

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

$I(J^P) = \frac{3}{2}(\frac{5}{2}^+)$ 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, G **33** 1 (2006).

$\Delta(1905)$ BREIT-WIGNER MASS

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
1855 to 1910 (≈ 1880) OUR ESTIMATE			
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			
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 $\pi N \rightarrow N\pi$
327 ± 51	MANLEY	92	IPWA $\pi N \rightarrow \pi N \ \& \ N\pi\pi$
270 ± 40	CANDLIN	84	DPWA $\pi^+ p \rightarrow \Sigma^+ K^+$
66.0 $^{+24.0}_{-16.0}$	CHEW	80	BPWA $\pi^+ p \rightarrow \pi^+ p$
220	² LONGACRE	75	IPWA $\pi N \rightarrow N\pi\pi$

$\Delta(1905)$ POLE POSITION

REAL PART

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
1805 to 1835 (≈ 1820) OUR ESTIMATE			
1805 \pm 10	ANISOVICH	12A	DPWA Multichannel
1819	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
1829	³ HOEHLER	93	SPED $\pi N \rightarrow \pi N$
1830 \pm 40	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
1769	SHRESTHA	12A	DPWA Multichannel
1800 \pm 15	ANISOVICH	10	DPWA Multichannel
1825	ARNDT	04	DPWA $\pi N \rightarrow \pi N, \eta N$
1793	VRANA	00	DPWA Multichannel
1832	ARNDT	95	DPWA $\pi N \rightarrow N\pi$
1794	ARNDT	91	DPWA $\pi N \rightarrow \pi N$ Soln SM90
1813 or 1808	⁴ LONGACRE	78	IPWA $\pi N \rightarrow N\pi\pi$

–2×IMAGINARY PART

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
265 to 300 (≈ 280) OUR ESTIMATE			
300 \pm 15	ANISOVICH	12A	DPWA Multichannel
247	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
303	³ HOEHLER	93	SPED $\pi N \rightarrow \pi N$
280 \pm 60	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
239	SHRESTHA	12A	DPWA Multichannel
300 \pm 20	ANISOVICH	10	DPWA Multichannel
270	ARNDT	04	DPWA $\pi N \rightarrow \pi N, \eta N$
302	VRANA	00	DPWA Multichannel
254	ARNDT	95	DPWA $\pi N \rightarrow N\pi$
230	ARNDT	91	DPWA $\pi N \rightarrow \pi N$ Soln SM90
193 or 187	⁴ LONGACRE	78	IPWA $\pi N \rightarrow N\pi\pi$

$\Delta(1905)$ ELASTIC POLE RESIDUE

MODULUS $|r|$

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
20 \pm 2	ANISOVICH	12A	DPWA Multichannel
15	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
25	HOEHLER	93	SPED $\pi N \rightarrow \pi N$
25 \pm 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 $\pi N \rightarrow \pi N, \eta N$
12	ARNDT	95	DPWA $\pi N \rightarrow N\pi$
14	ARNDT	91	DPWA $\pi N \rightarrow \pi N$ Soln SM90

PHASE θ

<u>VALUE ($^{\circ}$)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
-44 ± 5	ANISOVICH	12A	DPWA Multichannel
-30	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
-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 $\pi N \rightarrow \pi N, \eta N$
-4	ARNDT	95	DPWA $\pi N \rightarrow N\pi$
-40	ARNDT	91	DPWA $\pi N \rightarrow \pi N$ Soln SM90

$\Delta(1905)$ 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

<u>MODULUS (%)</u>	<u>PHASE ($^{\circ}$)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
25 ± 6	0 ± 15	ANISOVICH	12A	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 $N\rho$	>60 %
Γ_8 $N\rho, S=3/2, P$ -wave	
Γ_9 $N\rho, S=3/2, F$ -wave	
Γ_{10} $N\rho, S=1/2, F$ -wave	
Γ_{11} $N\gamma$	0.012–0.036 %
Γ_{12} $N\gamma, \text{helicity}=1/2$	0.002–0.006 %
Γ_{13} $N\gamma, \text{helicity}=3/2$	0.01–0.03 %

