Lepton Flavor violation

Low energy modes

$$\mu \to e\gamma, \quad \mu \to eee,$$

$$\mu^- + A \to e^- + A, \quad \mu^- + A \to e^+ + A', \quad \mu^+ e^- \to \mu^- e^+,$$

$$\tau \to e\gamma, \quad \tau \to \mu\gamma, \quad \tau \to eee,$$

$$\tau \to \mu\mu\mu, \quad \tau^+ \to e^+\mu^+\mu^-, \quad \tau^+ \to \mu^+ e^+ e^-,$$

$$\tau \to \mu\pi, \quad \tau \to e\pi, \quad \tau \to \mu K_S, \quad K_L^0 \to \mu e$$

No new physics at LHC

- Signals at LFV rare decays
- For example $\mu \to eee$ $\mu^- + A \to e^- + A,$
- What can we learn from pattern of LFV processes?

New physics at LHC

- Signals at LFV rare decays
- For example $\mu \to eee$ $\mu^- + A \to e^- + A,$
- What can we learn from pattern of LFV processes?
- SUSY discovered. $\mu \to eee$ $\mu \to e\gamma,$
- R-parity violation

New physics at LHC

- no Signals at LFV
- Minimal flavor violation?

Nightmare scenario

- No new physics at LHC no LFV

- Minimal flavor violation?
- Increasing scale? (naturalness)

- (g-2) of muon and electron

NSI in neutrinos

- Some model independent connection between NSI in neutrino oscillation
- Experiments?

- Implications of Signal for NSI in neutrino oscillation

High statisctics in LFV

- Plarized initial state
- Helicity structure
- CP violation

Radiative neutrino mass generation

- LFV signals in low energy and LHC
- Ways to establish the model
- Discriminate between models

Backup

Limits (slide by Stephane Lavignac)

Prospects for CLFV experiments

μ → e γ :

MEG update should reach 5×10^{-14} in 3 years of acquisition time

μ → eee :

Mu3e proposal at PSI aims at $\mathcal{O}(10^{-16})$ (improvement by 4 orders of magn.)

μ → e conversion in nuclei :

The projects mu2e at FNAL and COMET aim at a sensitivity below 10^{-16}
More ambitious projects under study at FNAL and J-PARC $\mathcal{O}(10^{-18})$

τ decays :

The upgraded LHCb experiment should reach a few 10^{-9} on $\tau \to \mu\mu\mu$
Future B factories (KEKB, SuperB) should probe the $10^{-9} - 10^{-10}$ level

Examples of constraints:

$\mu \to e\gamma$: $\frac{C^M_{\mu e\gamma}}{\Lambda^2_{NP}} \langle H^0 \rangle \, \bar{e}\sigma^{\mu\nu} P_M \mu \, F_{\mu\nu} \; + \; \text{h.c.}$ (M = L,R)

The exp. upper bound $\text{BR}\,(\mu \to e\gamma) \; < \; 5.7 \times 10^{-13}$ translates into

$$\Lambda_{NP} \; > \; \begin{cases} 7.8 \times 10^4 \,\text{TeV} & (C = 1) \\ 400 \,\text{TeV} & \left(C = \frac{\alpha_W}{4\pi}\right) \end{cases}$$

$\mu \to e\,e\,e$: $\frac{C^{MN}_{eee\mu}}{\Lambda^2_{NP}} \; (\bar{e}\gamma^\mu P_M e)\,(\bar{e}\gamma^\mu P_N \mu) \; + \; \text{h.c.}$ (M,N = L,R)

The exp. upper bound $\text{BR}\,(\mu \to eee) \; < \; 10^{-12}$ translates into

$$\Lambda_{NP} \; > \; \begin{cases} 210 \,\text{TeV} & (C = 1) \\ 11 \,\text{TeV} & \left(C = \frac{\alpha_W}{4\pi}\right) \end{cases}$$

→ CLFV starts to be sensitive to scales comparable to kaon physics:

$$\Lambda_{\text{NP}} \; \gtrsim \; \begin{cases} 2 \times 10^4 \,\text{TeV} & (C = 1) \\ 2 \times 10^3 \,\text{TeV} & \left(C = \frac{\alpha_S}{4\pi}\right) \end{cases} \qquad \frac{C}{\Lambda^2_{\text{NP}}} \, (\bar{s}d)(\bar{s}d)$$