Highlights from $K^{\pm}$ measurements @KLOE

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on behalf of the KLOE collaboration

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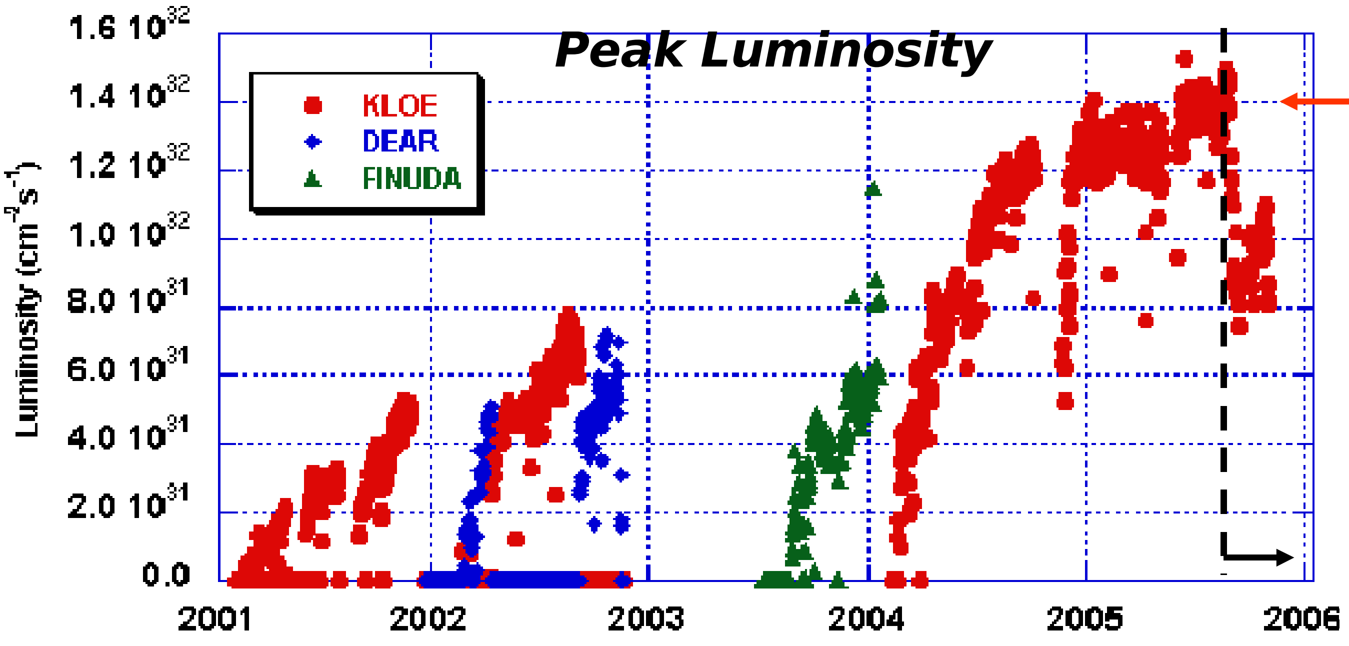
Outline

- DAΦNE & KLOE
- **Vus with kaons**
- **Tagging @ KLOE**
- $K^+ \to \mu^+ \nu(\gamma)$
- **Semileptonic decays**
- **Charged kaon lifetime**
- **Conclusions**

DAΦNE performance up to Dec 2005



L=1.4 x 10^{32} cm^{-2}s^{-1}

Off peak run

Day performance: 7-8 pb^{-1}

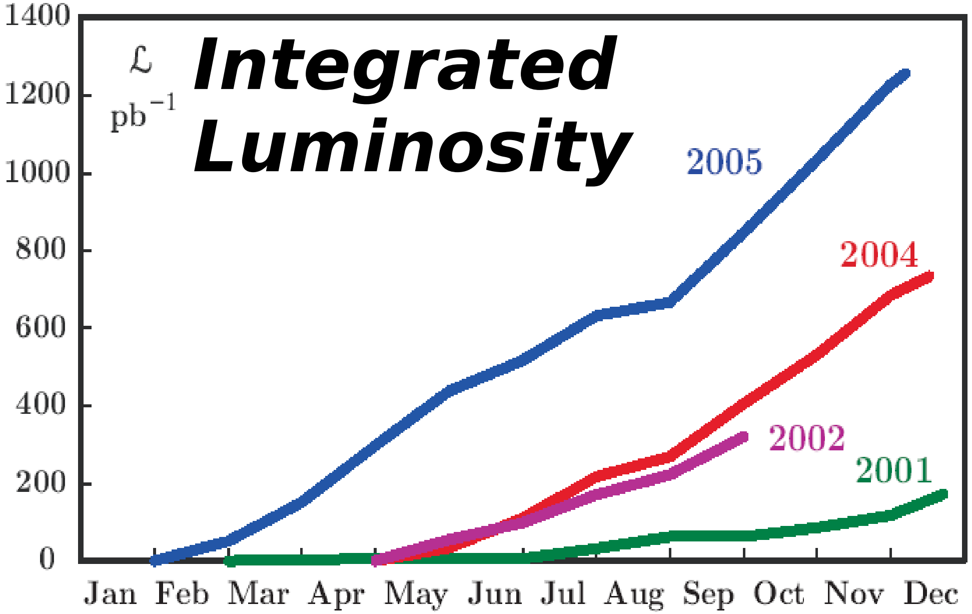
Best month $\int\mathcal{L}\,dt$ ~ 200 pb^{-1}

Total KLOE $\int\mathcal{L}\,dt$ ~ 2500 pb^{-1}

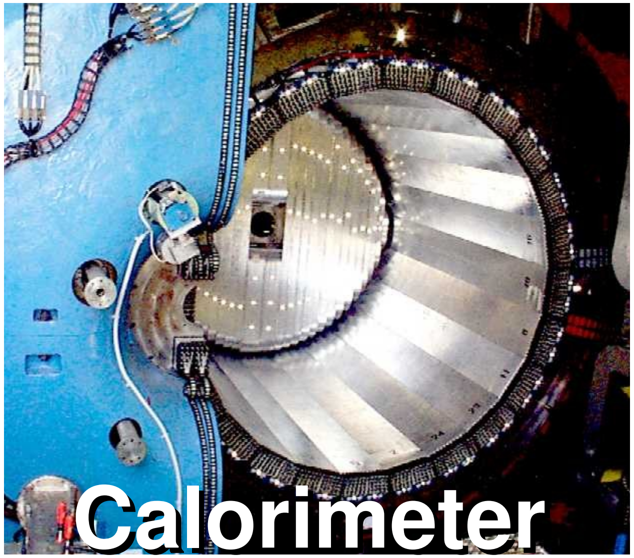
(2001 - 05)

→ ~2.5×10^9 K_SK_L pairs

→ ~3.6×10^9 K^+K^- pairs

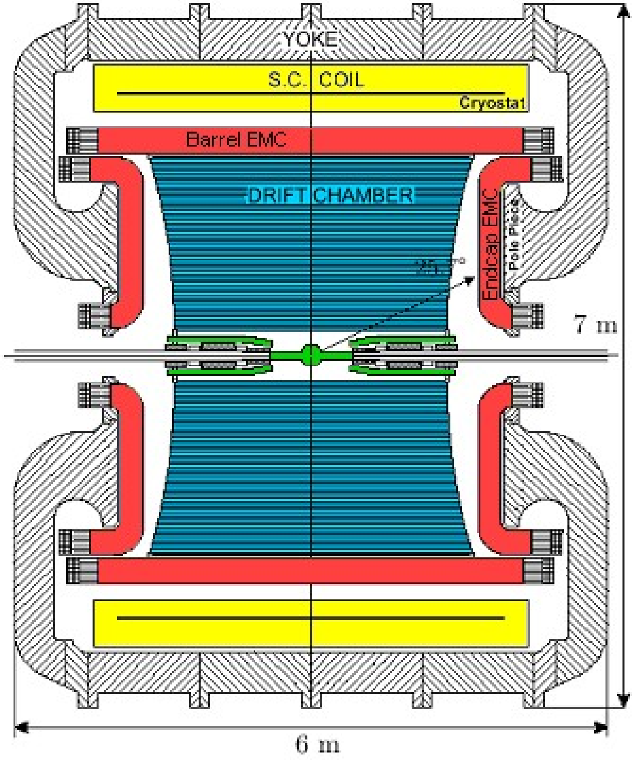


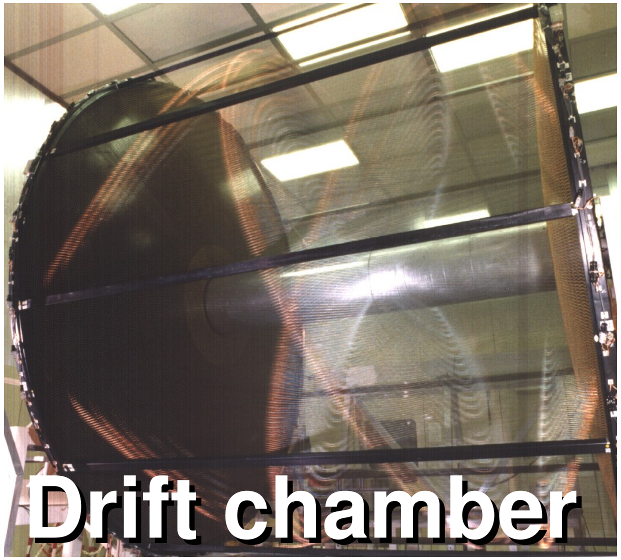
The KLOE detector



Lead/scintillating fiber
4880 PMTs
98% coverage of solid angle

Superconducting coil B = 0.52 T





4 m diameter × 3.3 m length
90% helium, 10% isobutane
12582/52140 sense/total wires
All-stereo geometry

$\sigma_E/E \cong 5.7\% / \sqrt{E\,(\mathrm{Ge}}$

$\sigma_t \cong 54\ \mathrm{ps} / \sqrt{E\,(\mathrm{GeV})} \oplus 50\ \mathrm{ps}$

(relative time between clusters)

$\sigma_{\gamma\gamma} \sim 2\ \mathrm{cm}$ (π^0 from $K_L \to \pi^+\pi^-\pi^0$)

$\sigma_p/p \cong 0.4\%$ (tracks with $\theta > 45°$)

$\sigma_x^{hit} \cong 150\ \mu\mathrm{m}\ (xy),\ 2\ \mathrm{mm}\ (z)$

$\sigma_x^{vertex} \sim 1\ \mathrm{mm}$

CKM matrix and V_{us}

$$V_{CKM} = \begin{pmatrix} \multicolumn{3}{c}{\boxed{V_{ud} \quad V_{us} \quad V_{ub}}} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix}$$

We check the unitarity of the CKM matrix required by the Standard Model. The lack of unitarity is a hint of new physics

The most precise test comes from the 1st row:

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

V_{ud} from super-allowed nuclear β decays

→ V_{us} from kaon decays

V_{ub} from B meson decays $|V_{ub}| \sim O(10^{-3})$

V_{us} from kaons decays

- From semileptonic decays

Form factor

Radiative and SU(2)corr

$$\Gamma(K \to \pi \ell \nu(\gamma)) = \frac{G^2 m_K^5}{768 \pi^3} C_K^2 \, |V_{us}|^2 \, |f_+^{K\pi}(0)|^2 \, I_K^\ell \, S_{ew} \, \left[1 + \delta_{SU(2)} + \delta_{em}\right]$$

$BR(K \to \pi l \nu) / \tau_K$

Phase space (λ_+,λ_0)

- From charged kaon leptonic decay
  (Marciano, **Phys.Rev.Lett.**93:231803,2004)

Lattice QCD

$$\frac{\Gamma(K \to \mu \nu(\gamma))}{\Gamma(\pi \to \mu \nu(\gamma))} = \left|\frac{V_{us}}{V_{ud}}\right|^2 \times \left|\frac{f_K}{f_\pi}\right|^2 \times \frac{M_\pi^3 (M_K^2 - M_\mu^2)}{M_K^3 (M_\pi^2 - M_\mu^2)} \left[1 - \frac{\alpha}{\pi}(C_\pi - C_K)\right]$$

KLOE can measure all experimental inputs for charged and neutral kaons:
branching ratios, lifetimes and form factors

Kaon pair production

The ϕ decays at rest producing a kaon pair: $K_L K_S$ or K^+K^-

The detection of a K guarantees the presence of the charge coniugated K with known momentum ⇒ **Tag mechanism**

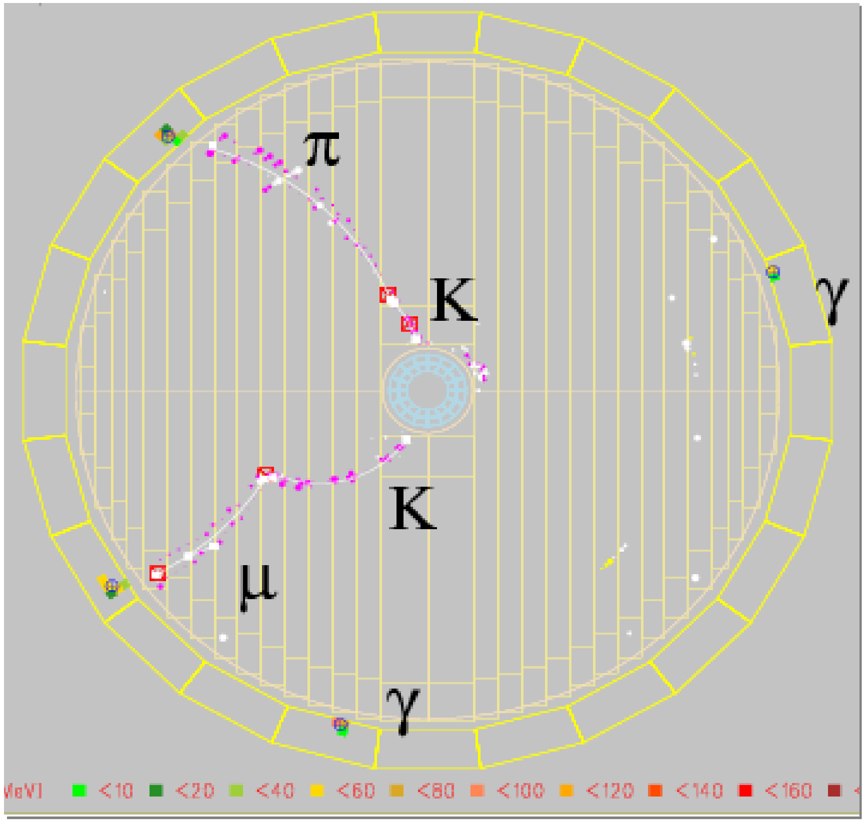
Normalization to the number of tags allows a precise measurement of absolute BRs

