

$\Delta(1620) \ 1/2^-$ $I(J^P) = \frac{3}{2}(\frac{1}{2}^-)$ Status: ****

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

 $\Delta(1620)$ POLE POSITION**REAL PART**

| <u>VALUE (MeV)</u> | <u>DOCUMENT ID</u> | <u>TECN</u> | <u>COMMENT</u> |
|---|--------------------|-------------|--|
| 1590 to 1610 (\approx 1600) OUR ESTIMATE | | | |
| 1597 \pm 5 | SOKHOYAN | 15A | DPWA Multichannel |
| 1603 \pm 7 \pm 2 | ¹ SVARC | 14 | L+P $\pi N \rightarrow \pi N$ |
| 1600 \pm 15 | CUTKOSKY | 80 | IPWA $\pi N \rightarrow \pi N$ |
| ● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ● | | | |
| 1577 | HUNT | 19 | DPWA Multichannel |
| 1600 | ROENCHEN | 15A | DPWA Multichannel |
| 1597 \pm 4 | ANISOVICH | 12A | DPWA Multichannel |
| 1595 | ARNDT | 06 | DPWA $\pi N \rightarrow \pi N, \eta N$ |
| 1607 | VRANA | 00 | DPWA Multichannel |
| 1608 | HOEHLER | 93 | SPED $\pi N \rightarrow \pi N$ |

¹Fit to the amplitudes of HOEHLER 79.

-2xIMAGINARY PART

| <u>VALUE (MeV)</u> | <u>DOCUMENT ID</u> | <u>TECN</u> | <u>COMMENT</u> |
|---|--------------------|-------------|--|
| 100 to 140 (\approx 120) OUR ESTIMATE | | | |
| 134 \pm 8 | SOKHOYAN | 15A | DPWA Multichannel |
| 114 \pm 12 \pm 4 | ¹ SVARC | 14 | L+P $\pi N \rightarrow \pi N$ |
| 120 \pm 20 | CUTKOSKY | 80 | IPWA $\pi N \rightarrow \pi N$ |
| ● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ● | | | |
| 101 | HUNT | 19 | DPWA Multichannel |
| 65 | ROENCHEN | 15A | DPWA Multichannel |
| 130 \pm 9 | ANISOVICH | 12A | DPWA Multichannel |
| 135 | ARNDT | 06 | DPWA $\pi N \rightarrow \pi N, \eta N$ |
| 148 | VRANA | 00 | DPWA Multichannel |
| 116 | HOEHLER | 93 | SPED $\pi N \rightarrow \pi N$ |

¹Fit to the amplitudes of HOEHLER 79.

 $\Delta(1620)$ ELASTIC POLE RESIDUE**MODULUS $|r|$**

| <u>VALUE (MeV)</u> | <u>DOCUMENT ID</u> | <u>TECN</u> | <u>COMMENT</u> |
|--|--------------------|-------------|--------------------------------|
| 15 to 20 (\approx 17) OUR ESTIMATE | | | |
| 20 \pm 3 | SOKHOYAN | 15A | DPWA Multichannel |
| 17 \pm 2 \pm 1 | ¹ SVARC | 14 | L+P $\pi N \rightarrow \pi N$ |
| 15 \pm 2 | CUTKOSKY | 80 | IPWA $\pi N \rightarrow \pi N$ |

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

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|------|-----------|-----|------|-----------------------------------|
| 16 | ROENCHEN | 15A | DPWA | Multichannel |
| 18±2 | ANISOVICH | 12A | DPWA | Multichannel |
| 15 | ARNDT | 06 | DPWA | $\pi N \rightarrow \pi N, \eta N$ |
| 19 | HOEHLER | 93 | SPED | $\pi N \rightarrow \pi N$ |

¹ Fit to the amplitudes of HOEHLER 79.

