New results on K physics from NA48 and NA62 experiments

Les Rencontres de Physique de la Vallée d'Aoste

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/CERN/

On behalf of NA48 and NA62 collaborations

Timeline

NA48

Beams: $K_L + K_S$

Primary goal: ε'/ε measurement

NA48/2

Beams: $K^+ + K^-$

Primary goal: Search for direct $\not{C}P$

NA62 – Phase II

Beam: K^+

Primary goal: $BR(K^+ \rightarrow \pi^+ \nu\nu)$

2006-2012: Design & Construction

1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013

NA48/1

Beams: K_S

Primary goal: Rare K_S and hyperon decays

NA62 – Phase I

Beams: $K^+ + K^-$

Primary goal: Lepton universality test

Tests for phase II

NA48/NA62 beam line and detectors

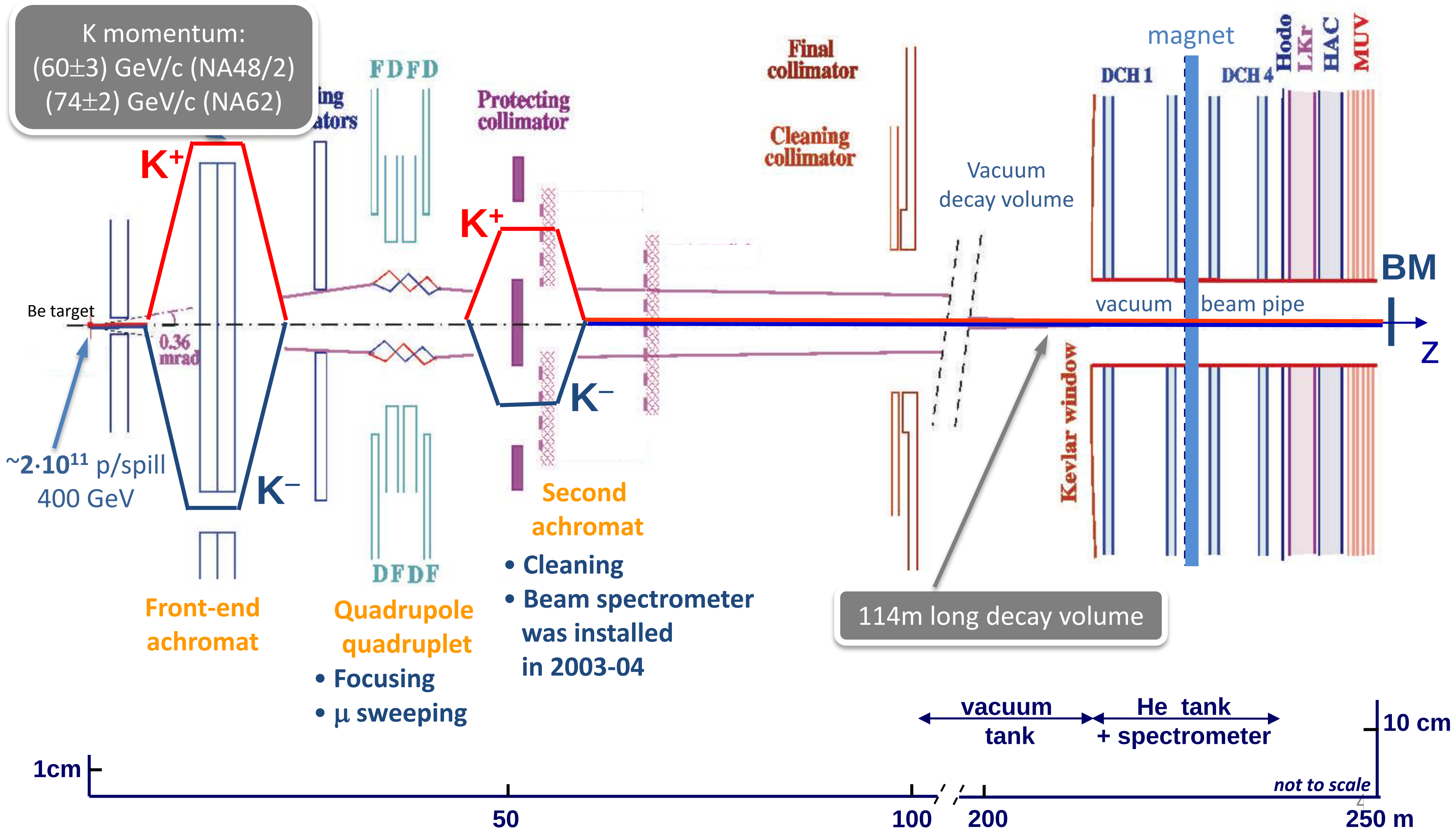
$K^{\pm}_{\mu 3}$ Form Factors Prelim.

New results with $K^{\pm} \rightarrow \pi^{\pm}\mu^{+}\mu^{-}$ NEW

BR($K^{\pm}_{e4}$) measurement NEW

R_K measurement [40% of data] FINAL

NA48/2 and NA62 (Phase I) beam line



NA48 detector

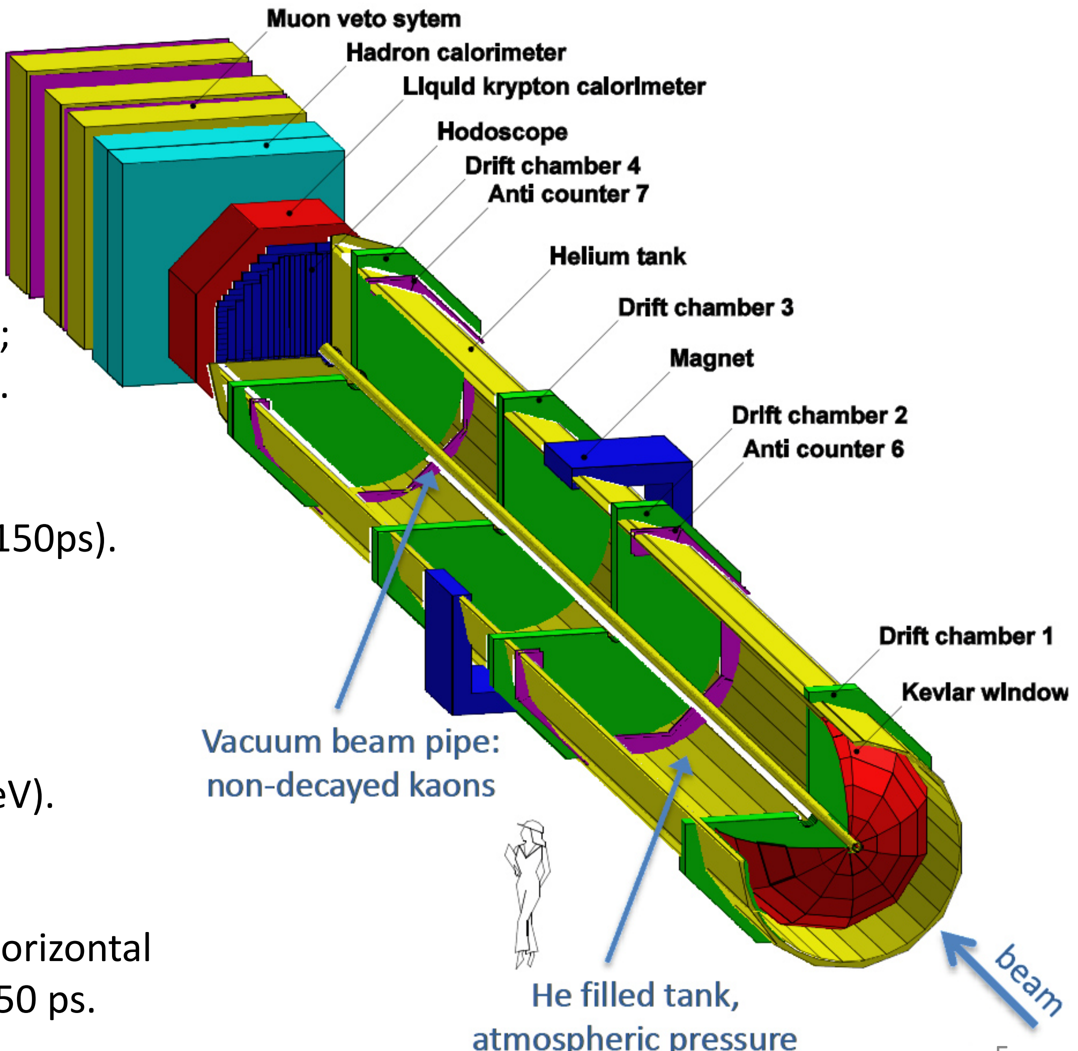
Main subdetectors:

- ❑ **Magnetic spectrometer (4 DCHs):**
  4 views/DCH: redundancy $\Rightarrow$ efficiency;
  periodically reverse the magnet polarity;
  NA48: $\Delta p/p = 1.00\% + 0.044\% * p$ [GeV/c];
  NA62: $\Delta p/p = 0.47\% + 0.020\% * p$ [GeV/c].

- ❑ **Hodoscope:**
  fast trigger, precise time measurement (150ps).