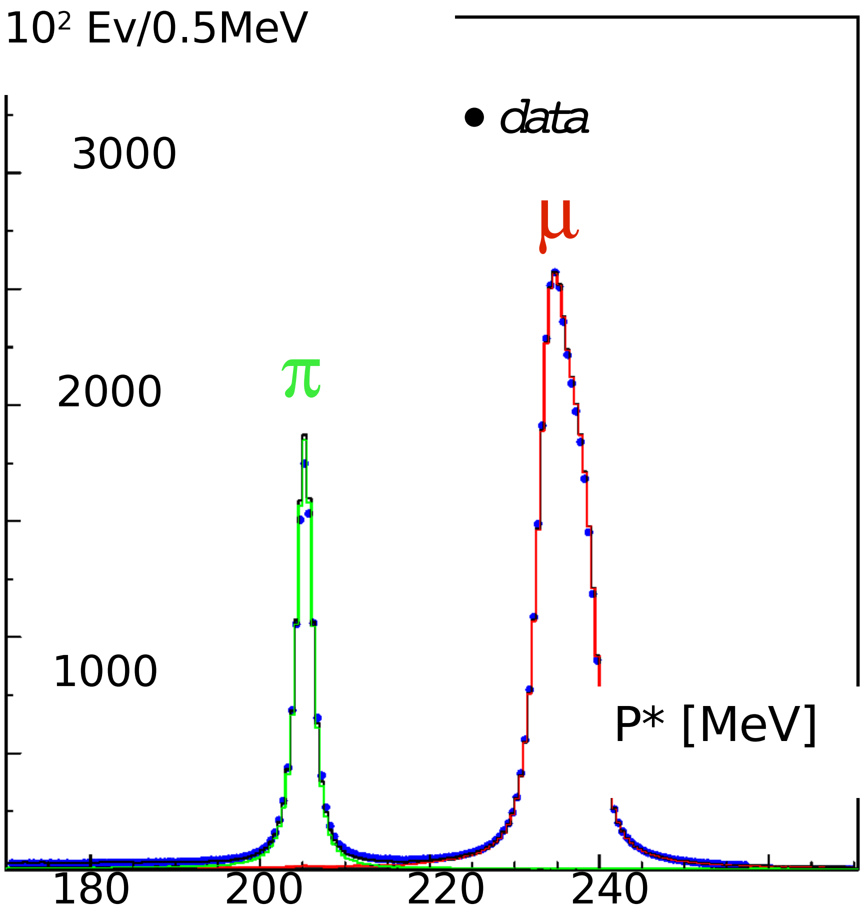
Φ	$K^{\pm}$
$\sigma(e^+e^- \rightarrow \phi) \approx 3\,\mu b$	$P_{LAB} = 127\,MeV/c$
$BR(\phi \rightarrow K^+K^-) \simeq 49\%$	$\lambda(K^+) = 95\,cm$

Tagging @ KLOE

$K^\pm$ events tagged using two body decays (about 85%):

$K^\pm \to \mu^\pm \nu$, $\pi^\pm \pi^0 \approx 1.5 \times 10^6$ K^+K^- ev/pb^{-1}





Measurement of the absolute branching ratio

$$K^{+} \rightarrow \mu^{+} \nu (\gamma)$$

Published on **Phys.Lett.B** 632:76-80,2006

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

Normalization sample N_{TAG} given by

$K^- \to \mu^- \overline{\nu}$ (Data sample 175 pb^{-1})

- Signal events obtained from the p* distribution

  (p*: momentum of secondary track in kaon c.m., pion mass assumed)

- Background subtraction
- Efficiency related to DC reconstruction only

  (tracking plus vertexing), evaluated directly on data

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

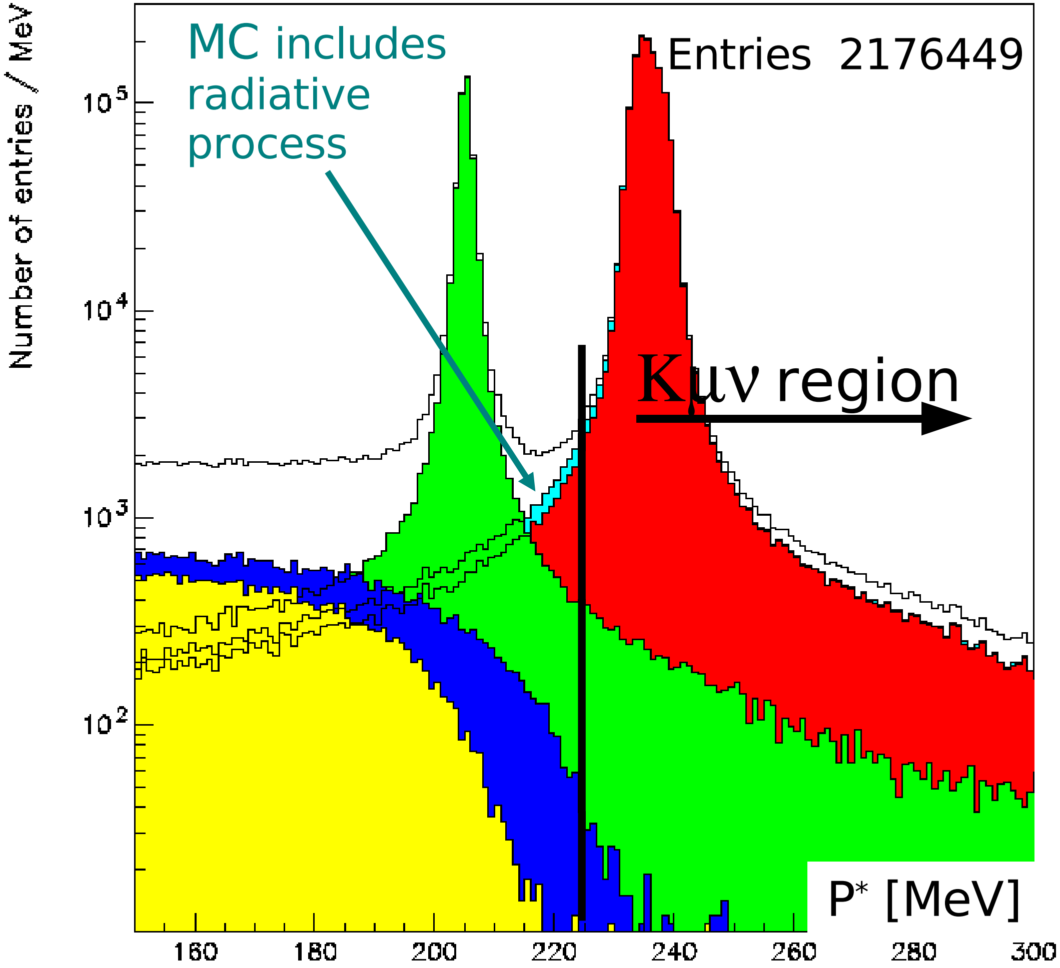
- Signal given by K⁺ decays in the FV (40 cm < ρ < 150 cm) of the Drift Chamber, using *~60 pb⁻¹*
- Background is mainly due to events with a π^0 in the final state:

🟩 $K^+ \to \pi^+ \pi^0$

🟦 $K^+ \to \pi^0 e^+ \nu_e$

🟨 $K^+ \to \pi^0 \mu^+ \nu_\mu$

$$BR = \frac{N_{K\mu\nu(\gamma)}}{N_{TAG}} \cdot \frac{1}{\epsilon_{DC}}$$



MC includes radiative process

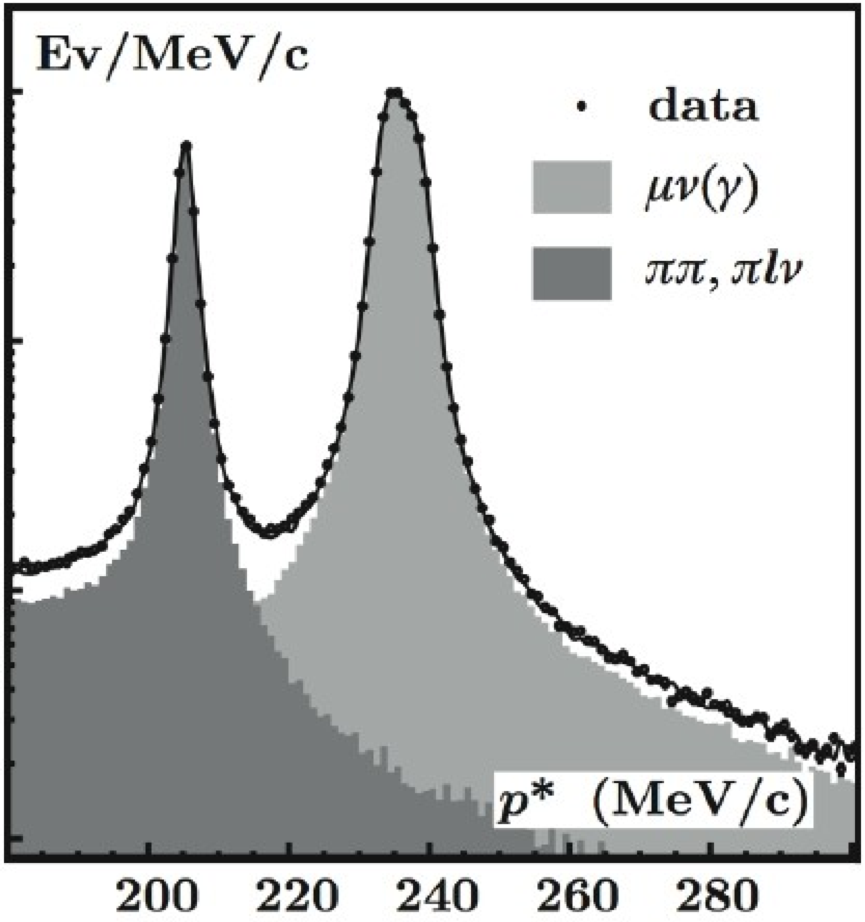
PLB 632(2006) 76

Result

- Fit of the momentum distribution of the charged secondary, p*

- 8 x 10^5 events

- Total accuracy 0.27%



$$BR(K^\pm \to \mu^\pm \nu_\mu (\gamma)) = 0.6366 \pm 0.009 \pm 0.015$$

Measurement of the K± semileptonic decays absolute branching ratios

$$K^{\pm} \rightarrow \pi^{0} e^{\pm} \nu_{e} \quad \& \quad K^{\pm} \rightarrow \pi^{0} \mu^{\pm} \nu_{\mu}$$

$K^{\pm}$ semileptonic decays

- 4 independent normalization samples ($K^{\pm} \to \mu^{\pm} \nu_{\mu}$, $K^{\pm} \to \pi^{\pm} \pi^{0}$)

  help us to keep under control systematic effects

  due to the tag selection (Data sample 410 pb^{-1})

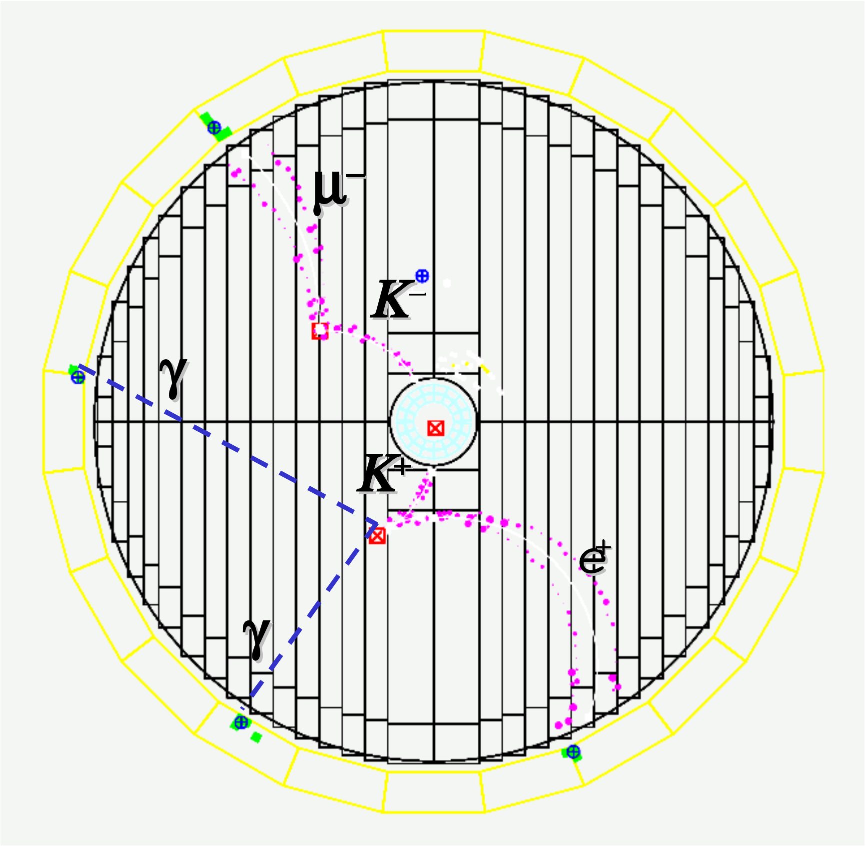
- Kinematical cuts to reject non semileptonic decays

- Fit of the charged secondary square mass spectrum m^2_{lept}

- Efficiency evaluated from MC and corrected for Data/MC ratio

$K^\pm_{l3}$ signal selection

- Two tracks vertex in the FV:
  40 cm < ρ < 150 cm
- Track of charged secondary
  extrapolated to EMC
- Two body decays cut:
  $p^*(m_\pi) < 195$ MeV/c
- π^0 reconstruction:
  2 neutral clusters in EMC
  with TOF matching the
  kaon decay vertex
- Mass of charged secondary
  from TOF measurement



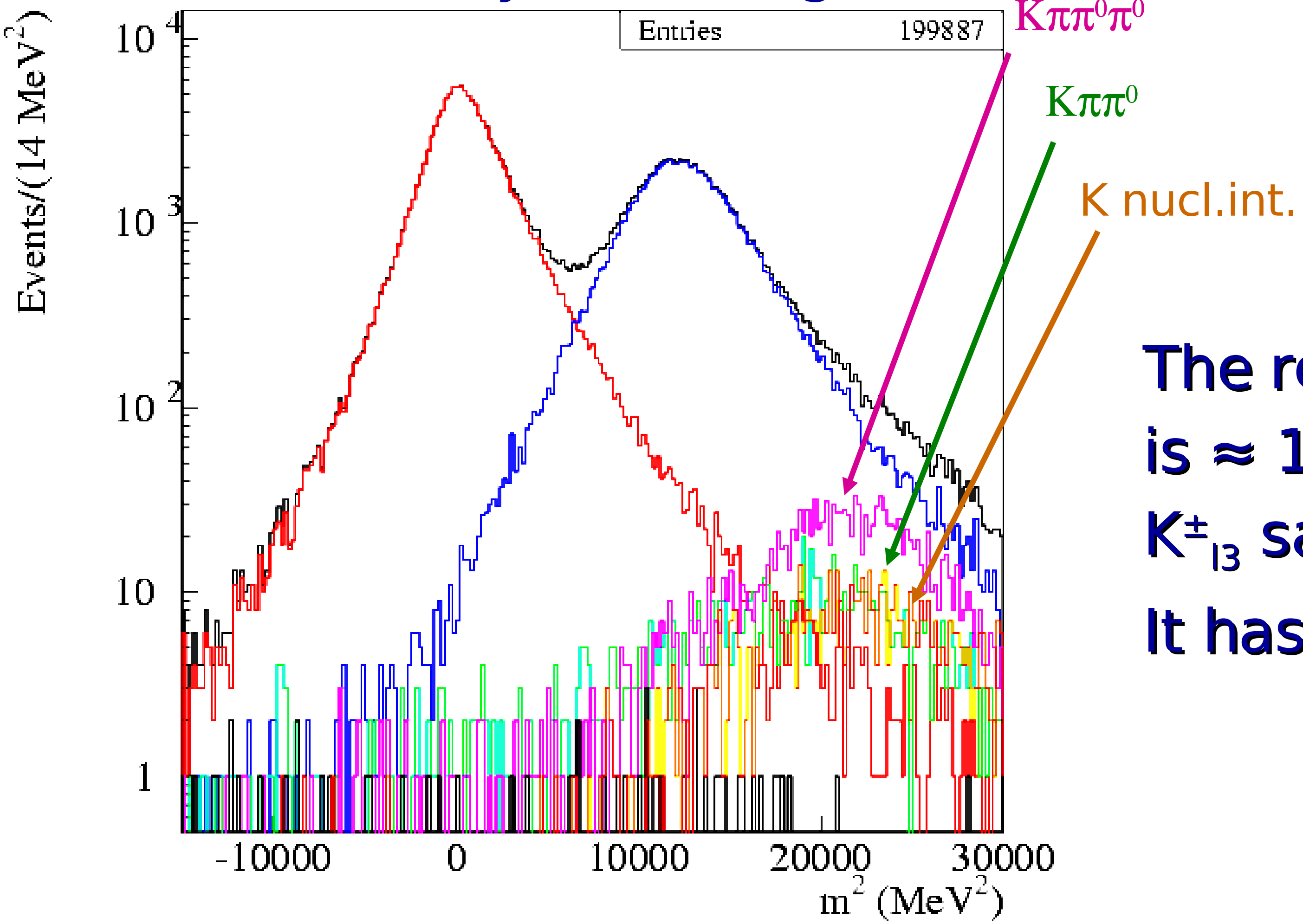
$$t^{decay}_{\pi^0} = \frac{(t_1 - L_1/c)+(t_2 - L_2/c)}{2}$$

$$m^2_{lept} = p^2_{lept}\cdot\left[\frac{c^2}{L^2_{lept}}(t_{lept} - t^{decay}_{\pi^0})^2 - 1\right]$$

$K^{\pm}_{l3}$ background (II)

The kinematical cuts reject ≈ 96% of the background events

The efficiency on the signal is ≈ 50% for both K_{e3} and $K_{\mu3}$



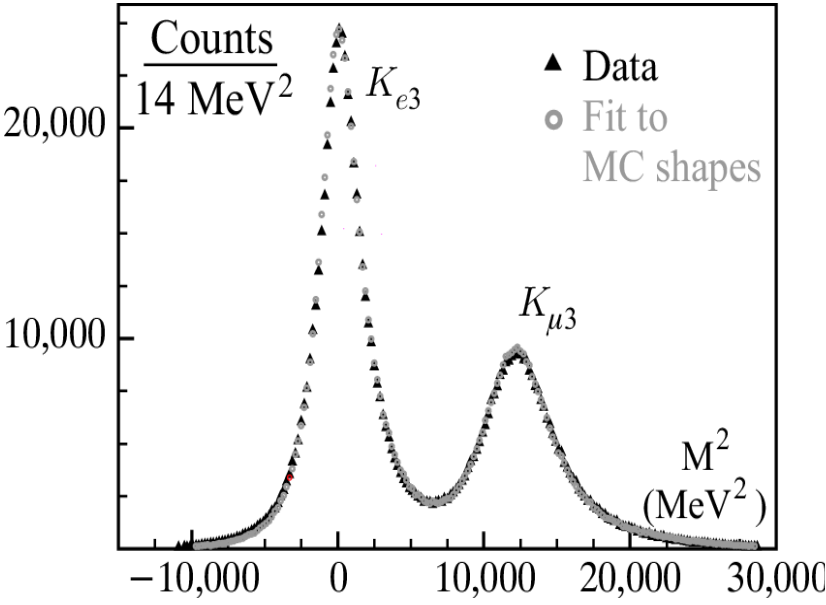
The residual background is ≈ 1.5% of the selected $K^{\pm}_{l3}$ sample.

