Leptonic decays @ NA48

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May 5, 2004

At NA48 we will focus on:

- Semileptonic Decays K^+_{l3} & K^0_{l3} for = e, μ
  - V_{US} is our ultimate goal
  - Better sensitivity to
    - Scalar interaction, f_S
    - Tensor interaction, f_T
  - Special attention to muon channels, f_- or $\xi = f_-/f_+$
- $K^+_{e3\gamma}$ $K^+_{\mu3\gamma}$ ------ Test of Chiral Perturbation
- $K^+_{e2}/K^+_{\mu2}$ ------- Test of lepton universality
- $K^+_{e2\gamma}$ $K^+_{\mu2\gamma}$ ------- Kaon Structure F_A, F_V

Why V_{us} is one of our main concerns?

Unitarity problem? V_{us} contributes 30-50 % to the error in the unitarity test from $V_{ud}^2 + V_{us}^2 + V_{ub}^2 = 1$ depending on the error taken for V_{ud}:

$$V_{ud}^2 + V_{us}^2 + V_{ub}^2 = 1 - \Delta$$

Is this telling us something about the previous measurements

$\Delta = (3.2 \pm 1.4) \times 10^{-3}$ (superallowed Fermi β decay V_{ud})

- Recent result based on 70K events from BNL-865:

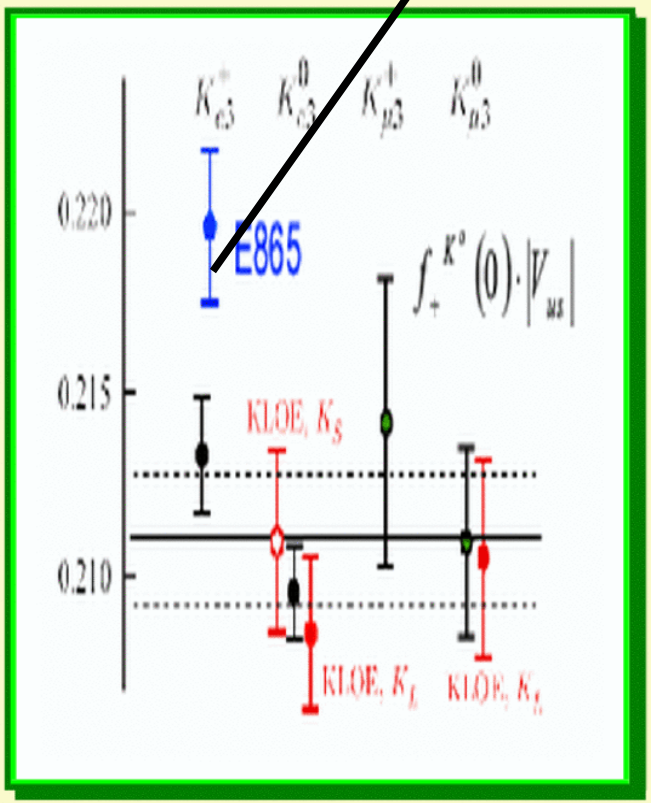
$|V_{us}|_{Kl3,old} = 0.2201 \pm 0.0016 \pm 0.0018$

$|V_{us}|_{E865} = 0.2285 \pm 0.0023 \pm 0.0019$

using Cirigliano's $f(0)(1+\delta)$,

3.0 σ higher than old K^+K^0 average

$|V_{us}|_{Kl3,old+E865} = 0.2220 \pm 0.0019$ (S=1.5) ± 0.0018



Why are we so happy about your visit today?...We need your theoretical input!

<u>Assuming K_{l3} decays:</u> 0^- to 0^-, pure V

$$\Gamma_{K_{e3}} \propto G_F^{enh} |V_{us}|^2 |f_+(0)|^2 I(\lambda_+, \lambda_0)(1+\delta_R)$$

$$f_{+,0}(q^2) = f_{+,0}(0)(1 + \lambda_{+,0}\frac{q^2}{m_\pi^2} + ...)$$

$$G_F^{enh} = G_F S_{EW}(M_\rho, M_W) \qquad S_{EW} = 1.0230 \pm 0.0003$$

$$f_+(0) = 0.961 \quad for \quad K^+$$
$$f_+(0) = 0.982 \quad for \quad K_L^0$$

$$\tilde{f}_+(0) = f_+(0)(1 + \delta_{SU(2)} + \delta_{EM})$$

- RED == Theoretical input needed
- GREEN == Experimental Input from our experiment

Theoretical Input at the moment

- δ_R *Ginsburg* (OK?)
- S_{EW} ***Marciano and Sirlin + Cirigliano***
- $f_+(0)$ *Leutwyler & Ross*
  - Correction δ_{QED} and $\delta_{SU(2)}$ *Cirigliano* (OK?)

Experimental input... no problem

- G_F
- Lifetime for K^+ and K_L
  - $\tau^{+/-} = (1.234 +/- 0.0024)\ 10^{-8}$ s
  - $^{TL} = (5.17 +/- 0.04)\ 10^{-8}$ s

New experimental input in near future!

