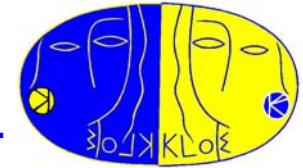


Status and perspectives of CP and CPT tests with neutral kaons at KLOE



Antonio Di Domenico*
on behalf of the KLOE Collaboration
*Università di Roma "La Sapienza" and
INFN sezione di Roma, Italy

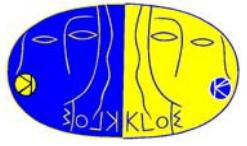


International Workshop on
discoveries in flavour physics at e^+e^- colliders

DIF06

Laboratori Nazionali di Frascati dell'INFN
February 28th - March 3rd, 2006

INFN
Istituto Nazionale
di Fisica Nucleare
Laboratori Nazionali di Frascati



Neutral kaons at a ϕ -factory

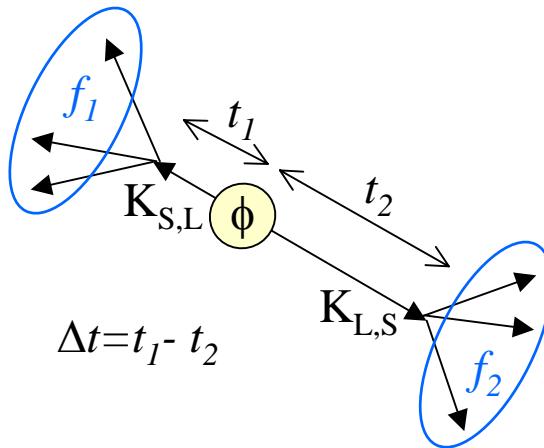
- $e^+e^- \rightarrow \phi$ $\sigma_\phi \sim 3 \text{ } \mu\text{b}$
 $W = m_\phi = 1019.4 \text{ MeV}$
- $\text{BR}(\phi \rightarrow K^0\bar{K}^0) \sim 34\%$
- $\sim 10^6$ neutral kaon pairs per pb^{-1} produced in an antisymmetric quantum state with $J^{PC} = 1^{--}$

$$p_K = 110 \text{ MeV/c}$$

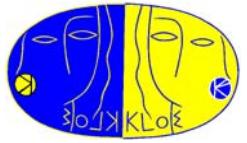
$$\lambda_S = 6 \text{ mm} \quad \lambda_L = 3.5 \text{ m}$$

$$|i\rangle = \frac{1}{\sqrt{2}} \left[|K^0(\vec{p})\rangle |\bar{K}^0(-\vec{p})\rangle - |\bar{K}^0(\vec{p})\rangle |K^0(-\vec{p})\rangle \right]$$

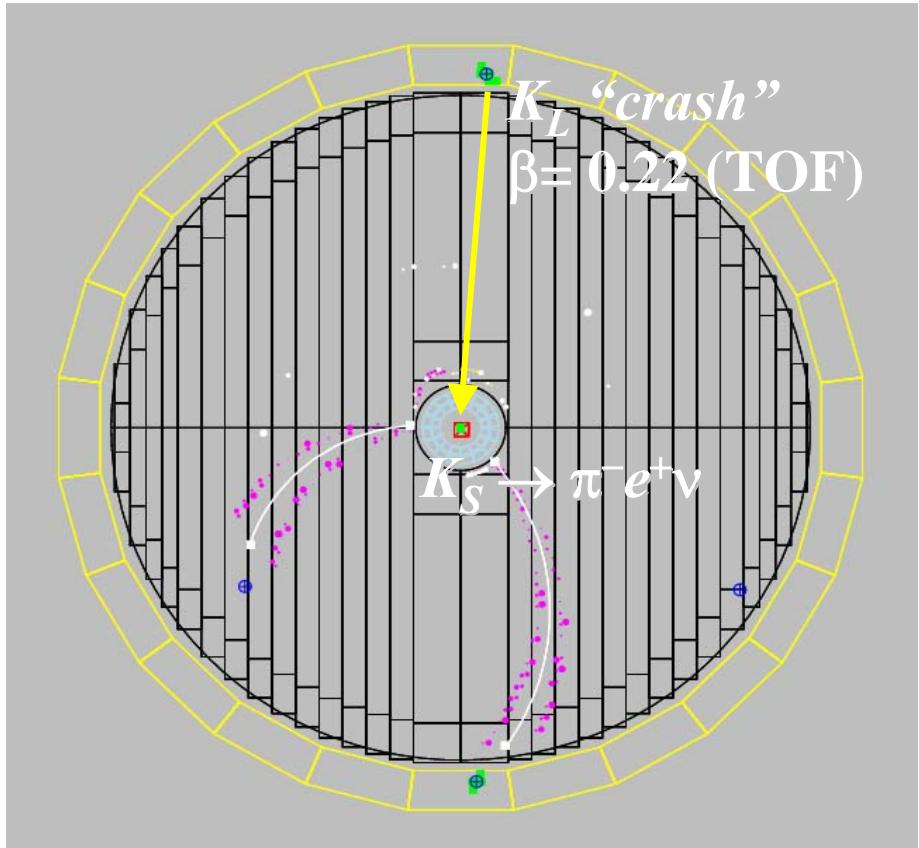
$$= \frac{N}{\sqrt{2}} \left[|K_S(\vec{p})\rangle |K_L(-\vec{p})\rangle - |K_L(\vec{p})\rangle |K_S(-\vec{p})\rangle \right]$$



The detection of a kaon at large (small) times tags a K_S (K_L)
 \Rightarrow possibility to select a pure K_S beam (unique at a ϕ -factory, not possible at fixed target experiments)



K_S and K_L Tagging

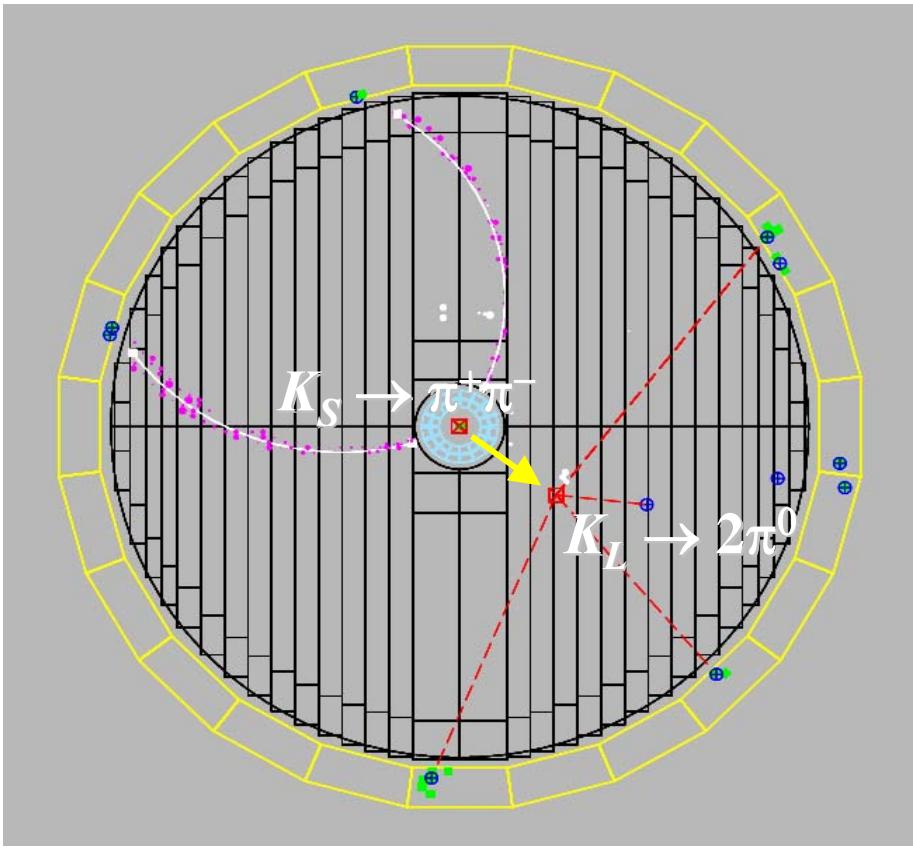


K_S tagged by K_L interaction in EmC

Efficiency ~ 30% (largely geometrical)

K_S angular resolution: ~ 1° (0.3° in ϕ)

K_S momentum resolution: ~ 2 MeV

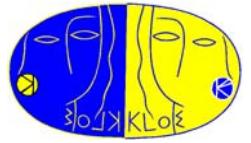


K_L tagged by K_S → $\pi^+\pi^-$ vertex at IP

Efficiency ~ 70% (mainly geometrical)

