$\Delta(1700)\ D_{33}$

$I(J^P) = \frac{3}{2}(\frac{3}{2}^-)$ 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).

$\Delta(1700)$ BREIT-WIGNER MASS

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
1670 to 1750 (≈ 1700) OUR ESTIMATE				
1695.0 ± 1.3	ARNDT	06	DPWA	$\pi N \rightarrow \pi N, \eta N$
1762 ± 44	MANLEY	92	IPWA	$\pi N \rightarrow \pi N$ & $N \pi\pi$
1710 ± 30	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
1680 ± 70	HOEHLER	79	IPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1770 ± 40	THOMA	08	DPWA	Multichannel
1687.9 ± 2.5	ARNDT	04	DPWA	$\pi N \rightarrow \pi N, \eta N$
1678 ± 1	PENNER	02C	DPWA	Multichannel
1732 ± 23	VRANA	00	DPWA	Multichannel
1690 ± 15	ARNDT	96	IPWA	$\gamma N \rightarrow \pi N$
1680	ARNDT	95	DPWA	$\pi N \rightarrow N \pi$
1655	LI	93	IPWA	$\gamma N \rightarrow \pi N$
1650	BARNHAM	80	IPWA	$\pi N \rightarrow N \pi\pi$
$1718.4^{+13.1}_{-13.0}$	[1] CHEW	80	BPWA	$\pi^+ p \rightarrow \pi^+ p$
1600	[2] LONGACRE	77	IPWA	$\pi N \rightarrow N \pi\pi$
1680	[3] LONGACRE	75	IPWA	$\pi N \rightarrow N \pi\pi$

$\Delta(1700)$ BREIT-WIGNER WIDTH

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
200 to 400 (≈ 300) OUR ESTIMATE				
375.5 ± 7.0	ARNDT	06	DPWA	$\pi N \rightarrow \pi N, \eta N$
600 ± 250	MANLEY	92	IPWA	$\pi N \rightarrow \pi N$ & $N \pi\pi$
280 ± 80	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
230 ± 80	HOEHLER	79	IPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
630 ± 150	THOMA	08	DPWA	Multichannel
364.8 ± 16.6	ARNDT	04	DPWA	$\pi N \rightarrow \pi N, \eta N$
606 ± 15	PENNER	02C	DPWA	Multichannel
119 ± 70	VRANA	00	DPWA	Multichannel
285 ± 20	ARNDT	96	IPWA	$\gamma N \rightarrow \pi N$
272	ARNDT	95	DPWA	$\pi N \rightarrow N \pi$
348	LI	93	IPWA	$\gamma N \rightarrow \pi N$
160	BARNHAM	80	IPWA	$\pi N \rightarrow N \pi\pi$
193.3 ± 26.0	[1] CHEW	80	BPWA	$\pi^+ p \rightarrow \pi^+ p$
200	[2] LONGACRE	77	IPWA	$\pi N \rightarrow N \pi\pi$
240	[3] LONGACRE	75	IPWA	$\pi N \rightarrow N \pi\pi$

Δ(1700) POLE POSITION

REAL PART

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
1620 to 1680 (≈ 1650) OUR ESTIMATE				
1632	ARNDT	06	DPWA	$\pi N \to \pi N, \eta N$
1651	[4] HOEHLER	93	SPED	$\pi N \to \pi N$
1675±25	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1610±35	THOMA	08	DPWA	Multichannel
1617	ARNDT	04	DPWA	$\pi N \to \pi N, \eta N$
1726	VRANA	00	DPWA	Multichannel
1655	ARNDT	95	DPWA	$\pi N \to N\pi$
1646	ARNDT	91	DPWA	$\pi N \to \pi N$ Soln SM90
1681 or 1672	[5] LONGACRE	78	IPWA	$\pi N \to N\pi\pi$
1600 or 1594	[2] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$

−2×IMAGINARY PART

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
160 to 240 (≈ 200) OUR ESTIMATE				
253	ARNDT	06	DPWA	$\pi N \to \pi N, \eta N$
159	[4] HOEHLER	93	SPED	$\pi N \to \pi N$
220±40	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
320±60	THOMA	08	DPWA	Multichannel
226	ARNDT	04	DPWA	$\pi N \to \pi N, \eta N$
118	VRANA	00	DPWA	Multichannel
242	ARNDT	95	DPWA	$\pi N \to N\pi$
208	ARNDT	91	DPWA	$\pi N \to \pi N$ Soln SM90
245 or 241	[5] LONGACRE	78	IPWA	$\pi N \to N\pi\pi$
208 or 201	[2] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$

