The final EURIDICE Meeting

Physics Highlights from KLOE

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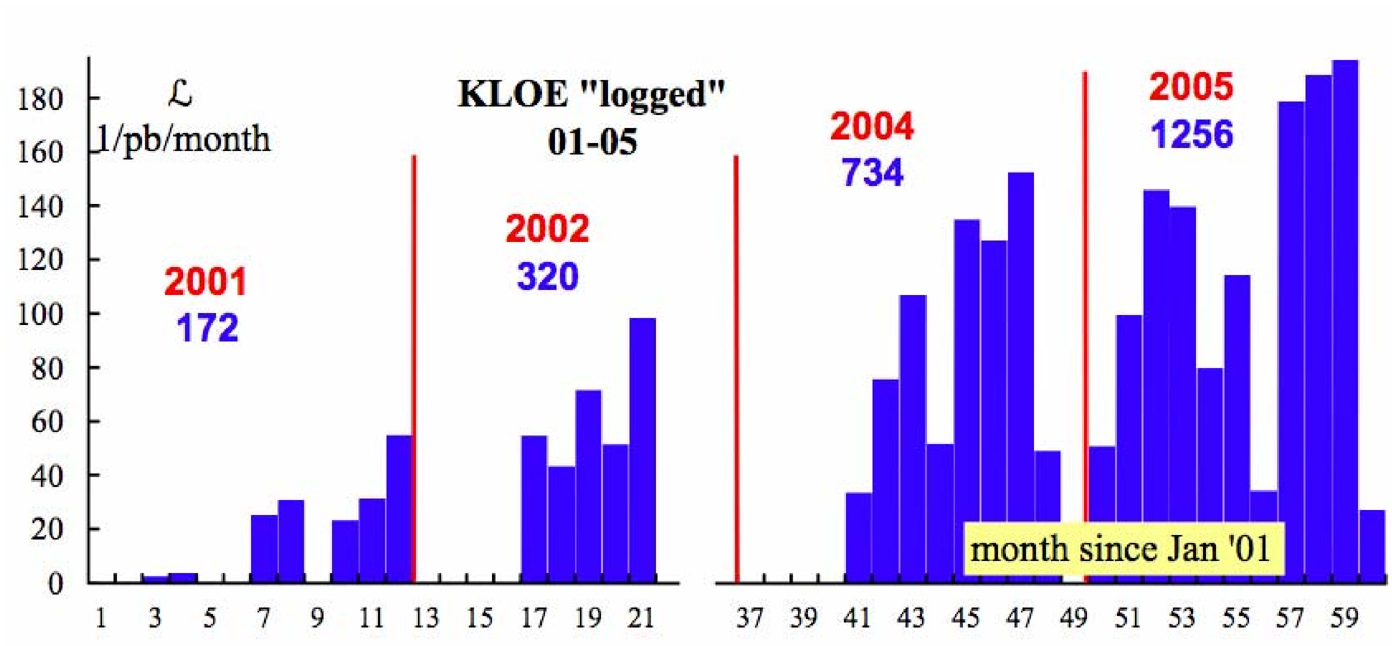
Kazimierz, August 24, 2006

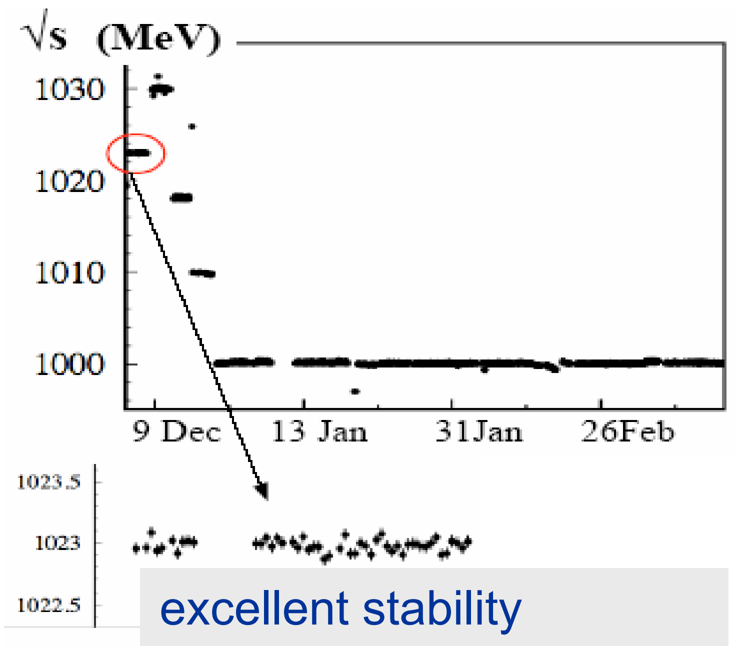
KLOE integrated luminosity at the ϕ peak



- **2001-2005 L_{int} = 2482 pb^{-1}**
- **2004-2005 L_{int} = 1990 pb^{-1}**
- **Best conditions: Sept/Oct/Nov 2005 ⇒ 179/189/194 pb^{-1}**

  stable luminosity, beam energy and backgrounds
- **Dec 5th end of run at 1020 MeV, start off peak run**

Off-peak data taking



excellent stability
in Daϕne operation and
also excellent data quality

Data acquisition Dec 5 - Mar 16, 2006

$\sqrt{s}$ (MeV)	**1023.**	**1030.**	**1018.**	**1010.**	**1000.**
L_{int} (pb^{-1})	**10.4**	**11.4**	**10.2**	**11.0**	**233.5**

- 4 points (10 pb^{-1}) in the 1010-1030 MeV region:
  - Calibration of KLOE energy scale, line shape
  - Model dependence of the f_0 production vs $\sqrt{s}$
  - $\sigma(e^+e^- \to \omega\pi^0)$, ϕ leptonic widths
- 200 pb^{-1} at $\sqrt{s}$ =1000 MeV:
  - **Measurement of the $\sigma(\pi^+\pi^-\gamma)$ down to $2m_\pi$**
  - Two-photon physics with KLOE: $\gamma\gamma \to \eta$, $\pi\pi$

Kaon Physics: results from 2001-2002 data

$K_S K_L \to \pi^+\pi^-\pi^+\pi^-$	Quantum Interference	**Draft in preparation**	
$K_S \to \pi^0\pi^0\pi^0$	UL on BR at 10^{-7}	**PLB 619 (2005) 61**	**PDG06**
$K_S \to \pi e \nu$	BR to 1.3%, form factor slope, charge asymmetry	**PLB 636 (2006) 173**	**PDG06**
$K_S \to \pi^+\pi^-, \pi^0\pi^0$	$\Gamma(\pi^+\pi^-)/\Gamma(\pi^0\pi^0)$ to ~0.25%	**Accepted by EPJC**	**PDG06**
$K_L \to \pi l \nu, \pi\pi\pi$	Absolute BR's to ~ 0.5%	**PLB 632 (2006) 43**	**PDG06**
K_L lifetime	K_L lifetime from Σ(BR)=1 from $K_L \to \pi^0\pi^0\pi^0$ to ~ 0.5%	**PLB 626 (2005) 15**	**PDG06**
$K_L \to \pi e \nu$	Form factor slopes	**PLB 636 (2006) 166**	**PDG06**
$K_L \to \pi e \nu \gamma$	BR to ~ 2 %	**Preliminary**	
$K_L \to \pi^+\pi^-$	BR to 1.1%	**PLB 638 (2006) 140**	**PDG06**
$K_L \to \gamma\gamma$	$\Gamma(\gamma\gamma)/\Gamma(\pi^0\pi^0\pi^0)$ to 1.1%	**PLB 566 (2003) 61**	
$K^+ \to \pi^+\pi^0\pi^0$	BR to 1.4%	**PLB 597 (2004) 139**	
$K^+ \to \mu^+\nu$	Absolute BR to ~ 0.27%	**PLB 632 (2006) 76**	**PDG06**
$K^\pm \to \pi^0 l^\pm \nu$	Absolute BR's to ~ 1.5%	**Preliminary**	
$K^\pm$ lifetime	two independent measurements	**Preliminary**	

Latest results: BR($K_L \rightarrow \pi^+\pi^-$)