- ❑ **Liquid Krypton EM calorimeter (LKr):**
  High granularity, quasi-homogenious;
  $\sigma_E/E = 3.2\%/E^{1/2} + 9\%/E + 0.42\%$ [GeV];
  $\sigma_x=\sigma_y=0.42/E^{1/2} + 0.6$mm (1.5mm@10GeV).

- ❑ **Muon Veto System (MUV):**
  Three planes of scintillator strips – two horizontal and one vertical (25 x25 cm2 cells); σ_t~350 ps.



$K^{\pm}_{\mu 3}$ → Physical motivation

- K_{l3} decays provide most accurate and theoretically cleanest way to access $|V_{us}|$:

$$\Gamma(K_{l3(\gamma)}) = \frac{G_K^2 G_F^2 m_K^5}{192\pi^3} S_{EW} |V_{us}||f_+(0)|^2 I_K^l(\lambda_{+0})(1+\delta^l_{SU(2)} + \delta^l_{EM})^2$$

- K_{l3} decays are described by **two form factors $f_{\pm}(t)$**:

$$M = \frac{G_F}{2} V_{us} \left[f_+(t)(P_K - P_\pi)^\mu \bar{u}_l \gamma_\mu (1-\gamma_5) u_\nu + f_-(t) m_l \bar{u}_l (1+\gamma_5) u_\nu \right]$$

(t is the 4-momentum transfer to the lepton system)

- $f_-(t)$ can be measured only with $K_{\mu 3}$ ($m_e \ll M_K$)
- $f_0(t)$ is defined as a linear combination of the two:

$$f_0(t) = f_+(t) + \frac{t}{m_K^2 - m_\pi^2} f_-(t)$$

By construction $f_+(0) = f_0(0)$

- $f_+(0)$ can not be measured directly, so normalize the form factors to it:

$$\bar{f}_+(t) = \frac{f_+(t)}{f_+(0)} \qquad \bar{f}_0(t) = \frac{f_0(t)}{f_+(0)} \qquad \bar{f}_+(0) = \bar{f}_0(0)$$

$K^{\pm}_{\mu 3}$ Form factors parameterizations

- **Class 1 parameterizations** → make use of physical quantities:
  - **Pole parameterization:** describes exchange of K* resonances with spin-parity $1^-/0^+$ and mass m_V/m_S. For f_+ dominance of K*(892); no obvious dominance for f_0.

$$\bar{f}_{+,0}(t) = \frac{m_{V,S}^2}{m_{V,S}^2 - t}$$

  - **Dispersive parameterization:** parameterization based on dispersive approach with free parameters Λ_+ and $\ln C$. Accurate polynomial approximations for the dispersive integrals $G(t)$ and $H(t)$ are available [PLB 683(2006), PRD 80(2009) 034034]

$$\begin{cases} \bar{f}_+(t) = \exp\left[\frac{t}{m_\pi^2}\left(\Lambda_+ + H(t)\right)\right] \\ \bar{f}_0(t) = \exp\left[\frac{t}{\Delta_{K\pi}}\left(\ln C + G(t)\right)\right] \end{cases}$$

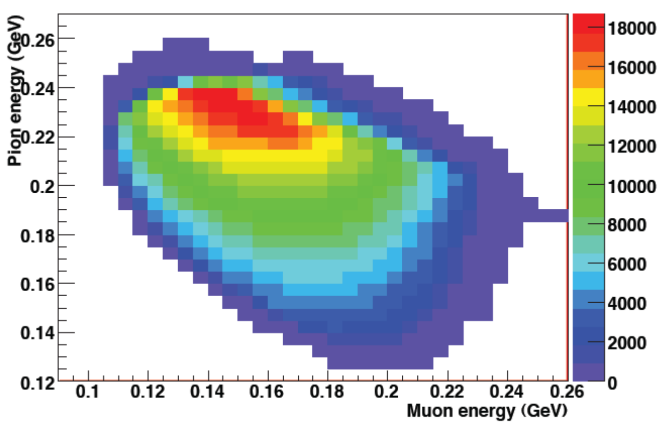
- **Class 2 parameterizations** → w/o physical meaning; more free parameters; expansions in the momentum transfer:
  - **Linear and quadratic parameterizations:** no sensitivity to λ''_0

$$\begin{cases} \bar{f}_{+,0}(t) = 1 + \lambda_{+,0}\frac{t}{m_\pi^2} \\ \bar{f}_{+,0}(t) = 1 + \lambda'_{+,0}\frac{t}{m_\pi^2} + \frac{1}{2}\lambda''_{+,0}\left(\frac{t}{m_\pi^2}\right)^2 \end{cases}$$

  - **z-fit parameterization:** infinite sum of terms depending on t and $t^+ = (m_K+m_\pi)^2$ [PRD74(2006) 096006]

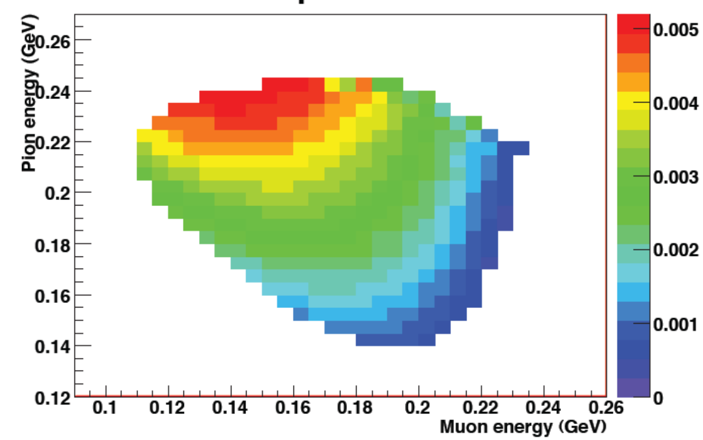
$K^{\pm}_{\mu3}$ Form Factors Preliminary Results

reconstructed data dalitz plot

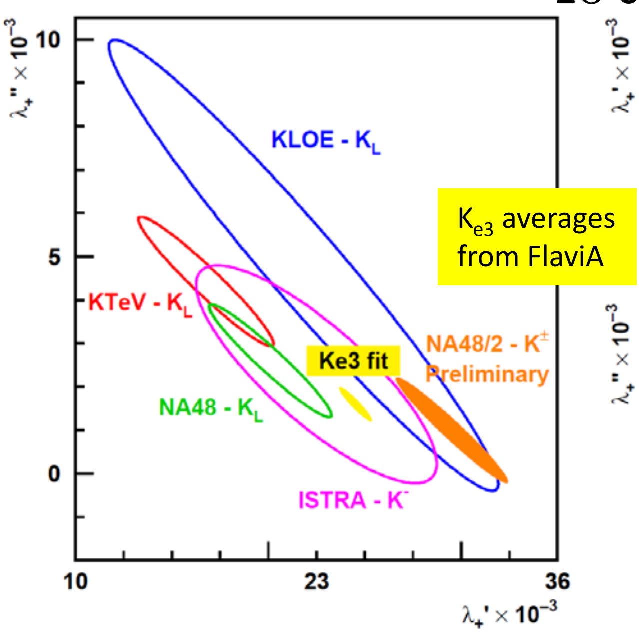


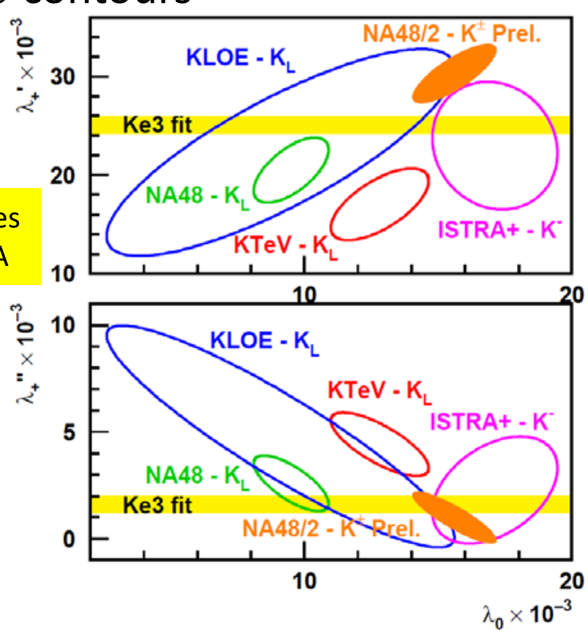
- **Applied corrections:**
  - Background subtraction.
  - Acceptance.
  - Radiative corrections.

corrected dalitz plot



1σ contours





Selected $K^{\pm}_{\mu3}$ events: 3.4 x 10^6

Quadratic ($x10^3$):

$\lambda'_+ = 30.3 \pm 2.7_{stat} \pm 1.4_{syst}$

$\lambda''_+ = 1.0 \pm 1.0_{stat} \pm 0.7_{syst}$

$\lambda_0 = 15.6 \pm 1.2_{stat} \pm 0.9_{syst}$

Pole (MeV/c^2):

$m_V = 836 \pm 7_{stat} \pm 9_{syst}$

$m_S = 1210 \pm 25_{stat} \pm 10_{syst}$

Dispersive ($x10^3$):

