

**$N(2120) 3/2^-$** 

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

Before the 2012 *Review*, all the evidence for a  $J^P = 3/2^-$  state with a mass above 1800 MeV was filed under a two-star  $N(2080)$ .

There is now evidence from ANISOVICH 12A for two  $3/2^-$  states in this region, so we have split the older data (according to mass) between a three-star  $N(1875)$  and a two-star  $N(2120)$ .

 **$N(2120)$  POLE POSITION****REAL PART**

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>2050 to 2150 (<math>\approx 2100</math>) OUR ESTIMATE</b>			
2115 $\pm$ 40	SOKHOYAN	15A	DPWA Multichannel
2094 $\pm$ 7 $\pm$ 11	SVARC	14	L+P $\pi N \rightarrow \pi N$
2050 $\pm$ 70	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$ (higher $m$ )
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
2357	HUNT	19	DPWA Multichannel
2115 $\pm$ 40	GUTZ	14	DPWA Multichannel
2110 $\pm$ 50	ANISOVICH	12A	DPWA Multichannel

**–2×IMAGINARY PART**

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>200 to 360 (<math>\approx 280</math>) OUR ESTIMATE</b>			
345 $\pm$ 35	SOKHOYAN	15A	DPWA Multichannel
296 $\pm$ 15 $\pm$ 4	SVARC	14	L+P $\pi N \rightarrow \pi N$
200 $\pm$ 80	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$ (higher $m$ )
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
503	HUNT	19	DPWA Multichannel
345 $\pm$ 35	GUTZ	14	DPWA Multichannel
340 $\pm$ 45	ANISOVICH	12A	DPWA Multichannel

 **$N(2120)$  ELASTIC POLE RESIDUE****MODULUS  $|r|$** 

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>10 to 30 (<math>\approx 20</math>) OUR ESTIMATE</b>			
11 $\pm$ 6	SOKHOYAN	15A	DPWA Multichannel
13 $\pm$ 1 $\pm$ 1	SVARC	14	L+P $\pi N \rightarrow \pi N$
30 $\pm$ 20	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$ (higher $m$ )
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
11 $\pm$ 6	GUTZ	14	DPWA Multichannel
13 $\pm$ 3	ANISOVICH	12A	DPWA Multichannel

**PHASE  $\theta$** 

<u>VALUE (<math>^{\circ}</math>)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>–40 to 20 (<math>\approx</math> – 10) OUR ESTIMATE</b>			
$-30 \pm 20$	SOKHOYAN	15A	DPWA Multichannel
$-2 \pm 4 \pm 9$	SVARC	14	L+P $\pi N \rightarrow \pi N$
$0 \pm 100$	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$ (higher $m$ )
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
$-30 \pm 20$	GUTZ	14	DPWA Multichannel
$-20 \pm 10$	ANISOVICH	12A	DPWA Multichannel

 **$N(2120)$  INELASTIC POLE RESIDUE**

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

**Normalized residue in  $N\pi \rightarrow N(2120) \rightarrow \Lambda K$** 

<u>MODULUS</u>	<u>PHASE (<math>^{\circ}</math>)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
$0.03 \pm 0.01$	$100 \pm 30$	ANISOVICH	12A	DPWA Multichannel

**Normalized residue in  $N\pi \rightarrow N(2120) \rightarrow \Sigma K$** 

<u>MODULUS</u>	<u>PHASE (<math>^{\circ}</math>)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
$0.02 \pm 0.015$	$-50 \pm 40$	ANISOVICH	12A	DPWA Multichannel

**Normalized residue in  $N\pi \rightarrow N(2120) \rightarrow N(1535)\pi$** 

<u>MODULUS</u>	<u>PHASE (<math>^{\circ}</math>)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
$0.15 \pm 0.08$	$-90 \pm 40$	GUTZ	14	DPWA Multichannel

**Normalized residue in  $N\pi \rightarrow N(2120) \rightarrow \Delta(1232)\pi$ , S-wave**

<u>MODULUS</u>	<u>PHASE (<math>^{\circ}</math>)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
$0.25 \pm 0.10$	undefined	SOKHOYAN	15A	DPWA Multichannel

