K^0_L

$I(J^P) = \frac{1}{2}(0^-)$

$m_{K^0_L} - m_{K^0_S}$

For earlier measurements, beginning with GOOD 61 and FITCH 61, see our 1986 edition, Physics Letters **170B** 132 (1986).

OUR FIT is described in the note on "*CP* violation in K_L decays" in the K^0_L Particle Listings. The result labeled "OUR FIT Assuming *CPT*" ["OUR FIT Not assuming *CPT*"] includes all measurements except those with the comment "Not assuming *CPT*" ["Assuming *CPT*"]. Measurements with neither comment do not assume *CPT* and enter both fits.

VALUE (10^{10} $\hbar$ s^{-1})	*DOCUMENT ID*	*TECN*	*COMMENT*
0.5292±0.0010 OUR FIT	Error includes scale factor of 1.2.		Assuming *CPT*
0.5290±0.0016 OUR FIT	Error includes scale factor of 1.2.		Not assuming *CPT*
0.5261±0.0015	[1,2] ALAVI-HARATI 03	KTEV	Assuming *CPT*
0.5288±0.0043	[2,3] ALAVI-HARATI 03	KTEV	Not assuming *CPT*
0.5240±0.0044 ±0.0033	APOSTOLA... 99C	CPLR	K^0-$\overline{K}^0$ to $\pi^+\pi^-$
0.5297±0.0030 ±0.0022	[4] SCHWINGEN... 95	E773	20–160 GeV *K* beams
0.5286±0.0028	[5] GIBBONS 93	E731	Assuming *CPT*
0.5257±0.0049 ±0.0021	[4] GIBBONS 93C	E731	Not assuming *CPT*
0.5340±0.00255±0.0015	[6] GEWENIGER 74C	SPEC	Gap method
0.5334±0.0040 ±0.0015	[6,7] GJESDAL 74	SPEC	Assuming *CPT*
• • • We do not use the following data for averages, fits, limits, etc. • • •			
0.5343±0.0063 ±0.0025	[8] ANGELOPO... 01	CPLR	
0.5295±0.0020 ±0.0003	[9] ANGELOPO... 98D	CPLR	Assuming *CPT*
0.5307±0.0013	[10] ADLER 96C	RVUE	
0.5274±0.0029 ±0.0005	[9] ADLER 95	CPLR	Sup. by ANGELOPOULOS 98D
0.482 ±0.014	[11] ARONSON 82B	SPEC	*E*=30–110 GeV
0.534 ±0.007	[12] CARNEGIE 71	ASPK	Gap method
0.542 ±0.006	[12] ARONSON 70	ASPK	Gap method
0.542 ±0.006	CULLEN 70	CNTR	

[1] ALAVI-HARATI 03 fit Δm and $\tau_{K^0_S}$ simultaneously. ϕ_{+-} is constrained to the Superweak value, i.e. *CPT* is assumed. See "K^0_S Mean Life" section for correlation information.

[2] The two ALAVI-HARATI 03 values use the same data. The first enters the "Assuming *CPT*" fit and the second enters the "Not assuming *CPT*" fit. They use 40–160 GeV *K* beams.

[3] ALAVI-HARATI 03 fit Δm, ϕ_{+-}, and τ_{K_S} simultaneously. See ϕ_{+-} in the "K_L *CP* violation" section for correlation information.

[4] Fits Δm and ϕ_{+-} simultaneously. GIBBONS 93C systematic error is from B. Winstein via private communication. 20–160 GeV *K* beams.

[5] GIBBONS 93 value assume $\phi_{+-} = \phi_{00} = \phi_{SW} = (43.7 \pm 0.2)^\circ$, i.e. assumes *CPT*. 20–160 GeV *K* beams.

[6] These two experiments have a common systematic error due to the uncertainty in the momentum scale, as pointed out in WAHL 89.

[7] GJESDAL 74 uses charge asymmetry in $K^0_{\ell 3}$ decays.

[8] ANGELOPOULOS 01 uses strong interactions strangeness tagging at two different times.

[9] Uses $\overline{K}^0_{e3}$ and K^0_{e3} strangeness tagging at production and decay. Assumes *CPT* conservation on $\Delta S = -\Delta Q$ transitions.

[10] ADLER 96C is the result of a fit which includes nearly the same data as entered into the "OUR FIT" value above.

[11] ARONSON 82 find that Δm may depend on the kaon energy.

[12] ARONSON 70 and CARNEGIE 71 use K^0_S mean life = $(0.862 \pm 0.006) \times 10^{-10}$ s. We have not attempted to adjust these values for the subsequent change in the K^0_S mean life or in η_{+-}.

K^0_L MEAN LIFE

VALUE (10^{-8} s)	*EVTS*	*DOCUMENT ID*		*TECN*
5.16 ±0.04 OUR FIT				
5.15 ±0.04 OUR AVERAGE				
5.154±0.044	0.4M	VOSBURGH	72	CNTR
5.15 ±0.14		DEVLIN	67	CNTR
• • • We do not use the following data for averages, fits, limits, etc. • • •				
5.0 ±0.5		[13] LOWYS	67	HLBC
6.1 $^{+1.5}_{-1.2}$	1700	ASTBURY	65C	CNTR
5.3 ±0.6		FUJII	64	OSPK
5.1 $^{+2.4}_{-1.3}$	15	DARMON	62	FBC
8.1 $^{+3.2}_{-2.4}$	34	BARDON	58	CNTR

[13] Sum of partial decay rates.

K^0_L DECAY MODES

	Mode		Fraction (Γ_i/Γ)	Scale factor/ Confidence level
	Semileptonic modes			
Γ_1	$\pi^\pm e^\mp \nu_e$ Called K^0_{e3}.	[a]	(40.40 ±0.22) %	S=2.8
Γ_2	$\pi^- e^+ \nu_e$			
Γ_3	$\pi^+ e^- \overline{\nu}_e$			
Γ_4	$\pi^\pm \mu^\mp \nu_\mu$ Called $K^0_{\mu3}$.	[a]	(26.96 ±0.35) %	S=4.6
Γ_5	$\pi^- \mu^+ \nu_\mu$			
Γ_6	$\pi^+ \mu^- \overline{\nu}_\mu$			
Γ_7	$(\pi \mu \text{atom})\nu$		(1.05 ±0.11) × 10^{-7}	
Γ_8	$\pi^0 \pi^\pm e^\mp \nu$	[a]	(5.20 ±0.11) × 10^{-5}	

Hadronic modes, including Charge conjugation×Parity Violating (*CPV*) modes

Γ_9	$3\pi^0$			$(19.83\ \pm0.20\ )\ \%$	S=2.1
Γ_{10}	$\pi^+\pi^-\pi^0$			$(12.47\ \pm0.15\ )\ \%$	S=2.8
Γ_{11}	$\pi^+\pi^-$	*CPV*		$(\ 1.975\pm0.015)\times10^{-3}$	S=1.7
Γ_{12}	$\pi^0\pi^0$	*CPV*		$(\ 8.83\ \pm0.08\ )\times10^{-4}$	S=1.6

Semileptonic modes with photons

Γ_{13}	$\pi^\pm e^\mp\nu_e\gamma$		[*a*,*b*,*c*]	$(\ 3.78\ \pm0.08\ )\times10^{-3}$	
Γ_{14}	$\pi^\pm\mu^\mp\nu_\mu\gamma$			$(\ 5.63\ \pm0.24\ )\times10^{-4}$	

Hadronic modes with photons or $\ell\overline{\ell}$ pairs

Γ_{15}	$\pi^0\pi^0\gamma$			$<\ 5.6\ \times10^{-6}$	
Γ_{16}	$\pi^+\pi^-\gamma$		[*b*,*c*]	$(\ 4.17\ \pm0.15\ )\times10^{-5}$	S=2.8
Γ_{17}	$\pi^0 2\gamma$		[*c*]	$(\ 1.47\ \pm0.09\ )\times10^{-6}$	S=2.2
Γ_{18}	$\pi^0\gamma e^+e^-$			$(\ 2.3\ \pm0.4\ )\times10^{-8}$	

Other modes with photons or $\ell\overline{\ell}$ pairs

Γ_{19}	2γ			$(\ 5.56\ \pm0.06\ )\times10^{-4}$	S=1.5
Γ_{20}	3γ			$<\ 2.4\ \times10^{-7}$	CL=90%
Γ_{21}	$e^+e^-\gamma$			$(10.0\ \pm0.5\ )\times10^{-6}$	S=1.5
Γ_{22}	$\mu^+\mu^-\gamma$			$(\ 3.59\ \pm0.11\ )\times10^{-7}$	S=1.3
Γ_{23}	$e^+e^-\gamma\gamma$		[*c*]	$(\ 5.95\ \pm0.33\ )\times10^{-7}$	
Γ_{24}	$\mu^+\mu^-\gamma\gamma$		[*c*]	$(\ 1.0\ {}^{+0.8}_{-0.6}\ )\times10^{-8}$	

Charge conjugation × Parity (*CP*) or Lepton Family number (*LF*) violating modes, or $\Delta S = 1$ weak neutral current (*S1*) modes

Γ_{25}	$\mu^+\mu^-$	*S1*		$(\ 6.87\ \pm0.12\ )\times10^{-9}$	
Γ_{26}	e^+e^-	*S1*		$(\ 9\ {}^{+6}_{-4}\ )\times10^{-12}$	
Γ_{27}	$\pi^+\pi^-e^+e^-$	*S1*	[*c*]	$(\ 3.11\ \pm0.19\ )\times10^{-7}$	
Γ_{28}	$\pi^0\pi^0e^+e^-$	*S1*		$<\ 6.6\ \times10^{-9}$	CL=90%
Γ_{29}	$\mu^+\mu^-e^+e^-$	*S1*		$(\ 2.69\ \pm0.27\ )\times10^{-9}$	
Γ_{30}	$e^+e^-e^+e^-$	*S1*		$(\ 3.72\ \pm0.27\ )\times10^{-8}$	
Γ_{31}	$\pi^0\mu^+\mu^-$	*CP*,*S1*	[*d*]	$<\ 3.8\ \times10^{-10}$	CL=90%
Γ_{32}	$\pi^0e^+e^-$	*CP*,*S1*	[*d*]	$<\ 2.8\ \times10^{-10}$	CL=90%
Γ_{33}	$\pi^0\nu\overline{\nu}$	*CP*,*S1*	[*e*]	$<\ 5.9\ \times10^{-7}$	CL=90%
Γ_{34}	$e^\pm\mu^\mp$	*LF*	[*a*]	$<\ 4.7\ \times10^{-12}$	CL=90%
Γ_{35}	$e^\pm e^\pm\mu^\mp\mu^\mp$	*LF*	[*a*]	$<\ 4.12\ \times10^{-11}$	CL=90%
Γ_{36}	$\pi^0\mu^\pm e^\mp$	*LF*	[*a*]	$<\ 6.2\ \times10^{-9}$	CL=90%

[*a*] The value is for the sum of the charge states or particle/antiparticle states indicated.

[*b*] Most of this radiative mode, the low-momentum γ part, is also included in the parent mode listed without γ's.

[*c*] See the Particle Listings below for the energy limits used in this measurement.

[*d*] Allowed by higher-order electroweak interactions.

[*e*] Violates *CP* in leading order. Test of direct *CP* violation since the indirect *CP*-violating and *CP*-conserving contributions are expected to be suppressed.

CONSTRAINED FIT INFORMATION

An overall fit to the mean life, a decay rate, and 14 branching ratios uses 25 measurements and one constraint to determine 9 parameters. The overall fit has a $\chi^2 = 78.0$ for 17 degrees of freedom.

The following *off-diagonal* array elements are the correlation coefficients $\left\langle \delta p_i \delta p_j \right\rangle / (\delta p_i \cdot \delta p_j)$, in percent, from the fit to parameters p_i, including 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_4	−72							
x_9	4	−58						
x_{10}	11	−46	−6					
x_{11}	38	−60	53	10				
x_{12}	11	−57	86	−2	65			
x_{16}	8	−13	11	2	21	14		
x_{19}	4	−51	86	−5	48	78	10	
Γ	0	0	0	0	0	0	0	0
	x_1	x_4	x_9	x_{10}	x_{11}	x_{12}	x_{16}	x_{19}

	Mode		Rate (10^8 s^{-1})	Scale factor
Γ_1	$\pi^\pm e^\mp \nu_e$ Called K^0_{e3}.	[*a*]	0.0783 ±0.0008	1.2
Γ_4	$\pi^\pm \mu^\mp \nu_\mu$ Called $K^0_{\mu 3}$.	[*a*]	0.0522 ±0.0008	1.8
Γ_9	$3\pi^0$		0.0384 ±0.0005	1.4
Γ_{10}	$\pi^+\pi^-\pi^0$		0.02417±0.00035	1.6
Γ_{11}	$\pi^+\pi^-$		(3.83 ±0.04) × 10^{-4}	1.2
Γ_{12}	$\pi^0\pi^0$		(1.712 ±0.021) × 10^{-4}	1.3
Γ_{16}	$\pi^+\pi^-\gamma$	[*b*,*c*]	(8.08 ±0.31) × 10^{-6}	2.5
Γ_{19}	2γ		(1.078 ±0.015) × 10^{-4}	1.3

K^0_L DECAY RATES

$\Gamma(\pi^+\pi^-\pi^0)$ Γ_{10}

VALUE (10^6 s^{-1})	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
2.417±0.035 OUR FIT Error includes scale factor of 1.6.					
2.33 ±0.11 OUR AVERAGE					
$2.32^{+0.13}_{-0.15}$	192	BALDO-...	75	HLBC	Assumes *CP*
2.35 ±0.20	180	[14] JAMES	72	HBC	Assumes *CP*
• • • We do not use the following data for averages, fits, limits, etc. • • •					
2.71 ±0.28	99	CHO	71	DBC	Assumes *CP*
2.5 ±0.3	98	[14] JAMES	71	HBC	Assumes *CP*
2.12 ±0.33	50	MEISNER	71	HBC	Assumes *CP*
2.20 ±0.35	53	WEBBER	70	HBC	Assumes *CP*
$2.62^{+0.28}_{-0.27}$	136	BEHR	66	HLBC	Assumes *CP*
3.26 ±0.77	18	ANDERSON	65	HBC	
1.4 ±0.4	14	FRANZINI	65	HBC	

[14] JAMES 72 is a final measurement and includes JAMES 71.

$\Gamma(\pi^\pm e^\mp \nu_e)$ Γ_1

VALUE (10^6 s^{-1})	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
7.83±0.08 OUR FIT Error includes scale factor of 1.2.					
• • • We do not use the following data for averages, fits, limits, etc. • • •					
7.81±0.56	620	CHAN	71	HBC	
$7.52^{+0.85}_{-0.72}$		AUBERT	65	HLBC	ΔS=ΔQ,*CP* assumed

$\Gamma(\pi^\pm e^\mp \nu_e) + \Gamma(\pi^\pm \mu^\mp \nu_\mu)$ $(\Gamma_1+\Gamma_4)$

VALUE (10^6 s^{-1})	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
13.05±0.12 OUR FIT Error includes scale factor of 1.1.					
• • • We do not use the following data for averages, fits, limits, etc. • • •					
12.4 ±0.7	410	[15] BURGUN	72	HBC	$K^+ p \rightarrow K^0 p \pi^+$
8.47±1.69	126	[15] MANN	72	HBC	$K^- p \rightarrow n \overline{K}^0$
13.1 ±1.3	252	[15] WEBBER	71	HBC	$K^- p \rightarrow n \overline{K}^0$
11.6 ±0.9	393	[15,16] CHO	70	DBC	$K^+ n \rightarrow K^0 p$
10.3 ±0.8	335	[16] HILL	67	DBC	$K^+ n \rightarrow K^0 p$
$9.85^{+1.15}_{-1.05}$	109	[15] FRANZINI	65	HBC	

[15] Assumes $\Delta S = \Delta Q$ rule.
[16] CHO 70 includes events of HILL 67.

K^0_L BRANCHING RATIOS

Semileptonic modes

$[\Gamma(\pi^\pm e^\mp \nu_e) + \Gamma(\pi^\pm \mu^\mp \nu_\mu)]/\Gamma_{\text{total}}$ $(\Gamma_1+\Gamma_4)/\Gamma$

VALUE	*DOCUMENT ID*
0.6736±0.0024 OUR FIT Error includes scale factor of 2.4.	

$\Gamma(\pi^{\pm}\mu^{\mp}\nu_{\mu})/\Gamma(\pi^{\pm}e^{\mp}\nu_{e})$ Γ_4/Γ_1

VALUE	*EVTS*	*DOCUMENT ID*		*TECN*
0.667 ±0.011 OUR FIT Error includes scale factor of 4.6.				
0.6660±0.0025 OUR AVERAGE				
0.6640±0.0014±0.0022	394K	[17] ALEXOPOU...	04	KTEV
0.702 ±0.011	33k	CHO	80	HBC
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.662 ±0.037	10k	WILLIAMS	74	ASPK
0.741 ±0.044	6700	BRANDENB...	73	HBC
0.662 ±0.030	1309	EVANS	73	HLBC
0.68 ±0.08	3548	BASILE	70	OSPK
0.71 ±0.05	770	BUDAGOV	68	HLBC

[17] Correlations between ALEXOPOULOS 04 branching ratios given in their Table V are included in our branching ratio fit.

$\Gamma((\pi\mu\text{atom})\nu)/\Gamma(\pi^{\pm}\mu^{\mp}\nu_{\mu})$ Γ_7/Γ_4

VALUE (units 10^{-7})	*EVTS*	*DOCUMENT ID*		*TECN*
3.90±0.39	155	[18] ARONSON	86	SPEC
• • • We do not use the following data for averages, fits, limits, etc. • • •				
seen	18	COOMBES	76	WIRE

[18] ARONSON 86 quote theoretical value of $(4.31 \pm 0.08) \times 10^{-7}$.

