892
P2      IOTA(1440) INTO K KBAR PI                       498+ 498+ 140
P3      IOTA(1440) INTO PI PI RHO                       140+ 140+ 769
P4      IOTA(1440) INTO DELTA PI                        983+ 140
P5      IOTA(1440) INTO ETA PI PI                       549+ 140+ 140
P6      IOTA(1440) INTO 4 PI                            140+ 140+ 140+ 140
P7      IOTA(1440) INTO GAMMA GAMMA                       0+   0

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                    27  IOTA(1440) PARTIAL WIDTHS (KEV)

W7      IOTA(1440) INTO (GAMMA GAMMA)*(P2)                    (G7)*(P2)
W7    A        8.0    OR LESS  CL=0.95  JENNI      83 SMK2    GAM GAM,KKBAR PI    1/84*
W7    A  THIS IS THE PARTIAL WIDTH TIMES THE IOTA(1440) BRANCHING FRACTION
W7    A  INTO K KBAR PI. SEE ALSO E(1420).

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                    27  IOTA(1440) BRANCHING RATIOS

R1      IOTA(1440) INTO (KBAR K*(892) + C.C.)/(K KBAR PI)(P1)/(P2)
R1             .50        .10          BAILLON    67 HBC      0.0 PBAR P          12/78

R3      IOTA(1440) INTO (ETA 2 PI)/(K KBAR PI)                (P5)/(P2)
R3           (1.1)   OR LESS  CL=.90   SCHARRE    80 SMK2     E+E-,J/PSI,E GAM    2/81
R3           (0.5)   OR LESS  CL=.90   EDWARDS    83 CBAL     J/PSI,HADR GAM     12/83*

R6      IOTA(1440) INTO                                       (P2)/(P1+P4)
R6             (K KBAR PI)/(DELTA PI + KBAR K*(892) + C.C)
R6           (0.25) OR LESS  CL=.90    EDWARDS    82 CBAL     J/PSI,ETA GAM      12/83*
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REFERENCES FOR IOTA(1440)

BAILLON 67 NC 50A 393 — +EDWARDS+D-ANDLAU+ASTIER+ (CERN+CDEF+IRAD)

SCHARRE 80 PL 97 B 329 — +TRILLING,ABRAMS,ALAM,BLOCKER+ (SLAC+LBL)

CHANOWIT 81 PRL 46 981 — CHANOWITZ (LBL)
LIPKIN 81 PL 106 B 114 — LIPKIN (FNAL)
SCHARRE 81 BONN CONF. 163 — D.L.SCHARRE (SLAC)
ALSO 81 SANTA CRUZ CONF. — COYNE,EDWARDS,+ (PRIN+CIT+HARV+STAN+SLAC)
ALSO 80 MORIOND II 83 — ASCHMAN,PARTRIDGE+(PRIN+CIT+HARV+STAN+SLAC)

ALTHOFF 82 ZPHY C 16 13 — +BOERNER,BURKHARDT+ (TASSO COLLABORATION)
BAILLON 82 PARIS CONFERENCE — P.BAILLON (CERN)
BARNES 82 PL 116 B 365 — T.BARNES AND F.E.CLOSE (RHEL)
BARNES 82 NP B 198 360 — +CLOSE,MONAGHAN (RHEL+OXF)
DONOGHUE 82 PL 112 B 409 — J.F.DONOGHUE AND H.GOMM (MASA)
EDWARDS 82 PRL 49 259 — +PARTRIDGE,PECK+ (CIT+HARV+PRIN+STAN+SLAC)
ALSO 83 PRL 50 219 — EDWARSD+PARTRIDGE+(CIT+HARV+PRIN+STAN+SLAC)
MINAMI 82 PL 113 B 69 — S.MINAMI (OSKC)
TANIMOTO 82 PL 116 B 198 — M.TANIMOTO (BIEL)

BAILLON 83 CERN/EP 83-82 — P.BAILLON (CERN)
EDWARDS 83 PRL 51 859 — +PARTRIDGE,PECK+ (CIT+HARV+PRIN+STAN+SLAC)
EINSWEIL 83 BRIGHTON CONF. — K.F.EINSWEILER+MARKIII COLLABORATION (SLAC)
JENNI 83 PR D 27 1031 — +BURKE,TELNOV,ABRAMS,BLOCKER+ (SLAC+LBL)


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f′(1525)

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13  F PRIME(1525,JPG=2++) I=0

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                    13  F PRIME MASS (MEV)

M   PRODUCED BY PION BEAM
M    N     (1502.0)   (25.0)           CORDEN     79 OMEG    12-15PI-P, N 2PI 12/79
M
M    C      1506.0      7.5            PAWLICKI   77 SPEC    6.PI N,K+K-      12/77
M           1492.0     29.0            GORLICH    80 ASPK    17 PI- P,POLARIZ 12/79
M    D      1496.0      9.      8.     CHABAUD    81 ASPK    6  PI-P          12/83*
M           1497.0      8.      9.     CHABAUD    81 ASPK    18.4 PI-P        12/83*
M          . . . . . . . . . .
M   AVG     1500.0      4.6     AVERAGE

M   PRODUCED BY K+- BEAM
M          (1515.0)    (7.0)           AMMAR      67 HBC      5.5 K-P,K KBAR   9/67
M        46(1514.)     (4.)            COLLEY     72 HBC     10.K+ P,K+ K-    12/72
M        47(1521.)     (7.)            VIDEAU     72 HBC     4.K- P,K KBAR    12/72
M
M       100 1519.       7.             AGUILAR    72 HBC     3.9,4.6 K-,K KB  12/72
M       120 1527.0      3.0            BRANDENBU  76 ASPK    13.K-P,K+K-       7/77
M       123 1522.0      6.0            BARREIRO   77 HBC     4.15 K-P,KS KS    7/77
M       166 1528.       7.             EVANGELIS  77 OMEG    10 K- P          12/77
M       650 1521.0      6.0            AGUILAR    81 HBC     4.2 K-P,LAM 2K    1/82
M       572 1521.0      3.0            ALHARRAN   81 HBC     8.25 K-P,LAM 2K   1/82
M           1529.0      3.0            ARMSTRONG  83 OMEG    18.5 K-P,K-K+LAM 12/83*
M          . . . . . . . . . .
M   AVG     1524.9      1.5     AVERAGE

M     C  WITH A PHASE SHIFT ANALYSIS
M     C  MASS  ERRORS ENLARGED BY US BY FACTOR 1.5.
M     N  FROM AN AMPLITUDE ANALYSIS WHERE THE F PRIME WIDTH AND
M     N  ELASTICITY ARE IN COMPLETE DISAGREEMENT WITH VALUES
M     N  OBTAINED FROM KKBAR CHANNEL MAKING THE SOLUTION DUBIOUS.
M     D  CHABAUD 81 IS A RE-ANALYSIS OF PAWLICKI 77 DATA.

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                    13  F PRIME WIDTH (MEV)

W   PRODUCED BY PION BEAM
W    N       (165.0)    (42.0)             CORDEN     79 OMEG    12-15PI-P, N 2PI 12/79
W            (150.0)    (83.0)    (50.0)   GORLICH    80 ASPK    17 PI- P,POLARIZ 12/79
W
W    C        66.0      15.0               PAWLICKI   77 SPEC    6.PI N,K+K-      12/77
W    M        92.0      39.0      22.0     POLYCHRON  79 STRC    7. PI-P,KS KS N  12/79
W    D        69.0      22.       16.      CHABAUD    81 ASPK    6  PI-P          12/83*
W            137.0      23.       21.      CHABAUD    81 ASPK    18.4 PI-P        12/83*
W          . . . . . . . . . .
W   AVG       83.7      16.0     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)

W   PRODUCED BY K+- BEAM
W            (35.0)    (25.0)              AMMAR      67 HBC      5.5 K-P, K KBAR  9/67
W        46  (28.)     (15.)               COLLEY     72 HBC     10.K+ P,K+ K-    12/72
W        47  (40.)     (10.)               VIDEAU     72 HBC     4.K- P,K KBAR    12/72
W
W       100   69.       22.                AGUILAR    72 HBC     3.9,4.6 K-P,K KB 12/72
W       120   61.0       8.0               BRANDENBU  76 ASPK    13.K-P,K+K-       7/77
W       123   62.0      19.0      14.0     BARREIRO   77 HBC     4.15 K-P,KS KS    7/77
W       166   72.0      25.0               EVANGELIS  77 OMEG    10 K- P          12/77
W       650   85.0      16.0               AGUILAR    81 HBC     4.2 K-P,LAM 2K    1/82
W       572   80.0      14.0      11.0     ALHARRAN   81 HBC     8.25 K-P,LAM 2K   1/82
W             83.0      15.0               ARMSTRONG  83 OMEG    18.5 K-P,K-K+LAM 12/83*
W          . . . . . . . . . .
W   AVG       70.3       5.1     AVERAGE

W     C  WITH A PHASE SHIFT ANALYSIS
W     C  WIDTH ERRORS ENLARGED BY US BY FACTOR 1.5.
W     M  FROM A FIT TO THE D WAVE WITH F-F PRIME INTERFERENCE. MASS FIXED
W     M  AT 1516 MEV.
W     N  SEE NOTE N UNDER MASS.
W     D  CHABAUD 81 IS A RE-ANALYSIS OF PAWLICKI 77 DATA.

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                    13  F PRIME PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      F PRIME INTO PI  PI                             140+ 140
P2      F PRIME INTO K KBAR                             498+ 498
P3      F PRIME INTO K K*(892)                          494+ 892
P4      F PRIME INTO ETA ETA                            549+ 549
P5      F PRIME INTO PI PI ETA                          140+ 140+ 549
P6      F PRIME INTO PI K KBAR                          140+ 498+ 498
P7      F PRIME INTO PI+ PI+ PI- PI-                    140+ 140+ 140+ 140
P8      F PRIME INTO GAMMA GAMMA                          0+   0

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                    13  F PRIME PARTIAL WIDTHS                                12/78

W8      F PRIME INTO GAMMA GAMMA (KEV)                        (G8)            12/78
W8 B D        0.77      0.06           ALTHOFF    82 TASS    GAM GAM,2K        9/83*

W8 B    USING BRANCHING RATIO F PRIME INTO K KBAR = 1.                        12/78
W8   D  SYSTEMATIC ERROR ADDED LINEARLY BY US

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                    13  F PRIME BRANCHING RATIOS

R1      F PRIME INTO (PI PI)/TOTAL                            (P1)
R1 C        (0.0086) OR LESS           BEUSCH     75 OSPK    8.9 PI-P,K0 K0 N 12/77
R1          (0.063)OR LESS  CL=0.90    BRANDENBU  76 ASPK    13.K-P,K+K-       7/77
R1          (0.045)OR LESS  CL=0.95    BARREIRO   77 HBC     4.15 K-P,KS KS    7/77
R1 C         0.012      0.004          PAWLICKI   77 SPEC    6.PI N,K+K-      12/77
R1   N      (0.19)     (0.03)          CORDEN     79 OMEG    12-15PI-P, N 2PI 12/79
R1 C D       0.0075     0.0025         MARTIN     79 RVUE                     12/79
R1           0.007      0.002          COSTA      80 OMEG    10 PI-P,K+ K- N   1/82
R1 C        (0.027)    (0.071)  (0.013)GORLICH    80 ASPK    17,18 PI-P POLAR 12/79
R1          (0.06) OR LESS  CL=.95     AGUILAR    81 HBC     4.2 K-P,LAM 2K    1/82
R1          . . . . . . . . .
R1  AVERAGE MEANINGLESS

R1 C    ASSUMING THAT THE F PRIME IS PRODUCED BY AN OPE
R1      PRODUCTION MECHANISM.
R1   D  MARTIN 79 USES THE PAWLICKI 77 DATA WITH DIFFERENT INPUT
R1      VALUE OF THE F INTO K KBAR BRANCHING RATIO.
R1   N  SEE NOTE N UNDER MASS.

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          (0.41) OR LESS  CL=.95     AGUILAR    72 HBC     3.9,4.6 K- P     12/72

R5      F PRIME INTO (PI K KBAR + K K*(892))/(K KBAR)         (P6+P3)/(P2)
R5          (0.4)  OR LESS  CL=.67     AMMAR      67 HBC                      10/67
R5          (0.35) OR LESS  CL=.95     AGUILAR    72 HBC     3.9,4.6 K- P     12/72

R6      F PRIME INTO (PI+ PI+ PI- PI-)/(K KBAR)               (P7)/(P2)
R6          (0.32) OR LESS  CL=.95     AGUILAR    72 HBC     3.9,4.6 K- P     12/72
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REFERENCES FOR F PRIME

BARNES 65 PRL 15 322 — +CULWICK,GUIDONI,KALBFLEISCH,GOZ+(BNL+SYRA)

CRENNELL 66 PRL 16 1025 — + KALBFLEISCH,LAI,SCARR,SCHUMANN + (BNL)I

ABRAMS 67 PRL 18 620 — +KEHOE,GLASSER,SECHI-ZORN,WOLSKY (MARYLAND)
AMMAR 67 PRL 19 1071 — +DAVIS,HWANG,DAGAN,DERRICK + (NWES+ANL) JP
BARNES 67 PRL 19 964 — +DORNAN,GOLDBERG,LEITNER + (BNL+SYRACUSE)ICJP

ALITTI 68 PRL 21 1705 — +BARNES,CRENNELL,FLAMINIO,GOLDBERG,+ (BNL)

LORSTAD 69 NP B 14 63 — B.LORSTAD,D-ANDLAU,ASTIER,+ (CDEF+CERN)
SCOTTER 69 NC 62 A 1057 — +ERSKINE,PALER,+ (BIRM+GLAS+LOIC+MPIM+OXF)

AGUILAR 72 PR D 6 29 — AGUILAR-BENITEZ,CHUNG,EISNER,SAMIOS (BNL)
COLLEY 72 NP B 50 1 — +JOBES,RIDDIFORD,GRIFFITHS,+ (BIRM+GLAS)
VIDEAU 72 PL 41 B 213 — +VIDEAU,ROUGE,BARRELET,DEBRION,+(EPOL+SACL)

BEUSCH 75 PL 60 B 101 — +BIRMAN,WEBSDALE,WETZEL (CERN+ETH)

BRANDENB 76 NP B 104 413 — BRANDENBURG,CARNEGIE,CASHMORE,DAVIER+(SLAC)

For notation, see key at front of Listings.


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BARREIRO 77 NP B 121 237      +DIAZ,GAY,HEMINGWAY,+  (CERN+AMST+NIJM+OXF)
EVANGELI 77 NP B 127 384      EVANGELISTA,+   (BARI+BONN+CERN+DARE+GLAS+)
LAVEN    77 NP B 127 43       +OTTER,KLEIN,+   (AACH+BERL+CERN+LOIC+WIEN)
PAWLICKI 77 PR D 15 3196      +AYRES,COHEN,DIEBOLD,KRAMER,WICKLUND  (ANL)I JP

BECKER   79 NP B 151  46      +BLANAR,BLUM,CERRADA+ (MPIM+CERN+ZEEM+CRAC)
CORDEN   79 NP B 157 250      +DOWELL,GARVEY,JOBES,+(BIRM+RHEL+TELA+LOWC)  JP
MARTIN   79 NP B 158 520      +OZMUTLU                               (DURH)
POLYCHRO 79 PR D 19 1317      POLYCHRONAKOS,CASON,BISHOP+      (NDAM+ANL)

COSTA    80 NP B 175 402      +       (BARI+BONN+CERN+GLAS+LIVP+MILA+WIEN)
GORLICH  80 NP B 174 16       +NICZYPORUK,ROZANSKA+ (CRAC+MPIM+CERN+ZEEM)

AGUILAR  81 ZPHY C 8 313      +ALBAJAR,ARMENTEROS,+ (CERN+CDEF+MADR+STOH)
ALHARRAN 81 NP B 191 26       +BAUBILLIER,+    (BIRM+CERN+GLAS+MICH+LPNP)
CHABAUD  81 APP B 12 575      +NICZYPORUK,BECKER+         (CERN+CRAC+MPIM)

ALTHOFF  82 PL 121 B 216      +BRANDELIK,BOERNER+   (TASSO COLLABORATION)
ARMSTRON 82 PL 110 B 77       +BAUBILLIER+(BARI+BIRM+CERN+MILA+LPNP+PAVI)
ETKIN    82 PR D 25 1786      +FOLEY,LAI,LINDENBAUM+ (BNL+CUNY+TUFT+VAND)
LUKE     82  DESY 82 73       D.LUKE                                 (DESY)

ARMSTRON 83 NP B 224 193      ARMSTRONG+  (BARI+BIRM+CERN+MILA+LPNP+PAVI)
GRAY     83 PR D 27 307       +KALOGEROPOULOS,NANDY,ROY,ZENONE       (SYRA)
JENNI    83 PR D 27 1031      +BURKE,TELNOV,ABRAMS,BLOCKER+      (SLAC+LBL)
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D(1530)

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84  D(1530,JPG=1++) I=0

NEEDS CONFIRMATION. OMITTED FROM TABLE.
NAMED D PRIME BY GAVILLET 82

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                84  D(1530) MASS (MEV)

M      271 1526.0     6.0         GAVILLET  82 HBC   0 4.2 K-P,LAM KKPI  9/83*

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                84  D(1530) WIDTH (MEV)

W      271  107.0    15.0         GAVILLET  82 HBC   0 4.2 K-P,LAM KKPI  9/83*

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                84  D(1530) PARTIAL DECAY MODES

                                                        DECAY MASSES
P1     D(1530) INTO K K*(892)                         494+ 892

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REFERENCES FOR D(1530)


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GAVILLET 82 ZPHY C 16 119     +ARMENTEROS,AGUILAR+  (CERN+CDEF+PADO+ROMA)

BAILLON  83  CERN/EP 83-82    P.BAILLON                              (CERN)
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ρ(1600) or ρ′

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65  RHO(1600,JPG=1-+) I=1
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NOTE ON ρ, ω, ϕ RADIAL EXCITATIONS

We no longer use primes to distinguish radial excitations: thus the mesons formerly named ρ′(1250), ρ′(1600), and ϕ′(1680) have now become ρ(1250), ρ(1600), and ϕ(1680), respectively. The not-yet-established radial excitation of the ω is temporarily called ω(rad. excit.).

The ρ(1600) has been seen in the $\rho^0\pi^+\pi^-$ final state in photoproduction (BINGHAM 72, DAVIER 73, SCHACHT 74, ALEXANDER 75, LEE 75, ATIYA 79, RICHARD 79, BARBER 80, ASTON1 81), in e^+e^- annihilation (BARBARINO 72, CONVERSI 74, CORDIER 79, COSME 79, BACCI 80, DELCOURT 81,82, BUON 82, AUGUSTIN 83), in electroproduction (KILLIAN 80), in muoproduction (SHAMBROOM 82), and in a π^+d experiment (DIBIANCA 81). If the $\pi^+\pi^-$ subsystem were in an S wave, as has often been assumed, one would also expect to see the ρ(1600) decaying into $\rho^0\pi^0\pi^0$. This has, however, not been seen (ATKINSON 82). Thus the most likely decay chain is $\rho(1600) \rightarrow A(1270)\pi \rightarrow \rho\pi\pi \rightarrow 4\pi$.

For the determination of the ρ(1600) parameters we turn to its relatively rare $\pi^+\pi^-$ and K^+K^- decays, which do not have the problems of the above decay chain. The $\pi^+\pi^-$ final state has been produced in π^-p interactions (HYAMS 73, BECKER 79), in photoproduction (ATIYA 79, ASTON1 80), and with weaker evidence in e^+e^- annihilation (reviewed by GENSINI 78, HEYN 80). The mass and width in these experiments are consistently 1600 MeV and 300 MeV, respectively. Note, however, that these parameters are the results of very simplified analyses which are not adequate for such a broad resonance. An attempt to determine the ρ(1600) pole position in a more model-independent way (LANG 79) from the HYAMS 73 data yields a mass at 1660 MeV.

The mass determination of BECKER 79 is very well confirmed in the K^+K^- system by CLELAND 82, and in K^+K^- and K_SK_L by BUON 82 in a global fit of all the vector mesons present in this energy range (see below). The ρ(1600) parameters in the Meson Table are based on these three determinations only.

The elusive ρ(1250) has been reclaimed in the diffractively photoproduced $\omega\pi^0$ system (ASTON 80, BARBER 80). However, the J^P determinations are complicated by the simultaneously present B(1235) resonance. In addition, other dynamical effects obscure the interpretation of the ρ(1250) as a resonance.

The radial excitations of the ω and the ϕ have been looked for in the channels K^+K^-, K_SK_L, $K_SK^{\mp}\pi^{\pm}$, $\omega\pi^+\pi^-$, and $\pi^+\pi^-\pi^0$, in e^+e^- annihilation and in photoproduction. We list the evidence for a state at 1680 MeV under the name ϕ(1680); however, the situation is far from clear. In a global analysis of all the channels above except $\pi^+\pi^-\pi^0$, BUON 82 conclude that the data are well described by the tails of the ρ, ω, and ϕ, the ρ(1600), a conspicuous ϕ(1680), and one ω(rad. excit.) hidden under the ρ(1600). This view is confirmed by AUGUSTIN 83 in preliminary K^+K^- data. The $\pi^+\pi^-\pi^0$ system is not yet reliably analyzed.

In photoproduction, however, no ϕ(1680) resonance is seen in the $\omega\pi^+\pi^-$ channel, but rather a broad threshold enhancement (ASTON2 80, ATKINSON1 83), and nothing is seen in $K\bar{K}\pi$ (ATKINSON1 83). In the K^+K^- channel, the ϕ(1680) has been found (ASTON2 81) with the same parameters as in e^+e^- annihilation, but its interference with the ϕ looks quite different.

A resonance with parameters similar to the ϕ(1680)

Mesons

Data Card Listings

$\rho(1600)$ $[\rho']$

has been found in the photoproduced $\pi^+\pi^-\pi^0$ system (ATKINSON3,4 83). Its interpretation is, however, complicated, as it may contain both the ω(rad. excit.) and the $\phi(1680)$. So far we list this evidence under the $\phi(1680)$.

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                         65  RHO(1600) MASS (MEV)

M  PI+ PI- MODE
M   H     (1590.)      (20.)                HYAMS     73 ASPK  0 17 PI-P,N PI+PI-   1/74
M  P       1610.       30.                  FROGGATT  77 RVUE  0 17 PI-P,PI+PI-N   12/77
M  P      (1575.)                           MARTIN    78 RVUE  0 17 PI-P,PI+PI-N   12/77
M    R     1600.0      10.0                 ATIYA     79 SPEC    50 GAM C,2PI      12/79
M          1598.0      24.0       22.0      BECKER    79 ASPK  0 17 PI- P POLARIZ  12/79
M   P     (1659.)      (25.)                LANG      79 RVUE  0                    1/82
M    M     1590.       20.                  ASTON 1   80 OMEG    20-70GAM P,2 PI    9/81
M  K KBAR MODE
M     1600 1582.       36.                  CLELAND   82 SPEC +- 50 PI P,KS K+-P    8/83*
M  MIXED MODES
M  G       1580.       20.                  BUON      82 DM1     E+E-,HADRONS       1/84*
M          . . . . . . . . . .
M   AVG    1595.7       7.3       AVERAGE

M  2(PI+ PI-) MODE
M      400 1430.       50.                  BINGHAM   72 HBC   0 9.3 GAM P,P 4PI   12/72
M    M     1550.       60.                  CONVERSI  74 OSPK  0 E+ E-,2(PI+PI-)   12/75
M      160 1550.       50.                  SCHACHT   74 STRC  0 5.5-9 G P,P 4PI   12/75
M      340 1450.      100.                  SCHACHT   74 STRC  0 9-18 G P,P 4PI    12/75
M   D   65(1570.)     (60.)                 ALEXANDER 75 HBC   0 7.5 GAM P,P 4PI   12/75
M   C     (1500.)                           ATIYA     79 SPEC    50 GAM C,4 PI+-    9/81
M   A     (1666.)     (39.)                 BACCI     80 FRAG    E+ E-, 2(PI+PI-)   9/81
M       34(1780.)                           KILLIAN   80 SPEC    11 E-P,2(PI+PI-)   9/81
M    M     1520.       30.                  ASTON 1   81 OMEG    20-70GAM P,4 PI    9/81
M  O       1654.       25.                  DIBIANCA  81 DBC   0 PI+D,PP2(PI+PI-)   1/82
M   B     (1540.)                           PENSO     82 RVUE    E+ E-, 2(PI+PI-)   9/81
M          . . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 2.2)

M   A   SIMPLE RELATIV. BREIT-WIGNER FIT WITH MODEL DEPENDENT WIDTH
M   B   ASSUMING RHO+EPSILON(1300) DECAY MODE INTERFERES WITH
M   B   A(1270)+PI BACKGROUND
M   C   PARAMETERS ROUGHLY ESTIMATED,NOT FROM A FIT
M   D   SKEW MASS DISTRIBUTION COMPENSATED BY ROSS-STODOLSKY FACTOR
M   H   INCLUDED IN BECKER 79 ANALYSIS
M    M  SIMPLE RELATIV. BREIT WIGNER FIT WITH CONSTANT WIDTH
M  O    ONE PEAK FIT RESULT.
M  P    FROM PHASE SHIFT ANALYSIS OF HYAMS 73 DATA
M    R  AN ADDITIONAL 40 MEV UNCERTAINTY IN BOTH THE MASS AND WIDTH
M    R  IS PRESENT DUE TO THE CHOICE OF THE BACKGROUND SHAPE.
M  G    FROM GLOBAL FIT OF RHO,OMEGA,PHI AND THEIR RADIAL EXCITATIONS TO
M  G    CHANNELS OMEGA PI+PI-,K+K-,KS KL,KS K+- PI-+.

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                         65  RHO(1600) WIDTH (MEV)

W  PI+ PI- MODE
W   H      (180.)      (50.)                HYAMS     73 ASPK  0 17 PI-P,N PI+PI-  12/75
W  P        300.      100.                  FROGGATT  77 RVUE  0 17 PI-P,PI+PI-N   12/77
W  P       (340.)                           MARTIN    78 RVUE  0 17 PI-P,PI+PI-N   12/77
W    R      283.0      14.0                 ATIYA     79 SPEC    50 GAM C,2PI      12/79
W           175.0      98.0       53.0      BECKER    79 ASPK  0 17 PI- P POLARIZ  12/79
W   P      (232.)     (34.)                 LANG      79 RVUE  0                    1/82
W    M      230.0      80.0                 ASTON 1   80 OMEG    20-70 GAM P,2PI    9/81
W  K KBAR MODE
W     1600  265.      120.                  CLELAND   82 SPEC +- 50 PI P,KS K+-P    8/83*
W  MIXED MODES
W  G        340.       80.                  BUON      82 DM1     E+E-,HADRONS       1/84*
W          . . . . . . . . . .
W   AVG     279.9      13.2       AVERAGE

W  2(PI+ PI-) MODE
W      400  650.      100.                  BINGHAM   72 HBC   0 9.3 GAM P,P 4PI   12/72
W    M      360.      100.                  CONVERSI  74 OSPK  0 E+ E-,2(PI+PI-)   12/75
W  E   160  400.      120.                  SCHACHT   74 STRC  0 5.5-9 G P,P 4PI   12/75
W  E   340  850.      200.                  SCHACHT   74 STRC  0 9-18 G P,P 4PI    12/75
W   D   65 (340.)    (160.)                 ALEXANDER 75 HBC   0 7.5 GAM P,P 4PI   12/75
W   C      (600.)                           ATIYA     79 SPEC    50 GAM C,4 PI+-    9/81
W   A      (700.)    (160.)                 BACCI     80 FRAG    E+ E-, 2(PI+PI-)   9/81
W       34 (100.)                           KILLIAN   80 SPEC    11 E-P,2(PI+PI-)   9/81
W   B      (230.)                           PENSO     80 RVUE    E+ E-, 2(PI+PI-)   9/81
W    M      400.       50.                  ASTON 1   81 OMEG    20-70GAM P,4 PI    9/81
W  O        400.      146.                  DIBIANCA  81 DBC   0 PI+D,PP2(PI+PI-)   1/82
W          . . . . . . . . . .
W   AVERAGE MEANINGLESS (SCALE FACTOR = 1.4)

W   A   SIMPLE RELATIV. BREIT-WIGNER FIT WITH MODEL DEPENDENT WIDTH
M   B   ASSUMING RHO+EPSILON(1300) DECAY MODE INTERFERES WITH
M   B   A(1270)+PI BACKGROUND
W   C   PARAMETERS ROUGHLY ESTIMATED,NOT FROM A FIT
W   D   SKEW MASS DISTRIBUTION COMPENSATED BY ROSS-STODOLSKY FACTOR
W  E    WIDTH ERRORS ENLARGED BY US TO 4*WIDTH/SQRT(N),SEE K*(892) NOTE
W   H   INCLUDED IN BECKER 79 ANALYSIS
W    M  SIMPLE RELATIV. BREIT WIGNER FIT WITH CONSTANT WIDTH
W  O    ONE PEAK FIT RESULT.
W  P    FROM PHASE SHIFT ANALYSIS OF HYAMS 73 DATA
W    R  AN ADDITIONAL 40 MEV UNCERTAINTY IN BOTH THE MASS AND WIDTH
W    R  IS PRESENT DUE TO THE CHOICE OF THE BACKGROUND SHAPE.
W  G    FROM GLOBAL FIT OF RHO,OMEGA,PHI AND THEIR RADIAL EXCITATIONS TO
W  G    CHANNELS OMEGA PI+PI-,K+K-,KS KL,KS K+- PI-+.

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                         65  RHO(1600) PARTIAL DECAY MODES

                                                           DECAY MASSES
P1      RHO(1600) INTO RHO PI+ PI-                        769+ 140+ 140
P2      RHO(1600) INTO 4 PI ALL CHARGED                   140+ 140+ 140+ 140
P3      RHO(1600) INTO RHO RHO                            769+ 769
P4      RHO(1600) INTO PI PI                              140+ 140
P5      RHO(1600) INTO KBAR K                             494+ 494
P6      RHO(1600) INTO PI OMEGA                           140+ 783
P7      RHO(1600) INTO RHO0 PI0 PI0                       769+ 135+ 135
P8      RHO(1600) INTO E+ E-                             .511+.511
P9      RHO(1600) INTO RHO+- PI-+ PI0                     769+ 140+ 135
P10     RHO(1600) INTO KBAR K*(892) + C.C.                494+ 892
P11     RHO(1600) INTO PI PI ETA                          140+ 140+ 549
P12     RHO(1600) INTO RHO PI PI                          769+ 140+ 140

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                         65  RHO(1600) PARTIAL WIDTHS (KEV)

W8      RHO(1600) INTO E+ E-                               (G8)

W8  D        (7.5)     (1.5)            DELCOUR2  81 DM1     E+ E-, 2(PI+PI-)  9/81

W8  D   MODEL DEPENDENT, NOT INDEPENDENT OF DELCOUR2 81 WIDTH TIMES E+E-
W8  D   BRANCHING RATIO BELOW

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                         65  RHO(1600) BRANCHING RATIOS

R1      RHO(1600) INTO (RHO PI+ PI-)/(4 PI, ALL CHARGED) (P1)/(P2)
R1 S         (0.80)                     BINGHAM   72  HBC    9.3 GAM P,P 4PI    1/73
R1      500   0.7       0.1             SCHACHT   74 STRC    5.5-18 G P,P 4PI  12/75
R1           (1.0)  APPROX.             DELCOUR2  81 DM1     E+E-,2(PI+PI-)     1/82
R1 S     THE PI PI SYSTEM IS IN S WAVE                                          1/73

R3      RHO(1600) INTO (PI+ PI-)/(4 PI, ALL CHARGED)       (P4)/(P2)
R3           (0.2)  OR LESS  2 SIGMA   BINGHAM   72  HBC    9.3 GAM P,P 2PI    1/73
R3           (0.14) OR LESS  ESTIMATE  DAVIER    73 STRC    6-18 G P,P 4PI     1/74
R3            0.13      0.05            ASTON 1   80 OMEG    20-70 GAM P,2PI    9/81

R4      RHO(1600) INTO (KBAR K)/(4 PI, ALL CHARGED)        (P5)/(P2)
R4           (0.04) OR LESS  CL=0.95   BINGHAM   72  HBC  0 9.3 GAM P          1/73
R4    D       0.015     0.010           DELCOUR2  81 DM1     E+E-,KBAR K        1/82
R4    D  ASSUMING RHO(1600) AND OMEGA RAD.EXIT. TO BE DEGENERATE IN MASS.

R5      RHO(1600) INTO (PI+PI-)/TOTAL                      (P4)
R5  E        (0.15) OR LESS             EISENBERG 73 HBC     5 PI+ P,DEL++2PI   1/74
R5  H        (0.25)    (0.05)           HYAMS     73 ASPK    17 PI-P,N PI+PI-   1/74
R5            0.20      0.05            MONTANET  73 HBC     PBAR P AT REST    12/77
R5 C         (0.20) OR LESS             COSTA 2   77 RVUE    E+E-,2 PI + 4 PI  12/77
R5  P        (0.30)    (0.05)           FROGGATT  77 RVUE    17 PI-P,PI+PI-N   12/77
R5 P         (0.15)TO 0.30              MARTIN    78 RVUE    17 PI-P,PI+PI-N   12/77
R5            0.287     0.043     0.042 BECKER    79 ASPK    17 PI- P POLARIZ  12/79
R5           . . . . . . . . . .
R5  AVERAGE MEANINGLESS (SCALE FACTOR = 1.3)

R5 C     ESTIMATE USING UNITARITY,TIME REVERSAL INVARIANCE,BREIT WIGNER
R5  E    ESTIMATED USING OPE MODEL.
R5  H    INCLUDED IN BECKER 79 ANALYSIS
R5 P     FROM PHASE SHIFT ANALYSIS OF HYAMS 73 DATA

R6      RHO(1600) INTO (RHO0 PI0 PI0)/(RHO+- PI-+ PI0)     (P7)/(P9)
R6           (0.15) OR LESS             ATKINSON  82 OMEG  0 20-70GAM P,4PI P  1/82

R7      RHO(1600) INTO (PI+ PI- + NEUTRALS)/(4PI,ALL CHARGED)
R7                                                         (P7+....)/(P2)
R7  U        (2.6)     (0.4)            BALLAM    74 HBC     9.3 GAMMA P       12/75
R7  U    UPPER LIMIT. BACKGROUND NOT SUBTRACTED

R8      RHO(1600) INTO (PI PI ETA)/(4 PI, ALL CHARGED)     (P11)/P2
R8           (0.1)  APPROX.             ASTON 1   80 OMEG    20-70 GAM P        1/82
R8            0.123     0.027           DELCOURT  82 DM1     E+E-,PI+PI-MM      9/83*

R9      RHO(1600) INTO (KBAR K*(892)+C.C.)/(4PI, ALL CHG)(P10)/(P2)
R9    D       0.15      0.03            DELCOUR2  81 DM1     E+E-,KBAR K PI     1/82
R9    D  ASSUMING RHO(1600) AND OMEGA RAD.EXIT. TO BE DEGENERATE IN MASS.

R10     RHO(1600) INTO (KBAR K)/(KBAR K*(892)+C.C.)        (P5)/P10)
R10           0.052     0.026           BUON      82 DM1     E+E-,HADRONS       1/84*

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                     65  RHO(1600)    G(I)*G(E+E-)/G(TOTAL)    (KEV)

         THIS COMBINATION OF A PARTIAL WIDTH WITH THE PARTIAL WIDTH INTO
         E+E- AND WITH THE TOTAL WIDTH IS OBTAINED FROM THE CROSS-SECTION
         INTO CHANNEL(I) IN E+E- ANNIHILATION.

G2      G(4 PI, ALL CHARGED)*G(E+E-)/G(TOTAL)              (G2)*(G8)/TOTAL
G2            2.83      0.42            BACCI     80 FRAG    E+ E-, 2(PI+PI-)   3/82
G2 P         (0.4)                      PENSO     80 RVUE    E+ E-, 2(PI+PI-)   3/82
G2            2.6       0.2             DELCOUR2  81 DM1     E+ E-, 2(PI+PI-)   3/82
G2           . . . . . . . . . .
G2  AVG       2.64      0.18     AVERAGE

G2 P     ASSUMING RHO+EPSILON DECAY MODE INTERFERES WITH A(1270)+PI
G2 P     BACKGROUND.

G5      G(KBAR K)*G(E+E-)/G(TOTAL)                         (G5)*(G8)/TOTAL
G5  M        (0.035)  (0.029)           BIZOT     80 DM1     E+ E-              3/82

G10     G(KBAR K*(892) + C.C.)*G(E+E-)/G(TOTAL)            (G10)*(G8)/TOTAL
G10 M        (0.305)  (0.071)           BIZOT     80 DM1     E+ E-              3/82

G12     G(RHO PI PI)*G(E+E-)/G(TOTAL)                      (G12)*(G8)/TOTAL
G12 M        (3.510)  (0.090)           BIZOT     80 DM1     E+ E-              3/82

G   M    MODEL DEPENDENT

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REFERENCES FOR RHO(1600)


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ALVENSLE 71 PRL 26 273          ALVENSLEBEN,BECKER,BERTRAM,CHEN,+(DESY+MIT) G
BRAUN    71 NP B30 213          +FRIDMAN, GERBER, GIVERNAUD,+  (STRASBOURB) G
BULOS    71 PRL 26 149          +BUSZA,KEHOE,BENISTON,+  (SLAC+UMD+IBM+LBL) G

BACCI    72 PL 38B 551          +PENSO,SALVINI,STELLA,BALDINI-CE(ROMA+FRAS) JPC
BARBARIN 72 LNC 3 689           BARBARINO,CERADINI,+   (FRAS+ROMA+PADO+UMD)IGJP
BARTOLI  72 PR D 6 2374         +FELICETTI,OGREN,+          (FRAS+ROMA+NAPL)IGJP
BINGHAM  72 PL 41B 635          +RABIN,ROSENFELD,SMADJA,YOST+(LBL,UCB,SLAC)IGJP
BRAMON   72 LNC 3 693           +GRECO (THEORETICAL PAPER)       (FRASCATI)
DIEBOLD  72 BATAVIA CONF.       R.DIEBOLD  RAPPORTEUR TALK            (ANL)
EISENBER 72 PR D 5 15           EISENBERG,BALLAM,DAGAN,+   (REHO+SLAC+TELA)
LAYSSAC  72 NC 10A 407          J.LAYSSAC,F.M.RENARD                 (MONP)
SMADJA   72 PHIL.CONF.PROC349 +BINGHAM,FRETTER,BALLAM,CHADWICK+(LBL+SLAC)

CERADINI 73 PL 43 B 341         +CONVERSI,EKSTRAND,GRILLI,+(ROMA+FRAS+PADO)IGJP
CHUNG    73 PL 47 B 526         +PROTOPOPESCU,LYNCH,FLATTE+   (BNL+LBL+USC)
DAVIER   73 NP B 58 31          +DERADO,FRIES,LIU,MOZLEY,ODIAN,PARK,+(SLAC)
EISENBER 73 PL 43 B 149         EISENBERG,KARSHON,MIKENBERG,PITLUCK,+(REHO)
HYAMS    73 NP B 64 134         +JONES,WEILHAMMER,BLUM,DIETL,+  (CERN+MPIM)
KREUZER  73 PR D 8 1431         H.J.KREUZER,A.N.KAMAL    (UNIV. OF ALBERTA)
OCHS     73 THESIS              THESIS                               (MPIM)
MONTANET 73 ERICE SCHOOL 518    L.MONTANET                           (CERN)
PARK     73 NP B 58 45          J.C.H.PARK                           (MPIM)  JP

BALLAM   74 NP B76 375          +CHADWICK,BINGHAM,FRETTER+  (SLAC+LBL+MPIM)
BERNABEI 74 LNC 11 261          +D.ANGELO,SPILLANTINI,VALENTE   (ROMA+FRAS)
CHALOUPK 74 PL 51 B 407         CHALOUPKA,FERRANDO,LOSTY,MONTANET    (CERN)
CONVERSI 74 PL 52B 493          +PAOLUZI,CERADINI,GRILLI+       (ROMA+FRAS)
ESTABROO 74 NP B79 301          P.ESTABROOKS,A.D.MARTIN              (DURH)
FERBEL   74 PR D9 824           T.FERBEL AND P.SLATTERY              (ROCH)
GRAYER   74 NP B 75 189         G.GRAYER,HYAMS,BLUM,DIETL,+     (CERN+MPIM)
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HIRSHFEL 74 NP B74 211         A.C.HIRSHFELD,G.KRAMER                  (HAMB)
SCHACHT  74 NP B81 205         +DERADO,FRIES,PARK,YOUNT                (MPIM)

ALEXANDE 75 PL 57B 487         ALEXANDER,BENARY,GANDSMAN,LISSAUER+  (TELA)
ALLES    75 NC 30A 136         ALLES-BORELLI,BERNARDINI+  (CERN+BGNA+FRAS)
CHUNG    75 PR D 11 2436       +PROTOPOPESCU,LYNCH,FLATTE+   (BNL+LBL+USC)
ESTABROO 75 NP B95 322         P.ESTABROOKS,A.D.MARTIN                 (DURH)
FROGGATT 75 NP B91 454         C.D.FROGGATT,J.L.PETERSEN          (GLAS+NORD)
HYAMS    75 NP B100 205        +JONES,WEILHAMMER,BLUM,DIETL+      (CERN+MPIM)
LANG     75 PL 58B 450         C.B.LANG,I.S.STEFANESCU                 (KARL)
LANGACKE 75 PR D 13 697        P.LANGACKER,G.SEGRE                     (PENN)
LEE      75 STANFORD CONF.213 WONYONG LEE                             (COLU)
ROOS     75 NP B 97 165        M.ROOS                                  (HELS)

BASSOMPI 76 PL 65 B 397        BASSOMPIERRE,BINDER,+        (MULH+STRB+TORI)
COMMON   76 NP B 103 109       A.K.COMMON                              (KENT)  JP
JOHNSON  76 PL 63 B 95         +MARTIN,PENNINGTON                 (DURH+CERN)  JP

BUDNEV   77 PL 70 B 365        N.M.BUDNEV,V.M.BUDNEV,V.V.SEREBRYAKOV(NOVO)
COSTA 1  77 PL 67 B 213        COSTA DE BEAUREGARD,PHAM,PIRE,TRUONG (EPOL)
COSTA 2  77 PL 71 B 345        COSTA DE BEAUREGARD,PIRE,T.N.TRUONG  (EPOL)
FROGGATT 77 NP B 129 89        C.D.FROGGATT,J.L.PETERSEN          (GLAS+BOHR)
GESSAROL 77 NP B 126 382       GESSAROLI+   (BGNA+FIRZ+GENO+MILA+OXF+PAVI)

GENSINI  78 PR D 17 1368       PAOLO M GENSINI                         (SLAC)
MARTIN   78 ANP  114 1         A.D.MARTIN,M.R.PENNINGTON               (CERN)

ATIYA    79 PRL 43 1691        +HOLMES,KNAPP,LEE,SETO,+    (COLU+ILL+FNAL)
BACCI    79 PL B 86 234        +DE ZORZI,PENSO,STELLA,+   (ROMA+BGNA+FRAS)
BECKER   79 NP B 151  46       +BLANAR,BLUM,CERRADA+ (MPIM+CERN+ZEEM+CRAC)
CORDEN   79 NP B 157 250       +DOWELL,GARVEY,JOBES,+(BIRM+RHEL+TELA+LOWC)  JP
CORDIER  79 PL 81 B 389        +DELCOURT,ESCHSTRUTH,FULDA+             (LALO)
COSME    79 NP B 152 215       +DUDELZAK,GRELAUD,JEAN-MARIE,JULLIAN+ (IPN)
LANG     79 PR D 19 956        C.B.LANG,A.MAS-PARAREDA                 (GRAZ)
RICHARD  79 FERMILAB SYMP.469 F.RICHARD                               (LALO)

ASTON 1  80 PL 92 B 215        (BONN+CERN+EPOL+GLAS+LANC+MCHS+ORSA+PARIS+)
ASTON 2  80 NP B 174 269       (BONN+CERN+EPOL+GLAS+LANC+MCHS+ORSA+PARIS+)
BARBER   80 ZPHY C 4 169       +DAINTON,BRODBECK,BROOKES,+(DARE+LANC+SHEF)
BACCI    80 PL 95 B 139        +DE ZORZI,PENSO,BALDINI-CELIO,+ (ROMA+FRAS)
BIZOT    80 MADISON CONF. 546 +BISELLO,BUON,CORDIER,DELCOURT,+(LALO+USTL)
HEYN     80 ZPHY C 7 169       M.F.HEYN,C.B.LANG                       (GRAZ)
KILLIAN  80 PR D 21 3005       +TREADWELL,AHRENS,BERKELMAN,CASSEL,+ (CORN)
O-DONNEL 80 PR D 22 711        P.J.O-DONNELL                        (TORONTO)
PENSO    80 PL 95 B 143        G.PENSO,TRAN N.TRUONG              (ROMA+EPOL)

ASTON 1  81 NP B 189 15        (BONN+CERN+EPOL+GLAS+LANC+MCHS+ORSA+PARIS+)
ASTON 2  81 PL 104 B 231       (BONN+CERN+EPOL+GLAS+LANC+MCHS+ORSA+PARIS+)
DELCOURT 81 PL 99 B 257        +BISELLO,BIZOT,BUON,CORDIER,MANE      (ORSAY)
DELCOUR2 81 BONN CONF. 205     B.DELCOURT                             (ORSAY)
    ALSO 82 PL 109B 129        CORDIER,+                              (ORSAY)
DIBIANCA 81 PR D 23 595        +FICKINGER,MALKO,DADO,ENGELER,+ (CASE+CARN)

ATKINSON 82 PL 108 B 55        + (BONN+CERN+GLAS+LANC+MCHS+CURI+RHEL+SHEF)
BUON     82 PL 118 B 221       +BISELLO,BIZOT,CORDIER,DELCOURT+(LALO+MONP)
DELCOURT 82 PL 113 B 93        +BISELLO,BIZOT,BUON,CORDIER,MANE       (LALO)
CLELAND  82 NP B 208 228       +DELFOSSE,DORSAZ,GLOOR(DURH+GEVA+LAUS+PITT)
PENSO    82 NC 68 A 213        +PENSO,TRAN N.TRUONG               (ROMA+EPOL)
SHAMBROO 82 PR D 26 1          +WILSON,ANDERSON,FRANCIS+(HARV+EFI+ILL+OXF)

AUGUSTIN 83  LAL/83-21         +AYACH,BISELLO,BALDINI+     (LALO+PADO+FRAS)
ATKINSO1 83 NP B 229 269         (BONN+CERN+GLAS+LANC+MCHS+IPNP+RHEL+SHEF)
ATKINSO2 83  CERN-EP/83-80       (BONN+CERN+GLAS+LANC+MCHS+IPNP+RHEL+SHEF)
ATKINSO3 83 PL 127 B 132         (BONN+CERN+GLAS+LANC+MCHS+IPNP+RHEL+SHEF)
ATKINSO4 83  CERN-EP/83-85       (BONN+CERN+GLAS+LANC+MCHS+IPNP+RHEL+SHEF)

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$\omega(1670)$

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45  OMEGA(1670,JPG=3--) I=0.

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                  45  OMEGA(1670) MASS (MEV)

M           1636.      20.               ARMENISE  68 DBC    5.1 PI+N,P(3PI)0   9/68
M   Q       1695.0     20.0              BARNES    69 HBC  0 4.6 K-P,OMEG2PI    2/74
M           1670.      20.               KENYON    69 DBC    8.  PI+N,P(3PI)0   8/69
M       200 1679.      17.               MATTHEWS  71 DBC    7.0 PI+N,P(3PI)0   1/71
M       500 1678.      14.               DIAZ      74 DBC    6.  PI+N,P(3PI)0   1/74
M     Q 200 1660.      13.               DIAZ      74 DBC    6.  PI+N,P(5PI)0   1/74
M   P   600 1669.      11.               WAGNER    75 HBC    7. PI+P,DEL++3PI  11/75
M     E 110(1700.0)  APPROX.             CERRADA   77 HBC    4.2 K-P,LAM 3PI   12/77
M   P E 430 1673.0     12.0              BALTAY    78 HBC    15 PI+P,DEL 3PI    4/78
M           1650.0    12.0               CORDEN    78 OMEG   8-12 PI- P,N 3PI  12/77
M        60 1685.0     20.0              BAUBILLIE 79 HBC    8.2K- P,BACKWARD  12/79
M           . . . . . . . . .
M   AVG     1667.9      4.6     AVERAGE

M     E  PHASE ROTATION SEEN FOR JP 3- (RHO PI) WAVE.
M   P    FROM A FIT TO I=0, JP=3- RHO PI PARTIAL WAVE
M     Q  FROM (OMEGA PI PI) MODE

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                  45  OMEGA(1670) WIDTH (MEV)

W            112.      60.               ARMENISE  68 DBC    5.1 PI+N,P(3PI)0   9/68
W     Q      (90.)    (20.)              BARNES    69 HBC  0 4.6 K-P,OMEG2PI    1/73
W            100.      40.               KENYON    69 DBC    8.  PI+N,P(3PI)0   8/69
W     S 200  155.      40.               MATTHEWS  71 DBC    7.0 PI+N,P(3PI)0  11/75
W       500  167.      40.               DIAZ      74 DBC    6.  PI+N,P(3PI)0   1/74
W     Q 200  122.      39.               DIAZ      74 DBC    6.  PI+N,P(5PI)0   1/74
W   P S 600  173.      28.               WAGNER    75 HBC    7. PI+P,DEL++3PI  11/75
W   P E 430  173.0     16.0              BALTAY    78 HBC    15 PI+P,DEL 3PI    4/78
W            253.0     39.0              CORDEN    78 OMEG   8-12 PI- P,N 3PI  12/77
W     S  60  160.0     80.0              BAUBILLIE 79 HBC    8.2K- P,BACKWARD  12/79
W            . . . . . . . . .
W   AVG      166.1     12.0     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)

W     E  PHASE ROTATION SEEN FOR JP 3- (RHO PI) WAVE.
W   P    FROM A FIT TO I=0, JP=3- RHO PI PARTIAL WAVE
W     S  WIDTH ERRORS ENLARGED BY US TO 4*WIDTH/SQRT(N),SEE K*(892) NOTE
W     Q  FROM (OMEGA PI PI ) MODE

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                  45  OMEGA(1670) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      OMEGA(1670) INTO 3 PI (INCL. RHO PI)             135+ 135+ 135
P2      OMEGA(1670) INTO 5 PI (INCL. OMEGA PI+PI-)       135+ 135+ 135+ 135+
P3      OMEGA(1670) INTO RHO PI                          769+ 135
P4      OMEGA(1670) INTO OMEGA 2 PI                      783+ 135+ 135
P5      OMEGA(1670) INTO B(1235) PI                     1234+ 135

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                  45  OMEGA(1670) BRANCHING RATIOS

R1      OMEGA(1670) INTO (5 PI)/(3 PI)                        (P2)/(P1)
R1      200    0.97     0.28          DIAZ      74 DBC     6.  PI+N,P(5PI)0  1/74

R2      OMEGA(1670) INTO (RHO PI)/(3 PI)                      (P3)/(P1)
R2      200   (0.70) OR MORE          MATTHEWS  71 DBC     7.0 PI+N,P(3PI)0 11/71

R3      OMEGA(1670) INTO (OMEGA 2 PI)/(RHO PI)                (P4)/(P3)
R3      100    0.71     0.27          DIAZ      74 DBC     6.  PI+N,P(5PI)0 12/78

R4      OMEGA(1670) INTO (B(1235) PI)/(RHO PI)                (P5)/(P3)
R4         POSSIBLY SEEN              DIAZ      74 DBC     6.  PI+N,P(5PI)0  1/74

R5      OMEGA(1670) INTO (B(1235)PI)/(OMEGA PI PI)            (P5)/(P4)
R5           1.0      0.0       0.25  BAUBILLIE 79 HBC     8.2K- P,BACKWARD 12/79

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REFERENCES FOR OMEGA(1670)


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ARMENISE 68 PL 26B 336         +GHIDINI,FORINO+ (BARI+BGNA  +FIRZ  +ORSAY)

BARNES   69 PRL 23 142         +CHUNG,EISNER,FLAMINIO,+                (BNL)
KENYON   69 PRL 23 146         +KINSON,SCARR,+               (BNL+UCND+ORNL)

ARMENISE 70 LNC 4 199          +GHIDINI,FORINO,CARTACCI,+ (BARI+BGNA+FIRZ)

MATTHEWS 71 PR D 3 2561        +PRENTICE,YOON,CARROLL,+          (TNTO+WISC)
MATTHEW1 71 LNC 1 361          +PRENTICE,YOON,CARROLL,+          (TNTO+WISC)

DIAZ     74 PRL 32 260         +DIBIANCA,FICKINGER,ANDERSON,+  (CASE+CARN)

WAGNER   75 PL 58B 201         +TABAK,CHEW                             (LBL)  JP

CERRADA  77 NP B 126 241       +BLOCKZIJL,HEINEN,+    (AMST+CERN+NIJM+OXF)  JP

BALTAY   78 PRL 40 87          +CAUTIS,KALELKAR                       (COLU)  JP
CORDEN   78 NP B 138 235       +CORBETT,ALEXANDER,+  (BIRM+RHEL+TELA+LOWC)

BAUBILLI 79 PL B 89 131        BAUBILLIER+        (BIRM+CERN+GLAS+MSU+LPNP)

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A(1680) or A_3

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34  A(1680,JPG=2--) I = 1
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We have dropped the subscript 3 on the A_3, and rename this meson A(1680).

Evidence for the existence of the A(1680) meson was previously confused due to its appearance near the $f\pi$ threshold in the diffractive-like process $\pi N \to \pi\pi\pi N$, much like the A(1270) meson. While everybody agreed that there was a ~300-MeV-wide $f\pi$ enhancement in the $J^P LM = 2^- S0$ partial wave at about 1650 MeV, some claimed nonresonant states (ANTIPOV1 73, ASCOLI1 73, BALTAY 77), while others saw evidence for a resonance in the phase variation with respect to other partial waves (OTTER 74, THOMPSON 74).

In the nondiffractive charge-exchange reaction $\pi^- p \to \pi^+\pi^-\pi^0\Delta^{++}$ (WAGNER 75, BALTAY 77, CAUTIS 77) and in the hypercharge-exchange reaction $K^- p \to \pi^+\pi^-\pi^0\Lambda$ at 4.2 GeV/c (CERRADA 77), there is no evidence for A(1680) production.

Definitive proof for the resonant nature of the A(1680) has been given by PERNEGR 78 (3π system diffractively produced on nuclei) and DAUM 80,81 and EVANGELISTA 81 (3π diffraction on proton target). In all these experiments, the $2^- S0^+$ ($f\pi$) partial-wave amplitude exhibits resonance-like phase variation.

In a simultaneous fit to the four 2^- waves ($\epsilon\pi$, $\rho\pi$, twice $f\pi$), DAUM 81 needs a heavier companion to the A(1680) in addition to the Deck background. This fit probably gives the most reliable estimates of the A(1680) and of its heavier companion, which we name A(2100).

Mesons

A(1680) [A_3], ϕ(1680) [ϕ']

34 A(1680) MASS (MEV)

```
M           1660.0     20.0            CASO       69 HBC   -  11 PI-P, PI-F    12/75
M       260 1660.      25.             CASO       72 HBC   +  11.7 PI+ P       12/75
M    P      1650.      30.             ANTIPOV1   73 CNTR  -  25.,40. PI- P    12/75
M    P      1660.      10.             ASCOLI 1   73 HBC   -  5.-25.PI- P,P A3 12/75
M  P E     (1600.)    (10.)            THOMPSON   74 HBC   +  13. PI+ P,P A3+  12/75
M       575 1640.      10.             KALELKAR   75 HBC   +  15 PI+P,P PI+F   12/75
M    P   2M 1662.0     10.0            BALTAY     77 HBC   0  15 PI+ P,P 3PI   12/77
M    R     (1650.0)                    PERNEGR    78 CNTR  -  9+13+15,PI- NUC.  4/78
M  P D      1657.0     14.0            DAUM       80 SPEC  -  63-94 PI- P, 3PI 12/79
M   L      (1710.0)   (20.0)           DAUM       81 SPEC  -  63,94 PI- P       1/82
M  P        1676.       6.             EVANGELIS  81 OMEG  -  12 PI-P,3PI P     1/82
M           . . . . . . . . . . .
M   AVG     1663.5      4.7     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
                           (SEE IDEOGRAM BELOW)

M    D      CLEAR PHASE ROTATION SEEN IN  (2-S),(2-P),(2-D) WAVES.
M    D      WE QUOTE CENTRAL VALUE AND SPREAD OF SINGLE-RESONANCE
M    D      FITS TO THREE CHANNELS.
M    E   EVIDENCE FOR A ROTATION OF THE PHASE CLAIMED.
M    L   FROM A TWO RESONANCE FIT TO FOUR 2-0+ WAVES. THIS SHOULD NOT BE
M    L   AVERAGED WITH ALL THE SINGLE RESONANCE FITS. SEE MINIREVIEW.
M  P     FROM A FIT TO JP=2-S (F PI) PARTIAL WAVE
M    R   CLEAR PHASE ROTATION SEEN IN (2-S) AND (2-P) WAVES
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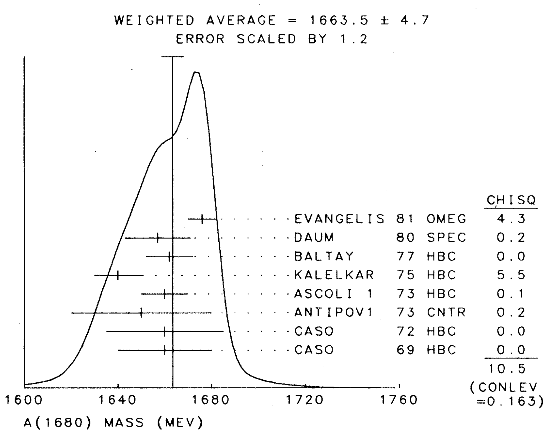


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34 A(1680) WIDTH (MEV)

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W       297  240.0      50.0           ARMENISE   69 DBC   +   5.1 PI+D,3PI++-  5/70
W           (130.)                     CASO       69 HBC   -   11 PI- P         6/68
W           (150.0)                    CASO       69 HBC   -  11.0 PI-P,PI- F   6/68
W  P         200. TO 400.              CASO       72 HBC   +  11.7 PI+ P        1/72
W       260  190.      100.            CASO       72 HBC   +  11.7 PI+ P       12/75
W  P         300.       50.            ANTIPOV1   73 CNTR  -  25.,40. PI- P    12/75
W  P         270.       60.            ASCOLI 1   73 HBC   -  5.-25.PI- P,P A3 12/75
W  P E      (310.)     (40.)           THOMPSON   74 HBC   +  13. PI+ P,P A3+  12/75
W       575  240.       30.            KALELKAR   75 HBC   +  15 PI+P,P PI+F   12/75
W  P   2000  285.0      60.0           BALTAY     77 HBC   0  15 PI+ P,P 3PI   12/77
W    R      (400.0)                    PERNEGR    78 CNTR  -  9+13+15,PI- NUC.  4/78
W  P D       219.0      20.0           DAUM       80 SPEC  -  63-94 PI- P, 3PI 12/79
W    L       312.0      50.0           DAUM       81 SPEC  -  63,94 PI- P       1/82
W  P         260.       20.            EVANGELIS  81 OMEG  -  12 PI-P,3PI P     1/82
W            . . . . . . . . . . .
W   AVG      248.3      11.2     AVERAGE

W    D      SEE NOTE D UNDER MASS.
W    E   EVIDENCE FOR A ROTATION OF THE PHASE CLAIMED.
W    L   FROM A TWO RESONANCE FIT TO FOUR 2-0+ WAVES. THIS SHOULD NOT BE
W    L   AVERAGED WITH ALL THE SINGLE RESONANCE FITS. SEE MINIREVIEW.
W  P     FROM A FIT TO JP=2- F PI PARTIAL WAVE
W    R   CLEAR PHASE ROTATION SEEN IN (2-S) AND (2-P) WAVES

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34 A(1680) PARTIAL DECAY MODES

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                                                         DECAY MASSES
P1      A(1680) INTO 3 PI                              135+ 135+ 135
P2      A(1680) INTO RHO PI                            135+ 769
P3      A(1680) INTO ETA PI                            135+ 549
P4      A(1680) INTO 5 PI                              140+ 140+ 140+ 140+
P5      A(1680) INTO K K*(892)                         498+ 892
P6      A(1680) INTO K KBAR PI                         498+ 498+ 135
P7      A(1680) INTO K KBAR                            498+ 498
P8      A(1680) INTO F PI                             1274+ 135
P9      A(1680) INTO OMEGA PI PI                       783+ 135+ 135
P10     A(1680) INTO 3 PI                              140+ 140+ 140
P11     A(1680) INTO EPSILON(1300) PI                 1300+ 140

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34 A(1680) BRANCHING RATIOS

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R2      A(1680)+- 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    L      0.29      0.05          DAUM      81 SPEC    63,94 PI- P        1/82
R2    L  FROM A TWO RESONANCE FIT TO FOUR 2-0+ WAVES.

R3      A(1680)+- INTO (PI+- F)/(ALL PI+- PI+ PI-)        (P8)/(P1C)
R3                     (WITH F INTO PI+ PI-)
R3          (0.59)                   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           0.76      0.24     0.34 ARMENISE  69 DBC  +   5.1 PI+D,3PI++-   5/70
R3    L      0.61      0.04          DAUM      81 SPEC    63,94 PI- P        1/82
R3    L  FROM A TWO RESONANCE FIT TO FOUR 2-0+ WAVES.
R3           . . . . . . . . . . .
R3   AVG     0.603     0.050   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)

R5      A(1680)+- 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      A+- 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

R11     A(1680)+- INTO (PI+- EPSILON)/(ALL PI+- PI+ PI-) (P11)/(P1C)
R11                    (WITH EPSILON INTO PI+ PI-)
R11   L      0.10      0.05          DAUM      81 SPEC    63,94 PI- P        1/82
R11   L  FROM A TWO RESONANCE FIT TO FOUR 2-0+ WAVES.

R12     D/S RATIO FOR A(1680) INTO F PI
R12   L      0.22      0.10          DAUM      81 SPEC    63,94 PI- P        1/82
R12   L  FROM A TWO RESONANCE FIT TO FOUR 2-0+ WAVES.

R13     A(1680)+- INTO K K*(892) / A(1680)+- INTO PI+- F (P5)/(P8)
R13M         0.075     0.025         ARMSTRONG 82 OMEG -  16 PI-P,K+K-PI-P  9/83*
R13M     FROM A PARTIAL WAVE ANALYSIS OF K+ K- PI- SYSTEM

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REFERENCES FOR A(1680)


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FORINO   65 PL 19 68            +GESSAROLI+       (BGNA+BARI+FIRZ+ORSA+SACL)

FOCACCI  66 PRL  17  890        CERN MISSING MASS SPECTROMETER GROUP (CERN)
LEVRAT   66 PL  22  714         CERN MISSING MASS SPECTROMETER GROUP (CERN)
LUBATTI  66 THESIS BERKELEY     H.J.LUBATTI                          (LRL)1-2-
VETLITSK 66 PL  21  579         VETLITSKY,GUSZAVIN,KLIGER,ZOLGANOV+  (ITEP)

DANYSZ   67 NC 51 A 801         DANYSZ+FRENCH+SIMAK                  (CERN)
DUBAL    67 NP B3 435           CERN MISSING MASS SPECTROMETER GROUP (CERN)
   ALSO  68 THESIS 1456         L.DUBAL                            (GENEVE)

BALTAY   68 PRL 20 887          +KUNG+YEH+FERBEL+     (COLU+ROCH+RUTG+YALE)I=1
BARTSCH  68 NP B 7 345          +KEPPEL,KRAUS,+             (AACH+BERL+CERN) JP
CASO     68 NC 54 A 983         +CONTE+CORDS+DIAZ+  (GENOVA+HAMB+MILA+SACL)
FERBEL   68 PHILA.CONF.335      T.FERBEL                          (ROCHESTER)
IOFFREDO 68 PRL 21 1212         +BRANDENBURG,BRENNER,EISENSTEIN+  (HARVARD)
LAMSA    68 PR 166 1395         +CASON+BISWAS+DERADO+GROVES+    (NOTREDAME)

ARMENISE 69 LNC 2 501           +GHIDINI,FORINO,CARTACCI+  (BARI+BGNA+FIRZ)
BARNES   69 PRL 23 142          +CHUNG,EISNER,FLAMINIO,+                (BNL)
CASO     69 LNC 2 437           +CONTE,TOMASINI,CANTORE+   (GENO+MILA+SACL)

BRANDENB 70 NP B16 369          +BRENNER,IOFFREDO,JOHNSON,KIM+    (HARVARD)
CRENNELL 70 PRL 24 781          +KARSHON,LAI,SCARR,SIMS                 (BNL)
CHIEN    70 PHILAD.CONF.P.275 C.Y.CHIEN, REVIEW             (JOHNS HOPKINS)
MIYASHIT 70 PR D 1 771          MIYASHITA,VON KROGH,KOPELMAN,LIBBY   (COLO)

BEKETOV  71 SJNP 4 765          +SOMBKOWSKY,KONOWALOV,KRUTSCHININ,+ (ITEP)  JP
PALER    71 PRL 26 1675         +BADEWITZ,BARTON,MILLER,PALFREY,TEBES(PURD)

ALEXANDE 72 NP B 45 29          ALEXANDER,BAR-NIR,BENARY,DAGAN,+     (TELA)
ARMENISE 72 LNC 4 201           +FORINO,CARTACCI,+          (BARI+BGNA+FIRZ)
CASO     72 NP B 36 349         +MADDOCK,BASSLER+(DURH+GENO+DESY+MILA+SACL)
HARRISON 72 PRL 28 775          +HEYDA,JOHNSON,KIM,LAW,MUELLER,+     (HARV)
SALZBERG 72 NP B 41 397         +HARRISON,HEYDA,JOHNSON,KIM,LAW,+    (HARV)

ANTIPOV1 73 NP B 63 153         +ASCOLI,BUSNELLO,FOCACCI,+      (CERN+SERP)  JP
ANTIPOV2 73 NP B 63 141         +ASCOLI,BUSNELLO,FOCACCI,+      (CERN+SERP)  JP
ASCOLI 1 73 PR D 7 669          INTERNAT. COLLABORATION               (ILL+)  JP
ASCOLI 2 73 PR D 8 3894         +JONES,WEINSTEIN,WYLD                  (ILL)  JP

ASCOLI   74 PR D9 1963          +CUTLER,JONES,KRUSE,ROBERTS,WEINSTEIN+(ILL)
LICHTMAN 74 NP B81 31           +BISWAS,CASON,KENNEY,MCGAHAN,+       (NDAM)
OTTER    74 NP B80 1            +RUDOLPH+          (AACH+BERL+BONN+CERN+HEID) JP
TABAK    74 BOSTON CONF.        +RONAT,ROSENFELD,LASINSKI+       (LBL+SLAC)  JP
THOMPSON 74 PRL 32 331          +BADEWITZ,GAIDOS,MCILWAIN,PALER,+    (PURD)  JP
    ALSO 74 NP B69 381          THOMPSON,BADEWITZ,GAIDOS,MCILWAIN+   (PURD)  JP

BEKETOV  75 SJNP 20 379         +ZOMBKOVSKII,KAIDALON,KONOVALOV+     (ITEP)
EMMS     75 PL 60 B 109         +JONES,KINSON,BELL,DALE+   (BIRM+DURH+RHEL)  JP
HORNE    75 PR D11 996          +S.HAGOPIAN,V.HAGOPIAN,BENSINGER+(FSU+BRAN)
KALELKAR 75 THESIS(NEVIS 207) M.S.KALELKAR                           (COLU)
WAGNER   75 PL 58B 201          +TABAK,CHEW                             (LBL)  JP

BALTAY   77 PRL 39 591          +CAUTIS,KALELKAR                  (COLUMBIA)  JP
CAUTIS   77  THESIS NEVIS 221 C.V.CAUTIS                          (COLUMBIA)  JP
CERRADA  77 NP B 126 241        +BLOCKZIJL,HEINEN,+    (AMST+CERN+NIJM+OXF)  JP

BALTAY   78 PR D 17 52          +CAUTIS,COHEN,CSORNA,KALELKAR+  (COLU+BING)
CORDEN   78 NP B 136 77         DOWELL,GARVEY,JOBES+  (BIRM+RHEL+TELA+LOWC)  JP
PERNEGR  78 NP B 134 436        +AEBISCHER+             (ETH+CERN+LOIC+MILA)
ROBERTS  78 PR D 18 59          +KRUSE,EDELSTEIN+       (ILL+CARN+NWES+ROCH)

DAUM     80 PL 89 B 285         +HERTZBERGER+(AMST+CERN+CRAC+MPIM+OXF+RHEL)  JP

DAUM     81 NP B 182 269        +HERTZBERGER+(AMST+CERN+CRAC+MPIM+OXF+RHEL)
EVANGELI 81 NP B 178 197        EVANGELISTA+(BARI+BONN+CERN+DARE+LIVP+MILA)
    ALSO 81 NP B 186 594        (ERRATUM)

ARMSTRON 82 NP B 202 1          +BACCAR(AACH+BARI+BONN+CERN+GLAS+LIVP+MILA)
BELLINI  82 NP B 199 1          + (CERN+MILA+JINR+BGNA+HELS+PAVI+WARS+VIEN)

CHEN     83 PR D 28 2304        +FENKER+(ARIZ+FNAL+FLOR+NDAM+TUFT+VAND+VPI)
LEEDOM   83 PR D 27 1426        +DE BONTE,GAIDOS,KEY,WONG+        (PURD+TNTO)
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ϕ(1680) or ϕ'

67 PHI(1680,JPG=1--) I=0

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FORMERLY CALLED PHI PRIME
FIRST IDENTIFIED USING DALITZ PLOT ANALYSIS OF
E+E- INTO K K*(892) (BIZOT 80, DELCOURT 81)

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67 PHI(1680) MASS (MEV)

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M          (1652.0)   (17.0)          COSME      79 OSPK  0 E+ E-,3PI         12/79

M        21 1679.      34.            ESPOSITO   80 FRAM    E+E-,3 PI          6/81
M     B     1690.      10.            ASTON      81 OMEG    25-70 GAM P,K+K-   9/81
M   C       1680.      10.            BUON       82 DM1     E+E-,HADRONS       1/84*
M    A     (1670.)    (20.)           ATKINSO3   83 OMEG    20-70 GAM P,3 PI   1/84*
M           . . . . . . . . . . .
M    AVG    1684.8      6.9     AVERAGE
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For notation, see key at front of Listings.

Mesons
$\phi(1680)$ $[\phi']$, g(1690)

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M    B  JP NOT UNAMBIGUOSLY 1-
M  C    FROM GLOBAL FIT OF RHO,OMEGA,PHI AND THEIR RADIAL EXCITATIONS TO
M  C    CHANNELS OMEGA PI+PI-,K+K-,KS KL,KS K+-PI-+. ASSUME MASS 1570 MEV
M  C    AND WIDTH 510 MEV FOR RHO RAD. EXIT.,MASS 1570 AND WIDTH 500 MEV
M  C    FOR OMEGA RADIAL EXCITATION.
M   A   MAY BE PHI OR OMEGA RADIAL EXCITATION. INTERPRETATION COMPLICATED.

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67 PHI(1680) WIDTH (MEV)

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W            (42.0)    (17.0)            COSME     79 OSPK  0 E+ E-,3PI          12/79

W        21   99.       49.              ESPOSITO  80 FRAM    E+E-,3 PI           6/81
W    B       100.       40.              ASTON     81 OMEG    25-70 GAM P,K+K-    9/81
W  C         185.       22.              BUON      82 DM1     E+E-,HADRONS        1/84*
W   A       (160.)     (20.)             ATKINSO3  83 OMEG    20-70 GAM P,3 PI    1/84*
W             . . . . . . . . . .
W   AVG      156.4      28.5     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)

W    B  JP NOT UNAMBIGUOSLY 1-
W  C    SEE NOTE C UNDER MASS.
W   A   MAY BE PHI OR OMEGA RADIAL EXCITATION. INTERPRETATION COMPLICATED.

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67 PHI(1680) PARTIAL DECAY MODES

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                                                              DECAY MASSES
P1     PHI(1680) INTO OMEGA 2 PI                             783+ 140+ 140
P2     PHI(1680) INTO 3 PI                                   140+ 140+ 135
P3     PHI(1680) INTO K KBAR                                 494+ 494
P4     PHI(1680) INTO K*(892) KBAR + C.C.                    892+ 494
P5     PHI(1680) INTO KS K PI                                498+ 494+ 140
P6     PHI(1680) INTO E+ E-                                  .511+.511

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67 PHI(1680) BRANCHING RATIOS

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R1     PHI(1680) INTO (OMEGA PI+PI-)/(K*(892) KBAR+C.C.)(P1)/(P4)
R1          (0.10) OR LESS               BUON      82 DM1     E+E-           8/83*

R2     PHI(1680) INTO (K KBAR)/(K*(892) KBAR+C.C.)        (P3)/(P4)
R2          0.07      0.01               BUON      82 DM1     E+E-           8/83*

R3     PHI(1680) INTO (K*(892) KBAR)/(KS K+- PI-+)        (P4)/(P5)
R3          DOMINANT                     MANE      82 DM1     E+E-,KS K+- PI-+  8/83*

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67 PHI(1680) G(I)*G(E+E-)/G(TOTAL) (KEV)

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        THIS COMBINATION OF A PARTIAL WIDTH WITH THE PARTIAL WIDTH INTO
        E+E- AND WITH THE TOTAL WIDTH IS OBTAINED FROM THE INTEGRATED
        CROSS SECTION INTO CHANNEL(I) IN E+E- ANNIHILATION.
        WE ONLY LIST DATA NOT HAVING BEEN USED TO DETERMINE THE PARTIAL
        WIDTH G(I) OR THE BRANCHING RATIO G(I)/TOTAL.

G1     G(OMEGA 2PI)*G(E+E-)/G(TOTAL)                     (G1)*(G6)/TOTAL
G1  M       (0.017)APPROX                BIZOT     80 DM1     0 E+ E-         3/82

G3     G(K KBAR)*G(E+E-)/G(TOTAL)                        (G3)*(G6)/TOTAL
G3  M       (0.053)   (0.035)            BIZOT     80 DM1     0 E+ E-         3/82

G4     G(K*(892) KBAR + C/C/)*G(E+E-)/G(TOTAL)           (G4)*(G6)/TOTAL
G4  M       (0.413)   (0.033)            BIZOT     80 DM1     0 E+ E-         3/82

G   M   MODEL DEPENDENT

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REFERENCES FOR PHI


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COSME     79 NP B 152 215       +DUDELZAK,GRELAUD,JEAN-MARIE,JULLIAN+(IPNP)

ASTON     80 NP B 174 269       (BONN+CERN+EPOL+GLAS+LANC+MCHS+ORSA+IPNP +)
BIZOT     80 MADISON CONF. 546  +BISELLO,BUON,CORDIER,DELCOURT,+(LALO+USTL)
ESPOSITO  80 LNC 28 195         +MARINI,PATTERI,NIGRO+(FRAS+NAPL+PADO+ROMA)

ASTON     81 PL 104 B 231       (BONN+CERN+EPOL+GLAS+LANC+MCHS+ORSA+PARIS+)
CORDIER   81 PL 106 B 155       +BISELLO,BIZOT,BUON,DELCOURT,MANE   (ORSAY)
DELCOURT  81 PL 99 B 257        +BISELLO,BIZOT,BUON,CORDIER,MANE    (ORSAY)
MANE      81 PL 99 B 261        +BISELLO,BIZOT,BUON,CORDIER,DELCOURT(ORSAY)

BUON      82 PL 118 B 221       +BISELLO,BIZOT,CORDIER,DELCOURT+(LALO+MONP)
MANE      82 PL 112 B 178       +BISELLO,BIZOT,BUON,DELCOURT,FAYARD,+(LALO)

AUGUSTIN  83 LAL/83-21          +AYACH,BISELLO,BALDINI+     (LALO+PADO+FRAS)
ATKINSO1  83 NP B 229 269       ATKINSON+   (BONN+CERN+GLAS+LANC+MCHS+IPNP+)
ATKINSO2  83 CERN-EP/83-80      ATKINSON+   (BONN+CERN+GLAS+LANC+MCHS+IPNP+)
ATKINSO3  83 PL 127 B 132       ATKINSON+   (BONN+CERN+GLAS+LANC+MCHS+IPNP+)
ATKINSO4  83 CERN-EP/83-85      ATKINSON+   (BONN+CERN+GLAS+LANC+MCHS+IPNP+)
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g(1690)

15 G(1690,JPG = 3-+) I=1

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15 G MASS (MEV)

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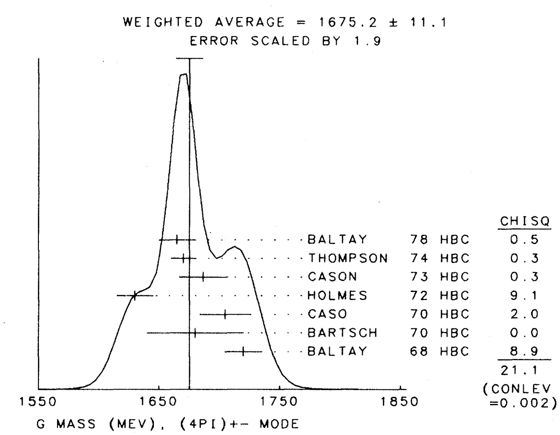
M       WE ONLY INCLUDE HIGH STATISTICS EXPERIMENTS IN THE AVERAGE FOR THE
M       2PI AND KKBAR MODES.

M     2 PI MODE
M
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           (1737.0)   (23.0)            ARMENISE  70 DBC    0 9 PI+ N            1/71
M        122 1650.0     35.0             BARTSCH   70 HBC  +  8 PI+ P,2 PI        5/70
M            1687.      21.              STUNTEBEC 70 HDBC  0 8. PI-P,5.4 PI+D    2/72
M            1678.      12.              MATTHEWS  71 DBC   0  7. PI+ N           2/72
M  E     600 1690.       7.              ENGLER    74 DBC    0 6. PI+N,PI+PI-P  12/75
M  G         1693.       8.              GRAYER    74 ASPK   0 17 PI-P,PI+PI-N   2/74
M  GI       (1692.)    (12.)             ESTABROOK 75 RVUE    17 PI-P,PI+PI-N   12/75
M   I       (1722.)     (3.)             HYAMS     75 ASPK   0 17 PI-P,PI+PI-N  12/75
M  E     175 1678.0     12.0             ANTIPOV   77 CIBS  0 25 PI-P,P 3PI      1/82
M        476 1679.0     11.0             BALTAY    78 HBC   0 15 PI+P,PI+PI-     4/78
M    M      (1734.0)   (10.0)            CORDEN    79 OMEG    12-15PI-P, N 2PI  12/79
M            1677.      14.              EVANGELIS 81 OMEG  - 12 PI-P,2PI P      1/82
M  E    MASS ERRORS ENLARGED BY US TO WIDTH/SQRT(N),SEE K*(892) TYPED NOTE
M  G    USES SAME DATA AS HYAMS 75
M   I   FROM PHASE-SHIFT ANALYSIS
M   I   ERROR TAKES ACCOUNT OF SPREAD OF DIFFERENT PHASE-SHIFT SOLUTIONS
M    M  FROM A PHASE SHIFT SOLUTION CONTAINING A F PRIME WIDTH
M    M  TWO TIMES LARGER THAN THE K KBAR RESULT.
M
M     K KBAR + K KBAR PI MODE
M
M          1690.0      16.0              ADERHOLZ  69 HBC  +   8 PI+ P,KKBARPI   8/69
M          1692.        6.               BLUM      75 ASPK   018.4 PI-P,N K+K-  11/75
M  P S  6K 1698.       12.               MARTIN 1  78 SPEC     10 PI P,KS K- P   4/78
M          1699.0       5.0              ALPER     80 CNTR  0 62 PI-P,K+ K- N    1/82
M   L     (1694.0)     (8.0)             COSTA     80 OMEG     10. PI-P,K+ K- N  1/82
M
M   L   THEY CANNOT DISTINGUISH BETWEEN G AND OMEGA(1670).
M  P    FROM A FIT TO JP=3- PARTIAL WAVE.
M   S   SYSTEMATIC ERROR ON MASS SCALE SUBTRACTED
M
M          . . . . . . . . . .
M   AVG    1690.9       2.6     AVERAGE

M     (4PI)+- MODE
M
M          1720.       15.               BALTAY    68 HBC  +   7, 8.5 PI+ P      6/68
M      144 1680.0      40.0              BARTSCH   70 HBC  +  8 PI+ P,4 PI       4/71
M   F  102(1689.0)    (20.0)             BARTSCH   70 HBC  +  8 PI+ P,2 RHO      4/71
M          1705.0      21.0              CASO      70 HBC   - 11.2PI-P,RHO 2PI   5/70
M          1630.       15.               HOLMES    72 HBC  +  10.-12. K+ P       1/73
M          1687.       20.               CASON     73 HBC  -  8.,18.5 PI- P      1/74
M   F     (1685.)     (14.)              CASON     73 HBC  -  8.,18.5 PI- P      1/74
M   F   66(1733.)      (9.)              KLIGER    74 HBC   - 4.5 PI-P,P 4PI    12/75
M          1670.       10.               THOMPSON  74 HBC  +  13 PI+ P          12/75
M      177 1665.0      15.0              BALTAY    78 HBC  +  15 PI+P,P 4PI      4/78
M   A     (1694.)      (6.)              EVANGELI  81 OMEG  - 12 PI-P,(4PI)-P    3/82
M   B     (1718.)     (10.)              EVANGELI  81 OMEG  - 12 PI-P,(4PI)-P    3/82
M   C     (1673.)      (9.)              EVANGELI  81 OMEG  - 12 PI-P,(4PI)-P    3/82
M          . . . . . . . . . .
M   AVG    1675.2      11.1     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.9)
                          (SEE IDEOGRAM BELOW)

M   A   FROM RHO- RHO0 MODE, NOT INDEPENDENT OF (B), (C)
M   B   FROM (A2)- PI0 MODE, NOT INDEPENDENT OF (A), (C)
M   C   FROM (A2)0 PI- MODE, NOT INDEPENDENT OF (A), (B)
M   F   FROM (RHO+- RHO0) MODE
```




```
M     OMEGA PI  MODE
M
M          1654.       24.               BARNHAM   70 HBC  + 10 K+ P,OMEGA PI   6/70
M          1686.        9.               THOMPSON  74 HBC  + 13 PI+ P          12/75
M          1666.0      14.0              GESSAROLI 77 HBC     11 PI-P,OMEGA PI 12/77
M          1690.       15.               EVANGELIS 81 OMEG  - 12 PI-P,OME PI P  1/82
M          . . . . . . . . . .
M   AVG    1680.1       6.6     AVERAGE

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15 G WIDTH (MEV)

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W       WE ONLY INCLUDE HIGH STATISTICS EXPERIMENTS IN THE AVERAGE FOR THE
W       2PI AND KKBAR MODES.

W     2 PI MODE
W
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            171.0     65.0              ARMENISE  70 DBC    0 9 PI+ D            1/71
W        122 180.0     30.0              BARTSCH   70 HBC  +  8 PI+ P,2 PI        5/70
W            267.      72.       46.     STUNTEBEC 70 HDBC  0 8. PI-P,5.4 PI+D    2/72
W            156.      36.               MATTHEWS  71 DBC   0  7. PI+ N           2/72
W        600 167.      40.               ENGLER    74 DBC    0 6. PI+N,PI+PI-P  12/75
W  G         200.      18.               GRAYER    74 ASPK   0 17 PI-P,PI+PI-N   2/74
W  GI       (240.)    (30.)              ESTABROOK 75 RVUE    17 PI-P,PI+PI-N   12/75
W   I       (267.)    (30.)              HYAMS     75 ASPK   0 17 PI-P,PI+PI-N  12/75
W  T     175 162.0     50.0              ANTIPOV   77 CIBS  0 25 PI-P,P 3PI      1/82
W        476 116.0     30.0              BALTAY    78 HBC   0 15 PI+P,PI+PI-     4/78
W           (206.0)  OR MORE   CL=.84    BECKER    79 ASPK  0 17 PI- P POLARIZ  12/79
W    M      (322.0)   (35.0)             CORDEN    79 OMEG    12-15PI-P, N 2PI  12/79
W            246.      37.               EVANGELIS 81 OMEG  - 12 PI-P,2PI P      1/82
W
W   I   FROM PHASE-SHIFT ANALYSIS
W   I   ERROR TAKES ACCOUNT OF SPREAD OF DIFFERENT PHASE-SHIFT SOLUTIONS
W  G    USES SAME DATA AS HYAMS 75 AND BECKER 79
W    M  FROM A PHASE SHIFT SOLUTION CONTAINING A F PRIME WIDTH
W    M  TWO TIMES LARGER THAN THE K KBAR RESULT.
W  T    WIDTH ERRORS ENLARGED BY US TO 4*WIDTH/SQRT(N),SEE K*(892) NOTE
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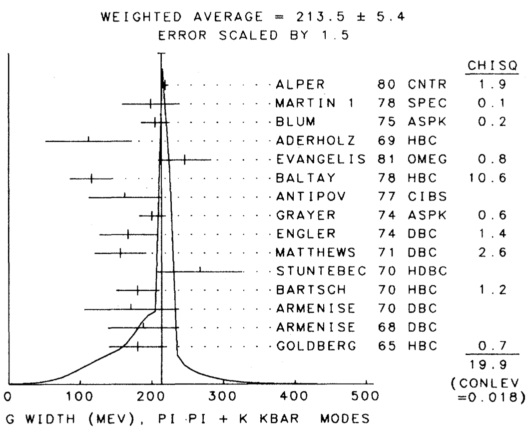
Mesons

g(1690)

