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WG3 program

www.physik.unizh.ch/~andries/WG3report

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talks in this workshop series

5	**LFV experiment**	
5.1	**rare muon decays**	
	LFV, status and prospects	**Toshinori Mori (Tokyo University)**
5.1.1	$\mu \to e^+\gamma$	
	Improving the $\mu \to e^+\gamma$ sensitivity, MEG and beyond	**Alessandro Baldini (INFN - Pisa)**
	Update on the status of MEG	**Hajime Nishiguchi (ICEPP, Tokyo)**
5.1.3	$\mu - e$ **conversion**	
	A High-Intensity, High-Luminosity Muon Source PRISM and Search for Muon to Electron Conversion	**Yoshitaka Kuno (Osaka University)**
	Final result of the SINDRUM II search for mu-e Conversion	**Wilhelm Bertl (PSI, Villigen)**
	Prospects for a Muon to Electron Conversion Experiment at Fermilab	**Jim Miller (Boston)**
5.2	τ **decay**	
5.2.1	**Babar/Belle**	
	Lepton Flavour violation in tau decays: status and perspectives	**Swagato Banerjee (University of Victoria)**
5.2.2	**LHC**	
	Status and plans of $\tau \to 3\mu$ at CMS	**Manuel Giffels (RWTH Aachen)**
5.3	$B \to \mu e$	
	Search for $B \to \mu e$ with LHCb	**Walter Bonivento (I.N.F.N. Cagliari, Italy)**
5.4	**in flight conversions**	
	A study on $\mu(e) - \tau$ conversion in deep inelastic scattering	**Yoshitaka Kuno (Osaka University)**
	Study of $\mu - \tau$ conversion with high-intensity muon beams	**Giovanni Marchiori (University of Pisa and INFN)**
	Feasibility study for a fixed target $\mu \to \tau$ conversion experiment	**Alberto Lusiani (INFN)**
8	**lepton universality**	
8.1	**pion decay**	
	Two new $\pi \to e\nu$ experiments	**Andries van der Schaaf (Zurich)**
8.2	**K decay**	
	Testing LFV measuring $K \to e\nu/K \to \mu\nu$ in NA48: status and perspectives	**Luca Fiorini (Camdridge)**
8.3	**tau decay**	
	Test of lepton universality in tau decay	**Olga Igonkina (Oregon)**

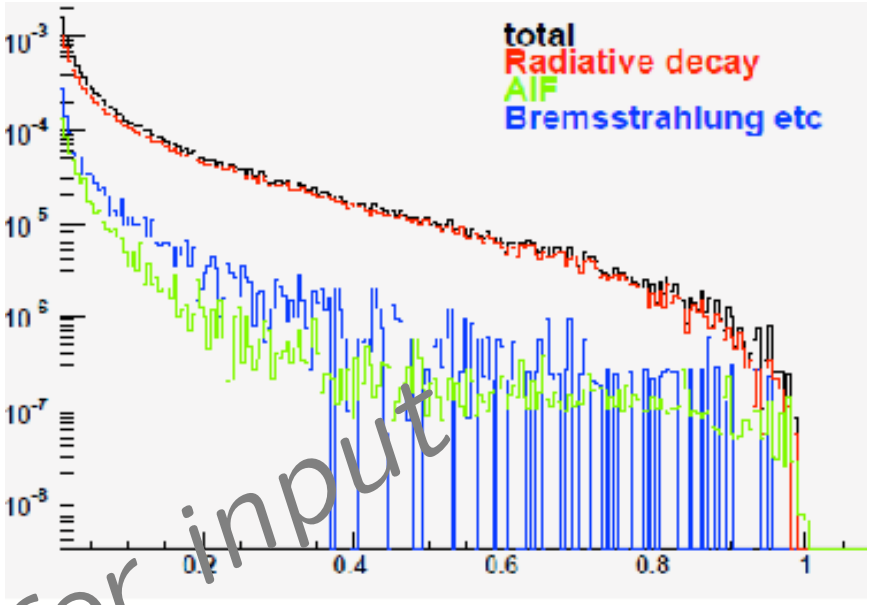
5 LFV experiment

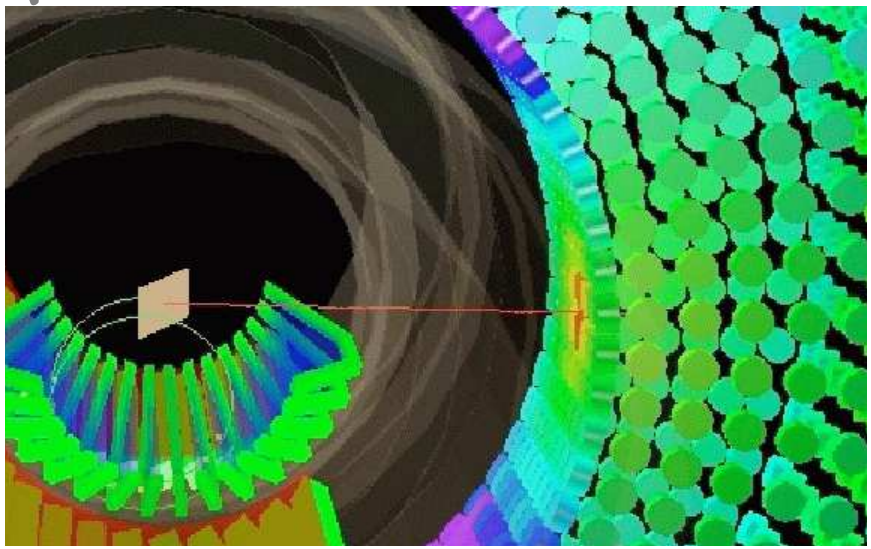
5.1 rare muon decays

5.1.1 $\mu \to e\gamma$

present limit 1.2×10^{-11} (90% C.L.) by MEGA
MEG at PSI aims at an improvement by ≈ 100
ready to start apart from vacuum window problem
limited by accidental coincidences