K_L angular resolution: ~ 1°

K_L momentum resolution: ~ 2 MeV



$K_S \rightarrow \pi^0 \pi^0 \pi^0$: search for a CP violating decay

Observation of $K_S \rightarrow 3\pi^0$ signals CP violation in mixing and/or in decay:

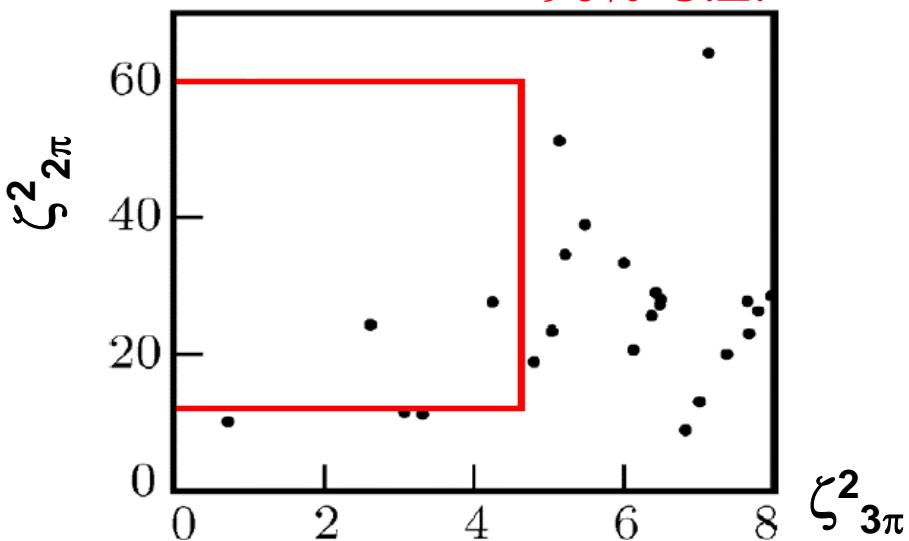
SM prediction: $\Gamma_S = \Gamma_L / \varepsilon + \varepsilon'^{000}/2$, $\Rightarrow \text{BR}(K_S \rightarrow 3\pi^0) \sim 2 \times 10^{-9}$

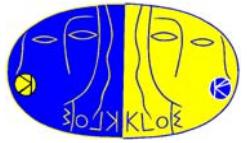
Present published results: $\text{BR}(K_S \rightarrow 3\pi^0) < 1.4 \times 10^{-5}$ (direct search, SND, '99)

$\text{BR}(K_S \rightarrow 3\pi^0) < 7.4 \times 10^{-7}$ (interferometry, NA48, '04)

$\text{BR}(K_S \rightarrow 3\pi^0) < 1.2 \times 10^{-7}$ (direct search, KLOE, '05)
90% C.L.

- Data sample: 450 pb^{-1}
 $\sim 4 \times 10^7 K_L$ -crash tag + $K_S \rightarrow \text{neutrals}$
- Require 6 prompt photons:
large background $\sim 40K$ events
- Analysis based on γ counting and kinematic fit
in the $2\pi^0$ and $3\pi^0$ hypothesis
- After all analysis cuts ($\varepsilon_{3\pi} = 24.4\%$)
 - 2 candidate events found
 - $3.13 \pm 0.82_{\text{stat}} \pm 0.37_{\text{syst}}$ expected bckg





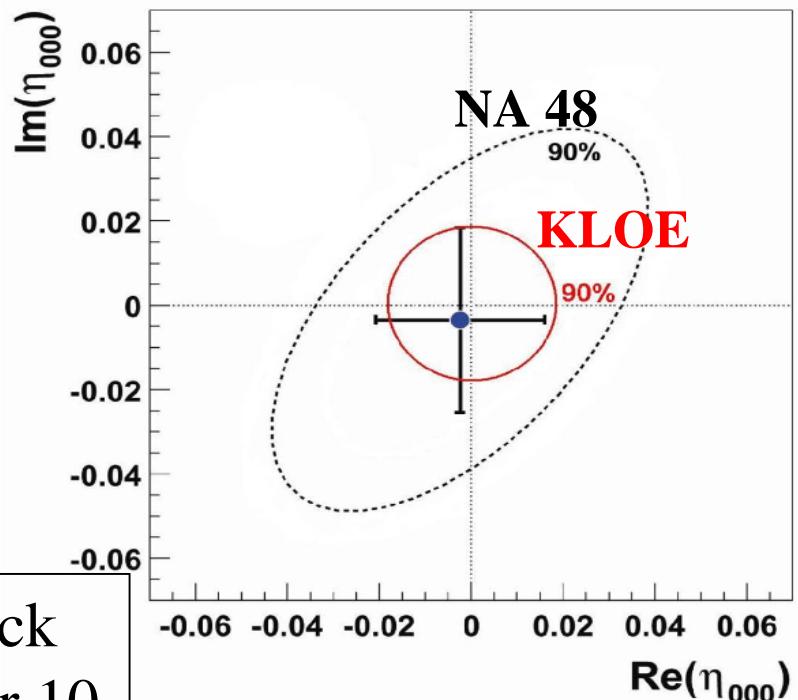
$K_S \rightarrow \pi^0 \pi^0 \pi^0$: test of CPT

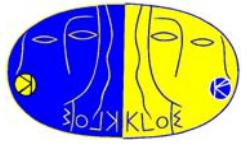
A limit on $\text{BR}(K_S \rightarrow 3\pi^0)$ translates into a limit on $|\eta_{000}|$

$$|\eta_{000}| = \left| \frac{A(K_S \rightarrow 3\pi^0)}{A(K_L \rightarrow 3\pi^0)} \right| = \sqrt{\frac{\tau_L}{\tau_S} \frac{\text{BR}(K_S \rightarrow 3\pi^0)}{\text{BR}(K_L \rightarrow 3\pi^0)}} < 0.018 \text{ at 90% C.L.}$$

The CPT test from unitarity was limited by the knowledge of $|\eta_{000}|$ at the 10^{-5} level; now it is limited by uncertainties on other factors, e.g. η_+ etc. (see later)

with full statistics of 2.5 fb^{-1} + improved bck rejection: $\Rightarrow \text{BR}$ limit improved by a factor 10





$K_L \rightarrow \pi^+\pi^-$: CP violation

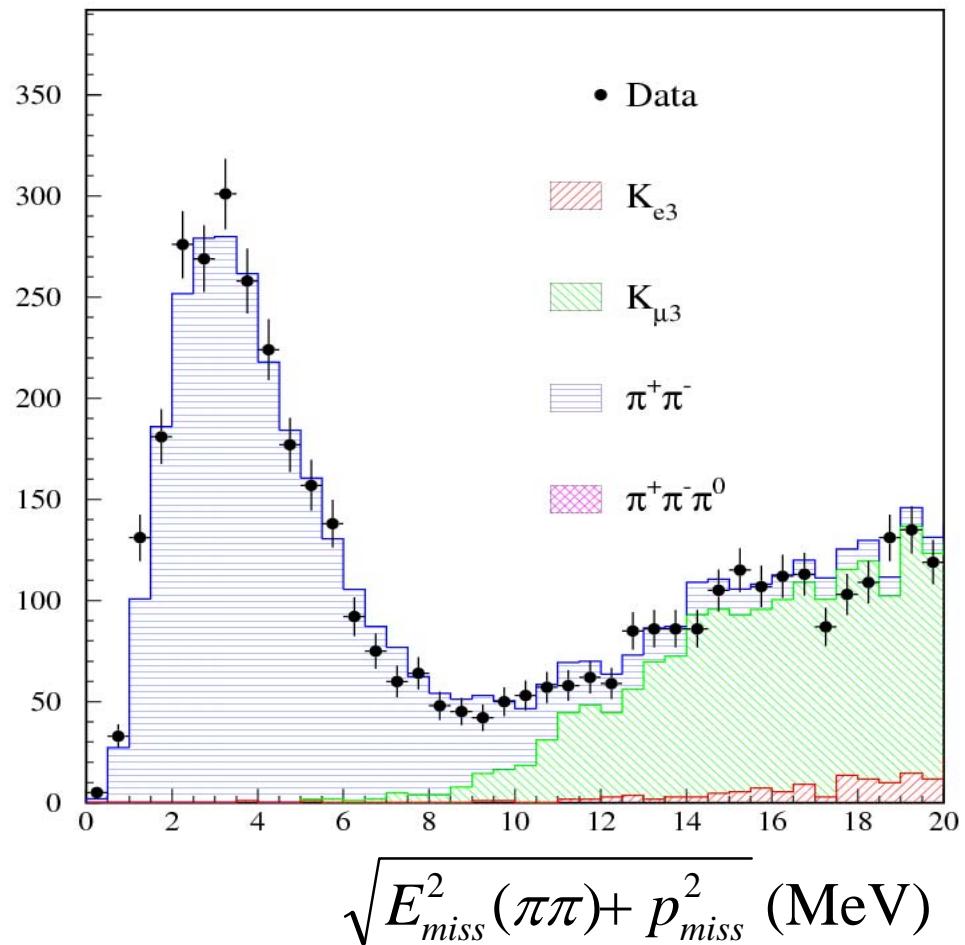
Data sample: 328 pb⁻¹

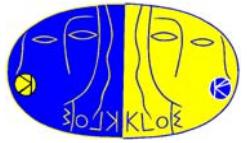
BR measurement to ~1%
 K_L beam tagged by $K_S \rightarrow \pi^+\pi^-$