$\Delta(1905)$ BRANCHING RATIOS

<u>$\Gamma(N\pi)/\Gamma_{total}$</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	<u>Γ_1/Γ</u>
9 to 15 OUR ESTIMATE				
13 ± 2	ANISOVICH	12A	DPWA Multichannel	
12.2 ± 0.1	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$	
8 ± 3	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$	
15 ± 2	HOEHLER	79	IPWA $\pi N \rightarrow \pi N$	

• • • 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	$\pi N \rightarrow \pi N, \eta N$
9 ± 1	VRANA	00	DPWA	Multichannel
12	ARNDT	95	DPWA	$\pi N \rightarrow N\pi$
12 ± 3	MANLEY	92	IPWA	$\pi N \rightarrow \pi N \& N\pi\pi$
11	CHEW	80	BPWA	$\pi^+ p \rightarrow \pi^+ p$

$(\Gamma_i \Gamma_f)^{1/2} / \Gamma_{\text{total}}$ in $N\pi \rightarrow \Delta(1905) \rightarrow \Sigma K$				$(\Gamma_1 \Gamma_2)^{1/2} / \Gamma$
VALUE	DOCUMENT ID	TECN	COMMENT	
-0.015 ± 0.003	CANDLIN	84	DPWA	$\pi^+ p \rightarrow \Sigma^+ K^+$

Note: Signs of couplings from $\pi N \rightarrow N\pi\pi$ 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 $\Delta(1232)\pi$.

$(\Gamma_i \Gamma_f)^{1/2} / \Gamma_{\text{total}}$ in $N\pi \rightarrow \Delta(1905) \rightarrow \Delta(1232)\pi, P\text{-wave}$				$(\Gamma_1 \Gamma_5)^{1/2} / \Gamma$
VALUE	DOCUMENT ID	TECN	COMMENT	
-0.04 ± 0.05	MANLEY	92	IPWA	$\pi N \rightarrow \pi N \& N\pi\pi$

$\Gamma(\Delta(1232)\pi, P\text{-wave}) / \Gamma_{\text{total}}$				Γ_5 / Γ
VALUE (%)	DOCUMENT ID	TECN	COMMENT	
45 ± 14	ANISOVICH	12A	DPWA	Multichannel
23 ± 1	VRANA	00	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •				
28 ± 7	SHRESTHA	12A	DPWA	Multichannel

$(\Gamma_i \Gamma_f)^{1/2} / \Gamma_{\text{total}}$ in $N\pi \rightarrow \Delta(1905) \rightarrow \Delta(1232)\pi, F\text{-wave}$				$(\Gamma_1 \Gamma_6)^{1/2} / \Gamma$
VALUE	DOCUMENT ID	TECN	COMMENT	
+0.20	² LONGACRE	75	IPWA	$\pi N \rightarrow N\pi\pi$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
+0.02 ± 0.03	MANLEY	92	IPWA	$\pi N \rightarrow \pi N \& N\pi\pi$

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

$(\Gamma_i \Gamma_f)^{1/2} / \Gamma_{\text{total}}$ in $N\pi \rightarrow \Delta(1905) \rightarrow N\rho, S=3/2, P\text{-wave}$				$(\Gamma_1 \Gamma_8)^{1/2} / \Gamma$
VALUE	DOCUMENT ID	TECN	COMMENT	
+0.30 to +0.36 OUR ESTIMATE				
+0.33	² LONGACRE	75	IPWA	$\pi N \rightarrow N\pi\pi$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
+0.33 ± 0.03	MANLEY	92	IPWA	$\pi N \rightarrow \pi N \& N\pi\pi$

$\Gamma(N\rho, S=3/2, P\text{-wave})/\Gamma_{\text{total}}$				Γ_8/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

$\Delta(1905)$ PHOTON DECAY AMPLITUDES

Papers on γN amplitudes predating 1981 may be found in our 2006 edition, Journal of Physics, G **33** 1 (2006).

