

$\Lambda(1520) \ 3/2^-$ $I(J^P) = 0(\frac{3}{2}^-)$ Status: ****

Discovered by FERRO-LUZZI 62; the elaboration in WATSON 63 is the classic paper on the Breit-Wigner analysis of a multichannel resonance.

The measurements of the mass, width, and elasticity published before 1975 are now obsolete and have been omitted. They were last listed in our 1982 edition Physics Letters **111B** 1 (1982).

Production and formation experiments agree quite well, so they are listed together here.

$\Lambda(1520)$ POLE POSITION

REAL PART

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
$1517 \begin{smallmatrix} +4 \\ -4 \end{smallmatrix}$	¹ KAMANO	15	DPWA Multichannel
1518	ZHANG	13A	DPWA Multichannel
1518.8	QIANG	10	SPEC $ep \rightarrow e'K^+X$ (fit to X)

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

¹From the preferred solution A in KAMANO 15.

−2×IMAGINARY PART

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
$15 \begin{smallmatrix} +10 \\ -8 \end{smallmatrix}$	¹ KAMANO	15	DPWA Multichannel
16	ZHANG	13A	DPWA Multichannel
17.2	QIANG	10	SPEC $ep \rightarrow e'K^+X$ (fit to X)

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

¹From the preferred solution A in KAMANO 15.

$\Lambda(1520)$ POLE RESIDUES

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

Normalized residue in $N\bar{K} \rightarrow \Lambda(1520) \rightarrow N\bar{K}$

MODULUS	PHASE (°)	DOCUMENT ID	TECN	COMMENT
0.431	−11	¹ KAMANO	15	DPWA Multichannel

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

¹From the preferred solution A in KAMANO 15.

Normalized residue in $N\bar{K} \rightarrow \Lambda(1520) \rightarrow \Sigma\pi$

MODULUS	PHASE (°)	DOCUMENT ID	TECN	COMMENT
0.435	−10	¹ KAMANO	15	DPWA Multichannel

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

¹From the preferred solution A in KAMANO 15.

Normalized residue in $N\bar{K} \rightarrow \Lambda(1520) \rightarrow \Sigma(1385)\pi$, S-wave

<u>MODULUS</u>	<u>PHASE ($^\circ$)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
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• • • We do not use the following data for averages, fits, limits, etc. • • •

0.431	-123	¹ KAMANO	15	DPWA Multichannel
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¹From the preferred solution A in KAMANO 15.**Normalized residue in $N\bar{K} \rightarrow \Lambda(1520) \rightarrow \Sigma(1385)\pi$, D-wave**

<u>MODULUS</u>	<u>PHASE ($^\circ$)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
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• • • We do not use the following data for averages, fits, limits, etc. • • •

0.0141	122	¹ KAMANO	15	DPWA Multichannel
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¹From the preferred solution A in KAMANO 15. **$\Lambda(1520)$ MASS**

<u>VALUE (MeV)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
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1519.5 \pm 1.0 OUR ESTIMATE**1519.54 \pm 0.17 OUR AVERAGE**

1519.6 \pm 0.5		ZHANG	13A	DPWA Multichannel
1520.4 \pm 0.6 \pm 1.5		QIANG	10	SPEC $e p \rightarrow e' K^+ X$ (fit to X)
1517.3 \pm 1.5	300	BARBER	80D	SPEC $\gamma p \rightarrow \Lambda(1520) K^+$
1517.8 \pm 1.2	5k	BARLAG	79	HBC $K^- p$ 4.2 GeV/c
1520.0 \pm 0.5		ALSTON-...	78	DPWA $\bar{K} N \rightarrow \bar{K} N$
1519.7 \pm 0.3	4k	CAMERON	77	HBC $K^- p$ 0.96–1.36 GeV/c
1519 \pm 1		GOPAL	77	DPWA $\bar{K} N$ multichannel
1519.4 \pm 0.3	2000	CORDEN	75	DBC $K^- d$ 1.4–1.8 GeV/c

 $\Lambda(1520)$ WIDTH

<u>VALUE (MeV)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
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15.6 \pm 1.0 OUR ESTIMATE**15.73 \pm 0.29 OUR AVERAGE** Error includes scale factor of 1.1.