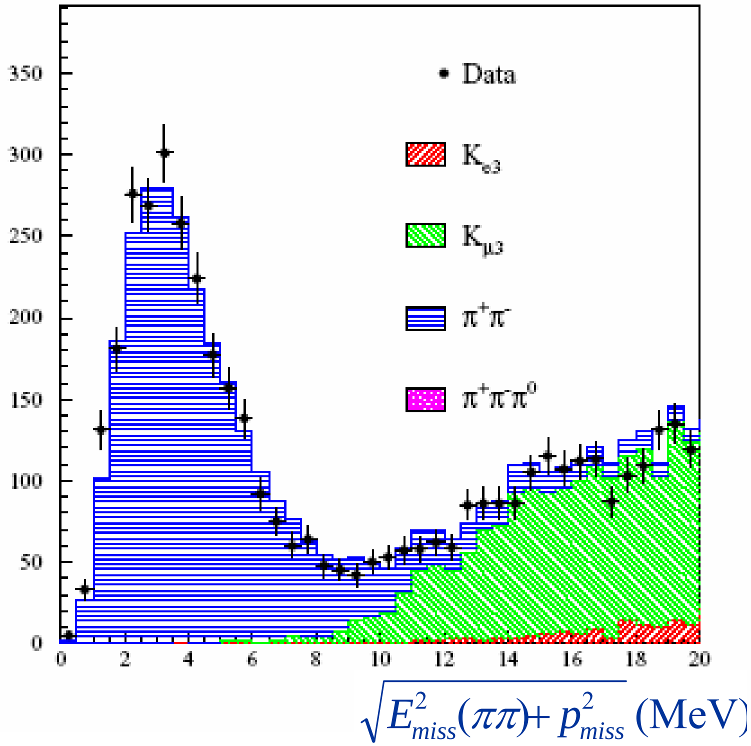
PLB 638 (2006) 140

Kinematics for signal separation

$K_L \rightarrow \pi\mu\nu$ events in the same sample for K_L counting

BR = (1.963±0.012±0.017)×10^-3^

σ_{rel}: 1.1% = 0.6%$_{stat} \oplus$ 0.9%$_{syst}$



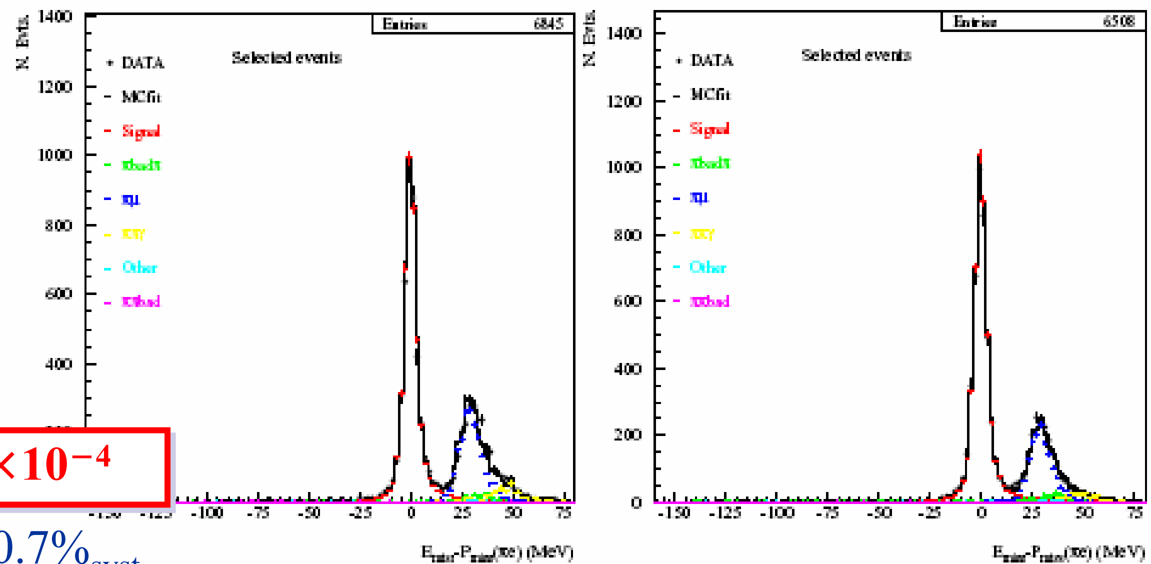
- in agreement with KTeV 2004
  BR = $(1.975 \pm 0.012) \times 10^{-3}$
- it confirms the 4–σ discrepancy with old measurements
  $(2.080 \pm 0.025) \times 10^{-3}$
- we get:
  $|\eta_{+-}| = (2.216 \pm 0.013) \times 10^{-3}$
  [BR($K_S \rightarrow \pi\pi$) and τ_L from KLOE, τ_S from PDG04]

$K_S \to \pi e \nu$: BR and A_S

PLB 636 (2006) 173

TOF e/π ID,
fit to $E_{miss} - p_{miss}$ *spectrum*

$K_S \to \pi^+\pi^-$ *events in the same sample for* K_S *counting*



Branching ratio

BR(πeν) = (7.046±0.077±0.049)×10^{-4}

fractional error: $1.3\% = 1.1\%_{stat} \oplus 0.7\%_{syst}$

Charge asymmetry

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

first measurement
$\delta A_S \sim 3{\times}10^{-3}$ *with 2.5 fb*$^{-1}$

K_{Se3} form factor slope

$\lambda_+ = (33.9 \pm 4.1) \times 10^{-3}$

first meas., compatible with K_L

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

$$1 + 4\,Re(x_+) = \frac{\Gamma_S}{\Gamma_L}$$

$$= \frac{BR(K_S \to \pi e \nu)\;\; \tau_L}{BR(K_L \to \pi e \nu)\;\; \tau_S}$$

$13\;10^{-3}$ (error on $BR(K_S \to \pi e \nu)$)

$6\;10^{-3}$ (error on τ_L)

$4\;10^{-3}$ (error on $BR(K_L \to \pi e \nu)$)

10^{-3} (error on τ_S)

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

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

1) Re x_-: CPT viol. and $\Delta S \neq \Delta Q$

$$A_S - A_L = 4\,(\mathrm{Re}\,x_- + \mathrm{Re}\,\delta)$$

A_L	KTeV	$\sigma = 0.75\times10^{-4}$
Re δ	**CPLEAR**	$\sigma = 3.4\times10^{-4}$

Re x_- = (−0.8 ± 2.5) 10^{-3}

Factor 5 improvement w.r.t. current most precise measurement (CPLEAR, $\sigma = 1.3\times10^{-2}$ **)**

2) Re y: CPT viol. and $\Delta S = \Delta Q$

$$A_S + A_L = 4\,(\mathrm{Re}\,\varepsilon - \mathrm{Re}\,y)$$

Re ε from PDG not assuming CPT

Re y = (0.4 ± 2.5) 10^{-3}

Comparable with best result (CPLEAR from unitarity, $\sigma = 3.1\times10^{-3}$ **)**

CPT test: the Bell-Steinberger relation

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

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

Semileptonic decays:

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

ππ decays:

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

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

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

πππ decays:

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

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

CPT test: inputs to B-S

$B(K_S \to \pi^+\pi^-)/B(K_S \to \pi^0\pi^0) = 2.2549 \pm 0.0054$

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

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

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

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

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

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

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

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

$\tau_S = 0.08958 \pm 0.00006$ ns

$\tau_L = 50.84 \pm 0.23$ns

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

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

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

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

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

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

Im $x_+ = (1.2 \pm 2.2) \times 10^{-2}$ by CPLEAR

A combined fit of CPLEAR data with KLOE-KTeV ($A_S - A_L$) gives a $\times 3$ improvement:

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

CPT test from unitarity: results

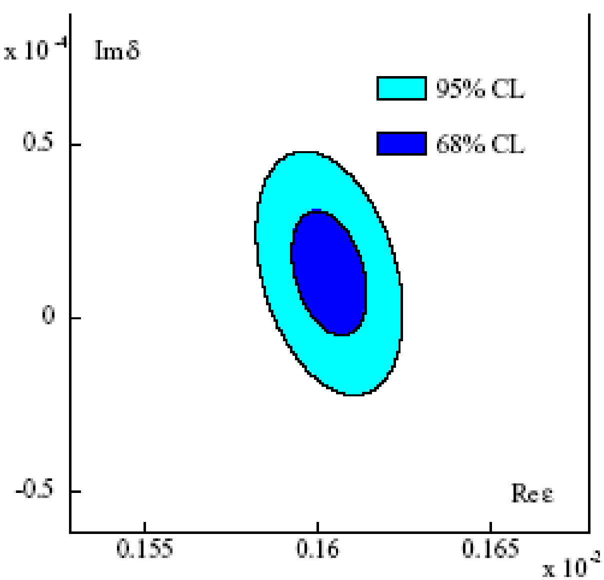
Re ε = $(160.2 \pm 1.3) \times 10^{-5}$
Im δ = $(1.2 \pm 1.9) \times 10^{-5}$

