NORTHWESTERN UNIVERSITY

NA48/2 Results on Charged Semileptonic Decays

(Ke3, Kμ3)

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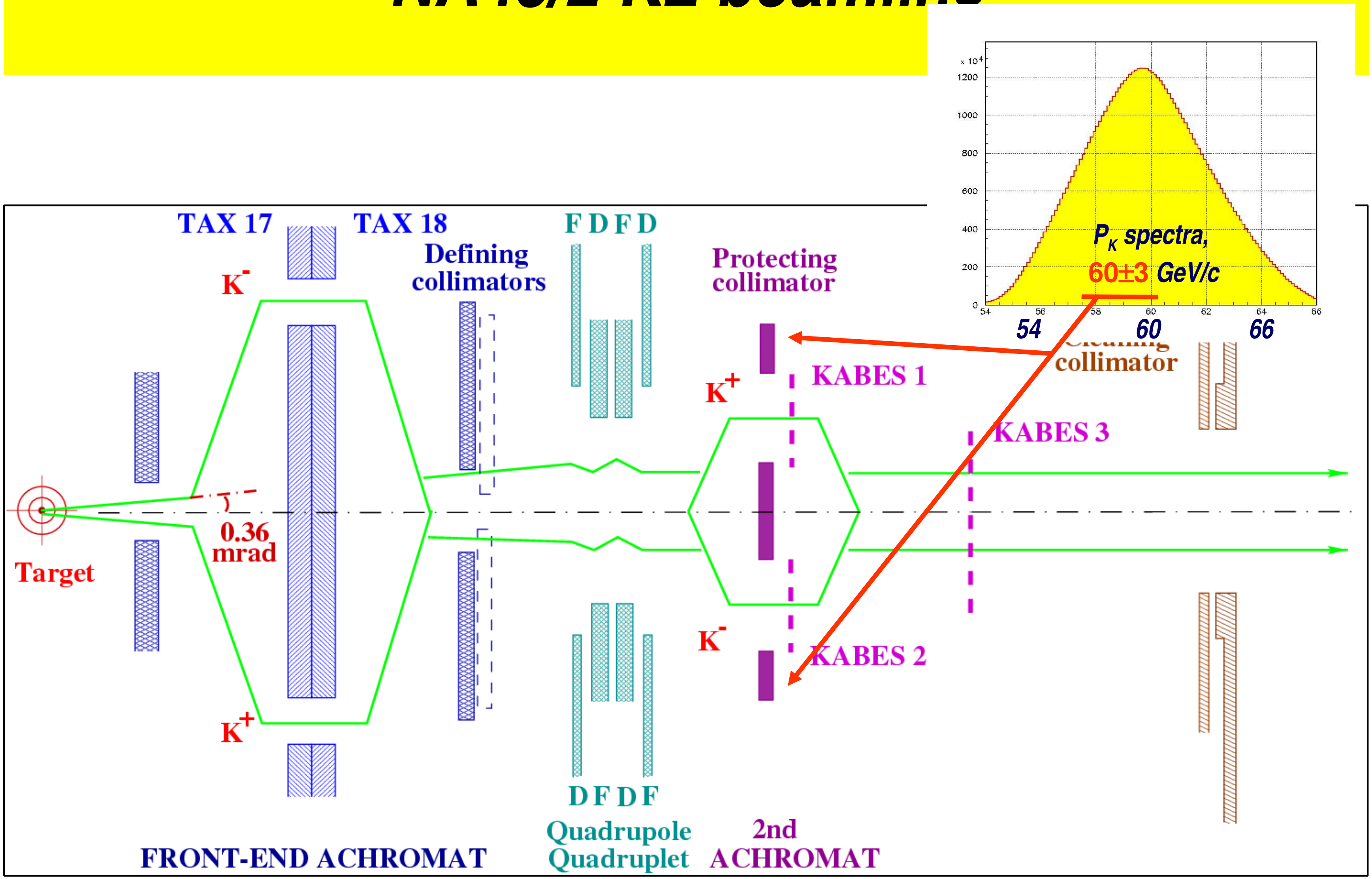
on behalf of the NA48/2 Collaboration

PANIC 05, October 24, 2005

NA48/2 K± beamline



NA48 Detector

Muon system:

s(t) ~ 350 ps

Spectrometer:

