$\Delta(1700)$ D_{33}

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

$\Delta(1700)$ BREIT-WIGNER MASS

VALUE (MeV)		*DOCUMENT ID*		*TECN*	*COMMENT*
1670 to 1750 (≈ 1700) OUR ESTIMATE					
1687.9 ± 2.5		ARNDT	04	DPWA	$\pi N \to \pi N, \eta N$
1762 ±44		MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
1710 ±30		CUTKOSKY	80	IPWA	$\pi N \to \pi N$
1680 ±70		HOEHLER	79	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
1678 ± 1		PENNER	02C	DPWA	Multichannel
1732 ±23		VRANA	00	DPWA	Multichannel
1690 ±15		ARNDT	96	IPWA	$\gamma N \to \pi N$
1680		ARNDT	95	DPWA	$\pi N \to N\pi$
1655		LI	93	IPWA	$\gamma N \to \pi N$
1650		BARNHAM	80	IPWA	$\pi N \to N\pi\pi$
$1718.4^{+13.1}_{-13.0}$	[1]	CHEW	80	BPWA	$\pi^+ p \to \pi^+ p$
1622		CRAWFORD	80	DPWA	$\gamma N \to \pi N$
1629		BARBOUR	78	DPWA	$\gamma N \to \pi N$
1600	[2]	LONGACRE	77	IPWA	$\pi N \to N\pi\pi$
1680	[3]	LONGACRE	75	IPWA	$\pi N \to N\pi\pi$

$\Delta(1700)$ BREIT-WIGNER WIDTH

VALUE (MeV)		*DOCUMENT ID*		*TECN*	*COMMENT*
200 to 400 (≈ 300) OUR ESTIMATE					
364.8 ± 16.6		ARNDT	04	DPWA	$\pi N \to \pi N, \eta N$
600 ±250		MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
280 ± 80		CUTKOSKY	80	IPWA	$\pi N \to \pi N$
230 ± 80		HOEHLER	79	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
606 ± 15		PENNER	02C	DPWA	Multichannel
119 ± 70		VRANA	00	DPWA	Multichannel
285 ± 20		ARNDT	96	IPWA	$\gamma N \to \pi N$
272		ARNDT	95	DPWA	$\pi N \to N\pi$
348		LI	93	IPWA	$\gamma N \to \pi N$
160		BARNHAM	80	IPWA	$\pi N \to N\pi\pi$
193.3 ± 26.0	[1]	CHEW	80	BPWA	$\pi^+ p \to \pi^+ p$
209		CRAWFORD	80	DPWA	$\gamma N \to \pi N$
216		BARBOUR	78	DPWA	$\gamma N \to \pi N$
200	[2]	LONGACRE	77	IPWA	$\pi N \to N\pi\pi$
240	[3]	LONGACRE	75	IPWA	$\pi N \to N\pi\pi$

Δ(1700) POLE POSITION

REAL PART

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
1620 to 1680 (≈ 1650) OUR ESTIMATE				
1617	ARNDT	04	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. • • •				
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				
226	ARNDT	04	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. • • •				
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*
16	ARNDT	04	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	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*
−47	ARNDT	04	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. • • •				
−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				
0.150±0.001	ARNDT	04	DPWA	$\pi N \to \pi N, \eta N$
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. • • •				
0.14 ±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	$\pi^+ p \to \pi^+ p$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to \Delta(1700) \to \Sigma K$ $(\Gamma_1\Gamma_2)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.002	LIVANOS	80	DPWA	$\pi p \to \Sigma K$
0.001 to 0.011	[6] 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 $N\pi \to \Delta(1700) \to \Delta(1232)\pi$, *S*-wave $(\Gamma_1\Gamma_5)^{1/2}/\Gamma$

VALUE		DOCUMENT ID		TECN	COMMENT
+0.21 to +0.29 OUR ESTIMATE					
$+0.32 \pm 0.06$		MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
$+0.18 \pm 0.04$		BARNHAM	80	IPWA	$\pi N \to N\pi\pi$
+0.30	2,7	LONGACRE	77	IPWA	$\pi N \to N\pi\pi$
+0.24	3	LONGACRE	75	IPWA	$\pi N \to N\pi\pi$

$\Gamma(\Delta(1232)\pi$, *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 $N\pi \to \Delta(1700) \to \Delta(1232)\pi$, *D*-wave $(\Gamma_1\Gamma_6)^{1/2}/\Gamma$

VALUE		DOCUMENT ID		TECN	COMMENT
+0.05 to +0.11 OUR ESTIMATE					
$+0.08 \pm 0.03$		MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
0.14 ± 0.04		BARNHAM	80	IPWA	$\pi N \to N\pi\pi$
+0.05	2,7	LONGACRE	77	IPWA	$\pi N \to N\pi\pi$
+0.10	3	LONGACRE	75	IPWA	$\pi N \to N\pi\pi$

