Measurement of the ratio of the charged kaon leptonic decays at NA62

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on behalf of the NA62 collaboration

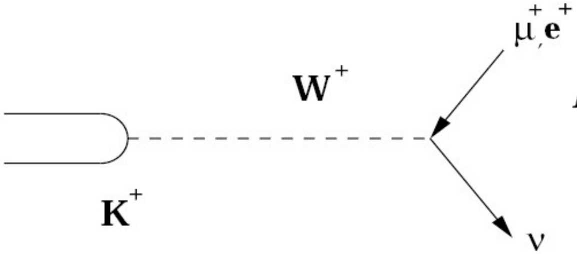
Birmingham, Bratislava, Bristol, CERN, Dubna, Fairfax, Ferrara, Florence, Frascati, Glasgow, Liverpool, Louvain, Mainz, Merced, Moscow, Naples, Perugia, Pisa, Prague, Protvino, Rome I, Rome II, San Luis Potosí, Stanford, Sofia, Turin

Overview

- Motivation
- Experimental setup
- Data analysis
- Results
- Conclusion

Ke2: Motivation

Within the Standard Model:

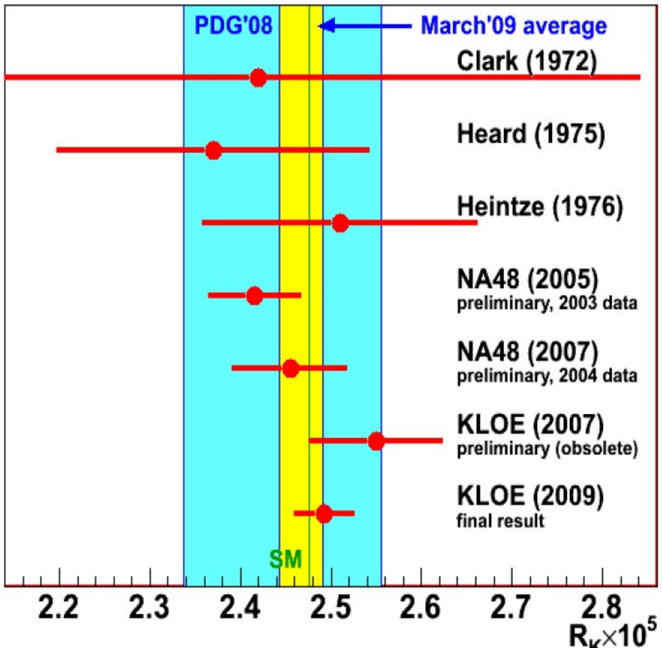


$$R_M := \frac{\Gamma(M \to e\nu_e(\gamma))}{\Gamma(M \to \mu\nu_\mu(\gamma))} = \frac{m_e^2}{m_\mu^2}\left(\frac{m_M^2 - m_e^2}{m_M^2 - m_\mu^2}\right)^2 \left(1 + \delta R_M\right)$$

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

V. Cirigliano, I. Rosell, Phys.Rev.Lett.99:231801,2007

For $K^{\pm}$: $R_K = (2.477 \pm 0.001) * 10^{-5}$

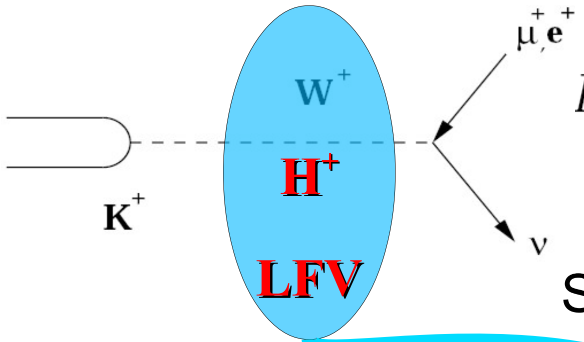


Experimental error on R_K:

more than order of magnitude larger than the theoretical

Ke2: Motivation

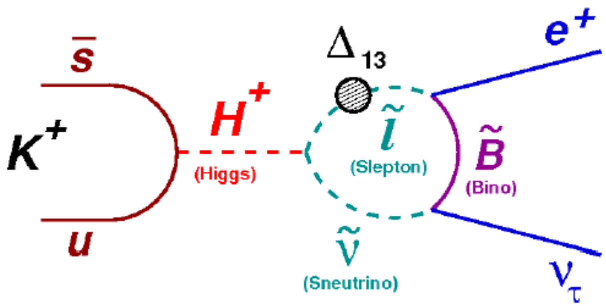
Within the Standard Model:



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

Standard Model prediction:

