# $\Delta(1905)\ 5/2^+$

$I(J^P) = \frac{3}{2}(\frac{5}{2}^+)$ Status: ****

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

## Δ(1905) POLE POSITION

### REAL PART

| *VALUE* (MeV) | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|
| **1770 to 1830 (≈ 1800) OUR ESTIMATE** | | | | |
| 1800± 6 | SOKHOYAN | 15A | DPWA | Multichannel |
| 1752± 3±2 | [1] SVARC | 14 | L+P | $\pi N \to \pi N$ |
| 1830±40 | CUTKOSKY | 80 | IPWA | $\pi N \to \pi N$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 1819 | HUNT | 19 | DPWA | Multichannel |
| 1795 | ROENCHEN | 15A | DPWA | Multichannel |
| 1800± 6 | GUTZ | 14 | DPWA | Multichannel |
| 1805±10 | ANISOVICH | 12A | DPWA | Multichannel |
| 1819 | ARNDT | 06 | DPWA | $\pi N \to \pi N, \eta N$ |
| 1793 | VRANA | 00 | DPWA | Multichannel |
| 1829 | HOEHLER | 93 | SPED | $\pi N \to \pi N$ |

[1] Fit to the amplitudes of HOEHLER 79.

### −2×IMAGINARY PART

| *VALUE* (MeV) | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|
| **260 to 340 (≈ 300) OUR ESTIMATE** | | | | |
| 290±15 | SOKHOYAN | 15A | DPWA | Multichannel |
| 346± 6±2 | [1] SVARC | 14 | L+P | $\pi N \to \pi N$ |
| 280±60 | CUTKOSKY | 80 | IPWA | $\pi N \to \pi N$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 253 | HUNT | 19 | DPWA | Multichannel |
| 247 | ROENCHEN | 15A | DPWA | Multichannel |
| 290±15 | GUTZ | 14 | DPWA | Multichannel |
| 300±15 | ANISOVICH | 12A | DPWA | Multichannel |
| 247 | ARNDT | 06 | DPWA | $\pi N \to \pi N, \eta N$ |
| 302 | VRANA | 00 | DPWA | Multichannel |
| 303 | HOEHLER | 93 | SPED | $\pi N \to \pi N$ |

[1] Fit to the amplitudes of HOEHLER 79.

## Δ(1905) ELASTIC POLE RESIDUE

### MODULUS $|r|$

| *VALUE* (MeV) | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|
| **15 to 25 (≈ 20) OUR ESTIMATE** | | | | |
| 19 ±2 | SOKHOYAN | 15A | DPWA | Multichannel |
| 24 ±1±1 | [1] SVARC | 14 | L+P | $\pi N \to \pi N$ |
| 25 ±8 | CUTKOSKY | 80 | IPWA | $\pi N \to \pi N$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 5.3 | ROENCHEN | 15A | DPWA | Multichannel |

| | | | | | |
|---|---|---|---|---|---|
| 19 | ±2 | GUTZ | 14 | DPWA | Multichannel |
| 20 | ±2 | ANISOVICH | 12A | DPWA | Multichannel |
| 15 | | ARNDT | 06 | DPWA | $\pi N \to \pi N, \eta N$ |
| 25 | | HOEHLER | 93 | SPED | $\pi N \to \pi N$ |

[1] Fit to the amplitudes of HOEHLER 79.

### PHASE $\theta$

| VALUE (°) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **−120 to −30 (≈ −50) OUR ESTIMATE** | | | | |
| − 45± 4 | SOKHOYAN | 15A | DPWA | Multichannel |
| −114± 1±2 | [1] SVARC | 14 | L+P | $\pi N \to \pi N$ |
| − 50±20 | CUTKOSKY | 80 | IPWA | $\pi N \to \pi N$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| − 89 | ROENCHEN | 15A | DPWA | Multichannel |
| − 45± 4 | GUTZ | 14 | DPWA | Multichannel |
| − 44± 5 | ANISOVICH | 12A | DPWA | Multichannel |
| − 30 | ARNDT | 06 | DPWA | $\pi N \to \pi N, \eta N$ |

[1] Fit to the amplitudes of HOEHLER 79.

