$\Delta(1620)\ 1/2^-$

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

$\Delta(1620)$ BREIT-WIGNER MASS

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
1600 to 1660 (≈ 1630) OUR ESTIMATE				
1600 ± 8	ANISOVICH	12A	DPWA	Multichannel
1615.2 ± 0.4	ARNDT	06	DPWA	$\pi N \to \pi N$, ηN
1620 ± 20	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
1610 ± 7	HOEHLER	79	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1600 ± 1	SHRESTHA	12A	DPWA	Multichannel
1625 ± 10	ANISOVICH	10	DPWA	Multichannel
1650 ± 25	THOMA	08	DPWA	Multichannel
1614.1 ± 1.1	ARNDT	04	DPWA	$\pi N \to \pi N$, ηN
1612 ± 2	PENNER	02C	DPWA	Multichannel
1617 ± 15	VRANA	00	DPWA	Multichannel
1672 ± 5	ARNDT	96	IPWA	$\gamma N \to \pi N$
1617	ARNDT	95	DPWA	$\pi N \to N \pi$
1669	LI	93	IPWA	$\gamma N \to \pi N$
1672 ± 7	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N \pi \pi$
1620	BARNHAM	80	IPWA	$\pi N \to N \pi \pi$
1712.8 ± 6.0	[1] CHEW	80	BPWA	$\pi^+ p \to \pi^+ p$
1786.7 ± 2.0	[1] CHEW	80	BPWA	$\pi^+ p \to \pi^+ p$
1580	[2] LONGACRE	77	IPWA	$\pi N \to N \pi \pi$
1600	[3] LONGACRE	75	IPWA	$\pi N \to N \pi \pi$

$\Delta(1620)$ BREIT-WIGNER WIDTH

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
130 to 150 (≈ 140) OUR ESTIMATE				
130 ± 11	ANISOVICH	12A	DPWA	Multichannel
146.9 ± 1.9	ARNDT	06	DPWA	$\pi N \to \pi N$, ηN
140 ± 20	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
139 ± 18	HOEHLER	79	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
112 ± 2	SHRESTHA	12A	DPWA	Multichannel
148 ± 15	ANISOVICH	10	DPWA	Multichannel
250 ± 60	THOMA	08	DPWA	Multichannel
141.0 ± 6.0	ARNDT	04	DPWA	$\pi N \to \pi N$, ηN
202 ± 7	PENNER	02C	DPWA	Multichannel
143 ± 42	VRANA	00	DPWA	Multichannel
147 ± 8	ARNDT	96	IPWA	$\gamma N \to \pi N$

108	ARNDT	95	DPWA	$\pi N \rightarrow N\pi$
184	LI	93	IPWA	$\gamma N \rightarrow \pi N$
154 ±37	MANLEY	92	IPWA	$\pi N \rightarrow \pi N$ & $N\pi\pi$
120	BARNHAM	80	IPWA	$\pi N \rightarrow N\pi\pi$
228.3±18.0	[1] CHEW	80	BPWA	$\pi^+ p \rightarrow \pi^+ p$ (lower mass)
30.0± 6.4	[1] CHEW	80	BPWA	$\pi^+ p \rightarrow \pi^+ p$ (higher mass)
120	[2] LONGACRE	77	IPWA	$\pi N \rightarrow N\pi\pi$
150	[3] LONGACRE	75	IPWA	$\pi N \rightarrow N\pi\pi$

Δ(1620) POLE POSITION

REAL PART

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
1590 to 1610 (≈ 1600) OUR ESTIMATE				
1597± 4	ANISOVICH	12A	DPWA	Multichannel
1595	ARNDT	06	DPWA	$\pi N \rightarrow \pi N$, ηN
1608	[4] HOEHLER	93	SPED	$\pi N \rightarrow \pi N$
1600±15	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1587	SHRESTHA	12A	DPWA	Multichannel
1596± 7	ANISOVICH	10	DPWA	Multichannel
1615±25	THOMA	08	DPWA	Multichannel
1594	ARNDT	04	DPWA	$\pi N \rightarrow \pi N$, ηN
1607	VRANA	00	DPWA	Multichannel
1585	ARNDT	95	DPWA	$\pi N \rightarrow N\pi$
1587	ARNDT	91	DPWA	$\pi N \rightarrow \pi N$ Soln SM90
1583 or 1583	[5] LONGACRE	78	IPWA	$\pi N \rightarrow N\pi\pi$
1575 or 1572	[2] LONGACRE	77	IPWA	$\pi N \rightarrow N\pi\pi$