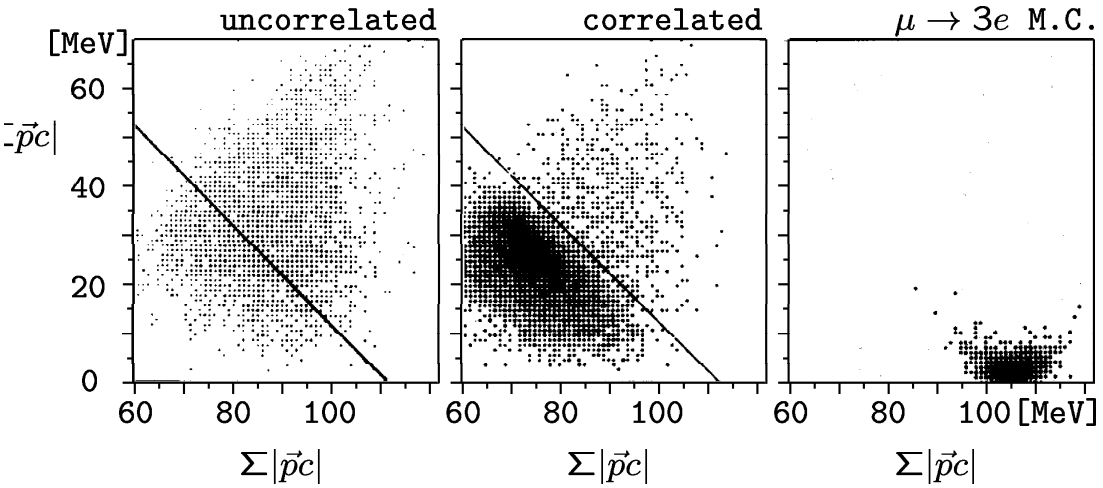
- **time resolution 0.15 ns fwhm**
- **angular resolution by scattering in target 19 mrad fwhm**
- **E_γ resolution 4.8% fwhm**



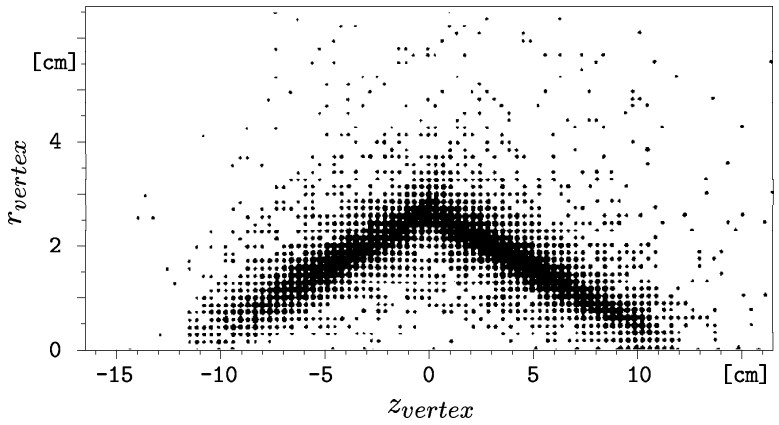


5.1.2 $\mu \to 3e$

- **usually less sensitive than $\mu \to e\gamma$**
- **old SINDRUM result: $B < 10^{-12}$**
- **background free**
- **10^{-14} should be possible but no plans**



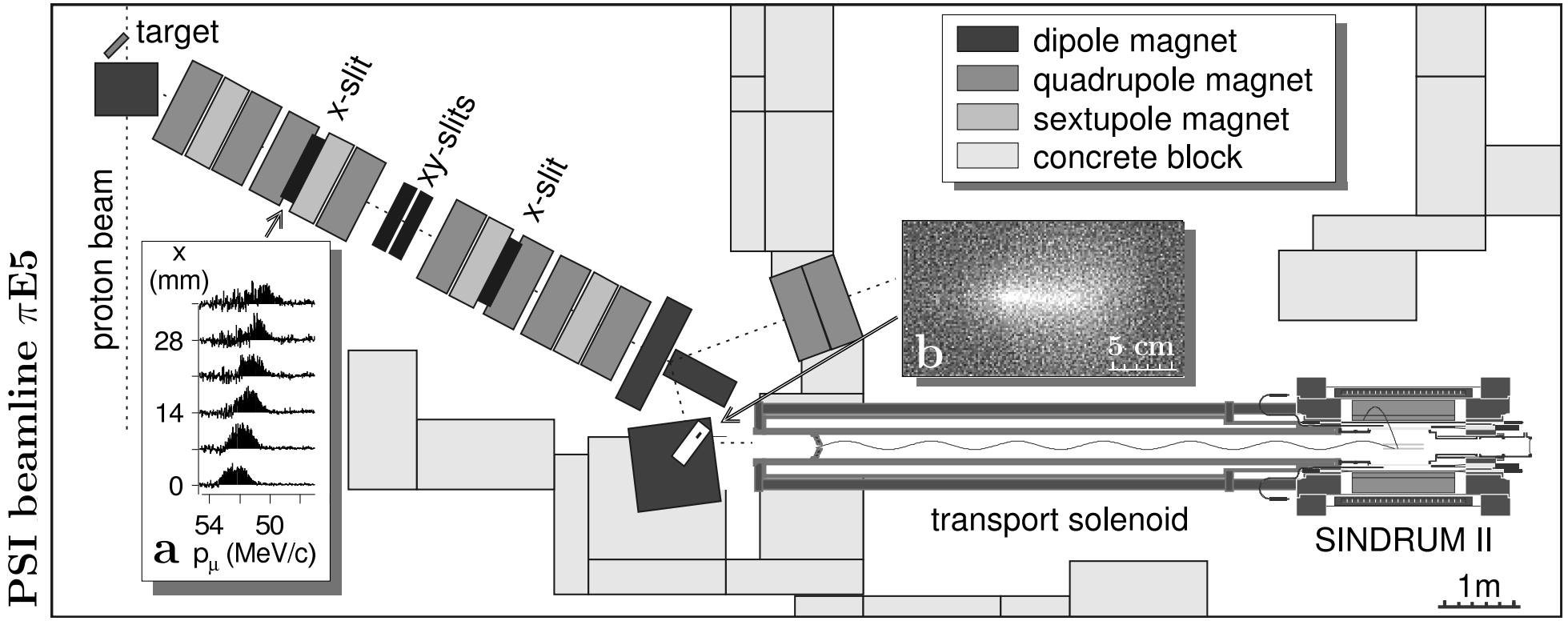
total momentum versus total energy



additional constraints from vertex

5.1.3 $\mu - e$ conversion

Final SINDRUM II result: $\Gamma(\mu^- \mathrm{Au} \rightarrow e^- \mathrm{Au}_{\mathrm{g.s.}})/\Gamma_{\mathrm{capture}}(\mu^- \mathrm{Au}) < 7 \times 10^{-13}$ $(90\%\mathrm{C.L.})$ [1]