$\Gamma(\pi^0\pi^{\pm}e^{\mp}\nu)/\Gamma_{\text{total}}$ Γ_8/Γ

VALUE (units 10^{-5})	*CL%*	*EVTS*	*DOCUMENT ID*		*TECN*
5.20±0.11 OUR AVERAGE					
5.21±0.07±0.09		5402	BATLEY	04	NA48
5.16±0.20±0.22		729	MAKOFF	93	E731
• • • We do not use the following data for averages, fits, limits, etc. • • •					
6.2 ±2.0		16	CARROLL	80C	SPEC
< 220	90		[19] DONALDSON	74	SPEC

[19] DONALDSON 74 uses $K^0_L \rightarrow \pi^+\pi^-\pi^0/(\text{all } K^0_L)$ decays = 0.126.

Hadronic modes,
including Charge conjugation×Parity Violating (*CPV*) modes

$\Gamma(3\pi^0)/\Gamma_{\text{total}}$ Γ_9/Γ

VALUE	*EVTS*	*DOCUMENT ID*		*TECN*
0.1983±0.0020 OUR FIT Error includes scale factor of 2.1.				
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.2105±0.0028	38k	[20] KREUTZ	95	NA31

[20] KREUTZ 95 measure $3\pi^0$, $\pi^+\pi^-\pi^0$, and $\pi e \nu_e$ modes. They assume PDG 1992 values for $\pi\mu\nu_{\mu}$, 2π, and 2γ modes. Excluded from fits because it is not independent of other KREUTZ 95 measurements which are in the fit.

$\Gamma(3\pi^0)/\Gamma(\pi^\pm e^\mp \nu_e)$ Γ_9/Γ_1

VALUE	*EVTS*	*DOCUMENT ID*		*TECN*
0.491 ±0.006 OUR FIT Error includes scale factor of 1.8.				
0.494 ±0.028 OUR AVERAGE Error includes scale factor of 5.9.				
0.4782±0.0014±0.0053	209K	[21] ALEXOPOU...	04	KTEV
0.545 ±0.004 ±0.009	38k	KREUTZ	95	NA31

[21] Correlations between ALEXOPOULOS 04 branching ratios given in their Table V are included in our branching ratio fit.

$\Gamma(3\pi^0)/[\Gamma(\pi^\pm e^\mp \nu_e)+\Gamma(\pi^\pm \mu^\mp \nu_\mu)+\Gamma(\pi^+\pi^-\pi^0)]$ $\Gamma_9/(\Gamma_1+\Gamma_4+\Gamma_{10})$

VALUE	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
0.2484±0.0031 OUR FIT Error includes scale factor of 2.1.					
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.251 ±0.014	549	BUDAGOV	68	HLBC	ORSAY measur.
0.277 ±0.021	444	BUDAGOV	68	HLBC	Ecole polytec.meas
0.31 $^{+0.07}_{-0.06}$	29	KULYUKINA	68	CC	
0.24 ±0.08	24	ANIKINA	64	CC	

$\Gamma(3\pi^0)/\Gamma(\pi^+\pi^-\pi^0)$ Γ_9/Γ_{10}

VALUE	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
1.590±0.025 OUR FIT Error includes scale factor of 2.2.					
1.611±0.014±0.034	38k	KREUTZ	95	NA31	
• • • We do not use the following data for averages, fits, limits, etc. • • •					
1.65 ±0.07	883	BARMIN	72B	HLBC	Error statistical only
1.80 ±0.13	1010	BUDAGOV	68	HLBC	
2.0 ±0.6	188	ALEKSANYAN	64B	FBC	

$\Gamma(\pi^+\pi^-\pi^0)/\Gamma_{\text{total}}$ Γ_{10}/Γ

VALUE	*DOCUMENT ID*
0.1247±0.0015 OUR FIT Error includes scale factor of 2.8.	

$\Gamma(\pi^+\pi^-\pi^0)/\Gamma(\pi^\pm e^\mp \nu_e)$ Γ_{10}/Γ_1

VALUE	*EVTS*	*DOCUMENT ID*		*TECN*
0.309 ±0.004 OUR FIT Error includes scale factor of 2.5.				
0.3092±0.0017 OUR AVERAGE				
0.3078±0.0005±0.0017	799K	[22] ALEXOPOU...	04	KTEV
0.336 ±0.003 ±0.007	28k	[23] KREUTZ	95	NA31

[22] Correlations between ALEXOPOULOS 04 branching ratios given in their Table V are included in our branching ratio fit.

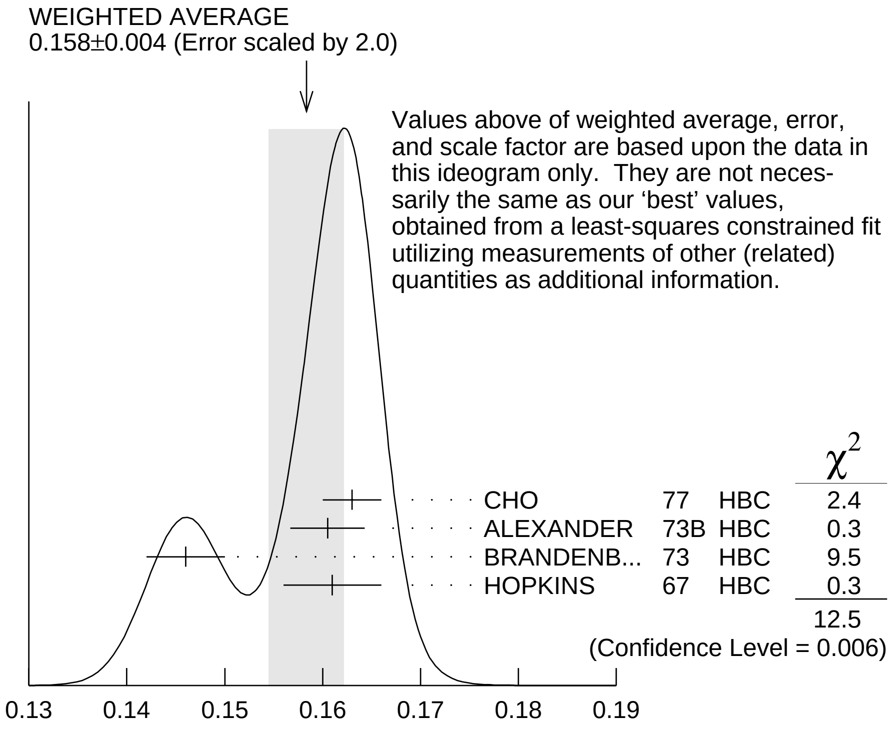
[23] KREUTZ 95 is not included in the fit because it is not independent of their $\Gamma(3\pi^0)/\Gamma(\pi^\pm e^\mp \nu_e)$ and $\Gamma(3\pi^0)/\Gamma(\pi^+\pi^-\pi^0)$ measurements, which are in the fit.

$\Gamma(\pi^+\pi^-\pi^0)/[\Gamma(\pi^\pm e^\mp \nu_e)+\Gamma(\pi^\pm \mu^\mp \nu_\mu)+\Gamma(\pi^+\pi^-\pi^0)]$ $\Gamma_{10}/(\Gamma_1+\Gamma_4+\Gamma_{10})$

VALUE	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
0.1562±0.0019 OUR FIT Error includes scale factor of 2.8.					
0.158 ±0.004 OUR AVERAGE Error includes scale factor of 2.0. See the ideogram below.					
0.163 ±0.003	6499	CHO	77	HBC	
0.1605±0.0038	1590	ALEXANDER	73B	HBC	
0.146 ±0.004	3200	BRANDENB...	73	HBC	
0.161 ±0.005		HOPKINS	67	HBC	

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

0.159 ±0.010	558	EVANS	73	HLBC	
0.167 ±0.016	1402	KULYUKINA	68	CC	
0.162 ±0.015	126	HAWKINS	66	HBC	
0.159 ±0.015	326	ASTBURY	65B	CC	
0.178 ±0.017	566	GUIDONI	65	HBC	
0.144 ±0.004	1729	HOPKINS	65	HBC	See HOPKINS 67



$\Gamma\left(\pi^+\pi^-\pi^0\right)/\left[\Gamma\left(\pi^\pm e^\mp \nu_e\right)+\Gamma\left(\pi^\pm \mu^\mp \nu_\mu\right)+\Gamma\left(\pi^+\pi^-\pi^0\right)\right]$

$\Gamma(\pi^+\pi^-)/\Gamma_{\text{total}}$ Γ_{11}/Γ

Violates *CP* conservation.

VALUE (units 10^{-3})	*DOCUMENT ID*	
1.975±0.015 OUR FIT	Error includes scale factor of 1.7.	
2.07 ±0.05	ETAFIT	05

$\Gamma(\pi^+\pi^-)/\Gamma(\pi^\pm e^\mp \nu_e)$ Γ_{11}/Γ_1

VALUE (units 10^{-3})	*EVTS*	*DOCUMENT ID*		*TECN*
4.89 ±0.04 OUR FIT	Error includes scale factor of 1.5.			
4.856±0.017±0.023	84K	[24] ALEXOPOU...	04	KTEV

[24] Correlations between ALEXOPOULOS 04 branching ratios given in their Table V are included in our branching ratio fit.

$\Gamma(\pi^+\pi^-)/[\Gamma(\pi^\pm e^\mp \nu_e)+\Gamma(\pi^\pm \mu^\mp \nu_\mu)]$ $\qquad\Gamma_{11}/(\Gamma_1+\Gamma_4)$

Violates *CP* conservation.

VALUE (units 10^{-3})	*EVTS*	*DOCUMENT ID*	*TECN*	*COMMENT*
2.932±0.029 OUR FIT	Error includes scale factor of 2.0.			
• • • We do not use the following data for averages, fits, limits, etc. • • •				
3.13 ±0.14	1687	COUPAL 85	SPEC	η_{+-}=2.28 ± 0.06
3.04 ±0.14	2703	DEVOE 77	SPEC	η_{+-}=2.25 ± 0.05
2.51 ±0.23	309	[25] DEBOUARD 67	OSPK	η_{+-}=2.00 ± 0.09
2.35 ±0.19	525	[25] FITCH 67	OSPK	η_{+-}=1.94 ± 0.08

[25] Old experiments excluded from fit. See subsection on η_{+-} in section on "PARAMETERS FOR $K^0_L \to 2\pi$ DECAY" below for average η_{+-} of these experiments and for note on discrepancy.

$\Gamma(\pi^\pm e^\mp \nu_e)/\Gamma(\text{2 tracks})$ $\qquad\Gamma_1/(\Gamma_1+\Gamma_4+0.03508\Gamma_9+\Gamma_{10}+\Gamma_{11})$

Γ(2 tracks) = $\Gamma(\pi^\pm e^\mp \nu_e)$ + $\Gamma(\pi^\pm \mu^\mp \nu_\mu)$ + 0.03508 $\Gamma(3\pi^0)$ + $\Gamma(\pi^+\pi^-\pi^0)$ + $\Gamma(\pi^+\pi^-)$ where 0.03508 is the fraction of $3\pi^0$ events with one Dalitz decay ($\pi^0 \to \gamma e^+ e^-$).

VALUE	*EVTS*	*DOCUMENT ID*	*TECN*
0.5005±0.0031 OUR FIT	Error includes scale factor of 3.8.		
0.4978±0.0035	6.8M	LAI 04B	NA48

$\Gamma(\pi^+\pi^-)/[\Gamma(\pi^\pm e^\mp \nu_e)+\Gamma(\pi^\pm \mu^\mp \nu_\mu)+\Gamma(\pi^+\pi^-\pi^0)]$ $\qquad\Gamma_{11}/(\Gamma_1+\Gamma_4+\Gamma_{10})$

Violates *CP* conservation.

VALUE (units 10^{-3})	*EVTS*	*DOCUMENT ID*	*TECN*	*COMMENT*
2.474±0.023 OUR FIT	Error includes scale factor of 2.0.			
• • • We do not use the following data for averages, fits, limits, etc. • • •				
2.60 ±0.07	4200	[26] MESSNER 73	ASPK	η_{+-} = 2.23 ± 0.05

[26] From same data as $\Gamma(\pi^+\pi^-)/\Gamma(\pi^+\pi^-\pi^0)$ MESSNER 73, but with different normalization.

$\Gamma(\pi^+\pi^-)/\Gamma(\pi^+\pi^-\pi^0)$ $\qquad\Gamma_{11}/\Gamma_{10}$

Violates *CP* conservation.

VALUE (units 10^{-2})	*EVTS*	*DOCUMENT ID*	*TECN*	*COMMENT*
1.583±0.021 OUR FIT	Error includes scale factor of 2.5.			
1.64 ±0.04	4200	MESSNER 73	ASPK	η_{+-} = 2.23

$\Gamma(\pi^0\pi^0)/\Gamma_{\text{total}}$ $\qquad\Gamma_{12}/\Gamma$

Violates *CP* conservation.

VALUE (units 10^{-3})	*DOCUMENT ID*
0.883±0.008 OUR FIT	Error includes scale factor of 1.6.

$\Gamma(\pi^0\pi^0)/\Gamma(\pi^+\pi^-)$ $\qquad\Gamma_{12}/\Gamma_{11}$

Violates *CP* conservation.

VALUE	*DOCUMENT ID*	*COMMENT*
0.4472±0.0033 OUR FIT	Error includes scale factor of 1.3.	
0.4458±0.0030	[27] ETAFIT 05	S = 1.1

[27] ETAFIT 05 error is scaled up by a factor S to account for disagreements among ϵ'/ϵ measurements.

$\Gamma(\pi^0\pi^0)/\Gamma(3\pi^0)$ Γ_{12}/Γ_9

Violates *CP* conservation.

VALUE (units 10^{-2})	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
0.4455±0.0023 OUR FIT	Error includes scale factor of 1.1.				
0.4446±0.0016±0.0019	100K	[28] ALEXOPOU...	04	KTEV	
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.37 ±0.08	29	BARMIN	70	HLBC	η_{00}=2.02 ± 0.23
0.32 ±0.15	30	BUDAGOV	70	HLBC	η_{00}=1.9 ± 0.5
0.46 ±0.11	57	BANNER	69	OSPK	η_{00}=2.2 ± 0.3

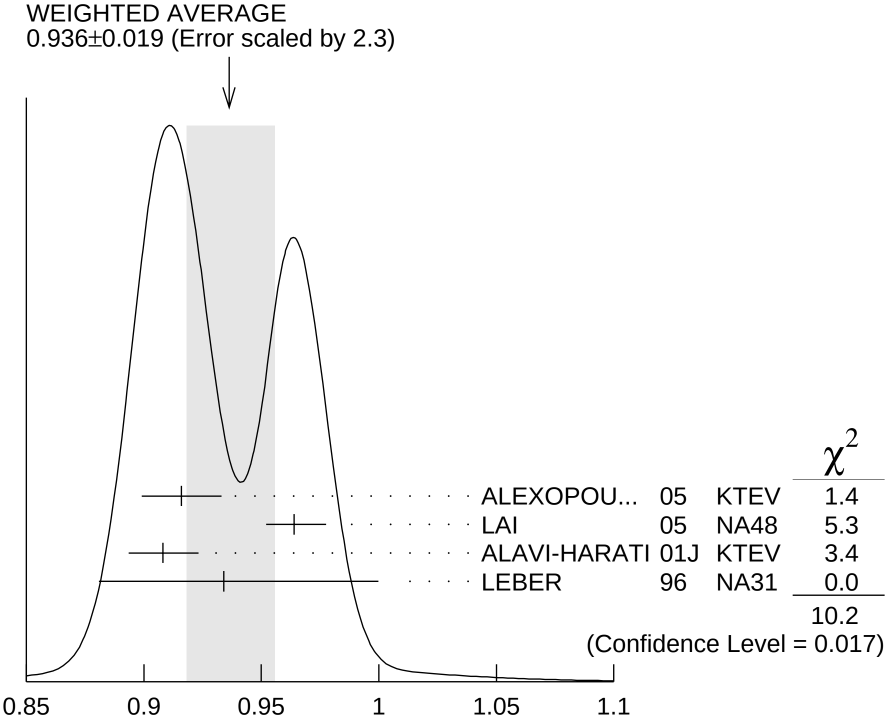
[28] Correlations between ALEXOPOULOS 04 branching ratios given in their Table V are included in our branching ratio fit.

Semileptonic modes with photons

$\Gamma(\pi^\pm e^\mp \nu_e \gamma)/\Gamma(\pi^\pm e^\mp \nu_e)$ Γ_{13}/Γ_1

VALUE (units 10^{-2})	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
0.936±0.019 OUR AVERAGE	Error includes scale factor of 2.3. See the ideogram below.				
0.916±0.017	4309	[29] ALEXOPOU...	05	KTEV	E^*_γ >30 MeV, $\theta^*_{e\gamma}$ >20°
$0.964\pm0.008^{+0.011}_{-0.009}$	19K	LAI	05	NA48	E^*_γ >30 MeV, $\theta^*_{e\gamma}$ >20°
$0.908\pm0.008^{+0.013}_{-0.012}$	15k	ALAVI-HARATI	01J	KTEV	$E^*_\gamma \geq$ 30 MeV, $\theta^*_{e\gamma} \geq$ 20°
$0.934\pm0.036^{+0.055}_{-0.039}$	1384	LEBER	96	NA31	$E^*_\gamma \geq$ 30 MeV, $\theta^*_{e\gamma} \geq$ 20°

[29] Also measured cut E^*_γ >10 MeV, $\theta^*_{e\gamma}$ >0° 14221 evts: $\Gamma(\pi^\pm e^\mp \nu_e \gamma)$ / $\Gamma(\pi^\pm e^\mp \nu_e)$ = (4.942 ± 0.062)%.



$\Gamma\left(\pi^\pm e^\mp \nu_e \gamma\right)/\Gamma\left(\pi^\pm e^\mp \nu_e\right)$ Γ_{13}/Γ_1

$\Gamma(\pi^{\pm}\mu^{\mp}\nu_{\mu}\gamma)/\Gamma(\pi^{\pm}\mu^{\mp}\nu_{\mu})$ Γ_{14}/Γ_{4}

VALUE (units 10^{-3})	*EVTS*	*DOCUMENT ID*	*TECN*	*COMMENT*
2.09±0.08 OUR AVERAGE				
2.09±0.09		[30] ALEXOPOU... 05	KTEV	$E^{*}_{\gamma} > 30$ MeV
$2.08\pm0.17^{+0.16}_{-0.21}$	252	BENDER 98	NA48	$E^{*}_{\gamma} \geq 30$ MeV

[30] Also measured cut E^{*}_{γ} >10 MeV, 1385 evts: $\Gamma(\pi^{\pm}\mu^{\mp}\nu_{\mu}\gamma)$ / $\Gamma(\pi^{\pm}\mu^{\mp}\nu_{\mu})$ = (0.530 ± 0.014 ± 0.012)%.

