NODE=S012

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

K^0_S MEAN LIFE

NODE=S012205

NODE=S012205

For earlier measurements, beginning with BOLDT 58B, see our 1986 edition, Physics Letters **170B** 130 (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.

NODE=S012T

VALUE (10^{-10} s)	EVTS	DOCUMENT ID		TECN	COMMENT	
0.8954 ±0.0004 OUR FIT		Error includes scale factor of 1.1. Assuming CPT				
0.89564±0.00033 OUR FIT		Not assuming CPT				
0.89589±0.00070		[1,2] ABOUZAID	11	KTEV	Not assuming CPT	TYPE=noCPT
0.89623±0.00047		[1,3] ABOUZAID	11	KTEV	Assuming CPT	OCCUR=2;TYPE=CPT
0.89562±0.00029±0.00043	20M	[4] AMBROSINO	11	KLOE	Not assuming CPT	TYPE=noCPT
0.89598±0.00048±0.00051	16M	LAI	02C	NA48		
0.8971 ±0.0021		BERTANZA	97	NA31		
0.8941 ±0.0014 ±0.0009		SCHWINGEN...	95	E773	Assuming CPT	TYPE=CPT
0.8929 ±0.0016		GIBBONS	93	E731	Assuming CPT	TYPE=CPT
• • • We do not use the following data for averages, fits, limits, etc. • • •						
0.8965 ±0.0007		[5] ALAVI-HARATI	03	KTEV	Assuming CPT	TYPE=CPT
0.8958 ±0.0013		[6] ALAVI-HARATI	03	KTEV	Not assuming CPT	OCCUR=2;TYPE=noCPT
0.8920 ±0.0044	214k	GROSSMAN	87	SPEC		
0.905 ±0.007		[7] ARONSON	82B	SPEC		
0.881 ±0.009	26k	ARONSON	76	SPEC		
0.8926 ±0.0032 ±0.0002		[8] CARITHERS	75	SPEC		
0.8937 ±0.0048	6M	GEWENIGER	74B	ASPK		
0.8958 ±0.0045	50k	[9] SKJEGGEST...	72	HBC		
0.856 ±0.008	19994	[10] DONALD	68B	HBC		
0.872 ±0.009	20000	[9,10] HILL	68	DBC		

[1] The two ABOUZAID 11 values use the same full KTeV dataset from 1996, 1997, and 1999. The first enters the "assuming CPT" fit and the second enters the "not assuming CPT" fit. NODE=S012T;LINKAGE=AB

[2] ABOUZAID 11 fit has Δm, τ_S, ϕ_ϵ, Re(ϵ'/ϵ), and Im(ϵ'/ϵ) as free parameters. See Im(ϵ'/ϵ) in the "K^0_L CP violation" section for correlation information. NODE=S012T;LINKAGE=AO

[3] ABOUZAID 11 fit has Δm and τ_S free but constrains ϕ_ϵ to the Superweak value, i.e. assumes CPT. This τ_S value is correlated with their $\Delta m = m_{K^0_L} - m_{K^0_S}$ measurement in the K^0_L listings. The correlation coefficient $\rho(\tau_S, \Delta m) = -0.670$. NODE=S012T;LINKAGE=AU

[4] Fit to the proper time distribution. NODE=S012T;LINKAGE=AM

[5] This ALAVI-HARATI 03 fit has Δm and τ_S free but constrains ϕ_{+-} to the Superweak value, i.e. assumes CPT. This τ_S value is correlated with their $\Delta m = m_{K^0_L} - m_{K^0_S}$ measurement in the K^0_L listings. The correlation coefficient $\rho(\tau_S,\Delta m) = -0.396$. Superseded by ABOUZAID 11. NODE=S012T;LINKAGE=TG

[6] This ALAVI-HARATI 03 fit has Δm, ϕ_{+-}, and τ_{K_S} free. See ϕ_{+-} in the "K_L CP violation" section for correlation information. Superseded by ABOUZAID 11. NODE=S012T;LINKAGE=S3

[7] ARONSON 82 find that K^0_S mean life may depend on the kaon energy. NODE=S012T;LINKAGE=A2

[8] CARITHERS 75 measures the Δm dependence of the total decay rate (inverse mean life) to be $\Gamma(K^0_S) = \left[(1.122 \pm 0.004) + 0.16(\Delta m - 0.5348)/\Delta m\right] 10^{10}$/s, or, in terms of mean life, CARITHERS 75 measures $\tau_S = (0.8913 \pm 0.0032) - 0.238\ [\Delta m - 0.5348]$ (10^{-10} s). We have adjusted the measurement to use our best values of (Δm = 0.5293 ± 0.0009) (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. NODE=S012T;LINKAGE=C2

[9] HILL 68 has been changed by the authors from the published value (0.865 ± 0.009) because of a correction in the shift due to η_{+-}. SKJEGGESTAD 72 and HILL 68 give detailed discussions of systematics encountered in this type of experiment. NODE=S012T;LINKAGE=H1

[10] Pre-1971 experiments are excluded from the average because of disagreement with later more precise experiments. NODE=S012T;LINKAGE=N

K^0_S DECAY MODES

NODE=S012210;NODE=S012

	Mode			Fraction (Γ_i/Γ)	Scale factor/ Confidence level	
	Hadronic modes					NODE=S012;CLUMP=A
Γ_1	$\pi^0\pi^0$			(30.69 ± 0.05) %		DESIG=2
Γ_2	$\pi^+\pi^-$			(69.20 ± 0.05) %		DESIG=1
Γ_3	$\pi^+\pi^-\pi^0$			$(3.5\ ^{+1.1}_{-0.9})\times10^{-7}$		DESIG=8
	Modes with photons or $\ell\bar{\ell}$ pairs					NODE=S012;CLUMP=B
Γ_4	$\pi^+\pi^-\gamma$		[a,b]	$(1.79\pm0.05)\times10^{-3}$		DESIG=5
Γ_5	$\pi^+\pi^-e^+e^-$			$(4.79\pm0.15)\times10^{-5}$		DESIG=13
Γ_6	$\pi^0\gamma\gamma$		[a]	$(4.9\pm1.8)\times10^{-8}$		DESIG=14
Γ_7	$\gamma\gamma$			$(2.63\pm0.17)\times10^{-6}$	S=3.1	DESIG=6
Γ_8	$\mu^+\mu^-\mu^+\mu^-$			$<5.1\times10^{-12}$	CL=90%	DESIG=16
	Semileptonic modes					NODE=S012;CLUMP=C
Γ_9	$\pi^\pm e^\mp\nu_e$		[c]	$(7.14\pm0.06)\times10^{-4}$		DESIG=11
Γ_{10}	$\pi^\pm\mu^\mp\nu_\mu$		[c,d]	$(4.56\pm0.20)\times10^{-4}$		DESIG=12
	***CP* violating (*CP*) and $\Delta S = 1$ weak neutral current (*S1*) modes**					NODE=S012;CLUMP=F
Γ_{11}	$3\pi^0$	*CP*		$<2.6\times10^{-8}$	CL=90%	DESIG=7
Γ_{12}	$\mu^+\mu^-$	*S1*		$<2.1\times10^{-10}$	CL=90%	DESIG=3
Γ_{13}	e^+e^-	*S1*		$<9\times10^{-9}$	CL=90%	DESIG=4
Γ_{14}	$\pi^0e^+e^-$	*S1*	[a]	$(3.0\ ^{+1.5}_{-1.2})\times10^{-9}$		DESIG=10
Γ_{15}	$\pi^0\mu^+\mu^-$	*S1*		$(2.9\ ^{+1.5}_{-1.2})\times10^{-9}$		DESIG=15