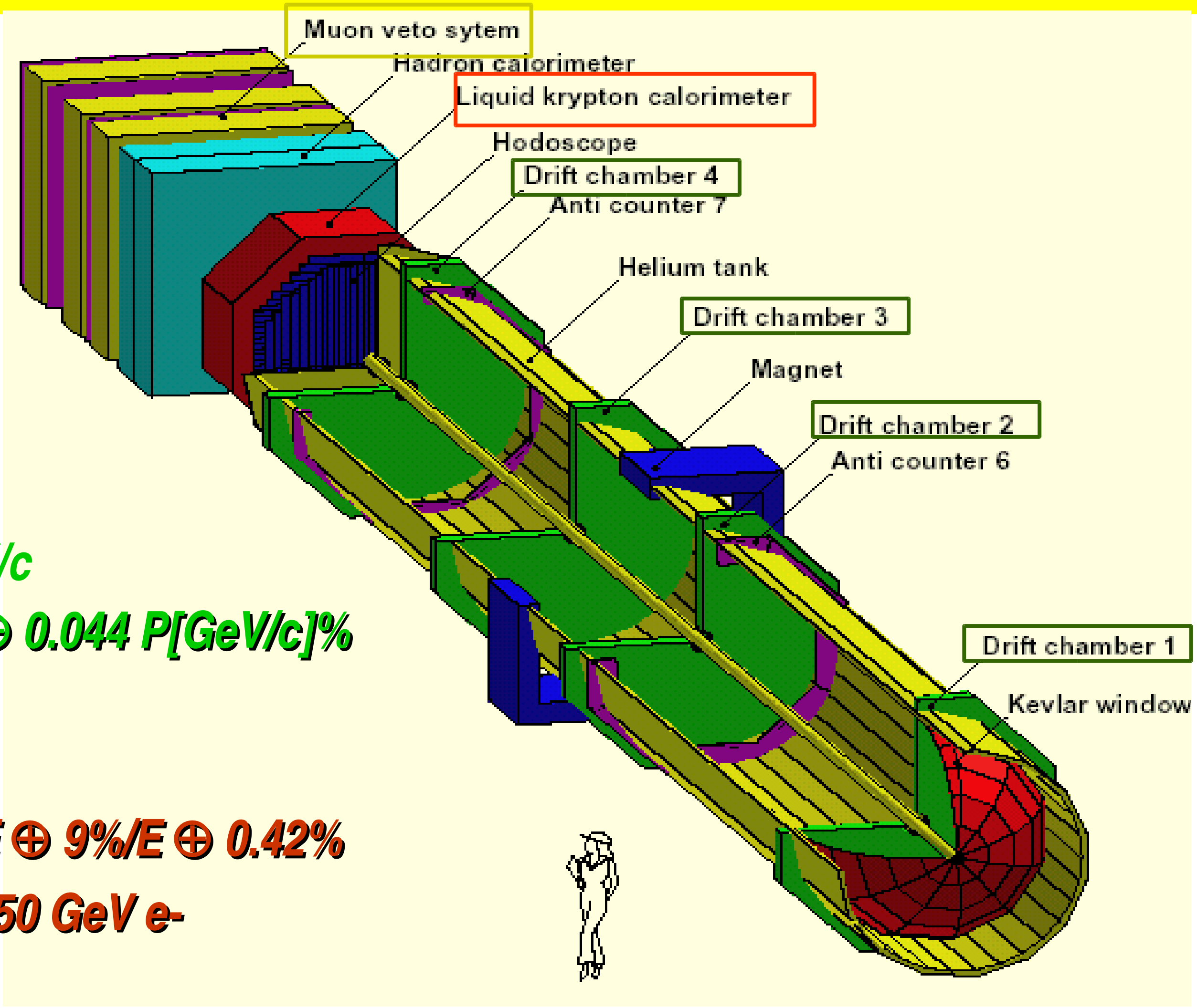
p_T kick ~120 MeV/c

$\sigma(P)/P \cong 1.02\% \oplus 0.044\ P[GeV/c]\%$

LKr Calorimeter:

$\sigma(E)/E \cong 3.2\%/\sqrt{E} \oplus 9\%/E \oplus 0.42\%$

s(t) ~ 265 ps for 50 GeV e-



Measurement of Br ($K^{\pm} \rightarrow \pi^0 e^{\pm} \nu$)

Measurement method:

- Normalize $K^{\pm}_{e3}$ events to $K^{\pm} \to \pi^{\pm}\pi^{0}$ events.

  (Br($K^{\pm} \to \pi^{\pm}\pi^{0}) = 0.2113 \pm 0.0014$)

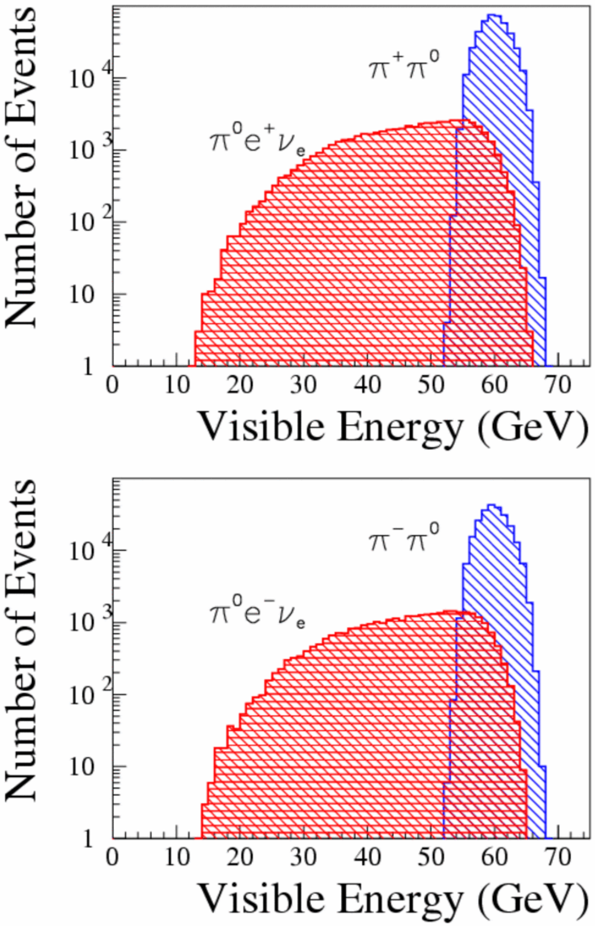
Data sample:

- Low intensity special run (8 hours) with minimum bias hodoscope trigger ($\epsilon_{\text{trigger}} \approx 99.8\%$)

- Selected events:

K^{+}_{e3}	59 k
K^{-}_{e3}	33 k
$K^{+} \to \pi^{+}\pi^{0}$	468 k
$K^{-} \to \pi^{-}\pi^{0}$	260 k

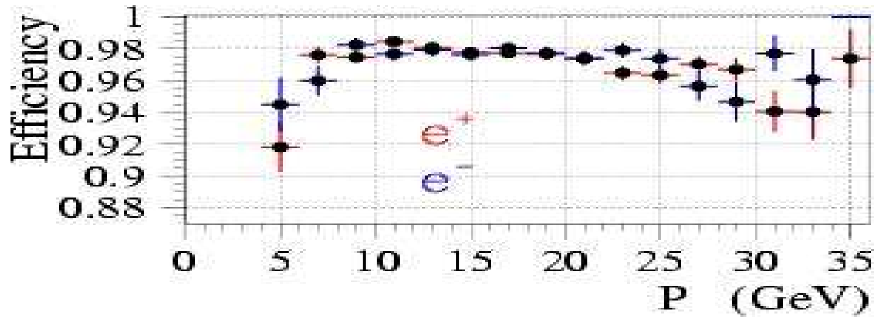
- Practically background-free.



