

$\Delta(1700) D_{33}$  $I(J^P) = \frac{3}{2}(\frac{3}{2}^-)$  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
<b>1670 to 1750 (<math>\approx 1700</math>) OUR ESTIMATE</b>			
1687.9 $\pm$ 2.5	ARNDT	04	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. ● ● ●			
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 $^{+13.1}_{-13.0}$	<sup>1</sup> 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	<sup>2</sup> LONGACRE	77	IPWA $\pi N \rightarrow N\pi\pi$
1680	<sup>3</sup> LONGACRE	75	IPWA $\pi N \rightarrow N\pi\pi$

 **$\Delta(1700)$  BREIT-WIGNER WIDTH**

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
<b>200 to 400 (<math>\approx 300</math>) OUR ESTIMATE</b>			
364.8 $\pm$ 16.6	ARNDT	04	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. ● ● ●			
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 $\pm$ 26.0	<sup>1</sup> 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	<sup>2</sup> LONGACRE	77	IPWA $\pi N \rightarrow N\pi\pi$
240	<sup>3</sup> 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>
<b>1620 to 1680 (<math>\approx 1650</math>) OUR ESTIMATE</b>			
1617	ARNDT	04	DPWA $\pi N \rightarrow \pi N, \eta N$
1651	<sup>4</sup> 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
1655	ARNDT	95	DPWA $\pi N \rightarrow N\pi$
1646	ARNDT	91	DPWA $\pi N \rightarrow \pi N$ Soln SM90
1681 or 1672	<sup>5</sup> LONGACRE	78	IPWA $\pi N \rightarrow N\pi\pi$
1600 or 1594	<sup>2</sup> 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>
<b>160 to 240 (<math>\approx 200</math>) OUR ESTIMATE</b>			
226	ARNDT	04	DPWA $\pi N \rightarrow \pi N, \eta N$
159	<sup>4</sup> 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
242	ARNDT	95	DPWA $\pi N \rightarrow N\pi$
208	ARNDT	91	DPWA $\pi N \rightarrow \pi N$ Soln SM90
245 or 241	<sup>5</sup> LONGACRE	78	IPWA $\pi N \rightarrow N\pi\pi$
208 or 201	<sup>2</sup> 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	04	DPWA $\pi N \rightarrow \pi N, \eta N$
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. ● ● ●			
16	ARNDT	95	DPWA $\pi N \rightarrow N\pi$
13	ARNDT	91	DPWA $\pi N \rightarrow \pi N$ Soln SM90

**PHASE  $\theta$** 

<u>VALUE (<math>^\circ</math>)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
–47	ARNDT	04	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. ● ● ●			
–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 ( $\Gamma_i/\Gamma$ )
$\Gamma_1$ $N\pi$	10–20 %
$\Gamma_2$ $\Sigma K$	
$\Gamma_3$ $N\pi\pi$	80–90 %
$\Gamma_4$ $\Delta\pi$	30–60 %
$\Gamma_5$ $\Delta(1232)\pi$ , <i>S</i> -wave	25–50 %
$\Gamma_6$ $\Delta(1232)\pi$ , <i>D</i> -wave	1–7 %
$\Gamma_7$ $N\rho$	30–55 %
$\Gamma_8$ $N\rho$ , <i>S</i> =1/2, <i>D</i> -wave	
$\Gamma_9$ $N\rho$ , <i>S</i> =3/2, <i>S</i> -wave	5–20 %
$\Gamma_{10}$ $N\rho$ , <i>S</i> =3/2, <i>D</i> -wave	
$\Gamma_{11}$ $N\gamma$	0.12–0.26 %
$\Gamma_{12}$ $N\gamma$ , helicity=1/2	0.08–0.16 %
$\Gamma_{13}$ $N\gamma$ , helicity=3/2	0.025–0.12 %

## $\Delta(1700)$ BRANCHING RATIOS

$\Gamma(N\pi)/\Gamma_{\text{total}}$	$\Gamma_1/\Gamma$
<u>VALUE</u>	<u>DOCUMENT ID</u> <u>TECN</u> <u>COMMENT</u>
<b>0.10 to 0.20 OUR ESTIMATE</b>	
0.150 ± 0.001	ARNDT    04    DPWA $\pi N \rightarrow \pi N, \eta N$
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	<sup>1</sup> 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	<sup>6</sup> 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>
<b>+0.21 to +0.29 OUR ESTIMATE</b>			
+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	<sup>2,7</sup> LONGACRE	77	IPWA $\pi N \rightarrow N\pi\pi$
+0.24	<sup>3</sup> LONGACRE	75	IPWA $\pi N \rightarrow N\pi\pi$

**$\Gamma(\Delta(1232)\pi, S\text{-wave}) / \Gamma_{\text{total}}$   $\Gamma_5 / \Gamma$**

<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>
<b>+0.05 to +0.11 OUR ESTIMATE</b>			
+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	<sup>2,7</sup> LONGACRE	77	IPWA $\pi N \rightarrow N\pi\pi$
+0.10	<sup>3</sup> LONGACRE	75	IPWA $\pi N \rightarrow N\pi\pi$

**$\Gamma(\Delta(1232)\pi, D\text{-wave}) / \Gamma_{\text{total}}$   $\Gamma_6 / \Gamma$**

<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>
<b>±0.11 to ±0.19 OUR ESTIMATE</b>			
+0.10±0.03	MANLEY	92	IPWA $\pi N \rightarrow \pi N$ & $N\pi\pi$
+0.04	<sup>2,7</sup> LONGACRE	77	IPWA $\pi N \rightarrow N\pi\pi$
-0.30	<sup>3</sup> LONGACRE	75	IPWA $\pi N \rightarrow N\pi\pi$

**$\Gamma(N\rho, S=3/2, S\text{-wave}) / \Gamma_{\text{total}}$   $\Gamma_9 / \Gamma$**

<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
<b>+0.104±0.015 OUR ESTIMATE</b>			
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
<b>+0.085±0.022 OUR ESTIMATE</b>			
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**

<sup>1</sup> Problems with CHEW 80 are discussed in section 2.1.11 of HOEHLER 83.

<sup>2</sup> 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.

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

<sup>4</sup> See HOEHLER 93 for a detailed discussion of the evidence for and the pole parameters of  $N$  and  $\Delta$  resonances as determined from Argand diagrams of  $\pi N$  elastic partial-wave amplitudes and from plots of the speeds with which the amplitudes traverse the diagrams.

<sup>5</sup> 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.

<sup>6</sup> 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.

<sup>7</sup> LONGACRE 77 considers this coupling to be well determined.

**$\Delta(1700)$  REFERENCES**For early references, see Physics Letters **111B** 70 (1982).

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	$\pi N$ 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		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		NP B197 365	K. Fujii <i>et al.</i>	(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 <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		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		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		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