## Δ(1905) INELASTIC POLE RESIDUE

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

### Normalized residue in $N\pi \to \Delta(1905) \to \Delta\pi$, P-wave

| MODULUS | PHASE (°) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| 0.19 ±0.07 | 10 ± 30 | SOKHOYAN | 15A | DPWA | Multichannel |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| 0.0870 | 72 | ROENCHEN | 15A | DPWA | Multichannel |
| 0.25 ±0.06 | 0 ± 15 | ANISOVICH | 12A | DPWA | Multichannel |

### Normalized residue in $N\pi \to \Delta(1905) \to \Delta\pi$, F-wave

| MODULUS | PHASE (°) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| 0.009 | 64 | ROENCHEN | 15A | DPWA | Multichannel |

### Normalized residue in $N\pi \to \Delta(1905) \to \Sigma K$

| MODULUS | PHASE (°) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| 0.001 | −155 | ROENCHEN | 15A | DPWA | Multichannel |

### Normalized residue in $N\pi \to \Delta(1905) \to N(1535)\pi$

| MODULUS | PHASE (°) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| 0.025±0.010 | 130 ± 35 | GUTZ | 14 | DPWA | Multichannel |

### Normalized residue in $N\pi \to \Delta(1905) \to \Delta(1232)\eta$

| MODULUS | PHASE (°) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| 0.07±0.02 | 40 ± 20 | GUTZ | 14 | DPWA | Multichannel |

## Δ(1905) BREIT-WIGNER MASS

| *VALUE* (MeV) | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|
| **1855 to 1910 (≈ 1880) OUR ESTIMATE** | | | | |
| 1883 ±19 | GOLOVATCH | 19 | DPWA | $\gamma p \to \pi^+\pi^- p$ |
| 1866 ± 9 | [1] HUNT | 19 | DPWA | Multichannel |
| 1856 ± 6 | SOKHOYAN | 15A | DPWA | Multichannel |
| 1857.8± 1.6 | [1] ARNDT | 06 | DPWA | $\pi N \to \pi N, \eta N$ |
| 1910 ±30 | CUTKOSKY | 80 | IPWA | $\pi N \to \pi N$ |
| 1905 ±20 | HOEHLER | 79 | IPWA | $\pi N \to \pi N$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 1856 ± 6 | GUTZ | 14 | DPWA | Multichannel |
| 1861 ± 6 | ANISOVICH | 12A | DPWA | Multichannel |
| 1818 ± 8 | [1] SHRESTHA | 12A | DPWA | Multichannel |
| 1873 ±77 | VRANA | 00 | DPWA | Multichannel |

[1] Statistical error only.

## Δ(1905) BREIT-WIGNER WIDTH

| *VALUE* (MeV) | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|
| **270 to 400 (≈ 330) OUR ESTIMATE** | | | | |
| 327 ± 69 | GOLOVATCH | 19 | DPWA | $\gamma p \to \pi^+\pi^- p$ |
| 289 ± 20 | [1] HUNT | 19 | DPWA | Multichannel |
| 325 ± 15 | SOKHOYAN | 15A | DPWA | Multichannel |
| 320.6± 8.6 | [1] ARNDT | 06 | DPWA | $\pi N \to \pi N, \eta N$ |
| 400 ±100 | CUTKOSKY | 80 | IPWA | $\pi N \to \pi N$ |
| 260 ± 20 | HOEHLER | 79 | IPWA | $\pi N \to \pi N$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 325 ± 15 | GUTZ | 14 | DPWA | Multichannel |
| 335 ± 18 | ANISOVICH | 12A | DPWA | Multichannel |
| 278 ± 18 | [1] SHRESTHA | 12A | DPWA | Multichannel |
| 461 ±111 | VRANA | 00 | DPWA | Multichannel |

[1] Statistical error only.

## Δ(1905) DECAY MODES

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

| | Mode | Fraction ($\Gamma_i/\Gamma$) |
|---|---|---|
| $\Gamma_1$ | $N\pi$ | 9–15 % |
| $\Gamma_2$ | $N\pi\pi$ | |
| $\Gamma_3$ | $\Delta(1232)\pi$ | 80–100 % |
| $\Gamma_4$ | $\Delta(1232)\pi$, $P$-wave | 23–43 % |
| $\Gamma_5$ | $\Delta(1232)\pi$, $F$-wave | 56–72 % |
| $\Gamma_6$ | $N\rho$ | |
| $\Gamma_7$ | $N\rho$, $S$=3/2, $P$-wave | seen |
| $\Gamma_8$ | $N(1535)\pi$ | $< 1$ % |
| $\Gamma_9$ | $N(1680)\pi$, $P$-wave | 5–15 % |

| | | |
|---|---|---|
| $\Gamma_{10}$ | $\Delta(1232)\eta$ | 2–6 % |
| $\Gamma_{11}$ | $N\gamma$ | 0.012–0.036 % |
| $\Gamma_{12}$ | $N\gamma$, helicity=1/2 | 0.002–0.006 % |
| $\Gamma_{13}$ | $N\gamma$, helicity=3/2 | 0.01–0.03 % |

