$N(1650)\ S_{11}$

$I(J^P) = \frac{1}{2}(\frac{1}{2}^-)$ Status: ∗∗∗∗

Most of the results published before 1975 were last included in our 1982 edition, Physics Letters **111B** 1 (1982). Some further obsolete results published before 1984 were last included in our 2006 edition, Journal of Physics, G **33** 1 (2006).

N(1650) BREIT-WIGNER MASS

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
1645 to 1670 (≈ 1655) OUR ESTIMATE				
1634.7± 1.1	ARNDT	06	DPWA	$\pi N \to \pi N, \eta N$
1659 ± 9	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N \pi\pi$
1650 ±30	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
1670 ± 8	HOEHLER	79	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1655 ±15	THOMA	08	DPWA	Multichannel
1651.2± 4.7	ARNDT	04	DPWA	$\pi N \to \pi N, \eta N$
1665 ± 2	PENNER	02C	DPWA	Multichannel
1647 ±20	BAI	01B	BES	$J/\psi \to p \overline{p} \eta$
1689 ±12	VRANA	00	DPWA	Multichannel
1677 ± 8	ARNDT	96	IPWA	$\gamma N \to \pi N$
1667	ARNDT	95	DPWA	$\pi N \to N \pi$
1712	[1] ARNDT	95	DPWA	$\pi N \to N \pi$
1669 ±17	BATINIC	95	DPWA	$\pi N \to N \pi, N \eta$
1713 ±27	[2] BATINIC	95	DPWA	$\pi N \to N \pi, N \eta$
1674	LI	93	IPWA	$\gamma N \to \pi N$
1672	MUSETTE	80	IPWA	$\pi^- p \to \Lambda K^0$
1680	SAXON	80	DPWA	$\pi^- p \to \Lambda K^0$
1700	[3] LONGACRE	77	IPWA	$\pi N \to N \pi\pi$
1660	[4] LONGACRE	75	IPWA	$\pi N \to N \pi\pi$

N(1650) BREIT-WIGNER WIDTH

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
145 to 185 (≈ 165) OUR ESTIMATE				
115.4± 2.8	ARNDT	06	DPWA	$\pi N \to \pi N, \eta N$
167.9± 9.4	GREEN	97	DPWA	$\pi N \to \pi N, \eta N$
173 ±12	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N \pi\pi$
150 ±40	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
180 ±20	HOEHLER	79	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
180 ±20	THOMA	08	DPWA	Multichannel
130.6± 7.0	ARNDT	04	DPWA	$\pi N \to \pi N, \eta N$
138 ± 7	PENNER	02C	DPWA	Multichannel
145 $^{+80}_{-45}$	BAI	01B	BES	$J/\psi \to p \overline{p} \eta$
202 ±40	VRANA	00	DPWA	Multichannel
160 ±12	ARNDT	96	IPWA	$\gamma N \to \pi N$

90	ARNDT	95	DPWA	$\pi N \to N\pi$
184	[1] ARNDT	95	DPWA	$\pi N \to N\pi$
215 ±32	BATINIC	95	DPWA	$\pi N \to N\pi$, $N\eta$
279 ±54	[2] BATINIC	95	DPWA	$\pi N \to N\pi$, $N\eta$
225	LI	93	IPWA	$\gamma N \to \pi N$
179	MUSETTE	80	IPWA	$\pi^- p \to \Lambda K^0$
120	SAXON	80	DPWA	$\pi^- p \to \Lambda K^0$
170	[3] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$
130	[4] LONGACRE	75	IPWA	$\pi N \to N\pi\pi$

N(1650) POLE POSITION

REAL PART

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
1640 to 1670 (≈ 1655) OUR ESTIMATE				
1648	ARNDT	06	DPWA	$\pi N \to \pi N$, ηN
1670	[5] HOEHLER	93	ARGD	$\pi N \to \pi N$
1640±20	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1645±15	THOMA	08	DPWA	Multichannel
1653	ARNDT	04	DPWA	$\pi N \to \pi N$, ηN
1663	VRANA	00	DPWA	Multichannel
1660±10	[6] ARNDT	98	DPWA	$\pi N \to \pi N$, ηN
1673	ARNDT	95	DPWA	$\pi N \to N\pi$
1689	[1] ARNDT	95	DPWA	$\pi N \to N\pi$
1657	ARNDT	91	DPWA	$\pi N \to \pi N$ Soln SM90
1648 or 1651	[7] LONGACRE	78	IPWA	$\pi N \to N\pi\pi$
1699 or 1698	[3] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$

