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REVIEW OF PARTICLE PROPERTIES: SUPPLEMENT TO 1974 EDITION

Particle Data Group

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This supplement to the 1974 edition of "Review of Particle Properties," Particle Data Group [Phys. Lett. 50B, No. 1 (1974)], contains an announcement concerning the postponement of the usual Review, a list of Errata, and a tabulation of the experimental results on the newly discovered mesons.

For several reasons, outlined below, the Particle Data Group has decided to postpone the next regular edition of the "Review of Particle Properties" until April 1976, at which time it will appear in *Reviews of Modern Physics*. In this supplement we present a brief list of errata to the 1974 edition,[1] and, because of the importance of the recently discovered mesons, we also give addenda to the Data Card Listings containing entries for these particles only. Two mini-reviews in the Listings discuss various aspects of these mesons.

Our reasons for delaying the regular edition are primarily the following: (1) Apart from the excitement generated by the new mesons, there has been somewhat of a shift in the last 2–3 years from experiments studying particle properties to those studying interaction properties. This diminution in new particle data, especially data of a dramatic nature (again with the exception noted above), leads us to believe that this time we can wait two years for a complete update. (2) In line with the shift in emphasis to interactions, the Berkeley members of the Group have been developing a data storage and retrieval system into which we plan to put all experimental data which we can extract from physics documents (journal articles, preprints, reports, theses, etc.). The primary usage of this system, at least initially, will be for such interaction properties as cross sections, angular and momentum distributions, polarization measurements, and density matrix elements. We are currently in the process of putting together our initial data base and are aiming to produce, as the first output of our system, an "Index of Particle Physics Data".[2] This Index will enable the user to locate articles on the basis of beam, target, momentum and, to a limited extent, reaction final state and properties measured. Since this project is presently occupying most of the time of the Berkeley Group, publishing the Review this year would significantly delay the Index. (3) Finally, the recent substantial increases in printing costs also contributed to the decision to postpone publication.

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[1] Particle Data Group: V. Chaloupka, C. Bricman, A. Barbaro-Galtieri, D. M. Chew, R. L. Kelly, T. A. Lasinski, A. Rittenberg, A. H. Rosenfeld, T. G. Trippe, F. Uchiyama, N. Barash-Schmidt, P. Söding, and M. Roos, Physics Letters **50B**, No. 1 (1974).

[2] Particle Data Group, "Index of Particle Physics Data", LBL-90 (to be issued).

ERRATA

Following is a list of errata in the 1974 edition of Review of Particle Properties [Phys. Lett. 50B, No. 1 (1974)]. Two page numbers are given for each item; the first is for the Review itself, and the second is for the associated 1974 Particle Properties Data Booklet.

In the Physical and Numerical Constants Table (p. 15/35), the line defining an atmosphere should read:

$$1 \text{ atmosphere} = 1033.2275 \text{ dynes cm}^{-2} = 1.01325 \text{ bar}.$$

In the Relativistic Kinematics Table (p. 21/51), equations 20-1 and 21-1 should read:

$$\gamma = \frac{s + m_b^2 - m_a^2}{2m_b\sqrt{s}} = \frac{m_b + E_a^{lab}}{\sqrt{s}} \qquad (20\text{-}1),$$

$$\eta = \frac{\sqrt{\Delta(s, m_a^2, m_b^2)}}{2m_b\sqrt{s}} = \frac{P_{inc}}{\sqrt{s}} \qquad (21\text{-}1).$$

In the Particle Detectors, Absorbers, and Ranges section, the Atomic and Nuclear Properties of Materials Table (p. 30/74-75) has several errors; as a result we reproduce the entire table, including updated values where they were available.

In the Electromagnetic Relations section (p. 31/76), ε and μ are defined to be the relative permittivity and permeability, respectively, for both CGS and MKSA units. To convert the MKSA formulas to more standard notation, where ε and μ are defined to be absolute, substitute

$$\varepsilon \text{ for } \varepsilon\varepsilon_0, \text{ and } \mu \text{ for } \mu\mu_0 .$$

