Testing the μ-e universality with $K^{\pm} \to l^{\pm}\nu$ decays

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on behalf of the NA48/2 collaboration

Cambridge, CERN, Chicago, Dubna, Edinburgh, Ferrara, Firenze, Mainz, Northwestern, Perugia, Pisa, Saclay, Siegen, Torino, Vienna

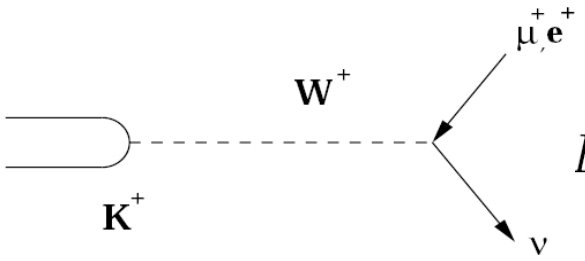
Overview

- Physics motivation
- Experimental setup
- Data analysis
- Preliminary result for 2003 data
- Conclusions

Motivation

Within the Standard Model:

M. Finkemeier: Phys.Lett.B387:391-394,1996



$$R_M := \frac{\Gamma(M \to e\nu_e(\gamma))}{\Gamma(M \to \mu\nu_\mu(\gamma))} = \frac{m_e^2}{m_\mu^2}\left(\frac{m_M^2 - m_e^2}{m_M^2 - m_\mu^2}\right)^2 \left(1 + \delta R_M\right)$$

where δR_M arises from the radiative corrections, $M=\pi^{\pm},K^{\pm}$

For $K^{\pm}$: $\delta R_K = -(3.78 \pm 0.04)\%$, leading to

$R_K = (2.472 \pm 0.001) * 10^{-5}$

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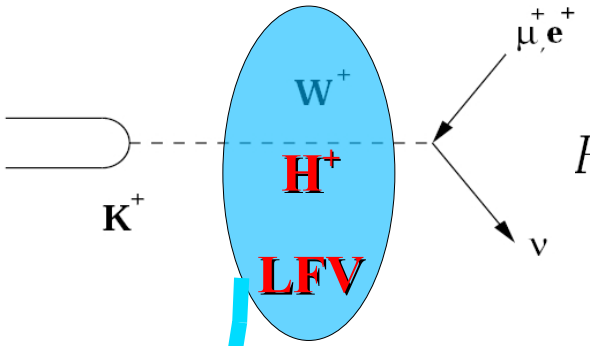

