

$\Delta(1700) D_{33}$

$I(J^P) = \frac{3}{2}(\frac{3}{2}^-)$ 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 1770 (≈ 1700) OUR ESTIMATE			
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. ● ● ●			
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 $\pi^+ p \rightarrow \pi^+ p$
1622	CRAWFORD	80	DPWA $\gamma N \rightarrow \pi N$
1629	BARBOUR	78	DPWA $\gamma N \rightarrow \pi N$
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			
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. ● ● ●			
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 $\pi^+ p \rightarrow \pi^+ p$
209	CRAWFORD	80	DPWA $\gamma N \rightarrow \pi N$
216	BARBOUR	78	DPWA $\gamma N \rightarrow \pi N$
200	² LONGACRE	77	IPWA $\pi N \rightarrow N\pi\pi$
240	³ LONGACRE	75	IPWA $\pi N \rightarrow N\pi\pi$

$\Delta(1700)$ POLE POSITION**REAL PART**

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
1620 to 1700 (≈ 1660) OUR ESTIMATE			
1655	ARNDT	95	DPWA $\pi N \rightarrow N\pi$
1651	⁴ HOEHLER	93	SPED $\pi N \rightarrow \pi N$
1675 \pm 25	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
1726	VRANA	00	DPWA Multichannel
1646	ARNDT	91	DPWA $\pi N \rightarrow \pi N$ Soln SM90
1681 or 1672	⁵ LONGACRE	78	IPWA $\pi N \rightarrow N\pi\pi$
1600 or 1594	² LONGACRE	77	IPWA $\pi N \rightarrow N\pi\pi$

– 2×IMAGINARY PART

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
150 to 250 (≈ 200) OUR ESTIMATE			
242	ARNDT	95	DPWA $\pi N \rightarrow N\pi$
159	⁴ HOEHLER	93	SPED $\pi N \rightarrow \pi N$
220 \pm 40	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
118	VRANA	00	DPWA Multichannel
208	ARNDT	91	DPWA $\pi N \rightarrow \pi N$ Soln SM90
245 or 241	⁵ LONGACRE	78	IPWA $\pi N \rightarrow N\pi\pi$
208 or 201	² LONGACRE	77	IPWA $\pi N \rightarrow N\pi\pi$

 $\Delta(1700)$ ELASTIC POLE RESIDUE**MODULUS $|r|$**

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
16	ARNDT	95	DPWA $\pi N \rightarrow N\pi$
10	HOEHLER	93	SPED $\pi N \rightarrow \pi N$
13 \pm 3	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
13	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>
– 12	ARNDT	95	DPWA $\pi N \rightarrow N\pi$
– 20 \pm 25	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
– 22	ARNDT	91	DPWA $\pi N \rightarrow \pi N$ Soln SM90

$\Delta(1700)$ 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 $\Delta(1232)\pi$, <i>S</i> -wave	25–50 %
Γ_6 $\Delta(1232)\pi$, <i>D</i> -wave	1–7 %
Γ_7 $N\rho$	30–55 %
Γ_8 $N\rho$, <i>S</i> =1/2, <i>D</i> -wave	
Γ_9 $N\rho$, <i>S</i> =3/2, <i>S</i> -wave	5–20 %
Γ_{10} $N\rho$, <i>S</i> =3/2, <i>D</i> -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 %

$\Delta(1700)$ BRANCHING RATIOS

$\Gamma(N\pi)/\Gamma_{\text{total}}$	Γ_1/Γ
<u>VALUE</u>	<u>DOCUMENT ID</u> <u>TECN</u> <u>COMMENT</u>
0.10 to 0.20 OUR ESTIMATE	
0.14±0.06	MANLEY 92 IPWA $\pi N \rightarrow \pi N$ & $N\pi\pi$
0.12±0.03	CUTKOSKY 80 IPWA $\pi N \rightarrow \pi N$
0.20±0.03	HOEHLER 79 IPWA $\pi N \rightarrow \pi N$
● ● ● 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 $\pi N \rightarrow N\pi$
0.16	¹ CHEW 80 BPWA $\pi^+ p \rightarrow \pi^+ p$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{\text{total}}$ in $N\pi \rightarrow \Delta(1700) \rightarrow \Sigma K$	$(\Gamma_1\Gamma_2)^{1/2}/\Gamma$
<u>VALUE</u>	<u>DOCUMENT ID</u> <u>TECN</u> <u>COMMENT</u>
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●	
0.002	LIVANOS 80 DPWA $\pi p \rightarrow \Sigma K$
0.001 to 0.011	⁶ DEANS 75 DPWA $\pi N \rightarrow \Sigma K$