Atomic and Nuclear Properties of Materials*

Material	Z	A	Nuclear cross section σ^a [barns]	Nuclear collision length L_{coll}^b [g/cm²]	Nuclear collision length L_{coll}^b [cm]	Absorption length λ^b [cm]	dE/dx min^c $\left[\frac{MeV}{g/cm^2}\right]$	dE/dx min^c $\left[\frac{MeV}{cm}\right]$	Radiation length L_{rad}^d [g/cm²]	Radiation length L_{rad}^d [cm]	Density^e [g/cm³] () is for gas [g/ℓ]	Refractive index n_i^e () is $(n-1)\times10^6$ for gas
H_2	1	1.01	0.039	43.0	607	790	4.12	0.292	63.05	890	0.0708 (0.090)	1.112 (140)
D_2	1	2.01	0.074	45.1	273	342	2.07	0.342	126.1	764	0.165	1.128
He	2	4.00	0.134	49.6	397	478	1.94	0.243	94.32	755	0.125 (0.178)	1.024 (35)
Li	3	6.94	0.215	53.6	100.4	120.6	1.65	0.902	82.76	155	0.534	-
Be	4	9.01	0.270	55.4	30.0	36.7	1.61	2.97	65.19	35.3	1.848	-
C	6	12.01	0.340	58.7	≈37.8	49.9	1.78	≈2.76	42.70	≈27.5	≈1.55^f	-
N_2	7	14.01	0.390	59.7	73.8	99.4	1.82	1.47	37.99	47.0	0.808 (1.25)	1.205 (300)
Ne	10	20.18	0.520	64.4	53.7	74.9	1.73	2.08	28.94	24.0	1.207 (0.90)	1.092 (67)
Al	13	26.98	0.650	68.9	25.5	37.2	1.62	4.37	24.01	8.9	2.70	-
A	18	39.95	0.890	74.5	53.2	80.9	1.51	2.11	19.55	14.0	1.40 (1.78)	1.233 (283)
Fe	26	55.85	1.160	79.9	10.2	17.1	1.48	11.6	13.84	1.76	7.87	-
Cu	29	63.54	1.270	83.1	9.3	14.8	1.44	12.9	12.86	1.43	8.96	-
Sn	50	118.69	2.040	96.6	13.2	22.8	1.28	9.4	8.82	1.21	7.31	-
W	74	183.85	2.810	108.6	5.6	10.3	1.17	22.6	6.76	0.35	19.3	-
Pb	82	207.19	3.080	111.7	9.8	18.5	1.13	12.8	6.37	0.56	11.35	-
U	92	238.03	3.380	116.9	≈6.2	12.0	1.09	≈20.7	6.00	≈0.32	≈18.95	-
Air				60.2	50000^g	67500^g	1.82	0.0022^g	36.66	30050^g	0.0012059^g (1.29)	1.000273^g (293)
H_2O				58.3	58.3	78.8	2.03	2.03	36.08	36.1	1.00	1.33
H_2 (bubble chamber 26°K)^h				43.0	≈683	887	4.12	≈0.26	63.05	≈1000	≈0.063^h	1.112
D_2 (bubble chamber 31°K)^h				45.1	≈322	403	2.07	≈0.29	126.1	≈900	≈0.140^h	1.110
H-Ne mixture (50 mole percent)^i				62.9	154.5	215	1.84	0.75	29.70	73.0	0.407	1.092
Propane (C_3H_8)^j				55.0	134	176	2.28	0.98	45.38	111	0.41^j (2.0)	1.25^j (1005)
Freon 13B1 (CF_3Br)^j				74.3	≈49.5	73.5	1.52	≈2.3	16.53	≈11	≈1.50^j (8.71)	1.238^j (750)
Ilford emulsion				79.5	23.6	39.1	1.44	5.49	11.02	2.94	3.815	-
NaI				91.9	25.0	41.3	1.32	4.84	9.49	2.59	3.67	1.775
LiF				61.1	23.1	30.7	1.69	4.46	39.25	14.9	2.64	1.394
Polyethylene (CH_2)				55.7	≈59.6	78.4	2.09	≈1.95	44.78	≈48	0.92-0.95	-
Mylar ($C_5H_4O_2$)				58.5	42.1	56.1	1.91	2.65	39.95	28.7	1.39	-
Polystyrene, scintillator (CH)^k				57.0	55.2	68.5	2.03	1.97	43.8	42.9	1.032	1.581
Lucite, Plexiglas ($C_5H_8O_2$)				57.7	≈48.9	65.0	1.95	≈1.65	40.55	≈34.5	1.16-1.20	≈1.49
Spark or proportional chamber$^\ell$				0.05%		0.03%	–	0.073	2.7%		0.046	-
Shielding concrete^m				64.9	26.0	32.2	1.70	4.25	26.7	10.7	2.5	-
CO_2^{n}				60.4	33800	46000	1.82	0.0033	36.2	20210	(1.79)^n	(410)^n
Freon 12 ($CC\ell_2F_2$)^n				68.1	13800	20200	1.64	0.0081	23.7	4810	(4.93)^n	(1080)^n
Freon 13 ($CC\ell F_3$)^n				66.0	15000	21400	1.70	0.0072	27.15	6380	(4.26)^n	(720)^n

*) Table revised January 1975 by J. Engler and F. Mönnig. For details and references, see CERN NP Internal Report 74-1.

a) σ of neutrons ($\approx \sigma$ of protons) at 20 GeV from Landolt-Bornstein, New Series I, Vol. 5. Energy dependence for all nuclei ≈ 1/2 percent/GeV (from 5–25 GeV).

b) $L_{coll} = A/(N.\sigma)$. In the absorption length the elastic scattering is subtracted.

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

d) From Y.S. Tsai, Pair Production and Bremsstrahlung of Charged Leptons, SLAC-PUB-1365 (1974), Table III.6.

e) Values for solids, or the liquid phase at boiling point, except where noted. Values in parentheses for gaseous phase STP (0°C, 1 atm.), except where noted.

f) Density variable.

g) Gas at 20°C.

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

i) Values for typical working condition with H_2 target: 50 mole percent, 29°K, 7 atm.

j) Values for typical chamber working conditions: Propane ~ 57°C, 8–10 atm. Freon 13B1 ~ 28°C, 8–10 atm.

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

ℓ) Values for typical construction: 2 layers 50 μm Cu/Be wires, 8 mm gap, 60% argon, 40% isobutane or CO_2; 2 layers 50 μm Mylar/Aclar foils.

m) Standard shielding blocks, typical composition O_2 52%, Si 32.5%, Ca 6%, Na 1.5%, Fe 2%, Al 4% plus reinforcing iron bars. Attenuation length $\ell = 115 \pm 5$ g/cm², also valid for earth (typical $\rho = 2.15$) from CERN-LRL-RHEL Shielding exp. UCRL 17841 (1968).

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

The New Heavy Mesons

In the following, we shall briefly review the experiments bearing on the recently-discovered $J/\psi(3100)$ and $\psi(3700)$ particles, as well as a peak in the e^+e^- total cross section, tentatively labeled X(4100) (whose resonant nature has not yet been established).

