# $N(1675)$ $D_{15}$

$I(J^P) = \frac{1}{2}(\frac{5}{2}^-)$ Status: ****

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** (1982).

## $N(1675)$ BREIT-WIGNER MASS

| *VALUE* (MeV) | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|
| **1670 to 1685 (≈ 1675) OUR ESTIMATE** | | | | |
| 1676± 2 | MANLEY | 92 | IPWA | $\pi N \to \pi N$ & $N\pi\pi$ |
| 1675±10 | CUTKOSKY | 80 | IPWA | $\pi N \to \pi N$ |
| 1679± 8 | HOEHLER | 79 | IPWA | $\pi N \to \pi N$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 1685± 4 | VRANA | 00 | DPWA | Multichannel |
| 1673± 5 | ARNDT | 96 | IPWA | $\gamma N \to \pi N$ |
| 1673 | ARNDT | 95 | DPWA | $\pi N \to N\pi$ |
| 1683±19 | BATINIC | 95 | DPWA | $\pi N \to N\pi$, $N\eta$ |
| 1666 | LI | 93 | IPWA | $\gamma N \to \pi N$ |
| 1685 | CRAWFORD | 80 | DPWA | $\gamma N \to \pi N$ |
| 1670 | SAXON | 80 | DPWA | $\pi^- p \to \Lambda K^0$ |
| 1680 | BARBOUR | 78 | DPWA | $\gamma N \to \pi N$ |
| 1650 | [1] LONGACRE | 77 | IPWA | $\pi N \to N\pi\pi$ |
| 1660 | [2] LONGACRE | 75 | IPWA | $\pi N \to N\pi\pi$ |

## $N(1675)$ BREIT-WIGNER WIDTH

| *VALUE* (MeV) | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|
| **140 to 180 (≈ 150) OUR ESTIMATE** | | | | |
| 159± 7 | MANLEY | 92 | IPWA | $\pi N \to \pi N$ & $N\pi\pi$ |
| 160±20 | CUTKOSKY | 80 | IPWA | $\pi N \to \pi N$ |
| 120±15 | HOEHLER | 79 | IPWA | $\pi N \to \pi N$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 131±10 | VRANA | 00 | DPWA | Multichannel |
| 154± 7 | ARNDT | 96 | IPWA | $\gamma N \to \pi N$ |
| 154 | ARNDT | 95 | DPWA | $\pi N \to N\pi$ |
| 142±23 | BATINIC | 95 | DPWA | $\pi N \to N\pi$, $N\eta$ |
| 136 | LI | 93 | IPWA | $\gamma N \to \pi N$ |
| 191 | CRAWFORD | 80 | DPWA | $\gamma N \to \pi N$ |
| 40 | SAXON | 80 | DPWA | $\pi^- p \to \Lambda K^0$ |
| 88 | BAKER | 79 | DPWA | $\pi^- p \to n\eta$ |
| 192 | BARBOUR | 78 | DPWA | $\gamma N \to \pi N$ |
| 130 | [1] LONGACRE | 77 | IPWA | $\pi N \to N\pi\pi$ |
| 150 | [2] LONGACRE | 75 | IPWA | $\pi N \to N\pi\pi$ |

## *N*(1675) POLE POSITION

### REAL PART

| *VALUE* (MeV) | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|
| **1655 to 1665 (≈ 1660) OUR ESTIMATE** | | | | |
| 1663 | ARNDT | 95 | DPWA | $\pi N \to N\pi$ |
| 1656 | [3] HOEHLER | 93 | ARGD | $\pi N \to \pi N$ |
| 1660 ± 10 | CUTKOSKY | 80 | IPWA | $\pi N \to \pi N$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 1674 | VRANA | 00 | DPWA | Multichannel |
| 1655 | ARNDT | 91 | DPWA | $\pi N \to \pi N$ Soln SM90 |
| 1663 or 1668 | [4] LONGACRE | 78 | IPWA | $\pi N \to N\pi\pi$ |
| 1649 or 1650 | [1] LONGACRE | 77 | IPWA | $\pi N \to N\pi\pi$ |

