$\Delta(1920)\ 3/2^+$

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

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

$\Delta(1920)$ BREIT-WIGNER MASS

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
1900 to 1970 (≈ 1920) OUR ESTIMATE				
1880 ± 30	GUTZ	14	DPWA	Multichannel
1900 ± 30	ANISOVICH	12A	DPWA	Multichannel
1920 ± 80	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
1868 ± 10	HOEHLER	79	IPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
2146 ± 32	SHRESTHA	12A	DPWA	Multichannel
1990 ± 35	HORN	08A	DPWA	Multichannel
2057 ± 1	PENNER	02C	DPWA	Multichannel
1889 ±100	VRANA	00	DPWA	Multichannel
2014 ± 16	MANLEY	92	IPWA	$\pi N \rightarrow \pi N$ & $N\pi\pi$
1840 ± 40	CANDLIN	84	DPWA	$\pi^+ p \rightarrow \Sigma^+ K^+$
1955.0 ± 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

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
180 to 300 (≈ 260) OUR ESTIMATE				
300 ± 40	GUTZ	14	DPWA	Multichannel
310 ± 60	ANISOVICH	12A	DPWA	Multichannel
300 ±100	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
220 ± 80	HOEHLER	79	IPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
400 ± 80	SHRESTHA	12A	DPWA	Multichannel
330 ± 60	HORN	08A	DPWA	Multichannel
525 ± 32	PENNER	02C	DPWA	Multichannel
123 ± 53	VRANA	00	DPWA	Multichannel
152 ± 55	MANLEY	92	IPWA	$\pi N \rightarrow \pi N$ & $N\pi\pi$
200 ± 40	CANDLIN	84	DPWA	$\pi^+ p \rightarrow \Sigma^+ K^+$
88.3 ± 35.0	[1] CHEW	80	BPWA	$\pi^+ p \rightarrow \pi^+ p$
62.0 ± 44.0	[1] CHEW	80	BPWA	$\pi^+ p \rightarrow \pi^+ p$

Δ(1920) POLE POSITION

REAL PART

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
1850 to 1950 (≈ 1900) OUR ESTIMATE				
1875±30	GUTZ	14	DPWA	Multichannel
1906±10±2	[2] SVARC	14	MLS	$\pi N \rightarrow \pi N$
1890±30	ANISOVICH	12A	DPWA	Multichannel
1900	[3] HOEHLER	93	SPED	$\pi N \rightarrow \pi N$
1900±80	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
2110	SHRESTHA	12A	DPWA	Multichannel
1980^{+25}_{-45}	HORN	08A	DPWA	Multichannel
1880	VRANA	00	DPWA	Multichannel

−2×IMAGINARY PART

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
200 to 400 (≈ 300) OUR ESTIMATE				
300± 40	GUTZ	14	DPWA	Multichannel
310± 20±11	[2] SVARC	14	MLS	$\pi N \rightarrow \pi N$
300± 60	ANISOVICH	12A	DPWA	Multichannel
300±100	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
386	SHRESTHA	12A	DPWA	Multichannel
310^{+40}_{-60}	HORN	08A	DPWA	Multichannel
120	VRANA	00	DPWA	Multichannel

Δ(1920) ELASTIC POLE RESIDUE

MODULUS |r|

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
16±6	GUTZ	14	DPWA	Multichannel
26±3±2	[2] SVARC	14	MLS	$\pi N \rightarrow \pi N$
17±8	ANISOVICH	12A	DPWA	Multichannel
24±4	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$

PHASE θ

VALUE (°)	DOCUMENT ID		TECN	COMMENT
− 50±25	GUTZ	14	DPWA	Multichannel
−130± 5±3	[2] SVARC	14	MLS	$\pi N \rightarrow \pi N$
− 40±20	ANISOVICH	12A	DPWA	Multichannel
−150±30	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$

Δ(1920) INELASTIC POLE RESIDUE

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

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

MODULUS (%)	PHASE (°)	DOCUMENT ID		TECN	COMMENT
15±4 OUR AVERAGE					
15±4	70 ± 20	GUTZ	14	DPWA	Multichannel
17±8	70 ± 20	ANISOVICH	12A	DPWA	Multichannel