[a] See the Particle Listings below for the energy limits used in this measurement. LINKAGE=KDS

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

[c] The value is for the sum of the charge states or particle/antiparticle states indicated. LINKAGE=SG

[d] Not a measurement. Calculated as $0.666\cdot B(\pi^\pm e^\mp\nu_e)$. LINKAGE=NM

CONSTRAINED FIT INFORMATION

An overall fit to 4 branching ratios uses 5 measurements and one constraint to determine 4 parameters. The overall fit has a $\chi^2 = 0.6$ for 2 degrees of freedom.

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

	x_1	x_2	x_9
x_2	−100		
x_9	−9	8	
x_{10}	−1	−3	0

K^0_S DECAY RATES

NODE=S012212

$\Gamma(\pi^\pm e^\mp\nu_e)$ Γ_9

NODE=S012W1
NODE=S012W1

VALUE (10^6 s^{-1})	EVTS	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
8.1 ±1.6	75	[1] AKHMETSHIN	99	CMD2	Tagged K^0_S using $\phi\to K^0_L K^0_S$
7.50±0.08		[2] PDG	98		
seen		BURGUN	72	HBC	$K^+p\to K^0p\pi^+$
9.3 ±2.5		AUBERT	65	HLBC	$\Delta S=\Delta Q$, *CP* cons. not assumed

[1] AKHMETSHIN 99 is from a measured branching ratio B($K^0_S \to \pi e \nu_e$)= $(7.2 \pm 1.4) \times 10^{-4}$ and $\tau_{K^0_S} = (0.8934 \pm 0.0008) \times 10^{-10}$ s. Not independent of measured branching ratio. NODE=S012W1;LINKAGE=AW

[2] PDG 98 from K^0_L measurements, assuming that $\Delta S = \Delta Q$ in K^0 decay so that $\Gamma(K^0_S \to \pi^\pm e^\mp \nu_e) = \Gamma(K^0_L \to \pi^\pm e^\mp \nu_e)$. NODE=S012W1;LINKAGE=P8

$\Gamma(\pi^\pm \mu^\mp \nu_\mu)$ Γ_{10}

NODE=S012W2
NODE=S012W2

VALUE (10^6 s^{-1})	DOCUMENT ID	
• • • We do not use the following data for averages, fits, limits, etc. • • •		
5.25 ± 0.07	[1] PDG	98

[1] PDG 98 from K^0_L measurements, assuming that $\Delta S = \Delta Q$ in K^0 decay so that $\Gamma(K^0_S \to \pi^\pm \mu^\mp \nu_\mu) = \Gamma(K^0_L \to \pi^\pm \mu^\mp \nu_\mu)$. NODE=S012W2;LINKAGE=P8

K^0_S BRANCHING RATIOS

NODE=S012215

Hadronic modes

NODE=S012405

$\Gamma(\pi^0 \pi^0)/\Gamma_{total}$ Γ_1/Γ

NODE=S012R2
NODE=S012R2

VALUE	EVTS	DOCUMENT ID		TECN
0.3069±0.0005 OUR FIT				
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.335 ±0.014	1066	BROWN	63	HLBC
0.288 ±0.021	198	CHRETIEN	63	HLBC
0.30 ±0.035		BROWN	61	HLBC

$\Gamma(\pi^+ \pi^-)/\Gamma_{total}$ Γ_2/Γ

NODE=S012R1
NODE=S012R1

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.6920±0.0005 OUR FIT					
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.670 ±0.010	3447	DOYLE	69	HBC	$\pi^- p \to \Lambda K^0$

$\Gamma(\pi^+ \pi^-)/\Gamma(\pi^0 \pi^0)$ Γ_2/Γ_1

NODE=S012R3
NODE=S012R3

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
2.255 ±0.005 OUR FIT					
2.2549±0.0054		[1] AMBROSINO	06C	KLOE	
• • • We do not use the following data for averages, fits, limits, etc. • • •					
2.2555±0.0012±0.0054		[2] AMBROSINO	06C	KLOE	
2.236 ±0.003 ±0.015	766k	[2] ALOISIO	02B	KLOE	
2.11 ±0.09	1315	EVERHART	76	WIRE	$\pi^- p \to \Lambda K^0$
2.169 ±0.094	16k	COWELL	74	OSPK	$\pi^- p \to \Lambda K^0$
2.16 ±0.08	4799	HILL	73	DBC	$K^+ d \to K^0 p p$
2.22 ±0.10	3068	[3] ALITTI	72	HBC	$K^+ p \to \pi^+ p K^0$
2.22 ±0.08	6380	MORSE	72B	DBC	$K^+ n \to K^0 p$
2.10 ±0.11	701	[4] NAGY	72	HLBC	$K^+ n \to K^0 p$
2.22 ±0.095	6150	[5] BALTAY	71	HBC	$K p \to K^0$ neutrals
2.282 ±0.043	7944	[6] MOFFETT	70	OSPK	$K^+ n \to K^0 p$
2.12 ±0.17	267	[4] BOZOKI	69	HLBC	
2.285 ±0.055	3016	[6] GOBBI	69	OSPK	$K^+ n \to K^0 p$
2.10 ±0.06	3700	MORFIN	69	HLBC	$K^+ n \to K^0 p$

OCCUR=2

[1] This result combines AMBROSINO 06C KLOE 2001-02 data with ALOISIO 02B KLOE 2000 data. $K^0_S \to \pi^+ \pi^-$ fully inclusive. NODE=S012R3;LINKAGE=AM

[2] Includes radiative decays $\pi^+ \pi^- \gamma$. NODE=S012R3;LINKAGE=AL

[3] The directly measured quantity is $K^0_S \to \pi^+ \pi^-$/all $K^0 = 0.345 \pm 0.005$. NODE=S012R3;LINKAGE=A

[4] NAGY 72 is a final result which includes BOZOKI 69. NODE=S012R3;LINKAGE=N

[5] The directly measured quantity is $K^0_S \to \pi^+ \pi^-$/all $\overline{K}^0 = 0.345 \pm 0.005$. NODE=S012R3;LINKAGE=B

