

**$N(2120) 3/2^-$**  $I(J^P) = \frac{1}{2}(3/2^-)$  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</math> 2100) OUR ESTIMATE</b>			
2130 $\pm$ 40	SARANTSEV	25	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	SOKHOYAN	15A	DPWA Multichannel
2115 $\pm$ 40	GUTZ	14	DPWA Multichannel

**-2 $\times$ IMAGINARY PART**

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>200 to 360 (<math>\approx</math> 280) OUR ESTIMATE</b>			
350 $\pm$ 35	SARANTSEV	25	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	SOKHOYAN	15A	DPWA Multichannel
345 $\pm$ 35	GUTZ	14	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</math> 20) 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 2120</math>) OUR ESTIMATE</b>			
$2140 \pm 35$	SARANTSEV	25	DPWA Multichannel
$2353 \pm 29$	<sup>1</sup> HUNT	19	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. • • •			
$2120 \pm 45$	SOKHOYAN	15A	DPWA Multichannel
$2120 \pm 35$	GUTZ	14	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 300</math>) OUR ESTIMATE</b>			
$360 \pm 35$	SARANTSEV	25	DPWA Multichannel
$503 \pm 62$	<sup>1</sup> HUNT	19	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. • • •			
$340 \pm 35$	SOKHOYAN	15A	DPWA Multichannel
$340 \pm 35$	GUTZ	14	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 %
$\Gamma_{10}$ $N\rho$	(28 $\pm$ 6 ) %
$\Gamma_{11}$ $N\rho$ , $S=1/2$	( 4.0 $\pm$ 2.0 ) %
$\Gamma_{12}$ $N\rho$ , $S=3/2$ , $S$ -wave	< 3 %
$\Gamma_{13}$ $N\rho$ , $S=3/2$ , $D$ -wave	( 5.0 $\pm$ 3.0 ) %
$\Gamma_{14}$ $N\sigma$	4–15 %
$\Gamma_{15}$ $N(1440)\pi$	( 6 $\pm$ 6 ) %
$\Gamma_{16}$ $N(1520)\pi$ , $P$ -wave	(10 $\pm$ 5 ) %
$\Gamma_{17}$ $N(1535)\pi$	7–23 %
$\Gamma_{18}$ $\Lambda K^*(892)$	< 0.2 %
$\Gamma_{19}$ $p\gamma$	0.16–2.1 %
$\Gamma_{20}$ $p\gamma$ , helicity=1/2	0.07–0.80 %
$\Gamma_{21}$ $p\gamma$ , helicity=3/2	0.09–1.3 %
$\Gamma_{22}$ $n\gamma$	0.04–0.72 %
$\Gamma_{23}$ $n\gamma$ , helicity=1/2	0.04–0.60 %
$\Gamma_{24}$ $n\gamma$ , helicity=3/2	0.001–0.12 %

**$N(2120)$  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>5–15 % OUR ESTIMATE</b>			
$5 \pm 2$	SEIFEN	25	DPWA Multichannel
$19 \pm 2$	<sup>1</sup> HUNT	19	DPWA Multichannel
$14 \pm 7$	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$ (higher $m$ )
$6 \pm 2$	HOEHLER	79	IPWA $\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •			
$5 \pm 3$	SOKHOYAN	15A	DPWA Multichannel
$5 \pm 3$	GUTZ	14	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>
<b>1–5 % OUR ESTIMATE</b>			
<1	MUELLER	20	DPWA Multichannel
$3.1 \pm 2.4$	<sup>1</sup> HUNT	19	DPWA Multichannel

<sup>1</sup>Statistical error only. **$\Gamma(N\eta')/\Gamma_{\text{total}}$   $\Gamma_3/\Gamma$** 

<u>VALUE (%)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>2–6 % OUR ESTIMATE</b>			
$4 \pm 2$	ANISOVICH	17C	DPWA Multichannel

 **$\Gamma(N\omega)/\Gamma_{\text{total}}$   $\Gamma_4/\Gamma$** 

<u>VALUE (%)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>4–20 % OUR ESTIMATE</b>			
$12 \pm 8$	DENISENKO	16	DPWA Multichannel

 **$\Gamma(\Lambda K)/\Gamma_{\text{total}}$   $\Gamma_5/\Gamma$** 

<u>VALUE (%)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>6–11 % OUR ESTIMATE</b>			
$8.5 \pm 2.5$	<sup>1</sup> HUNT	19	DPWA Multichannel

<sup>1</sup>Statistical error only. **$\Gamma(\Delta(1232)\pi)/\Gamma_{\text{total}}$   $\Gamma_7/\Gamma$** 

<u>VALUE (%)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>19 ± 5</b>			
	SARANTSEV	25	DPWA Multichannel

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

<u>VALUE (%)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>15–70 % OUR ESTIMATE</b>			
$8 \pm 3$	SARANTSEV	25	DPWA Multichannel
$10 \pm 5$	SEIFEN	25	DPWA Multichannel
$25 \pm 11$	<sup>1</sup> HUNT	19	DPWA Multichannel

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

 $50 \pm 20$  SOKHOYAN 15A DPWA Multichannel<sup>1</sup>Statistical error only.