——— Hadronic modes with photons or $\ell\overline{\ell}$ pairs ———

$\Gamma(\pi^{0}\pi^{0}\gamma)/\Gamma_{\text{total}}$ Γ_{15}/Γ

VALUE (units 10^{-6})	*CL%*	*EVTS*	*DOCUMENT ID*	*TECN*
< 5.6			BARR 94	NA31
• • • We do not use the following data for averages, fits, limits, etc. • • •				
<230	90	0	ROBERTS 94	E799

$\Gamma(\pi^{+}\pi^{-}\gamma)/\Gamma(\pi^{+}\pi^{-}\pi^{0})$ Γ_{16}/Γ_{10}

For earlier limits see our 1992 edition Physical Review **D45,** 1 June, Part II (1992).

VALUE (units 10^{-4})	*EVTS*	*DOCUMENT ID*	*TECN*	*COMMENT*
3.34±0.13 OUR FIT Error includes scale factor of 2.8.				
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1.23±0.13	516	[31,32] CARROLL 80B	SPEC	E_{γ} >20 MeV
2.33±0.23	546	[31,33] CARROLL 80B	SPEC	
3.56±0.26	1062	[31,34] CARROLL 80B	SPEC	E_{γ} >20 MeV

[31] CARROLL 80B quotes $B(\pi^{+}\pi^{-}\gamma)$ using normalization $B(\pi^{+}\pi^{-}\pi^{0})$ = 0.1239. We divide by this value to obtain their measured $\Gamma(\pi^{+}\pi^{-}\gamma)$ / $\Gamma(\pi^{+}\pi^{-}\pi^{0})$.

[32] Internal Bremsstrahlung component only.

[33] Direct γ emission component only.

[34] Both IB and DE components.

$\Gamma(\pi^{+}\pi^{-}\gamma)/\Gamma(\pi^{+}\pi^{-})$ Γ_{16}/Γ_{11}

VALUE (units 10^{-2})	*EVTS*	*DOCUMENT ID*	*TECN*	*COMMENT*
2.11±0.08 OUR FIT Error includes scale factor of 2.9.				
2.11±0.08 OUR AVERAGE Error includes scale factor of 2.9.				
2.08±0.02±0.02	8669	[35] ALAVI-HARATI 01B	KTEV	E^{*}_{γ} >20 MeV
2.30±0.07	3136	[36] RAMBERG 93	E731	E_{γ} >20 MeV

[35] ALAVI-HARATI 01B includes both Direct Emission (DE) and Inner Bremsstrahlung (IB) processes. They also report DE/(DE+IB)= 0.683 ± 0.011. The paper reports results for ρ propagator, linear, and quadratic form factors.

[36] RAMBERG 93 finds that fraction of Direct Emission (DE) decays with E_{γ} >20 MeV is 0.685 ± 0.041.

$\Gamma(\pi^0 2\gamma)/\Gamma_{\text{total}}$ Γ_{17}/Γ

VALUE (units 10^{-6})	*CL%*	*EVTS*	*DOCUMENT ID*	*TECN*	*COMMENT*
1.47±0.09 OUR AVERAGE	Error includes scale factor of 2.2. See the ideogram below.				
1.43±0.04±0.01		2.5k	[37] LAI 02B	NA48	
1.68±0.07±0.08		884	[38] ALAVI-HARATI 99B	KTEV	
1.7 ±0.2 ±0.2		63	[39] BARR 92	NA31	

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

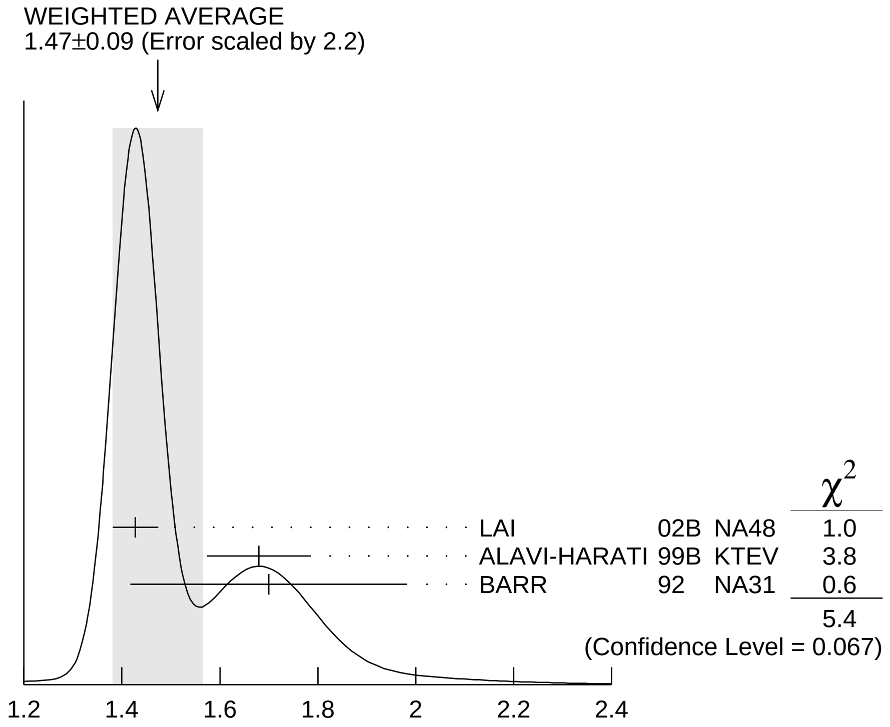
1.86±0.60±0.60		60	PAPADIMITR...91	E731	$m_{\gamma\gamma}$ > 280 MeV
<5.1	90		PAPADIMITR...91	E731	$m_{\gamma\gamma}$ < 264 MeV
2.1 ±0.6		14	[40] BARR 90C	NA31	$m_{\gamma\gamma}$ > 280 MeV

[37] LAI 02B reports $(1.36 \pm 0.03 \pm 0.03) \times 10^{-6}$ for $B(K^0_L \to \pi^0\pi^0) = 9.27 \times 10^{-4}$. We rescale to our best value $B(K^0_L \to \pi^0\pi^0) = (8.83 \pm 0.08) \times 10^{-4}$. Our first error is their experiment's error and our second error is the systematic error from using our best value. They also find that $B(\pi^0 2\gamma,\ m_{\gamma\gamma} < 110\ \text{MeV}) < 0.6 \times 10^{-8}$(90% CL).

[38] ALAVI-HARATI 99B finds that $\Gamma(\pi^0 2\gamma,\ m_{\gamma\gamma} < 240\ \text{MeV})) / \Gamma(\pi^0 2\gamma) = (17.3 \pm 1.3 \pm 1.5)\%$.

[39] BARR 92 find that $\Gamma(\pi^0 2\gamma,\ m_{\gamma\gamma} < 240\ \text{MeV})/\Gamma(\pi^0 2\gamma) < 0.09$ (90% CL).

[40] BARR 90C superseded by BARR 92.



$\Gamma(\pi^0 2\gamma)/\Gamma_{\text{total}}$ Γ_{17}/Γ

$\Gamma(\pi^0 \gamma e^+ e^-)/\Gamma_{\text{total}}$ Γ_{18}/Γ

VALUE (units 10^{-8})	*CL%*	*EVTS*	*DOCUMENT ID*	*TECN*
2.34±0.35±0.13		44	ALAVI-HARATI 01E	KTEV

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

<71	90	0	MURAKAMI 99	SPEC

Other modes with photons or $\ell\bar{\ell}$ pairs

$\Gamma(2\gamma)/\Gamma_{\text{total}}$ Γ_{19}/Γ

VALUE (units 10^{-4})	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
5.56±0.06 OUR FIT Error includes scale factor of 1.5.					
• • • We do not use the following data for averages, fits, limits, etc. • • •					
4.54±0.84		[41] BANNER	72B	OSPK	
4.5 ±1.0	23	ENSTROM	71	OSPK	K^0_L 1.5–9 GeV/c
5.0 ±1.0		[42] REPELLIN	71	OSPK	
5.5 ±1.1	90	KUNZ	68	OSPK	Norm.to 3 π(C+N)

[41] This value uses $(\eta_{00}/\eta_{+-})^2 = 1.05 \pm 0.14$. In general, $\Gamma(2\gamma)/\Gamma_{\text{total}} = [(4.32 \pm 0.55) \times 10^{-4}][(\eta_{00}/\eta_{+-})^2]$.

[42] Assumes regeneration amplitude in copper at 2 GeV is 22 mb. To evaluate for a given regeneration amplitude and error, multiply by (regeneration amplitude/22mb)^2.

$\Gamma(2\gamma)/\Gamma(3\pi^0)$ Γ_{19}/Γ_9

VALUE (units 10^{-3})	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
2.804±0.016 OUR FIT					
2.802±0.018 OUR AVERAGE					
2.79 ±0.02 ±0.02	27k	ADINOLFI	03	KLOE	
2.81 ±0.01 ±0.02		LAI	03	NA48	
• • • We do not use the following data for averages, fits, limits, etc. • • •					
2.13 ±0.43	28	BARMIN	71	HLBC	
2.24 ±0.28	115	BANNER	69	OSPK	
2.5 ±0.7	16	ARNOLD	68B	HLBC	Vacuum decay

$\Gamma(2\gamma)/\Gamma(\pi^0\pi^0)$ Γ_{19}/Γ_{12}

VALUE	*EVTS*	*DOCUMENT ID*		*TECN*
0.630±0.005 OUR FIT				
0.632±0.004±0.008	110k	BURKHARDT	87	NA31

$\Gamma(3\gamma)/\Gamma_{\text{total}}$ Γ_{20}/Γ

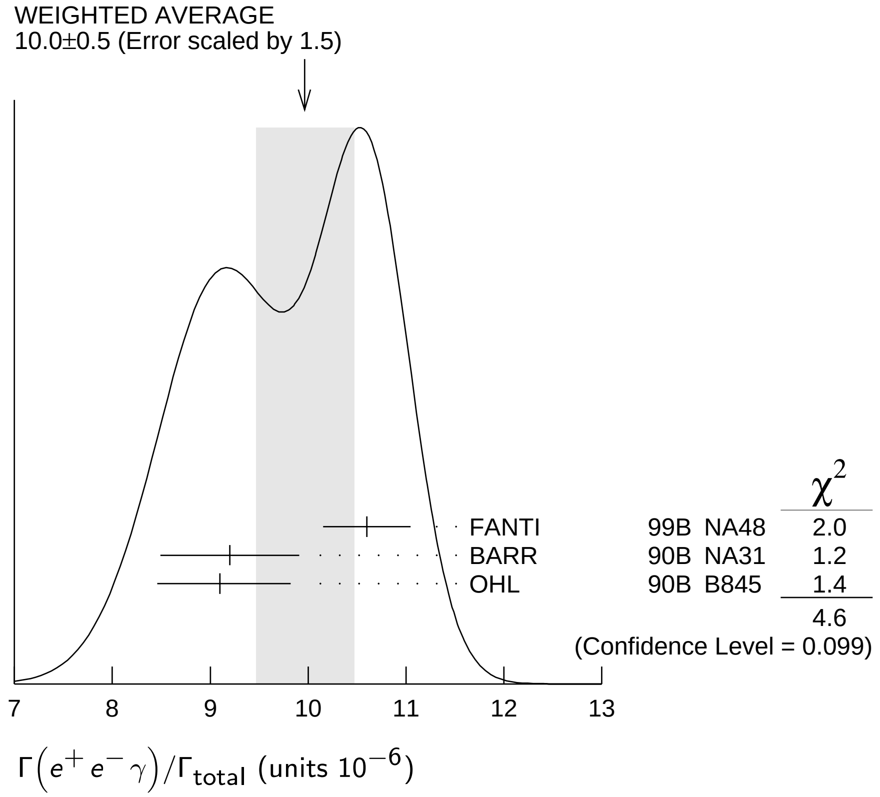
VALUE	*CL%*	*DOCUMENT ID*		*TECN*
$<2.4 \times 10^{-7}$	90	[43] BARR	95C	NA31

[43] Assumes a phase-space decay distribution.

$\Gamma(e^+e^-\gamma)/\Gamma_{\text{total}}$ Γ_{21}/Γ

VALUE (units 10^{-6})	*EVTS*	*DOCUMENT ID*		*TECN*
10.0±0.5 OUR AVERAGE Error includes scale factor of 1.5. See the ideogram below.				
10.6±0.2±0.4	6864	[44] FANTI	99B	NA48
9.2±0.5±0.5	1053	BARR	90B	NA31
$9.1 \pm 0.4^{+0.6}_{-0.5}$	919	OHL	90B	B845

[44] For FANTI 99B, the ±0.4 systematic error includes for uncertainties in the calculation, primarily uncertainties in the $\pi^0 \to e^+ e^- \gamma$ and $K^0_L \to \pi^0 \pi^0$ branching ratios, evaluated using our 1999 Web edition values.



$\Gamma(\mu^+ \mu^- \gamma)/\Gamma_{\rm total}$ Γ_{22}/Γ

VALUE (units 10^{-7})	*EVTS*	*DOCUMENT ID*		*TECN*
3.59±0.11 OUR AVERAGE	Error includes scale factor of 1.3.			
3.62±0.04±0.08	9100	ALAVI-HARATI	01G	KTEV
3.4 ±0.6 ±0.4	45	FANTI	97	NA48
3.23±0.23±0.19	197	SPENCER	95	E799

$\Gamma(e^+ e^- \gamma\gamma)/\Gamma_{\rm total}$ Γ_{23}/Γ

VALUE (units 10^{-7})	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
5.95±0.33 OUR AVERAGE					
5.84±0.15±0.32	1543	ALAVI-HARATI	01F	KTEV	E^*_γ >5 MeV
8.0 ±1.5 $^{+1.4}_{-1.2}$	40	SETZU	98	NA31	$E_\gamma > 5$ MeV
6.5 ±1.2 ±0.6	58	NAKAYA	94	E799	$E_\gamma > 5$ MeV
6.6 ±3.2		MORSE	92	B845	$E_\gamma > 5$ MeV

$\Gamma(\mu^+ \mu^- \gamma\gamma)/\Gamma_{\rm total}$ Γ_{24}/Γ

VALUE (units 10^{-9})	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
$10.4^{+7.5}_{-5.9}$±0.7	4	ALAVI-HARATI	00E	KTEV	$m_{\gamma\gamma} \geq 1$ MeV/c^2

Charge conjugation × Parity (CP) or Lepton Family number (LF) violating modes, or $\Delta S = 1$ weak neutral current ($S1$) modes

$\Gamma(\mu^+\mu^-)/\Gamma(\pi^+\pi^-)$ Γ_{25}/Γ_{11}

Test for $\Delta S = 1$ weak neutral current. Allowed by higher-order electroweak interaction.

VALUE (units 10^{-6})	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
3.48 ±0.05 OUR AVERAGE					
3.474±0.057	6210	AMBROSE	00	B871	
3.87 ±0.30	179	[45] AKAGI	95	SPEC	
3.38 ±0.17	707	HEINSON	95	B791	
• • • We do not use the following data for averages, fits, limits, etc. • • •					
3.9 ±0.3 ±0.1	178	[46] AKAGI	91B	SPEC	In AKAGI 95
3.45 ±0.18 ±0.13	368	[47] HEINSON	91	SPEC	In HEINSON 95
4.1 ±0.5	54	INAGAKI	89	SPEC	In AKAGI 91B
2.8 ±0.3 ±0.2	87	MATHIAZHA...	89B	SPEC	In HEINSON 91

[45] AKAGI 95 gives this number multiplied by the PDG 1992 average for $\Gamma(K^0_L \rightarrow \pi^+\pi^-)/\Gamma(\text{total})$.

[46] AKAGI 91B give this number multiplied by the 1990 PDG average for $\Gamma(K^0_L \rightarrow \pi^+\pi^-)/\Gamma(\text{total})$.

[47] HEINSON 91 give $\Gamma(K^0_L \rightarrow \mu\mu)/\Gamma_{\text{total}}$. We divide out the $\Gamma(K^0_L \rightarrow \pi^+\pi^-)/\Gamma_{\text{total}}$ PDG average which they used.

$\Gamma(e^+e^-)/\Gamma_{\text{total}}$ Γ_{26}/Γ

Test for $\Delta S = 1$ weak neutral current. Allowed by higher-order electroweak interaction.

VALUE (units 10^{-10})	*CL%*	*EVTS*	*DOCUMENT ID*		*TECN*
$0.087^{+0.057}_{-0.041}$		4	AMBROSE	98	B871
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<1.6	90	1	AKAGI	95	SPEC
<0.41	90	0	[48] ARISAKA	93B	B791

[48] ARISAKA 93B includes all events with <6 MeV radiated energy.

$\Gamma(\pi^+\pi^-e^+e^-)/\Gamma_{\text{total}}$ Γ_{27}/Γ

Test for $\Delta S = 1$ weak neutral current. Allowed by higher-order electroweak interaction.

VALUE (units 10^{-7})	*CL%*	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
3.11±0.19 OUR AVERAGE						
3.08±0.09±0.18		1125	[49] LAI	03C	NA48	
3.2 ±0.6 ±0.4		37	ADAMS	98	KTEV	
4.4 ±1.3 ±0.5		13	TAKEUCHI	98	SPEC	
• • • We do not use the following data for averages, fits, limits, etc. • • •						
<4.6	90		NOMURA	97	SPEC	$m_{ee} > 4$ MeV

[49] LAI 03C second error is 0.15(syst)±0.10(norm) combined in quadrature. The normalization uses $\text{BR}(K_L \rightarrow \pi^+\pi^-\pi^0) * \text{BR}(\pi^0 \rightarrow e^+e^-) = (1.505 \pm 0.047) \times 10^{-3}$ from our 2000 Edition.