Sample selection:
Electron and pion ID, Kaon mass cut

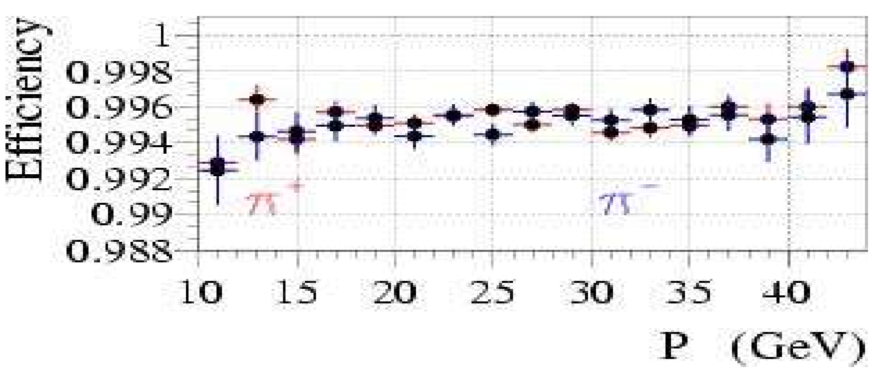
Electron: E/p > 0.95

Global efficiency (97.37±0.09) %

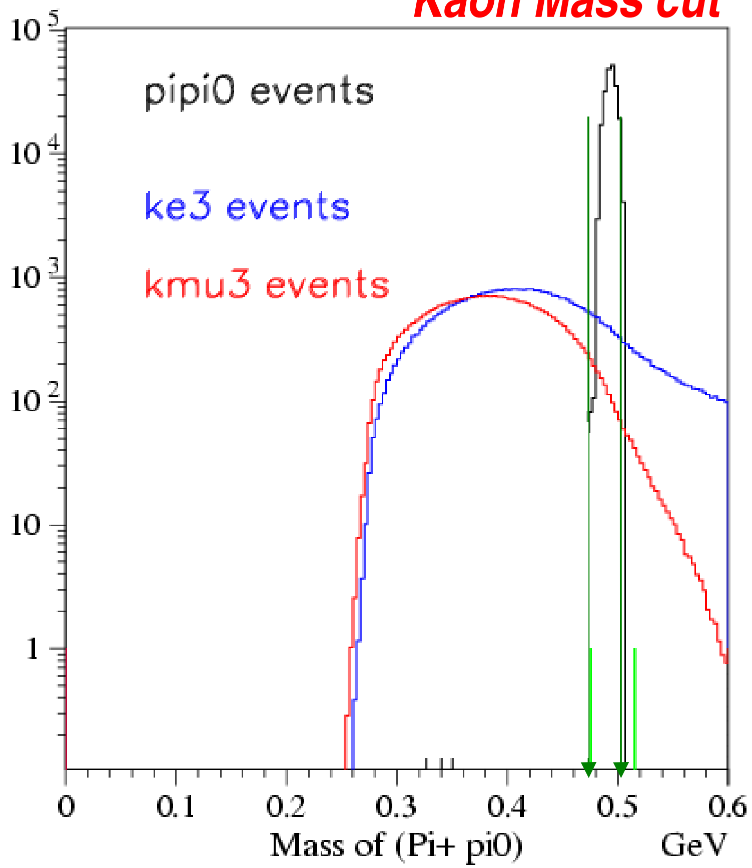


Pion: E/p < 0.95

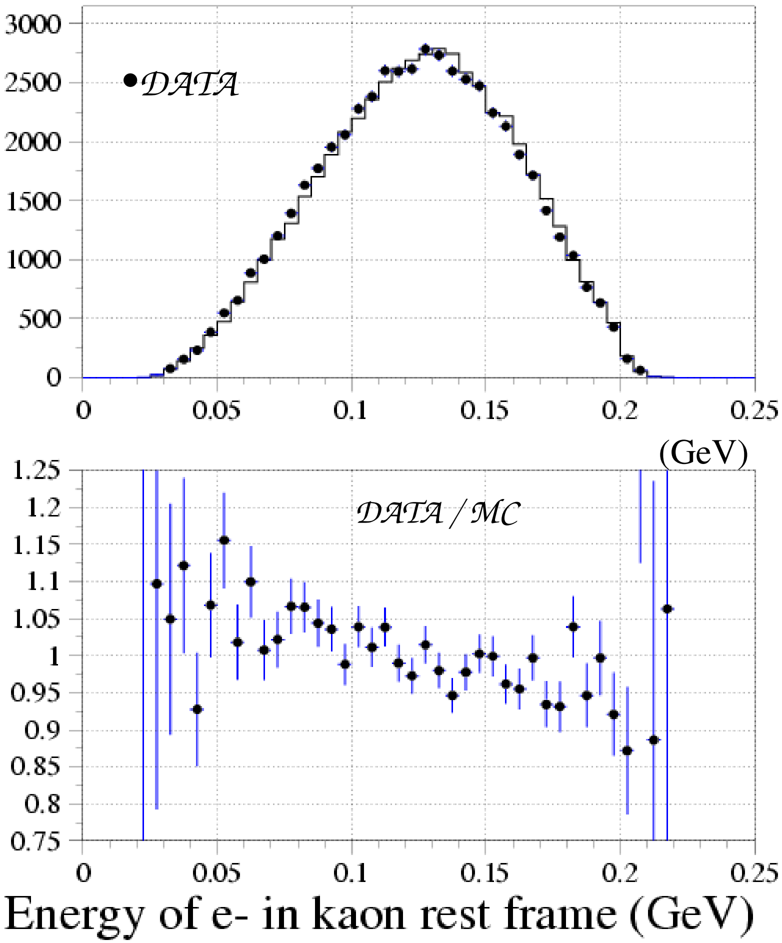
Global efficiency (99.522±0.001)%



Kaon Mass cut

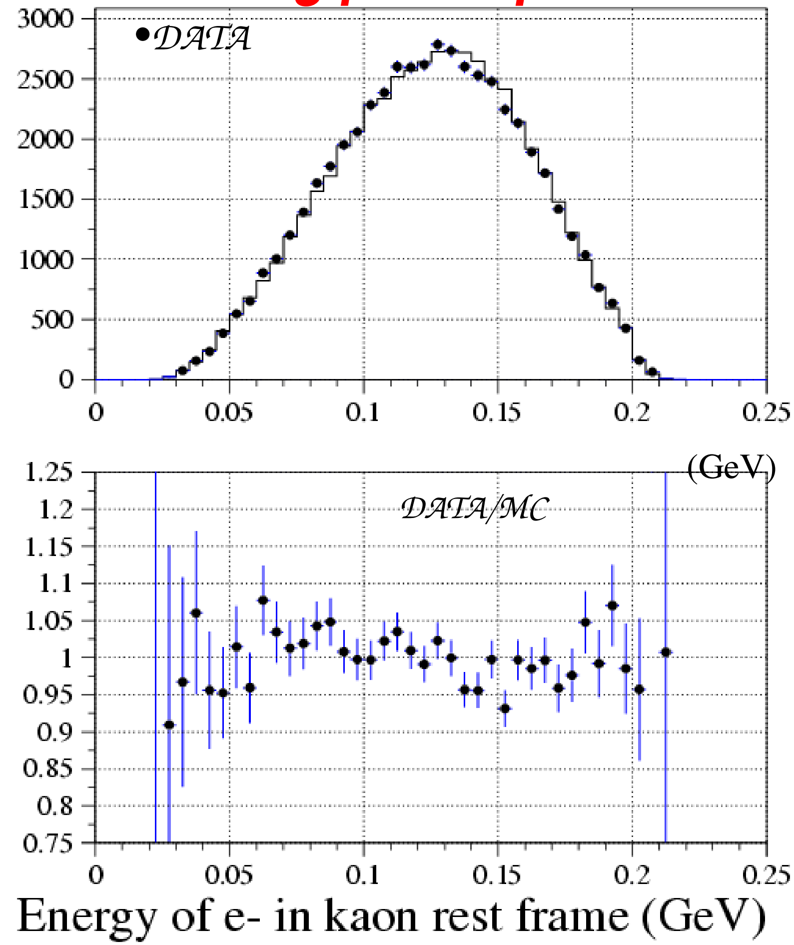


Radiative Corrs: Data/MC for $K^{\pm} \rightarrow \pi^{0} e^{\pm} \nu$



Without radiative corrections

Ginsberg prescription



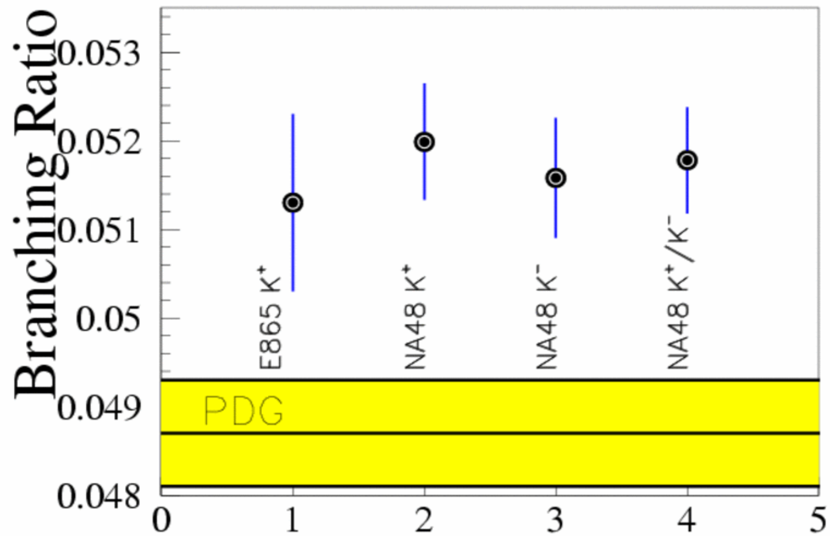
With radiative corrections

Preliminary **NA48/2 result** on $K^{\pm} \to \pi^0 e^{\pm} \nu$:

$$\text{Br}(K^{\pm} \to \pi^0 e^{\pm} \nu) = (5.14 \pm 0.02_{\text{stat}} \pm 0.06_{\text{syst}})\ \%$$

Systematics:

	σ_{syst}
* Detector acceptance	$\pm 0.038\%$
Trigger efficiency	$\pm 0.004\%$
* $\text{Br}(K^{+} \to \pi^{+}\pi^{0})$	$\pm 0.034\%$