−2×IMAGINARY PART

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
120 to 140 (≈ 130) OUR ESTIMATE				
130± 9	ANISOVICH	12A	DPWA	Multichannel
135	ARNDT	06	DPWA	$\pi N \rightarrow \pi N$, ηN
116	[4] HOEHLER	93	SPED	$\pi N \rightarrow \pi N$
120±20	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
107	SHRESTHA	12A	DPWA	Multichannel
130±10	ANISOVICH	10	DPWA	Multichannel
180±35	THOMA	08	DPWA	Multichannel
118	ARNDT	04	DPWA	$\pi N \rightarrow \pi N$, ηN
148	VRANA	00	DPWA	Multichannel
104	ARNDT	95	DPWA	$\pi N \rightarrow N\pi$
120	ARNDT	91	DPWA	$\pi N \rightarrow \pi N$ Soln SM90
143 or 149	[5] LONGACRE	78	IPWA	$\pi N \rightarrow N\pi\pi$
119 or 128	[2] LONGACRE	77	IPWA	$\pi N \rightarrow N\pi\pi$

$\Delta(1620)$ ELASTIC POLE RESIDUE

MODULUS $|r|$

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
18±2	ANISOVICH	12A	DPWA	Multichannel
15	ARNDT	06	DPWA	$\pi N \to \pi N$, ηN
19	HOEHLER	93	SPED	$\pi N \to \pi N$
15±2	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
17	ARNDT	04	DPWA	$\pi N \to \pi N$, ηN
14	ARNDT	95	DPWA	$\pi N \to N\pi$
15	ARNDT	91	DPWA	$\pi N \to \pi N$ Soln SM90

PHASE θ

VALUE (°)	DOCUMENT ID		TECN	COMMENT
−100± 5	ANISOVICH	12A	DPWA	Multichannel
− 92	ARNDT	06	DPWA	$\pi N \to \pi N$, ηN
− 95	HOEHLER	93	SPED	$\pi N \to \pi N$
−110±20	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
−104	ARNDT	04	DPWA	$\pi N \to \pi N$, ηN
−121	ARNDT	95	DPWA	$\pi N \to N\pi$
−125	ARNDT	91	DPWA	$\pi N \to \pi N$ Soln SM90

$\Delta(1620)$ INELASTIC POLE RESIDUE

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

Normalized residue in $N\pi \to \Delta(1620) \to \Delta\pi$, D-wave

MODULUS (%)	PHASE (°)	DOCUMENT ID		TECN	COMMENT
38±9	**−85 ± 30**	ANISOVICH	12A	DPWA	Multichannel

$\Delta(1620)$ DECAY MODES

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

	Mode	Fraction (Γ_i/Γ)
Γ_1	$N\pi$	20–30 %
Γ_2	$N\pi\pi$	70–80 %
Γ_3	$\Delta\pi$	30–60 %
Γ_4	$\Delta(1232)\pi$, D-wave	
Γ_5	$N\rho$	7–25 %
Γ_6	$N\rho$, S=1/2, S-wave	
Γ_7	$N\rho$, S=3/2, D-wave	
Γ_8	$N(1440)\pi$	
Γ_9	$N\gamma$	0.03–0.10 %
Γ_{10}	$N\gamma$, helicity=1/2	0.03–0.10 %