It has $m_{lept}^2 \approx m_\pi^2$

$K^{\pm}$ semileptonic decays

Fit m^2_{lept} spectrum with linear combination of Ke3 , Kμ3 shapes, and bck contributions.

Average of the four data samples.



- **Fractional accuracy:**

  1.8% for K_{e3} ; 2.4% for $K_{\mu 3}$

- **Systematic error studies to be completed**

$BR(K^{\pm}_{e3}) = 5.047(19)_{stat}(39)_{corr\text{-}stat}(81)_{syst}\%$

$BR(K^{\pm}_{\mu 3}) = 3.310(16)_{stat}(45)_{corr\text{-}stat}(65)_{syst}\%$

$\rho(K_{e3},K_{\mu 3}) = 0.42$

Preliminary

- Systematic dominated by uncertainty on tracking efficiency correction

Measurement of the charged kaon lifetime

$K^\pm$ lifetime

PDG

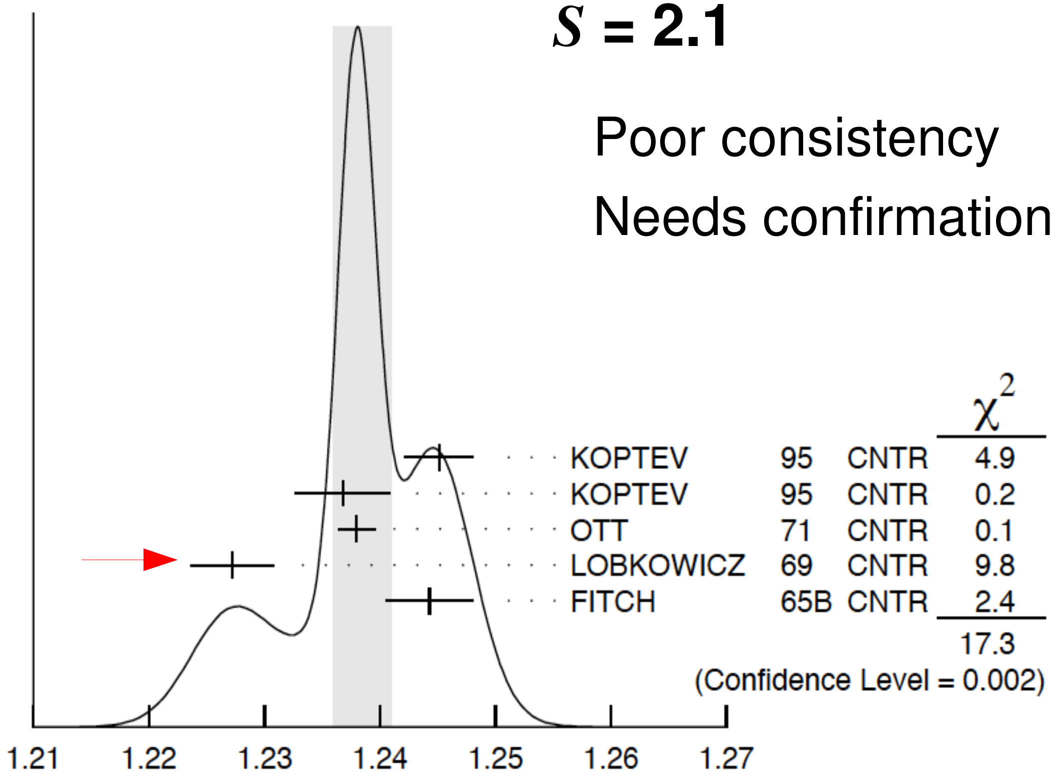
average

12.385(25) ns

S = 2.1

Poor consistency

Needs confirmation



			χ^2
KOPTEV	95	CNTR	4.9
KOPTEV	95	CNTR	0.2
OTT	71	CNTR	0.1
LOBKOWICZ	69	CNTR	9.8
FITCH	65B	CNTR	2.4
			17.3

(Confidence Level = 0.002)

Discrepancy between in-flight and at-rest measurements

Discrepancy among different stoppers in at-rest measurements

Confirmation is important for V_{us} determination.

$$\tau_{PDG} = (12.385 \pm 0.025)\ \text{ns}$$

$K^\pm$ lifetime

Given the tag, look for the decay vertex of the second kaon

- **Method #1: fit t^* distribution from decay length**

  Measure the charged K decay length taking into account the energy loss: $\tau^* = \Sigma_i \Delta L_i / \beta_i \gamma_i c$

- **Method #2: Directly measure decay time (in progress)**

  Use all the charged K decays with a π^0 in the final state to reconstruct decay time from π^0 clusters time

Two methods allow us cross check of systematics

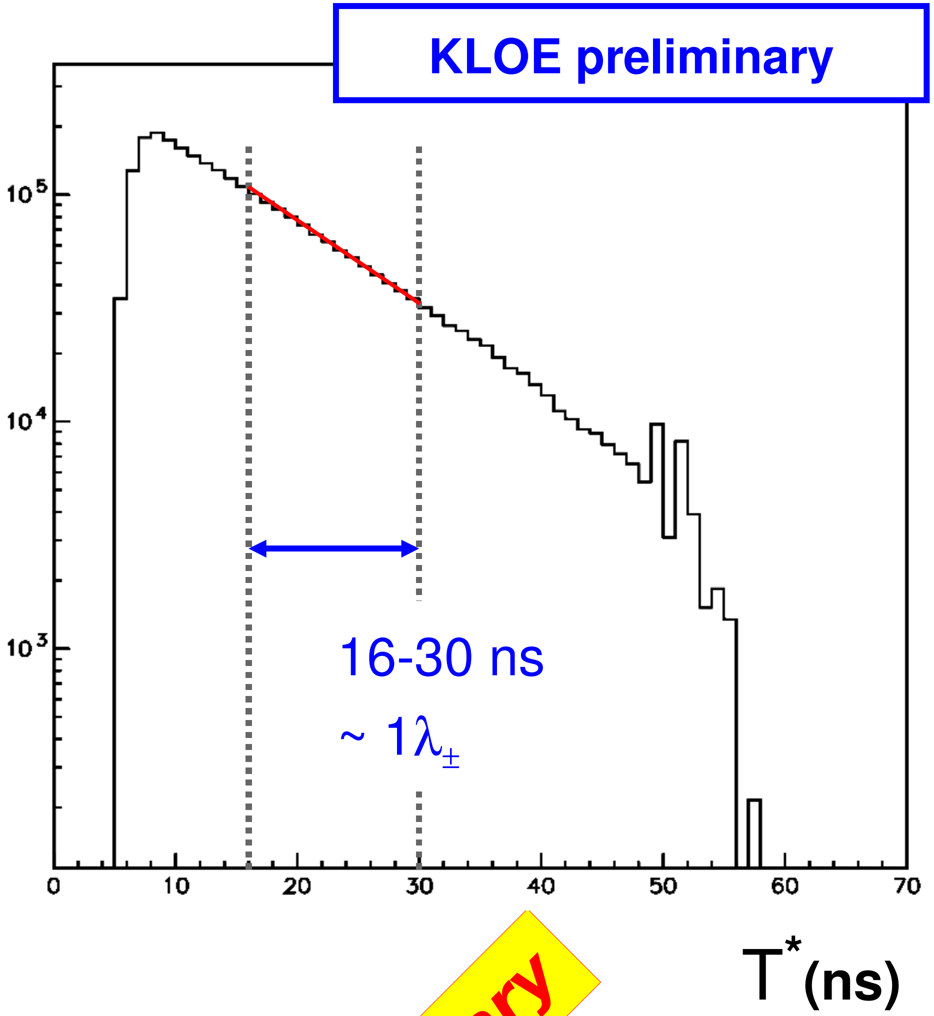
$K^{\pm}$ lifetime: method #1

- $K^{\pm} \to \mu^{\pm}\nu$ tag
- K decay vertex in the fiducial volume (using DC only)
- Signal K track extrapolated backwards to the IP
- dE/dx taken into account ⇒ 2mm step

$$T^{*} = \sum_{i} \Delta T_{i} = \sum_{i} \frac{\sqrt{1-\beta^{2}}}{c\beta} \Delta L_{i}$$

- Efficiency evaluated directly on data

Proper time fit



The proper time distribution, corrected with the efficiency, is fitted with a convolution of an exponential function and a resolution function.

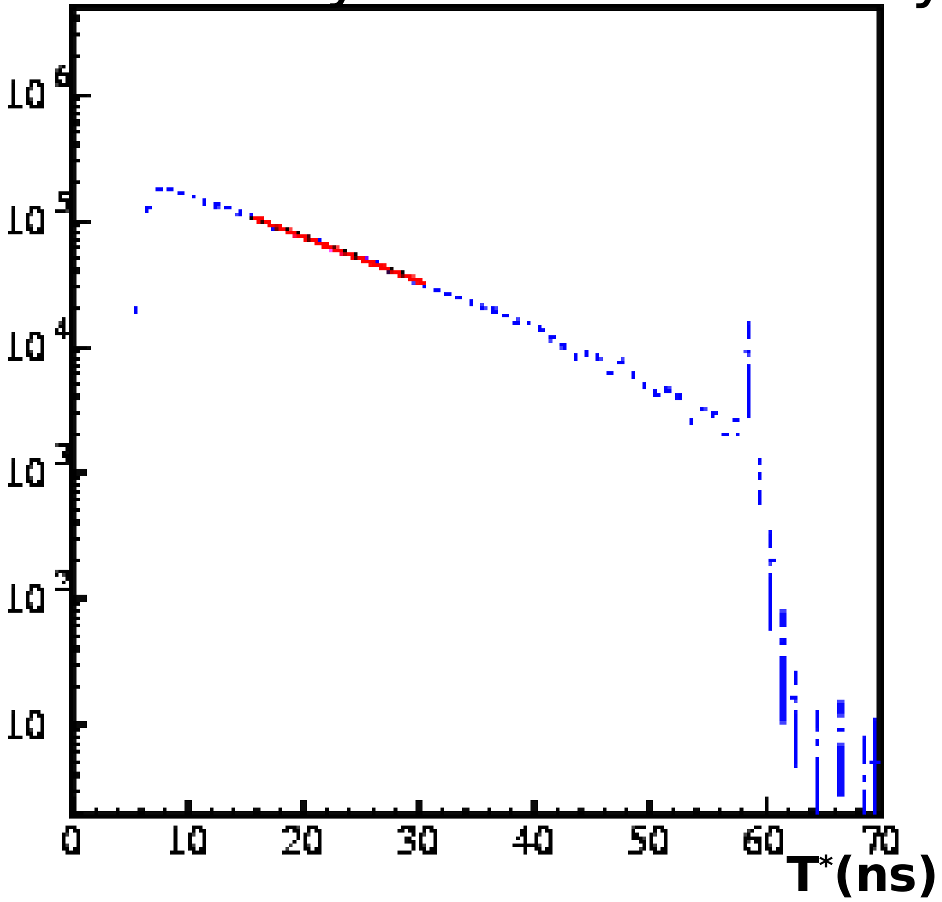
Fit between 16 and 30 ns

Preliminary

$$\tau^{\pm} = (12.377 \pm 0.044 \pm 0.065)\ ns$$

$K^{\pm}$ lifetime: method #2

- $K^{\pm} \to \mu^{\pm}\nu$ tag
- $K^{\pm} \to \pi^{0}$ X decay(looking for neutral clusters in the EC)
- $K^{\pm}$ neutral decay vertex(π^{0}) in the fiducial volume
- Efficiency evaluated directly on data



$$T^{*} = \left(t_{\gamma} - \frac{r_{\gamma}}{c} \right) \cdot \sqrt{1 - \beta_{K}^{2}}$$

Two methods allow cross check of systematics

V_{us} from KLOE results

V_{us} from KLOE results

	$K_L\,e3$	$K_L\,\mu3$	$K_S\,e3$	$K^\pm e3$	$K^\pm\mu3$
BR	0.4008(15)	0.2699(15)	$7.046(91)\times10^{-4}$	0.05047(92)	0.03310(80)
τ	50.84(23) ns		89.58(6) ps	12.367(78) ns	

Slopes KLOE final

$\lambda'_+ = 0.0256(18)$

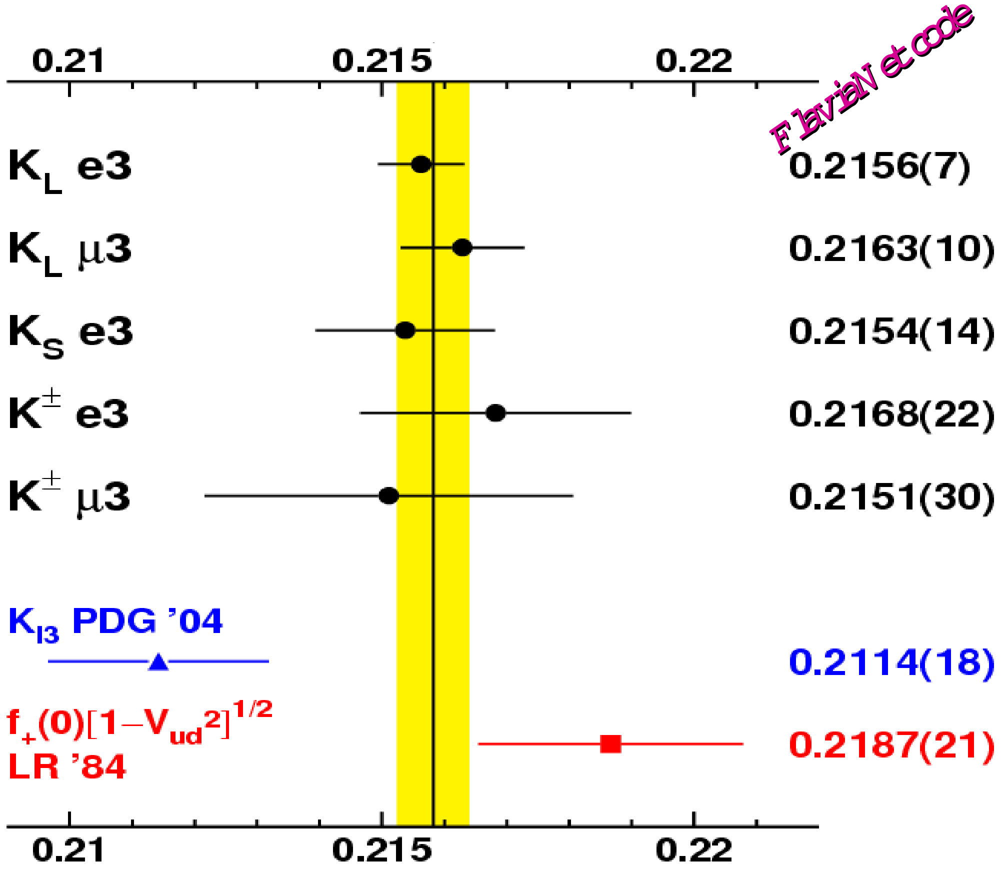
$\lambda''_+ = 0.0014(8)$

$\lambda_0 = 0.0156(26)$

KLOE prelim.