[1] SINDRUM II Collaboration, Eur. Phys. J. C 47, 337-346 (2006)

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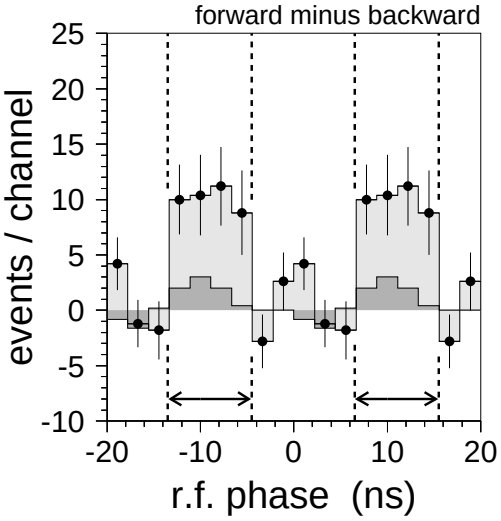
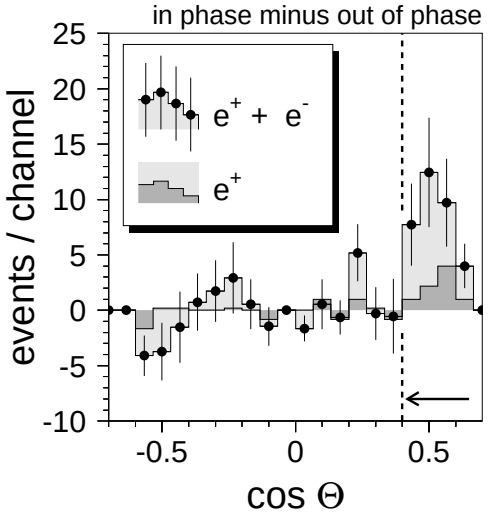
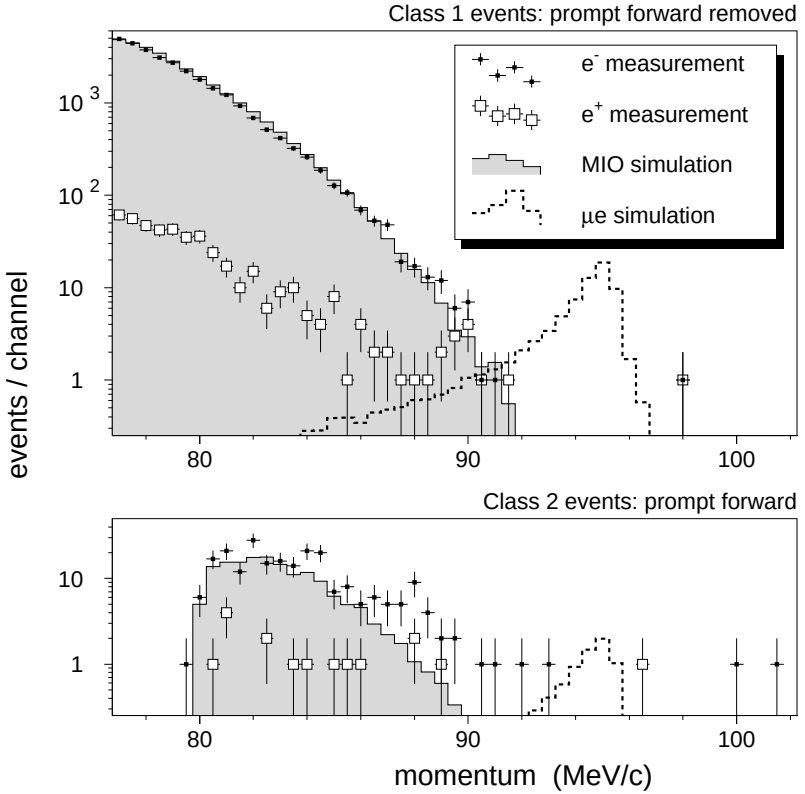
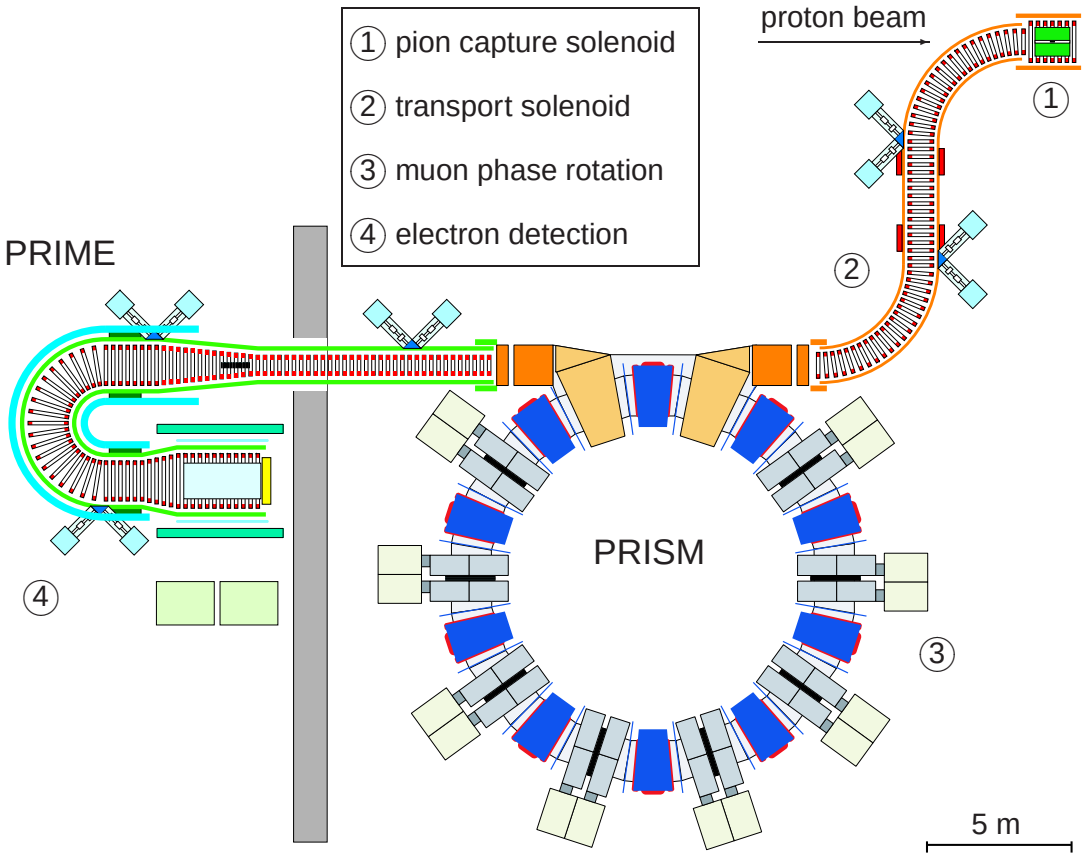
pions stop 10 m before the spectrometer but still some background is seen: radiative π^- capture followed by e^- and e^+ scattering off the target







