SUSY-Seesaw and PMNS angle θ_{13}

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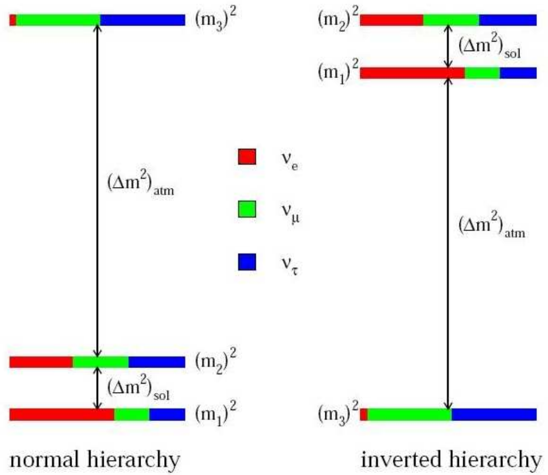
Casas, Moreno, BZ. [hep-ph 1008.XXX]

What is our work about?

$\mathrm{BR}(\mu \to e, \gamma)$ vs. θ_{13}

- Evidence for non-zero neutrino masses



$(\Delta m^2)_{\rm sol} = 8.0^{+0.6}_{-0.4} \times 10^{-5}\ [eV]^2 \qquad (\Delta m^2)_{\rm atm} = 2.4^{+0.6}_{-0.5} \times 10^{-3}\ [eV]^2$

- Neutrino mixings.

$$|\nu_\alpha> = \sum_{i=1}^{3} U^*_{\alpha i}|\nu_i>$$

$$U \rightarrow V \cdot \mathrm{diag}(e^{i\phi_1}, e^{i\phi_2}, 1)$$

$$V = \begin{pmatrix} c_{13}c_{12} & c_{13}s_{12} & s_{13}e^{-i\delta} \\ -c_{23}s_{12} - s_{23}s_{13}c_{12}e^{i\delta} & c_{23}c_{12} - s_{23}s_{13}s_{12}e^{i\delta} & s_{23}c_{13} \\ s_{23}s_{12} - c_{23}s_{13}c_{12}e^{i\delta} & -s_{23}c_{12} - c_{23}s_{13}s_{12}e^{i\delta} & c_{23}c_{13} \end{pmatrix}$$

- MNS matrix: 3 angles + 3 phases
- θ_{13}: less known parameter $0 \lesssim \theta_{13} \lesssim 10^\circ$.
- θ_{13} important for $\not{C}P$-phase δ (osc. experim.)

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Introduction: See-saw.

- Natural explanation for small neutrino masses: See-saw mechanism

$$\mathcal{L} \supset (\nu_R^c)_i^T (Y_\nu)_{ij} L_j \cdot H - \frac{1}{2} (\nu_R^c)_i^T \mathcal{M}_{ij} (\nu_R^c)_j$$

- Integrating out heavy neutrinos:

$$\mathcal{L}_{\text{eff}} \supset (Y_\nu L \cdot H)^T \mathcal{M}^{-1} (Y_\nu L \cdot H)$$

$$\kappa \equiv m_\nu / < H >^2 = Y_\nu^T D_M^{-1} Y_\nu$$

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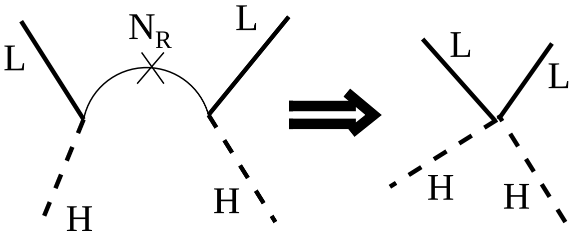
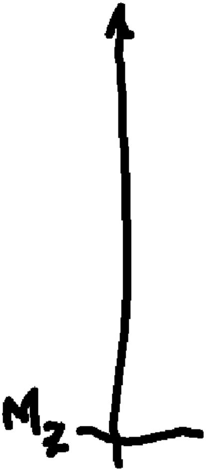
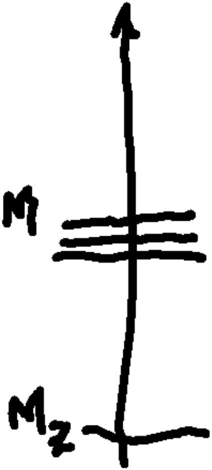




- $\sim 10^2$(GeV) $\quad \kappa = U^* D_\kappa U^\dagger$
- 9 param.