PHASE θ

| <u>VALUE (°)</u> | <u>DOCUMENT ID</u> | <u>TECN</u> | <u>COMMENT</u> |
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–120 to –80 (\approx –100) OUR ESTIMATE

| | | | | |
|-----------|--------------------|-----|------|---------------------------|
| –90±15 | SOKHOYAN | 15A | DPWA | Multichannel |
| –106±10±4 | ¹ SVARC | 14 | L+P | $\pi N \rightarrow \pi N$ |
| –110±20 | CUTKOSKY | 80 | IPWA | $\pi N \rightarrow \pi N$ |

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

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|--------|-----------|-----|------|-----------------------------------|
| –104 | ROENCHEN | 15A | DPWA | Multichannel |
| –100±5 | ANISOVICH | 12A | DPWA | Multichannel |
| –92 | ARNDT | 06 | DPWA | $\pi N \rightarrow \pi N, \eta N$ |
| –95 | HOEHLER | 93 | SPED | $\pi N \rightarrow \pi N$ |

¹ Fit to the amplitudes of HOEHLER 79.

$\Delta(1620)$ INELASTIC POLE RESIDUE

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

Normalized residue in $N\pi \rightarrow \Delta(1620) \rightarrow \Delta\pi, D\text{-wave}$

| <u>MODULUS</u> | <u>PHASE (°)</u> | <u>DOCUMENT ID</u> | <u>TECN</u> | <u>COMMENT</u> |
|----------------|------------------|--------------------|-------------|----------------|
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|-----------|----------|----------|-----|------|--------------|
| 0.42±0.06 | –90 ± 20 | SOKHOYAN | 15A | DPWA | Multichannel |
|-----------|----------|----------|-----|------|--------------|

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

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|-----------|----------|-----------|-----|------|--------------|
| 0.57 | 105 | ROENCHEN | 15A | DPWA | Multichannel |
| 0.38±0.09 | –85 ± 30 | ANISOVICH | 12A | DPWA | Multichannel |

Normalized residue in $N\pi \rightarrow \Delta(1620) \rightarrow \Sigma K$

| <u>MODULUS</u> | <u>PHASE (°)</u> | <u>DOCUMENT ID</u> | <u>TECN</u> | <u>COMMENT</u> |
|----------------|------------------|--------------------|-------------|----------------|
|----------------|------------------|--------------------|-------------|----------------|

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

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|------|------|----------|-----|------|--------------|
| 0.22 | –105 | ROENCHEN | 15A | DPWA | Multichannel |
|------|------|----------|-----|------|--------------|

Normalized residue in $N\pi \rightarrow \Delta(1620) \rightarrow N(1440)\pi$

| <u>MODULUS</u> | <u>PHASE (°)</u> | <u>DOCUMENT ID</u> | <u>TECN</u> | <u>COMMENT</u> |
|----------------|------------------|--------------------|-------------|----------------|
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|-----------|----------|----------|-----|------|--------------|
| 0.10±0.06 | –65 ± 30 | SOKHOYAN | 15A | DPWA | Multichannel |
|-----------|----------|----------|-----|------|--------------|

$\Delta(1620)$ BREIT-WIGNER MASS

| <u>VALUE (MeV)</u> | <u>DOCUMENT ID</u> | <u>TECN</u> | <u>COMMENT</u> |
|--------------------|--------------------|-------------|----------------|
|--------------------|--------------------|-------------|----------------|

1590 to 1630 (\approx 1610) OUR ESTIMATE

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|------------|--------------------|-----|------|--------------------------------------|
| 1635 ± 8 | GOLOVATCH | 19 | DPWA | $\gamma p \rightarrow \pi^+ \pi^- p$ |
| 1589 ± 3 | ¹ HUNT | 19 | DPWA | Multichannel |
| 1595 ± 8 | SOKHOYAN | 15A | DPWA | Multichannel |
| 1615.2±0.4 | ¹ ARNDT | 06 | DPWA | $\pi N \rightarrow \pi N, \eta N$ |
| 1620 ± 20 | CUTKOSKY | 80 | IPWA | $\pi N \rightarrow \pi N$ |
| 1610 ± 7 | HOEHLER | 79 | IPWA | $\pi N \rightarrow \pi N$ |

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

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|-----------|-----------------------|-----|------|--------------|
| 1600 ± 8 | ANISOVICH | 12A | DPWA | Multichannel |
| 1600 ± 1 | ¹ SHRESTHA | 12A | DPWA | Multichannel |
| 1612 ± 2 | PENNER | 02C | DPWA | Multichannel |
| 1617 ± 15 | VRANA | 00 | DPWA | Multichannel |

¹Statistical error only.

