

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

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

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

$\Delta(1950)$ POLE POSITION

REAL PART

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
1870 to 1890 ($\approx$ 1880) OUR ESTIMATE			
1875 $\pm$ 1	ROENCHEN	22	DPWA Multichannel
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 $\pi N \rightarrow \pi N$

¹Fit to the amplitudes of HOEHLER 79.

–2×IMAGINARY PART

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
220 to 260 ($\approx$ 240) OUR ESTIMATE			
166 $\pm$ 2	ROENCHEN	22	DPWA Multichannel
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 $\pi N \rightarrow \pi N$

¹Fit 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			
27 $\pm$ 1	ROENCHEN	22	DPWA Multichannel
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	$\pi N \rightarrow \pi N$

¹Fit to the amplitudes of HOEHLER 79.

PHASE θ

VALUE (°)	DOCUMENT ID	TECN	COMMENT
−40 to −24 ($\approx$ −32) OUR ESTIMATE			
1.1 ± 1.0	ROENCHEN	22	DPWA Multichannel
-24 ± 3	SOKHOYAN	15A	DPWA Multichannel
$-39 \pm 1 \pm 1$	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	$\pi N \rightarrow \pi N$

¹Fit 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 $N\pi \rightarrow \Delta(1950) \rightarrow \Sigma K$

MODULUS	PHASE (°)	DOCUMENT ID	TECN	COMMENT
0.020 ± 0.002	-40 ± 4	ROENCHEN	22	DPWA Multichannel
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 $N\pi \rightarrow \Delta(1950) \rightarrow \Delta\pi, F\text{-wave}$

MODULUS	PHASE (°)	DOCUMENT ID	TECN	COMMENT
0.30 ± 0.27	166 ± 1	ROENCHEN	22	DPWA Multichannel
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 $N\pi \rightarrow \Delta(1950) \rightarrow \Delta\pi, H\text{-wave}$

MODULUS	PHASE (°)	DOCUMENT ID	TECN	COMMENT
0.051 ± 0.004	-11 ± 1	ROENCHEN	22	DPWA Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.033	−97	ROENCHEN	15A	DPWA Multichannel

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

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

$\Delta(1950)$ BREIT-WIGNER MASS

<i>VALUE (MeV)</i>	<i>DOCUMENT ID</i>	<i>TECN</i>	<i>COMMENT</i>
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

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

¹Statistical error only.

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

VALUE (%)	DOCUMENT ID	TECN	COMMENT
57 $\pm$ 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 $\pm$ 0.2	ANISOVICH	17	DPWA Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •			
0.4 $\pm$ 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 $\pm$ 3	ANISOVICH	17	DPWA Multichannel
8 $\pm$ 1	¹ SHRESTHA	12A	DPWA Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •			
5 $\pm$ 4	SOKHOYAN	15A	DPWA Multichannel
2.8 $\pm$ 1.4	ANISOVICH	12A	DPWA Multichannel
36 $\pm$ 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 $\pm$ 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
-0.031 ± 0.002	-81 ± 4	ROENCHEN 22	DPWA	Multichannel
-0.067 ± 0.004	-10 ± 5	SOKHOYAN 15A	DPWA	Multichannel
• • • 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
-0.045 ± 0.002	-89 ± 2	ROENCHEN 22	DPWA	Multichannel
-0.095 ± 0.004	-10 ± 5	SOKHOYAN 15A	DPWA	Multichannel
• • • 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 (≈ -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 (≈ -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	$\gamma N \rightarrow \pi N$

¹Statistical error only.

$\Delta(1950)$ REFERENCES

ROENCHEN	22	EPJ A58 229	D. Roenchen <i>et al.</i>	(JULI, GWU, BONN+)
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.)
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