**Normalized residue in  $N\pi \rightarrow N(2120) \rightarrow \Delta(1232)\pi$ , D-wave**

<u>MODULUS</u>	<u>PHASE (<math>^{\circ}</math>)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
$0.15 \pm 0.06$	$-35 \pm 30$	SOKHOYAN	15A	DPWA Multichannel

**Normalized residue in  $N\pi \rightarrow N(2120) \rightarrow N\sigma$** 

<u>MODULUS</u>	<u>PHASE (<math>^{\circ}</math>)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
$0.09 \pm 0.05$	$-80 \pm 50$	SOKHOYAN	15A	DPWA Multichannel

 **$N(2120)$  BREIT-WIGNER MASS**

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>2060 to 2160 (<math>\approx</math> 2120) OUR ESTIMATE</b>			
$2353 \pm 29$	<sup>1</sup> HUNT	19	DPWA Multichannel
$2120 \pm 45$	SOKHOYAN	15A	DPWA Multichannel
$2060 \pm 80$	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
$2081 \pm 20$	HOEHLER	79	IPWA $\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
$2120 \pm 35$	GUTZ	14	DPWA Multichannel
$2150 \pm 60$	ANISOVICH	12A	DPWA Multichannel

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

### N(2120) BREIT-WIGNER WIDTH

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
<b>260 to 360 (<math>\approx</math> 300) OUR ESTIMATE</b>			
503 $\pm$ 62	<sup>1</sup> HUNT	19	DPWA Multichannel
340 $\pm$ 35	SOKHOYAN	15A	DPWA Multichannel
300 $\pm$ 100	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$ (higher $m$ )
265 $\pm$ 40	HOEHLER	79	IPWA $\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •			
340 $\pm$ 35	GUTZ	14	DPWA Multichannel
330 $\pm$ 45	ANISOVICH	12A	DPWA Multichannel

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

### N(2120) DECAY MODES

Mode	Fraction ( $\Gamma_i/\Gamma$ )
$\Gamma_1$ $N\pi$	5–15 %
$\Gamma_2$ $N\eta$	1–5 %
$\Gamma_3$ $N\eta'$	2–6 %
$\Gamma_4$ $N\omega$	4–20 %
$\Gamma_5$ $\Lambda K$	6–11 %
$\Gamma_6$ $N\pi\pi$	>27 %
$\Gamma_7$ $\Delta(1232)\pi$	>23 %
$\Gamma_8$ $\Delta(1232)\pi$ , S-wave	15–70 %
$\Gamma_9$ $\Delta(1232)\pi$ , D-wave	8–45 %
$\Gamma_{10}$ $N\rho$ , S=3/2, S-wave	< 3 %
$\Gamma_{11}$ $N\sigma$	4–15 %
$\Gamma_{12}$ $N(1535)\pi$	7–23 %
$\Gamma_{13}$ $\Lambda K^*(892)$	< 0.2 %
$\Gamma_{14}$ $p\gamma$	0.16–2.1 %
$\Gamma_{15}$ $p\gamma$ , helicity=1/2	0.07–0.80 %
$\Gamma_{16}$ $p\gamma$ , helicity=3/2	0.09–1.3 %
$\Gamma_{17}$ $n\gamma$	0.04–0.72 %
$\Gamma_{18}$ $n\gamma$ , helicity=1/2	0.04–0.60 %
$\Gamma_{19}$ $n\gamma$ , helicity=3/2	0.001–0.12 %

### N(2120) BRANCHING RATIOS

$\Gamma(N\pi)/\Gamma_{\text{total}}$				$\Gamma_1/\Gamma$
VALUE (%)	DOCUMENT ID	TECN	COMMENT	
<b>5–15 % OUR ESTIMATE</b>				
19 $\pm$ 2	<sup>1</sup> HUNT	19	DPWA Multichannel	
5 $\pm$ 3	SOKHOYAN	15A	DPWA Multichannel	

14±7	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$ (higher $m$ )
6±2	HOEHLER	79	IPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
5±3	GUTZ	14	DPWA	Multichannel
6±2	ANISOVICH	12A	DPWA	Multichannel

