$N(1520)\ 3/2^-$

$I(J^P) = \frac{1}{2}(\frac{3}{2}^-)$ Status: ∗∗∗∗

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

N(1520) POLE POSITION

REAL PART

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
1505 to 1515 (≈ 1510) OUR ESTIMATE				
1507±2	SOKHOYAN	15A	DPWA	Multichannel
1506±1±1	[1] SVARC	14	L+P	$\pi N \to \pi N$
1515	ARNDT	06	DPWA	$\pi N \to \pi N$, ηN
1510	HOEHLER	93	ARGD	$\pi N \to \pi N$
1510±5	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1492	SHKLYAR	13	DPWA	Multichannel
1507±3	ANISOVICH	12A	DPWA	Multichannel
1501	SHRESTHA	12A	DPWA	Multichannel
1506±9	BATINIC	10	DPWA	$\pi N \to N\pi$, $N\eta$
1504	VRANA	00	DPWA	Multichannel

−2×IMAGINARY PART

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
105 to 120 (≈ 110) OUR ESTIMATE				
111± 3	SOKHOYAN	15A	DPWA	Multichannel
115± 2±1	[1] SVARC	14	L+P	$\pi N \to \pi N$
113	ARNDT	06	DPWA	$\pi N \to \pi N$, ηN
120	HOEHLER	93	ARGD	$\pi N \to \pi N$
114±10	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
94	SHKLYAR	13	DPWA	Multichannel
111± 5	ANISOVICH	12A	DPWA	Multichannel
112	SHRESTHA	12A	DPWA	Multichannel
122± 9	BATINIC	10	DPWA	$\pi N \to N\pi$, $N\eta$
112	VRANA	00	DPWA	Multichannel

N(1520) ELASTIC POLE RESIDUE

MODULUS $|r|$

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
35±3 OUR ESTIMATE				
36±2	SOKHOYAN	15A	DPWA	Multichannel
33±1±1	[1] SVARC	14	L+P	$\pi N \to \pi N$
38	ARNDT	06	DPWA	$\pi N \to \pi N$, ηN
32	HOEHLER	93	ARGD	$\pi N \to \pi N$
35±2	CUTKOSKY	80	IPWA	$\pi N \to \pi N$

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

27	SHKLYAR	13	DPWA	Multichannel
36±3	ANISOVICH	12A	DPWA	Multichannel
35	BATINIC	10	DPWA	$\pi N \rightarrow N\pi$, $N\eta$

PHASE θ

VALUE (°)	DOCUMENT ID		TECN	COMMENT
−10±5 OUR ESTIMATE				
−14±3	SOKHOYAN	15A	DPWA	Multichannel
−15±1±1	[1] SVARC	14	L+P	$\pi N \rightarrow \pi N$
− 5	ARNDT	06	DPWA	$\pi N \rightarrow \pi N$, ηN
− 8	HOEHLER	93	ARGD	$\pi N \rightarrow \pi N$
−12±5	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
−35	SHKLYAR	13	DPWA	Multichannel
−14±3	ANISOVICH	12A	DPWA	Multichannel
− 7	BATINIC	10	DPWA	$\pi N \rightarrow N\pi$, $N\eta$

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

MODULUS	PHASE (°)	DOCUMENT ID		TECN	COMMENT
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

MODULUS	PHASE (°)	DOCUMENT ID		TECN	COMMENT
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 $N\pi \rightarrow N(1520) \rightarrow N\sigma$

MODULUS	PHASE (°)	DOCUMENT ID		TECN	COMMENT
0.08±0.03	−45 ± 25	SOKHOYAN	15A	DPWA	Multichannel

N(1520) BREIT-WIGNER MASS

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
1510 to 1520 (≈ 1515) OUR ESTIMATE				
1516 ± 2	SOKHOYAN	15A	DPWA	Multichannel
1505 ± 4	SHKLYAR	13	DPWA	Multichannel
1514.5± 0.2	ARNDT	06	DPWA	$\pi N \rightarrow \pi N$, ηN
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	SHRESTHA	12A	DPWA	Multichannel
1522 ± 8	BATINIC	10	DPWA	$\pi N \to N\pi$, $N\eta$
1509 ± 1	PENNER	02C	DPWA	Multichannel
1518 ± 3	VRANA	00	DPWA	Multichannel