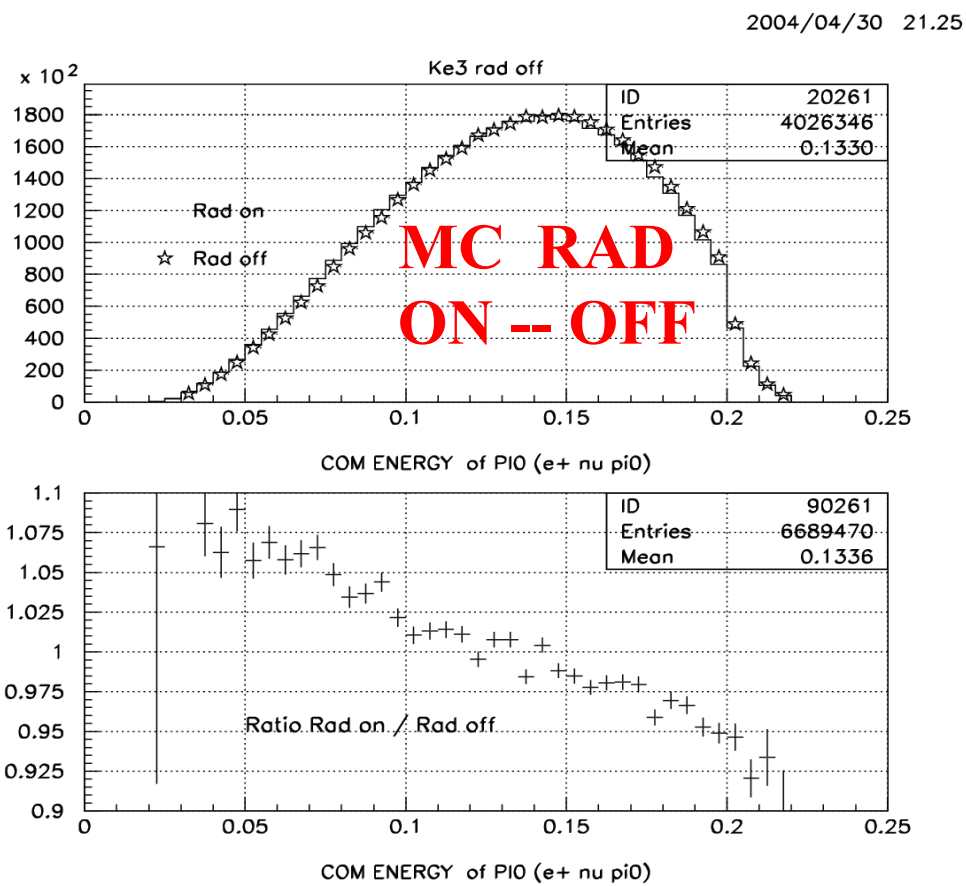
Mode	BR(%)	$10^3\lambda_+$	$10^3\lambda_0$	Data Sample
		K^+_{e3}		
PDG	4.87 ± 0.06	27.8 ± 1.9	—	—
BNL	5.13 ± 0.10	30.7 ± 0.4	—	70K (1998)
NA48 (a)	To be meas.	To be meas.	—	280K (2003)
NA48 (b)	To be meas.	To be meas.	—	100K (2003)
		K^0_{e3}		
PDG	38.79 ± 0.27	29.1 ± 1.8	—	—
NA48	XX$\pm$0.40	XX$\pm$1.5 (1.2)	—	2500K (1999)
		$K^+_{\mu 3}$		
PDG	3.27 ± 0.06	33 ± 10	4 ± 9	—
NA48 (a)	To be meas.	To be meas.	To be meas.	140K (2003)
NA48 (b)	To be meas.	To be meas.	To be meas.	50K (2003)
		$K^0_{\mu 3}$		
PDG	27.18 ± 0.25	33 ± 5	27 ± 6	—
NA48	to be meas.	to be meas.	to be meas.	3600K (1999)

