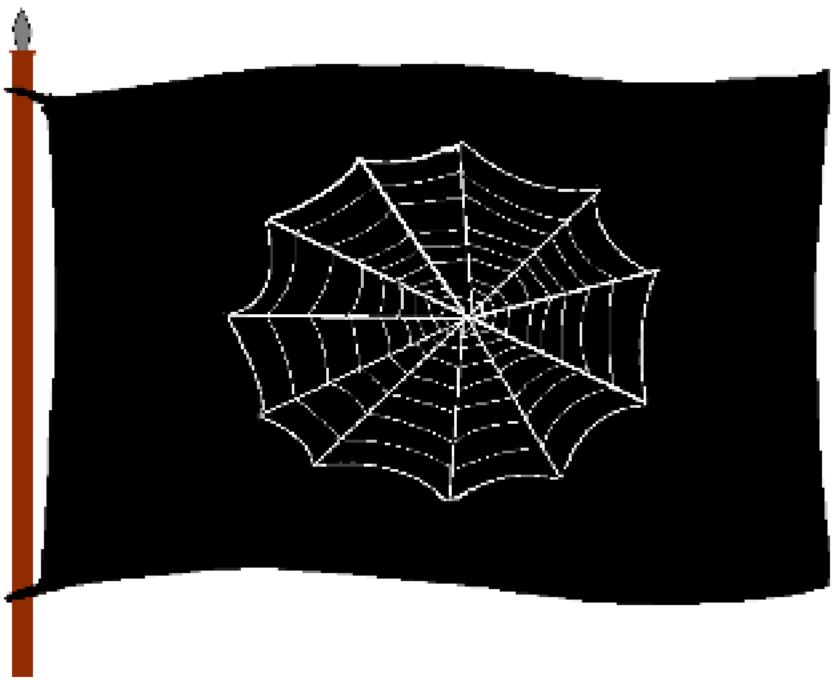
Charged Lepton Flavour violation and the physics potential of a Linear Collider



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- Neutrino Oscillations.
- See Saw Mechanism.
- SUSY Flavor and Charged Lepton Flavor Violation.

- An Abelian SU(5) model for Yukawa couplings:

  - Fitting Neutrino Parameters.

  - LFV: $BR\left(l_i \to l_j \gamma\right)$

  - Leptogenesis

- LHC stau flavor oscillations.

- Charged Slepton flavor oscillation at Linear colliders,

  - *CONCLUSIONS*

Neutrino Oscillations

$$\nu_{l\mathrm{L}}(x) = \sum_j U_{lj}\, \nu_{j\mathrm{L}}(x), \quad l = e, \mu, \tau,$$

$$P(\nu_{l(l')} \to \nu_{l'(l)}) \cong P(\bar{\nu}_{l(l')} \to \bar{\nu}_{l'(l)}) \cong \delta_{ll'} - 2|U_{ln}|^2 \left[\delta_{ll'} - |U_{l'n}|^2\right]$$

$$\left(1 - \cos\frac{\Delta m_{n1}^2}{2p} L\right).$$

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

EW interaction
Mixes Lepton
Flavor.

There is a matrix:
PVMS=U
Equivalent to
The CKM
in the
Quark sector.

Neutrino Masses and the "See-Saw" Mechanism

- Neutrino data: By now convincing for $m_\nu \neq 0$ and physics beyond SM
- What do we know?

Atmospheric problem	Solar problem
$\Delta m^2_{atm} = \left(2.6^{+0.4}_{-0.7}\right) \times 10^{-3}$ eV^2 $\sin^2 2\theta_{atm} > 0.90$	$\Delta m^2_{sol} = \left(8.1^{+0.5}_{-0.5}\right) \times 10^{-5}$ eV^2 $\sin^2 2\theta_{sol} = \left(0.86^{+0.05}_{-0.06}\right)$

$0.06 < \sin^2 2\theta_{13} < 0.13$
Reactor data (RENO, Daya Bay).

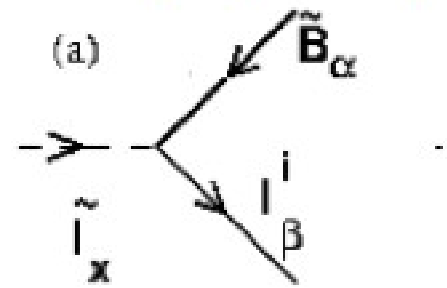
$$\mathcal{M} = \begin{pmatrix} 0 & m_\nu^D \\ m_\nu^{D^T} & M_R \end{pmatrix}$$

"See-Saw" explanation for tiny masses.

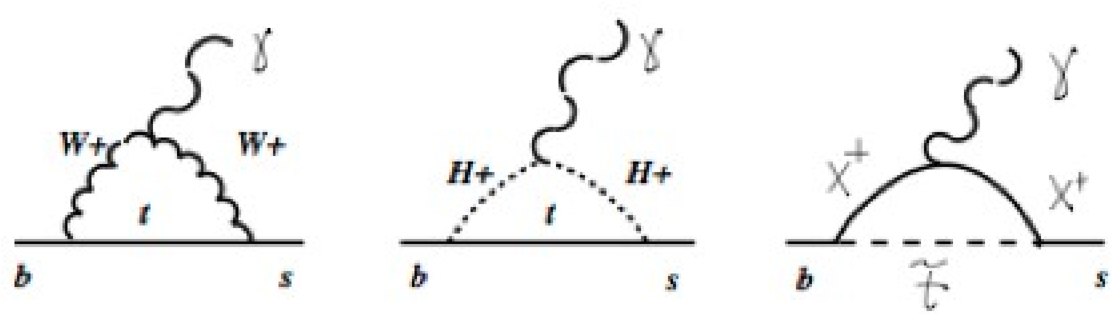
- The physical masses are:
  1. $m_1 \equiv m_{light} \simeq \frac{\left(m_\nu^D\right)^2}{M_R}$
  2. $m_2 \simeq M_R$
- For $(m_\nu^D)_{33} \approx (200 \text{ GeV})$ $(\lambda_\nu \approx \lambda_t)$ and $M_{N_3} \approx O(10^{14} \text{ GeV})$, $m_{eff} \approx 0.05$ eV

SUSY FLAVOR

R-parity warranties that SUSY particles only appear in pairs:



therefore SM model phenomenology is only modified at *loops level*:



The present average given by the

$$\mathrm{BR}(\mathrm{b} \to \mathrm{s}\gamma) = (3{,}55 \pm 0{,}24^{+0{,}09}_{-0{,}10} \pm 0{,}03) \times 10^{-4}$$

The SM prediction: $BR(b \to s\gamma) = (3.15 \pm 0.30) \times 10^{-4}$

Charged LFV in SUSY

Lepton pairs in chargino and neutralino decays:

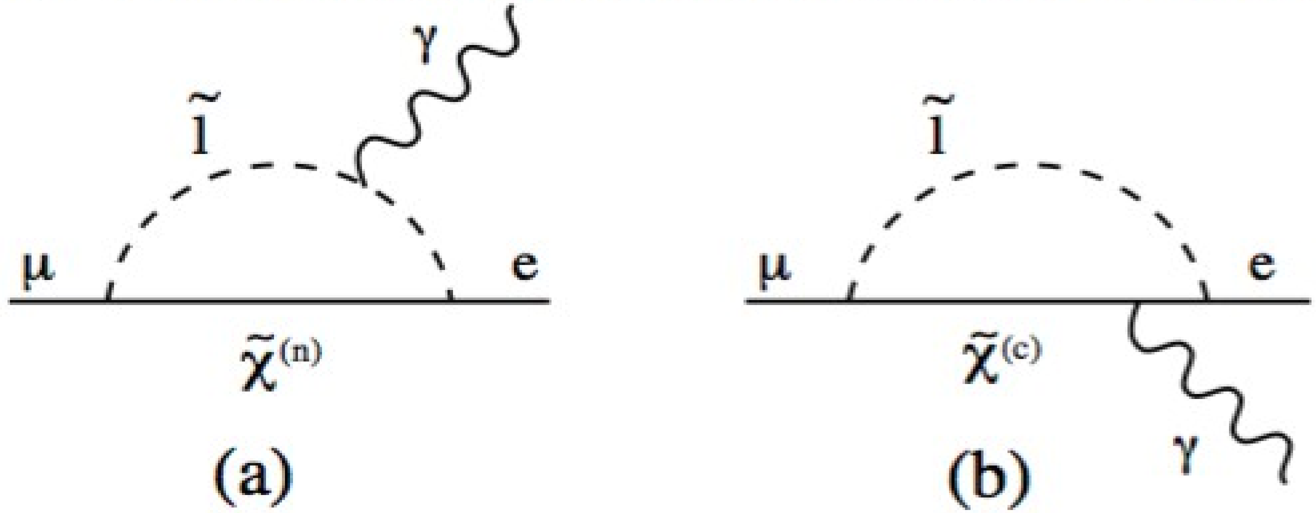
In the basis $\tilde{\ell}_i = (\tilde{e}_L, \tilde{\mu}_L, \tilde{\tau}_L, \tilde{e}_R^*, \tilde{\mu}_R^*, \tilde{\tau}_R^*)$, the slepton mass matrix:

$$\mathcal{L}_M = -\frac{1}{2}\tilde{\ell}^\dagger M_{\tilde{\ell}}^2 \tilde{\ell}, \qquad M_{\tilde{\ell}}^2 = \begin{pmatrix} M_{LL}^2 & M_{LR}^2 \\ M_{RL}^2 & M_{RR}^2 \end{pmatrix},$$

$$\begin{aligned}
M_{LL}^2 &= \frac{1}{2} m_\ell^\dagger m_\ell + M_L^2 - \frac{1}{2}(2m_W^2 - m_Z^2)\cos 2\beta\ I \\
M_{RR}^2 &= \frac{1}{2} m_\ell^\dagger m_\ell + M_R^2 - (m_Z^2 - m_W^2)\cos 2\beta\ I \\
M_{LR}^2 &= (A^e - \mu \tan\beta)\ m_\ell \\
M_{RL}^2 &= (M_{LR}^2)^\dagger
\end{aligned}$$

