$\Delta(1905)\ F_{35}$

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

Most of the results published before 1975 are now obsolete and have been omitted. They may be found in our 1982 edition, Physics Letters **111B** (1982).

$\Delta(1905)$ BREIT-WIGNER MASS

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
1865 to 1915 (≈ 1890) OUR ESTIMATE				
1855.7 ± 4.2	ARNDT	04	DPWA	$\pi N \to \pi N, \eta N$
1881 ±18	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
1910 ±30	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
1905 ±20	HOEHLER	79	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1873 ±77	VRANA	00	DPWA	Multichannel
1895 ± 8	ARNDT	96	IPWA	$\gamma N \to \pi N$
1850	ARNDT	95	DPWA	$\pi N \to N\pi$
1960 ±40	CANDLIN	84	DPWA	$\pi^+ p \to \Sigma^+ K^+$
$1787.0^{+\ 6.0}_{-\ 5.7}$	CHEW	80	BPWA	$\pi^+ p \to \pi^+ p$
1880	CRAWFORD	80	DPWA	$\gamma N \to \pi N$
1892	BARBOUR	78	DPWA	$\gamma N \to \pi N$
1830	[1] LONGACRE	75	IPWA	$\pi N \to N\pi\pi$

$\Delta(1905)$ BREIT-WIGNER WIDTH

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
270 to 400 (≈ 330) OUR ESTIMATE				
334 ± 22	ARNDT	04	DPWA	$\pi N \to \pi N, \eta N$
327 ± 51	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
400 ±100	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
260 ± 20	HOEHLER	79	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
461 ±111	VRANA	00	DPWA	Multichannel
354 ± 10	ARNDT	96	IPWA	$\gamma N \to \pi N$
294	ARNDT	95	DPWA	$\pi N \to N\pi$
270 ± 40	CANDLIN	84	DPWA	$\pi^+ p \to \Sigma^+ K^+$
$66.0^{+\ 24.0}_{-\ 16.0}$	CHEW	80	BPWA	$\pi^+ p \to \pi^+ p$
193	CRAWFORD	80	DPWA	$\gamma N \to \pi N$
159	BARBOUR	78	DPWA	$\gamma N \to \pi N$
220	[1] LONGACRE	75	IPWA	$\pi N \to N\pi\pi$

Δ(1905) POLE POSITION

REAL PART

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
1825 to 1835 (≈ 1830) OUR ESTIMATE				
1825	ARNDT	04	DPWA	$\pi N \to \pi N, \eta N$
1829	[2] 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. • • •				
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	[3] LONGACRE	78	IPWA	$\pi N \to N\pi\pi$

−2×IMAGINARY PART

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
265 to 300 (≈ 280) OUR ESTIMATE				
270	ARNDT	04	DPWA	$\pi N \to \pi N, \eta N$
303	[2] 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. • • •				
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	[3] LONGACRE	78	IPWA	$\pi N \to N\pi\pi$

Δ(1905) ELASTIC POLE RESIDUE

MODULUS $|r|$

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
16	ARNDT	04	DPWA	$\pi N \to \pi N, \eta N$
25	HOEHLER	93	SPED	$\pi N \to \pi N$
25 ± 8	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
12	ARNDT	95	DPWA	$\pi N \to N\pi$
14	ARNDT	91	DPWA	$\pi N \to \pi N$ Soln SM90

PHASE θ

VALUE (°)	*DOCUMENT ID*		*TECN*	*COMMENT*
− 25	ARNDT	04	DPWA	$\pi N \to \pi N, \eta N$
− 50 ± 20	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
− 4	ARNDT	95	DPWA	$\pi N \to N\pi$
− 40	ARNDT	91	DPWA	$\pi N \to \pi N$ Soln SM90

Δ(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	$\Delta(1232)\pi$, 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}	$N\gamma$	0.01–0.03 %
Γ_{12}	$N\gamma$, helicity=1/2	0.0–0.1 %
Γ_{13}	$N\gamma$, helicity=3/2	0.004–0.03 %

Δ(1905) BRANCHING RATIOS

$\Gamma(N\pi)/\Gamma_{total}$ Γ_1/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
0.09 to 0.15 OUR ESTIMATE				
0.120±0.002	ARNDT	04	DPWA	$\pi N \to \pi N, \eta N$
0.12 ±0.03	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
0.08 ±0.03	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
0.15 ±0.02	HOEHLER	79	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.09 ±0.01	VRANA	00	DPWA	Multichannel
0.12	ARNDT	95	DPWA	$\pi N \to N\pi$
0.11	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	$\pi^+ p \to \Sigma^+ K^+$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
−0.013	LIVANOS	80	DPWA	$\pi p \to \Sigma K$
0.021 to 0.054	[4] DEANS	75	DPWA	$\pi N \to \Sigma K$