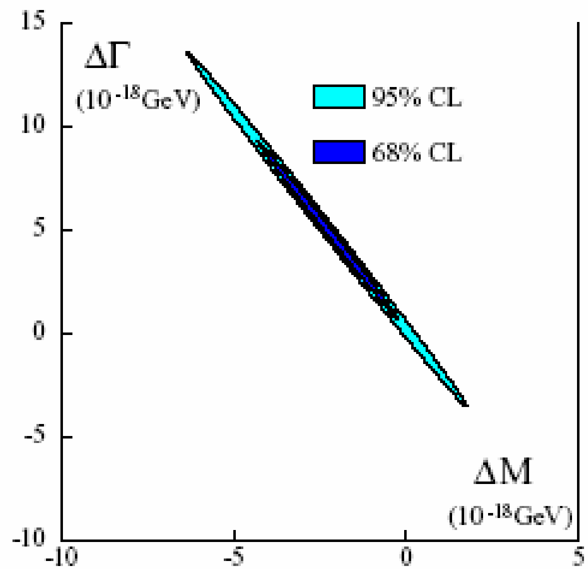
- *Uncertainty on Imδ is now dominated by ϕ_{+-} and ϕ_{00}*
- *Semileptonic sector contributes by ~ 10%*

Old:
Re $\varepsilon = (164.9 \pm 2.5)\ 10^{-5}$
Im $\delta = (2.4 \pm 5.0)\ 10^{-5}$

From Imδ and Reδ it is possible to extract limits on

$\Delta m = (m_{K0} - m_{\overline{K0}})$ and $\Delta\Gamma = (\Gamma_{K0} - \Gamma_{\overline{K0}})$





assuming CPT violation only in the mass matrix ($\Delta\Gamma = 0$):

$|m_{K0} - m_{\overline{K0}}| < 3\times10^{-19}$ GeV

Unitarity test of CKM matrix: V_{us} , V_{us}/V_{ud}

- **Unitarity test from 1st row:**

$$|V_{ud}|^2 + |V_{us}|^2 + |V_{ub}|^2 \sim |V_{ud}|^2 + |V_{us}|^2 \equiv 1 - \Delta$$

Precision test @ 10^{-3} level:

from super-allowed nuclear β-decays: $2|V_{ud}|\delta V_{ud} = 0.0005$

from semileptonic kaon decays: $2|V_{us}|\delta V_{us} = 0.0009$

- **$|V_{us}|$ extraction from K_{l3} decays**

$$\Gamma(K \rightarrow \pi l \nu(\gamma)) \propto |V_{us}\, f_+(0)|^2\, I(\lambda_t)\, S_{EW}(1 + \delta_{EM} + \delta_{SU(2)})$$

theory uncertainty: 0.8% on $f_+(0)$

- **$|V_{us}|/|V_{ud}|$ extraction from** $\Gamma(K^\pm \rightarrow \mu\nu(\gamma))/\Gamma(\pi^\pm \rightarrow \mu\nu(\gamma))$

$$\frac{\Gamma(K \rightarrow \mu\nu(\gamma))}{\Gamma(\pi \rightarrow \mu\nu(\gamma))} \propto \frac{|V_{us}|^2}{|V_{ud}|^2}\, \frac{f_K^2}{f_\pi^2}\, \frac{1 + \alpha C_K}{1 + \alpha C_\pi}$$

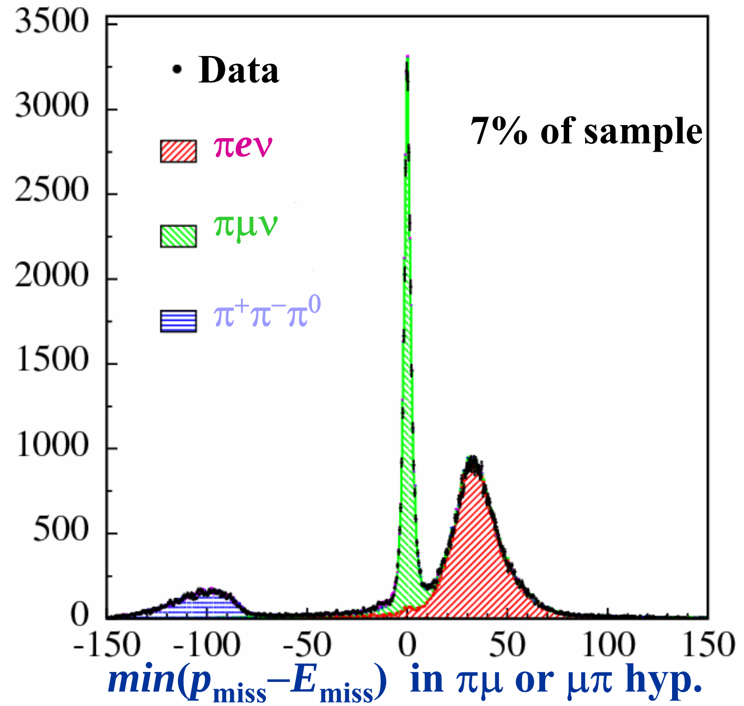
theory uncertainty: 1.3% on f_K/f_π

KLOE has measured all experimental inputs: BR, τ, λ

Dominant K_L BR's and τ_L

PLB 632 (2006) 43

- **$K_L \to \pi e\nu, \pi\mu\nu, \pi^+\pi^-\pi^0$:**
  K_L vertex reconstructed in DC
  Fit to $p_{miss} - E_{miss}$ spectrum



- **$K_L \to \pi^0\pi^0\pi^0$:**
  Photon vertex reconstructed by TOF

- **Absolute BR: $(N_{sig}/N_{tag}) \times 1/\varepsilon_{sig}$**
  ε_{geo} dominated by error on τ_L

- **Using the constraint $\sum BR(K_L) = 1$:**

	precision
$BR(K_L \to \pi e\nu) = 0.4007 \pm 0.0006_{stat} \pm 0.0014_{syst}$	3.8×10^{-3}
$BR(K_L \to \pi\mu\nu) = 0.2698 \pm 0.0006_{stat} \pm 0.0014_{syst}$	5.6×10^{-3}
$BR(K_L \to 3\pi^0) = 0.1997 \pm 0.0005_{stat} \pm 0.0019_{syst}$	9.8×10^{-3}
$BR(K_L \to \pi^+\pi^-\pi^0) = 0.1263 \pm 0.0005_{stat} \pm 0.0011_{syst}$	9.6×10^{-3}
$\tau_L = (50.72 \pm 0.17_{stat} \pm 0.33_{syst})$ ns	7.3×10^{-3}

