Supersymmetric Lepton Flavour Violation at the LHC and LC

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LHC/LC agenda meeting

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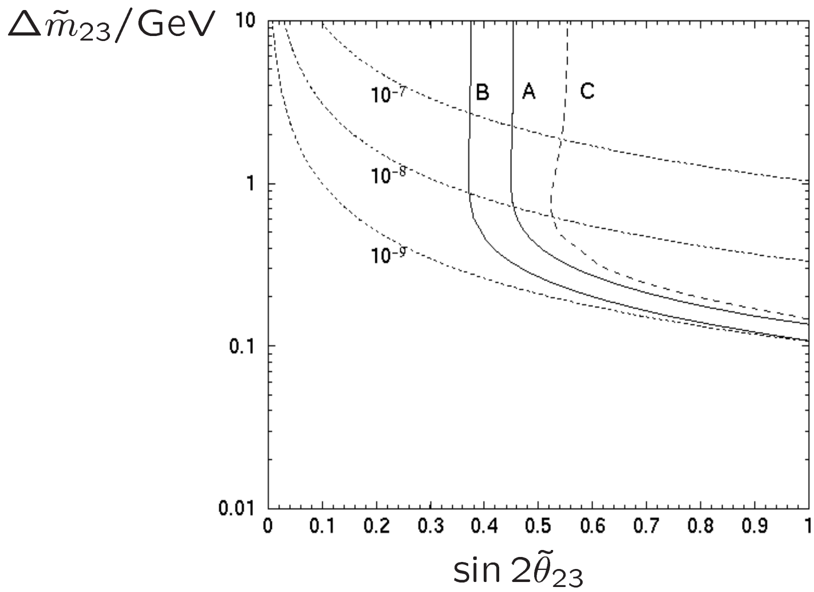
Sensitivity at future e^+e^- colliders to SLFV

$m_0 = 100$ GeV, $m_{1/2} = 200$ GeV, $A_0 = 0$ GeV, $\tan\beta = 3$, $sgn(\mu) = +$

$\sqrt{s} = 500$ GeV

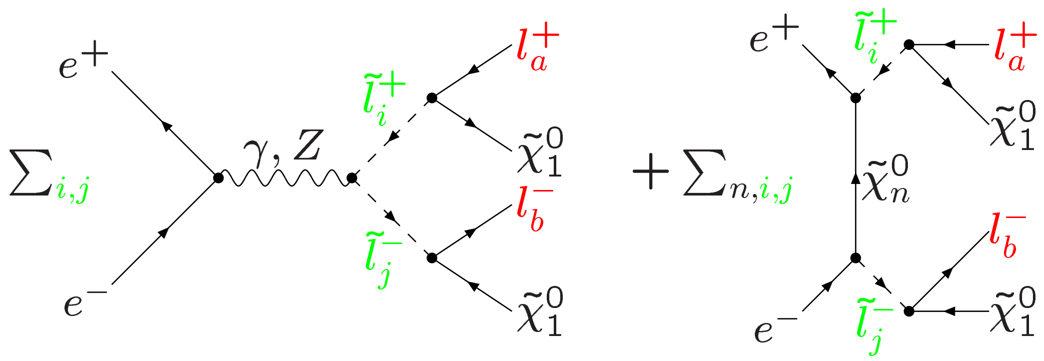


- sneutrino mass difference $\Delta\tilde{m}_{23} = m_{\tilde{\nu}_3} - m_{\tilde{\nu}_2}$
- sneutrino mixing angle $\tilde{\theta}_{23}$
- 3σ significance contours of
  - A: $e^+e^- \to \tilde{\nu}_i\tilde{\nu}_j^c(\tilde{\chi}_2^+\tilde{\chi}_1^-) \to \tau^\pm\mu^\pm\tilde{\chi}_1^+\tilde{\chi}_1^-$ for 500 fb^{-1}
  - B: as above for 1000 fb^{-1}
  - C: separate $\tilde{\nu}\tilde{\nu}^c$ contribution for 500 fb^{-1}
  - dotted lines: $Br(\tau \to \mu\gamma) = 10^{-7}, 10^{-8}, 10^{-9}$

Framework: SUSY seesaw models

see F. Deppisch, H. Päs, A.Redelbach, R. Rückl,
Eur. Phys. J. C **28** (2003),
Phys. Rev. D **69** (2004)