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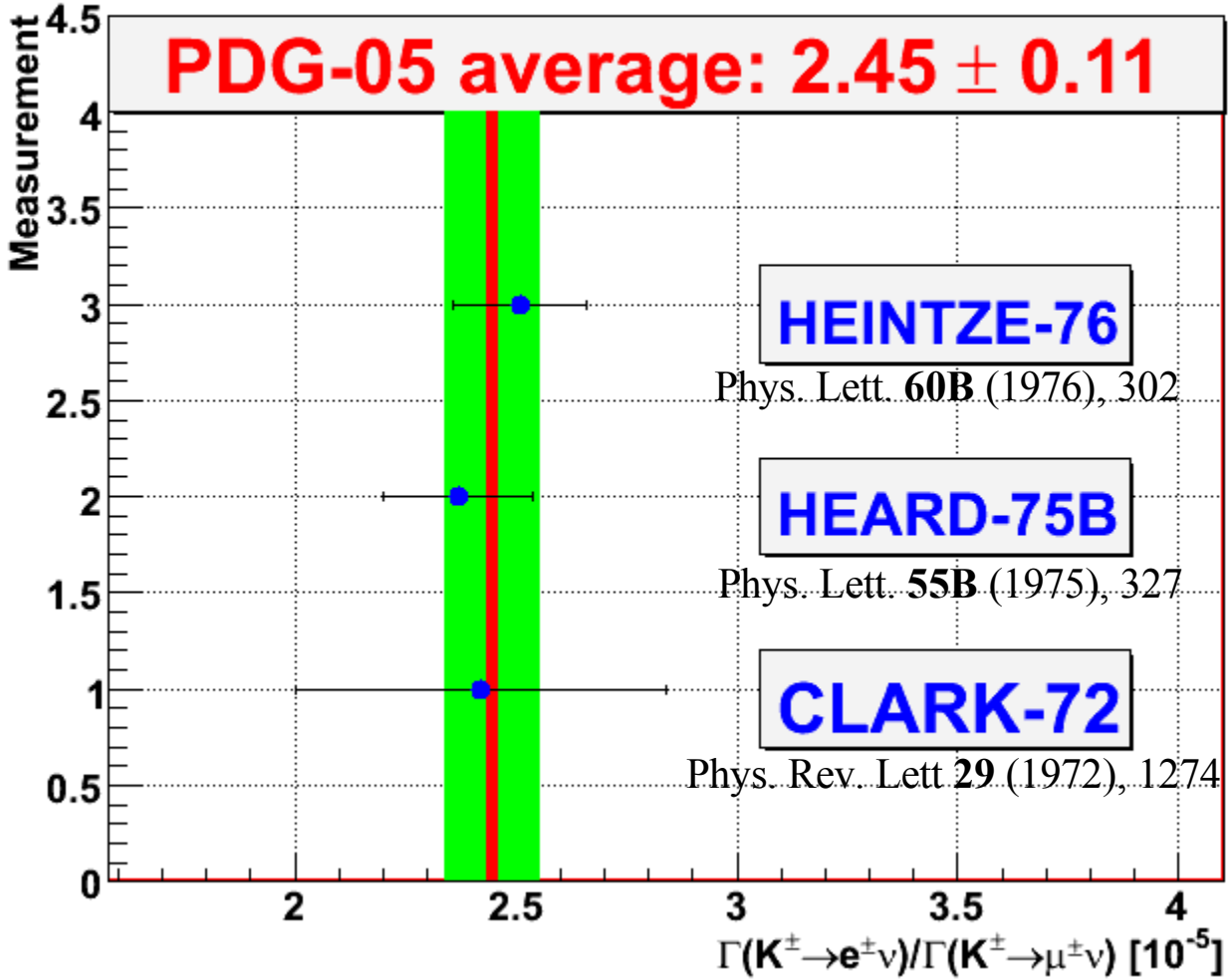
A. Masiero et al. Phys.Rev. D74 (2006) 011701

- **The value of R_K could be different in case of SUSY and LFV models – the correction could be as high as 3% in both directions**
- **Measurement of R_K tests the μ-e universality and provides a sensible test of the SM**

