

$\Delta(1950) 7/2^+$  $I(J^P) = \frac{3}{2}(\frac{7}{2}^+)$  Status: \*\*\*\*

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

 **$\Delta(1950)$  POLE POSITION****REAL PART**

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>1870 to 1890 (<math>\approx</math> 1880) OUR ESTIMATE</b>			
1888 $\pm$ 4	SOKHOYAN	15A	DPWA Multichannel
1877 $\pm$ 2 $\pm$ 1	<sup>1</sup> SVARC	14	L+P $\pi N \rightarrow \pi N$
1890 $\pm$ 15	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
1871	HUNT	19	DPWA Multichannel
1874	ROENCHEN	15A	DPWA Multichannel
1888 $\pm$ 4	GUTZ	14	DPWA Multichannel
1890 $\pm$ 4	ANISOVICH	12A	DPWA Multichannel
1876	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
1910	VRANA	00	DPWA Multichannel
1878	HOEHLER	93	ARGD $\pi N \rightarrow \pi N$

<sup>1</sup> Fit to the amplitudes of HOEHLER 79.

**–2×IMAGINARY PART**

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>220 to 260 (<math>\approx</math> 240) OUR ESTIMATE</b>			
245 $\pm$ 8	SOKHOYAN	15A	DPWA Multichannel
223 $\pm$ 4 $\pm$ 1	<sup>1</sup> SVARC	14	L+P $\pi N \rightarrow \pi N$
260 $\pm$ 40	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
206	HUNT	19	DPWA Multichannel
239	ROENCHEN	15A	DPWA Multichannel
245 $\pm$ 8	GUTZ	14	DPWA Multichannel
243 $\pm$ 8	ANISOVICH	12A	DPWA Multichannel
227	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
230	VRANA	00	DPWA Multichannel
230	HOEHLER	93	ARGD $\pi N \rightarrow \pi N$

<sup>1</sup> Fit to the amplitudes of HOEHLER 79.

 **$\Delta(1950)$  ELASTIC POLE RESIDUE****MODULUS  $|r|$** 

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>44 to 60 (<math>\approx</math> 52) OUR ESTIMATE</b>			
58 $\pm$ 2	SOKHOYAN	15A	DPWA Multichannel
44 $\pm$ 1	<sup>1</sup> SVARC	14	L+P $\pi N \rightarrow \pi N$
50 $\pm$ 7	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$

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

56	ROENCHEN	15A	DPWA	Multichannel
58 ± 2	GUTZ	14	DPWA	Multichannel
58 ± 2	ANISOVICH	12A	DPWA	Multichannel
53	ARNDT	06	DPWA	$\pi N \rightarrow \pi N, \eta N$
47	HOEHLER	93	ARGD	$\pi N \rightarrow \pi N$

<sup>1</sup> Fit to the amplitudes of HOEHLER 79.

### PHASE $\theta$

<u>VALUE (°)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>−40 to −24 (≈ −32) OUR ESTIMATE</b>			
−24 ± 3	SOKHOYAN	15A	DPWA Multichannel
−39 ± 1 ± 1	<sup>1</sup> SVARC	14	L+P $\pi N \rightarrow \pi N$
−33 ± 8	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$

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

−33	ROENCHEN	15A	DPWA	Multichannel
−24 ± 3	GUTZ	14	DPWA	Multichannel
−24 ± 3	ANISOVICH	12A	DPWA	Multichannel
−31	ARNDT	06	DPWA	$\pi N \rightarrow \pi N, \eta N$
−32	HOEHLER	93	ARGD	$\pi N \rightarrow \pi N$

<sup>1</sup> Fit to the amplitudes of HOEHLER 79.

## $\Delta(1950)$ INELASTIC POLE RESIDUE

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

### Normalized residue in $N\pi \rightarrow \Delta(1950) \rightarrow \Sigma K$

<u>MODULUS</u>	<u>PHASE (°)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.05 ± 0.01	−65 ± 25	ANISOVICH	12A	DPWA Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.031	−87	ROENCHEN	15A	DPWA Multichannel

### Normalized residue in $N\pi \rightarrow \Delta(1950) \rightarrow \Delta\pi, F\text{-wave}$

<u>MODULUS</u>	<u>PHASE (°)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.12 ± 0.04	undefined	SOKHOYAN	15A	DPWA Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.54	131	ROENCHEN	15A	DPWA Multichannel
0.12 ± 0.04	12 ± 10	ANISOVICH	12A	DPWA Multichannel

### Normalized residue in $N\pi \rightarrow \Delta(1950) \rightarrow \Delta\pi, H\text{-wave}$

<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. • • •				
0.033	−97	ROENCHEN	15A	DPWA Multichannel

### Normalized residue in $N\pi \rightarrow \Delta(1950) \rightarrow \Delta(1232)\eta$

<u>MODULUS</u>	<u>PHASE (°)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.035 ± 0.005	90 ± 25	GUTZ	14	DPWA Multichannel