[6] MOFFETT 70 is a final result which includes GOBBI 69. NODE=S012R3;LINKAGE=G

$\Gamma(\pi^+\pi^-\pi^0)/\Gamma_{total}$ Γ_3/Γ

NODE=S012R8
NODE=S012R8

VALUE (units 10^{-7})	EVTS	DOCUMENT ID		TECN	COMMENT
$3.5^{+1.1}_{-0.9}$ OUR AVERAGE					
$4.7^{+2.2}_{-1.7}{}^{+1.7}_{-1.5}$		[1] BATLEY	05	NA48	
$2.5^{+1.3}_{-1.0}{}^{+0.5}_{-0.6}$	500k	[2] ADLER	97B	CPLR	
$4.8^{+2.2}_{-1.6}\pm1.1$		[3] ZOU	96	E621	
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$4.1^{+2.5}_{-1.9}{}^{+0.5}_{-0.6}$		[4] ADLER	96E	CPLR	Sup. by ADLER 97B
$3.9^{+5.4}_{-1.8}{}^{+0.9}_{-0.7}$		[5] THOMSON	94	E621	Sup. by ZOU 96

[1] BATLEY 05 is obtained by measuring the interference parameters in K_S, $K_L \to \pi^+\pi^-\pi^0$: $\mathrm{Re}(\lambda) = 0.038 \pm 0.008 \pm 0.006$ and $\mathrm{Im}(\lambda) = -0.013 \pm 0.005 \pm 0.004$; the correlation coeff. between $\mathrm{Re}(\lambda)$ and $\mathrm{Im}(\lambda)$ is 0.66 (statistical only). NODE=S012R8;LINKAGE=BA

[2] ADLER 97B find the CP-conserving parameters $\mathrm{Re}(\lambda) = (28 \pm 7 \pm 3) \times 10^{-3}$, $\mathrm{Im}(\lambda) = (-10 \pm 8 \pm 2) \times 10^{-3}$. They estimate $\mathrm{B}(K^0_S \to \pi^+\pi^-\pi^0)$ from $\mathrm{Re}(\lambda)$ and the K^0_L decay parameters. See also ANGELOPOULOS 98C. NODE=S012R8;LINKAGE=E

[3] ZOU 96 is from the the measured quantities $|\rho_{+-0}| = 0.039^{+0.009}_{-0.006} \pm 0.005$ and $\phi_\rho = (-9 \pm 18)^\circ$. NODE=S012R8;LINKAGE=C

[4] ADLER 96E is from the measured quantities $\mathrm{Re}(\lambda) = 0.036 \pm 0.010^{+0.002}_{-0.003}$ and $\mathrm{Im}(\lambda)$ consistent with zero. Note that the quantity λ is the same as ρ_{+-0} used in other footnotes. NODE=S012R8;LINKAGE=D

[5] THOMSON 94 calculates this branching ratio from their measurements $|\rho_{+-0}| = 0.035^{+0.019}_{-0.011} \pm 0.004$ and $\phi_\rho = (-59 \pm 48)^\circ$ where $|\rho_{+-0}|e^{i\phi_\rho} = \mathrm{A}(K^0_S \to \pi^+\pi^-\pi^0, I=2)/\mathrm{A}(K^0_L \to \pi^+\pi^-\pi^0)$. NODE=S012R8;LINKAGE=B

Modes with photons or $\ell\bar{\ell}$ pairs

NODE=S012410

$\Gamma(\pi^+\pi^-\gamma)/\Gamma(\pi^+\pi^-)$ Γ_4/Γ_2

NODE=S012R5
NODE=S012R5

VALUE (units 10^{-3})	EVTS	DOCUMENT ID		TECN	COMMENT
2.59±0.08 OUR AVERAGE					
2.56±0.09	1286	RAMBERG	93	E731	p_γ >50 MeV/c
2.68±0.15		[1] TAUREG	76	SPEC	p_γ >50 MeV/c
• • • We do not use the following data for averages, fits, limits, etc. • • •					
7.10±0.22	3723	RAMBERG	93	E731	p_γ >20 MeV/c
3.0 ±0.6	29	[2] BOBISUT	74	HLBC	p_γ >40 MeV/c
2.8 ±0.6		[3] BURGUN	73	HBC	p_γ >50 MeV/c

OCCUR=2

[1] TAUREG 76 find direct emission contribution <0.06, CL = 90%. NODE=S012R5;LINKAGE=T

[2] BOBISUT 74 not included in average because p_γ cut differs. Estimates direct emission contribution to be 0.5 or less, CL = 95%. NODE=S012R5;LINKAGE=C

[3] BURGUN 73 estimates that direct emission contribution is 0.3 ± 0.6. NODE=S012R5;LINKAGE=B

$\Gamma(\pi^+\pi^-e^+e^-)/\Gamma_{total}$ Γ_5/Γ

NODE=S012R14
NODE=S012R14

VALUE (units 10^{-5})	EVTS	DOCUMENT ID		TECN	COMMENT
4.79±0.15 OUR AVERAGE					
4.83±0.11±0.14	23k	[1] BATLEY	11	NA48	2002 data
4.69±0.30	676	[2] LAI	03C	NA48	1998+1999 data
• • • We do not use the following data for averages, fits, limits, etc. • • •					
4.71±0.23±0.22	620	[2,3] LAI	03C	NA48	1999 data
4.5 ±0.7 ±0.4	56	LAI	00B	NA48	1998 data

OCCUR=2

[1] BATLEY 11 reports $[\Gamma(K^0_S \to \pi^+\pi^-e^+e^-)/\Gamma_{total}]$ / $[\mathrm{B}(K^0_L \to \pi^+\pi^-\pi^0)]$ / $[\mathrm{B}(\pi^0 \to e^+e^-\gamma)] = (3.28 \pm 0.06 \pm 0.04) \times 10^{-2}$ which we multiply by our best values $\mathrm{B}(K^0_L \to \pi^+\pi^-\pi^0) = (12.54 \pm 0.05) \times 10^{-2}$, $\mathrm{B}(\pi^0 \to e^+e^-\gamma) = (1.174 \pm 0.035) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best values. Also a limit on the absolute value of the interference between bremsstrahlung and E1 transition is given : $< 4 \times 10^{-7}$ at 90% C.L. NODE=S012R14;LINKAGE=BA

[2] Uses normalization $\mathrm{BR}(K_L \to \pi^+\pi^-\pi^0)$*$\mathrm{BR}(\pi^0 \to e^+e^-) = (1.505 \pm 0.047) \times 10^{-3}$ from our 2000 Edition. NODE=S012R14;LINKAGE=LA

[3] Second error is 0.16(syst)±0.15(norm) combined in quadrature. NODE=S012R14;LINKAGE=LB

$\Gamma(\pi^0\gamma\gamma)/\Gamma_{total}$ — Γ_6/Γ

NODE=S012R15
NODE=S012R15

VALUE (units 10^{-8})	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
4.9±1.6±0.9		17	[1] LAI	04	NA48	$m^2_{\gamma\gamma}/m^2_K > 0.2$
• • • We do not use the following data for averages, fits, limits, etc. • • •						
<33	90		LAI	03B	NA48	$m^2_{\gamma\gamma}/m^2_K > 0.2$

[1] Spectrum also measured and found consistent with the one generated by a constant matrix element. NODE=S012R15;LINKAGE=LA