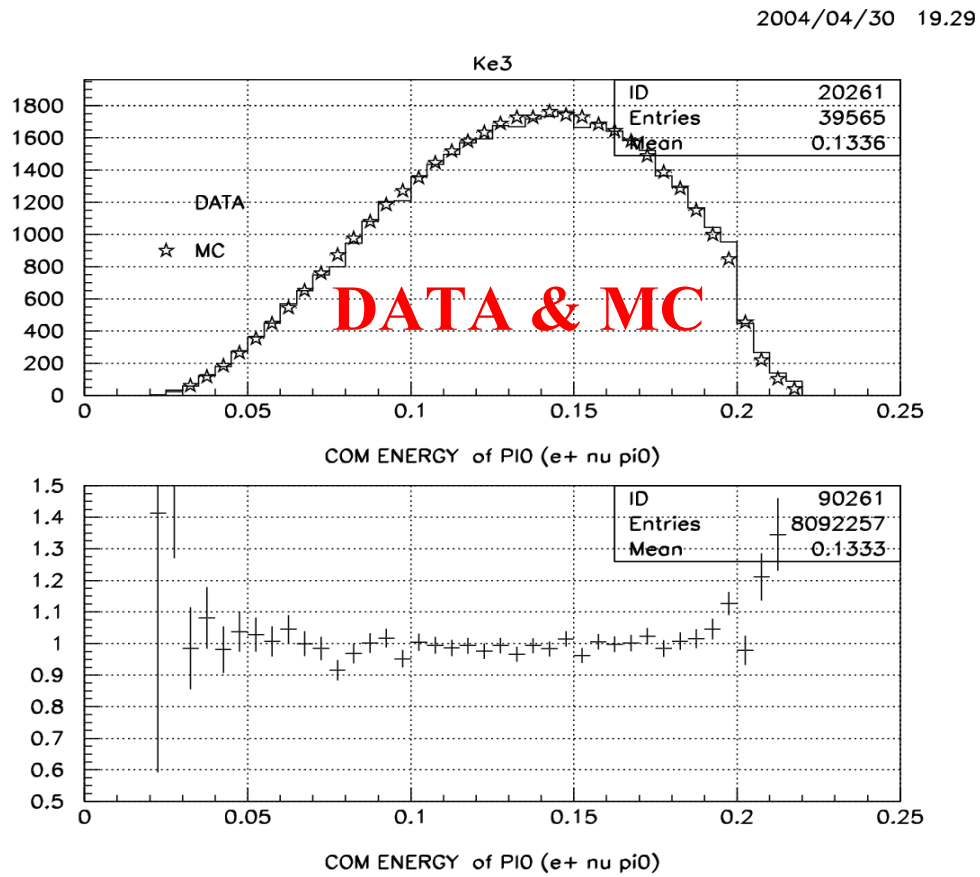
(a) Using Dalitz Decays (3 track events) as BNL

(b) Minimum Bias Run (8 hours of data taking)

K^+_{e3} analysis already containing radiative corrections & beam tunning

δ_R: QED radiative corrections a la' Ginsburg... effects observed on the π^0 distribution in the Center-Of-Mass ... If something wrong with Ginsburg, we will not be able to say from the data.





K^0_{e3} decay: Br & form factor analysis well advanced

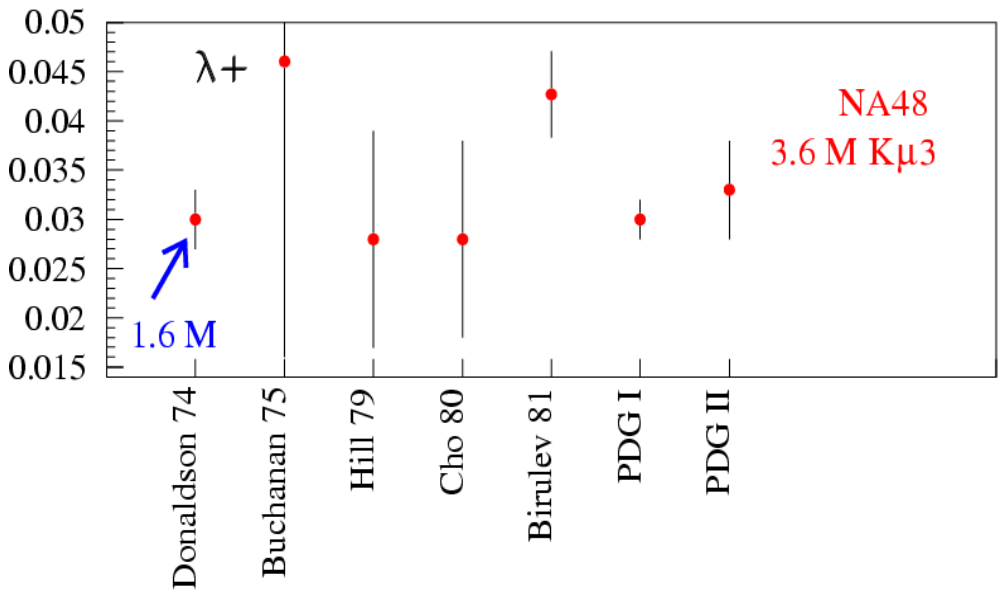
Br = (xxxx +/- 0.4)% (NA48)
= (38.79+/- 0.27)% (PDG)