Charged Lepton Flavor Violation

In SUSY flavor mixing lepton-slepton vertices can induce LFV diagrams:



Lepton-slepton flavor mixing is very constrained by the experimental limits:

$$
\begin{aligned}
BR(\mu \to e\gamma) &< 5.6 \times 10^{-13} \\
BR(\tau \to \mu\gamma) &< 4.4 \times 10^{-8} \\
BR(\tau \to e\gamma) &< 3.3 \times 10^{-8}
\end{aligned}
$$

Soft SUSY Breaking Terms

The soft SUSY breaking masses

$$-\mathcal{L}_{\text{soft}} = -\frac{1}{2}\left(M_3\lambda^a_{\tilde{g}}\lambda^a_{\tilde{g}} + M_2\lambda^i_{\widetilde{W}}\lambda^i_{\widetilde{W}} + M_1\lambda_{\widetilde{B}}\lambda_{\widetilde{B}} + \text{h.c.}\right)$$
$$+M_L^2\widetilde{L}^\dagger\widetilde{L} + M_Q^2\widetilde{Q}^\dagger\widetilde{Q} + M_U^2\widetilde{U}^*\widetilde{U} + M_D^2\widetilde{D}^*\widetilde{D} + M_E^2\widetilde{E}^*\widetilde{E} +$$
$$m^2_{H_d}\widetilde{H}_d^\dagger\widetilde{H}_d + m^2_{H_u}H_u^\dagger H_u - \left(B\mu\widetilde{H}_d^T H_u + \text{h.c.}\right)$$
$$+\left(y_\ell A_\ell H_d^\dagger\widetilde{L}\widetilde{E} + y_d A_d H_d^\dagger\widetilde{Q}\widetilde{D} - y_u A_u H_u^T\widetilde{Q}\widetilde{U} + \text{h.c.}\right),$$

Inspired from supergravity assume universal soft breaking, $\mathcal{L}_{\text{soft}}$:

$$\sum_{f,H} m_0^2\tilde{f}\tilde{f} + \sum_{\lambda} m_{\frac{1}{2}}\lambda\lambda + \sum_{f} A_0 Y_f\tilde{f}\tilde{F}H_f + B\mu H_u H_d$$

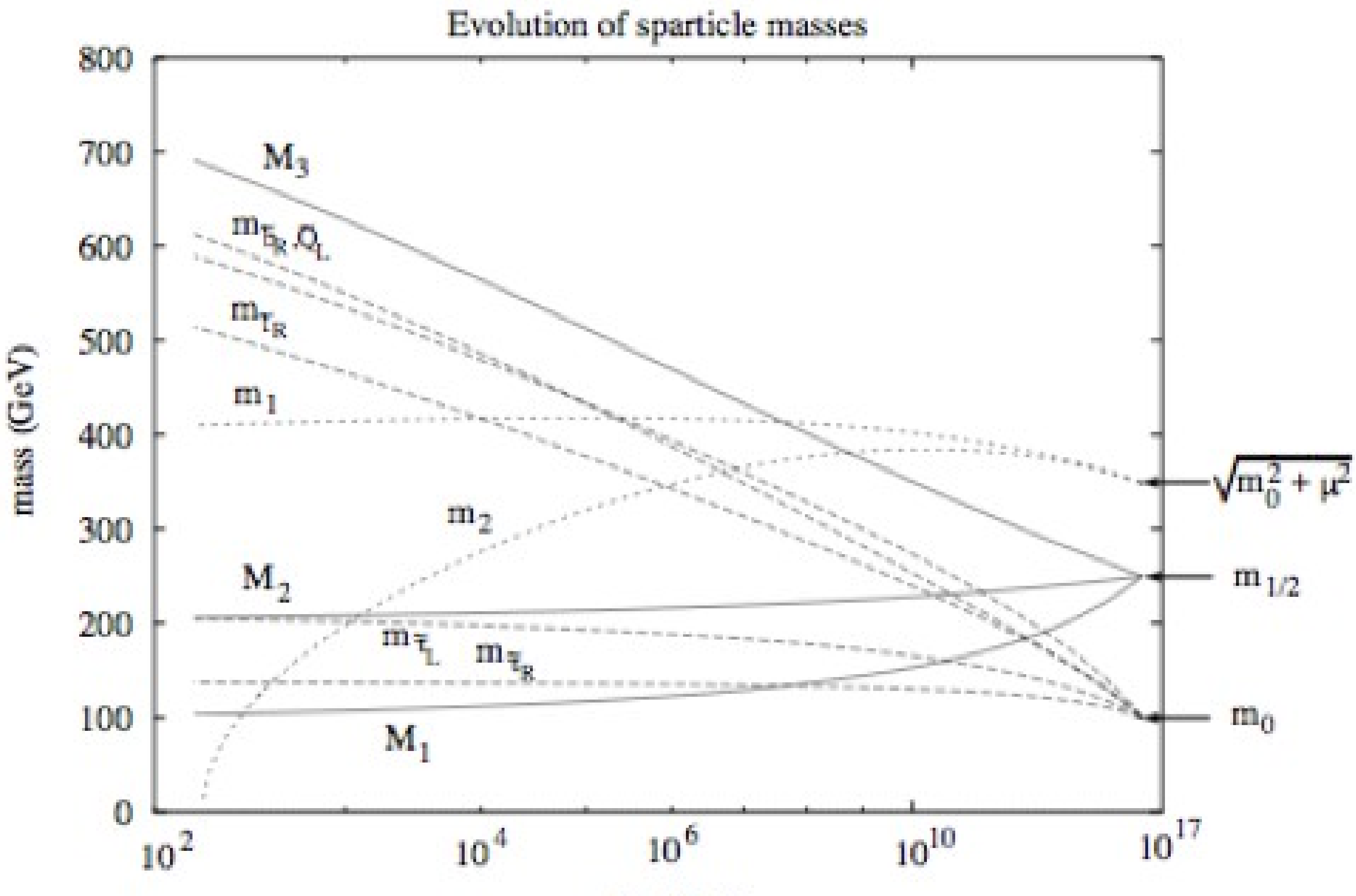
m_0, $m_{\frac{1}{2}}$, A_0, $\tan\beta$, sign(μ)

μ and A_0 can be complex, however their phases contraint to be $< 0{,}2$ rad by the bounds on the fermion EDM.

SUSY spectrum

CMSSM, mSUGRA. Parametros de masa universales:

$$m_0,\ M_{1/2},\ A_0,\ \mu_0,\ \alpha_G,\ M_{GUT},\ \tan\beta\ .$$



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See-saw Neutrinos and SUSY

Even if we start with universal soft terms at GUT, FV entries can be generated:

$$M_{\mathrm{GUT}} : m_{\tilde{\ell},\tilde{\nu}} \propto \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}, \quad \text{RGEs} \longrightarrow \begin{pmatrix} 1 & \star & \star \\ \star & 1 & \star \\ \star & \star & 1 \end{pmatrix}$$

- RGEs for the charged-lepton mass matrix

$$t\frac{d}{dt}(m^2_{\tilde{\ell}})^j_i = \frac{1}{16\pi^2}\left\{ \left(m^2_{\tilde{\ell}}\lambda^\dagger_\ell\lambda_\ell\right)^j_i + \left(m^2_{\tilde{\nu}}\lambda^\dagger_\nu\lambda_\nu\right)^j_i + \cdots \right\}$$

The corrections in the basis where $(\lambda^\dagger_\ell\lambda_\ell)^j_i$ is diagonal, are:

$$\delta m^2_{\tilde{\ell}} \propto \frac{1}{16\pi}\ln\frac{M_{\mathrm{GUT}}}{M_N}\lambda^\dagger_\nu\lambda_\nu m^2_{SUSY}$$

SU(5) RGE effects

The running of the soft terms from a higher scale (M_X) to M_{GUT} introduce non universalities on the soft terms :

- $M_x \to M_{GUT}$

10(Q_L,U_R,E_R), 5(D_R,L)

$$W_{\mathrm{SU}(5)} = \frac{1}{4} f_u^{ij}\, 10_i\, 10_j\, H + \sqrt{2} f_d^{ij}\, 10_i\, \overline{5}_j\, \overline{H} + f_\nu^{ij}\, 1_i\, \overline{5}_j\, H$$

$$f_u^{ij} = f_u^\delta,$$

$$f_d^{ij} = V_{CKM}^* \lambda_d^\delta V_{KM}^\dagger$$

The soft terms:

$$m_{10}\, \widetilde{10} * \widetilde{10} + m_5\, \widetilde{5} * \widetilde{5} + \cdots$$

$$\widetilde{\ell}_R \text{ in } 10's \to m^2_{\widetilde{\ell}_R} = V^\dagger_{\mathrm{CKM}} m^2_{10} V_{\mathrm{CKM}}$$

