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

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

Most of the results published before 1975 were last included in our 1982 edition, Physics Letters **111B** 1 (1982). Some further obsolete results published before 1984 were last included in our 2006 edition, Journal of Physics **G33** 1 (2006).

$\Delta(1905)$ BREIT-WIGNER MASS

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
1855 to 1910 (≈ 1880) OUR ESTIMATE				
1856 ± 6	GUTZ	14	DPWA	Multichannel
1861 ± 6	ANISOVICH	12A	DPWA	Multichannel
1857.8 ± 1.6	ARNDT	06	DPWA	$\pi N \rightarrow \pi N, \eta N$
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. • • •				
1818 ± 8	SHRESTHA	12A	DPWA	Multichannel
1890 ± 25	[1] ANISOVICH	10	DPWA	Multichannel
1855.7 ± 4.2	ARNDT	04	DPWA	$\pi N \rightarrow \pi N, \eta N$
1873 ± 77	VRANA	00	DPWA	Multichannel
1895 ± 8	ARNDT	96	IPWA	$\gamma N \rightarrow \pi N$
1850	ARNDT	95	DPWA	$\pi N \rightarrow N\pi$
1881 ± 18	MANLEY	92	IPWA	$\pi N \rightarrow \pi N$ & $N\pi\pi$
1960 ± 40	CANDLIN	84	DPWA	$\pi^+ p \rightarrow \Sigma^+ K^+$
$1787.0^{+6.0}_{-5.7}$	CHEW	80	BPWA	$\pi^+ p \rightarrow \pi^+ p$
1830	[2] LONGACRE	75	IPWA	$\pi N \rightarrow N\pi\pi$

$\Delta(1905)$ BREIT-WIGNER WIDTH

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
270 to 400 (≈ 330) OUR ESTIMATE				
325 ± 15	GUTZ	14	DPWA	Multichannel
335 ± 18	ANISOVICH	12A	DPWA	Multichannel
320.6 ± 8.6	ARNDT	06	DPWA	$\pi N \rightarrow \pi N, \eta N$
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. • • •				
278 ± 18	SHRESTHA	12A	DPWA	Multichannel
335 ± 30	ANISOVICH	10	DPWA	Multichannel
334 ± 22	ARNDT	04	DPWA	$\pi N \rightarrow \pi N, \eta N$
461 ± 111	VRANA	00	DPWA	Multichannel
354 ± 10	ARNDT	96	IPWA	$\gamma N \rightarrow \pi N$

294	ARNDT	95	DPWA	$\pi N \to N\pi$
327 ± 51	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
270 ± 40	CANDLIN	84	DPWA	$\pi^+ p \to \Sigma^+ K^+$
$66.0^{+24.0}_{-16.0}$	CHEW	80	BPWA	$\pi^+ p \to \pi^+ p$
220	[2] LONGACRE	75	IPWA	$\pi N \to N\pi\pi$

Δ(1905) POLE POSITION

REAL PART

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
1805 to 1835 (≈ 1820) OUR ESTIMATE				
1800± 6	GUTZ	14	DPWA	Multichannel
1752± 3±2	[3] SVARC	14	MLS	$\pi N \to \pi N$
1805±10	ANISOVICH	12A	DPWA	Multichannel
1819	ARNDT	06	DPWA	$\pi N \to \pi N$, ηN
1829	[4] HOEHLER	93	SPED	$\pi N \to \pi N$
1830±40	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1769	SHRESTHA	12A	DPWA	Multichannel
1800±15	ANISOVICH	10	DPWA	Multichannel
1825	ARNDT	04	DPWA	$\pi N \to \pi N$, ηN
1793	VRANA	00	DPWA	Multichannel
1832	ARNDT	95	DPWA	$\pi N \to N\pi$
1794	ARNDT	91	DPWA	$\pi N \to \pi N$ Soln SM90
1813 or 1808	[5] LONGACRE	78	IPWA	$\pi N \to N\pi\pi$

