

Δ(1930) D_{35}

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

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, G **33** 1 (2006).

Δ(1930) BREIT-WIGNER MASS

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
1900 to 2020 (≈ 1960) OUR ESTIMATE			
2233 ± 53	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
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. ● ● ●			
2046 ± 45	ARNDT	04	DPWA $\pi N \rightarrow \pi N, \eta N$
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 $\pi^+ p \rightarrow \pi^+ p$

Δ(1930) BREIT-WIGNER WIDTH

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
220 to 500 (≈ 360) OUR ESTIMATE			
773 ± 187	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
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. ● ● ●			
402 ± 198	ARNDT	04	DPWA $\pi N \rightarrow \pi N, \eta N$
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 $\pi^+ p \rightarrow \pi^+ p$

Δ(1930) POLE POSITION

REAL PART

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
1840 to 1960 (≈ 1900) OUR ESTIMATE			
2001	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
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. • • •

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×IMAGINARY PART

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
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175 to 360 (≈ 270) OUR ESTIMATE

387	ARNDT	06	DPWA	$\pi N \rightarrow \pi N, \eta N$
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. • • •

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>
7	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
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. • • •

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 θ

<u>VALUE (°)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
–12	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
–20±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 (Γ_i/Γ)
Γ_1 $N\pi$	0.05 to 0.15
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

$\Gamma(N\pi)/\Gamma_{\text{total}}$				Γ_1/Γ
<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
0.05 to 0.15 OUR ESTIMATE				
0.081 ± 0.012	ARNDT	06	DPWA	$\pi N \rightarrow \pi N, \eta N$
0.18 ± 0.02	MANLEY	92	IPWA	$\pi N \rightarrow \pi N \text{ \& } N\pi\pi$
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. • • •				
0.040 ± 0.014	ARNDT	04	DPWA	$\pi N \rightarrow \pi N, \eta N$
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	$\pi p \rightarrow \Sigma K$

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

Papers on γN amplitudes predating 1981 may be found in our 2006 edition, Journal of Physics, G **33** 1 (2006).

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

<u>VALUE (GeV^{-1/2})</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
-0.009 ± 0.028 OUR ESTIMATE			
-0.007 ± 0.010	ARNDT	96	IPWA $\gamma N \rightarrow \pi N$
0.009 ± 0.009	AWAJI	81	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 $\gamma N \rightarrow \pi N$

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

<u>VALUE (GeV^{-1/2})</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
-0.018 ± 0.028 OUR ESTIMATE			
0.005 ± 0.010	ARNDT	96	IPWA $\gamma N \rightarrow \pi N$
-0.025 ± 0.011	AWAJI	81	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 $\gamma N \rightarrow \pi N$

$\Delta(1930)$ 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.

$\Delta(1930)$ REFERENCES

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

ARNDT	06	PR C74 045205	R.A. Arndt <i>et al.</i>	(GWU)
PDG	06	JPG 33 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	πN 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		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