Hisano et al

- $M_{GUT} \to M_R$

$$W_{\mathrm{MSSM}+\nu_R} = Q^T\, f_u^\delta\, U\, H_2 + Q^T \left(V_{CKM}^\dagger f_d^\delta\right) D\, H_1 + L^T \left(V_{KM}^* f_\ell^\delta\right) E\, H_1 + L^T f_\nu^\delta\, N\, H_2$$

Remember that the $V_{KM} = V_\nu^+ \cdot V_l$ where $V_\nu^+ \cdot f_\nu^+ f_\nu \cdot V_\nu = (f_\nu^\delta)^2$ and $V_l^+ \cdot f_l^+ f_l \cdot V_l = (f_l^\delta)^2$. (Does not involve the RH neutrinos like the V_{NMS}). At scale M_R, the diagonal charged lepton Yukawa implies:

$$L^* \left(m_l^2\right)^{diag} L \to L^* \left[V_{KM}^\dagger \cdot \left(m_l^2\right)^{diag} \cdot V_{KM}\right] L$$

2 SU(5) inspired neutrino mass textures

$$Y_u \propto \begin{pmatrix} \varepsilon^6 & \varepsilon^5 & \varepsilon^3 \\ \varepsilon^5 & \varepsilon^4 & \varepsilon^2 \\ \varepsilon^3 & \varepsilon^2 & 1 \end{pmatrix}, \; Y_\ell \propto Y_d^T \propto \begin{pmatrix} \varepsilon^4 & \varepsilon^3 & \varepsilon \\ \varepsilon^3 & \varepsilon^2 & 1 \\ \varepsilon^3 & \varepsilon^2 & 1 \end{pmatrix}, \; Y_\nu \propto \begin{pmatrix} \varepsilon^{|1\pm n_1|} & \varepsilon^{|1\pm n_2|} & \varepsilon^{|1\pm n_3|} \\ \varepsilon^{|n_1|} & \varepsilon^{|n_2|} & \varepsilon^{|n_3|} \\ \varepsilon^{|n_1|} & \varepsilon^{|n_2|} & \varepsilon^{|n_3|} \end{pmatrix}$$

$$m_N \propto \begin{pmatrix} \varepsilon^{2|n_1|} & \varepsilon^{|n_1+n_2|} & \varepsilon^{|n_1+n_3|} \\ \varepsilon^{|n_1+n_2|} & \varepsilon^{2|n_2|} & \varepsilon^{|n_2+n_3|} \\ \varepsilon^{|n_1+n_3|} & \varepsilon^{|n_2+n_3|} & \varepsilon^{2|n_3|} \end{pmatrix} \quad m_{eff} \approx m_D^\nu 1 \frac{1}{M_N} m_D^{\nu\,T},$$

2 SU(5) inspired neutrino mass textures

$$Y_u \propto \begin{pmatrix} \varepsilon^6 & \varepsilon^5 & \varepsilon^3 \\ \varepsilon^5 & \varepsilon^4 & \varepsilon^2 \\ \varepsilon^3 & \varepsilon^2 & 1 \end{pmatrix}, \quad Y_\ell \propto Y_d^T \propto \begin{pmatrix} \varepsilon^4 & \varepsilon^3 & \varepsilon \\ \varepsilon^3 & \varepsilon^2 & 1 \\ \varepsilon^3 & \varepsilon^2 & 1 \end{pmatrix}, \quad Y_\nu \propto \begin{pmatrix} \varepsilon^{|1\pm n_1|} & \varepsilon^{|1\pm n_2|} & \varepsilon^{|1\pm n_3|} \\ \varepsilon^{|n_1|} & \varepsilon^{|n_2|} & \varepsilon^{|n_3|} \\ \varepsilon^{|n_1|} & \varepsilon^{|n_2|} & \varepsilon^{|n_3|} \end{pmatrix}$$

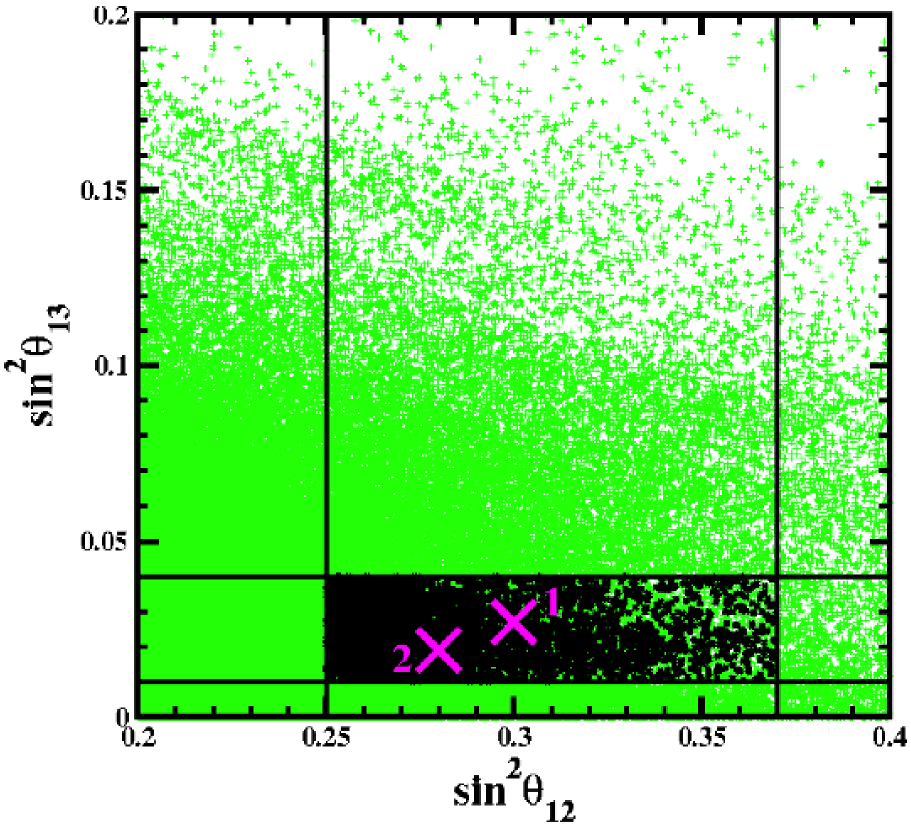
$$m_N \propto \begin{pmatrix} \varepsilon^{2|n_1|} & \varepsilon^{|n_1+n_2|} & \varepsilon^{|n_1+n_3|} \\ \varepsilon^{|n_1+n_2|} & \varepsilon^{2|n_2|} & \varepsilon^{|n_2+n_3|} \\ \varepsilon^{|n_1+n_3|} & \varepsilon^{|n_2+n_3|} & \varepsilon^{2|n_3|} \end{pmatrix} \qquad m_{eff} \approx m_D^{\nu} 1 \frac{1}{M_N} m_D^{\nu\,T},$$

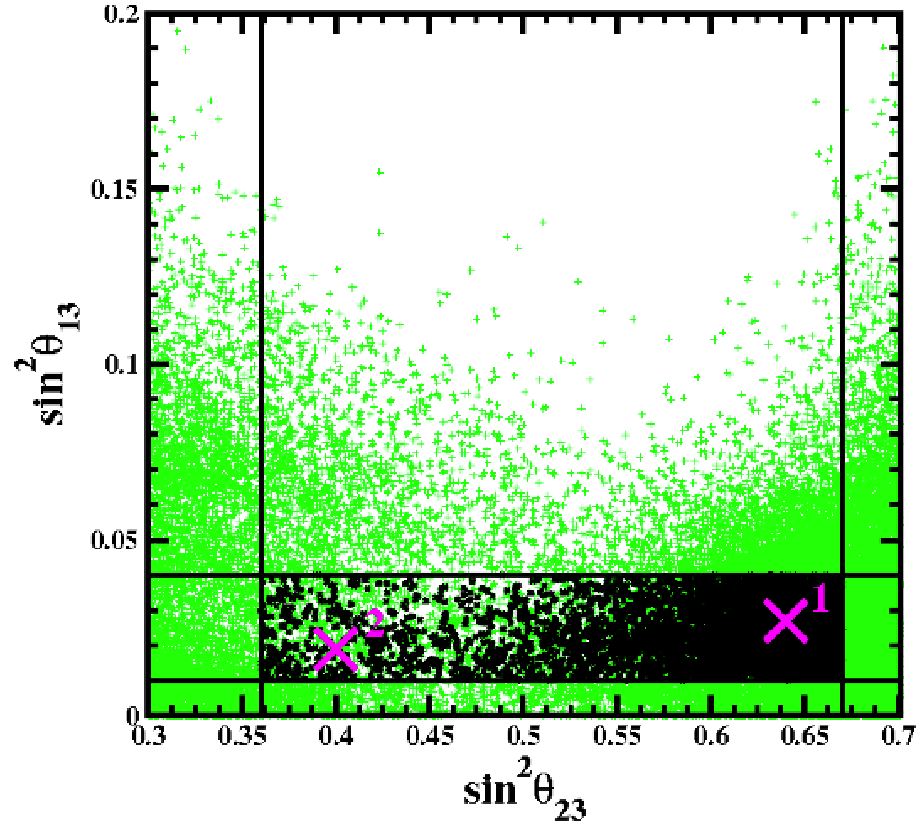
$$m_{eff} \propto \begin{pmatrix} \varepsilon^2 & \varepsilon & \varepsilon \\ \varepsilon & 1 & 1 \\ \varepsilon & 1 & 1 \end{pmatrix}$$