- $\sim 10^{12}$(GeV) $\quad M_1, M_2, M_3$
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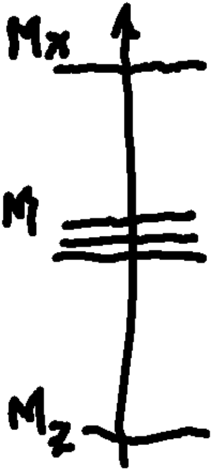

- $\sim 10^{15}$(GeV) $\quad Y_\nu = V_R D_Y V_L^\dagger$
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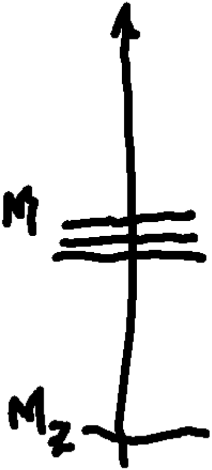
R-parametrization



- bottom-up:
  R-param.:
  $Y = D_M^{1/2} R D_\kappa^{1/2} U^\dagger$
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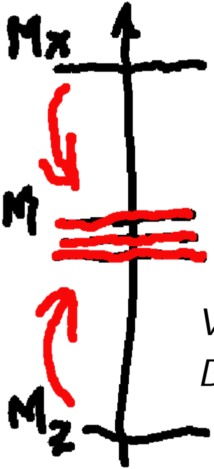
V_L-parametrization

- bottom-up/top-down: V_L-**param.**: $Y = V_R D_y V_L^\dagger$
- $V_L^\dagger V_L = V_R^\dagger V_R = \mathbf{1}$

$$V_R^\dagger D_M V_R^* = D_Y V_L^\dagger U D_\kappa^{-1} U^T V_L^* D_Y$$

V_L-parametrization



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Lepton flavor violation provided by supersimmetry:

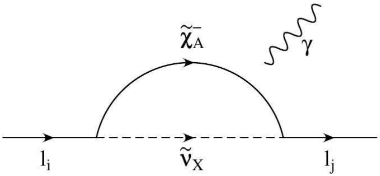
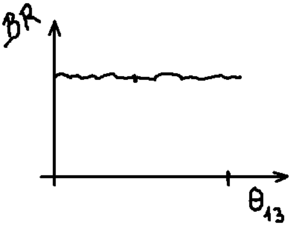


FIGURE: Feynman diagrams which give rise to $l_i \to l_j\gamma$.

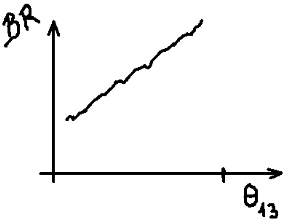
$$\mathbf{BR}(\mu \to e, \gamma)$$

V_L- parametrization:



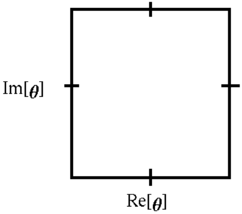
- Us

R- parametrization:



- Antusch, Arganda, Herrero, Teixeira [2006]

- Previous scans of the $R-$matrix:



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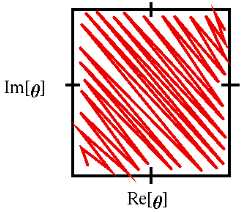

Solution

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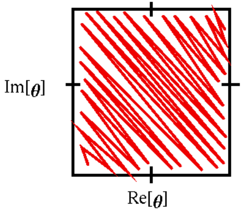