$\Gamma(\pi^0\pi^0e^+e^-)/\Gamma_{\text{total}}$ Γ_{28}/Γ

Test for $\Delta S = 1$ weak neutral current. Allowed by higher-order electroweak interaction.

VALUE (units 10^{-9})	*CL%*	*EVTS*	*DOCUMENT ID*		*TECN*
<6.6	90	1	ALAVI-HARATI	02C	E799

$\Gamma(\mu^+\mu^-e^+e^-)/\Gamma_{\text{total}}$ Γ_{29}/Γ

Test for $\Delta S = 1$ weak neutral current. Allowed by higher-order electroweak interaction.

VALUE (units 10^{-9})	*CL%*	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
2.69±0.27 OUR AVERAGE						
2.69±0.24±0.12		131	[50] ALAVI-HARATI	03B	KTEV	
2.9 $^{+6.7}_{-2.4}$		1	GU	96	E799	
• • • We do not use the following data for averages, fits, limits, etc. • • •						
2.62±0.40±0.17		43	ALAVI-HARATI	01H	KTEV	Sup. by ALAVI-HARATI 03B
<4900	90		BALATS	83	SPEC	

[50] ALAVI-HARATI 03B also measures the linear slope $\alpha = -1.59 \pm 0.37$.

$\Gamma(e^+e^-e^+e^-)/\Gamma_{\text{total}}$ Γ_{30}/Γ

Test for $\Delta S = 1$ weak neutral current. Allowed by higher-order electroweak interaction.

VALUE (units 10^{-8})	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
3.72±0.27 OUR AVERAGE					
3.72±0.18±0.23	441	ALAVI-HARATI	01D	KTEV	
3.96±0.78±0.32	27	GU	94	E799	
3.07±1.25±0.26	6	VAGINS	93	B845	
• • • We do not use the following data for averages, fits, limits, etc. • • •					
6 ±2 ±1	18	[51] AKAGI	95	SPEC	m_{ee} >470 MeV
7 ±3 ±2	6	[51] AKAGI	95	SPEC	m_{ee} >470 MeV
10.4 ±3.7 ±1.1	8	[52] BARR	95	NA31	
6 ±2 ±1	18	AKAGI	93	CNTR	Sup. by AKAGI 95
4 ±3	2	BARR	91	NA31	Sup. by BARR 95

[51] Values are for the total branching fraction, acceptance-corrected for the m_{ee} cuts shown.

[52] Distribution of angles between two e^+e^- pair planes favors $CP=-1$ for K^0_L.

$\Gamma(\pi^0\mu^+\mu^-)/\Gamma_{\text{total}}$ Γ_{31}/Γ

Violates *CP* in leading order. Test for $\Delta S = 1$ weak neutral current. Allowed by higher-order electroweak interaction.

VALUE (units 10^{-9})	*CL%*	*EVTS*	*DOCUMENT ID*		*TECN*
<0.38	90		ALAVI-HARATI	00D	KTEV
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<5.1	90	0	HARRIS	93	E799

$\Gamma(\pi^0e^+e^-)/\Gamma_{\text{total}}$ Γ_{32}/Γ

Violates *CP* in leading order. Direct and indirect *CP*-violating contributions are expected to be comparable and to dominate the *CP*-conserving part. LAI 02B result suggests that *CP*-violation effects dominate. Test for $\Delta S = 1$ weak neutral current. Allowed by higher-order electroweak interaction.

VALUE (units 10^{-10})	*CL%*	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
< 2.8	90		[53] ALAVI-HARATI	04A	KTEV	combined result

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

< 3.5	90		ALAVI-HARATI 04A	KTEV	
$0.0047^{+0.0022}_{-0.0018}$			[54] LAI 02B	NA48	*CP*-conserving part
< 5.1	90	2	ALAVI-HARATI 01	KTEV	
0.01 to 0.02			ALAVI-HARATI 99B	KTEV	*CP*-conserving part
< 43	90	0	HARRIS 93B	E799	
< 75	90	0	BARKER 90	E731	
< 55	90	0	OHL 90	B845	
< 400	90		BARR 88	NA31	
< 3200	90		JASTRZEM... 88	SPEC	

[53] Combined result of ALAVI-HARATI 04A 1999-2000 data set and ALAVI-HARATI 01 1997 data set.

[54] LAI 02B uses the absence of a signal in $K^0_L \rightarrow \pi^0\gamma\gamma$ with $m(\gamma\gamma) < m(\pi^0)$ and their a_V value to predict this value.

$\Gamma(\pi^0 \nu\overline{\nu})/\Gamma_{\text{total}}$ Γ_{33}/Γ

Violates *CP* in leading order. Test of direct *CP* violation since the indirect *CP*-violating and *CP*-conserving contributions are expected to be suppressed. Test of $\Delta S = 1$ weak neutral current.

VALUE (units 10^{-5})	*CL%*	*EVTS*	*DOCUMENT ID*	*TECN*
$<$ 0.059	90	0	ALAVI-HARATI 00	KTEV

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

< 0.16	90	0	ADAMS 99	KTEV
< 5.8	90	0	WEAVER 94	E799
< 22	90	0	GRAHAM 92	CNTR

$\Gamma(e^{\pm}\mu^{\mp})/\Gamma_{\text{total}}$ Γ_{34}/Γ

Test of lepton family number conservation.

VALUE (units 10^{-11})	*CL%*	*EVTS*	*DOCUMENT ID*	*TECN*
$<$0.47	90		AMBROSE 98B	B871

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

< 9.4	90	0	AKAGI 95	SPEC
< 3.9	90	0	ARISAKA 93	B791
< 3.3	90	0	[55] ARISAKA 93	B791

[55] This is the combined result of ARISAKA 93 and MATHIAZHAGAN 89.

$\Gamma(e^{\pm}e^{\pm}\mu^{\mp}\mu^{\mp})/\Gamma_{\text{total}}$ Γ_{35}/Γ

Test of lepton family number conservation.

VALUE (units 10^{-11})	*CL%*	*EVTS*	*DOCUMENT ID*	*TECN*	*COMMENT*
$<$ 4.12	90	0	ALAVI-HARATI 03B	KTEV	

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

< 12.3	90	0	[56] ALAVI-HARATI 01H	KTEV	Sup. by ALAVI-HARATI 03B
< 610	90	0	[56] GU 96	E799	

[56] Assuming uniform phase space distribution.

$\Gamma(\pi^0 \mu^\pm e^\mp)/\Gamma_{\text{total}}$ Γ_{36}/Γ

Test of lepton family number conservation.

VALUE	*CL%*	*DOCUMENT ID*	*TECN*
$<6.2 \times 10^{-9}$	90	ARISAKA 98	E799

ENERGY DEPENDENCE OF K^0_L DALITZ PLOT

For discussion, see note on Dalitz plot parameters in the $K^\pm$ section of the Particle Listings above. For definitions of a_v, a_t, a_u, and a_y, see the earlier version of the same note in the 1982 edition of this *Review* published in Physics Letters **111B** 70 (1982).

$\left|\text{matrix element}\right|^2 = 1 + gu + hu^2 + jv + kv^2 + fuv$

where $u = (s_3 - s_0) \,/\, m^2_\pi$ and $v = (s_2 - s_1) \,/\, m^2_\pi$

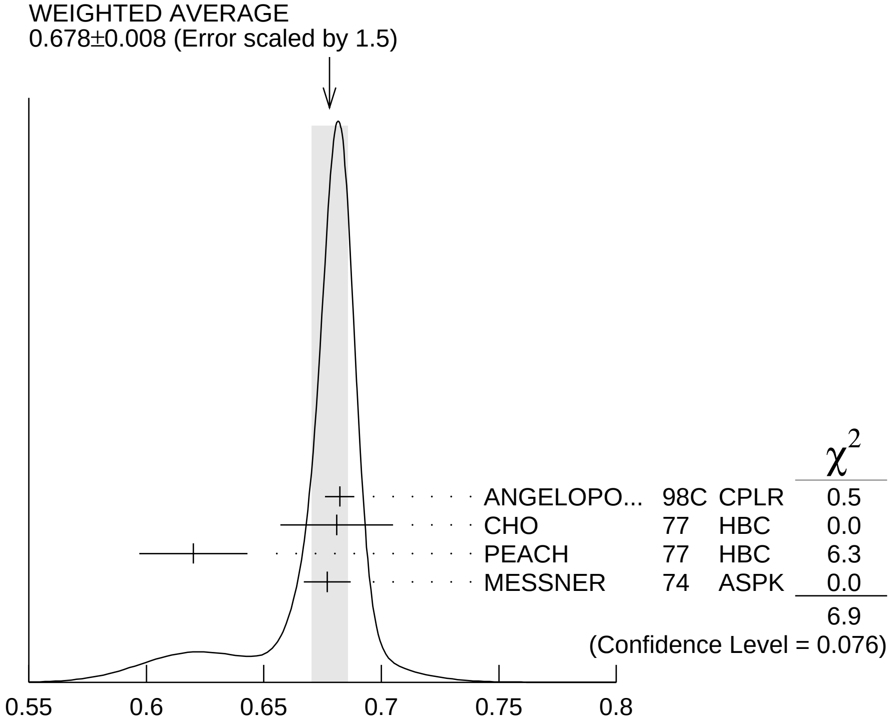
LINEAR COEFFICIENT g FOR $K^0_L \rightarrow \pi^+\pi^-\pi^0$

VALUE	*EVTS*	*DOCUMENT ID*	*TECN*	*COMMENT*
0.678 ±0.008 OUR AVERAGE	Error includes scale factor of 1.5. See the ideogram below.			
0.6823±0.0044±0.0044	500k	ANGELOPO... 98C	CPLR	
0.681 ±0.024	6499	CHO 77	HBC	
0.620 ±0.023	4709	PEACH 77	HBC	
0.677 ±0.010	509k	MESSNER 74	ASPK	$a_y = -0.917 \pm 0.013$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.69 ±0.07	192	[57] BALDO-... 75	HLBC	
0.590 ±0.022	56k	[57] BUCHANAN 75	SPEC	$a_u = -0.277 \pm 0.010$
0.619 ±0.027	20k	[57,58] BISI 74	ASPK	$a_t = -0.282 \pm 0.011$
0.612 ±0.032		[57] ALEXANDER 73B	HBC	
0.73 ±0.04	3200	[57] BRANDENB... 73	HBC	
0.608 ±0.043	1486	[57] KRENZ 72	HLBC	$a_t = -0.277 \pm 0.018$
0.650 ±0.012	29k	[57] ALBROW 70	ASPK	$a_y = -0.858 \pm 0.015$
0.593 ±0.022	36k	[57,59] BUCHANAN 70	SPEC	$a_u = -0.278 \pm 0.010$
0.664 ±0.056	4400	[57] SMITH 70	OSPK	$a_t = -0.306 \pm 0.024$
0.400 ±0.045	2446	[57] BASILE 68B	OSPK	$a_t = -0.188 \pm 0.020$
0.649 ±0.044	1350	[57] HOPKINS 67	HBC	$a_t = -0.294 \pm 0.018$
0.428 ±0.055	1198	[57] NEFKENS 67	OSPK	$a_u = -0.204 \pm 0.025$

[57] Quadratic dependence required by some experiments. (See sections on "QUADRATIC COEFFICIENT h" and "QUADRATIC COEFFICIENT k" below.) Correlations prevent us from averaging results of fits not including g, h, and k terms.

[58] BISI 74 value comes from quadratic fit with quad. term consistent with zero. g error is thus larger than if linear fit were used.

[59] BUCHANAN 70 result revised by BUCHANAN 75 to include radiative correlations and to use more reliable K^0_L momentum spectrum of second experiment (had same beam).



Linear coeff. g for $K_L^0 \to \pi^+\pi^-\pi^0$ matrix element squared

QUADRATIC COEFFICIENT h FOR $K_L^0 \to \pi^+\pi^-\pi^0$

VALUE	EVTS	DOCUMENT ID		TECN
0.076±0.006 OUR AVERAGE				
0.061±0.004±0.015	500k	ANGELOPO...	98C	CPLR
0.095±0.032	6499	CHO	77	HBC
0.048±0.036	4709	PEACH	77	HBC
0.079±0.007	509k	MESSNER	74	ASPK
• • • We do not use the following data for averages, fits, limits, etc. • • •				
−0.011±0.018	29k	[60] ALBROW	70	ASPK
0.043±0.052	4400	[60] SMITH	70	OSPK

See notes in section "LINEAR COEFFICIENT g FOR $K_L^0 \to \pi^+\pi^-\pi^0$ |MATRIX ELEMENT|^2" above.

[60] Quadratic coefficients h and k required by some experiments. (See section on "QUADRATIC COEFFICIENT k" below.) Correlations prevent us from averaging results of fits not including g, h, and k terms.

QUADRATIC COEFFICIENT k FOR $K_L^0 \to \pi^+\pi^-\pi^0$

VALUE	EVTS	DOCUMENT ID		TECN
0.0099±0.0015 OUR AVERAGE				
0.0104±0.0017±0.0024	500k	ANGELOPO...	98C	CPLR
0.024 ±0.010	6499	CHO	77	HBC
−0.008 ±0.012	4709	PEACH	77	HBC
0.0097±0.0018	509k	MESSNER	74	ASPK

LINEAR COEFFICIENT j FOR $K_L^0 \to \pi^+\pi^-\pi^0$ (*CP*-VIOLATING TERM)

Listed in *CP*-violation section below.

QUADRATIC COEFFICIENT f FOR $K_L^0 \to \pi^+\pi^-\pi^0$ (CP-VIOLATING TERM)

Listed in CP-violation section below.

QUADRATIC COEFFICIENT h FOR $K_L^0 \to \pi^0\pi^0\pi^0$

VALUE (units 10^{-3})	*EVTS*	*DOCUMENT ID*		*TECN*
−5.0±1.4 OUR AVERAGE	Error includes scale factor of 1.7.			
−6.1±0.9±0.5	14.7M	LAI	01B	NA48
−3.3±1.1±0.7	5M	[61] SOMALWAR	92	E731

[61] SOMALWAR 92 chose m_{π^+} as normalization to make it compatible with the Particle Data Group $K_L^0 \to \pi^+\pi^-\pi^0$ definitions.

K_L^0 FORM FACTORS

For discussion, see note on form factors in the $K^\pm$ section of the Particle Listings above.

In the form factor comments, the following symbols are used.

f_+ and f_- are form factors for the vector matrix element.

f_S and f_T refer to the scalar and tensor term.

$f_0 = f_+ + f_-\ t/(m^2_{K^0} - m^2_{\pi^+})$.

t = momentum transfer to the π.

λ_+ and λ_0 are the linear expansion coefficients of f_+ and f_0:

$f_+(t) = f_+(0)\ (1 + \lambda_+ t\ /m^2_{\pi^+})$

For quadratic expansion

$f_+(t) = f_+(0)\ (1 + \lambda'_+ t\ /m^2_{\pi^+} + \frac{\lambda''_\pm}{2}\ t^2/m^4_{\pi^+}\ )$

as used by KTeV. If there is a non-vanishing quadratic term, then λ_+ represents an average slope, which is then different from λ'_+.

NA48 and ISTRA quadratic expansion coefficients are converted with

$\lambda'_+{}^{PDG} = \lambda_+{}^{NA48}$ and $\lambda''_+{}^{PDG} = 2\ \lambda'_+{}^{NA48}$

$\lambda'_+{}^{PDG} = (\frac{m_{\pi^+}}{m_{\pi^0}})^2\ \lambda_+{}^{ISTRA}$ and

$\lambda''_+{}^{PDG} = 2\ (\frac{m_{\pi^+}}{m_{\pi^0}})^4\ \lambda'_+{}^{ISTRA}$

ISTRA linear expansion coefficients are converted with

$\lambda_+{}^{PDG} = (\frac{m_{\pi^+}}{m_{\pi^0}})^2\ \lambda_+{}^{ISTRA}$ and $\lambda_0{}^{PDG} = (\frac{m_{\pi^+}}{m_{\pi^0}})^2\ \lambda_0{}^{ISTRA}$

DP = Dalitz plot analysis.

PI = π spectrum analysis.

MU = μ spectrum analysis.

POL= μ polarization analysis.

BR = $K^0_{\mu 3}/K^0_{e3}$ branching ratio analysis.

E = positron or electron spectrum analysis.

RC = radiative corrections.

λ_+ (LINEAR ENERGY DEPENDENCE OF f_+ IN K^0_{e3} DECAY)

For radiative correction of K^0_{e3} DP, see GINSBERG 67, BECHERRAWY 70, CIRIGLIANO 02, CIRIGLIANO 04, and ANDRE 04. Results labeled OUR FIT are discussed in the review "$K^{\pm}_{\ell 3}$ and $K^0_{\ell 3}$ Form Factors" in the $K^{\pm}$ Listings.

VALUE (units 10^{-2})	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
2.82 ±0.09 OUR FIT	Error includes scale factor of 2.1. Assumes μ-e universality.				
2.84 ±0.05 OUR AVERAGE					
2.832±0.037±0.043	1.9M	ALEXOPOU...	04A	KTEV	PI, no $\mu = e$
2.88 ±0.04 ±0.11	5.6M	[62] LAI	04C	NA48	DP
2.45 ±0.12 ±0.22	366k	APOSTOLA...	00	CPLR	DP
3.06 ±0.34	74k	BIRULEV	81	SPEC	DP
3.12 ±0.25	500k	GJESDAL	76	SPEC	DP
2.70 ±0.28	25k	BLUMENTHAL	75	SPEC	DP
• • • We do not use the following data for averages, fits, limits, etc. • • •					
2.84 ±0.07 ±0.13	5.6M	[63] LAI	04C	NA48	DP
2.9 ±0.5	19k	[64] CHO	80	HBC	DP
2.5 ±0.5	12k	[64] ENGLER	78B	HBC	DP
3.48 ±0.44	18k	HILL	78	STRC	DP
4.4 ±0.6	24k	BUCHANAN	75	SPEC	DP
4.0 ±1.2	2171	WANG	74	OSPK	DP
4.5 ±1.4	5600	ALBROW	73	ASPK	DP
1.9 ±1.3	1871	BRANDENB...	73	HBC	PI transv.
2.2 ±1.4	1910	NEUHOFER	72	ASPK	PI
2.3 ±0.5	42k	BISI	71	ASPK	DP
5. ±1.	16k	CHIEN	71	ASPK	DP, no RC
2. ±1.3	1000	ARONSON	68	OSPK	PI
+2.3 ±1.2	4800	BASILE	68	OSPK	DP, no RC

[62] Results from linear fit and assuming only vector and axial couplings.