```
W      K KBAR + K KBAR PI MODE
W
W            112.0      60.0                ADERHOLZ  69 HBC  +   8 PI+ P,KKBARPI  8/69
W            205.       20.                 BLUM      75 ASPK   018.4 PI-P,N K+K- 11/75
W  P  6000   199.       40.                 MARTIN 1  78 SPEC     10 PI P,KS K- P  4/78
W            219.0       4.0                ALPER     80 CNTR  0 62 PI-P,K+ K- N   1/82
W    L      (186.0)    (11.0)               COSTA     80 OMEG     10. PI-P,K+ K- N  1/82
W
W    L  THEY CANNOT DISTINGUISH BETWEEN G AND OMEGA(1670).
W  P        FROM A FIT TO JP=3- PARTIAL WAVE.
W
W           . . . . . . . . . .
W   AVG      213.5       5.4     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
                        (SEE IDEOGRAM BELOW)
```

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W      (4PI)+- MODE
W
W            100.       35.                 BALTAY    68 HBC  +   7, 8.5 PI+ P      6/68
W       144  135.0      30.0                BARTSCH   70 HBC  +  8 PI+ P,4 PI       4/71
W        90 (180.0)    (30.0)               BARTSCH   70 HBC  +  8 PI+ P,A2 PI      4/71
W   F   102 (160.0)    (30.0)               BARTSCH   70 HBC  +  8 PI+ P,2 RHO
W            130.       30.                 HOLMES    72 HBC  +  10.-12. K+ P       1/73
W            169.       70.        48.      CASON     73 HBC  -  8.,18.5 PI- P      1/74
W   F       (125.)     (83.)      (35.)     CASON     73 HBC  -  8.,18.5 PI- P      1/74
W   F    66 (150.)                          KLIGER    74 HBC   - 4.5 PI-P,P 4PI    12/75
W            106.       25.                 THOMPSON  74 HBC  +  13 PI+ P          12/75
W       177  105.0      30.0                BALTAY    78 HBC  +  15 PI+P,P 4PI      4/78
W   A       (123.)     (13.)                EVANGELI  81 OMEG  - 12 PI-P,(4PI)-P    3/82
W   B       (230.)     (28.)                EVANGELI  81 OMEG  - 12 PI-P,(4PI)-P    3/82
W   C       (184.)     (33.)                EVANGELI  81 OMEG  - 12 PI-P,(4PI)-P    3/82
W           . . . . . . . . . .
W   AVG      117.8      12.9     AVERAGE

W   A   FROM RHO- RHO0 MODE, NOT INDEPENDENT OF (B), (C)
W   B   FROM (A2)- PI0 MODE, NOT INDEPENDENT OF (A), (C)
W   C   FROM (A2)0 PI- MODE, NOT INDEPENDENT OF (A), (B)
W   F   FROM (RHO+- RHO0) MODE

W      OMEGA PI  MODE
W
W            130.       73.        43.      BARNHAM   70 HBC  +  10 K+ P,OMEGA PI  6/70
W             89.       25.                 THOMPSON  74 HBC  +  13 PI+ P         12/75
W            160.0      56.0                GESSAROLI 77 HBC     11 PI-P,OMEGA PI 12/77
W            190.       65.                 EVANGELIS 81 OMEG  - 12 PI-P,OME PI P  1/82
W           . . . . . . . . . .
W   AVG      112.9      20.6     AVERAGE

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15 G PARTIAL DECAY MODES

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                                                          DECAY MASSES
P1      G INTO PI PI                                    140+ 140
P2      G INTO 4PI(INCL. PIO'S)                         140+ 140+ 140+ 140
P3      G INTO K KBAR PI                                498+ 498+ 140
P4      G INTO K KBAR                                   498+ 498
P5      G INTO PI PI RHO (EXCLUDING 2RHO+A2 PI)         140+ 140+ 769
P6      G INTO A2 PI                                   1318+ 140
P7      G INTO OMEGA PI                                 140+ 783
P8      G INTO 2 RHO                                    769+ 769
P9      G INTO PHI PI                                  1020+ 140
P10     G INTO ETA PI                                   549+ 140
P11     G+- INTO  3 PI CHARGED AND 1 PIO                140+ 140+ 140+ 140

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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 .2380+-.0129
P 2   -.7561   .7090+-.0189
P 3    .1510      -.7415   .0378+-.0122
P 4   -.1452      -.0478      -.0230   .0151+-.0031

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15 G BRANCHING RATIOS

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R1      G INTO (2PI)/TOTAL                                    (P1)
R1   P         0.22       0.04             MATTHEWS  71 HDBC  0  7. PI+N,PI-P      2/72
R1  G         (0.245)    (0.006)           ESTABROOK 75 RVUE    17 PI-P,PI+PI-N  12/75
R1             0.259      0.018     0.019  BECKER    79 ASPK  0 17 PI- P POLARIZ 12/79
R1             0.23       0.02             CORDEN    79 OMEG    12-15PI-P, N 2PI 12/79
R1           . . . . . . . . . .
R1  AVG        0.243      0.013    AVERAGE
R1  FIT        0.238      0.013  FROM FIT

R1  G   FROM PHASE-SHIFT ANALYSIS OF HYAMS 75 DATA
R1  H   INCLUDED IN BECKER 79 ANALYSIS
R1  P   OPE MODEL USED IN THIS ESTIMATION

R2      G INTO(2 PI)/(4 PI) CHARGED                           (P1)/(P11)
R2            (0.12) OR LESS               BALLAM    71 HBC  -   16. PI- P          2/72
R2            (0.2)  OR LESS               HOLMES    72 HBC  +  10.-12. K+ P        1/73
R2             0.35       0.11             CASON     73 HBC  -  8.,18.5 PI- P       1/74

R3      G0 INTO(2 PI)/(4 PI) ALL                              (P1)/(P2)
R3             0.30       0.10             BALTAY    78 HBC   0 15 PI+P,P 4PI       4/78
R3           . . . . . . . . . .
R3  FIT        0.336      0.026  FROM FIT

R4      G+- INTO (K KBAR)/(2PI)                               (P4)/(P1)
R4             0.191      0.040     0.037  GORLICH   80 ASPK  0 17,18 PI-P POLAR 12/79
R4           . . . . . . . . . .
R4  FIT        0.063      0.014  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)
R5      G+- INTO (K KBAR PI)/(2PI)                            (P3)/(P1)
R5 A           0.16       0.05             BARTSCH   70 HBC  +  8. PI+ P            2/72
R5 A    INCREASED BY US TO CORRESPOND TO G INTO (2PI)=.24
R5           . . . . . . . . . .
R5  FIT        0.159      0.051  FROM FIT

R6      G+- INTO (RHO 2PI)/(4 PI) CHARGED                     (P5+P6+P8)/(P11)
R6             CONSISTENT WITH 1.          CASO      68 HBC   -  11 PI- P           6/68
R6            (1.)       (0.15)            BARTSCH   70 HBC  +  8. PI+ P            2/72
R6             0.88       0.15             BALLAM    71 HBC  -   16. PI- P          2/72
R6             0.96       0.21             BALTAY    78 HBC  +  15 PI+P,P 4PI       4/78
R6           . . . . . . . . . .
R6  AVG        0.91       0.12     AVERAGE

R7      G+- INTO (2RHO)/(4 PI) CHARGED                        (P8)/(P11)
R7            (0.7)      (0.15)            BARTSCH   70 HBC  +  8. PI+ P            2/72
R7       66   (0.56)                       KLIGER    74 HBC   - 4.5 PI-P,P 4PI     12/75
R7  T         (0.13)     (0.09)            THOMPSON  74 HBC  +  13 PI+ P           12/75
R7             0.12       0.11             BALTAY    78 HBC  +  15 PI+P,P 4PI       4/78
R7  T   RHO RHO AND A2 PI MODES ARE INDISTINGUISHABLE

R8      G+- INTO (2 RHO)/(ALL RHO 2PI)                        (P8)/(P5+P6+P8)
R8             0.48       0.16             CASO      68 HBC   -  11 PI- P           6/68

R9      G+- INTO (PI A2)/(4 PI) CHARGED                       (P6)/(P11)
R9            (0.6)                        BALTAY    68 HBC  +   7,8.5 PI+P         6/68
R9            (0.6)      (0.15)            BARTSCH   70 HBC  +  8. PI+ P            2/72
R9             NOT SEEN                    CASON     73 HBC  -  8.,18.5 PI- P       1/74
R9  T         (0.36)     (0.14)            THOMPSON  74 HBC  +  13 PI+P             4/78
R9             0.66       0.08             BALTAY    78 HBC  +  15 PI+P,P 4PI       4/78
R9  T   RHO RHO AND A2 PI MODES ARE INDISTINGUISHABLE

R10     G+- INTO (PI OMEGA)/(4 PI) CHARGED                    (P7)/(P11)
R10            0.25       0.10             BALTAY    68 HBC  +   7-8.5 PI+P         5/68
R10            0.25       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           (0.09) OR LESS               KLIGER    74 HBC   - 4.5 PI-P,P 4PI     12/75
R10            0.33       0.07             THOMPSON  74 HBC  +  13 PI+ P           12/75
R10           (0.11) OR LESS  CL=0.95      BALTAY    78 HBC  +  15 PI+P,P 4PI       4/78
R10          . . . . . . . . . .
R10 AVG        0.233      0.050   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)

R11     G+- INTO (PI PHI)/(4 PI) CHARGED                      (P9)/(P11)
R11           (0.11) OR LESS               BALTAY    68 HBC  +   7,8.5 PI+P         6/68

R12     G+- INTO (PI+- 2PI+ 2PI- PI0)/(4 PI) CH.
R12           (0.15) OR LESS       .       BALTAY    68 HBC  +   7,8.5 PI+ P        6/68

R13     G+- INTO (PI ETA)/(4 PI) CHARGED                      (P10)/(P11)
R13           (0.02) OR LESS               THOMPSON  74 HBC  +  13 PI+ P           12/75

R14     G+- INTO (K KBAR)/TOTAL                               (P4)
R14  B         0.013      0.004            MARTIN 2  78 SPEC   -10 PI P,KS K- P     4/78
R14            0.013      0.003            COSTA     80 OMEG  0 10 PI-P,K+ K- N     1/82
R14  B  FROM SQRT(P1*P4)=0.056+-0.034 ASSUMING (2PI)/TOTAL=P1=0.24
R14          . . . . . . . . . .
R14 AVG        0.0130     0.0024  AVERAGE
R14 FIT        0.0151     0.0031 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)

R16     G+- INTO (PI OMEGA)/(PI OMEGA+ 2 RHO)                 (P7)/(P7+P8)
R16            0.22       0.08             CASON     73 HBC  -  8.,18.5 PI- P       1/74

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REFERENCES FOR G


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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)
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ARMENISE 70 LNC 4 199 +GHIDINI,FORINO,CARTACCI,+ (BARI+BGNA+FIRZ)
BARNHAM 70 PRL 24 1083 +COLLEY,JOBES,KENYON,PATHAK,RIDDIFORD(BIRM)
BARTSCH 70 NP B 22 109 +KRAUS,TSANOS,GROTE,KOTZAN+(AACH+BERL+CERN)
CASO 70 LNC 3 707 +CONTE,TOMASINI,CORDS+(GENO+HAMB+MILA+SACL)
KRAMER 70 PRL 25 396 +BARTON,GUTAY,LICHTMAN,MILLER,+ (PURDUE)
MAURER 70 THESIS NO.588 G.MAURER (STRASBOURG)
STUNTEBE 70 PL 32 B 391 STUNTEBECK,KENNEY,DEERY,BISWAS,CASON+(NDAM)

BALLAM 71 PR D 3 2606 +CHADWICK,GUIRAGOSSIAN,JOHNSON,+ (SLAC)
BRAUN 71 NP B 30 213 +FRIDMAN,GERBER,GIVERNAUD,KAHN,+ (STRB)
GRAYER 71 PL 35 B 610 +HYAMS,JONES,SCHLEIN,BLUM,+ (CERN+MPIM)JP3-
MATTHEWS 71 NP B 331 +PRENTICE,YOON,CARROLL,+ (TNTO+WISC)JP3-

ARMENISE 72 LNC 4 205 +FORINO,CARTACCI,+ (BARI+BGNA+FIRZ)
ALSO 75 LNC 14 177 +FOGLI-MUCIACCIA,FORINO+ (BARI+BGNA+FIRZ) JP
BOWEN 72 PRL 29 890 +EARLES,FAISSLER,BLIEDEN,+ (NEAS+STON)
CLAYTON 72 NP B 47 81 +MASON,MUIRHEAD,RIGOPOULOS,+ (LIVP+PATR)
GRAYER 72 PHIL.CONF.PROC. 5 +HYAMS,JONES,SCHLEIN,BLUM,DIETL+(CERN+MPIM)
HOLMES 72 PR D 6 3336 +FERBEL,SLATTERY,WERNER (ROCH)

ARNOLD 73 LNC 6 707 +ENGEL,ESCOUBES,KURTZ,LLORET,PATY,+ (STRB)
CASON 73 PR D 7 1971 +BISWAS,KENNEY,MADDEN,SANDER,SHEPHARD(NDAM)
CASON 1 73 NP B 64 14 +MADDEN,BISHOP,BISWAS,KENNEY,+ (NDAM)
HYAMS 73 NP B 64 134 +JONES,WEILHAMMER,BLUM,DIETL,+ (CERN+MPIM)
ROBERTSO 73 PR D 7 2554 ROBERTSON,WALKER,DAVIS (DUKE+WISC)

DUBOVIKO 74 SJNP 19 568 DUBOVIKOV,MATSYUK,NILOV,SOKOLOV (ITEP)
ENGLER 74 PR D10 2070 +KRAEMER,TOAFF,WEISSER,DIAZ+ (CARN+CASE)
GRAYER 74 NP B 75 189 G.GRAYER,HYAMS,BLUM,DIETL,+ (CERN+MPIM)
KLIGER 74 SJNP 19 428 +BEKETOV,GRECHKO,GUZHAVIN,DUBOVIKOV+ (ITEP)
OREN 74 NP B71 189 +COOPER,FIELDS,RHINES,WHITMORE,+ (ANL+OXF)
THOMPSON 74 NP B69 220 +GAIDOS,MCILWAIN,MILLER,MULERA,+ (PURD)

BLUM 75 PL 57B 403 +CHABAUD,DIETL,GARELICK,GRAYER+ (CERN+MPIM) JP
ESTABROO 75 NP B95 322 P.ESTABROOKS,A.D.MARTIN (DURH)
HYAMS 75 NP B100 205 +JONES,WEILHAMMER,BLUM,DIETL+ (CERN+MPIM)
KALELKAR 75 THESIS(NEVIS 207) M.S.KALELKAR (COLU)I=1
ANTIPOV 77 NP B 119 45 +BUSNELLO,DAMGAARD,KIENZLE+ (CERN+SERP)
GESSAROL 77 NP B 126 382 GESSAROLI,+ (BGNA+FIRZ+GENO+MILA+OXF+PAVI)

BALTAY 78 PR D 17 62 +CAUTIS,COHEN,CSORNA,SMITH,YEH,+(COLU+BING)
FORINO 78 NP B 139 413 +CARTACCI,+ (BGNA+FIRZ+GENO+MILA+OXF+PAVI) JP
MARTIN 1 78 PL 74 B 417 +OZMUTLU+BALDI,BOHRINGER,DORSAZ+(DURH+GEVA)
MARTIN 2 78 NP B 140 158 +OZMUTLU,BALDI,BOHRINGER,DORSAZ+(DURH+GEVA)
MARTIN 3 78 ANP 114 1 A.D.MARTIN,M.R.PENNINGTON (CERN)

BECKER 79 NP B 151 46 +BLANAR,BLUM,CERRADA+ (MPIM+CERN+ZEEM+CRAC)
CORDEN 79 NP B 157 250 +DOWELL,GARVEY,JOBES,+(BIRM+RHEL+TELA+LOWC) JP
EVANGELI 79 NP B 154 381 + (BARI+BONN+CERN+DARE+GLAS+LIVP+MILA+WIEN)

ALPER 80 PL 94 B 422 +BECKER,+ (AMST+CERN+CRAC+MPIM+OXF+RHEL)
COSTA 80 NP B 175 402 + (BARI+BONN+CERN+GLAS+LIVP+MILA+WIEN)
GORLICH 80 NP B 174 16 +NICZYPORUK,ROZANSKA+ (CRAC+MPIM+CERN+ZEEM)

EVANGELI 81 NP B 178 197 EVANGELISTA+(BARI+BONN+CERN+DARE+LIVP+MILA)

BARNETT 83 PL 120 B 455 +BLOCKUS,BURKA,CHIEN,CHRISTIAN+ (JHU)

θ(1690)

68 THETA(1690,JPG=2++) I=0

NAMED THETA BY EDWARDS 82
SEEN IN J/PSI INTO GAMMA THETA(1690), THEREFORE C=+.
THETA(1690) DECAYS INTO 2 ETA, THEREFORE IG=0+.
JP=2+ IS PREFERRED OVER 0+, HIGHER SPINS NOT STUDIED.
MASS AND WIDTH DETERMINATION COMPLICATED BY OVERLAP WITH F PRIME IN MASS SPECTRA. POSSIBLE CONNECTION OF THIS STATE WITH STRUCTURE SEEN IN J/PSI TO GAMMA RHO RHO AND IN J/PSI TO GAMMA ETA PI PI IS UNCLEAR (SEE HITLIN 83).

68 THETA(1690) MASS (MEV)

M		1640.	50.		EDWARDS	82	CBAL	0	J/PSI,GAM 2ETA	1/82
M		1708.0	30.0		FRANKLIN	82	SMK2		E+E-,GAM K+ K-	12/83*
M		(1719.0)	(6.0)		EINSWEILE	83	SMK3		E+E-,HADRONS GAM	12/83*
M		. . . . .	. . . . .							
M	AVG	1690.0	30.0	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)						

68 THETA(1690) WIDTH (MEV)

W		220.	100.	70.	EDWARDS	82	CBAL	0	J/PSI,GAM 2ETA	1/82
W		156.0	60.0		FRANKLIN	82	SMK2		E+E-,GAM K+ K-	12/83*
W		(117.0)	(23.0)		EINSWEILE	83	SMK3		E+E-,HADRONS GAM	12/83*
W		. . . . .	. . . . .							
W	AVG	177.3	49.0	AVERAGE						

68 THETA(1690) PARTIAL DECAY MODES

		DECAY MASSES
P1	THETA(1690) INTO ETA ETA	549+ 549
P2	THETA(1690) INTO K KBAR	498+ 498

REFERENCES FOR THETA(1690)

ALTHOFF 82 PL 121 B 216 +BRANDELIK,BOERNER+ (TASSO COLLABORATION)
ALTHOFF 82 ZPHY C 16 13 +BOERNER,BURKHARDT+ (TASSO COLLABORATION)
BARNES 82 PL 116 B 365 T.BARNES AND F.E.CLOSE (RHEL)
BARNES 82 NP B 198 360 +CLOSE,MONAGHAN (RHEL+OXF)
EDWARDS 82 PRL 48 458 +PARTRIDGE,PECK,+ (CIT+HARV+PRIN+STAN+SLAC)
FRANKLIN 82 SLAC-254 M.E.B.FRANKLIN (SLAC)
TANIMOTO 82 PL 116 B 198 M.TANIMOTO (BIEL)

BARNETT 83 PL 120 B 455 +BLOCKUS,BURKA,CHIEN,CHRISTIAN+ (JHU)
EINSWEIL 83 BRIGHTON CONF. K.F.EINSWEILER+MARKIII COLLABORATION (SLAC)
HITLIN 83 CORNELL CONF. D. HITLIN (CIT)

η(1700) →

63 ETA(1700,JPG=-+) I=EVEN

ENHANCEMENT SEEN IN THE ETA PI PI SYSTEM PRODUCED IN THE RADIATIVE DECAY OF THE J/PSI(3100). MAY CONTAIN SIGNIFICANT SUB-STRUCTURE. RELATION TO OTHER ENHANCEMENTS SEEN IN RADIATIVE J/PSI DECAY UNCLEAR (SEE HITLIN 83).
TENTATIVELY CALLED ETA(1700) BY US.
OMITTED FROM TABLE.

63 ETA(1700) MASS (MEV)

M	1700.0	45.	EDWARDS	83 CBAL	J/PSI,ETA 2PIGAM	12/83*

63 ETA(1700) WIDTH (MEV)

W	520.	110.	EDWARDS	83 CBAL	J/PSI,ETA 2PIGAM	12/83*

REFERENCES FOR ETA(1700)

EDWARDS 83 PRL 51 859 +PARTRIDGE,PECK+ (CIT+HARV+PRIN+STAN+SLAC)
HITLIN 83 CORNELL CONF. D. HITLIN (CIT)

S(1730) →

86 S(1730,JPG=0++) I=0

NAMED S* PRIME BY ETKIN 82
SEEN IN PHASE SHIFT ANALYSIS OF KOS KOS SYSTEM.
NEEDS CONFIRMATION. OMITTED FROM TABLE.

86 S(1730) MASS (MEV)

M	AB	(1771.0)	(77.0)	(53.0)	ETKIN1	82 MPS	0	23 PI-P,2KOS N	9/83*
M	A S	1730.0	30.0		ETKIN2	82 MPS	0	23 PI-P,2KOS N	2/84*

M A FROM AN AMPLITUDE ANALYSIS OF THE KOS KOS SYSTEM.
M B SUPERSEDED BY ETKIN2 82.
M S SYSTEMATIC ERROR ADDED LINEARLY BY US.

86 S(1730) WIDTH (MEV)

W	A	200.0	156.0	9.0	ETKIN1	82 MPS	0	23 PI-P,2KOS N	9/83*

W A FROM AN AMPLITUDE ANALYSIS OF THE KOS KOS SYSTEM.

86 S(1730) PARTIAL DECAY MODES

		DECAY MASSES
P1	S(1730) INTO K KBAR	498+ 498

REFERENCES FOR S(1730)

ETKIN1 82 PR D 25 1786 +FOLEY,LAI,LINDENBAUM+ (BNL+CUNY+TUFT+VAND) JP
ETKIN2 82 PR D 25 2446 +FOLEY,LAI,LINDENBAUM+ (BNL+CUNY+TUFT+VAND)

π(1770) →

75 PI(1770,JPG=0--) I=1

SEEN IN PARTIAL WAVE ANALYSIS OF THE DIFFRACTIVELY PRODUCED 3 PI SYSTEM.
NEEDS CONFIRMATION. OMITTED FROM TABLE.

75 PI(1770) MASS (MEV)

M	1100	1770.	30.	BELLINI	82 SPEC	-	40 PI-A,3PI A	8/83*

75 PI(1770) WIDTH (MEV)

W	1100	310.	50.	BELLINI	82 SPEC	-	40 PI-A,3PI A	8/83*

75 PI(1770) PARTIAL DECAY MODES

		DECAY MASSES
P1	PI(1770) INTO EPSILON PI	1300+ 140
P2	PI(1770) INTO RHO PI	769+ 140

75 PI(1770) BRANCHING RATIOS

R1	PI(1770) INTO (EPSILON PI)/TOTAL			(P1)			
R1	DOMINANT	BELLINI	82 SPEC	-	40 PI-A,3PI A		8/83*
R2	PI(1770) INTO (RHO PI)/TOTAL			(P2)			
R2	NOT SEEN	BELLINI	82 SPEC	-	40 PI-A,3PI A		8/83*

REFERENCES FOR PI(1770)

BELLINI 82 PRL 48 1697 +FRABETTI,IVANSHIN,LITKIN+ (MILA+BGNA+JINR)

Mesons

Data Card Listings

f(1810), ϕ(1850), S(1935)

f(1810)

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38  F(1810,JPG=2++) I=0

    FORMERLY CALLED X(1850).
    FROM AN AMPLITUDE ANALYSIS OF THE K+K- SYSTEM SEEN IN
    PI- P INTO K+ K- N AT 10 GEV/C. NOT CONFIRMED BY
    ETKIN 82. SEEN ALSO IN PI+PI- TO 2PI0 AMPLITUDE
    ANALYSIS (CASON 82),BUT NOT SEEN IN THE PARTIAL
    WAVE ANALYSIS OF THE PI+PI- SYSTEM.
    NEEDS CONFIRMATION. OMITTED FROM TABLE.

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                38  F(1810) MASS (MEV)

M  A    1857.0     35.0     24.0  COSTA      80 OMEG  0 10 PI-P,K+ K- N   1/82
M       1799.0     15.0           CASON      82 STRC  0 8 PI+P,PI+2PI0 P  8/83*
M
M   AVERAGE MEANINGLESS (SCALE FACTOR = 1.8)

M  A  ERROR INCREASED BY SPREAD OF TWO SOLUTIONS.

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                38  F(1810) WIDTH (MEV)

W  A     185.0    102.0    139.0  COSTA      80 OMEG  0 10 PI-P,K+ K- N   1/82
W        280.0     42.0     35.0  CASON      82 STRC  0 8 PI+P,PI+2PI0 P  8/83*
W   AVERAGE MEANINGLESS

W  A  ERROR INCREASED BY SPREAD OF TWO SOLUTIONS.

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                38  F(1810) PARTIAL DECAY MODES

                                                            DECAY MASSES
P1    F(1810) INTO K+ K-                                    494+ 494
P2    F(1810) INTO PI PI                                    140+ 140

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                38  F(1810) BRANCHING RATIOS

R1    F(1810) INTO ( K+ K- )/TOTAL                          (P1)
R1         SEEN                   COSTA      80 OMEG  0 10 PI-P,K+ K- N   1/82

R2    F(1810) INTO (PI PI)/TOTAL                            (P2)
R2          0.44      0.03        CASON      82 STRC  0 8 PI+P,PI+2PI0 P  8/83*

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                        REFERENCES FOR F(1810)

COSTA     80 NP B 175 402        +      (BARI+BONN+CERN+GLAS+LIVP+MILA+WIEN)

CASON     82 PRL 48 1316        +BISWAS,BAUMBAUGH,BISHOP,CANNATA+(NDAM+ANL)
ETKIN     82 PR D 25 1786       +FOLEY,LAI,LINDENBAUM+ (BNL+CUNY+TUFT+VAND)

CASON     83 PR D 28 1586       +CANNATA,BAUMBAUGH,BISHOP,WATSON+(NDAM+ANL)

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ϕ(1850)

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54  PHI(1850,JPG-   ) I=0

    SEEN IN THE K KBAR AND K KBAR PI MASS
    DISTRIBUTIONS.

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                54  PHI(1850) MASS (MEV)

M       123 1850.0     10.0           ALHARRAN  81 HBC     8.25 K-P,LAM 2K    1/82
M       430 1870.0     30.0     20.0  ARMSTRONG 82 OMEG    18.5 K-P,K-K+LAM  8/83*
M
M   AVG     1852.8      9.3      AVERAGE

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                54  PHI(1850) WIDTH (MEV)

W       123   80.0     40.0     30.0  ALHARRAN  81 HBC     8.25 K-P,LAM 2K    1/82
W       430  160.0     90.0     50.0  ARMSTRONG 82 OMEG    18.5 K-P,K-K+LAM  8/83*
W
W   AVG       96.0     32.0      AVERAGE

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                54  PHI(1850) PARTIAL DECAY MODES

                                                            DECAY MASSES
P1    PHI(1850) INTO K KBAR                                 494+ 494
P2    PHI(1850) INTO K*(892) K + C.C.                       892+ 494

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                54  PHI(1850) BRANCHING RATIOS

R1    PHI(1850) INTO (K*(892) K+C.C.)/(K KBAR)              (P2)/(P1)
R1           0.8       0.4        ALHARRAN  81 OMEG    8.25 K-P,LAM 2K    1/82

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                        REFERENCES FOR PHI(1850)

ASTON     80 PL 92 B 219         (BONN+CERN+EPOL+GLAS+LANC+MCHS+ORSA+PARIS+)

ALHARRAN 81 PL 101 B 357         +AMIRZADEH,+       (BIRM+CERN+GLAS+MICH+LPNP)

ARMSTRON 82 PL 110 B 77          +BAUBILLIER+(BARI+BIRM+CERN+MILA+LPNP+PAVI)  JP
CORDIER  82 PL 110 B 335         +BISELLO,BIZOT,BUON,DELCOURT,FAYARD,+(LALO)

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S(1935)

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31  S(1935,JPG=   )
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A narrow enhancement called the S(1935) has been observed in the antiproton-proton total cross section (CARROLL 74, CHALOUPKA 76, BRUCKNER 77, SAKAMOTO 79).

This observation has not been confirmed by other experiments (ALLEN 80, KAMAE 80, JASTRZEMBSKI 81, LOWENSTEIN 81), or the effect was found to be smaller in magnitude and larger in width (HAMILTON 80).

A recent experiment (SUMIYOSHI 82) has measured with high precision the $\bar{p}p$ total cross section, by an improved transmission method, rejecting both the narrow- (CARROLL 74) and broad- (HAMILTON 80) S hypotheses.

No significant signal is observed for a narrow S(1935) in backward antiproton-proton elastic scattering (GARNJOST 79), nor in the charge-exchange cross section (GARNJOST 75, CHALOUPKA 76, HAMILTON 80).

The nonexistence of the S is also confirmed by recent hadroproduction experiments (DAUM 81, BENSINGER 83, BARNETT 83).

The only observation in favor of a narrow S which remains unchallenged is the one of ASTON 80 in a photoproduction experiment. The weak statistical significance of the signal does not warrant taking the S(1935) as a well-established narrow resonance.

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                31  S MASS (MEV)

M        S CHANNEL NBAR N
M   C     (1940.)     (8.)              CLINE     70 HBC   0  .25-.74 PBAR P   2/72
M   B     (1968.)                       BENVENUTI 71 HBC   0  .1 - .8 PBAR P   2/72
M  S       1932.       2.               CARROLL   74 CNTR     S CHAN.PBAR P,D 12/75
M   C     (1942.)     (5.)              D-ANDLAU  75 HBC   0 .175-.750 PBAR P 12/75
M   Z     (1934.4)    (2.6)     (1.4)   KALOGERO  75 DBC   - PBAR N ANNIH     12/75
M  S       1935.9      1.0              CHALOUPKA 76 HBC   0 PBAR P TOT,ELAS  12/75
M          1939.0      3.0              BRUCKNER  77 SPEC  0 .4-.85 PBAR P     7/77
M          1935.5      1.0              SAKAMOTO  79 HBC   0 .37-.73 PB P     12/79
M          1930.0      2.0              ASTON     80 OMEG    GAM P,P PBAR X    1/82
M   A     (1949.)    (10.)              DEFOIX    80 HBC   0 PBAR P,5PI        1/80
M    M     1939.0      2.0              HAMILTO2  80 CNTR  0 S CHAN,PBAR P    12/79
M
M        PRODUCTION EXPERIMENTS
M        36(1940.0)   (1.0)             DAUM      80 CNTR  0 93 P P,PB P + X  12/79
M
M   AVERAGE MEANINGLESS (SCALE FACTOR = 1.7)

M   A   FROM ENERGY DEPENDENCE OF 5PI CROSS-SECTION.IG=1- FROM OBSERVATION
M   A   OF OMEGA RHO DECAY. P=+ AND J>1. A2 PI PI ALSO SEEN.
M   B   SEEN AS A BUMP IN THE PBAR P - KS KL  CROSS SECTION WITH JPC=1--.
M       NOT SEEN BY CARSON 72 WITH EQUAL STATISTICS.
M   C   FROM ENERGY DEPENDENCE OF FAR BACKWARD ELASTIC SCATTERING.
M       SOME INDICATION OF ADDITIONAL STRUCTURE.
M    M  I=0 FAVORED,J=0 OR 1,SEEN IN TOTAL PBAR P TOTAL CROSS-SECTION,
M    M  PRIMARLY FROM ANNIH. REACTIONS.  NOT SEEN IN PBAR D TOTAL AND
M    M  ANNIH. CROSS SECTIONS.
M   N   SEEN IN 3 CHARGED MODE. NOT SEEN BY BOWEN 73 WITH 6X STATISTICS.
M   S   NARROW BUMP SEEN IN TOTAL PBAR P,D CROSS-SECTIONS.ISOSPIN UNCERTAIN
M       NOT SEEN IN PBAR P CEX BY GARNJOST 75,CHALOUPKA 76. INTEGRATED
M       CROSS-SECTION 3X LARGER THAN BRUCKNER 77.
M   Z   NOT SEEN BY ALBERI 79 WITH COMPARABLE STATISTICS.

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                        31  S WIDTH (MEV)

W        S CHANNEL NBAR N
W   C       (49.)      (9.)           CLINE     70 HBC   0  .25-.74 PBAR P   2/72
W   B       (35.)                     BENVENUTI 71 HBC   0  .1 - .8 PBAR P   2/72
W  S          9.        4.      3.    CARROLL   74 CNTR    S CHAN.PBAR P,D  12/75
W   C       (57.5)     (5.)           D-ANDLAU  75 HBC   0 .175-.750 PBAR P 12/75
W   Z       (11.)     (11.)    (4.)   KALOGERO  75 DBC   - PBAR N ANNIH     12/75
W  S          8.8       4.3     3.2   CHALOUPKA 76 HBC   0 PBAR P TOT,ELAS  12/75
W            (4.0)  OR LESS           BRUCKNER  77 SPEC  0 .4-.85 PBAR P     7/77
W             2.8       1.4           SAKAMOTO  79 HBC   0 .37-.73 PB P     12/79
W            12.0       7.0           ASTON     80 OMEG    GAM P,P PBAR X    1/82
W   A       (80.)     (20.)           DEFOIX    80 HBC   0 PBAR P,5PI        1/80
W    M       22.0       6.0           HAMILTO2  80 CNTR  0 S CHAN,PBAR P    12/79
W
W        PRODUCTION EXPERIMENTS
W            (6.0)  APPROX.           DAUM      80 CNTR    93 P P,PB P + X  12/79
W
W   AVERAGE MEANINGLESS (SCALE FACTOR = 1.9)

W   SEE FOOTNOTES UNDER S MASS ABOVE

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                        31  S PARTIAL DECAY MODES

                                                                DECAY MASSES
P1      S INTO PBAR P                                         938+ 938

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                        REFERENCES FOR S(1935)

CLINE     68 PRL 21 1268         +ENGLISH,REEDER,TERRELL,TWITTY  (WISCONSIN)

CLINE     70  PREPRINT           D.CLINE,J.ENGLISH,D.D.REEDER        (WISC)J
  ALSO    70 KIEV CONF.          ASTIER RAPPORTEUR TALK

BENVENUT 71 PRL 27 283           BENVENUTI,CLINE,RUTZ,REEDER,SCHERER  (WISC)
PINSKI    71 PRL 27 1548         STEPHEN S. PINSKY             (UTAH+ARGONNE)

BIZZARRI 72 PR D 6 160           +GUIDONI,MARZANO,CASTELLI,+       (ROMA+TRST)
BOWEN 1   72 PRL 29 890          +EARLES,FAISSLER,BLIEDEN,+        (NEAS+STON)

BOWEN     73 PRL 30 332          +EARLES,FAISSLER,BLIEDEN,+        (NEAS+STON)
BURNS     73 PR D 8 1286         +CONDON,DONAHUE,MANDELKERN,PRICE,+      (UCI)
KIENZLE   73 PR D 7 3520         W.KIENZLE                              (CERN)

BURNS     74 NC 20A 463          +CONDON,MANDELKERN,PRICE,SCHULTZ        (UCI)
CARROLL   74 PRL 32 247          +CHIANG,KYCIA,LI,MAZUR,MICHAEL,+        (BNL)

ABASHIAN 75 PRL 34 691           +BEAMER,BROSS,EISENSTEIN,+     (ILL+ANL+ISU)
D-ANDLAU 75 PL 58B 223           +COHEN-GANOUNA,LALOUM,LUTZ,PETRI(CDEF+PISA)  JP
DEFOIX    75 PALERMO  CONF.      B.FRENCH, RAPPORTEURS TALK             (CDEF)
DONNACHI 75 NC 26 A 317          A.DONNACHIE,P.R.THOMAS           (MANCHESTER)
GARNJOST 75 PRL 35 1685          +KENNEY,POLLARD,ROSS,TRIPP,+      (LBL+MHCO)
KALOGERO 75 PRL 34 1047          KALOGEROPOULOS,TZANAKOS                (SYRA)
WEINGART 75 PRL 34 1201          WEINGARTEN,OKUBO                       (ROCH)

ABASHIAN 76 PR D 13 5            +WATSON,GELFAND,BUTTRAM,+(ILL+ANL+CHIC+ISU)
DEFOIX    76 STOCK.SYMP.NBAR-N   +LADRON DE GUEVARA,ANGELINI,+    (CDEF+PISA)
DOVER     76 PL 62 B 293         +KAHANA                                 (BNL)
CHALOUPK 76 PL 61 B 487          CHALOUPKA,+ (CERN+LIVP+MONS+PADO+ROMA+TRST)

BENKHEIR 77 PL B 68 483          BENKHEIRI,BOUCROT,+    (CERN+CDEF+EPOL+LALO)
BRUCKNER 77 PL 67 B 222          +GRANZ,INGHAM,KILIAN,LYNEN+(MPIH+HEID+CERN)
MONTANET 77 BOSTON CONF. 260     L.MONTANET                             (CERN)
ROSSI     77 PL 70 B 255         G.C.ROSSI,G.VENEZIANO                  (CERN)

CARTER    78 NP B 132 176        A.A.CARTER                             (LOQM)  JP
CUTTS     78 PR D 17 16          +GOOD,GRANNIS,GREEN,LEE,PITTMAN+(STON+WISC)
PENNINGT 78 NP B 137 77          M.R. PENNINGTON                        (CERN)

ALBERI    79 PL 83 B 247         +ALVEAR,CASTELLI,POROPAT+  (TRST+CERN+IFRJ)
ALSTON-G 79 PRL 43 1901          ALSTON-GARNJOST,HAMILTON+     (LBL+MTHO+BNL)
CARROLL   79 PR D 19 1950        +CHIANG,KYCIA,LI,LITTENBERG,+    (BNL+ROCH)
DELCOURT 79 PL B 86 395          +DERADO,BERTRAND,BISELLO,BIZOT,BUON,+(LALO)
GIBBARD   79 PRL 42 1593         +AHRENS,BERKELMAN,CASSEL,DAY,HARDING+(CORN)
KLUYVER   79 ZPHY C 2 351        J.C. KLUYVER                           (AMST)
RICHARD   79 BATAVIA CONF. 469   F. RICHARD                             (LALO)
SAKAMOTO 79 NP B 158 410         +HASHIMOTO,SAI,YAMAMOTO+               (TOKY)

ALLEN     80 BRESSANONE 175      5TH EUROPEAN SYMPOSIUM ON N-NBAR INTS.
ASTON     80 PL 93 B 517         (BONN+CERN+EPOL+GLAS+LANC+MCHS+ORSA+PARIS+)
BIONTA    80 PRL 46 970          +CARROLL,EDELSTEIN,+    (BNL+CARN+FNAL+SMAS)
CHUNG     80 PRL 45 1611         +ETKIN,BENSINGER,+(BNL+BRAN+CUNY+SMAS+MASA)
DAUM      80 PL 90 B 475         +HERTZBERGER+(AMST+CERN+CRAC+MPIM+OXF+RHEL)
DEFOIX    80 NP B 162 12         +DOBRZYNSKI,ANGELINI,BIGI,+      (CDEF+PISA)
   ALSO   80 NP B 162 41         ESPIGAT,DEFOIX,DOBRZYNSKI+       (CDEF+PISA)
HAMILTO1 80 PRL 44 1179          HAMILTON,PUN,TRIPP,LAZARUS,+ (LBL+BNL+MTHO)
HAMILTO2 80 PRL 44 1182          HAMILTON,PUN,TRIPP,LAZARUS,+ (LBL+BNL+MTHO)
KAMAE     80 PRL 44 1439         +AIHARA,CHIBA,FUJII,IWASAKI,+     (TOKY+HIRO)

DAUM      81 PL 100 B 439        +HERTZBERGER+(AMST+CERN+CRAC+MPIM+OXF+RHEL)
GANGULI   81 NP B 183 295        +CERRADA,DEFOIX,+(TIFR+CERN+CDEF+MADR+PISA)
JASTRZEM 81 PR D 23 2784         JASTRZEMBSKI,MANDELKERN,+     (TEMP+UCI+UNM)
LOWENSTE 81 PR D 23 2788         LOWENSTEIN,PEASLEE,+     (BNL+DOE+MSU+SYRA)

SUMIYOSH 82 PRL 49 628           +CHIBA,FUJII,IKEDA,TAKADA,+ (TOKY+KEK+TSUK)

BARNETT   83 PR D 27 493         +BLOCKUS,BURKA,CHIEN,CHRISTIAN+        (JHU)
BENSINGE 83 PR D 27 1417         BENSINGER,CHUNG       (BRAN+BNL+CINC+FSU+SMAS)
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h(2030)

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16  H(2030,JPG=4++) I=0

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                        16  H MASS (MEV)

M      700 2020.      30.             APEL      75 CNTR    40.  PI-P,N 2PI0 11/75
M          2050.      25.             BLUM      75 ASPK    18.4 PI-P,N K+K- 11/75
M   T     (1922.0)   (14.0)           ANTIPOV   77 CIBS  0 25 PI-P,P 3PI     1/82
M   M     (1935.0)   (13.0)           CORDEN    79 OMEG    12-15PI-P, N 2PI 12/79
M         (1988.0)    (7.0)           EVANGELIS 79 OMEG    10. PI-P,K+ K- N 12/79
M     M   (2040.0)   (10.0)           ROZANSKA  80 SPRK    18.PI-P,P PB N   12/79
M   M     (1978.0)    (5.0)           ALPER     80 CNTR    62 PI-P,K+ K- N   1/82
M   N      2015.0     28.0            CASON     82 STRC  0 8 PI+P,PI+2PI0 P  8/83*
M   E      2031.0     36.0            ETKIN     82 MPS   0 23 PI-P,2K0S N    9/83*
M   N   40K 2020.0    20.0            BINON     83 SPEC  0 38 PI-P,N 2PI0    9/83*
M
M    AVG   2026.9     11.7     AVERAGE

M     M   I=0,JP=4+ FROM AMPLITUDE ANALYSIS ASSUMING ONE PION EXCHANGE
M   T     WIDTH ERRORS ENLARGED BY US TO 4*WIDTH/SQRT(N),SEE K* TYPED NOTE
M   E     ETKIN 82 QUOTES ERRORS +25/-36 MEV. WE USE +-36 MEV IN THE AVERAGE.
M   N     FROM AMPLITUDE ANALYSIS OF REACTION PI+PI- TO 2PI0

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                        16  H WIDTH (MEV)

W      700  180.       60.            APEL      75 CNTR    40.  PI-P,N 2PI0 11/75
W           225.      120.     70.    BLUM      75 ASPK    18.4 PI-P,N K+K- 11/75
W   T      (107.0)    (56.0)          ANTIPOV   77 CIBS  0 25 PI-P,P 3PI     1/82
W   M      (263.0)    (57.0)          CORDEN    79 OMEG    12-15PI-P, N 2PI 12/79
W          (100.0)    (28.0)          EVANGELIS 79 OMEG    10. PI-P,K+ K- N 12/79
W     M    (140.0)    (15.0)          ROZANSKA  80 SPRK    18.PI-P,P PB N   12/79
W   M      (243.0)    (16.0)          ALPER     80 CNTR    62 PI-P,K+ K- N   1/82
W   N       186.0     103.0    58.0   CASON     82 STRC  0 8 PI+P,PI+2PI0 P  8/83*
W   E       305.0     119.0           ETKIN     82 MPS   0 23 PI-P,2K0S N    9/83*
W   N   40K 240.0      40.0           BINON     83 SPEC  0 38 PI-P,N 2PI0    9/83*
W
W    AVG    222.2      28.4    AVERAGE

W     M   I=0,JP=4+ FROM AMPLITUDE ANALYSIS ASSUMING ONE PION EXCHANGE
W   E     ETKIN 82 QUOTES ERRORS +36/-119 MEV. WE USE +-119 MEV.
W   N     FROM AMPLITUDE ANALYSIS OF REACTION PI+PI- TO 2PI0

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                        16  H PARTIAL DECAY MODES

                                                                DECAY MASSES
P1      H INTO PI PI                                          140+ 140
P2      H INTO K KBAR                                         498+ 498

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                        16  H BRANCHING RATIOS

R1      H INTO (PI PI)/TOTAL                                  (P1)
R1            0.17       0.02           CORDEN    79 OMEG    12-15PI-P, N 2PI 12/79
R1            0.16       0.03           CASON     82 STRC  0 8 PI+P,PI+2PI0 P  8/83*
R1
R1   AVG      0.167      0.017   AVERAGE

R2      H INTO (K KBAR)/(PI PI)                               (P2)/(P1)
R2            0.04       0.02     0.01  ETKIN     82 MPS   0 23 PI-P,2K0S N    9/83*

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                        REFERENCES FOR H(2030)

WAGNER    74 LONDON CONF.        F. WAGNER, RAPPORTEURS TALK            (MPIM)

APEL      75 PL 57B 398          +AUGENSTEIN+      (KARL+PISA+SERP+WIEN+CERN)  JP
BLUM      75 PL 57B 403          +CHABAUD,DIETL,GARELICK,GRAYER+ (CERN+MPIM)  JP

ANTIPOV   77 NP B 119 45         +BUSNELLO,DAMGAARD,KIENZLE+       (CERN+SERP)

CORDEN    79 NP B 157 250        +DOWELL,GARVEY,JOBES,+(BIRM+RHEL+TELA+LOWC)  JP
EVANGELI 79 NP B 154 381         + (BARI+BONN+CERN+DARE+GLAS+LIVP+MILA+WIEN)

ALPER     80 PL 94 B 422         +BECKER,+     (AMST+CERN+CRAC+MPIM+OXF+RHEL)

GOTTESMA 81 PR D 22 1503         GOTTESMAN,JACOBS,+      (SYRA+BRAN+BNL+CINC)
ROZANSKA 80 NP B 162 505         +BLUM,DIETL,GRAYER,LORENZ+       (MPIM+CERN)

CASON     82 PRL 48 1316         +BISWAS,BAUMBAUGH,BISHOP,CANNATA+(NDAM+ANL)
ETKIN     82 PR D 25 1786        +FOLEY,LAI,LINDENBAUM+ (BNL+CUNY+TUFT+VAND)

BINON     83  CERN-EP/83-98      +DONSKOV,DUTEIL,GOUANERE+  (SERP+BELG+LAPP)
CASON     83 PR D 28 1586        +CANNATA,BAUMBAUGH,BISHOP,WATSON+(NDAM+ANL)
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δ(2040) →

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17  DELTA(2040,JPG=4+-) I=1

SEEN IN PARTIAL WAVE ANALYSIS OF THE K KBAR AND
PI+PI-PI0 SYSTEMS.
NEEDS CONFIRMATION. OMITTED FROM TABLE.

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                        17  DELTA(2040) MASS (MEV)

M   Y     (1903.0)   (10.0)           BALDI     78 SPEC -  10 PI-P,P KS K-   12/77
M    M     2030.0     50.0            CORDEN    78 OMEG  0 15 PI- P,3 PI N   12/78
M    C     2040.0     30.0            CLELAND   82 SPEC +- 50 PI P,KS K+-P    8/83*
M
M   AVG    2037.4     25.7     AVERAGE

M    M   JP=4+ IS FAVORED , THOUGH 2+ CANNOT BE EXCLUDED.
M   Y    FROM A FIT TO THE Y(8,0) MOMENT. LIMITED BY PHASE SPACE.
M    C    FROM AN AMPLITUDE ANALYSIS
M

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                        17  DELTA(2040) WIDTH (MEV)

W   Y      (166.0)   (43.0)           BALDI     78 SPEC -  10PI-P,P KS K-    12/77
W    M      510.0    200.0            CORDEN    78 OMEG  0 15 PI- P,3 PI N   12/78
W    C      380.0    150.0            CLELAND   82 SPEC +- 50 PI P,KS K+-P    8/83*
W
W   AVG     426.8    120.0     AVERAGE

W    M   JP=4+ IS FAVORED , THOUGH 2+ CANNOT BE EXCLUDED.
W   Y    FROM A FIT TO THE Y(8,0) MOMENT. LIMITED BY PHASE SPACE.
W    C    FROM AN AMPLITUDE ANALYSIS
W

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                        17  DELTA(2040) PARTIAL DECAY MODES

                                                                DECAY MASSES
P1      DELTA(2040) INTO K KBAR                               494+ 494
P2      DELTA(2040) INTO PI+ PI- PI0                          140+ 140+ 135

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                        17  DELTA(2040) BRANCHING RATIOS

R1      DELTA(2040) INTO (K KBAR)/TOTAL                       (P1)
R1         SEEN                         BALDI     78 SPEC +- 10 PI-P,KS K- P    8/83*
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Mesons

Data Card Listings

$\delta(2040)$, A(2050), A(2100), T and U Regions, $\rho(2150)$

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R2     DELTA(2040) INTO (PI+ PI- PI0)/TOTAL                (P2)
R2        SEEN                         CORDEN    78 OMEG  0 15 PI- P,3 PI N   6/81

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                          REFERENCES FOR DELTA(2040)

BALDI    78 PL 74 B 413        +BOHRINGER,DORSAZ,HUNGERBULER,+    (GENEVA)  JP
CORDEN   78 NP B 136 77        DOWELL,GARVEY,JOBES+  (BIRM+RHEL+TELA+LOWC)  JP

DELFOSSE 81 NP B 183 349       +DORSAZ,EXTERMANN,GLOOR,WEILL,+ (GEVA+LAUS)

CLELAND  82 NP B 208 228       +DELFOSSE,DORSAZ,GLOOR(DURH+GEVA+LAUS+PITT)
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A(2050)

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                43  A(2050,JPG=3+-)  I=1

                FORMERLY CALLED A4 OR PI.
                NEEDS CONFIRMATION. OMITTED FROM TABLE.

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                43  A(2050) MASS  (MEV)

M      208 2080.    40.                KALELKAR  75 HBC  +  15 PI+P,P PI+G    12/75
M         (2100.)  APPROX              ANTIPOV   77 CIBS -  25PI-P,P PI-G     12/77
M         (2214.)   (15.)              BALTAY    77 HBC   0 15PI-P,DEL++3PI   12/77

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                43  A(2050) WIDTH  (MEV)

W      208  340.    80.                KALELKAR  75 HBC  +  15 PI+P,P PI+G    12/75
W          (500.)  APPROX.             ANTIPOV   77 CIBS -  25PI-P,P PI- G    12/77
W          (355.)   (21.)              BALTAY    77 HBC   0 15PI-P,DEL++3PI   12/77

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                43  A(2050) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1     A(2050) INTO 3PI                                  140+ 140+ 140
P2     A(2050) INTO G PI                                 1691+ 140

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                43  A(2050) BRANCHING RATIOS

R1     A(2050) INTO (G PI)/(ALL 3PI)                      (P2)/(P1)
R1        DOMINANT                     KALELKAR  75 HBC  +  15 PI+P,P 3PI     12/75

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                          REFERENCES FOR A(2050)

HUSON    68 PL 28 B 208        +LUBATTI,BELLINI,BINGHAM,+  (ORSA+MILA+LBL)

BEMPORAD 71 NP B 33 397        +DUFEY,CODLING,+        (CERN+ETH+LOIC+MILA)

CLAYTON  72 NP B 47 81         +MASON,MUIRHEAD,RIGOPOULOS,+    (LIVP+PATR)

BASTIEN  73 UPPSALA CONF. 73   +DUNN,HARRIS,LUBATTI,BINGHAM,+   (SEAT+UCB)

OREN     74 NP B71 189         +COOPER,FIELDS,RHINES,WHITMORE,+  (ANL+OXF)

DEUTSCHM 75 NP B99 397         DEUTSCHMANN,+        (ABBCCHW COLLABORATION)
KALELKAR 75 THESIS(NEVIS 207) M.S.KALELKAR                          (COLU)

ANTIPOV  77 NP B 119 45        +BUSNELLO,DAMGAARD,KIENZLE+     (CERN+SERP)
BALTAY   77 PRL 39 591         +CAUTIS,KALELKAR                 (COLUMBIA)  JP

HARRIS   81 ZPHY C 9 275       +DUNN,LUBATTI,MORIYASU,PODOLSKY+ (SEAT+UCB)
CAUTIS   77 THESIS NEVIS 221 C.V.CAUTIS                         (COLUMBIA)  JP

BALTAY   78 PR D 17 52         +CAUTIS,COHEN,CSORNA,KALELKAR+  (COLU+BING)
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A(2100)

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                20  A(2100,JPG=2--) I=1

                FORMERLY CALLED PI.
                SEEN IN THE (RHO PI), (EPSILON(1300) PI) AND (F PI)
                JP = 2- WAVES OF THE DIFFRACTIVELY PRODUCED 3 PI
                SYSTEM. NEEDS CONFIRMATION. OMITTED FROM TABLE.

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                20  A(2100) MASS (MEV)

M    L      2100.      150.            DAUM      81 CNTR     63,94 PI- P,3PI    1/82

M    L  FROM A TWO RESONANCE FIT TO FOUR 2-0+ WAVES.

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                20  A(2100) WIDTH (MEV)

W    L       651.       50.            DAUM      81 CNTR     63,94 PI- P,3PI    1/82

W    L  FROM A TWO RESONANCE FIT TO FOUR 2-0+ WAVES.

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                20  A(2100) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1     A(2100) INTO 3PI                                  140+ 140+ 140
P2     A(2100) INTO RHO PI                               769+ 140
P3     A(2100) INTO F PI                                 1274+ 140
P4     A(2100) INTO EPSILON(1300) PI                     1300+ 140

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                20  A(2100) BRANCHING RATIOS

R1     A(2100) INTO (RHO PI)/(ALL 3PI)                    (P2)/(P1)
R1   L          0.19      0.05         DAUM      81 CNTR     63,94 PI- P        1/82
R2     A(2100) INTO (F PI)/(ALL 3PI)                      (P3)/(P1)
R2   L          0.36      0.09         DAUM      81 CNTR     63,94 PI- P        1/82

R3     A(2100) INTO (EPSILON(1300) PI)/(ALL 3PI)          (P4)/(P1)
R3   L          0.45      0.07         DAUM      81 CNTR     63,94 PI- P        1/82

R4     D/S RATIO FOR A(2100) INTO F PI
R4   L          0.39      0.23         DAUM      81 CNTR     63,94 PI- P        1/82

R    L  FROM A TWO RESONANCE FIT TO FOUR 2-0+ WAVES.

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                          REFERENCES FOR A(2100)

DAUM     81 NP B 182 269       +HERTZBERGER+(AMST+CERN+CRAC+MPIM+OXF+RHEL)
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NOTE ON THE T AND U REGIONS

The observation of broad enhancements at 2190 and 2350 MeV comes from $\overline{p}p$ total cross-section measurements (ABRAMS 67), $\overline{p}p$ annihilation measurements (ALSPECTOR 73), $\overline{p}p$ elastic cross-section measurements (COUPLAND 77), and $\overline{p}p$ charge-exchange cross-section measurements (CUTTS 78). The mass regions centered around 2190 MeV and 2350 MeV have been called T and U regions, respectively.

Searches for resonances in exclusive $\overline{p}p$ annihilation channels which could be coupled to the enhancements observed in the $\overline{p}p$ total cross section and in $\overline{p}p$ elastic scattering have been unsuccessful, except for the two-body annihilation channels $\pi^+\pi^-$ and $\pi^0\pi^0$, where partial-wave analyses have shown that resonances are formed in the 2100-2500-MeV mass region (CARTER 77, DULUDE 78, MARTIN A 80, MARTIN B 80). We have listed the results of these analyses under the headings $\epsilon(2150)$ for the I=0, $J^P=2^+$ wave; $\rho(2150)$ for the I=1, $J^P=1^-$ wave; $\rho(2250)$ for the I=1, $J^P=3^-$ wave; $\epsilon(2300)$ for the I=0, $J^P=4^+$ wave; and $\rho(2350)$ for the I=1, $J^P=5^-$ wave.

Various structures coupled to $\overline{p}p$ and observed in production experiments are listed under the heading $\overline{N}N(1200\text{-}3600)$.

$\rho(2150)$

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                32  RHO(2150,JPG=1-+) I=1

                THIS ENTRY WAS PREVIOUSLY CALLED T1(2190).
                CONTAINS ONLY RESULTS FROM FORMATION EXPERIMENTS, FOR
                PRODUCTION EXPERIMENTS SEE THE NBAR N(1200-3600) ENTRY.
                SEE ALSO T,U MINI-REVIEWS.
                OMITTED FROM TABLE.

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                32  RHO(2150) MASS (MEV)

M        PBAR P INTO PI PI
M
M     P    (2100.0)  APPROX.           MARTIN A  80 RVUE                           1/82
M     P    (2170.0)  APPROX.           MARTIN B  80 RVUE                           1/82

M     P  I=1,JP=1- FROM SIMULTANEOUS ANALYSIS OF P PB --> PI-PI+ AND PI0 PI0
M        S CHANNEL NUCLEON ANTINUCLEON
M
M   B       2190.       10.            ABRAMS    70 CNTR     S CHANNEL PBAR N  1/73
M     I     2193.        2.            ALSPECTOR 73 CNTR     S CHANNEL PBAR P  1/74
M   E I     2155.0      15.0           COUPLAND  77 CNTR   0 .7-2.4PB-P,PB-P  12/77
M     I    (2190.0)  APPROX.           CUTTS     78 CNTR     .97-3. PB P,NB N 12/78
M    AVERAGE MEANINGLESS

M   B    SEEN AS BUMP IN I=1 STATE. SEE ALSO COOPER 68.
M   B    PEASLEE 75 CONFIRM PBAR P RESULTS OF ABRAMS 70,NO NARROW STRUCTURE
M   E    FROM A FIT TO THE TOTAL ELASTIC CROSS SECTION.
M     I  ISOSPINS 0 AND 1 NOT SEPARATED

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32 RHO(2150) WIDTH (MEV)

W PBAR P INTO PI PI
W
W P (200.0) APPROX. MARTIN A 80 RVUE 1/82
W P (250.0) APPROX. MARTIN B 80 RVUE 1/82

W P I=1,JP=1- FROM SIMULTANEOUS ANALYSIS OF P PB --> PI-PI+ AND PIO PIO

W S CHANNEL NUCLEON ANTINUCLEON
W
W B (85.) APPROX. ABRAMS 70 CNTR S CHANNEL PBAR N 7/67
W I 98. 8. ALSPECTOR 73 CNTR S CHANNEL PBAR P 1/74
W E I 135.0 75.0 COUPLAND 77 CNTR 0 .7-2.4PB-P,PB-P 12/77
W AVERAGE MEANINGLESS

W B SEE NOTE B ABOVE.
W E FROM A FIT TO THE TOTAL ELASTIC CROSS SECTION.
W I ISOSPINS 0 AND 1 NOT SEPARATED

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REFERENCES FOR RHO(2150)

ABRAMS 67 PRL 18 1209 +COOL,GIACOMELLI,KYCIA,LEONTIC,LI,+ (BNL)

COOPER 68 PRL 20 1059 +HYMAN,MANNER,MUSGRAVE,VOYVODIC (ANL)

BRICMAN 69 PL 29 B 451 +FERRO-LUZZI,BIZARD,+ (CERN+CAEN+SACL)

ABRAMS 70 PR D 1 1917 +COOL,GIACOMELLI,KYCIA,LEONTIC,LI,+ (BNL)

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)
DONALD 72 PL 40 B 586 +GALLETLY,EDWARDS,DE BILLY,+ (LIVP+LPNP)

ALSPECTO 73 PRL 30 511 ALSPECTOR,COHEN,CVIJANOVICH,+ (RUTG+UPNJ)
BACON 73 PR D 7 577 +BUTTERWORTH, (RHEL+LIVP)
BETTINI 73 NC 15 A 563 +GARNJOST,BIGI,+ (PADO+LBL+PISA+TORI)
DONALD 73 NP B 61 333 +EDWARDS,GIBBINS,BRIAND,DUBOC,+ (LIVP+LPNP)
NICHOLSO 73 PR D 7 2572 NICHOLSON,DELORME,CARROLL,+ (CIT+ROCH+BNL)

BERTANZA 74 NC 23A 209 +BIGI,CASALI,LARICCIA,+ (PISA+PADO+TORI)
HYAMS 74 NP B 73 202 +JONES,WEILHAMMER,BLUM,+ (CERN+MPIM)

DONNACHI 75 NC 26 A 317 A.DONNACHIE,P.R.THOMAS (MANCHESTER)
EISENHAN 75 NP B 96 109 EISENHANDLER,GIBSON,+ (LOQM+LIVP+DARE+RHEL)
HANDLER 75 NP B101 35 +JACQUES,JONES,PANDOULAS,+ (RUTG+STEV+ALBA)
HUESMAN 75 NC 25A 91 +GARNJOST,ROSS,+ (LBL+PADO+PISA+TORI)
PEASLEE 75 PL 57B 189 +DEMARZO,GUERRIERO,+ (CANB+BARI+BROW+MIT)

GAY 76 NC 31 A 593 +JEANNERET,BOGDANSKI,+(NEUC+LAUS+LIVP+LPNP)
ZEMANY 76 NP B 103 537 +MING MA,MOUNTZ,SMITH (MSU)

CARTER 1 77 PL 67 B 117 +COUPLAND,EISENHANDLER,ASTBURY,+(LOQM+RHEL) JP
CARTER 2 77 PL 67 B 122 A.A.CARTER (LOQM) JP
CARTER 3 77 NP B 127 202 +COUPLAND,ATKINSON,ARNISON+(LOQM+DARE+RHEL)
COUPLAND 77 PL 71 B 460 +EISENHANDLER,GIBSON,ASTBURY,+ (LOQM+RHEL)
JONES 77 NP B 119 476 M.D.JONES,R.J.PLANO (RUTG)
MONTANET 77 BOSTON CONF. 260 L.MONTANET (CERN)

CARTER 1 78 NP B 132 176 A.A.CARTER (LOQM) JP
CARTER 2 78 NP B 141 467 A.A.CARTER (LOQM)
CUTTS 78 PR D 17 16 +GOOD,GRANNIS,GREEN,LEE,PITTMAN+(STON+WISC)

MARTIN 79 PL 86 B 93 A.D. MARTIN,M.R. PENNINGTON (DURH)

MARTIN A 80 NP B 169 216 A.D. MARTIN,M.R. PENNINGTON (DURH) JP
MARTIN B 80 NP B 176 355 B.R.MARTIN,D.MORGAN (LOUC+RHEL) JP

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$\epsilon(2150)$ →

42 EPSILON(2150,JPG=2++) I=0

THIS ENTRY WAS PREVIOUSLY CALLED TO.
CONTAINS ONLY RESULTS FROM FORMATION EXPERIMENTS, FOR PRODUCTION EXPERIMENTS SEE THE NBAR N(1200-3600) ENTRY.
SEE ALSO T,U MINI-REVIEWS.
OMITTED FROM TABLE.

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42 EPSILON(2150) MASS (MEV)

M PBAR P INTO PI PI
M
M L (2150.0) APPROX. DULUDE2 78 OSPK 1.-2.PB P,PIOPIO 12/78
M P (2150.0) APPROX. MARTIN A 80 RVUE 1/82
M P (2170.0) APPROX. MARTIN B 80 RVUE 1/82

M L IG=0+,JP=2+ FROM PARTIAL WAVE AMPLITUDE ANALYSIS
M P I=0,JP=2+ FROM SIMULTANEOUS ANALYSIS OF P PB --> PI-PI+ AND PIO PIO

M S CHANNEL PBAR P OR NBAR N
M
M I 2193. 2. ALSPECTOR 73 CNTR S CHANNEL PBAR P 1/74
M E I 2155.0 15.0 COUPLAND 77 CNTR 0 .7-2.4PB-P,PB-P 12/77
M I (2190.0) APPROX. CUTTS 78 CNTR .97-3. PB P,NB N 12/78
M AVERAGE MEANINGLESS

M E FROM A FIT TO THE TOTAL ELASTIC CROSS SECTION.
M I ISOSPINS 0 AND 1 NOT SEPARATED

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42 EPSILON(2150) WIDTH (MEV)

W PBAR P INTO PI PI
W
W L (250.0) APPROX. DULUDE2 78 OSPK 1.-2.PB P,PIOPIO 12/78
W P (250.0) APPROX. MARTIN A 80 RVUE 1/82
W P (250.0) APPROX. MARTIN B 80 RVUE 1/82

W L IG=0+,JP=2+ FROM PARTIAL WAVE AMPLITUDE ANALYSIS
W P I=0,JP=2+ FROM SIMULTANEOUS ANALYSIS OF P PB --> PI-PI+ AND PIO PIO

W S CHANNEL PBAR P OR NBAR N
W
W I 98. 8. ALSPECTOR 73 CNTR S CHANNEL PBAR P 1/74
W E I 135.0 75.0 COUPLAND 77 CNTR 0 .7-2.4PB-P,PB-P 12/77
W AVERAGE MEANINGLESS

W E FROM A FIT TO THE TOTAL ELASTIC CROSS SECTION.
W I ISOSPINS 0 AND 1 NOT SEPARATED

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42 EPSILON(2150) PARTIAL DECAY MODES

DECAY MASSES
P1 EPSILON(2150) INTO PI PI 140+ 140

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REFERENCES FOR EPSILON(2150)

FIELDS 71 PRL 27 1749 +COOPER,RHINES,ALLISON (ANL+OXF)
YOH 71 PRL 26 922 +BARISH,CAROLL,LOBKOVICZ+ (CIT+BNL+ROCH)

DONALD 72 PL 40 B 586 +GALLETLY,EDWARDS,DE BILLY,+ (LIVP+LPNP)

ALSPECTO 73 PRL 30 511 ALSPECTOR,COHEN,CVIJANOVICH,+ (RUTG+UPNJ)
BACON 73 PR D 7 577 +BUTTERWORTH, (RHEL+LIVP)
DONALD 73 NP B 61 333 +EDWARDS,GIBBINS,BRIAND,DUBOC,+ (LIVP+LPNP)
NICHOLSO 73 PR D 7 2572 NICHOLSON,DELORME,CARROLL,+ (CIT+ROCH+BNL)

GAY 76 NC 31 A 593 +JEANNERET,BOGDANSKI,+(NEUC+LAUS+LIVP+LPNP)

COUPLAND 77 PL 71 B 460 +EISENHANDLER,GIBSON,ASTBURY,+ (LOQM+RHEL)

CUTTS 78 PR D 17 16 +GOOD,GRANNIS,GREEN,LEE,PITTMAN+(STON+WISC)
DULUDE1 78 PL 79 B 329 +LANOU,MASSIMO,PEASLEE+ (BROW+MIT+BARI) JP
DULUDE2 78 PL 79 B 335 +LANOU,MASSIMO,PEASLEE+ (BROW+MIT+BARI) JP

MARTIN 79 PL 86 B 93 A.D. MARTIN,M.R. PENNINGTON (DURH)

BOWCOCK 80 LNC 28 21 J.E.BOWCOCK,D.C.HODGSON (BIRM)
MARTIN A 80 NP B 169 216 A.D. MARTIN,M.R. PENNINGTON (DURH) JP
MARTIN B 80 NP B 176 355 B.R.MARTIN,D.MORGAN (LOUC+RHEL) JP

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$\xi(2220)$ →

82 XI(2220,JP=EVEN +) I=0

THIS STATE HAS BEEN SEEN IN THE K KBAR SYSTEM PRODUCED IN THE RADIATIVE DECAY OF J/PSI(3100)
NEEDS CONFIRMATION. OMITTED FROM TABLE.

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82 XI(2220) MASS (MEV)

M A (2220.) (35.) EINSWEILE 83 SMK3 E+E-,HADRONS GAM 12/83*
M A SYSTEMATIC ERROR ADDED LINEARLY BY US.

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82 XI(2220) WIDTH (MEV)

W A (30.) (30.) HITLIN 83 SMK3 E+E-,HADRONS GAM 12/83*
W A SYSTEMATIC ERROR ADDED LINEARLY BY US.

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REFERENCES FOR XI(2220)

EINSWEIL 83 BRIGHTON CONF. K.F.EINSWEILER+MARKIII COLLABORATION (SLAC)
HITLIN 83 CORNELL CONF. D.HITLIN (CIT)

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$g_T(2240)$ →

83 G/T(2240,JPG=2++) I=0

THIS ENTRY CONTAINS VARIOUS STATES OBSERVED IN PARTIAL WAVE ANALYSES OF THE PHI PHI SYSTEM.
NEEDS CONFIRMATION. OMITTED FROM TABLE.

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83 G/T(2240) MASS (MEV)

M1 D 2160.0 50.0 ETKIN 82 MPS 0 16 PI-P,2PHI N 9/83*
M1 D D/S RATIO IS 0.02 APPROXIMATELY

M2 2320.0 40.0 ETKIN 82 MPS 0 16 PI-P,2PHI N 9/83*

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83 G/T(2240) WIDTH (MEV)

W1 310.0 70.0 ETKIN 82 MPS 0 16 PI-P,2PHI N 9/83*

W2 220.0 70.0 ETKIN 82 MPS 0 16 PI-P,2PHI N 9/83*

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83 G/T(2240) PARTIAL DECAY MODES

DECAY MASSES
P1 G/T(2240) INTO PHI PHI 1020+1020

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REFERENCES FOR G/T(2240)

ETKIN 82 PRL 49 1620 +FOLEY,LONGACRE,LINDENBAUM,CHAN+ (BNL+CUNY)I JP
ALSO 83 BRIGHTON CONF. LINDENBAUM (BNL+CUNY)I JP

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Mesons

Data Card Listings

ρ(2250), ϵ(2300), ρ(2350)

ρ(2250)

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44  RHO(2250,JPG=3-+) I=1

    CONTAINS ONLY RESULTS FROM FORMATION EXPERIMENTS, FOR
    PRODUCTION EXPERIMENTS SEE THE NBAR N(1200-3600) ENTRY.
    SEE ALSO T,U MINI-REVIEWS.
    OMITTED FROM TABLE.

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                     44  RHO(2250) MASS (MEV)

M        PBAR P INTO PI PI OR K KB
M
M  J      (2150.0)  APPROX.              CARTER 1  77 CNTR  0 .7-2.4PB P,PIPI  12/77
M    K    (2140.0)  APPROX.              CARTER 2  78 CNTR  0 .7-2.4PB P,K-K+  12/78
M    P    (2300.0)  APPROX.              MARTIN A  80 RVUE                      1/82
M    P    (2250.0)  APPROX.              MARTIN B  80 RVUE                      1/82

M  J     I=1,JP=3- FROM AMPLITUDE ANALYSIS.
M    K   I=0,1.JP=3- FROM BARRELET ZERO ANALYSIS.
M    P   I=1,JP=3- FROM SIMULTANEOUS ANALYSIS OF P PB --> PI-PI+ AND PIO PIO

M        S CHANNEL NUCLEON ANTINUCLEON
M
M  B      2190.      10.                 ABRAMS    70 CNTR    S CHANNEL PBAR N  1/73
M    I    2193.       2.                 ALSPECTOR 73 CNTR    S CHANNEL PBAR P  1/74
M  E I    2155.0     15.0                COUPLAND  77 CNTR  0 .7-2.4PB-P,PB-P  12/77
M    I   (2190.0)  APPROX.               CUTTS     78 CNTR   .97-3. PB P,NB N  12/78
M   AVERAGE MEANINGLESS

M  B     SEEN AS BUMP IN I=1 STATE. SEE ALSO COOPER 68.
M  B     PEASLEE 75 CONFIRM PBAR P RESULTS OF ABRAMS 70,NO NARROW STRUCTURE
M  E     FROM A FIT TO THE TOTAL ELASTIC CROSS SECTION.
M    I   ISOSPINS 0 AND 1 NOT SEPARATED

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                     44  RHO(2250) WIDTH (MEV)

W        PBAR P INTO PI PI OR K KB
W
W  J      (200.0)  APPROX.               CARTER 1  77 CNTR  0 .7-2.4PB P,PIPI  12/77
W    K    (150.0)  APPROX.               CARTER 2  78 CNTR  0 .7-2.4PB P,K-K+  12/78
W    P    (200.0)  APPROX.               MARTIN A  80 RVUE                      1/82
W    P    (250.0)  APPROX.               MARTIN B  80 RVUE                      1/82

W  J     I=1,JP=3- FROM AMPLITUDE ANALYSIS.
W    K   I=0,1.JP=3- FROM BARRELET ZERO ANALYSIS.
W    P   I=1,JP=3- FROM SIMULTANEOUS ANALYSIS OF P PB --> PI-PI+ AND PIO PIO

W        S CHANNEL NUCLEON ANTINUCLEON
W
W  B      (85.)    APPROX.               ABRAMS    70 CNTR    S CHANNEL PBAR N  7/67
W    I     98.       8.                  ALSPECTOR 73 CNTR    S CHANNEL PBAR P  1/74
W  E I    135.0     75.0                 COUPLAND  77 CNTR  0 .7-2.4PB-P,PB-P  12/77
W   AVERAGE MEANINGLESS

W  B     SEE NOTE B ABOVE.
W  E     FROM A FIT TO THE TOTAL ELASTIC CROSS SECTION.
W    I   ISOSPINS 0 AND 1 NOT SEPARATED

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                        REFERENCES FOR RHO(2250)

ABRAMS    67 PRL 18 1209          +COOL,GIACOMELLI,KYCIA,LEONTIC,LI,+    (BNL)

COOPER    68 PRL 20 1059          +HYMAN,MANNER,MUSGRAVE,VOYVODIC        (ANL)

ABRAMS    70 PR D 1 1917          +COOL,GIACOMELLI,KYCIA,LEONTIC,LI,+    (BNL)

FIELDS    71 PRL 27 1749          +COOPER,RHINES,ALLISON             (ANL+OXF)
YOH       71 PRL 26 922           +BARISH,CAROLL,LOBKOVICZ+     (CIT+BNL+ROCH)

ALSPECTO  73 PRL 30 511           ALSPECTOR,COHEN,CVIJANOVICH,+    (RUTG+UPNJ)
BETTINI   73 NC 15 A 563          +GARNJOST,BIGI,+          (PADO+LBL+PISA+TORI)
DONNACHI  73 LNC 7 285            A.DONNACHIE,P.R.THOMAS         (MANCHESTER)
NICHOLSO  73 PR D 7 2572          NICHOLSON,DELORME,CARROLL,+   (CIT+ROCH+BNL)

BERTANZA  74 NC 23A 209           +BIGI,CASALI,LARICCIA,+     (PISA+PADO+TORI)

ZEMANY    76 NP B 103 537         +MING MA,MOUNTZ,SMITH                  (MSU)

CARTER 1  77 PL 67 B 117          +COUPLAND,EISENHANDLER,ASTBURY,+(LOQM+RHEL)  JP
CARTER 2  77 PL 67 B 122          A.A.CARTER                           (LOQM)  JP
CARTER 3  77 NP B 127 202         +COUPLAND,ATKINSON,ARNISON+(LOQM+DARE+RHEL)
COUPLAND  77 PL 71 B 460          +EISENHANDLER,GIBSON,ASTBURY,+  (LOQM+RHEL)
MONTANET  77 BOSTON CONF. 260     L.MONTANET                           (CERN)

CARTER 1  78 NP B 132 176         A.A.CARTER                           (LOQM)  JP
CARTER 2  78 NP B 141 467         A.A.CARTER                           (LOQM)
CUTTS     78 PR D 17 16           +GOOD,GRANNIS,GREEN,LEE,PITTMAN+(STON+WISC)

MARTIN    79 PL 86 B 93           A.D. MARTIN,M.R. PENNINGTON          (DURH)

MARTIN A  80 NP B 169 216         A.D. MARTIN,M.R. PENNINGTON          (DURH)  JP
MARTIN B  80 NP B 176 355         B.R.MARTIN,D.MORGAN             (LOUC+RHEL)  JP
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ϵ(2300)

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41  EPSILON(2300,JPG=4++) I=0

    THIS ENTRY WAS PREVIOUSLY CALLED U0(2350).
    CONTAINS ONLY RESULTS FROM FORMATION EXPERIMENTS, FOR
    PRODUCTION EXPERIMENTS SEE THE NBAR N(1200-3600) ENTRY.
    SEE ALSO T,U MINI-REVIEWS.
    OMITTED FROM TABLE.

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                     41  EPSILON(2300) MASS (MEV)

M        PBAR P INTO PI PI OR KB K
M
M  J      (2310.0)  APPROX.              CARTER 1  77 CNTR  0 .7-2.4PB P,PIPI  12/77
M    K    (2340.0)  APPROX.              CARTER 2  78 CNTR  0 .7-2.4PB P,K-K+  12/78
M         (2330.0)  APPROX.              DULUDE2   78 OSPK   1.-2.PB P,PIOPIO   1/82
M    P    (2300.0)  APPROX.              MARTIN A  80 RVUE                      1/82
M    P    (2300.0)  APPROX.              MARTIN B  80 RVUE                      1/82

M  J     I=0,JP=4+ FROM AMPLITUDE ANALYSIS.
M    K   I=0,JP=4+ FROM BARRELET ZERO ANALYSIS
M    P   I=0,JP=4+ FROM SIMULTANEOUS ANALYSIS OF P PB --> PI-PI+ AND PIO PIO

M        S CHANNEL PBAR P OR NBAR N
M
M         2375.      10.                 ABRAMS    70 CNTR    S CHANNEL NBAR N  1/71
M    I   (2359.)     (2.)                ALSPECTOR 73 CNTR    S CHANNEL PBAR P  1/74
M   EI   (2345)     (15.0)               COUPLAND  77 CNTR  0 .7-2.4PB-P,PB-P  12/77
M    I   (2380.0)  APPROX.               CUTTS     78 CNTR   .97-3. PB P,NB N  12/78

M  E     FROM A FIT TO THE TOTAL ELASTIC CROSS SECTION.
M    I   ISOSPINS 0 AND 1 NOT SEPARATED

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                     41  EPSILON(2300) WIDTH (MEV)

W        PBAR P INTO PI PI OR KB K
W
W  J      (210.0)  APPROX.               CARTER 1  77 CNTR  0 .7-2.4PB P,PIPI  12/77
W    K    (150.0)  APPROX.               CARTER 2  78 CNTR  0 .7-2.4PB P,K-K+  12/78
W    P    (200.)   APPROX.               MARTIN A  80 RVUE                      3/82

W  J     I=0,JP=4+ FROM AMPLITUDE ANALYSIS.
W    K   I=0,JP=4+ FROM BARRELET ZERO ANALYSIS
W    P   I=0,JP=4+ FROM SIMULTANEOUS ANAL. OF P PBAR --> PI-PI+ AND PIO PIO

W        S CHANNEL PBAR P OR NBAR N
W
W         (190.)   APPROX.               ABRAMS    70 CNTR    S CHANNEL NBAR N  1/71
W    I    (165.)    (18.)      (8.)      ALSPECTOR 73 CNTR    S CHANNEL PBAR P  1/74
W   EI    (135.0)  (150.0)    (65.0)     COUPLAND  77 CNTR  0 .7-2.4PB-P,PB-P  12/77

W  E     FROM A FIT TO THE TOTAL ELASTIC CROSS SECTION.
W    I   ISOSPINS 0 AND 1 NOT SEPARATED

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                        REFERENCES FOR EPSILON(2300)

BRICMAN   69 PL 29 B 451          +FERRO-LUZZI,BIZARD,+        (CERN+CAEN+SACL)

ABRAMS    70 PR D 1 1917          +COOL,GIACOMELLI,KYCIA,LEONTIC,LI,+    (BNL)

FIELDS    71 PRL 27 1749          +COOPER,RHINES,ALLISON             (ANL+OXF)
YOH       71 PRL 26 922           +BARISH,CAROLL,LOBKOVICZ+     (CIT+BNL+ROCH)

EASTMAN   72 NP B 51 29           +MING MA,OH,PARKER,SMITH,SPRAFKA       (MSU)

ALSPECTO  73 PRL 30 511           ALSPECTOR,COHEN,CVIJANOVICH,+    (RUTG+UPNJ)
DONNACHI  73 LNC 7 285            A.DONNACHIE,P.R.THOMAS         (MANCHESTER)
NICHOLSO  73 PR D 7 2572          NICHOLSON,DELORME,CARROLL,+   (CIT+ROCH+BNL)

HYAMS     74 NP B 73 202          +JONES,WEILHAMMER,BLUM,+         (CERN+MPIM)
MING MA   74 NP B68 214           +MOUNTZ,ZEMANY,SMITH                  (MICH)

DONNACHI  75 NC 26 A 317          A.DONNACHIE,P.R.THOMAS         (MANCHESTER)
EISENHAN  75 NP B 96 109          EISENHANDLER,GIBSON,+ (LOQM+LIVP+DARE+RHEL)

CARTER 1  77 PL 67 B 117          +COUPLAND,EISENHANDLER,ASTBURY,+(LOQM+RHEL)  JP
CARTER 2  77 PL 67 B 122          A.A.CARTER                           (LOQM)  JP
CARTER 3  77 NP B 127 202         +COUPLAND,ATKINSON,ARNISON+(LOQM+DARE+RHEL)
COUPLAND  77 PL 71 B 460          +EISENHANDLER,GIBSON,ASTBURY,+  (LOQM+RHEL)
MONTANET  77 BOSTON CONF. 260     L.MONTANET                           (CERN)

CARTER 1  78 NP B 132 176         A.A.CARTER                           (LOQM)  JP
CARTER 2  78 NP B 141 467         A.A.CARTER                           (LOQM)
CUTTS     78 PR D 17 16           +GOOD,GRANNIS,GREEN,LEE,PITTMAN+(STON+WISC)
DULUDE1   78 PL 79 B 329          +LANOU,MASSIMO,PEASLEE+     (BROW+MIT+BARI)  JP
DULUDE2   78 PL 79 B 335          +LANOU,MASSIMO,PEASLEE+     (BROW+MIT+BARI)  JP

MARTIN    79 PL 86 B 93           A.D. MARTIN,M.R. PENNINGTON          (DURH)

BOWCOCK   80 LNC 28 21            J.E.BOWCOCK,D.C.HODGSON              (BIRM)
MARTIN A  80 NP B 169 216         A.D. MARTIN,M.R. PENNINGTON          (DURH)  JP
MARTIN B  80 NP B 176 355         B.R.MARTIN,D.MORGAN             (LOUC+RHEL)  JP
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ρ(2350)

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33  RHO(2350,JPG=5-+) I=1

    THIS ENTRY WAS PREVIOUSLY CALLED U1(2400).
    CONTAINS ONLY RESULTS FROM FORMATION EXPERIMENTS, FOR
    PRODUCTION EXPERIMENTS SEE THE NBAR N(1200-3600) ENTRY.
    SEE ALSO T,U MINI-REVIEWS.
    OMITTED FROM TABLE.

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                     33  RHO(2350) MASS (MEV)

M        PBAR P INTO PI PI OR KB K
M  J      (2480.0)  APPROX.              CARTER 1  77 CNTR  0 .7-2.4PB P,PIPI  12/77
M    K    (2500.0)  APPROX.              CARTER 2  78 CNTR  0 .7-2.4PB P,K-K+  12/78
M    P    (2250.0)  APPROX.              MARTIN A  80 RVUE                      1/82
M    P    (2300.0)  APPROX.              MARTIN B  80 RVUE                      1/82

M  J     I=1,JP=5- FROM AMPLITUDE ANALYSIS.
M    K   I=0,1.JP=5- FROM BARRELET ZERO ANALYSIS.
M    P   I=1,JP=5- FROM SIMULTANEOUS ANALYSIS OF P PB --> PI-PI+ AND PIO PIO

M        S CHANNEL NUCLEON ANTINUCLEON
M
M  A      2350.      10.                 ABRAMS    70 CNTR    S CHANNEL NBAR N  1/73
M    N   (2360.0)   (25.0)               OH        70 HDBC  -OPBAR(P,N),K*K2PI  1/73
M    I   (2359.)     (2.)                ALSPECTOR 73 CNTR    S CHANNEL PBAR P  1/74
M   EI   (2345.0)   (15.0)               COUPLAND  77 CNTR  0 .7-2.4PB-P,PB-P  12/77
M    I   (2380.0)  APPROX.               CUTTS     78 CNTR   .97-3. PB P,NB N  12/78

M  A     FOR I=1 NBAR N
M  E     FROM A FIT TO THE TOTAL ELASTIC CROSS SECTION.
M    I   ISOSPINS 0 AND 1 NOT SEPARATED
M    N   NO EVIDENCE FOR THIS BUMP SEEN IN THE PBAR P DATA OF CHAPMAN 71
M    N   NARROW STATE NOT CONFIRMED BY OH 73 WITH MORE DATA.

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                     33  RHO(2350) WIDTH (MEV)

W        PBAR P INTO PI PI OR KB K
W  J      (210.0)  APPROX.               CARTER 1  77 CNTR  0 .7-2.4PB P,PIPI  12/77
W    K    (150.0)  APPROX.               CARTER 2  78 CNTR  0 .7-2.4PB P,K-K+  12/78
W    P    (300.0)  APPROX.               MARTIN A  80 RVUE                      1/82
W    P    (250.0)  APPROX.               MARTIN B  80 RVUE                      1/82

W  J     I=1,JP=5- FROM AMPLITUDE ANALYSIS.
W    K   I=0,1.JP=5- FROM BARRELET ZERO ANALYSIS.
W    P   I=1,JP=5- FROM SIMULTANEOUS ANALYSIS OF P PB --> PI-PI+ AND PIO PIO
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W S CHANNEL NUCLEON ANTINUCLEON

W							
W	(140.)	APPROX.		ABRAMS	67 CNTR	S CHANNEL PBAR N	1/73
W N	(60.0)	OR LESS		OH	70 HDBC	-OPBAR(P,N),K*K2PI	11/71
W I	(165.)	(18.)	(8.)	ALSPECTOR	73 CNTR	S CHANNEL PBAR P	1/74
W EI	(135.0)	(150.0)	(65.0)	COUPLAND	77 CNTR	0 .7-2.4PB-P,PB-P	12/77

W E FROM A FIT TO THE TOTAL ELASTIC CROSS SECTION.
W I ISOSPINS 0 AND 1 NOT SEPARATED
W N NO EVIDENCE FOR THIS BUMP SEEN IN THE PBAR P DATA OF CHAPMAN 71
W N NARROW STATE NOT CONFIRMED BY OH 73 WITH MORE DATA.

REFERENCES FOR RHO(2350)

ABRAMS	67 PRL 18 1209	+COOL,GIACOMELLI,KYCIA,LEONTIC,LI,+ (BNL)	
BRICMAN	69 PL 29 B 451	+FERRO-LUZZI,BIZARD,+ (CERN+CAEN+SACL)	
CASO	69 LNC 3 707	+CONTE,BENZ,+ (GENO+DESY+HAMB+MILA+SACL)	
ABRAMS	70 PR D 1 1917	+COOL,GIACOMELLI,KYCIA,LEONTIC,LI,+ (BNL)	
OH	70 PRL 24 1257	+PARKER,EASTMAN,SMITH,SPRAFKA,MA (MSU)	
CHAPMAN	71 PR D4 1275	+GREEN,LYS,MURPHY,RING,+ (MICH)	
FIELDS	71 PRL 27 1749	+COOPER,RHINES,ALLISON (ANL+OXF)	
YOH	71 PRL 26 922	+BARISH,CAROLL,LOBKOVICZ+ (CIT+BNL+ROCH)	
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)	
OH	72 NP B 51 57	+EASTMAN,MING MA,PARKER,SMITH,+ (MSU)	
ALSPECTO	73 PRL 30 511	ALSPECTOR,COHEN,CVIJANOVICH,+ (RUTG+UPNJ)	
NICHOLSO	73 PR D 7 2572	NICHOLSON,DELORME,CARROLL,+ (CIT+ROCH+BNL)	
HYAMS	74 NP B 73 202	+JONES,WEILHAMMER,BLUM,+ (CERN+MPIM)	
MING MA	74 NP B68 214	+MOUNTZ,ZEMANY,SMITH (MICH)	
DONNACHI	75 NC 26 A 317	A.DONNACHIE,P.R.THOMAS (MANCHESTER)	
EISENHAN	75 NP B 96 109	EISENHANDLER,GIBSON,+ (LOQM+LIVP+DARE+RHEL)	
CARTER 1	77 PL 67 B 117	+COUPLAND,EISENHANDLER,ASTBURY,+(LOQM+RHEL)	JP
CARTER 2	77 PL 67 B 122	A.A.CARTER (LOQM)	JP
CARTER 3	77 NP B 127 202	+COUPLAND,ATKINSON,ARNISON+(LOQM+DARE+RHEL)	
COUPLAND	77 PL 71 B 460	+EISENHANDLER,GIBSON,ASTBURY,+ (LOQM+RHEL)	
MONTANET	77 BOSTON CONF. 260	L.MONTANET (CERN)	
CARTER 1	78 NP B 132 176	A.A.CARTER (LOQM)	JP
CARTER 2	78 NP B 141 467	A.A.CARTER (LOQM)	
CUTTS	78 PR D 17 16	+GOOD,GRANNIS,GREEN,LEE,PITTMAN+(STON+WISC)	
MARTIN	79 PL 86 B 93	A.D. MARTIN,M.R. PENNINGTON (DURH)	
BOWCOCK	80 LNC 28 21	J.E.BOWCOCK,D.C.HODGSON (BIRM)	
MARTIN A	80 NP B 169 216	A.D. MARTIN,M.R. PENNINGTON (DURH)	JP
MARTIN B	80 NP B 176 355	B.R.MARTIN,D.MORGAN (LOUC+RHEL)	JP

δ(2450)

24 **DELTA(2450,JPG=6+-) I=1**

SEEN IN PARTIAL WAVE ANALYSIS OF THE K KBAR SYSTEM. NEEDS CONFIRMATION. OMITTED FROM TABLE.

24 DELTA(2450) MASS (MEV)

M C	2450.	130.	CLELAND	82 SPEC	+- 50 PI P,KS K+-P	8/83*

M C FROM AN AMPLITUDE ANALYSIS

24 DELTA(2450) WIDTH (MEV)

W C	400.	250.	CLELAND	82 SPEC	+- 50 PI P,KS K+-P	8/83*

M C FROM AN AMPLITUDE ANALYSIS

24 DELTA(2450) PARTIAL DECAY MODES

		DECAY MASSES
P1	DELTA(2450) INTO K KBAR	498+ 498

REFERENCES FOR DELTA(2450)

CLELAND 82 NP B 208 228 +DELFOSSE,DORSAZ,GLOOR(DURH+GEVA+LAUS+PITT)

r(2510)

89 **R(2510,JPG=6++) I=0**

SEEN IN PIO PIO.
NEEDS CONFIRMATION. OMITTED FROM TABLE.

89 R(2510) MASS (MEV)

M	2510.0	30.0	BINON	83 SPEC	0 38 PI-P,N 2PIO	9/83*

89 R(2510) WIDTH (MEV)

W	240.0	60.0	BINON	83 SPEC	0 23 PI-P,N 2PIO	9/83*

89 R(2510) PARTIAL DECAY MODES

		DECAY MASSES
P1	R(2510) INTO PI PI	135+ 135

REFERENCES FOR R(2510)

BINON 83 CERN-EP/83-98 +DONSKOV,DUTEIL,GOUANERE+ (SERP+BELG+LAPP) JP

e^+e^-(1100–2200)

7 **E+ E-(1100-2200,JPG=1-) I=**

THIS ENTRY CONTAINS NON-STRANGE VECTOR MESONS COUPLED TO E+ E-(PHOTON) BETWEEN PHI AND J/PSI MASS REGION. SEE ALSO RHO(1250) AND RHO(1600) MINI-REVIEW. SEE ALSO PHI(1670) OMITTED FROM TABLE.

7 E+ E-(1100-2200) MASSES AND WIDTHS (MEV)

M	(1097.0)	(16.0)	(19.0)	BARTALUCC	79 OSPK	7 GAM P,E+ E- P	12/79
W	(31.0)	(24.0)	(20.0)	BARTALUCC	79 OSPK	7 GAM P,E+ E- P	12/79
M	(1830.0)	APPROX.		PETERSON	78 SPEC	GAM P,K+ K- P	
W	(120.0)	APPROX.		PETERSON	78 SPEC	GAM P,K+ K- P	
M C	(2130.)	APPROX.		ESPOSIT1	78 FRAM	E+E-,K*(892)+..	12/78
W C	(30.)	APPROX.		ESPOSIT1	78 FRAM	E+E-,K*(892)+..	12/78
M A	(1820.)	APPROX.		SPINETTI	79 RVUE	E+E-,4 PI+- 2GAM	1/82
W A	(30.)	APPROX.		SPINETTI	79 RVUE	E+E-,4 PI+- 2GAM	1/82

A INTEGRATED CROSS-SECTION OF BARBIELLINI 77,BACCI 77,ESPOSITO 77.
C NOT SEEN BY DELCOURT 79.

REFERENCES FOR E+ E-(1100-2200)

BACCI	75 PL 58 B 481	+BIDOLI,PENSO,STELLA,BALDINI,+ (ROMA+FRAS)
BACCI	76 PL 64 B 356	+BIDOLI,PENSO,STELLA,BALDINI,+ (ROMA+FRAS)
BACCI	77 PL B 68 393	+DE ZORZI,PENSO,STELLA,BALDINI,+(ROMA+FRAS)
BARBIELL	77 PL B 68 397	BARBIELLINI,BARLETTA,+(FRAS+NAPL+PISA+SANI)
BARTALUC	77 NC A 39 374	BARTALUCCI BERTOLUCCI,BRADASCHIA(DESY+FRAS)
ESPOSITO	77 PL B 68 389	+FELICETTI,MARINI,+ (FRAS+NAPL+PADO+ROMA)
AMBROSIO	78 PL 80 B 141	+CERRITO,BEMPORAD,BROSCO,+ (NAPL+PISA+ROMA)
BALDINI	78 PL 78 B 167	+BATTISTONI,CAPON,BACCI,DEZORZI+(FRAS+ROMA)
ESPOSIT1	78 LNC 22 305	ESPOSITO,FELICETTI+ (FRAS+NAPL+PADO+ROMA)
ESPOSIT2	78 LNC 23 604	ESPOSITO,FELICETTI+ (FRAS+NAPL+PADO+ROMA)
PETERSON	78 PR D 18 3955	+DIXON,EHRLICH,GALIK,LARSON+ (CORN+HARV)
BARTALUC	79 NC 49 A 207	BARTALUCCI,BASINI,BERTOLUCCI+ (DESY+FRAS)
DELCOURT	79 BATAVIA CONF.499	+BERTRAND,BISELLO,BIZOT,BUON,CORDIER+(LALO)
ESPOSITO	79 LNC 25 5	+MARINI,PALLOTTA+ (FRAS+UMD+PADO+ROMA)
SPINETTI	79 BATAVIA CONF.506	M. SPINETTI (FRAS)
BALDINI	81 LNC 30 337	+BATTISTONI,CAPON,BACCI,DEZORZI+(FRAS+ROMA)

$\bar{N}$N(1200–3600)

51 **NBAR N(1200-3600)**

THIS ENTRY CONTAINS VARIOUS HIGH MASS, NON-STRANGE STRUCTURES COUPLED TO THE BARYON-ANTIBARYON SYSTEM AS WELL AS QUASI-NUCLEAR BOUND STATES BELOW THRESHOLD. SEE ALSO S,T,U DATA CARD LISTINGS AND MINIREVIEWS. EVIDENCE FOR STRUCTURES COUPLED TO THE ANTI-HYPERON NUCLEON (OR C.C.) SYSTEM IS LISTED UNDER K(2200). OMITTED FROM TABLE.

51 NBAR N(1200-3600) MASSES AND WIDTHS (MEV)

M W G	1210.	5.0	RICHTER	83 CNTR	0 STOPPED PBARS	9/83*
M W G	(1395.)		PAVLOPOUL	78 CNTR	STOPPED PBARS	1/78
M W G	1638.	3.0	RICHTER	83 CNTR	0 STOPPED PBARS	9/83*
M W G	(1646.)		PAVLOPOUL	78 CNTR	STOPPED PBARS	1/78
M W G	(1684.)		PAVLOPOUL	78 CNTR	STOPPED PBARS	1/78
M W G	1694.	2.0	RICHTER	83 CNTR	0 STOPPED PBARS	9/83*
M W G	1771.	1.0	RICHTER	83 CNTR	0 STOPPED PBARS	9/83*

W OBSERVED WIDTHS CONSISTENT WITH EXPERIMENTAL RESOLUTION.
G THEY LOOKED FOR RADIATIVE TRANSITIONS TO BOUND P PBAR STATES,
G MONO-ENERGETIC GAMMA RAYS DETECTED.

M ZD	(1794.5)	(1.4)	GRAY	71 DBC	- 0.PBAR D	1/72
W ZD	(8.)	OR LESS CL=.95	GRAY	71 DBC	- 0.PBAR D	1/72

D DECAYS TO FOUR OR MORE PIONS,I=1.
Z NOT SEEN BY AMSLER 80.

M Z	(1897.)	(1.)	KALOGERO	75 DBC	- PBAR N ANNIH	12/75
W Z	(25.)	(6.)	KALOGERO	75 DBC	- PBAR N ANNIH	12/75

Z NOT SEEN BY ALBERI 79, AMSLER 80.

M B	(1897.0)	(17.0)	ABASHIAN	76 STRC	8PI-P,P 3PI	12/77
W B	(110.0)	(82.0)	ABASHIAN	76 STRC	8PI-P,P 3PI	12/77

B PRODUCED BACKWARDS.

M R	(1920.0)	APPROX.	EVANGELIS	79 OMEG	10,16 PI-P,PB P	12/79
W	(190.0)	APPROX.	EVANGELIS	79 OMEG	10,16 PI-P,PB P	12/79

R I=1,JP=1- FROM A MASS DEPENDENT PARTIAL WAVE ANALYSIS TAKING
R SOLUTION A.

M I	1949.	10.	DEFOIX	80 HBC	0 0-1.2 PB P,5 PI	12/79
W I	80.	20.	DEFOIX	80 HBC	0 0-1.2 PB P,5 PI	12/79

I ISOSPIN = 1 FAVORED

Mesons

Data Card Listings

$\bar{N}N(1200-3600)$, X(1900-3600)

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M   Z  153(2020.0)     (3.0)           BENKHEIRI 77 OMEG  0 9,12PI-P,PPPBPI-  12/77
W   Z  153  (24.0)    (12.0)           BENKHEIRI 77 OMEG  0 9,12PI-P,PPPBPI-  12/77
    Z   NOT SEEN BY BIONTA 80, CARROLL 80, HAMILTON 80, BANKS 81, CHUNG 81,
    Z   BARNETT 83.
M    T    (2020.0)  APPROX.            EVANGELIS 79 OMEG    10,16 PI-P,PB P   12/79
W          (160.0)  APPROX.            EVANGELIS 79 OMEG    10,16 PI-P,PB P   12/79
     T  I=0,JP=2+ FROM A MASS DEPENDENT PARTIAL WAVE ANALYSIS TAKING
     T  SOLUTION A.

M   Z     (2022.0)     (6.0)           AZOOZ     83 HYBR +  6 PBARP,PNBAR3PI   9/83*
W   Z       (14.0)    (13.0)           AZOOZ     83 HYBR +  6 PBARP,PNBAR3PI   9/83*

M   Z     (2026.0)     (5.0)           AZOOZ     83 HYBR -  4 PBARP,PBARN3PI   9/83*
W   Z       (20.0)    (11.0)           AZOOZ     83 HYBR -  4 PBARP,PBARN3PI   9/83*

M  K       2080.       10.             KREYMER   80 STRC  0 13 PI-D,PPBN(N)     4/82
W  K        110.       20.             KREYMER   80 STRC  0 13 PI-D,PPBN(N)     4/82
   K    NEUTRON SPECTATOR. SEE ALSO NPPBPI-(P) CHANNEL FOLLOWING.

M  L       2090.0      20.0            KREYMER   80 STRC    13 PI-D,NPPBPI-P    1/82
W  L        170.0      50.0            KREYMER   80 STRC    13 PI-D,NPPBPI-P    1/82
   L    PROTON  SPECTATOR. SEE ALSO PPBN(N) CHANNEL ABOVE.

M    R    (2110.0)  APPROX.            EVANGELIS 79 OMEG    10,16 PI-P,PB P   12/79
W    R     (330.0)  APPROX.            EVANGELIS 79 OMEG    10,16 PI-P,PB P   12/79
     R  I=1,JP=3- FROM A MASS DEPENDENT PARTIAL WAVE ANALYSIS TAKING
     R  SOLUTION A.

M    N     2110.0      10.0            ROZANSKA  80 SPRK    18.PI-P,P PB N    12/79
W    N      190.0      10.0            ROZANSKA  80 SPRK    18.PI-P,P PB N    12/79
     N  I=1,JP=3- FROM AMPLITUDE ANALYSIS ASSUMING ONE PION EXCHANGE

M    S    (2141.)                      DONALD    73 HBC   0 S CHANNEL PBAR P  1/74
W    S      (14.)                      DONALD    73 HBC   0 S CHANNEL PBAR P  1/74
     S  SEEN IN FINAL STATE (OMEGA PI+ PI-)

M    M     2180.0      10.0            ROZANSKA  80 SPRK    18.PI-P,P PB N    12/79
W    M      270.0      10.0            ROZANSKA  80 SPRK    18.PI-P,P PB N    12/79
     M  I=0,JP=2+ FROM AMPLITUDE ANALYSIS ASSUMING ONE PION EXCHANGE.

M   K     (2190.0)                     KALBFLEIS 69 HBC     0 S-CHANNEL PBARP  7/69
W   K       BETWEEN 20 AND 80 MEV      KALBFLEIS 69 HBC     0 S-CHANNEL PBARP  7/69
    K   SEEN IN PBAR P TO RHO0 RHO0 PI0. IG=1-.
    K   NOT SEEN BY BACON 73, DONALD 73.
    K   NOT SEEN BY ZEMANY 76 IN RHO0 RHO0 PI-.

M   Z  58(2204.0)      (5.0)           BENKHEIRI 77 OMEG -  9,12PI-P,PPPBPI- 12/77
W   Z  58  (16.)     OR LESS           BENKHEIRI 77 OMEG -  9,12PI-P,PPPBPI- 12/77
    Z   NOT SEEN BY BIONTA 80, BANKS 81, CHUNG 81, BARNETT 83.

M   A     (2207.)     (13.)            ALLES-BOR 67 HBC   0 5.7 PBAR P        12/66
W   A       (62.)     (52.)            ALLES-BOR 67 HBC   0 5.7 PBAR P        12/66
    A   ALLES-BORELLI 67 SEE NEUTRAL MODE ONLY (PI+PI-PI0)

M          2210.0      79.0      21.0  EVANGEL2  79 OMEG    10. PI-P,K+ K- N 12/79
W          (203.0)  APPROX.            EVANGEL2  79 OMEG    10. PI-P,K+ K- N 12/79

M    R    (2260.0)  APPROX.            EVANGELIS 79 OMEG    10,16 PI-P,PB P   12/79
W    R     (440.0)  APPROX.            EVANGELIS 79 OMEG    10,16 PI-P,PB P   12/79
     R  I=0,JP=4+ FROM A MASS DEPENDENT PARTIAL WAVE ANALYSIS TAKING
     R  SOLUTION A.

M          2307.0       6.0            ALPER     80 CNTR  0 62 PI-P,K+ K- N    1/82
W           245.0      20.0            ALPER     80 CNTR  0 62 PI-P,K+ K- N    1/82

M    M     2380.0      10.0            ROZANSKA  80 SPRK    18.PI-P,P PB N    12/79
W    M      380.0      20.0            ROZANSKA  80 SPRK    18.PI-P,P PB N    12/79
     M  I=0,JP=4+ FROM AMPLITUDE ANALYSIS ASSUMING ONE PION EXCHANGE

M    M    (2450.0)    (10.0)           ROZANSKA  80 SPRK    18.PI-P,P PB N     1/80
W    M     (280.0)    (20.0)           ROZANSKA  80 SPRK    18.PI-P,P PB N    12/80
     M  I=1,JP=5- FROM AMPLITUDE ANALYSIS ASSUMING ONE PION EXCHANGE

M  J      (2480.0)    (30.0)           CARTER    77 CNTR  0 .7-2.4PB P,PIPI   12/77
W  J       (210.0)    (25.0)           CARTER    77 CNTR  0 .7-2.4PB P,PIPI   12/77
   J    I=1,JP=5- FROM AMPLITUDE ANALYSIS OF PABAR P INTO PI PI.

M    K    (2500.0)  APPROX.            CARTER    78 CNTR  0 .7-2.4PB P,K-K+   12/78
W    K     (150.0)  APPROX.            CARTER    78 CNTR  0 .7-2.4PB P,K-K+   12/78
     K  I=0,1.JP=5- FROM BARRELET ZERO ANALYSIS.

M         (2710.0)    (20.0)           ROZANSKA  80 SPRK    18.PI-P,P PB N    12/79
W          (170.0)    (40.0)           ROZANSKA  80 SPRK    18.PI-P,P PB N    12/79

M  V      (2850.0)     (5.0)           BRAUN     76 DBC  -  5.5PBAR D,N NBP+ 12/77
W  V        (39.)    OR LESS           BRAUN     76 DBC  -  5.5PBAR D,N NBP+ 12/77
   V    DECAYS TO NBAR N AND NBAR N PI. NOT SEEN BY BARNETT 83.

M  W      (3080.)     (20.)            ALEXANDER 72 HBC   0 6.94 PBAR P        1/73
W  W       (220.)     (70.)            ALEXANDER 72 HBC   0 6.94 PBAR P        1/73
   W    DECAYS TO 3PI+ 3PI-
   W    NOT SEEN BY KALELKAR 75 WITH 1.5 TIMES MORE DATA

M  X      (3370.)     (10.)            ALEXANDER 72 HBC   0 6.94 PBAR P        1/73
W  X       (150.)     (40.)            ALEXANDER 72 HBC   0 6.94 PBAR P        1/73
   X    DECAYS TO 4PI+ 4PI-

M  Y      (3390.)     (20.)            ALEXANDER 72 HBC   0 6.94 PBAR P        1/73
W  Y       (220.)    (100.)            ALEXANDER 72 HBC   0 6.94 PBAR P        1/73
   Y    DECAYS TO 3PI+ 3PI-
   Y    NOT SEEN BY KALELKAR 75 WITH 1.5 TIMES MORE DATA

M  Z      (3600.)     (20.)            ALEXANDER 72 HBC   0 6.94 PBAR P        1/73
W  Z       (140.)     (20.)            ALEXANDER 72 HBC   0 6.94 PBAR P        1/73
   Z    DECAYS TO 4PI+ 4PI-

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REFERENCES FOR NBAR N(1200-3600)


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ALLES-BO 67 NC 50 A 776        ALLES-BORELLI,FRENCH,FRISK,+    (CERN+BONN)G=-

KALBFLEI 69 PL 29 B  259       G.KALBFLEISCH,R.STRAND,V.VANDERBURG   (BNL)

ALEXANDE 70 PRL 25 63          +BAR-NIR,DAGAN,GIDAL,GRUNHAUS+   (TEL-AVIV)
KALBFLEI 70 PHILAD.CONF.P.409 G.KALBFLEISCH AND D.MILLER REVUES     (BNL)

GRAY     71 PRL 26 1491         +HAGERT,KALOGEROPOULOS               (SYRA)

ALEXANDE 72 NP B 45 29         ALEXANDER,BAR-NIR,BEVARY,DAGAN,+     (TELA)
BOGDANOV 72 PRL 28 1418        BOGDANOVA,DALKAROV,SHAPIRO           (ITEP)
BUGG     72 PR D 6 3047        +CONDO,HART,COHN,ENDORF,+  (TENN+ORNL+CINC)
CLAYTON  72 NP B 47 81         +MASON,MUIRHEAD,RIGOPOULOS,+    (LIVP+PATR)

BOWEN    73 PRL 30 332         +EARLES,FAISSLER,BLIEDEN,+       (NEAS+STON)
DONALD   73 NP B 61 333        +EDWARDS,GIBBINS,BRIAND,DUBOC,+ (LIVP+LPNP)
GRAY     73 PRL 30 1091        +PAPADOPOULOU,KARAGEROPOULOS,+  (ATEN+SYRA)
NICHOLSO 73 PR D 7 2572        NICHOLSON,DELORME,CARROLL,+   (CIT+ROCH+BNL)

HYAMS    74 NP B 73 202        +JONES,WEILHAMMER,BLUM,+         (CERN+MPIM)
DONNACHI 75 NC 26 A 317        A.DONNACHIE,P.R.THOMAS          (MANCHESTER)
EISENHAN 75 NP B 96 109        EISENHANDLER,GIBSON,+ (LOQM+LIVP+DARE+RHEL)
KALOGERO 75 PRL 34 1047        KALOGEROPOULOS,TZANAKOS               (SYRA)

ABASHIAN 76 PR D 13 5          +WATSON,GELFAND,BUTTRAM+(ILL+ANL+CHIC+IOWA)
BRAUN    76 PL B 60 481        +BRICK,FRIDMAN,GERBER,JUILLOT,MAURER+(STRB)
ZEMANY   76 NP B 103 537       +MING MA,MOUNTZ,SMITH                  (MSU)

BENKHEIR 77 PL B 68 483        BENKHEIRI,BOUCROT,+    (CERN+CDEF+EPOL+LALO)
CARTER   77 PL 67 B 117        +COUPLAND,EISENHANDLER,ASTBURY,+(LOQM+RHEL)  JP
EVANGELI 77 PL B 72 139        EVANGELISTA+      (BARI+BONN+CERN+DARE+GLAS+)

BALTAY   78 PR D 17 62         +CAUTIS,COHEN,CSORNA,KALELKAR+  (COLU+BING)
CARTER   78 NP B 141 467       A.A.CARTER                            (LOQM)
PAVLOPOU 78 PL 72 B 415        PAVLOPOULOS+       (KARL+BASL+CERN+STOH+STRB)
PENNINGT 78 NP B 137 77        M.R. PENNINGTON                       (CERN)

ALBERI   79 PL 83 B 247        +ALVEAR,CASTELLI,POROPAT+  (TRST+CERN+IFRJ)
ALSTON-G 79 PRL 43 1901        ALSTON-GARNJOST,HAMILTON+     (LBL+MTHO+BNL)
ARMSTRON 79 PL B 85 304        ARMSTRONG+ (AACH+BARI+BONN+CERN+GLAS+LIVP+)
BENKHEIR 79 PL 81 B 380        BENKHEIRI,BOUCROT,+    (EPOL+LALO+CDEF+CERN)
CARROLL  79 PR D 19 1950       +CHIANG,KYCIA,LI,LITTENBERG,+     (BNL+ROCH)
DELCOURT 79 PL B 86 395        +DERADO,BERTRAND,BISELLO,BIZOT,BUON,+(LALO)
EVANGELI 79 NP B 153 253       + (BARI+BONN+CERN+DARE+GLAS+LIVP+MILA+WIEN)
EVANGEL2 79 NP B 154 381       + (BARI+BONN+CERN+DARE+GLAS+LIVP+MILA+WIEN)
GIBBARD  79 PRL 42 1593        +AHRENS,BERKELMAN,CASSEL,DAY,HARDING+(CORN)
MARTIN   79 PL B 86 93         A.D. MARTIN,M.R. PENNINGTON           (DURH)

ALPER    80 PL 94 B 422        +BECKER,+     (AMST+CERN+CRAC+MPIM+OXF+RHEL)
AMSLER   80 PRL 44 853         +AUERBACH,MANDELKERN,+         (UNM+TEMP+UCI)
BIONTA   80 PRL 44 909         +CARROLL,EDELSTEIN,+    (BNL+CARN+FNAL+SMAS)
BIONTA 2 80 PRL 46 970         +CARROLL,EDELSTEIN,+    (BNL+CARN+FNAL+SMAS)
CARROLL  80 PRL 44 1572        +CHIANG,JOHNSON,CESTER,WEBB,+     (BNL+PRIN)
CHUNG    80 PRL 45 1611        +ETKIN,BENSINGER,+(BNL+BRAN+CUNY+SMAS+MASA)
DEFOIX   80 NP B 162 12        +DOBRZYNSKI,ANGELINI,BIGI,+      (CDEF+PISA)
HAMILTON 80 PRL 44 1179        +PUN,TRIPP,LAZARUS,NICHOLSON (LBL+BNL+MTHO)
KREYMER  80 PR D 22 36         +BAGGETT,FIEGUTH,ALAM,+(IND+PURD+SLAC+VAND)
ROZANSKA 80 NP B 162 505       +BLUM,DIETL,GRAYER,LORENZ+       (MPIM+CERN)

BANKS    81 PL 100 B 191       +BOOTH,CAMPBELL,ARMSTRONG,+      (LIVP+CERN)
CHUNG    81 PRL 46 395         +BENSINGER,+        (BNL+BRAN+CINC+FSU+SMAS)

AJALTOUN 82 NP B 209 301       AJALTOUNI,BACHMAN+     (CERN+NEUC+EPOL+CDEF)

AZOOZ    83 PL 122 B 471       +BUTTERWORTH(LOIC+RHEL+SACL+SLAC+TOHO+TUFT)
BARNETT  83 PR D 27 493        +BLOCKUS,BURKA,CHIEN,CHRISTIAN+        [illegible])
BENSINGE 83 PR D 27 1417       BENSINGER,CHUNG       (BRAN+BNL+CINC+FSU+S[illegible]
RICHTER  83 PL 126 B 284       +ADIELS            (BASL+KARL+STOH+STRB+TH[illegible]
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X(1900−3600)

46 X(1900-3600)

THIS ENTRY CONTAINS VARIOUS HIGH-MASS
NON-STRANGE PEAKS. OMITTED FROM TABLE.

The high-mass region is covered nearly continuously by evidence for peaks of various widths and decay modes. As a satisfactory grouping into particles is not yet possible, we list all the Y = 0 bumps coupled neither to $\bar{N}N$ nor to e^+e^-, and having M > 1900 MeV, together, ordered by increasing mass. Note that ANTIPOV 72 ($\pi^- p \to p MM^-$ at 25 and 40 GeV/c) see no narrow bumps.

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                  46  X(1900-3600)  MASSES AND WIDTHS  (MEV)

M        100(1898.)    (18.)              THOMPSON  74 HBC  +  13 PI+ P,2RHO    12/75
W        100 (108.)    (41.)     (27.)    THOMPSON  74 HBC  +  13 PI+ P,2RHO    12/75

M        100(1900.)    (40.)              BOESEBECK 68 HBC  +   8 PI+ P,PI+ PI0 12/75
W        100 (216.)   (105.)              BOESEBECK 68 HBC  +   8 PI+ P,PI+ PI0 12/75

M           (1970.)    (10.)              CHLIAPNIK 80 HBC   0 32 K+ P,2KS 2PI  12/79
W           (1970.)    (10.)              CHLIAPNIK 80 HBC   0 32 K+ P,2KS 2PI  12/79

M         30(1973.0)   (15.0)             CASO      70 HBC   - 11.2PI-P,RHO 2PI 12/75
W         30  (80.0)                      CASO      70 HBC   - 11.2PI-P,RHO 2PI 12/75

M    K    40(1975.0)   (12.0)             KRAMER    70 HBC  +  13.1 PI+ P,2PI   11/70
W    K    40  (52.0)   OR LESS  CL=.90    KRAMER    70 HBC  +  13.1 PI+ P,2PI   12/75
     K    2PI PEAK OF KRAMER NOT SEEN IN SAME EXP WITH MORE DATA(THOMPSON 74)

M         50(2070.)                       TAKAHASHI 72 HBC     8. PI-P,N 2PI    12/75
W         50 (160.)                       TAKAHASHI 72 HBC     8. PI-P,N 2PI    12/75

M    A    24(2145.)    (10.)              AJINENKO  80 HBC  +  32 K+P,PHI PI+ X  3/82
M    AW   10(2100.)    (20.)              BARTH     82 BEBC +  70 K+P,PHI PI+ P  9/83*
W    AW   24  (25.)    OR LESS            AJINENKO  80 HBC  +  32 K+P,PHI PI+ X  3/82
     A    ASTON 81 SEES NO PEAK, HAS 850 EVENTS IN AJINENKO+BARTH BINS.
     A    ARESTOV 80 SEES NO PEAK.
      W   COMPATIBLE WITH ESTIMATED EXPERIMENTAL RESOLUTION

M    E      (2157.0)   (10.0)             KRAMER    70 HBC  +  13.1 PI+ P,2PI   11/70
W    E        (68.0)   (22.0)             KRAMER    70 HBC  +  13.1 PI+ P,2PI   11/70
     E    EVIDENCE OF KRAMER 70 DISAPPEARED WITH MORE STATISTICS(THOMPSON 74)

M           (2190.0)   (10.0)             CLAYTON   67 HBC  +- 2.5PBAR,A2+OMEGA 10/67

M     C     (2207.0)   (22.0)             CASO      70 HBC   - 11.2PI- P,NOTE C  5/70
W     C      (130.0)                      CASO      70 HBC   - 11.2PI- P,NOTE C  5/70
      C   SEEN IN RHO- PI+ PI- (OMEGA AND ETA ANTISELECTED IN 4 PI SYSTEM)
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For notation, see key at front of Listings.


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M  B   126(2340.)    (20.)              BALTAY    75 HBC +   15 PI+P,P5PI     12/75
W  B   126 (180.)    (60.)              BALTAY    75 HBC +   15 PI+P,P5PI     12/75
   B    DOMINANT DECAY INTO RHO0 RHO0 PI+. BALTAY 78 FINDS CONFIRMATION
   B    IN 2PI+PI-2PI0 EVENTS WHICH CONTAIN RHO+ RHO0 PI0 AND 2RHO+PI-.

M         (2500.0)   (32.0)             ANDERSON  69 MMS  -  16 PI- P,BACKW9  8/69
W           (87.0)                      ANDERSON  69 MMS  -  16 PI- P,BACKW9  8/69

M      550(2620.)    (20.)              BAUD      69 MMS  -  8.-10. PI- P     9/69
W      550  (85.)    (30.)              BAUD      69 MMS  -  8.-10. PI- P     9/69

M         (2676.0)   (27.0)             CASO      70 HBC  - 11.2PI- P,NOTE C  5/70
W          (150.0)                      CASO      70 HBC  - 11.2PI- P,NOTE C  5/70
    C   SEEN IN RHO- PI+ PI- (OMEGA AND ETA ANTISELECTED IN 4 PI SYSTEM)

M      640(2800.)    (20.)              BAUD      69 MMS  -  8.-10. PI- P     9/69
W      640  (46.)    (10.)              BAUD      69 MMS  -  8.-10. PI- P     9/69

M  C    15(2820.)    (10.)              SABAU     71 HBC  + 8. PI+ P         11/71
W  C    15  (50.)    (10.)              SABAU     71 HBC  + 8. PI+ P         11/71
   C    SEEN IN (K KBAR PI PI)+ MASS DISTRIBUTION

M      230(2880.)    (20.)              BAUD      69 MMS  -  8.-10. PI- P     9/69
W      230  (15.)   OR LESS             BAUD      69 MMS  -  8.-10. PI- P     9/69

M  Y    43(3013.)     (5.)              YOST      71 HBC  + 11.PI+ P,P(8PI)+ 11/71
W  Y    43  (40.)   OR LESS             YOST      71 HBC  + 11.PI+ P,P(8PI)   5/71
   Y    4.3 S.D. EFFECT  . DECAY TO 7 PIONS
   Y    NOT SEEN BY KALELKAR 75 WITH 5 TIMES MORE DATA
M         (3025.0)   (20.0)             BAUD      70 MMS  - 10.5-13 PI- P     5/70
W           (25.0)  APPROX.             BAUD      70 MMS  - 10.5-13 PI- P     5/70

M         (3075.0)   (20.0)             BAUD      70 MMS  - 10.5-13 PI- P     5/70
W           (25.0)  APPROX.             BAUD      70 MMS  - 10.5-13 PI- P     5/70

M         (3145.0)   (20.0)             BAUD      70 MMS  - 10.5-15 PI- P     5/70
W           (10.0)  OR LESS             BAUD      70 MMS  - 10.5-15 PI- P     5/70

M         (3475.0)   (20.0)             BAUD      70 MMS  - 14-15.5 PI- P     5/70
W           (30.0)  APPROX.             BAUD      70 MMS  - 14-15.5 PI- P     5/70

M         (3535.0)   (20.0)             BAUD      70 MMS  - 14-15.5 PI- P     5/70
W           (30.0)  APPROX.             BAUD      70 MMS  - 14-15.5 PI- P     5/70

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REFERENCES FOR X(1900-3600)


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CLAYTON  67 HEIDBG.CONF.P.57   +MASON,MUIRHEAD,FILIPPAS+(LIVERPOOL+ATHENS)

BOESEBEC 68 NP B 4 501         BOESEBECK,DEUTSCHMANN,+(AACHEN+BERLIN+CERN)

ANDERSON 69 PRL 22 1390        +COLLINS,+                       (BNL+CARN)
BAUD     69 PL  30B 129        CERN BOSON SPECTROMETER GROUP        (CERN)

BAUD     70 PL 31 B 549        CERN BOSON SPECTROMETER GROUP        (CERN)
CASO     70 LNC 3 707          +CONTE,TOMASINI,CORDS+(GENO+HAMB+MILA+SACL)
KRAMER   70 PRL 25 396         +BARTON,GUTAY,LICHTMAN,MILLER,+    (PURDUE)

SABAU    71 LNC 1 514          +URETSKY                         (BUCH+ANL)
YOST     71 PR D 3 642         +MORRIS,ALBRIGHT,BRUCKER,LANNUTTI     (FSU)

TAKAHASH 72 PR D 6 1266        TAKAHASHI,BARISH,+     (TOHO+PENN+NDAM+ANL)

THOMPSON 74 NP B69 220         +GAIDOS,MCILWAIN,MILLER,MULERA,+     (PURD)

BALTAY   75 PRL 35 891         +CAUTIS,COHEN,KALELKAR,PISELLO,+(COLU+BING)
KALELKAR 75 THESIS(NEVIS 207)  M.S.KALELKAR                         (COLU)
KEMP     75 NC 27 A 155        +LOTTS,CONTRI,TEODORO+(DURH+GENO+MILA+LPNP)

BALTAY   78 PR D 17 52         +CAUTIS,COHEN,CSORNA,KALELKAR+  (COLU+BING)
BLANAR   79 PR D 20 615        +BOYER,EARLES,FAISSLER,GARELICK+     (NEAS)
CLINE    79 PRL 43 1771        +DE BONTE,GAIDOS,LEEDOM,KEY,+   (PURD+TNTO)

AJINENKO 80 PL 95 B 451        +CHLIAPNIKOV,+           (SERP+BELG+MONS+SACL)
CHLIAPNI 80 ZPHY C 3 285       CHLIAPNIKOV,GERDYUKOV,+    (SERP+BRUX+MONS)

ASTON    81 NP B 189 205       (BONN+CERN+EPOL+GLAS+LANC+MCHS+ORSA+RHEL++)

BARTH    82 PL 117 B 267       +DREVERMANN+(BELG+CERN+GENO+MONS+NIJM+SERP)

ATKINSON 83  CERN-EP/83-106    + (BONN+CERN+GLAS+LANC+MCHS+IPNP+RHEL+SHEF)

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NOTE ON THE CHARMONIUM SYSTEM

We group into this system those meson states commonly believed to consist of charmed-quark-charmed-antiquark pairs. Since the discovery of the $J/\psi(3100)$ (AUBERT 74, AUGUSTIN 74), this family has increased to 11, of which we tabulate 10 as well-established particles. Figure 1 shows the states of charmonium below the $\psi(3685)$, interpreted by the charmonium model, as of January 1984.

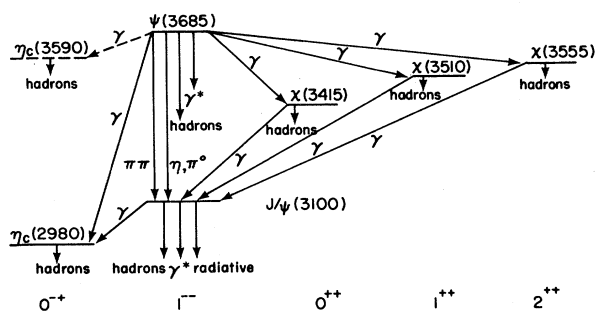

Fig. 1. The current state of knowledge of the charmonium system and transitions, as interpreted by the charmonium model. Uncertain states and transitions are indicated by dashed lines. The notation γ^* refers to decay processes involving intermediate virtual photons, including decays to e^+e^- and $\mu^+\mu^-$.

$\eta_c(2980)$

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26  ETA/C(2980,JPG=0-+) I=0

    OBSERVED IN THE INCLUSIVE GAMMA SPECTRUM GENERATED FROM
    PSI(3685) DECAY, THEREFORE C=+. FROM THE 4 PI DECAY
    G=+, THEREFORE I=0.
    FROM ANGULAR DISTRIBUTION IN J/PSI TO ETA/C, ETA/C TO
    PHI PHI, JP=0- (HITLIN 83).

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                    26  ETA/C(2980) MASS (MEV)

M  M    18 2982.      8.              HIMEL      80 SMK2    E+ E-             9/81
M  M       2980.      9.              PARTRIDGE  80 CBAL    E+ E-             9/81
M         (2980.)    (5.)             EINSWEILE  83 SMK3   PSI3685,ETAC GAM 12/83*
M         (2978.)    (5.)             EINSWEILE  83 SMK3   PSI3685,ETAC GAM 12/83*
M          . . . . . . . . . .
M   AVG    2981.1     6.0     AVERAGE

M  M    MASS ADJUSTED BY US TO CORRESPOND TO J/PSI(3100) MASS = 3097.

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                    26  ETA/C(2980) WIDTH (MEV)

W       18  (40.)    OR LESS  CL=.90  HIMEL      80 SMK2    E+ E-             9/81
W           (20.)    OR LESS  CL=.90  PARTRIDGE  80 CBAL    E+ E-             9/81
W           (33.)    OR LESS  CL=.90  EINSWEILE  83 SMK3   PSI3685,ETAC GAM 12/83*
W           (36.)    OR LESS  CL=.90  EINSWEILE  83 SMK3                    12/83*

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                    26  ETA/C(2980) PARTIAL DECAY MODES

P      HADRONIC DECAYS
P      ---------------
P11    ETA/C(2980) INTO 2(PI+PI-)                        140+ 140+ 140+ 140
P12    ETA/C(2980) INTO P PBAR                           938+ 938
P13    ETA/C(2980) INTO PI+ PI- P PBAR                   140+ 140+ 938+ 938
P14    ETA/C(2980) INTO K KBAR PI                        498+ 498+ 140
P15    ETA/C(2980) INTO PI+ PI- K+ K-                    140+ 140+ 494+ 494
P16    ETA/C(2980) INTO ETA PI+ PI-                      549+ 140+ 140
P17    ETA/C(2980) INTO PHI PHI                         1275+1275

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                    26  ETA/C(2980) BRANCHING RATIOS

R1     ETA/C(2980) INTO (2(PI+PI-))/TOTAL                (P11)
R1 A         0.013     0.009     0.006 HIMEL      80 SMK2   PSI3685,ETAC GAM  9/81

R2     ETA/C(2980) INTO (PBAR P)/TOTAL                   (P12)
R2 A         0.002     0.002     0.001 HIMEL      80 SMK2   PSI3685,ETAC GAM  9/81
R2           0.018     0.009           EINSWEILE 83 SMK3   PSI3685,ETAC GAM 12/83*
R2          . . . . . . . . . .
R2  AVG      0.0024    0.0015  AVERAGE

R3     ETA/C(2980) INTO (2PI PBAR P)/TOTAL               (P13)
R3          (0.012)OR LESS  CL=.90   HIMEL      80 SMK2   PSI3685,ETAC GAM  9/81

R4     ETA/C(2980) INTO (K KBAR PI)/TOTAL                (P14)
R4 A B       0.14      0.07      0.06  HIMEL      80 SMK2   PSI3685,ETAC GAM  9/81

R5     ETA/C(2980) INTO (2PI 2K)/TOTAL                   (P15)
R5 A         0.009     0.014     0.006 HIMEL      80 SMK2   PSI3685,ETAC GAM  9/81

R7     ETA/C(2980) INTO PHI PHI/TOTAL                    (P17)
R7          (0.01)    (0.004)          EINSWEILE 83 SMK3   PSI3685,ETAC GAM 12/83*

R  A    ESTIMATED USING BR ( PSI(3685) INTO ETA/C(2980) GAMMA) = .0043
R  A    THE ERRORS DO NOT CONTAIN THE UNCERTAINTY IN THE PSI(3685) DECAY.
R    B  NOT SEEN BY PARTRIDGE IN K+ K- PI0.
R    D  SYSTEMATIC ERROR ADDED LINEARLY BY US.

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                    REFERENCES FOR ETA/C(2980)

BLOOM    79 FERMILAB SYMP.92  E.D.BLOOM          (CIT+HARV+PRIN+SLAC+STAN)

HIMEL    80 PRL 45 1146       +TRILLING,ABRAMS,ALAM+         (SLAC+LBL+UCB)
PARTRIDG 80 PRL 45 1150       PARTRIDGE,PECK+    (CIT+HARV+PRIN+STAN+SLAC)

EINSWEIL 83 BRIGHTON CONF.    K.F.EINSWEILER+MARKIII COLLABORATION (SLAC)
HITLIN   83 CORNELL CONF.     D. HITLIN                              (CIT)
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J/ψ(3100)

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 70  J/PSI(3100,JPG=1--) I=0

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                 70  J/PSI(3100) MASS (MEV)

                 WE USE INDEPENDENT MEASUREMENTS OF THE J/PSI(3100)
                 MASS, THE PSI(3685) MASS AND THE MASS DIFFERENCE TO
                 PERFORM A CONSTRAINED FIT.

M         (3100.)                AUBERT    74 SPEC    28. PP(E+E-)    2/75
M   L     (3105.)    (3.)        AUGUSTIN  74 SMAG         E+E-       2/75
M          3103.      6.         BEMPORAD  75 FRAB         E+E-       1/76
M   O      3095.      4.         BOYARSKI  75 SMAG         E+E-       3/75
M   S      3089.5    31.         CRIEGEE   75 PLUT         E+E-       2/75
M          3098.      6.         PREPOST   75 SPEC    13.-21.GAMMA D  1/76
M          3096.0    30.0        SNYDER    76 SPEC    400 P BE,E+E-   1/77
M   F      3097.0     1.         BRANDELIK 79 DASP    E+ E-          12/79
M     9000(3095.44)  (0.46)      LEMOIGNE  79 GOLI    150 PI-BE,2MU  12/79
M      502 3096.93    0.09       ZHOLENTZ  80 OLYA    E+E- COLL.BEAMS 9/81
M      38K 3098.4     2.0        LEMOIGNE  82 GOLI    190 PI-BE,2MU   9/83*
M
M   AVG    3096.934   0.090   AVERAGE
M   FIT    3096.93    0.09    FROM FIT

M   E    SYSTEMATIC ERROR ADDED LINEARLY BY US
M   F    FROM A SIMULTANEOUS FIT TO E+ E-,MU+ MU- AND HADRONIC CHANNELS
M   F    ASSUMING G(E+ E-) = G(MU+ MU-)
M
M   L    BOYARSKI 75 IS A REEVALUATION OF AUGUSTIN 74 BASED
M   L    ON A RECALIBRATION OF THE SPEAR BEAM ENERGY.
M
M   O    MASS, WIDTH, PARTIAL WIDTHS, AND BRANCHING RATIOS ALL OBTAINED
M   O    FROM ONE OVERALL FIT TO DATA OF THIS EXPERIMENT.
M
M   S    ERROR OF ABOUT 1 PER CENT FROM THE UNCERTAINTY IN CALIBRATION OF
M   S    THE BEAM ENERGY.

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                 70  J/PSI(3100) WIDTH (KEV)

W           69.      15.         BOYARSKI  75 SMAG         E+E-       3/75
W           68.      26.         BALDINI1  75 FRAG         E+E-       1/76
W           60.      25.         ESPOSITO  75 FRAM         E+E-       1/76
W   F       58.      13.         BRANDELIK 79 DASP    E+ E-          12/79
W   F    FROM A SIMULTANEOUS FIT TO E+ E-,MU+ MU- AND HADRONIC CHANNELS
W   F    ASSUMING G(E+ E-) = G(MU+ MU-)
W
W   AVG     63.0      8.6     AVERAGE

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                 70  J/PSI(3100) PARTIAL DECAY MODES

                                                       DECAY MASSES
P1     J/PSI(3100) INTO E+ E-                        .511+.511
P2     J/PSI(3100) INTO MU+ MU-                      106+ 106
P3     J/PSI(3100) INTO HADRONS
P4     J/PSI(3100) INTO VIRTUAL GAMMA INTO HADRONS

P      HADRONIC DECAYS
P      ---------------
P11    J/PSI(3100) INTO PI+ PI-                      140+ 140
P12    J/PSI(3100) INTO PI+ PI- PIO                  140+ 140+ 135
P13    J/PSI(3100) INTO 2(PI+ PI-)                   140+ 140+ 140+ 140
P14    J/PSI(3100) INTO 2(PI+ PI-) PIO               140+ 140+ 140+ 140+
P15    J/PSI(3100) INTO 3(PI+ PI-)
P16    J/PSI(3100) INTO 3(PI+ PI-) PIO
P17    J/PSI(3100) INTO 4(PI+ PI-)
P18    J/PSI(3100) INTO 4(PI+ PI-) PIO
P19    J/PSI(3100) INTO K KBAR                       498+ 498
P20    J/PSI(3100) INTO K KBAR PI                    498+ 498+ 140
P21    J/PSI(3100) INTO PI+ PI- K+ K-                140+ 140+ 494+ 494
P22    J/PSI(3100) INTO 2(PI+ PI-) K+ K-
P23    J/PSI(3100) INTO PI+ PI- PIO K+ K-            140+ 140+ 135+ 494+
P24    J/PSI(3100) INTO RHO PI                       769+ 140
P25    J/PSI(3100) INTO RHO PI PI PI                 769+ 140+ 140+ 140
P26    J/PSI(3100) INTO OMEGA PI PI                  783+ 140+ 140
P27    J/PSI(3100) INTO OMEGA 4PI                    783+ 140+ 140+ 140+
P28    J/PSI(3100) INTO OMEGA K KBAR                 783+ 498+ 498
P29    J/PSI(3100) INTO OMEGA F                      783+1274
P30    J/PSI(3100) INTO OMEGA F PRIME                783+1525
P31    J/PSI(3100) INTO PHI PI PI                    1020+ 140+ 140
P32    J/PSI(3100) INTO PHI 2(PI+ PI-)               1020+ 140+ 140+ 140+
P33    J/PSI(3100) INTO PHI K KBAR                   1020+ 498+ 498
P34    J/PSI(3100) INTO PHI ETA                      1020+ 549
P35    J/PSI(3100) INTO PHI ETA PRIME                1020+ 958
P36    J/PSI(3100) INTO PHI F                        1020+1274
P37    J/PSI(3100) INTO PHI F PRIME                  1020+1525
P38    J/PSI(3100) INTO A2 PI                        1318+ 140
P39    J/PSI(3100) INTO A2 RHO                       1318+ 769
P40    J/PSI(3100) INTO K K*BAR(892) + C.C.          498+ 892
P41    J/PSI(3100) INTO K K*BAR(1430) + C.C.         498+1425
P42    J/PSI(3100) INTO K*(892) K*BAR(892)           892+ 892
P43    J/PSI(3100) INTO K*(1430) K*BAR(1430)         1425+1425
P44    J/PSI(3100) INTO K*(892) K*BAR(1430) + C.C.   892+1425
P45    J/PSI(3100) INTO P PBAR                       938+ 938
P46    J/PSI(3100) INTO P PBAR PIO                   938+ 938+ 135
P47    J/PSI(3100) INTO P NBAR PI-                   938+ 940+ 140
P48    J/PSI(3100) INTO P PBAR PI+ PI-               938+ 938+ 140+ 140
P49    J/PSI(3100) INTO P PBAR PI+ PI- PIO           938+ 938+ 140+ 140+
P50    J/PSI(3100) INTO P PBAR ETA                   938+ 938+ 549
P51    J/PSI(3100) INTO P PBAR OMEGA                 938+ 938+ 783
P52    J/PSI(3100) INTO LAMBDA ANTILAMBDA            1116+1116
P53    J/PSI(3100) INTO LAMBDA ANTISIGMA             1116+1192
P54    J/PSI(3100) INTO XI ANTIXI                    1315+1315
P55    J/PSI(3100) INTO PI B                         140+1234
P56    J/PSI(3100) INTO P PBAR ETA PRIME             938+ 938+ 958
P57    J/PSI(3100) INTO SIGMAO SIGMABARO             1192+1192
P58    J/PSI(3100) INTO 2(K+ K-)                     494+ 494+ 494+ 494
P59    J/PSI(3100) INTO N NBAR                       940+ 940
P60    J/PSI(3100) INTO N NBAR PI+ PI-               940+ 940+ 140+ 140
P61    J/PSI(3100) INTO SIGMA- SIGMABAR-             1192+1192
P62    J/PSI(3100) INTO N*(1232)++ N*(1232)--        1232+1232
P63    J/PSI(3100) INTO Y*(1385)- Y*(1385)+          1385+1385
P64    J/PSI(3100) INTO Y*(1385)+ Y*(1385)-          1385+1385
P65    J/PSI(3100) INTO Y*(1385)- SIGMABAR+          1385+ 135
P66    J/PSI(3100) INTO Y*(1385)+ SIGMABAR-          1385+1197
P67    J/PSI(3100) INTO PBAR N*(1440-1535)+          938+1440
P68    J/PSI(3100) INTO N*(1232)++ PBAR PI-          1232+ 938+ 140
P69    J/PSI(3100) INTO LAMBDA SIGMABAR+ PI-         1116+ 135+ 140
P70    J/PSI(3100) INTO LAMBDA SIGMABAR- PI+         1116+1197+ 140
P90    J/PSI(3100) INTO PHI S(975)                   1020+ 975
P91    J/PSI(3100) INTO P PBAR RHO                   938+ 938+ 769
P92    J/PSI(3100) INTO P K- ANTILAMBDA              938+ 494+1116
P93    J/PSI(3100) INTO P K- ANTISIGMAO              938+ 494+1192
P94    J/PSI(3100) INTO P K- Y*(1385)0               938+ 494+1385

P      RADIATIVE DECAYS
P      ----------------
P70    J/PSI(3100) INTO GAMMA GAMMA                  0+   0
P71    J/PSI(3100) INTO 3 GAMMA                      0+   0+   0
P72    J/PSI(3100) INTO PIO GAMMA                    135+ 0
P73    J/PSI(3100) INTO ETA GAMMA                    549+ 0
P74    J/PSI(3100) INTO ETA PRIME GAMMA              958+ 0
P75    J/PSI(3100) INTO ETA/C(2980) GAMMA            2981+ 0
P76    J/PSI(3100) INTO F GAMMA                      1274+ 0
P77    J/PSI(3100) INTO F PRIME GAMMA                1525+ 0
P78    J/PSI(3100) INTO D(1285) GAMMA                1283+ 0
P79    J/PSI(3100) INTO IOTA(1440) GAMMA             1440+ 0
P80    J/PSI(3100) INTO P PBAR GAMMA                 938+ 938+ 0
P81    J/PSI(3100) INTO THETA(1690) GAMMA            1690+ 0
P83    J/PSI(3100) INTO P PBAR PI+ PI- GAMMA         938+ 938+ 140+ 140+
P84    J/PSI(3100) INTO RHO RHO GAMMA                769+ 769+ 0
P85    J/PSI(3100) INTO 2PI+ 2PI- GAMMA              140+ 140+ 140+ 140+
P86    J/PSI(3100) INTO ETA PI+ PI- GAMMA            549+ 140+ 140+ 0
P87    J/PSI(3100) INTO ETA PIO PIO GAMMA            549+ 135+ 135+ 0

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                 70  J/PSI(3100) PARTIAL WIDTHS

W1       J/PSI(3100) INTO E+ E- (KEV)                      (G1)
W1          4.8      0.6         BOYARSKI  75 SMAG         E+E-       3/75
W1  B      (4.6)    (.8)         BALDINI1  75 FRAG         E+E-       1/76
W1          4.6      1.0         ESPOSITO  75 FRAM         E+E-       1/76
W1  B    ASSUMING EQUAL PARTIAL WIDTHS FOR (E+E-) AND (MU+MU-)
W1 F        4.4      0.6         BRANDELIK 79 DASP    E+ E-          12/79
W1 F     FROM A SIMULTANEOUS FIT TO E+ E-,MU+ MU- AND HADRONIC CHANNELS
W1 F     ASSUMING G(E+ E-) = G(MU+ MU-)
W1
W1  AVG     4.60     0.39     AVERAGE

W2       J/PSI(3100) INTO MU+ MU- (KEV)                    (G2)
W2          4.8      0.6         BOYARSKI  75 SMAG         E+E-       3/75
W2          5.0      1.0         ESPOSITO  75 FRAM         E+E-       1/76
W2
W2  AVG     4.85     0.51     AVERAGE

W3       J/PSI(3100) INTO HADRONS (KEV)                    (G3)
W3         59.      14.          BOYARSKI  75 SMAG         E+E-       3/75
W3         59.      24.          BALDINI1  75 FRAG         E+E-       1/76
W3         50.      25.          ESPOSITO  75 FRAM         E+E-       1/76
W3
W3  AVG    57.3     10.9      AVERAGE

W4       J/PSI(3100) INTO GAMMA INTO HADRONS (KEV)         (G4)
W4 C       12.       2.          BOYARSKI  75 SMAG         E+E-       1/76
W4 C     INCLUDED IN W3

W70      J/PSI(3100) INTO GAMMA GAMMA  (EV)                (G70)
W70        (5.4)  OR LESS CL=0.90  BRANDELIK 79 DASP    E+ E-        12/79

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                 70  J/PSI(3100) BRANCHING RATIOS

         FOR THE BRANCHING RATIOS R1 - R4, SEE ALSO THE PARTIAL
         WIDTHS ABOVE, AND (PARTIAL WIDTHS)*R1 BELOW.

R1       J/PSI(3100) INTO (E+ E-)/TOTAL                    (P1)/(P1+P2+P3)
R1          0.069    0.009       BOYARSKI  75 SMAG         E+E-       3/75

R2       J/PSI(3100) INTO (MU+ MU-)/TOTAL                  (P2)/(P1+P2+P3)
R2          0.069    0.009       BOYARSKI  75 SMAG         E+E-       3/75

R3       J/PSI(3100) INTO (HADRONS)/TOTAL                  (P3)/(P1+P2+P3)
R3          0.86     0.02        BOYARSKI  75 SMAG         E+E-       3/75

R4       J/PSI(3100) INTO (E+ E-)/(MU+ MU-)                (P1)/(P2)
R4          1.00     0.05        BOYARSKI  75 SMAG         E+E-       3/75
R4          0.93     0.10        FORD      75 SPEC         E+E-       2/75
R4           .91      .15        ESPOSITO  75 FRAM         E+E-       1/76
R4
R4  AVG     0.980    0.043    AVERAGE

R5       J/PSI(3100) INTO (GAMMA INTO HADRONS)/TOTAL       (P4)
R5 C         .17      .02        BOYARSKI  75 SMAG         E+E-       1/76
R5 C     INCLUDED IN R3


R        HADRONIC DECAYS
R        ---------------

R8       J/PSI(3100) INTO (PI+ PI-)/TOTAL (UNITS 10**-4)   (P11)
R8        1   1.6      1.6       VANNUCCI  77 SMAG         E+E-       1/77
R8        5   1.0      0.5       BRANDELIK 78 DASP         E+E-      12/78
R8
R8  AVG       1.05     0.48   AVERAGE

R9       J/PSI(3100) INTO (2(PI+ PI-))/TOTAL               (P13)
R9       76     .004     .001    JEAN-MARI 76 SMAG         E+E-       1/76

R10      J/PSI(3100) INTO (2(PI+ PI-) PIO)/TOTAL           (P14)
R10     675     .04      .01     JEAN-MARI 76 SMAG         E+E-       1/76
R10    1500   0.0364   0.0052    BURMESTER 77 PLUT         E+E-      12/77
R10     147  (0.0317) (0.0042)   FRANKLIN  83 SMK2     E+E-,HADRONS   9/83*
R10
R10 AVG       0.0372   0.0046 AVERAGE

R11      J/PSI(3100) INTO (3(PI+ PI-))/TOTAL               (P15)
R11      32     .004     .002    JEAN-MARI 76 SMAG         E+E-       1/76

R12      J/PSI(3100) INTO (3(PI+ PI-) PIO)/TOTAL           (P16)
R12     181     .029     .007    JEAN-MARI 76 SMAG         E+E-       1/76
R12      11   (0.028)  (0.009)   FRANKLIN  83 SMK2     E+E-,HADRONS   9/83*

R13      J/PSI(3100) INTO (4(PI+ PI-) PIO)/TOTAL           (P18)
R13      13     .009     .003    JEAN-MARI 76 SMAG         E+E-       1/76
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For notation, see key at front of Listings.

Mesons
J/ψ(3100)

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R14      J/PSI(3100) INTO (PI+ PI- K+ K-)/TOTAL              (P21)
R14    205     0.0072   0.0023          VANNUCCI  77 SMAG          E+E-              1/77

R15      J/PSI(3100) INTO (2(PI+ PI-) K+ K-)/TOTAL           (P22)
R15     30     0.0031   0.0013          VANNUCCI  77 SMAG          E+E-              1/77

R16      J/PSI(3100) INTO (RHO PI)/(PI+ PI- PI0)             (P24)/(P12)
R16           (.7)   OR MORE  CL=0.90   JEAN-MARI 76 SMAG          E+E-              1/76

R17      J/PSI(3100) INTO (RHO0 PI0)/(RHO+- PI-+)
R17            0.63     0.22            BARTEL 1  76 CNTR          E+E-              1/77
R17            0.59     0.17            JEAN-MARI 76 SMAG          E+E-              1/76
R17            0.53     0.15            ALEXANDER 78 PLUT       E+ E-                4/78
R17            0.46     0.14            BRANDELIK 78 DASP       E+E-,PI+PI-GAMMA     4/78
R17           (0.56)   (0.06)           SCHARRE   79 SMAG       E+E-                12/79
R17
R17 AVG        0.534    0.081     AVERAGE

R18      J/PSI(3100) INTO (RHO PI)/TOTAL                     (P24)
R18    543     0.010    0.002           BARTEL 1  76 CNTR          E+E-              1/77
R18    153     0.013    0.003           JEAN-MARI 76 SMAG          E+E-              1/76
R18    183     0.016    0.004           ALEXANDER 78 PLUT       E+ E-                4/78
R18            0.0133   0.0021          BRANDELIK 78 DASP       E+E-,PI+PI-GAMMA     4/78
R18    150    (0.013)  (0.003)          FRANKLIN  83 SMK2       E+E-,HADRONS         9/83*
R18
R18 AVG        0.0122   0.0012    AVERAGE

R19      J/PSI(3100) INTO (OMEGA PI PI)/(2(PI+ PI-) PI0)     (P26)/(P14)
R19   J       (.2)                      JEAN-MARI 76 SMAG          E+E-              1/76
R19   J  FINAL STATE  2(PI+PI-)PI0

R20      J/PSI(3100) INTO (RHO PI PI PI)/(2 (PI+ PI-) PI0)(P25)/(P14)
R20   J       (.3)                      JEAN-MARI 76 SMAG          E+E-              1/76
R20   J  FINAL STATE  2(PI+PI-)PI0

R21      J/PSI(3100) INTO (PHI PI+ PI-)/TOTAL                (P31)
R21     23     0.0021   0.0009          FELDMAN   77 SMAG          E+E-             12/77

R22      J/PSI(3100) INTO (K+ K-)/TOTAL     (UNITS 10**-4)  (P19)
R22      2     2.0      1.6             VANNUCCI  77 SMAG          E+E-              1/77
R22      7     2.2      0.9             BRANDELIK 79 DASP          E+E-             12/79
R22
R22 AVG        2.15     0.78      AVERAGE

R23      J/PSI(3100) INTO (K0S K0L)/TOTAL  (UNITS 10**-4)  (P19)
R23           (0.89)  OR LESS  CL=0.90  VANNUCCI  77 SMAG          E+E-              1/77

R24      J/PSI INTO (K+- K*(892)-+)/TOTAL (UNITS 10**-4)   (P40)
R24     39    41.      12.              BRAUNSCHW 76 DASP          E+E-              1/77
R24     48    32.       6.              VANNUCCI  77 SMAG          E+E-              1/77
R24     24   (26.4)    (5.7)            FRANKLIN  83 SMK2       E+E-,HADRONS         9/83*
R24
R24 AVG       33.8      5.4       AVERAGE

R25      J/PSI(3100) INTO (K0 K*(892)0)/TOTAL                (P40)
R25                                   (UNITS 10**-4)
R25     45    27.       6.              VANNUCCI  77 SMAG          E+E-              1/77

R26      J/PSI(3100) INTO (K+- K*(1430-+)/TOTAL              (P41)
R26           (0.0033)OR LESS  CL=0.90  BRAUNSCHW 76 DASP          E+E-              1/77

R27      J/PSI(3100) INTO (K0 K*(1430)0)/TOTAL               (P41)
R27           (0.002) OR LESS  CL=0.90  VANNUCCI  77 SMAG          E+E-              1/77

R28      J/PSI(3100) INTO (K*(892)0 K*(892)0)/TOTAL          (P42)
R28           (0.0005)OR LESS  CL=0.90  VANNUCCI  77 SMAG          E+E-              1/77

R29      J/PSI(3100) INTO (K*(1430)0 K*(1430)0)/TOTAL        (P43)
R29           (0.0029)OR LESS  CL=0.90  VANNUCCI  77 SMAG          E+E-              1/77

R30      J/PSI(3100) INTO (K*(892)0 K*(1430)0)/TOTAL         (P44)
R30     40     0.0067   0.0026          VANNUCCI  77 SMAG          E+E-              1/77

R31      J/PSI(3100) INTO (PBAR P)/TOTAL (UNITS 10**-3)      (P45)
R31            2.0      0.5             BESCH     78 BONA          E+E-              4/78
R31   A 331    2.2      0.2             PERUZZI   78 SMAG          E+E-              4/78
R31    133     2.5      0.4             BRANDELIK 79 DASP       E+ E-               12/79
R31S  1420    (2.16)   (0.22)           EATON     83 SMK2       E+E-,HADRONS GAM    12/83*
R31
R31 AVG        2.23     0.17      AVERAGE

R31S     SYSTEMATIC ERROR ADDED LINEARLY BY US.
R31   A  ASSUMING ANGULAR DISTRIBUTION (1.+COS(THETA)**2)

R32      J/PSI(3100) INTO (PBAR P)/(MU+ MU-)                 (P45)/(P2)
R32   A  20   (.051)   (.02)            WIIK      75 PLUT          E+E-              1/76
R32   A  ASSUMING ANGULAR DISTRIBUTION (1.+COS(THETA)**2)

R33      J/PSI INTO (LAMBDA ANTILAMBDA)/TOT (UNITS 10**-3)(P52)
R33    196     1.1      0.2             PERUZZI   78 SMAG       E+E-,L X,LBAR L      4/78
R33      5     2.6      1.6             BESCH     81 BONA          E+E-              1/82
R33S   365    (1.58)   (0.27)           EATON     83 SMK2       E+E-,HADRONS GAM    12/83*
R33S     SYSTEMATIC ERROR ADDED LINEARLY BY US.
R33
R33 AVG        1.12     0.20      AVERAGE

R34      J/PSI(3100) INTO (P PBAR PI0)/TOT (UNITS 10**-3)  (P46)
R34    109     1.00     0.15            PERUZZI   78 SMAG       E+E-,P PB            4/78
R34            1.4      0.4             BRANDELIK 79 DASP       E+ E-               12/79
R34     16    (1.0)    (0.3)            FRANKLIN  83 SMK2       E+E-,HADRONS         9/83*
R34S   685    (1.13)   (0.18)           EATON     83 SMK2       E+E-,HADRONS GAM    12/83*
R34S     SYSTEMATIC ERROR ADDED LINEARLY BY US.
R34
R34 AVG        1.05     0.14      AVERAGE

R35      J/PSI(3100) INTO (P PBAR PI+PI-)/TOT(UNTS 10**-3)(P48)
R35    533     5.5      0.6             PERUZZI   78 SMAG       E+E-,P PB 1-2PI      4/78
R35     48     3.8      1.6             BESCH     81 BONA          E+E-              1/82
R35S  1435    (6.46)   (0.60)           EATON     83 SMK2       E+E-,HADRONS GAM    12/83*
R35S     SYSTEMATIC ERROR ADDED LINEARLY BY US.
R35
R35 AVG        5.29     0.56      AVERAGE

R36      J/PSI INTO (P PBAR PI+ PI- PI0)/TOT (UNTS 10**-3)(P49)
R36      INCLUDING P PBAR PI+PI- GAMMA AND EXCLUDING OMEGA,ETA,ETA PRIME
R36     39     1.6      0.6             PERUZZI   78 SMAG       E+E-,P PB 2PI        4/78
R36S   364    (3.36)   (0.93)           EATON     83 SMK2       E+E-,HADRONS        12/83*
R36S     SYSTEMATIC ERROR ADDED LINEARLY BY US.

R37      J/PSI INTO (LAMBDA ANTISIGMA)/TOT (UNITS 10**-3)  (P53)
R37           (0.15) OR LESS  CL=0.90   PERUZZI   78 SMAG       E+E-,LAMBDA X        4/78

R38      J/PSI(3100) INTO (PI+- A2)/TOTAL
R38           (0.0043)OR LESS  CL=0.90  BRAUNSCHW 76 DASP          E+E-              1/77

R39      J/PSI(3100) INTO (OMEGA PI PI)/TOTAL                (P26)
R39    215     0.0078   0.00216         BURMESTER 77 PLUT          E+E-             12/77
R39    348     0.0068   0.0019          VANNUCCI  77 SMAG          E+E-              1/77
R39
R39 AVG        0.0068   0.0019    AVERAGE

R40      J/PSI(3100) INTO 2(K+ K-)/TOTAL                     (P58)
R40            0.0007   0.0003          VANNUCCI  77 SMAG          E+E-              1/77

R41      J/PSI(3100) INTO (OMEGA K KBAR)/TOTAL               (P28)
R41     22     0.0016   0.0010          FELDMAN   77 SMAG          E+E-             12/77

R42      J/PSI(3100) INTO (PHI K KBAR)/TOTAL                 (P33)
R42     14     0.0018   0.0008          FELDMAN   77 SMAG          E+E-             12/77
R43      J/PSI(3100) INTO (PHI ETA)/TOTAL                    (P34)
R43      5     0.0010   0.0006          VANNUCCI  77 SMAG          E+E-              1/77

R44      J/PSI(3100) INTO (PHI ETA PRIME)/TOTAL              (P35)
R44           (0.0013)OR LESS  CL=0.90 VANNUCCI  77 SMAG          E+E-              1/77

R45      J/PSI(3100) INTO (PHI F PRIME)/TOT (UNITS 10**-4)(P35)
R45B     6     8.0      5.0             VANNUCCI  77 SMAG          E+E-              1/77
R45B    46     3.4      1.3             GIDAL     81 SMK2          E+E-              2/84*
R45B     ASSUMES F PRIME INTO K KBAR IS 100 PER CENT.
R45
R45 AVG        3.7      1.3       AVERAGE

R70      J/PSI(3100) INTO (PHI S(975))/TOT (UNITS 10**-4) (P90)
R70     50     2.6      0.6             GIDAL     81 SMK2          E+E-              2/84*

R46      J/PSI(3100) INTO (P NBAR PI-)/TOT (UNITS 10**-3) (P47)
R46    194     2.16     0.29            PERUZZI   78 SMAG       E+E-,P PI-           4/78
R46B   204     2.04     0.27            PERUZZI   78 SMAG       E+E-,P PI+           4/78
R46     32     1.7      0.7             BESCH     81 BONA          E+E-              1/82
R46B     5     1.6      1.2             BESCH     81 BONA          E+E-              1/82
R46S  1288    (2.02)   (0.23)           EATON     83 SMK2       E+E-,HADRONS GAM    12/83*
R46S B1191    (1.93)   (0.23)           EATON     83 SMK2       E+E-,HADRONS GAM    12/83*
R46
R46 AVG        2.06     0.19      AVERAGE

R46S     SYSTEMATIC ERROR ADDED LINEARLY BY US.
R46B     FROM ANTI-CHANNEL (PBAR N PI+)

R47      J/PSI(3100) INTO (P PBAR ETA)/TOT (UNITS 10**-3) (P50)
R47    197     2.3      0.4             PERUZZI   78 SMAG       E+E-,P PB 0-2PI      4/78
R47            2.5      1.2             BRANDELIK 79 DASP       E+ E-               12/79
R47S   826    (2.03)   (0.28)           EATON     83 SMK2       E+E-,HADRONS GAM    12/83*
R47S     SYSTEMATIC ERROR ADDED LINEARLY BY US.
R47
R47 AVG        2.32     0.38      AVERAGE

R48      J/PSI(3100) INTO (P PBAR OMEGA)/TOT(UNITS 10**-3)(P51)
R48     77     1.6      0.3             PERUZZI   78 SMAG       E+E-,P PB 1-2PI      4/78
R48S   486    (1.10)   (0.35)           EATON     83 SMK2       E+E-,HADRONS GAM    12/83*
R48S     SYSTEMATIC ERROR ADDED LINEARLY BY US.

R49      J/PSI(3100) INTO (K0S K+- PI-+)/TOTAL
R49    126     0.0026   0.0007          VANNUCCI  77 SMAG          E+E-              1/77

R50      J/PSI(3100) INTO (PHI F)/TOTAL (UNITS 10**-4)     (P36)
R50           (3.7)   OR LESS  CL=0.90  VANNUCCI  77 SMAG          E+E-              1/77

R51      J/PSI(3100) INTO (PHI 2(PI+PI-))/TOTAL              (P32)
R51           (0.0015)OR LESS  CL=0.90  VANNUCCI  77 SMAG          E+E-              1/77

R52      J/PSI(3100) INTO (OMEGA F)/TOTAL                    (P29)
R52     81     0.0019   0.0008          VANNUCCI  77 SMAG          E+E-              1/77
R52     70     0.0040   0.0016          BURMESTER 77 PLUT          E+E-             12/77
R52
R52 AVG        0.00232  0.00084   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)

R53      J/PSI(3100) INTO (OMEGA F PRIME)/TOT(UNTS 10**-4)(P30)
R53           (1.6)   OR LESS  CL=0.90  VANNUCCI  77 SMAG          E+E-              1/77

R54      J/PSI(3100) INTO (PI+ PI- PI0 K+ K-)/TOTAL          (P23)
R54    309     0.012    0.003           VANNUCCI  77 SMAG          E+E-              1/77

R55      J/PSI(3100) INTO (RHO A2)/TOTAL                     (P39)
R55     36     0.0084   0.0045          VANNUCCI  77 SMAG          E+E-              1/77

R56      J/PSI(3100) INTO (OMEGA 2PI+ 2PI-)/TOTAL            (P27)
R56    140     0.0085   0.0034          VANNUCCI  77 SMAG          E+E-              1/77

R57      J/PSI(3100) INTO (XI- ANTIXI-)/TOTAL (10**-3)      (P54)
R57     51     1.4      0.5             PERUZZI   78 SMAG       E+E-,XI-X            4/78
R57 C   71    (3.2)    (0.8)            PERUZZI   78 SMAG       E+E-,L LBAR          4/78
R57S   194    (1.14)   (0.28)           EATON     83 SMK2       E+E-,HADRONS GAM    12/83*

R57S     SYSTEMATIC ERROR ADDED LINEARLY BY US.
R57 C    INCLUDES CHANNEL (XI0 ANTIXI0)

R58      J/PSI(3100) INTO (RHO+- PI-+)/(K*(892)+- K-+)      (P24)/(P40)
R58           (0.26)   (0.09)           PIERRE    76 SMAG          E+E-              4/77

R59      J/PSI(3100) INTO (B+- PI-+)/TOTAL                   (P55)
R59     87     0.0029   0.0007          BURMESTER 77 PLUT          E+E-             12/77

R60      J/PSI(3100) INTO (N NBAR)/TOTAL (UNITS 10**-2)     (P59)
R60            0.18     0.09            BESCH     78 BONA          E+E-              4/78

R61      J/PSI INTO (SIGMA0 SIGMABAR0)/TOT (UNITS 10**-3) (P57)
R61     52     1.3      0.4             PERUZZI   78 SMAG       E+E-,L LBAR          4/78
R61S    90    (1.58)   (0.41)           EATON     83 SMK2       E+E-,HADRONS GAM    12/83*
R61S     SYSTEMATIC ERROR ADDED LINEARLY BY US.

R62      J/PSI INTO (P PBAR ETA PRIME)/TOT (UNITS 10**-3) (P56)
R62     19     1.8      0.6             PERUZZI   78 SMAG       E+E-,P PB 1-2PI      4/78
R62S    19    (0.68)   (0.40)           EATON     83 SMK2       E+E-,HADRONS GAM    12/83*
R62S     SYSTEMATIC ERROR ADDED LINEARLY BY US.

R63      J/PSI INTO (N NBAR PI+ PI-)/TOTAL (UNITS 10**-3) (P60)
R63      5     3.8      3.6             BESCH     81 BONA          E+E-              1/82

R64      J/PSI INTO (SIGMA- SIGMABAR-)/TOT (UNITS 10**-3) (P61)
R64      3     2.4      2.6             BESCH     81 BONA          E+E-              1/82

R65      J/PSI(3100) INTO (K+ K- PI0)/TOTAL (UNITS 10**-4)(P20)
R65     25    (9.2)    (2.0)            FRANKLIN  83 SMK2       E+E-,HADRONS         9/83*

R66      J/PSI(3100) INTO (PI+PI-PI0)/TOTAL                  (P12)
R66    168    (0.015)  (0.002)          FRANKLIN  83 SMK2       E+E-,HADRONS         9/83*
R66           (0.0149) (0.0022)         EINSWEILE 83 SMK3       E+E-,HADRONS        12/83*

R67      J/PSI(3100) INTO N*(1232)++N*(1232)--/TOT *10**-3(P62)
R67S   233    (1.10)   (0.37)           EATON     83 SMK2       E+E-,HADRONS GAM     9/83*
R67S     SYSTEMATIC ERROR ADDED LINEARLY BY US.
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Mesons

Data Card Listings

J/ψ(3100)

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R68     J/PSI(3100) INTO Y*(1385)- Y*(1385)+ /TOT *10**-3(P63)
R68S     56   (0.86)   (0.40)            EATON     83 SMK2    E+E-,HADRONS GAM  9/83*
R68S     SYSTEMATIC ERROR ADDED LINEARLY BY US.

R69     J/PSI(3100) INTO Y*(1385)+ Y*(1385)- /TOT *10**-3(P64)
R69S     68   (1.03)   (0.49)            EATON     83 SMK2    E+E-,HADRONS GAM  9/83*
R69S     SYSTEMATIC ERROR ADDED LINEARLY BY US.

R70     J/PSI(3100) INTO Y*(1385)- SIGMABAR+ /TOT *10**-3(P65)
R70S     26   (0.29)   (0.21)            EATON     83 SMK2    E+E-,HADRONS GAM  9/83*
R70S     SYSTEMATIC ERROR ADDED LINEARLY BY US.

R71     J/PSI(3100) INTO Y*(1385)+ SIGMABAR+ /TOT *10**-3(P66)
R71S     28   (0.31)   (0.22)            EATON     83 SMK2    E+E-,HADRONS GAM  9/83*
R71S     SYSTEMATIC ERROR ADDED LINEARLY BY US.

R72     J/PSI(3100) INTO PBAR N*(1440-1535)+ /TOT *10**-3(P67)
R72S    189   (0.93)   (0.47)            EATON     83 SMK2    E+E-,HADRONS GAM  9/83*
R72S     SYSTEMATIC ERROR ADDED LINEARLY BY US.

R73     J/PSI(3100) INTO N*(1232)++ PBAR PI- /TOT *10**-3(P68)
R73S    332   (1.58)   (0.63)            EATON     83 SMK2    E+E-,HADRONS GAM  9/83*
R73S     SYSTEMATIC ERROR ADDED LINEARLY BY US.

R74     J/PSI(3100) INTO LAMBDA SIGMABAR+ PI-/TOT *10**-3(P69)
R74S    135   (1.53)   (0.55)            EATON     83 SMK2    E+E-,HADRONS GAM  9/83*
R74S     SYSTEMATIC ERROR ADDED LINEARLY BY US.

R75     J/PSI(3100) INTO LAMBDA SIGMABAR- PI+/TOT *10**-3(P70)
R75S    118   (1.38)   (0.56)            EATON     83 SMK2    E+E-,HADRONS GAM  9/83*
R75S     SYSTEMATIC ERROR ADDED LINEARLY BY US.

R76     J/PSI(3100) INTO P PBAR RHO          /TOT *10**-3(P91)
R76S     38   (0.31) OR LESS  CL=.90   EATON     83 SMK2    E+E-,HADRONS GAM  9/83*
R76S     SYSTEMATIC ERROR ADDED LINEARLY BY US.

R77     J/PSI(3100) INTO P K- ANTILAMBDA     /TOT *10**-3(P92)
R77S    307   (0.89)   (0.21)            EATON     83 SMK2    E+E-,HADRONS GAM  9/83*
R77S     SYSTEMATIC ERROR ADDED LINEARLY BY US.

R78     J/PSI(3100) INTO P K- ANTISIGMA0     /TOT *10**-3(P93)
R78S     90   (0.29)   (0.11)            EATON     83 SMK2    E+E-,HADRONS GAM  9/83*
R78S     SYSTEMATIC ERROR ADDED LINEARLY BY US.

R79     J/PSI(3100) INTO P K- Y*(1385)0      /TOT *10**-3(P94)
R79S     89   (0.51)   (0.44)            EATON     83 SMK2    E+E-,HADRONS GAM  9/83*
R79S     SYSTEMATIC ERROR ADDED LINEARLY BY US.


R       RADIATIVE DECAYS
R       ----------------

R71     J/PSI(3100) INTO (2 GAMMA)/TOTAL  (UNITS 10**-3) (P70)
R71           (0.5)  OR LESS  CL=0.90  BARTEL    77 CNTR         E+E-         4/77

R72     J/PSI(3100) INTO (PI0 GAMMA)/TOTAL (UNITS 10**-3)(P72)
R72      10    0.073    0.047            BRANDELIK 79 DASP    E+ E-          12/79

R73     J/PSI(3100) INTO (ETA GAMMA)/TOTAL (UNITS 10**-3)(P73)
R73      21    1.3      0.4              BARTEL    77 CNTR    E+E-,3 GAMMA     1/77
R73            0.82     0.10             BRANDELIK 79 DASP    E+ E-           12/79
R73E           0.88     0.19             KONIGSMAN 82 CBAL    E+ E-,3 GAMMA    4/82
R73E     SYSTEMATIC ERROR ADDED LINEARLY BY US.
R73          . . . . . . . . . .
R73 AVG        0.855    0.086   AVERAGE

R74     J/PSI(3100) INTO (ETA PRIME GAM)/TOT(UNTS 10**-3)(P74)
R74           (3.2)  OR LESS  CL=.90   MURTAS    76 FRAG         E+E-         4/77
R74      57   (2.4)    (0.7)             BARTEL 1  76 CNTR    E+E-,2 GAMMA RHO  1/77
R74       6    2.9      1.1              BRANDELIK 79 DASP    E+E-,3 GAMMA     12/79
R74B           3.8      1.3              SCHARRE   79 SMAG    E+E-, GAMMA X    12/79
R74            3.4      0.7              SCHARRE   79 SMAG    E+E-,2 PI 2GAMMA 12/79
R74E           4.1      0.9              KONIGSMAN 82 CBAL    E+ E-             4/82
R74E          (4.6)    (1.0)             EINSWEILE 83 SMK3    E+E-,HADRONS GAM 12/83*
R74E          (4.7)    (1.2)             EINSWEILE 83 SMK3    E+E-,HADRONS GAM 12/83*
R74          . . . . . . . . . .
R74 AVG        3.55     0.46    AVERAGE

R74B     FROM THE INCLUSIVE GAMMA DECAY SPECTRUM
R74E     SYSTEMATIC ERROR ADDED LINEARLY BY US.


R78     J/PSI(3100) INTO (3 GAMMA)/TOTAL  (UNITS 10**-3) (P71)
R78           (0.055)OR LESS  CL=0.90  PARTRIDGE 80 CNTR    E+E-,3 GAMMA      12/79

R80     J/PSI(3100) INTO (GAMMA + 2 OR MORE NEUTRALS)/TOTAL   (UNITS 10**-3)
R80            7.0      2.0              BARTEL    77 CNTR         E+E-         1/77

R81     J/PSI(3100) INTO (F GAMMA)/TOTAL (UNITS 10**-3)  (P76)
R81      35    2.0      0.7              ALEXANDER 78 PLUT  0 E+E-              4/78
R81   T  30    1.2      0.6              BRANDELIK 78 DASP    E+E-,PI+PI-GAMMA  4/78
R81A    178    1.48     0.55             EDWARDS1  82 CBAL    E+E-,2 PI0 GAMMA  2/82
R81A          (1.7)    (0.3)             EINSWEILE 83 SMK3    E+E-,HADRONS GAM 12/83*
R81          . . . . . . . . . .
R81 AVG        1.51     0.35    AVERAGE

R81   T  RE-STATED BY US TO TAKE ACCOUNT OF SPREAD OF E1,M2,E3 TRANSITIONS.
R81A     SYSTEMATIC ERROR ADDED LINEARLY BY US

R82     J/PSI(3100) INTO (F PRIME GAM)/TOT (UNITS 10**-3)(P77)
R82       3   (0.23) OR LESS  CL=0.90  ALEXANDE2 78 PLUT    E+E-,K+K- GAMMA   4/78
R82   S   4   (0.34) OR LESS  CL=0.90  BRANDELIK 79 DASP    E+E-,PI+PI-GAMMA 12/79
R82           (0.16)   (0.065)           EINSWEILE 83 SMK3    E+E-,HADRONS GAM 12/83*
R82   S  ASSUMING ISOTROPIC PRODUCTION AND DECAY OF THE F PRIME,AND ISOSPIN.

R84     J/PSI(3100) INTO (P PBAR GAM)/TOT (UNITS 10**-3) (P80)
R84           (0.11) OR LESS  CL=0.90  PERUZZI   78 SMAG    E+E-,P PB SHOWER  4/78
R84S     49   (0.38)   (0.14)            EATON     83 SMK2    E+E-,HADRONS GAM 12/83*
R84S     SYSTEMATIC ERROR ADDED LINEARLY BY US.

R85     J/PSI(3100) INTO (D(1285) GAM)/TOTAL             (P78)
R85   D       (0.006)OR LESS  CL=.90   SCHARRE   80 SMK2    E+E-              2/81
R85   D  USING BR(D INTO K KBAR PI)=0.12

R86     J/PSI(3100) INTO (IOTA(1440) GAM)/TOTAL          (P79)
R86C B         0.0043   0.0017           SCHARRE   80 SMK2    E+E-              2/81
R86S B         0.0040   0.0017           EDWARDS1  83 CBAL    J/PSI,ETA GAM    12/83*
R86S B        (0.0053) (0.0025)          EINSWEILE 83 SMK3    E+E-,HADRONS GAM 12/83*
R86          . . . . . . . . . .
R86 AVG        0.0042   0.0012  AVERAGE

R86   B  INCLUDES UNKNOWN BRANCHING FRACTION IOTA(1440) INTO K KBAR PI.
R86C     CORRECTED FOR SPIN-ZERO HYPOTHESIS FOR IOTA(1440).
R86S     SYSTEMATIC ERROR ADDED LINEARLY BY US.
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R87     J/PSI(3100) INTO (THETA(1690) GAM)/TOT (10**-4)  (P81)
R87 A         (3.8)    (1.6)             EDWARDS2  82 CBAL    E+E-,ETA ETA GAM  2/84*
R87SB         (4.8)    (1.6)             EINSWEILE 83 SMK3    E+E-,K+K- GAMMA  12/83*
R87SB         (6.0)    (3.4)             FRANKLI2  83 SMK2    E+E-,K+K- GAMMA   2/84*
R87 A    INCLUDES UNKNOWN BRANCHING FRACTION TO ETA ETA.
R87 B    INCLUDES UNKNOWN BRANCHING FRACTION TO K+K-.
R87S     SYSTEMATIC ERROR ADDED LINEARLY BY US.

R88     J/PSI(3100) INTO (XI(2220) GAM)/TOT UNITS 10**-4 (P82)
R88SB         (1.6)    (0.72)            EINSWEILE 83 SMK3    E+E-,HADRONS GAM 12/83*
R88 B    INCLUDES UNKNOWN BRANCHING FRACTION INTO K KBAR.
R88S     SYSTEMATIC ERROR ADDED LINEARLY BY US.

R89     J/PSI(3100) INTO P PBAR PI+ PI- GAMMA/TOT *10**-3(P83)
R89S     12    (.79) OR LESS  CL=.90   EATON     83 SMK2                      12/83*
R89S     SYSTEMATIC ERROR ADDED LINEARLY BY US.

R90     J/PSI(3100) INTO RHO0 RHO0 GAM/TOT (UNITS 10**-3)(P84)
R90S M         1.25     0.75             BURKE     82 SMK2    E+E-,HADRONS GAM 12/83*
R90  M   RHO RHO MASS LESS THAN 2.0 GEV.
R90S     SYSTEMATIC ERROR ADDED LINEARLY BY US.

R91     J/PSI(3100) INTO 2PI+ 2PI- GAM/TOT (UNITS 10**-3)(P85)
R91S M         4.85     1.65             BURKE     82 SMK2    E+E-,HADRONS GAM 12/83*
R91  M   4PI MASS LESS THAN 2.5 GEV.
R91S     SYSTEMATIC ERROR ADDED LINEARLY BY US.

R92     J/PSI(3100) INTO ETA PI+ PI-GAM/TOT(UNITS 10**-3)(P86)
R92S M         3.9      0.9              EDWARDS2  83 CBAL    J/PSI,HADR GAM   12/83*
R92  M   BROAD ENHANCEMENT AT 1700 MEV.
R92S     SYSTEMATIC ERROR ADDED LINEARLY BY US.

R93     J/PSI(3100) INTO ETA 2PI0 GAM/TOT  (UNITS 10**-3)(P87)
R93S M         2.6      1.2              EDWARDS2  83 CBAL    J/PSI,HADR GAM   12/83*
R93  M   BROAD ENHANCEMENT AT 1700 MEV.
R93S     SYSTEMATIC ERROR ADDED LINEARLY BY US.

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                  70  J/PSI(3100)    G(I)*G(E+E-)/G(TOTAL)  (KEV)

         THIS COMBINATION OF A PARTIAL WIDTH WITH THE PARTIAL WIDTH
         INTO E+E- AND WITH THE TOTAL WIDTH IS OBTAINED FROM THE INTEGRATED
         CROSS-SECTION INTO CHANNEL(I) IN THE E+E- ANNIHILATION.

G1      G(E+E-)*G(E+E-)/G(TOTAL)
G1 S           .32      .07              BALDINI1  75 FRAG         E+E-         1/76
G1             .34      .14              BEMPORAD  75 FRAB         E+E-         1/76
G1 S           .34      .09              ESPOSITO  75 FRAM         E+E-         1/76
G1 S           .36      .10              FORD      75 SPEC         E+E-
G1             0.35     0.02             BRANDELIK 79 DASP         E+E-        12/79
G1           . . . . . . . . . .
G1  AVG        0.348    0.018   AVERAGE

G2      G(MU+MU-)*G(E+E-)/G(TOTAL)
G2             .31      .09              BEMPORAD  75 FRAB         E+E-         1/76
G2             .51      .09              DASP1     75 DASP         E+E-         1/76
G2 S           .38      .05              ESPOSITO  75 FRAM         E+E-         1/76
G2 S           .46      .10              LIBERMAN  75 SPEC         E+E-         1/76
G2           . . . . . . . . . .
G2  AVG        0.401    0.037   AVERAGE

G3      G(HADRONIC)*G(E+E-)/G(TOTAL)
G3 S           4.       .8               BALDINI1  75 FRAG         E+E-         1/76
G3 S           3.9      .8               ESPOSITO  75 FRAM         E+E-         1/76
G3           . . . . . . . . . .
G3  AVG        3.95     0.57    AVERAGE

G   S    DATA REDUNDANT WITH BRANCHING RATIOS OR PARTIAL WIDTHS ABOVE

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REFERENCES FOR J/PSI(3100)


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CHRISTEN 70 PRL 25 1523        CHRISTENSON,HICKS,LEDERMAN+ (COLU+BNL+CERN)

ABRAMS   74 PRL 33 1453        +BRIGGS,AUGUSTIN,BOYARSKI+        (LBL+SLAC)
ASH      74 NCL 11 705         +ZORN,BARTOLI+    (FRAS+UMD+NAPL+PADO+ROMA)
AUBERT   74 PRL 33 1404        +BECKER,BIGGS,BURGER,CHEN,EVERHART(MIT+BNL)
AUGUSTIN 74 PRL 33 1406        +BOYARSKI,ABRAMS,BRIGGS+          (SLAC+LBL)
BACCI    74 PRL 33 1408        +BARTOLI,BARBARINO,BARBIELLINI+  (FRASCATI)
    ALSO 74 PRL 33 1649        FOR ERRATA
BALDINI- 74 NCL 11 711         BALDINI-CELIO,BACCI+         (FRASCATI+ROMA)
BARBIELL 74 NCL 11 718         BARBIELLINI,BEMPORAD+ (FRAS+NAPL+PISA+ROMA)
BRAUNSCH 74 PL 53B 393         BRAUNSCHWEIG+    (AACHEN+HAMB+MUNICH+TOKYO)

ANDREWS  75 PRL 34 231         +HARVEY,LOBKOWICZ,MAY,NORDBERG  (ROCH+CORN)
AUBERT   75 NP B 89 1          +BECKER,BIGGS,BURGER,GLENN,+       (MIT+BNL)
BACCI    75 NCL 12 269         +PENSO,STELLA,BALDINI-CELIO,+   (ROMA+FRAS)
BALDINI1 75 PL 58B 471         BALDINI-CELIO,BOZZO,CAPON,BACCI+(FRAS+ROMA)
BALDINI2 75 PL 58B 475         BALDINI-CELIO,CAPON,DEL FABBRO+ (FRAS+ROMA)
BEMPORAD 75 STANFORD SYMP.113 C.BEMPORAD                 (PISA+FRASCATI)
BLANAR   75 PRL 35 346         +BOYER,FAISSLER,GARELICK,GETTNER,+   (NEAS)
BOYARSKI 75 PRL 34 1357        +BREIDENBACH,BULOS,FELDMAN,+     (SLAC+LBL)JPC
BRAUNSCH 75 PL 53B 491         BRAUNSCHWEIG+    (AACHEN+HAMB+MUNICH+TOKYO)
BUSSER   75 PL 56 B 482        +BLUMENFELD,BANNER,+  (CERN+COLU+ROCK+SACL)
CAMERINI 75 PRL 35 483         +LEARNED,PREPOST,ASH,ANDERSON,+ (WISC+SLAC)
CRIEGEE  75 PL 53B 489         +DEHNE,FRANKE,HORLITZ,KRECHLOCK+     (DESY)
DAKIN    75 PL 56 B 405        +KREISLER,BOLON,HEILE+      (MASA+MIT+SLAC)
DASP1    75 PL 56B 491         BRAUNSCHWEIG,KONIGS,+ (AACH+DESY+MPIM+TOKY)
DASP2    75 PL 57B 297         BRAUNSCHWEIG,KONIGS,+ (AACH+DESY+MPIM+TOKY)
ESPOSITO 75 NCL 14 73          +BARTOLI,BISELLO,+    (FRAS+NAPL+PADO+ROMA)
FORD     75 PRL 34 604         +BERON,HILGER,HOFSTADTER+        (SLAC+PENN)
GITTELMA 75 PRL 35 1616        GITTELMAN+HANSON+LARSON+LOH+          (CORN)
GRECO    75 PL 56B 367         +PANCHERI-SRIVASTAVA,SRIVASTAVA       (FRAS)
HEINTZE  75 STANFORD SYMP.97   J.HEINTZE                       (HEIDELBERG)
JACKSON  75 NIM 128 13         J.D.JACKSON,D.SCHARRE                  (LBL)
KNAPP1   75 PRL 34 1040        +LEE,BRONSTEIN+   (COLU+HAWA+CORN+ILL+FNAL)
KNAPP2   75 PRL 34 1044        +LEE,BRONSTEIN+   (COLU+HAWA+CORN+ILL+FNAL)
LIBERMAN 75 STANFORD SYMP.55   A.D.LIBERMAN                      (STANFORD)
MARTIN   75 PRL 34 288         +BOLON,DAKIN,FELDMAN,HANSON+(MIT+MASA+SLAC)
PREPOST  75 STANFORD SYMP.241 R.PREPOST                         (WISCONSIN)
SIMPSON  75 PRL 35 699         +BERON,FORD,HILGER,HOFSTADTER,+ (STAN+PENN)
WIIK     75 STANFORD SYMP.69   B.H.WIIK                              (DESY)
YENNIE   75 PRL 34 239         D.R.YENNIE                         (CORNELL)

ANTIPOV  76 TBILISI CONF.N 8   +BESSUBOV,BUDANOV,BUSHNIN,DENISOV,+  (SERP)
BACCI    76  LNF-76/60(P)      +BALDINI-CELIO,CAPON+      (FRAS+ROMA+GENO)
BARTEL 1 76 PL 64 B 483        +DUINKER,OLSSON,STEFFEN,HEINTZE+(DESY+HEID)
BRAUNSCH 76 PL 63 B 487        BRAUNSCHWEIG,+   (AACH+DESY+HAMB+MPIM+TOKY)
BUSSER   76 NP B 113 189       +BLUMENFELD,BANNER,+  (CERN+COLU+ROCK+SACL)
JEAN-MAR 76 PRL 36 291         +ABRAMS,BOYARSKI,BREIDENBACH,+   (SLAC+LBL)IG
MURTAS   76 TBLISI CONF. N60   G.P.MURTAS                            (FRAS)
PIERRE   76 TBILISI CONF. N46 F.PIERRE                          (SLAC+LBL)
SNYDER   76 PRL 36 1415        +HOM,LEDERMAN,APPEL,KAPLAN+(COLU+FNAL+STON)
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BARTEL	77	PL 66 B 489	+DUINKER,OLSSON,HEINTZE,+	(DESY+HEID)
BIDDICK	77	PRL 38 1324	+BURNETT+	(UCSD+UMD+PAVI+PRIN+SLAC+STAN)
BURMESTE	77	PL 72 B 135	BURMESTER,CRIEGEE,+	(DESY+HAMB+SIEG+WUPP)
CORDEN	77	PL 68 B 96	+DOWELL,+	(BIRM+CERN+MPIM+NEUC+EPOL+RHEL)
FELDMAN	77	PL 33 C 285	+PERL	(LBL+SLAC)
VANNUCCI	77	PR D 15 1814	+ABRAMS,ALAM,BOYARSKI,+	(SLAC+LBL)
YAMADA	77	HAMB. CONF. P. 69	YAMADA	(DESY+TOKY)
ALEXANDE	78	PL 72 B 493	ALEXANDER,CRIEGEE,+	(DESY+HAMB+SIEG+WUPP)
BESCH	78	PL 78 B 347	+EISERMANN,KOWALSKI,V EYSS+	(BONN+DESY+MANZ)
BRANDELI	78	PL 74 B 292	BRANDELIK,CORDS+	(AACH+DESY+HAMB+MPIM+TOKY)
PERUZZI	78	PR D 17 2901	+PICCOLO,ALAM,BOYARSKI,GOLDHABER+	(SLAC+LBL)
BRANDELI	79	ZPHY C 1 233	BRANDELIK,CORDS,+	(AACH+DESY+HAMB+MPIM+TOKY)
KIRK	79	PRL 42 619	+GOODMAN,ALVERSON,+	(FNAL+HARV+ILL+OXF+TUFT)
LEMOIGNE	79	FERMILAB CONF.524	+ABOLINS,BARATE,+	(SACL+LOIC+SHMP+IND)
SCHARRE	79	SLAC-PUB-2321	D.L. SCHARRE	(SLAC+LBL)
ALSO	79	LBL 9502	ABRAMS,ALAM,BLOCKER,BOYARSKI,+	(SLAC+LBL)
PARTRIDG	80	PRL 44 712	PARTRIDGE,PECK,+	(CIT+HARV+PRIN+SLAC+STAN)
SCHARRE	80	PL 97 B 329	+TRILLING,ABRAMS,ALAM,BLOCKER+	(SLAC+LBL)
ZHOLENTZ	80	PL 96 B 214	+KURDADZE,LELCHUK,MISHNEV,NIKITIN+	(NOVO)
ALSO	81	YAD.PHYS. 34 1471	ZHOLENTZ ET AL.	(NOVO)
BESCH	81	ZPHY C 8 1	+EISERMANN,LOHR,KOWALSKI,+	(BONN+DESY+MANZ)
GIDAL	81	PL 107 B 153	+GOLDHABER,GUY,MILLIKAN,ABRAMS+	(SLAC+LBL)
BURKE	82	PRL 49 632	+TRILLING,ABRAMS,ALAM,BLOCKER+	(SLAC+LBL)
EDWARDS1	82	PR D 25 3065	+PARTRIDGE,PECK,+	(CIT+HARV+PRIN+STAN+SLAC)
EDWARDS2	82	PRL 48 458	+PARTRIDGE,PECK,+	(CIT+HARV+PRIN+STAN+SLAC)
KONIGSMA	82	MORIOND CONF.	KONIGSMANN,+	(STAN+CIT+HARV+PRIN+SLAC)
LEMOIGNE	82	PL 113 B 509	+BARATE,ASTBURY,MCEWEN+	(SACL+LOIC+SHMP+IND)
BARATE	83	PL 121 B 449	+BAREYRE,ASTBURY,MCEWEN	(SACL+LOIC+SHMP+IND)
EATON	83	SLAC-PUB-3122	+GOLDHABER,ABRAMS,ALAM,BOYARSKI+	(LBL+SLAC)
EDWARDS1	83	PRL 49 259	+PARTRIDGE,PECK+	(CIT+HARV+PRIN+STAN+SLAC)
EDWARDS2	83	PRL 51 859	+PARTRIDGE,PECK+	(CIT+HARV+PRIN+STAN+SLAC)
EINSWEIL	83	BRIGHTON CONF.	K.F.EINSWEILER+MARKIII COLLABORATION	(SLAC)
FRANKLIN	83	SLAC-PUB-3092	+FRANKLIN,FELDMAN,ABRAMS,ALAM+	(LBL+SLAC)
FRANKLI2	83	SLAC-254 THESIS	M.E.B.FRANKLIN	(STAN)

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$\chi(3415)$

56 CHI(3415,JPG=0++) I=0

OBSERVED IN THE RADIATIVE DECAY OF PSI(3685) INTO CHI(3415) GAMMA. THEREFORE C=+. THE OBSERVED DECAY INTO PI+ PI- OR K+ K- IMPLIES G=+, JP=0+,2+,... . THE ANGULAR DISTRIBUTION IS CONSISTENT WITH J=0. JP ABNORMAL EXCLUDED BY PI+ PI- AND K+ K- DECAYS. JP=0+ PREFERRED (FELDMAN 77) .

56 CHI(3415) MASS (MEV)

M		2(3407.0)	(8.0)	WIIK	75	DASP	E+E-,J/PSI 2 GAM	1/77
M	D	3415.0	9.0	BIDDICK	77	CNTR	E+E-,MONOCHR.GAM	3/77
M	D	3422.0	10.0	BARTEL	78	CNTR	E+E-,J/PSI 2 GAM	4/78
M	D M	3416.0	4.0	TANENBAUM	78	SMAG	E+ E-	12/78
M	D E	3414.8	1.1	HIMEL	79	SMK2	E+E-,HADRONS	3/82
M		. . . . .	. . . .					
M	AVG	3415.0	1.0	AVERAGE				

M D MASS VALUE SHIFTED BY US BY AMOUNT APPROPRIATE FOR
M D PSI(3685) MASS=3686 AND PSI(3100) MASS=3097.
M E SYSTEMATIC ERROR ADDED LINEARLY BY US
M M FROM A SIMULTANEOUS FIT TO RADIATIVE AND HADRONIC DECAY CHANNELS
M M SYSTEMATIC ERROR ADDED LINEARLY BY US

56 CHI(3415) PARTIAL DECAY MODES

		DECAY MASSES
P1	CHI(3415) INTO PI+ PI-	140+ 140
P2	CHI(3415) INTO K+ K-	494+ 494
P3	CHI(3415) INTO 2(PI+ PI-)	140+ 140+ 140+ 140
P4	CHI(3415) INTO 3(PI+ PI-)	
P5	CHI(3415) INTO PI+ PI- K+ K-	140+ 140+ 494+ 494
P6	CHI(3415) INTO J/PSI(3100) GAMMA	3097+ 0
P7	CHI(3415) INTO 2 GAMMA	0+ 0
P8	CHI(3415) INTO PI+ PI- P PBAR	140+ 140+ 938+ 938
P9	CHI(3415) INTO RHO0 PI+ PI-	769+ 140+ 140
P10	CHI(3415) INTO K*(892)0 K+/- PI-/+	892+ 494+ 140
P11	CHI(3415) INTO P PBAR	938+ 938

56 CHI(3415) BRANCHING RATIOS

R1	**CHI(3415) INTO (2 GAMMA)/TOTAL**					**(P7)**	
R1 T	(0.0017)OR LESS	CL=0.90	YAMADA	77	DASP	E+ E-,3 GAMMA	12/77
R2	**CHI(3415) INTO 2(PI+ PI-)/TOTAL**					**(P3)**	
R2 T	0.043	0.009	TANENBAUM	78	SMAG	PSI(3685)TO GAM CHI	12/78
R3	**CHI(3415) INTO (PI+ PI- K+ K-)/TOTAL**					**(P5)**	
R3 T	0.034	0.009	TANENBAUM	78	SMAG	PSI(3685)TO GAM CHI	12/78
R4	**CHI(3415) INTO 3(PI+ PI-)/TOTAL**					**(P4)**	
R4 T	0.017	0.006	TANENBAUM	78	SMAG	PSI(3685)TO GAM CHI	12/77
R5	**CHI(3415) INTO (PI+ PI-)/TOTAL**					**(P1)**	
R5 T	0.009	0.003	TANENBAUM	78	SMAG	PSI(3685)TO GAM CHI	12/77
R5 T	0.008	0.003	BRANDEL2	79	DASP	PSI(3685)TO GAM CHI	12/79
R5	. . . . .	. . . .					
R5 AVG	0.0085	0.0021	AVERAGE				
R6	**CHI(3415) INTO (K+ K-)/TOTAL**					**(P2)**	
R6 T	0.01	0.004	TANENBAUM	78	SMAG	PSI(3685)TO GAM CHI	12/77
R6 T	0.007	0.003	BRANDEL2	79	DASP	PSI(3685)TO GAM CHI	12/79
R6	. . . . .	. . . .					
R6 AVG	0.0081	0.0024	AVERAGE				
R7	**CHI(3415) INTO (PI+ PI- P PBAR)/TOTAL**					**(P8)**	
R7 T	0.006	0.002	TANENBAUM	78	SMAG	PSI(3685)TO GAM CHI	12/78
R8	**CHI(3415) INTO (J/PSI(3100) GAMMA)/TOTAL**					**(P6)**	
R8 T	0.024	0.024	TANENBAUM	78	SMAG	PSI(3685)TO GAM CHI	12/77
R8 T	0.017	0.011	BARTEL	78	CNTR	PSI(3685)TO GAM CHI	4/78
R8 T	0.037	0.024	BRANDEL2	79	DASP	PSI(3685)TO GAM CHI	12/79
R8 T	(0.068)OR LESS	CL=0.90	HIMEL	80	SMK2	PSI(3685)TO GAM CHI	9/81
R8 T S 17	0.0072	0.0029	OREGLIA	82	CBAL	PSI(3685)TO GAM CHI	2/82
R8	. . . . .	. . . .					
R8 AVG	0.0084	0.0028	AVERAGE				
R9	**CHI(3415) INTO (RHO0 PI+ PI-)/TOTAL**					**(P9)**	
R9 T	0.017	0.006	TANENBAUM	78	SMAG	PSI(3685)TO GAM CHI	12/78
R10	**CHI(3415) INTO (K*(892)0 K+ - PI- +)/TOTAL**					**(P10)**	
R10T	0.014	0.005	TANENBAUM	78	SMAG	PSI(3685)TO GAM CHI	12/78
R11	**CHI(3415) INTO (P PBAR)/TOTAL (UNITS 10**-2)**					**(P11)**	
R11T	(0.11) OR LESS	CL=0.90	BRANDEL2	79	DASP	PSI(3685)TO GAM CHI	3/82

R S SYSTEMATIC ERROR ADDED LINEARLY BY US.
R T CALCULATED USING PSI(3685) TO (GAMMA CHI(3415))/TOTAL=0.082 3/82
R T THE ERRORS DO NOT CONTAIN THE UNCERTAINTY IN THE PSI(3685) DECAY.

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REFERENCES FOR CHI(3415)

FELDMAN	75	PRL 35 821	+JEAN-MARIE,SADOULET,VANNUCCI,+	(LBL+SLAC)
ALSO	75	PRL 35 1189	(ERRATA)	
TANENBAU	75	PRL 35 1323	TANENBAUM,WHITAKER,ABRAMS,+	(LBL+SLAC)
WIIK	75	STANFORD SYMP.69	B.H.WIIK	(DESY)
BIDDICK	77	PRL 38 1324	+BURNETT+	(UCSD+UMD+PAVI+PRIN+SLAC+STAN)
FELDMAN	77	PL 33 C 285	+PERL	(LBL+SLAC)
YAMADA	77	HAMB. CONF. P. 69	YAMADA	(DESY+TOKY)
BARTEL	78	PL 79 B 492	DITTMANN,DUINKER,OLSSON,O?NEILL+	(DESY+HEID)
TANENBAU	78	PR D 17 1731	TANENBAUM,ALAM,BOYARSKI,+	(SLAC+LBL)
ALSO	82	PRIVATE COMM.	G.H.TRILLING	(LBL+UCB)
BRANDEL1	79	ZPHY C 1 233	BRANDELIK,CORDS,+	(AACH+DESY+HAMB+MPIM+TOKY)
BRANDEL2	79	NP B 160 426	BRANDELIK,CORDS,+	(AACH+DESY+HAMB+MPIM+TOKY)
HIMEL	79	THESIS SLAC-223	T.M.HIMEL	(SLAC)
ALSO	82	PRIVATE COMM.	G.H.TRILLING	(LBL+UCB)
KIRK	79	PRL 42 619	+GOODMAN,ALVERSON,+	(FNAL+HARV+ILL+OXF+TUFT)
HIMEL	80	PRL 44 920	+ABRAMS,ALAM,BLOCKER,+	(LBL+SLAC)
OREGLIA	82	PR D 25 2259	+PARTRIDGE,BLOOM,+	(SLAC+CIT+HARV+PRIN+STAN)

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$\chi(3510)$

55 CHI(3510,JPG=1++) I=0

FORMERLY CALLED PC.
OBSERVED IN THE RADIATIVE SEQUENTIAL DECAY OF THE PSI(3685) INTO CHI(3510) GAMMA, CHI(3510) INTO J/PSI(3100) GAMMA. THEREFORE, C=+.
THE LACK OF DECAYS INTO PI+ PI- OR K+K- IS SUGGESTIVE OF JP = ABNORMAL. THE DECAYS INTO 4PI AND 6PI IMPLY G=+, THUS I=0. J=0,2 EXCLUDED BY ANGULAR DISTRIBUTION IN THE (GAMMA J/PSI) DECAY. JP=1+ PREFERRED (FELDMAN 77, OREGLIA 82)

55 CHI(3510) MASS (MEV)

M		40	(3500.)	(10.)	TANENBAUM	75	SMAG	HADRONS GAM	12/77
M		7	(3507.0)	(7.0)	WIIK	75	DASP	E+E-,J/PSI 2 GAM	1/77
M			(3510.0)	(20.0)	BARTEL	76	CNTR	E+E-,J/PSI 2 GAM	1/77
M	D	367	3513.0	7.0	BIDDICK	77	CNTR	E+E-,MONOCHR.GAM	3/77
M	D		3507.0	3.0	BARTEL	78	CNTR	E+E-,J/PSI 2 GAM	4/78
M	D M		3505.0	5.0	TANENBAUM	78	SMAG	E+ E-	12/78
M		21	3509.0	11.0	BRANDEL2	79	DASP	E+E-,J/PSI 2GAM	12/79
M		15	(3520.)		LEMOIGNE	79	GOLI	150 PI-BE,2MU	12/79
M	D F	254	3510.1	1.1	HIMEL	80	SMK2	E+E-,J/PSI 2 GAM	9/81
M	P	91	3507.4	1.7	LEMOIGNE	82	GOLI	190 PI-BE,GAM2MU	3/82
M	E F		3510.4	0.6	OREGLIA	82	CBAL	E+E-,J/PSI 2 GAM	9/83*
M			. . . . .	. . . .					
M	AVG		3509.95	0.55	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)				

M D MASS VALUE SHIFTED BY US BY AMOUNT APPROPRIATE FOR
M D PSI(3685) MASS=3686 AND PSI(3100) MASS=3097
M E ASSUMING PSI(3685) MASS=3686 AND PSI(3100) MASS=3097.
M F SYSTEMATIC ERROR ADDED LINEARLY BY US
M M FROM A SIMULTANEOUS FIT TO RADIATIVE AND HADRONIC DECAY CHANNELS
M M SYSTEMATIC ERROR ADDED LINEARLY BY US
M P J/PSI MASS CONSTRAINED TO 3097.

55 CHI(3510) PARTIAL DECAY MODES

		DECAY MASSES
P1	CHI(3510) INTO J/PSI(3100) GAMMA	3097+ 0
P2	CHI(3510) INTO PI+ PI-	140+ 140
P3	CHI(3510) INTO K+ K-	494+ 494
P4	CHI(3510) INTO GAMMA GAMMA	0+ 0
P5	CHI(3510) INTO 2(PI+ PI-)	140+ 140+ 140+ 140
P6	CHI(3510) INTO 3(PI+ PI-)	
P7	CHI(3510) INTO PI+ PI- K+ K-	140+ 140+ 494+ 494
P8	CHI(3510) INTO PI+ PI- P PBAR	140+ 140+ 938+ 938
P9	CHI(3510) INTO RHO0 PI+ PI-	769+ 140+ 140
P10	CHI(3510) INTO K*(892)0 K+/- PI-/+	892+ 494+ 140
P11	CHI(3510) INTO P PBAR	938+ 938

55 CHI(3510) BRANCHING RATIOS

R1	**CHI(3510) INTO (J/PSI(3100) GAMMA)/TOTAL**					**(P1)**	
R1 T	(0.63)	(0.19)	BIDDICK	77	CNTR	PSI(3685)TO GAM CHI	12/77
R1 T	0.31	0.05	BARTEL	78	CNTR	PSI(3685)TO GAM CHI	4/78
R1 T	0.30	0.10	TANENBAUM	78	SMAG	PSI(3685)TO GAM CHI	12/78
R1 T	0.21	0.05	BRANDEL2	79	DASP	PSI(3685)TO GAM CHI	12/79
R1 T	0.30	0.08	HIMEL	80	SMK2	PSI(3685)TO GAM CHI	9/81
R1 T S 943	0.30	0.06	OREGLIA	82	CBAL	PSI(3685)TO GAM CHI	2/82
R1	. . . . .	. . . .					
R1 AVG	0.276	0.027	AVERAGE				
R2	**CHI(3510) INTO (PI+PI- AND K+K-)/TOTAL**					**(P2+P3)**	
R2 T	(0.0019)OR LESS		FELDMAN	77	SMAG	PSI(3685) TO GAM PC	12/77
R2 T	(0.0041)OR LESS	CL=0.90	BRANDEL2	79	DASP	PSI(3685)TO GAM CHI	12/79
R3	**CHI(3510) INTO (GAMMA GAMMA)/TOTAL**					**(P4)**	
R3 T	(0.0016)OR LESS	CL=0.90	YAMADA	77	DASP	E+ E-,3 GAMMA	12/77
R4	**CHI(3510) INTO 2(PI+ PI-)/TOTAL**					**(P5)**	
R4 T	0.018	0.005	TANENBAUM	78	SMAG	PSI(3685) TO GAM PC	12/78
R5	**CHI(3510) INTO (PI+ PI- K+ K-)/TOTAL**					**(P7)**	
R5 T	0.010	0.004	TANENBAUM	78	SMAG	PSI(3685) TO GAM PC	12/78

Mesons

Data Card Listings

$\chi(3510)$, $\chi(3555)$, $\eta_c(3590)$

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R6      CHI(3510) INTO 3(PI+ PI-)/TOTAL                        (P6)
R6 T          0.024    0.009            TANENBAUM 78 SMAG PSI(3685) TO GAM PC 12/78

R7      CHI(3510) INTO (PI+ PI- P PBAR)/TOTAL                  (P8)
R7 T          0.0015   0.0010           TANENBAUM 78 SMAG PSI(3685) TO GAM PC 12/78

R8      CHI(3510) INTO (RHO0 PI+ PI-)/TOTAL                    (P9)
R8 T          0.0043   0.0038           TANENBAUM 78 SMAG PSI(3685) TO GAM PC 12/78

R9      CHI(3510) INTO (K*(892)0 K+ - PI- +)/TOTAL             (P10)
R9 T          0.0035   0.0023           TANENBAUM 78 SMAG PSI(3685) TO GAM PC 12/78

R11     CHI(3510) INTO (P PBAR)/TOTAL                          (P11)
R11T         (0.0013)OR LESS CL=0.90  BRANDEL2  79 DASP PSI(3685)TO GAM CHI 12/79

R    S  SYSTEMATIC ERROR ADDED LINEARLY BY US.
R  T    ESTIMATED USING PSI(3685) TO (GAMMA PC)/TOTAL=0.080                 3/82
R  T    THE ERRORS DO NOT CONTAIN THE UNCERTAINTY IN THE PSI(3685) DECAY.

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REFERENCES FOR CHI(3510)


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DASP      75 PL 57B 407          BRAUNSCHWEIG,KONIGS,+ (AACH+DESY+MPIM+TOKY)
FELDMAN   75 STANFORD SYMP.39    G.J.FELDMAN                          (SLAC)
HEINTZE   75 STANFORD SYMP.97    J.HEINTZE                      (HEIDELBERG)
SIMPSON   75 PRL 35 699          +BERON,FORD,HILGER,HOFSTADTER,+ (STAN+PENN)
TANENBAU  75 PRL 35 1323         TANENBAUM,WHITAKER,ABRAMS,+      (LBL+SLAC)
WIIK      75 STANFORD SYMP.69    B.H.WIIK                             (DESY)

BARTEL    76 TBILISI CONF.N75    +DUINKER,OLSSON,HEINTZE,+        (DESY+HEID)

BIDDICK   77 PRL 38 1324         +BURNETT+    (UCSD+UMD+PAVI+PRIN+SLAC+STAN)
FELDMAN   77 PL 33 C 285         +PERL                            (LBL+SLAC)
YAMADA    77 HAMB. CONF. P. 69 YAMADA                             (DESY+TOKY)

BARTEL    78 PL 79 B 492         +DITTMANN,DUINKER,OLSSON,ONEILL+(DESY+HEID)
TANENBAU  78 PR D 17 1731        TANENBAUM,ALAM,BOYARSKI,+        (SLAC+LBL)
    ALSO 82  PRIVATE COMM.       G.H.TRILLING                      (LBL+UCB)

BRANDEL1  79 ZPHY C 1 233        BRANDELIK,CORDS,+(AACH+DESY+HAMB+MPIM+TOKY)
BRANDEL2  79 NP B 160 426        BRANDELIK,CORDS,+(AACH+DESY+HAMB+MPIM+TOKY)
KIRK      79 PRL 42 619          +GOODMAN,ALVERSON,+(FNAL+HARV+ILL+OXF+TUFT)
LEMOIGNE  79 FERMILAB CONF.524 +ABOLINS,BARATE,+        (SACL+LOIC+SHMP+IND)

HIMEL     80 PRL 44 920          +ABRAMS,ALAM,BLOCKER,+           (LBL+SLAC)
    ALSO 82  PRIVATE COMM.       G.H.TRILLING                      (LBL+UCB)

LEMOIGNE  82 PL 113 B 509        +BARATE,ASTBURY,MCEWEN+(SACL+LOIC+SHMP+IND)
OREGLIA   82 PR D 25 2259        +PARTRIDGE,BLOOM,+(SLAC+CIT+HARV+PRIN+STAN)
   ALSO  82  PRIVATE COMM.       M. OREGLIA                            (EFI)

BARATE    83 PL 121 B 449        +BAREYRE,ASTBURY,MCEWEN(SACL+LOIC+SHMP+IND)
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$\chi(3555)$

57 CHI(3555,JPG=2++) I=0

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                 OBSERVED IN RADIATIVE DECAY OF PSI(3685) INTO
        CHI(3555) GAMMA. THEREFORE C=+. THE OBSERVED DECAY INTO 4PI
        AND 6PI IMPLY G=+, THUS I=0.
        J=0 IS EXCLUDED BY THE ANGULAR DISTRIBUTION IN THE HADRONIC
        DECAYS. JP ABNORMAL EXCLUDED BY PI+ PI- AND K+ K- DECAYS.
        JP=2+ PREFERRED (FELDMAN 77, OREGLIA 82).

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57 CHI(3555) MASS (MEV)

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M          (3550.0)    (10.0)        TRILLING  76 SMAG   E+E-,HADRONS GAM  1/77
M         4(3543.0)    (10.0)        WHITAKER  76 SMAG   E+E-,J/PSI 2 GAM  1/77
M   D   360 3563.0      7.0          BIDDICK   77 CNTR   E+E-,MONOCHR.GAM  3/77
M   D       3553.0      4.0          BARTEL    78 CNTR   E+E-,J/PSI 2 GAM  4/78
M   D M     3553.0      5.0          TANENBAUM 78 SMAG   E+ E-            12/78
M        15 3551.0     11.0          BRANDEL2  79 DASP   E+E-,J/PSI 2GAM  12/79
M   D F  69 3557.       1.5          HIMEL     80 SMK2   E+E-,J/PSI 2 GAM  9/81
M   P    66 3553.4      2.2          LEMOIGNE  82 GOLI   190 PI-BE,GAM2MU  3/82
M   E F     3555.9      0.7          OREGLIA   82 CBAL   E+E-,J/PSI 2 GAM  9/83*
M           . . . . . . . . . .
M    AVG    3555.82     0.60     AVERAGE

M   D    MASS VALUE SHIFTED BY US BY AMOUNT APPROPRIATE FOR
M   D                PSI(3685) MASS=3686 AND PSI(3100) MASS=3097.
M   E    ASSUMING PSI(3685) MASS=3686 AND PSI(3100) MASS=3097.
M     F  SYSTEMATIC ERROR ADDED LINEARLY BY US.
M     M  FROM A SIMULTANEOUS FIT TO RADIATIVE AND HADRONIC DECAY CHANNELS
M     M              SYSTEMATIC ERROR ADDED LINEARLY BY US
M   P    J/PSI MASS CONSTRAINED TO 3097

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57 CHI(3555) PARTIAL DECAY MODES

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                                                         DECAY MASSES
P1      CHI(3555) INTO PI+ PI-                          140+ 140
P2      CHI(3555) INTO K+ K-                            494+ 494
P3      CHI(3555) INTO 2(PI+ PI-)                       140+ 140+ 140+ 140
P4      CHI(3555) INTO 3(PI+ PI-)
P5      CHI(3555) INTO PI+ PI- K+ K-                    140+ 140+ 494+ 494
P6      CHI(3555) INTO J/PSI(3100) GAMMA               3097+   0
P7      CHI(3555) INTO 2 GAMMA                            0+   0
P8      CHI(3555) INTO PI+ PI- P PBAR                   140+ 140+ 938+ 938
P9      CHI(3555) INTO RHO0 PI+ PI-                     769+ 140+ 140
P10     CHI(3555) INTO K*(892)0 K+/- PI-/+              892+ 494+ 140
P11     CHI(3555) INTO P PBAR                           938+ 938
P12     CHI(3555) INTO J/PSI(3100) PI+ PI- PI0         3097+ 140+ 140+ 135

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57 CHI(3555) BRANCHING RATIOS

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R1      CHI(3555) INTO (2 GAMMA)/TOTAL                     (P7)
R1 T         (0.0006)OR LESS  CL=0.90 YAMADA    77 DASP    E+ E-,3 GAMMA    12/77

R2      CHI(3555) INTO 2(PI+ PI-)/TOTAL                    (P3)
R2 T          0.023    0.005          TANENBAUM 78 SMAG PSI(3685)TO GAM CHI 12/78

R3      CHI(3555) INTO (PI+ PI- K+ K-)/TOTAL               (P5)
R3 T          0.020    0.005          TANENBAUM 78 SMAG PSI(3685)TO GAM CHI 12/78

R4      CHI(3555) INTO 3(PI+ PI-)/TOTAL                    (P4)
R4 T          0.012    0.008          TANENBAUM 78 SMAG PSI(3685)TO GAM CHI 12/78

R5      CHI(3555) INTO (PI+ PI- AND K+ K-)/TOTAL           (P1+P2)
R5 T          0.0026   0.0011         TANENBAUM 78 SMAG PSI(3685)TO GAM CHI 12/78

R6      CHI(3555) INTO (PI+ PI- P PBAR)/TOTAL              (P8)
R6 T          0.0035   0.0014         TANENBAUM 78 SMAG PSI(3685)TO GAM CHI 12/78

R7      CHI(3555) INTO (J/PSI(3100) GAMMA)/TOTAL           (P6)
R7 T         (0.30)   (0.14)          BIDDICK   77 CNTR PSI(3685)TO GAM CHI 12/77
R7 T          0.14     0.03           BARTEL    78 CNTR PSI(3685)TO GAM CHI  4/78
R7 T          0.12     0.14     0.07  SPITZER   78 PLUT PSI(3685)TO GAM CHI 12/78
R7 T          0.14     0.08           TANENBAUM 78 SMAG PSI(3685)TO GAM CHI 12/78
R7 T          0.19     0.05           BRANDEL2  79 DASP PSI(3685)TO GAM CHI 12/79
R7 T          0.15     0.04           HIMEL     80 SMK2 PSI(3685)TO GAM CHI  9/81
R7 T S 479    0.170    0.038          OREGLIA   82 CBAL PSI(3685)TO GAM CHI  2/82
R7            . . . . . . . . .
R7  AVG       0.155    0.018    AVERAGE

R8      CHI(3555) INTO (RHO0 PI+ PI-)/TOTAL                (P9)
R8 T          0.0071   0.0042         TANENBAUM 78 SMAG PSI(3685)TO GAM CHI 12/78

R9      CHI(3555) INTO (K*(892)0 K+ - PI- +)/TOTAL         (P10)
R9 T          0.0050   0.0029         TANENBAUM 78 SMAG PSI(3685)TO GAM CHI 12/78

R10     CHI(3555) INTO (PI+ PI-)/TOTAL (UNITS 10**-3)      (P1)
R10T     4    2.0      1.1            BRANDEL1  79 DASP PSI(3685)TO GAM CHI 12/79

R11     CHI(3555) INTO (K+ K-)/TOTAL (UNITS 10**-3)        (P2)
R11T     2    1.6      1.2            BRANDEL1  79 DASP PSI(3685)TO GAM CHI 12/79

R12     CHI(3555) INTO (P PBAR)/TOTAL (UNITS 10**-3)       (P11)
R12T         (1.0)  OR LESS CL=0.90   BRANDEL2  79 DASP PSI(3685)TO GAM CHI 12/79

R13     CHI(3555) INTO (J/PSI PI+PI-PI0)/TOTAL             (P12)
R13          (0.015)OR LESS  CL=.90   BARATE    81 SPEC   190 PI-BE,2PI2MU  1/82

R    S  SYSTEMATIC ERROR ADDED LINEARLY BY US.
R  T    ESTIMATED USING PSI(3685) TO (GAMMA CHI(3555))/TOTAL=0.074          3/82
R  T    THE ERRORS DO NOT CONTAIN THE UNCERTAINTY IN THE PSI(3685) DECAY.

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REFERENCES FOR CHI(3555)


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FELDMAN   75 PRL 35 821          +JEAN-MARIE,SADOULET,VANNUCCI,+  (LBL+SLAC)
    ALSO 75 PRL 35 1189  (ERRATA)
TANENBAU  75 PRL 35 1323         TANENBAUM,WHITAKER,ABRAMS,+      (LBL+SLAC)

TRILLING  76 STANFORD SYMP.437 G. H. TRILLING                          (LBL)
WHITAKER  76 PRL 37 1596         +TANENBAUM,ABRAMS,ALAM,BOYARSKI,+(SLAC+LBL)

BIDDICK   77 PRL 38 1324         +BURNETT+    (UCSD+UMD+PAVI+PRIN+SLAC+STAN)
FELDMAN   77 PL 33 C 285         +PERL                            (LBL+SLAC)
YAMADA    77 HAMB. CONF. P. 69 YAMADA                             (DESY+TOKY)

BARTEL    78 PL 79 B 492         DITTMANN,DUINKER,OLSSON,O?NEILL+(DESY+HEID)
SPITZER   78 KYOTO SUM.INST.47 H. SPITZER                             (HAMB)
TANENBAU  78 PR D 17 1731        TANENBAUM,ALAM,BOYARSKI,+        (SLAC+LBL)
    ALSO 82  PRIVATE COMM.       G.H.TRILLING                      (LBL+UCB)

BRANDEL1  79 ZPHY C 1 233        BRANDELIK,CORDS,+(AACH+DESY+HAMB+MPIM+TOKY)
BRANDEL2  79 NP B 160 426        BRANDELIK,CORDS,+(AACH+DESY+HAMB+MPIM+TOKY)
KIRK      79 PRL 42 619          +GOODMAN,ALVERSON,+(FNAL+HARV+ILL+OXF+TUFT)

HIMEL     80 PRL 44 920          +ABRAMS,ALAM,BLOCKER,+           (LBL+SLAC)
    ALSO 82  PRIVATE COMM.       G.H.TRILLING                      (LBL+UCB)

BARATE    81 PR D 24 2994        +ASTBURY,MCEWEN,+ (SACL+LOIC+SHMP+CERN+IND)

LEMOIGNE  82 PL 113 B 509        +BARATE,ASTBURY,MCEWEN+(SACL+LOIC+SHMP+IND)
OREGLIA   82 PR D 25 2259        +PARTRIDGE,BLOOM,+(SLAC+CIT+HARV+PRIN+STAN)
    ALSO 82  PRIVATE COMM.       M. OREGLIA                            (EFI)

BARATE    83 PL 121 B 449        +BAREYRE,ASTBURY,MCEWEN(SACL+LOIC+SHMP+IND)
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$\eta_c(3590)$

59 ETA/C(3590,JPG=) I=

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Evidence for the $\eta_c(3590)$ is based on the observation of a monochromatic gamma line in the inclusive photon spectrum for $\psi(3685)$ decays (EDWARDS 82). No exclusive decay modes are known at this time. A signal had been reported for a state at similar mass in the decay $\psi(3685) \to \gamma\gamma J/\psi(3100)$ (BARTEL 78), but this signal was not confirmed in an experiment with higher statistics (OREGLIA 82).

This particle needs confirmation, and thus is omitted from the Meson Table.

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59 ETA/C(3590) MASS (MEV)

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M    A     3594.0      5.0          EDWARDS   82 CBAL   E+E-,GAM INCL     1/82
M    A  ASSUMING MASS OF PSI(3685) = 3686 MEV.

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59 ETA/C(3590) WIDTH (MEV)

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W            (8.0)  OR LESS  CL=.95  EDWARDS   82 CBAL   E+E-,GAM INCL     1/82

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For notation, see key at front of Listings.

Mesons

$\eta_c(3590)$, $\psi(3685)$

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                        59  ETA/C(3590) PARTIAL DECAY MODES

                                                                DECAY MASSES
P1      ETA/C(3590) INTO HADRONS

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                        59  ETA/C(3590) BRANCHING RATIOS

R1      ETA/C(3590) INTO HADRONS                     (P1)
R1        SEEN                      EDWARDS   82 CBAL    E+E-,GAM INCL      1/82

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                              REFERENCES FOR ETA/C(3590)
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BARTEL   78 PL 79 B 492        +DITTMANN,DUINKER,OLSSON,+        (DESY+HEID)

PORTER   81 SLAC SUM.CONF.355 +EDWARDS,+          (CIT+HARV+PRIN+STAN+SLAC)

EDWARDS  82 PRL 48 70          +PARTRIDGE,PECK,+ (CIT+HARV+PRIN+STAN+SLAC)
OREGLIA  82 PR D 25 2259       +PARTRIDGE,BLOOM,+(SLAC+CIT+HARV+PRIN+STAN)
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$\psi(3685)$

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                        71  PSI(3685,JPG=1--) I=0

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                        71  PSI(3685) MASS (MEV)

                        WE USE INDEPENDENT MEASUREMENTS OF THE J/PSI(3100)
                        MASS, THE PSI(3685) MASS, AND THE MASS DIFFERENCE TO
                        PERFORM A CONSTRAINED FIT.

M  S       3680.3      37.           CRIEGEE   75 PLUT        E+E-          2/75
M   R     (3684.)     (5.)           LUTH      75 SMAG        E+E-          1/76
M          3684.       9.            PREPOST   75 SPEC    21. GAMMA D       1/76
M       140(3683.0)   (6.0)          LEMOIGNE  79 GOLI  0 150 PI-BE,2MU    12/79
M  F       3686.       3.            BRANDEL1  79 DASP  ' E+ E-            12/79
M       413 3686.00    0.10          ZHOLENTZ  80 OLYA    E+E- COLL.BEAMS   9/81
M          . . . . . . . . .
M   AVG    3686.000    0.100   AVERAGE
M   FIT    3686.00     0.10   FROM FIT

M  F    FROM A SIMULTANEOUS FIT TO E+ E-,MU+ MU- AND HADRONIC CHANNELS
M  F    ASSUMING G(E+ E-) = G(MU+ MU-)
M   R   REDUNDANT WITH DATA IN MASS DIFFERENCE BELOW
M   S   ERROR OF ABOUT 1 PER CENT FROM THE UNCERTAINTY IN CALIBRATION OF
M   S   THE BEAM ENERGY.

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                    71  PSI(3685) - J/PSI(3100) MASS DIFFERENCE (MEV)

DM          588.7       .8           LUTH      75 SMAG                      1/76
DM  R      (589.07)   (0.13)         ZHOLENTZ  80 OLYA    E+E-              3/82
DM          589.7      1.2           LEMOIGNE  82 GOLI    190 PI-BE,2MU     9/83*
DM          . . . . . . . . .
DM  AVG     589.01     0.67    AVERAGE
DM  FIT     589.06     0.13   FROM FIT

DM  R   REDUNDANT WITH DATA IN MASS ABOVE

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                        71  PSI(3685) WIDTH (KEV)

W           228.       56.           LUTH      75 SMAG
W   F       202.       57.           BRANDEL1  79 DASP    E+ E-            12/79
W   F   FROM A SIMULTANEOUS FIT TO E+ E-,MU+ MU- AND HADRONIC CHANNELS
W   F   ASSUMING G(E+ E-) = G(MU+ MU-)
W           . . . . . . . . .
W   AVG     215.2      39.9    AVERAGE

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                        71  PSI(3685) PARTIAL DECAY MODES

                                                                DECAY MASSES
P1      PSI(3685) INTO E+ E-                                .511+.511
P2      PSI(3685) INTO MU+ MU-                               106+ 106
P3      PSI(3685) INTO HADRONS
P4      PSI(3685) INTO VIRTUAL GAMMA INTO HADRONS

P       DECAYS INTO J/PSI(3100) + ANYTHING
P       --------------------------------
P11     PSI(3685) INTO J/PSI(3100) + ANYTHING
P12     PSI(3685) INTO J/PSI(3100) + NEUTRALS
P13     PSI(3685) INTO J/PSI(3100) PI+ PI-                 3097+ 140+ 140
P14     PSI(3685) INTO J/PSI(3100) PI0 PI0                 3097+ 135+ 135
P15     PSI(3685) INTO J/PSI(3100) ETA                     3097+ 549
P16     PSI(3685) INTO J/PSI(3100) GAMMA GAMMA             3097+   0+   0
P17     PSI(3685) INTO J/PSI(3100) PI0                     3097+ 135
P17                    SMALL -- NOT USED IN FIT

P       HADRONIC DECAYS
P       ---------------
P21     PSI(3685) INTO PI+ PI-                              140+ 140
P22     PSI(3685) INTO RHO PI                               769+ 140
P23     PSI(3685) INTO K+ K-                                494+ 494
P24     PSI(3685) INTO 2(PI+ PI-)                           140+ 140+ 140+ 140
P25     PSI(3685) INTO 2(PI+ PI-) PI0                       140+ 140+ 140+ 140+
P26     PSI(3685) INTO PI+ PI- K+ K-                        140+ 140+ 494+ 494
P27     PSI(3685) INTO PBAR P                               938+ 938
P28     PSI(3685) INTO LAMBDA ANTILAMBDA                   1116+1116
P29     PSI(3685) INTO XI ANTIXI                           1321+1321
P31     PSI(3685) INTO PI+ PI- P PBAR                       140+ 140+ 938+ 938
P32     PSI(3685) INTO  3(PI+ PI-)
P33     PSI(3685) INTO RHO0 PI+ PI-                         769+ 140+ 140
P34     PSI(3685) INTO K*(892)0 K+- PI-+                    892+ 494+ 140
P35     PSI(3685) INTO PBAR P PI0                           938+ 938+ 135
P36     PSI(3685) INTO PI+ PI- PI0                          140+ 140+ 135
P37     PSI(3685) INTO 3(PI+ PI-) PI0
P38     PSI(3685) INTO K+ K- PI0                            494+ 494+ 135
P39     PSI(3685) INTO K+- K*(892)-+                        494+ 892

P       RADIATIVE DECAYS
P       ----------------
P51     PSI(3685) INTO GAMMA GAMMA                            0+   0
P52     PSI(3685) INTO PI0 GAMMA                            135+   0
P53     PSI(3685) INTO ETA GAMMA                            549+   0
P54     PSI(3685) INTO ETA PRIME GAMMA                      958+   0
P56     PSI(3685) INTO CHI(3415) GAMMA                     3415+   0
P58     PSI(3685) INTO CHI(3510) GAMMA                     3510+   0
P59     PSI(3685) INTO CHI(3555) GAMMA                     3556+   0
P60     PSI(3685) INTO CHI(3510) + ANYTHING
P61     PSI(3685) INTO ETA/C(2980) GAMMA                   2981+   0
P62     PSI(3685) INTO IOTA(1440) GAMMA                    1440+   0
P63     PSI(3685) INTO ETA/C(3590) GAMMA                   3594+   0

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FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions, P_i, as follows: The diagonal elements are $P_i \pm \delta P_i$, where $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$, while the off-diagonal elements are the normalized correlation coefficients $\langle \delta P_i \delta P_j \rangle / (\delta P_i \cdot \delta P_j)$. For the definitions of the individual P_i, see the listings above; only those P_i appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

	$J/\psi\ \pi^+\pi^-$	$J/\psi\ \pi^0\pi^0$	$J/\psi\ \eta$	J/ψ+OTHER	NON-J/ψ
$J/\psi\ \pi^+\pi^-$	.3260+-.0238				
$J/\psi\ \pi^0\pi^0$	.4579	.1725+-.0176			
$J/\psi\ \eta$	-.0151	-.0069	.0278+-.0037		
J/ψ+OTHER	.2147	-.4634	-.0840	.0389+-.0248	
NON-J/ψ	-.8960	-.4103	-.0265	-.5165	.4348+-.0415

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                        71  PSI(3685) PARTIAL WIDTHS

W1      PSI(3685) INTO E+ E- (KEV)                           (G1)
W1           2.1       .3           LUTH      75 SMAG        E+E-          1/76
W1 F         2.        0.3          BRANDEL1  79 DASP    E+ E-            12/79
W1 F     FROM A SIMULTANEOUS FIT TO E+ E-,MU+ MU- AND HADRONIC CHANNELS
W1 F     ASSUMING G(E+ E-) = G(MU+ MU-)
W1          . . . . . . . . .
W1  AVG      2.05      0.21    AVERAGE

W3      PSI(3685) INTO HADRONS (KEV)                         (G3)
W3          224.       56.          LUTH      75 SMAG        E+E-          1/76

W51     PSI(3685) INTO GAMMA GAMMA (EV)                      (G51)
W51         43. OR LESS CL=0.90     BRANDEL1  79 DASP    E+ E-            12/79

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                        71  PSI(3685) BRANCHING RATIOS

R1      PSI(3685) INTO (E+ E-)/TOTAL                         (P1)
R1 L         .0088     .0013        FELDMAN   77 RVUE        E+E-         12/77
R1 L     FROM AN OVERALL FIT ASSUMING EQUAL PARTIAL WIDTHS FOR (E+E-)
R1 L     AND (MU+MU-). FOR A MEASUREMENT OF THE RATIO SEE THE ENTRY R4 BELOW
R1 L     INCLUDES LUTH 75,HILGER 75,BURMESTER 77

R2      PSI(3685) INTO (MU+ MU-)/TOTAL                       (P2)
R2 H         .0077     .0017        HILGER    75 SPEC        E+E-          1/76
R2 H     RE-STATED BY US USING (J/PSI(3100)+ANYTHING)/TOTAL =0.55

R3      PSI(3685) INTO (HADRONS)/TOTAL                       (P3)
R3    P      .981      .003         LUTH      75 SMAG        E+E-          1/76
R3    P  INCLUDES CASCADE DECAY INTO J/PSI(3100)                           4/77

R4      PSI(3685) INTO (MU+ MU-)/(E+ E-)                     (P2)/(P1)
R4           .89       .16          BOYARSKI  75 SMAG        E+E-         12/77

R5      PSI(3685) INTO (GAMMA INTO HADRONS)/TOTAL            (P4)
R5 C         .029      .004         LUTH      75 SMAG        E+E-          1/76
R5 C     INCLUDED IN R3


R       DECAYS INTO J/PSI(3100) + ANYTHING
R       --------------------------------

R10     PSI(3685) INTO (J/PSI(3100) + ANYTHING)/TOTAL       (P11)
R10          .57       .08          ABRAMS    75 SMAG        E+E-          1/76
R10         0.51      0.12          BRANDEL1  79 DASP    E+ E-            12/79
R10         . . . . . . . . .
R10 AVG     0.552     0.067    AVERAGE
R10 FIT     0.565     0.041   FROM FIT

R11     PSI(3685) INTO (J/PSI+NEU)/(J/PSI+ANYTHING)         (P12)/(P11)
R11          .41       .02          TANENBAUM 76 SMAG        E+E-          2/76
R11         . . . . . . . . .
R11 FIT     0.409     0.019   FROM FIT

R12     PSI(3685) INTO (J/PSI(3100) PI+ PI-)/TOTAL          (P13)
R12          .32       .04          ABRAMS1   75 SMAG        E+E-          1/76
R12          .36       .06          WIIK      75 DASP        E+E-          1/76
R12         . . . . . . . . .
R12 AVG     0.332     0.033    AVERAGE
R12 FIT     0.326     0.024   FROM FIT
R13     PSI(3685) INTO (J/PSI(3100) PI0 PI0)/TOTAL          (P14)
R13         0.17      0.029         ABRAMS1   75 SMAG        E+E-          1/77
R13          .18       .06          WIIK      75 DASP        E+E-          1/76
R13         . . . . . . . . .
R13 AVG     0.172     0.026    AVERAGE
R13 FIT     0.172     0.018   FROM FIT

R14     PSI(3685) INTO (J/PSI PI0 PI0)/(J/PSI PI+ PI-)     (P14)/(P13)
R14 H       (.64)     (.15)         HILGER    75 SPEC        E+E-          1/76
R14         0.53      0.06          TANENBAUM 76 SMAG        E+E-          1/77
R14 H   IGNORING THE (J/PSI ETA) AND (J/PSI GAMMA GAMMA) DECAYS
R14         . . . . . . . . .
R14 FIT     0.529     0.050   FROM FIT

R15     PSI(3685) INTO (J/PSI(3100) ETA)/TOTAL              (P15)
R15 S   44  (.043)    (.008)        TANENBAUM 76 SMAG        E+E-          1/76
R15    164  0.036     0.005         BARTEL    78 CNTR    E+E-              4/78
R15 S   17  (0.035)   (0.009)       BRANDEL2  79 DASP    E+E-,PSI 2GAM    12/79
R15    166  0.025     0.006         HIMEL     80 SMK2    E+E-              9/81
R15   D 386 0.0218    0.0049        OREGLIA   80 CBAL    E+E-,PSI 2GAM     9/81
R15         . . . . . . . . .
R15 AVG     0.0278    0.0045  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
R15 FIT     0.0278    0.0037 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)
                      (SEE IDEOGRAM BELOW)
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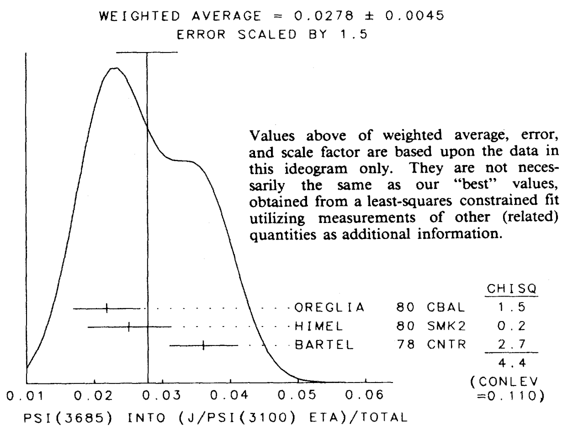
Mesons

Data Card Listings

$\psi(3685)$

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R16     PSI(3685) INTO (J/PSI(3100) PIO)/TOTAL            (P17)
R16        7    0.0015   0.0006          HIMEL      80 SMK2    E+E-              9/81
R16   D   23    0.0009   0.0003          OREGLIA    80 CBAL    PSI3685,PSI 2GAM  9/81
R16          . . . . . . . . .
R16 AVG         0.00102  0.00027   AVERAGE

R       HADRONIC DECAYS
R       ---------------

R20     PSI(3685) INTO (PI+ PI-)/TOTAL  (UNITS 10**-4)    (P21)
R20           (0.5)  OR LESS  CL=0.90  FELDMAN    77 SMAG           E+E-         12/77
R20            0.8       0.5           BRANDEL1   79 DASP      E+ E-             12/79

R22     PSI(3685) INTO (2(PI+ PI-) PIO)/TOTAL             (P25)
R22            .0035     .0015         ABRAMS     75 SMAG           E+E-          1/76
R22       42  (0.003)  (0.0008)        FRANKLIN   83 SMK2      E+E-,HADRONS       9/83*

R23     PSI(3685) INTO (K+ K-)/TOTAL  (UNITS 10**-4)      (P23)
R23           (0.5)  OR LESS  CL=0.90  FELDMAN    77 SMAG           E+E-         12/77
R23            1.0       0.7           BRANDEL1   79 DASP      E+ E-             12/79

R24     PSI(3685) INTO (PI+ PI- K+ K-)/TOTAL              (P26)
R24K           0.0016    0.0004        TANENBAUM 78 SMAG            E+E-         12/78
R24K     ASSUMING ENTIRELY STRONG DECAY                                          12/78

R25     PSI(3685) INTO (PBAR P)/TOTAL  (UNITS 10**-4)     (P27)
R25            2.3       0.7           FELDMAN    77 SMAG           E+E-         12/77
R25        4   1.4       0.8           BRANDEL1   79 DASP      E+ E-             12/79
R25          . . . . . . . . .
R25 AVG        1.91      0.53     AVERAGE

R26     PSI(3685) INTO (RHO PI)/TOTAL (UNITS 10**-4)      (P22)
R26   N       (10.)    OR LESS  CL=.90   ABRAMS     75 SMAG         E+E-          1/76
R26           (10.)    OR LESS CL=0.90   BARTEL 1   76 CNTR         E+E-          1/77
R26        1  (0.83) OR LESS CL=0.90     FRANKLIN   83 SMK2    E+E-,HADRONS       9/83*
R26   N  FINAL STATE RHOO PIO

R27     PSI(3685) INTO 2(PI+PI-)/TOTAL                    (P24)
R27            0.00045  0.0001         TANENBAUM 78 SMAG            E+E-         12/78

R28     PSI(3685) INTO (LAMBDA ANTILAMBDA)/TOTAL          (P28)
R28           (0.0004)OR LESS  CL=0.90 FELDMAN    77 SMAG           E+E-         12/77

R29     PSI(3685) INTO (XI- ANTIXI-)/TOTAL                (P29)
R29           (0.0002)                 FELDMAN    77 SMAG           E+E-         12/77

R31     PSI(3685) INTO (PI+ PI- P PBAR)/TO (UNITS 10**-3)(P31)
R31S           0.8       0.2           TANENBAUM 78 SMAG       E+ E-             12/78
R31S     ASSUMING ENTIRELY STRONG DECAY

R32     PSI(3685) INTO  3(PI+ PI-)/TOTAL (UNITS 10**-3)  (P32)
R32S           0.15      0.1           TANENBAUM 78 SMAG       E+ E-             12/78

R33     PSI(3685) INTO (RHOO PI+ PI-)/TOT (UNITS 10**-3) (P33)
R33            0.42      0.15          TANENBAUM 78 SMAG       E+ E-             12/78

R34     PSI(3685) INTO(K*(892)0K+-PI-+)/TOT(UNTS 10**-3) (P34)
R34            0.67      0.25          TANENBAUM 78 SMAG       E+ E-             12/78

R35     PSI(3685) INTO (P PBAR PIO)/TOTAL (UNITS 10**-4) (P35)
R35       9   (1.4)     (0.5)          FRANKLIN   83 SMK2      E+E-,HADRONS       9/83*

R36     PSI(3685) INTO (PI+PI-PIO)/TOTAL (UNITS 10**-5)  (P36)
R36       4   (8.5)     (4.6)          FRANKLIN   83 SMK2      E+E-,HADRONS       9/83*

R37     PSI(3685) INTO (3(PI+PI-)PIO)/TOTAL               (P37)
R37       6    (.0035)  (.0016)        FRANKLIN   83 SMK2      E+E-,HADRONS       9/83*

R38     PSI(3685) INTO (K+K-PIO)/TOTAL (UNITS 10**-5)     (P38)
R38       1   (2.96) OR LESS CL=0.90   FRANKLIN   83 SMK2      E+E-,HADRONS       9/83*

R39     PSI(3685) INTO (K+-K*(892)-+)/TOTAL (UNTS 10**-5)(P39)
R39       0   (1.79) OR LESS CL=0.90   FRANKLIN   83 SMK2      E+E-,HADRONS       9/83*

R       RADIATIVE DECAYS
R       ----------------

R42     PSI(3685) INTO (PIO GAMMA)/TOTAL                  (P52)
R42   U        (.0054)R LESS  CL=.95   LIBERMAN   75 SPEC           E+E-          1/76
R42            (.01) OR LESS  CL=.90   WIIK       75 DASP           E+E-          1/76

R43     PSI(3685) INTO (ETA GAMMA)/TOTAL (UNITS 10**-2)  (P53)
R43           (0.02)OR LESS  CL=0.90   YAMADA     77 DASP      E+ E-,3 GAMMA     12/77

R44     PSI(3685) INTO (ETA PRIME GAM)/TOT (UNTS 10**-2) (P54)
R44C          (0.023)OR LESS  CL=0.90  BARTEL 2   76 CNTR           E+E-         12/77
R44   R       (0.6)  OR LESS  CL=0.90  BRAUNSCHW 77 DASP            E+E-         12/77

R55     PSI(3685) INTO (CHI(3415) GAM)/TOT (UNITS 10**-2)(P56)
R55   A        7.5       2.6              WHITAKER  76 SMAG          E+E-          1/77
R55   A        7.2       2.3              BIDDICK   77 CNTR    E+E-,MONOCHR.GAM   3/77
R55D  A        9.7       2.2              GAISER    82 CBAL    E+E-,MONOCHR.GAM   3/82
R55          . . . . . . . . .
R55 AVG        8.2       1.4      AVERAGE

R58     PSI(3685) INTO (CHI(3510) GAM)/TOT (UNITS 10**-2)(P58)
R58   B        7.1       1.9              BIDDICK   77 CNTR    E+E-,MONOCHR.GAM   3/77
R58D  G        8.8       1.9              GAISER    82 CBAL    E+E-,MONOCHR.GAM   3/82
R58          . . . . . . . . .
R58 AVG        8.0       1.3      AVERAGE

R59     PSI(3685) INTO (CHI(3555) GAM)/TOT (UNITS 10**-2)(P59)
R59   B        7.0       2.0              BIDDICK   77 CNTR    E+E-,MONOCHR.GAM   3/77
R59D  F        7.7       1.7              GAISER    82 CBAL    E+E-,MONOCHR.GAM   3/82
R59          . . . . . . . . .
R59 AVG        7.4       1.3      AVERAGE

R60     PSI(3685) INTO (ETA/C(2980) GAM)/TOT(UNTS 10**-2)(P61)
R60   D        0.43      0.26             PARTRIDGE 80 CBAL    E+E-,MONOCHR.GAM   9/81

R61     PSI(3685) INTO (IOTA(1440) GAM)/TOT (UNTS 10**-3)(P62)
R61   E       (0.12) OR LESS  CL=.90    SCHARRE   80 SMAG    E+E-                 2/81

R62     PSI(3685) INTO (ETA/C(3590) GAM)/TOT(UNTS 10**-2)(P63)
R62           (0.2) TO  1.3   CL=.95    EDWARDS   82 CBAL    E+E-,MONOCHR.GAM   1/82

R     A  ANGULAR DISTRIBUTION (1+COS**2) ASSUMED
R     B  VALID FOR ISOTROPIC DISTRIBUTION OF THE PHOTON
R   C    THE VALUE IS NORMALIZED TO THE BRANCHING RATIO FOR PSI(3685)
R   C    INTO (J/PSI(3100) ETA)/TOTAL.
R     D  SYSTEMATIC ERROR ADDED LINEARLY BY US.
R     E  INCLUDES UNKNOWN BRANCHING FRACTION IOTA(1440) INTO K KBAR PI.
R     F  ANGULAR DISTRIBUTION (1-0.052*COS**2) ASSUMED
R     G  ANGULAR DISTRIBUTION (1-0.189*COS**2) ASSUMED
R     U  RE-STATED BY US USING (MU+MU-)/TOTAL = .0077
R     R  RE-STATED BY US USING TOTAL DECAY WIDTH 228 KEV.
R    S   LOW STATISTICS DATA REMOVED FROM AVERAGE.

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                 71  PSI(3685)     G(I)*G(E+E-)/G(TOTAL)  (KEV)

        THIS COMBINATION OF A PARTIAL WIDTH WITH THE PARTIAL WIDTH
        INTO E+E- AND WITH THE TOTAL WIDTH IS OBTAINED FROM THE INTEGRATED
        CROSS-SECTION INTO CHANNEL(I) IN THE E+E- ANNIHILATION.
        WE ONLY LIST DATA NOT HAVING BEEN USED TO DETERMINE THE PARTIAL
        WIDTH G(I) OR THE BRANCHING RATIO G(I)/TOTAL.

G3      G(HADRONIC)*G(E+E-)/G(TOTAL)
G3             2.2       .4            ABRAMS     75 SMAG           E+E-          1/76

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                         REFERENCES FOR PSI(3685)

ABRAMS   74 PRL 33 1453         +BRIGGS,AUGUSTIN,BOYARSKI+        (LBL+SLAC)

ABRAMS   75 STANFORD SYMP.25    G.S.ABRAMS                             (LBL)
ABRAMS1  75 PRL 34 1181         +BRIGGS,CHINOWSKY,FRIEDBERG,+    (LBL+SLAC)
AUBERT   75 PRL 33 1624         +BECKER,BIGGS,BURGER,GLENN+        (MIT+BNL)
BOYARSKI 75 PALERMO CONF. 54    +BREIDENBACH,BULOS,ABRAMS,BRIGGS+(SLAC+LBL)
CAMERINI 75 PRL 35 483          +LEARNED,PREPOST,ASH,ANDERSON,+ (WISC+SLAC)
CRIEGEE  75 PL 53B 489          +DEHNE,FRANKE,HORLITZ,KRECHLOCK+    (DESY)
DASP3    75 PL 57B 407          BRAUNSCHWEIG,KONIGS,+ (AACH+DESY+MPIM+TOKY)
FELDMAN  75 PRL 35 821          +JEAN-MARIE,SADOULET,VANNUCCI,+  (LBL+SLAC)
GRECO    75 PL 56B 367          +PANCHERI-SRIVASTAVA,SRIVASTAVA      (FRAS)
JACKSON  75 NIM 128 13          J.D.JACKSON,D.SCHARRE                 (LBL)
HILGER   75 PRL 35 625          +BERON,FORD,HOFSTADTER,HOWELL,+ (STAN+PENN)
LIBERMAN 75 STANFORD SYMP.55    A.D.LIBERMAN                    (STANFORD)
LUTH     75 PRL 35 1124         +BOYARSKI,LYNCH,BREIDENBACH,+    (SLAC+LBL)JPC
PREPOST  75 STANFORD SYMP.241 R.PREPOST                        (WISCONSIN)
SIMPSON  75 PRL 35 699          +BERON,FORD,HILGER,HOFSTADTER,+ (STAN+PENN)
WIIK     75 STANFORD SYMP.69    B.H.WIIK                              (DESY)
BARTEL 1 76 PL 64 B 483         +DUINKER,OLSSON,STEFFEN,HEINTZE+(DESY+HEID)
BARTEL 2 76 TBILISI CONF.N56    +DUINKER,OLSSON,HEINTZE,+       (DESY+HEID)
SNYDER   76 PRL 36 1415         +HOM,LEDERMAN,APPEL,KAPLAN+(COLU+FNAL+STON)
TANENBAU 76 PRL 36 402          TANENBAUM,ABRAMS,BOYARSKI,BULOS,+(SLAC+LBL)IG
WHITAKER 76 PRL 37 1596         +TANENBAUM,ABRAMS,ALAM,BOYARSKI,+(SLAC+LBL)

BIDDICK  77 PRL 38 1324         +BURNETT+    (UCSD+UMD+PAVI+PRIN+SLAC+STAN)
BRAUNSCH 77 PL 67 B 249         BRAUNSCHWEIG,+   (AACH+DESY+HAMB+MPIM+TOKY)
BURMESTE 77 PL 66 B 395         BURMESTER,CRIEGEE,+   (DESY+HAMB+SIEG+WUPP)
FELDMAN  77 PL 33 C 285         +PERL                            (LBL+SLAC)
YAMADA   77 HAMB. CONF. P. 69 YAMADA                            (DESY+TOKY)

BARTEL   78 PL 79 B 492         DITTMANN,DUINKER,OLSSON,O?NEILL+(DESY+HEID)
TANENBAU 78 PR D 17 1731        TANENBAUM,ALAM,BOYARSKI,+        (SLAC+LBL)

BRANDEL1 79 ZPHY C 1 233        BRANDELIK,CORDS,+(AACH+DESY+HAMB+MPIM+TOKY)
BRANDEL2 79 NP B 160 426        BRANDELIK,CORDS,+(AACH+DESY+HAMB+MPIM+TOKY)
LEMOIGNE 79 FERMILAB CONF.524 +ABOLINS,BARATE,+        (SACL+LOIC+SHMP+IND)

HIMEL    80 PRL 44 920          +ABRAMS,ALAM,BLOCKER,+           (LBL+SLAC)
OREGLIA  80 PRL 45 959          +PARTRIDGE+          (SLAC+CIT+HARV+PRIN+STAN)
PARTRIDG 80 PRL 45 1150         PARTRIDGE,PECK+      (CIT+HARV+PRIN+STAN+SLAC)
SCHARRE  80 PL 97 B 329         +TRILLING,ABRAMS,ALAM,BLOCKER+   (SLAC+LBL)
ZHOLENTZ 80 PL 96 B 214         +KURDADZE,LELCHUK,MISHNEV,NIKITIN+    (NOVO)
    ALSO 81 YAD.PHYS. 34 1471 ZHOLENTZ ET AL.                         (NOVO)

BARATE   81 PR D 24 2994        +ASTBURY,MCEWEN,+ (SACL+LOIC+SHMP+CERN+IND)

EDWARDS  82 PRL 48 70           +PARTRIDGE,PECK,+ (CIT+HARV+PRIN+STAN+SLAC)
GAISER   82 MORIOND CONF.       +EDWARDS,+          (CIT+HARV+PRIN+STAN+SLAC)
LEMOIGNE 82 PL 113 B 509        +BARATE,ASTBURY,MCEWEN+(SACL+LOIC+SHMP+IND)

BARATE   83 PL 121 B 449        +BAREYRE,ASTBURY,MCEWEN(SACL+LOIC+SHMP+IND)
FRANKLIN 83  SLAC-PUB-3092      +FRANKLIN,FELDMAN,ABRAMS,ALAM+   (LBL+SLAC)
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$\psi(3770)$

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53  PSI(3770,JPG=1- ) I=
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                     53  PSI(3770) MASS (MEV)

M  E       3772.0    (6.0)          RAPIDIS   77 SMAG  0 E+E-         12/77
M  E       3770.     (6.0)          BACINO    78 DLCO  0 E+E-          4/78
M  E       3764.0    (5.0)          SCHINDLER 80 SMAG    E+ E-        12/79
M  E    ERRORS INCLUDE SYSTEMATIC COMMON TO ALL EXPERIMENTS
M          . . . . . . . . . .
M   MASS   3769.9       2.5      FROM PSI(3685) MASS AND MASS DIFFERENCE
M                                BELOW
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                     53  PSI(3770) - PSI(3685) MASS DIFFERENCE (MEV)
DM           88.0      3.0          RAPIDIS   77 SMAG    E+E-         12/77
DM S         86.0      2.0          BACINO    78 DLCO    E+E-          2/82
DM S    SPEAR PSI PRIME MASS (3684) SUBTRACTED (SEE SCHINDLER 80)
DM           80.0      2.0          SCHINDLER 80 SMAG    E+ E-        12/79
DM         . . . . . . . . . .
DM  AVG      83.9      2.4     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.8)
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                     53  PSI(3770) WIDTH (MEV)
W            28.0      5.0          RAPIDIS   77 SMAG  0 E+E-         12/77
W            24.0      5.0          BACINO    78 DLCO  0 E+E-          4/78
W            24.0      5.0          SCHINDLER 80 SMAG    E+ E-        12/79
W          . . . . . . . . . .
W   AVG      25.3      2.9     AVERAGE
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                     53  PSI(3770) PARTIAL DECAY MODES

                                                      DECAY MASSES
P1      PSI(3770) INTO E+ E-                        .511+.511
P2      PSI(3770) INTO D DBAR                       1869+1869
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                     53  PSI(3770) PARTIAL WIDTHS (KEV)

W1      PSI(3770) INTO E+E-                         (G1)
W1 R         0.37      0.09         RAPIDIS   77 SMAG  0 E+E-         12/77
W1           0.18      0.06         BACINO    78 DLCO  0 E+E-          4/78
W1           0.276     0.050        SCHINDLER 80 SMAG    E+ E-         1/82
W1 R    SEE ALSO R2 BELOW
W1         . . . . . . . . . .
W1  AVG      0.257     0.046   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
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                     53  PSI(3770) BRANCHING RATIOS

R1      PSI(3770) INTO (D DBAR)/TOTAL               (P2)
R1         DOMINANT                 PERUZZI   77 SMAG    E+E-,D DBAR  12/77

R2      PSI(3770) INTO (E+ E-)/TOTAL (UNITS 10**-5)     (P1)
R2          1.3        0.2          RAPIDIS   77 SMAG  0 E+E-         12/77
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REFERENCES FOR PSI(3770)


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PERUZZI  77 PRL 39 1301     +PICCOLO,FELDMAN,PERL,+(SLAC,LBL,NWES+HAWA)
RAPIDIS  77 PRL 39 526      +GOBBI,LUKE,PERL,+(STAN+SLAC+LBL+NWES+HAWA)

BACINO   78 PRL 40 671      +BAUMGARTEN,BIRKWOOD,+ (SLAC+STAN+UCLA+UCI)

SCHINDLE 80 PR D 21 2716    SCHINDLER,SIEGRIST,ALAM,BOYARSKI+(SLAC+LBL)
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$\psi(4030)$

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72  PSI(4030,JPG=1- ) I=

SEEN CLEARLY SEPARATED FROM THE PSI(4160)
BY DASP AND CONFIRMED WITH LESS STATISTICS BY PLUTO
SEEN ALSO BY MARK I, DELCO AND THE CRYSTAL BALL
(KIRKBY 79).
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                     72  PSI(4030) MASS (MEV)

M          4028.0      2.5          GOLDHABER 77 SMAG       E+E-      12/77
M          4040.0     10.0          BRANDELIK 78 DASP    E+E-          4/78
M          . . . . . . . . . .
M   AVG    4028.7      2.8     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
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                     72  PSI(4030) WIDTH (MEV)

W            52.0     10.0          BRANDELIK 78 DASP    E+E-          4/78
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                     72  PSI(4030) PARTIAL DECAY MODES
                                                      DECAY MASSES
P1      PSI(4030) INTO D DBAR                       1869+1869
P2      PSI(4030) INTO D* DBAR AND D*BAR D          2007+1865
P3      PSI(4030) INTO D* D*BAR                     2007+2007
P4      PSI(4030) INTO J/PSI(3100) HADRONS
P5      PSI(4030) INTO E+ E-                        .511+.511
P6      PSI(4030) INTO MU+ MU-                       106+ 106
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                     72  PSI(4030) PARTIAL WIDTHS (KEV)

W5      PSI(4030) INTO E+E-                         (G5)
W5           0.75      0.15         BRANDELIK 78 DASP    E+ E-        12/78
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                     72  PSI(4030) BRANCHING RATIOS

R1      PSI(4030) INTO (DO DOBAR)/(DO* DOBAR+DO*BAR DO)  (P1)/(P2)
R1   P       0.05      0.03         GOLDHABER 77 SMAG  0 E+ E-        12/77

R2      PSI(4030) INTO (DO* DO*BAR)/(DO* DOBAR+DO*BAR DO)(P3)/(P2)
R2   P      32.0      12.0          GOLDHABER 77 SMAG  0 E+ E-        12/77

R    P  PHASE-SPACE FACTOR (P**3) EXPLICITLY REMOVED.

R3      PSI(4030) INTO J/PSI(3100) HADRONS              (P4)
R3         LOOKED FOR               BURMESTER 77 PLUT         E+E-     4/77

R4      PSI(4030) INTO (E+ E-)/TOTAL  (UNITS 10**-5)      (P5)
R4         (1.0) APPROX.            FELDMAN   77 SMAG    E+ E-        12/77
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REFERENCES FOR PSI(4030)


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AUGUSTIN 75 PRL 34 764      +BOYARSKI,ABRAMS,BRIGGS+           (SLAC+LBL)
BACCI    75 PL 58B 481      +BIDOLI,PENSO,STELLA,+            (ROMA+FRAS)
BOYARSKI 75 PRL 34 762      +BREIDENBACH,ABRAMS,BRIGGS,+       (SLAC+LBL)
ESPOSITO 75 PL 58B 478      +FELICETTI,PERUZZI,+  (FRAS+NAPL+PADO+ROMA)

PERUZZI  76 PRL 37 569      +PICCOLO,FELDMAN,NGUYEN,WISS,+     (SLAC+LBL)

BURMESTE 77 PL 66 B 395     +CRIEGEE,DEHNE+         (DESY+HAMB+SIEG+WUPP)
GOLDHABE 77 PL 69 B 503     GOLDHABER,WISS,ABRAMS,ALAM,LUTH,+(LBL+SLAC)
FELDMAN  77 PL 33 C 285     +PERL                              (LBL+SLAC)
LUTH     77 PL 70 B 120     +PIERRE,ABRAMS,ALAM,BOYARSKI,+     (LBL+SLAC)

BRANDELI 78 PL 76 B 361     BRANDELIK,CORDS+ (AACH+DESY+HAMB+MPIM+TOKY)
    ALSO 79 ZPHY C 1 233    BRANDELIK,CORDS,+(AACH+DESY+HAMB+MPIM+TOKY)

KIRKBY   79 FERMILAB SYMP.107 J. KIRKBY RAPPORTEUR                 (SLAC)

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$\psi(4160)$

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25  PSI(4160,JPG=1- ) I=

SEEN CLEARLY SEPARATED FROM THE PSI(4030)
BY DASP AND CONFIRMED WITH LESS STATISTICS BY PLUTO .
MARK I,DELCO AND THE CRYSTAL BALL SEE A PROMINENT
SHOULDER BUT NO SEPARATION (KIRKBY 79)
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                     25  PSI(4160) MASS (MEV)

M          4159.0     20.0          BRANDELIK 78 DASP    E+E-          4/78
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                     25  PSI(4160) WIDTH (MEV)

W            78.0     20.0          BRANDELIK 78 DASP    E+E-          4/78
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                     25  PSI(4160) PARTIAL DECAY MODES

                                                      DECAY MASSES
P1      PSI(4160) INTO E+ E-                        .511+.511
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                     25  PSI(4160) PARTIAL WIDTHS (KEV)

W1      PSI(4160) INTO E+ E-                        (G1)
W1           0.77      0.23         BRANDELIK 78 DASP    E+ E-        12/78
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REFERENCES FOR PSI(4160)


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BURMESTE 77 PL 66 B 395     +CRIEGEE,DEHNE+         (DESY+HAMB+SIEG+WUPP)

BRANDELI 78 PL 76 B 361     BRANDELIK,CORDS+ (AACH+DESY+HAMB+MPIM+TOKY)

KIRKBY   79 FERMILAB SYMP.107 J. KIRKBY RAPPORTEUR                 (SLAC)
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$\psi(4415)$

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73  PSI(4415,JPG=1- ) I=
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                     73  PSI(4415) MASS (MEV)

M          4414.      7.            SIEGRIST  76 SMAG       E+E-       2/76
M         (4400.)     APPROX.       KNIES     77 PLUT  0 E+E-,MU+ MU- 12/77
M          4417.0     10.0          BRANDELIK 78 DASP    E+E-          4/78
M          . . . . . . . . . .
M   AVG    4415.0      5.7     AVERAGE
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                     73  PSI(4415) WIDTH (MEV)

W            33.      10.           SIEGRIST  76 SMAG       E+E-       2/76
W            66.0     15.0          BRANDELIK 78 DASP    E+E-          4/78
W          . . . . . . . . . .
W   AVG      43.2     15.2     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.8)
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                     73  PSI(4415) PARTIAL DECAY MODES

                                                      DECAY MASSES
P1      PSI(4415) INTO E+ E-                        .511+.511
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                     73  PSI(4415) PARTIAL WIDTHS (KEV)

W1      PSI(4415) INTO E+ E-                        (G1)
W1           0.49      0.13         BRANDELIK 78 DASP    E+ E-        12/78
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Mesons

Data Card Listings

$\psi(4415)$, $\Upsilon(9460)$ $[\Upsilon(1S)]$, $\chi_b(9875)$ $[\chi_b(1^3P_0)]$, $\chi_b(9895)$ $[\chi_b(1^3P_1)]$

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                       73  PSI(4415) BRANCHING RATIOS

R1      PSI(4415) INTO (E+ E-)/TOTAL (UNITS 10**-5)
R1           1.3        .3              SIEGRIST  76 SMAG          E+E-          2/76

R2      PSI(4415) INTO HADRONS/TOTAL
R2          DOMINANT                    SIEGRIST  76 SMAG          E+E-          1/77

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                              REFERENCES FOR PSI(4415)

SIEGRIST 76 PRL 36 700         +ABRAMS,BOYARSKI,BREIDENBACH,+   (LBL+SLAC)

BURMESTE 77 PL 66 B 395        +CRIEGEE,DEHNE+        (DESY+HAMB+SIEG+WUPP)
KNIES    77 HAMBURG SYMP.93    G.KNIES HAMBURG TALK ON PLUTO COLLAB.(DESY)
LUTH     77 PL 70 B 120        +PIERRE,ABRAMS,ALAM,BOYARSKI,+   (LBL+SLAC)

BRANDELI 78 PL 76 B 361        BRANDELIK,CORDS+ (AACH+DESY+HAMB+MPIM+TOKY)

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$\Upsilon(9460)$ or $\Upsilon(1S)$

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49  UPSILON(9460,JPG=1- ) I=

REFLECTING COLLOQUIAL USAGE, WE GIVE ALSO THE SPECTRO-
SCOPIC NAMES OF THE UPSILON SYSTEM RESONANCES. AS IS
MOST COMMON IN THE LITERATURE, WE GIVE THE RADIAL
QUANTUM NUMBER RATHER THAN THE PRINCIPAL QUANTUM
NUMBER (I.E. THE RADIAL QUANTUM NUMBER PLUS THE
ORBITAL ANGULAR MOMENTUM). THUS, THE LOWEST CHI/B STATES ARE 1 3PJ
RATHER THAN 2 3PJ. NOTE THAT THE SPECTROSCOPIC ASSIGNMENT OF SOME
OF THE PARTICLES IS ONLY TENTATIVE AT THIS TIME.

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                       49  UPSILON(9460) MASS  (MEV)

M        FIXED TARGET EXPERIMENTS
M    I     (9410.)    (13.)            INNES      77 SPEC  0 400 P+A,MU+MU-   12/77

M        E+E- EXPERIMENTS
M          (9460.)    (10.)            BIENLEIN   78 CNTR   E+E-              4/78
M    D     (9456.3)   (11.0)           BERGER     79 PLUT   E+E-             12/79
M          (9457.)    (10.)            DARDEN     79 DASP   E+E-             12/79
M    D     (9433.)    (30.)            ANDREWS    80 CLEO   E+E-,HADRONS      9/81
M    D     (9434.5)   (30.0)           BOHRINGER  80 CUSB   E+E-,HADRONS      9/81
M    D     (9461.6)   (10.6)           NICZYPORU  81 LENA   E+E-,HADRONS      9/81
M    D     (9462.0)   (10.6)           ALBRECHT   82 DASP   E+E-,MU+MU-       8/83*
M           9460.6      0.4            ARTAMONOV  83 REDE   E+E-,HADRONS      8/83*
M           9459.9      0.2            GITTELMAN  83 REDE   E+E-,HADRONS      2/84*
M          . . . . . . . . . .
M   AVG     9460.04     0.28    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)

M   D    SYSTEMATIC ERROR ADDED LINEARLY BY US.
M   I    FROM 2-PEAK FIT

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                       49  UPSILON(9460) WIDTH (KEV)

W     B       45.       38.        14.     BERGER     80 PLUT   E+E-              9/81
W     B       38.       27.        11.     ALBRECHT   82 DASP   E+E-,MU+MU-       8/83*
W   D B       30.       23.        14.     NICZYPORU  82 LENA   E+E-,MU+MU-,HADR  8/83*
W   D B       48.        8.                ANDREWS    83 CLEO   E+E-,MU+MU-       9/83*
W           . . . . . . . . . .
W   AVG       44.3       6.6       AVERAGE

W     B  FROM R1,R2,W2 BELOW AND ASSUMING E-MU-TAU UNIVERSALITY
W   D    SYSTEMATIC ERRORS ADDED LINEARLY BY US.

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                       49  UPSILON(9460) PARTIAL DECAY MODES

                                                              DECAY MASSES
P1      UPSILON(9460)  INTO MU+ MU-                           106+ 106
P2      UPSILON(9460)  INTO  E+  E-                          .511+.511
P3      UPSILON(9460) INTO TAU+ TAU-                         1784+1784

P       HADRONIC DECAYS
P       ---------------
P11     UPSILON(9460)  INTO RHO PI                            769+ 140
P12     UPSILON(9460)  INTO J/PSI(3100) ANYTHING

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                       49  UPSILON(9460) PARTIAL WIDTHS (KEV)

W2      UPSILON(9460)  INTO  E+  E-                     (G2)
W2  E        (1.33)    (0.14)          BERGER     79 PLUT   E+E-             12/79
W2            1.08      0.25           BOCK       80 CNTR   E+E-,HADRONS      9/81
W2 D          1.07      0.23           MAGERAS    81 CUSB   E+E-,E+E-PI+PI-   9/81
W2 D         (1.23)    (0.20)          ALBRECHT   82 DASP   E+E-,MU+MU-       8/83*
W2 D A        1.13      0.17           NICZYPORU  82 LENA   E+E-,MU+MU-,HADR  8/83*
W2          . . . . . . . . . .
W2  AVG       1.10      0.12     AVERAGE

W2   A  ASSUMING E-MU-TAU UNIVERSALITY
W2 D    SYSTEMATIC ERRORS ADDED LINEARLY BY US.
W2  E   ASSUMING HADRONIC PARTIAL WIDTH EQUAL TO TOTAL WIDTH

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                       49  UPSILON(9460) BRANCHING RATIOS

R1      UPSILON(9460)  INTO(MU+ MU-)/TOTAL              (P1)
R1            0.022     0.020          BERGER     79 PLUT   E+E-             12/79
R1   A        0.025     0.021          DARDEN     79 DASP   E+E-             12/79
R1            0.014     0.034    0.014 BOCK       80 CNTR   E+E-,MU+MU-       9/81
R1      17    0.039     0.011          MUELLER    81 CLEO   E+E-,PI+PI-E+E-   9/81
R1   A       (0.032)   (0.016)         ALBRECHT   82 DASP   E+E-,MU+MU-       8/83*
R1 D A        0.038     0.017          NICZYPORU  82 LENA   E+E-,MU+MU-,HADR  8/83*
R1 D  1652    0.027     0.006          ANDREWS    83 CLEO   E+E-,MU+MU-       8/83*
R1          . . . . . . . . . .
R1  AVG       0.0291    0.0047   AVERAGE

R1   A  ASSUMING E-MU-TAU UNIVERSALITY

R2      UPSILON(9460)  INTO (E+  E-)/TOTAL              (P2)
R2            0.051     0.030          BERGER     80 PLUT   E+E-              9/81

R3      UPSILON(9460) INTO (TAU+ TAU-)/TOTAL            (P3)
R3 D          0.034     0.008          GILES      83 CLEO   E+E-,TAU+TAU-     9/83*

R11     UPSILON(9460)  INTO (RHO PI)/TOTAL              (P11)
R11          (.021)OR LESS             NICZYPORU 83 LENA    E+E-,HADRONS      9/83*

R12     UPSILON(9460)  INTO (J/PSI(3100) ANYTHING)/TOTAL (P12)
R12          (.02) OR LESS             NICZYPORU 83 LENA    E+E-,HADRONS      9/83*

R  D    SYSTEMATIC ERRORS ADDED LINEARLY BY US.

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                              REFERENCES FOR UPSILON(9460)

COBB     77 PL 72 B 273        +IWATA,FABJAN,GOLDBERG+(BNL+CERN+SYRA+YALE)
HERB     77 PRL 39 252         +HOM,LEDERMAN,APPEL,ITO,+  (COLU+FNAL+STON)
INNES    77 PRL 39 1240        +APPEL,BROWN,HERB,HOM,FISK+(COLU+FNAL+STON)

BERGER   78 PL 76 B 243        +ALEXANDER,DAUM,+(AACH+DESY+HAMB+SIEG+WUPG)
BIENLEIN 78 PL 78 B 360        +GLAWE,BOCK,BLANAR,+  (DESY+HAMB+HEID+MPIM)
DARDEN   78 PL 76 B 246        +HOFMANN,ALBRECHT,+    (DESY+DORT+HEID+LUND)
GARELICK 78 PR D 18 945        +GAUTHIER,HICKS,OLIVER,+    (NEAS+WASH+TUFT)
KAPLAN   78 PRL 40 435         +APPEL,HERB,HOM,LEDERMAN,+ (STON+FNAL+COLU)
YOH      78 PRL 41 684         +HERB,HOM,LEDERMAN,UENO,+  (COLU+FNAL+STON)

ANGELIS  79 PL 87 B 398        +BESCH,BLUMENFELD,+     (CERN+COLU+OXF+ROCK)
BADIER   79 PL 86 B 98         +BOUCROT,BURGUN+ (SACL+CERN+CDEF+EPOL+LALO)
BERGER   79 ZPHY C 1 343       +ALEXANDER+        (AACH+DESY+HAMB+SIEG+WUPG)
DARDEN   79 PL 80 B 419        +HOFMANN,ALBRECHT,+    (DESY+DORT+HEID+LUND)

ALBRECHT 80 PL 93 B 500        +CHILDERS,DARDEN+(DESY+DORT+HEID+LUND+ITEP)
ANDREWS  80 PRL 44 1108        + (CORN+HARV+ITHA+LEMO+ROCH+RUTG+SYRA+VAND)
BERGER   80 PL 93 B 497        +LACKAS,RAUPACH,+(AACH+DESY+HAMB+SIEG+WUPP)
BOCK     80 ZPHY C 6 125       +BLANAR,BLUM,BIENLEIN+(HEID+MPIM+DESY+HAMB)
BOHRINGE 80 PRL 44 1111        BOHRINGER,COSTANTINI,FINOCCHIARO(COLU+STON)
KOURKOUM 80 PL 91 B 481        KOURKOUMELIS+(ATHU+NTUA+BNL+CERN+SYRA+YALE)

MAGERAS  81 PRL 46 1115        +BOHRINGER,FINOCCHIARO+(COLU+STON+LSU+MPIM)
MUELLER  81 PRL 46 1181        + (RUTG+SYRA+LEMO+VAND+CORN+ITHA+HARV+ROCH)
NICZYPOR 81 PRL 46 92          NICZYPORUK,CHEN,VOGEL,WEGENER+(LENA COLLAB)

ALBRECHT 82 PL 116 B 383       +HOFMANN,SHUBERT+(DESY+DORT+HEID+LUND+ITEP)
ARTAMONO 82 PL 118 B 225       +BARU,BLINOV,BONDAR,BUKIN,GROSHEV+    (NOVO)
NICZYPOR 82 ZPHY 15 C 299      NICZYPORUK,FOLGER,BIENLEIN+   (LENA COLLAB)

ALBRECHT 83  DESY 83-101       +DREWS,HASEMANN+       (ARGUS COLLABORATION)
ANDREWS  83 PRL 50 807         +  (CORN+ITHA+HARV+OSU+ROCH+RUTG+SYRA+VAND)
ARTAMONO 83  PREPR.83-84       +BARU,BLINOV,BONDAR,BUKIN,GROSHEV+    (NOVO)
GILES    83 PRL 50 877         +  (HARV+OSU+ROCH+RUTG+SYRA+VAND+CORN+ITHA)
GITTELMA 83 CORNELL CONF.      B. GITTELMAN                          (CORN)
NICZYPOR 83 ZPHY 17 C 197      + (CRAC+ERLA+DESY+NIJM+PITT+SACL+TELA+WURZ)

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$\chi_b(9875)$ or $\chi_b(1^3P_0)$

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76  CHI/B(9875,JPG=    ) J=0 PREFERRED

OBSERVED IN RADIATIVE DECAY OF THE UPSILON(10025).
INTO CHI/B GAMMA, THEREFORE C=+.

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                       76  CHI/B(9875) MASS (MEV)

M     U     9872.9       5.8            KLOPFENST 83 CUSB    E+E-,GAMMAS HADR  9/83*

M     U  FROM GAMMA ENERGY BELOW, ASSUMING UPSILON(10025) MASS = 10023.4 MEV

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                       76  GAMMA ENERGY IN UPSILON(10025) DECAY (MEV)

DM    S      149.4       5.7            KLOPFENST 83 CUSB    E+E-,GAMMAS HADR  9/83*

DM    S  SYSTEMATIC ERROR ADDED LINEARLY BY US.

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                       76  CHI/B(9875) PARTIAL DECAY MODES

                                                         DECAY MASSES
P1      CHI/B(9875) INTO UPSILON(9460) GAMMA            9460+    0

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                       76  CHI/B(9875) BRANCHING RATIOS

R1      CHI/B(9875) INTO (UPSILON(9460) GAMMA)/TOTAL      (P1)
R1   T        (0.11) OR LESS  CL=.90    PAUSS      83 CUSB    E+E-,GAMMAS LEPT 12/83*
R1   T   CALCULATED USING UPSILON(10025)INTO CHI/B(9895)GAM/TOT = 0.035

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                              REFERENCES FOR CHI/B(9875)

KLOPFENS 83 PRL 51 160        KLOPFENSTEIN,HAN+ (STON+COLU+CORN+LSU+MPIM)
PAUSS    83 PL 130 B 439      +DIETL,EIGEN+      (MPIM+COLU+CORN+LSU+STON)

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$\chi_b(9895)$ or $\chi_b(1^3P_1)$

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77  CHI/B(9895,JPG=    ) J=1 PREFERRED

OBSERVED IN RADIATIVE DECAY OF THE UPSILON(10025).
INTO CHI/B GAMMA, THEREFORE C=+.

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                       77  CHI/B(9895) MASS (MEV)

M     U     9894.5       3.5                                                   9/83*

M     U  FROM GAMMA ENERGY BELOW ASSUMING UPSILON(10025) MASS = 10023.4 MEV

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For notation, see key at front of Listings. **Mesons**

$\chi_b(9895)$ $[\chi_b(1^3P_1)]$, $\chi_b(9915)$ $[\chi_b(1^3P_2)]$, $\Upsilon(10025)$ $[\Upsilon(2S)]$

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                       77  GAMMA ENERGY IN UPSILON(10025) DECAY (MEV)

DM   S      128.1       0.4               KLOPFENST 83 CUSB    E+E-,GAMMAS HADR  9/83*
DM   G     (127.5)     (5.2)              GAISER    83 CBAL    E+E-,HADRONS GAM 12/83*
DM   S      128.0       1.5               PAUSS     83 CUSB    E+E-,GAMMAS LEPT 12/83*
DM          . . . . . . . . .

DM   AVG    128.1       3.4      AVERAGE
DM     A SYSTEMATIC ERROR OF 3 MEV FROM THE CUSB RESULTS HAS BEEN ADDED
DM     LINEARLY BY US TO THE STATISTICAL ERROR ON THE AVERAGE.

DM   G  SYSTEMATIC ERROR ADDED LINEARLY BY US.
DM   S  STATISTICAL ERROR ONLY.

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                       77  CHI/B(9895) PARTIAL DECAY MODES

                                                              DECAY MASSES
P1     CHI/B(9895) INTO UPSILON(9460) GAMMA                 9460+    0

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                       77  CHI/B(9895) BRANCHING RATIOS

R1     CHI/B(9895) INTO (UPSILON(9460) GAMMA)/TOTAL       (P1)
R1            0.47      0.18              KLOPFENST 83 CUSB    E+E-,GAMMAS HADR  9/83*
R1   T        0.41      0.14              PAUSS     83 CUSB    E+E-,GAMMAS LEPT 12/83*
R1          . . . . . . . . .
R1  AVG       0.43      0.11     AVERAGE

R1   T   CALCULATED USING UPSILON(10025)TO CHI/B(9915) GAM/TOT=0.059+-0.014

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                                 REFERENCES FOR CHI/B(9895)

GAISER   83  SLAC-PUB-3232     J.E.GAISER+CRYSTAL BALL COLLABORATION(SLAC)
KLOPFENS 83 PRL 51 160         KLOPFENSTEIN,HAN+ (STON+COLU+CORN+LSU+MPIM)
PAUSS    83 PL 130 B 439       +DIETL,EIGEN+      (MPIM+COLU+CORN+LSU+STON)

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$\chi_b(9915)$ or $\chi_b(1^3P_2)$

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78  CHI/B(9915,JPG=    ) J=2 PREFERRED

OBSERVED IN RADIATIVE DECAY OF THE UPSILON(10025).
INTO CHI/B GAMMA, THEREFORE C=+.

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                       78  CHI/B(9915) MASS (MEV)

M    U     9914.6      2.4                                                    9/83*

M    U  FROM GAMMA ENERGY BELOW ASSUMING UPSILON(10025) MASS = 10023.4 MEV

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                       78  GAMMA ENERGY IN UPSILON(10025) DECAY (MEV)

DM   S      108.2       0.3               KLOPFENST 83 CUSB    E+E-,GAMMAS HADR  9/83*
DM   G     (108.3)     (3.9)              GAISER    83 CBAL    E+E-,HADRONS GAM 12/83*
DM   S      107.0       2.0       2.5     PAUSS     83 CUSB    E+E-,GAMMAS LEPT 12/83*
DM          . . . . . . . . .

DM   AVG    108.2       2.3      AVERAGE
DM     A SYSTEMATIC ERROR OF 2 MEV FROM THE CUSB RESULTS HAS BEEN ADDED
DM     LINEARLY BY US TO THE STATISTICAL ERROR ON THE AVERAGE.

DM   G  SYSTEMATIC ERROR ADDED LINEARLY BY US.
DM   S  STATISTICAL ERROR ONLY.

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                       78  CHI/B(9915) PARTIAL DECAY MODES

                                                              DECAY MASSES
P1     CHI/B(9915) INTO UPSILON(9460) GAMMA                 9460+    0

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                       78  CHI/B(9915) BRANCHING RATIOS

R1     CHI/B(9915) INTO (UPSILON(9460) GAMMA)/TOTAL       (P1)
R1            0.20      0.05              KLOPFENST 83 CUSB    E+E-,GAMMAS HADR  9/83*
R1   T        0.20      0.09              PAUSS     83 CUSB    E+E-,GAMMAS LEPT 12/83*
R1          . . . . . . . . .
R1  AVG       0.200     0.044    AVERAGE

R1   T   CALCULATED USING UPSILON(10025)TO CHI/B(9915) GAM/TOT=0.061+-0.014

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                                 REFERENCES FOR CHI/B(9915)

GAISER   83  SLAC-PUB-3232     J.E.GAISER+CRYSTAL BALL COLLABORATION(SLAC)
KLOPFENS 83 PRL 51 160         KLOPFENSTEIN,HAN+ (STON+COLU+CORN+LSU+MPIM)
PAUSS    83 PL 130 B 439       +DIETL,EIGEN+      (MPIM+COLU+CORN+LSU+STON)

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$\Upsilon(10025)$ or $\Upsilon(2S)$

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52  UPSILON(10025,JPG=1- ) I=

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                       52  UPSILON(10025) MASS  (GEV)

M  I        (10.060)  (0.030)             INNES     77 SPEC    400 P+A,MU+MU-    12/77
M   R       (10.020)  (0.020)             BIENLEIN  78 CNTR    E+E-               4/78
M   R       (10.012)  (0.020)             DARDEN    78 DASP    E+E-               4/78
M  DR       (10.0136) (0.0112)            NICZYPO1  81 LENA    E+E-,HADRONS       9/81
M            10.0231   0.0004             BARBER    83 REDE    E+E-               9/83*
M            10.0238   0.0005             ARTAMONOV 83 REDE    E+E-,HADRONS      12/83*
M           . . . . . . . . .
M   AVG      10.02337  0.00034  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)

M  D     SYSTEMATIC ERRORS ADDEED LINEARLY BY US
M  I     FROM 2-PEAK FIT
M  R     REDUNDANT WITH DATA IN MASS DIFFERENCE BELOW

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                       52  UPSILON(10025) WIDTH (KEV)

W  B         31.        9.         7.     MAGERAS   81 CUSB    E+E-,HADRONS        8/83*
W    M       31.       10.         7.     NICZYPO2  81 LENA    E+E-,L+L-PI+PI-     9/81
W  B D       27.        8.                ANDREWS   83 CLEO    E+E-,MU+MU-         9/83*
W           . . . . . . . . .
W   AVG      29.6       4.7      AVERAGE

W  B     FROM W2 AND R1 BELOW AND ASSUMING E-MU-TAU UNIVERSALITY
W    D   SYSTEMATIC ERRORS ADDED LINEARLY BY US
W    M   FROM W1 AND R1 ABOVE AND ASSUMING A LOG QUARKONIUM POTENTIAL

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                       52  UPSILON(10025)-UPSILON(9460) MASS DIFFERENCE (MEV)

DM   E      563.3       0.4                                                     2/84*
DM   E   EVALUATED BY US USING DIRECT MEASUREMENTS OF THE UPSILON(9460) AND
DM   E   UPSILON(10025) MASSES ABOVE.

DM          560.0      10.0               BIENLEIN  78 CNTR    E+E-                4/78
DM          555.0      11.0               DARDEN    78 DASP    E+E-                4/78
DM A        574.0      27.0               UENO      79 SPEC    400 P PT,MU+MU-    12/79
DM   D      560.7       3.8               ANDREWS   80 CLEO    E+E-,HADRONS        9/81
DM   D      559.        4.                BOHRINGER 80 CUSB    E+E-,HADRONS        9/81
DM   D      552.       11.                NICZYPO1  81 LENA    E+E-,HADRONS        9/81
DM          556.       10.                ALBRECHT  82 DASP    E+E-,MU+MU-         8/83*
DM         (562.0)     (3.0)              ALBRECHT  83 ARG     E+E-,HADRONS       12/83*
DM  B      (562.5)     (0.6)              BARBER    83 REDE    E+E-                9/83*
DM          . . . . . . . . .
DM  AVG     559.2       2.4      AVERAGE

DM A     FIXING THE UPSILON(9460) MASS AT 9460 MEV
DM  B    USING THE UPSILON(9460) MASS OF ARTAMONOV 82.
DM   D   SYSTEMATIC ERROR ADDED LINEARLY BY US.

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                       52  UPSILON(10025) PARTIAL DECAY MODES

                                                              DECAY MASSES
P1       UPSILON(10025) INTO MU+ MU-                          106+ 106
P2       UPSILON(10025) INTO  E+  E-                          .511+.511
P3       UPSILON(10025) INTO UPSILON(9460) PI PI              9460+ 140+ 140
P4       UPSILON(10025) INTO CHI/B(9915) GAMMA                9915+   0
P5       UPSILON(10025) INTO CHI/B(9895) GAMMA                9895+   0
P6       UPSILON(10025) INTO CHI/B(9875) GAMMA                9873+   0

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                       52  UPSILON(10025) PARTIAL WIDTHS (KEV)

W2       UPSILON(10025) INTO  E+  E-                        (G2)
W2  E         (0.35)   (0.14)             DARDEN    78 DASP    E+E-                4/78
W2 D S         0.49     0.11              ANDREWS   80 CLEO    E+E-,HADRONS        9/81
W2  E         (0.37)   (0.16)             BOCK      80 CNTR    E+E-,HADRONS        9/81
W2 D S         0.43     0.13              BOHRINGER 80 CUSB    E+E-,HADRONS        9/81
W2   S         0.56     0.08              MAGERAS   81 CUSB    E+E-,E+E-PI+PI-     9/81
W2 D S         0.48     0.13      0.09    NICZYPO1  81 LENA    E+E-,MU+MU-,HADR    9/81
W2          . . . . . . . . .
W2  AVG        0.507    0.051    AVERAGE

W2 D     SYSTEMATIC ERROR ADDED LINEARLY BY US.
W2  E    ASSUMING HADRONIC PARTIAL WIDTH EQUAL TO TOTAL WIDTH
W2   S   USING UPSILON(9460) PARTIAL WIDTH TO E+E- = 1.10 KEV

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                       52  UPSILON(10025) BRANCHING RATIOS

R1       UPSILON(10025) INTO(MU+ MU-)/TOTAL                 (P1)
R1            (0.038)OR LESS CL=0.90      NICZYPO1  81 LENA    E+E-,MU+MU-         9/81
R1 D     176    0.019     0.018           ANDREWS   83 CLEO    E+E-,MU+MU-         8/83*

R2       UPSILON(10025) INTO (E+  E-)/TOTAL                 (P2)
R2            SEEN                        COBB      77 SPEC     P P,E+ E- X       12/78

R3       UPSILON(10025) INTO (UPSILON(9460) PI PI)/TOTAL  (P3)
R3   E  23      0.23      0.08            MAGERAS   81 CUSB    E+E-,E+E-PI+PI-     9/81
R3   E   7      0.24      0.08            NICZYPO2  81 LENA    E+E-,L+L-PI+PI-     9/81
R3 D            0.191     0.018           GREEN     82 CLEO    E+E-,2PI MM/2MU     8/83*
R3 D           (0.179)   (0.030)          ALBRECHT  83 ARG     E+E-,HADRONS       12/83*
R3          . . . . . . . . .
R3  AVG         0.195     0.017  AVERAGE

R4       UPSILON(10025) INTO (CHI/B(9915) GAMMA)/TOTAL      (P4)
R4             0.061     0.014            KLOPFENST 83 CUSB    E+E-,GAMMA HADR     9/83*
R4 D          (0.063)   (0.027)           GAISER    83 CBAL    E+E-,GAMMA HADR    12/83*

R5       UPSILON(10025) INTO (CHI/B(9895) GAMMA)/TOTAL      (P5)
R5              .059      .014            KLOPFENST 83 CUSB    E+E-,GAMMA HADR     9/83*
R5 D          (0.060)   (0.027)           GAISER    83 CBAL    E+E-,GAMMA HADR    12/83*

R6       UPSILON(10025) INTO (CHI/B(9875) GAMMA)/TOTAL      (P6)
R6              .035      .014            KLOPFENST 83 CUSB    E+E-,GAMMA HADR     9/83*

R  D     SYSTEMATIC ERRORS ADDED LINEARLY BY US
R    E   ASSUMING THE BRANCHING RATIO OF UPSILON(9460) TO E+E- TO BE 0.025

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                                 REFERENCES FOR UPSILON(10025)

COBB      77 PL 72 B 273        +IWATA,FABJAN,GOLDBERG+(BNL+CERN+SYRA+YALE)
HERB      77 PRL 39 252         +HOM,LEDERMAN,APPEL,ITO,+  (COLU+FNAL+STON)
INNES     77 PRL 39 1240        +APPEL,BROWN,HERB,HOM,FISK+(COLU+FNAL+STON)

BIENLEIN  78 PL 78 B 360        +GLAWE,BOCK,BLANAR,+  (DESY+HAMB+HEID+MPIM)
DARDEN    78 PL 78 B 364        +HOFMANN,ALBRECHT,+   (DESY+DORT+HEID+LUND)
KAPLAN    78 PRL 40 435         +APPEL,HERB,HOM,LEDERMAN,+ (STON+FNAL+COLU)
YOH       78 PRL 41 684         +HERB,HOM,LEDERMAN,UENO,+  (COLU+FNAL+STON)

UENO      79 PRL 42 486         +BROWN,HERB,HOM,FISK,ITO,+ (FNAL+COLU+STON)

ANDREWS   80 PRL 44 1108        + (CORN+HARV+ITHA+LEMO+ROCH+RUTG+SYRA+VAND)
ARESTOV   80 IHEP 80-165        +BOGOLJUBSKI,+                        (SERP)
BOCK      80 ZPHY C 6 125       +BLANAR,BLUM,BIENLEIN+(HEID+MPIM+DESY+HAMB)
BOHRINGE  80 PRL 44 1111        BOHRINGER,COSTANTINI,FINOCCHIARO(COLU+STON)
KOURKOUM  80 PL 91 B 481        KOURKOUMELIS+(ATHU+NTUA+BNL+CERN+SYRA+YALE)

MAGERAS   81 PRL 46 1115        +BOHRINGER,FINOCCHIARO+(COLU+STON+LSU+MPIM)
MUELLER   81 PRL 46 1181        + (RUTG+SYRA+LEMO+VAND+CORN+ITHA+HARV+ROCH)
NICZYPO1  81 PL 99 B 169        NICZYPORUK,CHEN,VOGEL,WEGENER+(LENA COLLAB)
NICZYPO2  81 PL 100 B 95        NICZYPORUK,CHEN,FOLGER,LURZ,+ (LENA COLLAB)

ALBRECHT  82 PL 116 B 383       +HOFMANN,SHUBERT+(DESY+DORT+HEID+LUND+ITEP)
GREEN     82 PRL 49 617         +(RUTG+SYRA+VAND+CORN+ITHACA+HARV+OSU+ROCH)
    ALSO  83 CORNELL CONF.      +(RUTG+SYRA+VAND+CORN+ITHACA+HARV+OSU+ROCH)
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$\chi_b(10235)$ $[\chi_b(2^3P_0)]$, $\chi_b(10255)$ $[\chi_b(2^3P_1)]$, $\chi_b(10270)$ $[\chi_b(2^3P_2)]$, $\Upsilon(10355)$ $[\Upsilon(3S)]$


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ALBRECHT 83  DESY 83-101       +DREWS,HASEMANN+      (ARGUS COLLABORATION)
ANDREWS  83 PRL 50 807         +  (CORN+ITHA+HARV+OSU+ROCH+RUTG+SYRA+VAND)
ARTAMONO 83  PREPR.83-84       +BARU,BLINOV,BONDAR,BUKIN,GROSHEV+   (NOVO)
    ALSO 83 CORNELL CONF.      B. GITTTELMAN                         (CORN)
BARBER   83  DESY 83-067       +(DESY,ARGUS COLLAB+CRYSTAL BALL COLLABOR.)
    ALSO 83  SUB. TO PL        +(DESY,ARGUS COLLAB+CRYSTAL BALL COLLABOR.)
GAISER   83  SLAC-PUB-3232     J.E.GAISER+CRYSTAL BALL COLLABORATION(SLAC)
KLOPFENS 83 PRL 51 160         KLOPFENSTEIN,HAN+ (STON+COLU+CORN+LSU+MPIM)
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$\chi_b(10235)$ or $\chi_b(2^3P_0)$

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79  CHI/B(10235,JPG=    ) J=0 PREFERRED

OBSERVED IN RADIATIVE DECAY OF THE UPSILON(10355).
INTO CHI/B GAMMA, THEREFORE C=+.
OMITTED FROM TABLE.

                 79  CHI/B(10235) MASS (GEV)

M    U      10.2328   .0058                                          9/83*

M    U  FROM GAMMA ENERGY BELOW ASSUMING UPSILON(10355) MASS = 10355.5 MEV

             79  GAMMA ENERGY IN UPSILON(10355) DECAY (MEV)

DM   S       119.0      5.0          EIGEN     82 CUSB   E+E-,2 GAM L+L-   9/83*
DM   CD     (117.2)    (5.0)         HAN       82 CUSB   E+E-,GAMMAS HADR  9/83*
DM   S       122.1      0.7          LEE-FRANZ 83 RVUE   E+E-,GAMMAS HADR  9/83*
DM          . . . . . . . . .
DM   AVG     122.0      5.7     AVERAGE
DM      A SYSTEMATIC ERROR OF 5 MEV FROM THE CUSB RESULTS HAS BEEN ADDED
DM      LINEARLY BY US TO THE STATISTICAL ERROR ON THE AVERAGE.

DM   D  SYSTEMATIC ERROR ADDED LINEARLY BY US.
DM   S  STATISTICAL ERROR ONLY.
DM  C   SUPERSEDED BY LEE-FRANZINI 83.

                 79  CHI/B(10235) PARTIAL DECAY MODES

                                                       DECAY MASSES
P1      CHI/B(10235) INTO UPSILON(9460) GAMMA          9460+   0
P2      CHI/B(10235) INTO UPSILON(10025) GAMMA         10023+    0

                       REFERENCES FOR CHI/B(10235)
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EIGEN     82 PRL 49 1616       +BOHRINGER,HERB+  (MPIM+COLU+CORN+STON+LSU)
HAN       82 PRL 49 1612       +HORSTKOTTE,IMLAY+(COLU+STON+CORN+LSU+MPIM)

LEE-FRAN 83 EMS 83 CONF.       LEE-FRANZINI                          (COLU)
    ALSO 83 CORNELL CONF. 284 P. MICHAEL TUTS                        (COLU)
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$\chi_b(10255)$ or $\chi_b(2^3P_1)$

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80  CHI/B(10255,JPG=    ) J=1 PREFERRED

OBSERVED IN RADIATIVE DECAY OF THE UPSILON(10355).
INTO CHI/B GAMMA, THEREFORE C=+.

                 80  CHI/B(10255) MASS (GEV)
M    U      10.2537   .0034                                          9/83*

M    U  FROM GAMMA ENERGY BELOW ASSUMING UPSILON(10355) MASS = 10355.5 MEV.

             80  GAMMA ENERGY IN UPSILON(10355) DECAY (MEV)

DM   S        99.0      2.0          EIGEN     82 CUSB   E+E-,2 GAM L+L-   9/83*
DM   CD      (99.5)    (3.2)         HAN       82 CUSB   E+E-,GAMMAS HADR  9/83*
DM   S       101.4      0.3          LEE-FRANZ 83 RVUE   E+E-,GAMMAS HADR  9/83*
DM          . . . . . . . . .
DM   AVG     101.3      3.3     AVERAGE
DM      A SYSTEMATIC ERROR OF 3 MEV FROM THE CUSB RESULTS HAS BEEN ADDED
DM      LINEARLY BY US TO THE STATISTICAL ERROR ON THE AVERAGE.

DM   S  STATISTICAL ERROR ONLY.
DM   D  SYSTEMATIC ERROR ADDED LINEARLY BY US.
DM  C   SUPERSEDED BY LEE-FRANZINI 83.

                 80  CHI/B(10255) PARTIAL DECAY MODES

                                                       DECAY MASSES
P1      CHI/B(10255) INTO UPSILON(9460) GAMMA          9460+   0
P2      CHI/B(10255) INTO UPSILON(10025) GAMMA         10023+    0

                       REFERENCES FOR CHI/B(10255)
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EIGEN     82 PRL 49 1616       +BOHRINGER,HERB+  (MPIM+COLU+CORN+STON+LSU)
HAN       82 PRL 49 1612       +HORSTKOTTE,IMLAY+(COLU+STON+CORN+LSU+MPIM)

LEE-FRAN 83 EMS 83 CONF.       LEE-FRANZINI                          (COLU)
    ALSO 83 CORNELL CONF. 284 P. MICHAEL TUTS                        (COLU)
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$\chi_b(10270)$ or $\chi_b(2^3P_2)$

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81  CHI/B(10270,JPG=    ) J=2 PREFERRED

OBSERVED IN RADIATIVE DECAY OF THE UPSILON(10355).
INTO CHI/B GAMMA, THEREFORE C=+.

                 81  CHI/B(10270) MASS (GEV)

M    U      10.2710   .0024                                          9/83*

M    U  FROM GAMMA ENERGY BELOW ASSUMING UPSILON(10355) MASS = 10355.5 MEV.

             81  GAMMA ENERGY IN UPSILON(10355) DECAY (MEV)

DM   S        84.0      3.0          EIGEN     82 CUSB   E+E-,2 GAM L+L-   9/83*
DM   CD      (84.4)    (2.0)         HAN       82 CUSB   E+E-,GAMMAS HADR  9/83*
DM   S        84.2      0.3          LEE-FRANZ 83 RVUE   E+E-,GAMMAS HADR  9/83*
DM          . . . . . . . . .
DM   AVG      84.2      2.3     AVERAGE
DM      A SYSTEMATIC ERROR OF 2 MEV FROM THE CUSB RESULTS HAS BEEN ADDED
DM      LINEARLY BY US TO THE STATISTICAL ERROR ON THE AVERAGE.

DM   S  STATISTICAL ERROR ONLY.
DM   D  SYSTEMATIC ERROR ADDED LINEARLY BY US.
DM  C   SUPERSEDED BY LEE-FRANZINI 83.

                 81  CHI/B(10270) PARTIAL DECAY MODES

                                                       DECAY MASSES
P1      CHI/B(10270) INTO UPSILON(9460) GAMMA          9460+   0
P2      CHI/B(10270) INTO UPSILON(10025) GAMMA         10023+    0

                       REFERENCES FOR CHI/B(10270)
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EIGEN     82 PRL 49 1616       +BOHRINGER,HERB+  (MPIM+COLU+CORN+STON+LSU)
HAN       82 PRL 49 1612       +HORSTKOTTE,IMLAY+(COLU+STON+CORN+LSU+MPIM)

LEE-FRAN 83 EMS 83 CONF.       LEE-FRANZINI                          (COLU)
    ALSO 83 CORNELL CONF. 284 P. MICHAEL TUTS                        (COLU)
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$\Upsilon(10355)$ or $\Upsilon(3S)$

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48  UPSILON(10355,JPG=1- ) I=

                 48  UPSILON(10355) MASS  (GEV)

M    R      (10.351)  (0.004)  FROM UPSILON(9460) MASS AND MASS DIFF. BELOW
M            10.3555   0.0005        ARTAMONOV 83 REDE    E+E-,HADRONS      12/83*

M    R  REDUNDANT WITH DATA ON MASS DIFFERENCE BELOW.

                 48  UPSILON(10355) WIDTH (KEV)

W  B         23.0       9.0     6.0  PETERSON  82 CUSB   E+E-,GAMMAS HADR  8/83*
W  F D       13.0       7.0          ANDREWS   83 CLEO   E+E-,MU+MU-       9/83*
W          . . . . . . . . .
W    AVG     17.7       5.1     AVERAGE

W  B    MODEL DEPENDENT VALUE
W    D  SYSTEMATIC ERROR ADDED LINEARLY BY US.
W  F    FROM W2 AND R1 BELOW AND ASSUMING E-MU-TAU UNIVERSALITY.

         48  UPSILON(10355)-UPSILON(9460) MASS DIFFERENCE (MEV)

DM      E    895.5      0.6                                                2/84*
DM      E  EVALUATED BY US USING DIRECT MEASUREMENTS OF THE UPSILON(9460) AND
DM      E  UPSILON(10355) MASSES ABOVE.

DM A         950.0     30.0          UENO      79 SPEC   400 P PT,MU+MU-   12/79
DM   D       891.1      5.7          ANDREWS   80 CLEO   E+E-,HADRONS       9/81
DM   D       889.       6.           BOHRINGER 80 CUSB   E+E-,HADRONS       9/81
DM         . . . . . . . . .
DM   AVG     891.2      4.1     AVERAGE

DM A    FIXING THE UPSILON(9460) MASS AT 9460 MEV AND THE
DM A    UPSILON(10025)-UPSILON(9460) MASS DIFFERENCE AT 558 MEV.
DM   D  SYSTEMATIC ERROR ADDED LINEARLY BY US.

                 48  UPSILON(10355) PARTIAL DECAY MODES

                                                       DECAY MASSES
P1      UPSILON(10355) INTO MU+ MU-                     106+ 106
P2      UPSILON(10355) INTO  E+  E-                    .511+.511
P3      UPSILON(10355) INTO PI+PI- UPSILON(9460)        140+ 140+9460
P4      UPSILON(10355) INTO PI+ PI- UPSILON(10025)       140+  140+10023
P5      UPSILON(10355) INTO CHI/B(10270) GAMMA         10271+    0
P6      UPSILON(10355) INTO CHI/B(10255) GAMMA         10254+    0
P7      UPSILON(10355) INTO CHI/B(10235) GAMMA         10233+    0

                 48  UPSILON(10355) PARTIAL WIDTHS (KEV)

W2      UPSILON(10355) INTO (E+ E-)                     (G2)
W2 D S       0.39       0.09         ANDREWS   80 CLEO   E+E-,HADRONS       9/81
W2 D S       0.35       0.06         BOHRINGER 80 CUSB   E+E-,HADRONS       9/81
W2         . . . . . . . . .
W2   AVG     0.362      0.050   AVERAGE

W2 D    SYSTEMATIC ERROR ADDED LINEARLY BY US.
W2   S  USING UPSILON(9460) PARTIAL WIDTH TO E+E- = 1.10 KEV
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For notation, see key at front of Listings. **Mesons**

ϒ(10355) [ϒ(3S)], ϒ(10575) [ϒ(4S)], $K^{\pm}$, K^0, $K^*(892)$

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                 48  UPSILON(10355) BRANCHING RATIOS

R1      UPSILON(10355) INTO (MU+ MU-)/TOTAL              (P1)
R1 D  1096    0.033    0.02          ANDREWS   83 CLEO    E+E-,MU+MU-       8/83*

R3      UPSILON(10355) INTO (PI+PI- UPSILON(9460))/TOTAL (P3)
R3                                  (UNITS 10**-2)
R3 D  1680    4.9      1.4           GREEN     82 CLEO    E+E-,2PI MM/2MU   8/83*
R3 E    22    5.6      2.0           MAGERAS   82 CUSB    E+E-,HADRONS      8/83*
R3
R3  AVG       5.1      1.1     AVERAGE

R4      UPSILON(10355) INTO UPSILON(10025) PI+ PI-/TOTAL (P4)
R4                                  (UNITS 10**-2)
R4 G     5    3.1      3.1           MAGERAS   82 CUSB    E+E-,HADRONS      8/83*

R5      UPSILON(10355) INTO (CHI/B(10270) GAMMA)/TOTAL   (P5)
R5          0.127    0.041           LEE-FRANZ 83 RVUE    E+E-,GAMMA HADR  12/83*

R6      UPSILON(10355) INTO (CHI/B(10255) GAMMA)/TOTAL   (P6)
R6          0.156    0.042           LEE-FRANZ 83 RVUE    E+E-,GAMMA HADR  12/83*

R7      UPSILON(10355) INTO (CHI/B(10235) GAMMA)/TOTAL   (P7)
R7          0.076    0.035           LEE-FRANZ 83 RVUE    E+E-,GAMMA HADR  12/83*

R  D    SYSTEMATIC ERRORS ADDED LINEARLY BY US
R    E  ASSUMING THE BRANCHING RATIO OF UPSILON(9460) TO E+E- TO BE 0.025
R  G    ASSUMING THE BRANCHING RATIO OF UPSILON(10025) TO E+E- TO BE 0.016

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REFERENCES FOR UPSILON(10355)


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COBB     77 PL 72 B 273      +IWATA,FABJAN,GOLDBERG+(BNL+CERN+SYRA+YALE)
HERB     77 PRL 39 252       +HOM,LEDERMAN,APPEL,ITO,+   (COLU+FNAL+STON)
INNES    77 PRL 39 1240      +APPEL,BROWN,HERB,HOM,FISK+(COLU+FNAL+STON)

KAPLAN   78 PRL 40 435       +APPEL,HERB,HOM,LEDERMAN,+ (STON+FNAL+COLU)
YOH      78 PRL 41 684       +HERB,HOM,LEDERMAN,UENO,+   (COLU+FNAL+STON)

UENO     79 PRL 42 486       +BROWN,HERB,HOM,FISK,ITO,+ (FNAL+COLU+STON)

ANDREWS  80 PRL 44 1108      + (CORN+HARV+ITHA+LEMO+ROCH+RUTG+SYRA+VAND)
BOHRINGE 80 PRL 44 1111      BOHRINGER,COSTANTINI,FINOCCHIARO(COLU+STON)

GREEN    82 PRL 49 617       +(RUTG+SYRA+VAND+CORN+ITHACA+HARV+OSU+ROCH)
HAN      82 PRL 49 1612      +HORSTKOTTE,IMLAY+(COLU+STON+CORN+LSU+MPIM)
MAGERAS  82 PL 118 B 453     +HERB,IMLAY+         (COLU+CORN+LSU+MPIM+STON)
PETERSON 82 PL 114 B 277     +GIANNINI,LEE-FRANZINI+(COLU+STON+LSU+MPIM)

ANDREWS  83 PRL 50 807       +  (CORN+ITHA+HARV+OSU+ROCH+RUTG+SYRA+VAND)
ARTAMONO 83   PREPR.83-84    +BARU,BLINOV,BONDAR,BUKIN,GROSHEV+    (NOVO)
LEE-FRAN 83 EMS 83 CONF.     LEE-FRANZINI                          (COLU)
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ϒ(10575) or ϒ(4S) 47 UPSILON(10575,JPG=1-) I=

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                 47  UPSILON(10575) MASS  (GEV)

M    R      (10.573)  (0.004)  FROM UPSILON(9460) MASS AND MASS DIFF. BELOW
M    R   REDUNDANT WITH DATA ON MASS DIFFERENCE BELOW.

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                 47  UPSILON(10575) WIDTH (MEV)

W    D        19.8      10.5         ANDREWS   80 CLEO    E+E-,HADRONS      9/81
W             12.6       6.0         FINOCCHIA 80 CUSB    E+E-,HADRONS      9/81
W
W    AVG      14.4       5.2     AVERAGE

W    D   SYSTEMATIC ERROR ADDED LINERALY BY US.

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                 47  UPSILON(10575)-UPSILON(9460) MASS DIFFERENCE (MEV)

DM          1112.       5.           ANDREWS   80 CLEO    E+E-,HADRONS      9/81
DM   D      1114.       7.           FINOCCHIA 80 CUSB    E+E-,HADRONS      9/81
DM
DM   AVG    1112.7      4.1      AVERAGE

DM   D   SYSTEMATIC ERROR ADDED LINERALY BY US.

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                 47  UPSILON(10575) PARTIAL DECAY MODES

                                                        DECAY MASSES
P1     UPSILON(10575) INTO MU+ MU-                      106+ 106
P2     UPSILON(10575) INTO  E+  E-                      .511+.511

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                 47  UPSILON(10575) PARTIAL WIDTHS (KEV)

W2     UPSILON(10575) INTO (E+ E-)                  (G2)
W2   S        0.21      0.07         ANDREWS   80 CLEO    E+E-,HADRONS      9/81
W2   S        0.28      0.08         FINOCCHIA 80 CUSB    E+E-,HADRONS      9/81
W2
W2   AVG      0.240     0.053    AVERAGE

W2   S   USING UPSILON(9460) PARTIAL WIDTH TO E+E- = 1.10 KEV

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REFERENCES FOR UPSILON(10575)


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ANDREWS  80 PRL 45 219       + (CORN+HARV+ITHA+LEMO+ROCH+RUTG+SYRA+VAND)
FINOCCHI 80 PRL 45 222       FINOCCHIARO,GIANNINI,BOHRINGER,+(COLU+STON)
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S=±1, C=0, B=0 MESON STATES

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$K^{\pm}$ 10 CHARGED K(494,JP=0-) I=1/2

SEE STABLE PARTICLE DATA CARD LISTINGS

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K^0 11 NEUTRAL K(498,JP=0-) I=1/2

SEE STABLE PARTICLE DATA CARD LISTINGS

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$K^*(892)$ 18 K*(892,JP=1-) I=1/2

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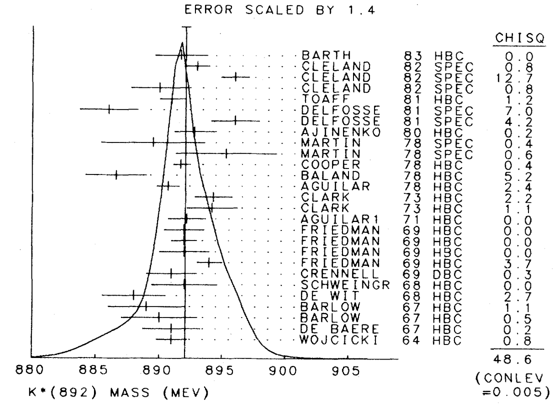
                 18  K*(892) MASS (MEV)

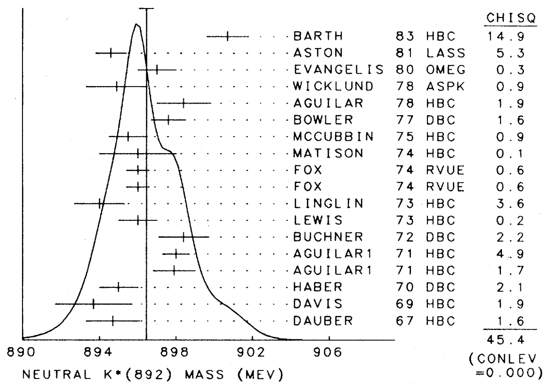
M   CHARGED ONLY. THIS IS WHAT APPEARS ON MESON TABLE
M   W  1700  891.0      1.2          WOJCICKI  64 HBC   -  1.7 K-P(K0 PI-) 12/75
M     D 620  891.       2.3          DE BAERE  67 HBC  +  3.5 K+P (K0 PI+) 12/75
M       720  890.       3.0          BARLOW    67 HBC  +- 1.2 PBARP(K0 PI) 12/75
M       600  889.       3.0          BARLOW    67 HBC  +- 1.2 PBARP(K PI)  12/75
M     D 540  888.       2.5          DE WIT    68 HBC   - 3.0 K-P          12/75
M     D 341  892.0      2.6          SCHWEINGR 68 HBC   -  5.5 K-P(K0 PI-) 12/75
M      1000  891.0      2.0          CRENNELL  69 DBC   -  3.9 K-N (K0PI-) 12/75
M      2886  894.       1.0          FRIEDMAN  69 HBC   -  2.1 K-P(K0 PI-) 12/75
M       728  892.       2.           FRIEDMAN  69 HBC   - 2.45 K-P(K0 PI-) 12/75
M      3229  892.       1.0          FRIEDMAN  69 HBC   - 2.6  K-P(K0 PI-) 12/75
M     D1027  892.       1.6          FRIEDMAN  69 HBC   - 2.7  K-P(K0 PI-) 12/75
M      4404  892.2      1.5          AGUILAR1  71 HBC   -  3.9,4.6 K- P    11/71
M     D 765  894.2      2.0          CLARK     73 HBC   - 3.13 K-P(K0 PI-) 12/75
M   W D1150  894.3      1.5          CLARK     73 HBC  -  3.3 K-P,P PI- K0 12/75
M    I 9000 (891.9)    (0.7)         PALER     75 HBC   - 14.3 K-P,K*- X+  12/75
M      1800  890.7      0.9          AGUILAR   78 HBC  +- .76 PB P,K KS PI 12/78
M      1225  886.6      2.4          BALAND    78 HBC  +- 12 PB P,INCLUSIV  4/78
M      6706  891.7      0.6          COOPER    78 HBC  +- .76 PB P,INCLUSV  4/78
M   X        895.3      4.0          MARTIN    78 SPEC +  10 K+-P,KS PI P  12/78
M   X        889.5      4.1          MARTIN    78 SPEC -  10 K+-P,KS PI P  12/78
M            892.8      1.6          AJINENKO  80 HBC  +  32 K+P            9/81
M       380  896.0      1.9          DELFOSSE  81 SPEC +  K+-P,K+- PI0 P    1/82
M       187  886.0      2.3          DELFOSSE  81 SPEC -  K+-P,K+- PI0 P    1/82
M      4100  891.0      1.0          TOAFF     81 HBC  -  6.5 K-P,K0 PI- P  1/82
M   W D 800  890.0      2.3          CLELAND   82 SPEC +  30 K+P,KS PI+P    8/83*
M   W D3200  896.0      1.1          CLELAND   82 SPEC +  50 K+P,KS PI+P    8/83*
M   W D3600  893.0      1.0          CLELAND   82 SPEC  - 50 K+P,KS PI-P    8/83*
M      3700  891.7      2.1          BARTH     83 HBC  +  70 K+P,K0 PI+ X  12/83*
M
M    AVG     892.08     0.37    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
                                (SEE IDEOGRAM BELOW)
```

WEIGHTED AVERAGE = 892.08 ± 0.37
ERROR SCALED BY 1.4




```
M   NEUTRAL ONLY.
M     D1040  894.7      1.4          DAUBER    67 HBC    02.0 K-P(K-PI+)   12/75
M       10K  893.7      2.0          DAVIS     69 HBC    0 12. K+P(K+PI-)  12/75
M   W  4300  895.0      1.0          HABER     70 DBC    0 3. K-N (K-PI+)  12/75
M     D2934  897.9      1.1          AGUILAR1  71 HBC    0 3.9,4.6 K- P    12/75
M     D5362  898.0      0.7          AGUILAR1  71 HBC    0 3.9,4.6 K- P    12/75
M     D1700  898.4      1.3          BUCHNER   72 DBC    04.6 K+ N,K+ PI-  12/72
M      3186  896.0      1.0          LEWIS     73 HBC    02.1-2.7 K+P       2/74
M     C      894.0      1.3          LINGLIN   73 HBC    02-13 K+P,K+PI-   12/75
M       10K  896.0      0.6          FOX       74 RVUE   0 2 K-P,K-PI+N    12/75
M            896.0      0.6          FOX       74 RVUE   0 2 K+N,K+PI-P    12/75
M     C      896.       2.           MATISON   74 HBC    012 K+P,K+PI-     12/75
M      3600  895.5      1.0          MCCUBBIN  75 HBC    0 3.6 K-P,K-PI+N  12/75
M    I  22K (897.1)    (0.7)         PALER     75 HBC    014.3 K-P,K*0 X0  12/75
M            897.6      0.9          BOWLER    77 DBC    05.4 K+D,K+PI-P P 12/77
M      1180  898.4      1.4          AGUILAR   78 HBC   0 .76 PB P,K KS PI 12/78
M    P      (895.7)    (0.3)         ESTABROOK 78 ASPK   013 K+-P,K+-PI+-  12/77
M            894.9      1.6          WICKLUND  78 ASPK  0 3,4,6 PI+-PN      4/78
M    C      (892.8)    (1.3)         LANG      79 RVUE  0                   1/82
M       28K  897.       1.           EVANGELIS 80 OMEG  0 10 PI-P           9/81
M            894.6       .8          ASTON     81 LASS  0 11 K-P,K- PI+ N   1/82
M      5900  900.7      1.1          BARTH     83 HBC   0 70 K+P,K+ PI- X  12/83*
M
M    AVG     896.45     0.37    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)
                                (SEE IDEOGRAM BELOW)
```

WEIGHTED AVERAGE = 896.45 ± 0.37
ERROR SCALED BY 1.6




```
M     C  FROM POLE EXTRAPOLATION.
M     D  MASS ERRORS ENLARGED BY US TO   GAMMA/SQRT(N). SEE TYPED NOTE.
M    I   INCLUSIVE REACTION. COMPLICATED BACKGROUND AND PHASE-SPACE EFFECTS
M  P     FROM PHASE SHIFT ANALYSIS OF 155000 EVENTS.
M  W     NUMBER OF EVENTS IN PEAK REEVALUATED BY US
M  X     SYSTEMATIC ERROR ADDED
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NOTE ON K*(892) MASSES AND MASS DIFFERENCES

Unrealistically small errors are reported by some experiments. We use simple "realistic" tests for the minimum errors on the determination of mass and width from a sample of N events:

$$\delta_{\min}(m) = \frac{\Gamma}{\sqrt{N}}\ , \quad \delta_{\min}(\Gamma) = 4\frac{\Gamma}{\sqrt{N}}\ .$$

(For a detailed discussion, see the 1971 edition of this note.) We consistently increase unrealistic errors before averaging.

