

$\Delta(1910) 1/2^+$  $I(J^P) = \frac{3}{2}(\frac{1}{2}^+)$  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* (generic for all A,B,E,G) **G33** 1 (2006).

 **$\Delta(1910)$  BREIT-WIGNER MASS**

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>1860 to 1910 (<math>\approx 1890</math>) OUR ESTIMATE</b>			
1860 $\pm 40$	ANISOVICH	12A	DPWA Multichannel
2067.9 $\pm 1.7$	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
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. ● ● ●			
1934 $\pm 5$	SHRESTHA	12A	DPWA Multichannel
1995 $\pm 12$	VRANA	00	DPWA Multichannel
2152	ARNDT	95	DPWA $\pi N \rightarrow N\pi$
1882 $\pm 10$	MANLEY	92	IPWA $\pi N \rightarrow \pi N \& N\pi\pi$
1960.1 $\pm 21.0$	<sup>1</sup> CHEW	80	BPWA $\pi^+ p \rightarrow \pi^+ p$
2121.4 $^{+13.0}_{-14.3}$	<sup>1</sup> CHEW	80	BPWA $\pi^+ p \rightarrow \pi^+ p$
1790	<sup>2</sup> 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>
<b>220 to 340 (<math>\approx 280</math>) OUR ESTIMATE</b>			
350 $\pm 55$	ANISOVICH	12A	DPWA Multichannel
543 $\pm 10$	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
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. ● ● ●			
211 $\pm 11$	SHRESTHA	12A	DPWA Multichannel
713 $\pm 465$	VRANA	00	DPWA Multichannel
760	ARNDT	95	DPWA $\pi N \rightarrow N\pi$
239 $\pm 25$	MANLEY	92	IPWA $\pi N \rightarrow \pi N \& N\pi\pi$
152.9 $\pm 60.0$	<sup>1</sup> CHEW	80	BPWA $\pi^+ p \rightarrow \pi^+ p$
172.2 $\pm 37.0$	<sup>1</sup> CHEW	80	BPWA $\pi^+ p \rightarrow \pi^+ p$
170	<sup>2</sup> 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>
<b>1830 to 1880 (<math>\approx</math> 1855) OUR ESTIMATE</b>			
1850 $\pm$ 40	ANISOVICH	12A	DPWA Multichannel
1771	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
1874	<sup>3</sup> 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	<sup>2</sup> 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>
<b>200 to 500 (<math>\approx</math> 350) OUR ESTIMATE</b>			
350 $\pm$ 45	ANISOVICH	12A	DPWA Multichannel
479	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
283	<sup>3</sup> 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	<sup>2</sup> 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  $\theta$** 

<u>VALUE (<math>^\circ</math>)</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>
<b>7±2</b>	<b>-110 ± 30</b>	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>
<b>16±9</b>	<b>95 ± 40</b>	ANISOVICH	12A DPWA	Multichannel

## $\Delta(1910)$ DECAY MODES

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

Mode	Fraction ( $\Gamma_i/\Gamma$ )
$\Gamma_1$ $N\pi$	15–30 %
$\Gamma_2$ $\Sigma K$	( 9± 5) %
$\Gamma_3$ $N\pi\pi$	
$\Gamma_4$ $\Delta\pi$	(60±28) %
$\Gamma_5$ $\Delta(1232)\pi, P\text{-wave}$	
$\Gamma_6$ $N\rho$	
$\Gamma_7$ $N\rho, S=3/2, P\text{-wave}$	
$\Gamma_8$ $N(1440)\pi$	
$\Gamma_9$ $N(1440)\pi, P\text{-wave}$	
$\Gamma_{10}$ $N\gamma$	0.0–0.02 %
$\Gamma_{11}$ $N\gamma, \text{helicity}=1/2$	0.0–0.02 %

## $\Delta(1910)$ BRANCHING RATIOS

$\Gamma(N\pi)/\Gamma_{\text{total}}$				$\Gamma_1/\Gamma$
<u>VALUE (%)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
<b>15 to 30 OUR ESTIMATE</b>				
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	<sup>1</sup> CHEW	80 BPWA	$\pi^+ p \rightarrow \pi^+ p$	
40	<sup>1</sup> 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 $\pi p \rightarrow \Sigma K$	

$\Gamma(\Sigma K) / \Gamma_{\text{total}}$				$\Gamma_2 / \Gamma$
VALUE (%)	DOCUMENT ID	TECN	COMMENT	
<b>9 ± 5</b>	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 $N\pi \rightarrow \Delta(1910) \rightarrow \Delta(1232)\pi$ , <i>P-wave</i>				$(\Gamma_1 \Gamma_5)^{1/2} / \Gamma$
VALUE	DOCUMENT ID	TECN	COMMENT	
+0.06	<sup>2</sup> LONGACRE	77	IPWA $\pi N \rightarrow N\pi\pi$	

$\Gamma(\Delta\pi) / \Gamma_{\text{total}}$				$\Gamma_4 / \Gamma$
VALUE (%)	DOCUMENT ID	TECN	COMMENT	
<b>60 ± 28</b>	ANISOVICH	12A	DPWA Multichannel	

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

$(\Gamma_i \Gamma_f)^{1/2} / \Gamma_{\text{total}}$ in $N\pi \rightarrow \Delta(1910) \rightarrow N(1440)\pi$ , <i>P-wave</i>				$(\Gamma_1 \Gamma_9)^{1/2} / \Gamma$
VALUE	DOCUMENT ID	TECN	COMMENT	
• • • We do not use the following data for averages, fits, limits, etc. • • •				
-0.39 ± 0.04	MANLEY	92	IPWA $\pi N \rightarrow \pi N$ & $N\pi\pi$	

$\Gamma(N(1440)\pi) / \Gamma_{\text{total}}$				$\Gamma_8 / \Gamma$
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  $\gamma N$  amplitudes predating 1981 may be found in our 2006 edition, *Journal of Physics* (generic for all A,B,E,G) **G33** 1 (2006).

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

VALUE ( $\text{GeV}^{-1/2}$ )	DOCUMENT ID	TECN	COMMENT
<b>+0.020<math>\pm</math>0.010 OUR ESTIMATE</b>			
0.022 $\pm$ 0.009	ANISOVICH	12A	DPWA Multichannel
-0.002 $\pm$ 0.008	ARNDT	96	IPWA $\gamma N \rightarrow \pi N$
0.014 $\pm$ 0.030	CRAWFORD	83	IPWA $\gamma N \rightarrow \pi N$
0.025 $\pm$ 0.011	AWAJI	81	DPWA $\gamma N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
0.030 $\pm$ 0.002	SHRESTHA	12A	DPWA Multichannel
0.032 $\pm$ 0.003	LI	93	IPWA $\gamma N \rightarrow \pi N$

### $\Delta(1910)$ FOOTNOTES

- <sup>1</sup> 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.
- <sup>2</sup> 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.
- <sup>3</sup> See HOEHLER 93 for a detailed discussion of the evidence for and the pole parameters of  $N$  and  $\Delta$  resonances as determined from Argand diagrams of  $\pi N$  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	JP G33 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	$\pi N$ 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