−2×IMAGINARY PART

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
265 to 300 (≈ 280) OUR ESTIMATE				
290±15	GUTZ	14	DPWA	Multichannel
346± 6±2	[3] SVARC	14	MLS	$\pi N \to \pi N$
300±15	ANISOVICH	12A	DPWA	Multichannel
247	ARNDT	06	DPWA	$\pi N \to \pi N$, ηN
303	[4] HOEHLER	93	SPED	$\pi N \to \pi N$
280±60	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
239	SHRESTHA	12A	DPWA	Multichannel
300±20	ANISOVICH	10	DPWA	Multichannel
270	ARNDT	04	DPWA	$\pi N \to \pi N$, ηN
302	VRANA	00	DPWA	Multichannel
254	ARNDT	95	DPWA	$\pi N \to N\pi$
230	ARNDT	91	DPWA	$\pi N \to \pi N$ Soln SM90
193 or 187	[5] LONGACRE	78	IPWA	$\pi N \to N\pi\pi$

Δ(1905) ELASTIC POLE RESIDUE

MODULUS |r|

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
19±2	GUTZ	14	DPWA	Multichannel
24±1±1	[3] SVARC	14	MLS	$\pi N \rightarrow \pi N$
20±2	ANISOVICH	12A	DPWA	Multichannel
15	ARNDT	06	DPWA	$\pi N \rightarrow \pi N$, ηN
25	HOEHLER	93	SPED	$\pi N \rightarrow \pi N$
25±8	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
16	ARNDT	04	DPWA	$\pi N \rightarrow \pi N$, ηN
12	ARNDT	95	DPWA	$\pi N \rightarrow N \pi$
14	ARNDT	91	DPWA	$\pi N \rightarrow \pi N$ Soln SM90

PHASE θ

VALUE (°)	DOCUMENT ID		TECN	COMMENT
− 45± 4	GUTZ	14	DPWA	Multichannel
−114± 1±2	[3] SVARC	14	MLS	$\pi N \rightarrow \pi N$
− 44± 5	ANISOVICH	12A	DPWA	Multichannel
− 30	ARNDT	06	DPWA	$\pi N \rightarrow \pi N$, ηN
− 50±20	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
− 25	ARNDT	04	DPWA	$\pi N \rightarrow \pi N$, ηN
− 4	ARNDT	95	DPWA	$\pi N \rightarrow N \pi$
− 40	ARNDT	91	DPWA	$\pi N \rightarrow \pi N$ Soln SM90

Δ(1905) INELASTIC POLE RESIDUE

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

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

MODULUS (%)	PHASE (°)	DOCUMENT ID		TECN	COMMENT
25±6	**0 ± 15**	ANISOVICH	12A	DPWA	Multichannel

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

MODULUS (%)	PHASE (°)	DOCUMENT ID		TECN	COMMENT
2.5±1.0	**130 ± 35**	GUTZ	14	DPWA	Multichannel

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

MODULUS (%)	PHASE (°)	DOCUMENT ID		TECN	COMMENT
7±2	**40 ± 20**	GUTZ	14	DPWA	Multichannel

$\Delta(1905)$ 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	ΣK	
Γ_3	$N\pi\pi$	85–95 %
Γ_4	$\Delta\pi$	<25 %
Γ_5	$\Delta(1232)\pi$, P-wave	
Γ_6	$\Delta(1232)\pi$, F-wave	
Γ_7	$N(1535)\pi$	
Γ_8	$\Delta(1232)\eta$	(4.0±2.0) %
Γ_9	$N\rho$	>60 %
Γ_{10}	$N\rho$, S=3/2, P-wave	
Γ_{11}	$N\rho$, S=3/2, F-wave	
Γ_{12}	$N\rho$, S=1/2, F-wave	
Γ_{13}	$N\gamma$	0.012–0.036 %
Γ_{14}	$N\gamma$, helicity=1/2	0.002–0.006 %
Γ_{15}	$N\gamma$, 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 to 15 OUR ESTIMATE				
13 ±2	GUTZ	14	DPWA	Multichannel
13 ±2	ANISOVICH	12A	DPWA	Multichannel
12.2±0.1	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. • • •				
6 ±1	SHRESTHA	12A	DPWA	Multichannel
12 ±3	ANISOVICH	10	DPWA	Multichannel
12.0±0.2	ARNDT	04	DPWA	$\pi N \to \pi N$, ηN
9 ±1	VRANA	00	DPWA	Multichannel
12	ARNDT	95	DPWA	$\pi N \to N\pi$
12 ±3	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
11	CHEW	80	BPWA	$\pi^+ p \to \pi^+ p$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to \Delta(1905) \to \Sigma K$ — $(\Gamma_1\Gamma_2)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
−0.015±0.003	CANDLIN	84	DPWA	$\pi^+ p \to \Sigma^+ K^+$