Processes



$$\sigma_{ab}^{\text{pair}} \propto \alpha^4 \frac{|(\delta m_L)^2_{ab}|^2}{\tilde{m}^2\Gamma^2}\, \sigma(e^+e^- \to \tilde{l}_a^+\,\tilde{l}_a^-) Br(\tilde{l}_a^+ \to l_a^+\,\tilde{\chi}_1^0) Br(\tilde{l}_a^- \to l_a^-\,\tilde{\chi}_1^0)$$

SLFV elements in the slepton mass matrix

$$\begin{aligned} \delta m_L^2 &= -\frac{1}{8\pi^2}(3m_0^2 + A_0^2)(Y_\nu^\dagger Y_\nu) \ln\left(\frac{M_X}{M_R}\right) \\ Y_\nu^\dagger Y_\nu &= \frac{M_R}{v^2 \sin^2\beta} U_{MNS} \cdot \text{diag}(m_{\nu_1}, m_{\nu_2}, m_{\nu_3}) \cdot U_{MNS}^\dagger \end{aligned}$$

degenerate Majorana mass M_R

Parameters

mSUGRA benchmark scenarios

Scenario	$m_{1/2}$/GeV	m_0/GeV	$\tan\beta$	$\tilde{m}_6$/GeV	$m_{\tilde{\chi}_1^0}$/GeV
B	250	100	10	208	98
C	400	90	10	292	164
G	375	120	20	292	154
I	350	180	35	313	143

- proposed for Linear Collider studies
  (Battaglia et al., Eur. Phys. J. C **22**, 535 (2001))

- consistent with direct searches, $b \to s\gamma$, Higgs searches, cosmology

neutrino parameters

- $\tan^2\theta_{23} = 1.40^{+1.37}_{-0.66}$

- $\tan^2\theta_{13} = 0.005^{+0.001}_{-0.005}$

- $\tan^2\theta_{12} = 0.36^{+0.35}_{-0.16}$

- $\Delta m^2_{12} = 3.30^{+0.3}_{-0.3} \cdot 10^{-5}$ eV^2

- $\Delta m^2_{23} = 3.10^{+1.0}_{-1.0} \cdot 10^{-3}$ eV^2

- $m_1 \approx 0 - 0.03$ eV

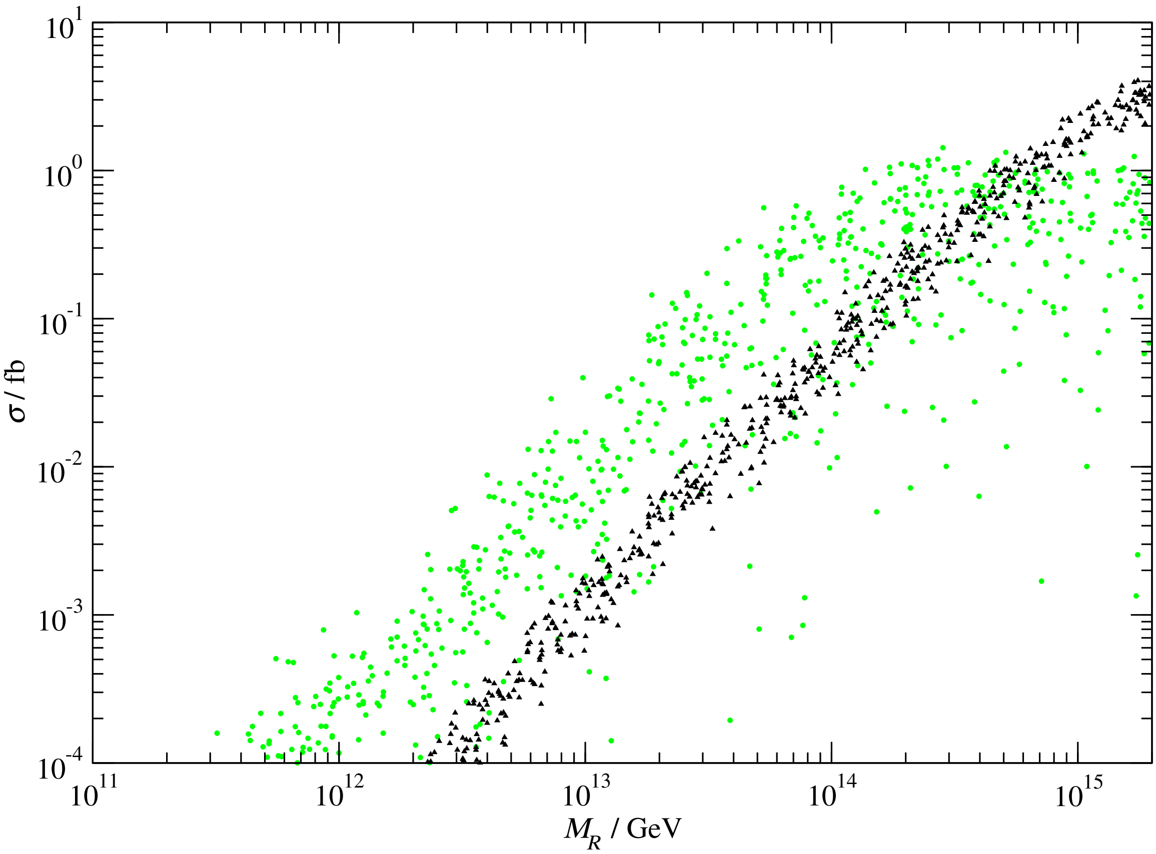
- central values from M.C. Gonzalez-Garcia et al, Phys. Rev. D **63** (2001) 033005, hep-ph/0009350