$R_K = (2.477 \pm 0.001) * 10^{-5}$

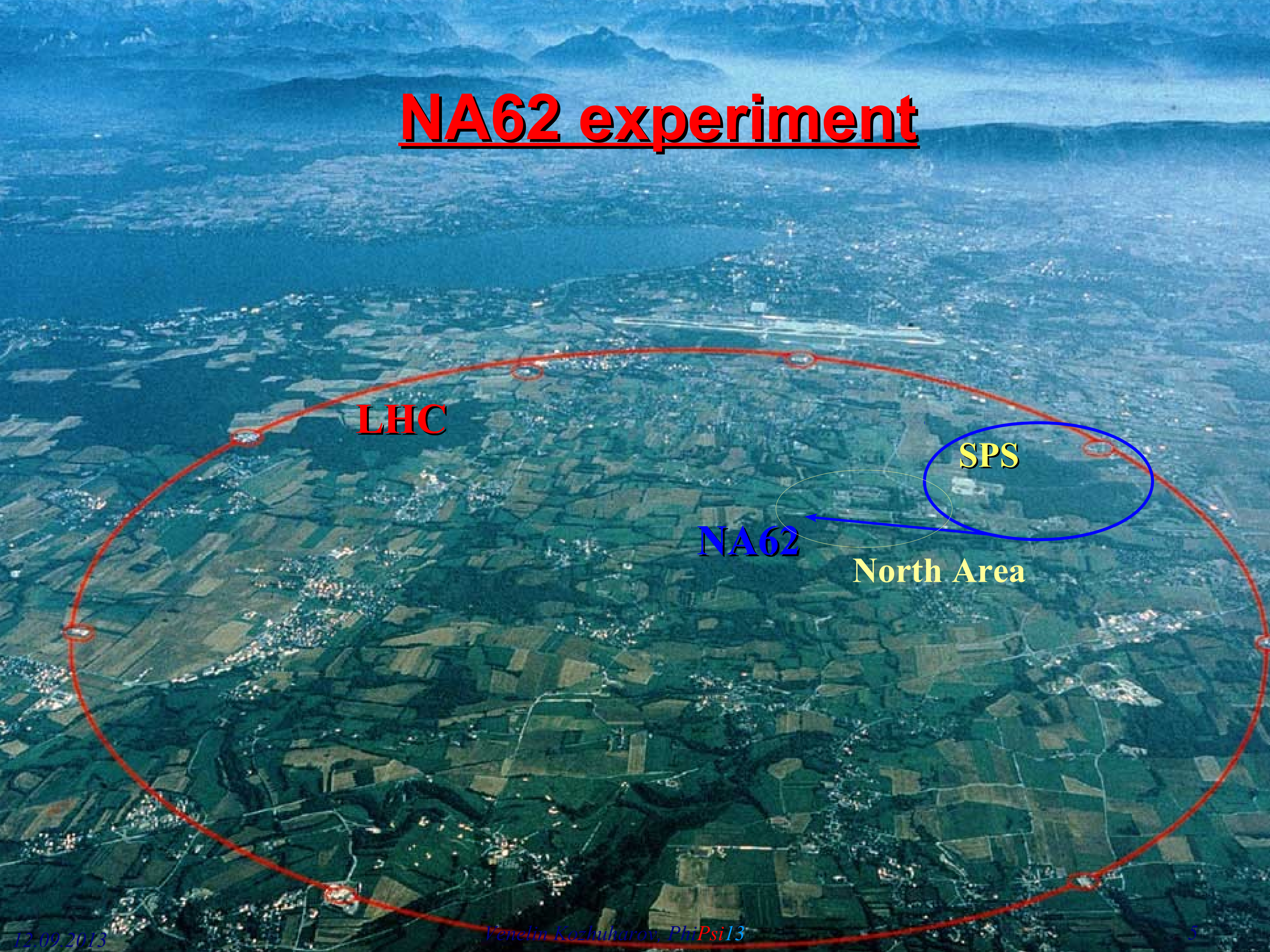


$$R_K^{\rm LFV} \simeq R_K^{\rm SM}\left[1 + \left(\frac{m_K^4}{M_H^4}\right)\left(\frac{m_\tau^2}{m_e^2}\right)|\Delta_R^{31}|^2 \tan^6\beta\right]$$

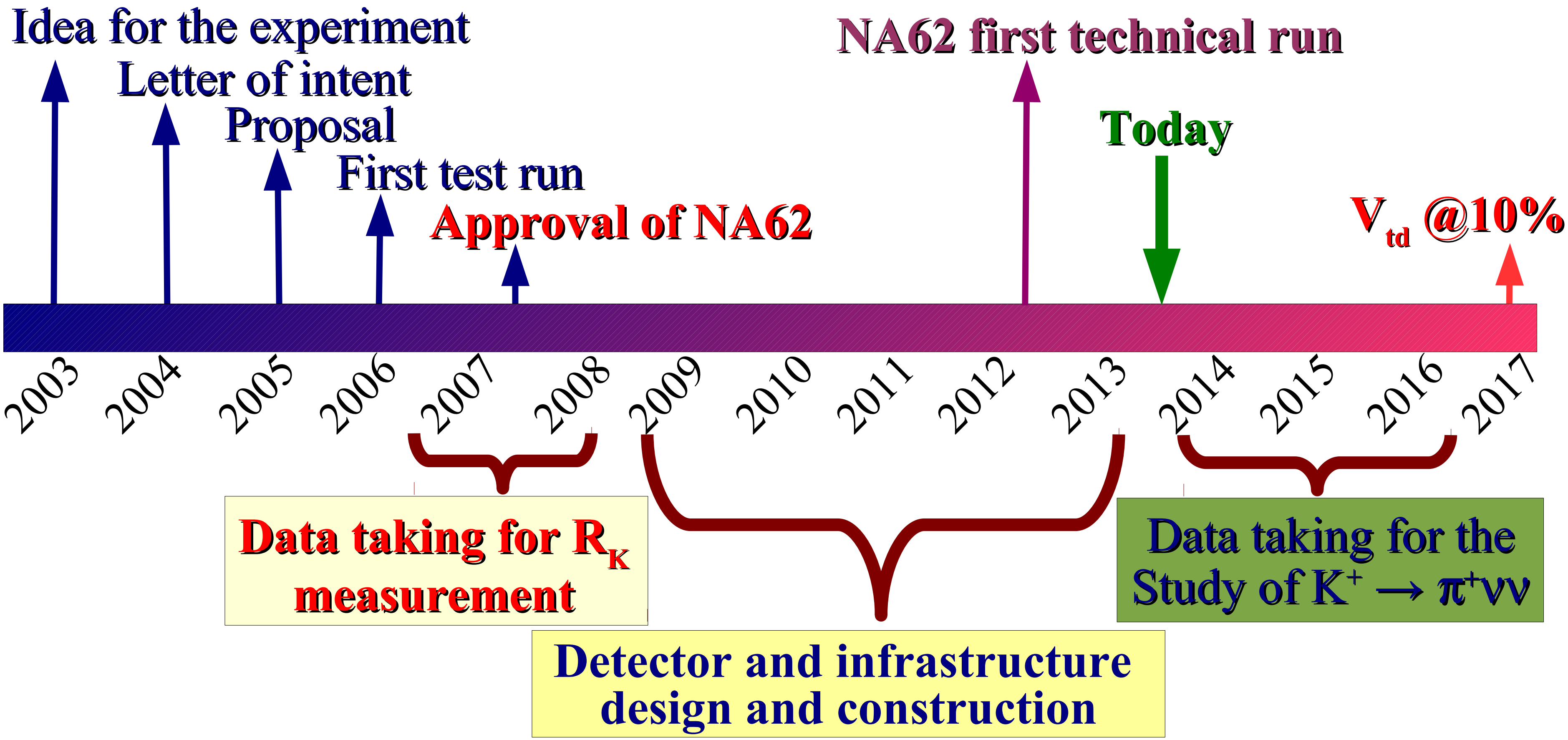
A. Masiero et al. Phys.Rev. D74 (2006) 011701

- The value of R_K could be different in case of SUSY and LFV models – the correction could be as high as %
- Measurement of R_K at with sub per cent precision tests the μ-e universality and provides a sensible test of the SM

