# $N(1710)\ 1/2^+$

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

Older and obsolete values are listed and referenced in the 2014 edition, Chinese Physics **C38** 070001 (2014).

## N(1710) POLE POSITION

### REAL PART

| VALUE (MeV) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **1680 to 1720 (≈ 1700) OUR ESTIMATE** | | | | |
| 1690±15 | ANISOVICH | 17A | DPWA | Multichannel |
| 1697±23 | [1] ANISOVICH | 17A | L+P | $\gamma p$, $\pi^- p \rightarrow K\Lambda$ |
| 1770± 5±2 | [2] SVARC | 14 | L+P | $\pi N \rightarrow \pi N$ |
| 1690±20 | CUTKOSKY | 80 | IPWA | $\pi N \rightarrow \pi N$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 1615 | HUNT | 19 | DPWA | Multichannel |
| 1651 | ROENCHEN | 15A | DPWA | Multichannel |
| 1690±15 | SOKHOYAN | 15A | DPWA | Multichannel |
| 1690±15 | GUTZ | 14 | DPWA | Multichannel |
| 1670 | SHKLYAR | 13 | DPWA | Multichannel |
| 1687±17 | ANISOVICH | 12A | DPWA | Multichannel |
| 1711±15 | [3] BATINIC | 10 | DPWA | $\pi N \rightarrow N\pi$, $N\eta$ |
| 1679 | VRANA | 00 | DPWA | Multichannel |
| 1690 | HOEHLER | 93 | SPED | $\pi N \rightarrow \pi N$ |
| 1698 | CUTKOSKY | 90 | IPWA | $\pi N \rightarrow \pi N$ |

[1] Statistical error only.
[2] Fit to the amplitudes of HOEHLER 79.
[3] BATINIC 10 finds evidence for a second $P_{11}$ state with all parameters except for the phase of the pole residue very similar to the parameters we give here.

### −2×IMAGINARY PART

| VALUE (MeV) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **80 to 160 (≈ 120) OUR ESTIMATE** | | | | |
| 155±25 | ANISOVICH | 17A | DPWA | Multichannel |
| 84±34 | [1] ANISOVICH | 17A | L+P | $\gamma p$, $\pi^- p \rightarrow K\Lambda$ |
| 98± 8±5 | [2] SVARC | 14 | L+P | $\pi N \rightarrow \pi N$ |
| 80±20 | CUTKOSKY | 80 | IPWA | $\pi N \rightarrow \pi N$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 169 | HUNT | 19 | DPWA | Multichannel |
| 121 | ROENCHEN | 15A | DPWA | Multichannel |
| 170±20 | SOKHOYAN | 15A | DPWA | Multichannel |
| 170±20 | GUTZ | 14 | DPWA | Multichannel |
| 159 | SHKLYAR | 13 | DPWA | Multichannel |
| 200±25 | ANISOVICH | 12A | DPWA | Multichannel |
| 174±16 | [3] BATINIC | 10 | DPWA | $\pi N \rightarrow N\pi$, $N\eta$ |
| 132 | VRANA | 00 | DPWA | Multichannel |
| 200 | HOEHLER | 93 | SPED | $\pi N \rightarrow \pi N$ |
| 88 | CUTKOSKY | 90 | IPWA | $\pi N \rightarrow \pi N$ |

[1] Statistical error only.

[2] Fit to the amplitudes of HOEHLER 79.
[3] BATINIC 10 finds evidence for a second $P_{11}$ state with all parameters except for the phase of the pole residue very similar to the parameters we give here.