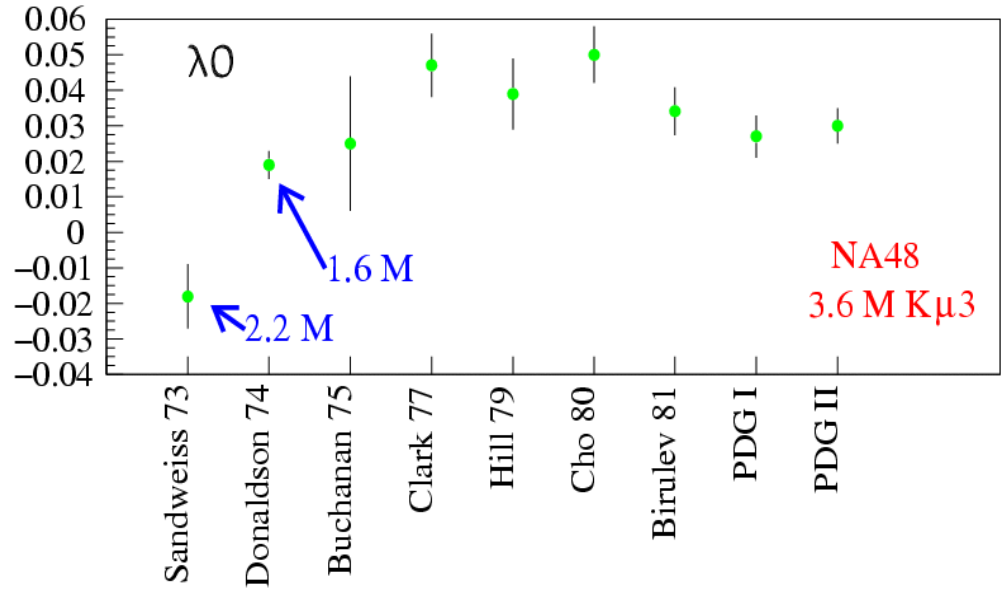
λ_+ = 0.xxxx +/- 0.0007 (stat.) +/- 0.0013 (syst.) (NA48)
= 0.0291 +/- 0.0018 (PDG)

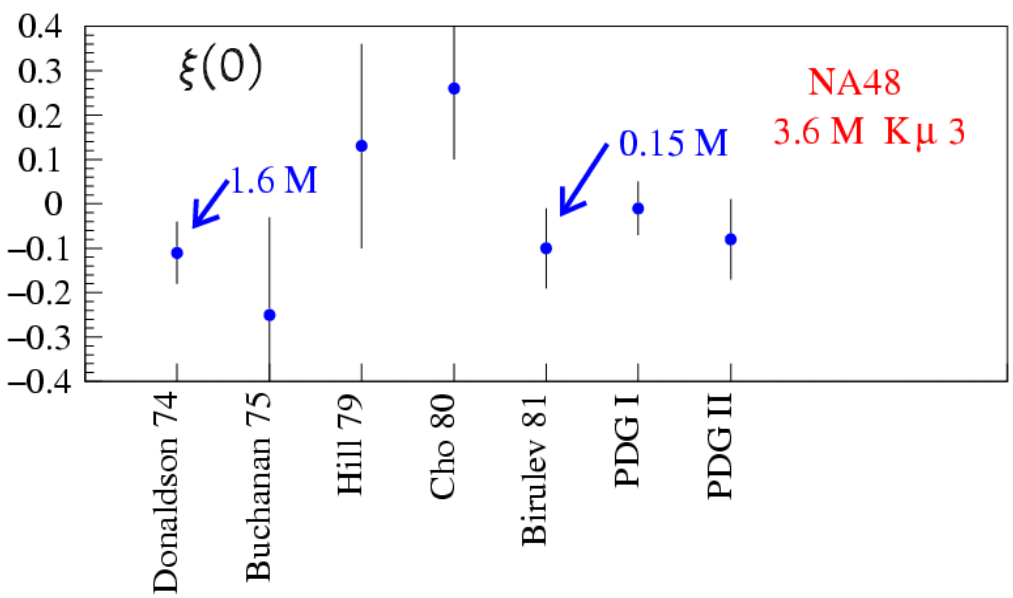
$|f_S/f_+(0)|$ = 0.xx^{+0.007}_{-0.010} +/- 0.012 (NA48)
< 0.04 @ 0.68% CL (PDG)

$|f_T/f_+(0)|$ = 0.xx^{+0.03}_{-0.04} +/- 0.03 (NA48)
< 0.23 @ 68% CL (PDG)

$K^0_{\mu 3}$ Form Factor Possibilities







Time will tell how well we can control the systematics and take advantage of the high statistics

