# $N(1680)\ F_{15}$

$I(J^P) = \frac{1}{2}(\frac{5}{2}^+)$ 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 1980 were last included in our 2006 edition, Journal of Physics, G **33** 1 (2006).

## N(1680) BREIT-WIGNER MASS

| *VALUE* (MeV) | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|
| **1680 to 1690 (≈ 1685) OUR ESTIMATE** | | | | |
| 1680.1± 0.2 | ARNDT | 06 | DPWA | $\pi N \rightarrow \pi N, \eta N$ |
| 1684 ± 4 | MANLEY | 92 | IPWA | $\pi N \rightarrow \pi N$ & $N \pi \pi$ |
| 1680 ±10 | CUTKOSKY | 80 | IPWA | $\pi N \rightarrow \pi N$ |
| 1684 ± 3 | HOEHLER | 79 | IPWA | $\pi N \rightarrow \pi N$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 1683.2± 0.7 | ARNDT | 04 | DPWA | $\pi N \rightarrow \pi N, \eta N$ |
| 1679 ± 3 | VRANA | 00 | DPWA | Multichannel |
| 1679 ± 5 | ARNDT | 96 | IPWA | $\gamma N \rightarrow \pi N$ |
| 1678 | ARNDT | 95 | DPWA | $\pi N \rightarrow N \pi$ |
| 1674 ±12 | BATINIC | 95 | DPWA | $\pi N \rightarrow N \pi, N \eta$ |
| 1682 | CRAWFORD | 80 | DPWA | $\gamma N \rightarrow \pi N$ |
| 1660 | [1] LONGACRE | 77 | IPWA | $\pi N \rightarrow N \pi \pi$ |
| 1670 | [2] LONGACRE | 75 | IPWA | $\pi N \rightarrow N \pi \pi$ |

## N(1680) BREIT-WIGNER WIDTH

| *VALUE* (MeV) | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|
| **120 to 140 (≈ 130) OUR ESTIMATE** | | | | |
| 128.0± 1.1 | ARNDT | 06 | DPWA | $\pi N \rightarrow \pi N, \eta N$ |
| 139 ± 8 | MANLEY | 92 | IPWA | $\pi N \rightarrow \pi N$ & $N \pi \pi$ |
| 120 ±10 | CUTKOSKY | 80 | IPWA | $\pi N \rightarrow \pi N$ |
| 128 ± 8 | HOEHLER | 79 | IPWA | $\pi N \rightarrow \pi N$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 134.4± 3.8 | ARNDT | 04 | DPWA | $\pi N \rightarrow \pi N, \eta N$ |
| 128 ± 9 | VRANA | 00 | DPWA | Multichannel |
| 124 ± 4 | ARNDT | 96 | IPWA | $\gamma N \rightarrow \pi N$ |
| 126 | ARNDT | 95 | DPWA | $\pi N \rightarrow N \pi$ |
| 126 ±20 | BATINIC | 95 | DPWA | $\pi N \rightarrow N \pi, N \eta$ |
| 121 | CRAWFORD | 80 | DPWA | $\gamma N \rightarrow \pi N$ |
| 150 | [1] LONGACRE | 77 | IPWA | $\pi N \rightarrow N \pi \pi$ |
| 130 | [2] LONGACRE | 75 | IPWA | $\pi N \rightarrow N \pi \pi$ |

# N(1680) POLE POSITION

## REAL PART

| VALUE (MeV) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **1665 to 1680 (≈ 1675) OUR ESTIMATE** | | | | |
| 1674 | ARNDT | 06 | DPWA | $\pi N \to \pi N, \eta N$ |
| 1673 | [3] HOEHLER | 93 | ARGD | $\pi N \to \pi N$ |
| 1667±5 | CUTKOSKY | 80 | IPWA | $\pi N \to \pi N$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 1678 | ARNDT | 04 | DPWA | $\pi N \to \pi N, \eta N$ |
| 1667 | VRANA | 00 | DPWA | Multichannel |
| 1670 | ARNDT | 95 | DPWA | $\pi N \to N \pi$ |
| 1670 | ARNDT | 91 | DPWA | $\pi N \to \pi N$ Soln SM90 |
| 1668 or 1674 | [4] LONGACRE | 78 | IPWA | $\pi N \to N \pi \pi$ |
| 1656 or 1653 | [1] LONGACRE | 77 | IPWA | $\pi N \to N \pi \pi$ |