```
                     18  K*(0) - K*(+-) MASS DIFF. (MEV)

D  W   283    6.3      4.1             BARASH    67 HBC      0 PBAR P          12/75
D   SD1400   (6.5)    (5.0)            FICENEC1  68 HBC        1.3 K- P        12/75
D   SD1600   (9.5)    (5.0)            FICENEC2  68 HBC        2.7 K- P        12/75
D     7338    5.7      1.7             AGUILAR1  71 HBC    -0 3.9,4.6 K- P     11/71
D     2980    7.7      1.7             AGUILAR   78 HBC   +- .76 PB P,K KS PI  12/78
D           . . . . . . . . . . .
D   AVG       6.7      1.2      AVERAGE

D     D  MASS ERRORS ENLARGED BY US TO   GAMMA/SQRT(N). SEE TYPED NOTE.
D    S   DATA WITH MASS ERROR OF 3 MEV OR MORE NOT AVERAGED
D  W     NUMBER OF EVENTS IN PEAK REEVALUATED BY US

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                     18  K*(892) WIDTH (MEV)

W  CHARGED ONLY. THIS IS WHAT APPEARS ON MESON TABLE
W  W D1700   46.0     5.0             WOJCICKI  64 HBC   -  1.7 K-P(K0 PI-)  12/75
W    D 620   56.0     9.0             DE BAERE  67 HBC   +  3.5 K+P(K0 PI+)  12/75
W      720   43.      9.0             BARLOW    67 HBC  +- 1.2 PBARP(K0 PI)  12/75
W    D 600   53.      9.0             BARLOW    67 HBC  +- 1.2 PBARP(K PI)   12/75
W    D 540   44.0     8.0             DE WIT    68 DBC   -  3. K- D          12/75
W    D2886   53.      4.0             FRIEDMAN  69 HBC   -  2.1 K-P(K0 PI-)  12/75
W    D 728   49.      7.3             FRIEDMAN  69 HBC   -  2.45K-P(K0 PI-)  12/75
W    D3229   46.      3.2             FRIEDMAN  69 HBC   -  2.6 K-P(K0 PI-)  12/75
W    D1027   49.      6.1             FRIEDMAN  69 HBC   -  2.7 K-P(K0 PI-)  12/75
W    D4404   54.3     3.3             AGUILAR1  71 HBC   -  3.9,4.6 K- P     12/75
W    D 765   46.3     6.7             CLARK     73 HBC  -  3.13K-P,P PI- K0  12/75
W  W D1150   48.2     5.7             CLARK     73 HBC  -  3.3 K-P,P PI- K0  12/75
W   I 9000  (52.1)   (2.2)            PALER     75 HBC   - 14.3 K-P,K*- X+   12/75
W     1800   45.8     3.6             AGUILAR   78 HBC  +- .76 PB P,K KS PI  12/78
W     1225   43.0     8.4             BALAND    78 HBC  +- 12 PB P,INCLUSIV   4/78
W    D6706   52.0     2.5             COOPER    78 HBC  +- .76 PB P,INCLUSV   4/78
W            50.9     2.3             MARTIN    78 SPEC +  10 K+-P,KS PI P   12/78
W            50.5     5.6             AJINENKO  80 HBC  +  32 K+P             9/81
W      380   62.6     3.8             DELFOSSE  81 SPEC +  K+-P,K+- PI0 P     1/82
W      187   50.5     3.9             DELFOSSE  81 SPEC -  K+-P,K+- PI0 P     1/82
W     4100   51.0     2.0             TOAFF     81 HBC  -  6.5 K-P,K0 PI- P   1/82
W  W D 800   64.0     9.2             CLELAND   82 SPEC +  30 K+P,KS PI+P     8/83*
W  W D3200   62.0     4.4             CLELAND   82 SPEC +  50 K+P,KS PI+P     8/83*
W  W D3600   55.0     4.0             CLELAND   82 SPEC  - 50 K+P,KS PI-P     8/83*
W     3700   42.8     7.1             BARTH     83 HBC  +  70 K+P,K0 PI+ X   12/83*
W           . . . . . . . . . . .
W   AVG      51.26    0.95     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
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W  NEUTRAL ONLY.
W    D1040   44.        5.5             DAUBER    67 HBC    0  2.0 K- P       12/75
W    D 10K   53.2       2.1             DAVIS     69 HBC    0 12. K+P(K+PI-)  12/75
W  W D4300   54.0       3.3             HABER     70 DBC    0 3. K-N (K-PI+)  12/75
W     2934   55.8       4.2      3.4    AGUILAR1  71 HBC    0 3.9,4.6 K- P    11/71
W    D5362   48.5       2.7             AGUILAR1  71 HBC    0 3.9,4.6 K- P    12/75
W    D1700   51.4       5.0             BUCHNER   72 DBC    04.6 K+ N,K+ PI-P 12/72
W    D3186   46.0       3.3             LEWIS     73 HBC    02.1-2.7 K+P      12/75
W   C       (46.5)     (1.5)            LINGLIN   73 HBC    02-13 K+P,K+PI-    1/74
W      10K   47.        2.              FOX       74 RVUE   0 2 K-P,K-PI+N    12/75
W            51.        2.              FOX       74 RVUE   0 2 K+N,K+PI-P    12/75
W   C       (47.)      (3.)             MATISON   74 HBC    012 K+P,K+PI-     12/75
W     3600   48.        3.       2.     MCCUBBIN  75 HBC    0 3.6 K-P,K-PI+N  12/75
W   I  22K  (50.6)     (2.5)            PALER     75 HBC    014.3 K-P,K*0 X0  12/75
W            48.9       2.5             BOWLER    77 DBC    05.4 K+D,K+PI-P P 12/77
W     1180   45.9       4.8             AGUILAR   78 HBC   0 .76 PB P,K KS PI 12/78
W   P       (52.9)     (0.4)            ESTABROOK 78 ASPK   013 K+-P,K+-PI+-  12/77
W            51.2       1.7             WICKLUND  78 ASPK  0 3,4,6 PI+-PN      4/78
W   C       (40.1)     (6.0)            LANG      79 RVUE  0                   1/82
W      28K   54.        2.              EVANGELIS 80 OMEG  0 10 PI-P           9/81
W            49.8       1.2             ASTON     81 LASS  0 11 K-P,K- PI+ N   1/82
W     5900   46.5       4.3             BARTH     83 HBC   0 70 K+P,K+ PI- X  12/83*
W           . . . . . . . . . . .
W   AVG      50.24      0.65     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)

W     C  FROM POLE EXTRAPOLATION.
W     D  WIDTH ERRORS ENLARGED BY US TO 4*GAMMA/SQRT(N). SEE TYPED NOTE.
W    I   INCLUSIVE REACTION. COMPLICATED BACKGROUND AND PHASE-SPACE EFFECTS
W  P     FROM PHASE SHIFT ANALYSIS OF 155000 EVENTS.
W  W     NUMBER OF EVENTS IN PEAK REEVALUATED BY US

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                     18  K*(892) PARTIAL DECAY MODES

                                                           DECAY MASSES
P1    K*(892) INTO K PI                                    494+ 140
P2    K*(892) INTO K PI PI                                 494+ 140+ 140
P3    K*(892) INTO K GAMMA                                 494+   0

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                     18  K*(892) PARTIAL WIDTHS (KEV)

W3    K*(892) INTO (K GAMMA)                       (G3)
W3          48.0      11.0          BERG      83 SPEC -  156 K-A,K PI A    1/82
W3          51.0       5.0          CHANDLEE  83 SPEC +  200 K+A,K PI A    9/83*
W3        . . . . . . . . .
W3   AVG    50.5       4.6     AVERAGE

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                     18  K*(892) BRANCHING RATIOS

R1    K*(892) INTO (K PI PI)/(K PI)                 (P2)/(P1)
R1      0    (0.002)OR LESS          WOJCICKI2 64 HBC   -  1.7 K-P
R1      0    (0.0007)R LESS  CL=0.95  JONGEJANS 78 HBC     4 K-P,P K0 2PI    4/78

R2    K*(892)  INTO (K  GAMMA)/TOTAL  (UNITS 10**-3)   (P3)
R2          (1.6)  OR LESS  CL=.95   BEMPORAD  72 CNTR +  10.-16. K+A,COUL  1/73
R2           1.5       0.7           CARITHERS 75 CNTR  0 8-16K0BAR A,COUL 12/75

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                     REFERENCES FOR K*(892)

ALSTON    61 PRL 6 300            ALSTON,ALVAREZ,EBERHARD,GOOD,GRAZIANO+(LRL)

ALEXANDE 62 PRL 8 447             ALEXANDER,KALBFLEISCH,MILLER,G SMITH  (LRL)
COLLEY    62 CERN CONF 315        D COLLEY,N GELFAND +     (COLUMBIA+RUTGERS)

CHADWICK 63 PL 6 309              CHADWICK,CRENNELL,DAVIES,BETTINI+(OXF+PADO)
GOLDHABE 63 ATHENS CONF 92        SULAMITH GOLDHABER                    (LRL)

WOJCICKI 64 PR 135 B 484          STANLEY G WOJCICKI                    (LRL)

ADELMAN   65 ATHENS 527           STUART LEE ADELMAN              (CAVENDISH)
FERRO-LU 65 NC 36 1101            FERRO-LUZZI,GEORGE,HENRI,JONGEJANS   (CERN)
FERRO-LU 65 NC 39 417             FERRO-LUZZI,GEORGE,GOLDSCHMIDT-CLER+ (CERN)
GELSEMA   65 THESIS               E.S.GELSEMA (SEE ALSO PL 10 341)(AMSTERDAM)
WANGLER   65 PR 137 B 414         WANGLER,ERWIN,WALKER              (WISCONSIN)

BARASH    67 PR  156  1399        BARASH,KIRSCH,MILLER,TAN          (COLUMBIA)
BARLOW    67 NC  50 A  701        +MONTANET,D-ANDLAU+   (CERN+CDEF+IRAD+LIVP)
BOMSE     67 PR 158 1298          +BORENSTEIN+COLE+GILLESPIE+  (JOHN HOPKINS)
CONFORTO 67 NP B3 469             +MARECHAL,MONTANET+CERN+CDEF+IPN+LIVERPOOL
DAUBER    67 PR 153 1403          +SCHLEIN,SLATER,TICHO                (UCLA)
DE BAERE 67 NC 51 A 401           +GOLDSCHMIDT-CLERMONT,HENRI+    (BRUX+CERN)
FRENCH    67 NC 42A 442           +KINSON+MCDONALD+RIDDIFORD+     (CERN+BIRM)
GEORGE    67 NC 49A 9             +GOLDSCHMIDT-CLERMONT+HENRI+    (CERN+BRUX)
SALLSTRO 67 NC 49A 348            SALLSTROM+OTTER+EKSPONG         (STOCKHOLM)

DE WIT    68  THESIS              S. DE WIT                       (AMSTERDAM)
FICENEC1 68 PR 169 1034           +HULSIZER+SWANSON+TROWER              (ILL)
FICENEC2 68 PR 175 1725           FICENEC, GORDON, TROWER          (ILLINOIS)
KANG      68 PR 176 1587          Y.W.KANG                             (IOWA)
SCHWEING 68 PR 166 1317           SCHWEINGRUBER,DERRICK,FIELDS+    (ANL+NWES)

CRENNELL 69 PRL 22  487           +KARSHON,LAI,ONEALL,SCARR             (BNL)
DAVIS     69 PRL 23 1071          +DERENZO,FLATTE,ALSTON,LYNCH,SOLMITZ  (LRL)
DE BAERE 69 NC 61 A 397           +GOLDSCHMIDT-CLERMONT,HENRI,+   (BELG+CERN)
FRIEDMAN 69  UCRL-18860           J.FRIEDMAN,PH.D. THESIS               (LRL)
JUHALA    69 PR 184  1461         +LEACOCK,RHODE,KOPELMAN,LIBBY,+  (ISU+COLO)
LIND      69 NP B 14 1            +ALEXANDER,FIRESTONE,FU,GOLDHABER     (LRL) JP

ATHERTON 70 NP B 16 416           +FRANEK,FRENCH,FRISK,BEDNAR+    (CERN+PRAG)
HABER     70 NP B 17 289          +SHAPIRA,ALEXANDER+   (REHO+SACL+BGNA+EPOL)

AGUILAR   71 PRL 26 466           +BARNES,BASSANO,EISNER,KINSON,SAMIOS  (BNL)
AGUILAR1 71 PR D 4 2583           +EISNER,KINSON                        (BNL)
BARNHAM   71 NP B 28 171          +COLLEY,JOBES,GRIFFITHS,HUGHES,+(BIRM+GLAS)
BUCHNER   71 NP B 29 381          +DEHM,GOEBEL,GOLDSCHMIDT,+ (MPIM+CERN+BELG)
CORDS     71 PR D 4 1974          +CARMONY,ERWIN,MEIERE,+     (PURD+UCD+IUPU)
MERCER    71 NP B32 381           +ANTICH,CALLAHAN,CHIEN,COX,+ (JOHN HOPKINS)
YUTA      71 PRL 26 1502          +DERRICK,ENGELMANN,MUSGRAVE         (ANL+EFI)

ABRAMOVI 72 NP B 39 189           ABRAMOVICH,CHALOUPKA,CHUNG,HILPERT,+ (CERN)
BINGHAM   72 NP B 41 1            +             (INTERNATIONAL K+ COLLABORATION)
BEMPORAD 72 NP B 51 1             +BEUSCH,FREUDENREICH,+      (CERN+ETH+LOIC)
BRUNET    72 NP B 37 114          +DANYSZ,GOLDSACK,+     (CDEF+SACL+LOIC+LOWC)
BUCHNER   72 NP B 45 333          +DEHM,CHARRIERE,CORNET,+   (MPIM+CERN+BRUX)
CRENNELL 72 PR D 6 1220           +GORDON,KWAN-WU LAI,SCARR             (BNL)
DEUTSCHM 72 NP B 36 373           DEUTSCHMANN,+          (ABCLV COLLABORATION)
ENGELMAN 72 PR D 5 2162           ENGELMANN,MUSGRAVE,FORMAN,+         (ANL+EFI)
ROUGE     72 NP B 46 29           +VIDEAU,VOLTE,DE BRION,+           (EPOL+SACL)
TIECKE    72 NP B 39 596          +GRIJNS,HEINEN,DE GROOT,+          (NIJM+AMST)
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BERTHON 73 NP B 63 54 +MONTANET,PAUL,BERTRANET,+ (CERN+SACL)
CHARRIER 73 NP B 51 317 CHARRIERE,DRIJARD,DE BAERE,+ (CERN+BELG)
CLARK 73 NP B 54 432 +LYONS,RADOJICIC (OXFORD)
LEWIS 73 NP B 60 283 +ALLEN,JACOBS,DANYSZ,BORG,+(LOWC+LOIC+CDEF)
LINGLIN 73 NP B 55 408 D.LINGLIN (CERN)
WALUCH 73 PR D 8 2837 +FLATTE,FRIEDMAN (LBL)

FOX 74 NP B80 403 G.C.FOX,M.L.GRISS (CIT)
MATISON 74 PR D9 1872 +GALTIERI,GARNJOST,FLATTE,FRIEDMAN,+ (LBL)

BRANDENB 75 PL 59 B 405 BRANDENBURG,CARNEGIE,CASHMORE,DAVIER+(SLAC)
CARITHER 75 PRL 35 349 CARITHERS,MUHLEMANN,UNDERWOOD,+ (ROCH+MCGI)
MCCUBBIN 75 NP B86 13 N.A.MCCUBBIN,L.LYONS (OXF)
PALER 75 NP B96 1 +TOVEY,SHAH,SPIRO,CHAURAND+(RHEL+SACL+EPOL)

KIRK 76 NP B 116 99 +KLEIN,COUNIHAN,+(AACH+BERL+CERN+LOIC+WIEN)

BOWLER 77 NP B 126 31 +DAINTON,DRAKE,WILLIAMS (OXFORD)

AGUILAR 78 NP B 141 101 +FERNANDEZ,COOPER,+ (MADR+TIFR+CERN+CDEF)
BALAND 78 NP B 140 220 +GRARD,JOHNSON,+ (MONS+BELG+CERN+LOIC+LALO)
BALDI 78 NP B 134 365 +BOHRINGER,DORSAZ,HUNGERBUHLER+ (GEVA)
COOPER 78 NP B 136 365 +GURTU,DOBRZYNSKI,+ (TIFR+CERN+CDEF+MADR)
ENGELEN 78 NP B 134 14 +JONGEJANS,HEMINGWAY,+ (NIJM+ZEEM+CERN+OXF)
ESTABROO 78 NP B 133 490 ESTABROOKS,CARNEGIE,+ (MONT+CARL+DURH+SLAC)
ALSO 78 PR D 17 658 ESTABROOKS,CARNEGIE+ (MONT+CARL+DURH+SLAC)
JONGEJAN 78 NP B 139 383 JONGEJANS,CERRADA,+ (ZEEM+CERN+NIJM+OXF)
MARTIN 78 NP B 134 392 +SHIMADA,BALDI,BOHRINGER,DORSAZ+(DURH+GEVA)
WICKLUND 78 PRD 17 1197 +AYRES,DIEBOLD,GREENE,KRAMER,PAWLICKI (ANL)
LANG 79 PR D 19 956 C.B.LANG,A.MAS-PARAREDA (GRAZ)

AJINENKO 80 ZPHY 5 177 +BARTH,DUJARDIN,+ (SERP+LIBH+MONS+SACL)
EVANGELI 80 NP B 165 383 + (BARI+BONN+CERN+DARE+GLAS+LIVP+MILA+WIEN)

ASTON 81 PL 106 B 235 +CARNEGIE,DUNWOODIE,DURKIN+(SLAC+CARL+OTTA) JP
BERG 81 PL 98 B 119 +CHANDLEE,BIEL,HEPPELMANN,+(ROCH+FNAL+MINN)
DELFOSSE 81 NP B 183 349 +GUISAN,MARTIN,MUHLEMANN,WEILL,+(GEVA+LAUS)
TOAFF 81 PR D 23 1500 +MUSGRAVE,AMMAR,DAVIS,ECKLUND,+ (ANL+KANS)

CLELAND 82 NP B 208 189 +DELFOSSE,DORSAZ,GLOOR(DURH+GEVA+LAUS+PITT)

BARTH 83 NP B 223 296 +DREVERMANN+(BRUX+CERN+GENO+MONS+NIJM+SERP)
BERG 83 THESIS D.BERG (ROCH)
CHANDLEE 83 COO 3065 354 +BERG,CIHANGIR,COLLICK+ (ROCH+FNAL+MINN)

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Q(1280) or Q_1

28 Q(1280,JP=1+) I=1/2

NOTE ON THE Q(1280) AND Q(1400)

We no longer use the subscripts 1 and 2 on the Q states.

Since all the recent high-statistics experiments investigating the partial-wave contents of the $K\pi\pi$ system diffractively produced on protons (BRANDENBURG 76, OTTER 76, VERGEEST 79, DAUM 81) give consistent evidence for the existence of two strangeness-one axial vector mesons, we have split the "Q region" entry into two entries: one for the Q(1280) resonance, with a mass around 1280 MeV, a width of the order of 100 MeV, and coupled mainly to the $K\rho$ channel; and another one for the Q(1400) resonance, with a mass around 1400 MeV, a width of the order of 180 MeV, and coupled mainly to the $K^*(892)\pi$ channel.

Notice that, whereas both Q(1280) and Q(1400) are produced in diffractive processes, the nondiffractive reactions (ARMENTEROS 64, CRENNELL 67,72, ASTIER 69, GAVILLET 78, ETKIN 80, RODEBACK 81, BAUBILLIER 82) select preferentially the production of one of the two states.

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28 Q(1280) MASS (MEV)

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M     PRODUCED BY BEAMS OTHER THAN K MESONS
M  A      1242.0     9.0     10.0  ASTIER     69 HBC    0 PBAR P            9/69
M  A  THIS IS THE C MESON.
M     45(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    310(1294.)    (10.)           RODEBACK   81 HBC     4 PI-P,LAM K 2PI   1/82
M     PRODUCED BY K-, BACKWARDS SCATTERING, HYPERON EXCHANGE
M       700 1275.0     10.0          GAVILLET  78 HBC  +  4.2 K-P,XI-KPIPI  4/78

M     PRODUCED BY K BEAMS
M           (1260.)                  DAVIS     72 HBC  +  12. K+ P          12/72
M           (1234.)     (12.)        FIRESTONE 72 DBC  +  12. K+ D           2/73
M           (1300.)    APPROX.       BRANDENB  76 ASPK +- 13 K+-P,(KPIPI)P 12/75
M     E     (1289.0)    (25.0)       CARNEGIE  77 ASPK +- 13 K+-P,P KPIPI   12/77
M           (1270.0)   APPROX.       OTTER     76 HBC   - 10-14-16K-P       12/77
M           (1300.0)   APPROX.       VERGEEST  79 HBC  +- 4.2 K-P,K PI PI   12/79
M            1270.       10.         DAUM      81 CNTR -  63 K-P,K 2PI P     1/82
M     T     (1276.0)   APPROX        TORNQVIST 82 RVUE                       9/83*

M     E   FROM A MODEL DEPENDENT FIT WITH GAUSSIAN BACKGROUND TO
M     E   BRANDENBURG 76 DATA.
M     T   FROM A UNITARIZED QUARK MODEL CALCULATION
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28 Q(1280) WIDTH (MEV)

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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      310  (66.)     (15.)          RODEBACK  81 HBC     4 PI-P,LAM K 2PI   1/82
W     PRODUCED BY K-, BACKWARDS SCATTERING, HYPERON EXCHANGE
W      700   75.0     15.0           GAVILLET  78 HBC  +  4.2 K-P,XI-KPIPI   4/78

W     PRODUCED BY K BEAMS
W           (120.)                   DAVIS     72 HBC  +  12. K+ P          12/72
W           (188.)     (21.)         FIRESTONE 72 DBC  +  12. K+ D          12/75
W           (200.)    APPROX.        BRANDENB  76 ASPK +- 13 K+-P,(KPIPI)P 12/75
W     E     (150.00)  (71.0)         CARNEGIE  77 ASPK +- 13 K+-P,P KPIPI   12/77
W           (150.0)   APPROX.        VERGEEST  79 HBC  +- 4.2 K-P,K PI PI   12/79
W             90.        8.          DAUM      81 CNTR -  63 K-P,K 2PI P     1/82

W     E   SEE NOTE E ABOVE.
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28 Q(1280) PARTIAL DECAY MODES

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                                                         DECAY MASSES
P1       Q(1280) INTO K*(892) PI                        892+ 140
P2       Q(1280) INTO K RHO                             498+ 769
P3       Q(1280) INTO K PI                              498+ 140
P4       Q(1280) INTO K ETA                             498+ 549
P5       Q(1280) INTO K OMEGA                           498+ 783
P6       Q(1280) INTO K PI PI                           498+ 140+ 140
P7       Q(1280) INTO KAPPA(1350) PI                   1350+ 140
P8       Q(1280) INTO K EPSILON(1300)                   498+1300
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28 Q(1280) PARTIAL WIDTHS (MEV)

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W1       Q(1280) INTO K*(892) PI                        (G1)
W1             2.0        2.0        CARNEGIE1 77 ASPK +- 13 K+-P,(KPIPI)P 12/78
W1            14.0       11.0        MAZZUCATO 79 HBC  +  4.2 K-P,XI-KPIPI 12/79
W1           . . . . . . . . . .
W1   AVG       2.4        2.0     AVERAGE

W2       Q(1280) INTO K RHO                             (G2)
W2            75.0        6.0        CARNEGIE1 77 ASPK +- 13 K+-P,(KPIPI)P 12/78
W2            57.0        5.0        MAZZUCATO 79 HBC  +  4.2 K-P,XI-KPIPI 12/79
W2           . . . . . . . . . .
W2   AVG      64.4        8.9     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.3)

W5       Q(1280) INTO K OMEGA                           (G5)
W5            24.0        3.0        CARNEGIE1 77 ASPK +- 13 K+-P,(KPIPI)P 12/78
W5             4.0        4.00       MAZZUCATO 79 HBC  +  4.2 K-P,XI-KPIPI 12/79
W5           . . . . . . . . . .
W5   AVG      16.8        9.6     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 4.0)

W7       Q(1280) INTO KAPPA(1350) PI                    (G7)
W7            26.0        6.0        CARNEGIE1 77 ASPK +- 13 K+-P,(KPIPI)P 12/78

W8       Q(1280) INTO EPSILON(1300) K                   (G8)
W8            22.0        5.0        CARNEGIE1 77 ASPK +- 13 K+-P,(KPIPI)P 12/78
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28 Q(1280) BRANCHING RATIOS

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R1       Q(1280) INTO K*(892) PI                        (P1)
R1 F          0.16       0.05        DAUM      81 CNTR    63 K-P,K 2PI P     1/82

R2       Q(1280) INTO K RHO                             (P2)
R2 F          0.42       0.06        DAUM      81 CNTR    63 K-P,K 2PI P     1/82
R2          DOMINANT                 RODEBACK  81 HBC     4 PI-P,LAM K 2PI   1/82

R3       Q(1280) INTO K OMEGA                           (P5)
R3 F          0.11       0.02        DAUM      81 CNTR    63 K-P,K 2PI P     1/82

R4       Q(1280) INTO KAPPA(1350) PI                    (P7)
R4 F          0.28       0.04        DAUM      81 CNTR    63 K-P,K 2PI P     1/82

R5       Q(1280) INTO K EPSILON(1300)                   (P8)
R5 F          0.03       0.02        DAUM      81 CNTR    63 K-P,K 2PI P     1/82

R6       Q(1280) INTO (K OMEGA)/(K RHO)                 (P5)/(P2)
R6          (0.30) OR LESS  CL=.95   RODEBACK  81 HBC     4 PI-P,LAM K 2PI   1/82

R9       D/S RATIO FOR Q(1280) INTO K*(892) PI
R9 F          1.0        0.7         DAUM      81 CNTR    63 K-P,K 2PI P     1/82

R  F     AVERAGE FROM LOW AND HIGH T DATA.
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REFERENCES FOR Q(1280)

ARMENTER 64 DUBNA CONF 1 577 ARMENTEROS,EDWARDS,D-ANDLAU + (CERN+CDEF)
ALSO 64 DUBNA CONF 1 617 R ARMENTEROS (RAPPORTEUR)
ARMENTER 64 PL 9 207 ARMENTEROS,EDWARDS,D-ANDLAU,+ (CERN+CDEF)
ALSO 66 PR 145 1095 BARASH,KIRSCH,MILLER,TAN (COLUMBIA)

ALMEIDA 65 PL 16 184 ALMEIDA,ATHERTON,BYER,DORNAN,FORSON+ (CAVE)

SHEN 66 PRL 17 726 +BUTTERWORTH,FU,GOLDHABERS,TRILLING (LRL)
ALSO 66 PRIVATE COMM. GERSON GOLDHABER (LRL)

Mesons

Data Card Listings

Q(1280) [Q_1], κ(1350)


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BASSOMPI 67 PL 26B 30          BASSOMPIERRE,GOLDSCHMIDT+  (CERN+BRUX+BIRM)IJP
BERLINGH 67 PRL 18 1087        BERLINGHIERI+FARBER+FERBEL+FORMAN    (ROCH)IJP
CRENNELL 67 PRL 19  44         +KALBFLEISCH,LAI,SCARR,SCHUMANN       (BNL)I
DE BAERE 67 NC 49A 374         +DEBAISIEUX+FAST+FILIPPAS+     (CERN+BRUX)
   ALSO PRIVATE COMMUNICATION BY B. JONGEJANS
GOLDHABE 67 PRL 19 976         G.GOLDHABER                           (LBL)

BARTSCH  68 NP B8 9            +COCCONI,+         (AACH+BERL+CERN+LOIC+VIEN)
BOMSE    68 PRL 20 1519        +BORENSTEIN,CALLAHAN,COLE,COX,+  (JOHNHOPK)  1+
DENEGRI  68 PRL 20 1194        +CALLAHAN+ETTLINGER+GILLESPIE+   (JOHNHOPK)  1+

ALEXANDE 69 NP B 13 503        G.ALEXANDER,FIRESTONE,GOLDHABER,+      (LRL)
ANDREWS  69 PRL 22 731         +LACH,LUDLAM,SANDWEISS,BERGER,+  (YALE+LRL)
ASTIER   69 NP B 10 65         +MARECHAL,MONTANET,+  (CDEF+CERN+IPNP+LIVP)IJP
BARBARO  69 PRL 22 1207        BARBARO-GALTIERI,DAVIS,FLATTE,+        (LRL)
BETTINI  69 NC 62 A 1038       +CRESTI,LIMENTANI,BERTAUZA,BIGI+(PADO+PISA)I
BISHOP   69 NP B 9 403         +GOSHAW,ERWIN,WALKER                  (WISC)
CHIEN    69 PL 29B 433         +MALAMUD,MELLEMA,RUDNICK,SCHLEIN+     (UCLA)
CHUNG    69 PR 182 1443        +EISNER+BALI+LUERS                     (BNL)
COLLEY   69 NC A 59 519        +EASTWOOD,+  (BIRM+GLAS+LOIC+MPIM+OXF+RHEL)
ERWIN    69 NP B 9 364         +WALKER,GOSHAW,WEINBERG     (WISC+PRIN+VAND)
FRIEDMAN 69  UCRL-18860        J.FRIEDMAN,PH.D. THESIS                (LRL)
WERNER   69 PR 188 2023        +AMMAR,DAVIS,KROPAC,YARGER,CHO,+ (NWES+ANL) 1+

ABRAMS   70 PR D 1 2433        +EISENSTEIN,KIM,MARSHALL,O-HALLORAN,+ (ILL)
ANTICH   70 NP B 20 201        +CARSON,CHIEN,COX,DENEGRI,ETTLINGER,+ (JHU)  1+
BOWLER   70 PL 31 B 318        M.G.BOWLER                          (OXFORD)
FARBER   70 PR D 1 78          +FERBEL,SLATTERY,YUTA                 (ROCH)  1+

BARNHAM  71 NP B25 49          +COLLEY,GRIFFITHS,ALPER, +  (BIRM+GLAS+OXF)
DENEGRI  71 NP B 28 13         +ANTICH,CALLAHAN,CARSON,CHIEN,COX,+   (JHU)  1+
FORMAN   71 PR D 3 2610        +GELFAND,LEARY,MOSER,SEIDL,WOLFSON    (EFI)
GARFINKE 71 PRL 26 1505        GARFINKEL,HOLLAND,CARMONY,LANDER+(PURD+UCD)  1+

ANDERSON 72 PR D 6 1823        +FRANKLIN,GODDEN,KOPELMAN,LIBBY,TAN  (COLO)
BINGHAM  72 NP B 48 589        +EISENSTEIN,GRARD,HERQUET,+     (CERN+BRUX)
BRANDENB 72 NP B 45 397        BRANDENBURG,BRODY,JOHNSON,LEITH,LOOS+(SLAC)
BRANDENB 72 PRL 28 932         BRANDENBURG,JOHNSON,LEITH,LOOS,LUSTE+(SLAC)
CRENNELL 72 PR D 6 1220        +GORDON,KWAN-WU LAI,SCARR              (BNL)
DAVIS    72 PR D 5 2688        +ALSTON,BARBARO,FLATTE,FRIEDMAN,LYNCH+(LBL)
FIRESTON 72 PR D 5 505         FIRESTONE,GOLDHABER,LISSAUER,TRILLING (LBL)
FIRESTON172 NP B 47 348        A.FIRESTONE                            (CIT)
FRATI    72 PR D 6 2361        +HALPERN,HARGIS,SNAPE,CARNAHAN,+(PENN+CINC)
HAATUFT  72 NP B 48 78         +ARNOLD,HAGUENAUER,+  (BERG+STRB+EPOL+MADR)

BARLOUTA 73 NP B 59 374        +DREVILLON,SHAH,+          (SACL+EPOL+RHEL)  JP
BINGHAM  73 NP B 52 31         +FARWEL,+        (LBL+ORSAY+BNL+SACLAY+MILAN)  JP
DE JONGH 73 NP B 58 110        +CORNET,CHARRIERE,+   (BRUX+MONS+CERN+MPIM)
JONES    73 NP B 52 383        G.T.JONES                             (CERN)  JP
LEWIS    73 NP B 60 283        +ALLEN,JACOBS,DANYSZ,BORG,+(LOWC+LOIC+CDEF)
WERNER   73 PR D 7 1275        +SLATTERY,FERBEL                 (ROCHESTER)

ANGELOPO 74 NC 20A 49          ANGELOPOULOS,FILIPPAS+(ATHU+ATEN+LIVP+VIEN)  JP
BOWLER   74 NP B74 493         +DAINTON,KADDOURA,AITCHISON             (OXF)
DAVIDSON 74 PR D9 77           +CHAPMAN,GREEN,LYS,ROE                 (MICH)
DEUTSCHM 74 PL 49B 388         DEUTSCHMANN,+    (AACH+BERL+CERN+LOIC+VIEN)  JP

ANTIPOV  75 NP B86 381         +ASCOLI,BUSNELLO,KIENZLE+   (SERP+CERN+ILL)  JP
BOWLER   75 NP B97 227         +GAME,AITCHISON,DAINTON            (OXF+DARE)
DORE     75 LNC 13 265         +GUIDONI,LAAKSO,MARINI,CONFORTO+(ROMA+RHEL)
DREVILLO 75 PL 55 B 245        DREVILLON,BORENSTEIN+      (EPOL+BOHR+CDEF)  JP
DUNWOODI 75 NP B91 189         DUNMOODIE,GRANT+      (CERN+BELG+MONS+MPIM)  JP
OTTER1   75 NP B84 333         + (AACH+BERL+CERN+LOIC+VIEN+ATHU+ATEN+LIVP)  JP
OTTER2   75 NP B93 365         +RUDOLPH,RUMPF+  (AACH+BERL+CERN+LOIC+VIEN)  JP
OTTER3   75 NP B96 29          +RUDOLPH,SEYFERT+(AACH+BERL+CERN+LOIC+VIEN)I,JP
TOVEY    75 NP B95 109         +HANSEN,BORENSTEIN,BORG+   (RHEL+EPOL+SACL)I,JP

BASDEVAN 76 PRL 37 977         BASDEVANT,BERGER                  (FNAL+ANL)
BOAL     76 PR D 14 2998       +EDWARDS,KAMAL,TORGESON            (ALBERTA)
BOWLER   76 JPG 3 775          M.G.BOWLER                          (OXFORD)
BRANDENB 76 PRL 26 703         BRANDENBURG,CARNEGIE,CASHMORE,DAVIER+(SLAC)  JP
OTTER    76 NP B 106 77        + (AACH+BERL+CERN+LOIC+VIEN+LPNP+RHEL+SACL)  JP
VERGEEST 76 PL 62 B 471        +ENGELEN,JONGEJANS,+   (AMST+CERN+NIJM+OXF)  JP

CARNEGIE 77 NP B 127 509       +CASHMORE,DAVIER,DUNWOODIE,LASINSKI+ (SLAC)
CARNEGIE177 PL B 68 287        +CASHMORE,DUNWOODIE,LASINSKI,+       (SLAC)

BEUSCH   78 PL 74 B 282        +BIRMAN,KONIGS,OTTER,+      (CERN+AACH+ETH)  JP
GAVILLET 78 PL 76 B 517        +DIAZ,DIONISI,+        (AMST+CERN+NIJM+OXF)  JP
WOHL     78 NP B 132 401       +PALER,CHAURAND,+        (LPNP+RHEL+SACLAY)

BASDEVAN 79 PR D 19 246        BASDEVANT,BERGER                       (ANL)
MAZZUCAT 79 NP B 156 532       MAZZUCATO,PENNINGTON+  (CERN+ZEEM+NIJM+OXF)
VERGEEST 79 NP B 158 265       +JONGEJANS,DIONISI,+   (NIJM+AMST+CERN+OXF)

BACON    80 NP B 162 189       +BARREY,BUTTERWORTH,ANSORGE,+   (LOIC+CAVE)
DIONISI  80 NP B 169 1         +GAVILLET,ARMENTEROS+ (CERN+MADR+CDEF+STOH)
ETKIN    80 PR D 22 42         +FOLEY,LINDENBAUM,KRAMER,+       (BNL+CUNY)  JP
IRVING   80 JPG 6 153          A.C.IRVING                            (LIVP)
RADFORD  80 NP B 167 181       RADFORD,BRANDENBURG                    (MIT)

DAUM     81 NP B 187 1         +HERTZBERGER+(AMST+CERN+CRAC+MPIM+OXF+RHEL)
OTTER    81 NP B 181 1           (AACH+BERL+LOIC+VIEN+BIRM+BELG+CERN+MONS)
RODEBACK 81 ZPHY C 9 9         +SJOGREN,ARMENTEROS,+ (CERN+CDEF+MADR+STOH)

BAUBILLI 82 NP B 202 21        BAUBILLIER+       (BIRM+CERN+GLAS+MSU+LPNP)
FERNANDE 82 ZPHY C 16 95       FERNANDEZ,AGUILAR+    (MADR+CERN+CDEF+STOH)  JP
GAVILLET 82 ZPHY C 16 119      +ARMENTEROS,AGUILAR+  (CERN+CDEF+PADO+ROMA)
TORNQVIS 82 NP B 203 268       TORNQVIST                             (HELS)

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κ(1350)

19 KAPPA(1350,JP=0+) I=1/2

The isodoublet S-wave Kπ phase shift δ_0^1 is compatible with elastic unitarity up to the Kη' threshold. It grows monotonically, reaching 90° at about 1350 MeV (MERCER 71, BINGHAM 72, FIRESTONE 71,72, MATISON 72,74, GALTIERI 73, YUTA 73, FOX 74, BAKER 75, LAUSCHER 75, BOWLER 77, ESTABROOKS 78, ASTON 81). The ambiguous "up" solution in the region of the K*(892) has been ruled out conclusively (MATISON 72,74, GALTIERI 73, BOWLER 77, ESTABROOKS 78).

The first inelastic two-body threshold is Kη, which, however, is very weakly coupled to the κ(1350), in accordance with the SU(3) prediction for the κ(1350)Kη coupling.

In the energy range 1350-1450 MeV, the phase shift exhibits rapid motion (BOWLER 77, ESTABROOKS 78, MARTIN 78), which has been taken as an indication of a κ resonance at 1500 MeV (ESTABROOKS 79). However, the phase-shift behavior can also be understood as a cusp effect due to the nearby Kη' threshold at 1455 MeV (TORNQVIST 82). Above this energy the inelasticity due to Kη' is important. The phase shift can be fitted up to about 1500 MeV in a unitary coupled-channel analysis with proper analytic structure with one resonance, the κ(1350), without background (TORNQVIST 82). This supports earlier interpretations (FIRESTONE 71,72, FRATI 72, ROUGE 72, CORDS 73, LAUSCHER 75, MORGAN 75, ENGELEN 78, ASTON 81) that this κ mass is indeed where δ_0^1 passes through 90°.

At still higher energies some evidence for a second scalar resonance exists (ASTON 81).

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                    19  KAPPA(1350) MASS (MEV)

M   C      (1425.)   APPROX.           ESTABROOK 78 ASPK    13 K+- P           12/77
M          (1450.0)  APPROX.           MARTIN    78 SPEC    10 K+-P,KS PI P    12/78
M   P      (1278.)    (50.)            LANG      79 RVUE  0                     1/82
M          (1400.)   APPROX.           ASTON     81 LASS  0 11 K-P,K- PI+ N     1/82
M   T      (1350.)                     TORNQVIST 82 RVUE    13 K+- P            1/82

M   C   FROM ELASTIC K PI PARTIAL WAVE ANAL. (SEE KAPPA(1350) MINI-REVIEW)
M   P   POLE EXTRAPOLATION USING FIRESTONE 72 AND MATISON 74 DATA.
M   T   FROM A UNITARIZED QUARK MODEL CALCULATION

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                    19  KAPPA(1350) WIDTH (MEV)

W   C       200-300 APPROX.            ESTABROOK 78 ASPK    13 K+- P           12/77
W   P       (540.)   (106.)            LANG      79 RVUE  0                     1/82
W           (250.)   APPROX.           ASTON     81 LASS  0 11 K-P,K- PI+ N     1/82
W   T       (430.)   OR MORE           TORNQVIST 82 RVUE    13 K+- P            1/82

W   C   FROM ELASTIC K PI PARTIAL WAVE ANAL. (SEE KAPPA(1350) MINI-REVIEW)
W   P   POLE EXTRAPOLATION USING FIRESTONE 72 AND MATISON 74 DATA.
W   T   FROM A UNITARIZED QUARK MODEL CALCULATION

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                    19  KAPPA(1350) PARTIAL DECAY MODES

                                                      DECAY MASSES
P1      KAPPA(1350) INTO K PI                        498+ 135
P2      KAPPA(1350) INTO K ETA                       498+ 549
P3      KAPPA(1350) INTO K ETA PRIME                 498+ 958

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                    19  KAPPA(1350) BRANCHING RATIOS

R1      KAPPA(1350) INTO (K PI)/TOTAL                (P1)
R1          (0.85) APPROX.           ASTON     81 LASS  0 11 K-P,K- PI+ N   1/82
R1  T       (0.93) APPROX.           TORNQVIST 82 RVUE    13 K+-P           1/82

R1  T   FROM A UNITARIZED QUARK MODEL CALCULATION

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REFERENCES FOR KAPPA(1350)


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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)
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AGUILAR   72 PR D 6 11          AGUILAR-BENITEZ,CHUNG,EISNER           (BNL)
BINGHAM   72 NP B 41 1          +              (INTERNATIONAL K+ COLLABORATION)
BUCHNER   72 NP B 45 333        +DEHM,CHARRIERE,CORNET,+   (MPIM+CERN+BRUX)
CHUNG     72 PRL 29 1570        +EISNER,AGUILAR-BENITEZ                (BNL)
CRENNELL  72 PR D 6 1220        +GORDON,KWAN-WU LAI,SCARR              (BNL)
DIEBOLD   72 BATAV.CONF. V.3 17R.DIEBOLD  RAPPORTEUR TALK              (ANL)
ENGELMAN  72 PR D 5 2162        ENGELMANN,MUSGRAVE,FORMAN,+        (ANL+EFI)
FIRESTON  72 PR D 5 2188        +GOLDHABER, LISSAUER, TRILLING       (LBL)PWA
FRATI     72 PR D 6 2361        +HALPERN,HARGIS,SNAPE,CARNAHAN,+(PENN+CINC)
MATISON   72 LBL 1537 (THESIS) REVISED VERSION WILL GO TO PHYS.REV.   LBL
ROUGE     72 NP B 46 29         +VIDEAU,VOLTE,DE BRION,+         (EPOL+SACL)

CORDS     73 NP B 54 109        +CARMONY,LANDER,MEIERE,+    (PURD+UCD+IUPU)
GALTIERI  73  LBL 1772          +MATISON,GARNJOST,FLATTE,FRIEDMAN+     (LBL)
LINGLIN   73 NP B 55 408        D.LINGLIN                             (CERN)
YUTA      73 NP B 52 70         +ENGELMANN,MUSGRAVE,FORMAN,+       (ANL+EFI)

FOX       74 NP B80 403         G.C.FOX,M.L.GRISS                      (CIT)
MATISON   74 PR D9 1872         +GALTIERI,GARNJOST,FLATTE,FRIEDMAN,+  (LBL)
MORGAN    74 PL 51B 71          D.MORGAN                              (RHEL)

BAKER     75 NP B99 211         +BANERJEE,CAMPBELL,ALLEN,MARCH+ (LOIC+LOWC)
LAUSCHER  75 NP B86 189         +OTTER,WIECZOREK,+     (ABCLV COLLABORATION)
MORGAN    75 ARGONNE CONF. 45   D.MORGAN                              (RHEL)

CHIEN     76 NP B 106 355       +FEIOCK,LUCAS,PEVSNER,ZOANIS     (BALTIMORE)

BOWLER    77 NP B 126  31       +DAINTON,DRAKE,WILLIAMS             (OXFORD)
SPIRO     77 NP B 125 162       +BARLOUTAUD,COMBER,PALER,+ (SACL+RHEL+EPOL)

BALDI     78 NP B 134 365       +BOHRINGER,DORSAZ,HUNGERBUHLER+       (GEVA)
ENGELEN   78 NP B 134 14        +JONGEJANS,HEMINGWAY,+ (NIJM+ZEEM+CERN+OXF)
ESTABROO  78 NP B 133 490       ESTABROOKS,CARNEGIE,+ (MONT+CARL+DURH+SLAC)
MARTIN    78 NP B 134 392       +SHIMADA,BALDI,BOHRINGER,DORSAZ+(DURH+GEVA)

ESTABROO  79 PR D 19 2678       P.ESTABROOKS                          (CARL)
LANG      79 PR D 19 956        C.B.LANG,A.MAS-PARAREDA               (GRAZ)

ASTON     81 PL 106 B 235       +CARNEGIE,DUNWOODIE,DURKIN+(SLAC+CARL+OTTA)  JP
TOAFF     81 PR D 23 1500       +MUSGRAVE,AMMAR,DAVIS,ECKLUND,+  (ANL+KANS)

TORNQVIS  82 PRL 49 624         N.A.TORNQVIST                         (HELS)
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Q(1400) or Q_2

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64  Q(1400,JP=1+) I=1/2

SEE MINI-REVIEW UNDER Q(1280)

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                  64  Q(1400) MASS (MEV)

M         (1420.)                   DAVIS     72 HBC  +  12. K+ P          12/72
M         (1368.)    (18.)          FIRESTONE 72 DBC  +  12. K+ D          12/77
M         (1400.)   APPROX.         BRANDENB  76 ASPK +- 13 K+-P,(KPIPI)P  12/75
M    E    (1404.0)   (10.0)         CARNEGIE  77 ASPK +- 13 K+-P,P KPIPI   12/77
M         (1400.0)  APPROX.         VERGEEST  79 HBC  +- 4.2 K-P,K PI PI   12/79
M          1415.      15.           ETKIN     80 MPS   0 6 K-P,K0 PI+ PI-   1/82
M          1410.      25.           DAUM      81 CNTR -  63 K-P,K 2PI P     1/82
M          1392.      18.           BAUBILLIE 82 HBC   0 8.25 K-P,KS 2PIN   9/83*
M    T    (1350.)   APPROX          TORNQVIST 82 RVUE                       9/83*
M          . . . . . . . . . .
M    AVG   1406.3     10.5      AVERAGE

M    E    FROM A MODEL DEPENDENT FIT WITH GAUSSIAN BACKGROUND TO
M    E    BRANDENBURG 76 DATA.
M    T    FROM A UNITARIZED QUARK MODEL CALCULATION

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                  64  Q(1400) WIDTH (MEV)

W           (80.)                   DAVIS     72 HBC  +  12. K+ P          12/72
W          (241.)    (30.)          FIRESTONE 72 DBC  +  12. K+ D          12/75
W          (160.)   APPROX.         BRANDENB  76 ASPK +- 13 K+-P,(KPIPI)P  12/75
W    E     (142.0)   (16.0)         CARNEGIE  77 ASPK +- 13 K+-P,P KPIPI   12/77
W          (200.0)  APPROX.         VERGEEST  79 HBC  +- 4.2 K-P,K PI PI   12/79
W           180.      10.           ETKIN     80 MPS   0 6 K-P,K0 PI+ PI-   1/82
W           195.      25.           DAUM      81 CNTR -  63 K-P,K 2PI P     1/82
W           276.      65.           BAUBILLIE 82 HBC   0 8.25 K-P,KS 2PIN   9/83*
W          . . . . . . . . . .
W    AVG    183.9      9.2      AVERAGE

W    E    SEE NOTE E ABOVE.

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                  64  Q(1400) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      Q(1400) INTO K*(892) PI                          892+ 140
P2      Q(1400) INTO K RHO                               498+ 769
P3      Q(1400) INTO K PI                                498+ 140
P4      Q(1400) INTO K ETA                               498+ 549
P5      Q(1400) INTO K OMEGA                             498+ 783
P6      Q(1400) INTO K PI PI                             498+ 140+ 140
P7      Q(1400) INTO KAPPA(1350) PI                     1350+ 140
P8      Q(1400) INTO K EPSILON(1300)                     498+1300

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                  64  Q(1400) PARTIAL WIDTHS (MEV)

W1      Q(1400) INTO K*(892) PI                        (G1)
W1          117.0      10.0          CARNEGIE1 77 ASPK +- 13 K+-P,(KPIPI)P 12/78

W2      Q(1400) INTO K RHO                             (G2)
W2            2.0       1.0          CARNEGIE1 77 ASPK +- 13 K+-P,(KPIPI)P 12/78

W5      Q(1400) INTO K OMEGA                           (G5)
W5           23.0      12.0          CARNEGIE1 77 ASPK +- 13 K+-P,(KPIPI)P 12/78

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                  64  Q(1400) BRANCHING RATIOS

R1      Q(1400) INTO K*(892) PI                        (P1)
R1 F          0.94      0.06         DAUM      81 CNTR   63 K-P,K 2PI P    1/82

R2      Q(1400) INTO K RHO                             (P2)
R2 F          0.03      0.03         DAUM      81 CNTR   63 K-P,K 2PI P    1/82

R3      Q(1400) INTO K OMEGA                           (P5)
R3 F          0.01      0.01         DAUM      81 CNTR   63 K-P,K 2PI P    1/82

R4      Q(1400) INTO KAPPA(1350) PI                    (P7)
R4 F         (0.00) APPROX.          DAUM      81 CNTR   63 K-P,K 2PI P    1/82

R5      Q(1400) INTO K EPSILON(1300) PI                (P8)
R5 F          0.02      0.02         DAUM      81 CNTR   63 K-P,K 2PI P    1/82

R9      D/S RATIO FOR Q INTO K*(892) PI
R9 F          0.04      0.01         DAUM      81 CNTR   63 K-P,K 2PI P    1/82

R  F    AVERAGE FROM LOW AND HIGH T DATA.

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REFERENCES FOR Q(1400)


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ARMENTER 64 DUBNA CONF 1 577  ARMENTEROS,EDWARDS,D-ANDLAU +    (CERN+CDEF)
    ALSO 64 DUBNA CONF 1 617  R ARMENTEROS (RAPPORTEUR)
ARMENTER 64 PL 9 207          ARMENTEROS,EDWARDS,D-ANDLAU,+    (CERN+CDEF)
    ALSO 66 PR  145  1095     BARASH,KIRSCH,MILLER,TAN         (COLUMBIA)

ALMEIDA  65 PL 16 184         ALMEIDA,ATHERTON,BYER,DORNAN,FORSON+ (CAVE)

SHEN     66 PRL  17  726      +BUTTERWORTH,FU,GOLDHABERS,TRILLING   (LRL)
    ALSO 66  PRIVATE COMM.   GERSON GOLDHABER                      (LRL)

BASSOMPI 67 PL 26B 30         BASSOMPIERRE,GOLDSCHMIDT+  (CERN+BRUX+BIRM)IJP
BERLINGH 67 PRL 18 1087       BERLINGHIERI+FARBER+FERBEL+FORMAN    (ROCH)IJP
CRENNELL 67 PRL 19  44        +KALBFLEISCH,LAI,SCARR,SCHUMANN      (BNL)I
DE BAERE 67 NC 49A 374        +DEBAISIEUX+FAST+FILIPPAS+       (CERN+BRUX)
    ALSO PRIVATE COMMUNICATION BY B. JONGEJANS
GOLDHABE 67 PRL 19 976        G.GOLDHABER                           (LBL)

BARTSCH  68 NP B8 9           +COCCONI,+        (AACH+BERL+CERN+LOIC+VIEN)
BOMSE    68 PRL 20 1519       +BORENSTEIN,CALLAHAN,COLE,COX,+  (JOHNHOPK)  1+
DENEGRI  68 PRL 20 1194       +CALLAHAN+ETTLINGER+GILLESPIE+   (JOHNHOPK)  1+

ALEXANDE 69 NP B 13 503       G.ALEXANDER,FIRESTONE,GOLDHABER,+     (LRL)
ANDREWS  69 PRL 22 731        +LACH,LUDLAM,SANDWEISS,BERGER,+  (YALE+LRL)
ASTIER   69 NP B 10 65        +MARECHAL,MONTANET,+  (CDEF+CERN+IPNP+LIVP)IJP
BARBARO  69 PRL 22 1207       BARBARO-GALTIERI,DAVIS,FLATTE,+       (LRL)
BETTINI  69 NC 62 A 1038      +CRESTI,LIMENTANI,BERTAUZA,BIGI+(PADO+PISA)I
BISHOP   69 NP B 9 403        +GOSHAW,ERWIN,WALKER                 (WISC)
CHIEN    69 PL 29B 433        +MALAMUD,MELLEMA,RUDNICK,SCHLEIN+    (UCLA)
CHUNG    69 PR 182 1443       +EISNER+BALI+LUERS                    (BNL)
COLLEY   69 NC A 59 519       +EASTWOOD,+  (BIRM+GLAS+LOIC+MPIM+OXF+RHEL)
ERWIN    69 NP B 9 364        +WALKER,GOSHAW,WEINBERG     (WISC+PRIN+VAND)
FRIEDMAN 69  UCRL-18860       J.FRIEDMAN,PH.D. THESIS               (LRL)
WERNER   69 PR 188 2023       +AMMAR,DAVIS,KROPAC,YARGER,CHO,+ (NWES+ANL) 1+

ABRAMS   70 PR D 1 2433       +EISENSTEIN,KIM,MARSHALL,O-HALLORAN,+ (ILL)
ANTICH   70 NP B 20 201       +CARSON,CHIEN,COX,DENEGRI,ETTLINGER,+ (JHU)  1+
BOWLER   70 PL 31 B 318       M.G.BOWLER                         (OXFORD)
FARBER   70 PR D 1 78         +FERBEL,SLATTERY,YUTA                (ROCH)  1+

BARNHAM  71 NP B25 49         +COLLEY,GRIFFITHS,ALPER, +  (BIRM+GLAS+OXF)
DENEGRI  71 NP B 28 13        +ANTICH,CALLAHAN,CARSON,CHIEN,COX,+   (JHU)  1+
FORMAN   71 PR D 3 2610       +GELFAND,LEARY,MOSER,SEIDL,WOLFSON    (EFI)
GARFINKE 71 PRL 26 1505       GARFINKEL,HOLLAND,CARMONY,LANDER+(PURD+UCD)  1+

ANDERSON 72 PR D 6 1823       +FRANKLIN,GODDEN,KOPELMAN,LIBBY,TAN  (COLO)
BINGHAM  72 NP B 48 589       +EISENSTEIN,GRARD,HERQUET,+     (CERN+BRUX)
BRANDENB 72 NP B 45 397       BRANDENBURG,BRODY,JOHNSON,LEITH,LOOS+(SLAC)
BRANDENB 72 PRL 28 932        BRANDENBURG,JOHNSON,LEITH,LOOS,LUSTE+(SLAC)
CRENNELL 72 PR D 6 1220       +GORDON,KWAN-WU LAI,SCARR             (BNL)
DAVIS    72 PR D 5 2688       +ALSTON,BARBARO,FLATTE,FRIEDMAN,LYNCH+(LBL)
FIRESTON 72 PR D 5 505        FIRESTONE,GOLDHABER,LISSAUER,TRILLING (LBL)
FIRESTON172 NP B 47 348       A.FIRESTONE                           (CIT)
FRATI    72 PR D 6 2361       +HALPERN,HARGIS,SNAPE,CARNAHAN,+(PENN+CINC)
HAATUFT  72 NP B 48 78        +ARNOLD,HAGUENAUER,+  (BERG+STRB+EPOL+MADR)

BARLOUTA 73 NP B 59 374       +DREVILLON,SHAH,+           (SACL+EPOL+RHEL)  JP
BINGHAM  73 NP B 52 31        +FARWEL,+        (LBL+ORSAY+BNL+SACLAY+MILAN)  JP
DE JONGH 73 NP B 58 110       +CORNET,CHARRIERE,+   (BRUX+MONS+CERN+MPIM)
JONES    73 NP B 52 383       G.T.JONES                            (CERN)  JP
LEWIS    73 NP B 60 283       +ALLEN,JACOBS,DANYSZ,BORG,+(LOWC+LOIC+CDEF)
WERNER   73 PR D 7 1275       +SLATTERY,FERBEL                (ROCHESTER)

ANGELOPO 74 NC 20A 49         ANGELOPOULOS,FILIPPAS+(ATHU+ATEN+LIVP+VIEN)  JP
BOWLER   74 NP B74 493        +DAINTON,KADDOURA,AITCHISON           (OXF)
DAVIDSON 74 PR D9 77          +CHAPMAN,GREEN,LYS,ROE               (MICH)
DEUTSCHM 74 PL 49B 388        DEUTSCHMANN,+     (AACH+BERL+CERN+LOIC+VIEN)  JP

ANTIPOV  75 NP B86 381        +ASCOLI,BUSNELLO,KIENZLE+   (SERP+CERN+ILL)  JP
BOWLER   75 NP B97 227        +GAME,AITCHISON,DAINTON          (OXF+DARE)
DORE     75 LNC 13 265        +GUIDONI,LAAKSO,MARINI,CONFORTO+(ROMA+RHEL)
DREVILLO 75 PL 55 B 245       DREVILLON,BORENSTEIN+       (EPOL+BOHR+CDEF)  JP
DUNWOODI 75 NP B91 189        DUNMOODIE,GRANT+       (CERN+BELG+MONS+MPIM)  JP
OTTER1   75 NP B84 333        + (AACH+BERL+CERN+LOIC+VIEN+ATHU+ATEN+LIVP)  JP
OTTER2   75 NP B93 365        +RUDOLPH,RUMPF+  (AACH+BERL+CERN+LOIC+VIEN)  JP
OTTER3   75 NP B96 29         +RUDOLPH,SEYFERT+(AACH+BERL+CERN+LOIC+VIEN)I,JP
TOVEY    75 NP B95 109        +HANSEN,BORENSTEIN,BORG+    (RHEL+EPOL+SACL)I,JP

BASDEVAN 76 PRL 37 977        BASDEVANT,BERGER                 (FNAL+ANL)
BOAL     76 PR D 14 2998      +EDWARDS,KAMAL,TORGESON            (ALBERTA)
BOWLER   76 JPG 3 775         M.G.BOWLER                          (OXFORD)
BRANDENB 76 PRL 26 703        BRANDENBURG,CARNEGIE,CASHMORE,DAVIER+(SLAC)  JP
OTTER    76 NP B 106 77       + (AACH+BERL+CERN+LOIC+VIEN+LPNP+RHEL+SACL)  JP
VERGEEST 76 PL 62 B 471       +ENGELEN,JONGEJANS,+    (AMST+CERN+NIJM+OXF)  JP

CARNEGIE 77 NP B 127 509      +CASHMORE,DAVIER,DUNWOODIE,LASINSKI+ (SLAC)
CARNEGIE177 PL B 68 287       +CASHMORE,DUNWOODIE,LASINSKI,+       (SLAC)

BEUSCH   78 PL 74 B 282       +BIRMAN,KONIGS,OTTER,+        (CERN+AACH+ETH)  JP
GAVILLET 78 PL 76 B 517       +DIAZ,DIONISI,+         (AMST+CERN+NIJM+OXF)  JP
WOHL     78 NP B 132 401      +PALER,CHAURAND,+         (LPNP+RHEL+SACLAY)

BASDEVAN 79 PR D 19 246       BASDEVANT,BERGER                      (ANL)
MAZZUCAT 79 NP B 156 532      MAZZUCATO,PENNINGTON+  (CERN+ZEEM+NIJM+OXF)
VERGEEST 79 NP B 158 265      +JONGEJANS,DIONISI,+   (NIJM+AMST+CERN+OXF)

BACON    80 NP B 162 189      +BARREY,BUTTERWORTH,ANSORGE,+   (LOIC+CAVE)
DIONISI  80 NP B 169 1        +GAVILLET,ARMENTEROS+ (CERN+MADR+CDEF+STOH)
ETKIN    80 PR D 22 42        +FOLEY,LINDENBAUM,KRAMER,+        (BNL+CUNY)  JP
IRVING   80 JPG 6 153         A.C.IRVING                           (LIVP)
RADFORD  80 NP B 167 181      RADFORD,BRANDENBURG                   (MIT)

DAUM     81 NP B 187 1        +HERTZBERGER+(AMST+CERN+CRAC+MPIM+OXF+RHEL)
OTTER    81 NP B 181 1          (AACH+BERL+LOIC+VIEN+BIRM+BELG+CERN+MONS)
RODEBACK 81 ZPHY C 9 9        +SJOGREN,ARMENTEROS,+ (CERN+CDEF+MADR+STOH)

BAUBILLI 82 NP B 202 21       BAUBILLIER+       (BIRM+CERN+GLAS+MSU+LPNP)
FERNANDE 82 ZPHY C 16 95      FERNANDEZ,AGUILAR+     (MADR+CERN+CDEF+STOH)
TORNQVIS 82 NP B 203 268      TORNQVIST                             (HELS)
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Mesons

Data Card Listings

K(1400) [K′], K*(1430)

K(1400) or K′ →

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21  K(1400,JP=0-) I=1/2

FORMERLY CALLED K PRIME.
OBSERVED IN K PI PI PARTIAL-WAVE ANALYSIS.
NOT SEEN BY VERGEEST 79.
WAIT CONFIRMATION. OMITTED FROM TABLE.

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                    21  K(1400) MASS (MEV)

M  A       (1400.)    APPROX.             BRANDENBU 76 ASPK +- 13 K+-P,KPIPI    12/77
M          (1460.)    APPROX.             DAUM      81 CNTR -  63 K-P,K 2PI P    1/82

M  A       COUPLED MAINLY TO K EPSILON(1300). DECAY INTO K*(892) PI SEEN.
M

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                    21  K(1400) WIDTH (MEV)

W  A        (250.)    APPROX.             BRANDENBU 76 ASPK +- 13 K+-P,KPIPI    12/77
W           (260.)    APPROX.             DAUM      81 CNTR -  63 K-P,K 2PI P    1/82

W  A       COUPLED MAINLY TO K EPSILON(1300). DECAY INTO K*(892) PI SEEN.

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                    21  K(1400) PARTIAL DECAY MODES

                                                            DECAY MASSES
P1      K(1400) INTO K*(892) PI                           892+ 140
P2      K(1400) INTO K RHO                                494+ 769
P3      K(1400) INTO KAPPA(1350) PI                      1350+ 140

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                    21  K(1400) PARTIAL WIDTHS (MEV)

W1      K(1400) INTO K*(892) PI                       (G1)
W1         (109.)    APPROX.              DAUM      81 CNTR    63 K-P,K 2PI P    1/82

W2      K(1400) INTO K RHO                            (G2)
W2          (34.)    APPROX.              DAUM      81 CNTR    63 K-P,K 2PI P    1/82

W3      K(1400) INTO KAPPA(1350) PI                   (G3)
W3         (117.)    APPROX.              DAUM      81 CNTR    63 K-P,K 2PI P    1/82
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REFERENCES FOR K(1400)


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BRANDENB 76 PRL 36 1239       BRANDENBURG,CARNEGIE,CASHMORE,DAVIER+(SLAC)  JP

VERGEEST 79 NP B 158 265      +JONGEJANS,DIONISI,+   (NIJM+AMST+CERN+OXF)

DAUM     81 NP B 187 1        +HERTZBERGER+(AMST+CERN+CRAC+MPIM+OXF+RHEL)

BARNES   82 PL 116 B 365      T.BARNES AND F.E.CLOSE                (RHEL)
TANIMOTO 82 PL 116 B 198      M.TANIMOTO                            (BIEL)
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K*(1430)

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22  K*(1430,JP=2+) I=1/2

WE CONSIDER THAT PHASE-SHIFT ANALYSES PROVIDE MORE
RELIABLE DETERMINATIONS OF THE MASS AND WIDTH.
SEE RHO(770) MINI-REVIEW.

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                    22  K*(1430) MASS (MEV)

M   CHARGED ONLY, WITH FINAL STATE K PI
M    D  39 1423.        11.0                BASSANO   67 HBC   - 4.6-5.0K-P,K0PI- 12/75
M    D  63 1427.0       12.0                SCHWEINGR 68 HBC   -  5.5 K- P (K PI) 12/77
M      220 1416.0       10.0                CRENNELL  69 DBC   -  3.9 K-N (K0PI-)  7/69
M    D  60 1414.        13.0                LIND      69 HBC   +   9. K+ P(K0 PI+) 12/77
M     1400 1420.0        3.1                AGUILAR1  71 HBC   -  3.9,4.6 K- P    11/71
M  W D 225 1425.         8.0                BARNHAM   71 HBC   + K+ P,K0 PI+ P    12/75
M    B     1428.0        4.6                MARTIN    78 SPEC + 10 K+-P,KS PI P H
M    B     1423.8        4.6                MARTIN    78 SPEC - 10 K+-P,KS PI P H
M    D 579(1448.5)      (5.0)               DELFOSSE  81 SPEC +  K+-P,K+- PI0 P     1/82
M    D 292(1431.8)      (5.6)               DELFOSSE  81 SPEC -  K+-P,K+- PI0 P     1/82
M      935 1423.0        5.0                TOAFF     81 HBC   -  6.5 K-P,K0 PI- P  1/82
M  W D 400 1436.         5.5                CLELAND   82 SPEC +  30 K+P,KS PI+P    8/83*
M  W D1500 1430.         3.2                CLELAND   82 SPEC +  50 K+P,KS PI+P    8/83*
M  W D1200 1430.         3.2                CLELAND   82 SPEC  - 50 K+P,KS PI-P    8/83*
M          . . . . . . . . . .
M   AVG     1426.3       1.5       AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)

M   NEUTRAL ONLY
M     2200 1421.1        2.6                DAVIS     69 HBC    0 12. K+ P(K+PI-)  9/69
M     1800 1419.1        3.7                AGUILAR1  71 HBC    0 3.9,4.6 K- P    11/71
M      600 1416.         6.                 CORDS     71 DBC   0 9. K+ N,K+ PI- P  2/72
M     1100 1427.         3.                 BUCHNER   72 DBC   0 4.6 K+ N,K+ PI-P 12/72
M    C     1420.1        4.3                LINGLIN   73 HBC   0 2-13 K+P,K+PI-    12/75
M      800 1421.6        4.2                MCCUBBIN  75 HBC    0 3.6 K-P,K-PI+N  12/75
M   E     (1423.0)      (3.0)               ETKIN     76 SPEC   06.K-P,K0 PI+PI-   7/77
M      300 1420.0        7.0                HENDRICKX 76 DBC    8.25 K+N,K+PI      7/77
M  P       1440.0       10.0                BOWLER    77 DBC   0 5.5 K+D,K PI P P 12/77
M   P     (1434.0)      (2.0)               ESTABROOK 78 ASPK  0 13K+-P,P K PI    12/77
M          1450.        30.                 ETKIN     80 SPEC  0 6.K-P,K0 PI+PI-N  3/82
M          1428.         3.                 ASTON     81 LASS  0 11 K-P,K- PI+ N   1/82
M   P     (1471.)      (12.)                BAUBILLIE 82 HBC   0 8.25 K-P,KS 2PIN  9/83*
M          . . . . . . . . . .
M   AVG     1423.2       1.5       AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)

M    B  SYSTEMATIC ERROR ADDED BY US.
M    C  FROM POLE EXTRAPOLATION, USING WORLD K+P DST
M    D  ERRORS ENLARGED BY US TO   GAMMA/SQRT(N). SEE TYPED NOTE ON K*(892)
M   E   SEE MORE RECENT PARTIAL WAVE ANALYSIS (ETKIN 80)
M  P    FROM PHASE SHIFT OR PARTIAL WAVE ANALYSIS.
M  W    NUMBER OF EVENTS IN PEAK REEAVALUATED BY US

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                    22  K*(1430) WIDTH (MEV)

W   CHARGED ONLY, WITH FINAL STATE K PI
W     1400   94.7      15.1      12.5   AGUILAR1  71 HBC   -  3.9,4.6 K- P     11/71
W            96.5       3.8             MARTIN    78 SPEC +  10 K+-P,KS PI P   12/78
W            97.7       4.0             MARTIN    78 SPEC -  10 K+-P,KS PI P   12/78
W    D 579  118.9      20.0             DELFOSSE  81 SPEC +  K+-P,K+- PI0 P     1/82
W    D 292   96.0      22.5             DELFOSSE  81 SPEC -  K+-P,K+- PI0 P     1/82
W      935   85.0      16.0             TOAFF     81 HBC  -  6.5 K-P,K0 PI- P   1/82
W  W D 400  109.       22.              CLELAND   82 SPEC +  30 K+P,KS PI+P    8/83*
W  W D1500  124.       12.8             CLELAND   82 SPEC +  50 K+P,KS PI+P    8/83*
W  W D1200  113.       12.8             CLELAND   82 SPEC  - 50 K+P,KS PI-P    8/83*
W           . . . . . . . . . . .
W   AVG      98.8       2.5     AVERAGE

W   NEUTRAL ONLY
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    D1100  109.       14.0             BUCHNER   72 DBC   0 4.6 K+ N,K+ PI-P 12/75
W   C       (61.0)    (14.0)            LINGLIN   73 HBC   0 2-13 K+P,K+PI-     1/74
W      800  116.       18.              MCCUBBIN  75 HBC    0 3.6 K-P,K-PI+N  12/75
W  P       (170.0)    (20.0)            BOWLER    77 DBC   0 5.5 K+D,K PI P P 12/77
W   P       (98.0)     (5.0)            ESTABROOK 78 ASPK  0 13K+-P,P K PI    12/77
W  P        140.       30.              ETKIN     80 SPEC  0 6.K-P,K0 PI+PI-N  3/82
W            98.        8.              ASTON     81 LASS  0 11 K-P,K- PI+ N   1/82
W   P      (143.)     (34.)             BAUBILLIE 82 HBC   0 8.25 K-P,KS 2PIN  9/83*
W           . . . . . . . . . . .
W   AVG     105.3       4.9     AVERAGE

W   C   FROM POLE EXTRAPOLATION, USING WORLD K+P DST
W    D  ERRORS ENLARGED BY US TO 4*GAMMA/SQRT(N). SEE K*(892) TYPED NOTE.
W  P    FROM PHASE SHIFT OR PARTIAL WAVE ANALYSIS.
W  W    NUMBER OF EVENTS IN PEAK REEAVALUATED BY US

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                    22  K*(1430) PARTIAL DECAY MODES

                                                            DECAY MASSES
P1      K*(1430) INTO K PI                                494+ 140
P2      K*(1430) INTO K*(892) PI                          892+ 140
P3      K*(1430) INTO K RHO                               494+ 769
P4      K*(1430) INTO K OMEGA                             494+ 783
P5      K*(1430) INTO K ETA                               494+ 549
P6      K*(1430) INTO K*(892) PI PI                       892+ 140+ 140
P7      K*(1430) INTO K OMEGA PI                          494+ 783+ 140
P8      K*(1430) INTO K GAMMA                             494+   0

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FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions, P_i, as follows: The diagonal elements are $P_i \pm \delta P_i$, where $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$, while the off-diagonal elements are the normalized correlation coefficients $\langle \delta P_i \delta P_j \rangle / (\delta P_i \cdot \delta P_j)$. For the definitions of the individual P_i, see the listings above; only those P_i appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

	P 1	P 2	P 3	P 4	P 5	P 6
P 1	.4479+-.0225					
P 2	.0734	.2455+-.0198				
P 3	.0193	.5320	.0883+-.0099			
P 4	-.1591	-.2417	-.1909	.0415+-.0152		
P 5	-.4419	-.4449	-.3453	-.0922	.0470+-.0265	
P 6	-.3919	-.4399	-.3434	-.0991	-.1164	.1298+-.0255

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                    22  K*(1430) PARTIAL WIDTHS

W8      K*(1430) INTO K GAMMA (KEV)                   (G8)
W8          240.       45.            CIHANGIR  82 SPEC +  200 PI+Z,Z A2      9/83*

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                    22  K*(1430) BRANCHING RATIOS

R1      K*(1430) INTO (K PI)/TOTAL                      (P1)
R1 P          0.49      0.02          ESTABROOK 78 ASPK +- 13K+-P,P K PI      12/77
R1 P          0.43      0.01          ASTON     81 LASS  0 11 K-P,K- PI+ N     1/82
R1 P     FROM PHASE SHIFTS ANALYSIS.
R1          . . . . . . . . . .
R1  AVG       0.442     0.024   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.7)
R1  FIT       0.448     0.023  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 2.7)

R2      K*(1430) INTO (K*(892) PI)/(K PI + K PI PI)     (P2)/(P1+P2+P3)
R2  QR       (0.45)    (0.13)         BADIER    65 HBC  -  3.0 K-P             1/78
R2  Q        (0.47)    (0.10)         BASSANO   67 HBC  -0 4.6, 5.0 K- P      10/67

R3      K*(1430) INTO (K RHO)/(K PI + K PI PI)          (P3)/(P1+P2+P3)
R3  QR       (0.14)    (0.07)         BADIER    65 HBC  -  3.0 K-P             1/78
R3  Q        (0.14)    (0.10)         BASSANO   67 HBC  -0 4.6, 5.0 K- P      10/67

R4      K*(1430) INTO (K*(892) PI) / (K PI)             (P2)/(P1)
R4            0.65      0.20          SHEN      66 HBC    0  N* PRODUCED      10/66
R4  Q        (0.63)    (0.20)         SHEN      66 HBC  +    NO N* PRODUCED  10/66
R4            0.52      0.12          SCHWEINGR 68 HBC    0 4.1+5.5 K- P     10/67
R4  Q   84   (0.93)    (0.11)         BISHOP    69 HBC      3.5 K+ P          9/69
R4            0.47      0.08          AGUILAR1  71 HBC      3.9,4.6 K- P     11/71
R4 AQ  150   (0.65)    (0.25)         ANTIPOV   75 ASPK  - 40 K-P,K*- P      12/75
R4            0.54      0.16          DEHM      74 DBC   0 4.6 K+ N          12/75
R4            0.62      0.19          LAUSCHER  75 HBC    010,16 K-P,K-PI+N 12/75
R4 A    K*(892) PI SIGNAL FROM PARTIAL WAVE ANALYSIS OF (K-PI+PI-) SYSTEM
R4          . . . . . . . . . .
R4  AVG       0.517     0.056   AVERAGE
R4  FIT       0.548     0.050  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

R5      K*(1430) INTO (K OMEGA) / K PI                  (P4)/(P1)
R5   R        0.19      0.16          BADIER    65 HBC   -  3.0 K-P            1/78
R5           (0.08) OR LESS           SHEN      66 HBC      4.6 K+P           8/66
R5           (0.2)  OR LESS           BASSOMPIE 69 HBC  +    5 K+ P           9/69
R5            0.13      0.07          BASSOMPIE 69 HBC    0 5 K+ P            9/69
R5            0.05      0.04          AGUILAR1  71 HBC      3.9-4.6 K- P     11/71
R5           (0.2)  OR LESS  CL=.95   CHUNG     74 HBC   - 7.3 K-P,K*- P     12/75
R5          . . . . . . . . . .
R5  AVG       0.075     0.034   AVERAGE
R5  FIT       0.093     0.035  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)
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For notation, see key at front of Listings.

Mesons

$K^{*}(1430)$, L(1580)

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R6       K*(1430) INTO (K RHO) / (K PI)                     (P3)/(P1)
R6            (0.09) OR LESS           CHUNG      65 HBC  + 0  3.9-4.2 PI- P   8/66
R6             0.26     0.16           SCHWEINGR 68 HBC    0 4.1+5.5 K- P    10/67
R6            (0.2)  OR LESS           BASSOMPIE 69 HBC  +    5 K+ P          9/69
R6            (0.3)  OR LESS           BASSOMPIE 69 HBC    0 5 K+ P           9/69
R6   Q   15   (0.11)   (0.06)          BISHOP    69 HBC       3.5 K+ P        9/69
R6             0.16     0.05           AGUILAR1  71 HBC       3.9,4.6 K- P   11/71
R6             0.02     0.10     0.02  DEHM      74 DBC   0 4.6 K+ N         12/75
R6           . . . . . . . . . .
R6   AVG       0.111    0.054   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
R6   FIT       0.197    0.024  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)
                        (SEE IDEOGRAM BELOW)
R6   S   USES RESULTS OF OTTER 75 (SEE R7 BELOW). WE DO NOT AVERAGE THIS
R6   S   STATISTICALLY REDUNDANT RATIO, BUT KEEP THE LAUSCHER 75 RESULT
R6   S   FOR R4 ABOVE.
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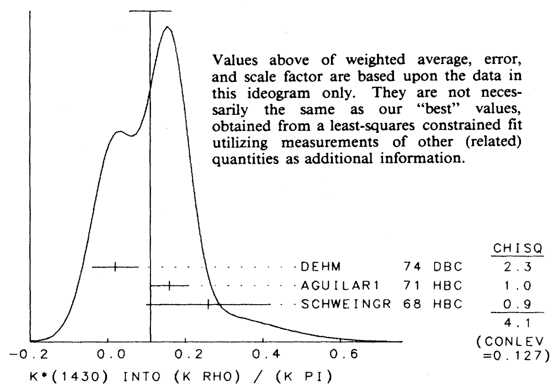
WEIGHTED AVERAGE = 0.111 ± 0.054
ERROR SCALED BY 1.4

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R7       K*(1430) INTO (K RHO) / (K*(892) PI)              (P3)/(P2)
R7            (0.39) OR LESS           BASSOMPIE 67 HBC  +   5. K+ P          9/67
R7            (0.40) OR LESS  CL=.90   FIELD     67 HBC   - 3.8 K- P          6/67
R7 P   130     0.13     0.09           OTTER     75 HBC    08,10,16 K-P,K* N 12/75
R7 AN         (0.03)   (0.03)          ANTIPOV   75 ASPK  - 40 K-P,K*- P     12/75
R7 P           0.36     0.10           VERGEEST  76 HBC   0 4.2 K-P,P KOPIPI 12/77
R7 P          (0.33) APPROX.           ETKIN     80 SPEC  0 6.K-P,KO PI+PI-N  3/82
R7             0.39     0.03           DAUM      81 CNTR    63 K-P,K 2PI P    1/82
R7             0.38     0.09           BAUBILLIE 82 HBC   0 8.25 K-P,KS 2PIN  9/83*
R7            (0.20)    APPROX.        FERNANDEZ 82 HBC    -4 PI-P,LAM K 2PI  9/83*
R7           . . . . . . . . . .
R7   AVG       0.365    0.042   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)
R7   FIT       0.360    0.035  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.4)
                        (SEE IDEOGRAM BELOW)
R7   N   K RHO MODE NOT OBSERVED
R7 A     FROM PARTIAL WAVE ANALYSIS OF (K-PI+PI-) SYSTEM
R7 P     FROM PARTIAL WAVE ANALYSIS OF (KO PI+ PI-) SYSTEM
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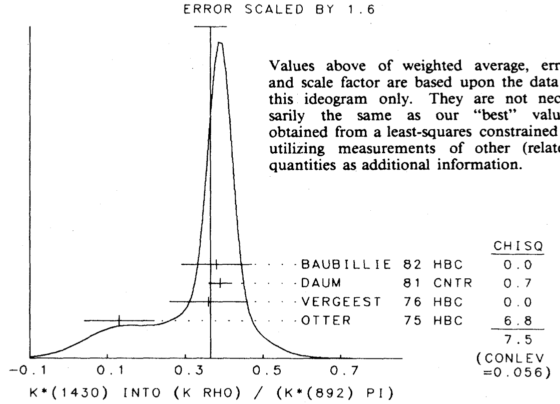
WEIGHTED AVERAGE = 0.365 ± 0.042
ERROR SCALED BY 1.6

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R8       K*(1430) INTO (K OMEGA) / (K*(892) PI)            (P4)/(P2)
R8   Q        (0.10)   (0.04)          FIELD     67 HBC   - 3.8 K- P          6/67

R9       K*(1430) INTO (K ETA) / (K*(892) PI)              (P5)/(P2)
R9   Q        (0.07)   (0.04)          FIELD     67 HBC   - 3.8 K- P          6/67

R10      K*(1430) INTO (K ETA) / (K PI)                    (P5)/(P1)
R10  R         0.05     0.06           BADIER    65 HBC   -   3.0 K-P         1/78
R10  R        (0.065)OR LESS           BASSOMPIE 69 HBC       5.0 K+P         1/78
R10           (0.02) OR LESS           BISHOP    69 HBC       3.5 K+ P        9/69
R10           (0.04) OR LESS  CL=.95   AGUILAR1  71 HBC       3.9-4.6 K- P   11/71
R10          . . . . . . . . . .
R10 FIT        0.105    0.062  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

R11      K*(1430) INTO (K*(892) PI PI)/TOTAL               (P6)
R11T           0.12     0.04           GOLDBERG  76 HBC  -  3 K-P,P KOPIPIPI 12/77
R11          . . . . . . . . . .
R11 FIT        0.130    0.026  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R12      K*(1430) INTO (K*(892) PI PI)/(K PI)              (P6)/(P1)
R12T R         0.21     0.08           JONGEJANS 78 HBC  -  4K-P,P KOOPIPIPI  4/78
R12          . . . . . . . . . .
R12 FIT        0.290    0.064  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

R13      K*(1430) INTO (K OMEGA PI)/TOTAL  (UNITS 10**-3) (P7)
R13        0   (0.72) OR LESS  CL=0.95  JONGEJANS 78 HBC     4 K-P,P KO 4PI    4/78

R    Q   FOLLOWING 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.
R     R  RESTATED BY US.
R   T    ASSUMING PI PI SYSTEM HAS ISO-SPIN 1, WHICH IS SUPPORTED BY
R   T    THE DATA

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REFERENCES FOR K*(1430)


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BADIER   65 PL 19 612          BADIER,DEMOULIN,GOLDBERG+  (EPOL+SACL+AMST)
CHUNG    65 PRL  15  325       +DAHL,HARDY,HESS,JACOBS,KIRZ,MILLER   (LRL)
FOCARDI  65 PL 16 351          FOCARDI,MINGUZZI RANZI,SERRA+(BOLOGNA+SACL)

SHEN     66 PRL  17  726       +BUTTERWORTH,FU,GOLDHABERS,TRILLING   (LRL)
    ALSO 66  PRIVATE COMM.    GERSON GOLDHABER                       (LRL)

BASSANO  67 PRL  19  968       +GOLDBERG,GOZ,BARNES,LEITNER+(BNL+SYRACUSE)
BASSOMPI 67 PL 26B 30          BASSOMPIERRE,GOLDSCHMIDT+  (CERN+BRUX+BIRM)IJP
CRENNELL 67 PRL 19  44         +KALBFLEISCH,LAI,SCARR,SCHUMANN       (BNL)
DAHL     67 PR 163 1377        +HARDY+HESS+KIRZ+MILLER               (LRL)
    ALSO 65 PRL 14 401         HARDY,CHUNG,DAHL,HESS,KIRZ,MILLER     (LRL)
DE BAERE 67 NC 51 A 401        +GOLDSCHMIDT-CLERMONT,HENRI+    (BRUX+CERN)
FIELD    67 PL 24B 638         +HENDRICKS+PICCIONI+YAGER         (LAJOLLA)
GOLDHABE 67 PRL 19  972        G.GOLDHABER,FIRESTONE,SHEN            (LRL)

ADERHOLZ 68 NP B 5  567        +DEUTSCHMANN+  (AACH+BERL+CERN+LOIC+VIENNA)
    ALSO 66 PL 22 357          BARTSCH,DEUTSCHMANN,MORRISON+   (ABCL(IC)V)
ANTICH   68 PRL 21 1842       +CALLAHAN,CARSON,COX,DENEGRI,+         (JHU)
DUBAL    68 THESIS   1456      L.DUBAL                            (GENEVE)
KANG     68 PR 176 1587        Y.W.KANG                             (IOWA)
SCHWEING 68 PR 166 1317        SCHWEINGRUBER,DERRICK,FIELDS+    (ANL+NWES)
   ALSO  67  THESIS            F.L.SCHWEINGRUBER   (NORTHWESTERN,EVANSTON)

BASSOMPI 69 NP  B13 189        BASSOMPIERE,GOLDSCHMIDT-CLERM.+ (CERN+BRUX) JP
BISHOP   69 NP B 9 403         +GOSHAW,ERWIN,WALKER                 (WISC)
CRENNELL 69 PRL 22  487        +KARSHON,LAI,ONEALL,SCARR             (BNL)
DAVIS    69 PRL 23 1071        +DERENZO,FLATTE,ALSTON,LYNCH,SOLMITZ  (LRL)
DE BAERE 69 NC 61 A 397        +GOLDSCHMIDT-CLERMONT,HENRI,+   (BELG+CERN)
FRIEDMAN 69  UCRL-18860        J.FRIEDMAN,PH.D. THESIS               (LRL)
LIND     69 NP B 14 1          +ALEXANDER,FIRESTONE,FU,GOLDHABER     (LRL) JP

ABRAMS   70 PR D 1 2433        +EISENSTEIN,KIM,MARSHALL,O.HALLORAN,+ (ILL)
AGUILAR  70 PRL 25 1362        AGUILAR-BENITEZ,BASSANO,EISNER,+ (BNL+PURD)

AGUILAR1 71 PR D 4 2583        +EISNER,KINSON                        (BNL)
BARNHAM  71 NP B 28 171        +COLLEY,JOBES,GRIFFITHS,HUGHES,+(BIRM+GLAS)
CORDS    71 PR D 4 1974        +CARMONY,ERWIN,MEIERE,+      (PURD+UCD+IUPU)

BUCHNER  72 NP B 45 333        +DEHM,CHARRIERE,CORNET,+   (MPIM+CERN+BRUX)
CRENNELL 72 PR D 6 1220        +GORDON,KWAN-WU LAI,SCARR             (BNL)
DEUTSCHM 72 NP B 36 373        DEUTSCHMANN,+            (ABCLV COLLABORATION)
ENGELMAN 72 PR D 5 2162        ENGELMANN,MUSGRAVE,FORMAN,+       (ANL+EFI)
FRATI    72 PR D 6 2361        +HALPERN,HARGIS,SNAPE,CARNAHAN,+(PENN+CINC)
ROUGE    72 NP B 46 29         +VIDEAU,VOLTE,DE BRION,+        (EPOL+SACL)
TIECKE   72 NP B 39 596        +GRIJNS,HEINEN,DE GROOT,+       (NIJM+AMST)

CHARRIER 73 NP B 51 317        CHARRIERE,DRIJARD,DE BAERE,+    (CERN+BELG)
    ALSO 75  PRIVATE COMM.     GOLDSCHMIDT-CLERMONT                 (CERN)
CLARK    73 NP B 54 432        +LYONS,RADOJICIC                   (OXFORD)
DE JONGH 73 NP B 58 110        +CORNET,CHARRIERE,+   (BRUX+MONS+CERN+MPIM)
LINGLIN  73 NP B 55 408        D.LINGLIN                            (CERN)
WALUCH   73 PR D 8 2837        +FLATTE,FRIEDMAN                      (LBL)

CHUNG    74 PL 51B 413         +EISNER,PROTOPOPESCU,SAMIOS,STRAND    (BNL)
DEHM     74 NP B75 47          +GOEBEL,WITTEK,WOLF,+ (MPIM+BRUX+MONS+CERN)

ANTIPOV  75 NP B86 381         +ASCOLI,BUSNELLO,KIENZLE+   (SERP+CERN+ILL)
LAUSCHER 75 NP B86 189         +OTTER,WIECZOREK,+   (ABCLV COLLABORATION)  JP
MCCUBBIN 75 NP B86 13          N.A.MCCUBBIN,L.LYONS                  (OXF)
OTTER    75 NP B84 333         + (AACH+BERL+CERN+LOIC+VIEN+ATHU+ATEN+LIVP)

ETKIN    76 PRL 36 1482        +FOLEY,GOLDMAN,LINDENBAUM,KIM,+  (BNL+CUNY)
GOLDBERG 76 LNC 17 253         J.GOLDBERG                          (HAIFA)
HENDRICK 76 NP B 112 189       +VIGNAUD,BURLAUD,+     (MONS+SACL+LPNP+BELG)
KIRK     76 NP B 116 99        +KLEIN,COUNIHAN,+(AACH+BERL+CERN+LOIC+WIEN)
VERGEEST 76 PL 62 B 471        +ENGELEN,JONGEJANS,+   (AMST+CERN+NIJM+OXF)  JP

BOWLER   77 NP B 126  31       +DAINTON,DRAKE,WILLIAMS            (OXFORD)

BALDI    78 NP B 134 365       +BOHRINGER,DORSAZ,HUNGERBUHLER+      (GEVA)
BOHM     78 PRL 41 1761        +VAN DALEN,+ (AACH,UCR+CERN+HARV+MUNI+NWES)
ENGELEN  78 NP B 134 14        +JONGEJANS,HEMINGWAY,+ (NIJM+ZEEM+CERN+OXF)
ESTABROO 78 NP B 133 490       ESTABROOKS,CARNEGIE,+ (MONT+CARL+DURH+SLAC)
    ALSO 78 PR D 17 658        ESTABROOKS,CARNEGIE+  (MONT+CARL+DURH+SLAC)
JONGEJAN 78 NP B 139 383       JONGEJANS,CERRADA,+    (ZEEM+CERN+NIJM+OXF)
MARTIN   78 NP B 134 392       +SHIMADA,BALDI,BOHRINGER,DORSAZ+(DURH+GEVA)

ETKIN    80 PR D 22 42         +FOLEY,LINDENBAUM,KRAMER,+       (BNL+CUNY)  JP

ASTON    81 PL 106 B 235       +CARNEGIE,DUNWOODIE,DURKIN+(SLAC+CARL+OTTA)  JP
DAUM     81 NP B 187 1         +HERTZBERGER+(AMST+CERN+CRAC+MPIM+OXF+RHEL)
DELFOSSE 81 NP B 183 349       +GUISAN,MARTIN,MUHLEMANN,WEILL,+(GEVA+LAUS)
TOAFF    81 PR D 23 1500       +MUSGRAVE,AMMAR,DAVIS,ECKLUND,+  (ANL+KANS)

BAUBILLI 82 NP B 202 21        BAUBILLIER+        (BIRM+CERN+GLAS+MSU+LPNP)
CIHANGIR 82 PL 117 B 123       +BERG,BIEL,CHANDLEE,FERBEL+(FNAL+MINN+ROCH)
CLELAND  82 NP B 208 189       +DELFOSSE,DORSAZ,GLOOR(DURH+GEVA+LAUS+PITT)
FERNANDE 82 ZPHY C 16 95       FERNANDEZ,AGUILAR+    (MADR+CERN+CDEF+STOH)
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L(1580) →

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39  L(1580,JP=2-) I=1/2

SEEN IN PARTIAL WAVE ANALYSIS OF THE K-PI+PI- SYSTEM
(OTTER 78). SEE L(1770) MINIREVIEW.
NEED CONFIRMATION OMITTED FROM TABLE.

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                 39  L(1580) MASS (MEV)

M        (1580.)   APPROX.           OTTER      79      -  10,14,16 K- P    12/79

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Mesons

Data Card Listings

L(1580), K*(1650), L(1770)

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                       39  L(1580) WIDTH (MEV)
W         (110.)  APPROX.         OTTER     79       -  10,14,16 K- P     12/79
------ --------- --------- --------- --------- --------- --------- --------
                       39  L(1580) PARTIAL DECAY MODES
                                                              DECAY MASSES
P1      L(1580) INTO K*(892) PI                             892+ 140
P2      L(1580) INTO K*(1430) PI                           1425+ 140
------ --------- --------- --------- --------- --------- --------- --------
                       39  L(1580) BRANCHING RATIOS
W1      L(1580) INTO K*(892) PI                             (P1)
W1         SEEN                   OTTER     79 HBC  -  10,14,16 K- P     12/79
W2      L(1580) INTO K*(1430) PI                            (P2)
W2         POSSIBLY SEEN          OTTER     79 HBC  -  10,14,16 K- P     12/79
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                         REFERENCES FOR L(1580)
OTTER     79 NP B 147 1       +RUDOLPH,+         (AACH+BERL+CERN+LOIC+WIEN)  JP
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K*(1650)

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29  K*(1650,JP=1-) I=1/2
   THIS ENTRY CONTAINS VARIOUS PEAKS OBSERVED IN THE
   1- WAVE OF THE K PI AND K PI PI SYSTEMS.
   WAIT CONFIRMATION.OMITTED FROM TABLE.
------ --------- --------- --------- --------- --------- --------- --------
                       29  K*(1650) MASS (MEV)
M        (1660.)                    CHARRIERE 73 HBC    0 5. K+ P,K P 3PI    1/73
M        (1650.)   APPROX.          ESTABROOK 78 ASPK   0 13 K+-P,K+-PI+-N 12/78
M         1500.      30.            ETKIN     80 MPS    0 6 K-P,K0 PI+ PI-   1/82
M         1800.      70.            ETKIN     80 MPS    0 6 K-P,K0 PI+ PI-   1/82
M        (1700.)   APPROX.          ASTON     81 LASS   0 11 K-P,K- PI+ N    1/82
M         1474.      25.            BAUBILLIE 82 HBC    0 8.25 K-P,KS 2PIN  9/83*
M         . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 3.1)
------ --------- --------- --------- --------- --------- --------- --------
                       29  K*(1650) WIDTH (MEV)
W          (60.)                    CHARRIERE 73 HBC    0 5. K+ P,K P 3PI    1/73
W          250-300 APPROX.          ESTABROOK 78 ASPK   0 13 K+-P,K+-PI+-N 12/78
W          170.      30.            ETKIN     80 MPS    0 6 K-P,K0 PI+ PI-   1/82
W          500.     100.            ETKIN     80 MPS    0 6 K-P,K0 PI+ PI-   1/82
W         (200.)   APPROX.          ASTON     81 LASS   0 11 K-P,K- PI+ N    1/82
W          275.      65.            BAUBILLIE 82 HBC    0 8.25 K-P,KS 2PIN  9/83*
W         . . . . . . . . .
W   AVERAGE MEANINGLESS (SCALE FACTOR = 2.4)
------ --------- --------- --------- --------- --------- --------- --------
                       29  K*(1650) PARTIAL DECAY MODES
                                                              DECAY MASSES
P1      K*(1650) INTO K PI                                  498+ 135
P2      K*(1650) INTO K ETA                                 498+ 549
------ --------- --------- --------- --------- --------- --------- --------
                       29  K*(1650) BRANCHING RATIOS
R1      K*(1650) INTO (K PI)/TOTAL                          (P1)
R1          (0.35) APPROX.            ASTON     81 LASS  0 11 K-P,K- PI+ N    1/82
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                         REFERENCES FOR K*(1650)
CHARRIER 73 NP B 51 317       CHARRIERE,DRIJARD,DE BAERE,+      (CERN+BELG)
ESTABROO 78 NP B 133 490      ESTABROOKS,CARNEGIE,+ (MONT+CARL+DURH+SLAC)
ETKIN    80 PR D 22 42        +FOLEY,LINDENBAUM,KRAMER,+         (BNL+CUNY)  JP
ASTON    81 PL 106 B 235      +CARNEGIE,DUNWOODIE,DURKIN+(SLAC+CARL+OTTA)  JP
BAUBILLI 82 NP B 202 21       BAUBILLIER+        (BIRM+CERN+GLAS+MSU+LPNP)
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L(1770)

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23  L(1770, JP=2-) I = 1/2
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The L(1770) is seen as a bump at a mass ~1.8 GeV in the diffractive-like processes KN → (Kππ)N. The effect is largely dominated by the J^P=2^- partial waves.

The long-standing questions concerning the resonant nature of the enhancement as well as its possible decay modes have been largely clarified. A detailed partial-wave analysis based on 200,000 diffractive $K^-p \to K^-\pi^+\pi^-p$ events (DAUM 81) establishes resonance-like phase variations and isolates several decay modes. The behavior of the extracted 2^- waves requires the existence of at least one L meson, but there are indications suggesting the presence of a second state in this mass region.

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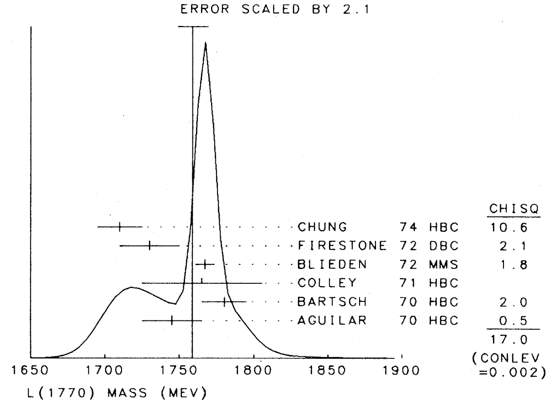
                       23  L(1770) MASS  (MEV)
M            1745.0      20.0             AGUILAR   70 HBC   -  4.6 K- P          6/70
M            1780.0      15.0             BARTSCH   70 HBC   -  10.1 K- P         1/71
M           (1760.0)    (15.0)            LUDLAM    70 HBC   -  12.6 K- P         1/73
M   X        1765.0      40.0             COLLEY    71 HBC  +  10.K+P,K 2PI       1/73
M           (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         60 1710.       15.              CHUNG     74 HBC   - 7.3K-P,K-OMEGA P 12/75
M           (1820.)    APPROX.            DAUM      81 CNTR -  63 K-P,K 2PI P     1/82
M           (1730.)    APPROX.            ARMSTRONG 83 OMEG -  18.5 K-P,3K P     9/83*
M            . . . . . . . . .
M    AVG     1758.9      10.0     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.1)
                             (SEE IDEOGRAM BELOW)

M   P    PRODUCED IN CONJUNCTION WITH EXCITED DEUTERON.
M   X    SYSTEMATIC ERRORS ADDED CORRESP. TO SPREAD OF DIFFERENT FITS.
```

WEIGHTED AVERAGE = 1758.9 ± 10.0
ERROR SCALED BY 2.1

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                       23  L(1770) WIDTH (MEV)
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            (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         60 110.        50.              CHUNG     74 HBC   - 7.3K-P,K-OMEGA P 12/75
W           (200.)     APPROX.            DAUM      81 CNTR -  63 K-P,K 2PI P     1/82
W           (220.)     APPROX.            ARMSTRONG 83 OMEG -  18.5 K-P,3K P     9/83*
W            . . . . . . . . .
W    AVG      135.1      20.9     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
                             (SEE IDEOGRAM BELOW)

W   P    PRODUCED IN CONJUNCTION WITH EXCITED DEUTERON
W   X    SYSTEMATIC ERRORS ADDED CORRESP. TO SPREAD OF DIFFERENT FITS.
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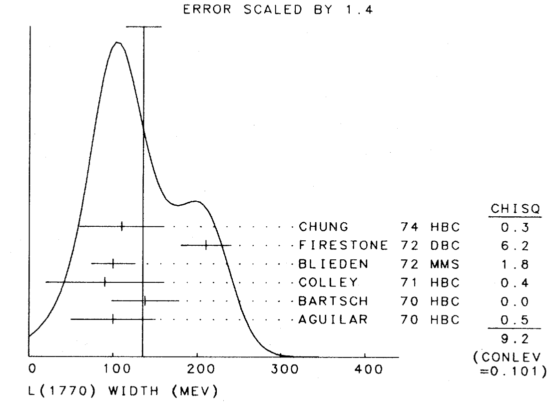
WEIGHTED AVERAGE = 135.1 ± 20.9
ERROR SCALED BY 1.4

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For notation, see key at front of Listings.


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                 23  L(1770) PARTIAL DECAY MODES

                                                         DECAY MASSES
P1     L(1770) INTO K PI PI                           498+ 135+ 135
P2     L(1770) INTO K*(1430) PI                       135+1425
P3     L(1770) INTO K PI PI PI                        498+ 135+ 135+ 135
P4     L(1770) INTO K*(892) PI                        892+ 135
P5     L(1770) INTO K*(892) RHO                       892+ 769
P6     L(1770) INTO K*(892) OMEGA                     892+ 783
P7     L(1770) INTO K*(892) PI PI                     892+ 135+ 135
P8     L(1770) INTO K OMEGA                           498+ 783
P9     L(1770) INTO K F                               498+1274
P10    L(1770) INTO K PHI                             494+   0

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                 23  L(1770) BRANCHING RATIOS

R1     L(1770) INTO (K*(1430) PI) / (K PI PI )           (P2)/(P1)
R1                     (K*(1430) INTO K PI)
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         (1.0)  OR  LESS         BARTSCH   70 HBC  -   10.1 K- P     1/71
R1         (1.0)  OR LESS          COLLEY    71 HBC     10. K+ P      11/71
R1  P      (1.0)  APPROX.          FIRESTONE 72 DBC  +  12. K+ D      12/72
R1         (0.6)  APPROX.          DAUM      81 CNTR   63 K-P,K 2PI P   1/82
R1  P   PRODUCED IN CONJUNCTION WITH EXCITED DEUTERON
R1   R  FOR DISCUSSION OF THE EXPERIMENTAL EVIDENCE ON OTHER DECAY
R1   R  MODES SEE HUGHES 71,SLATTERY 71,EISNER 74.

R2     L(1770) INTO (K OMEGA)/TOTAL                      (P8)
R2         SEEN                    CHUNG     74 HBC  -  7.3K-P,K-OMEGAP   1/82
R2         SEEN                    OTTER     81 HBC  +- 8.25,10,16 K+-P   1/82

R3     L(1770) INTO (K*(892) PI)/(K PI PI)               (P4)/(P1)
R3         (0.24) APPROX.          DAUM      81 CNTR    63 K-P,K 2PI P    1/82

R4     L(1770) INTO (K F)/(K PI PI)                      (P9)/(P1)
R4                     (F INTO PI PI)
R4         (0.16) APPROX.          DAUM      81 CNTR    63 K-P,K 2PI P    1/82

R5     L(1770) INTO (K PHI)/TOTAL                        (P10)
R5         SEEN                    ARMSTRONG 83 OMEG -  18.5 K-P,K-PHI    9/83*

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REFERENCES FOR L(1770)


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BARTSCH  66 PL 22 357           +DEUTSCHMANN,+   (AACH+BERL+CERN+LOIC+VIEN)

BERLINGH 67 PRL 18 1087         BERLINGHIERI+FARBER+FERBEL+FORMAN+   (ROCH)I
CARMONY  67 PRL  18  615        D.CARMONY,T.HENDRICKS,L.LANDER   (LA JOLLA)
JOBES    67 PL 26B 49           +BASSOMPIERRE,DE BAERE +   (BIRM+CERN+BRUX)

BARTSCH  68 NP B8 9             +COCCONI,+        (AACH+BERL+CERN+LOIC+VIEN)
DENEGRI  68 PRL 20 1194         +CALLAHAN+ETTLINGER+GILLESPIE+         (JHU)

ANDREWS  69 PRL 22 731          +LACH,LUDLAM,SANDWEISS,BERGER,+  (YALE+LRL)
BARBARO  69 PRL 22 1207         BARBARO-GALTIERI,DAVIS,FLATTE,+        (LRL)
COLLEY   69 NC A 59 519         +EASTWOOD,+  (BIRM+GLAS+LOIC+MPIM+OXF+RHEL)

AGUILAR  70 PRL 25 54           AGUILAR-BENITEZ,BARNES,BASSANO,CHUNG,+(BNL)
BARTSCH  70 PL 33 B 186         +DEUTSCHMANN,+   (AACH+BERL+CERN+LOIC+VIEN)
LUDLAM   70 PR D 2 1234         +SANDWEISS,SLAUGHTER                  (YALE)

COLLEY   71 NP B 26 71          +JOBES,KENYON,PATHAK,HUGHES,+   (BIRM+GLAS)
DENEGRI  71 NP B 28 13          +ANTICH,CALLAHAN,CARSON,CHIEN,COX,+   (JHU)  JP

ANDERSON 72 PR D 6 1823         +FRANKLIN,GODDEN,KOPELMAN,LIBBY,TAN  (COLO)
BLIEDEN  72 PL 39 B 668         +FINOCCHIARO,BOWEN,EARLES,+     (STON+NEAS)
FIRESTON 72 PR D 5 505          FIRESTONE,GOLDHABER,LISSAUER,TRILLING (LBL)

BARLOUTA 73 NP B 59 374         +DREVILLON,SHAH,+            (SACL+EPOL+RHEL)
BINGHAM  73 NP B 52 31          +FARWEL,+       (LBL+ORSAY+BNL+SACLAY+MILAN)
CHARRIER 73 NP B 51 317         CHARRIERE,DRIJARD,DE BAERE,+    (CERN+BELG)

CHUNG    74 PL 51B 412          +EISNER,PROTOPOPESCU,SAMIOS,STRAND     (BNL)
DEUTSCHM 74 PL 49B 388          DEUTSCHMANN,+    (AACH+BERL+CERN+LOIC+VIEN)  JP
EISNER   74 BOSTON CONF.        R.L.EISNER  REVIEW TALK                (BNL)

ANTIPOV  75 NP B86 381          +ASCOLI,BUSNELLO,KIENZLE+   (SERP+CERN+ILL)  JP
OTTER    75 NP B93 365          +RUDOLPH,RUMPF+  (AACH+BERL+CERN+LOIC+VIEN)  JP

OTTER    79 NP B 147 1          +RUDOLPH,+       (AACH+BERL+CERN+LOIC+WIEN)  JP

DAUM     81 NP B 187 1          +HERTZBERGER+(AMST+CERN+CRAC+MPIM+OXF+RHEL)
OTTER    81 NP B 181 1            (AACH+BERL+LOIC+VIEN+BIRM+BELG+CERN+MONS)

ARMSTRON 83 NP B 221 1          ARMSTRONG+  (BARI+BIRM+CERN+MILA+LPNP+PAVI)
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K*(1780)

60 K*(1780,JP=3-) I = 1/2

All the recent high-statistics experiments studying the Kπ system in KN → KπN interactions have shown clear evidence for the existence of a resonant effect at ~1800 MeV in the $J^P=3^-$ partial wave (BALDI 76, BRANDENBURG 76, CHUNG 78, CLELAND 80, ASTON 81). The intensity of the 3^- partial wave of the Kππ system produced in the charge-exchange process $K^-p \to K^0\pi^+\pi^-n$ also shows resonance-like behavior at ~1800 MeV (BEUSCH 78, ETKIN 80, BAUBILLIER 82). Since the mass values quoted for the Kπ and Kππ modes are not significantly different, it seems natural to consider them as alternative decay modes of a single resonance.

There appears to be some disagreement in the values of the width obtained using the Kπ channel. The measured values tend to become larger when the number of angular moments included in the fit increases. For the time being the observed discrepancies seem to originate from the explicit parametrization of the experimental distributions rather than from the data themselves.

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                 60  K*(1780) MASS (MEV)

M    M     1779.0     11.0              BALDI      76 SPEC +  10 K+P,K0 PI+P    12/77
M    A     1776.      26.               BRANDENB   76 ASPK   013 K+-P,K+-PI-+   12/75
M          1812.0     28.0              BEUSCH     78 OMEG    10K-P,K0 PI+PI-N  4/78
M          1786.0      8.0              CHUNG      78 MPS   0 K-P,K-PI+N 6 GEV  1/78
M          1850.      50.               ETKIN      80 MPS   0 6 K-P,K0 PI+ PI-  1/82
M    J     1786.      15.               ASTON 1    81 SPEC   011.K-P,K- PI+ N   2/81
M    K     1753.      25.       18.     ASTON 2    81 LASS  0 11 K-P,K- PI+ N   1/82
M      190 1762.0      9.0              TOAFF      81 HBC  -  6.5 K-P,K0 PI- P  1/82
M          1790.0     15.0              BAUBILLIE  82 HBC   0 8.25 K-P,KS2PIN   9/83*
M     2060 1784.0      9.0              CLELAND    82 SPEC +- 50 K+P,KS PI+-P   8/83*
M           . . . . . . . . . .
M    AVG   1779.8      4.1       AVERAGE

M    A  CONFIRMED BY PHASE SHIFT ANALYSIS OF ESTABROOKS 77,YIELDS JP=3-
M    J  FROM A FIT TO Y(6,0) MOMENT.
M    K  FROM ENERGY INDEPENDENT PWA.
M    M  FROM A FIT TO Y(6,2) MOMENT. JP=3- FOUND.

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                 60  K*(1780) WIDTH (MEV)

W    M      135.0     22.0              BALDI      76 SPEC +  10 K+P,K0 PI+P    12/77
W   E      (270.)    (70.)              BRANDENB   76 ASPK   013 K+-P,K+-PI-+   12/75
W  D        181.0     44.0              BEUSCH     78 OMEG    10K-P,K0 PI+PI-N  4/78
W            96.0     31.0              CHUNG      78 MPS   0 K-P,K-PI+N 6 GEV  1/78
W           240.      50.               ETKIN      80 MPS   0 6 K-P,K0 PI+ PI-  1/82
W    J      225.      60.               ASTON 1    81 SPEC   011.K-P,K- PI+ N   2/81
W    K      300.      170.      80.     ASTON 2    81 LASS  0 11 K-P,K- PI+ N   1/82
W      190  (80.)    APPROX.            TOAFF      81 HBC  -  6.5 K-P,K0 PI- P  1/82
W          (130.0)   APPROX             BAUBILLIE  82 HBC   0 8.25 K-P,KS2PIN   9/83*
W     2060  191.0     24.0              CLELAND    82 SPEC +- 50 K+P,KS PI+-P   8/83*
W           . . . . . . . . . .
W    AVG    160.9     19.2      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
                            (SEE IDEOGRAM BELOW)

W    D  ERRORS ENLARGED BY US TO 4*GAMMA/SQRT(N). SEE K*(892) TYPED NOTE.
W   E   ESTABROOKS 77 FIND THAT BRANDENBURG 76 DATA ARE CONSISTENT
W   E   WITH 175 MEV WIDTH.NOT AVERAGED.
W    J  FROM A FIT TO Y(6,0) MOMENT.
W    K  FROM ENERGY INDEPENDENT PWA.
W    M  FROM A FIT TO Y(6,2) MOMENT. JP=3- FOUND.
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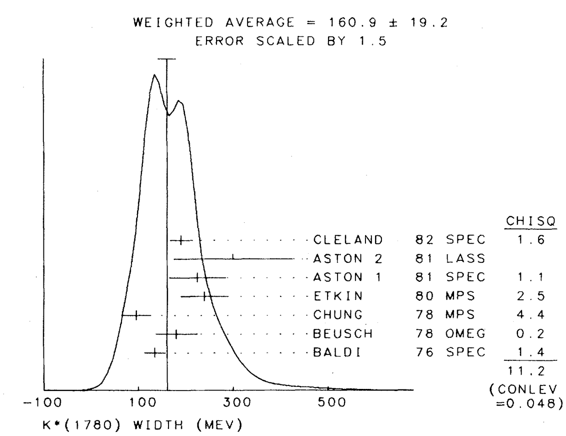


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                 60  K*(1780) PARTIAL DECAY MODES

                                                         DECAY MASSES
P1     K*(1780) INTO K PI                              494+ 140
P2     K*(1780) INTO K*(892) PI                        892+ 140
P3     K*(1780) INTO K RHO                             494+ 769
P4     K*(1780) INTO K*(1430) PI                       1425+ 140
P5     K*(1780) INTO K PI PI                           494+ 140+ 140
P6     K*(1780) INTO K*(892) RHO                       1275+ 769

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Mesons

Data Card Listings

$K^*(1780)$, $K(1830)$, $K^*(2060)$, $K(2250)$, $K(2320)$

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                  60  K*(1780) BRANCHING RATIOS

R4      K*(1780) INTO (K PI )/TOTAL                        (P1)
R4             0.19       0.02          ESTABROO  78 ASPK  0 13 K+-P,K PI      12/77
R4             0.16       0.01          ASTON 2   81 LASS  0 11 K-P,K- PI+ N    1/82
R4              . . . . . . . . . .
R4   AVG       0.166      0.012    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)

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                              REFERENCES FOR K*(1780)

CARMONY  71 PRL 27 1160         +CORDS,CLOPP,ERWIN,MEIERE,+ (PURD+UCD+IUPU)
FIRESTON 71 PL 36 B 513         FIRESTONE,GOLDHABER,LISSAUER,TRILLING (LBL)

AGUILAR  73 PRL 30 672          +CHUNG,EISNER,PROTOPOPESCU,SAMIOS,+   (BNL)
WALUCH   73 PR D 8 2837         +FLATTE,FRIEDMAN                      (LBL)

BALDI    76 PL 63 B 344         +BOEHRINGER,DORSAZ,HUNGERBUHLER,+  (GENEVA)  JP
BRANDENB 76 PL 60 B 478         BRANDENBURG,CARNEGIE,CASHMORE,DAVIER+(SLAC)  JP
SPIRO    76 PL 60 B 389         +BARLOUTAUD,PALER,CHAURAND+(SACL+RHEL+EPOL)  JP

BOWLER   77 NP B 126 31         +DAINTON,DRAKE,WILLIAMS            (OXFORD)  JP
CARMONY  77 PRD 16 1251         +CLOPP,LANDER,MEIERE,YEN,+  (PURD+UCD+IUPU)
GRASSLER 77 NP B 125 189        +KLUGOW,+  (AACHEN+BERLIN+CERN+LOIC+VIENNA)

BEUSCH   78 PL 74 B 282         +BIRMAN,KONIGS,OTTER,+       (CERN+AACH+ETH)  JP
CHUNG    78 PRL 40 355          +ETKIN,FLAMINO+   (BNL+BRAN+CUNY+MASA+PENN)  JP
ESTABROO 78 NP B 133 490        ESTABROOKS,CARNEGIE,+ (MONT+CARL+DURH+SLAC)  JP
    ALSO 78 PR D 17 658         ESTABROOKS,CARNEGIE+  (MONT+CARL+DURH+SLAC)

CLELAND  80 PL 97B 465          +DORSAZ,MARTIN,NEF,+  (PITT+GEVA+LAUS+DURH)  JP
ENGELEN  80 NP B 167 61         +JONGEJANS,DIONISI+    (NIJM+AMST+CERN+OXF)  JP
ETKIN    80 PR D 22 42          +FOLEY,LINDENBAUM,KRAMER,+        (BNL+CUNY)  JP

ASTON 1  81 PL 99 B 502         +DUNWOODIE,DURKIN,FIEGUTH+ (SLAC+CARL+OTTA)JP
ASTON 2  81 PL 106 B 235        +CARNEGIE,DUNWOODIE,DURKIN+(SLAC+CARL+OTTA)  JP
TOAFF    81 PR D 23 1500        +MUSGRAVE,AMMAR,DAVIS,ECKLUND,+  (ANL+KANS)

BAUBILLI 82 NP B 202 21         BAUBILLIER+        (BIRM+CERN+GLAS+MSU+LPNP)
CLELAND  82 NP B 208 189        +DELFOSSE,DORSAZ,GLOOR(DURH+GEVA+LAUS+PITT)
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K(1830)

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88  K(1830,JP=0-) I=1/2

SEEN IN PARTIAL WAVE ANALYSIS OF K- PHI SYSTEM.
NEEDS CONFIRMATION. OMITTED FROM TABLE.

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                  88  K(1830) MASS (MEV)

M         (1830.0)  APPROX              ARMSTRONG 83 OMEG -  18.5 K-P,3K P     9/83*

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                  88  K(1830) WIDTH (MEV)

W          (250.0)  APPROX              ARMSTRONG 83 OMEG -  18.5 K-P,3K P     9/83*

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                  88  K(1830) PARTIAL DECAY MODES

                                                           DECAY MASSES
P1      K(1830) INTO K PHI                                 494+1020

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                         REFERENCES FOR K(1830)
ARMSTRON 83 NP B 221 1       ARMSTRONG+  (BARI+BIRM+CERN+MILA+LPNP+PAVI)  JP
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$K^*(2060)$

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35  K*(2060,JP=4+) I=1/2

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                  35  K*(2060) MASS (MEV)

M        488 2115.      46.                 CARMONY    77 HBC    0 9 K+D,K+ PIONS    12/78
M    C      (2092.)    (21.)                ASTON 1    81 LASS   011.K-P,K- PI+ N     1/82
M     D      2070.     100.        40.      ASTON 2    81 LASS   011.K-P,K- PI+ N     1/82
M        650 2088.      20.                 BAUBILLIE  82 HBC  -  8.25 K-P,KS PI-P   8/83*
M    W B 400 2039.      10.                 CLELAND    82 SPEC +- 50 K+P,KS PI+-P    8/83*
M            . . . . . . . . . .
M    AVERAGE MEANINGLESS (SCALE FACTOR = 1.8)

M     B   FROM A FIT TO 8 MOMENTS.
M    W    NUMBER OF EVENTS EVALUATED BY US.
M     C   FROM A FIT TO Y(5,0), Y(7,0) AND Y(8,0) MOMENTS.
M     D   FROM ENERGY INDEPENDENT PWA.

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                  35  K*(2060) WIDTH (MEV)

W              300.       200.              CARMONY    77 HBC    0 9 K+D,K+ PIONS    12/78
W    C        (205.)      (70.)     (55.)   ASTON 1    81 LASS   011.K-P,K- PI+ N     1/82
W     D        240.       500.      100.    ASTON 2    81 LASS   011.K-P,K- PI+ N     1/82
W        650   170.       100.       50.    BAUBILLIE  82 HBC  -  8.25 K-P,KS PI-P   8/83*
W    W B 400   189.        35.              CLELAND    82 SPEC +- 50 K+P,KS PI+-P    8/83*
W    AVERAGE MEANINGLESS

W     B   FROM A FIT TO 8 MOMENTS.
W    W    NUMBER OF EVENTS EVALUATED BY US.
W     C   FROM A FIT TO Y(5,0), Y(7,0) AND Y(8,0) MOMENTS.
W     D   FROM ENERGY INDEPENDENT PWA.

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                  35  K*(2060) PARTIAL DECAY MODES

                                                           DECAY MASSES
P1      K*(2060) INTO K PI                                 494+ 140
P2      K*(2060) INTO K*(892) PI PI                        892+ 140+ 140
P3      K*(2060) INTO RHO K PI                             769+ 498+ 140
P4      K*(2060) INTO OMEGA K PI                           783+ 498+ 140
P5      K*(2060) INTO K*(892) PI PI PI                     892+ 140+ 140+ 135

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                  35  K*(2060) BRANCHING RATIOS

R1      K*(2060) INTO (K PI )/TOTAL                       (P1)
R1            0.07       0.01          ASTON 2    81 LASS  0 11 K-P,K- PI+ N    1/82

R2      K*(2060) INTO (K*(892) PI PI)/TOTAL               (P2)
R2          SEEN                       BAUBILLIE 82 HBC  -  8.25K-P,KS 3PI P  8/83*

R3      K*(2060) INTO (RHO K PI)/TOTAL                    (P3)
R3          SEEN                       BAUBILLIE 82 HBC  -  8.25K-P,KS 3PI P  8/83*

R4      K*(2060) INTO (OMEGA K PI)/TOTAL                  (P4)
R4          SEEN                       BAUBILLIE 82 HBC  -  8.25K-P,KS 3PI P  8/83*

R5      K*(2060) INTO (K*(892) 3 PI)/TOTAL                (P5)
R5          POSSIBLY SEEN              BAUBILLIE 82 HBC  -  8.25K-P,KS 3PI P  8/83*

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                              REFERENCES FOR K*(2060)

CARMONY  71 PRL 27 1160         +CORDS,CLOPP,ERWIN,MEIERE,+  (PURD+UCD+IND)

CARMONY  77 PRD 16 1251         +CLOPP,LANDER,MEIERE,YEN,+  (PURD+UCD+IUPU)

BROMBERG 80 PR D 22 1513        +HAGGERTY,ABRAMS,DZIERBA(CIT+FNAL+ILLC+IND)
CLELAND  80 PL 97B 465          +DORSAZ,MARTIN,NEF,+  (PITT+GEVA+LAUS+DURH)JP

ASTON 1  81 PL 99 B 502         +DUNWOODIE,DURKIN,FIEGUTH+ (SLAC+CARL+OTTA)JP
ASTON 2  81 PL 106 B 235        +CARNEGIE,DUNWOODIE,DURKIN+(SLAC+CARL+OTTA)  JP
BAUBILLI 82 PL 118 B 447        BAUBILLIER,BURNS+ (BIRM+CERN+GLAS+MSU+LPNP)
CLELAND  82 NP B 208 189        +DELFOSSE,DORSAZ,GLOOR(DURH+GEVA+LAUS+PITT)
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K(2250)

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40  K(2250,JP=2-) I=1/2

FORMERLY CALLED K*.
THIS ENTRY CONTAINS VARIOUS PEAKS IN STRANGE MESON
SYSTEMS REPORTED IN THE 2100-2300 MEV REGION AS WELL AS
ENHANCEMENTS SEEN IN ANTIHYPERON NUCLEON SYSTEM,EITHER
IN THE MASS SPECTRA OR IN THE JP=2- WAVE.
OMITTED FROM TABLE.

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                  40  K(2250) 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        37(2147.)    (4.)              CHLIAPNIK 79 HBC  +  K+P TO LAM-BAR P    1/80
M     Q     2235.     50.               BAUBILLIE 81 HBC  -  8. K-P,LAM PBAR     1/82
M     Q     2260.     20.               CLELAND   81 SPEC +- 50 K+P,LAM PBAR     1/82
M     Q     2200.0    40.0              ARMSTRONG 83 OMEG  - 18 K-P,LAM PBAR    12/83*
M           . . . . . . . . . . .
M    AVG    2246.5    16.8     AVERAGE

M    C   COMPILATION OF (ANTIHYP.-NUCLEON) MASS IN K+ P 8.-13.  GEV/C
M     Q  JP=2- FROM MOMENTS ANALYSIS.

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                  40  K(2250) 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        37  (40.)   APPROX.            CHLIAPNIK 79 HBC  +  K+P TO LAM-BAR P    1/80
W     Q     (200.)   APPROX.            BAUBILLIE 81 HBC  -  8. K-P,LAM PBAR     1/82
W     Q      210.     30.               CLELAND   81 SPEC +- 50 K+P,LAM PBAR     1/82
W     Q      150.0    30.0              ARMSTRONG 83 OMEG  - 18 K-P,LAM PBAR    12/83*
W           . . . . . . . . . . .
W    AVG     180.0    30.0     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)

W    C   COMPILATION OF (ANTIHYP.-NUCLEON) MASS IN K+ P 8.-13.  GEV/C
W     Q  JP=2- FROM MOMENTS ANALYSIS.

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                  40  K(2250) PARTIAL DECAY MODES

                                                           DECAY MASSES
P1      K(2250) INTO K PI PI                                498+ 135+ 135
P2      K(2250) INTO LAMBDA PBAR                           1116+ 938

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                              REFERENCES FOR K(2250)

ALEXANDE 68 PRL 20 755          ALEXANDER,FIRESTONE,GOLDHABER,SHEN    (LRL)

LISSAUER 70 NP B 18 491         +ALEXANDER,FIRESTONE,GOLDHABER        (LBL)

SLATTERY 71  UR-875-332(PREP) P.SLATTERY,A REVIEW OF STRANGE MESONS(ROCH)

CHLIAPNI 79 NP B 158 253        CHLIAPNIKOV,GERDYUKOV+     (CERN+BELG+MONS)


BAUBILLI 81 NP B 183 1          BAUBILLIER,+      (BIRM+CERN+GLAS+MSU+LPNP)  JP
CLELAND  81 NP B 184 1          +NEF,MARTIN,+          (PITT+GEVA+LAUS+DURH)  JP

ARMSTRON 83 NP B 227 365        ARMSTRONG+  (BARI+BIRM+CERN+MILA+LPNP+PAVI)
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K(2320)

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90  K(2320,JP=3+) I=1/2

THIS ENTRY CONTAINS ENHANCEMENTS SEEN IN THE
JP=3+ WAVE OF THE ANTIHYPERON NUCLEON SYSTEM
OMITTED FROM TABLE.

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                  90  K(2320) MASS (MEV)

M     P     2320.0    30.0              CLELAND   81 SPEC +- 50 K+P,LAM PBAR   12/83*
M     P     2330.0    40.0              ARMSTRONG 83 OMEG  - 18 K-P,LAM PBAR   12/83*
M           . . . . . . . . . . .
M    AVG    2323.6    24.0     AVERAGE

M     P  JP=3+ FROM MOMENTS ANALYSIS

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                         90  K(2320) WIDTH (MEV)

W     P     (250.0)  APPROX.              CLELAND   81 SPEC +- 50 K+P,LAM PBAR  12/83*
W     P      150.0     30.0               ARMSTRONG 83 OMEG  - 18 K-P,LAM PBAR  12/83*

W     P   JP=3+ FROM MOMENTS ANALYSIS
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                         90  K(2320) PARTIAL DECAY MODES

                                                            DECAY MASSES
P1      K(2320) INTO LAMBDA PBAR                           1116+ 938
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REFERENCES FOR K(2320)


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CLELAND  81 NP B 184 1        +NEF,MARTIN,+          (PITT+GEVA+LAUS+DURH)

ARMSTRON 83 NP B 227 365      ARMSTRONG+  (BARI+BIRM+CERN+MILA+LPNP+PAVI)
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K(2500)

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                         91  K(2500,JP=4-) I=1/2

                         THIS ENTRY CONTAINS ENHANCEMENTS SEEN IN THE
                         JP=4- WAVE OF THE ANTIHYPERON NUCLEON SYSTEM
                         OMITTED FROM TABLE.
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                         91  K(2500) MASS (MEV)

M     R      2490.0     20.0              CLELAND   81 SPEC +- 50 K+P,LAM PBAR  12/83*

M     R   JP=4- FROM MOMENTS ANALYSIS
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                         91  K(2500) WIDTH (MEV)

W     R     (250.0)  APPROX.              CLELAND   81 SPEC +- 50 K+P,LAM PBAR  12/83*

W     R   JP=4- FROM MOMENTS ANALYSIS
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REFERENCES FOR K(2500)


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CLELAND  81 NP B 184 1        +NEF,MARTIN,+          (PITT+GEVA+LAUS+DURH)
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C=±1 MESON STATES

$D^{\pm}$

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                         31  CHARGED D(1869,JP=0-) I=1/2

                         SEE STABLE PARTICLE DATA CARD LISTINGS
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D^{0}

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                         32  NEUTRAL D(1865,JP=0-) I=1/2

                         SEE STABLE PARTICLE DATA CARD LISTINGS
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$D^{*\pm}(2010)$

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                         62  CHARGED D*(2010,JP=1-) I=1/2
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                         62  CHARGED D*(2010) MASS (MEV)

M     G     (2008.)     (3.)              GOLDHABE  77 SMAG +- E+E-             12/77
M     P     (2008.6)    (1.0)             PERUZZI   77 SMAG +- E+E-             12/77
M
M    MASS    2010.1      0.7    FROM DO MASS (TRILLING 81 RVUE) AND
M                               MASS DIFFERENCE BELOW

M     G   FROM SIMULTANEOUS FIT TO D*+,D*0,D+,AND D0,NOT INDEPENDENT OF
M     G   FELDMAN 77 MASS DIFFERENCE BELOW.
M     P   PERUZZI 77 MASS NOT INDEPENDENT OF FELDMAN 77 MASS DIFFERENCE
M     P   BELOW AND PERUZZI 77 D0 MASS VALUE.
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                         62  (D*+) - (D0) MASS DIFFERENCE (MEV)

DM         30  145.3      0.5             FELDMAN   77 SMAG    D*+ TO D0 PI+    12/77
DM          2  145.2      0.6             BLIETSCHA 79 BEBC    NEUTRINO P       12/79
DM            (145.5)  APPROX.            AVERY     80 SPEC    GAMMA A           1/82
DM         60  145.5      0.3             FITCH     81 SPEC    PI- A             1/82
DM         14  145.5      0.5             YELTON    82 SMK2    29 E+E-,K-PI+     8/83*
DM         16  145.8      1.5             AHLEN     83 HRS     D*+ TO D0 PI+    12/83*
DM         12  145.1      1.8             BAILEY    83 SPEC    D*+- TO D0 PI+-   9/83*
DM         28  145.5      0.3             BAILEY    83 SPEC    D*+- TO D0 PI+-  12/83*
DM         14  145.1      0.5             BAILEY    83 SPEC    D*+- TO D0 PI+-  12/83*
DM
DM   AVG      145.41      0.16     AVERAGE
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                         62  (D*+) - (D*0) MASS DIFFERENCE (MEV)

EM    P        2.6        1.8             PERUZZI   77 SMAG +- E+E-             12/77
EM    P   NOT INDEPENDENT OF FELDMAN 77 MASS DIFFERENCE ABOVE, PERUZZI 77
EM    P   D0 MASS, AND GOLDHABER 77 D*0 MASS.
EM
EM   DMASS     2.9        1.3    FROM (D*+)-(D0) AND (D*0)-(D0)
EM                               MASS DIFFERENCES
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                         62  CHARGED D*(2010) WIDTH (MEV)

W         30   (2.0)   OR LESS  CL=.90    FELDMAN   77 SMAG    D*+ TO D0 PI+    12/77
W              (2.2)   OR LESS            YELTON    82 SMK2    29 E+E-,K-PI+PI-  8/83*
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                         62  CHARGED D*(2010) PARTIAL DECAY MODES

                                                            DECAY MASSES
P1      D*+(2010) INTO D0 PI+                              1865+ 140
P2      D*+(2010) INTO D+ GAMMA                            1869+   0
P3      D*+(2010) INTO D+ PI0                              1869+ 135

P       D*-(2010) MODES ARE CHARGE CONJUGATES OF ABOVE MODES
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                         62  CHARGED D*(2010) BRANCHING RATIOS

R1      D*+(2010) INTO (D0 PI+)/TOTAL                         (P1)
R1 G          0.6        0.15             GOLDHABE  77 SMAG +  E+E-             12/77
R1 G      ASSUMING THAT ISOSPIN IS CONSERVED IN THE DECAY

R2      D*+(2010) INTO (D+ GAMMA)/TOTAL                       (P2)
R2            0.08       0.07             KIRKBY    79 RVUE    E+ E-            12/79

R3      D*+(2010) INTO (D+ PI0)/TOTAL                         (P3)
R3    G       0.28       0.09             KIRKBY    79 RVUE    E+ E-            12/79
****** ********* ********* ********* ********* ********* ********* ********
```

REFERENCES FOR CHARGED D*(2010)


```
PERUZZI  76 PRL 37 569          +PICCOLO,FELDMAN,NGUYEN,WISS,+    (SLAC+LBL)

FELDMAN  77 PRL 38 1313         +PERUZZI,PICCOLO,ABRAMS,ALAM+     (SLAC+LBL)
PERUZZI  77 PRL 39 1301         +PICCOLO,FELDMAN,PERL,+(SLAC,LBL,NWES+HAWA)
GOLDHABE 77 PL 69 B 503         +WISS,ABRAMS,ALAM,BOYARSKI,+      (LBL+SLAC)

BLIETSCH 79 PL 86 B 108         BLIETSCHAU,+      (AACH+BONN+CERN+MPIM+OXF)
KIRKBY   79 BATAVIA CONF.107    J. KIRKBY                            (SLAC)

AVERY    80 PRL 44 1309         +WISS,BINKLEY,ATIYA,+        (ILL+FNAL+COLU)

FITCH    81 PRL 46 761          +DEVAUX,CAVAGLIA,MAY,+ (PRIN+SACL+TORI+BNL)
TRILLING 81 PRPL 75 57          G.H.TRILLING                      (LBL+UCB)

BEBEK    82 PRL 49 610          +(HARV+OSU+ROCH+RUTG+SYRA+VAND+CORN+ITHACA)
YELTON   82 PRL 49 430          +FELDMAN,GOLDHABER,+     (SLAC+LBL+UCB+HARV)

AHLEN    83 PRL 51 1147         +AKERLOF+       (ANL+IND+LBL+MICH+PURD+SLAC)
ALTHOFF  83 PL 126 B 493        +FISCHER,BURKHARDT+    (TASSO COLLABORATION)
BAILEY   83 PL 132 B 230        +BARDSLEY+  (AMST+BRIS+CERN+CRAC+MPIM+RHEL)
```


$D^{*0}(2010)$

```
                         61  NEUTRAL D*(2010,JP=1-) I=1/2
                         J CONSISTENT WITH 1, VALUE 0 RULED OUT (NGUYEN 77).
------ --------- --------- --------- --------- --------- --------- --------

                         61  NEUTRAL D*(2010) MASS (MEV)

M     G     (2006.)     (1.5)             GOLDHABE  77 SMAG    E+E-             12/77
M     G   FROM SIMULTANEOUS FIT TO D*+, D*0, D+, AND D0.
M
M    MASS    2007.2      2.1    FROM D0 MASS (TRILLING 81 RVUE) AND
M                               MASS DIFFERENCE BELOW
------ --------- --------- --------- --------- --------- --------- --------

                         61  (D*0) - (D0) MASS DIFFERENCE (MEV)

DM G          142.7      1.7              GOLDHABE  77 SMAG  0 E+E-              3/82
DM            142.2      2.0              SADROZIN  80 CBAL  0 D*0 TO D0 PI0     3/82
DM G      FROM SIMULTANEOUS FIT TO D*+, D*0, D+, AND D0.
DM
DM   AVG      142.5      1.3      AVERAGE
------ --------- --------- --------- --------- --------- --------- --------

                         61  NEUTRAL D*(2010) WIDTH (MEV)

W              (5.)    OR LESS            GOLDHAB2  76 SMAG    E+E- TO D*D*      3/77
------ --------- --------- --------- --------- --------- --------- --------

                         61  NEUTRAL D*(2010) PARTIAL DECAY MODES

                                                            DECAY MASSES
P1      D*0(2010) INTO D0 PI0                              1865+ 135
P2      D*0(2010) INTO D0 GAMMA                            1865+   0

P       D*0(2010)BAR MODES ARE CHARGE CONJUGATES OF ABOVE MODES
------ --------- --------- --------- --------- --------- --------- --------

                         61  NEUTRAL D*(2010) BRANCHING RATIOS

R1      D*0(2010) INTO (D0 GAMMA)/(D0 PI0 + D0 GAMMA)     (P2)/(P1+P2)
R1    G       0.45       0.15             GOLDHABE  77 SMAG    E+E-             12/77
R1    G   WE QUOTE THE NORMAL FIT VALUE FROM TABLE 1. THE ISO-SPIN
R1    G   CONSTRAINED FIT IS NOW KNOWN TO GIVE A D0 GAMMA FRACTION WHICH IS
R1    G   TOO LARGE. SEE DETAILS IN FOOTNOTE 21 OF FELDMAN 77 REVIEW.

R2      D*0(2010) INTO (D0 PI0)/TOTAL                         (P1)
R2    G       0.55       0.15             KIRKBY    79 RVUE    E+ E-            12/79
****** ********* ********* ********* ********* ********* ********* ********
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REFERENCES FOR NEUTRAL D*(2010)


```
GOLDHAB1 76 PRL 37 255          GOLDHABER,PIERRE,ABRAMS,ALAM,+   (LBL+SLAC)
GOLDHAB2 76 SLAC CONF. 379      G.GOLDHABER (AVAIL. AS LBL-5534) (LBL+SLAC)

GOLDHABE 77 PL 69 B 503         GOLDHABER,ABRAMS,ALAM+           (LBL+SLAC)
    ALSO 77 BANFF SUM.INST 75   G.J.FELDMAN                          (SLAC)
NGUYEN   77 PRL 39 262          +WISS,ABRAMS,ALAM,BOYARSKI,+     (LBL+SLAC)  J

KIRKBY   79 BATAVIA CONF.107    J. KIRKBY                            (SLAC)

