

$\Delta(1700) D_{33}$

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

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).

$\Delta(1700)$ BREIT-WIGNER MASS

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
1670 to 1750 (≈ 1700) OUR ESTIMATE			
1695.0 \pm 1.3	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
1762 \pm 44	MANLEY	92	IPWA $\pi N \rightarrow \pi N \ \& \ N\pi\pi$
1710 \pm 30	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
1680 \pm 70	HOEHLER	79	IPWA $\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
1790 \pm 30	HORN	08A	DPWA Multichannel
1770 \pm 40	THOMA	08	DPWA Multichannel
1687.9 \pm 2.5	ARNDT	04	DPWA $\pi N \rightarrow \pi N, \eta N$
1678 \pm 1	PENNER	02C	DPWA Multichannel
1732 \pm 23	VRANA	00	DPWA Multichannel
1690 \pm 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

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
200 to 400 (≈ 300) OUR ESTIMATE			
375.5 \pm 7.0	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
600 \pm 250	MANLEY	92	IPWA $\pi N \rightarrow \pi N \ \& \ N\pi\pi$
280 \pm 80	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
230 \pm 80	HOEHLER	79	IPWA $\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
580 \pm 60	HORN	08A	DPWA Multichannel
630 \pm 150	THOMA	08	DPWA Multichannel
364.8 \pm 16.6	ARNDT	04	DPWA $\pi N \rightarrow \pi N, \eta N$
606 \pm 15	PENNER	02C	DPWA Multichannel
119 \pm 70	VRANA	00	DPWA Multichannel
285 \pm 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	$\pi N \rightarrow N\pi\pi$

$\Delta(1700)$ POLE POSITION

REAL PART

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
1620 to 1680 (≈ 1650) OUR ESTIMATE			
1632	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
1651	⁴ HOEHLER	93	SPED $\pi N \rightarrow \pi N$
1675 ± 25	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
1640 ± 25	HORN	08A	DPWA Multichannel
1610 ± 35	THOMA	08	DPWA Multichannel
1617	ARNDT	04	DPWA $\pi N \rightarrow \pi N, \eta N$
1726	VRANA	00	DPWA Multichannel
1655	ARNDT	95	DPWA $\pi N \rightarrow N\pi$
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

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
160 to 240 (≈ 200) OUR ESTIMATE			
253	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
159	⁴ HOEHLER	93	SPED $\pi N \rightarrow \pi N$
220 ± 40	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
325 ± 35	HORN	08A	DPWA Multichannel
320 ± 60	THOMA	08	DPWA Multichannel
226	ARNDT	04	DPWA $\pi N \rightarrow \pi N, \eta N$
118	VRANA	00	DPWA Multichannel
242	ARNDT	95	DPWA $\pi N \rightarrow N\pi$
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 $|r|$

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
18	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
10	HOEHLER	93	SPED $\pi N \rightarrow \pi N$
13 ± 3	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
16	ARNDT	04	DPWA $\pi N \rightarrow \pi N, \eta N$
16	ARNDT	95	DPWA $\pi N \rightarrow N\pi$
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>
-40	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
-20 \pm 25	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
-47	ARNDT	04	DPWA $\pi N \rightarrow \pi N, \eta N$
-12	ARNDT	95	DPWA $\pi N \rightarrow N\pi$
-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 $\Delta(1232)\pi$, 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} $N(1535)\pi$	
Γ_{12} $\Delta(1232)\eta$	
Γ_{13} $N\gamma$	0.12–0.26 %
Γ_{14} $N\gamma$, helicity=1/2	0.08–0.16 %
Γ_{15} $N\gamma$, helicity=3/2	0.025–0.12 %

