

$\Delta(1905) F_{35}$

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

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
1865 to 1915 (\approx 1890) OUR ESTIMATE			
1857.8 \pm 1.6	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
1881 \pm 18	MANLEY	92	IPWA $\pi N \rightarrow \pi N \& N\pi\pi$
1910 \pm 30	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
1905 \pm 20	HOEHLER	79	IPWA $\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
1855.7 \pm 4.2	ARNDT	04	DPWA $\pi N \rightarrow \pi N, \eta N$
1873 \pm 77	VRANA	00	DPWA Multichannel
1895 \pm 8	ARNDT	96	IPWA $\gamma N \rightarrow \pi N$
1850	ARNDT	95	DPWA $\pi N \rightarrow N\pi$
1960 \pm 40	CANDLIN	84	DPWA $\pi^+ p \rightarrow \Sigma^+ K^+$
1787.0 ⁺ 6.0 - 5.7	CHEW	80	BPWA $\pi^+ p \rightarrow \pi^+ p$
1830	¹ LONGACRE	75	IPWA $\pi N \rightarrow N\pi\pi$

$\Delta(1905)$ BREIT-WIGNER WIDTH

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
270 to 400 (\approx 330) OUR ESTIMATE			
320.6 \pm 8.6	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
327 \pm 51	MANLEY	92	IPWA $\pi N \rightarrow \pi N \& N\pi\pi$
400 \pm 100	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
260 \pm 20	HOEHLER	79	IPWA $\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
334 \pm 22	ARNDT	04	DPWA $\pi N \rightarrow \pi N, \eta N$
461 \pm 111	VRANA	00	DPWA Multichannel
354 \pm 10	ARNDT	96	IPWA $\gamma N \rightarrow \pi N$
294	ARNDT	95	DPWA $\pi N \rightarrow N\pi$
270 \pm 40	CANDLIN	84	DPWA $\pi^+ p \rightarrow \Sigma^+ K^+$
66.0 ⁺ 24.0 - 16.0	CHEW	80	BPWA $\pi^+ p \rightarrow \pi^+ p$
220	¹ 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>
1825 to 1835 (\approx 1830) OUR ESTIMATE			
1819	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
1829	² 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. ● ● ●			
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	³ LONGACRE	78	IPWA $\pi N \rightarrow N\pi\pi$

–2xIMAGINARY PART

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
265 to 300 (\approx 280) OUR ESTIMATE			
247	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
303	² 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. ● ● ●			
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	³ 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>
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>
–30	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
–50 \pm 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

$\Delta(1905)$ DECAY MODES

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

Mode	Fraction (Γ_i/Γ)
Γ_1 $N\pi$	0.09 to 0.15
Γ_2 ΣK	
Γ_3 $N\pi\pi$	85–95 %
Γ_4 $\Delta\pi$	<25 %
Γ_5 $\Delta(1232)\pi$, <i>P</i> -wave	
Γ_6 $\Delta(1232)\pi$, <i>F</i> -wave	
Γ_7 $N\rho$	>60 %
Γ_8 $N\rho$, $S=3/2$, <i>P</i> -wave	
Γ_9 $N\rho$, $S=3/2$, <i>F</i> -wave	
Γ_{10} $N\rho$, $S=1/2$, <i>F</i> -wave	
Γ_{11} $N\gamma$	0.01–0.03 %
Γ_{12} $N\gamma$, helicity=1/2	0.0–0.1 %
Γ_{13} $N\gamma$, helicity=3/2	0.004–0.03 %

$\Delta(1905)$ BRANCHING RATIOS

$\Gamma(N\pi)/\Gamma_{\text{total}}$				Γ_1/Γ
<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
0.09 to 0.15 OUR ESTIMATE				
0.122±0.001	ARNDT	06	DPWA	$\pi N \rightarrow \pi N, \eta N$
0.12 ±0.03	MANLEY	92	IPWA	$\pi N \rightarrow \pi N \ \& \ N\pi\pi$
0.08 ±0.03	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
0.15 ±0.02	HOEHLER	79	IPWA	$\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
0.120±0.002	ARNDT	04	DPWA	$\pi N \rightarrow \pi N, \eta N$
0.09 ±0.01	VRANA	00	DPWA	Multichannel
0.12	ARNDT	95	DPWA	$\pi N \rightarrow N\pi$
0.11	CHEW	80	BPWA	$\pi^+ p \rightarrow \pi^+ p$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{\text{total}}$ in $N\pi \rightarrow \Delta(1905) \rightarrow \Sigma K$				$(\Gamma_1\Gamma_2)^{1/2}/\Gamma$
<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
−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 $N\pi \rightarrow \Delta(1905) \rightarrow \Delta(1232)\pi$, <i>P</i> -wave				$(\Gamma_1\Gamma_5)^{1/2}/\Gamma$
<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
−0.04±0.05	MANLEY	92	IPWA	$\pi N \rightarrow \pi N \ \& \ N\pi\pi$

$\Gamma(\Delta(1232)\pi, P\text{-wave})/\Gamma_{\text{total}} \quad \Gamma_5/\Gamma$

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.23±0.01	VRANA 00	DPWA	Multichannel

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

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
+0.02±0.03	MANLEY 92	IPWA	$\pi N \rightarrow \pi N \& N\pi\pi$
+0.20	¹ LONGACRE 75	IPWA	$\pi N \rightarrow N\pi\pi$

$\Gamma(\Delta(1232)\pi, F\text{-wave})/\Gamma_{\text{total}} \quad \Gamma_6/\Gamma$

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.44±0.01	VRANA 00	DPWA	Multichannel

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{\text{total}}$ in $N\pi \rightarrow \Delta(1905) \rightarrow N\rho, S=3/2, P\text{-wave} \quad (\Gamma_1\Gamma_8)^{1/2}/\Gamma$

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
+0.030 to +0.36 OUR ESTIMATE			
+0.33 ±0.03	MANLEY 92	IPWA	$\pi N \rightarrow \pi N \& N\pi\pi$
+0.33	¹ LONGACRE 75	IPWA	$\pi N \rightarrow N\pi\pi$

$\Gamma(N\rho, S=3/2, P\text{-wave})/\Gamma_{\text{total}} \quad \Gamma_8/\Gamma$

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.24±0.01	VRANA 00	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).

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

<u>VALUE (GeV^{-1/2})</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
+0.026±0.011 OUR ESTIMATE			
0.021±0.004	DUGGER 07	DPWA	$\gamma N \rightarrow \pi N$
0.022±0.005	ARNDT 96	IPWA	$\gamma N \rightarrow \pi N$
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. • • •			
0.018	DRECHSEL 07	DPWA	$\gamma N \rightarrow \pi N$
0.055±0.004	LI 93	IPWA	$\gamma N \rightarrow \pi N$

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

<u>VALUE (GeV^{-1/2})</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
-0.045±0.020 OUR ESTIMATE			
-0.046±0.005	DUGGER 07	DPWA	$\gamma N \rightarrow \pi N$
-0.045±0.005	ARNDT 96	IPWA	$\gamma N \rightarrow \pi N$
-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. • • •			
-0.028	DRECHSEL 07	DPWA	$\gamma N \rightarrow \pi N$
0.002±0.003	LI 93	IPWA	$\gamma N \rightarrow \pi N$

$\Delta(1905)$ FOOTNOTES

- ¹ From method II of LONGACRE 75: eyeball fits with Breit-Wigner circles to the T-matrix amplitudes.
- ² 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.
- ³ 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.

$\Delta(1905)$ REFERENCES

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

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	(KENT) 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>	(HELSE, 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