NODE=S011

K^0

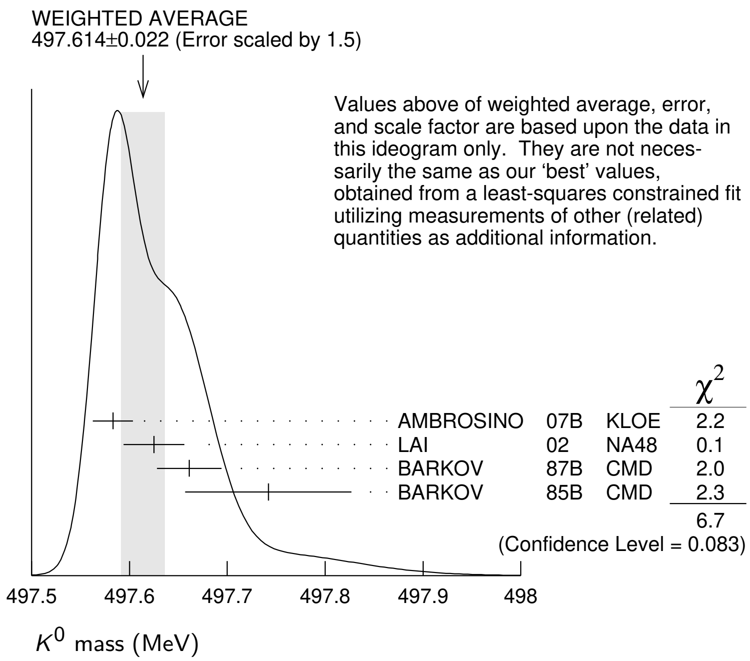
$I(J^P) = \frac{1}{2}(0^-)$

K^0 MASS

NODE=S011205

NODE=S011M

VALUE (MeV)	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
497.614±0.024 OUR FIT Error includes scale factor of 1.6.					
497.614±0.022 OUR AVERAGE Error includes scale factor of 1.5. See the ideogram below.					
497.583±0.005±0.020	35k	AMBROSINO	07B	KLOE	$e^+e^- \rightarrow K^0_L K^0_S$
497.625±0.001±0.031	655k	LAI	02	NA48	K^0_L beam
497.661±0.033	3713	BARKOV	87B	CMD	$e^+e^- \rightarrow K^0_L K^0_S$
497.742±0.085	780	BARKOV	85B	CMD	$e^+e^- \rightarrow K^0_L K^0_S$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
497.44 ±0.50		FITCH	67	OSPK	
498.9 ±0.5	4500	BALTAY	66	HBC	K^0 from $\overline{p}p$
497.44 ±0.33	2223	KIM	65B	HBC	K^0 from $\overline{p}p$
498.1 ±0.4		CHRISTENS...	64	OSPK	



$m_{K^0} - m_{K^\pm}$

NODE=S011210

NODE=S011DM

VALUE (MeV)	*EVTS*	*DOCUMENT ID*		*TECN*	*CHG*	*COMMENT*
3.937±0.028 OUR FIT Error includes scale factor of 1.8.						
• • • We do not use the following data for averages, fits, limits, etc. • • •						
3.95 ±0.21	417	HILL	68B	DBC	+	$K^+ d \rightarrow K^0 pp$
3.90 ±0.25	9	BURNSTEIN	65	HBC	−	
3.71 ±0.35	7	KIM	65B	HBC	−	$K^- p \rightarrow n\overline{K}^0$
5.4 ±1.1		CRAWFORD	59	HBC	+	
3.9 ±0.6		ROSENFELD	59	HBC	−	

