

$$\Delta(1232) \ 3/2^+$$

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

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

$\Delta(1232)$ POLE POSITIONS

REAL PART, MIXED CHARGES

| VALUE (MeV) | DOCUMENT ID | TECN | COMMENT |
|---|----------------------|------|--|
| 1209 to 1211 (≈ 1210) OUR ESTIMATE | | | |
| 1211 $\pm 1 \pm 1$ | ¹ SVARC | 14 | L+P $\pi N \rightarrow \pi N$ |
| 1210.5 ± 1.0 | ANISOVICH | 12A | DPWA Multichannel |
| 1210 ± 1 | CUTKOSKY | 80 | IPWA $\pi N \rightarrow \pi N$ |
| ● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ● | | | |
| 1218 | ROENCHEN | 15A | DPWA Multichannel |
| 1212 | SHRESTHA | 12A | DPWA Multichannel |
| 1211 ± 1 | ANISOVICH | 10 | DPWA Multichannel |
| 1211 | ARNDT | 06 | DPWA $\pi N \rightarrow \pi N, \eta N$ |
| 1210 | ARNDT | 04 | DPWA $\pi N \rightarrow \pi N, \eta N$ |
| 1209 | ² HOEHLER | 93 | ARGD $\pi N \rightarrow \pi N$ |

¹ Fit to the amplitudes of HOEHLER 79.

² 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.

–2xIMAGINARY PART, MIXED CHARGES

| VALUE (MeV) | DOCUMENT ID | TECN | COMMENT |
|---|----------------------|------|--|
| 98 to 102 (≈ 100) OUR ESTIMATE | | | |
| 98 $\pm 2 \pm 1$ | ¹ SVARC | 14 | L+P $\pi N \rightarrow \pi N$ |
| 99 ± 2 | ANISOVICH | 12A | DPWA Multichannel |
| 100 ± 2 | CUTKOSKY | 80 | IPWA $\pi N \rightarrow \pi N$ |
| ● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ● | | | |
| 92 | ROENCHEN | 15A | DPWA Multichannel |
| 98 | SHRESTHA | 12A | DPWA Multichannel |
| 100 ± 2 | ANISOVICH | 10 | DPWA Multichannel |
| 99 | ARNDT | 06 | DPWA $\pi N \rightarrow \pi N, \eta N$ |
| 100 | ARNDT | 04 | DPWA $\pi N \rightarrow \pi N, \eta N$ |
| 100 | ² HOEHLER | 93 | ARGD $\pi N \rightarrow \pi N$ |

¹ Fit to the amplitudes of HOEHLER 79.

² 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.

REAL PART, $\Delta(1232)^{++}$

| VALUE (MeV) | DOCUMENT ID | COMMENT |
|---|-------------|----------------------|
| ● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ● | | |
| 1212.50 ± 0.24 | BERNICHIA | 96 Fit to PEDRONI 78 |

–2×IMAGINARY PART, $\Delta(1232)^{++}$

| <u>VALUE (MeV)</u> | <u>DOCUMENT ID</u> | <u>TECN</u> | <u>COMMENT</u> |
|---|--------------------|-------------|-------------------|
| ● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ● | | | |
| 97.37±0.42 | BERNICHA 96 | | Fit to PEDRONI 78 |

REAL PART, $\Delta(1232)^+$

| <u>VALUE (MeV)</u> | <u>DOCUMENT ID</u> | <u>TECN</u> | <u>COMMENT</u> |
|---|--------------------|-------------|-----------------------------------|
| ● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ● | | | |
| 1211 ±1 to 1212 ± 1 | HANSTEIN 96 | | DPWA $\gamma N \rightarrow \pi N$ |
| 1206.9±0.9 to 1210.5 ± 1.8 | MIROSHNIC... 79 | | Fit photoproduction |

–2×IMAGINARY PART, $\Delta(1232)^+$

| <u>VALUE (MeV)</u> | <u>DOCUMENT ID</u> | <u>TECN</u> | <u>COMMENT</u> |
|---|--------------------------|-------------|-----------------------------------|
| ● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ● | | | |
| 102 ±2 to 99 ± 2 | ¹ HANSTEIN 96 | | DPWA $\gamma N \rightarrow \pi N$ |
| 111.2±2.0 to 116.6 ± 2.2 | MIROSHNIC... 79 | | Fit photoproduction |

¹The second (lower) value of HANSTEIN 96 here goes with the second (higher) value of the real part in the preceding data block.

