Status and perspectives on neutral kaon analysis

KLOE General meeting
LNF, December 14th, 2005

M. Palutan
M. Antonelli

1) Summary of 2005 results on 2001-2002 data

2) Future:

- what is left on 2001-2002 data sample
- analysis on 2004-2005 data sample

Slides from all of the group members + S.Giovannella

2005 results on 2001-2002 data

$K_S \to \pi^0\pi^0\pi^0$	M. Martini, S. Miscetti	**PLB 619 (2005) 61-70**
K_L **lifetime**	G. Lanfranchi	**PLB 626 (2005) 15-23**
BR of major K_L decays	M.Antonelli, P.Beltrame, M Dreucci, M.Moulson, M.P., A.Sibidanov	**Accepted by PLB**

$K_S \to \pi e \nu$	C. Gatti, T. Spadaro	KLOE memo 318 **draft ready** referees: C.Bini, M.Incagli
$K_S \to \pi^+\pi^-(\gamma)$ / $K_S \to \pi^0\pi^0$	C. Gatti, M.P., T. Spadaro	KLOE memo ready **draft ready** referees: C.Bini, F.Bossi
K_{Le3} **form factor slopes**	C. Gatti, M.Dreucci, M.Antonelli	KLOE memo 322 **draft in writing** referees: P.Franzini, V.Patera
$K_L \to \pi^+\pi^-$	M.Antonelli, M.Testa	KLOE memo ready **blessing today** referees: C.Bini,. P.Franzini

deadline for PDG06 Jan 15th

$K_S \to \pi e \nu$: results

Branching ratios:
410 pb^{-1} '01 + '02 data

$$BR(\pi^- e^+ \nu) = (3.529 \pm 0.057 \pm 0.027) \times 10^{-4}$$
$$BR(\pi^+ e^- \bar{\nu}) = (3.518 \pm 0.051 \pm 0.029) \times 10^{-4}$$
$$BR(\pi e \nu) = (7.048 \pm 0.076 \pm 0.050) \times 10^{-4}$$

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

Charge asymmetry:

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

With 2.5 fb^{-1}: $\delta A_S \sim 3 \times 10^{-3} \sim 2$ Re ε

Linear FF slope:

$$\lambda_+ = (33.8 \pm 4.1) \times 10^{-3}$$

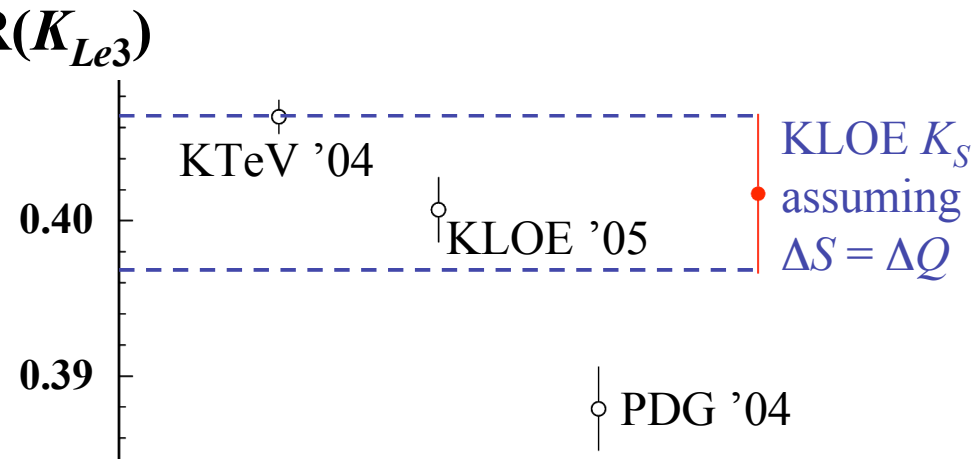
In good agreement with linear fit from K_L semileptonic form factor
[$(28.6 \pm 0.6) 10^{-3}$]

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

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

$\tau(K_S)$ = 89.58 ± 0.06 ps
PDG fit

$\tau(K_L)$ = 51.01 ± 0.20 ns
PDG + KLOE '05 (avg.)



We evaluate: $\Re(x_+) = \left[\dfrac{BR(K_{Se3})\,\tau_L}{BR(K_{Le3})\,\tau_S} - 1 \right]$

ratio of $\Delta S = \Delta Q$ violating and conserving amplitudes

$$\Re(x_+) = (\ 0.4 \pm 3.1 \pm 1.8)\ \ 10^{-3}$$

$\tau(K_S)$	PDG
$\tau(K_L)$	PDG + KLOE '05 (avg.)
BR($K_L \to \pi e \nu$)	KLOE

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

$K_S \to \pi e \nu$: CPT test

1) $\Re(x\_)$: CPT viol., $\Delta S = \Delta Q$ viol.

$$A_S - A_L = 4\,(\,\Re(x\_) + \Re(\delta)\,)$$

A_L	KTeV	$\sigma = 0.75 \times 10^{-4}$
$\Re(\delta)$	CPLEAR	$\sigma = 3.4 \times 10^{-4}$

$$\Re(x\_) = (\,-0.8 \pm 2.4 \pm 0.7)\;\; 10^{-3}$$

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

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

$$\Re(y) = (\,-0.8 \pm 2.4 \pm 0.7)\;\; 10^{-3}$$

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

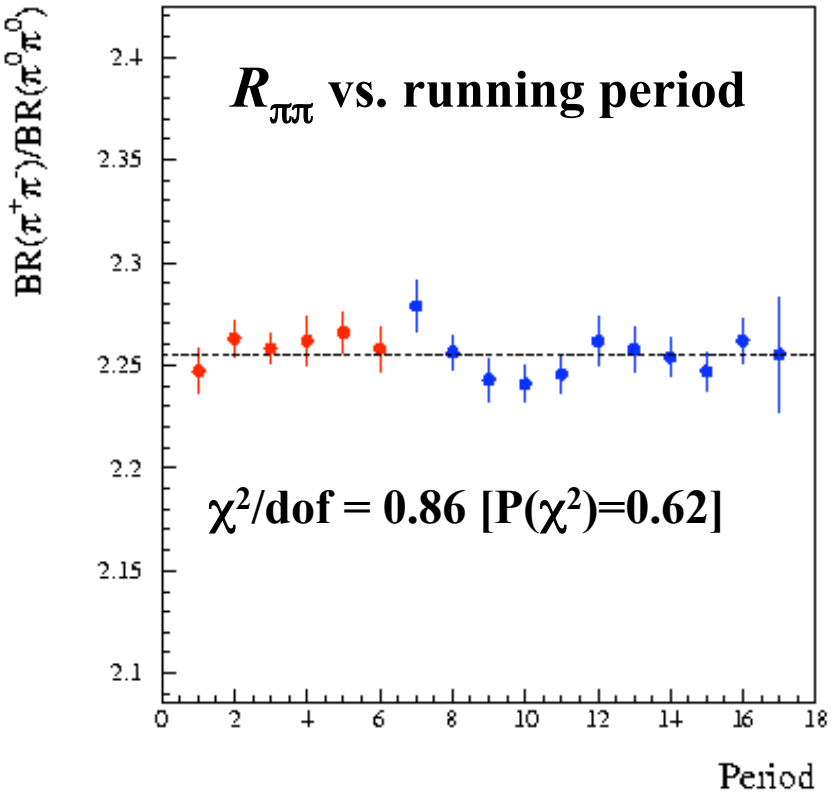
$\Gamma(K_S \to \pi^+\pi^-(\gamma))/\Gamma(K_S \to \pi^0\pi^0)$: result

KLOE '02 $2.236 \pm 0.003_{stat} \pm 0.007_{statsyst} \pm 0.013_{syst}$

(17 pb^{-1} '00 data)

KLOE '05 $\mathbf{2.2555 \pm 0.0012_{stat} \pm 0.0021_{statsyst} \pm 0.0050_{syst}}$

(410 pb^{-1} '01 +'02 data)



Fractional error on $R_{\pi\pi}$	
Source	**Error (10^{-3})**
Event counting	0.54
Cosmic veto	0.26
Stat corrections	0.89
$\pi^+\pi^-$ acceptance	1.61
$\pi^0\pi^0$ acceptance	1.02
Trigger	0.67
Tag	0.63
Background	0.10
FILFO	0.74
Total error	**2.5**

