

**$\Delta(1620) S_{31}$** 

$$I(J^P) = \frac{3}{2}(\frac{1}{2}^-) \text{ Status: } ****$$

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**

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
<b>1615 to 1675 (<math>\approx 1620</math>) OUR ESTIMATE</b>			
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. ● ● ●			
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**

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
<b>120 to 180 (<math>\approx 150</math>) OUR ESTIMATE</b>			
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. ● ● ●			
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>1580 to 1620 (<math>\approx</math> 1600) OUR ESTIMATE</b>			
1585	ARNDT	95	DPWA $\pi N \rightarrow N\pi$
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. ● ● ●			
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>100 to 130 (<math>\approx</math> 115) OUR ESTIMATE</b>			
104	ARNDT	95	DPWA $\pi N \rightarrow N\pi$
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. ● ● ●			
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>
14	ARNDT	95	DPWA $\pi N \rightarrow N\pi$
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. ● ● ●			
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>
–121	ARNDT	95	DPWA $\pi N \rightarrow N\pi$
–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. ● ● ●			
–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 ( $\Gamma_i/\Gamma$ )
$\Gamma_1$ $N\pi$	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 %
$\Gamma_6$ $N\rho$ , $S=1/2$ , <i>S-wave</i>	
$\Gamma_7$ $N\rho$ , $S=3/2$ , <i>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

$\Gamma(N\pi)/\Gamma_{\text{total}}$				$\Gamma_1/\Gamma$
<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
<b>0.2 to 0.3 OUR ESTIMATE</b>				
0.09±0.02	MANLEY	92	IPWA $\pi N \rightarrow \pi N$ & $N\pi\pi$	
0.25±0.03	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$	
0.35±0.06	HOEHLER	79	IPWA $\pi N \rightarrow \pi N$	
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
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 $N\pi \rightarrow \Delta(1620) \rightarrow \Delta(1232)\pi$ , <i>D-wave</i>				$(\Gamma_1\Gamma_4)^{1/2}/\Gamma$
<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 $\pi N \rightarrow N\pi\pi$	

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

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

$(\Gamma_i \Gamma_f)^{1/2} / \Gamma_{\text{total}}$ in $N\pi \rightarrow \Delta(1620) \rightarrow N(1440)\pi$	$(\Gamma_1 \Gamma_8)^{1/2} / \Gamma$		
VALUE	DOCUMENT ID	TECN	COMMENT
0.11 ± 0.05	BARNHAM	80	IPWA $\pi N \rightarrow N\pi\pi$

### $\Delta(1620)$ 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. ● ● ●			
0.042 ± 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.

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## $\Delta(1620)$ REFERENCES

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

ARNDT	96	PR C53 430	+Strakovsky, Workman	(VPI)
ARNDT	95	PR C52 2120	+Strakovsky, Workman, Pavan	(VPI, BRCO)
HOEHLER	93	$\pi N$ Newsletter 9 1		(KARL)
LI	93	PR C47 2759	+Arndt, Roper, Workman	(VPI)
MANLEY	92	PR D45 4002	+Saleski	(KENT) IJP
Also	84	PR D30 904	Manley, Arndt, Goradia, Teplitz	(VPI)
ARNDT	91	PR D43 2131	+Li, Roper, Workman, Ford	(VPI, TELE) IJP
WADA	84	NP B247 313	+Egawa, Imanishi, Ishii, Kato, Ukai+	(INUS)
CRAWFORD	83	NP B211 1	+Morton	(GLAS)
HOEHLER	83	Landolt-Boernstein 1/9B2		(KARLT)
PDG	82	PL 111B	Roos, Porter, Aguilar-Benitez+	(HELS, CIT, CERN)
AWAJI	81	Bonn Conf. 352	+Kajikawa	(NAGO)
Also	82	NP B197 365	Fujii, Hayashii, Iwata, Kajikawa+	(NAGO)
ARAI	80	Toronto Conf. 93		(INUS)
Also	82	NP B194 251	Arai, Fujii	(INUS)
BARNHAM	80	NP B168 243	+Glickman, Mier-Jedrzejowicz+	(LOIC)
CHEW	80	Toronto Conf. 123		(LBL) IJP
CRAWFORD	80	Toronto Conf. 107		(GLAS)
CUTKOSKY	80	Toronto Conf. 19	+Forsyth, Babcock, Kelly, Hendrick	(CMU, LBL) IJP
Also	79	PR D20 2839	Cutkosky, Forsyth, Hendrick, Kelly	(CMU, LBL) IJP
TAKEDA	80	NP B168 17	+Arai, Fujii, Ikeda, Iwasaki+	(TOKY, INUS)
HOEHLER	79	PDAT 12-1	+Kaiser, Koch, Pietarinen	(KARLT) IJP
Also	80	Toronto Conf. 3	Koch	(KARLT) IJP
BARBOUR	78	NP B141 253	+Crawford, Parsons	(GLAS)
LONGACRE	78	PR D17 1795	+Lasinski, Rosenfeld, Smadja+	(LBL, SLAC)
LONGACRE	77	NP B122 493	+Dolbeau	(SACL) IJP
Also	76	NP B108 365	Dolbeau, Triantis, Neveu, Cadiet	(SACL) IJP
FELLER	76	NP B104 219	+Fukushima, Horikawa, Kajikawa+	(NAGO, OSAK) IJP
LONGACRE	75	PL 55B 415	+Rosenfeld, Lasinski, Smadja+	(LBL, SLAC) IJP

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