

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

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

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

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>1360 to 1380 (<math>\approx</math> 1370) OUR ESTIMATE</b>			
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.

**-2xIMAGINARY PART**

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>160 to 190 (<math>\approx</math> 175) OUR ESTIMATE</b>			
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>46 to 54 (<math>\approx</math> 50) OUR ESTIMATE</b>			
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</math> –90) OUR ESTIMATE</b>			
– $82 \pm 5$	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>
• • • 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 (<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>
• • • 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>
• • • 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. ● ● ●			
$365 \pm 35$	ANISOVICH	12A	DPWA Multichannel
$248 \pm 5$	<sup>1</sup> SHRESTHA	12A	DPWA Multichannel
$437 \pm 141$	BATINIC	10	DPWA $\pi N \rightarrow N\pi, N\eta$
$668 \pm 41$	PENNER	02C	DPWA Multichannel
$490 \pm 120$	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.

<u>Mode</u>	<u>Fraction (<math>\Gamma_i/\Gamma</math>)</u>
$\Gamma_1$ $N\pi$	55–75 %

$\Gamma_2$	$N\eta$	<1 %
$\Gamma_3$	$N\pi\pi$	17–50 %
$\Gamma_4$	$\Delta(1232)\pi$ , <i>P</i> -wave	6–27 %
$\Gamma_5$	$N\sigma$	11–23 %
$\Gamma_6$	$p\gamma$ , helicity=1/2	0.035–0.048 %
$\Gamma_7$	$n\gamma$ , helicity=1/2	0.02–0.04 %

## **$N(1440)$ BRANCHING RATIOS**

### **$\Gamma(N\pi)/\Gamma_{\text{total}}$ $\Gamma_1/\Gamma$**

<u>VALUE (%)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>55 to 75 (<math>\approx 65</math>) OUR ESTIMATE</b>			
59 $\pm 2$	<sup>1</sup> HUNT	19	DPWA Multichannel
63 $\pm 2$	SOKHOYAN	15A	DPWA Multichannel
56 $\pm 2$	<sup>1</sup> SHKLYAR	13	DPWA Multichannel
78.7 $\pm 1.6$	<sup>1</sup> ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
68 $\pm 4$	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
51 $\pm 5$	HOEHLER	79	IPWA $\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
62 $\pm 3$	ANISOVICH	12A	DPWA Multichannel
64.8 $\pm 0.9$	<sup>1</sup> SHRESTHA	12A	DPWA Multichannel
62 $\pm 4$	BATINIC	10	DPWA $\pi N \rightarrow N\pi, N\eta$
57 $\pm 1$	PENNER	02C	DPWA Multichannel
72 $\pm 5$	VRANA	00	DPWA Multichannel

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

### **$\Gamma(N\eta)/\Gamma_{\text{total}}$ $\Gamma_2/\Gamma$**

<u>VALUE (%)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
0 $\pm 1$	VRANA	00	DPWA Multichannel

### **$\Gamma(\Delta(1232)\pi, P\text{-wave})/\Gamma_{\text{total}}$ $\Gamma_4/\Gamma$**

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

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

<u>VALUE (%)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
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±7	ANISOVICH	12A	DPWA	Multichannel
27±1	<sup>1</sup> SHRESTHA	12A	DPWA	Multichannel
12±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 $A_{1/2}$**

<u>MODULUS (<math>\text{GeV}^{-1/2}</math>)</u>	<u>PHASE (<math>^\circ</math>)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
$-0.044 \pm 0.005$	$-40 \pm 8$	SOKHOYAN	15A	DPWA Multichannel
$-0.054^{+0.004}_{-0.003}$	$5^{+2}_{-5}$	ROENCHEN	14	DPWA

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

-0.060	-23	ROENCHEN	15A	DPWA Multichannel
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## **$N(1440)$ BREIT-WIGNER PHOTON DECAY AMPLITUDES**

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

<u>VALUE (<math>\text{GeV}^{-1/2}</math>)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<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 $A_{1/2}$**

<u>VALUE (<math>\text{GeV}^{-1/2}</math>)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>0.035 to 0.055 (<math>\approx 0.045</math>) OUR ESTIMATE</b>			
$0.013 \pm 0.012$	<sup>1</sup> HUNT	19	DPWA Multichannel
$0.043 \pm 0.012$	ANISOVICH	13B	DPWA Multichannel
$0.048 \pm 0.004$	<sup>1</sup> CHEN	12A	DPWA $\gamma N \rightarrow \pi N$
$0.040 \pm 0.005$	<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).

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.)
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	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