- errors at anticipated 90% C.L. of running/proposed experiments

$$\sigma(e^+e^- \to \mu^+e^-(\tau^+\mu^-) + 2\tilde{\chi}_1^0)$$

SUSY scenario B (lightest slepton spectrum)

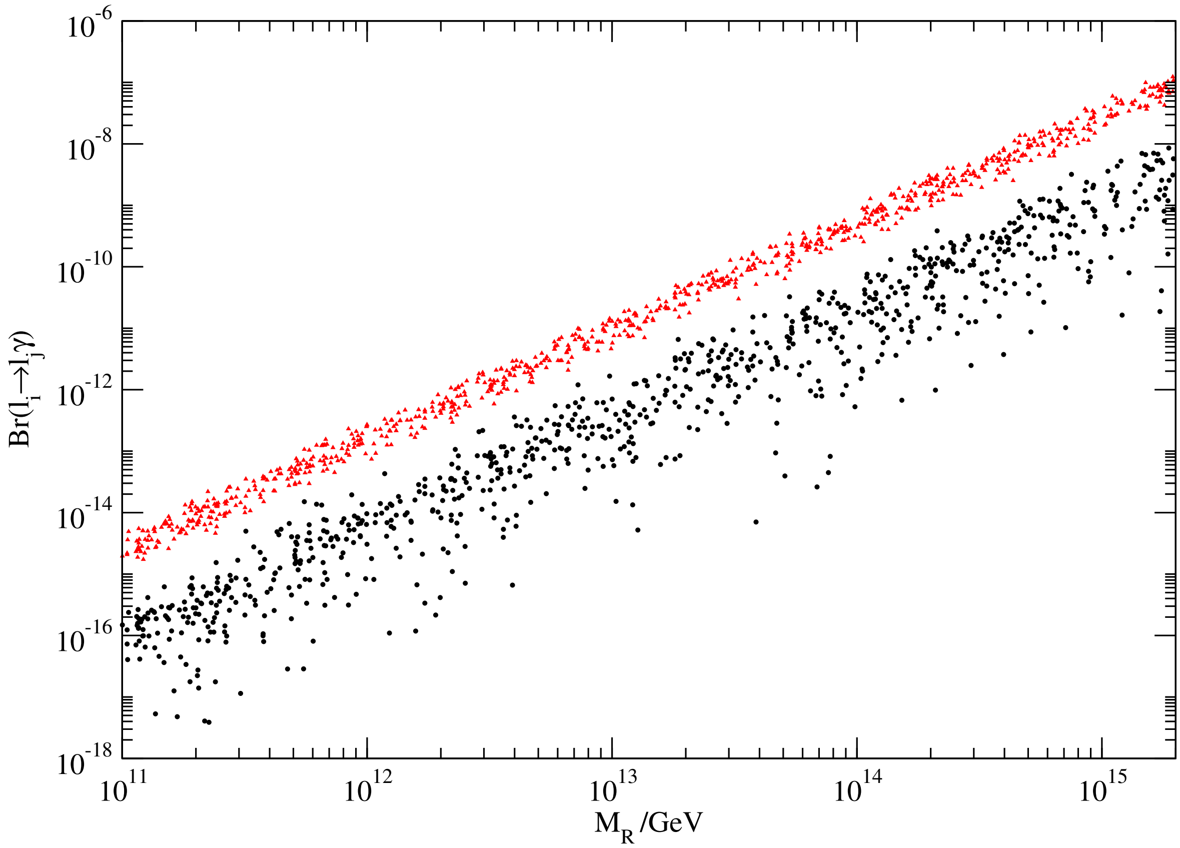
$\sqrt{s} = 500$ GeV



- see Phys. Rev. D **69** (2004)

