

N(1710) P₁₁

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

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).

The latest GWU analysis (ARNDT 06) finds no evidence for this resonance.

N(1710) BREIT-WIGNER MASS

| VALUE (MeV) | DOCUMENT ID | TECN | COMMENT |
|---|-----------------------|------|---|
| 1680 to 1740 (≈ 1710) OUR ESTIMATE | | | |
| 1717 ± 28 | MANLEY | 92 | IPWA πN → πN & Nππ |
| 1700 ± 50 | CUTKOSKY | 80 | IPWA πN → πN |
| 1723 ± 9 | HOEHLER | 79 | IPWA πN → πN |
| ● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ● | | | |
| 1752 ± 3 | PENNER | 02C | DPWA Multichannel |
| 1699 ± 65 | VRANA | 00 | DPWA Multichannel |
| 1720 ± 10 | ARNDT | 96 | IPWA γN → πN |
| 1766 ± 34 | ¹ BATINIC | 95 | DPWA πN → Nπ, Nη |
| 1706 | CUTKOSKY | 90 | IPWA πN → πN |
| 1730 | SAXON | 80 | DPWA π ⁻ p → ΛK ⁰ |
| 1720 | ² LONGACRE | 77 | IPWA πN → Nππ |
| 1710 | ³ LONGACRE | 75 | IPWA πN → Nππ |

N(1710) BREIT-WIGNER WIDTH

| VALUE (MeV) | DOCUMENT ID | TECN | COMMENT |
|---|-----------------------|------|---|
| 50 to 250 (≈ 100) OUR ESTIMATE | | | |
| 480 ± 230 | MANLEY | 92 | IPWA πN → πN & Nππ |
| 93 ± 30 | CUTKOSKY | 90 | IPWA πN → πN |
| 90 ± 30 | CUTKOSKY | 80 | IPWA πN → πN |
| 120 ± 15 | HOEHLER | 79 | IPWA πN → πN |
| ● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ● | | | |
| 386 ± 59 | PENNER | 02C | DPWA Multichannel |
| 143 ± 100 | VRANA | 00 | DPWA Multichannel |
| 105 ± 10 | ARNDT | 96 | IPWA γN → πN |
| 185 ± 61 | BATINIC | 95 | DPWA πN → Nπ, Nη |
| 540 | BELL | 83 | DPWA π ⁻ p → ΛK ⁰ |
| 550 | SAXON | 80 | DPWA π ⁻ p → ΛK ⁰ |
| 120 | ² LONGACRE | 77 | IPWA πN → Nππ |
| 75 | ³ LONGACRE | 75 | IPWA πN → Nππ |

N(1710) POLE POSITION

REAL PART

| VALUE (MeV) | DOCUMENT ID | TECN | COMMENT |
|---|--------------------------|------|-------------------------------------|
| 1670 to 1770 (\approx 1720) OUR ESTIMATE | | | |
| 1690 | ⁴ HOEHLER 93 | SPED | $\pi N \rightarrow \pi N$ |
| 1698 | CUTKOSKY 90 | IPWA | $\pi N \rightarrow \pi N$ |
| 1690 \pm 20 | CUTKOSKY 80 | IPWA | $\pi N \rightarrow \pi N$ |
| ● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ● | | | |
| 1679 | VRANA 00 | DPWA | Multichannel |
| 1770 | ARNDT 95 | DPWA | $\pi N \rightarrow N\pi$ |
| 1636 | ARNDT 91 | DPWA | $\pi N \rightarrow \pi N$ Soln SM90 |
| 1708 or 1712 | ⁵ LONGACRE 78 | IPWA | $\pi N \rightarrow N\pi\pi$ |
| 1720 or 1711 | ² LONGACRE 77 | IPWA | $\pi N \rightarrow N\pi\pi$ |

– 2xIMAGINARY PART

| VALUE (MeV) | DOCUMENT ID | TECN | COMMENT |
|---|--------------------------|------|-------------------------------------|
| 80 to 380 (\approx 230) OUR ESTIMATE | | | |
| 200 | ⁴ HOEHLER 93 | SPED | $\pi N \rightarrow \pi N$ |
| 88 | CUTKOSKY 90 | IPWA | $\pi N \rightarrow \pi N$ |
| 80 \pm 20 | CUTKOSKY 80 | IPWA | $\pi N \rightarrow \pi N$ |
| ● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ● | | | |
| 132 | VRANA 00 | DPWA | Multichannel |
| 378 | ARNDT 95 | DPWA | $\pi N \rightarrow N\pi$ |
| 544 | ARNDT 91 | DPWA | $\pi N \rightarrow \pi N$ Soln SM90 |
| 17 or 22 | ⁵ LONGACRE 78 | IPWA | $\pi N \rightarrow N\pi\pi$ |
| 123 or 115 | ² LONGACRE 77 | IPWA | $\pi N \rightarrow N\pi\pi$ |

