$\Delta(1910)\ 1/2^+$

$I(J^P) = \frac{3}{2}(\frac{1}{2}^+)$ 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 **G33** 1 (2006).

$\Delta(1910)$ BREIT-WIGNER MASS

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
1860 to 1910 (≈ 1890) OUR ESTIMATE				
1845 ±40	GUTZ	14	DPWA	Multichannel
1860 ±40	ANISOVICH	12A	DPWA	Multichannel
2067.9± 1.7	ARNDT	06	DPWA	$\pi N \to \pi N, \eta N$
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. • • •				
1934 ± 5	SHRESTHA	12A	DPWA	Multichannel
1995 ±12	VRANA	00	DPWA	Multichannel
2152	ARNDT	95	DPWA	$\pi N \to N\pi$
1882 ±10	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
1960.1±21.0	[1] CHEW	80	BPWA	$\pi^+ p \to \pi^+ p$
$2121.4^{+13.0}_{-14.3}$	[1] CHEW	80	BPWA	$\pi^+ p \to \pi^+ p$
1790	[2] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$

$\Delta(1910)$ BREIT-WIGNER WIDTH

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
220 to 340 (≈ 280) OUR ESTIMATE				
360 ± 60	GUTZ	14	DPWA	Multichannel
350 ± 55	ANISOVICH	12A	DPWA	Multichannel
543 ± 10	ARNDT	06	DPWA	$\pi N \to \pi N, \eta N$
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. • • •				
211 ± 11	SHRESTHA	12A	DPWA	Multichannel
713 ±465	VRANA	00	DPWA	Multichannel
760	ARNDT	95	DPWA	$\pi N \to N\pi$
239 ± 25	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
152.9± 60.0	[1] CHEW	80	BPWA	$\pi^+ p \to \pi^+ p$
172.2± 37.0	[1] CHEW	80	BPWA	$\pi^+ p \to \pi^+ p$
170	[2] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$

Δ(1910) POLE POSITION

REAL PART

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
1830 to 1880 (≈ 1855) OUR ESTIMATE				
1840±40	GUTZ	14	DPWA	Multichannel
1896±11	[3] SVARC	14	MLS	$\pi N \rightarrow \pi N$
1850±40	ANISOVICH	12A	DPWA	Multichannel
1771	ARNDT	06	DPWA	$\pi N \rightarrow \pi N$, ηN
1874	[4] HOEHLER	93	SPED	$\pi N \rightarrow \pi N$
1880±30	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1910	SHRESTHA	12A	DPWA	Multichannel
1880	VRANA	00	DPWA	Multichannel
1810	ARNDT	95	DPWA	$\pi N \rightarrow N\pi$
1950	ARNDT	91	DPWA	$\pi N \rightarrow \pi N$ Soln SM90
1792 or 1801	[2] LONGACRE	77	IPWA	$\pi N \rightarrow N\pi\pi$

−2×IMAGINARY PART

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
200 to 500 (≈ 350) OUR ESTIMATE				
370±60	GUTZ	14	DPWA	Multichannel
302±22	[3] SVARC	14	MLS	$\pi N \rightarrow \pi N$
350±45	ANISOVICH	12A	DPWA	Multichannel
479	ARNDT	06	DPWA	$\pi N \rightarrow \pi N$, ηN
283	[4] 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. • • •				
199	SHRESTHA	12A	DPWA	Multichannel
496	VRANA	00	DPWA	Multichannel
494	ARNDT	95	DPWA	$\pi N \rightarrow N\pi$
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
25±6	GUTZ	14	DPWA	Multichannel
29±2	[3] SVARC	14	MLS	$\pi N \rightarrow \pi N$
24±6	ANISOVICH	12A	DPWA	Multichannel
45	ARNDT	06	DPWA	$\pi N \rightarrow \pi N$, ηN
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. • • •				
53	ARNDT	95	DPWA	$\pi N \rightarrow N\pi$
37	ARNDT	91	DPWA	$\pi N \rightarrow \pi N$ Soln SM90

PHASE θ

VALUE (°)	DOCUMENT ID		TECN	COMMENT
-155 ± 30	GUTZ	14	DPWA	Multichannel
$-\ 83\pm\ 4\pm1$	[3] SVARC	14	MLS	$\pi N \to \pi N$
-145 ± 30	ANISOVICH	12A	DPWA	Multichannel
$+172$	ARNDT	06	DPWA	$\pi N \to \pi N$, ηN
$-\ 90\pm30$	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
-176	ARNDT	95	DPWA	$\pi N \to N\pi$
$-\ 91$	ARNDT	91	DPWA	$\pi N \to \pi N$ Soln SM90

$\Delta(1910)$ INELASTIC POLE RESIDUE

The "normalized residue" is the residue divided by $\Gamma_{pole}/2$.