Signal selection:

- K_L vertex reconstructed in DC
- PID using decay kinematics
- Fit with MC spectra

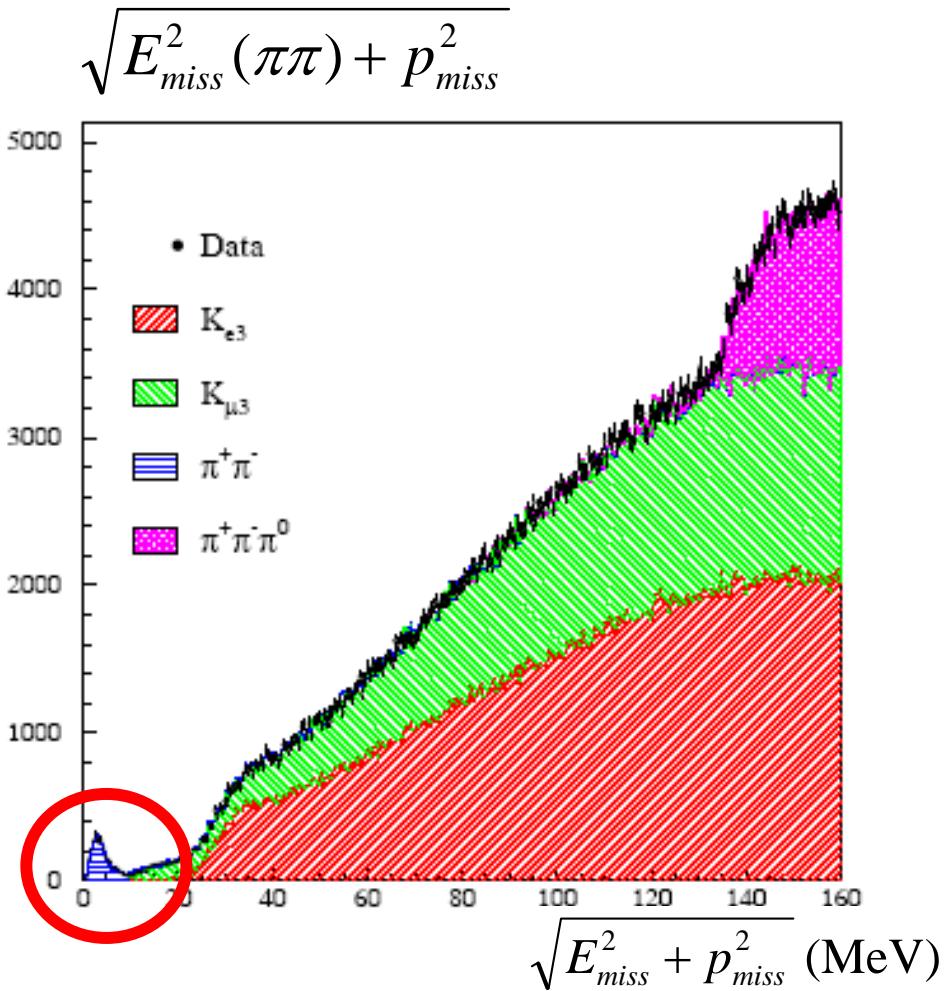
Normalization using $K_L \rightarrow \pi\mu\nu$
events in the same data set



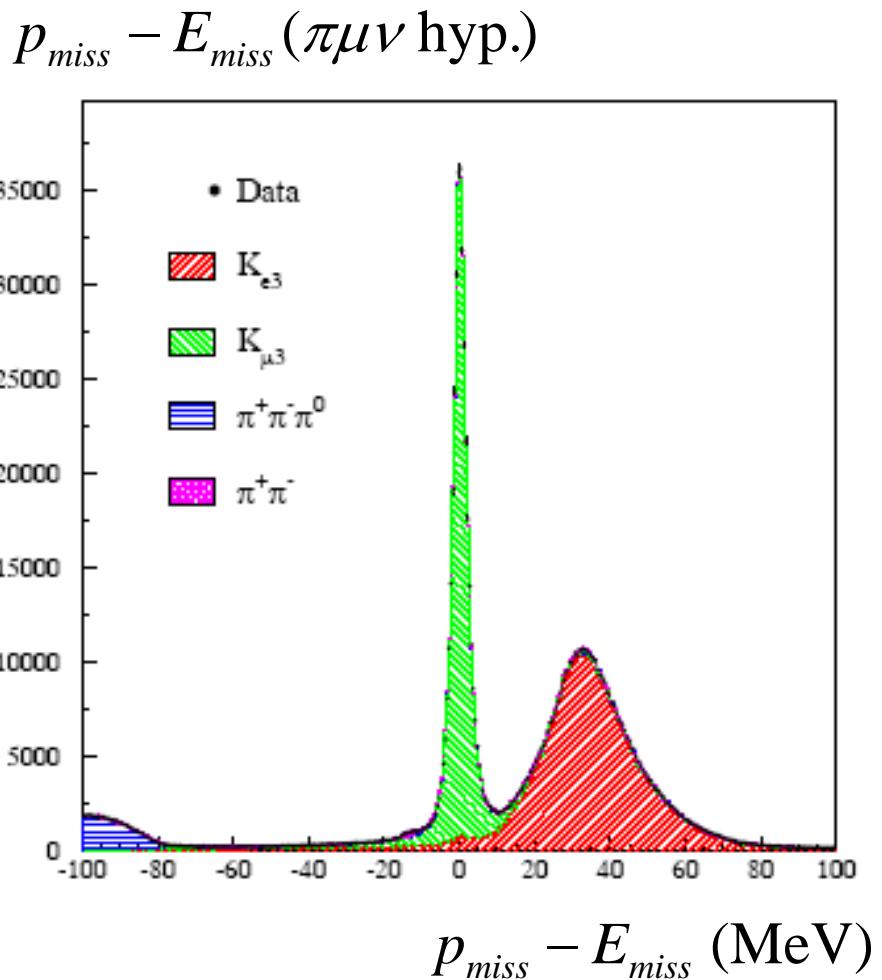


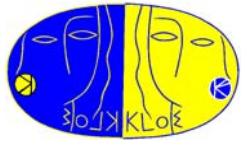
$K_L \rightarrow \pi^+\pi^-$: CP violation

