STOPPED MUONS WG

- BALDINI
- BLONDEL
- DE GOUVEA
- ELLIS
- GIUDICE
- JUNGMANN
- LOLA
- PALLADINO
- TOBE
- VACCHI
- VAN DER SCHAAF
- ZUBER

• exp

At previous plenary meeting talk by de Gouvea:

- precision measurement of $\mu \to e \nu \bar{\nu}$ (τ_μ, Michel parameters)
- rare decays
- model-independent approach based on effective operators
- CP violation in $\mu \to eee$

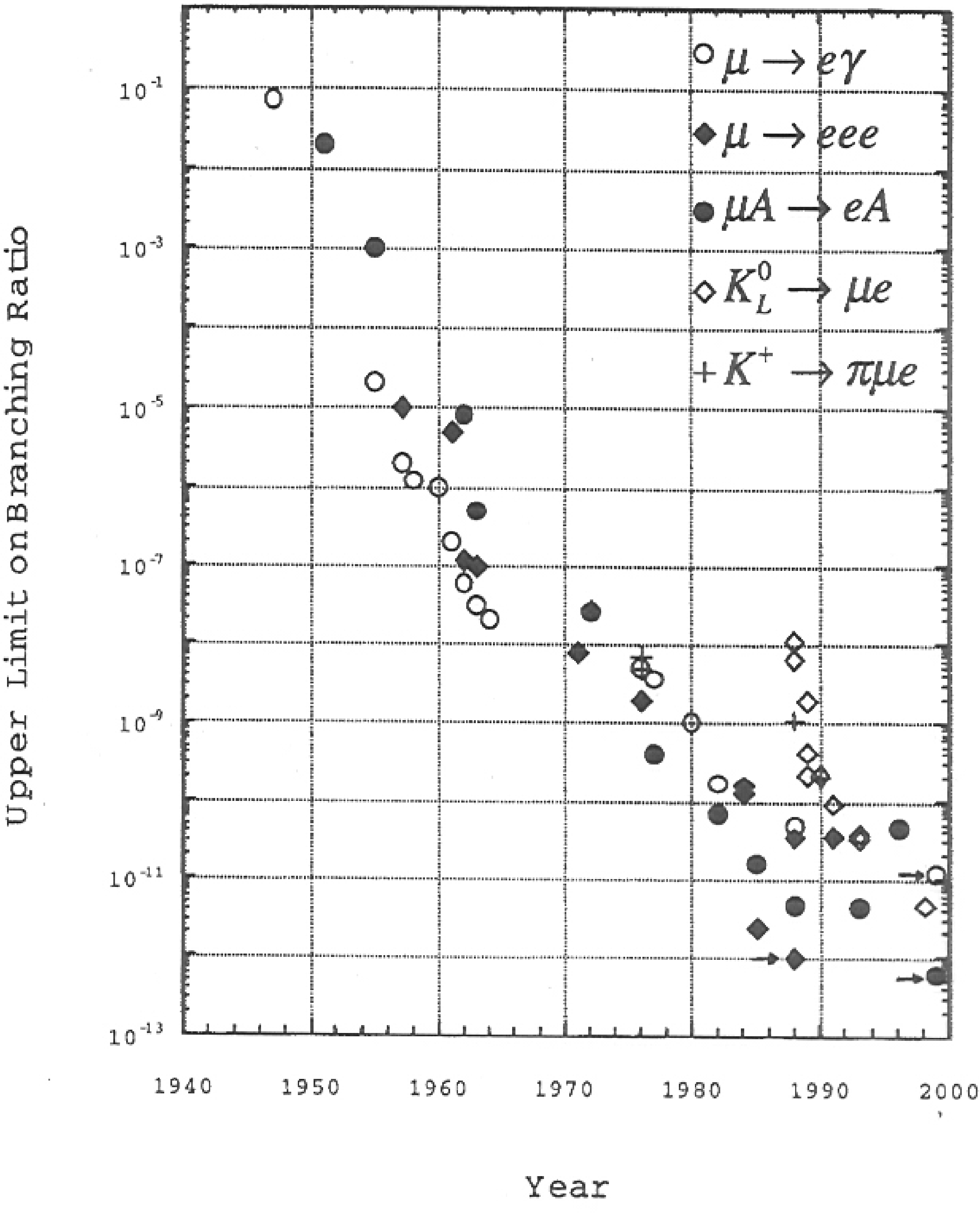
SUSY SCENARIOS

What do we learn from new experiments on rare μ decays?