17 \pm 1		ZHANG	13A	DPWA Multichannel
18.6 \pm 1.9 \pm 1.0		QIANG	10	SPEC $e p \rightarrow e' K^+ X$ (fit to X)
16.3 \pm 3.3	300	BARBER	80D	SPEC $\gamma p \rightarrow \Lambda(1520) K^+$
16 \pm 1		GOPAL	80	DPWA $\bar{K} N \rightarrow \bar{K} N$
14 \pm 3	677	¹ BARLAG	79	HBC $K^- p$ 4.2 GeV/c
15.4 \pm 0.5		ALSTON-...	78	DPWA $\bar{K} N \rightarrow \bar{K} N$
16.3 \pm 0.5	4k	CAMERON	77	HBC $K^- p$ 0.96–1.36 GeV/c
15.0 \pm 0.5		GOPAL	77	DPWA $\bar{K} N$ multichannel
15.5 \pm 1.6	2000	CORDEN	75	DBC $K^- d$ 1.4–1.8 GeV/c

¹From the best-resolution sample of $\Lambda\pi\pi$ events only.

$\Lambda(1520)$ DECAY MODES

Mode	Fraction (Γ_i/Γ)
Γ_1 $N\bar{K}$	(45 \pm 1) %
Γ_2 $\Sigma\pi$	(42 \pm 1) %
Γ_3 $\Lambda\pi\pi$	(10 \pm 1) %
Γ_4 $\Sigma(1385)\pi$, S-wave	
Γ_5 $\Sigma(1385)\pi$, D-wave	
Γ_6 $\Sigma(1385)\pi$	
Γ_7 $\Sigma(1385)\pi(\rightarrow \Lambda\pi\pi)$	
Γ_8 $\Lambda(\pi\pi)$ S-wave	
Γ_9 $\Sigma\pi\pi$	(0.9 \pm 0.1) %
Γ_{10} $\Lambda\gamma$	(0.85 \pm 0.15) %
Γ_{11} $\Sigma^0\gamma$	

CONSTRAINED FIT INFORMATION

An overall fit to 9 branching ratios uses 28 measurements and one constraint to determine 6 parameters. The overall fit has a $\chi^2 = 18.9$ for 23 degrees of freedom.

The following *off-diagonal* array elements are the correlation coefficients $\langle \delta x_i \delta x_j \rangle / (\delta x_i \delta x_j)$, in percent, from the fit to the branching fractions, $x_i \equiv \Gamma_i / \Gamma_{\text{total}}$. The fit constrains the x_i whose labels appear in this array to sum to one.

x_2	-63				
x_3	-32	-34			
x_9	-4	-3	-1		
x_{10}	-8	-7	-3	0	
x_{11}	-24	-21	-10	-1	-1
	x_1	x_2	x_3	x_9	x_{10}

$\Lambda(1520)$ BRANCHING RATIOS

See "Sign conventions for resonance couplings" in the Note on Λ and Σ Resonances.

$\Gamma(N\bar{K})/\Gamma_{\text{total}}$	Γ_1/Γ		
<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.45 \pm 0.01 OUR ESTIMATE			
0.448\pm0.007 OUR FIT			Error includes scale factor of 1.2.
0.456\pm0.010 OUR AVERAGE			
0.47 \pm 0.04	ZHANG	13A	DPWA Multichannel
0.47 \pm 0.02	GOPAL	80	DPWA $\bar{K}N \rightarrow \bar{K}N$
0.45 \pm 0.03	ALSTON-...	78	DPWA $\bar{K}N \rightarrow \bar{K}N$
0.448 \pm 0.014	CORDEN	75	DBC K^-d 1.4–1.8 GeV/c

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

0.43	¹ KAMANO	15	DPWA	Multichannel
0.47 ±0.01	GOPAL	77	DPWA	See GOPAL 80
0.42	MAST	76	HBC	$K^- p \rightarrow \bar{K}^0 n$

¹From the preferred solution A in KAMANO 15.