- Proposed scan: perturbativity

$$\mathrm{Tr}\, Y_\nu^\dagger Y_\nu \lesssim 3 \qquad \text{or} \quad \mathcal{O}(1)$$

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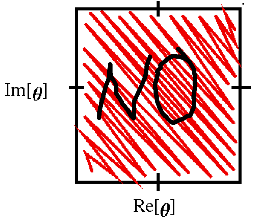

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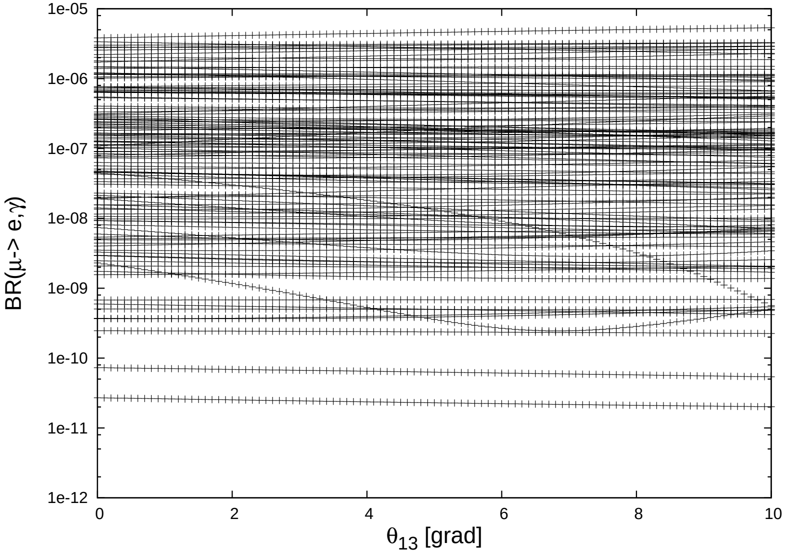
Without leptogenesis constraint



Conclusions

- Scanning the R parameter-space in its full perturbativity region, no appreciable dependence of the BR$(\mu \to e, \gamma)$ on θ_{13} is observed.
- New window of SUSY See-saw parameter-space open for future studies.

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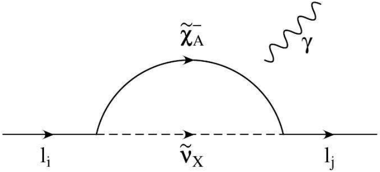


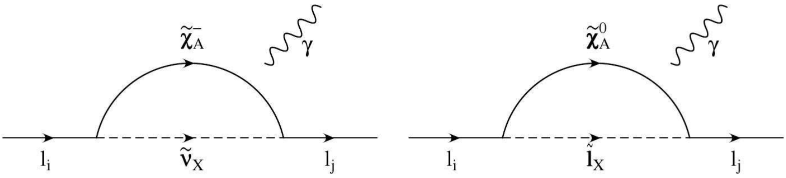
FIGURE: Feynman diagrams which give rise to $l_i \to l_j \gamma$.

- The important thing is...

$$A = A(m^2_{\tilde{L}ij}, \dots)$$

- $m^2_{\tilde{L}ij}$ diagonal at GUT-scale; but things change with RGE...

$$(m^2_{\tilde{L}})_{ij} \supset -\frac{1}{8\pi^2}(3m_0^2 + A_0^2)\left[(Y_\nu^\dagger)_{ik} \ln\left(\frac{M_X}{m_{M_k}}\right)\delta_{kl}(Y_\nu)_{lj}\right]$$



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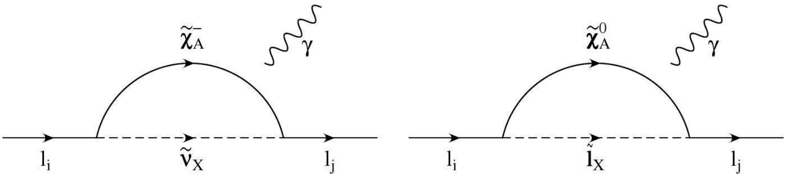

