

$N(1440) \ 1/2^+$ $I(J^P) = \frac{1}{2}(\frac{1}{2}^+)$ Status: ****

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

 $N(1440)$ POLE POSITION**REAL PART**

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
1360 to 1380 (\approx 1370) OUR ESTIMATE			
1366 \pm 3	SARANTSEV 25	DPWA	Multichannel
1374 \pm 3 \pm 4	¹ HOFERICH... 24	RVUE	$\pi N \rightarrow \pi N$
1353 \pm 1	ROENCHEN 22	DPWA	Multichannel
1363 \pm 2 \pm 2	² SVARC 14	L+P	$\pi N \rightarrow \pi N$
1375 \pm 30	CUTKOSKY 80	IPWA	$\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
1360	HUNT 19	DPWA	Multichannel
1355	ROENCHEN 15A	DPWA	Multichannel
1369 \pm 3	SOKHOYAN 15A	DPWA	Multichannel
1386	SHKLYAR 13	DPWA	Multichannel
1363 \pm 11	BATINIC 10	DPWA	$\pi N \rightarrow N\pi, N\eta$
1359	ARNDT 06	DPWA	$\pi N \rightarrow \pi N, \eta N$
1383	VRANA 00	DPWA	Multichannel
1385	HOEHLER 93	SPED	$\pi N \rightarrow \pi N$

¹ Roy-Steiner equations and Pade methods applied to πN scattering amplitudes and pionic atom data.

² Fit to the amplitudes of HOEHLER 79.

– 2×IMAGINARY PART

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
180 to 205 (\approx 190) OUR ESTIMATE			
192 \pm 4	SARANTSEV 25	DPWA	Multichannel
215 \pm 18 \pm 8	¹ HOFERICH... 24	RVUE	$\pi N \rightarrow \pi N$
203 \pm 2	ROENCHEN 22	DPWA	Multichannel
180 \pm 4 \pm 5	² SVARC 14	L+P	$\pi N \rightarrow \pi N$
180 \pm 40	CUTKOSKY 80	IPWA	$\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
186	HUNT 19	DPWA	Multichannel
215	ROENCHEN 15A	DPWA	Multichannel
189 \pm 5	SOKHOYAN 15A	DPWA	Multichannel
277	SHKLYAR 13	DPWA	Multichannel
151 \pm 13	BATINIC 10	DPWA	$\pi N \rightarrow N\pi, N\eta$
162	ARNDT 06	DPWA	$\pi N \rightarrow \pi N, \eta N$
316	VRANA 00	DPWA	Multichannel
164	HOEHLER 93	SPED	$\pi N \rightarrow \pi N$

¹ Roy-Steiner equations and Pade methods applied to πN scattering amplitudes and pionic atom data.

² Fit to the amplitudes of HOEHLER 79.

$N(1440)$ ELASTIC POLE RESIDUE**MODULUS $|r|$**

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
50 to 60 (≈ 55) OUR ESTIMATE			
$58 \pm 15 \pm 17$	¹ HOFERICH... 24	RVUE	$\pi N \rightarrow \pi N$
59 ± 1	ROENCHEN 22	DPWA	Multichannel
49 ± 3	SOKHOYAN 15A	DPWA	Multichannel
$50 \pm 1 \pm 2$	² SVARC 14	L+P	$\pi N \rightarrow \pi N$
52 ± 5	CUTKOSKY 80	IPWA	$\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
62	ROENCHEN 15A	DPWA	Multichannel
126	SHKLYAR 13	DPWA	Multichannel
48 ± 3	ANISOVICH 12A	DPWA	Multichannel
44	BATINIC 10	DPWA	$\pi N \rightarrow N\pi, N\eta$
38	ARNDT 06	DPWA	$\pi N \rightarrow \pi N, \eta N$
40	HOEHLER 93	SPED	$\pi N \rightarrow \pi N$

¹ Roy-Steiner equations and Pade methods applied to πN scattering amplitudes and pionic atom data.

² Fit to the amplitudes of HOEHLER 79.