N(1710) ELASTIC POLE RESIDUE

MODULUS $|r|$

| VALUE (MeV) | DOCUMENT ID | TECN | COMMENT |
|---|-------------|------|-------------------------------------|
| 15 | HOEHLER 93 | SPED | $\pi N \rightarrow \pi N$ |
| 9 | CUTKOSKY 90 | IPWA | $\pi N \rightarrow \pi N$ |
| 8 \pm 2 | CUTKOSKY 80 | IPWA | $\pi N \rightarrow \pi N$ |
| ● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ● | | | |
| 37 | ARNDT 95 | DPWA | $\pi N \rightarrow N\pi$ |
| 149 | ARNDT 91 | DPWA | $\pi N \rightarrow \pi N$ Soln SM90 |

PHASE θ

| VALUE ($^\circ$) | DOCUMENT ID | TECN | COMMENT |
|---|-------------|------|-------------------------------------|
| – 167 | CUTKOSKY 90 | IPWA | $\pi N \rightarrow \pi N$ |
| 175 \pm 35 | CUTKOSKY 80 | IPWA | $\pi N \rightarrow \pi N$ |
| ● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ● | | | |
| – 167 | ARNDT 95 | DPWA | $\pi N \rightarrow N\pi$ |
| 149 | ARNDT 91 | DPWA | $\pi N \rightarrow \pi N$ Soln SM90 |

N(1710) DECAY MODES

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

| Mode | Fraction (Γ_i/Γ) |
|--|--------------------------------|
| Γ_1 $N\pi$ | 10–20 % |
| Γ_2 $N\eta$ | (6.2 ± 1.0) % |
| Γ_3 $N\omega$ | (13.0 ± 2.0) % |
| Γ_4 ΛK | 5–25 % |
| Γ_5 ΣK | |
| Γ_6 $N\pi\pi$ | 40–90 % |
| Γ_7 $\Delta\pi$ | 15–40 % |
| Γ_8 $\Delta(1232)\pi$, <i>P</i> -wave | |
| Γ_9 $N\rho$ | 5–25 % |
| Γ_{10} $N\rho$, $S=1/2$, <i>P</i> -wave | |
| Γ_{11} $N\rho$, $S=3/2$, <i>P</i> -wave | |
| Γ_{12} $N(\pi\pi)_{S\text{-wave}}^{I=0}$ | 10–40 % |
| Γ_{13} $p\gamma$ | 0.002–0.05% |
| Γ_{14} $p\gamma$, helicity=1/2 | 0.002–0.05% |
| Γ_{15} $n\gamma$ | 0.0–0.02% |
| Γ_{16} $n\gamma$, helicity=1/2 | 0.0–0.02% |

N(1710) BRANCHING RATIOS

| $\Gamma(N\pi)/\Gamma_{\text{total}}$ | Γ_1/Γ |
|---|--|
| <u>VALUE</u> | <u>DOCUMENT ID</u> <u>TECN</u> <u>COMMENT</u> |
| 0.10 to 0.20 OUR ESTIMATE | |
| 0.09±0.04 | MANLEY 92 IPWA $\pi N \rightarrow \pi N$ & $N\pi\pi$ |
| 0.20±0.04 | CUTKOSKY 80 IPWA $\pi N \rightarrow \pi N$ |
| 0.12±0.04 | HOEHLER 79 IPWA $\pi N \rightarrow \pi N$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | |
| 0.14±0.08 | PENNER 02C DPWA Multichannel |
| 0.27±0.13 | VRANA 00 DPWA Multichannel |
| 0.08±0.14 | BATINIC 95 DPWA $\pi N \rightarrow N\pi$, $N\eta$ |
| | |
| $\Gamma(N\eta)/\Gamma_{\text{total}}$ | Γ_2/Γ |
| <u>VALUE</u> | <u>DOCUMENT ID</u> <u>TECN</u> <u>COMMENT</u> |
| 0.062±0.010 OUR AVERAGE | |
| 0.36 ±0.11 | PENNER 02C DPWA Multichannel |
| 0.06 ±0.01 | VRANA 00 DPWA Multichannel |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | |
| 0.16 ±0.10 | BATINIC 95 DPWA $\pi N \rightarrow N\pi$, $N\eta$ |
| | |
| $\Gamma(N\omega)/\Gamma_{\text{total}}$ | Γ_3/Γ |
| <u>VALUE</u> | <u>DOCUMENT ID</u> <u>TECN</u> <u>COMMENT</u> |
| 0.13±0.02 | PENNER 02C DPWA Multichannel |