$\Gamma(\Sigma\pi)/\Gamma_{\text{total}}$ Γ_2/Γ

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
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0.42 ±0.01 OUR ESTIMATE

0.421±0.007 OUR FIT Error includes scale factor of 1.2.

0.425±0.011 OUR AVERAGE

0.47 ±0.05	ZHANG	13A	DPWA	Multichannel
0.426±0.014	CORDEN	75	DBC	$K^- d$ 1.4–1.8 GeV/ <i>c</i>
0.418±0.017	BARBARO-...	69B	HBC	$K^- p$ 0.28–0.45 GeV/ <i>c</i>

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

0.446	¹ KAMANO	15	DPWA	Multichannel
0.46	KIM	71	DPWA	K-matrix analysis

¹From the preferred solution A in KAMANO 15.

$\Gamma(\Sigma\pi)/\Gamma(N\bar{K})$ Γ_2/Γ_1

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
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0.940±0.026 OUR FIT Error includes scale factor of 1.3.

0.95 ±0.04 OUR AVERAGE Error includes scale factor of 1.7. See the ideogram below.

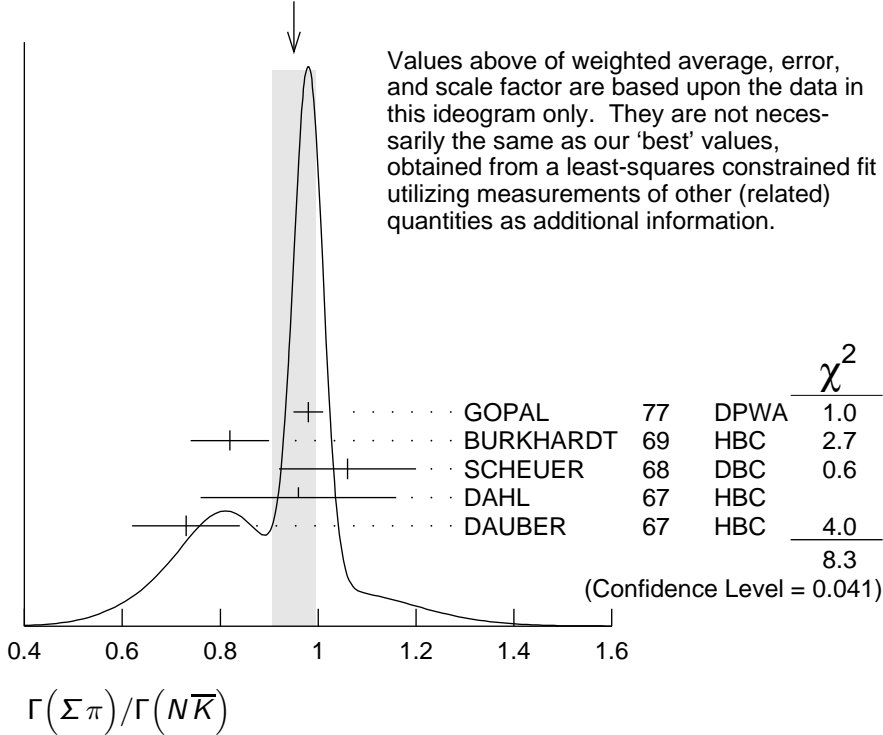
0.98 ±0.03	¹ GOPAL	77	DPWA	$\bar{K}N$ multichannel
0.82 ±0.08	BURKHARDT	69	HBC	$K^- p$ 0.8–1.2 GeV/ <i>c</i>
1.06 ±0.14	SCHEUER	68	DBC	$K^- N$ 3 GeV/ <i>c</i>
0.96 ±0.20	DAHL	67	HBC	$\pi^- p$ 1.6–4 GeV/ <i>c</i>
0.73 ±0.11	DAUBER	67	HBC	$K^- p$ 2 GeV/ <i>c</i>

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

1.06 ±0.12	BERTHON	74	HBC	Quasi-2-body σ
1.72 ±0.78	MUSGRAVE	65	HBC	

¹The $\bar{K}N \rightarrow \Sigma\pi$ amplitude at resonance is $+0.46 \pm 0.01$.