K_{Le3} form factor slopes

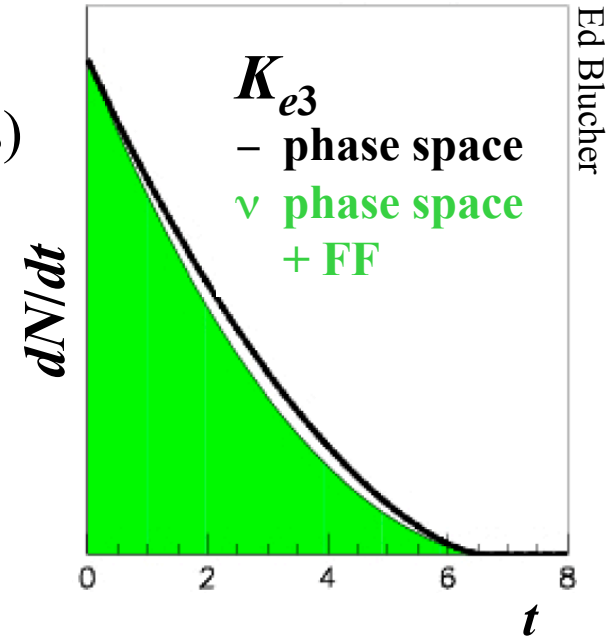
Form-factor slopes for $K \to \pi l \nu$ decays needed for extraction of V_{us} (evaluation of phase-space integrals)

Parametrization:

$t = (p_K - p_\pi)^2 / m^2_{\pi^+}$

For K_{e3}: $f_+(t) = f_+(0)\,[1 + \lambda_+ t]$ ***or***

$f_+(0)\,[1 + \lambda'_+ t + 1/2\,\lambda''_+ t^2]$



KLOE results for $K_L \to \pi e \nu$ decays:

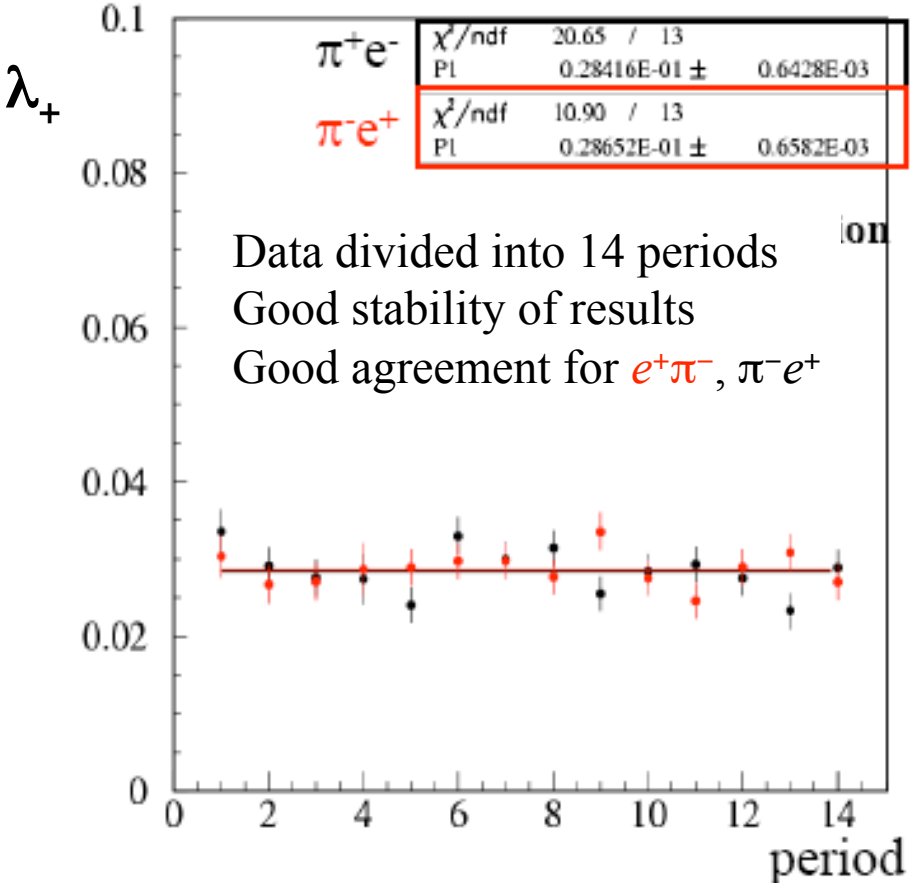
- 328 pb^{-1} of '01 + '02 data
- K_L decays tagged by $K_S \to \pi^+\pi^-$ satisfying trigger ($\varepsilon \sim 30\%$)
- Two tracks in fiducial volume forming vertex
- Kinematic cuts + TOF PID to reduce background (~ 0.7% final contamination)
- Separate measurement for each charge state ($e^+\pi^-$, π^+e^-) to check systematics

K_{Le3} form factor slopes: fit

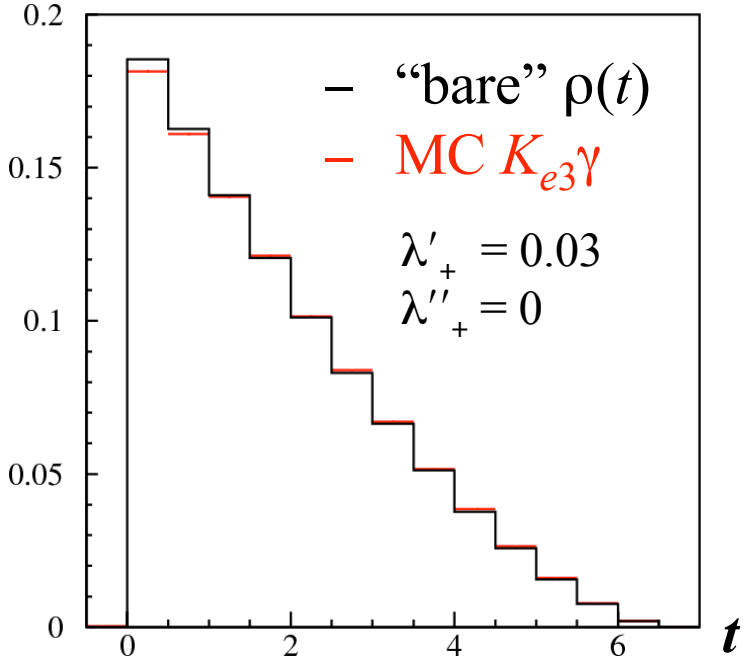
Divide data into 20 bins ($-3 < t < +7$)

$$N_i = N_0 \sum_{j=1}^{20} A_{ij}\, \varepsilon_j\, \rho_j(\lambda'_+, \lambda''_+)\, F_j^{\mathrm{FSR}}$$

- A_{ij} — Smearing matrix (MC)
- ε_j — Reconstruction efficiency
- ρ_j — "Bare" K_{e3} decay density
- F_j^{FSR} — FSR correction



Obtained from MC generator, affect mainly at low t



K_{Le3} form factor slopes: result

328 pb^{-1} '01 + '02 data , 2 × 10^6 K_{e3} decays

Linear fit:

	$\lambda_+ \times 10^{-3}$	χ^2/dof
$e^+\pi^-$	28.7 ± 0.7	156/181
π^+e^-	28.5 ± 0.6	174/181
All	28.6 ± 0.5	330/363

$\lambda_+ = (28.6 \pm 0.5 \pm 0.4) \times 10^{-3}$

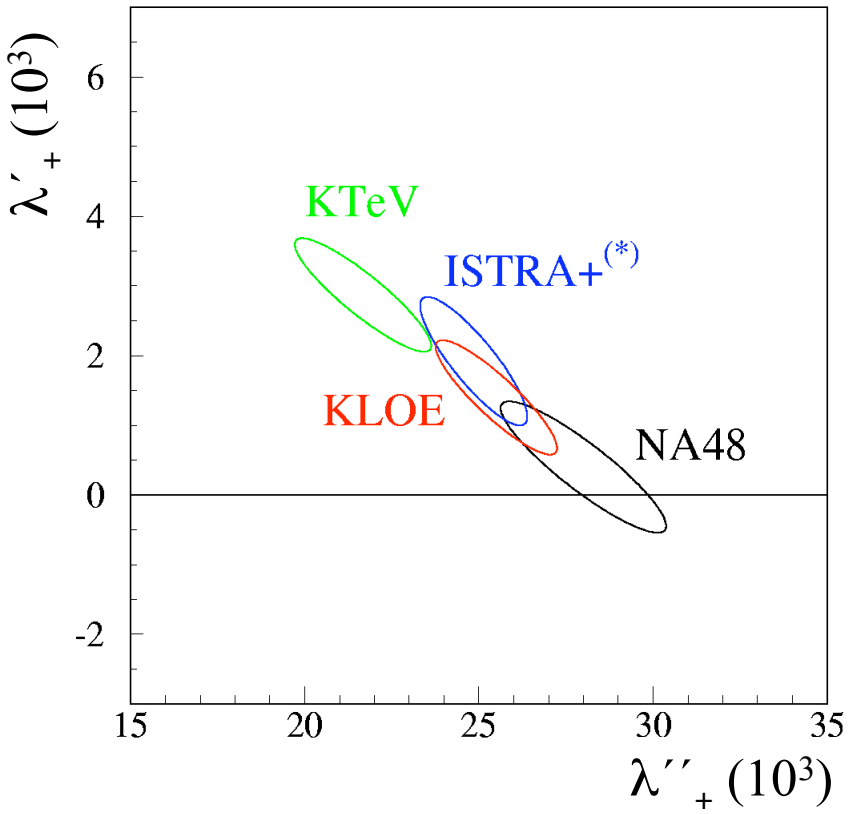
Quadratic fit:

	$\lambda'_+ \times 10^{-3}$	$\lambda''_+ \times 10^{-3}$	χ^2/dof
$e^+\pi^-$	24.6 ± 2.1	1.9 ± 1.0	152/180
π^+e^-	26.4 ± 2.1	1.0 ± 1.0	173/180
All	25.5 ± 1.5	1.4 ± 0.7	325/362

$\lambda'_+ = (25.5 \pm 1.5 \pm 1.0) \times 10^{-3}$

$\lambda''_+ = (1.4 \pm 0.7 \pm 0.3) \times 10^{-3}$

$\rho(\lambda'_+, \lambda''_+) = -0.95$



(*) ISTRA+ corrected

Interpretation of the results

1) KLOE measurement of $V_{us} \times f_+(0)$ from:

$BR(K_{Le3})$, $BR(K_{L\mu 3})$, τ_L	final results
$\Gamma(K_{Se3})/\Gamma(K_S \to \pi^+\pi^-)$, $\Gamma(K_S \to \pi^+\pi^-)/\Gamma(K_S \to \pi^0\pi^0)$	final results
$BR(K^{\pm}_{e3})$, $BR(K^{\pm}_{\mu 3})$, $\tau^{\pm}$	preliminary results

…+ V_{us}/V_{ud} from $K^{\pm}_{\mu 2}$ — final result

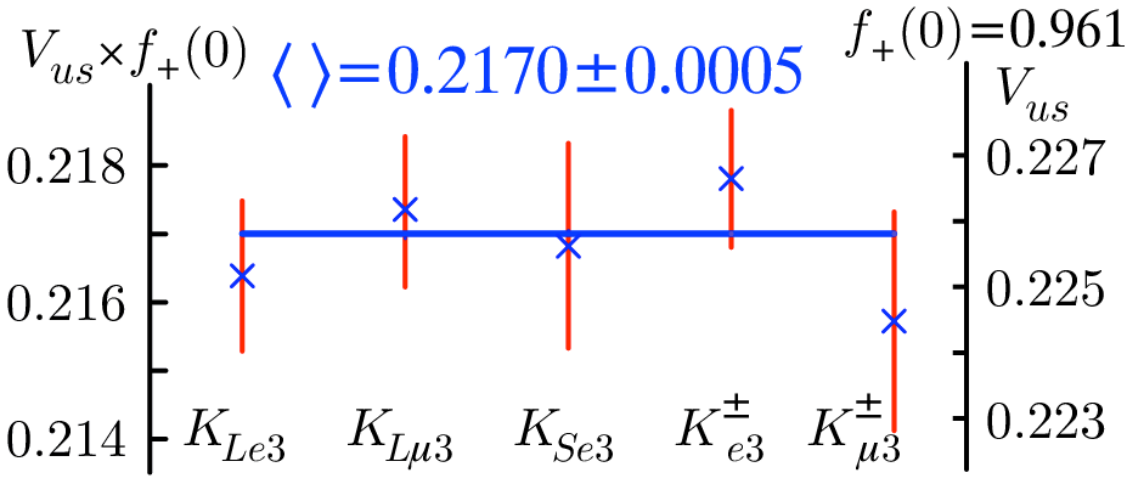
draft in 2006 ?

2) CPT test with Bell-Steinberger relation:

all of K_S–K_L results, most relevant are:
UL on $BR(K_S \to \pi^0\pi^0\pi^0)$
$BR(K_L \to \pi^+\pi^-)$
semileptonic K_S charge asymmetry (A_S)

draft after publ. of $K_L \to \pi^+\pi^-$

KLOE and V_{us}



Expect from unitarity

$V_{us} f_+(0) = 0.2181 \pm 0.0022$

$V_{ud} = 0.9739 \pm 0.0003$
Marciano, CKM '05
Hardy & Towner '04 (SFT)

$f_+(0) = 0.961 \pm 0.008$
Leutwyler & Roos

BR's from KLOE

	$K_L e3$	$K_L \mu 3$	$K_S e3$	$K^{\pm} e3$	$K^{\pm} \mu 3$
BR	0.4007	0.2698	0.00709	0.0505	0.0331
δBR	0.0015	0.0015	0.00009	0.0004	0.0005

K_L lifetime from KLOE

$\tau_L = (50.84 \pm 0.23)$ ns
Avg. of direct, Σ BR = 1 determinations

Quadratic form-factor parameterizations:

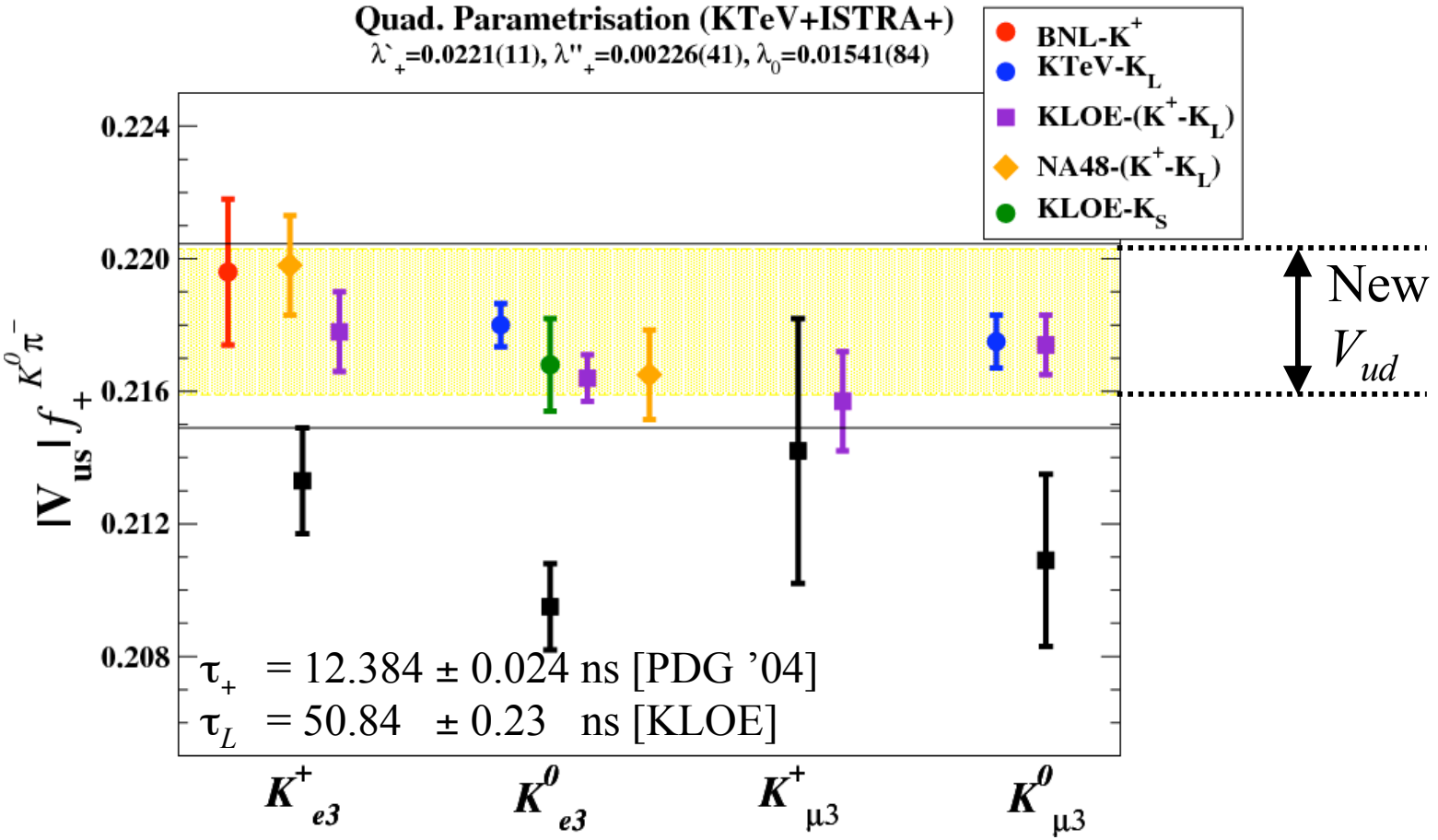
$\lambda'_+ = 0.0221 \pm 0.0011$
$\lambda''_+ = 0.0023 \pm 0.0004$
$\lambda_0 = 0.0154 \pm 0.0008$

⟨ **KTeV**, **ISTRA+** ⟩

KLOE λ_+ to be impl.

