$\mu \to e$ in R-Symmetric Supersymmetry

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Fok, Kribs

arXiv:1004.0556

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Introduction
MSSM flavor problem

- Slepton / squark generation mixings suppressed
  - $\delta_{ij} \equiv m_{ij}^2/m^2 \ll 1$ for many squark and slepton mass matrices
  - One solution
    - Enlarging the R-parity!!

Introduction

M ↑ SSM
R

- "R" = R-symmetric
- Z_2 R-parity ➔ U(1) R-symmetry
- Details, see KPW

  Kribs, Poppitz, and Weiner
  arXiv:0712.2039

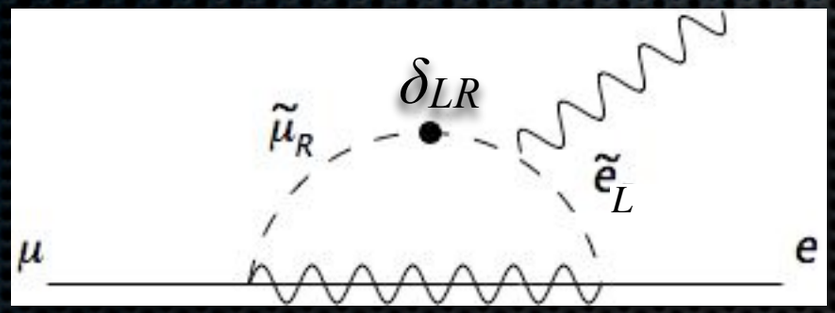
MRSSM
Gaugino/Higgsino masses

- SUSY particles R-charged, SM particles R-neutral
  - $m\widetilde{B}\widetilde{B}$, $\mu\widetilde{H}_u\widetilde{H}_d$...etc, forbidden by U(1)$_R$

1	$\widetilde{B}$		
0	B_μ	h_u	h_d
-1		$\widetilde{H}_u$	$\widetilde{H}_d$

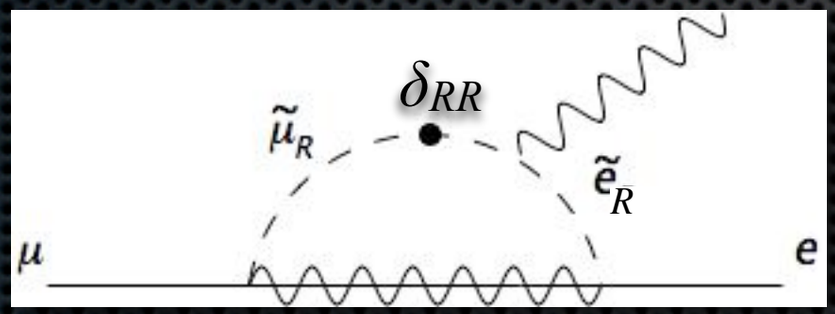
- Introduce new chiral superfields
  - $m\widetilde{B}\psi_B$, $\mu_u\widetilde{H}_u\psi_{Hu}$, $\mu_d\widetilde{H}_d\psi_{Hd}$ allowed
  - Dirac inos $N_{\tilde{B}} = \begin{pmatrix} \psi_B \\ \bar{B}^\dagger \end{pmatrix}, \quad N_{H_d} = \begin{pmatrix} \tilde{H}_d^0 \\ \psi_{H_d}^\dagger \end{pmatrix}$
  - Two higgsino masses, μ_u and μ_d

MRSSM
Lepton flavor violation



Forbidden in MRSSM
Allowed in MSSM

- $\delta_{LR} = 0$ by R-symmetry



Exists in MRSSM!

- $\delta_{RR,LL} \sim 1$ possible

Kribs, Poppitz, and Weiner
arXiv:0712.2039

What's new?

- KPW assumed
  - Mass insertion
  - No Higgsinos
  - $\mu \to e\gamma$ only

- FK
  - Mass eigenstates
  - Higgsinos
  - $\mu \to e$ conversion, $\mu \to 3e$

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Outline

- Parameters
  - Mixing angles
  - Mass hierachy
- Flavor violating processes
  - $\mu \to e\gamma$, $\mu \to e$ conversion in gold, $\mu \to 3e$
- Exclusion Plots from Experimental Bounds

Mixing angles

- LR slepton mixing forbidden by R-symmetry
  - 3x3 mixing matrix for each slepton "chirality"
- $\mu \to e$ processes
  - Two generation mixing