REAL PART, $\Delta(1232)^0$

| <u>VALUE (MeV)</u> | <u>DOCUMENT ID</u> | <u>TECN</u> | <u>COMMENT</u> |
|---|--------------------|-------------|-------------------|
| ● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ● | | | |
| 1213.20±0.66 | BERNICHA 96 | | Fit to PEDRONI 78 |

–2×IMAGINARY PART, $\Delta(1232)^0$

| <u>VALUE (MeV)</u> | <u>DOCUMENT ID</u> | <u>TECN</u> | <u>COMMENT</u> |
|---|--------------------|-------------|-------------------|
| ● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ● | | | |
| 104.10±1.01 | BERNICHA 96 | | Fit to PEDRONI 78 |

 $\Delta(1232)$ ELASTIC POLE RESIDUES**ABSOLUTE VALUE, MIXED CHARGES**

| <u>VALUE (MeV)</u> | <u>DOCUMENT ID</u> | <u>TECN</u> | <u>COMMENT</u> |
|---|-----------------------|-------------|-----------------------------------|
| 49 to 52 (≈ 50) OUR ESTIMATE | | | |
| 50 ±1 ±1 | ¹ SVARC 14 | L+P | $\pi N \rightarrow \pi N$ |
| 51.6±0.6 | ANISOVICH 12A | DPWA | Multichannel |
| 53 ±2 | CUTKOSKY 80 | IPWA | $\pi N \rightarrow \pi N$ |
| ● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ● | | | |
| 46 | ROENCHEN 15A | DPWA | Multichannel |
| 52 | ARNDT 06 | DPWA | $\pi N \rightarrow \pi N, \eta N$ |
| 53 | ARNDT 04 | DPWA | $\pi N \rightarrow \pi N, \eta N$ |
| 50 | HOEHLER 93 | ARGD | $\pi N \rightarrow \pi N$ |

PHASE, MIXED CHARGES

| <u>VALUE (°)</u> | <u>DOCUMENT ID</u> | <u>TECN</u> | <u>COMMENT</u> |
|---|--------------------|-------------|-----------------------------------|
| −48 to −45 (≈ −46) OUR ESTIMATE | | | |
| −46±1±1 | ¹ SVARC | 14 L+P | $\pi N \rightarrow \pi N$ |
| −46±1 | ANISOVICH | 12A DPWA | Multichannel |
| −47±1 | CUTKOSKY | 80 IPWA | $\pi N \rightarrow \pi N$ |
| ● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ● | | | |
| −36 | ROENCHEN | 15A DPWA | Multichannel |
| −47 | ARNDT | 06 DPWA | $\pi N \rightarrow \pi N, \eta N$ |
| −47 | ARNDT | 04 DPWA | $\pi N \rightarrow \pi N, \eta N$ |
| −48 | HOEHLER | 93 ARGD | $\pi N \rightarrow \pi N$ |
| ¹ Fit to the amplitudes of HOEHLER 79. | | | |

 $\Delta(1232)$ BREIT-WIGNER MASSES**MIXED CHARGES**

| <u>VALUE (MeV)</u> | <u>DOCUMENT ID</u> | <u>TECN</u> | <u>COMMENT</u> |
|---|-----------------------|-------------|-----------------------------------|
| 1230 to 1234 (≈ 1232) OUR ESTIMATE | | | |
| 1228 ±2 | ANISOVICH | 12A DPWA | Multichannel |
| 1231.1±0.2 | ¹ SHRESTHA | 12A DPWA | Multichannel |
| 1233.4±0.4 | ¹ ARNDT | 06 DPWA | $\pi N \rightarrow \pi N, \eta N$ |
| 1232 ±3 | CUTKOSKY | 80 IPWA | $\pi N \rightarrow \pi N$ |
| 1233 ±2 | HOEHLER | 79 IPWA | $\pi N \rightarrow \pi N$ |
| ● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ● | | | |
| 1230 ±2 | ANISOVICH | 10 DPWA | Multichannel |
| 1232.9±1.2 | ARNDT | 04 DPWA | $\pi N \rightarrow \pi N, \eta N$ |
| 1228 ±1 | PENNER | 02C DPWA | Multichannel |
| ¹ Statistical error only. | | | |