$\Lambda_+ = 28.5 \pm 0.6_{stat} \pm 0.7_{syst} \pm 0.5_{theor}$

$\ln C = 188.8 \pm 7.1_{stat} \pm 3.7_{syst} \pm 5.0_{theor}$

z-fit coming soon

$K^{\pm} \rightarrow \pi^{\pm}\mu^{+}\mu^{-}$ physics interest

- FCNC decays induced at 1-loop in SM.
- Rate dominated by long-distance contributions involving one photon exchange.
- Experimental situation so far:
  - 1997 → $K_{\pi\mu\mu}$ observed by **BNL E787**
  - 2000 → vector nature of the interactions established by **BNL E865**; upper limit on LNV $K^{+} \rightarrow \pi^{-}\mu^{+}\mu^{+}$
  - 2002 → limit on CP-violating rate asymmetry by **HyperCP**
  - Total world sample before NA48: **700 candidates**
- NA48 new measurements:
  - $BR(K^{\pm} \rightarrow \pi^{\pm}\mu^{+}\mu^{-})$
  - Form factors
  - Charge asymmetry
  - Forward-backward asymmetry
  - Upper limit on $K^{\pm} \rightarrow \pi^{\mp}\mu^{\pm}\mu^{\pm}$
  - Based on a sample 4.5x the total world statistics

$K^{\pm} \rightarrow \pi^{\pm}\mu^{+}\mu^{-}$ differential decay width:

$$\frac{d\Gamma}{dz} \propto \lambda^{3/2}(1, z, r_\pi^2)\sqrt{1-4\frac{r_\mu^2}{z}}\left(1+\frac{2r_\mu^2}{z}\right)|W(z)|^2$$

$$z = \left(M_{\mu\mu}/M_K\right)^2$$

1. Linear: $W(z) = G_F M_K^2 f_0 (1+z\delta)$
2. NLO χPT [JHEP 9808 (1998) 4]: $W(z) = G_F M_K^2 (a_+ + b_+ z) + W^{\pi\pi}(z)$
3. χPT + large-N_c QCD [PLB 595 (2004) 301]: $W(z) = W(\tilde{w}, \beta, z)$
4. χPT parameterization [hep-ph/0611175]: $W(z) = W(M_a, M_\rho, z)$

$$\Delta(K^{\pm}_{\pi\mu\mu}) = (BR^{+} - BR^{-})/(BR^{+} + BR^{-})$$

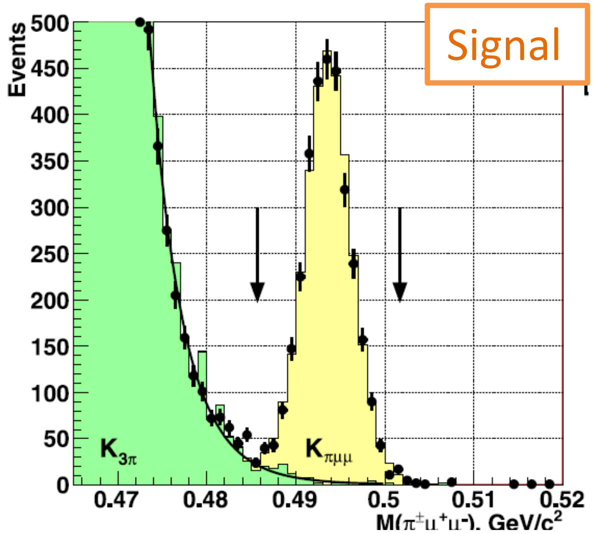
$$A_{FB} = \frac{N(\cos\theta_{K\mu} > 0) - N(\cos\theta_{K\mu} < 0)}{N(\cos\theta_{K\mu} > 0) + N(\cos\theta_{K\mu} < 0)}$$

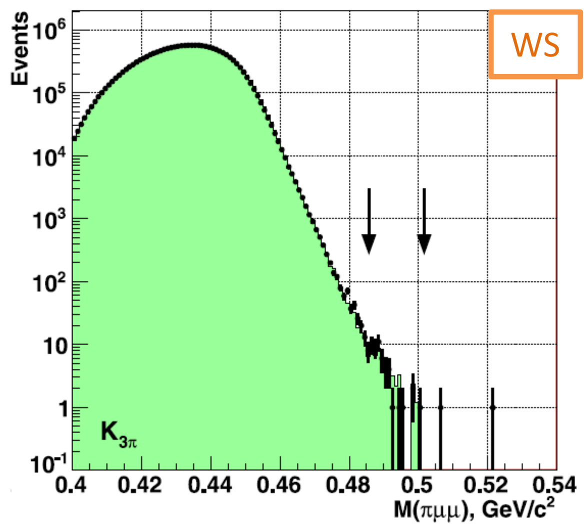
$K^{\pm} \rightarrow \pi^{\pm}\mu^{+}\mu^{-}$ analysis

- Common selection criteria for $K^{\pm} \rightarrow \pi^{\pm}\mu^{+}\mu^{-}$ and $K^{\pm} \rightarrow \pi^{\pm}\pi^{+}\pi^{-}$
  - 3 tracks in time forming a vertex within the decay volume
  - Track momenta > 10 GeV
  - Reconstructed Kaon momentum in [54;66] GeV/c
  - $p^{2}_{T} < 0.5 \times 10^{-3}$ (GeV/c)^2
- Selection criteria specific to $K^{\pm} \rightarrow \pi^{\pm}\mu^{+}\mu^{-}$:
  - One $\pi^{\pm}$ candidate with E/p<0.95
  - $\mu^{+}\mu^{-}$ pair with E/p<0.2 and associated hits in MUV
  - $|M_{\pi\pm\mu+\mu-} - M_K^{PDG}| < 8$ MeV/c^2
- Selection criteria specific to $K^{\pm} \rightarrow \pi^{\pm}\pi^{+}\pi^{-}$:
  - One $\pi^{\pm}$ candidate with E/p<0.95 (symmetrization)
  - $|M_{\pi\pm\pi+\pi-} - M_K^{PDG}| < 8$ MeV/c^2

- **Total signal sample: 3120 (2003 K^+ and 1117 K^-)**

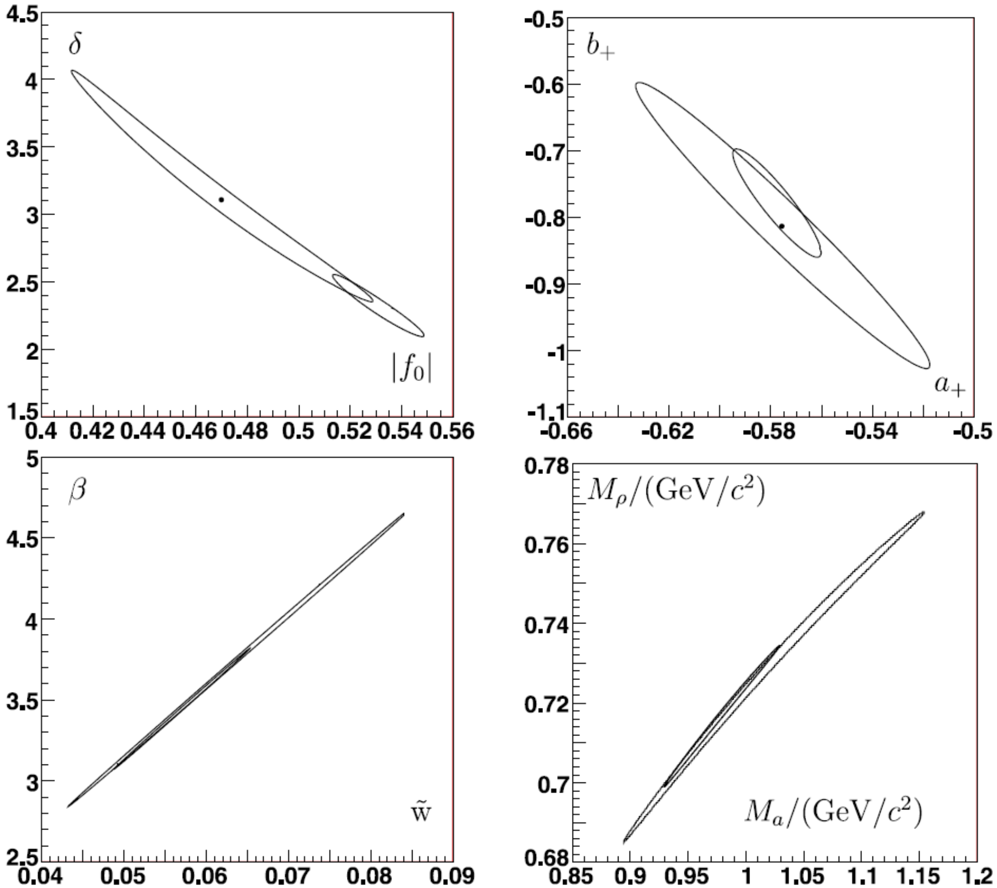
- $K_{3\pi}$ background in $K^{\pm} \rightarrow \pi^{\pm}\pi^{+}\pi^{-}$ sample:
  - $\pi \rightarrow \mu$ decay or mis-ID
  - Estimation with "wrong sign" $\pi^{\mp}\mu^{\pm}\mu^{\pm}$ events: $(3.3 \pm 0.5_{stat} \pm 0.5_{syst})\%$