## −2×IMAGINARY PART

| VALUE (MeV) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **110 to 135 (≈ 120) OUR ESTIMATE** | | | | |
| 115 | ARNDT | 06 | DPWA | $\pi N \to \pi N, \eta N$ |
| 135 | [3] HOEHLER | 93 | ARGD | $\pi N \to \pi N$ |
| 110±10 | CUTKOSKY | 80 | IPWA | $\pi N \to \pi N$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 120 | ARNDT | 04 | DPWA | $\pi N \to \pi N, \eta N$ |
| 122 | VRANA | 00 | DPWA | Multichannel |
| 120 | ARNDT | 95 | DPWA | $\pi N \to N \pi$ |
| 116 | ARNDT | 91 | DPWA | $\pi N \to \pi N$ Soln SM90 |
| 132 or 137 | [4] LONGACRE | 78 | IPWA | $\pi N \to N \pi \pi$ |
| 145 or 143 | [1] LONGACRE | 77 | IPWA | $\pi N \to N \pi \pi$ |

# N(1680) ELASTIC POLE RESIDUE

## MODULUS |r|

| VALUE (MeV) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| 42 | ARNDT | 06 | DPWA | $\pi N \to \pi N, \eta N$ |
| 44 | HOEHLER | 93 | ARGD | $\pi N \to \pi N$ |
| 34±2 | CUTKOSKY | 80 | IPWA | $\pi N \to \pi N$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 43 | ARNDT | 04 | DPWA | $\pi N \to \pi N, \eta N$ |
| 40 | ARNDT | 95 | DPWA | $\pi N \to N \pi$ |
| 37 | ARNDT | 91 | DPWA | $\pi N \to \pi N$ Soln SM90 |

## PHASE θ

| VALUE (°) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| − 4 | ARNDT | 06 | DPWA | $\pi N \to \pi N, \eta N$ |
| −17 | HOEHLER | 93 | ARGD | $\pi N \to \pi N$ |
| −25±5 | CUTKOSKY | 80 | IPWA | $\pi N \to \pi N$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 1 | ARNDT | 04 | DPWA | $\pi N \to \pi N, \eta N$ |
| + 1 | ARNDT | 95 | DPWA | $\pi N \to N \pi$ |
| −14 | ARNDT | 91 | DPWA | $\pi N \to \pi N$ Soln SM90 |

## N(1680) DECAY MODES

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

| | Mode | Fraction ($\Gamma_i/\Gamma$) |
|---|---|---|
| $\Gamma_1$ | $N\pi$ | 0.65 to 0.70 |
| $\Gamma_2$ | $N\eta$ | (0.0 ±1.0) % |
| $\Gamma_3$ | $\Lambda K$ | |
| $\Gamma_4$ | $\Sigma K$ | |
| $\Gamma_5$ | $N\pi\pi$ | 30–40 % |
| $\Gamma_6$ | $\Delta\pi$ | 5–15 % |
| $\Gamma_7$ | $\Delta(1232)\pi$, P-wave | 6–14 % |
| $\Gamma_8$ | $\Delta(1232)\pi$, F-wave | <2 % |
| $\Gamma_9$ | $N\rho$ | 3–15 % |
| $\Gamma_{10}$ | $N\rho$, S=1/2, F-wave | |
| $\Gamma_{11}$ | $N\rho$, S=3/2, P-wave | <12 % |
| $\Gamma_{12}$ | $N\rho$, S=3/2, F-wave | 1–5 % |
| $\Gamma_{13}$ | $N(\pi\pi)^{I=0}_{S\text{-wave}}$ | 5–20 % |
| $\Gamma_{14}$ | $p\gamma$ | 0.21–0.32 % |
| $\Gamma_{15}$ | $p\gamma$, helicity=1/2 | 0.001–0.011 % |
| $\Gamma_{16}$ | $p\gamma$, helicity=3/2 | 0.20–0.32 % |
| $\Gamma_{17}$ | $n\gamma$ | 0.021–0.046 % |
| $\Gamma_{18}$ | $n\gamma$, helicity=1/2 | 0.004–0.029 % |
| $\Gamma_{19}$ | $n\gamma$, helicity=3/2 | 0.01–0.024 % |

