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

$I(J^P) = 0(\frac{3}{2}^-)$ 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 $^{+4}_{-4}$	[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	$e p \to e' K^+ X$ (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	$e p \to e' K^+ X$ (fit to X)

[1] From 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 $N\overline{K} \to \Lambda(1520) \to N\overline{K}$

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 $N\overline{K} \to \Lambda(1520) \to \Sigma\pi$

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 $N\overline{K} \rightarrow \Lambda(1520) \rightarrow \Sigma(1385)\pi$, 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 $N\overline{K} \rightarrow \Lambda(1520) \rightarrow \Sigma(1385)\pi$, 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	$e p \rightarrow e' K^+ X$ (fit to X)
1517.3 ±1.5	300	BARBER	80D	SPEC	$\gamma p \rightarrow \Lambda(1520) K^+$
1517.8 ±1.2	5k	BARLAG	79	HBC	$K^- p$ 4.2 GeV/c
1520.0 ±0.5		ALSTON-...	78	DPWA	$\overline{K} N \rightarrow \overline{K} N$
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	$e p \rightarrow e' K^+ X$ (fit to X)
16.3 ±3.3	300	BARBER	80D	SPEC	$\gamma p \rightarrow \Lambda(1520) K^+$
16 ±1		GOPAL	80	DPWA	$\overline{K} N \rightarrow \overline{K} N$
14 ±3	677	[1] BARLAG	79	HBC	$K^- p$ 4.2 GeV/c
15.4 ±0.5		ALSTON-...	78	DPWA	$\overline{K} N \rightarrow \overline{K} N$
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 ±1) %
Γ_2	$\Sigma\pi$	(42 ±1) %
Γ_3	$\Lambda\pi\pi$	(10 ±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 ±0.1) %
Γ_{10}	$\Lambda\gamma$	(0.85±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.

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.

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

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

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

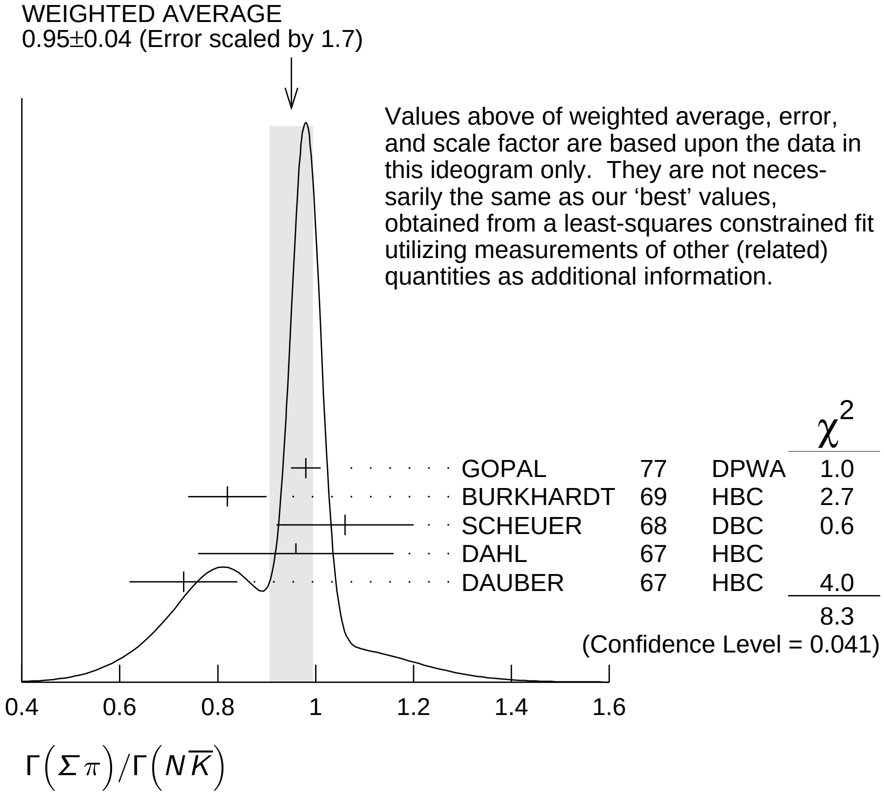
VALUE	DOCUMENT ID		TECN	COMMENT
0.42 ±0.01 OUR ESTIMATE				
0.421±0.007 OUR FIT Error includes scale factor of 1.2.				
0.425±0.011 OUR AVERAGE				
0.47 ±0.05	ZHANG	13A	DPWA	Multichannel
0.426±0.014	CORDEN	75	DBC	$K^- d$ 1.4–1.8 GeV/c
0.418±0.017	BARBARO-...	69B	HBC	$K^- p$ 0.28–0.45 GeV/c
• • • We do 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 $+0.46 \pm 0.01$.



$\Gamma(\Lambda\pi\pi)/\Gamma_{total}$ — 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	$K^- p \to \Lambda\pi\pi$

[1] Assumes $\Gamma(N\overline{K})/\Gamma_{total} = 0.46 \pm 0.02$.

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

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

$\Gamma(\Sigma(1385)\pi, D\text{-wave})/\Gamma_{total}$ — 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.

$\Gamma(\Sigma(1385)\pi)/\Gamma_{total}$ — 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

$\Gamma(\Sigma\pi\pi)/\Gamma_{total}$ — 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	$K^- p \to \Sigma\pi\pi$
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 $\Gamma(N\overline{K})/\Gamma_{total} = 0.46$.

$\Gamma(\Lambda\gamma)/\Gamma_{total}$ — 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					
$10.7\pm2.9^{+1.5}_{-0.4}$	32	TAYLOR	05	CLAS	$\gamma p \to K^+ \Lambda\gamma$
10.2±2.1±1.5	290	ANTIPOV	04A	SPNX	$p N(C) \to \Lambda(1520) K^+ N(C)$
8.0±1.4	238	MAST	68B	HBC	Using $\Gamma(N\overline{K})/\Gamma_{total} = 0.45$

$\Gamma(\Sigma^0\gamma)/\Gamma_{total}$ — 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 $\Gamma(\Lambda\gamma)/\Gamma_{total}$, 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 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