### −2×IMAGINARY PART

| *VALUE* (MeV) | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|
| **125 to 155 (≈ 140) OUR ESTIMATE** | | | | |
| 152 | ARNDT | 95 | DPWA | $\pi N \to N\pi$ |
| 126 | [3] HOEHLER | 93 | ARGD | $\pi N \to \pi N$ |
| 140 ± 10 | CUTKOSKY | 80 | IPWA | $\pi N \to \pi N$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 120 | VRANA | 00 | DPWA | Multichannel |
| 124 | ARNDT | 91 | DPWA | $\pi N \to \pi N$ Soln SM90 |
| 146 or 171 | [4] LONGACRE | 78 | IPWA | $\pi N \to N\pi\pi$ |
| 127 or 127 | [1] LONGACRE | 77 | IPWA | $\pi N \to N\pi\pi$ |

## *N*(1675) ELASTIC POLE RESIDUE

### MODULUS $|r|$

| *VALUE* (MeV) | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|
| 29 | ARNDT | 95 | DPWA | $\pi N \to N\pi$ |
| 23 | HOEHLER | 93 | ARGD | $\pi N \to \pi N$ |
| 31 ± 5 | CUTKOSKY | 80 | IPWA | $\pi N \to \pi N$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 28 | ARNDT | 91 | DPWA | $\pi N \to \pi N$ Soln SM90 |

### PHASE $\theta$

| *VALUE* (°) | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|
| − 6 | ARNDT | 95 | DPWA | $\pi N \to N\pi$ |
| −22 | HOEHLER | 93 | ARGD | $\pi N \to \pi N$ |
| −30 ± 10 | CUTKOSKY | 80 | IPWA | $\pi N \to \pi N$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| −17 | ARNDT | 91 | DPWA | $\pi N \to \pi N$ Soln SM90 |

## $N(1675)$ DECAY MODES

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

| | Mode | Fraction ($\Gamma_i/\Gamma$) |
|---|---|---|
| $\Gamma_1$ | $N\pi$ | 40–50 % |
| $\Gamma_2$ | $N\eta$ | (0.0 ± 1.0) % |
| $\Gamma_3$ | $\Lambda K$ | <1 % |
| $\Gamma_4$ | $\Sigma K$ | |
| $\Gamma_5$ | $N\pi\pi$ | 50–60 % |
| $\Gamma_6$ | $\Delta\pi$ | 50–60 % |
| $\Gamma_7$ | $\Delta(1232)\pi$, $D$-wave | |
| $\Gamma_8$ | $\Delta(1232)\pi$, $G$-wave | |
| $\Gamma_9$ | $N\rho$ | < 1–3 % |
| $\Gamma_{10}$ | $N\rho$, $S$=1/2, $D$-wave | |
| $\Gamma_{11}$ | $N\rho$, $S$=3/2, $D$-wave | |
| $\Gamma_{12}$ | $N\rho$, $S$=3/2, $G$-wave | |
| $\Gamma_{13}$ | $N(\pi\pi)^{I=0}_{S\text{-wave}}$ | |
| $\Gamma_{14}$ | $p\gamma$ | 0.004–0.023 % |
| $\Gamma_{15}$ | $p\gamma$, helicity=1/2 | 0.0–0.015 % |
| $\Gamma_{16}$ | $p\gamma$, helicity=3/2 | 0.0–0.011 % |
| $\Gamma_{17}$ | $n\gamma$ | 0.02–0.12 % |
| $\Gamma_{18}$ | $n\gamma$, helicity=1/2 | 0.006–0.046 % |
| $\Gamma_{19}$ | $n\gamma$, helicity=3/2 | 0.01–0.08 % |