SADROZIN 80 MADISON CONF. 681   SADROZINSKI,+     (PRIN+CIT+HARV+SLAC+STAN)
```

Mesons

Data Card Listings

D^{*0}(2010), $F^{\pm}$, F^{*}(2140), $B^{\pm}$, B^{0}, Exotic Mesons

TRILLING 81 PRPL 75 57 G.H.TRILLING (LBL+UCB)

****** ********* ********* ********* ********* ********* ********* ********

$F^{\pm}$

34 F+-(1970,JP=0-) I=0

SEE STABLE PARTICLE DATA CARD LISTINGS

****** ********* ********* ********* ********* ********* ********* ********

F^{*}(2140)

74 F*(2140,JPG=) I=

OMITTED FROM TABLE.

74 F* MASS (MEV)

M	2140.0	60.	BRANDELIK 77 DASP	+- E+E-,PI 3 GAMMA	12/77

74 (F*+) - (F0) MASS DIFFERENCE (MEV)

DM	110.	46.	BRANDELIK 79 DASP	+- E+E-,F GAMMA	12/79

74 F* PARTIAL DECAY MODES

		DECAY MASSES
P1	F* INTO F GAMMA	1971+ 0

74 F* BRANCHING RATIOS

R1	F* INTO (F GAMMA)/TOTAL		(P1)	
R1	PROBABLY SEEN	BRANDELIK 77 DASP	E+E-	12/77

****** ********* ********* ********* ********* ********* ********* ********

REFERENCES FOR F*(2140)

BRANDELI 77 PL 70 B 132 BRANDELIK,CORDS,+(AACH+DESY+HAMB+MPIM+TOKY)

BRANDELI 78 PL 76 B 361 BRANDELIK,CORDS,+(AACH+DESY+HAMB+MPIM+TOKY)

BRANDELI 79 PL 80 B 412 BRANDELIK,CORDS,+(AACH+DESY+HAMB+MPIM+TOKY)

****** ********* ********* ********* ********* ********* ********* ********

B=±1 MESON STATES

****** ********* ********* ********* ********* ********* ********* ********

$B^{\pm}$

41 CHARGED B(5271,JP=) I=

SEE STABLE PARTICLE DATA CARD LISTINGS

****** ********* ********* ********* ********* ********* ********* ********

B^{0}

42 NEUTRAL B(5274,JP=) I=

SEE STABLE PARTICLE DATA CARD LISTINGS

****** ********* ********* ********* ********* ********* ********* ********

EXOTIC MESON STATES

****** ********* ********* ********* ********* ********* ********* ********

EXOTICS

50 EXOTICS

THE PURPOSE OF THIS ENTRY IS TO PROVIDE A LIST OF REFERENCES FOR EXOTIC MESON SEARCHES (SEE THE SECTION ON THE NONRELATIVISTIC QUARK MODEL IN THE MISCELLANEOUS SECTION OF THIS REVIEW), AS WELL AS THEORETICALLY BASED SUGGESTIONS FOR EXPERIMENTS. NOTE THAT LIPKIN 73 PROPOSES EXPERIMENTS WHICH ARE CONCLUSIVE EVEN IF NEGATIVE RESULTS ARE OBTAINED.

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REFERENCES FOR EXOTICS

REPORTS ON SEARCHES

ROSENFEL 68 PHILA.CONF.P.455 A.H.ROSENFELD (LRL)

DODD 69 PR 177 1991 +JOLDERSMA, PALMER, SAMIOS (BNL)

CHO 70 PL 32 B 409 +DERRICK,JOHNSON,MUSGRAVE,+ (ANL+NWES+KANS)
GIACOMEL 70 PL 33 B 373 G.GIACOMELLI + (BGNA+SACL+AMST+REHO+EPOL)
LYS 70 PR D 2 2525 J.LYS+ (MICH)
ROSNER 70 EXP.MESON SPECTROSCOPY,ED. C.BALTAY AND A.H.ROSENFELD,P.499

BUHL 72 NP B 37 421 +CLINE,TERRELL (WISCONSIN)

COHEN 73 NP B 53 1 +FERBEL,SLATTERY,WERNER (ROCHESTER)
DURUSOY 73 PL 45 B 517 +BAUBILLIER,GEORGE,ARMENISE,+ (LPNP+BARI)

ALAM 74 PL 53B 207 +BRABSON,GALLOWAY,+ (IND+PURD+SLAC+VAND)
COHEN 74 BOSTON D.COHEN REVIEW TALK (COLU)
OREN 74 NP B71 189 +COOPER,FIELDS,RHINES,WHITMORE,+ (ANL+OXF)
BALTAY 75 PL 57B 293 +CAUTIS,COHEN,KALELKAR,PISELLO,+(COLU+BING)
DAVIS 75 NP B96 426 +AMMAR,KROPAC,YARGER,+ (KANS+CCAC+ANL)

BRUNDIER 76 PL 64 B 107 BRUNDIERS,BRUN,FLURI,+ (FREIBURG+SACL+ETH)

BOUCROT 77 NP B 121 251 +NAVACH,RIVET,+ (LALO+CERN+CDEF+EPOL)
HOOGLAND 77 NP B 126 109 +GRAYER,HYAMS,BLUM,DITL,+ (AMST+CERN+MPIM)
HOOGLAND 77 NP B 126 109 +GRAYER,HYAMS,BLUM,DITL,+ (AMST+CERN+MPIM)
MOSER 77 NP B 129 28 F.L.MOSER (EFI)

ALAM 78 PRL 40 1685 +BAGGETT,BAGLIN,BONAMY+(IND+PURD+SLAC+VAND)
ARMSTRON 78 PL 77 B 447 ARMSTRONG,FRAME,HUGHES,BIENLEIN+(GLAS+DESY)

LEMOIGNE 79 BATAVIA CONF.524 +ABOLINS,BARATE+ (SACL+LOIC+SHMP+IND)

KOOIJMAN 80 PRL 45 316 +ARENTON,AYRES,DIEBOLD,MAY+ (ANL+EFI)

AGUILAR 81 ZPHY C 6 109 +ALBAJAR,SJOGREN,+ (CERN+CDEF+MADR+STOH)
APEL 81 NP B 193 269 +AUGENSTEIN,BERTOLUCCI,DONSKOV,+(SERP+CERN)
BIONTA 81 PRL 46 970 +CARROLL,EDELSTEIN,+ (BNL+CARN+FNAL+SMAS)
EVANGELI 81 NP B 178 197 EVANGELISTA+(BARI+BONN+CERN+DARE+LIVP+MILA)
FRAME 81 PL 107 B 301 +HUGHES,COLLEY,ARMSTRONG,+ (GLAS+BIRM+CERN)
IRVING 81 NP B 193 1 +LOVERRE,AGUILAR,+ (CERN+CDEF+MADR+STOH)

SUGGESTIONS FOR SEARCHES

ROSNER 68 PRL 21 950,1468 J.L.ROSNER (TEL-AVIV)

ROSNER 70 EXP.MESON SPECTROSCOPY,ED. C.BALTAY AND A.H.ROSENFELD,P.499

FAIMAN 73 PL 43 B 307 D.FAIMAN,G.GOLDHABER,Y.ZARMI (CERN)
LIPKIN 73 PR D 7 2262 H.J.LIPKIN (ARGONNE+FNAL)

HOLMGREN 78 PL 77 B 304 +PENNINGTON (STOH+CERN)

ARENTON 82 PR D 25 2241 +AYRES,DIEBOLD,MAY,SWALLOW+ (ANL+ILL)

****** ********* ********* ********* ********* ********* ********* ********

For notation, see key at front of Listings.

Baryons
N's and Δ's

NOTE ON N AND Δ RESONANCES

I. Introduction

The excited states of the nucleon have been studied in a large number of formation and production experiments. Production experiments are not suitable for an accurate determination of resonance parameters, but they are of interest in searching for the many predicted nucleon resonances that decouple from the πN channel.[1]

The masses, widths, and elasticities of the N and Δ resonances in the main Baryon Table have been determined almost entirely from partial-wave analyses of πN elastic and charge-exchange scattering data (Sec. II). Similar methods of analysis have been used to get the branching fractions for decay into Nη, ΛK, and ΣK. The remaining branching fractions are from analyses of $\pi N \rightarrow N\pi\pi$ data, which so far have only taken into account the contributions from quasi-2-body intermediate states (Sec. III).

In addition to the usual Breit-Wigner parameters, the Data Card Listings give the locations and the residues of the poles of the resonant partial waves on the second sheet of the complex energy plane as obtained from πN partial-wave analyses and from the isobar model analyses of $\pi N \rightarrow N\pi\pi$. The Listings also give γN decay amplitudes of the resonances (Sec. IV), and there are brief remarks on electroproduction of nucleon resonances (Sec. V) and on nucleon resonances as seen in production experiments (Sec. VI).

Table 1 lists all the entries in the Listings and gives our evaluation of the status of each, both overall and channel by channel. We have made a number of changes since the 1982 edition. Four N and three Δ resonances have been removed from the main Baryon Table: the N(1990), N(2080), N(2200), and Δ(1600) have been reduced from 3-star to 2-star status, and the N(3030), Δ(2850), and Δ(3230) have been killed altogether [see the notes in the Listings for the N(~3000) and the Δ(~3000) for the reasons for this]. A resonance is considered to be well established only if it has been seen in at least two independent analyses and if its partial wave does not behave erratically or have large errors. Good reason for a cautious attitude is the fact that some recent data[2] differ appreciably from earlier data and from predictions of the analyses. Only the established resonances (overall status 3 or 4 stars) appear in the main Baryon Table.

Table 1. The status of the N and Δ resonances. Only those with an overall status of *** or **** are included in the main Baryon Table.

Particle	$L_{2I\cdot 2J}$	Overall status	Status as seen in -- Nπ	Nη	ΛK	ΣK	Δπ	Nγ
N(939)	P_{11}	****						
N(1440)	P_{11}	****	****	*			***	***
N(1520)	D_{13}	****	****	*			***	***
N(1535)	S_{11}	****	****	****			*	***
N(1540)	P_{13}	*					*	
N(1650)	S_{11}	****	****	*	***	**	***	***
N(1675)	D_{15}	****	****	*	*		***	***
N(1680)	F_{15}	****	****				***	***
N(1700)	D_{13}	***	***	*	**	*	**	**
N(1710)	P_{11}	***	***	*	**	*	***	**
N(1720)	P_{13}	****	****	*	**	*	*	*
N(1990)	F_{17}	**	**	*	*	*		*
N(2000)	F_{15}	**	**	*	*	*		
N(2080)	D_{13}	**	**	*	*			*
N(2090)	S_{11}	*	*					
N(2100)	P_{11}	*	*					
N(2190)	G_{17}	****	****	*	*	*		*
N(2200)	D_{15}	**	**	*	*			
N(2220)	H_{19}	****	****	*				
N(2250)	G_{19}	****	****	*				
N(2600)	I_{111}	***	***					
N(2700)	K_{113}	**	**					
N(~3000)								
Δ(1232)	P_{33}	****	****	F				****
Δ(1550)	P_{31}	*		o			*	
Δ(1600)	P_{33}	**	**	r			***	*
Δ(1620)	S_{31}	****	****	b			***	**
Δ(1700)	D_{33}	****	****	i		*	***	***
Δ(1900)	S_{31}	***	***		d	*		
Δ(1905)	F_{35}	****	****		d	*	**	**
Δ(1910)	P_{31}	****	****		e	*	*	*
Δ(1920)	P_{33}	***	***		n	*		
Δ(1930)	D_{35}	***	***	F		*	*	*
Δ(1940)	D_{33}	*	*	o				
Δ(1950)	F_{37}	****	****	r		*	**	***
Δ(2150)	S_{31}	*	*	b				
Δ(2200)	G_{37}	*	*	i				
Δ(2300)	H_{39}	**	**		d			
Δ(2350)	D_{35}	*	*		d			
Δ(2390)	F_{37}	*	*		e			
Δ(2400)	G_{39}	**	**		n			
Δ(2420)	H_{311}	****	****					
Δ(2750)	I_{313}	**	**					
Δ(2950)	K_{315}	**	**					
Δ(~3000)								

**** Good, clear, and unmistakable.
*** Good, but in need of clarification or not absolutely certain.
** Not established; needs confirmation.
* Evidence weak; could disappear.

The Data Card Listings in this edition have been much shortened by the omission of many now-obsolete results. Nearly all of the omitted results were published before 1975. There also used to be separate entries for bumps seen in production experiments — bumps with masses in the 1440-MeV region, the 1520-MeV region, etc. — but these have been removed. All the omitted material may be found in our 1982 edition.[3]

There are two recent extensive reviews of nucleon resonances.[4,5]

References for section I

1. R. Koniuk and N. Isgur, Phys. Rev. **D21**, 1868 (1980).

2. πN Newsletter No. 1 (1984), eds. G. Höhler and B.M.K. Nefkens.
3. Particle Data Group, Phys. Lett. **111B** (1982).
4. G. Höhler, *Pion-Nucleon Scattering*, Landolt-Börnstein Vol. **I/9b** (1983), ed. H. Schopper, Springer Verlag.
5. A.J.G. Hey and R.L. Kelly, Phys. Reports **96**, 71 (1983).

II. Two-body partial-wave analyses and determination of resonance parameters

(by G. Höhler, University of Karlsruhe)

πN partial-wave analysis: Even if all measurable πN → πN scattering data were measured with infinite accuracy, it would not be possible in the inelastic region to determine a unique set of partial waves from the data alone. It is essential to add theoretical constraints, and unitarity, analyticity, and isospin invariance are chosen in order to avoid using a specific model or parametrization that might bias the solution.

Atkinson et al.,[1] in a continuation of earlier work, have recently investigated how much the amplitudes are restricted by unitarity if the $d\sigma/d\Omega$ and P angular distributions for π^+p elastic scattering are given at a certain energy with very high precision. They found a variety of solutions, which differ from one another substantially in some of the lower partial waves and strongly in the tail of high partial waves. They concluded that cutting off the partial-wave expansion sharply (which was done in many early and some recent analyses[2,3,4]) is not justified.

In QCD, isospin is not exactly conserved in strong interactions because the masses of the up and down quarks are different. At present, the only experimental evidence for a violation is in the Δ(1232) region, where one expects an effect because of the splitting of the Δ^{++} and Δ^0 masses. Other cases reported in the literature turned out to be caused by errors in the data or the analysis.

The uniqueness problem remains serious even if one includes data for all three reactions and isospin invariance. Therefore it is necessary to add analyticity constraints. Many analyses used as input predictions for the forward amplitudes, which follow from total-cross-section data, the optical theorem, and forward dispersion relations, but this is still not nearly enough.

Constraints based on Mandelstam's 2-variable analyticity have so far been used successfully only in the analyses of the CMU-LBL[5] and Karlsruhe-Helsinki[6] groups. In both, long tails of high partial waves were admitted, but only some global effects of these waves should be taken seriously, not the value of a single high partial wave. The resonance masses, widths, and elasticities in the Baryon Table are mainly determined by these two analyses, whose partial-wave amplitudes are shown in Fig. 1.

Results from other recent analyses are suspect due to sharp cutoff of the partial waves and for other reasons (see Sec. 2.1 in Ref. 7). It is necessary to check if Hendry's solution[8] is compatible with analyticity.

Substantial progress in partial-wave analysis may be expected in 1984/85 when the final results of several experiments[9] will become available. Furthermore, the analysis will be simplified and improved if predictions for the tail of high partial waves, based on new evaluations of the nearby parts of the Mandelstam double spectral function[10] and of the left-hand cut singularities of the partial-wave dispersion relation,[11] are used. A good test of predictions for the highest resonances (masses > 2.2 GeV) is not yet possible because the data are still too poor. Evidence for resonances in this range has been reported by Koch[6] and by Hendry.[8]

Determination of resonance parameters: Since a dynamical theory of πN scattering does not yet exist, the "resonance parameters" are not defined in a unique way. One can fit the partial-wave amplitudes to a phenomenological ansatz consisting of a generalized Breit-Wigner form combined with a background term, and most of the earlier analyses, including the first CMU-LBL analysis and the KH 78 analysis,[6] used a prescription of this type. A more sophisticated multichannel coupled resonance scheme was applied in the recent work of the CMU-LBL group.[5] The parameters listed in the Baryon Table have been derived by these methods.

This approach has a difficulty which becomes more and more important as the energy increases: some "background terms" such as diffraction and ρ-exchange give contributions to the partial waves which resemble highly inelastic resonances (see Sec. 2.4.1.1 in Ref. 7). It is true that the energy dependence is different, but at high energies the speed with which an amplitude

For notation, see key at front of Listings.

Baryons
N's and Δ's

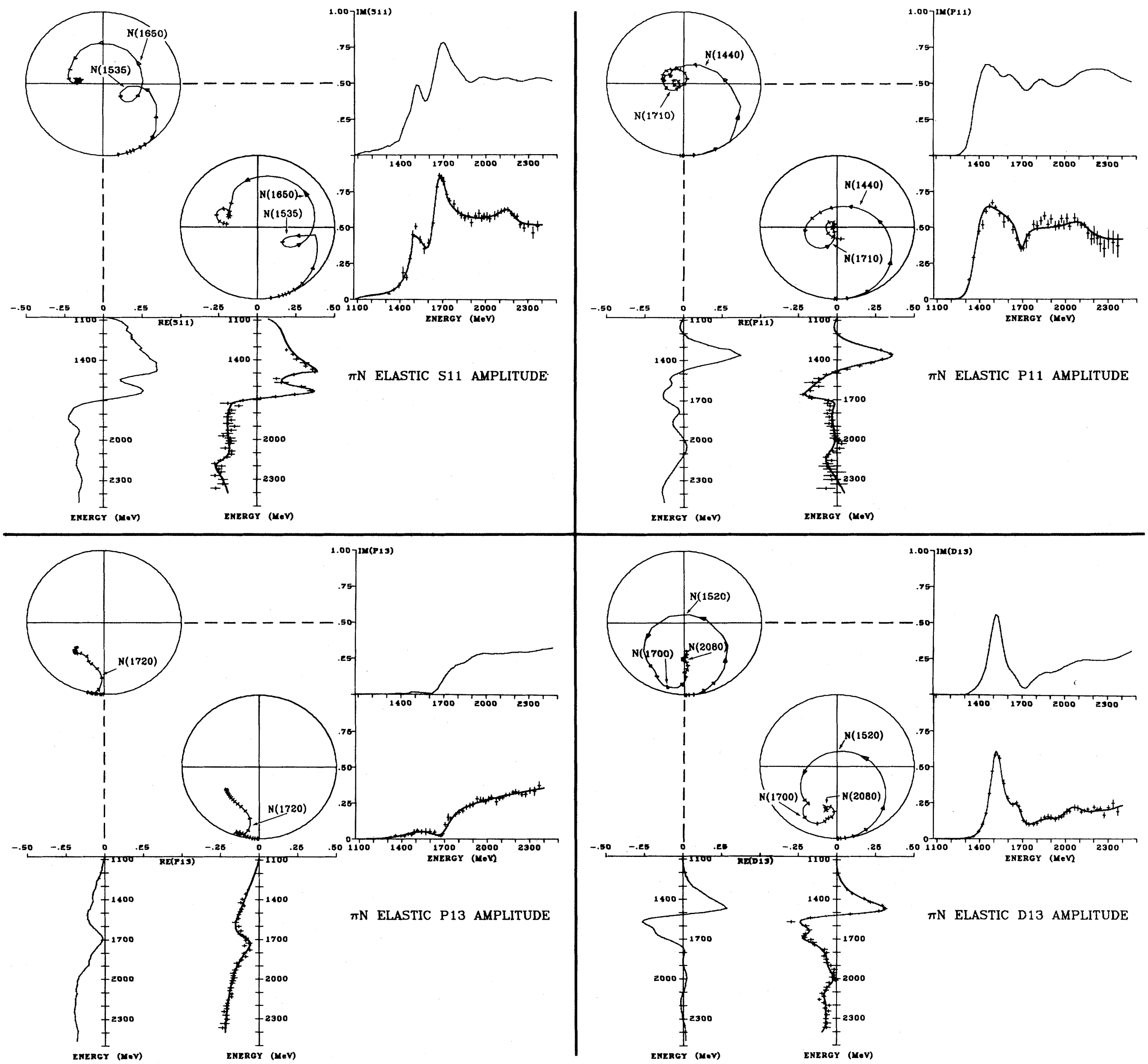

Fig. 1(a). The $L_{2I \cdot 2J} = S_{11}$, P_{11}, P_{13}, and D_{13} partial-wave amplitudes for πN elastic scattering. The upper plot for each amplitude is from HOEHLER 79 and the lower one is from CUTKOSKY 80. In the Argand plots, the ticks are at integral multiples of 50 MeV, and the established resonances are shown at their nominal positions. The real and imaginary parts of the amplitudes as functions of energy are shown projected in alignment with the Argand plots (in the projections of the CUTKOSKY 80 amplitudes, the "data points" are results of energy-independent fits, and the curves are from an energy-dependent fit to join them).

Baryons
N's and Δ's

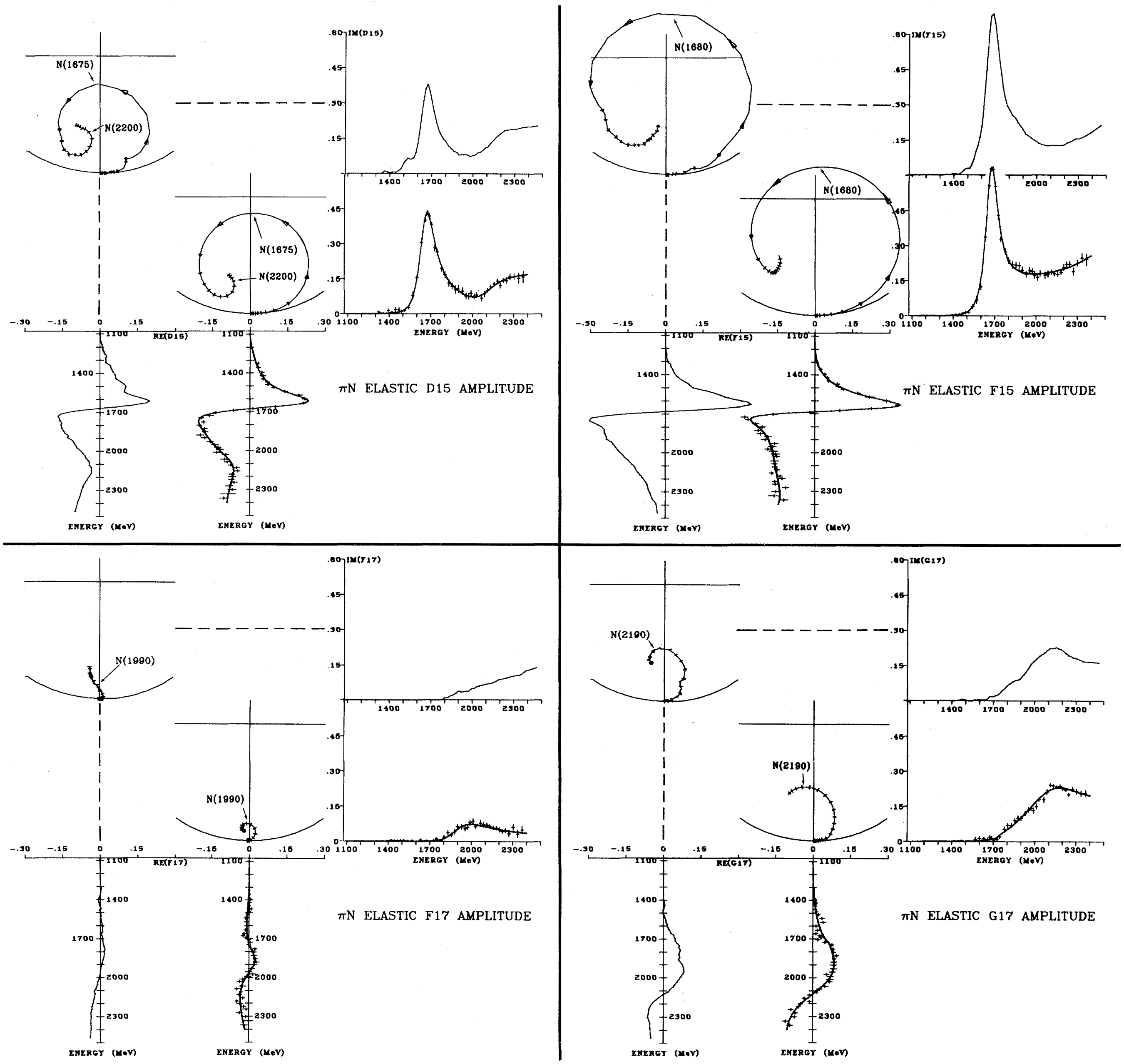

Fig. 1(b). The $L_{2I \cdot 2J} = D_{15}$, F_{15}, F_{17}, and G_{17} partial-wave amplitudes for πN elastic scattering. The upper plot for each amplitude is from HOEHLER 79 and the lower one is from CUTKOSKY 80. In the Argand plots, the ticks are at integral multiples of 50 MeV, and the established resonances are shown at their nominal positions. The real and imaginary parts of the amplitudes as functions of energy are shown projected in alignment with the Argand plots (in the projections of the CUTKOSKY 80 amplitudes, the "data points" are results of energy-independent fits, and the curves are from an energy-dependent fit to join them).

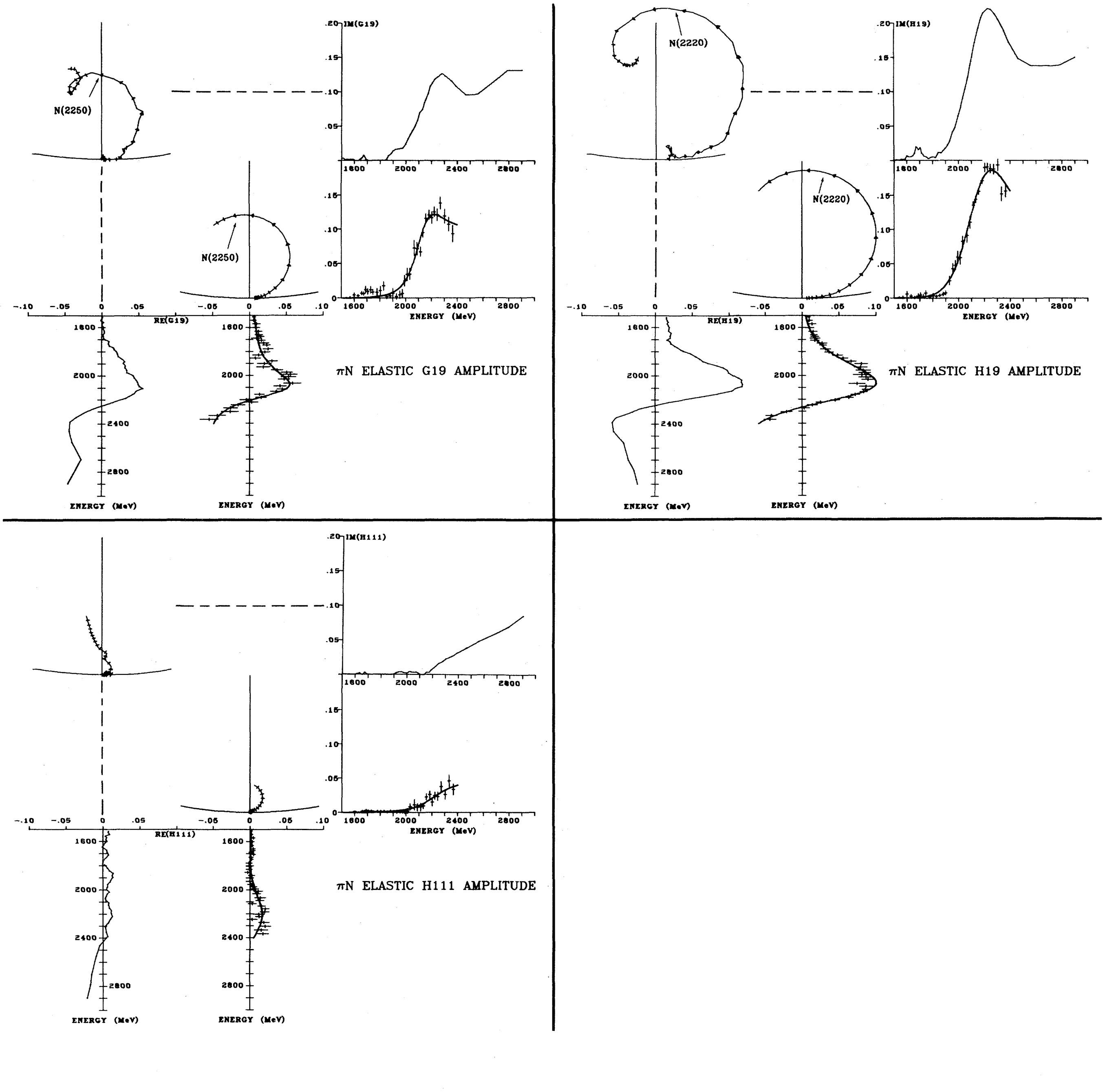

Fig. 1(c). The $L_{2I \cdot 2J} = G_{19}$, H_{19}, and H_{111} partial-wave amplitudes for πN elastic scattering. The upper plot for each amplitude is from HOEHLER 79 and the lower one is from CUTKOSKY 80. In the Argand plots, the ticks are at integral multiples of 50 MeV, and the established resonances are shown at their nominal positions. The real and imaginary parts of the amplitudes as functions of energy are shown projected in alignment with the Argand plots (in the projections of the CUTKOSKY 80 amplitudes, the "data points" are results of energy-independent fits, and the curves are from an energy-dependent fit to join them).

Baryons
N's and Δ's

Data Card Listings

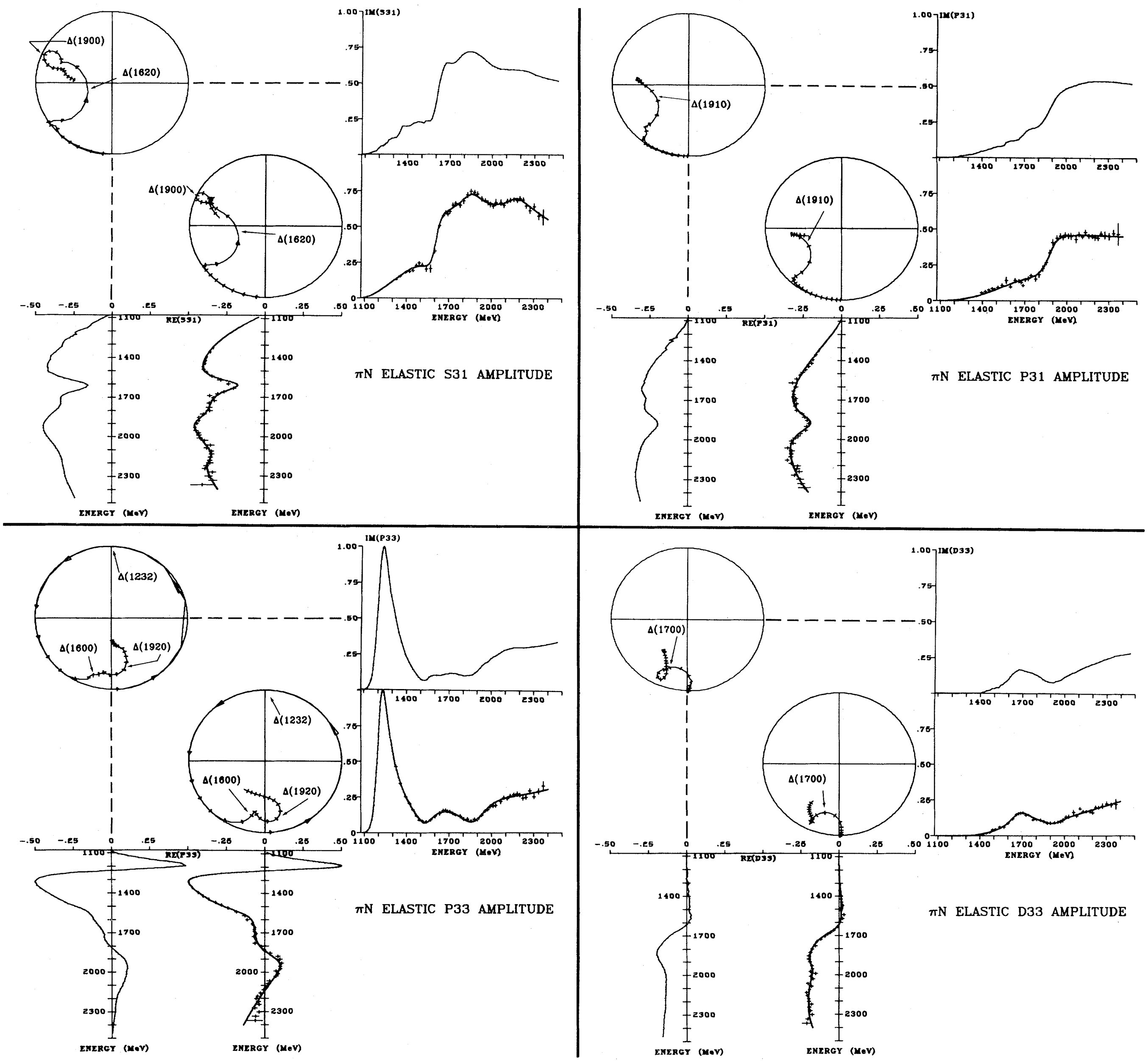

Fig. 1(d). The $L_{2I\cdot 2J} = S_{31}, P_{31}, P_{33}$, and D_{33} partial-wave amplitudes for πN elastic scattering. The upper plot for each amplitude is from HOEHLER 79 and the lower one is from CUTKOSKY 80. In the Argand plots, the ticks are at integral multiples of 50 MeV, and the established resonances are shown at their nominal positions. The real and imaginary parts of the amplitudes as functions of energy are shown projected in alignment with the Argand plots (in the projections of the CUTKOSKY 80 amplitudes, the "data points" are results of energy-independent fits, and the curves are from an energy-dependent fit to join them).

For notation, see key at front of Listings.

Baryons
N's and Δ's

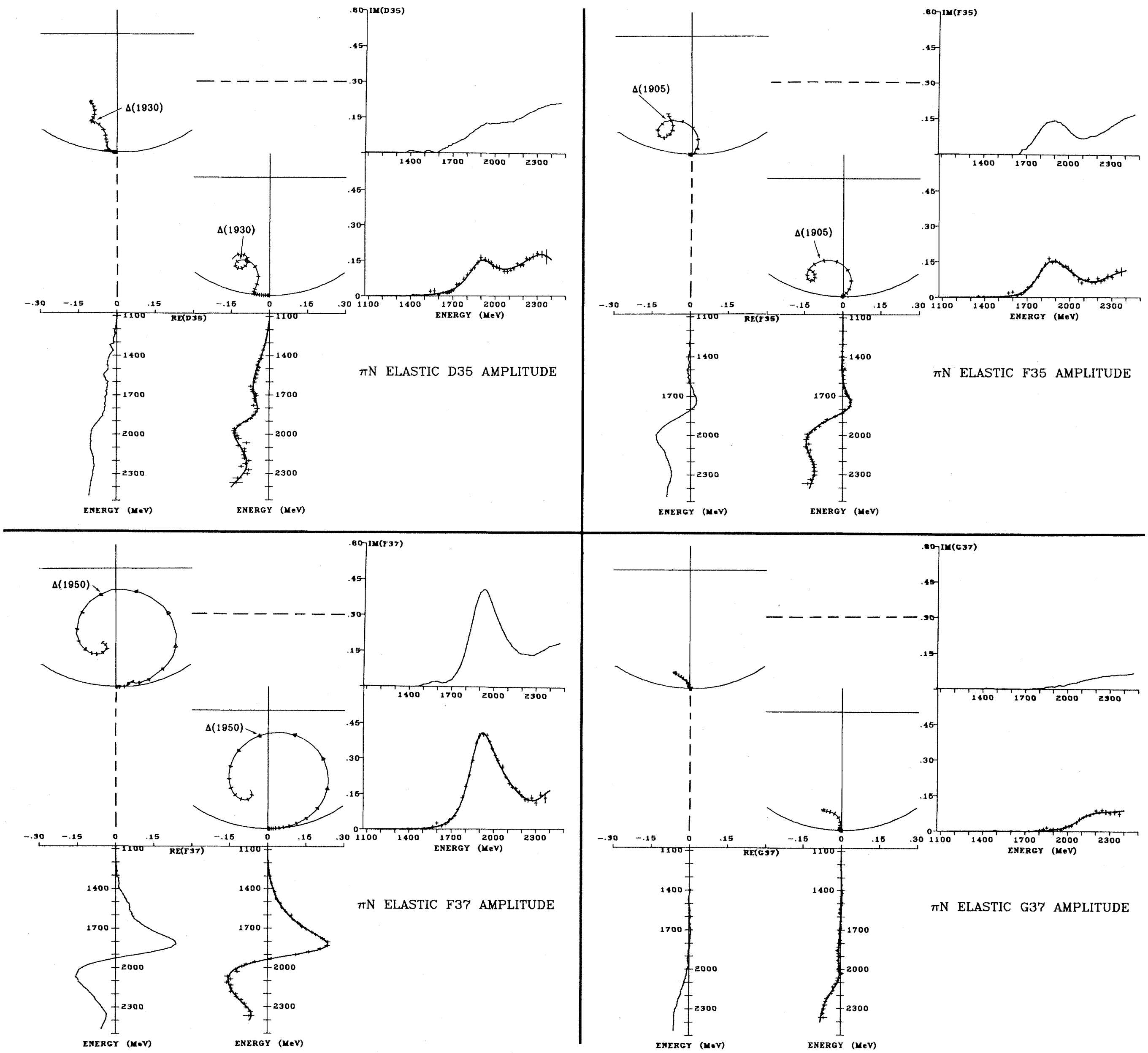

Fig. 1(e). The $L_{2I \cdot 2J}$ = D_{35}, F_{35}, F_{37}, and G_{37} partial-wave amplitudes for πN elastic scattering. The upper plot for each amplitude is from HOEHLER 79 and the lower one is from CUTKOSKY 80. In the Argand plots, the ticks are at integral multiples of 50 MeV, and the established resonances are shown at their nominal positions. The real and imaginary parts of the amplitudes as functions of energy are shown projected in alignment with the Argand plots (in the projections of the CUTKOSKY 80 amplitudes, the "data points" are results of energy-independent fits, and the curves are from an energy-dependent fit to join them).

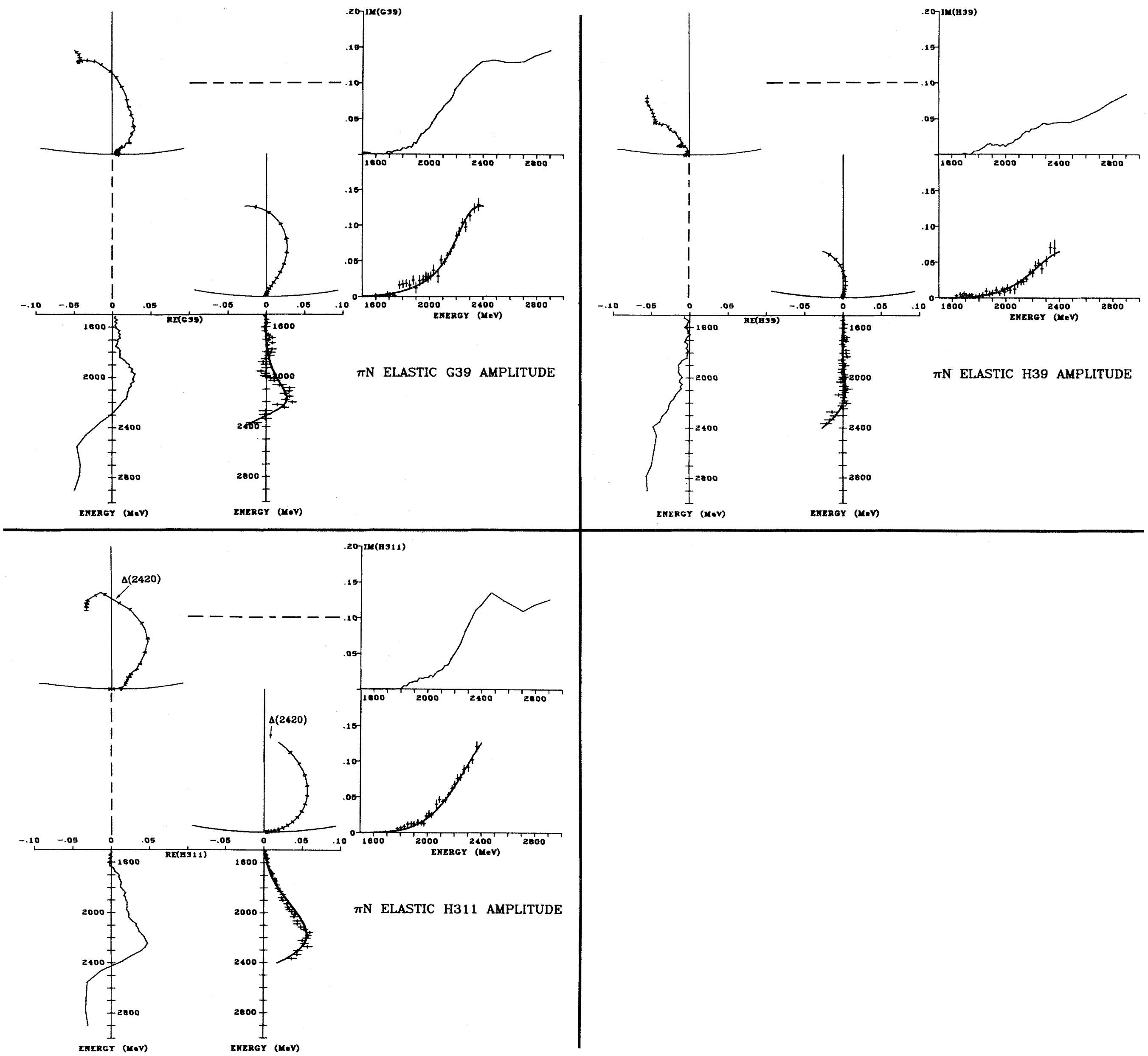

Fig. 1(f). The $L_{2I\cdot 2J}$ = G_{39}, H_{39}, and H_{311} partial-wave amplitudes for πN elastic scattering. The upper plot for each amplitude is from HOEHLER 79 and the lower one is from CUTKOSKY 80. In the Argand plots, the ticks are at integral multiples of 50 MeV, and the established resonances are shown at their nominal positions. The real and imaginary parts of the amplitudes as functions of energy are shown projected in alignment with the Argand plots (in the projections of the CUTKOSKY 80 amplitudes, the "data points" are results of energy-independent fits, and the curves are from an energy-dependent fit to join them).

traverses the complex plane cannot be accurately determined due to insufficient data. Furthermore, it is a dynamical question whether this background is part of the resonance mechanism.

If the resonances are ordered according to the shapes of their Argand plots, one finds a continuous transition from textbook-type resonances to tiny wiggles superimposed on a huge background. The Baryon Table lists all objects which have a "resonance-like" shape of the Argand diagram and a maximum of the speed. We have to leave it to the reader to decide which of these objects are "resonances" in the framework of his or her model.

The above discussion shows that a comparison of the resonance masses listed in the Baryon Table with predictions from quark-shell or -bag models or from lattice calculations has appreciable uncertainties, in particular where small mass splittings are concerned, since the models cannot yet treat the scattering process including the background.

The Data Card Listings contain a second set of resonance parameters: the locations and residues of the resonance poles on the second sheet of the s-plane. These numbers can be determined in a (more or less) model-independent way. However, it is a warning that Fonda et al.[12] were able to fit the resonant P_{33} amplitude *without a pole.* One needs a theoretical assumption that excludes parametrizations of this type.

It is remarkable that there exist families of resonances in each of which the splittings of the pole positions are comparable with the errors; i.e., a degeneracy is not excluded.[7] For example, all six isospin-1/2 partial waves from S_{11} to F_{15} have a well-established resonance with a pole near $\sqrt{s}$ = (1665-60i) MeV, and at least six of the seven possible isospin-3/2 resonances from S_{31} to F_{37} have a pole near (1880-120i) MeV.

Inelastic 2-body reactions: Partial-wave analyses of the inelastic 2-body reactions $\pi N \rightarrow N\eta$, ΛK, and ΣK may be carried out in a way similar to the analysis of $\pi N \rightarrow \pi N$. However, since the data are less complete and accurate, energy-dependent parametrizations must be used.

The most accurate results, which include information on the resonance masses and widths, follow from the $\pi^- p \rightarrow \Lambda K^0$ data of the Rutherford group.[13] In an energy-dependent analysis, the nonresonant and high waves were represented by a reggeized K^* exchange term.[13,14] Another analysis used a Lagrangian model for the long range forces.[15] In general, agreement with the $\pi N \rightarrow \pi N$ analyses is good, but there are discrepancies for the widths of the P_{11} N(1710) and the D_{15} N(1675) and for the mass of the D_{15} N(2200).

In the analysis of the less accurate $\pi^- p \rightarrow n\eta$ data,[16] the partial waves were parametrized as Breit-Wigner resonances without background. The resonance spectrum was assumed and the data were used to determine the couplings to the $n\eta$ channel. In some cases of relatively large couplings, the masses and widths were varied in a second step.

The results derived from the bubble chamber data for $\pi^+ p \rightarrow \Sigma^+ K^+$ [17] have larger uncertainties. Values of the resonance masses were assumed and Breit-Wigner formulas and an empirical ansatz for the background were used for partial waves up to F waves (the G waves are probably not negligible at 1.7 GeV/c). The recent addition of precise data from 1820 to 2350 MeV[18] has allowed an improved analysis.[19] The solution found is unique. Above 2 GeV, all the resonances with two or more stars are seen, but none of the 1-star states is supported.

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III. The $\pi N \to N\pi\pi$ channel

(by R.L. Crawford, University of Glasgow)

The $\pi N \to N\pi\pi$ reaction has been analyzed using isobar models, which are prompted by the observation that almost all $\pi N \to N\pi\pi$ events in the resonance region lie in quasi-2-body bands in the Dalitz plot. Thus it is assumed that any purely 3-body interaction is negligible and that the reaction proceeds entirely through quasi-2-body intermediate states.

The resulting parametrization contains the couplings of a number of the N and Δ resonances to these quasi-2-body states, and it is these which are given in the Listings. A more complete description of the analyses and of the definition of the couplings may be found in our 1982 edition.[1]

The Listings give the results from four analyses, none new to this edition.

LONGACRE 75 (LBL-SLAC)[2] is based on an analysis of 200,000 $\pi^- p \to p\pi^-\pi^0$, $\pi^- p \to n\pi^-\pi^+$, and $\pi^+ p \to p\pi^+\pi^0$ events with the c.m. energy between 1300 and 2000 MeV. It includes the intermediate states $\Delta(1232)\pi$, $N\rho$, and $N\epsilon$ (where ϵ is the isospin-0 S-wave $\pi\pi$ enhancement). The couplings and the T-matrix poles of 14 resonances are given.

LONGACRE 77 (Saclay)[3] is a similar analysis that fits 100K data points between 1380 and 1740 MeV. The couplings and pole positions of 16 resonances are given, including a P_{13} N(1540) and a P_{31} Δ(1550) suggested for the first time by this analysis.

NOVOSELLER 78 (Cal Tech)[4] is an analysis of $\pi^- p \to p\pi^-\pi^0$, $\pi^- p \to n\pi^-\pi^+$, and $\pi^+ p \to p\pi^+\pi^0$ events from 1650 to 1970 MeV and is based on the earlier LBL-SLAC energy-independent analysis.[5] Two solutions are given, with the second including the effects of single-pion exchange. They are noted in the Listings as being fits to Longacre 75 and Novoseller 78.

BARNHAM 80 (Imperial College)[6] is an analysis of 44,000 $\pi^+ p \to p\pi^+\pi^0$ and $\pi^+ p \to n\pi^+\pi^+$ events between 1440 and 1700 MeV. It thus gives information only about Δ resonances. Decays into $\Delta(1232)\pi$, $N\rho$, and $N(1440)\pi$ are considered. It again finds evidence for the P_{31} Δ(1550), but since it uses data also used by Longacre 77 it is not clear that it confirms this resonance.

It is difficult to assess the systematic uncertainties of the results from these analyses. Again, the reader is referred to our 1982 edition for more details.

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IV. Photoproduction and Compton Scattering

(by R.L. Crawford, University of Glasgow)

Most of the information about the γN couplings of the N and Δ resonances is obtained from partial-wave analyses of single-pion photoproduction. There is now a large amount of data, including many measurements from single and double polarization experiments giving up to six independent experimental observables in some energy ranges. Recently, some couplings have also been obtained from proton Compton scattering. All photoproduction analyses rely heavily on $\pi N \to \pi N$ analyses for knowledge about the existence, masses, and widths of the resonances; there are few photoproduction analyses that treat the masses and widths as free parameters, although the results obtained are of some interest since they give access to the charge +1 states. The results may be found in the appropriate sections of the Data Card Listings. We refer to an earlier edition of this Review[1] for more about the formalism of single-pion photoproduction.

There are three main methods for the partial-wave analysis of single-pion photoproduction.

(a) *The simple isobar model*: This is the simplest form of energy-dependent partial-wave analysis (DPWA): the partial waves are parametrized as Breit-Wigner resonances plus smooth background. The method is sufficiently flexible to give good fits to data, but there are possible problems concerned with the uniqueness of the solutions. This is overcome by the form of the parametrization, but it is not clear how this may introduce bias into the solution.

The Listings contain the couplings from isobar analyses of photoproduction from METCALF 74, TAKEDA 80, and BRATASHEVSKIJ 80. ISHII 80 is an isobar analysis of proton Compton scattering in the second resonance region.

(b) *Fixed-t dispersion relations (FTDR)*: In this method, the real parts of the production amplitudes are not parametrized directly but are calculated from the imaginary parts using fixed-t dispersion relations. The latter can be assumed to be resonance dominated and thus can be given a relatively simple parametrization in terms of Breit-Wigner resonances with a little background in the low-angular-momentum partial waves. Alternatively, a K-matrix formalism can be used. Compared to the isobar model, there are fewer parameters and the results may be less sensitive to the details of the parametrization. The method gives fewer problems in obtaining a unique solution than does the isobar model, but it is less flexible and tends to give poorer fits.

The Listings contain the results from the FTDR analyses of AZNAURYAN 77, BARBOUR 78, ARAI 80, CRAWFORD 80, FUJII 81, and AWAJI 81. NOELLE 78 is a hybrid analysis using FTDR in a coupled-channel isobar calculation.

(c) *Energy-independent analyses (IPWA)*: These evaluate the partial waves by fitting at a set of essentially single energies and should be the least biased of all the forms of analysis. At low energies, Watson's theorem[2] is used to fix the complex phases of many of the partial waves in order to get a single solution. This becomes more difficult as the energy increases due to the onset of inelasticity, and only BERENDS 77 uses this method up to the second resonance region. CRAWFORD 83 is an energy-independent analysis for energies below 1750 MeV, based on the CRAWFORD 80 FTDR analysis. It is described below.

***New analyses in the Listings*:** The most recent FTDR analysis, AWAJI 81 (Nagoya), is a revision of the 1979 Tokyo analysis (ARAI 80), and uses new data and more recent resonance parameters from πN elastic partial-wave analyses. It treats the production amplitudes differently depending on the energy. Below 2200 MeV a 3-channel K-matrix formalism is used, and above 2200 MeV a Regge parametrization is used for the dispersion integrals. Pseudo-resonances are used to describe the imaginary background, The couplings for resonances up to the F_{17} N(1990) are determined for both proton and neutron targets.

CRAWFORD 83 is an energy-independent analysis using only proton data for energies between 1200 and 1920 MeV. A unique solution is obtained at each energy by requiring that it not differ radically from the FTDR analysis of CRAWFORD 80. Although the constraints thus applied were the loosest possible that still gave stability of the energy-independent solutions, the two analyses are therefore not totally independent. However, CRAWFORD 83 gives a useful extension of the FTDR solution and achieves a significant improvement in the quality of the fits at all the single energies. The two analyses agree well and again there is weak evidence for the P_{31} Δ(1550).

***Resonance couplings in the Listings*:** The Listings in this edition omit a number of analyses that are now obsolete due to later analyses that used improved data sets. The omitted analyses are ROSSI 73, HEMMI1 73, HEMMI2 73, BENEVENTANO 74, KRIVETS 75 (isobar model), MOORHOUSE 73, DEVENISH 73, KNIES 74, MOORHOUSE 74, DEVENISH2 74, CRAWFORD 75, and BARBOUR 76 (FTDR). They may all be found in our 1982 edition.[3]

The errors for the couplings given in the Listings vary very widely for the different analyses since they have been obtained in different ways and are not comparable. METCALF 74, FELLER 76, AZNAURYAN 77, and ARAI 80 quote errors obtained from the sensitivity of the "best possible" χ^2 to the value of each coupling and thus give only statistical errors based on the data. In BARBOUR 78, CRAWFORD 80, and CRAWFORD 83, it is considered that systematic errors that depend on different forms of parametrization, including that for the background, are more important, and the errors given are an estimate of these. The errors given in AWAJI 81 also include a contribution from the uncertainty in the πN elasticity used to calculate the couplings from the partial waves.

Table 2 gives a compilation of the couplings obtained from BARBOUR 78, ARAI 80, CRAWFORD 80, FUJII 81, AWAJI 81, and CRAWFORD 83. The errors quoted are a combination of the statistical errors from the analyses and of the systematic differences between them. They are compared with the range of predictions from recent quark models.[4-7] There is qualitative agreement in that (1) any coupling whose sign is the same in all the quark models also has the same sign in the analyses, and (2) those couplings which are predicted to be zero or small do seem to be small.

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V. Electroproduction

The excitation of the N and Δ resonances by virtual photons has been investigated using pion and η electroproduction data. For example, a recent measurement of π^+ electroproduction[1] gives additional information about the switching in importance of the helicity 3/2 and 1/2 amplitudes for the D_{13} N(1520) and F_{15} N(1680) resonances. Such information provides tests of the single-quark transition model.[2] However, there is not much new information for the present Review of Particle Properties, so we refer to our last edition for a

Table 2. A compilation of measured γN decay couplings and predictions of the quark model. Sources are given in the text.

(a) Proton target couplings

Resonance	Helicity	Couplings ($GeV^{-1/2}\times10^{-3}$) Partial-wave analyses	Status	Quark-model predictions
N(1440) P_{11}	1/2	−69 ± 7	good	−50 to −5
N(1520) D_{13}	1/2	−22 ± 10	good	−41 to +6
	3/2	+167 ± 10	good	+95 to +174
N(1535) S_{11}	1/2	+73 ± 14	good	+97 to +147
N(1650) S_{11}	1/2	+48 ± 16	fair	−9 to +95
N(1675) D_{15}	1/2	+19 ± 12	good, ≠0	0 to +12
	3/2	+19 ± 12	good, ≠0	0 to +16
N(1680) F_{15}	1/2	−17 ± 10	good, ≠0	−7 to +24
	3/2	+127 ± 12	good	+47 to +154
N(1700) D_{13}	1/2	−22 ± 13	good, ≈0	−7 to +9
	3/2	0 ± 19	fair, ≈0	−12 to +33
N(1710) P_{11}	1/2	+5 ± 16	fair, ≈0	−47 to −7
N(1720) P_{13}	1/2	+52 ± 39	poor	−133 to +74
	3/2	−35 ± 24	fair	−65 to +46
N(1990) F_{17}	1/2	+24 ± 30	poor	−10 to −8
	3/2	31 ± 55	bad	−13 to −10
Δ(1232) P_{33}	1/2	−141 ± 5	good	−127 to −94
	3/2	−258 ± 11	good	−220 to −162
Δ(1550) P_{31}	1/2	+16 ± 16	?	?
Δ(1600) P_{33}	1/2	−20 ± 29	poor, ≈0	−61 to +2
	3/2	+1 ± 22	fair, ≈0	−107 to +4
Δ(1620) S_{31}	1/2	+19 ± 16	fair	+43 to +86
Δ(1700) D_{33}	1/2	+116 ± 17	fair	+78 to +106
	3/2	+77 ± 28	fair	+79 to +105
Δ(1900) S_{31}	1/2	+10 ± ?	?	−3
Δ(1905) F_{35}	1/2	+27 ± 13	good	−10 to +44
	3/2	−47 ± 19	fair	−41 to +15
Δ(1910) P_{31}	1/2	−12 ± 30	poor	−16 to +15
Δ(1920) P_{33}	1/2	+40 ± ?	?	—
	3/2	+23 ± ?	?	—
Δ(1930) D_{35}	1/2	−30 ± 40	poor	−17
	3/2	−10 ± 35	poor	−24
Δ(1950) F_{37}	1/2	−73 ± 14	good	−50 to −25
	3/2	−90 ± 13	good	−69 to −32

(b) Neutron target couplings

Resonance	Helicity	Couplings ($GeV^{-1/2}\times10^{-3}$) Partial-wave analyses	Status	Quark-model predictions
N(1440) P_{11}	1/2	+37 ± 19	fair	+4 to +38
N(1520) D_{13}	1/2	−65 ± 13	good	−52 to −23
	3/2	−144 ± 14	good	−144 to −102
N(1535) S_{11}	1/2	−76 ± 32	fair	−119 to −83
N(1650) S_{11}	1/2	−17 ± 37	poor	−45 to +4
N(1675) D_{15}	1/2	−47 ± 23	fair	−55 to −31
	3/2	−69 ± 19	fair	−78 to −44
N(1680) F_{15}	1/2	+31 ± 13	good	−32 to +27
	3/2	−30 ± 14	good	−25 to +2
N(1700) D_{13}	1/2	0 ± 56	bad	−15 to +23
	3/2	−2 ± 44	bad	−76 to −17
N(1710) P_{11}	1/2	−5 ± 23	fair	−21 to +29
N(1720) P_{13}	1/2	−2 ± 26	fair	−23 to +57
	3/2	−43 ± 94	bad	−61 to +12
N(1990) F_{17}	1/2	−49 ± 45	poor	−19 to −18
	3/2	−122 ± 55	poor	−25 to −23

brief review[3] and to a recent article for an extensive review[4] of electroproduction.

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VI. Production experiments

Partial-wave analyses of course separate partial waves, whereas a peak in a cross section or an invariant mass distribution usually cannot be disentangled from background and analyzed for its quantum numbers; and more than one resonance may be contributing to the peak. We used to have separate entries in the Listings for bumps seen in production experiments in the 1440-MeV region, the 1520-MeV region, etc., but these have been removed from this edition. They may be found in the 1982 edition.[1]

Reference for section VI

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S=0 I=1/2 NUCLEON STATES (N)

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p

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          16  PROTON(938, JP=1/2+)  I=1/2

          SEE STABLE PARTICLE DATA CARD LISTINGS
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****** ********* ********* ********* ********* ********* ********* ********
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n

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          17  NEUTRON(939, JP=1/2+)  I=1/2

          SEE STABLE PARTICLE DATA CARD LISTINGS
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****** ********* ********* ********* ********* ********* ********* ********
****** ********* ********* ********* ********* ********* ********* ********
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N(1440) P'_{11} Status: ****

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          61  N(1440, JP=1/2+) I=1/2   P'11

          MOST OF THE RESULTS PUBLISHED BEFORE 1975 ARE NOW
          OBSOLETE AND HAVE BEEN OMITTED.  THEY MAY BE FOUND IN
          OUR 1982 EDITION (PHYSICS LETTERS 111B).  HOWEVER,
          ALL THE REFERENCES HAVE BEEN RETAINED.

   IN ADDITION, RESULTS IN THIS REGION FROM PRODUCTION EXPERIMENTS,
   WHICH USED TO BE LISTED SEPARATELY AS THE NEXT ENTRY, HAVE BEEN
   ENTIRELY REMOVED.

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                     61  N(1440) MASS (MEV)

M    A      1415. OR 1390.           LONGACRE  75 IPWA    PI N TO 2PI N    11/75
M    A  THE 2 SETS OF PARAMETERS ARE FROM METHODS 1 AND 2 OF LONGACRE 75.   11/75
M         (1460.0)                   BERENDS   77 IPWA    PI-N PHOTOPROD.   1/78
M    B    (1380.0)                   LONGACRE  77 IPWA    PI N TO 2PI N    11/77
M    B  ALL LONGACRE77 PARAMETERS ARE FROM SOLUTION S2, EXCEPT FOR THE POLE 11/77
M    B  POSITION WHICH IS FROM SOLUTIONS S1 AND C1.                         11/77
M         (1417.0)                   BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
M    C    (1472.0)                   BAKER     79 DPWA  0 PI- P TO ETA N   12/79
M         (1450.0)   (30.0)          CUTKOSKY  79 IPWA    PI N TO PI N     12/79
M          1410.0     12.0           HOEHLER   79 IPWA    PI N TO PI N     12/79
M         (1411.0)                   CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
M          1440.0     30.0           CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                     61  N(1440) WIDTH (MEV)

W    A     180. OR  200.             LONGACRE  75 IPWA    PI N TO 2PI N    11/75
W         (279.0)                    BERENDS   77 IPWA    PI-N PHOTOPROD.   1/78
W    B    (200.0)                    LONGACRE  77 IPWA    PI N TO 2PI N    11/77
W         (331.0)                    BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
W    C    (113.0)                    BAKER     79 DPWA  0 PI- P TO ETA N   12/79
W         (370.0)   (80.0)           CUTKOSKY  79 IPWA    PI N TO PI N     12/79
W          135.0     10.0            HOEHLER   79 IPWA    PI N TO PI N     12/79
W         (334.0)                    CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
W          340.0     70.0            CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                     61  N(1440) REAL PART OF POLE POSITION (MEV)

RE       (1381.0)                    LONGACRE  75 IPWA    PI N TO 2PI N    11/75
RE   B    1360. OR 1333.             LONGACRE  77 IPWA    PI N TO 2PI N    11/77
RE       (1369.0)                    CUTKOSKY  79 IPWA    PI N TO PI N     12/79
RE        1375.0     30.0            CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                     61  N(1440) -2*IMAG PART OF POLE POSITION (MEV)

IM        (209.0)                    LONGACRE  75 IPWA    PI N TO 2PI N    11/75
IM   B     167. OR 234.              LONGACRE  77 IPWA    PI N TO 2PI N    11/77
IM        (178.0)                    CUTKOSKY  79 IPWA    PI N TO PI N     12/79
IM         180.0     40.0            CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                     61  N(1440) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER        (-9.0)                    CUTKOSKY  79 IPWA    PI N TO PI N     12/79
RER         -9.0     31.0            CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                     61  N(1440) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR       (-48.0)                    CUTKOSKY  79 IPWA    PI N TO PI N     12/79
IMR        -51.0      7.0            CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                     61  N(1440) ABSOLUTE VALUE OF POLE RESIDUE (MEV)

ABS         52.0      5.0            CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                     61  N(1440) PHASE OF POLE RESIDUE (RADIANS)

PH          -1.75     0.61           CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                     61  N(1440) PARTIAL DECAY MODES

                                                           DECAY MASSES
P1      N(1440) INTO N PI                                 938+ 140
P2      N(1440) INTO N EPSILON                            938+1300
P3      N(1440) INTO DELTA(1232) PI                      1232+ 140
P4      N(1440) INTO N PI PI                              938+ 140+ 140
P5      N(1440) INTO N GAMMA                              938+   0
P6      N(1440) INTO N RHO                                938+ 769
P7      N(1440) INTO P GAMMA, HELICITY=1/2                938+   0
P8      N(1440) INTO N GAMMA, HELICITY=1/2                940+   0
P9      N(1440) INTO N ETA                                940+ 549
P10     N(1440) INTO LAMBDA K                            1116+ 498
P11     N(1440) INTO N RHO, S=1/2, P-WAVE                 938+ 769
P12     N(1440) INTO N RHO, S=3/2, P-WAVE                 938+ 769

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                     61  N(1440) BRANCHING RATIOS

R1      N(1440) INTO (N PI)/TOTAL                        (P1)
R1          (0.65)    (0.05)         CUTKOSKY  79 IPWA    PI N TO PI N     12/79
R1           0.51      0.05          HOEHLER   79 IPWA    PI N TO PI N     12/79
R1           0.68      0.04          CUTKOSKY  80 IPWA    PI N TO PI N      1/82

R2      N(1440) FROM N PI INTO N ETA                     SQRT(P1*P9)
R2   D      (+0.328)                 FELTESSE  75 DPWA  0 1488 TO 1745 MEV 11/75
R2   D   AN ALTERNATIVE WHICH CAN NOT BE DISTINGUISHED FROM THIS IS TO HAVE 11/75
R2   D   A P13 RESONANCE WITH M=1530, W=79, AND COUPLING=+.271              11/75
R2   C   BAKER 79 FINDS A COUPLING OF THE N(1440) TO THE N ETA CHANNEL      12/79
R2   C   NEAR (BUT SLIGHTLY BELOW) THRESHOLD.                               12/79

R3      N(1440) FROM N PI TO DELTA(1232) PI              SQRT(P1*P3)
R3   A       -0.30 OR -0.37          LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R3   B      (-0.41)                  LONGACRE  77 IPWA    PI N TO 2PI N    11/77
R3   B   LONGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.

R4      N(1440) FROM N PI TO N RHO, S=1/2, P-WAVE        SQRT(P1*P11)
R4   A        0.0  OR -0.23          LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R4   B      (+0.11)                  LONGACRE  77 IPWA    PI N TO 2PI N    11/77

R5      N(1440) FROM N PI TO N RHO, S=3/2, P-WAVE        SQRT(P1*P12)
R5   B      (-0.18)                  LONGACRE  77 IPWA    PI N TO 2PI N    11/77
R5   B   LONGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.

R6      N(1440) FROM N PI TO N EPSILON                   SQRT(P1*P2)
R6   A        0.18 OR +0.23          LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R6   B      (+0.18)                  LONGACRE  77 IPWA    PI N TO 2PI N    11/77

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                     61  N(1440) PHOTON DECAY AMPLITUDES (GEV**-1/2)

       FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-
     REVIEW PRECEDING THE BARYON LISTINGS.

A1      N(1440) INTO P GAMMA, HELICITY=1/2 (GEV**-1/2)
A1          -0.070    0.023          METCALF   74 DPWA    PI N PHOTOPROD.   2/74
A1          -0.087    0.006          FELLER    76 DPWA    PI N PHOTOPROD.   2/77
A1          -0.038    0.013          AZNAURYAN 77 DPWA    PI0 PHTPRD,SOL 1 12/79
A1          -0.019    0.011          AZNAURYAN 77 DPWA    PI0 PHTPRD,SOL 2 12/79
A1         (-0.076)                  BERENDS   77 IPWA    PI-N PHOTOPROD.   1/78
A1          -0.075    0.015          BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
A1   N     (-0.125)                  NOELLE    78         PI-N PHOTOPROD.   1/80
A1   N   CONVERTED TO OUR CONVENTIONS USING M=1.486, W=.613 FROM NOELLE 78.  1/80
A1          -0.069    0.004          ARAI      80 DPWA    PI N PHOTO FIT 1 12/81
A1          -0.066    0.004          ARAI      80 DPWA    PI N PHOTO FIT 2 12/81
A1          -0.079    0.009          BRATASHEV 80 DPWA    PI N PHOTOPROD.  12/81
A1          -0.068    0.015          CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
A1          -0.0584   0.0148         ISHII     80 DPWA    P COMPTON SCAT   12/81
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Baryons

N(1440), N(1520)

Data Card Listings

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A1           -0.063    0.008            AWAJI     81 DPWA    PI N PHOTOPROD.   1/84*
A1           -0.069    0.018            CRAWFORD  83 IPWA    PI N PHOTOPROD.   1/84*

A2     N(1440) INTO N GAMMA, HELICITY=1/2 (GEV**-1/2)
A2            0.043    0.035            METCALF   74 DPWA    PI N PHOTOPROD.   2/74
A2           +0.059    0.016            BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
A2     N     (0.062)                    NOELLE    78         PI-N PHOTOPROD.   1/80
A2            0.023    0.009            ARAI      80 DPWA    PI N PHOTO FIT 1 12/81
A2            0.019    0.012            ARAI      80 DPWA    PI N PHOTO FIT 2 12/81
A2            0.056    0.015            CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
A2           -0.029    0.035            TAKEDA    80 DPWA    PI N PHOTOPROD.  12/81
A2            0.037    0.010            AWAJI     81 DPWA    PI N PHOTOPROD.   1/84*
A2            0.030    0.003            FUJII     81 DPWA    PI N PHOTOPROD.  12/81

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REFERENCES FOR N(1440)


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BAREYRE  64 PL 8 137           +BRICMAN,VALLADAS,VILLET, +     (SACL+CAEN) IJ
BAREYRE  65 PL 18 342          +BRICMAN, STIRLING, VILLET            (SACL)IJP
BRANDSEN 65 PR 139 B1566       +ODONNELL, MOORHOUSE             (DURH+RHEL)IJP
DALITZ   65 PL 14 159          R H DALITZ, R G MOORHOUSE          (OXF+RHEL)
ROPER    65 PR 138 B190        L D ROPER,R M WRIGHT,B T FELD      (LLL+MIT)IJP
THURNAUE 65 PRL 14 985         P G THURNAUER                          (ROCH)
NAMYSLOW 66 PR 157 1328        NAMYSLOWSKI,RAZMI,ROBERTS  (STAN+EDIN+LOIC)
JOHNSON  67 UCRL-17683 THESIS C H JOHNSON                             (LRL)
ROSENFEL 67 IRVINE CONF        A H ROSENFELD, P SODING                 (LRL)

BAREYRE  68 PR 165 1731        P BAREYRE, C BRICMAN, G VILLET       (SACL)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)
DONNACHI 69 NP 10B 433         A DONNACHIE, R KIRSOPP           (GLAS+EDIN)
WALKER   69 PR 182 1729        R L WALKER                            (CIT)IJP

AYED     70 KIEV CONF          R AYED,P BAREYRE, G VILLET           (SACL)IJP
AYED2    70 PL 31B 598         +BAREYRE,VILLET                       (SACL)
BERARDO  70 PRL 24 419         +HADDOCK,NEFKENS,..,PARSONS+..   (UCLA+LRL)
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,++                (IOFF)IJP
MICKENS  71 LNC  1  707        R E MICKENS                           (FISK)
ALMEHED  72 NP B40 157         +LOVELACE                        (LUND+RUTG)IJP
AYED     72 BATAVIA CONF       R AYED,P BAREYRE, Y LEMOIGNE          (SACL)

DEVENISH 73 PL 47B 53          DEVENISH,RANKIN,LYTH        (LOUC+BONN+LANC)IJP
HEMMI1   73 PL 43B 79          HEMMI,INAGAKI+          (KYOT+SAGA+KEK+TOKY)IJP
HEMMI2   73 NP B55 333         +INAGAKI,KIKUCHI,MAKI,MIYAKE+   (KYOT+TOKY)IJP
LEE      73 PRL 31 1029        LEE,SHAW         (UCI+ROYAL HOLLOWAY COLLEGE)IJP
LEMOIGNE 73 PURDUE CONF. 93    +GRANET,MARTY,AYED,BAREYRE,BORGEAUD,+(SACL)IJP
MOORHOUS 73 PL 43B 44          MOORHOUSE, OBERLACK                (GLAS+LBL)IJP
ROSSI    73 NC 13A 59          +PIAZZA,SUSINNO,+        (ROMA+FRAS+NAPL+PAVI)IJP
    ALSO 71 LNC 2 1183         CARBONARA,FIORE,+        (NAPL+FRAS+PAVI+ROMA)IJP
BENEVENT 74 NC 19A 529         BENEVENTANO,DANGELO,NOTARISTEFANI,+  (ROMA)IJP
DEVENISH 74 NP B81 330         DEVENISH,FROGGATT,MARTIN    (DESY+NORD+LOUC)
DEVENIS2 74 PL 52B 227         DEVENISH,LYTH,RANKIN        (DESY+LANC+BONN)IJP
KNIES    74 PR D9 2680         KNIES,MOORHOUSE,OBERLACK           (LBL+GLAS)IJP
METCALF  74 NP B76 253         W J METCALF,R L WALKER                 (CIT)IJP
MOORHOUS 74 PR D9 1            MOORHOUSE,OBERLACK,ROSENFELD       (GLAS+LBL)IJP

CRAWFORD 75 NP B97 125         R L CRAWFORD                          (GLAS)IJP
FELTESSE 75 NP B93 242         +AYED,BAREYRE,BORGEAUD,DAVID,ERNWEIN+(SACL)IJP
KRIVETS  75 SJNP 20 430        +MIROSHNICHENKO,NIKIFOROV,SANIN+      (KIEV)IJP
    ALSO 74 SJNP 19 112        KRIVETS,NIKIFOROV,SANIN,SHALATSKII    (KIEV)IJP
LONGACRE 75 PL 55B 415         +ROSENFELD,LASINSKI,SMADJA+       (LBL+SLAC)IJP
    ALSO 78 PR D17 1795        LONGACRE,LASINSKI,ROSENFELD+      (LBL+SLAC)
AYED     76 CEA-N-1921         AYED (THESIS)                         (SACL)IJP
BARBOUR  76 NP B111 358        I M BARBOUR,R L CRAWFORD              (GLAS)IJP
FELLER   76 NP B104 219        +FUKUSHIMA,HORIKAWA,KAJIKAWA+   (NAGO+OSAK)IJP
AZNAURYA 77  EFI-264(57)-77    +AKOPOV,BAGDASARYAN                   (YERE)IJP
BERENDS  77 NP B136 317        F A BERENDS,A DONNACHIE          (LEID+MCHS)IJP
LONGACRE 77 NP B122 493        LONGACRE,DOLBEAU                      (SACL)IJP
    ALSO 76 NP B108 365        DOLBEAU,TRIANTIS,NEVEU,CADIET         (SACL)IJP

BARBOUR  78 NP B141 253        BARBOUR,CRAWFORD,PARSONS              (GLAS)
NOELLE   78 PTP 60 778         P NOELLE                              (NAGO)
BAKER    79 NP B156 93         +BROWN,CLARK,DAVIES,DEPAGTER,EVANS+  (RHEL)IJP
CUTKOSKY 79 PR D20 2839        +FORSYTH,HENDRICK,KELLY          (CARN+LBL)IJP
HOEHLER  79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                               +KAISER,KOCH,PIETARINEN       (KARL)      IJP
    ALSO 80  TORONTO CONF 3    R KOCH                                (KARL)IJP

ARAI     80  TORONTO CONF 93   I ARAI                                (TOKY)
    ALSO 82 NP B194 251        I ARAI, H FUJII                       (TOKY)
BRATASHE 80 NP B166 525        BRATASHEVSKIJ,GORBENKO,DEREBCHINSKIJ+(KHAR)
CRAWFORD 80  TORONTO CONF 107 R L CRAWFORD                           (GLAS)
CUTKOSKY 80  TORONTO CONF 19   +FORSYTH,BABCOCK,KELLY,HENDRICK  (CARN+LBL)IJP
ISHII    80 NP B165 189        ISHII,EGAWA,KATO,MIYACHI+        (KYOT+TOKY)
TAKEDA   80 NP B168 17         TAKEDA,ARAI,FUJII,IKEDA,IWASAKI+      (TOKY)
AWAJI    81  BONN CONF 352     R KAJIKAWA (TALK)                     (NAGO)
    ALSO 82 NP B197 365        FUJII,HAYASHII,IWATA,KAJIKAWA+        (NAGO)
FUJII    81 NP B187 53         FUJII,HAYASHII,IWATA,KAJIKAWA+        (TOKY)
CRAWFORD 83 NP B211 1          R L CRAWFORD, W T MORTON              (GLAS)
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N(1520) D'_{13} Status: ****

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                 62  N(1520, JP=3/2-) I=1/2   D'13

                 MOST OF THE RESULTS PUBLISHED BEFORE 1975 ARE NOW
                 OBSOLETE AND HAVE BEEN OMITTED.  THEY MAY BE FOUND IN
                 OUR 1982 EDITION (PHYSICS LETTERS 111B).  HOWEVER,
                 ALL THE REFERENCES HAVE BEEN RETAINED.

     IN ADDITION, RESULTS IN THIS REGION FROM PRODUCTION EXPERIMENTS,
     WHICH USED TO BE LISTED SEPARATELY AS THE NEXT ENTRY, HAVE BEEN
     ENTIRELY REMOVED.

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                 62  N(1520) MASS (MEV)

M     A      1524. OR 1520.             LONGACRE  75 IPWA    PI N TO 2PI N    11/75
M     A  THE 2 SETS OF PARAMETERS ARE FROM METHODS 1 AND 2 OF LONGACRE 75.    11/75
M           (1510.0)                    BERENDS   77 IPWA    PI-N PHOTOPROD.   1/78
M     B     (1510.0)                    LONGACRE  77 IPWA    PI N TO 2PI N    11/77
M     B  ALL LONGACRE77 PARAMETERS ARE FROM SOLUTION S2, EXCEPT FOR THE POLE 11/77
M     B  POSITION WHICH IS FROM SOLUTIONS S1 AND C1.                          11/77
M           (1503.0)                    BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
M           (1525.0)   (15.0)           CUTKOSKY  79 IPWA    PI N TO PI N     12/79
M            1519.0      4.0            HOEHLER   79 IPWA    PI N TO PI N     12/79
M           (1504.0)                    CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
M            1525.0     10.0            CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                 62  N(1520) WIDTH (MEV)

W     A      120. OR  150.              LONGACRE  75 IPWA    PI N TO 2PI N    11/75
W           (105.0)                     BERENDS   77 IPWA    PI-N PHOTOPROD.   1/78
W     B     (110.0)                     LONGACRE  77 IPWA    PI N TO 2PI N    11/77
W           (135.0)                     BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
W           (183.0)                     BAKER     79 DPWA  0 PI- P TO ETA N   12/79
W           (125.0)    (25.0)           CUTKOSKY  79 IPWA    PI N TO PI N     12/79
W            114.0      7.0             HOEHLER   79 IPWA    PI N TO PI N     12/79
W           (124.0)                     CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
W            120.0     15.0             CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                 62  N(1520) REAL PART OF POLE POSITION (MEV)

RE          (1514.0)                    LONGACRE  75 IPWA    PI N TO 2PI N    11/75
RE    B      1508. OR 1505.             LONGACRE  77 IPWA    PI N TO 2PI N    11/77
RE          (1510.0)                    CUTKOSKY  79 IPWA    PI N TO PI N     12/79
RE           1510.0      5.0            CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                 62  N(1520) -2*IMAG PART OF POLE POSITION (MEV)

IM          (146.0)                     LONGACRE  75 IPWA    PI N TO 2PI N    11/75
IM    B      109.  OR 107.              LONGACRE  77 IPWA    PI N TO 2PI N    11/77
IM          (114.0)                     CUTKOSKY  79 IPWA    PI N TO PI N     12/79
IM           114.0     10.0             CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                 62  N(1520) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER          (34.0)                     CUTKOSKY  79 IPWA    PI N TO PI N     12/79
RER           34.0      2.0             CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                 62  N(1520) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR          (-8.0)                     CUTKOSKY  79 IPWA    PI N TO PI N     12/79
IMR           -7.0      3.0             CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                 62  N(1520) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      N(1520) INTO N PI                                 938+ 140
P2      N(1520) INTO DELTA(1232) PI                      1232+ 140
P3      N(1520) INTO N PI PI                              938+ 140+ 140
P4      N(1520)+ INTO NEUTRON PI+                         940+ 140
P5      N(1520)+ INTO P PI+ PI-                           938+ 140+ 140
P6      N(1520) INTO N ETA                                940+ 549
P7      N(1520) INTO N EPSILON                            938+1300
P8      N(1520) INTO N RHO                                938+ 769
P9      N(1520) INTO P GAMMA, HELICITY=1/2                938+   0
P10     N(1520) INTO P GAMMA, HELICITY=3/2                938+   0
P11     N(1520) INTO N GAMMA, HELICITY=1/2                940+   0
P12     N(1520) INTO N GAMMA, HELICITY=3/2                940+   0
P13     N(1520) INTO LAMBDA K                            1116+ 498
P14     N(1520) INTO DELTA(1232) PI, S-WAVE              1232+ 140
P15     N(1520) INTO DELTA(1232) PI, D-WAVE              1232+ 140
P16     N(1520) INTO N RHO, S=3/2, S-WAVE                 938+ 769

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                 62  N(1520) BRANCHING RATIOS

R1      N(1520) INTO (N PI)/TOTAL                              (P1)
R1           (0.56)   (0.06)            CUTKOSKY  79 IPWA    PI N TO PI N     12/79
R1            0.54     0.03             HOEHLER   79 IPWA    PI N TO PI N     12/79
R1            0.58     0.03             CUTKOSKY  80 IPWA    PI N TO PI N      1/82

R2      N(1520) FROM N PI TO N ETA                             SQRT(P1*P6)
R2           +0.011 OR +0.058           FELTESSE  75 DPWA  0 1488 TO 1745 MEV  1/76
R2           (0.02)                     BAKER     79 DPWA  0 PI- P TO ETA N   12/79

R3      N(1520) FROM N PI TO DELTA(1232) PI, S-WAVE            SQRT(P1*P14)
R3    A      +0.27 OR +0.24             LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R3    B     (+0.26)                     LONGACRE  77 IPWA    PI N TO 2PI N    11/77
R3    B  LONGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.

R4      N(1520) FROM N PI TO DELTA(1232) PI, D-WAVE            SQRT(P1*P15)
R4    A      +0.24 OR +0.30             LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R4    B     (+0.21)                     LONGACRE  77 IPWA    PI N TO 2PI N    11/77
R4    B  LONGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.

R5      N(1520) FROM N PI TO N RHO, S=3/2, S-WAVE              SQRT(P1*P16)
R5    A      +0.32 OR +0.24             LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R5    B     (+0.35)                     LONGACRE  77 IPWA    PI N TO 2PI N    11/77
R5    B  LONGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.

R6      N(1520) FROM N PI INTO N EPSILON                       SQRT(P1*P7)
R6    A       0.0  OR +0.17             LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R6    B     (+0.13)                     LONGACRE  77 IPWA    PI N TO 2PI N    11/77

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                 62  N(1520) PHOTON DECAY AMPLITUDES (GEV**-1/2)

          FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-
        REVIEW PRECEDING THE BARYON LISTINGS.

A1      N(1520) INTO P GAMMA, HELICITY=1/2 (GEV**-1/2)
A1           -0.006    0.006            METCALF   74 DPWA    PI N PHOTOPROD.   2/74
A1           -0.005    0.005            FELLER    76 DPWA    PI N PHOTOPROD.   2/77
A1           -0.003    0.003            AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 1 12/79
A1           -0.030    0.002            AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 2 12/79
A1          (-0.021)                    BERENDS   77 IPWA    PI-N PHOTOPROD.   1/78
A1           -0.016    0.008            BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
A1    N     (-0.008)                    NOELLE    78         PI-N PHOTOPROD.   1/80
A1    N  CONVERTED TO OUR CONVENTIONS USING M=1.528, W=.187 FROM NOELLE 78.    1/80
A1           -0.032    0.005            ARAI      80 DPWA    PI N PHOTO FIT 1 12/81
A1           -0.032    0.004            ARAI      80 DPWA    PI N PHOTO FIT 2 12/81
A1           -0.031    0.009            BRATASHEV 80 DPWA    PI N PHOTOPROD.  12/81
A1           -0.019    0.007            CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
A1           -0.0430   0.0063           ISHII     80 DPWA    P COMPTON SCAT   12/81
A1           -0.007    0.004            AWAJI     81 DPWA    PI N PHOTOPROD.   1/84*
A1           -0.028    0.014            CRAWFORD  83 IPWA    PI N PHOTOPROD.   1/84*
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A2		N(1520) INTO P GAMMA, HELICITY=3/2 (GEV**-1/2)						
A2		+0.165	0.011	METCALF	74	DPWA	PI N PHOTOPROD.	2/74
A2		+0.164	0.008	FELLER	76	DPWA	PI N PHOTOPROD.	2/77
A2		+0.182	0.006	AZNAURYAN	77	DPWA	PIO PHTPRD,SOL 1	12/79
A2		+0.133	0.002	AZNAURYAN	77	DPWA	PIO PHTPRD,SOL 2	12/79
A2		(+0.075)		BERENDS	77	IPWA	PI-N PHOTOPROD.	1/78
A2		+0.157	0.007	BARBOUR	78	DPWA	PI-N PHOTOPROD.	3/79
A2	N	(0.206)		NOELLE	78		PI-N PHOTOPROD.	1/80
A2		0.178	0.003	ARAI	80	DPWA	PI N PHOTO FIT 1	12/81
A2		0.162	0.003	ARAI	80	DPWA	PI N PHOTO FIT 2	12/81
A2		0.166	0.005	BRATASHEV	80	DPWA	PI N PHOTOPROD.	12/81
A2		0.167	0.010	CRAWFORD	80	DPWA	PI N PHOTOPROD.	12/81
A2		0.1695	0.0014	ISHII	80	DPWA	P COMPTON SCAT	12/81
A2		0.168	0.013	AWAJI	81	DPWA	PI N PHOTOPROD.	1/84*
A2		0.156	0.022	CRAWFORD	83	IPWA	PI N PHOTOPROD.	1/84*
A3		N(1520) INTO N GAMMA, HELICITY=1/2 (GEV**-1/2)						
A3		-0.066	0.010	METCALF	74	DPWA	PI N PHOTOPROD.	2/74
A3		-0.055	0.014	BARBOUR	78	DPWA	PI-N PHOTOPROD.	3/79
A3	N	(-0.060)		NOELLE	78		PI-N PHOTOPROD.	1/80
A3		-0.076	0.006	ARAI	80	DPWA	PI N PHOTO FIT 1	12/81
A3		-0.071	0.011	ARAI	80	DPWA	PI N PHOTO FIT 2	12/81
A3		-0.056	0.011	CRAWFORD	80	DPWA	PI N PHOTOPROD.	12/81
A3		-0.050	0.014	TAKEDA	80	DPWA	PI N PHOTOPROD.	12/81
A3		-0.066	0.013	AWAJI	81	DPWA	PI N PHOTOPROD.	1/84*
A3		-0.067	0.004	FUJII	81	DPWA	PI N PHOTOPROD.	12/81
A4		N(1520) INTO N GAMMA, HELICITY=3/2 (GEV**-1/2)						
A4		-0.118	0.013	METCALF	74	DPWA	PI N PHOTOPROD.	2/74
A4		-0.141	0.015	BARBOUR	78	DPWA	PI-N PHOTOPROD.	3/79
A4	N	(-0.127)		NOELLE	78		PI-N PHOTOPROD.	1/80
A4		-0.147	0.008	ARAI	80	DPWA	PI N PHOTO FIT 1	12/81
A4		-0.148	0.009	ARAI	80	DPWA	PI N PHOTO FIT 2	12/81
A4		-0.144	0.015	CRAWFORD	80	DPWA	PI N PHOTOPROD.	12/81
A4		-0.118	0.011	TAKEDA	80	DPWA	PI N PHOTOPROD.	12/81
A4		-0.124	0.009	AWAJI	81	DPWA	PI N PHOTOPROD.	1/84*
A4		-0.158	0.003	FUJII	81	DPWA	PI N PHOTOPROD.	12/81

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REFERENCES FOR N(1520)

FOR VERY EARLY REFERENCES, SEE RMP 37, 633 (1965).

KIRZ 63 PR 130 2481 J KIRZ, J SCHWARTZ, R D TRIPP (LRL)
BAREYRE 65 PL 18 342 + BRICMAN, STIRLING, VILLET (SACL)IJP
BRANDSEN 65 PR 139 B1566 +ODONNELL, MOORHOUSE (DURH+RHEL)IJP
CROUCH 65 DESY CONF II 21 + (BROW+CEA+HARV+MIT+PADO+REHO)
DERADO 65 ATHENS CONF 244 +KENNEY,LAMSA, + (NDAM+KNTY)
ROPER 65 PR 138 B190 L D ROPER,R M WRIGHT,B T FELD (LLL+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.
MERLO 66 P ROY SOC 289 489 J P MERLO, G VALLADAS (SACL)
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 (GLAS+RHEL)
JOHNSON 67 UCRL-17683 THESIS C H JOHNSON (LRL)
ROBERTS 67 PREPRINT R G ROBERTS (DURH)
ROSENFEL 67 IRVINE CONF A H ROSENFELD, P SODING (LRL)
BAREYRE 68 PR 165 1731 P BAREYRE, C BRICMAN, G VILLET (SACL)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 (SFLA)
DEANS2 69 PR 177 2623 S R DEANS (SFLA)
DONNACHI 69 NP 10B 433 A DONNACHIE, R KIRSOPP (GLAS+EDIN)
WALKER 69 PR 182 1729 R L WALKER (CIT)IJP
AYED 70 KIEV CONF R AYED,P BAREYRE, G VILLET (SACL)IJP
AYED2 70 PL 31B 598 +BAREYRE,VILLET (SACL)
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

DEVENISH 73 PL 47B 53 DEVENISH,RANKIN,LYTH (LOUC+BONN+LANC)IJP
HEMMI1 73 PL 43B 79 HEMMI,INAGAKI+ (KYOT+SAGA+KEK+TOKY)IJP
HEMMI2 73 NP B55 333 +INAGAKI,KIKUCHI,MAKI,MIYAKE+ (KYOT+TOKY)IJP
LEMOIGNE 73 PURDUE CONF. 93 +GRANET,MARTY,AYED,BAREYRE,BORGEAUD,+(SACL)IJP
MOORHOUS 73 PL 43B 44 MOORHOUSE, OBERLACK (GLAS+LBL)IJP
ROSSI 73 NC 13A 59 +PIAZZA,SUSINNO,+ (ROMA+FRAS+NAPL+PAVI)IJP
ALSO 71 LNC 2 1183 CARBONARA,FIORE,+ (NAPL+FRAS+PAVI+ROMA)IJP
BENEVENT 74 NC 19A 529 BENEVENTANO,DANGELO,NOTARISTEFANI,+ (ROMA)IJP
DEVENISH 74 NP B81 330 DEVENISH,FROGGATT,MARTIN (DESY+NORD+LOUC)
DEVENIS2 74 PL 52B 227 DEVENISH,LYTH,RANKIN (DESY+LANC+BONN)IJP
KNIES 74 PR D9 2680 KNIES,MOORHOUSE,OBERLACK (LBL+GLAS)IJP
METCALF 74 NP B76 253 W J METCALF,R L WALKER (CIT)IJP
MOORHOUS 74 PR D9 1 MOORHOUSE,OBERLACK,ROSENFELD (GLAS+LBL)IJP

CRAWFORD 75 NP B97 125 R L CRAWFORD (GLAS)IJP
FELTESSE 75 NP B93 242 +AYED,BAREYRE,BORGEAUD,DAVID,ERNWEIN+(SACL)IJP
KRIVETS 75 SJNP 20 430 +MIROSHNICHENKO,NIKIFOROV,SANIN+ (KIEV)IJP
ALSO 74 SJNP 19 112 KRIVETS,NIKIFOROV,SANIN,SHALATSKII (KIEV)IJP
LONGACRE 75 PL 55B 415 +ROSENFELD,LASINSKI,SMADJA+ (LBL+SLAC)IJP
ALSO 78 PR D17 1795 LONGACRE,LASINSKI,ROSENFELD+ (LBL+SLAC)
AYED 76 CEA-N-1921 AYED (THESIS) (SACL)IJP
BARBOUR 76 NP B111 358 I M BARBOUR,R L CRAWFORD (GLAS)IJP
FELLER 76 NP B104 219 +FUKUSHIMA,HORIKAWA,KAJIKAWA+ (NAGO+OSAK)IJP

AZNAURYA 77 EFI-264(57)-77 +AKOPOV,BAGDASARYAN (YERE)IJP
BERENDS 77 NP B136 317 F A BERENDS,A DONNACHIE (LEID+MCHS)IJP
LONGACRE 77 NP B122 493 LONGACRE,DOLBEAU (SACL)IJP
ALSO 76 NP B108 365 DOLBEAU,TRIANTIS,NEVEU,CADIET (SACL)IJP
BARBOUR 78 NP B141 253 BARBOUR,CRAWFORD,PARSONS (GLAS)
NOELLE 78 PTP 60 778 P NOELLE (NAGO)
BAKER 79 NP B156 93 +BROWN,CLARK,DAVIES,DEPAGTER,EVANS+ (RHEL)IJP
CUTKOSKY 79 PR D20 2839 +FORSYTH,HENDRICK,KELLY (CARN+LBL)IJP
HOEHLER 79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
+KAISER,KOCH,PIETARINEN (KARL) IJP
ALSO 80 TORONTO CONF 3 R KOCH (KARL)IJP

ARAI 80 TORONTO CONF 93 I ARAI (TOKY)
ALSO 82 NP B194 251 I ARAI, H FUJII (TOKY)
BRATASHE 80 NP B166 525 BRATASHEVSKIJ,GORBENKO,DEREBCHINSKIJ+(KHAR)
CRAWFORD 80 TORONTO CONF 107 R L CRAWFORD (GLAS)
CUTKOSKY 80 TORONTO CONF 19 +FORSYTH,BABCOCK,KELLY,HENDRICK (CARN+LBL)IJP
ISHII 80 NP B165 189 ISHII,EGAWA,KATO,MIYACHI+ (KYOT+TOKY)
TAKEDA 80 NP B168 17 TAKEDA,ARAI,FUJII,IKEDA,IWASAKI+ (TOKY)

AWAJI 81 BONN CONF 352 R KAJIKAWA (TALK) (NAGO)
ALSO 82 NP B197 365 FUJII,HAYASHII,IWATA,KAJIKAWA+ (NAGO)
FUJII 81 NP B187 53 FUJII,HAYASHII,IWATA,KAJIKAWA+ (TOKY)
CRAWFORD 83 NP B211 1 R L CRAWFORD, W T MORTON (GLAS)

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N(1535) S_{11}' Status: ****

63 N(1535, JP=1/2-) I=1/2 S'11

MOST OF THE RESULTS PUBLISHED BEFORE 1975 ARE NOW OBSOLETE AND HAVE BEEN OMITTED. THEY MAY BE FOUND IN OUR 1982 EDITION (PHYSICS LETTERS 111B). HOWEVER, NEARLY ALL THE REFERENCES HAVE BEEN RETAINED.

63 N(1535) MASS (MEV)

M	A	1520. OR 1510.		LONGACRE	75	IPWA	PI N TO 2PI N	11/75
M	A	THE 2 SETS OF PARAMETERS ARE FROM METHODS 1 AND 2 OF LONGACRE 75.						11/75
M		(1500.0)		BERENDS	77	IPWA	PI-N PHOTOPROD.	1/78
M		1547.0	6.0	BHANDARI	77	DPWA	0 USES ETA N CUSP	1/78
M	B	(1520.0)		LONGACRE	77	IPWA	PI N TO 2PI N	11/77
M	B	ALL LONGACRE77 PARAMETERS ARE FROM SOLUTION S2, EXCEPT FOR THE POLE						11/77
M	B	POSITION WHICH IS FROM SOLUTIONS S1 AND C1.						11/77
M		(1511.0)		BARBOUR	78	DPWA	PI-N PHOTOPROD.	3/79
M		(1540.0)	(20.0)	CUTKOSKY	79	IPWA	PI N TO PI N	12/79
M		1526.0	7.0	HOEHLER	79	IPWA	PI N TO PI N	12/79
M		(1513.0)		CRAWFORD	80	DPWA	PI N PHOTOPROD.	12/81
M		1550.0	40.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

63 N(1535) WIDTH (MEV)

W	A	75. OR 100.		LONGACRE	75	IPWA	PI N TO 2PI N	11/75
W		(57.0)		BERENDS	77	IPWA	PI-N PHOTOPROD.	1/78
W		139.0	33.0	BHANDARI	77	DPWA	0 USES ETA N CUSP	1/78
W	B	(135.0)		LONGACRE	77	IPWA	PI N TO 2PI N	11/77
W		(132.0)		BARBOUR	78	DPWA	PI-N PHOTOPROD.	3/79
W		(180.0)		BAKER	79	DPWA	0 PI- P TO ETA N	12/79
W		(270.0)	(50.0)	CUTKOSKY	79	IPWA	PI N TO PI N	12/79
W		120.0	20.0	HOEHLER	79	IPWA	PI N TO PI N	12/79
W		(136.0)		CRAWFORD	80	DPWA	PI N PHOTOPROD.	12/81
W		240.0	80.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

63 N(1535) REAL PART OF POLE POSITION (MEV)

RE		(1496.0)		LONGACRE	75	IPWA	PI N TO 2PI N	11/75
RE		1519.0	4.0	BHANDARI	77	DPWA	0 USES ETA N CUSP	1/78
RE	B	1525. OR 1527.		LONGACRE	77	IPWA	PI N TO 2PI N	11/77
RE		(1465.0)		CUTKOSKY	79	IPWA	PI N TO PI N	12/79
RE		1510.0	50.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

63 N(1535) -2*IMAG PART OF POLE POSITION (MEV)

IM		(103.0)		LONGACRE	75	IPWA	PI N TO 2PI N	11/75
IM		140.0	32.0	BHANDARI	77	DPWA	0 USES ETA N CUSP	1/78
IM	B	135. OR 123.		LONGACRE	77	IPWA	PI N TO 2PI N	11/77
IM		(256.0)		CUTKOSKY	79	IPWA	PI N TO PI N	12/79
IM		260.0	80.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

63 N(1535) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER		20.0	21.0	BHANDARI	77	DPWA	0 USES ETA N CUSP	1/78
RER		(48.0)		CUTKOSKY	79	IPWA	PI N TO PI N	12/79
RER		116.0	46.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

63 N(1535) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR		13.0	8.0	BHANDARI	77	DPWA	0 USES ETA N CUSP	1/78
IMR		(-67.0)		CUTKOSKY	79	IPWA	PI N TO PI N	12/79
IMR		31.0	92.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

63 N(1535) PARTIAL DECAY MODES

		DECAY MASSES
P1	N(1535) INTO N PI	938+ 140
P2	N(1535) INTO N ETA	940+ 549
P3	N(1535) INTO N PI PI	938+ 140+ 140
P4	N(1535) INTO N EPSILON	938+1300
P5	N(1535) INTO DELTA(1232) PI	1232+ 140
P6	N(1535) INTO N RHO	938+ 769
P7	N(1535) INTO P GAMMA, HELICITY=1/2	938+ 0
P8	N(1535) INTO N GAMMA, HELICITY=1/2	940+ 0
P9	N(1535) INTO LAMBDA K	1116+ 498
P10	N(1535) INTO N RHO, S=1/2, S-WAVE	938+ 769

63 N(1535) BRANCHING RATIOS

R1		N(1535) INTO (N PI)/TOTAL					(P1)	
R1		0.297	0.026	BHANDARI	77	DPWA	0 USES ETA N CUSP	1/78
R1		(0.45)	(0.06)	CUTKOSKY	79	IPWA	PI N TO PI N	12/79
R1		0.38	0.04	HOEHLER	79	IPWA	PI N TO PI N	12/79
R1		0.50	0.10	CUTKOSKY	80	IPWA	PI N TO PI N	1/82
R2		N(1535) FROM N PI INTO N ETA					SQRT(P1*P2)	
R2		(+0.48)		FELTESSE	75	DPWA	0 1488 TO 1745 MEV	11/75
R2		(+0.33)		BAKER	79	DPWA	0 PI- P TO ETA N	12/79
R3		N(1535) FROM N PI TO DELTA(1232) PI					SQRT(P1*P5)	
R3	A	0.0 OR -0.06		LONGACRE	75	IPWA	PI N TO 2PI N	11/75
R3	B	(0.00)		LONGACRE	77	IPWA	PI N TO 2PI N	11/77
R4		N(1535) FROM N PI TO N RHO, S=1/2, S-WAVE					SQRT(P1*P10)	
R4	A	+0.12 OR +0.09		LONGACRE	75	IPWA	PI N TO 2PI N	11/75
R4	B	(+0.10)		LONGACRE	77	IPWA	PI N TO 2PI N	11/77

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R5      N(1535) FROM N PI TO N EPSILON                    SQRT(P1*P4)
R5   A        0.1  OR -0.09             LONGACRE  75 IPWA    PI N TO 2PI N     11/75
R5   B       (-0.08)                    LONGACRE  77 IPWA    PI N TO 2PI N     11/77

R6      N(1535) INTO (P GAMMA)/TOTAL                      (P7)
R6   C        0.0042   0.0014           DEANS     72 MPWA    P ETA PHOTOPROD.   9/73
R6   C   BR=(DEANS72 RADIATIVE WIDTH)/(NOMINAL FULL WIDTH=100 MEV)                 9/73
R6   C   THE HICKS73 ENTRY UNDER R7 IS A MORE RECENT RESULT BY SAME GROUP.         9/73

R7      N(1535) FROM P GAMMA TO P ETA                     SQRT(P2*P7)
R7            (0.0366)                  HICKS     73 MPWA    GAM P-ETA P        9/73
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                     63  N(1535) PHOTON DECAY AMPLITUDES (GEV**-1/2)

       FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-
     REVIEW PRECEDING THE BARYON LISTINGS.

A1      N(1535) INTO P GAMMA, HELICITY=1/2 (GEV**-1/2)
A1           +0.063     0.013          METCALF   74 DPWA    PI N PHOTOPROD.    2/74
A1           +0.070     0.004          FELLER    76 DPWA    PI N PHOTOPROD.    2/77
A1           +0.046     0.007          AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 1 12/79
A1           +0.101     0.012          AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 2 12/79
A1          (+0.034)                   BERENDS   77 IPWA    PI-N PHOTOPROD.    1/78
A1           +0.082     0.019          BARBOUR   78 DPWA    PI-N PHOTOPROD.    3/79
A1   N      (0.046)                    NOELLE    78         PI-N PHOTOPROD.    1/80
A1   N   CONVERTED TO OUR CONVENTIONS USING M=1.548, W=.073 FROM NOELLE 78.   1/80
A1            0.083     0.007          ARAI      80 DPWA    PI N PHOTO FIT 1 12/81
A1            0.080     0.007          ARAI      80 DPWA    PI N PHOTO FIT 2 12/81
A1            0.029     0.007          BRATASHEV 80 DPWA    PI N PHOTOPROD.   12/81
A1            0.065     0.016          CRAWFORD  80 DPWA    PI N PHOTOPROD.   12/81
A1            0.0704    0.0091         ISHII     80 DPWA    P COMPTON SCAT    12/81
A1            0.077     0.021          AWAJI     81 DPWA    PI N PHOTOPROD.    1/84*
A1            0.053     0.015          CRAWFORD  83 IPWA    PI N PHOTOPROD.    1/84*

A2      N(1535) INTO N GAMMA, HELICITY=1/2 (GEV**-1/2)
A2           -0.051     0.021          METCALF   74 DPWA    PI N PHOTOPROD.    2/74
A2           -0.112     0.034          BARBOUR   78 DPWA    PI-N PHOTOPROD.    3/79
A2   N      (-0.048)                   NOELLE    78         PI-N PHOTOPROD.    1/80
A2           -0.075     0.019          ARAI      80 DPWA    PI N PHOTO FIT 1 12/81
A2           -0.075     0.018          ARAI      80 DPWA    PI N PHOTO FIT 2 12/81
A2           -0.098     0.026          CRAWFORD  80 DPWA    PI N PHOTOPROD.   12/81
A2           -0.011     0.017          TAKEDA    80 DPWA    PI N PHOTOPROD.   12/81
A2            0.035     0.014          AWAJI     81 DPWA    PI N PHOTOPROD.    1/84*
A2           -0.062     0.003          FUJII     81 DPWA    PI N PHOTOPROD.   12/81

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REFERENCES FOR N(1535)


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BAREYRE  65 PL 18 342           + BRICMAN, STIRLING, VILLET            (SACL)IJP
BRANDSEN 65 PR 139 B1566        +ODONNELL, MOORHOUSE              (DURH+RHEL)IJP
HENDRY   65 PL 18 171           A W HENDRY, R G MOORHOUSE              (RHEL)
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         (GLAS+RHEL)
JOHNSON  67 UCRL-17683 THESIS C H JOHNSON                               (LRL)
LOVELACE 67 HEIDELBERG C. 79    C LOVELACE                             (CERN)IJP

BAREYRE  68 PR 165 1731         P BAREYRE, C BRICMAN, G VILLET         (SACL)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                      (SFLA)
DELCOURT 69 PL 29B 75           DELCOURT,LEFRANCOIS,PEREZ-Y-JORBA,+  (ORSA)
DONNACHI 69 NP 10B 433          A DONNACHIE, R KIRSOPP            (GLAS+EDIN)
AYED     70 KIEV CONF           R AYED,P BAREYRE, G VILLET             (SACL)IJP
AYED2    70 PL 31B 598          +BAREYRE,VILLET                        (SACL)
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             (SFLA+CARN)
DEVENISH 73 PL 47B 53           DEVENISH,RANKIN,LYTH        (LOUC+BONN+LANC)IJP
HEMMI1   73 PL 43B 79           HEMMI,INAGAKI+          (KYOT+SAGA+KEK+TOKY)IJP
HICKS    73 PR D7 2614          +DEANS,JACOBS,LYONS+        (CARN+ORNL+SFLA)IJP
LEMOIGNE 73 PURDUE CONF. 93     +GRANET,MARTY,AYED,BAREYRE,BORGEAUD,+(SACL)IJP
MOORHOUS 73 PL 43B 44           MOORHOUSE, OBERLACK                (GLAS+LBL)IJP
ROSSI    73 NC 13A 59           +PIAZZA,SUSINNO,+      (ROMA+FRAS+NAPL+PAVI)IJP
    ALSO 71 LNC 2 1183          CARBONARA,FIORE,+      (NAPL+FRAS+PAVI+ROMA)IJP
BENEVENT 74 NC 19A 529          BENEVENTANO,DANGELO,NOTARISTEFANI,+  (ROMA)IJP
DEVENISH 74 NP B81 330          DEVENISH,FROGGATT,MARTIN    (DESY+NORD+LOUC)
DEVENIS2 74 PL 52B 227          DEVENISH,LYTH,RANKIN        (DESY+LANC+BONN)IJP
KNIES    74 PR D9 2680          KNIES,MOORHOUSE,OBERLACK           (LBL+GLAS)IJP
METCALF  74 NP B76 253          W J METCALF,R L WALKER                  (CIT)IJP
MOORHOUS 74 PR D9 1             MOORHOUSE,OBERLACK,ROSENFELD       (GLAS+LBL)IJP

CRAWFORD 75 NP B97 125          R L CRAWFORD                           (GLAS)IJP
FELTESSE 75 NP B93 242          +AYED,BAREYRE,BORGEAUD,DAVID,ERNWEIN+(SACL)IJP
KRIVETS  75 SJNP 20 430         +MIROSHNICHENKO,NIKIFOROV,SANIN+       (KIEV)IJP
    ALSO 74 SJNP 19 112         KRIVETS,NIKIFOROV,SANIN,SHALATSKII     (KIEV)IJP
LONGACRE 75 PL 55B 415          +ROSENFELD,LASINSKI,SMADJA+        (LBL+SLAC)IJP
    ALSO 78 PR D17 1795         LONGACRE,LASINSKI,ROSENFELD+       (LBL+SLAC)

AYED     76 CEA-N-1921          AYED (THESIS)                          (SACL)IJP
BARBOUR  76 NP B111 358         I M BARBOUR,R L CRAWFORD               (GLAS)IJP
FELLER   76 NP B104 219         +FUKUSHIMA,HORIKAWA,KAJIKAWA+     (NAGO+OSAK)IJP
AZNAURYA 77  EFI-264(57)-77     +AKOPOV,BAGDASARYAN                    (YERE)IJP
BERENDS  77 NP B136 317         F A BERENDS,A DONNACHIE           (LEID+MCHS)IJP
BHANDARI 77 PR D15 192          R BHANDARI,Y-A CHAO                    (CARN)IJP
LONGACRE 77 NP B122 493         LONGACRE,DOLBEAU                       (SACL)IJP
    ALSO 76 NP B108 365         DOLBEAU,TRIANTIS,NEVEU,CADIET          (SACL)IJP

BARBOUR  78 NP B141 253         BARBOUR,CRAWFORD,PARSONS               (GLAS)
NOELLE   78 PTP 60 778          P NOELLE                               (NAGO)
BAKER    79 NP B156 93          +BROWN,CLARK,DAVIES,DEPAGTER,EVANS+  (RHEL)IJP
CUTKOSKY 79 PR D20 2839         +FORSYTH,HENDRICK,KELLY            (CARN+LBL)IJP
HOEHLER  79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                                +KAISER,KOCH,PIETARINEN         (KARL)      IJP
    ALSO 80  TORONTO CONF 3     R KOCH                                 (KARL)IJP

ARAI     80  TORONTO CONF 93    I ARAI                                 (TOKY)
    ALSO 82 NP B194 251         I ARAI, H FUJII                        (TOKY)
BRATASHE 80 NP B166 525         BRATASHEVSKIJ,GORBENKO,DEREBCHINSKIJ+(KHAR)
CRAWFORD 80  TORONTO CONF 107 R L CRAWFORD                             (GLAS)
CUTKOSKY 80  TORONTO CONF 19    +FORSYTH,BABCOCK,KELLY,HENDRICK  (CARN+LBL)IJP
ISHII    80 NP B165 189         ISHII,EGAWA,KATO,MIYACHI+         (KYOT+TOKY)
TAKEDA   80 NP B168 17          TAKEDA,ARAI,FUJII,IKEDA,IWASAKI+       (TOKY)

AWAJI    81  BONN CONF 352      R KAJIKAWA (TALK)                      (NAGO)
    ALSO 82 NP B197 365         FUJII,HAYASHII,IWATA,KAJIKAWA+         (NAGO)
FUJII    81 NP B187 53          FUJII,HAYASHII,IWATA,KAJIKAWA+         (TOKY)
CRAWFORD 83 NP B211 1           R L CRAWFORD, W T MORTON               (GLAS)
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       SEE HERE IN THE 1982 EDITION (PHYSICS LETTERS 111B) FOR ADDITIONAL
       EARLY REFERENCES (NONE AFTER 1973) ON THE N ETA THRESHOLD.

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N(1540) P'_{13} Status: *

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                 109  N(1540, JP=3/2+) I=1/2   P'13

                 THIS RESONANCE HAS NOT BEEN SEEN IN PI N --> PI N
                 ANALYSES, AND ITS EXISTENCE IS THUS DOUBTFUL.

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                 109  N(1540) MASS (MEV)

M    A     (1540.0)                     LONGACRE  77 IPWA    PI N TO 2PI N     11/77
M    A   ALL LONGACRE77 PARAMETERS ARE FROM SOLUTION S2, EXCEPT FOR THE POLE 11/77
M    A   POSITION WHICH IS FROM SOLUTIONS S1 AND C1.                           11/77
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                 109  N(1540) WIDTH (MEV)

W    A     (200.0)                      LONGACRE  77 IPWA    PI N TO 2PI N     11/77
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                 109  N(1540) REAL PART OF POLE POSITION (MEV)

RE   A       1535. OR 1482.             LONGACRE  77 IPWA    PI N TO 2PI N     11/77
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                 109  N(1540) -2*IMAG PART OF POLE POSITION (MEV)

IM   A       207. OR 314.               LONGACRE  77 IPWA    PI N TO 2PI N     11/77
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                 109  N(1540) PARTIAL DECAY MODES

                                                                DECAY MASSES
P1      N(1540) INTO N PI                                       938+ 140
P2      N(1540) INTO N RHO, S=1/2, P-WAVE                       938+ 769
P3      N(1540) INTO N RHO, S=3/2, P-WAVE                       938+ 769
P4      N(1540) INTO DELTA(1232) PI,P-WAVE                     1232+ 140
P5      N(1540) INTO N EPSILON                                  938+1300
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                 109  N(1540) BRANCHING RATIOS

R1      N(1540) FROM N PI TO N RHO, S=1/2, P-WAVE         SQRT(P1*P2)
R1   A       (-0.08)                    LONGACRE  77 IPWA    PI N TO 2PI N     11/77
R2      N(1540) FROM N PI TO N RHO, S=3/2, P-WAVE         SQRT(P1*P3)
R2   A        (0.00)                    LONGACRE  77 IPWA    PI N TO 2PI N     11/77
R3      N(1540) FROM N PI TO DELTA(1232) PI, P-WAVE       SQRT(P1*P4)
R3   A       (+0.11)                    LONGACRE  77 IPWA    PI N TO 2PI N     11/77
R4      N(1540) FROM N PI TO N EPSILON                    SQRT(P1*P5)
R4   A        (0.00)                    LONGACRE  77 IPWA    PI N TO 2PI N     11/77
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                 109  N(1540) PHOTON DECAY AMPLITUDES (GEV**-1/2)

       FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-
     REVIEW PRECEDING THE BARYON LISTINGS.

A1      N(1540) INTO P GAMMA, HELICITY=1/2 (GEV**-1/2)
A1           -0.014     0.028           CRAWFORD  83 IPWA    PI N PHOTOPROD.    1/84*

A2      N(1540) INTO P GAMMA, HELICITY=3/2 (GEV**-1/2)
A2            0.009     0.027           CRAWFORD  83 IPWA    PI N PHOTOPROD.    1/84*
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REFERENCES FOR N(1540)


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LONGACRE 77 NP B122 493         LONGACRE,DOLBEAU                       (SACL)IJP
    ALSO 76 NP B108 365         DOLBEAU,TRIANTIS,NEVEU,CADIET          (SACL)IJP
CRAWFORD 83 NP B211 1           R L CRAWFORD, W T MORTON               (GLAS)
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N(1650) S''_{11} Status: ****

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                 66  N(1650, JP=1/2-) I=1/2   S''11

                 MOST OF THE RESULTS PUBLISHED BEFORE 1975 ARE NOW
                 OBSOLETE AND HAVE BEEN OMITTED.  THEY MAY BE FOUND IN
                 OUR 1982 EDITION (PHYSICS LETTERS 111B).  HOWEVER,
                 ALL THE REFERENCES HAVE BEEN RETAINED.

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                 66  N(1650) MASS (MEV)

M          (1675.0)                     KNASEL    75 DPWA  0 PI- P TO K0 LAM  11/75
M    A      1675. OR 1660.              LONGACRE  75 IPWA    PI N TO 2PI N     11/75
M    A   THE 2 SETS OF PARAMETERS ARE FROM METHODS 1 AND 2 OF LONGACRE 75.    11/75
M    B     (1700.0)    (5.0)            BAKER     77 IPWA  0 PI- P TO K LAM.   1/78
M    B     (1680.0)                     BAKER     77 DPWA  0 PI- P TO K LAM.   1/78
M    B   THE TWO ENTRIES FOR BAKER 77 ARE FOR AN IPWA USING THE BARRELET        1/78
M    B   ZERO METHOD AND A CONVENTIONAL ENERGY-DEPENDENT ANALYSIS.             1/78
M    C     (1700.0)                     LONGACRE  77 IPWA    PI N TO 2PI N     11/77
M    C   ALL LONGACRE77 PARAMETERS ARE FROM SOLUTION S2, EXCEPT FOR THE POLE 11/77
M    C   POSITION WHICH IS FROM SOLUTIONS S1 AND C1.                           11/77
M          (1680.0)                     BAKER     78 DPWA  0 PI- P TO K LAM    3/79
M          (1694.0)                     BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
M          (1640.0)    (30.0)           CUTKOSKY  79 IPWA    PI N TO PI N     12/79
M           1670.0       8.0            HOEHLER   79 IPWA    PI N TO PI N     12/79
M          (1688.0)                     CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
M           1650.0      30.0            CUTKOSKY  80 IPWA    PI N TO PI N      1/82
M          (1672.0)                     MUSETTE   80 IPWA  0 PI- P TO K LAM    1/82
M          (1680.0)                     SAXON     80 DPWA  0 PI- P TO K LAM   12/79
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For notation, see key at front of Listings.

Baryons
N(1650), N(1675)

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                   66  N(1650) WIDTH (MEV)

W          (170.0)                   KNASEL    75 DPWA  0 PI- P TO K0 LAM  11/75
W    A      150. OR  130.            LONGACRE  75 IPWA    PI N TO 2PI N    11/75
W    B     (130.0)   (10.0)          BAKER     77 IPWA  0 PI- P TO K LAM.   1/78
W    B      (90.0)                   BAKER     77 DPWA  0 PI- P TO K LAM.   1/78
W    C     (170.0)                   LONGACRE  77 IPWA    PI N TO 2PI N    11/77
W           (90.0)                   BAKER     78 DPWA  0 PI- P TO K LAM    3/79
W          (193.0)                   BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
W          (140.0)   (40.0)          CUTKOSKY  79 IPWA    PI N TO PI N     12/79
W           180.0     20.0           HOEHLER   79 IPWA    PI N TO PI N     12/79
W          (183.0)                   CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
W           150.0     40.0           CUTKOSKY  80 IPWA    PI N TO PI N      1/82
W          (179.0)                   MUSETTE   80 IPWA  0 PI- P TO K LAM    1/82
W          (120.0)                   SAXON     80 DPWA  0 PI- P TO K LAM   12/79

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                   66  N(1650) REAL PART OF POLE POSITION (MEV)

RE        (1648.0)                   LONGACRE  75 IPWA    PI N TO 2PI N    11/75
RE   C     1699. OR 1698.0           LONGACRE  77 IPWA    PI N TO 2PI N    11/77
RE        (1639.0)                   CUTKOSKY  79 IPWA    PI N TO PI N     12/79
RE         1640.0     20.0           CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                   66  N(1650) -2*IMAG PART OF POLE POSITION (MEV)

IM         (117.0)                   LONGACRE  75 IPWA    PI N TO 2PI N    11/75
IM   C      174. OR 173.             LONGACRE  77 IPWA    PI N TO 2PI N    11/77
IM         (140.0)                   CUTKOSKY  79 IPWA    PI N TO PI N     12/79
IM          150.0     30.0           CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                   66  N(1650) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER          (3.0)                   CUTKOSKY  79 IPWA    PI N TO PI N     12/79
RER          16.0     25.0           CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                   66  N(1650) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR        (-58.0)                   CUTKOSKY  79 IPWA    PI N TO PI N     12/79
IMR         -58.0     12.0           CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                   66  N(1650) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      N(1650) INTO N PI                                938+ 140
P2      N(1650) INTO N ETA                               940+ 549
P3      N(1650) INTO LAMBDA K                           1116+ 498
P4      N(1650) INTO P GAMMA, HELICITY=1/2               938+   0
P5      N(1650) INTO N GAMMA, HELICITY=1/2               940+   0
P6      N(1650) INTO N PI PI                             938+ 140+ 140
P7      N(1650) INTO N EPSILON                           938+1300
P8      N(1650) INTO N RHO                               938+ 769
P9      N(1650) INTO SIGMA K                            1189+ 494
P10     N(1650) INTO N RHO, S=1/2, S-WAVE                938+ 769
P11     N(1650) INTO N RHO, S=3/2, D-WAVE                938+ 769
P12     N(1650) INTO DELTA(1232) PI                     1232+ 140

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                   66  N(1650) BRANCHING RATIOS

R1      N(1650) INTO (N PI)/TOTAL                        (P1)
R1          (0.60)    (0.05)         CUTKOSKY  79 IPWA    PI N TO PI N     12/79
R1           0.61      0.04          HOEHLER   79 IPWA    PI N TO PI N     12/79
R1           0.65      0.10          CUTKOSKY  80 IPWA    PI N TO PI N      1/82

R2      N(1650) FROM N PI TO N ETA                       SQRT(P1*P2)
R2  E       (-0.09)                  BAKER     79 DPWA  0 PI- P TO ETA N   12/79
R2  E   THIS COUPLING WAS FIXED DURING FITTING, BUT THE NEGATIVE SIGN      12/79
R2  E   RELATIVE TO N(1535) IS WELL DETERMINED.                            12/79

R3      N(1650) FROM N PI TO LAMBDA K                    SQRT(P1*P3)
R3          (0.12)                   KNASEL    75 DPWA  0 PI- P TO K0 LAM  11/75
R3  B      (-0.23)    (0.01)         BAKER     77 IPWA  0 PI- P TO K LAM.   1/78
R3  B      (-0.25)                   BAKER     77 DPWA  0 PI- P TO K LAM.   1/78
R3  F      (-0.25)                   BAKER     78 DPWA  0 PI- P TO K LAM    3/79
R3  F   THE (UNDETERMINED) OVERALL PHASE OF ALL COUPLINGS HAS BEEN          3/79
R3  F   CHANGED TO AGREE WITH PREVIOUS CONVENTIONS. SUPERSEDED BY SAXON 80. 3/79
R3         (-0.22)                   SAXON     80 DPWA  0 PI- P TO K LAM   12/79
R3         (-0.22)                   BELL      83 DPWA 0  PI- P TO LAM K0   2/84*

R4      N(1650) FROM N PI TO SIGMA K                     SQRT(P1*P9)
R4  D        0.066 TO 0.137          DEANS     75 DPWA    PI N TO K SIGMA  11/75
R4  D   RANGE GIVEN IS FROM FOUR BEST SOLUTIONS.                           11/75
R4          (0.20)                   KNASEL    75 DPWA  0                  11/75
R4         (-0.254)                  LIVANOS   80 DPWA    PI P TO K SIGMA   1/82

R5      N(1650) FROM N PI TO DELTA(1232) PI              SQRT(P1*P12)
R5  A       -0.16 OR -0.15           LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R5  C      (-0.29)                   LONGACRE  77 IPWA    PI N TO 2PI N    11/77
R5  C   LONGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.

R6      N(1650) FROM N PI TO N RHO, S=1/2, S-WAVE        SQRT(P1*P10)
R6  A        0.23 OR +0.16           LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R6  C      (-0.17)                   LONGACRE  77 IPWA    PI N TO 2PI N    11/77

R7      N(1650) FROM N PI TO N RHO, S=3/2, D-WAVE        SQRT(P1*P11)
R7  C      (-0.29)                   LONGACRE  77 IPWA    PI N TO 2PI N    11/77
R7  C   LONGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.

R8      N(1650) FROM N PI TO N EPSILON                   SQRT(P1*P7)
R8  A       -0.23 OR -0.25           LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R8  C       (0.00)                   LONGACRE  77 IPWA    PI N TO 2PI N    11/77

R9      N(1650) FROM P GAMMA TO P ETA                    SQRT(P2*P4)
R9          (0.0101)                 HICKS     73 MPWA    GAM P-ETA P       9/73
R10     N(1650) FROM P GAMMA TO LAMBDA K                 SQRT(P3*P4)
R10         (0.002)OR LESS           ORITO2    69 CNTR    K LAM PHOTOPRO   10/71
R10         (0.0072)                 SCHORSCH  70 DPWA    K LAM PHOTOPRO.  10/71
R10         (0.0060)                 DEANS     72 MPWA    GAM P-K LM,SOL D  9/73

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                   66  N(1650) PHOTON DECAY AMPLITUDES (GEV**-1/2)

      FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-
    REVIEW PRECEDING THE BARYON LISTINGS.

A1      N(1650) INTO P GAMMA, HELICITY=1/2 (GEV**-1/2)
A1          +0.012     0.015         METCALF   74 DPWA    PI N PHOTOPROD.   2/74
A1          +0.068     0.009         FELLER    76 DPWA    PI N PHOTOPROD.   2/77
A1          +0.004     0.004         AZNAURYAN 77 DPWA    PI0 PHTPRD,SOL 1 12/79
A1          +0.003     0.004         AZNAURYAN 77 DPWA    PI0 PHTPRD,SOL 2 12/79
A1          +0.048     0.017         BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
A1           0.065     0.005         ARAI      80 DPWA    PI N PHOTO FIT 1 12/81
A1           0.061     0.005         ARAI      80 DPWA    PI N PHOTO FIT 2 12/81
A1           0.031     0.017         CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
A1           0.050     0.010         AWAJI     81 DPWA    PI N PHOTOPROD.   1/84*
A1           0.033     0.015         CRAWFORD  83 IPWA    PI N PHOTOPROD.   1/84*

A2      N(1650) INTO N GAMMA, HELICITY=1/2 (GEV**-1/2)
A2          -0.019     0.022         METCALF   74 DPWA    PI N PHOTOPROD.   2/74
A2          -0.045     0.024         BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
A2           0.010     0.020         ARAI      80 DPWA    PI N PHOTO FIT 1 12/81
A2           0.008     0.019         ARAI      80 DPWA    PI N PHOTO FIT 2 12/81
A2          -0.068     0.040         CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
A2          -0.011     0.011         TAKEDA    80 DPWA    PI N PHOTOPROD.  12/81
A2          -0.008     0.004         AWAJI     81 DPWA    PI N PHOTOPROD.   1/84*
A2           0.004     0.004         FUJII     81 DPWA    PI N PHOTOPROD.  12/81

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REFERENCES FOR N(1650)


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BAREYRE  65 PL 18 342           + BRICMAN, STIRLING, VILLET             (SACL)IJP
BRANDSEN 65 PL 19 420           +ODONNELL, MOORHOUSE               (DURH+RHEL)IJP
MICHAEL  66 PL 21 93            C MICHAEL                                (OXF)
JOHNSON  67 UCRL-17683 THESIS   C H JOHNSON                              (LRL)
BAREYRE  68 PR 165 1731         P BAREYRE, C BRICMAN, G VILLET          (SACL)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                                (ALAH)

BOTKE    69 PR 180 1417         J C BOTKE                               (UCSB)
DEANS    69 PR 185 1797         S DEANS, J WOOTEN                       (SFLA)
DEANS2   69 PR 177 2623         S R DEANS                               (SFLA)
DONNACHI 69 NP 10B 433          A DONNACHIE, R KIRSOPP             (GLAS+EDIN)
ORITO    69 LNC 1 936           S ORITO,S SASAKI                   (TOKY+OSAK)
ORITO2   69 INS J 113           S ORITO (THESIS)                        (TOKY)
AYED     70 KIEV CONF           R AYED,P BAREYRE, G VILLET              (SACL)IJP
AYED2    70 PL 31B 598          +BAREYRE,VILLET                         (SACL)
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 PR D6 1906          DEANS,JACOBS, LYONS,MONTGOMERY          (SFLA)IJP
DEVENISH 73 PL 47B 53           DEVENISH,RANKIN,LYTH          (LOUC+BONN+LANC)IJP
HICKS    73 PR D7 2614          +DEANS,JACOBS,LYONS+          (CARN+ORNL+SFLA)IJP
LANGBEIN 73 NP B53 251          LANGBEIN,WAGNER                         (MUNI)IJP
MOORHOUS 73 PL 43B 44           MOORHOUSE, OBERLACK                 (GLAS+LBL)IJP
DEVENISH 74 NP B81 330          DEVENISH,FROGGATT,MARTIN      (DESY+NORD+LOUC)
DEVENIS2 74 PL 52B 227          DEVENISH,LYTH,RANKIN          (DESY+LANC+BONN)IJP
KNIES    74 PR D9 2680          KNIES,MOORHOUSE,OBERLACK            (LBL+GLAS)IJP
METCALF  74 NP B76 253          W J METCALF,R L WALKER                   (CIT)IJP
MOORHOUS 74 PR D9 1             MOORHOUSE,OBERLACK,ROSENFELD        (GLAS+LBL)IJP

CRAWFORD 75 NP B97 125          R L CRAWFORD                            (GLAS)IJP
DEANS    75 NP B96 90           +MITCHELL,MONTGOMERY,+             (SFLA+ALAH)IJP
KNASEL   75 PR D11 1            +LINDQUIST,NELSON+        (CHIC+WUSL+OSU+ANL)IJP
LONGACRE 75 PL 55B 415          +ROSENFELD,LASINSKI,SMADJA+         (LBL+SLAC)IJP
    ALSO 78 PR D17 1795         LONGACRE,LASINSKI,ROSENFELD+        (LBL+SLAC)
AYED     76 CEA-N-1921          AYED (THESIS)                           (SACL)IJP
BARBOUR  76 NP B111 358         I M BARBOUR,R L CRAWFORD                (GLAS)IJP
FELLER   76 NP B104 219         +FUKUSHIMA,HORIKAWA,KAJIKAWA+      (NAGO+OSAK)IJP

AZNAURYA 77  EFI-264(57)-77     +AKOPOV,BAGDASARYAN                     (YERE)IJP
BAKER    77 NP B126 365         +BLISSET,BLOODWORTH,BROOME,HART+        (RHEL)IJP
LONGACRE 77 NP B122 493         LONGACRE,DOLBEAU                        (SACL)IJP
    ALSO 76 NP B108 365         DOLBEAU,TRIANTIS,NEVEU,CADIET           (SACL)IJP
WINNIK   77 NP B128 66          +TOAFF,REVEL,GOLDBERG,BERNY             (HAIF)I
BAKER    78 NP B141 29          +BLISSET,BLOODWORTH,BROOME+          (RL+CAMB)IJP
BARBOUR  78 NP B141 253         BARBOUR,CRAWFORD,PARSONS                (GLAS)
BAKER    79 NP B156 93          +BROWN,CLARK,DAVIES,DEPAGTER,EVANS+  (RHEL)IJP
CUTKOSKY 79 PR D20 2839         +FORSYTH,HENDRICK,KELLY             (CARN+LBL)IJP
HOEHLER  79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                                +KAISER,KOCH,PIETARINEN        (KARL)       IJP
    ALSO 80  TORONTO CONF 3     R KOCH                                  (KARL)IJP

ARAI     80  TORONTO CONF 93    I ARAI                                  (TOKY)
    ALSO 82 NP B194 251         I ARAI, H FUJII                         (TOKY)
CRAWFORD 80  TORONTO CONF 107 R L CRAWFORD                              (GLAS)
CUTKOSKY 80  TORONTO CONF 19    +FORSYTH,BABCOCK,KELLY,HENDRICK     (CARN+LBL)IJP
LIVANOS  80  TORONTO CONF 35    +BATON,COUTURES,KOCHOWSKI,NEVEU         (SACL)IJP
MUSETTE  80 NC 57A 37           M MUSETTE                               (BRUX)IJP
SAXON    80 NP B162 522         +BAKER,BELL,BLISSETT,BLOODWORTH+(RHEL+BRIS)IJP
TAKEDA   80 NP B168 17          TAKEDA,ARAI,FUJII,IKEDA,IWASAKI+        (TOKY)

AWAJI    81  BONN CONF 352      R KAJIKAWA (TALK)                       (NAGO)
    ALSO 82 NP B197 365         FUJII,HAYASHII,IWATA,KAJIKAWA+          (NAGO)
FUJII    81 NP B187 53          FUJII,HAYASHII,IWATA,KAJIKAWA+          (TOKY)
BELL     83 NP B222 389         +BLISSET,BROOME,DALEY,HART,LINTERN,+      (RL)IJP
CRAWFORD 83 NP B211 1           R L CRAWFORD, W T MORTON                (GLAS)
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N(1675) D'_{15} Status: ****

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                   64  N(1675, JP=5/2-) I=1/2   D'15

                   MOST OF THE RESULTS PUBLISHED BEFORE 1975 ARE NOW
                   OBSOLETE AND HAVE BEEN OMITTED.  THEY MAY BE FOUND IN
                   OUR 1982 EDITION (PHYSICS LETTERS 111B).  HOWEVER,
                   ALL THE REFERENCES HAVE BEEN RETAINED.

    IN ADDITION, RESULTS IN THIS REGION FROM PRODUCTION EXPERIMENTS,
    WHICH USED TO BE LISTED SEPARATELY IN AN ENTRY FOLLOWING THE
    N(1700), HAVE BEEN ENTIRELY REMOVED.

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Baryons

Data Card Listings

N(1675)

64 N(1675) MASS (MEV)

M	A	1660. OR 1660.		LONGACRE	75	IPWA	PI N TO 2PI N	11/75
M	A	THE 2 SETS OF PARAMETERS ARE FROM METHODS 1 AND 2 OF LONGACRE 75.						11/75
M	B	(1650.0)		LONGACRE	77	IPWA	PI N TO 2PI N	11/77
M	B	ALL LONGACRE77 PARAMETERS ARE FROM SOLUTION S2, EXCEPT FOR THE POLE						11/77
M	B	POSITION WHICH IS FROM SOLUTIONS S1 AND C1.						11/77
M		(1680.0)		BARBOUR	78	DPWA	PI-N PHOTOPROD.	3/79
M		(1680.0)	(15.0)	CUTKOSKY	79	IPWA	PI N TO PI N	12/79
M		1679.0	8.0	HOEHLER	79	IPWA	PI N TO PI N	12/79
M		(1685.0)		CRAWFORD	80	DPWA	PI N PHOTOPROD.	12/81
M		1675.0	10.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82
M		(1670.0)		SAXON	80	DPWA	0 PI- P TO K LAM	12/79

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64 N(1675) WIDTH (MEV)

W	A	145. OR 150.		LONGACRE	75	IPWA	PI N TO 2PI N	11/75
W	B	(130.0)		LONGACRE	77	IPWA	PI N TO 2PI N	11/77
W		(192.0)		BARBOUR	78	DPWA	PI-N PHOTOPROD.	3/79
W		(88.0)		BAKER	79	DPWA	0 PI- P TO ETA N	12/79
W		(180.0)	(30.0)	CUTKOSKY	79	IPWA	PI N TO PI N	12/79
W		120.0	15.0	HOEHLER	79	IPWA	PI N TO PI N	12/79
W		(191.0)		CRAWFORD	80	DPWA	PI N PHOTOPROD.	12/81
W		160.0	20.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82
W		(40.0)		SAXON	80	DPWA	0 PI- P TO K LAM	12/79

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64 N(1675) REAL PART OF POLE POSITION (MEV)

RE		(1663.0)		LONGACRE	75	IPWA	PI N TO 2PI N	11/75
RE	B	1649. OR 1650.		LONGACRE	77	IPWA	PI N TO 2PI N	11/77
RE		(1663.0)		CUTKOSKY	79	IPWA	PI N TO PI N	12/79
RE		1660.0	10.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

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64 N(1675) -2*IMAG PART OF POLE POSITION (MEV)

IM		(146.0)		LONGACRE	75	IPWA	PI N TO 2PI N	11/75
IM	B	127. OR 127.		LONGACRE	77	IPWA	PI N TO 2PI N	11/77
IM		(150.0)		CUTKOSKY	79	IPWA	PI N TO PI N	12/79
IM		140.0	10.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

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64 N(1675) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER		(33.0)		CUTKOSKY	79	IPWA	PI N TO PI N	12/79
RER		27.0	5.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

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64 N(1675) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR		(-11.0)		CUTKOSKY	79	IPWA	PI N TO PI N	12/79
IMR		-16.0	5.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

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64 N(1675) PARTIAL DECAY MODES

		DECAY MASSES
P1	N(1675) INTO N PI	938+ 140
P2	N(1675) INTO N ETA	940+ 549
P3	N(1675) INTO LAMBDA K	1116+ 498
P4	N(1675) INTO DELTA(1232) PI	1232+ 140
P5	N(1675) INTO N PI PI	938+ 140+ 140
P6	N(1675) INTO P GAMMA, HELICITY=1/2	938+ 0
P7	N(1675) INTO P GAMMA, HELICITY=3/2	938+ 0
P8	N(1675) INTO N GAMMA, HELICITY=1/2	940+ 0
P9	N(1675) INTO N GAMMA, HELICITY=3/2	940+ 0
P10	N(1675) INTO SIGMA K	1189+ 494
P11	N(1675) INTO DELTA(1232) PI, D-WAVE	1232+ 140
P12	N(1675) INTO N RHO, S=3/2, D-WAVE	938+ 769
P13	N(1675) INTO N EPSILON	938+1300

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64 N(1675) BRANCHING RATIOS

R1		**N(1675) INTO (N PI)/TOTAL**					**(P1)**	
R1		(0.35)	(0.06)	CUTKOSKY	79	IPWA	PI N TO PI N	12/79
R1		0.38	0.03	HOEHLER	79	IPWA	PI N TO PI N	12/79
R1		0.38	0.05	CUTKOSKY	80	IPWA	PI N TO PI N	1/82
R2		**N(1675) FROM N PI TO N ETA**					**SQRT(P1*P2)**	
R2		0.0 OR +0.009		FELTESSE	75	DPWA	0 1488 TO 1745 MEV	11/75
R2		(-0.07)		BAKER	79	DPWA	0 PI- P TO ETA N	12/79
R3		**N(1675) FROM N PI TO LAMBDA K**					**SQRT(P1*P3)**	
R3		-0.034	0.006	DEVENISH	74		0 FIXED T DISP REL	4/75
R3		COUPLING TO LAMBDA K NOT REQUIRED IN THE ANALYSES OF BAKER 77 AND						3/79
R3		BAKER 78						3/79
R3	C	(+0.036)		SAXON	80	DPWA	0 PI- P TO K LAM	12/79
R3	C	SUPERSEDES BAKER 78. COUPLING PHASE IS NEAR 90 DEGREES.						12/79
R3		(-0.01)		BELL	83	DPWA	0 PI- P TO LAM K0	2/84*
R4		**N(1675) FROM N PI TO SIGMA K**					**SQRT(P1*P10)**	
R4	D	LESS THAN 0.003		DEANS	75	DPWA	PI N TO K SIGMA	11/75
R4	D	RANGE GIVEN IS FROM FOUR BEST SOLUTIONS. DEANS 75 DISAGREES						11/75
R4	D	WITH PI+ P TO K+ SIGMA+ DATA OF WINNIK 77 AROUND 1920 MEV.						1/78
R5		**N(1675) FROM N PI TO DELTA(1232) PI, D-WAVE**					**SQRT(P1*P11)**	
R5	A	-0.45 OR -0.50		LONGACRE	75	IPWA	PI N TO 2PI N	11/75
R5	B	(-0.46)		LONGACRE	77	IPWA	PI N TO 2PI N	11/77
R5	B	LONGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.						
R5	E	(-0.5)		NOVOSELLE	78	IPWA	PI N TO 2PI N	3/79
R5	E	BW FIT TO LONGACRE 75 IPWA.						3/79
R6		**N(1675) FROM N PI INTO N RHO, S=3/2, D-WAVE**					**SQRT(P1*P12)**	
R6	B	(+0.15)		LONGACRE	77	IPWA	PI N TO 2PI N	11/77
R6	B	LONGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.						
R7		**N(1675) FROM N PI INTO N EPSILON**					**SQRT(P1*P13)**	
R7	B	(-0.03)		LONGACRE	77	IPWA	PI N TO 2PI N	11/77

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64 N(1675) PHOTON DECAY AMPLITUDES (GEV-1/2)**

FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-REVIEW PRECEDING THE BARYON LISTINGS.

A1	**N(1675) INTO P GAMMA, HELICITY=1/2 (GEV**-1/2)**						
A1	+0.010	0.013	METCALF	74	DPWA	PI N PHOTOPROD.	2/74
A1	+0.034	0.004	FELLER	76	DPWA	PI N PHOTOPROD.	2/77
A1	+0.034	0.003	AZNAURYAN	77	DPWA	PI0 PHTPRD,SOL 1	12/79
A1	+0.071	0.002	AZNAURYAN	77	DPWA	PI0 PHTPRD,SOL 2	12/79
A1	+0.022	0.010	BARBOUR	78	DPWA	PI-N PHOTOPROD.	3/79
A1	0.006	0.005	ARAI	80	DPWA	PI N PHOTO FIT 1	12/81
A1	0.006	0.004	ARAI	80	DPWA	PI N PHOTO FIT 2	12/81
A1	0.023	0.015	CRAWFORD	80	DPWA	PI N PHOTOPROD.	12/81
A1	0.034	0.005	AWAJI	81	DPWA	PI N PHOTOPROD.	1/84*
A1	0.021	0.011	CRAWFORD	83	IPWA	PI N PHOTOPROD.	1/84*
A2	**N(1675) INTO P GAMMA, HELICITY=3/2 (GEV**-1/2)**						
A2	+0.042	0.024	METCALF	74	DPWA	PI N PHOTOPROD.	2/74
A2	+0.019	0.009	FELLER	76	DPWA	PI N PHOTOPROD.	2/77
A2	+0.010	0.010	AZNAURYAN	77	DPWA	PI0 PHTPRD,SOL 1	12/79
A2	+0.002	0.021	AZNAURYAN	77	DPWA	PI0 PHTPRD,SOL 2	12/79
A2	+0.015	0.006	BARBOUR	78	DPWA	PI-N PHOTOPROD.	3/79
A2	0.030	0.004	ARAI	80	DPWA	PI N PHOTO FIT 1	12/81
A2	0.029	0.004	ARAI	80	DPWA	PI N PHOTO FIT 2	12/81
A2	0.003	0.012	CRAWFORD	80	DPWA	PI N PHOTOPROD.	12/81
A2	0.024	0.008	AWAJI	81	DPWA	PI N PHOTOPROD.	1/84*
A2	0.015	0.009	CRAWFORD	83	IPWA	PI N PHOTOPROD.	1/84*
A3	**N(1675) INTO N GAMMA, HELICITY=1/2 (GEV**-1/2)**						
A3	0.004	0.015	METCALF	74	DPWA	PI N PHOTOPROD.	2/74
A3	-0.066	0.020	BARBOUR	78	DPWA	PI-N PHOTOPROD.	3/79
A3	-0.039	0.017	ARAI	80	DPWA	PI N PHOTO FIT 1	12/81
A3	-0.025	0.027	ARAI	80	DPWA	PI N PHOTO FIT 2	12/81
A3	-0.059	0.015	CRAWFORD	80	DPWA	PI N PHOTOPROD.	12/81
A3	-0.021	0.011	TAKEDA	80	DPWA	PI N PHOTOPROD.	12/81
A3	-0.057	0.024	AWAJI	81	DPWA	PI N PHOTOPROD.	1/84*
A3	-0.033	0.004	FUJII	81	DPWA	PI N PHOTOPROD.	12/81
A4	**N(1675) INTO N GAMMA, HELICITY=3/2 (GEV**-1/2)**						
A4	-0.009	0.029	METCALF	74	DPWA	PI N PHOTOPROD.	2/74
A4	-0.073	0.014	BARBOUR	78	DPWA	PI-N PHOTOPROD.	3/79
A4	-0.066	0.026	ARAI	80	DPWA	PI N PHOTO FIT 1	12/81
A4	-0.071	0.022	ARAI	80	DPWA	PI N PHOTO FIT 2	12/81
A4	-0.059	0.020	CRAWFORD	80	DPWA	PI N PHOTOPROD.	12/81
A4	-0.030	0.012	TAKEDA	80	DPWA	PI N PHOTOPROD.	12/81
A4	-0.077	0.018	AWAJI	81	DPWA	PI N PHOTOPROD.	1/84*
A4	-0.069	0.004	FUJII	81	DPWA	PI N PHOTOPROD.	12/81

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REFERENCES FOR N(1675)

BAREYRE	65	PL 18 342	+ BRICMAN, STIRLING, VILLET	(SACL)IJP
BRANDSEN	65	PL 19 420	+ODONNELL, MOORHOUSE	(DURH+RHEL)IJP
DUKE	65	PRL 15 468	+JONES,KEMP,MURPHY,PRENTICE, +	(RHEL+OXF)IJP
JOHNSON	67	UCRL-17683 THESIS	C H JOHNSON	(LRL)
TRIPP	67	NP B3 10	+ LEITH, +	(LRL+SLAC+CERN+HEID+SACL)
BAREYRE	68	PR 165 1731	P BAREYRE, C BRICMAN, G VILLET	(SACL)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	(ALAH)
BOTKE	69	PR 180 1417	J C BOTKE	(UCSB)
DEANS	69	PR 185 1797	S DEANS, J WOOTEN	(SFLA)
DEANS2	69	PR 177 2623	S R DEANS	(SFLA)
DONNACHI	69	NP 10B 433	A DONNACHIE, R KIRSOPP	(GLAS+EDIN)
AYED	70	KIEV CONF	R AYED,P BAREYRE, G VILLET	(SACL)IJP
AYED2	70	PL 31B 598	+BAREYRE,VILLET	(SACL)
CARRERAS	70	NP 16B 35	B CARRERAS, A DONNACHIE	(DARE+MCHS)
DAVIES	70	NP B21 359	A DAVIES	(GLAS)
BRODY	71	PL 34B 665	+CASHMORE+..+HERNDON+..	(SLAC+LRL)
WAGNER	71	NP B25 411	F WAGNER, C LOVELACE	(CERN)
ALMEHED	72	NP B40 157	+LOVELACE	(LUND+RUTG)IJP
DEVENISH	73	PL 47B 53	DEVENISH,RANKIN,LYTH	(LOUC+BONN+LANC)IJP
HEMMI1	73	PL 43B 79	HEMMI,INAGAKI+	(KYOT+SAGA+KEK+TOKY)IJP
MOORHOUS	73	PL 43B 44	MOORHOUSE, OBERLACK	(GLAS+LBL)IJP
DEVENISH	74	NP B81 330	DEVENISH,FROGGATT,MARTIN	(DESY+NORD+LOUC)
DEVENIS2	74	PL 52B 227	DEVENISH,LYTH,RANKIN	(DESY+LANC+BONN)IJP
KNIES	74	PR D9 2680	KNIES,MOORHOUSE,OBERLACK	(LBL+GLAS)IJP
METCALF	74	NP B76 253	W J METCALF,R L WALKER	(CIT)IJP
MOORHOUS	74	PR D9 1	MOORHOUSE,OBERLACK,ROSENFELD	(GLAS+LBL)IJP
CRAWFORD	75	NP B97 125	R L CRAWFORD	(GLAS)IJP
DEANS	75	NP B96 90	+MITCHELL,MONTGOMERY,+	(SFLA+ALAH)IJP
FELTESSE	75	NP B93 242	+AYED,BAREYRE,BORGEAUD,DAVID,ERNWEIN+	(SACL)IJP
KRIVETS	75	SJNP 20 430	+MIROSHNICHENKO,NIKIFOROV,SANIN+	(KIEV)IJP
ALSO	74	SJNP 19 112	KRIVETS,NIKIFOROV,SANIN,SHALATSKII	(KIEV)IJP
LONGACRE	75	PL 55B 415	+ROSENFELD,LASINSKI,SMADJA+	(LBL+SLAC)IJP
ALSO	78	PR D17 1795	LONGACRE,LASINSKI,ROSENFELD+	(LBL+SLAC)
AYED	76	CEA-N-1921	AYED (THESIS)	(SACL)IJP
BARBOUR	76	NP B111 358	I M BARBOUR,R L CRAWFORD	(GLAS)IJP
FELLER	76	NP B104 219	+FUKUSHIMA,HORIKAWA,KAJIKAWA+	(NAGO+OSAK)IJP
AZNAURYA	77	EFI-264(57)-77	+AKOPOV,BAGDASARYAN	(YERE)IJP
BAKER	77	NP B126 365	+BLISSET,BLOODWORTH,BROOME,HART+	(RHEL)IJP
LONGACRE	77	NP B122 493	LONGACRE,DOLBEAU	(SACL)IJP
ALSO	76	NP B108 365	DOLBEAU,TRIANTIS,NEVEU,CADIET	(SACL)IJP
WINNIK	77	NP B128 66	+TOAFF,REVEL,GOLDBERG,BERNY	(HAIF)I
BAKER	78	NP B141 29	+BLISSET,BLOODWORTH,BROMME+	(RL+CAMB)IJP
BARBOUR	78	NP B141 253	BARBOUR,CRAWFORD,PARSONS	(GLAS)
NOVOSELL	78	NP B137 509	D E NOVOSELLER	(CIT)IJP
ALSO	78	NP B137 445	D E NOVOSELLER	(CIT)IJP
BAKER	79	NP B156 93	+BROWN,CLARK,DAVIES,DEPAGTER,EVANS+	(RHEL)IJP
CUTKOSKY	79	PR D20 2839	+FORSYTH,HENDRICK,KELLY	(CARN+LBL)IJP
HOEHLER	79	HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1	+KAISER,KOCH,PIETARINEN	(KARL) IJP
ALSO	80	TORONTO CONF 3	R KOCH	(KARL)IJP
ARAI	80	TORONTO CONF 93	I ARAI	(TOKY)
ALSO	82	NP B194 251	I ARAI, H FUJII	(TOKY)
CRAWFORD	80	TORONTO CONF 107	R L CRAWFORD	(GLAS)
CUTKOSKY	80	TORONTO CONF 19	+FORSYTH,BABCOCK,KELLY,HENDRICK	(CARN+LBL)IJP
SAXON	80	NP B162 522	+BAKER,BELL,BLISSETT,BLOODWORTH+	(RHEL+BRIS)IJP
TAKEDA	80	NP B168 17	TAKEDA,ARAI,FUJII,IKEDA,IWASAKI+	(TOKY)
AWAJI	81	BONN CONF 352	R KAJIKAWA (TALK)	(NAGO)
ALSO	82	NP B197 365	FUJII,HAYASHII,IWATA,KAJIKAWA+	(NAGO)
FUJII	81	NP B187 53	FUJII,HAYASHII,IWATA,KAJIKAWA+	(TOKY)
BELL	83	NP B222 389	+BLISSET,BROOME,DALEY,HART,LINTERN,+	(RL)IJP
CRAWFORD	83	NP B211 1	R L CRAWFORD, W T MORTON	(GLAS)

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N(1680) F_{15} Status: ****

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                    65  N(1680, JP=5/2+) I=1/2   F'15

                    MOST OF THE RESULTS PUBLISHED BEFORE 1975 ARE NOW
                    OBSOLETE AND HAVE BEEN OMITTED.  THEY MAY BE FOUND IN
                    OUR 1982 EDITION (PHYSICS LETTERS 111B).  HOWEVER,
                    ALL THE REFERENCES HAVE BEEN RETAINED.

      IN ADDITION, RESULTS IN THIS REGION FROM PRODUCTION EXPERIMENTS,
      WHICH USED TO BE LISTED SEPARATELY IN AN ENTRY FOLLOWING THE
      N(1700), HAVE BEEN ENTIRELY REMOVED.

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                    65  N(1680) MASS (MEV)

M          (1685.0)                 KNASEL    75 DPWA  0 PI- P TO KO LAM  11/75
M     A     1680. OR 1670.          LONGACRE  75 IPWA    PI N TO 2PI N    11/75
M     A  THE 2 SETS OF PARAMETERS ARE FROM METHODS 1 AND 2 OF LONGACRE 75.  11/75
M     B    (1660.0)                 LONGACRE  77 IPWA    PI N TO 2PI N    11/77
M     B  ALL LONGACRE77 PARAMETERS ARE FROM SOLUTION S2, EXCEPT FOR THE POLE 11/77
M     B  POSITION WHICH IS FROM SOLUTIONS S1 AND C1.                        11/77
M          (1680.0)                 BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
M          (1680.0)   (15.0)        CUTKOSKY  79 IPWA    PI N TO PI N     12/79
M           1684.0      3.0         HOEHLER   79 IPWA    PI N TO PI N     12/79
M          (1682.0)                 CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
M           1680.0     10.0         CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                    65  N(1680) WIDTH (MEV)

W           (155.0)                 KNASEL    75 DPWA  0 PI- P TO KO LAM  11/75
W     A      125. OR  130.          LONGACRE  75 IPWA    PI N TO 2PI N    11/75
W     B     (150.0)                 LONGACRE  77 IPWA    PI N TO 2PI N    11/77
W           (119.0)                 BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
W          (120.0)    (25.0)        CUTKOSKY  79 IPWA    PI N TO PI N     12/79
W            128.0      8.0         HOEHLER   79 IPWA    PI N TO PI N     12/79
W           (121.0)                 CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
W            120.0     10.0         CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                    65  N(1680) REAL PART OF POLE POSITION (MEV)

RE         (1688.0)                 LONGACRE  75 IPWA    PI N TO 2PI N    11/75
RE    B     1656. OR 1653.          LONGACRE  77 IPWA    PI N TO 2PI N    11/77
RE         (1666.0)                 CUTKOSKY  79 IPWA    PI N TO PI N     12/79
RE          1667.0      5.0         CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                    65  N(1680) -2*IMAG PART OF POLE POSITION (MEV)

IM          (132.0)                 LONGACRE  75 IPWA    PI N TO 2PI N    11/75
IM    B      145. OR 143.           LONGACRE  77 IPWA    PI N TO 2PI N    11/77
IM          (112.0)                 CUTKOSKY  79 IPWA    PI N TO PI N     12/79
IM           110.0     10.0         CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                    65  N(1680) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER          (31.0)                 CUTKOSKY  79 IPWA    PI N TO PI N     12/79
RER           31.0      2.0         CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                    65  N(1680) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR         (-15.0)                 CUTKOSKY  79 IPWA    PI N TO PI N     12/79
IMR          -14.0      3.0         CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                    65  N(1680) PARTIAL DECAY MODES

                                                           DECAY MASSES
P1      N(1680) INTO N PI                                 938+ 140
P2      N(1680) INTO N ETA                                940+ 549
P3      N(1680) INTO LAMBDA K                            1116+ 498
P4      N(1680) INTO DELTA(1232) PI                      1232+ 140
P5      N(1680) INTO N PI PI                              938+ 140+ 140
P6      N(1680) INTO P GAMMA, HELICITY=1/2                938+   0
P7      N(1680) INTO P GAMMA, HELICITY=3/2                938+   0
P8      N(1680) INTO N GAMMA, HELICITY=1/2                940+   0
P9      N(1680) INTO N GAMMA, HELICITY=3/2                940+   0
P10     N(1680) INTO N EPSILON                            938+1300
P11     N(1680) INTO N RHO                                938+ 769
P12     N(1680) INTO DELTA(1232) PI, P-WAVE              1232+ 140
P13     N(1680) INTO DELTA(1232) PI, F-WAVE              1232+ 140
P14     N(1680) INTO N RHO, S=3/2, P-WAVE                 938+ 769
P15     N(1680) INTO N RHO, S=3/2, F-WAVE                 938+ 769
P16     N(1680) INTO SIGMA K                             1189+ 494

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                    65  N(1680) BRANCHING RATIOS

R1      N(1680) INTO (N PI)/TOTAL                             (P1)
R1           (0.62)   (0.06)        CUTKOSKY  79 IPWA    PI N TO PI N     12/79
R1            0.65     0.02         HOEHLER   79 IPWA    PI N TO PI N     12/79
R1            0.62     0.05         CUTKOSKY  80 IPWA    PI N TO PI N      1/82

R2      N(1680) FROM N PI TO N ETA                          SQRT(P1*P2)
R2         NOT SEEN                 BAKER     79 DPWA  0 PI- P TO ETA N   12/79

R3      N(1680) INTO (N ETA)/TOTAL                            (P2)
R3    C      (0.0004)               BOTKE     69 MPWA    T POLE + RESON.  10/69
R3    C      (0.003)  (0.002)       DEANS     69 MPWA    T POLE + RESON.   5/70
R3    C       0.0005 OR 0.001       CARRERAS  70 MPWA    T POLE + RESON.   5/70
R3    C  PARAMETRIZATION USED COULD BE IN DANGER OF DOUBLE COUNTING

R4      N(1680) INTO (N ETA)/(N PI)                           (P2)/(P1)
R4           (0.027)OR LESS         HEUSCH    66 RVUE +  PIO, ETA PHOTO    9/66

R5      N(1680) FROM N PI TO LAMBDA K                       SQRT(P1*P3)
R5           -0.009    0.009        DEVENISH  74         0 FIXED T DISP REL  4/75
R5           (0.01)                 KNASEL    75 DPWA  0 PI- P TO KO LAM  11/75
R5       COUPLING TO LAMBDA K NOT REQUIRED IN THE ANALYSES OF BAKER 77,     2/84*
R5       SAXON 80, OR BELL 83.                                               2/84*

R6      N(1680) FROM N PI TO SIGMA K                        SQRT(P1*P16)
R6    D     LESS THAN 0.001         DEANS     75 DPWA    PI N TO K SIGMA  11/75
R6    D  RANGE GIVEN IS FROM 3 OF 4 BEST SOLUTIONS, NOT PRESENT IN SLTN.1.  11/75
R6    D  DEANS75 DISAGREES WITH PI+ P TO K+ SIGMA+ DATA OF WINNIK77          1/78
R6    D  AROUND 1920 MEV.                                                    1/78

R7      N(1680) FROM N PI TO DELTA(1232) PI, P-WAVE      SQRT(P1*P12)
R7    A        +0.26 OR +0.25           LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R7    B      (+0.27)                    LONGACRE  77 IPWA    PI N TO 2PI N    11/77
R7    B  LONGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.
R7    E      (+0.38)                    NOVOSELLE 78 IPWA    PI N TO 2PI N     3/79
R7    E  BW FIT TO LONGACRE 75 IPWA.                                           3/79

R8      N(1680) FROM N PI TO DELTA(1232) PI, F-WAVE      SQRT(P1*P13)
R8    A         0.  OR  -0.08           LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R8    B      (-0.07)                    LONGACRE  77 IPWA    PI N TO 2PI N    11/77
R8    E      (-0.05)                    NOVOSELLE 78 IPWA    PI N TO 2PI N     3/79

R9      N(1680) FROM N PI TO N RHO, S=3/2, P-WAVE        SQRT(P1*P14)
R9    A        +0.27 OR +0.30           LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R9    B      (+0.23)                    LONGACRE  77 IPWA    PI N TO 2PI N    11/77
R9    B  LONGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.
R9    E      (+0.34)                    NOVOSELLE 78 IPWA    PI N TO 2PI N     3/79

R10     N(1680) FROM N PI TO N RHO, S=3/2, F-WAVE        SQRT(P1*P15)
R10   B      (+0.15)                    LONGACRE  77 IPWA    PI N TO 2PI N    11/77
R10   B  LONGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.

R11     N(1680) FROM N PI TO N EPSILON                   SQRT(P1*P10)
R11   A        -0.28 OR -0.30           LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R11   B      (-0.31)                    LONGACRE  77 IPWA    PI N TO 2PI N    11/77
R11   B  LONGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.
R11   E      (-0.42)                    NOVOSELLE 78 IPWA    PI N TO 2PI N     3/79

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                 65  N(1680) PHOTON DECAY AMPLITUDES (GEV**-1/2)

        FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-
     REVIEW PRECEDING THE BARYON LISTINGS.

A1      N(1680) INTO P GAMMA, HELICITY=1/2 (GEV**-1/2)
A1            -0.008     0.011        METCALF   74 DPWA    PI N PHOTOPROD.   2/74
A1            -0.009     0.002        FELLER    76 DPWA    PI N PHOTOPROD.   2/77
A1            -0.007     0.002        AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 1 12/79
A1            +0.010     0.001        AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 2 12/79
A1            -0.005     0.015        BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
A1            -0.028     0.003        ARAI      80 DPWA    PI N PHOTO FIT 1 12/81
A1            -0.026     0.003        ARAI      80 DPWA    PI N PHOTO FIT 2 12/81
A1            -0.018     0.014        CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
A1            -0.009     0.006        AWAJI     81 DPWA    PI N PHOTOPROD.   1/84*
A1            -0.017     0.018        CRAWFORD  83 IPWA    PI N PHOTOPROD.   1/84*

A2      N(1680) INTO P GAMMA, HELICITY=3/2 (GEV**-1/2)
A2             0.129     0.016        METCALF   74 DPWA    PI N PHOTOPROD.   2/74
A2            +0.121     0.010        FELLER    76 DPWA    PI N PHOTOPROD.   2/77
A2            +0.112     0.002        AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 1 12/79
A2            +0.114     0.002        AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 2 12/79
A2            +0.138     0.021        BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
A2             0.115     0.003        ARAI      80 DPWA    PI N PHOTO FIT 1 12/81
A2             0.122     0.003        ARAI      80 DPWA    PI N PHOTO FIT 2 12/81
A2             0.141     0.014        CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
A2             0.115     0.008        AWAJI     81 DPWA    PI N PHOTOPROD.   1/84*
A2             0.132     0.010        CRAWFORD  83 IPWA    PI N PHOTOPROD.   1/84*

A3      N(1680) INTO N GAMMA, HELICITY=1/2 (GEV**-1/2)
A3             0.008     0.018        METCALF   74 DPWA    PI N PHOTOPROD.   2/74
A3            +0.037     0.010        BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
A3             0.026     0.005        ARAI      80 DPWA    PI N PHOTO FIT 1 12/81
A3             0.028     0.014        ARAI      80 DPWA    PI N PHOTO FIT 2 12/81
A3             0.044     0.012        CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
A3             0.025     0.010        TAKEDA    80 DPWA    PI N PHOTOPROD.  12/81
A3             0.017     0.014        AWAJI     81 DPWA    PI N PHOTOPROD.   1/84*
A3             0.032     0.003        FUJII     81 DPWA    PI N PHOTOPROD.  12/81

A4      N(1680) INTO N GAMMA, HELICITY=3/2 (GEV**-1/2)
A4             0.00      0.030        METCALF   74 DPWA    PI N PHOTOPROD.   2/74
A4            -0.038     0.018        BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
A4            -0.024     0.009        ARAI      80 DPWA    PI N PHOTO FIT 1 12/81
A4            -0.029     0.017        ARAI      80 DPWA    PI N PHOTO FIT 2 12/81
A4            -0.033     0.015        CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
A4            -0.035     0.012        TAKEDA    80 DPWA    PI N PHOTOPROD.  12/81
A4            -0.033     0.013        AWAJI     81 DPWA    PI N PHOTOPROD.   1/84*
A4            -0.023     0.005        FUJII     81 DPWA    PI N PHOTOPROD.  12/81

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REFERENCES FOR N(1680)

FOR VERY EARLY REFERENCES, SEE RMP 37, 633 (1965).


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BAREYRE  65 PL 18 342          + BRICMAN, STIRLING, VILLET            (SACL)IJP
BRANDSEN 65 PL 19 420          +ODONNELL, MOORHOUSE              (DURH+RHEL)IJP
CROUCH   65 DESY CONF II 21    +              (BROW+CEA+HARV+MIT+PADO+REHO)
DERADO   65 ATHENS CONF 244    +KENNEY,LAMSA, +                     (NDAM+KNTY)
DUKE     65 PRL 15 468         +JONES,KEMP,MURPHY,PRENTICE, +   (RHEL+OXF)IJP
HEUSCH   66 PRL 17 1019        C A HEUSCH, C Y PRESCOTT, R F DASHEN  (CIT)
MERLO    66 P ROY SOC 289 489  J P MERLO, G VALLADAS                    (SACL)
ROBERTS  67 PREPRINT           R G ROBERTS                              (DURH)
TRIPP    67 NP B3 10           + LEITH, +          (LRL+SLAC+CERN+HEID+SACL)

BANNER   68 PR 166 1347        +DETOEUF,FAYOUX,HAMEL, +          (SACL+CAEN)
BAREYRE  68 PR 165 1731        P BAREYRE, C BRICMAN, G VILLET        (SACL)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                                 (ALAH)
BOTKE    69 PR 180 1417        J C BOTKE                                (UCSB)
DEANS    69 PR 185 1797        S DEANS, J WOOTEN                        (SFLA)
DEANS2   69 PR 177 2623        S R DEANS                                (SFLA)
DONNACHI 69 NP 10B 433         A DONNACHIE, R KIRSOPP              (GLAS+EDIN)

AYED     70 KIEV CONF          R AYED,P BAREYRE, G VILLET            (SACL)IJP
AYED2    70 PL 31B 598         +BAREYRE,VILLET                          (SACL)
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
DEVENISH 73 PL 47B 53          DEVENISH,RANKIN,LYTH         (LOUC+BONN+LANC)IJP
HEMMI1   73 PL 43B 79          HEMMI,INAGAKI+           (KYOT+SAGA+KEK+TOKY)IJP
MOORHOUS 73 PL 43B 44          MOORHOUSE, OBERLACK                (GLAS+LBL)IJP
DEVENISH 74 NP B81 330         DEVENISH,FROGGATT,MARTIN     (DESY+NORD+LOUC)
DEVENIS2 74 PL 52B 227         DEVENISH,LYTH,RANKIN         (DESY+LANC+BONN)IJP
KNIES    74 PR D9 2680         KNIES,MOORHOUSE,OBERLACK            (LBL+GLAS)IJP
METCALF  74 NP B76 253         W J METCALF,R L WALKER                    (CIT)IJP
MOORHOUS 74 PR D9 1            MOORHOUSE,OBERLACK,ROSENFELD       (GLAS+LBL)IJP
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Baryons

Data Card Listings

N(1680), N(1700)


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CRAWFORD 75 NP B97 125         R L CRAWFORD                          (GLAS)IJP
DEANS    75 NP B96 90          +MITCHELL,MONTGOMERY,+           (SFLA+ALAH)IJP
KNASEL   75 PR D11 1           +LINDQUIST,NELSON+     (CHIC+WUSL+OSU+ANL)IJP
KRIVETS  75 SJNP 20 430        +MIROSHNICHENKO,NIKIFOROV,SANIN+     (KIEV)IJP
    ALSO 74 SJNP 19 112        KRIVETS,NIKIFOROV,SANIN,SHALATSKII   (KIEV)IJP
LONGACRE 75 PL 55B 415         +ROSENFELD,LASINSKI,SMADJA+      (LBL+SLAC)IJP
    ALSO 78 PR D17 1795        LONGACRE,LASINSKI,ROSENFELD+     (LBL+SLAC)

AYED     76 CEA-N-1921         AYED (THESIS)                         (SACL)IJP
BARBOUR  76 NP B111 358        I M BARBOUR,R L CRAWFORD              (GLAS)IJP
FELLER   76 NP B104 219        +FUKUSHIMA,HORIKAWA,KAJIKAWA+    (NAGO+OSAK)IJP
AZNAURYA 77  EFI-264(57)-77    +AKOPOV,BAGDASARYAN                   (YERE)IJP
BAKER    77 NP B126 365        +BLISSET,BLOODWORTH,BROOME,HART+      (RHEL)IJP
LONGACRE 77 NP B122 493        LONGACRE,DOLBEAU                      (SACL)IJP
    ALSO 76 NP B108 365        DOLBEAU,TRIANTIS,NEVEU,CADIET         (SACL)IJP
WINNIK   77 NP B128 66         +TOAFF,REVEL,GOLDBERG,BERNY           (HAIF)I
BARBOUR  78 NP B141 253        BARBOUR,CRAWFORD,PARSONS              (GLAS)
NOVOSELL 78 NP B137 509        D E NOVOSELLER                         (CIT)IJP
    ALSO 78 NP B137 445        D E NOVOSELLER                         (CIT)IJP

BAKER    79 NP B156 93         +BROWN,CLARK,DAVIES,DEPAGTER,EVANS+  (RHEL)IJP
CUTKOSKY 79 PR D20 2839        +FORSYTH,HENDRICK,KELLY          (CARN+LBL)IJP
HOEHLER  79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                               +KAISER,KOCH,PIETARINEN       (KARL)      IJP
    ALSO 80  TORONTO CONF 3    R KOCH                                (KARL)IJP
ARAI     80  TORONTO CONF 93   I ARAI                                (TOKY)
    ALSO 82 NP B194 251        I ARAI, H FUJII                       (TOKY)
CRAWFORD 80  TORONTO CONF 107  R L CRAWFORD                          (GLAS)
CUTKOSKY 80  TORONTO CONF 19   +FORSYTH,BABCOCK,KELLY,HENDRICK  (CARN+LBL)IJP
SAXON    80 NP B162 522        +BAKER,BELL,BLOODWORTH+         (RHEL+BRIS)IJP
TAKEDA   80 NP B168 17         TAKEDA,ARAI,FUJII,IKEDA,IWASAKI+      (TOKY)

AWAJI    81  BONN CONF 352     R KAJIKAWA (TALK)                     (NAGO)
    ALSO 82 NP B197 365        FUJII,HAYASHII,IWATA,KAJIKAWA+        (NAGO)
FUJII    81 NP B187 53         FUJII,HAYASHII,IWATA,KAJIKAWA+        (TOKY)
BELL     83 NP B222 389        +BLISSET,BROOME,DALEY,HART,LINTERN,+    (RL)IJP
CRAWFORD 83 NP B211 1          R L CRAWFORD, W T MORTON              (GLAS)
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N(1700) D''_{13} Status: ***

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                       18  N(1700, JP=3/2-) I=1/2   D''13

                MOST OF THE RESULTS PUBLISHED BEFORE 1975 ARE NOW
                OBSOLETE AND HAVE BEEN OMITTED.  THEY MAY BE FOUND IN
                OUR 1982 EDITION (PHYSICS LETTERS 111B).  HOWEVER,
                ALL THE REFERENCES HAVE BEEN RETAINED.

      IN ADDITION, RESULTS IN THIS REGION FROM PRODUCTION EXPERIMENTS,
      WHICH USED TO BE LISTED SEPARATELY AS THE NEXT ENTRY, HAVE BEEN
      ENTIRELY REMOVED.

      THE VARIOUS PARTIAL-WAVE ANALYSES DO NOT AGREE VERY WELL.

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                      18  N(1700) MASS  (MEV)

M     A     1710. OR 1710.           LONGACRE  75 IPWA    PI N TO 2PI N    11/75
M     A  THE 2 SETS OF PARAMETERS ARE FROM METHODS 1 AND 2 OF LONGACRE 75.  11/75
M     B    (1670.0)    (10.0)        BAKER     77 IPWA  0 PI- P TO K LAM.   1/78
M     C    (1690.0)                  BAKER     77 DPWA  0 PI- P TO K LAM.   1/78
M     B  THE TWO ENTRIES FOR BAKER 77 ARE FOR AN IPWA USING THE BARRELET     1/78
M     C  ZERO METHOD AND A CONVENTIONAL ENERGY-DEPENDENT ANALYSIS.           1/78
M     D    (1660.0)                  LONGACRE  77 IPWA    PI N TO 2PI N    11/77
M     D  ALL LONGACRE77 PARAMETERS ARE FROM SOLUTION S2, EXCEPT FOR THE POLE 11/77
M     D  POSITION WHICH IS FROM SOLUTIONS S1 AND C1.                         11/77
M           1690. TO 1710.           BAKER     78 DPWA  0 PI- P TO K LAM    3/79
M          (1719.0)                  BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
M     E    (1880.0)                  BAKER     79 DPWA  0 PI- P TO ETA N   12/79
M     E  THE HIGH MASS FOUND BY BAKER 79 MAY BE INFLUENCED BY THE N(2080).  12/79
M          (1670.0)    (25.0)        CUTKOSKY  79 IPWA    PI N TO PI N     12/79
M           1731.0      15.0         HOEHLER   79 IPWA    PI N TO PI N     12/79
M          (1709.0)                  CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
M           1675.0      25.0         CUTKOSKY  80 IPWA    PI N TO PI N      1/82
M          (1650.0)                  SAXON     80 DPWA  0 PI- P TO K LAM   12/79

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                      18  N(1700) WIDTH (MEV)

W     A      100. OR  300.           LONGACRE  75 IPWA    PI N TO 2PI N    11/75
W     B      (90.0)   (25.0)         BAKER     77 IPWA  0 PI- P TO K LAM.   1/78
W     C     (100.0)                  BAKER     77 DPWA  0 PI- P TO K LAM.   1/78
W     D     (600.0)                  LONGACRE  77 IPWA    PI N TO 2PI N    11/77
W             70. TO  100.           BAKER     78 DPWA  0 PI- P TO K LAM    3/79
W           (126.0)                  BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
W     E      (87.0)                  BAKER     79 DPWA  0 PI- P TO ETA N   12/79
W            (80.0)   (40.0)         CUTKOSKY  79 IPWA    PI N TO PI N     12/79
W            110.0     30.0          HOEHLER   79 IPWA    PI N TO PI N     12/79
W           (166.0)                  CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
W             90.0     40.0          CUTKOSKY  80 IPWA    PI N TO PI N      1/82
W            (70.0)                  SAXON     80 DPWA  0 PI- P TO K LAM   12/79
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                      18  N(1700) REAL PART OF POLE POSITION (MEV)

RE         (1710.0)                  LONGACRE  75 IPWA    PI N TO 2PI N    11/75
RE    D     1616. OR 1613.           LONGACRE  77 IPWA    PI N TO 2PI N    11/77
RE         (1660.0)                  CUTKOSKY  79 IPWA    PI N TO PI N     12/79
RE          1660.0     30.0          CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                      18  N(1700) -2*IMAG PART OF POLE POSITION (MEV)

IM          (607.0)                  LONGACRE  75 IPWA    PI N TO 2PI N    11/75
IM    D      577.  OR 575.           LONGACRE  77 IPWA    PI N TO 2PI N    11/77
IM           (76.0)                  CUTKOSKY  79 IPWA    PI N TO PI N     12/79
IM            90.0     40.0          CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                      18  N(1700) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER          (4.0)                   CUTKOSKY  79 IPWA    PI N TO PI N     12/79
RER           6.0      3.0           CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                      18  N(1700) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR         (-0.3)                   CUTKOSKY  79 IPWA    PI N TO PI N     12/79
IMR          0.0       5.0           CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                      18  N(1700) PARTIAL DECAY MODES

                                                        DECAY MASSES
P1      N(1700) INTO N PI                                 938+ 140
P2      N(1700) INTO LAMBDA K                            1116+ 498
P3      N(1700) INTO P GAMMA, HELICITY=3/2                938+   0
P4      N(1700) INTO P GAMMA, HELICITY=1/2                938+   0
P5      N(1700) INTO N GAMMA, HELICITY=3/2                940+   0
P6      N(1700) INTO N GAMMA, HELICITY=1/2                940+   0
P7      N(1700) INTO SIGMA K                             1189+ 494
P8      N(1700) INTO N EPSILON                            938+1300
P9      N(1700) INTO DELTA(1232) PI, S-WAVE              1232+ 140
P10     N(1700) INTO DELTA(1232) PI, D-WAVE              1232+ 140
P11     N(1700) INTO N RHO, S=3/2, S-WAVE                 938+ 769
P12     N(1700) INTO N ETA                                940+ 549

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                      18  N(1700) BRANCHING RATIOS

R1      N(1700) INTO (N PI)/TOTAL                       (P1)
R1          (0.10)    (0.02)         CUTKOSKY  79 IPWA    PI N TO PI N     12/79
R1           0.08      0.03          HOEHLER   79 IPWA    PI N TO PI N     12/79
R1           0.11      0.05          CUTKOSKY  80 IPWA    PI N TO PI N      1/82

R2      N(1700) FROM N PI TO N ETA                      SQRT(P1*P12)
R2          (0.065)                  BAKER     79 DPWA  0 PI- P TO ETA N   12/79

R3      N(1700) FROM N PI TO LAMBDA K                   SQRT(P1*P2)
R3           +0.026    0.019         DEVENISH  74         0 FIXED T DISP REL  4/75
R3    B     (-0.03)   (0.004)        BAKER     77 IPWA  0 PI- P TO K LAM.   1/78
R3    C     (-0.03)                  BAKER     77 DPWA  0 PI- P TO K LAM.   1/78
R3    F     (-0.04)                  BAKER     78 DPWA  0 PI- P TO K LAM    3/79
R3    F  THE (UNDETERMINED) OVERALL PHASE OF ALL COUPLINGS HAS BEEN          3/79
R3    F  CHANGED TO AGREE WITH PREVIOUS CONVENTIONS. SUPERSEDED BY SAXON 80. 3/79
R3          (-0.012)                 SAXON     80 DPWA  0 PI- P TO K LAM   12/79
R3          (-0.012)                 BELL      83 DPWA 0  PI- P TO LAM KO   2/84*

R4      N(1700) FROM N PI TO SIGMA K                    SQRT(P1*P7)
R4    G      LESS THAN 0.017         DEANS     75 DPWA    PI N TO K SIGMA  11/75
R4    G  RANGE GIVEN IS FROM FOUR BEST SOLUTIONS.                          11/75
R4           NOT SEEN                LIVANOS   80 DPWA    PI P TO K SIGMA   2/84*

R5      N(1700) FROM N PI TO DELTA(1232) PI, S-WAVE     SQRT(P1*P9)
R5    A      +0.15 OR +0.16          LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R5    D     (0.00)                   LONGACRE  77 IPWA    PI N TO 2PI N    11/77

R6      N(1700) FROM N PI TO DELTA(1232) PI, D-WAVE     SQRT(P1*P10)
R6    A      -0.10 OR -0.14          LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R6    D     (+0.12)                  LONGACRE  77 IPWA    PI N TO 2PI N    11/77

R7      N(1700) FROM N PI TO N RHO, S=3/2, S-WAVE       SQRT(P1*P11)
R7    A       0.  OR  -0.07          LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R7    D     (+0.07)                  LONGACRE  77 IPWA    PI N TO 2PI N    11/77

R8      N(1700) FROM N PI TO N EPSILON                  SQRT(P1*P8)
R8    A      -0.2  OR -0.2           LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R8    D     (0.00)                   LONGACRE  77 IPWA    PI N TO 2PI N    11/77

R9      N(1700) FROM P GAMMA TO LAMBDA K                SQRT((P3+P4)*P2)
R9          (0.0077)                 DEANS     72 MPWA    GAM P-K LM,SOL D  9/73

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                      18  N(1700) PHOTON DECAY AMPLITUDES (GEV**-1/2)

        FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-
      REVIEW PRECEDING THE BARYON LISTINGS.

A1      N(1700) INTO P GAMMA, HELICITY=1/2 (GEV**-1/2)
A1           0.0       0.034         METCALF   74 DPWA    PI N PHOTOPROD.   2/74
A1          -0.014     0.025         FELLER    76 DPWA    PI N PHOTOPROD.   2/77
A1          +0.078     0.008         AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 1 12/79
A1          +0.038     0.005         AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 2 12/79
A1          -0.033     0.021         BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
A1          -0.028     0.007         ARAI      80 DPWA    PI N PHOTO FIT 1 12/81
A1          -0.029     0.006         ARAI      80 DPWA    PI N PHOTO FIT 2 12/81
A1          -0.024     0.019         CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
A1          -0.002     0.013         AWAJI     81 DPWA    PI N PHOTOPROD.   1/84*
A1          -0.016     0.014         CRAWFORD  83 IPWA    PI N PHOTOPROD.   1/84*

A2      N(1700) INTO P GAMMA, HELICITY=3/2 (GEV**-1/2)
A2           0.0       0.029         METCALF   74 DPWA    PI N PHOTOPROD.   2/74
A2           0.0       0.014         FELLER    76 DPWA    PI N PHOTOPROD.   2/77
A2          -0.066     0.007         AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 1 12/79
A2          -0.048     0.007         AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 2 12/79
A2          -0.014     0.025         BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
A2          -0.002     0.005         ARAI      80 DPWA    PI N PHOTO FIT 1 12/81
A2           0.014     0.005         ARAI      80 DPWA    PI N PHOTO FIT 2 12/81
A2          -0.017     0.014         CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
A2           0.029     0.014         AWAJI     81 DPWA    PI N PHOTOPROD.   1/84*
A2          -0.009     0.012         CRAWFORD  83 IPWA    PI N PHOTOPROD.   1/84*

A3      N(1700) INTO N GAMMA, HELICITY=1/2 (GEV**-1/2)
A3           0.0       0.034         METCALF   74 DPWA    PI N PHOTOPROD.   2/74
A3          +0.050     0.042         BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
A3          -0.052     0.030         ARAI      80 DPWA    PI N PHOTO FIT 1 12/81
A3          -0.055     0.030         ARAI      80 DPWA    PI N PHOTO FIT 2 12/81
A3           0.052     0.035         CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
A3           0.006     0.024         AWAJI     81 DPWA    PI N PHOTOPROD.   1/84*
A3          -0.002     0.013         FUJII     81 DPWA    PI N PHOTOPROD.  12/81

A4      N(1700) INTO N GAMMA, HELICITY=3/2 (GEV**-1/2)
A4           0.0       0.044         METCALF   74 DPWA    PI N PHOTOPROD.   2/74
A4          +0.035     0.030         BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
A4          -0.037     0.036         ARAI      80 DPWA    PI N PHOTO FIT 1 12/81
A4          -0.035     0.024         ARAI      80 DPWA    PI N PHOTO FIT 2 12/81
A4           0.041     0.030         CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
A4          -0.033     0.017         AWAJI     81 DPWA    PI N PHOTOPROD.   1/84*
A4           0.018     0.018         FUJII     81 DPWA    PI N PHOTOPROD.  12/81

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REFERENCES FOR N(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 PR D6 1906 — DEANS,JACOBS, LYONS,MONTGOMERY (SFLA)IJP
HERNDON 72 LBL 1065 — +...ROSENFELD...+CASHMORE+... (LBL+SLAC)
DEVENISH 73 PL 47B 53 — DEVENISH,RANKIN,LYTH (LOUC+BONN+LANC)IJP
LANGBEIN 73 NP B53 251 — LANGBEIN,WAGNER (MUNI)IJP
DEVENISH 74 NP B81 330 — DEVENISH,FROGGATT,MARTIN (DESY+NORD+LOUC)
DEVENIS2 74 PL 52B 227 — DEVENISH,LYTH,RANKIN (DESY+LANC+BONN)IJP
KNIES 74 PR D9 2680 — KNIES,MOORHOUSE,OBERLACK (LBL+GLAS)IJP
METCALF 74 NP B76 253 — W J METCALF,R L WALKER (CIT)IJP
MOORHOUS 74 PR D9 1 — MOORHOUSE,OBERLACK,ROSENFELD (GLAS+LBL)IJP

CRAWFORD 75 NP B97 125 — R L CRAWFORD (GLAS)IJP
DEANS 75 NP B96 90 — +MITCHELL,MONTGOMERY,+ (SFLA+ALAH)IJP
LONGACRE 75 PL 55B 415 — +ROSENFELD,LASINSKI,SMADJA+ (LBL+SLAC)IJP
ALSO 78 PR D17 1795 — LONGACRE,LASINSKI,ROSENFELD+ (LBL+SLAC)
AYED 76 CEA-N-1921 — AYED (THESIS) (SACL)IJP
BARBOUR 76 NP B111 358 — I M BARBOUR,R L CRAWFORD (GLAS)IJP
FELLER 76 NP B104 219 — +FUKUSHIMA,HORIKAWA,KAJIKAWA+ (NAGO+OSAK)IJP
AZNAURYA 77 EFI-264(57)-77 — +AKOPOV,BAGDASARYAN (YERE)IJP
BAKER 77 NP B126 365 — +BLISSET,BLOODWORTH,BROOME,HART+ (RHEL)IJP
LONGACRE 77 NP B122 493 — LONGACRE,DOLBEAU (SACL)IJP
ALSO 76 NP B108 365 — DOLBEAU,TRIANTIS,NEVEU,CADIET (SACL)IJP
WINNIK 77 NP B128 66 — +TOAFF,REVEL,GOLDBERG,BERNY (HAIF)I

BAKER 78 NP B141 29 — +BLISSET,BLOODWORTH,BROOME+ (RL+CAMB)IJP
BARBOUR 78 NP B141 253 — BARBOUR,CRAWFORD,PARSONS (GLAS)
BAKER 79 NP B156 93 — +BROWN,CLARK,DAVIES,DEPAGTER,EVANS+ (RHEL)IJP
CUTKOSKY 79 PR D20 2839 — +FORSYTH,HENDRICK,KELLY (CARN+LBL)IJP
HOEHLER 79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1 — +KAISER,KOCH,PIETARINEN (KARL)IJP
ALSO 80 TORONTO CONF 3 — R KOCH (KARL)IJP

ARAI 80 TORONTO CONF 93 — I ARAI (TOKY)
ALSO 82 NP B194 251 — I ARAI, H FUJII (TOKY)
CRAWFORD 80 TORONTO CONF 107 — R L CRAWFORD (GLAS)
CUTKOSKY 80 TORONTO CONF 19 — +FORSYTH,BABCOCK,KELLY,HENDRICK (CARN+LBL)IJP
LIVANOS 80 TORONTO CONF 35 — +BATON,COUTURES,KOCHOWSKI,NEVEU (SACL)IJP
SAXON 80 NP B162 522 — +BAKER,BELL,BLISSETT,BLOODWORTH+(RHEL+BRIS)IJP

AWAJI 81 BONN CONF 352 — R KAJIKAWA (TALK) (NAGO)
ALSO 82 NP B197 365 — FUJII,HAYASHII,IWATA,KAJIKAWA+ (NAGO)
FUJII 81 NP B187 53 — FUJII,HAYASHII,IWATA,KAJIKAWA+ (TOKY)
BELL 83 NP B222 389 — +BLISSET,BROOME,DALEY,HART,LINTERN,+ (RL)IJP
CRAWFORD 83 NP B211 1 — R L CRAWFORD, W T MORTON (GLAS)

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N(1710) P''_{11} Status: ***

14 N(1710, JP=1/2+) I=1/2 P''11

MOST OF THE RESULTS PUBLISHED BEFORE 1975 ARE NOW OBSOLETE AND HAVE BEEN OMITTED. THEY MAY BE FOUND IN OUR 1982 EDITION (PHYSICS LETTERS 111B). HOWEVER, ALL THE REFERENCES HAVE BEEN RETAINED.

THE VARIOUS PARTIAL-WAVE ANALYSES DO NOT AGREE VERY WELL.

14 N(1710) MASS (MEV)

M		(1670.0)		KNASEL	75	DPWA	0 PI- P TO K0 LAM	11/75
M	A	1730. OR 1710.		LONGACRE	75	IPWA	PI N TO 2PI N	11/75
M	A	THE 2 SETS OF PARAMETERS ARE FROM METHODS 1 AND 2 OF LONGACRE 75.						11/75
M	B	(1625.0)	(10.0)	BAKER	77	IPWA	0 PI- P TO K LAM.	1/78
M	C	(1650.0)		BAKER	77	DPWA	0 PI- P TO K LAM.	1/78
M	B	THE TWO ENTRIES FOR BAKER 77 ARE FOR AN IPWA USING THE BARRELET						1/78
M	C	ZERO METHOD AND A CONVENTIONAL ENERGY-DEPENDENT ANALYSIS.						1/78
M	D	(1720.0)		LONGACRE	77	IPWA	PI N TO 2PI N	11/77
M	D	ALL LONGACRE77 PARAMETERS ARE FROM SOLUTION S2, EXCEPT FOR THE POLE						11/77
M	D	POSITION WHICH IS FROM SOLUTIONS S1 AND C1.						11/77
M		1650. TO 1680.		BAKER	78	DPWA	0 PI- P TO K LAM	3/79
M		(1721.0)		BARBOUR	78	DPWA	PI-N PHOTOPROD.	3/79
M		(1690.0)		BAKER	79	DPWA	0 PI- P TO ETA N	12/79
M		(1710.0)	(60.0)	CUTKOSKY	79	IPWA	PI N TO PI N	12/79
M		1723.0	9.0	HOEHLER	79	IPWA	PI N TO PI N	12/79
M		(1692.0)		CRAWFORD	80	DPWA	PI N PHOTOPROD.	12/81
M		1700.0	50.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82
M		(1730.0)		SAXON	80	DPWA	0 PI- P TO K LAM	12/79

14 N(1710) WIDTH (MEV)

W		(174.0)		KNASEL	75	DPWA	0 PI- P TO K0 LAM	11/75
W	A	165. OR 75.		LONGACRE	75	IPWA	PI N TO 2PI N	11/75
W	B	(160.0)	(6.0)	BAKER	77	IPWA	0 PI- P TO K LAM.	1/78
W	C	(95.0)		BAKER	77	DPWA	0 PI- P TO K LAM.	1/78
W	D	(120.0)		LONGACRE	77	IPWA	PI N TO 2PI N	11/77
W		90. TO 150.		BAKER	78	DPWA	0 PI- P TO K LAM	3/79
W		(167.0)		BARBOUR	78	DPWA	PI-N PHOTOPROD.	3/79
W		(97.0)		BAKER	79	DPWA	0 PI- P TO ETA N	12/79
W		(100.0)	(50.0)	CUTKOSKY	79	IPWA	PI N TO PI N	12/79
W		120.0	15.0	HOEHLER	79	IPWA	PI N TO PI N	12/79
W		(200.0)		CRAWFORD	80	DPWA	PI N PHOTOPROD.	12/81
W		90.0	30.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82
W		(550.0)		SAXON	80	DPWA	0 PI- P TO K LAM	12/79
W		(540.0)		BELL	83	DPWA	0 PI- P TO LAM K0	2/84*

14 N(1710) REAL PART OF POLE POSITION (MEV)

RE		(1708.0)		LONGACRE	75	IPWA	PI N TO 2PI N	11/75
RE	D	1720. OR 1711.		LONGACRE	77	IPWA	PI N TO 2PI N	11/77
RE		(1692.0)		CUTKOSKY	79	IPWA	PI N TO PI N	12/79
RE		1690.0	20.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

14 N(1710) -2*IMAG PART OF POLE POSITION (MEV)

IM		(17.0)		LONGACRE	75	IPWA	PI N TO 2PI N	11/75
IM	D	123. OR 115.		LONGACRE	77	IPWA	PI N TO 2PI N	11/77
IM		(88.0)		CUTKOSKY	79	IPWA	PI N TO PI N	12/79
IM		80.0	20.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

14 N(1710) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER	(-9.0)		CUTKOSKY	79	IPWA	PI N TO PI N	12/79
RER	-8.0	2.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

14 N(1710) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR	(0.1)		CUTKOSKY	79	IPWA	PI N TO PI N	12/79
IMR	1.0	5.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

14 N(1710) PARTIAL DECAY MODES

		DECAY MASSES
P1	N(1710) INTO N PI	938+ 140
P2	N(1710) INTO LAMBDA K	1116+ 498
P3	N(1710) INTO N ETA	940+ 549
P4	N(1710) INTO P GAMMA, HELICITY=1/2	938+ 0
P5	N(1710) INTO N GAMMA, HELICITY=1/2	940+ 0
P6	N(1710) INTO N PI PI	938+ 140+ 140
P7	N(1710) INTO N EPSILON	938+1300
P8	N(1710) INTO N RHO	938+ 769
P9	N(1710) INTO SIGMA K	1189+ 494
P10	N(1710) INTO DELTA(1232) PI	1232+ 140
P11	N(1710) INTO N RHO, S=1/2, P-WAVE	938+ 769
P12	N(1710) INTO N RHO, S=3/2, P-WAVE	938+ 769

14 N(1710) BRANCHING RATIOS

R1		**N(1710) INTO (N PI)/TOTAL**					**(P1)**	
R1		(0.19)	(0.05)	CUTKOSKY	79	IPWA	PI N TO PI N	12/79
R1		0.12	0.04	HOEHLER	79	IPWA	PI N TO PI N	12/79
R1		0.20	0.04	CUTKOSKY	80	IPWA	PI N TO PI N	1/82
R2		**N(1710) FROM N PI TO N ETA**					**SQRT(P1*P3)**	
R2		(0.22)		BAKER	79	DPWA	0 PI- P TO ETA N	12/79
R3		**N(1710) FROM N PI TO LAMBDA K**					**SQRT(P1*P2)**	
R3		(0.10)		KNASEL	75	DPWA	0 PI- P TO K0 LAM	11/75
R3	B	(-0.05)	(0.03)	BAKER	77	IPWA	0 PI- P TO K LAM.	1/78
R3	C	(-0.10)		BAKER	77	DPWA	0 PI- P TO K LAM.	1/78
R3	E	(-0.12)		BAKER	78	DPWA	0 PI- P TO K LAM	3/79
R3	E	THE (UNDETERMINED) OVERALL PHASE OF ALL COUPLINGS FROM BAKER 78						3/79
R3	E	HAS BEEN CHANGED TO AGREE WITH PREVIOUS CONVENTIONS. SUPERSEDED						3/79
R3	E	BY SAXON 80.						3/79
R3		(+0.14)		SAXON	80	DPWA	0 PI- P TO K LAM	12/79
R3		(+0.16)		BELL	83	DPWA	0 PI- P TO LAM K0	2/84*
R4		**N(1710) FROM N PI TO SIGMA K**					**SQRT(P1*P9)**	
R4	F	0.075 TO 0.203		DEANS	75	DPWA	PI N TO K SIGMA	11/75
R4	F	RANGE GIVEN IS FROM FOUR BEST SOLUTIONS.						11/75
R4		(-0.034)		LIVANOS	80	DPWA	PI P TO K SIGMA	1/82
R5		**N(1710) FROM N PI TO DELTA(1232) PI**					**SQRT(P1*P10)**	
R5	A	0.13 OR -0.20		LONGACRE	75	IPWA	PI N TO 2PI N	11/75
R5	D	(+0.17)		LONGACRE	77	IPWA	PI N TO 2PI N	11/77
R6		**N(1710) FROM N PI TO N RHO, S=1/2, P-WAVE**					**SQRT(P1*P11)**	
R6	A	+0.32 OR +0.20		LONGACRE	75	IPWA	PI N TO 2PI N	11/75
R6	D	(-0.19)		LONGACRE	77	IPWA	PI N TO 2PI N	11/77
R7		**N(1710) FROM N PI TO N RHO, S=3/2, P-WAVE**					**SQRT(P1*P12)**	
R7	D	(-0.31)		LONGACRE	77	IPWA	PI N TO 2PI N	11/77
R8		**N(1710) FROM N PI TO N EPSILON**					**SQRT(P1*P7)**	
R8	A	+0.18 OR +0.28		LONGACRE	75	IPWA	PI N TO 2PI N	11/75
R8	D	(+0.26)		LONGACRE	77	IPWA	PI N TO 2PI N	11/77
R9		**N(1710) FROM P GAMMA TO P ETA**					**SQRT(P3*P4)**	
R9		(0.0075)		HICKS	73	MPWA	GAM P-ETA P	9/73
R10		**N(1710) FROM P GAMMA TO LAMBDA K**					**SQRT(P2*P4)**	
R10		(0.0027)		ORITO2	69	CNTR	K LAM PHOTOPRO	10/71
R10		(0.0088)		SCHORSCH	70	DPWA	K LAM PHOTOPRO.	10/71
R10		(0.0104)		DEANS	72	MPWA	GAM P-K LM,SOL D	9/73

14 N(1710) PHOTON DECAY AMPLITUDES (GEV-1/2)**

FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-REVIEW PRECEDING THE BARYON LISTINGS.

A1	**N(1710) INTO P GAMMA, HELICITY=1/2 (GEV**-1/2)**						
A1	-0.068	0.024	METCALF	74	DPWA	PI N PHOTOPROD.	2/74
A1	+0.053	0.019	FELLER	76	DPWA	PI N PHOTOPROD.	2/77
A1	+0.001	0.039	BARBOUR	78	DPWA	PI-N PHOTOPROD.	3/79
A1	-0.009	0.006	ARAI	80	DPWA	PI N PHOTO FIT 1	12/81
A1	-0.012	0.005	ARAI	80	DPWA	PI N PHOTO FIT 2	12/81
A1	0.015	0.025	CRAWFORD	80	DPWA	PI N PHOTOPROD.	12/81
A1	0.028	0.009	AWAJI	81	DPWA	PI N PHOTOPROD.	1/84*
A1	0.006	0.018	CRAWFORD	83	IPWA	PI N PHOTOPROD.	1/84*
A2	**N(1710) INTO N GAMMA, HELICITY=1/2 (GEV**-1/2)**						
A2	0.048	0.045	METCALF	74	DPWA	PI N PHOTOPROD.	2/74
A2	-0.028	0.045	BARBOUR	78	DPWA	PI-N PHOTOPROD.	3/79
A2	0.005	0.013	ARAI	80	DPWA	PI N PHOTO FIT 1	12/81
A2	0.011	0.021	ARAI	80	DPWA	PI N PHOTO FIT 2	12/81
A2	-0.017	0.020	CRAWFORD	80	DPWA	PI N PHOTOPROD.	12/81
A2	0.000	0.018	AWAJI	81	DPWA	PI N PHOTOPROD.	1/84*
A2	-0.001	0.003	FUJII	81	DPWA	PI N PHOTOPROD.	12/81

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REFERENCES FOR N(1710)

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 (ALAH)
BOTKE 69 PR 180 1417 — J C BOTKE (UCSB)
DEANS 69 PR 185 1797 — S DEANS, J WOOTEN (SFLA)
DEANS2 69 PR 177 2623 — S R DEANS (SFLA)
DONNACHI 69 NP 10B 433 — A DONNACHIE, R KIRSOPP (GLAS+EDIN)
ORITO 69 LNC 1 936 — S ORITO,S SASAKI (TOKY+OSAK)
ORITO2 69 INS J 113 — S ORITO (THESIS) (TOKY)

AYED 70 KIEV CONF — R AYED,P BAREYRE, G VILLET (SACL)IJP
AYED2 70 PL 31B 598 — +BAREYRE,VILLET (SACL)
CARRERAS 70 NP 16B 35 — B CARRERAS, A DONNACHIE (DARE+MCHS)
DAVIES 70 NP B21 359 — A DAVIES (GLAS)

Baryons

Data Card Listings

N(1710), N(1720)


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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 PR D6 1906        DEANS,JACOBS, LYONS,MONTGOMERY     (SFLA)IJP

DEVENISH 73 PL 47B 53          DEVENISH,RANKIN,LYTH        (LOUC+BONN+LANC)IJP
HICKS     73 PR D7 2614        +DEANS,JACOBS,LYONS+        (CARN+ORNL+SFLA)IJP
LANGBEIN 73 NP B53 251         LANGBEIN,WAGNER                    (MUNI)IJP
MOORHOUS 73 PL 43B 44          MOORHOUSE, OBERLACK            (GLAS+LBL)IJP

DEVENISH 74 NP B81 330         DEVENISH,FROGGATT,MARTIN   (DESY+NORD+LOUC)
DEVENIS2 74 PL 52B 227         DEVENISH,LYTH,RANKIN       (DESY+LANC+BONN)IJP
KNIES     74 PR D9 2680        KNIES,MOORHOUSE,OBERLACK       (LBL+GLAS)IJP
METCALF   74 NP B76 253        W J METCALF,R L WALKER              (CIT)IJP
MOORHOUS 74 PR D9 1            MOORHOUSE,OBERLACK,ROSENFELD   (GLAS+LBL)IJP

CRAWFORD 75 NP B97 125         R L CRAWFORD                       (GLAS)IJP
DEANS     75 NP B96 90         +MITCHELL,MONTGOMERY,+         (SFLA+ALAH)IJP
FELTESSE 75 NP B93 242         +AYED,BAREYRE,BORGEAUD,DAVID,ERNWEIN+(SACL)IJP
KNASEL    75 PR D11 1          +LINDQUIST,NELSON+      (CHIC+WUSL+OSU+ANL)IJP
LONGACRE 75 PL 55B 415         +ROSENFELD,LASINSKI,SMADJA+    (LBL+SLAC)IJP
   ALSO  78 PR D17 1795        LONGACRE,LASINSKI,ROSENFELD+   (LBL+SLAC)
AYED      76 CEA-N-1921        AYED (THESIS)                      (SACL)IJP
BARBOUR   76 NP B111 358       I M BARBOUR,R L CRAWFORD           (GLAS)IJP
FELLER    76 NP B104 219       +FUKUSHIMA,HORIKAWA,KAJIKAWA+  (NAGO+OSAK)IJP
BAKER     77 NP B126 365       +BLISSET,BLOODWORTH,BROOME,HART+   (RHEL)IJP
LONGACRE 77 NP B122 493        LONGACRE,DOLBEAU                   (SACL)IJP
   ALSO  76 NP B108 365        DOLBEAU,TRIANTIS,NEVEU,CADIET      (SACL)IJP
WINNIK    77 NP B128 66        +TOAFF,REVEL,GOLDBERG,BERNY        (HAIF)I

BAKER     78 NP B141 29        +BLISSET,BLOODWORTH,BROOME+    (RL+CAMB)IJP
BARBOUR   78 NP B141 253       BARBOUR,CRAWFORD,PARSONS           (GLAS)
BAKER     79 NP B156 93        +BROWN,CLARK,DAVIES,DEPAGTER,EVANS+ (RHEL)IJP
CUTKOSKY 79 PR D20 2839        +FORSYTH,HENDRICK,KELLY        (CARN+LBL)IJP
HOEHLER   79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                               +KAISER,KOCH,PIETARINEN            (KARL)IJP
   ALSO 80   TORONTO CONF 3    R KOCH                             (KARL)IJP

ARAI      80   TORONTO CONF 93 I ARAI                             (TOKY)
   ALSO 82 NP B194 251         I ARAI, H FUJII                    (TOKY)
CRAWFORD 80   TORONTO CONF 107 R L CRAWFORD                       (GLAS)
CUTKOSKY 80   TORONTO CONF 19  +FORSYTH,BABCOCK,KELLY,HENDRICK (CARN+LBL)IJP
LIVANOS  80   TORONTO CONF 35  +BATON,COUTURES,KOCHOWSKI,NEVEU    (SACL)IJP
SAXON     80 NP B162 522       +BAKER,BELL,BLISSETT,BLOODWORTH+(RHEL+BRIS)IJP

AWAJI     81   BONN CONF 352   R KAJIKAWA (TALK)                  (NAGO)
   ALSO 82 NP B197 365         FUJII,HAYASHII,IWATA,KAJIKAWA+     (NAGO)
FUJII     81 NP B187 53        FUJII,HAYASHII,IWATA,KAJIKAWA+     (TOKY)
BELL      83 NP B222 389       +BLISSET,BROOME,DALEY,HART,LINTERN,+ (RL)IJP
CRAWFORD 83 NP B211 1          R L CRAWFORD, W T MORTON           (GLAS)
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N(1720) P''_{13} Status: ****

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          15  N(1720, JP=3/2+) I=1/2   P''13

          MOST OF THE RESULTS PUBLISHED BEFORE 1975 ARE NOW
          OBSOLETE AND HAVE BEEN OMITTED.  THEY MAY BE FOUND IN
          OUR 1982 EDITION (PHYSICS LETTERS 111B).  HOWEVER,
          ALL THE REFERENCES HAVE BEEN RETAINED.

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          15  N(1720) MASS (MEV)

M        (1850.0)                  KNASEL    75 DPWA  0 PI- P TO KO LAM  11/75
M   A     1695. OR 1720.           LONGACRE  75 IPWA    PI N TO 2PI N    11/75
M   A  THE 2 SETS OF PARAMETERS ARE FROM METHODS 1 AND 2 OF LONGACRE 75. 11/75
M   B    (1640.0)   (10.0)         BAKER     77 IPWA  0 PI- P TO K LAM.   1/78
M   C    (1710.0)                  BAKER     77 DPWA  0 PI- P TO K LAM.   1/78
M   B  BAKER 77 IS BASED ON AN IPWA USING THE BARRELET ZERO METHOD.       1/78
M   D    (1750.0)                  LONGACRE  77 IPWA    PI N TO 2PI N    11/77
M   D  ALL LONGACRE77 PARAMETERS ARE FROM SOLUTION S2, EXCEPT FOR THE POLE 11/77
M   D  POSITION WHICH IS FROM SOLUTIONS S1 AND C1.                       11/77
M         1710. TO 1790.           BAKER     78 DPWA  0 PI- P TO K LAM    3/79
M        (1809.0)                  BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
M        (1740.0)   (80.0)         CUTKOSKY  79 IPWA    PI N TO PI N     12/79
M         1710.0     20.0          HOEHLER   79 IPWA    PI N TO PI N     12/79
M        (1785.0)                  CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
M         1700.0     50.0          CUTKOSKY  80 IPWA    PI N TO PI N      1/82
M        (1690.0)                  SAXON     80 DPWA  0 PI- P TO K LAM   12/79

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          15  N(1720) WIDTH (MEV)

W        (327.0)                   KNASEL    75 DPWA  0 PI- P TO KO LAM  11/75
W   A     115. OR  150.            LONGACRE  75 IPWA    PI N TO 2PI N    11/75
W   B    (200.0)   (50.0)          BAKER     77 IPWA  0 PI- P TO K LAM.   1/78
W   C    (500.0)                   BAKER     77 DPWA  0 PI- P TO K LAM.   1/78
W   D    (130.0)                   LONGACRE  77 IPWA    PI N TO 2PI N    11/77
W         300. TO  400.            BAKER     78 DPWA  0 PI- P TO K LAM    3/79
W        (285.0)                   BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
W        (447.0)                   BAKER     79 DPWA  0 PI- P TO ETA N   12/79
W        (210.0)   (80.0)          CUTKOSKY  79 IPWA    PI N TO PI N     12/79
W         190.0    30.0            HOEHLER   79 IPWA    PI N TO PI N     12/79
W        (308.0)                   CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
W         125.0    70.0            CUTKOSKY  80 IPWA    PI N TO PI N      1/82
W        (120.0)                   SAXON     80 DPWA  0 PI- P TO K LAM   12/79

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          15  N(1720) REAL PART OF POLE POSITION (MEV)

RE       (1716.0)                  LONGACRE  75 IPWA    PI N TO 2PI N    11/75
RE  D     1745. OR 1748.0          LONGACRE  77 IPWA    PI N TO 2PI N    11/77
RE       (1702.0)                  CUTKOSKY  79 IPWA    PI N TO PI N     12/79
RE        1680.0     30.0          CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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          15  N(1720) -2*IMAG PART OF POLE POSITION (MEV)

IM       (124.0)                   LONGACRE  75 IPWA    PI N TO 2PI N    11/75
IM  D     135. OR 123.             LONGACRE  77 IPWA    PI N TO 2PI N    11/77
IM       (158.0)                   CUTKOSKY  79 IPWA    PI N TO PI N     12/79
IM        120.0      40.0          CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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          15  N(1720) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER       (-6.0)                   CUTKOSKY  79 IPWA    PI N TO PI N     12/79
RER       -8.0       2.0           CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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          15  N(1720) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR       (-8.0)                   CUTKOSKY  79 IPWA    PI N TO PI N     12/79
IMR       -3.0       4.0           CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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          15  N(1720) PARTIAL DECAY MODES

                                                       DECAY MASSES
P1      N(1720) INTO N PI                               938+ 140
P2      N(1720) INTO LAMBDA K                          1116+ 498
P3      N(1720) INTO N ETA                              940+ 549
P4      N(1720) INTO N PI PI                            938+ 140+ 140
P5      N(1720) INTO P GAMMA, HELICITY=3/2              938+   0
P6      N(1720) INTO P GAMMA, HELICITY=1/2              938+   0
P7      N(1720) INTO N GAMMA, HELICITY=3/2              940+   0
P8      N(1720) INTO N GAMMA, HELICITY=1/2              940+   0
P9      N(1720) INTO SIGMA K                           1189+ 494
P10     N(1720) INTO N RHO, S=1/2, P-WAVE               938+ 769
P11     N(1720) INTO N RHO, S=3/2, P-WAVE               938+ 769
P12     N(1720) INTO DELTA(1232) PI, P-WAVE            1232+ 140
P13     N(1720) INTO N EPSILON                          938+1300

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          15  N(1720) BRANCHING RATIOS

R1      N(1720) INTO (N PI)/TOTAL                      (P1)
R1           (0.19)    (0.05)      CUTKOSKY  79 IPWA    PI N TO PI N     12/79
R1            0.14      0.03       HOEHLER   79 IPWA    PI N TO PI N     12/79
R1            0.10      0.04       CUTKOSKY  80 IPWA    PI N TO PI N      1/82

R2      N(1720) FROM N PI TO N ETA                     SQRT(P1*P3)
R2          (-0.08)                BAKER     79 DPWA  0 PI- P TO ETA N   12/79

R3      N(1720) FROM N PI TO LAMBDA K                  SQRT(P1*P2)
R3   B      (-0.06)    (0.02)      BAKER     77 IPWA  0 PI- P TO K LAM.   1/78
R3   C      (-0.09)                BAKER     77 DPWA  0 PI- P TO K LAM.   1/78
R3   E      (-0.09)                BAKER     78 DPWA  0 PI- P TO K LAM    3/79
R3   E  THE (UNDETERMINED) OVERALL PHASE OF ALL COUPLINGS FROM HAS BEEN   3/79
R3   E  CHANGED TO AGREE WITH PREVIOUS CONVENTIONS. SUPERSEDED BY SAXON 80. 3/79
R3          (-0.11)                SAXON     80 DPWA  0 PI- P TO K LAM   12/79
R3          (-0.09)                BELL      83 DPWA 0  PI- P TO LAM KO   2/84*

R4      N(1720) FROM N PI TO SIGMA K                   SQRT(P1*P9)
R4   F        0.051 TO 0.087       DEANS     75 DPWA    PI N TO K SIGMA  11/75
R4   F  RANGE GIVEN IS FROM FOUR BEST SOLUTIONS.  DEANS 75 DISAGREES WITH 11/75
R4   F  PI+ P TO K+ SIGMA+ DATA OF WINNIK 77 AROUND 1920 MEV.             1/78

R5      N(1720) FROM N PI TO DELTA(1232)PI, P-WAVE     SQRT(P1*P12)
R5   D      (+0.17)                LONGACRE  77 IPWA    PI N TO 2PI N    11/77

R6      N(1720) FROM N PI TO N RHO, S=1/2, P-WAVE      SQRT(P1*P10)
R6   A       -0.35 OR -0.40        LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R6   D      (+0.26)                LONGACRE  77 IPWA    PI N TO 2PI N    11/77

R7      N(1720) FROM N PI TO N RHO, S=3/2, P-WAVE      SQRT(P1*P11)
R7   D      (-0.15)                LONGACRE  77 IPWA    PI N TO 2PI N    11/77

R8      N(1720) FROM N PI TO N EPSILON                 SQRT(P1*P13)
R8   D      (+0.19)                LONGACRE  77 IPWA    PI N TO 2PI N    11/77

R9      N(1720) FROM P GAMMA TO P ETA                  SQRT((P5+P6)*P3)
R9           (0.0052)              HICKS     73 MPWA    GAM P-ETA P       9/73

R10     N(1720) FROM P GAMMA TO LAMBDA K               SQRT((P5+P6)*P2)
R10          (0.0082)              DEANS     72 MPWA    GAM P-K LM,SOL D  9/73

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          15  N(1720) PHOTON DECAY AMPLITUDES (GEV**-1/2)

        FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-
      REVIEW PRECEDING THE BARYON LISTINGS.

A1      N(1720) INTO P GAMMA, HELICITY=1/2 (GEV**-1/2)
A1           0.0       0.025       METCALF   74 DPWA   PI N PHOTOPROD.   2/74
A1          +0.122     0.018       AZNAURYAN 77 DPWA   PIO PHTPRD,SOL 1 12/79
A1          +0.054     0.012       AZNAURYAN 77 DPWA   PIO PHTPRD,SOL 2 12/79
A1          +0.111     0.047       BARBOUR   78 DPWA   PI-N PHOTOPROD.   3/79
A1           0.051     0.009       ARAI      80 DPWA   PI N PHOTO FIT 1 12/81
A1           0.071     0.010       ARAI      80 DPWA   PI N PHOTO FIT 2 12/81
A1           0.038     0.050       CRAWFORD  80 DPWA   PI N PHOTOPROD.  12/81
A1          -0.004     0.007       AWAJI     81 DPWA   PI N PHOTOPROD.   1/84*
A1           0.044     0.066       CRAWFORD  83 IPWA   PI N PHOTOPROD.   1/84*

A2      N(1720) INTO P GAMMA, HELICITY=3/2 (GEV**-1/2)
A2           0.0       0.022       METCALF   74 DPWA   PI N PHOTOPROD.   2/74
A2          +0.034     0.015       AZNAURYAN 77 DPWA   PIO PHTPRD,SOL 1 12/79
A2           0.000     0.016       AZNAURYAN 77 DPWA   PIO PHTPRD,SOL 2 12/79
A2          -0.063     0.032       BARBOUR   78 DPWA   PI-N PHOTOPROD.   3/79
A2          -0.058     0.010       ARAI      80 DPWA   PI N PHOTO FIT 1 12/81
A2          -0.011     0.011       ARAI      80 DPWA   PI N PHOTO FIT 2 12/81
A2          -0.014     0.040       CRAWFORD  80 DPWA   PI N PHOTOPROD.  12/81
A2          -0.040     0.016       AWAJI     81 DPWA   PI N PHOTOPROD.   1/84*
A2          -0.024     0.006       CRAWFORD  83 IPWA   PI N PHOTOPROD.   1/84*

A3      N(1720) INTO N GAMMA, HELICITY=1/2 (GEV**-1/2)
A3           0.0       0.050       METCALF   74 DPWA   PI N PHOTOPROD.   2/74
A3          +0.007     0.020       BARBOUR   78 DPWA   PI-N PHOTOPROD.   3/79
A3          -0.019     0.033       ARAI      80 DPWA   PI N PHOTO FIT 1 12/81
A3           0.001     0.038       ARAI      80 DPWA   PI N PHOTO FIT 2 12/81
A3          -0.003     0.034       CRAWFORD  80 DPWA   PI N PHOTOPROD.  12/81
A3           0.002     0.005       AWAJI     81 DPWA   PI N PHOTOPROD.   1/84*

A4      N(1720) INTO N GAMMA, HELICITY=3/2 (GEV**-1/2)
A4           0.0       0.044       METCALF   74 DPWA   PI N PHOTOPROD.   2/74
A4          +0.051     0.051       BARBOUR   78 DPWA   PI-N PHOTOPROD.   3/79
A4          -0.139     0.039       ARAI      80 DPWA   PI N PHOTO FIT 1 12/81
A4          -0.134     0.044       ARAI      80 DPWA   PI N PHOTO FIT 2 12/81
A4           0.018     0.028       CRAWFORD  80 DPWA   PI N PHOTOPROD.  12/81
A4          -0.015     0.019       AWAJI     81 DPWA   PI N PHOTOPROD.   1/84*

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REFERENCES FOR N(1720)


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DONNACH1 68 PL 26B 161         A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
    ALSO 68 VIENNA 139         DONNACHIE  RAPPORTEUR.S TALK          (GLAS)
    ALSO 68 THESIS             R G KIRSOPP                           (EDIN)
RUSH     68 PR 173 1776        J E RUSH                              (ALAH)

BOTKE    69 PR 180 1417        J C BOTKE                             (UCSB)
DEANS    69 PR 185 1797        S DEANS, J WOOTEN                     (SFLA)
DEANS2   69 PR 177 2623        S R DEANS                             (SFLA)
DONNACHI 69 NP 10B 433         A DONNACHIE, R KIRSOPP           (GLAS+EDIN)
LEA      69 PL 29B 584         LEA,OADES,WARD,COWAN,+       (RHEL+BRIS+DARE)
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AYED 70 KIEV CONF R AYED,P BAREYRE, G VILLET (SACL)IJP
AYED2 70 PL 31B 598 +BAREYRE,VILLET (SACL)
CARRERAS 70 NP 16B 35 B CARRERAS, A DONNACHIE (DARE+MCHS)
DAVIES 70 NP B21 359 A DAVIES (GLAS)

APLIN 71 NP B32 253 +COWAN,GIBSON,GILMORE++ (RHEL+BRIS)
WAGNER 71 NP B25 411 F WAGNER, C LOVELACE (CERN)

ALMEHED 72 NP B40 157 +LOVELACE (LUND+RUTG)IJP
DEANS 72 PR D6 1906 DEANS,JACOBS, LYONS,MONTGOMERY (SFLA)IJP
DEVENISH 73 PL 47B 53 DEVENISH,RANKIN,LYTH (LOUC+BONN+LANC)IJP
HICKS 73 PR D7 2614 +DEANS,JACOBS,LYONS+ (CARN+ORNL+SFLA)IJP

DEVENISH 74 NP B81 330 DEVENISH,FROGGATT,MARTIN (DESY+NORD+LOUC)
DEVENIS2 74 PL 52B 227 DEVENISH,LYTH,RANKIN (DESY+LANC+BONN)IJP
KNIES 74 PR D9 2680 KNIES,MOORHOUSE,OBERLACK (LBL+GLAS)IJP
METCALF 74 NP B76 253 W J METCALF,R L WALKER (CIT)IJP

CRAWFORD 75 NP B97 125 R L CRAWFORD (GLAS)IJP
DEANS 75 NP B96 90 +MITCHELL,MONTGOMERY,+ (SFLA+ALAH)IJP
KNASEL 75 PR D11 1 +LINDQUIST,NELSON+ (CHIC+WUSL+OSU+ANL)IJP
LONGACRE 75 PL 55B 415 +ROSENFELD,LASINSKI,SMADJA+ (LBL+SLAC)IJP
ALSO 78 PR D17 1795 LONGACRE,LASINSKI,ROSENFELD+ (LBL+SLAC)

AYED 76 CEA-N-1921 AYED (THESIS) (SACL)IJP
BARBOUR 76 NP B111 358 I M BARBOUR,R L CRAWFORD (GLAS)IJP
MA 76 PR D13 3027 E MA,G L SHAW (OREG+UCI)IJP

AZNAURYA 77 EFI-264(57)-77 +AKOPOV,BAGDASARYAN (YERE)IJP
BAKER 77 NP B126 365 +BLISSET,BLOODWORTH,BROOME,HART+ (RHEL)IJP
LONGACRE 77 NP B122 493 LONGACRE,DOLBEAU (SACL)IJP
ALSO 76 NP B108 365 DOLBEAU,TRIANTIS,NEVEU,CADIET (SACL)IJP
WINNIK 77 NP B128 66 +TOAFF,REVEL,GOLDBERG,BERNY (HAIF)I

BAKER 78 NP B141 29 +BLISSET,BLOODWORTH,BROOME+ (RL+CAMB)IJP
BARBOUR 78 NP B141 253 BARBOUR,CRAWFORD,PARSONS (GLAS)

BAKER 79 NP B156 93 +BROWN,CLARK,DAVIES,DEPAGTER,EVANS+ (RHEL)IJP