* **Coefficients of O(1) in all entries.**

* **Any choices of n_i leads to the same m_{eff}**

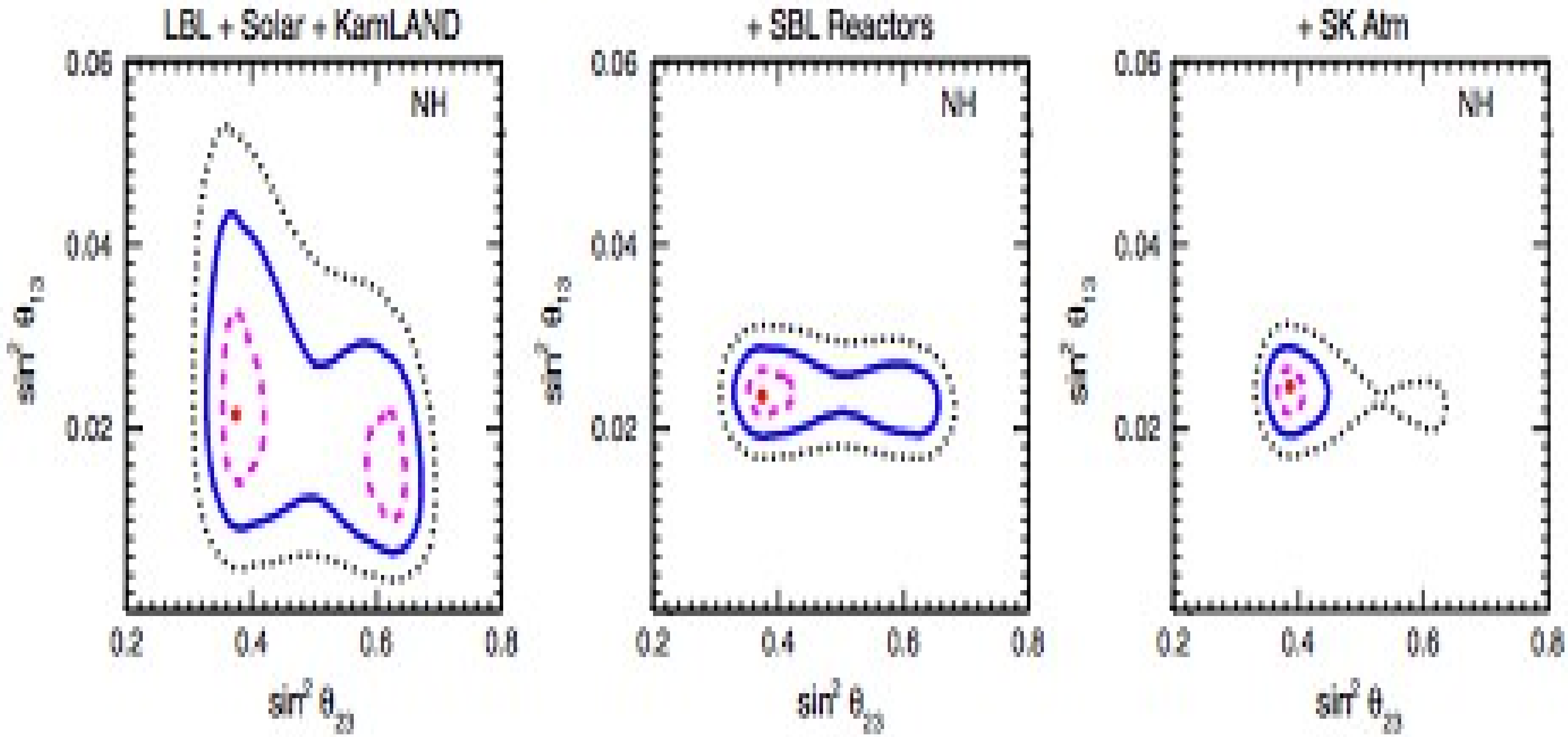
Fitting Of NEUTRINO PARAMETRES





$$0.25 < \sin^2\theta_{12} < 0.37,$$
$$0.36 < \sin^2\theta_{23} < 0.67,$$
$$0.013 < \sin^2\theta_{13} < 0.035,$$

$$\frac{m_{\nu_2}}{m_{\nu_3}} \sim 0.15$$



Data fitting from Flogli et al. **ArXiv:1205.5254, Phys.Rev. D86 (2012) 013012**

Charged-Lepton-Flavour Violation in the CMSSM with heavy right-handed neutrinos

$$V_\ell{}^T(Y_\ell Y_\ell{}^\dagger)V_\ell^* = \mathrm{diag}(y_e^2, y_\mu^2, y_\tau^2),$$
$$V_D{}^T(Y_\nu Y_\nu{}^\dagger)V_D^* = \mathrm{diag}(y_\nu^2, y_\nu^2, y_\nu^2),$$
$$U_N{}^T M_N U_N = \mathrm{diag}(M_1, M_2, M_3),$$
$$U_\nu{}^T m_{eff} U_\nu = \mathrm{diag}(m_{\nu_1}, m_{\nu_2}, m_{\nu_3}),$$

$$U_{MNS} \equiv U = V_\ell^\dagger U_\nu,$$

$$V_{LFV} = V_D^\dagger \cdot V_l$$

$$\sin^2\theta_{13} = |U_{e3}|^2, \quad s_{23}^2 \equiv \sin^2\theta_{23} = \frac{|U_{\mu 3}|^2}{1-|U_{e3}|^2},$$

$$c_{23}^2 \equiv \cos^2\theta_{23} = \frac{|U_{\tau 3}|^2}{1-|U_{e3}|^2}.$$

$$\tilde{m}_\ell^2 = \begin{pmatrix} m_{LL}^2 & m_{LR}^2 \\ m_{RL}^2 & m_{RR}^2 \end{pmatrix}$$

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

$$A_e = V_{l\nu}^T (A_e)^\delta$$

$$m_{LL}^2 = V_{LFV}^\dagger (m_{LL}^2)^\delta V_{LFV}$$

$$U_{MNS} \equiv U = V_\ell^\dagger U_\nu,$$

Fit	Y_ℓ	Y_ν	M_N
1	$\begin{pmatrix} \epsilon^4 & 1.5\epsilon^3 & 2\epsilon \\ 0.5\epsilon^3 & -1.9\epsilon^2 & -0.5\epsilon \\ 2\epsilon^3 & -1.9\epsilon^2 & 1.5 \end{pmatrix}$	$\begin{pmatrix} \epsilon^{\|1\pm n_1\|} & \epsilon^{\|1\pm n_2\|} & 1.75\epsilon^{\|1\pm n_3\|} \\ \epsilon^{\|n_1\|} & \epsilon^{\|n_2\|} & 1.25\epsilon^{\|n_3\|} \\ 1.3\epsilon^{\|n_1\|} & \epsilon^{\|n_2\|} & -2\epsilon^{\|n_3\|} \end{pmatrix}$	$\begin{pmatrix} \epsilon^{2\|n_1\|} & \epsilon^{\|n_1+n_2\|} & -1.3\epsilon^{\|n_1+n_3\|} \\ \epsilon^{\|n_1+n_2\|} & \epsilon^{2\|n_2\|} & \epsilon^{\|n_2+n_3\|} \\ -1.3\epsilon^{\|n_1+n_3\|} & \epsilon^{\|n_2+n_3\|} & -\epsilon^{2\|n_3\|} \end{pmatrix}$
	$\sin^2\theta_{13}$=0.027	$\sin^2\theta_{12}$=0.30	$\sin^2\theta_{23}$=0.64
2	$\begin{pmatrix} \epsilon^4 & 2\epsilon^3 & -1.75\epsilon \\ -0.5\epsilon^3 & 1.9\epsilon^2 & 0.5 \\ -0.5\epsilon^3 & -0.7\epsilon^2 & 1.25 \end{pmatrix}$	$\begin{pmatrix} \epsilon^{\|1\pm n_1\|} & \epsilon^{\|1\pm n_2\|} & 2\epsilon^{\|1\pm n_3\|} \\ 0.75\epsilon^{\|n_1\|} & \epsilon^{\|n_2\|} & -0.5\epsilon^{\|n_3\|} \\ \epsilon^{\|n_1\|} & \epsilon^{\|n_2\|} & 1.25\epsilon^{\|n_3\|} \end{pmatrix}$	$\begin{pmatrix} \epsilon^{2\|n_1\|} & \epsilon^{\|n_1+n_2\|} & -\epsilon^{\|n_1+n_3\|} \\ \epsilon^{\|n_1+n_2\|} & \epsilon^{2\|n_2\|} & \epsilon^{\|n_2+n_3\|} \\ -\epsilon^{\|n_1+n_3\|} & \epsilon^{\|n_2+n_3\|} & -\epsilon^{2\|n_3\|} \end{pmatrix}$
	$\sin^2\theta_{13}$=0.019	$\sin^2\theta_{12}$=0.28	$\sin^2\theta_{23}$=0.40