−2×IMAGINARY PART

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
150 to 180 (≈ 165) OUR ESTIMATE				
80	ARNDT	06	DPWA	$\pi N \to \pi N$, ηN
163	[5] HOEHLER	93	ARGD	$\pi N \to \pi N$
150±30	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
187±20	THOMA	08	DPWA	Multichannel
182	ARNDT	04	DPWA	$\pi N \to \pi N$, ηN
240	VRANA	00	DPWA	Multichannel
140±20	[6] ARNDT	98	DPWA	$\pi N \to \pi N$, ηN
82	ARNDT	95	DPWA	$\pi N \to N\pi$
192	[1] ARNDT	95	DPWA	$\pi N \to N\pi$
160	ARNDT	91	DPWA	$\pi N \to \pi N$ Soln SM90
117 or 119	[7] LONGACRE	78	IPWA	$\pi N \to N\pi\pi$
174 or 173	[3] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$

$N(1650)$ ELASTIC POLE RESIDUE

MODULUS $|r|$

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
14	ARNDT	06	DPWA	$\pi N \rightarrow \pi N, \eta N$
39	HOEHLER	93	ARGD	$\pi N \rightarrow \pi N$
60±10	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
69	ARNDT	04	DPWA	$\pi N \rightarrow \pi N, \eta N$
22	ARNDT	95	DPWA	$\pi N \rightarrow N\pi$
72	[1] ARNDT	95	DPWA	$\pi N \rightarrow N\pi$
54	ARNDT	91	DPWA	$\pi N \rightarrow \pi N$ Soln SM90

PHASE θ

VALUE (°)	*DOCUMENT ID*		*TECN*	*COMMENT*
−69	ARNDT	06	DPWA	$\pi N \rightarrow \pi N, \eta N$
−37	HOEHLER	93	ARGD	$\pi N \rightarrow \pi N$
−75±25	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
−55	ARNDT	04	DPWA	$\pi N \rightarrow \pi N, \eta N$
29	ARNDT	95	DPWA	$\pi N \rightarrow N\pi$
−85	[1] ARNDT	95	DPWA	$\pi N \rightarrow N\pi$
−38	ARNDT	91	DPWA	$\pi N \rightarrow \pi N$ Soln SM90

$N(1650)$ DECAY MODES

The following branching fractions are our estimates, not fits or averages.

	Mode	Fraction (Γ_i/Γ)
Γ_1	$N\pi$	0.60 to 0.95
Γ_2	$N\eta$	3–10 %
Γ_3	ΛK	3–11 %
Γ_4	ΣK	
Γ_5	$N\pi\pi$	10–20 %
Γ_6	$\Delta\pi$	1–7 %
Γ_7	$\Delta(1232)\pi$, D-wave	
Γ_8	$N\rho$	4–12 %
Γ_9	$N\rho$, S=1/2, S-wave	
Γ_{10}	$N\rho$, S=3/2, D-wave	
Γ_{11}	$N(\pi\pi)^{I=0}_{S\text{-wave}}$	<4 %
Γ_{12}	$N(1440)\pi$	<5 %
Γ_{13}	$p\gamma$	0.04–0.18 %
Γ_{14}	$p\gamma$, helicity=1/2	0.04–0.18 %
Γ_{15}	$n\gamma$	0.003–0.17 %
Γ_{16}	$n\gamma$, helicity=1/2	0.003–0.17 %

$N(1650)$ BRANCHING RATIOS

$\Gamma(N\pi)/\Gamma_{total}$ — Γ_1/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
0.60 to 0.95 OUR ESTIMATE				
1.0	ARNDT	06	DPWA	$\pi N \to \pi N, \eta N$
0.735±0.011	GREEN	97	DPWA	$\pi N \to \pi N, \eta N$
0.89 ±0.07	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
0.65 ±0.10	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
0.61 ±0.04	HOEHLER	79	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.70 ±0.15	THOMA	08	DPWA	Multichannel
1.000	ARNDT	04	DPWA	$\pi N \to \pi N, \eta N$
0.65 ±0.04	PENNER	02C	DPWA	Multichannel
0.74 ±0.02	VRANA	00	DPWA	Multichannel
0.99	ARNDT	95	DPWA	$\pi N \to N\pi$
0.27	[1] ARNDT	95	DPWA	$\pi N \to N\pi$
0.94 ±0.07	BATINIC	95	DPWA	$\pi N \to N\pi, N\eta$
0.49 ±0.21	[2] BATINIC	95	DPWA	$\pi N \to N\pi, N\eta$