**$\Delta(1950)$  BREIT-WIGNER MASS**

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
<b>1915 to 1950 (<math>\approx</math> 1930) OUR ESTIMATE</b>			
1943 $\pm$ 18	GOLOVATCH	19	DPWA $\gamma p \rightarrow \pi^+ \pi^- p$
1913 $\pm$ 4	<sup>1</sup> HUNT	19	DPWA Multichannel
1917 $\pm$ 4	ANISOVICH	17	DPWA Multichannel
1921.3 $\pm$ 0.2	<sup>1</sup> ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
1950 $\pm$ 15	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
1913 $\pm$ 8	HOEHLER	79	IPWA $\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •			
1917 $\pm$ 4	SOKHOYAN	15A	DPWA Multichannel
1917 $\pm$ 4	GUTZ	14	DPWA Multichannel
1915 $\pm$ 6	ANISOVICH	12A	DPWA Multichannel
1918 $\pm$ 1	<sup>1</sup> SHRESTHA	12A	DPWA Multichannel
1936 $\pm$ 5	VRANA	00	DPWA Multichannel

<sup>1</sup>Statistical error only. **$\Delta(1950)$  BREIT-WIGNER WIDTH**

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
<b>235 to 335 (<math>\approx</math> 285) OUR ESTIMATE</b>			
230 $\pm$ 88	GOLOVATCH	19	DPWA $\gamma p \rightarrow \pi^+ \pi^- p$
241 $\pm$ 10	<sup>1</sup> HUNT	19	DPWA Multichannel
251 $\pm$ 8	ANISOVICH	17	DPWA Multichannel
271.1 $\pm$ 1.1	<sup>1</sup> ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
340 $\pm$ 50	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
224 $\pm$ 10	HOEHLER	79	IPWA $\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •			
251 $\pm$ 8	SOKHOYAN	15A	DPWA Multichannel
251 $\pm$ 8	GUTZ	14	DPWA Multichannel
246 $\pm$ 10	ANISOVICH	12A	DPWA Multichannel
259 $\pm$ 4	<sup>1</sup> SHRESTHA	12A	DPWA Multichannel
245 $\pm$ 12	VRANA	00	DPWA Multichannel

<sup>1</sup>Statistical error only. **$\Delta(1950)$  DECAY MODES**

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

Mode	Fraction ( $\Gamma_j/\Gamma$ )
$\Gamma_1$ $N\pi$	35–45 %
$\Gamma_2$ $\Sigma K$	0.3–0.5 %
$\Gamma_3$ $N\pi\pi$	37–77 %
$\Gamma_4$ $\Delta(1232)\pi, F\text{-wave}$	1–9 %

$\Gamma_5$	$N(1680)\pi$ , $P$ -wave	3–9 %
$\Gamma_6$	$\Delta(1232)\eta$	< 0.6 %
$\Gamma_7$	$N\gamma$	0.06–0.14 %
$\Gamma_8$	$N\gamma$ , helicity=1/2	0.03–0.05 %
$\Gamma_9$	$N\gamma$ , helicity=3/2	0.04–0.09 %

## $\Delta(1950)$ BRANCHING RATIOS

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

<u>VALUE (%)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>35–45 % OUR ESTIMATE</b>			
38 ± 2	<sup>1</sup> HUNT	19	DPWA Multichannel
46 ± 2	ANISOVICH	17	DPWA Multichannel
47.1 ± 0.1	<sup>1</sup> ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
39 ± 4	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
38 ± 2	HOEHLER	79	IPWA $\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
0.046 ± 0.002	SOKHOYAN	15A	DPWA Multichannel
46 ± 2	GUTZ	14	DPWA Multichannel
45 ± 2	ANISOVICH	12A	DPWA Multichannel
45.6 ± 0.4	<sup>1</sup> SHRESTHA	12A	DPWA Multichannel
44 ± 1	VRANA	00	DPWA Multichannel

<sup>1</sup>Statistical error only.

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

<u>VALUE (%)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
57 ± 20	GOLOVATCH	19	DPWA $\gamma p \rightarrow \pi^+ \pi^- p$

### $\Gamma(\Sigma K)/\Gamma_{\text{total}}$ $\Gamma_2/\Gamma$

<u>VALUE (%)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.6 ± 0.2	ANISOVICH	17	DPWA Multichannel
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
0.4 ± 0.1	ANISOVICH	12A	DPWA Multichannel

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

<u>VALUE (%)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
5 ± 3	ANISOVICH	17	DPWA Multichannel
8 ± 1	<sup>1</sup> SHRESTHA	12A	DPWA Multichannel
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
5 ± 4	SOKHOYAN	15A	DPWA Multichannel
2.8 ± 1.4	ANISOVICH	12A	DPWA Multichannel
36 ± 1	VRANA	00	DPWA Multichannel

<sup>1</sup>Statistical error only.