K^0 MEAN SQUARE CHARGE RADIUS

NODE=S011220

NODE=S011SCR

VALUE (fm^2)	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
−0.077±0.010 OUR AVERAGE					
−0.077±0.007±0.011	5037	ABOUZAID	06	KTEV	$K^0_L \rightarrow \pi^+\pi^- e^+ e^-$
−0.090±0.021		LAI	03C	NA48	$K^0_L \rightarrow \pi^+\pi^- e^+ e^-$
−0.054±0.026		MOLZON	78		K_S regen. by electrons
• • • We do not use the following data for averages, fits, limits, etc. • • •					
−0.087±0.046		BLATNIK	79		VMD + dispersion relations
−0.050±0.130		FOETH	69B		K_S regen. by electrons

T-VIOLATION PARAMETER IN K^0-$\overline{K}^0$ MIXING

NODE=S011252

The asymmetry $A_T = \frac{\Gamma(\overline{K}^0 \to K^0) - \Gamma(K^0 \to \overline{K}^0)}{\Gamma(\overline{K}^0 \to K^0) + \Gamma(K^0 \to \overline{K}^0)}$ must vanish if T invariance holds.

NODE=S011252

ASYMMETRY A_T IN K^0-$\overline{K}^0$ MIXING

NODE=S011AT
NODE=S011AT

VALUE (units 10^{-3})	EVTS	DOCUMENT ID	TECN
6.6±1.3±1.0	640k	[1] ANGELOPO... 98E	CPLR

[1] ANGELOPOULOS 98E measures the asymmetry $A_T = [\Gamma(\overline{K}^0_{t=0} \to e^+ \pi^- \nu_{t=\tau}) - \Gamma(K^0_{t=0} \to e^- \pi^+ \overline{\nu}_{t=\tau})]/[\Gamma(\overline{K}^0_{t=0} \to e^+ \pi^- \nu_{t=\tau}) + \Gamma(K^0_{t=0} \to e^- \pi^+ \overline{\nu}_{t=\tau})]$ as a function of the neutral-kaon eigentime τ. The initial strangeness of the neutral kaon is tagged by the charge of the accompanying charged kaon in the reactions $p\overline{p} \to K^- \pi^+ K^0$ and $p\overline{p} \to K^+ \pi^- \overline{K}^0$. The strangeness at the time of the decay is tagged by the lepton charge. The reported result is the average value of A_T over the interval $1\tau_s < \tau < 20\tau_s$. From this value of A_T ANGELOPOULOS 01B, assuming CPT invariance in the $e\pi\nu$ decay amplitude, determine the T-violating as ΔS=ΔS conserving parameter (for its definition, see Review below) 4Re(ϵ) = $(6.2 \pm 1.4 \pm 1.0) \times 10^{-3}$. NODE=S011AT;LINKAGE=A

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NODE=S011254

CP-VIOLATION PARAMETERS

NODE=S011256

Re(ϵ)

NODE=S011REP
NODE=S011REP

VALUE (units 10^{-3})	DOCUMENT ID	TECN
1.596±0.013	[2] AMBROSINO 06H	KLOE
• • • We do not use the following data for averages, fits, limits, etc. • • •		
1.664±0.010	[3] LAI 05A	NA48

[2] AMBROSINO 06H uses Bell-Steinberger relations with the following measurements: B($K^0_L \to \pi^+\pi^-$) in AMBROSINO 06F, B($K^0_S \to \pi^0\pi^0\pi^0$) in AMBROSINO 05B, the K^0_S-semileptonic charge asymmetry in AMBROSINO 06E, and K^0-semileptonic results in ANGELOPOULOS 98F. NODE=S011REP;LINKAGE=AB

[3] LAI 05A values are obtained through unitarity (Bell-Steinberger relations), improving determination of η_{000} and combining other data from PDG 04 and APOSTOLAKIS 99B. NODE=S011REP;LINKAGE=LA