- **MECO planned to reach 10^{-16} using pulsed beam and large acceptance transport solenoids**
- **project is presently considered at Fermilab**



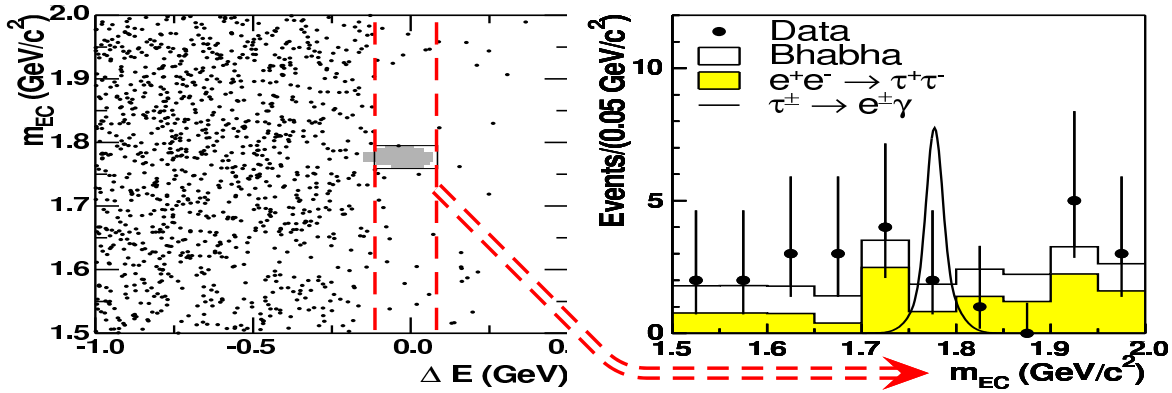
- **PRIME at J-PARC aims at a sensitivity around 10^{-18}**
- **first tests with six FFAG magnets are planned for this year**

5.2 τ decay [2]

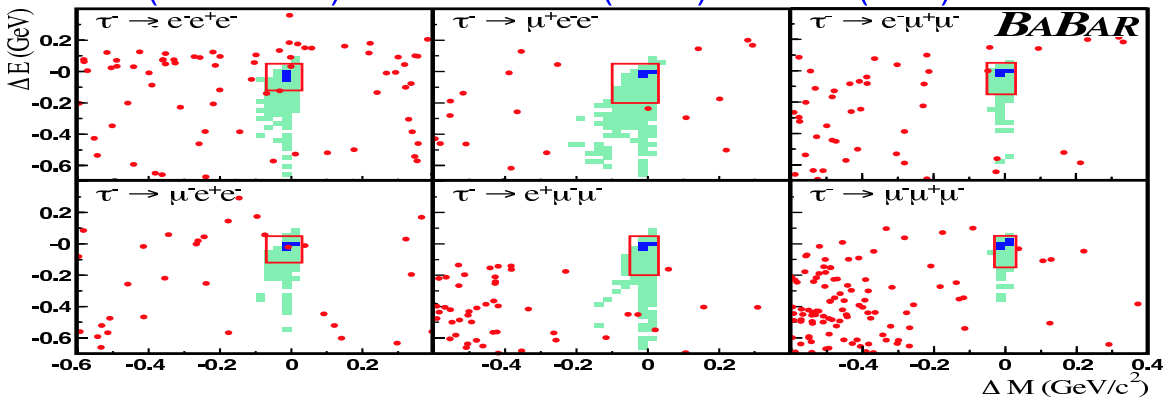
5.2.1 Babar/Belle

$e^+e^- \to \tau^+\tau^-$

- $\tau \to \ell\gamma$: Background rate from PDF(M_{EC}) in $\pm 2\sigma$ band in ΔE



- $\tau \to \ell\ell\ell$ ($\tau \to \ell hh'$): 2-D Fit PDF(ΔM) $\times$ PDF(ΔE)

