$\Gamma(e^+e^-)/\Gamma(\pi^+\pi^-)$ — Γ_{10}/Γ_1

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
< 1.5	90	BARMIN	86	XEBC
• • • We do not use the following data for averages, fits, limits, etc. • • •				
<16.0	90	[18] BITSADZE	86	CALO
<50.0	90	BOHM	69	OSPK

[18] Use $B(\pi^+\pi^-) = 0.6861$.

$\Gamma(\pi^0 e^+e^-)/\Gamma_{total}$ — Γ_{11}/Γ

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

VALUE (units 10^{-6})	CL%	EVTS	DOCUMENT ID		TECN
< 1.1	90	0	BARR	93B	NA31
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<45	90		GIBBONS	88	E731

NOTE ON CP VIOLATION IN $K_S \to 3\pi$

(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

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

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

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

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

$$\begin{aligned} \eta_{+-0} &= \eta_{000} \\ &= \epsilon + i\frac{\mathrm{Im}\ a_1}{\mathrm{Re}\ a_1} \ . \end{aligned}$$

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 $\mathrm{Im}(\eta_{000})$.

CP-VIOLATION PARAMETERS IN K^0_S DECAY

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

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

VALUE	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
<0.12	90	384	METCALF	72	ASPK	
• • • We do not use the following data for averages, fits, limits, etc. • • •						
<0.23	90	601	[19] BARMIN	85	HLBC	K^+ 850 MeV
<1.2	90	192	BALDO-...	75	HLBC	
<0.71	90	148	MALLARY	73	OSPK	Re(A)=−0.05 ± 0.17
<0.66	90	180	JAMES	72	HBC	
<1.2	90	99	JONES	72	OSPK	
<1.2	90	99	CHO	71	DBC	
<1.0	90	98	JAMES	71	HBC	Incl. in JAMES 72
<1.2	95	50	[20] MEISNER	71	HBC	CL=90% not avail.
<0.8	90	71	WEBBER	70	HBC	
<0.45	90		BEHR	66	HLBC	
<3.8	90	18	ANDERSON	65	HBC	Incl. in WEBBER 70

[19] 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.

[20] These authors find Re(A) = 2.75 ± 0.65, above value at Re(A) = 0.

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

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

VALUE	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
<0.1	90	632	[21] BARMIN	83	HLBC	
• • • We do not use the following data for averages, fits, limits, etc. • • •						
<0.28	90		[22] GJESDAL	74B	SPEC	Indirect meas.
<1.2	90	22	BARMIN	73	HLBC	

[21] 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.

[22] 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.