[63] Results from linear fit with $|f_S/f_+|$ and $|f_T/f_+|$ free.

[64] ENGLER 78B uses an unique K_{e3} subset of CHO 80 events and is less subject to systematic effects.

λ'_+(LINEAR K^0_{e3} FORM FACTOR FROM QUADRATIC FIT)

VALUE (units 10^{-2})	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
2.42 ±0.31 OUR AVERAGE	Error includes scale factor of 2.0.				
2.167±0.137±0.143	1.9M	ALEXOPOU...	04A	KTEV	PI, no $\mu = e$
2.80 ±0.19 ±0.15	5.6M	LAI	04C	NA48	DP

λ''_+(QUADRATIC K^0_{e3} FORM FACTOR)

VALUE (units 10^{-2})	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
0.18 ±0.12 OUR AVERAGE	Error includes scale factor of 2.1.				
0.287±0.057±0.053	1.9M	ALEXOPOU...	04A	KTEV	PI, no $\mu = e$
0.04 ±0.08 ±0.04	5.6M	[65] LAI	04C	NA48	DP

[65] Values doubled to agree with PDG conventions described above.

λ_+ (LINEAR ENERGY DEPENDENCE OF f_+ IN $K^0_{\mu 3}$ DECAY)

See also the corresponding entries and notes in section "$\xi_A = f_-/f_+$" above and section "λ_0 (LINEAR ENERGY DEPENDENCE OF f_0 IN $K^0_{\mu 3}$ DECAY)" below. For radiative correction of $K^0_{\mu 3}$ Dalitz plot see GINSBERG 70 and BECHERRAWY 70. Results labeled OUR FIT are discussed in the review "$K^{\pm}_{\ell 3}$ and $K^0_{\ell 3}$ Form Factors" in the $K^{\pm}$ Listings.

VALUE (units 10^{-2})	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
2.82 ±0.09 OUR FIT					Error includes scale factor of 2.1. Assumes μ-e universality.
2.82 ±0.24 OUR FIT					Error includes scale factor of 2.5.
2.745±0.088±0.063	1.5M	ALEXOPOU...	04A	KTEV	DP, no $\mu = e$
2.813±0.051	3.4M	ALEXOPOU...	04A	KTEV	PI, DP, $\mu = e$
4.27 ±0.44	150k	BIRULEV	81	SPEC	DP
2.8 ±1.0	14k	CHO	80	HBC	DP
2.8 ±1.1	16k	HILL	79	STRC	DP
4.6 ±3.0	32k	BUCHANAN	75	SPEC	DP
3.0 ±0.3	1.6M	DONALDSON	74B	SPEC	DP

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

3.37 ±0.33	129k	DZHORD...	77	SPEC	Repl. by BIRULEV 81
4.6 ±0.8	82k	ALBRECHT	74	WIRE	Repl. by BIRULEV 81
8.5 ±1.5	9086	ALBROW	72	ASPK	DP
11. ±4.	16k	DALLY	72	ASPK	DP
7. ±2.	16k	CHIEN	70	ASPK	Repl. by DALLY 72

λ'_+(LINEAR $K^0_{\mu 3}$ FORM FACTOR FROM QUADRATIC FIT)

VALUE (units 10^{-2})	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
1.703±0.319±0.177	1.5M	ALEXOPOU...	04A	KTEV	DP, no $\mu = e$
2.064±0.175	3.4M	ALEXOPOU...	04A	KTEV	PI, DP, $\mu = e$

λ''_+(QUADRATIC $K^0_{\mu 3}$ FORM FACTOR)

VALUE (units 10^{-2})	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
0.443±0.131±0.072	1.5M	ALEXOPOU...	04A	KTEV	DP, no $\mu = e$
0.320±0.069	3.4M	ALEXOPOU...	04A	KTEV	PI, DP, $\mu = e$

λ_0 (LINEAR ENERGY DEPENDENCE OF f_0 IN $K^0_{\mu 3}$ DECAY)

Wherever possible, we have converted the above values of $\xi(0)$ into values of λ_0 using the associated λ^{μ}_+ and $d\xi(0)/d\lambda_+$. Results labeled OUR FIT are discussed in the review "$K^{\pm}_{\ell 3}$ and $K^0_{\ell 3}$ Form Factors" in the $K^{\pm}$ Listings.

VALUE (units 10^{-2})	*$d\lambda_0/d\lambda_+$*	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
1.79 ± 0.22 OUR FIT						Error includes scale factor of 2.1. Correlation is $d\lambda_0/d\lambda_+ = -0.72$. Assumes μ-e universality.
1.80 ± 0.28 OUR FIT						Error includes scale factor of 2.5. Correlation is $d\lambda_0/d\lambda_+ = -0.39$.
1.8 ± 0.8	0.06		KL3FIT	05	RVUE	$\lambda_+ = 0.030$
1.657± 0.125	−0.44	1.5M	[66] ALEXOPOU...	04A	KTEV	DP, no $\mu = e$

1.635 ± 0.121	−0.85	3.4M	[66] ALEXOPOU...	04A	KTEV	PI, DP, $\mu = e$
3.41 ± 0.67	unknown	150k	[67] BIRULEV	81	SPEC	DP
+5.0 ± 0.8	−0.11	14k	CHO	80	HBC	DP
+3.9 ± 1.0	−0.67	16k	HILL	79	STRC	DP
+4.7 ± 0.9	1.06	207k	[68] CLARK	77	SPEC	POL
+2.5 ± 1.9	+0.5	32k	[69] BUCHANAN	75	SPEC	DP
+1.9 ± 0.4	−0.47	1.6M	[70] DONALDSON	74B	SPEC	DP
−1.8 ± 0.9	+0.49	2.2M	[68] SANDWEISS	73	CNTR	POL

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

4.1 ± 0.8		14k	[71] CHO	80	HBC	BR, λ_+=0.028
+4.85 ± 0.76		47k	DZHORD...	77	SPEC	In BIRULEV 81
+2.4 ± 1.1		82k	ALBRECHT	74	WIRE	In BIRULEV 81
+6. ± 3.		6700	[72] BRANDENB...	73	HBC	BR, λ_+=0.019 ± 0.013
−6.0 ± 3.8	−0.71	1385	[73] PEACH	73	HLBC	DP
−4.3 ± 5.2	−1.39	9086	[74] ALBROW	72	ASPK	DP
−6.7 ± 22.7	unknown	16k	[75] DALLY	72	ASPK	DP
−33.3 ± 3.4	+1.	3140	[76] BASILE	70	OSPK	DP
$-14.0^{+4.3}_{-2.2}$	+0.49		[68] LONGO	69	CNTR	POL
+8. ± 7.	−0.54	1371	[68] CARPENTER	66	OSPK	DP

[66] ALEXOPOULOS 04A slopes are calculated from their Table III.

[67] BIRULEV 81 gives $d\lambda_0/d\lambda_+ = -1.5$, giving an unreasonably narrow error ellipse which dominates all other results. We use $d\lambda_0/d\lambda_+ = 0$.

[68] λ_0 value is for $\lambda_+ = 0.03$ calculated by us from $\xi(0)$ and $d\xi(0)/d\lambda_+$.

[69] BUCHANAN 75 value is from their appendix A and uses only $K_{\mu 3}$ data. $d\lambda_0/d\lambda_+$ was obtained by private communication, C.Buchanan, 1976.

[70] DONALDSON 74B $d\lambda_0/d\lambda_+$ obtained from figure 18.

[71] CHO 80 BR result not independent of their Dalitz plot result.

[72] Fit for λ_0 does not include this value but instead includes the $K_{\mu 3}/K_{e3}$ result from this experiment.

[73] PEACH 73 assumes $\lambda_+ = 0.025$. Calculated by us from $\xi(0)$ and $d\xi(0)/d\lambda_+$.

[74] ALBROW 72 λ_0 is calculated by us from ξ_A, λ_+ and $d\xi(0)/d\lambda_+$. They give $\lambda_0 = -0.043 \pm 0.039$ for $\lambda_- = 0$. We use our larger calculated error.

[75] DALLY 72 gives $f_0 = 1.20 \pm 0.35$, $\lambda_0 = -0.080 \pm 0.272$, $\lambda_0{}' = -0.006 \pm 0.045$, but with a different definition of λ_0. Our quoted λ_0 is his λ_0/f_0. We cannot calculate true λ_0 error without his (λ_0, f_0) correlations. See also note on DALLY 72 in section ξ_A.

[76] BASILE 70 λ_0 is for $\lambda_+ = 0$. Calculated by us from ξ_A with $d\xi(0)/d\lambda_+ = 0$. BASILE 70 is incompatible with all other results. Authors suggest that efficiency estimates might be responsible.

λ_0(LINEAR f_0 $K^0_{\mu 3}$ FORM FACTOR FROM QUADRATIC FIT)

VALUE (units 10^{-2})	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
1.281±0.136±0.122	1.5M	ALEXOPOU...	04A	KTEV	DP, no $\mu = e$
1.372±0.131	3.4M	ALEXOPOU...	04A	KTEV	PI, DP, $\mu = e$

$|f_S/f_+|$ FOR K^0_{e3} DECAY

Ratio of scalar to f_+ couplings.

VALUE (units 10^{-2})	*CL%*	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
$\mathbf{1.5^{+0.7}_{-1.0}\pm1.2}$		5.6M	[77] LAI	04C	NA48	

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

$<$ 9.5	95	18k	HILL	78	STRC	
$<$ 7.	68	48k	BIRULEV	76	SPEC	See also BIRULEV 81
$<$ 4.	68	25k	BLUMENTHAL	75	SPEC	
$<$19.	95	5600	ALBROW	73	ASPK	
$<$15.	68		KULYUKINA	67	CC	

[77] Results from linear fit with $|f_S/f_+|$ and $|f_T/f_+|$ free.

$|f_T/f_+|$ FOR K^0_{e3} DECAY

Ratio of tensor to f_+ couplings.

VALUE (units 10^{-2})	*CL%*	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
$\mathbf{5^{+3}_{-4}\pm3}$		5.6M	[78] LAI	04C	NA48	

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

$<$ 40.	95	18k	HILL	78	STRC	
$<$ 34.	68	48k	BIRULEV	76	SPEC	See also BIRULEV 81
$<$ 23.	68	25k	BLUMENTHAL	75	SPEC	
$<$100.	95	5600	ALBROW	73	ASPK	
$<$100.	68		KULYUKINA	67	CC	

[78] Results from linear fit with $|f_S/f_+|$ and $|f_T/f_+|$ free.

$|f_T/f_+|$ FOR $K^0_{\mu3}$ DECAY

Ratio of tensor to f_+ couplings.

VALUE (units 10^{-2})	*DOCUMENT ID*		*TECN*
12.±12.	BIRULEV	81	SPEC

M^e_V (POLE MASS FOR K^0_{e3} DECAY)

VALUE (MeV)	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
878 ± 8 OUR AVERAGE	Error includes scale factor of 1.1.				
881.03± 5.12±4.94	1.9M	ALEXOPOU...	04A	KTEV	PI, no $\mu = e$
859 ±18	5.6M	LAI	04C	NA48	

M^μ_V (POLE MASS FOR $K^0_{\mu3}$ DECAY)

VALUE (MeV)	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
889.19±12.81±9.92	1.5M	ALEXOPOU...	04A	KTEV	DP, no $\mu = e$
882.32± 6.54	3.4M	ALEXOPOU...	04A	KTEV	PI, DP, $\mu = e$

M^μ_S (POLE MASS FOR $K^0_{\mu3}$ DECAY)

VALUE (MeV)	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
1167.14±28.30±31.04	1.5M	ALEXOPOU...	04A	KTEV	PI, no $\mu = e$
1173.80±39.47	3.4M	ALEXOPOU...	04A	KTEV	PI, DP, $\mu = e$

α_{K^*} DECAY FORM FACTOR FOR $K_L \rightarrow e^+ e^- \gamma$

α_{K^*} is the constant in the model of BERGSTROM 83 which measures the relative strength of the vector-vector transition $K_L \rightarrow K^* \gamma$ with $K^* \rightarrow \rho, \omega, \phi \rightarrow \gamma^*$ and the pseudoscalar-pseudoscalar transition $K_L \rightarrow \pi, \eta, \eta' \rightarrow \gamma\gamma^*$.

VALUE	*EVTS*	*DOCUMENT ID*	*TECN*
−0.33 ±0.05 OUR AVERAGE			
$-0.36 \pm 0.06 \pm 0.02$	6864	FANTI 99B	NA48
-0.28 ± 0.13		BARR 90B	NA31
$-0.280^{+0.099}_{-0.090}$		OHL 90B	B845

α_{K^*} DECAY FORM FACTOR FOR $K_L \rightarrow \mu^+ \mu^- \gamma$

α_{K^*} is the constant in the model of BERGSTROM 83 described in the previous section.

VALUE	*EVTS*	*DOCUMENT ID*	*TECN*
−0.158±0.027 OUR AVERAGE			
$-0.160^{+0.026}_{-0.028}$	9100	ALAVI-HARATI 01G	KTEV
$-0.04\ ^{+0.24}_{-0.21}$		FANTI 97	NA48

$\alpha^{\text{eff}}_{K^*}$ DECAY FORM FACTOR FOR $K_L \rightarrow e^+ e^- e^+ e^-$

$\alpha^{\text{eff}}_{K^*}$ is the parameter describing the relative strength of an intermediate pseudoscalar decay amplitude and a vector meson decay amplitude in the model of BERGSTROM 83. It takes into account both the radiative effects and the form factor. Since there are two $e^+ e^-$ pairs here compared with one in $e^+ e^- \gamma$ decays, a factorized expression is used for the $e^+ e^- e^+ e^-$ decay form factor.

VALUE	*EVTS*	*DOCUMENT ID*	*TECN*
−0.14±0.16±0.15	441	ALAVI-HARATI 01D	KTEV

a_1/a_2 FORM FACTOR FOR M1 DIRECT EMISSION AMPLITUDE

Form factor $= \tilde{g}_{M1}\left[1 + \frac{a_1/a_2}{(M^2_\rho - M^2_K) + 2M_K E^*_\gamma}\right]$ as described in ALAVI-HARATI 00B.

VALUE (GeV^2)	*EVTS*	*DOCUMENT ID*	*TECN*	*COMMENT*
−0.734±0.022 OUR AVERAGE				
$-0.81\ ^{+0.07}_{-0.13} \pm 0.02$		[79] LAI 03C	NA48	$\pi^+ \pi^- e^+ e^-$
$-0.737 \pm 0.026 \pm 0.022$		[80] ALAVI-HARATI 01B		$\pi^+ \pi^- \gamma$
$-0.720 \pm 0.028 \pm 0.009$	1766	[81] ALAVI-HARATI 00B	KTEV	$\pi^+ \pi^- e^+ e^-$

[79] LAI 03C also measured $\tilde{g}_{M1} = 0.99^{+0.28}_{-0.27} \pm 0.07$.

[80] ALAVI-HARATI 01B fit gives χ^2/DOF = 38.8/27. Linear and quadratic fits give χ^2/DOF = 43.2/27 and 37.6/26 respectively.

[81] ALAVI-HARATI 00B also measured $\tilde{g}_{M1} = 1.35^{+0.20}_{-0.17} \pm 0.04$.