STATUS AFTER LHC

- susy discovered
- many sparticle masses known

STATUS OF RARE MUON PROCESSES



PSI	$\mu \to e\gamma$	10^{-14}
SINDRUM II, PSI	$\mu \to 3\ e$	?
MECO, BNL	$\mu^- Ti \to e^- Ti$	10^{-16}

PRISM $\mu \to e\gamma$: $[10^{-15}]$ $\mu^- Ti \to e^- Ti$: 10^{-18}

IS IT USEFUL TO IMPROVE SEARCHES ?

Th : yes

- Source of lepton violation not equal to ordinary ν oscillations

- In SUSY test of mixing angles not accessible at high-energy colliders

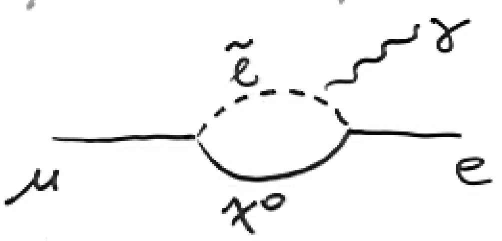
$\not{\text{SUSY}}$ $\rightarrow$ susy masses
susy CKM angles and phases

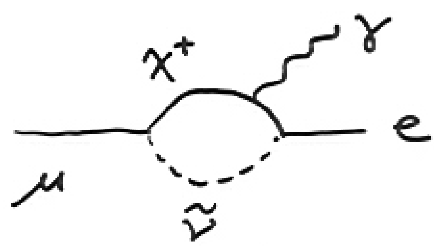
RARE μ-decays in SUSY

SUSY:
- L violation in slepton soft terms
  - from ν_R
  - from GUT effects
- L violation from $\not{R}$

$\mu \to e\gamma$

$\not{L}$ in soft terms





$$BR(\mu \to e\gamma) \sim \frac{\alpha^3}{G_F^2} \frac{\tilde{\theta}_{\mu e}^2}{\tilde{m}^4}$$

- $\not{L}$ in $\tilde{\theta}_{\mu e}$
- Not suppressed by $1/M_{\nu_R}$ (as in SM)
- Enhanced by $\tan\beta$

To make predictions: how large is $\tilde{\theta}_{\mu e}$?

Most conservative estimate in supergravity:

- $\tilde{\theta}_{\mu e} = 0$ at M_{Pl}

$\tilde{\theta}_{\mu e}$ generated by quantum loops

- because of ν_R effects
- because of GUT effects

ν_R EFFECTS

$$\mathcal{L} = \lambda_\nu \, \bar{\ell}_L \, \nu_R \, H_u + \lambda_e \, \bar{\ell}_L \, e_R \, H_d + M_{\nu_R} \, \nu_R \, \nu_R$$

- Family L violated
  (analogous to CKM in quark sector)
- Induces non-diagonal $\tilde{\ell}_L$
  mass-matrix elements

$$\delta \tilde{m}_e^2 \sim \frac{1}{16\pi^2} \left(3\tilde{m}^2 + A^2\right) \lambda_\nu^+ \lambda_\nu \log \frac{M_{Pe}^2}{M_{\nu_R}^2}$$