Δ(1620) BREIT-WIGNER WIDTH

| VALUE (MeV) | DOCUMENT ID | TECN | COMMENT |
|-------------|-------------|------|---------|
|-------------|-------------|------|---------|

110 to 150 (≈ 130) OUR ESTIMATE

| | | | | |
|-------------|--------------------|-----|------|--------------------------------------|
| 144 ± 16 | GOLOVATCH | 19 | DPWA | $\gamma p \rightarrow \pi^+ \pi^- p$ |
| 107 ± 7 | ¹ HUNT | 19 | DPWA | Multichannel |
| 135 ± 9 | SOKHOYAN | 15A | DPWA | Multichannel |
| 146.9 ± 1.9 | ¹ ARNDT | 06 | DPWA | $\pi N \rightarrow \pi N, \eta N$ |
| 140 ± 20 | CUTKOSKY | 80 | IPWA | $\pi N \rightarrow \pi N$ |
| 139 ± 18 | HOEHLER | 79 | IPWA | $\pi N \rightarrow \pi N$ |

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

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|----------|-----------------------|-----|------|--------------|
| 130 ± 11 | ANISOVICH | 12A | DPWA | Multichannel |
| 112 ± 2 | ¹ SHRESTHA | 12A | DPWA | Multichannel |
| 202 ± 7 | PENNER | 02C | DPWA | Multichannel |
| 143 ± 42 | VRANA | 00 | DPWA | Multichannel |

¹Statistical error only.

Δ(1620) DECAY MODES

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

| Mode | Fraction (Γ_i/Γ) |
|---|--------------------------------|
| Γ_1 $N\pi$ | 25–35 % |
| Γ_2 $N\pi\pi$ | 55–80 % |
| Γ_3 $\Delta(1232)\pi$ | |
| Γ_4 $\Delta(1232)\pi, D\text{-wave}$ | 52–72 % |
| Γ_5 $N\rho$ | |
| Γ_6 $N\rho, S=1/2, S\text{-wave}$ | seen |
| Γ_7 $N\rho, S=3/2, D\text{-wave}$ | seen |
| Γ_8 $N(1440)\pi$ | 3–9 % |
| Γ_9 $N\gamma, \text{helicity}=1/2$ | 0.03–0.10 % |

Δ(1620) BRANCHING RATIOS

| $\Gamma(N\pi)/\Gamma_{\text{total}}$ | Γ_1/Γ |
|--------------------------------------|-------------------|
|--------------------------------------|-------------------|

| VALUE (%) | DOCUMENT ID | TECN | COMMENT |
|-----------|-------------|------|---------|
|-----------|-------------|------|---------|

25 to 35 (≈ 30) OUR ESTIMATE

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|------------|--------------------|-----|------|-----------------------------------|
| 24 ± 2 | ¹ HUNT | 19 | DPWA | Multichannel |
| 28 ± 3 | SOKHOYAN | 15A | DPWA | Multichannel |
| 31.5 ± 0.1 | ¹ ARNDT | 06 | DPWA | $\pi N \rightarrow \pi N, \eta N$ |
| 25 ± 3 | CUTKOSKY | 80 | IPWA | $\pi N \rightarrow \pi N$ |
| 35 ± 6 | HOEHLER | 79 | IPWA | $\pi N \rightarrow \pi N$ |

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

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|--------|--------------|-----------|-----|------|--------------|
| 28 ± 3 | | ANISOVICH | 12A | DPWA | Multichannel |
| 33 ± 2 | ¹ | SHRESTHA | 12A | DPWA | Multichannel |
| 34 ± 1 | | PENNER | 02C | DPWA | Multichannel |
| 45 ± 5 | | VRANA | 00 | DPWA | Multichannel |

¹Statistical error only.