Number of $K_L \rightarrow \pi^+\pi^-$ from fit of



Number di $K_L \rightarrow \pi\mu\nu$ from fit of





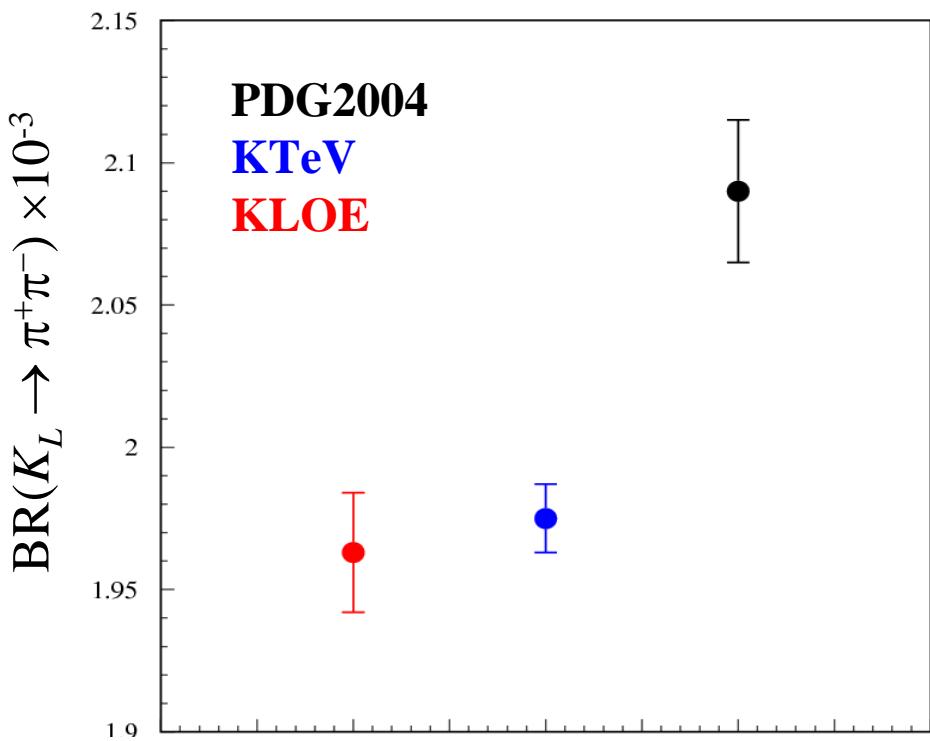
$K_L \rightarrow \pi^+ \pi^-$: CP violation

KLOE

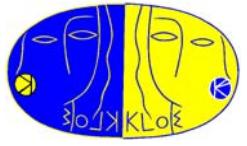
$$\text{BR}(K_L \rightarrow \pi^+ \pi^-) = (1.963 \pm 0.012 \pm 0.017) \times 10^{-3}$$

Preliminary result

- in agreement with KTeV [PRD70 (2004), 092006]
 $\text{BR} = (1.975 \pm 0.012) \times 10^{-3}$
- it confirms the discrepancy (4 standard deviations)
with PDG04 = $(2.080 \pm 0.025) \times 10^{-3}$
- using $\text{BR}(K_S \rightarrow \pi\pi)$ and τ_L from KLOE and τ_S from PDG04:
 $|\varepsilon| = (2.216 \pm 0.013) \times 10^{-3}$
PDG04 $|\varepsilon| = (2.280 \pm 0.013) \times 10^{-3}$



1.6 σ agreement with prediction from Unitarity Triangle



$K_S \rightarrow \pi e\nu$: Results

Branching ratios:

data sample: 410 pb⁻¹

$$\text{BR}(K_S \rightarrow \pi^- e^+ \nu) = (3.528 \pm 0.057 \pm 0.027) \times 10^{-4}$$

$$\text{BR}(K_S \rightarrow \pi^+ e^- \bar{\nu}) = (3.517 \pm 0.051 \pm 0.029) \times 10^{-4}$$

$$\text{BR}(K_S \rightarrow \pi e\nu) = (7.046 \pm 0.076 \pm 0.050) \times 10^{-4}$$

BR($\pi e\nu$) [KLOE '02, 17 pb⁻¹]: $(6.91 \pm 0.34 \pm 0.15) \times 10^{-4}$

Charge asymmetry: $A_S = \frac{\Gamma(K_S \rightarrow \pi^- e^+ \nu) - \Gamma(K_S \rightarrow \pi^+ e^- \bar{\nu})}{\Gamma(K_S \rightarrow \pi^- e^+ \nu) + \Gamma(K_S \rightarrow \pi^+ e^- \bar{\nu})}$

$$A_S = (1.5 \pm 9.6 \pm 2.9) \times 10^{-3}$$

with 2.5 fb⁻¹: $\delta A_S \sim 3 \times 10^{-3} \sim 2 \text{ Re } \varepsilon$



Semileptonic decay amplitudes: definitions

$$\langle \pi^- \ell^+ \nu | K^0 \rangle = a + b$$

$$\langle \pi^+ \ell^- \bar{\nu} | K^0 \rangle = c + d$$

$$\langle \pi^+ \ell^- \bar{\nu} | \bar{K}^0 \rangle = a^* - b^*$$

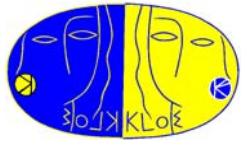
$$\langle \pi^- \ell^+ \nu | \bar{K}^0 \rangle = c^* - d^*$$

	CP	T	CPT	$\Delta S = \Delta Q$
a	$\Im=0$	$\Im=0$		
b	$\Re=0$	$\Im=0$	$=0$	
c	$\Im=0$	$\Im=0$		$=0$
d	$\Re=0$	$\Im=0$	$=0$	$=0$

CPT violation: $y = -\frac{b}{a}$

$\Delta S = \Delta Q$ violation: $x_+ = \frac{c^*}{a}$

CPT violation & $\Delta S = \Delta Q$ violation : $x_- = -\frac{d^*}{a}$



$K_S \rightarrow \pi e \nu$: test of $\Delta S = \Delta Q$ rule

Test of $\Delta S = \Delta Q$ rule:

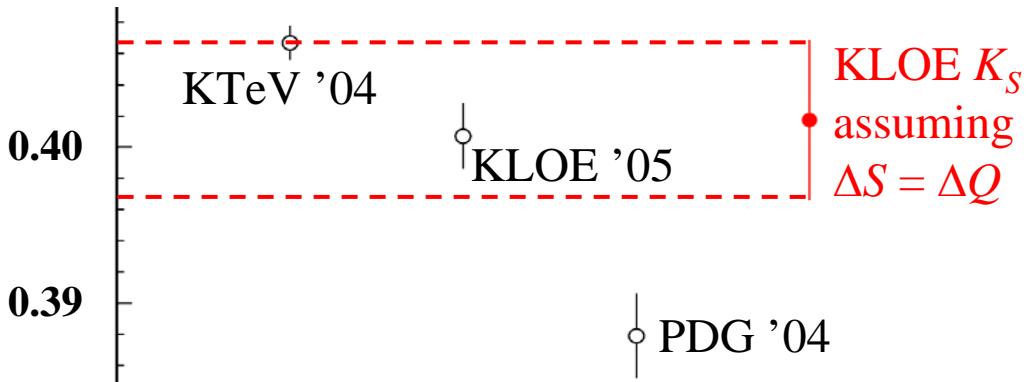
$$\tau(K_S) = 89.58 \pm 0.06 \text{ ps}$$

PDG fit

$$\tau(K_L) = 50.84 \pm 0.23 \text{ ns}$$

KLOE '05 (avg.)

$\text{BR}(K_{Le3})$



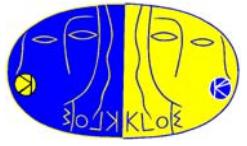
$$\Re x_+ = \frac{1}{4} \left(\frac{\text{BR}(K_S \rightarrow \pi e \nu)}{\text{BR}(K_L \rightarrow \pi e \nu)} \frac{\tau_L}{\tau_S} - 1 \right)$$

ratio of $\Delta S = \Delta Q$ violating and conserving amplitudes (CPT cons.) SM pred. $O(10^{-7})$

$$\Re x_+ = (-0.5 \pm 3.1 \pm 1.8) \times 10^{-3}$$

$\tau(K_S)$	PDG
$\tau(K_L)$	KLOE '05 (avg.)
$\text{BR}(K_L \rightarrow \pi e \nu)$	KLOE

Factor 2 improvement w.r.t. current most precise measurement (CPLEAR, $\sigma = 6.1 \times 10^{-3}$)



$K_S \rightarrow \pi \nu \bar{\nu}$: test of CPT

- $\Re x_-$: CPT viol., $\Delta S = \Delta Q$ viol.

$$A_S - A_L = 4 (\Re x_- + \Re \delta)$$

$$\left. \begin{array}{lll} A_L & \text{KTeV} & \sigma = 0.75 \times 10^{-4} \\ \Re \delta & \text{CPLEAR} & \sigma = 3.4 \times 10^{-4} \end{array} \right\}$$

$$\Re x_- = (-0.8 \pm 2.4 \pm 0.7) \times 10^{-3}$$

Factor 5 improvement w.r.t. current most precise measurement
(CPLEAR, $\sigma = 1.3 \times 10^{-2}$)

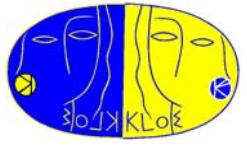
- $\Re y$: CPT viol., $\Delta S = \Delta Q$ cons.

