Lepton Universality Tests with Kaons

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for the

Flavianet Working Group on Kaon Decays

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Flavianet Kaon Working Group

http://www.lnf.infn.it/wg/vus/

Working Group on Precise SM Tests in K Decays

Kaon WG home
FlaviaNet home

Master Formulae
Branching Ratios
Lifetimes
Form Factors

Radiative
Corrections
SU(3) Breaking
Form Factors

Contacts

News
Talks
Acknowledgements

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Introduction & Outline

Violation of Lepton Universality:

Predicted by practically every **New Physics** model.

Kaon physics:

- Two main possibilites to test Lepton Universality:

$\mathbf{K_{l3}}$ **decays**	$\mathbf{K_{l2}}$ **decays**
$\mathbf{K_{e3}/K_{\mu 3}}$, form factors	$\mathbf{K_{e2}/K_{\mu 2}}$

- So far precisions poor (compared to e.g. pion decay), tests on levels of 1-2% (K_{l3}) or even 4% ($K_{e2}/K_{\mu 2}$).
- Since $\sim$2005: Many new data available (blue: first reported at KAON07)
  - $\mathbf{K_{l3}}$: KLOE ($K_{e3}^{\pm}$, $K_{\mu 3}^{\pm}$, $K_{L,l3}$ form factors), ISTRA+ (K_{e3}^{-}), NA48 ($K_{e3}^{\pm}$, $K_{\mu 3}^{\pm}$, $K_{L,\mu 3}$ form factors).
  - $\mathbf{K_{e2}/K_{\mu 2}}$: $2\times$ NA48/2, KLOE.

K_{l3} Decays

K_{l3} — *Introduction*

Expectations in for LFV in $\mathbf{K_{l3}}$:

- Test for LFV in the vector current (different from K_{l2}, π_{l2} decays!).

  $\Longrightarrow$ To be compared with searches for LFV in τ decays:

  $\tau \to \mathbf{e}\nu\bar{\nu}/\tau \to \mu\nu\bar{\nu} \quad \Longrightarrow \quad \mathbf{g_\mu^2/g_e^2 = 0.9998 \pm 0.0040}$

- SM transitions proceed via tree-level diagrams:

  Possible violations of Lepton Universality from New Physics will always be small.

  $\Longrightarrow$ Precision measurements necessary!

Two possibilities to search for violation of Lepton Universality:

- Deviation of $\mathbf{\Gamma(K_{\mu 3})/\Gamma(K_{e3})}$ from SM prediction.
- Possible differences in **form factors** between $K_{\mu 3}$ and K_{e3}.

K_{l3} *Widths and Lepton Universality*

$\mathbf{K_{l3}}$ master formula:

$$\boldsymbol{\Gamma(K_{l3(\gamma)}) = \frac{G_F^2 m_K^5}{192\pi^3} C_K^2 S_{EW} |V_{us}|^2 |f_+(0)|^2 I_K^l (1+\delta_K^l)^2}$$

with: $\mathbf{C_K^2 = 1}$ for K^0, $= \frac{1}{2}$ for $K^\pm$.

$\mathbf{S_{EW} = 1.0232}$: short-distance EW correction.

$\mathbf{f_+(0)}$: hadronic matrix element at $q^2 = 0$ (different for $K^\pm$, K^0).

$\mathbf{I_K^l = I_K^l(\lambda_+, \lambda_0)}$: integral of form factors over phase space.

$\mathbf{(1+\delta_K^l)^2 \approx 1 + 2\delta_{SU(2)}^l + 2\delta_{EM}^l}$: form factor corrections for $SU(2)$ breaking and long-distance EM interactions.

- Lepton flavour independent: C_K, S_{EW}, $\delta^l_{SU(2)}$
- Lepton flavour dependent: I^l_K, δ^l_{EM}

In case of **Lepton Non-Universality:** $\mathbf{G_F^\mu \neq G_F^e}$

K_{l3} ***Widths and Lepton Universality***

- **EM corrections** are small
  (Cirigliano et al. (2002), updated by Cirigliano, Neufeld;
  errors are taken as uncorrelated [has to be improved].)

	$\delta^{\mathbf{e}}_{\mathbf{EM}}$ [%]	$\delta^{\mu}_{\mathbf{EM}}$ [%]	$(\mathbf{1}+\delta^{\mu}_{\mathbf{K}})^{\mathbf{2}}/(\mathbf{1}+\delta^{\mathbf{e}}_{\mathbf{K}})^{\mathbf{2}}$
$\mathbf{K^0_{l3}}$	$+\mathbf{0.52(10)}$	$+\mathbf{0.80(15)}$	$\mathbf{1.006(4)}$
$\mathbf{K^\pm_{l3}}$	$+\mathbf{0.03(10)}$	$-\mathbf{0.12(15)}$	$\mathbf{0.997(4)}$

- **Phase space corrections** are large and depend
  on form factor slopes λ'_+, λ''_+, λ_0.

  Use form factor values from global Flavianet fit
  (assuming lepton universality in the slopes and taking correlations into account).

	$\mathbf{I^e_K}$	$\mathbf{I^\mu_K}$	$\mathbf{I^\mu_K/I^e_K}$
$\mathbf{K_{L,l3}}$	$\mathbf{0.15454(29)}$	$\mathbf{0.10209(31)}$	$\mathbf{0.6617(16)}$
$\mathbf{K^\pm_{l3}}$	$\mathbf{0.15889(30)}$	$\mathbf{0.10504(32)}$	$\mathbf{0.6611(16)}$

K_{l3} Widths and Lepton Universality

$\Longrightarrow$ **Standard Model expectation:**

$$\mathbf{R_{K\mu3/Ke3}} \equiv \frac{\Gamma(K_{\mu3})}{\Gamma(K_{e3})} = \left(\frac{G_F^\mu}{G_F^e}\right)^2 \frac{I_K^\mu}{I_K^e} \frac{(1+\delta_K^\mu)^2}{(1+\delta_K^e)^2} = \begin{cases} \mathbf{0.6657(31)} & K_L \\ \mathbf{0.6591(31)} & K^\pm \end{cases}$$

(Comparable uncertainties from I_K estimation and EM corrections.)

Parameter for Lepton Universality violation:

$$\mathbf{r_{\mu e}} = \frac{(R_{K\mu3/Ke3})_{\text{obs}}}{(R_{K\mu3/Ke3})_{\text{SM}}} = \frac{\Gamma(K_{\mu3})}{\Gamma(K_{e3})} \frac{I_K^e}{I_K^\mu} \frac{(1+\delta_K^e)^2}{(1+\delta_K^\mu)^2} = \frac{\mathbf{G_F^\mu}}{\mathbf{G_F^e}}$$

Situation with 2004 data (using current form factor slopes and EM corrections):