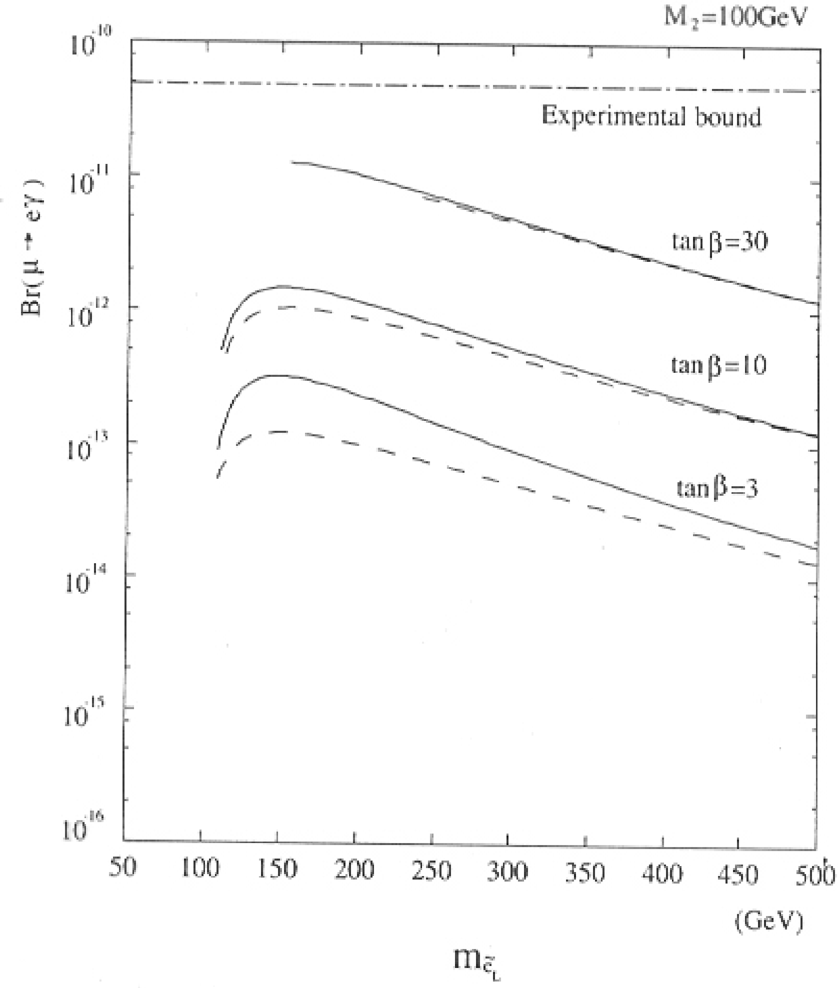
Predictions depend on V_ν^{KM} assumptions

Examples:

1) $V_\nu^{KM} = V_q^{KM}$

2) V_ν^{KM} ansatz fitting ν oscillation data

ν_R effect with $V_\nu^{KM} = V_q^{KM}$



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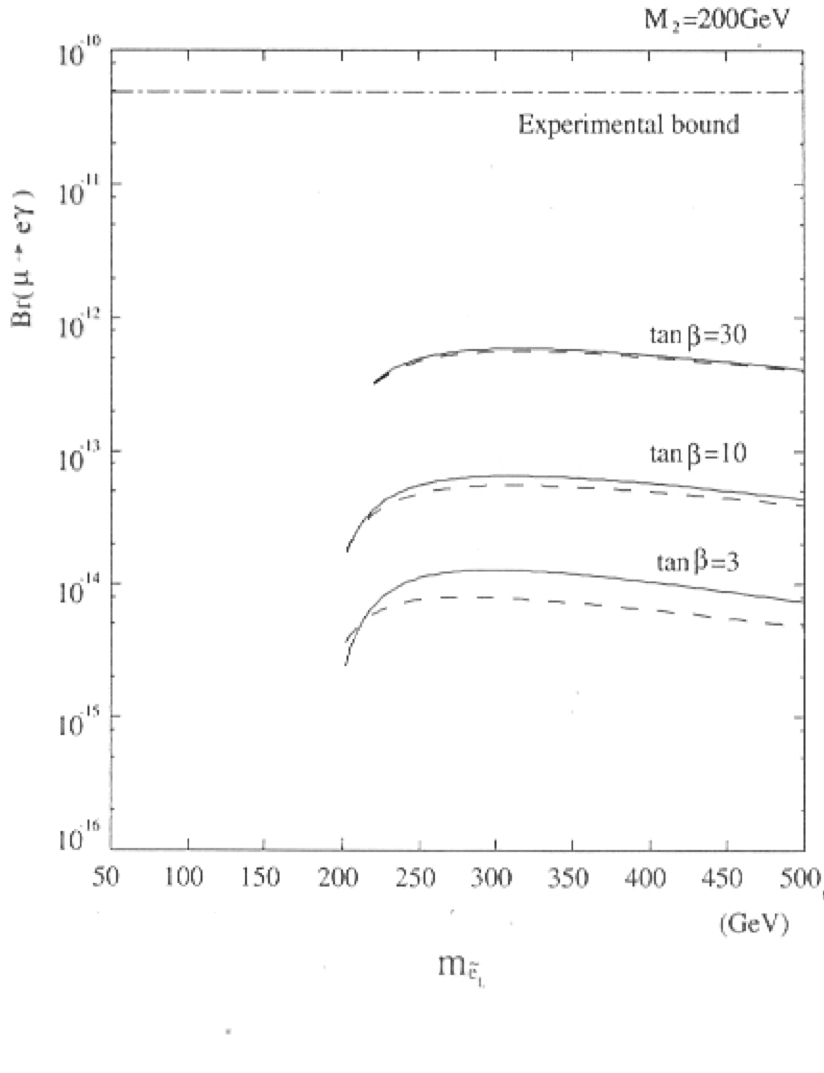

