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

$I(J^P) = 0(\frac{3}{2}^-)$ 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.

Λ(1520) POLE POSITION

REAL PART

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
1517 $^{+4}_{-4}$	[1] KAMANO	15	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1518	ZHANG	13A	DPWA	Multichannel
1518.8	QIANG	10	SPEC	$e p \rightarrow e' K^+ X$ (fit to X)

[1] From the preferred solution A in KAMANO 15.

−2×IMAGINARY PART

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
15 $^{+10}_{-\ 8}$	[1] KAMANO	15	DPWA	Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •				
16	ZHANG	13A	DPWA	Multichannel
17.2	QIANG	10	SPEC	$e p \rightarrow e' K^+ X$ (fit to X)

[1] From the preferred solution A in KAMANO 15.

Λ(1520) POLE RESIDUES

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

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

MODULUS	*PHASE (°)*	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.431	−11	[1] KAMANO	15	DPWA	Multichannel

[1] From the preferred solution A in KAMANO 15.

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

MODULUS	*PHASE (°)*	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.435	−10	[1] KAMANO	15	DPWA	Multichannel

[1] From the preferred solution A in KAMANO 15.

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

MODULUS	*PHASE (°)*	*DOCUMENT ID*	*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.431	−123	[1] KAMANO 15	DPWA	Multichannel

[1] From the preferred solution A in KAMANO 15.

Normalized residue in $N\overline{K} \to \Lambda(1520) \to \Sigma(1385)\pi$, *D*-wave

MODULUS	*PHASE (°)*	*DOCUMENT ID*	*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.0141	122	[1] KAMANO 15	DPWA	Multichannel

[1] From the preferred solution A in KAMANO 15.

$\Lambda(1520)$ MASS

VALUE (MeV)	*EVTS*	*DOCUMENT ID*	*TECN*	*COMMENT*
1519.5 ±1.0 OUR ESTIMATE				
1519.54±0.17 OUR AVERAGE				
1519.6 ±0.5		ZHANG 13A	DPWA	Multichannel
1520.4 ±0.6 ±1.5		QIANG 10	SPEC	$e p \to e' K^+ X$ (fit to X)
1517.3 ±1.5	300	BARBER 80D	SPEC	$\gamma p \to \Lambda(1520) K^+$
1517.8 ±1.2	5k	BARLAG 79	HBC	$K^- p$ 4.2 GeV/c
1520.0 ±0.5		ALSTON-... 78	DPWA	$\overline{K} N \to \overline{K} N$
1519.7 ±0.3	4k	CAMERON 77	HBC	$K^- p$ 0.96–1.36 GeV/c
1519 ±1		GOPAL 77	DPWA	$\overline{K} N$ multichannel
1519.4 ±0.3	2000	CORDEN 75	DBC	$K^- d$ 1.4–1.8 GeV/c

$\Lambda(1520)$ WIDTH

VALUE (MeV)	*EVTS*	*DOCUMENT ID*	*TECN*	*COMMENT*
15.6 ±1.0 OUR ESTIMATE				
15.73±0.29 OUR AVERAGE		Error includes scale factor of 1.1.		
17 ±1		ZHANG 13A	DPWA	Multichannel
18.6 ±1.9 ±1.0		QIANG 10	SPEC	$e p \to e' K^+ X$ (fit to X)
16.3 ±3.3	300	BARBER 80D	SPEC	$\gamma p \to \Lambda(1520) K^+$
16 ±1		GOPAL 80	DPWA	$\overline{K} N \to \overline{K} N$
14 ±3	677	[1] BARLAG 79	HBC	$K^- p$ 4.2 GeV/c
15.4 ±0.5		ALSTON-... 78	DPWA	$\overline{K} N \to \overline{K} N$
16.3 ±0.5	4k	CAMERON 77	HBC	$K^- p$ 0.96–1.36 GeV/c
15.0 ±0.5		GOPAL 77	DPWA	$\overline{K} N$ multichannel
15.5 ±1.6	2000	CORDEN 75	DBC	$K^- d$ 1.4–1.8 GeV/c