As of March 1975, the best known of these particles is the $J/\psi(3100)$. A summary of the experiments relevant to this particle is given in Table I. It has been observed in the e^+e^- mass spectrum produced in p-Be collisions at the AGS (AUBERT 74), and in e^+e^-, charged hadronic, and also $\mu^+\mu^-$ decay modes formed at SPEAR (AUGUSTIN 74). It has also been observed in e^+e^- collisions at ADONE (BACCI 74), at DORIS (BRAUNSCHWEIG 74,75; CRIEGEE 75), and at SPEAR (FORD 75), in photoproduction at FNAL (KNAPP1 75), in n-Be collisions at FNAL (KNAPP2 75), and in photoproduction using a mixture of real and low-q^2 virtual photons at SLAC (DAKIN 75). A Wisconsin-SLAC collaboration has also observed production of the $J/\psi(3100)$, as well as the $\psi(3700)$, in a bremsstrahlung beam of peak energies ranging from 13.5 to 21.5 GeV (Univ. of Wisconsin-SLAC collaboration, private communication).

TABLE I. List of Experiments Bearing on the $J/\psi(3100)$ Meson.

Accelerator	Authors	Decay e^+e^-	Decay $\mu^+\mu^-$	Decay Hadrons	Decay Others	Comments
		Formation in e^+e^- Collisions				
SPEAR	AUGUSTIN 74, LYNCH 75	×	×[a]	×		• Co-discovery; see AUBERT 74
SPEAR	FORD 75	×	×		$\gamma\gamma$[b]	• $\gamma\gamma$ decay mode forbidden if $J=1$, or if $C=-1$ and C conserved
ADONE	BACCI 74	(See following 3 papers)				
ADONE	ASH 74	×	×	×		
ADONE	BALDINI-CELIO 74	×	×	×		
ADONE	BARBIELLINI 74	×				
DORIS	BRAUNSCHWEIG 74	×				
DORIS	BRAUNSCHWEIG 75				$\gamma\gamma$,[b] $\pi^0\gamma$[b]	• $\gamma\gamma$ decay mode forbidden if $J=1$, or if $C=-1$ and C conserved
DORIS	CRIEGEE 75			×		• Signal in collinear 2-prongs also observed
		Production in Hadron Collisions				
BNL-AGS	AUBERT 74	×				• From p-Be at 28 GeV/c: Co-discovery; see AUGUSTIN 74
BNL-AGS	CHRISTENSON 70		×[c]			• From p-U at 28 GeV/c: Observed a shoulder above 3 GeV in $\mu^+\mu^-$ mass spectrum
FNAL	KNAPP2 75		×			• From n-Be at 70 - 250 GeV/c
		Photoproduction				
FNAL	KNAPP1 75		×			• From γ-Be at 80 - 200 GeV: Observed signal of about 60 events above background.
SLAC	DAKIN 75		×			• From γ-Be at 14 - 20.5 GeV: Observed 5 events (where 1 event expected)
SLAC	MARTIN 75	×[b]				• From γ-N at 14 - 20.5 GeV
CORNELL	ANDREWS 75	×[b]				• From γ-Be at 11.1 GeV

[a] These are only *probable* $\mu^+\mu^-$ events; they are called "collinear events which are not e^+e^-".
[b] Upper limits only.
[c] No conclusion drawn, however, on the existence of a narrow resonance.

Evidence bearing on the hadronic nature of the J/ψ(3100) comes from the observation of a large forward photoproduction cross section. Using vector dominance arguments one derives a total cross section for J/ψ(3100) on nucleons over a large energy range of the order of 1 mb (ANDREWS 75, DAKIN 75, KNAPP1 75, MARTIN 75). Although this cross section is an order of magnitude smaller than the corresponding cross sections of the well-known vector mesons, it is large enough to suggest that the J/ψ(3100) is probably a hadron.

A preliminary assignment of $I^G(J^P)C = 0^-(1^-)-$ may be made based on the following arguments. A study of the decay angular distribution into lepton pairs (BRAUNSCHWEIG 74, LYNCH 75), and an observed 3-standard-deviation interference effect with QED in the $\mu^+\mu^-$ decay mode (LYNCH 75) suggest that the J/ψ(3100) has the same JPC quantum numbers as a photon, provided parity is conserved in this decay. Non-observation of 2γ decays (BRAUNSCHWEIG 75, FORD 75) supports this interpretation. The observation of a $\Lambda\bar{\Lambda}$ decay mode (SLAC-LBL collaboration, private communication), even though the branching fraction appears to be small, indicates isospin zero, provided the J/ψ(3100) is a hadron and the decay to $\Lambda\bar{\Lambda}$ is not electromagnetic. If I = 0 and C = −1, G-parity must be negative. Support for this assignment comes from the fact (LYNCH 75) that the relative rates for the decay into an odd vs even number of pions is consistent with the assumption that G is conserved in the former and violated in the latter. A natural interpretation, not yet confirmed, is that the J/ψ(3100) is produced in e^+e^- annihilation via a single time-like photon in the direct channel.

The second particle, the ψ(3700), has been observed in e^+e^- collisions at SPEAR (ABRAMS 74) and at DORIS (CRIEGEE 75), with cross sections of the same order of magnitude as the J/ψ(3100). It is therefore likely that its formation also takes place via one-photon annihilation, and its quantum numbers would therefore be those of the photon, $J^{PC} = 1^{--}$. No direct evidence for this assignment exists yet. The decay ψ(3700) → J/ψ(3100) + 2π (LYNCH 75, ABRAMS 75) suggests that the G-parity is the same as for the J/ψ(3100). If GC = +1, then I is even.