$\overline{f}_S$ DECAY FORM FACTOR FOR $K^0_L \rightarrow \pi^\pm \pi^0 e^\mp \nu_e$

VALUE	*DOCUMENT ID*	*TECN*
0.049±0.011 OUR AVERAGE Error includes scale factor of 1.7.		
$0.052 \pm 0.006 \pm 0.002$	BATLEY 04	NA48
$0.010 \pm 0.016 \pm 0.017$	MAKOFF 93	E731

$\overline{f}_P$ DECAY FORM FACTOR FOR $K^0_L \to \pi^\pm \pi^0 e^\mp \nu_e$

VALUE	*DOCUMENT ID*		*TECN*
−0.052±0.012 OUR AVERAGE			
−0.051±0.011±0.005	BATLEY	04	NA48
−0.079±0.049±0.022	MAKOFF	93	E731

λ_g DECAY FORM FACTOR FOR $K^0_L \to \pi^\pm \pi^0 e^\mp \nu_e$

VALUE	*DOCUMENT ID*		*TECN*
0.085±0.020 OUR AVERAGE			
0.087±0.019±0.006	BATLEY	04	NA48
0.014±0.087±0.070	MAKOFF	93	E731

$\overline{h}$ DECAY FORM FACTOR FOR $K^0_L \to \pi^\pm \pi^0 e^\mp \nu_e$

VALUE	*DOCUMENT ID*		*TECN*
−0.30±0.13 OUR AVERAGE			
−0.32±0.12±0.07	BATLEY	04	NA48
−0.07±0.31±0.31	MAKOFF	93	E731

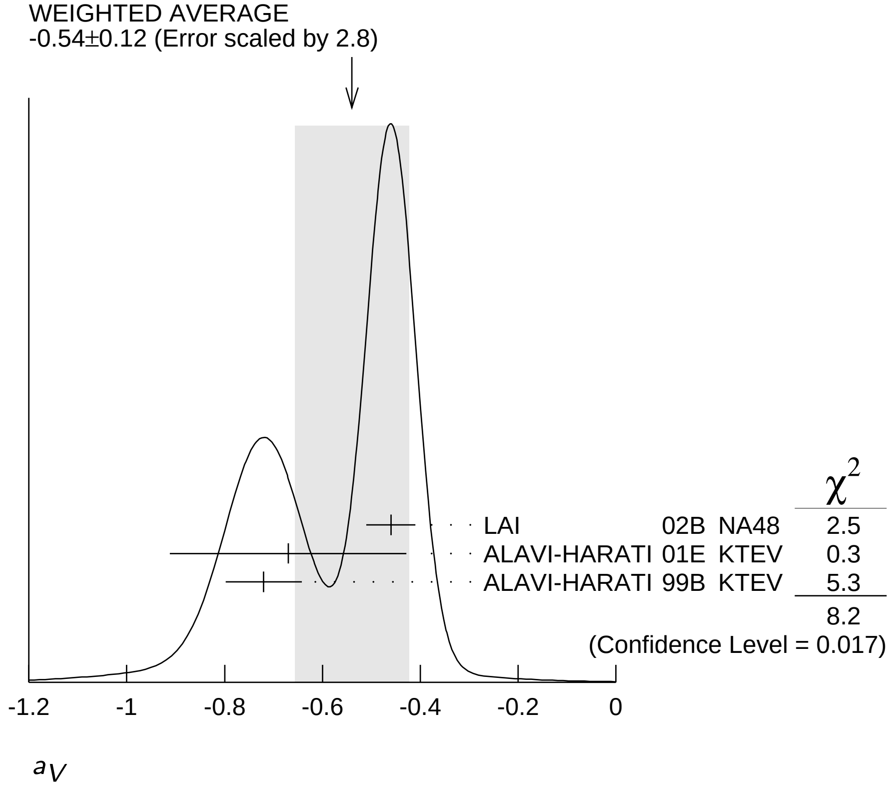
L_3 CHIRAL PERT. THEO. PARAM. FOR $K^0_L \to \pi^\pm \pi^0 e^\mp \nu_e$

VALUE (units 10^{-3})	*DOCUMENT ID*		*TECN*
−3.96±0.28 OUR AVERAGE	Error includes scale factor of 1.6.		
−4.1 ±0.2	BATLEY	04	NA48
−3.4 ±0.4	[82] MAKOFF	93	E731

[82] MAKOFF 93 sign has been changed to negative to agree with the sign convention used in BATLEY 04.

a_V, VECTOR MESON EXCHANGE CONTRIBUTION

VALUE	*DOCUMENT ID*		*TECN*	*COMMENT*
−0.54±0.12 OUR AVERAGE	Error includes scale factor of 2.8.			See the ideogram below.
−0.46±0.03±0.04	LAI	02B	NA48	$K^0_L \to \pi^0 2\gamma$
−0.67±0.21±0.12	ALAVI-HARATI	01E	KTEV	$K^0_L \to \pi^0 e^+ e^- \gamma$
−0.72±0.05±0.06	ALAVI-HARATI	99B	KTEV	$K^0_L \to \pi^0 2\gamma$



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CP-VIOLATION PARAMETERS IN K^0_L DECAYS

CHARGE ASYMMETRY IN $K^0_{\ell 3}$ DECAYS

Such asymmetry violates CP. It is related to Re(ϵ).

δ_L = weighted average of $\delta_L(\mu)$ and $\delta_L(e)$

VALUE (%)	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
0.332±0.006 OUR AVERAGE	Includes data from the 2 datablocks that follow this one.				
0.333±0.050	33M	WILLIAMS	73	ASPK	$K_{\mu 3}$ + K_{e3}

$\delta_L(\mu) = [\Gamma(\pi^-\mu^+\nu_\mu) - \Gamma(\pi^+\mu^-\overline{\nu}_\mu)]$/SUM

Only the combined value below is put into the Meson Summary Table.

VALUE (%)	*EVTS*	*DOCUMENT ID*		*TECN*
The data in this block is included in the average printed for a previous datablock.				
0.304±0.025 OUR AVERAGE				
0.313±0.029	15M	GEWENIGER	74	ASPK
0.278±0.051	7.7M	PICCIONI	72	ASPK
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.60 ±0.14	4.1M	MCCARTHY	73	CNTR
0.57 ±0.17	1M	[83] PACIOTTI	69	OSPK
0.403±0.134	1M	[83] DORFAN	67	OSPK

[83] PACIOTTI 69 is a reanalysis of DORFAN 67 and is corrected for $\mu^+\mu^-$ range difference in MCCARTHY 72.

$\delta_L(e) = [\Gamma(\pi^- e^+ \nu_e) - \Gamma(\pi^+ e^- \overline{\nu}_e)]/\text{SUM}$

Only the combined value below is put into the Meson Summary Table.

VALUE (%)	*EVTS*	*DOCUMENT ID*	*TECN*
The data in this block is included in the average printed for a previous datablock.			
0.334 ±0.007 OUR AVERAGE			
0.3322±0.0058±0.0047	298M	ALAVI-HARATI 02	
0.341 ±0.018	34M	GEWENIGER 74	ASPK
0.318 ±0.038	40M	FITCH 73	ASPK
0.346 ±0.033	10M	MARX 70	CNTR
• • • We do not use the following data for averages, fits, limits, etc. • • •			
0.36 ±0.18	600k	ASHFORD 72	ASPK
0.246 ±0.059	10M	[84] SAAL 69	CNTR
0.224 ±0.036	10M	[84] BENNETT 67	CNTR

[84] SAAL 69 is a reanalysis of BENNETT 67.

PARAMETERS FOR $K^0_L \rightarrow 2\pi$ DECAY

$$\eta_{+-} = \mathrm{A}(K^0_L \rightarrow \pi^+\pi^-) \;/\; \mathrm{A}(K^0_S \rightarrow \pi^+\pi^-)$$
$$\eta_{00} = \mathrm{A}(K^0_L \rightarrow \pi^0\pi^0) \;/\; \mathrm{A}(K^0_S \rightarrow \pi^0\pi^0)$$

The fitted values of $|\eta_{+-}|$ and $|\eta_{00}|$ given below are the results of a fit to $|\eta_{+-}|$, $|\eta_{00}|$, $|\eta_{00}/\eta_{+-}|$, and Re(ϵ'/ϵ). Independent information on $|\eta_{+-}|$ and $|\eta_{00}|$ can be obtained from the fitted values of the $K^0_L \rightarrow \pi\pi$ and $K^0_S \rightarrow \pi\pi$ branching ratios and the K^0_L and K^0_S lifetimes. This information is included as data in the $|\eta_{+-}|$ and $|\eta_{00}|$ sections with a Document ID "BRFIT." See the note "*CP* violation in K_L decays" above for details.

$|\eta_{00}| = |\mathrm{A}(K^0_L \rightarrow 2\pi^0) \;/\; \mathrm{A}(K^0_S \rightarrow 2\pi^0)|$

VALUE (units 10^{-3})	*DOCUMENT ID*	*TECN*	*COMMENT*
2.226±0.015 OUR FIT Error includes scale factor of 1.4.			
2.232±0.025	[85] BRFIT 05		S = 1.7
• • • We do not use the following data for averages, fits, limits, etc. • • •			
2.47 ±0.31 ±0.24	ANGELOPO... 98	CPLR	
2.49 ±0.40	[86] ADLER 96B	CPLR	Sup. by ANGELOPOULOS 98
2.33 ±0.18	CHRISTENS... 79	ASPK	
2.71 ±0.37	[87] WOLFF 71	OSPK	Cu reg., 4γ's
2.95 ±0.63	[87] CHOLLET 70	OSPK	Cu reg., 4γ's

[85] BRFIT 05 error is scaled up by a factor S to account for disagreements among the $K_L \rightarrow \pi\pi$ branching ratio measurements.

[86] Error is statistical only.

[87] CHOLLET 70 gives $|\eta_{00}| = (1.23 \pm 0.24)\times$(regeneration amplitude, 2 GeV/c Cu)/10000mb. WOLFF 71 gives $|\eta_{00}| = (1.13 \pm 0.12)\times$(regeneration amplitude, 2 GeV/c Cu)/10000mb. We compute both $|\eta_{00}|$ values for (regeneration amplitude, 2 GeV/c Cu) = 24 ± 2mb. This regeneration amplitude results from averaging over FAISSNER 69, extrapolated using optical-model calculations of Bohm et al., Physics Letters **27B** 594 (1968) and the data of BALATS 71. (From H. Faissner, private communication).

$|\eta_{+-}| = |A(K^0_L \to \pi^+\pi^-) \,/\, A(K^0_S \to \pi^+\pi^-)|$

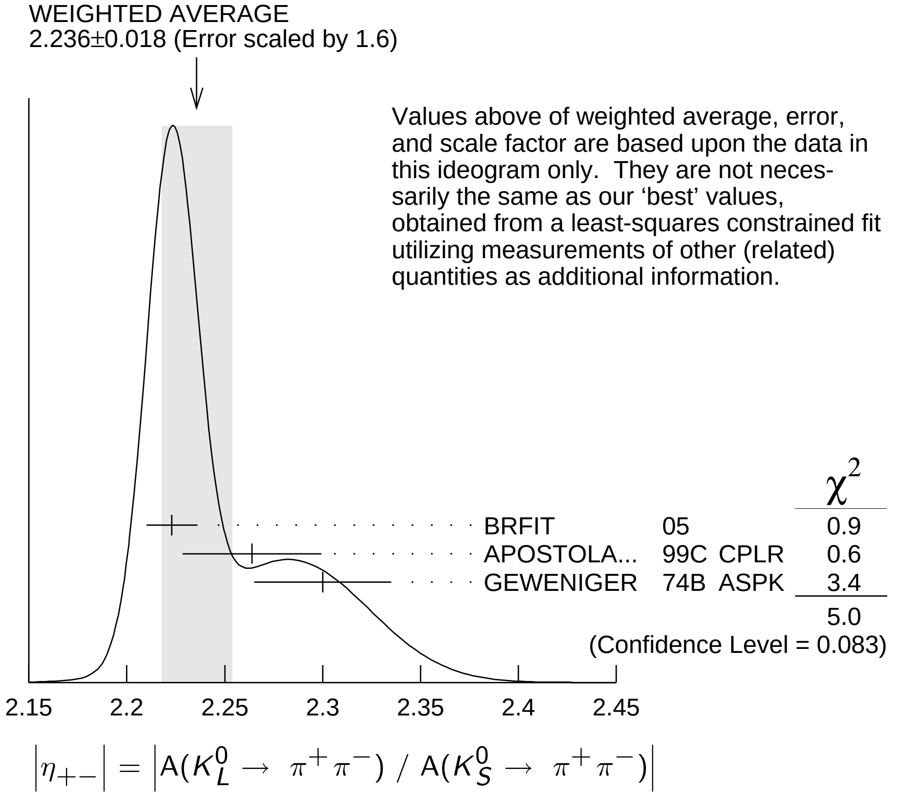
VALUE (units 10^{-3})	*EVTS*	*DOCUMENT ID*	*TECN*	*COMMENT*
2.237±0.015 OUR FIT Error includes scale factor of 1.4.				
2.236±0.018 OUR AVERAGE Error includes scale factor of 1.6. See the ideogram below.				
2.223±0.013		[88] BRFIT 05		S = 1.2
2.264±0.023±0.027	70M	[89] APOSTOLA... 99C	CPLR	K^0-$\overline{K}^0$ asymmetry
2.30 ±0.035		GEWENIGER 74B	ASPK	
• • • We do not use the following data for averages, fits, limits, etc. • • •				
2.228±0.010		[90] ALEXOPOU... 04	KTEV	
2.310±0.043±0.031		[91] ADLER 95B	CPLR	K^0-$\overline{K}^0$ asymmetry
2.32 ±0.14 ±0.03	10^5	ADLER 92B	CPLR	K^0-$\overline{K}^0$ asymmetry

[88] BRFIT 05 error is scaled up by a factor S to account for disagreements among the $K_L \to \pi\pi$ branching ratio measurements.

[89] APOSTOLAKIS 99C report $(2.264 \pm 0.023 \pm 0.026 + 9.1[\tau_S - 0.8934]) \times 10^{-3}$. We evaluate for our 1998 best value $\tau_S = (0.8934 \pm 0.0008) \times 10^{-10}$ s.

[90] ALEXOPOULOS 04 $|\eta_{+-}|$ uses their $K^0_L \to \pi\pi$ branching fractions, $\tau_S = (0.8963 \pm 0.0005) \times 10^{-10}$ s from the average of KTeV and NA48 τ_S measurements, and assumes that $\Gamma(K^0_S \to \pi \ell \nu_\ell) = \Gamma(K^0_L \to \pi \ell \nu_\ell)$ giving $B(K^0_S \to \pi \ell \nu_\ell) = 0.118\%$. Their η_{+-} is not directly used in our fit, but enters our fit via their branching ratio measurements.

[91] ADLER 95B report $(2.312 \pm 0.043 \pm 0.030 - 1[\Delta m - 0.5274] + 9.1[\tau_S - 0.8926]) \times 10^{-3}$. We evaluate for our 1996 best values $\Delta m = (0.5304 \pm 0.0014) \times 10^{-10}\ \hbar \mathrm{s}^{-1}$ and $\tau_S = (0.8927 \pm 0.0009) \times 10^{-10}$ s. Superseded by APOSTOLAKIS 99C.



Values above of weighted average, error, and scale factor are based upon the data in this ideogram only. They are not necessarily the same as our 'best' values, obtained from a least-squares constrained fit utilizing measurements of other (related) quantities as additional information.

$|\epsilon| = (2|\eta_{+-}| + |\eta_{00}|)/3$

This expression is a very good approximation, good to about one part in 10^{-4} because of the small measured value of $\phi_{00} - \phi_{+-}$ and small theoretical ambiguities.

VALUE (units 10^{-3})	*DOCUMENT ID*
2.233±0.015 OUR FIT Error includes scale factor of 1.4.	

$|\eta_{00}/\eta_{+-}|$

VALUE	*EVTS*	*DOCUMENT ID*		*TECN*
0.9950±0.0008 OUR FIT Error includes scale factor of 1.6.				
0.9930±0.0020 OUR AVERAGE				
0.9931±0.0020		[92,93] BARR	93D	NA31
0.9904±0.0084±0.0036		[94] WOODS	88	E731
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.9939±0.0013±0.0015	1M	[92] BARR	93D	NA31
0.9899±0.0020±0.0025		[92] BURKHARDT	88	NA31

[92] This is the square root of the ratio *R* given by BURKHARDT 88 and BARR 93D.

[93] This is the combined results from BARR 93D and BURKHARDT 88, taking into account a common systematic uncertainty of 0.0014.

[94] We calculate $|\eta_{00}/\eta_{+-}| = 1-3(\epsilon'/\epsilon)$ from WOODS 88 (ϵ'/ϵ) value.

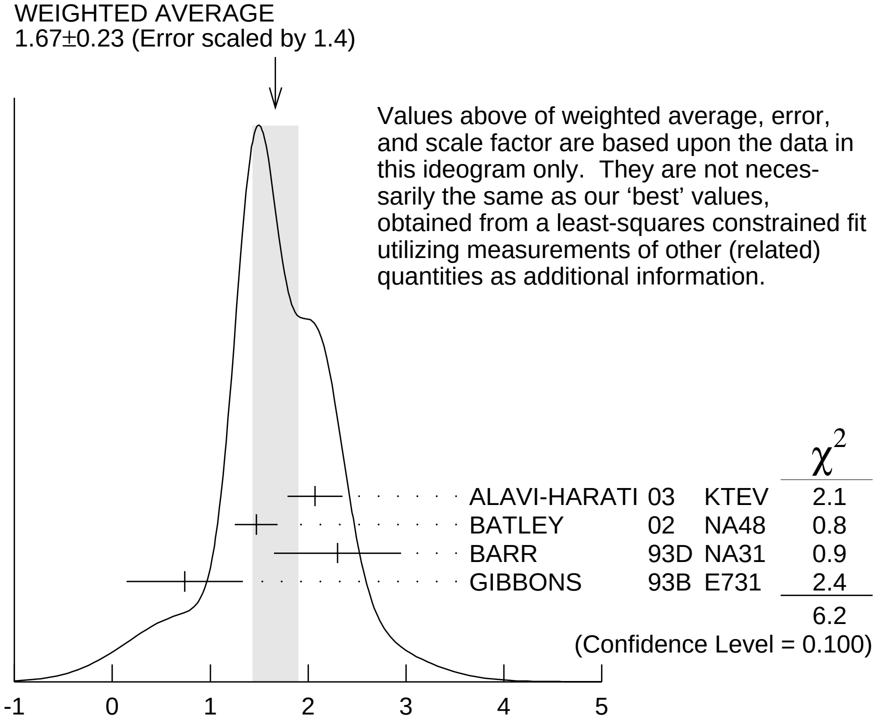
$\mathrm{Re}(\epsilon'/\epsilon) = (1-|\eta_{00}/\eta_{+-}|)/3$

VALUE (units 10^{-3})	*DOCUMENT ID*		*TECN*	*COMMENT*
1.67±0.26 OUR FIT Error includes scale factor of 1.6.				
1.67±0.23 OUR AVERAGE Error includes scale factor of 1.4. See the ideogram below.				
2.07±0.28	ALAVI-HARATI	03	KTEV	
1.47±0.22	BATLEY	02	NA48	
2.3 ±0.65	[95,96] BARR	93D	NA31	
0.74±0.52±0.29	GIBBONS	93B	E731	
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1.53±0.26	LAI	01C	NA48	Incl. in BATLEY 02
2.80±0.30±0.28	ALAVI-HARATI	99D	KTEV	In ALAVI-HARATI 03
1.85±0.45±0.58	FANTI	99C	NA48	In LAI 01C
2.0 ±0.7	[97] BARR	93D	NA31	
−0.4 ±1.4 ±0.6	PATTERSON	90	E731	in GIBBONS 93B
3.3 ±1.1	[97] BURKHARDT	88	NA31	
3.2 ±2.8 ±1.2	[95] WOODS	88	E731	

[95] These values are derived from $|\eta_{00}/\eta_{+-}|$ measurements. They enter the average in this section but enter the fit via the $|\eta_{00}/\eta_{+-}|$ only.

[96] This is the combined results from BARR 93D and BURKHARDT 88, taking into account their common systematic uncertainty.

[97] These values are derived from $|\eta_{00}/\eta_{+-}|$ measurements.