$K^{\pm} \rightarrow \pi^{\pm}\mu^{+}\mu^{-}$ results

$K^{\pm} \rightarrow \pi^{\pm}\mu^{+}\mu^{-}$ form factors



Smaller ellipses from NA48/2 $K_{\pi ee}$ measurement
[PLB 677 (2009) 246]

Model independent branching fractions:

$BR(K^{\pm} \rightarrow \pi^{\pm}\mu^{+}\mu^{-}) = (9.62 \pm 0.21_{stat} \pm 0.11_{syst} \pm 0.07_{ext}) \times 10^{-8}$

E865: $(9.22 \pm 0.77) \times 10^{-8}$

HyperCP: $(9.8 \pm 1.1) \times 10^{-8}$

Charge asymmetry:

$|\Delta(K^{\pm}_{\pi\mu\mu})| < 2.9 \times 10^{-2}$ at 90% CL

5x improvement of precision

SM → 10^{-4} SUSY → 10^{-3}

Forward-Backward asymmetry:

$|A_{FB}| < 2.3 \times 10^{-2}$ at 90% CL

Limit from di-photon intermediate state and MSSM contribution: 10^{-3}

Upper limit on LNV $BR(K^{\pm} \rightarrow \pi^{\mp}\mu^{\pm}\mu^{\pm})$:

$< 1.1 \times 10^{-9}$ at 90% CL

x3 improvement on the limit

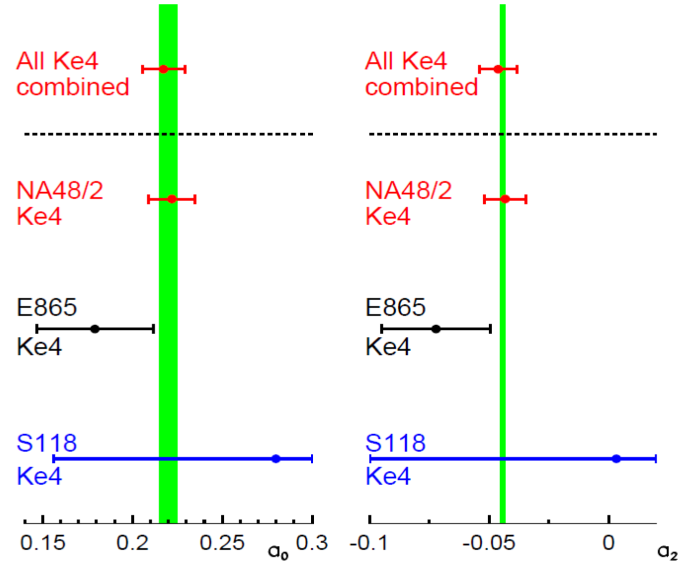
→bound on the effective Majorana neutrino mass <300 GeV/c^2

$K^{\pm}_{e4}$ in NA48

- More than 10^6 $K^{\pm}_{e4}$ collected during 2003+2004 data taking
- Final measurement of relative form factors and $\pi\pi$–scattering lengths on the total data set already published
  [EPJ C70 (2010)635]
- BR($K^{\pm}_{e4}$) is necessary to access the absolute form factors.
- Rather poor experimental knowledge on the BR($K^{\pm}_{e4}$):
  - 2.4% total error in PDG 2010
  - The most precise measurement is by BNL E865 [Phys.Rev.Lett.87:221801] based on 388k K^{+}_{e4}
  - No measurement on K^{-}_{e4} available
- NA48/2 aim: measurement of the ratio $\Gamma(K^{\pm}_{e4})/\Gamma(K_{3\pi\pm})$ with few permille precision

Relative form factors:

$f'_s/f_s =$	0.152	$\pm\, 0.007_{\rm stat}$	$\pm\, 0.005_{\rm syst}$
$f''_s/f_s =$	-0.073	$\pm\, 0.007_{\rm stat}$	$\pm\, 0.006_{\rm syst}$
$f'_e/f_s =$	0.068	$\pm\, 0.006_{\rm stat}$	$\pm\, 0.007_{\rm syst}$
$f_p/f_s =$	-0.048	$\pm\, 0.003_{\rm stat}$	$\pm\, 0.004_{\rm syst}$
$g_p/f_s =$	0.868	$\pm\, 0.010_{\rm stat}$	$\pm\, 0.010_{\rm syst}$
$g'_p/f_s =$	0.089	$\pm\, 0.017_{\rm stat}$	$\pm\, 0.013_{\rm syst}$
$h_p/f_s =$	-0.398	$\pm\, 0.015_{\rm stat}$	$\pm\, 0.008_{\rm syst}$



$\pi\pi$-scattering lengths a_0 and a_2

$K^{\pm}_{e4}$ analysis

- Common selection criteria for $K^{\pm} \rightarrow \pi^{+}\pi^{-}e^{\pm}\nu$ and $K^{\pm} \rightarrow \pi^{\pm}\pi^{+}\pi^{-}$
  - 3 tracks in time, forming a vertex within the decay volume
  - No MUV hit associated with any of the tracks
- Selection criteria specific to $K^{\pm} \rightarrow \pi^{+}\pi^{-}e^{\pm}\nu$:
  - One $e^{\pm}$ candidate with E/p>0.90 and E>3 GeV
  - Additional π-e separation via LDA
  - Two $\pi^{\pm}$ candidates with E/p<0.8 and P>5 GeV/c
  - Cuts against $K_{3\pi}$ and $K_{2\pi D}$ backgrounds
- Selection criteria specific to $K^{\pm} \rightarrow \pi^{\pm}\pi^{+}\pi^{-}$:
  - Three $\pi^{\pm}$ candidates
  - $|M_{\pi\pm\pi+\pi-} - M_K^{PDG}| < 12$ MeV/c^2
  - $|Pt| < 25$ MeV/c
  - $54 < P_K < 66$ GeV/c
- Reconstruction of $K^{\pm} \rightarrow \pi^{+}\pi^{-}e^{\pm}\nu$:
  - Impose K mass and find the two solutions for P_K
  - Pick the closest to 60 GeV/c
  - $54 < P_K < 66$ GeV/c
- $K_{3\pi\pm}$ background in $K^{\pm} \rightarrow \pi^{+}\pi^{-}e^{\pm}\nu$ sample:
  - Estimated with wrong sign events: $e^{\mp}\pi^{\pm}\pi^{\pm}$
  - Suppressed by 10^{-10} due to $\Delta S = \Delta Q$
  - Background = 2 x WS

$$BR(K_{e4}) = \frac{N_4 - N_{BG}}{N_3} \times \frac{A_3}{A_4} \times \frac{\varepsilon_3}{\varepsilon_4} \times BR(K_{3\pi\pm})$$

INGREDIENTS:

N_4 → selected Ke4 candidates: **1.11×10^6**

7.12×10^5 K^+ and 3.97×10^5 K^-

N_{BG} → background to K_{e4}: 0.95%

N_3 → selected $K_{3\pi}$ candidates: 1.9×10^9

Acceptances (Geant3 based simulation used):

A_4 → acceptance of K_{e4}: 18.22%

A_3 → acceptance of $K_{3\pi}$: 24.18%

Trigger efficiencies (measured):