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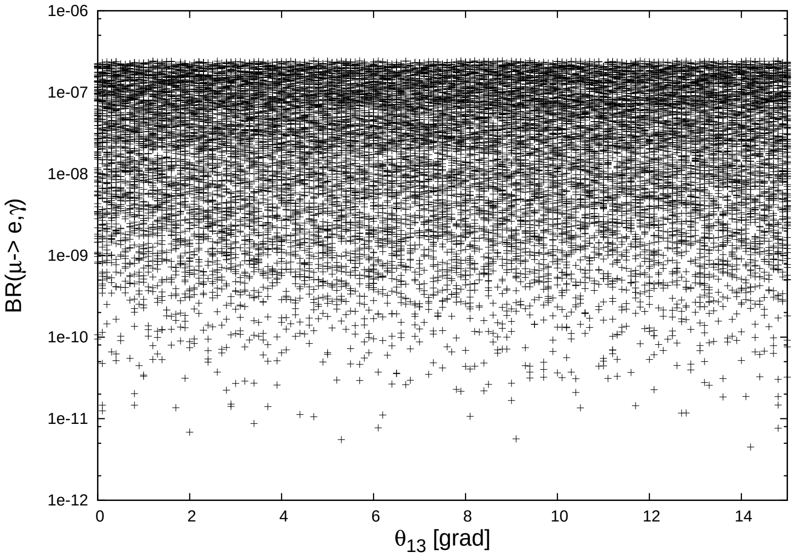

1e-06
1e-07
1e-08
1e-09
1e-10
1e-11
1e-12
BR(μ-> e,γ)
0
2
4
6
8
10
12
14
θ13 [grad]

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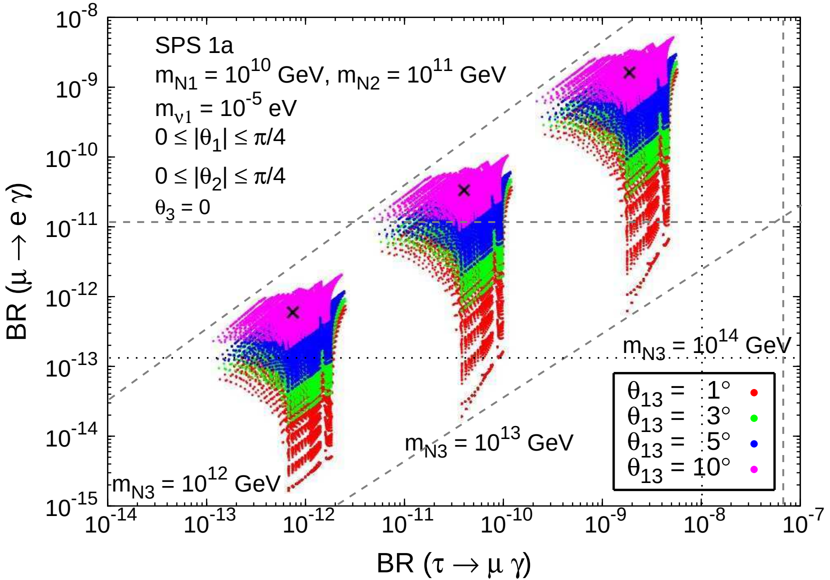
SPS 1a
m_N1 = 10^10 GeV, m_N2 = 10^11 GeV
m_ν1 = 10^-5 eV
0 ≤ |θ_1| ≤ π/4
0 ≤ |θ_2| ≤ π/4
θ_3 = 0
m_N3 = 10^12 GeV
m_N3 = 10^13 GeV
m_N3 = 10^14 GeV
θ_13 = 1°
θ_13 = 3°
θ_13 = 5°
θ_13 = 10°
BR (μ → e γ)
BR (τ → μ γ)
10^-8
10^-9
10^-10
10^-11
10^-12
10^-13
10^-14
10^-15
10^-14
10^-13
10^-12
10^-11
10^-10
10^-9
10^-8
10^-7