## N(1680) BRANCHING RATIOS

### $\Gamma(N\pi)/\Gamma_{total}$ — $\Gamma_1/\Gamma$

| VALUE | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **0.65 to 0.70 OUR ESTIMATE** | | | | |
| 0.701±0.001 | ARNDT | 06 | DPWA | $\pi N \to \pi N, \eta N$ |
| 0.70 ±0.03 | MANLEY | 92 | IPWA | $\pi N \to \pi N$ & $N\pi\pi$ |
| 0.62 ±0.05 | CUTKOSKY | 80 | IPWA | $\pi N \to \pi N$ |
| 0.65 ±0.02 | HOEHLER | 79 | IPWA | $\pi N \to \pi N$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 0.670±0.004 | ARNDT | 04 | DPWA | $\pi N \to \pi N, \eta N$ |
| 0.69 ±0.02 | VRANA | 00 | DPWA | Multichannel |
| 0.68 | ARNDT | 95 | DPWA | $\pi N \to N\pi$ |
| 0.69 ±0.04 | BATINIC | 95 | DPWA | $\pi N \to N\pi, N\eta$ |

### $(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(1680) \to N\eta$ — $(\Gamma_1\Gamma_2)^{1/2}/\Gamma$

| VALUE | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| not seen | BAKER | 79 | DPWA | $\pi^- p \to n\eta$ |

### $\Gamma(N\eta)/\Gamma_{total}$ — $\Gamma_2/\Gamma$

| VALUE | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **0.00 ±0.01** | VRANA | 00 | DPWA | Multichannel |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| $0.0015^{+0.0035}_{-0.0010}$ | TIATOR | 99 | DPWA | $\gamma p \rightarrow p\eta$ |
| 0.01 ±0.004 | BATINIC | 95 | DPWA | $\pi N \rightarrow N\pi$, $N\eta$ |

### $(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \rightarrow N(1680) \rightarrow \Lambda K$ — $(\Gamma_1\Gamma_3)^{1/2}/\Gamma$

Coupling to $\Lambda K$ not required in the analyses of SAXON 80 or BELL 83.

Note: Signs of couplings from $\pi N \rightarrow N\pi\pi$ 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 $N\pi \rightarrow N(1680) \rightarrow \Delta(1232)\pi$, P-wave — $(\Gamma_1\Gamma_7)^{1/2}/\Gamma$

| VALUE | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **−0.31 to −0.21 OUR ESTIMATE** | | | | |
| −0.26±0.04 | MANLEY | 92 | IPWA | $\pi N \rightarrow \pi N$ & $N\pi\pi$ |
| −0.27 | [1,5] LONGACRE | 77 | IPWA | $\pi N \rightarrow N\pi\pi$ |
| −0.25 | [2] LONGACRE | 75 | IPWA | $\pi N \rightarrow N\pi\pi$ |

### $\Gamma(\Delta(1232)\pi$, P-wave$)/\Gamma_{total}$ — $\Gamma_7/\Gamma$

| VALUE | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| 0.14±0.03 | VRANA | 00 | DPWA | Multichannel |

### $(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \rightarrow N(1680) \rightarrow \Delta(1232)\pi$, F-wave — $(\Gamma_1\Gamma_8)^{1/2}/\Gamma$

| VALUE | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **+0.03 to +0.11 OUR ESTIMATE** | | | | |
| +0.07±0.03 | MANLEY | 92 | IPWA | $\pi N \rightarrow \pi N$ & $N\pi\pi$ |
| +0.07 | [1,5] LONGACRE | 77 | IPWA | $\pi N \rightarrow N\pi\pi$ |
| +0.08 | [2] LONGACRE | 75 | IPWA | $\pi N \rightarrow N\pi\pi$ |

