Measurement of $BR(K \rightarrow e\nu_e)/BR(K \rightarrow \mu\nu_\mu)$ in NA62

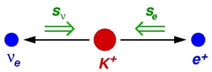
Antonino Sergi

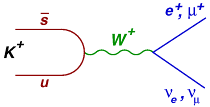
CERN

On behalf of NA62 collaboration

HQL10, October 2010, LNF - Frascati

R_K - LFV test





- $R_K = \frac{\Gamma(K \to e\nu_e)}{\Gamma(K \to \mu\nu_\mu)}$
- $BR(K \to e\nu) \approx O(10^{-5})$
  $BR(K \to \mu\nu) \approx 63\%$
- In the SM:
  $$R_K = \underbrace{\left(\frac{m_e}{m_\mu}\right)^2}_{helicity} \left(\frac{m_K^2 - m_e^2}{m_K^2 - m_\mu^2}\right)^2 (1 + \underbrace{\delta R_{QED}}_{Rad\ Corr}) = (2.477 \pm 0.001) 10^{-5}$$
  [PRL 99 (2007), 231801]

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  - Radiative correction (few %) due to $K \to e\nu_e\gamma(IB)$, by definition included into R_K

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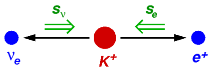

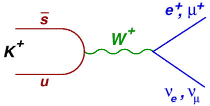

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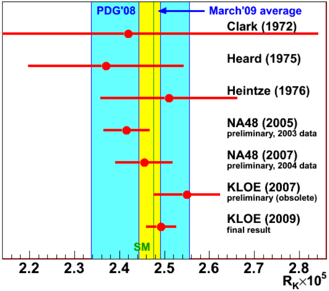


- Experimentally:
  - $R_K = (2.45 \pm 0.11)10^{-5}$ (PDG 2008, '70s measurements)
    $\delta R_K/R_K \approx 4.5\%$
  - $R_K = (2.493 \pm 0.031)10^{-5}$ (arXiv:0907:3594, KLOE)
    $\delta R_K/R_K \approx 1.3\%$
  - It's worth to improve it because of its small and well predicted value

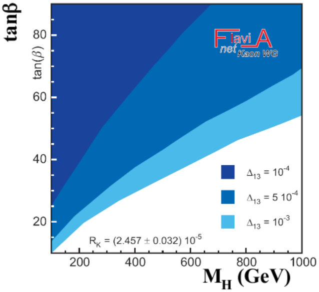
R_K in case of New Physics (MSSM)

- Expected effects within $\delta R_K/R_K \approx 10^{-4} - 10^{-2}$
- A specific case:

$$R_K^{MSSM} = R_K^{SM}\left[1 + \left(\frac{m_K}{m_H}\right)^4 \left(\frac{m_\tau}{m_e}\right)^2 |\Delta_{13}|^2 \tan^6\beta\right]$$

with $m_H = 500\text{GeV}/c^2$, $|\Delta_{13}| = 5\times10^{-4}$ e $\tan\beta = 40$

$R_K^{MSSM} = R_K^{SM}(1 + 0.013)$ [PRD 74 (2006) 011701, JHEP 0811 (2008) 042]



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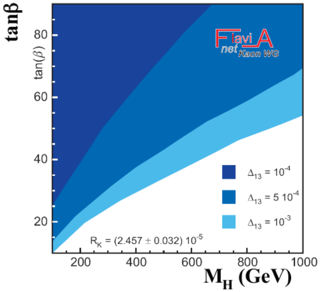

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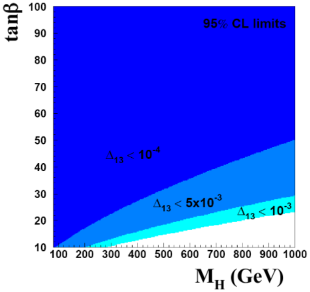

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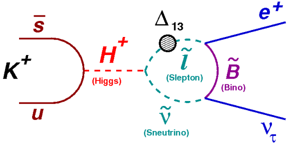

π and B have the same effect, but:

- in R_π it's suppressed by $(m_\pi/m_K)^4 \approx 10^{-3}$
- $B \to e\nu_e$ is out of reach and $\frac{B\to\mu\nu_\mu}{B\to\tau\nu_\tau}$ has $\approx 50\%$ enhancement

NA62 (Phase I): R_K measurement

- Goal: $\delta R_K / R_K \approx 0.5\%$
- Dedicated strategy for K_{e2} $(K \rightarrow e\nu_e)$
- High statistics K_{e2} (150K)
- Backgrounds $< 10\%$