## $\Delta(1905)$ BRANCHING RATIOS

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

| VALUE (%) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **9 to 15 (≈ 12) OUR ESTIMATE** | | | | |
| 17 ±1 | [1] HUNT | 19 | DPWA | Multichannel |
| 13 ±2 | SOKHOYAN | 15A | DPWA | Multichannel |
| 12.2±0.1 | [1] ARNDT | 06 | DPWA | $\pi N \to \pi N, \eta N$ |
| 8 ±3 | CUTKOSKY | 80 | IPWA | $\pi N \to \pi N$ |
| 15 ±2 | HOEHLER | 79 | IPWA | $\pi N \to \pi N$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 13 ±2 | GUTZ | 14 | DPWA | Multichannel |
| 13 ±2 | ANISOVICH | 12A | DPWA | Multichannel |
| 6 ±1 | [1] SHRESTHA | 12A | DPWA | Multichannel |
| 9 ±1 | VRANA | 00 | DPWA | Multichannel |

[1] Statistical error only.

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

| VALUE | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **0.85±0.15** | GOLOVATCH | 19 | DPWA | $\gamma p \to \pi^+\pi^- p$ |

### $\Gamma(\Delta(1232)\pi$, $P$-wave$)/\Gamma_{\text{total}}$ $\Gamma_4/\Gamma$

| VALUE (%) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| 8.4± 0.5 | [1] HUNT | 19 | DPWA | Multichannel |
| 33 ±10 | SOKHOYAN | 15A | DPWA | Multichannel |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 45 ±14 | ANISOVICH | 12A | DPWA | Multichannel |
| 28 ± 7 | [1] SHRESTHA | 12A | DPWA | Multichannel |
| 23 ± 1 | VRANA | 00 | DPWA | Multichannel |

[1] Statistical error only.

### $\Gamma(\Delta(1232)\pi$, $F$-wave$)/\Gamma_{\text{total}}$ $\Gamma_5/\Gamma$

| VALUE (%) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| 49±9 | [1] HUNT | 19 | DPWA | Multichannel |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 64±8 | [1] SHRESTHA | 12A | DPWA | Multichannel |
| 44±1 | VRANA | 00 | DPWA | Multichannel |

[1] Statistical error only.

### $\Gamma(N\rho, S{=}3/2, P\text{-wave})/\Gamma_{total}$ $\Gamma_7/\Gamma$

| VALUE (%) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| $26\pm9$ | [1] HUNT | 19 | DPWA | Multichannel |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| $< 6$ | [1] SHRESTHA | 12A | DPWA | Multichannel |
| $24\pm1$ | VRANA | 00 | DPWA | Multichannel |

[1] Statistical error only.

### $\Gamma(N(1535)\pi)/\Gamma_{total}$ $\Gamma_8/\Gamma$

| VALUE (%) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| $<1$ | GUTZ | 14 | DPWA | Multichannel |

### $\Gamma(N(1680)\pi, P\text{-wave})/\Gamma_{total}$ $\Gamma_9/\Gamma$

| VALUE (%) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| $10\pm5$ | SOKHOYAN | 15A | DPWA | Multichannel |

### $\Gamma(\Delta(1232)\eta)/\Gamma_{total}$ $\Gamma_{10}/\Gamma$

| VALUE (%) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| $4\pm2$ | GUTZ | 14 | DPWA | Multichannel |

## $\Delta(1905)$ PHOTON DECAY AMPLITUDES AT THE POLE

### $\Delta(1905) \to N\gamma$, helicity-1/2 amplitude $A_{1/2}$

| MODULUS ($GeV^{-1/2}$) | PHASE (°) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| $0.025\pm0.005$ | $-28\pm12$ | SOKHOYAN | 15A | DPWA | Multichannel |
| $0.013^{+0.013}_{-0.005}$ | $64^{+72}_{-36}$ | ROENCHEN | 14 | DPWA | |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| 0.053 | 89 | ROENCHEN | 15A | DPWA | Multichannel |

### $\Delta(1905) \to N\gamma$, helicity-3/2 amplitude $A_{3/2}$

| MODULUS ($GeV^{-1/2}$) | PHASE (°) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| $-0.050\pm0.004$ | $5\pm10$ | SOKHOYAN | 15A | DPWA | Multichannel |
| $0.072\pm0.016$ | $113^{+13}_{-7}$ | ROENCHEN | 14 | DPWA | |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| $-0.030$ | 80 | ROENCHEN | 15A | DPWA | Multichannel |

