K^0_S

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

K^0_S MEAN LIFE

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.

VALUE (10^{-10} s)	EVTS	DOCUMENT ID		TECN	COMMENT
0.8953 ±0.0006 OUR FIT	Error includes scale factor of 1.4. Assuming *CPT*				
0.8958 ±0.0006 OUR FIT	Error includes scale factor of 1.2. Not assuming *CPT*				
0.8965 ±0.0007		[1,2] ALAVI-HARATI	03	KTEV	Assuming *CPT*
0.8958 ±0.0013		[2,3] ALAVI-HARATI	03	KTEV	Not assuming *CPT*
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*
0.8929 ±0.0016		GIBBONS	93	E731	Assuming *CPT*
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.8920 ±0.0044	214k	GROSSMAN	87	SPEC	
0.905 ±0.007		[4] ARONSON	82B	SPEC	
0.881 ±0.009	26k	ARONSON	76	SPEC	
0.8926 ±0.0032 ±0.0002		[5] CARITHERS	75	SPEC	
0.8937 ±0.0048	6M	GEWENIGER	74B	ASPK	
0.8958 ±0.0045	50k	[6] SKJEGGEST...	72	HBC	
0.856 ±0.008	19994	[7] DONALD	68B	HBC	
0.872 ±0.009	20000	[7,8] HILL	68	DBC	

[1] 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 $\rho(\tau_S,\Delta m) = -0.396$.

[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.

[3] 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.

[4] ARONSON 82 find that K^0_S mean life may depend on the kaon energy.

[5] 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 ($\Delta m = 0.5292 \pm 0.0010$) ($10^{10}\ \hbar\ \mathrm{s}^{-1}$). Our first error is their experiment's error and our second error is the systematic error from using our best values.

[6] 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.

[7] Pre-1971 experiments are excluded from the average because of disagreement with later more precise experiments.

[8] 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.

K^0_S DECAY MODES

	Mode			Fraction (Γ_i/Γ)	Scale factor/ Confidence level
	Hadronic modes				
Γ_1	$\pi^0\pi^0$			(31.05 ± 0.14) %	S=1.1
Γ_2	$\pi^+\pi^-$			(68.95 ± 0.14) %	S=1.1
Γ_3	$\pi^+\pi^-\pi^0$			$(3.2\ ^{+1.2}_{-1.0}) \times 10^{-7}$	
	Modes with photons or $\ell\overline{\ell}$ pairs				
Γ_4	$\pi^+\pi^-\gamma$		[a,b]	$(1.79\pm0.05) \times 10^{-3}$	
Γ_5	$\pi^+\pi^-e^+e^-$			$(4.69\pm0.30) \times 10^{-5}$	
Γ_6	$\pi^0\gamma\gamma$		[b]	$(4.9\ \pm1.8\ ) \times 10^{-8}$	
Γ_7	$\gamma\gamma$			$(2.80\pm0.07) \times 10^{-6}$	
	Semileptonic modes				
Γ_8	$\pi^\pm e^\mp \nu_e$		[c]	$(6.9\ \pm0.4\ ) \times 10^{-4}$	
Γ_9	$\pi^\pm \mu^\mp \nu_\mu$		[c]		
	***CP* violating (*CP*) and $\Delta S = 1$ weak neutral current (*S1*) modes**				
Γ_{10}	$3\pi^0$	*CP*		$< 1.4 \times 10^{-5}$	CL=90%
Γ_{11}	$\mu^+\mu^-$	*S1*		$< 3.2 \times 10^{-7}$	CL=90%
Γ_{12}	e^+e^-	*S1*		$< 1.4 \times 10^{-7}$	CL=90%
Γ_{13}	$\pi^0 e^+ e^-$	*S1*	[b]	$(3.0\ ^{+1.5}_{-1.2}) \times 10^{-9}$	
Γ_{14}	$\pi^0 \mu^+ \mu^-$	*S1*		$(2.9\ ^{+1.5}_{-1.2}) \times 10^{-9}$	

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

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

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

CONSTRAINED FIT INFORMATION

An overall fit to 3 branching ratios uses 14 measurements and one constraint to determine 2 parameters. The overall fit has a $\chi^2 =$ 18.8 for 13 degrees of freedom.