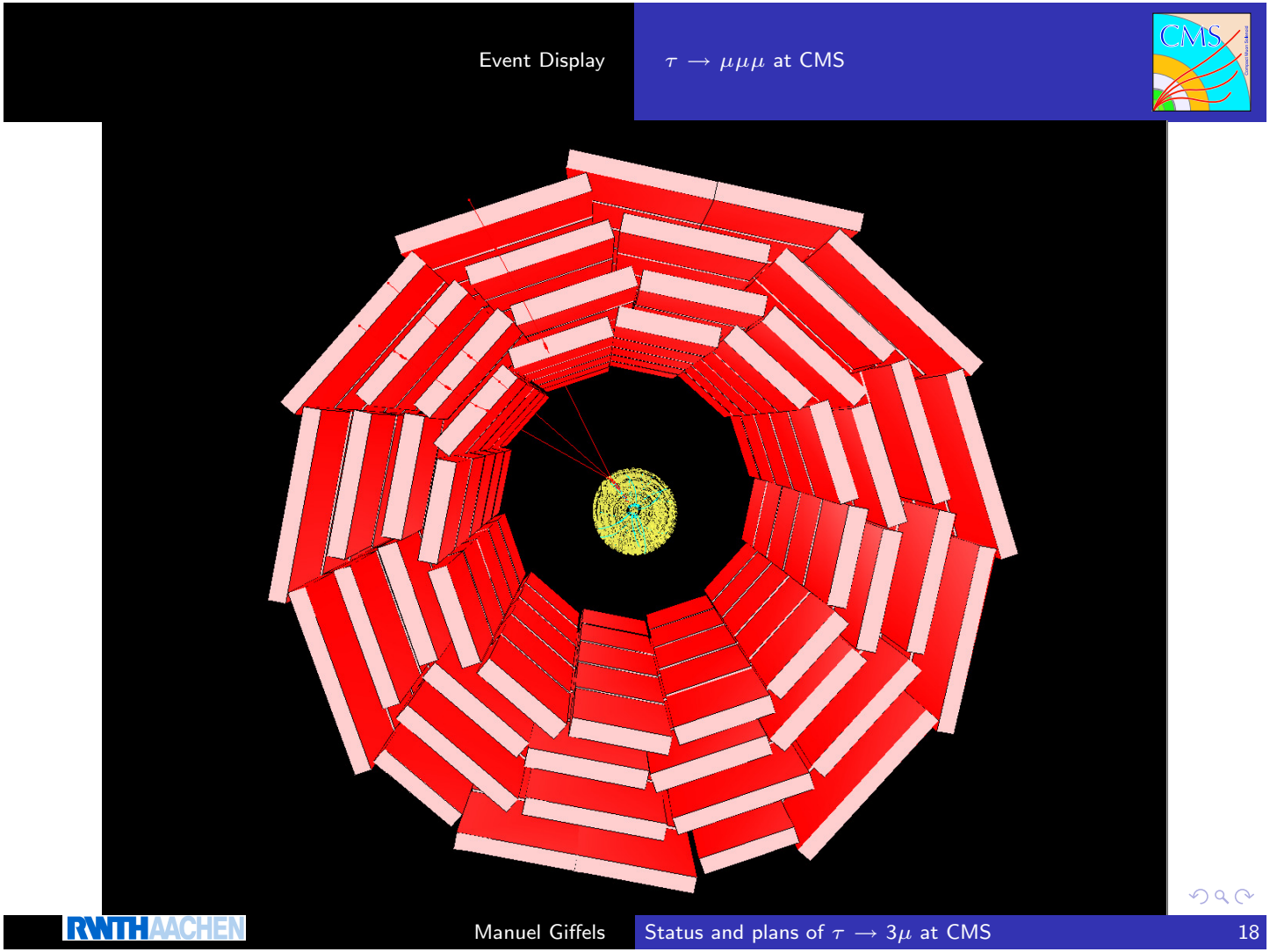


background sets in at the level of 10^{-7}

[2] Wednesday 10:15 Mike Roney: *Experimental prospects for rare tau decays*

5.2.2 LHC

http://giffels.web.cern.ch/giffels/talks/giffels_LHCD_Flavour_Jun06.pdf



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5.3 $B \to \mu e$

- **has been studied by LHCb**
- **could be mediated by Pati-Salam leptoquarks which treats lepton number as a fourth color.**
- **kinematically similar to the well studied decay $B \to \mu^+\mu^-$**

90% lower limits on M_{PS} in TeV

c.s.		$K_L \to \mu^\pm e^\mp$	$\frac{\pi^+ \to e^+\nu}{\pi^+ \to \mu^+\nu}$	$\frac{K^+ \to e^+\nu}{K^+ \to \mu^+\nu}$	$B_d^0 \to e^\pm\mu^\mp$	$B_s^0 \to e^\pm\mu^\mp$	$B^+ \to e^+\nu$	$B^+ \to \mu^+\nu$
1	$e\mu\tau$	2278	250	4.9				
2	$\mu e\tau$	2278	76	130				
3	$e\tau\mu$		250		50			28
4	$\mu\tau e$		76		50		19	
5	$\tau\mu e$			4.9		20.7	19	
6	$\tau e\mu$			130		20.7		28

