

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

$$I(J^P) = \frac{3}{2}(\frac{1}{2}^+) \text{ Status: } ****$$

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).

$\Delta(1910)$ BREIT-WIGNER MASS

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
1860 to 1910 (≈ 1890) OUR ESTIMATE			
1860 ± 40	ANISOVICH	12A	DPWA Multichannel
2067.9 ± 1.7	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
1910 ± 40	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
1888 ± 20	HOEHLER	79	IPWA $\pi N \rightarrow \pi N$
● ● ● 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 $\pi N \rightarrow N\pi$
1882 ± 10	MANLEY	92	IPWA $\pi N \rightarrow \pi N \ \& \ N\pi\pi$
1960.1 ± 21.0	¹ CHEW	80	BPWA $\pi^+ p \rightarrow \pi^+ p$
2121.4 $^{+13.0}_{-14.3}$	¹ CHEW	80	BPWA $\pi^+ p \rightarrow \pi^+ p$
1790	² LONGACRE	77	IPWA $\pi N \rightarrow N\pi\pi$

$\Delta(1910)$ BREIT-WIGNER WIDTH

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
220 to 340 (≈ 280) OUR ESTIMATE			
350 ± 55	ANISOVICH	12A	DPWA Multichannel
543 ± 10	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
225 ± 50	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
280 ± 50	HOEHLER	79	IPWA $\pi N \rightarrow \pi N$
● ● ● 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 $\pi N \rightarrow N\pi$
239 ± 25	MANLEY	92	IPWA $\pi N \rightarrow \pi N \ \& \ N\pi\pi$
152.9 ± 60.0	¹ CHEW	80	BPWA $\pi^+ p \rightarrow \pi^+ p$
172.2 ± 37.0	¹ CHEW	80	BPWA $\pi^+ p \rightarrow \pi^+ p$
170	² LONGACRE	77	IPWA $\pi N \rightarrow N\pi\pi$

$\Delta(1910)$ POLE POSITION

REAL PART

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
1830 to 1880 (\approx 1855) OUR ESTIMATE			
1850 \pm 40	ANISOVICH	12A	DPWA Multichannel
1771	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
1874	³ HOEHLER	93	SPED $\pi N \rightarrow \pi N$
1880 \pm 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

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
200 to 500 (\approx 350) OUR ESTIMATE			
350 \pm 45	ANISOVICH	12A	DPWA Multichannel
479	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
283	³ HOEHLER	93	SPED $\pi N \rightarrow \pi N$
200 \pm 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 $\pi N \rightarrow N\pi\pi$

$\Delta(1910)$ ELASTIC POLE RESIDUE

MODULUS $|r|$

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
24 \pm 6	ANISOVICH	12A	DPWA Multichannel
45	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
38	HOEHLER	93	SPED $\pi N \rightarrow \pi N$
20 \pm 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

<u>VALUE (°)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
−145 \pm 30	ANISOVICH	12A	DPWA Multichannel
+172	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
−90 \pm 30	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
−176	ARNDT	95	DPWA $\pi N \rightarrow N\pi$
−91	ARNDT	91	DPWA $\pi N \rightarrow \pi N$ Soln SM90

$\Delta(1910)$ INELASTIC POLE RESIDUE

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

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

<u>MODULUS (%)</u>	<u>PHASE (°)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
7±2	-110 ± 30	ANISOVICH	12A DPWA	Multichannel

Normalized residue in $N\pi \rightarrow \Delta(1910) \rightarrow \Delta\pi, P\text{-wave}$

<u>MODULUS (%)</u>	<u>PHASE (°)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
16±9	95 ± 40	ANISOVICH	12A 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 $\Delta(1232)\pi, P\text{-wave}$	
Γ_6 $N\rho$	
Γ_7 $N\rho, S=3/2, P\text{-wave}$	
Γ_8 $N(1440)\pi$	
Γ_9 $N(1440)\pi, P\text{-wave}$	
Γ_{10} $N\gamma$	0.0–0.02 %
Γ_{11} $N\gamma, \text{helicity}=1/2$	0.0–0.02 %

$\Delta(1910)$ BRANCHING RATIOS

$\Gamma(N\pi)/\Gamma_{total}$	Γ_1/Γ
<u>VALUE (%)</u>	<u>DOCUMENT ID</u> <u>TECN</u> <u>COMMENT</u>
15 to 30 OUR ESTIMATE	
12 ± 3	ANISOVICH 12A DPWA Multichannel
23.9± 0.1	ARNDT 06 DPWA $\pi N \rightarrow \pi N, \eta N$
19 ± 3	CUTKOSKY 80 IPWA $\pi N \rightarrow \pi N$
24 ± 6	HOEHLER 79 IPWA $\pi N \rightarrow \pi N$
● ● ● 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 $\pi N \rightarrow N\pi$
23 ± 8	MANLEY 92 IPWA $\pi N \rightarrow \pi N \& N\pi\pi$
17	¹ CHEW 80 BPWA $\pi^+ p \rightarrow \pi^+ p$
40	¹ CHEW 80 BPWA $\pi^+ p \rightarrow \pi^+ p$

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

VALUE	DOCUMENT ID	TECN	COMMENT
< 0.03	CANDLIN 84	DPWA	$\pi^+ p \rightarrow \Sigma^+ K^+$
• • • We do not use the following data for averages, fits, limits, etc. • • •			
-0.019	LIVANOS 80	DPWA	$\pi p \rightarrow \Sigma K$

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

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

Note: Signs of couplings from $\pi N \rightarrow N\pi\pi$ 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 $\Delta(1232)\pi$.

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

VALUE	DOCUMENT ID	TECN	COMMENT
+0.06	² LONGACRE 77	IPWA	$\pi N \rightarrow N\pi\pi$

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

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

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

VALUE	DOCUMENT ID	TECN	COMMENT
+0.29	² LONGACRE 77	IPWA	$\pi N \rightarrow N\pi\pi$

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

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

$\Gamma(N(1440)\pi) / \Gamma_{\text{total}}$ Γ_8 / 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

$\Delta(1910)$ PHOTON DECAY AMPLITUDES

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

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

<u>VALUE (GeV^{-1/2})</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
+0.003±0.014 OUR ESTIMATE			
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	$\gamma N \rightarrow \pi N$

$\Delta(1910)$ 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 $\pi N \rightarrow N\pi\pi$ 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 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.

$\Delta(1910)$ REFERENCES

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

ANISOVICH	12A	EPJ A48 15	A.V. Anisovich <i>et al.</i>	(BONN, PNPI)
SHRESTHA	12A	PR C86 055203	M. Shrestha, D.M. Manley	(KSU)
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.)
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	(KSA) 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)
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 <i>et al.</i>	(HEL, 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	77	NP B122 493	R.S. Longacre, J. Dolbeau	(SACL) IJP
Also		NP B108 365	J. Dolbeau <i>et al.</i>	(SACL) IJP