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

VALUE ($\text{GeV}^{-1/2}$)	DOCUMENT ID	TECN	COMMENT
+0.026 ± 0.011 OUR ESTIMATE			
0.025 ± 0.004	ANISOVICH	12A	DPWA Multichannel
0.019 ± 0.002	WORKMAN	12A	DPWA $\gamma N \rightarrow N\pi$
0.021 ± 0.004	DUGGER	07	DPWA $\gamma N \rightarrow \pi N$
0.021 ± 0.010	CRAWFORD	83	IPWA $\gamma N \rightarrow \pi N$
0.043 ± 0.020	AWAJI	81	DPWA $\gamma N \rightarrow \pi N$
• • • 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 $\gamma N \rightarrow \pi N$
0.022 ± 0.005	ARNDT	96	IPWA $\gamma N \rightarrow \pi N$
0.055 ± 0.004	LI	93	IPWA $\gamma N \rightarrow \pi N$

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

VALUE ($\text{GeV}^{-1/2}$)	DOCUMENT ID	TECN	COMMENT
-0.045 ± 0.020 OUR ESTIMATE			
-0.049 ± 0.004	ANISOVICH	12A	DPWA Multichannel
-0.038 ± 0.004	WORKMAN	12A	DPWA $\gamma N \rightarrow N\pi$
-0.046 ± 0.005	DUGGER	07	DPWA $\gamma N \rightarrow \pi N$
-0.056 ± 0.028	CRAWFORD	83	IPWA $\gamma N \rightarrow \pi N$
-0.025 ± 0.023	AWAJI	81	DPWA $\gamma N \rightarrow \pi N$
• • • 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 $\gamma N \rightarrow \pi N$
-0.045 ± 0.005	ARNDT	96	IPWA $\gamma N \rightarrow \pi N$
0.002 ± 0.003	LI	93	IPWA $\gamma N \rightarrow \pi N$

$\Delta(1905)$ 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 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.
- ⁴ LONGACRE 78 values are from a search for poles in the unitarized T-matrix. The first (second) value uses, in addition to $\pi N \rightarrow N\pi\pi$ data, elastic amplitudes from a Saclay (CERN) partial-wave analysis.

Δ(1905) REFERENCES

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

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)
ANISOVICH	10	EPJ A44 203	A.V. Anisovich <i>et al.</i>	(BONN, PNPI)
DRECHSEL	07	EPJ A34 69	D. Drechsel, S.S. Kamalov, L. Tiator	(MAINZ, JINR)
DUGGER	07	PR C76 025211	M. Dugger <i>et al.</i>	(Jefferson Lab CLAS Collab.)
ARNDT	06	PR C74 045205	R.A. Arndt <i>et al.</i>	(GWU)
PDG	06	JPG 33 1	W.-M. Yao <i>et al.</i>	(PDG Collab.)
ARNDT	04	PR C69 035213	R.A. Arndt <i>et al.</i>	(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 <i>et al.</i>	(VPI, BRCO)
HOEHLER	93	πN Newsletter 9 1	G. Hohler	(KARL)
LI	93	PR C47 2759	Z.J. Li <i>et al.</i>	(VPI)
MANLEY	92	PR D45 4002	D.M. Manley, E.M. Saleski	(KSA) IJP
Also		PR D30 904	D.M. Manley <i>et al.</i>	(VPI)
ARNDT	91	PR D43 2131	R.A. Arndt <i>et al.</i>	(VPI, TELE) IJP
CANDLIN	84	NP B238 477	D.J. Candlin <i>et al.</i>	(EDIN, RAL, LOWC)
CRAWFORD	83	NP B211 1	R.L. Crawford, W.T. Morton	(GLAS)
PDG	82	PL 111B 1	M. Roos <i>et al.</i>	(HELS, CIT, CERN)
AWAJI	81	Bonn Conf. 352	N. Awaji, R. Kajikawa	(NAGO)
Also		NP B197 365	K. Fujii <i>et al.</i>	(NAGO)
CHEW	80	Toronto Conf. 123	D.M. Chew	(LBL) IJP
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
LONGACRE	78	PR D17 1795	R.S. Longacre <i>et al.</i>	(LBL, SLAC)
LONGACRE	75	PL 55B 415	R.S. Longacre <i>et al.</i>	(LBL, SLAC) IJP
