$\Delta(1910)$ P_{31}

$I(J^P) = \frac{3}{2}(\frac{1}{2}^+)$ 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).

$\Delta(1910)$ BREIT-WIGNER MASS

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
1870 to 1920 (≈ 1910) OUR ESTIMATE				
1882 ±10	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
1910 ±40	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
1888 ±20	HOEHLER	79	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
2152	ARNDT	95	DPWA	$\pi N \to N\pi$
1960.1±21.0	[1] CHEW	80	BPWA	$\pi^+ p \to \pi^+ p$
$2121.4^{+13.0}_{-14.3}$	[1] CHEW	80	BPWA	$\pi^+ p \to \pi^+ p$
1921	CRAWFORD	80	DPWA	$\gamma N \to \pi N$
1899	BARBOUR	78	DPWA	$\gamma N \to \pi N$
1790	[2] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$

$\Delta(1910)$ BREIT-WIGNER WIDTH

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
190 to 270 (≈ 250) OUR ESTIMATE				
239 ±25	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
225 ±50	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
280 ±50	HOEHLER	79	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
760	ARNDT	95	DPWA	$\pi N \to N\pi$
152.9±60.0	[1] CHEW	80	BPWA	$\pi^+ p \to \pi^+ p$
172.2±37.0	[1] CHEW	80	BPWA	$\pi^+ p \to \pi^+ p$
351	CRAWFORD	80	DPWA	$\gamma N \to \pi N$
230	BARBOUR	78	DPWA	$\gamma N \to \pi N$
170	[2] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$

$\Delta(1910)$ POLE POSITION

REAL PART

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
1830 to 1880 (≈ 1855) OUR ESTIMATE				
1810	ARNDT	95	DPWA	$\pi N \to N\pi$
1874	[3] HOEHLER	93	SPED	$\pi N \to \pi N$
1880±30	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1950	ARNDT	91	DPWA	$\pi N \to \pi N$ Soln SM90
1792 or 1801	[2] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$

−2×IMAGINARY PART

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
200 to 500 (≈ 350) OUR ESTIMATE				
494	ARNDT	95	DPWA	$\pi N \rightarrow N\pi$
283	[3] HOEHLER	93	SPED	$\pi N \rightarrow \pi N$
200±40	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
398	ARNDT	91	DPWA	$\pi N \rightarrow \pi N$ Soln SM90
172 or 165	[2] LONGACRE	77	IPWA	$\pi N \rightarrow N\pi\pi$

Δ(1910) ELASTIC POLE RESIDUE

MODULUS |r|

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
53	ARNDT	95	DPWA	$\pi N \rightarrow N\pi$
38	HOEHLER	93	SPED	$\pi N \rightarrow \pi N$
20±4	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
37	ARNDT	91	DPWA	$\pi N \rightarrow \pi N$ Soln SM90

PHASE θ

VALUE (°)	*DOCUMENT ID*		*TECN*	*COMMENT*
−176	ARNDT	95	DPWA	$\pi N \rightarrow N\pi$
− 90±30	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
− 91	ARNDT	91	DPWA	$\pi N \rightarrow \pi N$ Soln SM90

Δ(1910) DECAY MODES

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

	Mode	Fraction (Γ_i/Γ)
Γ_1	$N\pi$	15–30 %
Γ_2	ΣK	
Γ_3	$N\pi\pi$	
Γ_4	$\Delta\pi$	
Γ_5	$\Delta(1232)\pi$, P-wave	
Γ_6	$N\rho$	
Γ_7	$N\rho$, S=3/2, P-wave	
Γ_8	$N(1440)\pi$	
Γ_9	$N(1440)\pi$, P-wave	
Γ_{10}	$N\gamma$	0.0–0.2 %
Γ_{11}	$N\gamma$, helicity=1/2	0.0–0.2 %

$\Delta(1910)$ BRANCHING RATIOS

$\Gamma(N\pi)/\Gamma_{total}$ — Γ_1/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
0.15 to 0.3 OUR ESTIMATE				
0.23 ± 0.08	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
0.19 ± 0.03	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
0.24 ± 0.06	HOEHLER	79	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.26	ARNDT	95	DPWA	$\pi N \to N\pi$
0.17	[1] CHEW	80	BPWA	$\pi^+ p \to \pi^+ p$
0.40	[1] CHEW	80	BPWA	$\pi^+ p \to \pi^+ p$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to \Delta(1910) \to \Sigma K$ — $(\Gamma_1\Gamma_2)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
$<$ 0.03	CANDLIN	84	DPWA	$\pi^+ p \to \Sigma^+ K^+$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
-0.019	LIVANOS	80	DPWA	$\pi p \to \Sigma K$
0.082 to 0.184	[4] DEANS	75	DPWA	$\pi N \to \Sigma K$

Note: Signs of couplings from $\pi N \to N\pi\pi$ analyses were changed in the 1986 edition to agree with the baryon-first convention; the overall phase ambiguity is resolved by choosing a negative sign for the $\Delta(1620)$ S_{31} coupling to $\Delta(1232)\pi$.