CPT-VIOLATION PARAMETERS

NODE=S011255

In K^0-$\overline{K}^0$ mixing, if CP-violating interactions include a T conserving part then NODE=S011255

$$|K_S\rangle = [|K_1\rangle + (\epsilon+\delta)|K_2\rangle]/\sqrt{1+|\epsilon+\delta|^2}$$
$$|K_L\rangle = [|K_2\rangle + (\epsilon-\delta)|K_1\rangle]/\sqrt{1+|\epsilon-\delta|^2}$$

where

$$|K_1\rangle = [|K^0\rangle + |\overline{K}^0\rangle]/\sqrt{2}$$
$$|K_2\rangle = [|K^0\rangle - |\overline{K}^0\rangle]/\sqrt{2}$$

and

$$|\overline{K}^0\rangle = CP|K^0\rangle.$$

The parameter δ specifies the CPT-violating part.

Estimates of δ are given below assuming the validity of the ΔS=ΔQ rule. See also THOMSON 95 for a test of CPT-symmetry conservation in K^0 decays using the Bell-Steinberger relation.

REAL PART OF δ

NODE=S011DRE
NODE=S011DRE
NODE=S011DRE

A nonzero value violates CPT invariance.

VALUE (units 10^{-4})	EVTS	DOCUMENT ID	TECN	COMMENT
2.3± 2.7		[4] AMBROSINO 06H	KLOE	
• • • We do not use the following data for averages, fits, limits, etc. • • •				
2.4± 2.8		[5] APOSTOLA... 99B	RVUE	
2.9± 2.6±0.6	1.3M	[6] ANGELOPO... 98F	CPLR	
180 ±200	6481	[7] DEMIDOV 95		$K_{\ell 3}$ reanalysis

[4] AMBROSINO 06H uses Bell-Steinberger relations with the following measurements: B($K^0_L \to \pi^+\pi^-$) in AMBROSINO 06F, B($K^0_S \to \pi^0\pi^0\pi^0$) in AMBROSINO 05B, the K^0_S-semileptonic charge asymmetry in AMBROSINO 06E, and K^0-semileptonic results in ANGELOPOULOS 98F. NODE=S011DRE;LINKAGE=AB

[5] APOSTOLAKIS 99B assumes only unitarity and combines CPLEAR and other results. NODE=S011DRE;LINKAGE=AP

[6] ANGELOPOULOS 98F use ΔS=ΔQ. If ΔS=ΔQ is not assumed, they find Reδ=$(3.0 \pm 3.3 \pm 0.6) \times 10^{-4}$. NODE=S011DRE;LINKAGE=B

[7] DEMIDOV 95 reanalyzes data from HART 73 and NIEBERGALL 74. NODE=S011DRE;LINKAGE=A

IMAGINARY PART OF δ NODE=S011DIM

A nonzero value violates CPT invariance. NODE=S011DIM

VALUE (units 10^{-5})	EVTS	DOCUMENT ID		TECN	COMMENT
0.4± 2.1		[8] AMBROSINO	06H	KLOE	
• • • We do not use the following data for averages, fits, limits, etc. • • •					
− 0.2± 2.0		[9] LAI	05A	NA48	
2.4± 5.0		[10] APOSTOLA...	99B	RVUE	
− 90 ± 290 ±100	1.3M	[11] ANGELOPO...	98F	CPLR	
2100 ±3700	6481	[12] DEMIDOV	95		$K_{\ell 3}$ reanalysis

NODE=S011DIM

[8] AMBROSINO 06H uses Bell-Steinberger relations with the following measurements: B($K^0_L \to \pi^+\pi^-$) in AMBROSINO 06F, B($K^0_S \to \pi^0\pi^0\pi^0$) in AMBROSINO 05B, the K^0_S-semileptonic charge asymmetry in AMBROSINO 06E, and K^0-semileptonic results in ANGELOPOULOS 98F. NODE=S011DIM;LINKAGE=AB

[9] LAI 05A values are obtained through unitarity (Bell-Steinberger relations), improving determination of η_{000} and combining other data from PDG 04 and APOSTOLAKIS 99B. NODE=S011DIM;LINKAGE=LA