NA62 experiment

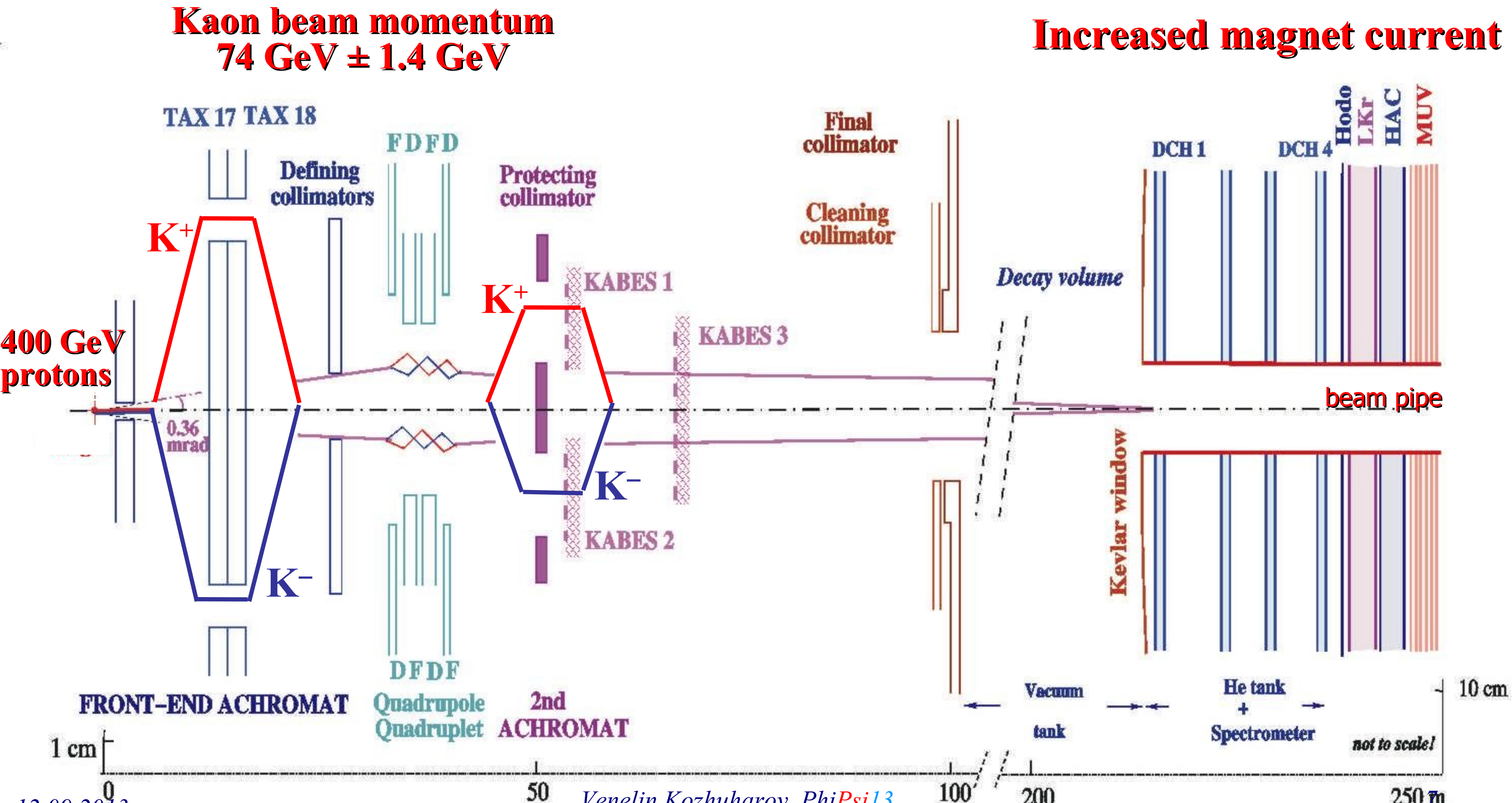


NA62 experiment



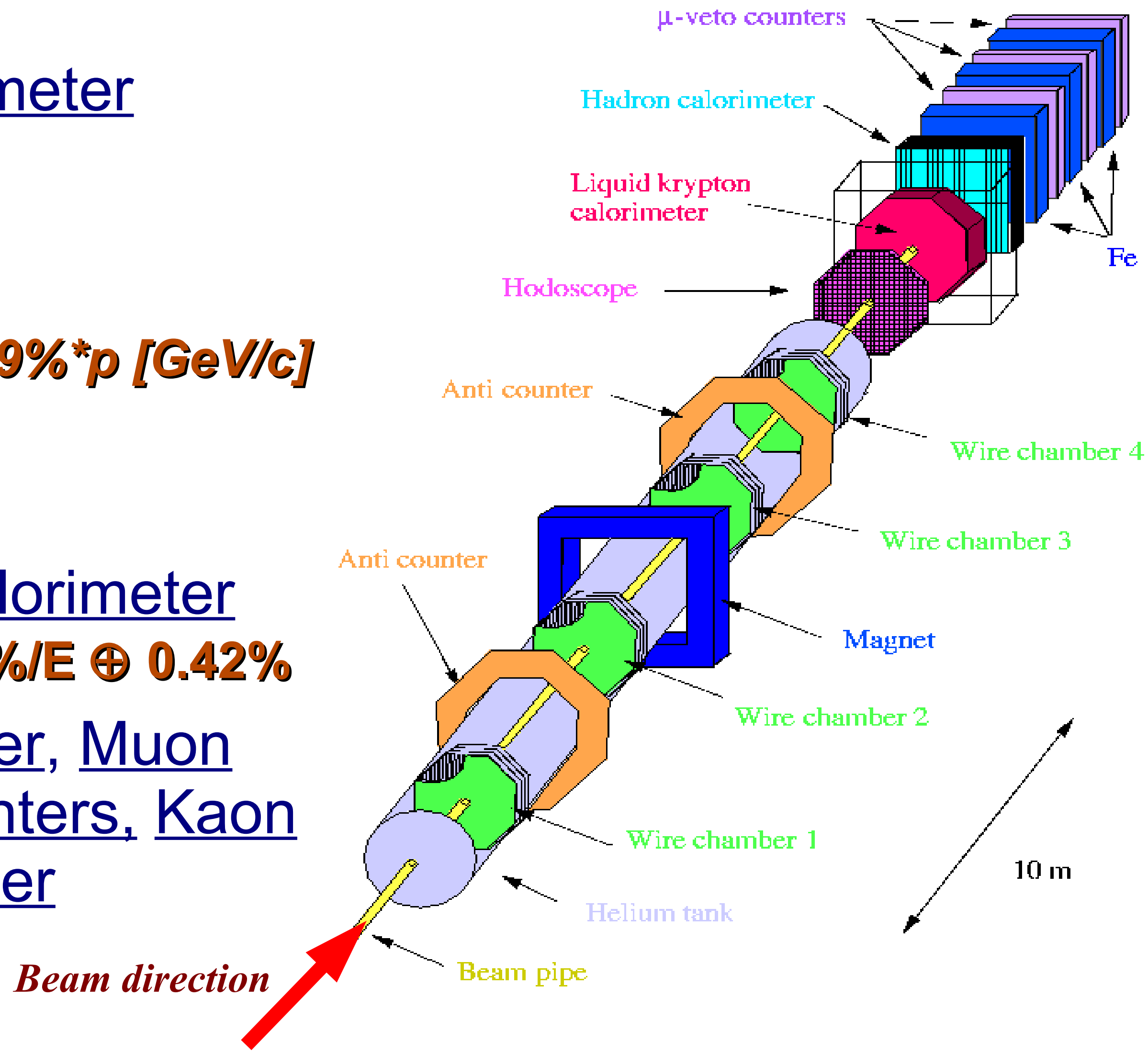
Beam setup

Using NA48/2 beam and detector setup



Detector setup

- Magnetic spectrometer (DCH)
  4 drift chambers
  $p_{\perp}^{kick}$ = 265 MeV/c
  $\Delta p/p = 0.48\% \oplus 0.009\% * p$ [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