CUTKOSKY 79 PR D20 2839 +FORSYTH,HENDRICK,KELLY (CARN+LBL)IJP
HOEHLER 79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
+KAISER,KOCH,PIETARINEN (KARL)IJP
ALSO 80 TORONTO CONF 3 R KOCH (KARL)IJP

ARAI 80 TORONTO CONF 93 I ARAI (TOKY)
ALSO 82 NP B194 251 I ARAI, H FUJII (TOKY)
CRAWFORD 80 TORONTO CONF 107 R L CRAWFORD (GLAS)
CUTKOSKY 80 TORONTO CONF 19 +FORSYTH,BABCOCK,KELLY,HENDRICK (CARN+LBL)IJP
SAXON 80 NP B162 522 +BAKER,BELL,BLISSETT,BLOODWORTH+(RHEL+BRIS)IJP

AWAJI 81 BONN CONF 352 R KAJIKAWA (TALK) (NAGO)
ALSO 82 NP B197 365 FUJII,HAYASHII,IWATA,KAJIKAWA+ (NAGO)
BELL 83 NP B222 389 +BLISSET,BROOME,DALEY,HART,LINTERN,+ (RL)IJP
CRAWFORD 83 NP B211 1 R L CRAWFORD, W T MORTON (GLAS)

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N(1990) F_{17} Status: **

→ 17 N(1990, JP=7/2+) I=1/2 F17

MOST OF THE RESULTS PUBLISHED BEFORE 1975 ARE NOW OBSOLETE AND HAVE BEEN OMITTED. THEY MAY BE FOUND IN OUR 1982 EDITION (PHYSICS LETTERS 111B). HOWEVER, ALL THE REFERENCES HAVE BEEN RETAINED.

THE VARIOUS ANALYSES DO NOT AGREE VERY WELL WITH ONE ANOTHER.

17 N(1990) MASS (MEV)

M	(1999.0)		BARBOUR	78	DPWA	PI-N PHOTOPROD.	3/79
M	(1970.0)	(80.0)	CUTKOSKY	79	IPWA	PI N TO PI N	12/79
M	2005.0	150.0	HOEHLER	79	IPWA	PI N TO PI N	12/79
M	(2018.0)		CRAWFORD	80	DPWA	PI N PHOTOPROD.	12/81
M	1970.0	50.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

17 N(1990) WIDTH (MEV)

W	(216.0)		BARBOUR	78	DPWA	PI-N PHOTOPROD.	3/79
W	(325.0)	(150.0)	CUTKOSKY	79	IPWA	PI N TO PI N	12/79
W	350.0	100.0	HOEHLER	79	IPWA	PI N TO PI N	12/79
W	(295.0)		CRAWFORD	80	DPWA	PI N PHOTOPROD.	12/81
W	350.0	120.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

17 N(1990) REAL PART OF POLE POSITION (MEV)

RE	(1899.0)		CUTKOSKY	79	IPWA	PI N TO PI N	12/79
RE	1900.0	30.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

17 N(1990) -2*IMAG PART OF POLE POSITION (MEV)

IM	(208.0)		CUTKOSKY	79	IPWA	PI N TO PI N	12/79
IM	260.0	60.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

17 N(1990) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER	(3.0)		CUTKOSKY	79	IPWA	PI N TO PI N	12/79
RER	5.0	4.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

17 N(1990) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR	(-6.0)		CUTKOSKY	79	IPWA	PI N TO PI N	12/79
IMR	-8.0	4.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

17 N(1990) PARTIAL DECAY MODES

		DECAY MASSES
P1	N(1990) INTO N PI	938+ 140
P2	N(1990) INTO N PI PI	938+ 140+ 140
P3	N(1990) INTO N ETA	940+ 549
P4	N(1990) INTO LAMBDA K	1116+ 498
P5	N(1990) INTO P GAMMA, HELICITY=3/2	938+ 0
P6	N(1990) INTO P GAMMA, HELICITY=1/2	938+ 0
P7	N(1990) INTO N GAMMA, HELICITY=3/2	940+ 0
P8	N(1990) INTO N GAMMA, HELICITY=1/2	940+ 0
P9	N(1990) INTO SIGMA K	1189+ 494

17 N(1990) BRANCHING RATIOS

R1		**N(1990) INTO (N PI)/TOTAL**					**(P1)**	
R1		(0.06)	(0.02)	CUTKOSKY	79	IPWA	PI N TO PI N	12/79
R1		0.04	0.02	HOEHLER	79	IPWA	PI N TO PI N	12/79
R1		0.06	0.02	CUTKOSKY	80	IPWA	PI N TO PI N	1/82
R2		**N(1990) FROM N PI TO N ETA**					**SQRT(P1*P3)**	
R2		(-0.043)		BAKER	79	DPWA	0 PI- P TO ETA N	12/79
R3		**N(1990) FROM N PI TO LAMBDA K**					**SQRT(P1*P4)**	
R3		-0.021	0.033	DEVENISH	74		0 FIXED T DISP REL	4/75
R3		NOT SEEN		SAXON	80	DPWA	0 PI- P TO K LAM	12/79
R3		(+0.01)		BELL	83	DPWA	0 PI- P TO LAM KO	2/84*
R4		**N(1990) FROM N PI TO SIGMA K**					**SQRT(P1*P9)**	
R4		(0.06)		LANGBEIN	73	IPWA	PI N-K SIG,SOL 1	9/73
R4	A	0.010 TO 0.023		DEANS	75	DPWA	PI N TO K SIGMA	11/75
R4	A	RANGE GIVEN IS FROM FOUR BEST SOLUTIONS.						11/75
R5		**N(1990) FROM P GAMMA TO P ETA**					**SQRT((P5+P6)*P3)**	
R5		(0.0045)		HICKS	73	MPWA	GAM P-ETA P	9/73
R6		**N(1990) FROM P GAMMA TO LAMBDA K**					**SQRT((P5+P6)*P4)**	
R6		(0.0034)		DEANS	72	MPWA	GAM P-K LM,SOL D	9/73

17 N(1990) PHOTON DECAY AMPLITUDES (GEV**-1/2)

FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-REVIEW PRECEDING THE BARYON LISTINGS.

A1	**N(1990) INTO P GAMMA, HELICITY=1/2 (GEV**-1/2)**						
A1	(0.040)		BARBOUR	78	DPWA	PI-N PHOTOPROD.	3/79
A1	0.001	0.040	CRAWFORD	80	DPWA	PI N PHOTOPROD.	12/81
A1	0.030	0.029	AWAJI	81	DPWA	PI N PHOTOPROD.	1/84*
A2	**N(1990) INTO P GAMMA, HELICITY=3/2 (GEV**-1/2)**						
A2	(+0.004)		BARBOUR	78	DPWA	PI-N PHOTOPROD.	3/79
A2	0.004	0.025	CRAWFORD	80	DPWA	PI N PHOTOPROD.	12/81
A2	0.086	0.060	AWAJI	81	DPWA	PI N PHOTOPROD.	1/84*
A3	**N(1990) INTO N GAMMA, HELICITY=1/2 (GEV**-1/2)**						
A3	(-0.069)		BARBOUR	78	DPWA	PI-N PHOTOPROD.	3/79
A3	-0.078	0.030	CRAWFORD	80	DPWA	PI N PHOTOPROD.	12/81
A3	(-0.001)		AWAJI	81	DPWA	PI N PHOTOPROD.	1/84*
A4	**N(1990) INTO N GAMMA, HELICITY=3/2 (GEV**-1/2)**						
A4	(-0.072)		BARBOUR	78	DPWA	PI-N PHOTOPROD.	3/79
A4	-0.116	0.045	CRAWFORD	80	DPWA	PI N PHOTOPROD.	12/81
A4	(-0.178)		AWAJI	81	DPWA	PI N PHOTOPROD.	1/84*

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REFERENCES FOR N(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 (SFLA)
DEANS2 69 PR 177 2623 S R DEANS (SFLA)
LEA 69 PL 29B 584 LEA,OADES,WARD,COWAN,+ (RHEL+BRIS+DARE)
AYED 70 PL 31B 598 +BAREYRE,VILLET (SACL)
APLIN 71 NP B32 253 +COWAN,GIBSON,GILMORE++ (RHEL+BRIS)
ALMEHED 72 NP B40 157 +LOVELACE (RUTG)IJP
DEANS 72 PR D6 1906 DEANS,JACOBS, LYONS,MONTGOMERY (SFLA)IJP
HICKS 73 PR D7 2614 +DEANS,JACOBS,LYONS+ (CARN+ORNL+SFLA)IJP
LANGBEIN 73 NP B53 251 LANGBEIN,WAGNER (MUNI)IJP
DEVENISH 74 NP B81 330 DEVENISH,FROGGATT,MARTIN (DESY+NORD+LOUC)
DEANS 75 NP B96 90 +MITCHELL,MONTGOMERY,+ (SFLA+ALAH)IJP

AYED 76 CEA-N-1921 AYED (THESIS) (SACL)IJP
BARBOUR 76 NP B111 358 I M BARBOUR,R L CRAWFORD (GLAS)IJP
MA 76 PR D13 3027 E MA,G L SHAW (OREG+UCI)IJP
WINNIK 77 NP B128 66 +TOAFF,REVEL,GOLDBERG,BERNY (HAIF)I
BARBOUR 78 NP B141 253 BARBOUR,CRAWFORD,PARSONS (GLAS)
BAKER 79 NP B156 93 +BROWN,CLARK,DAVIES,DEPAGTER,EVANS+ (RHEL)IJP
CUTKOSKY 79 PR D20 2839 +FORSYTH,HENDRICK,KELLY (CARN+LBL)IJP
HOEHLER 79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
+KAISER,KOCH,PIETARINEN (KARL)IJP
ALSO 80 TORONTO CONF 3 R KOCH (KARL)IJP

CRAWFORD 80 TORONTO CONF 107 R L CRAWFORD (GLAS)
CUTKOSKY 80 TORONTO CONF 19 +FORSYTH,BABCOCK,KELLY,HENDRICK (CARN+LBL)IJP
SAXON 80 NP B162 522 +BAKER,BELL,BLISSETT,BLOODWORTH+(RHEL+BRIS)IJP
AWAJI 81 BONN CONF 352 R KAJIKAWA (TALK) (NAGO)
ALSO 82 NP B197 365 FUJII,HAYASHII,IWATA,KAJIKAWA+ (NAGO)
BELL 83 NP B222 389 +BLISSET,BROOME,DALEY,HART,LINTERN,+ (RL)IJP
CRAWFORD 83 NP B211 1 R L CRAWFORD, W T MORTON (GLAS)

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N(2000) F''_{15} Status: **

→ 06 N(2000, JP=5/2+) I=1/2 F''15

OLDER RESULTS HAVE BEEN RETAINED SIMPLY BECAUSE THERE IS LITTLE INFORMATION AT ALL ABOUT THIS STATE.

06 N(2000) MASS (MEV)

M		(2175.0)		ALMEHED	72	IPWA		2/72
M		(1930.0)		DEANS	72	MPWA	GAM P-K LM,SOL D	9/73
M	A	(1970.0)		LANGBEIN	73	IPWA	PI N-K SIG,SOL 2	9/73
M	A	NOT SEEN IN SOLUTION 1 OF LANGBEIN 73.						9/73
M		(2025.0)		AYED	76	IPWA		11/77
M		1882.0	10.0	HOEHLER	79	IPWA	PI N TO PI N	12/79

Baryons

N(2000), N(2080)

Data Card Listings

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                    06  N(2000) WIDTH (MEV)

W          (150.0)                      ALMEHED   72 IPWA                        2/72
W          (112.0)                      DEANS     72 MPWA    GAM P-K LM,SOL D    9/73
W    A     (170.0)                      LANGBEIN  73 IPWA    PI N-K SIG,SOL 2    9/73
W          (157.0)                      AYED      76 IPWA                       11/77
W            95.0     20.0              HOEHLER   79 IPWA    PI N TO PI N       12/79

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                    06  N(2000) PARTIAL DECAY MODES

                                                                  DECAY MASSES
P1       N(2000) INTO N PI                                      938+ 140
P2       N(2000) INTO LAMBDA K                                 1116+ 498
P3       N(2000) INTO P GAMMA, HELICITY=3/2                     938+   0
P4       N(2000) INTO P GAMMA, HELICITY=1/2                     938+   0
P5       N(2000) INTO N GAMMA, HELICITY=3/2                     940+   0
P6       N(2000) INTO N GAMMA, HELICITY=1/2                     940+   0
P7       N(2000) INTO SIGMA K                                  1189+ 494
P8       N(2000) INTO N ETA                                     940+ 549

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                    06  N(2000) BRANCHING RATIOS

R1       N(2000) INTO (N PI)/TOTAL                               (P1)
R1           (0.25)                     ALMEHED   72 IPWA                        2/72
R1           (0.08)                     AYED      76 IPWA                       11/77
R1            0.04      0.02            HOEHLER   79 IPWA    PI N TO PI N       12/79

R2       N(2000) FROM N PI TO N ETA                              SQRT(P1*P8)
R2          (+0.03)                     BAKER     79 DPWA   0 PI- P TO ETA N    12/79

R3       N(2000) FROM N PI TO LAMBDA K                           SQRT(P1*P2)
R3         NOT SEEN                     SAXON     80 DPWA   0 PI- P TO K LAM    12/79

R4       N(2000) FROM N PI TO SIGMA K                            SQRT(P1*P7)
R4   A        (0.05)                    LANGBEIN  73 IPWA    PI N-K SIG,SOL 2    9/73
R4   B        (0.022)                   DEANS     75 DPWA    PI N TO K SIGMA    11/75
R4   B    VALUE GIVEN IS FROM SOLUTION 1, NOT PRESENT IN SOLUTIONS 2,3,4.       11/75

R5       N(2000) FROM P GAMMA TO LAMBDA K                        SQRT((P3+P4)*P2)
R5            (0.0022)                  DEANS     72 MPWA    GAM P-K LM,SOL D    9/73

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                               REFERENCES FOR N(2000)

ALMEHED   72 NP B40 157          +LOVELACE                              (RUTG)IJP
DEANS     72 PR D6 1906          DEANS,JACOBS, LYONS,MONTGOMERY         (SFLA)IJP
LANGBEIN 73 NP B53 251           LANGBEIN,WAGNER                        (MUNI)IJP
DEANS     75 NP B96 90           +MITCHELL,MONTGOMERY,+            (SFLA+ALAH)IJP
AYED      76 CEA-N-1921          AYED (THESIS)                          (SACL)IJP
MA        76 PR D13 3027         E MA,G L SHAW                      (OREG+UCI)IJP

BAKER     79 NP B156 93          +BROWN,CLARK,DAVIES,DEPAGTER,EVANS+  (RHEL)IJP
HOEHLER   79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                                 +KAISER,KOCH,PIETARINEN                (KARL)IJP
   ALSO 80  TORONTO CONF 3       R KOCH                                 (KARL)IJP
SAXON     80 NP B162 522         +BAKER,BELL,BLISSETT,BLOODWORTH+(RHEL+BRIS)IJP

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N(2080) D'''_{13} Status: **

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→              16  N(2080, JP=3/2-) I=1/2   D'''13

               THERE IS SOME EVIDENCE THAT TWO RESONANCES EXIST IN
               THIS WAVE BETWEEN 1800 AND 2200 MEV (SEE CUTKOSKY 80).
               THE SOLUTION OF HOEHLER 79 IS QUITE DIFFERENT.

     MOST OF THE RESULTS PUBLISHED BEFORE 1975 ARE NOW OBSOLETE AND HAVE
     BEEN OMITTED.  THEY MAY BE FOUND IN OUR 1982 EDITION (PHYSICS LETTERS
     111B).  HOWEVER, ALL THE REFERENCES HAVE BEEN RETAINED.

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                    16  N(2080) MASS (MEV)

M    A     (1830.0)   (50.0)            CUTKOSKY  79 IPWA    PI N TO PI N       12/79
M    B     (2100.0)   (80.0)            CUTKOSKY  79 IPWA    PI N TO PI N       12/79
M    AB  CUTKOSKY 79 FIND A LOWER MASS D13 RESONANCE, AS WELL AS ONE IN THIS    12/79
M    AB  MASS REGION.  BOTH ARE LISTED HERE, AND LABELED A AND B.               12/79
M           2081.0      20.0            HOEHLER   79 IPWA    PI N TO PI N       12/79
M    C      1880.0     100.0            CUTKOSKY  80 IPWA    PI N TO PI N        1/82
M    D      2060.0      80.0            CUTKOSKY  80 IPWA    PI N TO PI N        1/82
M    CD  CUTKOSKY 80 AGAIN FINDS A LOWER MASS D13 RESONANCE, AS WELL AS ONE      1/82
M    CD  IN THIS MASS REGION.  BOTH ARE LISTED HERE, LABELED C AND D.            1/82
M          (1900.0)                     SAXON     80 DPWA   0 PI- P TO K LAM    12/79
M          (1920.0)                     BELL      83 DPWA 0  PI- P TO LAM KO     2/84*

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                    16  N(2080) WIDTH (MEV)

W    A      (125.0)   (50.0)            CUTKOSKY  79 IPWA    PI N TO PI N       12/79
W    B      (300.0)  (100.0)            CUTKOSKY  79 IPWA    PI N TO PI N       12/79
W            265.0      40.0            HOEHLER   79 IPWA    PI N TO PI N       12/79
W    C       180.0      60.0            CUTKOSKY  80 IPWA    PI N TO PI N        1/82
W    D       300.0     100.0            CUTKOSKY  80 IPWA    PI N TO PI N        1/82
W           (240.0)                     SAXON     80 DPWA   0 PI- P TO K LAM    12/79
W           (320.0)                     BELL      83 DPWA 0  PI- P TO LAM KO     2/84*

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                    16  N(2080) REAL PART OF POLE POSITION  (MEV)

RE   A     (1818.0)                     CUTKOSKY  79 IPWA    PI N TO PI N       12/79
RE   B     (2053.0)                     CUTKOSKY  79 IPWA    PI N TO PI N       12/79
RE   C      1880.0     100.0            CUTKOSKY  80 IPWA    PI N TO PI N        1/82
RE   D      2050.0      70.0            CUTKOSKY  80 IPWA    PI N TO PI N        1/82

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                    16  N(2080) -2*IMAG PART OF POLE POSITION  (MEV)

IM   A      (122.0)                     CUTKOSKY  79 IPWA    PI N TO PI N       12/79
IM   B      (308.0)                     CUTKOSKY  79 IPWA    PI N TO PI N       12/79
IM   C       160.0      80.0            CUTKOSKY  80 IPWA    PI N TO PI N        1/82
IM   D       200.0      80.0            CUTKOSKY  80 IPWA    PI N TO PI N        1/82

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                    16  N(2080) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER  A        (3.0)                     CUTKOSKY  79 IPWA    PI N TO PI N       12/79
RER  B       (24.0)                     CUTKOSKY  79 IPWA    PI N TO PI N       12/79
RER  C        -2.0      14.0            CUTKOSKY  80 IPWA    PI N TO PI N        1/82
RER  D        30.0      20.0            CUTKOSKY  80 IPWA    PI N TO PI N        1/82

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                    16  N(2080) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR  A       (-3.0)                     CUTKOSKY  79 IPWA    PI N TO PI N       12/79
IMR  B      (-10.0)                     CUTKOSKY  79 IPWA    PI N TO PI N       12/79
IMR  C        10.0       5.0            CUTKOSKY  80 IPWA    PI N TO PI N        1/82
IMR  D         0.0      52.0            CUTKOSKY  80 IPWA    PI N TO PI N        1/82

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                    16  N(2080) PARTIAL DECAY MODES

                                                                  DECAY MASSES
P1       N(2080) INTO N PI                                      938+ 140
P2       N(2080) INTO N PI PI                                   938+ 140+ 140
P3       N(2080) INTO N ETA                                     940+ 549
P4       N(2080) INTO LAMBDA K                                 1116+ 498
P5       N(2080) INTO P GAMMA, HELICITY=3/2                     938+   0
P6       N(2080) INTO P GAMMA, HELICITY=1/2                     938+   0
P7       N(2080) INTO N GAMMA, HELICITY=3/2                     940+   0
P8       N(2080) INTO N GAMMA, HELICITY=1/2                     940+   0
P9       N(2080) INTO SIGMA K                                  1189+ 494

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                    16  N(2080) BRANCHING RATIOS

R1       N(2080) INTO (N PI)/TOTAL                               (P1)
R1   A       (0.06)    (0.03)           CUTKOSKY  79 IPWA    PI N TO PI N       12/79
R1   B       (0.13)    (0.05)           CUTKOSKY  79 IPWA    PI N TO PI N       12/79
R1            0.06      0.02            HOEHLER   79 IPWA    PI N TO PI N       12/79
R1   C        0.10      0.04            CUTKOSKY  80 IPWA    PI N TO PI N        1/82
R1   D        0.14      0.07            CUTKOSKY  80 IPWA    PI N TO PI N        1/82

R2       N(2080) FROM N PI TO N ETA                              SQRT(P1*P3)
R2         NOT SEEN                     BAKER     79 DPWA   0 PI- P TO ETA N    12/79

R3       N(2080) FROM N PI TO LAMBDA K                           SQRT(P1*P4)
R3          (+0.03)                     SAXON     80 DPWA   0 PI- P TO K LAM    12/79
R3          (+0.04)                     BELL      83 DPWA 0  PI- P TO LAM KO     2/84*

R4       N(2080) FROM N PI TO SIGMA K                            SQRT(P1*P9)
R4   E       0.014 TO 0.037             DEANS     75 DPWA    PI N TO K SIGMA    11/75
R4   E    RANGE GIVEN IS FROM FOUR BEST SOLUTIONS.  DISAGREES WITH PI+ P TO     11/75
R4   E    K+ SIGMA+ DATA OF WINNIK 77 AROUND 1920 MEV.                           1/78

R5       N(2080) FROM P GAMMA TO P ETA                           SQRT((P5+P6)*P3)
R5           (0.0037)                   HICKS     73 MPWA    GAM P-ETA P         9/73

R6       N(2080) FROM P GAMMA TO LAMBDA K                        SQRT((P5+P6)*P4)
R6           (0.0070)                   DEANS     72 MPWA    GAM P-K LM,SOL D    9/73

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                    16  N(2080) PHOTON DECAY AMPLITUDES (GEV**-1/2)

      FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-
    REVIEW PRECEDING THE BARYON LISTINGS.

A1       N(2080) INTO P GAMMA, HELICITY=1/2 (GEV**-1/2)
A1           0.026     0.052            DEVENIS2  74 DPWA    PI N PHOTOPROD.     4/75
A1          -0.020     0.008            AWAJI     81 DPWA    PI N PHOTOPROD.     1/84*

A2       N(2080) INTO P GAMMA, HELICITY=3/2 (GEV**-1/2)
A2           0.128     0.057            DEVENIS2  74 DPWA    PI N PHOTOPROD.     4/75
A2           0.017     0.011            AWAJI     81 DPWA    PI N PHOTOPROD.     1/84*

A3       N(2080) INTO N GAMMA, HELICITY=1/2 (GEV**-1/2)
A3           0.053     0.083            DEVENIS2  74 DPWA    PI N PHOTOPROD.     4/75
A3           0.007     0.013            AWAJI     81 DPWA    PI N PHOTOPROD.     1/84*

A4       N(2080) INTO N GAMMA, HELICITY=3/2 (GEV**-1/2)
A4           0.100     0.141            DEVENIS2  74 DPWA    PI N PHOTOPROD.     4/75
A4          -0.053     0.034            AWAJI     81 DPWA    PI N PHOTOPROD.     1/84*

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                               REFERENCES FOR N(2080)

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+BRIS+DARE)
DONNACHI 69 NP 10B 433           A DONNACHIE, R KIRSOPP            (GLAS+EDIN)
AYED     70 PL 31B 598           +BAREYRE,VILLET                        (SACL)
CARRERAS 70 NP 16B 35            B CARRERAS, A DONNACHIE           (DARE+MCHS)
APLIN    71 NP  B32 253          +COWAN,GIBSON,GILMORE++           (RHEL+BRIS)
ALMEHED  72 NP B40 157           +LOVELACE                         (LUND+RUTG)IJP
DEANS    72 PR D6 1906           DEANS,JACOBS, LYONS,MONTGOMERY         (SFLA)IJP
HICKS    73 PR D7 2614           +DEANS,JACOBS,LYONS+         (CARN+ORNL+SFLA)IJP
DEVENIS2 74 PL 52B 227           DEVENISH,LYTH,RANKIN         (DESY+LANC+BONN)IJP
DEANS    75 NP B96 90            +MITCHELL,MONTGOMERY,+            (SFLA+ALAH)IJP
AYED     76 CEA-N-1921           AYED (THESIS)                          (SACL)IJP
MA       76 PR D13 3027          E MA,G L SHAW                      (OREG+UCI)IJP
WINNIK   77 NP B128 66           +TOAFF,REVEL,GOLDBERG,BERNY            (HAIF)I
BAKER    79 NP B156 93           +BROWN,CLARK,DAVIES,DEPAGTER,EVANS+  (RHEL)IJP
CUTKOSKY 79 PR D20 2839          +FORSYTH,HENDRICK,KELLY            (CARN+LBL)IJP
HOEHLER  79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                                 +KAISER,KOCH,PIETARINEN                (KARL)IJP
   ALSO 80  TORONTO CONF 3       R KOCH                                 (KARL)IJP

CUTKOSKY 80  TORONTO CONF 19     +FORSYTH,BABCOCK,KELLY,HENDRICK  (CARN+LBL)IJP
SAXON    80 NP B162 522          +BAKER,BELL,BLISSETT,BLOODWORTH+(RHEL+BRIS)IJP
AWAJI    81  BONN CONF 352       R KAJIKAWA (TALK)                      (NAGO)
   ALSO 82 NP B197 365           FUJII,HAYASHII,IWATA,KAJIKAWA+         (NAGO)
BELL     83 NP B222 389          +BLISSET,BROOME,DALEY,HART,LINTERN,+   (RL)IJP

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N(2090) S'''_{11} Status: *

04 N(2090, JP=1/2-) I=1/2 S'''11

ANY STRUCTURE IN THIS WAVE ABOVE 1800 MEV IS LISTED HERE. A FEW EARLY RESULTS THAT ARE NOW OBSOLETE HAVE BEEN OMITTED.

04 N(2090) MASS (MEV)

M	1880.0	20.0	HOEHLER	79	IPWA	PI N TO PI N	12/79
M	2180.0	80.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

04 N(2090) WIDTH (MEV)

W	95.0	30.0	HOEHLER	79	IPWA	PI N TO PI N	12/79
W	350.0	100.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

04 N(2090) REAL PART OF POLE POSITION (MEV)

RE	2150.0	70.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

04 N(2090) -2*IMAG PART OF POLE POSITION (MEV)

IM	350.0	100.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

04 N(2090) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER	40.0	20.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

04 N(2090) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR	0.0	60.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

04 N(2090) PARTIAL DECAY MODES

		DECAY MASSES
P1	N(2090) INTO N PI	938+ 140
P2	N(2090) INTO LAMBDA K	1116+ 498

04 N(2090) BRANCHING RATIOS

R1	**N(2090) INTO (N PI)/TOTAL**					**(P1)**	
R1	0.09	0.05	HOEHLER	79	IPWA	PI N TO PI N	12/79
R1	0.18	0.08	CUTKOSKY	80	IPWA	PI N TO PI N	1/82
R2	**N(2090) FROM N PI TO LAMBDA K**					**SQRT(P1*P2)**	
R2	NOT SEEN		SAXON	80	DPWA	0 PI- P TO K LAM	12/79

REFERENCES FOR N(2090)

ROYCHOUD 71 NP B27 125 R K ROYCHOUDHURY,B H BRANSDEN (DURH)IJP
ALMEHED 72 NP B40 157 +LOVELACE (LUND+RUTG)IJP
AYED 76 CEA-N-1921 AYED (THESIS) (SACL)IJP
MA 76 PR D13 3027 E MA,G L SHAW (OREG+UCI)IJP
HOEHLER 79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
+KAISER,KOCH,PIETARINEN (KARL)IJP
ALSO 80 TORONTO CONF 3 R KOCH (KARL)IJP
CUTKOSKY 80 TORONTO CONF 19 +FORSYTH,BABCOCK,KELLY,HENDRICK (CARN+LBL)IJP
SAXON 80 NP B162 522 +BAKER,BELL,BLISSETT,BLOODWORTH+(RHEL+BRIS)IJP

N(2100) P'''_{11} Status: *

132 N(2100, JP=1/2+) I=1/2 P'''11

132 N(2100) MASS (MEV)

M	2050.0	20.0	HOEHLER	79	IPWA	PI N TO PI N	1/82
M	2125.0	75.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

132 N(2100) WIDTH (MEV)

W	200.0	30.0	HOEHLER	79	IPWA	PI N TO PI N	1/82
W	260.0	100.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

132 N(2100) REAL PART OF POLE POSITION (MEV)

RE	2120.0	40.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

132 N(2100) -2*IMAG PART OF POLE POSITION (MEV)

IM	240.0	80.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

132 N(2100) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER	11.0	7.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

132 N(2100) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR	8.0	6.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

132 N(2100) PARTIAL DECAY MODES

		DECAY MASSES
P1	N(2100) INTO N PI	938+ 140

132 N(2100) BRANCHING RATIOS

R1	**N(2100) INTO (N PI)/TOTAL**					**(P1)**	
R1	0.10	0.04	HOEHLER	79	IPWA	PI N TO PI N	1/82
R1	0.12	0.03	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

REFERENCES FOR N(2100)

HOEHLER 79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
+KAISER,KOCH,PIETARINEN (KARL)IJP
KOCH 80 TORONTO CONF 3 R KOCH (KARL)IJP
CUTKOSKY 80 TORONTO CONF 19 +FORSYTH,BABCOCK,KELLY,HENDRICK (CARN+LBL)IJP

N(2190) G_{17} Status: ****

71 N(2190, JP=7/2-) I=1/2 G17

MOST OF THE RESULTS PUBLISHED BEFORE 1975 ARE NOW OBSOLETE AND HAVE BEEN OMITTED. THEY MAY BE FOUND IN OUR 1982 EDITION (PHYSICS LETTERS 111B). HOWEVER, ALL THE REFERENCES HAVE BEEN RETAINED.

71 N(2190) MASS (MEV)

M	(2117.0)		BARBOUR	78	DPWA	PI-N PHOTOPROD.	3/79
M	2140.0	40.0	HENDRY	78	MPWA	PI N TO PI N	12/79
M	(2140.0)		BAKER	79	DPWA	0 PI- P TO ETA N	12/79
M	(2150.0)	(100.0)	CUTKOSKY	79	IPWA	PI N TO PI N	12/79
M	2140.0	12.0	HOEHLER	79	IPWA	PI N TO PI N	12/79
M	(2098.0)		CRAWFORD	80	DPWA	PI N PHOTOPROD.	12/81
M	2200.0	70.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82
M	(2180.0)		SAXON	80	DPWA	0 PI- P TO K LAM	12/79

71 N(2190) WIDTH (MEV)

W	(220.0)		BARBOUR	78	DPWA	PI-N PHOTOPROD.	3/79
W	270.0	50.0	HENDRY	78	MPWA	PI N TO PI N	12/79
W	(319.0)		BAKER	79	DPWA	0 PI- P TO ETA N	12/79
W	(300.0)	(100.0)	CUTKOSKY	79	IPWA	PI N TO PI N	12/79
W	390.0	30.0	HOEHLER	79	IPWA	PI N TO PI N	12/79
W	(238.0)		CRAWFORD	80	DPWA	PI N PHOTOPROD.	12/81
W	500.0	150.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82
W	(80.0)		SAXON	80	DPWA	0 PI- P TO K LAM	12/79

71 N(2190) REAL PART OF POLE POSITION (MEV)

RE	(2111.0)		CUTKOSKY	79	IPWA	PI N TO PI N	12/79
RE	2100.0	50.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

71 N(2190) -2*IMAG PART OF POLE POSITION (MEV)

IM	(308.0)		CUTKOSKY	79	IPWA	PI N TO PI N	12/79
IM	400.0	160.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

71 N(2190) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER	(24.0)		CUTKOSKY	79	IPWA	PI N TO PI N	12/79
RER	22.0	14.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

71 N(2190) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR	(-12.0)		CUTKOSKY	79	IPWA	PI N TO PI N	12/79
IMR	-13.0	20.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

71 N(2190) PARTIAL DECAY MODES

		DECAY MASSES
P1	N(2190) INTO N PI	938+ 140
P2	N(2190) INTO LAMBDA K	1116+ 494
P3	N(2190) INTO N PI PI	938+ 140+ 140
P4	N(2190) INTO P GAMMA, HELICITY=3/2	938+ 0
P5	N(2190) INTO P GAMMA, HELICITY=1/2	938+ 0
P6	N(2190) INTO N GAMMA, HELICITY=3/2	940+ 0
P7	N(2190) INTO N GAMMA, HELICITY=1/2	940+ 0
P8	N(2190) INTO N ETA	940+ 549
P9	N(2190) INTO SIGMA K	1189+ 494

71 N(2190) BRANCHING RATIOS

R1	**N(2190) INTO (N PI)/TOTAL**					**(P1)**	
R1	0.16	0.04	HENDRY	78	MPWA	PI N TO PI N	12/79
R1	(0.16)	(0.07)	CUTKOSKY	79	IPWA	PI N TO PI N	12/79
R1	0.14	0.02	HOEHLER	79	IPWA	PI N TO PI N	12/79
R1	0.12	0.06	CUTKOSKY	80	IPWA	PI N TO PI N	1/82
R2	**N(2190) FROM N PI TO N ETA**					**SQRT(P1*P8)**	
R2	(+0.052)		BAKER	79	DPWA	0 PI- P TO ETA N	12/79

# Baryons
# Data Card Listings
N(2190), N(2200), N(2220)

R3 N(2190) FROM N PI TO LAMBDA K SQRT(P1*P2)
R3 (-0.02) SAXON 80 DPWA 0 PI- P TO K LAM 12/79
R3 (-0.02) BELL 83 DPWA 0 PI- P TO LAM KO 2/84*

R4 N(2190) FROM N PI TO SIGMA K SQRT(P1*P9)
R4 A 0.014 TO 0.019 DEANS 75 DPWA PI N TO K SIGMA 11/75
R4 A RANGE GIVEN IS FROM FOUR BEST SOLUTIONS. DISAGREES WITH PI+ P TO 11/75
R4 A K+ SIGMA+ DATA OF WINNIK 77 AROUND 1920 MEV. 1/78

R5 N(2190) FROM P GAMMA TO P ETA SQRT((P4+P5)*P8)
R5 (0.0094) HICKS 73 MPWA GAM P-ETA P 9/73

R6 N(2190) FROM P GAMMA TO LAMBDA K SQRT((P4+P5)*P2)
R6 (0.0161) DEANS 72 MPWA GAM P-K LM,SOL D 9/73

71 N(2190) PHOTON DECAY AMPLITUDES (GEV**-1/2)

FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-REVIEW PRECEDING THE BARYON LISTINGS.

A1 N(2190) INTO P GAMMA, HELICITY=1/2 (GEV**-1/2)
A1 (-0.030) BARBOUR 78 DPWA PI-N PHOTOPROD. 3/79
A1 (-0.055) CRAWFORD 80 DPWA PI N PHOTOPROD. 12/81

A2 N(2190) INTO P GAMMA, HELICITY=3/2 (GEV**-1/2)
A2 (+0.180) BARBOUR 78 DPWA PI-N PHOTOPROD. 3/79
A2 (0.081) CRAWFORD 80 DPWA PI N PHOTOPROD. 12/81

A3 N(2190) INTO N GAMMA, HELICITY=1/2 (GEV**-1/2)
A3 (-0.085) BARBOUR 78 DPWA PI-N PHOTOPROD. 3/79
A3 (-0.042) CRAWFORD 80 DPWA PI N PHOTOPROD. 12/81

A4 N(2190) INTO N GAMMA, HELICITY=3/2 (GEV**-1/2)
A4 (+0.007) BARBOUR 78 DPWA PI-N PHOTOPROD. 3/79
A4 (-0.126) CRAWFORD 80 DPWA PI N PHOTOPROD. 12/81

REFERENCES FOR N(2190)

DIDDENS 63 PRL 10 262 +JENKINS, KYCIA, RILEY (BNL) I
HOEHLER 64 PL 12 149 G HOEHLER, J GIESECKE (KARL) I
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
YOKOSAWA 66 PRL 16 714 +SUWA,HILL,ESTERLING, BOOTH (ANL+CHIC) JP
BUSZA 67 NC 52A 331 +DAVIS,DUFF,HEYMANN, + (LOUC+LOWC)

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+BRIS+DARE)
ANDERSON 70 PRL 25 699 +BLESER,BLIEDEN,COLLINS,+ (BNL+CARN)
AYED 70 KIEV CONF R AYED,P BAREYRE, G VILLET (SACL)IJP
AYED2 70 PL 31B 598 +BAREYRE,VILLET (SACL)
HULL 70 PR D2 1783 J HULL, R LEACOCK (ISU)

AMALDI 71 PL 34B 435 +BIANCASTELLI,BOSIO,+ (SANI+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 PR D6 1906 DEANS,JACOBS, LYONS,MONTGOMERY (SFLA)IJP
OTT 72 PL 42B 133 +TRISCHUK,VAVRA,RICHARDS,+ (MCGI+STLO+IOWA)IJP
ALSO 72 MCGILL THESIS J VAVRA (MCGI) JP
HICKS 73 PR D7 2614 +DEANS,JACOBS,LYONS+ (CARN+ORNL+SFLA)IJP

ABE 74 PL 53B 114 +ALSPECTOR,BOMBEROWITZ+ (RUTG+UPNJ+FSU)
DEANS 75 NP B96 90 +MITCHELL,MONTGOMERY,+ (SFLA+ALAH)IJP
AYED 76 CEA-N-1921 AYED (THESIS) (SACL)IJP
MA 76 PR D13 3027 E MA,G L SHAW (OREG+UCI)IJP
WINNIK 77 NP B128 66 +TOAFF,REVEL,GOLDBERG,BERNY (HAIF)I
BARBOUR 78 NP B141 253 BARBOUR,CRAWFORD,PARSONS (GLAS)
HENDRY 78 PRL 41 222 A W HENDRY (IND+LBL)IJP
-- THE ANALYSIS AND RESULTS ARE DISCUSSED MORE FULLY IN HENDRY 81.
BAKER 79 NP B156 93 +BROWN,CLARK,DAVIES,DEPAGTER,EVANS+ (RHEL)IJP
CUTKOSKY 79 PR D20 2839 +FORSYTH,HENDRICK,KELLY (CARN+LBL)IJP
HOEHLER 79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
+KAISER,KOCH,PIETARINEN (KARL)IJP
ALSO 80 TORONTO CONF 3 R KOCH (KARL)IJP

CRAWFORD 80 TORONTO CONF 107 R L CRAWFORD (GLAS)
CUTKOSKY 80 TORONTO CONF 19 +FORSYTH,BABCOCK,KELLY,HENDRICK (CARN+LBL)IJP
SAXON 80 NP B162 522 +BAKER,BELL,BLISSETT,BLOODWORTH+(RHEL+BRIS)IJP
HENDRY 81 ANP 136 1 A W HENDRY (IND)
BELL 83 NP B222 389 +BLISSET,BROOME,DALEY,HART,LINTERN,+ (RL)IJP
CRAWFORD 83 NP B211 1 R L CRAWFORD, W T MORTON (GLAS)

N(2200) D''_{15} Status: **

05 N(2200, JP=5/2-) I=1/2 D''15

THE MASS IS NOT WELL DETERMINED. A FEW EARLY RESULTS HAVE BEEN OMITTED.

05 N(2200) MASS (MEV)

M 2228.0 30.0 HOEHLER 79 IPWA PI N TO PI N 12/79
M 2180.0 80.0 CUTKOSKY 80 IPWA PI N TO PI N 1/82
M (1920.0) SAXON 80 DPWA 0 PI- P TO K LAM 12/79
M (1900.0) BELL 83 DPWA 0 PI- P TO LAM KO 2/84*

05 N(2200) WIDTH (MEV)

W 310.0 50.0 HOEHLER 79 IPWA PI N TO PI N 12/79
W 400.0 100.0 CUTKOSKY 80 IPWA PI N TO PI N 1/82
W (220.0) SAXON 80 DPWA 0 PI- P TO K LAM 12/79
W (130.0) BELL 83 DPWA 0 PI- P TO LAM KO 2/84*

05 N(2200) REAL PART OF POLE POSITION (MEV)

RE 2100.0 60.0 CUTKOSKY 80 IPWA PI N TO PI N 1/82

05 N(2200) -2*IMAG PART OF POLE POSITION (MEV)

IM 360.0 80.0 CUTKOSKY 80 IPWA PI N TO PI N 1/82

05 N(2200) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER 0.0 17.0 CUTKOSKY 80 IPWA PI N TO PI N 1/82

05 N(2200) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR -20.0 10.0 CUTKOSKY 80 IPWA PI N TO PI N 1/82

05 N(2200) PARTIAL DECAY MODES

DECAY MASSES
P1 N(2200) INTO N PI 938+ 140
P2 N(2200) INTO N ETA 940+ 549
P3 N(2200) INTO LAMBDA K 1116+ 498

05 N(2200) BRANCHING RATIOS

R1 N(2200) INTO (N PI)/TOTAL (P1)
R1 0.07 0.02 HOEHLER 79 IPWA PI N TO PI N 12/79
R1 0.10 0.03 CUTKOSKY 80 IPWA PI N TO PI N 1/82

R2 N(2200) FROM N PI TO N ETA SQRT(P1*P2)
R2 (0.066) BAKER 79 DPWA 0 PI- P TO ETA N 12/79

R3 N(2200) FROM N PI TO LAMBDA K SQRT(P1*P3)
R3 (-0.05) SAXON 80 DPWA 0 PI- P TO K LAM 12/79
R3 (-0.03) BELL 83 DPWA 0 PI- P TO LAM KO 2/84*

REFERENCES FOR N(2200)

ALMEHED 72 NP B40 157 +LOVELACE (LUND+RUTG)IJP
AYED 76 CEA-N-1921 AYED (THESIS) (SACL)IJP
MA 76 PR D13 3027 E MA,G L SHAW (OREG+UCI)IJP
BAKER 77 NP B126 365 +BLISSET,BLOODWORTH,BROOME,HART+ (RHEL)IJP
BAKER 79 NP B156 93 +BROWN,CLARK,DAVIES,DEPAGTER,EVANS+ (RHEL)IJP
HOEHLER 79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
+KAISER,KOCH,PIETARINEN (KARL)IJP
ALSO 80 TORONTO CONF 3 R KOCH (KARL)IJP
CUTKOSKY 80 TORONTO CONF 19 +FORSYTH,BABCOCK,KELLY,HENDRICK (CARN+LBL)IJP
SAXON 80 NP B162 522 +BAKER,BELL,BLISSETT,BLOODWORTH+(RHEL+BRIS)IJP
BELL 83 NP B222 389 +BLISSET,BROOME,DALEY,HART,LINTERN,+ (RL)IJP

N(2220) H_{19} Status: ****

90 N(2220, JP=9/2+) I=1/2 H19

MOST OF THE RESULTS PUBLISHED BEFORE 1975 ARE NOW OBSOLETE AND HAVE BEEN OMITTED. THEY MAY BE FOUND IN OUR 1982 EDITION (PHYSICS LETTERS 111B). HOWEVER, ALL THE REFERENCES HAVE BEEN RETAINED.

90 N(2220) MASS (MEV)

M 2300.0 100.0 HENDRY 78 MPWA PI N TO PI N 12/79
M (2050.0) BAKER 79 DPWA 0 PI- P TO ETA N 12/79
M (2250.0) CUTKOSKY 79 IPWA PI N TO PI N 12/79
M 2205.0 10.0 HOEHLER 79 IPWA PI N TO PI N 12/79
M 2230.0 80.0 CUTKOSKY 80 IPWA PI N TO PI N 1/82

90 N(2220) WIDTH (MEV)

W 450.0 150.0 HENDRY 78 MPWA PI N TO PI N 12/79
W (450.0) CUTKOSKY 79 IPWA PI N TO PI N 12/79
W 365.0 30.0 HOEHLER 79 IPWA PI N TO PI N 12/79
W 500.0 150.0 CUTKOSKY 80 IPWA PI N TO PI N 1/82

90 N(2220) REAL PART OF POLE POSITION (MEV)

RE (2180.0) CUTKOSKY 79 IPWA PI N TO PI N 12/79
RE 2160.0 80.0 CUTKOSKY 80 IPWA PI N TO PI N 1/82

90 N(2220) -2*IMAG PART OF POLE POSITION (MEV)

IM (400.0) CUTKOSKY 79 IPWA PI N TO PI N 12/79
IM 480.0 100.0 CUTKOSKY 80 IPWA PI N TO PI N 1/82

90 N(2220) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER (37.0) CUTKOSKY 79 IPWA PI N TO PI N 12/79
RER 32.0 20.0 CUTKOSKY 80 IPWA PI N TO PI N 1/82

90 N(2220) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR (-21.0) CUTKOSKY 79 IPWA PI N TO PI N 12/79
IMR -32.0 20.0 CUTKOSKY 80 IPWA PI N TO PI N 1/82

For notation, see key at front of Listings.

Baryons

N(2220), N(2250), N(2600), N(2700)

90 N(2220) PARTIAL DECAY MODES

		DECAY MASSES
P1	N(2220) INTO N PI	938+ 140
P2	N(2220) INTO N ETA	940+ 549
P3	N(2220) INTO LAMBDA K	1116+ 498

90 N(2220) BRANCHING RATIOS

R1	N(2220) INTO (N PI)/TOTAL				(P1)	
R1	0.12	0.04	HENDRY	78 MPWA	PI N TO PI N	12/79
R1	(0.20)		CUTKOSKY	79 IPWA	PI N TO PI N	12/79
R1	0.18	0.015	HOEHLER	79 IPWA	PI N TO PI N	12/79
R1	0.15	0.03	CUTKOSKY	80 IPWA	PI N TO PI N	1/82
R2	N(2220) FROM N PI TO N ETA				SQRT(P1*P2)	
R2	(0.034)		BAKER	79 DPWA	0 PI- P TO ETA N	12/79
R3	N(2220) FROM N PI TO LAMBDA K				SQRT(P1*P3)	
R3	NOT SEEN		SAXON	80 DPWA	0 PI- P TO K LAM	12/79
R3	NOT REQUIRED		BELL	83 DPWA 0	PI- P TO LAM KO	2/84*

REFERENCES FOR N(2220)

BUSZA 67 NC 52A 331 +DAVIS,DUFF,HEYMANN,NIMMON + (LOUC+LOWC)
AYED 70 KIEV CONF R AYED,P BAREYRE, G VILLET (SACL)IJP
AYED2 70 PL 31B 598 +BAREYRE,VILLET (SACL)
HULL 70 PR D2 1783 J HULL, R LEACOCK (ISU)
AYED 76 CEA-N-1921 AYED (THESIS) (SACL)IJP
MA 76 PR D13 3027 E MA,G L SHAW (OREG+UCI)IJP
HENDRY 78 PRL 41 222 A W HENDRY (IND+LBL)IJP
-- THE ANALYSIS AND RESULTS ARE DISCUSSED MORE FULLY IN HENDRY 81.

BAKER 79 NP B156 93 +BROWN,CLARK,DAVIES,DEPAGTER,EVANS+ (RHEL)IJP
CUTKOSKY 79 PR D20 2839 +FORSYTH,HENDRICK,KELLY (CARN+LBL)IJP
HOEHLER 79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
+KAISER,KOCH,PIETARINEN (KARL)IJP
ALSO 80 TORONTO CONF 3 R KOCH (KARL)IJP

CUTKOSKY 80 TORONTO CONF 19 +FORSYTH,BABCOCK,KELLY,HENDRICK (CARN+LBL)IJP
SAXON 80 NP B162 522 +BAKER,BELL,BLISSETT,BLOODWORTH+(RHEL+BRIS)IJP
HENDRY 81 ANP 136 1 A W HENDRY (IND)
BELL 83 NP B222 389 +BLISSET,BROOME,DALEY,HART,LINTERN,+ (RL)IJP

N(2250) G_{19} Status: ****

113 N(2250, JP=9/2-) I=1/2 G'19

113 N(2250) MASS (MEV)

M	2200.0	100.0	HENDRY	78 MPWA	PI N TO PI N	12/79
M	(2200.0)		CUTKOSKY	79 IPWA	PI N TO PI N	12/79
M	2268.0	15.0	HOEHLER	79 IPWA	PI N TO PI N	12/79
M	2250.0	80.0	CUTKOSKY	80 IPWA	PI N TO PI N	1/82

113 N(2250) WIDTH (MEV)

W	350.0	100.0	HENDRY	78 MPWA	PI N TO PI N	12/79
W	(330.0)		CUTKOSKY	79 IPWA	PI N TO PI N	12/79
W	300.0	40.0	HOEHLER	79 IPWA	PI N TO PI N	12/79
W	480.0	120.0	CUTKOSKY	80 IPWA	PI N TO PI N	1/82

113 N(2250) REAL PART OF POLE POSITION (MEV)

RE	(2169.0)		CUTKOSKY	79 IPWA	PI N TO PI N	12/79
RE	2150.0	50.0	CUTKOSKY	80 IPWA	PI N TO PI N	1/82

113 N(2250) -2*IMAG PART OF POLE POSITION (MEV)

IM	(290.0)		CUTKOSKY	79 IPWA	PI N TO PI N	12/79
IM	360.0	100.0	CUTKOSKY	80 IPWA	PI N TO PI N	1/82

113 N(2250) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER	(15.0)		CUTKOSKY	79 IPWA	PI N TO PI N	12/79
RER	13.0	7.0	CUTKOSKY	80 IPWA	PI N TO PI N	1/82

113 N(2250) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR	(-7.0)		CUTKOSKY	79 IPWA	PI N TO PI N	12/79
IMR	-15.0	6.0	CUTKOSKY	80 IPWA	PI N TO PI N	1/82

113 N(2250) PARTIAL DECAY MODES

		DECAY MASSES
P1	N(2250) INTO N PI	938+ 140
P2	N(2250) INTO LAMBDA K	1116+ 498
P3	N(2250) INTO N ETA	940+ 549

113 N(2250) BRANCHING RATIOS

R1	N(2250) INTO (N PI)/TOTAL				(P1)	
R1	0.09	0.02	HENDRY	78 MPWA	PI N TO PI N	12/79
R1	(0.10)		CUTKOSKY	79 IPWA	PI N TO PI N	12/79
R1	0.10	0.02	HOEHLER	79 IPWA	PI N TO PI N	12/79
R1	0.10	0.02	CUTKOSKY	80 IPWA	PI N TO PI N	1/82
R2	N(2250) FROM N PI TO N ETA				SQRT(P1*P3)	
R2	(-0.043)		BAKER	79 DPWA	0 PI- P TO ETA N	12/79
R3	N(2250) FROM N PI TO LAMBDA K				SQRT(P1*P2)	
R3	NOT SEEN		SAXON	80 DPWA	0 PI- P TO K LAM	12/79
R3	(-0.02)		BELL	83 DPWA 0	PI- P TO LAM KO	2/84*

REFERENCES FOR N(2250)

AYED 76 CEA-N-1921 AYED (THESIS) (SACL)IJP
HENDRY 78 PRL 41 222 A W HENDRY (IND+LBL)IJP
-- THE ANALYSIS AND RESULTS ARE DISCUSSED MORE FULLY IN HENDRY 81.
BAKER 79 NP B156 93 +BROWN,CLARK,DAVIES,DEPAGTER,EVANS+ (RHEL)IJP
CUTKOSKY 79 PR D20 2839 +FORSYTH,HENDRICK,KELLY (CARN+LBL)IJP
HOEHLER 79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
+KAISER,KOCH,PIETARINEN (KARL)IJP
ALSO 80 TORONTO CONF 3 R KOCH (KARL)IJP
CUTKOSKY 80 TORONTO CONF 19 +FORSYTH,BABCOCK,KELLY,HENDRICK (CARN+LBL)IJP
SAXON 80 NP B162 522 +BAKER,BELL,BLISSETT,BLOODWORTH+(RHEL+BRIS)IJP
HENDRY 81 ANP 136 1 A W HENDRY (IND)
BELL 83 NP B222 389 +BLISSET,BROOME,DALEY,HART,LINTERN,+ (RL)IJP

N(2600) I_{111} Status: ***

120 N(2600, JP=11/2-) I=1/2 I1 11

120 N(2600) MASS (MEV)

M	2700.0	100.0	HENDRY	78 MPWA	PI N TO PI N	12/79
M	2577.0	50.0	HOEHLER	79 IPWA	PI N TO PI N	12/79

120 N(2600) WIDTH (MEV)

W	900.0	100.0	HENDRY	78 MPWA	PI N TO PI N	12/79
W	400.0	100.0	HOEHLER	79 IPWA	PI N TO PI N	12/79

120 N(2600) PARTIAL DECAY MODES

		DECAY MASSES
P1	N(2600) INTO N PI	938+ 140

120 N(2600) BRANCHING RATIOS

R1	N(2600) INTO (N PI)/TOTAL				(P1)	
R1	0.08	0.02	HENDRY	78 MPWA	PI N TO PI N	12/79
R1	0.05	0.01	HOEHLER	79 IPWA	PI N TO PI N	12/79

REFERENCES FOR N(2600)

HENDRY 78 PRL 41 222 A W HENDRY (IND+LBL)IJP
-- THE ANALYSIS AND RESULTS ARE DISCUSSED MORE FULLY IN HENDRY 81.
HOEHLER 79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
+KAISER,KOCH,PIETARINEN (KARL)IJP
ALSO 80 TORONTO CONF 3 R KOCH (KARL)IJP
HENDRY 81 ANP 136 1 A W HENDRY (IND)

N(2700) K_{113} Status: **

121 N(2700, JP=13/2+) I=1/2 K1 13

121 N(2700) MASS (MEV)

M	3000.0	100.0	HENDRY	78 MPWA	PI N TO PI N	12/79
M	2612.0	45.0	HOEHLER	79 IPWA	PI N TO PI N	12/79

121 N(2700) WIDTH (MEV)

W	900.0	150.0	HENDRY	78 MPWA	PI N TO PI N	12/79
W	350.0	50.0	HOEHLER	79 IPWA	PI N TO PI N	12/79

121 N(2700) PARTIAL DECAY MODES

		DECAY MASSES
P1	N(2700) INTO N PI	938+ 140

121 N(2700) BRANCHING RATIOS

R1	N(2700) INTO (N PI)/TOTAL				(P1)	
R1	0.07	0.02	HENDRY	78 MPWA	PI N TO PI N	12/79
R1	0.04	0.01	HOEHLER	79 IPWA	PI N TO PI N	12/79

REFERENCES FOR N(2700)

HENDRY 78 PRL 41 222 A W HENDRY (IND+LBL)IJP
-- THE ANALYSIS AND RESULTS ARE DISCUSSED MORE FULLY IN HENDRY 81.
HOEHLER 79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
+KAISER,KOCH,PIETARINEN (KARL)IJP
ALSO 80 TORONTO CONF 3 R KOCH (KARL)IJP
HENDRY 81 ANP 136 1 A W HENDRY (IND)

~3000 MEV REGION - FORMATION EXPERIMENTS

128 N(~3000) I=1/2

WE LIST HERE MISCELLANEOUS HIGH-MASS CANDIDATES FOR ISOSPIN-1/2 RESONANCES FOUND IN PARTIAL-WAVE ANALYSES. SO FAR, NO ANALYSIS OF THIS REGION HAS USED ALL THE AVAILABLE DATA OR INCORPORATED ANALYTICITY CONSTRAINTS.

OUR 1982 EDITION ALSO HAD AN N(3030), AN N(3245), AN N(3690), AND AN N(3755). NOTHING HAS BEEN HEARD FROM THEM SINCE THE 1960'S, AND UNDER THE AUTHORITY GRANTED UNTO US BY THE STATUTE OF LIMITATIONS WE DECLARE THEM TO BE DEAD. THE LAST THREE WERE NARROW PEAKS SEEN IN PRODUCTION EXPERIMENTS. THE N(3030) WAS DEDUCED FROM TOTAL-CROSS-SECTION AND 180-DEG-ELASTIC-CROSS-SECTION MEASUREMENTS; PLACED IN THE MAIN BARYON TABLE IN THE ANYTHING-GOES 1960'S, IT REMAINED THERE DUE TO INATTENTION UNTIL THIS EDITION.

128 N(~3000) MASS (MEV)

M	3500.0	200.0	HENDRY	78	MPWA	PI N L115	12/79
M	3800.0	200.0	HENDRY	78	MPWA	PI N M117	12/79
M	4100.0	200.0	HENDRY	78	MPWA	PI N N119	12/79
M	(2600.0)		KOCH	80	IPWA	PI N D13	2/84*
M	(3100.0)		KOCH	80	IPWA	PI N L115	2/84*
M	(3500.0)		KOCH	80	IPWA	PI N M117	2/84*
M	3500.0 TO 4000.0		KOCH	80	IPWA	PI N N119	2/84*

128 N(~3000) WIDTH (MEV)

W	1300.0	200.0	HENDRY	78	MPWA	PI N L115	12/79
W	1600.0	200.0	HENDRY	78	MPWA	PI N M117	12/79
W	1900.0	300.0	HENDRY	78	MPWA	PI N N119	12/79

128 N(~3000) PARTIAL DECAY MODES

		DECAY MASSES
P1	N(~3000) INTO N PI	938+ 140

128 N(~3000) BRANCHING RATIOS

R1	N(~3000) INTO (N PI)/TOTAL					(P1)	
R1	0.055	0.02	HENDRY	78	MPWA	PI N L115	12/79
R1	0.040	0.015	HENDRY	78	MPWA	PI N M117	12/79
R1	0.030	0.015	HENDRY	78	MPWA	PI N N119	12/79

REFERENCES FOR N(~3000)

HENDRY 78 PRL 41 222 A W HENDRY (IND+LBL)IJP
-- THE ANALYSIS AND RESULTS ARE DISCUSSED MORE FULLY IN HENDRY 81.
KOCH 80 TORONTO CONF 3 R KOCH (KARL)IJP
HENDRY 81 ANP 136 1 A W HENDRY (IND)IJP

S=0 I=3/2 NUCLEON STATES (Δ)

Δ(1232) P'_{33} Status: ****

33 DELTA(1232, JP=3/2+) I=3/2 P'33

MOST OF THE RESULTS PUBLISHED BEFORE 1977 ARE NOW OBSOLETE AND HAVE BEEN OMITTED. THEY MAY BE FOUND IN OUR 1982 EDITION (PHYSICS LETTERS 111B). HOWEVER, ALL THE REFERENCES HAVE BEEN RETAINED.

IN ADDITION, RESULTS IN THIS REGION FROM PRODUCTION EXPERIMENTS, WHICH USED TO BE LISTED SEPARATELY AS THE NEXT ENTRY, HAVE BEEN ENTIRELY REMOVED.

33 DELTA(1232) MASS (MEV)

M	1233.0	2.0	HOEHLER	79	IPWA	PI N TO PI N	12/79
M	1232.0	3.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82
M++	1231.1	0.2	PEDRONI	78	DPWA	++ PI N 70-370 MEV	3/82
M++	1230.9	0.3	KOCH	80	IPWA	++ PI N TO PI N	1/82
M++	1230.6	0.2	ZIDELL	80	DPWA	++ PI N 0-350 MEV	1/82
M+	(1231.8)		BERENDS	75	IPWA	+ GAM P TO PI NUC	4/75
M+	(1231.2)		BARBOUR	78	DPWA	PI-N PHOTOPROD.	3/79
M+	1234.9	1.4	MIROSHNIC	79		+ FIT PHOTOPROD.	12/79
M+	(1231.6)		CRAWFORD	80	DPWA	PI N PHOTOPROD.	12/81
M0	1233.8	0.2	PEDRONI	78	DPWA	0 PI N 70-370 MEV	3/82
M0	1233.6	0.5	KOCH	80	IPWA	0 PI N TO PI N	1/82
M0	1232.5	0.3	ZIDELL	80	DPWA	0 PI N 0-350 MEV	1/82

33 DELTA(1232) WIDTH (MEV)

W	116.0	5.0	HOEHLER	79	IPWA	PI N TO PI N	12/79
W	120.0	5.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82
W++	111.3	0.5	PEDRONI	78	DPWA	++ PI N 70-370 MEV	3/82
W++	111.0	1.0	KOCH	80	IPWA	++ PI N TO PI N	1/82
W++	113.2	0.3	ZIDELL	80	DPWA	++ PI N 0-350 MEV	1/82
W+	(111.0)		BARBOUR	78	DPWA	PI-N PHOTOPROD.	3/79
W+	131.1	2.4	MIROSHNIC	79		+ FIT PHOTOPROD.	12/79
W+	(111.2)		CRAWFORD	80	DPWA	PI N PHOTOPROD.	12/81
W0	117.9	0.9	PEDRONI	78	DPWA	0 PI N 70-370 MEV	3/82
W0	113.0	1.5	KOCH	80	IPWA	0 PI N TO PI N	1/82
W0	121.3	0.4	ZIDELL	80	DPWA	0 PI N 0-350 MEV	1/82

33 (DELTA0) - (DELTA++) MASS DIFFERENCE (MEV)

D	A	(2.7)	(0.3)	PEDRONI	78	DPWA	PI N 70-370 MEV	3/82
D	A	REDUNDANT WITH DATA IN MASS LISTING.						
D	A	USING PI+-D AS WELL, PEDRONI 78 DETERMINE (M- - M++)+(M0 - M+)/3 =						3/82
D	A	4.6+-0.2 MEV.						3/82

33 (DELTA0) - (DELTA++) WIDTH DIFFERENCE (MEV)

WD	A	(6.6)	(1.0)	PEDRONI	78	DPWA	PI N 70-370 MEV	3/82
WD	A	REDUNDANT WITH DATA IN MASS LISTING.						2/84*

33 DELTA(1232) REAL PART OF POLE POSITION (MEV)

RE		1210.0	1.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82
R++	B	1209.6	0.5	VASAN	76		++ FIT CARTER 73	1/76
R++	B	FROM FITS TO COULOMB-BARRIER-CORRECTED CARTER 73 PHASE SHIFT.						3/79
R++	C	1210.5 TO 1210.8		VASAN	76		++ FIT CARTER 73	1/76
R++	C	FROM FITS TO CARTER 73 NUCLEAR PHASE SHIFT WITHOUT COULOMB BARRIER						3/79
R++	C	CORRECTIONS.						3/79
R++	D	(1210.4)	(0.17)	ZIDELL	78		++ FIT ZIDELL 78	3/79
R++	D	FIT TO ZIDELL 78 NUCLEAR PHASE SHIFT WITHOUT COULOMB						3/79
R++	D	BARRIER CORRECTIONS.						3/79
R++	E	1210.70	0.16	ZIDELL	80	DPWA	++ PI N 0-350 MEV	1/82
R++	E	FIT TO ZIDELL 80 NUCLEAR PHASE SHIFTS. THE ACCURACY CLAIMED ON THE						2/84*
R++	E	REAL PART IS CONSIDERABLY BETTER THAN IS ALLOWED BY UNCERTAINTIES						2/84*
R++	E	IN THE BEAM MOMENTUM.						2/84*
RE+		1208.0	2.0	CAMPBELL	76		+ FIT PHOTOPROD.	2/77
RE+		1206.9+-0.9 TO 1210.5+-1.8		MIROSHNIC	79		+ FIT PHOTOPROD.	12/79
RE0	B	1210.75	0.6	VASAN	76		0 FIT CARTER 73	1/76
RE0	C	(1210.2)		VASAN	76		0 FIT CARTER 73	1/76
RE0	D	(1209.5)	(0.41)	ZIDELL	78		0 FIT ZIDELL 78	3/79
RE0	E	1210.30	0.36	ZIDELL	80	DPWA	0 PI N 0-350 MEV	1/82

33 DELTA(1232) -IMAG PART OF POLE POSITION (MEV)

IM		50.0	1.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82
I++	B	50.4	0.5	VASAN	76		++ FIT CARTER 73	1/76
I++	C	49.9 TO 50.0		VASAN	76		++ FIT CARTER 73	1/76
I++	D	(49.745)	(0.14)	ZIDELL	78		++ FIT ZIDELL 78	3/79
I++	E	49.61	0.12	ZIDELL	80	DPWA	++ PI N 0-350 MEV	1/82
IM+		53.0	2.0	CAMPBELL	76		+ FIT PHOTOPROD.	2/77
IM+		55.6+-1.0 TO 58.3+-1.1		MIROSHNIC	79		+ FIT PHOTOPROD.	12/79
IM0	B	52.8	0.6	VASAN	76		0 FIT CARTER 73	1/76
IM0	C	52.9 TO 53.1		VASAN	76		0 FIT CARTER 73	1/76
IM0	D	(52.45)	(0.2)	ZIDELL	78		0 FIT ZIDELL 78	3/79
IM0	E	54.0	0.26	ZIDELL	80	DPWA	0 PI N 0-350 MEV	1/82

33 DELTA(1232) ABSOLUTE VALUE OF ELASTIC POLE RESIDUE (MEV)

ABS		53.0	2.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82
A++	B	52.4 TO 53.2		VASAN	76		++ FIT CARTER 73	1/76
A++	C	52.1 TO 52.4		VASAN	76		++ FIT CARTER 73	1/76
AB0	B	54.8 TO 55.0		VASAN	76		++ FIT CARTER 73	1/76
AB0	C	55.2 TO 55.3		VASAN	76		++ FIT CARTER 73	1/76

33 DELTA(1232) PHASE OF ELASTIC POLE RESIDUE (RADIANS)

PH		-0.82	0.02	CUTKOSKY	80	IPWA	PI N TO PI N	1/82
P++	B	-0.822 TO -0.833		VASAN	76		++ FIT CARTER 73	1/76
P++	C	-0.823 TO -0.830		VASAN	76		++ FIT CARTER 73	1/76
PH0	B	-0.840 TO -0.847		VASAN	76		++ FIT CARTER 73	1/76
PH0	C	-0.848 TO -0.856		VASAN	76		++ FIT CARTER 73	1/76

33 DELTA(1232) PHASE OF M1+(3/2) PHOTOPRODUCTION MULTIPOLE AMPLITUDE POLE RESIDUE

M1P	INFORMATION ON THE PHASE (AND MAGNITUDE) OF THE M1+(3/2) MULTIPOLE	12/79
M1P	AMPLITUDE POLE RESIDUE IS CONTAINED IMPLICITLY IN THE PAPER OF	12/79
M1P	MIROSHNICHENKO 79. THEY FIND THAT THE PHASE IS CONSISTENT WITH	12/79
M1P	BEING EQUAL TO THAT OF THE ELASTIC POLE RESIUDE.	12/79

33 DELTA(1232) MAGNETIC MOMENT (NUCLEAR MAGNETONS)

MM	+4.7 TO +6.7	NEFKENS	78	PI P TO PI P GAM	12/79

33 DELTA(1232) PARTIAL DECAY MODES

		DECAY MASSES
P1	DELTA(1232) INTO N PI	938+ 140
P2	DELTA(1232) INTO N GAMMA	938+ 0
P3	DELTA(1232) INTO N PI PI	938+ 140+ 140
P4	DELTA(1232) INTO NUCLEON GAMMA, HELICITY=1/2	938+ 0
P5	DELTA(1232) INTO NUCLEON GAMMA, HELICITY=3/2	938+ 0

33 DELTA(1232) BRANCHING RATIOS

R1	DELTA(1232)0 INTO (N PI)/TOTAL				(P1)	
R1	(1.0)	HOEHLER	79	IPWA	PI N TO PI N	12/79
R1	(1.0)	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

For notation, see key at front of Listings.

33 DELTA(1232) PHOTON DECAY AMPLITUDES (GEV-1/2)**

FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-REVIEW PRECEDING THE BARYON LISTINGS.

A1 DELTA(1232) INTO NUCLEON GAMMA, HELICITY=1/2 (GEV-1/2)**

A1		-0.140	0.006	METCALF	74	DPWA	PI N PHOTOPROD.	2/74
A1		-0.141	0.004	FELLER	76	DPWA	PI N PHOTOPROD.	2/77
A1		-0.136	0.002	AZNAURYAN	77	DPWA	PIO PHTPRD,SOL 1	12/79
A1		-0.139	0.002	AZNAURYAN	77	DPWA	PIO PHTPRD,SOL 2	12/79
A1		-0.142	0.007	BARBOUR	78	DPWA	PI-N PHOTOPROD.	3/79
A1	N	(-0.140)		NOELLE	78		PI-N PHOTOPROD.	1/80
A1	N	CONVERTED TO OUR CONVENTIONS USING M=1.232, W=.110 FROM NOELLE 78.						1/80
A1		-0.147	0.001	ARAI	80	DPWA	PI N PHOTO FIT 1	12/81
A1		-0.145	0.001	ARAI	80	DPWA	PI N PHOTO FIT 2	12/81
A1		-0.136	0.006	CRAWFORD	80	DPWA	PI N PHOTOPROD.	12/81
A1		-0.138	0.004	AWAJI	81	DPWA	PI N PHOTOPROD.	1/84*
A1		-0.145	0.015	CRAWFORD	83	IPWA	PI N PHOTOPROD.	1/84*

A2 DELTA(1232) INTO NUCLEON GAMMA, HELICITY=3/2 (GEV-1/2)**

A2		-0.254	0.007	METCALF	74	DPWA	PI N PHOTOPROD.	2/74
A2		-0.256	0.003	FELLER	76	DPWA	PI N PHOTOPROD.	2/77
A2		-0.255	0.002	AZNAURYAN	77	DPWA	PIO PHTPRD,SOL 1	12/79
A2		-0.256	0.002	AZNAURYAN	77	DPWA	PIO PHTPRD,SOL 2	12/79
A2		-0.271	0.010	BARBOUR	78	DPWA	PI-N PHOTOPROD.	3/79
A2	N	(-0.247)		NOELLE	78		PI-N PHOTOPROD.	1/80
A2		-0.264	0.002	ARAI	80	DPWA	PI N PHOTO FIT 1	12/81
A2		-0.261	0.002	ARAI	80	DPWA	PI N PHOTO FIT 2	12/81
A2		-0.247	0.010	CRAWFORD	80	DPWA	PI N PHOTOPROD.	12/81
A2		-0.259	0.006	AWAJI	81	DPWA	PI N PHOTOPROD.	1/84*
A2		-0.263	0.026	CRAWFORD	83	IPWA	PI N PHOTOPROD.	1/84*

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REFERENCES FOR DELTA(1232)

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 (OXF)
MICHAEL 67 PR 156 1677 — MICHAEL (RHEL)IJP
DONNACHI 68 PL 26B 161 — DONNACHIE,LOVELACE,KIRSOPP (CERN)
BERENDS 71 NP B30 575 — +WEAVER (CEA+MIT+TUFT)
CARTER 71 NP B26 445 — +WILLIAMS, BUGG, BUSSEY, DANCE (CAVE+RHEL)

ALMEHED 72 NP B40 157 — +LOVELACE (LUND+RUTG)IJP
BALL 72 PRL 28 1143 — +CAMPBELL,LEE,SHAW (UTAH+BOIS+UCI)
PDG 72 PL 39B 103 — SODING,BARTELS,+ (DESY+LBL+BRAN+CERN+HELS)IJP
BALL 73 PR D7 2789 — BALL,LEE,SHAW (UTAH+UCI)IJP
CARTER 73 NP B58 378 — CARTER,BUGG,CARTER (CAVE+LOQM)IJP
CHENG 73 PR D7 2249 — CHENG,LICHTENBERG (IND)IJP
DEVENISH 73 PL 47B 53 — DEVENISH,RANKIN,LYTH (LOUC+BONN+LANC)IJP
FONDA 73 PR D8 353 — FONDA,GHIRARDI,SHAW (ICTP-TRIESTE+TRST)IJP
MOORHOUS 73 PL 43B 44 — MOORHOUSE, OBERLACK (GLAS+LBL)IJP
NOGOVA 73 NP B61 445 — NOGOVA,PISUT(IP SLOVAK ACAD SCI+COMENIUS U)IJP
ALSO 73 NP B61 438 — NOGOVA,PISUT+(IP SLOVK ACAD SCI+COMENIUS U)IJP
ALSO 73 NP B65 544 — NOGOVA,PISUT+(IP SLOVK ACAD SCI+COMENIUS U)IJP
TSCHANG 73 NP B59 445 — TSCHANG,PARKINSON (FLOR+GAINESVILLE)IJP

HENYEY 74 PR D9 302 — HENYEY,KANE (MICH)IJP
KNIES 74 PR D9 2680 — KNIES,MOORHOUSE,OBERLACK (LBL+GLAS)IJP
METCALF 74 NP B76 253 — W J METCALF,R L WALKER (CIT)IJP
MOORHOUS 74 PR D9 1 — MOORHOUSE,OBERLACK,ROSENFELD (GLAS+LBL)IJP
OLSSON 74 LNC 10 333 — OLSSON (CERN)IJP
PFEIL 74 NP B73 166 — PFEIL,ROLLNIK,STANKOWSKI (BONN)
SPEARMAN 74 PR D10 1660 — T D SPEARMAN (TRIN)
SUZUKI 74 NP B68 413 — SUZUKI,KUROKAWA,KONDO (TOKY)

BALL 75 PR D11 1171 — J S BALL,R L GOBLE (UTAH)IJP
BERENDS 75 NP B84 342 — BERENDS,DONNACHIE (LEID+MCHS)
CRAWFORD 75 NP B97 125 — R L CRAWFORD (GLAS)IJP
GANENKO 75 SJNP 22 522 — +KRIVETS,MIROSHNICHENKO,NIKIFOROV+ (KIEV)IJP
KRIVETS 75 SJNP 20 430 — +MIROSHNICHENKO,NIKIFOROV,SANIN+ (KIEV)IJP
ALSO 74 SJNP 19 112 — KRIVETS,NIKIFOROV,SANIN,SHALATSKII (KIEV)IJP
LICHTENB 75 LNC 12 616 — D B LICHTENBERG (IND)IJP
NIGRO 75 NP B84 201 — NIGRO,SPILLANTINI,VALENTE (PADO+FRAS)

AYED 76 CEA-N-1921 — AYED (THESIS) (SACL)IJP
BARBOUR 76 NP B111 358 — I M BARBOUR,R L CRAWFORD (GLAS)IJP
CAMPBELL 76 PR D14 2431 — CAMPBELL,SHAW,BALL (BOIS+UCI+UTAH)IJP
FELLER 76 NP B104 219 — +FUKUSHIMA,HORIKAWA,KAJIKAWA+ (NAGO+OSAK)IJP
GANENKO1 76 SJNP 24 284 — +KRIVETS,MIROSHNICHENKO,NIKIFOROV+ (KIEV)IJP
GANENKO2 76 SJNP 24 594 — +GORBENKO,KRIVETS,KOLESNIKOV+ (KIEV)IJP
VASAN 76 NP B106 535 — S S VASAN (CARN)IJP
ALSO 76 NP B106 526 — S S VASAN (CARN)IJP
ZABEV 76 SJNP 24 70 — ZABEV,KUZNETSOV,STUKOV (TMSK)IJP

AZNAURYA 77 EFI-264(57)-77 — +AKOPOV,BAGDASARYAN (YERE)IJP
BARBOUR 78 NP B141 253 — BARBOUR,CRAWFORD,PARSONS (GLAS)
NEFKENS 78 PR D18 3911 — +ARMAN,BALLAGH,GLODIS,HADDOCK+ (UCLA+CATH)IJP
NOELLE 78 PTP 60 778 — P NOELLE (NAGO)
PEDRONI 78 NP A300 321 — +GABATHULER,DOMINGO,HIRT+ (SIN+GREN+KARL++)IJP
ZIDELL 78 LNC 21 140 — V S ZIDELL,R A ARNDT,L D ROPER (VPI)IJP
HOEHLER 79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1 — +KAISER,KOCH,PIETARINEN (KARL)IJP
ALSO 80 TORONTO CONF 3 — R KOCH (KARL)IJP
MIROSHNI 79 SJNP 29 94 — MIROSHNICHENKO,NIKIFOROV,SANIN+ (KHAR)IJP

ARAI 80 TORONTO CONF 93 — I ARAI (TOKY)
ALSO 82 NP B194 251 — I ARAI, H FUJII (TOKY)
CRAWFORD 80 TORONTO CONF 107 — R L CRAWFORD (GLAS)
CUTKOSKY 80 TORONTO CONF 19 — +FORSYTH,BABCOCK,KELLY,HENDRICK (CARN+LBL)IJP
KOCH 80 NP A336 331 — R KOCH, E PIETARINEN (KARL)IJP
ZIDELL 80 PR D21 1255 — V S ZIDELL,R A ARNDT,L D ROPER (VPI)IJP

AWAJI 81 BONN CONF 352 — R KAJIKAWA (TALK) (NAGO)
ALSO 82 NP B197 365 — FUJII,HAYASHII,IWATA,KAJIKAWA+ (NAGO)
CRAWFORD 83 NP B211 1 — R L CRAWFORD, W T MORTON (GLAS)

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Δ(1550) P'_{31} Status: *

110 DELTA(1550, JP=1/2+) I=3/2 P'31

THIS RESONANCE HAS NOT BEEN SEEN IN PI N --> PI N ANALYSES, AND ITS EXISTENCE IS THUS DOUBTFUL.

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110 DELTA(1550) MASS (MEV)

M	A	(1550.0)		LONGACRE	77	IPWA	PI N TO 2PI N	11/77
M	A	ALL LONGACRE77 PARAMETERS ARE FROM SOLUTION S2, EXCEPT FOR THE POLE						11/77
M	A	POSITION WHICH IS FROM SOLUTIONS S1 AND C1.						11/77
M		(1525.0)		BARNHAM	80	IPWA ++	PI N TO 2PI N	12/79
M		(1506.0)		CRAWFORD	80	DPWA	PI N PHOTOPROD.	12/81

110 DELTA(1550) WIDTH (MEV)

W	A	(110.0)		LONGACRE	77	IPWA	PI N TO 2PI N	11/77
W		(40.0)		BARNHAM	80	IPWA ++	PI N TO 2PI N	12/79
W		(137.0)		CRAWFORD	80	DPWA	PI N PHOTOPROD.	12/81

110 DELTA(1550) REAL PART OF POLE POSITION (MEV)

RE	A	1554. OR 1553.		LONGACRE	77	IPWA	PI N TO 2PI N	11/77

110 DELTA(1550) -2*IMAG PART OF POLE POSITION (MEV)

IM	A	105. OR 104.		LONGACRE	77	IPWA	PI N TO 2PI N	11/77

110 DELTA(1550) PARTIAL DECAY MODES

		DECAY MASSES
P1	DELTA(1550) INTO N PI	938+ 140
P2	DELTA(1550) INTO DELTA(1232) PI	1232+ 140
P3	DELTA(1550) INTO N RHO, S=3/2	938+ 769

110 DELTA(1550) BRANCHING RATIOS

R1 DELTA(1550) FROM N PI TO DELTA(1232) PI SQRT(P1*P2)

R1	A	(+0.11)		LONGACRE	77	IPWA	PI N TO 2PI N	11/77
R1		0.13	0.05	BARNHAM	80	IPWA ++	PI N TO 2PI N	12/79

R2 DELTA(1550) FROM N PI TO N RHO, S=3/2 SQRT(P1*P3)

R2	A	(+0.08)		LONGACRE	77	IPWA	PI N TO 2PI N	11/77
R2		0.17	0.05	BARNHAM	80	IPWA ++	PI N TO 2PI N	12/79

110 DELTA(1550) PHOTON DECAY AMPLITUDES (GEV-1/2)**

FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-REVIEW PRECEDING THE BARYON LISTINGS.

A1 DELTA(1550) INTO NUCLEON GAMMA, HELICITY=1/2 (GEV-1/2)**

A1		(0.013)		CRAWFORD	80	DPWA	PI N PHOTOPROD.	12/81
A1		0.016	0.016	CRAWFORD	83	IPWA	PI N PHOTOPROD.	1/84*

REFERENCES FOR DELTA(1550)

LONGACRE 77 NP B122 493 — LONGACRE,DOLBEAU (SACL)IJP
ALSO 76 NP B108 365 — DOLBEAU,TRIANTIS,NEVEU,CADIET (SACL)IJP
BARNHAM 80 NP B168 243 — BARNHAM,GLICKMAN,MIER-JEDRZEJOWICZ+ (LOIC)
CRAWFORD 80 TORONTO CONF 107 — R L CRAWFORD (GLAS)
CRAWFORD 83 NP B211 1 — R L CRAWFORD, W T MORTON (GLAS)

Δ(1600) P''_{33} Status: **

19 DELTA(1600, JP=3/2+) I=3/2 P''33

MOST OF THE RESULTS PUBLISHED BEFORE 1975 ARE NOW OBSOLETE AND HAVE BEEN OMITTED. THEY MAY BE FOUND IN OUR 1982 EDITION (PHYSICS LETTERS 111B). HOWEVER, ALL THE REFERENCES HAVE BEEN RETAINED.

THE AGREEMENT AMONG THE VARIOUS ANALYSES IS NOT VERY GOOD.

19 DELTA(1600) MASS (MEV)

M	A	1900. OR 1640.		LONGACRE	75	IPWA	PI N TO 2PI N	11/75
M	A	THE 2 SETS OF PARAMETERS ARE FROM METHODS 1 AND 2 OF LONGACRE 75.						11/75
M	B	(1560.0)		LONGACRE	77	IPWA	PI N TO 2PI N	11/77
M	B	ALL LONGACRE77 PARAMETERS ARE FROM SOLUTION S2, EXCEPT FOR THE POLE						11/77
M	B	POSITION WHICH IS FROM SOLUTIONS S1 AND C1.						11/77
M		(1640.0)	(50.0)	CUTKOSKY	79	IPWA	PI N TO PI N	12/79
M		1522.0	13.0	HOEHLER	79	IPWA	PI N TO PI N	12/79
M		(1690.0)		BARNHAM	80	IPWA ++	PI N TO 2PI N	12/79
M		1600.0	50.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

19 DELTA(1600) WIDTH (MEV)

W	A	205. OR 300.		LONGACRE	75	IPWA	PI N TO 2PI N	11/75
W	B	(180.0)		LONGACRE	77	IPWA	PI N TO 2PI N	11/77
W		(370.0)	(70.0)	CUTKOSKY	79	IPWA	PI N TO PI N	12/79
W		220.0	40.0	HOEHLER	79	IPWA	PI N TO PI N	12/79
W		(250.0)		BARNHAM	80	IPWA ++	PI N TO 2PI N	12/79
W		300.0	100.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

19 DELTA(1600) REAL PART OF POLE POSITION (MEV)

RE		(1609.0)		LONGACRE	75	IPWA	PI N TO 2PI N	11/75
RE	B	1541. OR 1542.		LONGACRE	77	IPWA	PI N TO 2PI N	11/77
RE		(1547.0)		CUTKOSKY	79	IPWA	PI N TO PI N	12/79
RE		1550.0	40.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

Baryons

Data Card Listings

Δ(1600), Δ(1620)

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            19  DELTA(1600) -2*IMAG PART OF POLE POSITION (MEV)

IM       (323.0)                      LONGACRE  75 IPWA    PI N TO 2PI N     11/75
IM  B     178. OR 178.0               LONGACRE  77 IPWA    PI N TO 2PI N     11/77
IM       (230.0)                      CUTKOSKY  79 IPWA    PI N TO PI N      12/79
IM        200.0      60.0             CUTKOSKY  80 IPWA    PI N TO PI N       1/82

            19  DELTA(1600) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER      (-18.0)                      CUTKOSKY  79 IPWA    PI N TO PI N      12/79
RER       -15.0       6.0             CUTKOSKY  80 IPWA    PI N TO PI N       1/82

            19  DELTA(1600) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR      (-11.0)                      CUTKOSKY  79 IPWA    PI N TO PI N      12/79
IMR        8.0        8.0             CUTKOSKY  80 IPWA    PI N TO PI N       1/82

            19  DELTA(1600) PARTIAL DECAY MODES

                                                              DECAY MASSES
P1     DELTA(1600) INTO N PI                                  938+ 140
P2     DELTA(1600) INTO SIGMA K                              1189+ 494
P3     DELTA(1600) INTO DELTA(1232) PI, P-WAVE               1232+ 140
P4     DELTA(1600) INTO DELTA(1232) PI, F-WAVE               1232+ 140
P5     DELTA(1600) INTO N RHO, S=1/2, P-WAVE                  938+ 769
P6     DELTA(1600) INTO N RHO, S=3/2, P-WAVE                  938+ 769
P7     DELTA(1600) INTO N(1440) PI                           1440+ 140

            19  DELTA(1600) BRANCHING RATIOS

R1     DELTA(1600) INTO (N PI)/TOTAL                      (P1)
R1          (0.20)   (0.04)           CUTKOSKY  79 IPWA    PI N TO PI N      12/79
R1           0.21     0.06            HOEHLER   79 IPWA    PI N TO PI N      12/79
R1           0.18     0.04            CUTKOSKY  80 IPWA    PI N TO PI N       1/82

R2     DELTA(1600) FROM N PI TO SIGMA K                   SQRT(P1*P2)
R2  C        0.006 TO 0.042           DEANS     75 DPWA    PI N TO K SIGMA   11/75
R2  C  RANGE GIVEN IS FROM FOUR BEST SOLUTIONS.                              11/75
R2  C  DEANS75 DISAGREES WITH PI+ P TO K+ SIGMA+ DATA OF WINNIK77              1/78
R2  C  AROUND 1920 MEV.                                                       1/78

R3     DELTA(1600) FROM N PI TO DELTA(1232) PI, P-WAVE    SQRT(P1*P3)
R3  A       -0.36 OR -0.30            LONGACRE  75 IPWA    PI N TO 2PI N     11/75
R3  B       (-0.34)                   LONGACRE  77 IPWA    PI N TO 2PI N     11/77
R3  B  LONGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.
R3  D       (0.3)                     NOVOSELLE 78 IPWA    PI N TO 2PI N      3/79
R3  D  BW FIT TO LONGACRE 75 IPWA, PHASE IS NEAR -90 DEGREES.                 3/79
R3  E       (0.27)                    NOVOSELLE 78 IPWA    PI N TO 2PI N      3/79
R3  E  BW FIT TO NOVOSELLER 78 IPWA, PHASE IS NEAR -90 DEGREES. THIS FIT     12/79
R3  E  ASSUMES THE MASS IS NEAR 1900 MEV.                                    12/79
R3  F       -0.24     0.05            BARNHAM   80 IPWA ++ PI N TO 2PI N     12/79
R3  F  THE COUPLING SIGNS (WHERE DETERMINED) OF BARNHAM 79 HAVE BEEN         12/79
R3  F  CHANGED TO AGREE WITH THE CONVENTION OF LONGACRE 77.                  12/79

R4     DELTA(1600) FROM N PI TO DELTA(1232) PI, F-WAVE    SQRT(P1*P4)
R4  B       (+0.07)                   LONGACRE  77 IPWA    PI N TO 2PI N     11/77

R5     DELTA(1600) FROM N PI TO N RHO, S=1/2, P-WAVE      SQRT(P1*P5)
R5  B       (-0.10)                   LONGACRE  77 IPWA    PI N TO 2PI N     11/77

R6     DELTA(1600) FROM N PI TO N RHO, S=3/2, P-WAVE      SQRT(P1*P6)
R6  B       (-0.10)                   LONGACRE  77 IPWA    PI N TO 2PI N     11/77

R7     DELTA(1600) FROM N PI TO N(1440) PI                SQRT(P1*P7)
R7  F       -0.23     0.04            BARNHAM   80 IPWA ++ PI N TO 2PI N     12/79

            19  DELTA(1600) PHOTON DECAY AMPLITUDES (GEV**-1/2)

       FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-
     REVIEW PRECEDING THE BARYON LISTINGS.

A1     DELTA(1600) INTO NUCLEON GAMMA, HELICITY=1/2 (GEV**-1/2)
A1           0.0      0.038           METCALF    74 DPWA   PI N PHOTOPROD.    2/74
A1           0.0      0.020           FELLER     76 DPWA   PI N PHOTOPROD.    2/77
A1          +0.006    0.018           AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 1 12/79
A1          -0.119    0.014           AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 2 12/79
A1           0.000    0.030           BARBOUR    78 DPWA   PI-N PHOTOPROD.    3/79
A1           0.005    0.020           CRAWFORD   80 DPWA   PI N PHOTOPROD.   12/81
A1          -0.046    0.013           AWAJI      81 DPWA   PI N PHOTOPROD.    1/84*
A1          -0.039    0.030           CRAWFORD   83 IPWA   PI N PHOTOPROD.    1/84*

A2     DELTA(1600) INTO NUCLEON GAMMA, HELICITY=3/2 (GEV**-1/2)
A2           0.0      0.033           METCALF    74 DPWA   PI N PHOTOPROD.    2/74
A2           0.0      0.015           FELLER     76 DPWA   PI N PHOTOPROD.    2/77
A2          -0.133    0.042           AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 1 12/79
A2          -0.088    0.037           AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 2 12/79
A2           0.000    0.045           BARBOUR    78 DPWA   PI-N PHOTOPROD.    3/79
A2          -0.009    0.020           CRAWFORD   80 DPWA   PI N PHOTOPROD.   12/81
A2           0.025    0.031           AWAJI      81 DPWA   PI N PHOTOPROD.    1/84*
A2          -0.013    0.014           CRAWFORD   83 IPWA   PI N PHOTOPROD.    1/84*

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REFERENCES FOR DELTA(1600)


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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
AYED2    70 PL 31B 598           +BAREYRE,VILLET                         (SACL)
BOWLER   70 NP 17B 331           +CASHMORE                                (OXF)
FEUERBAC 70 NP 16B 85            FEUERBACHER+HOLLADAY                    (VAND)
ALMEHED  72 NP B40 157           +LOVELACE                      (LUND+RUTG)IJP
DEVENISH 73 PL 47B 53            DEVENISH,RANKIN,LYTH      (LOUC+BONN+LANC)IJP
DEVENIS2 74 PL 52B 227           DEVENISH,LYTH,RANKIN      (DESY+LANC+BONN)IJP
KNIES    74 PR D9 2680           KNIES,MOORHOUSE,OBERLACK       (LBL+GLAS)IJP
METCALF  74 NP B76 253           W J METCALF,R L WALKER              (CIT)IJP

DEANS    75 NP B96 90            +MITCHELL,MONTGOMERY,+         (SFLA+ALAH)IJP
LONGACRE 75 PL 55B 415           +ROSENFELD,LASINSKI,SMADJA+    (LBL+SLAC)IJP
   ALSO  78 PR D17 1795          LONGACRE,LASINSKI,ROSENFELD+      (LBL+SLAC)
AYED     76 CEA-N-1921           AYED (THESIS)                      (SACL)IJP
FELLER   76 NP B104 219          +FUKUSHIMA,HORIKAWA,KAJIKAWA+  (NAGO+OSAK)IJP
AZNAURYA 77  EFI-264(57)-77      +AKOPOV,BAGDASARYAN                (YERE)IJP
LONGACRE 77 NP B122 493          LONGACRE,DOLBEAU                   (SACL)IJP
   ALSO  76 NP B108 365          DOLBEAU,TRIANTIS,NEVEU,CADIET      (SACL)IJP
WINNIK   77 NP B128 66           +TOAFF,REVEL,GOLDBERG,BERNY         (HAIF)I
BARBOUR  78 NP B141 253          BARBOUR,CRAWFORD,PARSONS            (GLAS)
NOVOSELL 78 NP B137 509          D E NOVOSELLER                      (CIT)IJP
   ALSO  78 NP B137 445          D E NOVOSELLER                      (CIT)IJP
CUTKOSKY 79 PR D20 2839          +FORSYTH,HENDRICK,KELLY        (CARN+LBL)IJP
HOEHLER  79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                                 +KAISER,KOCH,PIETARINEN            (KARL)IJP
   ALSO 80  TORONTO CONF 3       R KOCH                              (KARL)IJP
BARNHAM  80 NP B168 243          BARNHAM,GLICKMAN,MIER-JEDRZEJOWICZ+ (LOIC)
CRAWFORD 80  TORONTO CONF 107    R L CRAWFORD                        (GLAS)
CUTKOSKY 80  TORONTO CONF 19     +FORSYTH,BABCOCK,KELLY,HENDRICK  (CARN+LBL)IJP

AWAJI    81  BONN CONF 352       R KAJIKAWA (TALK)                   (NAGO)
   ALSO 82 NP B197 365           FUJII,HAYASHII,IWATA,KAJIKAWA+      (NAGO)
CRAWFORD 83 NP B211 1            R L CRAWFORD, W T MORTON            (GLAS)
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Δ(1620) S_{31} Status: ****

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            82  DELTA(1620, JP=1/2-) I=3/2   S'31

            MOST OF THE RESULTS PUBLISHED BEFORE 1975 ARE NOW
            OBSOLETE AND HAVE BEEN OMITTED.  THEY MAY BE FOUND IN
            OUR 1982 EDITION (PHYSICS LETTERS 111B).  HOWEVER,
            ALL THE REFERENCES HAVE BEEN RETAINED.

            82  DELTA(1620) MASS (MEV)

M    A      1625. OR 1600.            LONGACRE  75 IPWA    PI N TO 2PI N     11/75
M    A  THE 2 SETS OF PARAMETERS ARE FROM METHODS 1 AND 2 OF LONGACRE 75.    11/75
M    B     (1580.0)                   LONGACRE  77 IPWA    PI N TO 2PI N     11/77
M    B  ALL LONGACRE77 PARAMETERS ARE FROM SOLUTION S2, EXCEPT FOR THE POLE 11/77
M    B  POSITION WHICH IS FROM SOLUTIONS S1 AND C1.                          11/77
M          (1662.0)                   BARBOUR   78 DPWA    PI-N PHOTOPROD.    3/79
M          (1620.0)     (20.0)        CUTKOSKY  79 IPWA    PI N TO PI N      12/79
M           1610.0       7.0          HOEHLER   79 IPWA    PI N TO PI N      12/79
M          (1620.0)                   BARNHAM   80 IPWA ++ PI N TO 2PI N     12/79
M    C     (1712.8)     (6.0)         CHEW      80 BPWA ++ PI+P TO PI+P       1/82
M    D     (1786.7)     (2.0)         CHEW      80 BPWA ++ PI+P TO PI+P       1/82
M    CD CHEW 80 REPORTS TWO S31 RESONANCES AT SOMEWHAT HIGHER MASSES THAN     2/84*
M    CD OTHER ANALYSES.  THEY ARE LISTED HERE, AS C AND D.  PROBLEMS WITH    2/84*
M    CD THIS ANALYSIS ARE DISCUSSED IN SEC.2.1.11 OF HOEHLER 83.             2/84*
M          (1657.0)                   CRAWFORD  80 DPWA    PI N PHOTOPROD.   12/81
M           1620.0      20.0          CUTKOSKY  80 IPWA    PI N TO PI N       1/82

            82  DELTA(1620) WIDTH (MEV)

W    A      160. OR  150.             LONGACRE  75 IPWA    PI N TO 2PI N     11/75
W    B     (120.0)                    LONGACRE  77 IPWA    PI N TO 2PI N     11/77
W          (180.0)                    BARBOUR   78 DPWA    PI-N PHOTOPROD.    3/79
W          (140.0)     (20.0)         CUTKOSKY  79 IPWA    PI N TO PI N      12/79
W           139.0       18.0          HOEHLER   79 IPWA    PI N TO PI N      12/79
W          (120.0)                    BARNHAM   80 IPWA ++ PI N TO 2PI N     12/79
W    C     (228.3)     (18.0)         CHEW      80 BPWA ++ PI+P TO PI+P       1/82
W    D      (30.0)      (6.4)         CHEW      80 BPWA ++ PI+P TO PI+P       1/82
W          (161.0)                    CRAWFORD  80 DPWA    PI N PHOTOPROD.   12/81
W           140.0       20.0          CUTKOSKY  80 IPWA    PI N TO PI N       1/82

            82  DELTA(1620) REAL PART OF POLE POSITION (MEV)

RE         (1583.0)                   LONGACRE  75 IPWA    PI N TO 2PI N     11/75
RE   B      1575. OR 1572.            LONGACRE  77 IPWA    PI N TO 2PI N     11/77
RE         (1597.0)                   CUTKOSKY  79 IPWA    PI N TO PI N      12/79
RE          1600.0      15.0          CUTKOSKY  80 IPWA    PI N TO PI N       1/82

            82  DELTA(1620) -2*IMAG PART OF POLE POSITION (MEV)

IM         (143.0)                    LONGACRE  75 IPWA    PI N TO 2PI N     11/75
IM   B      119. OR 128.0             LONGACRE  77 IPWA    PI N TO 2PI N     11/77
IM         (120.0)                    CUTKOSKY  79 IPWA    PI N TO PI N      12/79
IM          120.0       20.0          CUTKOSKY  80 IPWA    PI N TO PI N       1/82

            82  DELTA(1620) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER        (-6.0)                     CUTKOSKY  79 IPWA    PI N TO PI N      12/79
RER         -5.0        5.0           CUTKOSKY  80 IPWA    PI N TO PI N       1/82

            82  DELTA(1620) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR        (-15.0)                    CUTKOSKY  79 IPWA    PI N TO PI N      12/79
IMR         -14.0       3.0           CUTKOSKY  80 IPWA    PI N TO PI N       1/82

            82  DELTA(1620) PARTIAL DECAY MODES

                                                              DECAY MASSES
P1     DELTA(1620) INTO N PI                                  938+ 140
P2     DELTA(1620) INTO N PI PI                               938+ 140+ 140
P3     DELTA(1620) INTO NUCLEON GAMMA, HELICITY=1/2           938+   0
P4     DELTA(1620) INTO DELTA(1232) PI                       1232+ 140
P5     DELTA(1620) INTO N RHO                                 938+ 769
P6     DELTA(1620) INTO N RHO, S=1/2, S-WAVE                  938+ 769
P7     DELTA(1620) INTO N RHO, S=3/2, D-WAVE                  938+ 769
P8     DELTA(1620) INTO N(1440) PI                           1440+ 140

            82  DELTA(1620) BRANCHING RATIOS

R1     DELTA(1620) INTO (N PI)/TOTAL                      (P1)
R1          (0.25)   (0.04)           CUTKOSKY  79 IPWA    PI N TO PI N      12/79
R1           0.35     0.06            HOEHLER   79 IPWA    PI N TO PI N      12/79
R1   C      (0.60)                    CHEW      80 BPWA ++ PI+P TO PI+P       1/82
R1   D      (0.36)                    CHEW      80 BPWA ++ PI+P TO PI+P       1/82
R1           0.25     0.03            CUTKOSKY  80 IPWA    PI N TO PI N       1/82

R2     DELTA(1620) FROM N PI TO DELTA(1232) PI            SQRT(P1*P4)
R2   A      +0.40 OR +0.40            LONGACRE  75 IPWA    PI N TO 2PI N     11/75
R2   B      (+0.39)                   LONGACRE  77 IPWA    PI N TO 2PI N     11/77
R2   B  LONGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.
R2   E      +0.33     0.06            BARNHAM   80 IPWA ++ PI N TO 2PI N     12/79
R2   E  THE COUPLING SIGNS (WHERE DETERMINED) OF BARNHAM 80 HAVE BEEN        12/79
R2   E  CHANGED TO AGREE WITH THE CONVENTION OF LONGACRE 77.                 12/79
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R3 DELTA(1620) FROM N PI TO N RHO, S=1/2, S-WAVE SQRT(P1*P6)

R3	A	0.18 OR -0.28		LONGACRE	75	IPWA	PI N TO 2PI N	11/75
R3	B	(-0.08)		LONGACRE	77	IPWA	PI N TO 2PI N	11/77
R3	E	-0.40	0.10	BARNHAM	80	IPWA	++ PI N TO 2PI N	12/79

R4 DELTA(1620) FROM N PI TO N RHO, S=3/2, D-WAVE SQRT(P1*P7)

R4	B	(+0.13)		LONGACRE	77	IPWA	PI N TO 2PI N	11/77

R5 DELTA(1620) FROM N PI TO N(1440) PI SQRT(P1*P8)

R5	E	0.11	0.05	BARNHAM	80	IPWA	++ PI N TO 2PI N	12/79

82 DELTA(1620) PHOTON DECAY AMPLITUDES (GEV-1/2)**

FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-REVIEW PRECEDING THE BARYON LISTINGS.

A1 DELTA(1620) INTO NUCLEON GAMMA, HELICITY=1/2 (GEV-1/2)**

A1	0.105	0.038	METCALF	74	DPWA	PI N PHOTOPROD.	2/74
A1	-0.005	0.016	FELLER	76	DPWA	PI N PHOTOPROD.	2/77
A1	-0.014	0.030	AZNAURYAN	77	DPWA	PIO PHTPRD,SOL 1	12/79
A1	0.000	0.014	AZNAURYAN	77	DPWA	PIO PHTPRD,SOL 2	12/79
A1	+0.034	0.028	BARBOUR	78	DPWA	PI-N PHOTOPROD.	3/79
A1	-0.022	0.007	ARAI	80	DPWA	PI N PHOTO FIT 1	12/81
A1	-0.026	0.008	ARAI	80	DPWA	PI N PHOTO FIT 2	12/81
A1	0.021	0.020	CRAWFORD	80	DPWA	PI N PHOTOPROD.	12/81
A1	0.126	0.021	TAKEDA	80	DPWA	PI N PHOTOPROD.	12/81
A1	0.010	0.015	AWAJI	81	DPWA	PI N PHOTOPROD.	1/84*
A1	0.035	0.010	CRAWFORD	83	IPWA	PI N PHOTOPROD.	1/84*

REFERENCES FOR DELTA(1620)

CARRUTHE 60 PRL 4 303 — P CARRUTHERS (CORN) I
DEVLIN 62 PR 125 690 — T J DEVLIN, B J MOYER, V PEREZ-MENDEZ (LRL) I
BAREYRE 65 PL 18 342 — + BRICMAN, STIRLING, VILLET (SACL)IJP
DEVLIN 65 PRL 14 1031 — T J DEVLIN,J SOLOMON,G BERTSCH (PRIN) I

JOHNSON 67 UCRL-17683 THESIS — C H JOHNSON (LRL)
BAREYRE 68 PR 165 1731 — P BAREYRE, C BRICMAN, G VILLET (SACL)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)

DONNACHI 69 NP 10B 433 — A DONNACHIE, R KIRSOPP (GLAS+EDIN)
AYED 70 KIEV CONF — R AYED,P BAREYRE, G VILLET (SACL)IJP
AYED2 70 PL 31B 598 — +BAREYRE,VILLET (SACL)
BOWLER 70 NP 17B 331 — +CASHMORE (OXF)
DAVIES 70 NP B21 359 — A DAVIES (GLAS)
ALMEHED 72 NP B40 157 — +LOVELACE (LUND+RUTG)IJP
DEVENISH 73 PL 47B 53 — DEVENISH,RANKIN,LYTH (LOUC+BONN+LANC)IJP
HEMMI1 73 PL 43B 79 — HEMMI,INAGAKI+ (KYOT+SAGA+KEK+TOKY)IJP
MOORHOUS 73 PL 43B 44 — MOORHOUSE, OBERLACK (GLAS+LBL)IJP

DEVENIS2 74 PL 52B 227 — DEVENISH,LYTH,RANKIN (DESY+LANC+BONN)IJP
KNIES 74 PR D9 2680 — KNIES,MOORHOUSE,OBERLACK (LBL+GLAS)IJP
METCALF 74 NP B76 253 — W J METCALF,R L WALKER (CIT)IJP
MOORHOUS 74 PR D9 1 — MOORHOUSE,OBERLACK,ROSENFELD (GLAS+LBL)IJP
CRAWFORD 75 NP B97 125 — R L CRAWFORD (GLAS)IJP
DEANS 75 NP B96 90 — +MITCHELL,MONTGOMERY,+ (SFLA+ALAH)IJP
KRIVETS 75 SJNP 20 430 — +MIROSHNICHENKO,NIKIFOROV,SANIN+ (KIEV)IJP
ALSO 74 SJNP 19 112 — KRIVETS,NIKIFOROV,SANIN,SHALATSKII (KIEV)IJP
LONGACRE 75 PL 55B 415 — +ROSENFELD,LASINSKI,SMADJA+ (LBL+SLAC)IJP
ALSO 78 PR D17 1795 — LONGACRE,LASINSKI,ROSENFELD+ (LBL+SLAC)

AYED 76 CEA-N-1921 — AYED (THESIS) (SACL)IJP
BARBOUR 76 NP B111 358 — I M BARBOUR,R L CRAWFORD (GLAS)IJP
FELLER 76 NP B104 219 — +FUKUSHIMA,HORIKAWA,KAJIKAWA+ (NAGO+OSAK)IJP
AZNAURYA 77 EFI-264(57)-77 — +AKOPOV,BAGDASARYAN (YERE)IJP
LONGACRE 77 NP B122 493 — LONGACRE,DOLBEAU (SACL)IJP
ALSO 76 NP B108 365 — DOLBEAU,TRIANTIS,NEVEU,CADIET (SACL)IJP
BARBOUR 78 NP B141 253 — BARBOUR,CRAWFORD,PARSONS (GLAS)
CUTKOSKY 79 PR D20 2839 — +FORSYTH,HENDRICK,KELLY (CARN+LBL)IJP
HOEHLER 79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1 — +KAISER,KOCH,PIETARINEN (KARL)IJP
ALSO 80 TORONTO CONF 3 — R KOCH (KARL)IJP

ARAI 80 TORONTO CONF 93 — I ARAI (TOKY)
ALSO 82 NP B194 251 — I ARAI, H FUJII (TOKY)
BARNHAM 80 NP B168 243 — BARNHAM,GLICKMAN,MIER-JEDRZEJOWICZ+ (LOIC)
CHEW 80 TORONTO CONF 123 — D M CHEW (LBL)IJP
CRAWFORD 80 TORONTO CONF 107 — R L CRAWFORD (GLAS)
CUTKOSKY 80 TORONTO CONF 19 — +FORSYTH,BABCOCK,KELLY,HENDRICK (CARN+LBL)IJP
TAKEDA 80 NP B168 17 — TAKEDA,ARAI,FUJII,IKEDA,IWASAKI+ (TOKY)
AWAJI 81 BONN CONF 352 — R KAJIKAWA (TALK) (NAGO)
ALSO 82 NP B197 365 — FUJII,HAYASHII,IWATA,KAJIKAWA+ (NAGO)
CRAWFORD 83 NP B211 1 — R L CRAWFORD, W T MORTON (GLAS)
HOEHLER 83 LANDOLT-BORNSTEIN VOL I 9B2 — G HOEHLER (KARL)

Δ(1700) D_{33} Status: ****

10 DELTA(1700, JP=3/2-) I=3/2 D'33

MOST OF THE RESULTS PUBLISHED BEFORE 1975 ARE NOW OBSOLETE AND HAVE BEEN OMITTED. THEY MAY BE FOUND IN OUR 1982 EDITION (PHYSICS LETTERS 111B). HOWEVER, ALL THE REFERENCES HAVE BEEN RETAINED.

10 DELTA(1700) MASS (MEV)

M	A	1725. OR 1680.			LONGACRE	75	IPWA		PI N TO 2PI N	11/75
M	A	THE 2 SETS OF PARAMETERS ARE FROM METHODS 1 AND 2 OF LONGACRE 75.								11/75
M	B	(1600.0)			LONGACRE	77	IPWA		PI N TO 2PI N	11/77
M	B	ALL LONGACRE77 PARAMETERS ARE FROM SOLUTION S2, EXCEPT FOR THE POLE								11/77
M	B	POSITION WHICH IS FROM SOLUTIONS S1 AND C1.								11/77
M		(1629.0)			BARBOUR	78	DPWA		PI-N PHOTOPROD.	3/79
M		(1730.0)	(30.0)		CUTKOSKY	79	IPWA		PI N TO PI N	12/79
M		1680.0	70.0		HOEHLER	79	IPWA		PI N TO PI N	12/79
M		(1650.0)			BARNHAM	80	IPWA	++	PI N TO 2PI N	12/79
M	C	(1718.4)	(13.1)	(13.0)	CHEW	80	BPWA	++	PI+P TO PI+P	1/82
M	C	PROBLEMS WITH THIS ANALYSIS ARE DISCUSSED IN SEC.2.1.11 OF								2/84*
M	C	HOEHLER 83.								2/84*
M		(1622.0)			CRAWFORD	80	DPWA		PI N PHOTOPROD.	12/81
M		1710.0	30.0		CUTKOSKY	80	IPWA		PI N TO PI N	1/82

10 DELTA(1700) WIDTH (MEV)

W	A	190. OR 240.		LONGACRE	75	IPWA		PI N TO 2PI N	11/75
W	B	(200.0)		LONGACRE	77	IPWA		PI N TO 2PI N	11/77
W		(216.0)		BARBOUR	78	DPWA		PI-N PHOTOPROD.	3/79
W		(300.0)	(100.0)	CUTKOSKY	79	IPWA		PI N TO PI N	12/79
W		230.0	80.0	HOEHLER	79	IPWA		PI N TO PI N	12/79
W		(160.0)		BARNHAM	80	IPWA	++	PI N TO 2PI N	12/79
W	C	(193.3)	(26.0)	CHEW	80	BPWA	++	PI+P TO PI+P	1/82
W		(209.0)		CRAWFORD	80	DPWA		PI N PHOTOPROD.	12/81
W		280.0	80.0	CUTKOSKY	80	IPWA		PI N TO PI N	1/82

10 DELTA(1700) REAL PART OF POLE POSITION (MEV)

RE		(1681.0)		LONGACRE	75	IPWA	PI N TO 2PI N	11/75
RE	B	1600. OR 1594.		LONGACRE	77	IPWA	PI N TO 2PI N	11/77
RE		(1691.0)		CUTKOSKY	79	IPWA	PI N TO PI N	12/79
RE		1675.0	25.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

10 DELTA(1700) -2*IMAG PART OF POLE POSITION (MEV)

IM		(245.0)		LONGACRE	75	IPWA	PI N TO 2PI N	11/75
IM	B	208. OR 201.0		LONGACRE	77	IPWA	PI N TO 2PI N	11/77
IM		(292.0)		CUTKOSKY	79	IPWA	PI N TO PI N	12/79
IM		220.0	40.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

10 DELTA(1700) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER	(24.0)		CUTKOSKY	79	IPWA	PI N TO PI N	12/79
RER	12.0	3.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

10 DELTA(1700) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR	(-2.0)		CUTKOSKY	79	IPWA	PI N TO PI N	12/79
IMR	-4.0	5.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

10 DELTA(1700) PARTIAL DECAY MODES

		DECAY MASSES
P1	DELTA(1700) INTO N PI	938+ 140
P2	DELTA(1700) INTO N PI PI	938+ 140+ 140
P3	DELTA(1700) INTO SIGMA K	1189+ 494
P4	DELTA(1700) INTO NUCLEON GAMMA, HELICITY=1/2	938+ 0
P5	DELTA(1700) INTO NUCLEON GAMMA, HELICITY=3/2	938+ 0
P6	DELTA(1700) INTO DELTA(1232) PI	1232+ 140
P7	DELTA(1700) INTO DELTA(1232) PI, S-WAVE	1232+ 140
P8	DELTA(1700) INTO DELTA(1232) PI, D-WAVE	1232+ 140
P9	DELTA(1700) INTO N RHO, S=3/2, S-WAVE	938+ 769
P10	DELTA(1700) INTO N RHO, S=1/2, D-WAVE	938+ 769
P11	DELTA(1700) INTO N RHO, S=3/2, D-WAVE	938+ 769

10 DELTA(1700) BRANCHING RATIOS

R1 DELTA(1700) INTO (N PI)/TOTAL (P1)

R1		(0.12)	(0.04)	CUTKOSKY	79	IPWA		PI N TO PI N	12/79
R1		0.20	0.03	HOEHLER	79	IPWA		PI N TO PI N	12/79
R1	C	(0.16)		CHEW	80	BPWA	++	PI+P TO PI+P	1/82
R1		0.12	0.03	CUTKOSKY	80	IPWA		PI N TO PI N	1/82

R2 DELTA(1700) FROM N PI TO SIGMA K SQRT(P1*P3)

R2	D	0.001 TO 0.011	DEANS	75	DPWA	PI N TO K SIGMA	11/75
R2	D	RANGE GIVEN IS FROM FOUR BEST SOLUTIONS.					11/75
R2	D	DEANS75 DISAGREES WITH PI+ P TO K+ SIGMA+ DATA OF WINNIK77					1/78
R2	D	AROUND 1920 MEV.					1/78
R2		(.002)	LIVANOS	80	DPWA	PI P TO K SIGMA	1/82

R3 DELTA(1700) FROM N PI TO DELTA(1232) PI, S-WAVE SQRT(P1*P7)

R3	A	-0.25 OR -0.24		LONGACRE	75	IPWA	PI N TO 2PI N	11/75
R3	B	(-0.30)		LONGACRE	77	IPWA	PI N TO 2PI N	11/77
R3	B	LONGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.						
R3	E	-0.18	0.04	BARNHAM	80	IPWA	++ PI N TO 2PI N	12/79
R3	E	THE COUPLING SIGNS (WHERE DETERMINED) OF BARNHAM 80 HAVE BEEN						12/79
R3	E	CHANGED TO AGREE WITH THE CONVENTION OF LONGACRE 77.						12/79

R4 DELTA(1700) FROM N PI TO DELTA(1232) PI, D-WAVE SQRT(P1*P8)

R4	A	0. OR -0.10		LONGACRE	75	IPWA	PI N TO 2PI N	11/75
R4	B	(-0.05)		LONGACRE	77	IPWA	PI N TO 2PI N	11/77
R4	E	0.14	0.04	BARNHAM	80	IPWA	++ PI N TO 2PI N	12/79

R5 DELTA(1700) FROM N PI TO N RHO, S=3/2, S-WAVE SQRT(P1*P9)

R5	A	0.20 OR +0.30		LONGACRE	75	IPWA	PI N TO 2PI N	11/75
R5	B	(-0.04)		LONGACRE	77	IPWA	PI N TO 2PI N	11/77

R6 DELTA(1700) FROM N PI TO N RHO, S=1/2, D-WAVE SQRT(P1*P10)

R6	E	-0.17	0.05	BARNHAM	80	IPWA	++ PI N TO 2PI N	12/79

R7 DELTA(1700) FROM N PI TO N RHO, S=3/2, D-WAVE SQRT(P1*P11)

R7	E	0.18	0.07	BARNHAM	80	IPWA	++ PI N TO 2PI N	12/79

10 DELTA(1700) PHOTON DECAY AMPLITUDES (GEV-1/2)**

FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-REVIEW PRECEDING THE BARYON LISTINGS.

A1 DELTA(1700) INTO NUCLEON GAMMA, HELICITY=1/2 (GEV-1/2)**

A1	0.0	0.048	METCALF	74	DPWA	PI N PHOTOPROD.	2/74
A1	+0.072	0.033	FELLER	76	DPWA	PI N PHOTOPROD.	2/77
A1	+0.147	0.013	AZNAURYAN	77	DPWA	PIO PHTPRD,SOL 1	12/79
A1	+0.136	0.013	AZNAURYAN	77	DPWA	PIO PHTPRD,SOL 2	12/79
A1	+0.130	0.037	BARBOUR	78	DPWA	PI-N PHOTOPROD.	3/79
A1	0.112	0.006	ARAI	80	DPWA	PI N PHOTO FIT 1	12/81
A1	0.130	0.006	ARAI	80	DPWA	PI N PHOTO FIT 2	12/81
A1	0.123	0.022	CRAWFORD	80	DPWA	PI N PHOTOPROD.	12/81
A1	0.089	0.033	AWAJI	81	DPWA	PI N PHOTOPROD.	1/84*
A1	0.111	0.017	CRAWFORD	83	IPWA	PI N PHOTOPROD.	1/84*

A2 DELTA(1700) INTO NUCLEON GAMMA, HELICITY=3/2 (GEV-1/2)**

A2	0.0	0.041	METCALF	74	DPWA	PI N PHOTOPROD.	2/74
A2	+0.087	0.023	FELLER	76	DPWA	PI N PHOTOPROD.	2/77
A2	+0.053	0.003	AZNAURYAN	77	DPWA	PIO PHTPRD,SOL 1	12/79
A2	+0.022	0.003	AZNAURYAN	77	DPWA	PIO PHTPRD,SOL 2	12/79
A2	+0.098	0.036	BARBOUR	78	DPWA	PI-N PHOTOPROD.	3/79
A2	0.047	0.007	ARAI	80	DPWA	PI N PHOTO FIT 1	12/81

Baryons
Δ(1700), Δ(1900), Δ(1905)

A2	0.050	0.007	ARAI	80	DPWA	PI N PHOTO FIT 2	12/81
A2	0.102	0.015	CRAWFORD	80	DPWA	PI N PHOTOPROD.	12/81
A2	0.060	0.015	AWAJI	81	DPWA	PI N PHOTOPROD.	1/84*
A2	0.107	0.015	CRAWFORD	83	IPWA	PI N PHOTOPROD.	1/84*

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REFERENCES FOR DELTA(1700)

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)
DONNACHI 69 NP 10B 433 — A DONNACHIE, R KIRSOPP (GLAS+EDIN)

AYED 70 KIEV CONF — R AYED,P BAREYRE, G VILLET (SACL)IJP
AYED2 70 PL 31B 598 — +BAREYRE,VILLET (SACL)
BOWLER 70 NP 17B 331 — +CASHMORE (OXF)
DAVIES 70 NP B21 359 — A DAVIES (GLAS)
FEUERBAC 70 NP 16B 85 — FEUERBACHER+HOLLADAY (VAND)

ALMEHED 72 NP B40 157 — +LOVELACE (LUND+RUTG)IJP
DEVENISH 73 PL 47B 53 — DEVENISH,RANKIN,LYTH (LOUC+BONN+LANC)IJP
MOORHOUS 73 PL 43B 44 — MOORHOUSE, OBERLACK (GLAS+LBL)IJP

DEVENIS2 74 PL 52B 227 — DEVENISH,LYTH,RANKIN (DESY+LANC+BONN)IJP
KNIES 74 PR D9 2680 — KNIES,MOORHOUSE,OBERLACK (LBL+GLAS)IJP
METCALF 74 NP B76 253 — W J METCALF,R L WALKER (CIT)IJP
MOORHOUS 74 PR D9 1 — MOORHOUSE,OBERLACK,ROSENFELD (GLAS+LBL)IJP

CRAWFORD 75 NP B97 125 — R L CRAWFORD (GLAS)IJP
DEANS 75 NP B96 90 — +MITCHELL,MONTGOMERY,+ (SFLA+ALAH)IJP
GAIDOS 75 PR D12 2565 — GAIDOS,MILLER (PURD)IJP
LONGACRE 75 PL 55B 415 — +ROSENFELD,LASINSKI,SMADJA+ (LBL+SLAC)IJP
ALSO 78 PR D17 1795 — LONGACRE,LASINSKI,ROSENFELD+ (LBL+SLAC)

AYED 76 CEA-N-1921 — AYED (THESIS) (SACL)IJP
BARBOUR 76 NP B111 358 — I M BARBOUR,R L CRAWFORD (GLAS)IJP
FELLER 76 NP B104 219 — +FUKUSHIMA,HORIKAWA,KAJIKAWA+ (NAGO+OSAK)IJP

AZNAURYA 77 EFI-264(57)-77 — +AKOPOV,BAGDASARYAN (YERE)IJP
LONGACRE 77 NP B122 493 — LONGACRE,DOLBEAU (SACL)IJP
ALSO 76 NP B108 365 — DOLBEAU,TRIANTIS,NEVEU,CADIET (SACL)IJP
WINNIK 77 NP B128 66 — +TOAFF,REVEL,GOLDBERG,BERNY (HAIF)I

BARBOUR 78 NP B141 253 — BARBOUR,CRAWFORD,PARSONS (GLAS)
CUTKOSKY 79 PR D20 2839 — +FORSYTH,HENDRICK,KELLY (CARN+LBL)IJP
HOEHLER 79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1 — +KAISER,KOCH,PIETARINEN (KARL)IJP
ALSO 80 TORONTO CONF 3 — R KOCH (KARL)IJP

ARAI 80 TORONTO CONF 93 — I ARAI (TOKY)
ALSO 82 NP B194 251 — I ARAI, H FUJII (TOKY)
BARNHAM 80 NP B168 243 — BARNHAM,GLICKMAN,MIER-JEDRZEJOWICZ+ (LOIC)
CHEW 80 TORONTO CONF 123 — D M CHEW (LBL)IJP
CRAWFORD 80 TORONTO CONF 107 — R L CRAWFORD (GLAS)
CUTKOSKY 80 TORONTO CONF 19 — +FORSYTH,BABCOCK,KELLY,HENDRICK (CARN+LBL)IJP
LIVANOS 80 TORONTO CONF 35 — +BATON,COUTURES,KOCHOWSKI,NEVEU (SACL)IJP

AWAJI 81 BONN CONF 352 — R KAJIKAWA (TALK) (NAGO)
ALSO 82 NP B197 365 — FUJII,HAYASHII,IWATA,KAJIKAWA+ (NAGO)
CRAWFORD 83 NP B211 1 — R L CRAWFORD, W T MORTON (GLAS)
HOEHLER 83 LANDOLT-BORNSTEIN VOL I 9B2 — G HOEHLER (KARL)

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Δ(1900) S''_{31} Status: ***

30 DELTA(1900, JP=1/2-) I=3/2 S''31

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30 DELTA(1900) MASS (MEV)

M	(1850.0)	(35.0)	CUTKOSKY	79	IPWA	PI N TO PI N	12/79
M	1908.0	30.0	HOEHLER	79	IPWA	PI N TO PI N	12/79
M	(1918.5)	(23.0)	CHEW	80	BPWA	++ PI+P TO PI+P	1/82
M	(1803.0)		CRAWFORD	80	DPWA	PI N PHOTOPROD.	12/81
M	1890.0	50.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

30 DELTA(1900) WIDTH (MEV)

W	(130.0)	(40.0)	CUTKOSKY	79	IPWA	PI N TO PI N	12/79
W	140.0	40.0	HOEHLER	79	IPWA	PI N TO PI N	12/79
W	(93.5)	(54.0)	CHEW	80	BPWA	++ PI+P TO PI+P	1/82
W	(137.0)		CRAWFORD	80	DPWA	PI N PHOTOPROD.	12/81
W	170.0	50.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

30 DELTA(1900) REAL PART OF POLE POSITION (MEV)

RE	(1844.0)		CUTKOSKY	79	IPWA	PI N TO PI N	12/79
RE	1870.0	40.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

30 DELTA(1900) -2*IMAG PART OF POLE POSITION (MEV)

IM	(142.0)		CUTKOSKY	79	IPWA	PI N TO PI N	12/79
IM	180.0	50.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

30 DELTA(1900) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER	(7.0)		CUTKOSKY	79	IPWA	PI N TO PI N	12/79
RER	9.0	4.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

30 DELTA(1900) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR	(-1.0)		CUTKOSKY	79	IPWA	PI N TO PI N	12/79
IMR	3.0	7.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

30 DELTA(1900) PARTIAL DECAY MODES

		DECAY MASSES
P1	DELTA(1900) INTO N PI	938+ 140
P2	DELTA(1900) INTO SIGMA K	1189+ 494

30 DELTA(1900) BRANCHING RATIOS

R1 DELTA(1900) INTO (N PI)/TOTAL (P1)

R1		(0.08)	(0.03)	CUTKOSKY	79	IPWA	PI N TO PI N	12/79
R1		0.08	0.04	HOEHLER	79	IPWA	PI N TO PI N	12/79
R1		(0.28)		CHEW	80	BPWA	++ PI+P TO PI+P	1/82
R1		0.10	0.03	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

R2 DELTA(1900) FROM N PI TO SIGMA K SQRT(P1*P2)

R2		(0.11)		LANGBEIN	73	IPWA	PI N-K SIG,SOL 1	9/73
R2		(0.12)		LANGBEIN	73	IPWA	PI N-K SIG,SOL 2	9/73
R2	A	(0.076)		DEANS	75	DPWA	PI N TO K SIGMA	11/75

R2 A VALUE GIVEN IS FROM SOLUTION 1, NOT PRESENT IN SOLUTIONS 2,3,4. 11/75

30 DELTA(1900) PHOTON DECAY AMPLITUDES (GEV**-1/2)

FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-REVIEW PRECEDING THE BARYON LISTINGS.

A1 DELTA(1900) INTO NUCLEON GAMMA, HELICITY=1/2 (GEV**-1/2)

A1		-0.006 TO -0.025		CRAWFORD	80	DPWA	PI N PHOTOPROD.	12/81
A1		0.029	0.008	AWAJI	81	DPWA	PI N PHOTOPROD.	1/84*
A1		-0.004	0.016	CRAWFORD	83	IPWA	PI N PHOTOPROD.	1/84*
A1		. . . . . .	. . . . .					
A1	AVG	0.022	0.013	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.8)				

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REFERENCES FOR DELTA(1900)

LANGBEIN 73 NP B53 251 — LANGBEIN,WAGNER (MUNI)IJP
DEANS 75 NP B96 90 — +MITCHELL,MONTGOMERY,+ (SFLA+ALAH)IJP
AYED 76 CEA-N-1921 — AYED (THESIS) (SACL)IJP
WINNIK 77 NP B128 66 — +TOAFF,REVEL,GOLDBERG,BERNY (HAIF)I
CUTKOSKY 79 PR D20 2839 — +FORSYTH,HENDRICK,KELLY (CARN+LBL)IJP
HOEHLER 79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1 — +KAISER,KOCH,PIETARINEN (KARL)IJP
ALSO 80 TORONTO CONF 3 — R KOCH (KARL)IJP

CHEW 80 TORONTO CONF 123 — D M CHEW (LBL)IJP
CRAWFORD 80 TORONTO CONF 107 — R L CRAWFORD (GLAS)
CUTKOSKY 80 TORONTO CONF 19 — +FORSYTH,BABCOCK,KELLY,HENDRICK (CARN+LBL)IJP

AWAJI 81 BONN CONF 352 — R KAJIKAWA (TALK) (NAGO)
ALSO 82 NP B197 365 — FUJII,HAYASHII,IWATA,KAJIKAWA+ (NAGO)
CRAWFORD 83 NP B211 1 — R L CRAWFORD, W T MORTON (GLAS)

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Δ(1905) F_{35} Status: ****

11 DELTA(1905, JP=5/2+) I=3/2 F35

MOST OF THE RESULTS PUBLISHED BEFORE 1975 ARE NOW OBSOLETE AND HAVE BEEN OMITTED. THEY MAY BE FOUND IN OUR 1982 EDITION (PHYSICS LETTERS 111B). HOWEVER, ALL THE REFERENCES HAVE BEEN RETAINED.

CUTKOSKY 80 ALSO FINDS WEAK EVIDENCE FOR A HIGHER MASS F35 RESONANCE IN ADDITION TO THIS STATE. BOTH RESONANCES ARE LISTED HERE FOR NOW.

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11 DELTA(1905) MASS (MEV)

M	A	1870. OR 1830.			LONGACRE	75	IPWA	PI N TO 2PI N	11/75
M	A	THE 2 SETS OF PARAMETERS ARE FROM METHODS 1 AND 2 OF LONGACRE 75.							11/75
M		(1892.0)			BARBOUR	78	DPWA	PI-N PHOTOPROD.	3/79
M		(1920.0)	(30.0)		CUTKOSKY	79	IPWA	PI N TO PI N	12/79
M		1905.0	20.0		HOEHLER	79	IPWA	PI N TO PI N	12/79
M		(1787.0)	(6.0)	(5.7)	CHEW	80	BPWA	++ PI+P TO PI+P	1/82
M		(1880.0)			CRAWFORD	80	DPWA	PI N PHOTOPROD.	12/81
M	B	1910.0	30.0		CUTKOSKY	80	IPWA	PI N TO PI N	1/82
M	C	2200.0	125.0		CUTKOSKY	80	IPWA	PI N TO PI N	1/82
M	BC	CUTKOSKY 80 FINDS A HIGHER MASS F35 RESONANCE AS WELL AS THE ONE IN							1/82
M	BC	THIS MASS REGION. THEY ARE LISTED HERE AS B AND C.							1/82

11 DELTA(1905) WIDTH (MEV)

W	A	255. OR 220.			LONGACRE	75	IPWA	PI N TO 2PI N	11/75
W		(159.0)			BARBOUR	78	DPWA	PI-N PHOTOPROD.	3/79
W		(340.0)	(80.0)		CUTKOSKY	79	IPWA	PI N TO PI N	12/79
W		260.0	20.0		HOEHLER	79	IPWA	PI N TO PI N	12/79
W		(66.0)	(24.0)	(16.0)	CHEW	80	BPWA	++ PI+P TO PI+P	1/82
W		(193.0)			CRAWFORD	80	DPWA	PI N PHOTOPROD.	12/81
W	B	400.0	100.0		CUTKOSKY	80	IPWA	PI N TO PI N	1/82
W	C	400.0	125.0		CUTKOSKY	80	IPWA	PI N TO PI N	1/82

11 DELTA(1905) REAL PART OF POLE POSITION (MEV)

RE		(1813.0)		LONGACRE	75	IPWA	PI N TO 2PI N	11/75
RE		(1865.0)		CUTKOSKY	79	IPWA	PI N TO PI N	12/79
RE	B	1830.0	40.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82
RE	C	2150.0	100.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

11 DELTA(1905) -2*IMAG PART OF POLE POSITION (MEV)

IM		(193.0)		LONGACRE	75	IPWA	PI N TO 2PI N	11/75
IM		(266.0)		CUTKOSKY	79	IPWA	PI N TO PI N	12/79
IM	B	280.0	60.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82
IM	C	350.0	100.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

For notation, see key at front of Listings.


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          11  DELTA(1905) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER          (20.0)                  CUTKOSKY  79 IPWA    PI N TO PI N     12/79
RER   B       16.0      8.0          CUTKOSKY  80 IPWA    PI N TO PI N      1/82
RER   C      -14.0     13.0          CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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          11  DELTA(1905) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR          (-5.0)                  CUTKOSKY  79 IPWA    PI N TO PI N     12/79
IMR   B     -19.0       8.0          CUTKOSKY  80 IPWA    PI N TO PI N      1/82
IMR   C       8.0      22.0          CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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          11  DELTA(1905) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      DELTA(1905) INTO N PI                            938+ 140
P2      DELTA(1905) INTO N PI PI                         938+ 140+ 140
P3      DELTA(1905) INTO SIGMA K                        1189+ 494
P4      DELTA(1905) INTO DELTA(1232) PI                 1232+ 140
P5      DELTA(1905) INTO NUCLEON GAMMA, HELICITY=1/2     938+   0
P6      DELTA(1905) INTO NUCLEON GAMMA, HELICITY=3/2     938+   0
P7      DELTA(1905) INTO N RHO                           938+ 769
P8      DELTA(1905) INTO DELTA(1232) PI, P-WAVE         1232+ 140
P9      DELTA(1905) INTO DELTA(1232) PI, F-WAVE         1232+ 140
P10     DELTA(1905) INTO N RHO, S=3/2, P-WAVE            938+ 769

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          11  DELTA(1905) BRANCHING RATIOS

R1      DELTA(1905) INTO (N PI)/TOTAL                       (P1)
R1           (0.15)    (0.02)        CUTKOSKY  79 IPWA    PI N TO PI N     12/79
R1            0.15      0.02         HOEHLER   79 IPWA    PI N TO PI N     12/79
R1           (0.11)                  CHEW      80 BPWA ++ PI+P TO PI+P      1/82
R1    B       0.08      0.03         CUTKOSKY  80 IPWA    PI N TO PI N      1/82
R1    C       0.07      0.04         CUTKOSKY  80 IPWA    PI N TO PI N      1/82

R2      DELTA(1905) FROM N PI TO SIGMA K                   SQRT(P1*P3)
R2  D        0.021 TO 0.054          DEANS     75 DPWA    PI N TO K SIGMA  11/75
R2  D    RANGE GIVEN IS FROM FOUR BEST SOLUTIONS.                          11/75
R2          (-0.013)                 LIVANOS   80 DPWA    PI P TO K SIGMA   1/82

R3      DELTA(1905) FROM N PI TO DELTA(1232) PI, F-WAVE  SQRT(P1*P9)
R3    A       -0.12 OR -0.20         LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R3    E     (-0.17)                  NOVOSELLE 78 IPWA    PI N TO 2PI N     3/79
R3    E  BW FIT TO LONGACRE 75 IPWA.                                        3/79
R3    F     (-0.06)                  NOVOSELLE 78 IPWA    PI N TO 2PI N     3/79
R3    F  BW FIT TO NOVOSELLER 78 IPWA.                                      3/79

R4      DELTA(1905) FROM N PI TO N RHO, S=3/2, P-WAVE    SQRT(P1*P10)
R4    A       -0.28 OR -0.33         LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R4    E     (-0.26)                  NOVOSELLE 78 IPWA    PI N TO 2PI N     3/79
R4    G       -0.11 TO -0.33         NOVOSELLE 78 IPWA    PI N TO 2PI N     3/79
R4    G  BW FIT TO NOVOSELLER 78 IPWA, PHASE IS NEAR 90 DEGREES.           12/79

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          11  DELTA(1905) PHOTON DECAY AMPLITUDES (GEV**-1/2)

   FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-
 REVIEW PRECEDING THE BARYON LISTINGS.

A1      DELTA(1905) INTO NUCLEON GAMMA, HELICITY=1/2 (GEV**-1/2)
A1          +0.047     0.067         METCALF   74 DPWA    PI N PHOTOPROD.   2/74
A1          -0.001     0.012         AZNAURYAN 77 DPWA    PI0 PHTPRD,SOL 1 12/79
A1          +0.063     0.018         AZNAURYAN 77 DPWA    PI0 PHTPRD,SOL 2 12/79
A1          +0.033     0.018         BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
A1           0.022     0.010         ARAI      80 DPWA    PI N PHOTO FIT 1 12/81
A1           0.031     0.009         ARAI      80 DPWA    PI N PHOTO FIT 2 12/81
A1           0.024     0.014         CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
A1           0.043     0.020         AWAJI     81 DPWA    PI N PHOTOPROD.   1/84*
A1           0.021     0.010         CRAWFORD  83 IPWA    PI N PHOTOPROD.   1/84*

A2      DELTA(1905) INTO NUCLEON GAMMA, HELICITY=3/2 (GEV**-1/2)
A2          -0.028     0.066         METCALF   74 DPWA    PI N PHOTOPROD.   2/74
A2          -0.094     0.027         AZNAURYAN 77 DPWA    PI0 PHTPRD,SOL 1 12/79
A2          -0.101     0.018         AZNAURYAN 77 DPWA    PI0 PHTPRD,SOL 2 12/79
A2          -0.055     0.019         BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
A2          -0.029     0.007         ARAI      80 DPWA    PI N PHOTO FIT 1 12/81
A2          -0.045     0.006         ARAI      80 DPWA    PI N PHOTO FIT 2 12/81
A2          -0.072     0.035         CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
A2          -0.025     0.023         AWAJI     81 DPWA    PI N PHOTOPROD.   1/84*
A2          -0.056     0.028         CRAWFORD  83 IPWA    PI N PHOTOPROD.   1/84*

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REFERENCES FOR DELTA(1905)


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DONNACH1 68 PL 26B 161        A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
    ALSO 68 VIENNA 139        DONNACHIE  RAPPORTEUR'S TALK          (GLAS)
    ALSO 68 THESIS            R G KIRSOPP                           (EDIN)

AYED     70 KIEV CONF         R AYED,P BAREYRE, G VILLET            (SACL)IJP
AYED2    70 PL 31B 598        +BAREYRE,VILLET                       (SACL)
DAVIES   70 NP B21 359        A DAVIES                              (GLAS)
FEUERBAC 70 NP 16B 85         FEUERBACHER+HOLLADAY                  (VAND)
KALMUS   70 PR D2 1824        G KALMUS, G BORREANI, J LOUIE          (LRL)

ALMEHED  72 NP B40 157        +LOVELACE                        (LUND+RUTG)IJP
MEHTANI  72 PRL 29 1634       +FUNG, KERNAN, SCHALK, +          (UCR +LBL)
LANGBEIN 73 NP B53 251        LANGBEIN,WAGNER                       (MUNI)IJP
DEVENIS2 74 PL 52B 227        DEVENISH,LYTH,RANKIN        (DESY+LANC+BONN)IJP
KNIES    74 PR D9 2680        KNIES,MOORHOUSE,OBERLACK          (LBL+GLAS)IJP
METCALF  74 NP B76 253        W J METCALF,R L WALKER                 (CIT)IJP

CRAWFORD 75 NP B97 125        R L CRAWFORD                          (GLAS)IJP
DEANS    75 NP B96 90         +MITCHELL,MONTGOMERY,+           (SFLA+ALAH)IJP
LONGACRE 75 PL 55B 415        +ROSENFELD,LASINSKI,SMADJA+       (LBL+SLAC)IJP
    ALSO 78 PR D17 1795       LONGACRE,LASINSKI,ROSENFELD+      (LBL+SLAC)

AYED     76 CEA-N-1921        AYED (THESIS)                         (SACL)IJP
BARBOUR  76 NP B111 358       I M BARBOUR,R L CRAWFORD              (GLAS)IJP
CUTKOSKY 76 PRL 37 645        CUTKOSKY,HENDRICK,KELLY           (CARN+LBL)IJP
    ALSO 76 OXFORD CONF. 49   CUTKOSKY,HENDRICK,CHAO+      (CARN+LBL+BRIS)IJP
AZNAURYA 77  EFI-264(57)-77   +AKOPOV,BAGDASARYAN                   (YERE)IJP
WINNIK   77 NP B128 66        +TOAFF,REVEL,GOLDBERG,BERNY           (HAIF)I

BARBOUR  78 NP B141 253       BARBOUR,CRAWFORD,PARSONS              (GLAS)
NOVOSELL 78 NP B137 509       D E NOVOSELLER                         (CIT)IJP
    ALSO 78 NP B137 445       D E NOVOSELLER                         (CIT)IJP

CUTKOSKY 79 PR D20 2839       +FORSYTH,HENDRICK,KELLY           (CARN+LBL)IJP
HOEHLER  79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                              +KAISER,KOCH,PIETARINEN               (KARL)IJP
    ALSO 80  TORONTO CONF 3   R KOCH                                (KARL)IJP

ARAI     80  TORONTO CONF 93  I ARAI                                (TOKY)
    ALSO 82 NP B194 251       I ARAI, H FUJII                       (TOKY)
CHEW     80  TORONTO CONF 123 D M CHEW                               (LBL)IJP
CRAWFORD 80  TORONTO CONF 107 R L CRAWFORD                          (GLAS)
CUTKOSKY 80  TORONTO CONF 19  +FORSYTH,BABCOCK,KELLY,HENDRICK  (CARN+LBL)IJP
LIVANOS  80  TORONTO CONF 35  +BATON,COUTURES,KOCHOWSKI,NEVEU       (SACL)IJP

AWAJI    81  BONN CONF 352    R KAJIKAWA (TALK)                     (NAGO)
    ALSO 82 NP B197 365       FUJII,HAYASHII,IWATA,KAJIKAWA+        (NAGO)
CRAWFORD 83 NP B211 1         R L CRAWFORD, W T MORTON              (GLAS)
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Δ(1910) P''_{31} Status: ****

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          12  DELTA(1910, JP=1/2+) I=*/2   P''31

          MOST OF THE RESULTS PUBLISHED BEFORE 1975 ARE NOW
          OBSOLETE AND HAVE BEEN OMITTED.  THEY MAY BE FOUND IN
          OUR 1982 EDITION (PHYSICS LETTERS 111B).  HOWEVER,
          ALL THE REFERENCES HAVE BEEN RETAINED.

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          12  DELTA(1910) MASS (MEV)

M    A     (1790.0)                 LONGACRE  77 IPWA    PI N TO 2PI N    11/77
M    A   ALL LONGACRE77 PARAMETERS ARE FROM SOLUTION S2, EXCEPT FOR THE POLE 11/77
M    A   POSITION WHICH IS FROM SOLUTIONS S1 AND C1.                       11/77
M          (1899.0)                 BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
M          (1920.0)    (50.0)       CUTKOSKY  79 IPWA    PI N TO PI N     12/79
M           1888.0      20.0        HOEHLER   79 IPWA    PI N TO PI N     12/79
M    B     (1715.2)    (21.0)       CHEW      80 BPWA ++ PI+P TO PI+P      1/82
M    C     (1778.4)     (9.0)       CHEW      80 BPWA ++ PI+P TO PI+P      1/82
M    D     (1960.1)    (21.0)       CHEW      80 BPWA ++ PI+P TO PI+P      1/82
M    E     (2121.4)    (13.0)  (14.3) CHEW    80 BPWA ++ PI+P TO PI+P      1/82
M    BC  CHEW 80 REPORTS FOUR RESONANCES IN THE P31 WAVE.  ALL ARE LISTED  2/84*
M    DE  HERE LABELED B-E.  PROBLEMS WITH THIS ANALYSIS ARE DISCUSSED IN   2/84*
M    DE  SEC.2.1.11 OF HOEHLER 83.                                         2/84*
M          (1921.0)                 CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
M           1910.0      40.0        CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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          12  DELTA(1910) WIDTH (MEV)

W    A      (170.0)                 LONGACRE  77 IPWA    PI N TO 2PI N    11/77
W           (230.0)                 BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
W           (300.0)   (100.0)       CUTKOSKY  79 IPWA    PI N TO PI N     12/79
W            280.0      50.0        HOEHLER   79 IPWA    PI N TO PI N     12/79
W    B       (93.3)    (55.0)       CHEW      80 BPWA ++ PI+P TO PI+P      1/82
W    C       (23.0)    (29.0)       CHEW      80 BPWA ++ PI+P TO PI+P      1/82
W    D      (152.9)    (60.0)       CHEW      80 BPWA ++ PI+P TO PI+P      1/82
W    E      (172.2)    (37.0)       CHEW      80 BPWA ++ PI+P TO PI+P      1/82
W           (351.0)                 CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
W            225.0      50.0        CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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          12  DELTA(1910) REAL PART OF POLE POSITION (MEV)

RE   A      1792. OR 1801.0         LONGACRE  77 IPWA    PI N TO 2PI N    11/77
RE         (1871.0)                 CUTKOSKY  79 IPWA    PI N TO PI N     12/79
RE          1880.0      30.0        CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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          12  DELTA(1910) -2*IMAG PART OF POLE POSITION (MEV)

IM   A       172.  OR 165.          LONGACRE  77 IPWA    PI N TO 2PI N    11/77
IM          (200.0)                 CUTKOSKY  79 IPWA    PI N TO PI N     12/79
IM           200.0      40.0        CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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          12  DELTA(1910) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER          (-0.6)                 CUTKOSKY  79 IPWA    PI N TO PI N     12/79
RER            0.0      10.0        CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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          12  DELTA(1910) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR         (-18.0)                 CUTKOSKY  79 IPWA    PI N TO PI N     12/79
IMR          -20.0       4.0        CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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          12  DELTA(1910) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      DELTA(1910) INTO N PI                            938+ 140
P2      DELTA(1910) INTO N PI PI                         938+ 140+ 140
P3      DELTA(1910) INTO SIGMA K                        1189+ 494
P4      DELTA(1910) INTO DELTA(1232) PI                 1232+ 140
P5      DELTA(1910) INTO NUCLEON GAMMA, HELICITY=1/2     938+   0
P6      DELTA(1910) INTO N RHO,S=*/2                     938+ 769

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          12  DELTA(1910) BRANCHING RATIOS

R1      DELTA(1910) INTO (N PI)/TOTAL                      (P1)
R1           (0.19)    (0.04)       CUTKOSKY  79 IPWA    PI N TO PI N     12/79
R1            0.24      0.06        HOEHLER   79 IPWA    PI N TO PI N     12/79
R1   B       (0.18)                 CHEW      80 BPWA ++ PI+P TO PI+P      1/82
R1   C       (0.20)                 CHEW      80 BPWA ++ PI+P TO PI+P      1/82
R1   D       (0.17)                 CHEW      80 BPWA ++ PI+P TO PI+P      1/82
R1   E       (0.40)                 CHEW      80 BPWA ++ PI+P TO PI+P      1/82
R1            0.19      0.03        CUTKOSKY  80 IPWA    PI N TO PI N      1/82

R2      DELTA(1910) FROM N PI TO SIGMA K                  SQRT(P1*P3)
R2   F       0.082 TO 0.184         DEANS     75 DPWA    PI N TO K SIGMA  11/75
R2   F   RANGE GIVEN IS FROM FOUR BEST SOLUTIONS.                         11/75
R2          (-0.019)                LIVANOS   80 DPWA    PI P TO K SIGMA   1/82
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Baryons — Data Card Listings

Δ(1910), Δ(1920), Δ(1930)

R3 DELTA(1910) FROM N PI TO DELTA(1232) PI SQRT(P1*P4)
R3 A (-0.06) LONGACRE 77 IPWA PI N TO 2PI N 11/77

R4 DELTA(1910) FROM N PI TO N RHO, S=3/2 SQRT(P1*P6)
R4 A (-0.29) LONGACRE 77 IPWA PI N TO 2PI N 11/77
R4 G (-0.17) NOVOSELLE 78 IPWA PI N TO 2PI N 3/79
R4 G EVIDENCE FOR THIS COUPLING IS WEAK, SEE NOVOSELLER 78. THIS 12/79
R4 G COUPLING ASSUMES THE MASS IS NEAR 1820 MEV. 12/79

12 DELTA(1910) PHOTON DECAY AMPLITUDES (GEV**-1/2)

FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-REVIEW PRECEDING THE BARYON LISTINGS.

A1 DELTA(1910) INTO NUCLEON GAMMA, HELICITY=1/2 (GEV**-1/2)
A1 -0.032 0.065 METCALF 74 DPWA PI N PHOTOPROD. 2/74
A1 +0.040 0.013 AZNAURYAN 77 DPWA PIO PHTPRD,SOL 1 12/79
A1 +0.039 0.012 AZNAURYAN 77 DPWA PIO PHTPRD,SOL 2 12/79
A1 -0.035 0.021 BARBOUR 78 DPWA PI-N PHOTOPROD. 3/79
A1 -0.012 0.005 ARAI 80 DPWA PI N PHOTO FIT 1 12/81
A1 -0.031 0.004 ARAI 80 DPWA PI N PHOTO FIT 2 12/81
A1 -0.005 0.030 CRAWFORD 80 DPWA PI N PHOTOPROD. 12/81
A1 0.025 0.011 AWAJI 81 DPWA PI N PHOTOPROD. 1/84*
A1 0.014 0.030 CRAWFORD 83 IPWA PI N PHOTOPROD. 1/84*

REFERENCES FOR DELTA(1910)

CARYANN 65 PR 138 B433 CARAYANNOPOULOS,TAUTFEST,WILLMANN (PURD)
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
AYED2 70 PL 31B 598 +BAREYRE,VILLET (SACL)
DAVIES 70 NP B21 359 A DAVIES (GLAS)
FEUERBAC 70 NP 16B 85 FEUERBACHER+HOLLADAY (VAND)
ALMEHED 72 NP B40 157 +LOVELACE (LUND+RUTG)IJP
LANGBEIN 73 NP B53 251 LANGBEIN,WAGNER (MUNI)IJP

DEVENIS2 74 PL 52B 227 DEVENISH,LYTH,RANKIN (DESY+LANC+BONN)IJP
KNIES 74 PR D9 2680 KNIES,MOORHOUSE,OBERLACK (LBL+GLAS)IJP
METCALF 74 NP B76 253 W J METCALF,R L WALKER (CIT)IJP
CRAWFORD 75 NP B97 125 R L CRAWFORD (GLAS)IJP
DEANS 75 NP B96 90 +MITCHELL,MONTGOMERY,+ (SFLA+ALAH)IJP
AYED 76 CEA-N-1921 AYED (THESIS) (SACL)IJP
BARBOUR 76 NP B111 358 I M BARBOUR,R L CRAWFORD (GLAS)IJP
CUTKOSKY 76 PRL 37 645 CUTKOSKY,HENDRICK,KELLY (CARN+LBL)IJP
ALSO 76 OXFORD CONF. 49 CUTKOSKY,HENDRICK,CHAO+ (CARN+LBL+BRIS)IJP

AZNAURYA 77 EFI-264(57)-77 +AKOPOV,BAGDASARYAN (YERE)IJP
LONGACRE 77 NP B122 493 LONGACRE,DOLBEAU (SACL)IJP
ALSO 76 NP B108 365 DOLBEAU,TRIANTIS,NEVEU,CADIET (SACL)IJP
WINNIK 77 NP B128 66 +TOAFF,REVEL,GOLDBERG,BERNY (HAIF)I
BARBOUR 78 NP B141 253 BARBOUR,CRAWFORD,PARSONS (GLAS)
NOVOSELL 78 NP B137 509 D E NOVOSELLER (CIT)IJP
ALSO 78 NP B137 445 D E NOVOSELLER (CIT)IJP
CUTKOSKY 79 PR D20 2839 +FORSYTH,HENDRICK,KELLY (CARN+LBL)IJP
HOEHLER 79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
+KAISER,KOCH,PIETARINEN (KARL)IJP
ALSO 80 TORONTO CONF 3 R KOCH (KARL)IJP

ARAI 80 TORONTO CONF 93 I ARAI (TOKY)
ALSO 82 NP B194 251 I ARAI, H FUJII (TOKY)
CHEW 80 TORONTO CONF 123 D M CHEW (LBL)IJP
CRAWFORD 80 TORONTO CONF 107 R L CRAWFORD (GLAS)
CUTKOSKY 80 TORONTO CONF 19 +FORSYTH,BABCOCK,KELLY,HENDRICK (CARN+LBL)IJP
LIVANOS 80 TORONTO CONF 35 +BATON,COUTURES,KOCHOWSKI,NEVEU (SACL)IJP

AWAJI 81 BONN CONF 352 R KAJIKAWA (TALK) (NAGO)
ALSO 82 NP B197 365 FUJII,HAYASHII,IWATA,KAJIKAWA+ (NAGO)
CRAWFORD 83 NP B211 1 R L CRAWFORD, W T MORTON (GLAS)
HOEHLER 83 LANDOLT-BORNSTEIN VOL I 9B2 G HOEHLER (KARL)

Δ(1920) P‴33 Status: ***

117 DELTA(1920, JP=3/2+) I=3/2 P'''33

MOST OF THE RESULTS PUBLISHED BEFORE 1975 ARE NOW OBSOLETE AND HAVE BEEN OMITTED. THEY MAY BE FOUND IN OUR 1982 EDITION (PHYSICS LETTERS 111B). HOWEVER, ALL THE REFERENCES HAVE BEEN RETAINED.

117 DELTA(1920) MASS (MEV)

M (1960.0) (80.0) CUTKOSKY 79 IPWA PI N TO PI N 12/79
M 1868.0 10.0 HOEHLER 79 IPWA PI N TO PI N 12/79
M A (1955.0) (13.0) CHEW 80 BPWA ++ PI+P TO PI+P 1/82
M B (2065.0) (13.6) (12.9) CHEW 80 BPWA ++ PI+P TO PI+P 1/82
M AB CHEW 80 REPORTS TWO P33 RESONANCES IN THIS MASS REGION. BOTH ARE 2/84*
M AB LISTED HERE, LABELED A AND B. PROBLEMS WITH THIS ANALYSIS ARE 2/84*
M AB DISCUSSED IN SEC.2.1.11 OF HOEHLER 83. 2/84*
M 1920.0 80.0 CUTKOSKY 80 IPWA PI N TO PI N 1/82

117 DELTA(1920) WIDTH (MEV)

W (300.0) (100.0) CUTKOSKY 79 IPWA PI N TO PI N 12/79
W 220.0 80.0 HOEHLER 79 IPWA PI N TO PI N 12/79
W A (88.3) (35.0) CHEW 80 BPWA ++ PI+P TO PI+P 1/82
W B (62.0) (44.0) CHEW 80 BPWA ++ PI+P TO PI+P 1/82
W 300.0 100.0 CUTKOSKY 80 IPWA PI N TO PI N 1/82

117 DELTA(1920) REAL PART OF POLE POSITION (MEV)

RE (1933.0) CUTKOSKY 79 IPWA PI N TO PI N 12/79
RE 1900.0 80.0 CUTKOSKY 80 IPWA PI N TO PI N 1/82

117 DELTA(1920) -2*IMAG PART OF POLE POSITION (MEV)

IM (280.0) CUTKOSKY 79 IPWA PI N TO PI N 12/79
IM 300.0 100.0 CUTKOSKY 80 IPWA PI N TO PI N 1/82

117 DELTA(1920) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER (-10.0) CUTKOSKY 79 IPWA PI N TO PI N 12/79
RER -21.0 7.0 CUTKOSKY 80 IPWA PI N TO PI N 1/82

117 DELTA(1920) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR (-27.0) CUTKOSKY 79 IPWA PI N TO PI N 12/79
IMR -12.0 11.0 CUTKOSKY 80 IPWA PI N TO PI N 1/82

117 DELTA(1920) PARTIAL DECAY MODES

DECAY MASSES
P1 DELTA(1920) INTO N PI 938+ 140
P2 DELTA(1920) INTO SIGMA K 1189+ 494

117 DELTA(1920) BRANCHING RATIOS

R1 DELTA(1920) INTO (N PI)/TOTAL (P1)
R1 (0.17) (0.04) CUTKOSKY 79 IPWA PI N TO PI N 12/79
R1 0.14 0.04 HOEHLER 79 IPWA PI N TO PI N 12/79
R1 A (0.24) CHEW 80 BPWA ++ PI+P TO PI+P 1/82
R1 B (0.18) CHEW 80 BPWA ++ PI+P TO PI+P 1/82
R1 0.20 0.05 CUTKOSKY 80 IPWA PI N TO PI N 1/82

R2 DELTA(1920) FROM N PI TO SIGMA K SQRT(P1*P2)
R2 C 0.048 TO 0.120 DEANS 75 DPWA PI N TO K SIGMA 11/75
R2 C RANGE GIVEN IS FROM FOUR BEST SOLUTIONS. 11/75
R2 (-0.049) LIVANOS 80 DPWA PI P TO K SIGMA 1/82

117 DELTA(1920) PHOTON DECAY AMPLITUDES (GEV**-1/2)

FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-REVIEW PRECEDING THE BARYON LISTINGS.

A1 DELTA(1920) INTO NUCLEON GAMMA, HELICITY=1/2 (GEV**-1/2)
A1 0.040 0.014 AWAJI 81 DPWA PI N PHOTOPROD. 1/84*

A2 DELTA(1920) INTO NUCLEON GAMMA, HELICITY=3/2 (GEV**-1/2)
A2 0.023 0.017 AWAJI 81 DPWA PI N PHOTOPROD. 1/84*

REFERENCES FOR DELTA(1920)

KIRSOPP 68 THESIS R G KIRSOPP (EDIN)
ROYCHOUD 71 NP B27 125 R K ROYCHOUDHURY,B H BRANSDEN (DURH)IJP
ALMEHED 72 NP B40 157 +LOVELACE (LUND+RUTG)IJP
LANGBEIN 73 NP B53 251 LANGBEIN,WAGNER (MUNI)IJP
DEANS 75 NP B96 90 +MITCHELL,MONTGOMERY,+ (SFLA+ALAH)IJP
CUTKOSKY 79 PR D20 2839 +FORSYTH,HENDRICK,KELLY (CARN+LBL)IJP
HOEHLER 79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
+KAISER,KOCH,PIETARINEN (KARL)IJP
ALSO 80 TORONTO CONF 3 R KOCH (KARL)IJP

CHEW 80 TORONTO CONF 123 D M CHEW (LBL)IJP
CUTKOSKY 80 TORONTO CONF 19 +FORSYTH,BABCOCK,KELLY,HENDRICK (CARN+LBL)IJP
LIVANOS 80 TORONTO CONF 35 +BATON,COUTURES,KOCHOWSKI,NEVEU (SACL)IJP
AWAJI 81 BONN CONF 352 R KAJIKAWA (TALK) (NAGO)
ALSO 82 NP B197 365 FUJII,HAYASHII,IWATA,KAJIKAWA+ (NAGO)
HOEHLER 83 LANDOLT-BORNSTEIN VOL I 9B2 G HOEHLER (KARL)

Δ(1930) D′35 Status: ***

13 DELTA(1930, JP=5/2-) I=3/2 D'35

MOST OF THE RESULTS PUBLISHED BEFORE 1975 ARE NOW OBSOLETE AND HAVE BEEN OMITTED. THEY MAY BE FOUND IN OUR 1982 EDITION (PHYSICS LETTERS 111B). HOWEVER, ALL THE REFERENCES HAVE BEEN RETAINED.

THE AGREEMENT AMONG THE VARIOUS ANALYSES IS NOT VERY GOOD.

13 DELTA(1930) MASS (MEV)

M (2024.0) BARBOUR 78 DPWA PI-N PHOTOPROD. 3/79
M (1930.0) (20.0) CUTKOSKY 79 IPWA PI N TO PI N 12/79
M 1901.0 15.0 HOEHLER 79 IPWA PI N TO PI N 12/79
M (1910.0) (15.0) (17.2) CHEW 80 BPWA ++ PI+P TO PI+P 1/82
M (2000.0) CRAWFORD 80 DPWA PI N PHOTOPROD. 12/81
M 1940.0 30.0 CUTKOSKY 80 IPWA PI N TO PI N 1/82

13 DELTA(1930) WIDTH (MEV)

W (462.0) BARBOUR 78 DPWA PI-N PHOTOPROD. 3/79
W (280.0) (90.0) CUTKOSKY 79 IPWA PI N TO PI N 12/79
W 195.0 60.0 HOEHLER 79 IPWA PI N TO PI N 12/79
W (74.8) (17.0) (16.0) CHEW 80 BPWA ++ PI+P TO PI+P 1/82
W (442.0) CRAWFORD 80 DPWA PI N PHOTOPROD. 12/81
W 320.0 60.0 CUTKOSKY 80 IPWA PI N TO PI N 1/82

13 DELTA(1930) REAL PART OF POLE POSITION (MEV)

RE (1908.0) CUTKOSKY 79 IPWA PI N TO PI N 12/79
RE 1890.0 50.0 CUTKOSKY 80 IPWA PI N TO PI N 1/82

13 DELTA(1930) -2*IMAG PART OF POLE POSITION (MEV)

IM (226.0) CUTKOSKY 79 IPWA PI N TO PI N 12/79
IM 260.0 60.0 CUTKOSKY 80 IPWA PI N TO PI N 1/82

13 DELTA(1930) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER (13.0) CUTKOSKY 79 IPWA PI N TO PI N 12/79
RER 17.0 7.0 CUTKOSKY 80 IPWA PI N TO PI N 1/82

For notation, see key at front of Listings.

Baryons
Δ(1930), Δ(1940), Δ(1950)

13 DELTA(1930) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR	(2.0)		CUTKOSKY	79	IPWA	PI N TO PI N	12/79
IMR	-6.0	12.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

13 DELTA(1930) PARTIAL DECAY MODES

		DECAY MASSES
P1	DELTA(1930) INTO N PI	938+ 140
P2	DELTA(1930) INTO SIGMA K	1189+ 494

13 DELTA(1930) BRANCHING RATIOS

R1 DELTA(1930) INTO (N PI)/TOTAL (P1)

R1	(0.12)	(0.03)	CUTKOSKY	79	IPWA	PI N TO PI N	12/79
R1	0.04	0.03	HOEHLER	79	IPWA	PI N TO PI N	12/79
R1	(0.11)		CHEW	80	BPWA	++ PI+P TO PI+P	1/82
R1	0.14	0.04	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

R2 DELTA(1930) FROM N PI TO SIGMA K SQRT(P1*P2)

R2 A	0.018 TO 0.035		DEANS	75	DPWA	PI N TO K SIGMA	11/75
R2 A	RANGE GIVEN IS FROM FOUR BEST SOLUTIONS.						11/75
R2	(-0.031)		LIVANOS	80	DPWA	PI P TO K SIGMA	1/82

13 DELTA(1930) PHOTON DECAY AMPLITUDES (GEV**-1/2)

FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-REVIEW PRECEDING THE BARYON LISTINGS.

A1 DELTA(1930) INTO NUCLEON GAMMA, HELICITY=1/2 (GEV**-1/2)

A1	-0.062	0.064	BARBOUR	78	DPWA	PI-N PHOTOPROD.	3/79
A1	-0.038	0.047	CRAWFORD	80	DPWA	PI-N PHOTOPROD.	12/81
A1	0.009	0.009	AWAJI	81	DPWA	PI N PHOTOPROD.	1/84*

A2 DELTA(1930) INTO NUCLEON GAMMA, HELICITY=3/2 (GEV**-1/2)

A2	+0.019	0.054	BARBOUR	78	DPWA	PI-N PHOTOPROD.	3/79
A2	-0.023	0.080	CRAWFORD	80	DPWA	PI N PHOTOPROD.	12/81
A2	-0.025	0.011	AWAJI	81	DPWA	PI N PHOTOPROD.	1/84*

REFERENCES FOR DELTA(1930)

DONNACHI1 68 PL 26B 161 — A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
KIRSOPP 68 THESIS — R G KIRSOPP (EDIN)

DONNACHI 69 NP 10B 433 — A DONNACHIE, R KIRSOPP (GLAS+EDIN)
LEA 69 PL 29B 584 — LEA,OADES,WARD,COWAN,+ (RHEL+BRIS+DARE)
AYED 70 PL 31B 598 — +BAREYRE,VILLET (SACL)
FEUERBAC 70 NP 16B 85 — FEUERBACHER+HOLLADAY (VAND)
APLIN 71 NP B32 253 — +COWAN,GIBSON,GILMORE++ (RHEL+BRIS)
ALMEHED 72 NP B40 157 — +LOVELACE (LUND+RUTG)IJP
LANGBEIN 73 NP B53 251 — LANGBEIN,WAGNER (MUNI)IJP

CRAWFORD 75 NP B97 125 — R L CRAWFORD (GLAS)IJP
DEANS 75 NP B96 90 — +MITCHELL,MONTGOMERY,+ (SFLA+ALAH)IJP

AYED 76 CEA-N-1921 — AYED (THESIS) (SACL)IJP
BARBOUR 76 NP B111 358 — I M BARBOUR,R L CRAWFORD (GLAS)IJP
CUTKOSKY 76 PRL 37 645 — CUTKOSKY,HENDRICK,KELLY (CARN+LBL)IJP
ALSO 76 OXFORD CONF. 49 — CUTKOSKY,HENDRICK,CHAO+ (CARN+LBL+BRIS)IJP
WINNIK 77 NP B128 66 — +TOAFF,REVEL,GOLDBERG,BERNY (HAIF)I
BARBOUR 78 NP B141 253 — BARBOUR,CRAWFORD,PARSONS (GLAS)
CUTKOSKY 79 PR D20 2839 — +FORSYTH,HENDRICK,KELLY (CARN+LBL)IJP
HOEHLER 79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1 — +KAISER,KOCH,PIETARINEN (KARL)IJP
ALSO 80 TORONTO CONF 3 — R KOCH (KARL)IJP
CHEW 80 TORONTO CONF 123 — D M CHEW (LBL)IJP
CRAWFORD 80 TORONTO CONF 107 — R L CRAWFORD (GLAS)
CUTKOSKY 80 TORONTO CONF 19 — +FORSYTH,BABCOCK,KELLY,HENDRICK (CARN+LBL)IJP
LIVANOS 80 TORONTO CONF 35 — +BATON,COUTURES,KOCHOWSKI,NEVEU (SACL)IJP

AWAJI 81 BONN CONF 352 — R KAJIKAWA (TALK) (NAGO)
ALSO 82 NP B197 365 — FUJII,HAYASHII,IWATA,KAJIKAWA+ (NAGO)
CRAWFORD 83 NP B211 1 — R L CRAWFORD, W T MORTON (GLAS)

Δ(1940) D''_{33} Status: *

136 DELTA(1940, JP=3/2-) I=3/2 D''33

136 DELTA(1940) MASS (MEV)

M	1940.0	100.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82
M	(2058.1)	(34.5)	CHEW	80	BPWA	++ PI+P TO PI+P	1/82

136 DELTA(1940) WIDTH (MEV)

W	200.0	100.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82
W	(198.4)	(45.5)	CHEW	80	BPWA	++ PI+P TO PI+P	1/82

136 DELTA(1940) REAL PART OF POLE POSITION (MEV)

RE	1900.0	100.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

136 DELTA(1940) -2*IMAG PART OF POLE POSITION (MEV)

IM	200.0	60.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

136 DELTA(1940) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER	-6.0	5.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

136 DELTA(1940) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR	6.0	5.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

136 DELTA(1940) PARTIAL DECAY MODES

		DECAY MASSES
P1	DELTA(1940) INTO N PI	938+ 140

136 DELTA(1940) BRANCHING RATIOS

R1 DELTA(1940) INTO (N PI)/TOTAL (P1)

R1	0.05	0.02	CUTKOSKY	80	IPWA	PI N TO PI N	1/82
R1	(0.18)		CHEW	80	BPWA	++ PI+P TO PI+P	1/82

136 DELTA(1940) PHOTON DECAY AMPLITUDES (GEV**-1/2)

FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-REVIEW PRECEDING THE BARYON LISTINGS.

A1 DELTA(1940) INTO NUCLEON GAMMA, HELICITY=1/2 (GEV**-1/2)

A1	-0.036	0.058	AWAJI	81	DPWA	PI N PHOTOPROD.	1/84*

A2 DELTA(1940) INTO NUCLEON GAMMA, HELICITY=3/2 (GEV**-1/2)

A2	-0.031	0.012	AWAJI	81	DPWA	PI N PHOTOPROD.	1/84*

REFERENCES FOR DELTA(1940)

CHEW 80 TORONTO CONF 123 — D M CHEW (LBL)IJP
CUTKOSKY 80 TORONTO CONF 19 — +FORSYTH,BABCOCK,KELLY,HENDRICK (CARN+LBL)IJP
AWAJI 81 BONN CONF 352 — R KAJIKAWA (TALK) (NAGO)
ALSO 82 NP B197 365 — FUJII,HAYASHII,IWATA,KAJIKAWA+ (NAGO)

Δ(1950) F'_{37} Status: ****

83 DELTA(1950, JP=7/2+) I=3/2 F'37

MOST OF THE RESULTS PUBLISHED BEFORE 1975 ARE NOW OBSOLETE AND HAVE BEEN OMITTED. THEY MAY BE FOUND IN OUR 1982 EDITION (PHYSICS LETTERS 111B). HOWEVER, ALL THE REFERENCES HAVE BEEN RETAINED.

IN ADDITION, RESULTS IN THIS REGION FROM PRODUCTION EXPERIMENTS, WHICH USED TO BE LISTED SEPARATELY AS THE NEXT ENTRY, HAVE BEEN ENTIRELY REMOVED.

83 DELTA(1950) MASS (MEV)

M A	1930. OR 1925.			LONGACRE	75	IPWA	PI N TO 2PI N	11/75
M A	THE 2 SETS OF PARAMETERS ARE FROM METHODS 1 AND 2 OF LONGACRE 75.							11/75
M	(1912.0)			BARBOUR	78	DPWA	PI-N PHOTOPROD.	3/79
M	(1950.0)	(20.0)		CUTKOSKY	79	IPWA	PI N TO PI N	12/79
M	1913.0	8.0		HOEHLER	79	IPWA	PI N TO PI N	12/79
M	(1855.0)	(11.0)	(10.0)	CHEW	80	BPWA	++ PI+P TO PI+P	1/82
M	(1902.0)			CRAWFORD	80	DPWA	PI N PHOTOPROD.	12/81
M	1950.0	15.0		CUTKOSKY	80	IPWA	PI N TO PI N	1/82

83 DELTA(1950) WIDTH (MEV)

W A	235. OR 240.			LONGACRE	75	IPWA	PI N TO 2PI N	11/75
W	(198.0)			BARBOUR	78	DPWA	PI-N PHOTOPROD.	3/79
W	(340.0)	(60.0)		CUTKOSKY	79	IPWA	PI N TO PI N	12/79
W	224.0	10.0		HOEHLER	79	IPWA	PI N TO PI N	12/79
W	(157.2)	(22.0)	(19.0)	CHEW	80	BPWA	++ PI+P TO PI+P	1/82
W	(225.0)			CRAWFORD	80	DPWA	PI N PHOTOPROD.	12/81
W	340.0	50.0		CUTKOSKY	80	IPWA	PI N TO PI N	1/82

83 DELTA(1950) REAL PART OF POLE POSITION (MEV)

RE	(1924.0)		LONGACRE	75	IPWA	PI N TO 2PI N	11/75
RE	(1892.0)		CUTKOSKY	79	IPWA	PI N TO PI N	12/79
RE	1890.0	15.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

83 DELTA(1950) -2*IMAG PART OF POLE POSITION (MEV)

IM	(258.0)		LONGACRE	75	IPWA	PI N TO 2PI N	11/75
IM	(248.0)		CUTKOSKY	79	IPWA	PI N TO PI N	12/79
IM	260.0	40.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

83 DELTA(1950) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER	(43.0)		CUTKOSKY	79	IPWA	PI N TO PI N	12/79
RER	42.0	7.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

83 DELTA(1950) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR	(-24.0)		CUTKOSKY	79	IPWA	PI N TO PI N	12/79
IMR	-27.0	7.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

83 DELTA(1950) PARTIAL DECAY MODES

		DECAY MASSES
P1	DELTA(1950) INTO N PI	938+ 140
P2	DELTA(1950) INTO SIGMA K	1189+ 494
P3	DELTA(1950) INTO DELTA(1232) PI	1232+ 140
P4	DELTA(1950) INTO SIGMA(1385) K	1385+ 494
P5	DELTA(1950) INTO DELTA(1232) RHO	1232+ 769
P6	DELTA(1950) INTO NEUTRON PI+ PI+	940+ 140+ 140
P7	DELTA(1950) INTO DELTA(1232) PI PI (NOT RHO)	1232+ 140+ 140
P8	DELTA(1950) INTO NUCLEON GAMMA, HELICITY=1/2	938+ 0
P9	DELTA(1950) INTO NUCLEON GAMMA, HELICITY=3/2	938+ 0

Baryons

Data Card Listings

Δ(1950), Δ(2150), Δ(2200)

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P10     DELTA(1950) INTO N RHO                                     938+ 769
P11     DELTA(1950) INTO DELTA(1232) PI, F-WAVE                   1232+ 140
P12     DELTA(1950) INTO DELTA(1232) PI, H-WAVE                   1232+ 140
P13     DELTA(1950) INTO N RHO, S=3/2, F-WAVE                      938+ 769
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                     83  DELTA(1950) BRANCHING RATIOS

R1       DELTA(1950) INTO (N PI)/TOTAL                      (P1)
R1            (0.40)    (0.02)       CUTKOSKY  79 IPWA    PI N TO PI N     12/79
R1             0.38      0.02        HOEHLER   79 IPWA    PI N TO PI N     12/79
R1            (0.44)                 CHEW      80 BPWA ++ PI+P TO PI+P      1/82
R1             0.39      0.04        CUTKOSKY  80 IPWA    PI N TO PI N      1/82

R2       DELTA(1950) FROM N PI TO SIGMA K                   SQRT(P1*P2)
R2   B         0.022 TO 0.040        DEANS     75 DPWA    PI N TO K SIGMA  11/75
R2   B    RANGE GIVEN IS FROM FOUR BEST SOLUTIONS.                         11/75
R2   B    DEANS75 AND LANGBEIN73 DISAGREE WITH PI+ P TO K+ SIGMA+ DATA OF   1/78
R2   B    WINNIK77 AROUND 1920 MEV.                                         1/78

R3       DELTA(1950) FROM N PI TO DELTA(1232) PI, F-WAVE  SQRT(P1*P11)
R3    A       -0.25 OR -0.32         LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R3    C       (0.21)                 NOVOSELLE 78 IPWA    PI N TO 2PI N     3/79
R3    C   BW FIT TO LONGACRE 75 IPWA, PHASE IS NEAR -60 DEGREES.            3/79
R3    D       (0.38)                 NOVOSELLE 78 IPWA    PI N TO 2PI N     3/79
R3    D   BW FIT TO NOVOSELLER 78 IPWA, PHASE IS NEAR -60 DEGREES.          3/79

R4       DELTA(1950) FROM N PI TO N RHO, S=3/2, F-WAVE    SQRT(P1*P13)
R4    A        0.18 OR -0.24         LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R4    E       (0.24)                 NOVOSELLE 78 IPWA    PI N TO 2PI N     3/79
R4    E   BW FIT TO LONGACRE 75 IPWA, PHASE IS NEAR 120 DEGREES.            3/79
R4    F       (0.43)                 NOVOSELLE 78 IPWA    PI N TO 2PI N     3/79
R4    F   BW FIT TO NOVOSELLER 78 IPWA, PHASE IS NEAR 120 DEGREES.          3/79
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                  83  DELTA(1950) PHOTON DECAY AMPLITUDES (GEV**-1/2)

      FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-
    REVIEW PRECEDING THE BARYON LISTINGS.

A1      DELTA(1950) INTO NUCLEON GAMMA, HELICITY=1/2 (GEV**-1/2)
A1            -0.059     0.029      METCALF   74 DPWA    PI N PHOTOPROD.   2/74
A1            -0.078     0.008      AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 1 12/79
A1            -0.132     0.015      AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 2 12/79
A1            -0.058     0.013      BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
A1            -0.091     0.005      ARAI      80 DPWA    PI N PHOTO FIT 1 12/81
A1            -0.083     0.005      ARAI      80 DPWA    PI N PHOTO FIT 2 12/81
A1            -0.067     0.014      CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
A1            -0.068     0.007      AWAJI     81 DPWA    PI N PHOTOPROD.   1/84*

A2      DELTA(1950) INTO NUCLEON GAMMA, HELICITY=3/2 (GEV**-1/2)
A2            -0.093     0.024      METCALF   74 DPWA    PI N PHOTOPROD.   2/74
A2            -0.160     0.016      AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 1 12/79
A2            -0.169     0.015      AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 2 12/79
A2            -0.075     0.020      BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
A2            -0.101     0.005      ARAI      80 DPWA    PI N PHOTO FIT 1 12/81
A2            -0.100     0.005      ARAI      80 DPWA    PI N PHOTO FIT 2 12/81
A2            -0.082     0.017      CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
A2            -0.094     0.016      AWAJI     81 DPWA    PI N PHOTOPROD.   1/84*
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                         REFERENCES FOR DELTA(1950)

HOELHER  63 NP 48 470          G HOEHLER, G EBEL                      (KARL) 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
HOEHLER  64 PL 12 149          G HOEHLER, J GIESECKE                  (KARL) I
DUKE     65 PRL 15 468         +JONES,KEMP,MURPHY,PRENTICE, +    (RHEL+OXF)IJP
HOLLADAY 65 PR 139 B1348       W G HOLLADAY                           (VAND)
YOKOSAWA 66 PRL 16 714         +SUWA, HILL, ESTERLING, BOOTH     (ANL+CHIC)IJP
JOHNSON  67 UCRL-17683 THESIS C H JOHNSON                             (LRL)
BAREYRE  68 PR 165 1731        P BAREYRE, C BRICMAN, G VILLET         (SACL)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)
DONNACHI 69 NP 10B 433         A DONNACHIE, R KIRSOPP            (GLAS+EDIN)

AYED     70 KIEV CONF          R AYED,P BAREYRE, G VILLET             (SACL)IJP
AYED2    70 PL 31B 598         +BAREYRE,VILLET                        (SACL)
DAVIES   70 NP B21 359         A DAVIES                               (GLAS)
FEUERBAC 70 NP 16B 85          FEUERBACHER+HOLLADAY                   (VAND)
KALMUS   70 PR D2 1824         G KALMUS, G BORREANI, J LOUIE           (LRL)
ROYCHOUD 71 NP B27 125         R A ROYCHOUDHURY,B H BRANSDEN          (DURH)IJP
ALMEHED  72 NP B40 157         +LOVELACE                         (LUND+RUTG)IJP
MEHTANI  72 PRL 29 1634        +FUNG, KERNAN, SCHALK, +           (UCR +LBL)
LANGBEIN 73 NP B53 251         LANGBEIN,WAGNER                        (MUNI)IJP
DEVENIS2 74 PL 52B 227         DEVENISH,LYTH,RANKIN         (DESY+LANC+BONN)IJP
AYED     74 PRIVATE COMM.      AYED,BAREYRE                           (SACL)IJP
    ALSO 73 AIX CONFERENCE     AYED,BAREYRE                           (SACL)IJP
KNIES    74 PR D9 2680         KNIES,MOORHOUSE,OBERLACK           (LBL+GLAS)IJP
METCALF  74 NP B76 253         W J METCALF,R L WALKER                  (CIT)IJP
MOORHOUS 74 PR D9 1            MOORHOUSE,OBERLACK,ROSENFELD       (GLAS+LBL)IJP

CRAWFORD 75 NP B97 125         R L CRAWFORD                           (GLAS)IJP
DEANS    75 NP B96 90          +MITCHELL,MONTGOMERY,+            (SFLA+ALAH)IJP
LONGACRE 75 PL 55B 415         +ROSENFELD,LASINSKI,SMADJA+        (LBL+SLAC)IJP
    ALSO 78 PR D17 1795        LONGACRE,LASINSKI,ROSENFELD+       (LBL+SLAC)
AYED     76 CEA-N-1921         AYED (THESIS)                          (SACL)IJP
BARBOUR  76 NP B111 358        I M BARBOUR,R L CRAWFORD               (GLAS)IJP
CUTKOSKY 76 PRL 37 645         CUTKOSKY,HENDRICK,KELLY            (CARN+LBL)IJP
    ALSO 76 OXFORD CONF. 49    CUTKOSKY,HENDRICK,CHAO+       (CARN+LBL+BRIS)IJP
VASAN2   76 NP B106 526        S S VASAN                              (CARN)IJP
AZNAURYA 77  EFI-264(57)-77    +AKOPOV,BAGDASARYAN                    (YERE)IJP
WINNIK   77 NP B128 66         +TOAFF,REVEL,GOLDBERG,BERNY            (HAIF)I
BARBOUR  78 NP B141 253        BARBOUR,CRAWFORD,PARSONS               (GLAS)
NOVOSELL 78 NP B137 509        D E NOVOSELLER                          (CIT)IJP
    ALSO 78 NP B137 445        D E NOVOSELLER                          (CIT)IJP

CUTKOSKY 79 PR D20 2839        +FORSYTH,HENDRICK,KELLY            (CARN+LBL)IJP
HOEHLER  79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                               +KAISER,KOCH,PIETARINEN                (KARL)IJP
    ALSO 80  TORONTO CONF 3    R KOCH                                 (KARL)IJP
ARAI     80  TORONTO CONF 93   I ARAI                                 (TOKY)
    ALSO 82 NP B194 251        I ARAI, H FUJII                        (TOKY)
CHEW     80  TORONTO CONF 123 D M CHEW                                 (LBL)IJP
CRAWFORD 80  TORONTO CONF 107 R L CRAWFORD                            (GLAS)
CUTKOSKY 80  TORONTO CONF 19   +FORSYTH,BABCOCK,KELLY,HENDRICK    (CARN+LBL)IJP

AWAJI    81  BONN CONF 352     R KAJIKAWA (TALK)                      (NAGO)
    ALSO 82 NP B197 365        FUJII,HAYASHII,IWATA,KAJIKAWA+         (NAGO)
CRAWFORD 83 NP B211 1          R L CRAWFORD, W T MORTON               (GLAS)

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Δ(2150) S_{31}''' Status: *

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  ———>      137  DELTA(2150, JP=1/2-) I=3/2  S'''31

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                     137  DELTA(2150) MASS (MEV)

M          2150.0     100.0        CUTKOSKY  80 IPWA    PI N TO PI N       1/82
M     A   (2047.4)    (27.0)       CHEW      80 BPWA ++ PI+P TO PI+P       1/82
M     B   (2203.2)     (8.4)       CHEW      80 BPWA ++ PI+P TO PI+P       1/82
M     AB  CHEW 80 REPORTS TWO S31 RESONANCES IN THIS MASS REGION LABELED   1/82
M     AB  A AND B.  PROBLEMS WITH THIS ANALYSIS ARE DISCUSSED IN SEC.2.1.11 2/84*
M     AB  HOEHLER 83.                                                      2/84*
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                     137  DELTA(2150) WIDTH (MEV)

W           200.0     100.0        CUTKOSKY  80 IPWA    PI N TO PI N       1/82
W     A    (121.6)    (62.0)       CHEW      80 BPWA ++ PI+P TO PI+P       1/82
W     B    (120.5)    (45.0)       CHEW      80 BPWA ++ PI+P TO PI+P       1/82
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              137  DELTA(2150) REAL PART OF POLE POSITION (MEV)

RE         2140.0      80.0        CUTKOSKY  80 IPWA    PI N TO PI N       1/82
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              137  DELTA(2150) -2*IMAG PART OF POLE POSITION (MEV)

IM          200.0      80.0        CUTKOSKY  80 IPWA    PI N TO PI N       1/82
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              137  DELTA(2150) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER           4.0      10.0        CUTKOSKY  80 IPWA    PI N TO PI N       1/82
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              137  DELTA(2150) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR          -6.0       6.0        CUTKOSKY  80 IPWA    PI N TO PI N       1/82
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                     137  DELTA(2150) PARTIAL DECAY MODES

                                                              DECAY MASSES
P1        DELTA(2150) INTO N PI                               938+ 140
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                     137  DELTA(2150) BRANCHING RATIOS

R1        DELTA(2150) INTO (N PI)/TOTAL                      (P1)
R1             0.08      0.02      CUTKOSKY  80 IPWA    PI N TO PI N       1/82
R1    A       (0.41)               CHEW      80 BPWA ++ PI+P TO PI+P       1/82
R1    B       (0.37)               CHEW      80 BPWA ++ PI+P TO PI+P       1/82
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                         REFERENCES FOR DELTA(2150)

CHEW     80  TORONTO CONF 123 D M CHEW                                (LBL)IJP
CUTKOSKY 80  TORONTO CONF 19  +FORSYTH,BABCOCK,KELLY,HENDRICK    (CARN+LBL)IJP
HOEHLER  83 LANDOLT-BORNSTEIN VOL I 9B2        G HOEHLER              (KARL)

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Δ(2200) G_{37} Status: *

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  ———>      135  DELTA(2200, JP=7/2-) I=3/2  G37

   THE AGREEMENT AMONG THE VARIOUS ANALYSES IS NOT VERY GOOD.

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                     135  DELTA(2200) MASS (MEV)

M          2280.0      80.0        HENDRY    78 MPWA    PI N TO PI N       1/82
M         (2200.0)                 CUTKOSKY  79 IPWA    PI N TO PI N       1/82
M          2215.0      60.0        HOEHLER   79 IPWA    PI N TO PI N       1/82
M          2200.0      80.0        CUTKOSKY  80 IPWA    PI N TO PI N       1/82
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                     135  DELTA(2200) WIDTH (MEV)

W           400.0     150.0        HENDRY    78 MPWA    PI N TO PI N       1/82
W          (350.0)                 CUTKOSKY  79 IPWA    PI N TO PI N       1/82
W           400.0     100.0        HOEHLER   79 IPWA    PI N TO PI N       1/82
W           450.0     100.0        CUTKOSKY  80 IPWA    PI N TO PI N       1/82
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              135  DELTA(2200) REAL PART OF POLE POSITION  (MEV)

RE        (2094.0)                 CUTKOSKY  79 IPWA    PI N TO PI N       1/82
RE         2100.0      50.0        CUTKOSKY  80 IPWA    PI N TO PI N       1/82
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              135  DELTA(2200) -2*IMAG PART OF POLE POSITION  (MEV)

IM         (294.0)                 CUTKOSKY  79 IPWA    PI N TO PI N       1/82
IM          340.0      80.0        CUTKOSKY  80 IPWA    PI N TO PI N       1/82
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              135  DELTA(2200) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER          (2.0)                 CUTKOSKY  79 IPWA    PI N TO PI N       1/82
RER           3.0       5.0        CUTKOSKY  80 IPWA    PI N TO PI N       1/82
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135 DELTA(2200) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR	(-7.0)		CUTKOSKY	79	IPWA	PI N TO PI N	1/82
IMR	-8.0	3.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

135 DELTA(2200) PARTIAL DECAY MODES

		DECAY MASSES
P1	DELTA(2200) INTO N PI	938+ 140

135 DELTA(2200) BRANCHING RATIOS

R1 DELTA(2200) INTO (N PI)/TOTAL (P1)

R1	0.09	0.02	HENDRY	78	MPWA	PI N TO PI N	1/82
R1	(0.05)		CUTKOSKY	79	IPWA	PI N TO PI N	1/82
R1	0.05	0.02	HOEHLER	79	IPWA	PI N TO PI N	1/82
R1	0.06	0.02	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

REFERENCES FOR DELTA(2200)

HENDRY 78 PRL 41 222 A W HENDRY (IND+LBL)IJP
-- THE ANALYSIS AND RESULTS ARE DISCUSSED MORE FULLY IN HENDRY 81.
CUTKOSKY 79 PR D20 2839 +FORSYTH,HENDRICK,KELLY (CARN+LBL)IJP
HOEHLER 79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1 +KAISER,KOCH,PIETARINEN (KARL)IJP
ALSO 80 TORONTO CONF 3 R KOCH (KARL)IJP
CUTKOSKY 80 TORONTO CONF 19 +FORSYTH,BABCOCK,KELLY,HENDRICK (CARN+LBL)IJP
HENDRY 81 ANP 136 1 A W HENDRY (IND)

Δ(2300) H_{39} Status: **

→ **123 DELTA(2300, JP=9/2+) I=3/2 H39**

123 DELTA(2300) MASS (MEV)

M	2450.0	100.0	HENDRY	78	MPWA	PI N TO PI N	12/79
M	2217.0	80.0	HOEHLER	79	IPWA	PI N TO PI N	12/79
M	(2204.5)	(3.4)	CHEW	80	BPWA ++	PI+P TO PI+P	1/82
M	2400.0	125.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

123 DELTA(2300) WIDTH (MEV)

W	500.0	200.0	HENDRY	78	MPWA	PI N TO PI N	12/79
W	300.0	100.0	HOEHLER	79	IPWA	PI N TO PI N	12/79
W	(32.3)	(1.0)	CHEW	80	BPWA ++	PI+P TO PI+P	1/82
W	425.0	150.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

123 DELTA(2300) REAL PART OF POLE POSITION (MEV)

RE	2370.0	80.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

123 DELTA(2300) -2*IMAG PART OF POLE POSITION (MEV)

IM	420.0	160.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

123 DELTA(2300) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER	9.0	4.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

123 DELTA(2300) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR	-3.0	5.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

123 DELTA(2300) PARTIAL DECAY MODES

		DECAY MASSES
P1	DELTA(2300) INTO N PI	938+ 140

123 DELTA(2300) BRANCHING RATIOS

R1 DELTA(2300) INTO (N PI)/TOTAL (P1)

R1	0.08	0.02	HENDRY	78	MPWA	PI N TO PI N	12/79
R1	0.03	0.02	HOEHLER	79	IPWA	PI N TO PI N	12/79
R1	(0.05)		CHEW	80	BPWA ++	PI+P TO PI+P	1/82
R1	0.06	0.02	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

REFERENCES FOR DELTA(2300)

HENDRY 78 PRL 41 222 A W HENDRY (IND+LBL)IJP
-- THE ANALYSIS AND RESULTS ARE DISCUSSED MORE FULLY IN HENDRY 81.
HOEHLER 79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1 +KAISER,KOCH,PIETARINEN (KARL)IJP
ALSO 80 TORONTO CONF 3 R KOCH (KARL)IJP
CHEW 80 TORONTO CONF 123 D M CHEW (LBL)IJP
CUTKOSKY 80 TORONTO CONF 19 +FORSYTH,BABCOCK,KELLY,HENDRICK (CARN+LBL)IJP
HENDRY 81 ANP 136 1 A W HENDRY (IND)

Δ(2350) D''_{35} Status: *

→ **134 DELTA(2350, JP=5/2-) I=3/2 D''35**

134 DELTA(2350) MASS (MEV)

M	2305.0	26.0	HOEHLER	79	IPWA	PI N TO PI N	1/82
M	2400.0	125.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

134 DELTA(2350) WIDTH (MEV)

W	300.0	70.0	HOEHLER	79	IPWA	PI N TO PI N	1/82
W	400.0	150.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

134 DELTA(2350) REAL PART OF POLE POSITION (MEV)

RE	2400.0	125.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

134 DELTA(2350) -2*IMAG PART OF POLE POSITION (MEV)

IM	400.0	150.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

134 DELTA(2350) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER	5.0	17.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

134 DELTA(2350) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR	-14.0	10.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

134 DELTA(2350) PARTIAL DECAY MODES

		DECAY MASSES
P1	DELTA(2350) INTO N PI	938+ 140

134 DELTA(2350) BRANCHING RATIOS

R1 DELTA(2350) INTO (N PI)/TOTAL (P1)

R1	0.04	0.02	HOEHLER	79	IPWA	PI N TO PI N	1/82
R1	0.20	0.10	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

REFERENCES FOR DELTA(2350)

HOEHLER 79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1 +KAISER,KOCH,PIETARINEN (KARL)IJP
ALSO 80 TORONTO CONF 3 R KOCH (KARL)IJP
CUTKOSKY 80 TORONTO CONF 19 +FORSYTH,BABCOCK,KELLY,HENDRICK (CARN+LBL)IJP

Δ(2390) F''_{37} Status: *

→ **133 DELTA(2390, JP=7/2+) I=3/2 F''37**

133 DELTA(2390) MASS (MEV)

M	2425.0	60.0	HOEHLER	79	IPWA	PI N TO PI N	1/82
M	2350.0	100.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

133 DELTA(2390) WIDTH (MEV)

W	300.0	80.0	HOEHLER	79	IPWA	PI N TO PI N	1/82
W	300.0	100.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

133 DELTA(2390) REAL PART OF POLE POSITION (MEV)

RE	2350.0	100.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

133 DELTA(2390) -2*IMAG PART OF POLE POSITION (MEV)

IM	260.0	100.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

133 DELTA(2390) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER	0.0	13.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

133 DELTA(2390) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR	-12.0	6.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

133 DELTA(2390) PARTIAL DECAY MODES

		DECAY MASSES
P1	DELTA(2390) INTO N PI	938+ 140

Baryons

Data Card Listings

Δ(2390), Δ(2400), Δ(2420), Δ(2750)

133 DELTA(2390) BRANCHING RATIOS

R1	DELTA(2390) INTO (N PI)/TOTAL				(P1)	
R1	0.07	0.04	HOEHLER	79 IPWA	PI N TO PI N	1/82
R1	0.08	0.04	CUTKOSKY	80 IPWA	PI N TO PI N	1/82

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REFERENCES FOR DELTA(2390)

HOEHLER 79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
+KAISER,KOCH,PIETARINEN (KARL)IJP
ALSO 80 TORONTO CONF 3 R KOCH (KARL)IJP
CUTKOSKY 80 TORONTO CONF 19 +FORSYTH,BABCOCK,KELLY,HENDRICK (CARN+LBL)IJP

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Δ(2400) G_{39} Status: **

→ 124 DELTA(2400, JP=9/2-) I=3/2 G39

124 DELTA(2400) MASS (MEV)

M	2200.0	100.0	HENDRY	78 MPWA	PI N TO PI N	12/79
M	2468.0	50.0	HOEHLER	79 IPWA	PI N TO PI N	12/79
M	2300.0	100.0	CUTKOSKY	80 IPWA	PI N TO PI N	1/82

124 DELTA(2400) WIDTH (MEV)

W	450.0	200.0	HENDRY	78 MPWA	PI N TO PI N	12/79
W	480.0	100.0	HOEHLER	79 IPWA	PI N TO PI N	12/79
W	330.0	100.0	CUTKOSKY	80 IPWA	PI N TO PI N	1/82

124 DELTA(2400) REAL PART OF POLE POSITION (MEV)

RE	2260.0	60.0	CUTKOSKY	80 IPWA	PI N TO PI N	1/82

124 DELTA(2400) -2*IMAG PART OF POLE POSITION (MEV)

IM	320.0	160.0	CUTKOSKY	80 IPWA	PI N TO PI N	1/82

124 DELTA(2400) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER	7.0	4.0	CUTKOSKY	80 IPWA	PI N TO PI N	1/82

124 DELTA(2400) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR	-3.0	3.0	CUTKOSKY	80 IPWA	PI N TO PI N	1/82

124 DELTA(2400) PARTIAL DECAY MODES

		DECAY MASSES
P1	DELTA(2400) INTO N PI	938+ 140

124 DELTA(2400) BRANCHING RATIOS

R1	DELTA(2400) INTO (N PI)/TOTAL				(P1)	
R1	0.10	0.03	HENDRY	78 MPWA	PI N TO PI N	12/79
R1	0.06	0.03	HOEHLER	79 IPWA	PI N TO PI N	12/79
R1	0.05	0.02	CUTKOSKY	80 IPWA	PI N TO PI N	1/82

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REFERENCES FOR DELTA(2400)

AYED 76 CEA-N-1921 AYED (THESIS) (SACL)IJP
HENDRY 78 PRL 41 222 A W HENDRY (IND+LBL)IJP
-- THE ANALYSIS AND RESULTS ARE DISCUSSED MORE FULLY IN HENDR
HOEHLER 79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
+KAISER,KOCH,PIETARINEN (KARL)IJP
ALSO 80 TORONTO CONF 3 R KOCH (KARL)IJP
CUTKOSKY 80 TORONTO CONF 19 +FORSYTH,BABCOCK,KELLY,HENDRICK (CARN+LBL)IJP
HENDRY 81 ANP 136 1 A W HENDRY (IND)

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Δ(2420) H_{311} Status: ****

84 DELTA(2420, JP=11/2+) I=3/2 H3 11

MOST OF THE RESULTS PUBLISHED BEFORE 1975 ARE NOW OBSOLETE AND HAVE BEEN OMITTED. THEY MAY BE FOUND IN OUR 1982 EDITION (PHYSICS LETTERS 111B). HOWEVER, ALL THE REFERENCES HAVE BEEN RETAINED.

IN ADDITION, RESULTS IN THIS REGION FROM PRODUCTION EXPERIMENTS, WHICH USED TO BE LISTED SEPARATELY AS THE NEXT ENTRY, HAVE BEEN ENTIRELY REMOVED.

84 DELTA(2420) MASS (MEV)

M	2400.0	60.0	HENDRY	78 MPWA	PI N TO PI N	12/79
M	2416.0	17.0	HOEHLER	79 IPWA	PI N TO PI N	12/79
M	(2358.0)	(9.0)	CHEW	80 BPWA ++	PI+P TO PI+P	1/82
M	2400.0	125.0	CUTKOSKY	80 IPWA	PI N TO PI N	1/82

84 DELTA(2420) WIDTH (MEV)

W	460.0	100.0	HENDRY	78 MPWA	PI N TO PI N	12/79
W	340.0	28.0	HOEHLER	79 IPWA	PI N TO PI N	12/79
W	(202.2)	(45.0)	CHEW	80 BPWA ++	PI+P TO PI+P	1/82
W	450.0	150.0	CUTKOSKY	80 IPWA	PI N TO PI N	1/82

84 DELTA(2420) REAL PART OF POLE POSITION (MEV)

RE	2360.0	100.0	CUTKOSKY	80 IPWA	PI N TO PI N	1/82

84 DELTA(2420) -2*IMAG PART OF POLE POSITION (MEV)

IM	420.0	100.0	CUTKOSKY	80 IPWA	PI N TO PI N	1/82

84 DELTA(2420) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER	16.0	8.0	CUTKOSKY	80 IPWA	PI N TO PI N	1/82

84 DELTA(2420) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR	-9.0	11.0	CUTKOSKY	80 IPWA	PI N TO PI N	1/82

84 DELTA(2420) PARTIAL DECAY MODES

		DECAY MASSES
P1	DELTA(2420) INTO N PI	938+ 140
P2	DELTA(2420) INTO SIGMA K	1197+ 494

84 DELTA(2420) BRANCHING RATIOS

R1	DELTA(2420) INTO (N PI)/TOTAL				(P1)	
R1	0.11	0.02	HENDRY	78 MPWA	PI N TO PI N	12/79
R1	0.08	0.015	HOEHLER	79 IPWA	PI N TO PI N	12/79
R1	(0.22)		CHEW	80 BPWA ++	PI+P TO PI+P	1/82
R1	0.08	0.03	CUTKOSKY	80 IPWA	PI N TO PI N	1/82

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REFERENCES FOR DELTA(2420)

BELLAMY 67 PRL 19 476 +BUCKLEY,DOBINSON, + (LOWC+LOUC) JP
AYED 70 KIEV CONF R AYED,P BAREYRE, G VILLET (SACL)IJP
AYED2 70 PL 31B 598 +BAREYRE,VILLET (SACL)
BRANSDEN 71 NP B26 511 +OGDEN (DURH)IJP
ALSO 70 NP B16 461 ROYCHOUDHURY,PERRIN,BRANSDEN (DURH)IJP
ROYCHOUD 71 NP B27 125 R K ROYCHOUDHURY,B H BRANSDEN (DURH)IJP
OTT 72 PL 42B 133 +TRISCHUK,VAVRA,RICHARDS,+ (MCGI+STLO+IOWA)IJP
ALSO 72 MCGILL THESIS J. VAVRA (MCGI) JP
REY 74 PRL 32 908 REY,LENNOX,POIRIER,PRETZL (NDAM+MPIM)IP
ALSO 74 PRL 33 250 REY,LENNOX,POIRIER,PRETZL (NDAM+MPIM)IP
ALSO 75 PR D11 1777 LENNOX,POIRIER,REY,SANDER+ (NDAM+FNAL+ANL)IP

AYED 76 CEA-N-1921 AYED (THESIS) (SACL)IJP
HENDRY 78 PRL 41 222 A W HENDRY (IND+LBL)IJP
-- THE ANALYSIS AND RESULTS ARE DISCUSSED MORE FULLY IN HENDRY 81.
HOEHLER 79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
+KAISER,KOCH,PIETARINEN (KARL)IJP
ALSO 80 TORONTO CONF 3 R KOCH (KARL)IJP
CHEW 80 TORONTO CONF 123 D M CHEW (LBL)IJP
CUTKOSKY 80 TORONTO CONF 19 +FORSYTH,BABCOCK,KELLY,HENDRICK (CARN+LBL)IJP
HENDRY 81 ANP 136 1 A W HENDRY (IND)

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Δ(2750) I_{313} Status: **

→ 125 DELTA(2750, JP=13/2-) I=3/2 I3 13

125 DELTA(2750) MASS (MEV)

M	2650.0	100.0	HENDRY	78 MPWA	PI N TO PI N	12/79
M	2794.0	80.0	HOEHLER	79 IPWA	PI N TO PI N	12/79

125 DELTA(2750) WIDTH (MEV)

W	500.0	100.0	HENDRY	78 MPWA	PI N TO PI N	12/79
W	350.0	100.0	HOEHLER	79 IPWA	PI N TO PI N	12/79

125 DELTA(2750) PARTIAL DECAY MODES

		DECAY MASSES
P1	DELTA(2750) INTO N PI	938+ 140

125 DELTA(2750) BRANCHING RATIOS

R1	DELTA(2750) INTO (N PI)/TOTAL				(P1)	
R1	0.05	0.01	HENDRY	78 MPWA	PI N TO PI N	12/79
R1	0.04	0.015	HOEHLER	79 IPWA	PI N TO PI N	12/79

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REFERENCES FOR DELTA(2750)

HENDRY 78 PRL 41 222 A W HENDRY (IND+LBL)IJP
-- THE ANALYSIS AND RESULTS ARE DISCUSSED MORE FULLY IN HENDRY 81.
HOEHLER 79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
+KAISER,KOCH,PIETARINEN (KARL)IJP
ALSO 80 TORONTO CONF 3 R KOCH (KARL)IJP
HENDRY 81 ANP 136 1 A W HENDRY (IND)

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Δ(2950) K_{315} Status: **

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126 DELTA(2950, JP=15/2+) I=3/2   K3 15
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              126 DELTA(2950) MASS (MEV)

M       2850.0    100.0        HENDRY    78 MPWA    PI N TO PI N     12/79
M       2990.0    100.0        HOEHLER   79 IPWA    PI N TO PI N     12/79
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              126 DELTA(2950) WIDTH (MEV)

W        700.0    200.0        HENDRY    78 MPWA    PI N TO PI N     12/79
W        330.0    100.0        HOEHLER   79 IPWA    PI N TO PI N     12/79
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              126 DELTA(2950) PARTIAL DECAY MODES

                                                       DECAY MASSES
P1    DELTA(2950) INTO N PI                           938+ 140
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              126 DELTA(2950) BRANCHING RATIOS

R1    DELTA(2950) INTO (N PI)/TOTAL                (P1)
R1         0.03      0.01      HENDRY    78 MPWA    PI N TO PI N     12/79
R1         0.04      0.02      HOEHLER   79 IPWA    PI N TO PI N     12/79
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                    REFERENCES FOR DELTA(2950)

HENDRY   78 PRL 41 222         A W HENDRY                  (IND+LBL)IJP
         -- THE ANALYSIS AND RESULTS ARE DISCUSSED MORE FULLY IN HENDRY 81.
HOEHLER  79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                               +KAISER,KOCH,PIETARINEN          (KARL)IJP
   ALSO  80  TORONTO CONF 3    R KOCH                           (KARL)IJP
HENDRY   81 ANP 136 1          A W HENDRY                         (IND)
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~3000 MEV REGION - FORMATION EXPERIMENTS

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              127 DELTA(~3000) I=3/2

              WE LIST HERE MISCELLANEOUS HIGH-MASS CANDIDATES FOR
              ISOSPIN-3/2 RESONANCES FOUND IN PARTIAL-WAVE ANALYSES.
              SO FAR, NO ANALYSIS OF THIS REGION HAS USED ALL THE
              AVAILABLE DATA OR INCORPORATED ANALYTICITY CONSTRAINTS.

  OUR 1982 EDITION ALSO HAD A DELTA(2850) AND A DELTA (3230).
  NOTHING HAS BEEN HEARD FROM THEM IN 10 YEARS, AND UNDER THE
  AUTHORITY GRANTED UNTO US BY THE STATUTE OF LIMITATIONS, WE
  DECLARE THEM TO BE DEAD.  THE EVIDENCE FOR THEM WAS DEDUCED FROM
  TOTAL-CROSS-SECTION AND 180-DEG-ELASTIC-CROSS-SECTION MEASUREMENTS.
  PLACED IN THE MAIN BARYON TABLE IN THE ANYTHING-GOES 1960'S, THEY
  REMAINED THERE DUE TO INATTENTION UNTIL THIS EDITION.

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              127 DELTA(~3000) MASS (MEV)

M       2850.0    150.0        HENDRY    78 MPWA    PI N  I311       12/79
M       3200.0    200.0        HENDRY    78 MPWA    PI N  K313       12/79
M       3300.0    200.0        HENDRY    78 MPWA    PI N  L317       12/79
M       3700.0    200.0        HENDRY    78 MPWA    PI N  M319       12/79
M       4100.0    300.0        HENDRY    78 MPWA    PI N  N321       12/79
M      (3300.0)                KOCH      80 IPWA    PI N  L317       2/84*
M      (3500.0)                KOCH      80 IPWA    PI N  M315       2/84*
M     IN ADDITION, KOCH 80 REPORT SOME EVIDENCE FOR AN S31 DELTA(2700)   2/82
M     AND A P33 DELTA(2800).                                          2/84*
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              127 DELTA(~3000) WIDTH (MEV)

W        700.0    200.0        HENDRY    78 MPWA    PI N  I311       12/79
W       1000.0    300.0        HENDRY    78 MPWA    PI N  K313       12/79
W       1100.0    300.0        HENDRY    78 MPWA    PI N  L317       12/79
W       1300.0    400.0        HENDRY    78 MPWA    PI N  M319       12/79
W       1600.0    500.0        HENDRY    78 MPWA    PI N  N321       12/79
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              127 DELTA(~3000) PARTIAL DECAY MODES

                                                       DECAY MASSES
P1    DELTA(~3000) INTO N PI                          938+ 140
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              127 DELTA(~3000) BRANCHING RATIOS

R1    DELTA(~3000) INTO (N PI)/TOTAL               (P1)
R1         0.06      0.02      HENDRY    78 MPWA    PI N  I311       12/79
R1         0.045     0.02      HENDRY    78 MPWA    PI N  K313       12/79
R1         0.03      0.01      HENDRY    78 MPWA    PI N  L317       12/79
R1         0.025     0.01      HENDRY    78 MPWA    PI N  M319       12/79
R1         0.018     0.01      HENDRY    78 MPWA    PI N  N321       12/79
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                    REFERENCES FOR DELTA(~3000)

HENDRY   78 PRL 41 222         A W HENDRY                  (IND+LBL)IJP
         -- THE ANALYSIS AND RESULTS ARE DISCUSSED MORE FULLY IN HENDRY 81.
KOCH     80  TORONTO CONF 3    R KOCH                           (KARL)IJP
HENDRY   81 ANP 136 1          A W HENDRY                         (IND)

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NOTE ON THE S = +1 BARYON SYSTEM

The evidence for strangeness +1 baryon resonances was thoroughly reviewed in our 1976 edition,[1] and has been reviewed more recently by Kelly[2] and by Oades.[3] One new partial-wave analysis[4] has been published since our 1982 edition. As usual, the results permit no definite conclusion — the same story heard for 15 years. The general feeling, supported by the prejudice against baryons not make up of three quarks, is that the suggestive counterclockwise movement in the Argand diagram of some of the partial waves is not real evidence for true Breit-Wigner resonances. But until the dynamics of the KN system is better understood, the possibility that Z* resonances exist will not be finally laid to rest.

References

1. Particle Data Group, Rev. Mod. Phys. **48**, S188 (1976).
2. R.L. Kelly, in *Proceedings of the Meeting on Exotic Resonances* (Hiroshima, 1978), ed. I. Endo et al.
3. G.C. Oades, in *Low and Intermediate Energy Kaon-Nucleon Physics* (1981), ed. E. Ferrari and G. Violini.
4. K. Nakajima et al., Phys. Lett. **112B**, 80 (1982).


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S=1 EXOTIC STATES (Z)

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$Z_0(1780)$ P_{01} Status: *

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              95 Z0(1780, JP=1/2+) I=0       P01

              WILSON 72, GIACOMELLI 74, AND NAKAJIMA 82 FIND SOME
              SOLUTIONS WITH RESONANT-LIKE BEHAVIOR IN THE P01
              PARTIAL WAVE.  THE EFFECT SEEN IN THE I=0 TOTAL CROSS
              SECTION, IF A RESONANCE, MUST HAVE SPIN=1/2, BECAUSE
              THE INELASTIC CROSS SECTION IS VERY SMALL AND THE
              TOTAL CROSS SECTION IS ABOUT 4*PI/K**2.

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              95 Z0(1780) MASS (MEV)

M          1780.0     10.0         COOL      70 CNTR +  K+P, D TOTAL      1/71
M     A    SEEN                    DOWELL    70 CNTR     K+P,D TOTAL      7/70
M     A    SEE ALSO DISCUSSION OF LYNCH 70.                               7/70
M     B   (1800.0)                 WILSON    72 PWA     K+N P01 WAVE      3/72
M     B  ESTIMATE OF PARAMETERS FROM BW + QUADRATIC BACKGROUND FIT TO P01. 3/72
M      C  (1750.0)                 CARROLL   73 CNTR    KN I=0 TCS,FIT 1  9/73
M      C  (1825.0)                 CARROLL   73 CNTR    KN I=0 TCS,FIT 2  9/73
M      C FIT 1=FIT OF SINGLE L=1 BW+BACKGROUND TO I=0 TCS FROM 0.4-1.1 GEV/C 9/73
M      C FIT 2=FIT OF L=1 AND L=2 BWS TO SAME DATA,SEE Z0(1865) FOR L=2 PART 9/73
M         (1740.0)                 GIACOMEL  74 PWA    0.38-1.51 GEV/C   10/74
M         (1778.0)                 NAKAJIMA  82 PWA     KN 0.2-1.6 GEV/C  1/84*
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              95 Z0(1780) WIDTH (MEV)

W          (565.0)                 COOL      70 CNTR +  K+P, D TOTAL      1/71
W     B    (300.0)                 WILSON    72 PWA     K+N P01 WAVE      3/72
W      C   (600.0)                 CARROLL   73 CNTR    KN I=0 TCS,FIT 1  9/73
W      C   (845.0)                 CARROLL   73 CNTR    KN I=0 TCS,FIT 2  9/73
W          (300.0)                 GIACOMEL  74 PWA     0.38-1.51 GEV/C  10/74
W          (662.0)                 NAKAJIMA  82 PWA     KN 0.2-1.6 GEV/C  1/84*
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              95 Z0(1780) PARTIAL DECAY MODES

                                                       DECAY MASSES
P1    Z0(1780) INTO N K                                940+ 494
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Baryons

Data Card Listings

$Z_0(1780)$, $Z_0(1865)$, $Z_1(1900)$

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                   95  Z0(1780) BRANCHING RATIOS

R1      Z0(1780) INTO (N K)/TOTAL                          (P1)
R1            (0.95)                COOL      70 CNTR +  K+P, D TOTAL      1/71
R1   B        (0.85)                WILSON    72 PWA     K+N P01 WAVE      3/72
R1    C       (0.75)                CARROLL   73 CNTR    IF J=1/2,FIT 1    9/73
R1    C       (0.91)                CARROLL   73 CNTR    IF J=1/2,FIT 2    9/73
R1            (0.85)                GIACOMEL  74  PWA    .38-1.51 GEV/C   10/74
R1            (0.56)                NAKAJIMA  82 PWA     KN 0.2-1.6 GEV/C  1/84*

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                      REFERENCES FOR Z0(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)
CARROLL   73 PL 45B 531          +KYCIA,LI,MICHAEL,MOCKETT,RAHM+      (BNL)I
GIACOMEL  74 NP B71 138          GIACOMELLI,+          (BGNA+GLAS+ROMA+TRST)IJP
NAKAJIMA  82 PL 112B 80          +KIM,KOBAYASHI,MASAIKE,MURAKAMI,+    (KEK)IJP
                                 PAPERS NOT REFERRED TO IN DATA CARDS

LYNCH     70 DUKE 9              G LYNCH (REVIEWER)                    (LRL)
HIRATA    71 NP B30 157          +GOLDHABER,HALL,SEEGER,TRILLING,WOHL  (LBL)IJP
BOWEN     73 PR D7 22            +JENKINS,KALBACH,PETERSEN +     (ARIZ+MICH)
JOHNSON   74 PL 50B 343          JOHNSON,VLASSOPULOS             (CERN+DURH)
CAMERON   75 PALERMO CONF.       +CAPILUPPI+      (BGNA+EDIN+GLAS+PISA+RHEL)IJP
BIGI      76 NP B110 25          +CAMERON+        (BGNA+EDIN+GLAS+PISA+RHEL)IJP
ROIESNEL  79 PR D20 1646         C ROIESNEL                            (MIT)
MARTIN    80 TORONTO CONF. 355   B R MARTIN,G C OADES            (LOUC+AARH)
OADES     81 ROME CONF. 53       LOW + INTERMEDIATE ENERGY KN PHYSICS (AARH)
CORDEN    82 PR D25 720          +COX,KELSEY,LAWRENCE,WATKINS+   (BIRM+LPNP)

        SEE OUR 1982 EDITION (PHYS. LETT. 111B) FOR A NUMBER OF OTHER
        REFERENCES TO EXPERIMENTAL WORK IN THIS REGION.

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$Z_0(1865)$ D_{03} Status: *

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                96  Z0(1865, JP=3/2-) I=0        D03

                THIS EFFECT IS STRONGLY ASSOCIATED WITH THE K* N
                THRESHOLD.  SEE ALSO THE Z0(1780).

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                96  Z0(1865) MASS (MEV)

M          (1860.0)   (15.0)         CARTER    67 THEO    DISPERSION REL.   8/67
M          (1868.0)   (10.0)         COOL      70 CNTR    K+P, D TOTAL      8/67
M          (1830.0)                  AARON     73 MPWA    I=0 KN .6-1.6G/C  9/73
M     A    (1840.0)                  CARROLL   73 CNTR    KN I=0 TCS,FIT 2  9/73
M     A  FIT2=FIT OF L=1 AND L=2 BWS TO I=0 TCS FROM 0.4-1.1 GEV/C.         9/73
M     A  SEE Z0(1780) FOR FIT 1 AND L=1 PART OF FIT 2.                      9/73
M          (1907.0)                  NAKAJIMA  82 PWA     KN 0.2-1.6 GEV/C  1/84*

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                96  Z0(1865) WIDTH (MEV)

W           (200.0)   (50.0)         CARTER    67 THEO                      8/67
W           (160.0)   (30.0)         COOL      70 CNTR                      8/67
W           (100.0)                  AARON     73 MPWA    I=0 KN .6-1.6G/C  9/73
W     A      (75.0)                  CARROLL   73 CNTR    KN I=0 TCS,FIT 2  9/73
W           (291.0)                  NAKAJIMA  82 PWA     KN 0.2-1.6 GEV/C  1/84*

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                96  Z0(1865) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      Z0(1865) INTO N K                              940+ 494
P2      Z0(1865) INTO N K*(892)                        938+ 892

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                96  Z0(1865) BRANCHING RATIOS

R1      Z0(1865) INTO (N K)/TOTAL                    (P1)
R1           (0.155)  (0.025)        CARTER    67 THEO    IF J=3/2          9/73
R1           (0.115)  (0.025)        COOL      70 CNTR    IF J=3/2          9/73
R1    A      (0.085)                 CARROLL   73 CNTR    IF J=3/2,FIT 2    9/73
R1           (0.35)                  NAKAJIMA  82 PWA     KN 0.2-1.6 GEV/C  1/84*

R2      Z0(1865) INTO (N K*(892))/TOTAL              (P2)
R2              MAIN INELASTIC DECAY    HIRATA    68 HBC                    11/68

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                      REFERENCES FOR Z0(1865)

CARTER    67 PRL 18 801          A A CARTER                           (CAVE)
HIRATA    68 PRL 21 1485         HIRATA, WOHL, GOLDHABER, TRILLING     (LRL)
COOL      70 PR D1 1887          COOL,GIACOMELLI,KYCIA,LEONTIC,LI +    (BNL)
    ALSO 66 PRL 17 102           +GIACOMELLI,KYCIA,LEONTIC,LI,LUNDBY,+ (BNL) I
    ALSO 69 PL 30B 564           ABRAMS,COOL,GIACOMELLI,KYCIA,LI +     (BNL)
AARON     73 PR D7 1401          AARON,RICH,HOGAN,SRIVASTAVA     (LASL+NEAS)IJP
CARROLL   73 PL 45B 531          +KYCIA,LI,MICHAEL,MOCKETT,RAHM+      (BNL)I
NAKAJIMA  82 PL 112B 80          +KIM,KOBAYASHI,MASAIKE,MURAKAMI,+    (KEK)IJP

                                 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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$Z_1(1900)$ P_{13} Status: *

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                97  Z1(1900, JP=3/2+) I=1        P13

                THIS EFFECT IS STRONGLY ASSOCIATED WITH THE K-DELTA
                THRESHOLD.

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                97  Z1(1900) MASS (MEV)

M    A     (1932.0)                  AYED      70 IPWA    P13,SOL.I         6/70
M    A     (1899.0)                  AYED      70 IPWA    P13,SOL.II        6/70
M    A     (2030.0)                  AYED      70 IPWA    S11,SOL.III       6/70
M    A      THREE SOLNS IN ORDER OF DECREASING SIGNIFICANCE. THOUGH AYED 70
M    A      GIVE PARAMETERS,THEY CONCLUDE RESONANT INTERPRETATION DOUBTFUL.
M     B    (1830.0)                  BARNETT   70 IPWA    P13,SOLN III      9/73
M     B     RESONANCE SIGNAL BARELY ABOVE BACKGROUND DUE TO THE LARGE ERRORS
M     B     IN THE AMPLITUDES RESULTING FROM THE ANALYSIS
M           1900.0      10.0         COOL      70 CNTR ++ K+P TOTAL         1/71
M          (1880.0)                  ALBROW    71 IPWA ++  SOL. GAMMA      10/71
M    C     (1890.0)                  KATO      71 IPWA    SOL  I(FIT BW)   10/71
M    C     (2040.0)                  KATO      71 IPWA    SOL II(FIT BW)   10/71
M    C   KATO 71 ESTIMATE RESONANCE PARAMETERS -- UPDATED PHASE SHIFTS      3/72
M    C   PUBLISHED IN MILLER 72.                                            3/72
M          (1931.0)                  NAKAJIMA  82 PWA     KN 0.2-1.6 GEV/C  1/84*

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                97  Z1(1900) WIDTH (MEV)

W    A      (520.0)                  AYED      70 IPWA    K+P               6/70
W    A      (397.0)                  AYED      70 IPWA    K+P               6/70
W    A      (557.0)                  AYED      70 IPWA    K+P               6/70
W     B     (120.0)                  BARNETT   70 IPWA    P13,SOLN III      9/73
W           (240.0)                  COOL      70 CNTR ++ K+- TOTAL         1/71
W           (190.0)                  ALBROW    71 IPWA ++ SOL. GAMMA       10/71
W    C      (280.0)                  KATO      71 IPWA    SOL  I(FIT BW)   10/71
W    C      (260.0)                  KATO      71 IPWA    SOL II(FIT BW)   10/71
W           (347.0)                  NAKAJIMA  82 PWA     KN 0.2-1.6 GEV/C  1/84*

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                97  Z1(1900) REAL PART OF POLE POSITION                     4/75

RE   D     (1787.0)                  ARNDT     74 DPWA    K+ P ELASTIC      4/75
RE   D   SUPERSEDED BY ARNDT 78.                                            3/79
RE         (1796.0)                  ARNDT     78 DPWA    K+ P              3/79

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                97  Z1(1900) -IMAGINARY PART OF POLE POSITION               4/75

IM   D      (100.0)                  ARNDT     74 DPWA    K+ P ELASTIC      4/75
IM          (101.0)                  ARNDT     78 DPWA    K+ P              3/79

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                97  Z1(1900) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      Z1(1900) INTO N K                              938+ 494
P2      Z1(1900) INTO DELTA(1232) K                   1232+ 494

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                97  Z1(1900) BRANCHING RATIOS

R1      Z1(1900) INTO (N K)/TOTAL                      (P1)
R1            (0.10) OR LESS         CARTER    67 THEO    DISPERSION REL.   8/67
R1   A        (0.16)                 AYED      70 IPWA                      6/70
R1   A        (0.20)                 AYED      70 IPWA                      6/70
R1   A        (0.17)                 AYED      70 IPWA                      6/70
R1    B       (0.12)                 BARNETT   70 IPWA    P13,SOLN III      9/73
R1            (0.12) (ASSUMING J=3/2) COOL     70 CNTR ++ K+P TOTAL         1/71
R1            (0.15)                 ALBROW    71 IPWA ++ SOL. GAMMA       10/71
R1   C        (0.22)                 KATO      71 IPWA    SOL  I(FIT BW)   10/71
R1   C        (0.27)                 KATO      71 IPWA    SOL II(FIT BW)   10/71
R1            (0.24)                 NAKAJIMA  82 PWA     KN 0.2-1.6 GEV/C  1/84*

R2      Z1(1900) INTO (DELTA(1232) K)/TOTAL            (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 Z1(1900)

BLAND     67 PRL 18 1077         +BOWLER,BROWN,G+S GOLDHABER,SEEGER,+  (LRL)
CARTER    67 PRL 18 801          A A CARTER                           (CAVE)

AYED      70 PL 32B 404          +BAREYRE, FELTESSE, VILLET          (SACL)IJP
BARNETT   70 U MD,RPT 70-101     BARNETT,GOLDMAN,LAASANEN,STEINBERG   (UMD)IJP
    ALSO 70 DUKE 443             BARNETT,GOLDMAN,LAASANEN,STEINBERG   (UMD)IJP
COOL      70 PR D1 1887          +GIACOMELLI, KYCIA, LEONTIC, LI, +   (BNL) I
    ALSO 66 PRL 17 102           COOL,GIACOMELLI,KYCIA,LEONTIC,LI +   (BNL)

ALBROW    71 NP  B30 273         +ANDERSON,ALMEHED,...,UDO,WAGNER    (CERN)IJP
    ALSO 70 DUKE  375            ERNE,SENS,WAGNER                    (CERN)IJP
KATO      71 MORIOND             +KOEHLER,...,YOKOSAWA,BURLESON  (ANL+NWES)IJP
    ALSO 70 DUKE 367             A YOKOSAWA                           (ANL)IJP
    ALSO 70 PRL 24 615           KATO,KOEHLER,NOVEY,YOKOSAWA+    (ANL+NWES)IJP

GRIFFITH  72 NP B38 365          +HIRATA,HUGHES +      (BGNA+GLAS+ROMA+TRST)
MILLER    72 NP B37 401          +NOVEY,YOKOSAWA,CUTKOSKY +  (ANL+CARN+NWES)IJP
ARNDT     74 PRL 33 987          ARNDT,HACKMAN,ROPER,STEINBERG    (VPI+UMD)IJP
ARNDT     78 PR D18 3278         ARNDT,ROPER,STEINBERG            (VPI+UMD)
NAKAJIMA  82 PL 112B 80          +KIM,KOBAYASHI,MASAIKE,MURAKAMI,+    (KEK)IJP

     REVIEW TALKS AND PAPERS ---
LEVISETT  69 LUND CONF 341       R LEVI SETTI  (RAPPORTEUR)           (CHIC)
GOLDHABE  70 DUKE   407          G GOLDHABER (REVIEWER)                (LRL)
DOWELL    72  NAL REVIEW         REVIEW TALK IN BARYON SESSION        (BIRM)
LOVELACE  72  NAL REVIEW         RAPPORTEUR'S TALK                    (RUTG)
DOWELL    73 PURDUE CONF. 157    DOWELL                               (BIRM)
CUTKOSKY  74 LONDON CONF II-54   CUTKOSKY                             (CARN)
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For notation, see key at front of Listings.

Baryons

$Z_1(1900)$, $Z_1(2150)$, $Z_1(2500)$, Λ's and Σ's