Measurements



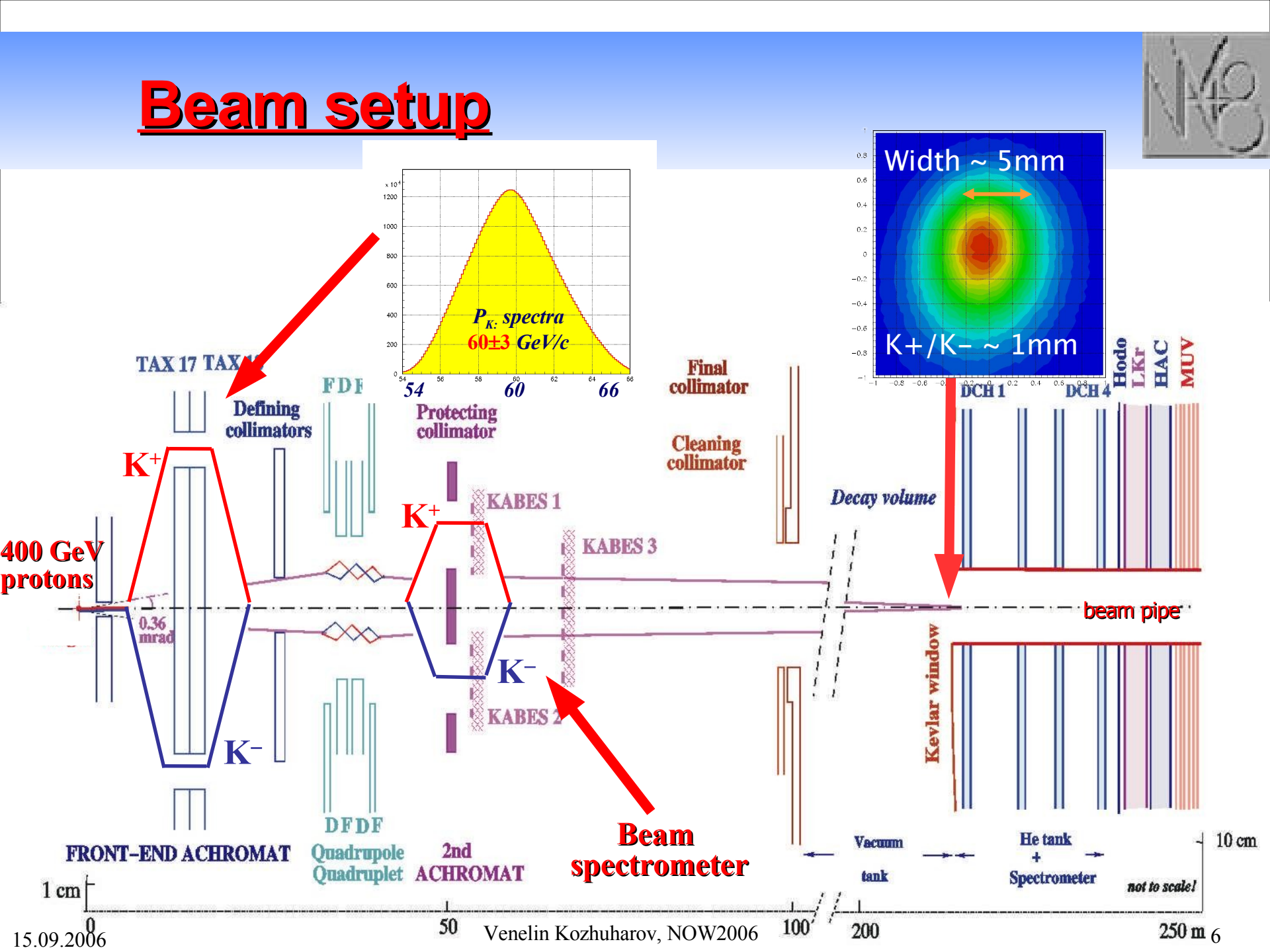
Standard Model

$R_K = (2.472 \pm 0.001) \times 10^{-5}$

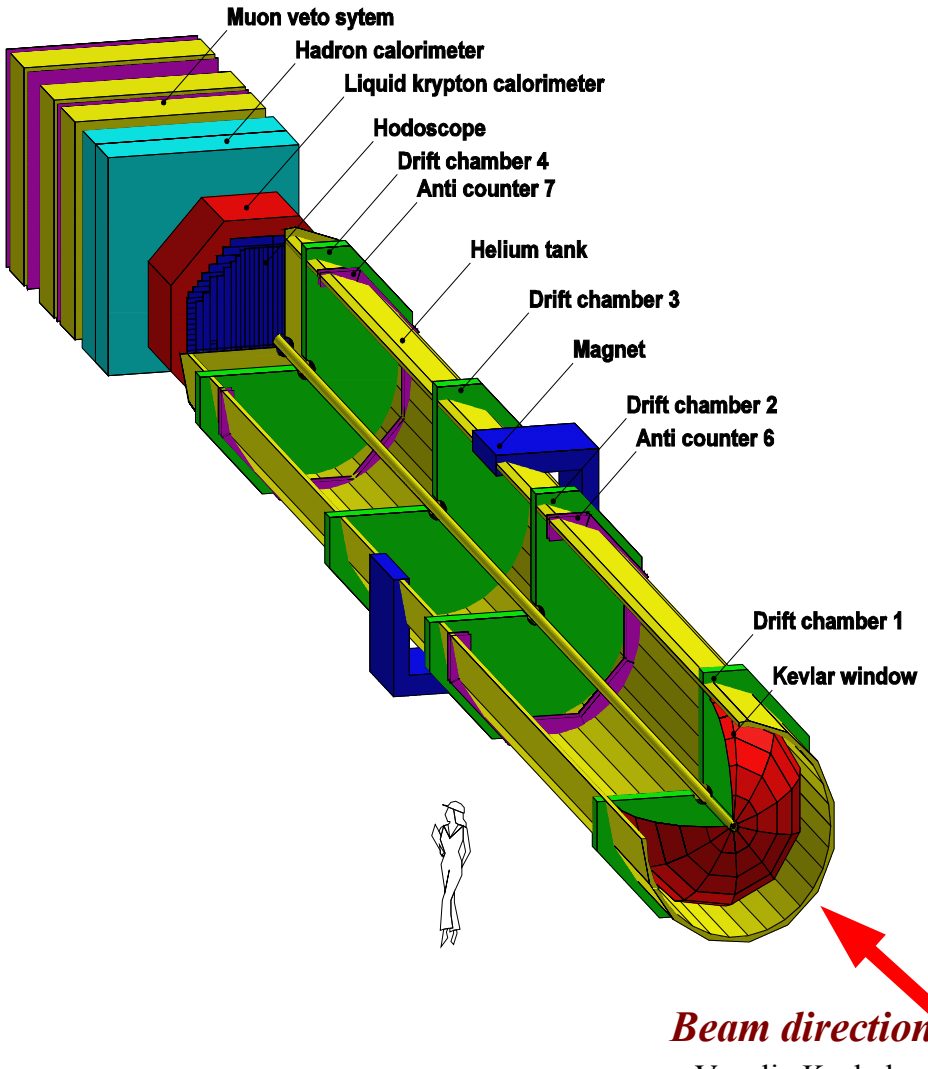
Experiments with stopped kaons

- Experimental error on R_K: ***two orders of magnitude larger than the theoretical***

Beam setup


$P_{K^\pm}$ spectra
60±3 GeV/c
54
60
66
Width ~ 5mm
K+/K− ~ 1mm
TAX 17
FDF
Defining collimators
Protecting collimator
Final collimator
Cleaning collimator
Hodo
LKr
HAC
MUV
DCH 1
DCH 4
K+
K+
KABES 1
KABES 3
Decay volume
400 GeV protons
0.36 mrad
beam pipe
K−
K−
KABES 2
Kevlar window
DFDF
FRONT-END ACHROMAT
Quadrupole Quadruplet
2nd ACHROMAT
Beam spectrometer
Vacuum tank
He tank + Spectrometer
not to scale!
10 cm
1 cm
0
50
100
200
250 m

Detector setup



- Magnetic spectrometer
  4 drift chambers
  $p_{\perp}^{kick}$ = 121 MeV/c
  $\Delta p/p = 1\% \oplus 0.044 * p$ [GeV/c]
- Hodoscope
  $\sigma(t)$ = 150 ps
- Liquid Krypton Calorimeter
  $\Delta E/E \cong 3.2\%/\sqrt{E} \oplus 9\%/E \oplus 0.42\%$
- Hadron Calorimeter, Muon counters, Anticounters, Kaon Beam Spectrometer

Experiment primarily designed for the measurement of the charge asymmetry in $K^{\pm} \to \pi^- \pi^+ \pi^{\pm}$ and $K^{\pm} \to \pi^0 \pi^0 \pi^{\pm}$ decays

2003 run: **~ 50 days nominal conditions**

~ 12 hour special run

2004 run: **~ 60 days nominal conditions**

~ 56 hour special run

~ 200 TB of data recorded

The huge statistics (~$4 \cdot 10^9$ $K^{\pm} \to \pi^+\pi^-\pi^{\pm}$) allows to study rare kaon decays with high precision