$$c_{L,R} = cos\theta_{L,R}$$
$$s_{L,R} = sin\theta_{L,R}$$

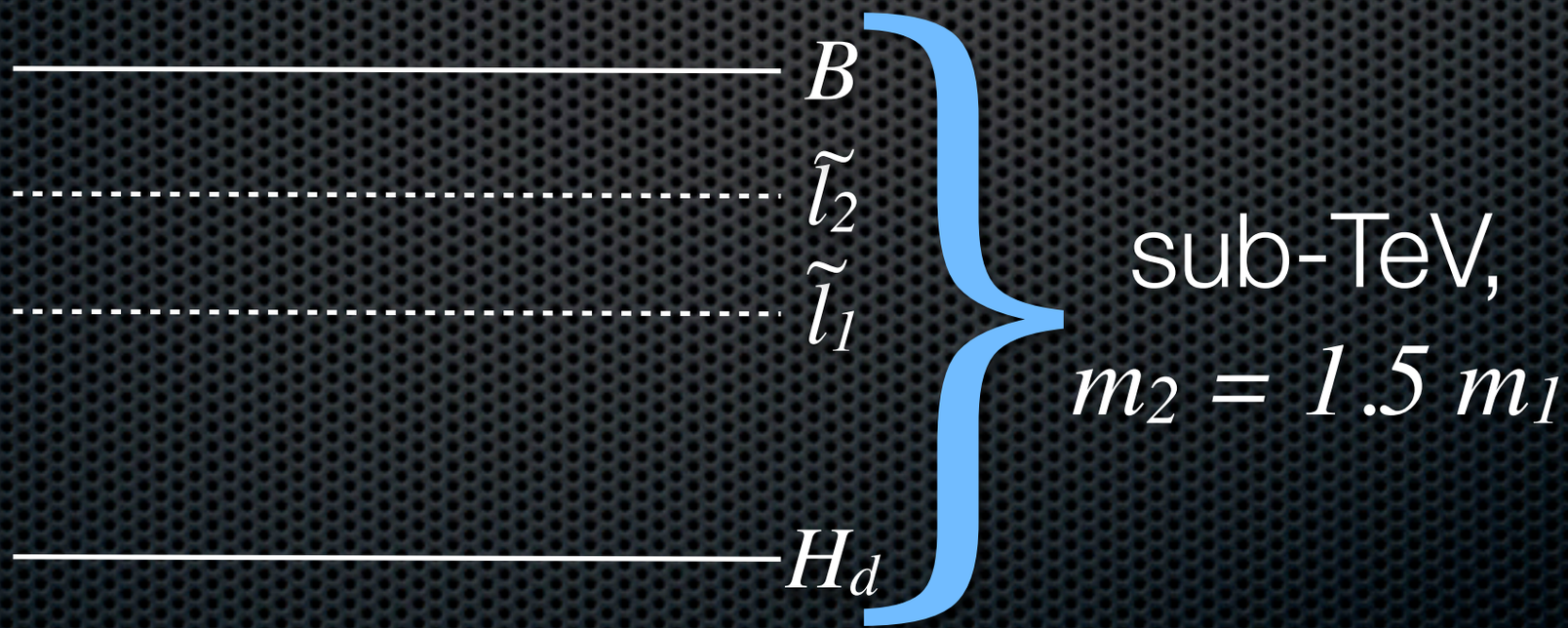
mixing parameter
$$sin\ 2\theta_{L,R}$$

	$\tilde{e}_L$	$\tilde{\mu}_L$	$\tilde{\tau}_L$				
$\tilde{l}_{1L}$	c_L	s_L	0	0	0	0	
$\tilde{l}_{2L}$	$-s_L$	c_L	0	0	0	0	
	0	0	1	0	0	0	
	0	0	0	c_R	s_R	0	$\tilde{l}_{1R}$
	0	0	0	$-s_R$	c_R	0	$\tilde{l}_{2R}$
	0	0	0	0	0	1	
				$\tilde{e}_R$	$\tilde{\mu}_R$	$\tilde{\tau}_R$	

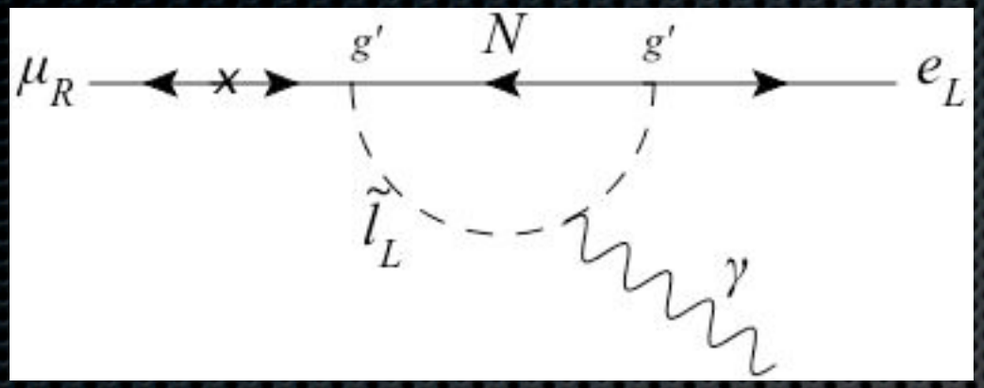
Mass hierarchy

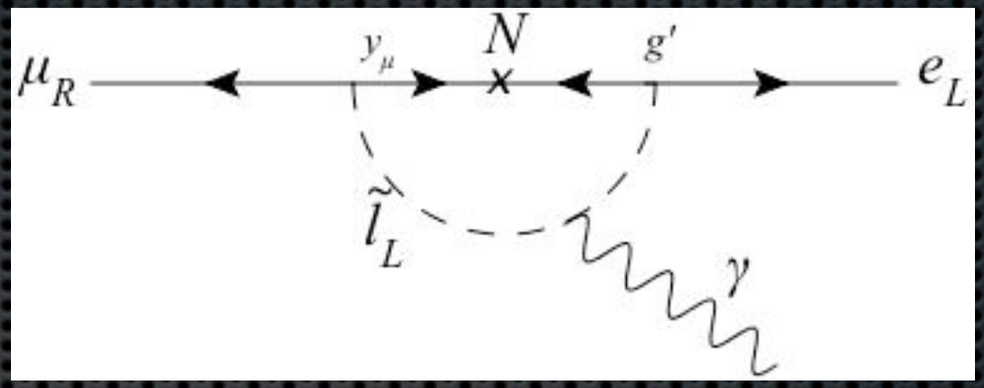
W O(TeV) To avoid $\Delta\rho$ being too big