 $\Delta(1232)^{++}$ MASS

| <u>VALUE (MeV)</u> | <u>DOCUMENT ID</u> | <u>TECN</u> | <u>COMMENT</u> |
|---|--------------------|-------------|--------------------------------------|
| ● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ● | | | |
| 1230.55±0.20 | GRIDNEV | 06 DPWA | $\pi N \rightarrow \pi N$ |
| 1231.88±0.29 | BERNICHIA | 96 | Fit to PEDRONI 78 |
| 1230.5 ±0.2 | ABAEV | 95 IPWA | $\pi N \rightarrow \pi N$ |
| 1230.9 ±0.3 | KOCH | 80B IPWA | $\pi N \rightarrow \pi N$ |
| 1231.1 ±0.2 | PEDRONI | 78 | $\pi N \rightarrow \pi N$ 70–370 MeV |

 $\Delta(1232)^+$ MASS

| <u>VALUE (MeV)</u> | <u>DOCUMENT ID</u> | <u>COMMENT</u> |
|---|--------------------|---------------------|
| ● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ● | | |
| 1234.9±1.4 | MIROSHNIC... 79 | Fit photoproduction |

$\Delta(1232)^0$ MASS

| <u>VALUE (MeV)</u> | <u>DOCUMENT ID</u> | <u>TECN</u> | <u>COMMENT</u> |
|---|--------------------|-------------|--------------------------------------|
| ● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ● | | | |
| 1231.3 \pm 0.6 | BREITSCHOP..06 | CNTR | Using new CHEX data |
| 1233.40 \pm 0.22 | GRIDNEV 06 | DPWA | $\pi N \rightarrow \pi N$ |
| 1234.35 \pm 0.75 | BERNICHA 96 | | Fit to PEDRONI 78 |
| 1233.1 \pm 0.3 | ABAEV 95 | IPWA | $\pi N \rightarrow \pi N$ |
| 1233.6 \pm 0.5 | KOCH 80B | IPWA | $\pi N \rightarrow \pi N$ |
| 1233.8 \pm 0.2 | PEDRONI 78 | | $\pi N \rightarrow \pi N$ 70–370 MeV |

 $m_{\Delta^0} - m_{\Delta^{++}}$

| <u>VALUE (MeV)</u> | <u>DOCUMENT ID</u> | <u>TECN</u> | <u>COMMENT</u> |
|--|-------------------------|-------------|---------------------------|
| ● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ● | | | |
| 2.86 \pm 0.30 | GRIDNEV 06 | DPWA | $\pi N \rightarrow \pi N$ |
| 2.25 \pm 0.68 | BERNICHA 96 | | Fit to PEDRONI 78 |
| 2.6 \pm 0.4 | ABAEV 95 | IPWA | $\pi N \rightarrow \pi N$ |
| 2.7 \pm 0.3 | ¹ PEDRONI 78 | | See the masses |
| ¹ Using $\pi^\pm d$ as well, PEDRONI 78 determine $(M^- - M^{++}) + (M^0 - M^+)/3 = 4.6 \pm 0.2$ MeV. | | | |

 $\Delta(1232)$ BREIT-WIGNER WIDTHS**MIXED CHARGES**

| <u>VALUE (MeV)</u> | <u>DOCUMENT ID</u> | <u>TECN</u> | <u>COMMENT</u> |
|---|---------------------------|-------------|-----------------------------------|
| 114 to 120 (\approx 117) OUR ESTIMATE | | | |
| 110 \pm 3 | ANISOVICH 12A | DPWA | Multichannel |
| 113.0 \pm 0.5 | ¹ SHRESTHA 12A | DPWA | Multichannel |
| 118.7 \pm 0.6 | ¹ ARNDT 06 | DPWA | $\pi N \rightarrow \pi N, \eta N$ |
| 120 \pm 5 | CUTKOSKY 80 | IPWA | $\pi N \rightarrow \pi N$ |
| 116 \pm 5 | HOEHLER 79 | IPWA | $\pi N \rightarrow \pi N$ |
| ● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ● | | | |
| 112 \pm 4 | ANISOVICH 10 | DPWA | Multichannel |
| 118.0 \pm 2.2 | ARNDT 04 | DPWA | $\pi N \rightarrow \pi N, \eta N$ |
| 106 \pm 1 | PENNER 02C | DPWA | Multichannel |