Normalized residue in $N\pi \to \Delta(1910) \to \Sigma K$

MODULUS (%)	PHASE (°)	DOCUMENT ID		TECN	COMMENT
7±2	**−110 ± 30**	ANISOVICH	12A	DPWA	Multichannel

Normalized residue in $N\pi \to \Delta(1910) \to \Delta\pi$, P-wave

MODULUS (%)	PHASE (°)	DOCUMENT ID		TECN	COMMENT
16±9	**95 ± 40**	ANISOVICH	12A	DPWA	Multichannel

Normalized residue in $N\pi \to \Delta(1910) \to \Delta(1232)\eta$

MODULUS (%)	PHASE (°)	DOCUMENT ID		TECN	COMMENT
11±4	**−150 ± 50**	GUTZ	14	DPWA	Multichannel

$\Delta(1910)$ 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	(9± 5) %
Γ_3	$N\pi\pi$	
Γ_4	$\Delta\pi$	(60±28) %
Γ_5	$\Delta(1232)\pi$, P-wave	
Γ_6	$\Delta(1232)\eta$	(9± 4) %
Γ_7	$N\rho$	
Γ_8	$N\rho$, S=3/2, P-wave	
Γ_9	$N(1440)\pi$	
Γ_{10}	$N(1440)\pi$, P-wave	
Γ_{11}	$N\gamma$	0.0–0.02 %
Γ_{12}	$N\gamma$, helicity=1/2	0.0–0.02 %

$\Delta(1910)$ BRANCHING RATIOS

$\Gamma(N\pi)/\Gamma_{total}$ — Γ_1/Γ

VALUE (%)	DOCUMENT ID		TECN	COMMENT
15 to 30 OUR ESTIMATE				
12 ± 3	GUTZ	14	DPWA	Multichannel
12 ± 3	ANISOVICH	12A	DPWA	Multichannel
23.9 ± 0.1	ARNDT	06	DPWA	$\pi N \to \pi N$, ηN
19 ± 3	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
24 ± 6	HOEHLER	79	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
17 ± 1	SHRESTHA	12A	DPWA	Multichannel
29 ± 21	VRANA	00	DPWA	Multichannel
26	ARNDT	95	DPWA	$\pi N \to N\pi$
23 ± 8	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
17	[1] CHEW	80	BPWA	$\pi^+ p \to \pi^+ p$
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	$\pi p \to \Sigma K$

$\Gamma(\Sigma K)/\Gamma_{total}$ — Γ_2/Γ

VALUE (%)	DOCUMENT ID		TECN	COMMENT
9±5	ANISOVICH	12A	DPWA	Multichannel

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	$\pi N \to N\pi\pi$

$\Gamma(\Delta\pi)/\Gamma_{total}$ — Γ_4/Γ

VALUE (%)	DOCUMENT ID		TECN	COMMENT
60±28	ANISOVICH	12A	DPWA	Multichannel

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to \Delta(1910) \to N\rho$, S=3/2, P-wave — $(\Gamma_1\Gamma_8)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
+0.29	[2] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \rightarrow \Delta(1910) \rightarrow N(1440)\pi$, P-wave — $(\Gamma_1\Gamma_{10})^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
-0.39 ± 0.04	MANLEY	92	IPWA	$\pi N \rightarrow \pi N$ & $N\pi\pi$

$\Gamma(N(1440)\pi)/\Gamma_{total}$ — Γ_9/Γ

VALUE (%)	DOCUMENT ID		TECN	COMMENT
56 ± 7	VRANA	00	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •				
47 ± 6	SHRESTHA	12A	DPWA	Multichannel

$\Gamma(\Delta(1232)\eta)/\Gamma_{total}$ — Γ_6/Γ

VALUE (%)	DOCUMENT ID		TECN	COMMENT
9 ± 4	GUTZ	14	DPWA	Multichannel

Δ(1910) PHOTON DECAY AMPLITUDES

Papers on γN amplitudes predating 1981 may be found in our 2006 edition, Journal of Physics **G33** 1 (2006).

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

VALUE ($GeV^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
$+0.020\pm0.010$ OUR ESTIMATE				
0.026 ± 0.008	GUTZ	14	DPWA	Multichannel
0.022 ± 0.009	ANISOVICH	12A	DPWA	Multichannel
-0.002 ± 0.008	ARNDT	96	IPWA	$\gamma N \rightarrow \pi N$
0.014 ± 0.030	CRAWFORD	83	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. • • •				
0.030 ± 0.002	SHRESTHA	12A	DPWA	Multichannel
0.032 ± 0.003	LI	93	IPWA	$\gamma N \rightarrow \pi N$

Δ(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 $\pi N \rightarrow N\pi\pi$ 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] Fit to the amplitudes of HOEHLER 79.

[4] 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.

Δ(1910) REFERENCES

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

GUTZ	14	EPJ A50 74	E. Gutz *et al.*	(CBELSA/TAPS Collab.)
SVARC	14	PR C89 045205	A. Svarc *et al.*	
ANISOVICH	12A	EPJ A48 15	A.V. Anisovich *et al.*	(BONN, PNPI)
SHRESTHA	12A	PR C86 055203	M. Shrestha, D.M. Manley	(KSU)
ARNDT	06	PR C74 045205	R.A. Arndt *et al.*	(GWU)
PDG	06	JP G33 1	W.-M. Yao *et al.*	(PDG Collab.)
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	(KSA) IJP
Also		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)
CRAWFORD	83	NP B211 1	R.L. Crawford, W.T. Morton	(GLAS)
HOEHLER	83	Landolt-Boernstein 1/9B2	G. Hohler	(KARLT)
PDG	82	PL 111B 1	M. Roos *et al.*	(HELS, CIT, CERN)
AWAJI	81	Bonn Conf. 352	N. Awaji, R. Kajikawa	(NAGO)
Also		NP B197 365	K. Fujii *et al.*	(NAGO)
CHEW	80	Toronto Conf. 123	D.M. Chew	(LBL) IJP
CUTKOSKY	80	Toronto Conf. 19	R.E. Cutkosky *et al.*	(CMU, LBL) IJP
Also		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		Toronto Conf. 3	R. Koch	(KARLT) IJP
LONGACRE	77	NP B122 493	R.S. Longacre, J. Dolbeau	(SACL) IJP
Also		NP B108 365	J. Dolbeau *et al.*	(SACL) IJP