$$A_S + A_L = 4 (\Re \varepsilon - \Re y)$$

$\Re \varepsilon$ from PDG not assuming CPT

$$\Re y = (0.4 \pm 2.4 \pm 0.7) \times 10^{-3}$$

Comparable with best result (CPLEAR from unitarity, $\sigma = 3.1 \times 10^{-3}$)



CPT test: the Bell-Steinberger relation

Measurements of K_S K_L observables can be used for the CPT test from unitarity :

$$(1 + i \tan \phi_{SW}) [\text{Re } \varepsilon - i \text{Im } \delta] = \frac{1}{\Gamma_S} \sum_f A^*(K_S \rightarrow f) A(K_L \rightarrow f) = \sum_f \alpha_f$$

$$\alpha_{+-} = \eta_{+-} B(K_S \rightarrow \pi^+ \pi^-)$$

$$\alpha_{kl3} = 2\tau_S/\tau_L B(K_L l3)$$

$$\alpha_{00} = \eta_{00} B(K_S \rightarrow \pi^0 \pi^0)$$

$$[\text{Re } \varepsilon - \text{Re } y - i(\text{Im } \delta + \text{Im } x_+)]$$

$$\alpha_{+-\gamma} = \eta_{+-} B(K_S \rightarrow \pi^+ \pi^- \gamma)$$

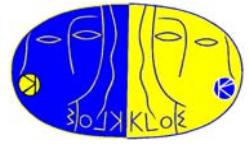
$$= 2\tau_S/\tau_L B(K_L l3)$$

$$[(A_S + A_L)/4 - i(\text{Im } \delta + \text{Im } x_+)]$$

$$\alpha_{+-0} = \tau_S/\tau_L \eta_{+-0}^* B(K_L \rightarrow \pi^+ \pi^- \pi^0)$$

$$\alpha_{000} = \tau_S/\tau_L \eta_{000}^* B(K_L \rightarrow \pi^0 \pi^0 \pi^0)$$

CPT test: inputs to the Bell-Steinberger relation



$$B(K_S \rightarrow \pi^+ \pi^-)/B(K_S \rightarrow \pi^0 \pi^0) = 2.2549 \pm 0.0059$$

$$B(K_S \rightarrow \pi^+ \pi^- \gamma) < 9 \times 10^{-5}$$

$$B(K_L \rightarrow \pi^+ \pi^- \gamma) = (29 \pm 1) \times 10^{-6}$$

$$B(K_L \rightarrow \pi l \nu) = 0.6705 \pm 0.0022$$

$$B(K_S \rightarrow \pi^+ \pi^- \pi^0) = (3.2 \pm 1.2) \times 10^{-7}$$

$$B(K_L \rightarrow \pi^+ \pi^- \pi^0) = 0.1263 \pm 0.0012$$

$$B(K_S \rightarrow \pi^0 \pi^0 \pi^0) < 1.2 \times 10^{-7}$$

$$\phi^{SW} = (0.759 \pm 0.001)$$

$$\phi^{000} = \phi^{+-0} = \phi^{+\gamma} = [0, 2\pi]$$

$$\tau_S = 0.08958 \pm 0.00006 \text{ ns}$$

$$\tau_L = 50.84 \pm 0.23 \text{ ns}$$

$$A_L = (3.32 \pm 0.06) \times 10^{-3}$$

$$A_S = (1.5 \pm 10.0) \times 10^{-3}$$

$$B(K_L \rightarrow \pi^+ \pi^-) = (1.963 \pm 0.021) \times 10^{-3}$$

$$B(K_L \rightarrow \pi^0 \pi^0) = (8.65 \pm 0.10) \times 10^{-4}$$

$$\phi^{+-} = 0.757 \pm 0.012$$

$$\phi^{00} = 0.763 \pm 0.014$$

$$\text{Im } x_+ = (0.8 \pm 0.7) \times 10^{-2}$$

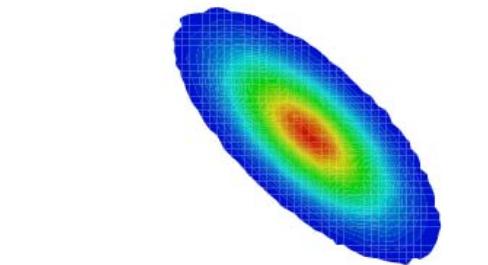
KLOE measurements

Im x_+ from a combined fit of KLOE + CPLEAR data

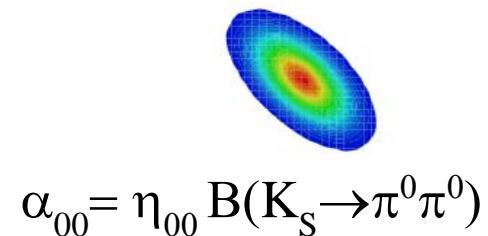


CPT test: accuracy on α_i

We get the following results on each term of the sum



$$\alpha_{+-} = \eta_{+-} B(K_S \rightarrow \pi^+ \pi^-)$$



$$\alpha_{00} = \eta_{00} B(K_S \rightarrow \pi^0 \pi^0)$$

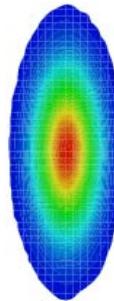


$$\alpha_{+-\gamma} = \eta_{+-} B(K_S \rightarrow \pi^+ \pi^- \gamma)$$

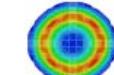
10^{-4}

Im
↑
Re

$$2\tau_S/\tau_L B(K_L l3) [(A_S + A_L)/4 - i \operatorname{Im} x_+]$$

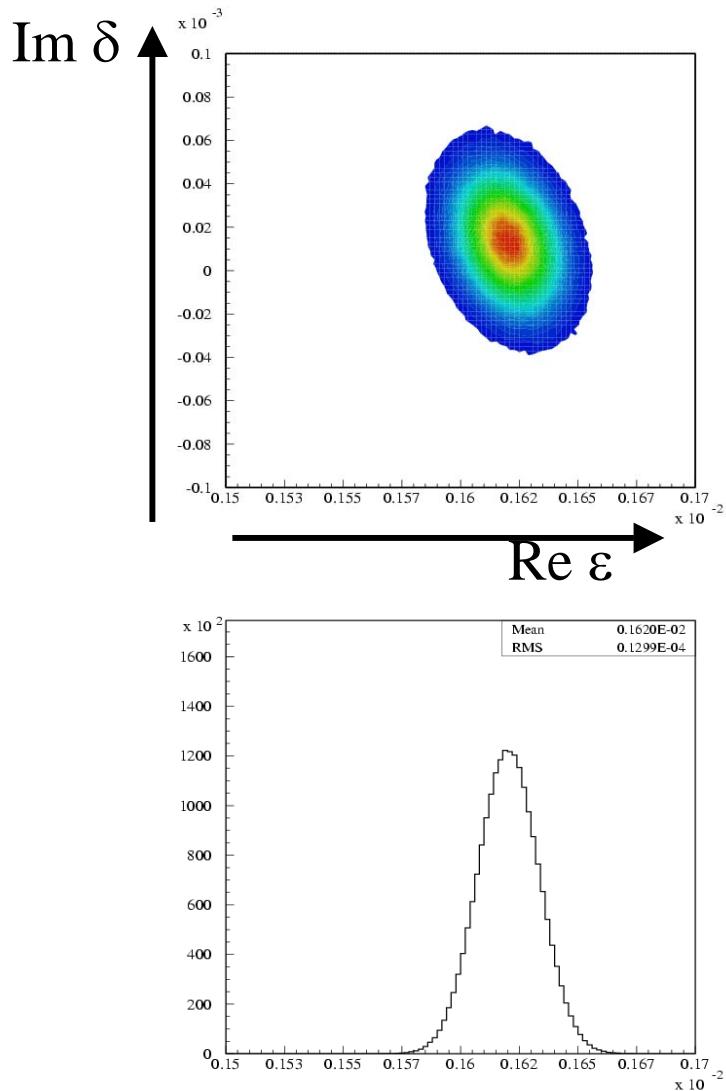


$$\alpha_{+-0} = \tau_S/\tau_L \eta_{+-0} {}^*B(K_L \rightarrow \pi^+ \pi^- \pi^0)$$



$$\alpha_{000} = \tau_S/\tau_L \eta_{000} {}^*B(K_L \rightarrow \pi^0 \pi^0 \pi^0)$$