Event selection

Geometry

- 1 track in the detector acceptance
- Decay vertex
- Veto of extra photons

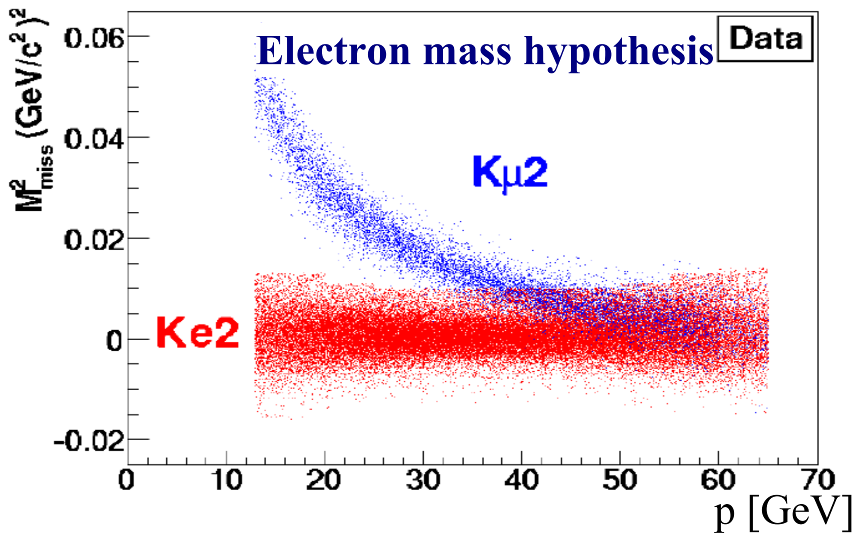
Kinematics

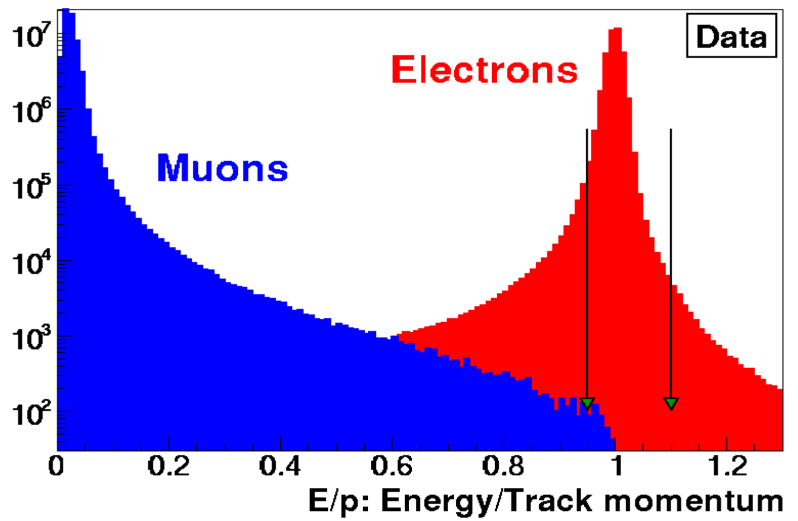
- 13 GeV/c < P < 65 GeV/c
- Missing mass: $M_{miss}^2 = (P^4_K - P^4_e)^2$

  P_K: from K3π decays

Particle identification

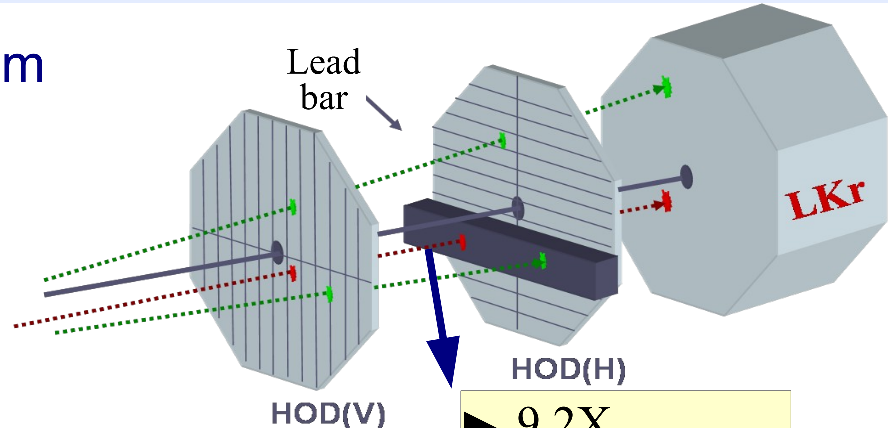
- E: energy in the LKR
- p: momentum from DCH
  electrons: (0.9-0.95) < E/p < 1.1
  muons: E/p < 0.85



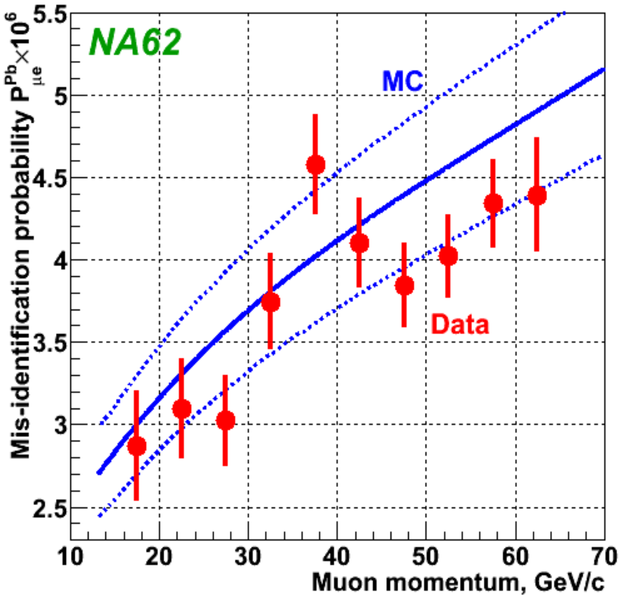


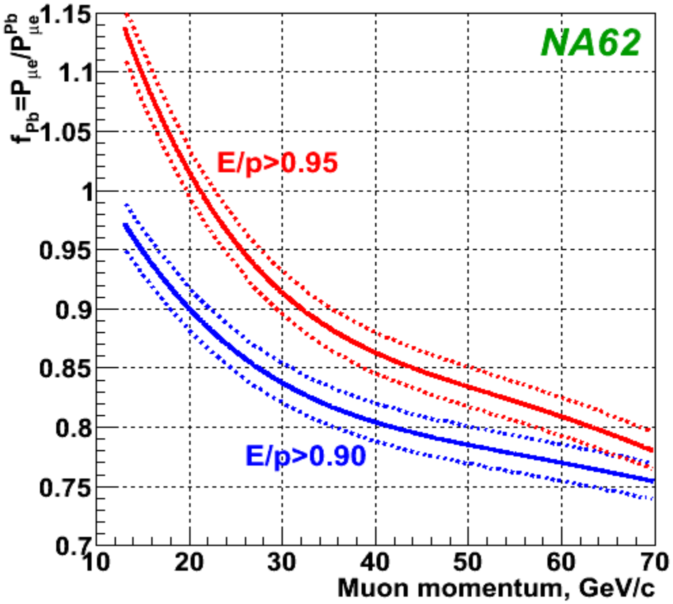
Background estimation

- Dominant background contribution is from Kμ2 decays
  - Catastrophic energy loss in LKr
- Measured from data
  - Lead plate placed in front of the LKr
    - 55% of the total statistics
  - Clean sample of muons



