$\Delta(1930)$ D_{35}

$I(J^P) = \frac{3}{2}(\frac{5}{2}^-)$ 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).

The various analyses are not in good agreement.

$\Delta(1930)$ BREIT-WIGNER MASS

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
1920 to 1970 (≈ 1930) OUR ESTIMATE				
1956 ± 22	MANLEY	92	IPWA	$\pi N \rightarrow \pi N$ & $N\pi\pi$
1940 ± 30	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
1901 ± 15	HOEHLER	79	IPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1932 ±100	VRANA	00	DPWA	Multichannel
1955 ± 15	ARNDT	96	IPWA	$\gamma N \rightarrow \pi N$
2056	ARNDT	95	DPWA	$\pi N \rightarrow N\pi$
1963	LI	93	IPWA	$\gamma N \rightarrow \pi N$
$1910.0^{+15.0}_{-17.2}$	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*
250 to 450 (≈ 350) OUR ESTIMATE				
530 ±140	MANLEY	92	IPWA	$\pi N \rightarrow \pi N$ & $N\pi\pi$
320 ± 60	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
195 ± 60	HOEHLER	79	IPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
316 ±237	VRANA	00	DPWA	Multichannel
350 ± 20	ARNDT	96	IPWA	$\gamma N \rightarrow \pi N$
590	ARNDT	95	DPWA	$\pi N \rightarrow N\pi$
260	LI	93	IPWA	$\gamma N \rightarrow \pi N$
$74.8^{+17.0}_{-16.0}$	CHEW	80	BPWA	$\pi^+ p \rightarrow \pi^+ p$
442	CRAWFORD	80	DPWA	$\gamma N \rightarrow \pi N$
462	BARBOUR	78	DPWA	$\gamma N \rightarrow \pi N$

Δ(1930) POLE POSITION

REAL PART

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
1840 to 1940 (≈ 1890) OUR ESTIMATE				
1913	ARNDT	95	DPWA	$\pi N \rightarrow N\pi$
1850	[1] HOEHLER	93	SPED	$\pi N \rightarrow \pi N$
1890±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×IMAGINARY PART

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
200 to 300 (≈ 250) OUR ESTIMATE				
246	ARNDT	95	DPWA	$\pi N \rightarrow N\pi$
180	[1] HOEHLER	93	SPED	$\pi N \rightarrow \pi N$
260±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

Δ(1930) ELASTIC POLE RESIDUE

MODULUS |r|

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
8	ARNDT	95	DPWA	$\pi N \rightarrow N\pi$
20	HOEHLER	93	SPED	$\pi N \rightarrow \pi N$
18±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 θ

VALUE (°)	DOCUMENT ID		TECN	COMMENT
−47	ARNDT	95	DPWA	$\pi N \rightarrow N\pi$
−20±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

Δ(1930) DECAY MODES

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

	Mode	Fraction (Γ_i/Γ)
Γ_1	$N\pi$	10–20 %
Γ_2	ΣK	
Γ_3	$N\pi\pi$	
Γ_4	$N\gamma$	0.0–0.02 %
Γ_5	$N\gamma$, helicity=1/2	0.0–0.01 %
Γ_6	$N\gamma$, helicity=3/2	0.0–0.01 %

$\Delta(1930)$ BRANCHING RATIOS

$\Gamma(N\pi)/\Gamma_{total}$ Γ_1/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
0.1 to 0.2 OUR ESTIMATE				
0.18 ± 0.02	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
0.14 ± 0.04	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
0.04 ± 0.03	HOEHLER	79	IPWA	$\pi N \to \pi N$
• • • 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	$\pi N \to N\pi$
0.11	CHEW	80	BPWA	$\pi^+ p \to \pi^+ p$

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

VALUE	DOCUMENT ID		TECN	COMMENT
<0.015	CANDLIN	84	DPWA	$\pi^+ p \to \Sigma^+ K^+$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
-0.031	LIVANOS	80	DPWA	$\pi p \to \Sigma K$
0.018 to 0.035	[2] DEANS	75	DPWA	$\pi N \to \Sigma K$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to \Delta(1930) \to N\pi\pi$ $(\Gamma_1\Gamma_3)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
not seen	LONGACRE	75	IPWA	$\pi N \to N\pi\pi$

$\Delta(1930)$ PHOTON DECAY AMPLITUDES

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

VALUE (GeV$^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
-0.009 ± 0.028 OUR ESTIMATE				
-0.007 ± 0.010	ARNDT	96	IPWA	$\gamma N \to \pi N$
0.009 ± 0.009	AWAJI	81	DPWA	$\gamma N \to \pi N$
-0.030 ± 0.047	CRAWFORD	80	DPWA	$\gamma N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
-0.019 ± 0.001	LI	93	IPWA	$\gamma N \to \pi N$
-0.062 ± 0.064	BARBOUR	78	DPWA	$\gamma N \to \pi N$

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

VALUE (GeV$^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
-0.018 ± 0.028 OUR ESTIMATE				
0.005 ± 0.010	ARNDT	96	IPWA	$\gamma N \to \pi N$
-0.025 ± 0.011	AWAJI	81	DPWA	$\gamma N \to \pi N$
-0.033 ± 0.060	CRAWFORD	80	DPWA	$\gamma N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.009 ± 0.001	LI	93	IPWA	$\gamma N \to \pi N$
$+0.019\pm0.054$	BARBOUR	78	DPWA	$\gamma N \to \pi N$

$\Delta(1930)$ FOOTNOTES

[1] See HOEHLER 93 for a detailed discussion of the evidence for and the pole parameters of N and Δ resonances as determined from Argand diagrams of πN elastic partial-wave amplitudes and from plots of the speeds with which the amplitudes traverse the diagrams.

[2] 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 *et al.*	(VPI, BRCO)
HOEHLER	93	πN Newsletter 9 1	G. Hohler	(KARL)
LI	93	PR C47 2759	Z.J. Li *et al.*	(VPI)
MANLEY	92	PR D45 4002	D.M. Manley, E.M. Saleski	(KENT) IJP
Also	84	PR D30 904	D.M. Manley *et al.*	(VPI)
ARNDT	91	PR D43 2131	R.A. Arndt *et al.*	(VPI, TELE) IJP
CANDLIN	84	NP B238 477	D.J. Candlin *et al.*	(EDIN, RAL, LOWC)
PDG	82	PL 111B	M. Roos *et al.*	(HELS, CIT, CERN)
AWAJI	81	Bonn Conf. 352	N. Awaji, R. Kajikawa	(NAGO)
Also	82	NP B197 365	K. Fujii *et al.*	(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 *et al.*	(CMU, LBL) IJP
Also	79	PR D20 2839	R.E. Cutkosky *et al.*	(CMU, LBL) IJP
LIVANOS	80	Toronto Conf. 35	P. Livanos *et al.*	(SACL) IJP
HOEHLER	79	PDAT 12-1	G. Hohler *et al.*	(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 *et al.*	(SFLA, ALAH) IJP
LONGACRE	75	PL 55B 415	R.S. Longacre *et al.*	(LBL, SLAC) IJP