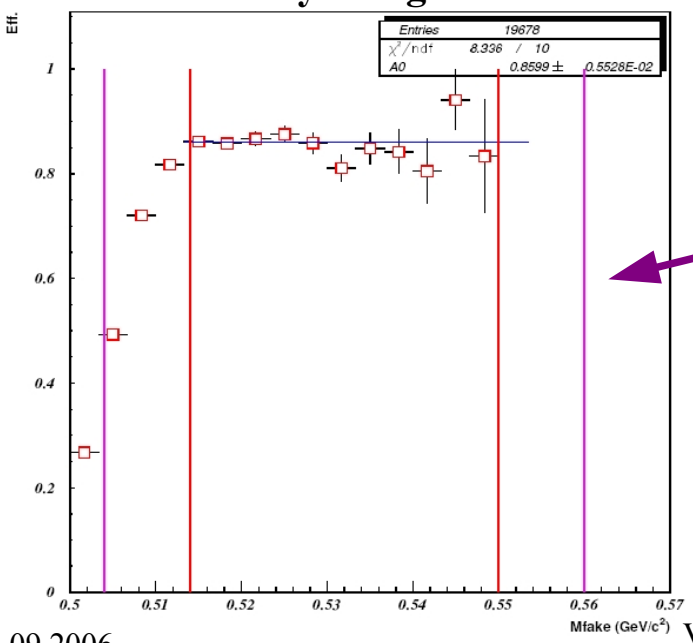
2003 data: Trigger

- Kμ2 events: **signal from the charged hodosope**
- Ke2 events
  - **L1 trigger:** – hodoscope signal + Energy deposition in the EM calorimeter > 10GeV
  - **L2 trigger:** – online kinematics reconstruction

$$M_{Fake}^2 = M_K^2 + M_\pi^2 - S$$

$S=(p_K-p_\pi)^2$, $p_K=(0,0,60)$ GeV/c

L2 efficiency using Ke3 events



$K^\pm \to \pi^\pm \pi^0$ events: M_{Fake} peaks at 495 MeV

online cut

L2 trigger efficiency

(85.6 ± 0.5(stat) ± 0.2(syst))%

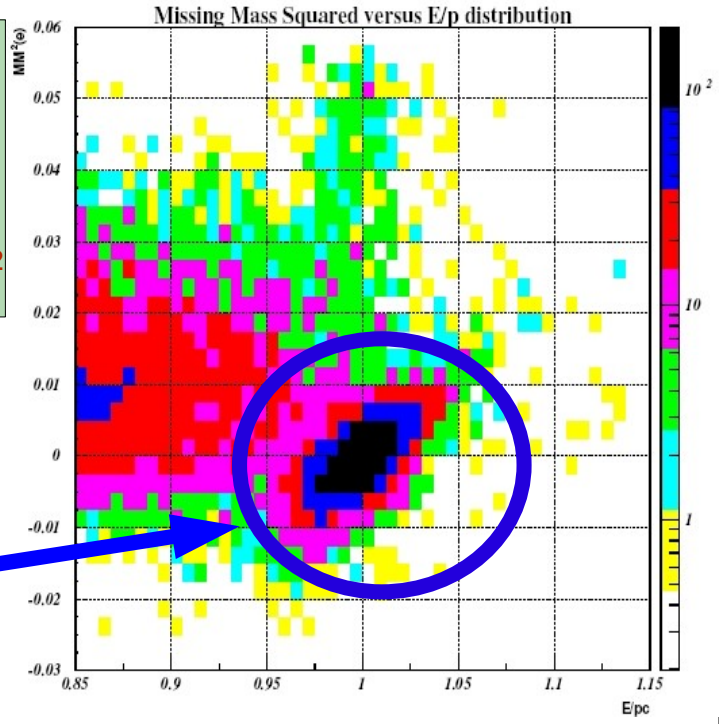
2003 data: Event Selection

- The similarity between the decays allows to exploit systematics cancellation
  - Charged track with momentum 15 GeV<P<55 GeV
  - No extra clusters with E_{cl} > 1.5 GeV, no hits in the anticounters, no in time tracks.
  - Vertex reconstructed within 2000 cm < Zvtx < 8500cm

- **Kμ2 selection:**
  - Muon hypothesis
  - $|M_{miss}^2| < 0.02$ (GeV/c^2)^2

- **Ke2 selection:**
  - PID: E/Pc>0.95
  - Electron hypothesis
  - $|M_{miss}^2| < 0.02$ (GeV/c^2)^2