$\Gamma(N\eta)/\Gamma_{total}$ — Γ_2/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
0.023±0.022 OUR AVERAGE	Error includes scale factor of 4.3.			
0.010±0.006	PENNER	02C	DPWA	Multichannel
0.06 ±0.01	VRANA	00	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.15 ±0.06	THOMA	08	DPWA	Multichannel
0.06 ±0.05	BATINIC	95	DPWA	$\pi N \to N\pi, N\eta$
0.02 ±0.03	[2] BATINIC	95	DPWA	$\pi N \to N\pi, N\eta$

$\Gamma(\Lambda K)/\Gamma_{total}$ — Γ_3/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
0.029±0.004 OUR AVERAGE	Error includes scale factor of 1.2.			
0.04 ±0.01	SHKLYAR	05	DPWA	Multichannel
0.027±0.004	PENNER	02C	DPWA	Multichannel

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(1650) \to \Lambda K$ — $(\Gamma_1\Gamma_3)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
−0.27 to −0.17 OUR ESTIMATE				
−0.22	BELL	83	DPWA	$\pi^- p \to \Lambda K^0$
−0.22	SAXON	80	DPWA	$\pi^- p \to \Lambda K^0$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(1650) \to \Sigma K$ — $(\Gamma_1\Gamma_4)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
−0.254	LIVANOS	80	DPWA	$\pi p \to \Sigma K$

Note: Signs of couplings from $\pi N \to N\pi\pi$ analyses were changed in the 1986 edition to agree with the baryon-first convention; the overall phase ambiguity is resolved by choosing a negative sign for the $\Delta(1620)$ S_{31} coupling to $\Delta(1232)\pi$.

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(1650) \to \Delta(1232)\pi$, D-wave — $(\Gamma_1\Gamma_7)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
+0.15 to 0.23 OUR ESTIMATE				
$+0.12\pm0.04$	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
$+0.29$	[3,8] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$
$+0.15$	[4] LONGACRE	75	IPWA	$\pi N \to N\pi\pi$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$+0.26\pm0.14$	THOMA	08	DPWA	Multichannel

$\Gamma(\Delta(1232)\pi, D\text{-wave})/\Gamma_{total}$ — Γ_7/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
0.02 ± 0.01	VRANA	00	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.10 ± 0.05	THOMA	08	DPWA	Multichannel

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(1650) \to N\rho$, S=1/2, S-wave — $(\Gamma_1\Gamma_9)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
$\pm$0.03 to $\pm$0.19 OUR ESTIMATE				
-0.01 ± 0.09	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
$+0.17$	[3,8] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$
-0.16	[4] LONGACRE	75	IPWA	$\pi N \to N\pi\pi$

$\Gamma(N\rho, S=1/2, S\text{-wave})/\Gamma_{total}$ — Γ_9/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
0.01 ± 0.01	VRANA	00	DPWA	Multichannel

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(1650) \to N\rho$, S=3/2, D-wave — $(\Gamma_1\Gamma_{10})^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
+0.17 to +0.29 OUR ESTIMATE				
$+0.16\pm0.06$	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
$+0.29$	[3,8] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$

$\Gamma(N\rho, S=3/2, D\text{-wave})/\Gamma_{total}$ — Γ_{10}/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
0.13 ± 0.03	VRANA	00	DPWA	Multichannel

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(1650) \to N(\pi\pi)^{I=0}_{S\text{-wave}}$ — $(\Gamma_1\Gamma_{11})^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
+0.04 to +0.18 OUR ESTIMATE				
$+0.12\pm0.08$	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
0.00	[3,8] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$
$+0.25$	[4] LONGACRE	75	IPWA	$\pi N \to N\pi\pi$

$\Gamma(N(\pi\pi)^{I=0}_{S\text{-wave}})/\Gamma_{total}$ — Γ_{11}/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
0.01 ± 0.01	VRANA	00	DPWA	Multichannel

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \rightarrow N(1650) \rightarrow N(1440)\pi$ — $(\Gamma_1\Gamma_{12})^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
$+0.11\pm0.06$	MANLEY	92	IPWA	$\pi N \rightarrow \pi N$ & $N\pi\pi$

$\Gamma(N(1440)\pi)/\Gamma_{total}$ — Γ_{12}/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
0.03 ± 0.01	VRANA	00	DPWA	Multichannel

N(1650) PHOTON DECAY AMPLITUDES

Papers on γN amplitudes predating 1981 may be found in our 2006 edition, Journal of Physics, G **33** 1 (2006).