```
KELLY   75 ANL-HEP-CP-75-58  REVIEW TALK IN BARYON SESSION          (LBL)
URBAN   75 PL 60B 77         URBAN                                  (LBL)
MARTIN  76 OXFORD CONF. 409  RAPPORTEUR'S TALK                      (LOUC)
KELLY   78 HUPD-7813 44      MTG. ON EXOTIC RESONANCES, HIROSHIMA   (LBL)
OADES   81 ROME CONF. 53     LOW + INTERMEDIATE ENERGY KN PHYSICS   (AARH)

         SEE ALSO OUR 1982 EDITION (PHYS. LETT. 111B) FOR A LARGE NUMBER OF
         OTHER REFERENCES TO THEORETICAL AND EXPERIMENTAL WORK IN THIS REGION.
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$Z_1(2150)$ BUMPS Status: *

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               93  Z1(2150, JP=     ) I=1
                   A SMALL BUMP IN THE TOTAL CROSS SECTION AT 1.8 GEV/C.
------ --------- --------- --------- --------- --------- --------- --------
               93  Z1(2150) MASS (MEV)
M          2150.0     20.0              ABRAMS     70 CNTR ++ K+P TOTAL       10/71
------ --------- --------- --------- --------- --------- --------- --------
               93  Z1(2150) WIDTH (MEV)
W         (175.0)                       ABRAMS     70 CNTR +  K+P TOTAL       10/71
------ --------- --------- --------- --------- --------- --------- --------
               93  Z1(2150) PARTIAL DECAY MODES
                                                                 DECAY MASSES
P1     Z1(2150) INTO N K                                       938+ 494
------ --------- --------- --------- --------- --------- --------- --------
               93  Z1(2150) BRANCHING RATIOS
R1     Z1(2150) INTO (N K)/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
****** ********* ********* ********* ********* ********* ********* ********
                    REFERENCES FOR Z1(2150)
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ABRAMS   70 PR  D1 1917      +COOL,GIACOMELLI,KYCIA,LEONTIC,LI +   (BNL)
   ALSO 67 PRL 19 257        ABRAMS,COOL,GIACOMELLI,KYCIA,LEONTIC+ (BNL)
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$Z_1(2500)$ BUMPS Status: *

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               94  Z1(2500, JP=     ) I=1
                   A SMALL BUMP IN THE TOTAL CROSS SECTION AT 2.7 GEV/C.
------ --------- --------- --------- --------- --------- --------- --------
               94  Z1(2500) MASS (MEV)
M          2500.0     20.0              ABRAMS     70 CNTR ++ K+P TOTAL       10/71
------ --------- --------- --------- --------- --------- --------- --------
               94  Z1(2500) WIDTH (MEV)
W         (160.0)                       ABRAMS     70 CNTR ++ K+P TOTAL       10/71
------ --------- --------- --------- --------- --------- --------- --------
               94  Z1(2500) PARTIAL DECAY MODES
                                                                 DECAY MASSES
P1     Z1(2500) INTO N K                                       938+ 494
------ --------- --------- --------- --------- --------- --------- --------
               94  Z1(2500) BRANCHING RATIOS
R1     Z1(2500) INTO (N K)/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
****** ********* ********* ********* ********* ********* ********* ********
                    REFERENCES FOR Z1(2500)
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ABRAMS   70 PR  D1 1917      +COOL,GIACOMELLI,KYCIA,LEONTIC,LI +   (BNL)
   ALSO 67 PRL 19 257        ABRAMS,COOL,GIACOMELLI,KYCIA,LEONTIC+ (BNL)
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NOTE ON Λ AND Σ RESONANCES

I. Introduction

Progress in Y^*'s has ground to a halt. Whether the field is dead or is merely in suspended animation, to be revived eventually at the lower energy accelerators such as KEK and TRIUMF, remains to be seen. Since the 1982 edition, there has been a paper giving new data on K^-n elastic scattering,[1] and that is it: no new partial-wave analyses, no new Y^*'s promoted to the Baryon Table (in fact, we have removed three — see below). Nor does there appear to be a single new experiment on Y^*'s, planned or in progress, anywhere in the world.

Table 1 is an attempt to evaluate the status, both overall and channel by channel, of each Y^* in the Listings; the evaluations are of course partly subjective. A blank indicates there is no evidence at all: either the relevant couplings are small or the resonance does not really exist. The main Baryon Table includes only the established resonances (overall status 3 or 4 stars). We have reduced the Λ(2585), the Σ(2455), and the Σ(2620)

Table 1. The status of the Λ and Σ resonances. Only those with an overall status of *** or **** are included in the main Baryon Table.

			Status as seen in --			
Particle	$L_{I \cdot 2J}$	Overall status	$N\bar{K}$	$\Lambda\pi$	$\Sigma\pi$	Other channels
Λ(1116)	P_{01}	****				$N\pi$ (weakly)
Λ(1405)	S_{01}	****	****	F	****	
Λ(1520)	D_{03}	****	****	o	****	$\Lambda\pi\pi$, $\Lambda\gamma$
Λ(1600)	P_{01}	***	***	r	**	
Λ(1670)	S_{01}	****	****	b	****	$\Lambda\eta$
Λ(1690)	D_{03}	****	****	i	****	$\Lambda\pi\pi$, $\Sigma\pi\pi$
Λ(1800)	S_{01}	***	***	d	**	$N\bar{K}^*$, $\Sigma(1385)\pi$
Λ(1800)	P_{01}	***	***	d	**	$N\bar{K}^*$
Λ(1820)	F_{05}	****	****	e	****	$\Sigma(1385)\,\pi$
Λ(1830)	D_{05}	****	***	n	****	$\Sigma(1385)\,\pi$
Λ(1890)	P_{03}	****	****	F	**	$N\bar{K}^*$, $\Sigma(1385)\pi$
Λ(2000)		*		o	*	$\Lambda\omega$, $N\bar{K}^*$
Λ(2020)	F_{07}	*	*	r	*	
Λ(2100)	G_{07}	****	****	b	***	$\Lambda\omega$, $N\bar{K}^*$
Λ(2110)	F_{05}	***	**	i	*	$\Lambda\omega$, $N\bar{K}^*$
Λ(2325)	D_{03}	*	*	d		$\Lambda\omega$
Λ(2350)		***	***	d	*	
Λ(2585)		**	**	e		
				n		
Σ(1193)	P_{11}	****				$N\pi$ (weakly)
Σ(1385)	P_{13}	****		****	****	
Σ(1480)		*	*	*	*	
Σ(1560)		**		**	**	
Σ(1580)	D_{13}	**	*	*		
Σ(1620)	S_{11}	**	**	*	*	
Σ(1660)	P_{11}	***	***	*	**	
Σ(1670)	D_{13}	****	****	****	****	several others
Σ(1690)		**	*	**	*	$\Lambda\pi\pi$
Σ(1750)	S_{11}	***	***	**	*	$\Sigma\eta$
Σ(1770)	P_{11}	*				
Σ(1775)	D_{15}	****	****	****	***	several others
Σ(1840)	P_{13}	*	*	**	*	
Σ(1880)	P_{11}	**	**	**		$N\bar{K}^*$
Σ(1915)	F_{15}	****	***	****	***	$\Sigma(1385)\pi$
Σ(1940)	D_{13}	***	*	***	**	quasi-2-body
Σ(2000)	S_{11}	*		*		$N\bar{K}^*$, $\Lambda(1520)\pi$
Σ(2030)	F_{17}	****	****	****	**	several others
Σ(2070)	F_{15}	*	*		*	
Σ(2080)	P_{13}	**		**		
Σ(2100)	G_{17}	*		*	*	
Σ(2250)		***	***	*	*	
Σ(2455)		**	*			
Σ(2620)		**	*			
Σ(3000)		*	*	*		
Σ(3170)		*				multi-body

**** Good, clear, and unmistakable.
*** Good, but in need of clarification or not absolutely certain.
** Not established; needs confirmation.
* Evidence weak; could disappear.

from 3-star to 2-star status and removed them from the main Table: they are seen only as ripples in isospin-unfolded total cross sections, and nothing at all has been learned about them since 1970. Several of the 1- and 2-star resonances may eventually disappear, but there are probably many resonances yet to be discovered underlying the established ones.

None of the Y^*'s proposed in the last decade couple strongly to the main 2-body decay channels $N\bar{K}$, $\Lambda\pi$, and $\Sigma\pi$, and thus they seldom appear in cross sections or invariant mass distributions. However, when the reactions $\bar{K}N \to \bar{K}N$, $\bar{K}N \to \Lambda\pi$, and $\bar{K}N \to \Sigma\pi$ are partial-wave analyzed, some of the amplitudes are found to traverse small, more-or-less resonance-like counterclockwise circles. The question in each case is: Is this really a resonance, or is it an idle meander? Is the effect even real, or is it the result of imperfect data and analysis procedures?

What follows is the review of Y^*'s, somewhat revised, that appeared in the 1982 edition: it summarizes "recent" progress and problems. (For another brief overview, see Tripp.[2]) In the Data Card Listings, some obsolete results, nearly all from before 1975, have been removed. This has been done only for the established Y^*'s, where the addition of much improved data to partial-wave analyses has really made obsolete the older results. Where little new has been learned in the last decade [such as for the Λ(1405)], or where the situation is uncertain, nothing has been removed.

II. Formation experiments

(by G.P. Gopal, Rutherford Appleton Laboratory)

Partial-wave analyses have been made mainly for the $N\bar{K}$, $\Lambda\pi$, and $\Sigma\pi$ channels, but there are also a few results for the ΞK, $\Lambda\omega$, and some quasi-2-body channels. The early analyses usually covered only the range of a single bubble chamber experiment. Although the amplitudes obtained often did not join smoothly with those from analyses in neighboring mass ranges, they did give fairly reliable information about the strongly coupled resonances. The more recent analyses have used the Breit-Wigner forms of these dominant resonances as input to provide constraints in determining the overall amplitudes and thus to get information about the less strongly coupled resonances. Besides covering wider ranges, some of the more ambitious of the analyses at the lower energies have treated several channels simultaneously, so that unitarity constraints are automatically satisfied and only a single mass and width is obtained for each resonance.

In the mid and late 1970's, a large amount of new data became available. Results from several large K^-p bubble chamber experiments were published.[3-6] Other bubble chamber experiments studied K^-n reactions[7] and $K^0_L p$ reactions.[8] Counter experiments measured the $K^-p \to \bar{K}^0 n$ total and differential cross sections at low energies,[9] the K^-p polarizations down to 1630 MeV for the first time,[10] the K^-p polarizations from 1700 to 1900 MeV with an order of magnitude increase in statistics,[11] the K^-n elastic angular distributions from 1600 to 1800 MeV[12] and from 1900 to 2300 MeV,[13] and the 180° K^-p and 0° $\Sigma^-\pi^+$ differential cross sections from 1550 to 1900 MeV.[14]

In the following, we compare the more recent partial-wave analyses with each other and with the data. Some of the data have yet to be incorporated into any analysis.

The $N\bar{K}$ channel: The most recent analysis[15] is an update of the old Rutherford Lab-Imperial College (RLIC 77) analysis.[16] As before, it is a conventional energy-dependent analysis with the added constraint that the masses and widths of the resonances had to be consistent with those determined in the inelastic channels analyzed previously — $\Lambda\pi$, $\Sigma\pi$, $\Lambda(1520)\pi$, $\Sigma(1385)\pi$, and $N\bar{K}^*(892)$. The analysis also goes closer to threshold: the range covered is 1470 to 2170 MeV. It includes all the $N\bar{K}$ data mentioned above except for the high-statistics charge-exchange counter measurements[9] (which disagree with both the earlier and the latest[4] high-statistics bubble chamber measurements), the backward elastic data,[14] and the most recent K^-n elastic data.[1] As before, angular distributions (a total of 5110 data points) were fit directly. The new amplitudes are not very different from the RLIC 77 amplitudes for this channel. However, the K^-n data removed some of the uncertainties in the Σ spectrum.

The LBL-Mt. Holyoke-CERN analysis[17] covers the narrower range of 1500 to 1940 MeV and also includes most of the new data. It is an energy-dependent analysis using a unitary background parametrized in terms of scattering lengths. The cusp effects at the $\Lambda\eta$ and $\Sigma\eta$ thresholds are included by introducing a square-root singularity in the energy variation of the widths of the appropriate resonances. This group's own high-statistics charge-exchange data[9] (which do not agree with bubble chamber measurements) all but kill the less well-established resonances.

The University College, London (UCL) K-matrix energy-dependent analysis[18] covers from 1540 to 2000 MeV. The NK amplitudes are consistent with those of the other analyses over most of this range. However, at the low end there are major differences, indicating the absence of constraints from the Λ(1520), which lies just outside the range covered. The K^-n angular distributions and K^-p polarization measurements are not very well described by this analysis.

The above analyses, all below 2200 MeV, are complemented by the College de France-Saclay (CdF-S) energy-dependent analysis[6] covering from 2070 to 2440 MeV. Besides the conventional polynomial parametrization of the background amplitudes, also tried is a parametrization using constraints imposed by the duality hypothesis (that s-channel backgrounds come exclusively from the t-channel Pomeron exchange amplitude). With 30 fewer free parameters, the results are consistent with the conventional approach.

The Σπ channel: There is very little agreement, particularly in the lower partial waves, between the two multichannel analyses.[16,18] The low-energy $K^0_L p \rightarrow \Sigma^0\pi^+$ data[8] are better explained by the RLIC 77 amplitudes than by the UCL amplitudes. At the high end, there is good continuity between the RLIC 77 amplitudes and those from the single-channel analysis of the CdF-S collaboration[6] covering from 2070 to 2440 MeV. The Λ(1520) and Λ(2110) resonances, which lie outside the range covered by the UCL analysis, clearly provide strong constraints on the amplitudes.

The Λπ channel: This isospin-1 channel has been the subject of many energy-dependent and -independent analyses (for example, RLIC 77,[16] UCL,[18] Baillon-Litchfield,[19] de Bellefon-Berthon,[20] and Van Horn[21]). However, even the widespread use of the method of Barrelet zeroes has not helped to resolve the Σ spectrum — probably because most Σ resonances simply do not couple strongly to the initial $N\overline{K}$ channel.

Quasi-2-body channels: The RLIC group has made energy-dependent analyses of the Λ(1520)π, Σ(1385)π, and $N\overline{K}^*(892)$ channels over the widest ranges for which data are available. The data were extracted from the appropriate 3-particle final states by making 4-variable fits to an incoherent superposition of quasi-2-body final states and 3-particle Lorentz-invariant phase space. The quality of the fits suggests a maximum model-dependent systematic uncertainty of 10%. The Λω channel has been analyzed from threshold to 2440 MeV by the CdF-S collaboration.[6]

Sign conventions for resonance couplings: In terms of the isospin-0 and -1 elastic scattering amplitudes A_0 and A_1, the amplitude for $K^-p \rightarrow \overline{K}^0 n$ scattering is $\pm(A_1\text{-}A_0)/2$, where the sign depends on conventions used in conjunction with the Clebsch-Gordan coefficients (such as, is the baryon or the meson the "first" particle). If this reaction is partial-wave analyzed and if the overall phase is chosen so that, say, the D_{15} Σ(1775) amplitude at resonance points along the positive imaginary axis (points "up"), then any Σ at resonance will point "up" and any Λ at resonance will point "down" (along the negative imaginary axis). Thus the phase at resonance determines the isospin. The above ignores background amplitudes in the resonating partial waves.

That is the basic idea. In a similar but somewhat more complicated way, the phases of the $\overline{K}N \rightarrow \Lambda\pi$ and $\overline{K}N \rightarrow \Sigma\pi$ amplitudes for a resonating partial wave help determine the SU(3) multiplet to which the resonance belongs. Again, a convention has to be adopted for some overall arbitrary phases: which way is "up"? Our convention is that of Levi-Setti[22] and is shown in Fig. 1, which also compares experimental results with theoretical predictions for the signs of several other resonances. In the Listings, a + or − sign in front of a measurement of an inelastic resonance coupling indicates the sign (the *absence* of a sign means that the sign is not determined, *not* that it is positive). For more details, see Appendix II of our 1982 edition.[23]

Argand plots: Figure 2 shows some representative Argand plots of partial-wave amplitudes. For the $N\overline{K}$ channel we show the amplitudes from RLIC 77[16] and from LBL-Mt. Holyoke-CERN,[17] and for the Λπ and Σπ channels we show those from RLIC 77[16] and from UCL.[18]

Errors on masses and widths: The errors quoted on resonance parameters from partial-wave analyses are often only statistical, and the parameters can change by more than these errors when a different parametrization of the waves is used. Furthermore, the different analyses use more or less the same data, so it is not really appropriate to treat the different determinations of the resonance parameters as independent or to average them together. In any case, the spread of the masses, widths, and branching fractions from the different analyses is certainly a better indication of the uncertainties than are the quoted errors. In the Baryon Table, usually a range reflecting the spread of the values is given rather than a particular value with error.

For three states, the Λ(1520), the Λ(1820), and the Σ(1775), there is enough information to make an overall fit to the various branching fractions. It is then necessary to use the quoted errors, but the errors obtained from the fit should not be taken seriously.

III. Production experiments

Partial-wave analyses of course separate partial waves, whereas a peak in a cross section or an invariant mass distribution usually cannot be disentangled from background and analyzed for its quantum numbers; and more than one resonance may be contributing to the peak. Results from partial-wave analyses and from production experiments are generally kept separate in the Listings, and in the Baryon Table results from production experiments are used only for the low mass states: the Σ(1385) and Λ(1405) of course lie below the $\overline{K}N$ threshold and everything about them comes from production experiments; and production and formation experiments agree quite well in the case of Λ(1520) and results have been combined. There is some disagreement between production and formation experiments in the 1600-1700-MeV region: see the Note on the Σ(1670).

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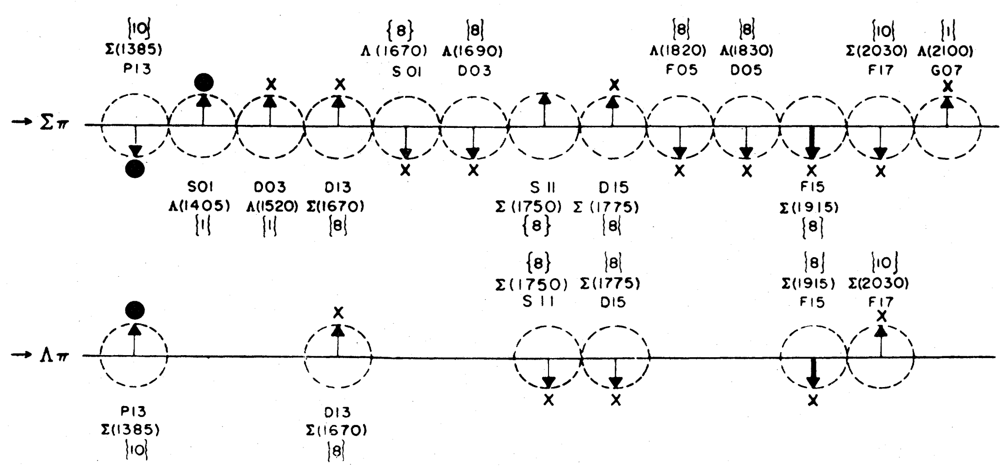


Fig. 1. The signs of the imaginary parts of resonating amplitudes in the $\overline{K}N \rightarrow \Lambda\pi$ and $\Sigma\pi$ channels. The signs of the Σ(1385) and Λ(1405), marked with a •, are set by convention, and then the others are determined relative to them. The signs required by the SU(3) assignments of the resonances are shown with an arrow, and the experimentally determined signs are shown with an ×.

For notation, see key at front of Listings.

Baryons

Λ's and Σ's

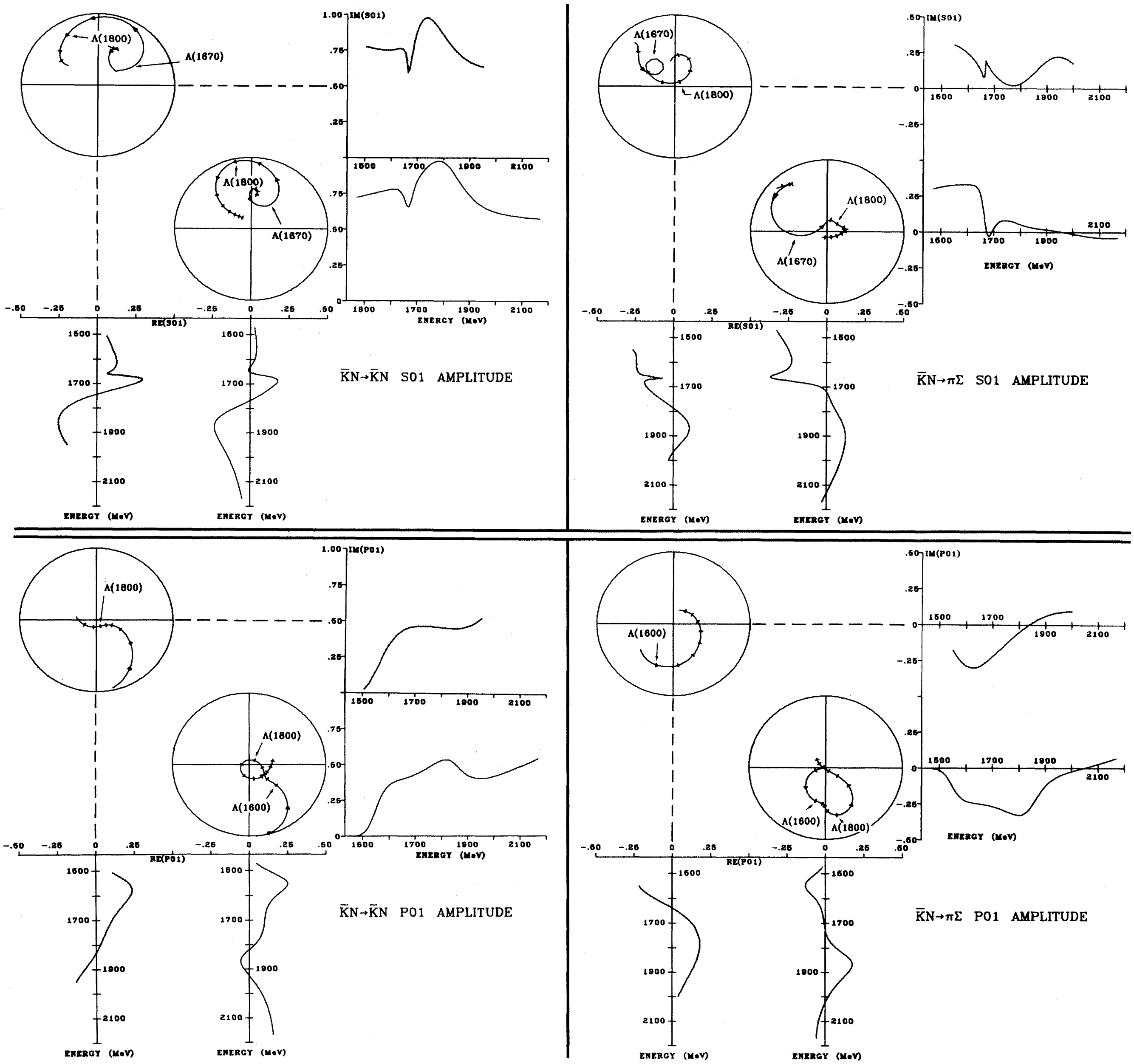


Fig. 2(a). The $L_{I \cdot 2J} = S_{01}$ and P_{01} partial-wave amplitudes for $\bar{K}N$ scattering in the elastic and $\Sigma\pi$ channels. The lower plot for each amplitude is from RLIC 77, the upper plots for the elastic amplitudes are from ALSTON 78, and the upper plots for the $\Sigma\pi$ amplitudes are from MARTIN 77. In the Argand plots, the ticks are at integral multiples of 50 MeV, and the established resonances are shown at their nominal positions [the S_{01} Λ(1405) is of course below threshold and is not shown]. The real and imaginary parts of the amplitudes as functions of energy are shown projected in alignment with the Argand plots.

Baryons

Data Card Listings

Λ's and Σ's

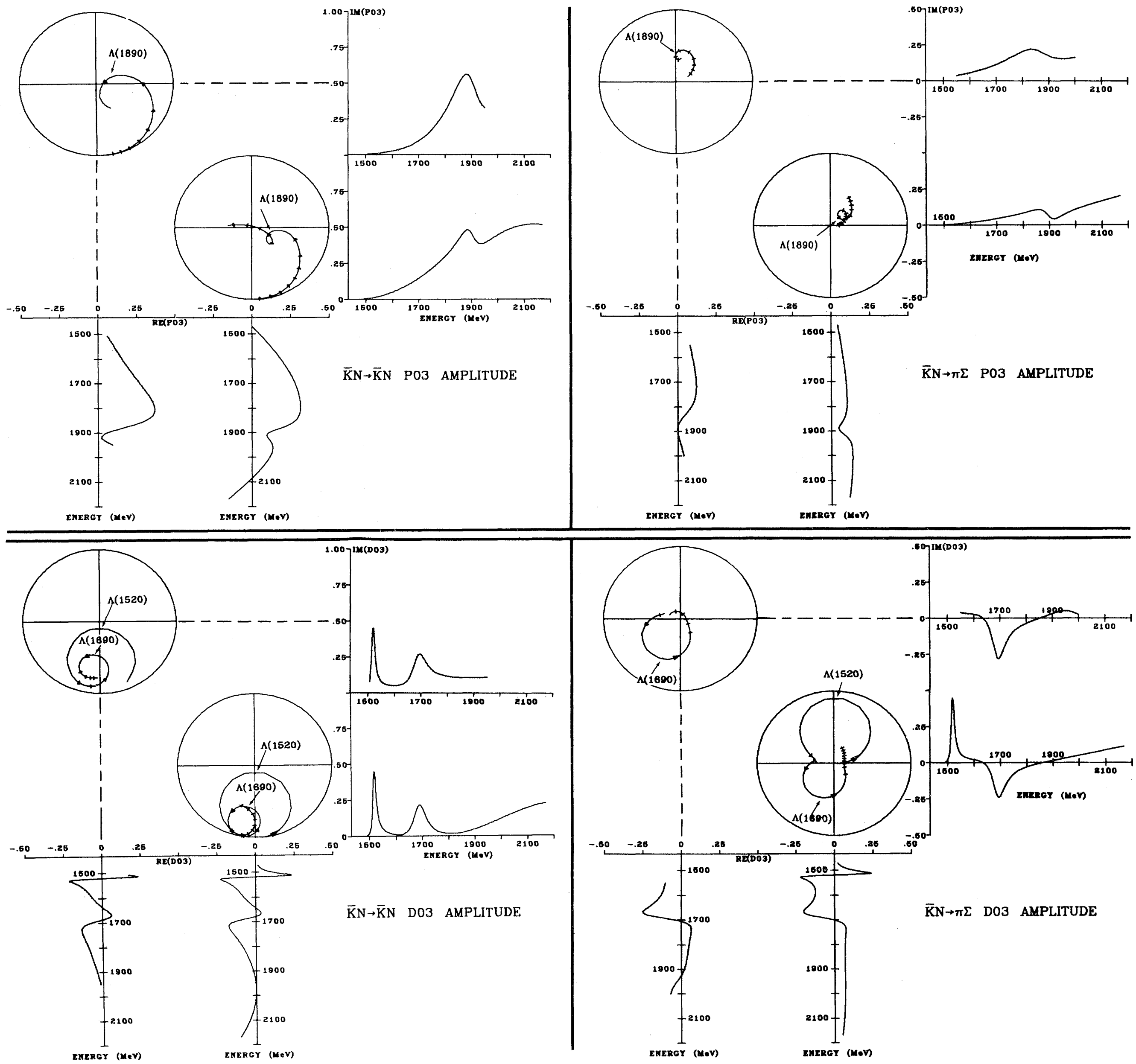


Fig. 2(b). The $L_{I\cdot 2J} = P_{03}$ and D_{03} partial-wave amplitudes for $\bar{K}N$ scattering in the elastic and $\Sigma\pi$ channels. The lower plot for each amplitude is from RLIC 77, the upper plots for the elastic amplitudes are from ALSTON 78, and the upper plots for the $\Sigma\pi$ amplitudes are from MARTIN 77. In the Argand plots, the ticks are at integral multiples of 50 MeV, and the established resonances are shown at their nominal positions. The real and imaginary parts of the amplitudes as functions of energy are shown projected in alignment with the Argand plots.

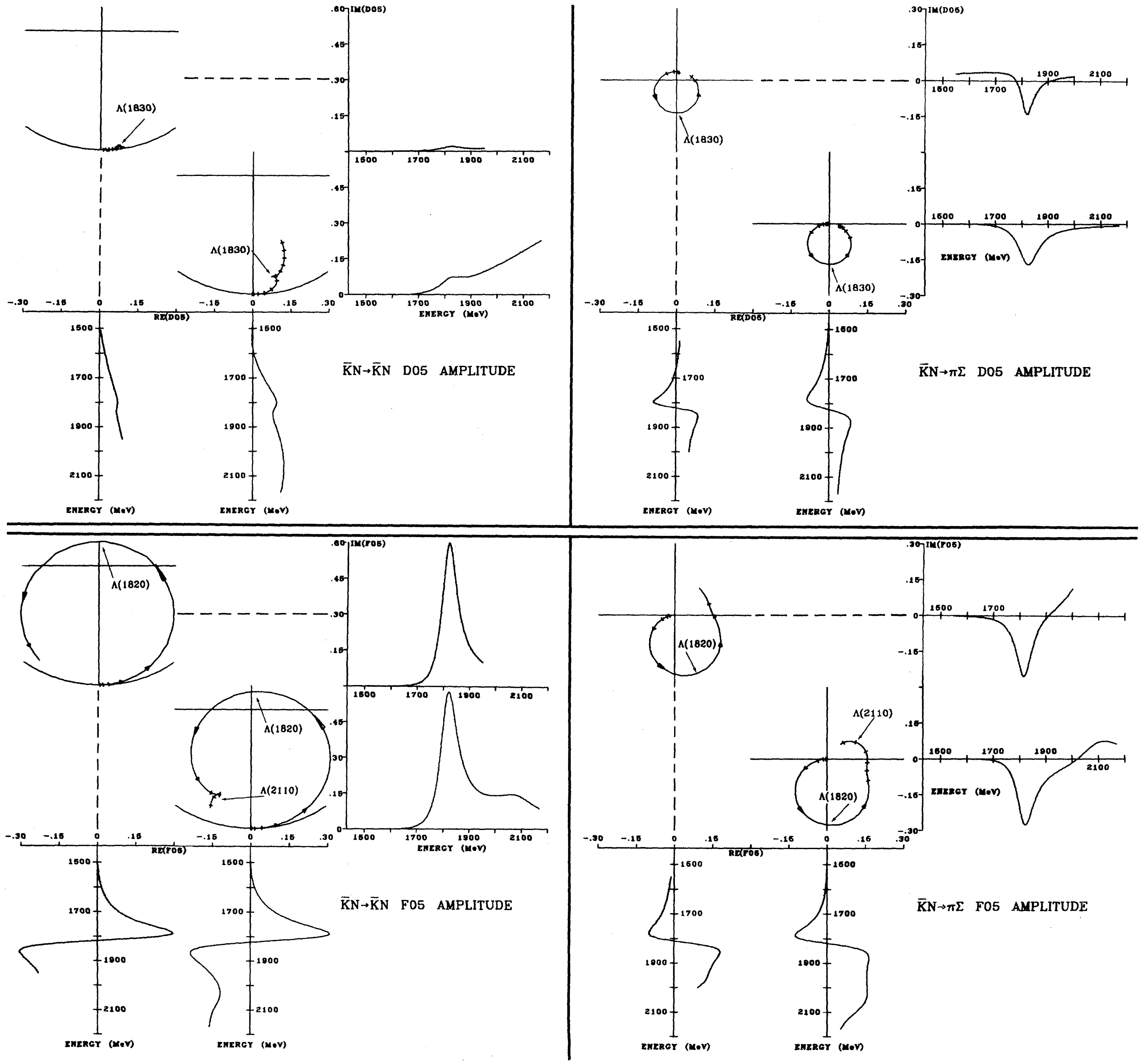


Fig. 2(c). The $L_{I\cdot 2J} = D_{05}$ and F_{05} partial-wave amplitudes for $\bar{K}N$ scattering in the elastic and $\Sigma\pi$ channels. The lower plot for each amplitude is from RLIC 77, the upper plots for the elastic amplitudes are from ALSTON 78, and the upper plots for the $\Sigma\pi$ amplitudes are from MARTIN 77. In the Argand plots, the ticks are at integral multiples of 50 MeV, and the established resonances are shown at their nominal positions. The real and imaginary parts of the amplitudes as functions of energy are shown projected in alignment with the Argand plots.

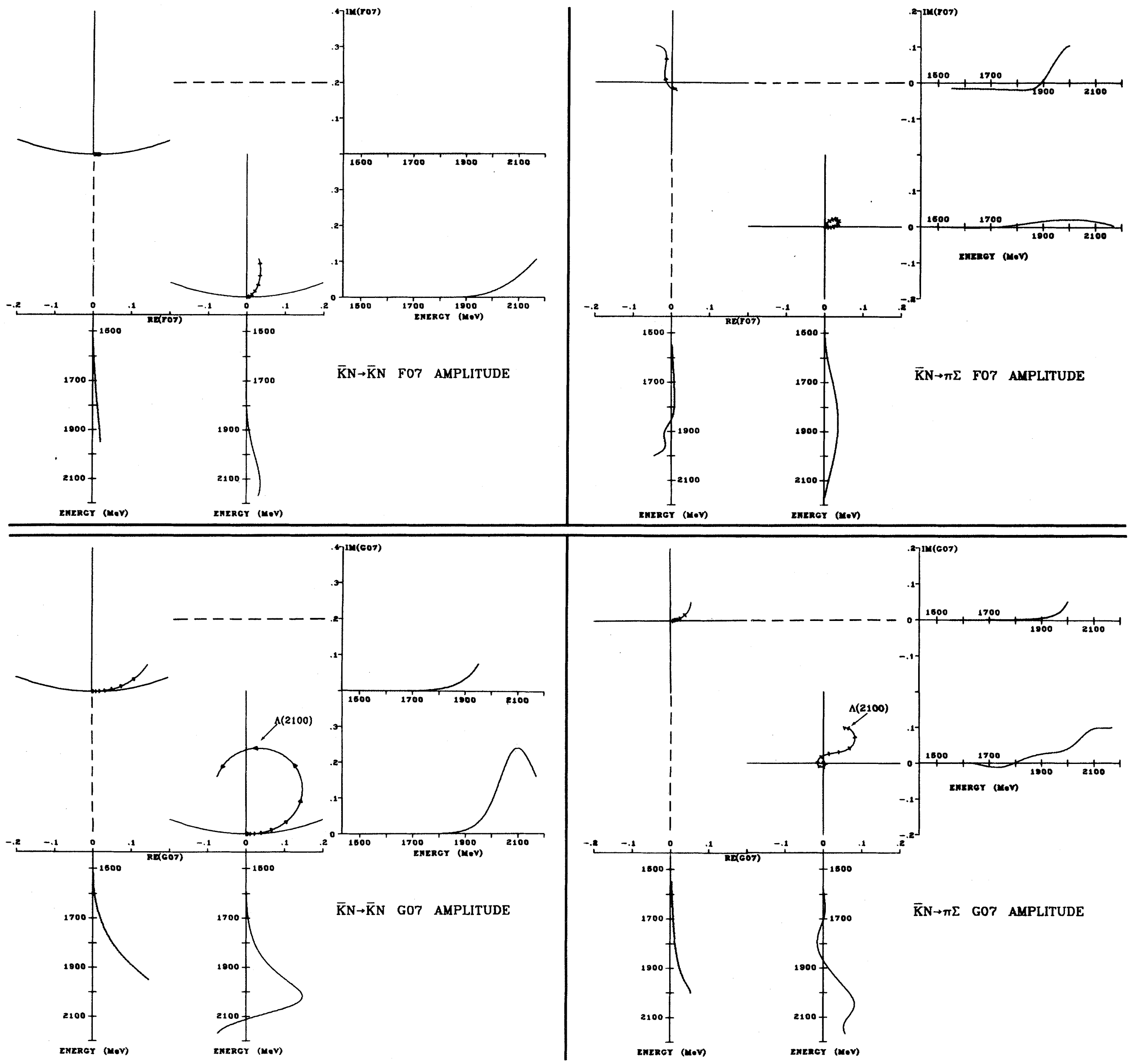
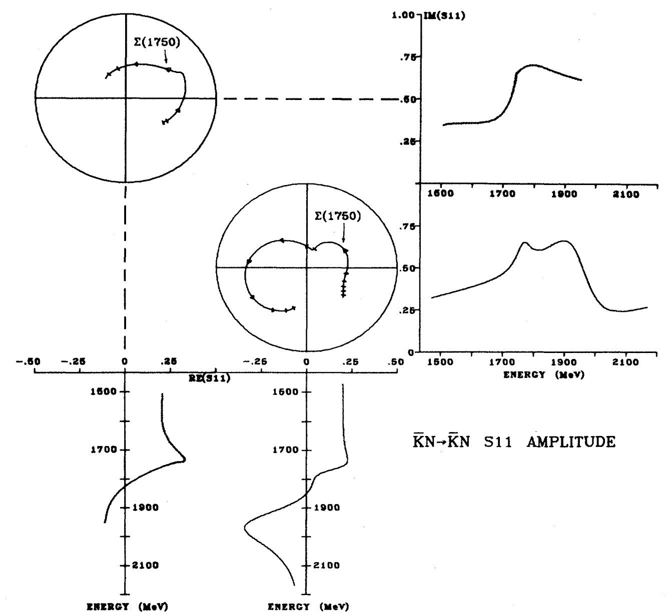
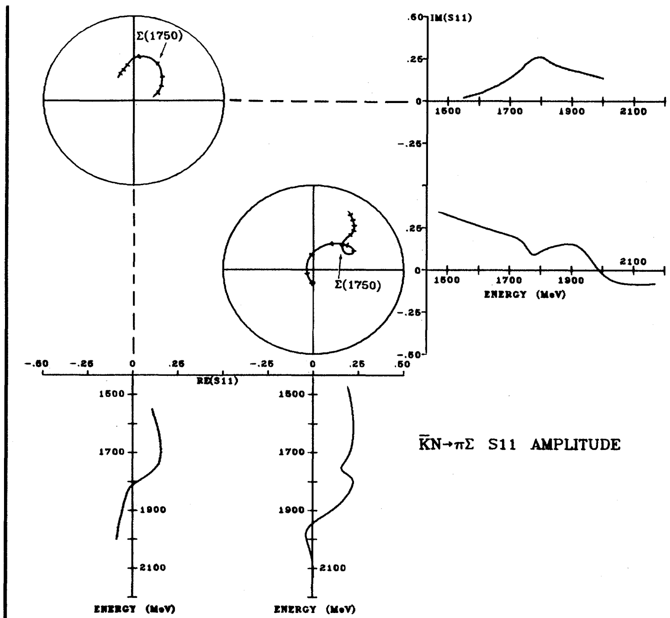


Fig. 2(d). The $L_{I\cdot 2J} = F_{07}$ and G_{07} partial-wave amplitudes for $\bar{K}N$ scattering in the elastic and $\Sigma\pi$ channels. The lower plot for each amplitude is from RLIC 77, the upper plots for the elastic amplitudes are from ALSTON 78, and the upper plots for the $\Sigma\pi$ amplitudes are from MARTIN 77. In the Argand plots, the ticks are at integral multiples of 50 MeV, and the established resonance is shown at its nominal position. The real and imaginary parts of the amplitudes as functions of energy are shown projected in alignment with the Argand plots.

For notation, see key at front of Listings.

Baryons
Λ's and Σ's





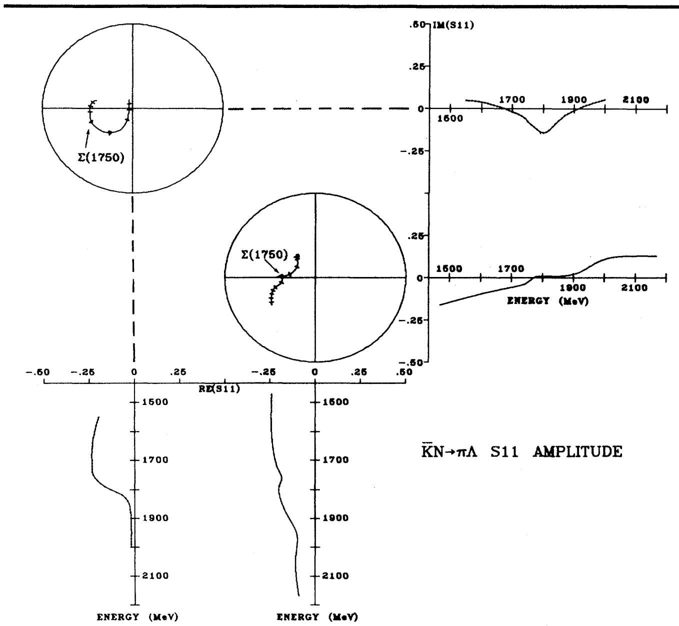
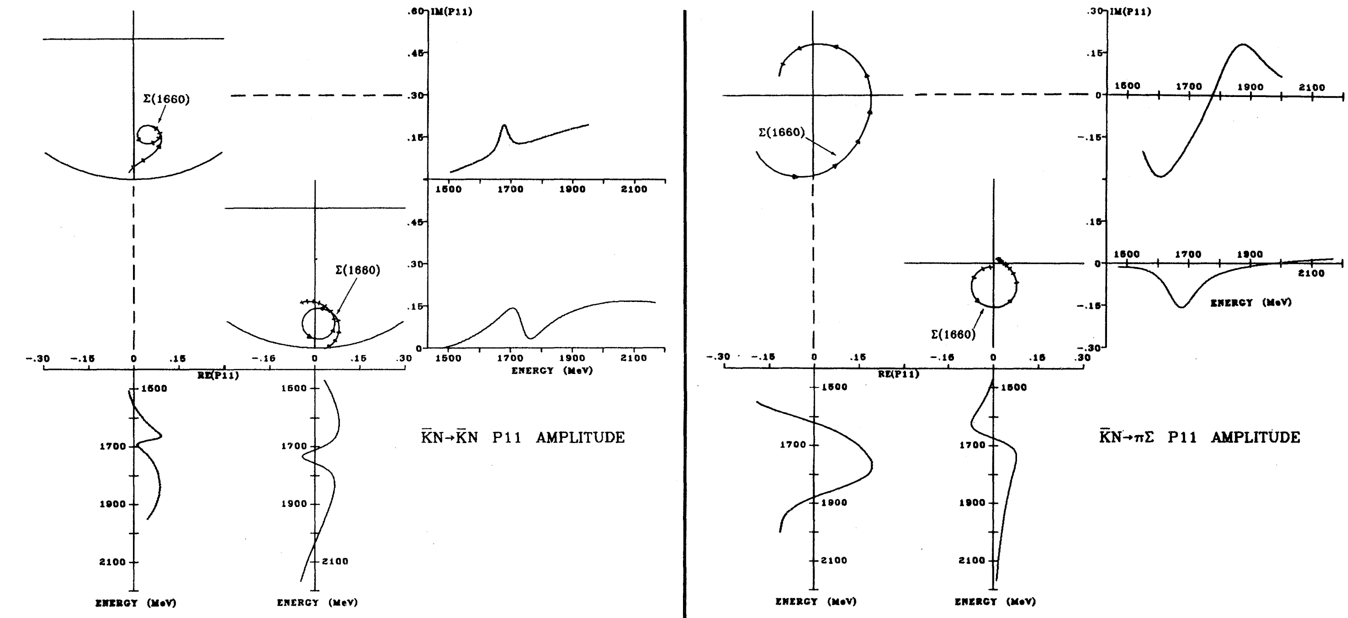


Fig. 2(e). The $L_{I\cdot 2J} = S_{11}$ partial-wave amplitudes for $\bar{K}N$ scattering in the elastic, $\Lambda\pi$, and $\Sigma\pi$ channels. The lower plot for each amplitude is from RLIC 77, the upper plot for the elastic amplitude is from ALSTON 78, and the upper plots for the $\Lambda\pi$ and $\Sigma\pi$ channels are from MARTIN 77. In the Argand plots, the ticks are at integral multiples of 50 MeV, and the established resonance is shown at its nominal position. The real and imaginary parts of the amplitudes as functions of energy are shown projected in alignment with the Argand plots.

Baryons

Λ's and Σ's



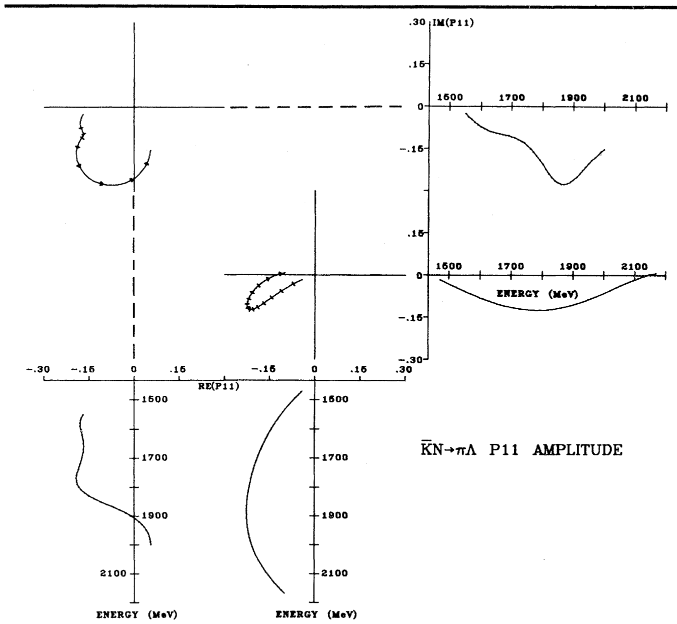
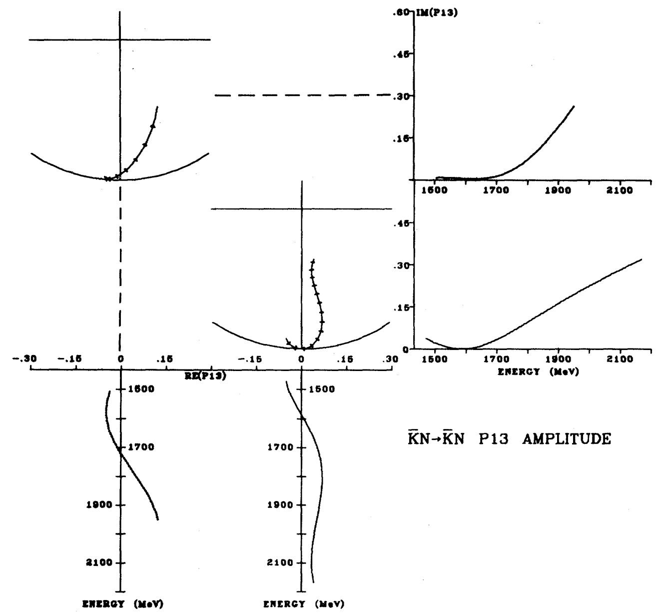
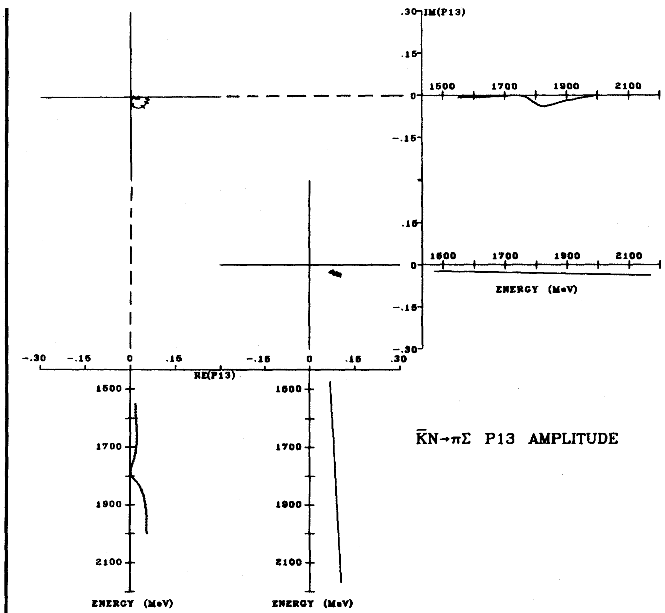


Fig. 2(f). The $L_{I\cdot 2J} = P_{11}$ partial-wave amplitudes for $\overline{K}N$ scattering in the elastic, $\Lambda\pi$, and $\Sigma\pi$ channels. The lower plot for each amplitude is from RLIC 77, the upper plot for the elastic amplitude is from ALSTON 78, and the upper plots for the $\Lambda\pi$ and $\Sigma\pi$ channels are from MARTIN 77. In the Argand plots, the ticks are at integral multiples of 50 MeV, and the established resonance is shown at its nominal position. The real and imaginary parts of the amplitudes as functions of energy are shown projected in alignment with the Argand plots.





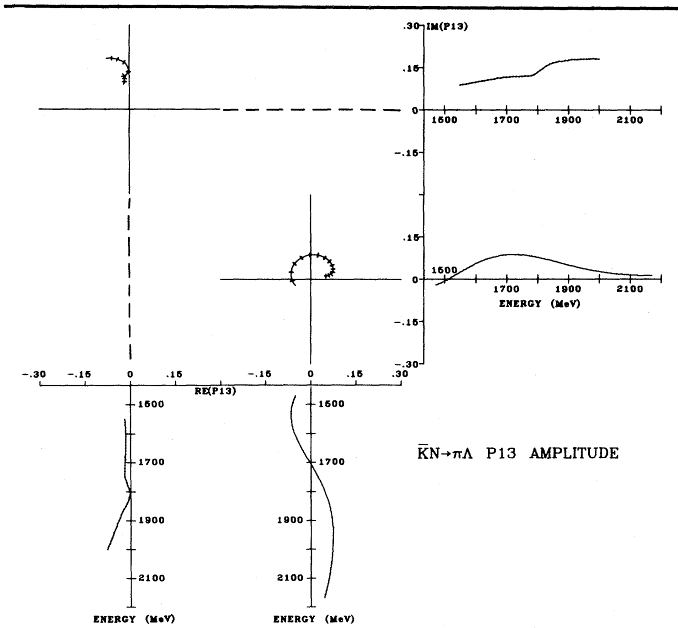
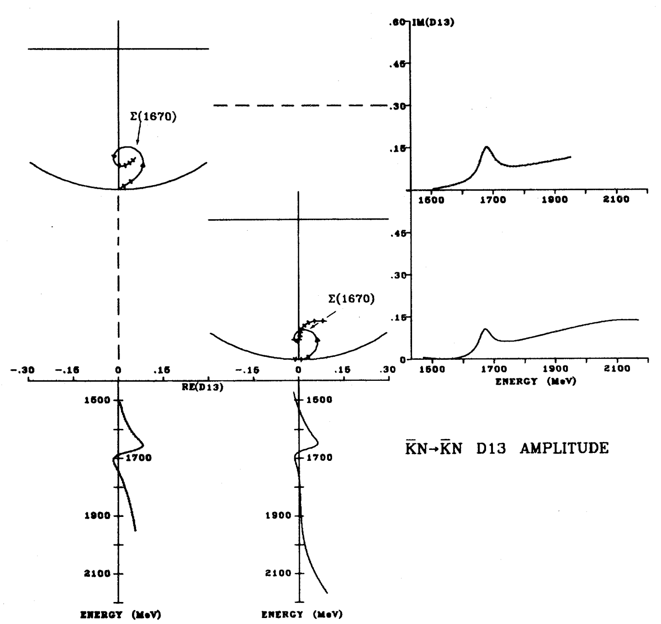
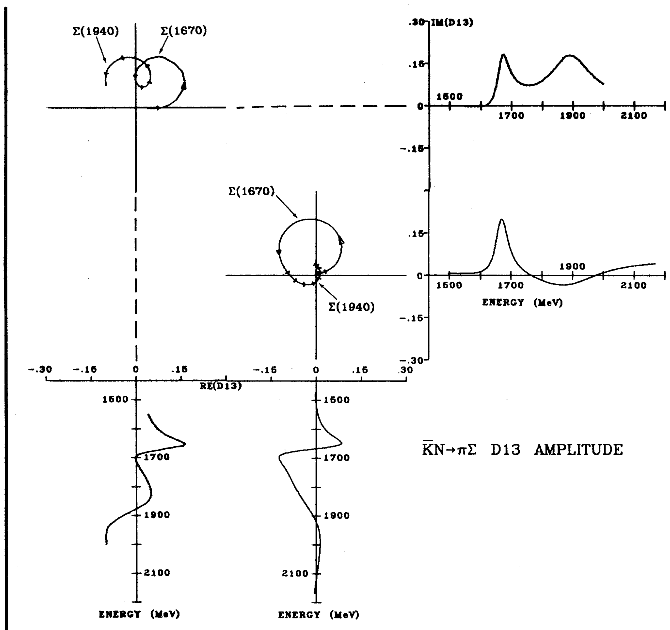


Fig. 2(g). The $L_{I \cdot 2J} = P_{13}$ partial-wave amplitudes for $\bar{K}N$ scattering in the elastic, $\Lambda\pi$, and $\Sigma\pi$ channels. The lower plot for each amplitude is from RLIC 77, the upper plot for the elastic amplitude is from ALSTON 78, and the upper plots for the $\Lambda\pi$ and $\Sigma\pi$ channels are from MARTIN 77. In the Argand plots, the ticks are at integral multiples of 50 MeV [the Σ(1385) is of course below threshold and is not shown]. The real and imaginary parts of the amplitudes as functions of energy are shown projected in alignment with the Argand plots.





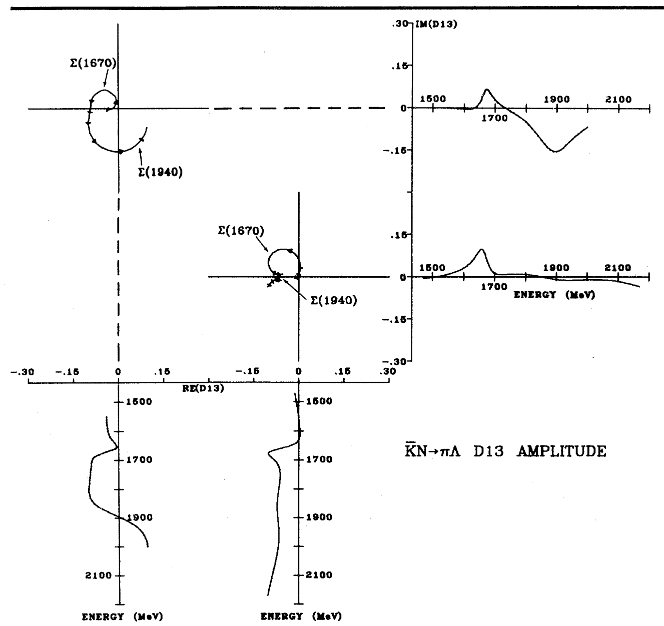
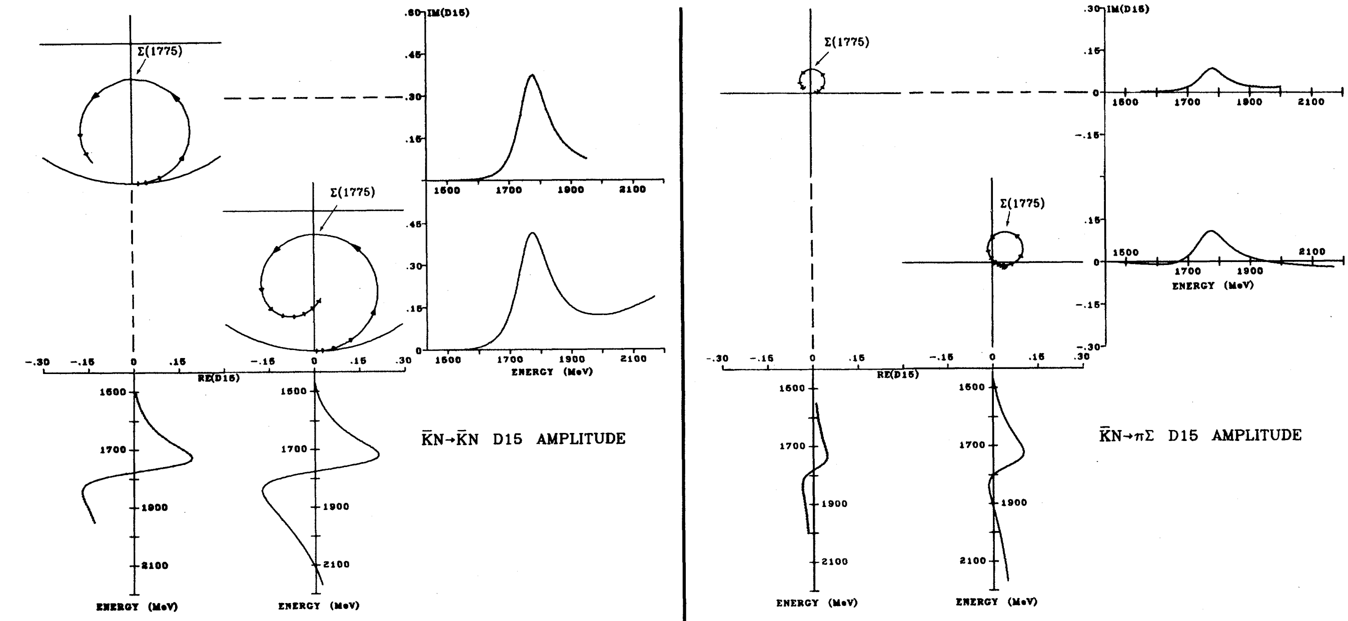


Fig. 2(h). The $L_{I\cdot 2J} = D_{13}$ partial-wave amplitudes for $\bar{K}N$ scattering in the elastic, $\Lambda\pi$, and $\Sigma\pi$ channels. The lower plot for each amplitude is from RLIC 77, the upper plot for the elastic amplitude is from ALSTON 78, and the upper plots for the $\Lambda\pi$ and $\Sigma\pi$ channels are from MARTIN 77. In the Argand plots, the ticks are at integral multiples of 50 MeV, and the established resonances are shown at their nominal positions. The real and imaginary parts of the amplitudes as functions of energy are shown projected in alignment with the Argand plots.



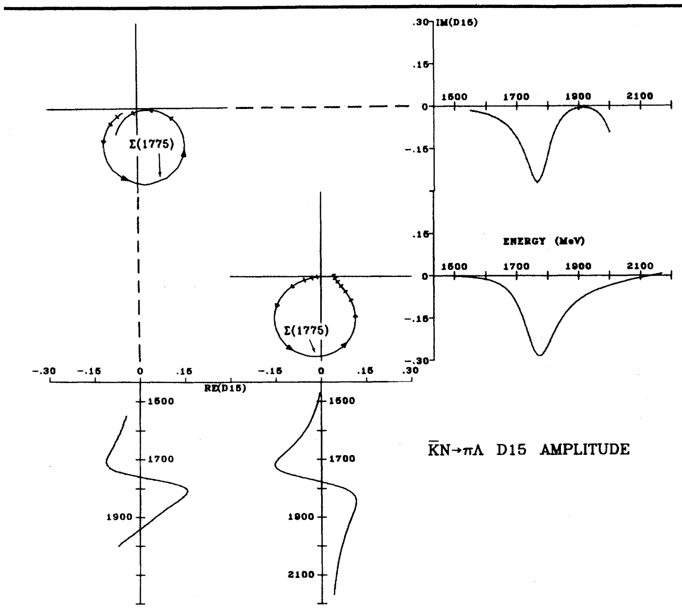
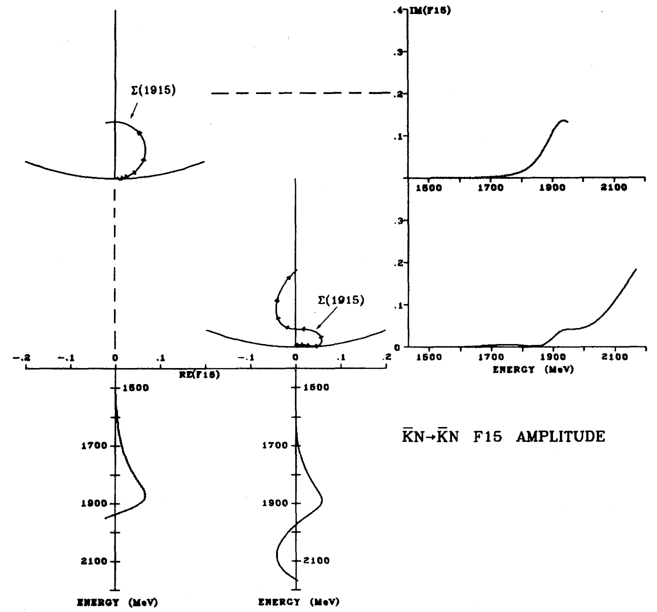


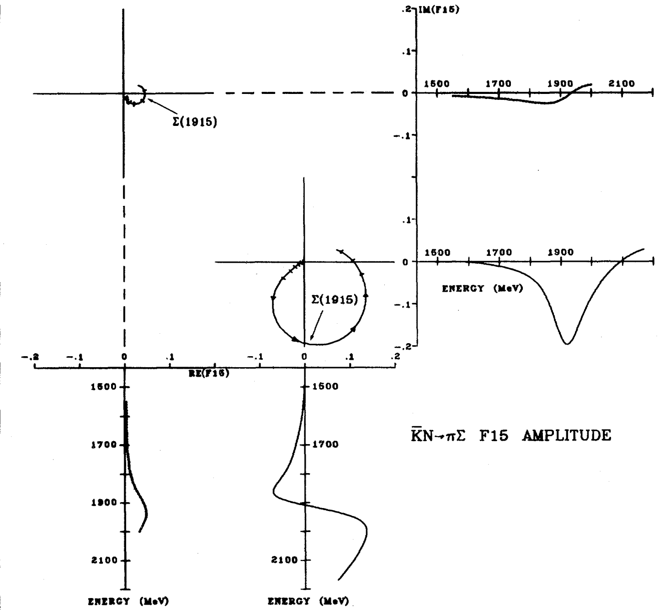
Fig. 2(i). The $L_{I \cdot 2J} = D_{15}$ partial-wave amplitudes for $\overline{K}N$ scattering in the elastic, $\Lambda\pi$, and $\Sigma\pi$ channels. The lower plot for each amplitude is from RLIC 77, the upper plot for the elastic amplitude is from ALSTON 78, and the upper plots for the $\Lambda\pi$ and $\Sigma\pi$ channels are from MARTIN 77. In the Argand plots, the ticks are at integral multiples of 50 MeV, and the established resonance is shown at its nominal position. The real and imaginary parts of the amplitudes as functions of energy are shown projected in alignment with the Argand plots.

Baryons

Data Card Listings

Λ's and Σ's





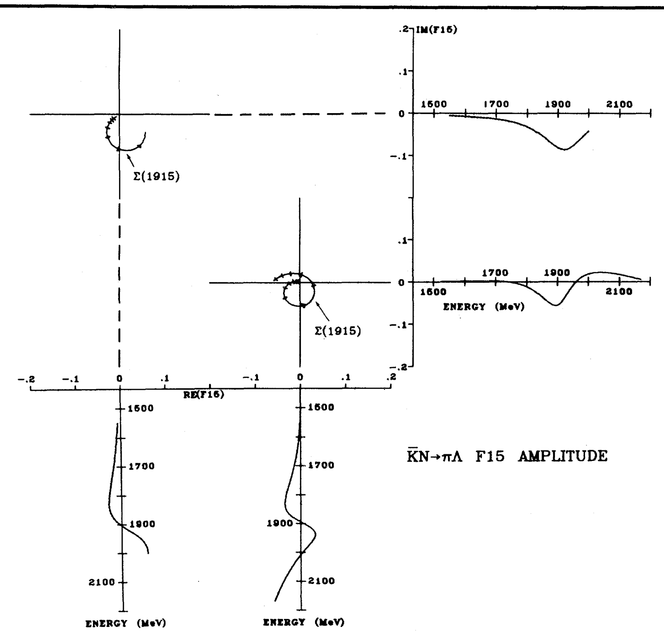
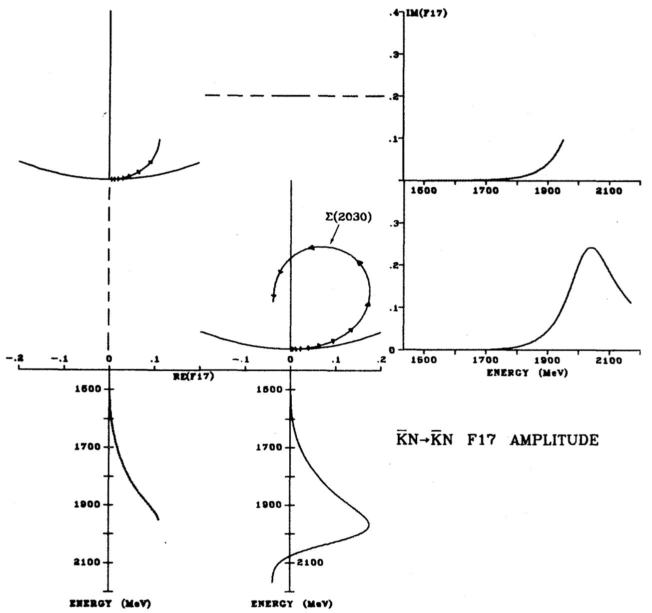
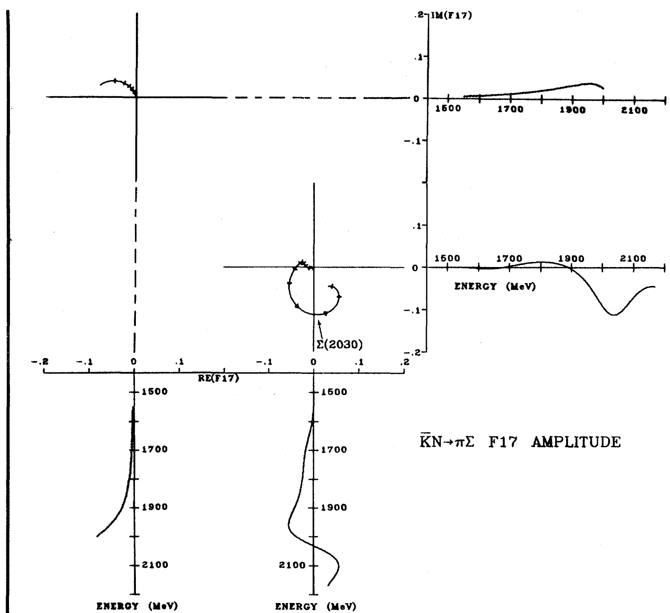


Fig. 2(j). The $L_{I \cdot 2J} = F_{15}$ partial-wave amplitudes for $\overline{K}N$ scattering in the elastic, $\Lambda\pi$, and $\Sigma\pi$ channels. The lower plot for each amplitude is from RLIC 77, the upper plot for the elastic amplitude is from ALSTON 78, and the upper plots for the $\Lambda\pi$ and $\Sigma\pi$ channels are from MARTIN 77. In the Argand plots, the ticks are at integral multiples of 50 MeV, and the established resonance is shown at its nominal position. The real and imaginary parts of the amplitudes as functions of energy are shown projected in alignment with the Argand plots.





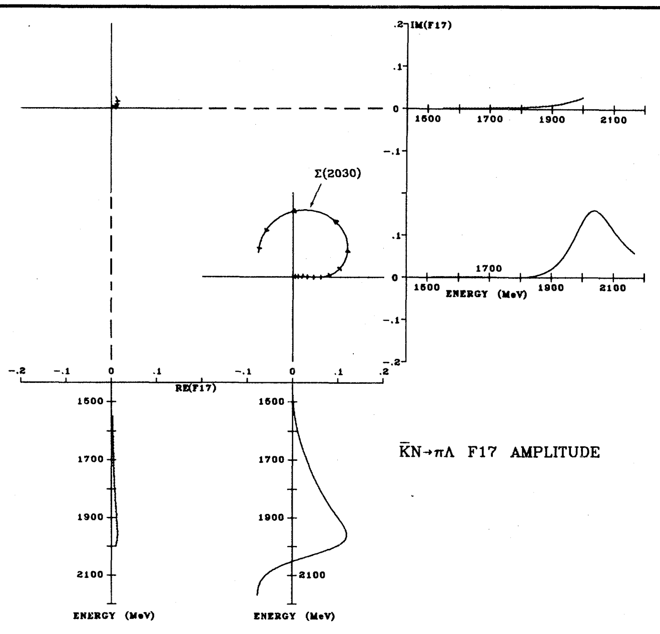


Fig. 2(k). The $L_{I \cdot 2J} = F_{17}$ partial-wave amplitudes for $\bar{K}N$ scattering in the elastic, $\Lambda\pi$, and $\Sigma\pi$ channels. The lower plot for each amplitude is from RLIC 77, the upper plot for the elastic amplitude is from ALSTON 78, and the upper plots for the $\Lambda\pi$ and $\Sigma\pi$ channels are from MARTIN 77. In the Argand plots, the ticks are at integral multiples of 50 MeV, and the established resonance is shown at its nominal position. The real and imaginary parts of the amplitudes as functions of energy are shown projected in alignment with the Argand plots.

Baryons

Data Card Listings

Λ's and Σ's, Λ, $\Lambda(1405)$, $\Lambda(1520)$

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13. Y. Declais et al., CERN 77-16 (1977).
14. M. Alston-Garnjost et al., Phys. Rev. **D21**, 1191 (1980).
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16. G.P. Gopal et al., Nucl. Phys. **B119**, 362 (1977).
17. M. Alston-Garnjost et al., Phys. Rev. **D18**, 182 (1978).
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20. A. de Bellefon and A. Berthon, Nucl. Phys. **B109**, 129 (1976).
21. A.J. Van Horn, Nucl. Phys. **B87**, 145 (1975).
22. R. Levi-Setti, in *Proceedings of the Lund International Conference on Elementary Particles* (Lund, 1969), p. 339.
23. Particle Data Group, Phys. Lett. **111B** (1982).

S=-1 I=0 HYPERON STATES (Λ)

Λ

18 LAMBDA(1116, JP=1/2+) I=0

SEE STABLE PARTICLE DATA CARD LISTINGS

$\Lambda(1405)$ S'_{01} Status: ****

37 LAMBDA(1405, JP=1/2-) I=0
PRODUCTION EXPERIMENTS

THIS RESONANCE IS IDENTIFIED WITH THE VIRTUAL BOUND STATE IN THE N-KBAR SYSTEM FOUND IN THE ANALYSIS OF LOW ENERGY K-P INTERACTIONS. WE LIST THOSE RESULTS SEPARATELY IN THE NEXT ENTRY. WE USE ONLY PRODUCTION EXPERIMENTS FOR GETTING THE MASS AND WIDTH FOR THE BARYON TABLE.

37 LAMBDA(1405) MASS (MEV) (PROD. EXP.)

M		(1405.0)		ALSTON	61	HBC	K-P 1.15 GEV/C	
M		(1410.0)		ALEXANDER	62	HBC	PI-P 2.1 GEV/C	
M		(1405.0)		ALSTON	62	HBC	K-P 1.2-.5 GEV/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 GEV/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 2.1-2.7GEV/C	6/68
M		. . . . .	. . . .					
M	AVG	1402.4	3.5	AVERAGE				

37 LAMBDA(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 2.1-2.7GEV/C	6/68
W		. . . . .	. . . .					
W	AVG	38.1	3.9	AVERAGE				

37 LAMBDA(1405) PARTIAL DECAY MODES (PROD. EXP.)

		DECAY MASSES
P1	LAMBDA(1405) INTO SIGMA PI	1189+ 140

REFERENCES FOR LAMBDA(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+SACL)
BIRMINGH	66 PR 152 1148		(BIRM+GLAS+LOIC+OXF+RHEL)
GALTIERI	68 PRL 21 573	BARBARO-GALTIERI,CHADWICK +	(LRL+SLAC)

1405 MEV REGION: EXTRAPOLATIONS BELOW THRESHOLD

24 LAMBDA(1405, JP=1/2-) I=0 S'01
EXTRAPOLATIONS BELOW THRESHOLD

SEE THE NOTE IN THE PREVIOUS ENTRY. THE DIFFICULTIES IN EXTRAPOLATING FROM THE PHYSICAL REGION TO THE RESONANCE LOCATION ARE DISCUSSED BY DALITZ 67.

THE QUESTION ON WHETHER LAMBDA(1405) IS AN N-KBAR BOUND STATE OR A CDD POLE (DALITZ 70, RAJASEKARAN 72) HAS BEEN INVESTIGATED BY CLINE 71, MARTIN 71, GALTIERI 72, AND DOBSON 72. THE LAST TWO PAPERS CONCLUDE THAT THE DATA CANNOT TELL THE DIFFERENCE.

THE (N KBAR)/(SIGMA PI) COUPLING RATIO IS DISCUSSED BY OADES 77.

24 LAMBDA(1405) MASS (MEV)

M		1410.7	(1.0)	KIM	65	HBC	0-EFF-RANGE FIT	7/66
M		1409.6	(1.7)	SAKITT	65	HBC	0-EFF-RANGE FIT	7/66
M		DATA OF SAKITT ARE USED IN FIT BY KITTEL.						
M		1407.5	(1.2)	KITTEL	66	HBC	0-EFF-RANGE FIT	7/66
M		1403.0	(3.0)	KIM	67	HBC	K MATRIX FIT(KP)	8/67
M		1416.0	(4.0)	MARTIN	69	HBC	CONST. K MATRIX	10/69
M		(1421.0)		MARTIN	70	RVUE	CONST. K MATRIX	6/70
M	A	(1406.0)		CHAO	73	DPWA	0-RNG. FIT.SOL B	9/73
M	A	SEE ALSO THE ACCOMPANYING PAPER OF THOMAS 73.						9/73

24 LAMBDA(1405) WIDTH (MEV)

W		37.0	(3.2)	KIM	65	HBC		7/66
W		28.2	(4.1)	SAKITT	65	HBC		7/66
W		34.1	(4.1)	KITTEL	66	HBC		7/66
W		50.0	(5.0)	KIM	67	HBC	K MATRIX FIT(KP)	8/67
W		29.0	(6.0)	MARTIN	69	HBC	CONST. K MATRIX	10/69
W		(20.0)		MARTIN	70	RVUE	CONST. K MATRIX	6/70
W	B	(55.0)		CHAO	73	DPWA	0-RNG. FIT.SOL B	9/73
W	B	ASYMMETRIC SHAPE, W/2=41 MEV BELOW RESONANCE, 14 MEV ABOVE.						9/73

REFERENCES FOR LAMBDA(1405) (EXTRAPOLATIONS)

KIM	65 PRL 14 29	J K KIM	(COLU)IJP
SAKITT	65 PR 139 B719	+DAY,GLASSER,SEEMAN,FRIEDMAN, +	(UMD+LRL)IJP
KITTEL	66 PL 21 349	W KITTEL, G OTTER, I WACEK	(VIEN)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	(DURH)IJP
CHAO	73 NP B56 46	CHAO,KRAEMER,THOMAS,MARTIN	(RHEL+CARN+LOUC)IJP
ALSO	73 NP B56 15	THOMAS,ENGLER,FISK,KRAEMER	(CARN)IJ

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	(LIVP)
KADYK	66 PRL 17 599	+OREN, G+S GOLDHABER, TRILLING	(LRL)IJP
DALITZ	67 PR 153 1617	DALITZ, WONG, RAJASEKARAN	(OXF+BOMB)
DALITZ	70 DUKE-HR 70 03	R D DALITZ	(OXF)
CLINE	71 PRL 26 1194	D CLINE,R LAUMANN,J MAPP	(WISC)
MARTIN	71 PL 35B 62	A D MARTIN,B R MARTIN,ROSS	(DURH+LOUC+RHEL)
DOBSON	72 PR D6 3256	P N DOBSON,R MCELHANEY	(HAWA)
GALTIERI	72 LBL 555	A BARBARO-GALTIERI	(LBL)
RAJASEKA	72 PR D5 610	RAJASEKARAN	(TIFR)
ALSO	EARLIER PAPERS CITED	IN RAJASEKARAN72	
SHAW	73 PURDUE CONF. 417	SHAW	(UCI)IJP
OADES	77 NC 42A 462	G C OADES,G RASCHE	(AARH+ZURI)IJP

$\Lambda(1520)$ D'_{03} Status: ****

38 LAMBDA(1520, JP=3/2-) I=0 D'03

THE MEASUREMENTS OF THE MASS, WIDTH, AND ELASTICITY THAT WERE PUBLISHED BEFORE 1975 ARE NOW OBSOLETE AND HAVE BEEN REMOVED. THEY WERE LAST LISTED IN OUR 1982 EDITION (PHYSICS LETTERS 111B). ALL THE REFERENCES HAVE BEEN RETAINED.

PRODUCTION AND FORMATION EXPERIMENTS AGREE QUITE WELL WITH EACH OTHER, SO THE TWO ARE LISTED TOGETHER HERE.

THE DECAY MODE LAMBDA PI PI IS LARGELY DUE TO SIGMA(1385) PI. ONLY THE VALUES OF (SIGMA(1385) PI)/(LAMBDA 2PI) GIVEN BY MAST 72 AND CORDEN 75 ARE BASED ON REAL 3-BODY PARTIAL WAVE ANALYSES (THE OLDER RESULTS USED CRUDER METHODS). THE DISCREPANCY BETWEEN THE TWO RESULTS IS ESSENTIALLY DUE TO THE DIFFERENT HYPOTHESES MADE CONCERNING THE SHAPE OF THE EPSILON MESON.

38 LAMBDA(1520) MASS (MEV)

M	2000	1519.4	0.3	CORDEN	75	DBC	K- D 1.4-1.8GV/C	4/75
M	4K	1519.7	0.3	CAMERON	77	HBC	K-P 0.96-1.36GEV	1/78
M		1519.0	1.0	RLIC	77	DPWA	KBAR N MULTICHNL	1/76
M		1520.0	0.5	ALSTON	78	DPWA	KBAR N ELASTIC	1/78
M	5K	1517.8	1.2	BARLAG	79	HBC	K-P AT 4.2 GEV/C	12/79
M	300	1517.3	1.5	BARBER	80	SPEC	GAM P TO K+ Y*	2/82
M		1519.0	1.0	GOPAL	80	DPWA	KBAR N ELASTIC	12/81
M		. . . . .	. . . .					
M	AVG	1519.50	0.18	AVERAGE				

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                    38  LAMBDA(1520) WIDTH (MEV)

W      2000   15.5       1.6              CORDEN    75 DBC     K- D 1.4-1.8GV/C  4/75
W        4K   16.3       0.5              CAMERON   77 HBC     K-P 0.96-1.36GEV  1/78
W             15.0       0.5              RLIC      77 DPWA    KBAR N MULTICHNL  1/76
W             15.4       0.5              ALSTON    78 DPWA    KBAR N ELASTIC    1/78
W  A    677   14.0       3.0              BARLAG    79 HBC     K-P AT 4.2 GEV/C 12/79
W  A     FROM BEST-RESOLUTION SAMPLE OF LAMBDA PI PI EVENTS ONLY.                12/79
W       300   16.3       3.3              BARBER    80 SPEC    GAM P TO K+ Y*    2/82
W             16.0       1.0              GOPAL     80 DPWA    KBAR N ELASTIC   12/81
W                . . . . . . . . . . .
W   AVG       15.59      0.27    AVERAGE

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                    38  LAMBDA(1520) PARTIAL DECAY MODES

                                                              DECAY MASSES
P1      LAMBDA(1520) INTO N KBAR                             938+ 494
P2      LAMBDA(1520) INTO SIGMA PI                          1189+ 140
P3      LAMBDA(1520) INTO LAMBDA PI PI                      1116+ 140+ 140
P4      LAMBDA(1520) INTO LAMBDA GAMMA                      1116+   0
P5      LAMBDA(1520) INTO SIGMA0 GAMMA                      1192+   0
P6      LAMBDA(1520) INTO SIGMA PI PI                       1192+ 140+ 140
P7      LAMBDA(1520) INTO SIGMA(1385) PI                    1385+ 140
P8      LAMBDA(1520) INTO SIGMA(1385) PI (TO LAMBDA PI PI)1116+ 140+ 140
P9      LAMBDA(1520) INTO LAMBDA EPSILON                    1520+1300

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FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions, P_i, as follows: The diagonal elements are $P_i \pm \delta P_i$, where $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$, while the off-diagonal elements are the normalized correlation coefficients $\langle \delta P_i \delta P_j \rangle / (\delta P_i \cdot \delta P_j)$. For the definitions of the individual P_i, see the listings above; only those P_i appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

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        P 1        P 2        P 3        P 4        P 5        P 6
P 1 .4475+-.0066
P 2   -.6724  .4214+-.0067
P 3   -.2834    -.3058  .0952+-.0043
P 4   -.0895    -.0870    -.0370  .0079+-.0014
P 5   -.2280    -.2217    -.0942    -.0180  .0195+-.0034
P 6   -.0342    -.0333    -.0141    -.0027    -.0069  .0086+-.0005


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                    38  LAMBDA(1520) BRANCHING RATIOS

R1      LAMBDA(1520) INTO (SIGMA PI)/(N KBAR)             (P2)/(P1)
R1             1.72      0.78          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      0.14          SCHEUER   68 DBC   0 K-N 3 GEV/C      10/69
R1             0.82      0.08          BURKHARDT 69 HBC     K-P .8-1.2 GEV/C 10/69
R1            (1.06)    (0.12)         BERTHON   74 HBC   0 QUASI 2 BODY CS  10/74
R1   B         0.98      0.03          RLIC      77 DPWA    KBAR N MULTICHNL  1/76
R1   B  N KBAR TO SIGMA PI AMPLITUDE AT RESONANCE IS +0.46 +/- 0.01.          1/76
R1            . . . . . . . . . . .
R1  AVG        0.951     0.044   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)
R1  FIT        0.942     0.026  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)

R2      LAMBDA(1520) INTO (LAMBDA PI PI)/(N KBAR)         (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             0.19      0.04          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            (0.27)    (0.13)         BERTHON   74 HBC   0 QUASI 2 BODY CS  10/74
R2            . . . . . . . . . . .
R2  AVG        0.202     0.021   AVERAGE
R2  FIT        0.213     0.011  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R3      LAMBDA(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 GEV/C  9/66
R3            . . . . . . . . . . .
R3  AVG        3.94      0.59    AVERAGE
R3  FIT        4.43      0.23   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R4      LAMBDA(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        0.79      0.14   FROM FIT

R5      LAMBDA(1520) INTO (SIGMA0 GAMMA)/TOTAL (PERCENT) (P5)
R5   C         2.0       0.35          MAST      68 HBC     SEE NOTE S       10/69
R5   C     RATIOS CALCULATED FROM R4, ASSUMING SU(3). NEEDED TO CONSTRAIN
R5   C     ALL THE LAMBDA(1520) BRANCHING RATIOS TO BE UNITY.
R5            . . . . . . . . . . .
R5  FIT        1.95      0.34   FROM FIT

R6      LAMBDA(1520) INTO (N KBAR)/TOTAL                  (P1)
R6             0.448     0.014         CORDEN    75 DBC     K- D 1.4-1.8GV/C  4/75
R6            (0.42)                   MAST      76 HBC   0 K- P CEX          1/76
R6   D        (0.47)    (0.01)         RLIC      77 DPWA    KBAR N MULTICHNL  1/76
R6   D  (N KBAR)/TOTAL FROM RLIC 77 IS SUPERSEDED BY GOPAL 80.
R6             0.45      0.03          ALSTON    78 DPWA    KBAR N ELASTIC    1/78
R6             0.47      0.02          GOPAL     80 DPWA    KBAR N ELASTIC   12/81
R6            . . . . . . . . . . .
R6  AVG        0.455     0.011   AVERAGE
R6  FIT        0.4475    0.0066 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)
R7      LAMBDA(1520) INTO (SIGMA PI)/TOTAL                (P2)
R7             0.55      0.09          WATSON    63 HBC     K-P ALL CHANNELS 10/71
R7             0.418     0.017         GALTIERI  69 HBC   0 K-P .28-.45GEV/C  6/69
R7            (0.46)                   KIM       71 DPWA    K-MATRIX ANAL.    3/71
R7             0.426     0.014         CORDEN    75 DBC     K- D 1.4-1.8GV/C  4/75
R7            . . . . . . . . . . .
R7  AVG        0.425     0.011   AVERAGE
R7  FIT        0.4214    0.0067 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

R8      LAMBDA(1520) INTO (SIGMA PI PI)/TOTAL             (P6)
R8             0.010     0.0015        GALTIERI  69 HBC   0 K-P .28-.45GEV/C 10/69
R8   E         0.0085    0.0006        MAST2     73 MPWA    K-P TO 2PI SIG    9/73
R8   E  BASED ON ASSUMED ELASTICITY OF 0.46.                                  9/73
R8   F         0.007     0.002         CORDEN    75 DBC     K- D 1.4-1.8GV/C  4/75
R8   F  MUCH OF THE SIGMA PI PI DECAY PROCEEDS VIA SIGMA(1385) PI.            4/75
R8            . . . . . . . . . . .
R8  AVG       0.00858   0.00054  AVERAGE
R8  FIT       0.00857   0.00054 FROM FIT

R9      LAMBDA(1520) TO SIGMA(1385) PI TO LM 2PI/LM 2PI  (P8)/(P3)
R9          MORE THAN    0.10          CLINE     69 DBC     K-D TO 2PI LAM N  9/69
R9   G         0.39      0.10          BURKHARDT 71 HBC     LAM. 3PI PROD.    3/71
R9   G  CENTRAL BIN(1514-1524) GIVES .74+-.10 -- OTHER BINS LOWER BY 2-5SIG
R9   H        (1.0)                    CHAN      72 IPWA    K-P TO LAM 2PI    2/73
R9   H  ONLY THE SIGMA(1385) DS03 SEEMS TO CONTRIBUTE.
R9   I         0.82      0.10          MAST      73 IPWA    K-P TO 2PI LAM   12/72
R9   I  BOTH SIGMA(1385) DS03 AND SIGMA (PI PI) DP03 CONTRIBUTE.
R9             0.58      0.22          CORDEN    75 DBC     K- D 1.4-1.8GV/C  4/75

R10     LAMBDA(1520) INTO (SIGMA(1385) PI)/TOTAL          (P7)
R10            0.041     0.005         CHAN      72 HBC     K-P TO LAM 2PI    3/71

R11     LAMBDA(1520) INTO (LAMBDA PI PI)/TOTAL            (P3)
R11  J         0.11      0.01          MAST      73 IPWA    K-P TO 2PI LAM    9/73
R11  J  BASED ON ASSUMED ELASTICITY OF 0.46+/-0.02.                           9/73
R11            0.091     0.006         CORDEN    75 DBC     K- D 1.4-1.8GV/C  4/75
R11           . . . . . . . . . . .
R11 AVG        0.0960    0.0084  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)
R11 FIT        0.0952    0.0043 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R12     LAMBDA(1520) INTO (LAMBDA EPSILON)/TOTAL          (P9)
R12            0.20      0.08          CORDEN    75 DBC     K- D 1.4-1.8GV/C  4/75


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REFERENCES FOR LAMBDA(1520)


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FERRO-LU 62 PRL 8 28          M FERRO-LUZZI,R D TRIPP,M B WATSON    (LRL)IJP
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+SACL)
MUSGRAVE 65 NC 35 735         +PETMEZAS,+       (BIRM+CERN+EPOL+LOIC+SACL)

BIRMINGH 66 PR 152 1148                        (BIRM+GLAS+LOIC+OXF+RHEL)
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+SACL)
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)
BERLEY   70 PR D1 1996        +YAMIN,KOFLER,MANN,MEISNER+ (BNL+MASA+YALE)IJP

BURKHARDT71 NP  B27 64        +FILTHUTH,KLUGE,OBERLACK++ (HEID+CERN+SACL)
COLLEY   71 NP  B31 61        +COX,EASTWOOD,FRY+..  (BIRM+EDIN+GLAS+LOIC)
KIM      71 PRL 27 356        J K KIM                              (HARV)IJP
    ALSO 70 DUKE 161          J K KIM                              (HARV)IJP

CHAN     72 PRL 28 256        +BUT.-SHAFER,HERTZBACH,KOFLER++ (MASA+YALE)
MAST     73 PR D7 5           +ALSTON-GARNJOST,BANGERTER,+          (LBL)IJP
MAST2    73 PRD 7 3212        +BANGERTER,ALSTON-GARNJOST,+          (LBL)IJP
BERTHON  74 NC 21A 146        BERTHON,TRISTRAM,+    (CDEF+RHEL+SACL+STRB)
GOLOWICH 74 PRD 10 3861       E GOLOWICH                           (SLAC)
CORDEN   75 NP B84 306        CORDEN,COX,DARTNELL,KENYON,ONEALE,+  (BIRM)

MAST     76 PRD 14 13         MAST,ALSTON-GARNJOST,BANGERTER+       (LBL)
CAMERON  77 NP B131 399       +FRANEK,GOPAL,KALMUS,MCPHERSON+ (RHEL+LOIC)IJP
RLIC     77 NP B119 362       GOPAL,ROSS,VAN HORN,MCPHERSON+  (LOIC+RHEL)IJP
ALSTON   78 PR D18 182        +KENNEY,POLLARD,ROSS+       (LBL+MTHO+CERN)IJP
    ALSO 77 PRL 38 1007       ALSTON-GARNJOST,KENNEY,+    (LBL+MTHO+CERN)IJP
BARLAG   79 NP B149 220       +BLOKZIJL,JONGEJANS+   (AMST+CERN+NIJM+OXF)
BARBER   80 ZPHY C7 17        +DAINTON,LEE,MARSHALL+      (DARE+LANC+SHEF)
GOPAL    80  TORONTO CONF 159 G P GOPAL                            (RHEL)IJP
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Λ(1600) P'_{01} Status: ***

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                    101  LAMBDA(1600, JP=1/2+) I=0       P'01

                    SEE THE NOTE FOR THE LAMBDA(1800, JP=1/2+) P''01.
                    SOMEWHERE IN THIS REGION THERE IS PROBABLY ONE,
                    AND PERHAPS TWO, P01 STATES.

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                    101  LAMBDA(1600) MASS (MEV)

M    1    (1570.0)                     KIM       71 DPWA    K-MATRIX ANAL.    1/76
M    1  POSSIBLE EFFECT IN SIGMA PI AND N KBAR CHANNELS.
M          1620.0     10.0             LANGBEIN  72 IPWA    MULTICHANNEL      1/76
M          1596.0     (6.0)            KANE      74 DPWA    K-P TO PI SIG    12/81
M     2    1646.0      7.0             CARROLL   76 DPWA    I=0 TOTAL CS      2/77
M     2  TOTAL CROSS SECTION BUMP WITH (J+1/2)X=0.04.
M     3    1572. OR 1617.              MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
M     3  THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESONANCE
M     3  PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.
M          1573.0     25.0             RLIC      77 DPWA    KBAR N MULTICHNL  1/76
M          1703.0    100.0             ALSTON    78 DPWA    KBAR N ELASTIC    1/78
M          1568.0    (20.0)            GOPAL     80 DPWA    KBAR N ELASTIC   12/81

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                    101  LAMBDA(1600) WIDTH (MEV)

W    1      (50.0)                     KIM       71 DPWA    K-MATRIX ANAL.    1/76
W            60.0     10.0             LANGBEIN  72 IPWA    MULTICHANNEL      1/76
W           175.0    (20.0)            KANE      74 DPWA    K-P TO PI SIG    12/81
W     2     (20.0)                     CARROLL   76 DPWA    I=0 TOTAL CS      2/77
W     3     247. OR 271.               MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
W           147.0     50.0             RLIC      77 DPWA    KBAR N MULTICHNL  1/76
W           593.0    200.0             ALSTON    78 DPWA    KBAR N ELASTIC    1/78
W           116.0    (20.0)            GOPAL     80 DPWA    KBAR N ELASTIC   12/81

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                    101  LAMBDA(1600) PARTIAL DECAY MODES

                                                              DECAY MASSES
P1      LAMBDA(1600) INTO N KBAR                             938+ 494
P2      LAMBDA(1600) INTO SIGMA PI                          1189+ 140

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Baryons

Data Card Listings

Λ(1600), Λ(1670), Λ(1690)

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                    101  LAMBDA(1600) BRANCHING RATIOS

R1       LAMBDA(1600) INTO (N KBAR)/TOTAL                       (P1)
R1             0.25       0.15           LANGBEIN  72 IPWA     MULTICHANNEL       1/76
R1    3        0.30 OR  0.29             MARTIN    77 DPWA     KBAR N MULTICHNL  11/77
R1    C       (0.24)    (0.04)           RLIC      77 DPWA     KBAR N MULTICHNL   1/76
R1    C    (N KBAR)/TOTAL FROM RLIC 77 IS SUPERSEDED BY GOPAL 80.
R1             0.14       0.05           ALSTON    78 DPWA     KBAR N ELASTIC     1/78
R1             0.23      (0.04)          GOPAL     80 DPWA     KBAR N ELASTIC    12/81

R2       LAMBDA(1600) FROM N KBAR TO SIGMA PI                   SQRT(P1*P2)
R2             0.28       0.09           LANGBEIN  72 IPWA     MULTICHANNEL       1/76
R2            -0.33      (0.11)          KANE      74 DPWA     K-P TO PI SIG     12/81
R2          NOT SEEN                     HEPP2     76 DPWA -0 K- NUC TO SIG PI   2/77
R2    3       -0.39 OR -0.39             MARTIN    77 DPWA     KBAR N MULTICHNL  11/77
R2            -0.16       0.04           RLIC      77 DPWA     KBAR N MULTICHNL   1/76

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                    REFERENCES FOR LAMBDA(1600)

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
KANE      74  LBL-2452           D F KANE                                (LBL)IJP

CARROLL   76 PRL 37 806          +CHIANG,KYCIA,LI,MAZUR,MICHAEL+          (BNL)I
HEPP2     76 PL 65B 487          +BRAUN,GRIMM,STROBELE,THOL+(CERN+HEID+MPIM)IJP

MARTIN    77 NP B127 349         MARTIN,PIDCOCK,MOORHOUSE          (LOUC+GLAS)IJP
   ALSO   77 NP B126 266         MARTIN,PIDCOCK                         (LOUC)
   ALSO   77 NP B126 285         MARTIN,PIDCOCK                         (LOUC)IJP
RLIC      77 NP B119 362         GOPAL,ROSS,VAN HORN,MCPHERSON+   (LOIC+RHEL)IJP
ALSTON    78 PR D18 182          +KENNEY,POLLARD,ROSS+        (LBL+MTHO+CERN)IJP
   ALSO   77 PRL 38 1007         ALSTON-GARNJOST,KENNEY,+     (LBL+MTHO+CERN)IJP
GOPAL     80  TORONTO CONF 159 G P GOPAL                                (RHEL)IJP

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Λ(1670) S''_{01} Status: ****

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               40  LAMBDA(1670, JP=1/2-) I=0        S''01

               THE MEASUREMENTS OF THE MASS, WIDTH, AND ELASTICITY
               THAT WERE PUBLISHED BEFORE 1974 ARE NOW OBSOLETE AND
               HAVE BEEN REMOVED.  THEY WERE LAST LISTED IN OUR 1982
               EDITION (PHYSICS LETTERS 111B).  ALL THE REFERENCES
               HAVE BEEN RETAINED.

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                    40  LAMBDA(1670) MASS (MEV)

M             1679.0      (1.0)          KANE      74 DPWA     K-P TO PI SIG     12/81
M             1665.0      (5.0)          PREVOST   74 DPWA 0- K-N TO S(1385)PI 10/74
M             1675.0      (2.0)          HEPP2     76 DPWA -0 K- NUC TO SIG PI   2/77
M     A      (1664.0)                    MARTIN    77 DPWA     KBAR N MULTICHNL  11/77
M     A   MARTIN 77 OBTAINS IDENTICAL RESONANCE PARAMETERS FROM THE
M     A   T-MATRIX POLE AND FROM A B-W FIT.
M             1670.0      (5.0)          RLIC      77 DPWA     KBAR N MULTICHNL   1/76
M             1671.0      (3.0)          ALSTON    78 DPWA     KBAR N ELASTIC     1/78
M             1667.0      (5.0)          GOPAL     80 DPWA     KBAR N ELASTIC    12/81

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                    40  LAMBDA(1670) WIDTH (MEV)

W               40.0      (3.0)          KANE      74 DPWA     K-P TO PI SIG     12/81
W               19.0      (5.0)          PREVOST   74 DPWA 0- K-N TO S(1385)PI 10/74
W               46.0      (5.0)          HEPP2     76 DPWA -0 K- NUC TO SIG PI   2/77
W     A        (12.0)                    MARTIN    77 DPWA     KBAR N MULTICHNL  11/77
W               45.0     (10.0)          RLIC      77 DPWA     KBAR N MULTICHNL   1/76
W               29.0      (5.0)          ALSTON    78 DPWA     KBAR N ELASTIC     1/78
W               29.0      (5.0)          GOPAL     80 DPWA     KBAR N ELASTIC    12/81

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                    40  LAMBDA(1670) PARTIAL DECAY MODES

                                                             DECAY MASSES
P1       LAMBDA(1670) INTO N KBAR                           938+ 494
P2       LAMBDA(1670) INTO LAMBDA ETA                      1116+ 549
P3       LAMBDA(1670) INTO SIGMA PI                        1189+ 140
P4       LAMBDA(1670) INTO SIGMA(1385) PI                  1385+ 140

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                    40  LAMBDA(1670) BRANCHING RATIOS

R1       LAMBDA(1670) INTO (N KBAR)/TOTAL                       (P1)
R1    A       (0.15)                     MARTIN    77 DPWA     KBAR N MULTICHNL  11/77
R1    B       (0.20)     (0.03)          RLIC      77 DPWA     KBAR N MULTICHNL   1/76
R1    B    (N KBAR)/TOTAL FROM RLIC 77 IS SUPERSEDED BY GOPAL 80.
R1             0.17      (0.03)          ALSTON    78 DPWA     KBAR N ELASTIC     1/78
R1             0.18      (0.03)          GOPAL     80 DPWA     KBAR N ELASTIC    12/81

R2       LAMBDA(1670) FROM N KBAR TO LAMBDA ETA                 SQRT(P1*P2)
R2    C        0.20  OR 0.23             BERLEY    65 HBC      0                  7/66
R2    C    THE FIRST VALUE ASSUMES THE BRANCHING RATIO INTO LAMBDA ETA IS
R2    C SMALL, THE SECOND THAT IT IS LARGE.  BECAUSE THE RESONANCE IS NEAR
R2    C THE LAMBDA ETA THRESHOLD, THE BRANCHING RATIO AFFECTS THE MOMENTUM
R2    C DEPENDENCE OF THE TOTAL WIDTH, AND THUS ALSO THE RESONANCE PARA-
R2    C METERS OBTAINED BY FITTING TO THE DATA.
R2            (0.26)                     ARMENT-3  69 HBC      0                  9/69
R2            (0.24)                     KIM       71 DPWA     K-MATRIX ANAL.     3/71
R2            +0.20      (0.05)          BAXTER    73 DPWA     0 K- P TO NEUTRALS 10/74

R3       LAMBDA(1670) FROM N KBAR TO SIGMA PI                   SQRT(P1*P3)
R3            -0.27      (0.02)          KANE      74 DPWA     K-P TO PI SIG     12/81
R3            -0.23      (0.03)          LONDON    75 HLBC  0 K- P TO SIGO PIO   4/75
R3            -0.29      (0.03)          HEPP2     76 DPWA -0 K- NUC TO SIG PI   2/77
R3    A      (-0.13)                     MARTIN    77 DPWA     KBAR N MULTICHNL  11/77
R3            -0.31      (0.03)          RLIC      77 DPWA     KBAR N MULTICHNL   1/76

R4       LAMBDA(1670) FROM N KBAR TO SIGMA(1385) PI             SQRT(P1*P4)
R4            -0.18       0.05           PREVOST   74 DPWA 0- K-N TO S(1385)PI 10/74

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                    REFERENCES FOR LAMBDA(1670)

BERLEY    65 PRL 15 641          +CONNOLLY, HART, RAUM, STONEHILL, +     (BNL)IJP
BIRMINGH  66 PR 152 1148                       (BIRM+GLAS+LOIC+OXF+RHEL)
ARMENT-1  68 NP B8 195           ARMENTEROS, BAILLON, +     (CERN+HEID+SACL)IJP
ARMENT-2  68 NP B8 223           ARMENTEROS, BAILLON, +     (CERN+HEID+SACL)IJP

ARMENT-3  69 LUND PAPER 229      ARMENTEROS, BAILLON, +     (CERN+HEID+SACL)IJP
   VALUES ARE QUOTED IN LEVI SETTI 69.
ARMENT-4  69 NP B14 91           ARMENTEROS, BAILLON, +     (CERN+HEID+SACL)IJP
BERLEY    69 PL 30B 430          + HART, RAHM, WILLIS, YAMAMOTO          (BNL)IJP
LEVISETT  69 LUND 339            R LEVI SETTI  (RAPPORTEUR)             (CHIC)
GALTIERI  70 DUKE 173            A BARBARO GALTIERI                      (LRL)IJP

CONFORTO  71 NP  B34  41         +LEVI SETTI,LASINSKI..OBERLACK++ (EFI+HEID)IJP
KIM       71 PRL 27 356          J K KIM                                (HARV)IJP
   ALSO   70 DUKE 161            J K KIM                                (HARV)IJP
LANGBEIN  72 NP B47 477          +WAGNER                                (MPIM)IJP
BAXTER    73 NP B67 125          BAXTER,BUCKINGHAM,CORBETT,DUNN,+        (OXF)IJP
HART      73 PURDUE CONF. 311    +RICE,BACASTOW,FUNG,+  (TENN+UCR+MASA+BUFF)IJP
KANE      74  LBL-2452           D F KANE                                (LBL)IJP
PREVOST   74 NP B69 246          PREVOST,BARLOUTAUD,+         (SACL+CERN+HEID)
LONDON    75 NP B85 289          LONDON,YU,BOYD,+  (BNL+CERN+EPOL+ORSA+TORI)

HEPP2     76 PL 65B 487          +BRAUN,GRIMM,STROBELE,THOL+(CERN+HEID+MPIM)IJP
MARTIN    77 NP B127 349         MARTIN,PIDCOCK,MOORHOUSE          (LOUC+GLAS)IJP
   ALSO   77 NP B126 266         MARTIN,PIDCOCK                         (LOUC)
   ALSO   77 NP B126 285         MARTIN,PIDCOCK                         (LOUC)IJP
RLIC      77 NP B119 362         GOPAL,ROSS,VAN HORN,MCPHERSON+   (LOIC+RHEL)IJP
ALSTON    78 PR D18 182          +KENNEY,POLLARD,ROSS+        (LBL+MTHO+CERN)IJP
   ALSO   77 PRL 38 1007         ALSTON-GARNJOST,KENNEY,+     (LBL+MTHO+CERN)IJP
GOPAL     80  TORONTO CONF 159 G P GOPAL                                (RHEL)IJP

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Λ(1690) D''_{03} Status: ****

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               55  LAMBDA(1690, JP=3/2-) I=0        D''03

               THE MEASUREMENTS OF THE MASS, WIDTH, AND ELASTICITY
               THAT WERE PUBLISHED BEFORE 1974 ARE NOW OBSOLETE AND
               HAVE BEEN REMOVED.  THEY WERE LAST LISTED IN OUR 1982
               EDITION (PHYSICS LETTERS 111B).  ALL THE REFERENCES
               HAVE BEEN RETAINED.

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                    55  LAMBDA(1690) MASS (MEV)

M             1689.0      (1.0)          KANE      74 DPWA     K-P TO PI SIG     12/81
M             1692.0      (4.0)          CARROLL   76 DPWA     I=0 TOTAL CS       2/77
M             1690.0      (3.0)          HEPP2     76 DPWA -0 K- NUC TO SIG PI   2/77
M     A       1687. OR 1689.             MARTIN    77 DPWA     KBAR N MULTICHNL  11/77
M     A   THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESONANCE
M     A   PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.
M     A   ANOTHER 3/2- LAMBDA AT 1966 MEV IS ALSO SUGGESTED BY MARTIN 77,
M     A   BUT IS VERY UNCERTAIN.
M             1690.0      (5.0)          RLIC      77 DPWA     KBAR N MULTICHNL   1/76
M             1692.0      (5.0)          ALSTON    78 DPWA     KBAR N ELASTIC     1/78
M             1690.0      (5.0)          GOPAL     80 DPWA     KBAR N ELASTIC    12/81

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                    55  LAMBDA(1690) WIDTH (MEV)

W               60.0      (4.0)          KANE      74 DPWA     K-P TO PI SIG     12/81
W              (38.0)                    CARROLL   76 DPWA     I=0 TOTAL CS       2/77
W               82.0      (8.0)          HEPP2     76 DPWA -0 K- NUC TO SIG PI   2/77
W     A         62. OR 62.               MARTIN    77 DPWA     KBAR N MULTICHNL  11/77
W               60.0      (5.0)          RLIC      77 DPWA     KBAR N MULTICHNL   1/76
W               64.0     (10.0)          ALSTON    78 DPWA     KBAR N ELASTIC     1/78
W               61.0      (5.0)          GOPAL     80 DPWA     KBAR N ELASTIC    12/81

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                    55  LAMBDA(1690) PARTIAL DECAY MODES

                                                             DECAY MASSES
P1       LAMBDA(1690) INTO N KBAR                           938+ 494
P2       LAMBDA(1690) INTO SIGMA PI                        1189+ 140
P3       LAMBDA(1690) INTO LAMBDA PI PI                    1116+ 140+ 140
P4       LAMBDA(1690) INTO SIGMA PI PI                     1192+ 140+ 140
P5       LAMBDA(1690) INTO SIGMA(1385) PI, S-WAVE          1385+ 140
P6       LAMBDA(1690) INTO LAMBDA ETA                      1116+ 549

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                    55  LAMBDA(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
  SIGMA(1385), FOR THEN NINE TIMES AS MUCH LAMBDA PI PI DECAY WOULD BE
  REQUIRED.

R1       LAMBDA(1690) INTO (N KBAR)/TOTAL                       (P1)
R1    A        0.28 OR  0.26             MARTIN    77 DPWA     KBAR N MULTICHNL  11/77
R1    B       (0.24)     (0.03)          RLIC      77 DPWA     KBAR N MULTICHNL   1/76
R1    B    (N KBAR)/TOTAL FROM RLIC 77 IS SUPERSEDED BY GOPAL 80.
R1             0.22      (0.03)          ALSTON    78 DPWA     KBAR N ELASTIC     1/78
R1             0.23      (0.03)          GOPAL     80 DPWA     KBAR N ELASTIC    12/81

R2       LAMBDA(1690) FROM N KBAR TO SIGMA PI                   SQRT(P1*P2)
R2            -0.28      (0.02)          KANE      74 DPWA     K-P TO PI SIG     12/81
R2            -0.28      (0.03)          LONDON    75 HLBC  0 K- P TO SIGO PIO   4/75
R2            -0.29      (0.03)          HEPP2     76 DPWA -0 K- NUC TO SIG PI   2/77
R2    A       -0.30 OR -0.28             MARTIN    77 DPWA     KBAR N MULTICHNL  11/77
R2            -0.25      (0.03)          RLIC      77 DPWA     KBAR N MULTICHNL   1/76

R3       LAMBDA(1690) FROM N KBAR TO LAMBDA PI PI               SQRT(P1*P3)
R3    C       (0.25)     (0.02)          BARTLEY   68 HDBC  0 LAM 2PI CROS SEC 11/68
R3    C    ONLY CROSS-SECTION DATA USED. ENHANCEMENT NOT SEEN BY PREVOST 71,     3/72

R4       LAMBDA(1690) FROM N KBAR TO SIGMA PI PI                SQRT(P1*P4)
R4            (0.21)                     ARMENT-2  68 HDBC  0 K-N TO SIG PI PI 11/68

R5       LAMBDA(1690) FROM N KBAR TO LAMBDA ETA                 SQRT(P1*P6)
R5             0.00      (0.03)          BAXTER    73 DPWA  0 K- P TO NEUTRALS 10/74
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R6     LAMBDA(1690) FROM N KBAR TO SIGMA(1385) PI S-WAVESQRT(P1*P5)
R6          +0.27      0.04            PREVOST   74 DPWA O- K-N TO S(1385)PI 10/74

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                              REFERENCES FOR LAMBDA(1690)

ARMENT-1 68 NP B8 195          ARMENTEROS, BAILLON, +      (CERN+HEID+SACL)IJP
ARMENT-2 68 NP B8 216          ARMENTEROS, BAILLON, +      (CERN+HEID+SACL) I
ARMENT-3 68 NP B8 223          ARMENTEROS, BAILLON, +      (CERN+HEID+SACL)IJP
BARTLEY  68 PRL 21 1111        +CHU,DOWD,GREENE,+            (TUFT+FSU+BRAN) I
BUGG     68 PR 168 1466        +GILMORE, KNIGHT, +          (BIRM+CAVE+RHEL) I
   ALSO 67 PRL 18 62           DAVIES,DOWELL,+              (BIRM+CAVE+RHEL) I
CONFORTO 68 NP B8 265          +HARMSEN, LASINSKI, +            (CHIC+HEID)IJP

ARMENT-4 69 NP B14 91          ARMENTEROS, BAILLON, +      (CERN+HEID+SACL)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
PREVOST  71  AMSTERDAM CONF    + CHS COLLABORATION         (CERN+HEID+SACL)
LANGBEIN 72 NP B47 477         +WAGNER                                 (MPIM)IJP
BAXTER   73 NP B67 125         BAXTER,BUCKINGHAM,CORBETT,DUNN,+        (OXF)IJP
HART     73 PURDUE CONF. 311   +RICE,BACASTOW,FUNG,+  (TENN+UCR+MASA+BUFF)IJP
KANE     74  LBL-2452          D F KANE                                 (LBL)IJP
PREVOST  74 NP B69 246         PREVOST,BARLOUTAUD,+        (SACL+CERN+HEID)

LONDON   75 NP B85 289         LONDON,YU,BOYD,+  (BNL+CERN+EPOL+ORSA+TORI)
CARROLL  76 PRL 37 806         +CHIANG,KYCIA,LI,MAZUR,MICHAEL+          (BNL)I
HEPP2    76 PL 65B 487         +BRAUN,GRIMM,STROBELE,THOL+(CERN+HEID+MPIM)IJP

MARTIN   77 NP B127 349        MARTIN,PIDCOCK,MOORHOUSE         (LOUC+GLAS)IJP
   ALSO 77 NP B126 266         MARTIN,PIDCOCK                          (LOUC)
   ALSO 77 NP B126 285         MARTIN,PIDCOCK                          (LOUC)IJP
RLIC     77 NP B119 362        GOPAL,ROSS,VAN HORN,MCPHERSON+  (LOIC+RHEL)IJP
ALSTON   78 PR D18 182         +KENNEY,POLLARD,ROSS+       (LBL+MTHO+CERN)IJP
   ALSO 77 PRL 38 1007         ALSTON-GARNJOST,KENNEY,+    (LBL+MTHO+CERN)IJP
GOPAL    80  TORONTO CONF 159 G P GOPAL                               (RHEL)IJP
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Λ(1800) S_{01}'' Status: ***

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              36  LAMBDA(1800, JP=1/2-) I=0          S'''01

              THE S01 AMPLITUDE SHOWS A RATHER CLEAR SECOND RESONANCE
              BEHAVIOR IN THE 1700-1900 MEV REGION.  THERE ARE MAJOR
              DISAGREEMENTS ABOUT THE MASS, WIDTH, AND COUPLINGS.

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              36  LAMBDA(1800) MASS (MEV)

M         (1872.0)   (10.0)            BRICMAN   70 DPWA   TOT, ELAS, CHEX   1/71
M         (1780.0)                     KIM       71 DPWA   K-MATRIX ANAL.    3/71
M          1830.0    (20.0)            LANGBEIN  72 IPWA   MULTICHANNEL     12/72
M     1    1767. OR 1842.              MARTIN    77 DPWA   KBAR N MULTICHNL 11/77
M     1  THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESONANCE
M     1  PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.
M          1825.0    (20.0)            RLIC      77 DPWA   KBAR N MULTICHNL  1/76
M          1725.0    (20.0)            ALSTON    78 DPWA   KBAR N ELASTIC    1/78
M          1841.0    (10.0)            GOPAL     80 DPWA   KBAR N ELASTIC   12/81

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              36  LAMBDA(1800) WIDTH (MEV)

W         (100.0)    (20.0)            BRICMAN   70 DPWA   TOT, ELAS, CHEX   1/71
W          (40.0)                      KIM       71 DPWA   K-MATRIX ANAL.    3/71
W          70.0      (15.0)            LANGBEIN  72 IPWA   MULTICHANNEL     12/72
W     1    435. OR 473.                MARTIN    77 DPWA   KBAR N MULTICHNL 11/77
W          230.0     (20.0)            RLIC      77 DPWA   KBAR N MULTICHNL  1/76
W          185.0     (20.0)            ALSTON    78 DPWA   KBAR N ELASTIC    1/78
W          228.0     (20.0)            GOPAL     80 DPWA   KBAR N ELASTIC   12/81

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              36  LAMBDA(1800) PARTIAL DECAY MODES

                                                              DECAY MASSES
P1      LAMBDA(1800) INTO N KBAR                              938+ 494
P2      LAMBDA(1800) INTO SIGMA PI                            1189+ 140
P3      LAMBDA(1800) INTO SIGMA(1385) PI                      1385+ 140
P4      LAMBDA(1800) INTO N K*(892), S1 WAVE                   940+ 892
P5      LAMBDA(1800) INTO N K*(892), D3 WAVE                   940+ 892

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              36  LAMBDA(1800) BRANCHING RATIOS

R1      LAMBDA(1800) INTO (N KBAR)/TOTAL                     (P1)
R1          (0.18)   (0.02)            BRICMAN   70 DPWA    TOT, ELAS, CHEX   1/71
R1          (0.80)                     KIM       71 DPWA    K-MATRIX ANAL.    3/71
R1           0.35    (0.15)            LANGBEIN  72 IPWA    MULTICHANNEL     12/72
R1    1      1.21 OR  0.70             MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
R1    C     (0.37)   (0.05)            RLIC      77 DPWA    KBAR N MULTICHNL  1/76
R1    C  (N KBAR)/TOTAL FROM RLIC 77 IS SUPERSEDED BY GOPAL 80.
R1           0.28    (0.05)            ALSTON    78 DPWA    KBAR N ELASTIC    1/78
R1           0.36    (0.04)            GOPAL     80 DPWA    KBAR N ELASTIC   12/81

R2      LAMBDA(1800) FROM N KBAR TO SIGMA PI             SQRT(P1*P2)
R2          (0.24)                     KIM       71 DPWA    K-MATRIX ANAL.    3/71
R2    1     -0.74 OR -0.43             MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
R2          -0.08    (0.05)            RLIC      77 DPWA    KBAR N MULTICHNL  1/76

R3      LAMBDA(1800) FROM N KBAR TO SIGMA(1385) PI      SQRT(P1*P3)
R3    2     +0.056    0.028            CAMERON   78 DPWA  O K-P TO S(1385)PI  1/78
R3    2  SIGN CHANGED TO BE IN ACCORD WITH THE BARYON-FIRST CONVENTION.     12/79

R4      LAMBDA(1800) FROM N KBAR TO N K*(892), S1 WAVE   SQRT(P1*P4)
R4    3     -0.17     0.03             CAMERON2  78 DPWA    K-P TO K*N       12/79
R4    3  THE SIGN HERE IS CHANGED TO BE IN ACCORD WITH THE BARYON-FIRST    12/79
R4    3  CONVENTION.                                                       12/79

R5      LAMBDA(1800) FROM N KBAR TO N K*(892), D3 WAVE   SQRT(P1*P5)
R5          -0.13     0.04             CAMERON2  78 DPWA    K-P TO K*N       12/79

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                              REFERENCES FOR LAMBDA(1800)

BRICMAN  70 PL 33B 511         C BRICMAN, M FERRO-LUZZI, J P LAGNAUX(CERN)IJP
KIM      71 PRL 27 356         J K KIM                                 (HARV)IJP
   ALSO 70 DUKE 161            J K KIM                                 (HARV)IJP
LANGBEIN 72 NP B47 477         +WAGNER                                 (MPIM)IJP

MARTIN   77 NP B127 349        MARTIN,PIDCOCK,MOORHOUSE         (LOUC+GLAS)IJP
   ALSO 77 NP B126 266         MARTIN,PIDCOCK                          (LOUC)
   ALSO 77 NP B126 285         MARTIN,PIDCOCK                          (LOUC)IJP
RLIC     77 NP B119 362        GOPAL,ROSS,VAN HORN,MCPHERSON+  (LOIC+RHEL)IJP
ALSTON   78 PR D18 182         +KENNEY,POLLARD,ROSS+       (LBL+MTHO+CERN)IJP
   ALSO 77 PRL 38 1007         ALSTON-GARNJOST,KENNEY,+    (LBL+MTHO+CERN)IJP
CAMERON  78 NP B143 189        +FRANEK,GOPAL,BACON,BUTTERWORTH+(RHEL+LOIC)IJP
CAMERON2 78 NP B146 327        +FRANEK,GOPAL,KALMUS,MCPHERSON,+(RHEL+LOIC)IJP
GOPAL    80  TORONTO CONF 159 G P GOPAL                               (RHEL)IJP
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Λ(1800) P_{01}'' Status: ***

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              77  LAMBDA(1800, JP=1/2+) I=0          P''01

              THE EVIDENCE FOR THIS STATE IS SOMEWHAT CONFUSED.   IT
              WAS FIRST SUGGESTED IN A PARTIAL WAVE ANALYSIS OF
              N KBAR DATA BY THE BEHAVIOUR OF THE P01 AMPLITUDE
              WHEN IT WAS PARAMETRIZED AS A TWO-STRAIGHT-LINE
              BACKGROUND (ARMENTEROS 68).

     ALMOST ALL THE RECENT ANALYSES CONTAIN A P01 STATE, AND SOMETIMES
  TWO, BUT THE MASSES, WIDTHS, AND BRANCHING RATIOS VARY GREATLY.
  SEE ALSO THE LAMBDA(1600) P01 LISTING.

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              77  LAMBDA(1800) MASS (MEV)

M         (1745.0)                     ARMENTERO 68 HBC    O ELASTIC, CH EXCH 11/68
M         (1740.0)                     BAILEY    69 DPWA   O ELASTIC, CH EXCH 10/70
M         (1800.0)                     ARMENTERO 70 HBC    O ELASTIC, CH EX    6/70
M         (1750.0)                     ARMENTERO 70 HBC    O SIGMA PI          6/70
M     N   (1690.0)   (10.0)            GALTIERI  70 HBC    O SIG PI,EDPWA      7/70
M     N  ERROR STATIST. ONLY- NO ERROR DUE TO PARTICULAR P.W.ANAL. INCLUDED  1/71
M         (1755.0)                     KIM       71 DPWA   K-MATRIX ANAL.     3/71
M          1780.0     20.0             LANGBEIN  72 IPWA   MULTICHANNEL      12/72
M          1746.0     10.0             PREVOST   74 DPWA O- K-N TO S(1385)PI 10/74
M     1    1735.0      5.0             CARROLL   76 DPWA   I=0 TOTAL CS       2/77
M     3    1861. OR 1953.              MARTIN    77 DPWA   KBAR N MULTICHNL  11/77
M     3  THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESONANCE
M     3  PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.
M          1853.0     20.0             RLIC      77 DPWA   KBAR N MULTICHNL   1/76
M          1841.0    (20.0)            GOPAL     80 DPWA   KBAR N ELASTIC    12/81

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              77  LAMBDA(1800) WIDTH (MEV)

W         (147.0)                      ARMENTERO 68 HBC    O
W         (300.0)                      BAILEY    69 DPWA   O ELASTIC, CH EXCH 10/70
W          (30.0)                      ARMENTERO 70 HBC    O ELASTIC, CH EX    6/70
W          (70.0)                      ARMENTERO 70 HBC    O SIGMA PI          6/70
W     N    (22.0)                      GALTIERI  70 HBC    O SIG PI,EDPWA      7/70
W          (35.0)                      KIM       71 DPWA   K-MATRIX ANAL.     3/71
W          120.0      10.0             LANGBEIN  72 IPWA   MULTICHANNEL      12/72
W           46.0      20.0             PREVOST   74 DPWA O- K-N TO S(1385)PI 10/74
W     1    (28.0)                      CARROLL   76 DPWA   I=0 TOTAL CS       2/77
W     3    535. OR 585.                MARTIN    77 DPWA   KBAR N MULTICHNL  11/77
W          166.0      20.0             RLIC      77 DPWA   KBAR N MULTICHNL   1/76
W           90.0      20.0             CAMERON2  78 DPWA   K-P TO K*(892) N  12/79
W          164.0     (20.0)            GOPAL     80 DPWA   KBAR N ELASTIC    12/81

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              77  LAMBDA(1800) PARTIAL DECAY MODES

                                                              DECAY MASSES
P1      LAMBDA(1800) INTO N KBAR                              938+ 494
P2      LAMBDA(1800) INTO SIGMA PI                            1189+ 140
P3      LAMBDA(1800) INTO SIGMA(1385) PI                      1385+ 140
P4      LAMBDA(1800) INTO N K*(892), P1 WAVE                   940+ 892
P5      LAMBDA(1800) INTO N K*(892), P3 WAVE                   940+ 892

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              77  LAMBDA(1800) BRANCHING RATIOS

R1      LAMBDA(1800) INTO (N KBAR)/TOTAL                     (P1)
R1          (0.4)                      ARMENTERO 68 DPWA   O ELASTIC, CH EXCH 11/68
R1          (0.55)                     BAILEY    69 DPWA   O ELASTIC, CH EXCH 10/70
R1          (0.15)                     ARMENTERO 70 DPWA   O ELASTIC, CH EXCH 10/70
R1          (0.30)                     KIM       71 DPWA   K-MATRIX ANAL.     3/71
R1           0.36     0.05             LANGBEIN  72 IPWA   MULTICHANNEL      12/72
R1    3      0.52 OR  0.49             MARTIN    77 DPWA   KBAR N MULTICHNL  11/77
R1    C     (0.21)   (0.04)            RLIC      77 DPWA   KBAR N MULTICHNL   1/76
R1    C  (N KBAR)/TOTAL FROM RLIC 77 IS SUPERSEDED BY GOPAL 80.
R1           0.24    (0.04)            GOPAL     80 DPWA   KBAR N ELASTIC    12/81

R2      LAMBDA(1800) FROM N KBAR TO SIGMA PI             SQRT(P1*P2)
R2  2      (+0.20)                     ARMENTERO 70 DPWA  O K-P TO SIGMA PI   6/70
R2  2  PUBLISHED SIGN CHANGED TO AGREE WITH LUND 1969 CONVENTION (SEE NOTE  10/74
R2  2  ON LAMBDA AND SIGMA RESONANCES).                                    10/74
R2  N      (-0.13)   (0.03)            GALTIERI  70 DPWA  O K-P TO SIGMA PI   7/70
R2         (0.17)                      KIM       71 DPWA    K-MATRIX ANAL.    3/71
R2         (0.01) OR LESS              LANGBEIN  72 IPWA    MULTICHANNEL     12/72
R2    3    +0.25 OR +0.23              MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
R2         -0.24      0.04             RLIC      77 DPWA    KBAR N MULTICHNL  1/76

R3      LAMBDA(1800) FROM N KBAR TO SIGMA(1385) PI      SQRT(P1*P3)
R3          +0.18     0.10             PREVOST   74 DPWA O- K-N TO S(1385)PI 10/74

R4      LAMBDA(1800) FROM N KBAR TO N K*(892), P1 WAVE   SQRT(P1*P4)
R4    4     -0.14     0.03             CAMERON2  78 DPWA    K-P TO K*N       12/79
R4    4  THE SIGN HERE IS CHANGED TO BE IN ACCORD WITH THE BARYON-FIRST    12/79
R4    4  CONVENTION.                                                       12/79

R5      LAMBDA(1800) FROM N KBAR TO N K*(892), P3 WAVE   SQRT(P1*P5)
R5          +0.35     0.06             CAMERON2  78 DPWA    K-P TO K*N       12/79

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Baryons

Data Card Listings

Λ(1800), Λ(1820), Λ(1830)


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                         REFERENCES FOR LAMBDA(1800)

ARMENTER 68 NP B8 195          ARMENTEROS, BAILLON, +      (CERN+HEID+SACL)IJP
BAILEY   69 THESIS UCRL-50617  DAVID SAAL BAILEY                      (LLL)IJP
ARMENTER 70 DUKE CONF 123      ARMENTEROS, BAILLON, +      (CERN+HEID+SACL)IJP
GALTIERI 70 DUKE CONF 173      A BARBARO-GALTIERI                     (LRL)IJP
KIM      71 PRL 27 356         J K KIM                               (HARV)IJP
   ALSO  70 DUKE 161           J K KIM                               (HARV)IJP
LANGBEIN 72 NP B47 477         +WAGNER                               (MPIM)IJP

PREVOST  74 NP B69 246         PREVOST,BARLOUTAUD,+         (SACL+CERN+HEID)
CARROLL  76 PRL 37 806         +CHIANG,KYCIA,LI,MAZUR,MICHAEL+        (BNL)I
MARTIN   77 NP B127 349        MARTIN,PIDCOCK,MOORHOUSE         (LOUC+GLAS)IJP
   ALSO  77 NP B126 266        MARTIN,PIDCOCK                          (LOUC)
   ALSO  77 NP B126 285        MARTIN,PIDCOCK                        (LOUC)IJP
RLIC     77 NP B119 362        GOPAL,ROSS,VAN HORN,MCPHERSON+  (LOIC+RHEL)IJP
CAMERON2 78 NP B146 327        +FRANEK,GOPAL,KALMUS,MCPHERSON,+(RHEL+LOIC)IJP
GOPAL    80  TORONTO CONF 159  G P GOPAL                             (RHEL)IJP
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Λ(1820) F_{05} Status: ****

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            39  LAMBDA(1820, JP=5/2+) I=0           F'05

            FOR MOST RESULTS PUBLISHED BEFORE 1973 (THEY ARE
            NOW OBSOLETE), SEE OUR 1982 EDITION (PHYSICS LETTERS
            111B).  ALL THE REFERENCES HAVE BEEN RETAINED.

            THIS STATE IS WELL ESTABLISHED.  MOST OF THE QUOTED ER-
            RORS ARE STATISTICAL ONLY.  THE SYSTEMATIC ERRORS DUE
            TO THE PARTICULAR PARAMETRIZATIONS USED IN THE P.W.A.
    ARE NOT INCLUDED.  FOR THIS REASON WE DO NOT CALCULATE WEIGHTED
    AVERAGES FOR THE MASS AND WIDTH.

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            39  LAMBDA(1820) MASS (MEV)

M         1821.0     (2.0)          KANE      74 DPWA   K-P TO PI SIG     12/81
M        (1830.0)                   DECLAIS   77 DPWA   KBAR N TO KBAR N   1/78
M    A    1817. OR 1819.            MARTIN    77 DPWA   KBAR N MULTICHNL  11/77
M    A  THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESONANCE
M    A  PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.
M         1822.0     (2.0)          RLIC      77 DPWA   KBAR N MULTICHNL   1/76
M         1819.0     (2.0)          ALSTON    78 DPWA   KBAR N ELASTIC     1/78
M         1823.0     (3.0)          GOPAL     80 DPWA   KBAR N ELASTIC    12/81

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            39  LAMBDA(1820) WIDTH (MEV)

W          87.0      (3.0)          KANE      74 DPWA   K-P TO PI SIG     12/81
W         (82.0)                    DECLAIS   77 DPWA   KBAR N TO KBAR N   1/78
W    A     76. OR 76.               MARTIN    77 DPWA   KBAR N MULTICHNL  11/77
W          81.0      (5.0)          RLIC      77 DPWA   KBAR N MULTICHNL   1/76
W          72.0      (5.0)          ALSTON    78 DPWA   KBAR N ELASTIC     1/78
W          77.0      (5.0)          GOPAL     80 DPWA   KBAR N ELASTIC    12/81

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            39  LAMBDA(1820) PARTIAL DECAY MODES

                                                             DECAY MASSES
P1      LAMBDA(1820) INTO N KBAR                             938+ 494
P2      LAMBDA(1820) INTO SIGMA PI                           1189+ 140
P3      LAMBDA(1820) INTO SIGMA PI PI                        1192+ 140+ 140
P4      LAMBDA(1820) INTO LAMBDA ETA                         1116+ 549
P5      LAMBDA(1820) INTO SIGMA(1385) PI, P-WAVE             1385+ 140
P6      LAMBDA(1820) INTO SIGMA(1385) PI, F-WAVE             1385+ 140

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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  .5940+-.0304
P 2   -.2306    .1320+-.0288
P 3   -.2081      .0481    .1046+-.0293
P 4   -.3697     -.5263     -.5507   .1468+-.0447
P 5   -.0910      .0210      .0190     -.1571   .0155+-.0086
P 6   -.0568      .0131      .0118     -.1198      .0052   .0071+-.0063

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            39  LAMBDA(1820) BRANCHING RATIOS

        ERRORS QUOTED BY EXPERIMENTERS DO NOT INCLUDE UNCERTAINTY DUE
        TO PARAMETRIZATION USED IN THE P.W.A.  THEY SHOULD BE INCREASED.

R1      LAMBDA(1820) INTO (N KBAR)/TOTAL                   (P1)
R1         (0.51)                  DECLAIS   77 DPWA    KBAR N TO KBAR N   1/78
R1   A      0.59 OR  0.58          MARTIN    77 DPWA    KBAR N MULTICHNL  11/77
R1   B     (0.57)    (0.02)        RLIC      77 DPWA    KBAR N MULTICHNL   1/76
R1   B   (N KBAR)/TOTAL FROM RLIC 77 IS SUPERSEDED BY GOPAL 80.
R1          0.60      0.03         ALSTON    78 DPWA    KBAR N ELASTIC     1/78
R1          0.58     (0.02)        GOPAL     80 DPWA    KBAR N ELASTIC    12/81
R1
R1  FIT     0.594     0.030   FROM FIT

R2      LAMBDA(1820) FROM N KBAR TO SIGMA PI               SQRT(P1*P2)
R2         -0.28     (0.01)        KANE      74 DPWA    K-P TO PI SIG     12/81
R2   A     -0.25 OR -0.25          MARTIN    77 DPWA    KBAR N MULTICHNL  11/77
R2         -0.28      0.03         RLIC      77 DPWA    KBAR N MULTICHNL   1/76
R2
R2  FIT     0.280     0.030   FROM FIT

R3      LAMBDA(1820) FROM N KBAR TO LAMBDA ETA             SQRT(P1*P4)
R3         -0.096     0.040    0.020 RADER      73 MPWA                     9/73
R3
R3  FIT     0.096     0.026   FROM FIT

R4      LAMBDA(1820) INTO (SIGMA(1385) PI)/TOTAL           (P5)
R4          0.20      0.05             BIRGE      65 HBC    0 K-P TO LAM PI PI  7/66
R4
R4  FIT     0.105     0.029   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.5)

R5      LAMBDA(1820) INTO (SIGMA PI PI)/TOTAL              (P3)
R5   C     NO CLEAR SIGNAL                ARMENT-4   68 HDBC   0 K-N TO SIG PI PI 11/68
R5   C   THERE IS A SUGGESTION OF A BUMP, ENOUGH TO BE CONSISTENT WITH
R5   C   WHAT IS EXPECTED FROM SIGMA(1385) TO SIGMA PI DECAY -- ABOUT 0.02.
R5
R5  FIT     0.147     0.045   FROM FIT

R6      LAMBDA(1820) FROM N KBAR TO SIGMA(1385) PI P-WAVESQRT(P1*P5)
R6         +0.27      0.03             PREVOST   74 DPWA 0- K-N TO S(1385)PI 10/74
R6   D     -0.167     0.054            CAMERON   78 DPWA  0 K-P TO S(1385)PI  1/78
R6   D   THE SIGN HERE AND IN R7 IS CHANGED TO BE IN ACCORD WITH THE         12/79
R6   D   BARYON-FIRST CONVENTION.                                            12/79
R6
R6  AVG MOD 0.246     0.044   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)
R6  FIT     0.249     0.034   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.5)

R7      LAMBDA(1820) FROM N KBAR TO SIGMA(1385) PI F-WAVESQRT(P1*P6)
R7   D     +0.065     0.029            CAMERON   78 DPWA  0 K-P TO S(1385)PI  1/78
R7
R7  FIT     0.065     0.029   FROM FIT

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                         REFERENCES FOR LAMBDA(1820)

CHAMBERL 62 PR 125 1696        CHAMBERLAIN,CROWE,KEEFE,KERTH, +      (LRL) I
GALTIERI 63 PL 6 296           A BARBARO-GALTIERI,A HUSSAIN,R D TRIPP(LRL)IJ
SODICKSO 64 PR 133 B757        SODICKSON,MANNELLI,FRISCH,WAHLIG  (MIT+BNL) J
BIRGE    65 ATHENS CONF   296  +ELY,KALMUS,KERNAN,LOUIE,SAHOURIA, +  (LRL)IJP
HOLLEY   65 UCRL-16274 THESIS  W R HOLLEY                            (LRL) J
BIRMINGH 66 PR 152 1148                   (BIRM+GLAS+LOIC+OXF+RHEL)
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+SACL)IJP
ARMENT-1 67 PL 24B 198         ARMENTEROS, F LUZZI, +      (CERN+HEID+SACL)IJP
ARMENT-2 67 ZEIT PHYS 202 486  ARMENTEROS, F LUZZI, +      (CERN+HEID+SACL)IJP
BELL     67 PRL 19 936         R B BELL                               (LRL)IJP
ARMENT-3 68 NP B8 195          ARMENTEROS, BAILLON, +      (CERN+HEID+SACL)IJP
ARMENT-4 68 NP B8 216          ARMENTEROS, BAILLON, +      (CERN+HEID+SACL) I
BUGG     68 PR 168 1466        +GILMORE, KNIGHT,    +      (RHEL+BIRM+CAVE) I
CONFORTO 68 NP B8 265          +HARMSEN, LASINSKI, +             (CHIC+HEID)IJP
LASINSKI 68 PR 163 1792        LASINSKI, LEVI SETTI, PREDAZZI         (CHIC) JP

BRICMAN  70 PL 31B 152         +FERRO LUZZI, PERREAU,+     (CERN+CAEN+SACL)
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

PREVOST  71  AMSTERDAM CONF    + CHS COLLABORATION         (CERN+HEID+SACL)
KANE     72 PR D5 1583         D F KANE                               (LBL)IJP
LANGBEIN 72 NP B47 477         +WAGNER                               (MPIM)IJP
RADER    73 NC 16A 178         +BARLOUTAUD,+     (SACL+HEID+CERN+RHEL+CDEF)
KANE     74  LBL-2452          D F KANE                               (LBL)IJP
PREVOST  74 NP B69 246         PREVOST,BARLOUTAUD,+         (SACL+CERN+HEID)

DECLAIS  77  CERN 77-16        +DUCHON,LOUVEL,PATRY,SEGUINOT+  (CAEN+CERN)IJP
MARTIN   77 NP B127 349        MARTIN,PIDCOCK,MOORHOUSE         (LOUC+GLAS)IJP
   ALSO  77 NP B126 266        MARTIN,PIDCOCK                          (LOUC)
   ALSO  77 NP B126 285        MARTIN,PIDCOCK                        (LOUC)IJP
RLIC     77 NP B119 362        GOPAL,ROSS,VAN HORN,MCPHERSON+  (LOIC+RHEL)IJP
ALSTON   78 PR D18 182         +KENNEY,POLLARD,ROSS+      (LBL+MTHO+CERN)IJP
   ALSO  77 PRL 38 1007        ALSTON-GARNJOST,KENNEY,+   (LBL+MTHO+CERN)IJP
CAMERON  78 NP B143 189        +FRANEK,GOPAL,BACON,BUTTERWORTH+(RHEL+LOIC)IJP
GOPAL    80  TORONTO CONF 159  G P GOPAL                             (RHEL)IJP
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Λ(1830) D_{05} Status: ****

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            56  LAMBDA(1830, JP=5/2-) I=0           D05

            FOR RESULTS PUBLISHED BEFORE 1973 (THEY ARE
            NOW OBSOLETE), SEE OUR 1982 EDITION (PHYSICS LETTERS
            111B).  ALL THE REFERENCES HAVE BEEN RETAINED.

            THE BEST EVIDENCE FOR THIS RESONANCE COMES FROM THE
            SIGMA PI CHANNEL.  IT IS WELL ESTABLISHED.

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            56  LAMBDA(1830) MASS (MEV)

M         1825.0     (1.0)          KANE      74 DPWA   K-P TO PI SIG     12/81
M    A    1817. OR 1818.            MARTIN    77 DPWA   KBAR N MULTICHNL  11/77
M    A  THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESONANCE
M    A  PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.
M         1825.0    (10.0)          RLIC      77 DPWA   KBAR N MULTICHNL   1/76
M         1831.0    (10.0)          GOPAL     80 DPWA   KBAR N ELASTIC    12/81

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            56  LAMBDA(1830) WIDTH (MEV)

W         119.0      (3.0)          KANE      74 DPWA   K-P TO PI SIG     12/81
W    A     56. OR 56.               MARTIN    77 DPWA   KBAR N MULTICHNL  11/77
W          94.0     (10.0)          RLIC      77 DPWA   KBAR N MULTICHNL   1/76
W         100.0     (10.0)          GOPAL     80 DPWA   KBAR N ELASTIC    12/81

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            56  LAMBDA(1830) PARTIAL DECAY MODES

                                                             DECAY MASSES
P1      LAMBDA(1830) INTO N KBAR                             938+ 494
P2      LAMBDA(1830) INTO SIGMA PI                           1189+ 140
P3      LAMBDA(1830) INTO SIGMA(1385) PI, D-WAVE             1385+ 140
P4      LAMBDA(1830) INTO LAMBDA ETA                         1116+ 549

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                    56  LAMBDA(1830) BRANCHING RATIOS

R1      LAMBDA(1830) INTO (N KBAR)/TOTAL                       (P1)
R1   A        0.04 OR  0.04            MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
R1   B       (0.04)   (0.03)           RLIC      77 DPWA    KBAR N MULTICHNL  1/76
R1   B   (N KBAR)/TOTAL FROM RLIC 77 IS SUPERSEDED BY GOPAL 80.
R1            0.02    (0.02)           ALSTON    78 DPWA    KBAR N ELASTIC    1/78
R1            0.08    (0.03)           GOPAL     80 DPWA    KBAR N ELASTIC   12/81

R2      LAMBDA(1830) FROM N KBAR TO SIGMA PI               SQRT(P1*P2)
R2           -0.15    (0.01)           KANE      74 DPWA    K-P TO PI SIG    12/81
R2   A       -0.17 OR -0.17            MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
R2           -0.17    (0.03)           RLIC      77 DPWA    KBAR N MULTICHNL  1/76

R3      LAMBDA(1830) FROM N KBAR TO LAMBDA ETA             SQRT(P1*P4)
R3           -0.044    0.020           RADER     73 MPWA                      9/73

R4      LAMBDA(1830) FROM N KBAR TO SIGMA(1385) PI D-WAVESQRT(P1*P3)
R4           +0.13     0.03            PREVOST   74 DPWA 0- K-N TO S(1385)PI 10/74
R4   C       +0.141    0.014           CAMERON   78 DPWA  0 K-P TO S(1385)PI  1/78
R4   C   CAMERON  78 UPPER LIMIT ON G-WAVE DECAY IS 0.03.  THE SIGN HERE IS  12/79
R4   C   CHANGED TO BE IN ACCORD WITH THE BARYON-FIRST CONVENTION.           12/79

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REFERENCES FOR LAMBDA(1830)


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ARMENTER 67 PL 24B 198          ARMENTEROS, F-LUZZI, +       (CERN+HEID+SACL)IJP
BELL     67 PRL 19 936          R B BELL                                 (LRL)IJP
ARMENTER 68 NP B8 195           ARMENTEROS, BAILLON, +       (CERN+HEID+SACL)IJP
CONFORTO 68 NP B8 265           +HARMSEN, LASINSKI, +             (CHIC+HEID)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
RADER    73 NC 16A 178          +BARLOUTAUD,+      (SACL+HEID+CERN+RHEL+CDEF)

KANE     74  LBL-2452           D F KANE                                 (LBL)IJP
PREVOST  74 NP B69 246          PREVOST,BARLOUTAUD,+          (SACL+CERN+HEID)

MARTIN   77 NP B127 349         MARTIN,PIDCOCK,MOORHOUSE           (LOUC+GLAS)IJP
   ALSO  77 NP B126 266         MARTIN,PIDCOCK                          (LOUC)
   ALSO  77 NP B126 285         MARTIN,PIDCOCK                          (LOUC)IJP
RLIC     77 NP B119 362         GOPAL,ROSS,VAN HORN,MCPHERSON+  (LOIC+RHEL)IJP
ALSTON   78 PR D18 182          +KENNEY,POLLARD,ROSS+        (LBL+MTHO+CERN)IJP
   ALSO  77 PRL 38 1007         ALSTON-GARNJOST,KENNEY,+     (LBL+MTHO+CERN)IJP
CAMERON  78 NP B143 189         +FRANEK,GOPAL,BACON,BUTTERWORTH+(RHEL+LOIC)IJP
GOPAL    80  TORONTO CONF 159 G P GOPAL                                 (RHEL)IJP
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Λ(1890) P_{03} Status: ****

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                    60  LAMBDA(1890, JP=3/2+) I=0          P03

                    FOR RESULTS PUBLISHED BEFORE 1974 (THEY ARE
                    NOW OBSOLETE), SEE OUR 1982 EDITION (PHYSICS LETTERS
                    111B).  ALL THE REFERENCES HAVE BEEN RETAINED.

                    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  LAMBDA(1890) MASS (MEV)

M            1894.0      10.0          HEMINGWA  75 DPWA  0 K- P TO KBAR N   11/75
M    A      (1900.0)                   NAKKASYA  75 DPWA  0 K-P TO LAM. OMG.  1/76
M    A   FOUND IN ONE OF TWO BEST SOLUTIONS.                                  1/76
M             SEEN                     BACCARI   77 IPWA  0 K-P TO LAM. OMG.  1/78
M    B       1856. OR 1868.            MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
M    B   THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESONANCE
M    B   PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.
M            1900.0       5.0          RLIC      77 DPWA    KBAR N MULTICHNL  1/76
M            1908.0      10.0          ALSTON    78 DPWA    KBAR N ELASTIC    1/78
M            1897.0      (5.0)         GOPAL     80 DPWA    KBAR N ELASTIC   12/81

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                    60  LAMBDA(1890) WIDTH (MEV)

W             107.0      10.0          HEMINGWA  75 DPWA  0 K- P TO KBAR N   11/75
W    A       (100.0)                   NAKKASYA  75 DPWA  0 K-P TO LAM. OMG.  1/76
W    B        191. OR 193.             MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
W              72.0      10.0          RLIC      77 DPWA    KBAR N MULTICHNL  1/76
W             119.0      20.0          ALSTON    78 DPWA    KBAR N ELASTIC    1/78
W              74.0     (10.0)         GOPAL     80 DPWA    KBAR N ELASTIC   12/81

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                    60  LAMBDA(1890) PARTIAL DECAY MODES

                                                             DECAY MASSES
P1      LAMBDA(1890) INTO N KBAR                            938+ 494
P2      LAMBDA(1890) INTO SIGMA PI                         1189+ 140
P3      LAMBDA(1890) INTO LAMBDA OMEGA                     1116+ 783
P4      LAMBDA(1890) INTO SIGMA(1385) PI, P-WAVE           1385+ 140
P5      LAMBDA(1890) INTO SIGMA(1385) PI, F-WAVE           1385+ 140
P6      LAMBDA(1890) INTO N K*(892), P1 WAVE                940+ 892

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                    60  LAMBDA(1890) BRANCHING RATIOS

R1      LAMBDA(1890) INTO (N KBAR)/TOTAL                       (P1)
R1            0.24      0.04           HEMINGWA  75 DPWA  0 K- P TO KBAR N   11/75
R1   B        0.36 OR  0.34            MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
R1   C       (0.18)    (0.02)          RLIC      77 DPWA    KBAR N MULTICHNL  1/76
R1   C   (N KBAR)/TOTAL FROM RLIC 77 IS SUPERSEDED BY GOPAL 80.
R1            0.34      0.05           ALSTON    78 DPWA    KBAR N ELASTIC    1/78
R1            0.20     (0.02)          GOPAL     80 DPWA    KBAR N ELASTIC   12/81

R2      LAMBDA(1890) INTO (SIGMA PI)/TOTAL                     (P2)
R2           (0.03) OR LESS            LANGBEIN  72 IPWA     MULTICHANNEL    12/72

R3      LAMBDA(1890) FROM N KBAR TO SIGMA PI               SQRT(P1*P2)
R3   B       +0.15 OR +0.14            MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
R3           -0.09      0.03           RLIC      77 DPWA    KBAR N MULTICHNL  1/76

R4      LAMBDA(1890) FROM N KBAR TO LAMBDA OMEGA           SQRT(P1*P3)
R4   A       (0.032)                   NAKKASYA  75 DPWA  0 K-P TO LAM. OMG.  1/76

R5      LAMBDA(1890) FROM N KBAR TO SIGMA(1385) PI P-WAVESQRT(P1*P4)
R5           LESS THAN 0.03            CAMERON   78 DPWA  0 K-P TO S(1385)PI  1/78

R6      LAMBDA(1890) FROM N KBAR TO SIGMA(1385) PI F-WAVESQRT(P1*P5)
R6   D       -0.126     0.055          CAMERON   78 DPWA  0 K-P TO S(1385)PI  1/78
R6   D   SIGN CHANGED TO BE IN ACCORD WITH THE BARYON-FIRST CONVENTION.     12/79

R7      LAMBDA(1890) FROM N KBAR TO N K*(892), P1 WAVE     SQRT(P1*P6)
R7   E       -0.07      0.03           CAMERON2  78 DPWA    K-P TO K*N       12/79
R7   E   THE SIGN HERE IS CHANGED TO BE IN ACCORD WITH THE BARYON-FIRST      12/79
R7   E   CONVENTION.  UPPER LIMITS ON THE P3 AND F3 WAVES ARE EACH 0.03.     12/79

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REFERENCES FOR LAMBDA(1890)


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ARMENTER 67 NP B3 592           ARMENTEROS, F-LUZZI, +       (CERN+HEID+SACL)IJP
ARMENTERO68 NP B8 195           ARMENTEROS, BAILLON, +       (CERN+HEID+SACL)IJP
BUGG     68 PR 168 1466         +GILMORE, KNIGHT, +           (RHEL+BIRM+CAVE) I
CONFORTO 68 NP B8 265           +HARMSEN, LASINSKI, +             (CHIC+HEID)IJP
GALTIERI 68 PRL 21 573          BARBARO-GALTIERI, MATISON, +      (LRL+SLAC)
LEVISETT 69 LUND 339            R.LEVI SETTI  (RAPPORTEUR)               (EFI)

BRICMAN  70 PL 31B 152          +FERRO LUZZI, PERREAU,+      (CERN+CAEN+SACL)
BRICMAN1 70 PL 33B 511          +FERRO-LUZZI,LAGNAUX                     (CERN)
ALBROW   71 NP  B29 413         +ANDERSON,BOSNJAKOVIC,DAUM,ERNZ,+        (CERN)
CONFORTO 71 NP  B34  41         +LEVI SETTI,LASINSKI..OBERLACK++ (EFI+HEID)IJP
KIM      71 PRL 27 356          J K KIM                                 (HARV)IJP
   ALSO  70 DUKE 161            J K KIM                                 (HARV)IJP
LANGBEIN 72 NP B47 477          +WAGNER                                 (MPIM)IJP

LEA      73 NP B56 77           +MARTIN,MOORHOUSE+     (RHEL+LOUC+GLAS+AARH)IJP
HEMINGWA 75 NP B91 12           HEMINGWAY,EADES,HARMSEN+     (CERN+HEID+MPIM)IJP
NAKKASYA 75 NP B93 85           A NAKKASYAN                             (CERN)IJP

BACCARI  77 NC 41A 96           +POULARD,REVEL,TALLINI+            (SACL+CDEF)IJP
MARTIN   77 NP B127 349         MARTIN,PIDCOCK,MOORHOUSE           (LOUC+GLAS)IJP
   ALSO  77 NP B126 266         MARTIN,PIDCOCK                          (LOUC)
   ALSO  77 NP B126 285         MARTIN,PIDCOCK                          (LOUC)IJP
RLIC     77 NP B119 362         GOPAL,ROSS,VAN HORN,MCPHERSON+  (LOIC+RHEL)IJP
ALSTON   78 PR D18 182          +KENNEY,POLLARD,ROSS+        (LBL+MTHO+CERN)IJP
   ALSO  77 PRL 38 1007         ALSTON-GARNJOST,KENNEY,+     (LBL+MTHO+CERN)IJP
CAMERON  78 NP B143 189         +FRANEK,GOPAL,BACON,BUTTERWORTH+(RHEL+LOIC)IJP
CAMERON2 78 NP B146 327         +FRANEK,GOPAL,KALMUS,MCPHERSON,+(RHEL+LOIC)IJP
GOPAL    80  TORONTO CONF 159 G P GOPAL                                 (RHEL)IJP
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Λ(2000)   Status: *

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                    89  LAMBDA(2000,          ) I=0

                    WE LIST HERE ALL THE AMBIGUOUS RESONANCE POSSIBLITIES
                    WITH A MASS AROUND 2 GEV.  THE PROPOSED QUANTUM NUMBERS
                    ARE D3 (GALTIERI 70 IN SIGMA PI), D3+F5, P3+D5, OR
                    P1+D3 (BRANDSTETTER 72 IN LAMBDA OMEGA), AND S1
        (CAMERON2 78 IN N K*).  THE FIRST TWO OF THE ABOVE ANALYSES SHOULD NOW
        BE CONSIDERED OBSOLETE.

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                    89  LAMBDA(2000) MASS (MEV)

M           (2010.0)    (30.0)         GALTIERI  70 DPWA  0 K-P TO SIGMA PI   7/70
M    1       1935. TO 1971.            BRANDSTE  72 DPWA  0 K-P TO LAM. OMG.  1/74
M    1       1951. TO 2034.            BRANDSTE  72 DPWA  0 K-P TO LAM. OMG.  1/74
M    1   PARAMETERS QUOTED ARE RANGES FROM THREE BEST FITS, THE LOWER        11/75
M    1   (HIGHER) MASS STATE PROBABLY HAS J.LE.3/2(5/2).                     11/75
M            2030.0      30.0          CAMERON2  78 DPWA    K-P TO K*(892) N 12/79

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                    89  LAMBDA(2000) WIDTH (MEV)

W            (130.0)    (50.0)         GALTIERI  70 DPWA  0 K-P TO SIGMA PI   7/70
W    1        180. TO   240. (LWR. MASS) BRANDSTE 72 DPWA 0 K-P TO LAM. OMG.  1/74
W    1         73. TO   154. (HGR. MASS) BRANDSTE 72 DPWA 0 K-P TO LAM. OMG.  1/74
W             125.0      25.0          CAMERON2  78 DPWA    K-P TO K*(892) N 12/79

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                    89  LAMBDA(2000) PARTIAL DECAY MODES

                                                             DECAY MASSES
P1      LAMBDA(2000) INTO N KBAR                            938+ 494
P2      LAMBDA(2000) INTO SIGMA PI                         1189+ 140
P3      LAMBDA(2000) INTO LAMBDA OMEGA                     1116+ 783
P4      LAMBDA(2000) INTO N K*(892), S1 WAVE                940+ 892
P5      LAMBDA(2000) INTO N K*(892), D3 WAVE                940+ 892

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                    89  LAMBDA(2000) BRANCHING RATIOS

R1      LAMBDA(2000) FROM N KBAR TO SIGMA PI               SQRT(P1*P2)
R1          (-0.20)    (0.04)          GALTIERI  70 DPWA  0 K-P TO SIGMA PI   7/70

R2      LAMBDA(2000) FROM N KBAR TO LAMBDA OMEGA           SQRT(P1*P3)
R2   1        0.17   TO 0.25 (LWR.)    BRANDSTE  72 DPWA  0 K-P TO LAM. OMG.  1/74
R2   1        0.04   TO 0.15 (HGR.)    BRANDSTE  72 DPWA  0 K-P TO LAM. OMG.  1/74

R3      LAMBDA(2000) FROM N KBAR TO N K*(892), S1 WAVE   SQRT(P1*P4)
R3   2       -0.12      0.03           CAMERON2  78 DPWA    K-P TO K*N       12/79
R3   2   THE SIGN HERE IS CHANGED TO BE IN ACCORD WITH THE BARYON-FIRST      12/79
R3   2   CONVENTION.                                                         12/79
R4      LAMBDA(2000) FROM N KBAR TO N K*(892), D3 WAVE   SQRT(P1*P5)
R4           +0.09      0.03           CAMERON2  78 DPWA    K-P TO K*N       12/79

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REFERENCES FOR LAMBDA(2000)


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GALTIERI 70 DUKE CONF 173       A BARBARO-GALTIERI                       (LRL)IJP
BRANDSTE 72 NP B39 13           BRANDSTETTER,BUTTERWORTH,+ (RHEL+CDEF+SACL)
CAMERON2 78 NP B146 327         +FRANEK,GOPAL,KALMUS,MCPHERSON,+(RHEL+LOIC)IJP
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Baryons

Data Card Listings

Λ(2000), Λ(2020), Λ(2100)

PAPERS NOT REFERRED TO IN DATA CARDS

NAKKASYA 75 NP B93 85 A NAKKASYAN (CERN)IJP

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Λ(2020) F_{07} Status: *

27 LAMBDA(2020, JP=7/2+) I=0 F07

EFFECTS IN THIS PARTIAL WAVE HAVE BEEN OBSERVED AT DIFFERENT ENERGIES IN TWO CHANNELS. IN LITCHFIELD 71, NEED FOR THE STATE RESTS SOLELY ON POSSIBLY INCONSISTENT POLARIZATION MEASUREMENT AT 1.784 GEV/C. HEMINGWAY 75 ANALYSIS OF N KBAR DOES NOT REQUIRE THIS STATE. RLIC 77 DO NOT NEED IT IN EITHER N KBAR OR SIGMA PI. WITH NEW K- NEUTRON ANGULAR DISTRIBUTIONS INCLUDED, DECLAIS 77 SEE THIS STATE. HOWEVER, THIS AND OTHER NEW DATA ARE INCLUDED IN GOPAL 80 AND THIS STATE IS NOT REQUIRED. BACARI 77 WEAKLY SUPPORTS THIS STATE.

