

$\Delta(1620) S_{31}$  $I(J^P) = \frac{3}{2}(\frac{1}{2}^-)$  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).

 **$\Delta(1620)$  BREIT-WIGNER MASS**

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>1600 to 1660 (<math>\approx 1630</math>) OUR ESTIMATE</b>			
1614.1 $\pm$ 1.1	ARNDT	04	DPWA $\pi N \rightarrow \pi N, \eta N$
1672 $\pm$ 7	MANLEY	92	IPWA $\pi N \rightarrow \pi N$ & $N\pi\pi$
1620 $\pm$ 20	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
1610 $\pm$ 7	HOEHLER	79	IPWA $\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
1612 $\pm$ 2	PENNER	02C	DPWA Multichannel
1617 $\pm$ 15	VRANA	00	DPWA Multichannel
1672 $\pm$ 5	ARNDT	96	IPWA $\gamma N \rightarrow \pi N$
1617	ARNDT	95	DPWA $\pi N \rightarrow N\pi$
1669	LI	93	IPWA $\gamma N \rightarrow \pi N$
1620	BARNHAM	80	IPWA $\pi N \rightarrow N\pi\pi$
1712.8 $\pm$ 6.0	<sup>1</sup> CHEW	80	BPWA $\pi^+ p \rightarrow \pi^+ p$
1786.7 $\pm$ 2.0	<sup>1</sup> CHEW	80	BPWA $\pi^+ p \rightarrow \pi^+ p$
1657	CRAWFORD	80	DPWA $\gamma N \rightarrow \pi N$
1662	BARBOUR	78	DPWA $\gamma N \rightarrow \pi N$
1580	<sup>2</sup> LONGACRE	77	IPWA $\pi N \rightarrow N\pi\pi$
1600	<sup>3</sup> LONGACRE	75	IPWA $\pi N \rightarrow N\pi\pi$

 **$\Delta(1620)$  BREIT-WIGNER WIDTH**

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>135 to 150 (<math>\approx 145</math>) OUR ESTIMATE</b>			
141.0 $\pm$ 6.0	ARNDT	04	DPWA $\pi N \rightarrow \pi N, \eta N$
154 $\pm$ 37	MANLEY	92	IPWA $\pi N \rightarrow \pi N$ & $N\pi\pi$
140 $\pm$ 20	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
139 $\pm$ 18	HOEHLER	79	IPWA $\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
202 $\pm$ 7	PENNER	02C	DPWA Multichannel
143 $\pm$ 42	VRANA	00	DPWA Multichannel
147 $\pm$ 8	ARNDT	96	IPWA $\gamma N \rightarrow \pi N$
108	ARNDT	95	DPWA $\pi N \rightarrow N\pi$
184	LI	93	IPWA $\gamma N \rightarrow \pi N$
120	BARNHAM	80	IPWA $\pi N \rightarrow N\pi\pi$
228.3 $\pm$ 18.0	<sup>1</sup> CHEW	80	BPWA $\pi^+ p \rightarrow \pi^+ p$ (lower mass)
30.0 $\pm$ 6.4	<sup>1</sup> CHEW	80	BPWA $\pi^+ p \rightarrow \pi^+ p$ (higher mass)

161	CRAWFORD	80	DPWA	$\gamma N \rightarrow \pi N$
180	BARBOUR	78	DPWA	$\gamma N \rightarrow \pi N$
120	<sup>2</sup> LONGACRE	77	IPWA	$\pi N \rightarrow N\pi\pi$
150	<sup>3</sup> LONGACRE	75	IPWA	$\pi N \rightarrow N\pi\pi$

### $\Delta(1620)$ POLE POSITION

#### REAL PART

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>1590 to 1610 (<math>\approx 1600</math>) OUR ESTIMATE</b>			
1594	ARNDT	04	DPWA $\pi N \rightarrow \pi N, \eta N$
1608	<sup>4</sup> HOEHLER	93	SPED $\pi N \rightarrow \pi N$
1600 $\pm$ 15	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
1607	VRANA	00	DPWA Multichannel
1585	ARNDT	95	DPWA $\pi N \rightarrow N\pi$
1587	ARNDT	91	DPWA $\pi N \rightarrow \pi N$ Soln SM90
1583 or 1583	<sup>5</sup> LONGACRE	78	IPWA $\pi N \rightarrow N\pi\pi$
1575 or 1572	<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>115 to 120 (<math>\approx 118</math>) OUR ESTIMATE</b>			
118	ARNDT	04	DPWA $\pi N \rightarrow \pi N, \eta N$
116	<sup>4</sup> HOEHLER	93	SPED $\pi N \rightarrow \pi N$
120 $\pm$ 20	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
148	VRANA	00	DPWA Multichannel
104	ARNDT	95	DPWA $\pi N \rightarrow N\pi$
120	ARNDT	91	DPWA $\pi N \rightarrow \pi N$ Soln SM90
143 or 149	<sup>5</sup> LONGACRE	78	IPWA $\pi N \rightarrow N\pi\pi$
119 or 128	<sup>2</sup> LONGACRE	77	IPWA $\pi N \rightarrow N\pi\pi$