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

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
+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	^{2,7} LONGACRE	77	IPWA $\pi N \rightarrow N\pi\pi$
+0.24	³ LONGACRE	75	IPWA $\pi N \rightarrow N\pi\pi$

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

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.90±0.02	VRANA	00	DPWA Multichannel

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

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
+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	^{2,7} LONGACRE	77	IPWA $\pi N \rightarrow N\pi\pi$
+0.10	³ LONGACRE	75	IPWA $\pi N \rightarrow N\pi\pi$

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

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.04±0.01	VRANA	00	DPWA Multichannel

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

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

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

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
±0.11 to ±0.19 OUR ESTIMATE			
+0.10±0.03	MANLEY	92	IPWA $\pi N \rightarrow \pi N$ & $N\pi\pi$
+0.04	^{2,7} LONGACRE	77	IPWA $\pi N \rightarrow N\pi\pi$
-0.30	³ LONGACRE	75	IPWA $\pi N \rightarrow N\pi\pi$

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

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

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

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

$\Delta(1700)$ PHOTON DECAY AMPLITUDES **$\Delta(1700) \rightarrow N\gamma$, helicity-1/2 amplitude $A_{1/2}$**

VALUE ($\text{GeV}^{-1/2}$)	DOCUMENT ID	TECN	COMMENT
+0.104±0.015 OUR ESTIMATE			
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 $\gamma N \rightarrow \pi N$
0.112±0.006	ARAI	80	DPWA $\gamma N \rightarrow \pi N$ (fit 1)
0.130±0.006	ARAI	80	DPWA $\gamma N \rightarrow \pi N$ (fit 2)
0.123±0.022	CRAWFORD	80	DPWA $\gamma N \rightarrow \pi N$
● ● ● 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 $\gamma N \rightarrow \pi N$
+0.130±0.037	BARBOUR	78	DPWA $\gamma N \rightarrow \pi N$
+0.072±0.033	FELLER	76	DPWA $\gamma N \rightarrow \pi N$

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

VALUE ($\text{GeV}^{-1/2}$)	DOCUMENT ID	TECN	COMMENT
+0.085±0.022 OUR ESTIMATE			
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 $\gamma N \rightarrow \pi N$
0.047±0.007	ARAI	80	DPWA $\gamma N \rightarrow \pi N$ (fit 1)
0.050±0.007	ARAI	80	DPWA $\gamma N \rightarrow \pi N$ (fit 2)
0.102±0.015	CRAWFORD	80	DPWA $\gamma N \rightarrow \pi N$
● ● ● 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 $\gamma N \rightarrow \pi N$
+0.098±0.036	BARBOUR	78	DPWA $\gamma N \rightarrow \pi N$
+0.087±0.023	FELLER	76	DPWA $\gamma N \rightarrow \pi N$

 $\Delta(1700)$ 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 The range given is from the four best solutions. DEANS 75 disagrees with $\pi^+ p \rightarrow \Sigma^+ K^+$ 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).

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 <i>et al.</i>	(VPI, BRCO)
HOEHLER	93	π N 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	84	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
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 <i>et al.</i>	(HELS, CIT, CERN)
AWAJI	81	Bonn Conf. 352	N. Awaji, R. Kajikawa	(NAGO)
Also	82	NP B197 365	K. Fujii <i>et al.</i>	(NAGO)
ARAI	80	Toronto Conf. 93	I. Arai	(INUS)
Also	82	NP B194 251	I. Arai, H. Fujii	(INUS)
BARNHAM	80	NP B168 243	K.W.J. Barnham <i>et al.</i>	(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 <i>et al.</i>	(CMU, LBL) IJP
Also	79	PR D20 2839	R.E. Cutkosky <i>et al.</i>	(CMU, LBL) IJP
LIVANOS	80	Toronto Conf. 35	P. Livanos <i>et al.</i>	(SACL) IJP
HOEHLER	79	PDAT 12-1	G. Hohler <i>et al.</i>	(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 <i>et al.</i>	(LBL, SLAC)
LONGACRE	77	NP B122 493	R.S. Longacre, J. Dolbeau	(SACL) IJP
Also	76	NP B108 365	J. Dolbeau <i>et al.</i>	(SACL) IJP
WINNIK	77	NP B128 66	M. Winnik <i>et al.</i>	(HAIF) I
FELLER	76	NP B104 219	P. Feller <i>et al.</i>	(NAGO, OSAK) IJP
DEANS	75	NP B96 90	S.R. Deans <i>et al.</i>	(SFLA, ALAH) IJP
LONGACRE	75	PL 55B 415	R.S. Longacre <i>et al.</i>	(LBL, SLAC) IJP