

**$\Delta(1930) D_{35}$**

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

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.

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

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
<b>1900 to 2020 (<math>\approx</math> 1960) OUR ESTIMATE</b>			
2046 $\pm$ 45	ARNDT	04	DPWA $\pi N \rightarrow \pi N, \eta N$
1956 $\pm$ 22	MANLEY	92	IPWA $\pi N \rightarrow \pi N \& N\pi\pi$
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. ● ● ●			
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 $\gamma N \rightarrow \pi N$
1910.0 <sup>+</sup> 15.0 - 17.2	CHEW	80	BPWA $\pi^+ p \rightarrow \pi^+ p$
2000	CRAWFORD	80	DPWA $\gamma N \rightarrow \pi N$
2024	BARBOUR	78	DPWA $\gamma N \rightarrow \pi N$

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

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
<b>220 to 500 (<math>\approx</math> 360) OUR ESTIMATE</b>			
402 $\pm$ 198	ARNDT	04	DPWA $\pi N \rightarrow \pi N, \eta N$
530 $\pm$ 140	MANLEY	92	IPWA $\pi N \rightarrow \pi N \& N\pi\pi$
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. ● ● ●			
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 $\gamma N \rightarrow \pi N$
74.8 <sup>+</sup> 17.0 - 16.0	CHEW	80	BPWA $\pi^+ p \rightarrow \pi^+ p$
442	CRAWFORD	80	DPWA $\gamma N \rightarrow \pi N$
462	BARBOUR	78	DPWA $\gamma N \rightarrow \pi N$

## $\Delta(1930)$ POLE POSITION

### REAL PART

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>1840 to 1960 (<math>\approx 1900</math>) OUR ESTIMATE</b>			
1966	ARNDT	04	DPWA $\pi N \rightarrow \pi N, \eta N$
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
1913	ARNDT	95	DPWA $\pi N \rightarrow N\pi$
2018	ARNDT	91	DPWA $\pi N \rightarrow \pi N$ Soln SM90

### – 2×IMAGINARY PART

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>175 to 360 (<math>\approx 270</math>) OUR ESTIMATE</b>			
364	ARNDT	04	DPWA $\pi N \rightarrow \pi N, \eta N$
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
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>
16	ARNDT	04	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. ● ● ●			
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>
–21	ARNDT	04	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. ● ● ●			
–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 ( $\Gamma_i/\Gamma$ )
$\Gamma_1$ $N\pi$	0.05 to 0.15
$\Gamma_2$ $\Sigma K$	
$\Gamma_3$ $N\pi\pi$	
$\Gamma_4$ $N\gamma$	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

$\Gamma(N\pi)/\Gamma_{\text{total}}$	$\Gamma_1/\Gamma$
<u>VALUE</u>	<u>DOCUMENT ID</u> <u>TECN</u> <u>COMMENT</u>
<b>0.05 to 0.15 OUR ESTIMATE</b>	
0.040 ± 0.014	ARNDT    04    DPWA $\pi N \rightarrow \pi N, \eta N$
0.18 ± 0.02	MANLEY    92    IPWA $\pi N \rightarrow \pi N \ \& \ N\pi\pi$
0.14 ± 0.04	CUTKOSKY    80    IPWA $\pi N \rightarrow \pi N$
0.04 ± 0.03	HOEHLER    79    IPWA $\pi N \rightarrow \pi N$
● ● ● 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 $\pi N \rightarrow N\pi$
0.11	CHEW    80    BPWA $\pi^+ p \rightarrow \pi^+ p$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{\text{total}}$ in $N\pi \rightarrow \Delta(1930) \rightarrow \Sigma K$	$(\Gamma_1\Gamma_2)^{1/2}/\Gamma$
<u>VALUE</u>	<u>DOCUMENT ID</u> <u>TECN</u> <u>COMMENT</u>
< 0.015	CANDLIN    84    DPWA $\pi^+ p \rightarrow \Sigma^+ K^+$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●	
–0.031	LIVANOS    80    DPWA $\pi p \rightarrow \Sigma K$
0.018 to 0.035	<sup>2</sup> DEANS    75    DPWA $\pi N \rightarrow \Sigma K$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{\text{total}}$ 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 $\pi N \rightarrow N\pi\pi$

## $\Delta(1930)$ PHOTON DECAY AMPLITUDES

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

$\text{VALUE (GeV}^{-1/2}\text{)}$	<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 $\gamma N \rightarrow \pi N$		
0.009 ± 0.009	AWAJI    81    DPWA $\gamma N \rightarrow \pi N$		
–0.030 ± 0.047	CRAWFORD    80    DPWA $\gamma N \rightarrow \pi N$		
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
–0.019 ± 0.001	LI    93    IPWA $\gamma N \rightarrow \pi N$		
–0.062 ± 0.064	BARBOUR    78    DPWA $\gamma N \rightarrow \pi N$		

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

VALUE ( $\text{GeV}^{-1/2}$ )	DOCUMENT ID	TECN	COMMENT
<b>-0.018±0.028 OUR ESTIMATE</b>			
0.005±0.010	ARNDT	96	IPWA $\gamma N \rightarrow \pi N$
-0.025±0.011	AWAJI	81	DPWA $\gamma N \rightarrow \pi N$
-0.033±0.060	CRAWFORD	80	DPWA $\gamma N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
0.009±0.001	LI	93	IPWA $\gamma N \rightarrow \pi N$
+0.019±0.054	BARBOUR	78	DPWA $\gamma N \rightarrow \pi N$

### $\Delta(1930)$ 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).

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, BRCC)
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