* Radiative events	$\pm 0.006\%$
* MC statistics	$\pm 0.022\%$
Total systematics	$\pm 0.056\%$
Statistical uncertainty	$\pm 0.017\%$



*) ***For final result expect total syst. error ~ 0.0013 x Br(ππ)***

*) ***Error will be reduced in the future by NA48***

PDG

Measurement of Br ($K^{\pm} \rightarrow \pi^0 \mu^{\pm} \nu$)

Muon ID: *cross checked with 2 different methods*

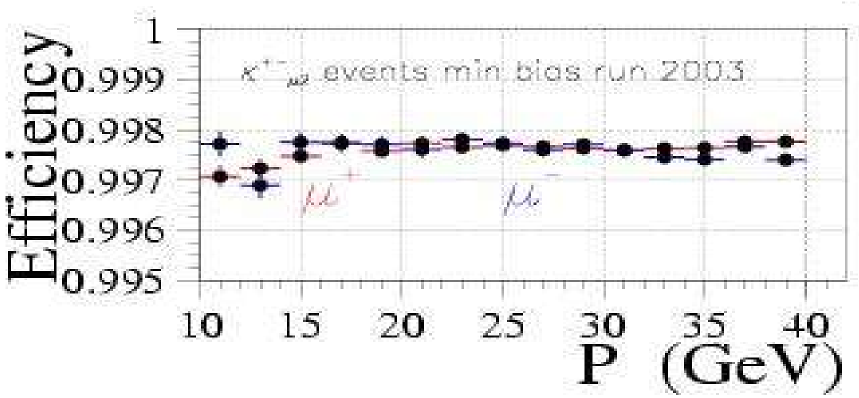
1. Using Muon Detector (standard)

2. Using the minimum ionizing particle signal in calorimeters

Method 1

Using the Muon Detector,

- *a hit in time with the hodoscopes of 2ns*



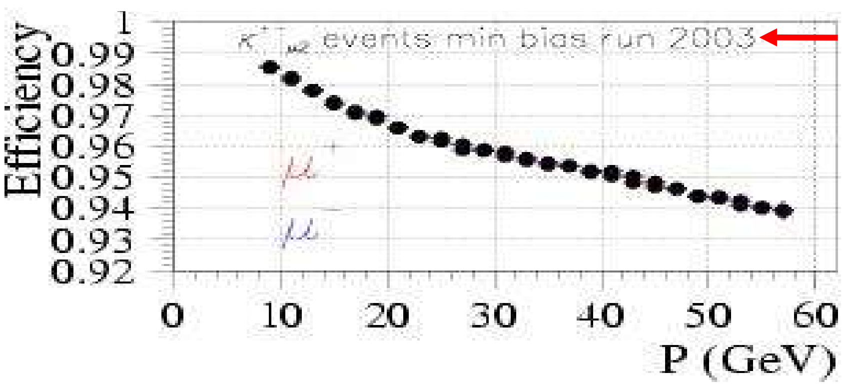
Global Efficiency:

(99.763 ± 0.002)%

Method 2:

Signals in Calorimeters :

- *LKr (cluster<1.5 GeV) & HAC (cluster<5 GeV)*



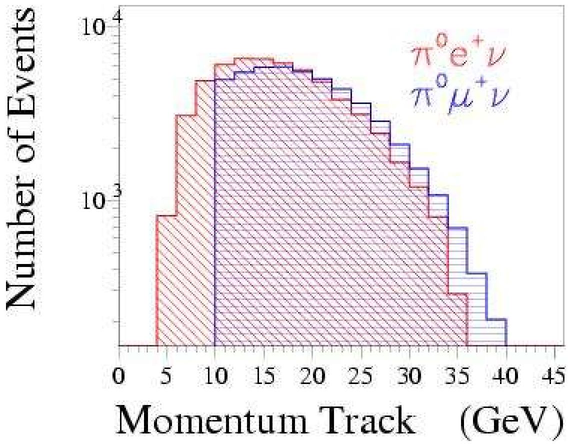
Global efficiency:

