

$N(1520) \ 3/2^-$ $I(J^P) = \frac{1}{2}(3/2^-)$ Status: ****Older and obsolete values are listed and referenced in the 2014 edition, Chinese Physics **C38** 070001 (2014). **$N(1520)$ POLE POSITION****REAL PART**

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
1505 to 1515 (\approx 1510) OUR ESTIMATE			
1507 \pm 2	SOKHOYAN	15A	DPWA Multichannel
1506 \pm 1 \pm 1	¹ SVARC	14	L+P $\pi N \rightarrow \pi N$
1510 \pm 5	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
1500	HUNT	19	DPWA Multichannel
1512	ROENCHEN	15A	DPWA Multichannel
1492	SHKLYAR	13	DPWA Multichannel
1507 \pm 3	ANISOVICH	12A	DPWA Multichannel
1506 \pm 9	BATINIC	10	DPWA $\pi N \rightarrow N\pi, N\eta$
1515	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
1504	VRANA	00	DPWA Multichannel
1510	HOEHLER	93	ARGD $\pi N \rightarrow \pi N$

¹Fit to the amplitudes of HOEHLER 79.**-2xIMAGINARY PART**

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
105 to 120 (\approx 110) OUR ESTIMATE			
111 \pm 3	SOKHOYAN	15A	DPWA Multichannel
115 \pm 2 \pm 1	¹ SVARC	14	L+P $\pi N \rightarrow \pi N$
114 \pm 10	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
117	HUNT	19	DPWA Multichannel
89	ROENCHEN	15A	DPWA Multichannel
94	SHKLYAR	13	DPWA Multichannel
111 \pm 5	ANISOVICH	12A	DPWA Multichannel
122 \pm 9	BATINIC	10	DPWA $\pi N \rightarrow N\pi, N\eta$
113	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
112	VRANA	00	DPWA Multichannel
120	HOEHLER	93	ARGD $\pi N \rightarrow \pi N$

¹Fit to the amplitudes of HOEHLER 79. **$N(1520)$ ELASTIC POLE RESIDUE****MODULUS $|r|$**

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
32 to 38 (\approx 35) OUR ESTIMATE			
36 \pm 2	SOKHOYAN	15A	DPWA Multichannel
33 \pm 1 \pm 1	¹ SVARC	14	L+P $\pi N \rightarrow \pi N$
35 \pm 2	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$

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

37	ROENCHEN	15A	DPWA	Multichannel
27	SHKLYAR	13	DPWA	Multichannel
36±3	ANISOVICH	12A	DPWA	Multichannel
35	BATINIC	10	DPWA	$\pi N \rightarrow N\pi, N\eta$
38	ARNDT	06	DPWA	$\pi N \rightarrow \pi N, \eta N$
32	HOEHLER	93	ARGD	$\pi N \rightarrow \pi N$

¹ Fit to the amplitudes of HOEHLER 79.

PHASE θ

<u>VALUE (°)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
−15 to −5 (≈ −10) OUR ESTIMATE			
−14±3	SOKHOYAN	15A	DPWA Multichannel
−15±1±1	¹ SVARC	14	L+P $\pi N \rightarrow \pi N$
−12±5	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$

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

−6	ROENCHEN	15A	DPWA	Multichannel
−35	SHKLYAR	13	DPWA	Multichannel
−14±3	ANISOVICH	12A	DPWA	Multichannel
−7	BATINIC	10	DPWA	$\pi N \rightarrow N\pi, N\eta$
−5	ARNDT	06	DPWA	$\pi N \rightarrow \pi N, \eta N$
−8	HOEHLER	93	ARGD	$\pi N \rightarrow \pi N$

¹ Fit to the amplitudes of HOEHLER 79.