N(1520) BREIT-WIGNER WIDTH

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
100 to 125 (≈ 115) OUR ESTIMATE				
113 ± 4	SOKHOYAN	15A	DPWA	Multichannel
100 ± 2	SHKLYAR	13	DPWA	Multichannel
103.6 ± 0.4	ARNDT	06	DPWA	$\pi N \to \pi N$, ηN
120 ± 15	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
114 ± 7	HOEHLER	79	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
114 ± 5	ANISOVICH	12A	DPWA	Multichannel
117 ± 1	SHRESTHA	12A	DPWA	Multichannel
132 ± 11	BATINIC	10	DPWA	$\pi N \to N\pi$, $N\eta$
100 ± 2	PENNER	02C	DPWA	Multichannel
124 ± 4	VRANA	00	DPWA	Multichannel

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	$N\eta$	< 1 %
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

$\Gamma(N\pi)/\Gamma_{total}$ — Γ_1/Γ

VALUE (%)	DOCUMENT ID		TECN	COMMENT
55 to 65 OUR ESTIMATE				
61 ±2	SOKHOYAN	15A	DPWA	Multichannel
57 ±2	SHKLYAR	13	DPWA	Multichannel
63.2±0.1	ARNDT	06	DPWA	$\pi N \to \pi N$, ηN
58 ±3	CUTKOSKY	80	IPWA	$\pi N \to \pi N$
54 ±3	HOEHLER	79	IPWA	$\pi N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
62 ±3	ANISOVICH	12A	DPWA	Multichannel
62.7±0.5	SHRESTHA	12A	DPWA	Multichannel
55 ±5	BATINIC	10	DPWA	$\pi N \to N\pi$, $N\eta$
56 ±1	PENNER	02C	DPWA	Multichannel
63 ±2	VRANA	00	DPWA	Multichannel

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

VALUE (%)	DOCUMENT ID		TECN	COMMENT
0 ±1	SHKLYAR	13	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.1 ±0.1	BATINIC	10	DPWA	$\pi N \to N\pi$, $N\eta$
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
0.08±0.01	TIATOR	99	DPWA	$\gamma p \to p\eta$

$\Gamma(\Delta(1232)\pi, S\text{-wave})/\Gamma_{total}$ — Γ_5/Γ

VALUE (%)	DOCUMENT ID		TECN	COMMENT
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	SHRESTHA	12A	DPWA	Multichannel
15 ±2	VRANA	00	DPWA	Multichannel

$\Gamma(\Delta(1232)\pi, D\text{-wave})/\Gamma_{total}$ — Γ_6/Γ

VALUE (%)	DOCUMENT ID		TECN	COMMENT
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	SHRESTHA	12A	DPWA	Multichannel
11 ±2	VRANA	00	DPWA	Multichannel

$\Gamma(N\sigma)/\Gamma_{total}$ — Γ_7/Γ

VALUE (%)	DOCUMENT ID		TECN	COMMENT
<2	SOKHOYAN	15A	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •				
<1	SHRESTHA	12A	DPWA	Multichannel
<4	THOMA	08	DPWA	Multichannel
1 ± 1	VRANA	00	DPWA	Multichannel

N(1520) PHOTON DECAY AMPLITUDES AT THE POLE

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

MODULUS (GeV$^{-1/2}$)	PHASE (°)	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	

$N(1520) \rightarrow p\gamma$, helicity-3/2 amplitude $A_{3/2}$

MODULUS (GeV$^{-1/2}$)	PHASE (°)	DOCUMENT ID		TECN	COMMENT
0.131 ± 0.006	4 ± 4	SOKHOYAN	15A	DPWA	Multichannel
$0.117^{+0.006}_{-0.010}$	26 ± 2	ROENCHEN	14	DPWA	

N(1520) BREIT-WIGNER PHOTON DECAY AMPLITUDES

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

VALUE (GeV$^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
-0.020 ± 0.005 OUR ESTIMATE				
-0.024 ± 0.004	SOKHOYAN	15A	DPWA	Multichannel
-0.019 ± 0.002	WORKMAN	12A	DPWA	$\gamma N \rightarrow N\pi$
-0.028 ± 0.002	DUGGER	07	DPWA	$\gamma N \rightarrow \pi N$
-0.038 ± 0.003	AHRENS	02	DPWA	$\gamma N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
-0.015 ± 0.001	SHKLYAR	13	DPWA	Multichannel
-0.022 ± 0.004	ANISOVICH	12A	DPWA	Multichannel
-0.034 ± 0.001	SHRESTHA	12A	DPWA	Multichannel
-0.027	DRECHSEL	07	DPWA	$\gamma N \rightarrow \pi N$
-0.003	PENNER	02D	DPWA	Multichannel
$-0.052 \pm 0.010 \pm 0.007$	[2] MUKHOPAD...	98		$\gamma p \rightarrow \eta p$