130

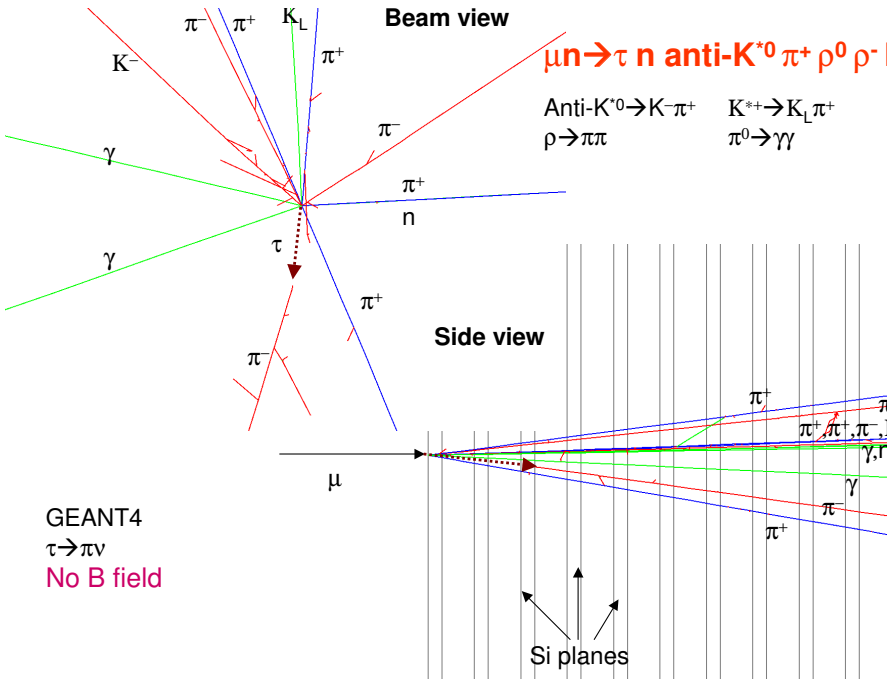
105

LHCb limits

5.4 in flight $\mu \rightarrow \tau$ conversions

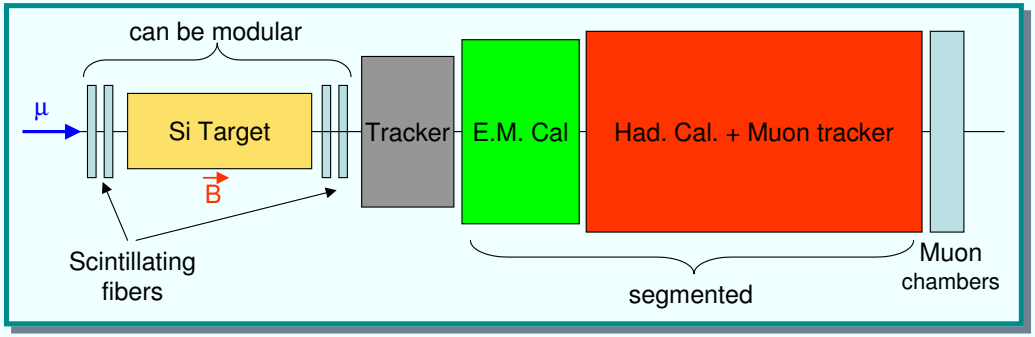
- **has been studied within MSSM:**
  S. Kanemura, Y. Kuno, M. Kuze and T. Ota,
  Search for lepton flavor violating mu $\mu \rightarrow \tau X$ reactions with high energy muons
  Nucl. Phys. Proc. Suppl. 144 (2005) 268.

- **experimentally it looks challenging:**
- **$10^{11}\mu$ s^{-1} with low duty cycle on the detector**



Detector feasibility

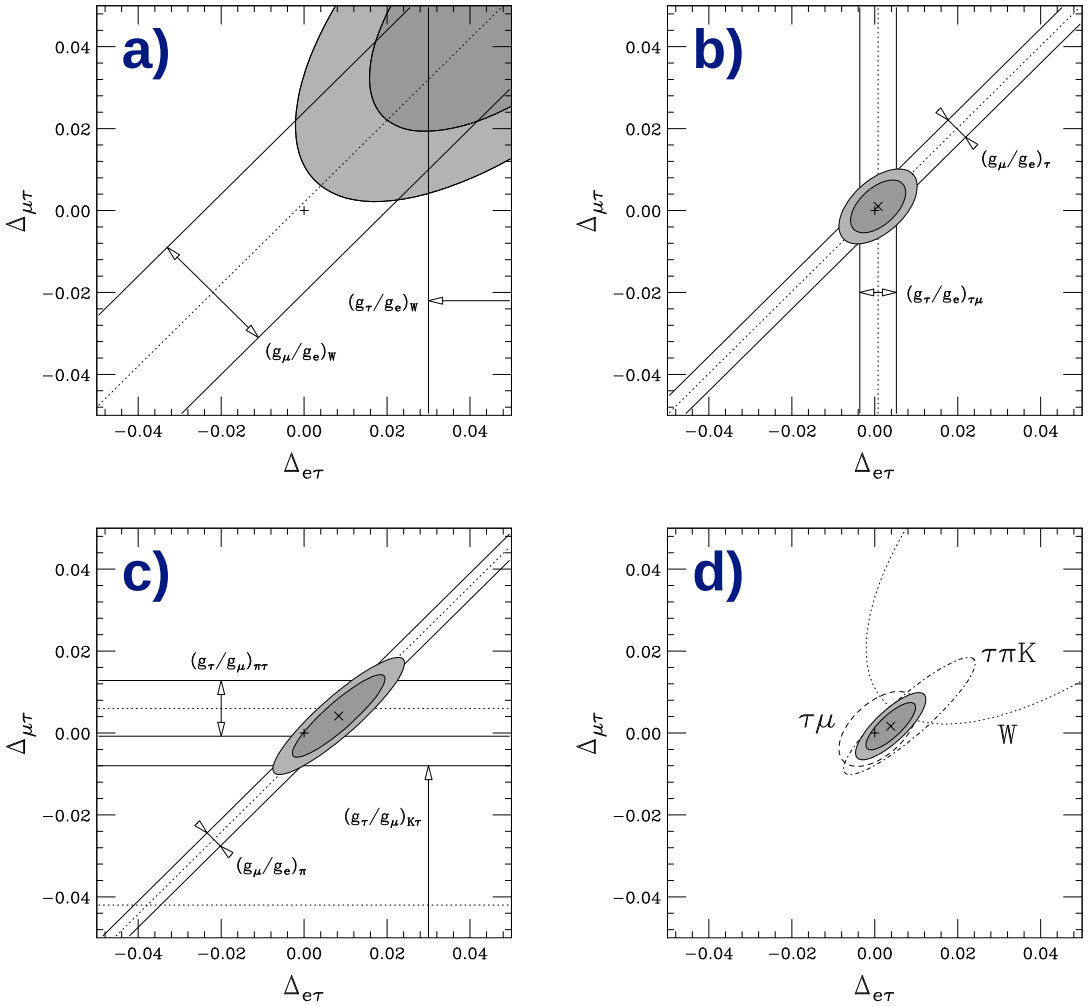
- experiment interesting if it probes $\sigma_{\mu\to\tau} \approx 2$ ab for 200 GeV muons, i.e. $\mathrm{BR}(\tau \to \mu\eta) < 0.3 \cdot 10^{-8}$
  - no significant contribute from heavy quark Higgs-mediated processes
    (using estimated cross-section in Y.Kuno Nov.2005 presentation, with updated LFV limits)



- without full simulation, guestimate one needs 1000 produced $\mu N \to \tau X$ conversions
  → $3{\cdot}10^{20}$ 200 GeV-muons/year on 10 cm-deep silicon target
- detector appears not to be feasible
  - too large muon flux on calorimeters, especially hadronic one
    (too large detected energy fluctuations due to muon flux)
  - could spread the muon flux on larger surface, but too expensive

8 Experimental tests of lepton universality

Generalize the $l\overline{\nu}_l W$ coupling to $\mathcal{L} = \sum_{l=e,\mu,\tau} \frac{g_l}{\sqrt{2}} W_\mu \overline{\nu}_l \gamma^\mu (\frac{1-\gamma_5}{2}) l$ + h.c.