using $f_+(0)=0.961(8)$, $V_{ud}=0.97377(27)$

$\Delta = 1 - V_{ud}^2 - V_{us}^2 = (-13\pm10)\times10^{-4}$



$$\langle V_{us}\times f_+(0)\rangle_{KLOE\,AV.} = 0.2158\pm0.0006\ (\sim 0.3\%)$$

From unitarity

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

  Leutwyler and Roos Z. [Phys. **C25**, 91, 1984]

- $V_{ud}=0.97377(27)$

  Marciano and Sirlin [Phys.Rev.Lett.96 032002,2006]

$V_{us}\times f_+(0) = 0.2187(21)$

K_L $[G_F(\mu)/G_F(e)]^2 = 1.0065(98)$

cfr with PDG04 1.047(14)

$K^\pm$ $[G_F(\mu)/G_F(e)]^2 = 0.9843(251)$

cfr with PDG04 1.004(16)

V_{ud} - V_{us} plane

$|V_{us}/V_{ud}|$ can be extracted from the ratio:
$$\frac{\Gamma(K \to \mu\nu_\mu(\gamma))}{\Gamma(\pi \to \mu\nu_\mu(\gamma))} \propto \frac{|V_{us}|^2 f_K}{|V_{ud}|^2 f_\pi}$$

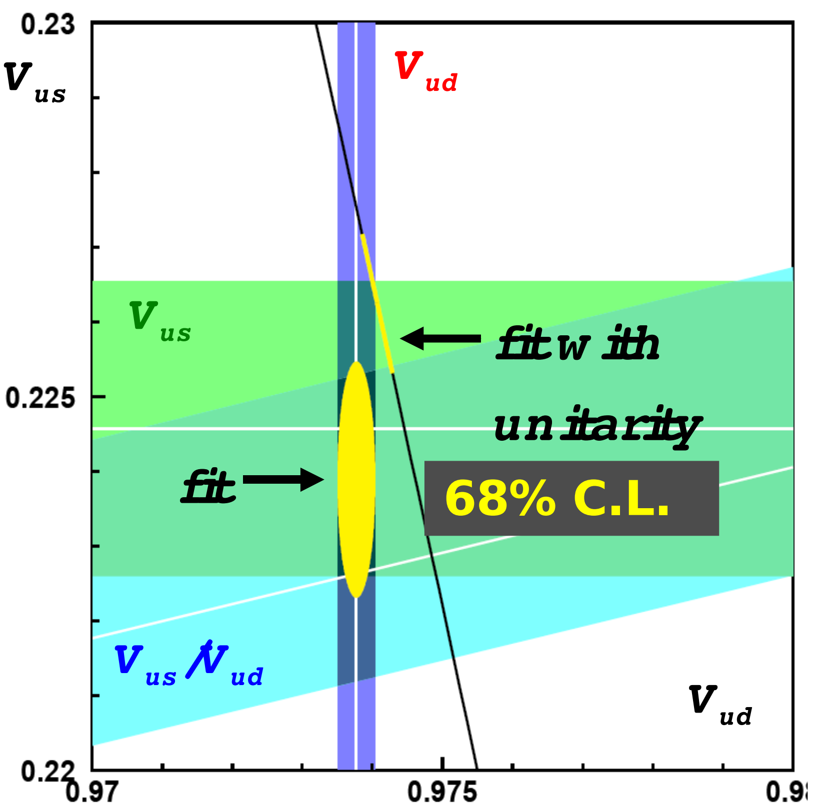
$f_K/f_\pi = 1.208(2)(^{+7}_{-14})$ from lattice MILC Coll. PoS LAT2006

$$V_{us} / V_{ud} = 0.2286(^{+27}_{-15})$$

Fitting with V_{ud}, V_{us} + unitarity constraint

$V_{us} = 0.2246(20)$
$V_{ud} = 0.97377(27)$
$\chi^2/\mathrm{dof} = 0.35/1$
$P(\chi^2) = 0.56$

$V_{us} = 0.2262(9)$
$V_{ud} = 0.97407(22)$
$\chi^2/\mathrm{dof} = 3.74/2$
$P(\chi^2) = 0.15$



$K^{\pm}$ at KLOE - summary

Absolute **BR($K^+ \to \mu^+\nu(\gamma)$)** with **0.27%** accuracy

Phys.Lett.B 632:76-80,2006

Independent determination of **V_{us}** at **1%** level

$K^{\pm} \to \pi^0 l^{\pm} \nu_l$ absolute BR and **lifetime**: **preliminary** results

Together with the results on neutral kaons gives a significant contribution to the determination of **V_{us} x $f^+(0)$ 0.2%** level

BR($K^{\pm} \to \pi^{\pm}\pi^0$) in progress

Using 2 fb^{-1} collected KLOE will measure:

$K^{\pm} \to \pi^0 l^{\pm} \nu_l$ form factors, BR($K^{\pm} \to \pi^0\pi^0 l^{\pm} \nu_l$)

BR($K \to e\nu$)/BR($K \to \mu\nu$) to test e-μ universality

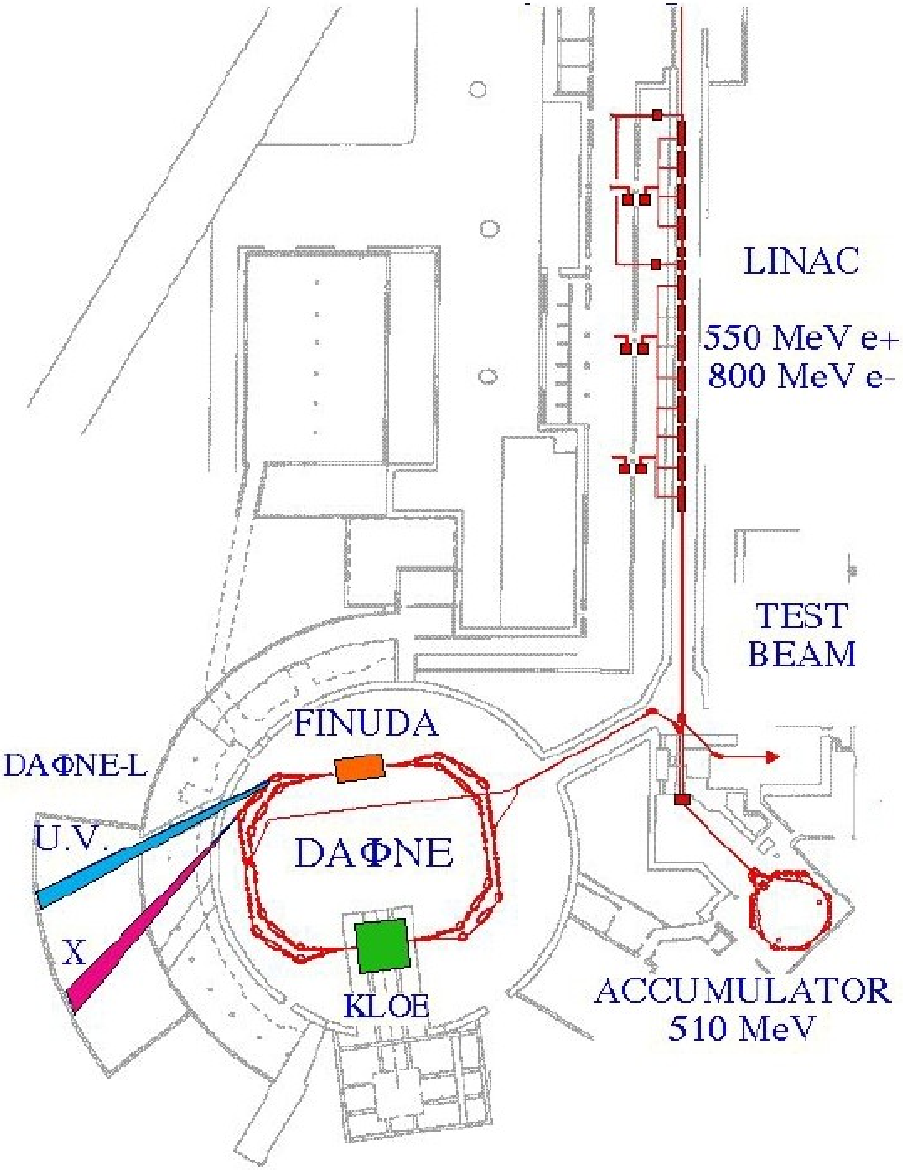
About 6 x 10^4 Ke2 events produced with 2.5fb^{-1}

Spare slides

DAΦNE

Double **A**nnular ring

Φ for **N**ice **E**xperiments



DAΦNE

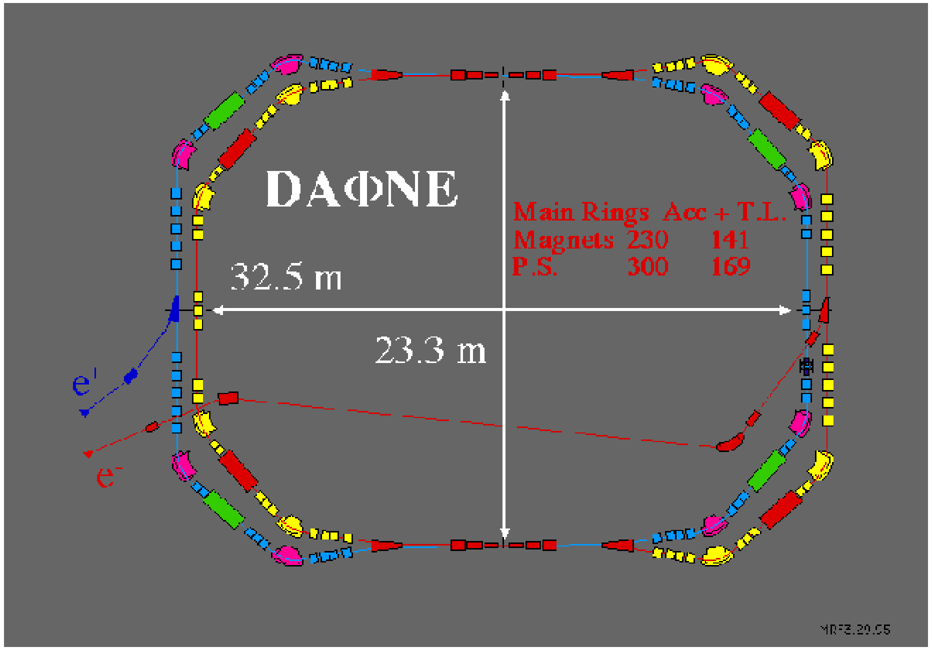
electron-positron collider

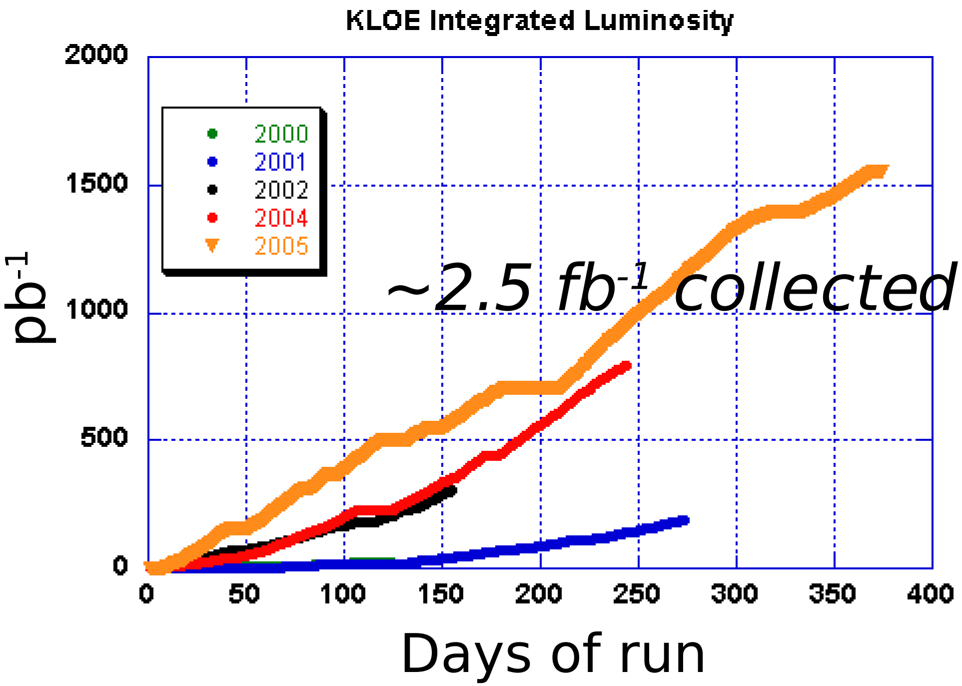
$\sqrt{s} = m_\phi = 1.019$ GeV $\sigma(\phi) \approx 3\ \mu b$

2 rings to minimize beam-beam interactions

12.5 mrad crossing angle

2 interaction regions (KLOE - DEAR/FINUDA)





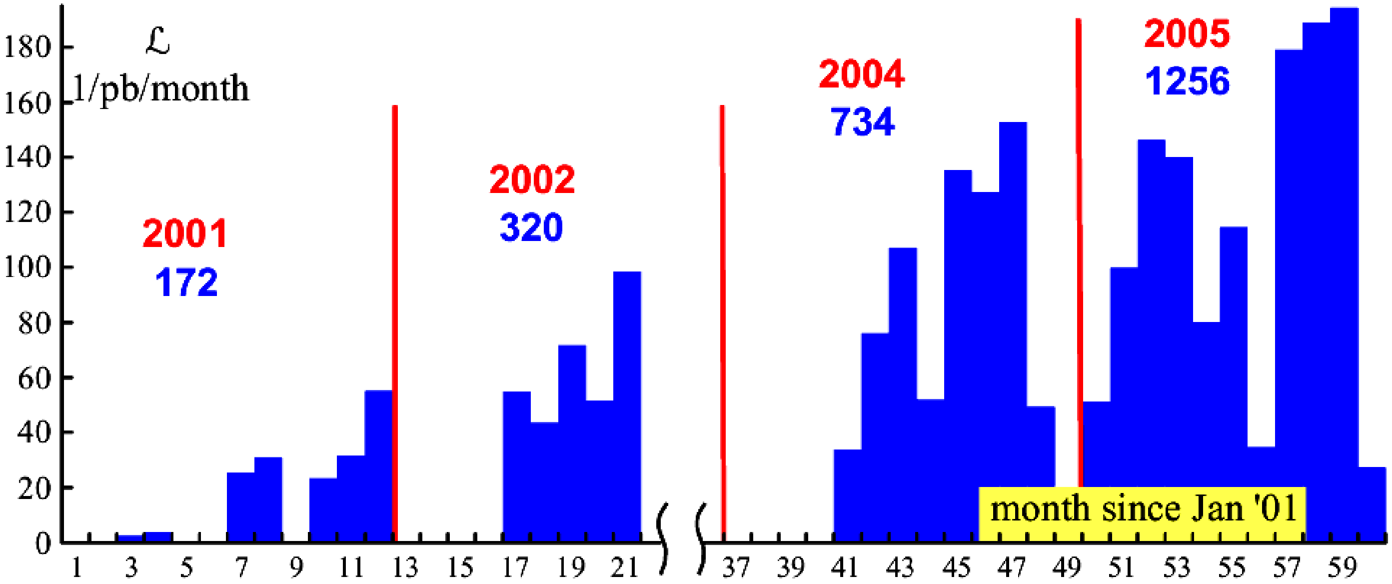
~2.5 fb^{-1} collected

The DAϕNE e^+e collider

- Collisions at c.m. energy around the ϕ mass:
  $\sqrt{s} \sim 1019.4$ MeV
- Angle between the beams at crossing:
  $\alpha_{crs} \sim 12.5$ mrad
- Residual laboratory momentum of ϕ:
  $p_\phi \sim 13$ MeV/c
- Cross section for ϕ production @ peak:
  $\sigma_\phi \sim 3.1\ \mu b$