The X(4100) has been observed as a broad enhancement in the e^+e^- total cross section at SPEAR (AUGUSTIN 75). Although the interpretation is still unclear, if it is in fact a resonance, then its large width suggests that it is hadronic. Further, as in the case of the ψ(3700), if one-photon annihilation is responsible for the effect, the quantum numbers would then be those of the photon, $J^{PC} = 1^{--}$.

Note added in proof: after this mini-review was completed, an additional paper, BOYARSKI 75, was received. The results of this paper, which support the above preliminary assignments of the J/ψ(3100) quantum numbers, are included in the following Listings.

Extracting Resonance Widths from e^+e^- Colliding Beam Formation Experiments

In an e^+e^- colliding beam formation experiment, the true shape of an observed resonance is distorted primarily by the effects of (1) soft-photon processes, and (2) beam energy spread due to processes such as quantum fluctuations in emission of synchrotron radiation. The spread in energy due to (2) may usually be approximated by a Gaussian distribution, the effect of which vanishes rapidly at energies sufficiently removed from resonance. The major effect of (1) is a decrease in the effective c.m. energy for some fraction of the collisions, because of the emission of bremsstrahlung by the electron or positron before annihilation. Hence, though the nominal beam energy may be well above the resonance region, a certain fraction of the collisions occur at or near resonance. This gives rise to the well-known high-mass radiative tails of the J/ψ(3100) and ψ(3700) resonances. These radiative processes, taken all together, can decrease the peak cross section for a narrow resonance by 50% or more, depending on the mass and the observed width.

Because of these effects, perhaps the most reliable means for determining resonance widths is to use a method based on the area under the line shape. This method, familiar in nuclear physics, minimizes the sensitivity to the details of the beam energy spread. Corrections for the radiative processes, which depend on the limits of integration of the areas, still need to be made. This discussion assumes the resolution is adequate to allow a reasonable separation of signal from background (which itself is subject to radiative processes).

For formation of a resonance of mass M in e^+e^- collisions, with subsequent decay via channel i,

$$\sigma_i(W) = \sigma_0 \frac{\Gamma_e \Gamma_i/4}{(M-W)^2 + \Gamma^2/4} ,$$

where W is the total center of mass energy; Γ, Γ_e, and Γ_i are the total width and partial widths for coupling to e^+e^- and channel i, respectively; and a Breit-Wigner line shape with energy-independent partial widths is assumed. The quantity σ_0 is given by

$$\sigma_0(W) = \frac{4\pi(2J+1)}{W^2} ,$$

where J is the spin of the resonance. For a narrow resonance, the area under the resonant line is given by

$$A_i = \frac{\pi}{2} \frac{\Gamma_e \Gamma_i}{\Gamma} \sigma_0(M) ,$$

independent of the energy resolution of the apparatus (but after correction for reduction in peak height and radiative tail caused by soft-photon processes). This area is tabulated in the Data Card Listings in the section labeled Integrated Channel Cross Sections. Substituting for σ_0, we have

$$\frac{\Gamma_e \Gamma_i}{\Gamma} = \frac{M^2}{2(2J+1)\pi^2} A_i .$$

Determination of the area for different decay channels thus makes it possible to determine the various partial widths.

This mini-review is based largely on "Notes from the SLAC Theory Workshop on the ψ", ed. R. Pearson, SLAC-PUB-1515 (1974). We also wish to thank J. D. Jackson of LBL, Y.-S. Tsai of SLAC, and M. Chanowitz of LBL for fruitful discussions.

Note on the Data Card Listings

The closing date for data for the following Listings was March 28, 1975. We recognize that, because of the intense interest in, and activity relating to, the new mesons, some of the values tabulated may already be superseded by the time of publication of this supplement. We hope, nevertheless, that these Listings will at least serve as a starting point for those studying the new particles. As always we urge the reader to refer to the original articles for all details.

The meaning of the columns and the various abbreviations appearing below can be found in the Illustrative Key in the 1974 edition of the Review. Several new abbreviations for measurement techniques (or detectors) have been introduced this year; they are

ELEC	Electronic detector - a combination of chambers, counters, etc.
DASP	DESY double-arm spectrometer
PLUT	DESY PLUTO detector
SMAG	SPEAR magnetic detector
SPEC	Spectrometer

J/ψ(3100)

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70  J/PSI (3100,JPGI CONSISTENT WITH 1--0)

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                    70  J/PSI(3100) MASS (MEV)