$(\Gamma_i \Gamma_f)^{1/2} / \Gamma_{\text{total}}$ in $N\pi \rightarrow N(1710) \rightarrow \Lambda K$ $(\Gamma_1 \Gamma_4)^{1/2} / \Gamma$

| VALUE | DOCUMENT ID | TECN | COMMENT |
|------------------------------------|-------------|------|--|
| +0.12 to +0.18 OUR ESTIMATE | | | |
| +0.16 | BELL | 83 | DPWA $\pi^- p \rightarrow \Lambda K^0$ |
| +0.14 | SAXON | 80 | DPWA $\pi^- p \rightarrow \Lambda K^0$ |

$\Gamma(\Lambda K) / \Gamma_{\text{total}}$ Γ_4 / Γ

| VALUE | DOCUMENT ID | TECN | COMMENT |
|-------------|-------------|------|-------------------|
| 0.05 ± 0.03 | SHKLYAR | 05 | DPWA Multichannel |
| 0.05 ± 0.02 | PENNER | 02C | DPWA Multichannel |
| 0.1 ± 0.1 | VRANA | 00 | DPWA Multichannel |

$\Gamma(\Sigma K) / \Gamma_{\text{total}}$ Γ_5 / Γ

| VALUE | DOCUMENT ID | TECN | COMMENT |
|---|-------------|------|-------------------|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | |
| 0.07 ± 0.07 | PENNER | 02C | DPWA Multichannel |

$(\Gamma_i \Gamma_f)^{1/2} / \Gamma_{\text{total}}$ in $N\pi \rightarrow N(1710) \rightarrow \Sigma K$ $(\Gamma_1 \Gamma_5)^{1/2} / \Gamma$

| VALUE | DOCUMENT ID | TECN | COMMENT |
|---|-------------|------|-----------------------------------|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | |
| -0.034 | LIVANOS | 80 | DPWA $\pi p \rightarrow \Sigma K$ |

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 $\Delta(1232)\pi$.

$(\Gamma_i \Gamma_f)^{1/2} / \Gamma_{\text{total}}$ in $N\pi \rightarrow N(1710) \rightarrow \Delta(1232)\pi, P\text{-wave}$ $(\Gamma_1 \Gamma_8)^{1/2} / \Gamma$

| VALUE | DOCUMENT ID | TECN | COMMENT |
|------------------------------------|-----------------------|------|---|
| ±0.16 to ±0.22 OUR ESTIMATE | | | |
| -0.21 ± 0.04 | MANLEY | 92 | IPWA $\pi N \rightarrow \pi N \& N\pi\pi$ |
| -0.17 | ² LONGACRE | 77 | IPWA $\pi N \rightarrow N\pi\pi$ |
| +0.20 | ³ LONGACRE | 75 | IPWA $\pi N \rightarrow N\pi\pi$ |

$\Gamma(\Delta(1232)\pi, P\text{-wave}) / \Gamma_{\text{total}}$ Γ_8 / Γ

| VALUE | DOCUMENT ID | TECN | COMMENT |
|-------------|-------------|------|-------------------|
| 0.39 ± 0.08 | VRANA | 00 | DPWA Multichannel |

$(\Gamma_i \Gamma_f)^{1/2} / \Gamma_{\text{total}}$ in $N\pi \rightarrow N(1710) \rightarrow N\rho, S=1/2, P\text{-wave}$ $(\Gamma_1 \Gamma_{10})^{1/2} / \Gamma$

| VALUE | DOCUMENT ID | TECN | COMMENT |
|------------------------------------|-----------------------|------|---|
| ±0.09 to ±0.19 OUR ESTIMATE | | | |
| +0.05 ± 0.06 | MANLEY | 92 | IPWA $\pi N \rightarrow \pi N \& N\pi\pi$ |
| +0.19 | ² LONGACRE | 77 | IPWA $\pi N \rightarrow N\pi\pi$ |
| -0.20 | ³ LONGACRE | 75 | IPWA $\pi N \rightarrow N\pi\pi$ |