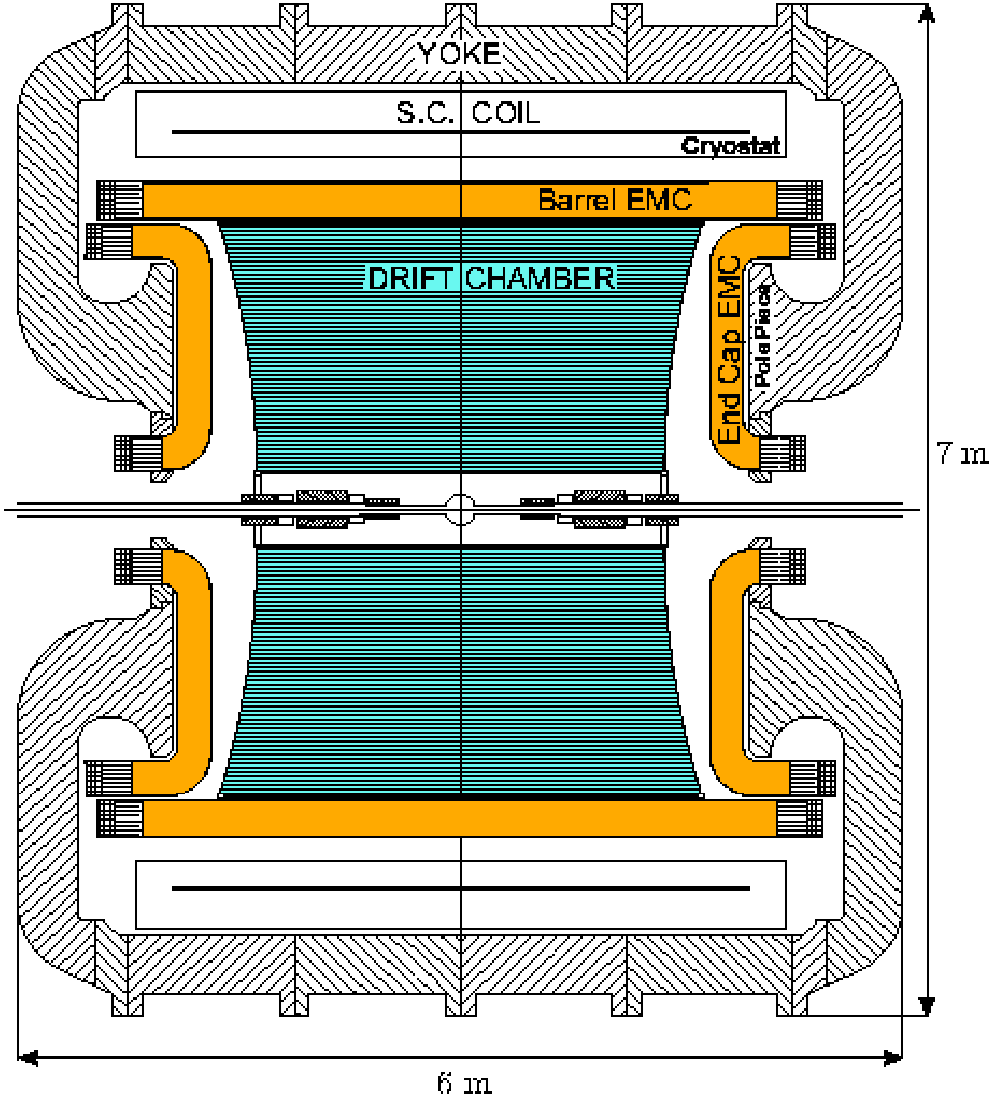
Grand total (2001/5):
$\int L = 2.5\ fb^{-1}$.
$L_{peak} = 1.3 \times 10^{32}\ cm^{-2}s^{-1}$

Results presented in this talk from 2001/2 data: $\int L = 450\ pb^{-1}$.



KLOE plots: end 2005

K LOng Experiment



Spherical ***beam pipe***
10 cm Ø, 0.5 mm thick in Be-Al alloy
to minimize regeneration,
scattering and γ conversion

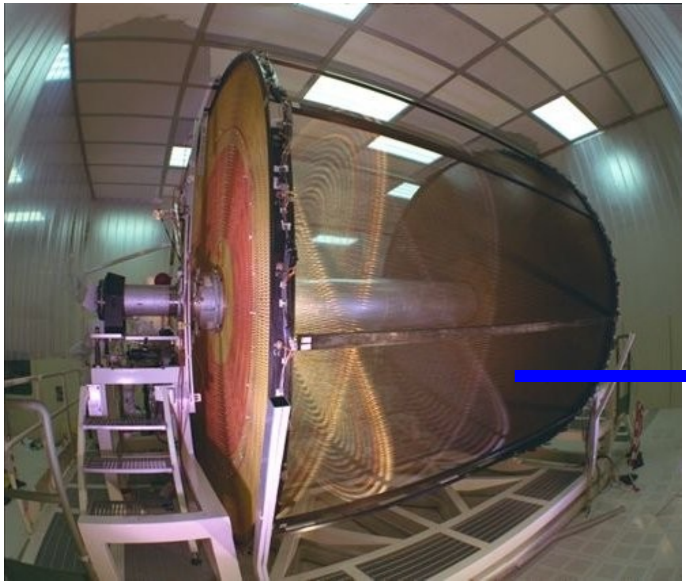
Large volume ***drift chamber***
4 cm Ø, L=3.4 m, carbon-fiber frame,
low density gas (90% He – 10% C_4H_{10}),
12582 all stereo squared cells,
tungsten and aluminium wires (52140)

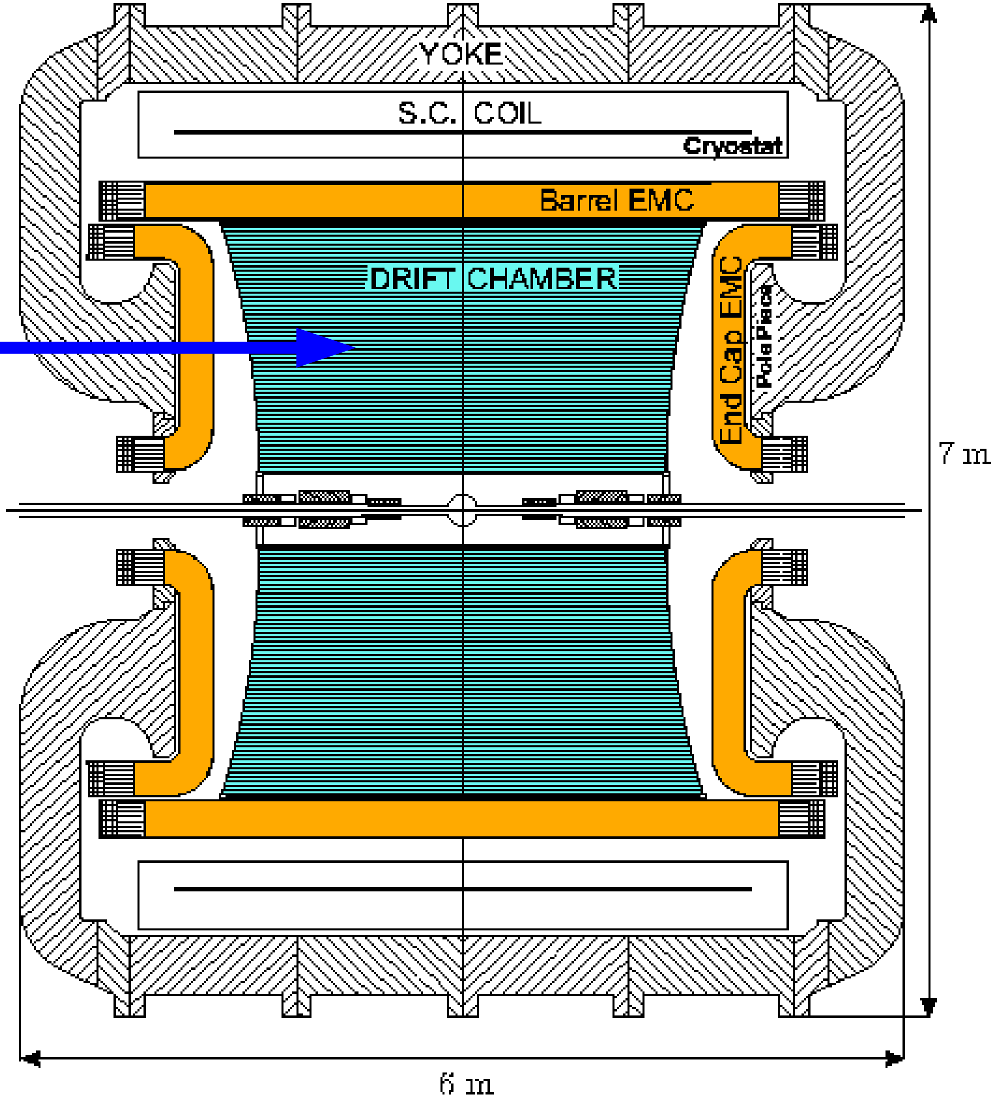
$\sim 4\pi$ ***calorimeter***, 4880 cells
$15X_0$ thick, 0.5 mm lead
1mmØ scintillating fibers