H_u gives negligible contribution



$\mu \to e\gamma$

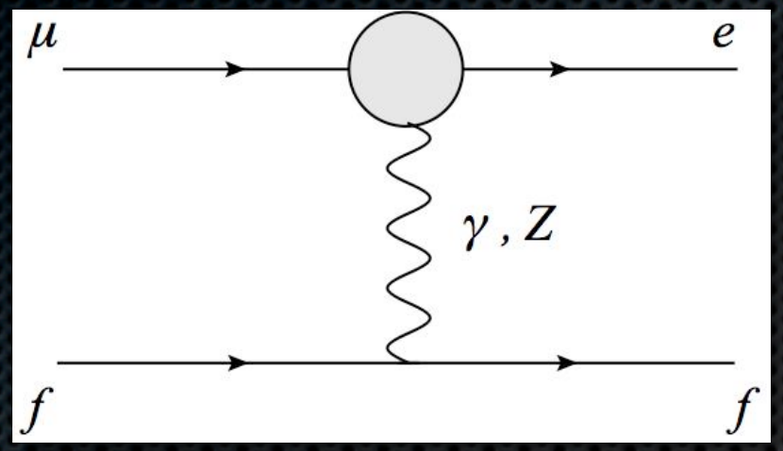


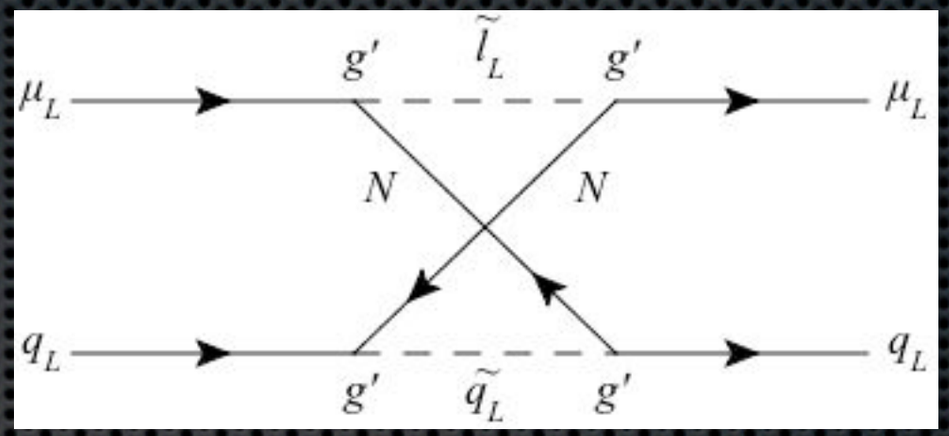


- BR < 1.2 x 10^{-11} → M. Ahmed et al. [MEGA Collaboration], Phys.Rev. D **65**, 112002 (2002) arXiv:hep-ex/0111030
- Insensitive to tanβ
- Amplitude proportional to sin $2\theta_L$

J. Adam et al. [MEG Collaboration], arXiv:0908.2594 [hep-ex]

$\mu \rightarrow e$ conversion in gold





W.H. Bertl et al. [SINDRUM II Collaboration],
Eur. Phys. J. C **47**,337 (2006)

- Muon beam → Fixed gold target
- Normalized rate < 7.0×10^{-13}
- Again insensitive to tanβ

$\mu \to 3e$

- Same types of diagrams in $\mu \to e$ conversion.
- Weaker than the combined constraints from $\mu \to e\gamma$, $\mu \to e$ conversion.

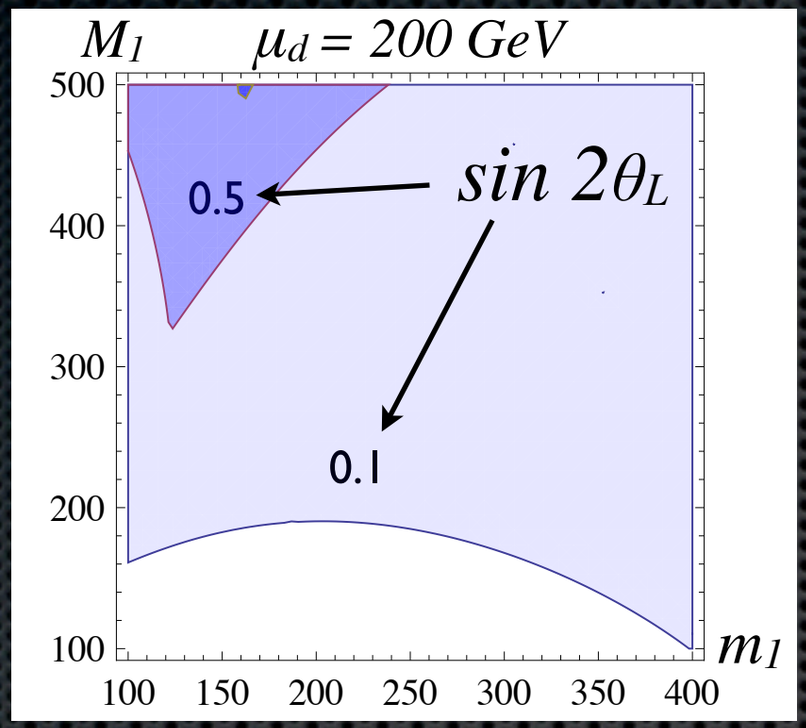
For details, see Fok, Kribs
hep-ph/arXiv:1004.0556