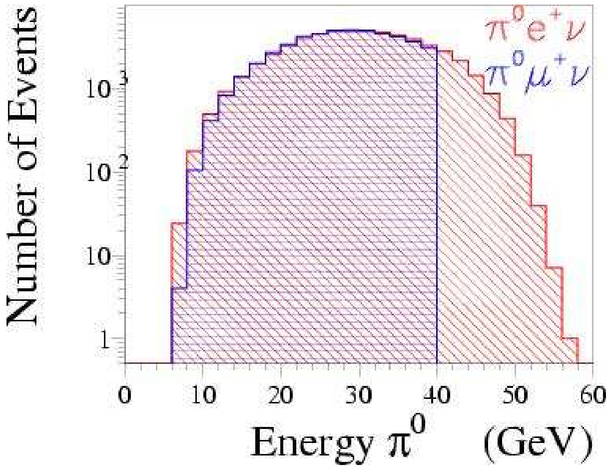
(96.16 ± 0.01) %

$K^{\pm} \rightarrow \pi^0 \mu^{\pm} \nu$ *sample selection*

Keep $\pi^0\mu^{\pm}\nu$ selection criteria as close as possible to $\pi^0 e^{\pm}\nu$

Selected Events	
$\pi^0 e^+ \nu$	*59K*
$\pi^0 e^- \nu$	*33K*
$\pi^0 \mu^+ \nu$	*50K*
$\pi^0 \mu^- \nu$	*27K*





Some relevant differences:

1. Particle ID – track momentum cuts,

2. Mass dependent kinematic distributions: track and π^0 (CM) energy,

3. Radiative corrections: Ke3 ~ 0.2% vs. $K\mu3$ ~ 0.02%,

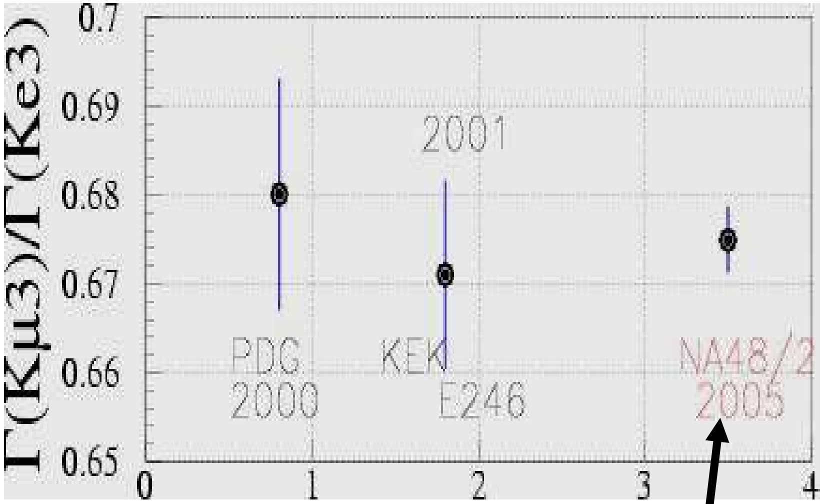
4. Form factor parameterization: $K\mu3$ depends on both λ_+ and λ_0.

Result for $\Gamma(K\mu3)/\Gamma(Ke3)$

NA48/2: Br ($K\mu^{\pm}3$) / Br ($Ke^{\pm}3$) =

0.6749 ± 0.0035 (stat) ± 0.0011 (syst) ± 0.0021 (syst λ_+,λ_0)

Systematics include	
Trigger efficiency	0.0004
MC statistics and particle ID efficiency	0.0011
Background subtraction	< 0.0001
Stability of result under change of $\lambda+$, λ_0	0.0021

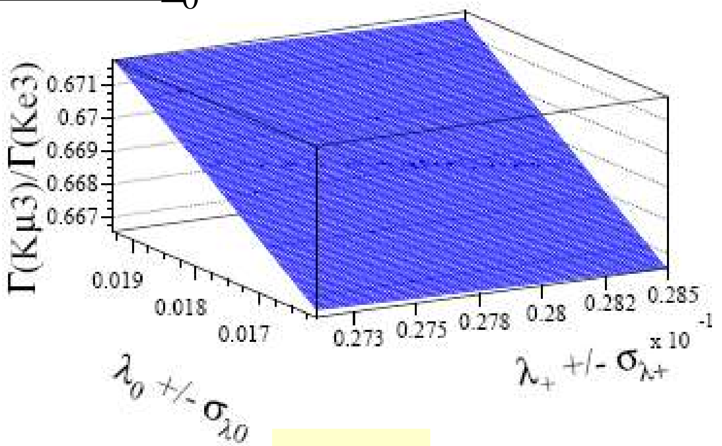


Notice improvement in the error compared to previous results

Theory and experiment for $\Gamma(K\mu3) / \Gamma(Ke3)$

$$\frac{\Gamma(K\mu3)}{\Gamma(Ke3)} = \frac{0.645 + 2.087\,\lambda_+ + 1.464\,\lambda_0 + 3.375\,\lambda_+^2 + 2.573\,\lambda_0^2}{1 + 3.457\,\lambda_+ + 4.783\,\lambda_+^2}$$