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

x_2	−100
	x_1

K^0_S DECAY RATES

$\Gamma(\pi^\pm e^\mp \nu_e)$ — Γ_8

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	[9] AKHMETSHIN	99	CMD2	Tagged K^0_S using $\phi \to K^0_L K^0_S$
7.50±0.08		[10] PDG	98		
seen		BURGUN	72	HBC	$K^+ p \to K^0 p \pi^+$
9.3 ±2.5		AUBERT	65	HLBC	$\Delta S = \Delta Q$, CP cons. not assumed

[9] 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.

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

$\Gamma(\pi^\pm \mu^\mp \nu_\mu)$ — Γ_9

VALUE (10^6 s^{-1})	DOCUMENT ID	
• • • We do not use the following data for averages, fits, limits, etc. • • •		
5.25±0.07	[11] PDG	98

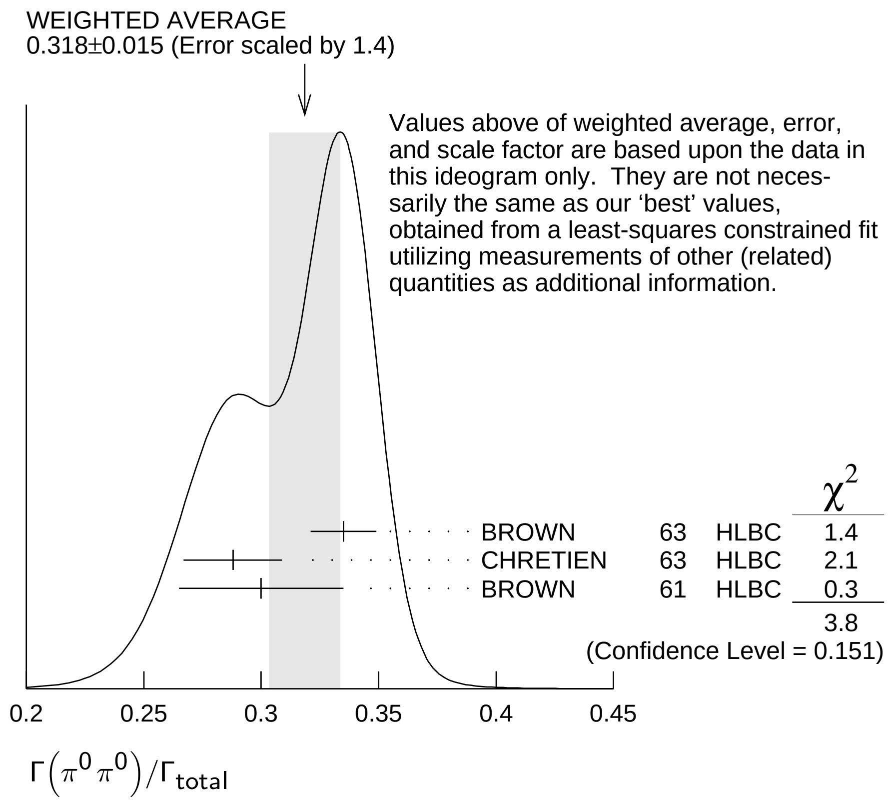
[11] PDG 98 from K^0_L measurements, assuming that $\Delta S = \Delta Q$ in K^0 decay so that $\Gamma(K^0_S \to \pi^\pm \mu^\mp \nu_\mu) = \Gamma(K^0_L \to \pi^\pm \mu^\mp \nu_\mu)$.

K^0_S BRANCHING RATIOS

Hadronic modes

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

VALUE	EVTS	DOCUMENT ID		TECN
0.3105±0.0014 OUR FIT Error includes scale factor of 1.1.				
0.318 ±0.015 OUR AVERAGE Error includes scale factor of 1.4. See the ideogram below.				
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

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.6895±0.0014 OUR FIT Error includes scale factor of 1.1.					
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

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
2.221±0.014 OUR FIT Error includes scale factor of 1.1.					
2.225±0.014 OUR AVERAGE Error includes scale factor of 1.1.					
2.236±0.003±0.015	766k	ALOISIO	02B	KLOE	Incl. Rad. Decays $(\pi^+\pi^-\gamma)$
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	[12] 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	[13] NAGY	72	HLBC	$K^+ n \to K^0 p$
2.22 ± 0.095	6150	[14] BALTAY	71	HBC	$K p \to K^0$ neutrals
2.282 ± 0.043	7944	[15] MOFFETT	70	OSPK	$K^+ n \to K^0 p$
2.10 ± 0.06	3700	MORFIN	69	HLBC	$K^+ n \to K^0 p$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
2.12 ± 0.17	267	[13] BOZOKI	69	HLBC	
2.285 ± 0.055	3016	[15] GOBBI	69	OSPK	$K^+ n \to K^0 p$

[12] The directly measured quantity is $K^0_S \to \pi^+\pi^-/\text{all } K^0 = 0.345 \pm 0.005$.
[13] NAGY 72 is a final result which includes BOZOKI 69.
[14] The directly measured quantity is $K^0_S \to \pi^+\pi^-/\text{all } \overline{K}^0 = 0.345 \pm 0.005$.
[15] MOFFETT 70 is a final result which includes GOBBI 69.