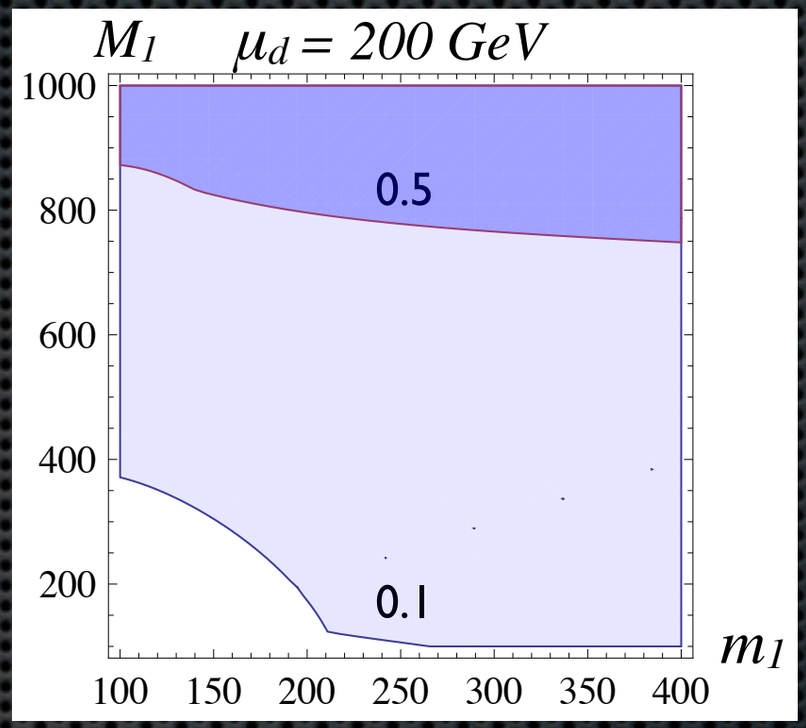
Combined exclusion plots

Masses in GeV

LH

$sin\ 2\theta_R = 0$

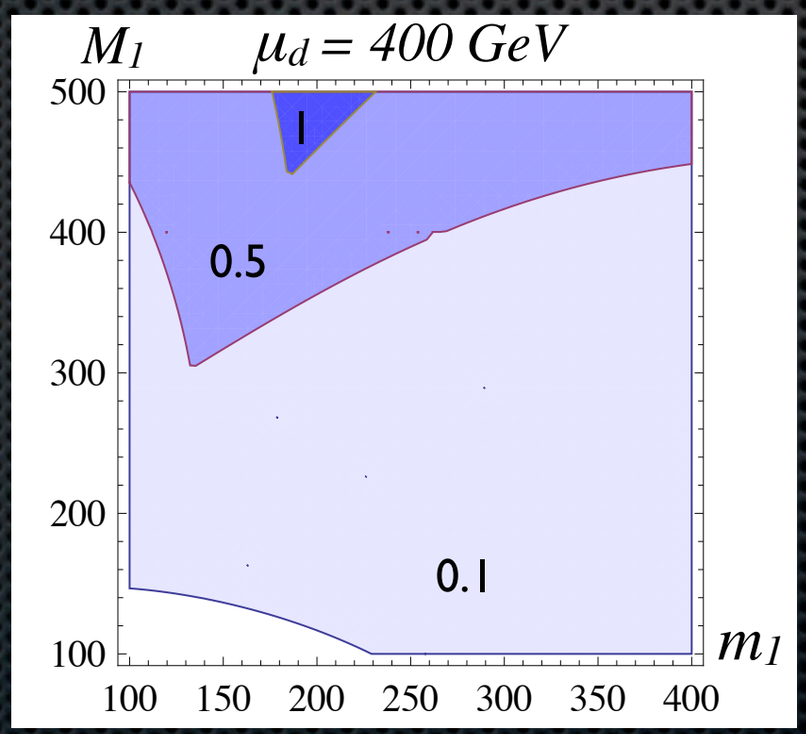


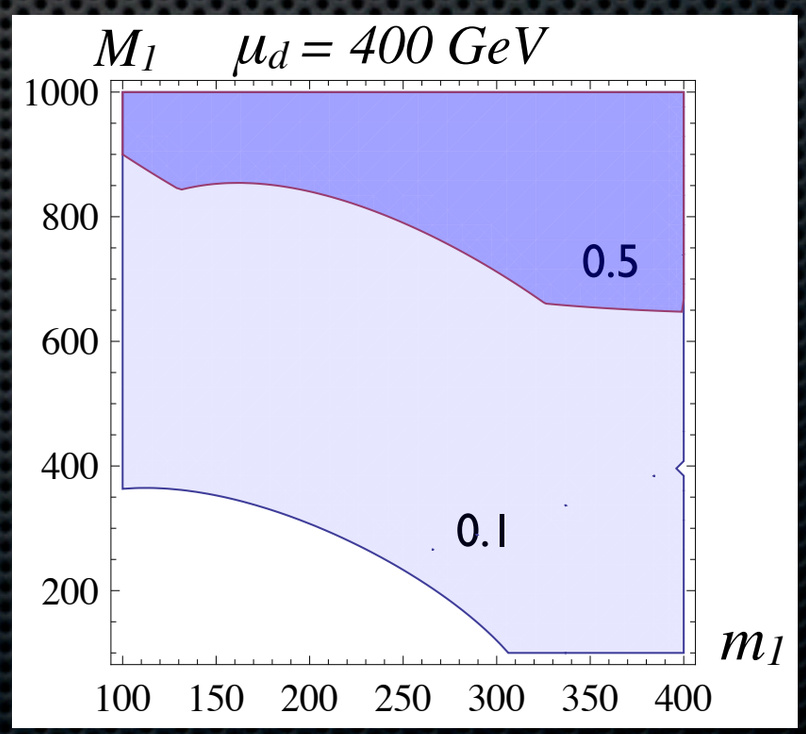


RH

$sin\ 2\theta_L = 0$

LH





RH

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Conclusion!

- Maximal RH sleptons mixing ruled out by $\mu \to e$ conversion
- Order one $\mu - e$ LFV possible with LH slepton mixing for sub-TeV non-degenerate sleptons
- Project X @ Fermilab can constrain $sin\ 2\theta_{L,R}$ down to ~10^{-3} from $\mu \to e$ conversion