## $\Delta(1905)$ BREIT-WIGNER PHOTON DECAY AMPLITUDES

### $\Delta(1905) \to N\gamma$, helicity-1/2 amplitude $A_{1/2}$

| VALUE ($GeV^{-1/2}$) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **0.017 to 0.027 (≈ 0.022) OUR ESTIMATE** | | | | |
| $0.019\pm0.0076$ | GOLOVATCH | 19 | DPWA | $\gamma p \to \pi^+\pi^- p$ |
| $0.077\pm0.010$ | [1] HUNT | 19 | DPWA | Multichannel |
| $0.025\pm0.005$ | SOKHOYAN | 15A | DPWA | Multichannel |
| $0.020\pm0.002$ | [1] DUGGER | 13 | DPWA | $\gamma N \to \pi N$ |
| $0.019\pm0.002$ | [1] WORKMAN | 12A | DPWA | $\gamma N \to \pi N$ |

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

| | | | | |
|---|---|---|---|---|
| 0.025 ± 0.005 | GUTZ | 14 | DPWA | Multichannel |
| 0.025 ± 0.004 | ANISOVICH | 12A | DPWA | Multichannel |
| 0.066 ± 0.018 | [1] SHRESTHA | 12A | DPWA | Multichannel |
| 0.018 | DRECHSEL | 07 | DPWA | $\gamma N \to \pi N$ |

[1] Statistical error only.

### $\Delta(1905) \to N\gamma$, helicity-3/2 amplitude $A_{3/2}$

| *VALUE* ($GeV^{-1/2}$) | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|
| **−0.055 to −0.035 (≈ −0.045) OUR ESTIMATE** | | | | |
| −0.0432 ± 0.0173 | GOLOVATCH | 19 | DPWA | $\gamma p \to \pi^+\pi^- p$ |
| −0.053 ± 0.029 | [1] HUNT | 19 | DPWA | Multichannel |
| −0.050 ± 0.005 | SOKHOYAN | 15A | DPWA | Multichannel |
| −0.049 ± 0.005 | [1] DUGGER | 13 | DPWA | $\gamma N \to \pi N$ |
| −0.038 ± 0.004 | WORKMAN | 12A | DPWA | $\gamma N \to \pi N$ |

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

| | | | | |
|---|---|---|---|---|
| −0.050 ± 0.005 | GUTZ | 14 | DPWA | Multichannel |
| −0.049 ± 0.004 | ANISOVICH | 12A | DPWA | Multichannel |
| −0.223 ± 0.029 | [1] SHRESTHA | 12A | DPWA | Multichannel |
| −0.028 | DRECHSEL | 07 | DPWA | $\gamma N \to \pi N$ |

[1] Statistical error only.

## $\Delta(1905)$ REFERENCES

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


| | | | | |
|---|---|---|---|---|
| GOLOVATCH | 19 | PL B788 371 | E. Golovatch *et al.* | (CLAS Collab.) |
| HUNT | 19 | PR C99 055205 | B.C. Hunt, D.M. Manley | |
| 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.) |
| PDG | 14 | CP C38 070001 | K. Olive *et al.* | (PDG Collab.) |
| ROENCHEN | 14 | EPJ A50 101 | D. Roenchen *et al.* | |
| Also | | EPJ A51 63 (errat.) | D. Roenchen *et al.* | |
| SVARC | 14 | PR C89 045205 | A. Svarc *et al.* | (RBI Zagreb, UNI Tuzla) |
| DUGGER | 13 | PR C88 065203 | M. Dugger *et al.* | (JLab CLAS Collab.) |
| ANISOVICH | 12A | EPJ A48 15 | A.V. Anisovich *et al.* | (BONN, PNPI) |
| SHRESTHA | 12A | PR C86 055203 | M. Shrestha, D.M. Manley | (KSU) |
| WORKMAN | 12A | PR C86 015202 | R. Workman *et al.* | (GWU) |
| DRECHSEL | 07 | EPJ A34 69 | D. Drechsel, S.S. Kamalov, L. Tiator | (MAINZ, JINR) |
| ARNDT | 06 | PR C74 045205 | R.A. Arndt *et al.* | (GWU) |
| VRANA | 00 | PRPL 328 181 | T.P. Vrana, S.A. Dytman, T.-S.H. Lee | (PITT, ANL) |
| HOEHLER | 93 | $\pi N$ Newsletter 9 1 | G. Hohler | (KARL) |
| 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 |
| HOEHLER | 79 | PDAT 12-1 | G. Hohler *et al.* | (KARLT) IJP |
| Also | | Toronto Conf. 3 | R. Koch | (KARLT) IJP |