V_{us}: summary of recent measurements

Thanks to F. Mescia
(see hep-ph/0411097)



The V_{us}–V_{ud} plane

Inputs:

$V_{us} = 0.2258 \pm 0.0020$ (K_{l3} KLOE)

$V_{ud} = 0.97390 \pm 0.00027$ (Marciano)

$V_{us}/V_{ud} = 0.2294 \pm 0.0026$ ($K_{\mu 2}$ KLOE)

Fit results:

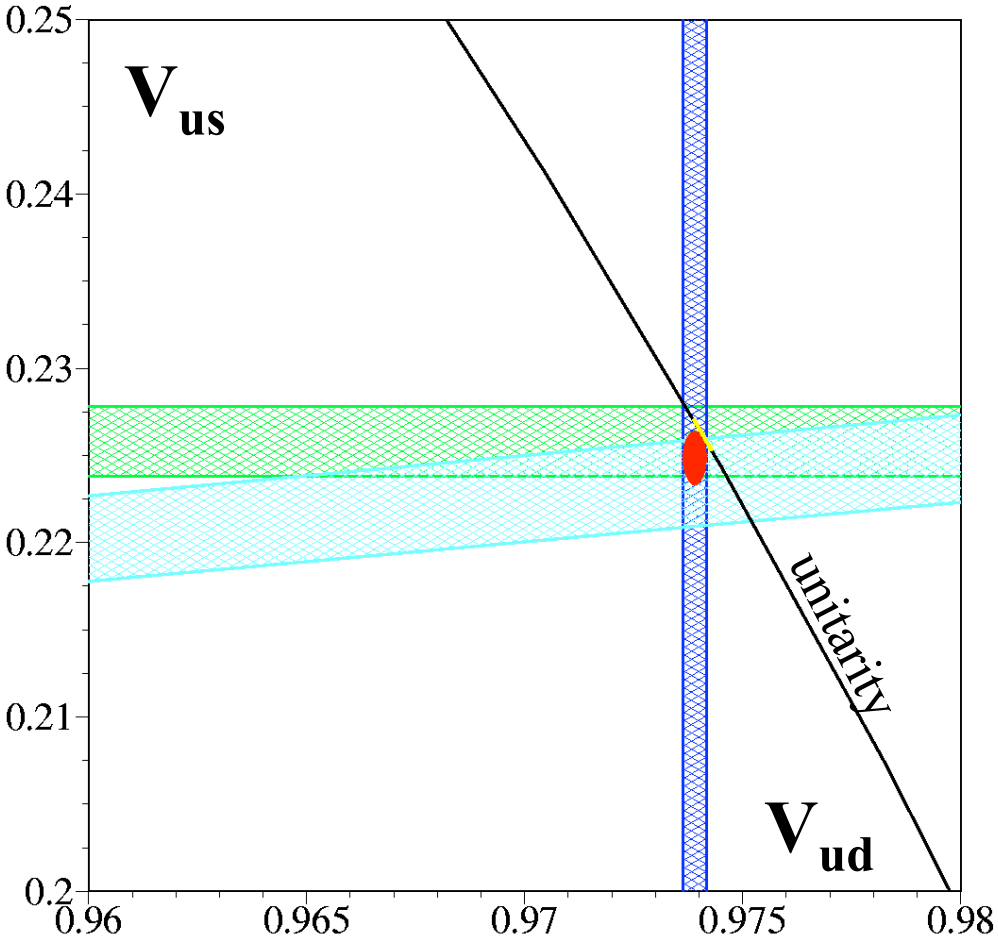
$V_{us} = 0.2249 \pm 0.0016$

$V_{ud} = 0.97390 \pm 0.00027$

Fit results assuming unitarity:

$V_{us} = 0.2262 \pm 0.0009$

$P(\chi^2) = 0.43$



fit by M.Antonelli, E. De Lucia

CPT test: the Bell-Steinberger relation

Measurements of K_S K_L observables can be used for CPT test

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

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

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

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

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

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

$$\alpha_{kl3} = 2\tau_S/\tau_L\,B(K_L l3)\,[\mathrm{Re}\,\varepsilon - \mathrm{Re}\,y - i(\mathrm{Im}\,\delta + \mathrm{Im}\,x_+)]$$
$$= 2\tau_S/\tau_L\,B(K_L l3)\,[2\mathrm{Re}\,\varepsilon - (A_S + A_L)/4 - i(\mathrm{Im}\,\delta + \mathrm{Im}\,x_+)]$$

Calculated with KLOE results by M.Antonelli

CPT test: inputs

$\tau_S = 0.08958 \pm 0.00006$ ns

$\tau_L = 50.84 \pm 0.23$ ns

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

$B(K_L \to \pi^+\pi^-) = (1.930 \pm 0.017) \times 10^{-3}$

$B(K_L \to \pi^0\pi^0) = (9.32 \pm 0.12) \times 10^{-4}$

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

$\phi^{00} = 0.762 \pm 0.014$

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

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

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

$B(K_S \to \pi l \nu) = (11.77 \pm 0.15) \times 10^{-4}$

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

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

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

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

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

$B(K_L \to \pi^0\pi^0\pi^0) = 0.1997 \pm 0.0020$

$\phi^{SW} = (43.51 \pm 0.06)^O$

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

Im x_+ from a combined fit of KLOE + CPLEAR

$A_S - A_L = 4(\mathrm{Re}\,\delta + \mathrm{Re}\,x_-) = (-1.8 \pm 10.0) \times 10^{-3}$

$A_S + A_L = 4(\mathrm{Re}\,\varepsilon - \mathrm{Re}\,y) = (4.7 \pm 10.0) \times 10^{-3}$

+ CPLEAR time dependent asymmetry:

$(R^*_-(t) - R_+(t))/(+) + (R^*_+(t) - R_-(t))/(+)$

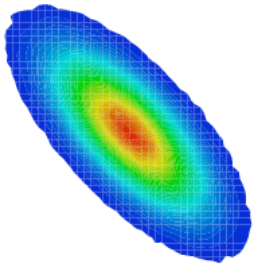
$\mathrm{Re}\,\delta = (3.0 \pm 3.3 \pm 0.6) \times 10^{-4}$	1	0.44	-0.56	-0.61
$\mathrm{Im}\,\delta = (-1.5 \pm 2.3 \pm 0.3) \times 10^{-2}$		1	-0.97	-0.91
$\mathrm{Re}\,x_- = (0.2 \pm 1.3 \pm 0.3) \times 10^{-2}$			1	0.96
$\mathrm{Im}\,x_+ = (1.2 \pm 2.2 \pm 0.3) \times 10^{-2}$				1

Result:

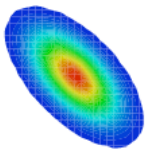
$\mathrm{Re}\,\delta = (3.3 \pm 2.8) \times 10^{-4}$	1	-0.27	-0.23	-0.35
$\mathrm{Im}\,\delta = (-1.1 \pm 0.7) \times 10^{-2}$		1	-0.58	-0.12
$\mathrm{Re}\,x_- = (-0.03 \pm 0.25) \times 10^{-2}$			1	0.57
$\mathrm{Im}\,x_+ = (0.8 \pm 0.7) \times 10^{-2}$				1

CPT test: accuracy on α_i

We get the following results on each term of the sum

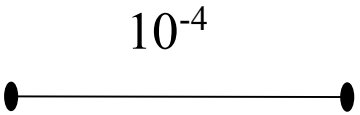


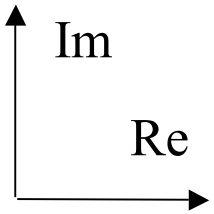
$\alpha_{+-} = \eta_{+-}\, B(K_S \to \pi^+\pi^-)$