Table 1: *Indicative textures for Y_ℓ, Y_ν and M_N, corresponding to the two crosses in Fig 1, with the indicated values of the neutrino mixing angles. The n_i are Abelian charges to be determined.*

$$V_{LFV} = V_D^\dagger \cdot V_l$$

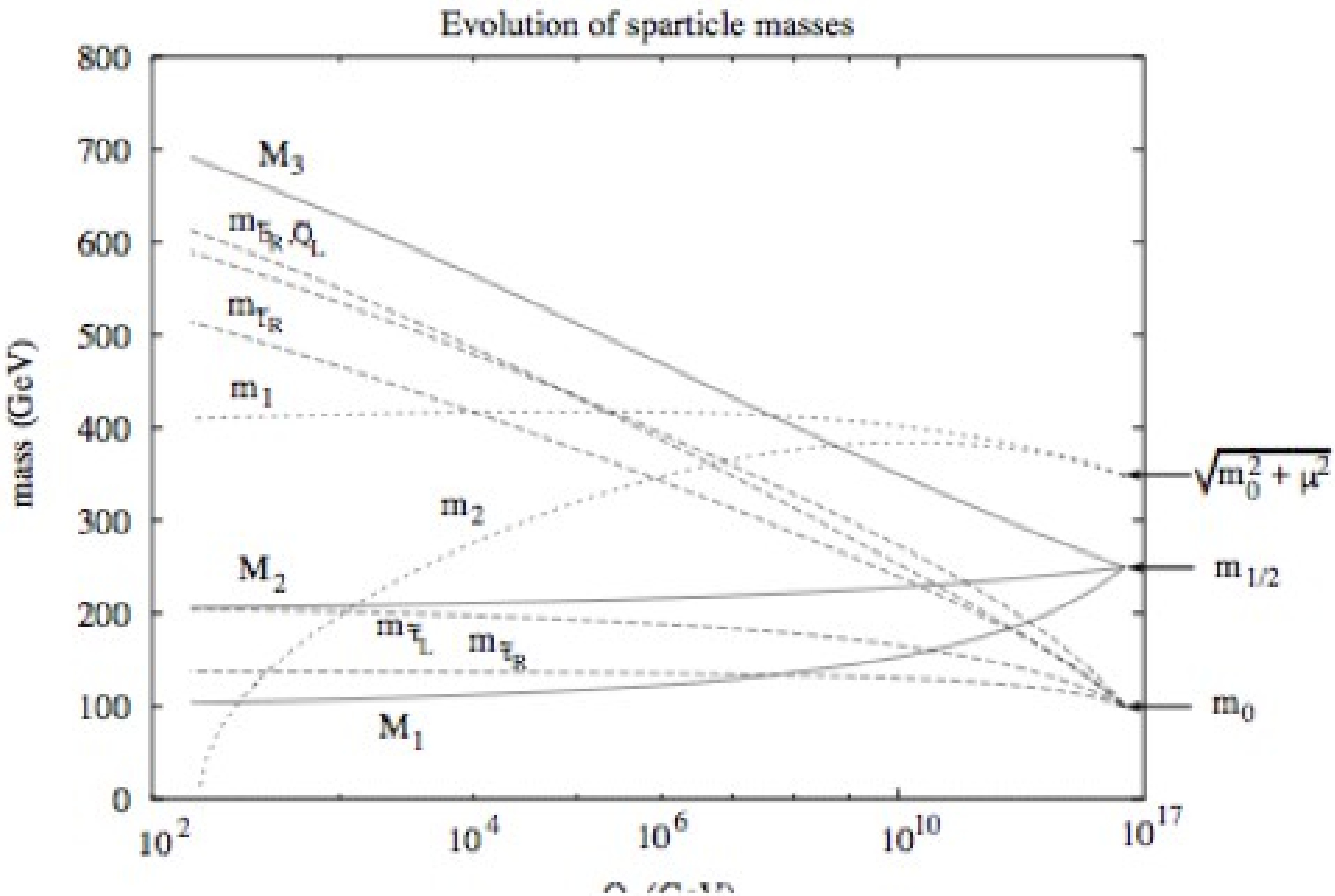
n_i	$\{n_1 = 1, n_2 = 0, n_3 = 0\}$	$\{n_1 = 2, n_2 = 1, n_3 = 0\}$	$\{n_1 = 2, n_2 = 0, n_3 = 1\}$	$\{n_1 = 0, n_2 = 1, n_3 = 0\}$
V_{LFV}	$\begin{pmatrix} 0.805 & -0.385 & -0.451 \\ 0.182 & 0.885 & -0.429 \\ 0.565 & 0.263 & 0.782 \end{pmatrix}$	$\begin{pmatrix} 0.805 & -0.385 & -0.452 \\ -0.064 & 0.700 & -0.711 \\ 0.590 & 0.601 & 0.539 \end{pmatrix}$	$\begin{pmatrix} -0.820 & 0.343 & 0.458 \\ 0.494 & 0.829 & 0.263 \\ -0.289 & 0.441 & -0.849 \end{pmatrix}$	$\begin{pmatrix} 0.806 & -0.401 & -0.436 \\ -0.437 & -0.899 & 0.016 \\ -0.399 & 0.178 & -0.901 \end{pmatrix}$

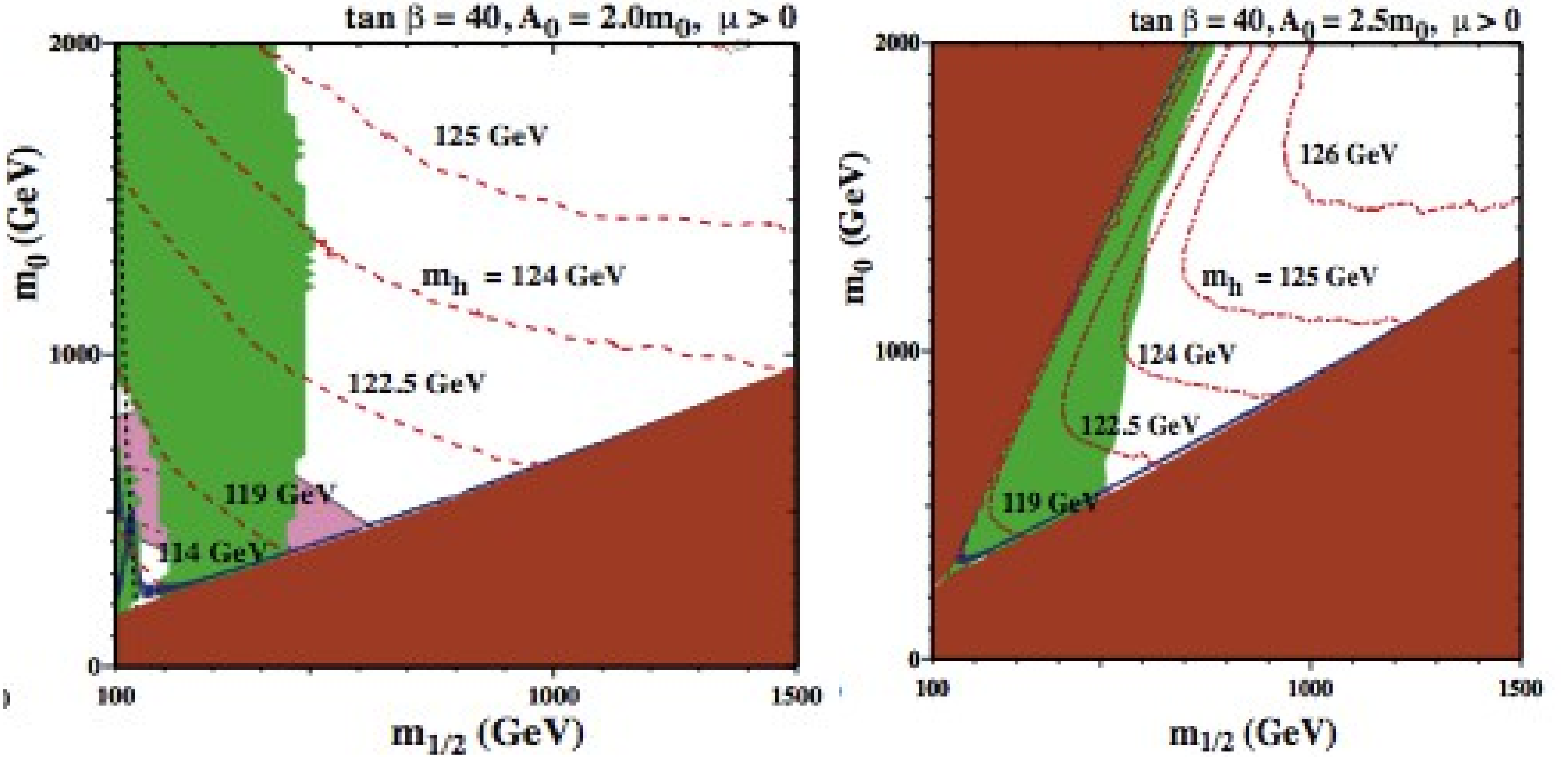
Table 2: *Values of V_{LFV} with $\varepsilon = 0.2$ for Fit 2 of Table 1 with large V_ℓ. Fom left to right, we see the following features: (i) V_D is small, leading to large V_{LFV}, (ii) and (iii) V_D is large and so is V_{LFV}, (iv) V_D is large and cancellations with V_ℓ occur in the 2-3 sector, suppressing LFV. In the last two examples, the heavy Majorana mass matrix has an inverse hierarchy.*