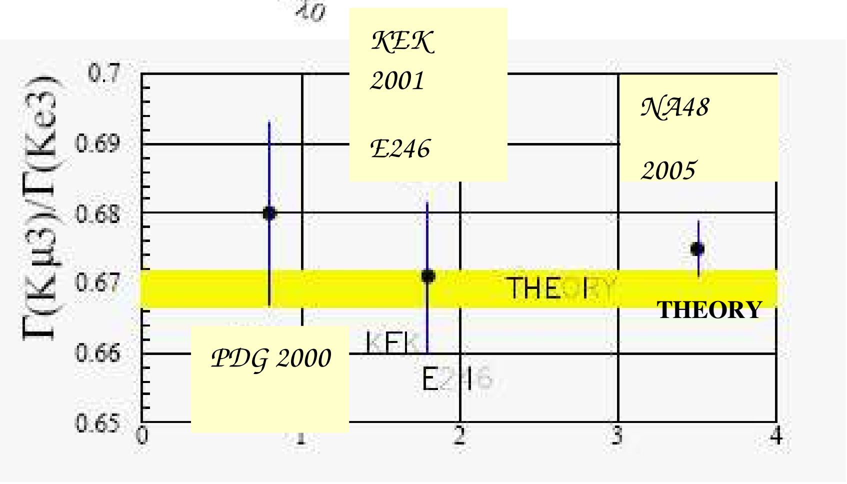
(J. Bijnens, G. Colangelo, G. Ecker, J. Gasser, hep-ph/9411311)



Measured values – PDG 2004 :

$$\lambda_+ = (2.78 \pm 0.07) \times 10^{-2}$$

$$\lambda_0 = (1.77 \pm 0.16) \times 10^{-2}$$



Good agreement between SM and experiment: λ_0, λ_+ & $\Gamma(K\mu3)/\Gamma(Ke3)$

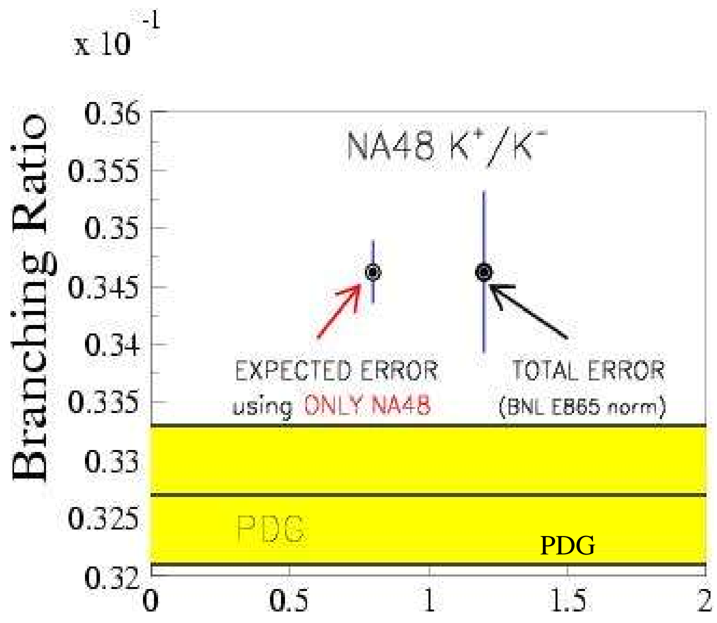
Result for the Br(K$\mu^{\pm}$3)

Using the published BNL E865 result Br(Ke$^{\pm}$3) = (5.13 ± 0.10)% :

Br(K$\mu^{\pm}$3) = (3.462 ± 0.018 (stat) ± 0.006 (syst) ±

0.011 (syst λ_{+}, λ_0) ± 0.068 (norm BNL E865 Ke3)) %

Systematics include	
Trigger efficiency	*0.00003*
MC statistics and particle ID efficiency	*0.00006*
Background subtraction	*< 0.00001*
Stability of result under change of λ_{+},λ_0	*0.00011*



Vus from NA48/2 results

- ***Master formula:***

$$\Gamma(Kl3) \propto G_F |V_{us}|^2 |f_+(0)|^2 I_K^l(\lambda_{+,0})(1+\delta^K_{SU(2)}+\delta^{Kl}_{em})^2$$

	$\delta^K_{SU(2)}(\%)$	$\delta^{Kl}_{em}(\%)$
K^+_{e3}	***2.31(22)***	***-0.10(16)***
$K^+_{\mu 3}$	***2.31(22)***	***+0.20(20)***
		hep-ph/0411097 F. Mescia

