$\Delta(1600)$ $3/2^+$

$I(J^P) = \frac{3}{2}(\frac{3}{2}^+)$ Status: ∗∗∗∗

Older and obsolete values are listed and referenced in the 2014 edition, Chinese Physics **C38** 070001 (2014).

$\Delta(1600)$ POLE POSITION

REAL PART

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
1460 to 1560 (≈ 1510) OUR ESTIMATE				
1515±20	SOKHOYAN	15A	DPWA	Multichannel
1469±10±5	[1] SVARC	14	L+P	$\pi N \to \pi N$
1550±40	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1619	HUNT	19	DPWA	Multichannel
1552	ROENCHEN	15A	DPWA	Multichannel
1498±25	ANISOVICH	12A	DPWA	Multichannel
1457	ARNDT	06	DPWA	$\pi N \to \pi N$, ηN
1599	VRANA	00	DPWA	Multichannel
1550	HOEHLER	93	SPED	$\pi N \to \pi N$

[1] Fit to the amplitudes of HOEHLER 79.

−2×IMAGINARY PART

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
200 to 340 (≈ 270) OUR ESTIMATE				
250±30	SOKHOYAN	15A	DPWA	Multichannel
314±18±8	[1] SVARC	14	L+P	$\pi N \to \pi N$
200±60	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
295	HUNT	19	DPWA	Multichannel
350	ROENCHEN	15A	DPWA	Multichannel
230±50	ANISOVICH	12A	DPWA	Multichannel
400	ARNDT	06	DPWA	$\pi N \to \pi N$, ηN
312	VRANA	00	DPWA	Multichannel

[1] Fit to the amplitudes of HOEHLER 79.

$\Delta(1600)$ ELASTIC POLE RESIDUE

MODULUS $|r|$

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
10 to 40 (≈ 25) OUR ESTIMATE				
13±3	SOKHOYAN	15A	DPWA	Multichannel
38±2±2	[1] SVARC	14	L+P	$\pi N \to \pi N$
17±4	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
23	ROENCHEN	15A	DPWA	Multichannel
11±6	ANISOVICH	12A	DPWA	Multichannel
44	ARNDT	06	DPWA	$\pi N \to \pi N$, ηN

[1] Fit to the amplitudes of HOEHLER 79.

PHASE θ

VALUE (°)	DOCUMENT ID		TECN	COMMENT
150 to 210 (≈ 180) OUR ESTIMATE				
-155 ± 20	SOKHOYAN	15A	DPWA	Multichannel
$173\pm\ 5\pm5$	[1] SVARC	14	L+P	$\pi N \to \pi N$
-150 ± 30	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
-155	ROENCHEN	15A	DPWA	Multichannel
-160 ± 33	ANISOVICH	12A	DPWA	Multichannel
$+147$	ARNDT	06	DPWA	$\pi N \to \pi N$, ηN

[1] Fit to the amplitudes of HOEHLER 79.

Δ(1600) INELASTIC POLE RESIDUE

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

Normalized residue in $N\pi \to \Delta(1600) \to \Delta\pi$, P-wave

MODULUS	PHASE (°)	DOCUMENT ID		TECN	COMMENT
0.15 ± 0.04	30 ± 35	SOKHOYAN	15A	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.31	31	ROENCHEN	15A	DPWA	Multichannel
0.14 ± 0.10	154 ± 40	ANISOVICH	12A	DPWA	Multichannel

Normalized residue in $N\pi \to \Delta(1600) \to \Delta\pi$, F-wave

MODULUS	PHASE (°)	DOCUMENT ID		TECN	COMMENT
0.010 ± 0.005		SOKHOYAN	15A	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.013	29	ROENCHEN	15A	DPWA	Multichannel
0.010 ± 0.005		ANISOVICH	12A	DPWA	Multichannel

Normalized residue in $N\pi \to \Delta(1600) \to \Sigma K$

MODULUS	PHASE (°)	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.13	-5.6	ROENCHEN	15A	DPWA	Multichannel