SUSY spectrum

CMSSM, mSUGRA. Parametros de masa universales:

$$m_0,\ M_{1/2},\ A_0,\ \mu_0,\ \alpha_G,\ M_{GUT},\ \tan\beta\ .$$

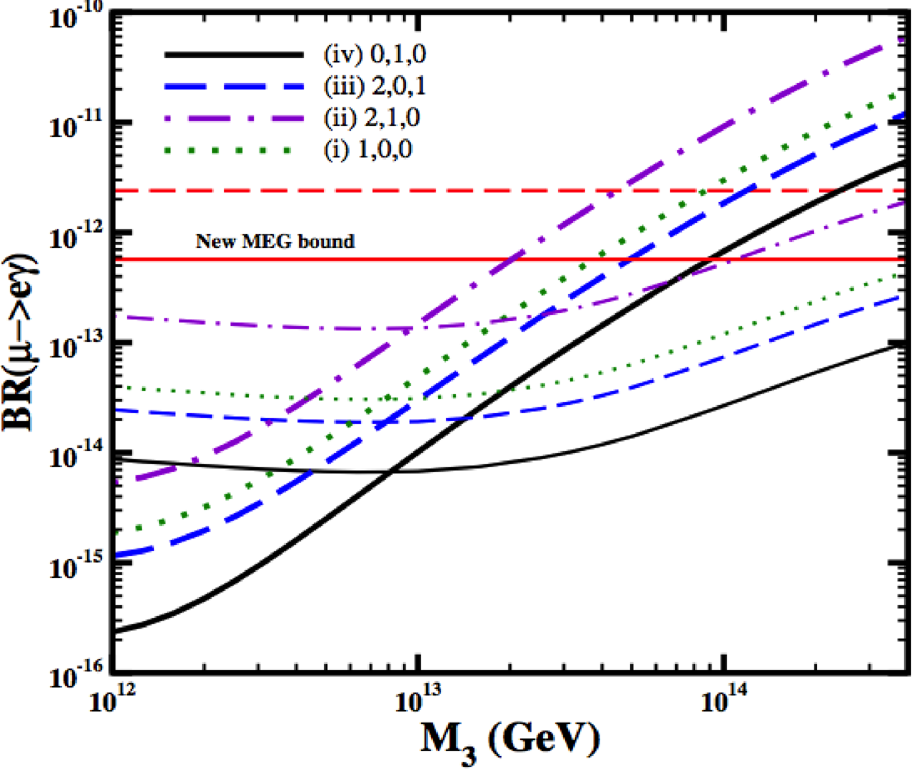


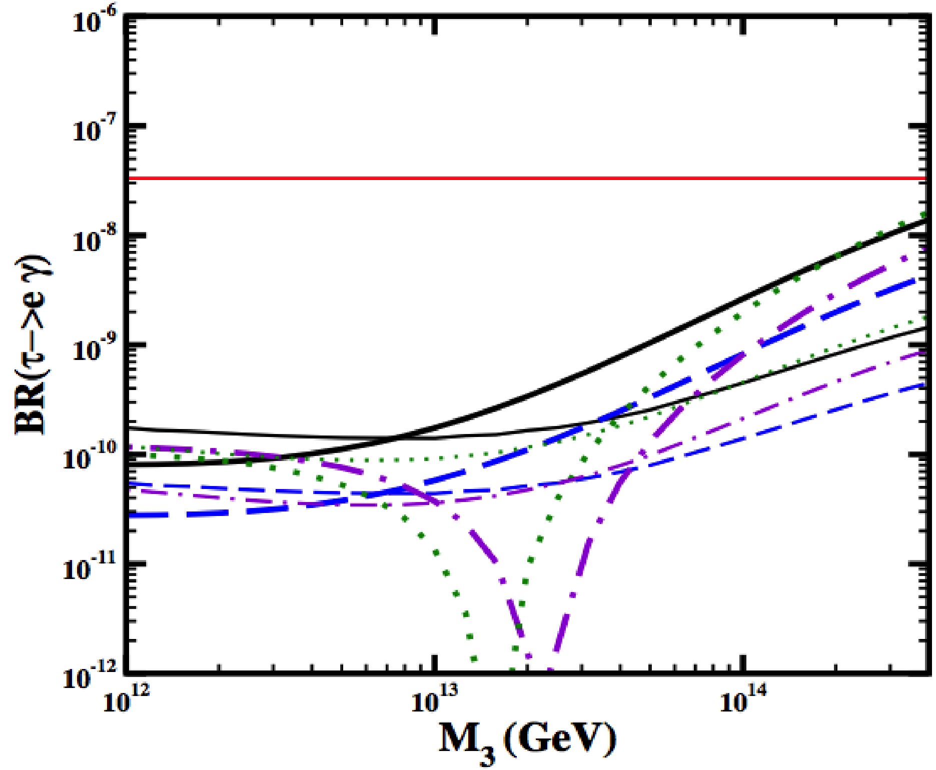


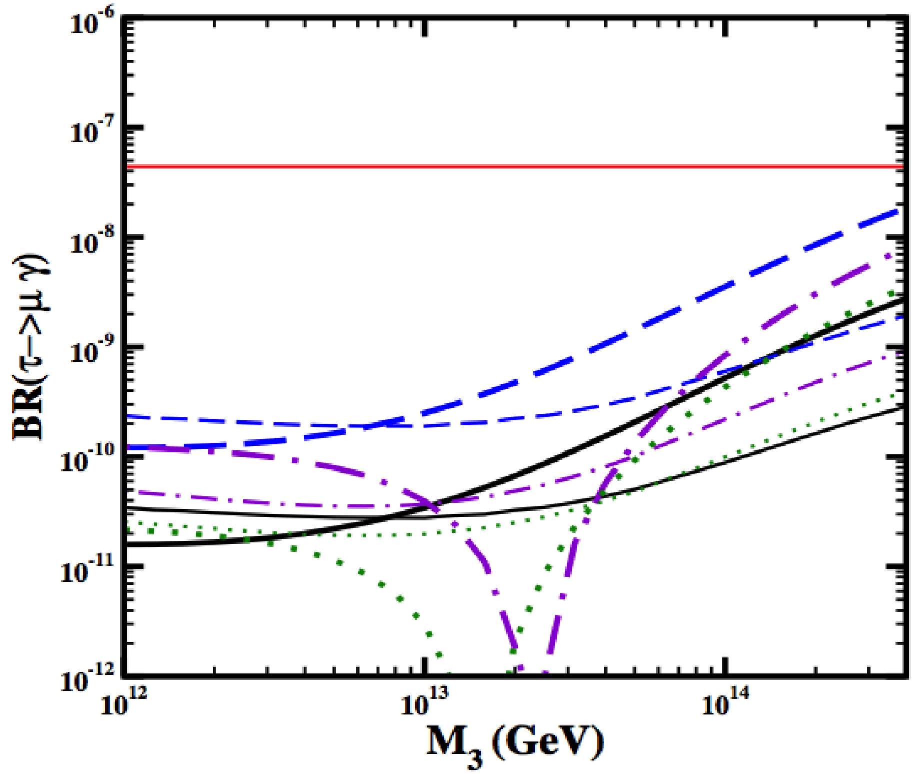
Ellis, Olive

$$(a)\quad \tan\beta = 16, \quad m_0 = 300\ \mathrm{GeV}, \quad M_{1/2} = 910\ \mathrm{GeV}, \quad A_0 = 1320\ \mathrm{GeV}\,,$$

$$(b)\quad \tan\beta = 45, \quad m_0 = 1070\ \mathrm{GeV}, \quad M_{1/2} = 1890\ \mathrm{GeV}, \quad A_0 = 1020\ \mathrm{GeV}\,.$$







LFV RADIATIVE DECAYS:

Thick, tb=16
Thin,   tb= 45

LEPTOGENESIS AND LFV

$$Y_B = (6.16 \pm 0.16) \times 10^{-10}$$

WMAP value

$$Y_B \simeq -10^{-2} \kappa \epsilon_1 ,$$

Whash-out factor

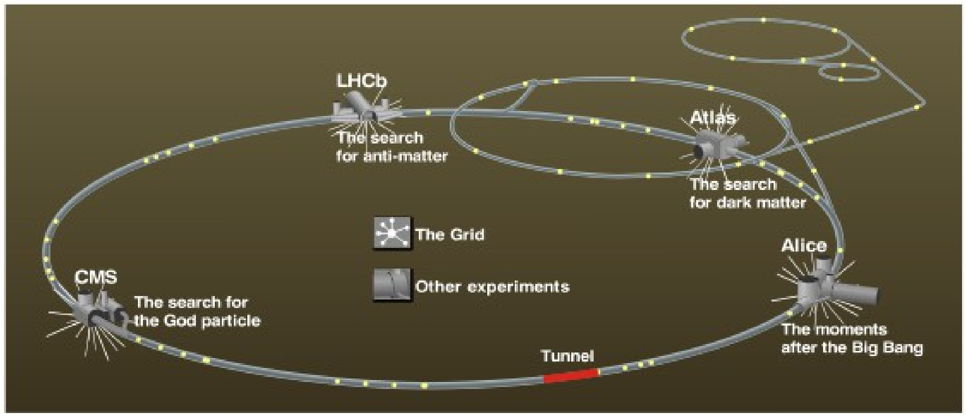
$$\tilde{m}_1 = \frac{v_u^2}{M_1} (\lambda_\nu^\dagger \lambda_\nu)_{11} ,$$