### $\Delta(1620)$ ELASTIC POLE RESIDUE

#### MODULUS $|r|$

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
17	ARNDT	04	DPWA $\pi N \rightarrow \pi N, \eta N$
19	HOEHLER	93	SPED $\pi N \rightarrow \pi N$
15 $\pm$ 2	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
14	ARNDT	95	DPWA $\pi N \rightarrow N\pi$
15	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>
-104	ARNDT	04	DPWA $\pi N \rightarrow \pi N, \eta N$
-95	HOEHLER	93	SPED $\pi N \rightarrow \pi N$
-110 $\pm$ 20	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
-121	ARNDT	95	DPWA $\pi N \rightarrow N\pi$
-125	ARNDT	91	DPWA $\pi N \rightarrow \pi N$ Soln SM90

## $\Delta(1620)$ DECAY MODES

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

Mode	Fraction ( $\Gamma_j/\Gamma$ )
$\Gamma_1$ $N\pi$	20–30 %
$\Gamma_2$ $N\pi\pi$	70–80 %
$\Gamma_3$ $\Delta\pi$	30–60 %
$\Gamma_4$ $\Delta(1232)\pi$ , <i>D-wave</i>	
$\Gamma_5$ $N\rho$	7–25 %
$\Gamma_6$ $N\rho$ , <i>S=1/2, S-wave</i>	
$\Gamma_7$ $N\rho$ , <i>S=3/2, D-wave</i>	
$\Gamma_8$ $N(1440)\pi$	
$\Gamma_9$ $N\gamma$	0.004–0.044 %
$\Gamma_{10}$ $N\gamma$ , helicity=1/2	0.004–0.044 %

## $\Delta(1620)$ BRANCHING RATIOS

<u><math>\Gamma(N\pi)/\Gamma_{\text{total}}</math></u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	<u><math>\Gamma_1/\Gamma</math></u>
<b>0.2 to 0.3 OUR ESTIMATE</b>				
0.310 $\pm$ 0.004	ARNDT	04	DPWA $\pi N \rightarrow \pi N, \eta N$	
0.09 $\pm$ 0.02	MANLEY	92	IPWA $\pi N \rightarrow \pi N$ & $N\pi\pi$	
0.25 $\pm$ 0.03	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$	
0.35 $\pm$ 0.06	HOEHLER	79	IPWA $\pi N \rightarrow \pi N$	
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
0.34 $\pm$ 0.01	PENNER	02C	DPWA Multichannel	
0.45 $\pm$ 0.05	VRANA	00	DPWA Multichannel	
0.29	ARNDT	95	DPWA $\pi N \rightarrow N\pi$	
0.60	<sup>1</sup> CHEW	80	BPWA $\pi^+ p \rightarrow \pi^+ p$ (lower mass)	
0.36	<sup>1</sup> CHEW	80	BPWA $\pi^+ p \rightarrow \pi^+ p$ (higher mass)	

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  $N\pi \rightarrow \Delta(1620) \rightarrow \Delta(1232)\pi$ , *D-wave*  $(\Gamma_1 \Gamma_4)^{1/2} / \Gamma$**

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>−0.36 to −0.28 OUR ESTIMATE</b>			
−0.24 ± 0.03	MANLEY	92	IPWA $\pi N \rightarrow \pi N$ & $N\pi\pi$
−0.33 ± 0.06	BARNHAM	80	IPWA $\pi N \rightarrow N\pi\pi$
−0.39	<sup>2,6</sup> LONGACRE	77	IPWA $\pi N \rightarrow N\pi\pi$
−0.40	<sup>3</sup> LONGACRE	75	IPWA $\pi N \rightarrow N\pi\pi$

**$\Gamma(\Delta(1232)\pi, D\text{-wave}) / \Gamma_{\text{total}}$   $\Gamma_4 / \Gamma$**

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.39 ± 0.02	VRANA	00	DPWA Multichannel