$N(1650) \rightarrow p\gamma$, helicity-1/2 amplitude $A_{1/2}$

VALUE ($GeV^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
$+0.053\pm0.016$ OUR ESTIMATE				
0.100 ± 0.035	[9] ANISOVICH	09A	DPWA	$\gamma d \rightarrow \eta N(N)$
0.022 ± 0.007	DUGGER	07	DPWA	$\gamma N \rightarrow \pi N$
0.069 ± 0.005	ARNDT	96	IPWA	$\gamma N \rightarrow \pi N$
0.033 ± 0.015	CRAWFORD	83	IPWA	$\gamma N \rightarrow \pi N$
0.050 ± 0.010	AWAJI	81	DPWA	$\gamma N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.033	DRECHSEL	07	DPWA	$\gamma N \rightarrow \pi N$
0.049	PENNER	02D	DPWA	Multichannel
0.068 ± 0.003	LI	93	IPWA	$\gamma N \rightarrow \pi N$
0.091	WADA	84	DPWA	Compton scattering

$N(1650) \rightarrow n\gamma$, helicity-1/2 amplitude $A_{1/2}$

VALUE ($GeV^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
-0.015 ± 0.021 OUR ESTIMATE				
-0.055 ± 0.020	[10] ANISOVICH	09A	DPWA	$\gamma d \rightarrow \eta N(N)$
-0.015 ± 0.005	ARNDT	96	IPWA	$\gamma N \rightarrow \pi N$
-0.008 ± 0.004	AWAJI	81	DPWA	$\gamma N \rightarrow \pi N$
0.004 ± 0.004	FUJII	81	DPWA	$\gamma N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.009	DRECHSEL	07	DPWA	$\gamma N \rightarrow \pi N$
-0.011	PENNER	02D	DPWA	Multichannel
-0.002 ± 0.002	LI	93	IPWA	$\gamma N \rightarrow \pi N$

N(1650) $\gamma p \rightarrow \Lambda K^+$ AMPLITUDES

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $p\gamma \rightarrow N(1650) \rightarrow \Lambda K^+$ — (E_{0+} amplitude)

VALUE (units 10^{-3})	DOCUMENT ID		TECN
• • • We do not use the following data for averages, fits, limits, etc. • • •			
7.8 ± 0.3	WORKMAN	90	DPWA
8.13	TANABE	89	DPWA

$p\gamma \to N(1650) \to \Lambda K^+$ phase angle θ (E_{0+} amplitude)

VALUE (degrees)	DOCUMENT ID		TECN
• • • We do not use the following data for averages, fits, limits, etc. • • •			
-107 ± 3	WORKMAN	90	DPWA
-107.8	TANABE	89	DPWA

N(1650) FOOTNOTES

[1] ARNDT 95 finds two distinct states.

[2] BATINIC 95 finds two distinct states. This second resonance was associated with the $N(2090)\ S_{11}$.

[3] LONGACRE 77 pole positions are from a search for poles in the unitarized T-matrix; the first (second) value uses, in addition to $\pi N \to N\pi\pi$ data, elastic amplitudes from a Saclay (CERN) partial-wave analysis. The other LONGACRE 77 values are from eyeball fits with Breit-Wigner circles to the T-matrix amplitudes.

[4] From method II of LONGACRE 75: eyeball fits with Breit-Wigner circles to the T-matrix amplitudes.

[5] See HOEHLER 93 for a detailed discussion of the evidence for and the pole parameters of N and Δ resonances as determined from Argand diagrams of πN elastic partial-wave amplitudes and from plots of the speeds with which the amplitudes traverse the diagrams.

[6] ARNDT 98 also lists pole residues, which display more model dependence than do the associated pole positions.

[7] LONGACRE 78 values are from a search for poles in the unitarized T-matrix. The first (second) value uses, in addition to $\pi N \to N\pi\pi$ data, elastic amplitudes from a Saclay (CERN) partial-wave analysis.

[8] LONGACRE 77 considers this coupling to be well determined.

[9] This ANISOVICH 09A amplitude is evaluated at the pole position; the phase is $(25\pm20)^\circ$.

[10] This ANISOVICH 09A amplitude is evaluated at the pole position; the phase is $(30\pm25)^\circ$.