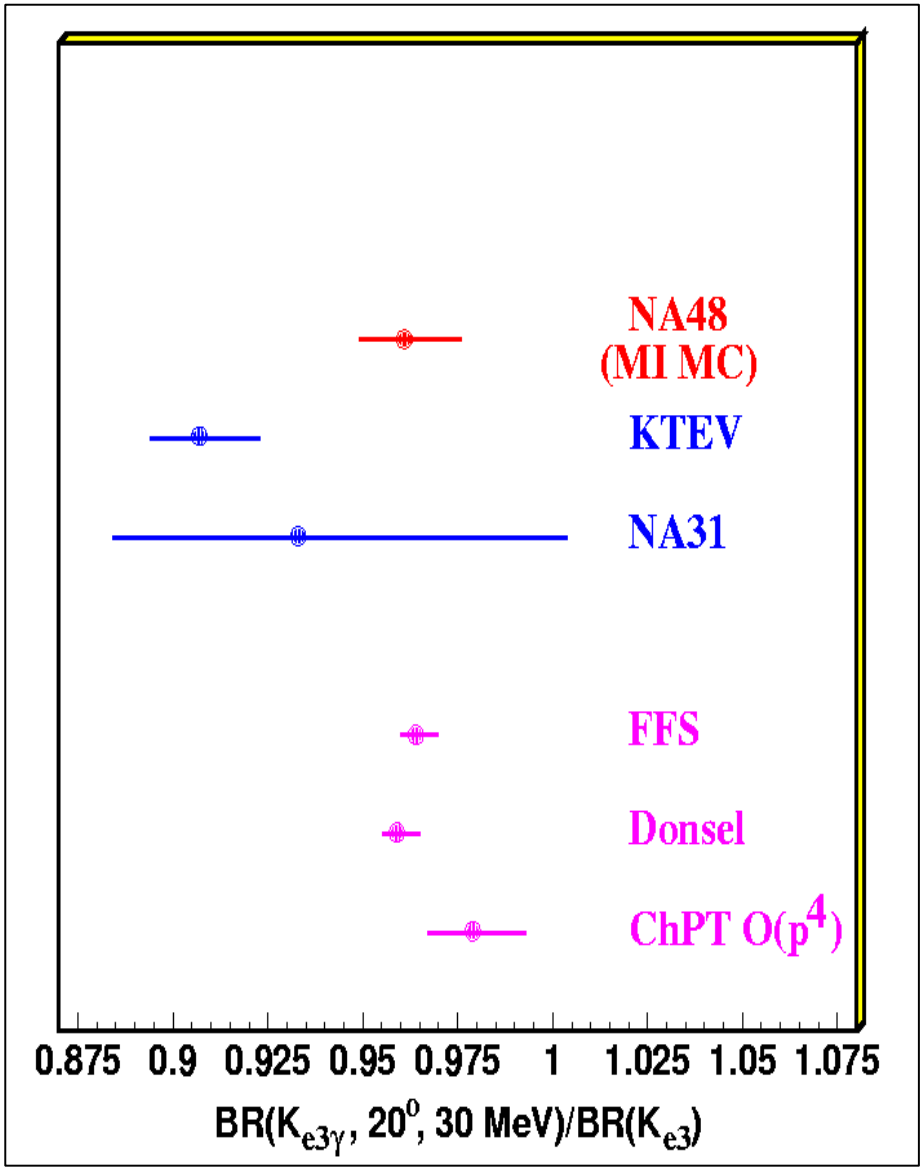
Here we have to care about the SU(3) due to $m_\mu >> m_e$ allowing terms proportional to $\xi(0)$

Radiative corrections & Chiral Perturbation tests: $K_{e3\gamma}$ & $K_{\mu3\gamma}$

KL results already available:
Br(Ke3g/Ke3)
= (0.964 +/- 0.008 +/- 0.012)%
A comparison of the branching ratio measurements & predictions:

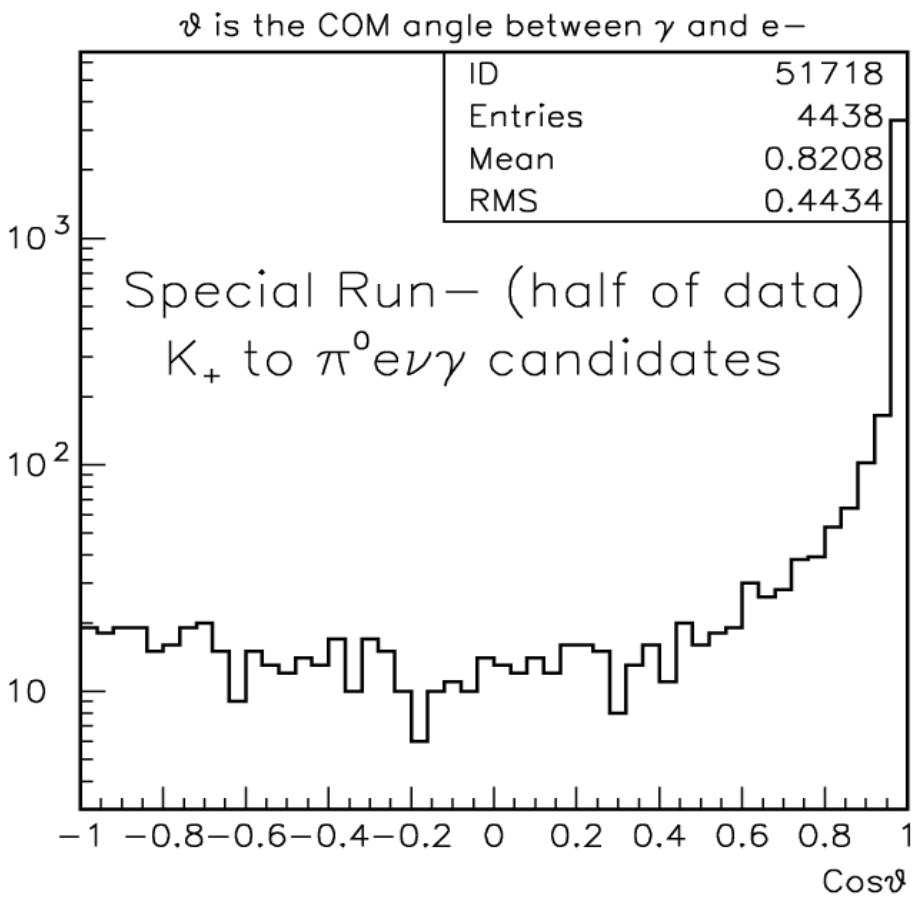
- **NA31**
- **KteV**

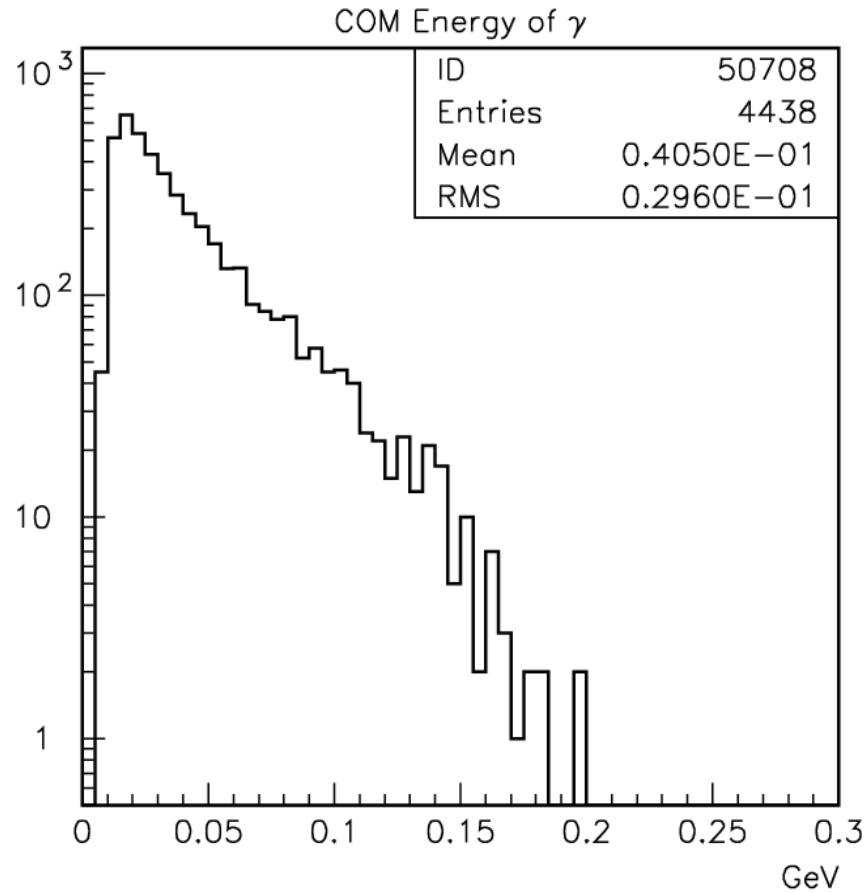
→ **Fearing, Fischbach and Smith**
→ **M. G. Doncel**
→ **Chiral perturbation theory $O(p^4)$**



$K_{e3\gamma}$ in K^+ could be done... $K_{\mu 3\gamma}$ dominated by background

- **Example of the γ distributions in the Special Run**





What about $K_{e2\gamma}$ & $K_{\mu 2\gamma}$? Sensitive to new physics....

