$\Delta(1620)\ S_{31}$

$I(J^P) = \frac{3}{2}(\frac{1}{2}^-)$ 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 1980 were last included in our 2006 edition, Journal of Physics, G **33** 1 (2006).

Δ(1620) BREIT-WIGNER MASS

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
1600 to 1660 (≈ 1630) OUR ESTIMATE				
1615.2 ± 0.4	ARNDT	06	DPWA	$\pi N \to \pi N, \eta N$
1672 ± 7	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
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. • • •				
1614.1 ± 1.1	ARNDT	04	DPWA	$\pi N \to \pi N, \eta N$
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	$\gamma N \to \pi N$
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	$\pi^+ p \to \pi^+ p$
1657	CRAWFORD	80	DPWA	$\gamma N \to \pi N$
1580	[2] LONGACRE	77	IPWA	$\pi N \to N\pi\pi$
1600	[3] LONGACRE	75	IPWA	$\pi N \to N\pi\pi$

Δ(1620) BREIT-WIGNER WIDTH

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
135 to 150 (≈ 145) OUR ESTIMATE				
146.9 ± 1.9	ARNDT	06	DPWA	$\pi N \to \pi N, \eta N$
154 ± 37	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
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. • • •				
141.0 ± 6.0	ARNDT	04	DPWA	$\pi N \to \pi N, \eta N$
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	$\pi N \to N\pi$
184	LI	93	IPWA	$\gamma N \to \pi N$
120	BARNHAM	80	IPWA	$\pi N \to N\pi\pi$

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)
161	CRAWFORD	80	DPWA	$\gamma N \rightarrow \pi N$
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				
1595	ARNDT	06	DPWA	$\pi N \rightarrow \pi N, \eta N$
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. • • •				
1594	ARNDT	04	DPWA	$\pi N \rightarrow \pi N, \eta N$
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
115 to 120 (≈ 118) OUR ESTIMATE				
135	ARNDT	06	DPWA	$\pi N \rightarrow \pi N, \eta N$
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. • • •				
118	ARNDT	04	DPWA	$\pi N \rightarrow \pi N, \eta N$
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	$\pi N \rightarrow N \pi \pi$

Δ(1620) ELASTIC POLE RESIDUE

MODULUS |r|

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

PHASE θ

VALUE (°)	DOCUMENT ID		TECN	COMMENT
− 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

$\Delta(1620)$ 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	$N\gamma$	0.004–0.044 %
Γ_{10}	$N\gamma$, helicity=1/2	0.004–0.044 %

$\Delta(1620)$ BRANCHING RATIOS

$\Gamma(N\pi)/\Gamma_{total}$ — Γ_1/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
0.2 to 0.3 OUR ESTIMATE				
0.315±0.001	ARNDT	06	DPWA	$\pi N \to \pi N$, ηN
0.09 ±0.02	MANLEY	92	IPWA	$\pi N \to \pi N$ & $N\pi\pi$
0.25 ±0.03	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
0.35 ±0.06	HOEHLER	79	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.310±0.004	ARNDT	04	DPWA	$\pi N \to \pi N$, ηN
0.34 ±0.01	PENNER	02C	DPWA	Multichannel
0.45 ±0.05	VRANA	00	DPWA	Multichannel
0.29	ARNDT	95	DPWA	$\pi N \to N\pi$
0.60	[1] CHEW	80	BPWA	$\pi^+ p \to \pi^+ p$ (lower mass)
0.36	[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 $N\pi \rightarrow \Delta(1620) \rightarrow \Delta(1232)\pi$, *D*-wave — $(\Gamma_1\Gamma_4)^{1/2}/\Gamma$

VALUE	DOCUMENT ID		TECN	COMMENT
−0.36 to −0.28 OUR ESTIMATE				
−0.24±0.03	MANLEY	92	IPWA	$\pi N \rightarrow \pi N$ & $N\pi\pi$
−0.33±0.06	BARNHAM	80	IPWA	$\pi N \rightarrow N\pi\pi$
−0.39	[2,6] LONGACRE	77	IPWA	$\pi N \rightarrow N\pi\pi$
−0.40	[3] LONGACRE	75	IPWA	$\pi N \rightarrow N\pi\pi$

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

VALUE	DOCUMENT ID		TECN	COMMENT
0.39±0.02	VRANA	00	DPWA	Multichannel

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

VALUE	DOCUMENT ID		TECN	COMMENT
+0.12 to +0.22 OUR ESTIMATE				
+0.15±0.02	MANLEY	92	IPWA	$\pi N \rightarrow \pi N$ & $N\pi\pi$
+0.40±0.10	BARNHAM	80	IPWA	$\pi N \rightarrow N\pi\pi$
+0.08	[2,6] LONGACRE	77	IPWA	$\pi N \rightarrow N\pi\pi$
+0.28	[3] LONGACRE	75	IPWA	$\pi N \rightarrow N\pi\pi$

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

VALUE	DOCUMENT ID		TECN	COMMENT
0.14±0.03	VRANA	00	DPWA	Multichannel

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

VALUE	DOCUMENT ID		TECN	COMMENT
−0.15 to −0.03 OUR ESTIMATE				
−0.06±0.02	MANLEY	92	IPWA	$\pi N \rightarrow \pi N$ & $N\pi\pi$
−0.13	[2,6] LONGACRE	77	IPWA	$\pi N \rightarrow N\pi\pi$

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

VALUE	DOCUMENT ID		TECN	COMMENT
0.02±0.01	VRANA	00	DPWA	Multichannel

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

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

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

VALUE	DOCUMENT ID		TECN	COMMENT
0.00±0.01	VRANA	00	DPWA	Multichannel

Δ(1620) PHOTON DECAY AMPLITUDES

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

VALUE ($GeV^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
+0.027±0.011 OUR ESTIMATE				
0.035±0.020	ARNDT	96	IPWA	$\gamma N \rightarrow \pi N$
0.035±0.010	CRAWFORD	83	IPWA	$\gamma N \rightarrow \pi N$
0.010±0.015	AWAJI	81	DPWA	$\gamma N \rightarrow \pi N$
−0.022±0.007	ARAI	80	DPWA	$\gamma N \rightarrow \pi N$ (fit 1)
−0.026±0.008	ARAI	80	DPWA	$\gamma N \rightarrow \pi N$ (fit 2)
0.021±0.020	CRAWFORD	80	DPWA	$\gamma N \rightarrow \pi N$
0.126±0.021	TAKEDA	80	DPWA	$\gamma N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
−0.050	PENNER	02D	DPWA	Multichannel
0.042±0.003	LI	93	IPWA	$\gamma N \rightarrow \pi N$
0.066	WADA	84	DPWA	Compton scattering
−0.005±0.016	FELLER	76	DPWA	$\gamma N \rightarrow \pi N$

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).

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	(KENT) 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)
ARAI	80	Toronto Conf. 93	I. Arai	(INUS)
Also		NP B194 251	I. Arai, H. Fujii	(INUS)
BARNHAM	80	NP B168 243	K.W.J. Barnham *et al.*	(LOIC)
CHEW	80	Toronto Conf. 123	D.M. Chew	(LBL) IJP
CRAWFORD	80	Toronto Conf. 107	R.L. Crawford	(GLAS)
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
TAKEDA	80	NP B168 17	H. Takeda *et al.*	(TOKY, INUS)
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
FELLER	76	NP B104 219	P. Feller *et al.*	(NAGO, OSAK) IJP
LONGACRE	75	PL 55B 415	R.S. Longacre *et al.*	(LBL, SLAC) IJP