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
−0.04±0.05	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$

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

VALUE	DOCUMENT ID		TECN	COMMENT
0.23±0.01	VRANA	00	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
+0.02±0.03	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
+0.20	[1] LONGACRE	75	IPWA	$\pi N \to N\pi\pi$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
+0.17	[5] NOVOSELLER	78	IPWA	$\pi N \to N\pi\pi$
+0.06	[6] NOVOSELLER	78	IPWA	$\pi N \to N\pi\pi$

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

VALUE	DOCUMENT ID		TECN	COMMENT
0.44±0.01	VRANA	00	DPWA	Multichannel

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

VALUE	DOCUMENT ID		TECN	COMMENT
+0.030 to +0.36 OUR ESTIMATE				
+0.33 ±0.03	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
+0.33	[1] LONGACRE	75	IPWA	$\pi N \to N\pi\pi$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
+0.26	[5] NOVOSELLER	78	IPWA	$\pi N \to N\pi\pi$
+0.11 to +0.33	[7] NOVOSELLER	78	IPWA	$\pi N \to N\pi\pi$

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

VALUE	DOCUMENT ID		TECN	COMMENT
0.24±0.01	VRANA	00	DPWA	Multichannel

$\Delta(1905)$ PHOTON DECAY AMPLITUDES

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

VALUE ($GeV^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
+0.026±0.011 OUR ESTIMATE				
0.022±0.005	ARNDT	96	IPWA	$\gamma N \to \pi N$
0.021±0.010	CRAWFORD	83	IPWA	$\gamma N \to \pi N$
0.043±0.020	AWAJI	81	DPWA	$\gamma N \to \pi N$
0.022±0.010	ARAI	80	DPWA	$\gamma N \to \pi N$ (fit 1)
0.031±0.009	ARAI	80	DPWA	$\gamma N \to \pi N$ (fit 2)
0.024±0.014	CRAWFORD	80	DPWA	$\gamma N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.055±0.004	LI	93	IPWA	$\gamma N \to \pi N$
+0.033±0.018	BARBOUR	78	DPWA	$\gamma N \to \pi N$

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

VALUE ($GeV^{-1/2}$)	*DOCUMENT ID*		*TECN*	*COMMENT*
-0.045 ± 0.020 OUR ESTIMATE				
-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	$\gamma N \rightarrow \pi N$
-0.029 ± 0.007	ARAI	80	DPWA	$\gamma N \rightarrow \pi N$ (fit 1)
-0.045 ± 0.006	ARAI	80	DPWA	$\gamma N \rightarrow \pi N$ (fit 2)
-0.072 ± 0.035	CRAWFORD	80	DPWA	$\gamma N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.002 ± 0.003	LI	93	IPWA	$\gamma N \rightarrow \pi N$
-0.055 ± 0.019	BARBOUR	78	DPWA	$\gamma N \rightarrow \pi N$

$\Delta(1905)$ 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.

[4] The range given for DEANS 75 is from the four best solutions.

[5] A Breit-Wigner fit to the HERNDON 75 IPWA.

[6] A Breit-Wigner fit to the NOVOSELLER 78B IPWA.

[7] A Breit-Wigner fit to the NOVOSELLER 78B IPWA; the phase is near 90°.

$\Delta(1905)$ REFERENCES

For early references, see Physics Letters **111B** 70 (1982).

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	(KENT) IJP
Also	84	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	M. Roos *et al.*	(HELS, CIT, CERN)
AWAJI	81	Bonn Conf. 352	N. Awaji, R. Kajikawa	(NAGO)
Also	82	NP B197 365	K. Fujii *et al.*	(NAGO)
ARAI	80	Toronto Conf. 93	I. Arai	(INUS)
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CUTKOSKY	80	Toronto Conf. 19	R.E. Cutkosky *et al.*	(CMU, LBL) IJP
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HOEHLER	79	PDAT 12-1	G. Hohler *et al.*	(KARLT) IJP
Also	80	Toronto Conf. 3	R. Koch	(KARLT) IJP

BARBOUR	78	NP B141 253	I.M. Barbour, R.L. Crawford, N.H. Parsons	(GLAS)
LONGACRE	78	PR D17 1795	R.S. Longacre *et al.*	(LBL, SLAC)
NOVOSELLER	78	NP B137 509	D.E. Novoseller	(CIT) IJP
NOVOSELLER	78B	NP B137 445	D.E. Novoseller	(CIT) IJP
DEANS	75	NP B96 90	S.R. Deans *et al.*	(SFLA, ALAH) IJP
HERNDON	75	PR D11 3183	D. Herndon *et al.*	(LBL, SLAC)
LONGACRE	75	PL 55B 415	R.S. Longacre *et al.*	(LBL, SLAC) IJP