N(1650) REFERENCES

For early references, see Physics Letters **111B** 1 (1982).

ANISOVICH	09A	EPJ A41 13	A.V. Anisovich *et al.*	(BONN, PNPI, BASL)
THOMA	08	PL B659 87	U. Thoma *et al.*	(CB-ELSA Collab.)
DRECHSEL	07	EPJ A34 69	D. Drechsel, S.S. Kamalov, L. Tiator	(MAINZ, JINR)
DUGGER	07	PR C76 025211	M. Dugger *et al.*	(Jefferson Lab CLAS Collab.)
ARNDT	06	PR C74 045205	R.A. Arndt *et al.*	(GWU)
PDG	06	JPG 33 1	W.-M. Yao *et al.*	(PDG Collab.)
SHKLYAR	05	PR C72 015210	V. Shklyar, H. Lenske, U. Mosel	(GIES)
ARNDT	04	PR C69 035213	R.A. Arndt *et al.*	(GWU, TRIU)
PENNER	02C	PR C66 055211	G. Penner, U. Mosel	(GIES)
PENNER	02D	PR C66 055212	G. Penner, U. Mosel	(GIES)
BAI	01B	PL B510 75	J.Z. Bai *et al.*	(BES Collab.)
VRANA	00	PRPL 328 181	T.P. Vrana, S.A. Dytman,, T.-S.H. Lee	(PITT+)
ARNDT	98	PR C58 3636	R.A. Arndt *et al.*	
GREEN	97	PR C55 R2167	A.M. Green, S. Wycech	(HELS, WINR)
ARNDT	96	PR C53 430	R.A. Arndt, I.I. Strakovsky, R.L. Workman	(VPI)
ARNDT	95	PR C52 2120	R.A. Arndt *et al.*	(VPI, BRCO)
BATINIC	95	PR C51 2310	M. Batinic *et al.*	(BOSK, UCLA)
Also		PR C57 1004 (erratum)	M. Batinic *et al.*	
HOEHLER	93	πN Newsletter 9 1	G. Hohler	(KARL)
LI	93	PR C47 2759	Z.J. Li *et al.*	(VPI)
MANLEY	92	PR D45 4002	D.M. Manley, E.M. Saleski	(KENT) IJP
Also		PR D30 904	D.M. Manley *et al.*	(VPI)
ARNDT	91	PR D43 2131	R.A. Arndt *et al.*	(VPI, TELE) IJP
WORKMAN	90	PR C42 781	R.L. Workman	(VPI)
TANABE	89	PR C39 741	H. Tanabe, M. Kohno, C. Bennhold	(MANZ)
Also		NC 102A 193	M. Kohno, H. Tanabe, C. Bennhold	(MANZ)

WADA	84	NP B247 313	Y. Wada *et al.*	(INUS)
BELL	83	NP B222 389	K.W. Bell *et al.*	(RL) IJP
CRAWFORD	83	NP B211 1	R.L. Crawford, W.T. Morton	(GLAS)
PDG	82	PL 111B 1	M. Roos *et al.*	(HELS, CIT, CERN)
AWAJI	81	Bonn Conf. 352	N. Awaji, R. Kajikawa	(NAGO)
Also		NP B197 365	K. Fujii *et al.*	(NAGO)
FUJII	81	NP B187 53	K. Fujii *et al.*	(NAGO, OSAK)
CUTKOSKY	80	Toronto Conf. 19	R.E. Cutkosky *et al.*	(CMU, LBL) IJP
Also		PR D20 2839	R.E. Cutkosky *et al.*	(CMU, LBL) IJP
LIVANOS	80	Toronto Conf. 35	P. Livanos *et al.*	(SACL) IJP
MUSETTE	80	NC 57A 37	M. Musette	(BRUX) IJP
SAXON	80	NP B162 522	D.H. Saxon *et al.*	(RHEL, BRIS) IJP
HOEHLER	79	PDAT 12-1	G. Hohler *et al.*	(KARLT) IJP
Also		Toronto Conf. 3	R. Koch	(KARLT) IJP
LONGACRE	78	PR D17 1795	R.S. Longacre *et al.*	(LBL, SLAC)
LONGACRE	77	NP B122 493	R.S. Longacre, J. Dolbeau	(SACL) IJP
Also		NP B108 365	J. Dolbeau *et al.*	(SACL) IJP
LONGACRE	75	PL 55B 415	R.S. Longacre *et al.*	(LBL, SLAC) IJP