Δ(1600) BREIT-WIGNER MASS

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
1500 to 1640 (≈ 1570) OUR ESTIMATE				
1664 ± 16	[1] HUNT	19	DPWA	Multichannel
1520 ± 20	SOKHOYAN	15A	DPWA	Multichannel
1600 ± 50	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
1522 ± 13	HOEHLER	79	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1510 ± 20	ANISOVICH	12A	DPWA	Multichannel
$1626\pm\ 8$	[1] SHRESTHA	12A	DPWA	Multichannel
$1667\pm\ 1$	PENNER	02C	DPWA	Multichannel
1687 ± 44	VRANA	00	DPWA	Multichannel

[1] Statistical error only.

Δ(1600) BREIT-WIGNER WIDTH

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
200 to 300 (≈ 250) OUR ESTIMATE				
322± 46	[1] HUNT	19	DPWA	Multichannel
235± 30	SOKHOYAN	15A	DPWA	Multichannel
300±100	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
220± 40	HOEHLER	79	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
220± 45	ANISOVICH	12A	DPWA	Multichannel
225± 18	[1] SHRESTHA	12A	DPWA	Multichannel
397± 10	PENNER	02C	DPWA	Multichannel
493± 75	VRANA	00	DPWA	Multichannel

[1] Statistical error only.

Δ(1600) DECAY MODES

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

	Mode	Fraction (Γ_i/Γ)
Γ_1	$N\pi$	8–24 %
Γ_2	$N\pi\pi$	75–90 %
Γ_3	$\Delta(1232)\pi$	73–83 %
Γ_4	$\Delta(1232)\pi$, P-wave	72–82 %
Γ_5	$\Delta(1232)\pi$, F-wave	<2 %
Γ_6	$N(1440)\pi$	
Γ_7	$N(1440)\pi$, P-wave	15–25 %
Γ_8	$N\gamma$	0.001–0.035 %
Γ_9	$N\gamma$, helicity=1/2	0.0–0.02 %
Γ_{10}	$N\gamma$, helicity=3/2	0.001–0.015 %

Δ(1600) BRANCHING RATIOS

$\Gamma(N\pi)/\Gamma_{total}$ — Γ_1/Γ

VALUE (%)	DOCUMENT ID		TECN	COMMENT
8 to 24 (≈ 16) OUR ESTIMATE				
10.7±1.9	[1] HUNT	19	DPWA	Multichannel
14 ±4	SOKHOYAN	15A	DPWA	Multichannel
18 ±4	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
21 ±6	HOEHLER	79	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
12 ±5	ANISOVICH	12A	DPWA	Multichannel
8 ±2	[1] SHRESTHA	12A	DPWA	Multichannel
13 ±1	PENNER	02C	DPWA	Multichannel
28 ±5	VRANA	00	DPWA	Multichannel

[1] Statistical error only.

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

VALUE (%)	DOCUMENT ID		TECN	COMMENT
64±6	[1] HUNT	19	DPWA	Multichannel
77±5	SOKHOYAN	15A	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •				
78±6	ANISOVICH	12A	DPWA	Multichannel
70±3	[1] SHRESTHA	12A	DPWA	Multichannel
59±10	VRANA	00	DPWA	Multichannel

[1] Statistical error only.

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

VALUE (%)	DOCUMENT ID		TECN	COMMENT
<2	SOKHOYAN	15A	DPWA	Multichannel

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

VALUE (%)	DOCUMENT ID		TECN	COMMENT
22±5	[1] HUNT	19	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •				
22±3	[1] SHRESTHA	12A	DPWA	Multichannel
13±4	VRANA	00	DPWA	Multichannel

[1] Statistical error only.