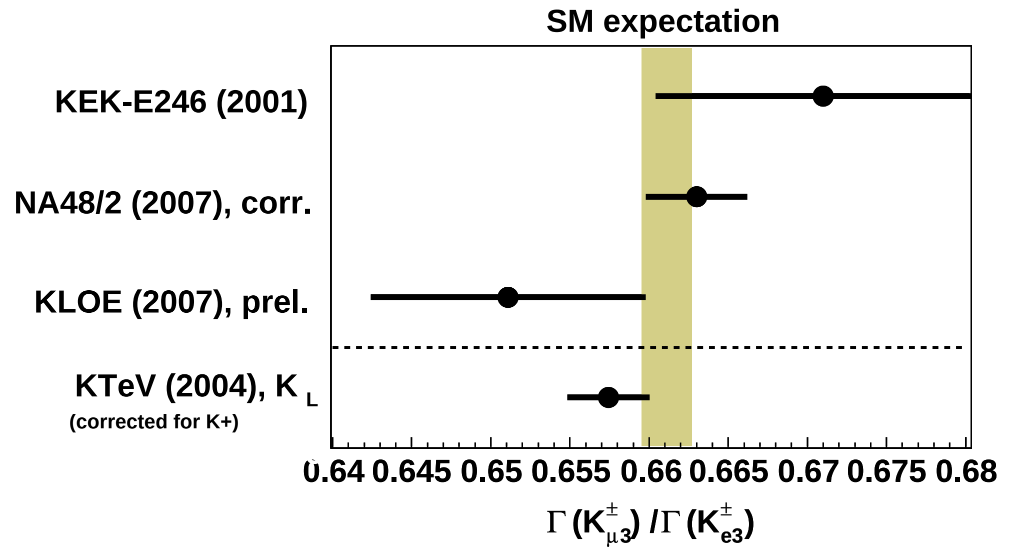
- $K^\pm$ modes: $\mathbf{r_{\mu e}^\pm = 1.019(13)}$
- K_L modes: $\mathbf{r_{\mu e}^L = 1.054(15)}$

$\Longrightarrow$ Intriguing deviation from Unity?!

(Compare with $\tau \to l\nu\bar{\nu}$: $g_\mu^2/g_e^2 = 0.9998(40)$)

Direct Measurements on $\Gamma(K_{\mu3})/\Gamma(K_{e3})$

	Channel	$\Gamma(K_{\mu3})/\Gamma(K_{e3})$	
KTeV (PRL 93, 2004)	K_L	0.6640 ± 0.0026	
KEK-E246 (PLB 513, 2001)	K^+	0.671 ± 0.011	Using stopped kaons.
NA48/2 (EPJC 50, 2007)	$K^\pm$	0.663 ± 0.003	EPJ value corrected at KAON07.
KLOE (prelim. 2007)	$K^\pm$	0.6511 ± 0.0087	



Determination of $\Gamma(K_{\mu 3})/\Gamma(K_{e3})$

Global *Flavianet* fit to all Kaon data

- Includes: All $K^{\pm}$, K_L, K_S BR's, form factor slopes, lifetimes.

$\Longrightarrow$ M. Palutan, KAON07

$K_{L,S}$

18 input measurements:

5 KTeV ratios
NA48 K_{e3}/2t and $\Gamma(3\pi^0)$
4 KLOE BRs
KLOE, NA48 $\pi^+\pi^-/K_{l3}$
KLOE, NA48 $\gamma\gamma/3\pi^0$
PDG ETAFIT for $\pi^+\pi^-/\pi^0\pi^0$
KLOE τ_L from $3\pi^0$
Vosburgh '72 τ_L

1 constraint: ΣBR=1

K^{+-}

31 input measurements:

5 older τ values in PDG
2 KLOE τ
KLOE BR($\mu\nu$)
KLOE $Ke3$, $K\mu3$ BRs
ISTRA+ $K_{e3}/\pi\pi^0$
NA48/2 $K_{e3}/\pi\pi^0$, $K_{\mu3}/\pi\pi^0$
E865 K_{e3}/Kdal
6 Chiang '72 BRs
3 old $\pi\pi^0/\mu\nu$
2 old $Ke3$/2 body
3 $K\mu3/Ke3$ (2 old)
2 old + 1 KLOE results on 3π

$+$ form factor slopes

Determination of $\Gamma(K_{\mu 3})/\Gamma(K_{e3})$

- **$K^{\pm}$ modes:** $\boxed{\mathbf{r^{\pm}_{\mu e} = 1.0059(87)}}$ (was $1.019(13)$ before)

  Error dominated by experiments (incl. scale factors).

- **$K_{L,S}$ modes:** $\boxed{\mathbf{r^{L,S}_{\mu e} = 1.0039(56)}}$ (was $1.054(15)$ before)

  Similar errors from experiments and knowledge on δ_{EM}.

- **Combination** of both modes: $\boxed{\mathbf{r_{\mu e} = 1.0045(50)}}$

  (taking into account $\rho = 0.12$)

  $\Longrightarrow$ **No indication of Lepton universality violation.**

Conclusions on $\mathbf{\Gamma(K_{\mu 3})/\Gamma(K_{e3})}$:

– Kaon sensitivity coming closer to τ decays! $((g_\mu^2/g_e^2)_{\tau\to l\nu\bar{\nu}} = 0.9998(40))$

– Experimental (BR, ff's) and theoretical errors (δ_{EM}) comparable.

K_{l3} — Form Factors

$\mathbf{K_{l3}}$ form factors:

K_{l3} matrix element:

$$\mathcal{M} \propto \mathbf{f_+(q^2)(p_K + p_\pi)^\mu \bar{u}_l \gamma_\mu (1+\gamma_5) u_v + f_-(q^2) m_l \bar{u}_l \gamma_\mu (1+\gamma_5) u_v}$$

Scalar form factor: $\mathbf{f_0(q^2) = f_+(q^2) + \frac{q^2}{m_K^2 - m_\pi^2} f_-(q^2)}$

Linear/quadratic expansion:

$$f_+(q^2) = f_+(0)\left(1 + \lambda'_+ \frac{q^2}{m_{\pi^+}^2} + \frac{1}{2}\lambda''_+ \frac{q^4}{m_{\pi^+}^4}\right)$$

$$f_0(q^2) = f_+(0)\left(1 + \lambda_0 \frac{q^2}{m_{\pi^+}^2}\right)$$

(Not necessarily the best — but used by all experiments.)

K_{l3} — Form Factor Data

Current Data on K_{l3} form factor slopes:

	Channel	$\lambda'_+ \times 10^3$	$\lambda''_+ \times 10^3$	$\lambda_0 \times 10^3$
KTeV 2004	$\mathbf{K_L e3}$	21.7 ± 2.0	2.9 ± 0.8	
	$\mathbf{K_L \mu 3}$	17.0 ± 3.7	4.4 ± 1.5	12.8 ± 1.8
KLOE 2006	$\mathbf{K_L e3}$	25.5 ± 1.8	1.4 ± 0.8	
KLOE prel.	$\mathbf{K_L \mu 3}$	with $K_L e3$	with $K_L e3$	15.6 ± 2.6
NA48 2004	$\mathbf{K_L e3}$	28.0 ± 2.4	0.4 ± 0.9	
NA48 2007	$\mathbf{K_L \mu 3}$	16.8 ± 3.3	4.0 ± 1.4	9.1 ± 1.4
ISTRA 2004	$\mathbf{K^- e3}$	24.9 ± 1.7	1.9 ± 0.9	
ISTRA 2004	$\mathbf{K^- \mu 3}$	23.0 ± 6.4	2.3 ± 2.3	17.1 ± 2.2

(KLOE $K_{\mu 3}$ data not used due to combined fit with K_{e3}.)