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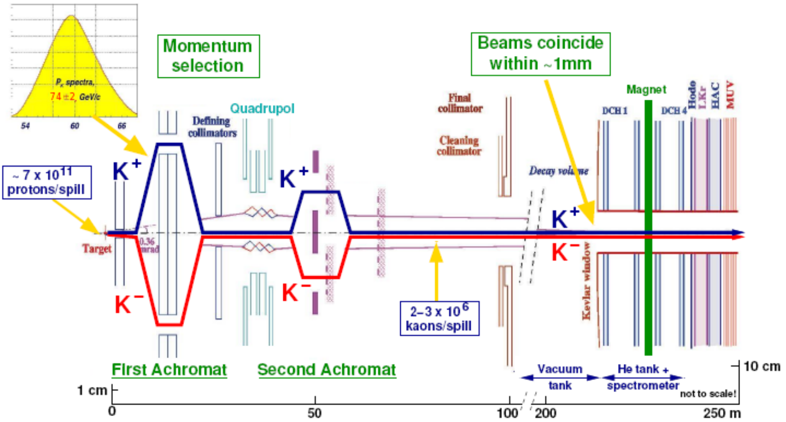

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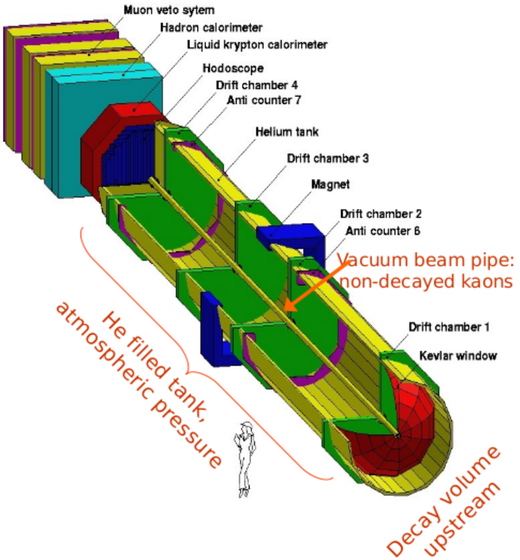
- Dedi
- High
- Back



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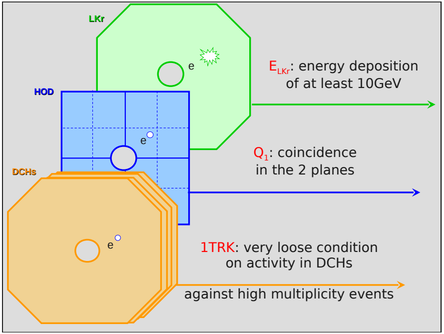
- Some detector features:
  - Spectrometer (4 DCHs): 4 views/DCH $\left(\frac{\sigma_p}{p} = (0.47\% + 0.02\%\ p)[GeV/c]\right)$
  - Liquid Kr EM Calorimeter: $\left(\frac{\sigma_E}{E} = (3.2\%/\sqrt{E} + 9\%/E + 0.42\%)[GeV]\right)$ $\left(\sigma_x = \sigma_y = (0.42\%/\sqrt{E} + 0.6)mm\right)$
  - Hodoscope: trigger and fast timing $\left(\sigma_t = 200ps\right)$

Strategy

- K_{e2} and $K_{\mu 2}$ are collected simultaneously:
  - independent from K flux (no normalization required)
  - cancellation at first order of several systematic effect (reconstruction/trigger efficiencies, time varying effects)
- Event counting in 10 bins of lepton momentum:
  $R_K = \frac{N(K_{e2})-B(K_{e2})}{N(K_{\mu 2})-B(K_{\mu 2})} \frac{A(K_{e2})}{A(K_{\mu 2})} \frac{\epsilon(K_{e2})}{\epsilon(K_{\mu 2})} \frac{\epsilon_e^{PID}}{\epsilon_\mu^{PID}} \frac{1}{\epsilon_{LKr}}$
- MC (validated on data) used only for corrections:
  - acceptance (geometry)
  - backgrounds (μ catastrophic bremsstrahlung)
- Main systematics from $B(K_{e2})$

Trigger



Minimum bias

High efficiency but low purity

- K_{e2}:
  $Q1 \times E_{LKr} \times 1TRK$
  Purity $\approx 10^{-5}$
- $K_{\mu 2}$: $Q1 \times 1TRK/D$
  downscaling (D) from
  50 to 150 Purity $\approx 2\%$

Efficiency of K_{e2} trigger

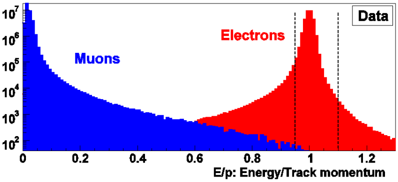
monitored using $K_{\mu 2}$
and other control triggers

E_{LKr} inefficiency

$< 0.1\%$
for $p > 15$ GeV/c

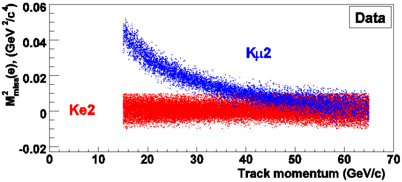
Criteria common to K_{e2} and $K_{\mu 2}$

- 1 reconstructed track
- Geometrical acceptance
- Decay vertex
- Veto extra energy in LKr
- $15 GeV/c < p_{trk} < 65 GeV/c$