Δ(1700) ELASTIC POLE RESIDUE

MODULUS $|r|$

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
18	ARNDT	06	DPWA	$\pi N \to \pi N, \eta N$
10	HOEHLER	93	SPED	$\pi N \to \pi N$
13±3	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
16	ARNDT	04	DPWA	$\pi N \to \pi N, \eta N$
16	ARNDT	95	DPWA	$\pi N \to N\pi$
13	ARNDT	91	DPWA	$\pi N \to \pi N$ Soln SM90

PHASE θ

VALUE (°)	*DOCUMENT ID*		*TECN*	*COMMENT*
−40	ARNDT	06	DPWA	$\pi N \to \pi N, \eta N$
−20±25	CUTKOSKY	80	IPWA	$\pi N \to \pi N$

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

−47	ARNDT	04	DPWA	$\pi N \to \pi N$, ηN
−12	ARNDT	95	DPWA	$\pi N \to N\pi$
−22	ARNDT	91	DPWA	$\pi N \to \pi N$ Soln SM90

Δ(1700) DECAY MODES

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

	Mode	Fraction (Γ_i/Γ)
Γ_1	$N\pi$	10–20 %
Γ_2	ΣK	
Γ_3	$N\pi\pi$	80–90 %
Γ_4	$\Delta\pi$	30–60 %
Γ_5	$\Delta(1232)\pi$, S-wave	25–50 %
Γ_6	$\Delta(1232)\pi$, D-wave	1–7 %
Γ_7	$N\rho$	30–55 %
Γ_8	$N\rho$, S=1/2, D-wave	
Γ_9	$N\rho$, S=3/2, S-wave	5–20 %
Γ_{10}	$N\rho$, S=3/2, D-wave	
Γ_{11}	$N\gamma$	0.12–0.26 %
Γ_{12}	$N\gamma$, helicity=1/2	0.08–0.16 %
Γ_{13}	$N\gamma$, helicity=3/2	0.025–0.12 %

Δ(1700) BRANCHING RATIOS

$\Gamma(N\pi)/\Gamma_{total}$ — Γ_1/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
0.10 to 0.20 OUR ESTIMATE				
0.156±0.001	ARNDT	06	DPWA	$\pi N \to \pi N$, ηN
0.14 ±0.06	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
0.12 ±0.03	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
0.20 ±0.03	HOEHLER	79	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.15 ±0.08	THOMA	08	DPWA	Multichannel
0.150±0.001	ARNDT	04	DPWA	$\pi N \to \pi N$, ηN
0.14 ±0.01	PENNER	02C	DPWA	Multichannel
0.05 ±0.01	VRANA	00	DPWA	Multichannel
0.16	ARNDT	95	DPWA	$\pi N \to N\pi$
0.16	[1] CHEW	80	BPWA	$\pi^+ p \to \pi^+ p$

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 $N\pi \rightarrow \Delta(1700) \rightarrow \Delta(1232)\pi$, S-wave — $(\Gamma_1\Gamma_5)^{1/2}/\Gamma$

VALUE		DOCUMENT ID		TECN	COMMENT
+0.21 to +0.29 OUR ESTIMATE					
+0.32±0.06		MANLEY	92	IPWA	$\pi N \rightarrow \pi N$ & $N\pi\pi$
+0.18±0.04		BARNHAM	80	IPWA	$\pi N \rightarrow N\pi\pi$
+0.30	[2,6]	LONGACRE	77	IPWA	$\pi N \rightarrow N\pi\pi$
+0.24	[3]	LONGACRE	75	IPWA	$\pi N \rightarrow N\pi\pi$

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

VALUE	DOCUMENT ID		TECN	COMMENT
0.90±0.02	VRANA	00	DPWA	Multichannel

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \rightarrow \Delta(1700) \rightarrow \Delta(1232)\pi$, D-wave — $(\Gamma_1\Gamma_6)^{1/2}/\Gamma$

VALUE		DOCUMENT ID		TECN	COMMENT
+0.05 to +0.11 OUR ESTIMATE					
+0.08±0.03		MANLEY	92	IPWA	$\pi N \rightarrow \pi N$ & $N\pi\pi$
0.14±0.04		BARNHAM	80	IPWA	$\pi N \rightarrow N\pi\pi$
+0.05	[2,6]	LONGACRE	77	IPWA	$\pi N \rightarrow N\pi\pi$
+0.10	[3]	LONGACRE	75	IPWA	$\pi N \rightarrow N\pi\pi$