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

MODULUS (%)	PHASE (°)	DOCUMENT ID		TECN	COMMENT
9±3	**80 ± 40**	ANISOVICH	12A	DPWA	Multichannel

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

MODULUS (%)	PHASE (°)	DOCUMENT ID		TECN	COMMENT
20±12	**−120 ± 30**	ANISOVICH	12A	DPWA	Multichannel

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

MODULUS (%)	PHASE (°)	DOCUMENT ID		TECN	COMMENT
28±7	**−95 ± 35**	ANISOVICH	12A	DPWA	Multichannel

Normalized residue in $N\pi \rightarrow \Delta(1920) \rightarrow N(1535)\pi$

MODULUS (%)	PHASE (°)	DOCUMENT ID		TECN	COMMENT
3±2	**35 ± 45**	GUTZ	14	DPWA	Multichannel

Normalized residue in $N\pi \rightarrow \Delta(1920) \rightarrow N a_0(980)$

MODULUS (%)	PHASE (°)	DOCUMENT ID		TECN	COMMENT
3±2	**−85 ± 45**	GUTZ	14	DPWA	Multichannel

Δ(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	$\Delta(1232)\eta$	(12 ±5) %
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

$\Gamma(N\pi)/\Gamma_{total}$ — Γ_1/Γ

VALUE (%)	DOCUMENT ID		TECN	COMMENT
5 to 20 OUR ESTIMATE				
8±4	GUTZ	14	DPWA	Multichannel
8±4	ANISOVICH	12A	DPWA	Multichannel
20±5	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
14±4	HOEHLER	79	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
16±4	SHRESTHA	12A	DPWA	Multichannel
15±8	HORN	08A	DPWA	Multichannel
15±1	PENNER	02C	DPWA	Multichannel
5±4	VRANA	00	DPWA	Multichannel
2±2	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
24	[1] CHEW	80	BPWA	$\pi^+ p \to \pi^+ p$
18	[1] CHEW	80	BPWA	$\pi^+ p \to \pi^+ p$

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to \Delta(1920) \to \Sigma K$ — $(\Gamma_1\Gamma_2)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
−0.052±0.015	CANDLIN	84	DPWA	$\pi^+ p \to \Sigma^+ K^+$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
−0.049	LIVANOS	80	DPWA	$\pi p \to \Sigma K$

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

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

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

VALUE	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
−0.13±0.04	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$

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

VALUE (%)	DOCUMENT ID		TECN	COMMENT
22±12	ANISOVICH	12A	DPWA	Multichannel
41± 3	VRANA	00	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •				
7± 5	SHRESTHA	12A	DPWA	Multichannel

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

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

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

VALUE	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
+0.06±0.07	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$

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

VALUE (%)	DOCUMENT ID		TECN	COMMENT
53±8	VRANA	00	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •				
<20	SHRESTHA	12A	DPWA	Multichannel

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

VALUE (%)	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
<2	GUTZ	14	DPWA	Multichannel
6±4	HORN	08A	DPWA	Multichannel

$\Gamma(N a_0(980))/\Gamma_{total}$ — Γ_8/Γ

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

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

VALUE (%)	DOCUMENT ID		TECN	COMMENT
12±5 OUR AVERAGE				
11±6	GUTZ	14	DPWA	Multichannel
15±8	ANISOVICH	12A	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •				
10±5	HORN	08A	DPWA	Multichannel

Δ(1920) PHOTON DECAY AMPLITUDES

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

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

VALUE ($GeV^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
0.110±0.030	GUTZ	14	DPWA	Multichannel
$0.130^{+0.030}_{-0.060}$	ANISOVICH	12A	DPWA	Multichannel
0.040±0.014	AWAJI	81	DPWA	$\gamma N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.051±0.010	SHRESTHA	12A	DPWA	Multichannel
0.022±0.008	HORN	08A	DPWA	Multichannel
−0.007	PENNER	02D	DPWA	Multichannel

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

VALUE ($GeV^{-1/2}$)	*DOCUMENT ID*		*TECN*	*COMMENT*
-0.105 ± 0.035	GUTZ	14	DPWA	Multichannel
$-0.115^{+0.025}_{-0.050}$	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. • • •				
0.017 ± 0.015	SHRESTHA	12A	DPWA	Multichannel
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] Fit to the amplitudes of HOEHLER 79.

[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.

$\Delta(1920)$ 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)
HORN	08A	EPJ A38 173	I. Horn *et al.*	(CB-ELSA Collab.)
Also		PRL 101 202002	I. Horn *et al.*	(CB-ELSA Collab.)
ARNDT	06	PR C74 045205	R.A. Arndt *et al.*	(GWU)
PDG	06	JP G33 1	W.-M. Yao *et al.*	(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	(KSA) IJP
Also		PR D30 904	D.M. Manley *et al.*	(VPI)
CANDLIN	84	NP B238 477	D.J. Candlin *et al.*	(EDIN, RAL, LOWC)
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