$\Delta(1905)\ 5/2^+$

$I(J^P) = \frac{3}{2}(\frac{5}{2}^+)$ Status: ****

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

Δ(1905) POLE POSITION

REAL PART

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
1750 to 1800 (≈ 1770) OUR ESTIMATE				
1707± 1	ROENCHEN	22	DPWA	Multichannel
1800± 6	SOKHOYAN	15A	DPWA	Multichannel
1752± 3±2	[1] SVARC	14	L+P	$\pi N \to \pi N$
1830±40	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1819	HUNT	19	DPWA	Multichannel
1795	ROENCHEN	15A	DPWA	Multichannel
1800± 6	GUTZ	14	DPWA	Multichannel
1805±10	ANISOVICH	12A	DPWA	Multichannel
1819	ARNDT	06	DPWA	$\pi N \to \pi N, \eta N$
1793	VRANA	00	DPWA	Multichannel
1829	HOEHLER	93	SPED	$\pi N \to \pi N$

[1] Fit to the amplitudes of HOEHLER 79.

−2×IMAGINARY PART

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
260 to 340 (≈ 300) OUR ESTIMATE				
127± 4	ROENCHEN	22	DPWA	Multichannel
290±15	SOKHOYAN	15A	DPWA	Multichannel
346± 6±2	[1] SVARC	14	L+P	$\pi N \to \pi N$
280±60	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
253	HUNT	19	DPWA	Multichannel
247	ROENCHEN	15A	DPWA	Multichannel
290±15	GUTZ	14	DPWA	Multichannel
300±15	ANISOVICH	12A	DPWA	Multichannel
247	ARNDT	06	DPWA	$\pi N \to \pi N, \eta N$
302	VRANA	00	DPWA	Multichannel
303	HOEHLER	93	SPED	$\pi N \to \pi N$

[1] Fit to the amplitudes of HOEHLER 79.

Δ(1905) ELASTIC POLE RESIDUE

MODULUS $|r|$

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
15 to 25 (≈ 20) OUR ESTIMATE				
3.7±1.0	ROENCHEN	22	DPWA	Multichannel
19 ±2	SOKHOYAN	15A	DPWA	Multichannel
24 ±1 ±1	[1] SVARC	14	L+P	$\pi N \to \pi N$
25 ±8	CUTKOSKY	80	IPWA	$\pi N \to \pi N$

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

5.3		ROENCHEN	15A	DPWA	Multichannel
19	±2	GUTZ	14	DPWA	Multichannel
20	±2	ANISOVICH	12A	DPWA	Multichannel
15		ARNDT	06	DPWA	$\pi N \to \pi N, \eta N$
25		HOEHLER	93	SPED	$\pi N \to \pi N$

[1] Fit to the amplitudes of HOEHLER 79.

PHASE θ

VALUE (°)	DOCUMENT ID		TECN	COMMENT
−120 to −30 (≈ −45) OUR ESTIMATE				
− 92± 6	ROENCHEN	22	DPWA	Multichannel
− 45± 4	SOKHOYAN	15A	DPWA	Multichannel
−114± 1±2	[1] SVARC	14	L+P	$\pi N \to \pi N$
− 50±20	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
− 89	ROENCHEN	15A	DPWA	Multichannel
− 45± 4	GUTZ	14	DPWA	Multichannel
− 44± 5	ANISOVICH	12A	DPWA	Multichannel
− 30	ARNDT	06	DPWA	$\pi N \to \pi N, \eta N$

[1] Fit to the amplitudes of HOEHLER 79.

$\Delta(1905)$ INELASTIC POLE RESIDUE

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

Normalized residue in $N\pi \to \Delta(1905) \to \Delta\pi$, *P*-wave

MODULUS	PHASE (°)	DOCUMENT ID		TECN	COMMENT
0.10 ±0.01	−109 ± 7	ROENCHEN	22	DPWA	Multichannel
0.19 ±0.07	10 ± 30	SOKHOYAN	15A	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.0870	72	ROENCHEN	15A	DPWA	Multichannel
0.25 ±0.06	0 ± 15	ANISOVICH	12A	DPWA	Multichannel

Normalized residue in $N\pi \to \Delta(1905) \to \Delta\pi$, *F*-wave

MODULUS	PHASE (°)	DOCUMENT ID		TECN	COMMENT
0.017±0.002	18 ± 8	ROENCHEN	22	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.009	64	ROENCHEN	15A	DPWA	Multichannel

Normalized residue in $N\pi \to \Delta(1905) \to \Sigma K$

MODULUS	PHASE (°)	DOCUMENT ID		TECN	COMMENT
0.0020±0.0002	154 ± 6	ROENCHEN	22	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.001	−155	ROENCHEN	15A	DPWA	Multichannel

Normalized residue in $N\pi \to \Delta(1905) \to N(1535)\pi$

MODULUS	PHASE (°)	DOCUMENT ID		TECN	COMMENT
0.025±0.010	130 ± 35	GUTZ	14	DPWA	Multichannel