$\Gamma(N\rho, S=1/2, P\text{-wave}) / \Gamma_{\text{total}}$ Γ_{10} / Γ

| VALUE | DOCUMENT ID | TECN | COMMENT |
|-------------|-------------|------|-------------------|
| 0.17 ± 0.01 | VRANA | 00 | DPWA Multichannel |

| $(\Gamma_i \Gamma_f)^{1/2} / \Gamma_{\text{total}}$ in $N\pi \rightarrow N(1710) \rightarrow N\rho, S=3/2, P\text{-wave}$ | $(\Gamma_1 \Gamma_{11})^{1/2} / \Gamma$ |
|---|---|
| VALUE | DOCUMENT ID TECN COMMENT |
| +0.31 | ² LONGACRE 77 IPWA $\pi N \rightarrow N\pi\pi$ |

| $(\Gamma_i \Gamma_f)^{1/2} / \Gamma_{\text{total}}$ in $N\pi \rightarrow N(1710) \rightarrow N(\pi\pi)_{S\text{-wave}}^{I=0}$ | $(\Gamma_1 \Gamma_{12})^{1/2} / \Gamma$ |
|---|---|
| VALUE | DOCUMENT ID TECN COMMENT |
| ± 0.14 to ± 0.22 OUR ESTIMATE | |
| +0.04 ± 0.05 | MANLEY 92 IPWA $\pi N \rightarrow \pi N$ & $N\pi\pi$ |
| -0.26 | ² LONGACRE 77 IPWA $\pi N \rightarrow N\pi\pi$ |
| -0.28 | ³ LONGACRE 75 IPWA $\pi N \rightarrow N\pi\pi$ |

| $\Gamma(N(\pi\pi)_{S\text{-wave}}^{I=0}) / \Gamma_{\text{total}}$ | Γ_{12} / Γ |
|---|----------------------------|
| VALUE | DOCUMENT ID TECN COMMENT |
| 0.01 ± 0.01 | VRANA 00 DPWA Multichannel |

N(1710) PHOTON DECAY AMPLITUDES

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

N(1710) → $\rho\gamma$, helicity-1/2 amplitude $A_{1/2}$

| VALUE (GeV ^{-1/2}) | DOCUMENT ID | TECN | COMMENT |
|---|-------------|------|------------------------------|
| +0.009 ± 0.022 OUR ESTIMATE | | | |
| 0.007 ± 0.015 | ARNDT 96 | IPWA | $\gamma N \rightarrow \pi N$ |
| 0.006 ± 0.018 | CRAWFORD 83 | IPWA | $\gamma N \rightarrow \pi N$ |
| 0.028 ± 0.009 | AWAJI 81 | DPWA | $\gamma N \rightarrow \pi N$ |
| ● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ● | | | |
| 0.044 | PENNER 02D | DPWA | Multichannel |
| -0.037 ± 0.002 | LI 93 | IPWA | $\gamma N \rightarrow \pi N$ |

N(1710) → $n\gamma$, helicity-1/2 amplitude $A_{1/2}$

| VALUE (GeV ^{-1/2}) | DOCUMENT ID | TECN | COMMENT |
|---|-------------|------|------------------------------|
| -0.002 ± 0.014 OUR ESTIMATE | | | |
| -0.002 ± 0.015 | ARNDT 96 | IPWA | $\gamma N \rightarrow \pi N$ |
| 0.000 ± 0.018 | AWAJI 81 | DPWA | $\gamma N \rightarrow \pi N$ |
| -0.001 ± 0.003 | FUJII 81 | DPWA | $\gamma N \rightarrow \pi N$ |
| ● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ● | | | |
| -0.024 | PENNER 02D | DPWA | Multichannel |
| 0.052 ± 0.003 | LI 93 | IPWA | $\gamma N \rightarrow \pi N$ |

N(1710) $\gamma p \rightarrow \Lambda K^+$ AMPLITUDES

| $(\Gamma_i \Gamma_f)^{1/2} / \Gamma_{\text{total}}$ in $p\gamma \rightarrow N(1710) \rightarrow \Lambda K^+$ | $(M_{1-} \text{ amplitude})$ |
|--|------------------------------|
| VALUE (units 10 ⁻³) | DOCUMENT ID TECN |
| ● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ● | |
| -10.6 ± 0.4 | WORKMAN 90 DPWA |
| - 7.21 | TANABE 89 DPWA |