## $N(1675)$ BRANCHING RATIOS

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

| VALUE | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **0.4 to 0.5 OUR ESTIMATE** | | | | |
| 0.47 ± 0.02 | MANLEY | 92 | IPWA | $\pi N \to \pi N$ & $N\pi\pi$ |
| 0.38 ± 0.05 | CUTKOSKY | 80 | IPWA | $\pi N \to \pi N$ |
| 0.38 ± 0.03 | HOEHLER | 79 | IPWA | $\pi N \to \pi N$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 0.35 ± 0.01 | VRANA | 00 | DPWA | Multichannel |
| 0.38 | ARNDT | 95 | DPWA | $\pi N \to N\pi$ |
| 0.31 ± 0.06 | BATINIC | 95 | DPWA | $\pi N \to N\pi$, $N\eta$ |

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

| 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. • • • | | | | |
| 0.001 ± 0.001 | BATINIC | 95 | DPWA | $\pi N \to N\pi$, $N\eta$ |

### $(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(1675) \to N\eta$ $(\Gamma_1\Gamma_2)^{1/2}/\Gamma$

| VALUE | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| −0.07 | BAKER | 79 | DPWA | $\pi^- p \to n\eta$ |
| +0.009 | FELTESSE | 75 | DPWA | Soln A; see BAKER 79 |

### $(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(1675) \to \Lambda K$ $(\Gamma_1\Gamma_3)^{1/2}/\Gamma$

| VALUE | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **±0.04 to ±0.08 OUR ESTIMATE** | | | | |
| −0.01 | BELL | 83 | DPWA | $\pi^- p \to \Lambda K^0$ |
| +0.036 | [5] SAXON | 80 | DPWA | $\pi^- p \to \Lambda K^0$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| −0.034±0.006 | DEVENISH | 74B | | Fixed-$t$ dispersion rel. |

### $(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(1675) \to \Sigma K$ $(\Gamma_1\Gamma_4)^{1/2}/\Gamma$

| VALUE | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| <0.003 | [6] DEANS | 75 | DPWA | $\pi N \to \Sigma K$ |

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 $N\pi \to N(1675) \to \Delta(1232)\pi$, $D$-wave $(\Gamma_1\Gamma_7)^{1/2}/\Gamma$

| VALUE | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **+0.46 to +0.50 OUR ESTIMATE** | | | | |
| +0.496±0.003 | MANLEY | 92 | IPWA | $\pi N \to \pi N$ & $N\pi\pi$ |
| +0.46 | [1,7] LONGACRE | 77 | IPWA | $\pi N \to N\pi\pi$ |
| +0.50 | [2] LONGACRE | 75 | IPWA | $\pi N \to N\pi\pi$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| +0.5 | [8] NOVOSELLER | 78 | IPWA | $\pi N \to N\pi\pi$ |

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

| VALUE | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| 0.63±0.02 | VRANA | 00 | DPWA | Multichannel |

### $(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(1675) \to N\rho$, $S$=1/2, $D$-wave $(\Gamma_1\Gamma_{10})^{1/2}/\Gamma$

| VALUE | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| +0.04±0.02 | MANLEY | 92 | IPWA | $\pi N \to \pi N$ & $N\pi\pi$ |

### $\Gamma(N\rho, S$=1/2, $D$-wave$)/\Gamma_{total}$ $\Gamma_{10}/\Gamma$

| VALUE | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| 0.00±0.01 | VRANA | 00 | DPWA | Multichannel |

### $(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(1675) \to N\rho$, $S$=3/2, $D$-wave $(\Gamma_1\Gamma_{11})^{1/2}/\Gamma$

| VALUE | | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **−0.12 to −0.06 OUR ESTIMATE** | | | | | |
| −0.03±0.02 | | MANLEY | 92 | IPWA | $\pi N \to \pi N$ & $N\pi\pi$ |
| −0.15 | [1,7] | LONGACRE | 77 | IPWA | $\pi N \to N\pi\pi$ |