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

VALUE (units 10^{-7})	EVTS	DOCUMENT ID		TECN	COMMENT
$3.2^{+1.2}_{-1.0}$ OUR AVERAGE					
$2.5^{+1.3}_{-1.0}{}^{+0.5}_{-0.6}$	500k	[16] ADLER	97B	CPLR	
$4.8^{+2.2}_{-1.6} \pm 1.1$		[17] ZOU	96	E621	
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$4.1^{+2.5}_{-1.9}{}^{+0.5}_{-0.6}$		[18] ADLER	96E	CPLR	Sup. by ADLER 97B
$3.9^{+5.4}_{-1.8}{}^{+0.9}_{-0.7}$		[19] THOMSON	94	E621	Sup. by ZOU 96

[16] ADLER 97B find the *CP*-conserving parameters $\text{Re}(\lambda) = (28 \pm 7 \pm 3) \times 10^{-3}$, $\text{Im}(\lambda) = (-10 \pm 8 \pm 2) \times 10^{-3}$. They estimate $\text{B}(K^0_S \to \pi^+\pi^-\pi^0)$ from $\text{Re}(\lambda)$ and the K^0_L decay parameters. See also ANGELOPOULOS 98C.
[17] ZOU 96 is from the the measured quantities $|\rho_{+-0}| = 0.039^{+0.009}_{-0.006} \pm 0.005$ and $\phi_\rho = (-9 \pm 18)^\circ$.
[18] ADLER 96E is from the measured quantities $\text{Re}(\lambda) = 0.036 \pm 0.010^{+0.002}_{-0.003}$ and $\text{Im}(\lambda)$ consistent with zero. Note that the quantity λ is the same as ρ_{+-0} used in other footnotes.
[19] 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 $|\rho_{+-0}| e^{i\phi_\rho} = \text{A}(K^0_S \to \pi^+\pi^-\pi^0, I = 2)/\text{A}(K^0_L \to \pi^+\pi^-\pi^0)$.

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

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

VALUE (units 10^{-3})	EVTS	DOCUMENT ID		TECN	COMMENT
2.60 ± 0.08 OUR AVERAGE					
2.56 ± 0.09	1286	RAMBERG	93	E731	$p_\gamma > 50$ MeV/c
2.68 ± 0.15		[20] TAUREG	76	SPEC	$p_\gamma > 50$ MeV/c
2.8 ± 0.6		[21] BURGUN	73	HBC	$p_\gamma > 50$ MeV/c
• • • We do not use the following data for averages, fits, limits, etc. • • •					
7.10 ± 0.22	3723	RAMBERG	93	E731	$p_\gamma > 20$ MeV/c
3.0 ± 0.6	29	[22] BOBISUT	74	HLBC	$p_\gamma > 40$ MeV/c

[20] TAUREG 76 find direct emission contribution <0.06, CL = 90%.
[21] BURGUN 73 estimates that direct emission contribution is 0.3 ± 0.6.
[22] BOBISUT 74 not included in average because p_γ cut differs. Estimates direct emission contribution to be 0.5 or less, CL = 95%.

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

VALUE (units 10^{-5})	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
4.69±0.30	676	[23] 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	[23,24] LAI	03C	NA48	1999 data
4.5 ±0.7 ±0.4	56	LAI	00B	NA48	1998 data

[23] Uses normalization $\text{BR}(K_L \to \pi^+\pi^-\pi^0)$*$\text{BR}(\pi^0 \to e^+e^-) = (1.505 \pm 0.047) \times 10^{-3}$ from our 2000 Edition.
[24] Second error is 0.16(syst)±0.15(norm) combined in quadrature.

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

VALUE (units 10^{-8})	*CL%*	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
4.9±1.6±0.9		17	[25] 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	$m^2_{\gamma\gamma}/m^2_K > 0.2$

[25] Spectrum also measured and found consistent with the one generated by a constant matrix element.