K_{l3} — *Form Factor Slopes*

K_{e3} slopes only:

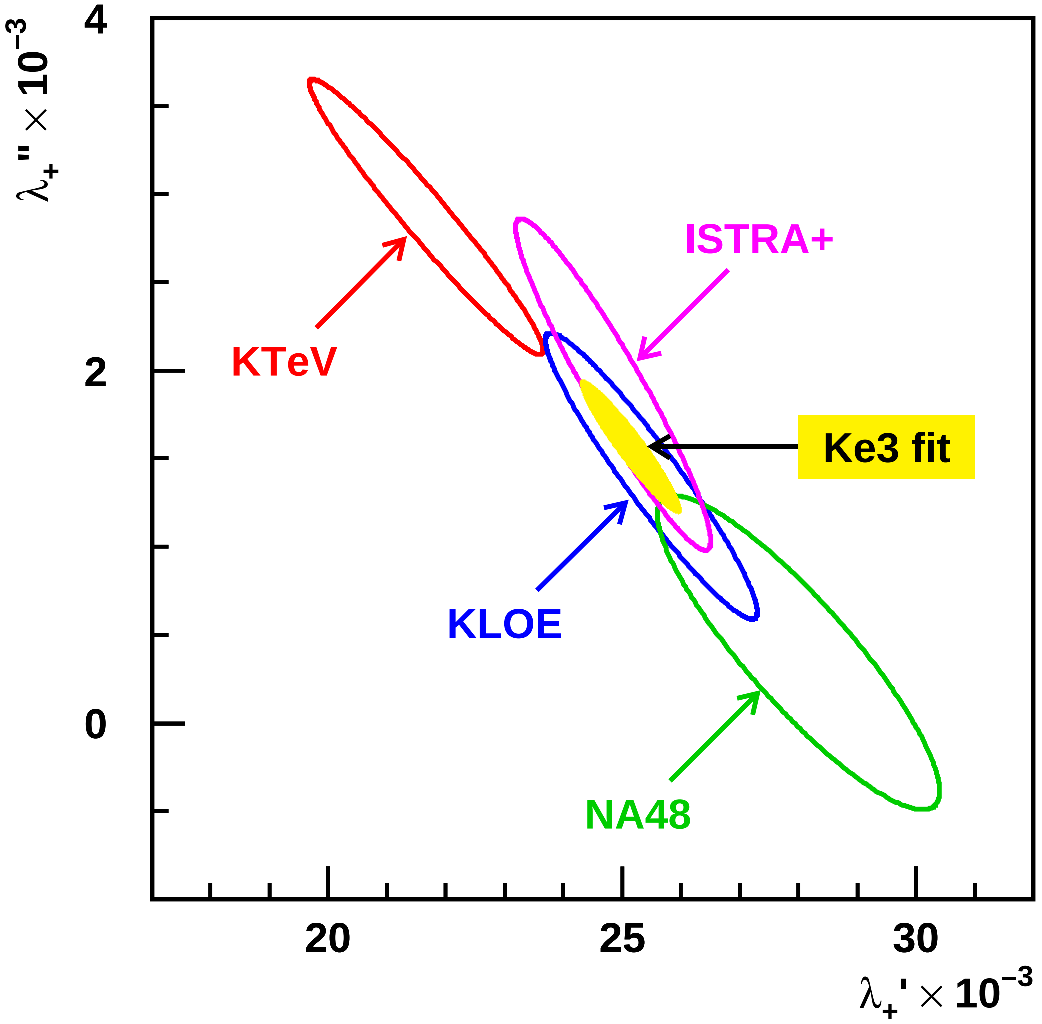
Combined fit:

$$\lambda'_+ = (\mathbf{25.1 \pm 0.9}) \times \mathbf{10^3}$$

$$\lambda''_+ = (\mathbf{1.6 \pm 0.4}) \times \mathbf{10^3}$$

Correlation $\rho = -\mathbf{94.1}\%$

(Ellipses $= 1\,\sigma$ contours)



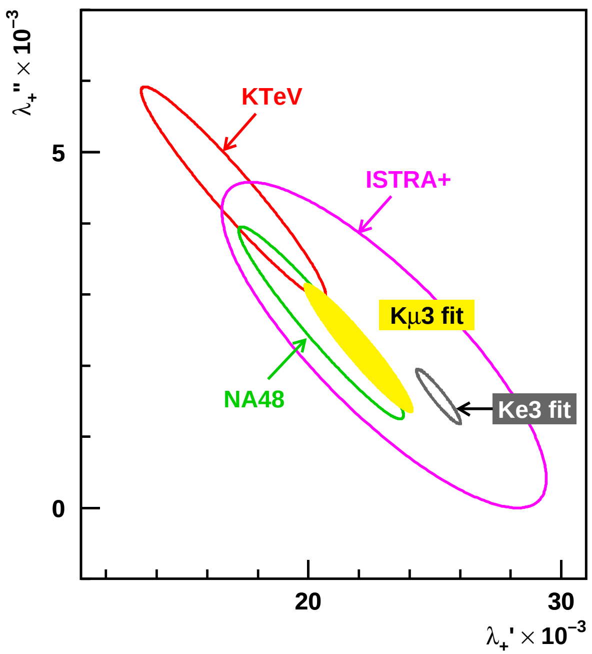
K_{l3} — *Form Factor Slopes*

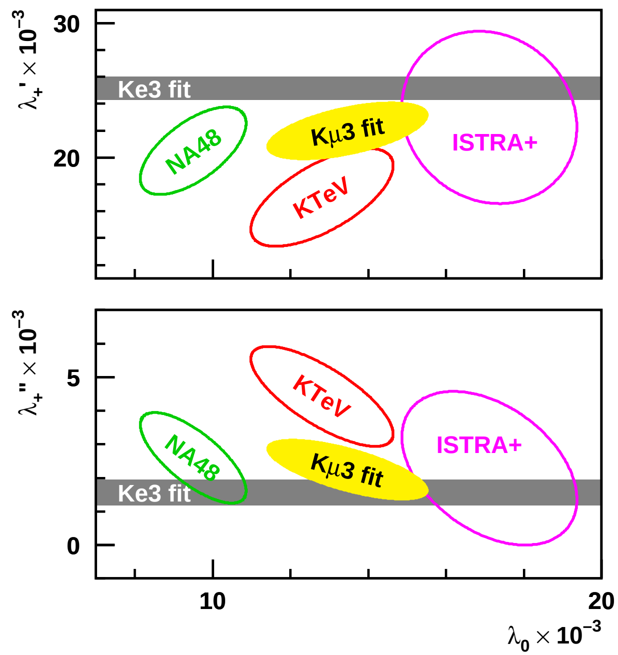
$K_{\mu 3}$ slopes only:

$$\lambda'_+ = (22.0 \pm 2.2) \times 10^3$$
$$\lambda''_+ = (2.3 \pm 0.9) \times 10^3$$
$$\lambda_0 = (13.5 \pm 2.1) \times 10^3$$

Correlations:

	λ'_+	λ''_+
λ'_+		-0.949
λ_0	0.540	-0.679

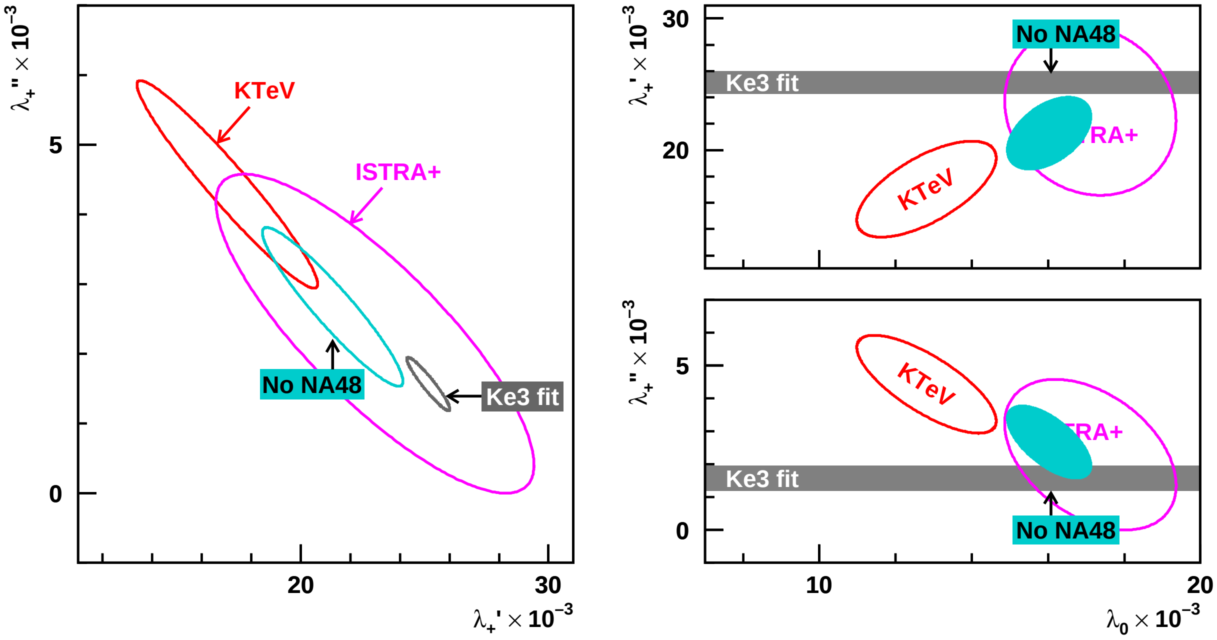




Agreement with K_{e3} poor, mostly driven by NA48/2 value on λ_0.

K_{l3} — *Form Factor Slopes*

Excluding NA48 $K_{L,\mu3}$ from the fit:



Non-SM Interactions in K_{l3}

Right-handed currents in the quark sector:

(Bernard, Oertel, Passemar, Stern, PLB 638 (2006).
$\Longrightarrow$ Talks Passemar, Stern, KAON07)

- Charged current interaction:

$$\mathcal{L}_{CC} = \tilde{g}\left[l_\mu + \frac{1}{2} \begin{pmatrix} u \\ c \\ t \end{pmatrix} (\mathcal{V}_{\text{eff}}\gamma_\mu + \mathcal{A}_{\text{eff}}\gamma_\mu\gamma_5) \begin{pmatrix} d \\ s \\ b \end{pmatrix} \right] W^\mu + \text{h.c.}$$

Standard Model: $\boxed{\mathcal{V}_{\text{eff}} = -\mathcal{A}_{\text{eff}} = V_{\text{CKM}}}$

- Absence of right-handed CC well-tested in the lepton sector.

However: Need not to be the same in the quark sector.

No stringent tests of right-handed quark couplings so far!

Non-SM Interactions in K_{l3}

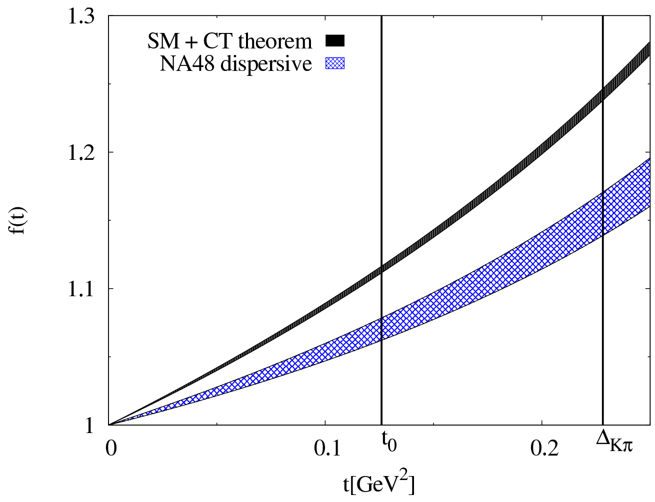
$K_{\mu 3}$ Decays:

- In the chiral limit: Normalized scalar form factor $f_0(q^2)/f_+(0)$ known at the Callan-Treiman point $q^2 = \Delta_{K\pi} = m_K^2 - m_\pi^2$ from BR measurements.
  RH currents would cause a deviation.
- $\ln C = \ln f(\Delta_{K\pi})$ can be measured using dispersive approach for form factor parametrization.
- NA48 fit of $K_{L\,\mu 3}$ data:

$$\ln C = 0.1438(80)_{\text{stat}}(112)_{\text{syst}}$$

$$2(\epsilon_S - \epsilon_{NS}) + \tilde{\Delta}_{CT} = -0.071 \pm 0.015$$

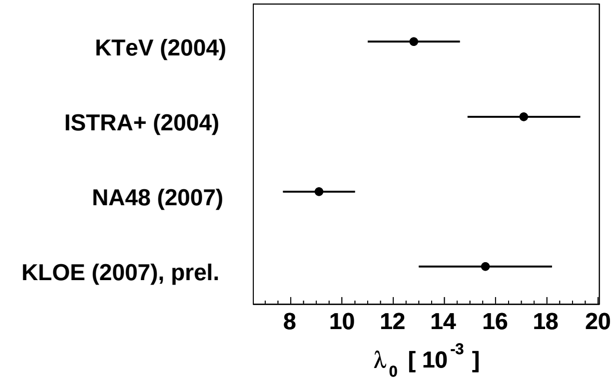
ϵ_S, ϵ_{NS}: Parameters of RH currents.
$\tilde{\Delta}_{CT}$: χPT correction $\sim \mathcal{O}(10^{-3})$

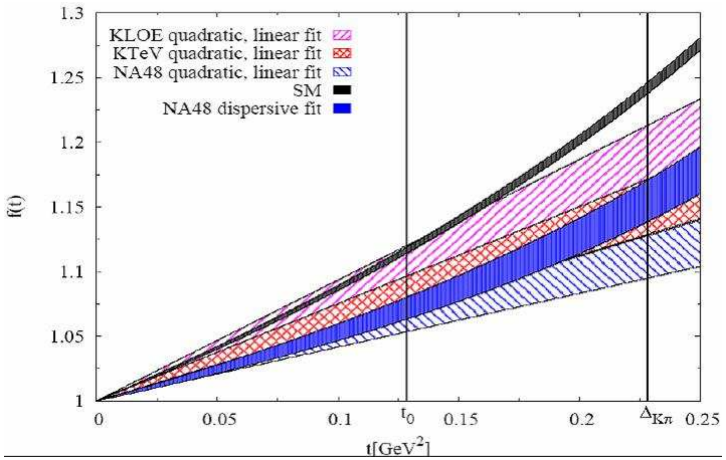


Non-SM Interactions in K_{l3}

Conclusions on Right-Handed Quark Currents:

- NA48 sees effect ($\sim 5\sigma$) in $K_{\mu 3}$ at the Callan-Treiman point.
- No other experiment has (yet) performed a fit with dispersive parametrization.
- *However:* Other experiments disagree with NA48 in slope λ_0 of scalar form factor. Correlation between λ_0 and $\ln C$ unclear.
- Data of other experiments need to be investigated.