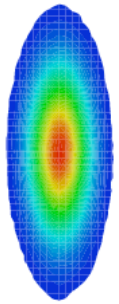


$\alpha_{00} = \eta_{00}\, B(K_S \to \pi^0\pi^0)$

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

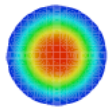






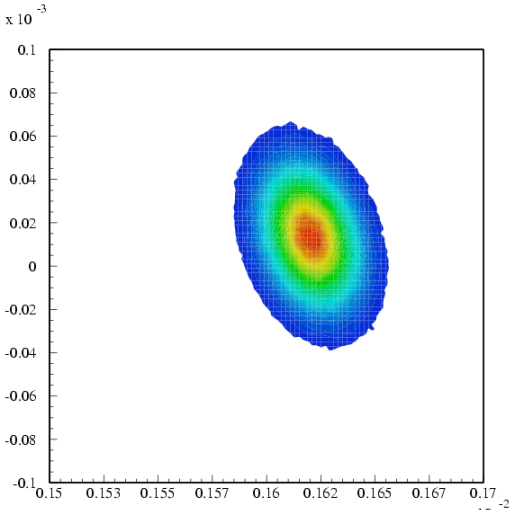
$2\tau_S/\tau_L\, B(K_L l3)$
$[\,(A_S+A_L)/4 - i\,\mathrm{Im}\, x_+\,]$

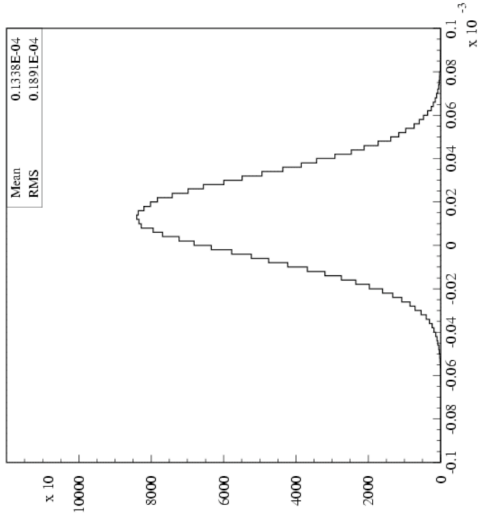
$\alpha_{+-0} = \tau_S/\tau_L\, \eta_{+-0}{}^{*} B(K_L \to \pi^+\pi^-\pi^0)$

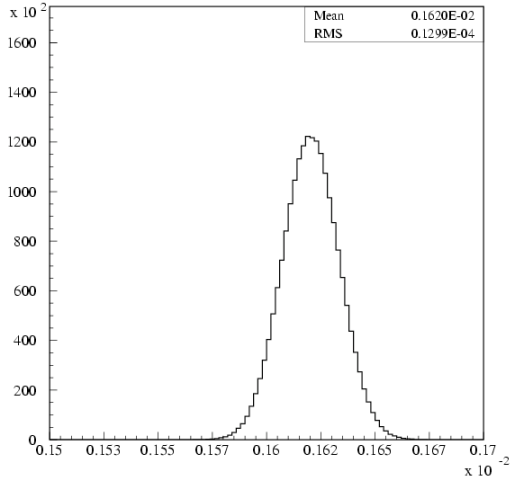


$\alpha_{000} = \tau_S/\tau_L\, \eta_{000}{}^{*} B(K_L \to \pi^0\pi^0\pi^0)$

CPT test: KLOE result







Re ε = (162.0 ± 1.3) 10^{-5}
Im δ =(1.3 ± 1.9) 10^{-5}

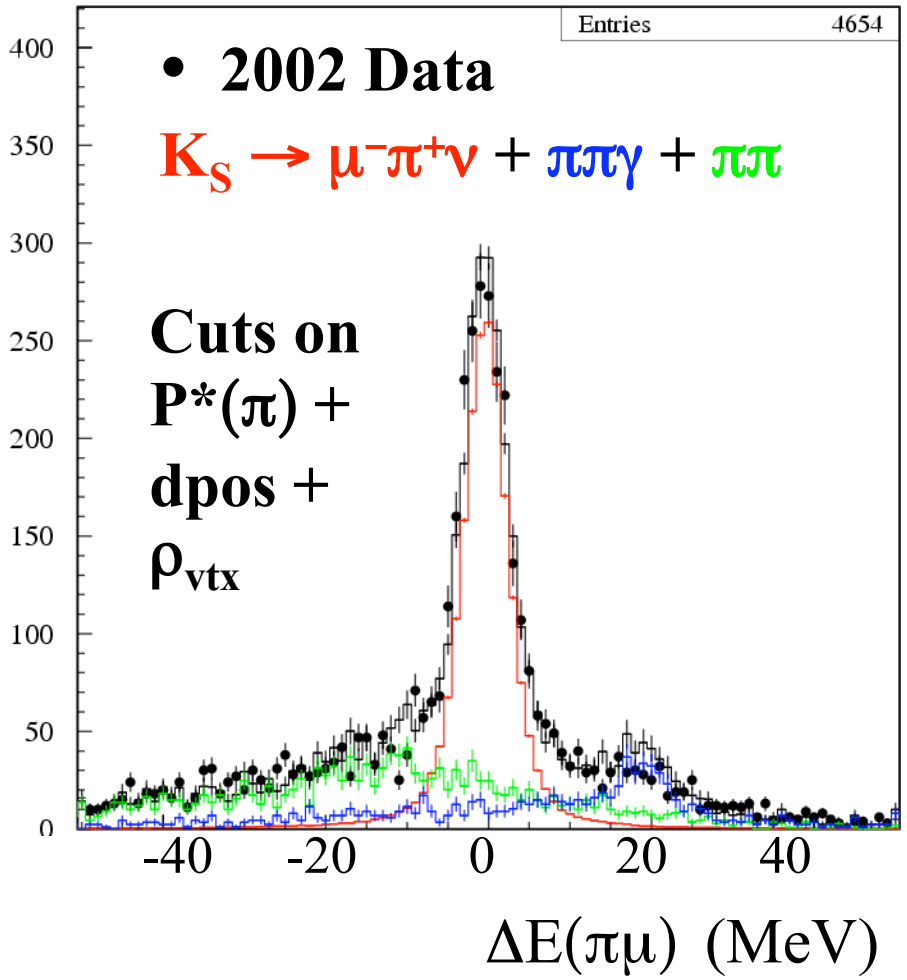
CPLEAR:
Re ε = (164.9 ± 2.5) 10^{-5}
Im δ =(2.4 ± 5.0) 10^{-5}

What is left on 2001-2002 data

$K_S \rightarrow \pi\mu\nu$	S. Chi, T.Spadaro	preliminary results for winter conf.
$\pi^+\pi^- \pi^+\pi^-$ interferometry	M. Antonelli, Di Domenico, M. Testa,	KLOE memo 310 ref. : F.Ambrosino, M.Napolitano
$K_{L\mu 3}$ form factor slopes	M.Antonelli, M.Dreucci, C.Gatti, A.Sibidanov	just started
BR($K_{Le3\gamma}$)	M.Antonelli M.Dreucci, C.Gatti (+ student?)	not yet started
ν_μ mass	A. Zaitsev	just started
incoherent regeneration	S.Bocchetta, A.Passeri F.Ceradini	in progress

$K_S \to \pi\mu\nu$

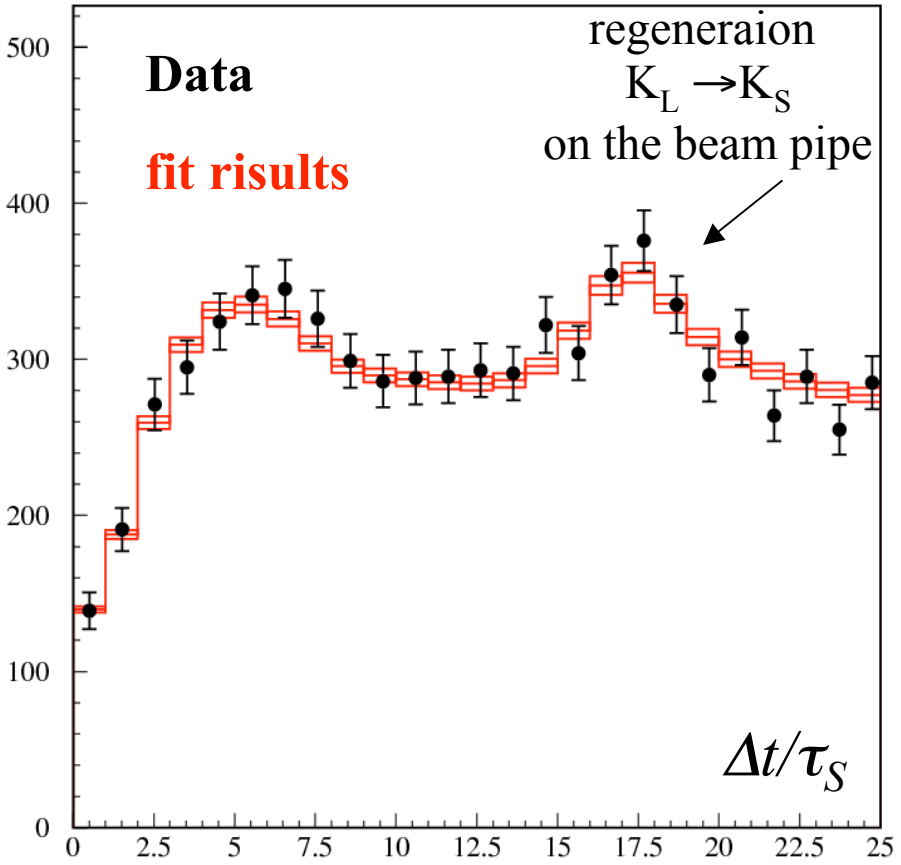
- Measurement never done before
- More difficult than K_{Se3}:
  1) Lower BR: expect 4×10^{-4}
  2) Background events from $K_S \to \pi\pi$, $\pi \to \mu\nu$: same PIDs of the signal
- Preselection + TOF + dpos + ρ_{vtx} + $p^*(\pi)$ *vs* $p^*(\mu)$
- Efficiency estimate from $K_{L\mu3}$ early decays and from MC + data control samples: on the way