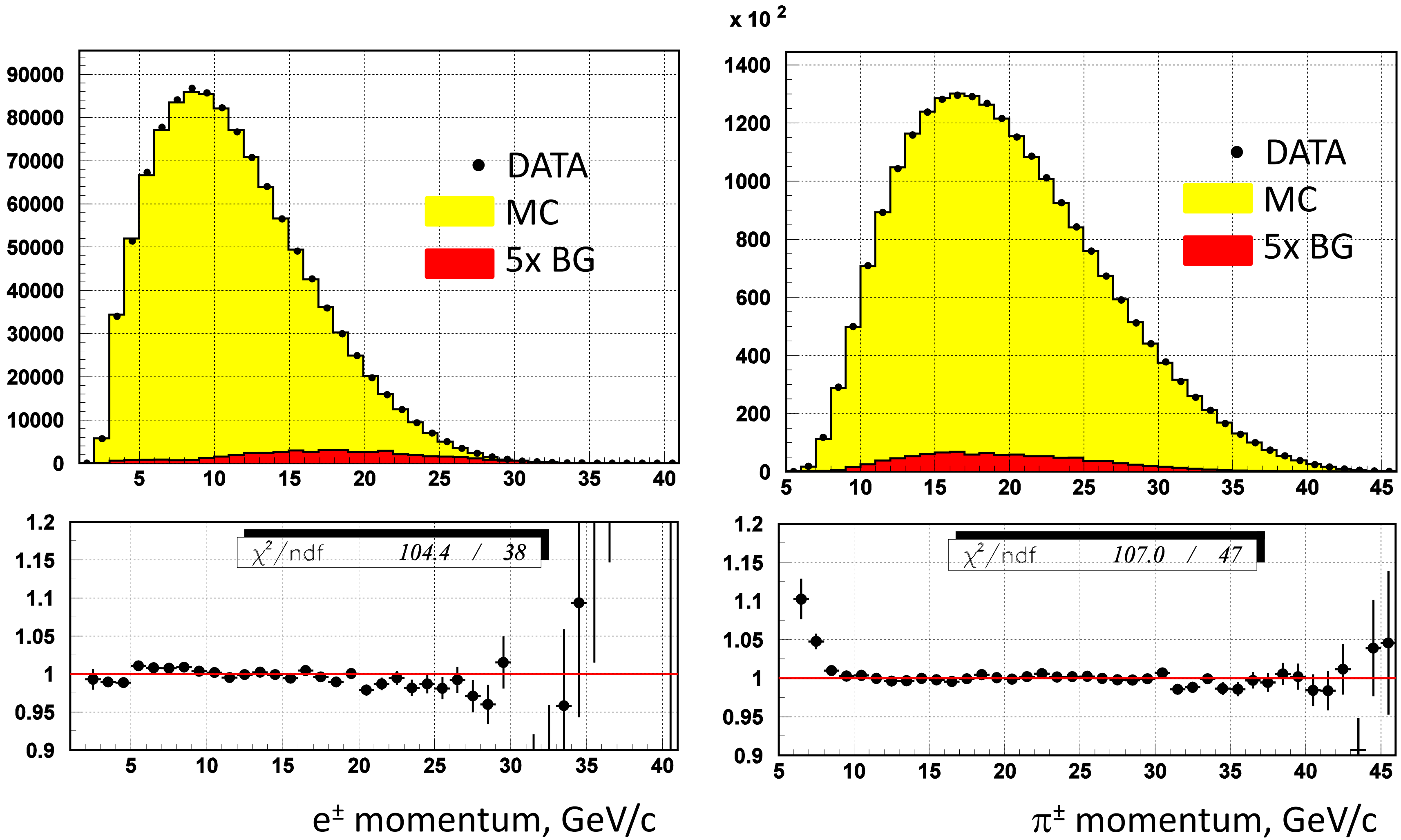
ε_3 → for K_{e4}: 98.3%

ε_4 → for $K_{3\pi}$: 97.5%

Branching ratio of $K_{3\pi\pm}$: (5.59 ± 0.04)%

0.72% external error on $BR(K_{e4})$

DATA/MC comparisons



Preliminary result BR(Ke4)

BR(K_{e4}) calculated separately for each data-set, for K^+ and K^-, and then averaged:

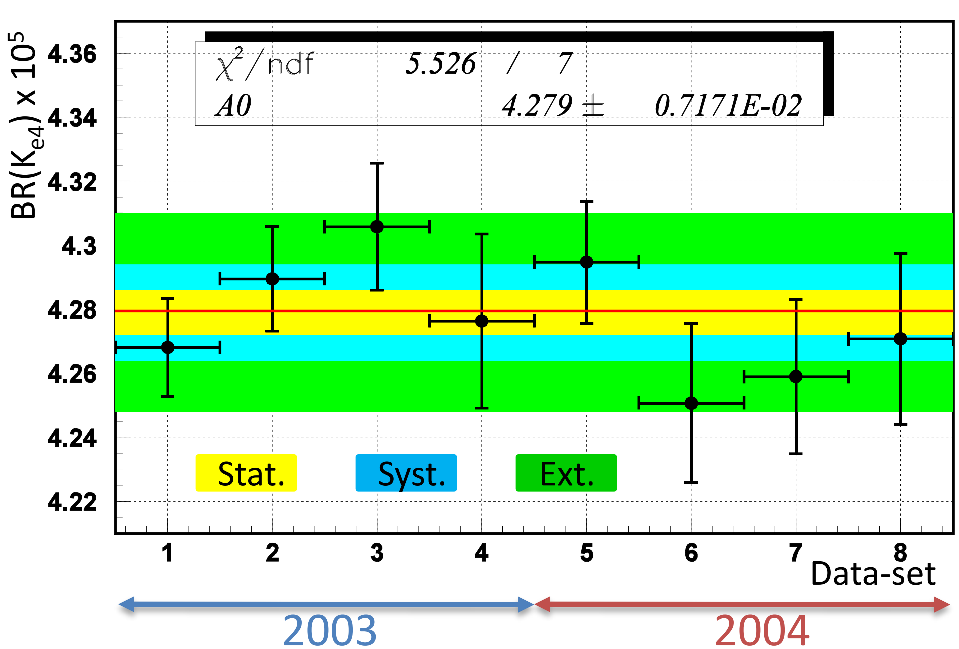
BR($K^{\pm}_{e4}$) = $(4.279 \pm 0.004_{stat} \pm 0.005_{trig(stat)} \pm 0.015_{syst} \pm 0.031_{ext}) \times 10^{-5}$

= $(4.279 \pm 0.035_{tot}) \times 10^{-5}$ (0.8%)

BR(K^{+}_{e4}) = $(4.277 \pm 0.009_{stat+trig}) \times 10^{-5}$

BR(K^{-}_{e4}) = $(4.283 \pm 0.012_{stat+trig}) \times 10^{-5}$

PDG 2010 $(4.09 \pm 0.10)\times 10^{-5}$ (2.4%)



Source	Uncertainty [%]
Acceptance and beam geometry	0.18
Muon vetoing	0.16
Accidental activity	0.15
Background	0.14
Particle ID	0.09
Radiative effects	0.08
Independent analysis	0.10

Measurement with 0.4% precision:

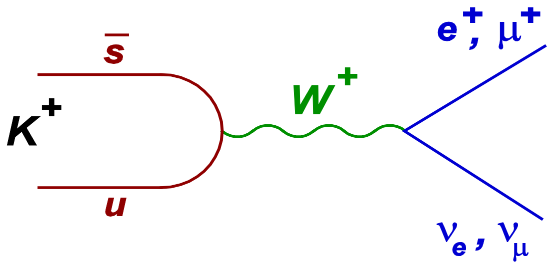
$\Gamma(K_{e4})/\Gamma(K_{3\pi}) = (7.654 \pm 0.030_{tot}) \times 10^{-4}$

PDG: $(7.31 \pm 0.16) \times 10^{-4}$ (2.1%)

LFV test with NA62 - Motivation

- The ratio of K_{e2} and $K_{\mu 2}$ decays is sensitive to LFV
- R_K in Standard Model:

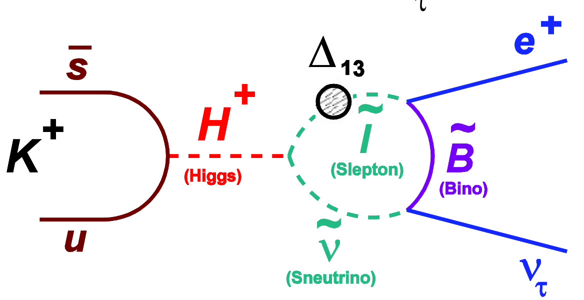
$$R_K = \frac{\Gamma(K^\pm \to e^\pm \upsilon)}{\Gamma(K^\pm \to \mu^\pm \upsilon)} = \frac{m_e^2}{m_\mu^2} \cdot \left(\frac{m_K^2 - m_e^2}{m_K^2 - m_\mu^2} \right)^2 \cdot \left(1 + \delta R_K^{\text{rad.corr.}}\right)$$



  - Hadronic uncertainties cancel in the ratio
  - Helicity suppression ($f \sim 10^{-5}$)
  - Radiative correction (few %) due to $K^+ \to e^+ \nu\gamma$ (IB) process, by definition included into R_K
- SM prediction with 0.04% accuracy: **$R_K^{SM} = (2.477 \pm 0.001) \times 10^{-5}$** *[Phys. Lett. 99 (2007) 231801]*
- R_K sensitive to New Physics
- In MSSM – H^+ mediated lepton flavor violating contribution with emission of ν_τ.

[PRD 74 (2006) 011701, JHEP 0811 (2008) 042]

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



- Example: with $|\Delta_{13}|=5\times10^{-4}$, $\tan\beta=40$, $M_H=500$ GeV/c^2, the enhancement is **experimentally accessible** (1.3%)

R_K - experimental status

- PDG'08 average (1970s measurements):

  $R_K=(2.45\pm0.11)\times10^{-5}$ ($\delta R_K/R_K=4.5\%$)

- Recent improvement: KLOE (Frascati)
  - Data collected in 2001–2005
  - 13.8K K_{e2} candidates, 16% background

  $R_K=(2.493\pm0.031)\times10^{-5}$ ($\delta R_K/R_K=1.3\%$)

  [arXiv:0907:3594]

NA62 (phase I) goal:
dedicated data taking strategy, **~150K K_{e2}** candidates, **<10%** background, **$\delta R_K/R_K<0.5\%$** as needed for stringent SM test.

Measurement strategy

- $K_{e2}/K_{\mu2}$ candidates are collected simultaneously:
  - no dependence on K flux;
  - cancellation of several effects at first order.

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

Selected K_{l2} candidates

Background events

Acceptances (MC)

ID eff.