$\Delta(1700)$ BRANCHING RATIOS

<u>$\Gamma(N\pi)/\Gamma_{\text{total}}$</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	<u>Γ_1/Γ</u>
0.10 to 0.20 OUR ESTIMATE				
0.156 \pm 0.001	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$	
0.14 \pm 0.06	MANLEY	92	IPWA $\pi N \rightarrow \pi N$ & $N\pi\pi$	
0.12 \pm 0.03	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$	
0.20 \pm 0.03	HOEHLER	79	IPWA $\pi N \rightarrow \pi N$	
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
0.20 \pm 0.07	HORN	08A	DPWA Multichannel	
0.15 \pm 0.08	THOMA	08	DPWA Multichannel	
0.150 \pm 0.001	ARNDT	04	DPWA $\pi N \rightarrow \pi N, \eta N$	
0.14 \pm 0.01	PENNER	02C	DPWA Multichannel	
0.05 \pm 0.01	VRANA	00	DPWA Multichannel	
0.16	ARNDT	95	DPWA $\pi N \rightarrow N\pi$	
0.16	¹ CHEW	80	BPWA $\pi^+ p \rightarrow \pi^+ p$	

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	^{2,6} LONGACRE 77	IPWA	$\pi N \rightarrow N\pi\pi$
+0.24	³ LONGACRE 75	IPWA	$\pi N \rightarrow N\pi\pi$

$\Gamma(\Delta(1232)\pi, S\text{-wave})/\Gamma_{\text{total}}$ 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	^{2,6} LONGACRE 77	IPWA	$\pi N \rightarrow N\pi\pi$
+0.10	³ LONGACRE 75	IPWA	$\pi N \rightarrow N\pi\pi$

$\Gamma(\Delta(1232)\pi, D\text{-wave})/\Gamma_{\text{total}}$ 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-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-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	^{2,6} LONGACRE 77	IPWA	$\pi N \rightarrow N\pi\pi$
-0.30	³ LONGACRE 75	IPWA	$\pi N \rightarrow N\pi\pi$

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

$\Gamma(N(1535)\pi)/\Gamma_{\text{total}}$					Γ_{11}/Γ
<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. • • •					
0.04±0.02	HORN	08A	DPWA	Multichannel	

$\Gamma(\Delta(1232)\eta)/\Gamma_{\text{total}}$					Γ_{12}/Γ
<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. • • •					
0.02±0.01	HORN	08A	DPWA	Multichannel	

$\Delta(1700)$ PHOTON DECAY AMPLITUDES

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

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

<u>VALUE ($\text{GeV}^{-1/2}$)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
+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. • • •				
0.160±0.040	HORN	08A	DPWA	Multichannel
0.226	DRECHSEL	07	DPWA	$\gamma N \rightarrow \pi N$
0.096	PENNER	02D	DPWA	Multichannel
0.121±0.004	LI	93	IPWA	$\gamma N \rightarrow \pi N$

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

<u>VALUE ($\text{GeV}^{-1/2}$)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
+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. • • •				
0.150±0.030	HORN	08A	DPWA	Multichannel
0.210	DRECHSEL	07	DPWA	$\gamma N \rightarrow \pi N$
0.154	PENNER	02D	DPWA	Multichannel
0.115±0.004	LI	93	IPWA	$\gamma N \rightarrow \pi N$

$\Delta(1700)$ 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 LONGACRE 77 considers this coupling to be well determined.

$\Delta(1700)$ REFERENCES

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

HORN	08A	EPJ A38 173	I. Horn <i>et al.</i>	(CB-ELSA Collab.)
Also		PRL 101 202002	I. Horn <i>et al.</i>	(CB-ELSA Collab.)
THOMA	08	PL B659 87	U. Thoma <i>et al.</i>	(CB-ELSA Collab.)
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)
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	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
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 <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)
BARNHAM	80	NP B168 243	K.W.J. Barnham <i>et al.</i>	(LOIC)
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	77	NP B122 493	R.S. Longacre, J. Dolbeau	(SACL) IJP
Also		NP B108 365	J. Dolbeau <i>et al.</i>	(SACL) IJP
LONGACRE	75	PL 55B 415	R.S. Longacre <i>et al.</i>	(LBL, SLAC) IJP