$$Br(\mu \to e\gamma),\ Br(\tau \to \mu\gamma)$$

Scenario B

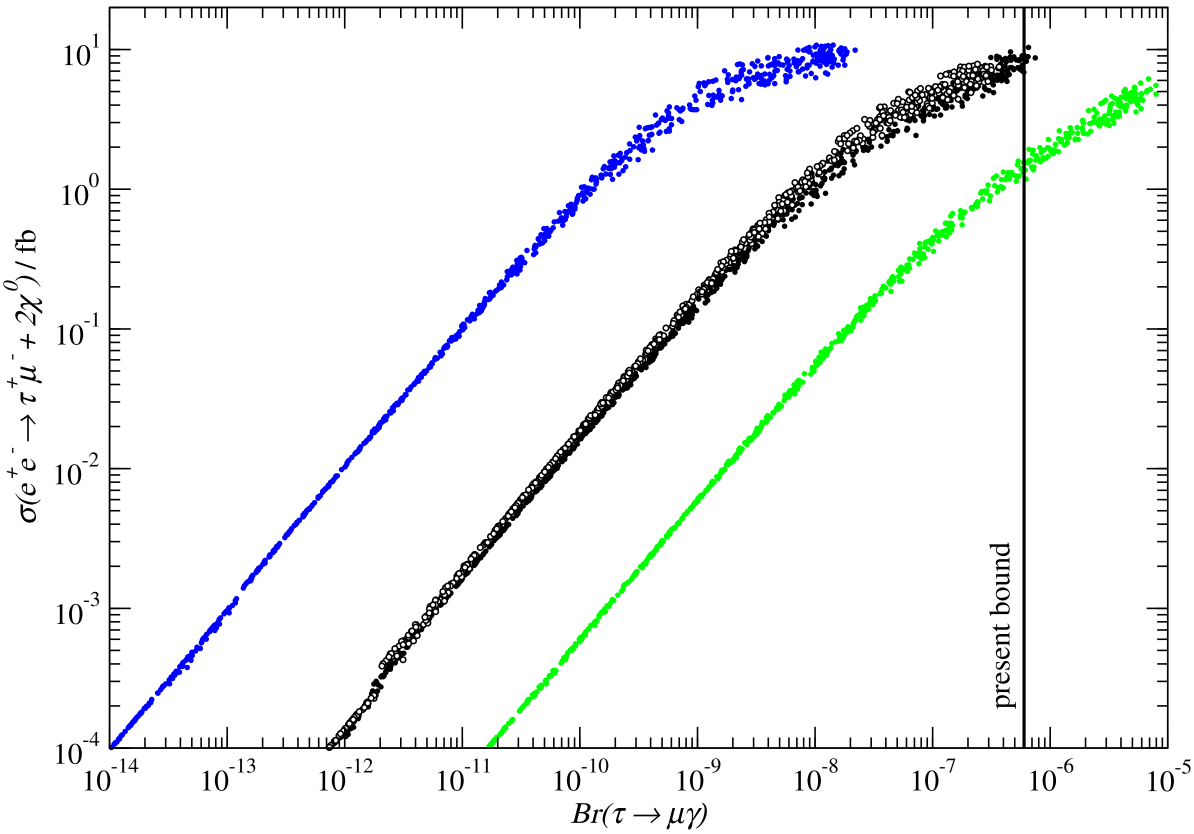


- see Eur. Phys. J. C **28** (2002)