WEIGHTED AVERAGE
 0.95 ± 0.04 (Error scaled by 1.7)



$\Gamma(\Lambda\pi\pi)/\Gamma_{\text{total}}$

Γ_3/Γ

VALUE	DOCUMENT ID	TECN	COMMENT
0.10 ± 0.01 OUR ESTIMATE			
0.095 ± 0.005 OUR FIT			Error includes scale factor of 1.2.
0.096 ± 0.008 OUR AVERAGE			Error includes scale factor of 1.6.
0.091 ± 0.006	CORDEN	75	DBC $K^- d$ 1.4–1.8 GeV/c
0.11 ± 0.01	¹ MAST	73B	IPWA $K^- p \rightarrow \Lambda\pi\pi$

¹ Assumes $\Gamma(N\bar{K})/\Gamma_{\text{total}} = 0.46 \pm 0.02$.

$\Gamma(\Lambda\pi\pi)/\Gamma(N\bar{K})$

Γ_3/Γ_1

VALUE	DOCUMENT ID	TECN	COMMENT
0.212 ± 0.012 OUR FIT			Error includes scale factor of 1.2.
0.202 ± 0.021 OUR AVERAGE			
0.22 ± 0.03	BURKHARDT	69	HBC $K^- p$ 0.8–1.2 GeV/c
0.19 ± 0.04	SCHEUER	68	DBC $K^- N$ 3 GeV/c
0.17 ± 0.05	DAHL	67	HBC $\pi^- p$ 1.6–4 GeV/c
0.21 ± 0.18	DAUBER	67	HBC $K^- p$ 2 GeV/c
• • •			We do not use the following data for averages, fits, limits, etc. • • •
0.27 ± 0.13	BERTHON	74	HBC Quasi-2-body σ
0.2	KIM	71	DPWA K-matrix analysis

$\Gamma(\Sigma\pi)/\Gamma(\Lambda\pi\pi)$				Γ_2/Γ_3
<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
4.43±0.25 OUR FIT	Error includes scale factor of 1.2.			
3.9 ±0.6 OUR AVERAGE				
3.9 ±1.0	UHLIG 67	HBC	$K^- p$ 0.9–1.0 GeV/ c	
3.3 ±1.1	BIRMINGHAM 66	HBC	$K^- p$ 3.5 GeV/ c	
4.5 ±1.0	ARMENTEROS65C	HBC		

$\Gamma(\Sigma(1385)\pi, S\text{-wave})/\Gamma_{\text{total}}$				Γ_4/Γ
<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. • • •				
0.121	¹ KAMANO 15	DPWA	Multichannel	
¹ From the preferred solution A in KAMANO 15.				

$\Gamma(\Sigma(1385)\pi, D\text{-wave})/\Gamma_{\text{total}}$				Γ_5/Γ
<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. • • •				
0.003	¹ KAMANO 15	DPWA	Multichannel	
¹ From the preferred solution A in KAMANO 15.				

$\Gamma(\Sigma(1385)\pi)/\Gamma_{\text{total}}$				Γ_6/Γ
<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
0.041±0.005	CHAN 72	HBC	$K^- p \rightarrow \Lambda\pi\pi$	

$\Gamma(\Sigma(1385)\pi(\rightarrow \Lambda\pi\pi))/\Gamma(\Lambda\pi\pi)$				Γ_7/Γ_3
The $\Lambda\pi\pi$ mode is largely due to $\Sigma(1385)\pi$. Only the values of $(\Sigma(1385)\pi) / (\Lambda\pi\pi)$ given by MAST 73B and CORDEN 75 are based on real 3-body partial-wave analyses. The discrepancy between the two results is essentially due to the different hypotheses made concerning the shape of the $(\pi\pi)_{S\text{-wave}}$ state.				

