

$\Delta(1930) 5/2^-$  $I(J^P) = \frac{3}{2}(\frac{5}{2}^-)$  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* **G33** 1 (2006).

 **$\Delta(1930)$  BREIT-WIGNER MASS**

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
<b>1900 to 2000 (<math>\approx</math> 1950) OUR ESTIMATE</b>			
2233 $\pm$ 53	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
1940 $\pm$ 30	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
1901 $\pm$ 15	HOEHLER	79	IPWA $\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •			
1930 $\pm$ 12	SHRESTHA	12A	DPWA Multichannel
2046 $\pm$ 45	ARNDT	04	DPWA $\pi N \rightarrow \pi N, \eta N$
1932 $\pm$ 100	VRANA	00	DPWA Multichannel
1955 $\pm$ 15	ARNDT	96	IPWA $\gamma N \rightarrow \pi N$
2056	ARNDT	95	DPWA $\pi N \rightarrow N\pi$
1963	LI	93	IPWA $\gamma N \rightarrow \pi N$
1956 $\pm$ 22	MANLEY	92	IPWA $\pi N \rightarrow \pi N \& N\pi\pi$
1910.0 <sup>+</sup> <sub>-</sub> 15.0 17.2	CHEW	80	BPWA $\pi^+ p \rightarrow \pi^+ p$

 **$\Delta(1930)$  BREIT-WIGNER WIDTH**

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
<b>220 to 500 (<math>\approx</math> 360) OUR ESTIMATE</b>			
773 $\pm$ 187	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
320 $\pm$ 60	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
195 $\pm$ 60	HOEHLER	79	IPWA $\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •			
235 $\pm$ 39	SHRESTHA	12A	DPWA Multichannel
402 $\pm$ 198	ARNDT	04	DPWA $\pi N \rightarrow \pi N, \eta N$
316 $\pm$ 237	VRANA	00	DPWA Multichannel
350 $\pm$ 20	ARNDT	96	IPWA $\gamma N \rightarrow \pi N$
590	ARNDT	95	DPWA $\pi N \rightarrow N\pi$
260	LI	93	IPWA $\gamma N \rightarrow \pi N$
530 $\pm$ 140	MANLEY	92	IPWA $\pi N \rightarrow \pi N \& N\pi\pi$
74.8 <sup>+</sup> <sub>-</sub> 17.0 16.0	CHEW	80	BPWA $\pi^+ p \rightarrow \pi^+ p$

**$\Delta(1930)$  POLE POSITION****REAL PART**

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>1840 to 1960 (<math>\approx</math> 1900) OUR ESTIMATE</b>			
1848 $\pm$ 9 $\pm$ 19	<sup>1</sup> SVARC	14	MLS $\pi N \rightarrow \pi N$
2001	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
1850	<sup>2</sup> HOEHLER	93	SPED $\pi N \rightarrow \pi N$
1890 $\pm$ 50	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •			
1882	SHRESTHA	12A	DPWA Multichannel
1966	ARNDT	04	DPWA $\pi N \rightarrow \pi N, \eta N$
1883	VRANA	00	DPWA Multichannel
1913	ARNDT	95	DPWA $\pi N \rightarrow N\pi$
2018	ARNDT	91	DPWA $\pi N \rightarrow \pi N$ Soln SM90

**– 2 $\times$ IMAGINARY PART**

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>175 to 360 (<math>\approx</math> 270) OUR ESTIMATE</b>			
321 $\pm$ 17 $\pm$ 7	<sup>1</sup> SVARC	14	MLS $\pi N \rightarrow \pi N$
387	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
180	<sup>2</sup> HOEHLER	93	SPED $\pi N \rightarrow \pi N$
260 $\pm$ 60	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •			
187	SHRESTHA	12A	DPWA Multichannel
364	ARNDT	04	DPWA $\pi N \rightarrow \pi N, \eta N$
250	VRANA	00	DPWA Multichannel
246	ARNDT	95	DPWA $\pi N \rightarrow N\pi$
398	ARNDT	91	DPWA $\pi N \rightarrow \pi N$ Soln SM90

 **$\Delta(1930)$  ELASTIC POLE RESIDUE****MODULUS  $|r|$** 

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
9 $\pm$ 1 $\pm$ 1	<sup>1</sup> SVARC	14	MLS $\pi N \rightarrow \pi N$
7	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
20	HOEHLER	93	SPED $\pi N \rightarrow \pi N$
18 $\pm$ 6	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •			
16	ARNDT	04	DPWA $\pi N \rightarrow \pi N, \eta N$
8	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>
–37 $\pm$ 3 $\pm$ 7	<sup>1</sup> SVARC	14	MLS $\pi N \rightarrow \pi N$
–12	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
–20 $\pm$ 40	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$

• • • We do not use the following data for averages, fits, limits, etc. • • •

–21	ARNDT	04	DPWA	$\pi N \rightarrow \pi N, \eta N$
–47	ARNDT	95	DPWA	$\pi N \rightarrow N\pi$
–24	ARNDT	91	DPWA	$\pi N \rightarrow \pi N$ Soln SM90