Experimental limits on violations of lepton universality from

a) W decay
b) τ decay
c) π and K decay
d) the combination of a) - c)

$g_l \equiv g(1 - \epsilon_l/2)$
$\Delta_{ll'} \equiv \epsilon_l - \epsilon_{l'}$

Violations could either be at the level of the $l\bar{\nu}_l W$ and $l\bar{l}Z$ couplings, or only apparent through non-SM contributions:

- **in W, Z and π decay resulting from R-parity violating extensions to the MSSM[3]**
- **in W decay resulting from charged Higgs bosons[4]**
- **in K and B decay resulting from LFV contributions in SUSY[5]**
- **in Υ decay resulting from a light Higgs boson[6]**
- **in π and K decay resulting from scalar interactions[7]**

[3] O. Lebedev, W. Loinaz and T. Takeuchi, Phys. Rev. D 61 (2000) 115005.
M. J. Ramsey-Musolf, Phys. Rev. D 62 (2000) 056009.
[4] J. h. Park, JHEP 0610 (2006) 077.
[5] A. Masiero, P. Paradisi and R. Petronzio, Phys. Rev. D 74, 011701 (2006).
[6] M.A. Sanchis-Lozano, Workshop on B-Factories and New Measurements, September 13-14, 2006, KEK, arXiv:hep-ph/0610046.
[7] B.A. Campbell and D.W. Maybury, Nucl. Phys .B709, 419 (2005).

8.1 pion decay

$$R^{\rm tree}_{e/\mu} \equiv \frac{\Gamma^{\rm tree}_{\pi\to e\bar{\nu}}}{\Gamma^{\rm tree}_{\pi\to\mu\bar{\nu}}} = (\frac{g_e}{g_\mu}\times\frac{m_e}{m_\mu}\times\frac{1-m_e^2/m_\pi^2}{1-m_\mu^2/m_\pi^2})^2$$

Radiative corrections lower this value by 3.74(1)% [8]:

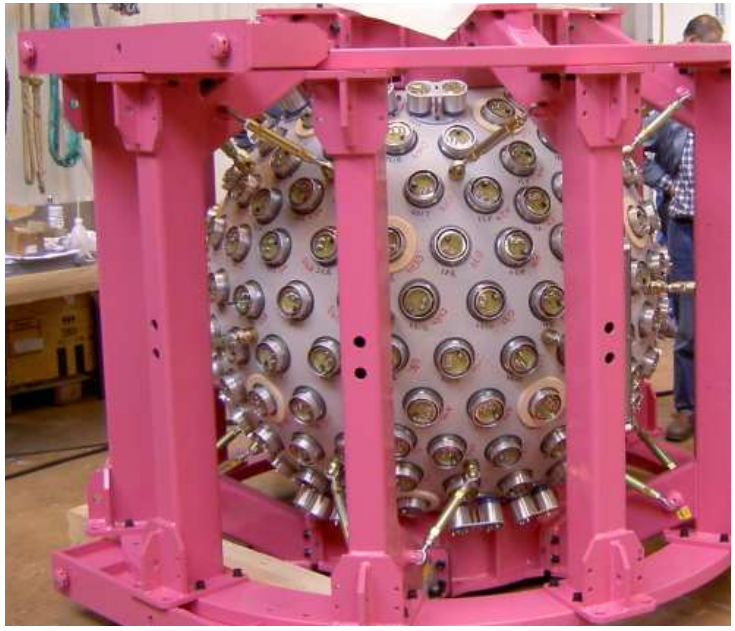
$$R^{\rm SM}_{e/\mu} = 1.2350(5)\times 10^{-4}$$

Two experiments [9] contribute to the present world average for the measured value:

$$R^{\rm exp}_{e/\mu} = 1.230(4)\times 10^{-4}$$

$$g_\mu/g_e = 1.0021(16)$$

Two new experiments at PSI and TRIUM) aiming at a tenfold improvement wil start data taking this year.



Pure CsI Crystall ball of the PEN experiment at PSI

[8] R. Decker and M. Finkemeier, Nucl. Phys. B 438, 17 (1995).
[9] G. Czapek *et al.*, Phys. Rev. Lett. 70, 17 (1993).
D.I. Britton *et al.*, Phys. Rev. Lett. 68 (1992) 3000.