## *N*(1710) ELASTIC POLE RESIDUE

### MODULUS $|r|$

| VALUE (MeV) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **4 to 10 (≈ 7) OUR ESTIMATE** | | | | |
| 6 ±3 | SOKHOYAN | 15A | DPWA | Multichannel |
| 5 ±1±1 | [1] SVARC | 14 | L+P | $\pi N \rightarrow \pi N$ |
| 8 ±2 | CUTKOSKY | 80 | IPWA | $\pi N \rightarrow \pi N$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 3.2 | ROENCHEN | 15A | DPWA | Multichannel |
| 6 ±3 | GUTZ | 14 | DPWA | Multichannel |
| 11 | SHKLYAR | 13 | DPWA | Multichannel |
| 6 ±4 | ANISOVICH | 12A | DPWA | Multichannel |
| 24 | [2] BATINIC | 10 | DPWA | $\pi N \rightarrow N\pi$, $N\eta$ |
| 15 | HOEHLER | 93 | SPED | $\pi N \rightarrow \pi N$ |
| 9 | CUTKOSKY | 90 | IPWA | $\pi N \rightarrow \pi N$ |

[1] Fit to the amplitudes of HOEHLER 79.
[2] BATINIC 10 finds evidence for a second $P_{11}$ state with all parameters except for the phase of the pole residue very similar to the parameters we give here.

### PHASE $\theta$

| VALUE (°) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **120 to 260 (≈ 190) OUR ESTIMATE** | | | | |
| 130±35 | SOKHOYAN | 15A | DPWA | Multichannel |
| −104± 7±3 | [1] SVARC | 14 | L+P | $\pi N \rightarrow \pi N$ |
| 175±35 | CUTKOSKY | 80 | IPWA | $\pi N \rightarrow \pi N$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 55 | ROENCHEN | 15A | DPWA | Multichannel |
| 120±45 | GUTZ | 14 | DPWA | Multichannel |
| 9 | SHKLYAR | 13 | DPWA | Multichannel |
| 120±70 | ANISOVICH | 12A | DPWA | Multichannel |
| 20 | [2] BATINIC | 10 | DPWA | $\pi N \rightarrow N\pi$, $N\eta$ |
| −167 | CUTKOSKY | 90 | IPWA | $\pi N \rightarrow \pi N$ |

[1] Fit to the amplitudes of HOEHLER 79.
[2] BATINIC 10 finds evidence for a second $P_{11}$ state with all parameters except for the phase of the pole residue very similar to the parameters we give here.

## *N*(1710) INELASTIC POLE RESIDUE

The "normalized residue" is the residue divided by $\Gamma_{pole}/2$.

### Normalized residue in $N\pi \rightarrow N(1710) \rightarrow N\eta$

| MODULUS | PHASE (°) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| 0.12±0.04 | 0 ± 45 | ANISOVICH | 12A | DPWA | Multichannel |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| 0.16 | −180 | ROENCHEN | 15A | DPWA | Multichannel |

### Normalized residue in $N\pi \to N(1710) \to \Lambda K$

| MODULUS | PHASE (°) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| 0.16±0.05 | −160 ± 25 | ANISOVICH | 17A | DPWA | Multichannel |
| $0.12^{+0.24}_{-0.12}$ | −119 ± 83 | [1] ANISOVICH | 17A | L+P | $\gamma p$, $\pi^- p \to K\Lambda$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| 0.12 | −32 | ROENCHEN | 15A | DPWA | Multichannel |
| 0.17±0.06 | −110 ± 20 | ANISOVICH | 12A | DPWA | Multichannel |

[1] Statistical error only.

### Normalized residue in $N\pi \to N(1710) \to \Sigma K$

| MODULUS | PHASE (°) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| 0.004 | −43 | ROENCHEN | 15A | DPWA | Multichannel |

### Normalized residue in $N\pi \to N(1710) \to N(1535)\pi$

| MODULUS | PHASE (°) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| 0.10±0.04 | 140 ± 40 | GUTZ | 14 | DPWA | Multichannel |

