Lepton Flavor Violation in a R parity breaking scenario
A good (best?) theory for COMET

Joe Sato with Masato Yamanaka

In preparation

Lepton Flavor Violation in a R parity breaking scenario

Best Understanding for

Remarkable Implication

From COMET

0.COMET

COMET (COherent Muon Electron Transittion)

http://comet.phys.sci.osaka-u.ac.jp/

- Br for cLFV processes are quite model dependent

- Need other experiment(s) with

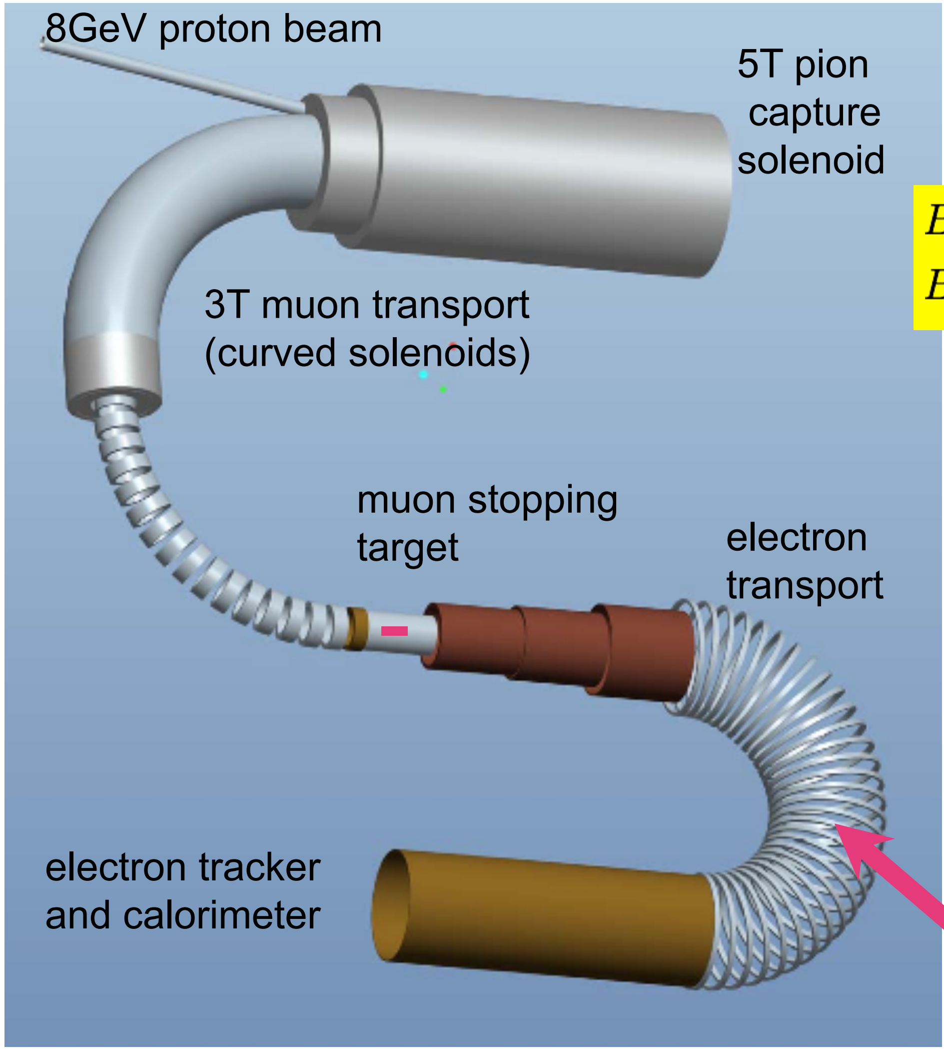
  different physics process (with better sensitivity)!

  independently on MEG result

- COMET (COherent Muon Electron Transittion)

  starting construction at J-Parc

μ-e conversion : COMET (E21) at J-PARC



$$B(\mu^- + Al \rightarrow e^- + Al) = 2.6 \times 10^{-17}$$
$$B(\mu^- + Al \rightarrow e^- + Al) < 6 \times 10^{-17} \quad (90\% C.L.)$$

- 10^{11} muon stops/sec for 56 kW proton beam power.
- C-shape muon beam line and C-shape electron transport followed by electron detection system.
- Stage-1 approved in 2009.