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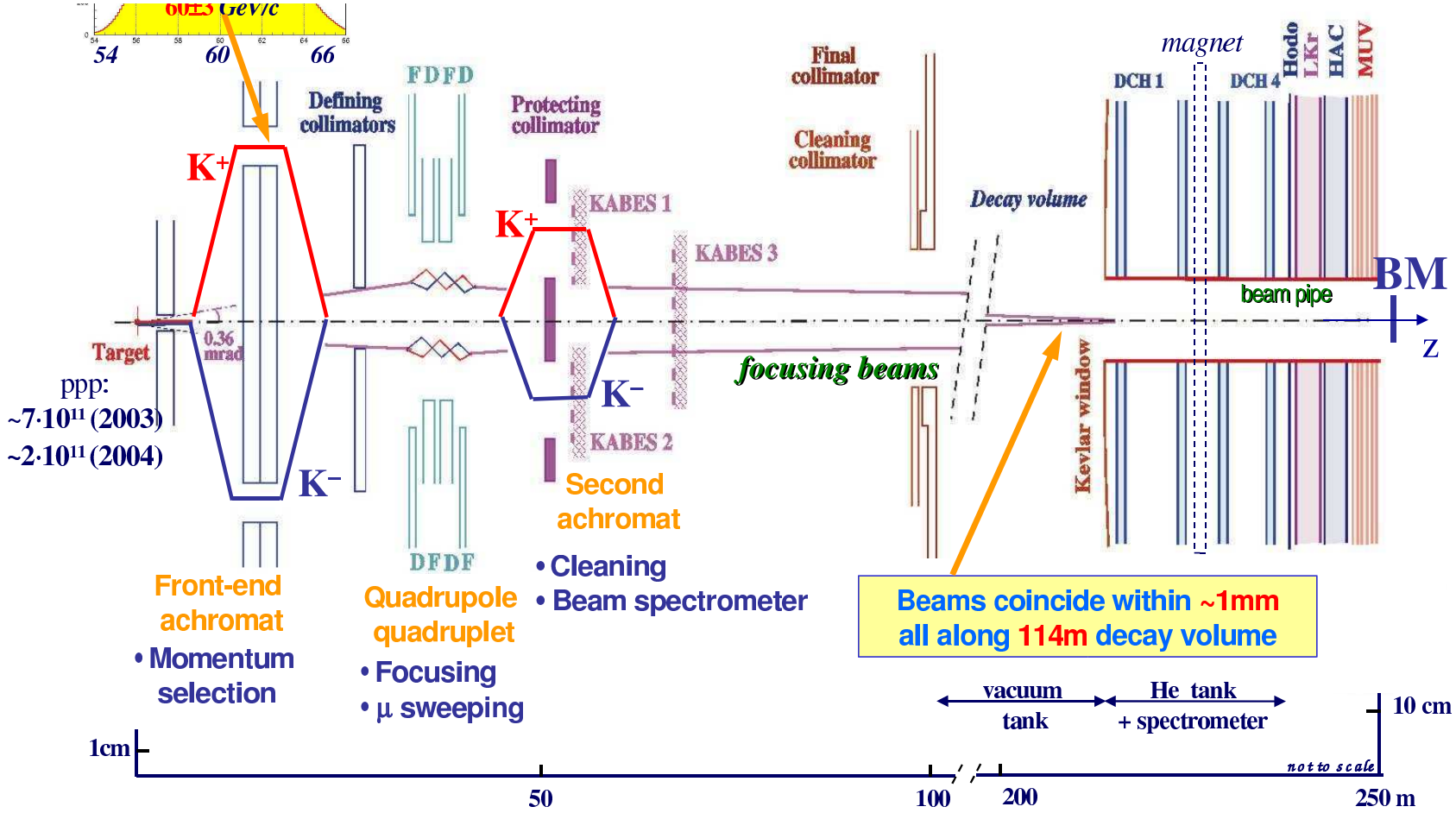
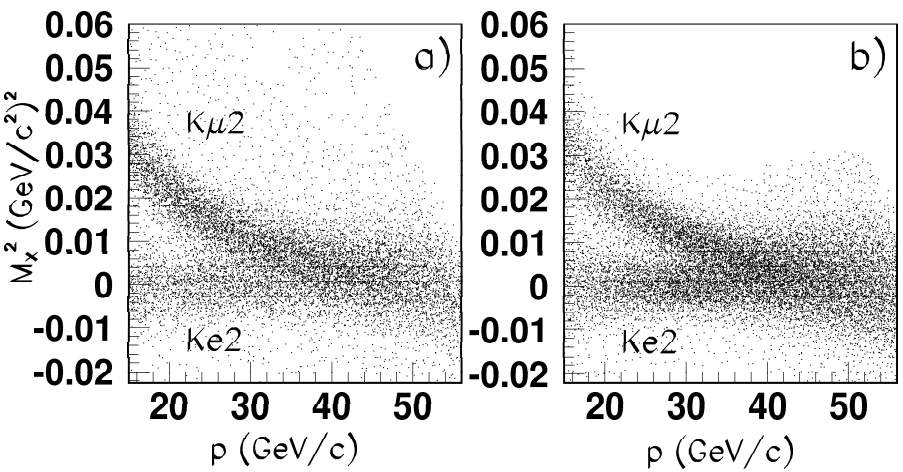
8.2 K decay

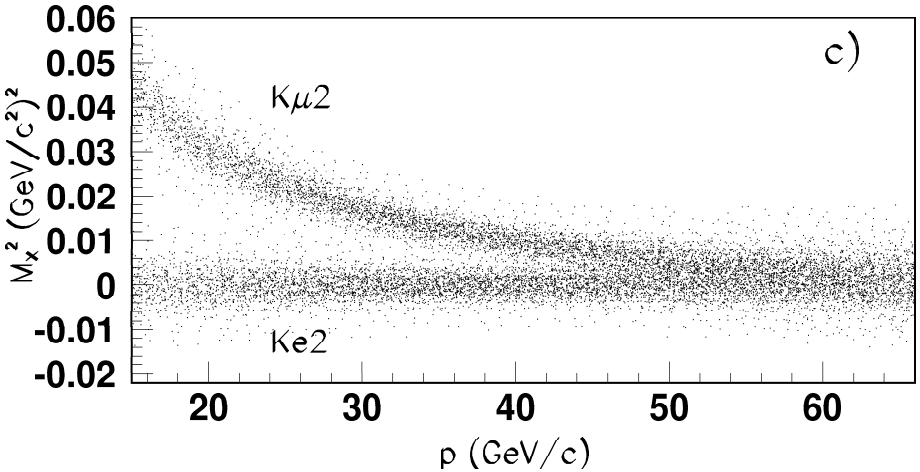
NA48/2 at CERN



Distributions of M_X^2 versus p for K_{e2} and $K_{\mu 2}$ decays.
In the M_X calculation the electron mass is assumed.



measurement 2004 **simulation 2004**



simulation 2007

8.3 tau decay

will be discussed by Mike Roney

Conclusions

- improvements by typically two orders of magnitude are expected in many tests of LFV
- improvements by typically one order of magnitude are expected in many tests of lepton universality
- for most of these sections first versions are available
- text can be improved and linked better to the theory part
- please interfere!