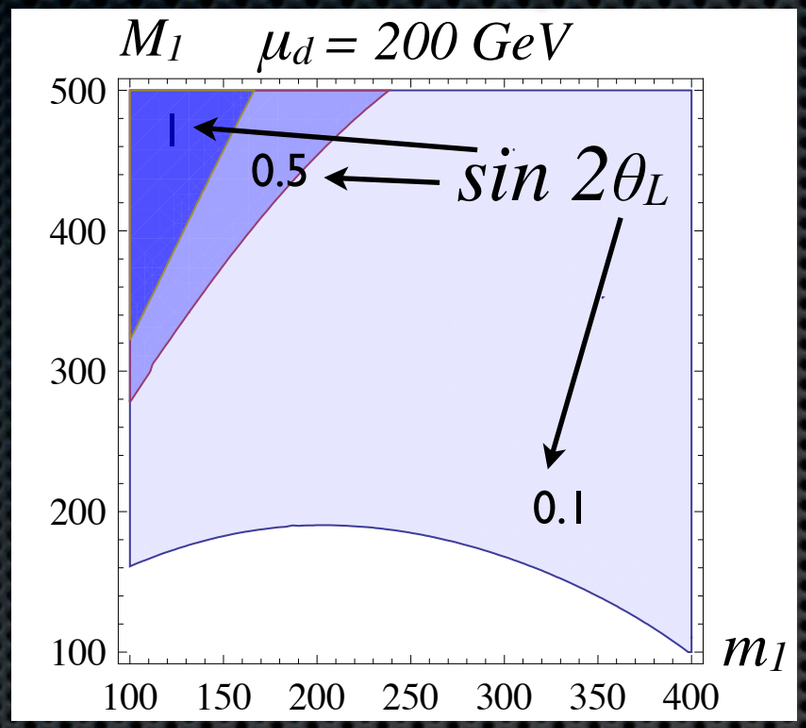
Project X and the Science of the Intensity Frontier, white paper, Fermilab, 2010. http://www.fnal.gov/pub/projectx/pdfs/ProjectXwhitepaperJan.v2.pdf