- ▶ $9.2X_0$
- ▶ 20% total area





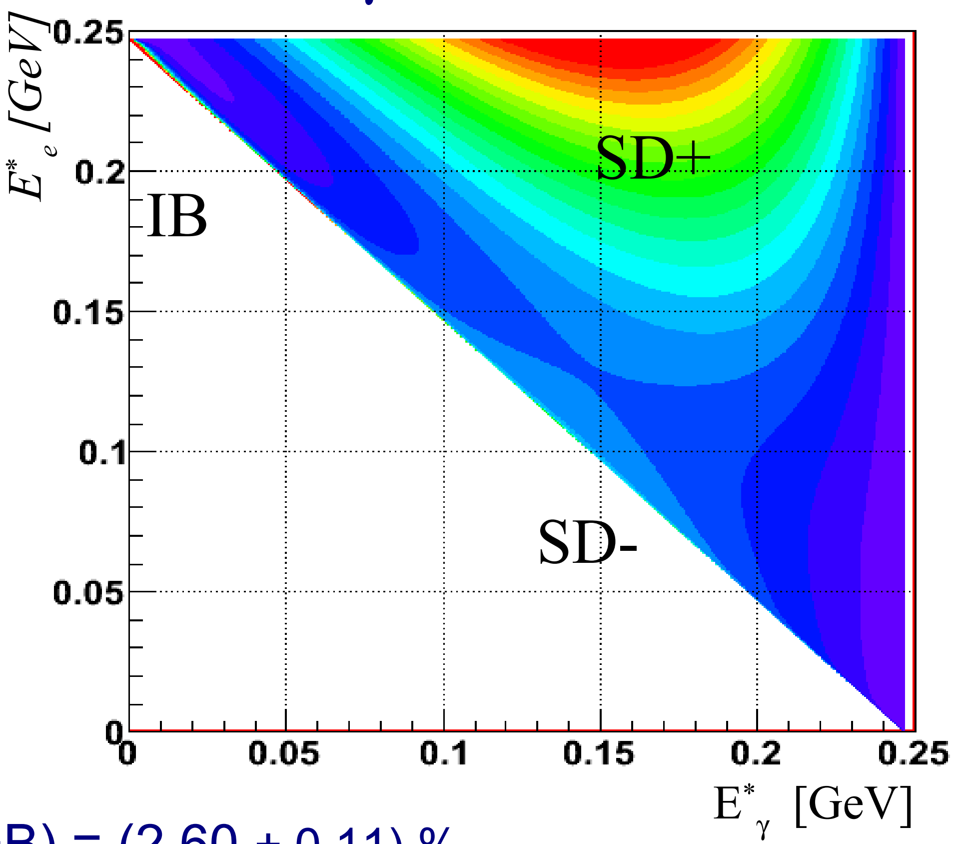
MC used to correct for muon energy loss in the lead bar

- Decrease the systematic uncertainty
  - $\delta P_{\mu e}/P_{\mu e}$ = 10%
  - **$\delta f_{Pb}/f_{Pb}$ = 2%**

Ke2γ background

- The definition of RK includes the IB part of Ke2γ
- Structure dependent contribution treated as background
  - SD not helicity suppressed
  - Rate comparable to Ke2
- SD- kinematically incompatible with Ke2
- SD+ is background if γ misses LKr or absorbed in the lead bar

Ke2γ in kaon rest frame

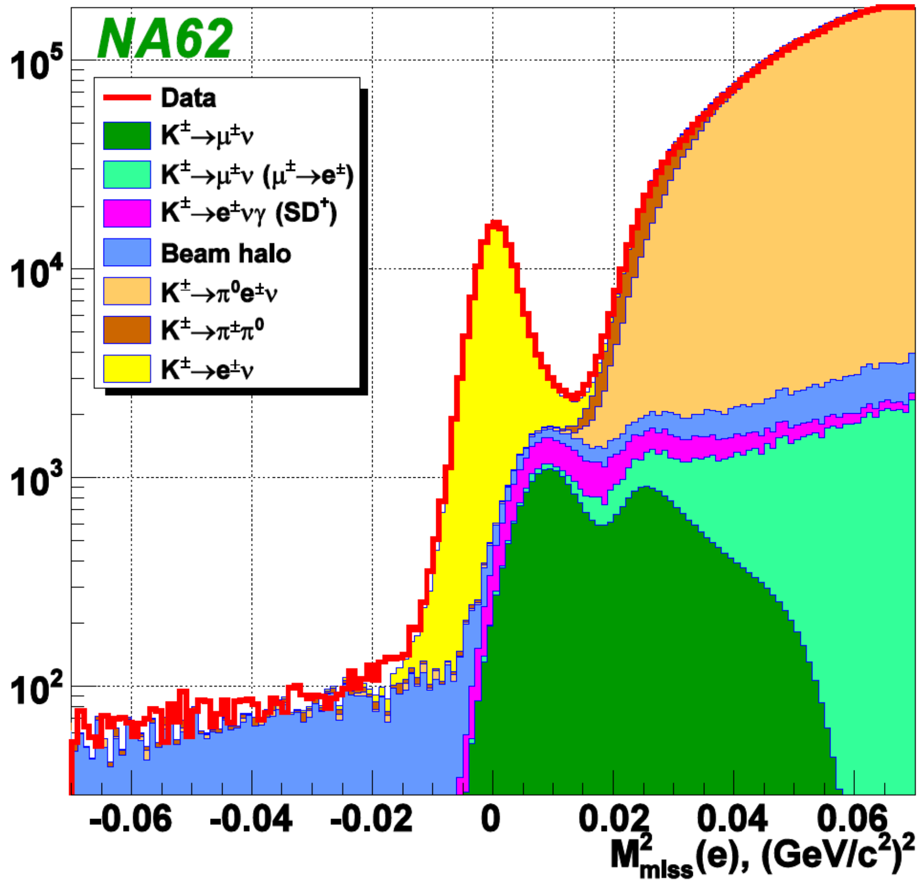


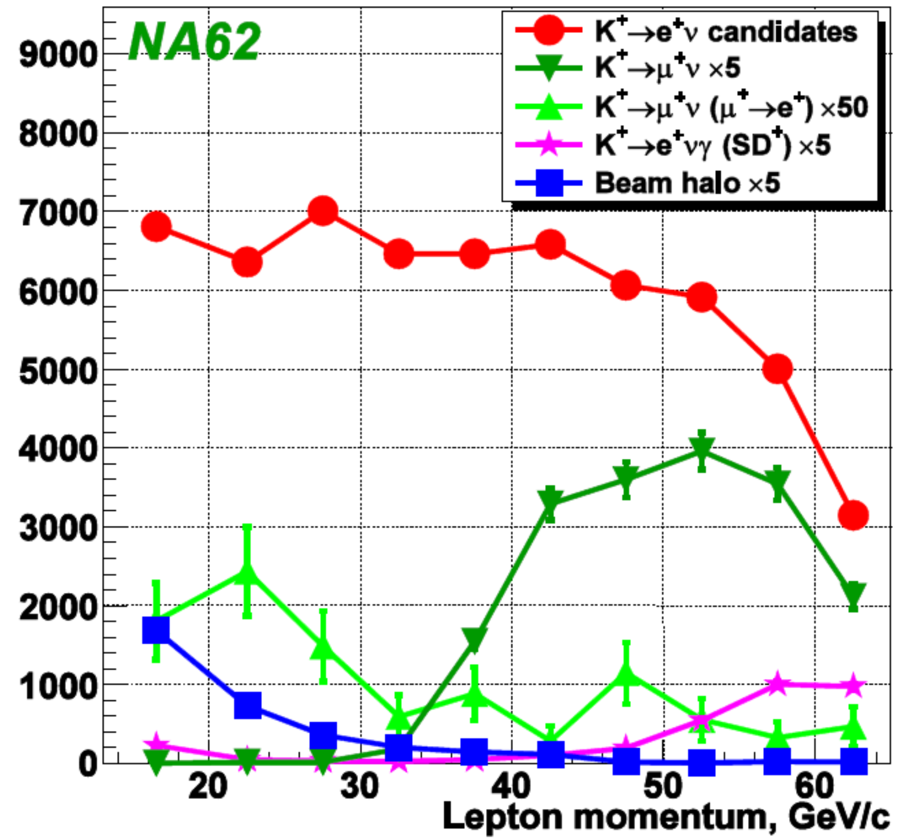
Estimated using MC simulation: B/(S+B) = (2.60 ± 0.11) %