$\Gamma(N\pi\pi)/\Gamma_{\text{total}}$ **Γ_2/Γ**

| <u>VALUE</u> | | <u>DOCUMENT ID</u> | <u>TECN</u> | <u>COMMENT</u> |
|------------------|--|--------------------|-------------|--------------------------------------|
| 0.90±0.10 | | GOLOVATCH 19 | DPWA | $\gamma p \rightarrow \pi^+ \pi^- p$ |

$\Gamma(\Delta(1232)\pi, D\text{-wave})/\Gamma_{\text{total}}$ **Γ_4/Γ**

| <u>VALUE (%)</u> | | <u>DOCUMENT ID</u> | <u>TECN</u> | <u>COMMENT</u> |
|------------------|--------------|--------------------|-------------|----------------|
| 48 ± 4 | ¹ | HUNT 19 | DPWA | Multichannel |
| 62 ± 10 | | SOKHOYAN 15A | DPWA | Multichannel |

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

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|---------|--------------|-----------|-----|------|--------------|
| 60 ± 17 | | ANISOVICH | 12A | DPWA | Multichannel |
| 32 ± 2 | ¹ | SHRESTHA | 12A | DPWA | Multichannel |
| 39 ± 2 | | VRANA | 00 | DPWA | Multichannel |

¹Statistical error only.

$\Gamma(N\rho, S=1/2, S\text{-wave})/\Gamma_{\text{total}}$ **Γ_6/Γ**

| <u>VALUE (%)</u> | | <u>DOCUMENT ID</u> | <u>TECN</u> | <u>COMMENT</u> |
|------------------|--------------|--------------------|-------------|----------------|
| 27 ± 4 | ¹ | HUNT 19 | DPWA | Multichannel |

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

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|--------|--------------|----------|-----|------|--------------|
| 26 ± 2 | ¹ | SHRESTHA | 12A | DPWA | Multichannel |
| 14 ± 3 | | VRANA | 00 | DPWA | Multichannel |

¹Statistical error only.

$\Gamma(N\rho, S=3/2, D\text{-wave})/\Gamma_{\text{total}}$ **Γ_7/Γ**

| <u>VALUE (%)</u> | | <u>DOCUMENT ID</u> | <u>TECN</u> | <u>COMMENT</u> |
|------------------|--------------|--------------------|-------------|----------------|
| <0.04 | ¹ | HUNT 19 | DPWA | Multichannel |

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

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|-------|--|-------|----|------|--------------|
| 2 ± 1 | | VRANA | 00 | DPWA | Multichannel |
|-------|--|-------|----|------|--------------|

¹Statistical error only.

$\Gamma(N(1440)\pi)/\Gamma_{\text{total}}$ **Γ_8/Γ**

| <u>VALUE (%)</u> | | <u>DOCUMENT ID</u> | <u>TECN</u> | <u>COMMENT</u> |
|------------------|--------------|--------------------|-------------|----------------|
| <0.02 | ¹ | HUNT 19 | DPWA | Multichannel |
| 6 ± 3 | | SOKHOYAN 15A | DPWA | Multichannel |

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

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| 9 ± 1 | ¹ | SHRESTHA | 12A | DPWA | Multichannel |
| 0 ± 1 | | VRANA | 00 | DPWA | Multichannel |

¹Statistical error only.