Phase space integral, linear parameterization

(after G. Calderon and G. Lopez Castro, hep-ph/0111272)

$$I_K^e(\lambda_{+,0}) = 0.1603 \pm 0.0004$$

$$I_K^\mu(\lambda_{+,0}) = 0.1070 \pm 0.0005$$

→ ***two independent, consistent values !***

$$K_{e3} \Rightarrow Vus|f+(0)| = 0.2192 \pm 0.0015$$

$$K_{\ 3} \Rightarrow Vus|f+(0)| = 0.2204 \pm 0.0015$$

V_{us} → error dominated by theoretical uncertainties

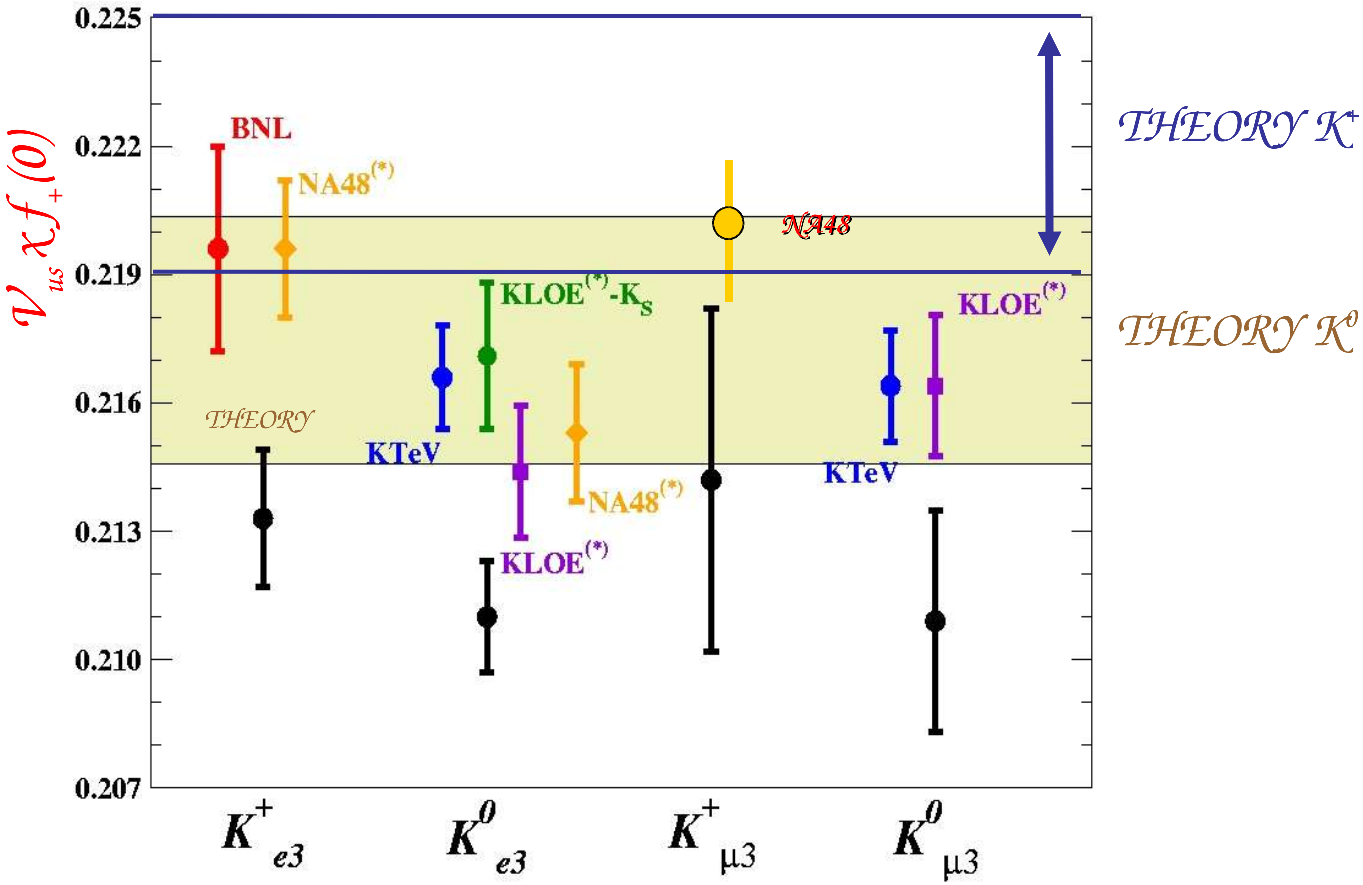
- → SM => V_{us} = 0.2265 ± 0.0022 – CKM expt. + unitarity condition

- → Leutwyler-Roos: $f_+(0)_{KL}$=0.961 ± 0.008 → $f_+(0)_{K+}$=0.982± 0.008
    - Factor of 1.022 applied (SU(2) breaking term) to get K^+
  - Therefore
    - SM :
      - V_{us} | $f_+(0)$| = 0.2224 +/- 0.0028
  - Compared to
    - NA48/2 :
      - K_{e3} → V_{us} |$f_+(0)$| = 0.2192 +/- 0.0015
      - $K_{\mu 3}$ → V_{us} |$f_+(0)$| = 0.2204 +/- 0.0015

Good agreement between SM and NA48/2, but now details to be taken care by theorists!!!

Status of Vus from Semileptonic Kaon decays

SM is well !!



Future plans: remeasure main Br's for K+ …

- *Special run 2004: form factors and radiative decays Ke3γ*
- *1 track Analysis*
  - *Only the information from the PT and momentum of the track, and particle ID – improve e.g. Br(ππ).*