

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

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

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 (\approx 1510) OUR ESTIMATE			
1515 \pm 20	SOKHOYAN	15A	DPWA Multichannel
1469 \pm 10 \pm 5	¹ SVARC	14	L+P $\pi N \rightarrow \pi N$
1550 \pm 40	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
1619	HUNT	19	DPWA Multichannel
1552	ROENCHEN	15A	DPWA Multichannel
1498 \pm 25	ANISOVICH	12A	DPWA Multichannel
1457	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
1599	VRANA	00	DPWA Multichannel
1550	HOEHLER	93	SPED $\pi N \rightarrow \pi N$

¹Fit to the amplitudes of HOEHLER 79.

−2×IMAGINARY PART

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

¹Fit to the amplitudes of HOEHLER 79.

$\Delta(1600)$ ELASTIC POLE RESIDUE

MODULUS $|r|$

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

¹Fit to the amplitudes of HOEHLER 79.

PHASE θ

<u>VALUE ($^\circ$)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
150 to 210 (\approx 180) OUR ESTIMATE			
-155 ± 20	SOKHOYAN	15A	DPWA Multichannel
$173 \pm 5 \pm 5$	¹ SVARC	14	L+P $\pi N \rightarrow \pi N$
-150 ± 30	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
• • • 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 $\pi N \rightarrow \pi N, \eta N$
¹ Fit to the amplitudes of HOEHLER 79.			

 $\Delta(1600)$ INELASTIC POLE RESIDUE

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

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

<u>MODULUS</u>	<u>PHASE ($^\circ$)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
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 $N\pi \rightarrow \Delta(1600) \rightarrow \Delta\pi$, F -wave

<u>MODULUS</u>	<u>PHASE ($^\circ$)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
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 $N\pi \rightarrow \Delta(1600) \rightarrow \Sigma K$

<u>MODULUS</u>	<u>PHASE ($^\circ$)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.13	-5.6	ROENCHEN	15A	DPWA Multichannel

 $\Delta(1600)$ BREIT-WIGNER MASS

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
1500 to 1640 (\approx 1570) OUR ESTIMATE			
1664 ± 16	¹ HUNT	19	DPWA Multichannel
1520 ± 20	SOKHOYAN	15A	DPWA Multichannel
1600 ± 50	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
1522 ± 13	HOEHLER	79	IPWA $\pi N \rightarrow \pi N$

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

1510 ± 20	ANISOVICH	12A	DPWA	Multichannel
1626 ± 8	¹ SHRESTHA	12A	DPWA	Multichannel
1667 ± 1	PENNER	02C	DPWA	Multichannel
1687 ± 44	VRANA	00	DPWA	Multichannel

¹Statistical error only.

$\Delta(1600)$ 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 $\pi N \rightarrow \pi N$
220 ± 40	HOEHLER	79	IPWA $\pi N \rightarrow \pi N$
• • • 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

¹Statistical error only.

$\Delta(1600)$ 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 %

$\Delta(1600)$ BRANCHING RATIOS

$\Gamma(N\pi)/\Gamma_{\text{total}}$					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	$\pi N \rightarrow \pi N$	
21 ± 6	HOEHLER	79	IPWA	$\pi N \rightarrow \pi N$	

• • • 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

¹Statistical error only.

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

<u>VALUE (%)</u>		<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
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

¹Statistical error only.

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

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

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

<u>VALUE (%)</u>		<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
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

¹Statistical error only.

$\Delta(1600)$ PHOTON DECAY AMPLITUDES AT THE POLE

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

<u>MODULUS ($\text{GeV}^{-1/2}$)</u>	<u>PHASE ($^\circ$)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
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
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$\Delta(1600) \rightarrow N\gamma$, helicity-3/2 amplitude $A_{3/2}$

<u>MODULUS ($\text{GeV}^{-1/2}$)</u>	<u>PHASE ($^\circ$)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
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
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$\Delta(1600)$ BREIT-WIGNER PHOTON DECAY AMPLITUDES **$\Delta(1600) \rightarrow N\gamma$, helicity-1/2 amplitude $A_{1/2}$**

VALUE ($\text{GeV}^{-1/2}$)	DOCUMENT ID	TECN	COMMENT
−0.060 to −0.030 (\approx −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 $\gamma N \rightarrow \pi N$
● ● ● 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 ($\text{GeV}^{-1/2}$)	DOCUMENT ID	TECN	COMMENT
−0.050 to −0.020 (\approx −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.			

 $\Delta(1600)$ REFERENCESFor 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 <i>et al.</i>	
SOKHOYAN	15A	EPJ A51 95	V. Sokhoyan <i>et al.</i>	(CBELSA/TAPS Collab.)
PDG	14	CP C38 070001	K. Olive <i>et al.</i>	(PDG Collab.)
ROENCHEN	14	EPJ A50 101	D. Roenchen <i>et al.</i>	
Also		EPJ A51 63 (errat.)	D. Roenchen <i>et al.</i>	
SVARC	14	PR C89 045205	A. Svarc <i>et al.</i>	(RBI Zagreb, UNI Tuzla)
ANISOVICH	12A	EPJ A48 15	A.V. Anisovich <i>et al.</i>	(BONN, PNPI)
SHRESTHA	12A	PR C86 055203	M. Shrestha, D.M. Manley	(KSU)
ARNDT	06	PR C74 045205	R.A. Arndt <i>et al.</i>	(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 <i>et al.</i>	(CMU, LBL) IJP
Also		PR D20 2839	R.E. Cutkosky <i>et al.</i>	(CMU, LBL) IJP
HOEHLER	79	PDAT 12-1	G. Hohler <i>et al.</i>	(KARLT) IJP
Also		Toronto Conf. 3	R. Koch	(KARLT) IJP