$\Delta(1620)$ PHOTON DECAY AMPLITUDES AT THE POLE **$\Delta(1620) \rightarrow N\gamma$, helicity-1/2 amplitude $A_{1/2}$**

| <i>MODULUS</i> ($\text{GeV}^{-1/2}$) | <i>PHASE</i> ($^\circ$) | <i>DOCUMENT ID</i> | <i>TECN</i> | <i>COMMENT</i> |
|---|---------------------------|--------------------|-------------|-------------------|
| 0.054 ± 0.007 | -6 ± 7 | SOKHOYAN | 15A | DPWA Multichannel |
| $-0.028^{+0.006}_{-0.002}$ | -166^{+1}_{-4} | ROENCHEN | 14 | DPWA |
| ● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ● | | | | |
| 0.014 | 26 | ROENCHEN | 15A | DPWA Multichannel |

 $\Delta(1620)$ BREIT-WIGNER PHOTON DECAY AMPLITUDES **$\Delta(1620) \rightarrow N\gamma$, helicity-1/2 amplitude $A_{1/2}$**

| <i>VALUE</i> ($\text{GeV}^{-1/2}$) | <i>DOCUMENT ID</i> | <i>TECN</i> | <i>COMMENT</i> |
|---|---------------------------|-------------|--------------------------------------|
| 0.030 to 0.060 (≈ 0.050) OUR ESTIMATE | | | |
| 0.029 ± 0.0062 | GOLOVATCH 19 | DPWA | $\gamma p \rightarrow \pi^+ \pi^- p$ |
| 0.0124 ± 0.0007 | ¹ HUNT 19 | DPWA | Multichannel |
| 0.055 ± 0.007 | SOKHOYAN 15A | DPWA | Multichannel |
| 0.029 ± 0.003 | ¹ WORKMAN 12A | DPWA | $\gamma N \rightarrow N\pi$ |
| 0.050 ± 0.002 | ¹ DUGGER 07 | DPWA | $\gamma N \rightarrow \pi N$ |
| ● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ● | | | |
| 0.052 ± 0.005 | ANISOVICH 12A | DPWA | Multichannel |
| -0.003 ± 0.003 | ¹ SHRESTHA 12A | DPWA | Multichannel |
| 0.066 | DRECHSEL 07 | DPWA | $\gamma N \rightarrow \pi N$ |
| -0.050 | PENNER 02D | DPWA | Multichannel |
| ¹ Statistical error only. | | | |

 $\Delta(1620)$ REFERENCESFor early references, see Physics Letters **111B** 1 (1982).

| | | | |
|---------------|------------------------|--------------------------------------|-------------------------|
| GOLOVATCH 19 | PL B788 371 | E. Golovatch <i>et al.</i> | (CLAS Collab.) |
| HUNT 19 | PR C99 055205 | B.C. Hunt, D.M. Manley | |
| ROENCHEN 15A | EPJ A51 70 | D. Roenchen <i>et al.</i> | |
| SOKHOYAN 15A | EPJ A51 95 | V. Sokhoyan <i>et al.</i> | (CBELSA/TAPS Collab.) |
| PDG 14 | CP C38 070001 | K. Olive <i>et al.</i> | (PDG Collab.) |
| ROENCHEN 14 | EPJ A50 101 | D. Roenchen <i>et al.</i> | |
| Also | EPJ A51 63 (errat.) | D. Roenchen <i>et al.</i> | |
| SVARC 14 | PR C89 045205 | A. Svarc <i>et al.</i> | (RBI Zagreb, UNI Tuzla) |
| ANISOVICH 12A | EPJ A48 15 | A.V. Anisovich <i>et al.</i> | (BONN, PNPI) |
| SHRESTHA 12A | PR C86 055203 | M. Shrestha, D.M. Manley | (KSU) |
| WORKMAN 12A | PR C86 015202 | R. Workman <i>et al.</i> | (GWU) |
| DRECHSEL 07 | EPJ A34 69 | D. Drechsel, S.S. Kamalov, L. Tiator | (MAINZ, JINR) |
| DUGGER 07 | PR C76 025211 | M. Dugger <i>et al.</i> | (JLab CLAS Collab.) |
| ARNDT 06 | PR C74 045205 | R.A. Arndt <i>et al.</i> | (GWU) |
| 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, ANL) |
| HOEHLER 93 | πN Newsletter 9 1 | G. Hohler | (KARL) |
| 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 |
| HOEHLER 79 | PDAT 12-1 | G. Hohler <i>et al.</i> | (KARLT) IJP |
| Also | Toronto Conf. 3 | R. Koch | (KARLT) IJP |