### $\Gamma(N(1680)\pi, P\text{-wave})/\Gamma_{\text{total}}$ $\Gamma_5/\Gamma$

<u>VALUE (%)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
6 ± 3	SOKHOYAN	15A	DPWA Multichannel

$\Gamma(\Delta(1232)\eta)/\Gamma_{\text{total}}$				$\Gamma_6/\Gamma$
VALUE (%)	DOCUMENT ID	TECN	COMMENT	
$0.3 \pm 0.3$	ANISOVICH	17	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •				
<1	GUTZ	14	DPWA	Multichannel

### $\Delta(1950)$ PHOTON DECAY AMPLITUDES AT THE POLE

#### $\Delta(1950) \rightarrow N\gamma$ , helicity-1/2 amplitude $A_{1/2}$

MODULUS ( $\text{GeV}^{-1/2}$ )	PHASE ( $^\circ$ )	DOCUMENT ID	TECN	COMMENT
$-0.067 \pm 0.004$	$-10 \pm 5$	SOKHOYAN	15A	DPWA Multichannel
$-0.071 \pm 0.004$	$-14^{+2}_{-4}$	ROENCHEN	14	DPWA
• • • We do not use the following data for averages, fits, limits, etc. • • •				
-0.068	-19	ROENCHEN	15A	DPWA Multichannel

#### $\Delta(1950) \rightarrow N\gamma$ , helicity-3/2 amplitude $A_{3/2}$

MODULUS ( $\text{GeV}^{-1/2}$ )	PHASE ( $^\circ$ )	DOCUMENT ID	TECN	COMMENT
$-0.095 \pm 0.004$	$-10 \pm 5$	SOKHOYAN	15A	DPWA Multichannel
$-0.089^{+0.008}_{-0.007}$	$-10^{+3}_{-1}$	ROENCHEN	14	DPWA
• • • We do not use the following data for averages, fits, limits, etc. • • •				
-0.084	-19	ROENCHEN	15A	DPWA Multichannel

### $\Delta(1950)$ BREIT-WIGNER PHOTON DECAY AMPLITUDES

#### $\Delta(1950) \rightarrow N\gamma$ , helicity-1/2 amplitude $A_{1/2}$

VALUE ( $\text{GeV}^{-1/2}$ )	DOCUMENT ID	TECN	COMMENT
<b>-0.075 to -0.065 (<math>\approx -0.070</math>) OUR ESTIMATE</b>			
$-0.0698 \pm 0.0141$	GOLOVATCH	19	DPWA $\gamma p \rightarrow \pi^+ \pi^- p$
$-0.047 \pm 0.002$	<sup>1</sup> HUNT	19	DPWA Multichannel
$-0.067 \pm 0.005$	ANISOVICH	17	DPWA Multichannel
$-0.083 \pm 0.004$	WORKMAN	12A	DPWA $\gamma N \rightarrow N\pi$
• • • We do not use the following data for averages, fits, limits, etc. • • •			
$-0.067 \pm 0.005$	SOKHOYAN	15A	DPWA Multichannel
$-0.067 \pm 0.005$	GUTZ	14	DPWA Multichannel
$-0.071 \pm 0.004$	ANISOVICH	12A	DPWA Multichannel
$-0.065 \pm 0.001$	<sup>1</sup> SHRESTHA	12A	DPWA Multichannel
-0.094	DRECHSEL	07	DPWA $\gamma N \rightarrow \pi N$

<sup>1</sup>Statistical error only.

#### $\Delta(1950) \rightarrow N\gamma$ , helicity-3/2 amplitude $A_{3/2}$

VALUE ( $\text{GeV}^{-1/2}$ )	DOCUMENT ID	TECN	COMMENT
<b>-0.100 to -0.080 (<math>\approx -0.090</math>) OUR ESTIMATE</b>			
$-0.1181 \pm 0.0193$	GOLOVATCH	19	DPWA $\gamma p \rightarrow \pi^+ \pi^- p$
$-0.074 \pm 0.002$	<sup>1</sup> HUNT	19	DPWA Multichannel
$-0.094 \pm 0.004$	ANISOVICH	17	DPWA Multichannel
$-0.096 \pm 0.004$	WORKMAN	12A	DPWA $\gamma N \rightarrow N\pi$

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

−0.094 ±0.004	SOKHOYAN	15A	DPWA	Multichannel
−0.094 ±0.004	GUTZ	14	DPWA	Multichannel
−0.094 ±0.005	ANISOVICH	12A	DPWA	Multichannel
−0.083 ±0.001	<sup>1</sup> SHRESTHA	12A	DPWA	Multichannel
−0.121	DRECHSEL	07	DPWA	$\gamma N \rightarrow \pi N$

<sup>1</sup>Statistical error only.

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## Δ(1950) REFERENCES

GOLOVATCH	19	PL B788 371	E. Golovatch <i>et al.</i>	(CLAS Collab.)
HUNT	19	PR C99 055205	B.C. Hunt, D.M. Manley	
ANISOVICH	17	PL B766 357	A.V. Anisovich <i>et al.</i>	
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.)
GUTZ	14	EPJ A50 74	E. Gutz <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)
ARNDT	06	PR C74 045205	R.A. Arndt <i>et al.</i>	(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 <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

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