τ_L from $K_L \to \pi^0\pi^0\pi^0$

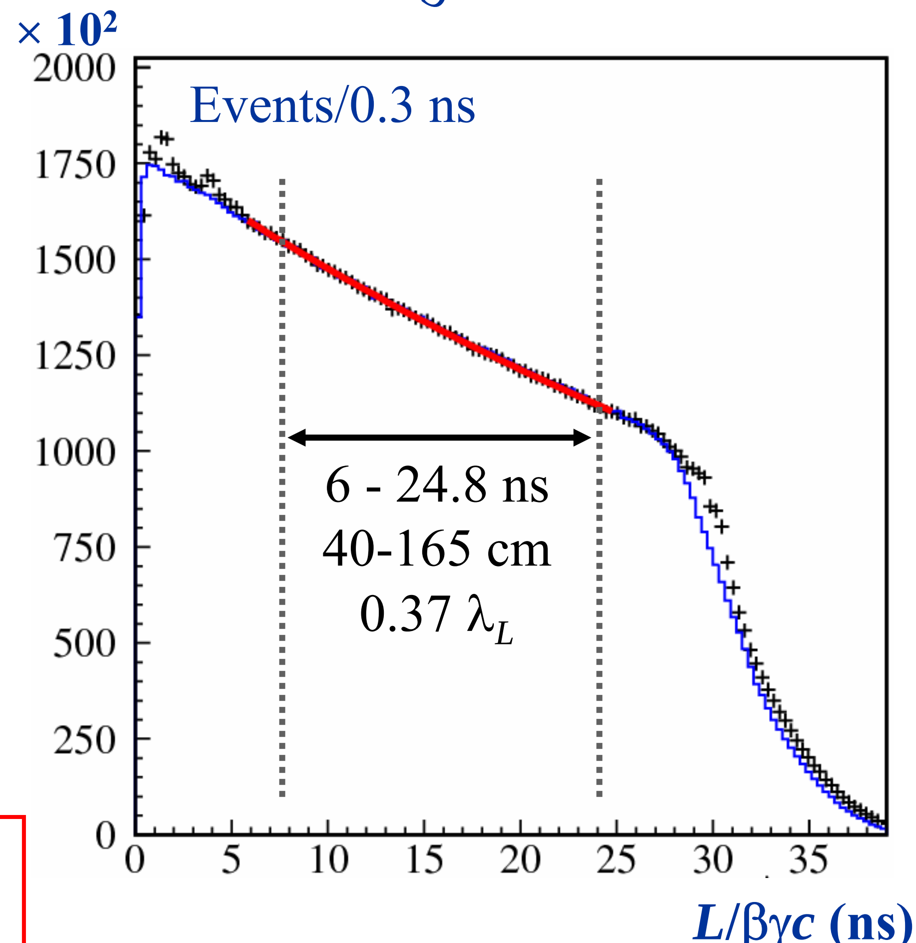
PLB 626 (2005) 15

- Excellent lever arm for lifetime measurement (P_K = 110 MeV)
- K_L momentum known from tag
- Uniform reconstruction efficiency with respect to L_K

$\tau_L = 50.92 \pm 0.17_{stat} \pm 0.25_{syst}$ ns

$\sigma_{rel} \sim 5.9\times10^{-3}$

Average with result from K_L BR's:
$\tau_L = 50.84 \pm 0.23$ ns
$\sigma_{rel} \sim 4.5\times10^{-3}$



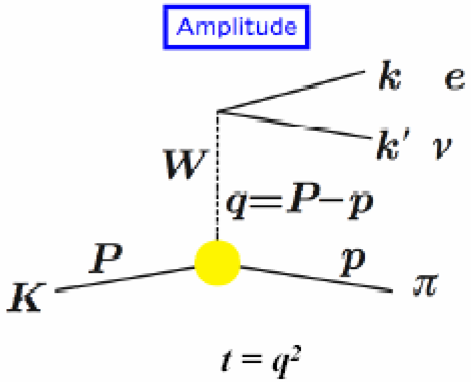
Vosburg, '72
$\tau_L = 51.54 \pm 0.44$ ns

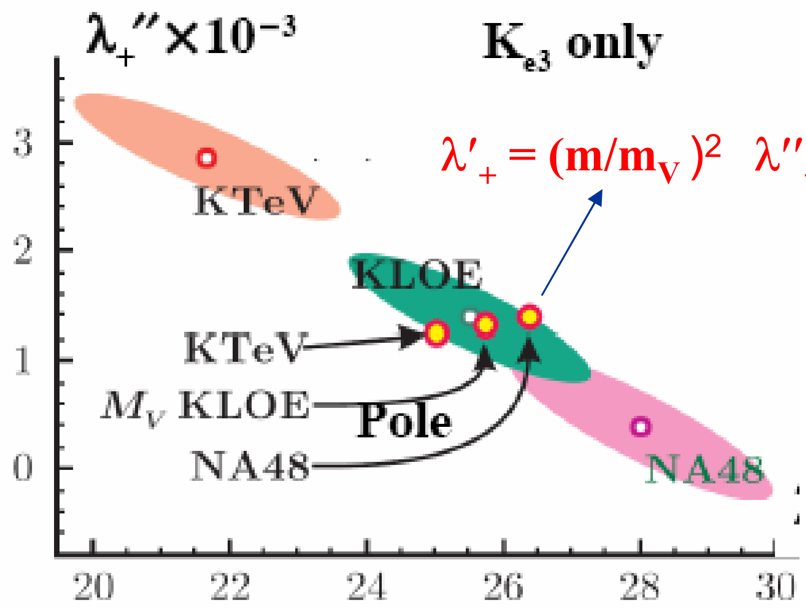
K_{Le3} form factor slopes

PLB 636 (2006) 166

Measurement of the dependence of semileptonic *ff* from momentum transfer, t

- Fit to *t*-spectrum





$\lambda'_+ = (m/m_V)^2 \quad \lambda''_+ = 2(m/m_V)^4$

Quadratic:

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

$\lambda''_+ = (1.4 \pm 0.7 \pm 0.4) \times 10^{-3}$

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

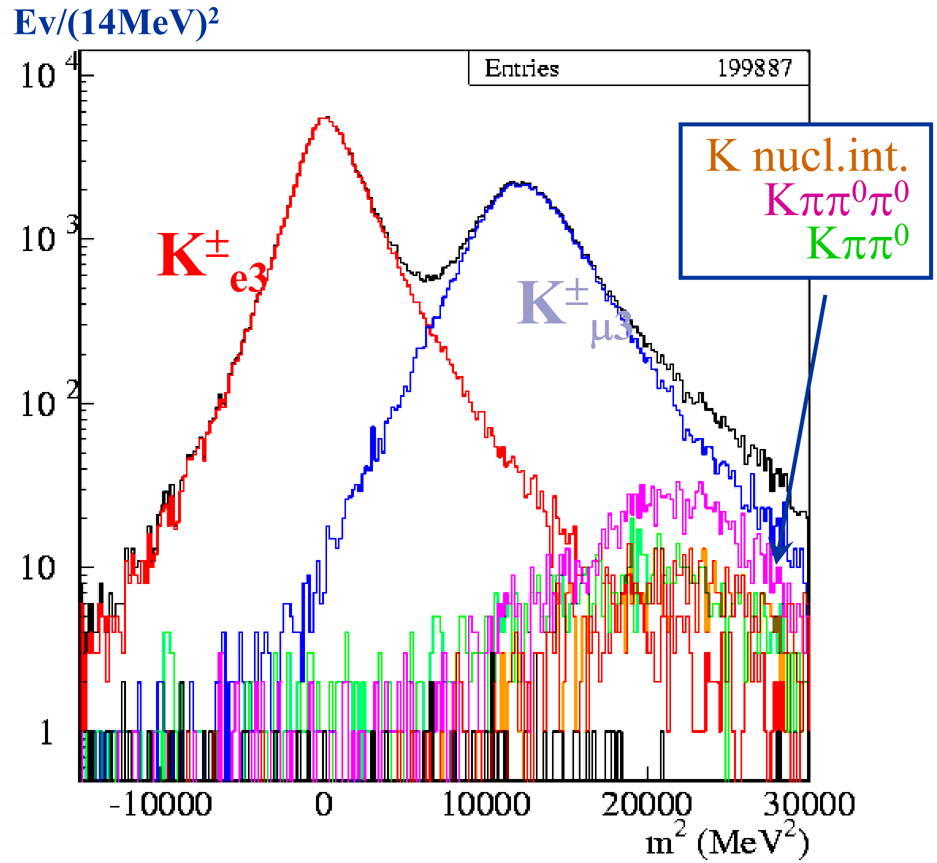
Pole model:

$m_V = (870 \pm 7)$ MeV

BR($K^{\pm} \to \pi^0 l^{\pm} \nu$)

- $K^+ \to \pi^0 l^+ \nu$ decays are tagged by $K^- \to \mu^- \nu$ and $K^- \to \pi^- \pi^0$
- $K^{\pm} \to \pi^0 e^{\pm} \nu$ and $K^{\pm} \to \pi^0 \mu^{\pm} \nu$ are separated by fitting the lepton mass spectrum, obtained from **TOF:**

$$t^{decay}_K = t_{lept} - L_{lept}/\beta(m_{lept})c = t_\gamma - L_\gamma/c$$



Preliminary results :

BR($K^{\pm}_{e3}$) = ($5.047 \pm 0.019_{stat} \pm 0.039_{syst}$)$\times 10^{-2}$
BR($K^{\pm}_{\mu3}$) = ($3.310 \pm 0.016_{stat} \pm 0.045_{syst}$)$\times 10^{-2}$

Current precision :

σ(Ke3) = 1.4%

σ(Kμ3) = 2.4%

V_{us} $f_+(0)$ from KLOE

Unitarity band:

$V_{us} = (1-V_{ud}^2)^{0.5}$

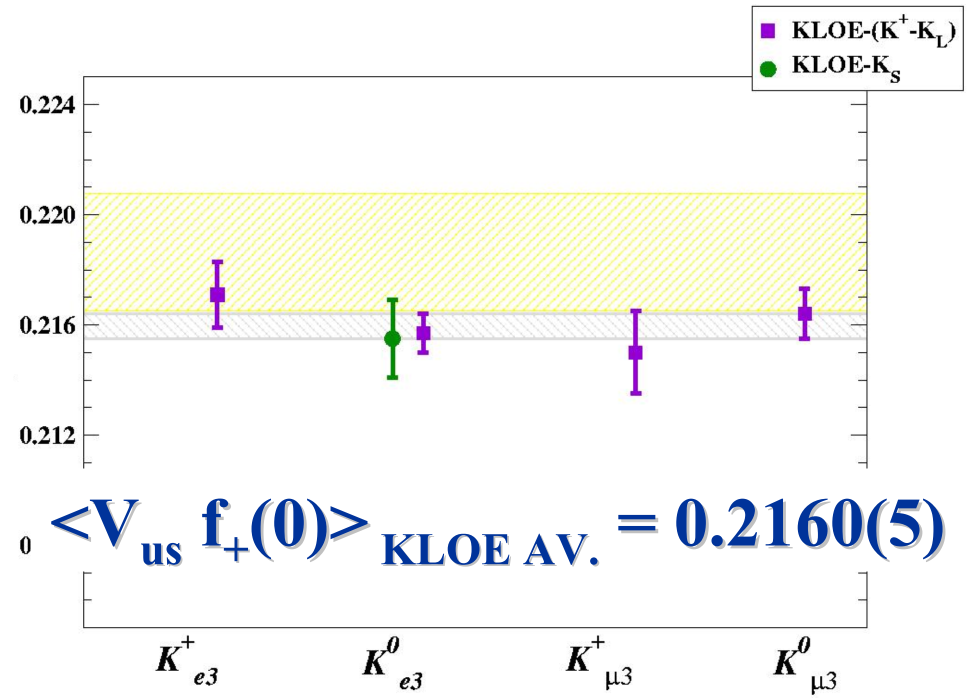
V_{ud}=0.97377(27)

Marciano and Sirlin 2006

$f_+(0)$=0.961(8)

Leutwyler and Roos 1984

$V_{us} \times f_+(0) = 0.2187(22)$



$\langle V_{us}\ f_+(0)\rangle_{\text{KLOE AV.}} = 0.2160(5)$

$\langle V_{us}\ f_+(0)\rangle_{\text{KLOE+other,new}} = 0.2164(4)$

Improving the sensitivity of the CKM unitarity test :

– new results on charged kaons from KLOE

– better estimates of f_K/f_π and $f_+(0)$ from lattice

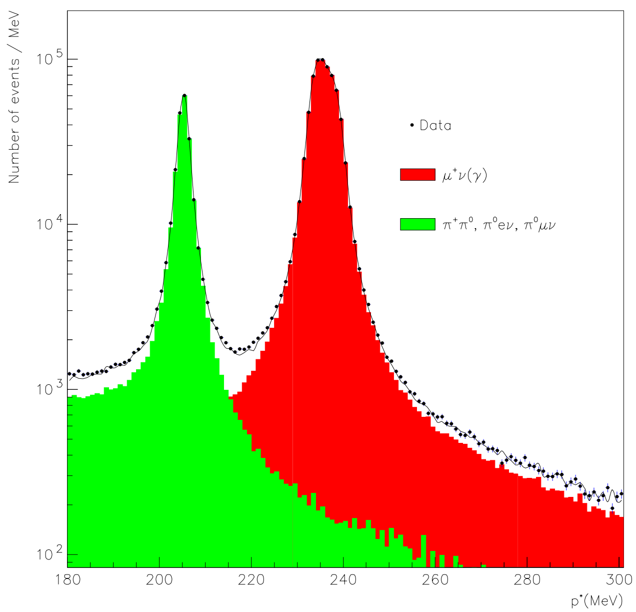
– better estimates of SU(2) and rad corrections to V_{ud} from nuclear β decay (now at 1-2%)
(0.047% change of V_{ud} or 0.88% change of V_{us} ⇒ 1σ change of $\Delta = 1 - V_{us}^2 - V_{ud}^2$)

– KLOE 2.5 fb^{-1} data sample should definitively clarify the *ff* picture, improve BR's and lifetimes

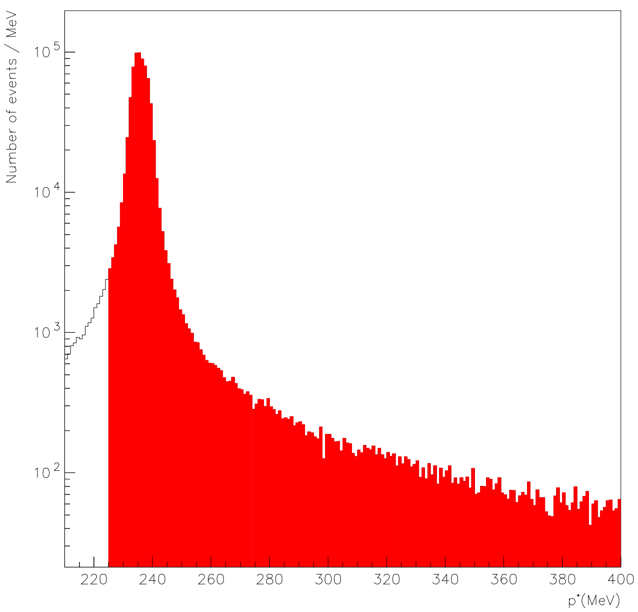
BR($K^+ \to \mu^+\nu(\gamma)$)

PLB 632 (2006) 76

Tag from $K^- \to \mu^-\nu$
Subtraction of $\pi^+\pi^0$, $\pi^0 l^+ \nu$ background



Event counting in (225,400) MeV window of the momentum distribution in K rest frame



$$\mathbf{BR(K^+ \to \mu^+\nu(\gamma)) = 0.6366 \pm 0.0009_{stat.} \pm 0.0015_{syst.}}$$

The V_{us} – V_{ud} plane

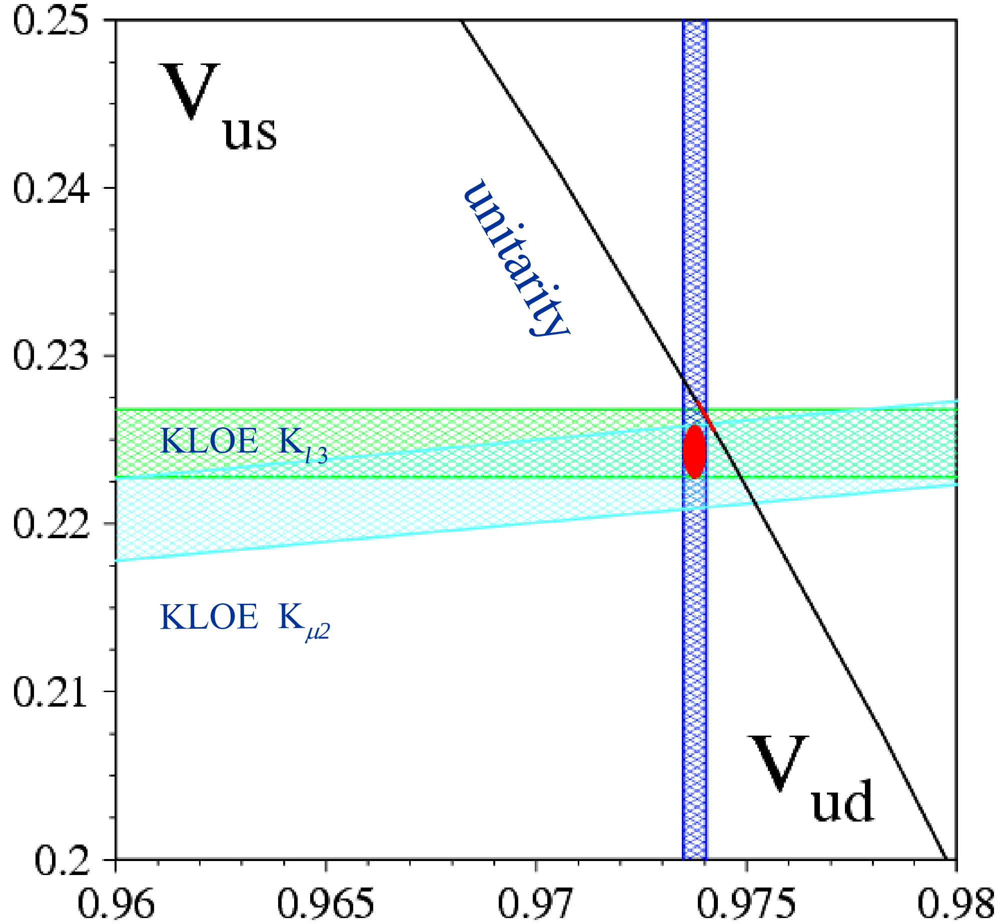
- Using $f_K/f_\pi = 1.198(3)(^{+16}_{-5})$ from MILC Coll. (2005) and KLOE BR($K^+ \to \mu^+\nu$) we get $V_{us}/V_{ud} = 0.2294 \pm 0.0026$
- $V_{us} = 0.2248 \pm 0.0020$
  K_{l3} KLOE, using $f_+(0)=0.961(8)$
- $V_{ud} = 0.97377 \pm 0.00027$
  Marciano and Sirlin
  Phys.Rev.Lett.96 032002,2006