Electron transport with curved solenoid would make momentum and charge selection.

COMET Collaboration (as of April, 2013)

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117 collaborators
27 institutes
12 countries

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1. Introduction

Since COMET Meeting 11, We have considered (quested)

a good (best?) Scenario for COMET

The definition of “good”

COMET find a new physics (= $\mu^- N \to e^- N$)

in advance to other experiments, LHC , MEG, etc, within a model often considered

VS other cLFV experiments

$\mu^- N \to e^- N$ Can be Tree

$\mu^+ \to e^+ \gamma$ Be Loop only, dipole

Gauge Symmetry forbids tree contribution

$\mu^+ \to e^+ e^- e^+$ Must be Loop

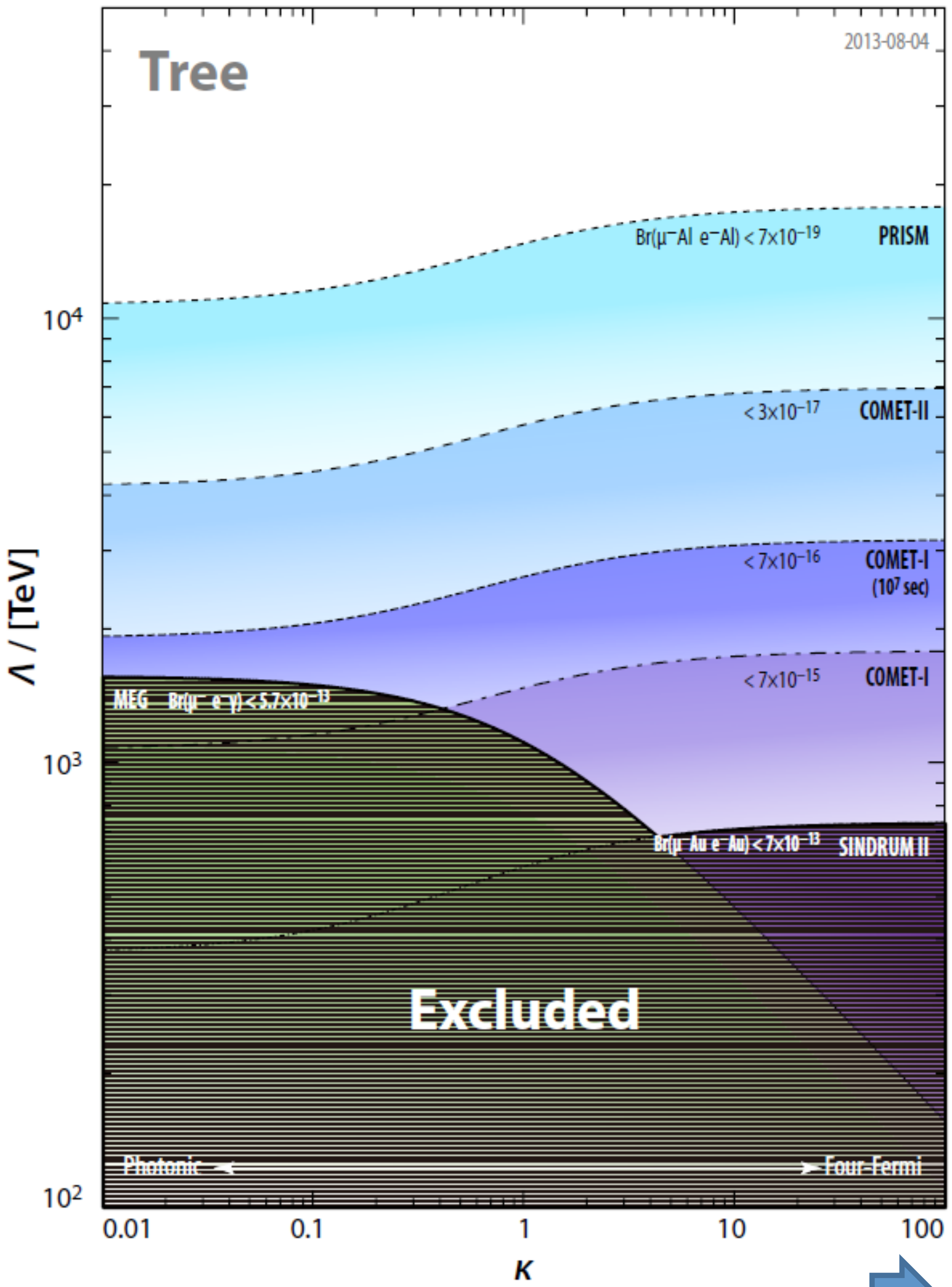
In terms of effective theory

$$\mathcal{L} = \frac{1}{1+\kappa}\frac{m_\mu}{\Lambda^2}\bar{\mu}_{\mathrm{R}}\sigma^{\mu\nu}e_{\mathrm{L}}F_{\mu\nu} + \frac{\kappa}{1+\kappa}\frac{1}{\Lambda^2}(\bar{\mu}_{\mathrm{L}}\gamma^{\mu}e_{\mathrm{L}})(\bar{q}_{\mathrm{L}}\gamma_{\mu}q_{\mathrm{L}})$$