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

$\Lambda(1520)$ DECAY MODES

	Mode	Fraction (Γ_i/Γ)
Γ_1	$N\overline{K}$	(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	$\Lambda(\pi\pi)_{S\text{-wave}}$	
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 $\left\langle \delta x_i \delta x_j \right\rangle / (\delta x_i \cdot \delta x_j)$, 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.

$$\begin{array}{r|rrrrr}
x_2 & -63 & & & & \\
x_3 & -32 & -34 & & & \\
x_9 & -4 & -3 & -1 & & \\
x_{10} & -8 & -7 & -3 & 0 & \\
x_{11} & -24 & -21 & -10 & -1 & -1 \\
\hline
 & x_1 & x_2 & x_3 & x_9 & x_{10}
\end{array}$$

$\Lambda(1520)$ BRANCHING RATIOS

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

$\Gamma(N\overline{K})/\Gamma_{\text{total}}$ Γ_1/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
0.45 $\pm$0.01 OUR ESTIMATE				
0.448$\pm$0.007 OUR FIT Error includes scale factor of 1.2.				
0.456$\pm$0.010 OUR AVERAGE				
0.47 $\pm$0.04	ZHANG	13A	DPWA	Multichannel
0.47 $\pm$0.02	GOPAL	80	DPWA	$\overline{K}N \rightarrow \overline{K}N$
0.45 $\pm$0.03	ALSTON-...	78	DPWA	$\overline{K}N \rightarrow \overline{K}N$
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	$K^- p \to \overline{K}^0 n$

[1] From the preferred solution A in KAMANO 15.

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

VALUE	*DOCUMENT ID*		*TECN*	*COMMENT*
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/c
0.418±0.017	BARBARO-...	69B	HBC	$K^- p$ 0.28–0.45 GeV/c

• • • 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

[1] From the preferred solution A in KAMANO 15.

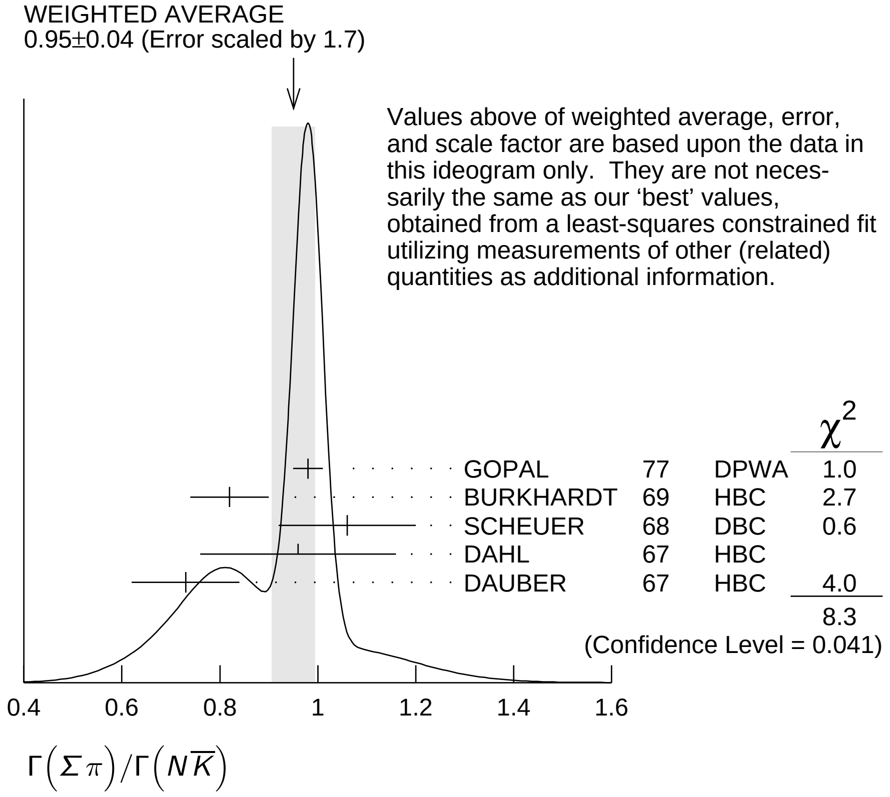
$\Gamma(\Sigma\pi)/\Gamma(N\overline{K})$ Γ_2/Γ_1