[10] APOSTOLAKIS 99B assumes only unitarity and combines CPLEAR and other results. NODE=S011DIM;LINKAGE=AP

[11] If ΔS=ΔQ is not assumed, ANGELOPOULOS 98F finds Imδ=$(-15 \pm 23 \pm 3) \times 10^{-3}$. NODE=S011DIM;LINKAGE=B

[12] DEMIDOV 95 reanalyzes data from HART 73 and NIEBERGALL 74. NODE=S011DIM;LINKAGE=A

Re(y) NODE=S011YRE

A non-zero value would violate CPT invariance in $\Delta S = \Delta Q$ amplitude. Re(y) is the following combination of K_{e3} decay amplitudes: NODE=S011YRE

$$\mathrm{Re(y)} = \mathrm{Re}\Big(\frac{A(\overline{K}^0 \to e^-\pi^+\overline{\nu}_e)^* - A(K^0 \to e^+\pi^-\nu_e)}{A(\overline{K}^0 \to e^-\pi^+\overline{\nu}_e)^* + A(K^0 \to e^+\pi^-\nu_e)} \Big)$$

VALUE (units 10^{-3})	EVTS	DOCUMENT ID		TECN
0.4±2.5	13k	[13] AMBROSINO	06E	KLOE
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.3±3.1		[14] APOSTOLA...	99B	CPLR

NODE=S011YRE

[13] They use the PDG 04 for the K^0_L semileptonic charge asymmetry and PDG 04 (CP review, CPT NOT ASSUMED) for Re(ϵ). NODE=S011YRE;LINKAGE=AM

[14] Constrained by Bell-Steinberger (or unitarity) relation. NODE=S011YRE;LINKAGE=AP

Re(x−) NODE=S011XRM

A non-zero value would violate CPT invariance in decay amplitudes with $\Delta S \neq \Delta Q$. x_-, used here to define Re(x_-), and x_+, used below in the $\Delta S = \Delta Q$ section are the following combinations of K_{e3} decay amplitudes: NODE=S011XRM

$$x_\pm = \frac{1}{2}\Big(\frac{A(\overline{K}^0 \to \pi^- e^+ \nu_e)}{A(K^0 \to \pi^- e^+ \nu_e)} \pm \frac{A(K^0 \to \pi^+ e^- \overline{\nu}_e)^*}{A(\overline{K}^0 \to \pi^+ e^- \overline{\nu}_e)^*} \Big).$$

VALUE (units 10^{-3})	EVTS	DOCUMENT ID		TECN	COMMENT
−2.9± 2.0		[15] AMBROSINO	06H	KLOE	
• • • We do not use the following data for averages, fits, limits, etc. • • •					
−0.8± 2.5	13k	[16] AMBROSINO	06E	KLOE	
−0.5± 3.0		[17] APOSTOLA...	99B	CPLR	Strangeness tagged
2 ±13 ±3	650k	ANGELOPO...	98F	CPLR	Strangeness tagged

NODE=S011XRM

[15] AMBROSINO 06H uses Bell-Steinberger relations with the following measurements: B($K^0_L \to \pi^+\pi^-$) in AMBROSINO 06F, B($K^0_S \to \pi^0\pi^0\pi^0$) in AMBROSINO 05B, the K^0_S-semileptonic charge asymmetry in AMBROSINO 06E, and K^0-semileptonic results in ANGELOPOULOS 98F. NODE=S011XRM;LINKAGE=AB

[16] Uses PDG 04 for the K^0_L semileptonic charge asymmetry and Re(δ) from CPLEAR, ANGELOPOULOS 98F. NODE=S011XRM;LINKAGE=AM

[17] Constrained by Bell-Steinberger (or unitarity) relation. NODE=S011XRM;LINKAGE=AP

$\left| m_{K^0} - m_{\overline{K}^0} \right| / m_{\mathrm{average}}$ NODE=S011215