Note: Signs of couplings from $\pi N \to N\pi\pi$ analyses were changed in the 1986 edition to agree with the baryon-first convention; the overall phase ambiguity is resolved by choosing a negative sign for the $\Delta(1620)$ S_{31} coupling to $\Delta(1232)\pi$.

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to \Delta(1905) \to \Delta(1232)\pi$, P-wave — $(\Gamma_1\Gamma_5)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
-0.04 ± 0.05	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$

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

VALUE (%)	DOCUMENT ID		TECN	COMMENT
45 ± 14	ANISOVICH	12A	DPWA	Multichannel
$23\pm\ 1$	VRANA	00	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$28\pm\ 7$	SHRESTHA	12A	DPWA	Multichannel

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to \Delta(1905) \to \Delta(1232)\pi$, F-wave — $(\Gamma_1\Gamma_6)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
$+0.20$	[2] LONGACRE	75	IPWA	$\pi N \to N\pi\pi$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$+0.02\pm0.03$	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$

$\Gamma(\Delta(1232)\pi$, F-wave$)/\Gamma_{total}$ — Γ_6/Γ

VALUE (%)	DOCUMENT ID		TECN	COMMENT
44 ± 1	VRANA	00	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •				
64 ± 8	SHRESTHA	12A	DPWA	Multichannel

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

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

$\Gamma(\Delta(1232)\eta)/\Gamma_{total}$ — Γ_8/Γ

VALUE (%)	DOCUMENT ID		TECN	COMMENT
4 ± 2	GUTZ	14	DPWA	Multichannel

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to \Delta(1905) \to N\rho$, S=3/2, P-wave — $(\Gamma_1\Gamma_{10})^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
+0.30 to +0.36 OUR ESTIMATE				
$+0.33$	[2] LONGACRE	75	IPWA	$\pi N \to N\pi\pi$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$+0.33\pm0.03$	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$

$\Gamma(N\rho$, S=3/2, P-wave$)/\Gamma_{total}$ — Γ_{10}/Γ

VALUE (%)	DOCUMENT ID		TECN	COMMENT
24 ± 1	VRANA	00	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$<\ 6$	SHRESTHA	12A	DPWA	Multichannel

Δ(1905) PHOTON DECAY AMPLITUDES

Papers on γN amplitudes predating 1981 may be found in our 2006 edition, Journal of Physics **G33** 1 (2006).

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

VALUE ($GeV^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
+0.022±0.005 OUR ESTIMATE				
0.025±0.005	GUTZ	14	DPWA	Multichannel
0.020±0.002	DUGGER	13	DPWA	$\gamma N \to \pi N$
0.025±0.004	ANISOVICH	12A	DPWA	Multichannel
0.019±0.002	WORKMAN	12A	DPWA	$\gamma N \to \pi N$
0.021±0.004	DUGGER	07	DPWA	$\gamma N \to \pi N$
0.021±0.010	CRAWFORD	83	IPWA	$\gamma N \to \pi N$
0.043±0.020	AWAJI	81	DPWA	$\gamma N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.066±0.018	SHRESTHA	12A	DPWA	Multichannel
0.028±0.012	[1] ANISOVICH	10	DPWA	Multichannel
0.018	DRECHSEL	07	DPWA	$\gamma N \to \pi N$
0.022±0.005	ARNDT	96	IPWA	$\gamma N \to \pi N$
0.055±0.004	LI	93	IPWA	$\gamma N \to \pi N$