Superconducting coil B = 0.52 T

Remind: $\lambda_L = 3.5$m

KLOE - Drift Chamber





$\sigma_{r\phi}$ = 150 μm

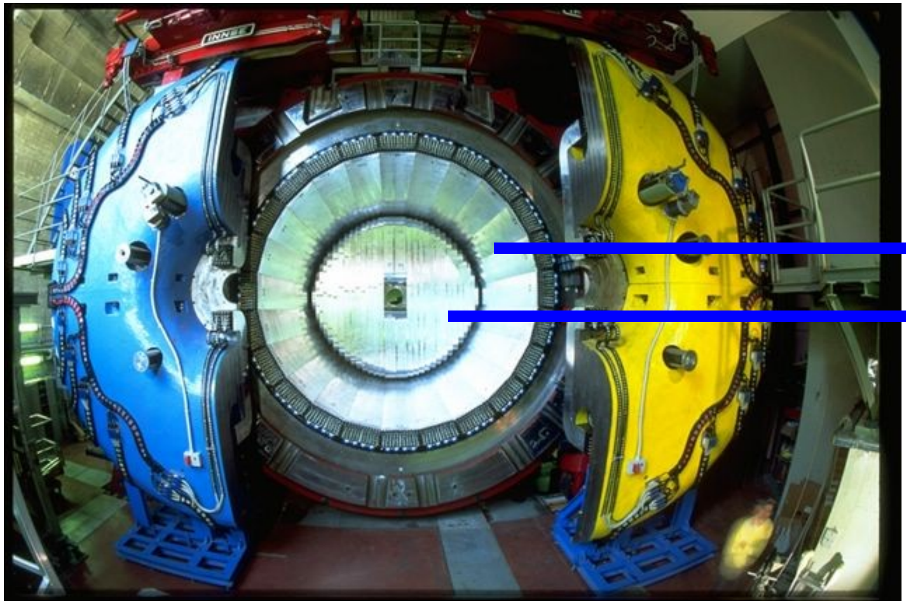
σ_z = 2 mm

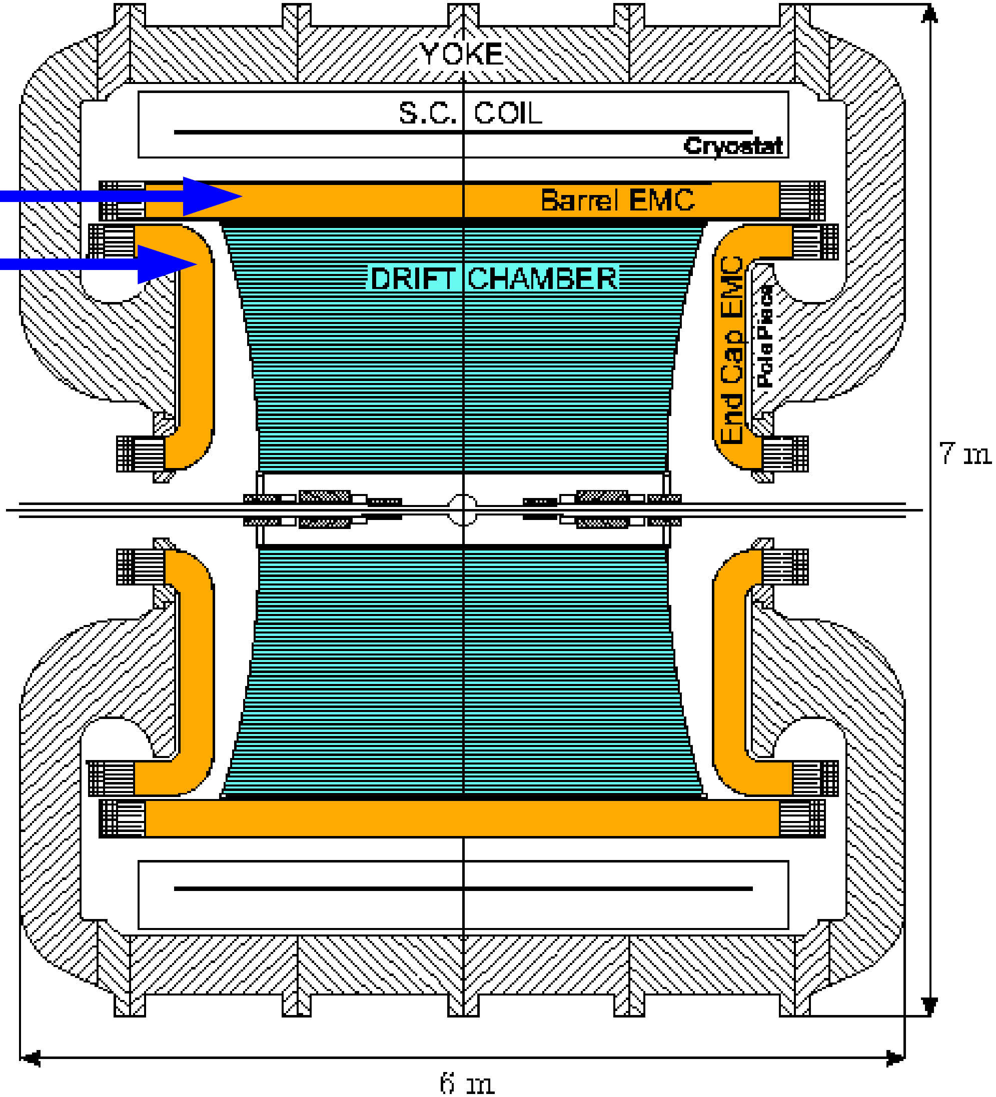
$\sigma_p/p \sim 4 \times 10^{-3}$

$\sigma_{vertex} \sim$ 3 mm

$\sigma(m_{\pi\pi}) \sim$ 1 MeV

KLOE - EM Calorimeter





σ_t = 57 ps / $\sqrt{(E[GeV])} \oplus$ 100 ps

σ_E = 0.057 / $\sqrt{(E[GeV])}$

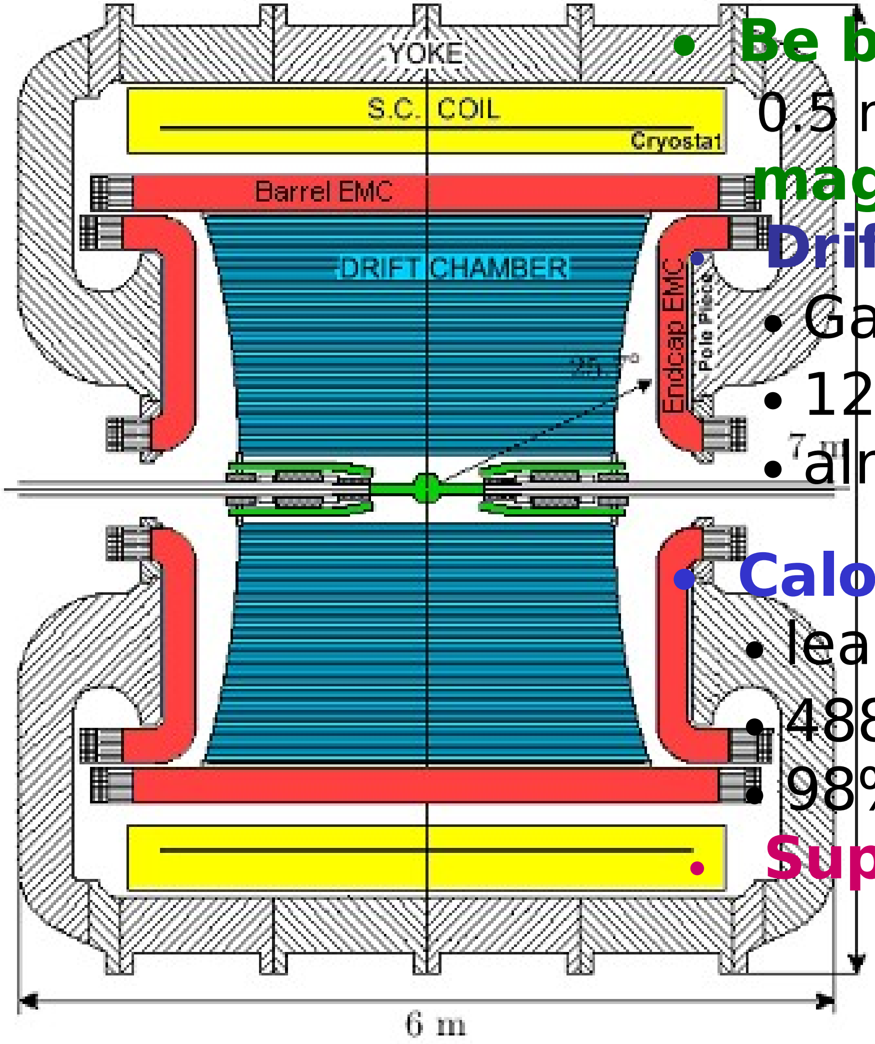
σ_{shower} = 1.3 cm / $\sqrt{(E[GeV])}$

$\sigma_{vertex}(\gamma\gamma)$ = 1.5 cm ($K_L \to \pi^+\pi^-\pi^0$)

ε > 95% for E_γ > 20 MeV

π/e PID based on TOF

The KLOE experiment

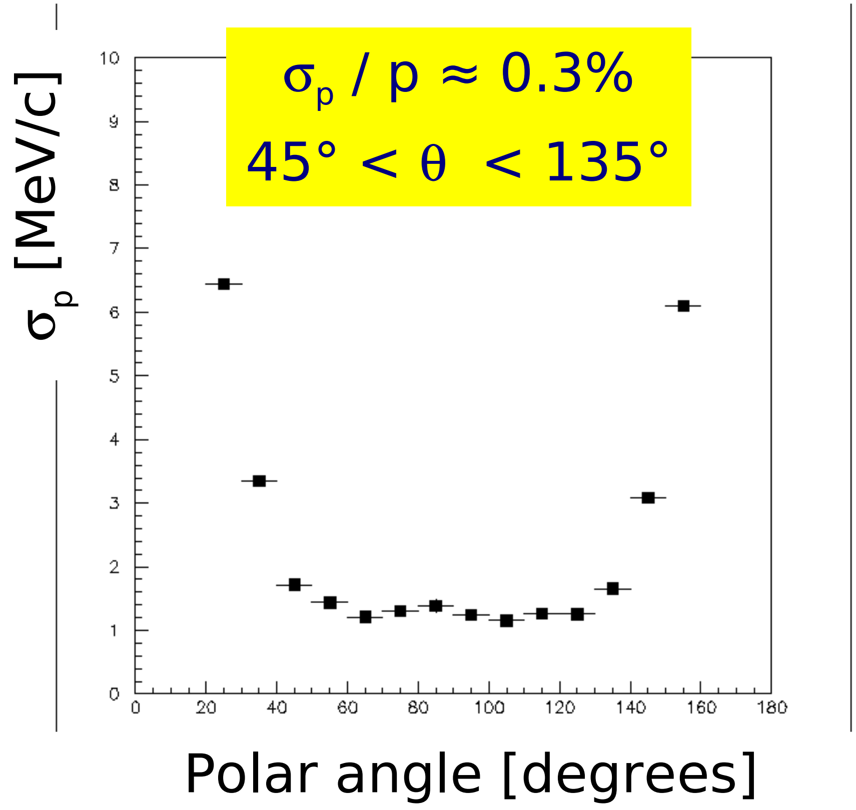


- **Be beam pipe** (spherical, 10 cm ∅, 0.5 mm thick) + **instrumented permanent magnet quadrupoles** (32 PMT’s)
- **Drift chamber** (4 m ∅ × 3.75 m, CF frame)
  - Gas mixture: 90% He + 10% iso-C_4H_{10}
  - 12582 stereo sense wires
  - almost squared cells
- **Calorimeter**
  - lead/scintillating fibers (1 mm ∅), 15 X_0
  - 4880 PMT’s
  - 98% solid angle coverage
- **Superconducting coil** (B = 0.52 T)

Tracking in the DC

drift chamber resolution $\sigma_{r\varphi} \approx 150\ \mu m$

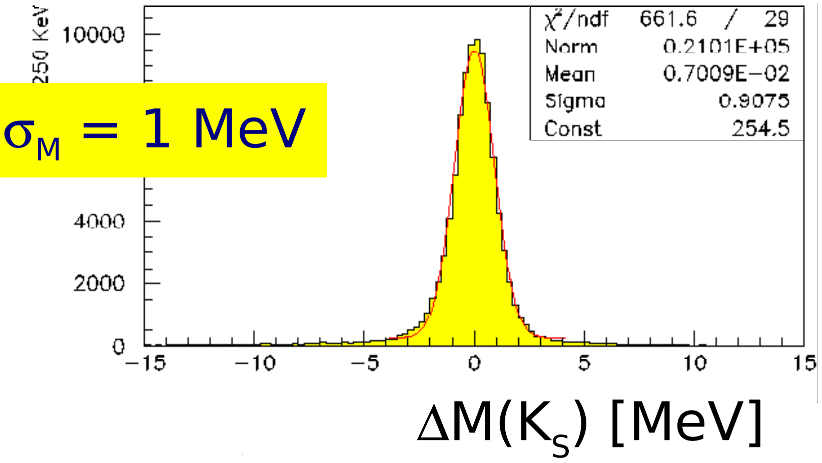
Bhabha scattering events



$\sigma_p / p \approx 0.3\%$

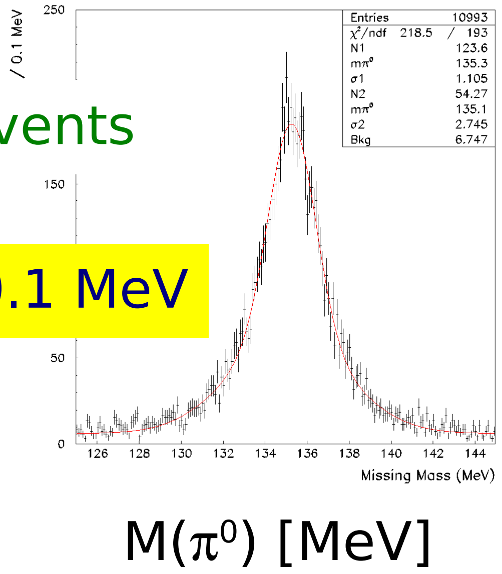
$45° < \theta < 135°$

$K_S \rightarrow \pi^+\pi^-$ events



σ_M = 1 MeV

$K_L \rightarrow \pi^+\pi^-\pi^0$ events

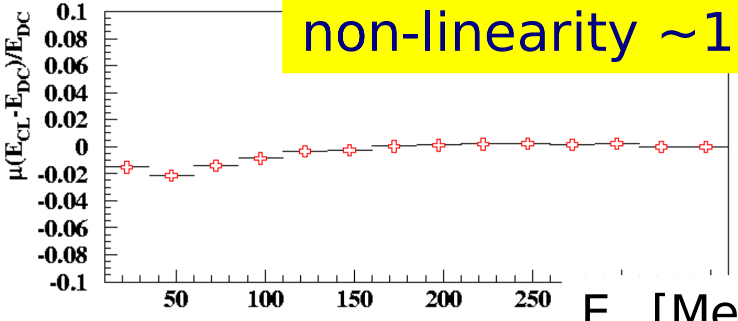


$M(\pi^0) = 135.3 \pm 0.1$ MeV

Measuring photons

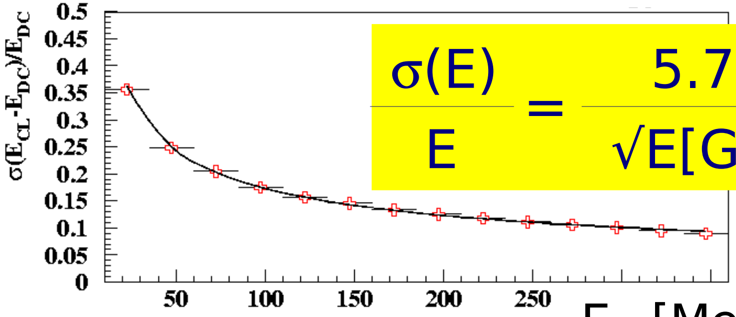
Energy resolution

$\phi \to \pi^+\pi^-\pi^0$ E_γ from tracking



non-linearity ~1%

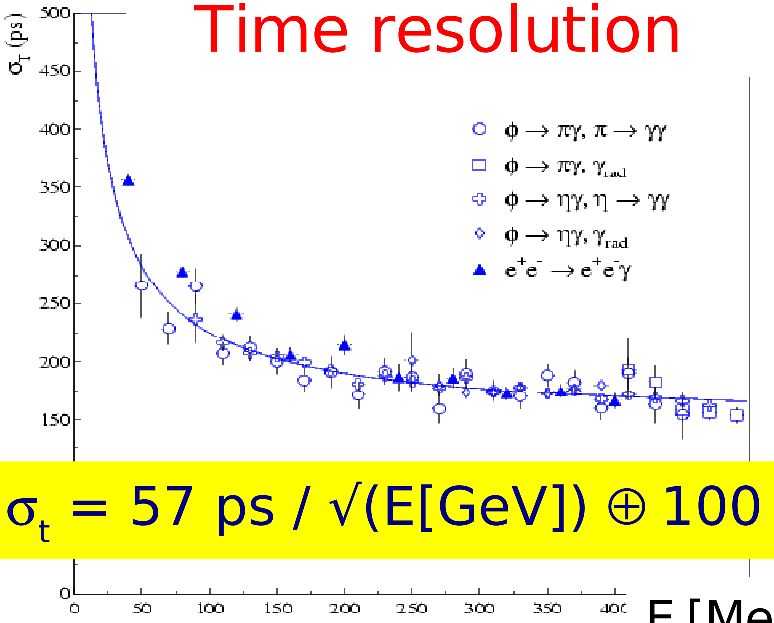
E_{DC}[MeV]



$$\frac{\sigma(E)}{E} = \frac{5.7\%}{\sqrt{E[\mathrm{GeV}]}}$$

E_{DC}[MeV]

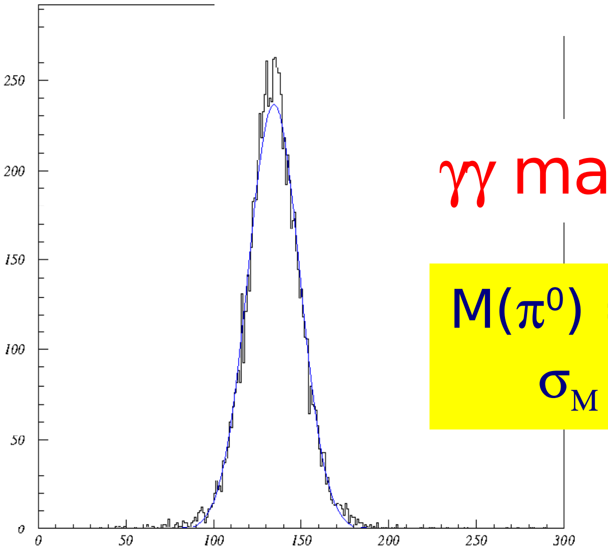
Time resolution



σ_t = 57 ps / $\sqrt{(E[\mathrm{GeV}])}$ ⊕ 100 ps

E_γ[MeV]

γγ mass resolution



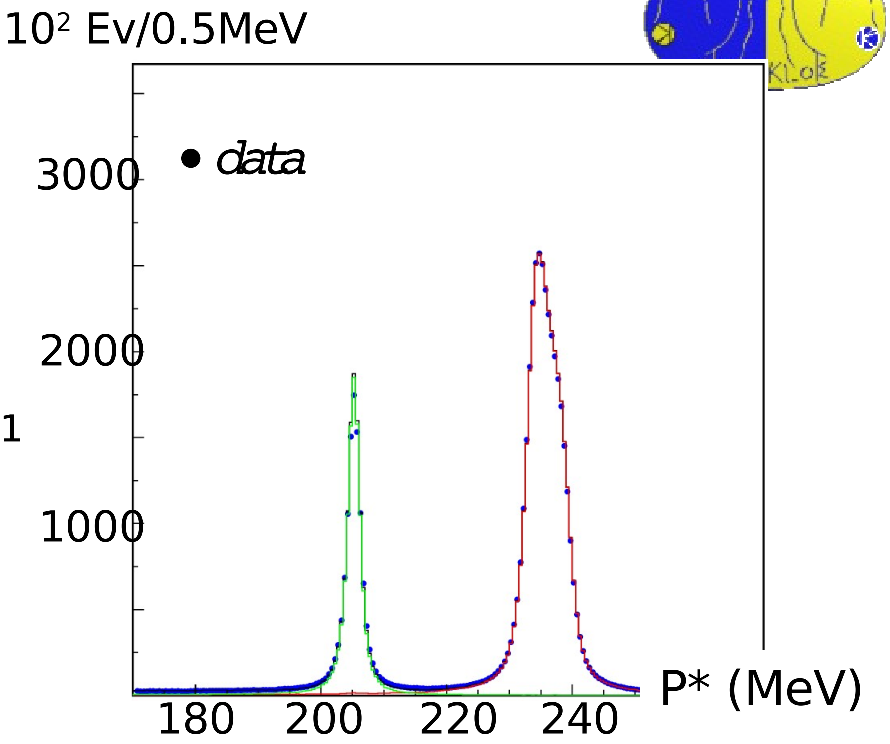
M(π^0) = 134.5 MeV

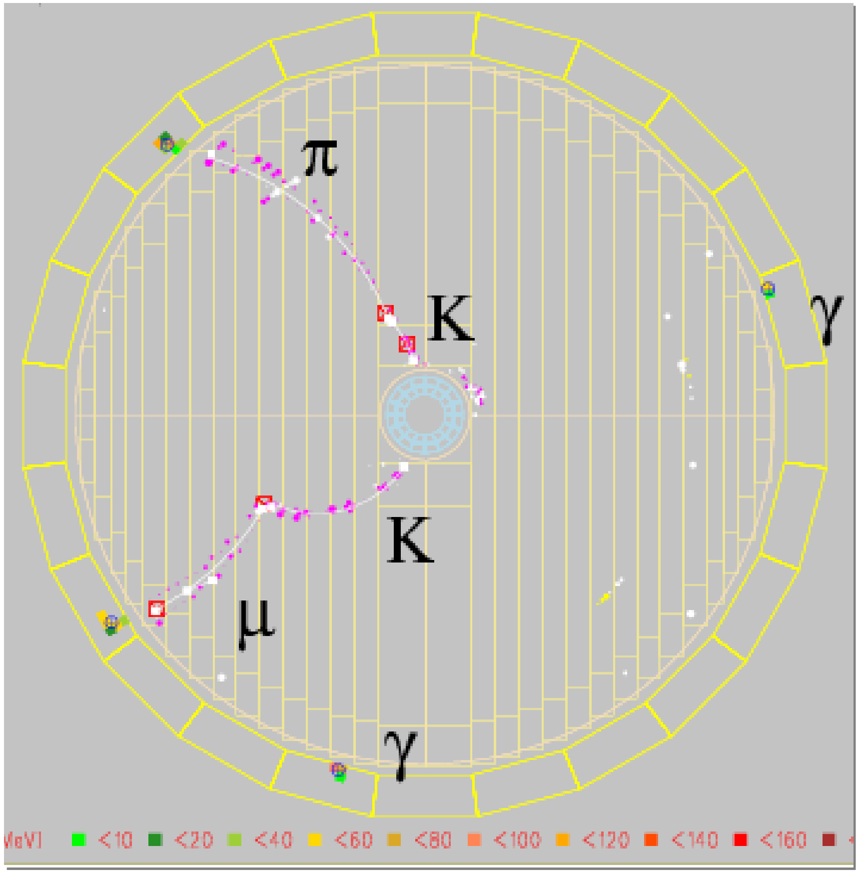
$\sigma_M \approx$ 14 MeV

Tag mechanism (I)