Event counting from the fit to $E_{miss}(\pi\mu) - P_{miss}$: ~ 3% stat error, **NOW**

Interference in the channel $\phi \rightarrow K_S K_L \rightarrow \pi^+\pi^-\pi^+\pi^-$

- Kinematic fit
- Efficiency with data/MC corrections
- Systematic checks:
  - $M_{inv}(4\pi)$ *vs* Δt
  - fit *vs* resolution
  - fit *vs* cut on χ^2_{fit}
- Δm compatible with PDG
- Fit to extract the decoherence parameter (Δm fixed to PDG):



$$\zeta_{KS\text{-}KL} = 0.043\ ^{+0.038}_{-0.035}{}_{stat} \pm 0.008_{syst}$$

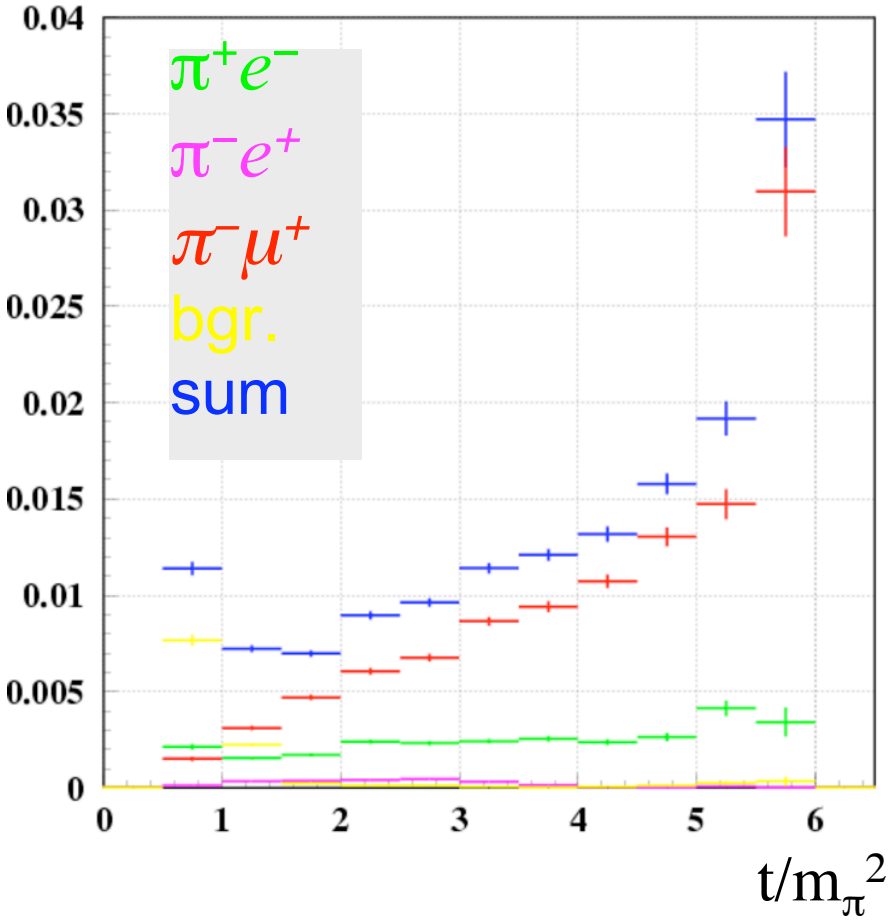
$$\zeta_{K0\text{-}K0} = (0.24\ ^{+0.21}_{-0.19}{}_{stat} \pm 0.02_{syst})10^{-5}$$

$K_{L\mu 3}$ form factor slopes

A first attempt to fit the slope parameters on $K_{L\mu 3}$ decays has been made (A. Sibidanov)

Analysis status of the art:

- muon cluster efficiency ready
- all informations needed to reach the required purity combined into a NN (TOF, E/p, I, $E_{miss} - cP_{miss}$)
- 20% data-MC discrepancy in NN output
- results on λ_0 depend on the fit range



$\pi^+\mu^-$ background

Analysis on 2004-2005 data sample (1)

Rare K_S decays

$K_S \to \pi^+\pi^- \pi^0$	A.Antonelli, M.Moulson, D.Bowring	advanced status
$K_S \to \pi^0\pi^0\pi^0$	M.Martini, S.Miscetti	update in progress
$K_S \to \gamma\gamma$, γe^+e^-	M.Martini, S.Miscetti	$\gamma\gamma$ in progress
$K_S \to \pi^+\pi^- e^+e^-$	F.Crucianelli, C.Gatti	just started
$K_S \to \pi^+\pi^-\gamma$	M.Palutan, T.Spadaro	not yet started
$K_S \to \mu^+\mu^-$, e^+e^-	……	not yet started

All of the following analyses need the MC 04-05 production

$K_S \to \pi^+\pi^-\pi^0$: analysis strategy

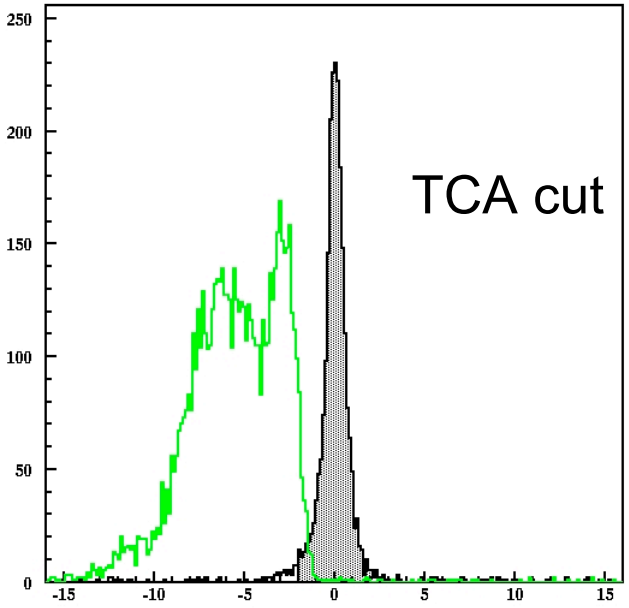
PDG04: BR=$(3.2\pm1.2)\times10^{-7}$

χPT: BR=$(2.4\pm0.7)\times10^{-7}$

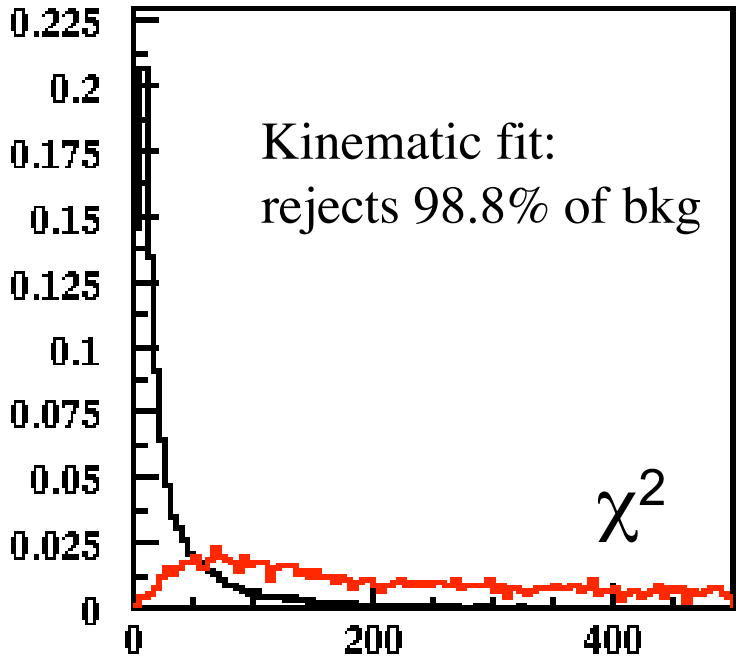
After preselection (Kcr+2trks+π^0):

- S/B =7×10^{-4} (τ' and Dalitz)
- 16 signal evts. with 740 pb^{-1} (ε_{sig}=7%)

Powerful rejection cuts: TCA, kinematic fit, p*, E_{free}



min[ΔTOF(π^+), ΔTOF(π^-)] for MC `ksppp` and `dalitz`



N_{found}=6; N_{bkg}=3.5±1.3; ε_{sig}=1.4%

$K_S \to \pi^+\pi^-\pi^0$: prospects for 2 fb^{-1}

Result presented at KPW05 based on 740 pb^{-1}

$$\mathbf{BR = 2.8\ ^{+3.7}_{-2.1} \times 10^{-7}}$$

Assuming	Results for 2 fb^{-1}
• Central value does not change • No further effort made to reduce background	• BR = $(2.8^{+2.0}_{-1.5}) \times 10^{-7}$ • ~16 counts, of which ~9 background
• Further efforts completely eliminate background	• BR = $(2.8^{+1.4}_{-1.1}) \times 10^{-7}$ • ~7 signal counts

Errors do not (yet) include uncertainty in background.