Trigger eff.

Downscaling of $K_{\mu2}$ trigger

Global LKr eff. f_{LKr}=0.9980(3)

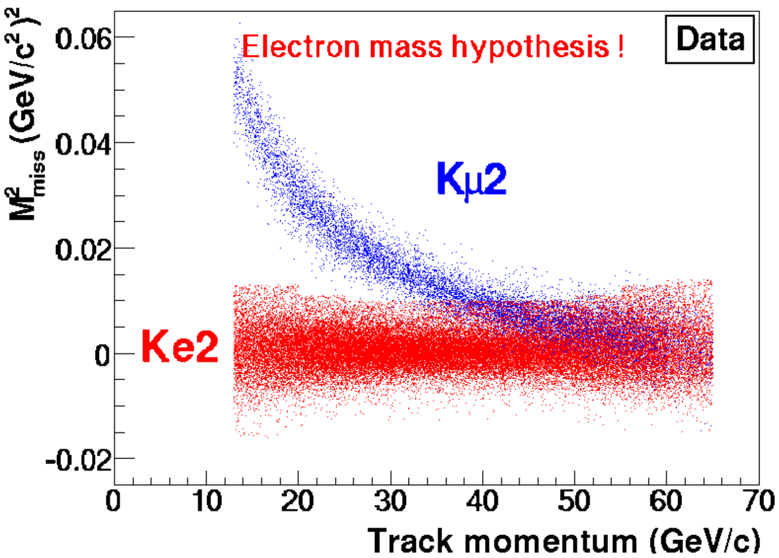
- R_K calculated in 10 lepton momentum bins (strong dependencies of backgrounds)
- Main source of systematic errors: **$N_B(K_{e2})$**

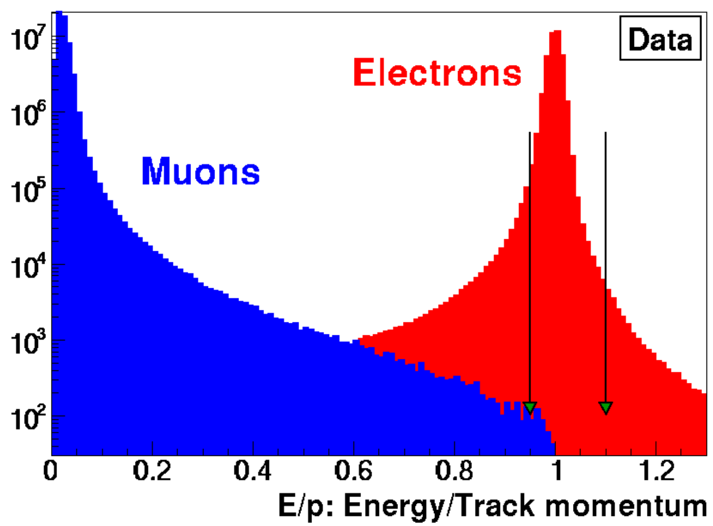
K_{e2} and $K_{\mu 2}$ selection

- **Common selection part:**
  - one reconstructed track;
  - geometrical acceptance cuts;
  - decay vertex defined as closest approach of track and nominal kaon axis;
  - veto extra LKr energy deposition;
  - track momentum 13 < p < 65 GeV/c

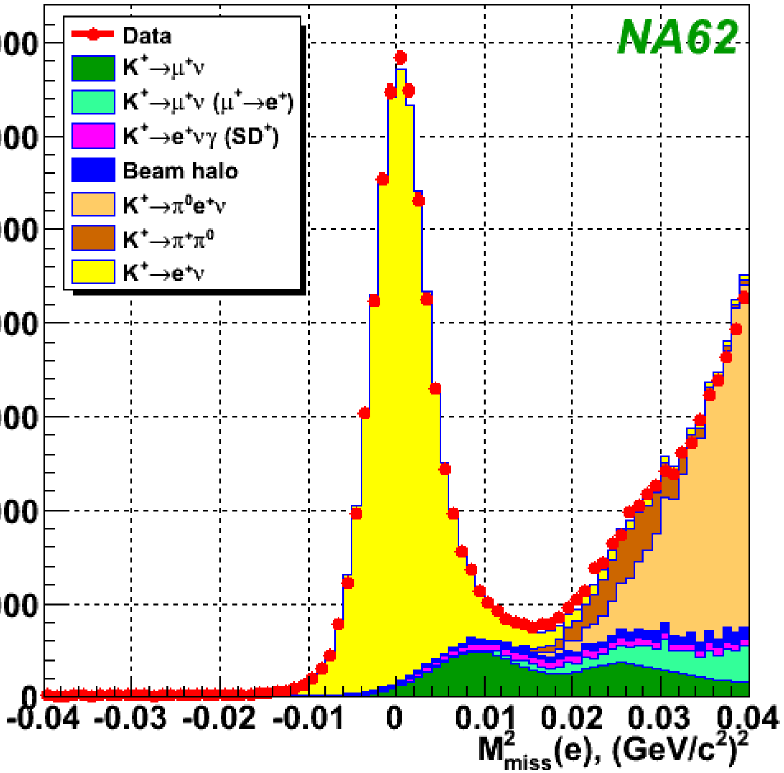
- **Kinematic separation:**
  - Missing mass: $M^2_{miss} = (P_K - P_l)^2$
  - P_K average measured by $K_{3\pi}$
  - Sufficient separation at p < 35 GeV/c

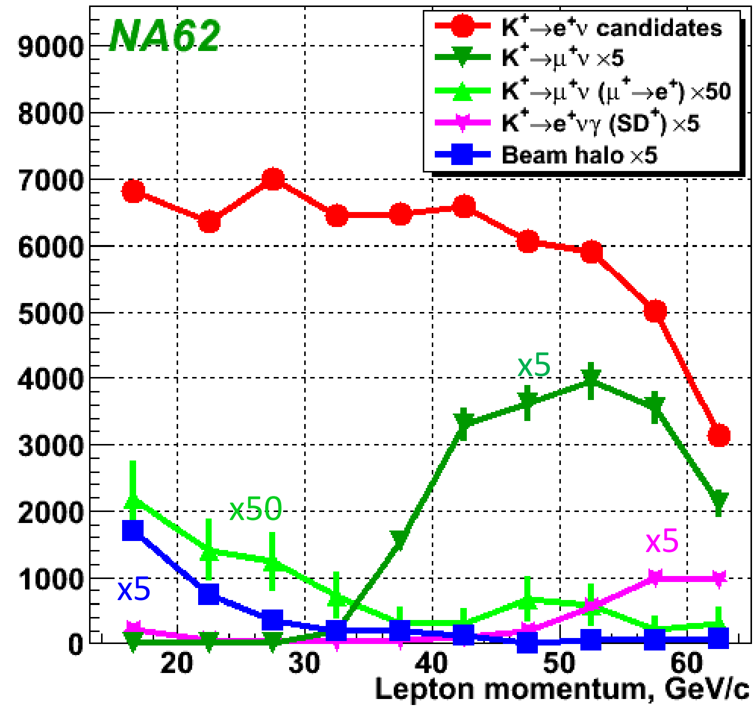
- **Particle ID:**
  - E/p (energy in LKr/track momentum)
    - For electrons: 0.95 < E/p < 1.1
    - For muons: E/p < 0.85
  - Suppression of $\mu^\pm$ in $e^\pm$ sample by $x10^6$





K_{e2} events and background

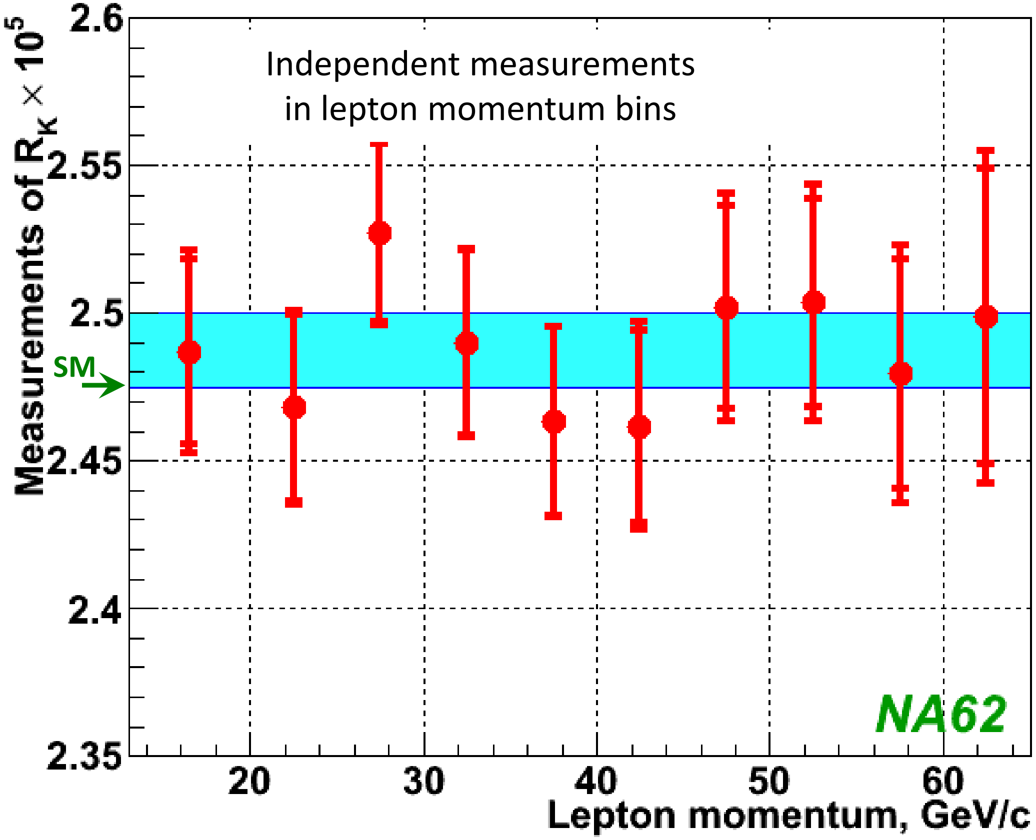




40% of the total data set
59813 K_{e2}^+ candidates
(99.27 ± 0.05)% electron ID efficiency
(8.71 ± 0.24)% B/(S+B)