CPT test: KLOE result



KLOE preliminary:

$$\begin{aligned} \text{Re } \epsilon &= (160.2 \pm 1.3) \times 10^{-5} \\ \text{Im } \delta &= (1.2 \pm 1.9) \times 10^{-5} \end{aligned}$$

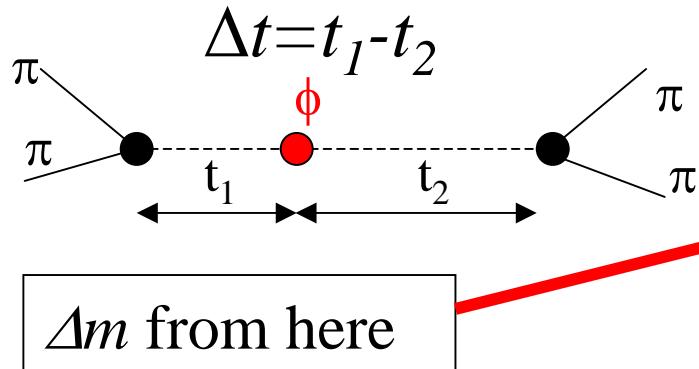
CPLEAR:

$$\begin{aligned} \text{Re } \epsilon &= (164.9 \pm 2.5) 10^{-5} \\ \text{Im } \delta &= (2.4 \pm 5.0) 10^{-5} \end{aligned}$$

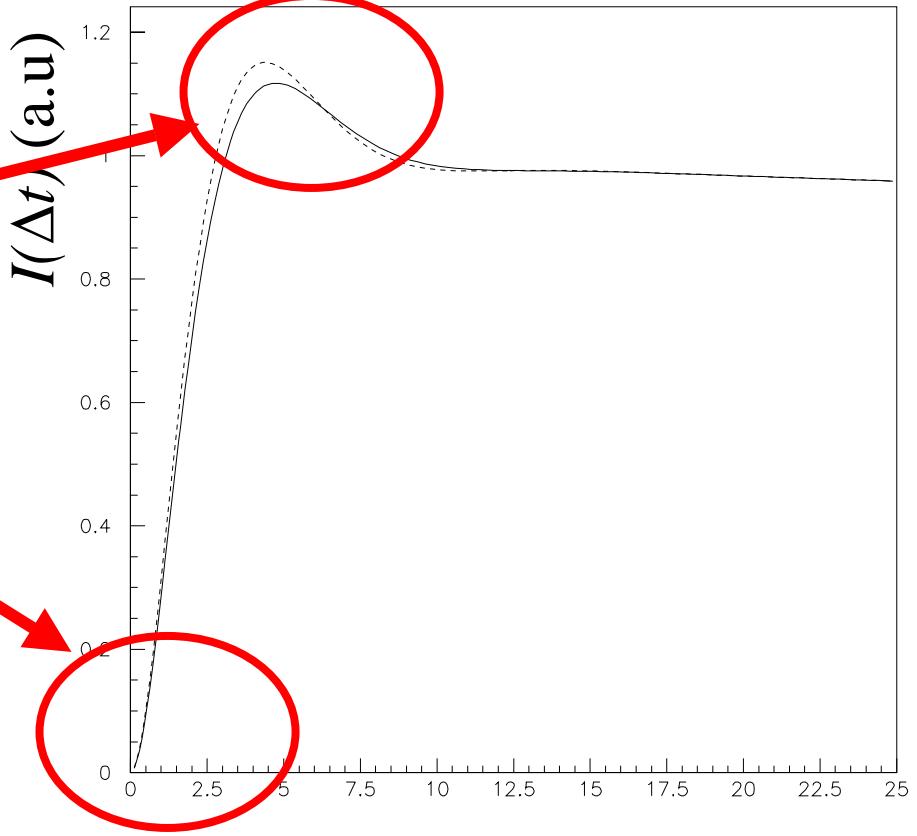


Kaon interferometry: $\phi \rightarrow K_S K_L \rightarrow \pi^+ \pi^- \pi^+ \pi^-$

$$I(\pi^+ \pi^-, \pi^+ \pi^-; |\Delta t|) \propto \left\{ e^{-\Gamma_L |\Delta t|} + e^{-\Gamma_S |\Delta t|} - 2 \cdot e^{-(\Gamma_S + \Gamma_L)|\Delta t|/2} \cos(\Delta m |\Delta t|) \right\}$$



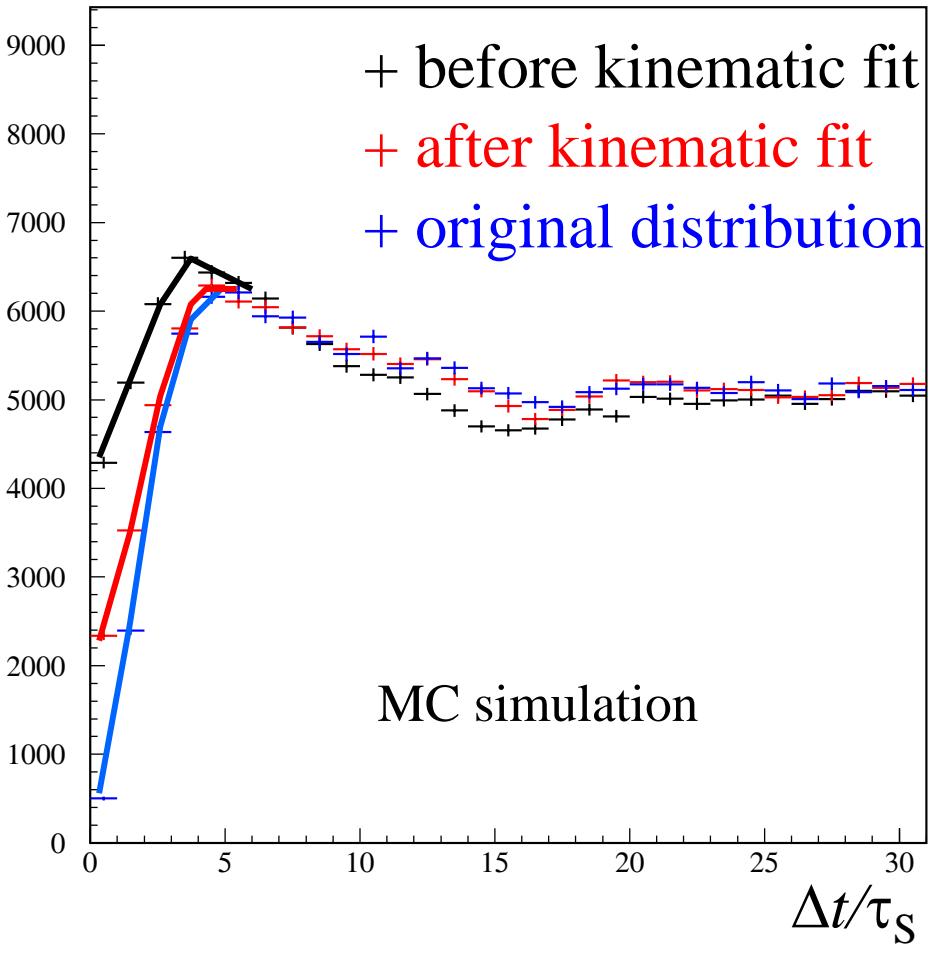
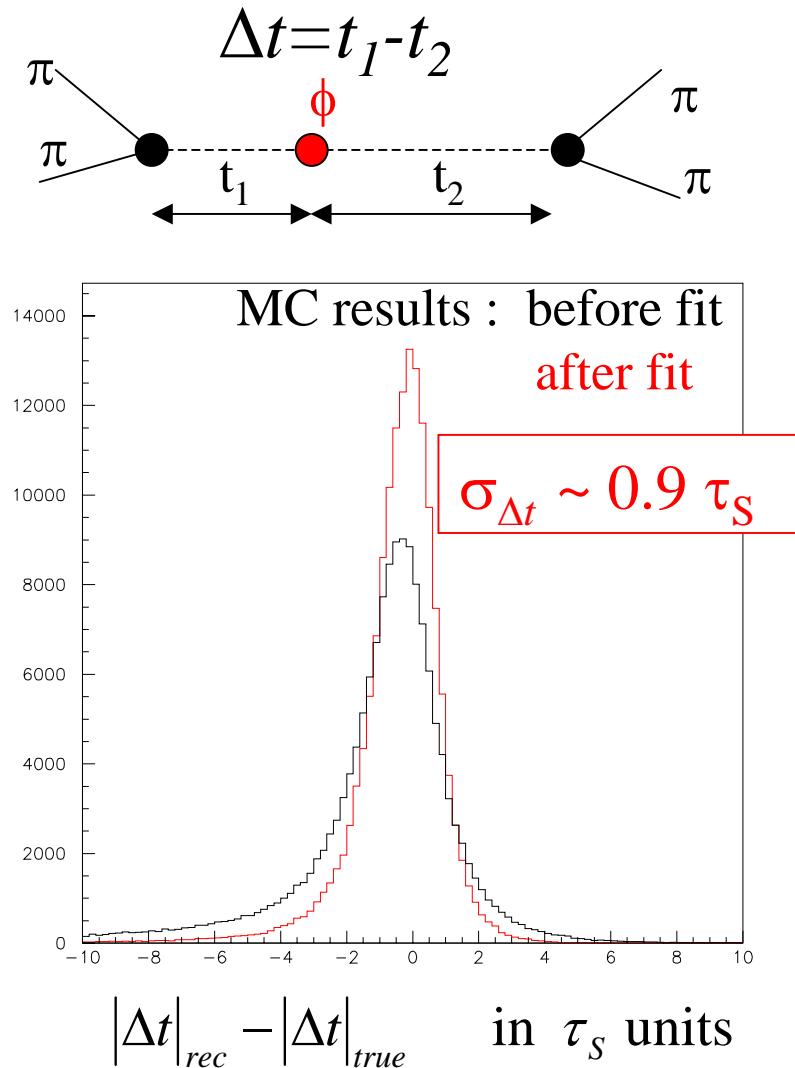
no simultaneous decays
($\Delta t=0$) in the same
final state due to the
destructive
quantum interference