$K_S \rightarrow \pi^0\pi^0\pi^0$: prospects for 2 fb^{-1}

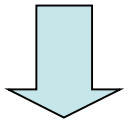
- Published result on 2001-2002 sample: **BR($K_S \rightarrow 3\pi^0$) < 1.2 x 10^{-7}**

(SM expect. BR ~ 1.9 x 10^{-9})

- Analysis: K_L-crash tag + six prompt photons + Kinematic fit + ζ_2, ζ_3 estimators
- N_{found}=2; N_{bkg}=3.13 ± 0.82 ± 0.37 ; $\varepsilon_{sig\,|\,tag}$ = 24.4%
- BKG composition: 88% double splitting, 6% double accidental, 6% fake Kcrash

What should we expect (as of KPW05):

1) Increase of statistics: **× 5 Luminosity** + × 1.3 K_L vtx tag
2) Improved bkg rejection:
   - tuning of recover splitting algorithm: N_{found}=0; N_{bkg}=3.13 → ~ 2
   - further improvement is expected on kinematic rejection



factor 1/10 at best

$K_S \to \gamma\gamma$

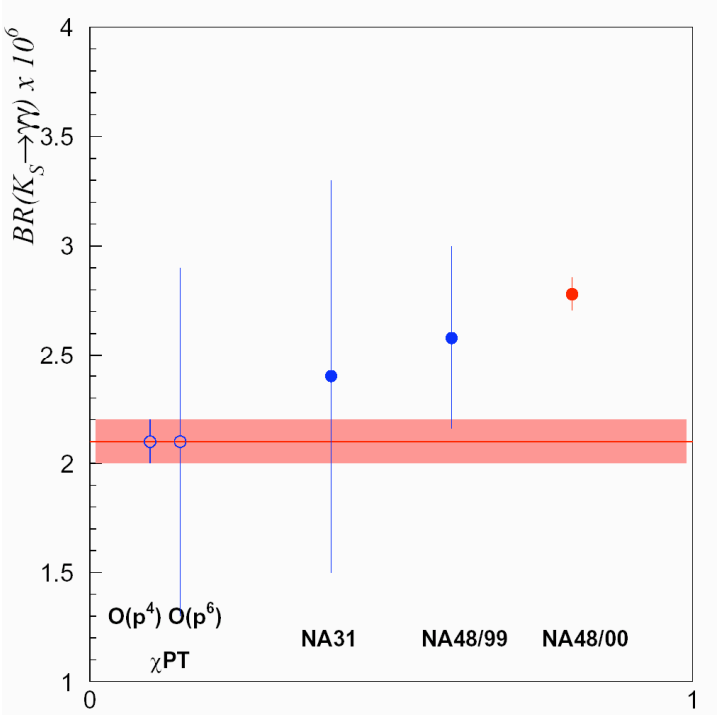
• NA48/1 measurement with 2.6% accuracy:

$BR(K_S \to \gamma\gamma) = (2.78 \pm 0.06 \pm 0.04) \times 10^{-6}$

obtained from a fit to the Z vertex distribution

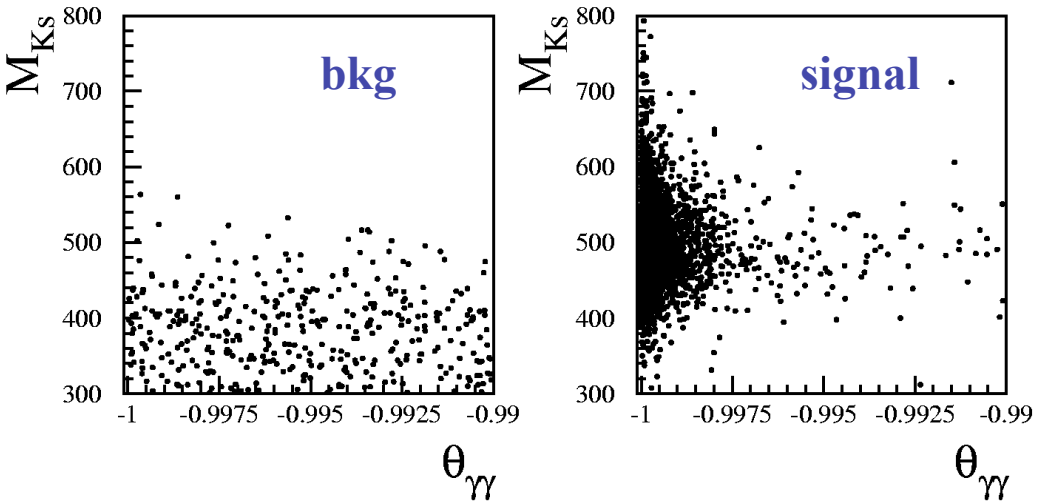
($K_L \to \gamma\gamma$ background is a relevant component in the fit)

• Differs from CHPT O(p4) by 30%, useful to fix O(p6) counterterm.



Analysis strategy:

- K_L-crash tag
- No recover splitting (major bkg = $K_S \to 2\pi^0$ with two merged/lost photons) and large angular acceptance
- Kinematic fit to exploit two body kinematics



Event yield for 2.5 fb^{-1}:

80×10^6 K_L-crash events expected

$\Rightarrow$ $N(K_S \to \gamma\gamma$, tagged) = 2240 events

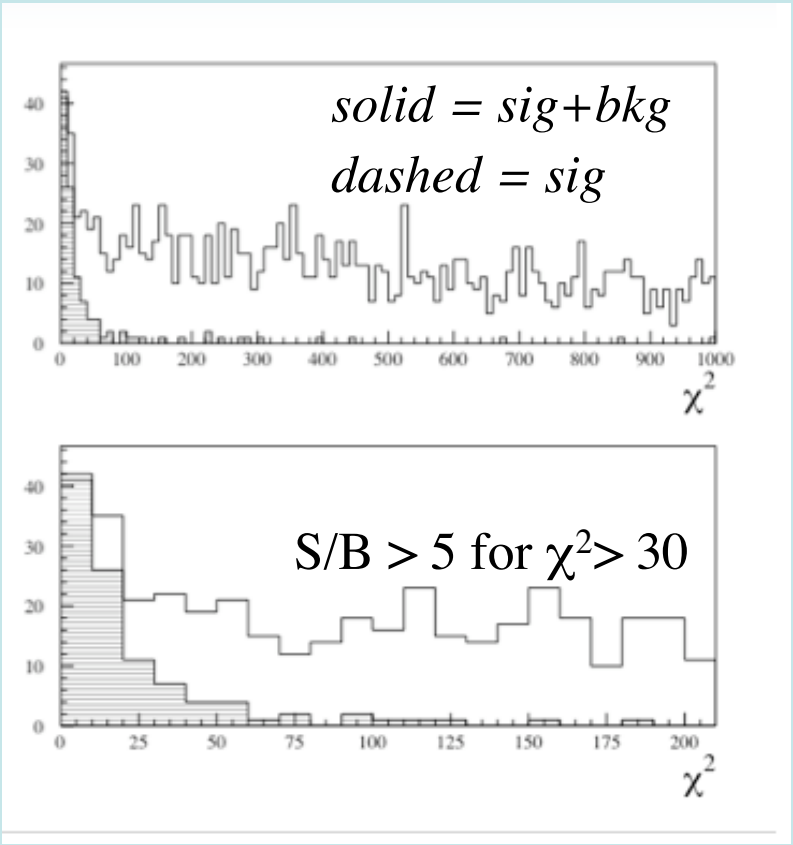
acceptance: > 0.8 (no kine cuts)