## N(1710) BREIT-WIGNER MASS

| VALUE (MeV) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **1680 to 1740 (≈ 1710) OUR ESTIMATE** | | | | |
| 1648±16 | [1] HUNT | 19 | DPWA | Multichannel |
| 1715±20 | SOKHOYAN | 15A | DPWA | Multichannel |
| 1737±17 | [1] SHKLYAR | 13 | DPWA | Multichannel |
| 1700±50 | CUTKOSKY | 80 | IPWA | $\pi N \to \pi N$ |
| 1723± 9 | HOEHLER | 79 | IPWA | $\pi N \to \pi N$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 1715±20 | GUTZ | 14 | DPWA | Multichannel |
| 1710±20 | ANISOVICH | 12A | DPWA | Multichannel |
| 1662± 7 | [1] SHRESTHA | 12A | DPWA | Multichannel |
| 1729±16 | [2] BATINIC | 10 | DPWA | $\pi N \to N\pi$, $N\eta$ |
| 1752± 3 | PENNER | 02C | DPWA | Multichannel |
| 1699±65 | VRANA | 00 | DPWA | Multichannel |

[1] Statistical error only.

[2] BATINIC 10 finds evidence for a second $P_{11}$ state with all parameters except for the phase of the pole residue very similar to the parameters we give here.

## N(1710) BREIT-WIGNER WIDTH

| VALUE (MeV) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **80 to 200 (≈ 140) OUR ESTIMATE** | | | | |
| 195± 46 | [1] HUNT | 19 | DPWA | Multichannel |
| 175± 15 | SOKHOYAN | 15A | DPWA | Multichannel |
| 368±120 | [1] SHKLYAR | 13 | DPWA | Multichannel |
| 93± 30 | CUTKOSKY | 90 | IPWA | $\pi N \to \pi N$ |
| 90± 30 | 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. • • •

| | | | | |
|---|---|---|---|---|
| 175±15 | GUTZ | 14 | DPWA | Multichannel |
| 200±18 | ANISOVICH | 12A | DPWA | Multichannel |
| 116±17 | [1] SHRESTHA | 12A | DPWA | Multichannel |
| 180±17 | [2] BATINIC | 10 | DPWA | $\pi N \to N\pi$, $N\eta$ |
| 386±59 | PENNER | 02C | DPWA | Multichannel |
| 143±100 | VRANA | 00 | DPWA | Multichannel |

[1] Statistical error only.
[2] BATINIC 10 finds evidence for a second $P_{11}$ state with all parameters except for the phase of the pole residue very similar to the parameters we give here.

## *N*(1710) DECAY MODES

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

| | Mode | Fraction ($\Gamma_i/\Gamma$) |
|---|---|---|
| $\Gamma_1$ | $N\pi$ | 5–20 % |
| $\Gamma_2$ | $N\eta$ | 10–50 % |
| $\Gamma_3$ | $N\omega$ | 1–5 % |
| $\Gamma_4$ | $\Lambda K$ | 5–25 % |
| $\Gamma_5$ | $\Sigma K$ | seen |
| $\Gamma_6$ | $N\pi\pi$ | 14–48 % |
| $\Gamma_7$ | $\Delta(1232)\pi$, $P$-wave | 3–9 % |
| $\Gamma_8$ | $N\rho$, $S$=1/2, $P$-wave | 11–23 % |
| $\Gamma_9$ | $N\sigma$ | <16 % |
| $\Gamma_{10}$ | $N(1535)\pi$ | 9–21 % |
| $\Gamma_{11}$ | $p\gamma$, helicity=1/2 | 0.002–0.08 % |
| $\Gamma_{12}$ | $n\gamma$, helicity=1/2 | 0.0–0.02% |