¹ Statistical error only. **$\Delta(1232)^{++}$ WIDTH**

| <u>VALUE (MeV)</u> | <u>DOCUMENT ID</u> | <u>TECN</u> | <u>COMMENT</u> |
|---|--------------------|-------------|--------------------------------------|
| ● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ● | | | |
| 112.2 \pm 0.7 | GRIDNEV 06 | DPWA | $\pi N \rightarrow \pi N$ |
| 109.07 \pm 0.48 | BERNICHA 96 | | Fit to PEDRONI 78 |
| 111.0 \pm 1.0 | KOCH 80B | IPWA | $\pi N \rightarrow \pi N$ |
| 111.3 \pm 0.5 | PEDRONI 78 | | $\pi N \rightarrow \pi N$ 70–370 MeV |

 $\Delta(1232)^+$ WIDTH

| <u>VALUE (MeV)</u> | <u>DOCUMENT ID</u> | <u>COMMENT</u> |
|---|--------------------|---------------------|
| ● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ● | | |
| 131.1 \pm 2.4 | MIROSHNIC... 79 | Fit photoproduction |

$\Delta(1232)^0$ WIDTH

| <u>VALUE (MeV)</u> | <u>DOCUMENT ID</u> | <u>TECN</u> | <u>COMMENT</u> |
|---|--------------------|-------------|--------------------------------------|
| ● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ● | | | |
| 112.5 ± 1.9 | BREITSCHOP..06 | CNTR | Using new CHEX data |
| 116.9 ± 0.7 | GRIDNEV | 06 DPWA | $\pi N \rightarrow \pi N$ |
| 117.58 ± 1.16 | BERNICHIA | 96 | Fit to PEDRONI 78 |
| 113.0 ± 1.5 | KOCH | 80B IPWA | $\pi N \rightarrow \pi N$ |
| 117.9 ± 0.9 | PEDRONI | 78 | $\pi N \rightarrow \pi N$ 70–370 MeV |

 Δ^0 - Δ^{++} WIDTH DIFFERENCE

| <u>VALUE (MeV)</u> | <u>DOCUMENT ID</u> | <u>TECN</u> | <u>COMMENT</u> |
|---|--------------------|-------------|---------------------------|
| ● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ● | | | |
| 4.66 ± 1.0 | GRIDNEV | 06 DPWA | $\pi N \rightarrow \pi N$ |
| 8.45 ± 1.11 | BERNICHIA | 96 | Fit to PEDRONI 78 |
| 5.1 ± 1.0 | ABAEV | 95 IPWA | $\pi N \rightarrow \pi N$ |
| 6.6 ± 1.0 | PEDRONI | 78 | See the widths |

 $\Delta(1232)$ DECAY MODES

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

| Mode | Fraction (Γ_i/Γ) |
|-------------------------------------|--------------------------------|
| Γ_1 $N\pi$ | 99.4 % |
| Γ_2 $N\gamma$ | 0.55–0.65 % |
| Γ_3 $N\gamma$, helicity=1/2 | 0.11–0.13 % |
| Γ_4 $N\gamma$, helicity=3/2 | 0.44–0.52 % |
| Γ_5 pe^+e^- | $(4.2 \pm 0.7) \times 10^{-5}$ |

 $\Delta(1232)$ BRANCHING RATIOS

| $\Gamma(N\pi)/\Gamma_{\text{total}}$ | | | | | Γ_1/Γ |
|---|--------------------|-------------|-----------------------------------|--|-------------------------------------|
| <u>VALUE</u> | <u>DOCUMENT ID</u> | <u>TECN</u> | <u>COMMENT</u> | | |
| 0.994 OUR ESTIMATE | | | | | |
| 1.00 | ARNDT | 06 DPWA | $\pi N \rightarrow \pi N, \eta N$ | | |
| 1.0 | CUTKOSKY | 80 IPWA | $\pi N \rightarrow \pi N$ | | |
| 1.0 | HOEHLER | 79 IPWA | $\pi N \rightarrow \pi N$ | | |
| ● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ● | | | | | |
| 0.994 | SHRESTHA | 12A DPWA | Multichannel | | |
| 1.0 | ANISOVICH | 10 DPWA | Multichannel | | |
| 1.000 | ARNDT | 04 DPWA | $\pi N \rightarrow \pi N, \eta N$ | | |
| 1.00 | PENNER | 02C DPWA | Multichannel | | |