### $\Gamma(\Delta(1232)\pi$, F-wave$)/\Gamma_{total}$ — $\Gamma_8/\Gamma$

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

### $(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \rightarrow N(1680) \rightarrow N\rho$, S=3/2, P-wave — $(\Gamma_1\Gamma_{11})^{1/2}/\Gamma$

| VALUE | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **−0.30 to −0.10 OUR ESTIMATE** | | | | |
| −0.20±0.05 | MANLEY | 92 | IPWA | $\pi N \rightarrow \pi N$ & $N\pi\pi$ |
| −0.23 | [1,5] LONGACRE | 77 | IPWA | $\pi N \rightarrow N\pi\pi$ |
| −0.30 | [2] LONGACRE | 75 | IPWA | $\pi N \rightarrow N\pi\pi$ |

### $\Gamma(N\rho$, S=3/2, P-wave$)/\Gamma_{total}$ — $\Gamma_{11}/\Gamma$

| VALUE | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| 0.05±0.01 | VRANA | 00 | DPWA | Multichannel |

### $(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(1680) \to N\rho$, $S$=3/2, $F$-wave — $(\Gamma_1\Gamma_{12})^{1/2}/\Gamma$

| VALUE | | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **−0.18 to −0.10 OUR ESTIMATE** | | | | | |
| −0.13±0.03 | | MANLEY | 92 | IPWA | $\pi N \to \pi N$ & $N\pi\pi$ |
| −0.15 | [1,5] | LONGACRE | 77 | IPWA | $\pi N \to N\pi\pi$ |

### $\Gamma(N\rho$, $S$=3/2, $F$-wave$)/\Gamma_{total}$ — $\Gamma_{12}/\Gamma$

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

### $(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(1680) \to N(\pi\pi)^{I=0}_{S\text{-wave}}$ — $(\Gamma_1\Gamma_{13})^{1/2}/\Gamma$

| VALUE | | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **+0.25 to +0.35 OUR ESTIMATE** | | | | | |
| +0.29±0.04 | | MANLEY | 92 | IPWA | $\pi N \to \pi N$ & $N\pi\pi$ |
| +0.31 | [1,5] | LONGACRE | 77 | IPWA | $\pi N \to N\pi\pi$ |
| +0.30 | [2] | LONGACRE | 75 | IPWA | $\pi N \to N\pi\pi$ |

### $\Gamma(N(\pi\pi)^{I=0}_{S\text{-wave}})/\Gamma_{total}$ — $\Gamma_{13}/\Gamma$

| VALUE | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| 0.09±0.01 | VRANA | 00 | DPWA | Multichannel |

## $N(1680)$ PHOTON DECAY AMPLITUDES

### $N(1680) \to p\gamma$, helicity-1/2 amplitude $A_{1/2}$

| VALUE (GeV$^{-1/2}$) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **−0.015±0.006 OUR ESTIMATE** | | | | |
| −0.010±0.004 | ARNDT | 96 | IPWA | $\gamma N \to \pi N$ |
| −0.017±0.018 | CRAWFORD | 83 | IPWA | $\gamma N \to \pi N$ |
| −0.009±0.006 | AWAJI | 81 | DPWA | $\gamma N \to \pi N$ |
| −0.028±0.003 | ARAI | 80 | DPWA | $\gamma N \to \pi N$ (fit 1) |
| −0.026±0.003 | ARAI | 80 | DPWA | $\gamma N \to \pi N$ (fit 2) |
| −0.018±0.014 | CRAWFORD | 80 | DPWA | $\gamma N \to \pi N$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| −0.006±0.002 | LI | 93 | IPWA | $\gamma N \to \pi N$ |

### $N(1680) \to p\gamma$, helicity-3/2 amplitude $A_{3/2}$

| VALUE (GeV$^{-1/2}$) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **+0.133±0.012 OUR ESTIMATE** | | | | |
| 0.145±0.005 | ARNDT | 96 | IPWA | $\gamma N \to \pi N$ |
| 0.132±0.010 | CRAWFORD | 83 | IPWA | $\gamma N \to \pi N$ |
| 0.115±0.008 | AWAJI | 81 | DPWA | $\gamma N \to \pi N$ |
| 0.115±0.003 | ARAI | 80 | DPWA | $\gamma N \to \pi N$ (fit 1) |
| 0.122±0.003 | ARAI | 80 | DPWA | $\gamma N \to \pi N$ (fit 2) |
| 0.141±0.014 | CRAWFORD | 80 | DPWA | $\gamma N \to \pi N$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 0.154±0.002 | LI | 93 | IPWA | $\gamma N \to \pi N$ |

