

$\Delta(1920) \ 3/2^+$ $I(J^P) = \frac{3}{2}(\frac{3}{2}^+)$ 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).

The latest GWU analysis (ARNDT 06) finds no evidence for this resonance.

$\Delta(1920)$ BREIT-WIGNER MASS

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
1900 to 1970 (≈ 1920) OUR ESTIMATE			
1900 \pm 30	ANISOVICH	12A	DPWA Multichannel
2014 \pm 16	MANLEY	92	IPWA $\pi N \rightarrow \pi N$ & $N\pi\pi$
1920 \pm 80	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
1868 \pm 10	HOEHLER	79	IPWA $\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
1990 \pm 35	HORN	08A	DPWA Multichannel
2057 \pm 1	PENNER	02C	DPWA Multichannel
1889 \pm 100	VRANA	00	DPWA Multichannel
1840 \pm 40	CANDLIN	84	DPWA $\pi^+ p \rightarrow \Sigma^+ K^+$
1955.0 \pm 13.0	¹ CHEW	80	BPWA $\pi^+ p \rightarrow \pi^+ p$
2065.0 $^{+13.6}_{-12.9}$	¹ CHEW	80	BPWA $\pi^+ p \rightarrow \pi^+ p$

$\Delta(1920)$ BREIT-WIGNER WIDTH

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
180 to 300 (≈ 260) OUR ESTIMATE			
310 \pm 60	ANISOVICH	12A	DPWA Multichannel
152 \pm 55	MANLEY	92	IPWA $\pi N \rightarrow \pi N$ & $N\pi\pi$
300 \pm 100	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
220 \pm 80	HOEHLER	79	IPWA $\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
330 \pm 60	HORN	08A	DPWA Multichannel
525 \pm 32	PENNER	02C	DPWA Multichannel
123 \pm 53	VRANA	00	DPWA Multichannel
200 \pm 40	CANDLIN	84	DPWA $\pi^+ p \rightarrow \Sigma^+ K^+$
88.3 \pm 35.0	¹ CHEW	80	BPWA $\pi^+ p \rightarrow \pi^+ p$
62.0 \pm 44.0	¹ CHEW	80	BPWA $\pi^+ p \rightarrow \pi^+ p$

$\Delta(1920)$ POLE POSITION**REAL PART**

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
1850 to 1950 (\approx 1900) OUR ESTIMATE			
1890 \pm 30	ANISOVICH	12A	DPWA Multichannel
1900	² HOEHLER	93	SPED $\pi N \rightarrow \pi N$
1900 \pm 80	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •			
1980 ⁺²⁵ ₋₄₅	HORN	08A	DPWA Multichannel
1880	VRANA	00	DPWA Multichannel
not seen	ARNDT	91	DPWA $\pi N \rightarrow \pi N$ Soln SM90

-2 \times IMAGINARY PART

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
200 to 400 (\approx 300) OUR ESTIMATE			
300 \pm 60	ANISOVICH	12A	DPWA Multichannel
300 \pm 100	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •			
310 ⁺⁴⁰ ₋₆₀	HORN	08A	DPWA Multichannel
120	VRANA	00	DPWA Multichannel
not seen	ARNDT	91	DPWA $\pi N \rightarrow \pi N$ Soln SM90

 $\Delta(1920)$ ELASTIC POLE RESIDUE**MODULUS $|r|$**

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
17 \pm 8	ANISOVICH	12A	DPWA Multichannel
24 \pm 4	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$

PHASE θ

<u>VALUE ($^\circ$)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
-40 \pm 20	ANISOVICH	12A	DPWA Multichannel
-150 \pm 30	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$

 $\Delta(1920)$ INELASTIC POLE RESIDUE

The "normalized residue" is the residue divided by Γ_{pole} .

Normalized residue in $N\pi \rightarrow \Delta(1920) \rightarrow \Delta\eta$

<u>MODULUS (%)</u>	<u>PHASE ($^\circ$)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
17\pm8	70\pm20	ANISOVICH	12A	DPWA Multichannel

Normalized residue in $N\pi \rightarrow \Delta(1920) \rightarrow \Sigma K$

<u>MODULUS (%)</u>	<u>PHASE ($^\circ$)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
9\pm3	80\pm40	ANISOVICH	12A	DPWA Multichannel

Normalized residue in $N\pi \rightarrow \Delta(1920) \rightarrow \Delta\pi$, P -wave

<u>MODULUS (%)</u>	<u>PHASE (°)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
20±12	-120 ± 30	ANISOVICH	12A DPWA	Multichannel

Normalized residue in $N\pi \rightarrow \Delta(1920) \rightarrow \Delta\pi$, F -wave

<u>MODULUS (%)</u>	<u>PHASE (°)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
28±7	-95 ± 35	ANISOVICH	12A DPWA	Multichannel

$\Delta(1920)$ DECAY MODES

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

Mode	Fraction (Γ_i/Γ)
Γ_1 $N\pi$	5–20 %
Γ_2 ΣK	(2.14±0.30) %
Γ_3 $N\pi\pi$	
Γ_4 $\Delta(1232)\pi$, P -wave	
Γ_5 $\Delta(1232)\pi$, F -wave	
Γ_6 $N(1440)\pi$, P -wave	
Γ_7 $N(1535)\pi$	
Γ_8 $N a_0(980)$	
Γ_9 $\Delta(1232)\eta$	(15 ± 8) %
Γ_{10} $N\gamma$	0.0–0.4 %
Γ_{11} $N\gamma$, helicity=1/2	0.0–0.2 %
Γ_{12} $N\gamma$, helicity=3/2	0.0–0.2 %