| $\Gamma(pe^+e^-)/\Gamma_{\text{total}}$ | | | | Γ_5/Γ |
|---|-----------------------------|--|--|-------------------------------------|
| <u>VALUE (units 10^{-5})</u> | <u>DOCUMENT ID</u> | | | |
| 4.19 ± 0.34 ± 0.62 | ¹ ADAMCZEW... 17 | | | |

¹ The systematic uncertainty includes the model dependence.

$\Delta(1232)$ PHOTON DECAY AMPLITUDES AT THE POLE **$\Delta(1232) \rightarrow N\gamma$, helicity-1/2 amplitude $A_{1/2}$**

| <u>MODULUS ($\text{GeV}^{-1/2}$)</u> | <u>PHASE ($^\circ$)</u> | <u>DOCUMENT ID</u> | <u>TECN</u> | <u>COMMENT</u> |
|---|------------------------------------|--------------------|-------------|----------------|
| $-0.114^{+0.010}_{-0.003}$ | -9^{+4}_{-2} | ROENCHEN | 14 | DPWA |

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

| | | | | |
|----------|--------|----------|-----|-------------------|
| -0.117 | -6.6 | ROENCHEN | 15A | DPWA Multichannel |
|----------|--------|----------|-----|-------------------|

 $\Delta(1232) \rightarrow N\gamma$, helicity-3/2 amplitude $A_{3/2}$

| <u>MODULUS ($\text{GeV}^{-1/2}$)</u> | <u>PHASE ($^\circ$)</u> | <u>DOCUMENT ID</u> | <u>TECN</u> | <u>COMMENT</u> |
|---|------------------------------------|--------------------|-------------|----------------|
| $-0.229^{+0.003}_{-0.004}$ | $3^{+0.3}_{-0.4}$ | ROENCHEN | 14 | DPWA |

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

| | | | | |
|----------|-------|----------|-----|-------------------|
| -0.226 | 2.8 | ROENCHEN | 15A | DPWA Multichannel |
|----------|-------|----------|-----|-------------------|

 $\Delta(1232)$ BREIT-WIGNER PHOTON DECAY AMPLITUDES

Papers on γN amplitudes predating 1981 may be found in our 2006 edition, Journal of Physics **G33** 1 (2006).

 $\Delta(1232) \rightarrow N\gamma$, helicity-1/2 amplitude $A_{1/2}$

| <u>VALUE ($\text{GeV}^{-1/2}$)</u> | <u>DOCUMENT ID</u> | <u>TECN</u> | <u>COMMENT</u> |
|---|--------------------|-------------|----------------|
|---|--------------------|-------------|----------------|

 -0.142 to -0.129 (≈ -0.135) OUR ESTIMATE

| | | | |
|---------------------------------|----------------------|-----|---|
| -0.131 ± 0.004 | ANISOVICH | 12A | DPWA Multichannel |
| -0.139 ± 0.002 | ¹ WORKMAN | 12A | DPWA $\gamma N \rightarrow N\pi$ |
| -0.139 ± 0.004 | ¹ DUGGER | 07 | DPWA $\gamma N \rightarrow \pi N$ |
| -0.137 ± 0.005 | AHRENS | 04A | DPWA $\vec{\gamma}\vec{p} \rightarrow N\pi$ |
| $-0.1357 \pm 0.0013 \pm 0.0037$ | BLANPIED | 01 | LEGS $\gamma p \rightarrow p\gamma, p\pi^0, n\pi^+$ |
| -0.131 ± 0.001 | ¹ BECK | 00 | IPWA $\vec{\gamma}p \rightarrow p\pi^0, n\pi^+$ |
| -0.140 ± 0.005 | KAMALOV | 99 | DPWA $\gamma N \rightarrow \pi N$ |
| -0.1294 ± 0.0013 | HANSTEIN | 98 | IPWA $\gamma N \rightarrow \pi N$ |
| -0.1278 ± 0.0012 | DAVIDSON | 97 | DPWA $\gamma N \rightarrow \pi N$ |