BACK UP

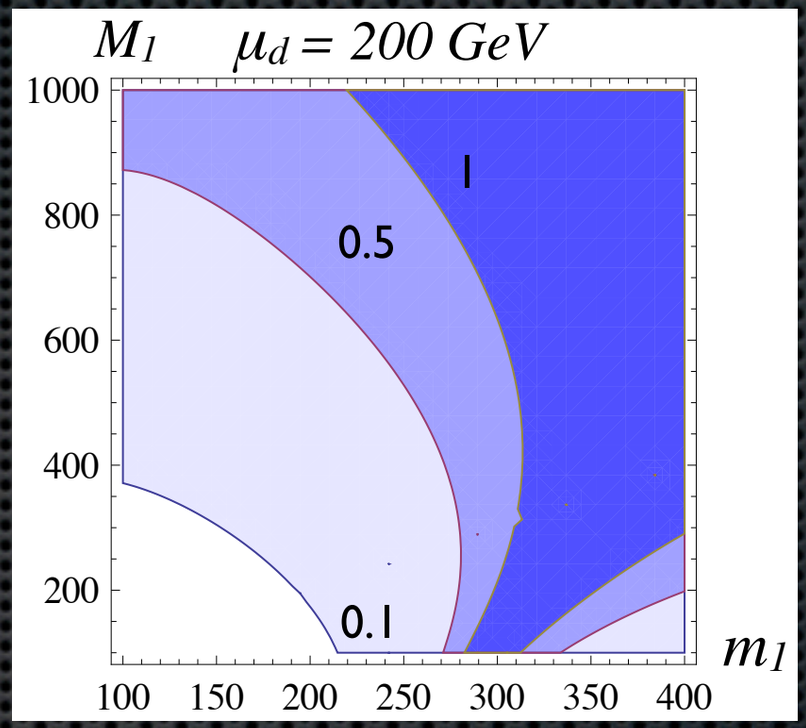
$\mu \to e\gamma$ Exclusion plots

BR < 1.2 x 10^{-11} MEGA, MEG

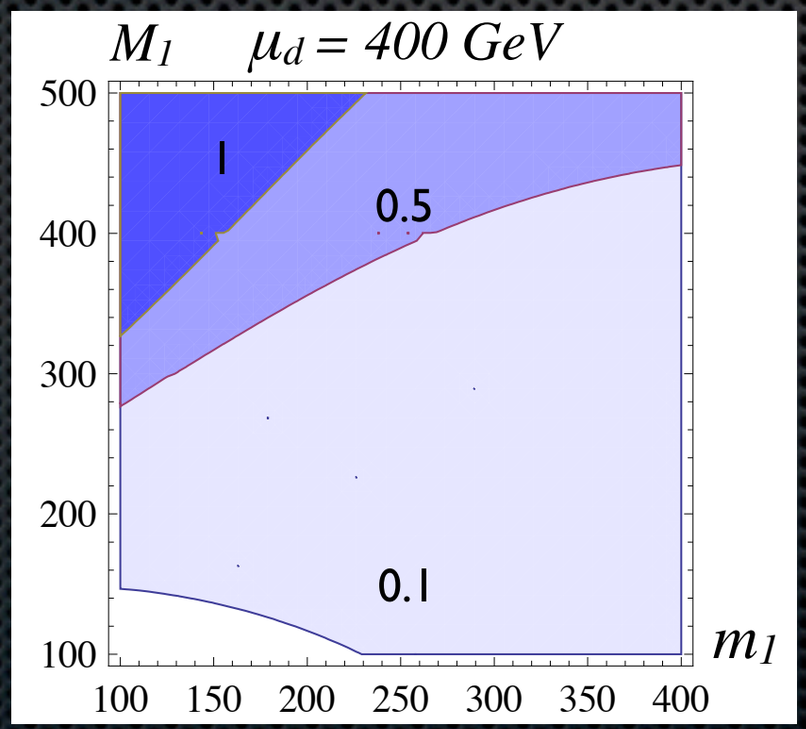
LH



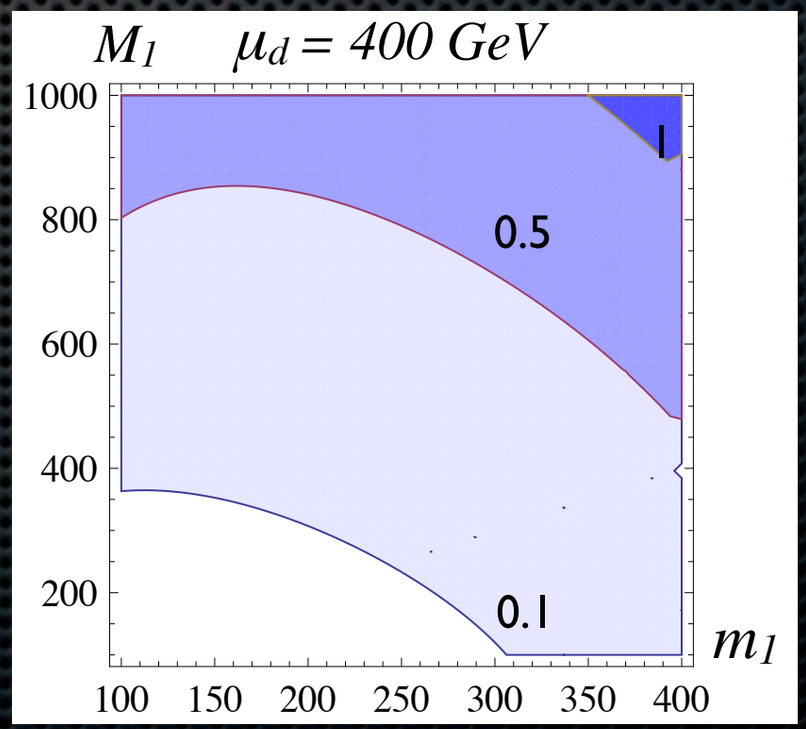
RH



LH



RH



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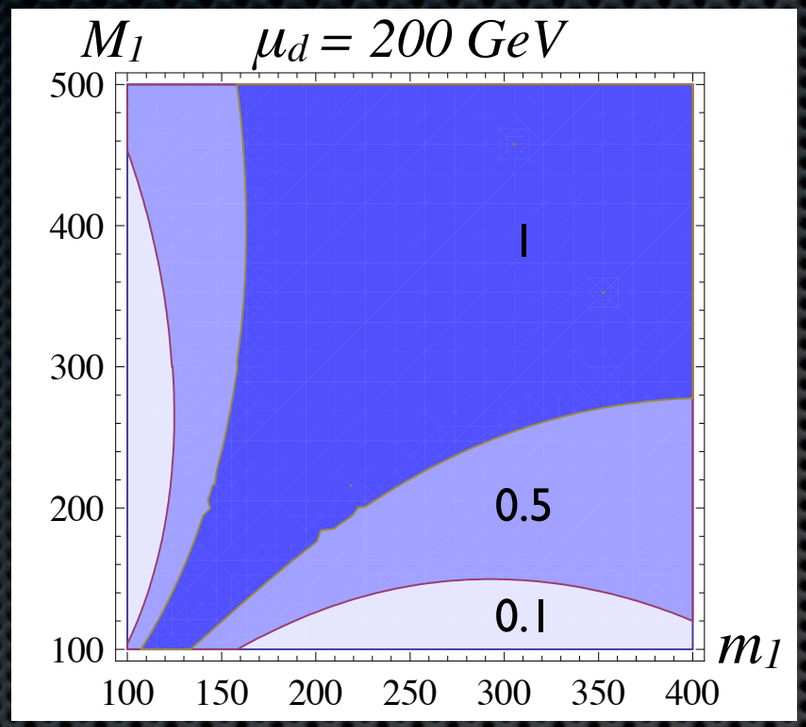
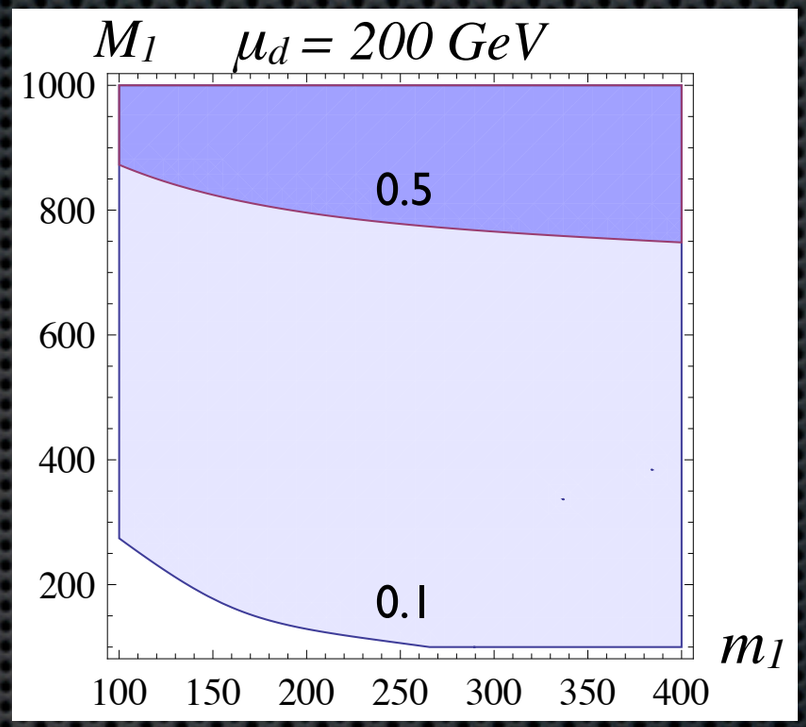
$(\mu \to e)_{Au}$ Exclusion plots