Normalized residue in $N\pi \rightarrow \Delta(1905) \rightarrow \Delta(1232)\eta$

MODULUS	*PHASE (°)*	*DOCUMENT ID*		*TECN*	*COMMENT*
0.07±0.02	40 ± 20	GUTZ	14	DPWA	Multichannel

$\Delta(1905)$ BREIT-WIGNER MASS

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
1855 to 1910 (≈ 1880) OUR ESTIMATE				
1883 ±19	GOLOVATCH	19	DPWA	$\gamma p \rightarrow \pi^+\pi^- p$
1866 ± 9	[1] HUNT	19	DPWA	Multichannel
1856 ± 6	SOKHOYAN	15A	DPWA	Multichannel
1857.8± 1.6	[1] ARNDT	06	DPWA	$\pi N \rightarrow \pi N$, ηN
1910 ±30	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
1905 ±20	HOEHLER	79	IPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1856 ± 6	GUTZ	14	DPWA	Multichannel
1861 ± 6	ANISOVICH	12A	DPWA	Multichannel
1818 ± 8	[1] SHRESTHA	12A	DPWA	Multichannel
1873 ±77	VRANA	00	DPWA	Multichannel

[1] Statistical error only.

$\Delta(1905)$ BREIT-WIGNER WIDTH

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
270 to 400 (≈ 330) OUR ESTIMATE				
327 ± 69	GOLOVATCH	19	DPWA	$\gamma p \rightarrow \pi^+\pi^- p$
289 ± 20	[1] HUNT	19	DPWA	Multichannel
325 ± 15	SOKHOYAN	15A	DPWA	Multichannel
320.6± 8.6	[1] ARNDT	06	DPWA	$\pi N \rightarrow \pi N$, ηN
400 ±100	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
260 ± 20	HOEHLER	79	IPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
325 ± 15	GUTZ	14	DPWA	Multichannel
335 ± 18	ANISOVICH	12A	DPWA	Multichannel
278 ± 18	[1] SHRESTHA	12A	DPWA	Multichannel
461 ±111	VRANA	00	DPWA	Multichannel

[1] Statistical error only.

$\Delta(1905)$ DECAY MODES

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

	Mode	Fraction (Γ_i/Γ)
Γ_1	$N\pi$	9–15%
Γ_2	$N\pi\pi$	>65%
Γ_3	$\Delta(1232)\pi$	>48%
Γ_4	$\Delta(1232)\pi$, P-wave	8–43%
Γ_5	$\Delta(1232)\pi$, F-wave	40–58%

Γ_6	$N\rho$, S=3/2, P-wave	17–35%
Γ_7	$N(1535)\pi$	< 1 %
Γ_8	$N(1680)\pi$, P-wave	5–15%
Γ_9	$\Delta(1232)\eta$	2–6%
Γ_{10}	$N\gamma$	0.012–0.036 %
Γ_{11}	$N\gamma$, helicity=1/2	0.002–0.006 %
Γ_{12}	$N\gamma$, helicity=3/2	0.01–0.03 %

$\Delta(1905)$ BRANCHING RATIOS

$\Gamma(N\pi)/\Gamma_{total}$ Γ_1/Γ

VALUE (%)	DOCUMENT ID		TECN	COMMENT
9–15% OUR ESTIMATE				
17 ±1	[1] HUNT	19	DPWA	Multichannel
13 ±2	SOKHOYAN	15A	DPWA	Multichannel
12.2±0.1	[1] ARNDT	06	DPWA	$\pi N \to \pi N$, ηN
8 ±3	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
15 ±2	HOEHLER	79	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
13 ±2	GUTZ	14	DPWA	Multichannel
13 ±2	ANISOVICH	12A	DPWA	Multichannel
6 ±1	[1] SHRESTHA	12A	DPWA	Multichannel
9 ±1	VRANA	00	DPWA	Multichannel

[1] Statistical error only.

$\Gamma(N\pi\pi)/\Gamma_{total}$ Γ_2/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
>65% OUR ESTIMATE				
0.85±0.15	GOLOVATCH	19	DPWA	$\gamma p \to \pi^+\pi^- p$

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

VALUE (%)	DOCUMENT ID		TECN	COMMENT
8–43% OUR ESTIMATE				
8.4± 0.5	[1] HUNT	19	DPWA	Multichannel
33 ±10	SOKHOYAN	15A	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •				
45 ±14	ANISOVICH	12A	DPWA	Multichannel
28 ± 7	[1] SHRESTHA	12A	DPWA	Multichannel
23 ± 1	VRANA	00	DPWA	Multichannel

[1] Statistical error only.

$\Gamma(\Delta(1232)\pi$, F-wave$)/\Gamma_{total}$ Γ_5/Γ

VALUE (%)	DOCUMENT ID		TECN	COMMENT
40–58% OUR ESTIMATE				
49±9	[1] HUNT	19	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •				
64±8	[1] SHRESTHA	12A	DPWA	Multichannel
44±1	VRANA	00	DPWA	Multichannel

[1] Statistical error only.