M          (3100.)  APPROX.            AUBERT    74 SPEC  0 28. PP(E+E-)    2/75*
M  FL      (3105.)    (3.)             AUGUSTIN  74 SMAG  0 3.10 E+E-(+ALL)  2/75*
M   P      (3101.)    (2.)             BALDINI-  74 ELEC  0 3.1 E+E-(+ALL)   2/75*
M          (3090.)                     BRAUNSCH  74 DASP  0 3.10 E+E-(+E+E-). 2/75*
M  O        3095.      4.              BOYARSKI  75 SMAG  0 3.1 E+E-(+ALL)   3/75*
M  S       (3089.5)                    CRIEGEE   75 PLUT  0 3.10 E+E-(+ALL)  2/75*
M  F       (3105.)                     FORD      75 SPEC  0 3.1 E+E-(2LEPT.) 2/75*
M          (3100.)  APPROX.            KNAPP1    75 SPEC  0 GAMMA-BE(MU+MU-) 2/75*
M          (3100.)  APPROX.            KNAPP2    75 SPEC  0     N-BE(MU+MU-) 2/75*
M  LP      (3095.)    (5.)             LYNCH     75 SMAG  0 3.10 E+E-(+ALL)  2/75*
M  F    AUGUSTIN 74 AND FORD 75 VALUES ARE NOT INDEPENDENT MASS                2/75*
M  F    MEASUREMENTS. THEY RESULT FROM THE SAME BEAM ENERGY CALIBRATION,       2/75*
M  F    AND ARE THUS BOTH SUBJECT TO THE RECALIBRATION REFERRED TO IN          2/75*
M  F    NOTE L.                                                                2/75*
M   L   LYNCH 75 IS A REEVALUATION OF AUGUSTIN 74 BASED ON A RECALIBRATION     3/75*
M   L   OF THE SPEAR BEAM ENERGY. SUPERSEDED BY BOYARSKI 75.                   3/75*
M   P   PRELIMINARY RESULTS.                                                   2/75*
M  O    MASS, WIDTH, PARTIAL WIDTHS, AND BRANCHING RATIOS ALL OBTAINED         3/75*
M  O    FROM ONE OVERALL FIT TO DATA OF THIS EXPERIMENT.                       3/75*
M  S    ERROR OF ABOUT 1 PER CENT FROM THE UNCERTAINTY IN CALIBRATION OF       2/75*
M  S    THE BEAM ENERGY.                                                       2/75*

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                    70  J/PSI(3100) WIDTH (KEV)

        THESE VALUES (AS WELL AS THE PARTIAL WIDTHS GIVEN BELOW) ARE
        BASED ON INTEGRATED CHANNEL CROSS SECTIONS WITH THE
        ASSUMPTIONS THAT JP=1- AND THAT THE TOTAL WIDTH IS THE SUM OF THE
        HADRON, (E+ E-), AND (MU+ MU-) WIDTHS.  UNLESS OTHERWISE NOTED,
        RADIATIVE CORRECTIONS ARE ASSUMED INCLUDED (SEE JACKSON 74 AND
        YENNIE 75).

W  BP       (32.)     (12.)            BALDINI-  74 ELEC  0 3.10 E+E-(+ALL)  2/75*
W  O         69.       15.             BOYARSKI  75 SMAG  0 3.1 E+E-(+ALL)   3/75*
W  LP       (77.)     (19.)            LYNCH     75 SMAG  0 3.10 E+E-(+ALL)  2/75*
W  B    CALCULATED BY US ASSUMING THE TOTAL WIDTH TO BE THE SUM OF THEIR       2/75*
W  B    HADRON, (E+ E-), AND (MU+ MU-) PARTIAL WIDTHS.                         2/75*
W   P   PRELIMINARY RESULTS.                                                   2/75*
W  O    FROM OVERALL FIT.  SEE NOTE ON BOYARSKI 75 MASS.                       3/75*
W  L    SUPERSEDED BY BOYARSKI 75.                                             3/75*

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                    70  J/PSI(3100) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      J/PSI(3100) INTO E+ E-                             .5+  .5
P2      J/PSI(3100) INTO MU+ MU-                          105+ 105
P3      J/PSI(3100) INTO HADRONS
P4      J/PSI(3100) INTO 2 GAMMA                            0+   0
            ABOVE MODE FORBIDDEN IF J=1, OR IF C=-1 (AND C IS CONSERVED).
            SEE BRAUNSCHWEIG 75.
P5      J/PSI(3100) INTO PI0 GAMMA                        134+   0
P6      J/PSI(3100) INTO K+ K-                            493+ 493
P7      J/PSI(3100) INTO PROTON ANTIPROTON                938+ 938
P8      J/PSI(3100) INTO K+ K- PI+ PI-                    493+ 493+ 139+ 139
P9      J/PSI(3100) INTO 3PI                              139+ 139+ 134
P10     J/PSI(3100) INTO RHO PI                           770+ 139
P11     J/PSI(3100) INTO 5PI
P12     J/PSI(3100) INTO OMEGA PI+ PI-                    782+ 139+ 139
P13     J/PSI(3100) INTO 7PI
P14     J/PSI(3100) INTO LAMBDA ANTILAMBDA               1115+1115

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                    70  J/PSI(3100) PARTIAL WIDTHS (KEV)

        SEE NOTE ABOVE ON TOTAL WIDTH.

W1      J/PSI(3100) INTO E+ E-                          (G1)                   2/75*
W1  P       (3.4)     (1.2)            BALDINI-  74 ELEC  0 3.1 E+E-(+E+E-)  2/75*
W1 O         4.8       0.6             BOYARSKI  75 SMAG  0 3.1 E+E-(+E+E-)  3/75*
W1  L       (5.2)     (1.3)            LYNCH     75 SMAG  0 3.1 E+E-(+E+E-)  2/75*
W1  P   PRELIMINARY RESULTS NOT INDEPENDENT OF THEIR IC1, IC2, AND IC3         2/75*
W1  P   CROSS SECTIONS BELOW.                                                  2/75*
W1 O    FROM OVERALL FIT.  SEE NOTE ON BOYARSKI 75 MASS.                       3/75*
W1  L   PRELIMINARY RESULT. SUPERSEDED BY BOYARSKI 75.                         3/75*

W2      J/PSI(3100) INTO MU+ MU-                        (G2)                   2/75*
W2  P       (2.4)     (1.1)            BALDINI-  74 ELEC  0 3.1E+E-(MU+MU-)  2/75*
W2 O         4.8       0.6             BOYARSKI  75 SMAG  0 3.1 E+E-(MU+MU-) 3/75*
W2  P   PRELIMINARY RESULTS NOT INDEPENDENT OF THEIR IC1, IC2, AND IC3         2/75*
W2  P   CROSS SECTIONS BELOW.                                                  2/75*
W2 O    FROM OVERALL FIT.  SEE NOTE ON BOYARSKI 75 MASS.                       3/75*