BR < 7.0 x 10^{-13} SINDRUM II

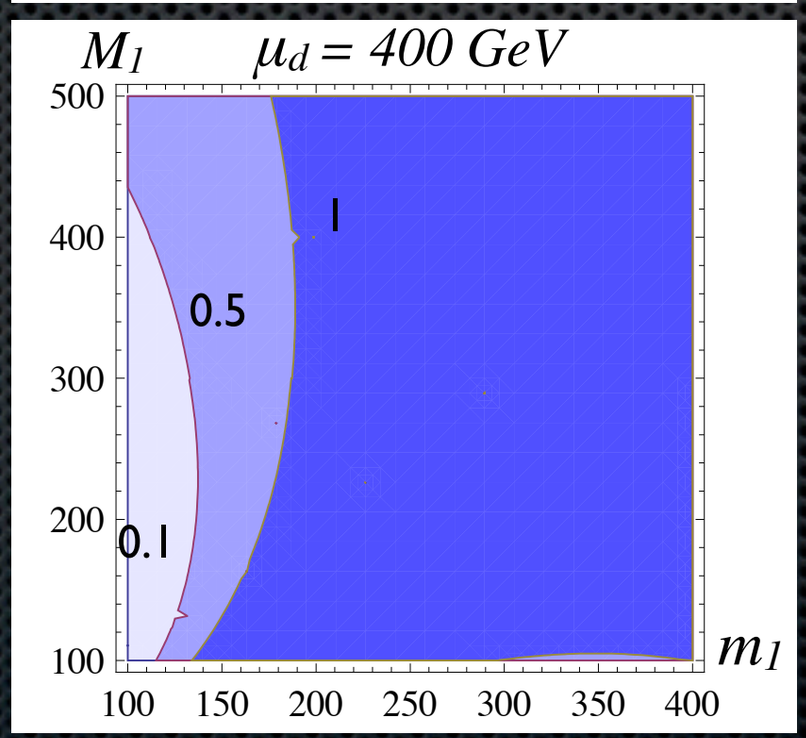
LH

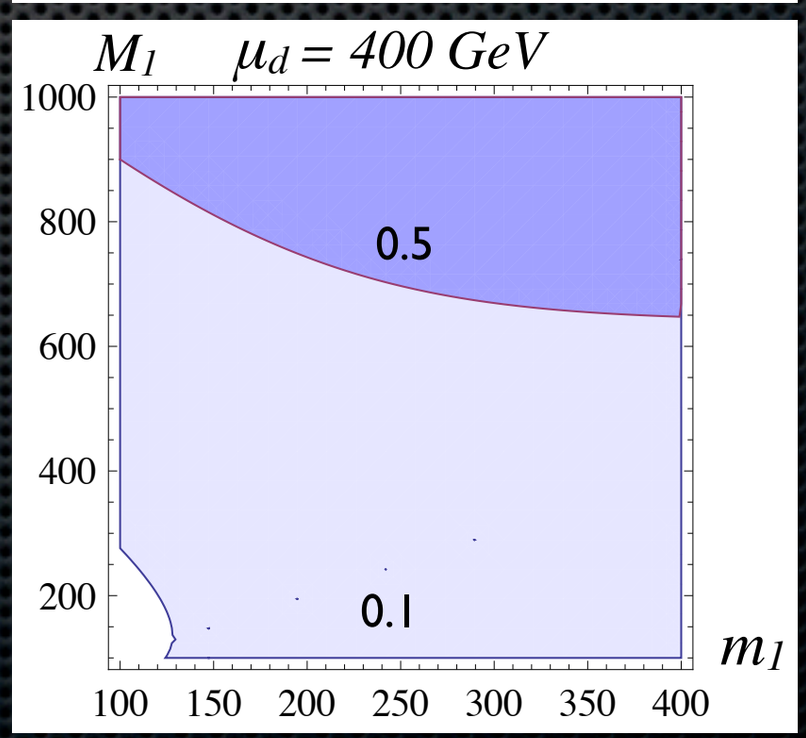




RH

LH





RH

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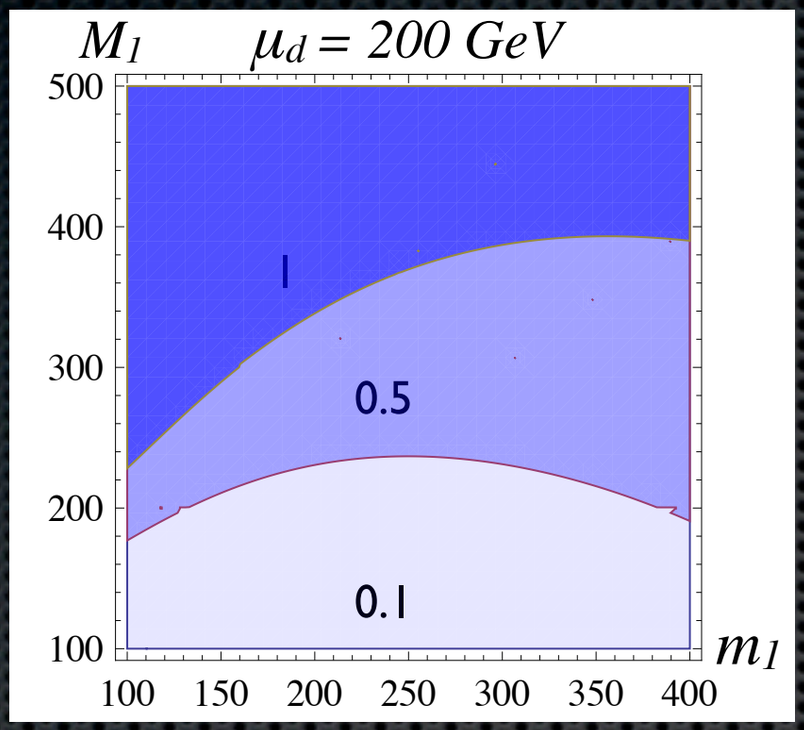
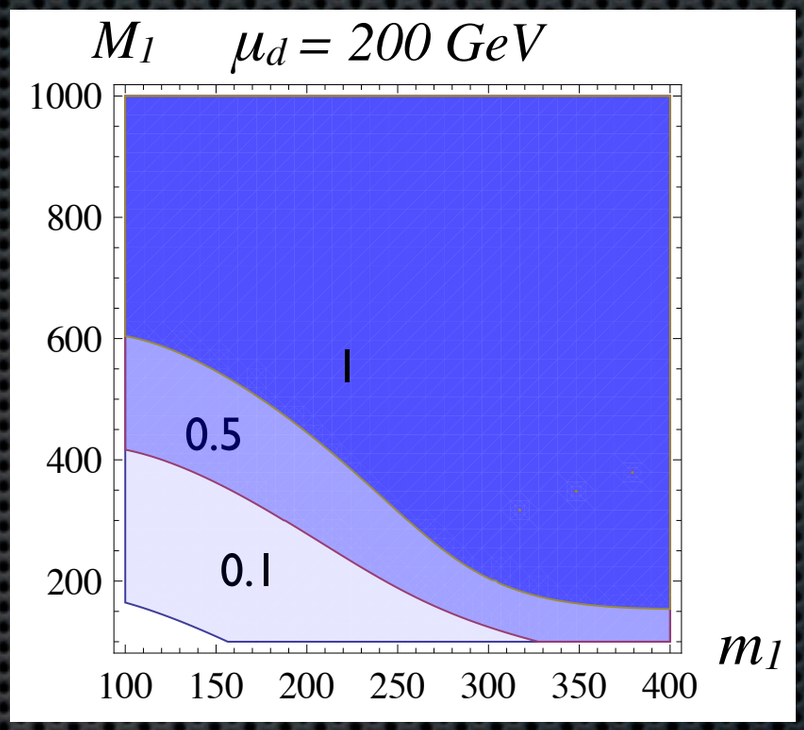
$\mu \to 3e$ Exclusion plots