Fit of the above results:

$V_{us} = 0.2242 \pm 0.0016$
$V_{ud} = 0.97377 \pm 0.00027$
$P(\chi^2) = 0.8$

Fit assuming unitarity:

$V_{us} = 0.2264 \pm 0.0009$
$P(\chi^2) = 0.1$



Hadron Physics

$\phi \to \pi^+\pi^-\pi^0$	Dalitz plot analysis	**PLB 561(2003) 65**
$\phi \to f_0\gamma \to \pi^+\pi^-\gamma$	f_0 coupling to ϕ, $\pi\pi$, KK	**PLB 634(2006) 148**
$\phi \to f_0\gamma \to \pi^0\pi^0\gamma$	BR($\phi \to \pi^0\pi^0\gamma$) to 5%	**PLB 537(2002) 21**
	Dalitz plot analysis, stat/syst improvements	**Draft in preparation**
$\phi \to \eta\, \pi^0\, \gamma$	BR($\phi \to a_0(980)\, \gamma$) to 10%	**PLB 536(2002) 209**
	stat/syst improvements	**In progress**
$\phi \to \eta'\gamma$ ($\eta\, \gamma$)	$\Gamma(\phi \to \eta'\gamma)/\Gamma(\phi \to \eta\, \gamma)$ to 12%, mixing angle to 5%	**PLB 541(2002) 45**
	stat/syst improvements	**Draft in preparation**
$\eta \to \gamma\gamma$	η mass measurement	**Preliminary**
$\eta \to \pi^+\pi^+\pi^0$	η mass measurement, Dalitz plot analysis	**In progress, Draft in prep.**
$\eta \to \pi^0\pi^0\pi^0$	Dalitz plot analysis	**Preliminary**
$\eta \to \pi^0\gamma\gamma$	BR, $m_{\gamma\gamma}$ spectrum	**In progress**
$\eta \to \pi^+\pi^- e^+e^-$	photon coupling	**In progress**
$\eta \to \pi^+\pi^-$	UL on BR at 10^{-5}	**PLB 606(2005) 276**
$\eta \to \pi^0\pi^0$	UL	**In progress**
$\eta \to \gamma\gamma\gamma$	UL on BR at 10^{-5}	**PLB 591(2004) 49**
$e^+e^- \to \pi^+\pi^-\gamma$	$a_{\mu}\|_{had}$ $(0.35<s_\pi<0.95\ GeV^2)$ to ~ 1%	**PLB 606(2005) 12**
	$a_{\mu}\|_{had}$ down to threshold	**In progress**
$e^+e^- \to e^+e^-$ ($\mu^+\mu^-$)	$\Gamma_{lept}(\phi)$ to 1.5% and lepton universality test	**PLB 608(2005) 199**

$\pi^+\pi^-\gamma$ at large angle: looking for $f_0(980)$

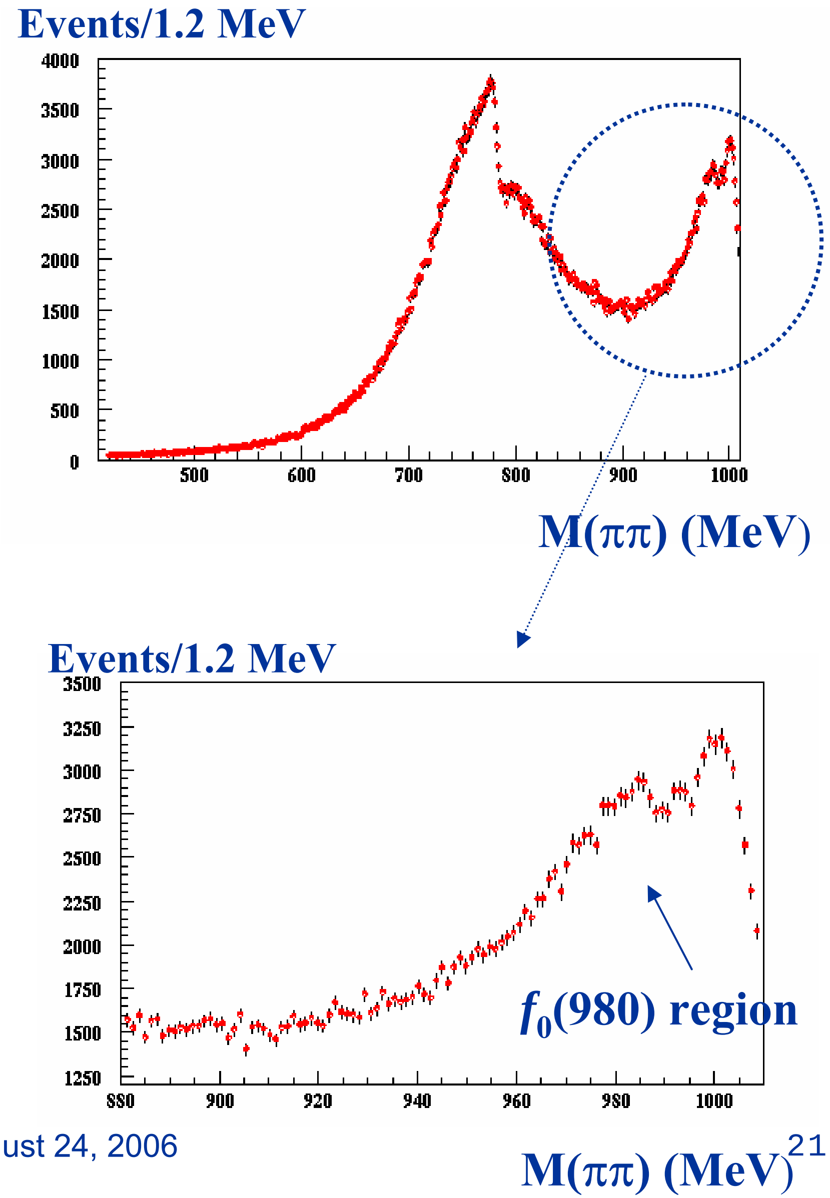
PLB 634 (2006) 148

- $e^+e^- \rightarrow \pi^+\pi^-\gamma$ events with the photon at large angle ($45° < \vartheta_\gamma < 135°$)

- Main contributions:
  ISR (radiative return to ρ, ω)
  FSR

- Search for the f_0 signal as a deviation on $M(\pi^+\pi^-)$ spectrum from the expected ISR + FSR shape

676,000 events selected (2001+2002)



$f_0 \to \pi^+\pi^-$: fit to the $M_{\pi\pi}$ spectrum

$$\frac{d\sigma}{dm} = \left(\frac{d\sigma}{dm}\right)_{ISR+FSR+\rho\pi} + bckg(\pi^+\pi^-\pi^0 + \mu^+\mu^-\gamma) + \left(\frac{d\sigma}{dm}\right)_{Scalar} + \left(\frac{d\sigma}{dm}\right)_{\text{int}.Scalar+FSR}$$

Kaon-loop [N.N.Achasov, V.N.Ivanchenko, NPB315 (1989) 465] [N.N.Achasov, V.V.Gubin, PRD 56 (1997) 4084]

M_{f0} (MeV)	981 ÷ 985
g^2_{fK+K-} $/4\pi$ (GeV^2)	1.2 ÷ 3.4
$R = g^2_{fK+K-}$ $/g^2_{f\pi+\pi-}$	2.0 ÷ 2.9

No-structure [G.Isidori et al., hep-ph/0603241]