W3      J/PSI(3100) INTO HADRONS                        (G3)                   2/75*
W3  P       (26.)     (11.)            BALDINI-  74 ELEC  0 3.1 E+E-(+HAD.)  2/75*
W3 O         59.       14.             BOYARSKI  75 SMAG  0 3.1 E+E-(+HAD.)  3/75*
W3  P   PRELIMINARY RESULTS NOT INDEPENDENT OF THEIR IC1, IC2, AND IC3         2/75*
W3  P   CROSS SECTIONS BELOW.                                                  2/75*
W3 O    FROM OVERALL FIT.  SEE NOTE ON BOYARSKI 75 MASS.                       3/75*

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                    70  J/PSI(3100) BRANCHING RATIOS

R1       J/PSI(3100) INTO (E+ E-)/(HADRONS)              (P1)/(P3)               2/75*
R1   P        (0.13)    (0.04)          BALDINI-   74 ELEC  0 3.10 E+E-(+ALL)    2/75*
R1   P    PRELIMINARY RESULTS NOT INDEPENDENT OF THEIR IC1 AND IC3 CROSS         2/75*
R1   P    SECTIONS BELOW.                                                        2/75*

R2       J/PSI(3100) INTO (MU+ MU-)/(HADRONS)            (P2)/(P3)               2/75*
R2   P        (0.09)    (0.03)          BALDINI-   74 ELEC  0 3.10 E+E-(+ALL)    2/75*
R2   P    PRELIMINARY RESULTS NOT INDEPENDENT OF THEIR IC2 AND IC3 CROSS         2/75*
R2   P    SECTIONS BELOW.

R3       J/PSI(3100) INTO (E+ E-)/(MU+ MU-)              (P1)/(P2)               2/75*
R3   O         1.00      0.05           BOYARSKI   75 SMAG  0 3.1 E+E-(2LEPT.)   3/75*
R3             0.93      0.10           FORD       75 SPEC  0 3.1 E+E-(2LEPT.)   2/75*
R3   O    FROM OVERALL FIT.  SEE NOTE ON BOYARSKI 75 MASS.                       3/75*
R3            . . . . . . . . .
R3   AVG       0.986     0.045    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

R4       J/PSI(3100) INTO (2 GAMMA)/(E+ E-)              (P4)/(P1)               2/75*
R4   B        (0.050)OR LESS  CL=.90    BRAUNSCH   75 DASP  0 3.1 E+E-(GAMMAS)   2/75*
R4   B    NOT INDEPENDENT OF THEIR IC1 AND IC4 CROSS SECTIONS BELOW.             2/75*

R5       J/PSI(3100) INTO (PIO GAMMA)/(E+ E-)            (P5)/(P1)               2/75*
R5   B        (0.13) OR LESS  CL=.90    BRAUNSCH   75 DASP  0 3.1 E+E-(GAMMAS)   2/75*
R5   B    NOT INDEPENDENT OF THEIR IC1 AND IC5 CROSS SECTIONS BELOW.             2/75*

R6       J/PSI(3100) INTO (3PI (INCL. RHO PI))/TOTAL     (P9)                    2/75*
R6   P        OBSERVED                  LYNCH      75 SMAG  0 3.1 E+E-           2/75*
R6   P    PRELIMINARY RESULT.                                                    2/75*

R7       J/PSI(3100) INTO (5PI (INCL. OMEGA PI PI))/TOTAL                        2/75*
R7                                                       (P11)                   2/75*
R7   P        OBSERVED                  LYNCH      75 SMAG  0 3.1 E+E-           2/75*
R7   P    PRELIMINARY RESULT.                                                    2/75*

R8       J/PSI(3100) INTO (K+ K- PI+ PI-)/TOTAL          (P8)                    2/75*
R8   P        OBSERVED                  LYNCH      75 SMAG  0 3.1 E+E-           2/75*
R8   P    PRELIMINARY RESULT.                                                    2/75*

R9       J/PSI(3100) INTO (PROTON ANTIPROTON)/TOTAL      (P7)                    2/75*
R9   P        OBSERVED                  LYNCH      75 SMAG  0 3.1 E+E-           2/75*
R9   P    PRELIMINARY RESULT.                                                    2/75*

R10      J/PSI(3100) INTO (E+ E-)/TOTAL                  (P1)                    3/75*
R10  O         0.069     0.009          BOYARSKI   75 SMAG  0 3.1 E+E-(+E+E-)    3/75*
R10  O    FROM OVERALL FIT.  SEE NOTE ON BOYARSKI 75 MASS.                       3/75*

R11      J/PSI(3100) INTO (MU+ MU-)/TOTAL                (P2)                    3/75*
R11  O         0.069     0.009          BOYARSKI   75 SMAG  0 3.1 E+E-(MU+MU-)   3/75*
R11  O    FROM OVERALL FIT.  SEE NOTE ON BOYARSKI 75 MASS.                       3/75*

R12      J/PSI(3100) INTO (HADRONS)/TOTAL                (P3)                    3/75*
R12  O         0.86      0.02           BOYARSKI   75 SMAG  0 3.1 E+E-(+HAD.)    3/75*
R12  O    FROM OVERALL FIT.  SEE NOTE ON BOYARSKI 75 MASS.                       3/75*

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                    70  J/PSI(3100) INTEGRATED CHANNEL CROSS SECTIONS
                        (UNITS=NANOBARN*GEV=MICROBARN*MEV=MILLIBARN*KEV)

