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

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

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

Δ(1950) POLE POSITION

REAL PART

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
1870 to 1890 (≈ 1880) OUR ESTIMATE				
1875± 1	ROENCHEN	22	DPWA	Multichannel
1888± 4	SOKHOYAN	15A	DPWA	Multichannel
1877± 2±1	[1] SVARC	14	L+P	$\pi N \to \pi N$
1890±15	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1871	HUNT	19	DPWA	Multichannel
1874	ROENCHEN	15A	DPWA	Multichannel
1888± 4	GUTZ	14	DPWA	Multichannel
1890± 4	ANISOVICH	12A	DPWA	Multichannel
1876	ARNDT	06	DPWA	$\pi N \to \pi N, \eta N$
1910	VRANA	00	DPWA	Multichannel
1878	HOEHLER	93	ARGD	$\pi N \to \pi N$

[1] Fit to the amplitudes of HOEHLER 79.

−2×IMAGINARY PART

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
220 to 260 (≈ 240) OUR ESTIMATE				
166± 2	ROENCHEN	22	DPWA	Multichannel
245± 8	SOKHOYAN	15A	DPWA	Multichannel
223± 4±1	[1] SVARC	14	L+P	$\pi N \to \pi N$
260±40	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
206	HUNT	19	DPWA	Multichannel
239	ROENCHEN	15A	DPWA	Multichannel
245± 8	GUTZ	14	DPWA	Multichannel
243± 8	ANISOVICH	12A	DPWA	Multichannel
227	ARNDT	06	DPWA	$\pi N \to \pi N, \eta N$
230	VRANA	00	DPWA	Multichannel
230	HOEHLER	93	ARGD	$\pi N \to \pi N$

[1] Fit to the amplitudes of HOEHLER 79.

Δ(1950) ELASTIC POLE RESIDUE

MODULUS $|r|$

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
44 to 60 (≈ 52) OUR ESTIMATE				
27±1	ROENCHEN	22	DPWA	Multichannel
58±2	SOKHOYAN	15A	DPWA	Multichannel
44±1	[1] SVARC	14	L+P	$\pi N \to \pi N$
50±7	CUTKOSKY	80	IPWA	$\pi N \to \pi N$

• • • 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	$\pi N \to \pi N, \eta N$
47	HOEHLER	93	ARGD	$\pi N \to \pi N$

[1] Fit to the amplitudes of HOEHLER 79.

PHASE θ

VALUE (°)	DOCUMENT ID		TECN	COMMENT
−40 to −24 (≈ − 32) OUR ESTIMATE				
1.1±1.0	ROENCHEN	22	DPWA	Multichannel
−24 ±3	SOKHOYAN	15A	DPWA	Multichannel
−39 ±1 ±1	[1] SVARC	14	L+P	$\pi N \to \pi N$
−33 ±8	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
• • • 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	$\pi N \to \pi N, \eta N$
−32	HOEHLER	93	ARGD	$\pi N \to \pi N$

[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 $N\pi \to \Delta(1950) \to \Sigma K$

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 $N\pi \to \Delta(1950) \to \Delta\pi$, F-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 $N\pi \to \Delta(1950) \to \Delta\pi$, H-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 $N\pi \rightarrow \Delta(1950) \rightarrow \Delta(1232)\eta$

MODULUS	PHASE (°)	DOCUMENT ID		TECN	COMMENT
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

[1] Statistical 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

[1] Statistical 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

$\Gamma(N\pi)/\Gamma_{total}$ 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	$\pi N \to \pi N$, ηN
39 ±4	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
38 ±2	HOEHLER	79	IPWA	$\pi N \to \pi N$
• • • 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

[1] Statistical error only.

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

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

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

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

[1] Statistical error only.

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

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

$\Gamma(\Delta(1232)\eta)/\Gamma_{total}$ 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 ($GeV^{-1/2}$)	PHASE (°)	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 ($GeV^{-1/2}$)	PHASE (°)	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 ($GeV^{-1/2}$)	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	$\gamma N \rightarrow \pi N$

[1] Statistical error only.

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

VALUE ($GeV^{-1/2}$)	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	$\gamma N \to \pi N$

[1] Statistical error only.

Δ(1950) REFERENCES

ROENCHEN	22	EPJ A58 229	D. Roenchen *et al.*	(JULI, GWU, BONN+)
GOLOVATCH	19	PL B788 371	E. Golovatch *et al.*	(CLAS Collab.)
HUNT	19	PR C99 055205	B.C. Hunt, D.M. Manley	
ANISOVICH	17	PL B766 357	A.V. Anisovich *et al.*	
ROENCHEN	15A	EPJ A51 70	D. Roenchen *et al.*	
SOKHOYAN	15A	EPJ A51 95	V. Sokhoyan *et al.*	(CBELSA/TAPS Collab.)
GUTZ	14	EPJ A50 74	E. Gutz *et al.*	(CBELSA/TAPS Collab.)
PDG	14	CP C38 070001	K. Olive *et al.*	(PDG Collab.)
SVARC	14	PR C89 045205	A. Svarc *et al.*	(RBI Zagreb, UNI Tuzla)
ANISOVICH	12A	EPJ A48 15	A.V. Anisovich *et al.*	(BONN, PNPI)
SHRESTHA	12A	PR C86 055203	M. Shrestha, D.M. Manley	(KSU)
WORKMAN	12A	PR C86 015202	R. Workman *et al.*	(GWU)
DRECHSEL	07	EPJ A34 69	D. Drechsel, S.S. Kamalov, L. Tiator	(MAINZ, JINR)
ARNDT	06	PR C74 045205	R.A. Arndt *et al.*	(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 *et al.*	(CMU, LBL) IJP
Also		PR D20 2839	R.E. Cutkosky *et al.*	(CMU, LBL) IJP
HOEHLER	79	PDAT 12-1	G. Hohler *et al.*	(KARLT) IJP
Also		Toronto Conf. 3	R. Koch	(KARLT) IJP