$\Delta(1620)$ BRANCHING RATIOS

$\Gamma(N\pi)/\Gamma_{total}$ — Γ_1/Γ

VALUE (%)	DOCUMENT ID		TECN	COMMENT
20 to 30 OUR ESTIMATE				
28 ± 3	ANISOVICH	12A	DPWA	Multichannel
31.5 ± 0.1	ARNDT	06	DPWA	$\pi N \to \pi N, \eta N$
25 ± 3	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
35 ± 6	HOEHLER	79	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
33 ± 2	SHRESTHA	12A	DPWA	Multichannel
23 ± 5	ANISOVICH	10	DPWA	Multichannel
22 ±12	THOMA	08	DPWA	Multichannel
31.0 ± 0.4	ARNDT	04	DPWA	$\pi N \to \pi N, \eta N$
34 ± 1	PENNER	02C	DPWA	Multichannel
45 ± 5	VRANA	00	DPWA	Multichannel
29	ARNDT	95	DPWA	$\pi N \to N\pi$
9 ± 2	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
60	[1] CHEW	80	BPWA	$\pi^+ p \to \pi^+ p$ (lower mass)
36	[1] CHEW	80	BPWA	$\pi^+ p \to \pi^+ p$ (higher mass)

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

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to \Delta(1620) \to \Delta(1232)\pi$, D-wave — $(\Gamma_1\Gamma_4)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
−0.36 to −0.28 OUR ESTIMATE				
−0.33±0.06	BARNHAM	80	IPWA	$\pi N \to N\pi\pi$
−0.39	[2,6] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$
−0.40	[3] LONGACRE	75	IPWA	$\pi N \to N\pi\pi$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
−0.24±0.03	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$

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

VALUE (%)	DOCUMENT ID		TECN	COMMENT
60±17	ANISOVICH	12A	DPWA	Multichannel
39± 2	VRANA	00	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •				
32± 2	SHRESTHA	12A	DPWA	Multichannel
48±25	THOMA	08	DPWA	Multichannel

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to \Delta(1620) \to N\rho$, S=1/2, S-wave — $(\Gamma_1\Gamma_6)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
+0.12 to +0.22 OUR ESTIMATE				
+0.40±0.10	BARNHAM	80	IPWA	$\pi N \to N\pi\pi$
+0.08	[2,6] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$
+0.28	[3] LONGACRE	75	IPWA	$\pi N \to N\pi\pi$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
+0.15±0.02	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$

$\Gamma(N\rho, S=1/2, S\text{-wave})/\Gamma_{total}$ — Γ_6/Γ

VALUE (%)	DOCUMENT ID		TECN	COMMENT
14±3	VRANA	00	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •				
26±2	SHRESTHA	12A	DPWA	Multichannel

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to \Delta(1620) \to N\rho, S=3/2, D\text{-wave}$ — $(\Gamma_1\Gamma_7)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
−0.15 to −0.03 OUR ESTIMATE				
−0.13	[2,6] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
−0.03±0.01	SHRESTHA	12A	DPWA	Multichannel
−0.06±0.02	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$

$\Gamma(N\rho, S=3/2, D\text{-wave})/\Gamma_{total}$ — Γ_7/Γ

VALUE (%)	DOCUMENT ID		TECN	COMMENT
2±1	VRANA	00	DPWA	Multichannel

$(\Gamma_i\Gamma_f)^{1/2}/\Gamma_{total}$ in $N\pi \to \Delta(1620) \to N(1440)\pi$ — $(\Gamma_1\Gamma_8)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
0.11±0.05	BARNHAM	80	IPWA	$\pi N \to N\pi\pi$

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

VALUE (%)	DOCUMENT ID		TECN	COMMENT
0± 1	VRANA	00	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •				
9± 1	SHRESTHA	12A	DPWA	Multichannel
19±12	THOMA	08	DPWA	Multichannel

