

# Δ(1930) $D_{35}$

$$I(J^P) = \frac{3}{2}(\frac{5}{2}^-) \text{ Status: } ***$$

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).

The various analyses are not in good agreement.

## Δ(1930) BREIT-WIGNER MASS

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
<b>1920 to 1970 (≈ 1930) OUR ESTIMATE</b>			
1956 ± 22	MANLEY	92	IPWA πN → πN & Nππ
1940 ± 30	CUTKOSKY	80	IPWA πN → πN
1901 ± 15	HOEHLER	79	IPWA πN → πN
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
1932 ± 100	VRANA	00	DPWA Multichannel
1955 ± 15	ARNDT	96	IPWA γN → πN
2056	ARNDT	95	DPWA πN → Nπ
1963	LI	93	IPWA γN → πN
1910.0 <sup>+</sup> <sub>-</sub> 15.0 17.2	CHEW	80	BPWA π <sup>+</sup> p → π <sup>+</sup> p
2000	CRAWFORD	80	DPWA γN → πN
2024	BARBOUR	78	DPWA γN → πN

## Δ(1930) BREIT-WIGNER WIDTH

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
<b>250 to 450 (≈ 350) OUR ESTIMATE</b>			
530 ± 140	MANLEY	92	IPWA πN → πN & Nππ
320 ± 60	CUTKOSKY	80	IPWA πN → πN
195 ± 60	HOEHLER	79	IPWA πN → πN
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
316 ± 237	VRANA	00	DPWA Multichannel
350 ± 20	ARNDT	96	IPWA γN → πN
590	ARNDT	95	DPWA πN → Nπ
260	LI	93	IPWA γN → πN
74.8 <sup>+</sup> <sub>-</sub> 17.0 16.0	CHEW	80	BPWA π <sup>+</sup> p → π <sup>+</sup> p
442	CRAWFORD	80	DPWA γN → πN
462	BARBOUR	78	DPWA γN → πN

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

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>1840 to 1940 (<math>\approx</math> 1890) OUR ESTIMATE</b>			
1913	ARNDT	95	DPWA $\pi N \rightarrow N\pi$
1850	<sup>1</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. ● ● ●			
1883	VRANA	00	DPWA Multichannel
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>200 to 300 (<math>\approx</math> 250) OUR ESTIMATE</b>			
246	ARNDT	95	DPWA $\pi N \rightarrow N\pi$
180	<sup>1</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. ● ● ●			
250	VRANA	00	DPWA Multichannel
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>
8	ARNDT	95	DPWA $\pi N \rightarrow N\pi$
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. ● ● ●			
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>
-47	ARNDT	95	DPWA $\pi N \rightarrow N\pi$
-20 $\pm$ 40	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
-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 ( $\Gamma_i/\Gamma$ )
$\Gamma_1$ $N\pi$	10–20 %
$\Gamma_2$ $\Sigma K$	
$\Gamma_3$ $N\pi\pi$	
$\Gamma_4$ $N\gamma$	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

$\Gamma(N\pi)/\Gamma_{\text{total}}$				$\Gamma_1/\Gamma$
<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	

### 0.1 to 0.2 OUR ESTIMATE

0.18±0.02	MANLEY	92	IPWA	πN → πN & Nππ
0.14±0.04	CUTKOSKY	80	IPWA	πN → πN
0.04±0.03	HOEHLER	79	IPWA	πN → πN
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
0.09±0.08	VRANA	00	DPWA	Multichannel
0.11	ARNDT	95	DPWA	πN → Nπ
0.11	CHEW	80	BPWA	π <sup>+</sup> p → π <sup>+</sup> p

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{\text{total}}$ in $N\pi \rightarrow \Delta(1930) \rightarrow \Sigma K$				$(\Gamma_1\Gamma_2)^{1/2}/\Gamma$
<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	

$< 0.015$	CANDLIN	84	DPWA	π <sup>+</sup> p → Σ <sup>+</sup> K <sup>+</sup>
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
-0.031	LIVANOS	80	DPWA	πp → ΣK
0.018 to 0.035	<sup>2</sup> DEANS	75	DPWA	πN → ΣK

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{\text{total}}$ in $N\pi \rightarrow \Delta(1930) \rightarrow N\pi\pi$				$(\Gamma_1\Gamma_3)^{1/2}/\Gamma$
<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	

not seen	LONGACRE	75	IPWA	πN → Nππ
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## $\Delta(1930)$ PHOTON DECAY AMPLITUDES

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

<u>VALUE (GeV<sup>-1/2</sup>)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>-0.009±0.028 OUR ESTIMATE</b>			
-0.007±0.010	ARNDT	96	IPWA γN → πN
0.009±0.009	AWAJI	81	DPWA γN → πN
-0.030±0.047	CRAWFORD	80	DPWA γN → πN
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
-0.019±0.001	LI	93	IPWA γN → πN
-0.062±0.064	BARBOUR	78	DPWA γN → πN

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

<u>VALUE (GeV<sup>-1/2</sup>)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>-0.018±0.028 OUR ESTIMATE</b>			
0.005±0.010	ARNDT	96	IPWA γN → πN
-0.025±0.011	AWAJI	81	DPWA γN → πN
-0.033±0.060	CRAWFORD	80	DPWA γN → πN
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
0.009±0.001	LI	93	IPWA γN → πN
+0.019±0.054	BARBOUR	78	DPWA γN → πN

## $\Delta(1930)$ FOOTNOTES

- <sup>1</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>2</sup> The range given for DEANS 75 is from the four best solutions.

## $\Delta(1930)$ REFERENCES

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

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	84	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	M. Roos <i>et al.</i>	(HELS, CIT, CERN)
AWAJI	81	Bonn Conf. 352	N. Awaji, R. Kajikawa	(NAGO)
Also	82	NP B197 365	K. Fujii <i>et al.</i>	(NAGO)
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	79	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	80	Toronto Conf. 3	R. Koch	(KARLT) IJP
BARBOUR	78	NP B141 253	I.M. Barbour, R.L. Crawford, N.H. Parsons	(GLAS)
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