CP-Violiting N1 Decay

$$|\epsilon_1| \leq \frac{3}{8\pi} \frac{M_1}{v_u^2} (m_3 - m_1)$$

	(i)	(ii)	(iii)	(iv)
$M_1(GeV)$	$4.3 \cdot 10^{12}$ $8.6 \cdot 10^{10}$	$2.6 \cdot 10^{11}$ $5.3 \cdot 10^{9}$	$5.4 \cdot 10^{11}$ $1.1 \cdot 10^{10}$	$2.3 \cdot 10^{12}$ $4.7 \cdot 10^{10}$
$\tilde{m}_1(eV)$	0.19 0.11	0.78 0.48	5.17 3.18	1.19 0.7
Y_B^{max}	$1.0 \cdot 10^{-8}$ $3.6 \cdot 10^{-10}$	$1.2 \cdot 10^{-10}$ $4.3 \cdot 10^{-12}$	$2.8 \cdot 10^{-11}$ $9.7 \cdot 10^{-13}$	$6.6 \cdot 10^{-10}$ $2.3 \cdot 10^{-11}$
Y_B^*	$1.3 \cdot 10^{-10}$ $2.8 \cdot 10^{-12}$	$3.5 \cdot 10^{-11}$ $7 \cdot 10^{-13}$	$1.2 \cdot 10^{-12}$ $2.6 \cdot 10^{-14}$	$3.2 \cdot 10^{-12}$ $6.9 \cdot 10^{-14}$

LC vs. LHC searches



LHC hadron collider sleptons appear in gaugino cascade decays:

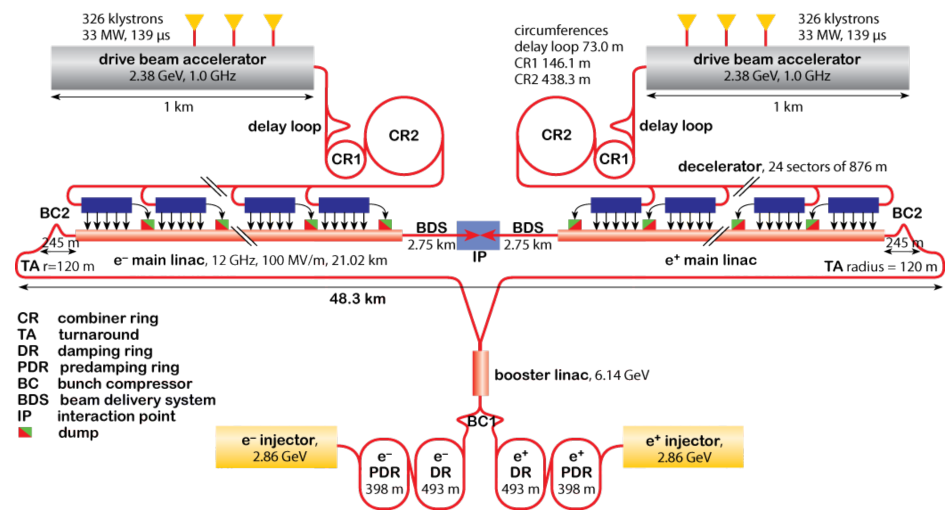
$$\tilde{\chi}_2^0 \to \tilde{l}_i^\pm l_i^\mp$$

$$\tilde{l}_i^\pm \to l_j^\pm \tilde{\chi}_1^0$$

Collider in the post-LHC era for Physics up to the multi-TeV center of mass colliding beam energy range (nominal 3 TeV).

$$e^+e^- \to \tilde{\ell}_i^- \tilde{\ell}_j^+ \to \tau^\pm \mu^\mp \tilde{\chi}_1^0 \tilde{\chi}_1^0$$

$$e^+e^- \to \tilde{\nu}_i \tilde{\nu}_j^c \to \tau^\pm \mu^\mp \tilde{\chi}_1^+ \tilde{\chi}_1^-$$



$\chi_2 \rightarrow \chi + \tau^{\pm} + \mu^{\mp}$ at LHC.

- On-shell slepton production:

$$
\begin{aligned}
BR(\chi_2 \rightarrow \chi\tau^{\pm}\mu^{\mp}) &= \sum_{i=1}^{3} BR(\chi_2 \rightarrow \tilde{l}_i\mu)BR(\tilde{l}_i \rightarrow \tau\chi) \\
&+ BR(\chi_2 \rightarrow \tilde{l}_i\tau)BR(\tilde{l}_i \rightarrow \mu\chi)
\end{aligned}
$$

Bartl et al,
hep-ph/0510074

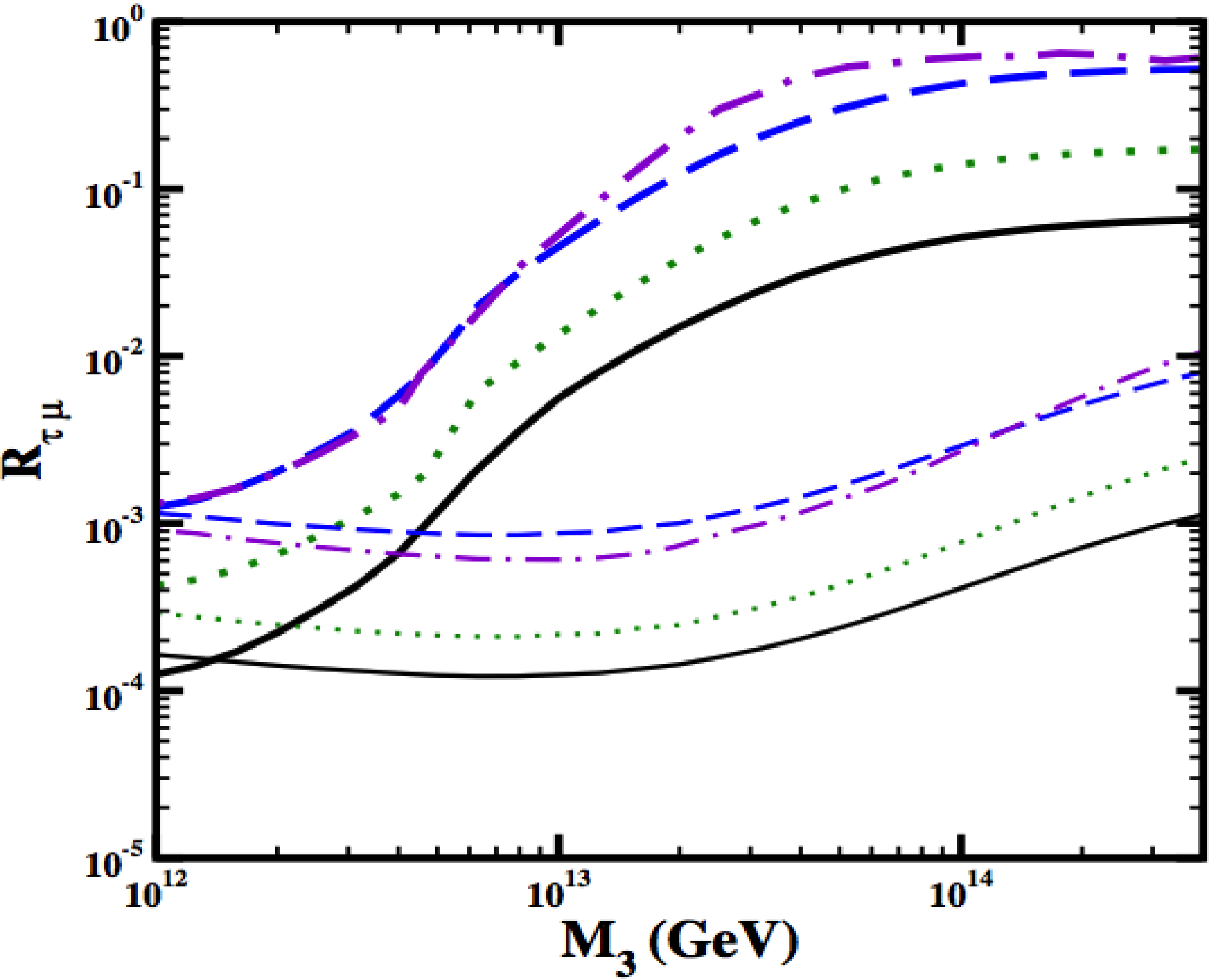
- the signal in the τ channel to be optimal is definded by the following:

B

(i) $m_{\chi_2^0} > m_{\tilde{\tau}} > m_\chi^0$ (on-shell condition)

(ii) $m_{\tilde{\tau}} >> m_\chi^0$ (hadronised τs in the final state)

(iii) Moderate values of m_χ^0 (phase space and luminosity considerations).