$\mathrm{Re}(\epsilon'/\epsilon) = (1-\left|\eta_{00}/\eta_{+-}\right|)/3$

ϕ_{+-}, PHASE of η_{+-}

The dependence of the phase on Δm and τ_S is given for each experiment in the comments below, where Δm is the $K^0_L - K^0_S$ mass difference in units 10^{10} $\hbar s^{-1}$ and τ_s is the K_S mean life in units 10^{-10} s. We also give the regeneration phase ϕ_f in the comments below.

OUR FIT is described in the note on "*CP* violation in K_L decays" in the K^0_L Particle Listings. Most experiments in this section are included in both the "Not Assuming *CPT*" and "Assuming *CPT*" fits. In the latter fit, they have little direct influence on ϕ_{+-} because their errors are large compared to that assuming *CPT*, but they influence Δm and τ_s through their dependencies on these parameters, which are given in the footnotes. Only ALAVI-HARATI 03 is excluded from the "Assuming *CPT*" fit because we explicitly include their Δm and τ_s measurements which assume *CPT*.

VALUE (°)	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
43.52±0.06 OUR FIT		Error includes scale factor of 1.3. Assuming *CPT*			
43.4 ±0.7 OUR FIT		Error includes scale factor of 1.3. Not assuming *CPT*			
44.12±0.72±1.20		[98] ALAVI-HARATI	03	KTEV	Not assuming *CPT*
42.9 ±0.6 ±0.3	70M	[99] APOSTOLA...	99C	CPLR	K^0-$\overline{K}^0$ asymmetry
43.0 ±0.8 ±0.2		[100,101] SCHWINGEN...	95	E773	$CH_{1.1}$ regenerator
41.4 ±0.9 ±0.3		[101,102] GIBBONS	93	E731	B_4C regenerator
44.4 ±1.6 ±0.6		[103] CAROSI	90	NA31	Vacuum regen.
43.3 ±1.0 ±0.5		[104] GEWENIGER	74B	ASPK	Vacuum regen.

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

42.5 ± 0.4 ± 0.4		[105,106] ADLER	96C	RVUE	
43.4 ± 1.1 ± 0.3		[107] ADLER	95B	CPLR	K^0-$\overline{K}^0$ asymmetry
42.3 ± 4.4 ± 1.4	10^5	[108] ADLER	92B	CPLR	K^0-$\overline{K}^0$ asymmetry
47.7 ± 2.0 ± 0.9		[101,109] KARLSSON	90	E731	
44.3 ± 2.8 ± 0.2		[110] CARITHERS	75	SPEC	C regenerator

[98] ALAVI-HARATI 03 ϕ_{+-} is correlated with their $\Delta m = m_{K^0_L} - m_{K^0_S}$ and τ_{K_S} measurements in the K^0_L and K^0_S sections respectively. The correlation coefficients are $\rho(\phi_{+-},\Delta m) = +0.955$, $\rho(\phi_{+-},\tau_S) = -0.871$, and $\rho(\tau_S,\Delta m) = -0.840$. *CPT* is not assumed. Uses scintillator Pb regenerator.

[99] APOSTOLAKIS 99C measures $\phi_{+-} = (43.19 \pm 0.53 \pm 0.28) + 300\,[\Delta m - 0.5301]$ ($^\circ$). We have adjusted the measurement to use our best values of ($\Delta m = 0.5292 \pm 0.0010$) ($10^{10}$ $\hbar$ s^{-1}). Our first error is their experiment's error and our second error is the systematic error from using our best values.

[100] SCHWINGENHEUER 95 measures $\phi_{+-} = (43.53 \pm 0.76) + 173\,[\Delta m - 0.5282] - 275\,[\tau_S - 0.8926]$ ($^\circ$). We have adjusted the measurement to use our best values of ($\Delta m = 0.5292 \pm 0.0010$) ($10^{10}$ $\hbar$ s^{-1}), ($\tau_S = 0.8953 \pm 0.0006$) ($10^{-10}$ s). Our first error is their experiment's error and our second error is the systematic error from using our best values.

[101] These experiments measure $\phi_{+-}-\phi_f$ and calculate the regeneration phase from the power law momentum dependence of the regeneration amplitude using analyticity and dispersion relations. SCHWINGENHEUER 95 [GIBBONS 93] includes a systematic error of 0.35° [0.5°] for uncertainties in their modeling of the regeneration amplitude.

[102] GIBBONS 93 measures $\phi_{+-} = (42.21 \pm 0.9) + 189\,[\Delta m - 0.5257] - 460\,[\tau_S - 0.8922]$ ($^\circ$). We have adjusted the measurement to use our best values of ($\Delta m = 0.5292 \pm 0.0010$) ($10^{10}$ $\hbar$ s^{-1}), ($\tau_S = 0.8953 \pm 0.0006$) ($10^{-10}$ s). Our first error is their experiment's error and our second error is the systematic error from using our best values. This is actually reported in SCHWINGENHEUER 95, footnote 8. GIBBONS 93 reports ϕ_{+-} $(42.2 \pm 1.4)^\circ$. They measure $\phi_{+}-\phi_f$ and calculate the regeneration phase ϕ_f from the power law momentum dependence of the regeneration amplitude using analyticity. An error of 0.6° is included for possible uncertainties in the regeneration phase.

[103] CAROSI 90 measures $\phi_{+-} = (46.9 \pm 1.4 \pm 0.7) + 579\,[\Delta m - 0.5351] + 303\,[\tau_S - 0.8922]$ ($^\circ$). We have adjusted the measurement to use our best values of ($\Delta m = 0.5292 \pm 0.0010$) ($10^{10}$ $\hbar$ s^{-1}), ($\tau_S = 0.8953 \pm 0.0006$) ($10^{-10}$ s). Our first error is their experiment's error and our second error is the systematic error from using our best values.

[104] GEWENIGER 74B measures $\phi_{+-} = (49.4 \pm 1.0) + 565\,[\Delta m - 0.540]$ ($^\circ$). We have adjusted the measurement to use our best values of ($\Delta m = 0.5292 \pm 0.0010$) ($10^{10}$ $\hbar$ s^{-1}). Our first error is their experiment's error and our second error is the systematic error from using our best values.

[105] ADLER 96C measures $\phi_{+-} = (43.82 \pm 0.41) + 339\,[\Delta m - 0.5307] - 252\,[\tau_S - 0.8922]$ ($^\circ$). We have adjusted the measurement to use our best values of ($\Delta m = 0.5292 \pm 0.0010$) ($10^{10}$ $\hbar$ s^{-1}), ($\tau_S = 0.8953 \pm 0.0006$) ($10^{-10}$ s). Our first error is their experiment's error and our second error is the systematic error from using our best values.

[106] ADLER 96C is the result of a fit which includes nearly the same data as entered into the "OUR FIT" value in the 1996 edition of this Review (Physical Review **D54** 1 (1996)).

[107] ADLER 95B measures $\phi_{+-} = (42.7 \pm 0.9 \pm 0.6) + 316\,[\Delta m - 0.5274] + 30\,[\tau_S - 0.8926]$ ($^\circ$). We have adjusted the measurement to use our best values of ($\Delta m = 0.5292 \pm 0.0010$) ($10^{10}$ $\hbar$ s^{-1}), ($\tau_S = 0.8953 \pm 0.0006$) ($10^{-10}$ s). Our first error is

their experiment's error and our second error is the systematic error from using our best values.

[108] ADLER 92B quote separately two systematic errors: ±0.4 from their experiment and ±1.0 degrees due to the uncertainty in the value of Δm.

[109] KARLSSON 90 systematic error does not include regeneration phase uncertainty.

[110] CARITHERS 75 measures $\phi_{+-} = (45.5 \pm 2.8) + 224\ [\Delta m - 0.5348]\ (^\circ)$. We have adjusted the measurement to use our best values of $(\Delta m = 0.5292 \pm 0.0010)\ (10^{10}\ \hbar\ \mathrm{s}^{-1})$. Our first error is their experiment's error and our second error is the systematic error from using our best values. $\phi_f = -40.9 \pm 2.6^\circ$.

ϕ_{00}, PHASE OF η_{00}

See comment in ϕ_{+-} header above for treatment of Δm and τ_S dependence, as well as for the inclusion of data in both the "Assuming *CPT*" and "Not Assuming *CPT*" fits.

OUR FIT is described in the note on "*CP* violation in K_L decays" in the K_L^0 Particle Listings.

VALUE (°)	*DOCUMENT ID*	*TECN*	*COMMENT*
43.50±0.06 OUR FIT	Error includes scale factor of 1.3.		Assuming *CPT*
43.7 ±0.8 OUR FIT	Error includes scale factor of 1.2.		Not assuming *CPT*
44.5 ±2.3 ±0.6	[111] CAROSI 90	NA31	
• • • We do not use the following data for averages, fits, limits, etc. • • •			
41.6 ±5.9 ±0.2	[112] ANGELOPO... 98	CPLR	
50.8 ±7.1 ±1.7	[113] ADLER 96B	CPLR	Sup. by ANGELOPOULOS 98
47.4 ±1.4 ±0.9	[114] KARLSSON 90	E731	

[111] CAROSI 90 measures $\phi_{00} = (47.1 \pm 2.1 \pm 1.0) + 579\ [\Delta m - 0.5351] + 252\ [\tau_S - 0.8922]\ (^\circ)$. We have adjusted the measurement to use our best values of $(\Delta m = 0.5292 \pm 0.0010)\ (10^{10}\ \hbar\ \mathrm{s}^{-1})$, $(\tau_S = 0.8953 \pm 0.0006)\ (10^{-10}\ \mathrm{s})$. Our first error is their experiment's error and our second error is the systematic error from using our best values.

[112] ANGELOPOULOS 98 measures $\phi_{00} = (42.0 \pm 5.6 \pm 1.9) + 240\ [\Delta m - 0.5307]\ (^\circ)$. We have adjusted the measurement to use our best values of $(\Delta m = 0.5292 \pm 0.0010)\ (10^{10}\ \hbar\ \mathrm{s}^{-1})$. Our first error is their experiment's error and our second error is the systematic error from using our best values. The τ_S dependence is negligible.

[113] ADLER 96B identified initial neutral kaon individually as being a K^0 or a $\overline{K}^0$. The systematic uncertainty is ±1.5° combined in quadrature with ±0.8° due to Δm.

[114] KARLSSON 90 systematic error does not include regeneration phase uncertainty.

$\phi_\epsilon = (2\phi_{+-} + \phi_{00})/3$

This expression is a very good approximation, good to about 10^{-3} degrees because of the small measured values of $\phi_{00} - \phi_{+-}$ and Re ϵ'/ϵ, and small theoretical ambiguities.

VALUE (°)	*DOCUMENT ID*	*COMMENT*
43.51 ±0.05 OUR FIT	Error includes scale factor of 1.2.	Assuming *CPT*
43.5 ±0.7 OUR FIT	Error includes scale factor of 1.3.	Not assuming *CPT*
43.5105±0.0004±0.0548	[115] SUPERWEAK 04	Assuming *CPT*

[115] SUPERWEAK 04 is a fake measurement used to impose the *CPT* or Superweak constraint $\phi_{+-} = \phi_{SW} = 2\ \frac{\Delta m}{\hbar}\ (\frac{\tau_S \tau_L}{\tau_L - \tau_S})$. This "measurement" is linearized using values near the RPP 2004 edition values of Δm, τ_S and τ_L, and then adjusted to our current values as described in the following "measurement". SUPERWEAK 04 measures $\phi_\epsilon = (43.5131 \pm 0.0004) + 54\ [\Delta m - 0.5290] + 32\ [\tau_S - 0.8958]\ (^\circ)$. We have adjusted the measurement to use our best values of $(\Delta m = 0.5292 \pm 0.0010)\ (10^{10}\ \hbar\ \mathrm{s}^{-1})$, $(\tau_S = 0.8953 \pm 0.0006)\ (10^{-10}\ \mathrm{s})$. Our first error is their experiment's error and our second error is the systematic error from using our best values.

DECAY-PLANE ASYMMETRY IN $\pi^+\pi^-e^+e^-$ DECAYS

This is the *CP*-violating asymmetry

$$A= \frac{N_{\sin\phi\cos\phi>0.0}-N_{\sin\phi\cos\phi<0.0}}{N_{\sin\phi\cos\phi>0.0}+N_{\sin\phi\cos\phi<0.0}}$$

where ϕ is the angle between the e^+e^- and $\pi^+\pi^-$ planes in the K^0_L rest frame.

CP ASYMMETRY *A* in $K^0_L \rightarrow \pi^+\pi^-e^+e^-$

VALUE (%)	*DOCUMENT ID*		*TECN*
13.8±2.2 OUR AVERAGE			
14.2±3.0±1.9	LAI	03C	NA48
13.6±2.5±1.2	ALAVI-HARATI	00B	KTEV

PARAMETERS FOR $e^+e^-e^+e^-$ DECAYS

These are the *CP*-violating parameters in the ϕ distribution, where ϕ is the angle between the planes of the two e^+e^- paris in the kaon rest frame:

$$d\Gamma/d\phi \ \propto \ 1 + \beta_{CP} \cos(2\phi) + \gamma_{CP} \sin(2\phi)$$

β_{CP} from $K^0_L \rightarrow e^+e^-e^+e^-$

VALUE	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
−0.23±0.09±0.02	441	ALAVI-HARATI	01D	KTEV	$M_{ee} > 8$ MeV/c^2

γ_{CP} from $K^0_L \rightarrow e^+e^-e^+e^-$

VALUE	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
−0.09±0.09±0.02	441	ALAVI-HARATI	01D	KTEV	$M_{ee} > 8$ MeV/c^2

CHARGE ASYMMETRY IN $\pi^+\pi^-\pi^0$ DECAYS

These are *CP*-violating charge-asymmetry parameters, defined at beginning of section “LINEAR COEFFICIENT *g* FOR $K^0_L \rightarrow \pi^+\pi^-\pi^0$ above.

See also note on Dalitz plot parameters in $K^\pm$ section and note on “*CP* violation in K_L decays” above.

LINEAR COEFFICIENT *j* FOR $K^0_L \rightarrow \pi^+\pi^-\pi^0$

VALUE	*EVTS*	*DOCUMENT ID*		*TECN*
0.0012±0.0008 OUR AVERAGE				
0.0010±0.0024±0.0030	500k	ANGELOPO...	98C	CPLR
−0.001 ±0.011	6499	CHO	77	
0.001 ±0.003	4709	PEACH	77	
0.0013±0.0009	3M	SCRIBANO	70	
0.0 ±0.017	4400	SMITH	70	OSPK
0.001 ±0.004	238k	BLANPIED	68	

QUADRATIC COEFFICIENT *f* FOR $K^0_L \rightarrow \pi^+\pi^-\pi^0$

VALUE	*EVTS*	*DOCUMENT ID*		*TECN*
0.0045±0.0024±0.0059	500k	ANGELOPO...	98C	CPLR

PARAMETERS for $K^0_L \to \pi^+\pi^-\gamma$ DECAY

$|\eta_{+-\gamma}| = |\mathrm{A}(K^0_L \to \pi^+\pi^-\gamma$, *CP* violating$)/\mathrm{A}(K^0_S \to \pi^+\pi^-\gamma)|$

VALUE (units 10^{-3})	*EVTS*		*DOCUMENT ID*		*TECN*
2.35 ±0.07 OUR AVERAGE					
2.359±0.062±0.040	9045		MATTHEWS	95	E773
2.15 ±0.26 ±0.20	3671		RAMBERG	93B	E731

$\phi_{+-\gamma}$ = phase of $\eta_{+-\gamma}$

VALUE (°)	*EVTS*		*DOCUMENT ID*		*TECN*
44 ± 4 OUR AVERAGE					
43.8± 3.5± 1.9	9045		MATTHEWS	95	E773
72 ±23 ±17	3671		RAMBERG	93B	E731

$|\epsilon'_{+-\gamma}|/\epsilon$ for $K^0_L \to \pi^+\pi^-\gamma$

VALUE	*CL%*	*EVTS*		*DOCUMENT ID*		*TECN*
<0.3	90	3671	[116]	RAMBERG	93B	E731

[116] RAMBERG 93B limit on $|\epsilon'_{+-\gamma}|/\epsilon$ assumes than any difference between η_{+-} and $\eta_{+-\gamma}$ is due to direct *CP* violation.

T VIOLATION TESTS IN K^0_L DECAYS

Im(ξ) in $K^0_{\mu 3}$ DECAY (from transverse μ pol.)

Test of *T* reversal invariance.

VALUE	*EVTS*		*DOCUMENT ID*		*TECN*	*COMMENT*
−0.007±0.026 OUR AVERAGE						
0.009±0.030	12M		MORSE	80	CNTR	Polarization
0.35 ±0.30	207k	[117]	CLARK	77	SPEC	POL, t=0
−0.085±0.064	2.2M	[118]	SANDWEISS	73	CNTR	POL, t=0
−0.02 ±0.08			LONGO	69	CNTR	POL, t=3.3
−0.2 ±0.6			ABRAMS	68B	OSPK	Polarization
• • • We do not use the following data for averages, fits, limits, etc. • • •						
0.012±0.026			SCHMIDT	79	CNTR	Repl. by MORSE 80

[117] CLARK 77 value has additional $\xi(0)$ dependence $+0.21\mathrm{Re}[\xi(0)]$.

[118] SANDWEISS 73 value corrected from value quoted in their paper due to new value of Re(ξ). See footnote 4 of SCHMIDT 79.

CPT-INVARIANCE TESTS IN K^0_L DECAYS

PHASE DIFFERENCE $\phi_{00} - \phi_{+-}$

Test of *CPT*.

OUR FIT is described in the note on "*CP* violation in K_L decays" in the K^0_L Particle Listings.