A test of CPT invariance. "Our Evaluation" is described in the "Tests of Conservation Laws" section. It assumes CPT invariance in the decay and neglects some contributions from decay channels other than $\pi\pi$. NODE=S011215

VALUE	CL%	DOCUMENT ID		TECN
<8 × 10^{-19}	90	PDG	08	
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$(-3 \pm 4) \times 10^{-18}$		[18] ANGELOPO...	99B	RVUE

NODE=S011DMM

[18] ANGELOPOULOS 99B assumes only unitarity and combines CPLEAR and other results. NODE=S011DMM;LINKAGE=AN

$(\Gamma_{K^0} - \Gamma_{\overline{K}^0})/m_{\text{average}}$ NODE=S011217

A test of *CPT* invariance. NODE=S011217

VALUE	DOCUMENT ID	TECN	
			NODE=S011DGM
(7.8±8.4) × 10^{-18}	[19] ANGELOPO... 99B	RVUE	

[19] ANGELOPOULOS 99B assumes only unitarity and combines CPLEAR with other results. Correlated with $(m_{K^0} - m_{\overline{K}^0})$ / m_{average} with a correlation coefficient of −0.95. NODE=S011DGM;LINKAGE=AN

TESTS OF $\Delta S = \Delta Q$ RULE NODE=S011260

Re(x_+) NODE=S011XRP

A non-zero value would violate the $\Delta S = \Delta Q$ rule in *CPT* conserving transitions. x_+ is defined above in the Re(x_-) section. NODE=S011XRP

VALUE (units 10^{-3})	EVTS	DOCUMENT ID	TECN	
				NODE=S011XRP
−0.9± 3.0 OUR AVERAGE				
−2 ±10		[20] BATLEY 07D	NA48	
−0.5± 3.6	13k	[21] AMBROSINO 06E	KLOE	
−1.8± 6.1		[22] ANGELOPO... 98D	CPLR	

[20] Result obtained from the measurement $\Gamma(K^0_S \to \pi e \nu) / \Gamma(K^0_L \to \pi e \nu) = 0.993 \pm 0.34$, neglecting possible *CPT* non-invariance and using PDG 06 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=S011XRP;LINKAGE=BA

[21] Re(x_+) can be shown to be equal to the following combination of rates: NODE=S011XRP;LINKAGE=AM

$$\mathrm{Re}(x_+) = \frac{1}{2}\,\frac{\Gamma(K^0_S \to \pi e \nu) - \Gamma(K^0_L \to \pi e \nu)}{\Gamma(K^0_S \to \pi e \nu) + \Gamma(K^0_L \to \pi e \nu)}$$

which is valid up to first order in terms violating *CPT* and/or the $\Delta S = \Delta Q$ rule.