$\Rightarrow N_{sig} = 1800$ events

$K_S \rightarrow \gamma\gamma$: a first look at data

A kinematic fit is performed to test the $K_S \rightarrow \gamma\gamma$ hypothesis: data *vs* MC comparison on χ^2_{fit}

MC only

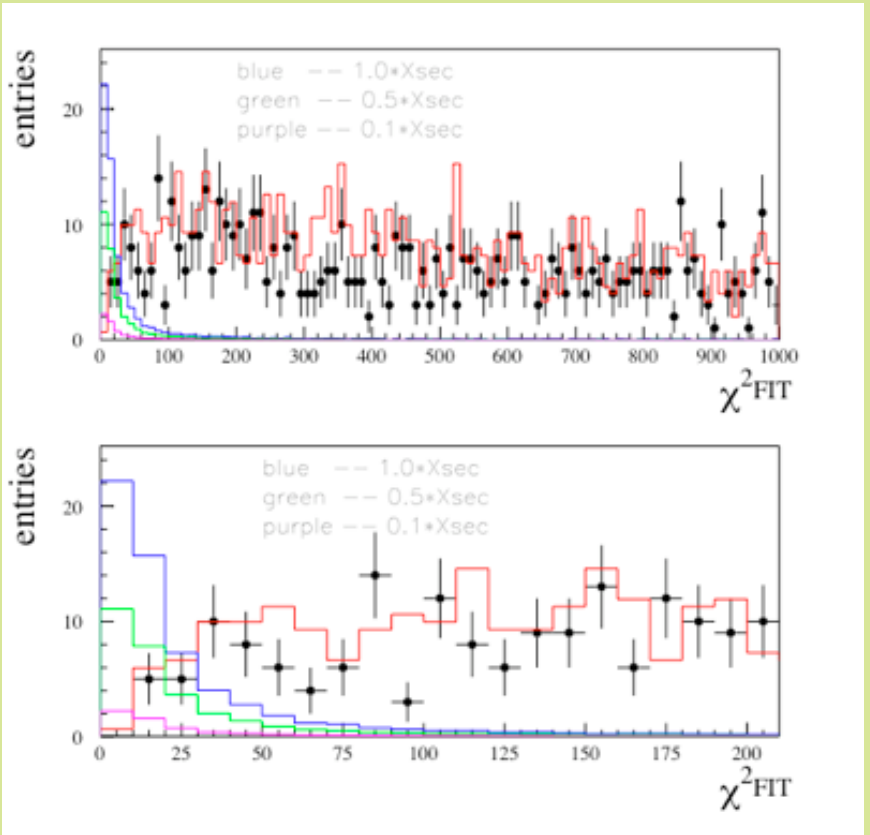


data vs MC

dots = 450 pb^{-1} of 2001-2002 data

expected sig for publ. BR, sig/5, sig/10

MC bkg



$K_S \to \pi^+\pi^- e^+ e^-$

• NA48 measurement with 6.4% accuracy:

$$\mathbf{BR}(K_S \to \pi^+\pi^- e^+ e^-) = (4.71 \pm 0.23 \pm 0.22) \times 10^{-5}$$

based on **620** events (1999 data, EPJ C30 33, 2003)

• They also measured the CP-violating asimmetry

$$A = \frac{N(\sin\phi\cos\phi>0) - N(\sin\phi\cos\phi>0)}{N(\sin\phi\cos\phi>0) + N(\sin\phi\cos\phi>0)} = (-1.1\pm4.1)10^{-2}$$

where ϕ is the angle between the e^+e^- and $\pi^+\pi^-$ planes in K_S rest frame

(for K_L NA48+KTeV measured $A=(13.8 \pm 2.2)10^{-2}$)

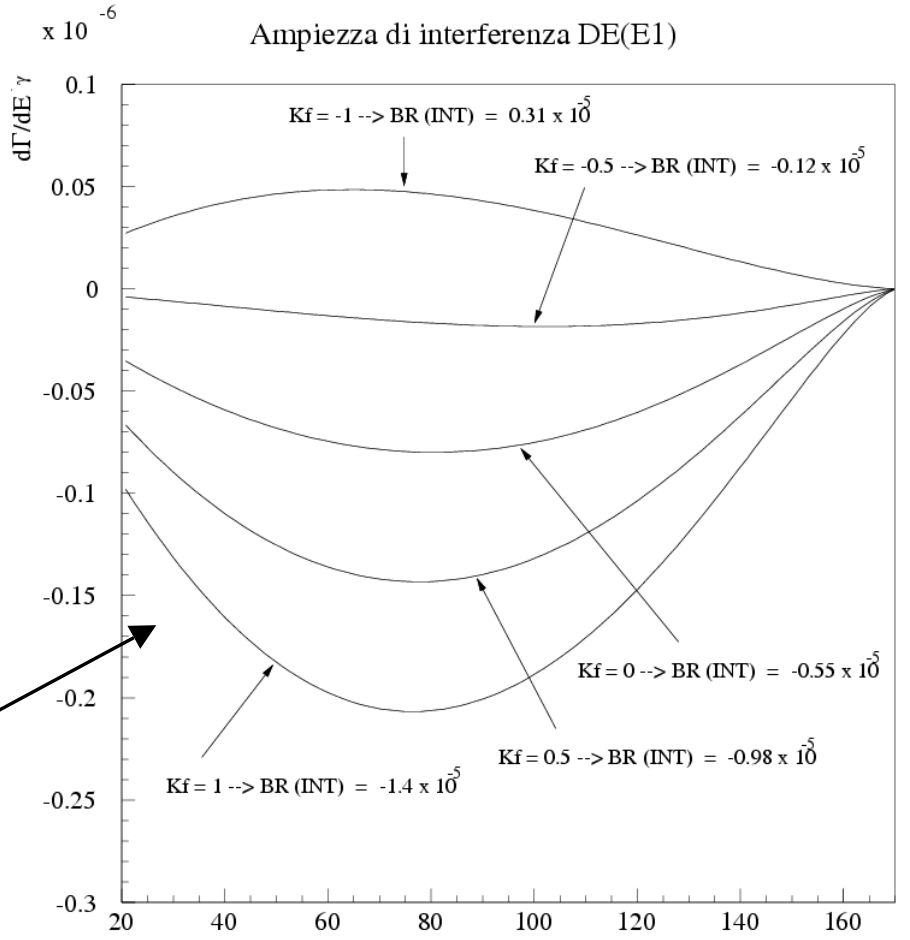
KLOE event yield with 2.5 fb^{-1}: ≈ 35000 events with Kcrash tag
Acceptance for >= 3 trk vertex: ≈ 0.1 (MC generator already included in DBV24)
Kinematic closure to evaluate the missing track momentum

$K_S \to \pi\pi\gamma$: photon spectrum

- Physics interest is in the analysis of γ energy spectrum: interference between IB and E1-DE terms estimated in χpT to give a BR ~ 10^{-5}–10^{-6}
- Theoretical prediction based on $O(p^2)$-loop + $O(p^4)$-counterterm
- Sum of loop and counter term can lead either to an expected **excess** or **lack** of events
- Toy MC fit: using 10^6 events with $E^*_\gamma > 20$ MeV, sensitivity to BR's around 10^{-6}
- Events selected NOW:

  5×10^7 $K_S \to \pi^+\pi^-(\gamma)$,

  3.5×10^5, $E^*_\gamma > 20$ MeV
- 2 fb^{-1}: 2×10^6 evts, $E^*_\gamma > 20$ MeV



Physics target reachable with 2 fb^{-1}

Analysis on 2004-2005 data sample (2)

1) Improve on K_{Se3} (A_S), $K_{S\mu 3}$, $K_L \to \gamma\gamma$, K_{l3} ff slopes, τ_L, major BR(K_L)

limited by stat. fifty-fifty limited by syst.

present result

2) Improve on BR($K_L \to \pi^+\pi^-$): KLOE present result is $6\times10^{-3}_{stat} + 6.6\times10^{-3}_{syst}$

(KTeV: 6×10^{-3})

3) Measure BR($K_L \to \pi^0\pi^0$): KTeV fractional error is 1.2×10^{-2}

(2.4% stat from C.Bloise last presentation on this item)

CONCLUSIONS

1) Impact of KLOE results on neutral kaon physics made a considerable step during 2005:

$BR(K_S \to \pi^0\pi^0\pi^0)$, τ_L, $BR(K_L)$, $BR(K_{Se3})$, $BR(K_S \to \pi\pi)$, K_{Le3} ff

2) First part of 2006: first measurement of $BR(K_{S\mu 3})$

3) Next year a number of rare K_S decays:

$\pi^0\pi^0\pi^0$, $\pi^+\pi^-\pi^0$, $\gamma\gamma$, $\pi^+\pi^- e^+e^-$, $\pi^+\pi^-\gamma$,…!!!