$N(1520) \rightarrow p\gamma$, helicity-3/2 amplitude $A_{3/2}$

VALUE (GeV$^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
0.140 ± 0.010 OUR ESTIMATE				
0.130 ± 0.006	SOKHOYAN	15A	DPWA	Multichannel
0.141 ± 0.002	WORKMAN	12A	DPWA	$\gamma N \rightarrow N\pi$
0.143 ± 0.002	DUGGER	07	DPWA	$\gamma N \rightarrow \pi N$
0.147 ± 0.010	AHRENS	02	DPWA	$\gamma N \rightarrow \pi N$

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

0.146±0.001	SHKLYAR	13	DPWA	Multichannel
0.131±0.010	ANISOVICH	12A	DPWA	Multichannel
0.127±0.003	SHRESTHA	12A	DPWA	Multichannel
0.161	DRECHSEL	07	DPWA	$\gamma N \to \pi N$
0.151	PENNER	02D	DPWA	Multichannel
0.130±0.020±0.015	[2] MUKHOPAD...	98		$\gamma p \to \eta p$

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

VALUE (GeV$^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
−0.050±0.010 OUR ESTIMATE				
−0.049±0.008	ANISOVICH	13B	DPWA	Multichannel
−0.046±0.006	CHEN	12A	DPWA	$\gamma N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
−0.038±0.003	SHRESTHA	12A	DPWA	Multichannel
−0.077	DRECHSEL	07	DPWA	$\gamma N \to \pi N$
−0.084	PENNER	02D	DPWA	Multichannel

$N(1520) \to n\gamma$, helicity-3/2 amplitude $A_{3/2}$

VALUE (GeV$^{-1/2}$)	DOCUMENT ID		TECN	COMMENT
−0.115±0.010 OUR ESTIMATE				
−0.113±0.012	ANISOVICH	13B	DPWA	Multichannel
−0.115±0.005	CHEN	12A	DPWA	$\gamma N \to \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
−0.101±0.004	SHRESTHA	12A	DPWA	Multichannel
−0.154	DRECHSEL	07	DPWA	$\gamma N \to \pi N$
−0.159	PENNER	02D	DPWA	Multichannel

N(1520) FOOTNOTES

[1] Fit to the amplitudes of HOEHLER 79.

[2] MUKHOPADHYAY 98 uses an effective Lagrangian approach to analyze η photoproduction data. The *ratio* of the $A_{3/2}$ and $A_{1/2}$ amplitudes is determined, with less model dependence than the amplitudes themselves, to be $A_{3/2}/A_{1/2} = -2.5 \pm 0.5 \pm 0.4$.

N(1520) REFERENCES

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

SOKHOYAN	15A	EPJ A51 95	V. Sokhoyan *et al.*	(CBELSA/TAPS Collab.)
PDG	14	CP C38 070001	K. Olive *et al.*	(PDG Collab.)
ROENCHEN	14	EPJ A50 101	D. Roenchen *et al.*	
Also		EPJ A51 63 (errat.)	D. Roenchen *et al.*	
SVARC	14	PR C89 045205	A. Svarc *et al.*	
ANISOVICH	13B	EPJ A49 67	A.V. Anisovich *et al.*	
SHKLYAR	13	PR C87 015201	V. Shklyar, H. Lenske, U. Mosel	(GIES)
ANISOVICH	12A	EPJ A48 15	A.V. Anisovich *et al.*	(BONN, PNPI)
CHEN	12A	PR C86 015206	W. Chen *et al.*	(DUKE, GWU, MSST, ITEP+)
SHRESTHA	12A	PR C86 055203	M. Shrestha, D.M. Manley	(KSU)
WORKMAN	12A	PR C86 015202	R. Workman *et al.*	(GWU)
BATINIC	10	PR C82 038203	M. Batinic *et al.*	(ZAGR)
THOMA	08	PL B659 87	U. Thoma *et al.*	(CB-ELSA Collab.)
DRECHSEL	07	EPJ A34 69	D. Drechsel, S.S. Kamalov, L. Tiator	(MAINZ, JINR)

DUGGER	07	PR C76 025211	M. Dugger *et al.*	(JLab CLAS Collab.)
ARNDT	06	PR C74 045205	R.A. Arndt *et al.*	(GWU)
ARNDT	05	PR C72 045202	R.A. Arndt *et al.*	(GWU, PNPI)
AHRENS	02	PRL 88 232002	J. Ahrens *et al.*	(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 *et al.*	
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 *et al.*	(CMU, LBL) IJP
Also		PR D20 2839	R.E. Cutkosky *et al.*	(CMU, LBL) IJP
HOEHLER	79	PDAT 12-1	G. Hohler *et al.*	(KARLT) IJP
Also		Toronto Conf. 3	R. Koch	(KARLT) IJP