BR < 1.0 x 10^{-12} SINDRUM

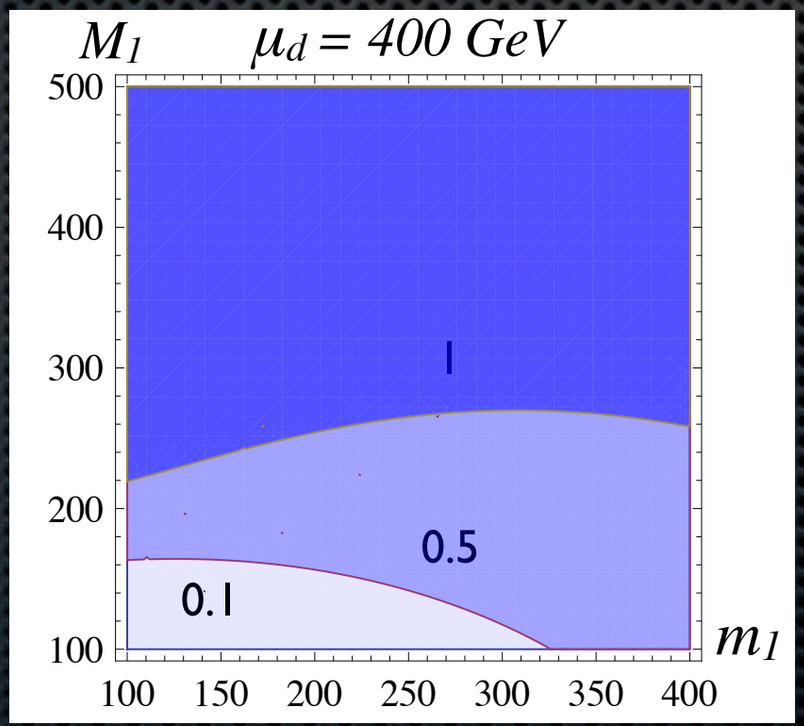
LH



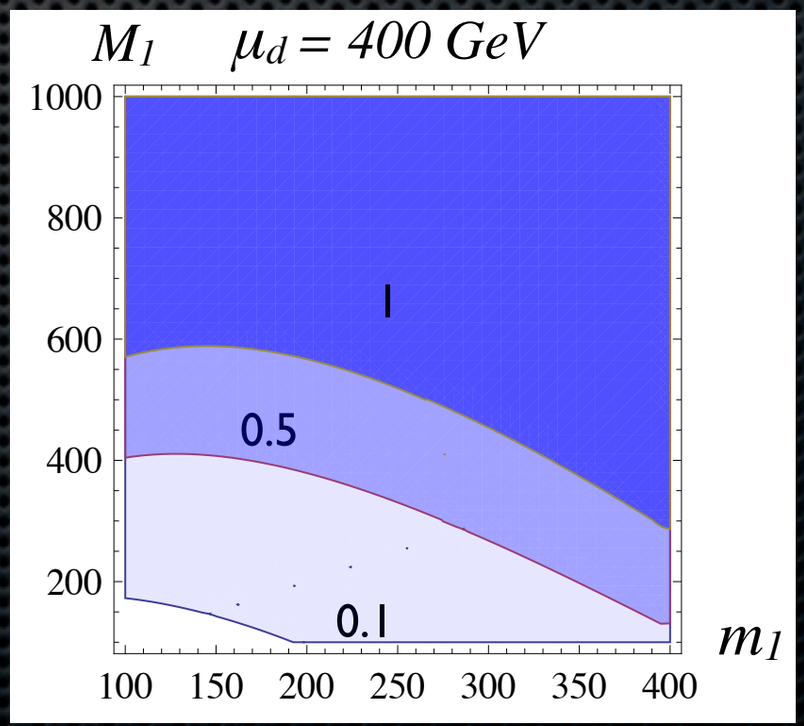
RH



LH



RH



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LR slepton mixing

- Chiral superfields QUDLE have R charge +1, H_u and H_d have R charge 0.
- Yukawa in superpotential
- $y_d\, E^c H_d L$ gives $\tilde{f}_R^* \tilde{H}_d f_L$ and $f_R^\dagger \tilde{H}_d \tilde{f}_L$
- $\tilde{f}_L$ and $\tilde{f}_R^*$ have the same R-charge (+1)
- LF mixing term $\tilde{f}_R^* (M^2_{LR}) \tilde{f}_L$ forbidden