N(1520) INELASTIC POLE RESIDUE

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

Normalized residue in $N\pi \rightarrow N(1520) \rightarrow \Delta\pi$, S-wave

<u>MODULUS</u>	<u>PHASE (°)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.33±0.04	155 ± 15	SOKHOYAN	15A	DPWA Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.33±0.05	150 ± 20	ANISOVICH	12A	DPWA Multichannel

Normalized residue in $N\pi \rightarrow N(1520) \rightarrow \Delta\pi$, D-wave

<u>MODULUS</u>	<u>PHASE (°)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.25±0.03	105 ± 18	SOKHOYAN	15A	DPWA Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.25±0.03	100 ± 20	ANISOVICH	12A	DPWA Multichannel

Normalized residue in $N\pi \rightarrow N(1520) \rightarrow N\eta$

<u>MODULUS</u>	<u>PHASE (°)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.026	95	ROENCHEN	15A	DPWA Multichannel

Normalized residue in $N\pi \rightarrow N(1520) \rightarrow \Lambda K$

<u>MODULUS</u>	<u>PHASE (°)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.069	158	ROENCHEN	15A	DPWA Multichannel

Normalized residue in $N\pi \rightarrow N(1520) \rightarrow \Sigma K$

<u>MODULUS</u>	<u>PHASE ($^\circ$)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.049	-41	ROENCHEN	15A DPWA	Multichannel

Normalized residue in $N\pi \rightarrow N(1520) \rightarrow N\sigma$

<u>MODULUS</u>	<u>PHASE ($^\circ$)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.08 ± 0.03	-45 ± 25	SOKHOYAN	15A DPWA	Multichannel

 $N(1520)$ BREIT-WIGNER MASS

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
1510 to 1520 (≈ 1515) OUR ESTIMATE			
1512.0 ± 1.5	¹ HUNT	19	DPWA Multichannel
1516 ± 2	SOKHOYAN	15A	DPWA Multichannel
1505 ± 4	¹ SHKLYAR	13	DPWA Multichannel
1514.5 ± 0.2	¹ ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
1525 ± 10	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
1519 ± 4	HOEHLER	79	IPWA $\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •			
1517 ± 3	ANISOVICH	12A	DPWA Multichannel
1512.6 ± 0.5	¹ SHRESTHA	12A	DPWA Multichannel
1522 ± 8	BATINIC	10	DPWA $\pi N \rightarrow N\pi, N\eta$
1509 ± 1	PENNER	02C	DPWA Multichannel
1518 ± 3	VRANA	00	DPWA Multichannel

¹Statistical error only. **$N(1520)$ BREIT-WIGNER WIDTH**

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
100 to 120 (≈ 110) OUR ESTIMATE			
121 ± 3	¹ HUNT	19	DPWA Multichannel
113 ± 4	SOKHOYAN	15A	DPWA Multichannel
100 ± 2	¹ SHKLYAR	13	DPWA Multichannel
103.6 ± 0.4	¹ ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
120 ± 15	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
114 ± 7	HOEHLER	79	IPWA $\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •			
114 ± 5	ANISOVICH	12A	DPWA Multichannel
117 ± 1	¹ SHRESTHA	12A	DPWA Multichannel
132 ± 11	BATINIC	10	DPWA $\pi N \rightarrow N\pi, N\eta$
100 ± 2	PENNER	02C	DPWA Multichannel
124 ± 4	VRANA	00	DPWA Multichannel

¹Statistical error only.

$N(1520)$ DECAY MODES

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

Mode	Fraction (Γ_i/Γ)
Γ_1 $N\pi$	55–65 %
Γ_2 $N\eta$	0.07–0.09 %
Γ_3 $N\pi\pi$	25–35 %
Γ_4 $\Delta(1232)\pi$	22–34 %
Γ_5 $\Delta(1232)\pi$, S -wave	15–23 %
Γ_6 $\Delta(1232)\pi$, D -wave	7–11 %
Γ_7 $N\sigma$	< 2 %
Γ_8 $p\gamma$	0.31–0.52 %
Γ_9 $p\gamma$, helicity=1/2	0.01–0.02 %
Γ_{10} $p\gamma$, helicity=3/2	0.30–0.50 %
Γ_{11} $n\gamma$	0.30–0.53 %
Γ_{12} $n\gamma$, helicity=1/2	0.04–0.10 %
Γ_{13} $n\gamma$, helicity=3/2	0.25–0.45 %

 $N(1520)$ BRANCHING RATIOS

$\Gamma(N\pi)/\Gamma_{\text{total}}$					Γ_1/Γ
VALUE (%)	DOCUMENT ID	TECN	COMMENT		
55 to 65 (≈ 60) OUR ESTIMATE					
58.3 ± 1.5	¹ HUNT	19	DPWA	Multichannel	
61 ± 2	SOKHOYAN	15A	DPWA	Multichannel	
57 ± 2	¹ SHKLYAR	13	DPWA	Multichannel	
63.2 ± 0.1	¹ ARNDT	06	DPWA	$\pi N \rightarrow \pi N, \eta N$	
58 ± 3	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$	
54 ± 3	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	
62.7 ± 0.5	¹ SHRESTHA	12A	DPWA	Multichannel	
55 ± 5	BATINIC	10	DPWA	$\pi N \rightarrow N\pi, N\eta$	
56 ± 1	PENNER	02C	DPWA	Multichannel	
63 ± 2	VRANA	00	DPWA	Multichannel	

¹Statistical error only.