E. Passemar, KAON07

Situation not yet clarified.

$$\mathbf{K_{e2}/K_{\mu 2}}$$

$K_{e2}/K_{\mu 2}$ — *Introduction*

Standard Model Prediction:

- $\mathbf{R_K = \Gamma(K_{e2})/\Gamma(K_{\mu 2})}$ text book exercise for helicity suppression, but must include radiative corrections: (M. Finkemeier, PLB 387 (1996))

$$\mathbf{R_K} = R_K^{(0)}(1+\delta R_K^{\text{rad.corr.}}) = 2.569\times 10^{-5}\times(0.9622\pm 0.0004)$$
$$= \mathbf{(2.472\pm 0.001)\times 10^{-5}}$$

$\Longrightarrow$ SM prediction has precision of 0.04%!

Caveat: Radiative corrections model dependent (VMD).
More thorough χPT study underway (Cirigliano).

Possibilities for non-SM Physics in $\mathbf{K_{e2}/K_{\mu 2}}$:

- K_{e2} is strongly suppressed and extremely well-known in the SM

$\Longrightarrow$ Non-SM effects *a priori* are easier to detect than in e.g. K_{l3}.

- SUSY: LFV $H^{\pm}$ couplings may enhance/lower SM K_{e2} decay width by up to $2-3\%$.

(Masiero, Paradisi, Petronzio (2006)) $\Longrightarrow$ P.Paradisi, KAON07)

$K_{e2}/K_{\mu 2}$ — *Measurements*

PDG 2006: Three measurements from the 1970's

$$\mathbf{\Gamma(K_{e2})/\Gamma(K_{\mu 2}) = (2.45 \pm 0.11) \times 10^{-5}}$$

Three new **preliminary measurements:**

- **NA48/2 (2003 data), presented in 2005:**
  - About 4000 signal events from normal running period.
  - Systematics dominated by trigger efficiencies.

$$\mathbf{\Gamma(K_{e2})/\Gamma(K_{\mu 2}) = (2.416 \pm 0.043 \pm 0.024) \times 10^{-5}}$$

- **NA48/2 (2004 data), presented at KAON07:**
  - About 4000 signal events from special minimum bias trigger.
  - Small systematics, except background.
    (measured from data $\longrightarrow$ large statistical uncertainty in syst. error.)
  - Completely uncorrelated with 2003 measurement.

$$\mathbf{\Gamma(K_{e2})/\Gamma(K_{\mu 2}) = (2.455 \pm 0.045 \pm 0.041) \times 10^{-5}}$$

$K_{e2}/K_{\mu 2}$ — *Measurements*

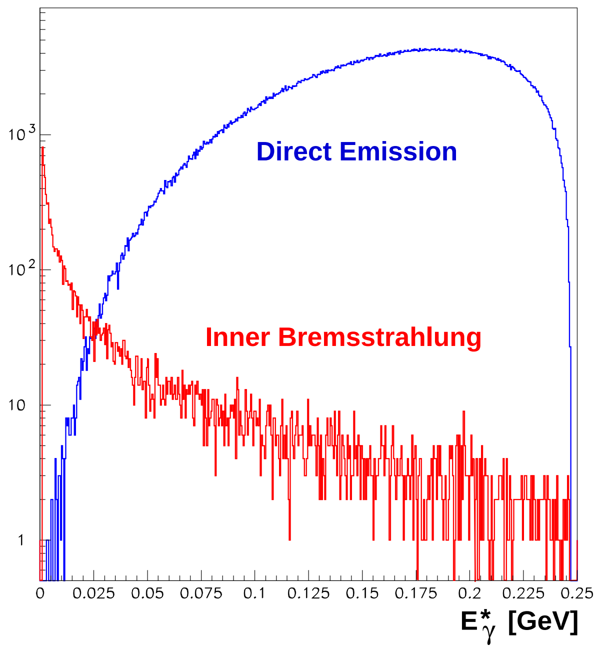
- **KLOE, presented at KAON07:**
  - About 8000 signal events from 1.7 fb^{-1}.
  - Statistics dominated by MC, conservative systematics estimation.

$$\mathbf{\Gamma(K_{e2})/\Gamma(K_{\mu 2}) = (2.55 \pm 0.05 \pm 0.05) \times 10^{-5}}$$

Treatment of radiative corrections:

- SM prediction includes IB, excludes DE.
- All experiments measure inclusive $\Gamma(K_{e2(\gamma)})/\Gamma(K_{\mu 2(\gamma)})$, but correct for DE contributions.

$\Longrightarrow$ Can easily be combined and compared with SM expectation.

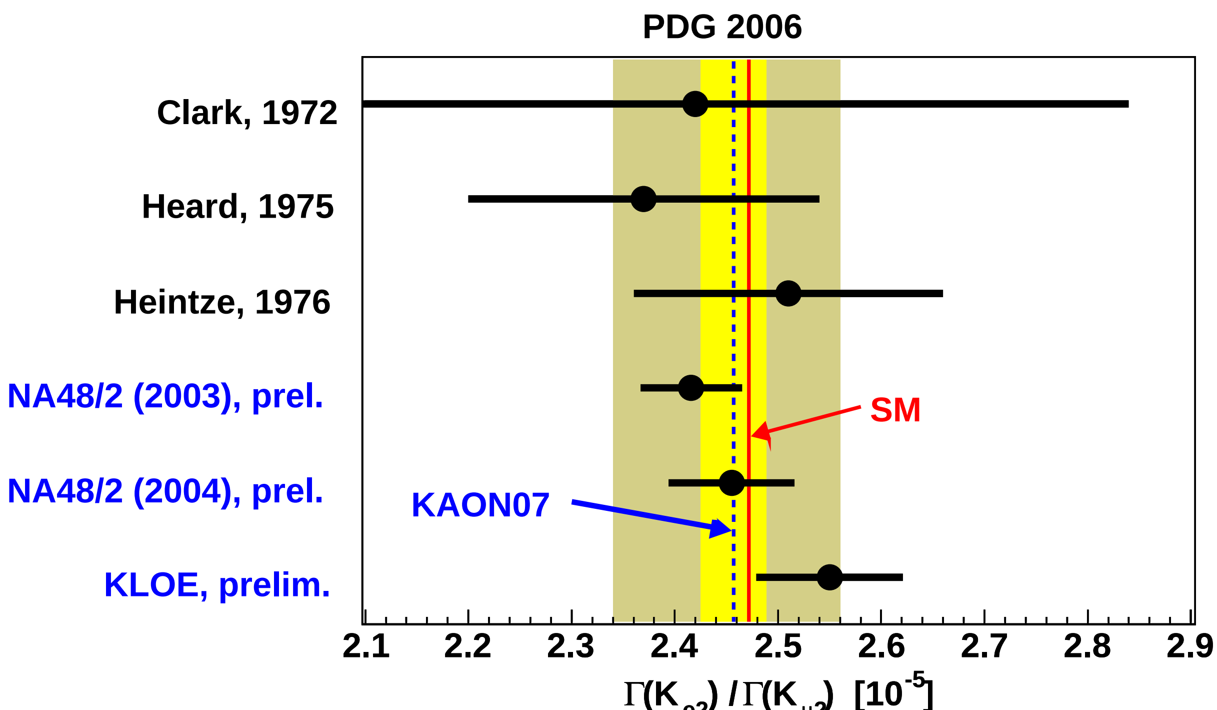


$K_{e2}/K_{\mu 2}$ — ***Measurements***

Combine all preliminary results and PDG2006:

$$\boxed{\Gamma(K_{e2})/\Gamma(K_{\mu 2}) = (2.457 \pm 0.032) \times 10^{-5}} \quad (\chi^2/n_{\text{dof}} = 2.44/3)$$