<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.58±0.22		CORDEN 75	DBC	$K^- d$ 1.4–1.8 GeV/ c
0.82±0.10		¹ MAST 73B	IPWA	$K^- p \rightarrow \Lambda\pi\pi$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
<0.44	90	WIELAND 11	SPHR	$\gamma p \rightarrow K^+ \Lambda(1520)$
0.39±0.10		² BURKHARDT 71	HBC	$K^- p \rightarrow (\Lambda\pi\pi)\pi$
¹ Both $\Sigma(1385)\pi DS_{03}$ and $\Sigma(\pi\pi) DP_{03}$ contribute.				
² The central bin (1514–1524 MeV) gives 0.74 ± 0.10 ; other bins are lower by 2-to-5 standard deviations.				

$\Gamma(\Lambda(\pi\pi)_{S\text{-wave}})/\Gamma(\Lambda\pi\pi)$				Γ_8/Γ_3
<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
0.20±0.08	CORDEN 75	DBC	$K^- d$ 1.4–1.8 GeV/ c	

$\Gamma(\Sigma\pi\pi)/\Gamma_{\text{total}}$ Γ_9/Γ

VALUE	DOCUMENT ID	TECN	COMMENT
0.009 ± 0.001 OUR ESTIMATE			
0.0086 ± 0.0005 OUR FIT			
0.0086 ± 0.0005 OUR AVERAGE			
0.007 ± 0.002	¹ CORDEN	75	DBC $K^- d$ 1.4–1.8 GeV/c
0.0085 ± 0.0006	² MAST	73	MPWA $K^- p \rightarrow \Sigma\pi\pi$
0.010 ± 0.0015	BARBARO-...	69B	HBC $K^- p$ 0.28–0.45 GeV/c

¹ Much of the $\Sigma\pi\pi$ decay proceeds via $\Sigma(1385)\pi$.
² Assumes $\Gamma(N\bar{K})/\Gamma_{\text{total}} = 0.46$.

$\Gamma(\Lambda\gamma)/\Gamma_{\text{total}}$ Γ_{10}/Γ

VALUE (units 10^{-3})	EVTS	DOCUMENT ID	TECN	COMMENT
8.5 ± 1.5 OUR ESTIMATE				
8.8 ± 1.1 OUR FIT				
8.8 ± 1.1 OUR AVERAGE				
10.7 ± 2.9 ^{+1.5} _{-0.4}	32	TAYLOR	05	CLAS $\gamma p \rightarrow K^+ \Lambda\gamma$
10.2 ± 2.1 ± 1.5	290	ANTIPOV	04A	SPNX $pN(C) \rightarrow \Lambda(1520)K^+N(C)$
8.0 ± 1.4	238	MAST	68B	HBC Using $\Gamma(N\bar{K})/\Gamma_{\text{total}} = 0.45$

$\Gamma(\Sigma^0\gamma)/\Gamma_{\text{total}}$ Γ_{11}/Γ

VALUE	DOCUMENT ID	TECN	COMMENT
0.0193 ± 0.0034 OUR FIT			
0.02 ± 0.0035	¹ MAST	68B	HBC Not measured; see note

¹ Calculated from $\Gamma(\Lambda\gamma)/\Gamma_{\text{total}}$, assuming SU(3). Needed to constrain the sum of all the branching ratios to be unity.