κ must be very large.

Second term is relevant with $\mu^- N \to e^- N$

MEG



PRISM

COMET Phase-II

COMET Phase-I

Scalar mode has an enhancement
= heavier effective mass

$$\mu^+ \to e^+ e^- e^+$$

Second term is irrelevant = loop effect ?

Do we have a theory fulfilling those property?

Yes, SUSY without R parity

2. SUSY without R Parity

R Parity : stabilize proton, give Dark matter cndidate

Howerver

To explain the reason why we do not observe SUSY at LHC

R Parity Breaking theory is often considered

Maximal theory in relativistic field theory include SUSY
= Motivation for SUSY, *Haag et al*

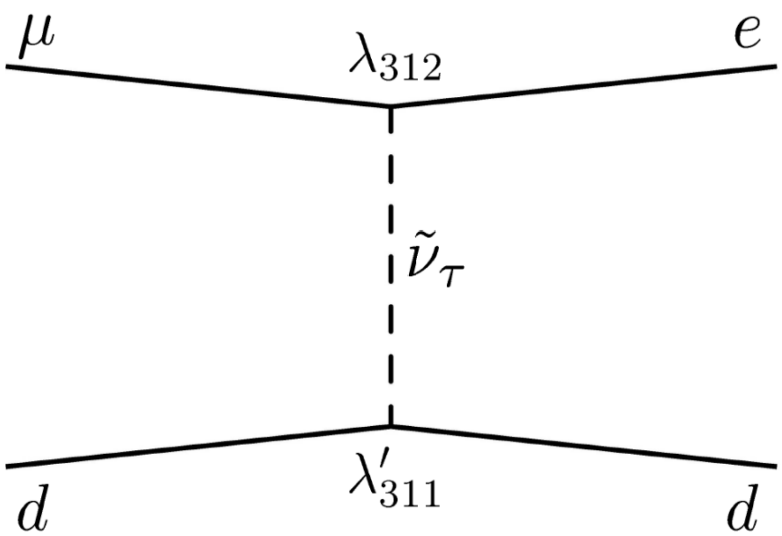
To Keep proton stability , baryon number is imposed

$$W_{\mathrm{RPV}} = \lambda_{ijk} L_i L_j E_k^c + \lambda'_{ijk} L_i Q_j D_j^c$$

For COMET we consider $\{\lambda_{132}$,and/or $\lambda_{231}\}$ and λ'_{311} .