$\Gamma(N\eta)/\Gamma_{\text{total}}$					Γ_2/Γ
VALUE (%)	DOCUMENT ID	TECN	COMMENT		
0.03 ± 0.01	¹ HUNT	19	DPWA	Multichannel	
<1	SHKLYAR	13	DPWA	Multichannel	
0.08 ± 0.01	TIATOR	99	DPWA	$\gamma p \rightarrow p\eta$	

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

0.1 ±0.1	BATINIC	10	DPWA	$\pi N \rightarrow N\pi, N\eta$
0.2 ±0.1	THOMA	08	DPWA	Multichannel
0.08 to 0.12	ARNDT	05	DPWA	Multichannel
0.23±0.04	PENNER	02C	DPWA	Multichannel
0 ±1	VRANA	00	DPWA	Multichannel

¹Statistical error only.

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

Γ_5/Γ

VALUE (%)	DOCUMENT ID	TECN	COMMENT
21 ±2	¹ HUNT	19	DPWA Multichannel
19 ±4	SOKHOYAN	15A	DPWA Multichannel

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

19 ±4	ANISOVICH	12A	DPWA	Multichannel
9.3±0.7	¹ SHRESTHA	12A	DPWA	Multichannel
15 ±2	VRANA	00	DPWA	Multichannel

¹Statistical error only.

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

Γ_6/Γ

VALUE (%)	DOCUMENT ID	TECN	COMMENT
6 ±1	¹ HUNT	19	DPWA Multichannel
9 ±2	SOKHOYAN	15A	DPWA Multichannel

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

9 ±2	ANISOVICH	12A	DPWA	Multichannel
6.3±0.5	¹ SHRESTHA	12A	DPWA	Multichannel
11 ±2	VRANA	00	DPWA	Multichannel

¹Statistical error only.

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

Γ_7/Γ

VALUE (%)	DOCUMENT ID	TECN	COMMENT
<0.7	¹ HUNT	19	DPWA Multichannel
<2	SOKHOYAN	15A	DPWA Multichannel

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

<1	¹ SHRESTHA	12A	DPWA	Multichannel
<4	THOMA	08	DPWA	Multichannel
1 ±1	VRANA	00	DPWA	Multichannel

¹Statistical error only.

$N(1520)$ PHOTON DECAY AMPLITUDES AT THE POLE

$N(1520) \rightarrow p\gamma$, helicity-1/2 amplitude $A_{1/2}$

MODULUS ($\text{GeV}^{-1/2}$)	PHASE ($^\circ$)	DOCUMENT ID	TECN	COMMENT
-0.023 ± 0.004	-6 ± 5	SOKHOYAN	15A	DPWA Multichannel
$-0.024^{+0.008}_{-0.003}$	-17^{+16}_{-6}	ROENCHEN	14	DPWA

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

-0.031	-17	ROENCHEN	15A	DPWA Multichannel
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$N(1520) \rightarrow p\gamma$, 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>
0.131 ± 0.006	4 ± 4	SOKHOYAN	15A	DPWA Multichannel
$0.117^{+0.006}_{-0.010}$	26 ± 2	ROENCHEN	14	DPWA
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
0.075	1.7	ROENCHEN	15A	DPWA Multichannel

 $N(1520)$ BREIT-WIGNER PHOTON DECAY AMPLITUDES **$N(1520) \rightarrow p\gamma$, helicity-1/2 amplitude $A_{1/2}$**