$\Lambda(1520)$ REFERENCES

KAMANO	15	PR C92 025205	H. Kamano <i>et al.</i>	(ANL, OSAK)
ZHANG	13A	PR C88 035205	H. Zhang <i>et al.</i>	(KSU)
WIELAND	11	EPJ A47 47	F. Wieland <i>et al.</i>	(ELSA SAPHIR Collab.)
QIANG	10	PL B694 123	Y. Qiang <i>et al.</i>	(DUKE, JEFF, PNPI, GWU+)
TAYLOR	05	PR C71 054609	S. Taylor <i>et al.</i>	(JLab CLAS Collab.)
Also		PR C72 039902 (errata.)	S. Taylor <i>et al.</i>	(JLab CLAS Collab.)
ANTIPOV	04A	PL B604 22	Yu.M. Antipov <i>et al.</i>	(IHEP SPHINX Collab.)
PDG	82	PL 111B 1	M. Roos <i>et al.</i>	(HEL5, CIT, CERN)
BARBER	80D	ZPHY C7 17	D.P. Barber <i>et al.</i>	(DARE, LANC, SHEF)
GOPAL	80	Toronto Conf. 159	G.P. Gopal	(RHEL) IJP
BARLAG	79	NP B149 220	S.J.M. Barlag <i>et al.</i>	(AMST, CERN, NIJM+)
ALSTON-...	78	PR D18 182	M. Alston-Garnjost <i>et al.</i>	(LBL, MTHO+) IJP
Also		PRL 38 1007	M. Alston-Garnjost <i>et al.</i>	(LBL, MTHO+) IJP
CAMERON	77	NP B131 399	W. Cameron <i>et al.</i>	(RHEL, LOIC) IJP
GOPAL	77	NP B119 362	G.P. Gopal <i>et al.</i>	(LOIC, RHEL) IJP
MAST	76	PR D14 13	T.S. Mast <i>et al.</i>	(LBL)
CORDEN	75	NP B84 306	M.J. Corden <i>et al.</i>	(BIRM)
BERTHON	74	NC 21A 146	A. Berthon <i>et al.</i>	(CDEF, RHEL, SACL+)
MAST	73	PR D7 3212	T.S. Mast <i>et al.</i>	(LBL) IJP
MAST	73B	PR D7 5	T.S. Mast <i>et al.</i>	(LBL) IJP
CHAN	72	PRL 28 256	S.B. Chan <i>et al.</i>	(MASA, YALE)
BURKHARDT	71	NP B27 64	E. Burkhardt <i>et al.</i>	(HEID, CERN, SACL)
KIM	71	PRL 27 356	J.K. Kim	(HARV) IJP
Also		Duke Conf. 161	J.K. Kim	(HARV) IJP
Hyperon Resonances,		1970		
BARBARO-...	69B	Lund Conf. 352	A. Barbaro-Galtieri <i>et al.</i>	(LRL)
Also		Duke Conf. 95	R.D. Tripp	(LRL)
Hyperon Resonances		1970		

BURKHARDT	69	NP B14 106	E. Burkhardt <i>et al.</i>	(HEID, EFI, CERN+)
MAST	68B	PRL 21 1715	T.S. Mast <i>et al.</i>	(LRL)
SCHEUER	68	NP B8 503	J.C. Scheuer <i>et al.</i>	(SABRE Collab.)
DAHL	67	PR 163 1377	O.I. Dahl <i>et al.</i>	(LRL)
DAUBER	67	PL 24B 525	P.M. Dauber <i>et al.</i>	(UCLA)
UHLIG	67	PR 155 1448	R.P. Uhlig <i>et al.</i>	(UMD, NRL)
BIRMINGHAM	66	PR 152 1148	M. Haque <i>et al.</i>	(BIRM, GLAS, LOIC, OXF+)
ARMENTEROS	65C	PL 19 338	R. Armenteros <i>et al.</i>	(CERN, HEID, SACL)
MUSGRAVE	65	NC 35 735	B. Musgrave <i>et al.</i>	(BIRM, CERN, EPOL+)
WATSON	63	PR 131 2248	M.B. Watson, M. Ferro-Luzzi, R.D. Tripp	(LRL) IJP
FERRO-LUZZI	62	PRL 8 28	M. Ferro-Luzzi, R.D. Tripp, M.B. Watson	(LRL) IJP