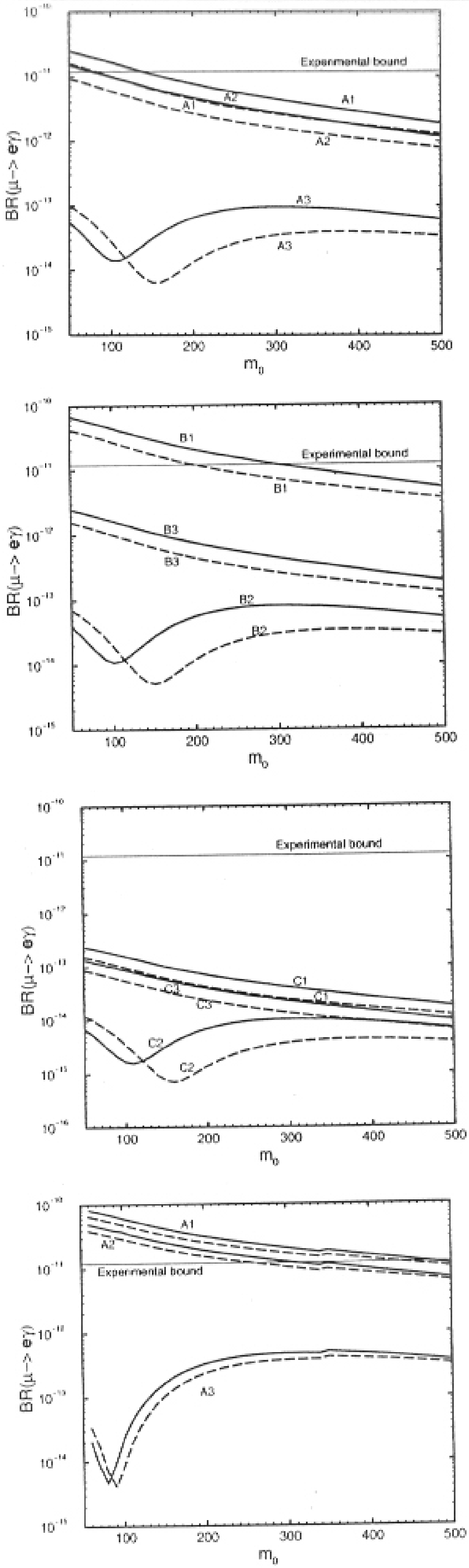

ν_R effect with V_ν^{KM} from ν-oscillation data

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LEONTARIS
LOLA
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Figure 2: *Predictions for $BR(\mu \to e\gamma)$ and $BR(\tau \to \mu\gamma)$ for texture A of Section 4, assuming the values $m_{1/2} = 250$ GeV, $\tan\beta = 3$ and $A_0 = -m_{1/2}$. The solid lines correspond to positive μ, and the dashed ones to $\mu < 0$. The results are for the three specific choice of the undetermined numerical coefficients c_{ij} shown in the text. We see that, for fixed m_0, the $\mu \to e\gamma$ curves are more sensitive to the c_{ij} than are those for $\tau \to \mu\gamma$.*

GUT effects

Above SU_5 GUT threshold

e_R and u_R in same multiplet.