## *N*(1710) BRANCHING RATIOS

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

| VALUE (%) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **5 to 20 (≈ 10) OUR ESTIMATE** | | | | |
| 12±6 | [1] HUNT | 19 | DPWA | Multichannel |
| 5±3 | SOKHOYAN | 15A | DPWA | Multichannel |
| 2±2 | [1] SHKLYAR | 13 | PWA | Multichannel |
| 20±4 | CUTKOSKY | 80 | IPWA | $\pi N \to \pi N$ |
| 12±4 | HOEHLER | 79 | IPWA | $\pi N \to \pi N$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 5±3 | GUTZ | 14 | DPWA | Multichannel |
| 5±4 | ANISOVICH | 12A | DPWA | Multichannel |
| 15±4 | [1] SHRESTHA | 12A | DPWA | Multichannel |
| 22±24 | [2] BATINIC | 10 | DPWA | $\pi N \to N\pi$, $N\eta$ |
| 14±8 | PENNER | 02C | DPWA | Multichannel |
| 27±13 | VRANA | 00 | DPWA | Multichannel |

[1] Statistical error only.
[2] BATINIC 10 finds evidence for a second $P_{11}$ state with all parameters except for the phase of the pole residue very similar to the parameters we give here.

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

| VALUE (%) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **10 to 50 (≈ 30) OUR ESTIMATE** | | | | |
| 18±10 | MUELLER | 20 | DPWA | Multichannel |
| 17± 8 | [1] HUNT | 19 | DPWA | Multichannel |
| 45± 4 | [1] SHKLYAR | 13 | DPWA | Multichannel |
| 17±10 | ANISOVICH | 12A | DPWA | Multichannel |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 11± 7 | [1] SHRESTHA | 12A | DPWA | Multichannel |
| 6± 8 | [2] BATINIC | 10 | DPWA | $\pi N \to N\pi$, $N\eta$ |
| 36±11 | PENNER | 02C | DPWA | Multichannel |
| 6± 1 | VRANA | 00 | DPWA | Multichannel |

[1] Statistical error only.
[2] BATINIC 10 finds evidence for a second $P_{11}$ state with all parameters except for the phase of the pole residue very similar to the parameters we give here.

### $\Gamma(N\omega)/\Gamma_{total}$ — $\Gamma_3/\Gamma$

| VALUE (%) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **1 to 5 (≈ 3) OUR ESTIMATE** | | | | |
| 2±2 | DENISENKO | 16 | DPWA | Multichannel |
| 3±2 | [1] SHKLYAR | 13 | DPWA | Multichannel |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 13±2 | PENNER | 02C | DPWA | Multichannel |

[1] Statistical error only.

### $\Gamma(\Lambda K)/\Gamma_{total}$ — $\Gamma_4/\Gamma$

| VALUE (%) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **5 to 25 (≈ 15) OUR ESTIMATE** | | | | |
| 1.8± 1.5 | [1] HUNT | 19 | DPWA | Multichannel |
| 23 ± 7 | ANISOVICH | 12A | DPWA | Multichannel |
| 5 ± 3 | SHKLYAR | 05 | DPWA | Multichannel |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 8 ± 4 | [1] SHRESTHA | 12A | DPWA | Multichannel |
| 5 ± 2 | PENNER | 02C | DPWA | Multichannel |
| 10 ±10 | VRANA | 00 | DPWA | Multichannel |

[1] Statistical error only.

### $\Gamma(\Sigma K)/\Gamma_{total}$ — $\Gamma_5/\Gamma$

| VALUE (%) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 7±7 | PENNER | 02C | DPWA | Multichannel |

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

| VALUE (%) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **3–9 % OUR ESTIMATE** | | | | |
| 28±9 | [1] HUNT | 19 | DPWA | Multichannel |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 6±3 | [1] SHRESTHA | 12A | DPWA | Multichannel |
| 39±8 | VRANA | 00 | DPWA | Multichannel |

[1] Statistical error only.

### $\Gamma(N\rho, S{=}1/2, P\text{-wave})/\Gamma_{total}$ — $\Gamma_8/\Gamma$

| VALUE (%) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **11–23 % OUR ESTIMATE** | | | | |
| 17±9 | [1] HUNT | 19 | DPWA | Multichannel |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 17±6 | [1] SHRESTHA | 12A | DPWA | Multichannel |
| 17±1 | VRANA | 00 | DPWA | Multichannel |

[1] Statistical error only.