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27 LAMBDA(2020) MASS (MEV)

M	(2020.0)	(20.0)	GALTIERI	70	DPWA	0	K-P TO SIGMA PI	7/70
M	(2100.0)	(30.0)	LITCHFIE	71	DPWA		K-P TO KBAR N	10/71
M	(2140.0)		BACCARI	77	DPWA	0	K-P TO LAM. OMG.	1/78
M	(2117.0)		DECLAIS	77	DPWA		KBAR N TO KBAR N	1/78

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27 LAMBDA(2020) WIDTH (MEV)

W	(160.0)	(30.0)	GALTIERI	70	DPWA	0	K-P TO SIGMA PI	7/70
W	(120.0)	(30.0)	LITCHFIE	71	DPWA		K-P TO KBAR N	10/71
W	(128.0)		BACCARI	77	DPWA	0	K-P TO LAM. OMG.	1/78
W	(167.0)		DECLAIS	77	DPWA		KBAR N TO KBAR N	1/78

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27 LAMBDA(2020) PARTIAL DECAY MODES

		DECAY MASSES
P1	LAMBDA(2020) INTO N KBAR	938+ 494
P2	LAMBDA(2020) INTO SIGMA PI	1189+ 140
P3	LAMBDA(2020) INTO LAMBDA OMEGA	1116+ 783

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27 LAMBDA(2020) BRANCHING RATIOS

R1	**LAMBDA(2020) INTO (N KBAR)/TOTAL**						**(P1)**	
R1	(0.05)	(0.02)	LITCHFIE	71	DPWA		K-P TO KBAR N	10/71
R1	(0.05)		DECLAIS	77	DPWA		KBAR N TO KBAR N	1/78
R2	**LAMBDA(2020) FROM N KBAR TO SIGMA PI**						**SQRT(P1*P2)**	
R2	(-0.15)	(0.02)	GALTIERI	70	DPWA	0	K-P TO SIGMA PI	7/70
R3	**LAMBDA(2020) FROM N KBAR TO LAMBDA OMEGA**						**SQRT(P1*P3)**	
R3	LESS THAN 0.05		BACCARI	77	DPWA	0	K-P TO LAM. OMG.	1/78

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REFERENCES FOR LAMBDA(2020)

GALTIERI 70 DUKE CONF 173 A BARBARO-GALTIERI (LRL)IJP
LITCHFIE 71 NP B30 125 LITCHFIELD,...+LESQUOY,+.. (RHEL+CDEF+SACL)IJP

BACCARI 77 NC 41A 96 +POULARD,REVEL,TALLINI+ (SACL+CDEF)IJP
DECLAIS 77 CERN 77-16 +DUCHON,LOUVEL,PATRY,SEGUINOT+ (CAEN+CERN)IJP

PAPERS NOT REFERRED TO IN DATA CARDS

HEMINGWA 75 NP B91 12 HEMINGWAY,EADES,HARMSEN+ (CERN+HEID+MPIM)IJP

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Λ(2100) G_{07} Status: ****

41 LAMBDA(2100, JP=7/2-) I=0 G07

FOR MOST RESULTS PUBLISHED BEFORE 1973 (THEY ARE NOW OBSOLETE), SEE OUR 1982 EDITION (PHYSICS LETTERS 111B). ALL THE REFERENCES HAVE BEEN RETAINED.

THIS ENTRY ONLY INCLUDES RESULTS FROM PARTIAL-WAVE ANALYSES. PARAMETERS OF PEAKS SEEN IN CROSS SECTIONS AND INVARIANT-MASS DISTRIBUTIONS AROUND 2100 MEV ARE GIVEN IN A SEPARATE ENTRY BELOW.

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41 LAMBDA(2100) MASS (MEV)

M		2115.0	(10.0)	KANE	74	DPWA		K-P TO PI SIG	12/81
M		2105.0	(10.0)	HEMINGWAY	75	DPWA	0	K- P TO KBAR N	11/75
M	A	2110. OR 2089.		NAKKASYA	75	DPWA	0	K-P TO LAM. OMG.	11/75
M	A	QUOTED PARAMETERS CORRESPOND TO THE TWO BEST SOLUTIONS FOUND.							11/75
M	A	EACH HAS THE LAMBDA(2100) AND ONE ADDITIONAL RESONANCE (P3 OR F5).							11/75
M		(2094.0)		BACCARI	77	DPWA	0	K-P TO LAM. OMG.	1/78
M		(2094.0)		DECLAIS	77	DPWA		KBAR N TO KBAR N	1/78
M		2110.0	(10.0)	RLIC	77	DPWA		KBAR N MULTICHNL	1/76
M		2106.0	(30.0)	BELLEFON	78	DPWA	0	KBAR N TO KBAR N	1/78
M		2104.0	(10.0)	GOPAL	80	DPWA		KBAR N ELASTIC	12/81

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41 LAMBDA(2100) WIDTH (MEV)

W		152.0	(15.0)	KANE	74	DPWA		K-P TO PI SIG	12/81
W		241.0	(30.0)	HEMINGWAY	75	DPWA	0	K- P TO KBAR N	11/75
W	A	244. OR 302.		NAKKASYA	75	DPWA	0	K-P TO LAM. OMG.	11/75
W		(98.0)		BACCARI	77	DPWA	0	K-P TO LAM. OMG.	1/78
W		(250.0)		DECLAIS	77	DPWA		KBAR N TO KBAR N	1/78
W		250.0	(30.0)	RLIC	77	DPWA		KBAR N MULTICHNL	1/76
W		157.0	(40.0)	BELLEFON	78	DPWA	0	KBAR N TO KBAR N	1/78

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41 LAMBDA(2100) PARTIAL DECAY MODES

		DECAY MASSES
P1	LAMBDA(2100) INTO N KBAR	938+ 494
P2	LAMBDA(2100) INTO SIGMA PI	1189+ 140
P3	LAMBDA(2100) INTO XI K	1321+ 498
P4	LAMBDA(2100) INTO LAMBDA OMEGA	1116+ 783
P5	LAMBDA(2100) INTO LAMBDA ETA	1116+ 549
P6	LAMBDA(2100) INTO N K*(892), D3 WAVE	940+ 892
P7	LAMBDA(2100) INTO N K*(892), G1 WAVE	940+ 892

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41 LAMBDA(2100) BRANCHING RATIOS

R1		**LAMBDA(2100) INTO (N KBAR)/TOTAL**						**(P1)**	
R1		0.31	(0.03)	HEMINGWA	75	DPWA	0	K- P TO KBAR N	11/75
R1		(0.29)		DECLAIS	77	DPWA		KBAR N TO KBAR N	1/78
R1	C	(0.30)	(0.03)	RLIC	77	DPWA		KBAR N MULTICHNL	1/76
R1	C	(N KBAR)/TOTAL FROM RLIC 77 IS SUPERSEDED BY GOPAL 80.							
R1		0.24	(0.06)	BELLEFON	78	DPWA	0	KBAR N TO KBAR N	1/78
R1		0.34	(0.03)	GOPAL	80	DPWA		KBAR N ELASTIC	12/81
R2		**LAMBDA(2100) FROM N KBAR TO SIGMA PI**						**SQRT(P1*P2)**	
R2		+0.11	(0.01)	KANE	74	DPWA		K-P TO PI SIG	12/81
R2		+0.12	(0.04)	RLIC	77	DPWA		KBAR N MULTICHNL	1/76
R3		**LAMBDA(2100) FROM N KBAR TO XI K**						**SQRT(P1*P3)**	
R3		(0.05)		TRIPP	67	RVUE	0	K-P TO XI K	8/67
R3		(0.003)		MULLER	69	DPWA	0		7/70
R3		0.035	0.018	LITCHFIE	71	DPWA		K-P TO XI K	3/72
R4		**LAMBDA(2100) FROM N KBAR TO LAMBDA OMEGA**						**SQRT(P1*P4)**	
R4	A	0.122 OR 0.154		NAKKASYA	75	DPWA	0	K-P TO LAM. OMG.	11/75
R4	D	(-0.070)		BACCARI	77	DPWA	0	GD37-WAVE	1/78
R4	D	(+0.011)		BACCARI	77	DPWA	0	GG17-WAVE	1/78
R4	D	(+0.008)		BACCARI	77	DPWA	0	GG37-WAVE	1/78
R4	D	NOTE THAT THE 3 ENTRIES FOR BACCARI77 ARE FOR 3 DIFFERENT WAVES.							1/78
R5		**LAMBDA(2100) FROM N KBAR TO LAMBDA ETA**						**SQRT(P1*P5)**	
R5		-0.050	0.020	RADER	73	MPWA			9/73
R6		**LAMBDA(2100) FROM N KBAR TO N K*(892), D3 WAVE**						**SQRT(P1*P6)**	
R6		+0.21	0.04	CAMERON2	78	DPWA		K-P TO K*N	12/79
R7		**LAMBDA(2100) FROM N KBAR TO N K*(892), G1 WAVE**						**SQRT(P1*P7)**	
R7	E	-0.04	0.03	CAMERON2	78	DPWA		K-P TO K*N	12/79
R7	E	THE SIGN HERE IS CHANGED TO BE IN ACCORD WITH THE BARYON-FIRST							12/79
R7	E	CONVENTION. THE UPPER LIMIT ON THE G3 WAVE IS 0.03.							12/79

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REFERENCES FOR LAMBDA(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+HEID+SACL)
BURGUN 68 NP B8 447 +MEYER,PAULI, + (SACL+CDEF+RHEL)
DAUM 68 NP B7 19 +ERNE, LAGNAUX, SENS, STEUER, UDO (CERN)JP
MULLER 69 THESIS,UCRL 19372 R A MULLER (LRL)

BERTHON1 70 NP B24 417 +VRANA, BUTTERWORTH, + (CDEF+RHEL+SACL)IJP
GALTIERI 70 DUKE CONF 173 A BARBARO-GALTIERI (LRL)IJP
LITCHFIE 71 NP B30 125 LITCHFIELD,...+LESQUOY,+ (RHEL+CDEF+SACL)IJP
BRANDSTE 72 NP B39 13 BRANDSTETTER+...+TALLINI (RHEL+CDEF+SACL)IJP
KANE 72 PR D5 1583 D F KANE (LBL)IJP
RADER 73 NC 16A 178 +BARLOUTAUD,+ (SACL+HEID+CERN+RHEL+CDEF)
KANE 74 LBL-2452 D F KANE (LBL)IJP

HEMINGWA 75 NP B91 12 HEMINGWAY,EADES,HARMSEN+ (CERN+HEID+MPIM)IJP
NAKKASYA 75 NP B93 85 A NAKKASYAN (CERN)IJP

BACCARI 77 NC 41A 96 +POULARD,REVEL,TALLINI+ (SACL+CDEF)IJP
DECLAIS 77 CERN 77-16 +DUCHON,LOUVEL,PATRY,SEGUINOT+ (CAEN+CERN)IJP
RLIC 77 NP B119 362 GOPAL,ROSS,VAN HORN,MCPHERSON+ (LOIC+RHEL)IJP
BELLEFON 78 NC 42A 403 +BERTHON,BILLOIR,BRUNET+ (CDEF+SACL)IJP
CAMERON2 78 NP B146 327 +FRANEK,GOPAL,KALMUS,MCPHERSON,+(RHEL+LOIC)IJP
GOPAL 80 TORONTO CONF 159 G P GOPAL (RHEL)IJP

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2100 MEV REGION – PRODUCTION AND σ_{TOTAL} EXP'TS

25 LAMBDA(2100, JP=) I=0 PRODUCTION EXPERIMENTS

SEE THE NOTE TO THE G07 LAMBDA(2100), IN FRONT OF 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 LAMBDA(2100), BUT MAY CONTAIN A SMALL CONTRIBUTION FROM THE SUGGESTED BUT NOT ESTABLISHED OTHER RESONANCES IN THIS REGION.

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25 LAMBDA(2100) MASS (MEV) (PROD. EXP.)

M	(2097.0)	(6.0)	BOCK	65	HBC		PBAR P 5.7 GEV/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 LAMBDA(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 LAMBDA(2100) PARTIAL DECAY MODES (PROD. EXP.)

		DECAY MASSES
P1	LAMBDA(2100) INTO N KBAR	938+ 494
P2	LAMBDA(2100) INTO N KBAR PI	938+ 498+ 140
P3	LAMBDA(2100) INTO LAMBDA ETA	1116+ 549
P4	LAMBDA(2100) INTO LAMBDA OMEGA	1116+ 783

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For notation, see key at front of Listings.

Baryons

Λ(2100), Λ(2110), Λ(2325), Λ(2350)

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                    25  LAMBDA(2100) BRANCHING RATIOS (PROD. EXP.)

R1       LAMBDA(2100) INTO (N KBAR)/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       LAMBDA(2100) INTO (N KBAR PI)/TOTAL                 (P2)
R2                SEEN                    BOCK      65 HBC

R3       LAMBDA(2100) FROM N KBAR TO LAMBDA ETA              SQRT(P1*P3)
R3             (0.09) OR LESS             FLATTE 2  67 HBC    0 K-P TO LAM ETA       6/68

R4       LAMBDA(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 LAMBDA(2100) (PROD. EXP.)

BOCK      65 PL  17 166       +COOPER,FRENCH,KINSON, +          (CERN+SACL)
COOL      66 PRL 16 1228      +GIACOMELLI,KYCIA,LEONTIC,LI,LUNDBY,+ (BNL) I
   SUPERSEDED BY COOL 70.
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+SACL)
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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Λ(2110) F''_{05} Status: ***

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                    35  LAMBDA(2110, JP=5/2+) I=0        F''05

                    FOR RESULTS PUBLISHED BEFORE 1974 (THEY ARE
                    NOW OBSOLETE), SEE OUR 1982 EDITION (PHYSICS LETTERS
                    111B).  ALL THE REFERENCES HAVE BEEN RETAINED.

                    THIS RESONANCE IS IN THE BARYON TABLE, BUT THE
                    EVIDENCE FOR IT COULD BE IMPROVED.

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                    35  LAMBDA(2110) MASS (MEV)

M           2112.0      7.0          KANE      74 DPWA    K-P TO PI SIG     12/81
M     A    (2103.0)                  NAKKASYA  75 DPWA  0 K-P TO LAM. OMG.   1/76
M     A  FOUND IN ONE OF TWO BEST SOLUTIONS.                                 1/76
M          (2137.0)                  BACCARI   77 DPWA  0 K-P TO LAM. OMG.   1/78
M           2140.0     (20.0)        BELLEFON  77 DPWA  0 K- P TO SIG PI    11/77
M           2100.0     (50.0)        RLIC      77 DPWA    KBAR N MULTICHNL   1/76
M           2106.0     (50.0)        BELLEFON  78 DPWA  0 KBAR N TO KBAR N   1/78
M           2125.0     (25.0)        CAMERON2  78 DPWA    K-P TO K*(892) N 12/79
M           2092.0     (25.0)        GOPAL     80 DPWA    KBAR N ELASTIC    12/81

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                    35  LAMBDA(2110) WIDTH (MEV)

W            190.0     (30.0)        KANE      74 DPWA    K-P TO PI SIG     12/81
W     A     (391.0)                  NAKKASYA  75 DPWA  0 K-P TO LAM. OMG.   1/76
W           (132.0)                  BACCARI   77 DPWA  0 K-P TO LAM. OMG.   1/78
W            140.0     (20.0)        BELLEFON  77 DPWA  0 K- P TO SIG PI    11/77
W            200.0     (50.0)        RLIC      77 DPWA    KBAR N MULTICHNL   1/76
W            251.0     (50.0)        BELLEFON  78 DPWA  0 KBAR N TO KBAR N   1/78
W            160.0     (30.0)        CAMERON2  78 DPWA    K-P TO K*(892) N 12/79
W            245.0     (25.0)        GOPAL     80 DPWA    KBAR N ELASTIC    12/81

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                    35  LAMBDA(2110) PARTIAL DECAY MODES

                                                              DECAY MASSES
P1       LAMBDA(2110) INTO N KBAR                            938+ 494
P2       LAMBDA(2110) INTO SIGMA PI                         1189+ 140
P3       LAMBDA(2110) INTO LAMBDA OMEGA                     1116+ 783
P4       LAMBDA(2110) INTO SIGMA(1385) PI, P-WAVE           1385+ 140
P5       LAMBDA(2110) INTO N K*(892), F1 WAVE                940+ 892

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                    35  LAMBDA(2110) BRANCHING RATIOS

R1       LAMBDA(2110) FROM N KBAR TO SIGMA PI                SQRT(P1*P2)
R1            +0.20     (0.03)       KANE      74 DPWA    K-P TO PI SIG     12/81
R1            +0.14     (0.01)       BELLEFON  77 DPWA  0 K- P TO SIG PI     1/76
R1           (+0.10)    (0.03)       RLIC      77 DPWA    KBAR N MULTICHNL   1/76

R2       LAMBDA(2110) INTO (N KBAR)/TOTAL                    (P1)
R2    B       (0.07)    (0.03)       RLIC      77 DPWA    KBAR N MULTICHNL   1/76
R2    B  (N KBAR)/TOTAL FROM RLIC 77 IS SUPERSEDED BY GOPAL 80.
R2    C        0.27     (0.06)       BELLEFON  78 DPWA  0 KBAR N TO KBAR N   1/78
R2   C   THE PUBLISHED ERROR OF 0.6 WAS A MISPRINT.                         12/79
R2             0.07     (0.03)       GOPAL     80 DPWA    KBAR N ELASTIC    12/81

R3       LAMBDA(2110) FROM N KBAR TO LAMBDA OMEGA            SQRT(P1*P3)
R3    A       (0.112)                NAKKASYA  75 DPWA  0 K-P TO LAM. OMG.   1/76
R3            LESS THAN 0.05         BACCARI   77 DPWA  0 K-P TO LAM. OMG.   1/78

R4       LAMBDA(2110) FROM N KBAR TO SIGMA(1385) PI P-WAVESQRT(P1*P4)
R4    D       +0.071      0.025      CAMERON   78 DPWA  0 K-P TO S(1385)PI   1/78
R4    D  CAMERON  78 UPPER LIMIT ON F-WAVE DECAY IS 0.03.  THE SIGN HERE IS 12/79
R4    D  CHANGED TO BE IN ACCORD WITH THE BARYON-FIRST CONVENTION.          12/79

R5       LAMBDA(2110) FROM N KBAR TO N K*(892), F1 WAVE   SQRT(P1*P5)
R5    E       -0.17       0.04       CAMERON2  78 DPWA    K-P TO K*N        12/79
R5    E  THE SIGN HERE IS CHANGED TO BE IN ACCORD WITH THE BARYON-FIRST     12/79
R5    E  CONVENTION.  UPPER LIMITS ON THE P3 AND F3 WAVES ARE EACH 0.03.    12/79

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                       REFERENCES FOR LAMBDA(2110)

BERTHON1 70 NP B24 417        +VRANA,BUTTERWORTH,+        (CDEF+RHEL+SACL)IJP
LITCHFIE 71 NP  B30 125       LITCHFIELD,...+LESQUOY,+.. (RHEL+CDEF+SACL)IJP
KANE      72 PR D5 1583       D F KANE                                (LBL)IJP
KANE      74  LBL-2452        D F KANE                                (LBL)IJP
NAKKASYA 75 NP B93 85         A NAKKASYAN                            (CERN)IJP
BACCARI  77 NC 41A 96         +POULARD,REVEL,TALLINI+            (SACL+CDEF)IJP
BELLEFON 77 NC 37A 175        DE BELLEFON,BERTHON,BILLOIR+       (CDEF+SACL)IJP
RLIC      77 NP B119 362      GOPAL,ROSS,VAN HORN,MCPHERSON+     (LOIC+RHEL)IJP

BELLEFON 78 NC 42A 403        +BERTHON,BILLOIR,BRUNET+           (CDEF+SACL)IJP
CAMERON  78 NP B143 189       +FRANEK,GOPAL,BACON,BUTTERWORTH+(RHEL+LOIC)IJP
CAMERON2 78 NP B146 327       +FRANEK,GOPAL,KALMUS,MCPHERSON,+(RHEL+LOIC)IJP
GOPAL     80  TORONTO CONF 159 G P GOPAL                             (RHEL)IJP

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Λ(2325) D''_{03} Status: *

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                    112  LAMBDA(2325, JP=3/2-) I=0        D''03

                      BACCARI 77 FIND THIS STATE WITH JP EITHER 3/2- OR
                    3/2+ IN A DPWA OF K- P TO LAMBDA OMEGA FROM 2070 TO
                    2436 MEV.  A SUBSEQUENT SEMI-ENERGY-INDEPENDENT PWA
                    FROM THRESHOLD TO 2436 MEV SELECTS 3/2-.
                    BELLEFON 78 (SAME GROUP) ALSO SEE THIS STATE IN A
                    DPWA OF K- P ELASTIC AND CHARGE-EXCHANGE DATA
                    IN THE SAME ENERGY RANGE, AND FIND JP=3/2- OR 3/2+.
                    THEY AGAIN PREFER JP=3/2-, BUT ONLY ON THE BASIS
                    OF MODEL DEPENDENT CONSIDERATIONS.

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                    112  LAMBDA(2325) MASS (MEV)

M          2327.0      20.0          BACCARI   77 DPWA  0 K-P TO LAM. OMG.   1/78
M          2342.0      30.0          BELLEFON  78 DPWA  0 KBAR N TO KBAR N   1/78

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                    112  LAMBDA(2325) WIDTH (MEV)

W           160.0      40.0          BACCARI   77 IPWA  0 K-P TO LAM. OMG.   1/78
W           177.0      40.0          BELLEFON  78 DPWA  0 KBAR N TO KBAR N   1/78

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                    112  LAMBDA(2325) PARTIAL DECAY MODES

                                                              DECAY MASSES
P1       LAMBDA(2325) INTO N KBAR                            938+ 494
P2       LAMBDA(2325) INTO LAMBDA OMEGA                     1116+ 783

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                    112  LAMBDA(2325) BRANCHING RATIOS

R1       LAMBDA(2325) FROM N KBAR TO LAMBDA OMEGA            SQRT(P1*P2)
R1    3        0.06      0.02        BACCARI   77 IPWA  0 DS33-WAVE          1/78
R1    3        0.05      0.02        BACCARI   77 DPWA  0 DD13-WAVE          1/78
R1    3        0.08      0.03        BACCARI   77 DPWA  0 DD33-WAVE          1/78
R1    3  NOTE THAT THE 3 ENTRIES FOR BACCARI77 ARE FOR 3 DIFFERENT WAVES.    1/78

R2       LAMBDA(2325) INTO (N KBAR)/TOTAL                    (P1)
R2             0.19      0.06        BELLEFON  78 DPWA  0 KBAR N TO KBAR N   1/78

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                       REFERENCES FOR LAMBDA(2325)

BACCARI  77 NC 41A 96         +POULARD,REVEL,TALLINI+            (SACL+CDEF)IJP
BELLEFON 78 NC 42A 403        +BERTHON,BILLOIR,BRUNET+           (CDEF+SACL)IJP

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Λ(2350) BUMPS Status: ***

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                    42  LAMBDA(2350, JP=    ) I=0    PRODUCTION EXPERIMENTS

                    DAUM 68 FAVORS JP=7/2- OR 9/2+. BRICMAN 70 FAVORS 9/2+.
                    LASINSKI 71 SUGGESTS THREE STATES IN THIS REGION
                    USING A POMERON + RESONANCES MODEL.  THERE ARE NOW ALSO
   THREE FORMATION EXPERIMENTS FROM THE COLLEGE DE FRANCE-SACLAY GROUP
   WHICH WE INCLUDE HERE, BELEFON 77, BACCARI 77, AND BELLEFON 78, WHICH
   FIND 9/2+ IN DPWAS OF KBAR N TO SIGMA PI, LAMBDA OMEGA, AND KBAR N.

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                    42  LAMBDA(2350) MASS (MEV) (PROD. EXP.)

M          2340.0      (7.0)         BUGG      68 CNTR    K-P, D TOTAL       6/68
M          2358.0      (6.0)         BRICMAN   70 CNTR  0 TOTAL AND CH EX    6/70
M          2344.0     (15.0)         COOL      70 CNTR    K-P, D TOTAL      10/70
M         (2360.0)    (20.0)         LU        70 CNTR  0 GAMMA P TO K+ Y*   1/71
M         (2372.0)                   BACCARI   77 DPWA  0 K-P TO LAM. OMG.   1/78
M          2365.0      20.0          BELLEFON  77 DPWA  0 K- P TO SIG PI    11/77
M          2370.0      50.0          BELLEFON  78 DPWA  0 KBAR N TO KBAR N   1/78

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                    42  LAMBDA(2350) WIDTH (MEV) (PROD. EXP.)

W           140.0     (20.0)         BUGG      68 CNTR    K-P, D TOTAL       6/68
W           324.0     (30.0)         BRICMAN   70 CNTR  0 TOTAL AND CH EX    6/70
W          (190.0)                   COOL      70 CNTR    K-P, D TOTAL      10/70
W           (55.0)                   LU        70 CNTR  0 GAMMA P TO K+ Y*   1/71
W          (257.0)                   BACCARI   77 DPWA  0 K-P TO LAM. OMG.   1/78
W           110.0      20.0          BELLEFON  77 DPWA  0 K- P TO SIG PI    11/77
W           204.0      50.0          BELLEFON  78 DPWA  0 KBAR N TO KBAR N   1/78

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                    42  LAMBDA(2350) PARTIAL DECAY MODES (PROD. EXP.)

                                                              DECAY MASSES
P1       LAMBDA(2350) INTO N KBAR                            938+ 494
P2       LAMBDA(2350) INTO SIGMA PI                         1189+ 140
P3       LAMBDA(2350) INTO LAMBDA OMEGA                     1116+ 783

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                    42  LAMBDA(2350) BRANCHING RATIOS (PROD. EXP.)

R1       LAMBDA(2350) INTO (N KBAR)/TOTAL                    (P1)
R1             0.12      0.04        BELLEFON  78 DPWA  0 KBAR N TO KBAR N   1/78
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R2      LAMBDA(2350) FROM N KBAR TO SIGMA PI            SQRT(P1*P2)
R2         -0.11      0.02          BELLEFON  77 DPWA  0 K- P TO SIG PI    11/77

R3      LAMBDA(2350) FROM N KBAR TO LAMBDA OMEGA        SQRT(P1*P3)
R3           LESS THAN 0.05         BACCARI   77 DPWA  0 K-P TO LAM. OMG.   1/78

R4      LAMBDA(2350) INTO (N KBAR)/TOTAL                (J+1/2)*(P1)
R4         J IS NOT DETERMINED IN THESE EXPTS.  THE FOLLOWING IS (J+1/2)*P1
R4           (0.57)                 BUGG      68 CNTR    K-P, D TOTAL       3/78
R4            1.1         0.25      BRICMAN   70 CNTR  0 TOTAL AND CH EX    3/78
R4           (1.0)                  COOL      70 CNTR    K-P, D TOTAL       3/78

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                     REFERENCES FOR LAMBDA(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+SACL)
COOL      70 PR D1 1887         +GIACOMELLI, KYCIA, LEONTIC, LI, +    (BNL) I
LU        70 PR D2 1846         +GREENBERG, HUGHES, MINEHART, MORI,+ (YALE)

BACCARI   77 NC 41A 96          +POULARD,REVEL,TALLINI+         (SACL+CDEF)IJP
BELLEFON  77 NC 37A 175         DE BELLEFON,BERTHON,BILLOIR+    (CDEF+SACL)IJP
BELLEFON  78 NC 42A 403         +BERTHON,BILLOIR,BRUNET+        (CDEF+SACL)IJP

                                PAPERS NOT REFERRED TO IN DATA CARDS
COOL      66 PRL 16 1228        +GIACOMELLI,KYCIA,LEONTIC,LI,LUNDBY,+ (BNL) I
   SUPERSEDED BY COOL 70.
LASINSKI  71 NP  B29  125       T A LASINSKI                         (EFI)IJP
BELLEFO2  75 NC 28A 289         DE BELLEFON,BERTHON,BILLOIR+    (CDEF+SACL)
   PRESENTLY LISTED UNDER SIGMA(2250), BUT ISOSPIN UNDETERMINED.

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Λ(2585) BUMPS Status: **

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  ———→       7  LAMBDA(2585, JP-    ) I=0     PRODUCTION EXPERIMENTS

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             7  LAMBDA(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  LAMBDA(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  LAMBDA(2585) PARTIAL DECAY MODES (PROD. EXP.)

                                                          DECAY MASSES
P1       LAMBDA(2585) INTO N KBAR                         938+ 494

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             7  LAMBDA(2585) BRANCHING RATIOS (PROD. EXP.)

R1      LAMBDA(2585) INTO (N KBAR)/TOTAL                 (P1)
R1         J IS NOT KNOWN.  THE FOLLOWING IS (J+1/2)*P1.
R1            (1.0)                 ABRAMS    70 CNTR    K-P, D TOTAL      10/70
R1   C        (0.12)     (0.12)     BRICMAN   70 CNTR    TOTAL AND CH EX   10/70
R1   C    RESONANCE AT END OF REGION ANALYZED -- NO CLEAR SIGNAL.

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                     REFERENCES FOR LAMBDA(2585) (PROD. EXP.)

COOL      66 PRL 16 1228        +GIACOMELLI,KYCIA,LEONTIC,LUNDBY +     (BNL)I
   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+SACL)
LU        70 PR D2 1846         +GREENBERG, HUGHES, MINEHART, MORI,+ (YALE)
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S=−1 I=1 HYPERON STATES (Σ)

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Σ⁺

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             19  SIGMA+(1189, JP=1/2+) I=1

                 SEE STABLE PARTICLE DATA CARD LISTINGS

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Σ⁻

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             20  SIGMA-(1197, JP=1/2+) I=1

                 SEE STABLE PARTICLE DATA CARD LISTINGS

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Σ⁰

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             21  SIGMA0(1193, JP=1/2+) I=1

                 SEE STABLE PARTICLE DATA CARD LISTINGS

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Σ(1385) P_{13}' Status: ****

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           43  SIGMA(1385, JP=3/2+) I=1          P'13

           SERIOUS INCOMPATIBILITIES EXIST BETWEEN DIFFERENT
           MEASUREMENTS OF THE SIGMA(1385) MASS AND WIDTH. THESE
           INCOMPATIBILITIES ARE AT LEAST PARTIALLY ACCOUNTED FOR
           BY SOME EXPERIMENTS QUOTING UNREALISTICALLY SMALL
   ERRORS. WE CONSISTENTLY INCREASE UNREALISTIC ERRORS BEFORE AVERAGING
   (SEE THE TYPED NOTE ON K*(892)).

   IN THE LISTINGS BELOW WE ATTEMPT TO OBTAIN THE BEST VALUES FOR THE
   SEPARATE CHARGE STATE MASSES AND WIDTHS. THUS WE DO NOT USE RESULTS
   QUOTED FOR MIXED CHARGES.

   WE NO LONGER USE EVERY PUBLISHED VALUE, BUT AVERAGE ONLY THE MOST
   SIGNIFICANT DETERMINATIONS. NEITHER DO WE AVERAGE RESULTS FROM
   INCLUSIVE EXPERIMENTS WITH LARGE BACKGROUNDS OR RESULTS WHICH ARE NOT
   ACCOMPANIED BY AT LEAST A DISCUSSION ON EXPERIMENTAL RESOLUTION.
   NEVERTHELESS SYSTEMATIC DIFFERENCES BETWEEN EXPERIMENTS REMAIN (SEE
   THE IDEOGRAMS INSERTED IN THE DATA CARD LISTINGS BELOW). THESE
   DIFFERENCES COULD ARISE FROM INTERFERENCE EFFECTS THAT CHANGE WITH
   PRODUCTION MECHANISM AND/OR BEAM MOMENTUM. THEY CAN ALSO BE ACCOUNTED
   FOR IN PART BY DIFFERENCES IN THE PARAMETRIZATIONS EMPLOYED (SEE
   BORENSTEIN 74 FOR A DISCUSSION ON THIS POINT). THUS BORENSTEIN 74 USE A
   BREIT-WIGNER WITH ENERGY INDEPENDENT WIDTH, SINCE A P-WAVE WAS FOUND
   TO GIVE UNSATISFACTORY FITS. CAMERON 78 USE THE SAME FORM.
   ON THE OTHER HAND HOLMGRAN 77 OBTAIN A GOOD FIT TO THEIR LAMBDA PI MASS
   SPECTRUM WITH A P-WAVE BREIT-WIGNER, BUT INCLUDE THE PARTIAL WIDTH FOR
   THE SIGMA PI DECAY MODE IN THE PARAMETRIZATION.

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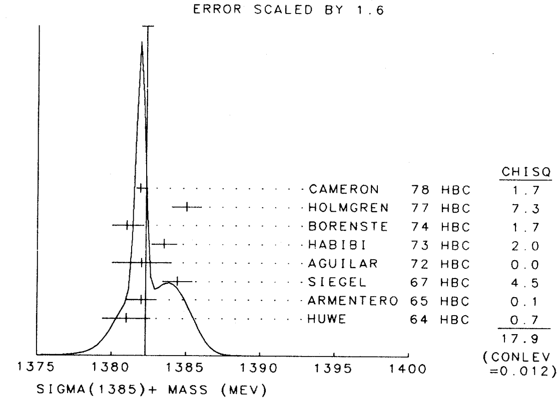
                  43  SIGMA(1385) MASS (MEV)

M         141(1384.0)                 ALSTON    60 HBC  +- K-P 1.15 GEV/C
M            (1385.0)                 BERGE     61 HBC  +- K-P .4-.85 GEV/C
M          38(1384.0)                 MARTIN    61 HBC  +0 K20 P .98 GEV/C
M            (1392.0)     (7.0)       COLLEY    62 HLBC -0 PI- PRP 2. GEV/C
M            (1389.0)     (3.0)       BALTAY    65 HBC  +- PBAR P 3.7 GEV/C  7/66
M            (1392.0)    (10.0)       MUSGRAVE  65 HBC  +-0PBAR P 3-4 GEV/C  7/66
M         200(1384.8)     (2.0)       ATHERTON  71 HBC  +- LAM PI+ + C.C.   11/77
M         190(1380.0)     (5.0)       AMMANN    73 DBC  +- K-N 4.5GEV/C     11/77
M         200(1386.0)                 ATHERTO1  75 HBC  +-0PBAR P 5.7 GEV/C  1/76
M         242(1394.0)     (5.0)       DIONISI   78 HBC  +- K-P TO Y* K KBAR  3/79
M    I     1K(1383.0)     (1.0)       BANERJEE  79 HBC  +- LAM PI+ + C.C.    1/80
M    I    500(1388.0)     (2.0)       BANERJEE  79 HBC  +- LAM PI- + C.C.    1/80
M    I     FROM FIT TO INCLUSIVE LAMBDA PI + C.C. SPECTRA

MO        106(1381.0)     (4.0)       CURTIS    63 OSPK  0 PI-P 1.5 GEV/C
MO E      240 1385.1       2.5        THOMAS    73 HBC   0 PI-P TO PIOKOLM  11/77
MO E       ERROR ENLARGED BY US TO GAMMA/SQRT(N). SEE TYPED NOTE ON K* MASS.
MO 2     3100 1380.0       2.0        BORENSTE  74 HBC   0 K-P TO(1385)+PIS 11/77
MO 2       FROM FIT TO LAM PIO MASS SPECTRUM (IN LAM PI+ PI- PIO EVENTS) WITH
MO 2       WO FIXED AT 34 MEV.
MO   F    500(1389.0)     (3.0)       BAUBILLIE 79 HBC   0 K-P AT 8.25 GEV   1/80
MO   F     FROM FIT TO INCLUSIVE LAMBDA PIO SPECTRUM WITH WIDTH FIXED AT
MO   F     40 MEV.
MO            . . . . . . . . . . .
MO   AVG      1382.0       2.5      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)

M+ E      154(1376.0)     (3.9)       ELY       61 HLBC +  K-P 1.11 GEV/C   11/77
M+        170(1375.0)     (3.9)       COOPER    64 HBC  +  K-P 1.45 GEV/C   11/77
M+        859 1381.0       1.6        HUWE      64 HBC  +  K-P 1.22 GEV/C
M+        750 1382.0       1.0        ARMENTERO 65 HBC  +  K-P .9-1.2 GEV/C
M+ E      250(1384.3)     (1.9)       SMITH     65 HBC  +  K-P 1.8 GEV/C    11/77
M+ E      250(1382.6)     (2.1)       SMITH     65 HBC  +  K-P 1.95 GEV/C   11/77
M+ E       62(1383.0)     (8.0)       BIRMINGHA 66 HBC  +  K-P 3.5 GEV/C    11/77
M+        135(1378.0)     (5.0)       LONDON    66 HBC  +  K-P 2.24 GEV/C   11/77
M+       1260 1384.4       1.0        SIEGEL    67 HBC  +  K-P AT 2.1 GEV/C 10/69
M+         46(1390.0)     (6.0)       AGUILAR   70 HBC  +  K-P 4 GEV/SIG.PI 11/77
M+        400 1382.0       2.0        AGUILAR   72 HBC  +  K-P TO LAM+PIS   10/74
M+       2300 1383.5       0.85       HABIBI    73 HBC  +  K-P TO 2PI LAM    9/73
M+   R   3740(1382.0)     (1.0)       BERTHON   74 HBC  +  K-P 1263-1843MEV 10/74
M+   R     ERRORS STATISTICAL ONLY. RESOLUTION NOT UNFOLDED.
M+       6846 1381.0       1.0        BORENSTE  74 HBC  +  K-P TO(1385)+PIS 10/74
M+   I       (1380.0)     (2.0)       BARDADIN  75 HBC  +  K- P 14.3 GEV/C  11/77
M+ HI     22K(1385.0)     (3.0)       BARREIRO  77 HBC  +  K-P AT 4.2 GEV   11/77
M+ H       INCLUDES DATA OF HOLMGREN 77
M+       2594 1385.0       1.0        HOLMGREN  77 HBC  +  K-P AT 4.2 GEV   11/77
M+       6900 1381.9       0.3        CAMERON   78 HBC  +  K-P 0.96-1.36GEV 11/77
M+   I     7K(1381.0)     (2.0)       BAUBILLIE 79 HBC  +  K-P AT 8.25 GEV   1/80
M+         2K(1391.0)     (2.0)       CAUTIS    79 HYBR +  PI+/K-P 11.5 GEV  1/80
M+   I    100(1390.0)     (2.0)       SUGAHARA  79 HBC  +  PI-P AT 6 GEV/C   1/80
M+        600(1385.1)     (1.2)       BAKER     80 HYBR +  PI+P 7 GEV/C      2/82
M+        750(1383.2)     (1.0)       BAKER     80 HYBR +  K-P 7 GEV/C       2/82
M+
M+   I     FROM FIT TO INCLUSIVE LAMBDA PI SPECTRUM
M+ E       ERROR ENLARGED BY US TO GAMMA/SQRT(N). SEE TYPED NOTE ON K* MASS.
M+            . . . . . . . . . . .
M+   AVG      1382.29      0.39     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)
                           (SEE IDEOGRAM BELOW)
```

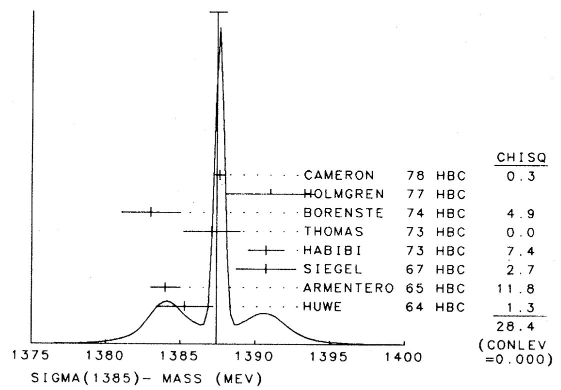
WEIGHTED AVERAGE = 1382.29 ± 0.39
ERROR SCALED BY 1.6



For notation, see key at front of Listings.


```
M-       93(1382.0)     (3.0)              DAHL      61 DBC  -  K-D 0.45 GEV/C     11/77
M- E    224(1376.0)     (4.4)              ELY       61 HLBC -  K-P 1.11 GEV/C     11/77
M-      200(1392.0)     (6.2)              COOPER    64 HBC  -  K-P 1.45 GEV/C     11/77
M- E   1086 1385.3       1.9               HUWE      64 HBC  -  K-P 1.15-1.30GEV  11/77
M-     1380 1384.0       1.0               ARMENTERO 65 HBC  -  K-P .9-1.2 GEV/C
M- E    120(1391.5)     (2.6)              SMITH     65 HBC  -  K-P 1.8 GEV/C      11/77
M- E     58(1399.8)     (2.2)              SMITH     65 HBC  -  K-P 1.95 GEV/C     11/77
M-       15(1389.0)     (9.0)              LONDON    66 HBC  -  K-P AT 2.24 GEV    11/77
M-      370 1390.7       2.0               SIEGEL    67 HBC  -  K-P AT 2.1 GEV/C  10/69
M-     1900 1390.7       1.2               HABIBI    73 HBC  -  K-P TO 2PI LAM      9/73
M- E    630 1387.1       1.9               THOMAS    73 HBC  -  PI-P TO PI-K+LM    11/77
M-   R 3060(1389.0)     (1.0)              BERTHON   74 HBC  -  K-P 1263-1843MEV  10/74
M-   R   ERRORS STATISTICAL ONLY. RESOLUTION NOT UNFOLDED.
M-     2303 1383.0       2.0               BORENSTE  74 HBC  -  K-P TO(1385)+PIS  10/74
M-   I     (1383.0)     (2.0)              BARDADIN  75 HBC  -  K- P 14.3 GEV/C   11/77
M- HI   12K(1387.0)     (3.0)              BARREIRO  77 HBC  -  K-P AT 4.2 GEV    11/77
M- H     INCLUDES DATA OF HOLMGREN 77
M-      193 1391.0       3.0               HOLMGREN  77 HBC  -  K-P AT 4.2 GEV    11/77
M-     9720 1387.6       0.3               CAMERON   78 HBC  -  K-P 0.96-1.36GEV  11/77
M-   I 4.5K(1383.0)     (1.0)              BAUBILLIE 79 HBC  -  K-P AT 8.25 GEV    1/80
M-   I  150(1380.0)     (6.0)              SUGAHARA  79 HBC  -  PI-P AT 6 GEV/C    1/80
M-
M-   I   FROM FIT TO INCLUSIVE LAMBDA PI SPECTRUM
M- E     ERROR ENLARGED BY US TO GAMMA/SQRT(N). SEE TYPED NOTE ON K* MASS.
M-
M-  AVG     1387.44     0.58    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.2)
                                (SEE IDEOGRAM BELOW)
```

WEIGHTED AVERAGE = 1387.44 ± 0.58
ERROR SCALED BY 2.2

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43 (SIGMA(1385)-)-(SIGMA(1385)+) MASS DIFFERENCE (MEV)

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D-+ R      (0.0)     (4.2)            ELY       61 HLBC +- K-P 1.11 GEV/C     8/66
D-+ R     (17.0)     (7.0)            COOPER    64 HBC  +- K-P 1.45 GEV/C    10/69
D-+ R      (4.3)     (2.2)            HUWE      64 HBC  +- K-P 1.22 GEV/C     8/66
D-+ R     .(2.0)     (1.5)            ARMENTERO 65 HBC  +- K-P .9-1.2 GEV/C   8/66
D-+ R      (7.2)     (2.1)            SMITH     65 HBC  +- K-P 1.8 GEV/C      9/66
D-+ R     (17.2)     (2.0)            SMITH     65 HBC  +- K-P 1.95 GEV/C     9/66
D-+ R     (11.0)     (9.0)            LONDON    66 HBC  +- K-P 2.24 GEV/C     8/66
D-+         9.0       6.0             LONDON    66 HBC  +- LAMBDA 3 PI EVTS   7/66
D-+ R      (6.3)     (2.0)            SIEGEL    67 HBC  +- K-P AT 2.1 GEV/C  10/69
D-+ R      (7.2)     (1.4)            HABIBI    73 HBC  +- K-P TO 2PI LAM     9/73
D-+ R    BETWEEN -2 AND +6 CL=.95     BORENSTE  74 HBC  +- K-P TO(1385)+PIS  11/77
D-+
D-+ R   REDUNDANT WITH DATA IN MASS LISTINGS

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43 (SIGMA(1385)0) - (SIGMA(1385)+) MASS DIFFER. (MEV)

```
D0+ R    BETWEEN -4 AND +4 CL=.95     BORENSTE  74 HBC  +0 K-P TO(1385)+PIS  11/77
D0+ R   REDUNDANT WITH DATA IN MASS LISTINGS

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43 (SIGMA(1385)-) - (SIGMA(1385)0) MASS DIFFER. (MEV)

```
D-0 R      (2.0)     (2.4)            THOMAS    73 HBC  -0 PI-P TO PI-K+LM   11/77
D-0 R   REDUNDANT WITH DATA IN MASS LISTINGS

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43 SIGMA(1385) WIDTH (MEV)

```
W       141  (64.0)                     ALSTON    60 HBC  +- K-P 1.15 GEV/C
W            (40.0)                     BERGE     61 HBC  +- K-P .4-.85 GEV/C
W        38  (20.0)  OR LESS            MARTIN    61 HBC  +0 K20 P .98 GEV/C
W            (80.0)   (10.0)            COLLEY    62 HLBC -0 PI- PRP 2. GEV/C
W            (26.0)    (5.0)            BALTAY    65 HBC  +- PBAR P 3.7 GEV/C  7/66
W            (38.0)    (9.0)            MUSGRAVE  65 HBC  +-0PBAR P 3-4 GEV/C  7/66
W     T 200  (20.0)    (4.0)            ATHERTON  71 HBC  +- LAM PI+ + C.C.   11/77
W     T  FIT B.W. + PHASE SPACE BCKGRD
W     R 200  (35.0)    (5.0)            ATHERTON  71 HBC  +- LAM PI+ + C.C.   11/77
W     R  FIT B.W. AND NO BCKGRD
W       190  (61.0)   (10.0)            AMMANN    73 DBC  +- K-N 4.5GEV/C     11/77
W       200  (89.0)   (23.0)            ATHERTON1 75 HBC  +-0PBAR P 5.7 GEV/C 11/77
W    D       (20.0)   (10.0)            ALSTON    78 DPWA -0 KBAR N ONLY       1/78
W    D   WITH MASS FIXED AT 1385 MEV.   FROM RESULTS OF PARTIAL WAVE ANALYSIS  1/78
W    D   OF KBAR N SYSTEM EXTRAPOLATED BELOW THRESHOLD.                        1/78
W       242  (53.0)   (14.0)            DIONISI   78 HBC  +- K-P TO Y* K KBAR  3/79
W    I   1K  (35.0)    (2.0)            BANERJEE  79 HBC  +- LAM PI+ + C.C.    1/80
W    I  500  (36.0)    (4.0)            BANERJEE  79 HBC  +- LAM PI- + C.C.    1/80
W    I   FROM FIT TO INCLUSIVE LAMBDA PI + C.C. SPECTRA

WO      106  (30.0)    (9.0)            CURTIS    63 OSPK  0 PI-P 1.5 GEV/C
WO E    240   39.3     10.2             THOMAS    73 HBC   0 PI-P TO PIOKOLM  11/77
WO E     ERROR ENLARGED BY US TO 4*GAMMA/SQRT(N). SEE TYPED NOTE ON K* MASS.
WO   C 3100  (53.0)    (8.0)            BORENSTE  74 HBC   0 K-P TO(1385)+PIS 11/77
WO   C 3100 CONSISTENT WITH WO=W+=W-    BORENSTE  74 HBC   0 K-P TO(1385)+PIS 11/77
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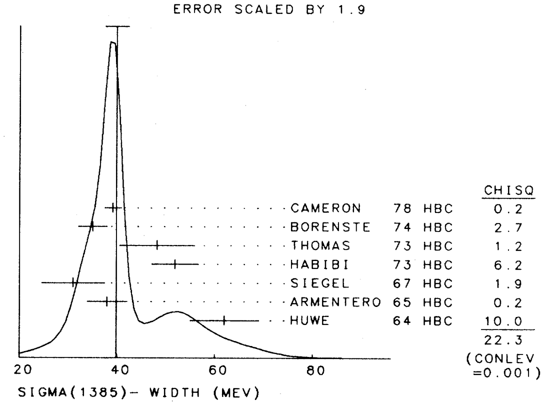
W+ E   154  (48.0)    (16.0)            ELY       61 HLBC +  K-P 1.11 GEV/C    11/77
W+ E   170  (51.0)    (16.0)            COOPER    64 HBC  +  K-P 1.45 GEV/C    11/77
W+ E   859   46.5       6.4             HUWE      64 HBC  +  K-P 1.15-1.30GEV 11/77
W+ E   750   32.0       4.7             ARMENTERO 65 HBC  +  K-P .95-1.20 GEV 11/77
W+ E   250  (30.3)     (7.5)            SMITH     65 HBC  +  K-P 1.8 GEV/C     11/77
W+ E   250  (33.1)     (8.3)            SMITH     65 HBC  +  K-P 1.95 GEV/C    11/77
W+ E    62  (25.0)    (32.0)            BIRMINGHA 66 HBC  +  K-P 3.5 GEV/C     11/77
W+ E  1260   36.0       4.0             SIEGEL    67 HBC  +  K-P AT 2.1 GEV/C 11/77
W+ E    46  (33.0)    (20.0)            AGUILAR   70 HBC  +  K-P 4 GEV/SIG.PI 11/77
W+     400   32.5       6.0             AGUILAR   72 HBC  +  K-P TO LAM+PIS   10/74
W+ E  2300   38.3       3.2             HABIBI    73 HBC  +  K-P TO 2PI LAM    11/77
W+   R 3740  (48.0)     (3.0)           BERTHON   74 HBC  +  K-P 1263-1843MEV 10/74
W+   R   ERRORS STATISTICAL ONLY. RESOLUTION NOT UNFOLDED.
W+ 1  6846   34.0       1.6             BORENSTE  74 HBC  +  K-P TO(1385)+PIS 11/77
W+ 1  RESULTS FROM LAM PI+ PI- AND LAM PI+ PI- PI0 COMBINED BY US.
W+   I      (40.0)     (3.2)            BARDADIN  75 HBC  +  K- P 14.3 GEV/C  11/77
W+ HI  22K  (43.0)     (5.0)            BARREIRO  77 HBC  +  K-P AT 4.2 GEV   11/77
W+ H     INCLUDES DATA OF HOLMGREN 77
W+    2594   34.0       2.0             HOLMGREN  77 HBC  +  K-P AT 4.2 GEV   11/77
W+    6900   35.5       1.9             CAMERON   78 HBC  +  K-P 0.96-1.36GEV 11/77
W+   I  7K  (37.0)     (2.0)            BAUBILLIE 79 HBC  +  K-P AT 8.25 GEV   1/80
W+      2K  (30.0)     (4.0)            CAUTIS    79 HYBR +  PI+/K-P 11.5 GEV  1/80
W+   I 100  (30.0)     (6.0)            SUGAHARA  79 HBC  +  PI-P AT 6 GEV/C   1/80
W+     600  (40.0)     (3.0)            BAKER     80 HYBR +  PI+P 7 GEV/C      2/82
W+     750  (37.0)     (2.0)            BAKER     80 HYBR +  K-P 7 GEV/C       2/82
W+
W+   I   FROM FIT TO INCLUSIVE LAMBDA PI SPECTRUM
W+ E     ERROR ENLARGED BY US TO 4*GAMMA/SQRT(N). SEE TYPED NOTE ON K* MASS.
W+
W+  AVG     34.96      0.92     AVERAGE

W-          (40.0)                      DAHL      61 DBC  -  K-D 0.45 GEV/C
W- E   224  (66.0)    (18.0)            ELY       61 HLBC -  K-P 1.11 GEV/C    11/77
W- E   200  (88.0)    (24.0)            COOPER    64 HBC  -  K-P 1.45 GEV/C    11/77
W-    1086   62.0       7.0             HUWE      64 HBC  -  K-P 1.15-1.30GEV
W- E  1382   38.0       4.1             ARMENTERO 65 HBC  -  K-P .95-1.20 GEV 11/77
W- E   120  (29.2)    (10.6)            SMITH     65 HBC  -  K-P 1.80 GEV/C    11/77
W- E    58  (17.1)     (8.9)            SMITH     65 HBC  -  K-P 1.95 GEV/C    11/77
W- E   370   31.0       6.5             SIEGEL    67 HBC  -  K-P AT 2.1 GEV/C 11/77
W- E  1900   51.9       4.8             HABIBI    73 HBC  -  K-P TO 2PI LAM    11/77
W- E   630   48.2       7.7             THOMAS    73 HBC  -  PI-P TO PI-KOLM   11/77
W-   R 3060  (40.0)     (3.0)           BERTHON   74 HBC  -  K-P 1263-1843MEV 10/74
W-   R   ERRORS STATISTICAL ONLY. RESOLUTION NOT UNFOLDED.
W- 1  2303   35.0       3.0             BORENSTE  74 HBC  -  K-P TO(1385)+PIS 11/77
W- 1  RESULTS FROM LAM PI+ PI- AND LAM PI+ PI- PI0 COMBINED BY US.
W-   I      (47.0)     (6.0)            BARDADIN  75 HBC  -  K- P 14.3 GEV/C  11/77
W- HI  12K  (45.0)     (5.0)            BARREIRO  77 HBC  -  K-P AT 4.2 GEV   11/77
W- H     INCLUDES DATA OF HOLMGREN 77
W-     193  (35.0)    (10.0)            HOLMGREN  77 HBC  -  K-P AT 4.2 GEV   11/77
W-    9720   39.2       1.7             CAMERON   78 HBC  -  K-P 0.96-1.36GEV 11/77
W-   I 4.5K (44.0)     (4.0)            BAUBILLIE 79 HBC  -  K-P AT 8.25 GEV   1/80
W-   I 150  (58.0)     (4.0)            SUGAHARA  79 HBC  -  PI-P AT 6 GEV/C   1/80
W-
W-   I   FROM FIT TO INCLUSIVE LAMBDA PI SPECTRUM
W- E     ERROR ENLARGED BY US TO 4*GAMMA/SQRT(N). SEE TYPED NOTE ON K* MASS.
W-
W-  AVG     39.9       2.4      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.9)
                                (SEE IDEOGRAM BELOW)
```

WEIGHTED AVERAGE = 39.9 ± 2.4
ERROR SCALED BY 1.9

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43 SIGMA(1385) REAL PART OF POLE POSITION

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RE+        1379.0      1.0              LICHTENB  74        +  EXTRAP HABIBI73    4/75
RE-        1383.0      1.0              LICHTENB  74        -  EXTRAP HABIBI73    4/75

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43 SIGMA(1385) IMAGINARY PART OF POLE POSITION

```
IM+          17.5      1.5              LICHTENB  74        +  EXTRAP HABIBI73    4/75
IM-          22.5      1.5              LICHTENB  74        -  EXTRAP HABIBI73    4/75

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43 SIGMA(1385) PARTIAL DECAY MODES

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                                                          DECAY MASSES
P1      SIGMA(1385) INTO LAMBDA PI                      1116+ 140
P2      SIGMA(1385) INTO SIGMA PI                       1189+ 140
P3      SIGMA(1385) INTO LAMBDA GAMMA                   1116+   0
P4      SIGMA(1385) INTO N KBAR                          938+ 494
P5      SIGMA(1385) INTO SIGMA GAMMA                    1197+   0

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Baryons

Data Card Listings

Σ(1385), Σ(1480), Σ(1560)

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                 43  SIGMA(1385) BRANCHING RATIOS

R1      SIGMA(1385) INTO (SIGMA PI)/(LAMBDA PI)             (P2)/(P1)
R1            (0.04)   (0.04)          BASTIEN   61 HBC  +-
R1            (0.04) OR LESS           ALSTON    62 HBC  +-0K-P 1.15 GEV/C
R1             0.09     0.04           HUWE      64 HBC  +- K-P 1.2-1.7 GEV
R1             0.163    0.041          ARMENTERO 65 HBC  +- K-P .95-1.20 GEV   7/66
R1             0.08     0.06           LONDON    66 HBC  +  K-P 2.24 GEV/C     7/66
R1             0.13     0.04           PAN       69 HBC  +  PI+ P - K Y PI    12/72
R1             0.13     0.04           COLLEY    71 DBC  -0 K-N 1.5 GEV PROD 10/71
R1             0.16     0.07           AGUILAR   72 HBC  +  K-P 3.9,4.6 GEV   10/74
R1             0.18     0.04           MAST2     73 MPWA +- K-P - 2PI SIG/LM   9/73
R1             0.10     0.05           THOMAS    73 HBC  -  PI-P TO PI K Y     9/73
R1             0.16     0.03           BERTHON   74 HBC  +  K-P 1263-1843MEV 11/77
R1             0.11     0.02           BERTHON   74 HBC  -  K-P 1263-1843MEV 11/77
R1             0.21     0.05           BORENSTE  74 HBC  +  K-P TO(1385)+PIS 10/74
R1             0.20     0.06           DIONISI   78 HBC  +- K-P TO Y* K KBAR  3/79
R1            . . . . . . . . . .
R1  AVG        0.135    0.011     AVERAGE

R2      SIGMA(1385) INTO (LAMBDA GAMMA)/TOTAL               (P3)
R2        1    (0.17)   (0.17)         MEISNER   72 HBC  0  1 EVENT ONLY       1/73

R3      SIGMA(1385) FROM N KBAR TO LAMBDA PI                SQRT(P1*P4)
R3 C          +0.586    0.319          DEVENISH  74       0 FIXED T DISP REL   4/75
R3 C     EXTRAPOLATION OF PARAMETRIZED AMPLITUDE BELOW THRESHOLD               4/75

R4      SIGMA(1385) INTO (LAMBDA GAMMA)/(LAMBDA PI)         (P3)/(P1)
R4            (0.06) OR LESS  CL=.90   COLAS     75 HLBC  0 K-P 575-970 MEV    1/76

R5      SIGMA(1385) INTO (SIGMA GAMMA)/(LAMBDA PI)          (P5)/(P1)
R5            (0.05) OR LESS  CL=.90   COLAS     75 HLBC  0 K-P 575-970 MEV    1/76

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                          REFERENCES FOR SIGMA(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, +              (COLU+RUTG) 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+HEID+SACL)
BALTAY   65 PR 140 B1027       +SANDWEISS,TAFT,CULWICK,KOPP, +  (YALE+BNL)
MUSGRAVE 65 NC 35 735          +PETMEZAS,+          (BIRM+CERN+EPOL+LOIC+SACL)
SMITH    65 THESIS (UCLA)      L T SMITH                              (UCLA)

BIRMINGH 66 PR 152 1148                             (BIRM+GLAS+LOIC+OXF+RHEL)
LONDON   66 PR 143 1034        +RAU,SAMIOS,YAMAMOTO,GOLDBERG,+  (BNL+SYRA) J
SIEGEL   67 UCRL 18041 THESIS  D M SIEGEL                              (LRL)
PAN      69 PRL 23 808         +FORMAN                                (PENN) I
AGUILAR  70 PRL 25 58          +BARNES, BASSANO, CHUNG, EISNER,+(BNL+SYRA)
ATHERTON 71 NP B29 477         +CELNIKIER,CLAYTON,FRENCH,FRISK,+      (CERN)
COLLEY   71 NP  B31 61         +COX,EASTWOOD,FRY+..  (BIRM+EDIN+GLAS+LOIC)

AGUILAR  72 PR D6 29           AGUILAR-BENITEZ,CHUNG,EISNER,SAMIOS   (BNL)
MEISNER  72 NC 12A 62          G MEISNER               (U NC GREENSBORO+LBL)
AMMANN   73 PRD 7 1345         +CARMONY,GARFINKEL,GUTAY,+        (PURD+IUPU)
MAST2    73 PRD 7 3212         +BANGERTER,ALSTON-GARNJOST,+          (LBL)IJP
    ALSO 73 PRD 7 5            MAST,BANGERTER,ALSTON-GARNJOST,+      (LBL)IJP
HABIBI   73 NEVIS 199(THESIS)  M HABIBI                               (COLU)
    ALSO 73 PURD73, PG. 387    BALTAY,BRIDGEWATER,COOPER,+       (COLU+BING)
THOMAS   73 NP B56 15          THOMAS,ENGLER,FISK,KRAEMER             (CARN) JP

BERTHON  74 NC 21A 146         BERTHON,TRISTRAM,+    (CDEF+RHEL+SACL+STRB)
BORENSTE 74 PR D9 3006         BORENSTEIN,KALBFLEISCH,STRAND,+  (BNL+MICH)
DEVENISH 74 NP B81 330         DEVENISH,FROGGATT,MARTIN    (DESY+NORD+LOUC)
LICHTENB 74 PRD 10 3865        D B LICHTENBERG                         (IND)
    ALSO 74 PRIV. COMM.        D B LICHTENBERG                         (IND)

ATHERTO1 75 NC 25A 1           ATHERTON,BAR-NIR,FRENCH                (CERN)
BARDADIN 75 NP B98 418         BARDADIN-OTWINOWSKA+         (SACL+EPOL+RHEL)
COLAS    75 NP B91 253         COLAS,FARWELL,FERRER,SIX               (ORSA)

BARREIRO 77 NP B126 319        +BERGE,GANGULI,BLOKZIJL+    (CERN+AMST+NIJM)
HOLMGREN 77 NP B119 261        +AGUILAR-BENITEZ,KLUYVER+   (CERN+AMST+NIJM)
ALSTON   78 PR D18 182         ALSTON-GARNJOST,KENNEY+      (LBL+MHCO+CERN)
CAMERON  78 NP B143 189        +FRANEK,GOPAL,BACON,BUTTERWORTH+(RHEL+LOIC)
DIONISI  78 PL 78B 154         +ARMENTEROS,DIAZ          (CERN+AMST+NIJM+OXF)

BANERJEE 79 ZPHY C3 1          +GANGULI,MALHOTRA,RAGHAVAN,SUDHAKAR  (TIFR)
BAUBILLI 79 NP B148 18         BAUBILLIER+          (BIRM+CERN+GLAS+MSU+LPNP)
CAUTIS   79 NP B156 507        +BALLAM,BOUCHEZ,CARROLL,CHADWICK+     (SLAC)
SUGAHARA 79 NP B156 237        +OCHIAI,FUKUI,COOPER+          (KEK+OSKC+KINK)
BAKER    80 NP B166 207        +CHIMA,DORNAN,GIBBS,HALL,MILLER+      (LOIC)

                               PAPERS NOT REFERRED TO IN DATA CARDS

MALAMUD  64 PL 10 145          E MALAMUD, P E SCHLEIN           (CERN+UCLA) JP
SHAFER   64 PR 134 B1372       J B SHAFER, D O HUWE                    (LRL) JP
HUNGERBU 74 PRD 10 2051        HUNGERBUHLER,MAJKA,+   (YALE+FNAL+BNL+PITT)
WALTER   79 ZPHY C3 89         +BECKER+     (BERL+AACH+CERN+SERP+SACL+VIEN)
AGUILAR  80 ZPHY C6 109        AGUILAR-BENITEZ+          (MADR+STOH+CERN+CDEF)
BALAND   80 ZPHY C3 187        +POIRET+(MONS+SERP+SACL+ALMA-ATA+MOSU+BELG)
BIAGI    81 ZPHY C9 305        +       (BRIS+CAMB+GEVA+HEID+LAUS+LOQM+RHEL)

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Σ(1480) BUMPS   Status: *

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         23  SIGMA(1480, JP=    ) I=1       PRODUCTION EXPERIMENTS

             PEAKS ARE SEEN IN LAMBDA PI AND SIGMA PI SPECTRA IN
             THE REACTION PI+P TO K+ PI Y AT 1.7 GEV/C.  ALSO THE
             Y POLARIZATION OSCILLATES IN THE SAME REGION.

    SEE MILLER 70 FOR A DISCUSSION OF THIS STATE.  HE SUGGESTS A POSSIBLE
    ALTERNATE EXPLANATION IN TERMS OF A REFLECTION OF N(1675) DECAY
    TO LAMBDA K. HOWEVER, SUCH AN EXPLANATION FOR THE K+ SIGMA+ PIO
    CHANNEL SEEMS UNLIKELY (SEE PAN 70) IN TERMS OF KNOWN DELTA(1650)
    DECAY INTO SIGMA K. IN ADDITION SUCH REFLECTIONS WOULD ALSO HAVE
    TO ACCOUNT FOR THE OSCILLATION OF THE Y POLARIZATION IN THE 1480
    MASS REGION.

    HANSON 71, WITH FEWER DATA THAN PAN 70, CAN NEITHER CONFIRM NOR
    DENY THE EXISTENCE OF THIS STATE.  MAST 75 SEES NO STRUCTURE IN THIS
    MASS REGION IN K- P TO LAMBDA PIO.

    ENGELEN 81 PERFORM A MULTI-CHANNEL ANALYSIS OF K-P --> KO PI- P AT
    4.2 GEV/C.  THEY OBSERVE A 3.5 STD. DEV. SIGNAL AT 1480 MEV IN P KOBAR
    WHICH CANNOT BE EXPLAINED AS A REFLECTION OF ANY COMPETING CHANNEL.

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             23  SIGMA(1480) MASS (MEV) (PROD. EXP.)

M          1479.0     10.0        PAN      70 HBC  +  PI+P TO K PI LAM  3/71
M          1465.0     15.0        PAN      70 HBC  +  PI+P TO K PI SIG  3/71
M          1485.0     10.0        CLINE    73 MPWA    K- D TO LM PI- P  9/73
M      120(1480.0)                ENGELEN  80 HBC  +  K-P TO KO PI- P   2/82

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             23  SIGMA(1480) WIDTH (MEV) (PROD. EXP.)

W            31.0     15.0        PAN      70 HBC  +  PI+P TO K PI LAM  3/71
W            30.0     20.0        PAN      70 HBC  +  PI+P TO K PI SIG  3/71
W            40.0     20.0        CLINE    73 MPWA    K- D TO LM PI- P  9/73
W      120   80.0     20.0        ENGELEN  80 HBC  +  K-P TO KO PI- P   2/82

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             23  SIGMA(1480) PARTIAL DECAY MODES (PROD. EXP.)

                                                     DECAY MASSES
P1      SIGMA(1480) INTO N KBAR                      938+ 494
P2      SIGMA(1480) INTO LAMBDA PI                  1116+ 140
P3      SIGMA(1480) INTO SIGMA PI                   1189+ 140

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             23  SIGMA(1480) BRANCHING RATIOS (PROD. EXP.)
R1      SIGMA(1480) INTO (SIGMA PI)/(LAMBDA PI)          (P3)/(P2)
R1             0.82      0.51         PAN      70 HBC  +                    3/71

R2      SIGMA(1480) INTO (PROTON KOBAR)/(LAMBDA PI)      (P1)/(P2)
R2             0.36      0.25         PAN      70 HBC  +                    3/71

R3      SIGMA(1480) INTO (N KBAR)/TOTAL                  (P1)
R3          SMALL                     CLINE    73 MPWA    K- D TO LM PI- P  9/73

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                     REFERENCES FOR SIGMA(1480) (PROD. EXP.)

PAN      70 PR D2, 49          +FORMAN,KO,HAGOPIAN,SELOVE              (PENN)
CLINE    73 LNC 6 205          CLINE,LAUMANN,MAPP                      (WISC)IJP
ENGELEN  80 NP B167 61         +HEINEN,KITTEL,METZGER+(NIJM+AMST+CERN+OXF)

                               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)        (PURD)
HANSON   71 PR D4 1296         +KALMUS,LOUIE                           (LBL) I
MAST     75 PRD 11 3078        +ALSTON-GARNJOST,BANGERTER+             (LBL)

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Σ(1560) BUMPS   Status: **

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         80  SIGMA(1560, JP=    ) I=1       PRODUCTION EXPERIMENTS

             THIS ENTRY LISTS PEAKS REPORTED IN MASS SPECTRA AROUND
             1560 MEV WITHOUT IMPLYING THAT THEY ARE NECESSARILY
             RELATED.

             DIONISI 78 OBSERVE A 6 STD. DEV. ENHANCEMENT AT 1553
             MEV IN THE CHARGED (LAMBDA/SIGMA PI) MASS SPECTRA
             FROM K-P --> LAMBDA/SIGMA PI K KBAR AT 4.2 GEV/C.
             IN A CERN ISR EXPERIMENT, LOCKMAN 78 REPORT A NARROW
    6 STD. DEV. ENHANCEMENT AT 1572 MEV IN THE LAMBDA PI+/PI- SYSTEMS
    FROM THE REACTION PP --> LAMBDA PI+ PI- + ANYTHING AT C.M. ENERGIES
    OF 53 AND 62 GEV.

    THESE ENHANCEMENTS ARE UNLIKELY TO BE ASSOCIATED WITH THE SIGMA(1580)
    (WHICH HAS NOT BEEN CONFIRMED BY SEVERAL RECENT EXPERIMENTS - SEE
    THE DATA CARD LISTINGS BELOW).

    CARROLL 76 OBSERVE A BUMP AT 1550 MEV (AS WELL AS AT 1580 MEV) IN THE
    K-N I=1 TOTAL CROSS SECTION, BUT UNCERTAINTIES IN CROSS SECTION
    MEASUREMENTS OUTSIDE THE MASS RANGE OF THE EXPERIMENT PRECLUDE
    ESTIMATING ITS SIGNIFICANCE.

    SEE ALSO MEADOWS 80 FOR A REVIEW OF THIS STATE.

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             80  SIGMA(1560) MASS (MEV) (PROD. EXP.)

M       121 1553.0      7.0       DIONISI  78 HBC  +- K-P TO Y* K KBAR  3/79
M        40 1572.0      4.0       LOCKMAN  78 SPEC +- PP TO L PI PI X  12/79

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             80  SIGMA(1560) WIDTH (MEV) (PROD. EXP.)

W       121   79.0     30.0       DIONISI  78 HBC  +- K-P TO Y* K KBAR  3/79
W  C     40   15.0      6.0       LOCKMAN  78 SPEC +- PP TO L PI PI X  12/79
W  C    OBSERVED WIDTH CONSISTENT WITH EXPERIMENTAL RESOLUTION.

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             80  SIGMA(1560) PARTIAL DECAY MODES (PROD. EXP.)

                                                     DECAY MASSES
P1      SIGMA(1560) INTO LAMBDA PI                  1116+ 140
P2      SIGMA(1560) INTO SIGMA PI                   1189+ 140

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             80  SIGMA(1560) BRANCHING RATIOS (PROD. EXP.)

R1      SIGMA(1560) INTO SIGMA PI/(SIGMA PI + LAMBDA PI)  (P2)/(P1+P2)
R1             0.35      0.12     DIONISI  78 HBC  +- K-P TO Y* K KBAR  3/79

R2      SIGMA(1560) INTO (LAMBDA PI)/TOTAL                (P1)
R2          SEEN                  LOCKMAN  78 SPEC +- PP TO L PI PI X  12/79

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                         REFERENCES FOR SIGMA(1560) (PROD. EXP.)

DIONISI  78 PL 78B 154         +ARMENTEROS,DIAZ+       (CERN+AMST+NIJM+OXF)I
LOCKMAN  78  CEN DPHPE 78-01   +MEYER,RANDER,POSTER,SCHLEIN+    (UCLA+SACL)

                               PAPERS NOT REFERRED TO IN DATA CARDS

CARROLL  76 PRL 37 806         +CHIANG,KYCIA,LI,MAZUR,MICHAEL+        (BNL)I
MEADOWS  80 TORONTO CONF. 283 B T MEADOWS                            (CINC)
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Σ(1580) D'_{13} Status: **

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               00  SIGMA(1580, JP=3/2-) I=1        D'13

               OBSERVED IN K- N I=1 TOTAL CS WITHOUT JP ASSIGNMENT AT
               BNL(LI 73, CARROLL 73, CARROLL 76) AND IN PWA OF K- P
               --> LAMBDA PI FOR CM ENERGIES=1560-1600 MEV BY
               LITCHFIELD 74.  LITCHFIELD 74 FINDS JP=3/2-.  NOT SEEN
               BY ENGLER 78 OR BY CAMERON 78 (WITH LARGER STATISTICS),
               IN KLONG P TO PI+ LAMBDA AND PI+ SIGMAO.

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               00  SIGMA(1580) MASS (MEV)

M  L       1582.0       4.0           LITCHFIEL 74 DPWA  0 K- P TO LAM PI    4/75
M    C     1583.0       4.0           CARROLL   76 DPWA    I=1 TOTAL CS      2/77

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               00  SIGMA(1580) WIDTH (MEV)

W  L         11.0       4.0           LITCHFIEL 74 DPWA  0 K- P TO LAM PI    4/75
W    C      (15.0)                    CARROLL   76 DPWA    I=1 TOTAL CS      2/77

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               00  SIGMA(1580) PARTIAL DECAY MODES

                                                       DECAY MASSES
P1      SIGMA(1580) INTO N KBAR                       938+ 494
P2      SIGMA(1580) INTO LAMBDA PI                   1116+ 140
P3      SIGMA(1580) INTO SIGMA PI                    1189+ 140

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               00  SIGMA(1580) BRANCHING RATIOS

R1      SIGMA(1580) INTO (N KBAR)/TOTAL                  (P1)
R1 L         +0.03      0.01          LITCHFIEL 74 DPWA    KBAR N MULTICHNL  4/75
R1 L     MAIN EFFECT OBSERVED BY LITCHFIELD 74 IS IN PI LAMBDA FINAL STATE,  4/75
R1 L     KBAR N AND SIGMA PI COUPLINGS ALSO ESTIMATED FROM MULTICHANNEL FIT  4/75
R1 L     INCLUDING TOTAL CROSS SECTION DATA (LI 73).                         4/75
R1   C   TOTAL CROSS SECTION BUMP WITH (J+1/2)X=.06   SEEN BY CARROLL 76     2/77

R2      SIGMA(1580) FROM N KBAR TO LAMBDA PI             SQRT(P1*P2)
R2 L         +0.10      0.02          LITCHFIEL 74 DPWA  0 K- P TO LAM PI    4/75
R2          NOT SEEN                  CAMERON   78 HBC  + KL P TO PI+ LAM    1/78
R2          NOT SEEN                  ENGLER    78  HBC + KL P TO PI+ LAM    2/77

R3      SIGMA(1580) FROM N KBAR TO SIGMA PI              SQRT(P1*P3)
R3 L         +0.03      0.04          LITCHFIEL 74 DPWA    KBAR N MULTICHNL  4/75
R3          NOT SEEN                  CAMERON   78 HBC  + KL P TO PI+ SIGO   1/78
R3          NOT SEEN                  ENGLER    78  HBC + KL P TO PI+ SIGO   2/77

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                         REFERENCES FOR SIGMA(1580)

LITCHFIE 74 PL 51B 509        LITCHFIELD                         (CERN)IJP
CARROLL  76 PRL 37 806        +CHIANG,KYCIA,LI,MAZUR,MICHAEL+        (BNL)I
ENGLER   76 PL 63B 231        +KEYES,KRAEMER,SCHLERETH,TANAKA+ (CARN+ANL)I
CAMERON  78 NP B132 189       +CAPILUPPI+        (BGNA+EDIN+GLAS+PISA+RHEL)I
ENGLER   78 PR D18 3061       +KEYES,KRAEMER,TANAKA,CHO,+        (CARN+ANL)

                              PAPERS NOT REFERRED TO IN DATA CARDS

CARROLL  73 APS BRKLY MTG 208 CARROLL,CHIANG,KYCIA,LI,MAZUR,MICHAEL+(BNL)I
LI       73 PURDUE CONF. 283  LI                                      (BNL)I
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Σ(1620) S'_{11} Status: **

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               32  SIGMA(1620, JP=1/2-) I=1        S'11

               THE S11 STATE AT 1697 MEV REPORTED BY VANHORN 75 IS
               INTERMEDIATE IN MASS BETWEEN THE SIGMA(1620) AND
               SIGMA(1750).  WE TENTATIVELY LIST IT UNDER SIGMA(1750).
               CARROLL 76 SEES TWO BUMPS IN THE I=1 TOTAL CROSS
               SECTIONS NEAR THIS MASS.

   PRODUCTION EXPERIMENTS ARE LISTED SEPARATELY IN THE NEXT ENTRY.

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               32  SIGMA(1620) MASS (MEV)

M          (1620.0)                   KIM       71 DPWA    K-MATRIX ANAL.    3/71
M           1630.0     (10.0)         LANGBEIN  72 IPWA    MULTICHANNEL     12/72
M     L     1608.0       5.0          CARROLL   76 DPWA    I=1 TOTAL CS      2/77
M     H     1633.0      10.0          CARROLL   76 DPWA    I=1 TOTAL CS      2/77
M    1     (1600.0)     (6.0)         MORRIS    78 DPWA -  K- N TO LAM PI-   3/79
M    1   AN EQUALLY GOOD FIT IS OBTAINED WITHOUT INCLUDING THIS RESONANCE.   3/79

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               32  SIGMA(1620) WIDTH (MEV)

W            (40.0)                   KIM       71 DPWA    K-MATRIX ANAL.    3/71
W             65.0     (20.0)         LANGBEIN  72 IPWA    MULTICHANNEL     12/72
W     L      (15.0)                   CARROLL   76 DPWA    I=1 TOTAL CS      2/77
W     H      (10.0)                   CARROLL   76 DPWA    I=1 TOTAL CS      2/77
W    1       (87.0)    (19.0)         MORRIS    78 DPWA -  K- N TO LAM PI-   3/79

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               32  SIGMA(1620) PARTIAL DECAY MODES

                                                       DECAY MASSES
P1      SIGMA(1620) INTO N KBAR                       938+ 494
P2      SIGMA(1620) INTO SIGMA PI                    1189+ 140
P3      SIGMA(1620) INTO LAMBDA PI                   1116+ 135

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               32  SIGMA(1620) BRANCHING RATIOS

R1      SIGMA(1620) INTO (N KBAR)/TOTAL                  (P1)
R1           (0.05)                   KIM       71 DPWA    K-MATRIX ANAL.    3/71
R1 A          0.05  OR LESS           WONG      71 DPWA    K-+P--LAM+PI     10/71
R1            0.22     (0.02)         LANGBEIN  72 IPWA    MULTICHANNEL     12/72
R1    L  TOTAL CROSS SECTION BUMP WITH (J+1/2)X=.06   SEEN BY CARROLL 76     2/77
R1    H  TOTAL CROSS SECTION BUMP WITH (J+1/2)X=.04   SEEN BY CARROLL 76     2/77
R1 A     K-MATRIX FIT(NEGLECTS 3-BODY CHANNELS) REQUIRES NO RESONANCE       10/71

R2      SIGMA(1620) FROM N KBAR TO SIGMA PI              SQRT(P1*P2)
R2           (0.08)                   KIM       71 DPWA    K-MATRIX ANAL.    3/71
R2            0.40     (0.06)         LANGBEIN  72 IPWA    MULTICHANNEL     12/72
R2          NOT SEEN                  HEPP2     76 DPWA -0 K- NUC TO SIG PI  2/77

R3      SIGMA(1620) FROM N KBAR TO LAMBDA PI             SQRT(P1*P3)
R3           (0.15)                   KIM       71 DPWA    K-MATRIX ANAL.    3/71
R3          NOT SEEN                  BAILLON   75 IPWA    KBAR N TO LAM PI 11/75
R3  1        (0.12)    (0.02)         MORRIS    78 DPWA -  K- N TO LAM PI-   3/79

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                         REFERENCES FOR SIGMA(1620)

KIM      71 PRL 27 356        J K KIM                              (HARV)IJP
   ALSO  70 DUKE 161          J K KIM                              (HARV)IJP
WONG     71 NC 2A 353         N S WONG                             (YALE)IJP
LANGBEIN 72 NP B47 477        +WAGNER                              (MPIM)IJP

BAILLON  75 NP B94 39         P BAILLON, P J LITCHFIELD       (CERN+RHEL)IJP
CARROLL  76 PRL 37 806        +CHIANG,KYCIA,LI,MAZUR,MICHAEL+        (BNL)I
HEPP2    76 PL 65B 487        +BRAUN,GRIMM,STROBELE,THOL+(CERN+HEID+MPIM)IJP
MORRIS   78 PR D17 55         +ALBRIGHT,COLLERAINE,KIMEL,LANNUTTI   (FSU)IJP

                              PAPERS NOT REFERRED TO IN DATA CARDS

VANHORN  75 NP B87 145        A J VAN HORN                          (LBL)IJP
   ALSO  75 NP B87 157        A J VAN HORN                          (LBL)IJP
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1620 MEV REGION – PRODUCTION EXPERIMENTS

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               78  SIGMA(1620, JP=    ) I=1     PRODUCTION EXPERIMENTS

               FORMATION EXPERIMENTS ARE LISTED SEPARATELY IN THE
               PREVIOUS ENTRY.

               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 SIGMA(1670). SEE MILLER
   70 FOR A REVIEW OF THESE CONFLICTS.

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               78  SIGMA(1620) MASS (MEV) (PROD. EXP.)

M   N     (1616.0)    (8.0)           CRENNELL  68 DBC  +- K-D 3.9 GEV/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-N 4.5 GEV/C     9/73

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               78  SIGMA(1620) WIDTH (MEV) (PROD. EXP.)

W   N       (66.0)    (16.0)          CRENNELL  68 DBC  +- SEE NOTE N ABOVE 11/68
W       20   30.0      10.0           BLUMENFEL 69 HBC  +                    9/69
W            72.0      22.0     15.0  CRENNELL  69 DBC  +-                   9/69
W            55.0      24.0           AMMANN    70 DBC     K-N 4.5 GEV/C     9/73

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               78  SIGMA(1620) PARTIAL DECAY MODES (PROD. EXP.)

                                                       DECAY MASSES
P1      SIGMA(1620) INTO N KBAR                       938+ 494
P2      SIGMA(1620) INTO LAMBDA PI                   1116+ 140
P3      SIGMA(1620) INTO SIGMA(1385) PI              1385+ 140
P4      SIGMA(1620) INTO LAMBDA PI PI                1116+ 140+ 140
P5      SIGMA(1620) INTO SIGMA PI                    1189+ 140
P6      SIGMA(1620) INTO LAMBDA(1405) PI             1405+ 140

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               78  SIGMA(1620) BRANCHING RATIOS (PROD. EXP.)

R1      SIGMA(1620) INTO (LAMBDA PI PI)/(LAMBDA PI)      (P4)/(P3)
R1        14    (2.5)  APPROX          BLUMENFEL 69 HBC  +

R2      SIGMA(1620) INTO (N KBAR)/(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      SIGMA(1620) INTO (LAMBDA PI)/TOTAL               (P2)
R3            LARGE                   CRENNELL  68 DBC  +-                  11/68

R4      SIGMA(1620) INTO (SIGMA(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      SIGMA(1620) INTO (SIGMA PI)/(LAMBDA PI)          (P5)/(P2)
R5           (1.1)(95 PC UPPER LIMIT) AMMANN    70 DBC     K-N 4.5 GEV/C     9/73

R6      SIGMA(1620) INTO (LAMBDA(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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Baryons

Data Card Listings

Σ(1620), Σ(1660), Σ(1670)

REFERENCES FOR SIGMA(1620) (PROD. EXP.)

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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,+     (PURD+IND)
    ALSO 73 PR D7 1345           AMMANN,CARMONY,GARFINKEL,        (PURD+IUPU)

                                 PAPERS NOT REFERRED TO IN DATA CARDS

ARMENTER 68 NP B8 183            ARMENTEROS,BAILLON +        (CERN+HEID+SACL)
LEVISETT 69 LUND CONF            R LEVI SETTI    (RAPPORTEUR)           (EFI)
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)            (PURD)
SABRE    70 NP B16 201           SABRE COLLAB.      (SACL+AMST+BGNA+REHO+EPOL)
HUNGERBU 74 PR D10 2051          HUNGERBUHLER,MAJKA,+     (YALE+FNAL+BNL+PITT)
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Σ(1660) P'_{11} Status: ***

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79  SIGMA(1660, JP=1/2+) I=1          P'11

FOR RESULTS PUBLISHED BEFORE 1974 (THEY ARE
NOW OBSOLETE), SEE OUR 1982 EDITION (PHYSICS LETTERS
111B).  ALL THE REFERENCES HAVE BEEN RETAINED.

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79  SIGMA(1660) MASS (MEV)

M        1670.0   (20.0)             KANE      74 DPWA   K-P TO PI SIG     12/81
M   A   (1660.0)  (30.0)             BAILLON   75 IPWA   KBAR N TO LAM PI  11/75
M   A  FROM SOLUTION 1 OF BAILLON 75, NOT PRESENT IN SOLUTION 2            11/75
M   B   (1671.0)   (2.0)             PONTE     75 DPWA  0 K- P TO LAM PI    1/76
M   B   FROM SOLUTION 2 OF PONTE 75, NOT PRESENT IN SOLUTION 1.             1/76
M        1668.0   (25.0)             VANHORN   75 DPWA  0 K- P TO LAM PI0  11/75
M    C   1565. OR 1597.              MARTIN    77 DPWA   KBAR N MULTICHNL  11/77
M    C  THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESONANCE
M    C  PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.
M        1676.0   (15.0)             RLIC      77 DPWA   KBAR N MULTICHNL   1/76
M        1679.0   (10.0)             ALSTON    78 DPWA   KBAR N ELASTIC     1/78
M        1670.0   (10.0)             GOPAL     80 DPWA   KBAR N ELASTIC    12/81

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79  SIGMA(1660) WIDTH (MEV)

W        250.0   (110.0)             KANE      74 DPWA   K-P TO PI SIG     12/81
W   A    (80.0)   (40.0)             BAILLON   75 IPWA   KBAR N TO LAM PI  11/75
W   B    (81.0)   (10.0)             PONTE     75 DPWA  0 K- P TO LAM PI    1/76
W        230.0   (165.0)   (60.0)    VANHORN   75 DPWA  0 K- P TO LAM PI0  11/75
W    C   202. OR 217.                MARTIN    77 DPWA   KBAR N MULTICHNL  11/77
W        120.0    (20.0)             RLIC      77 DPWA   KBAR N MULTICHNL   1/76
W         38.0    (10.0)             ALSTON    78 DPWA   KBAR N ELASTIC     1/78
W        152.0    (20.0)             GOPAL     80 DPWA   KBAR N ELASTIC    12/81

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79  SIGMA(1660) PARTIAL DECAY MODES

                                                       DECAY MASSES
P1      SIGMA(1660) INTO N KBAR                        938+ 494
P2      SIGMA(1660) INTO SIGMA PI                      1189+ 140
P3      SIGMA(1660) INTO LAMBDA PI                     1116+ 140

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79  SIGMA(1660) BRANCHING RATIOS

R1      SIGMA(1660) FROM N KBAR TO SIGMA PI            SQRT(P1*P2)
R1         -0.11    (0.01)           KANE      74 DPWA   K-P TO PI SIG     12/81
R1       NOT SEEN                    HEPP2     76 DPWA -0 K- NUC TO SIG PI  2/77
R1   C     -0.34 OR -0.37            MARTIN    77 DPWA   KBAR N MULTICHNL  11/77
R1         -0.16    (0.03)           RLIC      77 DPWA   KBAR N MULTICHNL   1/76

R2      SIGMA(1660) INTO (N KBAR)/TOTAL                (P1)
R2   C      0.27 OR  0.29            MARTIN    77 DPWA   KBAR N MULTICHNL  11/77
R2   D     LESS THAN 0.04            RLIC      77 DPWA   KBAR N MULTICHNL   1/76
R2   D  (N KBAR)/TOTAL FROM RLIC 77 IS SUPERSEDED BY GOPAL 80.
R2          0.10    (0.05)           ALSTON    78 DPWA   KBAR N ELASTIC     1/78
R2          0.12    (0.03)           GOPAL     80 DPWA   KBAR N ELASTIC    12/81

R3      SIGMA(1660) FROM N KBAR TO LAMBDA PI           SQRT(P1*P3)
R3  A     (-0.04)   (0.02)           BAILLON   75 IPWA   KBAR N TO LAM PI  11/75
R3  B     (+0.16)   (0.01)           PONTE     75 DPWA  0 K- P TO LAM PI    1/76
R3          0.12    (0.12)   (0.04)  VANHORN   75 DPWA  0 K- P TO LAM PI0  11/75
R3   C     -0.10 OR -0.11            MARTIN    77 DPWA   KBAR N MULTICHNL  11/77
R3         LESS THAN 0.04            RLIC      77 DPWA   KBAR N MULTICHNL   1/76

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REFERENCES FOR SIGMA(1660)

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ARMENTER 70 DUKE 123             ARMENTEROS, BAILLON, +        (CERN+HEID)IJP
KIM      71 PRL 27 356           J K KIM                            (HARV)IJP
    ALSO 70 DUKE 161             J K KIM                            (HARV)IJP
HART     73 PURDUE CONF. 311     +RICE,BACASTOW,FUNG,+  (TENN+UCR+MASA+BUFF)IJP
LEA      73 NP B56 77            +MARTIN,MOORHOUSE+     (RHEL+LOUC+GLAS+AARH)IJP
KANE     74 LBL-2452             D F KANE                            (LBL)IJP

BAILLON  75 NP B94 39            P BAILLON, P J LITCHFIELD     (CERN+RHEL)IJP
PONTE    75 PRD 12 2597          +HERTZBACH,BUTTON-SHAFER+  (MASA+TENN+UCR)IJP
VANHORN  75 NP B87 145           A J VAN HORN                        (LBL)IJP
    ALSO 75 NP B87 157           A J VAN HORN                        (LBL)IJP

HEPP2    76 PL 65B 487           +BRAUN,GRIMM,STROBELE,THOL+(CERN+HEID+MPIM)IJP
MARTIN   77 NP B127 349          MARTIN,PIDCOCK,MOORHOUSE      (LOUC+GLAS)IJP
    ALSO 77 NP B126 266          MARTIN,PIDCOCK                      (LOUC)
    ALSO 77 NP B126 285          MARTIN,PIDCOCK                      (LOUC)IJP
RLIC     77 NP B119 362          GOPAL,ROSS,VAN HORN,MCPHERSON+  (LOIC+RHEL)IJP
ALSTON   78 PR D18 182           +KENNEY,POLLARD,ROSS+      (LBL+MTHO+CERN)IJP
    ALSO 77 PRL 38 1007          ALSTON-GARNJOST,KENNEY,+   (LBL+MTHO+CERN)IJP
GOPAL    80  TORONTO CONF 159    G P GOPAL                           (RHEL)IJP
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NOTE ON THE Σ(1670)

Production experiments: The measured $\Sigma\pi/\Sigma\pi\pi$ branching ratio for produced Σ(1670)'s is strongly dependent on momentum transfer. This was first discovered by EBERHARD 69, who suggested that there exist two Σ resonances with the same mass and quantum numbers: one with a large $\Sigma\pi\pi$ [mainly $\Lambda(1405)\pi$] decay mode produced peripherally, and the other with a large $\Sigma\pi$ decay mode produced at larger angles. These results were confirmed by AGUILAR-BENITEZ 70, ASPELL 74, ESTES 74, and TIMMERMANS 76. The most likely quantum numbers for both the $\Sigma\pi$ and the $\Lambda(1405)\pi$ states are D_{13}. There is also possibly a third Σ, the Σ(1690) in the Listings, the main evidence for which is a large $\Lambda\pi/\Sigma\pi$ branching ratio. These topics have been reviewed by EBERHARD 73 and by MILLER 70.

Formation experiments: Two states are also observed near this mass in formation experiments. One of these, the D_{13} Σ(1670), has the same quantum numbers as those observed in production and has a large $\Sigma\pi/\Sigma\pi\pi$ branching ratio. It may well be the Σ(1670) produced at larger angles (see TIMMERMANS 76). The other state, the P_{11} Σ(1660), has different quantum numbers from those seen in production, and its $\Sigma\pi/\Sigma\pi\pi$ branching ratio is unknown. Thus its relation to the produced Σ(1670)'s remains obscure.

Σ(1670) D''_{13} Status: ****

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44  SIGMA(1670, JP=3/2-) I=1          D''13

FOR MOST RESULTS PUBLISHED BEFORE 1974 (THEY ARE
NOW OBSOLETE), SEE OUR 1982 EDITION (PHYSICS LETTERS
111B).  ALL THE REFERENCES HAVE BEEN RETAINED.

RESULTS FROM PRODUCTION EXPERIMENTS ARE LISTED
SEPARATELY IN THE NEXT ENTRY.

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44  SIGMA(1670) MASS (MEV)

M        1670.0    (2.0)             KANE      74 DPWA   K-P TO PI SIG     12/81
M        1685.0   (20.0)             BAILLON   75 IPWA   KBAR N TO LAM PI  11/75
M   A   (1671.0)   (3.0)             PONTE     75 DPWA  0 K- P TO LAM PI    1/76
M   A  FROM SOLUTION 1 OF PONTE 75.                                         1/76
M   B   (1655.0)   (2.0)             PONTE     75 DPWA  0 K- P TO LAM PI    1/76
M   B  FROM SOLUTION 2 OF PONTE 75.                                         1/76
M        1659.0   (12.0)    (5.0)    VANHORN   75 DPWA  0 K- P TO LAM PI0  11/75
M       (1650.0)                     BELLEFON  76 IPWA  0 K- P TO LAM PI    2/77
M        1670.0    (6.0)             HEPP2     76 DPWA -0 K- NUC TO SIG PI  2/77
M    C   1667. OR 1668.              MARTIN    77 DPWA   KBAR N MULTICHNL  11/77
M    C  THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESONANCE
M    C  PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.
M        1670.0    (5.0)             RLIC      77 DPWA   KBAR N MULTICHNL   1/76
M        1679.0   (10.0)             ALSTON    78 DPWA   KBAR N ELASTIC     1/78
M        1682.0    (5.0)             GOPAL     80 DPWA   KBAR N ELASTIC    12/81

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44  SIGMA(1670) WIDTH (MEV)

W         79.0     (6.0)             KANE      74 DPWA   K-P TO PI SIG     12/81
W         85.0    (25.0)             BAILLON   75 IPWA   KBAR N TO LAM PI  11/75
W   A    (44.0)   (11.0)             PONTE     75 DPWA  0 K- P TO LAM PI    1/76
W   B    (76.0)    (5.0)             PONTE     75 DPWA  0 K- P TO LAM PI    1/76
W         32.0    (11.0)             VANHORN   75 DPWA  0 K- P TO LAM PI0  11/75
W        (80.0)                      BELLEFON  76 IPWA  0 K- P TO LAM PI    2/77
W         56.0     (3.0)             HEPP2     76 DPWA -0 K- NUC TO SIG PI  2/77
W    C    46. OR 46.                 MARTIN    77 DPWA   KBAR N MULTICHNL  11/77
W         50.0     (5.0)             RLIC      77 DPWA   KBAR N MULTICHNL   1/76
W         56.0    (20.0)             ALSTON    78 DPWA   KBAR N ELASTIC     1/78
W         79.0    (10.0)             GOPAL     80 DPWA   KBAR N ELASTIC    12/81

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                44  SIGMA(1670) PARTIAL DECAY MODES

                                                         DECAY MASSES
P1      SIGMA(1670) INTO N KBAR                          938+ 494
P2      SIGMA(1670) INTO LAMBDA PI                      1116+ 140
P3      SIGMA(1670) INTO SIGMA PI                       1189+ 140
P4      SIGMA(1670) INTO LAMBDA PI PI                   1116+ 140+ 140
P5      SIGMA(1670) INTO SIGMA PI PI                    1192+ 140+ 140
P6      SIGMA(1670) INTO SIGMA(1385) PI, S-WAVE         1385+ 140
P7      SIGMA(1670) INTO LAMBDA(1405) PI                1405+ 140
P8      SIGMA(1670) INTO LAMBDA(1520) PI                1520+ 140
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                44  SIGMA(1670) BRANCHING RATIOS

R1      SIGMA(1670) INTO (N KBAR)/TOTAL              (P1)
R1  C       0.07 OR  0.07       MARTIN     77 DPWA    KBAR N MULTICHNL 11/77
R1  D      (0.08)   (0.03)      RLIC       77 DPWA    KBAR N MULTICHNL  1/76
R1  D   (N KBAR)/TOTAL FROM RLIC 77 IS SUPERSEDED BY GOPAL 80.
R1          0.11    (0.03)      ALSTON     78 DPWA    KBAR N ELASTIC    1/78
R1          0.10    (0.03)      GOPAL      80 DPWA    KBAR N ELASTIC   12/81

R2      SIGMA(1670) INTO (LAMBDA PI PI)/TOTAL        (P4)
R2         (0.11) OR LESS       ARMENTE3   68 HBC     K-P (P1=.09)      9/69

R3      SIGMA(1670) INTO (SIGMA PI PI)/TOTAL         (P5)
R3  E      (0.14) OR LESS       ARMENTE3   68 HBC     K-P AND D-P1=.09 11/68
R3  E   RATIO ONLY FOR (SIG2PI) SYSTEM IN I=1, WHICH CANNOT BE SIGMA(1385)  11/68

R4      SIGMA(1670) INTO (LAMBDA(1405) PI)/TOTAL     (P7)
R4         (0.06) OR LESS       ARMENTE3   68 HBC     K-P AND D-P1=.09 11/68

R5      SIGMA(1670) FROM N KBAR TO LAMBDA PI         SQRT(P1*P2)
R5         +0.018    0.060      DEVENISH   74       0 FIXED T DISP REL  4/75
R5         +0.06    (0.02)      BAILLON    75 IPWA    KBAR N TO LAM PI 11/75
R5  A      (0.08)   (0.01)      PONTE      75 DPWA  0 K- P TO LAM PI    1/76
R5  B      (0.17)   (0.01)      PONTE      75 DPWA  0 K- P TO LAM PI    1/76
R5         +0.09    (0.02)      VANHORN    75 DPWA  0 K- P TO LAM PI0  11/75
R5         (+0.05)              BELLEFON   76 IPWA  0 K- P TO LAM PI    2/77
R5  C      +0.08 OR +0.08       MARTIN     77 DPWA    KBAR N MULTICHNL 11/77
R5         +0.10    (0.02)      RLIC       77 DPWA    KBAR N MULTICHNL  1/76
R5  F       0.17    (0.03)      MORRIS     78 DPWA -  K- N TO LAM PI-   3/79
R5  F       0.13    (0.02)      MORRIS     78 DPWA -  K- N TO LAM PI-   3/79
R5  F   RESULTS ARE WITH AND WITHOUT AN S11 SIG(1620) IN THE FIT.

R6      SIGMA(1670) FROM N KBAR TO SIGMA PI          SQRT(P1*P3)
R6         +0.21    (0.03)      KANE       74 DPWA    K-P TO PI SIG    12/81
R6         +0.20    (0.01)      HEPP2      76 DPWA -0 K- NUC TO SIG PI  2/77
R6  C      +0.18 OR +0.17       MARTIN     77 DPWA    KBAR N MULTICHNL 11/77
R6         +0.21    (0.02)      RLIC       77 DPWA    KBAR N MULTICHNL  1/76

R7      SIGMA(1670) FROM N KBAR TO SIGMA(1385) PI, S-WAVESQRT(P1*P6)
R7  G      (0.17)   (0.02)      SIMS       68 DBC  -  LAM 2PI CROS.SEC 10/71
R7  G   SIMS 68 USES ONLY CROSS-SECT. DATA. RESULT USED AS UPPER LIMIT ONLY  3/72
R7         +0.11     0.03       PREVOST    74 DPWA 0- K-N TO S(1385)PI 10/74

R8      SIGMA(1670) INTO (LAM(1405)PI)*(N KBAR)/TOTAL**2 (P7*P1)
R8         (0.03) OR LESS       BERLEY     69 HBC   0 K-P .6-.82 GEV/C  5/70
R8  H       0.007   (0.002)     BRUCKER    70 DBC  -  K-N TO SIG 2PI   10/71
R8  H   ASSUMING LAMBDA(1405) PI CROSS SECTION BUMP DUE ONLY TO 3/2- RESON. 10/71

R9      SIGMA(1670) INTO (LAM(1405) PI)/(SIGMA(1385) PI) (P7)/(P6)
R9          0.23    (0.08)      BRUCKER    70 DBC  -  K-N TO SIG 2PI   10/71

R10     SIGMA(1670) FROM N KBAR TO LAMBDA(1520) PI   SQRT(P1*P8)
R10 I       0.081    0.016      CAMERON    77 DPWA  0 P-WAVE DECAY      1/78
R10 I   CAMERON77 UPPER LIMIT ON F-WAVE DECAY IS 0.03                   1/78
R10 I   ASSUMES LAMBDA(1520) ELASTICITY=.46.                            1/78
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REFERENCES FOR SIGMA(1670)


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BASTIEN1 63 PRL 10 188 P L8BASTIEN, J P BERGE                     (LRL) IJ
BASTIEN2 63 UCRL-10779 THESIS P L BASTIEN                         (LRL) IJ
T-ZADEH  63 PRL 11 470        TAHER-ZADEH,PROWSE,SCHLEIN,SLATER,+ (UCLA) JP
BERLEY   64 DUBNA CONF I 565  +CONNOLLY,HART,RAHM,STONEHILL, +    (BNL)IJP
SCHLEIN  66 UCLA-1016         P E  SCHLEIN, T G  TRIPPE           (UCLA) JP
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+SACL)
ARMENTER 68 NP B8 195         ARMENTEROS,BAILLON +         (CERN+HEID+SACL)IJP
ARMENTE1 68 NP B8 183         ARMENTEROS,BAILLON +         (CERN+HEID+SACL)IJP
ARMENTE2 68 NP B8 223         ARMENTEROS+BAILLON +         (CERN+HEID+SACL)IJP
ARMENTE3 68 PL 28B 521        ARMENTEROS,BAILLON +         (CERN+HEID+SACL)I
SIMS     68 PRL 21 1413       SIMS,ALBRIGHT,BARTLEY,MEER+  (FSU+TUFT+BRAN)

ARMENTE4 69 NP B10 459        ARMENTEROS,BAILLON,MINTEN +       (CERN+SACL) J
ARMENT-5 69 NP B14 91         ARMENTEROS, BAILLON, +       (CERN+HEID+SACL)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
PREVOST  71  AMSTERDAM CONF   + CHS COLLABORATION          (CERN+HEID+SACL)

LANGBEIN 72 NP B47 477        +WAGNER                                 (MPIM)IJP
BAXTER   73 NP B67 125        BAXTER,BUCKINGHAM,CORBETT,DUNN,+        (OXF)IJP
HART     73 PURDUE CONF. 311  +RICE,BACASTOW,FUNG,+  (TENN+UCR+MASA+BUFF)IJP
DEVENISH 74 NP B81 330        DEVENISH,FROGGATT,MARTIN    (DESY+NORD+LOUC)
KANE     74  LBL-2452         D F KANE                                (LBL)IJP
PREVOST  74 NP B69 246        PREVOST,BARLOUTAUD,+        (SACL+CERN+HEID)

BAILLON  75 NP B94 39         P BAILLON, P J LITCHFIELD         (CERN+RHEL)IJP
PONTE    75 PRD 12 2597       +HERTZBACH,BUTTON-SHAFER+   (MASA+TENN+UCR)IJP
VANHORN  75 NP B87 145        A J VAN HORN                            (LBL)IJP
   ALSO  75 NP B87 157        A J VAN HORN                            (LBL)IJP

BELLEFON 76 NP B109 129       DE BELLEFON,BERTHON                     (CDEF)IJP
HEPP2    76 PL 65B 487        +BRAUN,GRIMM,STROBELE,THOL+(CERN+HEID+MPIM)IJP
CAMERON  77 NP B131 399       +FRANEK,GOPAL,KALMUS,MCPHERSON+ (RHEL+LOIC)IJP
MARTIN   77 NP B127 349       MARTIN,PIDCOCK,MOORHOUSE          (LOUC+GLAS)IJP
   ALSO  77 NP B126 266       MARTIN,PIDCOCK                          (LOUC)
   ALSO  77 NP B126 285       MARTIN,PIDCOCK                          (LOUC)IJP
RLIC     77 NP B119 362       GOPAL,ROSS,VAN HORN,MCPHERSON+  (LOIC+RHEL)IJP

ALSTON   78 PR D18 182        +KENNEY,POLLARD,ROSS+       (LBL+MTHO+CERN)IJP
   ALSO  77 PRL 38 1007       ALSTON-GARNJOST,KENNEY,+    (LBL+MTHO+CERN)IJP
MORRIS   78 PR D17 55         +ALBRIGHT,COLLERAINE,KIMEL,LANNUTTI     (FSU)IJP
GOPAL    80  TORONTO CONF 159 G P GOPAL                               (RHEL)IJP
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Σ(1670) BUMPS

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                51  SIGMA(1670, JP=    ) I=1 PROD. AND CROSS SECT. EXPS

                FORMATION EXPERIMENTS ARE LISTED SEPARATELY IN THE
                PRECEDING ENTRY.

                PROBABLY THERE ARE TWO STATES AT SAME MASS WITH SAME
                QUANTUM NUMBERS, ONE DECAYING INTO SIGMA PI AND LAMBDA
                PI, THE OTHER INTO LAMBDA(1405) PI.  SEE THE NOTE
                PRECEDING THE PRECEDING ENTRY.

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                51  SIGMA(1670) MASS (MEV) (PROD. EXP.)

M          (1685.0)                 ALEXANDER 62 HBC  -0 PI-P 2-2.2 GEV/C
M           1660.0     10.0         ALVAREZ   63 HBC  +  K-P 1.51 GEV/C
M          (1665.0)    (5.0)        BUGG      68 CNTR    K-P, D TOTAL C.S
M   A    70(1661.0)    (9.0)        PRIMER    68 HBC  +  K-P 4.6-5. GEV/C   7/68
M   A       SEE BARNES 69 FOR NEW ANALYSIS OF DATA (3 TIMES MORE DATA)    10/69
M           1670.0      6.0         AGUILAR   70 HBC     SIG.PI K-P 4 GEV   5/70
M           1668.0     10.0         AGUILAR   70 HBC     SIG.2PI K-P 4GEV   5/70
M           1665.0      1.0         APSELL    74 HBC     K- P 2.87 GEV/C    4/75
M      1200 1688+/-2. OR 1683+/-5.  BERTHON   74 HBC   0 QUASI 2 BODY CS    4/75
M    B      1670.0      4.0         CARROLL   76 DPWA    I=1 TOTAL CS       2/77
M    B  TOTAL CROSS SECTION BUMP WITH (J+1/2)X=.23                          2/77
M    C      1675.0     10.0         HEPP1     76 DBC   - K-N 1.6-1.75 GEV   2/77
M    C  ENHANCEMENTS IN SIG P1 AND SIG P1 P1 CHANNEL CROSS SECTIONS.        2/77
M           1655. TO 1677.          TIMMERMA  76 HBC  +  K- P 4.2 GEV/C     2/77
M   D   150(1668.0)   (10.0)        FERRER    81 OMEG -  PI-P 9,12 GEV/C    2/82
M   D   BACKWARD PRODUCTION IN LAMBDA PI- K+ FINAL STATE.

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                51  SIGMA(1670) WIDTH (MEV) (PROD. EXP.)

W           (45.0)                  ALEXANDER 62 HBC  -0
W            40.0      10.0         ALVAREZ   63 HBC  +
W           (30.0)    (15.0)        BUGG      68 CNTR                      11/66
W   A    70 (60.0)    (20.0)        PRIMER    68 HBC  +  K-P 4.6-5. GEV/C   7/68
W           110.0      12.0         AGUILAR   70 HBC     SIG.PI K-P 4 GEV   5/70
W           135.0      40.0   30.0  AGUILAR   70 HBC     SIG.2PI K-P 4GEV   5/70
W            67.0       2.4         APSELL    74 HBC     K- P 2.87 GEV/C    4/75
W    B      (52.0)                  CARROLL   76 DPWA    I=1 TOTAL CS       2/77
W            48. TO 63.             TIMMERMA  76 HBC  +  K- P 4.2 GEV/C     2/77
W   D   150 (90.0)    (20.0)        FERRER    81 OMEG -  PI-P 9,12 GEV/C    2/82

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                51  SIGMA(1670) PARTIAL DECAY MODES (PROD. EXP.)

                                                           DECAY MASSES
P1      SIGMA(1670) INTO N KBAR                            938+ 494
P2      SIGMA(1670) INTO LAMBDA PI                        1116+ 140
P3      SIGMA(1670) INTO SIGMA PI                         1189+ 140
P4      SIGMA(1670) INTO LAMBDA PI PI                     1116+ 140+ 140
P5      SIGMA(1670) INTO SIGMA PI PI                      1192+ 140+ 140
P6      SIGMA(1670) INTO SIGMA(1385) PI                   1385+ 140
P7      SIGMA(1670) INTO LAMBDA(1405) PI                  1405+ 140

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                51  SIGMA(1670) BRANCHING RATIOS (PROD. EXP.)

R1      SIGMA(1670) INTO (N KBAR)/(SIGMA PI)               (P1)/(P3)
R1        0    (0.19) OR LESS       ALVAREZ   63 HBC  +  K-P 1.15 GEV/C
R1             (0.5)+- 0.25 OR MORE SMITH     63 HBC  -0
R1             (0.6)  OR LESS       LONDON    66 HBC  +  K-P 2.25 GEV/C     7/66
R1             (0.025)              BUGG      68 CNTR  0 ASSUMING J=3/2    11/66
R1        0    (0.24) OR LESS       PRIMER    68 HBC  +  K-P 4.6-5. GEV/C   7/68
R1             (0.26) OR LESS       BARNES    69 HBC  +  K-P 3.9-5 GEV/C   10/69
R1             (0.2)  OR LESS       AGUILAR   70 HBC                        5/70
R1             (0.10) OR LESS       BERTHON   74 HBC   0 QUASI 2 BODY CS    4/75
R1             (0.03) OR LESS       TIMMERMA  76 HBC  +  K- P 4.2 GEV/C     2/77

R2      SIGMA(1670) INTO (LAMBDA PI)/(SIGMA PI)            (P2)/(P3)
R2      130    (1.20)               ALVAREZ   63 HBC  +  K-P 1.15 GEV/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 GEV/C     7/66
R2       33     0.11      0.06      BUTTON-S  68 HBC  +  K-P AT 1.7 GEV/C 10/69
R2  A     0    (0.0)                PRIMER    68 HBC  +  K-P 3.9-5 GEV/C   10/69
R2  A   PRIMER 68 ASSUMED THIS DECAY TO BE ALL SIGMA(1690) - SEE BARNES 69
R2  A   FOR NEWW 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             (0.55)    (0.11)     BERTHON   74 HBC   0 QUASI 2 BODY CS    4/75
R2              0.76      0.09      ESTES     74 HBC   0 K-P,2.1+2.6GEV/C  11/75
R2             (0.45)+/- 0.07 OR LESS  TIMMERMA  76 HBC  +  K- P 4.2 GEV/C     2/77
R3      SIGMA(1670) INTO (LAMBDA PI PI)/(SIGMA PI)         (P4)/(P3)
R3       90    (0.56)               ALVAREZ   63 HBC  +  K-P 1.15 GEV/C
R3             (0.17)               SMITH     63 HBC  -0
R3             (0.6)  OR LESS       LONDON    66 HBC  + K-P AT 2.25 GEV/C   7/66

R4      SIGMA(1670) INTO (SIGMA PI PI)/(SIGMA PI)          (P5)/(P3)
R4      180    (0.56)               ALVAREZ   63 HBC  +  K-P 1.15 GEV/C
R4          LARGEST AT SMALL ANGLES ESTES     74 HBC   0 K-P,2.1+2.6GEV/C  11/75
R4   C         (0.2)OR LESS         HEPP1     76 DBC   - K-N 1.6-1.75 GEV   2/77

R5      SIGMA(1670) INTO (LAMBDA(1405) PI)/(SIGMA PI)      (P7)/(P3)
R5       50     3.0       1.6       LONDON    66 HBC  +  K-P 2.25 GEV/C     7/66
R5  A    17    (0.58)    (0.20)     PRIMER    68 HBC  +  K-P 4.6-5. GEV/C   7/68
R5          LARGEST AT SMALL ANGLES ESTES     74 HBC  +- K-P 2.1+2.6GEV/C  11/75
R5 DE       1.8+/-0.3 TO 0.02+/-0.07  TIMMERMA  76 HBC  +  K-P 4.2 GEV/C   11/77
R5  E   DEPENDING ON PRODUCTION ANGLE

R6      SIGMA(1670) INTO (SIGMA PI)/(SIGMA PI PI)          (P3)/(P5)
R6              0.4    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  F       BETWEEN 2.5 AND 0.24    EBERHARD  69 HBC     K-P AT 2.6 GEV/C   9/69
R6  F   DEPENDING ON THE PRODUCTION ANGLE
R6 G        VARIES WITH PROD. ANGLE APSELL    74 HBC  +  K-P 2.87 GEV/C     4/75
R6             (1.39)    (0.16)     BERTHON   74 HBC   0 QUASI 2 BODY CS    4/75
R6 G    APSELL 74, ESTES 74 AND TIMMERMANS 76 FIND STRONG BRANCHING RATIO
R6 G    DEPENDENCE ON PRODUCTION ANGLE, AS IN EARLIER PROD. EXPERIMENTS.

R7      SIGMA(1670) INTO (LAMBDA(1405) PI)/(SIGMA PI PI) (P7)/(P5)
R7              0.90      0.10     0.16  EBERHARD  65 HBC  +  K-P 2.45 GEV/C     7/66
R7              1.00      0.02      APSELL    74 HBC     K- P 2.87 GEV/C    4/75
R7              0.97      0.08      TIMMERMA  76  HBC    K- P 4.2 GEV/C     2/77

R8      SIGMA(1670) INTO (LAM(1405) PI)/(SIGMA(1385) PI) (P7)/(P6)
R8             (0.8)  OR LESS       EBERHARD  65 HBC  +  K-P 2.45 GEV/C     7/66
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Baryons

Data Card Listings

Σ(1670), Σ(1690), Σ(1750)

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R9       SIGMA(1670) INTO (LAMBDA PI PI)/(SIGMA PI PI)    (P4)/(P5)
R9            0.35      0.2            BIRMINGHA 66 HBC  +  K-P AT 3.5 GEV/C 11/67

R10      SIGMA(1670) INTO (LAMBDA PI)/(SIGMA PI PI)       (P2)/(P5)
R10          (0.2)  OR LESS            BIRMINGHA 66 HBC  +  K-P AT 3.5 GEV/C 11/67

R11      SIGMA(1670) INTO (LAMBDA PI)/(LAMBDA PI + SIG PI)(P2)/(P2+P3)
R11          (0.6)  OR LESS            AGUILAR   70 HBC                       5/70

R12      SIGMA(1670) INTO (SIGMA(1385) PI)/(SIGMA PI)     (P6)/(P3)
R12          (0.21)+/- 0.05 OR LESS    TIMMERMA  76  HBC    K- P 4.2 GEV/C    2/77

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51 SIGMA(1670) QUANTUM NUMBERS (PROD. EXP.)

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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 SIGMA(1670) (PROD. EXP.)

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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                    (BIRM+GLAS+LOIC+OXF+RHEL)
LONDON   66 PR 143 1034        +RAU,SAMIOS,YAMAMOTO,GOLDBERG,+  (BNL+SYRA) IJ
BUGG     68 PR 168 1466        +GILMORE,KNIGHT,DAVIES+    (BIRM+CAVE+RHEL)I
BUTTON-S 68 PRL 21 1123        J BUTTON-SHAFER                 (MASA+LRL) JP
PRIMER   68 PRL 20 610         +GOLDBERG,JAEGER,BARNES,DORNAN + (SYRA+BNL)

BARNES   69 BNL 13823          +CHUNG,EISNER,FLAMINIO+          (BNL+SYRA)
EBERHARD 69 PRL 22 200         +FRIEDMAN,PRIPSTEIN,ROSS              (LRL)
AGUILAR  70 PRL 25 58          +BARNES, BASSANO, CHUNG, EISNER,+(BNL+SYRA)

APSELL   74 PRD 10 1419        APSELL,FORD,GOUREVITCH+(BRAN+UMD+SYRA+TUFT)I
BERTHON  74 NC 21A 146         BERTHON,TRISTRAM,+     (CDEF+RHEL+SACL+STRB)
ESTES    74 LBL-3827 (THESIS)  R D ESTES                             (LBL)

CARROLL  76 PRL 37 806         +CHIANG,KYCIA,LI,MAZUR,MICHAEL+       (BNL)I
HEPP1    76 NP B115 82         +BRAUN,GRIMM,STROBELE,THOL+(CERN+HEID+MPIM)I
TIMMERMA 76 NP B112 77         TIMMERMANS,ENGELEN+    (NIJM+CERN+AMST+OXF) JP
FERRER   81 NP B178 373        +TREILLE,RIVET,VOLTE+ (CERN+CDEF+EPOL+LALO)

                               PAPERS NOT REFERRED TO IN DATA CARDS

LEVEQUE  65 PL 18 69           +            (SACL+EPOL+GLAS+LOIC+OXF+RHEL) JP
LEE      66 PRL 17 45          Y Y LEE, D D REEDER, R W HARTUNG     (WISC) JP
EBERHARD 67 PR 163 1446        +PRIPSTEIN,SHIVELY,KRUSE,SWANSON  (LRL+ILL)IJP
MILLER   70 DUKE 229           D H MILLER    (REVIEW TALK)            (PURD)
EBERHARD 73 PURDUE CONF. 247   P EBERHARD                            (LBL)IJP
HUNGERBU 74 PRD 10 2051        HUNGERBUHLER,MAJKA,+   (YALE+FNAL+BNL+PITT)
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Σ(1690) BUMPS Status: **

58 SIGMA(1690, JP=) I=1 PRODUCTION EXPERIMENTS

SEE THE NOTE PRECEDING THE SIGMA(1670) LISTINGS. SEEN IN PRODUCTION EXPERIMENTS ONLY, MAINLY IN LAMBDA PI.

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58 SIGMA(1690) MASS (MEV) (PROD. EXP.)

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M           30(1715.0)   (12.0)            COLLEY    67 HBC  +  K-P 6 GEV/C        8/67
M      A    60(1694.0)   (24.0)            PRIMER    68 HBC  +  K-P 4.6-5 GEV/C    7/68
M      A     SEE SIGMA(1670) LISTING-AGUILAR 70 WITH THREE TIMES THE DATA OF
M      A     PRIMER 68  SHOW THAT THEY HAVE NO EVIDENCE FOR SIGMA(1690)
M       B     (1700.0)    (6.0)            SIMS      68 HBC  -  K-N TO LAM PI PI 11/68
M       B    THIS ANALYSIS, WHICH IS DIFFICULT AND REQUIRES SEVERAL ASSUMPTIONS
M       B    AND SHOWS NO UNAMBIGUOUS SIGMA(1690) SIGNAL, SUGGESTS JP=5/2+.
M       B    SUCH A Y* WOULD LEAD ALL PREVIOUSLY KNOWN Y* TRAJECTORIES.
M           15(1698.0)   (20.0)            ADERHOLZ  69 HBC  +  PI+P 8 GEV/C      12/79
M           46(1682.0)    (2.0)            BLUMENFEL 69 HBC  +  K0 LONG + PROTON   9/69
M             (1700.0)   (20.0)            MOTT      69 HBC  +  K-P 5.5 GEV/C      9/69
M      C    70(1698.0)   (20.0)            GODDARD   79 HBC  +  PI+P 10.3 GEV/C   12/79
M      C     FROM (LAMBDA PI+) K+ FINAL STATE. J>1/2 NOT REQUIRED BY DATA.
M      D    40(1707.0)   (20.0)            GODDARD   79 HBC  +  PI+P 10.3 GEV/C   12/79
M      D     FROM (LAMBDA PI+) (K PI)+ FINAL STATE. J>1/2 INDICATED, BUT LARGE
M      D     BACKGROUND PRECLUDES DEFINITE CONCLUSION.

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58 SIGMA(1690) WIDTH (MEV) (PROD. EXP.)

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W           30 (100.0)   (35.0)            COLLEY    67 HBC  +                     8/67
W      A    60 (105.0)   (35.0)            PRIMER    68 HBC  +                     7/68
W       B       (62.0)   (14.0)            SIMS      68 HBC  -  SEE NOTE N ABOVE  11/68
W           15 (142.0)   (40.0)            ADERHOLZ  69 HBC  +  PI+P 8 GEV/C      12/79
W           46  (25.0)   (10.0)            BLUMENFEL 69 HBC  +                     9/69
W              (130.0)   (25.0)            MOTT      69 HBC  +                     9/69
W      C    70 (240.0)   (60.0)            GODDARD   79 HBC  +  PI+P 10.3 GEV/C   12/79
W      D    40 (130.0)  (100.0)   (60.0)   GODDARD   79 HBC  +  PI+P 10.3 GEV/C   12/79

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58 SIGMA(1690) PARTIAL DECAY MODES (PROD. EXP.)

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                                                          DECAY MASSES
P1       SIGMA(1690) INTO N KBAR                         938+ 494
P2       SIGMA(1690) INTO LAMBDA PI                     1116+ 140
P3       SIGMA(1690) INTO SIGMA PI                      1189+ 140
P4       SIGMA(1690) INTO SIGMA(1385) PI                1385+ 140
P5       SIGMA(1690) INTO LAMBDA PI PI (INCLUDING P4)   1116+ 140+ 140

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58 SIGMA(1690) BRANCHING RATIOS (PROD. EXP.)

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R1       SIGMA(1690) INTO (N KBAR)/(LAMBDA PI)            (P1)/(P2)
R1       18     0.4      0.25          COLLEY    67 HBC  +  6/30 EVENTS        8/67
R1             (0.2)  OR LESS          MOTT      69 HBC  +                     9/69
R1            SMALL                    GODDARD   79 HBC  +  PI+P 10.2 GEV/C   12/79

R2       SIGMA(1690) INTO (SIGMA PI)/(LAMBDA PI)          (P3)/(P2)
R2            0.3       0.3            COLLEY    67 HBC  +  4/30 EVENTS        8/67
R2           (0.4)  OR LESS  CL=.90    MOTT      69 HBC  +                     9/69
R2          SMALL                      GODDARD   79 HBC  +  PI+P 10.2 GEV/C   12/79

R3       SIGMA(1690) INTO (SIGMA(1385) PI)/(LAMBDA PI)    (P4)/(P2)
R3           (0.5)  OR LESS            MOTT      69 HBC  +                     9/69

R4       SIGMA(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       SIGMA(1690) INTO (SIGMA(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 SIGMA(1690) (PROD. EXP.)

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COLLEY   67 PL 24B 489                  (BIRM+GLAS+LOIC+MUNI+OXF+RHEL) I
DERRICK  67 PRL 18 266         +FIELDS, LOKEN, AMMAR,            (ANL+NWES) I
   REPLACED BY MOTT 69.
PRIMER   68 PRL 20 610         +GOLDBERG, JAEGER, BARNES, + (SYRACUSE+BNL) I
SIMS     68 PRL 21 1413        +ALBRIGHT, +                 (FSU+TUFT+BRAN) I

ADERHOLZ 69 NP B11 259         +BARTSCH,SCHULTE+(AACH+BERL+CERN+CRAC+WARS)I
BLUMENFE 69 PL 29B 58          B J BLUMENFELD, G R KALBFLEISCH        (BNL) I
MOTT     69 PR 177 1966        +AMMAR, DAVIS, KROPAC, +          (NWES+ANL) I

GODDARD  79 PR D19 1350        +KEY,LUSTE,PRENTICE,YOON,GORDON+ (TNTO+BNL)I,J

                               PAPERS NOT REFERRED TO IN DATA CARDS

AGUILAR  70 PRL 25 58          AGUILAR-BENITEZ,BARNES,BASSANO+  (BNL+SYRA)
COOPER   70 NP B23 605         +MANNER,MUSGRAVE,POLLARD,VOYVODIC      (ANL)I
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Σ(1750) S''_{11} Status: ***

57 SIGMA(1750, JP=1/2-) I=1 S''11

FOR MOST RESULTS PUBLISHED BEFORE 1974 (THEY ARE NOW OBSOLETE), SEE OUR 1982 EDITION (PHYSICS LETTERS 111B). ALL THE REFERENCES HAVE BEEN RETAINED.

THERE IS EVIDENCE FOR THIS STATE IN MANY PARTIAL-WAVE ANALYSES, BUT WITH RATHER WIDE VARIATIONS IN THE MASS, WIDTH AND COUPLINGS. THE LATEST ANALYSES INDICATED SIGNIFICANT COUPLINGS TO N KBAR AND LAMBDA PI, AS WELL AS SIGMA ETA WHOSE THRESHOLD IS NEARBY AT 1746 MEV (JONES 74).

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57 SIGMA(1750) MASS (MEV)

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M             (1785.0)    (12.0)           CHU       74 DBC   - FIT SIG- ETA CS   10/74
M      A      (1760.0)     (5.0)           JONES     74 HBC   0 FIT SIG0 ETA CS    1/74
M      A   S-WAVE BW FIT TO THRSHLD C.S., NO BKGND. ERRORS STATISTICAL ONLY        1/74
M             (1739.0)    (10.0)           PREVOST   74 DPWA 0- K-N TO S(1385)PI 10/74
M     B       (1780.0)    (30.0)           BAILLON   75 IPWA    KBAR N TO LAM PI 11/75
M     B    FROM SOLUTION 1 OF BAILLON 75.                                         11/75
M     C       (1700.0)    (30.0)           BAILLON   75 IPWA    KBAR N TO LAM PI   1/76
M     C    FROM SOLUTION 2 OF BAILLON 75.                                          1/76
M             (1697.0)    (20.0)   (10.0)  VANHORN   75 DPWA  0 K- P TO LAM PI0   11/75
M             (1730.0)                     BELLEFON  76 IPWA  0 K- P TO LAM PI     2/77
M      D       1715.0      10.0            CARROLL   76 DPWA    I=1 TOTAL CS       2/77
M      D   A TOTAL CROSS SECTION BUMP WITH (J+1/2)X=0.30.
M      E       1800. OR 1813.              MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
M      E   THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESONANCE
M      E   PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.
M              1770.0      15.0            RLIC      77 DPWA    KBAR N MULTICHNL   1/76
M              1770.0      10.0            ALSTON    78 DPWA    KBAR N ELASTIC     1/78
M              1756.0     (10.0)           GOPAL     80 DPWA    KBAR N ELASTIC    12/81

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57 SIGMA(1750) WIDTH (MEV)

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W              (89.0)     (33.0)           CHU       74 DBC   - FIT SIG- ETA CS   10/74
W      A       (92.0)      (7.0)           JONES     74 HBC   0 FIT SIG+ETA CS     1/74
W             (108.0)     (20.0)           PREVOST   74 DPWA 0- K-N TO S(1385)PI 10/74
W     B       (140.0)     (30.0)           BAILLON   75 IPWA    KBAR N TO LAM PI 11/75
W     C       (160.0)     (50.0)           BAILLON   75 IPWA    KBAR N TO LAM PI   1/76
W              (66.0)     (14.0)   (12.0)  VANHORN   75 DPWA  0 K- P TO LAM PI0   11/75
W             (110.0)                      BELLEFON  76 IPWA  0 K- P TO LAM PI     2/77
W      D       (10.0)                      CARROLL   76 DPWA    I=1 TOTAL CS       2/77
W      E       117. OR 119.                MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
W               60.0       10.0            RLIC      77 DPWA    KBAR N MULTICHNL   1/76
W              161.0       20.0            ALSTON    78 DPWA    KBAR N ELASTIC     1/78
W               64.0      (10.0)           GOPAL     80 DPWA    KBAR N ELASTIC    12/81

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57 SIGMA(1750) PARTIAL DECAY MODES

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                                                          DECAY MASSES
P1       SIGMA(1750) INTO N KBAR                         938+ 494
P2       SIGMA(1750) INTO SIGMA ETA                     1192+ 549
P3       SIGMA(1750) INTO LAMBDA PI                     1116+ 135
P4       SIGMA(1750) INTO SIGMA PI                      1189+ 140
P5       SIGMA(1750) INTO SIGMA(1385) PI                1385+ 140
P6       SIGMA(1750) INTO LAMBDA(1520) PI               1520+ 140

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57 SIGMA(1750) BRANCHING RATIOS

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R1       SIGMA(1750) INTO (N KBAR)/TOTAL                           (P1)
R1     E       0.06 OR  0.05               MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
R1     F      (0.15)    (0.03)             RLIC      77 DPWA    KBAR N MULTICHNL   1/76
R1     F   (N KBAR)/TOTAL FROM RLIC 77 IS SUPERSEDED BY GOPAL 80.
R1             0.33      0.05              ALSTON    78 DPWA    KBAR N ELASTIC     1/78
R1             0.14     (0.03)             GOPAL     80 DPWA    KBAR N ELASTIC    12/81

R2       SIGMA(1750) FROM N KBAR TO SIGMA ETA                 SQRT(P1*P2)
R2             SEEN                        CLINE     69 DBC   -  THRESHOLD BUMP    9/69
R2     A      (0.23)    (0.01)             JONES     74 HBC   0 FIT SIG+ETA CS     1/74
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R3      SIGMA(1750) FROM N KBAR TO LAMBDA PI              SQRT(P1*P3)
R3           (-0.120)  (0.077)        DEVENISH  74         0 FIXED T DISP REL  4/75
R3   B       (-0.12)   (0.02)         BAILLON   75 IPWA      KBAR N TO LAM PI 11/75
R3   C       (-0.13)   (0.03)         BAILLON   75 IPWA      KBAR N TO LAM PI  1/76
R3           (-0.13)   (0.04)         VANHORN   75 DPWA  0 K- P TO LAM PI0   11/75
R3           (-0.12)                  BELLEFON  76 IPWA  0 K- P TO LAM PI     2/77
R3    E       -0.10 OR -0.09          MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
R3            (0.04)   (0.03)         RLIC      77 DPWA    KBAR N MULTICHNL  1/76

R4      SIGMA(1750) FROM N KBAR TO SIGMA PI               SQRT(P1*P4)
R4            (0.13)   (0.02)         LANGBEIN  72 IPWA    MULTICHANNEL     12/72
R4    E       +0.06 OR +0.06          MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
R4            -0.09     0.05          RLIC      77 DPWA    KBAR N MULTICHNL  1/76

R5      SIGMA(1750) FROM N KBAR TO SIGMA(1385) PI         SQRT(P1*P4)
R5            +0.18     0.15          PREVOST   74 DPWA 0- K-N TO S(1385)PI 10/74

R6      SIGMA(1750) FROM N KBAR TO LAMBDA(1520) PI        SQRT(P1*P6)
R6    G         0.032    0.021        CAMERON   77 DPWA  0 P-WAVE DECAY       1/78
R6    G  ASSUMES LAMBDA(1520) ELASTICITY=.46                                  1/78

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REFERENCES FOR SIGMA(1750)


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FERRO-LU 66 BERKELEY CONF 183 M FERRO LUZZI  (RAPPORTEUR)          (CERN)
CLINE    67 PL 25B 41         CLINE, OLSSON                        (WISC)IJP
MEYER    67 HEIDELBERG C 117  J MEYER  (RAPPORTEUR)                (SACL)IJP
ARMENTER 68 NP B8 183         ARMENTEROS, BAILLON, +    (CERN+HEID+SACL)IJP
ARMENTER 69 LUND CONF PAPER   ARMENTEROS, BAILLON, +    (CERN+HEID+SACL)IJP
ARMENTER 70 DUKE 123          ARMENTEROS, BAILLON, +         (CERN+HEID)IJP
HARRISON 70 FSU-HEP 70 3 1    W C HARRISON (THESIS)                (FSU)
CONFORTO 71 NP  B34  41       +LEVI SETTI,LASINSKI..OBERLACK++ (EFI+HEID)IJP
KIM      71 PRL 27 356        J K KIM                              (HARV)IJP
   ALSO  70 DUKE 161          J K KIM                              (HARV)IJP
LANGBEIN 72 NP B47 477        +WAGNER                              (MPIM)IJP

BAXTER   73 NP B67 125        BAXTER,BUCKINGHAM,CORBETT,DUNN,+      (OXF)IJP
CHU      74 NC 20A 35         CHU,BARTLEY,+  (SUNY PLATTSBURGH+TUFT+BRAN)IJP
JONES    74 NP B73 141        JONES                                (CHIC)IJP
DEVENISH 74 NP B81 330        DEVENISH,FROGGATT,MARTIN   (DESY+NORD+LOUC)
PREVOST  74 NP B69 246        PREVOST,BARLOUTAUD,+       (SACL+CERN+HEID)

BAILLON  75 NP B94 39         P BAILLON, P J LITCHFIELD      (CERN+RHEL)IJP
VANHORN  75 NP B87 145        A J VAN HORN                          (LBL)IJP
   ALSO  75 NP B87 157        A J VAN HORN                          (LBL)IJP

BELLEFON 76 NP B109 129       DE BELLEFON,BERTHON                  (CDEF)IJP
CARROLL  76 PRL 37 806        +CHIANG,KYCIA,LI,MAZUR,MICHAEL+       (BNL)I
CAMERON  77 NP B131 399       +FRANEK,GOPAL,KALMUS,MCPHERSON+ (RHEL+LOIC)IJP
MARTIN   77 NP B127 349       MARTIN,PIDCOCK,MOORHOUSE       (LOUC+GLAS)IJP
   ALSO  77 NP B126 266       MARTIN,PIDCOCK                       (LOUC)
   ALSO  77 NP B126 285       MARTIN,PIDCOCK                       (LOUC)IJP
RLIC     77 NP B119 362       GOPAL,ROSS,VAN HORN,MCPHERSON+  (LOIC+RHEL)IJP

ALSTON   78 PR D18 182        +KENNEY,POLLARD,ROSS+      (LBL+MTHO+CERN)IJP
   ALSO  77 PRL 38 1007       ALSTON-GARNJOST,KENNEY,+   (LBL+MTHO+CERN)IJP
GOPAL    80  TORONTO CONF 159 G P GOPAL                            (RHEL)IJP
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Σ(1770) P''_{11} Status: *

→ **100 SIGMA(1770, JP=1/2+) I=1 P''11**

EVIDENCE FOR THIS STATE NOW RESTS SOLELY ON SOLUTION 1 OF BAILLON 75 - BUT THE LAMBDA PI PARTIAL WAVE AMPLITUDES OF THIS SOLUTION ARE IN DISAGREEMENT WITH AMPLITUDES FROM MOST OTHER LAMBDA PI ANALYSES.

100 SIGMA(1770) MASS (MEV)

```
M   3      (1772.0)                   KANE      72 DPWA    K-P TO SIGMA PI  11/77
M   3   STATE IS NOT REQUIRED IN KANE 74 WHICH SUPERSEDES KANE 72.          12/81
M    1     1770.0     20.0            BAILLON   75 IPWA    KBAR N TO PI LAM 11/75
M    1  FROM SOLUTION 1 OF BAILLON 75, NOT PRESENT IN SOLUTION 2.            1/76
M   2      (1738.0)   (10.0)          RLIC      77 DPWA    KBAR N MULTICHNL  1/76
M   2   STATE REQUIRED TO FIT I=1 TOTAL X-SECTION OF CARROLL 76 IN KBAR N   12/81
M   2   CHANNEL. NEW K-P POLARIZATION AND K- NEUTRON DIFFERENTIAL X-SECTION 12/81
M   2   DATA MORE CONSISTENT WITH SIGMA(1660) P'11 IN GOPAL 80 ANALYSIS.    12/81
```

100 SIGMA(1770) WIDTH (MEV)

```
W   3      (80.0)                     KANE      72 DPWA    K-P TO SIGMA PI  11/77
W    1      80.0      30.0            BAILLON   75 IPWA    KBAR N TO PI LAM 11/75
W   2      (72.0)    (10.0)           RLIC      77 DPWA    KBAR N MULTICHNL  1/76
```

100 SIGMA(1770) PARTIAL DECAY MODES

```
                                                          DECAY MASSES
P1      SIGMA(1770) INTO N KBAR                         938+ 494
P2      SIGMA(1770) INTO LAMBDA PI                     1116+ 140
P3      SIGMA(1770) INTO SIGMA PI                      1189+ 140
```

100 SIGMA(1770) BRANCHING RATIOS

```
R1      SIGMA(1770) INTO (N KBAR)/TOTAL                    (P1)
R1  2       (0.14)   (0.04)           RLIC      77 DPWA    KBAR N MULTICHNL  1/76

R2      SIGMA(1770) FROM N KBAR TO LAMBDA PI              SQRT(P1*P2)
R2   1      -0.08      0.02           BAILLON   75 IPWA    KBAR N TO PI LAM 11/75
R2          LESS THAN 0.04            RLIC      77 DPWA    KBAR N MULTICHNL  1/76

R3      SIGMA(1770) FROM N KBAR TO SIGMA PI               SQRT(P1*P3)
R3  3      (-0.108)                   KANE      72 DPWA    K-P TO SIGMA PI  11/77
R3          LESS THAN 0.04            RLIC      77 DPWA    KBAR N MULTICHNL  1/76

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REFERENCES FOR SIGMA(1770)


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KANE     72 PR D5 1583        D F KANE                              (LBL)
BAILLON  75 NP B94 39         P BAILLON, P J LITCHFIELD      (CERN+RHEL)IJP
RLIC     77 NP B119 362       GOPAL,ROSS,VAN HORN,MCPHERSON+  (LOIC+RHEL)IJP
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PAPERS NOT REFERRED TO IN DATA CARDS


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KANE     74  LBL-2452           D F KANE                               (LBL)IJP
CARROLL  76 PRL 37 806          +CHIANG,KYCIA,LI,MAZUR,MICHAEL,+       (BNL)I
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Σ(1775) D_{15} Status: ****

45 SIGMA(1775, JP=5/2-) I=1 D15

FOR MOST RESULTS PUBLISHED BEFORE 1974 (THEY ARE NOW OBSOLETE), SEE OUR 1982 EDITION (PHYSICS LETTERS 111B). ALL THE REFERENCES HAVE BEEN RETAINED.

45 SIGMA(1775) MASS (MEV)

```
M           1772.0      (6.0)         KANE      74 DPWA    K-P TO PI SIG    12/81
M           1775.0      10.0          BAILLON   75 IPWA    KBAR N TO LAM PI 11/75
M           1774.0      10.0          VANHORN   75 DPWA  0 K- P TO LAM PI0  11/75
M          (1765.0)                   BELLEFON  76 IPWA  0 K- P TO LAM PI    2/77
M     A     1772. OR 1777.            MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
M     A  THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESONANCE
M     A  PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.
M           1774.0       5.0          RLIC      77 DPWA    KBAR N MULTICHNL  1/76
M           1777.0       5.0          ALSTON    78 DPWA    KBAR N ELASTIC    1/78
M           1778.0      (5.0)         GOPAL     80 DPWA    KBAR N ELASTIC   12/81
```

45 SIGMA(1775) WIDTH (MEV)

```
W            154.0     (10.0)         KANE      74 DPWA    K-P TO PI SIG    12/81
W            125.0      15.0          BAILLON   75 IPWA    KBAR N TO LAM PI 11/75
W            146.0      18.0          VANHORN   75 DPWA  0 K- P TO LAM PI0  11/75
W           (120.0)                   BELLEFON  76 IPWA  0 K- P TO LAM PI    2/77
W     A      102. OR 103.             MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
W            130.0      10.0          RLIC      77 DPWA    KBAR N MULTICHNL  1/76
W            116.0      10.0          ALSTON    78 DPWA    KBAR N ELASTIC    1/78
W            137.0     (10.0)         GOPAL     80 DPWA    KBAR N ELASTIC   12/81
W            . . . . . . . . . .
W    AVG     125.9       6.0      AVERAGE
```

45 SIGMA(1775) PARTIAL DECAY MODES

```
                                                          DECAY MASSES
P1      SIGMA(1775) INTO N KBAR                         938+ 494
P2      SIGMA(1775) INTO LAMBDA PI                     1116+ 135
P3      SIGMA(1775) INTO LAMBDA(1520) PI               1520+ 140
P4      SIGMA(1775) INTO SIGMA(1385) PI, D-WAVE        1385+ 140
P5      SIGMA(1775) INTO SIGMA PI                      1189+ 140
P6      SIGMA(1775) INTO SIGMA ETA                     1192+ 549
P7      SIGMA(1775) INTO SIGMA PI PI                   1192+ 140+ 140
```

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	.4520+-.0333					
P 2	-.1658	.1497+-.0139				
P 3	-.7170	.1184	.1869+-.0259			
P 4	-.5842	.0969	.4174	.0790+-.0099		
P 5	-.2374	.0394	.1695	.1387	.0374+-.0121	
P 6	-.1406	-.4778	-.3639	-.1568	-.3887	.0950+-.0270

45 SIGMA(1775) BRANCHING RATIOS

ERRORS QUOTED BY EXPERIMENTERS DO NOT INCLUDE UNCERTAINTY DUE TO PARAMETRIZATION USED IN THE P.W.A. THEY SHOULD BE INCREASED.

```
R1      SIGMA(1775) INTO (N KBAR)/TOTAL                    (P1)
R1   A       0.37 OR  0.36            MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
R1   B      (0.41)   (0.03)           RLIC      77 DPWA    KBAR N MULTICHNL  1/76
R1   B  (N KBAR)/TOTAL FROM RLIC 77 IS SUPERSEDED BY GOPAL 80.
R1           0.37      0.03           ALSTON    78 DPWA    KBAR N ELASTIC    1/78
R1           0.40     (0.02)          GOPAL     80 DPWA    KBAR N ELASTIC   12/81
R1          . . . . . . . . . .
R1  FIT      0.452     0.033   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.9)

R2      SIGMA(1775) FROM N KBAR TO LAMBDA PI              SQRT(P1*P2)
R2          -0.259     0.048          DEVENISH  74         0 FIXED T DISP REL  4/75
R2          -0.25      0.02           BAILLON   75 IPWA    KBAR N TO LAM PI 11/75
R2          -0.28      0.04     0.05  VANHORN   75 DPWA  0 K- P TO LAM PI0  11/75
R2         (-0.30)                    BELLEFON  76 IPWA  0 K- P TO LAM PI    2/77
R2   A      -0.29 OR -0.28            MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
R2          -0.28      0.03           RLIC      77 DPWA    KBAR N MULTICHNL  1/76
R2          . . . . . . . . . .
R2  AVG MOD  0.261     0.015   AVERAGE
R2  FIT      0.260     0.014   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R3      SIGMA(1775) FROM N KBAR TO LAMBDA(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   C      -0.305     0.010          CAMERON   77 DPWA  0 K-P TO L(1520)PI  1/78
R3   C  LISTED RATE COMBINES P- AND F-WAVE DECAYS AND ASSUMES LAMBDA(1520)   1/78
R3   C  ELASTICITY=.46. THE CAMERON 77 RESULTS FOR THE SEPARATE P- AND       1/78
R3   C  F-WAVE DECAYS ARE -0.303+/-.010 AND -0.037+/-.014, RESPECTIVELY.    12/79
R3   C  THE SIGNS ARE CHANGED HERE TO BE IN ACCORD WITH THE BARYON-FIRST    12/79
R3   C  CONVENTION.                                                         12/79
R3          . . . . . . . . . .
R3  AVG MOD  0.3031    0.0086  AVERAGE
R3  FIT      0.291     0.015   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.7)
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Baryons

$\Sigma(1775)$, $\Sigma(1840)$, $\Sigma(1880)$


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R4      SIGMA(1775) FROM N KBAR TO SIGMA(1385) PI, D-WAVESQRT(P1*P4)
R4            (0.24)    (0.03)           ARMENT-2  67 HBC   0 K-P TO LAM PI PI   8/67
R4   D        (0.32)    (0.06)           SIMS      68 DBC   -  K-N TO LAM PI PI 11/68
R4   D   SIMS 68 USES ONLY CROSS-SECT. DATA. RESULT USED AS UPPER LIMIT ONLY  3/72
R4            +0.20     0.02             PREVOST   74 DPWA 0- K-N TO S(1385)PI 10/74
R4    C       -0.184    0.011            CAMERON   78 DPWA  0 K-P TO S(1385)PI   1/78
R4    C  CAMERON  78 UPPER LIMIT ON G-WAVE DECAY IS 0.03.                        1/78
R4          . . . . . . . . . . .
R4   AVG MOD   0.1877   0.0096  AVERAGE
R4   FIT       0.1889   0.0096 FROM FIT

R5      SIGMA(1775) FROM N KBAR TO SIGMA PI                 SQRT(P1*P5)
R5             0.09     (0.01)           KANE      74 DPWA   K-P TO PI SIG     12/81
R5    A       +0.08 OR +0.08             MARTIN    77 DPWA   KBAR N MULTICHNL  11/77
R5            +0.13     0.02             RLIC      77 DPWA   KBAR N MULTICHNL   1/76
R5          . . . . . . . . . . .
R5   FIT       0.130    0.020  FROM FIT

R6      SIGMA(1775) INTO (LAMBDA PI)/(N KBAR)               (P2)/(P1)
R6             0.33     0.05             UHLIG     67 HBC   0 K-P,.9 GEV/C       9/66
R6          . . . . . . . . . . .
R6   FIT       0.331    0.042  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

R7      SIGMA(1775) INTO (LAMBDA(1520)PI)/(N KBAR)          (P3)/(P1)
R7             0.28     0.05             UHLIG     67 HBC   0 K-P,.9 GEV/C       9/66
R7          . . . . . . . . . . .
R7   FIT       0.413    0.082  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 2.5)

R8      SIGMA(1775) INTO (SIGMA(1385)PI)/(N KBAR)           (P4)/(P1)
R8             0.25     0.09             UHLIG     67 HBC   0 K-P,.9 GEV/C       9/66
R8          . . . . . . . . . . .
R8   FIT       0.175    0.031  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.4)

R9      SIGMA(1775) INTO (SIGMA PI PI)/TOTAL                (P7)
R9    E       (0.12)                     ARMENT-2  68 HDBC -0 K-N TO SIG PI PI 11/68
R9    E   FOR ABOUT 3/4 OF THIS, THE SIGMA PI SYSTEM HAS I=0 AND IS ALMOST
R9    E ENTIRELY LAMBDA(1520).  FOR THE REST, THE SIGMA PI HAS I=1.  THIS
R9    E IS ABOUT WHAT IS EXPECTED FROM THE KNOWN RATE SIGMA(1775) TO
R9    E SIGMA(1385) PI, AS SEEN IN LAMBDA PI PI.

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REFERENCES FOR SIGMA(1775)


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GALTIERI 63 PL 6 296          A BARBARO-GALTIERI,A HUSSAIN,R D TRIPP(LRL)IJ
ARMENTER 65 PL 19 338         ARMENTEROS, +                  (CERN+HEID+SACL)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
FENSTER  66 PRL 17 841        +GELFAND,HARMSEN,L-SETTI,+  (CHIC+ANL+CERN)IJP
      -- FENSTER 66 IS SUPERSEDED BY BARLETTA 72
ARMENTER 67 PL 24B 198        ARMENTEROS,FERRO-LUZZI+        (CERN+HEID+SACL)IJP
ARMENT-2 67 ZEIT.PHYS.202 486 ARMENTEROS,FERRO-LUZZI+        (CERN+HEID+SACL)
UHLIG    67 PR 155 1448       +CHARLTON,CONDON,GLASSER,YODH,+   (UMD+NRL)

ARMENT-1 68 NP B8 195         ARMENTEROS, BAILLON, +         (CERN+HEID+SACL)IJP
ARMENT-2 68 NP B8 216         ARMENTEROS, BAILLON, +         (CERN+HEID+SACL) I
BUGG     68 PR 168 1466       +GILMORE,KNIGHT,DAVIES+        (BIRM+CAVE+RHEL)I
CONFORTO 68 NP B8 265         +HARMSEN, LASINSKI, +               (CHIC+HEID)IJP
    SUPERSEDED BY CONFORTO 71.
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
HARRISON 70 FSU-HEP 70 3 1    W C HARRISON (THESIS)                  (FSU)

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
PREVOST  71  AMSTERDAM CONF   + CHS COLLABORATION            (CERN+HEID+SACL)

BARLETTA 72 NP B40 45         W A BARLETTA                           (EFI) IJP
KANE     72 PR D5 1583        D F KANE                               (LBL)IJP
LANGBEIN 72 NP B47 477        +WAGNER                               (MPIM)IJP
DEVENISH 74 NP B81 330        DEVENISH,FROGGATT,MARTIN   (DESY+NORD+LOUC)
KANE     74  LBL-2452         D F KANE                               (LBL)IJP
PREVOST  74 NP B69 246        PREVOST,BARLOUTAUD,+          (SACL+CERN+HEID)

BAILLON  75 NP B94 39         P BAILLON, P J LITCHFIELD        (CERN+RHEL)IJP
VANHORN  75 NP B87 145        A J VAN HORN                           (LBL)IJP
   ALSO 75 NP B87 157         A J VAN HORN                           (LBL)IJP

BELLEFON 76 NP B109 129       DE BELLEFON,BERTHON                   (CDEF)IJP
CAMERON  77 NP B131 399       +FRANEK,GOPAL,KALMUS,MCPHERSON+ (RHEL+LOIC)IJP
MARTIN   77 NP B127 349       MARTIN,PIDCOCK,MOORHOUSE         (LOUC+GLAS)IJP
   ALSO 77 NP B126 266        MARTIN,PIDCOCK                        (LOUC)
   ALSO 77 NP B126 285        MARTIN,PIDCOCK                        (LOUC)IJP
RLIC     77 NP B119 362       GOPAL,ROSS,VAN HORN,MCPHERSON+  (LOIC+RHEL)IJP

ALSTON   78 PR D18 182        +KENNEY,POLLARD,ROSS+        (LBL+MTHO+CERN)IJP
   ALSO 77 PRL 38 1007        ALSTON-GARNJOST,KENNEY,+     (LBL+MTHO+CERN)IJP
CAMERON  78 NP B143 189       +FRANEK,GOPAL,BACON,BUTTERWORTH+(RHEL+LOIC)IJP
GOPAL    80  TORONTO CONF 159 G P GOPAL                             (RHEL)IJP
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$\Sigma(1840)$ P''_{13} Status: *

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→    01  SIGMA(1840, JP=3/2+) I=1        P''13

         FOR THE TIME BEING, WE LIST ALL RESONANCE CLAIMS IN THE
         P13 WAVE IN THE 1700-1900 MEV MASS REGION TOGETHER
         UNDER THIS HEADING.

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                01  SIGMA(1840) MASS (MEV)

M           1840.0    (10.0)           LANGBEIN  72 IPWA   MULTICHANNEL      12/72
M    1     (1720.0)   (30.0)           BAILLON   75 IPWA   KBAR N TO LAM PI  11/75
M    1   FROM SOLUTION 1 OF BAILLON 75, NOT PRESENT IN SOLUTION 2.            1/76
M           1925.0   (200.0)           VANHORN   75 DPWA  0 K- P TO LAM PIO  11/75
M     2     1798. OR 1802.             MARTIN    77 DPWA   KBAR N MULTICHNL  11/77
M     2  THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESONANCE
M     2  PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.

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                01  SIGMA(1840) WIDTH (MEV)

W           120.0     (10.0)           LANGBEIN  72 IPWA   MULTICHANNEL      12/72
W    1     (120.0)    (30.0)           BAILLON   75 IPWA   KBAR N TO LAM PI  11/75
W           65.0      (50.0)   (20.0)  VANHORN   75 DPWA 0 K- P TO LAM PIO   11/75
W     2     93. OR 93.                 MARTIN    77 DPWA   KBAR N MULTICHNL  11/77

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                01  SIGMA(1840) PARTIAL DECAY MODES

                                                         DECAY MASSES
P1      SIGMA(1840) INTO N KBAR                         938+ 494
P2      SIGMA(1840) INTO SIGMA PI                      1189+ 140
P3      SIGMA(1840) INTO LAMBDA PI                     1116+ 135

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                01  SIGMA(1840) BRANCHING RATIOS

R1      SIGMA(1840) INTO (N KBAR)/TOTAL                      (P1)
R1             0.37     (0.13)         LANGBEIN  72 IPWA   MULTICHANNEL      12/72
R1    2        0.0 OR 0.0              MARTIN    77 DPWA   KBAR N MULTICHNL  11/77

R2      SIGMA(1840) FROM N KBAR TO SIGMA PI                  SQRT(P1*P2)
R2             0.15     (0.04)         LANGBEIN  72 IPWA   MULTICHANNEL      12/72
R2    2       -0.04 OR -0.04           MARTIN    77 DPWA   KBAR N MULTICHNL  11/77

R3      SIGMA(1840) FROM N KBAR TO LAMBDA PI                 SQRT(P1*P3)
R3             0.20     (0.04)         LANGBEIN  72 IPWA   MULTICHANNEL      12/72
R3            +0.122     0.078         DEVENISH  74       0 FIXED T DISP REL  4/75
R3   1       (+0.11)    (0.02)         BAILLON   75 IPWA   KBAR N TO LAM PI  11/75
R3            +0.06     (0.04)         VANHORN   75 DPWA 0 K- P TO LAM PIO   11/75
R3    2       +0.03 OR +0.03           MARTIN    77 DPWA   KBAR N MULTICHNL  11/77
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REFERENCES FOR SIGMA(1840)


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LANGBEIN 72 NP B47 477        +WAGNER                               (MPIM)IJP
DEVENISH 74 NP B81 330        DEVENISH,FROGGATT,MARTIN   (DESY+NORD+LOUC)
BAILLON  75 NP B94 39         P BAILLON, P J LITCHFIELD        (CERN+RHEL)IJP
VANHORN  75 NP B87 145        A J VAN HORN                           (LBL)IJP
   ALSO 75 NP B87 157         A J VAN HORN                           (LBL)IJP

MARTIN   77 NP B127 349       MARTIN,PIDCOCK,MOORHOUSE         (LOUC+GLAS)IJP
   ALSO 77 NP B126 266        MARTIN,PIDCOCK                        (LOUC)
   ALSO 77 NP B126 285        MARTIN,PIDCOCK                        (LOUC)IJP
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$\Sigma(1880)$ P'''_{11} Status: **

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→    67  SIGMA(1880, JP=1/2+) I=1        P'''11

         A RESONANCE IS SUGGESTED BY SEVERAL PARTIAL-WAVE
         ANALYSES ACROSS THIS REGION, BUT WITH WIDE VARIATIONS
         IN THE MASS AND OTHER PARAMETERS.  WE LIST HERE
         ALL CLAIMS WHICH LIE WELL ABOVE THE SIGMA(1770).

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                67  SIGMA(1880) MASS (MEV)

M           1882.0     40.0            SMART     68 DPWA -0 K- N TO LAM PI    7/68
M          (1850.0)                    BAILEY    69 DPWA  0 ELASTIC, CH EXCH 10/70
M           ABOUT 1850.0               ARMENTERO 70 IPWA -0 ELASTIC, CH EXCH  6/70
M           1950.0     50.0            GALTIERI  70 DPWA -0 K- N TO LAM PI    7/70
M           1920.0     30.0            LITCHFIEL 70 DPWA -0 K- N TO LAM PI    6/70
M     2    (1898.0)                    LEA       73 DPWA   MULTICHNL K-MTRX   9/73
M     2  ONLY UNCONSTRAINED STATES FROM TABLE 1 OF LEA73 ARE IN LISTINGS.     9/73
M    1     (1960.0)   (30.0)           BAILLON   75 IPWA   KBAR N TO LAM PI  11/75
M    1   FROM SOLUTION 1 OF BAILLON 75, NOT PRESENT IN SOLUTION 2.            1/76
M           1985.0     50.0            VANHORN   75 DPWA  0 K- P TO LAM PIO  11/75
M     3     1847. OR 1863.             MARTIN    77 DPWA   KBAR N MULTICHNL  11/77
M     3  THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESONANCE
M     3  PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.
M           1870.0     10.0            CAMERON2  78 DPWA   K-P TO K*(892) N 12/79
M           1826.0    (20.0)           GOPAL     80 DPWA   KBAR N ELASTIC    12/81

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                67  SIGMA(1880) WIDTH (MEV)

W           222.0     150.0            SMART     68 DPWA -0 K- N TO LAM PI    7/68
W          (200.0)                     BAILEY    69 DPWA  0 ELASTIC, CH EXCH 10/70
W          ABOUT 30.0                  ARMENTERO 70 IPWA -0 ELASTIC, CH EXCH  6/70
W           200.0      50.0            GALTIERI  70 DPWA -0 K- N TO LAM PI    7/70
W           170.0      40.0            LITCHFIEL 70 DPWA -0 K- N TO LAM PI    6/70
W     2    (222.2)                     LEA       73 DPWA   MULTICHNL K-MTRX   9/73
W    1     (260.0)    (40.0)           BAILLON   75 IPWA   KBAR N TO LAM PI  11/75
W           220.0     140.0            VANHORN   75 DPWA  0 K- P TO LAM PIO  11/75
W     3     216. OR 220.               MARTIN    77 DPWA   KBAR N MULTICHNL  11/77
W            80.0      10.0            CAMERON2  78 DPWA   K-P TO K*(892) N 12/79
W            86.0     (15.0)           GOPAL     80 DPWA   KBAR N ELASTIC    12/81

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                67  SIGMA(1880) PARTIAL DECAY MODES

                                                         DECAY MASSES
P1      SIGMA(1880) INTO N KBAR                         938+ 494
P2      SIGMA(1880) INTO LAMBDA PI                     1116+ 135
P3      SIGMA(1880) INTO SIGMA PI                      1197+ 140
P4      SIGMA(1880) INTO N K*(892), P1 WAVE             940+ 892
P5      SIGMA(1880) INTO N K*(892), P3 WAVE             940+ 892

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                67  SIGMA(1880) BRANCHING RATIOS

R1      SIGMA(1880) INTO (N KBAR)/TOTAL                      (P1)
R1            (0.22)                   BAILEY    69 DPWA  0 ELASTIC, CH EXCH 10/70
R1            (0.20)                   ARMENTERO 70 IPWA -0 ELASTIC, CH EXCH  6/70
R1    2       (0.31)                   LEA       73 DPWA   MULTICHNL K-MTRX   9/73
R1    3        0.27 OR  0.27           MARTIN    77 DPWA   KBAR N MULTICHNL  11/77
R1             0.06     (0.02)         GOPAL     80 DPWA   KBAR N ELASTIC    12/81
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For notation, see key at front of Listings.


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R2      SIGMA(1880) FROM N KBAR TO LAMBDA PI                 SQRT(P1*P2)
R2             -0.11      0.03               SMART      68 DPWA -0 K- N TO LAM PI     7/68
R2             -0.09      0.04               GALTIERI   70 DPWA -0 K- N TO LAM PI     7/70
R2             -0.14      0.03               LITCHFIEL  70 DPWA -0 K- N TO LAM PI     6/70
R2    2       (-0.30)                        LEA        73 DPWA    MULTICHNL K-MTRX   9/73
R2             -0.169     0.119              DEVENISH   74       0 FIXED T DISP REL   4/75
R2   1        (-0.12)    (0.02)              BAILLON    75 IPWA    KBAR N TO LAM PI  11/75
R2             +0.05      0.07      0.02     VANHORN    75 DPWA  0 K- P TO LAM PI0   11/75
R2    3        -0.24 OR -0.24                MARTIN     77 DPWA    KBAR N MULTICHNL  11/77

R3      SIGMA(1880) FROM N KBAR TO SIGMA PI                  SQRT(P1*P3)
R3    2       NOT SEEN                       LEA        73 DPWA    MULTICHNL K-MTRX   9/73
R3    3        +0.30 OR +0.29                MARTIN     77 DPWA    KBAR N MULTICHNL  11/77

R4      SIGMA(1880) FROM N KBAR TO N K*(892), P1 WAVE    SQRT(P1*P4)
R4    4        -0.05      0.03               CAMERON2   78 DPWA    K-P TO K*N        12/79
R4    4  THE SIGN HERE IS CHANGED TO BE IN ACCORD WITH THE BARYON-FIRST             12/79
R4    4  CONVENTION.                                                                12/79

R5      SIGMA(1880) FROM N KBAR TO N K*(892), P3 WAVE    SQRT(P1*P5)
R5             +0.11      0.03               CAMERON2   78 DPWA    K-P TO K*N        12/79

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REFERENCES FOR SIGMA(1880)


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SMART    68 PR 169 1330        W M SMART                                (LRL)IJP
BAILEY   69 THESIS UCRL-50617 DAVID SAAL BAILEY                         (LLL)IJP
ARMENTER 70 DUKE CONF 123      ARMENTEROS, BAILLON, +             (CERN+HEID)IJP
GALTIERI 70 DUKE CONF 173      A BARBARO-GALTIERI                       (LRL)IJP
LITCHFIE 70 NP B22 269         P J LITCHFIELD                          (RHEL)IJP

LEA      73 NP B56 77          +MARTIN,MOORHOUSE+    (RHEL+LOUC+GLAS+AARH)IJP
DEVENISH 74 NP B81 330         DEVENISH,FROGGATT,MARTIN   (DESY+NORD+LOUC)
BAILLON  75 NP B94 39          P BAILLON, P J LITCHFIELD          (CERN+RHEL)IJP
VANHORN  75 NP B87 145         A J VAN HORN                             (LBL)IJP
    ALSO 75 NP B87 157         A J VAN HORN                             (LBL)IJP

MARTIN   77 NP B127 349        MARTIN,PIDCOCK,MOORHOUSE           (LOUC+GLAS)IJP
    ALSO 77 NP B126 266        MARTIN,PIDCOCK                          (LOUC)
    ALSO 77 NP B126 285        MARTIN,PIDCOCK                          (LOUC)IJP
CAMERON2 78 NP B146 327        +FRANEK,GOPAL,KALMUS,MCPHERSON,+(RHEL+LOIC)IJP
GOPAL    80  TORONTO CONF 159 G P GOPAL                                (RHEL)IJP
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Σ(1915) F'_{15} Status: ****

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                 46  SIGMA(1915, JP=5/2+) I=1        F'15

                 FOR RESULTS PUBLISHED BEFORE 1974 (THEY ARE
                 NOW OBSOLETE), SEE OUR 1982 EDITION (PHYSICS LETTERS
                 111B).  ALL THE REFERENCES HAVE BEEN RETAINED.

                 THIS RESONANCE WAS FIRST SEEN IN THE TOTAL-CROSS-SEC-
                 TION MEASUREMENTS OF COOL 66.  IN THIS ENTRY, HOWEVER,
                 WE LIST ONLY THE RESULTS FROM PARTIAL-WAVE ANALYSES.
  SEE THE NEXT ENTRY FOR THE PARAMETERS OF PEAKS SEEN AROUND 1900-1950
  MEV IN CROSS SECTIONS AND INVARIANT-MASS DISTRIBUTIONS.  WE MAKE THIS
  SEPARATION BECAUSE ONLY THE PARTIAL-WAVE ANALYSES ISOLATE THE F15 WAVE.
  SEE ALSO THE NOTE TO THE NEXT ENTRY.

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                 46  SIGMA(1915) MASS (MEV)

M           1920.0     (5.0)                 KANE       74 DPWA    K-P TO PI SIG     12/81
M           1920.0     30.0                  BAILLON    75 IPWA    KBAR N TO LAM PI  11/75
M           1914.0     10.0                  HEMINGWA   75 DPWA  0 K- P TO KBAR N    11/75
M           1920.0     15.0       20.0       VANHORN    75 DPWA  0 K- P TO LAM PI0   11/75
M          (1915.0)                          BELLEFON   76 IPWA  0 K- P TO LAM PI     2/77
M     A     1900.0      4.0                  CORDEN     76 DPWA  - K- N TO PI- LAM    2/77
M     A  PREFERRED SOLUTION 3, SEE CORDEN 76 FOR OTHER POSSIBLILITES.                  2/77
M     A  CORDEN 76 INCLUDES THE DATA OF COX 70 AS A SUBSAMPLE
M     B     1894.0      5.0                  CORDEN1    77       - K- N TO PI SIG    11/77
M     B     1909.0      5.0                  CORDEN1    77       - K- N TO PI SIG    11/77
M     B  THE 2 ENTRIES FOR CORDEN177 ARE FROM 2 DIFFERENT ACCEPTABLE SLTNS.          11/77
M        NOT SEEN                            DECLAIS    77 DPWA    KBAR N TO KBAR N   1/78
M     C     1925. OR 1933.                   MARTIN     77 DPWA    KBAR N MULTICHNL  11/77
M     C  THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESONANCE
M     C  PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.
M           1920.0     10.0                  RLIC       77 DPWA    KBAR N MULTICHNL   1/76
M           1937.0     20.0                  ALSTON     78 DPWA    KBAR N ELASTIC     1/78

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                 46  SIGMA(1915) WIDTH (MEV)

W            162.0    (25.0)                 KANE       74 DPWA    K-P TO PI SIG     12/81
W             70.0     20.0                  BAILLON    75 IPWA    KBAR N TO LAM PI  11/75
W             85.0     15.0                  HEMINGWA   75 DPWA  0 K- P TO KBAR N    11/75
W            102.0     18.0                  VANHORN    75 DPWA  0 K- P TO LAM PI0   11/75
W            (60.0)                          BELLEFON   76 IPWA  0 K- P TO LAM PI     2/77
W     A       75.0     14.0                  CORDEN     76 DPWA  - K- N TO PI- LAM    2/77
W     B      107.0     14.0                  CORDEN1    77       - K- N TO PI SIG    11/77
W     B       85.0     13.0                  CORDEN1    77       - K- N TO PI SIG    11/77
W     C      171. OR 173.                    MARTIN     77 DPWA    KBAR N MULTICHNL  11/77
W            130.0     10.0                  RLIC       77 DPWA    KBAR N MULTICHNL   1/76
W            161.0     20.0                  ALSTON     78 DPWA    KBAR N ELASTIC     1/78

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                 46  SIGMA(1915) PARTIAL DECAY MODES

                                                             DECAY MASSES
P1      SIGMA(1915) INTO N KBAR                             938+ 494
P2      SIGMA(1915) INTO LAMBDA PI                         1116+ 140
P3      SIGMA(1915) INTO SIGMA PI                          1189+ 140
P4      SIGMA(1915) INTO SIGMA(1385) PI, P-WAVE            1385+ 140
P5      SIGMA(1915) INTO SIGMA(1385) PI, F-WAVE            1385+ 140

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                 46  SIGMA(1915) BRANCHING RATIOS

R1      SIGMA(1915) INTO (N KBAR)/TOTAL                     (P1)
R1             0.11     (0.04)               HEMINGWA   75 DPWA  0 K- P TO KBAR N    11/75
R1    C        0.08 OR  0.08                 MARTIN     77 DPWA    KBAR N MULTICHNL  11/77
R1    D       (0.05)    (0.03)               RLIC       77 DPWA    KBAR N MULTICHNL   1/76
R1    D  (N KBAR)/TOTAL FROM RLIC 77 IS SUPERSEDED BY GOPAL 80.
R1             0.14     (0.05)               ALSTON     78 DPWA    KBAR N ELASTIC     1/78
R1    E        0.03     (0.02)               GOPAL      80 DPWA    KBAR N ELASTIC    12/81
R1    E  MASS AND WIDTH FIXED TO RLIC 77 VALUES DUE TO LOW ELASTICITY.              12/81
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R2      SIGMA(1915) FROM N KBAR TO LAMBDA PI                 SQRT(P1*P2)
R2            -0.087    (0.056)              DEVENISH   74       0 FIXED T DISP REL   4/75
R2            -0.06     (0.02)               BAILLON    75 IPWA    KBAR N TO LAM PI  11/75
R2            -0.09     (0.02)               VANHORN    75 DPWA  0 K- P TO LAM PI0   11/75
R2           (-0.10)                         BELLEFON   76 IPWA  0 K- P TO LAM PI     2/77
R2    A       -0.10      0.01                CORDEN     76 DPWA  - K- N TO PI- LAM    2/77
R2    C       -0.09 OR -0.09                 MARTIN     77 DPWA    KBAR N MULTICHNL  11/77
R2            -0.09     (0.03)               RLIC       77 DPWA    KBAR N MULTICHNL   1/76

R3      SIGMA(1915) FROM N KBAR TO SIGMA PI                  SQRT(P1*P3)
R3            -0.16     (0.03)               KANE       74 DPWA    K-P TO PI SIG     12/81
R3    B       -0.17      0.01                CORDEN1    77       - K- N TO PI SIG    11/77
R3    B       -0.15      0.02                CORDEN1    77       - K- N TO PI SIG    11/77
R3    C       -0.05 OR -0.05                 MARTIN     77 DPWA    KBAR N MULTICHNL  11/77
R3            -0.19     (0.03)               RLIC       77 DPWA    KBAR N MULTICHNL   1/76
R3                 . . . . . . . . .
R3   AVG MOD   0.1660    0.0089   AVERAGE

R4      SIGMA(1915) FROM N KBAR TO SIGMA(1385) PI, P-WAVESQRT(P1*P4)
R4           LESS THAN 0.01                  CAMERON    78 DPWA  0 K-P TO S(1385)PI   1/78

R5      SIGMA(1915) FROM N KBAR TO SIGMA(1385) PI, F-WAVESQRT(P1*P5)
R5    F       +0.039     0.009               CAMERON    78 DPWA  0 K-P TO S(1385)PI   1/78
R5    F  THE SIGN IS CHANGED TO BE IN ACCORD WITH THE BARYON-FIRST                  12/79
R5    F  CONVENTION.                                                                12/79

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REFERENCES FOR SIGMA(1915)


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SMART    66 PRL 17 556         W M SMART,A KERNAN,G E KALMUS,R P ELY (LRL)IJP
ARMENTER 67 PL 24B 198         ARMENTEROS,FERRO-LUZZI+     (CERN+HEID+SACL)
ARMENTE1 67 NP B3 592          ARMENTEROS,FERRO-LUZZI+     (CERN+HEID+SACL)
CONFORTO 68 NP B8 265          +HARMSEN, LASINSKI, +            (CHIC+HEID)
SMART    68 PR 169 1330        W M SMART                                (LRL)IJP

BERTHON  70 NP B20 476         +RANGAN, VRANA,           + (CDEF+RHEL+SACL)IJP
BERTHON1 70 NP B24 417         +VRANA, BUTTERWORTH, +      (CDEF+RHEL+SACL)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                          (RHEL)IJP

CONFORTO 71 NP  B34  41        +LEVI SETTI,LASINSKI..OBERLACK++ (EFI+HEID)IJP
LITCHFIE 71 NP  B30 125        LITCHFIELD,...+LESQUOY,+.. (RHEL+CDEF+SACL)IJP
KANE     72 PR D5 1583         D F KANE                                 (LBL)IJP
DEVENISH 74 NP B81 330         DEVENISH,FROGGATT,MARTIN   (DESY+NORD+LOUC)
KANE     74  LBL-2452          D F KANE                                 (LBL)IJP

BAILLON  75 NP B94 39          P BAILLON, P J LITCHFIELD          (CERN+RHEL)IJP
HEMINGWA 75 NP B91 12          HEMINGWAY,EADES,HARMSEN+      (CERN+HEID+MPIM)IJP
VANHORN  75 NP B87 145         A J VAN HORN                             (LBL)IJP
    ALSO 75 NP B87 157         A J VAN HORN                             (LBL)IJP

BELLEFON 76 NP B109 129        DE BELLEFON,BERTHON                     (CDEF)IJP
CORDEN   76 NP B104 382        +COX,DARTNELL,KENYON,ONEALE,SUMOROK+ (BIRM)IJP

CORDEN1  77 NP B125 61         +COX,KENYON,ONEALE,STUBBS,SUMOROK+    (BIRM)IJP
DECLAIS  77  CERN 77-16        +DUCHON,LOUVEL,PATRY,SEGUINOT+  (CAEN+CERN)IJP
MARTIN   77 NP B127 349        MARTIN,PIDCOCK,MOORHOUSE           (LOUC+GLAS)IJP
    ALSO 77 NP B126 266        MARTIN,PIDCOCK                          (LOUC)
    ALSO 77 NP B126 285        MARTIN,PIDCOCK                          (LOUC)IJP
RLIC     77 NP B119 362        GOPAL,ROSS,VAN HORN,MCPHERSON+  (LOIC+RHEL)IJP
ALSTON   78 PR D18 182         +KENNEY,POLLARD,ROSS+        (LBL+MTHO+CERN)IJP
    ALSO 77 PRL 38 1007        ALSTON-GARNJOST,KENNEY,+     (LBL+MTHO+CERN)IJP
CAMERON  78 NP B143 189        +FRANEK,GOPAL,BACON,BUTTERWORTH+(RHEL+LOIC)IJP
GOPAL    80  TORONTO CONF 159 G P GOPAL                                (RHEL)IJP
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1915 MEV REGION – PRODUCTION AND σ_{TOTAL} EXP'TS

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                 29  SIGMA(1915, JP=    ) I=1     PRODUCTION EXPERIMENTS

                 SEE THE NOTES TO THE SIGMA(1915) AND SIGMA(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 SIGMA(1915) SEEN IN PARTIAL-WAVE
  ANALYSES.  THE INVARIANT-MASS PEAKS SEEM MORE LIKELY TO BE ASSOCIATED
  WITH THE D13 SIGMA(1940).

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                 29  SIGMA(1915) MASS (MEV) (PROD. EXP.)

M          CROSS-SECTION PEAKS --
M           1905.0      5.0                  BUGG       68 CNTR    K-P, D TOTAL      11/66
M           1906.0      6.0                  BRICMAN    70 CNTR  0 TOTAL AND CH EX    6/70
M           1912.0     10.0                  COOL       70 CNTR    K-P, D TOTAL      10/70
M          INVARIANT-MASS-DISTRIBUTION PEAKS --
M          (1942.0)    (9.0)                 BOCK       65 HBC     PBAR P 5.7 GEV/C
M           1940.0     11.0                  AGUILAR    70 HBC   + 3.9-4.6 GEV/C K-   5/70
M         42 1979.0    14.0                  BRIEFEL    77 HBC   + XI K MODE 2.9K-P   1/78
M     B  200(1910.0)  (17.0)                 FERRER     81 OMEG  - PI-P 9,12 GEV/C    2/82
M     B   BACKWARD PRODUCTION IN LAMBDA PI- K+ FINAL STATE.
M          ELASTIC DCS --                                                          2/73
M     1     1931.0   9.0                     DADO       72 HBC   0 K-P ELSTC DCS      2/73
M     1   G7 INDICATED BY LEGENDRE COEFFS.,G9 NOT RULED OUT.                        2/73

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                 29  SIGMA(1915) WIDTH (MEV) (PROD. EXP.)

W          CROSS-SECTION PEAKS --
W             60.0     10.0                  BUGG       68 CNTR                      11/66
W             50.0     12.0                  BRICMAN    70 CNTR  0 TOTAL AND CH EX    6/70
W            (30.0)                          COOL       70 CNTR    K-P, D TOTAL      10/70
W          INVARIANT-MASS-DISTRIBUTION PEAKS --
W            (36.0)   (20.0)   (36.0)        BOCK       65 HBC
W             90.0     20.0                  AGUILAR    70 HBC   + 3.9-4.6 GEV/C K-   5/70
W         42  69.0     32.0                  BRIEFEL    77 HBC   + XI K MODE 2.9K-P   1/78
W     B  200 (87.0)   (25.0)                 FERRER     81 OMEG  - PI-P 9,12 GEV/C    2/82
W          ELASTIC DCS --                                                          2/73
W     1       70.0     14.0                  DADO       72 HBC   0 K-P ELSTC DCS      2/73

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Baryons

Data Card Listings

Σ(1915), Σ(1940), Σ(2000)

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                29  SIGMA(1915) PARTIAL DECAY MODES (PROD. EXP.)

                                                               DECAY MASSES
P1      SIGMA(1915) INTO N KBAR                               938+ 494
P2      SIGMA(1915) INTO LAMBDA PI                           1116+ 135
P3      SIGMA(1915) INTO SIGMA PI                            1189+ 140
P4      SIGMA(1915) INTO XI K                                1315+ 494

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                29  SIGMA(1915) BRANCHING RATIOS (PROD. EXP.)

R1      SIGMA(1915) INTO (N KBAR)/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        0.62     0.08          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      SIGMA(1915) INTO (N KBAR)/(SIGMA PI)                 (P1)/(P3)
R2           (0.37) OR LESS           BARNES    69 HBC    +  1 STAN. DEV.    10/69

R3      SIGMA(1915) INTO (LAMBDA PI)/(SIGMA PI)              (P2)/(P3)
R3           (0.28) OR LESS           BARNES    69 HBC    +  1 STAN. DEV.    10/69

R4      SIGMA(1915) INTO (XI K)/TOTAL                        (P4)
R4       42   SEEN                    BRIEFEL   77 HBC    +  K-P 2.87 GEV     1/78

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                      REFERENCES FOR SIGMA(1915) (PROD. EXP.)
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BOCK      65 PL 17 166           +COOPER,FRENCH,KINSON, +         (CERN+SACL) 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
PRIMER    68 PRL 20 610          +GOLDBERG,JAEGER,BARNES,DORNAN + (SYRA+BNL)
    SUPERSEDED BY BARNES 69 AND AGUILAR-BENITEZ 70.
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+SACL)
COOL      70 PR D1 1887          +GIACOMELLI, KYCIA, LEONTIC, LI, +    (BNL) I
DADO      72 PRL 29 1695         +BIRMAN,GOLDBERG,WEISS                (HAIF)JP
BRIEFEL   77 PRD 16 2706         +GOUREVITCH,CHANG+      (BRAN+UMD+SYRA+TUFT)
FERRER    81 NP B178 373         +TREILLE,RIVET,VOLTE+ (CERN+CDEF+EPOL+LALO)
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Σ(1940) D'''13   Status: ***

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                98  SIGMA(1940, JP=3/2-) I=1          D'''13

                FOR RESULTS PUBLISHED BEFORE 1974 (THEY ARE
                NOW OBSOLETE), SEE OUR 1982 EDITION (PHYSICS LETTERS
                111B).  ALL THE REFERENCES HAVE BEEN RETAINED.

                SOME, NOT ALL, PARTIAL WAVE ANALYSES SUGGEST A STATE IN
                THIS REGION.  IT IS PERHAPS ASSOCIATED WITH THE BUMPS
                SEEN IN PRODUCTION EXPERIMENTS NEAR THIS MASS (SEE THE
                PRECEDING ENTRY).  THIS STATE IS NOT REQUIRED IN
                K- NEUTRON TO (PI SIGMA)- ANALYSIS OF GOYAL 77.  KBAR N
                ANALYSIS (GOPAL 80) WITH K- NEUTRON ELASTIC DATA
                DOES NOT REQUIRE THIS STATE.

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                98  SIGMA(1940) MASS (MEV)

M            1935.0     (80.0)              KANE      74 DPWA     K-P TO PI SIG     12/81
M            1940.0      20.0               LITCHFI2  74 DPWA   0 K-P TO L(1520)PI  10/74
M            1950.0      20.0               LITCHFI3  74 DPWA   0 K-P TO KBAR DEL   10/74
M            1950.0      30.0               BAILLON   75 IPWA     KBAR N TO LAM PI  11/75
M            1949.0      40.0       60.0    VANHORN   75 DPWA   0 K- P TO LAM PI0   11/75
M    A      (1940.0)                        BELLEFON  76 IPWA   0 K- P TO LAM PI     2/77
M    A   SLIGHT BUMP IN MODULUS OF F7 WAVE.                                          2/77
M     B      1886. OR 1893.                 MARTIN    77 DPWA     KBAR N MULTICHNL  11/77
M     B  THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESONANCE
M     B  PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.
M            1920.0      50.0               RLIC      77 DPWA     KBAR N MULTICHNL   1/76

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                98  SIGMA(1940) WIDTH (MEV)

W             330.0     (80.0)              KANE      74 DPWA     K-P TO PI SIG     12/81
W              60.0      20.0               LITCHFI2  74 DPWA   0 K-P TO L(1520)PI  10/74
W              70.0      30.0       20.0    LITCHFI3  74 DPWA   0 K-P TO KBAR DEL   10/74
W             150.0      75.0               BAILLON   75 IPWA     KBAR N TO LAM PI  11/75
W             160.0      70.0       40.0    VANHORN   75 DPWA   0 K- P TO LAM PI0   11/75
W     B       157. OR 159.                  MARTIN    77 DPWA     KBAR N MULTICHNL  11/77
W             300.0      80.0               RLIC      77 DPWA     KBAR N MULTICHNL   1/76
W             170.0      25.0               CAMERON2  78 DPWA     K-P TO K*(892) N  12/79

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                98  SIGMA(1940) PARTIAL DECAY MODES

                                                               DECAY MASSES
P1      SIGMA(1940) INTO N KBAR                               938+ 494
P2      SIGMA(1940) INTO LAMBDA PI                           1116+ 140
P3      SIGMA(1940) INTO SIGMA PI                            1189+ 140
P4      SIGMA(1940) INTO LAMBDA(1520) PI, P-WAVE             1520+ 135
P5      SIGMA(1940) INTO LAMBDA(1520) PI, F-WAVE             1520+ 135
P6      SIGMA(1940) INTO DELTA(1232) KBAR, S-WAVE            1232+ 494
P7      SIGMA(1940) INTO DELTA(1232) KBAR, D-WAVE            1232+ 494
P8      SIGMA(1940) INTO SIGMA(1385) PI, S-WAVE              1385+ 140
P9      SIGMA(1940) INTO N K*(892), S3 WAVE                   940+ 892

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                98  SIGMA(1940) BRANCHING RATIOS

R1      SIGMA(1940) INTO (N KBAR)/TOTAL                      (P1)
R1    B        0.14 OR  0.13          MARTIN    77 DPWA     KBAR N MULTICHNL 11/77
R1           LESS THAN 0.04           RLIC      77 DPWA     KBAR N MULTICHNL  1/76
R1       NO SIGNAL FOR THIS STATE WITH X LARGER THAN ABOUT 0.03 IN THE       11/75
R1       ANALYSIS OF HEMINGWAY 75.                                           11/75

R2      SIGMA(1940) FROM N KBAR TO LAMBDA PI                 SQRT(P1*P2)
R2           -0.153     0.070             DEVENISH  74          0 FIXED T DISP REL  4/75
R2           -0.04      0.02              BAILLON   75 IPWA     KBAR N TO LAM PI 11/75
R2           -0.05      0.03     0.02     VANHORN   75 DPWA   0 K-P TO LAM PI0   11/75
R2    B      -0.15 OR -0.14               MARTIN    77 DPWA     KBAR N MULTICHNL 11/77
R2           -0.06      0.03              RLIC      77 DPWA     KBAR N MULTICHNL  1/76

R3      SIGMA(1940) FROM N KBAR TO SIGMA PI                  SQRT(P1*P3)
R3           -0.14     (0.04)             KANE      74 DPWA     K-P TO PI SIG    12/81
R3    B      +0.16 OR +0.16               MARTIN    77 DPWA     KBAR N MULTICHNL 11/77
R3           -0.08      0.04              RLIC      77 DPWA     KBAR N MULTICHNL  1/76

R4      SIGMA(1940) FROM N KBAR TO LAMBDA(1520) PI P-WAVESQRT(P1*P4)
R4    C      -0.11      0.04              LITCHFI2  74 DPWA   0 K-P TO L(1520)PI 10/74
R4    C  ASSUMES LAMBDA(1520) ELASTICITY=.45,SIGN RLTV. TO SIG(2030) DECAY.    10/74
R4    D      LESS THAN 0.03               CAMERON   77 DPWA   0 K-P TO L(1520)PI  1/78
R4    D  ASSUMES LAMBDA(1520) ELASTICITY=.46.                                    1/78

R5      SIGMA(1940) FROM N KBAR TO LAMBDA(1520) PI F-WAVESQRT(P1*P5)
R5    C      -0.08      0.04              LITCHFI2  74 DPWA   0 K-P TO L(1520)PI 10/74
R5    D       0.062     0.021             CAMERON   77 DPWA   0 K-P TO L(1520)PI  1/78

R6      SIGMA(1940) FROM N KBAR TO DEL(1232) KBAR,S-WAVE SQRT(P1*P6)
R6    E      -0.16      0.05              LITCHFI3  74 DPWA   0 K-P TO KBAR DEL  10/74
R6    E  SIGN RELATIVE TO SIGMA(2030) DECAY                                      10/74

R7      SIGMA(1940) FROM N KBAR TO DEL(1232) KBAR,D-WAVE SQRT(P1*P7)
R7    E      -0.14      0.05              LITCHFI3  74 DPWA   0 K-P TO KBAR DEL  10/74

R8      SIGMA(1940) FROM N KBAR TO SIGMA(1385) PI, S-WAVESQRT(P1*P8)
R8    F      +0.066     0.025             CAMERON   78 DPWA   0 K-P TO S(1385)PI  1/78
R8    F  SIGN CHANGED TO BE IN ACCORD WITH THE BARYON-FIRST CONVENTION.         12/79

R9      SIGMA(1940) FROM N KBAR TO N K*(892), S3 WAVE    SQRT(P1*P9)
R9    G      -0.09      0.02              CAMERON2  78 DPWA     K-P TO K*N       12/79
R9    G  UPPER LIMITS ON THE D1 AND D3 WAVES ARE EACH 0.03.                      12/79

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                      REFERENCES FOR SIGMA(1940)
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GALTIERI 70 DUKE CONF 173     A BARBARO-GALTIERI                     (LRL)IJP
LITCHFIE 70 NP B22 269        P J LITCHFIELD                        (RHEL)IJP
KANE     72 PR D5 1583        D F KANE                               (LBL)IJP
LEA      73 NP B56 77         +MARTIN,MOORHOUSE+    (RHEL+LOUC+GLAS+AARH)IJP

DEVENISH 74 NP B81 330        DEVENISH,FROGGATT,MARTIN   (DESY+NORD+LOUC)
KANE     74  LBL-2452         D F KANE                               (LBL)IJP
LITCHFI2 74 NP B74 19         LITCHFIELD,HEMINGWAY,BAILLON,+  (CERN+HEID)IJP
LITCHFI3 74 NP B74 39         LITCHFIELD,HEMINGWAY,BAILLON,+  (CERN+HEID)IJP

BAILLON  75 NP B94 39         P BAILLON, P J LITCHFIELD       (CERN+RHEL)IJP
HEMINGWA 75 NP B91 12         HEMINGWAY,EADES,HARMSEN+   (CERN+HEID+MPIM)IJP
VANHORN  75 NP B87 145        A J VAN HORN                           (LBL)IJP
    ALSO 75 NP B87 157        A J VAN HORN                           (LBL)IJP

BELLEFON 76 NP B109 129       DE BELLEFON,BERTHON                   (CDEF)IJP
CAMERON  77 NP B131 399       +FRANEK,GOPAL,KALMUS,MCPHERSON+ (RHEL+LOIC)IJP
GOYAL    77 PR D16 2746       +SODHI                                (DELH)
MARTIN   77 NP B127 349       MARTIN,PIDCOCK,MOORHOUSE        (LOUC+GLAS)IJP
    ALSO 77 NP B126 266       MARTIN,PIDCOCK                        (LOUC)
    ALSO 77 NP B126 285       MARTIN,PIDCOCK                        (LOUC)IJP
RLIC     77 NP B119 362       GOPAL,ROSS,VAN HORN,MCPHERSON+  (LOIC+RHEL)IJP
CAMERON  78 NP B143 189       +FRANEK,GOPAL,BACON,BUTTERWORTH+(RHEL+LOIC)IJP
CAMERON2 78 NP B146 327       +FRANEK,GOPAL,KALMUS,MCPHERSON,+(RHEL+LOIC)IJP
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Σ(2000) S'''11   Status: *

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                02  SIGMA(2000, JP=1/2-) I=1          S'''11

                WE LIST HERE ALL REPORTED S11 STATES LYING ABOVE
                THE SIGMA(1750).