Because of λ_t effects ⇒

⇒ 3[rd] gen split from other 2

- Lepton violation mainly in right-handed sector

(chargino diagram suppressed)

SU5 GUT effect

arXiv:hep-ph/9510309 16 Oct 95

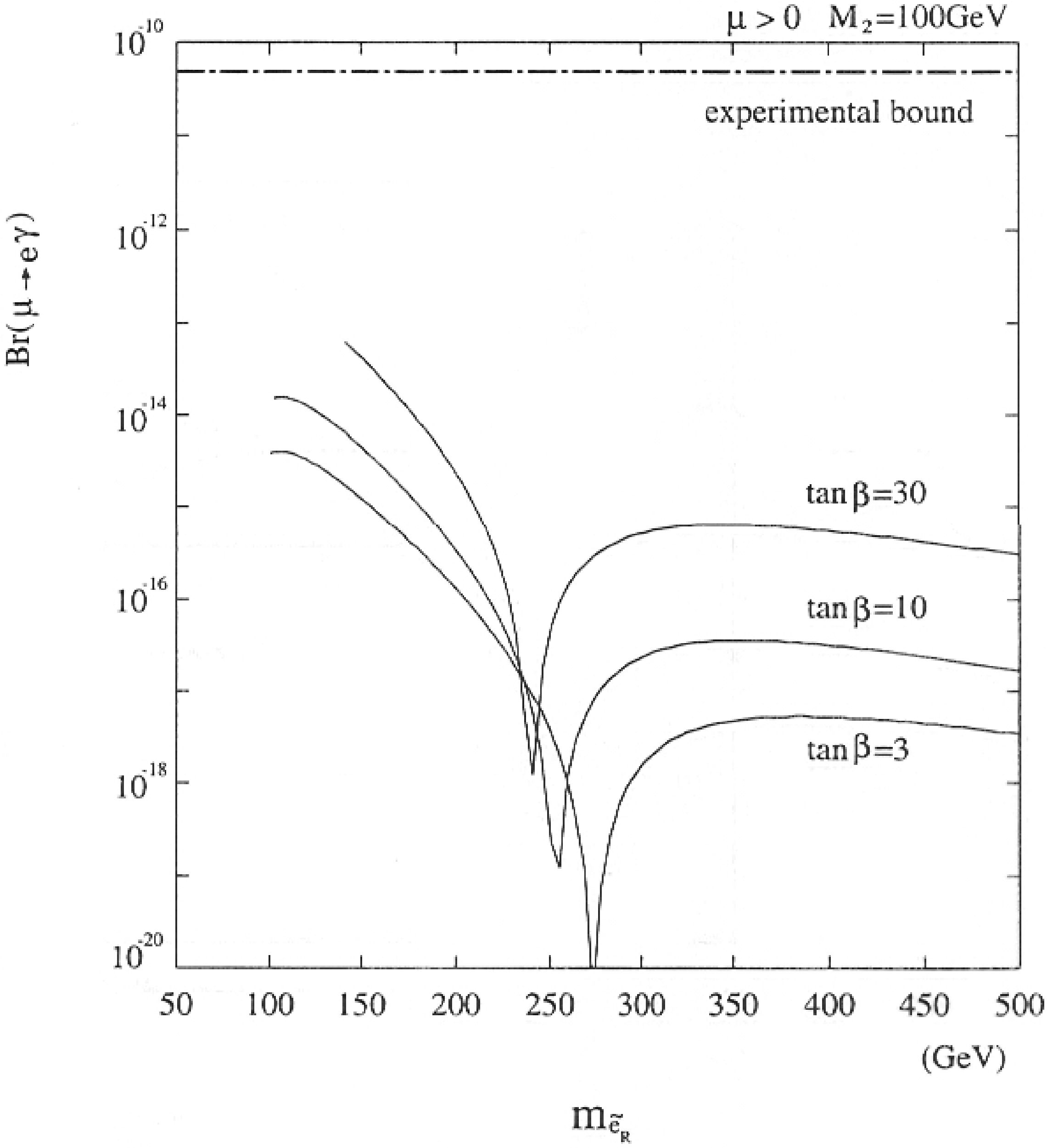

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Fig. 14

$\mu \to 3e$

- γ, Z penguins, box diagrams
- γ dominates (because of IR log):

$$\frac{\Gamma(\mu \to 3e)}{\Gamma(\mu \to e\gamma)} = 6 \times 10^{-3}$$

μ-e conversion

- If γ dominates

$$\frac{\Gamma(\mu\text{-e conv})}{\Gamma(\mu \to e\gamma)} \simeq 6 \times 10^{-3}$$