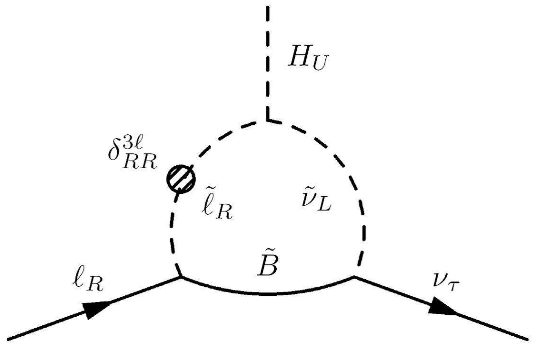
- Huge improvement w.r.t PDG 2006, $\sigma_{\text{rel.}} = 1.3\%$ now!
- Perfect agreement with SM expectation.



$K_{e2}/K_{\mu 2}$ — Restrictions on New Physics

Limit on LFV in $H^\pm$ coupling:

(Masiero, Paradisi, Petronzio, PRD 74, 2006)



LFV Yukawa coupling:

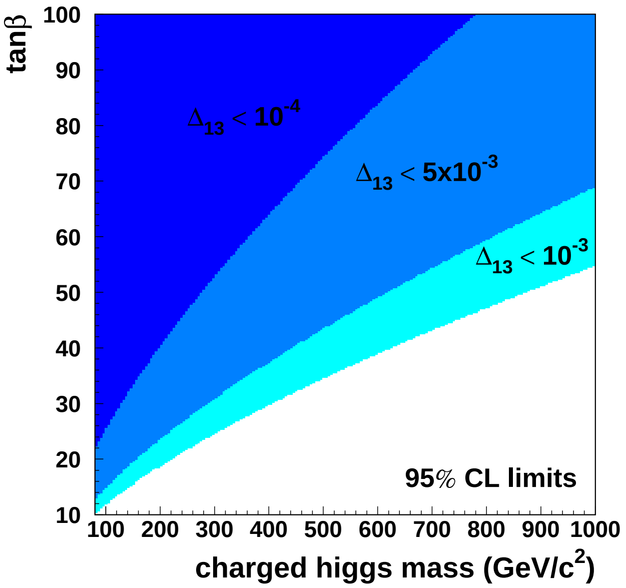
$$l\mathbf{H}^\pm\nu_\tau \;\rightarrow\; \frac{\mathbf{g_2}}{\sqrt{\mathbf{2}}}\frac{\mathbf{m}_\tau}{\mathbf{M_W}}\,\boldsymbol{\Delta}_{\mathbf{13}}\,\tan^{\mathbf{2}}\beta$$

Lepton-flavour violating term: $\boldsymbol{\Delta}_{\mathbf{13}}$

(should be $\leq 10^{-3}$ from EW theory, but $\neq 0$)

Limit on LFV in K_{e2} converts to limit on $\boldsymbol{\Delta}_{\mathbf{13}} = \boldsymbol{\Delta}_{\mathbf{13}}(M_{H^\pm}, \tan\beta)$:

$$\mathbf{R}_\mathbf{K}^{\mathsf{LFV}} \approx \mathbf{R}_\mathbf{K}^{\mathsf{SM}}\left[1+\left(\frac{\mathbf{m_K^4}}{\mathbf{M_{H^\pm}^4}}\right)\left(\frac{\mathbf{m}_\tau^\mathbf{2}}{\mathbf{M_e^2}}\right)|\boldsymbol{\Delta}_{\mathbf{13}}|^{\mathbf{2}}\tan^{\mathbf{6}}\beta\right]$$



$K_{e2}/K_{\mu 2}$ — Comparison with $B \to \tau\nu_\tau$

$\mathrm{B}^\pm \to \tau^\pm \nu_\tau$ Decays:

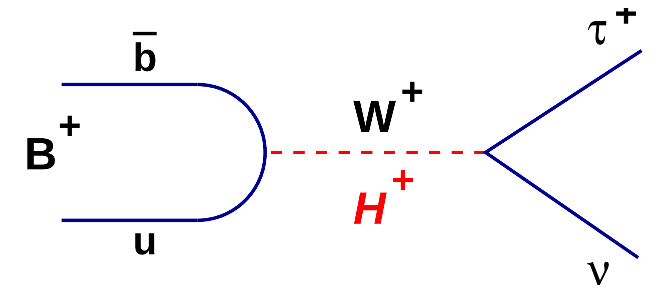
- Also in $\mathrm{B}^\pm \to \tau^\pm \nu_\tau$:
  Possible transition via $H^\pm$,
  sensitivity to $M_{H^\pm}$, $\tan\beta$.
- No LFV required
  $\Longrightarrow$ No Δ_{13} term
- Dependency on $M_{H^\pm}$, $\tan\beta$:
  (Isidori, Paradisi,PLB 639,2006)

$$\frac{\mathrm{Br}_{\mathrm{SUSY}}}{\mathrm{Br}_{\mathrm{SM}}} = \left[1 - \left(\frac{m_B^2}{M_{H^\pm}^2}\right) \frac{\tan^2\beta}{1 + \epsilon_0 \tan\beta}\right]^2$$

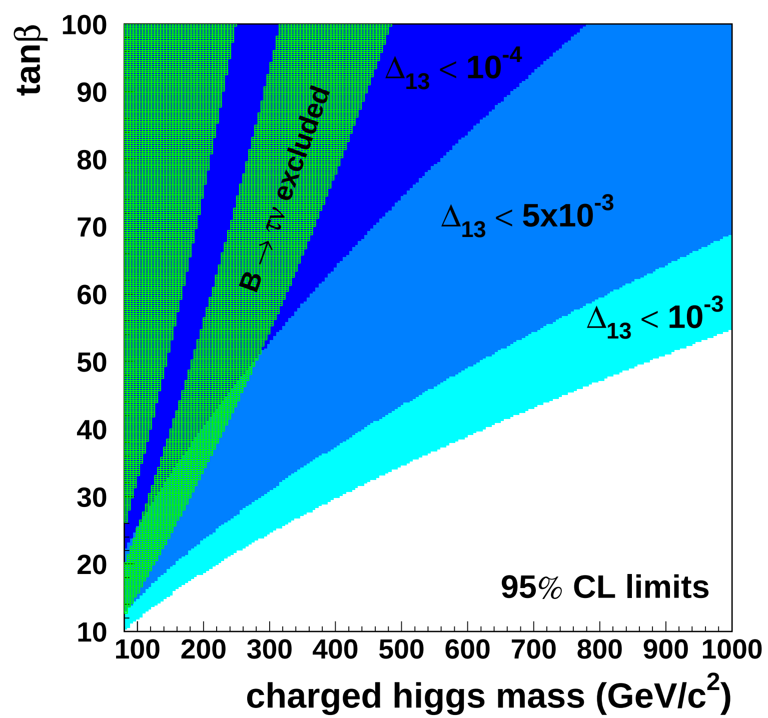
$(\epsilon_0 \sim 0.01)$

For non-tiny Δ_{13}:

Sensitivity to $\mathrm{H}^\pm$ in $\mathrm{K}_{e2}/\mathrm{K}_{\mu 2}$
better than in $\mathrm{B} \to \tau\nu_\tau$!