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to \Delta(1910) \to \Delta(1232)\pi$, P-wave — $(\Gamma_1\Gamma_5)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
$+0.06$	[2] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to \Delta(1910) \to N\rho$, S=3/2, P-wave — $(\Gamma_1\Gamma_7)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
$+0.29$	[2] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$+0.17$	[5] NOVOSELLER	78	IPWA	$\pi N \to N\pi\pi$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to \Delta(1910) \to N(1440)\pi$, P-wave — $(\Gamma_1\Gamma_9)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
-0.39 ± 0.04	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$

$\Delta(1910)$ PHOTON DECAY AMPLITUDES

$\Delta(1910) \to N\gamma$, helicity-1/2 amplitude $A_{1/2}$

VALUE ($\mathrm{GeV}^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
+0.003±0.014 OUR ESTIMATE				
−0.002±0.008	ARNDT	96	IPWA	$\gamma N \to \pi N$
0.014±0.030	CRAWFORD	83	IPWA	$\gamma N \to \pi N$
0.025±0.011	AWAJI	81	DPWA	$\gamma N \to \pi N$
−0.012±0.005	ARAI	80	DPWA	$\gamma N \to \pi N$ (fit 1)
−0.031±0.004	ARAI	80	DPWA	$\gamma N \to \pi N$ (fit 2)
−0.005±0.030	CRAWFORD	80	DPWA	$\gamma N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.032±0.003	LI	93	IPWA	$\gamma N \to \pi N$
−0.035±0.021	BARBOUR	78	DPWA	$\gamma N \to \pi N$

$\Delta(1910)$ FOOTNOTES

[1] CHEW 80 reports four resonances in the P_{31} wave — see also the $\Delta(1750)$. Problems with this analysis are discussed in section 2.1.11 of HOEHLER 83.

[2] LONGACRE 77 pole positions are from a search for poles in the unitarized T-matrix; the first (second) value uses, in addition to $\pi N \to N\pi\pi$ data, elastic amplitudes from a Saclay (CERN) partial-wave analysis. The other LONGACRE 77 values are from eyeball fits with Breit-Wigner circles to the T-matrix amplitudes.

[3] 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.

[4] The range given for DEANS 75 is from the four best solutions.

[5] Evidence for this coupling is weak; see NOVOSELLER 78. This coupling assumes the mass is near 1820 MeV.

$\Delta(1910)$ REFERENCES

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

ARNDT	96	PR C53 430	+Strakovsky, Workman	(VPI)
ARNDT	95	PR C52 2120	+Strakovsky, Workman, Pavan	(VPI, BRCO)
HOEHLER	93	πN Newsletter 9 1		(KARL)
LI	93	PR C47 2759	+Arndt, Roper, Workman	(VPI)
MANLEY	92	PR D45 4002	+Saleski	(KENT) IJP
Also	84	PR D30 904	Manley, Arndt, Goradia, Teplitz	(VPI)
ARNDT	91	PR D43 2131	+Li, Roper, Workman, Ford	(VPI, TELE) IJP
CANDLIN	84	NP B238 477	+Lowe, Peach, Scotland+	(EDIN, RAL, LOWC)
CRAWFORD	83	NP B211 1	+Morton	(GLAS)
HOEHLER	83	Landolt-Boernstein 1/9B2		(KARLT)
PDG	82	PL 111B	Roos, Porter, Aguilar-Benitez+	(HELS, CIT, CERN)
AWAJI	81	Bonn Conf. 352	+Kajikawa	(NAGO)
Also	82	NP B197 365	Fujii, Hayashii, Iwata, Kajikawa+	(NAGO)
ARAI	80	Toronto Conf. 93		(INUS)
Also	82	NP B194 251	Arai, Fujii	(INUS)

CHEW	80	Toronto Conf. 123		(LBL) IJP
CRAWFORD	80	Toronto Conf. 107		(GLAS)
CUTKOSKY	80	Toronto Conf. 19	+Forsyth, Babcock, Kelly, Hendrick	(CMU, LBL) IJP
Also	79	PR D20 2839	Cutkosky, Forsyth, Hendrick, Kelly	(CMU, LBL) IJP
LIVANOS	80	Toronto Conf. 35	+Baton, Coutures, Kochowski, Neveu	(SACL) IJP
HOEHLER	79	PDAT 12-1	+Kaiser, Koch, Pietarinen	(KARLT) IJP
Also	80	Toronto Conf. 3	Koch	(KARLT) IJP
BARBOUR	78	NP B141 253	+Crawford, Parsons	(GLAS)
NOVOSELLER	78	NP B137 509		(CIT) IJP
Also	78B	NP B137 445	Novoseller	(CIT) IJP
LONGACRE	77	NP B122 493	+Dolbeau	(SACL) IJP
Also	76	NP B108 365	Dolbeau, Triantis, Neveu, Cadiet	(SACL) IJP
DEANS	75	NP B96 90	+Mitchell, Montgomery+	(SFLA, ALAH) IJP