correlation of high- and low-energy signals

Scenarios C, G($\circ$), B, I

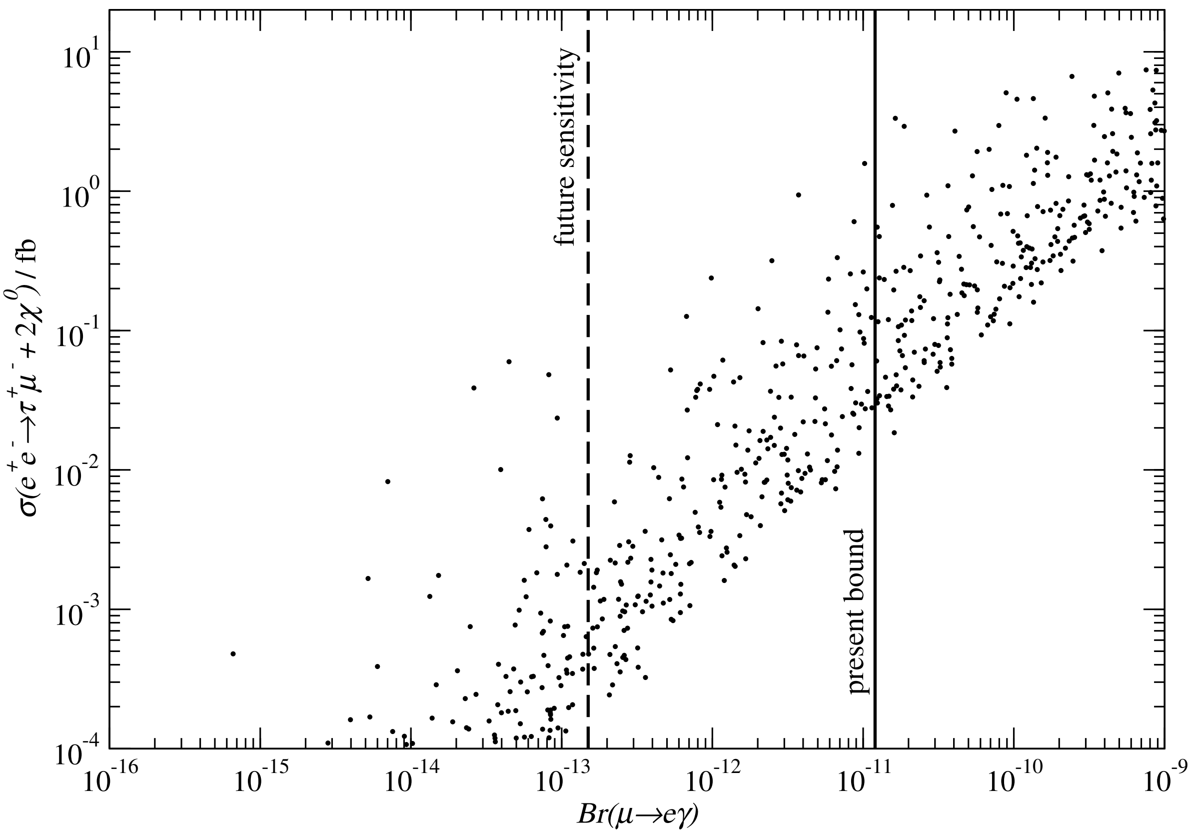
$\sqrt{s} = 800$ GeV



- LHC sensitivity goal: $Br(\tau \to \mu\gamma) \approx 10^{-8}$
- see Phys. Rev. D **69** (2004)

Scenario B

$\sqrt{s} = 800$ GeV



- see Phys. Rev. D **69** (2004)

Conclusions

- Scenario B, $M_R = 10^{13} - 10^{15}$ GeV
  - LFV in slepton pair production
    at a $\sqrt{s} = 500$ GeV LC
    $\rightarrow \sigma(e^+e^- \rightarrow \mu^+e^- + 2\tilde{\chi}_1^0) \approx 10^{-2} - 1$ fb
    $\rightarrow \sigma(e^+e^- \rightarrow \tau^+\mu^- + 2\tilde{\chi}_1^0) \approx 10^{-3} - 3$ fb
  - LFV in lepton decays
    $\rightarrow Br(\mu \rightarrow e\gamma) = 10^{-13} - 10^{-9}$
    $\rightarrow Br(\tau \rightarrow \mu\gamma) = 10^{-11} - 4 \cdot 10^{-8}$

- correlation between radiative decays and slepton pair production
  - $Br(\tau \rightarrow \mu\gamma) = 10^{-8}$ (reachable at LHC)
    $\rightarrow \sigma(e^+e^- \rightarrow \tau^+\mu^- + 2\tilde{\chi}_1^0) \approx 0.05 - 10$ fb
  - $Br(\mu \rightarrow e\gamma) < 10^{-13}$ (sensitivity at PSI)
    $\rightarrow \sigma(e^+e^- \rightarrow \tau^+\mu^- + 2\tilde{\chi}_1^0)$ non-observable

- strong dependence on
  - SUSY parameters
  - Majorana mass spectrum
  - neutrino Yukawa couplings (partly constrained by neutrino masses and mixings)