VALUE (°)		*DOCUMENT ID*		*TECN*	*COMMENT*
−0.02 ±0.04 OUR FIT Error includes scale factor of 2.1. Assuming *CPT*					
0.2 ±0.4 OUR FIT Not assuming *CPT*					
−0.023±0.020	[119]	SUPERWEAK	04		Assuming *CPT*
0.39 ±0.22 ±0.45	[120]	ALAVI-HARATI	03	KTEV	
−0.30 ±0.88	[121]	SCHWINGEN...	95		Combined E731, E773

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

0.62	±0.71	±0.75	SCHWINGEN...95		E773
−1.6	±1.2		[122] GIBBONS	93	E731
0.2	±2.6	±1.2	[123] CAROSI	90	NA31
−0.3	±2.4	±1.2	KARLSSON	90	E731

[119] SUPERWEAK 04 is a fake experiment to constrain ϕ_{00}-ϕ_{+-} to a small value as described in the note "*CP* violation in K_L decays."

[120] ALAVI-HARATI 03 fit Re(ϵ'/ϵ), Im(ϵ'/ϵ), Δm, τ_S, and ϕ_{+-} simultaneously, not assuming *CPT*. Phase difference is obtained from $\phi_{00} - \phi_{+-} \approx -3\mathrm{Im}(\epsilon'/\epsilon)$ for small $|\epsilon'/\epsilon|$.

[121] This SCHWINGENHEUER 95 values is the combined result of SCHWINGENHEUER 95 and GIBBONS 93, accounting for correlated systematic errors.

[122] GIBBONS 93 give detailed dependence of systematic error on lifetime (see the section on the K^0_S mean life) and mass difference (see the section on $m_{K^0_L} - m_{K^0_S}$).

[123] CAROSI 90 is excluded from the fit because it it is not independent of ϕ_{+-} and ϕ_{00} values.

PHASE DIFFERENCE $\phi_{+-} - \phi_{SW}$

Test of *CPT*. The Superweak phase $\phi_{SW} \equiv \tan^{-1}(2\Delta m/\Delta\Gamma)$ where $\Delta m = m_{K^0_L} - m_{K^0_S}$ and $\Delta\Gamma = \hbar(\tau_L - \tau_S)/(\tau_L\tau_S)$.

VALUE (°)	*DOCUMENT ID*		*TECN*
0.61±0.62±1.01	[124] ALAVI-HARATI	03	KTEV

[124] ALAVI-HARATI 03 fit is the same as their ϕ_{+-}, τ_{K_S}, Δm fit, except that the parameter $\phi_{+-} - \phi_{SW}$ is used in place of ϕ.

$\mathrm{Re}(\frac{2}{3}\eta_{+-} + \frac{1}{3}\eta_{00}) - \frac{\delta_L}{2}$

Test of *CPT*

VALUE (units 10^{-6})	*DOCUMENT ID*		*TECN*	*COMMENT*
−3±35	[125] ALAVI-HARATI	02	E799	Uses δ_L from K_{e3} decays

[125] ALAVI-HARATI 02 uses PDG 00 values of η_{+-} and η_{00}.

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$x = \mathrm{A}(\overline{K}^0 \rightarrow \pi^-\ell^+\nu)/\mathrm{A}(K^0 \rightarrow \pi^-\ell^+\nu) = \mathrm{A}(\Delta S{=}{-}\Delta Q)/\mathrm{A}(\Delta S{=}\Delta Q)$

REAL PART OF *x*

VALUE		*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
−0.0018±0.0041±0.0045			ANGELOPO...	98D	CPLR	K_{e3} from K^0
• • • We do not use the following data for averages, fits, limits, etc. • • •						
0.10	$^{+0.18}_{-0.19}$	79	SMITH	75B	WIRE	$\pi^- p \rightarrow K^0 \Lambda$
0.04	±0.03	4724	NIEBERGALL	74	ASPK	$K^+ p \rightarrow K^0 p \pi^+$
−0.008	±0.044	1757	FACKLER	73	OSPK	K_{e3} from K^0
−0.03	±0.07	1367	HART	73	OSPK	K_{e3} from $K^0 \Lambda$
−0.070	±0.036	1079	MALLARY	73	OSPK	K_{e3} from $K^0 \Lambda$X

0.03 ± 0.06	410	[126] BURGUN	72	HBC	$K^+ p \to K^0 p \pi^+$
$0.04^{+0.10}_{-0.13}$	100	[127] GRAHAM	72	OSPK	$K_{\mu3}$ from $K^0 \Lambda$
-0.05 ± 0.09	442	[127] GRAHAM	72	OSPK	$\pi^- p \to K^0 \Lambda$
$0.26^{+0.10}_{-0.14}$	126	MANN	72	HBC	$K^- p \to n \overline{K}^0$
-0.13 ± 0.11	342	[127] MANTSCH	72	OSPK	K_{e3} from $K^0 \Lambda$
$0.04^{+0.07}_{-0.08}$	222	[126] BURGUN	71	HBC	$K^+ p \to K^0 p \pi^+$
$0.25^{+0.07}_{-0.09}$	252	WEBBER	71	HBC	$K^- p \to n \overline{K}^0$
0.12 ± 0.09	215	[128] CHO	70	DBC	$K^+ d \to K^0 p p$
-0.020 ± 0.025		[129] BENNETT	69	CNTR	Charge asym+ Cu regen.
$0.09^{+0.14}_{-0.16}$	686	LITTENBERG	69	OSPK	$K^+ n \to K^0 p$
0.03 ± 0.03		[129] BENNETT	68	CNTR	
$0.09^{+0.07}_{-0.09}$	121	JAMES	68	HBC	$\overline{p} p$
$0.17^{+0.16}_{-0.35}$	116	FELDMAN	67B	OSPK	$\pi^- p \to K^0 \Lambda$
0.17 ± 0.10	335	[128] HILL	67	DBC	$K^+ d \to K^0 p p$
$0.035^{+0.11}_{-0.13}$	196	AUBERT	65	HLBC	K^+ charge exchange
$0.06^{+0.18}_{-0.44}$	152	[130] BALDO-...	65	HLBC	K^+ charge exchange
$-0.08^{+0.16}_{-0.28}$	109	[131] FRANZINI	65	HBC	$\overline{p} p$

[126] BURGUN 72 is a final result which includes BURGUN 71.

[127] First GRAHAM 72 value is second GRAHAM 72 value combined with MANTSCH 72.

[128] CHO 70 is analysis of unambiguous events in new data and HILL 67.

[129] BENNETT 69 is a reanalysis of BENNETT 68.

[130] BALDO-CEOLIN 65 gives x and θ converted by us to Re(x) and Im(x).

[131] FRANZINI 65 gives x and θ for Re(x) and Im(x). See SCHMIDT 67.

IMAGINARY PART OF *x*

Assumes $m_{K^0_L} - m_{K^0_S}$ positive. See Listings above.

VALUE	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
0.0012±0.0019±0.0009	640k	ANGELOPO...	01B	CPLR	K_{e3} from K^0
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.0012 ± 0.0019	640k	[132] ANGELOPO...	98E	CPLR	K_{e3} from K^0
$-0.10^{+0.16}_{-0.19}$	79	SMITH	75B	WIRE	$\pi^- p \to K^0 \Lambda$
-0.06 ± 0.05	4724	NIEBERGALL	74	ASPK	$K^+ p \to K^0 p \pi^+$
-0.017 ± 0.060	1757	FACKLER	73	OSPK	K_{e3} from K^0
0.09 ± 0.07	1367	HART	73	OSPK	K_{e3} from $K^0 \Lambda$
$0.107^{+0.092}_{-0.074}$	1079	MALLARY	73	OSPK	K_{e3} from $K^0 \Lambda X$
$0.07^{+0.06}_{-0.07}$	410	[133] BURGUN	72	HBC	$K^+ p \to K^0 p \pi^+$

0.12	$^{+0.17}_{-0.16}$	100	[134] GRAHAM	72	OSPK	$K_{\mu 3}$ from $K^0\Lambda$
0.05	± 0.13	442	[134] GRAHAM	72	OSPK	$\pi^- p \rightarrow K^0\Lambda$
0.21	$^{+0.15}_{-0.12}$	126	MANN	72	HBC	$K^- p \rightarrow n\overline{K}^0$
-0.04	± 0.16	342	[134] MANTSCH	72	OSPK	K_{e3} from $K^0\Lambda$
0.12	$^{+0.08}_{-0.09}$	222	[133] BURGUN	71	HBC	$K^+ p \rightarrow K^0 p\pi^+$
0.0	± 0.08	252	WEBBER	71	HBC	$K^- p \rightarrow n\overline{K}^0$
-0.08	± 0.07	215	[135] CHO	70	DBC	$K^+ d \rightarrow K^0 pp$
-0.11	$^{+0.10}_{-0.11}$	686	LITTENBERG	69	OSPK	$K^+ n \rightarrow K^0 p$
$+0.22$	$^{+0.37}_{-0.29}$	121	JAMES	68	HBC	$\overline{p}p$
0.0	± 0.25	116	FELDMAN	67B	OSPK	$\pi^- p \rightarrow K^0\Lambda$
-0.20	± 0.10	335	[135] HILL	67	DBC	$K^+ d \rightarrow K^0 pp$
-0.21	$^{+0.11}_{-0.15}$	196	AUBERT	65	HLBC	K^+ charge exchange
-0.44	$^{+0.32}_{-0.19}$	152	[136] BALDO-...	65	HLBC	K^+ charge exchange
$+0.24$	$^{+0.40}_{-0.30}$	109	[137] FRANZINI	65	HBC	$\overline{p}p$

[132] Superseded by ANGELOPOULOS 01B.

[133] BURGUN 72 is a final result which includes BURGUN 71.

[134] First GRAHAM 72 value is second GRAHAM 72 value combined with MANTSCH 72.

[135] Footnote 10 of HILL 67 should read +0.58, not −0.58 (private communication) CHO 70 is analysis of unambiguous events in new data and HILL 67.

[136] BALDO-CEOLIN 65 gives x and θ converted by us to Re(x) and Im(x).

[137] FRANZINI 65 gives x and θ for Re(x) and Im(x). See SCHMIDT 67.

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ADLER	92B	PL B286 180	R. Adler *et al.*	(CPLEAR Collab.)
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MORSE	92	PR D45 36	W.M. Morse *et al.*	(BNL, YALE, VASS)
PDG	92	PR D45, 1 June, Part II	K. Hikasa *et al.*	(KEK, LBL, BOST+)
SOMALWAR	92	PRL 68 2580	S.V. Somalwar *et al.*	(FNAL E731 Collab.)
AKAGI	91B	PRL 67 2618	T. Akagi *et al.*	(TOHOK, TOKY, KYOT, KEK)
BARR	91	PL B259 389	G.D. Barr *et al.*	(CERN, EDIN, MANZ, LALO+)
HEINSON	91	PR D44 R1	A.P. Heinson *et al.*	(UCI, UCLA, LANL+)
PAPADIMITR...	91	PR D44 R573	V. Papadimitriou *et al.*	(FNAL E731 Collab.)
BARKER	90	PR D41 3546	A.R. Barker *et al.*	(FNAL E731 Collab.)
Also	88	PRL 61 2661	L.K. Gibbons *et al.*	(FNAL E731 Collab.)
BARR	90B	PL B240 283	G.D. Barr *et al.*	(CERN, EDIN, MANZ, LALO+)
BARR	90C	PL B242 523	G.D. Barr *et al.*	(CERN, EDIN, MANZ, LALO+)
CAROSI	90	PL B237 303	R. Carosi *et al.*	(CERN, EDIN, MANZ, LALO+)
KARLSSON	90	PRL 64 2976	M. Karlsson *et al.*	(FNAL E731 Collab.)
OHL	90	PRL 64 2755	K.E. Ohl *et al.*	(BNL E845 Collab.)
OHL	90B	PRL 65 1407	K.E. Ohl *et al.*	(BNL E845 Collab.)
PATTERSON	90	PRL 64 1491	J.R. Patterson *et al.*	(FNAL E731 Collab.)
INAGAKI	89	PR D40 1712	T. Inagaki *et al.*	(KEK, TOKY, KYOT)
MATHIAZHA...	89	PRL 63 2181	C. Mathiazhagan *et al.*	(UCI, UCLA, LANL+)
MATHIAZHA...	89B	PRL 63 2185	C. Mathiazhagan *et al.*	(UCI, UCLA, LANL+)
WAHL	89	CERN-EP/89-86	H. Wahl	(CERN)
BARR	88	PL B214 303	G.D. Barr *et al.*	(CERN, EDIN, MANZ, LALO+)
BURKHARDT	88	PL B206 169	H. Burkhardt *et al.*	(CERN, EDIN, MANZ+)
JASTRZEM...	88	PRL 61 2300	E. Jastrzembski *et al.*	(BNL, YALE)
WOODS	88	PRL 60 1695	M. Woods *et al.*	(FNAL E731 Collab.)
BURKHARDT	87	PL B199 139	H. Burkhardt *et al.*	(CERN, EDIN, MANZ+)
ARONSON	86	PR D33 3180	S.H. Aronson *et al.*	(BNL, CHIC, STAN+)
Also	82	PRL 48 1078	S.H. Aronson *et al.*	(BNL, CHIC, STAN+)
PDG	86C	PL 170B 132	M. Aguilar-Benitez *et al.*	(CERN, CIT+)
COUPAL	85	PRL 55 566	D.P. Coupal *et al.*	(CHIC, SACL)
BALATS	83	SJNP 38 556	M.Y. Balats *et al.*	(ITEP)
		Translated from YAF 38 927.		
BERGSTROM	83	PL 131B 229	L. Bergstrom, E. Masso, P. Singer	(CERN)
ARONSON	82	PRL 48 1078	S.H. Aronson *et al.*	(BNL, CHIC, STAN+)
ARONSON	82B	PRL 48 1306	S.H. Aronson *et al.*	(BNL, CHIC, PURD)
Also	82B	PL 116B 73	E. Fischbach *et al.*	(PURD, BNL, CHIC)
Also	83	PR D28 476	S.H. Aronson *et al.*	(BNL, CHIC, PURD)
Also	83B	PR D28 495	S.H. Aronson *et al.*	(BNL, CHIC, PURD)
PDG	82B	PL 111B 70	M. Roos *et al.*	(HELS, CIT, CERN)
BIRULEV	81	NP B182 1	V.K. Birulev *et al.*	(JINR)
Also	80	SJNP 31 622	V.K. Birulev *et al.*	(JINR)
		Translated from YAF 31 1204.		
CARROLL	80B	PRL 44 529	A.S. Carroll *et al.*	(BNL, ROCH)
CARROLL	80C	PL 96B 407	A.S. Carroll *et al.*	(BNL, ROCH)
CHO	80	PR D22 2688	Y. Cho *et al.*	(ANL, CMU)
MORSE	80	PR D21 1750	W.M. Morse *et al.*	(BNL, YALE)
CHRISTENS...	79	PRL 43 1209	J.H. Christenson *et al.*	(NYU)
HILL	79	NP B153 39	D.G. Hill *et al.*	(BNL, SLAC, SBER)
SCHMIDT	79	PRL 43 556	M.P. Schmidt *et al.*	(YALE, BNL)
ENGLER	78B	PR D18 623	A. Engler *et al.*	(CMU, ANL)
HILL	78	PL 73B 483	D.G. Hill *et al.*	(BNL, SLAC, SBER)
CHO	77	PR D15 587	Y. Cho *et al.*	(ANL, CMU)
CLARK	77	PR D15 553	A.R. Clark *et al.*	(LBL)
Also	75	Thesis LBL-4275	G. Shen	(LBL)
DEVOE	77	PR D16 565	R. Devoe *et al.*	(EFI, ANL)
DZHORD...	77	SJNP 26 478	V.P. Dzhordzhadze *et al.*	(JINR)
		Translated from YAF 26 910.		
PEACH	77	NP B127 399	K.J. Peach *et al.*	(BGNA, EDIN, GLAS+)
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		Translated from YAF 24 340.		

COOMBES	76	PRL 37 249	R.W. Coombes *et al.*	(STAN, NYU)
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ALBRECHT	74	PL 48B 393	K.F. Albrecht	(JINR, BERL, BUDA, PRAG, SERP+)
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GJESDAL	74	PL 52B 113	S. Gjesdal *et al.*	(CERN, HEIDH)
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ALEXANDER	73B	NP B65 301	G. Alexander *et al.*	(TELA, HEID)
BRANDENB...	73	PR D8 1978	G.W. Brandenburg *et al.*	(SLAC)
EVANS	73	PR D7 36	G.R. Evans *et al.*	(EDIN, CERN)
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ASHFORD	72	PL 38B 47	V.A. Ashford *et al.*	(UCSD)
BANNER	72B	PRL 29 237	M. Banner *et al.*	(PRIN)
BARMIN	72B	SJNP 15 638 Translated from YAF 15 1152.	V.V. Barmin *et al.*	(ITEP)
BURGUN	72	NP B50 194	G. Burgun *et al.*	(SACL, CERN, OSLO)
DALLY	72	PL 41B 647	E.B. Dally *et al.*	(SLAC, JHU, UCLA)
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GRAHAM	72	NC 9A 166	M.F. Graham *et al.*	(ILL, NEAS)
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BALATS	71	SJNP 13 53 Translated from YAF 13 93.	M.Y. Balats *et al.*	(ITEP)
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CHAN	71	Thesis LBL-350	J.H.S. Chan	(LBL)
CHIEN	71	PL 35B 261	C.Y. Chien *et al.*	(JHU, SLAC, UCLA)
Also	72	PL 41B 647	E.B. Dally *et al.*	(SLAC, JHU, UCLA)
CHO	71	PR D3 1557	Y. Cho *et al.*	(CMU, BNL, CASE)

ENSTROM	71	PR D4 2629	J. Enstrom *et al.*	(SLAC, STAN)
Also	70	Thesis SLAC-0125	J.E. Enstrom	(STAN)
JAMES	71	PL 35B 265	F. James *et al.*	(CERN, SACL, OSLO)
MEISNER	71	PR D3 59	G.W. Meisner *et al.*	(MASA, BNL, YALE)
REPELLIN	71	PL 36B 603	J.P. Repellin *et al.*	(ORSAY, CERN)
WEBBER	71	PR D3 64	B.R. Webber *et al.*	(LRL)
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WOLFF	71	PL 36B 517	B. Wolff *et al.*	(ORSAY, CERN)
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JAMES	68	NP B8 365	F. James, H. Briand	(IPNP, CERN)
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