

$$\Delta(1950) \ 7/2^+$$

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

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

$\Delta(1950)$ POLE POSITION

REAL PART

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
1870 to 1890 (\approx 1880) OUR ESTIMATE			
1888 \pm 4	SOKHOYAN	15A	DPWA Multichannel
1877 \pm 2 \pm 1	¹ 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 $\pi N \rightarrow \pi N$

¹ Fit to the amplitudes of HOEHLER 79.

–2×IMAGINARY PART

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
220 to 260 (\approx 240) OUR ESTIMATE			
245 \pm 8	SOKHOYAN	15A	DPWA Multichannel
223 \pm 4 \pm 1	¹ 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 $\pi N \rightarrow \pi N$

¹ Fit to the amplitudes of HOEHLER 79.

$\Delta(1950)$ ELASTIC POLE RESIDUE

MODULUS $|r|$

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
44 to 60 (\approx 52) OUR ESTIMATE			
58 \pm 2	SOKHOYAN	15A	DPWA Multichannel
44 \pm 1	¹ 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	$\pi N \rightarrow \pi N$

¹ Fit to the amplitudes of HOEHLER 79.

PHASE θ

<u>VALUE (°)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
−40 to −24 (≈ −32) OUR ESTIMATE			
−24±3	SOKHOYAN	15A	DPWA Multichannel
−39±1±1	¹ 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	$\pi N \rightarrow \pi N$

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

¹Statistical error only.

$\Delta(1950)$ BREIT-WIGNER WIDTH

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

¹Statistical error only.

$\Delta(1950)$ DECAY MODES

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

Mode	Fraction (Γ_j/Γ)
Γ_1 $N\pi$	35–45 %
Γ_2 ΣK	0.3–0.5 %
Γ_3 $N\pi\pi$	37–77 %
Γ_4 $\Delta(1232)\pi, F\text{-wave}$	1–9 %

Γ_5	$N(1680)\pi$, P -wave	3–9 %
Γ_6	$\Delta(1232)\eta$	< 0.6 %
Γ_7	$N\gamma$	0.06–0.14 %
Γ_8	$N\gamma$, helicity=1/2	0.03–0.05 %
Γ_9	$N\gamma$, helicity=3/2	0.04–0.09 %

$\Delta(1950)$ BRANCHING RATIOS

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

VALUE (%)	DOCUMENT ID	TECN	COMMENT
35–45 % OUR ESTIMATE			
38 ± 2	¹ HUNT	19	DPWA Multichannel
46 ± 2	ANISOVICH	17	DPWA Multichannel
47.1 ± 0.1	¹ 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	¹ SHRESTHA	12A	DPWA Multichannel
44 ± 1	VRANA	00	DPWA Multichannel

¹Statistical error only.

$\Gamma(N\pi\pi)/\Gamma_{\text{total}}$ Γ_3/Γ

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

$\Gamma(\Sigma K)/\Gamma_{\text{total}}$ Γ_2/Γ

VALUE (%)	DOCUMENT ID	TECN	COMMENT
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

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

VALUE (%)	DOCUMENT ID	TECN	COMMENT
5 ± 3	ANISOVICH	17	DPWA Multichannel
8 ± 1	¹ 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

¹Statistical error only.

$\Gamma(N(1680)\pi, P\text{-wave})/\Gamma_{\text{total}}$ Γ_5/Γ

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

$\Gamma(\Delta(1232)\eta)/\Gamma_{\text{total}}$ Γ_6/Γ

VALUE (%)	DOCUMENT ID	TECN	COMMENT
0.3±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±0.004	-10 ± 5	SOKHOYAN 15A	DPWA	Multichannel
-0.071±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±0.004	-10 ± 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
-0.075 to -0.065 (\approx -0.070) OUR ESTIMATE			
-0.0698±0.0141	GOLOVATCH 19	DPWA	$\gamma p \rightarrow \pi^+ \pi^- p$
-0.047 ±0.002	¹ HUNT 19	DPWA	Multichannel
-0.067 ±0.005	ANISOVICH 17	DPWA	Multichannel
-0.083 ±0.004	WORKMAN 12A	DPWA	$\gamma N \rightarrow N\pi$
• • • We do not use the following data for averages, fits, limits, etc. • • •			
-0.067 ±0.005	SOKHOYAN 15A	DPWA	Multichannel
-0.067 ±0.005	GUTZ 14	DPWA	Multichannel
-0.071 ±0.004	ANISOVICH 12A	DPWA	Multichannel
-0.065 ±0.001	¹ SHRESTHA 12A	DPWA	Multichannel
-0.094	DRECHSEL 07	DPWA	$\gamma N \rightarrow \pi N$

¹Statistical error only. $\Delta(1950) \rightarrow N\gamma$, helicity-3/2 amplitude $A_{3/2}$

VALUE ($\text{GeV}^{-1/2}$)	DOCUMENT ID	TECN	COMMENT
-0.100 to -0.080 (\approx -0.090) OUR ESTIMATE			
-0.1181±0.0193	GOLOVATCH 19	DPWA	$\gamma p \rightarrow \pi^+ \pi^- p$
-0.074 ±0.002	¹ HUNT 19	DPWA	Multichannel
-0.094 ±0.004	ANISOVICH 17	DPWA	Multichannel
-0.096 ±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	¹ SHRESTHA	12A	DPWA	Multichannel
-0.121	DRECHSEL	07	DPWA	$\gamma N \rightarrow \pi N$

¹ Statistical error only.

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	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