$\Gamma(\gamma\gamma)/\Gamma_{total}$ — Γ_7/Γ

NODE=S012R7
NODE=S012R7

VALUE (units 10^{-6})	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
2.63 ±0.17 OUR AVERAGE			Error includes scale factor of 3.1.			
2.26 ±0.12 ±0.06		711	[1] AMBROSINO	08C	KLOE	$\phi \to K^0_S K^0_L$
2.713±0.063±0.005		7.5k	[2] LAI	03	NA48	
• • • We do not use the following data for averages, fits, limits, etc. • • •						
2.58 ±0.36 ±0.22		149	LAI	00	NA48	
2.2 ±1.1		16	[3] BARR	95B	NA31	
2.4 ±0.9		35	[4] BARR	95B	NA31	OCCUR=2
< 13	90		BALATS	89	SPEC	
2.4 ±1.2		19	BURKHARDT	87	NA31	
<133	90		BARMIN	86B	XEBC	

[1] AMBROSINO 08C reports $(2.26 \pm 0.12 \pm 0.06) \times 10^{-6}$ from a measurement of $[\Gamma(K^0_S \to \gamma\gamma)/\Gamma_{total}] \times [B(K^0_S \to \pi^0\pi^0)]$ assuming $B(K^0_S \to \pi^0\pi^0) = (30.69 \pm 0.05) \times 10^{-2}$. NODE=S012R7;LINKAGE=AM

[2] LAI 03 reports $[\Gamma(K^0_S \to \gamma\gamma)/\Gamma_{total}] / [B(K^0_S \to \pi^0\pi^0)] = (8.84 \pm 0.18 \pm 0.10) \times 10^{-6}$ which we multiply by our best value $B(K^0_S \to \pi^0\pi^0) = (30.69 \pm 0.05) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value. NODE=S012R7;LINKAGE=LB

[3] BARR 95B result is calculated using $B(K_L \to \gamma\gamma) = (5.86 \pm 0.17) \times 10^{-4}$. NODE=S012R7;LINKAGE=A

[4] BARR 95B quotes this as the combined BARR 95B + BURKHARDT 87 result after rescaling BURKHARDT 87 to use same branching ratios and lifetimes as BARR 95B. NODE=S012R7;LINKAGE=B

$\Gamma(\mu^+\mu^-\mu^+\mu^-)/\Gamma_{total}$ — Γ_8/Γ

NODE=S012R00
NODE=S012R00

VALUE	CL%	DOCUMENT ID		TECN
<5.1 × 10^{-12}	90	[1] AAIJ	23AE	LHCB

[1] AAIJ 23AE uses 5.1 fb^{-1} of LHCb data recorded from 2016 to 2018. NODE=S012R00;LINKAGE=A

Semileptonic modes

NODE=S012415

$\Gamma(\pi^\pm e^\mp \nu_e)/\Gamma_{total}$ — Γ_9/Γ

NODE=S012R13
NODE=S012R13

VALUE (units 10^{-4})	EVTS	DOCUMENT ID		TECN	COMMENT
7.14 ±0.06 OUR FIT					
7.04 ±0.08 OUR AVERAGE					
7.046±0.18±0.16		[1] BATLEY	07D	NA48	$K^0(\overline{K}^0)(t) \to \pi e \nu$
6.91 ±0.34±0.15	624	[2] ALOISIO	02	KLOE	Tagged K^0_S using $\phi \to K^0_L K^0_S$
• • • We use the following data for averages but not for fits. • • •					
7.05 ±0.09	13k	[3] AMBROSINO	06E	KLOE	Not fitted — NOTFITTED
• • • We do not use the following data for averages, fits, limits, etc. • • •					
7.2 ±1.4	75	AKHMETSHIN	99	CMD2	Tagged K^0_S using $\phi \to K^0_L K^0_S$

[1] Reconstructed from $K^0(\overline{K}^0)(t) \to \pi e \nu$ distributions using PDG values of $B(K^0_L \to \pi e \nu) = 0.4053 \pm 0.0015$, $\tau_L = (5.114 \pm 0.021) \times 10^{-8}$ s and $\tau_S = (0.8958 \pm 0.0005) \times 10^{-10}$ s. NODE=S012R13;LINKAGE=BA

[2] Uses the PDG 00 value for $B(K^0_S \to \pi^+\pi^-)$. NODE=S012R13;LINKAGE=A

[3] Obtained by imposing $\Sigma_i B(K^0_S \to i) = 1$, where i runs over all the four branching ratios $\pi^+\pi^-$, $\pi^0\pi^0$, $\pi e \nu$, and $\pi \mu \nu$. Input value of $B(K^0_S \to \pi^+\pi^-) / B(K^0_S \to \pi^0\pi^0)$ from AMBROSINO 06C is used. To derive $\Gamma(K^0_S \to \pi^+ \mu \nu) / \Gamma(K^0_S \to \pi^+ e \nu)$, lepton universality is assumed, radiative corrections from ANDRE 07 are used, and phase space integrals are taken from KTeV, ALEXOPOULOS 04A. This branching fraction enters our fit via their $\Gamma(\pi^\pm e^\mp \nu_e) / \Gamma(\pi^+\pi^-)$ branching ratio measurement. NODE=S012R13;LINKAGE=AM

$\Gamma(\pi^\pm \mu^\mp \nu_\mu)/\Gamma_{total}$ — Γ_{10}/Γ

NODE=S012R18
NODE=S012R18

VALUE (units 10^{-4})	EVTS	DOCUMENT ID		TECN	COMMENT
4.56±0.20 OUR FIT					
4.56±0.11±0.17	7223	[1] BABUSCI	20	KLOE	direct measurement

[1] Value obtained by normalizing to the KLOE measurement $B(K^0_S \to \pi^+\pi^-) = (69.196 \pm 0.051)\%$. Also comparison with the PDG 18 based derived value leads to a lepton flavor universality test $|V_{us}\ f_+(0)|^2_{K^0_S \to \pi\mu\nu} / |V_{us}\ f_+(0)|^2_{K^0_S \to \pi e \nu} = 0.975 \pm 0.044$. NODE=S012R18;LINKAGE=A

$\Gamma(\pi^{\pm} e^{\mp} \nu_e)/\Gamma(\pi^+\pi^-)$ Γ_9/Γ_2

NODE=S012R17
NODE=S012R17

VALUE (units 10^{-3})	EVTS	DOCUMENT ID		TECN
1.032 ±0.008 OUR FIT				
1.0338±0.0054±0.0064		[1] BABUSCI	23	KLOE
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1.019 ±0.011 ±0.007	13k	[2] AMBROSINO	06E	KLOE

[1] BABUSCI 23 measured $\Gamma(K^0_S \rightarrow \pi e \nu)/\Gamma(K^0_S \rightarrow \pi^+\pi^-) = (1.0421 \pm 0.0066 \pm 0.0075) \times 10^{-3}$ based on data collected from 2004 to 2005. About 50k signal events were reconstructed from the dataset corresponding to an integrated luminosity of 1.63 fb^{-1}. The quoted value is their combination of this result with the previous measurement of AMBROSINO 06E. The correlation coefficient between the two measurements is 12%. NODE=S012R17;LINKAGE=A

[2] AMBROSINO 06E result is included in BABUSCI 23. NODE=S012R17;LINKAGE=B

CP violating (*CP*) and $\Delta S = 1$ weak neutral current (*S1*) modes

NODE=S012420

$\Gamma(3\pi^0)/\Gamma_{total}$ Γ_{11}/Γ

NODE=S012R9
NODE=S012R9
NODE=S012R9

Violates *CP* conservation.