PHASE θ

<u>VALUE ($^\circ$)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
-100 to -80 (≈ -90) OUR ESTIMATE			
$-65 \pm 2 \pm 11$	¹ HOFERICH... 24	RVUE	$\pi N \rightarrow \pi N$
-104 ± 2	ROENCHEN 22	DPWA	Multichannel
-82 ± 5	SOKHOYAN 15A	DPWA	Multichannel
$-88 \pm 1 \pm 2$	² SVARC 14	L+P	$\pi N \rightarrow \pi N$
-100 ± 35	CUTKOSKY 80	IPWA	$\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
-98	ROENCHEN 15A	DPWA	Multichannel
-60	SHKLYAR 13	DPWA	Multichannel
-78 ± 4	ANISOVICH 12A	DPWA	Multichannel
-88	BATINIC 10	DPWA	$\pi N \rightarrow N\pi, N\eta$
-98	ARNDT 06	DPWA	$\pi N \rightarrow \pi N, \eta N$

¹ Roy-Steiner equations and Pade methods applied to πN scattering amplitudes and pionic atom data.

² Fit to the amplitudes of HOEHLER 79.

 $N(1440)$ INELASTIC POLE RESIDUE

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

Normalized residue in $N\pi \rightarrow N(1440) \rightarrow N\eta$

<u>MODULUS</u>	<u>PHASE ($^\circ$)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.084 ± 0.002	-28 ± 2	ROENCHEN 22	DPWA	Multichannel
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
0.078	-27	ROENCHEN 15A	DPWA	Multichannel

Normalized residue in $N\pi \rightarrow N(1440) \rightarrow \Delta\pi$, P -wave

<u>MODULUS</u>	<u>PHASE ($^\circ$)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.27 ± 0.02	38 ± 5	SOKHOYAN	15A DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.27 ± 0.02	40 ± 5	ANISOVICH	12A DPWA	Multichannel

Normalized residue in $N\pi \rightarrow N(1440) \rightarrow \Lambda K$

<u>MODULUS</u>	<u>PHASE ($^\circ$)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.025 ± 0.005	-92 ± 43	ROENCHEN	22 DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.016	145	ROENCHEN	15A DPWA	Multichannel

Normalized residue in $N\pi \rightarrow N(1440) \rightarrow \Sigma K$

<u>MODULUS</u>	<u>PHASE ($^\circ$)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.002 ± 0.003	-32 ± 77	ROENCHEN	22 DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.027	113	ROENCHEN	15A DPWA	Multichannel

Normalized residue in $N\pi \rightarrow N(1440) \rightarrow N(\pi\pi)_{S=0}^{I=0}$ $-wave$

<u>MODULUS</u>	<u>PHASE ($^\circ$)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.21 ± 0.04	-136 ± 4	SOKHOYAN	15A DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.21 ± 0.05	-135 ± 7	ANISOVICH	12A DPWA	Multichannel

 $N(1440)$ BREIT-WIGNER MASS

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
1410 to 1470 (≈ 1440) OUR ESTIMATE			
1410 ± 10	SARANTSEV	25	DPWA Multichannel
1417 ± 4	¹ HUNT	19	DPWA Multichannel
1515 ± 15	¹ SHKLYAR	13	DPWA Multichannel
1485.0 ± 1.2	¹ ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
1440 ± 30	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
1410 ± 12	HOEHLER	79	IPWA $\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •			
1430 ± 10	SOKHOYAN	15A	DPWA Multichannel
1412 ± 2	¹ SHRESTHA	12A	DPWA Multichannel
1439 ± 19	BATINIC	10	DPWA $\pi N \rightarrow N\pi, N\eta$
1518 ± 5	PENNER	02C	DPWA Multichannel
1479 ± 80	VRANA	00	DPWA Multichannel

¹Statistical error only. **$N(1440)$ BREIT-WIGNER WIDTH**

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
250 to 450 (≈ 350) OUR ESTIMATE			
290 ± 30	SARANTSEV	25	DPWA Multichannel
257 ± 11	¹ HUNT	19	DPWA Multichannel
605 ± 90	¹ SHKLYAR	13	DPWA Multichannel

284 ± 18	¹ ARNDT	06	DPWA	$\pi N \rightarrow \pi N, \eta N$
340 ± 70	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
135 ± 10	HOEHLER	79	IPWA	$\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
360 ± 30	SOKHOYAN	15A	DPWA	Multichannel
248 ± 5	¹ SHRESTHA	12A	DPWA	Multichannel
437 ± 141	BATINIC	10	DPWA	$\pi N \rightarrow N\pi, N\eta$
668 ± 41	PENNER	02C	DPWA	Multichannel
490 ± 120	VRANA	00	DPWA	Multichannel

¹Statistical error only.

