

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

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

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
<b>1360 to 1380 (<math>\approx</math> 1370) OUR ESTIMATE</b>			
1353 $\pm$ 1	ROENCHEN 22	DPWA	Multichannel
1369 $\pm$ 3	SOKHOYAN 15A	DPWA	Multichannel
1363 $\pm$ 2 $\pm$ 2	<sup>1</sup> 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	$\pi N \rightarrow \pi N$

<sup>1</sup> Fit to the amplitudes of HOEHLER 79.

#### −2×IMAGINARY PART

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
<b>180 to 205 (<math>\approx</math> 190) OUR ESTIMATE</b>			
203 $\pm$ 2	ROENCHEN 22	DPWA	Multichannel
189 $\pm$ 5	SOKHOYAN 15A	DPWA	Multichannel
180 $\pm$ 4 $\pm$ 5	<sup>1</sup> 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	$\pi N \rightarrow \pi N$

<sup>1</sup> 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>
<b>50 to 60 (<math>\approx 55</math>) OUR ESTIMATE</b>			
59 $\pm$ 1	ROENCHEN	22	DPWA Multichannel
49 $\pm$ 3	SOKHOYAN	15A	DPWA Multichannel
50 $\pm$ 1 $\pm$ 2	<sup>1</sup> SVARC	14	L+P $\pi N \rightarrow \pi N$
52 $\pm$ 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 $\pm$ 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 $\pi N \rightarrow \pi N$

<sup>1</sup> Fit to the amplitudes of HOEHLER 79.

### PHASE $\theta$

<u>VALUE (<math>^\circ</math>)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>-100 to -80 (<math>\approx -90</math>) OUR ESTIMATE</b>			
-104 $\pm$ 2	ROENCHEN	22	DPWA Multichannel
- 82 $\pm$ 5	SOKHOYAN	15A	DPWA Multichannel
- 88 $\pm$ 1 $\pm$ 2	<sup>1</sup> SVARC	14	L+P $\pi N \rightarrow \pi N$
-100 $\pm$ 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 $\pm$ 4	ANISOVICH	12A	DPWA Multichannel
- 88	BATINIC	10	DPWA $\pi N \rightarrow N\pi, N\eta$
- 98	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$

<sup>1</sup> 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 (<math>^\circ</math>)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.084 $\pm$ 0.002	-28 $\pm$ 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 $N\pi \rightarrow N(1440) \rightarrow \Delta\pi, P\text{-wave}$

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

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

<u>MODULUS</u>	<u>PHASE (<math>^\circ</math>)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
$0.025 \pm 0.005$	$-92 \pm 43$	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 (<math>^\circ</math>)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
$0.002 \pm 0.003$	$-32 \pm 77$	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 $N\pi \rightarrow N(1440) \rightarrow N(\pi\pi)_{S=0}^{I=0}$

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

## **$N(1440)$ BREIT-WIGNER MASS**

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>1410 to 1470 (<math>\approx 1440</math>) OUR ESTIMATE</b>			
$1417 \pm 4$	<sup>1</sup> HUNT	19	DPWA Multichannel
$1430 \pm 10$	SOKHOYAN	15A	DPWA Multichannel
$1515 \pm 15$	<sup>1</sup> SHKLYAR	13	DPWA Multichannel
$1485.0 \pm 1.2$	<sup>1</sup> ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
$1440 \pm 30$	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
$1410 \pm 12$	HOEHLER	79	IPWA $\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
$1430 \pm 8$	ANISOVICH	12A	DPWA Multichannel
$1412 \pm 2$	<sup>1</sup> SHRESTHA	12A	DPWA Multichannel
$1439 \pm 19$	BATINIC	10	DPWA $\pi N \rightarrow N\pi, N\eta$
$1518 \pm 5$	PENNER	02C	DPWA Multichannel
$1479 \pm 80$	VRANA	00	DPWA Multichannel

<sup>1</sup>Statistical error only.

## **$N(1440)$ BREIT-WIGNER WIDTH**

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>250 to 450 (<math>\approx 350</math>) OUR ESTIMATE</b>			
$257 \pm 11$	<sup>1</sup> HUNT	19	DPWA Multichannel
$360 \pm 30$	SOKHOYAN	15A	DPWA Multichannel
$605 \pm 90$	<sup>1</sup> SHKLYAR	13	DPWA Multichannel
$284 \pm 18$	<sup>1</sup> ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
$340 \pm 70$	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
$135 \pm 10$	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	<sup>1</sup> 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

<sup>1</sup>Statistical error only.