$\mathrm{Br}(B \to \tau\nu) = (1.42 \pm 0.44) \cdot 10^{-4}$
(current BaBar/Belle average)



$K_{e2}/K_{\mu 2}$ — *Near Future*

KLOE:

- Has $\sim 20\%$ more data on tape.
- Another ~ 3000 events with other reconstruction method.
- Improve MC statistics & systematics

$\Longrightarrow$ Should arrive at $\sigma_{\text{rel}}(\mathbf{R_K}) \sim \pm\mathbf{1}\%$.

P-326: (also known as NA48/3)

- Similar setup as for NA48/2 (2004) prel. measurement, use of most parts of existing NA48 apparatus.
- Plan: 4 months (June-October 2007) run period

  $\Longrightarrow$ Collect $\sim 150\,000$ K_{e2} decays.

$\Longrightarrow$ Goal to reach $\sigma_{\text{rel}}(\mathbf{R_K}) \sim \pm\mathbf{0.3}\%$.

$K_{e2}/K_{\mu2}$ — *P-326 run 2007*

- **Beam parameters 2007** optimized for $K_{e2}/K_{\mu2}$ w.r.t. 2004:
  - Kaon mean momentum p: 60 GeV/c $\rightarrow$ 75 GeV/c
  - Kaon momentum bite $\Delta p/p$: $\pm$3 GeV/c $\rightarrow$ $\pm$2.5 GeV/c
  - p_T kick from spectrometer magnet: 120 MeV/c $\rightarrow$ 263 MeV/c

$\Longrightarrow$ **Improved kinematic separation** of K_{e2}!

- **Minimum bias trigger:**
  - for $\mathbf{K_{e2}}$: Hodoscope hits
    $+$ min. energy in the LKr
  - for $\mathbf{K_{\mu 2}}$ (downscaled):
    Just hodoscope ($\epsilon > 99\%$)

Experience from 2004 run:

Systematics under control.

Only systematic $> 0.2\%$:

Background to K_{e2},
error is statistical.

Sourse	Preliminary	Relative error
Ke2 sample statistics		1.85%
Kmu2 sample statistics		0.05%
E/p correction for the electrons (E/p>0.95 cut)		0.18%
E/p correction for the electrons (flatness with Ptrk)		0.16%
E/p correction for the muons (E/p<0.2 cut)		Negligible
Trigger efficiency		0.3%
MC statistics Ke2		0.3%
Acceptance systematics		0.07%
Radiative corrections		0.12%
Muons with E/p>0.95 flatness		0.2%
Background subtraction		1.59%
Total statistical error		*1.85%*
Total systematics error		*1.66%*

V. Kozhuharov, KAON07

$K_{e2}/K_{\mu 2}$ — *P-326 run 2007*

Background to $\mathbf{K_{e2}}$:

Mainly $K_{\mu 2}$ in K_{e2} sample.

- $p_{\text{track}} < 35$ GeV/c: $(\sim 43\%)$

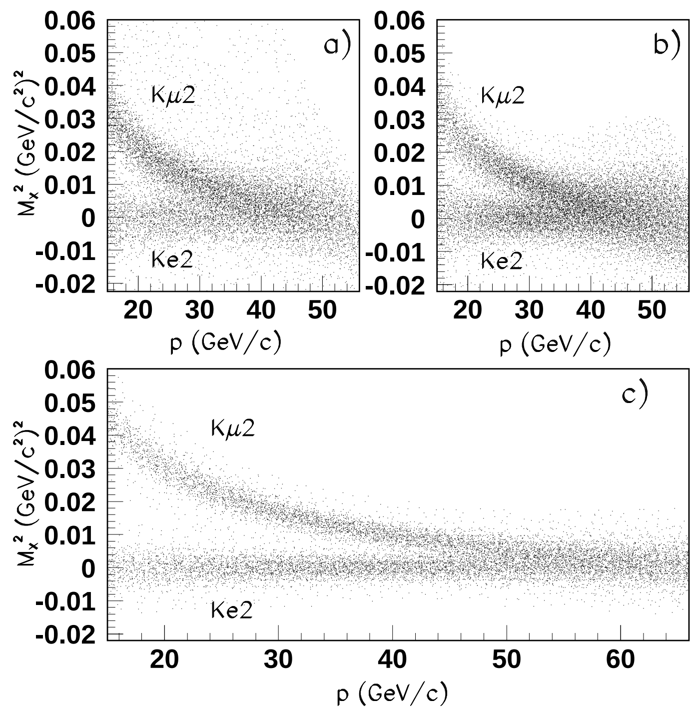
  Kinematic separation

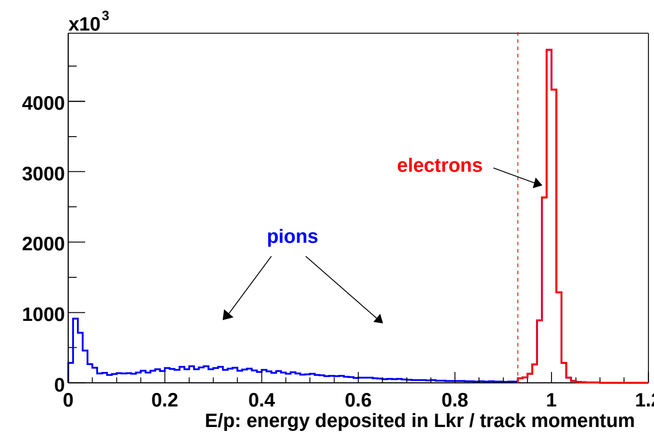
  Build M^2_{miss} under e-assumption.

- $p_{\text{track}} > 35$ GeV/c: $(\sim 57\%)$

  Electron identification

  Require electron-ID from $E_{\text{Lkr}}/p_{\text{track}}$.