### $N(1680) \to n\gamma$, helicity-1/2 amplitude $A_{1/2}$

| VALUE ($GeV^{-1/2}$) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **+0.029±0.010 OUR ESTIMATE** | | | | |
| 0.030±0.005 | ARNDT | 96 | IPWA | $\gamma N \to \pi N$ |
| 0.017±0.014 | AWAJI | 81 | DPWA | $\gamma N \to \pi N$ |
| 0.032±0.003 | FUJII | 81 | DPWA | $\gamma N \to \pi N$ |
| 0.026±0.005 | ARAI | 80 | DPWA | $\gamma N \to \pi N$ (fit 1) |
| 0.028±0.014 | ARAI | 80 | DPWA | $\gamma N \to \pi N$ (fit 2) |
| 0.044±0.012 | CRAWFORD | 80 | DPWA | $\gamma N \to \pi N$ |
| 0.025±0.010 | TAKEDA | 80 | DPWA | $\gamma N \to \pi N$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 0.022±0.002 | LI | 93 | IPWA | $\gamma N \to \pi N$ |

### $N(1680) \to n\gamma$, helicity-3/2 amplitude $A_{3/2}$

| VALUE ($GeV^{-1/2}$) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **−0.033±0.009 OUR ESTIMATE** | | | | |
| −0.040±0.015 | ARNDT | 96 | IPWA | $\gamma N \to \pi N$ |
| −0.033±0.013 | AWAJI | 81 | DPWA | $\gamma N \to \pi N$ |
| −0.023±0.005 | FUJII | 81 | DPWA | $\gamma N \to \pi N$ |
| −0.024±0.009 | ARAI | 80 | DPWA | $\gamma N \to \pi N$ (fit 1) |
| −0.029±0.017 | ARAI | 80 | DPWA | $\gamma N \to \pi N$ (fit 2) |
| −0.033±0.015 | CRAWFORD | 80 | DPWA | $\gamma N \to \pi N$ |
| −0.035±0.012 | TAKEDA | 80 | DPWA | $\gamma N \to \pi N$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| −0.048±0.002 | LI | 93 | IPWA | $\gamma N \to \pi N$ |

## N(1680) FOOTNOTES

[1] 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.

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

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

[4] 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.

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

## N(1680) REFERENCES

For early references, see Physics Letters **111B** 1 (1982). For very early references, see Reviews of Modern Physics **37** 633 (1965).


| | | | | |
|---|---|---|---|---|
| ARNDT | 06 | PR C74 045205 | R.A. Arndt *et al.* | (GWU) |
| PDG | 06 | JPG 33 1 | W.-M. Yao *et al.* | (PDG Collab.) |
| ARNDT | 04 | PR C69 035213 | R.A. Arndt *et al.* | (GWU, TRIU) |
| VRANA | 00 | PRPL 328 181 | T.P. Vrana, S.A. Dytman,, T.-S.H. Lee | (PITT+) |
| TIATOR | 99 | PR C60 035210 | L. Tiator *et al.* | |
| 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 | $\pi N$ 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 |
| 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) |
| ARAI | 80 | Toronto Conf. 93 | I. Arai | (INUS) |
| Also | | NP B194 251 | I. Arai, H. Fujii | (INUS) |
| CRAWFORD | 80 | Toronto Conf. 107 | R.L. Crawford | (GLAS) |
| 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 |
| SAXON | 80 | NP B162 522 | D.H. Saxon *et al.* | (RHEL, BRIS) IJP |
| TAKEDA | 80 | NP B168 17 | H. Takeda *et al.* | (TOKY, INUS) |
| BAKER | 79 | NP B156 93 | R.D. Baker *et al.* | (RHEL) 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 |