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

| | | | |
|--------------------|-----------------------|-----|-----------------------------------|
| -0.137 ± 0.001 | ¹ SHRESTHA | 12A | DPWA Multichannel |
| -0.136 ± 0.005 | ANISOVICH | 10 | DPWA Multichannel |
| -0.140 | DRECHSEL | 07 | DPWA $\gamma N \rightarrow \pi N$ |
| -0.129 ± 0.001 | ARNDT | 02 | DPWA $\gamma p \rightarrow N\pi$ |
| -0.128 | PENNER | 02D | DPWA Multichannel |
| -0.1312 | HANSTEIN | 98 | DPWA $\gamma N \rightarrow \pi N$ |

¹Statistical error only.

$\Delta(1232) \rightarrow N\gamma$, helicity-3/2 amplitude $A_{3/2}$

| <u>VALUE (GeV^{-1/2})</u> | <u>DOCUMENT ID</u> | <u>TECN</u> | <u>COMMENT</u> |
|---|-----------------------|-------------|---|
| -0.262 to -0.248 (\approx -0.255) OUR ESTIMATE | | | |
| -0.254 \pm 0.005 | ANISOVICH | 12A | DPWA Multichannel |
| -0.262 \pm 0.003 | WORKMAN | 12A | DPWA $\gamma N \rightarrow N\pi$ |
| -0.258 \pm 0.005 | DUGGER | 07 | DPWA $\gamma N \rightarrow \pi N$ |
| -0.256 \pm 0.003 | AHRENS | 04A | DPWA $\vec{\gamma}\vec{p} \rightarrow N\pi$ |
| -0.2669 \pm 0.0016 \pm 0.0078 | BLANPIED | 01 | LEGS $\gamma p \rightarrow p\gamma, p\pi^0, n\pi^+$ |
| -0.251 \pm 0.001 | BECK | 00 | IPWA $\vec{\gamma}p \rightarrow p\pi^0, n\pi^+$ |
| -0.258 \pm 0.006 | KAMALOV | 99 | DPWA $\gamma N \rightarrow \pi N$ |
| -0.2466 \pm 0.0013 | HANSTEIN | 98 | IPWA $\gamma N \rightarrow \pi N$ |
| -0.2524 \pm 0.0013 | DAVIDSON | 97 | DPWA $\gamma N \rightarrow \pi N$ |
| ● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ● | | | |
| -0.251 \pm 0.001 | ¹ SHRESTHA | 12A | DPWA Multichannel |
| -0.267 \pm 0.008 | ANISOVICH | 10 | DPWA Multichannel |
| -0.265 | DRECHSEL | 07 | DPWA $\gamma N \rightarrow \pi N$ |
| -0.243 \pm 0.001 | ARNDT | 02 | DPWA $\gamma p \rightarrow N\pi$ |
| -0.247 | PENNER | 02D | DPWA Multichannel |
| -0.2522 | HANSTEIN | 98 | DPWA $\gamma N \rightarrow \pi N$ |