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

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

### $(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to N(1675) \to N(\pi\pi)^{I=0}_{S\text{-wave}}$ $(\Gamma_1\Gamma_{13})^{1/2}/\Gamma$

| VALUE | | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| +0.03 | [1,7] | LONGACRE | 77 | IPWA | $\pi N \to N\pi\pi$ |

## $N(1675)$ PHOTON DECAY AMPLITUDES

### $N(1675) \to p\gamma$, helicity-1/2 amplitude $A_{1/2}$

| VALUE (GeV$^{-1/2}$) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **+0.019±0.008 OUR ESTIMATE** | | | | |
| 0.015±0.010 | ARNDT | 96 | IPWA | $\gamma N \to \pi N$ |
| 0.021±0.011 | CRAWFORD | 83 | IPWA | $\gamma N \to \pi N$ |
| 0.034±0.005 | AWAJI | 81 | DPWA | $\gamma N \to \pi N$ |
| 0.006±0.005 | ARAI | 80 | DPWA | $\gamma N \to \pi N$ (fit 1) |
| 0.006±0.004 | ARAI | 80 | DPWA | $\gamma N \to \pi N$ (fit 2) |
| 0.023±0.015 | CRAWFORD | 80 | DPWA | $\gamma N \to \pi N$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 0.012±0.002 | LI | 93 | IPWA | $\gamma N \to \pi N$ |
| +0.022±0.010 | BARBOUR | 78 | DPWA | $\gamma N \to \pi N$ |
| +0.034±0.004 | FELLER | 76 | DPWA | $\gamma N \to \pi N$ |

### $N(1675) \to p\gamma$, helicity-3/2 amplitude $A_{3/2}$

| VALUE (GeV$^{-1/2}$) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **+0.015±0.009 OUR ESTIMATE** | | | | |
| 0.010±0.007 | ARNDT | 96 | IPWA | $\gamma N \to \pi N$ |
| 0.015±0.009 | CRAWFORD | 83 | IPWA | $\gamma N \to \pi N$ |
| 0.024±0.008 | AWAJI | 81 | DPWA | $\gamma N \to \pi N$ |
| 0.030±0.004 | ARAI | 80 | DPWA | $\gamma N \to \pi N$ (fit 1) |
| 0.029±0.004 | ARAI | 80 | DPWA | $\gamma N \to \pi N$ (fit 2) |
| 0.003±0.012 | CRAWFORD | 80 | DPWA | $\gamma N \to \pi N$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 0.021±0.002 | LI | 93 | IPWA | $\gamma N \to \pi N$ |
| +0.015±0.006 | BARBOUR | 78 | DPWA | $\gamma N \to \pi N$ |
| +0.019±0.009 | FELLER | 76 | DPWA | $\gamma N \to \pi N$ |

### $N(1675) \rightarrow n\gamma$, helicity-1/2 amplitude $A_{1/2}$

| VALUE ($GeV^{-1/2}$) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **$-0.043 \pm 0.012$ OUR ESTIMATE** | | | | |
| $-0.049 \pm 0.010$ | ARNDT | 96 | IPWA | $\gamma N \rightarrow \pi N$ |
| $-0.057 \pm 0.024$ | AWAJI | 81 | DPWA | $\gamma N \rightarrow \pi N$ |
| $-0.033 \pm 0.004$ | FUJII | 81 | DPWA | $\gamma N \rightarrow \pi N$ |
| $-0.039 \pm 0.017$ | ARAI | 80 | DPWA | $\gamma N \rightarrow \pi N$ (fit 1) |
| $-0.025 \pm 0.027$ | ARAI | 80 | DPWA | $\gamma N \rightarrow \pi N$ (fit 2) |
| $-0.059 \pm 0.015$ | CRAWFORD | 80 | DPWA | $\gamma N \rightarrow \pi N$ |
| $-0.021 \pm 0.011$ | TAKEDA | 80 | DPWA | $\gamma N \rightarrow \pi N$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| $-0.060 \pm 0.003$ | LI | 93 | IPWA | $\gamma N \rightarrow \pi N$ |
| $-0.066 \pm 0.020$ | BARBOUR | 78 | DPWA | $\gamma N \rightarrow \pi N$ |