$\Delta(1920)$ BRANCHING RATIOS

$\Gamma(N\pi)/\Gamma_{\text{total}}$					Γ_1/Γ
<u>VALUE (%)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>		
5 to 20 OUR ESTIMATE					
8±4	ANISOVICH	12A DPWA	Multichannel		
2±2	MANLEY	92 IPWA	$\pi N \rightarrow \pi N$ & $N\pi\pi$		
20±5	CUTKOSKY	80 IPWA	$\pi N \rightarrow \pi N$		
14±4	HOEHLER	79 IPWA	$\pi N \rightarrow \pi N$		
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●					
15±8	HORN	08A DPWA	Multichannel		
15±1	PENNER	02C DPWA	Multichannel		
5±4	VRANA	00 DPWA	Multichannel		
24	¹ CHEW	80 BPWA	$\pi^+ p \rightarrow \pi^+ p$		
18	¹ CHEW	80 BPWA	$\pi^+ p \rightarrow \pi^+ p$		

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{\text{total}}$ in $N\pi \rightarrow \Delta(1920) \rightarrow \Sigma K$					$(\Gamma_1\Gamma_2)^{1/2}/\Gamma$
<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>		
-0.052±0.015	CANDLIN	84 DPWA	$\pi^+ p \rightarrow \Sigma^+ K^+$		
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●					
-0.049	LIVANOS	80 DPWA	$\pi p \rightarrow \Sigma K$		

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

<u>VALUE (%)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
2.14±0.30 OUR AVERAGE			
4 ±2	ANISOVICH	12A	DPWA Multichannel
2.1 ±0.3	PENNER	02C	DPWA Multichannel

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{\text{total}}$ in $N\pi \rightarrow \Delta(1920) \rightarrow \Delta(1232)\pi$, *P-wave* $(\Gamma_1\Gamma_4)^{1/2}/\Gamma$

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
-0.13±0.04	MANLEY	92	IPWA $\pi N \rightarrow \pi N \& N\pi\pi$

$\Gamma(\Delta(1232)\pi, P\text{-wave})/\Gamma_{\text{total}}$ Γ_4/Γ

<u>VALUE (%)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
22±12	ANISOVICH	12A	DPWA Multichannel
41±3	VRANA	00	DPWA Multichannel

$\Gamma(\Delta(1232)\pi, F\text{-wave})/\Gamma_{\text{total}}$ Γ_5/Γ

<u>VALUE (%)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
45±20	ANISOVICH	12A	DPWA Multichannel

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{\text{total}}$ in $N\pi \rightarrow \Delta(1920) \rightarrow N(1440)\pi$, *P-wave* $(\Gamma_1\Gamma_6)^{1/2}/\Gamma$

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
+0.06±0.07	MANLEY	92	IPWA $\pi N \rightarrow \pi N \& N\pi\pi$

$\Gamma(N(1440)\pi, P\text{-wave})/\Gamma_{\text{total}}$ Γ_6/Γ

<u>VALUE (%)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
53±8	VRANA	00	DPWA Multichannel

$\Gamma(N(1535)\pi)/\Gamma_{\text{total}}$ Γ_7/Γ

<u>VALUE (%)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
• • • We do not use the following data for averages, fits, limits, etc. • • •			
6±4	HORN	08A	DPWA Multichannel

$\Gamma(N_{a_0}(980))/\Gamma_{\text{total}}$ Γ_8/Γ

<u>VALUE (%)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
• • • We do not use the following data for averages, fits, limits, etc. • • •			
4±2	HORN	08A	DPWA Multichannel

$\Gamma(\Delta(1232)\eta)/\Gamma_{\text{total}}$ Γ_9/Γ

<u>VALUE (%)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
15±8	ANISOVICH	12A	DPWA Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •			
10±5	HORN	08A	DPWA Multichannel

$\Delta(1920)$ PHOTON DECAY AMPLITUDES

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

$\Delta(1920) \rightarrow N\gamma$, helicity-1/2 amplitude $A_{1/2}$

<u>VALUE (GeV^{-1/2})</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.130 ^{+0.030} -0.060	ANISOVICH	12A	DPWA Multichannel
0.040±0.014	AWAJI	81	DPWA $\gamma N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
0.022±0.008	HORN	08A	DPWA Multichannel
-0.007	PENNER	02D	DPWA Multichannel

$\Delta(1920) \rightarrow N\gamma$, helicity-3/2 amplitude $A_{3/2}$

<u>VALUE (GeV^{-1/2})</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
-0.115 ^{+0.025} -0.050	ANISOVICH	12A	DPWA Multichannel
0.023±0.017	AWAJI	81	DPWA $\gamma N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
0.042±0.012	HORN	08A	DPWA Multichannel
-0.001	PENNER	02D	DPWA Multichannel

$\Delta(1920)$ FOOTNOTES

¹ CHEW 80 reports two P_{33} resonances in this mass region. Problems with this analysis are discussed in section 2.1.11 of HOEHLER 83.

² 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.

$\Delta(1920)$ REFERENCES

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

ANISOVICH	12A	EPJ A48 15	A.V. Anisovich <i>et al.</i>	(BONN, PNPI)
HORN	08A	EPJ A38 173	I. Horn <i>et al.</i>	(CB-ELSA Collab.)
Also		PRL 101 202002	I. Horn <i>et al.</i>	(CB-ELSA Collab.)
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.)
PENNER	02C	PR C66 055211	G. Penner, U. Mosel	(GIES)
PENNER	02D	PR C66 055212	G. Penner, U. Mosel	(GIES)
VRANA	00	PRPL 328 181	T.P. Vrana, S.A. Dytman,, T.-S.H. Lee	(PITT+)
HOEHLER	93	πN Newsletter 9 1	G. Hohler	(KARL)
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)
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