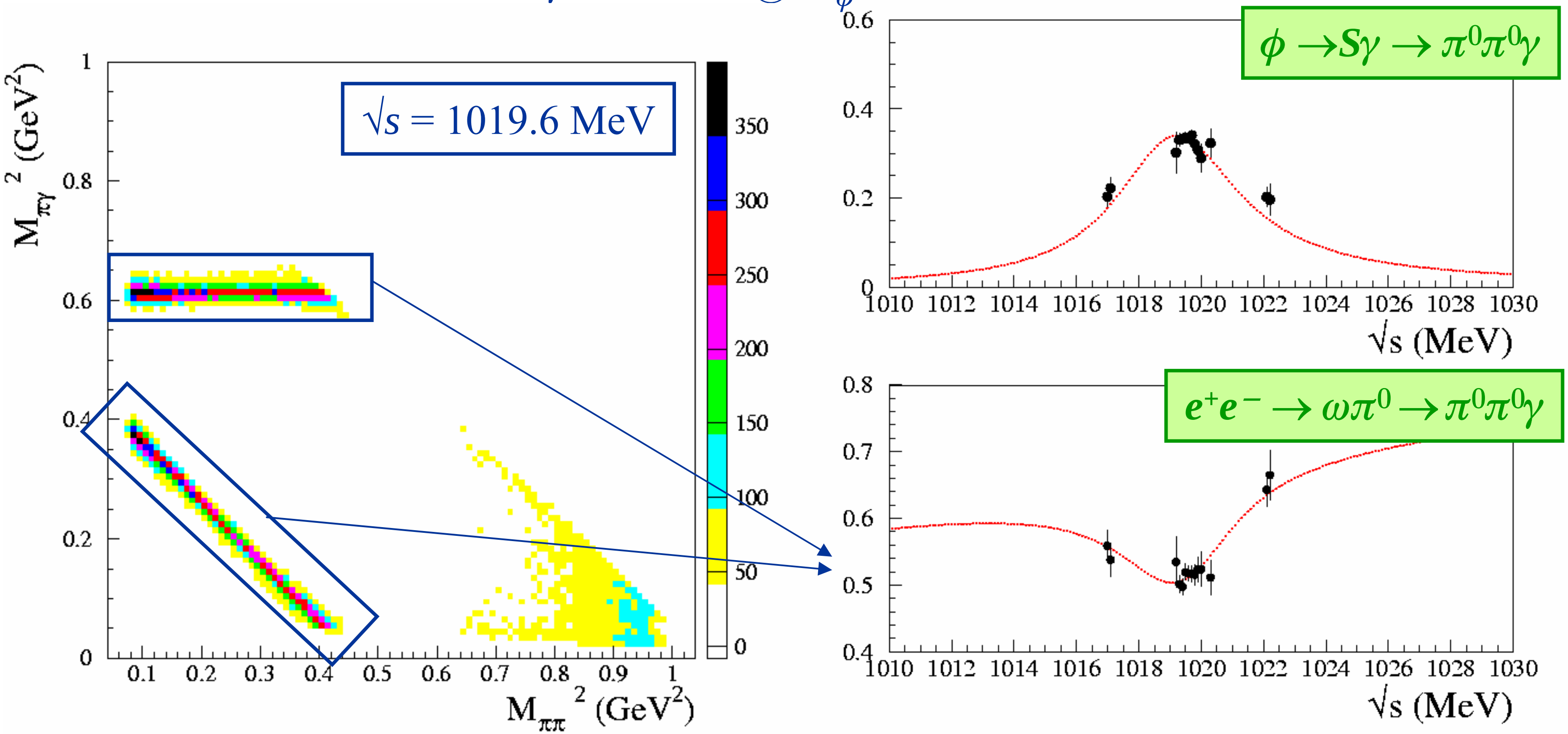
M_{f0} (MeV)	968 ÷ 979
$g_{\phi f\gamma}$ (GeV^{-1})	1.2 ÷ 1.8
$g_{f\pi+\pi-}$ (GeV)	0.9 ÷ 1.2
g_{fK+K-} (GeV)	1.2 ÷ 2.8
$R= g^2_{fK+K-}$ $/g^2_{f\pi+\pi-}$	1.7 ÷ 4.8

- Peak at $M_{\pi\pi}$~980 MeV due to $\phi \to f_0(980)\gamma$, with negative interf. with FSR
- In both models **the $f_0(980)$ is strongly coupled to kaons and to the ϕ**
- **The introduction of $\sigma(600)$ does not improve the fit**

The $\pi^0\pi^0\gamma$ final state

450 pb^{-1} from 2001 – 2002 data taking ~ 400k events

Two main contributions to $\pi^0\pi^0\gamma$ final state @ M_ϕ:



New analysis scheme w.r.t. PLB537 (2002) 21:

- ✓ Allow for interference between $e^+e^- \to \omega\pi^0$ and $\phi \to S\gamma$
- ✓ Bi-dimensional analysis of Dalitz-plot : $M(\pi^0\pi^0)$ vs $M(\pi^0\gamma)$

Summary table and comparison

KL fit results:

$\pi^0\pi^0$: $\sigma(600)$ [but with fixed values] needed to describe data,

$\pi^+\pi^-$: $\sigma(600)$ is not needed

both channels: $f_0(980)$ strongly coupled to KK

NS fit results:

both channels: only $f_0(980)$ sufficient to describe data

$\pi^0\pi^0$ wrt $\pi^+\pi^-$: weaker KK coupling

model	$f_0(980)$ param.	$\pi^+\pi^-\gamma$	$\pi^0\pi^0\gamma$
Kaon Loop	m_{f0} (MeV)	980 ÷ 987	976 ÷ 987
	g_{fKK} (GeV)	5.0 ÷ 6.3	3.3 ÷ 5.0
	$g_{f\pi+\pi-}$ (GeV)	3.0 ÷ 4.2	1.4 ÷ 2.0
	$R=g^2_{fKK}/g^2_{f\pi+\pi-}$	2.2 ÷ 2.8	3.0 ÷ 7.3
No Structure	m_{f0} (MeV)	973 ÷ 981	981 ÷ 987
	g_{fKK} (GeV)	1.6 ÷ 2.3	0.1 ÷ 1.0
	$g_{f\pi+\pi-}$ (GeV)	0.9 ÷ 1.1	1.3 ÷ 1.4
	$R=g^2_{fKK}/g^2_{f\pi+\pi-}$	2.6 ÷ 4.4	0.01 ÷ 0.5
	$g_{\phi f\gamma}$ (GeV^{-1})	1.2 ÷ 2.0	2.5 ÷ 2.7

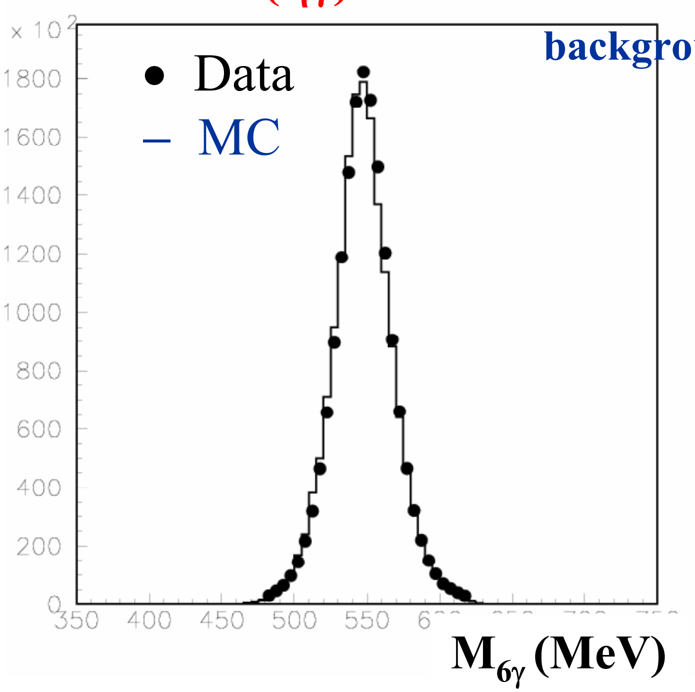
$\phi \to \eta'\gamma/\eta\gamma$

427 pb^{-1} @ $\sqrt{s} = M_\phi$ from 2001/2002 data

- $\phi \to \eta'\gamma$, $\eta' \to \pi^+\pi^-\eta$, $\eta \to 3\pi^0$
  $\eta' \to \pi^0\pi^0\eta$, $\eta \to \pi^+\pi^-\pi^0$ } **2 tracks + 7 photons**
- $\phi \to \eta\gamma$, $\eta \to 3\pi^0$ **7 photons**