VALUE (units 10^{-7})	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
< 0.26	90	590M	[1] BABUSCI	13C	KLOE	$\phi \rightarrow K^0_L K^0_S$
• • • We do not use the following data for averages, fits, limits, etc. • • •						
< 1.2	90	37.8M	AMBROSINO	05B	KLOE	
< 7.4	90	4.9M	[2] LAI	05A	NA48	
<140	90	7M	ACHASOV	99D	SND	
<190	90	17300	[3] ANGELOPO...	98B	CPLR	
<370	90		BARMIN	83	HLBC	

[1] BABUSCI 13C uses 1.7 fb^{-1} of data of $\phi \rightarrow K^0_L K^0_S$ decays with K^0_L interaction in the calorimeter, collected from 2004 to 2005. No candidate events were found in the data with an expected background of $0.04^{+0.15}_{-0.03}$ events. Upper limit is obtained by normalizing to $K^0_S \rightarrow 2\pi^0$ decays. NODE=S012R9;LINKAGE=B

[2] LAI 05A value is obtained from their bound on $|\eta_{000}|$ (not assuming *CPT*) and $B(K^0_L \rightarrow 3\pi^0) = 0.211 \pm 0.003$, and PDG 04 values for K^0_L and K^0_S lifetimes. If *CPT* is assumed then $B(K^0_S \rightarrow 3\pi^0)_{CPT} < 2.3 \times 10^{-7}$ at 90% CL NODE=S012R9;LINKAGE=LA

[3] ANGELOPOULOS 98B is from $\text{Im}(\eta_{000}) = -0.05 \pm 0.12 \pm 0.05$, assuming $\text{Re}(\eta_{000}) = \text{Re}(\epsilon) = 1.635 \times 10^{-3}$ and using the value $B(K^0_L \rightarrow \pi^0\pi^0\pi^0) = 0.2112 \pm 0.0027$. NODE=S012R9;LINKAGE=A

$\Gamma(\mu^+\mu^-)/\Gamma_{total}$ Γ_{12}/Γ

NODE=S012R11
NODE=S012R11

Test for $\Delta S = 1$ weak neutral current. Allowed by first-order weak interaction combined with electromagnetic interaction.

NODE=S012R11

VALUE	CL%	DOCUMENT ID		TECN
<2.1 × 10^{-10}	90	[1] AAIJ	20AE	LHCB
• • • We do not use the following data for averages, fits, limits, etc. • • •				
<8 × 10^{-10}	90	[2] AAIJ	17BQ	LHCB
<9 × 10^{-9}	90	[3] AAIJ	13G	LHCB
<3.2 × 10^{-7}	90	GJESDAL	73	ASPK
<7 × 10^{-6}	90	HYAMS	69B	OSPK

[1] AAIJ 20AE uses 8.6 fb^{-1} of LHCb data from 2011 to 2012 and 2016 to 2018. The result utilizes the normalization mode branching fraction $B(K^0_S \rightarrow \pi^+\pi^-) = (69.20 \pm 0.05) \times 10^{-2}$ from PDG 18. Supersedes AAIJ 17BQ. NODE=S012R11;LINKAGE=B

[2] AAIJ 17BQ uses 3.0 fb^{-1} of pp collisions at $\sqrt{s} = 7$ and 8 TeV. The result utilizes the normalization mode branching fraction $B(K^0_S \rightarrow \pi^+\pi^-) = (69.20 \pm 0.05) \times 10^{-2}$ from PDG 16. Supersedes AAIJ 13G. NODE=S012R11;LINKAGE=A

[3] AAIJ 13G uses 1.0 fb^{-1} of pp collisions at $\sqrt{s} = 7$ TeV. They obtained $B(K^0_S \rightarrow \mu^+\mu^-) < 11 \times 10^{-9}$ at 95% C.L. NODE=S012R11;LINKAGE=AA

$\Gamma(e^+e^-)/\Gamma_{total}$ Γ_{13}/Γ

NODE=S012R12
NODE=S012R12

Test for $\Delta S = 1$ weak neutral current. Allowed by first-order weak interaction combined with electromagnetic interaction.

NODE=S012R12

VALUE (units 10^{-7})	CL%	DOCUMENT ID		TECN	COMMENT
< 0.09	90	[1] AMBROSINO	09A	KLOE	$e^+e^- \rightarrow \phi \rightarrow K^0_S K^0_L$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
< 1.4	90	ANGELOPO...	97	CPLR	
< 28	90	BLICK	94	CNTR	Hyperon facility
<100	90	BARMIN	86	XEBC	

[1] AMBROSINO 09A reports $< 0.09 \times 10^{-7}$ from a measurement of $[\Gamma(K^0_S \rightarrow e^+e^-)/\Gamma_{total}]$ / $[B(K^0_S \rightarrow \pi^+\pi^-)]$ assuming $B(K^0_S \rightarrow \pi^+\pi^-) = (69.20 \pm 0.05) \times 10^{-2}$. NODE=S012R12;LINKAGE=AM

$\Gamma(\pi^0 e^+ e^-)/\Gamma_{total}$ — Γ_{14}/Γ

NODE=S012R10

Test for $\Delta S = 1$ weak neutral current. Allowed by first-order weak interaction combined with electromagnetic interaction.

NODE=S012R10

NODE=S012R10

VALUE (units 10^{-9})	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
$\mathbf{3.0^{+1.5}_{-1.2}\pm0.2}$		7	[1] BATLEY	03	NA48	m_{ee} >0.165 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •						
< 140	90		LAI	01	NA48	
< 1100	90	0	BARR	93B	NA31	
<45000	90		GIBBONS	88	E731	

[1] BATLEY 03 extrapolate also to the full kinematical region using a constant form factor and a vector matrix element. The resulting branching ratio is $(5.8^{+2.9}_{-2.4}) \times 10^{-9}$.

NODE=S012R10;LINKAGE=BA

$\Gamma(\pi^0 \mu^+ \mu^-)/\Gamma_{total}$ — Γ_{15}/Γ

NODE=S012R16

Test for $\Delta S = 1$ weak neutral current. Allowed by first-order weak interaction combined with electromagnetic interaction.

NODE=S012R16

NODE=S012R16

VALUE (units 10^{-9})	EVTS	DOCUMENT ID		TECN	COMMENT
$\mathbf{2.9^{+1.5}_{-1.2}\pm0.2}$	6	[1] BATLEY	04A	NA48	NA48/1 K^0_S beam

[1] Background estimate is $0.22^{+0.18}_{-0.11}$ events. Branching ratio assumes a vector matrix element and unit form factor.

NODE=S012R16;LINKAGE=BA

K^0_S FORM FACTORS

NODE=S012240

For discussion, see note on $K_{\ell 3}$ form factors in the $K^\pm$ section of the Particle Listings above. Because the semileptonic branching fraction is smaller in K^0_S than K^0_L by the ratio of the mean lives, the K^0_S semileptonic form factor has so far been measured only in the K_{e3} mode using the linear expansion $f_+(t) = f_+(0)\,(1 + \lambda_+ t\,/m^2_{\pi^+})$, which gives the vector form factor $f_+(t)$ relative to its value at $t = 0$.