### $\Gamma(N\sigma)/\Gamma_{total}$ — $\Gamma_9/\Gamma$

| VALUE (%) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **<16 % OUR ESTIMATE** | | | | |
| <16 | [1] HUNT | 19 | DPWA | Multichannel |

[1] Statistical error only.

### $\Gamma(N(1535)\pi)/\Gamma_{total}$ — $\Gamma_{10}/\Gamma$

| VALUE (%) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| 15±6 | GUTZ | 14 | DPWA | Multichannel |

## N(1710) PHOTON DECAY AMPLITUDES AT THE POLE

### $N(1710) \to p\gamma$, helicity-1/2 amplitude $A_{1/2}$

| MODULUS (GeV$^{-1/2}$) | PHASE (°) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| $0.028^{+0.009}_{-0.002}$ | $103^{+20}_{-6}$ | ROENCHEN | 14 | DPWA | |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| 0.020 | −83 | ROENCHEN | 15A | DPWA | Multichannel |

## N(1710) BREIT-WIGNER PHOTON DECAY AMPLITUDES

### $N(1710) \to p\gamma$, helicity-1/2 amplitude $A_{1/2}$

| VALUE (GeV$^{-1/2}$) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| 0.014±0.008 | [1] HUNT | 19 | DPWA | Multichannel |
| 0.050±0.010 | SOKHOYAN | 15A | DPWA | Multichannel |
| −0.050±0.001 | [1] SHKLYAR | 13 | DPWA | Multichannel |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 0.05 ±0.01 | GUTZ | 14 | DPWA | Multichannel |
| 0.052±0.015 | ANISOVICH | 12A | DPWA | Multichannel |
| −0.008±0.003 | [1] SHRESTHA | 12A | DPWA | Multichannel |
| 0.044 | PENNER | 02D | DPWA | Multichannel |

[1] Statistical error only.

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

| VALUE (GeV$^{-1/2}$) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| 0.0053±0.0003 | [1] HUNT | 19 | DPWA | Multichannel |
| −0.040 ±0.020 | ANISOVICH | 13B | DPWA | Multichannel |

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

| | | | | |
|---|---|---|---|---|
| 0.017 ±0.003 | [1] SHRESTHA | 12A | DPWA | Multichannel |
| −0.024 | PENNER | 02D | DPWA | Multichannel |

[1] Statistical error only.

## *N*(1710) REFERENCES

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


| | | | | |
|---|---|---|---|---|
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| HUNT | 19 | PR C99 055205 | B.C. Hunt, D.M. Manley | |
| ANISOVICH | 17A | PRL 119 062004 | A.V. Anisovich *et al.* | |
| DENISENKO | 16 | PL B755 97 | I. Denisenko *et al.* | |
| ROENCHEN | 15A | EPJ A51 70 | D. Roenchen *et al.* | |
| SOKHOYAN | 15A | EPJ A51 95 | V. Sokhoyan *et al.* | (CBELSA/TAPS Collab.) |
| GUTZ | 14 | EPJ A50 74 | E. Gutz *et al.* | (CBELSA/TAPS Collab.) |
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| SHRESTHA | 12A | PR C86 055203 | M. Shrestha, D.M. Manley | (KSU) |
| BATINIC | 10 | PR C82 038203 | M. Batinic *et al.* | (ZAGR) |
| SHKLYAR | 05 | PR C72 015210 | V. Shklyar, H. Lenske, U. Mosel | (GIES) |
| PENNER | 02C | PR C66 055211 | G. Penner, U. Mosel | (GIES) |
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| HOEHLER | 93 | $\pi N$ Newsletter 9 1 | G. Hohler | (KARL) |
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| CUTKOSKY | 80 | Toronto Conf. 19 | R.E. Cutkosky *et al.* | (CMU, LBL) IJP |
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