Uncertainty mainly due to the measurement of the Br(Ke2γ_{SD})

Eur. Phys. J. C64 (2009) 627

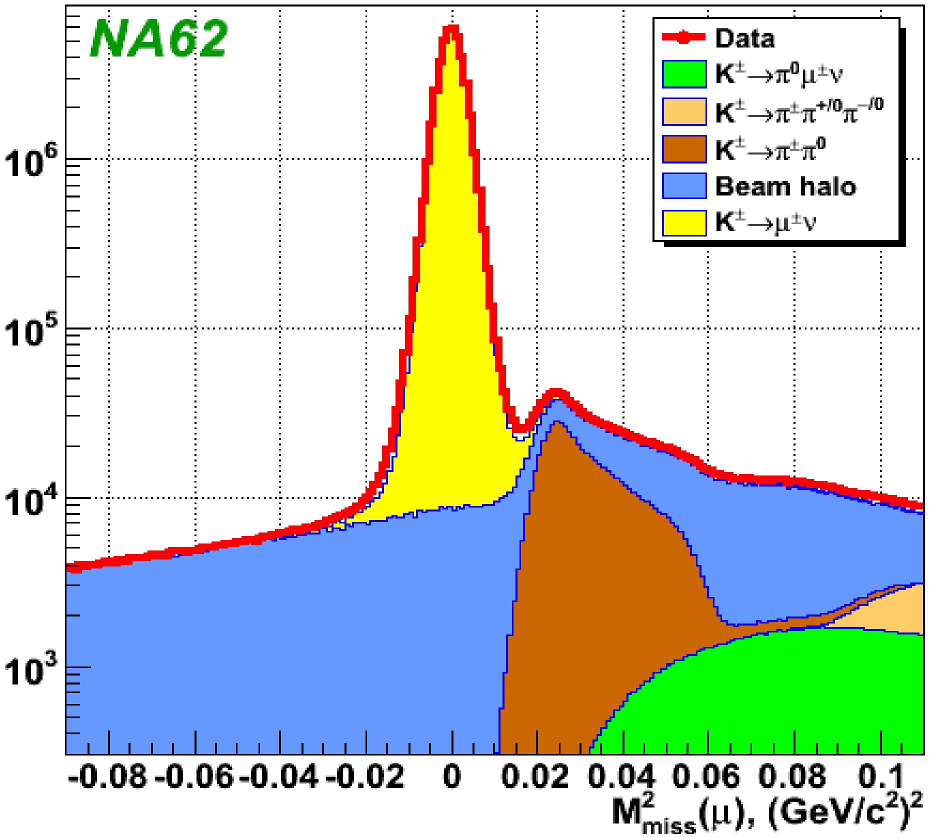
Ke2 events

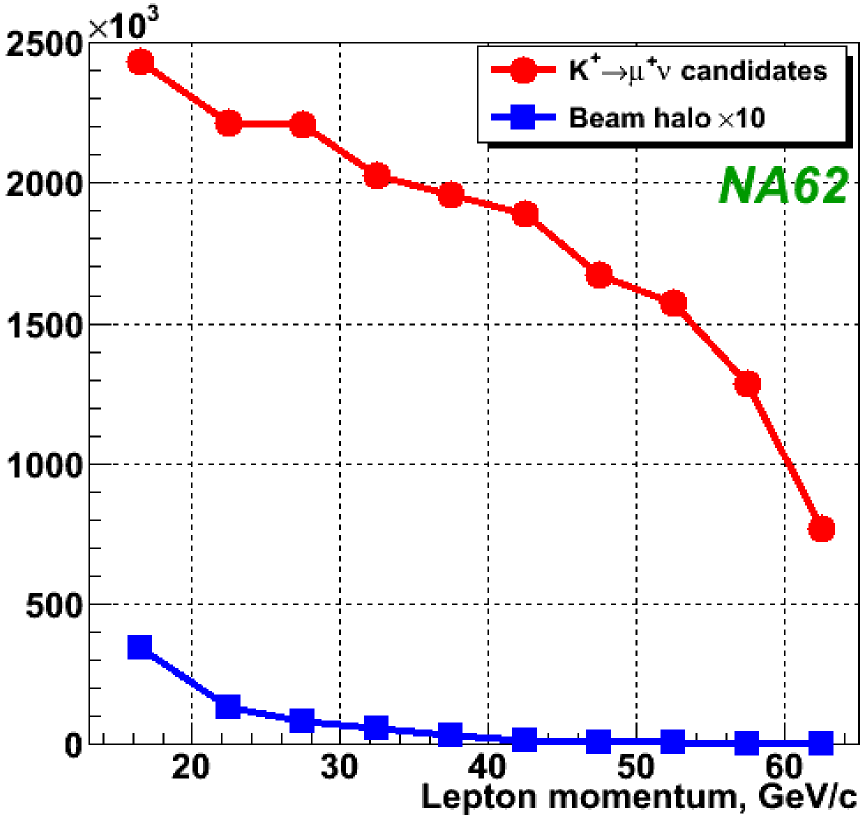




- Reconstructed 145958 Ke2 candidates
  - Total background contribution: B/(S+B) = (10.95± 0.27)%

Kμ2 events





- Reconstructed 42.8 $*10^6$ Kμ2 candidates
- Low background contribution: (0.50 ± 0.01)%

R_K extraction

$$R_K = \frac{1}{D} \cdot \frac{N(K_{e2}) - N_B(K_{e2})}{N(K_{\mu2}) - N_B(K_{\mu2})} \cdot \frac{A(K_{\mu2})}{A(K_{e2})} \cdot \frac{f_\mu \times \epsilon(K_{\mu2})}{f_e \times \epsilon(K_{e2})} \cdot \frac{1}{f_{\mathrm{LKr}}}$$

$N(K_{l2})$	*K_{l2} event candidates*
$N_B(K_{l2})$	*Background in Kl2*
f_l	*Lepton ID efficiency*
f_{LKr}	*Global LKr efficiency*
$\epsilon(K_{l2})$	*K_{l2} trigger efficiency*
$A(K_{l2})$	*K_{l2} accceptance*
D	*Downscaling of Kμ2 trigger*