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                02  SIGMA(2000) MASS (MEV)

M            2004.0      40.0               VANHORN   75 DPWA   0 K-P TO LAM PI0    11/75
M     1      1755. OR 1834.                 MARTIN    77 DPWA     KBAR N MULTICHNL  11/77
M     1  THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESONANCE
M     1  PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.
M            1955.0      15.0               RLIC      77 DPWA     KBAR N MULTICHNL   1/76
M            1944.0     (15.0)              GOPAL     80 DPWA     KBAR N ELASTIC    12/81

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                02  SIGMA(2000) WIDTH (MEV)

W             116.0      40.0               VANHORN   75 DPWA   0 K-P TO LAM PI0    11/75
W     1       413. OR 450.                  MARTIN    77 DPWA     KBAR N MULTICHNL  11/77
W             170.0      40.0               RLIC      77 DPWA     KBAR N MULTICHNL   1/76
W             215.0     (25.0)              GOPAL     80 DPWA     KBAR N ELASTIC    12/81

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                02  SIGMA(2000) PARTIAL DECAY MODES

                                                               DECAY MASSES
P1      SIGMA(2000) INTO N KBAR                               938+ 494
P2      SIGMA(2000) INTO LAMBDA PI                           1116+ 135
P3      SIGMA(2000) INTO SIGMA PI                            1197+ 140
P4      SIGMA(2000) INTO LAMBDA(1520) PI                     1520+ 140
P5      SIGMA(2000) INTO N K*(892), S1 WAVE                   940+ 892
P6      SIGMA(2000) INTO N K*(892), D3 WAVE                   940+ 892

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                02  SIGMA(2000) BRANCHING RATIOS
R1      SIGMA(2000) INTO (N KBAR)/TOTAL                      (P1)
R1    1        0.62 OR  0.57          MARTIN    77 DPWA     KBAR N MULTICHNL 11/77
R1    C       (0.44)   (0.05)         RLIC      77 DPWA     KBAR N MULTICHNL  1/76
R1    C  (N KBAR)/TOTAL FROM RLIC 77 IS SUPERSEDED BY GOPAL 80.
R1             0.51    (0.05)         GOPAL     80 DPWA     KBAR N ELASTIC   12/81

R2      SIGMA(2000) FROM N KBAR TO LAMBDA PI                 SQRT(P1*P2)
R2          NOT SEEN                  BAILLON   75 IPWA     KBAR N TO LAM PI 11/75
R2           +0.07      0.02     0.01 VANHORN   75 DPWA   0 K-P TO LAM PI0   11/75
R2    1      -0.19 OR -0.18           MARTIN    77 DPWA     KBAR N MULTICHNL 11/77
R2             0.08     0.03          RLIC      77 DPWA     KBAR N MULTICHNL  1/76
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R3     SIGMA(2000) FROM N KBAR TO SIGMA PI              SQRT(P1*P3)
R3   1       +0.26 OR +0.24          MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
R3           +0.20     0.04          RLIC      77 DPWA    KBAR N MULTICHNL  1/76

R4     SIGMA(2000) FROM N KBAR TO LAMBDA(1520) PI       SQRT(P1*P4)
R4   2       +0.081    0.021         CAMERON   77 DPWA  0 P-WAVE DECAY      1/78
R4   2  ASSUMES LAMBDA(1520) ELASTICITY=0.46.  THE SIGN IS CHANGED HERE TO  12/79
R4   2  BE IN ACCORD WITH THE BARYON-FIRST CONVENTION.                      12/79

R5     SIGMA(2000) FROM N KBAR TO N K*(892), S1 WAVE    SQRT(P1*P5)
R5   3       +0.10     0.02          CAMERON2  78 DPWA    K-P TO K*N        12/79
R5   3  THE SIGN HERE IS CHANGED TO BE IN ACCORD WITH THE BARYON-FIRST      12/79
R5   3  CONVENTION.                                                         12/79

R6     SIGMA(2000) FROM N KBAR TO N K*(892), D3 WAVE    SQRT(P1*P6)
R6           -0.07     0.03          CAMERON2  78 DPWA    K-P TO K*N        12/79

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REFERENCES FOR SIGMA(2000)


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BAILLON  75 NP B94 39            P BAILLON, P J LITCHFIELD       (CERN+RHEL)IJP
VANHORN  75 NP B87 145           A J VAN HORN                          (LBL)IJP
    ALSO 75 NP B87 157           A J VAN HORN                          (LBL)IJP

CAMERON  77 NP B131 399          +FRANEK,GOPAL,KALMUS,MCPHERSON+ (RHEL+LOIC)IJP
MARTIN   77 NP B127 349          MARTIN,PIDCOCK,MOORHOUSE        (LOUC+GLAS)IJP
    ALSO 77 NP B126 266          MARTIN,PIDCOCK                       (LOUC)
    ALSO 77 NP B126 285          MARTIN,PIDCOCK                       (LOUC)IJP
RLIC     77 NP B119 362          GOPAL,ROSS,VAN HORN,MCPHERSON+  (LOIC+RHEL)IJP
CAMERON2 78 NP B146 327          +FRANEK,GOPAL,KALMUS,MCPHERSON,+(RHEL+LOIC)IJP
GOPAL    80  TORONTO CONF 159 G P GOPAL                               (RHEL)IJP
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Σ(2030) F_{17} Status: ****

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                    47  SIGMA(2030, JP=7/2+) I=1        F17

                    FOR MOST RESULTS PUBLISHED BEFORE 1974 (THEY ARE
                    NOW OBSOLETE), SEE OUR 1982 EDITION (PHYSICS LETTERS
                    111B).  ALL THE REFERENCES HAVE BEEN RETAINED.

                    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.

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                    47  SIGMA(2030) MASS (MEV)

M            2020.0     (6.0)           KANE      74 DPWA    K-P TO PI SIG     12/81
M            2025.0     10.0            LITCHFI1  74 DPWA  0 K-P TO L(1820)PI  10/74
M            2035.0     10.0            LITCHFI2  74 DPWA  0 K-P TO L(1520)PI  10/74
M            2020.0     30.0            LITCHFI3  74 DPWA  0 K-P TO KBAR DEL   10/74
M            2035.0     15.0            BAILLON   75 IPWA    KBAR N TO LAM PI  11/75
M            2038.0     10.0            HEMINGWA  75 DPWA  0 K- P TO KBAR N    11/75
M            2042.0     11.0            VANHORN   75 DPWA  0 K-P TO LAM PIO    11/75
M           (2030.0)                    BELLEFON  76 IPWA  0 K- P TO LAM PI     2/77
M    A       2030.0      3.0            CORDEN    76 DPWA  - K- N TO PI- LAM    2/77
M    A  PREFERRED SOLUTION 3, SEE CORDEN 76 FOR OTHER POSSIBILITIES.            2/77
M            2038.0     10.0            CORDEN2   77       - K- N TO K* N      11/77
M            2027. TO 2057.             GOYAL     77 DPWA  - K- N TO SIG PI     1/78
M            2040.0      5.0            RLIC      77 DPWA    KBAR N MULTICHNL   1/76
M            2036.0     (5.0)           GOPAL     80 DPWA    KBAR N ELASTIC    12/81

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                    47  SIGMA(2030) WIDTH (MEV)

W             111.0     (5.0)           KANE      74 DPWA    K-P TO PI SIG     12/81
W              70. TO  125.             LITCHFI1  74 DPWA  0 K-P TO L(1820)PI  10/74
W             160.0     20.0            LITCHFI2  74 DPWA  0 K-P TO L(1520)PI  10/74
W             200.0     30.0            LITCHFI3  74 DPWA  0 K-P TO KBAR DEL   10/74
W             180.0     20.0            BAILLON   75 IPWA    KBAR N TO LAM PI  11/75
W             172.0     15.0            HEMINGWA  75 DPWA  0 K- P TO KBAR N    11/75
W             178.0     13.0            VANHORN   75 DPWA  0 K-P TO LAM PIO    11/75
W            (160.0)                    BELLEFON  76 IPWA  0 K- P TO LAM PI     2/77
W    A        201.0      9.0            CORDEN    76 DPWA  - K- N TO PI- LAM    2/77
W             137.0     40.0            CORDEN2   77       - K- N TO K* N      11/77
W            (260.0)                    DECLAIS   77 DPWA    KBAR N TO KBAR N   1/78
W             126. TO  195.             GOYAL     77 DPWA  - K- N TO SIG PI     1/78
W             190.0     10.0            RLIC      77 DPWA    KBAR N MULTICHNL   1/76
W             172.0    (10.0)           GOPAL     80 DPWA    KBAR N ELASTIC    12/81

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                    47  SIGMA(2030) PARTIAL DECAY MODES

                                                           DECAY MASSES
P1      SIGMA(2030) INTO N KBAR                             938+ 494
P2      SIGMA(2030) INTO LAMBDA PI                         1116+ 135
P3      SIGMA(2030) INTO SIGMA PI                          1189+ 140
P4      SIGMA(2030) INTO XI K                              1321+ 498
P5      SIGMA(2030) INTO LAMBDA(1820) PI, P-WAVE           1820+ 135
P6      SIGMA(2030) INTO LAMBDA(1520) PI, D-WAVE           1520+ 135
P7      SIGMA(2030) INTO LAMBDA(1520) PI, G-WAVE           1520+ 135
P8      SIGMA(2030) INTO DELTA(1232) KBAR, F-WAVE          1232+ 494
P9      SIGMA(2030) INTO DELTA(1232) KBAR, H-WAVE          1232+ 494
P10     SIGMA(2030) INTO SIGMA(1385) PI, F-WAVE            1385+ 140
P11     SIGMA(2030) INTO N K*(892), F1 WAVE                 940+ 892
P12     SIGMA(2030) INTO N K*(892), F3 WAVE                 940+ 892

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                    47  SIGMA(2030) BRANCHING RATIOS

R1      SIGMA(2030) INTO (N KBAR)/TOTAL                     (P1)
R1            0.18      0.03            HEMINGWA  75 DPWA  0 K- P TO KBAR N    11/75
R1           (0.15)                     DECLAIS   77 DPWA    KBAR N TO KBAR N   1/78
R1   B       (0.24)    (0.02)           RLIC      77 DPWA    KBAR N MULTICHNL   1/76
R1   B  (N KBAR)/TOTAL FROM RLIC 77 IS SUPERSEDED BY GOPAL 80.
R1            0.19     (0.03)           GOPAL     80 DPWA    KBAR N ELASTIC    12/81

R2     SIGMA(2030) FROM N KBAR TO LAMBDA PI               SQRT(P1*P2)
R2           +0.195    0.053         DEVENISH  74        0 FIXED T DISP REL   4/75
R2           +0.18     0.02          BAILLON   75 IPWA     KBAR N TO LAM PI  11/75
R2           +0.20     0.01          VANHORN   75 DPWA   0 K-P TO LAM PIO    11/75
R2          (0.20)                   BELLEFON  76 IPWA   0 K- P TO LAM PI     2/77
R2   A       +0.20     0.01          CORDEN    76 DPWA   - K- N TO PI- LAM    2/77
R2           +0.18     0.02          RLIC      77 DPWA     KBAR N MULTICHNL   1/76

R3     SIGMA(2030) FROM N KBAR TO SIGMA PI                SQRT(P1*P3)
R3           -0.10    (0.01)         KANE      74 DPWA     K-P TO PI SIG     12/81
R3   C       -0.09     0.01          CORDEN1   77          - K- N TO PI SIG  11/77
R3   C       -0.06     0.01          CORDEN1   77          - K- N TO PI SIG  11/77
R3   C  THE 2 ENTRIES FOR CORDEN177 ARE FROM 2 DIFFERENT ACCEPTABLE SLTNS.   11/77
R3  D       (-0.085)  (0.02)         GOYAL     77 DPWA   - K- N TO SIG PI     1/78
R3  D   THIS COUPLING IS EXTRACTED FROM UNNORMALIZED DATA.                    1/78
R3           -0.15     0.03          RLIC      77 DPWA     KBAR N MULTICHNL   1/76

R4     SIGMA(2030) FROM N KBAR TO XI K                    SQRT(P1*P4)
R4          (0.05) OR LESS           TRIPP     67 RVUE   0 K-P TO XI K        8/67
R4          (0.05) OR LESS           BURGUN    68 DPWA   0 K-P TO XI K       10/69
R4          (0.023)                  MULLER    69 DPWA   0                    7/70

R5     SIGMA(2030) FROM N KBAR TO LAMBDA(1820) PI P-WAVESQRT(P1*P5)
R5   E        0.18     0.04          LITCHFI1  74 DPWA   0 K-P TO L(1820)PI 10/74
R5   E  ASSUMES LAMBDA(1820) ELASTICITY=.6                                   10/74
R5            0.14     0.02          CORDEN2   75 DBC    - KBAR PI- NUCLEON 11/75
R5          . . . . . . . . . . .
R5   AVG      0.148    0.018    AVERAGE

R6     SIGMA(2030) FROM N KBAR TO LAMBDA(1520) PI D-WAVESQRT(P1*P6)
R6   F        0.14     0.03          LITCHFI2  74 DPWA   0 K-P TO L(1520)PI 10/74
R6   F  ASSUMES LAMBDA(1520) ELASTICITY=.45                                  10/74
R6  G       (0.10)    (0.03)         CORDEN2   75 DBC    - KBAR PI- NUCLEON 11/75
R6  G   UPPER LIMIT                                                          11/75
R6   H       +0.114    0.010         CAMERON   77 DPWA   0 K-P TO L(1520)PI  1/78
R6   H  ASSUMES LAMBDA(1520) ELASTICITY=.46.  THE SIGN IS CHANGED HERE TO    12/79
R6   H  BE IN ACCORD WITH THE BARYON-FIRST CONVENTION.                       12/79
R6          . . . . . . . . . . .
R6   AVG      0.1166   0.0095   AVERAGE

R7     SIGMA(2030) FROM N KBAR TO LAMBDA(1520) PI G-WAVESQRT(P1*P7)
R7   F        0.02     0.02          LITCHFI2  74 DPWA   0 K-P TO L(1520)PI 10/74
R7   H       +0.146    0.010         CAMERON   77 DPWA   0 K-P TO L(1520)PI  1/78
R7          . . . . . . . . . . .
R7   AVG      0.121    0.050    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 5.6)

R8     SIGMA(2030) FROM N KBAR TO DEL(1232) KBAR,F-WAVE SQRT(P1*P8)
R8            0.16     0.03          LITCHFI3  74 DPWA   0 K-P TO KBAR DEL  10/74
R8   G      (0.17)    (0.03)         CORDEN2   75 DBC    - KBAR PI- NUCLEON 11/75
R8   G   UPPER LIMIT                                                         11/75

R9     SIGMA(2030) FROM N KBAR TO DEL(1232) KBAR,H-WAVE SQRT(P1*P9)
R9            0.00     0.02          LITCHFI3  74 DPWA   0 K-P TO KBAR DEL  10/74

R10    SIGMA(2030) FROM N KBAR TO SIGMA(1385) PI, F-WAVESQRT(P1*P10)
R10  I       +0.153    0.026         CAMERON   78 DPWA   0 K-P TO S(1385)PI  1/78
R10  I  THE SIGN IS CHANGED HERE TO BE IN ACCORD WITH THE BARYON-FIRST       12/79
R10  I  CONVENTION.                                                          12/79

R11    SIGMA(2030) FROM N KBAR TO N K*(892), F1 WAVE    SQRT(P1*P11)
R11          -0.02     0.01          CORDEN2   77            K-D TO K*N      12/79
R11  J       +0.06     0.03          CAMERON2  78 DPWA       K-P TO K*N      12/79
R11  J  THE SIGN HERE IS CHANGED TO BE IN ACCORD WITH THE BARYON-FIRST       12/79
R11  J  CONVENTION.                                                          12/79
R11         . . . . . . . . . . .
R11 AVG MOD   0.024    0.012    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)

R12    SIGMA(2030) FROM N KBAR TO N K*(892), F3 WAVE    SQRT(P1*P12)
R12          -0.12     0.02          CORDEN2   77            K-D TO K*N      12/79
R12  K       +0.04     0.03          CAMERON2  78 DPWA       K-P TO K*N      12/79
R12  K  THE UPPER LIMIT ON THE G3 WAVE IS 0.03.                              12/79
R12         . . . . . . . . . . .
R12 AVG MOD   0.095    0.037    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.2)

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REFERENCES FOR SIGMA(2030)


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WOHL     66 PRL 17 107           C G WOHL, F T SOLMITZ, M L STEVENSON  (LRL)IJP
TRIPP    67 NP B3 10             + LEITH, +       (LRL+SLAC+  CERN+HEID+SACL)
BURGUN   68 NP B8 447            +MEYER,PAULI,TALLINI +    (SACL+CDEF+RHEL)
DAUM     68 NP B7 19             +ERNE,LAGNAUX,SENS,STEUER,UDO        (CERN)JP
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,        +   (CDEF+RHEL+SACL)IJP
BERTHON1 70 NP B24 417           +VRANA, BUTTERWORTH, +     (CDEF+RHEL+SACL)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                       (RHEL)IJP

CAMPBELL 71 NP B25 75            +MORTON, NEGUS, GOYAL, MILLER   (GLAS+LOIC)IJP
LITCHFIE 71 NP  B30 125          LITCHFIELD,...+LESQUOY,+.. (RHEL+CDEF+SACL)IJP
KANE     72 PR D5 1583           D F KANE                              (LBL)IJP

DEVENISH 74 NP B81 330           DEVENISH,FROGGATT,MARTIN   (DESY+NORD+LOUC)
KANE     74  LBL-2452            D F KANE                              (LBL)IJP
LITCHFI1 74 NP B74 12            LITCHFIELD,HEMINGWAY,BAILLON,+  (CERN+HEID)IJP
LITCHFI2 74 NP B74 19            LITCHFIELD,HEMINGWAY,BAILLON,+  (CERN+HEID)IJP
LITCHFI3 74 NP B74 39            LITCHFIELD,HEMINGWAY,BAILLON,+  (CERN+HEID)IJP

BAILLON  75 NP B94 39            P BAILLON, P J LITCHFIELD       (CERN+RHEL)IJP
CORDEN2  75 NP B92 365           +COX,DARTNELL,KENYON,ONEALE,SUMOROK+ (BIRM)IJP
HEMINGWA 75 NP B91 12            HEMINGWAY,EADES,HARMSEN+   (CERN+HEID+MPIM)IJP
VANHORN  75 NP B87 145           A J VAN HORN                          (LBL)IJP
    ALSO 75 NP B87 157           A J VAN HORN                          (LBL)IJP
BELLEFON 76 NP B109 129          DE BELLEFON,BERTHON                  (CDEF)IJP
CORDEN   76 NP B104 382          +COX,DARTNELL,KENYON,ONEALE,SUMOROK+ (BIRM)IJP

CAMERON  77 NP B131 399          +FRANEK,GOPAL,KALMUS,MCPHERSON+ (RHEL+LOIC)IJP
CORDEN1  77 NP B125 61           +COX,KENYON,ONEALE,STUBBS,SUMOROK+   (BIRM)IJP
CORDEN2  77 NP B121 365          +COX,KENYON,ONEALE,STUBBS,SUMOROK+   (BIRM)IJP
DECLAIS  77  CERN 77-16          +DUCHON,LOUVEL,PATRY,SEGUINOT+  (CAEN+CERN)IJP
GOYAL    77 PRD 16 2746          D P GOYAL,A V SODHI                  (DELH)IJP
RLIC     77 NP B119 362          GOPAL,ROSS,VAN HORN,MCPHERSON+  (LOIC+RHEL)IJP
CAMERON  78 NP B143 189          +FRANEK,GOPAL,BACON,BUTTERWORTH+(RHEL+LOIC)IJP
CAMERON2 78 NP B146 327          +FRANEK,GOPAL,KALMUS,MCPHERSON,+(RHEL+LOIC)IJP
GOPAL    80  TORONTO CONF 159 G P GOPAL                               (RHEL)IJP
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Baryons

Data Card Listings

Σ(2030), Σ(2070), Σ(2080), Σ(2100)

2030 MEV REGION – PRODUCTION AND σ_{TOTAL} EXP'TS

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                    28  SIGMA(2030, JP=    ) I=1      PRODUCTION EXPERIMENTS

                    SEE THE NOTE ON THE F17 SIGMA(2030), IN FRONT OF 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 SIGMA(2030),
    BUT MAY CONTAIN A SMALL CONTRIBUTION FROM THE SUGGESTED BUT NOT ESTAB-
    LISHED OTHER RESONANCES IN THIS REGION.

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                    28  SIGMA(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

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                    28  SIGMA(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

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                    28  SIGMA(2030) PARTIAL DECAY MODES (PROD. EXP.)

                                                        DECAY MASSES
P1      SIGMA(2030) INTO N KBAR                       938+ 494
P2      SIGMA(2030) INTO N KBAR PI                    938+ 498+ 140

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                    28  SIGMA(2030) BRANCHING RATIOS (PROD. EXP.)

R1      SIGMA(2030) INTO (N KBAR)/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      SIGMA(2030) INTO (N KBAR PI)/TOTAL               (P2)
R2            SEEN                  BOCK         HBC

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REFERENCES FOR SIGMA(2030) (PROD. EXP.)


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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+SACL)
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}'' Status: *

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                    34  SIGMA(2070, JP=5/2+) I=1       F''15

                    THIS STATE SUGGESTED BY BERTHON 70 NOW FINDS
                    CONFIRMATION IN GOPAL 80 WITH NEW K-P POLARIZATION AND
                    K- NEUTRON ANGULAR DISTRIBUTIONS.  THE VERY BROAD STATE
                    SEEN IN KANE 72 IS NOT REQUIRED IN THE LATER (KANE 74)
                    ANALYSIS OF PI SIGMA.

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                    34  SIGMA(2070) MASS (MEV)

M        (2070.0)   (10.0)          BERTHON1  70 DPWA -  K- P TO SIG PI     1/71
M        (2057.0)                   KANE      72 DPWA    K-P TO SIGMA PI    1/73
M         2051.0    (25.0)          GOPAL     80 DPWA    KBAR N ELASTIC    12/81

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                    34  SIGMA(2070) WIDTH (MEV)

W         (140.0)   (20.0)          BERTHON1  70 DPWA -  K- P TO SIG PI     1/71
W         (906.0)                   KANE      72 DPWA    K-P TO SIGMA PI    1/73
W          300.0    (30.0)          GOPAL     80 DPWA    KBAR N ELASTIC    12/81

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                    34  SIGMA(2070) PARTIAL DECAY MODES

                                                        DECAY MASSES
P1      SIGMA(2070) INTO N KBAR                       938+ 494
P2      SIGMA(2070) INTO SIGMA PI                     1189+ 140

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                    34  SIGMA(2070) BRANCHING RATIOS

R1      SIGMA(2070) FROM N KBAR TO SIGMA PI              SQRT(P1*P2)
R1         (+0.12)   (0.02)         BERTHON1  70 DPWA -  K- P TO SIG PI     1/71
R1         (+0.104)                 KANE      72 DPWA    K-P TO SIGMA PI    1/73

R2      SIGMA(2070) INTO (N KBAR)/TOTAL                  (P1)
R2          0.08     (0.03)         GOPAL     80 DPWA    KBAR N ELASTIC    12/81

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REFERENCES FOR SIGMA(2070)


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BERTHON1 70 NP B24 417          +VRANA,BUTTERWORTH,+       (CDEF+RHEL+SACL)IJP
KANE     72 PR D5 1583          D F KANE                              (LBL)
GOPAL    80  TORONTO CONF 159 G P GOPAL                            (RHEL)IJP

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Σ(2080) P_{13}''' Status: **

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                    88  SIGMA(2080, JP=3/2+) I=1       P'''13

                    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  SIGMA(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
M     1     2120.0    40.0          BAILLON   75 IPWA    KBAR N TO LAM PI 11/75
M     1  FROM SOLUTION 1 OF BAILLON 75.                                     1/76
M     2     2140.0    40.0          BAILLON   75 IPWA    KBAR N TO LAM PI  1/76
M     2  FROM SOLUTION 2 OF BAILLON 75.                                     1/76
M           2140.0    30.0          BELLEFO1  75 DPWA  0 K- P TO LAM PIO  11/75
M    3      2070. TO 2120.          BELLEFON  76 IPWA  0 K- P TO LAM PI     2/77
M    3   SUPERSEDES BELLEFO1 75.                                            2/77
M     4     2091.0     7.0          CORDEN    76 DPWA  - K- N TO PI- LAM    2/77
M     4  PREFERRED SOLUTION 3, SEE CORDEN 76 FOR OTHER POSSIBLILITES,       2/77
M     4  INCLUDING A D15 AT THIS MASS.                                      2/77
M     4  CORDEN 76 INCLUDES THE DATA OF COX 70 AS A SUBSAMPLE.

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                    88  SIGMA(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
W     1      240.0    50.0          BAILLON   75 IPWA    KBAR N TO LAM PI 11/75
W     2      200.0    50.0          BAILLON   75 IPWA    KBAR N TO LAM PI  1/76
W            180.0    20.0          BELLEFO1  75 DPWA  0 K- P TO LAM PIO  11/75
W    3      (100.0)                 BELLEFON  76 IPWA  0 K- P TO LAM PI     2/77
W     4      186.0    48.0          CORDEN    76 DPWA  - K- N TO PI- LAM    2/77

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                    88  SIGMA(2080) PARTIAL DECAY MODES

                                                        DECAY MASSES
P1      SIGMA(2080) INTO N KBAR                       938+ 494
P2      SIGMA(2080) INTO LAMBDA PI                    1116+ 140

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                    88  SIGMA(2080) BRANCHING RATIOS

R1      SIGMA(2080) FROM N KBAR TO LAMBDA PI             SQRT(P1*P2)
R1          (-0.16)   (0.03)        COX       70 DPWA -  K- N TO LAM PI     6/70
R1          (-0.09)   (0.03)        LITCHFIEL 70 DPWA -0 K- N TO LAM PI     6/70
R1    1      -0.13     0.04         BAILLON   75 IPWA    KBAR N TO LAM PI 11/75
R1    2      -0.13     0.04         BAILLON   75 IPWA    KBAR N TO LAM PI  1/76
R1           +0.19     0.03         BELLEFO1  75 DPWA  0 K- P TO LAM PIO  11/75
R1   3      (-0.10)                 BELLEFON  76 IPWA  0 K- P TO LAM PI     2/77
R1    4      -0.10     0.03         CORDEN    76 DPWA  - K- N TO PI- LAM    2/77

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REFERENCES FOR SIGMA(2080)


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COX      70 NP B19 61           +ISLAM, COLLEY, +     (BIRM+EDIN+GLAS+LOIC)IJP
LITCHFIE 70 NP B22 269          P J LITCHFIELD                       (RHEL)IJP
BAILLON  75 NP B94 39           P BAILLON, P J LITCHFIELD       (CERN+RHEL)IJP
BELLEFO1 75 NP B90 1            DE BELLEFON,BERTHON,BRUNET+     (CDEF+SACL)IJP

BELLEFON 76 NP B109 129         DE BELLEFON,BERTHON                  (CDEF)IJP
CORDEN   76 NP B104 382         +COX,DARTNELL,KENYON,ONEALE,SUMOROK+ (BIRM)IJP

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Σ(2100) G_{17} Status: *

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                    26  SIGMA(2100, JP=7/2-) I=1       G17

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                    26  SIGMA(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  SIGMA(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  SIGMA(2100) PARTIAL DECAY MODES

                                                        DECAY MASSES
P1      SIGMA(2100) INTO N KBAR                       938+ 494
P2      SIGMA(2100) INTO LAMBDA PI                    1116+ 135
P3      SIGMA(2100) INTO SIGMA PI                     1189+ 140

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                    26  SIGMA(2100) BRANCHING RATIOS

R1      SIGMA(2100) FROM N KBAR TO LAMBDA PI             SQRT(P1*P2)
R1          (-0.07)   (0.02)        GALTIERI  70 DPWA  0 K-P TO LAMBDA PI  7/70

R2      SIGMA(2100) FROM N KBAR 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 SIGMA(2100)


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GALTIERI 70 DUKE CONF 173       A BARBARO-GALTIERI                    (LRL)IJP

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Σ(2250) BUMPS Status: ***

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                 48  SIGMA(2250, JP=     ) I=1       PRODUCTION EXPERIMENTS

                 THE PARTIAL-WAVE ANALYSIS RESULTS ARE TOO WEAK TO
                 WARRANT SEPARATING THEM FROM THE PRODUCTION AND CROSS-
                 SECTION EXPERIMENTS.
     LASINSKI 71 IN KBAR N, USING A POMERON+RESONANCES MODEL, AND
 BELLEFON1 76, BELLEFON 77, AND BELLEFON 78 (COLLEGE DE FRANCE-
 SACLAY GROUP) IN DPWA'S OF KBAR N TO LAMBDA PI, SIGMA PI, AND KBAR N,
 RESPECTIVELY, SUGGEST THE PRESENCE OF TWO RESONANCES AROUND THIS
 MASS VALUE.

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                 48  SIGMA(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 GEV/C
M          2250.0      7.0             BUGG      68 CNTR     K-P, D TOTAL      6/68
M          2280.0     14.0             AGUILAR   70 HBC   +  K- 3.9-4.6 GEV/C  5/70
M          2237.0     11.0             BRICMAN   70 CNTR  0 TOTAL AND CH EX    6/70
M          2255.0     10.0             COOL      70 CNTR     K-P, D TOTAL     10/70
M         (2250.0)   (20.0)            LU        70 CNTR  0 GAMMA P TO K+ Y*   1/71
M    B    (2260.0)   (30.0)            BELLEFO1  75 DPWA     D5 WAVE          11/75
M    B    (2215.0)   (10.0)            BELLEFO1  75 DPWA     G9 OR H11 WAVE   11/75
M    B    EVIDENCE FOR 2 RESONANCES IN THIS LAMBDA PI DPWA                    11/75
M    1     2300.0     30.0             BELLEFO2  75 HBC   0 K- P TO XI*0 K0   11/75
M    V     2251.0     30.0      20.0   VANHORN   75 DPWA  0 K-P TO LAM PI0    11/75
M    V    VANHORN72 VALUE FROM A DPWA THAT FINDS JP=5/2+.
M    2    (2260.0)                     BELLEFON  76 IPWA  0 D5 WAVE            2/77
M    2    (2215.0)                     BELLEFON  76 IPWA  0 G9 WAVE            2/77
M    2    SUPERSEDES BELLEFO1 75.                                              2/77
M          2275.0     20.0             BELLEFON  77 DPWA  0 D5 WAVE           11/77
M          2215.0     20.0             BELLEFON  77 DPWA  0 G9 WAVE           11/77
M          2270.0     50.0             BELLEFON  78 DPWA  0 D5 WAVE            1/78
M          2210.0     30.0             BELLEFON  78 DPWA  0 G9 WAVE            1/78

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                 48  SIGMA(2250) WIDTH (MEV) (PROD. EXP.)

W          (150.0)                     BLANPIED  65 CNTR     GAMMA P TO K+ Y*
W           (21.0)   (17.0)    (21.0)  BOCK      65 HBC      PBAR P 5.7 GEV/C
W           230.0     20.0             BUGG      68 CNTR     K-P, D TOTAL      6/68
W           100.0     20.0             AGUILAR   70 HBC   +  K- 3.9-4.6 GEV/C  5/70
W           164.0     50.0             BRICMAN   70 CNTR  0 TOTAL AND CH EX    6/70
W          (170.0)                     COOL      70 CNTR     K-P, D TOTAL     10/70
W          (125.0)                     LU        70 CNTR  0 GAMMA P TO K+ Y*   1/71
W    B     (100.0)   (20.0)            BELLEFO1  75 DPWA     D5 WAVE          11/75
W    B      (60.0)   (40.0)    (20.0)  BELLEFO1  75 DPWA     G9 OR H11 WAVE   11/75
W    1      130.0     20.0             BELLEFO2  75 HBC   0 K- P TO XI*0 K0   11/75
W    V      192.0     30.0             VANHORN   75 DPWA  0 K-P TO LAM PI0    11/75
W    2     (100.0)                     BELLEFON  76 IPWA  0 D5 WAVE            2/77
W    2     (140.0)                     BELLEFON  76 IPWA  0 G9 WAVE            2/77
W            70.0     20.0             BELLEFON  77 DPWA  0 D5 WAVE           11/77
W            60.0     20.0             BELLEFON  77 DPWA  0 G9 WAVE           11/77
W           120.0     40.0             BELLEFON  78 DPWA  0 D5 WAVE            1/78
W            80.0     20.0             BELLEFON  78 DPWA  0 G9 WAVE            1/78

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                 48  SIGMA(2250) PARTIAL DECAY MODES (PROD. EXP.)

                                                            DECAY MASSES
P1      SIGMA(2250) INTO N KBAR                            938+ 494
P2      SIGMA(2250) INTO LAMBDA PI                        1116+ 135
P3      SIGMA(2250) INTO SIGMA PI                         1189+ 140
P4      SIGMA(2250) INTO N KBAR PI                         938+ 498+ 140
P5      SIGMA(2250) INTO XI(1530) K                       1533+ 498

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                 48  SIGMA(2250) BRANCHING RATIOS (PROD. EXP.)

R1      SIGMA(2250) INTO (N KBAR)/TOTAL                     (P1)
R1         0.08      0.02              BELLEFON  78 DPWA  0 D5 WAVE            1/78
R1         0.02      0.01              BELLEFON  78 DPWA  0 G9 WAVE            1/78

R2      SIGMA(2250) FROM N KBAR TO LAMBDA PI                SQRT(P1*P2)
R2        -0.18 (FOR JP=9/2-)          GALTIERI  70 DPWA     K-P TO LAMBDA PI 10/70
R2   B   (+0.12)    (0.03)             BELLEFO1  75 DPWA     D5 WAVE          11/75
R2   B   (-0.09)    (0.02)             BELLEFO1  75 DPWA     G9 OR H11 WAVE   11/75
R2    V   -0.16      0.03              VANHORN   75 DPWA  0 K-P TO LAM PI0    11/75
R2   2   (+0.11)                       BELLEFON  76 IPWA  0 D5 WAVE            2/77
R2   2   (-0.10)                       BELLEFON  76 IPWA  0 G9 WAVE            2/77

R3      SIGMA(2250) FROM N KBAR TO SIGMA PI                 SQRT(P1*P3)
R3        +0.07 (FOR JP=9/2-)          GALTIERI  70 DPWA     K-P TO SIGMA PI  10/70
R3        +0.06      0.02              BELLEFON  77 DPWA  0 D5 WAVE           11/77
R3        -0.03      0.02              BELLEFON  77 DPWA  0 G9 WAVE           11/77

R4      SIGMA(2250) INTO (N KBAR)/(SIGMA PI)                (P1)/(P3)
R4         (0.18) OR LESS              BARNES    69 HBC   +  1 STAN DEV LIMIT 10/69

R5      SIGMA(2250) INTO (LAMBDA PI)/(SIGMA PI)             (P2)/(P3)
R5         (0.18) OR LESS              BARNES    69 HBC   +  1 STAN DEV LIMIT 10/69

R6      SIGMA(2250) FROM K- P TO XI(1530)0 K0               SQRT(P1*P5)
R6   1     0.09      0.02              BELLEFO2  75 HBC   0 K- P TO XI*0 K0   11/75
R6   1  SEEN IN DD5 WAVE IN NEUTRAL CHANNEL ONLY, ISOSPIN UNDETERMINED.       11/75

R7      SIGMA(2250) INTO (N KBAR)/TOTAL                     (J+1/2)*(P1)
R7         J IS NOT DETERMINED IN THESE EXPTS.  THE FOLLOWING IS (J+1/2)*P1.
R7         (0.47)                      BUGG      68 CNTR                       3/78
R7         (0.16)    (0.12)            BRICMAN   70 CNTR  0 TOTAL AND CH EX    3/78
R7         (0.42)                      COOL      70 CNTR     K-P, D TOTAL      3/78

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REFERENCES FOR SIGMA(2250) (PROD. EXP.)


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BLANPIED 65 PRL 14 741          +GREENBERG,HUGHES,KITCHING, +     (YALE+CEA)
BOCK     65 PL 17 166           +COOPER,FRENCH,KINSON, +         (CERN+SACL)
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+SACL)
COOL     70 PR D1 1887          +GIACOMELLI, KYCIA, LEONTIC, LI, +     (BNL) I
GALTIERI 70 DUKE CONF 173       A BARBARO-GALTIERI                   (LRL)IJP
LU       70 PR D2 1846          +GREENBERG, HUGHES, MINEHART, MORI,+ (YALE)
BELLEFO1 75 NP B90 1            DE BELLEFO2,BERTHON,BRUNET+     (CDEF+SACL)IJP
BELLEFO2 75 NC 28A 289          DE BELLEFO2,BERTHON,BILLOIR+    (CDEF+SACL)
VANHORN  75 NP B87 145          A J VAN HORN                          (LBL)IJP
    ALSO 75 NP B87 157          A J VAN HORN                          (LBL)IJP

BELLEFON 76 NP B109 129         DE BELLEFON,BERTHON                  (CDEF)IJP
BELLEFON 77 NC 37A 175          DE BELLEFON,BERTHON,BILLOIR+    (CDEF+SACL)IJP
BELLEFON 78 NC 42A 403          +BERTHON,BILLOIR,BRUNET+        (CDEF+SACL)IJP

                                PAPERS NOT REFERRED TO IN DATA CARDS

COOL     66 PRL 16 1228         +GIACOMELLI,KYCIA,LEONTIC,LI,LUNDBY,+ (BNL) I
   SUPERSEDED BY COOL 70.
DAUBER   66 PL 23 154           +SCHLEIN, SLATER, STORK, TICHO   (UCLA+LRL) J
   SUGGESTS J=9/2 RESONANT BEHAVIOR IN SIGMA- PI+, BUT APPEARS
         INCONSISTENT WITH PARAMETERS OF COOL 66.
DAUM     68 NP B7 19            +ERNE, LAGNAUX, SENS, STEUER, UDO    (CERN)JP
LASINSKI 71 NP  B29  125        T A LASINSKI                          (EFI)IJP
HEMINGWA 75 NP B91 12           HEMINGWAY,EADES,HARMSEN+   (CERN+HEID+MPIM)IJP
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Σ(2455) BUMPS Status: **

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→                53  SIGMA(2455, JP=     ) I=1       PRODUCTION EXPERIMENTS

                 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  SIGMA(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

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                 53  SIGMA(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  SIGMA(2455) PARTIAL DECAY MODES (PROD. EXP.)

                                                            DECAY MASSES
P1      SIGMA(2455) INTO N KBAR                            938+ 494

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                 53  SIGMA(2455) BRANCHING RATIOS (PROD. EXP.)

R1      SIGMA(2455) INTO (N KBAR)/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 SIGMA(2455) (PROD. EXP.)


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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+SACL)

                                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 Status: **

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→                54  SIGMA(2620, JP=     ) I=1       PRODUCTION EXPERIMENTS

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                 54  SIGMA(2620) MASS (MEV) (PROD. EXP.)

M          2620.0     15.0             ABRAMS    70 CNTR     K-P, D TOTAL     10/70
M          2542.0     22.0             DIBIANCA  75 DBC      XI K PI           1/76

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                 54  SIGMA(2620) WIDTH (MEV) (PROD. EXP.)
W         (175.0)                      ABRAMS    70 CNTR     K-P, D TOTAL     10/70
W          221.0      81.0             DIBIANCA  75 DBC      XI K PI           1/76

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                 54  SIGMA(2620) PARTIAL DECAY MODES (PROD. EXP.)

                                                            DECAY MASSES
P1      SIGMA(2620) INTO N KBAR                            938+ 494

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                 54  SIGMA(2620) BRANCHING RATIOS (PROD. EXP.)

R1      SIGMA(2620) INTO (N KBAR)/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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Baryons

Data Card Listings

Σ(2620), Σ(3000), Σ(3170), Ξ's

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                         REFERENCES FOR SIGMA(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+SACL)

DIBIANCA 75 NP B98 137        DIBIANCA,ENDORFR                      (CARN)

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Σ(3000) BUMPS   Status: *

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               59  SIGMA(3000, JP=    ) I=1     PRODUCTION EXPERIMENTS

               ENHANCEMENT IN LAMBDA PI AND KBAR N INVARIANT MASS
               SPECTRA AND IN MISSING MASS OF NEUTRALS RECOILING
               AGAINST K0.  EVIDENCE NOT CONCLUSIVE.  OMITTED FROM
               TABLE.

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               59  SIGMA(3000) MASS (MEV) (PROD. EXP.)

M        (3000.0)                 EHRLICH   66 HBC   0 PI-P 7.91 GEV/C   9/66

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               59  SIGMA(3000) PARTIAL DECAY MODES (PROD. EXP.)

                                                          DECAY MASSES
P1     SIGMA(3000) INTO N KBAR                         938+ 494
P2     SIGMA(3000) INTO LAMBDA PI                     1116+ 140

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                         REFERENCES FOR SIGMA(3000) (PROD. EXP.)

EHRLICH  66 PR 152 1194       R EHRLICH, W SELOVE, H YUTA      (PENN+BNL) I

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Σ(3170) BUMPS   Status: *

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               118  SIGMA(3170, JP=    ) I=1    PRODUCTION EXPERIMENTS

                SEEN BY AMIRZADEH 79 AS A NARROW 6.5 STD. DEV.
                ENHANCEMENT IN THE REACTION K-P --> Y* PI- USING DATA
                FROM TWO INDEPENDENT HIGH STATISTICS BUBBLE CHAMBER
                EXPERIMENTS AT 8.25 AND 6.5 GEV/C.  THE DOMINANT DECAY
                MODES ARE INTO MULTI-BODY, MULTI-STRANGE FINAL STATES
                AND THE PRODUCTION IS VIA I=3/2 BARYON EXCHANGE.  I=1
                IS FAVORED.
                IN NEED OF CONFIRMATION.  OMITTED FROM TABLES.

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               118  SIGMA(3170) MASS  (MEV) (PROD. EXP.)

M       35 3170.0      5.0          AMIRZAD   79 HBC  +  K-P TO Y* PI-    12/79

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               118  SIGMA(3170) WIDTH  (MEV) (PROD. EXP.)

W  C    35  (20.0)  OR LESS         AMIRZAD   79 HBC  +  K-P TO Y* PI-    12/79
W  C    OBSERVED WIDTH CONSISTENT WITH EXPERIMENTAL RESOLUTION.

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               118  SIGMA(3170) PARTIAL DECAY MODES (PROD. EXP.)

                                                          DECAY MASSES
P1      SIGMA(3170) INTO LAMBDA K KBAR + PIONS
P2      SIGMA(3170) INTO SIGMA K KBAR + PIONS
P3      SIGMA(3170) INTO XI K + PIONS

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               118  SIGMA(3170) BRANCHING RATIOS (PROD. EXP.)

R1      SIGMA(3170) INTO (LAMBDA K KBAR + PIONS)/TOTAL   (P1)
R1          SEEN                    AMIRZAD   79 HBC  +  K-P TO Y* PI-    12/79

R2      SIGMA(3170) INTO (SIGMA K KBAR + PIONS)/TOTAL    (P2)
R2          SEEN                    AMIRZAD   79 HBC  +  K-P TO Y* PI-    12/79

R3      SIGMA(3170) INTO (XI K + PIONS)/TOTAL            (P3)
R3          SEEN                    AMIRZAD   79 HBC  +  K-P TO Y* PI-    12/79

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                         REFERENCES FOR SIGMA(3170) (PROD. EXP.)

AMIRZAD  79 PL 89B 125        AMIRZADEH+  (BIRM+CERN+GLAS+MSU+LPNP+CAMB+)I
    ALSO 80 TORONTO CONF. 263 J B KINSON+ (BIRM+CERN+GLAS+MSU+LPNP+CAMB+)I

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NOTE ON Ξ RESONANCES

The Ξ resonance situation has always been unhappy. This is because: (1) Ξ resonances can only be produced as a part of a final state, and so the analysis is more complicated than if direct formation were possible; (2) they are produced with small cross sections (typically a few μb); and (3) the final states are topologically complicated and difficult to study with electronic techniques. Thus our early knowledge of Ξ resonances came entirely from bubble chamber experiments, where the numbers of events are small, and our best information about Ξ resonances is still from bubble chamber experiments.

Until fairly recently only the Ξ(1530) was really well established. However, the late 1970's saw a major improvement with the results of GAY 76 and HEMINGWAY 77. The Ξ(1820) and Ξ(2030) were firmly established as narrow states (widths of about 20 MeV), and the spin of the Ξ(1820) was found to be 3/2 (TEODORO 78).

Since then, however, not much has changed, although there is some improved evidence for the Ξ(2250) and the Ξ(2370). There is probably at least one other Ξ in the 1850-2000-MeV region, and there are indications of several others above 2000 MeV. Indeed, there should be many Ξ resonances below 2500 MeV, and the broad (and not completely established) Ξ(1940) could well be a mixture of several of them. For now we are forced to group together disparate observations and await new results. The disagreements among experiments are shown in ideograms in the Listings.

Results from experiments using electronic methods have recently become available. BIAGI 81 used the CERN hyperon beam to study inclusive $\Lambda\overline{K}$ and $\Xi\pi$ mass spectra from 102 and 135 GeV/c Ξ^- incident on hydrogen and deuterium. They saw a large Ξ(1820) signal in $\Lambda\overline{K}$ as well as a peak at about 1700 MeV, which might be associated with the threshold enhancement seen by DIONISI 78. The Ξ(1940) appears as a broad bump in the $\Xi\pi$ mass spectrum, and there is a very clean Ξ(1530) signal. And Brookhaven multiparticle spectrometer measurements of $K^- p \rightarrow K^+$ anything at 5 GeV/c (JENKINS 83) have seen all the well-established Ξ resonances and also the less well-established Ξ(2250), Ξ(2370), and Ξ(2500).

The table below gives our evaluation of the present status of the Ξ resonances. For a detailed review, see Meadows.[1]

Reference

1. B.T. Meadows, in *Proceedings of the IVth International Conference on Baryon Resonances* (Toronto, 1980), ed. N. Isgur, p. 283.

Table 1. The status of the Ξ resonances. Only those with an overall status of *** or **** are included in the main Baryon Table.

			Status as seen in --				
Particle	$L_{2I \cdot 2J}$	Overall status	Ξπ	ΛK	ΣK	Ξ(1530)π	Other channels
Ξ(1318)	P_{11}	****					Weak to Λπ
Ξ(1530)	P_{13}	****	****				
Ξ(1630)		*	*				
Ξ(1680)		**		*	**		
Ξ(1820)	13	***	*	***	**	***	
Ξ(1940)		**	**			**	
Ξ(2030)	1	***		**	***		
Ξ(2120)		*		*			
Ξ(2250)		**					3-body decays
Ξ(2370)	1	**					3-body decays
Ξ(2500)		*		*	*		3-body decays

**** Good, clear, and unmistakable.
*** Good, but in need of clarification or not absolutely certain.
** Not established; needs confirmation.
* Evidence weak; could disappear.

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S=-2 I=1/2 HYPERON STATES (Ξ)

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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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Ξ^0

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                   23  XI0(1315, JP=1/2 ) I=1/2

                   SEE STABLE PARTICLE DATA CARD LISTINGS

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Ξ(1530) P_{13} Status: ****

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                   49  XI(1530, JP=3/2+) I=1/2  P13

                   THIS IS THE ONLY XI RESONANCE WHOSE PROPERTIES ARE
                   ALL AT LEAST REASONABLY WELL KNOWN.  SPIN-PARITY 3/2+
                   IS 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(1530) MASS (MEV)

M    MIXED CHARGES
M        20(1535.0)                  BERTANZA  62 HBC  -0 K-P 2.3 GEV/C
M        55(1529.0)     (5.0)        PJERROU   62 HBC  -0 K-P 1.8 GEV/C
M          (1532.0)     (2.0)        BADIER    64 HBC  -0 K-P 3 GEV/C

M-   NEGATIVE CHARGE ONLY
M-       38 1535.7       3.2         LONDON    66 HBC  -  K-P 2.24 GEV/C    7/66
M-      334(1534.7)     (1.1)        BALTAY    72 HBC  -  K-P 1.75 GEV      1/73
M-      185 1536.2       1.6         KIRSCH    72 HBC  -  K-P 2.87GEV/C     2/72
M-          1535.3       2.0         ROSS2     73 HBC  -  XI KBAR PI (PI)   2/74
M-       48(1540.0)     (3.0)        BERTHON   74 HBC  -  QUASI 2 BODY CS  10/74
M-          1534.5       1.2         BELLEFO2  75 HBC  -  K-P TO XI- K PI  11/75
M-          . . . . . . . . . .
M-   AVG    1535.18      0.84    AVERAGE
M-   FIT    1534.97      0.63   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

M0   NEUTRAL CHARGE ONLY
M0       76 1528.7       1.1         LONDON    66 HBC   0 K-P 2.24 GEV/C    7/66
M0       59 1531.4       0.8         BADIER    72 HBC   0 K-P AT 3.95GEV/C 10/71
M0     1262 1532.0       0.4         BALTAY    72 HBC   0 K-P 1.75 GEV      1/73
M0      324 1531.3       0.6         BORENSTEI 72 HBC   0 K-P 2.2GEV/C      2/72
M0      286 1532.3       0.7         KIRSCH    72 HBC   0 K-P 2.87GEV/C     2/72
M0          1533.0       1.0         ROSS2     73 HBC     XI KBAR PI (PI)   2/74
M0       97(1533.6)     (1.4)        BERTHON   74 HBC   0 QUASI 2 BODY CS  10/74
M0          1532.2       0.7         BELLEFO2  75 HBC   0 K-P TO XI- K PI  11/75
M0       80(1527.0)     (6.0)        SIXEL     79 HBC   0 INCL. K-P 10 GEV  1/80
M0      100(1535.0)     (4.0)        SIXEL     79 HBC   0 INCL. K-P 16 GEV  1/80
M0   A 2700(1532.1)     (0.6)        BAUBILLIE 81 HBC   0 K-P AT 8.25 GEV   2/82
M0   A    FIT TO INCLUSIVE SPECTRUM.  RESOLUTION (5 MEV) NOT UNFOLDED.
M0      450(1530.0)     (1.0)        BIAGI     81 SPEC -  HYPERON BEAM      2/82
M0          . . . . . . . . . .
M0   AVG    1531.78      0.34    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
M0   FIT    1531.80      0.31   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)
                        (SEE IDEOGRAM BELOW)
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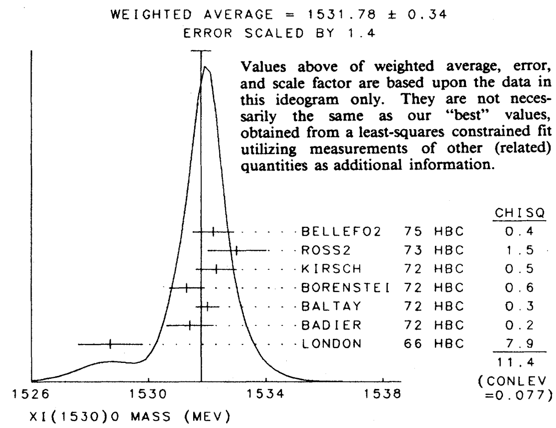


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                49  (XI(1530)-) - (XI(1530)0) MASS DIFFERENCE (MEV)

D              5.7       3.0              PJERROU   65 HBC  -0 1.8-1.95 GEV/C    7/66
D    B        (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    B        (3.9)     (1.8)             KIRSCH    72 HBC  -0 K- P 2.87 GEV/C   2/72
D    B      REDUNDANT WITH DATA IN MASS LISTING.
D           . . . . . . . . . .
D    AVG       2.92      0.91     AVERAGE
D    FIT       3.17      0.64   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                49  XI(1530) WIDTH (MEV)

W    MIXED CHARGES
W        20  (35.0)   OR LESS             BERTANZA  62 HBC  -0 K-P 2.3 GEV/C

W-   NEGATIVE CHARGE ONLY
W-             7.8       3.5       7.8    BALTAY    72 HBC  -  K-P 1.75 GEV      1/73
W-            16.2       4.6              KIRSCH    72 HBC  -  XI- PI0,XI0 PI-   2/72
W-             8.3       3.6              ROSS2     73 HBC  -  XI KBAR PI (PI)   2/74
W-             9.6       2.8              BELLEFO2  75 HBC  -  K-P TO XI- K PI  11/75
W-          . . . . . . . . . .
W-   AVG      10.1       1.9      AVERAGE

W0   NEUTRAL CHARGE ONLY
W0             7.0       2.0              SCHLEIN   63 HBC   0 1.8, 1.95 GEV/C
W0             7.0       7.0              BERGE     66 HBC   0 1.5-1.7 GEV/C     7/66
W0             8.5       3.5              LONDON    66 HBC   0 2.24 GEV/C        7/66
W0            11.0       2.0              BADIER    72 HBC   0 K-P AT 3.95GEV/C 10/71
W0             9.0       0.7              BALTAY    72 HBC   0 K-P 1.75 GEV      1/73
W0             8.4       1.4              BORENSTEI 72 HBC   0 XI- PI+ MODE      2/72
W0            11.0       1.8              KIRSCH    72 HBC   0 XI- PI+           2/72
W0             9.1       2.4              ROSS2     73 HBC   0 XI KBAR PI (PI)   2/74
W0             9.5       1.2              BELLEFO2  75 HBC   0 K-P TO XI- K PI  11/75
W0   C   80  (19.0)     (6.0)             SIXEL     79 HBC   0 INCL. K-P 10 GEV  1/80
W0   C  100  (14.0)     (5.0)             SIXEL     79 HBC   0 INCL. K-P 16 GEV  1/80
W0   C     EXPERIMENTAL RESOLUTION OF 15 MEV NOT UNFOLDED.
W0   D 2700  (12.8)     (1.0)             BAUBILLIE 81 HBC   0 K-P AT 8.25 GEV   2/82
W0   D    FIT TO INCLUSIVE SPECTRUM.  RESOLUTION (5 MEV) NOT UNFOLDED.
W0          . . . . . . . . . .
W0   AVG       9.14      0.48     AVERAGE

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                49  XI(1530) REAL PART OF POLE POSITION

RE0         1531.6      0.4               LICHTENB  74       0 EXTRAP HABIBI73   4/75
RE-         1534.4      1.1               LICHTENB  74       - EXTRAP HABIBI73   4/75

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                49  XI(1530) IMAGINARY PART OF POLE POSITION

IM0            4.45     0.35              LICHTENB  74       0 EXTRAP HABIBI73   4/75
IM-            3.9      1.75       3.9    LICHTENB  74       - EXTRAP HABIBI73   4/75

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                49  XI(1530) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      XI(1530) INTO XI PI                              1321+ 140
P2      XI(1530) INTO XI GAMMA                           1321+   0

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                49  XI(1530) BRANCHING RATIOS (MEV)

R1      XI(1530) INTO (XI GAMMA)/TOTAL                (P2)
R1             (0.04) OR LESS  CL=.90   KALBFLEI  75 HBC  -  K-P AT 2.18 GEV   1/76

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REFERENCES FOR XI(1530)


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BERTANZA 62 PRL 9 180          +BRISSON,CONNOLLY,GOLDBERG,GRAY,+(BNL+SYRA) IJ
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+SACL+AMST) I
PJERROU  65 PRL 14 275         +SCHLEIN,SLATER,SMITH,STORK,TICHO     (UCLA)
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Baryons

Ξ(1530), Ξ(1630), Ξ(1680), Ξ(1820)


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BERGE    66 PR 147 945          +EBERHARD,HUBBARD,MERRILL,B-SHAFER,+  (LRL) I
LONDON   66 PR 143 1034         +RAU,SAMIOS,YAMAMOTO,GOLDBERG,+  (BNL+SYRA) IJ
MERRILL  66 UCRL-16455 THESIS D W MERRILL                          (LRL) JP

BADIER   72 NP B37 429          +BARRELET,CHARLTON,VIDEAU             (EPOL)
BALTAY   72 PL 42B 129          +BRIDGEWATER,COOPER,GERSHWIN,+  (COLU+BING)
    ALSO 73 NEVIS 199 THESIS    HABIBI                                (COLU)
BORENSTE 72 PR D5 1559          BORENSTEIN,DANBURG,KALBFLEISCH++ (BNL+MICH) I
KIRSCH   72 NP B40 349          SCHMIDT+CHANG,HEMINGWAY(BRAN+UMD+SYRA+TUFT) I

ROSS2    73 PURDUE CONF. 355    ROSS,LLOYD,RADOJICIC                   (OXF)
BERTHON  74 NC 21A 146          BERTHON,TRISTRAM,+    (CDEF+RHEL+SACL+STRB)
LICHTENB 74 PRD 10 3865         D B LICHTENBERG                        (IND)
    ALSO 74 PRIV. COMM.         D B LICHTENBERG                        (IND)

BELLEFO2 75 NC 28A 289          DE BELLEFON,BERTHON,BILLOIR+    (CDEF+SACL)
KALBFLEI 75 PRD 11 987          KALBFLEISCH,STRAND,CHAPMAN        (BNL+MICH)
SIXEL    79 NP B159 125         +BOTTCHER,KLEIN+ (AACH+BERL+CERN+LOIC+VIEN)
BAUBILLI 81 NP B192 1           BAUBILLIER+         (BIRM+CERN+GLAS+MSU+LPNP)
BIAGI    81 ZPHY C9 305         +       (BRIS+CAMB+GEVA+HEID+LAUS+LOQM+RHEL)

                                PAPERS NOT REFERRED TO IN DATA CARDS

SHAFER   66 PR 142 883          BUTTON-SHAFER,LINDSEY,MURRAY,SMITH    (LRL) JP
HUNGERBU 74 PRD 10 2051         HUNGERBUHLER,MAJKA,+   (YALE+FNAL+BNL+PITT)
BRIEFEL  75 PRD 12 1859         +GOUREVITCH,KIRSCH+    (BRAN+UMD+SYRA+TUFT)
BRIEFEL  77 PRD 16 2706         +GOUREVITCH,CHANG+     (BRAN+UMD+SYRA+TUFT)
MAZZUCAT 81 NP B178 1           MAZZUCATO,PENNINO+     (AMST+CERN+NIJM+OXF)
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Ξ(1630) Status: *

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21  XI(1630, JP=    ) I=1/2

SEEN ONLY IN THE XI PI CHANNEL.

BARTSCH 69 SEE A SMALL, BROAD ENHANCEMENT NEAR
1650 MEV - IT IS NOT CLEAR THAT IT IS THE SAME
PHENOMENON AS BRIEFEL 77, WHO FIND CS=2.6+-0.9
MICROBARNS AT 2.87 GEV/C INCIDENT K- MOMENTUM.
BORENSTEIN 72 SEE NO EFFECT IN THIS REGION.  THEY FIND
CS<2 MICROBARNS AT 2.18 GEV/C.

   ROSS 72 ARGUE THAT THE EFFECT THEY SEE IS NOT THE SAME AS THAT
SEEN BY BRIEFEL 77 (WHOSE PRELIMINARY RESULTS WERE REPORTED IN
BMST 70), AND FIND CS=2+-1 MICROBARNS AT 3.3 GEV/C.
BELLEFON 75 FIND A CS OF AROUND 10 MICROBARNS NEAR 2 GEV/C,
BUT LESS THAN 3 MICROBARNS AROUND 2.3 GEV/C.
  NOT SEEN BY HASSALL 81 IN A HIGH STATISTICS BUBBLE CHAMBER
EXPERIMENT (46 EVENTS/MICROBARN) AT 6.5 GEV/C.
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                  21  XI(1630) MASS (MEV)

M        29 1606.0      6.0          ROSS      72 HBC   0 K-P AT 3.1-3.7     3/72
M        34 1633.0     12.0          BELLEFO2  75 HBC   0 K-P TO XI- K PI   11/75
M        31 1624.0      3.0          BRIEFEL   77 HBC   0 K-P 2.87 GEV/C     1/78
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                  21  XI(1630) WIDTH (MEV)

W        29   21.0      7.0          ROSS      72 HBC   0 XI-PI+ K*0(890)    3/72
W        34   40.0     15.0          BELLEFO2  75 HBC   0 K-P TO XI- K PI   11/75
W    A   31  (22.5)                  BRIEFEL   77 HBC   0 K-P 2.87 GEV/C     1/78
W    A   GOODNESS OF FIT INSENSITIVE TO VALUES BETWEEN 15 AND 30 MEV.
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                  21  XI(1630) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      XI(1630) INTO XI PI                              1321+ 140

        SEEN IN K- P TO XI- PI+ K0 AND XI- PI0 K+.
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                         REFERENCES FOR XI(1630)
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ROSS     72 PL 38B 177          +BURAN,LLOYD,MULVEY,RADOJICIC          (OXF) I
BELLEFO2 75 NC 28A 289          DE BELLEFON,BERTHON,BILLOIR+    (CDEF+SACL)
BRIEFEL  77 PRD 16 2706         +GOUREVITCH,CHANG+     (BRAN+UMD+SYRA+TUFT)
    ALSO 70 DUKE CONF. 317      BMST                   (BRAN+UMD+SYRA+TUFT)

                                PAPERS NOT REFERRED TO IN DATA CARDS

APSELL   69 PRL 23 884          +                      (BRAN+UMD+SYRA+TUFT)
    SUPERSEDED BY BMST 70.
BARTSCH  69 PL 28B 439          +                 (AACH+BERL+CERN+LOIC+VIEN)
KALBFLEI 70 DUKE CONF 331       G R KALBFLEISCH                        (BNL) I
    SUMMARIZES EVIDENCE FOR ISOSPIN ONE-HALF.
BORENSTE 72 PR D5 1559          BORENSTEIN,DANBURG,KALBFLEISCH++ (BNL+MICH) I
SCHMIDT  73 PURDUE CONF. 363    SCHMIDT                               (BRAN)
HUNGERBU 74 PRD 10 2051         HUNGERBUHLER,MAJKA,+   (YALE+FNAL+BNL+PITT)
BRIEFEL  75 PRD 12 1859         +GOUREVITCH,KIRSCH+    (BRAN+UMD+SYRA+TUFT)
HASSALL  81 NP B189 397         +ANSORGE,CARTER,NEALE,RUSHBROOKE+(CAMB+MSU)
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Ξ(1680) Status: **

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5  XI(1680, JP=1/2-) I=1/2

SEEN BY DIONISI 78 AS A THRESHOLD ENHANCEMENT IN BOTH
THE NEUTRAL AND NEGATIVELY CHARGED SIGMA KBAR MASS
SPECTRA FROM THE REACTIONS K-P --> (SIGMA KBAR) K PI
AT 4.2 GEV/C.  THE DATA FROM THE SIGMA KBAR CHANNELS
ALONE CANNOT DISTINGUISH BETWEEN A RESONANCE
INTERPRETATION AND A LARGE SCATTERING LENGTH.

  WEAKER EVIDENCE FOR AN ENHANCEMENT AT THE SAME MASS IS SEEN IN THE
CORRESPONDING LAMBDA KBAR CHANNELS AND A COUPLED CHANNEL ANALYSIS
YIELDS RESULTS CONSISTENT WITH A NEW XI.

  THE HYPERON BEAM EXPERIMENT OF BIAGI 81 OBSERVE AN ENHANCEMENT AT
1700 MEV IN THE DIFFRACTIVELY PRODUCED LAMBDA K- SYSTEM.  A PEAK IS
ALSO OBSERVED IN THE LAMBDA K0 MASS SPECTRUM AT 1660 MEV WHICH IS
CONSISTENT WITH A RESONANCE OF MASS 1720 MEV DECAYING INTO SIGMA0
K0, WITH THE GAMMA FROM THE SIGMA0 DECAY NOT DETECTED.
IN NEED OF FUTHER CONFIRMATION.  OMITTED FROM THE TABLES.
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                  5  XI(1680) MASS (MEV)

M0  NEUTRAL CHARGE
M0  A  175(1699.0)    (5.0)          DIONISI   78 HBC   0 K-P AT 4.2 GEV/C  3/79
M0  A   FROM FIT TO SIGMA+ K- SPECTRUM                                      3/79
M0  B  183(1684.0)    (5.0)          DIONISI   78 HBC   0 K-P AT 4.2 GEV/C  3/79
M0  B   FROM COUPLED CHANNEL ANALYSIS OF SIGMA+ K- AND LAMBDA K0 SPECTRA    3/79

M-  NEGATIVE CHARGE
M-  C   45(1694.0)    (6.0)          DIONISI   78 HBC   -  K-P AT 4.2 GEV/C  3/79
M-  C   FROM COUPLED CHANNEL ANALYSIS OF SIGMA0 K- AND LAMBDA K- SPECTRA    3/79
M-  D  150(1700.0)   (10.0)          BIAGI     81 SPEC -  HYPERON BEAM      2/82
M-  D   FIT TO INCLUSIVE SPECTRUM FROM XI-N --> LAM K- X
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                  5  XI(1680) WIDTH (MEV)

W0  NEUTRAL CHARGE
W0  A  175  (44.0)   (23.0)          DIONISI   78 HBC   0 K-P AT 4.2 GEV/C  3/79
W0  B  183  (20.0)    (4.0)          DIONISI   78 HBC   0 K-P AT 4.2 GEV/C  3/79

W-  NEGATIVE CHARGE
W-  C   45  (26.0)    (6.0)          DIONISI   78 HBC   -  K-P AT 4.2 GEV/C  3/79
W-  D  150  (47.0)   (14.0)          BIAGI     81 SPEC -  HYPERON BEAM      2/82

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                  5  XI(1680) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      XI(1680) INTO SIGMA KBAR                         1192+ 498
P2      XI(1680) INTO LAMBDA KBAR                        1116+ 498
P3      XI(1680) INTO XI PI                              1315+ 135
P4      XI(1680) INTO XI(1530) PI                        1533+ 135
P5      XI(1680) INTO XI PI PI (INCLUDING P4)            1315+ 135+ 135

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                  5  XI(1680) BRANCHING RATIOS

R1      XI(1680) INTO (SIGMA KBAR)/(LAMBDA KBAR)          (P1)/(P2)
R1  E        (2.7)     (0.9)          DIONISI   78 HBC   0 K-P AT 4.2 GEV/C  3/79
R1  E    NEUTRAL CHARGE
R1  F        (3.1)     (1.4)          DIONISI   78 HBC   -  K-P AT 4.2 GEV/C  3/79
R1  F    NEGATIVE CHARGE

R2      XI(1680) INTO (XI PI)/(SIGMA KBAR)                (P3)/(P1)
R2           (0.09) OR LESS           DIONISI   78 HBC   0 K-P AT 4.2 GEV/C  3/79

R3      XI(1680) INTO (XI- PI+ PI0)/(SIGMA KBAR)          (P5)/(P1)
R3           (0.04) OR LESS           DIONISI   78 HBC   0 K-P AT 4.2 GEV/C  3/79

R4      XI(1680) INTO (XI- PI+ PI-)/(SIGMA KBAR)          (P5)/(P1)
R4           (0.03) OR LESS           DIONISI   78 HBC   -  K-P AT 4.2 GEV/C  3/79

R5      XI(1680) INTO (XI(1530) PI)/(SIGMA KBAR)          (P4)/(P1)
R5           (0.06) OR LESS           DIONISI   78 HBC   -  K-P AT 4.2 GEV/C  3/79
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                         REFERENCES FOR XI(1680)
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DIONISI  78 PL 80B 145          +DIAZ,ARMENTEROS+      (CERN+AMST+NIJM+OXF)I,JP
BIAGI    81 ZPHY C9 305         +       (BRIS+CAMB+GEVA+HEID+LAUS+LOQM+RHEL)
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Ξ(1820) Status: ***

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50  XI(1820, JP=3/2 ) I=1/2

WE LIST HERE EVERYTHING REPORTED IN THE MASS RANGE
1750-1875 MEV.
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The clearest evidence for this state comes from GAY 76, who saw an 8-standard-deviation peak in ΛK^- as well as signals in $\Xi(1530)\pi$ and $\Sigma\overline{K}$. The peak is narrow ($\Gamma = 21 \pm 7$ MeV), whereas earlier (and much smaller) experiments found widths of up to 100 MeV (see the Listings below). A spin-parity analysis of the GAY 76 data, but with more events (TEODORO 78), favors spin 3/2 but cannot make a parity discrimination.

BIAGI 81 used the CERN hyperon beam to study Ξ^- interactions in hydrogen and deuterium. The diffractively produced ΛK^- system has a broad peak ($\Gamma = 72 \pm 20$ MeV) at 1830 MeV on top of a substantial background. There is also a smaller peak in the inclusive ΛK_S^0 spectrum.

Neither GAY 76 nor BIAGI 81 saw a peak in the $\Xi\pi$ channel. It is possible that $\Xi\pi$ peaks seen in this region by some lower momentum experiments are at least partly due to the $\Xi(1940)$, with a shape distorted by the limited phase space available (SMITH 65). The situa-

tion is further confused because some of the experiments were forced to add several different channels together to overcome poor statistics (CRENNELL 70, BADIER 71).

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                       50  XI(1820) MASS (MEV)

M          (1770.0)                     HALSTEINS 63 FBC  -0 K-FR 3.5 GEV/C
M       30 1814.0      4.0              BADIER    65 HBC   0 LAMBDA KOBAR
M       29 1817.0      7.0              SMITH 1   65 HBC  -0 LAMBDA KBAR
M       40 1830.0     10.0              ALITTI    69 HBC  -  LAM, SIG KBAR    9/69
M  A    25 1830.0     10.0              CRENNELL  70 DBC  -0 3.6, 3.9 GEV/C  10/70
M  A    FROM FIT TO INCLUSIVE XI PI, XI PI PI AND LAMBDA K- SPECTRA
M   B      (1826.0)   (12.0)            CRENNELL  70 DBC  -0 3.6, 3.9 GEV/C  11/77
M   B   FROM FIT TO INCLUSIVE XI PI AND XI PI PI SPECTRA ONLY
M  C    28 1762.0      8.0              BADIER    72 HBC  -0 XI PI,XI2PI,K Y 10/71
M  C    38 1838.0      5.0              BADIER    72 HBC   -0XI PI,XI2PI,K Y 10/71
M  C    BADIER 72 ADDS ALL CHANNELS AND DIVIDES PEAK IN LOWER AND HIGHER
M  C    MASS REGIONS. THE DATA CAN ALSO BE FITTED WITH A SINGLE BREIT-
M  C    WIGNER OF MASS 1800 AND WIDTH 150 MEV.
M    D  30 1821.0      5.0              ROSS1     73 HBC  -0 LAMBDA K-/KBAR0  2/74
M    D  LESS SIGNIFICANT ENHANCEMENTS SEEN IN XI(1530) PI (M=1825,W=100)
M    D  AND SIGMA KBAR (M=1810+-9,W=16+-11).
M          1807.0     27.0              DIBIANCA  75 DBC  -0 XI 2PI, XI* PI   1/76
M      130 1823.0      2.0              GAY       76 HBC  -  K- P AT 4.2 GEV  2/77
M       74 1797.0     19.0              BRIEFEL   77 HBC   0 XI PI (2.87 K-P) 1/78
M       68 1829.0      9.0              BRIEFEL   77 HBC  -0 XI(1530) PI      1/78
M       39 1860.0     14.0              BRIEFEL   77 HBC  -  SIGMA- KOBAR     1/78
M       44 1870.0      9.0              BRIEFEL   77 HBC   0 LAMBDA KOBAR     1/78
M       57 1813.0      4.0              BRIEFEL   77 HBC  -  LAMBDA K-        1/78
M    E 300 1830.0      6.0              BIAGI     81 SPEC -  HYPERON BEAM     2/82
M    E  FIT TO INCLUSIVE SPECTRUM FROM XI-N --> LAM K- X
M          1822.0      6.0              JENKINS   83 MPS  -  K- P TO K+ MM    1/84*
                    (SEE IDEOGRAM BELOW)
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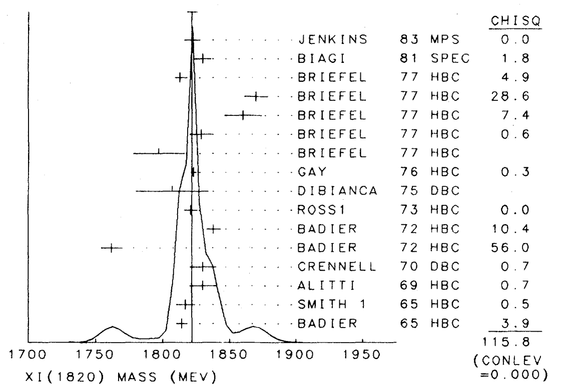


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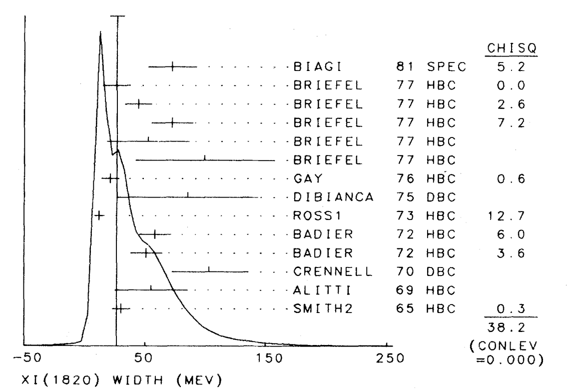
                       50  XI(1820) WIDTH (MEV)

W             (80.0)  OR LESS           HALSTEINS 63 FBC  -0 K-FR 3.5 GEV/C
W             (12.0)    (4.0)           BADIER    65 HBC   0 LAMBDA KOBAR
W              30.0     7.0             SMITH2    65 HBC  -0 LAMBDA KBAR
W              55.0    40.0     20.0    ALITTI    69 HBC  -  LAM, SIG KBAR    9/69
W  A          103.0    38.0     24.0    CRENNELL  70 DBC  -0 3.6, 3.9 GEV/C  10/70
W   B         (48.0)  (36.0)   (19.0)   CRENNELL  70 DBC  -0 3.6, 3.9 GEV/C  11/77
W  C           51.0    13.0             BADIER    72 HBC  -0 LOWER MASS      10/71
W  C           58.0    13.0             BADIER    72 HBC  -0 HIGHER MASS     10/71
W    D  30     12.0     4.0             ROSS1     73 HBC  -0 LAMBDA K-/KBAR0  2/74
W              85.0    58.0             DIBIANCA  75 DBC  -0 XI 2PI, XI* PI   1/76
W      130     21.0     7.0             GAY       76 HBC  -  K- P AT 4.2 GEV  2/77
W       74     99.0    57.0             BRIEFEL   77 HBC   0 XI PI (2.87 K-P) 1/78
W       68     52.0    34.0             BRIEFEL   77 HBC  -0 XI(1530) PI      1/78
W       39     72.0    17.0             BRIEFEL   77 HBC  -  SIGMA- KOBAR     1/78
W       44     44.0    11.0             BRIEFEL   77 HBC   0 LAMBDA KOBAR     1/78
W       57     26.0    11.0             BRIEFEL   77 HBC  -  LAMBDA K-        1/78
W    E 300     72.0    20.0             BIAGI     81 SPEC -  HYPERON BEAM     2/82
                    (SEE IDEOGRAM BELOW)
```

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                  50  XI(1820) PARTIAL DECAY MODES

                                                           DECAY MASSES
P1     XI(1820) INTO LAMBDA KBAR                          1116+ 498
P2     XI(1820) INTO XI PI                                1321+ 140
P3     XI(1820) INTO SIGMA KBAR                           1197+ 498
P4     XI(1820) INTO XI(1530) PI                          1533+ 140
P5     XI(1820) INTO XI PI PI (EXCLUDING P4)              1321+ 140+ 140

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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 .4974+-.0871
P 2   -.7612    .1889+-.0529
P 3    .1335      -.5080    .1463+-.0477
P 4   -.8220       .5813      -.5009    .1674+-.0647


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                  50  XI(1820) BRANCHING RATIOS

R1      XI(1820) INTO (LAMBDA KBAR)/TOTAL                  (P1)
R1           0.30      0.15            ALITTI    69 HBC  -  K-P 3.9-5.0 GEV   9/69
R1           . . . . . . . . . .
R1   FIT     0.497     0.087   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.8)

R2      XI(1820) INTO (XI PI)/TOTAL                        (P2)
R2           0.10      0.10            ALITTI    69 HBC  -  K-P 3.9-5.0 GEV   9/69
R2           . . . . . . . . . .
R2   FIT     0.189     0.053   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)
R21     XI(1820) INTO (XI PI)/(LAMBDA KBAR)                (P2)/(P1)
R21          0.20      0.20            BADIER    65 HBC   0 K-P AT 3 GEV      7/66
R21         (0.36) OR LESS  CL=.95     GAY       76 HBC  -  K- P AT 4.2 GEV   2/77
R21          . . . . . . . . . .
R21  FIT     0.38      0.16    FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.5)

R22     XI(1820) INTO (XI PI)/(XI(1530) PI)                (P2)/(P4)
R22          1.5       0.6       0.4   APSELL    70 HBC   0 K-P AT 2.87 GEV   6/70
R22          . . . . . . . . . .
R22  FIT     1.13      0.36    FROM FIT

R3      XI(1820) INTO (SIGMA KBAR)/TOTAL                   (P3)
R3          (0.02) OR LESS             TRIPP     67 RVUE                      8/67
R3           0.30      0.15            ALITTI    69 HBC  -  K-P 3.9-5.0 GEV   9/69
R3           . . . . . . . . . .
R3   FIT     0.146     0.048   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R31     XI(1820) INTO (SIGMA KBAR)/(LAMBDA KBAR)           (P3)/(P1)
R31          0.24      0.10            GAY       76 HBC  -  K- P AT 4.2 GEV   2/77
R31          . . . . . . . . . .
R31  FIT     0.29      0.10    FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R4      XI(1820) INTO (XI(1530) PI)/TOTAL                  (P4)
R4           0.30      0.15            ALITTI    69 HBC  -  K-P 3.9-5.0 GEV   9/69
R4   F      (0.25) OR LESS             DAUBER    69 HBC     K-P 2.7 GEV/C     9/69
R4   F   USES IN PART THE SAME DATA AS SMITH 65
R4    G      NOT SEEN                  HASSALL   81 HBC     K-P 6.5 GEV/C     2/82
R4    G  INCLUDING XI PI PI
R4           . . . . . . . . . .
R4   FIT     0.167     0.065   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.6)

R41     XI(1820) INTO (XI(1530) PI)/(LAMBDA KBAR)          (P4)/(P1)
R41          0.26      0.13            SMITH1    65 HBC  -0 K-P 2.45-2.70GEV
R41          1.0       0.3             GAY       76 HBC  -  K- P AT 4.2 GEV   2/77
R41          . . . . . . . . . .
R41  AVG     0.38      0.27     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.3)
R41  FIT     0.34      0.18    FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.7)

R51     XI(1820) INTO (XI PI PI)/(LAMBDA KBAR)             (P5)/(P1)
R51         (0.1)  OR MORE             SMITH1    65 HBC  -0 K-P 2.45-2.70GEV

R52     XI(1820) INTO (XI PI PI)/(XI(1530) PI)             (P5)/(P4)
R52 H       (0.3)     (0.5)            APSELL    70 HBC   0 K-P AT 2.87 GEV   6/70
R52 H    OR LESS. UPPER LIMIT FOR THE 3-BODY DECAY
R52        CONSISTENT WITH ZERO        GAY       76 HBC  -  K-P AT 4.2 GEV   11/77

R53     XI(1820) INTO (XI PI PI (INCL. XI(1530) PI)/(LAMBDA KBAR)
R53                                                        (P4+P5)/(P1)
R53  I      (0.14) OR LESS             BADIER    65 HBC   0 1 STD.DEV.LIMIT  11/77
R53  I   FOR THE DECAY MODE (XI- PI+ PI0) ONLY

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REFERENCES FOR XI(1820)


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HALSTEIN 63 SIENA CONF 173     HALSTEINSLID,+   (BERG+CERN+EPOL+RHEL+LOUC) I
BADIER   65 PL 16 171          +DEMOULIN,GOLDBERG, +        (EPOL+SACL+AMST) I
SMITH1   65 PRL 14 25          +LINDSEY,BUTTON-SHAFER,MURRAY            (LRL)IJP
SMITH2   65 ATHENS CONF 251    G A SMITH, J S LINDSEY                   (LRL)
TRIPP    67 NP B3 10           + LEITH, +          (LRL+SLAC+CERN+HEID+SACL)
    USES DATA OF SMITH1.

ALITTI   69 PRL 22 79          +BARNES,FLAMINIO,METZGER, +      (BNL+SYRA) I
DAUBER   69 PR 179 1262        +BERGE, HUBBARD, MERRILL, MULLER       (LRL)
APSELL   70 PRL 24 777         +                     (BRAN+UMD+SYRA+TUFT) I
CRENNELL 70 PR 1D 847          +KARSHON, LAI, ONEALL, SCARR, SCHUMANN(BNL)
BADIER   72 NP B37 429         +BARRELET,CHARLTON,VIDEAU             (EPOL)
ROSS1    73 PURDUE CONF. 345   ROSS,LLOYD,RADOJICIC                   (OXF)

DIBIANCA 75 NP B98 137         DIBIANCA,ENDORF                       (CARN)
GAY      76 PL 62B 477         +ARMENTEROS,BERGE,GAVILLET+(AMST+CERN+NIJM)IJ
BRIEFEL  77 PRD 16 2706        +GOUREVITCH,CHANG+     (BRAN+UMD+SYRA+TUFT)
    ALSO 70 DUKE CONF. 317     BMST                   (BRAN+UMD+SYRA+TUFT)
BIAGI    81 ZPHY C9 305        +       (BRIS+CAMB+GEVA+HEID+LAUS+LOQM+RHEL)
HASSALL  81 NP B189 397        +ANSORGE,CARTER,NEALE,RUSHBROOKE+(CAMB+MSU)
JENKINS  83 PRL 51 951         +ALBRIGHT,DIAMOND,+(FSU+BRAN+LBL+CINC+SMAS)

                               PAPERS NOT REFERRED TO IN DATA CARDS

SMITH    64 PRL 13 61          +LINDSEY,MURRAY,BUTTON-SHAFER+         (LRL) IJP
MERRILL  68 PR 167 1202        D W MERRILL, J BUTTON-SHAFER           (LRL)
APSELL   69 PRL 23 884         +                      (BRAN+UMD+SYRA+TUFT)
    SUPERSEDED BY BRIEFEL 77.
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Baryons

Data Card Listings

Ξ(1820), Ξ(1940), Ξ(2030)

SCHMIDT 73 PURDUE CONF. 363 SCHMIDT (BRAN)
BRIEFEL 75 PRD 12 1859 +GOUREVITCH,KIRSCH+ (BRAN+UMD+SYRA+TUFT)
TEODORO 78 PL 77B 451 +DIAZ,DIONISI,BLOKZIJL+(AMST+CERN+NIJM+OXF) JP

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Ξ(1940) Status: **

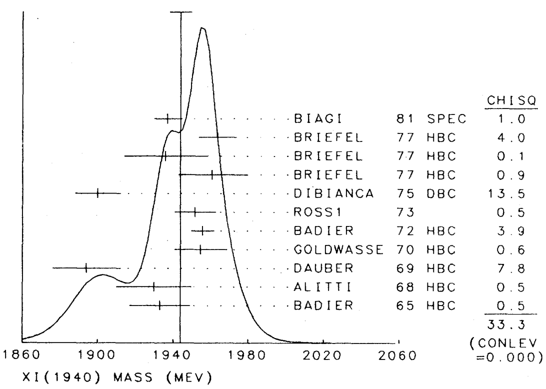
52 XI(1940, JP=) I=1/2

WE LIST UNDER XI(1940) EVERYTHING REPORTED IN THE MASS RANGE 1875-2000 MEV.

52 XI(1940) MASS (MEV)

M	35	1933.0	16.0	BADIER	65	HBC	0 XI- PI+	
M	27	1930.0	20.0	ALITTI	68	HBC	0 XI- PI+	11/68
M	66	1894.0	18.0	DAUBER	69	HBC	- XI PI	11/68
M	21	1955.0	14.0	GOLDWASSE	70	HBC	- XI PI	10/70
M	29	1956.0	6.0	BADIER	72	HBC	XI PI,XI2PI,K Y	10/71
M	25	1952.0	11.0	ROSS1	73		(XI PI)-	2/74
M		1900.0	12.0	DIBIANCA	75	DBC	XI PI	1/76
M	139	1961.0	18.0	BRIEFEL	77	HBC	0 XI-PI+(2.87 K-P)	1/78
M	44	1936.0	22.0	BRIEFEL	77	HBC	- XI0PI-(2.87 K-P)	1/78
M	56	1964.0	10.0	BRIEFEL	77	HBC	-0 XI(1530) PI	1/78
M	A 150	1937.0	7.0	BIAGI	81	SPEC	0 HYPERON BEAM	2/82

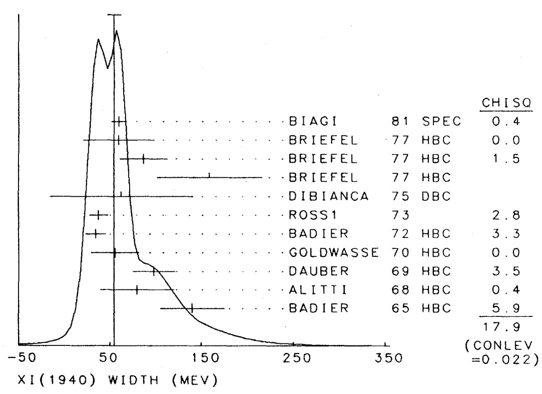
M A FIT TO INCLUSIVE SPECTRUM FROM XI-N --> XI- PI+ X
(SEE IDEOGRAM BELOW)



52 XI(1940) WIDTH (MEV)

W	35	140.0	35.0	BADIER	65	HBC	0 XI- PI+	
W	27	80.0	40.0	ALITTI	68	HBC	0 XI- PI+	11/68
W	66	98.0	23.0	DAUBER	69	HBC	- XI PI	11/68
W	21	56.0	26.0	GOLDWASSE	70	HBC	- XI PI	10/70
W	29	35.0	11.0	BADIER	72	HBC	XI PI,XI2PI,K Y	10/71
W		38.0	10.0	ROSS1	73		(XI PI)-	2/74
W		63.0	78.0	DIBIANCA	75	DBC	XI PI	1/76
W	139	159.0	57.0	BRIEFEL	77	HBC	0 XI-PI+(2.87 K-P)	1/78
W	44	87.0	26.0	BRIEFEL	77	HBC	- XI0PI-(2.87 K-P)	1/78
W	56	60.0	39.0	BRIEFEL	77	HBC	-0 XI(1530) PI	1/78
W	A 150	60.0	8.0	BIAGI	81	SPEC	0 HYPERON BEAM	2/82

(SEE IDEOGRAM BELOW)



52 XI(1940) PARTIAL DECAY MODES

		DECAY MASSES
P1	XI(1940) INTO XI PI	1321+ 140
P2	XI(1940) INTO XI(1530) PI	1533+ 140
P3	XI(1940) INTO XI PI PI (EXCLUDING P2)	1321+ 140+ 140
P4	XI(1940) INTO XI0 PI-	1315+ 140
P5	XI(1940) INTO XI- PI0	1321+ 135
P6	XI(1940) INTO SIGMA KBAR	1197+ 498

52 XI(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 ONLY OBSERVED BY HASSALL 81 WHO SEE A 3 SIGMA EFFECT IN SIGMA KBAR.

R1 XI(1940) INTO (XI PI)/(XI(1530) PI) (P1)/(P2)
R1 2.8 0.7 0.6 APSELL 70 HBC 0 6/70

R2 XI(1940) INTO (XI PI PI)/(XI(1530) PI) (P3)/(P2)
R2 0.0 0.3 APSELL 70 HBC 0 6/70

R3 XI(1940) INTO (XI0 PI-)/(XI- PI0) (P4)/(P5)
R3 25 2.6 6.0 1.6 ROSS1 73 (XI PI)- 2/74

R4 XI(1940) INTO (SIGMA KBAR)/TOTAL (P6)
R4 17 POSSIBLY SEEN HASSALL 81 HBC - K-P AT 6.5 GEV/C 2/82

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REFERENCES FOR XI(1940)

BADIER 65 PL 16 171 +DEMOULIN,GOLDBERG, + (EPOL+SACL+AMST) I
ALITTI 68 PRL 21 1119 +FLAMINIO,METZGER,RADOJICIC,+ (BNL+SYRA) I
DAUBER 69 PR 179 1262 +BERGE, HUBBARD, MERRILL, MULLER (LRL) I
APSELL 70 PRL 24 777 + (BRAN+UMD+SYRA+TUFT) I
GOLDWASS 70 PR 1D 1960 E L GOLDWASSER, P F SCHULTZ (ILLINOIS)
BADIER 72 NP B37,429 +BARRELET,CHARLTON,VIDEAU (EPOL)
ROSS1 73 PURDUE CONF. 345 ROSS,LLOYD,RADOJICIC (OXF)

DIBIANCA 75 NP B98 137 DIBIANCA,ENDORF (CARN)
BRIEFEL 77 PRD 16 2706 +GOUREVITCH,CHANG+ (BRAN+UMD+SYRA+TUFT)
ALSO 70 DUKE CONF. 317 BMST (BRAN+UMD+SYRA+TUFT)
BIAGI 81 ZPHY C9 305 + (BRIS+CAMB+GEVA+HEID+LAUS+LOQM+RHEL)
HASSALL 81 NP B189 397 +ANSORGE,CARTER,NEALE,RUSHBROOKE+(CAMB+MSU)

PAPERS NOT REFERRED TO IN DATA CARDS

APSELL 69 PRL 23 884 + (BRAN+UMD+SYRA+TUFT)
SUPERSEDED BY BMST 70.
SCHMIDT 73 PURDUE CONF. 363 SCHMIDT (BRAN)
BRIEFEL 75 PRD 12 1859 +GOUREVITCH,KIRSCH+ (BRAN+UMD+SYRA+TUFT)

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Ξ(2030) Status: ***

68 XI(2030, JP=5/2 OR GREATER) I=1/2

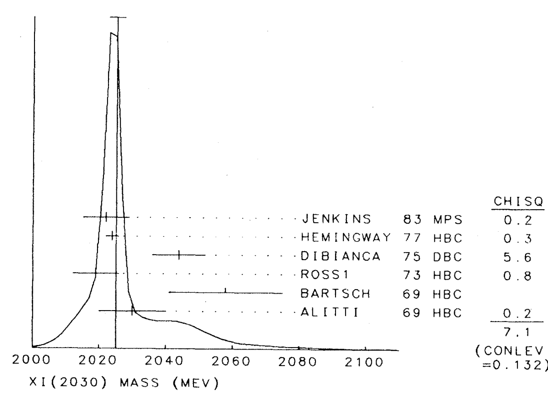
THE EVIDENCE FOR THIS STATE HAS BEEN MUCH IMPROVED BY HEMINGWAY 77, WHO SEE AN 8 STD. DEV. ENHANCEMENT IN SIGMA KBAR AND A WEAKER COUPLING TO LAMBDA KBAR. ALITTI 68 AND HEMINGWAY 77 OBSERVE NO SIGNALS IN THE XI PI PI (OR XI(1530) PI) CHANNEL, IN CONTRAST TO DIBIANCA 75. THE DECAY INTO LAMBDA/SIGMA KBAR PI REPORTED BY BARTSCH 69 IS ALSO NOT CONFIRMED BY HEMINGWAY 77.

A MOMENTS ANALYSIS OF THE HEMINGWAY 77 DATA INDICATES THAT THE SPIN IS GREATER THAN OR EQUAL TO 5/2 AT A LEVEL OF 3 STD. DEVIATIONS.

68 XI(2030) MASS (MEV)

M	42	2030.0	10.0	ALITTI	69	HBC	- K-P 3.9-5 GEV/C	9/69
M	40	2058.0	17.0	BARTSCH	69	HBC	-0 K-P 10 GEV/C	9/69
M	15	2019.0	7.0	ROSS1	73	HBC	-0 SIGMA KBAR	2/74
M		2044.0	8.0	DIBIANCA	75	DBC	-0 XI 2PI, XI* PI	1/76
M	200	2024.0	2.0	HEMINGWAY	77	HBC	- K-P AT 4.2 GEV	11/77
M		2022.0	7.0	JENKINS	83	MPS	- K- P TO K+ MM	1/84*

(SEE IDEOGRAM BELOW)



68 XI(2030) WIDTH (MEV)

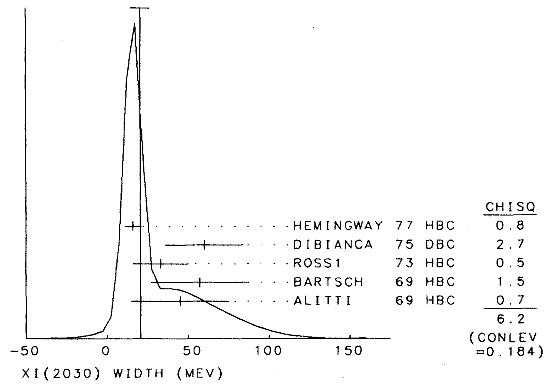
W		45.0	40.0	20.0	ALITTI	69	HBC	- K-P 3.9-5 GEV/C	9/69
W		57.0	30.0		BARTSCH	69	HBC	-0 K-P 10 GEV/C	9/69
W	15	33.0	17.0		ROSS1	73	HBC	-0 SIGMA KBAR	2/74
W		60.0	24.0		DIBIANCA	75	DBC	-0 XI 2PI, XI* PI	1/76
W	200	16.0	5.0		HEMINGWAY	77	HBC	- K-P AT 4.2 GEV	11/77

(SEE IDEOGRAM BELOW)

For notation, see key at front of Listings.

Baryons

Ξ(2030), Ξ(2120), Ξ(2250), Ξ(2370)



68 XI(2030) PARTIAL DECAY MODES

		DECAY MASSES
P1	XI(2030) INTO XI PI	1321+ 140
P2	XI(2030) INTO LAMBDA KBAR	1116+ 498
P3	XI(2030) INTO SIGMA KBAR	1197+ 498
P4	XI(2030) INTO XI(1530) PI	1533+ 140
P5	XI(2030) INTO XI PI PI (EXCLUDING P4)	1321+ 140+ 140
P6	XI(2030) INTO LAMBDA KBAR PI	1116+ 498+ 140
P7	XI(2030) INTO SIGMA KBAR PI	1189+ 498+ 140

68 XI(2030) BRANCHING RATIOS

R1	XI(2030) INTO (XI PI)/(MODES P1 TO P4)						(P1)/(P1+P2+P3+P4)	
R1	(0.30) OR LESS			ALITTI	69 HBC	-	1 STD DEV LIMIT	9/69
R11	XI(2030) INTO (XI PI)/(SIGMA KBAR)						(P1)/(P3)	
R11	(0.19) OR LESS		CL=.95	HEMINGWAY	77 HBC	-	K-P AT 4.2 GEV	11/77
R2	XI(2030) INTO (LAMBDA KBAR)/(MODES P1 TO P4)						(P2)/(P1+P2+P3+P4)	
R2	0.25	0.15		ALITTI	69 HBC	-	K-P 3.9-5 GEV/C	9/69
R21	XI(2030) INTO (LAMBDA KBAR)/(SIGMA KBAR)						(P2)/(P3)	
R21	0.22	0.09		HEMINGWAY	77 HBC	-	K-P AT 4.2 GEV	11/77
R3	XI(2030) INTO (SIGMA KBAR)/(MODES P1 TO P4)						(P3)/(P1+P2+P3+P4)	
R3	0.75	0.20		ALITTI	69 HBC	-	K-P 3.9-5 GEV/C	9/69
R4	XI(2030) INTO (XI(1530) PI)/(MODES P1 TO P4)						(P4)/(P1+P2+P3+P4)	
R4	(0.15) OR LESS			ALITTI	69 HBC	-	1 STD DEV LIMIT	9/69
R41	XI(2030) INTO (XI PI PI INCL. XI(1530) PI)/(SIGMA KBAR)							
R41							(P4+P5)/(P3)	
R41 A	(0.11) OR LESS		CL=.95	HEMINGWAY	77 HBC	-	K-P AT 4.2 GEV	11/77
R41 A	FOR THE DECAY MODE (XI- PI+ PI-) ONLY							
R6	XI(2030) INTO (LAMBDA KBAR PI)/TOTAL						(P6)	
R6	SEEN			BARTSCH	69 HBC		K-P AT 10 GEV	11/77
R61	XI(2030) INTO (LAMBDA KBAR PI)/(SIGMA KBAR)						(P6)/(P3)	
R61	(0.32) OR LESS		CL=.95	HEMINGWAY	77 HBC	-	K-P AT 4.2 GEV	11/77
R7	XI(2030) INTO (SIGMA KBAR PI)/TOTAL						(P7)	
R7	SEEN			BARTSCH	69 HBC		K-P AT 10 GEV	11/77
R71	XI(2030) INTO (SIGMA KBAR PI)/(SIGMA KBAR)						(P7)/(P3)	
R71 B	(0.04) OR LESS		CL=.95	HEMINGWAY	77 HBC	-	K-P AT 4.2 GEV	11/77
R71 B	FOR THE DECAY MODE (SIGMA+- K- PI-+) ONLY							

REFERENCES FOR XI(2030)

ALITTI 69 PRL 22 79 +BARNES,FLAMINIO,METZGER, + (BNL+SYRA) I
BARTSCH 69 PL 28B 439 + (AACH+BERL+CERN+LOIC+VIEN)
ROSS1 73 PURDUE CONF. 345 ROSS,LLOYD,RADOJICIC (OXF)

DIBIANCA 75 NP B98 137 DIBIANCA,ENDORF (CARN)
HEMINGWA 77 PL 68B 197 HEMINGWAY,ARMENTEROS+ (AMST+CERN+NIJM+OXF) IJ
ALSO 76 PL 62B 477 GAY,ARMENTEROS,BERGE+ (AMST+CERN+NIJM)
JENKINS 83 PRL 51 951 +ALBRIGHT,DIAMOND,+(FSU+BRAN+LBL+CINC+SMAS)

Ξ(2120) Status: *

103 XI(2120, JP=) I=1/2

THIS EFFECT IS REPORTED IN GAY 76 AS A FOUR STANDARD DEVIATION ENHANCEMENT IN LAMBDA K-. AN ANALYSIS OF THE SAME DATA BY HEMINGWAY 77, BUT WITH ADDITIONAL STATISTICS, POINTS OUT THAT THE SIGNIFICANCE OF THE ENHANCEMENT IS GREATLY REDUCED IF A RESTRICTIVE FOUR-MOMENTUM CUT (U-CUT) IS MADE. THIS SUGGESTS AN ANOMALOUS PRODUCTION MECHANISM IF THE STATE IS GENUINE.

CHLIAPNIKOV 79 REPORT A BUMP OF 18 EVENTS AT 2137 MEV IN AN INCLUSIVE ANTI-LAMBDA K+ SPECTRUM FROM K+P INTERACTIONS AT 32 GEV/C. THE K+ ARE NOT UNIQUELY IDENTIFIED. BUMPS WITH LOWER NUMBERS OF EVENTS ARE ALSO REPORTED AT 2240, 2830, AND 2540 MEV.

IN NEED OF CONFIRMATION, OMITTED FROM TABLES.

103 XI(2120) MASS (MEV)

M	2123.0	7.0	GAY	76 HBC	-	K- P AT 4.2 GEV	2/77
M	18(2137.0)	(4.0)	CHLIAPNIK	79 HBC	+	ANTI-LAMBDA K+	1/80

103 XI(2120) WIDTH (MEV)

W	25.0	12.0	GAY	76 HBC	-	K- P AT 4.2 GEV	2/77
W	18 (20.0)	OR LESS	CHLIAPNIK	79 HBC	+	ANTI-LAMBDA K+	1/80

103 XI(2120) PARTIAL DECAY MODES

		DECAY MASSES
P1	XI(2120) INTO LAMBDA KBAR	1116+ 498

103 XI(2120) BRANCHING RATIOS

R1	XI(2120) INTO (LAMBDA KBAR)/TOTAL				(P1)	
R1	SEEN	GAY	76 HBC	-	K- P AT 4.2 GEV	2/77

REFERENCES FOR XI(2120)

GAY 76 PL 62B 477 +ARMENTEROS,BERGE,GAVILLET+(AMST+CERN+NIJM)I
HEMINGWA 77 PL 68B 197 HEMINGWAY,ARMENTEROS+ (AMST+CERN+NIJM+OXF)
CHLIAPNI 79 NP B158 253 CHLIAPNIKOV,GERDYUKOV+ (SERP+BELG+MONS)

Ξ(2250) Status: **

22 XI(2250, JP=)

THE EVIDENCE FOR THIS STATE IS MIXED. 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. NOT SEEN BY HASSALL 81 WITH 45 EVENTS/MICROBARN AT 6.5 GEV/C. SEEN BY JENKINS 83.

22 XI(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	2214.0	5.0	JENKINS	83 MPS	-	K- P TO K+ MM	1/84*

22 XI(2250) WIDTH (MEV)

W	130.0	80.0	BARTSCH	69 HBC			9/69
W	LESS THAN	30.0	GOLDWASSE	70 HBC	-	K-P 5.5 GEV/C	10/70

22 XI(2250) PARTIAL DECAY MODES

		DECAY MASSES
P1	XI(2250) INTO XI PI PI	1321+ 140+ 140
P2	XI(2250) INTO LAMBDA KBAR PI	1116+ 498+ 140
P3	XI(2250) INTO SIGMA KBAR PI	1197+ 498+ 140

REFERENCES FOR XI(2250)

BARTSCH 69 PL 28B 439 + (AACH+BERL+CERN+LOIC+VIEN)
GOLDWASS 70 PR 1D 1960 E L GOLDWASSER, P F SCHULTZ (ILL)
JENKINS 83 PRL 51 951 +ALBRIGHT,DIAMOND,+(FSU+BRAN+LBL+CINC+SMAS)

PAPERS NOT REFERRED TO IN DATA CARDS

HASSALL 81 NP B189 397 +ANSORGE,CARTER,NEALE,RUSHBROOKE+(CAMB+MSU)

Ξ(2370) Status: **

131 XI(2370, JP=) I=1/2

SEEN BY AMIRZADEH 80 AND HASSALL 81 IN THE CHARGED AND NEUTRAL LAMBDA/SIGMA KBAR PI MASS SPECTRA FROM THE REACTIONS K-P --> XI(1530) K AND XI(1530) K PI. AMIRZADEH 80 ALSO OBSERVE A SMALL EFFECT AT THE SAME MASS IN THE OMEGA- K MASS SPECTRUM. KINSON 80 RE-ANALYSE THE DATA OF AMIRZADEH 80 BUT WITH 50 PER CENT MORE STATISTICS. IN NEED OF FURTHER CONFIRMATION. OMITTED FROM TABLES.

131 XI(2370) MASS (MEV)

M	2392.0	27.0	DIBIANCA	75 DBC		XI 2PI	1/76
M	94 2373.0	8.0	AMIRZAD	80 HBC	-0	K-P AT 8.25 GEV	1/80
M	50(2370.0)		HASSALL	81 HBC	-0	K-P AT 6.5 GEV/C	2/82
M	2356.0	10.0	JENKINS	83 MPS	-	K- P TO K+ MM	1/84*
M							
M AVG	2367.7	7.0	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)				

131 XI(2370) WIDTH (MEV)

W	75.0	69.0	DIBIANCA	75 DBC		XI 2PI	1/76
W	94 80.0	25.0	AMIRZAD	80 HBC	-0	K-P AT 8.25 GEV	1/80
W	50 (80.0)		HASSALL	81 HBC	-0	K-P AT 6.5 GEV/C	2/82
W							
W AVG	79.4	23.5	AVERAGE				

Baryons

Data Card Listings

$\Xi(2370)$, $\Xi(2500)$, Ω^-, Λ_c^+, $\Sigma_c(2450)$, A^+, Λ_b^0, DIBARYONS

131 XI(2370) PARTIAL DECAY MODES

		DECAY MASSES
P1	XI(2370) INTO LAMBDA KBAR PI (INCL. P4+P6)	1116+ 498+ 140
P2	XI(2370) INTO SIGMA KBAR PI (INCL. P5+P6)	1197+ 498+ 140
P3	XI(2370) INTO OMEGA- K	1672+ 498
P4	XI(2370) INTO LAMBDA ANTI-K*(892)	1116+ 892
P5	XI(2370) INTO SIGMA ANTI-K*(892)	1197+ 892
P6	XI(2370) INTO SIGMA(1385) KBAR	1385+ 498

131 XI(2370) BRANCHING RATIOS

R1	XI(2370) INTO (LAMBDA KBAR PI)/TOTAL			(P1)		
R1	SEEN	AMIRZAD	80 HBC	-0 K-P AT 8.25 GEV		1/80
R2	XI(2370) INTO (SIGMA KBAR PI)/TOTAL			(P2)		
R2	SEEN	AMIRZAD	80 HBC	-0 K-P AT 8.25 GEV		1/80
R3	XI(2370) INTO (LAMBDA/SIGMA KBAR PI)/TOTAL			(P1+P2)		
R3	50 SEEN	HASSALL	81 HBC	-0 K-P AT 6.5 GEV/C		2/82
R4	XI(2370) INTO (OMEGA- K)/TOTAL			(P3)		
R4	0.09 0.04	KINSON	80 HBC	- K-P AT 8.25 GEV		2/82
R5	XI(2370) INTO (LAMBDA/SIGMA ANTI-K*(892))/TOTAL			(P4+P5)		
R5	0.22 0.13	KINSON	80 HBC	- K-P AT 8.25 GEV		2/82
R6	XI(2370) INTO (SIGMA(1385) KBAR)/TOTAL			(P6)		
R6	0.12 0.08	KINSON	80 HBC	- K-P AT 8.25 GEV		2/82

REFERENCES FOR XI(2370)

DIBIANCA 75 NP B98 137 DIBIANCA,ENDORF (CARN)
AMIRZAD 80 PL 90B 324 AMIRZADEH+ (BIRM+CERN+GLAS+MSU+LPNP)I
KINSON 80 TORONTO CONF. 263 J B KINSON+ (BIRM+CERN+GLAS+MSU+LPNP)I
HASSALL 81 NP B189 397 +ANSORGE,CARTER,NEALE,RUSHBROOKE+(CAMB+MSU)
JENKINS 83 PRL 51 951 +ALBRIGHT,DIAMOND,+(FSU+BRAN+LBL+CINC+SMAS)

$\Xi(2500)$ Status: *

99 XI(2500, JP=) I=1/2

THE ALITTI 69 PEAK MIGHT BE INSTEAD THE XI(2370) OR MIGHT BE NEITHER THE XI(2370) NOR THE XI(2500).

99 XI(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	2505.0	10.0	JENKINS	83 MPS	- K- P TO K+ MM	1/84*

99 XI(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

99 XI(2500) PARTIAL DECAY MODES

		DECAY MASSES
P1	XI(2500) INTO XI PI	1321+ 140
P2	XI(2500) INTO LAMBDA KBAR	1116+ 498
P3	XI(2500) INTO SIGMA KBAR	1197+ 498
P4	XI(2500) INTO XI(1530) PI	1533+ 140
P5	XI(2500) INTO LAMBDA (OR SIGMA) KBAR PI	1116+ 498+ 140
P6	XI(2500) INTO XI PI PI	1321+ 140+ 140

99 XI(2500) BRANCHING RATIOS

R1	XI(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(2500) INTO (LAMBDA KBAR)/(MODES P1 THRU P4)			(P2)/(P1+P2+P3+P4)	
R2	0.5 0.2	ALITTI	69 HBC	-	9/69
R3	XI(2500) INTO (SIGMA KBAR)/(MODES P1 THRU P4)			(P3)/(P1+P2+P3+P4)	
R3	0.5 0.2	ALITTI	69 HBC	-	9/69
R4	XI(2500) INTO (XI(1530) 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(2500) INTO (LAMBDA (OR SIGMA) KBAR PI)/TOTAL			(P5)	
R5	SEEN	BARTSCH	69 HBC	-0	9/69
R6	XI(2500) INTO (XI PI PI)/TOTAL			(P6)	
R6	SEEN	BARTSCH	69 HBC	-0	9/69

REFERENCES FOR XI(2500)

ALITTI 69 PRL 22 79 +BARNES,FLAMINIO,METZGER, + (BNL+SYRA) I
BARTSCH 69 PL 28B 439 + (AACH+BERL+CERN+LOIC+VIEN)
JENKINS 83 PRL 51 951 +ALBRIGHT,DIAMOND,+(FSU+BRAN+LBL+CINC+SMAS)

S=−3 I=0 HYPERON STATE (Ω)

Ω^-

24 OMEGA-(1672, JP=) I=0

SEE STABLE PARTICLE DATA CARD LISTINGS

CHARMED BARYONS

Λ_c^+

33 LAMBDA/C+(2282, JP=)

SEE STABLE PARTICLE DATA CARD LISTINGS

$\Sigma_c(2450)$ Status: **

104 SIGMA/C(2450, JP=)

THE SIGMA/C DECAYS TO LAMBDA/C PI, AND THE SCHISM IN MASSES HERE REFLECTS THAT IN MEASUREMENTS OF THE LAMBDA/C MASS (THE HIGHER MASSES ARE PRESENTLY FAVORED). THE IMPRESSIVE AGREEMENT ON THE SIGMA/C-LAMBDA/C MASS DIFFERENCE STRONGLY INDICATES THIS TO BE THE CASE, RATHER THAN THAT TWO STATES (THE SIGMA/C AND Y*/C) ARE BEING OBSERVED.

THIS PARTICLE IS AT ABOUT THE 2-AND-1/2-STAR LEVEL. A DEFINITIVE EXPERIMENT IS NEEDED.

104 SIGMA/C(2450) MASS (MEV)

M	1	2426.0	12.0	CAZZOLI	75 HBC	++ NU P IN BNL 7-FT	3/77
M	9	(2460.0)		KNAPP	76 SPEC	- GAMMA BE	11/81
M	1	(2439.0)	OR MORE	BARISH	77 DBC	++ NU D IN 12-FT	3/77
M	6	2425.0	10.0	BALTAY	79 HLBC	++ NU NE-H IN 15-FT	12/79
M	1	2457.0	4.0	CALICCHIO	80 HBC	+ NU P IN BEBC-TST	11/81
M	1	2454.0	5.0	BOSETTI	82 HBC	++ NU P IN BEBC	3/82

104 (SIGMA/C)-(LAMBDA/C+) MASS DIFFERENCE (MEV)

D	1	166.0	15.0	CAZZOLI	75 HBC	++ NU P IN BNL 7-FT	11/81
D	6	168.0	3.0	BALTAY	79 HLBC	++ NU NE-H IN 15-FT	12/79
D	1	168.0	3.0	CALICCHIO	80 HBC	+ NU P IN BEBC-TST	11/81
D	1	166.0	1.0	BOSETTI	82 HBC	++ NU P IN BEBC	3/82

104 SIGMA/C(2450) PARTIAL DECAY MODES

		DECAY MASSES
P1	SIGMA/C(2450) INTO LAMBDA/C+ PI	2282+ 140

REFERENCES FOR SIGMA/C(2450)

CAZZOLI 75 PRL 34 1125 +CNOPS,CONNOLLY,LOUTTIT,MURTAGH, + (BNL)
KNAPP 76 PRL 37 882 +LEE,LEUNG,SMITH, + (COLU+HAWA+ILL+FNAL)
BARISH 77 PR D15 1 +DERRICK,DOMBECK,MUSGRAVE, + (ANL+PURD)
BALTAY 79 PRL 42 1721 +CAROUMBALIS,FRENCH,HIBBS, + (COLU+BNL)I
CALICCHI 80 PL 93B 521 + (BARI+BIRM+BRUX+CERN+EPOL+RHEL+SACL+LOUC)
BOSETTI 82 PL 109B 234 +GRAESSLER, + (AACH+BONN+CERN+MPIM+OXF)

THEORY AND REVIEW

DERUJULA 75 PR D12 147 +GEORGI,GLASHOW (HARV)
LEE 77 PR D15 157 +QUIGG,ROSNER (FNAL)
TRILLING 81 PRPL 75 57 G H TRILLING (LBL)

A^+

45 A+(2460, JP=)

SEE STABLE PARTICLE DATA CARD LISTINGS

BOTTOM (BEAUTY) BARYON

Λ_b^0

40 LAMBDA/B0(5500, JP=)

SEE STABLE PARTICLE DATA CARD LISTINGS

NOTE ON DIBARYON RESONANCES

(by L.D. Roper, Virginia Polytechnic Institute and State University)

The first modern theoretical discussion of dibaryon resonances was probably by Oakes.[1] The first experimental hint of them was in a Λp invariant mass distribution by Dahl,[2] and in a pp partial-wave analysis by

Arndt[3] for the $^1D_2$ state. [The notation is $^{(2S+1)}L_J$, where S is the total spin, L is the orbital angular momentum, and J is the total angular momentum. The Pauli principle restricts two nucleons to be in one of the following states:

$$I=0:\ ({}^3S_1,{}^3D_1),{}^1P_1,{}^3D_2,({}^3D_3,{}^3G_3),{}^1F_3,{}^3G_4,\cdots$$

$$I=1:\ {}^1S_0,{}^3P_0,{}^3P_1,({}^3P_2,{}^3F_2),{}^1D_2,{}^3F_3,\cdots\ .$$

Here the states that couple together (same J^P) are grouped together in parentheses. Similarly, only certain states are allowed for ΛΛ, etc.]

Interest in dibaryons rose dramatically in 1977 when strong energy dependence was unexpectedly observed in pp polarization experiments at Argonne.[4] Also, in that year and the next, Hoshizaki claimed the existence of dibaryon resonances in a pp partial-wave analysis.[5] In the same year Jaffe gave a detailed theoretical treatment of multiquark states.[6] There is now a vast literature on dibaryon resonances.

However, there is still disagreement about what "dibaryon resonances" are. There is little doubt of the existence of distinct structures in NN partial-wave amplitudes that look very much like ordinary highly inelastic resonances, such as are seen in πN scattering. The question is whether these structures are caused by resonance poles in the complex energy plane or by some other structure of the scattering amplitude.

One aspect of the arguments about dibaryon resonances is whether they are calculable in terms of quark theory or should instead be calculated using some hadron interaction theory without reference to the underlying quarks. Both approaches have had successes and failures, so possibly both will make contributions to unraveling the mysteries of dibaryon resonances.

The idea that dibaryon resonances are "pseudo-resonances"[7] has taken some new turns. The idea is that box diagrams (e.g., involving NΔ in NN scattering) create resonance-like loops in the Argand diagram without resonance poles actually existing. The problem with believing this is whether poles would be created when one unitarizes the box-diagram calculations in order to calculate physical scattering amplitudes. Kloet and Tjon[8] have recently shown that a model exists in which, indeed, this is the case. However, resonance hunters should definitely report pole positions rather than looping Argand diagrams in the future. All who suggest that the NN $^1D_2$ or $^3F_3$ resonance-like structure is a resonance or is instead due to some other dynamics must take their case to the world collection of NN scattering data in the form of a detailed partial-wave analysis, and should report the existence or nonexistence of resonance poles.

Closely related to the work described above is that by Ueda,[9] in which Faddeev πNN dynamics is fitted to the NN partial-wave amplitudes. Although the fit is not good, the approximately correct structure is present. The interesting point is that poles do occur on the "resonance" sheets in the complex energy plane. Ueda claims this work is important because many claims for resonance poles assume that the poles exist, but the Faddeev approach does not make such prior assumptions.

VerWest[10] recently reported separable potential model fits to the $^1D_2$ and $^3F_3$ NN amplitudes and claims some solutions had no resonance poles, but Kloet and Tjon[11] have shown that these potential model fits all do, indeed, have resonance poles.

The dinucleon resonances also communicate with the γd and πd channels. There is not much γd data, and the multipole analysis does not yield much certainty about which dibaryons are involved. In the πd case, uncertainties abound, and the partial-wave analysis yields poor fits compared to the NN analyses. In addition to NN analyses, results from partial-wave analyses of $\pi d \to \pi d$, $\pi d \to \pi pn$, $pp \to \pi d$, and $\gamma d \to pn$ scattering are listed below. Most of these strongly indicate the existence of dibaryon resonances in the $^1D_2$ and $^3F_3$ NN states, and some indicate possible resonances in the $^1S_0$, $^3S_1$, $^3P_1$, $^3P_2$, $^3D_3$, $^1F_3$, and $^1G_4$ states.

Since our last edition, many papers have been published about dibaryon resonances, but very little new hard information has emerged. There are ten new references for dinucleons and only one new reference for strange dibaryons giving new values for the resonance-pole (or Breit-Wigner) parameters. However, most of the new references for dinucleons are merely new fits to NN partial-wave amplitudes.

A notable paper is that of Semianczuk et al.,[12] in which two prominent peaks are seen in the np invariant mass spectrum from $dp \to (np)p$ deuteron breakup. However, a recent preprint by Katayama et al.[13] claims to have done a similar experiment and did not see the peaks.

Since our last edition, only one paper has appeared giving data for the strange dibaryon states. It appears that the strangeness −1 dominant resonance is in the $^3S_1$ state, an SU(3) partner of the deuteron. An excellent review is given by Dalitz.[14] He concludes that the $S = -1$ $^3S_1$ resonance pole probably exists. However, May et al.[15] report no enhancements in the $\Sigma^+ n$, $\Sigma^0 p$, or Λp invariant mass spectra in the $K^- d \to \pi^- X$ reaction, and Arenton et al.[16] report no enhancement in the Λp spectrum in the $pp \to \Lambda p K^+$ reaction.

In the Listings below, we separate the determinations of pole positions and Breit-Wigner parameters. To be a resonance, the pole must occur on the lower half of the second sheet for the elastic channel; it may be a bound state or resonance for inelastic channels.

In summary, this reviewer feels that the evidence, both experimental and theoretical, for the $^1D_2$ and $^3F_3$ dinucleon resonances is now very strong. The theoretical calculations almost all now agree that resonance poles occur in the NN amplitudes. The disagreement among production experiments is inherent in the difficulties of that kind of experiment; overlapping highly inelastic resonances are very difficult to see in final states.

For more detailed reviews of dibaryons, with a wide variety of opinions, see Hoshizaki,[17] Bugg,[18] Kamae,[19] Vinh Mau,[20] Kroll,[21] and Locher.[22]

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DIBARYONS

S=0 DIBARYONS

106 BARYON NUMBER 2, STRANGENESS 0 STATES

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IN THIS SECTION WE USE THE FOLLOWING ABBREVIATIONS FOR TYPES
OF ANALYSES--

DB       D P -> P P N (DEUTERON BREAKUP); INVARIANT MASSES
GDPN     GAMMA D -> P N PARTIAL-WAVE ANALYSIS RESONANCE
         PARAMETRIZATION
NN       FIT TO NN ELASTIC PARTIAL-WAVE ANALYSIS RESULTS
NNF      FIT TO NN FORWARD AMPLITUDES
NPT      NP TOTAL CROSS SECTION BREIT-WIGNER FIT
PID      PI- D ELASTIC PARTIAL-WAVE ANALYSIS RESONANCE
         PARAMETRIZATION
PIDC     PI D DIFFERENTIAL CROSS SECTION BREIT-WIGNER FIT
PIDI     PI D -> PI P N AMPLITUDE ANALYSIS RESONANCE
         PARAMETRIZATION
PNI      P N -> P P PI- CROSS SECTIONS BREIT-WIGNER FIT
PPPD     P P -> PI+ D PARTIAL-WAVE ANALYSIS RESONANCE
         PARAMETRIZATION
```

NN(2170) I=1, $^1D_2$ Status: **

→ **106 B=2, S=0, 1D2 -- BREIT-WIGNER MASS (MEV)**

```
    BREIT-WIGNER MASS APPROXIMATELY EQUALS RE(POLE POSITION).

M       (2170.0)             HOSHIZAKI 79 NN   1D2 ASSUMED BCDGRND  1/82
M       (2180.0)             ARVIEUX   80 PID  1D2                  1/82
M   A   (2185.0)             KAMO      80 PPPD 1D2                  1/82
M       (2170.0)             HOFTIEZE  81 PIDI 1D2                  1/82
M   B   (2140.0)             KANAI     81 PID  1D2 SOL. B AND C     1/82
M        2140. TO 2160.      DAKHNO    82 PNI  1D2                 12/83*
M   C   (2116.0)             UEDA      82 NN   1D2 FADDEEV ''FIT'' 12/83*
M
M   A  KAMO 80 DID NOT TRY FITS WITH FEWER THAN SIX RESONANCES.     1/82
M   B  KANAI 81 FIT WITH NO RESONANCES WAS VERY POOR AND DID NOT TRY 1/82
M   B  OTHER FITS WITH FEWER THAN FOUR RESONANCES.                  1/82
M   C  UEDA 82 REPORTS AS ''MASS'' BUT DOES NOT EXPLAIN HOW CALCULATED 12/83*
M   C  FROM POLE POSITION.                                         12/83*
```

106 B=2, S=0, 1D2 -- BREIT-WIGNER WIDTH (MEV)

```
    BREIT-WIGNER WIDTH APPROXIMATELY EQUALS 2 TIMES IM(POLE POSITION).

W        100. TO 150.        HOSHIZAKI 79 NN   1D2 ASSUMED BCKGRND  1/82
W   A   (134.0)              KAMO      80 PPPD 1D2                  1/82
W        (75.0)              HOFTIEZE  81 PIDI 1D2                  1/82
W   B    (56.0)              KANAI     81 PID  1D2 SOL. B           1/82
W   B    (54.0)              KANAI     81 PID  1D2 SOL. C           1/82
W         50. TO 100.        DAKHNO    82 PNI                      12/83*
W   C    (61.0)              UEDA      82 NN   1D2 FADDEEV ''FIT'' 12/83*
```

106 B=2, S=0, 1D2 -- BREIT-WIGNER ELASTICITY

```
    BREIT-WIGNER ELASTICITY APPROXIMATELY EQUALS
    ABS(RESIDUE OF POLE)/IM(POLE POS.).

R1        (0.1)              HOSHIZAKI 79 NN   1D2                  1/82
```

106 B=2, S=0, 1D2 -- RE(POLE POSITION) (MEV)

RE(POLE POSITION) APPROXIMATELY EQUALS BREIT-WIGNER MASS.

RE		(2045.0)		BHANDARI	81	NN	1D2 K-MATRIX FIT	1/82
RE		(2135.0)		BHANDARI	81	NN	1D2 M-MATRIX FIT	1/82
RE		(2150.0)		EDWARDS	81	NN	1D2 K-MATRIX FIT	1/82
RE	D	(2153.0)		KLOET	81	NN	1D2 POT. MODEL FIT	1/82
RE	E	(2110.0)		UEDA	82	NN	1D2 FADDEEV ''FIT''	12/83*
RE	F	2120. TO 2150.		BHANDARI	83	NN	1D2 M-MATRIX FIT	12/83*
RE	E	2149. TO 2150.		KLOET	83	NN	1D2 COUP. CHAN. FIT	12/83*

RE
RE D KLOET 81 DOES NOT SHOW GOODNESS OF FIT TO 1D2. 1/82
RE E NOT A GOOD FIT TO PARTIAL-WAVE AMPLITUDES. 12/83*
RE F BHANDARI 83 CLAIMS 1D2 IS AN N-DELTA BOUND STATE. 12/83*

106 B=2, S=0, 1D2 -- IM(POLE POSITION) (MEV)

IM(POLE POSITION) APPROXIMATELY EQUALS ONE-HALF BREIT-WIGNER WIDTH.

IM		(110.0)		BHANDARI	81	NN	1D2 K-MATRIX FIT	1/82
IM		(90.0)		BHANDARI	81	NN	1D2 M-MATRIX FIT	1/82
IM		(56.0)		EDWARDS	81	NN	1D2 K-MATRIX FIT	1/82
IM	D	(46.0)		KLOET	81	NN	1D2 POT. MODEL FIT	1/82
IM	E	(54.0)		UEDA	82	NN	1D2 FADDEEV ''MDFIT	
IM	F	80. TO 100.		BHANDARI	83	NN	1D2 M-MATRIX FIT	12/83*
IM	E	39. TO 45.		KLOET	83	NN	1D2 COUP. CHAN. FIT	12/83*

106 B=2, S=0, 1D2 -- ABS(RESIDUE)/IM(POLE POSITION)

ABS(RES)/IM(POLE POSITION) APPROXIMATELY EQUALS BREIT-WIGNER ELASTICITY.

RES		(0.175)		BHANDARI	81	NN	1D2 K-MATRIX FIT	1/82
RES		(0.2)		BHANDARI	81	NN	1D2 M-MATRIX FIT	1/82
RES		(0.29)		EDWARDS	81	NN	1D2 K-MATRIX FIT	1/82
RES	F	0.1 TO 0.3		BHANDARI	83	NN	1D2 M-MATRIX FIT	12/83*

NN(2250) I=1, $^3F_3$ Status: **

106 B=2, S=0, 3F3 -- BREIT-WIGNER MASS (MEV)

M	G	(2390.0)		GREIN	78	NNF	3F3	1/82
M		(2220.0)		HOSHIZAKI	78	NN	3F3 ASSUMED BCKGRND	1/82
M	H	2260. (FIXED)		IKEDA	80	GDPN	3F3 SOL. A	1/82
M		2296.0	11.0	IKEDA	80	GDPN	3F3 SOL. A'	1/82
M		2307.0	12.0	IKEDA	80	GDPN	3F3 SOL. B''	1/82
M	A	(2185.0)		KAMO	80	PPPD	3F3	1/82
M	B	(2260.0)		KANAI	81	PID	3F3 SOL. B AND C	1/82
M		2251. TO 2266.		BHANDARI	82	NN	3F3	12/83*
M		2220. TO 2260.		DAKHNO	82	PNI	3F3(OR 3D3/3G3) M	
M	G	(2310.0)		GREIN	82	NNF	3F3	12/83*
M	I	2200.0	10.0	SHAMU	82	NPT	3F3	12/83*
M	C	(2155.0)		UEDA	82	NN	3F3 FADDEEV ''FIT''	12/83*

M
M G GREIN 78 AND GREIN 82 SEE NO 1D2 RESONANCE. 1/82
M H IKEDA 80 GIVES TWO OTHER SOLUTIONS WITH POORER FITS TO DATA. 1/82
M I THIS IS AN N P RESONANCE. 12/83*

106 B=2, S=0, 3F3 -- BREIT-WIGNER WIDTH (MEV)

W	G	(290.0)		GREIN	78	NNF	3F3	1/82
W		50. TO 100.		HOSHIZAKI	78	NN	3F3 ASSUMED BCKGRND	1/82
W	H	200. (FIXED)		IKEDA	80	GDPN	3F3 SOL. A	1/82
W		177.0	32.0	IKEDA	80	GDPN	3F3 SOL. A'	1/82
W		213.0	54.0	IKEDA	80	GDPN	3F3 SOL. B''	1/82
W	A	(81.0)		KAMO	80	PPPD	3F3	1/82
W	B	(181.0)		KANAI	81	PID	3F3 SOL. B	1/82
W	B	(171.0)		KANAI	81	PID	3F3 SOL. C	1/82
W		70. TO 100.		BHANDARI	82	NN	3F3	12/83*
W		100. TO 200.		DAKHNO	82	PNI	3F3(OR 3D3/3G3)	12/83*
W	I	134.0	9.0	SHAMU	82	NPT	3F3	12/83*
W	C	(60.0)		UEDA	82	NN	3F3 FADDEEV ''FIT''	12/83*

106 B=2, S=0, 3F3 -- BREIT-WIGNER ELASTICITY

R1		(0.2)		HOSHIZAKI	78	NN	3F3	1/82
R1	J	0.11 TO 0.13		BHANDARI	82	NN	3F3	12/83*
R1	K	0.096	0.012	SHAMU	82	NPT	3F3	12/83*

R1 J BHANDARI 82 REPORTS R(PI D)=0.2 TO 0.3 AND R(N DELTA)=0.6 TO 0.7. 12/83*
R1 K THIS NP VALUE IS EQUIVALENT TO (0.19+-0.02) FOR PP. 12/83*

106 B=2, S=0, 3F3 -- RE(POLE POSITION) (MEV)

RE		(2190.0)		BHANDARI	81	NN	3F3 K-MATRIX FIT	1/82
RE		(2215.0)		BHANDARI	81	NN	3F3 M-MATRIX FIT	1/82
RE		(2185.0)		EDWARDS	81	NN	3F3 K-MATRIX FIT	1/82
RE		(2175.0)		KLOET	81	NN	3F3 POT. MODEL FIT	1/82
RE		2218. TO 2200.		BHANDARI	82	NN	3F3 BREIT-WIG. FIT	12/83*
RE	E	(2134.0)		UEDA	82	NN	3F3 FADDEEV ''FIT''	12/83*
RE	E	(2211.0)		VERWEST	82	NN	3F3 POT. MODEL FIT	12/83*
RE	L	2210. TO 2220.		BHANDARI	83	NN	3F3 M-MATRIX FIT	12/83*
RE	E	2148. TO 2149.		KLOET	83	NN	3F3 COUP. CHAN. FIT	12/83*
RE	M	2162. TO 2173.		KLOET	83	NN	3F3 COUP. CHAN. FIT	12/83*

RE L BHANDARI 83 CLAIMS 3F3 IS NOT AN N-DELTA BOUND STATE. 12/83*
RE M KLOET 83 FOUND TWO NEARBY 3F3 POLES. 12/83*

106 B=2, S=0, 3F3 -- IM(POLE POSITION) (MEV)

IM		(65.0)		BHANDARI	81	NN	3F3 K-MATRIX FIT	1/82
IM		(70.0)		BHANDARI	81	NN	3F3 M-MATRIX FIT	1/82
IM		(70.0)		EDWARDS	81	NN	3F3 K-MATRIX FIT	1/82
IM		(43.0)		KLOET	81	NN	3F3 POT. MODEL FIT	1/82
IM		45. TO 60.		BHANDARI	82	NN	3F3 BREIT-WIG. FIT	12/83*
IM	E	(52.0)		UEDA	82	NN	3F3 FADDEEV ''FIT''	12/83*
IM	E	(35.0)		VERWEST	82	NN	3F3 POT. MODEL FIT	12/83*
IM	L	60. TO 80.		BHANDARI	83	NN	3F3 M-MATRIX FIT	12/83*
IM	E	33. TO 38.		KLOET	83	NN	3F3 COUP. CHAN. FIT	12/83*
IM	M	43. TO 48.		KLOET	83	NN	3F3 COUP. CHAN. FIT	12/83*

106 B=2, S=0, 3F3 -- ABS(RESIDUE)/IM(POLE POSITION)

RES		(0.15)		BHANDARI	81	NN	3F3 K-MATRIX FIT	1/82
RES		(0.15)		BHANDARI	81	NN	3F3 M-MATRIX FIT	1/82
RES		(0.30)		EDWARDS	81	NN	3F3 K-MATRIX FIT	1/82
RES		0.08 TO 0.13		BHANDARI	82	NN	3F3 BREIT-WIG. FIT	12/83*
RES	L	0.1 TO 0.2		BHANDARI	83	NN	M-MATRIX FIT	12/83*

OTHER NN Status: *

106 B=2, S=0 MISCELL. -- BREIT-WIGNER MASS (MEV)

M	N	(2170.0)	(10.0)	ALADASHVI	76	DB	PP INVARIANT MASS	12/83*
M		(2250.0)		GREIN	80	NNF	3S1 OR 3D3	1/82
M		(2190.0)		HASHIMOTO	80	NN	1F3 ASSUMED BCKGRND	1/82
M		(2352.0)	(69.0)	IKEDA	80	GDPN	3S1 SOL. A	1/82
M		2380. (FIXED)		IKEDA	80	GDPN	3S1 SOL. A'	1/82
M		(2290.0)	(14.0)	IKEDA	80	GDPN	3P2 SOL. C	1/82
M		2380. (FIXED)		IKEDA	80	GDPN	3S1 SOL. C	1/82
M		(2377.0)	(17.0)	IKEDA	80	GDPN	3D3 SOL. B''	1/82
M	A	(2100.0)		KAMO	80	PPPD	1S0	1/82
M	A	(2117.0)		KAMO	80	PPPD	3P2	1/82
M	A	(2148.0)		KAMO	80	PPPD	3F2	1/82
M	A	(2159.0)		KAMO	80	PPPD	3P1	1/82
M	B	(2290.0)		KANAI	81	PID	3P2 SOL. B	1/82
M	B	(2300.0)		KANAI	81	PID	3P2 SOL. C	1/82
M	B	(2510.0)		KANAI	81	PID	1G4 SOL. B	1/82
M	B	(2530.0)		KANAI	81	PID	1S0 SOL. C	1/82
M		(2250.0)		GREIN	82	NNF	3S1 OR 3D3	12/83*
M		(2362.0)		AKEMOTO	83	PIDC		12/83*
M		(2429.0)		AKEMOTO	83	PIDC		12/83*
M		(2722.0)		AKEMOTO	83	PIDC		12/83*
M	N	(2020.0)		SIEMIARC	83	DB	NP INVARIANT MASS	12/83*
M	N	(2130.0)		SIEMIARC	83	DB	NP INVARIANT MASS	12/83*

M
M N KATAYAMA 83 DOES NOT SEE THESE ENHANCEMENTS. 12/83*

106 B=2, S=0 MISCELL. -- BREIT-WIGNER WIDTH (MEV)

W	N	(50.0)		ALADASHVI	76	DB	PP INVARIANT MASS	12/83*
W		(100.0)		GREIN	80	NNF	3S1 OR 3D3	1/82
W		(50.0)		HASHIMOTO	80	NN	1F3 ASSUMED BCKGRND	1/82
W		(342.0)	(69.0)	IKEDA	80	GDPN	3S1 SOL. A	1/82
W		200. (FIXED)		IKEDA	80	GDPN	3S1 SOL. A'	1/82
W		(263.0)	(55.0)	IKEDA	80	GDPN	3P2 SOL. C	1/82
W		200. (FIXED)		IKEDA	80	GDPN	3S1 SOL. C	1/82
W		(214.0)	(52.0)	IKEDA	80	GDPN	3D3 SOL. B''	1/82
W	A	(315.0)		KAMO	80	PPPD	1S0	1/82
W	A	(58.0)		KAMO	80	PPPD	3P2	1/82
W	A	(5.0)		KAMO	80	PPPD	3F2	1/82
W	A	(51.0)		KAMO	80	PPPD	3P1	1/82
W	B	(139.0)		KANAI	81	PID	3P2 SOL. B	1/82
W	B	(150.0)		KANAI	81	PID	3P2 SOL. C	1/82
W	B	(122.0)		KANAI	81	PID	1G4 SOL. B	1/82
W	B	(66.0)		KANAI	81	PID	1S0 SOL. C	1/82
W		(317.0)		AKEMOTO	83	PIDC		12/83*
W		(103.0)		AKEMOTO	83	PIDC		12/83*
W		(223.0)		AKEMOTO	83	PIDC		12/83*
W	N	(45.0)	(20.0)	SIEMIARC	83	DB	NP INVARIANT MASS	12/83*
W	N	(20.0)	(10.0)	SIEMIARC	83	DB	NP INVARIANT MASS	12/83*

106 B=2, S=0 MISCELL. -- BREIT-WIGNER ELASTICITY

R1		(0.12)		HASHIMOTO	80	NN	1F3 ASSUMED BCKGRND	1/82

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REFERENCES FOR B=2, S=0 STATES

ALADASHV 76 NP A274 486 — ALADASHVILI,GLAGOLEV+ (JINR+WARS+WINR)
GREIN 78 NP B137 173 — W GREIN,P KROLL (KARL+WUPP)
HOSHIZAK 78 PTP 60 1796 — N HOSHIZAKI (KYOT)
HOSHIZAK 79 PTP 61 129 — N HOSHIZAKI (KYOT)
ARVIEUX 80 NP A350 205 — J ARVIEUX,A S RINAT (GREN+REHO+SACL)
GREIN 80 PL 96B 176 — W GREIN,A KRONIG,P KROLL (SIN+WUPP)
HASHIMOT 80 PTP 64 1693 — K HASHIMOTO,N HOSHIZAKI (KYOT)
IKEDA 80 NP B172 509 — +ARAI,FUJII,FUJII,IWASAKI+ (TOKY+KEK+INUS)
KAMO 80 LNC 29 289 — H KAMO,W WATARI (OSAK)
ALSO 80 PTP 64 2144 — KAMO,WATARI,YONEZAWA (OSAK+HIRO)

BHANDARI 81 PRL 46 1111 — +ARNDT,ROPER,VERWEST (VPI+TAMU)
EDWARDS 81 PR D23 1978 — B J EDWARDS (ANL)
HOFTIEZE 81 PR C23 407 — +BAKER,CLEMENT,DRAGOSET+ (RICE+HOUS+BONN)
KANAI 81 PTP 65 266 — +MINAKA,NAKAMURA+ (TMU+KAGO+TWAS+SAGA)
KLOET 81 PL 106B 24 — W M KLOET,J A TJON (RUTG+UTRE)

BHANDARI 82 LNC 34 65 — R BHANDARI (VPI)
DAKHNO 82 PL 114B 409 — +KRAVTSOV,LOBACHEV,MAKAROV,MEDVEDEV+ (LENI)
ALSO 82 SJNP 36(1) 83 — +KRAVTSOV,LOBACHEV,MAKAROV,MEDVEDEV+ (LENI)
GREIN 82 NP A377 505 — W GREIN,P KROLL (SIN+WUPP)
SHAMU 82 PR D25 2008 — +SOGA,SHILTS,LISOWSKI (WMIU+LASL)
UEDA 82 PL 119B 281 — T UEDA (OSAK)
VERWEST 82 PR C25 482 — B J VERWEST (TAMU)

AKEMOTO 83 PRL 50 400 — +BABA,ENDO,HIMENIYA,INOUE+ (HIRO+UOEH)
BHANDARI 83 PR D27 296 — R BHANDARI (VPI)
KLOET 83 NP A392 271 — W M KLOET,T A TJON (ITPU)
SIEMIARC 83 PL 128B 367 — SIEMIARCZUK,STEPANIAK,ZIELINSKI (WINR)

PAPERS NOT REFERRED TO IN DATA CARDS

HIDAKA 77 PL 70B 479 — +BERETVAS,NIELD,SPINKA+ (ANL)
FRASCARI 80 PL 91B 345 — +BRISSAUD,DIDELEZ,PERRIN+ (IPN+GREN+NEUC)
KUBODERA 80 JPG 6 171 — +LOCHER,MYHRER,THOMAS (SIN+NORD+TRIU)
ARGAN 81 PRL 46 96 — +AUDIT,DEBOTTON,FAURE,MARTIN (SACL)
ARVIEUX 81 PL 103B 99 — J ARVIEUX (GREN+SACL)
BOLGER 81 PRL 46 167 — +BOSCHITZ,PROBSTLE,SMITH (KARL+SIN+ERLA+)
GREIN 81 JPG 7 1355 — W GREIN,M LOCHER (SIN)
HOLT 81 PRL 47 472 — +SPECHT,STEPHENSON,ZEIDMAN+ (ANL+LASL+)
KLOET 81 NP A364 346 — W KLOET,R SILBAR (RUTG+LASL)
MINEHART 81 PRL 46 1185 — +BOSWELL,DAVIS,DAY,MCCARTHY+ (VIRG+LASL)
MIZUTANI 81 PL 107B 177 — +FAYARD,LAMOT,NAHABETIAN (LYON+REGE)
RINAT 81 PL 104B 182 — A RINAT,J ARVIEUX (GREN+REHO+SACL)
TAMAS 81 NP A358 347 — G TAMAS (SACL)
LISOWSKI 82 PRL 49 255 — +SHAMU,AUCHAMPAUGH,KING,MOORE+ (LASL)
ABLEEV 83 NP A393 491 — +ABDUSHUKUROV,AVRAMENKO,DIMITROV+ (JINR)
KATAYAMA 83 PREPRINT — +KAJITA,KOISO,KUBOTA,SAI,SAKAMOTO+ (TOKY)
KLOET 83 PR C27 430 — W M KLOET,T A TJON (ITPU)

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Baryons

DIBARYONS

S=−1 DIBARYON

107 BARYON NUMBER 2, STRANGENESS -1 STATES

IN THIS SECTION WE USE THE FOLLOWING ABBREVIATIONS FOR TYPES OF ANALYSES--

BB	BARYON-BARYON SCATTERING COMBINED AMPLITUDE ANALYSIS
LNIM	LAMBDA-N INVARIANT MASS
LPIM	LAMBDA-P INVARIANT MASS
LPPIM	LAMBDA-P-PI INVARIANT MASS
SPIM	SIGMA-P INVARIANT MASS

ΛN(2130) I=1/2, $^3S_1$ Status: **

107 B=2, S=-1 -- BREIT-WIGNER MASS (MEV)

BREIT-WIGNER MASS APPROXIMATELY EQUALS RE(POLE POSITION).

M	A	2098.0	6.0	COHN	64	LNIM	Q=0	1/82
M	B	(2126.0)		CLINE	68	LPIM	3S1 Q=1	1/82
M	B	(2130.0)		ALEXANDER	69	LPIM	Q=1	1/82
M	C	(2130.0)		JAIN	69	LPIM	Q=1	1/82
M	B	2128.7	0.2	TAN	69	LPIM	Q=1	1/82
M	B	(2138.8)	(0.7)	TAN	69	LPIM	Q=1	1/82
M	B	(2129.0)		EASTWOOD	71	LPIM	Q=1	1/82
M	D	2127.0	1.0	SIMS	71	LPIM	LNIM Q=0,1	1/82
M	E	2125.2	2.5	SHAHBAZI	73	LPIM	Q=1	1/82
M	E	(2251.4)	(3.9)	SHAHBAZI	73	LPIM	Q=1	1/82
M	F	(2115.0)		SODHI	75	LPIM	Q=1	1/82
M	B	2129.0	0.4	BRAUN	77	LPIM	Q=1	1/82
M	G	(2130.0)		GOYAL	78	LPIM	Q=1	1/82
M	H	(2320.0)		GOYAL	80	SPIM	Q=0	1/82
M	I	(2255.5)	(0.4)	SHAHBAZIA	82	LPIM	Q=1 FIT 1	12/83*
M	I	(2257.4)	(2.3)	SHAHBAZIA	82	LPIM	Q=1 FIT 2	12/83*
M	I	(2350.8)	(2.4)	SHAHBAZIA	82	LPIM	Q=1 FIT 1	12/83*
M	I	(2358.4)	(1.3)	SHAHBAZIA	82	LPIM	Q=1 FIT 2	12/83*
M	I	(2495.2)	(8.7)	SHAHBAZIA	82	LPIM	Q=0,1	12/83*

M	A	SIGMA- D TO LAMBDA N X.	1/82
M	B	K- D TO PI- LAMBDA P.	1/82
M	C	GOYAL 71 RAISES DOUBTS ABOUT THE EXPERIMENTAL PROCEDURE USED	1/82
M	C	IN JAIN 69. JAIN STUDIED K- EMULSION TO LAMBDA P.	1/82
M	D	K- D TO PI- LAMBDA P, PI- LAMBDA PI+ N, AND PI- LAMBDA PIO P.	1/82
M	E	N P TO LAMBDA P X FOR P IN CARBON 12.	1/82
M	F	K- D TO PI- PIO LAMBDA P.	1/82
M	G	GOYAL 78 SEES ANOTHER UNCERTAIN PEAK AT 2195-2210 MEV.	1/82
M	G	K- D TO 2PI- PI+ LAMBDA P.	1/82
M	H	K- D TO PI+ PI- SIGMA- P.	1/82
M	I	SIMULTANEOUS FIT TO INVARIANT MASS AND LAMBDA-P ELASTIC	12/83*
M	I	SCATTERING EFFECTIVE CROSS SECTION.	12/83*

107 B=2, S=-1 -- BREIT-WIGNER WIDTH (MEV)

BREIT-WIGNER WIDTH APPROXIMATELY EQUALS 2 TIMES IM(POLE POSITION).

W	A	20.0	10.0	COHN	64	LPIM	Q=0	1/82
W	B	10. OR LESS		CLINE	68	LPIM	3S1 Q=1	1/82
W	C	(20.0)		JAIN	69	LPIM	Q=1	1/82
W	B	7.0	0.6	TAN	69	LPIM	Q=1	1/82
W	B	(9.1)	(2.4)	TAN	69	LPIM	Q=1	1/82
W	B	(10.)		EASTWOOD	71	LPIM	Q=1	1/82
W	D	8.0	1.0	SIMS	71	LPIM	Q=1	1/82
W	E	20.6	5.2	SHAHBAZI	73	LPIM	Q=1 2125 PEAK	1/82
W	E	(21.1)	(5.4)	SHAHBAZI	73	LPIM	Q=1 2251 PEAK	1/82
W	F	(150.0)		SODHI	75	LPIM	Q=1	1/82
W	B	5.9	1.6	BRAUN	77	LPIM	Q=1	1/82
W	H	(25.0)		GOYAL	80	SPIM	Q=0	1/82
W	I	(15.6)	(0.8)	SHAHBAZIA	82	LPIM	Q=1 FIT 1	12/83*
W	I	(18.1)	(1.1)	SHAHBAZIA	82	LPIM	Q=1 FIT 2	12/83*
W	I	(44.2)	(2.2)	SHAHBAZIA	82	LPIM	Q=1 FIT 1	12/83*
W	I	(77.2)	(6.6)	SHAHBAZIA	82	LPIM	Q=1 FIT 2	12/83*
W	I	(204.7)	(5.6)	SHAHBAZIA	82	LPIM	Q=0,1	12/83*

107 B=2, S=-1 -- RE(POLE POSITION) (MEV)

RE(POLE POSITION) APPROXIMATELY EQUALS BREIT-WIGNER MASS.

RE	J	(2132.0)	NAGELS	79	BB	3S1 Q=1	1/82
RE	J	(2137.0)	NAGELS	79	BB	3S1 Q=0	1/82
RE	B	(2129.0)	DOSCH	80	LPIM	3S1 Q=1	1/82
RE		(2127.0)	TAKAHASHI	80	BB	3S1 Q=0,1,2	1/82
RE		(2148.0)	TAKAHASHI	80	BB	1P Q=0,1,2	1/82

RE	J	NAGELS 79 REPORTS POLE POSITION FOR TWO DIFFERENT 3S1 CHARGE	1/82
RE	J	STATES.	1/82

107 B=2, S=-1 -- IM(POLE POSITION) (MEV)

IM(POLE POSITION) APPROXIMATELY EQUALS ONE-HALF BREIT-WIGNER WIDTH.

IM	J	(2.4)	NAGELS	79	BB	3S1 Q=1	1/82
IM	J	(2.6)	NAGELS	79	BB	3S1 Q=0	1/82
IM	B	(5.0)	DOSCH	80	LPIM	3S1 Q=1	1/82
IM		(9.0)	TAKAHASHI	80	BB	3S1 Q=0,1,2	1/82
IM		(8.0)	TAKAHASHI	80	BB	1P Q=0,1,2	1/82

REFERENCES FOR B=2, S=-1 STATES

COHN	64 PRL 22 668	H O COHN,K H BHATT,W M BUGG (ORNL+TENN)
CLINE	68 PRL 20 1452	D CLINE,R LAUMANN,J MAPP (WISC)
ALEXANDE	69 PRL 22 483	ALEXANDER,HALL,JEW,KALMUS,KERNAN (LBL+UCR)
JAIN	69 PR 187 1816	P L JAIN (BUFF)
TAN	69 PRL 23 395	T H TAN (SLAC)
EASTWOOD	71 PR D3 2603	+FRY,HEATHCOTE,ISLAN+ (BIRM+EDIN+GLAS+LOIC)
SIMS	71 PR D3 1162	+O'NEAL,ALBRIGHT,BRUCKER,LANUTTI (FSU)
SHAHBAZI	73 NP B53 19	B SHAHBAZIAN,A TIMONINA (JINR)
SODHI	75 NP B97 403	A SODHI,D GOYAL (DELH)
BRAUN	77 NP B124 45	+GRIMM,HEPP,STROEBELE,THOEL+ (HEID+MPIM)
GOYAL	78 PR D18 948	D GOYAL,A SODHI (DELH)
NAGELS	79 PR D20 1633	M NAGELS,T RIJKEN,J DESWART (NIJM)
DOSCH	80 ZPC 3 249	H DOSCH,I STAMATESCU (HEID)
GOYAL	80 PTP 64 700	D GOYAL,J MISRA (DELH)
TAKAHASH	80 NP A336 347	TAKAHASHI,IWAMURA,KIMURA,KUME (TOKY)
SHAHBAZI	82 NP A374 73C	SHAHBAZIAN,TEMNIKOV,TIMONINA (JINR)

PAPERS NOT REFERRED TO IN DATA CARDS

PIROUE	64 PL 11 164	P A PIROUE (PRIN)
ALEXANDE	68 PR 173 1452	+KASHORN,SHAPIRA+ (REHO+HEID)
BUNNEL	70 PR D2 98	+DERRICK,FIELDS,HYMAN,KEYES (NWES+ANL)
GOYAL	71 PR D3 1259	D P GOYAL (DELH)
KADYK	71 NP B27 13	+ALEXANDER,CHAN,GAPOSCHKIN,TRILLING (LBL)
DOSCH	78 PR D18 4071	H G DOSCH,V HEPP (HEID)
MIZUNO	79 PTP 62 1691	T MIZUNO (TOKY)
ROOSEN	79 NC B49 217	+VANDERVELDE-WILQUET,WICKENS+ (LOUC+BRUX)
D'AGOSTI	81 PL 104B 330	(ROMA+SACL+VAND)
KIMURA	81 PTP 65 649	M KIMURA,Y IWAMURA,Y TAKAHASHI (TOKY)
TOKER	81 NP A362 405	G TOKER,A GAL,J EISENBERG (HEBR+TELA)

S=−2 DIBARYON Status: *

108 BARYON NUMBER 2, STRANGENESS -2 STATES

IN THIS SECTION WE USE THE FOLLOWING ABBREVIATIONS FOR MEASURED QUANTITIES--

LLIM	LAMBDA-LAMBDA INVARIANT MASS
LLPI	LAMBDA-LAMBDA-PI INVARIANT MASS
XPIM	XI-P INVARIANT MASS

108 B=2, S=-2 -- MASS (MEV)

M	A	(2367.0)	(4.0)	BEILLIERE	72	LLIM	Q=0 GAUSSIAN FIT	1/82
M	B	(2365.3)	(9.6)	SHAHBAZIA	73	LLIM	Q=0	1/82
M	C	(2480.0)		GOYAL	80	XPIM	Q=0	1/82
M	B	(3568.3)		SHAHBAZIA	82	LPPI	Q=1	12/83*

M			
M	A	K- D TO XI- P KO.	1/82
M	B	N P TO LAMBDA LAMBDA X AND PI- P TO LAMBDA LAMBDA X FOR P IN C12.	1/82
M	C	GOYAL 80 ALSO SEES A SHOULDER AT 2360 MEV.	1/82

108 B=2, S=0 -- WIDTH (MEV)

W	A	(15.0)	(4.0)	BEILLIERE	72	LLIM	Q=0 GAUSSIAN FIT	1/82
W	B	(47.0)	(15.7)	SHAHBAZIA	73	LLIM	Q=0	1/82

REFERENCES FOR B=2, S=-2 STATES

BEILLIER	72 PL 39B 671	BEILLIERE,MAYEUR+ (BRUX+CERN+TUFT+LOUC)
SHAHBAZI	73 NP B53 19	B SHAHBAZIAN,A TIMONINA (JINR)
GOYAL	80 PR D21 607	D GOYAL,J MISRA,A SODHI (DELH)
SHAHBAZI	82 NP A374 73C	SHAHBAZIAN,TEMNIKOV,TIMONINA (JINR)

PAPERS NOT REFERRED TO IN DATA CARDS

CARROLL	78 PRL 41 777	+CHIANG,JOHNSON,KYCIA,KI,+ (BNL+PRIN)
D'AGOSTI	82 NP B209 1	(INFN+SACL+VAND+CERN)

APPENDIX I

THE STATUS OF THE STANDARD MODEL OF ELECTROWEAK INTERACTIONS

(by R.N. Cahn, LBL)

The standard SU(2)×U(1) model of electroweak interactions has (aside from the masses of the fermions and the Higgs boson) three fundamental parameters.[1] Thus the model is fully specified by measuring three independent constants. Two of these are well established: $G_F = 1.16637\times10^{-5}$ GeV^{-2} and $\alpha = 1/137.036$. The measurement of one more parameter suffices to determine all the predictions of the theory, assuming that quark distributions in the hadrons are known and that radiative corrections can be dealt with. For the present we ignore radiative corrections.

Prior to the discoveries of the W and Z, the third measurement was made in neutral-current experiments and conventionally expressed in terms of $\sin^2\theta_W$. See the section on the Standard Model of Electroweak Interactions. The usual model, which has only doublet Higgs bosons, has the value unity for the parameter $\rho = M_W^2/(M_Z^2\cos^2\theta_W)$, ignoring radiative corrections. A multitude of neutral-current experiments have produced values for the mixing angle which are in good agreement and thus provide strong evidence for the standard model. Among the experiments are:

1. Neutrino and antineutrino deep inelastic scattering from isosinglet targets.
2. Neutrino and antineutrino deep inelastic scattering by protons.
3. Elastic $\nu_\mu p$ and $\overline{\nu}_\mu p$ scattering.
4. Exclusive and inclusive π production in neutral-current events.
5. Neutrino disintegration of the deuteron: $\overline{\nu}_e d \to \overline{\nu}_e np$.
6. Polarized-electron deuteron deep inelastic scattering.
7. Forward-backward asymmetry in $e^+e^- \to \mu^+\mu^-$.
8. Elastic νe scattering.

The data for these processes and a comparison with the predictions of the standard model are given in two extensive reviews.[2,3] The conclusion of these and all similar studies is that all available data are consistent with the standard model. Moreover, if it is treated as a free parameter, the value of ρ is consistent with unity, the value it has in the simplest model. For example, Kim et al. find $\rho = 1.002 \pm 0.015 \pm (0.011)$ and $\sin^2\theta_W = 0.234 \pm 0.013 \pm (0.009)$, where the parentheses indicate a theoretical uncertainty. If only the data from deep inelastic scattering and from the e-d experiment are used, the results are $\rho = 0.992 \pm 0.017 \pm (0.011)$ and $\sin^2\theta_W = 0.224 \pm 0.015 \pm (0.012)$.

Some of the most precise data are used in the accompanying figure, which shows the region of the ρ—$\sin^2\theta_W$ plane allowed by data for deep inelastic scattering from an isoscalar target and for the scattering of polarized electrons by deuterons. It is important to notice that the allowed values of the two variables are correlated. The curves were obtained from the following formulas:

$$R_{\nu N} = \frac{\sigma^{NC}_{\nu N}}{\sigma^{CC}_{\nu N}} = \rho\frac{\frac{1}{2} - \sin^2\theta_W + \frac{20}{27}\sin^4\theta_W + \epsilon(\frac{1}{6} - \frac{1}{3}\sin^2\theta_W + \frac{20}{27}\sin^4\theta_W)}{1 + \frac{1}{3}\epsilon},$$

$$R_{\overline{\nu}N} = \frac{\sigma^{NC}_{\overline{\nu}N}}{\sigma^{CC}_{\overline{\nu}N}} = \rho\frac{\frac{1}{6} - \frac{1}{3}\sin^2\theta_W + \frac{20}{27}\sin^4\theta_W + \epsilon(\frac{1}{2} - \sin^2\theta_W + \frac{20}{27}\sin^4\theta_W)}{\frac{1}{3} + \epsilon}.$$

The parameter ϵ is the ratio of antiquark momentum to quark momentum in the nucleon. It is related to the ratio of the neutrino charged-current cross section to the antineutrino charged-current cross section:

$$\frac{\sigma^{CC}_{\nu N}}{\sigma^{CC}_{\overline{\nu}N}} = \frac{1 + \frac{1}{3}\epsilon}{\frac{1}{3} + \epsilon}.$$

The curves correspond to the limits $R_{\nu N} = 0.31 - 0.33$, $R_{\overline{\nu}N} = 0.357 - 0.397$, indicative of the results of the CHARM collaboration,[4] with ϵ taken to be 0.20.

The polarized-electron deuteron scattering experiment measured the asymmetry in the cross section for left-handed (σ_L) and right-handed (σ_R) electrons:

$$A = \frac{\sigma_R - \sigma_L}{\sigma_R + \sigma_L}.$$

In the quark parton model, this has the form (with $q^2 > 0$ for deep inelastic scattering)

$$\frac{A}{q^2} = a_1 + a_2\left[\frac{1-(1-y)^2}{1+(1-y)^2}\right],$$

where y is the fraction of the incident lepton's energy lost in the collision. For an isoscalar target like the deuteron, and ignoring the antiquarks, the standard model gives

$$a_1 = -\frac{G_F}{2\sqrt{2}\pi\alpha}\frac{9}{10}\rho\left(1 - \frac{20}{9}\sin^2\theta_W\right)$$

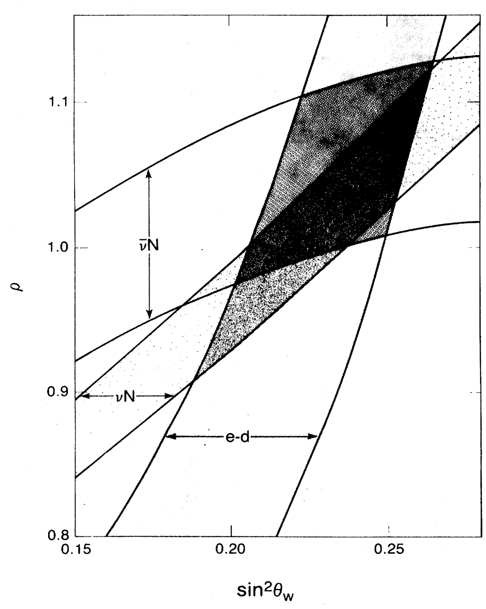
$$a_2 = -\frac{G_F}{2\sqrt{2}\pi\alpha}\frac{9}{10}\rho\left(1 - 4\sin^2\theta_W\right).$$

The best determined linear combination of the parameters a_1 and a_2 is

$$0.24a_2 + 0.97a_1 = (-8.1 \pm 1.1)\times10^{-5}\ \text{GeV}^{-2}.$$

This is inferred from Ref. 5, and the uncertainty corresponds to 1σ. The 1σ extremes are shown in the figure.

Once the masses of the W and Z are known, either one or their ratio (or any other single combination) can be used as the third



measured parameter, replacing the neutral-current data. For example, we can use the ratio of the masses as the third parameter. Then $\sin^2\theta_W$ is simply a parameter derived from the measured quantities G_F and α. It can always be eliminated from any expression in favor of G_F, α, and M_W/M_Z. It is convenient, however, to retain it by defining:

$$\cos^2\theta_W = M_W^2/M_Z^2 .$$

This is now a definition and is not modified by radiative corrections.[6] However, the lowest order prediction for M_W^2 is modified by corrections of order α:

$$M_W^2 = \frac{\pi\alpha}{\sqrt{2}G_F\sin^2\theta_W(1-\Delta r)} .$$

The quantity Δr is of order α and depends on the masses of the leptons, quarks, and Higgs boson. The dominant terms are due to vacuum polarization by light fermions. If the t quark mass is set to 36 GeV and the Higgs boson mass to the mass of the Z, the value of Δr is 0.0696 ± 0.0020. This value is not very sensitive to these last two assumed values.

As of this writing (December 1983) the most recent results[7,8] from the UA-1 and and UA-2 experiments at the CERN SPS collider for the W and Z masses are (in GeV)

	M_W	M_Z
UA-1	80.9 ± 1.5(*stat*)	95.6 ± 1.4(*stat*)
UA-2	$81.0 \pm 2.5 \pm 1.3$	$91.9 \pm 1.3 \pm 1.4$

Thus we find from the definition of $\cos^2\theta_W$

	$\sin^2\theta_W$
UA-1	0.284 ± 0.016(*stat*)
UA-2	0.223 ± 0.027(*stat*)

The systematic uncertainties may make the total uncertainty about twice as large as the indicated statistical uncertainties.

Given the uncertainties in the data above, a detailed test of the model is not possible. That the neutral-current data are consistent with $\rho = 1$ and with a single value of $\sin^2\theta_W$ is important evidence for the model. Moreover, the W and Z masses are consistent with this value for the weak mixing angle. A detailed test of the model awaits higher precision data on the weak boson masses. Such data will permit a single test involving the four measured parameters α, G_F, M_W, and M_Z, and one additional test comparing the derived quantity $\sin^2\theta_W$ with the value obtained in neutral-current experiments. In making this comparison, it will be necessary to include radiative corrections for the neutral-current experiments.[9] Their effect is to lower the values of $\sin^2\theta_W$ discussed in connection with the neutral-current experiments to a value 0.217 ± 0.014.

Should such a high-precision test reveal a discrepancy with the radiatively corrected theory, it could indicate that the model needs fundamental modification. Small deviations from the predictions described above could arise if the t quark mass or Higgs boson mass is far from the value assumed or if there are additional generations of fermions. At present there is no indication of the need for a modification of the theory, but the tests are not yet very stringent.

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APPENDIX II

THE PERTURBATIVE QCD COUPLING CONSTANT

(by I. Hinchliffe, LBL)

This note is concerned with the definition of the running coupling constant and of the scale parameter Λ in QCD. It is intended to be pedagogical rather than rigorous; one of the many excellent reviews can be consulted for more details.[1]. Comments will be made on the theoretical uncertainties inherent in attempts to extract Λ from the data, but no critique of individual experiments will be given.

In the limit of zero quark masses QCD contains only one fundamental parameter, its coupling constant (α_s). In a field theory it is necessary to define a coupling constant order by order in perturbation theory. If a process is calculated beyond leading order, divergences can arise in the integrations over momenta flowing in closed loops of Feynman diagrams. These divergences are removed by absorbing them into a renormalized coupling constant (α). In order to do this, α is defined in terms of some quantity calculated to the same order in perturbation theory. This constitutes the renormalization scheme.

In the familiar case of QED, the coupling constant (α_{EM}) is defined to be the value of the photon-electron-electron coupling in the limit of zero photon momentum when the electrons are on their mass shells (mass-shell renormalization scheme). This definition is readily related to the scattering rate for low-energy electrons off a static source. Notice that the relevant energy scale characterizing the coupling constant definition is the electron mass (m_e). If some other QED process with momentum scale Q is calculated (e.g., $e^+e^- \to e^+e^-$ at wide angle and with center-of-mass energy $\sqrt{s} = Q >> m_e$), the cross section can be written as a power series in α_{EM} and will have the following form

$$A\left[1 + \frac{B\alpha_{EM}}{\pi}\log(Q^2/m_e^2) + \cdots\right].$$

Here the term A is the rate calculated to lowest nontrivial order in α_{EM}, and B is constant. In the $e^+e^- \to e^+e^-$ case, $A \propto \alpha_{EM}^2/s$. In the asymptotic limit $Q >> m_e$, the term $\frac{B\alpha_{EM}}{\pi}\log(Q^2/m_e^2)$ could become of order one, and the perturbation series would fail to converge. Fortunately these terms, and all terms of order $\alpha_{EM}^N\log^N(Q^2/m_e^2)$, can be summed. This summation leads to the introduction of a coupling constant which depends on Q. This running coupling constant $\alpha_{REM}(Q)$ is such that $\alpha_{REM}(m_e) = \alpha_{EM}$, and if $\alpha_{REM}(Q)$ is expanded as a power series in α_{EM} and inserted into the term A, all the terms $\alpha_{EM}^N \log^N(Q^2/m_e^2)$ are reproduced.

In QED, $\alpha_{REM}(Q)$ is a rather slow function of Q increasing with Q so that $\alpha_{REM}(m_w) \approx 1/128$.[2] In contrast, the running coupling constant in QCD decreases relatively rapidly as Q rises due to the self-interactions of the gluons.[3] The coupling constant is large at Q $\approx m_\pi$, the scale of hadronic binding. A perturbation expansion will not therefore enable one to calculate the hadron spectrum and obtain α_s from the values of the hadron masses.

In the absence of strong coupling techniques we are restricted to using perturbation theory to calculate processes from QCD and to determine α_s. We can only use processes which have a large momentum scale and hence a small α_s. As an illustration consider the ratio

$$R = \frac{\sigma(e^+e^- \to \text{hadrons})}{\sigma(e^+e^- \to \mu^+\mu^-)}$$

$$\equiv 3\sum_i Q_i^2 \left(1 + \frac{\alpha_s(s)}{\pi} + N\frac{\alpha_s^2(s)}{\pi^2} + \cdots\right). \quad (1)$$

Here we are assuming that $\sqrt{s}$, the center-of-mass energy, is large compared to quark masses; the sum i runs over all quarks of charge Q_i and N is a numerical factor. We have used $\alpha_s(s)$ since $\sqrt{s}$ is the only scale present in the problem. If we assume that $N\alpha_s(s)/\pi \ll 1$, then, by comparing with data to leading order in $\alpha_s(s)$ [the $\alpha_s(s)/\pi$ term], we could determine $\alpha_s(Q)$, confident that the leading terms reproduce the full perturbation series fairly well.

It is usual to introduce the parameter Λ to parametrize the Q^2 dependence of $\alpha_s(Q^2)$:[3]

$$\alpha_s(Q^2) = \frac{12\pi}{(33-2f)\log(Q^2/\Lambda^2)}, \quad (2)$$

where f is the number of quark flavors with mass less than Q/2. Λ now appears as the fundamental parameter in QCD. Unfortunately if we do not know the coefficient N in Eq. (1), then Λ is arbitrary in the following sense. Rescale $\Lambda = x\Lambda'$; then

$$\alpha_s(Q^2,\Lambda) = \alpha_s(Q^2,\Lambda')\left[1 + \frac{(33-2f)}{6\pi}\alpha_s(Q^2,\Lambda')\log x + O(\alpha_s^2)\right].$$

If Eq. (1) is now rewritten as a series in $\alpha_s(Q^2,\Lambda')$, then the coefficient N will change. If we have neglected this term, then Λ and Λ′ are equivalent! A fit to the data to leading order can of course still be used to determine a Λ_{LO} defined by Eq. (2), but we have no guarantee that another process will yield the same Λ_{LO}. The situation only clarifies (or becomes more muddled depending on one's point of view) when we know the coefficient N.

We should of course check that $N\alpha_s(s)/\pi \ll 1$, so that the perturbation series is reliable. Unfortunately N is not well defined; it depends on the renormalization scheme. We cannot define α_s in the same way as α_{EM} was defined in QED, since perturbation theory is unreliable in that region of momenta. One possibility is to define $\alpha_s(Q^2)$ as the value of the three-gluon vertex (or quark-quark-gluon vertex) when the invariant masses of the particles are $-Q^2$. This is the momentum-space scheme,[4] and α_s is denoted by $\alpha_{MOM}(Q^2)$. $\alpha_{MOM}(Q^2)$ is not related directly to any physical process. The scheme is difficult to calculate with and produces a gauge-dependent $\alpha_s(Q^2)$; much more convenient is the minimal-subtraction scheme (MS). Here loop integrals are evaluated in n dimensions. The divergences appear as singularities of the form $1/(n-4)$. These terms are dropped and $\alpha_{MS}(Q^2)$ so defined.[5] These singularities are always accompanied by log 4π and the Euler constant $\gamma_E = 0.577\cdots$; these can be dropped also (the $\overline{MS}$ scheme) and an $\alpha_{\overline{MS}}(Q^2)$ defined.[6] The coupling constants in all these schemes are related as follows (α_{MOM} is defined in Feynman gauge):

$$\alpha_{MOM}(Q^2) = \alpha_{MS}(Q^2)\left[1 + x\alpha_{MS}(Q^2)\cdots\right],$$

$$x = 3.57 - 0.38f;$$

$$\alpha_{MOM}(Q^2) = \alpha_{\overline{MS}}(Q^2)\left[1 + x'\alpha_{\overline{MS}}(Q^2)\cdots\right],$$

$$x' = 1.86 - 0.48f.$$

The $\overline{MS}$ and MOM schemes are most frequently used. Other schemes are also possible; for example we could define $\alpha_R(Q^2)$ so that

$$R \equiv 3\sum Q_i^2\left[1 + \frac{\alpha_R(Q^2)}{\pi}\right]$$

with no correction at $Q^2 = s_0$. Then

$$\alpha_R(s_0) = \alpha_{\overline{MS}}(s_0)\left[1 + N'\frac{\alpha_{\overline{MS}}(s_0)}{\pi}\right]$$

with $N' = 2 - 0.1f$.[7]

It is now clear that N will depend on the scheme so that the size of $N\alpha_s/\pi$ is a scheme dependent. This simple fact can lead to long discussions about which scheme is best and which processes have reliable perturbation expansions.[8]

Beyond leading order Eq. (2) does not accurately represent the Q^2 dependence of $\alpha_s(Q^2)$. To next order we have

$$\alpha_s(Q^2) = \frac{12\pi}{(33-2f)\log(Q^2/\Lambda^2)}$$

$$\times\left\{1 - \frac{6(153-19f)}{(33-2f)^2}\frac{\log\left[\log(Q^2/\Lambda^2)\right]}{\log(Q^2/\Lambda^2)} + \frac{D}{\log(Q^2/\Lambda^2)}\right\} \quad (3)$$

where D is arbitrary to this order. If $\alpha = \alpha_{\overline{MS}}$, it is customary[6] to define $\Lambda_{\overline{MS}}$ from Eq. (3) with D = 0; but other definitions are possible. It seems that some confusion could be avoided by abolishing Λ and simply quoting $\alpha_s(Q^2)$ in some scheme at some $Q^2 = Q_0^2$.

There are several more theoretical complications in QCD predictions. In the case of R the scale Q^2 was unambiguous; this is not always the case. For example, the production of three jets in e^+e^- collisions is predicted by QCD but is Q^2 equal to s or to the invariant mass of a jet pair? To leading order in QCD, we cannot tell. The coefficient of the next-to-leading term will change if Q^2 is changed (c.f., the shift in N as Λ was rescaled above), further complicating the issue of whether the perturbation series is reliable.

Many processes are also subject to "higher twist corrections." For example, if we retain quark masses, R receives corrections depending on m_q^2/s so that extra parameters enter QCD predictions. Some higher twist corrections are purely kinematic in origin and can be calculated if the quark masses are known. Unfortunately other higher twist corrections cannot be calculated (e.g., those in deep inelastic scattering); they are all of order $1/Q^2$ relative to the perturbation theory, but the coefficients are unknown.

In comparing quoted values for α_s or Λ, the following must be considered:

1. What order in perturbation theory was used?
2. What renormalization scheme was used?
3. What scale Q^2 was used?
4. If the Q range of the experiment covers some quark masses, how were thresholds dealt with?
5. How were higher twist terms parametrized?

For example, attempts have been made to extract α_s (or Λ) from data on 3-jet events in e^+e^- annihilation. Issues 1 and 5 appear to be pertinent here. The perturbation expansion is not very reliable[9] so the value of Λ depends on the order used. Issue 5 manifests itself in the dependence of α_s upon Monte Carlo program parameters used to parametrize jet fragmentation.[10] Values of α_s quoted from these data range from 0.12 to 0.21.[10] In contrast, data on deep inelastic scattering do not suffer from problems concerning the perturbation theory, and values of Λ_{LO} range from 125 to 275 MeV.[11]

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APPENDIX III

THE KOBAYASHI-MASKAWA MIXING MATRIX

(by F.J. Gilman, SLAC)

In the "standard model" with SU(2)×U(1) as the gauge group of electroweak interactions, both the quarks and leptons are assigned to be left-handed doublets and right-handed singlets. The quark mass eigenstates are not the same as the weak eigenstates, and the matrix connecting them has become known as the Kobayashi-Maskawa matrix[1] since an explicit parametrization in the six-quark case was first published by them in 1973.

By convention, the three charge 2/3 quarks (u, c, and t) are unmixed, and all the mixing is expressed in terms of a 3×3 unitary matrix V operating on the charge $-1/3$ quarks (d, s, b):

$$\begin{pmatrix} d' \\ s' \\ b' \end{pmatrix} = \begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix} \begin{pmatrix} d \\ s \\ b \end{pmatrix} . \tag{1}$$

Kobayashi and Maskawa[1] themselves used a parameterization involving four angles, θ_1, θ_2, θ_3, δ:

$$\begin{pmatrix} d' \\ s' \\ b' \end{pmatrix} = \begin{pmatrix} c_1 & -s_1c_3 & -s_1s_3 \\ s_1c_2 & c_1c_2c_3 - s_2s_3e^{i\delta} & c_1c_2s_3 + s_2c_3e^{i\delta} \\ s_1s_2 & c_1s_2c_3 + c_2s_3e^{i\delta} & c_1s_2s_3 - c_2c_3e^{i\delta} \end{pmatrix} \begin{pmatrix} d \\ s \\ b \end{pmatrix} , \tag{2}$$

where $c_i = \cos\theta_i$ and $s_i = \sin\theta_i$ for i = 1,2,3. In the limit $\theta_2 = \theta_3 = 0$, this reduces to the usual Cabibbo mixing with θ_1 identified with the Cabibbo angle (up to a sign). The angles θ_1, θ_2, θ_3 can all be made to lie in the first quadrant (so that all s_i, c_i are positive) by an appropriate redefinition of quark field phases.

Slightly different forms of the Kobayashi-Maskawa parametrization are found in the literature. The K-M matrix used in the 1982 Review of Particle Properties is obtained by letting $s_1 \to -s_1$ and $\delta \to \delta+\pi$ in the matrix given above. An alternative used in another review[2] is to change Eq. (2) by $s_1 \to -s_1$ but leave δ unchanged. With this change in s_1, θ_1 becomes the usual Cabibbo angle, with the "correct" sign (i.e., $d' = d\cos\theta_1 + s\sin\theta_1$), in the limit $\theta_2 = \theta_3 = 0$. The angles θ_1, θ_2, θ_3 can, as before, all be taken to lie in the first quadrant by adjusting quark field phases. Since all these parametrizations are referred to as "the" Kobayashi-Maskawa form, some care about which one is being used is needed when the quadrant in which δ lies is under discussion.

A quite different parametrization is due to Maiani[3] in terms of angles θ, β, γ, and δ':

$$V = \begin{pmatrix} c_\beta c_\theta & c_\beta s_\theta & s_\beta \\ -s_\gamma c_\theta s_\beta e^{i\delta'} - s_\theta c_\gamma & c_\gamma c_\theta - s_\gamma s_\beta s_\theta e^{i\delta'} & s_\gamma c_\beta e^{i\delta'} \\ -s_\beta c_\gamma c_\theta + s_\gamma s_\theta e^{-i\delta'} & -c_\gamma s_\beta s_\theta - s_\gamma c_\theta e^{-i\delta'} & c_\gamma c_\beta \end{pmatrix} \tag{3}$$

where $c_\beta = \cos\beta$, $s_\beta = \sin\beta$, etc. With $\beta = \gamma = 0$, the first two generations of quarks decouple from the third, and θ is directly the Cabibbo angle. No physics can depend on which of the above parametrizations (or any other) is used as long as it is used consistently and care is taken to be sure that no other choice of phases is in conflict.

The values of individual Kobayashi-Maskawa matrix elements can in principle all be determined from weak decays of the relevant quarks, or, in some cases, from deep inelastic neutrino scattering. Our present knowledge comes from the following sources:

(1) Nuclear beta decay, when compared to muon decay, gives

$$|V_{ud}| = 0.9737 \pm 0.0025 \tag{4}$$

in one evaluation[4] and

$$|V_{ud}| = 0.9730 \pm 0.0024 \tag{5}$$

in another.[5]

(2) An analysis of hyperon and $K_{\ell 3}$ decays yielded[4]

$$|V_{us}| = 0.219 \pm 0.011 , \tag{6}$$

where the quoted uncertainty includes a statistical minimization error of ± 0.003 and an estimate of $\sim 5\%$ theoretical uncertainty due to SU(3) symmetry breaking. For the hyperon decays this involved a simultaneous χ^2 fit to $|V_{us}|$ and the SU(3) parameter $\alpha_D = D/(D+F)$. A subsequent analysis using some new data on hyperon decays and similar theoretical inputs for form factors, etc., gave[5]

$$|V_{us}| = 0.227 \pm 0.003 \pm 0.013 . \tag{7}$$

The first error is statistical and the second represents an estimate of the effect of SU(3) symmetry breaking. A recent CERN hyperon experiment carried out a series of different Cabibbo fits with various experimental and theoretical inputs.[6] Results are quoted for the effective "vector" and "axial-vector" Cabibbo angles and the overall Cabibbo angles (see Table III of Ref. 6). A representative value is

$$|V_{us}| = 0.231 \pm 0.003 , \tag{8}$$

where the quoted error is statistical and does not include an estimate of the uncertainty due to SU(3) symmetry breaking.

(3) From neutrino and antineutrino production of charm, the CDHS group has deduced[7]

$$|V_{cd}| = 0.24 \pm 0.03 . \tag{9}$$

Values of $|V_{cs}|$ from such experiments are dependent on assumptions about the strange quark density in the parton-sea and are not well enough constrained to give information which is not already in hand from $|V_{cd}|$ and $|V_{cb}|$ (see below), plus unitarity.

(4) The ratio $|V_{ub}/V_{cb}|$ is obtained from the semileptonic decay of B mesons by fitting to the lepton energy spectrum as a sum of contributions involving $b \to u$ and $b \to c$. The relative overall phase space factor between the two processes is calculated from the usual four-fermion interaction with one massive fermion

(c quark or u quark) in the final state. The value of this factor is between 0.4 and 0.5, depending on the quark masses used. We use 0.45, in which case the experimental lack of observation of the hard lepton spectrum characteristic of $b \to u\ell\bar{\nu}_\ell$, which is quoted as a limit[8]

$$\frac{\Gamma(b \to u\ell\bar{\nu}_\ell)}{\Gamma(b \to c\ell\bar{\nu}_\ell)} < 0.05 \,, \tag{10}$$

translates to

$$\frac{|V_{ub}|}{|V_{uc}|} < 0.15 \,. \tag{11}$$

There are some theoretical uncertainties in this analysis stemming from the fact that the physical decays involve actual hadrons, primarily pseudoscalar B mesons, and not free quarks as is assumed in the calculations of the lepton spectra for $b \to u\ell\bar{\nu}_\ell$ and $b \to c\ell\bar{\nu}_\ell$.

(5) The magnitude of V_{cb} itself can be determined if the measured semileptonic bottom hadron partial width is assumed to be that of a b quark decaying through the usual V-A interaction:

$$\Gamma(b \to c\ell\bar{\nu}_\ell) = \frac{BR(b \to c\ell\bar{\nu}_\ell)}{\tau_b} = \frac{G_F^2 m_b^5}{192\pi^3} F(m_b, m_c)\,|V_{cb}|^2 \,, \tag{12}$$

where τ_b is the b lifetime and $F(m_b, m_c)$ is the phase space factor chosen above as 0.45. Following S. Stone[8] and using an average semileptonic branching ratio of 0.116 ± 0.006 (which from Eq. (10) is $BR(b \to c\ell\bar{\nu}_\ell)$ to withing 5%), a bottom hadron lifetime between 0.6 and 1.4×10^{-12} sec, and m_b between 4.8 and 5.2 GeV/c^2:

$$0.036 < |V_{cb}| < 0.070 \,. \tag{13}$$

Using Eqs. (4), (6), (11), and (13) together with unitarity and the assumption that there are only three generations, the 90% confidence limits on the magnitude of matrix elements of the complete matrix are:[8]

$$\begin{bmatrix} 0.9705 \text{ to } 0.9770 & 0.21 \text{ to } 0.24 & 0. \text{ to } 0.014 \\ 0.21 \text{ to } 0.24 & 0.971 \text{ to } 0.973 & 0.036 \text{ to } 0.070 \\ 0. \text{ to } 0.024 & 0.036 \text{ to } 0.069 & 0.997 \text{ to } 0.999 \end{bmatrix} .$$

Similar values for these matrix elements, are found in several other analyses.[9,10] The ranges shown are for the individual matrix elements. The constraints of unitarity connect different elements, so choosing a specific value for one element restricts the range of the others. The data do not preclude there being more than three generations. However, the entries deduced from unitarity might be altered when the K-M matrix is expanded to accommodate more generations.

Further information on the angles requires theoretical assumptions. In particular, as CP-violating amplitudes involve $\sin\delta$, assuming that observed CP violation is solely related to a nonzero value of δ allows additional constraints to be brought to bear. While hadronic matrix elements whose values are imprecisely known now enter, the constraints from CP violation in the neutral kaon system are tight enough that there may be no solution at all for certain quark masses, values of δ, etc. See Refs. 11, 12, and 13. Additional correlated bounds on quark masses and mixing angles can be obtained from $K_L^0 \to \mu^+\mu^-$, which involves a hadronic matrix element known from $K_{\ell 3}$ decay.[14]

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ACCESSING AND USING PARTICLE PHYSICS DATABASES

A number of publicly accessible computer databases containing particle physics information now exist at various institutions. Some of these databases are for literature searching, allowing the user to locate papers of interest, while others contain actual numerical data. The following discussion gives some idea of what is available and how to get started using these databases. The two locations covered are SLAC and Rutherford Appleton Laboratory (RAL).

The SLAC Particle Physics Databases

The databases of interest at SLAC are: (1) HEP, a literature-searching guide for all particle physics journal articles, preprints, reports, theses, etc., indexed by the standard bibliographic quantities and, starting sometime in mid-1984, also indexed by accelerator, detector, beam momentum, reactions and particles studied, etc.; (2) RPP, containing the Data Card Listings from the Review of Particle Properties, indexed by particle property; and (3) EXPERIMENTS, a guide to current and past particle physics experiments, indexed similarly to the HEP database. In addition, it is hoped that the Durham-RAL databases discussed below will also be available at SLAC in the near future.

All these databases are managed by the SPIRES database management system, which runs interactively under VM/CMS on SLAC's mainframe IBM computers. To enter SPIRES, once you are logged onto the computer, key in CALL SPIRES. You can then obtain information about the database you are interested in by typing in, say, EXPLAIN RPP. To actually access the database, enter, for example, SELECT RPP. You may then find out what terms are available for searching on by keying in SHOW INDEXES. To see the form of the contents of a particular index, say the PP (particle property) index of the RPP database, key in BROWSE PP; this will give you an idea of what kinds of expressions appear in this index, and thus will suggest what form you should use in your search. Then to do an actual search for information, say for the RPP Data Card Listings on the η meson mass, you would key in a command like FIND PP ETA MASS, followed by the command TYPE; this would print out the Listings for the η mass. At any time, you may get help by typing in such commands as EXPLAIN EXPLAIN, EXPLAIN SHOW INDEXES, EXPLAIN BROWSE, EXPLAIN FIND, EXPLAIN TYPE, etc. When you are finished searching, key in EXIT, which gets you out of SPIRES.

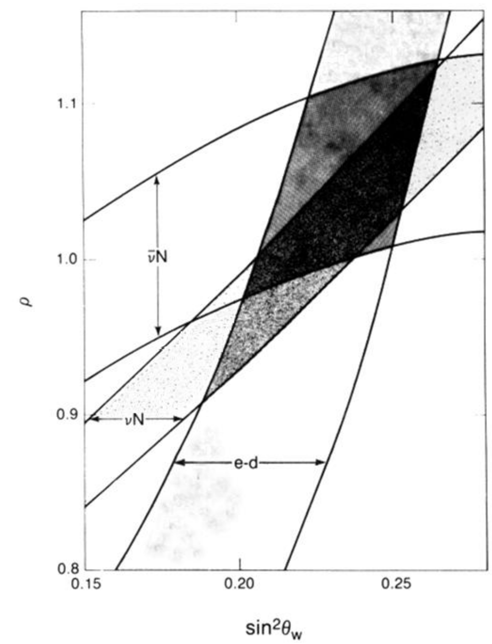
Anyone who has an account on the SLAC computing system can access these databases online. If you do not have an account and cannot find anyone who does (at main laboratories, ask at the library), please contact SLAC directly. An extensive wall poster, "A Guide to VM Spires," is available from the SLAC library. For more information, contact Alan Rittenberg at LBL (CMS-id AXRVX, tel. 415-486-4723, or 451-4723 on FTS), or Louise Addis at SLAC (CMS-id ADDIS, tel. 415-854-3300, ext. 2411).

The Durham-RAL Particle Physics Databases

These databases contain compilations of current and past experimental particle physics data (e.g., reaction cross sections), and are available for interactive searching under CMS on Rutherford Appleton Laboratory's mainframe IBM computer. The topics included are: (1) two-body (and quasi-two-body) reactions; (2) hadron and photon one- and two-particle inclusive distributions; (3) lepton-produced inclusive data (i.e., deep inelastic scattering, structure functions, etc.); and (4) data from e^+e^- annihilations. The databases also contain complete bibliographic information on these and other related topics, plus status information of current particle physics experiments. To insure that the databases are up to date, experimentalists are urged to send their data to the compilers immediately on completion.

The databases can be easily used by anyone having network access to the RAL computers; a guest identifier PDG (password PDG) is available for those who do not have their own CMS account. An EXEC file, HEPDATA, on the UDISK gives direct access to the databases, and contains an extensive built-in HELP facility to assist the unfamiliar user. Data is retrieved using a simple keyword-based search, and can be displayed in either tabular or graphical form.

For more information, or a guide to the service, please contact Michael Whalley at Durham University, England (CMS-id MRW; tel. 0385-64971, ext. 591), or Richard Roberts at RAL (CMS-id RGR; tel. 0235-21900, ext. 5259).



1.1
1.0
0.9
0.8
ρ
$\bar{\nu}$N
νN
e-d
0.15
0.20
0.25
$\sin^2\theta_w$