**$(\Gamma_i \Gamma_f)^{1/2} / \Gamma_{\text{total}}$  in  $N\pi \rightarrow \Delta(1620) \rightarrow N\rho, S=1/2, S\text{-wave}$   $(\Gamma_1 \Gamma_6)^{1/2} / \Gamma$**

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>+0.12 to +0.22 OUR ESTIMATE</b>			
+0.15 ± 0.02	MANLEY	92	IPWA $\pi N \rightarrow \pi N$ & $N\pi\pi$
+0.40 ± 0.10	BARNHAM	80	IPWA $\pi N \rightarrow N\pi\pi$
+0.08	<sup>2,6</sup> LONGACRE	77	IPWA $\pi N \rightarrow N\pi\pi$
+0.28	<sup>3</sup> LONGACRE	75	IPWA $\pi N \rightarrow N\pi\pi$

**$\Gamma(N\rho, S=1/2, S\text{-wave}) / \Gamma_{\text{total}}$   $\Gamma_6 / \Gamma$**

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.14 ± 0.03	VRANA	00	DPWA Multichannel

**$(\Gamma_i \Gamma_f)^{1/2} / \Gamma_{\text{total}}$  in  $N\pi \rightarrow \Delta(1620) \rightarrow N\rho, S=3/2, D\text{-wave}$   $(\Gamma_1 \Gamma_7)^{1/2} / \Gamma$**

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>−0.15 to −0.03 OUR ESTIMATE</b>			
−0.06 ± 0.02	MANLEY	92	IPWA $\pi N \rightarrow \pi N$ & $N\pi\pi$
−0.13	<sup>2,6</sup> LONGACRE	77	IPWA $\pi N \rightarrow N\pi\pi$

**$\Gamma(N\rho, S=3/2, D\text{-wave}) / \Gamma_{\text{total}}$   $\Gamma_7 / \Gamma$**

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.02 ± 0.01	VRANA	00	DPWA Multichannel

**$(\Gamma_i \Gamma_f)^{1/2} / \Gamma_{\text{total}}$  in  $N\pi \rightarrow \Delta(1620) \rightarrow N(1440)\pi$   $(\Gamma_1 \Gamma_8)^{1/2} / \Gamma$**

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.11 ± 0.05	BARNHAM	80	IPWA $\pi N \rightarrow N\pi\pi$

**$\Gamma(N(1440)\pi) / \Gamma_{\text{total}}$   $\Gamma_8 / \Gamma$**

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.00 ± 0.01	VRANA	00	DPWA Multichannel

**$\Delta(1620)$  PHOTON DECAY AMPLITUDES** **$\Delta(1620) \rightarrow N\gamma$ , helicity-1/2 amplitude  $A_{1/2}$** 

VALUE ( $\text{GeV}^{-1/2}$ )	DOCUMENT ID	TECN	COMMENT
<b>+0.027±0.011 OUR ESTIMATE</b>			
0.035±0.020	ARNDT	96	IPWA $\gamma N \rightarrow \pi N$
0.035±0.010	CRAWFORD	83	IPWA $\gamma N \rightarrow \pi N$
0.010±0.015	AWAJI	81	DPWA $\gamma N \rightarrow \pi N$
-0.022±0.007	ARAI	80	DPWA $\gamma N \rightarrow \pi N$ (fit 1)
-0.026±0.008	ARAI	80	DPWA $\gamma N \rightarrow \pi N$ (fit 2)
0.021±0.020	CRAWFORD	80	DPWA $\gamma N \rightarrow \pi N$
0.126±0.021	TAKEDA	80	DPWA $\gamma N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
-0.050	PENNER	02D	DPWA Multichannel
0.042±0.003	LI	93	IPWA $\gamma N \rightarrow \pi N$
0.066	WADA	84	DPWA Compton scattering
+0.034±0.028	BARBOUR	78	DPWA $\gamma N \rightarrow \pi N$
-0.005±0.016	FELLER	76	DPWA $\gamma N \rightarrow \pi N$

 **$\Delta(1620)$  FOOTNOTES**

- <sup>1</sup> CHEW 80 reports two  $S_{31}$  resonances at somewhat higher masses than other analyses. Problems with this analysis 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> LONGACRE 77 considers this coupling to be well determined.

 **$\Delta(1620)$  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
WADA	84	NP B247 313	Y. Wada <i>et al.</i>	(INUS)
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
TAKEDA	80	NP B168 17	H. Takeda <i>et al.</i>	(TOKY, INUS)
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
FELLER	76	NP B104 219	P. Feller <i>et al.</i>	(NAGO, OSAK) IJP
LONGACRE	75	PL 55B 415	R.S. Longacre <i>et al.</i>	(LBL, SLAC) IJP

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