Not always true (because of absence of logs)

R-parity violation

see talk by A. de Gouvêa

- Effect from 4-fermion operators
  ($\mu \to 3e$ tree level, $\mu \to e\gamma$ loops)

- 3 cases

	$\mu \to e\gamma$	$\mu \to 3e$	μ-e conv.
1)	loop	tree	loop
2)	loop	loop	loop
3)	loop	loop	tree

(13)

Table 1: *The ratios of branching ratios* $\mathrm{Br}(\mu^+ \to e^+\gamma)/\mathrm{Br}(\mu^+ \to e^+e^-e^+)$ *and* $\mathrm{R}(\mu^- \to e^- \text{ in Ti})/\mathrm{Br}(\mu^+ \to e^+e^-e^+)$, *P-odd asymmetries* A_P *for* $\mu^+ \to e^+\gamma$, A_{P_1} *and* A_{P_2} *for* $\mu^+ \to e^+e^-e^+$ *are shown when the listed pair of Yukawa couplings is dominant. Case (1), (2), (3) refers to the representative classes of models discussed in Secs. 4.1, 4.2, and 4.3, respectively. Here, we assume* $m_{\tilde{\nu},\tilde{l}_R} = 100$ *GeV and no mixing in the charged slepton mass matrix, and* $m_{\tilde{q}} = 300$ *GeV. We also show a typical result obtained for the MSSM with heavy right-handed neutrinos and R-parity conservation [7].*

	$\frac{\mathrm{Br}(\mu\to e\gamma)}{\mathrm{Br}(\mu\to 3e)}$	$\frac{\mathrm{R}(\mu\to e \text{ in Ti})}{\mathrm{Br}(\mu\to 3e)}$	A_P	A_{P_1}	A_{P_2}	A_{P_1}/A_{P_2}
Case (1)						
$\lambda_{131}\lambda_{231}$	1×10^{-4}	2×10^{-3}	−100%	+19%	−15%	−1.3
$\lambda_{121}\lambda_{122}$	8×10^{-4}	7×10^{-3}	+100%	−19%	+15%	−1.3
$\lambda_{131}\lambda_{132}$	8×10^{-4}	5×10^{-3}	+100%	−19%	+15%	−1.3
Case (2)						
$\lambda_{132}\lambda_{232}$	1.2	18	−100%	−25%	−5%	5.6
$\lambda_{133}\lambda_{233}$	3.7	18	−100%	−25%	−4%	6.2
$\lambda_{231}\lambda_{232}$	3.6	18	+100%	+25%	+4%	6.2
$\lambda'_{122}\lambda'_{222}$	1.4	18	−100%	−25%	−4%	5.7
$\lambda'_{123}\lambda'_{223}$	2.2	18	−100%	−25%	−4%	5.9
Case (3)						
$\lambda'_{111}\lambda'_{211}$	0.4	3×10^{2}	−100%	−26%	−5%	5.4
$\lambda'_{112}\lambda'_{212}$	0.5	8×10^{4}	−100%	−26%	−5%	5.4
$\lambda'_{113}\lambda'_{213}$	0.7	1×10^{5}	−100%	−26%	−5%	5.5
$\lambda'_{121}\lambda'_{221}$	1.1	2×10^{5}	−100%	−26%	−5%	5.6
MSSM with ν_R	1.6×10^{2}	0.92	−100%	10%	17%	0.6

DE GOUVEA - LOLA - TOBE

CONCLUSIONS

- Rare μ processes complementary to high-energy searches
- Reveal new sources of $\not{L}$ beyond ν oscillations
- In supergravity models expected at experimental sensitivity level
- Information on susy mechanism
- $\mu \to eee$ could be discovery mode