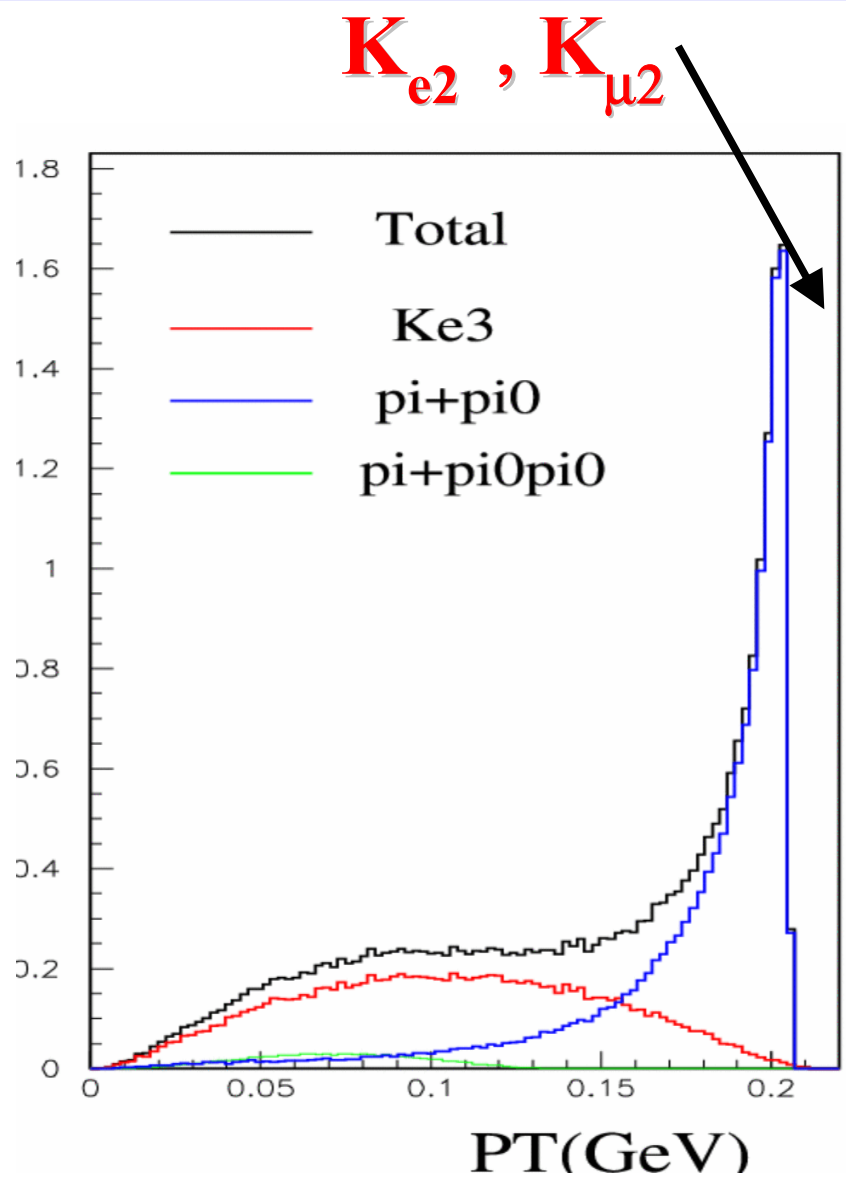
- Besides radiative effects for K_{e2} / $K_{\mu 2}$ Is it worth looking at bigger sample?

In contrast to experiments where the kaon are stopped, we most keep in mind that in our environment, we are:

- No access to muon polarization

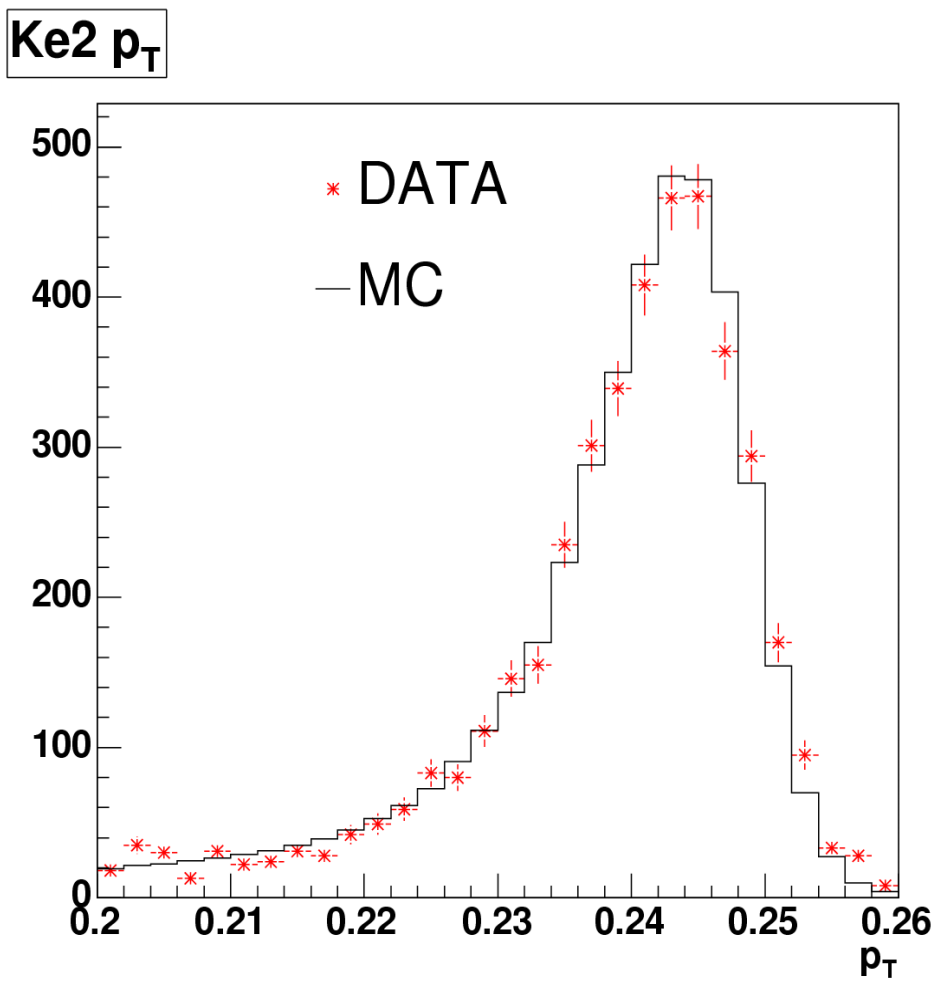
<u>In addition</u>, to being

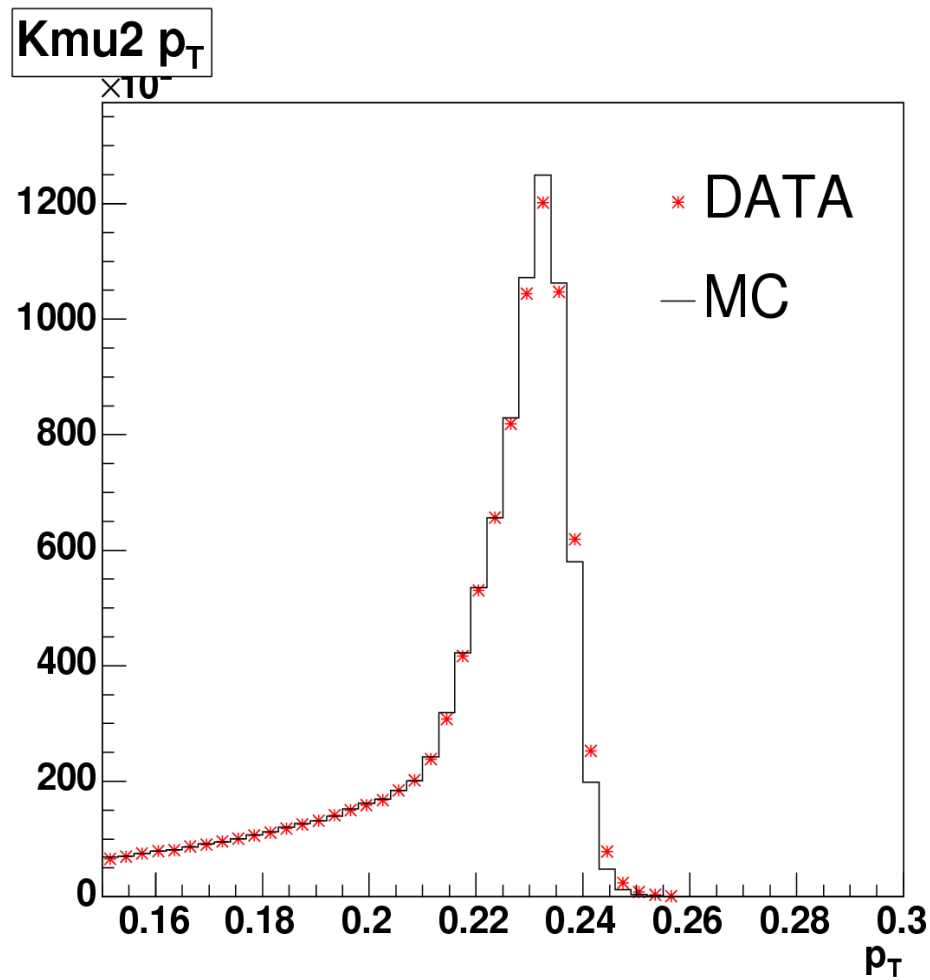
- Limited in phase space in order to reduce backgrounds



"New" $K_{e\,2}/K_{\mu 2}$ well advance...

$K_{e\,2}$ Sample 10 X larger than any single measurement available





K_{e2} and $K_{\mu 2}$ Could be improved if needed...

- **2003 -- with a trigger downscaled by 20 and running for a fraction of the total data taking, we collected:**
  - **Ke2 5K (Better than PDG) & Kmu 1000K for normalization.**
  - **In principle, we could 100K events could be collected in 2004 if collaboration was convinced that it is important...**

Conclusion....

- **In the near future we will be able to provide escential new experimental input for V_{us} coming from --- BR and Form Factor:**
  - K^+_{e3}, $K^+_{\mu 3}$
  - K^0_{e3}, $K^0_{\mu 3}$
- **In addition to Br for $K^0_{e3\gamma}$ & $K^+_{e3\gamma}$**
- **New measurement of K^+_{e2} / $K^+_{\mu 2}$**

➔ **We hope the necessary theoretical input will be ready as well...**