         FOR A DISCUSSION OF THIS QUANTITY, SEE THE MINI-REVIEW ABOVE
         ON EXTRACTING RESONANCE WIDTHS.
         WE GIVE THE INTEGRATED CHANNEL CROSS SECTION IN THE NORMAL DATA
         COLUMNS AND THE CORRESPONDING VALUE OF (P1*PI*W) IN THE COMMENTS
         FIELD AT THE RIGHT HAND END OF THE CARD.  IF THE AUTHOR GIVES ONLY
         ONE OF THESE, WE CALCULATE THE OTHER ASSUMING J=1, M=3.1 GEV.  THUS
         ICI=(2.40 MILLIBARNS)*(PI*PI*W).
         UNLESS OTHERWISE NOTED, RADIATIVE CORRECTIONS ARE ASSUMED
         INCLUDED (SEE JACKSON 74 AND YENNIE 75).

IC1      J/PSI(3100) FROM E+ E- INTO E+ E-               CHANNEL(1+1)            2/75*
IC1 SC        (0.96)    (0.4)           BACCI      74 ELEC  0 .4   +- .1   KEV   2/75*
IC1 PD        (0.88)    (0.30)          BALDINI-   74 ELEC  0 .37  +- .13  KEV   2/75*
IC1 S         (0.459)   (0.110)         BARBIELL   74 ELEC  0 .187 +- .050 KEV   2/75*
IC1  B         0.56      0.12           BRAUNSCH   74 DASP  0 .23  +- .05  KEV   2/75*
IC1  C         0.86      0.24           FORD       75 SPEC  0 .36  +- .10  KEV   2/75*
IC1 S     PRELIMINARY RESULTS.  BARBIELLINI 74 VALUE SUPERSEDES BACCI 74.        2/75*
IC1 S     SYSTEMATIC ERRORS AND RADIATIVE CORRECTIONS ARE NOT INCLUDED.          2/75*
IC1  C    WE CALCULATE IC1 FROM THEIR VALUE OF (P1*P1*W).                        2/75*
IC1 P     PRELIMINARY RESULT.                                                    2/75*
IC1  D    WE CALCULATE (P1*P1*W) FROM THEIR VALUE OF IC1.                        2/75*
IC1  B    RADIATIVE CORRECTIONS NOT INCLUDED.                                    2/75*

IC2      J/PSI(3100) FROM E+ E- INTO MU+ MU-             CHANNEL(1+2)            2/75*
IC2 P         (0.61)    (0.18)          BALDINI-   74 ELEC  0 .25  +- .08  KEV   2/75*
IC2 P     PRELIMINARY RESULT.  WE CALCULATE (P1*P2*W) FROM THEIR VALUE           2/75*
IC2 P     OF IC2.                                                                2/75*

IC3      J/PSI(3100) FROM E+ E- INTO HADRONS             CHANNEL(1+3)            2/75*
IC3 PA        (4.7)     (1.6)           ASH        74 ELEC  0 2.0  +- .7   KEV   2/75*
IC3 P         (6.7)     (2.4)           BALDINI-   74 ELEC  0 2.8  +- 1.0  KEV   2/75*
IC3 P     PRELIMINARY RESULTS. WE CALCULATE (P1*P3*W) FROM THEIR VALUE           2/75*
IC3 P     OF IC3.                                                                2/75*
IC3  A    RADIATIVE CORRECTIONS APPARENTLY NOT INCLUDED.                         2/75*

IC4      J/PSI(3100) FROM E+ E- INTO 2 GAMMA             CHANNEL(1+4)            2/75*
IC4  B        (0.028)OR LESS  CL=.90    BRAUNSCH   75 DASP  0 .012 OR LESS KEV   2/75*
IC4              CONSISTENT WITH ZERO   FORD       75 SPEC  0                    2/75*
IC4  B    RADIATIVE CORRECTIONS NOT INCLUDED.                                    2/75*

IC5      J/PSI(3100) FROM E+ E- INTO PIO GAMMA          CHANNEL(1+5)             2/75*
IC5  B        (0.073)OR LESS  CL=.90    BRAUNSCH   75 DASP  0 .030 OR LESS KEV   2/75*
IC5  B    RADIATIVE CORRECTIONS NOT INCLUDED.                                    2/75*

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                         REFERENCES FOR J/PSI(3100)

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)
   ALSO 75  COO-3069-285       AUBERT,BECKER,BIGGS,BURGER,GLENN+ (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+NAPO+PISA+ROMA)
BRAUNSCH 74 PL 53B 393         BRAUNSCHWEIG+     (AACHEN+HAMB+MUNICH+TOKYO)
JACKSON  74  MEMO JDJ/74-3     J.D.JACKSON                             (LBL)
   ALSO 74  MEMO JDJ/74-4      J.D.JACKSON,D.SCHARRE                   (LBL)