$$\begin{aligned}
\mathcal{L} &= \{\lambda_{132}(\tilde{\nu}_\tau \bar{\mu}_R e_L - \tilde{\tau}\bar{\mu}_R \nu_e) + \mathrm{h.c}\} \\
&= \{\lambda_{231}(\tilde{\nu}_\tau \bar{e}_R \mu_L - \tilde{\tau}\bar{e}_R \nu_\mu) + \mathrm{h.c}\} \\
&= \{\lambda'_{311}(\tilde{\nu}_\tau \bar{d}_R d_L - \tilde{\tau}\bar{d}_R u_L) + \mathrm{h.c}\}
\end{aligned}$$

$\mu^- N \to e^- N$ can occur at tree level

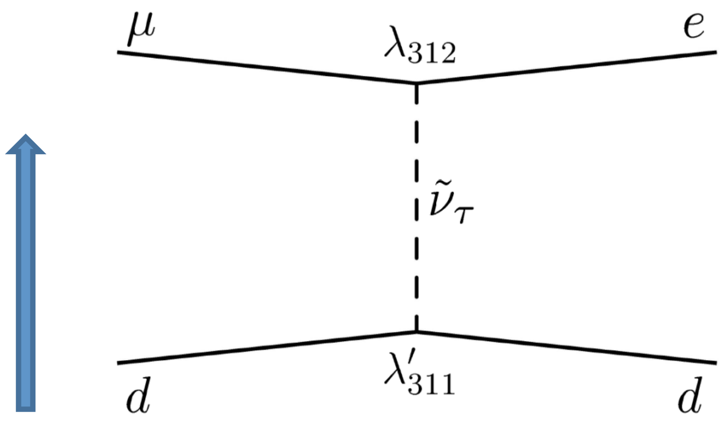


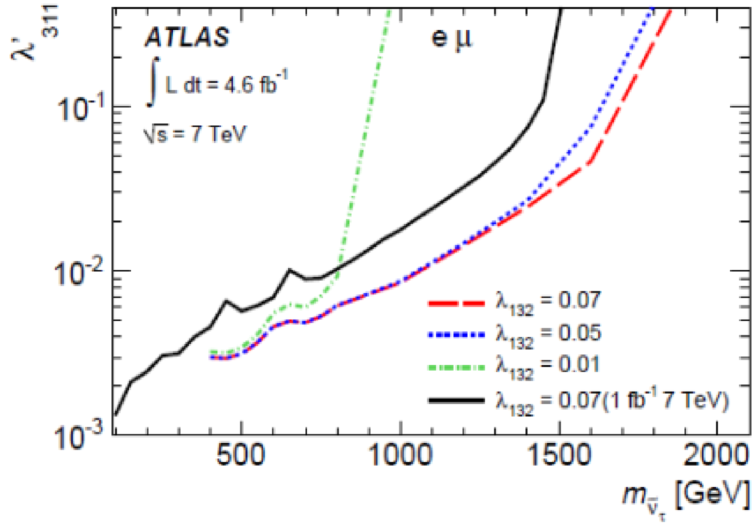
$$\{\frac{\lambda_{132}\lambda^{'*}}{m_{\tilde{\nu}}^2}\bar{\mu}_R e_L \bar{d}_L d_R + \text{h.c.}\}$$

Current bound gives for 1TeV sneutrino $\lambda_{132}\lambda^{'*}$ < 10^-6

LHC measures it and give a constraint 1

Search for a heavy narrow resonance decaying to $e\mu$, $e\tau$, or $\mu\tau$ with the ATLAS detector in $\sqrt{s} = 7$ TeV pp collisions at the LHC CERN-PH-EP-2012-326