K^0_S REFERENCES

BARR 93B PL B304 381 +Buchholz+ (CERN, EDIN, MANZ, LALO, PISA, SIEG)
GIBBONS 93 PRL 70 1199 +Barker, Briere, Makoff+ (FNAL E731 Collab.)
RAMBERG 93 PRL 70 2525 +Bock, Coleman, Enagonio, Hsiung+ (FNAL E731 Collab.)
BALATS 89 SJNP 49 828 +Berezin, Bogdanov, Vishnevskii, Vishnyakov+ (ITEP)
Translated from YAF 49 1332.
GIBBONS 88 PRL 61 2661 +Papadimitriou+ (FNAL E731 Collab.)
BURKHARDT 87 PL B199 139 + (CERN, EDIN, MANZ, LALO, PISA, SIEG)
GROSSMAN 87 PRL 59 18 +Heller, James, Shupe+ (MINN, MICH, RUTG)
BARMIN 86 SJNP 44 622 +Barylov, Davidenko, Demidov+ (ITEP)
Translated from YAF 44 965.
BARMIN 86B NC 96A 159 +Barylov, Chistyakova, Chuvilo+ (ITEP, PADO)
BITSADZE 86 PL 167B 138 +Budagov (CMNS, SOFI, SERP, TBIL, JINR, BAKU+)
PDG 86B PL 170B 130 Aguilar-Benitez, Porter+ (CERN, CIT+)
VASSERMAN 86 JETPL 43 588 +Golubev, Gluskin, Druzhinin+ (NOVO)
Translated from ZETFP 43 457.
BARMIN 85 NC 85A 67 +Barylov, Chistyakova, Chuvilo+ (ITEP, PADO)
Also 85B SJNP 41 759 Barmin, Barylov, Volkov+ (ITEP)
Translated from YAF 41 1187.
BARMIN 83 PL 128B 129 +Barylov, Chistyakova, Chuvilo+ (ITEP, PADO)
Also 84 SJNP 39 269 Barmin, Barylov, Golubchikov+ (ITEP, PADO)
Translated from YAF 39 428.
ARONSON 82 PRL 48 1078 +Bernstein+ (BNL, CHIC, STAN, WISC)
ARONSON 82B PRL 48 1306 +Bock, Cheng, Fischbach (BNL, CHIC, PURD)
Also 82B PL 116B 73 Fischbach, Cheng+ (PURD, BNL, CHIC)
Also 83 PR D28 476 Aronson, Bock, Cheng+ (BNL, CHIC, PURD)
Also 83B PR D28 495 Aronson, Bock, Cheng+ (BNL, CHIC, PURD)
ARONSON 76 NC 32A 236 +McIntyre, Roehrig+ (WISC, EFI, UCSD, ILLC)
EVERHART 76 PR D14 661 +Kraus, Lande, Long, Lowenstein+ (PENN)
TAUREG 76 PL 65B 92 +Zech, Dydak, Navarria+ (HEIDH, CERN, DORT)
BALDO-... 75 NC 25A 688 Baldo-Ceolin, Bobisut, Calimani+ (PADO, WISC)
CARITHERS 75 PRL 34 1244 +Modis, Nygren, Pun+ (COLU, NYU)
BOBISUT 74 LNC 11 646 +Huzita, Mattioli, Puglierin (PADO)
COWELL 74 PR D10 2083 +Lee-Franzini, Orcutt, Franzini+ (STON, COLU)
GEWENIGER 74B PL 48B 487 +Gjesdal, Presser+ (CERN, HEIDH)
GJESDAL 74B PL 52B 119 +Presser, Steffen+ (CERN, HEIDH)
BARMIN 73 PL 46B 465 +Barylov, Davidenko, Demidov+ (ITEP)
BARMIN 73B PL 47B 463 +Barylov, Davidenko, Demidov+ (ITEP)
BURGUN 73 PL 46B 481 +Bertranet, Lesquoy, Muller, Pauli+ (SACL, CERN)
FACKLER 73 PRL 31 847 +Frisch, Martin, Smoot, Sompayrac (MIT)
GJESDAL 73 PL 44B 217 +Presser, Steffen, Steinberger+ (CERN, HEIDH)
HILL 73 PR D8 1290 +Sakitt, Samios, Burris, Engler+ (BNL, CMU)
MALLARY 73 PR D7 1953 +Binnie, Gallivan, Gomez, Peck, Sciulli+ (CIT)
ALITTI 72 PL 39B 568 +Lesquoy, Muller (SACL)
BANNER 72B PRL 29 237 +Cronin, Hoffman, Knapp, Shochet (PRIN)
BURGUN 72 NP B50 194 +Lesquoy, Muller, Pauli+ (SACL, CERN, OSLO)
JAMES 72 NP B49 1 +Montanet, Paul, Saetre+ (CERN, SACL, OSLO)
JONES 72 NC 9A 151 +Abashian, Graham, Mantsch, Orr, Smith+ (ILL)
METCALF 72 PL 40B 703 +Neuhofer, Niebergall+ (CERN, IPN, WIEN)
MORSE 72B PRL 28 388 +Nauenberg, Bierman, Sager+ (COLO, PRIN, UMD)
NAGY 72 NP B47 94 +Telbisz, Vestergombi (BUDA)
Also 69 PL 30B 498 Bozoki, Fenyves, Gombosi, Nagy+ (BUDA)
SKJEGGEST... 72 NP B48 343 Skjeggestad, James+ (OSLO, CERN, SACL)
BALTAY 71 PRL 27 1678 +Bridgewater, Cooper, Gershwin, Habibi+ (COLU)
Also 71 Nevis 187 Thesis Cooper (COLU)
CHO 71 PR D3 1557 +Dralle, Canter, Engler, Fisk+ (CMU, BNL, CASE)
JAMES 71 PL 35B 265 +Montanet, Paul, Pauli+ (CERN, SACL, OSLO)
MEISNER 71 PR D3 59 +Mann, Hertzbach, Kofler+ (MASA, BNL, YALE)
REPELLIN 71 PL 36B 603 +Wolff, Chollet, Gaillard, Jane+ (ORSAY, CERN)
MOFFETT 70 BAPS 15 512 +Gobbi, Green, Hakel, Rosen (ROCH)
WEBBER 70 PR D1 1967 +Solmitz, Crawford, Alston-Garnjost (LRL)
Also 69 UCRL 19226 Thesis Webber (LRL)