E – energy deposition in LKR
P – momentum from the spectrometer

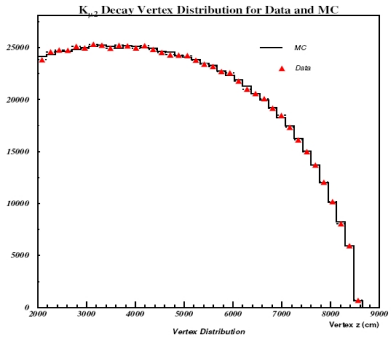


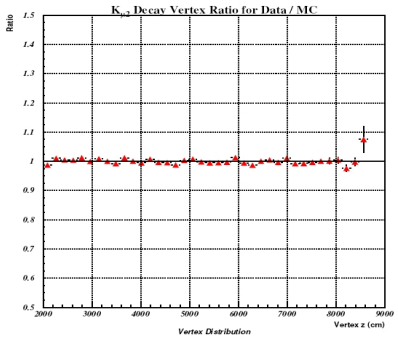
Ke2 events

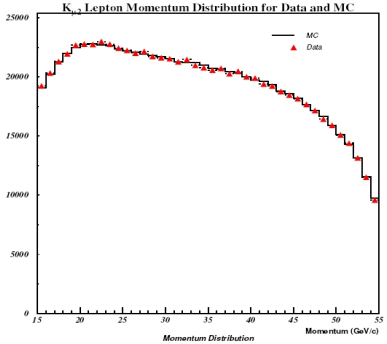
Found 5329 Ke2 candicates

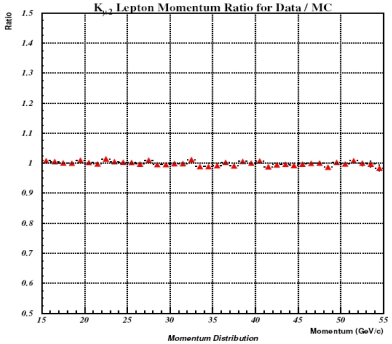
2003 data: MC simulation

- Full Geant3 based simulation of the detector response



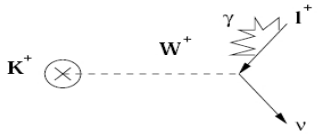


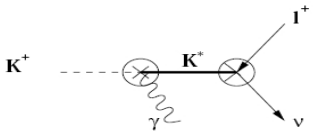


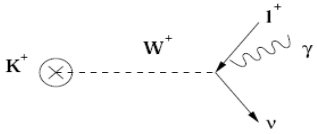


Difference in acceptance: $\Delta(R_K)=1.116 \pm 0.002(stat) \pm 0.006(syst)$

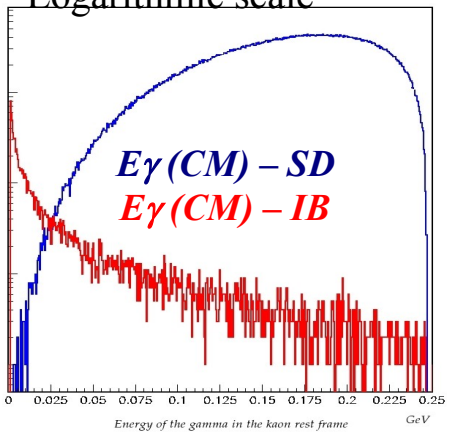
- Radiative corrections







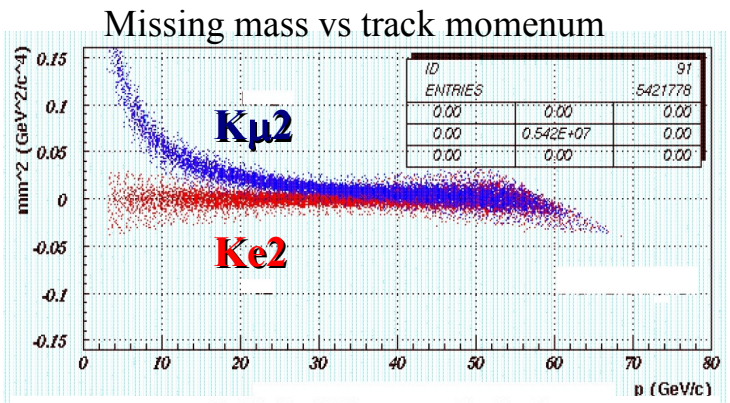
Logarithmic scale

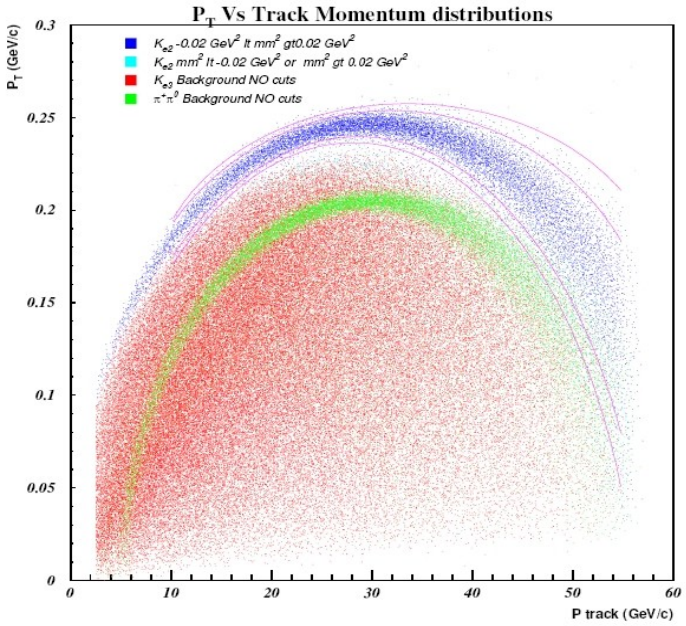


Decay	B.R.	Acceptance	Correction
Ke2g Eg>3MeV (IB)	$1.56 \cdot 10^{-6}$	0.33 · A(Ke2)	+6.5%
Ke2g SD	$1.5 \cdot 10^{-5}$	$2.4 \cdot 10^{-3}$ · A(Ke2)	-0.22%
Kμ2g Eg>3MeV (IB)	$6.5 \cdot 10^{-3}$	0.37 · A(Km2)	-0.64%