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

VALUE	DOCUMENT ID		TECN	COMMENT
0.04±0.01	VRANA	00	DPWA	Multichannel

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \rightarrow \Delta(1700) \rightarrow N\rho$, S=1/2, D-wave — $(\Gamma_1\Gamma_8)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
+0.17±0.05	BARNHAM	80	IPWA	$\pi N \rightarrow N\pi\pi$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \rightarrow \Delta(1700) \rightarrow N\rho$, S=3/2, S-wave — $(\Gamma_1\Gamma_9)^{1/2}/\Gamma$

VALUE		DOCUMENT ID		TECN	COMMENT
±0.11 to ±0.19 OUR ESTIMATE					
+0.10±0.03		MANLEY	92	IPWA	$\pi N \rightarrow \pi N$ & $N\pi\pi$
+0.04	[2,6]	LONGACRE	77	IPWA	$\pi N \rightarrow N\pi\pi$
−0.30	[3]	LONGACRE	75	IPWA	$\pi N \rightarrow N\pi\pi$

$\Gamma(N\rho$, S=3/2, S-wave$)/\Gamma_{total}$ — Γ_9/Γ

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

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \rightarrow \Delta(1700) \rightarrow N\rho$, S=3/2, D-wave — $(\Gamma_1\Gamma_{10})^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
0.18±0.07	BARNHAM	80	IPWA	$\pi N \rightarrow N\pi\pi$

Δ(1700) PHOTON DECAY AMPLITUDES

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

Δ(1700) → $N\gamma$, helicity-1/2 amplitude $A_{1/2}$

VALUE (GeV$^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
+0.104±0.015 OUR ESTIMATE				
0.125±0.003	DUGGER	07	DPWA	$\gamma N \rightarrow \pi N$
0.090±0.025	ARNDT	96	IPWA	$\gamma N \rightarrow \pi N$
0.111±0.017	CRAWFORD	83	IPWA	$\gamma N \rightarrow \pi N$
0.089±0.033	AWAJI	81	DPWA	$\gamma N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.226	DRECHSEL	07	DPWA	$\gamma N \rightarrow \pi N$
0.096	PENNER	02D	DPWA	Multichannel
0.121±0.004	LI	93	IPWA	$\gamma N \rightarrow \pi N$

Δ(1700) → $N\gamma$, helicity-3/2 amplitude $A_{3/2}$

VALUE (GeV$^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
+0.085±0.022 OUR ESTIMATE				
0.105±0.003	DUGGER	07	DPWA	$\gamma N \rightarrow \pi N$
0.097±0.020	ARNDT	96	IPWA	$\gamma N \rightarrow \pi N$
0.107±0.015	CRAWFORD	83	IPWA	$\gamma N \rightarrow \pi N$
0.060±0.015	AWAJI	81	DPWA	$\gamma N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.210	DRECHSEL	07	DPWA	$\gamma N \rightarrow \pi N$
0.154	PENNER	02D	DPWA	Multichannel
0.115±0.004	LI	93	IPWA	$\gamma N \rightarrow \pi N$

Δ(1700) FOOTNOTES

1 Problems with CHEW 80 are discussed in section 2.1.11 of HOEHLER 83.

2 LONGACRE 77 pole positions 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. The other LONGACRE 77 values are from eyeball fits with Breit-Wigner circles to the T-matrix amplitudes.

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

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 $\pi N \rightarrow N\pi\pi$ data, elastic amplitudes from a Saclay (CERN) partial-wave analysis.

6 LONGACRE 77 considers this coupling to be well determined.

Δ(1700) REFERENCES

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

THOMA	08	PL B659 87	U. Thoma *et al.*	(CB-ELSA Collab.)
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	JPG 33 1	W.-M. Yao *et al.*	(PDG Collab.)
ARNDT	04	PR C69 035213	R.A. Arndt *et al.*	(GWU, TRIU)
PENNER	02C	PR C66 055211	G. Penner, U. Mosel	(GIES)
PENNER	02D	PR C66 055212	G. Penner, U. Mosel	(GIES)
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		PR D30 904	D.M. Manley *et al.*	(VPI)
ARNDT	91	PR D43 2131	R.A. Arndt *et al.*	(VPI, TELE) IJP
CRAWFORD	83	NP B211 1	R.L. Crawford, W.T. Morton	(GLAS)
HOEHLER	83	Landolt-Boernstein 1/9B2	G. Hohler	(KARLT)
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)
BARNHAM	80	NP B168 243	K.W.J. Barnham *et al.*	(LOIC)
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	77	NP B122 493	R.S. Longacre, J. Dolbeau	(SACL) IJP
Also		NP B108 365	J. Dolbeau *et al.*	(SACL) IJP
LONGACRE	75	PL 55B 415	R.S. Longacre *et al.*	(LBL, SLAC) IJP