$\pi\gamma \rightarrow N(1710) \rightarrow \Lambda K^+$ phase angle θ (M_{1-} amplitude)

VALUE (degrees) DOCUMENT ID TECN

• • • We do not use the following data for averages, fits, limits, etc. • • •

| | | | |
|--------|---------|----|------|
| 215 ±3 | WORKMAN | 90 | DPWA |
| 176.3 | TANABE | 89 | DPWA |

N(1710) FOOTNOTES

- ¹ BATINIC 95 finds a second state with a 6 MeV mass difference.
- ² 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.
- ³ From method II of LONGACRE 75: eyeball fits with Breit-Wigner circles to the T-matrix amplitudes.
- ⁴ 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.
- ⁵ 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.

N(1710) REFERENCES

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

| | | | | |
|----------|-----|------------------------|---|--------------------|
| ARNDT | 06 | PR C74 045205 | R.A. Arndt <i>et al.</i> | (GWU) |
| PDG | 06 | JPG 33 1 | W.-M. Yao <i>et al.</i> | (PDG Collab.) |
| SHKLYAR | 05 | PR C72 015210 | V. Shklyar, H. Lenske, U. Mosel | (GIES) |
| PENNER | 02C | PR C66 055211 | G. Penner, U. Mosel | (GIES) |
| PENNER | 02D | PR C66 055212 | G. Penner, U. Mosel | (GIES) |
| 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 <i>et al.</i> | (VPI, BRCO) |
| BATINIC | 95 | PR C51 2310 | M. Batinic <i>et al.</i> | (BOSK, UCLA) |
| Also | | PR C57 1004 (erratum) | M. Batinic <i>et al.</i> | |
| HOEHLER | 93 | πN Newsletter 9 1 | G. Hohler | (KARL) |
| LI | 93 | PR C47 2759 | Z.J. Li <i>et al.</i> | (VPI) |
| MANLEY | 92 | PR D45 4002 | D.M. Manley, E.M. Saleski | (KENT) IJP |
| Also | | PR D30 904 | D.M. Manley <i>et al.</i> | (VPI) |
| ARNDT | 91 | PR D43 2131 | R.A. Arndt <i>et al.</i> | (VPI, TELE) IJP |
| CUTKOSKY | 90 | PR D42 235 | R.E. Cutkosky, S. Wang | (CMU) |
| 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) |
| BELL | 83 | NP B222 389 | K.W. Bell <i>et al.</i> | (RL) IJP |
| CRAWFORD | 83 | NP B211 1 | R.L. Crawford, W.T. Morton | (GLAS) |
| PDG | 82 | PL 111B 1 | M. Roos <i>et al.</i> | (HELSE, CIT, CERN) |
| AWAJI | 81 | Bonn Conf. 352 | N. Awaji, R. Kajikawa | (NAGO) |
| Also | | NP B197 365 | K. Fujii <i>et al.</i> | (NAGO) |
| FUJII | 81 | NP B187 53 | K. Fujii <i>et al.</i> | (NAGO, OSAK) |
| CUTKOSKY | 80 | Toronto Conf. 19 | R.E. Cutkosky <i>et al.</i> | (CMU, LBL) IJP |
| Also | | PR D20 2839 | R.E. Cutkosky <i>et al.</i> | (CMU, LBL) IJP |
| LIVANOS | 80 | Toronto Conf. 35 | P. Livanos <i>et al.</i> | (SACL) IJP |
| SAXON | 80 | NP B162 522 | D.H. Saxon <i>et al.</i> | (RHEL, BRIS) IJP |
| HOEHLER | 79 | PDAT 12-1 | G. Hohler <i>et al.</i> | (KARLT) IJP |
| Also | | Toronto Conf. 3 | R. Koch | (KARLT) IJP |
| LONGACRE | 78 | PR D17 1795 | R.S. Longacre <i>et al.</i> | (LBL, SLAC) |
| LONGACRE | 77 | NP B122 493 | R.S. Longacre, J. Dolbeau | (SACL) IJP |
| Also | | NP B108 365 | J. Dolbeau <i>et al.</i> | (SACL) IJP |
| LONGACRE | 75 | PL 55B 415 | R.S. Longacre <i>et al.</i> | (LBL, SLAC) IJP |