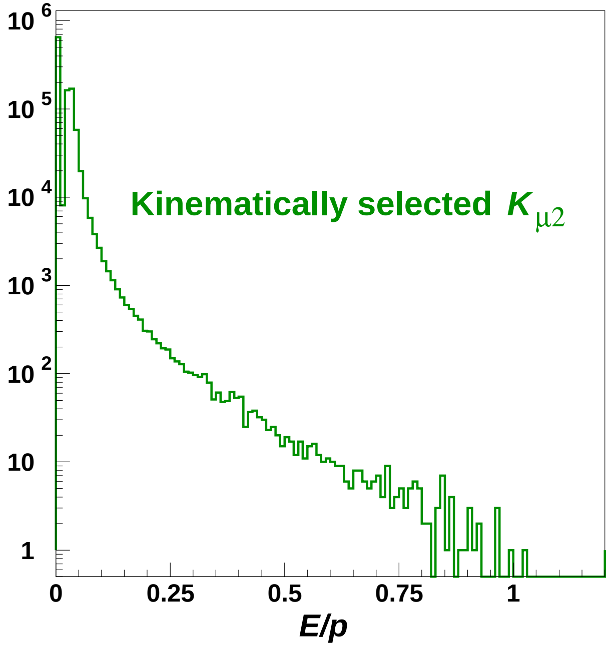


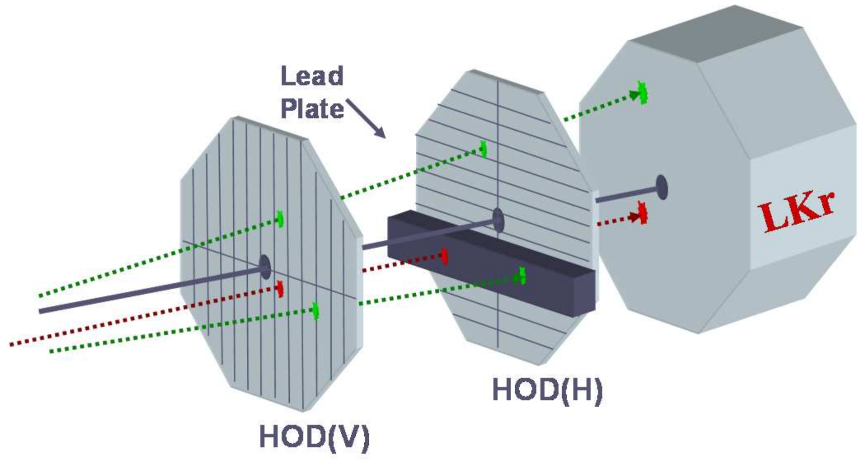
$K_{e2}/K_{\mu 2}$ — *P-326 run 2007*

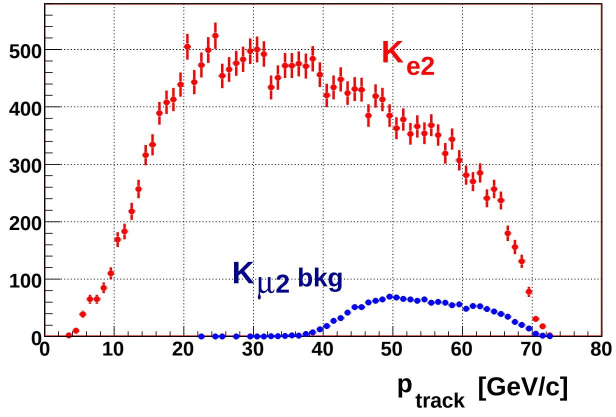
Problem at high momenta:

- **Catastrophic energy-loss** of $\sim 5 \cdot 10^{-6}$ of muons in the LKr.
  $\Longrightarrow$ mis-identified as electrons.

- Solution:
  Lead bar between hodoscope planes in front of LKr, covering $\sim 18\%$ of acceptance
  $\Longrightarrow$ Only μ pass, E/p measured in LKr.



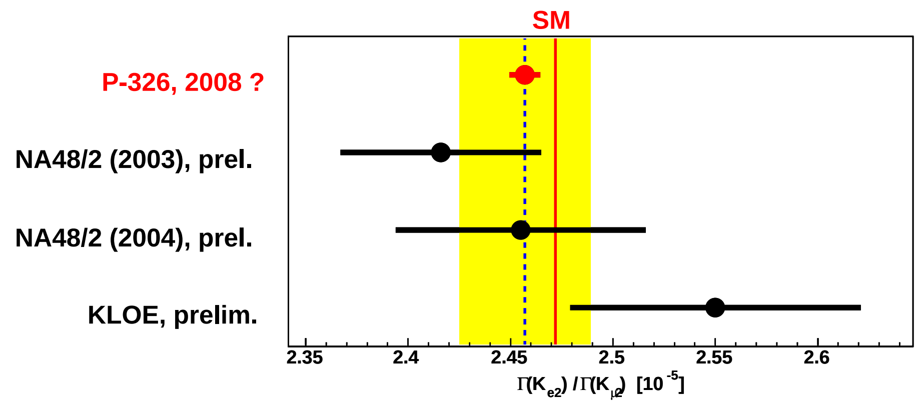




$K_{e2}/K_{\mu2}$ — *Expectations*

Expected precision on $K_{e2}/K_{\mu2}$:

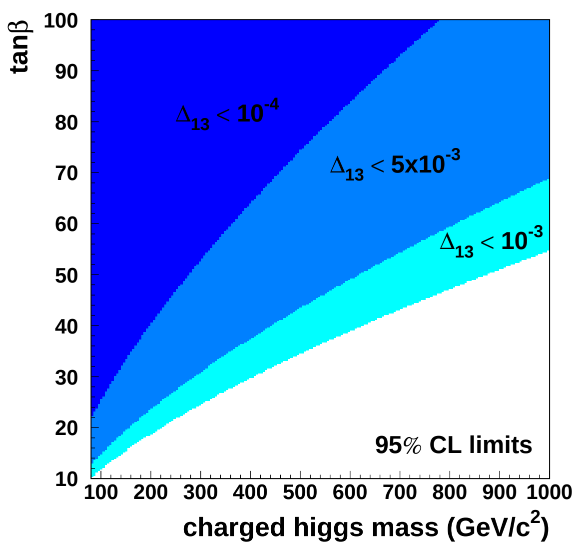
- Statistical: $\pm\mathbf{0.28\%}$
- Systematic: $\leq \pm\mathbf{0.2\%}$



Overall expected reach:

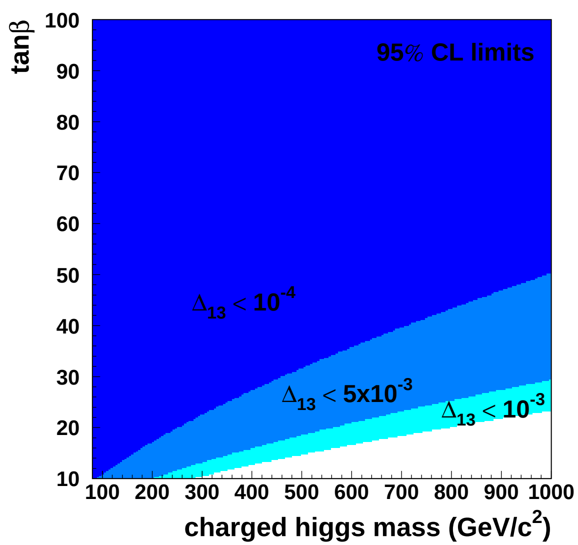
$$\sigma(\mathbf{R_K})/\mathbf{R_K} \approx \pm\mathbf{0.32\%}$$

KAON07:



KAON09 ?!

same R_K central value



Conclusions

- **K_{l3} Decays:**
  - New **BR results** agree with SM expectation on **0.5% level.** Theoretical uncertainties start to be important.
  - Indication for non-SM couplings from NA48 $K_L\mu3$ decays needs to be investigated with data of other experiments.
- **Ratio $\mathbf{\Gamma(K_{e2})/\Gamma(K_{\mu2})}$:**
  - Two new preliminary results reported by KLOE and NA48/2.

    $\Longrightarrow$ **Precision on $\mathbf{\Gamma(K_{e2})/\Gamma(K_{\mu2})}$** now **1.3%**.
  - P-326 will perform dedicated run this year to reach $\sigma_{\text{rel}}(\mathbf{\Gamma(K_{e2})/\Gamma(K_{\mu2})}) \sim \mathbf{0.3\%}$

    $\Longrightarrow$ Sensitivity to LFV in SUSY!