Δ(1620) PHOTON DECAY AMPLITUDES

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

$\Delta(1620) \to N\gamma$, helicity-1/2 amplitude $A_{1/2}$

VALUE ($GeV^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
+0.027±0.011 OUR ESTIMATE				
0.052±0.005	ANISOVICH	12A	DPWA	Multichannel
0.029±0.003	WORKMAN	12A	DPWA	$\gamma N \to N\pi$
0.050±0.002	DUGGER	07	DPWA	$\gamma N \to \pi N$
0.035±0.010	CRAWFORD	83	IPWA	$\gamma N \to \pi N$
0.010±0.015	AWAJI	81	DPWA	$\gamma N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
−0.003±0.003	SHRESTHA	12A	DPWA	Multichannel
0.063±0.012	ANISOVICH	10	DPWA	Multichannel
0.066	DRECHSEL	07	DPWA	$\gamma N \to \pi N$
−0.050	PENNER	02D	DPWA	Multichannel
0.035±0.020	ARNDT	96	IPWA	$\gamma N \to \pi N$
0.042±0.003	LI	93	IPWA	$\gamma N \to \pi N$
0.066	WADA	84	DPWA	Compton scattering

Δ(1620) FOOTNOTES

[1] CHEW 80 reports two S_{31} resonances at somewhat higher masses than other analyses. 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] From method II of LONGACRE 75: eyeball fits with Breit-Wigner circles to the T-matrix amplitudes.

[4] 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.

[5] LONGACRE 78 values 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.

[6] LONGACRE 77 considers this coupling to be well determined.

Δ(1620) REFERENCES

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

ANISOVICH	12A	EPJ A48 15	A.V. Anisovich *et al.*	(BONN, PNPI)	
SHRESTHA	12A	PR C86 055203	M. Shrestha, D.M. Manley	(KSU)	
WORKMAN	12A	PR C86 015202	R. Workman *et al.*	(GWU)	
ANISOVICH	10	EPJ A44 203	A.V. Anisovich *et al.*	(BONN, PNPI)	
THOMA	08	PL B659 87	U. Thoma *et al.*	(CB-ELSA Collab.)	
DRECHSEL	07	EPJ A34 69	D. Drechsel, S.S. Kamalov, L. Tiator	(MAINZ, JINR)	
DUGGER	07	PR C76 025211	M. Dugger *et al.*	(Jefferson Lab CLAS Collab.)	
ARNDT	06	PR C74 045205	R.A. Arndt *et al.*	(GWU)	
PDG	06	JPG 33 1	W.-M. Yao *et al.*	(PDG Collab.)	
ARNDT	04	PR C69 035213	R.A. Arndt *et al.*	(GWU, TRIU)	
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+)	
ARNDT	96	PR C53 430	R.A. Arndt, I.I. Strakovsky, R.L. Workman	(VPI)	
ARNDT	95	PR C52 2120	R.A. Arndt *et al.*	(VPI, BRCO)	
HOEHLER	93	πN Newsletter 9 1	G. Hohler	(KARL)	
LI	93	PR C47 2759	Z.J. Li *et al.*	(VPI)	
MANLEY	92	PR D45 4002	D.M. Manley, E.M. Saleski	(KSA)	IJP
Also		PR D30 904	D.M. Manley *et al.*	(VPI)	
ARNDT	91	PR D43 2131	R.A. Arndt *et al.*	(VPI, TELE)	IJP
WADA	84	NP B247 313	Y. Wada *et al.*	(INUS)	
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 *et al.*	(HELS, CIT, CERN)	
AWAJI	81	Bonn Conf. 352	N. Awaji, R. Kajikawa	(NAGO)	
Also		NP B197 365	K. Fujii *et al.*	(NAGO)	
BARNHAM	80	NP B168 243	K.W.J. Barnham *et al.*	(LOIC)	
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
HOEHLER	79	PDAT 12-1	G. Hohler *et al.*	(KARLT)	IJP
Also		Toronto Conf. 3	R. Koch	(KARLT)	IJP
LONGACRE	78	PR D17 1795	R.S. Longacre *et al.*	(LBL, SLAC)	
LONGACRE	77	NP B122 493	R.S. Longacre, J. Dolbeau	(SACL)	IJP
Also		NP B108 365	J. Dolbeau *et al.*	(SACL)	IJP
LONGACRE	75	PL 55B 415	R.S. Longacre *et al.*	(LBL, SLAC)	IJP