N(1440) DECAY MODES

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

Mode	Fraction (Γ_i/Γ)
Γ_1 $N\pi$	55–75 %
Γ_2 $N\eta$	< 1 %
Γ_3 $N\pi\pi$	17–50 %
Γ_4 $\Delta(1232)\pi$	6–27 %
Γ_5 $N\rho$	(18 ± 6) %
Γ_6 $N\rho, S=1/2$	(9 ± 4) %
Γ_7 $N\rho, S=3/2$	(9 ± 4) %
Γ_8 $N\sigma$	11–23 %
Γ_9 $p\gamma, \text{helicity}=1/2$	0.035–0.048 %
Γ_{10} $n\gamma, \text{helicity}=1/2$	0.02–0.04 %

N(1440) BRANCHING RATIOS

$\Gamma(N\pi)/\Gamma_{\text{total}}$					Γ_1/Γ
VALUE (%)	DOCUMENT ID	TECN	COMMENT		
55 to 75 (≈ 65) OUR ESTIMATE					
66 ± 3	SEIFEN	25	DPWA	Multichannel	
59 ± 2	¹ HUNT	19	DPWA	Multichannel	
56 ± 2	¹ SHKLYAR	13	DPWA	Multichannel	
78.7 ± 1.6	¹ ARNDT	06	DPWA	$\pi N \rightarrow \pi N, \eta N$	
68 ± 4	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$	
51 ± 5	HOEHLER	79	IPWA	$\pi N \rightarrow \pi N$	
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●					
63 ± 2	SOKHOYAN	15A	DPWA	Multichannel	
64.8 ± 0.9	¹ SHRESTHA	12A	DPWA	Multichannel	
62 ± 4	BATINIC	10	DPWA	$\pi N \rightarrow N\pi, N\eta$	
57 ± 1	PENNER	02C	DPWA	Multichannel	
72 ± 5	VRANA	00	DPWA	Multichannel	

¹Statistical error only.

$\Gamma(N\eta)/\Gamma_{\text{total}}$ Γ_2/Γ

VALUE (%) DOCUMENT ID TECN COMMENT

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

0 ± 1 VRANA 00 DPWA Multichannel

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

VALUE (%) DOCUMENT ID TECN COMMENT

6 to 27 (≈ 15) OUR ESTIMATE

15 ± 7 SARANTSEV 25 DPWA Multichannel

10 ± 6 SEIFEN 25 DPWA Multichannel

22 ± 4 ¹HUNT 19 DPWA Multichannel

12 $\begin{smallmatrix} +5 \\ -3 \end{smallmatrix}$ SHKLYAR 16 DPWA Multichannel

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

20 ± 7 SOKHOYAN 15A DPWA Multichannel

6.5 ± 0.8 ¹SHRESTHA 12A DPWA Multichannel

16 ± 1 VRANA 00 DPWA Multichannel

¹Statistical error only.

$\Gamma(N\rho)/\Gamma_{\text{total}}$ Γ_5/Γ

VALUE (%) DOCUMENT ID TECN COMMENT

18 ± 6 SARANTSEV 25 DPWA Multichannel

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

VALUE (%) DOCUMENT ID TECN COMMENT

9 ± 4 SARANTSEV 25 DPWA Multichannel

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

VALUE (%) DOCUMENT ID TECN COMMENT

9 ± 4 SARANTSEV 25 DPWA Multichannel

$\Gamma(N\sigma)/\Gamma_{\text{total}}$ Γ_8/Γ

VALUE (%) DOCUMENT ID TECN COMMENT

15 ± 5 SARANTSEV 25 DPWA Multichannel

17 ± 6 SEIFEN 25 DPWA Multichannel

16 ± 3 ¹HUNT 19 DPWA Multichannel

27 $\begin{smallmatrix} +4 \\ -9 \end{smallmatrix}$ SHKLYAR 16 DPWA Multichannel

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

17 ± 6 SOKHOYAN 15A DPWA Multichannel

27 ± 1 ¹SHRESTHA 12A DPWA Multichannel

12 ± 1 VRANA 00 DPWA Multichannel

¹Statistical error only.