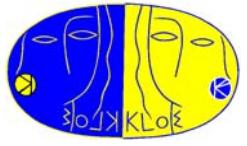




$$\phi \rightarrow K_S K_L \rightarrow \pi^+ \pi^- \pi^+ \pi^-$$

A kinematic fit is performed to improve the vertex and Δt resolution:





$$\phi \rightarrow K_S K_L \rightarrow \pi^+ \pi^- \pi^+ \pi^-$$

- Analysed data: $L=380 \text{ pb}^{-1}$
- Fit including Δt resolution and efficiency effects + regeneration
- Γ_S, Γ_L fixed from PDG

KLOE PRELIMINARY

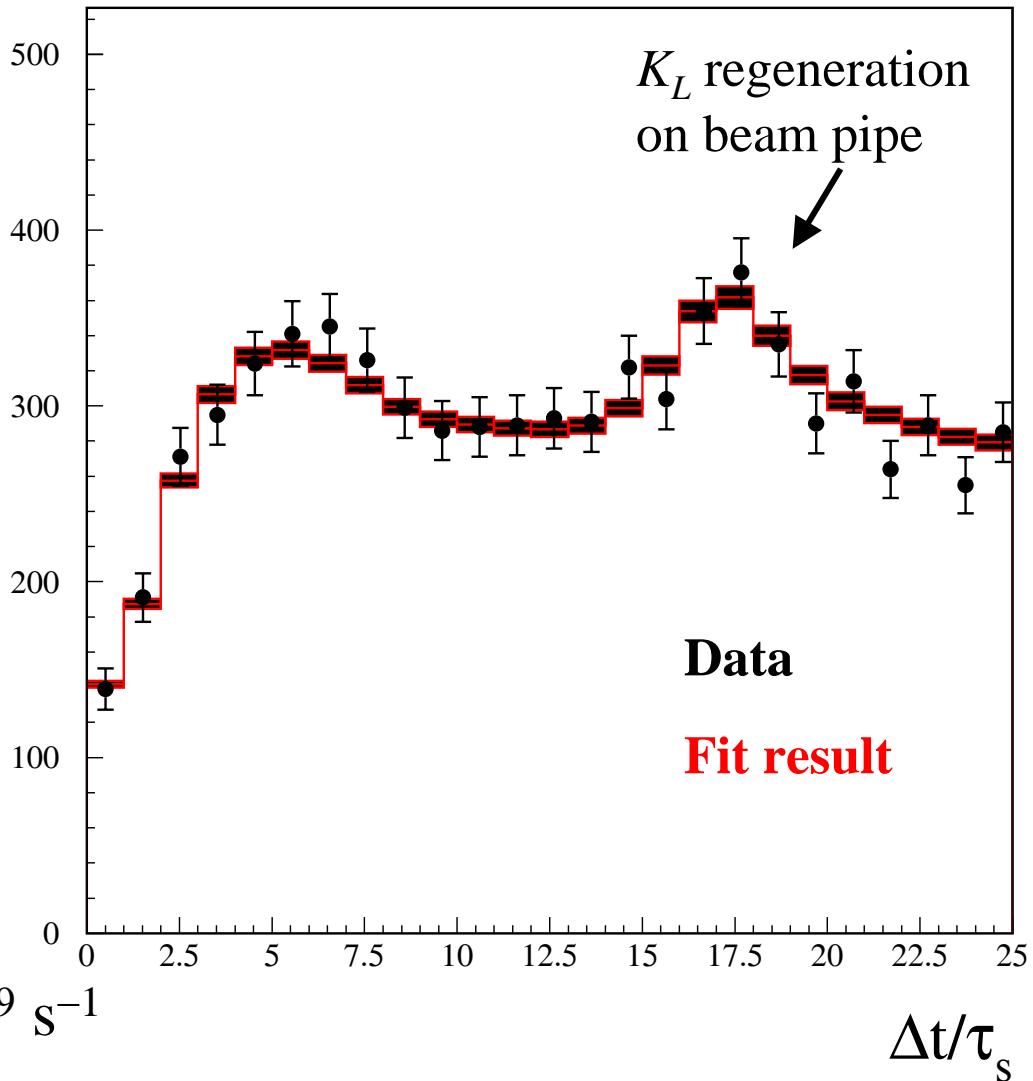
$$\Delta m = (5.34 \pm 0.34) \times 10^9 \text{ s}^{-1}$$

At 2.5 fb^{-1} $\Delta m \pm 0.14 \times 10^9 \text{ s}^{-1}$

PDG '04:

$$(5.290 \pm 0.016) \times 10^9 \text{ s}^{-1}$$

$$\text{Best (Ktev'03)} (5.288 \pm 0.043) \times 10^9 \text{ s}^{-1}$$





$\phi \rightarrow K_S K_L \rightarrow \pi^+ \pi^- \pi^+ \pi^-$: test of quantum coherence

$$I(\pi^+ \pi^-, \pi^+ \pi^-; \Delta t) = \frac{N}{2} \left[\left| \langle \pi^+ \pi^-, \pi^+ \pi^- | K^0 \bar{K}^0(\Delta t) \rangle \right|^2 + \left| \langle \pi^+ \pi^-, \pi^+ \pi^- | \bar{K}^0 K^0(\Delta t) \rangle \right|^2 - 2\Re \left(\langle \pi^+ \pi^-, \pi^+ \pi^- | K^0 \bar{K}^0(\Delta t) \rangle \langle \pi^+ \pi^-, \pi^+ \pi^- | \bar{K}^0 K^0(\Delta t) \rangle^* \right) \right]$$



$\phi \rightarrow K_S K_L \rightarrow \pi^+ \pi^- \pi^+ \pi^-$: test of quantum coherence

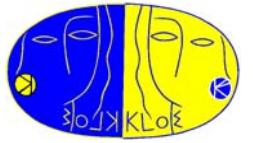
$$I(\pi^+ \pi^-, \pi^+ \pi^-; \Delta t) = \frac{N}{2} \left[\left| \langle \pi^+ \pi^-, \pi^+ \pi^- | K^0 \bar{K}^0(\Delta t) \rangle \right|^2 + \left| \langle \pi^+ \pi^-, \pi^+ \pi^- | \bar{K}^0 K^0(\Delta t) \rangle \right|^2 - \underbrace{(1 - \zeta_{0\bar{0}})}_{\text{circled}} \cdot 2\Re \left(\langle \pi^+ \pi^-, \pi^+ \pi^- | K^0 \bar{K}^0(\Delta t) \rangle \langle \pi^+ \pi^-, \pi^+ \pi^- | \bar{K}^0 K^0(\Delta t) \rangle^* \right) \right]$$