ANDREWS  75 PRL 34 231         +HARVEY,LOBKOWICZ,MAY,NORDBERG  (ROCH+CORN)
   ALSO 75  UR-518             ANDREWS,HARVEY,LOBKOWICZ,MAY+   (ROCH+CORN)
BOYARSKI 75  SLAC1572-LBL3695 +BREIDENBACH,ABRAMS,BRIGGS+       (SLAC+LBL)
BRAUNSCH 75 PL 53B 491         BRAUNSCHWEIG+     (AACHEN+HAMB+MUNICH+TOKYO)
CRIEGEE  75 PL 53B 489         +DEHNE,FRANKE,HORLITZ,KRECHLOCK+     (DESY)
DAKIN    75  UMHEP 75-1        +KREISLER,BOLON,HEILE+     (MASA+MIT+SLAC)
FORD     75 PRL 34 604         +BERON,HILGER,HOFSTADTER+       (SLAC+PENN)
KNAPP1   75  COO-1195-315      +LEE,BRONSTEIN+   (COLU+HAWA+CORN+ILL+FNAL)
KNAPP2   75  COO-1195-316      +LEE,BRONSTEIN+   (COLU+HAWA+CORN+ILL+FNAL)
LYNCH    75  CORAL GABLES CON.+AUGUSTIN,ABRAMS,BRIGGS+          (SLAC+LBL)
MARTIN   75 PRL 34 288         +BOLON,DAKIN,FELDMAN,HANSON+(MIT+MASA+SLAC)
YENNIE   75 PRL 34 239         D.R.YENNIE                         (CORNELL)

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ψ(3700)

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         71  PSI (3700,JPG=    ) I=

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                    71  PSI(3700) MASS (MEV)

M   L      (3695.)     (4.)             ABRAMS     74 SMAG  0 3.7 E+E-(+HAD)     2/75*
M   S      (3680.3)                     CRIEGEE    75 PLUT  0 3.70 E+E-(+ALL)    2/75*
M   LP     (3684.)     (5.)             LYNCH      75 SMAG  0 3.70 E+E-(+ALL)    2/75*
M   L   LYNCH 75 IS A REEVALUATION OF ABRAMS 74 BASED ON A RECALIBRATION         2/75*
M   L   OF THE SPEAR BEAM ENERGY.                                                2/75*
M   S   ERROR OF ABOUT 1 PER CENT FROM THE UNCERTAINTY IN CALIBRATION OF         2/75*
M   S   THE BEAM ENERGY.                                                         2/75*
M   P   PRELIMINARY RESULTS.                                                     2/75*

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                    71  PSI(3700) WIDTH (KEV)

W   P       200. TO 1000.               LYNCH      75 SMAG  0 3.70 E+E-(+ALL)    2/75*
W   P   UPPER AND LOWER LIMITS OBTAINED IN DIFFERENT WAYS, SEE LYNCH 75.         2/75*
W   P   PRELIMINARY RESULT.                                                      2/75*

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                    71  PSI(3700) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      PSI(3700) INTO E+ E-                              .5+ .5
P2      PSI(3700) INTO MU+ MU-                           105+ 105
P3      PSI(3700) INTO HADRONS
P4      PSI(3700) INTO J/PSI(3100) PI+ PI-              3100+ 139+ 139
P5      PSI(3700) INTO J/PSI(3100) ANYTHING
P6      PSI(3700) INTO J/PSI(3100) NEUTRALS

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                    71  PSI(3700) PARTIAL WIDTHS (KEV)

W1      PSI(3700) INTO E+ E-                             (G1)                    2/75*
W1  P        (2.2)     (0.6)            LYNCH      75 SMAG  0 E+ E- +(ALL)       2/75*
W1  P   PRELIMINARY RESULT, USING J=1.                                           2/75*

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                    71  PSI(3700) BRANCHING RATIOS

R1      PSI(3700) INTO (J/PSI(3100) PI+ PI-)/ALL         (P4)                    2/75*
R1           (0.31)    (0.04)           ABRAMS     75 SMAG  0 3.7 E+E-(+ALL)     2/75*

R2      PSI(3700) INTO (J/PSI(3100) ANYTHING)/ALL        (P5)                    2/75*
R2           (0.54)    (0.08)           ABRAMS     75 SMAG  0 3.7 E+E-(+ALL)     2/75*

R3      PSI(3700) INTO (J/PSI(3100) NEUTRALS)/(J/PSI(3100) ANYTHING)             2/75*
R3                                                       (P6)/(P5)               2/75*
R3           (0.46)    (0.03)           ABRAMS     75 SMAG  0 3.7 E+E-(+ALL)     2/75*

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                         REFERENCES FOR PSI(3700)

ABRAMS   74 PRL 33 1453        +BRIGGS,AUGUSTIN,BOYARSKI+          (LBL+SLAC)
JACKSON  74  MEMOS JDJ/74-1,3 J.D.JACKSON                              (LBL)
   ALSO 74  MEMO JDJ/74-4      J.D.JACKSON,D.SCHARRE                   (LBL)

ABRAMS   75  LBL3669-SLAC1556 +BRIGGS,BOYARSKI,BREIDENBACH+     (LBL+SLAC)
AUBERT   75 PRL 33 1624        +BECKER,BIGGS,BURGER,GLENN+         (MIT+BNL)
CRIEGEE  75 PL 53B 489         +DEHNE,FRANKE,HORLITZ,KRECHLOCK+       (DESY)
LYNCH    75  CORAL GABLES CON.+AUGUSTIN,ABRAMS,BRIGGS+          (SLAC+LBL)

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X(4100) →

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         72  X (4100,JPG=    ) I=

         OBSERVED AS A BROAD (250-300 MEV) ENHANCEMENT
         IN ELECTRON-POSITRON TOTAL CROSS SECTION AT SPEAR
         (AUGUSTIN 75). INTERPRETATION UNCLEAR BETWEEN NEW
         THRESHOLD AND A BROAD RESONANCE. OMITTED FROM TABLE.

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                    72  X(4100)  MASS (MEV)

M          (4150.)                      AUGUSTIN   75 SPEAR 0 2.4-5.0 E+E-     . 2/75*

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                         REFERENCES FOR X(4100)

AUGUSTIN 75 PRL 34 764         +BOYARSKI,ABRAMS,BRIGGS+            (SLAC+LBL)

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