[22] Obtained neglecting *CPT* violating amplitudes. NODE=S011XRP;LINKAGE=AN

K^0 REFERENCES NODE=S011

PDG	08	PL B667 1	C. Amsler *et al.*	(PDG Collab.)	REFID=52166
AMBROSINO	07B	JHEP 0712 073	F. Ambrosino *et al.*	(KLOE Collab.)	REFID=52111
BATLEY	07D	PL B653 145	J.R. Batley *et al.*	(CERN NA48 Collab.)	REFID=51876
ABOUZAID	06	PRL 96 101801	E. Abouzaid *et al.*	(KTeV Collab.)	REFID=51111
AMBROSINO	06E	PL B636 173	F. Ambrosino *et al.*	(KLOE Collab.)	REFID=51073
AMBROSINO	06F	PL B638 140	F. Ambrosino *et al.*	(KLOE Collab.)	REFID=51074
AMBROSINO	06H	JHEP 0612 011	F. Ambrosino *et al.*	(KLOE Collab.)	REFID=51654
PDG	06	JPG 33 1	W.-M. Yao *et al.*	(PDG Collab.)	REFID=51004
AMBROSINO	05B	PL B619 61	F. Ambrosino *et al.*	(KLOE Collab.)	REFID=50682
LAI	05A	PL B610 165	A. Lai *et al.*	(CERN NA48 Collab.)	REFID=50597
PDG	04	PL B592 1	S. Eidelman *et al.*		REFID=49653
LAI	03C	EPJ C30 33	A. Lai *et al.*	(CERN NA48 Collab.)	REFID=49502
LAI	02	PL B533 196	A. Lai *et al.*	(CERN NA48 Collab.)	REFID=48724
ANGELOPO...	01B	EPJ C22 55	A. Angelopoulos *et al.*	(CPLEAR Collab.)	REFID=48507
ANGELOPO...	99B	PL B471 332	A. Angelopoulos *et al.*	(CPLEAR Collab.)	REFID=47563
APOSTOLA...	99B	PL B456 297	A. Apostolakis *et al.*	(CPLEAR Collab.)	REFID=47035
ANGELOPO...	98D	PL B444 38	A. Angelopoulos *et al.*	(CPLEAR Collab.)	REFID=46539
Also		EPJ C22 55	A. Angelopoulos *et al.*	(CPLEAR Collab.)	REFID=48507
ANGELOPO...	98E	PL B444 43	A. Angelopoulos *et al.*	(CPLEAR Collab.)	REFID=46540
ANGELOPO...	98F	PL B444 52	A. Angelopoulos *et al.*	(CPLEAR Collab.)	REFID=46541
Also		EPJ C22 55	A. Angelopoulos *et al.*	(CPLEAR Collab.)	REFID=48507
DEMIDOV	95	PAN 58 968	V. Demidov, K. Gusev, E. Shabalin	(ITEP)	REFID=44350
From YAF 58 1041.					
THOMSON	95	PR D51 1412	G.B. Thomson, Y. Zou	(RUTG)	REFID=44142
BARKOV	87B	SJNP 46 630	L.M. Barkov *et al.*	(NOVO)	REFID=40413
		Translated from YAF 46 1088.			
BARKOV	85B	JETPL 42 138	L.M. Barkov *et al.*	(NOVO)	REFID=11047
		Translated from ZETFP 42 113.			
BLATNIK	79	LNC 24 39	S. Blatnik, J. Stahov, C.B. Lang	(TUZL, GRAZ)	REFID=48613
MOLZON	78	PRL 41 1213	W.R. Molzon *et al.*	(EFI+)	REFID=48614
NIEBERGALL	74	PL 49B 103	F. Niebergall *et al.*	(CERN, ORSAY, VIEN)	REFID=11362
HART	73	NP B66 317	J.C. Hart *et al.*	(CAVE, RHEL)	REFID=11335
FOETH	69B	PL 30B 276	H. Foeth *et al.*	(AACH, CERN, TORI)	REFID=48617
HILL	68B	PR 168 1534	D.G. Hill *et al.*	(BNL, CMU)	REFID=11046
FITCH	67	PR 164 1711	V.L. Fitch *et al.*	(PRIN)	REFID=11045
BALTAY	66	PR 142 932	C. Baltay *et al.*	(YALE, BNL)	REFID=11044
BURNSTEIN	65	PR 138 B895	R.A. Burnstein, H.A. Rubin	(UMD)	REFID=11042
KIM	65B	PR 140B 1334	J.K. Kim, L. Kirsch, D. Miller	(COLU)	REFID=11043
CHRISTENS...	64	PRL 13 138	J.H. Christenson *et al.*	(PRIN)	REFID=11041
CRAWFORD	59	PRL 2 112	F.S. Crawford *et al.*	(LRL)	REFID=11039
ROSENFELD	59	PRL 2 110	A.H. Rosenfeld, F.T. Solmitz, R.D. Tripp	(LRL)	REFID=11040