NODE=S012240

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

NODE=S012L+E
NODE=S012L+E

VALUE (units 10^{-2})	EVTS	DOCUMENT ID		TECN
3.39±0.41	15k	AMBROSINO	06E	KLOE

NODE=S012219

CP VIOLATION IN $K_S \to 3\pi$

Written 1996 by T. Nakada (Paul Scherrer Institute) and L. Wolfenstein (Carnegie-Mellon University).

The possible final states for the decay $K^0 \to \pi^+\pi^-\pi^0$ have isospin $I = 0$, 1, 2, and 3. The $I = 0$ and $I = 2$ states have $CP = +1$ and K_S can decay into them without violating CP symmetry, but they are expected to be strongly suppressed by centrifugal barrier effects. The $I = 1$ and $I = 3$ states, which have no centrifugal barrier, have $CP = -1$ so that the K_S decay to these requires CP violation.

In order to see CP violation in $K_S \to \pi^+\pi^-\pi^0$, it is necessary to observe the interference between K_S and K_L decay, which determines the amplitude ratio

$$\eta_{+-0} = \frac{A(K_S \to \pi^+\pi^-\pi^0)}{A(K_L \to \pi^+\pi^-\pi^0)} . \qquad (1)$$

If η_{+-0} is obtained from an integration over the whole Dalitz plot, there is no contribution from the $I = 0$ and $I = 2$ final states and a nonzero value of η_{+-0} is entirely due to CP violation.

Only $I = 1$ and $I = 3$ states, which are $CP = -1$, are allowed for $K^0 \to \pi^0\pi^0\pi^0$ decays and the decay of K_S into $3\pi^0$ is an unambiguous sign of CP violation. Similarly to η_{+-0}, η_{000} is defined as

$$\eta_{000} = \frac{A(K_S \to \pi^0\pi^0\pi^0)}{A(K_L \to \pi^0\pi^0\pi^0)} \ . \qquad (2)$$

If one assumes that CPT invariance holds and that there are no transitions to $I = 3$ (or to nonsymmetric $I = 1$ states), it can be shown that

$$\eta_{+-0} = \eta_{000} = \epsilon + i\frac{\mathrm{Im}\ a_1}{\mathrm{Re}\ a_1} \ . \qquad (3)$$

With the Wu-Yang phase convention, a_1 is the weak decay amplitude for K^0 into $I = 1$ final states; ϵ is determined from CP violation in $K_L \to 2\pi$ decays. The real parts of η_{+-0} and η_{000} are equal to $\mathrm{Re}(\epsilon)$. Since currently-known upper limits on $|\eta_{+-0}|$ and $|\eta_{000}|$ are much larger than $|\epsilon|$, they can be interpreted as upper limits on $\mathrm{Im}(\eta_{+-0})$ and $\mathrm{Im}(\eta_{000})$ and so as limits on the CP-violating phase of the decay amplitude a_1.

CP-VIOLATION PARAMETERS IN K^0_S DECAY

NODE=S012250

A_S = [$\Gamma(K^0_S \to \pi^- e^+ \nu_e)$ - $\Gamma(K^0_S \to \pi^+ e^- \overline{\nu}_e)$] / SUM

NODE=S012AS

Such asymmetry violates *CP*. If *CPT* is assumed then $A_S = 2\ \mathrm{Re}(\epsilon)$.

NODE=S012AS
NODE=S012AS

VALUE (units 10^{-3})	EVTS	DOCUMENT ID		TECN
−3.8±5.0±2.6	83k	[1] ANASTASI	18A	KLOE
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1.5±9.6±2.9	13k	AMBROSINO	06E	KLOE

[1] ANASTASI 18A result is a combination of the new measurement and AMBROSINO 06E. The new ANASTASI 18A measurement using data collected from 2004–2005, which corresponds to an integrated luminosity of 1.63 fb^{-1} is $A_S = (-4.9 \pm 5.7 \pm 2.6) \times 10^{-3}$.

NODE=S012AS;LINKAGE=B

PARAMETERS FOR $K^0_S \to 3\pi$ DECAY

NODE=S012220

$\mathrm{Im}(\eta_{+-0})^2$ = $\Gamma(K^0_S \to \pi^+\pi^-\pi^0$, *CP*-violating) / $\Gamma(K^0_L \to \pi^+\pi^-\pi^0)$

NODE=S012ET+

CPT assumed valid (i.e. $\mathrm{Re}(\eta_{+-0}) \simeq 0$).

NODE=S012ET+
NODE=S012ET+

VALUE	CL%	EVTS	DOCUMENT ID		TECN
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<0.23	90	601	[1] BARMIN	85	HLBC
<0.12	90	384	METCALF	72	ASPK

[1] BARMIN 85 find $\mathrm{Re}(\eta_{+-0}) = (0.05 \pm 0.17)$ and $\mathrm{Im}(\eta_{+-0}) = (0.15 \pm 0.33)$. Includes events of BALDO-CEOLIN 75.

NODE=S012ET+;LINKAGE=B

Im(η_{+-0}) = Im(A($K^0_S \to \pi^+\pi^-\pi^0$, CP-violating) / A($K^0_L \to \pi^+\pi^-\pi^0$))

NODE=S012E+
NODE=S012E+

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
$-0.002 \pm 0.009^{+0.002}_{-0.001}$	500k	[1] ADLER	97B	CPLR	
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$-0.002 \pm 0.018 \pm 0.003$	137k	[2] ADLER	96D	CPLR	Sup. by ADLER 97B
$-0.015 \pm 0.017 \pm 0.025$	272k	[3] ZOU	94	SPEC	

[1] ADLER 97B also find Re(η_{+-0}) $= -0.002 \pm 0.007^{+0.004}_{-0.001}$. See also ANGELOPOULOS 98C. NODE=S012E+;LINKAGE=C

[2] The ADLER 96D fit also yields Re(η_{+-0}) $= 0.006 \pm 0.013 \pm 0.001$ with a correlation $+0.66$ between real and imaginary parts. Their results correspond to $|\eta_{+-0}| < 0.037$ with 90% CL. NODE=S012E+;LINKAGE=B

[3] ZOU 94 use theoretical constraint Re(η_{+-0}) = Re(ϵ) = 0.0016. Without this constraint they find Im(η_{+-0}) $= 0.019 \pm 0.061$ and Re(η_{+-0}) $= 0.019 \pm 0.027$. NODE=S012E+;LINKAGE=A

Im(η_{000})^2 = Γ($K^0_S \to 3\pi^0$) / Γ($K^0_L \to 3\pi^0$)

NODE=S012ET0

CPT assumed valid (i.e. Re(η_{000}) $\simeq$ 0). This limit determines branching ratio $\Gamma(3\pi^0)/\Gamma_{total}$ above. NODE=S012ET0

NODE=S012ET0

VALUE	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •						
<0.1	90	632	[1] BARMIN	83	HLBC	
<0.28	90		[2] GJESDAL	74B	SPEC	Indirect meas.