### $N(1675) \rightarrow n\gamma$, helicity-3/2 amplitude $A_{3/2}$

| VALUE ($GeV^{-1/2}$) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **$-0.058 \pm 0.013$ OUR ESTIMATE** | | | | |
| $-0.051 \pm 0.010$ | ARNDT | 96 | IPWA | $\gamma N \rightarrow \pi N$ |
| $-0.077 \pm 0.018$ | AWAJI | 81 | DPWA | $\gamma N \rightarrow \pi N$ |
| $-0.069 \pm 0.004$ | FUJII | 81 | DPWA | $\gamma N \rightarrow \pi N$ |
| $-0.066 \pm 0.026$ | ARAI | 80 | DPWA | $\gamma N \rightarrow \pi N$ (fit 1) |
| $-0.071 \pm 0.022$ | ARAI | 80 | DPWA | $\gamma N \rightarrow \pi N$ (fit 2) |
| $-0.059 \pm 0.020$ | CRAWFORD | 80 | DPWA | $\gamma N \rightarrow \pi N$ |
| $-0.030 \pm 0.012$ | TAKEDA | 80 | DPWA | $\gamma N \rightarrow \pi N$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| $-0.074 \pm 0.003$ | LI | 93 | IPWA | $\gamma N \rightarrow \pi N$ |
| $-0.073 \pm 0.014$ | BARBOUR | 78 | DPWA | $\gamma N \rightarrow \pi N$ |

## $N(1675)$ 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 $\pi N \rightarrow N\pi\pi$ 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 $\pi N \rightarrow N\pi\pi$ data, elastic amplitudes from a Saclay (CERN) partial-wave analysis.

[5] SAXON 80 finds the coupling phase is near $90^\circ$.

[6] The range given is from the four best solutions. DEANS 75 disagrees with $\pi^+ p \rightarrow \Sigma^+ K^+$ data of WINNIK 77 around 1920 MeV.

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

[8] A Breit-Wigner fit to the HERNDON 75 IPWA.

## *N*(1675) REFERENCES

For early references, see Physics Letters **111B** 70 (1982).


| | | | | |
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| VRANA | 00 | PRPL 328 181 | T.P. Vrana, S.A. Dytman,, T.-S.H. Lee | (PITT+) |
| 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 | 98 | 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 |
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| BAKER | 79 | NP B156 93 | R.D. Baker *et al.* | (RHEL) IJP |
| HOEHLER | 79 | PDAT 12-1 | G. Hohler *et al.* | (KARLT) IJP |
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| BARBOUR | 78 | NP B141 253 | I.M. Barbour, R.L. Crawford, N.H. Parsons | (GLAS) |
| LONGACRE | 78 | PR D17 1795 | R.S. Longacre *et al.* | (LBL, SLAC) |
| NOVOSELLER | 78 | NP B137 509 | D.E. Novoseller | (CIT) IJP |
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| LONGACRE | 77 | NP B122 493 | R.S. Longacre, J. Dolbeau | (SACL) IJP |
| Also | 76 | NP B108 365 | J. Dolbeau *et al.* | (SACL) IJP |
| WINNIK | 77 | NP B128 66 | M. Winnik *et al.* | (HAIF) I |
| FELLER | 76 | NP B104 219 | P. Feller *et al.* | (NAGO, OSAK) IJP |
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| LONGACRE | 75 | PL 55B 415 | R.S. Longacre *et al.* | (LBL, SLAC) IJP |
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