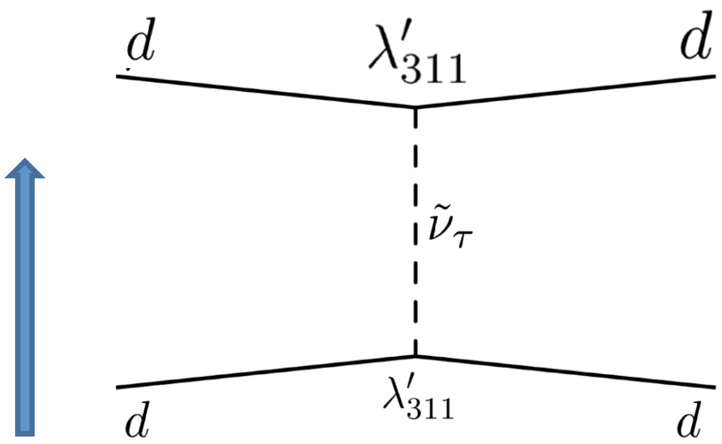
Current bound gives $\lambda_{132}\lambda'^{*}$ < 10^-3
for 1 TeV sneutrino

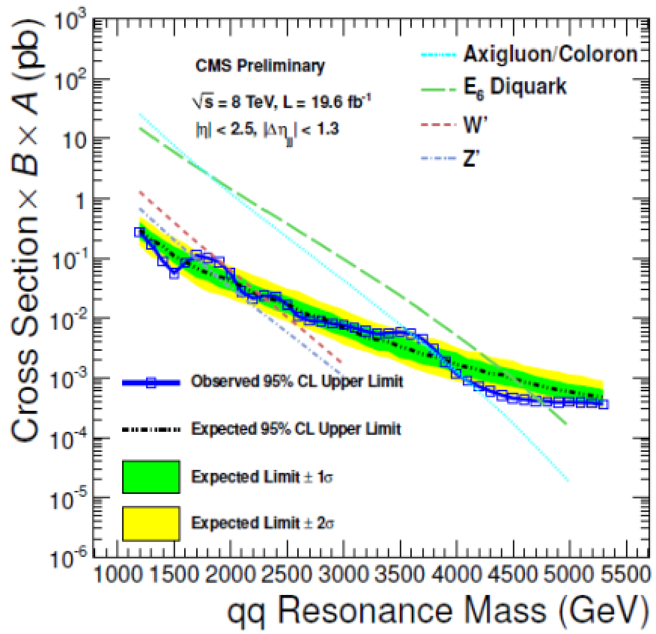
LHC measures it and give a constraint 2

Search for Narrow Resonances using the Dijet Mass Spectrum with 19.6 fb^{-1} of pp Collisions at $\sqrt{s} = 8$ TeV

CMS PAS EXO-12-059

It is not a search for LFV. A Kind of Z' search



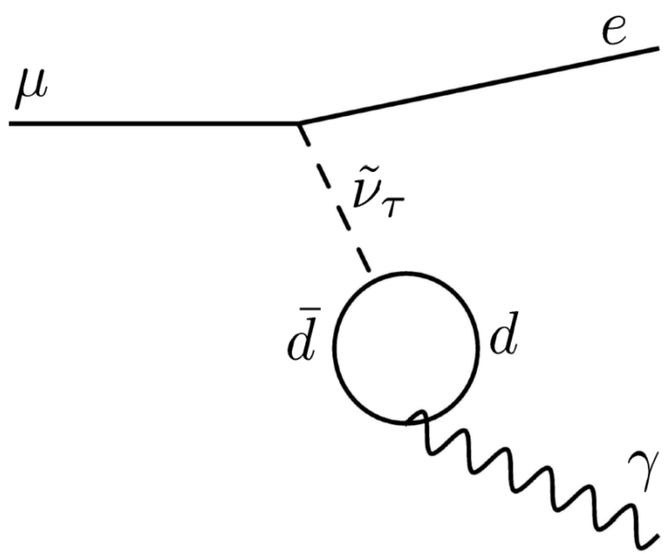


Current bound gives for 1 TeV sneutrino

λ'^{*} < 10^-1

$$\mu^+ \to e^+\gamma \qquad\qquad \mu^+ \to e^+e^-e^+$$

1-loop ?