[1] BARMIN 83 find Re(η_{000}) $= (-0.08 \pm 0.18)$ and Im(η_{000}) $= (-0.05 \pm 0.27)$. Assuming *CPT* invariance they obtain the limit quoted above. NODE=S012ET0;LINKAGE=B

[2] GJESDAL 74B uses $K2\pi$, $K_{\mu 3}$, and K_{e3} decay results, unitarity, and *CPT*. Calculates $|(\eta_{000})| = 0.26 \pm 0.20$. We convert to upper limit. NODE=S012ET0;LINKAGE=G

Im(η_{000}) = Im($A(K^0_S \to \pi^0\pi^0\pi^0)/A(K^0_L \to \pi^0\pi^0\pi^0)$)

NODE=S012E0

$K^0_S \to \pi^0\pi^0\pi^0$ violates *CP* conservation, in contrast to $K^0_S \to \pi^+\pi^-\pi^0$ which has a *CP*-conserving part. NODE=S012E0

NODE=S012E0

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
-0.001 ± 0.016 OUR AVERAGE					
$0.000 \pm 0.009 \pm 0.013$	4.9M	[1] LAI	05A	NA48	Assumes *CPT*
$-0.05 \pm 0.12 \pm 0.05$	17300	[2] ANGELOPO...	98B	CPLR	Assumes *CPT*

[1] LAI 05A assumes Re(η_{000})=Re(ϵ)=1.66 $\times$ 10^{-3}. The equivalent limit is $|\eta_{000}|_{CPT}$ <0.025 at 90% CL Without assuming *CPT* invariance, they obtain Re(η_{000})=$-0.002 \pm 0.011 \pm 0.015$ and Im(η_{000})=$-0.003 \pm 0.013 \pm 0.017$ with a statistical correlation coefficient of 0.77 and an overall correlation coefficient of 0.57 between imaginary and real part. The equivalent limit is $|\eta_{000}|$ <0.045 at 90% CL NODE=S012E0;LINKAGE=LA

[2] ANGELOPOULOS 98B assumes Re(η_{000}) = Re(ϵ) = 1.635×10^{-3}. Without assuming *CPT* invariance, they obtain Re(η_{000}) $= 0.18 \pm 0.14 \pm 0.06$ and Im(η_{000}) $= 0.15 \pm 0.20 \pm 0.03$. NODE=S012E0;LINKAGE=A

$|\eta_{000}|$ = $|A(K^0_S \to 3\pi^0)/A(K^0_L \to 3\pi^0)|$

NODE=S012AE0

A non-zero value violates CP invariance. NODE=S012AE0

NODE=S012AE0

VALUE	CL%	EVTS	DOCUMENT ID		TECN
<0.0088	90	590M	BABUSCI	13C	KLOE
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<0.018	90	37.8M	AMBROSINO	05B	KLOE
<0.045	90	4.9M	LAI	05A	NA48

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

NODE=S012230

This is the *CP*-violating asymmetry NODE=S012230

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

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

CP asymmetry *A* in $K^0_S \to \pi^+\pi^-e^+e^-$

NODE=S012DPA
NODE=S012DPA

VALUE (%)	DOCUMENT ID		TECN	COMMENT
-0.4 ± 0.8 OUR AVERAGE				
-0.4 ± 0.8	[1] BATLEY	11	NA48	2002 data
-1.1 ± 4.1	LAI	03C	NA48	1998+1999 data
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$0.5 \pm 4.0 \pm 1.6$	LAI	03C	NA48	1999 data

OCCUR=2

[1] The result is used to set the limit $A < 1.5\%$ at 90% C.L. NODE=S012DPA;LINKAGE=BA