$\Gamma(N\rho, S{=}3/2, P\text{-wave})/\Gamma_{total}$ Γ_6/Γ

VALUE (%)	DOCUMENT ID		TECN	COMMENT
17–35% OUR ESTIMATE				
26±9	[1] HUNT	19	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •				
< 6	[1] SHRESTHA	12A	DPWA	Multichannel
24±1	VRANA	00	DPWA	Multichannel

[1] Statistical error only.

$\Gamma(N(1535)\pi)/\Gamma_{total}$ Γ_7/Γ

VALUE (%)	DOCUMENT ID		TECN	COMMENT
< 1 % OUR ESTIMATE				
<1	GUTZ	14	DPWA	Multichannel

$\Gamma(N(1680)\pi, P\text{-wave})/\Gamma_{total}$ Γ_8/Γ

VALUE (%)	DOCUMENT ID		TECN	COMMENT
5–15% OUR ESTIMATE				
10±5	SOKHOYAN	15A	DPWA	Multichannel

$\Gamma(\Delta(1232)\eta)/\Gamma_{total}$ Γ_9/Γ

VALUE (%)	DOCUMENT ID		TECN	COMMENT
2–6% OUR ESTIMATE				
4±2	GUTZ	14	DPWA	Multichannel

$\Delta(1905)$ PHOTON DECAY AMPLITUDES AT THE POLE

$\Delta(1905) \to N\gamma$, helicity-1/2 amplitude $A_{1/2}$

MODULUS ($GeV^{-1/2}$)	PHASE (°)	DOCUMENT ID		TECN	COMMENT
0.055±0.004	−159 ± 2	ROENCHEN	22	DPWA	Multichannel
0.025±0.005	−28 ± 12	SOKHOYAN	15A	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.053	89	ROENCHEN	15A	DPWA	Multichannel

$\Delta(1905) \to N\gamma$, helicity-3/2 amplitude $A_{3/2}$

MODULUS ($GeV^{-1/2}$)	PHASE (°)	DOCUMENT ID		TECN	COMMENT
−0.168±0.020	172 ± 0.9	ROENCHEN	22	DPWA	Multichannel
−0.050±0.004	5 ± 10	SOKHOYAN	15A	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •					
−0.030	80	ROENCHEN	15A	DPWA	Multichannel

$\Delta(1905)$ BREIT-WIGNER PHOTON DECAY AMPLITUDES

$\Delta(1905) \to N\gamma$, helicity-1/2 amplitude $A_{1/2}$

VALUE ($GeV^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
0.017 to 0.027 (≈ 0.022) OUR ESTIMATE				
0.019±0.0076	GOLOVATCH	19	DPWA	$\gamma p \to \pi^+\pi^- p$
0.077±0.010	[1] HUNT	19	DPWA	Multichannel
0.025±0.005	SOKHOYAN	15A	DPWA	Multichannel
0.020±0.002	[1] DUGGER	13	DPWA	$\gamma N \to \pi N$
0.019±0.002	[1] WORKMAN	12A	DPWA	$\gamma N \to \pi N$

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

0.025±0.005	GUTZ	14	DPWA	Multichannel
0.025±0.004	ANISOVICH	12A	DPWA	Multichannel
0.066±0.018	[1] SHRESTHA	12A	DPWA	Multichannel
0.018	DRECHSEL	07	DPWA	$\gamma N \to \pi N$

[1] Statistical error only.

$\Delta(1905) \to N\gamma$, helicity-3/2 amplitude $A_{3/2}$

VALUE ($GeV^{-1/2}$)	*DOCUMENT ID*		*TECN*	*COMMENT*
−0.055 to −0.035 (≈ −0.045) OUR ESTIMATE				
−0.0432±0.0173	GOLOVATCH	19	DPWA	$\gamma p \to \pi^+\pi^- p$
−0.053 ±0.029	[1] HUNT	19	DPWA	Multichannel
−0.050 ±0.005	SOKHOYAN	15A	DPWA	Multichannel
−0.049 ±0.005	[1] DUGGER	13	DPWA	$\gamma N \to \pi N$
−0.038 ±0.004	WORKMAN	12A	DPWA	$\gamma N \to \pi N$

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

−0.050 ±0.005	GUTZ	14	DPWA	Multichannel
−0.049 ±0.004	ANISOVICH	12A	DPWA	Multichannel
−0.223 ±0.029	[1] SHRESTHA	12A	DPWA	Multichannel
−0.028	DRECHSEL	07	DPWA	$\gamma N \to \pi N$

[1] Statistical error only.

$\Delta(1905)$ REFERENCES

For early references, see Physics Letters **111B** 1 (1982).

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	
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)
DUGGER	13	PR C88 065203	M. Dugger *et al.*	(JLab CLAS Collab.)
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