<u>VALUE ($\text{GeV}^{-1/2}$)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
-0.030 to -0.015 (≈ -0.025) OUR ESTIMATE			
-0.034 ± 0.003	¹ HUNT	19	DPWA Multichannel
-0.024 ± 0.004	SOKHOYAN	15A	DPWA Multichannel
-0.015 ± 0.001	¹ SHKLYAR	13	DPWA Multichannel
-0.019 ± 0.002	¹ WORKMAN	12A	DPWA $\gamma N \rightarrow N\pi$
-0.028 ± 0.002	¹ DUGGER	07	DPWA $\gamma N \rightarrow \pi N$
-0.038 ± 0.003	¹ AHRENS	02	DPWA $\gamma N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
-0.022 ± 0.004	ANISOVICH	12A	DPWA Multichannel
-0.034 ± 0.001	¹ SHRESTHA	12A	DPWA Multichannel
-0.027	DRECHSEL	07	DPWA $\gamma N \rightarrow \pi N$
-0.003	PENNER	02D	DPWA Multichannel
$-0.052 \pm 0.010 \pm 0.007$	¹ MUKHOPAD...	98	$\gamma p \rightarrow \eta p$

¹Statistical error only. **$N(1520) \rightarrow p\gamma$, helicity-3/2 amplitude $A_{3/2}$**

<u>VALUE ($\text{GeV}^{-1/2}$)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.135 to 0.145 (≈ 0.140) OUR ESTIMATE			
0.142 ± 0.003	¹ HUNT	19	DPWA Multichannel
0.130 ± 0.006	SOKHOYAN	15A	DPWA Multichannel
0.146 ± 0.001	¹ SHKLYAR	13	DPWA Multichannel
0.141 ± 0.002	¹ WORKMAN	12A	DPWA $\gamma N \rightarrow N\pi$
0.143 ± 0.002	¹ DUGGER	07	DPWA $\gamma N \rightarrow \pi N$
0.147 ± 0.010	¹ AHRENS	02	DPWA $\gamma N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
0.131 ± 0.010	ANISOVICH	12A	DPWA Multichannel
0.127 ± 0.003	¹ SHRESTHA	12A	DPWA Multichannel
0.161	DRECHSEL	07	DPWA $\gamma N \rightarrow \pi N$
0.151	PENNER	02D	DPWA Multichannel
$0.130 \pm 0.020 \pm 0.015$	¹ MUKHOPAD...	98	$\gamma p \rightarrow \eta p$

¹Statistical error only.

$N(1520) \rightarrow n\gamma$, helicity-1/2 amplitude $A_{1/2}$

VALUE ($\text{GeV}^{-1/2}$)	DOCUMENT ID	TECN	COMMENT
–0.055 to –0.040 (\approx – 0.050) OUR ESTIMATE			
–0.072±0.003	¹ HUNT	19	DPWA Multichannel
–0.049±0.008	ANISOVICH	13B	DPWA Multichannel
–0.046±0.006	¹ CHEN	12A	DPWA $\gamma N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
–0.038±0.003	¹ SHRESTHA	12A	DPWA Multichannel
–0.077	DRECHSEL	07	DPWA $\gamma N \rightarrow \pi N$
–0.084	PENNER	02D	DPWA Multichannel

¹Statistical error only. **$N(1520) \rightarrow n\gamma$, helicity-3/2 amplitude $A_{3/2}$**

VALUE ($\text{GeV}^{-1/2}$)	DOCUMENT ID	TECN	COMMENT
–0.120 to –0.100 (\approx – 0.115) OUR ESTIMATE			
–0.123±0.006	¹ HUNT	19	DPWA Multichannel
–0.113±0.012	ANISOVICH	13B	DPWA Multichannel
–0.115±0.005	¹ CHEN	12A	DPWA $\gamma N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
–0.101±0.004	¹ SHRESTHA	12A	DPWA Multichannel
–0.154	DRECHSEL	07	DPWA $\gamma N \rightarrow \pi N$
–0.159	PENNER	02D	DPWA Multichannel

¹Statistical error only. **$N(1520)$ REFERENCES**

For early references, see Physics Letters **111B** 1 (1982). For very early references, see Reviews of Modern Physics **37** 633 (1965).

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	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)
THOMA	08	PL B659 87	U. Thoma <i>et al.</i> (CB-ELSA Collab.)
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)
ARNDT	05	PR C72 045202	R.A. Arndt <i>et al.</i> (GWU, PNPI)
AHRENS	02	PRL 88 232002	J. Ahrens <i>et al.</i> (Mainz MAMI GDH/A2 Collab.)
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)
TIATOR	99	PR C60 035210	L. Tiator <i>et al.</i>
MUKHOPAD...	98	PL B444 7	N.C. Mukhopadhyay, N. Mathur
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