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

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

VALUE (%) DOCUMENT ID TECN COMMENT

**1–5 % OUR ESTIMATE**

<1	MUELLER	20	DPWA	Multichannel
3.1±2.4	<sup>1</sup> HUNT	19	DPWA	Multichannel

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

**$\Gamma(N\eta')/\Gamma_{\text{total}}$   $\Gamma_3/\Gamma$**

VALUE (%) DOCUMENT ID TECN COMMENT

**2–6 % OUR ESTIMATE**

4±2	ANISOVICH	17C	DPWA	Multichannel
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**$\Gamma(N\omega)/\Gamma_{\text{total}}$   $\Gamma_4/\Gamma$**

VALUE (%) DOCUMENT ID TECN COMMENT

**4–20 % OUR ESTIMATE**

12±8	DENISENKO	16	DPWA	Multichannel
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**$\Gamma(\Lambda K)/\Gamma_{\text{total}}$   $\Gamma_5/\Gamma$**

VALUE (%) DOCUMENT ID TECN COMMENT

**6–11 % OUR ESTIMATE**

8.5±2.5	<sup>1</sup> HUNT	19	DPWA	Multichannel
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<sup>1</sup>Statistical error only.

**$\Gamma(\Delta(1232)\pi, S\text{-wave})/\Gamma_{\text{total}}$   $\Gamma_8/\Gamma$**

VALUE (%) DOCUMENT ID TECN COMMENT

**15–70 % OUR ESTIMATE**

25±11	<sup>1</sup> HUNT	19	DPWA	Multichannel
50±20	SOKHOYAN	15A	DPWA	Multichannel

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

**$\Gamma(\Delta(1232)\pi, D\text{-wave})/\Gamma_{\text{total}}$   $\Gamma_9/\Gamma$**

VALUE (%) DOCUMENT ID TECN COMMENT

**8–45 % OUR ESTIMATE**

34±11	<sup>1</sup> HUNT	19	DPWA	Multichannel
20±12	SOKHOYAN	15A	DPWA	Multichannel

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

**$\Gamma(N\rho, S=3/2, S\text{-wave})/\Gamma_{\text{total}}$   $\Gamma_{10}/\Gamma$**

VALUE (%) DOCUMENT ID TECN COMMENT

**< 3 % OUR ESTIMATE**

<3	<sup>1</sup> HUNT	19	DPWA	Multichannel
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<sup>1</sup>Statistical error only.

$\Gamma(N\sigma)/\Gamma_{\text{total}}$				$\Gamma_{11}/\Gamma$
VALUE (%)	DOCUMENT ID	TECN	COMMENT	
<b>4–15 % OUR ESTIMATE</b>				
9 ± 5	<sup>1</sup> HUNT	19	DPWA	Multichannel
11 ± 4	SOKHOYAN	15A	DPWA	Multichannel

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

$\Gamma(N(1535)\pi)/\Gamma_{\text{total}}$				$\Gamma_{12}/\Gamma$
VALUE (%)	DOCUMENT ID	TECN	COMMENT	
<b>7–23 % OUR ESTIMATE</b>				
15 ± 8	GUTZ	14	DPWA	Multichannel

$\Gamma(\Lambda K^*(892))/\Gamma_{\text{total}}$				$\Gamma_{13}/\Gamma$
VALUE (%)	DOCUMENT ID	TECN	COMMENT	
<b>&lt; 0.2 % OUR ESTIMATE</b>				
< 0.2	ANISOVICH	17B	DPWA	Multichannel

### **$N(2120)$ PHOTON DECAY AMPLITUDES AT THE POLE**

#### **$N(2120) \rightarrow p\gamma$ , helicity-1/2 amplitude $A_{1/2}$**

MODULUS ( $\text{GeV}^{-1/2}$ )	PHASE ( $^\circ$ )	DOCUMENT ID	TECN	COMMENT
0.130 ± 0.045	− 40 ± 25	SOKHOYAN	15A	DPWA Multichannel

#### **$N(2120) \rightarrow p\gamma$ , helicity-3/2 amplitude $A_{3/2}$**

MODULUS ( $\text{GeV}^{-1/2}$ )	PHASE ( $^\circ$ )	DOCUMENT ID	TECN	COMMENT
0.160 ± 0.060	− 30 ± 15	SOKHOYAN	15A	DPWA Multichannel