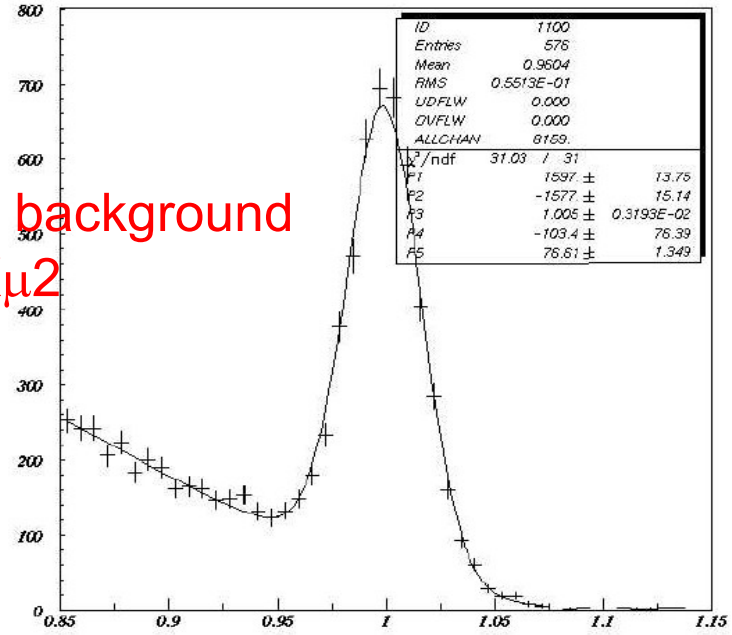
$\Delta(R_K)=1.063 \pm 0.005$

2003 data: Background in Ke2





Dominant background is Kμ2

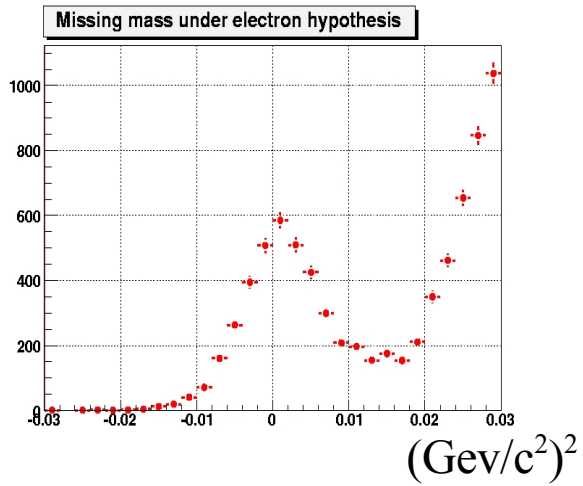


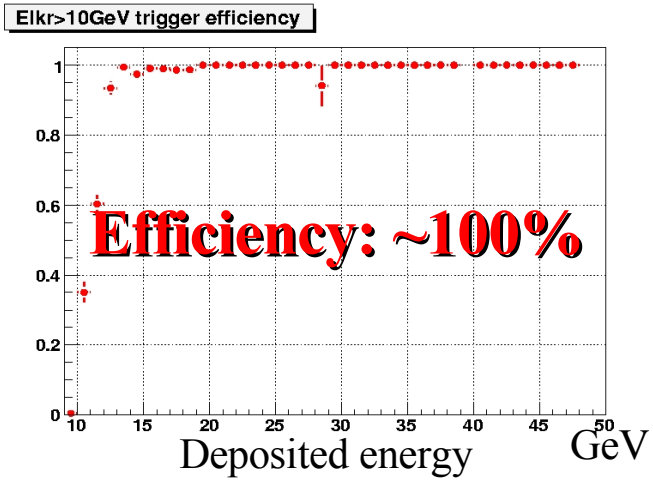
Background events: 659 ± 26

Signal events: $4670 \pm 77(\text{stat})^{+29}_{-8}(\text{syst})$

2004 data

- Dedicated data taking period:
  - 60 GeV kaon beam with diminished intensity
  - No Level-2 trigger – using only minimum bias triggers
- Simpler selection – better control of the systematics
- Analysis performed in momentum bins
  - Better background subtraction



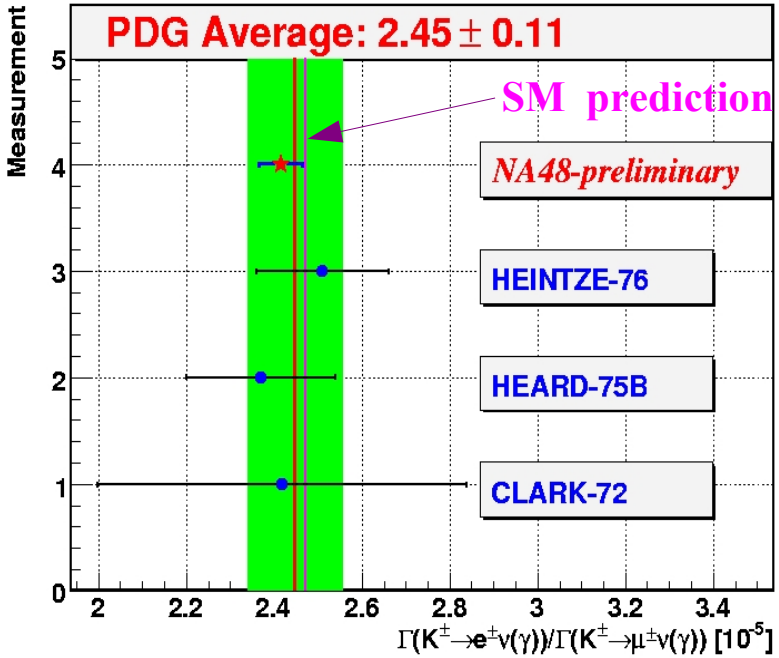


- Sample with similar statistics as in 2003

Results

$$\frac{\Gamma(K^{\pm} \to e^{\pm}\nu(\gamma))}{\Gamma(K^{\pm} \to \mu^{\pm}\nu(\gamma))}$$

Standard Model (theory)	(2.472 ± 0.001) * 10^{-5}
PDG	(2.45 ± 0.11) * 10^{-5}
NA48: 2003 data	***(2.416 ± 0.043 ± 0.024) * 10^{-5}***
NA48: 2004 data	***in progress***



NA48 measurement is already **two times** more precise than the world average

Conclusion

- $K^{\pm} \rightarrow l^{\pm} \nu$ decays provide a very challenging opportunity to search for physics beyond the Standard Model
- Preliminary result for R_K based on 2003 data sample presented
- 2004 data analysis very advanced
- A sub-percent precision measurement of R_K will allow to probe for New Physics or rule out regions in the parameters space in different models