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

VALUE (units 10^{-6})	*CL%*	*EVTS*	*DOCUMENT ID*		*TECN*
2.80±0.07 OUR AVERAGE					
2.81±0.07±0.01		7.5k	[26] LAI	03	NA48
2.58±0.36±0.22		149	LAI	00	NA48
2.4 ±0.9		35	[27] BARR	95B	NA31
• • • We do not use the following data for averages, fits, limits, etc. • • •					
2.2 ±1.1		16	[28] BARR	95B	NA31
< 13	90		BALATS	89	SPEC
2.4 ±1.2		19	BURKHARDT	87	NA31
<133	90		BARMIN	86B	XEBC

[26] LAI 03 reports $(2.78 \pm 0.06 \pm 0.04) \times 10^{-6}$ for $\text{B}(K^0_S \to \pi^0\pi^0) = (31.39 \pm 0.28) \times 10^{-2}$. We rescale to our best value $\text{B}(K^0_S \to \pi^0\pi^0) = (31.05 \pm 0.14) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.
[27] 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.
[28] BARR 95B result is calculated using $\text{B}(K_L \to \gamma\gamma) = (5.86 \pm 0.17) \times 10^{-4}$.

Semileptonic modes

$\Gamma(\pi^{\pm} e^{\mp} \nu_e)/\Gamma_{total}$ — Γ_8/Γ

VALUE (units 10^{-4})	EVTS	DOCUMENT ID		TECN	COMMENT
6.9 ±0.4 OUR AVERAGE					
6.91±0.34±0.15	624	[29] ALOISIO	02	KLOE	Tagged K^0_S using $\phi \to K^0_L K^0_S$
7.2 ±1.4	75	AKHMETSHIN	99	CMD2	Tagged K^0_S using $\phi \to K^0_L K^0_S$

[29] Uses the PDG 00 value for B($K^0_S \to \pi^+ \pi^-$).

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

$\Gamma(3\pi^0)/\Gamma_{total}$ — Γ_{10}/Γ

Violates *CP* conservation.

VALUE (units 10^{-5})	CL%	EVTS	DOCUMENT ID		TECN
<1.4	90	7M	ACHASOV	99D	SND
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<1.9	90	17300	[30] ANGELOPO...	98B	CPLR
<3.7	90		BARMIN	83	HLBC

[30] ANGELOPOULOS 98B is from Im(η_{000}) = $-0.05 \pm 0.12 \pm 0.05$, assuming Re(η_{000}) = Re(ϵ) = 1.635×10^{-3} and using the value B($K^0_L \to \pi^0 \pi^0 \pi^0$) = 0.2112 ± 0.0027.

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

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

VALUE (units 10^{-5})	CL%	DOCUMENT ID		TECN
<0.032	90	GJESDAL	73	ASPK
• • • We do not use the following data for averages, fits, limits, etc. • • •				
<0.7	90	HYAMS	69B	OSPK

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

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

VALUE (units 10^{-7})	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
< 1.4	90		ANGELOPO...	97	CPLR	
• • • We do not use the following data for averages, fits, limits, etc. • • •						
< 28	90	0	BLICK	94	CNTR	Hyperon facility
<100	90		BARMIN	86	XEBC	

$\Gamma(\pi^0 e^+ e^-)/\Gamma_{total}$ — Γ_{13}/Γ

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

VALUE (units 10^{-9})	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
$\mathbf{3.0^{+1.5}_{-1.2} \pm 0.2}$		7	[31] 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

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

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

VALUE (units 10^{-9})	EVTS	DOCUMENT ID		TECN	COMMENT
$2.9^{+1.5}_{-1.2}\pm0.2$	6	[32] BATLEY	04A	NA48	NA48/1 K^0_S beam

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

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CP-VIOLATION PARAMETERS IN K^0_S DECAY

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

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

VALUE	CL%	EVTS	DOCUMENT ID		TECN
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<0.23	90	601	[33] BARMIN	85	HLBC
<0.12	90	384	METCALF	72	ASPK

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

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

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
$-0.002\pm0.009^{+0.002}_{-0.001}$	500k	[34] ADLER	97B	CPLR	
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$-0.002\pm0.018\pm0.003$	137k	[35] ADLER	96D	CPLR	Sup. by ADLER 97B
$-0.015\pm0.017\pm0.025$	272k	[36] ZOU	94	SPEC	

[34] ADLER 97B also find $\text{Re}(\eta_{+-0}) = -0.002 \pm 0.007^{+0.004}_{-0.001}$. See also ANGELOPOULOS 98C.