K^0_S REFERENCES

NODE=S012

AAIJ	23AE	PR D108 L031102	R. Aaij *et al.*	(LHCb Collab.)	REFID=62337
BABUSCI	23	JHEP 2302 098	D. Babusci *et al.*	(KLOE-2 Collab.)	REFID=62108
AAIJ	20AE	PRL 125 231801	R. Aaij *et al.*	(LHCb Collab.)	REFID=60699
BABUSCI	20	PL B804 135378	D. Babusci *et al.*	(KLOE-2 Collab.)	REFID=60393
ANASTASI	18A	JHEP 1809 021	A. Anastasi *et al.*	(KLOE-2 Collab.)	REFID=59251
PDG	18	PR D98 030001	M. Tanabashi *et al.*	(PDG Collab.)	REFID=59304
AAIJ	17BQ	EPJ C77 678	R. Aaij *et al.*	(LHCb Collab.)	REFID=58357
PDG	16	CP C40 100001	C. Patrignani *et al.*	(PDG Collab.)	REFID=57140
AAIJ	13G	JHEP 1301 090	R. Aaij *et al.*	(LHCb Collab.)	REFID=54858
BABUSCI	13C	PL B723 54	D. Babusci *et al.*	(KLOE-2 Collab.)	REFID=55083
ABOUZAID	11	PR D83 092001	E. Abouzaid *et al.*	(FNAL KTeV Collab.)	REFID=53712
AMBROSINO	11	EPJ C71 1604	F. Ambrosino *et al.*	(KLOE Collab.)	REFID=16403
BATLEY	11	PL B694 301	J.R. Batley *et al.*	(CERN NA48/1 Collab.)	REFID=53568
AMBROSINO	09A	PL B672 203	F. Ambrosino *et al.*	(KLOE Collab.)	REFID=52835
AMBROSINO	08C	JHEP 0805 051	F. Ambrosino *et al.*	(KLOE Collab.)	REFID=52321
ANDRE	07	ANP 322 2518	T. Andre	(EFI)	REFID=50524
BATLEY	07D	PL B653 145	J.R. Batley *et al.*	(CERN NA48 Collab.)	REFID=51876
AMBROSINO	06C	EPJ C48 767	F. Ambrosino *et al.*	(KLOE Collab.)	REFID=51068
AMBROSINO	06E	PL B636 173	F. Ambrosino *et al.*	(KLOE Collab.)	REFID=51073
AMBROSINO	05B	PL B619 61	F. Ambrosino *et al.*	(KLOE Collab.)	REFID=50682
BATLEY	05	PL B630 31	J.R. Batley *et al.*	(NA48 Collab.)	REFID=50953
LAI	05A	PL B610 165	A. Lai *et al.*	(CERN NA48 Collab.)	REFID=50597
ALEXOPOU...	04A	PR D70 092007	T. Alexopoulos *et al.*	(FNAL KTeV Collab.)	REFID=50243
BATLEY	04A	PL B599 197	J.R. Batley *et al.*	(NA48 Collab.)	REFID=50127
LAI	04	PL B578 276	A. Lai *et al.*	(CERN NA48 Collab.)	REFID=49654
PDG	04	PL B592 1	S. Eidelman *et al.*	(PDG Collab.)	REFID=49653
ALAVI-HARATI	03	PR D67 012005	A. Alavi-Harati *et al.*	(FNAL KTeV Collab.)	REFID=49244
Also		PR D70 079904 (errat.)	A. Alavi-Harati *et al.*	(FNAL KTeV Collab.)	REFID=50236
BATLEY	03	PL B576 43	J.R. Batley *et al.*	(CERN NA48 Collab.)	REFID=49534
LAI	03	PL B551 7	A. Lai *et al.*	(CERN NA48 Collab.)	REFID=49148
LAI	03B	PL B556 105	A. Lai *et al.*	(CERN NA48 Collab.)	REFID=49257
LAI	03C	EPJ C30 33	A. Lai *et al.*	(CERN NA48 Collab.)	REFID=49502
ALOISIO	02	PL B535 37	A. Aloisio *et al.*	(KLOE Collab.)	REFID=48727
ALOISIO	02B	PL B538 21	A. Aloisio *et al.*	(KLOE Collab.)	REFID=48770
LAI	02C	PL B537 28	A. Lai *et al.*	(CERN NA48 Collab.)	REFID=48765
LAI	01	PL B514 253	A. Lai *et al.*	(CERN NA48 Collab.)	REFID=48191
LAI	00	PL B493 29	A. Lai *et al.*	(CERN NA48 Collab.)	REFID=47830
LAI	00B	PL B496 137	A. Lai *et al.*	(CERN NA48 Collab.)	REFID=47921
PDG	00	EPJ C15 1	D.E. Groom *et al.*	(PDG Collab.)	REFID=47469
ACHASOV	99D	PL B459 674	M.N. Achasov *et al.*		REFID=47048
AKHMETSHIN	99	PL B456 90	R.R. Akhmetshin *et al.*	(Novosibirsk CMD-2 Collab.)	REFID=47032
ANGELOPO...	98B	PL B425 391	A. Angelopoulos *et al.*	(CPLEAR Collab.)	REFID=46084
ANGELOPO...	98C	EPJ C5 389	A. Angelopoulos *et al.*	(CPLEAR Collab.)	REFID=46264
PDG	98	EPJ C3 1	C. Caso *et al.*	(PDG Collab.)	REFID=45838
ADLER	97B	PL B407 193	R. Adler *et al.*	(CPLEAR Collab.)	REFID=45617
ANGELOPO...	97	PL B413 232	A. Angelopoulos *et al.*	(CPLEAR Collab.)	REFID=45750
BERTANZA	97	ZPHY C73 629	L. Bertanza	(PISA, CERN, EDIN, MAINZ, ORSAY+)	REFID=45296
ADLER	96D	PL B370 167	R. Adler *et al.*	(CPLEAR Collab.)	REFID=44839
ADLER	96E	PL B374 313	R. Adler *et al.*	(CPLEAR Collab.)	REFID=44892
ZOU	96	PL B369 362	Y. Zou *et al.*	(RUTG, MINN, MICH)	REFID=44835
BARR	95B	PL B351 579	G.D. Barr *et al.*	(CERN, EDIN, MAINZ, LALO+)	REFID=44282
SCHWINGEN...	95	PRL 74 4376	B. Schwingenheuer *et al.*	(EFI, CHIC+)	REFID=44259
BLICK	94	PL B334 234	A.M. Blick *et al.*	(SERP, JINR)	REFID=43957
THOMSON	94	PL B337 411	G.B. Thomson *et al.*	(RUTG, MINN, MICH)	REFID=44020
ZOU	94	PL B329 519	Y. Zou *et al.*	(RUTG, MINN, MICH)	REFID=43893
BARR	93B	PL B304 381	G.D. Barr *et al.*	(CERN, EDIN, MAINZ, LALO+)	REFID=43338
GIBBONS	93	PRL 70 1199	L.K. Gibbons *et al.*	(FNAL E731 Collab.)	REFID=43209
Also		PR D55 6625	L.K. Gibbons *et al.*	(FNAL E731 Collab.)	REFID=45465
RAMBERG	93	PRL 70 2525	E. Ramberg *et al.*	(FNAL E731 Collab.)	REFID=43263
BALATS	89	SJNP 49 828	M.Y. Balats *et al.*	(ITEP)	REFID=40977
		Translated from YAF 49 1332.			
GIBBONS	88	PRL 61 2661	L.K. Gibbons *et al.*	(FNAL E731 Collab.)	REFID=40624
BURKHARDT	87	PL B199 139	H. Burkhardt *et al.*	(CERN, EDIN, MAINZ+)	REFID=40237
GROSSMAN	87	PRL 59 18	N. Grossman *et al.*	(MINN, MICH, RUTG)	REFID=40230
BARMIN	86	SJNP 44 622	V.V. Barmin *et al.*	(ITEP)	REFID=40228
		Translated from YAF 44 965.			
BARMIN	86B	NC 96A 159	V.V. Barmin *et al.*	(ITEP, PADO)	REFID=40231
PDG	86B	PL 170B 130	M. Aguilar-Benitez *et al.*	(CERN, CIT+)	REFID=41168
BARMIN	85	NC 85A 67	V.V. Barmin *et al.*	(ITEP, PADO)	REFID=11119
Also		SJNP 41 759	V.V. Barmin *et al.*	(ITEP)	REFID=11120
		Translated from YAF 41 1187.			
BARMIN	83	PL 128B 129	V.V. Barmin *et al.*	(ITEP, PADO)	REFID=11117
Also		SJNP 39 269	V.V. Barmin *et al.*	(ITEP, PADO)	REFID=11118
		Translated from YAF 39 428.			
ARONSON	82	PRL 48 1078	S.H. Aronson *et al.*	(BNL, CHIC, STAN+)	REFID=11411
ARONSON	82B	PRL 48 1306	S.H. Aronson *et al.*	(BNL, CHIC, PURD)	REFID=11401
Also		PL 116B 73	E. Fischbach *et al.*	(PURD, BNL, CHIC)	REFID=11402
Also		PR D28 476	S.H. Aronson *et al.*	(BNL, CHIC, PURD)	REFID=11403
Also		PR D28 495	S.H. Aronson *et al.*	(BNL, CHIC, PURD)	REFID=11404
ARONSON	76	NC 32A 236	S.H. Aronson *et al.*	(WISC, EFI, UCSD+)	REFID=11110
EVERHART	76	PR D14 661	G.C. Everhart *et al.*	(PENN)	REFID=11111
TAUREG	76	PL 65B 92	H. Taureg *et al.*	(HEIDH, CERN, DORT)	REFID=11112
BALDO-...	75	NC 25A 688	M. Baldo-Ceolin *et al.*	(PADO, WISC)	REFID=11108
CARITHERS	75	PRL 34 1244	W.C.J. Carithers *et al.*	(COLU, NYU)	REFID=11109
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HILL	73	PR D8 1290	D.G. Hill *et al.*	(BNL, CMU)	REFID=11102
ALITTI	72	PL 39B 568	J. Alitti, E. Lesquoy, A. Muller	(SACL)	REFID=11088
BURGUN	72	NP B50 194	G. Burgun *et al.*	(SACL, CERN, OSLO)	REFID=11306
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Also		Thesis Nevis 187	W.A. Cooper	(COLU)	REFID=11083
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DOYLE	69	Thesis UCRL 18139	J.C. Doyle	(LRL)	REFID=11074
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