Δ(1600) PHOTON DECAY AMPLITUDES AT THE POLE

$\Delta(1600) \to N\gamma$, helicity-1/2 amplitude $A_{1/2}$

MODULUS ($GeV^{-1/2}$)	PHASE (°)	DOCUMENT ID		TECN	COMMENT
0.053±0.010	130 ± 15	SOKHOYAN	15A	DPWA	Multichannel
$0.193^{+0.023}_{-0.024}$	151^{+9}_{-15}	ROENCHEN	14	DPWA	
• • • We do not use the following data for averages, fits, limits, etc. • • •					
−0.230	−42	ROENCHEN	15A	DPWA	Multichannel

$\Delta(1600) \to N\gamma$, helicity-3/2 amplitude $A_{3/2}$

MODULUS ($GeV^{-1/2}$)	PHASE (°)	DOCUMENT ID		TECN	COMMENT
0.055±0.010	152 ± 15	SOKHOYAN	15A	DPWA	Multichannel
$-0.254^{+0.085}_{-0.086}$	110^{+10}_{-6}	ROENCHEN	14	DPWA	
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.332	−71	ROENCHEN	15A	DPWA	Multichannel

Δ(1600) BREIT-WIGNER PHOTON DECAY AMPLITUDES

$\Delta(1600) \to N\gamma$, helicity-1/2 amplitude $A_{1/2}$

VALUE ($GeV^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
−0.060 to −0.030 (≈ −0.045) OUR ESTIMATE				
0.0082±0.0014	[1] HUNT	19	DPWA	Multichannel
−0.051 ±0.010	SOKHOYAN	15A	DPWA	Multichannel
−0.018 ±0.015	[1] ARNDT	96	IPWA	$\gamma N \to \pi N$

• • • We do not use the following data for averages, fits, limits, etc. • • •

−0.050 ±0.009		ANISOVICH	12A	DPWA	Multichannel
0.006 ±0.005	[1]	SHRESTHA	12A	DPWA	Multichannel
0.0		PENNER	02D	DPWA	Multichannel

[1] Statistical error only.

$\Delta(1600) \rightarrow N\gamma$, helicity-3/2 amplitude $A_{3/2}$

VALUE ($GeV^{-1/2}$)	DOCUMENT ID	TECN	COMMENT
−0.050 to −0.020 (≈ − 0.035) OUR ESTIMATE			
0.048±0.014	[1] HUNT 19	DPWA	Multichannel
−0.055±0.010	SOKHOYAN 15A	DPWA	Multichannel
−0.025±0.015	[1] ARNDT 96	IPWA	$\gamma N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •			
−0.040±0.012	ANISOVICH 12A	DPWA	Multichannel
0.052±0.008	[1] SHRESTHA 12A	DPWA	Multichannel
−0.024	PENNER 02D	DPWA	Multichannel

[1] Statistical error only.

$\Delta(1600)$ REFERENCES

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

HUNT	19	PR C99 055205	B.C. Hunt, D.M. Manley	
ROENCHEN	15A	EPJ A51 70	D. Roenchen *et al.*	
SOKHOYAN	15A	EPJ A51 95	V. Sokhoyan *et al.*	(CBELSA/TAPS Collab.)
PDG	14	CP C38 070001	K. Olive *et al.*	(PDG Collab.)
ROENCHEN	14	EPJ A50 101	D. Roenchen *et al.*	
Also		EPJ A51 63 (errat.)	D. Roenchen *et al.*	
SVARC	14	PR C89 045205	A. Svarc *et al.*	(RBI Zagreb, UNI Tuzla)
ANISOVICH	12A	EPJ A48 15	A.V. Anisovich *et al.*	(BONN, PNPI)
SHRESTHA	12A	PR C86 055203	M. Shrestha, D.M. Manley	(KSU)
ARNDT	06	PR C74 045205	R.A. Arndt *et al.*	(GWU)
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, ANL)
ARNDT	96	PR C53 430	R.A. Arndt, I.I. Strakovsky, R.L. Workman	(VPI)
HOEHLER	93	πN Newsletter 9 1	G. Hohler	(KARL)
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