# $\Delta(1940)\ 3/2^-$

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

OMITTED FROM SUMMARY TABLE

## Δ(1940) POLE POSITION

### REAL PART

| *VALUE* (MeV) | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|
| **1850 to 2050 (≈ 1950) OUR ESTIMATE** | | | | |
| 2040± 40 | SARANTSEV | 25 | DPWA | Multichannel |
| 1878± 11±5.5 | [1] SVARC | 14 | L+P | $\pi N \to \pi N$ |
| 1900±100 | CUTKOSKY | 80 | IPWA | $\pi N \to \pi N$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 2139 | HUNT | 19 | DPWA | Multichannel |
| 2040± 50 | SOKHOYAN | 15A | DPWA | Multichannel |
| 2040± 50 | GUTZ | 14 | DPWA | Multichannel |

[1] Fit to the amplitudes of HOEHLER 79.

### −2×IMAGINARY PART

| *VALUE* (MeV) | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|
| **200 to 500 (≈ 350) OUR ESTIMATE** | | | | |
| 450±50 | SARANTSEV | 25 | DPWA | Multichannel |
| 212±21±6 | [1] SVARC | 14 | L+P | $\pi N \to \pi N$ |
| 200±60 | CUTKOSKY | 80 | IPWA | $\pi N \to \pi N$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 400 | HUNT | 19 | DPWA | Multichannel |
| 450±90 | SOKHOYAN | 15A | DPWA | Multichannel |
| 450±90 | GUTZ | 14 | DPWA | Multichannel |

[1] Fit to the amplitudes of HOEHLER 79.

## Δ(1940) ELASTIC POLE RESIDUE

### MODULUS $|r|$

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

[1] Fit to the amplitudes of HOEHLER 79.

### PHASE $\theta$

| *VALUE* (°) | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|
| **150 to 250 (≈ 200) OUR ESTIMATE** | | | | |
| − 90±35 | SOKHOYAN | 15A | DPWA | Multichannel |
| 140± 7±7 | [1] SVARC | 14 | L+P | $\pi N \to \pi N$ |
| 135±45 | CUTKOSKY | 80 | IPWA | $\pi N \to \pi N$ |

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

| | | | | |
|---|---|---|---|---|
| − 50±35 | GUTZ | 14 | DPWA | Multichannel |

[1] Fit to the amplitudes of HOEHLER 79.

## Δ(1940) INELASTIC POLE RESIDUE

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

### Normalized residue in $N\pi \to \Delta(1940) \to \Delta(1232)\eta$

| MODULUS | PHASE (°) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| <0.01 | undefined | GUTZ | 14 | DPWA | Multichannel |

### Normalized residue in $N\pi \to \Delta(1940) \to N(1535)\pi$

| MODULUS | PHASE (°) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| <0.03 | undefined | GUTZ | 14 | DPWA | Multichannel |

### Normalized residue in $N\pi \to \Delta(1940) \to \Delta(1232)\pi$, *S*-wave

| MODULUS | PHASE (°) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| 0.12±0.06 | 120 ± 45 | SOKHOYAN | 15A | DPWA | Multichannel |

### Normalized residue in $N\pi \to \Delta(1940) \to \Delta(1232)\pi$, *D*-wave

| MODULUS | PHASE (°) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| 0.06±0.04 | −80 ± 35 | SOKHOYAN | 15A | DPWA | Multichannel |

## Δ(1940) BREIT-WIGNER MASS

| VALUE (MeV) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **1940 to 2060 (≈ 2000) OUR ESTIMATE** | | | | |
| 2060± 40 | SARANTSEV | 25 | DPWA | Multichannel |
| 2137± 13 | [1] HUNT | 19 | DPWA | Multichannel |
| 1940±100 | CUTKOSKY | 80 | IPWA | $\pi N \to \pi N$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 2050± 40 | SOKHOYAN | 15A | DPWA | Multichannel |
| 2050± 40 | GUTZ | 14 | DPWA | Multichannel |

[1] Statistical error only.

## Δ(1940) BREIT-WIGNER WIDTH

| VALUE (MeV) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **300 to 500 (≈ 400) OUR ESTIMATE** | | | | |
| 460± 50 | SARANTSEV | 25 | DPWA | Multichannel |
| 400± 43 | [1] HUNT | 19 | DPWA | Multichannel |
| 200±100 | CUTKOSKY | 80 | IPWA | $\pi N \to \pi N$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 450± 70 | SOKHOYAN | 15A | DPWA | Multichannel |
| 450± 70 | GUTZ | 14 | DPWA | Multichannel |

[1] Statistical error only.