#### **$N(2120) \rightarrow n\gamma$ , helicity-1/2 amplitude $A_{1/2}$**

MODULUS ( $\text{GeV}^{-1/2}$ )	PHASE ( $^\circ$ )	DOCUMENT ID	TECN	COMMENT
0.080 ± 0.030	15 ± 25	ANISOVICH	17E	DPWA Multichannel

#### **$N(2120) \rightarrow n\gamma$ , helicity-3/2 amplitude $A_{3/2}$**

MODULUS ( $\text{GeV}^{-1/2}$ )	PHASE ( $^\circ$ )	DOCUMENT ID	TECN	COMMENT
− 0.033 ± 0.020	− 60 ± 35	ANISOVICH	17E	DPWA Multichannel

### **$N(2120)$ BREIT-WIGNER PHOTON DECAY AMPLITUDES**

#### **$N(2120) \rightarrow p\gamma$ , helicity-1/2 amplitude $A_{1/2}$**

VALUE ( $\text{GeV}^{-1/2}$ )	DOCUMENT ID	TECN	COMMENT
0.047 ± 0.009	<sup>1</sup> HUNT	19	DPWA Multichannel
0.130 ± 0.050	SOKHOYAN	15A	DPWA Multichannel

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

0.130 ± 0.050	GUTZ	14	DPWA Multichannel
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<sup>1</sup> Statistical error only.

### $N(2120) \rightarrow p\gamma$ , helicity-3/2 amplitude $A_{3/2}$

VALUE (GeV <sup>-1/2</sup> )	DOCUMENT ID	TECN	COMMENT
0.001±0.007	<sup>1</sup> HUNT	19	DPWA Multichannel
0.160±0.065	SOKHOYAN	15A	DPWA Multichannel
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
0.160±0.065	GUTZ	14	DPWA Multichannel

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

### $N(2120) \rightarrow n\gamma$ , helicity-1/2 amplitude $A_{1/2}$

VALUE (GeV <sup>-1/2</sup> )	DOCUMENT ID	TECN	COMMENT
-0.020±0.013	<sup>1</sup> HUNT	19	DPWA Multichannel
0.081±0.030	ANISOVICH	17E	DPWA Multichannel
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
0.110±0.045	ANISOVICH	13B	DPWA Multichannel

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

### $N(2120) \rightarrow n\gamma$ , helicity-3/2 amplitude $A_{3/2}$

VALUE (GeV <sup>-1/2</sup> )	DOCUMENT ID	TECN	COMMENT
-0.00 ±0.02	<sup>1</sup> HUNT	19	DPWA Multichannel
-0.032±0.020	ANISOVICH	17E	DPWA Multichannel
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
0.040±0.030	ANISOVICH	13B	DPWA Multichannel

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

## $N(2120)$ REFERENCES

MUELLER	20	PL B803 135323	J. Mueller <i>et al.</i>	(CBELSA/TAPS Collab.)
HUNT	19	PR C99 055205	B.C. Hunt, D.M. Manley	
ANISOVICH	17B	PL B771 142	A.V. Anisovich <i>et al.</i>	
ANISOVICH	17C	PL B772 247	A.V. Anisovich <i>et al.</i>	
ANISOVICH	17E	PR C96 055202	A.V. Anisovich <i>et al.</i>	(BONN, PNPI, JLAB+)
DENISENKO	16	PL B755 97	I. Denisenko <i>et al.</i>	
SOKHOYAN	15A	EPJ A51 95	V. Sokhoyan <i>et al.</i>	(CBELSA/TAPS Collab.)
GUTZ	14	EPJ A50 74	E. Gutz <i>et al.</i>	(CBELSA/TAPS 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>	
ANISOVICH	12A	EPJ A48 15	A.V. Anisovich <i>et al.</i>	(BONN, PNPI)
CUTKOSKY	80	Toronto Conf. 19	R.E. Cutkosky <i>et al.</i>	(CMU, LBL)
HOEHLER	79	PDAT 12-1	G. Hohler <i>et al.</i>	(KARLT)