

$\Delta(1910) P_{31}$

$I(J^P) = \frac{3}{2}(\frac{1}{2}^+)$ 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, G **33** 1 (2006).

$\Delta(1910)$ BREIT-WIGNER MASS

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
1870 to 1920 (≈ 1910) OUR ESTIMATE			
2067.9 \pm 1.7	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
1882 \pm 10	MANLEY	92	IPWA $\pi N \rightarrow \pi N \& N\pi\pi$
1910 \pm 40	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
1888 \pm 20	HOEHLER	79	IPWA $\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
1995 \pm 12	VRANA	00	DPWA Multichannel
2152	ARNDT	95	DPWA $\pi N \rightarrow N\pi$
1960.1 \pm 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

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
190 to 270 (≈ 250) OUR ESTIMATE			
543 \pm 10	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
239 \pm 25	MANLEY	92	IPWA $\pi N \rightarrow \pi N \& N\pi\pi$
225 \pm 50	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
280 \pm 50	HOEHLER	79	IPWA $\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
713 \pm 465	VRANA	00	DPWA Multichannel
760	ARNDT	95	DPWA $\pi N \rightarrow N\pi$
152.9 \pm 60.0	¹ CHEW	80	BPWA $\pi^+ p \rightarrow \pi^+ p$
172.2 \pm 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

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
1830 to 1880 (≈ 1855) OUR ESTIMATE			
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. • • •

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>
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200 to 500 (≈ 350) OUR ESTIMATE

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

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>
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45	ARNDT	06	DPWA	$\pi N \rightarrow \pi N, \eta N$
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

<u>VALUE (°)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
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+172	ARNDT	06	DPWA	$\pi N \rightarrow \pi N, \eta N$
– 90±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

$\Delta(1910)$ 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	$N\rho, S=3/2, P\text{-wave}$	
Γ_8	$N(1440)\pi$	
Γ_9	$N(1440)\pi, P\text{-wave}$	
Γ_{10}	$N\gamma$	0.0–0.2 %
Γ_{11}	$N\gamma, \text{helicity}=1/2$	0.0–0.2 %

$\Delta(1910)$ BRANCHING RATIOS

$\Gamma(N\pi)/\Gamma_{\text{total}}$					Γ_1/Γ
<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>		
0.15 to 0.3 OUR ESTIMATE					
0.239 ± 0.001	ARNDT	06	DPWA	$\pi N \rightarrow \pi N, \eta N$	
0.23 ± 0.08	MANLEY	92	IPWA	$\pi N \rightarrow \pi N \ \& \ N\pi\pi$	
0.19 ± 0.03	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$	
0.24 ± 0.06	HOEHLER	79	IPWA	$\pi N \rightarrow \pi N$	
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.29 ± 0.21	VRANA	00	DPWA	Multichannel	
0.26	ARNDT	95	DPWA	$\pi N \rightarrow N\pi$	
0.17	¹ CHEW	80	BPWA	$\pi^+ p \rightarrow \pi^+ p$	
0.40	¹ CHEW	80	BPWA	$\pi^+ p \rightarrow \pi^+ p$	

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{\text{total}}$ in $N\pi \rightarrow \Delta(1910) \rightarrow \Sigma K$					$(\Gamma_1\Gamma_2)^{1/2}/\Gamma$
<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>		
< 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	$\pi p \rightarrow \Sigma K$	

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 $N\pi \rightarrow \Delta(1910) \rightarrow \Delta(1232)\pi, P\text{-wave}$					$(\Gamma_1\Gamma_5)^{1/2}/\Gamma$
<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>		
$+0.06$	² LONGACRE	77	IPWA	$\pi N \rightarrow N\pi\pi$	

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{\text{total}}$ in $N\pi \rightarrow \Delta(1910) \rightarrow N\rho, S=3/2, P\text{-wave}$					$(\Gamma_1\Gamma_7)^{1/2}/\Gamma$
<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>		
$+0.29$	² LONGACRE	77	IPWA	$\pi N \rightarrow N\pi\pi$	

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{\text{total}}$ in $N\pi \rightarrow \Delta(1910) \rightarrow N(1440)\pi, P\text{-wave}$					$(\Gamma_1\Gamma_9)^{1/2}/\Gamma$
<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>		
-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
0.56±0.07	VRANA	00	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 $A_{1/2}$

VALUE (GeV ^{-1/2})	DOCUMENT ID	TECN	COMMENT
+0.003±0.014 OUR ESTIMATE			
-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. ● ● ●			
0.032±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).

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	(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)
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>	(HEL5, 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