Decoherence parameter:

$$\zeta_{0\bar{0}} = 0 \rightarrow \text{QM}$$

$$\zeta_{0\bar{0}} = 1 \rightarrow \text{total decoherence}$$

$\phi \rightarrow K_S K_L \rightarrow \pi^+ \pi^- \pi^+ \pi^-$: test of quantum coherence



$$I(\pi^+ \pi^-, \pi^+ \pi^-; \Delta t) = \frac{N}{2} \left[\left| \langle \pi^+ \pi^-, \pi^+ \pi^- | K^0 \bar{K}^0(\Delta t) \rangle \right|^2 + \left| \langle \pi^+ \pi^-, \pi^+ \pi^- | \bar{K}^0 K^0(\Delta t) \rangle \right|^2 \right. \\ \left. - \left(1 - \zeta_{0\bar{0}} \right) \cdot 2 \Re \left(\langle \pi^+ \pi^-, \pi^+ \pi^- | K^0 \bar{K}^0(\Delta t) \rangle \langle \pi^+ \pi^-, \pi^+ \pi^- | \bar{K}^0 K^0(\Delta t) \rangle^* \right) \right]$$

Decoherence parameter:

$$\zeta_{0\bar{0}} = 0 \rightarrow \text{QM}$$

$$\zeta_{0\bar{0}} = 1 \rightarrow \text{total decoherence}$$

- Fit including Δt resolution and efficiency effects + regeneration
- $\Gamma_s, \Gamma_L, \Delta m$ fixed from PDG

KLOE preliminary result:

$$\zeta_{0\bar{0}} = (2.4 \pm 2.0_{\text{STAT}} \pm 0.2_{\text{SYST}}) \times 10^{-6}$$



$$\text{with } 2.5 \text{ fb}^{-1} : \\ \pm 0.8_{\text{STAT}} \times 10^{-6}$$

From CPLEAR data, Bertlmann et al.
(PR D60 (1999) 114032) obtain:

$$\zeta_{0\bar{0}} = 0.4 \pm 0.7$$

as CP viol. $O(|\eta_{+-}|^2) \sim 10^{-6}$
=> high sensitivity to ζ



Decoherence and CPT violation

Modified Liouville – von Neumann equation for the density matrix of the kaon system:

$$\dot{\rho}(t) = \underbrace{-iH\rho + i\rho H^\dagger}_{\text{QM}} + \underbrace{L(\rho)}_{\text{extra term inducing decoherence: pure state} \Rightarrow \text{mixed state}}$$

Possible decoherence due quantum gravity effects:

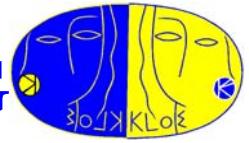
Hawking [1] suggested that at a microscopic level, in a quantum gravity picture, non-trivial space-time fluctuations could give rise to decoherence effects, which would necessarily entail a violation of CPT [2].

J. Ellis et al.[3-5] => model of decoherence for neutral kaons => 3 new CPTV param. α, β, γ :

$$L(\rho) = L(\rho; \alpha, \beta, \gamma)$$
$$\alpha, \gamma > 0 , \quad \alpha\gamma > \beta^2$$

$$\text{At most: } \alpha, \beta, \gamma = O\left(\frac{M_K^2}{M_{PLANCK}}\right) \approx 2 \times 10^{-20} \text{ GeV}$$

[1] Hawking, Comm.Math.Phys.87 (1982) 395; [2] Wald, PR D21 (1980) 2742;[3] Ellis et. al, NP B241 (1984) 381; PRD53 (1996)3846 [4] Huet, Peskin, NP B434 (1995) 3; [5] Benatti, Floreanini, NPB511 (1998) 550



The fit with $I(\pi^+ \pi^-, \pi^+ \pi^-; \Delta t, \alpha, \beta, \gamma)$ gives:

KLOE preliminary

$$\begin{aligned}\alpha &= (-10^{+41}_{-31}{}_{STAT} \pm 9_{SYST}) \times 10^{-17} \text{ GeV} \\ \beta &= (3.7^{+6.9}_{-9.2}{}_{STAT} \pm 1.8_{SYST}) \times 10^{-19} \text{ GeV} \\ \gamma &= (-0.4^{+5.8}_{-5.1}{}_{STAT} \pm 1.2_{SYST}) \times 10^{-21} \text{ GeV}\end{aligned}$$

with $L = 2.5 \text{ fb}^{-1}$:

$$\begin{aligned}&\pm 15_{STAT} \times 10^{-17} \text{ GeV} \\ \rightarrow &\pm 3.3_{STAT} \times 10^{-19} \text{ GeV} \\ &\pm 2.2_{STAT} \times 10^{-21} \text{ GeV}\end{aligned}$$

CLEAR

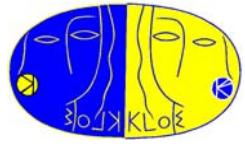
$$\begin{aligned}\alpha &= (-0.5 \pm 2.8) \times 10^{-17} \text{ GeV} \\ \beta &= (2.5 \pm 2.3) \times 10^{-19} \text{ GeV} \\ \gamma &= (1.1 \pm 2.5) \times 10^{-21} \text{ GeV}\end{aligned}$$



Perspectives with KLOE-2 at DAΦNE-2

Mode	Test of	Param.	Present best measurement	KLOE-2 L=20 - 50 fb ⁻¹
$K_S \rightarrow 3\pi^0$	CP	BR	$<1.2 \times 10^{-7}$	$<5 \times 10^{-9}$ - seen
$K_S \rightarrow \pi e \nu$	CP, CPT	A_S	$(1.5 \pm 11) \times 10^{-3}$	$\pm(1 - 2) \times 10^{-3}$
$K_L \rightarrow \pi e \nu$	CP, CPT	A_L	$(3322 \pm 58 \pm 47) \times 10^{-6}$	$\pm(25 - 40) \times 10^{-6}$
$\pi^+ \pi^- \pi^+ \pi^-$	QM	ζ_{00}	$(2.4 \pm 2.0) \times 10^{-6}$	$\pm(0.1 - 0.2) \times 10^{-6}$
$\pi^+ \pi^- \pi^+ \pi^-$	QM	ζ_{SL}	0.043 ± 0.038	$\pm(0.002 - 0.003)$
$\pi^+ \pi^- \pi^+ \pi^-$	CPT & QM	α	$(-0.5 \pm 2.8) \times 10^{-17} \text{ GeV}$	$\pm(2 - 3) \times 10^{-17} \text{ GeV}$
$\pi^+ \pi^- \pi^+ \pi^-$	CPT & QM	β	$(2.5 \pm 2.3) \times 10^{-19} \text{ GeV}$	$\pm(0.1 - 0.2) \times 10^{-19} \text{ GeV}$
$\pi^+ \pi^- \pi^+ \pi^-$	CPT & QM	γ	$(1.1 \pm 2.5) \times 10^{-21} \text{ GeV}$	$\pm(0.2 - 0.3) \times 10^{-21} \text{ GeV}$
$\pi^+ \pi^- \pi^+ \pi^-$	CPT & Bose corr.	$\text{Re}(\omega)$	-	$\pm(2 - 3) \times 10^{-5}$
$\pi^+ \pi^- \pi^+ \pi^-$	CPT & Bose corr.	$\text{Im}(\omega)$	-	$\pm(2 - 3) \times 10^{-5}$
$\pi^+ \pi^- \pi e \nu$	CPT & Lorentz	Δa_Z	-	$O(10^{-18} \text{ GeV})$
$\pi^+ \pi^- \pi e \nu$	CPT & Lorentz	$\Delta a_{X,Y}$	$<10^{-21} \text{ GeV}$	$O(10^{-18} \text{ GeV})$

NEUTRAL KAON INTERFEROMETRY AT A Φ -FACTORY: from Quantum Mechanics to Quantum Gravity



Laboratori Nazionali di Frascati dell'INFN

March 24th, 2006 (9:30 – 18:30)

Aula Touschek

A one-day workshop devoted to discuss the potentialities
of neutral kaon interferometry at a ϕ -factory:

Decoherence and novel CPT violation in quantum gravity

Open quantum dynamics and complete positivity

CPT and Lorentz symmetry breaking

Entanglement, Bell's inequalities and other
tests of Quantum Mechanics

CPT violation and Bell-Steinberger relation

Review of experimental results and perspectives

Speakers:

G. Amelino-Camelia (Roma), J. Bernabeu (Valencia),
R. Bertlmann (Vienna), A. Bramon (Barcelona),
R. Floreanini (Trieste), A. Go (CERN), B. Hiesmayr (Vienna),
G. Isidori (LNF), R. Lehnert (MIT), N. Mavromatos (London)

Organization: A. Di Domenico (Roma)

E-mail: antonio.didomenico@roma1.infn.it