No !

$$\lambda'\left(-\frac{1}{3}\right) e\frac{m_d q_\mu}{8\pi^2}\int_0^1 dx(1-2x)\log(m_d^2-(x-x^2)q^2)$$

Proportional to q_μ & q^2

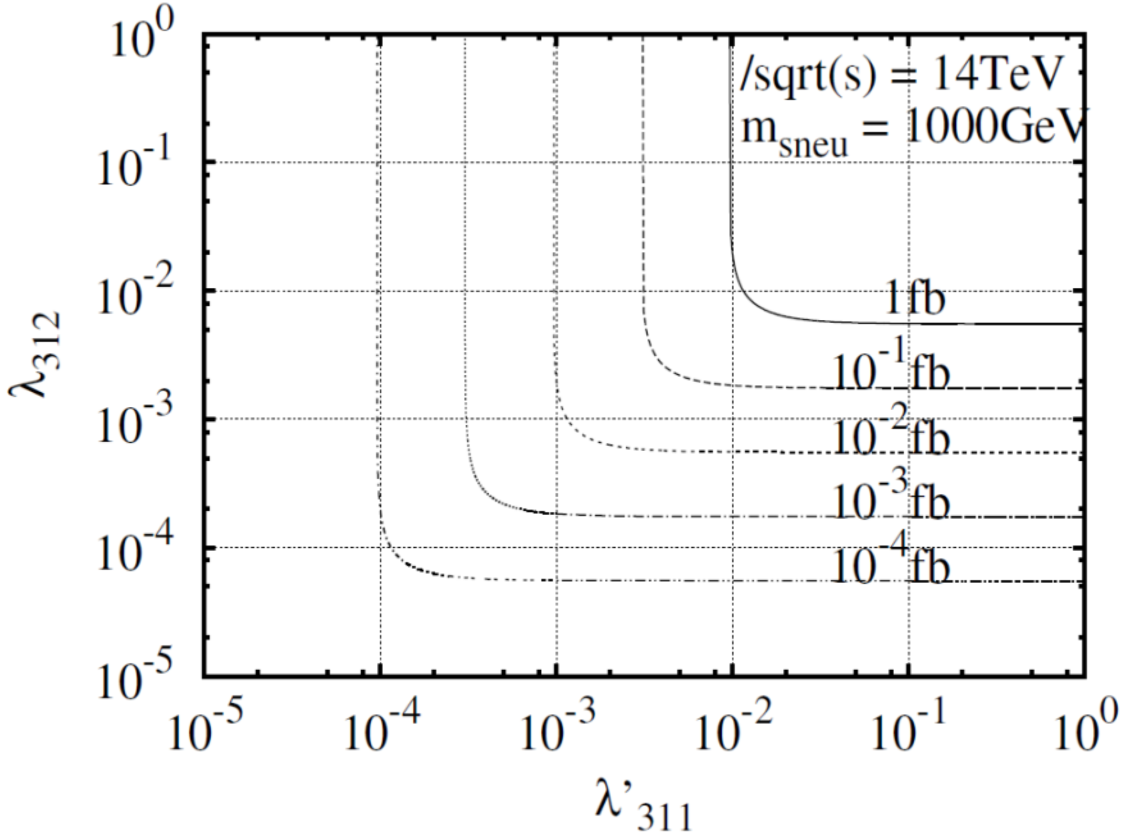
For real photon and electrons attached at the photon, no contribution

At best 2-loop effect = negligibly small

3. Other experiments

3.1 LHC in near future

Preliminary



Cross Section to mu e via sneutrino

Production : λ'^*

-- > Vertical line

Mue or dd : λ'^* vs λ_{132}

Which is larger ?

3.2. Neutrino oscillation
Non Standard Interaction

LFV in neutrino

LFV in pion decay $\mathcal{L} = -\bar{\mu}_R \nu_e \bar{u}_L d_r + \mathrm{h.c.}$

Given by SU(2) transformation to conversion process

+ Chiral enhancement

NSI ～ 10^-5 or less Ratio of amplitude to weak interaction

It is said 10^-4 is a reach with Mt detector !!?
Can we have 100Mt detector ?

4.Summary

Within SUSY, we have a model

Only COMET observe new physics

How to check?

Other CLFV see nothing !
VLHC may observe ???
Neutrino oscillation ???