### N(1440) DECAY MODES

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

Mode	Fraction ( $\Gamma_i/\Gamma$ )
$\Gamma_1$ $N\pi$	55–75 %
$\Gamma_2$ $N\eta$	<1 %
$\Gamma_3$ $N\pi\pi$	17–50 %
$\Gamma_4$ $\Delta(1232)\pi, P\text{-wave}$	6–27 %
$\Gamma_5$ $N\sigma$	11–23 %
$\Gamma_6$ $p\gamma, \text{helicity}=1/2$	0.035–0.048 %
$\Gamma_7$ $n\gamma, \text{helicity}=1/2$	0.02–0.04 %

### N(1440) BRANCHING RATIOS

$\Gamma(N\pi)/\Gamma_{\text{total}}$					$\Gamma_1/\Gamma$
VALUE (%)	DOCUMENT ID	TECN	COMMENT		
<b>55 to 75 (≈ 65) OUR ESTIMATE</b>					
59 ± 2	<sup>1</sup> HUNT	19	DPWA	Multichannel	
63 ± 2	SOKHOYAN	15A	DPWA	Multichannel	
56 ± 2	<sup>1</sup> SHKLYAR	13	DPWA	Multichannel	
78.7 ± 1.6	<sup>1</sup> 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	<sup>1</sup> 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

<sup>1</sup>Statistical error only.

$\Gamma(N\eta)/\Gamma_{\text{total}}$					$\Gamma_2/\Gamma$
VALUE (%)	DOCUMENT ID	TECN	COMMENT		

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

0 ± 1	VRANA	00	DPWA	Multichannel
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$\Gamma(\Delta(1232)\pi, P\text{-wave})/\Gamma_{\text{total}}$   $\Gamma_4/\Gamma$

VALUE (%)	DOCUMENT ID	TECN	COMMENT
<b>6 to 27 (<math>\approx 15</math>) OUR ESTIMATE</b>			
22 $\pm 4$	<sup>1</sup> HUNT	19	DPWA Multichannel
12 $^{+5}_{-3}$	SHKLYAR	16	DPWA Multichannel
20 $\pm 7$	SOKHOYAN	15A	DPWA Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •			
21 $\pm 8$	ANISOVICH	12A	DPWA Multichannel
6.5 $\pm 0.8$	<sup>1</sup> SHRESTHA	12A	DPWA Multichannel
16 $\pm 1$	VRANA	00	DPWA Multichannel

<sup>1</sup>Statistical error only.

$\Gamma(N\sigma)/\Gamma_{\text{total}}$   $\Gamma_5/\Gamma$

VALUE (%)	DOCUMENT ID	TECN	COMMENT
16 $\pm 3$	<sup>1</sup> HUNT	19	DPWA Multichannel
27 $^{+4}_{-9}$	SHKLYAR	16	DPWA Multichannel
17 $\pm 6$	SOKHOYAN	15A	DPWA Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •			
17 $\pm 7$	ANISOVICH	12A	DPWA Multichannel
27 $\pm 1$	<sup>1</sup> SHRESTHA	12A	DPWA Multichannel
12 $\pm 1$	VRANA	00	DPWA Multichannel

<sup>1</sup>Statistical 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 $\pm 0.007$	-30 $\pm 3$	ROENCHEN	22	DPWA Multichannel
-0.044 $\pm 0.005$	-40 $\pm 8$	SOKHOYAN	15A	DPWA Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •				
-0.060	-23	ROENCHEN	15A	DPWA Multichannel

**$N(1440)$  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
<b>-0.080 to -0.050 (<math>\approx -0.065</math>) OUR ESTIMATE</b>			
-0.091 $\pm 0.007$	<sup>1</sup> HUNT	19	DPWA Multichannel
-0.061 $\pm 0.006$	SOKHOYAN	15A	DPWA Multichannel
-0.085 $\pm 0.003$	<sup>1</sup> SHKLYAR	13	DPWA Multichannel
-0.056 $\pm 0.001$	<sup>1</sup> WORKMAN	12A	DPWA $\gamma N \rightarrow N\pi$
-0.051 $\pm 0.002$	<sup>1</sup> DUGGER	07	DPWA $\gamma N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •			
-0.061 $\pm 0.008$	ANISOVICH	12A	DPWA Multichannel
-0.084 $\pm 0.003$	<sup>1</sup> SHRESTHA	12A	DPWA Multichannel
-0.061	DRECHSEL	07	DPWA $\gamma N \rightarrow \pi N$
-0.087	PENNER	02D	DPWA Multichannel

<sup>1</sup>Statistical error only.

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

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

<sup>1</sup>Statistical error only.

## $N(1440)$ REFERENCES

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

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	
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	$\pi N$ 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