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

[36] ZOU 94 use theoretical constraint $\text{Re}(\eta_{+-0}) = \text{Re}(\epsilon) = 0.0016$. Without this constraint they find $\text{Im}(\eta_{+-0}) = 0.019 \pm 0.061$ and $\text{Re}(\eta_{+-0}) = 0.019 \pm 0.027$.

$\mathrm{Im}(\eta_{000})^2 = \Gamma(K^0_S \to 3\pi^0) / \Gamma(K^0_L \to 3\pi^0)$

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

VALUE	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •						
<0.1	90	632	[37] BARMIN	83	HLBC	
<0.28	90		[38] GJESDAL	74B	SPEC	Indirect meas.

[37] BARMIN 83 find $\mathrm{Re}(\eta_{000}) = (-0.08 \pm 0.18)$ and $\mathrm{Im}(\eta_{000}) = (-0.05 \pm 0.27)$. Assuming *CPT* invariance they obtain the limit quoted above.

[38] GJESDAL 74B uses $K2\pi$, $K_{\mu3}$, and K_{e3} decay results, unitarity, and *CPT*. Calculates $|(\eta_{000})| = 0.26 \pm 0.20$. We convert to upper limit.

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

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

VALUE	EVTS	DOCUMENT ID		TECN
−0.05±0.12±0.05	17300	[39] ANGELOPO...	98B	CPLR

[39] ANGELOPOULOS 98B assumes $\mathrm{Re}(\eta_{000}) = \mathrm{Re}(\epsilon) = 1.635 \times 10^{-3}$. Without assuming *CPT* invariance, they obtain $\mathrm{Re}(\eta_{000}) = 0.18 \pm 0.14 \pm 0.06$ and $\mathrm{Im}(\eta_{000}) = 0.15 \pm 0.20 \pm 0.03$.

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_S rest frame.

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

VALUE (%)	DOCUMENT ID		TECN	COMMENT
−1.1±4.1	LAI	03C	NA48	1998+1999 data
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.5±4.0±1.6	LAI	03C	NA48	1999 data

K^0_S REFERENCES

BATLEY	04A	PL B599 197	J.R. Batley *et al.*	(NA48 Collab.)
LAI	04	PL B578 276	A. Lai *et al.*	(CERN NA48 Collab.)
ALAVI-HARATI	03	PR D67 012005	A. Alavi-Harati *et al.*	(FNAL KTeV Collab.)
Also	04B	PR D70 079904(erratum)	A. Alavi-Harati *et al.*	(FNAL KTeV Collab.)
BATLEY	03	PL B576 43	J.R. Batley *et al.*	(CERN NA48 Collab.)
LAI	03	PL B551 7	A. Lai *et al.*	(CERN NA48 Collab.)
LAI	03B	PL B556 105	A. Lai *et al.*	(CERN NA48 Collab.)
LAI	03C	EPJ C30 33	A. Lai *et al.*	(CERN NA48 Collab.)
ALOISIO	02	PL B535 37	A. Aloisio *et al.*	(KLOE Collab.)
ALOISIO	02B	PL B538 21	A. Aloisio *et al.*	(KLOE Collab.)
LAI	02C	PL B537 28	A. Lai *et al.*	(CERN NA48 Collab.)
LAI	01	PL B514 253	A. Lai *et al.*	(CERN NA48 Collab.)
LAI	00	PL B493 29	A. Lai *et al.*	(CERN NA48 Collab.)
LAI	00B	PL B496 137	A. Lai *et al.*	(CERN NA48 Collab.)
PDG	00	EPJ C15 1	D.E. Groom *et al.*	
ACHASOV	99D	PL B459 674	M.N. Achasov *et al.*	