$K^{\pm}$ events tagged using two body decays (about 85%):

$K^{\pm} \to \mu^{\pm}\nu\,,\ \pi^{\pm}\pi^{0} \approx 1.5 \times 10^{6}\ K^{+}K^{-}$ ev/pb^{-1}





Two-body decays identified as peaks in the momentum spectrum of secondary tracks in the kaon rest frame $P^{*}(m_{\pi})$

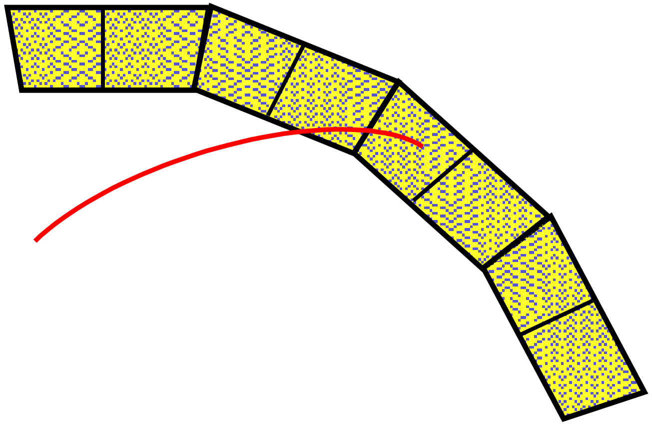
$$\epsilon_{TAG} \simeq 36\% \Rightarrow \begin{array}{l} \simeq 3.4 \times 10^{5}\ \mu\nu\ tags/pb^{-1} \\ \simeq 1.1 \times 10^{5}\ \pi\pi^{0}\ tags/pb^{-1} \end{array}$$

Tag mechanism (II)

To minimize the impact of the trigger efficiency on the signal side we restrict our normalization sample N_{TAG} to 2-body decays which provide themselves the Emc trigger of the event:

self-triggering tags

Emc trigger: 2 trigger sectors over threshold ~50 MeV



The μ fires two sectors:

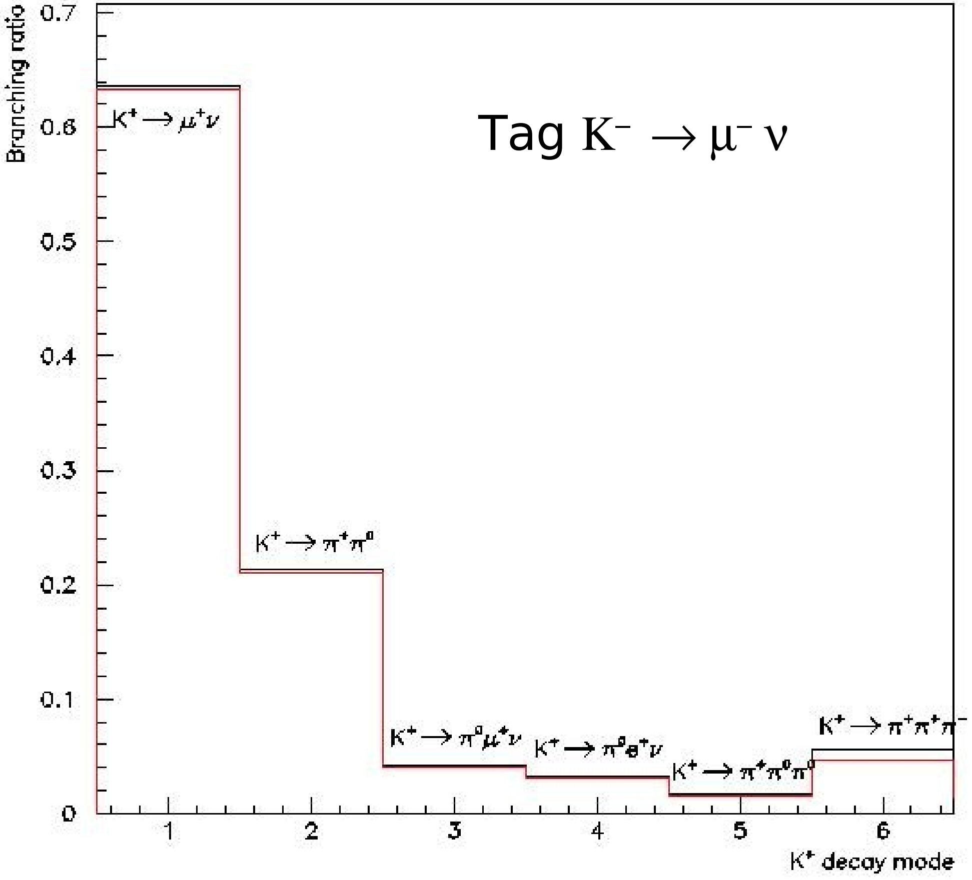
$\varepsilon_{\text{Trigger}} \sim 35\%$

The photons from the π^0 fire two sectors

$\varepsilon_{\text{Trigger}} \sim 75\%$

Tag bias

Measuring the BRs we must take into account a correction due to the bias on the signal sample induced by the tag selection **Tag bias**



The correction C_{TB} is evaluated from MC and is given by:

$$C_{TB} = BR_{MC}(\text{with tag}) \,/\, BR_{MC}(\text{without tag})$$

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

- Signal given by K$^+$ decay in the DC FV (40 cm < ρ < 150 cm)
  Using ~60 pb^{-1}
- Background given by events with π^0 in the final state:

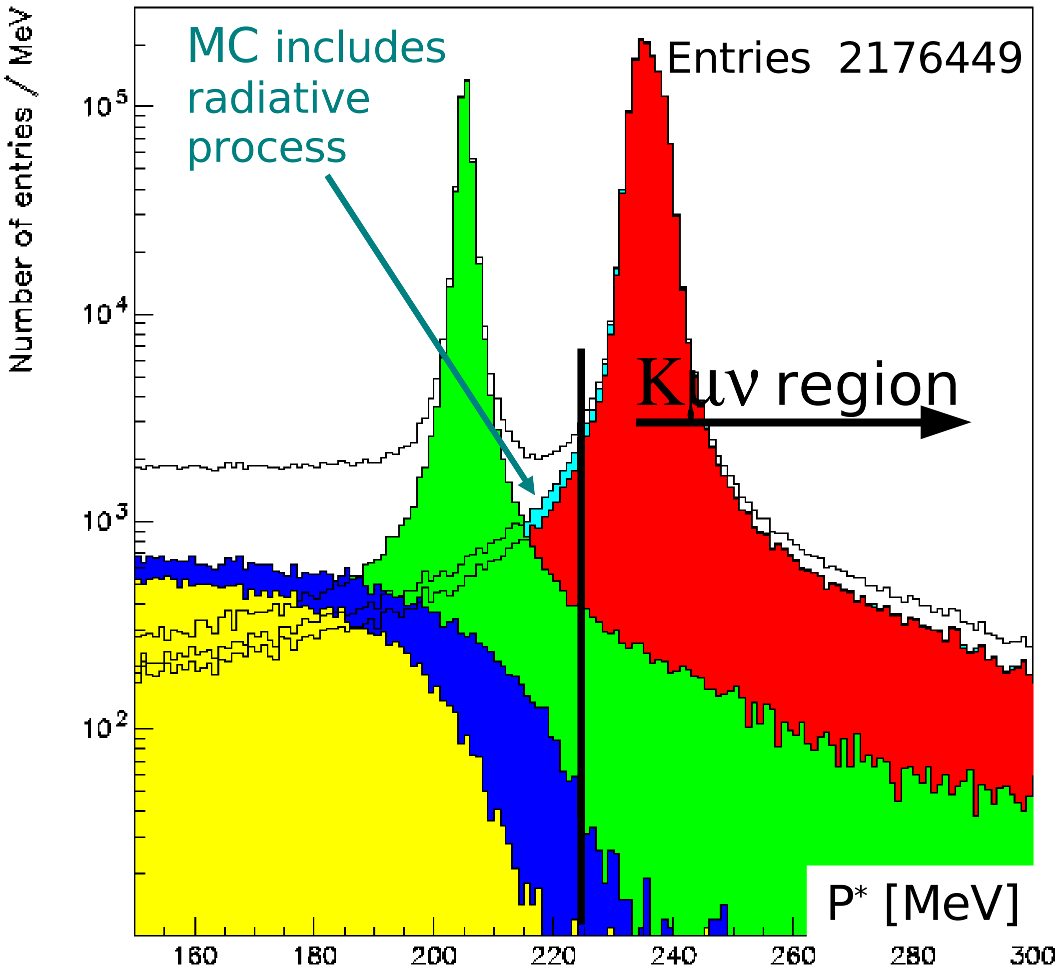
$K^+ \to \pi^+ \pi^0$ $\quad$ $K^+ \to \pi^0 e^+ \nu_e$

$\boxed{K^+ \to \pi^0 \mu^+ \nu_\mu}$

$$BR = \frac{N_{K\mu\nu(\gamma)}}{N_{TAG}} \cdot \frac{1}{\epsilon_{DC}} \cdot \frac{1}{C_{TB}}$$

Tag bias estimated from MC:

C_{TB} = 1.0164 +/- 0.0002



ε_{DC} evaluation

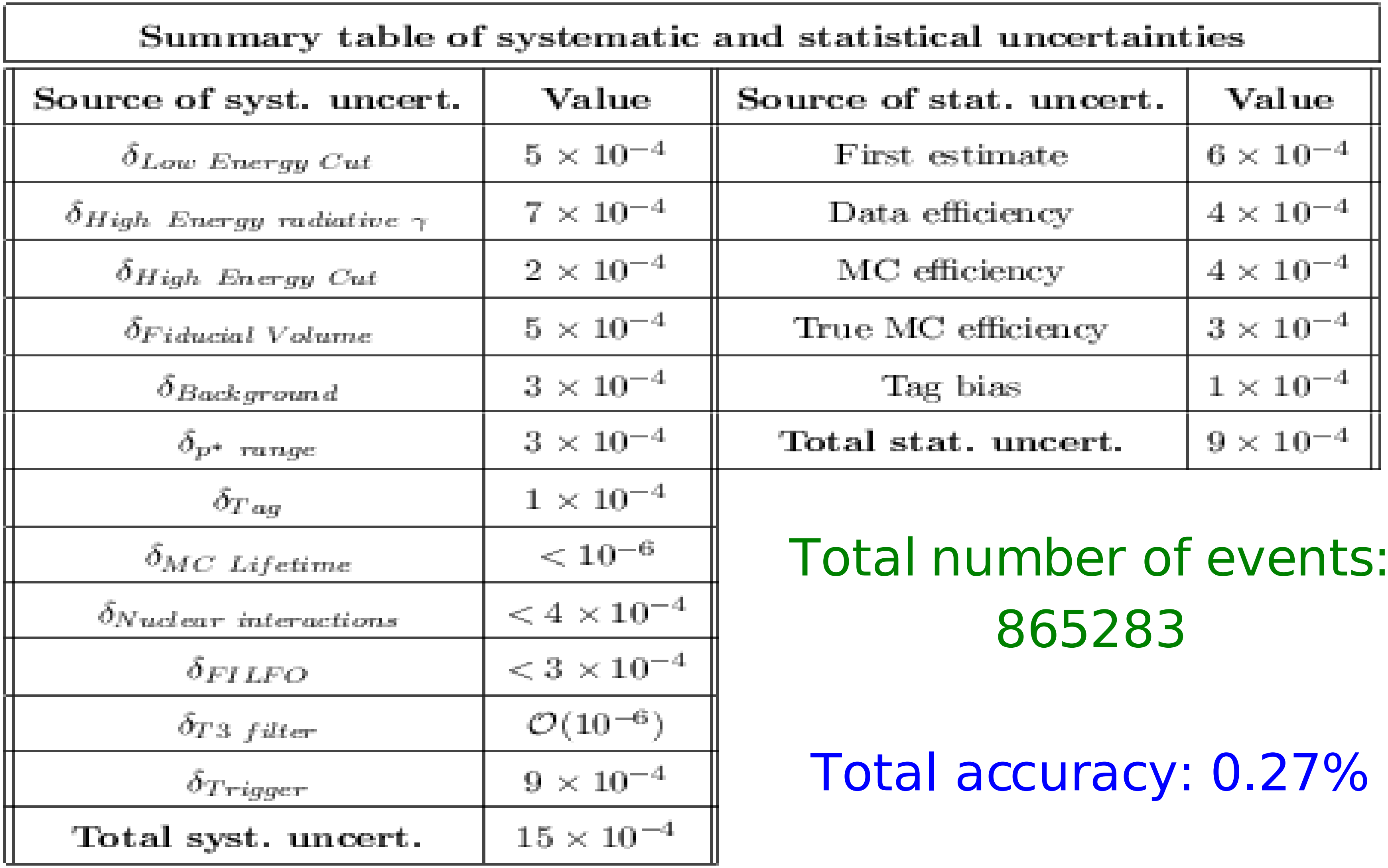
- Efficiency has been evaluated with an uncorrelated sample selected using only calorimeter information (Data sample of *~115 pb*$^{-1}$)

- Double K$\mu\nu$ events have a typical signature in the EMC i.e. 2 isolated clusters with energy in the range $80 < E_{CLU} < 320$ MeV

- Acceptance for radiative photons

Result

$$BR = 0.6366 \pm 0.0009_{stat.} \pm 0.0015_{syst.}$$



Summary table of systematic and statistical uncertainties

Source of syst. uncert.	Value
$\delta_{Low\ Energy\ Cut}$	5×10^{-4}
$\delta_{High\ Energy\ radiative\ \gamma}$	7×10^{-4}
$\delta_{High\ Energy\ Cut}$	2×10^{-4}
$\delta_{Fiducial\ Volume}$	5×10^{-4}
$\delta_{Background}$	3×10^{-4}
$\delta_{p^*\ range}$	3×10^{-4}
δ_{Tag}	1×10^{-4}
$\delta_{MC\ Lifetime}$	$< 10^{-6}$
$\delta_{Nuclear\ interactions}$	$< 4 \times 10^{-4}$
δ_{FILFO}	$< 3 \times 10^{-4}$
$\delta_{T3\ filter}$	$\mathcal{O}(10^{-6})$
$\delta_{Trigger}$	9×10^{-4}
Total syst. uncert.	15×10^{-4}