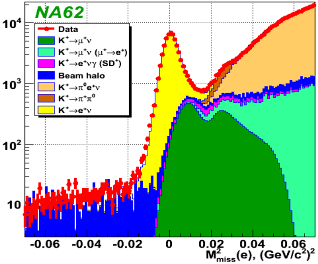


Criteria selecting K_{e2} or $K_{\mu 2}$

- $|m^2_{miss}(l)| < 0.01 (GeV/c^2)^2$
- PID:
  - $0.9 < E/p < 1.1$ for electrons
  - $E/p < 0.85$ for muons
  - Suppression of μ in e sample by 10^6



Backgrounds



Backgrounds for K_{e2}

$K_{\mu 2}$	$(6.10 \pm 0.22)\%$
$K_{\mu 2}(\mu \to e)$	$(0.27 \pm 0.04)\%$
$K_{e2\gamma}\ (SD^+)$	$(1.15 \pm 0.17)\%$
Beam halo	$(1.14 \pm 0.06)\%$
K_{e3}	$(0.06 \pm 0.01)\%$
$K_{2\pi}$	$(0.06 \pm 0.01)\%$

$K_{e2\gamma}\ (SD^+)$

Background for definition of R_K
Rate similar to K_{e2}
Poorly known (20%)

Theory: $BR = (1.12 \pm 1.34)10^{-5}$

Measurement: $BR = (1.52 \pm 0.23)10^{-5}$

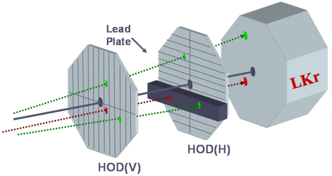
Now measured in NA62 data sample

Beam halo

Measured by means of the K^- data sample

μ mis-identification as electron

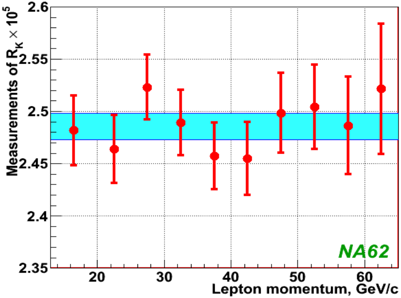
Due to "catastrophic" bremsstrahlung
$P(\mu \to e) \approx 3 \cdot 10^{-6} \Rightarrow P(\mu \to e)/R_K \approx 10\%$
Pure μ sample using lead filter (removing $\mu \to e\nu_e$)



Final result (40% of data sample)

Uncertainties

Source	$\delta R_K \times 10^5$
Statistical	0.011
$K_{\mu 2}$	0.005
$K_{e2\gamma}$ (SD^+)	0.004
Beam halo	0.001
Acceptance	0.002
Positron ID	0.001
DCH alignmnent	0.001
1-track trigger	0.002
Total	0.013



Precision and accuracy

59,963 K_{e2} candidates
Positron ID efficiency: $(99.27 \pm 0.05)\%$
$B/(S+B) = (8.78 \pm 0.29)\%$
$\delta R_K / R_K = 0.52\%$

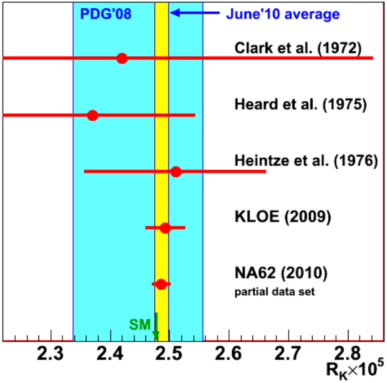
Perspectives

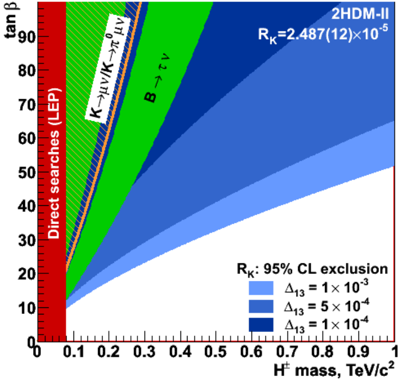
With the full sample $\approx 150K$ K_{e2}:
statistical uncertainty 0.3%,
total uncertainty $\approx$ 0.4% within reach
(in agreement with the original goal)

Result

$$R_K = (2.486 \pm 0.011_{stat} \pm 0.007_{syst}) \times 10^{-5}$$

World Average





World average	$R_K \times 10^5$	Precision
March 2009	(2.467 ± 0.024)	0.97%
June 2010	(2.487 ± 0.012)	0.48%

Conclusions

- Kaon physics shows again to be a good tool for investigation in the flavour sector
- NA62 R_K measurement

  $$R_K = (2.486 \pm 0.011_{stat} \pm 0.007_{syst}) \times 10^{-5}$$

  is currently in agreement with SM prediction
- Final result based on the full data sample should be ready in few months
- Precision measurements are placing non-trivial bounds on 2HDM parameters
- NA62 will not stop here