LHC signal:

Thick, tb=16
Thin, tb= 45

$$R_{\tau\mu} = \Gamma(\chi_2 \to \chi + \tau^{\pm} + \mu^{\mp})/\Gamma(\chi_2 \to \chi + \tau^{\pm} + \tau^{\mp})$$

$$R_{\mu\tau} < 0.1$$

LFV at LC

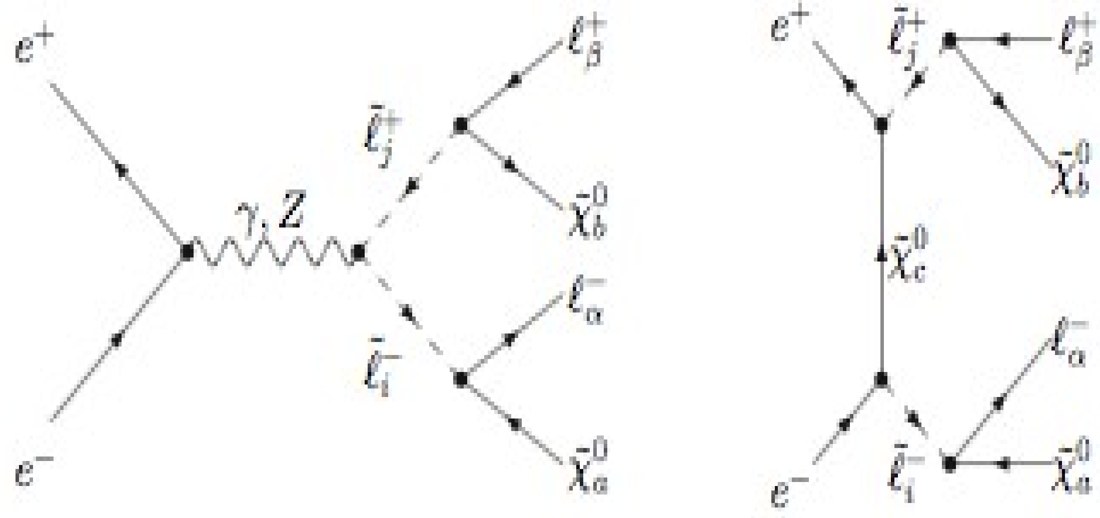
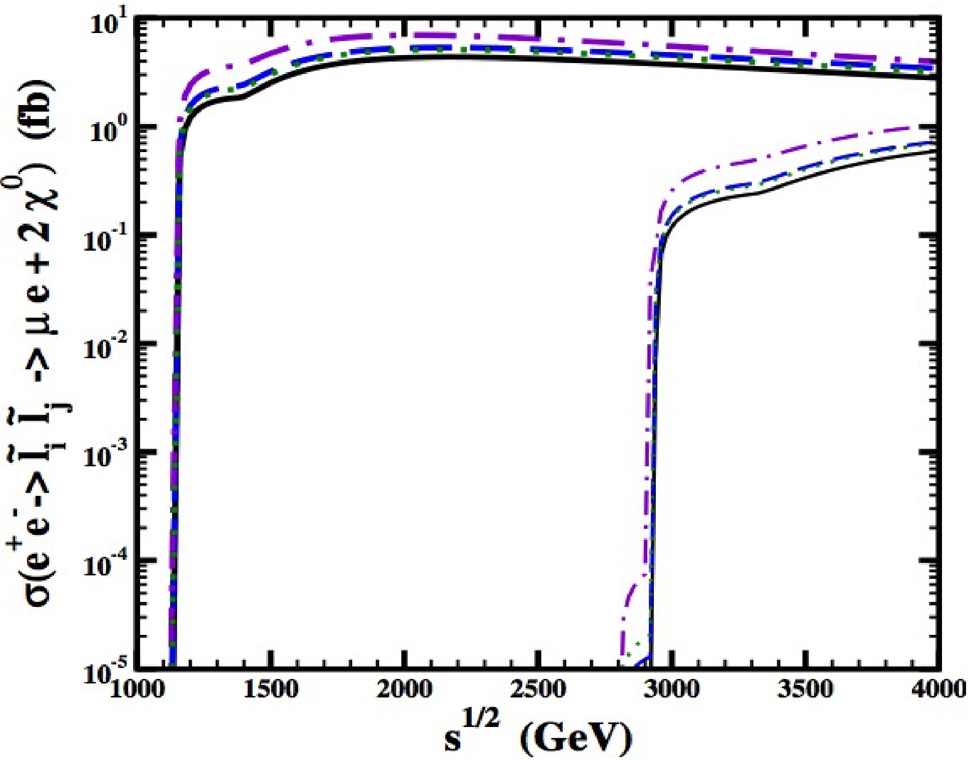


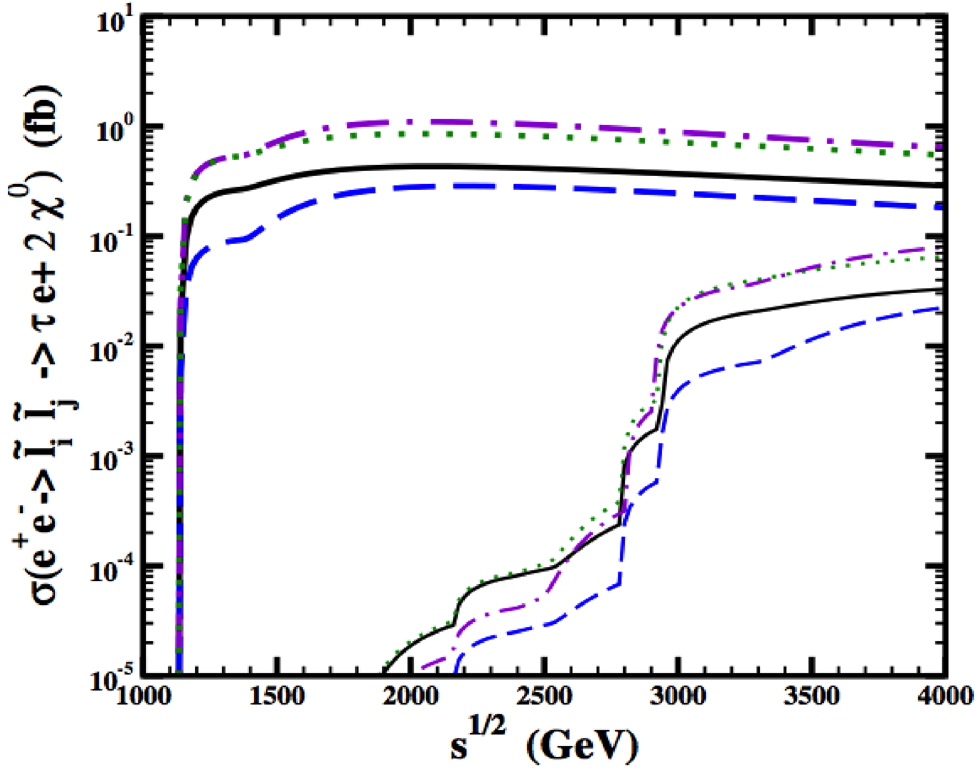
Figure 1: *Feynman diagrams for $e^+e^- \to \tilde{\ell}_j^+\tilde{\ell}_i^- \to \ell_\beta^+\ell_\alpha^-\tilde{\chi}_b^0\tilde{\chi}_a^0$. The arrows on scalar lines indicate lepton number flow. Similar diagrams -appropriately modified- exist for charginos.*

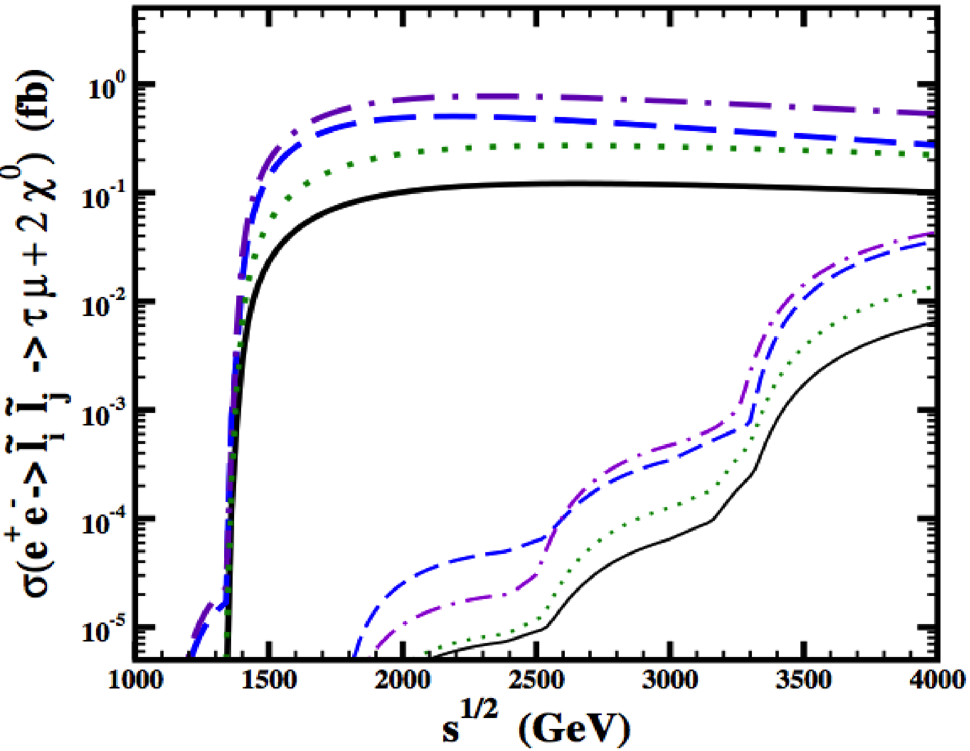
Direc production in Slepton pair decays:

$$e^+e^- \to \tilde{\ell}_i^-\tilde{\ell}_j^+ \to \tau^\pm\mu^\mp\tilde{\chi}_1^0\tilde{\chi}_1^0$$

$$e^+e^- \to \tilde{\nu}_i\tilde{\nu}_j^c \to \tau^\pm\mu^\mp\tilde{\chi}_1^+\tilde{\chi}_1^-$$







LC signals:

Thick, tb=16
Thin, tb= 45

Conclusions

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- Among others, the LHC data, with a neutral Higgs of about 125 GeV implies that observation of slepton flavor violation at a LC will be possible for energies beyond 1 TeV.

- We found also a point with large A-term and lower spectrum can present both good prospects for LFV detection at LC and at the LHC, without giving up the condition of soft terms GUT universality.