## Δ(1940) DECAY MODES

| | Mode | Fraction ($\Gamma_i/\Gamma$) |
|---|---|---|
| $\Gamma_1$ | $N\pi$ | 1–20 % |
| $\Gamma_2$ | $N\pi\pi$ | >81 % |
| $\Gamma_3$ | $\Delta(1232)\pi$ | (38±10) % |
| $\Gamma_4$ | $\Delta(1232)\pi$, *S*-wave | 1–65 % |
| $\Gamma_5$ | $\Delta(1232)\pi$, *D*-wave | 5–20 % |
| $\Gamma_6$ | $N\rho$ | (24± 6) % |
| $\Gamma_7$ | $N\rho$, $S$=1/2 | ( 6± 4) % |
| $\Gamma_8$ | $N\rho$, $S$=3/2 , *S*-wave | 75–85 % |
| $\Gamma_9$ | $N\rho$, $S$=3/2 , *D*-wave | ( 8± 4) % |
| $\Gamma_{10}$ | $N(1440)\pi$ | ( 5± 5) % |
| $\Gamma_{11}$ | $N(1520)\pi$, *P*-wave | ( 7± 5) % |
| $\Gamma_{12}$ | $N(1535)\pi$ | 2–14 % |
| $\Gamma_{13}$ | $Na_0(980)$ | seen |
| $\Gamma_{14}$ | $\Delta(1232)\eta$ | 4–16 % |
| $\Gamma_{15}$ | $N\gamma$ | 0.06–2.53 % |
| $\Gamma_{16}$ | $N\gamma$, helicity=1/2 | 0.06–1.51 % |
| $\Gamma_{17}$ | $N\gamma$, helicity=3/2 | 0–1.02 % |

## Δ(1940) BRANCHING RATIOS

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

| VALUE (%) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **1–20 % OUR ESTIMATE** | | | | |
| 13±6 | SEIFEN | 25 | DPWA | Multichannel |
| 16±4 | [1] HUNT | 19 | DPWA | Multichannel |
| 5±2 | CUTKOSKY | 80 | IPWA | $\pi N \to \pi N$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 2±1 | SOKHOYAN | 15A | DPWA | Multichannel |
| 2±1 | GUTZ | 14 | DPWA | Multichannel |

[1] Statistical error only.

### $\Gamma(\Delta(1232)\pi)/\Gamma_{\text{total}}$ $\Gamma_3/\Gamma$

| VALUE (%) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **38±10** | SARANTSEV | 25 | DPWA | Multichannel |

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

| VALUE (%) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **1–65 % OUR ESTIMATE** | | | | |
| 21 ± 8 | SARANTSEV | 25 | DPWA | Multichannel |
| 16 ± 6 | SEIFEN | 25 | DPWA | Multichannel |
| < 0.9 | [1] HUNT | 19 | DPWA | Multichannel |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 46 ±20 | SOKHOYAN | 15A | DPWA | Multichannel |

[1] Statistical error only.

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

| VALUE (%) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **5–20 % OUR ESTIMATE** | | | | |
| 17 ± 9 | SARANTSEV | 25 | DPWA | Multichannel |
| 30 ±12 | SEIFEN | 25 | DPWA | Multichannel |
| < 6.3 | [1] HUNT | 19 | DPWA | Multichannel |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 12 ± 7 | SOKHOYAN | 15A | DPWA | Multichannel |

[1] Statistical error only.

### $\Gamma(N\rho)/\Gamma_{total}$ $\Gamma_6/\Gamma$

| VALUE (%) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **24±6** | SARANTSEV | 25 | DPWA | Multichannel |

### $\Gamma(N\rho, S{=}1/2)/\Gamma_{total}$ $\Gamma_7/\Gamma$

| VALUE (%) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **6±4** | SARANTSEV | 25 | DPWA | Multichannel |

### $\Gamma(N\rho, S{=}3/2, S\text{-wave})/\Gamma_{total}$ $\Gamma_8/\Gamma$

| VALUE (%) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **75–85 % OUR ESTIMATE** | | | | |
| 10±5 | SARANTSEV | 25 | DPWA | Multichannel |
| 80±5 | [1] HUNT | 19 | DPWA | Multichannel |

[1] Statistical error only.