Source of stat. uncert.	Value
First estimate	6×10^{-4}
Data efficiency	4×10^{-4}
MC efficiency	4×10^{-4}
True MC efficiency	3×10^{-4}
Tag bias	1×10^{-4}
Total stat. uncert.	9×10^{-4}

Total number of events: 865283

Total accuracy: 0.27%

$K^{\pm} \to \pi^{\pm} \pi^{0}$

- Normalization N_{TAG} given by 175 pb^{-1} from 2002's data selftriggering $K^{-} \to \mu^{-} \bar{\nu}$
- Counting events in the distribution of secondary track momentum in the kaon rest frame p*
- Fit together signal and backgrounds Km2 and 3-bodies

- Efficiency related to DC reconstruction only (tracking plus vertexing), evaluated on data

$K^{\pm}_{l3}$ background (I)

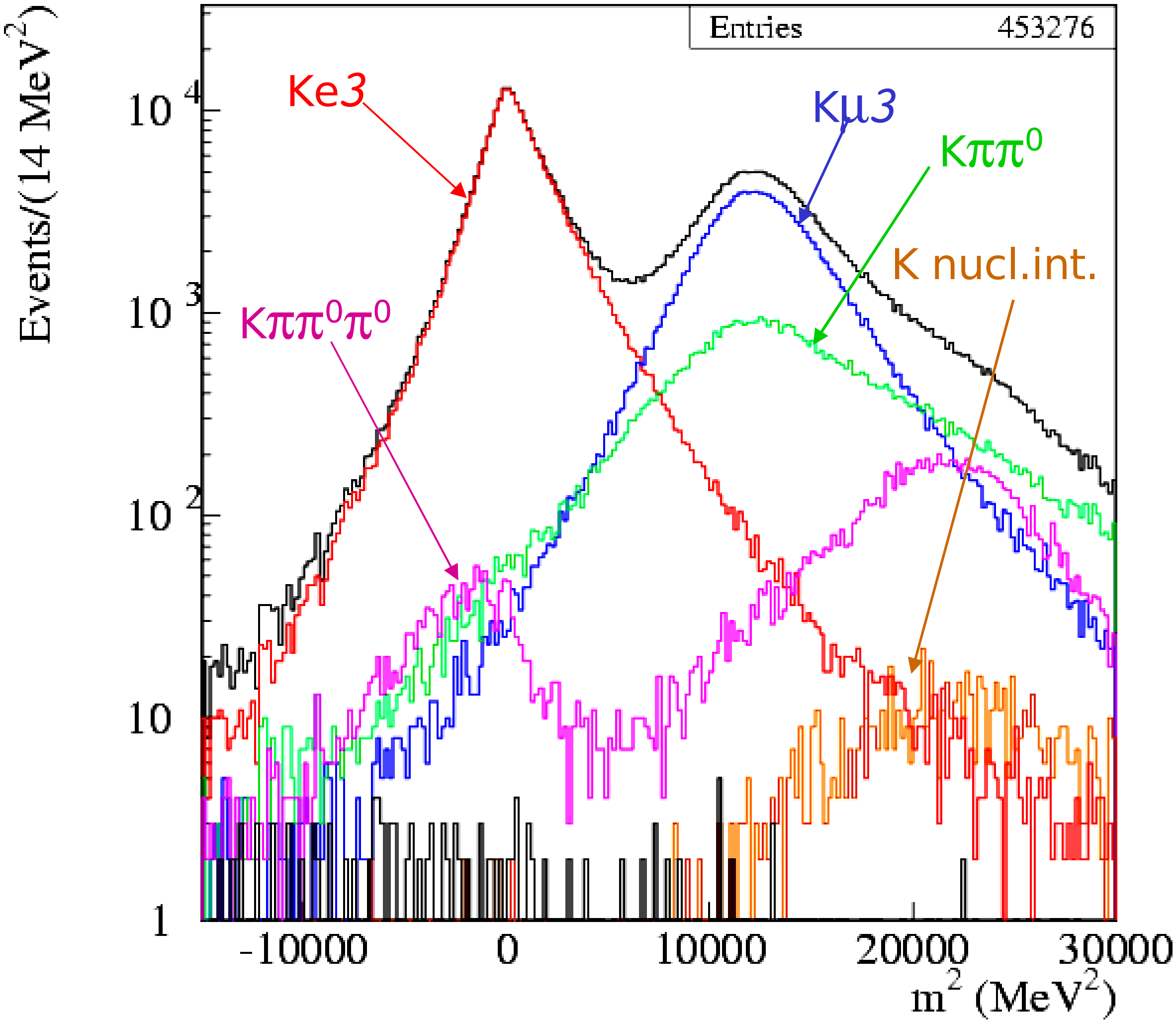
$K^{\pm} \to \pi^{\pm}\pi^{0}\pi^{0}$ with a π^{0} undergoing a Dalitz decay, or with a wrong cluster associated to $\pi^{\pm}$, give a m_l^2 under the Ke3 peak

⇒ cut requiring

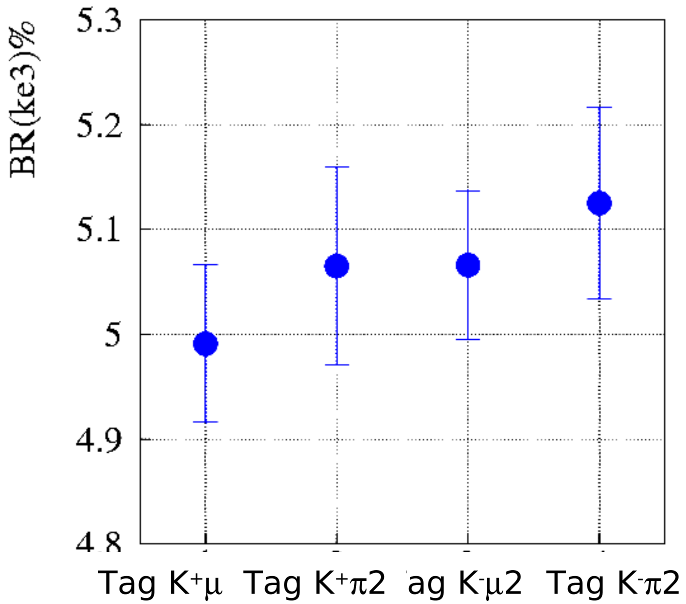
$|E_{miss} - P_{miss}| < 90$ MeV

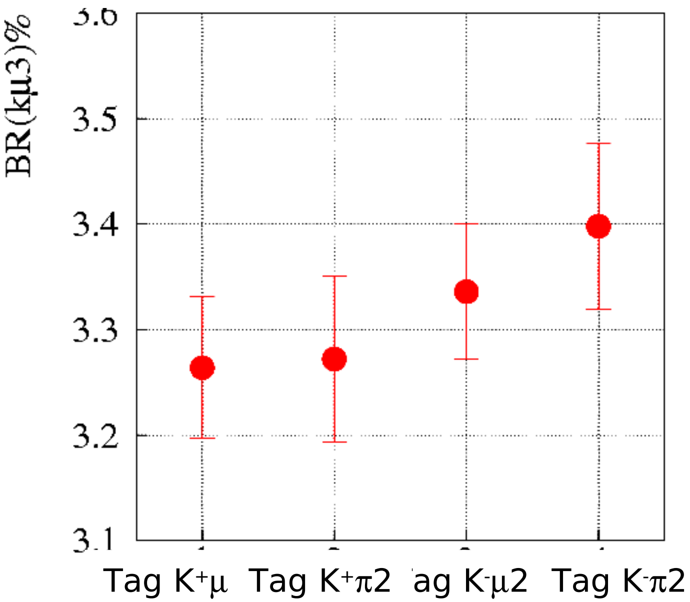
$K^{\pm} \to \pi^{\pm}\pi^{0}$ with early $\pi^{\pm} \to \mu^{\pm}\nu$, give m_l^2 under the Kμ3 peak

⇒ rejected using the missing momentum of the secondary track in the pion rest frame ($P^*_{sec} < 90$ MeV)



Kl3 preliminary results





- Averages accounting for correlations:

BR(Ke3)	**5.047** ± **0.046**
BR(Kμ3)	**3.310** ± **0.040**

- χ^2/dof for the 4 measurements:

$$Ke3: \quad \chi^2/dof = 3.20/3 \rightarrow P(\chi^2) \simeq 36\%$$

$$K\mu3: \quad \chi^2/dof = 5.32/3 \rightarrow P(\chi^2) \simeq 15\%$$

- The **error accounts for** the data and Monte Carlo statistics used in the fit, the MC statistics for the efficiency evaluation, the Data/MC efficiency corrections, and the systematics on the tag selection. It is dominated by the error on Data/MC efficiency correction.

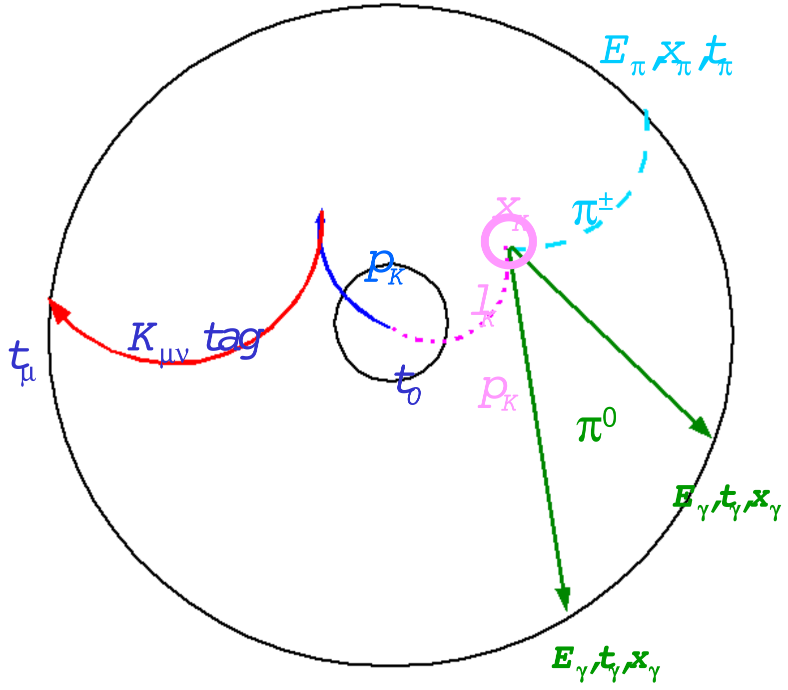
- Still to be evaluated the systematics due to the signal selection efficiency, to the nuclear interaction, and to the momentum dependency of the tracking efficiency

Vertex reconstruction efficiency

The K track on the tagging side is extrapolated backwards to the signal hemisphere

Step along the extrapolated kaon looking for the best neutral vertex

Using the arrival time of the γ's from the π^0 decay



FV $\equiv$ 40 cm $\leq \rho \leq$ 150 cm

$$\epsilon_{trk+vtx} = \frac{DC\ vtx\,(K \to X) \wedge \pi^0\ vtx\,(K \to X\pi^0) \in FV}{\pi^0\ vtx\,(K \to X\pi^0) \in FV}$$

Systematics estimate

Source of systematic uncertainties	Systematic uncertainties (ps)
Fit range	± 60
Time binning	± 20
Efficiency correction	± 10
Beam Pipe thickness	± 10
DC wall thickness	± 15

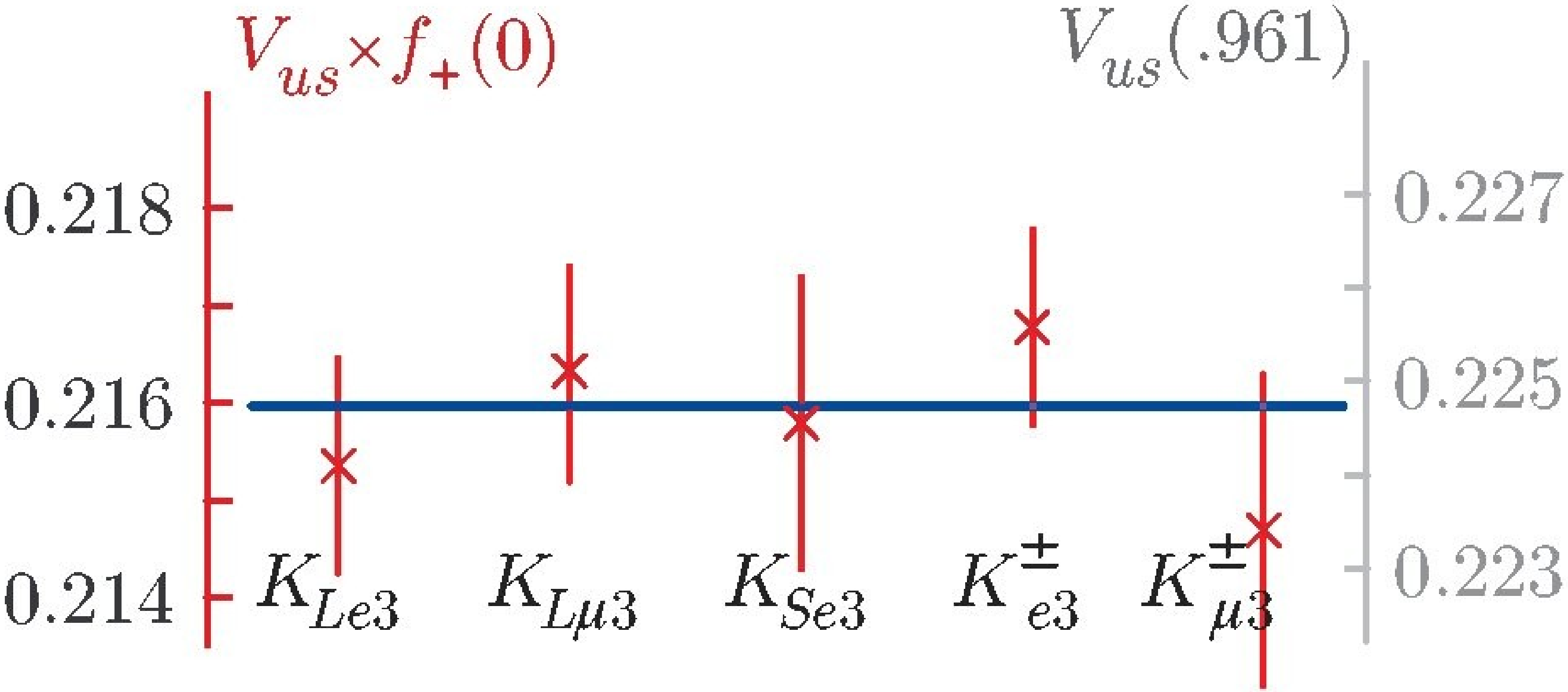
Systematic uncertainties of the order of 65 ps

V_{us} from semileptonic decays

$\tau(K_L)=50.84\pm0.23$ ns

$\langle V_{us}\times f_+(0)\rangle_{\mathrm{KLOE}}=0.2160\pm0.0005$

$\chi^2/\mathrm{dof}=1.9/4$



from V_{ud} and unitarity: $V_{us}\times f_+(0)=0.2187\pm0.0022$

V_{us} and semileptonic decays

$$\Gamma(K \to \pi\ell\nu(\gamma)) = \frac{G^2 m_K^5}{768\pi^3} C_K^2 \boxed{|V_{us}|}^2 \, |f_+^{K\pi}(0)|^2 \, I_K^\ell \, S_{ew} \, \left[1 + \delta_{SU(2)} + \delta_{em}\right]$$

$BR(K\to\pi l\nu) / \tau_K$

Clebsh-Gordan isospin factor
$C_K = 1$ ($1/\sqrt{2}$) for K^0 ($K^\pm$)

Phase-space integral

isospin-breaking + long-distance e.m. corrections (≈ %)

Short-distance ew correction
$\approx 1 + (2\alpha/\pi)\, ln\, (M_Z / M_K)$

$f^{K\pi}(t)$: $K \to \pi$ form factor
$t = (p_K - p_\pi)^2$

<u>*Experimental inputs*</u>:

- branching ratios
- K lifetime
- K mass
- form factor (t dependence)

<u>*Theoretical inputs*</u>:

- form factors at t=0
- phase-space integral
- SU(2), em, ew corrections