¹Statistical error only. **$\Delta(1232) \rightarrow N\gamma$, E_2/M_1 ratio**

| <u>VALUE</u> | <u>DOCUMENT ID</u> | <u>TECN</u> | <u>COMMENT</u> |
|---|--------------------|-------------|---|
| -0.030 to -0.020 (\approx -0.025) OUR ESTIMATE | | | |
| -0.0274 \pm 0.0003 \pm 0.0030 | AHRENS | 04A | DPWA $\vec{\gamma}\vec{p} \rightarrow N\pi$ |
| -0.020 \pm 0.002 | ARNDT | 02 | DPWA $\gamma p \rightarrow N\pi$ |
| -0.0307 \pm 0.0026 \pm 0.0024 | BLANPIED | 01 | LEGS $\gamma p \rightarrow p\gamma, p\pi^0, n\pi^+$ |
| -0.016 \pm 0.004 \pm 0.002 | GALLER | 01 | DPWA $\gamma p \rightarrow \gamma p$ |
| -0.025 \pm 0.001 \pm 0.002 | BECK | 00 | IPWA $\vec{\gamma}p \rightarrow p\pi^0, n\pi^+$ |
| -0.0233 \pm 0.0017 | HANSTEIN | 98 | IPWA $\gamma N \rightarrow \pi N$ |
| -0.015 \pm 0.005 | ¹ ARNDT | 97 | IPWA $\gamma N \rightarrow \pi N$ |
| -0.0319 \pm 0.0024 | DAVIDSON | 97 | DPWA $\gamma N \rightarrow \pi N$ |
| ● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ● | | | |
| -0.022 | DRECHSEL | 07 | DPWA $\gamma N \rightarrow \pi N$ |
| -0.026 | PENNER | 02D | DPWA Multichannel |
| -0.0254 \pm 0.0010 | HANSTEIN | 98 | DPWA $\gamma N \rightarrow \pi N$ |
| -0.025 \pm 0.002 \pm 0.002 | BECK | 97 | IPWA $\gamma N \rightarrow \pi N$ |
| -0.030 \pm 0.003 \pm 0.002 | BLANPIED | 97 | DPWA $\gamma N \rightarrow \pi N, \gamma N$ |

¹This ARNDT 97 value is very sensitive to the database being fitted. The result is from a fit to the full pion photoproduction database, apart from the BLANPIED 97 cross-section measurements. **$\Delta(1232) \rightarrow N\gamma$, absolute value of E_2/M_1 ratio at pole**

| <u>VALUE</u> | <u>DOCUMENT ID</u> | <u>TECN</u> | <u>COMMENT</u> |
|---|--------------------|-------------|-----------------------------------|
| ● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ● | | | |
| 0.065 \pm 0.007 | ARNDT | 97 | DPWA $\gamma N \rightarrow \pi N$ |
| 0.058 | HANSTEIN | 96 | DPWA $\gamma N \rightarrow \pi N$ |

$\Delta(1232) \rightarrow N\gamma$, phase of E_2/M_1 ratio at pole

| VALUE | DOCUMENT ID | TECN | COMMENT |
|---|-------------|------|-----------------------------------|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | |
| -122 ± 5 | ARNDT | 97 | DPWA $\gamma N \rightarrow \pi N$ |
| -127.2 | HANSTEIN | 96 | DPWA $\gamma N \rightarrow \pi N$ |

 $\Delta(1232)$ MAGNETIC MOMENTS **$\Delta(1232)^{++}$ MAGNETIC MOMENT**

The values are extracted from UCLA and SIN data on $\pi^+ p$ bremsstrahlung using a variety of different theoretical approximations and methods. Our estimate is *only* a rough guess of the range we expect the moment to lie within.

| VALUE (μ_N) | DOCUMENT ID | TECN | COMMENT |
|---|----------------|------|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | |
| 6.14 ± 0.51 | LOPEZCAST...01 | DPWA | $\pi^+ p \rightarrow \pi^+ p \gamma$ |
| $4.52 \pm 0.50 \pm 0.45$ | BOSSHARD | 91 | $\pi^+ p \rightarrow \pi^+ p \gamma$ (SIN data) |
| 3.7 to 4.2 | LIN | 91B | $\pi^+ p \rightarrow \pi^+ p \gamma$ (from UCLA data) |
| 4.6 to 4.9 | LIN | 91B | $\pi^+ p \rightarrow \pi^+ p \gamma$ (from SIN data) |
| 5.6 to 7.5 | WITTMAN | 88 | $\pi^+ p \rightarrow \pi^+ p \gamma$ (from UCLA data) |
| 6.9 to 9.8 | HELLER | 87 | $\pi^+ p \rightarrow \pi^+ p \gamma$ (from UCLA data) |
| 4.7 to 6.7 | NEFKENS | 78 | $\pi^+ p \rightarrow \pi^+ p \gamma$ (UCLA data) |

 $\Delta(1232)^+$ MAGNETIC MOMENT

| VALUE (μ_N) | DOCUMENT ID | COMMENT |
|---|----------------------|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | |
| $2.7^{+1.0}_{-1.3} \pm 1.5 \pm 3$ | ¹ KOTULLA | 02 $\gamma p \rightarrow p \pi^0 \gamma'$ |

¹The second error is systematic, the third is an estimate of theoretical uncertainties.

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