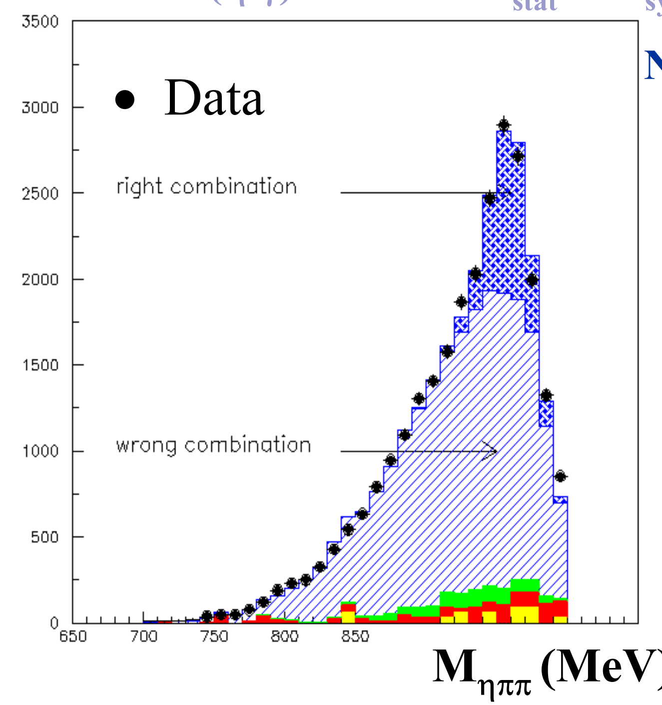
$N(\eta\gamma) = 1665000 \pm 1300$

background free



$N(\eta'\gamma) = 3405 \pm 61_{stat} \pm 28_{syst}$

$N_{bckg} = 345$



$BR(\phi \to \eta'\gamma)/BR(\phi \to \eta\gamma)$: results

$$R = \frac{BR(\phi \to \eta'\gamma)}{BR(\phi \to \eta\gamma)} = \frac{N(\eta'\gamma) \quad \varepsilon_{\eta\gamma}\, BR(\eta \to \pi^0\pi^0\pi^0)}{N(\eta\gamma) \quad [BR_{crg}\varepsilon_{crg} + BR_{ntr}\varepsilon_{ntr}]} \, K_\rho$$

Interf.
$\phi \to \eta/\eta'\gamma$
$\rho \to \eta/\eta'\gamma$

$$BR_{crg} = BR(\eta' \to \pi^+\pi^-\eta)\, BR(\eta \to \pi^0\pi^0\pi^0)$$

$$BR_{nrt} = BR(\eta' \to \pi^0\pi^0\eta)\, BR(\eta \to \pi^+\pi^-\pi^0)$$

from PDG

Source	Syst. Err.
Filfo-Evcl	1%
TRK	1%
VTX	1%
Bkg	0.1%
$\varepsilon\eta / \varepsilon\eta'$	0.4%
$\chi 2$	1.5%
BR's	**3%**
K_ρ	1%
Total	**4%**

$$\mathbf{R = (4.74 \pm 0.09_{stat} \pm 0.20_{syst}) \times 10^{-3}}$$

$$\mathbf{BR(\phi \to \eta'\gamma) = (6.17 \pm 0.12 \pm 0.28) \times 10^{-5}}$$

Systematics dominated by the knowledge of η,η′ BR's

In agreement with previous KLOE result, PLB541 (2002) 45:

$$R = (4.70 \pm 0.47_{stat} \pm 0.31_{sys}) \cdot 10^{-3}$$

$$BR(\phi \to \eta'\gamma) = (6.10 \pm 0.61 \pm 0.43) \cdot 10^{-5}$$

η/η′ mixing and η′ gluon content

The η/η′ mixing angle in the quark flavour basis, φ_P , can be extracted from the ratio R using the formula [Bramon et al., Eur. Phys. J. C7 (1999) 271]

$$R = \frac{BR(\phi \to \eta'\gamma)}{BR(\phi \to \eta\gamma)} = \cot^2 \varphi_P \left(1 - \frac{m_s}{\overline{m}} \cdot \frac{Z_{NS}}{Z_S} \cdot \frac{\tan \varphi_V}{\sin 2\varphi_P}\right)^2 \cdot \left(\frac{p_{\eta'}}{p_\eta}\right)^3$$

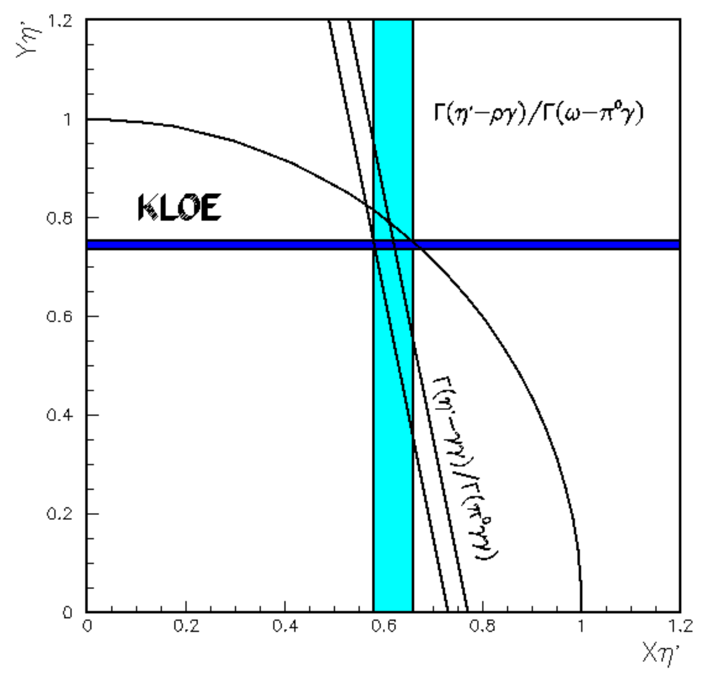
$$\varphi_P = (41.5 \pm 0.3_{stat} \pm 0.7_{syst} \pm 0.6_{th})°$$

Combined analysis to evaluate a possible gluon content of η'

$$\eta' = X \frac{1}{\sqrt{2}} | u\bar{u} + d\bar{d} > + Y | s\bar{s} > + Z | glue >$$

$$Z^2 > 0 \Leftrightarrow X^2 + Y^2 < 1$$

$$X^2 + Y^2 = 0.93 \pm 0.06$$



Conclusions

KLOE has obtained new results, mostly based on a sample of 450 pb^{-1}, including

- **Measurements of the K_S-K_L and $K^{\pm}$ decay channels with precision ~ 1% or better**
- **Best limit on $K_S \to \pi^0\pi^0\pi^0$**
- **First measurement of K_S semileptonic charge asymmetry**
- **Evidence for $\phi \to f_0\gamma$ from $M_{\pi\pi}$ and f-b asymmetry in the channel $\pi^+\pi^-\gamma$ (talk by S.Mueller on σ_{had})**
- **η/η' mixing with $\eta' \to \pi^+\pi^- 7\gamma$**
- **Dalitz plot analysis of $\eta \to \pi^+\pi^- \pi^0$**
- **η mass**

With the analyses of the 2.5 fb^{-1} data sample we can address/improve:

- **QM interference studies**
- **$BR(K_S \to \gamma\gamma)$, $BR(K_S \to \pi^+\pi^-\pi^0)$, $BR(K_S \to \pi^+\pi^- e^+e^-)$**
- **$UL(K_S \to \pi^0\pi^0\pi^0)$, $UL(K_S \to e^+e^-)$**
- **Semileptonic BR's, lifetimes, *ff* slopes**
- **$BR(K_L \to \pi\pi)$ to few 10^{-3}**
- **$\Gamma(K^{\pm} \to e^{\pm}\nu)/\Gamma(K^{\pm} \to \mu^{\pm}\nu)$ to few 10^{-2}**
- **Combined fit of both, charged and neutral, $\pi\pi\gamma$ final states and searches for $f_0/a_0 \to KK$**
- **Search for $\sigma(600)$ with off-peak data using the reaction $\gamma\gamma \to \pi^0\pi^0$ (talk by F. Nguyen)**
- **$\eta \to \pi^+\pi^- e^+e^-$, $\eta \to \pi^0\gamma\gamma$, $\eta \to \pi^+\pi^-\gamma$, $\mu^+\mu^-\gamma$, η' decays**