### $\Gamma(N\rho, S{=}3/2, D\text{-wave})/\Gamma_{total}$ $\Gamma_9/\Gamma$

| VALUE (%) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **8±4** | SARANTSEV | 25 | DPWA | Multichannel |

### $\Gamma(N(1440)\pi)/\Gamma_{total}$ $\Gamma_{10}/\Gamma$

| VALUE (%) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **5±5** | SEIFEN | 25 | DPWA | Multichannel |

### $\Gamma(N(1520)\pi, P\text{-wave})/\Gamma_{total}$ $\Gamma_{11}/\Gamma$

| VALUE (%) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **7±5** | SEIFEN | 25 | DPWA | Multichannel |

### $\Gamma(N(1535)\pi)/\Gamma_{total}$ $\Gamma_{12}/\Gamma$

| VALUE (%) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **2–14 % OUR ESTIMATE** | | | | |
| 20±13 | SEIFEN | 25 | DPWA | Multichannel |
| 8± 6 | GUTZ | 14 | DPWA | Multichannel |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 2± 1 | HORN | 08A | DPWA | Multichannel |

### $\Gamma(N a_0(980))/\Gamma_{total}$ $\Gamma_{13}/\Gamma$

| VALUE (%) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **seen OUR ESTIMATE** | | | | |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 2±1 | HORN | 08A | DPWA | Multichannel |

### $\Gamma(\Delta(1232)\eta)/\Gamma_{total}$ $\Gamma_{14}/\Gamma$

| VALUE (%) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **4–16 % OUR ESTIMATE** | | | | |
| 10±6 | GUTZ | 14 | DPWA | Multichannel |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 4±2 | HORN | 08A | DPWA | Multichannel |

## Δ(1940) PHOTON DECAY AMPLITUDES AT THE POLE

### Δ(1940) → Nγ, helicity-1/2 amplitude $A_{1/2}$

| MODULUS ($GeV^{-1/2}$) | PHASE (°) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| 0.045±0.025 | −40 ± 30 | SARANTSEV | 25 | DPWA | Multichannel |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| $0.170^{+0.120}_{-0.100}$ | −10 ± 30 | SOKHOYAN | 15A | DPWA | Multichannel |

### Δ(1940) → Nγ, helicity-3/2 amplitude $A_{3/2}$

| MODULUS ($GeV^{-1/2}$) | PHASE (°) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| 0.080±0.030 | −75 ± 30 | SARANTSEV | 25 | DPWA | Multichannel |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| 0.150±0.080 | −10 ± 30 | SOKHOYAN | 15A | DPWA | Multichannel |

## Δ(1940) BREIT-WIGNER PHOTON DECAY AMPLITUDES

### Δ(1940) → Nγ, helicity-1/2 amplitude $A_{1/2}$

| VALUE ($GeV^{-1/2}$) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| 0.052 ±0.025 | SARANTSEV | 25 | DPWA | Multichannel |
| 0.1614±0.0031 | [1] HUNT | 19 | DPWA | Multichannel |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| $0.170\ ^{+0.110}_{-0.080}$ | SOKHOYAN | 15A | DPWA | Multichannel |
| $0.170\ ^{+0.110}_{-0.080}$ | GUTZ | 14 | DPWA | Multichannel |

[1] Statistical error only.

### Δ(1940) → Nγ, helicity-3/2 amplitude $A_{3/2}$

| VALUE ($GeV^{-1/2}$) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| 0.095±0.030 | SARANTSEV | 25 | DPWA | Multichannel |
| −0.209±0.023 | [1] HUNT | 19 | DPWA | Multichannel |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 0.150±0.080 | SOKHOYAN | 15A | DPWA | Multichannel |
| 0.150±0.080 | GUTZ | 14 | DPWA | Multichannel |

[1] Statistical error only.

# $\Delta(1940)$ REFERENCES


| | | | | |
|---|---|---|---|---|
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| SEIFEN | 25 | EPJ A61 173 | T. Seifen *et al.* | (CBELSA/TAPS Collab.) |
| HUNT | 19 | PR C99 055205 | B.C. Hunt, D.M. Manley | |
| 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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| ANISOVICH | 12A | EPJ A48 15 | A.V. Anisovich *et al.* | (BONN, PNPI) |
| HORN | 08A | EPJ A38 173 | I. Horn *et al.* | (CB-ELSA Collab.) |
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