Source	B/(S+B)
$K_{\mu 2}$	(6.11±0.22)%
$K_{\mu 2}$ ($\mu \to e$)	(0.27±0.04)%
$K_{e2\gamma}$ (SD$^+$)	(1.07±0.05)%
Beam halo	(1.16±0.06)%
$K_{e3(D)}$	(0.05±0.03)%
$K_{2\pi(D)}$	(0.05±0.03)%

The NA62 result



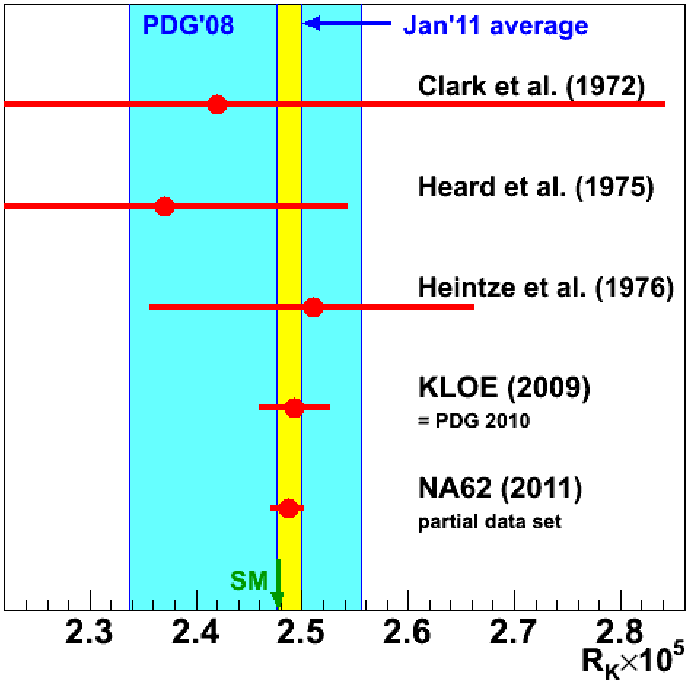
Uncertainties

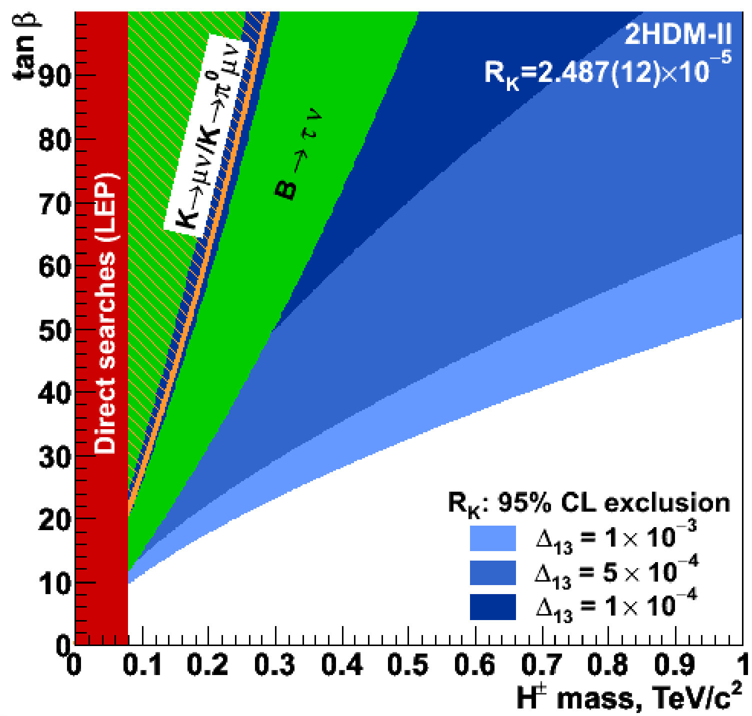
Source	$\delta R_K \times 10^5$
Statistical	0.011
$K_{\mu 2}$ background	0.005
Beam halo	0.001
$K_{e2\gamma}$ (SD^+) background	0.001
K_{e3} and $K_{2\pi}$ background	0.001
Helium purity	0.003
Positron ID	0.001
DCH alignment	0.001
Acceptance	0.002
1-track trigger	0.002
LKr readout inefficiency	0.001
Total	**0.013**

$$R_K = (2.487 \pm 0.011_{stat} \pm 0.007_{syst}) \times 10^{-5}$$
$$= (2.487 \pm 0.013) \times 10^{-5}$$

0.5% precision

R_K - Summary





Exclusion limits at 95% CL derived from the new R_K world average

World average	$\delta R_K \times 10^5$	Precision
March 2009	2.467±0.024	0.97%
Today	2.487±0.012	0.48%

R_K measurements are currently in agreement with the SM expectation within 1σ.

The whole 2007 sample of NA62 experiment will allow statistical uncertainty **~0.3%** and total uncertainty of **~0.4%**.

Summary

- New results from NA48 and NA62 experiments presented.

- $K^{\pm}_{\mu 3}$ form factors measured with high precision: [preliminary]
  - with K^{+} for the first time
  - competitive measurement with high precision
  - $K^{\pm}_{e3}$ analysis in progress

- Many measurements from $K^{\pm} \rightarrow \pi^{\pm}\mu^{+}\mu^{-}$ decays with improved precision [for full details: PLB 697 (2011) 107].

- BR($K^{\pm}_{e4}$) measured with 3x better precision (and for the first time for K^{-}): [preliminary]
  - 0.4% measurement of the ratio $\Gamma(K^{\pm}_{e4})/\Gamma(K_{3\pi\pm})$;
  - absolute form factors coming soon;
  - BR(K^{00}_{e4}) and form factors coming soon;
  - possibility to complete the K_{l4} picture within NA48 with measurements of $K^{\pm}_{\mu 4}$ and $K^{00}_{\mu 4}$ branching ratios and form factors.

- The final R_K result on 40% of the data set already published: [arXiv:1101.4805[hep-ex], accepted by PLB]
  - 0.5% precision achieved, result consistent with SM prediction;
  - final result on full data set coming soon.

- Currently the future program of NA62 is in an active preparation:
  - measurement of ultra-rare $K^{+} \rightarrow \pi^{+}\nu\nu$ decay (BR ~ 10^{-10} → 10% precision)

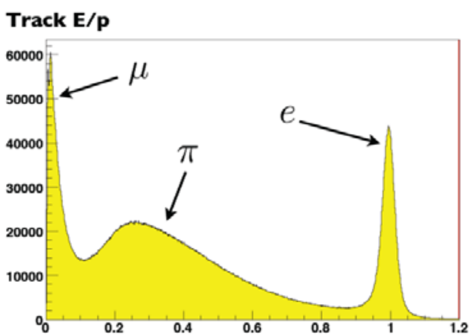
Spares

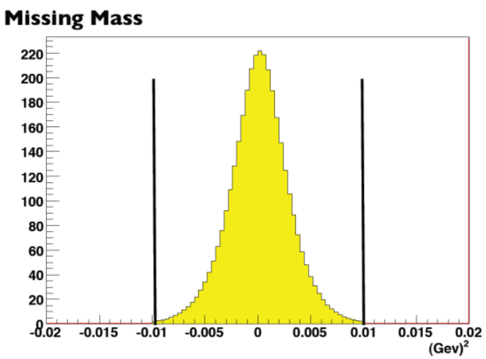
$K^{\pm}_{\mu3}$ Form Factors Analysis

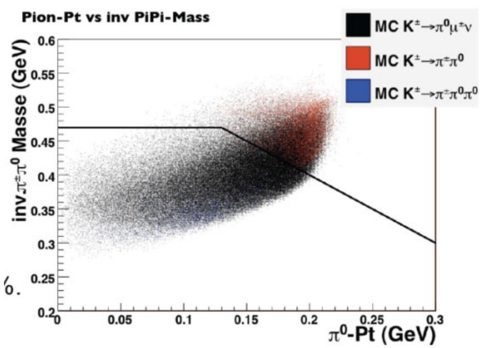
- Selection
  - 1 good track with P>10 GeV/c
  - Muon ID → MUV hit and E/p
  - 1 good $\pi^0 \rightarrow \gamma\gamma$ with $|m_{\gamma\gamma} - m_{\pi0}| < 10$ MeV
- Reconstruction:
  - Timing between photon clusters and muon track
  - Missing mass calculation with $K_{\mu3\pm}$ hypothesis
    $M^2_{miss} = (P_K - P_\mu - P_{\pi0})^2$; $|M^2_{miss}| < 10$ MeV^2