### $\Delta(1930)$ DECAY MODES

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

Mode	Fraction ( $\Gamma_i/\Gamma$ )
$\Gamma_1$ $N\pi$	5–15 %
$\Gamma_2$ $\Sigma K$	
$\Gamma_3$ $N\pi\pi$	
$\Gamma_4$ $N\gamma$	0.0–0.02 %
$\Gamma_5$ $N\gamma$ , helicity=1/2	0.0–0.01 %
$\Gamma_6$ $N\gamma$ , helicity=3/2	0.0–0.01 %

### $\Delta(1930)$ BRANCHING RATIOS

$\Gamma(N\pi)/\Gamma_{\text{total}}$   $\Gamma_1/\Gamma$

VALUE (%) DOCUMENT ID TECN COMMENT

**5 to 15 OUR ESTIMATE**

$8.1 \pm 1.2$	ARNDT	06	DPWA	$\pi N \rightarrow \pi N, \eta N$
14 $\pm 4$	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
4 $\pm 3$	HOEHLER	79	IPWA	$\pi N \rightarrow \pi N$

• • • We do not use the following data for averages, fits, limits, etc. • • •

$7.9 \pm 0.4$	SHRESTHA	12A	DPWA	Multichannel
$4.0 \pm 1.4$	ARNDT	04	DPWA	$\pi N \rightarrow \pi N, \eta N$
9 $\pm 8$	VRANA	00	DPWA	Multichannel
11	ARNDT	95	DPWA	$\pi N \rightarrow N\pi$
18 $\pm 2$	MANLEY	92	IPWA	$\pi N \rightarrow \pi N \& N\pi\pi$
11	CHEW	80	BPWA	$\pi^+ p \rightarrow \pi^+ p$

$(\Gamma_i \Gamma_f)^{1/2}/\Gamma_{\text{total}}$  in  $N\pi \rightarrow \Delta(1930) \rightarrow \Sigma K$   $(\Gamma_1 \Gamma_2)^{1/2}/\Gamma$

VALUE DOCUMENT ID TECN COMMENT

$< 0.015$	CANDLIN	84	DPWA	$\pi^+ p \rightarrow \Sigma^+ K^+$
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• • • We do not use the following data for averages, fits, limits, etc. • • •

–0.031	LIVANOS	80	DPWA	$\pi p \rightarrow \Sigma K$
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$(\Gamma_i \Gamma_f)^{1/2}/\Gamma_{\text{total}}$  in  $N\pi \rightarrow \Delta(1930) \rightarrow N\pi\pi$   $(\Gamma_1 \Gamma_3)^{1/2}/\Gamma$

VALUE DOCUMENT ID TECN COMMENT

not seen	LONGACRE	75	IPWA	$\pi N \rightarrow N\pi\pi$
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## $\Delta(1930)$ PHOTON DECAY AMPLITUDES

Papers on  $\gamma N$  amplitudes predating 1981 may be found in our 2006 edition, *Journal of Physics* **G33** 1 (2006).

### $\Delta(1930) \rightarrow N\gamma$ , helicity-1/2 amplitude $A_{1/2}$

VALUE ( $\text{GeV}^{-1/2}$ )	DOCUMENT ID	TECN	COMMENT
<b><math>-0.009 \pm 0.028</math> OUR ESTIMATE</b>			
$-0.007 \pm 0.010$	ARNDT	96	IPWA $\gamma N \rightarrow \pi N$
$0.009 \pm 0.009$	AWAJI	81	DPWA $\gamma N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •			
$0.011 \pm 0.003$	SHRESTHA	12A	DPWA Multichannel
$-0.019 \pm 0.001$	LI	93	IPWA $\gamma N \rightarrow \pi N$

### $\Delta(1930) \rightarrow N\gamma$ , helicity-3/2 amplitude $A_{3/2}$

VALUE ( $\text{GeV}^{-1/2}$ )	DOCUMENT ID	TECN	COMMENT
<b><math>-0.018 \pm 0.028</math> OUR ESTIMATE</b>			
$0.005 \pm 0.010$	ARNDT	96	IPWA $\gamma N \rightarrow \pi N$
$-0.025 \pm 0.011$	AWAJI	81	DPWA $\gamma N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •			
$0.002 \pm 0.002$	SHRESTHA	12A	DPWA Multichannel
$0.009 \pm 0.001$	LI	93	IPWA $\gamma N \rightarrow \pi N$

## $\Delta(1930)$ FOOTNOTES

<sup>1</sup> Fit to the amplitudes of HOEHLER 79.

<sup>2</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.

## $\Delta(1930)$ REFERENCES

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

SVARC	14	PR C89 045205	A. Svarc <i>et al.</i>	
SHRESTHA	12A	PR C86 055203	M. Shrestha, D.M. Manley	(KSU)
ARNDT	06	PR C74 045205	R.A. Arndt <i>et al.</i>	(GWU)
PDG	06	JP G33 1	W.-M. Yao <i>et al.</i>	(PDG Collab.)
ARNDT	04	PR C69 035213	R.A. Arndt <i>et al.</i>	(GWU, TRIU)
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	(KSA) 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
CANDLIN	84	NP B238 477	D.J. Candlin <i>et al.</i>	(EDIN, RAL, LOWC)
PDG	82	PL 111B 1	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)
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
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
LONGACRE	75	PL 55B 415	R.S. Longacre <i>et al.</i>	(LBL, SLAC) IJP