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

<u>VALUE (%)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>8-45 % OUR ESTIMATE</b>			
11 ± 4	SARANTSEV	25	DPWA Multichannel
14 ± 7	SEIFEN	25	DPWA Multichannel
34 ± 11	<sup>1</sup> HUNT	19	DPWA Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •			
20 ± 12	SOKHOYAN	15A	DPWA Multichannel

<sup>1</sup>Statistical error only. $\Gamma(N\rho)/\Gamma_{\text{total}}$  $\Gamma_{10}/\Gamma$ 

<u>VALUE (%)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>28 ± 6</b>	SARANTSEV	25	DPWA Multichannel

 $\Gamma(N\rho, S=1/2)/\Gamma_{\text{total}}$  $\Gamma_{11}/\Gamma$ 

<u>VALUE (%)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>4 ± 2</b>	SARANTSEV	25	DPWA Multichannel

 $\Gamma(N\rho, S=3/2, S\text{-wave})/\Gamma_{\text{total}}$  $\Gamma_{12}/\Gamma$ 

<u>VALUE (%)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>&lt; 3 % OUR ESTIMATE</b>			
19 ± 5	SARANTSEV	25	DPWA Multichannel
< 3	<sup>1</sup> HUNT	19	DPWA Multichannel

<sup>1</sup>Statistical error only. $\Gamma(N\rho, S=3/2, D\text{-wave})/\Gamma_{\text{total}}$  $\Gamma_{13}/\Gamma$ 

<u>VALUE (%)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>5 ± 3</b>	SARANTSEV	25	DPWA Multichannel

 $\Gamma(N\sigma)/\Gamma_{\text{total}}$  $\Gamma_{14}/\Gamma$ 

<u>VALUE (%)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>4-15 % OUR ESTIMATE</b>			
5 ± 3	SARANTSEV	25	DPWA Multichannel
4 ± 3	SEIFEN	25	DPWA Multichannel
9 ± 5	<sup>1</sup> HUNT	19	DPWA Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •			
11 ± 4	SOKHOYAN	15A	DPWA Multichannel

<sup>1</sup>Statistical error only. $\Gamma(N(1440)\pi)/\Gamma_{\text{total}}$  $\Gamma_{15}/\Gamma$ 

<u>VALUE (%)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>6 ± 6</b>	SEIFEN	25	DPWA Multichannel

 $\Gamma(N(1520)\pi, P\text{-wave})/\Gamma_{\text{total}}$  $\Gamma_{16}/\Gamma$ 

<u>VALUE (%)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>10 ± 5</b>	SEIFEN	25	DPWA Multichannel

$\Gamma(N(1535)\pi)/\Gamma_{\text{total}}$					$\Gamma_{17}/\Gamma$
VALUE (%)	DOCUMENT ID	TECN	COMMENT		
<b>7-23 % OUR ESTIMATE</b>					
< 2	SEIFEN	25	DPWA	Multichannel	
15±8	GUTZ	14	DPWA	Multichannel	

$\Gamma(\Lambda K^*(892))/\Gamma_{\text{total}}$					$\Gamma_{18}/\Gamma$
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	
$-0.025 \pm 0.015$	$40 \pm 25$	SARANTSEV	25	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$0.130 \pm 0.045$	$-40 \pm 25$	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	
$-0.045 \pm 0.015$	$25 \pm 25$	SARANTSEV	25	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$0.160 \pm 0.060$	$-30 \pm 15$	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	
$0.080 \pm 0.030$	$15 \pm 25$	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	
$-0.033 \pm 0.020$	$-60 \pm 35$	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	
$0.026 \pm 0.015$	SARANTSEV	25	DPWA	Multichannel
$0.047 \pm 0.009$	<sup>1</sup> HUNT	19	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$0.130 \pm 0.050$	SOKHOYAN	15A	DPWA	Multichannel
$0.130 \pm 0.050$	GUTZ	14	DPWA	Multichannel

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

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

VALUE ( $\text{GeV}^{-1/2}$ )	DOCUMENT ID	TECN	COMMENT	
$0.047 \pm 0.015$	SARANTSEV	25	DPWA	Multichannel
$0.001 \pm 0.007$	<sup>1</sup> HUNT	19	DPWA	Multichannel

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

$0.160 \pm 0.065$	SOKHOYAN	15A	DPWA	Multichannel
$0.160 \pm 0.065$	GUTZ	14	DPWA	Multichannel

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

### $N(2120) \rightarrow n\gamma$ , 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>
$-0.020 \pm 0.013$	<sup>1</sup> HUNT	19	DPWA Multichannel
$0.081 \pm 0.030$	ANISOVICH	17E	DPWA Multichannel

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

$0.110 \pm 0.045$	ANISOVICH	13B	DPWA	Multichannel
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<sup>1</sup>Statistical error only.

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

<u>VALUE (<math>\text{GeV}^{-1/2}</math>)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
$-0.00 \pm 0.02$	<sup>1</sup> HUNT	19	DPWA Multichannel
$-0.032 \pm 0.020$	ANISOVICH	17E	DPWA Multichannel

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

$0.040 \pm 0.030$	ANISOVICH	13B	DPWA	Multichannel
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<sup>1</sup>Statistical error only.

## $N(2120)$ REFERENCES

SARANTSEV	25	PR C112 015202	A.V. Sarantsev <i>et al.</i>	(Bonn-Gatchina Collab.)
SEIFEN	25	EPJ A61 173	T. Seifen <i>et al.</i>	(CBELSA/TAPS Collab.)
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)