$N(1440)$ PHOTON DECAY AMPLITUDES AT THE POLE **$N(1440) \rightarrow p\gamma$, 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>
-0.060 ± 0.006	-30 ± 7	SARANTSEV	25	DPWA Multichannel
-0.090 ± 0.007	-30 ± 3	ROENCHEN	22	DPWA Multichannel
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
-0.060	-23	ROENCHEN	15A	DPWA Multichannel
-0.044 ± 0.005	-40 ± 8	SOKHOYAN	15A	DPWA Multichannel

 $N(1440) \rightarrow n\gamma$, 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>
0.041 ± 0.005	23 ± 10	ANISOVICH	17E	DPWA Multichannel

 $N(1440)$ BREIT-WIGNER PHOTON DECAY AMPLITUDES **$N(1440) \rightarrow p\gamma$, helicity-1/2 amplitude $A_{1/2}$**

<u>VALUE ($\text{GeV}^{-1/2}$)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
-0.080 to -0.050 (≈ -0.065) OUR ESTIMATE			
-0.076 ± 0.008	SARANTSEV	25	DPWA Multichannel
-0.091 ± 0.007	¹ HUNT	19	DPWA Multichannel
-0.085 ± 0.003	¹ SHKLYAR	13	DPWA Multichannel
-0.056 ± 0.001	¹ WORKMAN	12A	DPWA $\gamma N \rightarrow N\pi$
-0.051 ± 0.002	¹ DUGGER	07	DPWA $\gamma N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
-0.061 ± 0.006	SOKHOYAN	15A	DPWA Multichannel
-0.084 ± 0.003	¹ SHRESTHA	12A	DPWA Multichannel
-0.061	DRECHSEL	07	DPWA $\gamma N \rightarrow \pi N$
-0.087	PENNER	02D	DPWA Multichannel

¹Statistical error only. **$N(1440) \rightarrow n\gamma$, helicity-1/2 amplitude $A_{1/2}$**

<u>VALUE ($\text{GeV}^{-1/2}$)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.035 to 0.055 (≈ 0.045) OUR ESTIMATE			
0.013 ± 0.012	¹ HUNT	19	DPWA Multichannel
0.053 ± 0.007	ANISOVICH	17E	DPWA Multichannel
0.048 ± 0.004	¹ CHEN	12A	DPWA $\gamma N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
0.043 ± 0.012	ANISOVICH	13B	DPWA Multichannel
0.040 ± 0.005	¹ SHRESTHA	12A	DPWA Multichannel
0.054	DRECHSEL	07	DPWA $\gamma N \rightarrow \pi N$
0.121	PENNER	02D	DPWA Multichannel

¹Statistical error only.

N(1440) REFERENCESFor early references, see Physics Letters **111B** 1 (1982).

SARANTSEV	25	PR C112 015202	A.V. Sarantsev <i>et al.</i>	(Bonn-Gatchina Collab.)
SEIFEN	25	EPJ A61 173	T. Seifen <i>et al.</i>	(CBELSA/TAPS Collab.)
HOFERICHT...	24	PL B853 138698	M. Hoferichter <i>et al.</i>	(BERN, MADU, BONN+)
ROENCHEN	22	EPJ A58 229	D. Roenchen <i>et al.</i>	(JULI, GWU, BONN+)
HUNT	19	PR C99 055205	B.C. Hunt, D.M. Manley	
ANISOVICH	17E	PR C96 055202	A.V. Anisovich <i>et al.</i>	(BONN, PNPI, JLAB+)
SHKLYAR	16	PR C93 045206	V. Shklyar, H. Lenske, U. Mosel	(GIES)
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.)
SVARC	14	PR C89 045205	A. Svarc <i>et al.</i>	(RBI Zagreb, UNI Tuzla)
ANISOVICH	13B	EPJ A49 67	A.V. Anisovich <i>et al.</i>	
SHKLYAR	13	PR C87 015201	V. Shklyar, H. Lenske, U. Mosel	(GIES)
ANISOVICH	12A	EPJ A48 15	A.V. Anisovich <i>et al.</i>	(BONN, PNPI)
CHEN	12A	PR C86 015206	W. Chen <i>et al.</i>	(DUKE, GWU, MSST, ITEP+)
SHRESTHA	12A	PR C86 055203	M. Shrestha, D.M. Manley	(KSU)
WORKMAN	12A	PR C86 015202	R. Workman <i>et al.</i>	(GWU)
BATINIC	10	PR C82 038203	M. Batinic <i>et al.</i>	(ZAGR)
DRECHSEL	07	EPJ A34 69	D. Drechsel, S.S. Kamalov, L. Tiator	(MAINZ, JINR)
DUGGER	07	PR C76 025211	M. Dugger <i>et al.</i>	(JLab CLAS Collab.)
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)
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