AKHMETSHIN	99	PL B456 90	R.R. Akhmetshin *et al.*	(Novosibirsk CMD-2 Collab.)
ANGELOPO...	98B	PL B425 391	A. Angelopoulos *et al.*	(CPLEAR Collab.)
ANGELOPO...	98C	EPJ C5 389	A. Angelopoulos *et al.*	(CPLEAR Collab.)
PDG	98	EPJ C3 1	C. Caso *et al.*	
ADLER	97B	PL B407 193	R. Adler *et al.*	(CPLEAR Collab.)
ANGELOPO...	97	PL B413 232	A. Angelopoulos *et al.*	(CPLEAR Collab.)
BERTANZA	97	ZPHY C73 629	L. Bertanza	(PISA, CERN, EDIN, MANZ, ORSAY+)
ADLER	96D	PL B370 167	R. Adler *et al.*	(CPLEAR Collab.)
ADLER	96E	PL B374 313	R. Adler *et al.*	(CPLEAR Collab.)
ZOU	96	PL B369 362	Y. Zou *et al.*	(RUTG, MINN, MICH)
BARR	95B	PL B351 579	G.D. Barr *et al.*	(CERN, EDIN, MANZ, LALO+)
SCHWINGEN...	95	PRL 74 4376	B. Schwingenheuer *et al.*	(EFI, CHIC+)
BLICK	94	PL B334 234	A.M. Blick *et al.*	(SERP, JINR)
THOMSON	94	PL B337 411	G.B. Thomson *et al.*	(RUTG, MINN, MICH)
ZOU	94	PL B329 519	Y. Zou *et al.*	(RUTG, MINN, MICH)
BARR	93B	PL B304 381	G.D. Barr *et al.*	(CERN, EDIN, MANZ, LALO+)
GIBBONS	93	PRL 70 1199	L.K. Gibbons *et al.*	(FNAL E731 Collab.)
Also	97	PR D55 6625	L.K. Gibbons *et al.*	(FNAL E731 Collab.)
RAMBERG	93	PRL 70 2525	E. Ramberg *et al.*	(FNAL E731 Collab.)
BALATS	89	SJNP 49 828	M.Y. Balats *et al.*	(ITEP)
		Translated from YAF 49 1332.		
GIBBONS	88	PRL 61 2661	L.K. Gibbons *et al.*	(FNAL E731 Collab.)
BURKHARDT	87	PL B199 139	H. Burkhardt *et al.*	(CERN, EDIN, MANZ+)
GROSSMAN	87	PRL 59 18	N. Grossman *et al.*	(MINN, MICH, RUTG)
BARMIN	86	SJNP 44 622	V.V. Barmin *et al.*	(ITEP)
		Translated from YAF 44 965.		
BARMIN	86B	NC 96A 159	V.V. Barmin *et al.*	(ITEP, PADO)
PDG	86B	PL 170B 130	M. Aguilar-Benitez *et al.*	(CERN, CIT+)
BARMIN	85	NC 85A 67	V.V. Barmin *et al.*	(ITEP, PADO)
Also	85B	SJNP 41 759	V.V. Barmin *et al.*	(ITEP)
		Translated from YAF 41 1187.		
BARMIN	83	PL 128B 129	V.V. Barmin *et al.*	(ITEP, PADO)
Also	84	SJNP 39 269	V.V. Barmin *et al.*	(ITEP, PADO)
		Translated from YAF 39 428.		
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)
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ARONSON	76	NC 32A 236	S.H. Aronson *et al.*	(WISC, EFI, UCSD+)
EVERHART	76	PR D14 661	G.C. Everhart *et al.*	(PENN)
TAUREG	76	PL 65B 92	H. Taureg *et al.*	(HEIDH, CERN, DORT)
BALDO-...	75	NC 25A 688	M. Baldo-Ceolin *et al.*	(PADO, WISC)
CARITHERS	75	PRL 34 1244	W.C.J. Carithers *et al.*	(COLU, NYU)
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COWELL	74	PR D10 2083	P.L. Cowell *et al.*	(STON, COLU)
GEWENIGER	74B	PL 48B 487	C. Geweniger *et al.*	(CERN, HEIDH)
GJESDAL	74B	PL 52B 119	S. Gjesdal *et al.*	(CERN, HEIDH)
BURGUN	73	PL 46B 481	G. Burgun *et al.*	(SACL, CERN)
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HILL	73	PR D8 1290	D.G. Hill *et al.*	(BNL, CMU)
ALITTI	72	PL 39B 568	J. Alitti, E. Lesquoy, A. Muller	(SACL)
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METCALF	72	PL 40B 703	M. Metcalf *et al.*	(CERN, IPN, WIEN)
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NAGY	72	NP B47 94	E. Nagy, F. Telbisz, G. Vesztergombi	(BUDA)
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Also	71	Thesis Nevis 187	W.A. Cooper	(COLU)
MOFFETT	70	BAPS 15 512	R. Moffett *et al.*	(ROCH)
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