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

VALUE ($GeV^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
−0.045±0.010 OUR ESTIMATE				
−0.050±0.005	GUTZ	14	DPWA	Multichannel
−0.049±0.005	DUGGER	13	DPWA	$\gamma N \to \pi N$
−0.049±0.004	ANISOVICH	12A	DPWA	Multichannel
−0.038±0.004	WORKMAN	12A	DPWA	$\gamma N \to \pi N$
−0.046±0.005	DUGGER	07	DPWA	$\gamma N \to \pi N$
−0.056±0.028	CRAWFORD	83	IPWA	$\gamma N \to \pi N$
−0.025±0.023	AWAJI	81	DPWA	$\gamma N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
−0.223±0.029	SHRESTHA	12A	DPWA	Multichannel
−0.042±0.015	[1] ANISOVICH	10	DPWA	Multichannel
−0.028	DRECHSEL	07	DPWA	$\gamma N \to \pi N$
−0.045±0.005	ARNDT	96	IPWA	$\gamma N \to \pi N$
0.002±0.003	LI	93	IPWA	$\gamma N \to \pi N$

Δ(1905) FOOTNOTES

[1] ANISOVICH 10 finds an alternate solution for this resonance. The only statistically significant differences are in the Breit-Wigner mass and γp couplings.

[2] From method II of LONGACRE 75: eyeball fits with Breit-Wigner circles to the T-matrix amplitudes.

[3] Fit to the amplitudes of HOEHLER 79.

[4] See HOEHLER 93 for a detailed discussion of the evidence for and the pole parameters of N and Δ resonances as determined from Argand diagrams of πN elastic partial-wave amplitudes and from plots of the speeds with which the amplitudes traverse the diagrams.

[5] LONGACRE 78 values are from a search for poles in the unitarized T-matrix. The first (second) value uses, in addition to $\pi N \to N\pi\pi$ data, elastic amplitudes from a Saclay (CERN) partial-wave analysis.

Δ(1905) REFERENCES

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

GUTZ	14	EPJ A50 74	E. Gutz *et al.*	(CBELSA/TAPS Collab.)	
SVARC	14	PR C89 045205	A. Svarc *et al.*		
DUGGER	13	PR C88 065203	M. Dugger *et al.*	(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)	
ANISOVICH	10	EPJ A44 203	A.V. Anisovich *et al.*	(BONN, PNPI)	
DRECHSEL	07	EPJ A34 69	D. Drechsel, S.S. Kamalov, L. Tiator	(MAINZ, JINR)	
DUGGER	07	PR C76 025211	M. Dugger *et al.*	(Jefferson Lab CLAS Collab.)	
ARNDT	06	PR C74 045205	R.A. Arndt *et al.*	(GWU)	
PDG	06	JP G33 1	W.-M. Yao *et al.*	(PDG Collab.)	
ARNDT	04	PR C69 035213	R.A. Arndt *et al.*	(GWU, TRIU)	
VRANA	00	PRPL 328 181	T.P. Vrana, S.A. Dytman,, T.-S.H. Lee	(PITT+)	
ARNDT	96	PR C53 430	R.A. Arndt, I.I. Strakovsky, R.L. Workman	(VPI)	
ARNDT	95	PR C52 2120	R.A. Arndt *et al.*	(VPI, BRCO)	
HOEHLER	93	πN Newsletter 9 1	G. Hohler	(KARL)	
LI	93	PR C47 2759	Z.J. Li *et al.*	(VPI)	
MANLEY	92	PR D45 4002	D.M. Manley, E.M. Saleski	(KSA)	IJP
Also		PR D30 904	D.M. Manley *et al.*	(VPI)	
ARNDT	91	PR D43 2131	R.A. Arndt *et al.*	(VPI, TELE)	IJP
CANDLIN	84	NP B238 477	D.J. Candlin *et al.*	(EDIN, RAL, LOWC)	
CRAWFORD	83	NP B211 1	R.L. Crawford, W.T. Morton	(GLAS)	
PDG	82	PL 111B 1	M. Roos *et al.*	(HELS, CIT, CERN)	
AWAJI	81	Bonn Conf. 352	N. Awaji, R. Kajikawa	(NAGO)	
Also		NP B197 365	K. Fujii *et al.*	(NAGO)	
CHEW	80	Toronto Conf. 123	D.M. Chew	(LBL)	IJP
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
LONGACRE	78	PR D17 1795	R.S. Longacre *et al.*	(LBL, SLAC)	
LONGACRE	75	PL 55B 415	R.S. Longacre *et al.*	(LBL, SLAC)	IJP