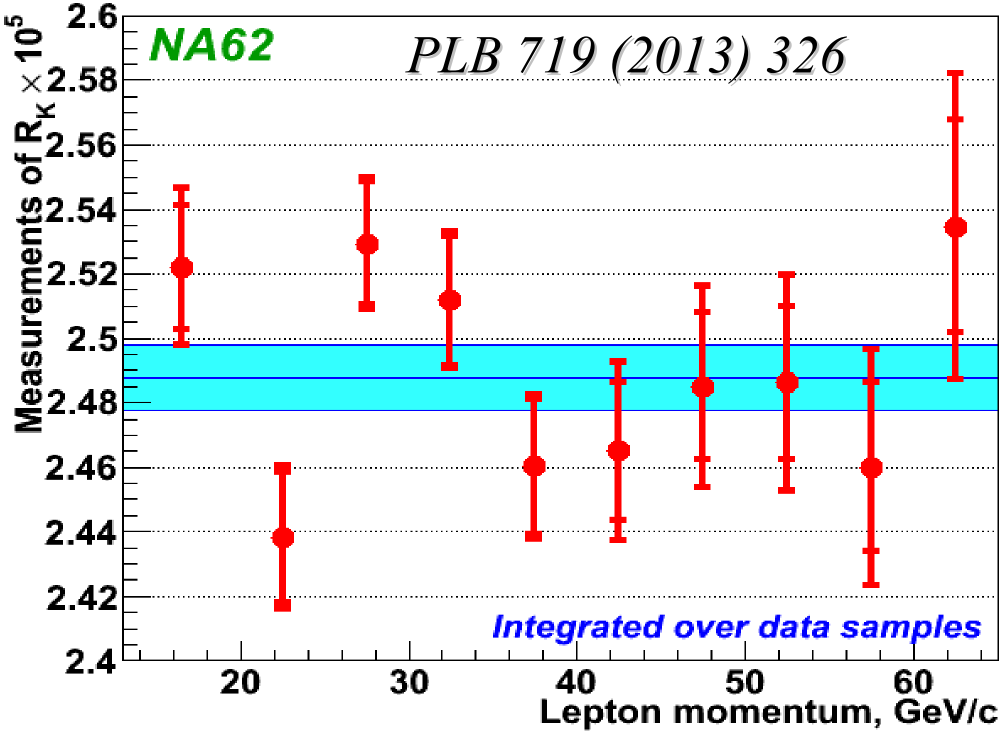
Total systematic: 0.007 * 10^{-5}

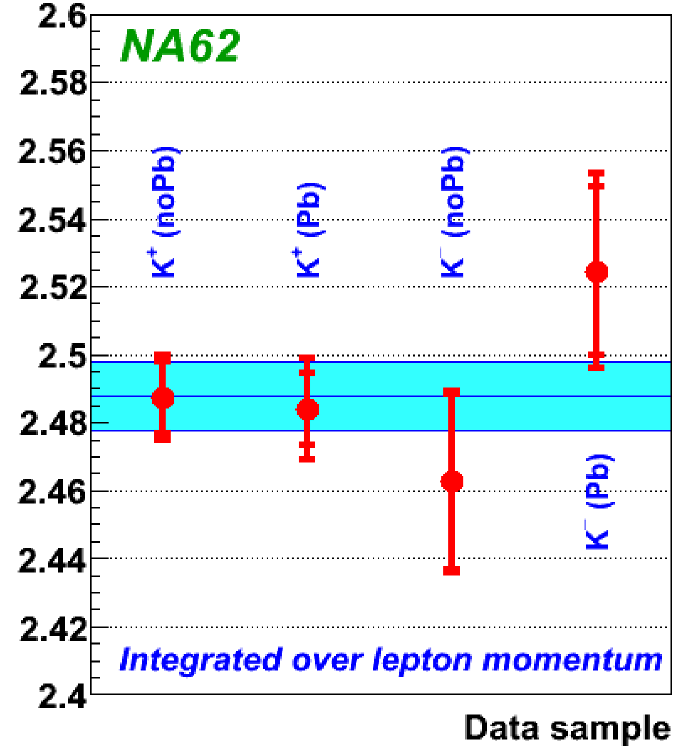
Total statistical: 0.007 * 10^{-5}

MC used for acceptance calculation

Systematic effect	$\Delta R_K * 10^5$
Kμ2 background	0.004
Ke2γ (SD+) background	0.002
Ke3 and K2π background	0.003
Beam halo	0.002
Matter composition	0.002
Acceptance	0.002
DCH alignment	0.001
Electron ID	0.001
1-track trigger eff.	0.001
LKr readout ineff.	0.001

Results





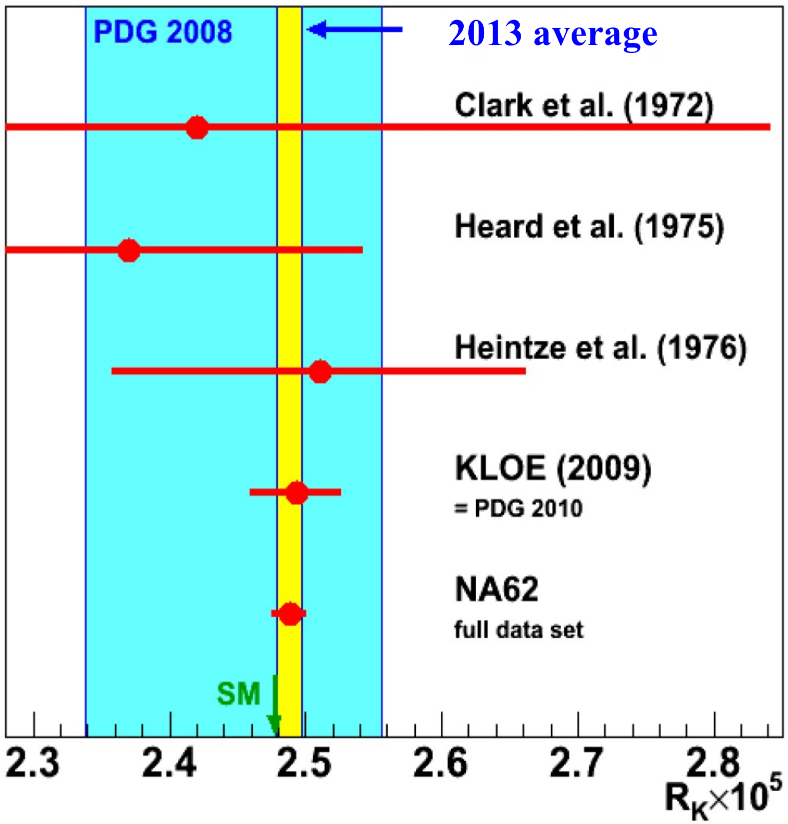
- 4 data samples:
  K^+(noPb), K^+(Pb), K^-(noPb), K^-(Pb)
- 10 momentum intervals