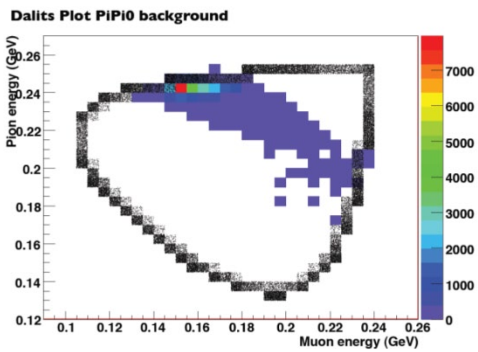
- **Selected $K^{\pm}_{\mu3}$ events: 3.4 x 10^6**

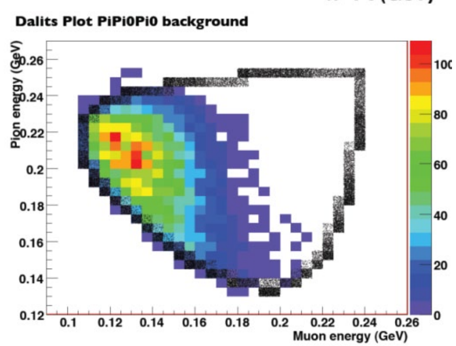
- $\pi\pi^0$ background:
  - $\pi \rightarrow \mu$ or mis-ID can fake $K^{\pm}_{\mu3}$
  - w/o suppression it is 20%
  - cut in $(M_{\pi\pi0}, P^t_{\pi})$ space helps to reduce it to 0.6%
  - well localized on the Dalitz-plot
- $\pi\pi^0\pi^0$ background:
  - small contribution (0.14%)
  - no dedicated cut → accounted in the fit
- Radiative effects:
  - Simulation with C. Gatti code provided by KLOE [EPJ C45 (2006) 417]
  - Small effect on $K^{\pm}_{\mu3}$ acceptance
  - 1% effect on Dalitz plot slope

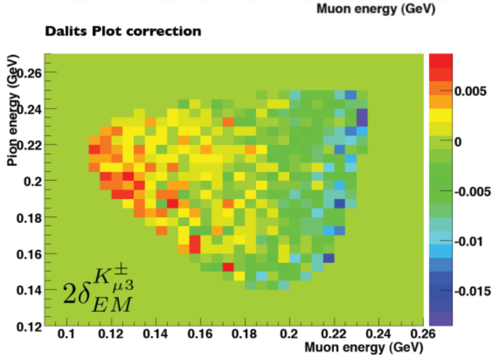












$K^{\pm} \to \pi^{\pm}\mu^{+}\mu^{-}$ form factors

Model (1) $\rho(|f_0|, \delta) = -0.993$ $\chi^2/\text{ndf} = 12.0/15$

$|f_0| = 0.470 \pm 0.039_{\text{stat.}} \pm 0.006_{\text{syst.}} \pm 0.002_{\text{ext.}} = 0.470 \pm 0.040$

$\delta = 3.11 \pm 0.56_{\text{stat.}} \pm 0.11_{\text{syst.}} = 3.11 \pm 0.57$

Model (2) $\rho(a_+, b_+) = -0.976$ $\chi^2/\text{ndf} = 14.8/15$

$a_+ = -0.575 \pm 0.038_{\text{stat.}} \pm 0.006_{\text{syst.}} \pm 0.002_{\text{ext.}} = -0.575 \pm 0.039$

$b_+ = -0.813 \pm 0.142_{\text{stat.}} \pm 0.028_{\text{syst.}} \pm 0.005_{\text{ext.}} = -0.813 \pm 0.145$

Model (3) $\rho(\tilde{w}, \beta) = 0.999$ $\chi^2/\text{ndf} = 13.7/15$

$\tilde{w} = 0.064 \pm 0.014_{\text{stat.}} \pm 0.003_{\text{syst.}} = 0.064 \pm 0.014$

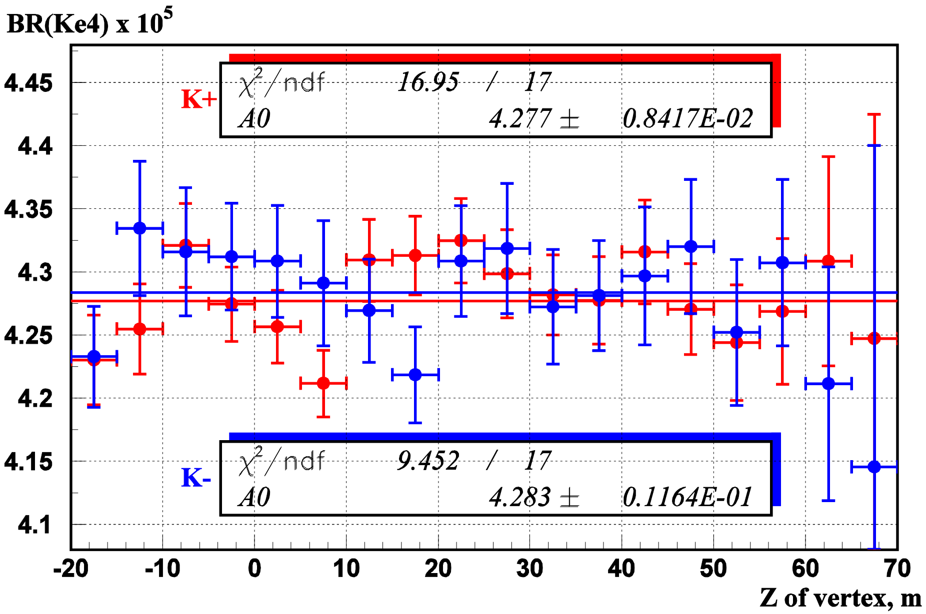
$\beta = 3.77 \pm 0.61_{\text{stat.}} \pm 0.12_{\text{syst.}} \pm 0.02_{\text{ext.}} = 3.77 \pm 0.62$

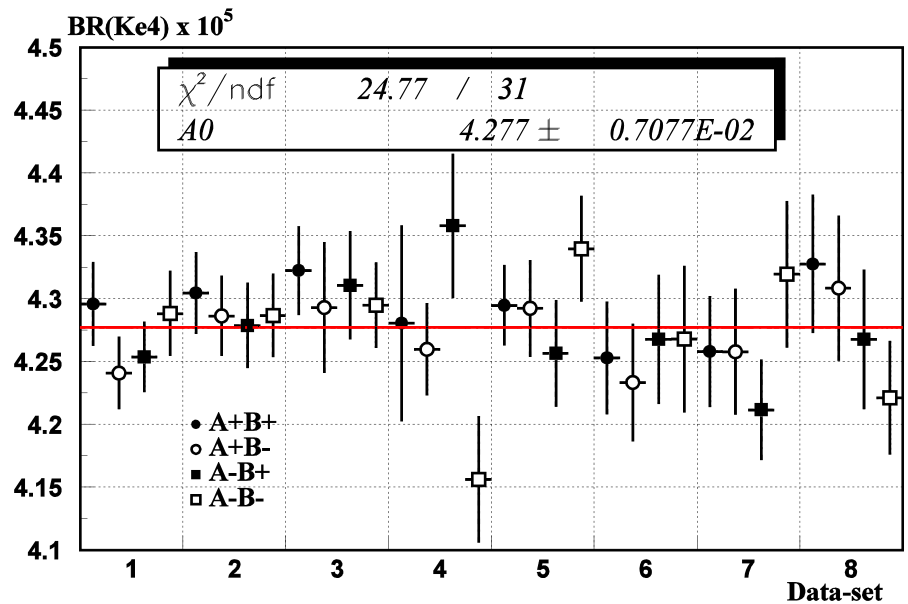
Model (4) $\rho(M_a, M_\rho) = 0.999$ $\chi^2/\text{ndf} = 15.4/15$

$M_a/(\text{GeV}/c^2) = 0.993 \pm 0.083_{\text{stat.}} \pm 0.016_{\text{syst.}} \pm 0.001_{\text{ext.}} = 0.993 \pm 0.085$

$M_\rho/(\text{GeV}/c^2) = 0.721 \pm 0.027_{\text{stat.}} \pm 0.005_{\text{syst.}} \pm 0.001_{\text{ext.}} = 0.721 \pm 0.028$

BR(Ke4) - Stability of the result





Acceptance of K_{e4} and $K_{3\pi}$ is Z_{vtx} dependent
Perfect stability both for K^+ and K^-

The magnet polarities in the beam line (A) and in the spectrometer (B) were periodically reversed (for charge asymmetry measurements)