VALUE	*DOCUMENT ID*		*TECN*	*COMMENT*
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	$\overline{K} N$ multichannel
0.82 ±0.08	BURKHARDT	69	HBC	$K^- p$ 0.8–1.2 GeV/c
1.06 ±0.14	SCHEUER	68	DBC	$K^- N$ 3 GeV/c
0.96 ±0.20	DAHL	67	HBC	$\pi^- p$ 1.6–4 GeV/c
0.73 ±0.11	DAUBER	67	HBC	$K^- p$ 2 GeV/c

• • • 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	

[1] The $\overline{K} N \to \Sigma\pi$ amplitude at resonance is +0.46 ± 0.01.



$\Gamma(\Lambda\pi\pi)/\Gamma_{\text{total}}$ 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 $\Gamma(N\overline{K})/\Gamma_{\text{total}} = 0.46 \pm 0.02$.

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

VALUE	*DOCUMENT ID*	*TECN*	*COMMENT*
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	ARMENTEROS 65C	HBC	

$\Gamma(\Sigma(1385)\pi, S\text{-wave})/\Gamma_{\text{total}}$ Γ_4/Γ

VALUE	*DOCUMENT ID*	*TECN*	*COMMENT*
• • • 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

VALUE	*DOCUMENT ID*	*TECN*	*COMMENT*
• • • 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

VALUE	*DOCUMENT ID*	*TECN*	*COMMENT*
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 $(\Sigma(1385)\pi)$ / $(\Lambda 2\pi)$ 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.

VALUE	*CL%*	*DOCUMENT ID*	*TECN*	*COMMENT*
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

VALUE	*DOCUMENT ID*	*TECN*	*COMMENT*
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 $\Gamma(N\overline{K})/\Gamma_{\text{total}} = 0.46$.

$\Gamma(\Lambda\gamma)/\Gamma_{\text{total}}$ 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					
$10.7 \pm 2.9^{+1.5}_{-0.4}$	32	TAYLOR	05	CLAS	$\gamma p \rightarrow K^+ \Lambda\gamma$
10.2±2.1±1.5	290	ANTIPOV	04A	SPNX	$p N(\text{C}) \rightarrow \Lambda(1520) K^+ N(\text{C})$
8.0±1.4	238	MAST	68B	HBC	Using $\Gamma(N\overline{K})/\Gamma_{\text{total}} = 0.45$

$\Gamma(\Sigma^0\gamma)/\Gamma_{\text{total}}$ 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.

Λ(1520) REFERENCES

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

BURKHARDT	69	NP B14 106	E. Burkhardt *et al.*	(HEID, EFI, CERN+)
MAST	68B	PRL 21 1715	T.S. Mast *et al.*	(LRL)
SCHEUER	68	NP B8 503	J.C. Scheuer *et al.*	(SABRE Collab.)
DAHL	67	PR 163 1377	O.I. Dahl *et al.*	(LRL)
DAUBER	67	PL 24B 525	P.M. Dauber *et al.*	(UCLA)
UHLIG	67	PR 155 1448	R.P. Uhlig *et al.*	(UMD, NRL)
BIRMINGHAM	66	PR 152 1148	M. Haque *et al.*	(BIRM, GLAS, LOIC, OXF+)
ARMENTEROS	65C	PL 19 338	R. Armenteros *et al.*	(CERN, HEID, SACL)
MUSGRAVE	65	NC 35 735	B. Musgrave *et al.*	(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