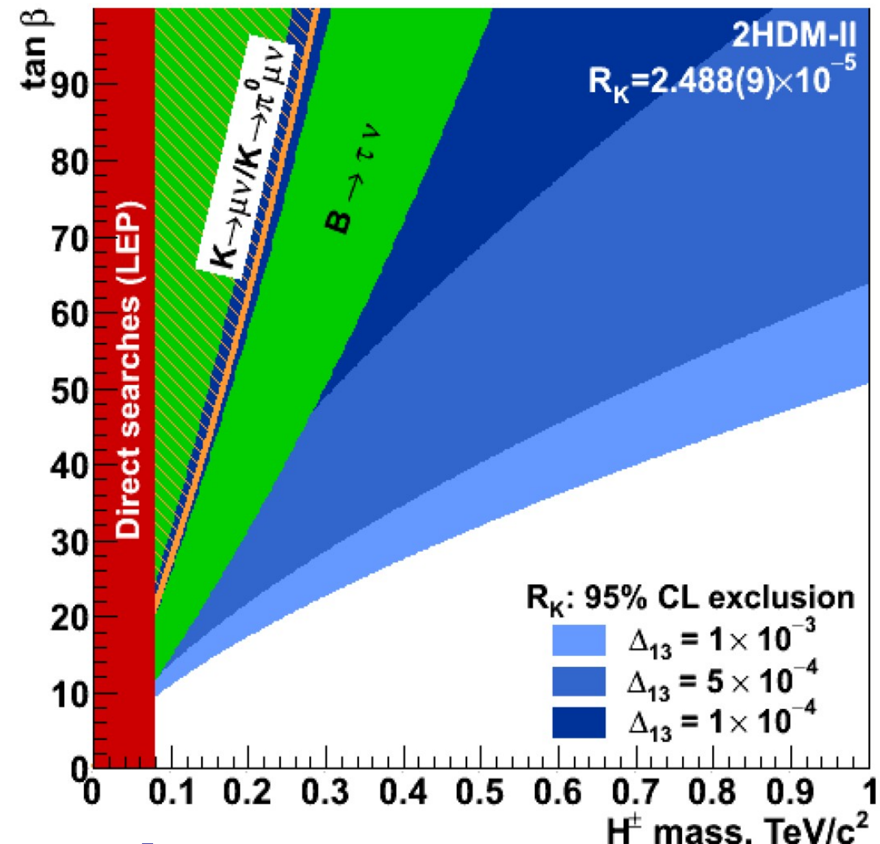
40 independent bins

χ2/ndf = 47/39

NA62 result: $R_K = (2.488 \pm 0.007stat \pm 0.007syst) * 10^{-5}$

R_K average





- Combined result: $R_K = (2.488 \pm 0.009) * 10^{-5}$

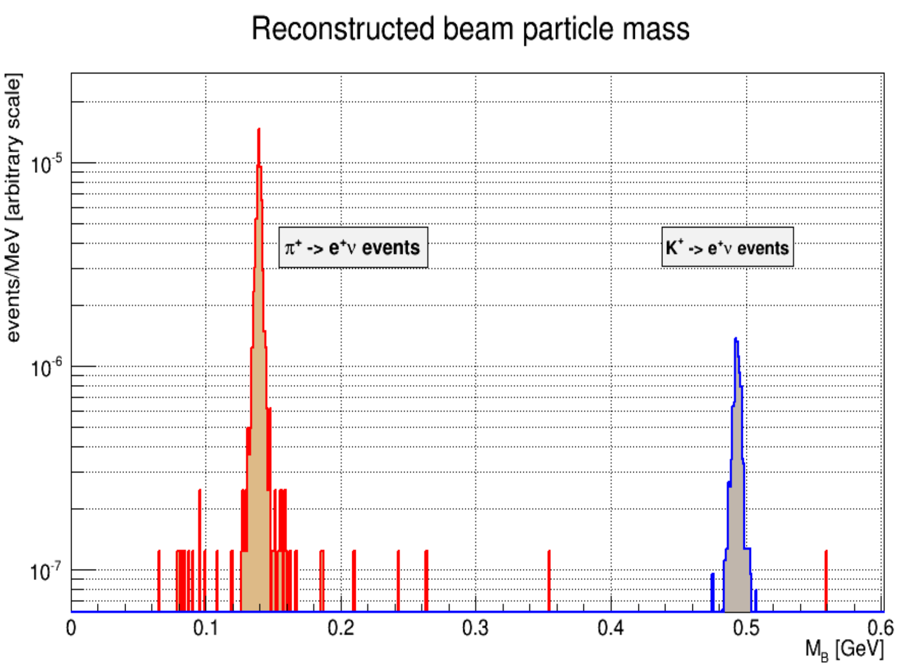
0.36% precision, still compatible with the SM prediction!

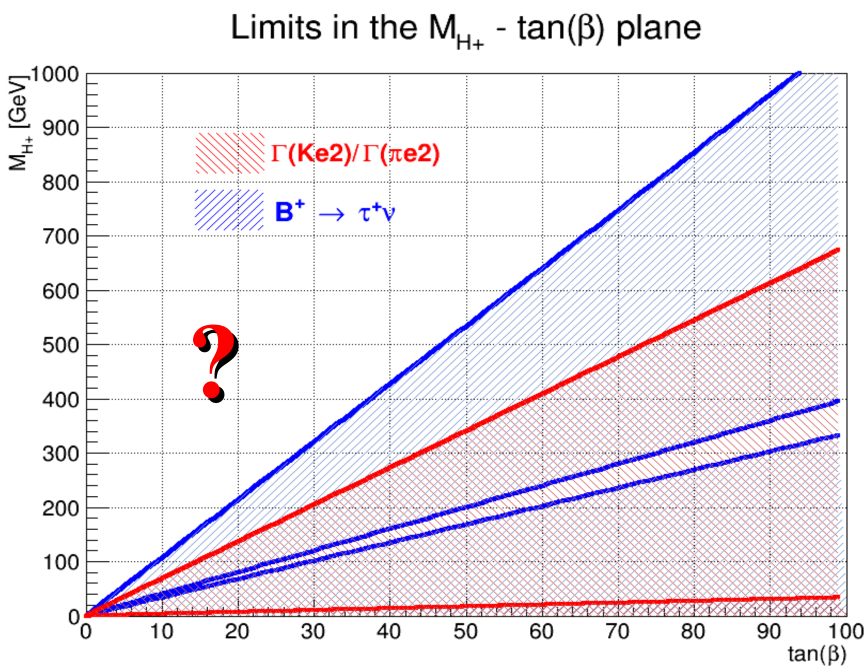
- Still order of magnitude bigger error than the theory

NA62 might be able to achieve 0.2%

Measurement of Γ(Ke2)/Γ(πe2)

- **Is it possible to profit from simultaneous pion and kaon beams?**
- Standard Model: $R^l_{K\pi} = \left|\frac{V_{us}}{V_{ud}}\right|^2 \times \frac{f_K^2 m_K}{f_\pi^2 m_\pi} \times \left(\frac{1 - m_l^2/m_K^2}{1 - m_l^2/m_\pi^2}\right)^2 \times (1 + \delta_{em})$
- MSSM: $R^l_{K\pi}(\mathrm{MSSM}) = R^l_{K\pi}(\mathrm{SM}) \times (1 - r_H^K)^2, \;\; r_H^K = \frac{m_K^2}{M_{H+}^2}\left(1 - \frac{m_d}{m_s}\right)\frac{\tan^2\beta}{1 + \epsilon_0 \tan\beta}$
- **0.5 % measurement sensitive to inaccessible regions to B→τν**





Conclusion

- Rare kaon decays provide a very challenging opportunity to probe the Standard Model
- Final result for R_K based on 2007 NA62 data presented
- Data driven estimations where possible
- Order of magnitude improvement on the precision
- Result compatible with the Standard Model
- NA62 is the present laboratory of charged kaon physics