$\Gamma(\Delta(1232)\pi$, *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 $N\pi \to \Delta(1700) \to N\rho$, S=1/2, *D*-wave $(\Gamma_1\Gamma_8)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
$+0.17 \pm 0.05$	BARNHAM	80	IPWA	$\pi N \to N\pi\pi$

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

VALUE		DOCUMENT ID		TECN	COMMENT
$\pm$0.11 to $\pm$0.19 OUR ESTIMATE					
$+0.10 \pm 0.03$		MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
+0.04	2,7	LONGACRE	77	IPWA	$\pi N \to N\pi\pi$
-0.30	3	LONGACRE	75	IPWA	$\pi N \to N\pi\pi$

$\Gamma(N\rho$, 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 $N\pi \to \Delta(1700) \to N\rho$, S=3/2, *D*-wave $(\Gamma_1\Gamma_{10})^{1/2}/\Gamma$

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

Δ(1700) PHOTON DECAY AMPLITUDES

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

VALUE ($GeV^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
+0.104±0.015 OUR ESTIMATE				
0.090±0.025	ARNDT	96	IPWA	$\gamma N \to \pi N$
0.111±0.017	CRAWFORD	83	IPWA	$\gamma N \to \pi N$
0.089±0.033	AWAJI	81	DPWA	$\gamma N \to \pi N$
0.112±0.006	ARAI	80	DPWA	$\gamma N \to \pi N$ (fit 1)
0.130±0.006	ARAI	80	DPWA	$\gamma N \to \pi N$ (fit 2)
0.123±0.022	CRAWFORD	80	DPWA	$\gamma N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.096	PENNER	02D	DPWA	Multichannel
0.121±0.004	LI	93	IPWA	$\gamma N \to \pi N$
+0.130±0.037	BARBOUR	78	DPWA	$\gamma N \to \pi N$
+0.072±0.033	FELLER	76	DPWA	$\gamma N \to \pi N$

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

VALUE ($GeV^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
+0.085±0.022 OUR ESTIMATE				
0.097±0.020	ARNDT	96	IPWA	$\gamma N \to \pi N$
0.107±0.015	CRAWFORD	83	IPWA	$\gamma N \to \pi N$
0.060±0.015	AWAJI	81	DPWA	$\gamma N \to \pi N$
0.047±0.007	ARAI	80	DPWA	$\gamma N \to \pi N$ (fit 1)
0.050±0.007	ARAI	80	DPWA	$\gamma N \to \pi N$ (fit 2)
0.102±0.015	CRAWFORD	80	DPWA	$\gamma N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.154	PENNER	02D	DPWA	Multichannel
0.115±0.004	LI	93	IPWA	$\gamma N \to \pi N$
+0.098±0.036	BARBOUR	78	DPWA	$\gamma N \to \pi N$
+0.087±0.023	FELLER	76	DPWA	$\gamma N \to \pi N$

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

[6] The range given is from the four best solutions. DEANS 75 disagrees with $\pi^+ p \to \Sigma^+ K^+$ data of WINNIK 77 around 1920 MeV.

[7] LONGACRE 77 considers this coupling to be well determined.

Δ(1700) REFERENCES

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

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	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)
ARAI	80	Toronto Conf. 93	I. Arai	(INUS)
Also		NP B194 251	I. Arai, H. Fujii	(INUS)
BARNHAM	80	NP B168 243	K.W.J. Barnham *et al.*	(LOIC)
CHEW	80	Toronto Conf. 123	D.M. Chew	(LBL) IJP
CRAWFORD	80	Toronto Conf. 107	R.L. Crawford	(GLAS)
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
LIVANOS	80	Toronto Conf. 35	P. Livanos *et al.*	(SACL) IJP
HOEHLER	79	PDAT 12-1	G. Hohler *et al.*	(KARLT) IJP
Also		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)
LONGACRE	77	NP B122 493	R.S. Longacre, J. Dolbeau	(SACL) IJP
Also		NP B108 365	J. Dolbeau *et al.*	(SACL) IJP
WINNIK	77	NP B128 66	M. Winnik *et al.*	(HAIF) I
FELLER	76	NP B104 219	P. Feller *et al.*	(NAGO, OSAK) IJP
DEANS	75	NP B96 90	S.R. Deans *et al.*	(SFLA, ALAH) IJP
LONGACRE	75	PL 55B 415	R.S. Longacre *et al.*	(LBL, SLAC) IJP