

$$N(1440) \ 1/2^+$$

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

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 (≈ 1370) OUR ESTIMATE			
1374 $\pm$ 3 $\pm$ 4	¹ HOFERICH... 24	RVUE	$\pi N \rightarrow \pi N$
1353 $\pm$ 1	ROENCHEN 22	DPWA	Multichannel
1369 $\pm$ 3	SOKHOYAN 15A	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
1386	SHKLYAR 13	DPWA	Multichannel
1370 $\pm$ 4	ANISOVICH 12A	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 $\times$ IMAGINARY PART

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
180 to 205 (≈ 190) OUR ESTIMATE			
215 $\pm$ 18 $\pm$ 8	¹ HOFERICH... 24	RVUE	$\pi N \rightarrow \pi N$
203 $\pm$ 2	ROENCHEN 22	DPWA	Multichannel
189 $\pm$ 5	SOKHOYAN 15A	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
277	SHKLYAR 13	DPWA	Multichannel
190 $\pm$ 7	ANISOVICH 12A	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 $|r|$**

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
50 to 60 (≈ 55) OUR ESTIMATE			
$58 \pm 15 \pm 17$	¹ HOFERICHT... 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

VALUE ($^\circ$)	DOCUMENT ID	TECN	COMMENT
−100 to −80 (≈ -90) OUR ESTIMATE			
$-65 \pm 2 \pm 11$	¹ HOFERICHT... 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 $N\pi \rightarrow N(1440) \rightarrow N\eta$

MODULUS	PHASE ($^\circ$)	DOCUMENT ID	TECN	COMMENT
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

MODULUS	PHASE ($^\circ$)	DOCUMENT ID	TECN	COMMENT
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 $N\pi \rightarrow N(1440) \rightarrow \Lambda K$

MODULUS	PHASE (°)	DOCUMENT ID	TECN	COMMENT
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 $N\pi \rightarrow N(1440) \rightarrow \Sigma K$

MODULUS	PHASE (°)	DOCUMENT ID	TECN	COMMENT
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 $N\pi \rightarrow N(1440) \rightarrow N(\pi\pi)_{S=0}^{I=0}$

MODULUS	PHASE (°)	DOCUMENT ID	TECN	COMMENT
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

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
1410 to 1470 (≈ 1440) OUR ESTIMATE			
1417 ± 4	¹ HUNT	19	DPWA Multichannel
1430 ± 10	SOKHOYAN	15A	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 ± 8	ANISOVICH	12A	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

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
250 to 450 (≈ 350) OUR ESTIMATE			
257± 11	¹ HUNT	19	DPWA Multichannel
360± 30	SOKHOYAN	15A	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. • • •

365 ± 35	ANISOVICH	12A	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 $\Delta(1232)\pi$, <i>P</i> -wave	6–27 %
Γ_5 $N\sigma$	11–23 %
Γ_6 $p\gamma$, helicity=1/2	0.035–0.048 %
Γ_7 $n\gamma$, 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					
59 ± 2	¹ HUNT	19	DPWA	Multichannel	
63 ± 2	SOKHOYAN	15A	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. • • •					
62 ± 3	ANISOVICH	12A	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	

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

VALUE (%)	DOCUMENT ID	TECN	COMMENT
6 to 27 (≈ 15) OUR ESTIMATE			
22 ± 4	¹ HUNT	19	DPWA Multichannel
12 $+5$ -3	SHKLYAR	16	DPWA Multichannel
20 ± 7	SOKHOYAN	15A	DPWA Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •			
21 ± 8	ANISOVICH	12A	DPWA Multichannel
6.5 ± 0.8	¹ SHRESTHA	12A	DPWA Multichannel
16 ± 1	VRANA	00	DPWA Multichannel

¹Statistical error only. $\Gamma(N\sigma)/\Gamma_{\text{total}}$ Γ_5/Γ

VALUE (%)	DOCUMENT ID	TECN	COMMENT
16 ± 3	¹ HUNT	19	DPWA Multichannel
27 $+4$ -9	SHKLYAR	16	DPWA Multichannel
17 ± 6	SOKHOYAN	15A	DPWA Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •			
17 ± 7	ANISOVICH	12A	DPWA Multichannel
27 ± 1	¹ SHRESTHA	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 $A_{1/2}$**

MODULUS ($\text{GeV}^{-1/2}$)	PHASE ($^\circ$)	DOCUMENT ID	TECN	COMMENT
-0.090 ± 0.007	-30 ± 3	ROENCHEN	22	DPWA Multichannel
-0.044 ± 0.005	-40 ± 8	SOKHOYAN	15A	DPWA Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •				
-0.060	-23	ROENCHEN	15A	DPWA Multichannel

 $N(1440) \rightarrow n\gamma$, helicity-1/2 amplitude $A_{1/2}$

MODULUS ($\text{GeV}^{-1/2}$)	PHASE ($^\circ$)	DOCUMENT ID	TECN	COMMENT
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 $A_{1/2}$**

VALUE ($\text{GeV}^{-1/2}$)	DOCUMENT ID	TECN	COMMENT
-0.080 to -0.050 (≈ -0.065) OUR ESTIMATE			
-0.091 ± 0.007	¹ HUNT	19	DPWA Multichannel
-0.061 ± 0.006	SOKHOYAN	15A	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±0.008	ANISOVICH	12A	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 $A_{1/2}$

VALUE (GeV ^{−1/2})	DOCUMENT ID	TECN	COMMENT
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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.

$N(1440)$ REFERENCES

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

HOERICHT...	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