Lepton Flavor Violation At The LHC
The SUSY - Flavor Interplay

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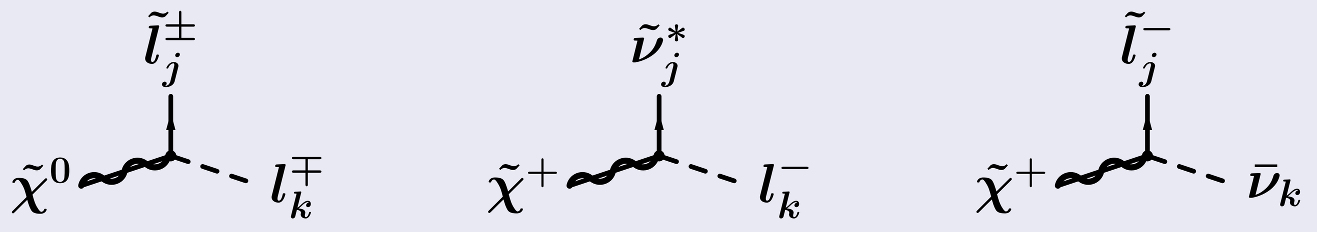
SUSY - Flavor Interplay

- SUSY $\Longrightarrow$ Flavor: if superpartner masses are flavor dependent: new handles on the underlying flavor theory.
- Flavor $\Longrightarrow$ SUSY: if superpartner masses are flavor dependent: need to reassess search techniques.
- Natural SUSY models exist with flavor dependent superpartner masses, consistent with all low-energy bounds on flavor changing processes.
  Examples: gauge-gravity hybrid models (Feng Lester Nir Shadmi), GMSB models with matter-messenger couplings (Shadmi Szabo)
  ...
- If fermion masses are explained by some underlying flavor theory (e.g., Froggatt Nielsen symmetry) $\rightarrow$ this flavor theory also controls the non-universal contributions to scalar masses $\rightarrow$ slepton masses would give additional handles on flavor charges.

SUSY Lepton Flavor Violating (LFV) Models - Phenomenology

Focusing on SUSY LFV models:

- Slepton masses (especially the first 2 generations) are not necessarily degenerate.
- Slepton-Gaugino-Lepton interactions can be generation dependent:

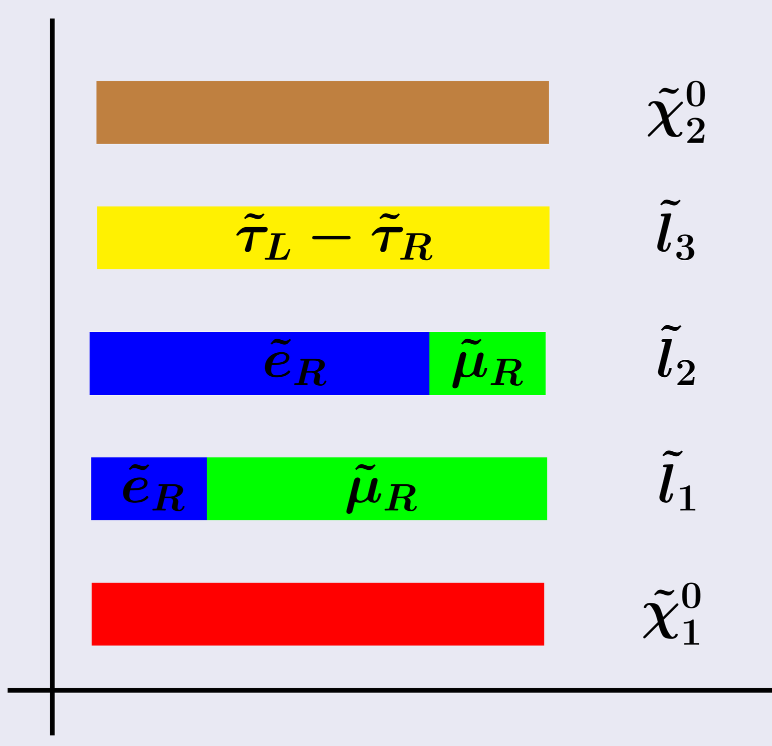


Two types of questions then arise

1. Are existing methods for measuring the SUSY spectrum still efficient ? If not, can new techniques be developed ?
2. Can the slepton masses and mixings be measured ?

Model Playground

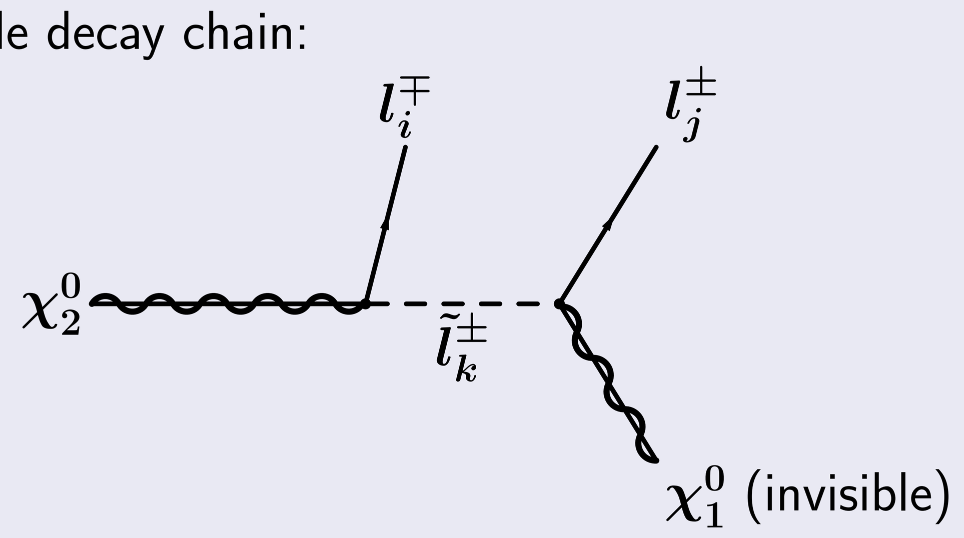
The SUSY LFV models examined in this work have the spectra structure:



$$\begin{pmatrix} \tilde{l}_1 \\ \tilde{l}_2 \end{pmatrix} \equiv \begin{pmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{pmatrix} \begin{pmatrix} \tilde{e}_R \\ \tilde{\mu}_R \end{pmatrix}$$

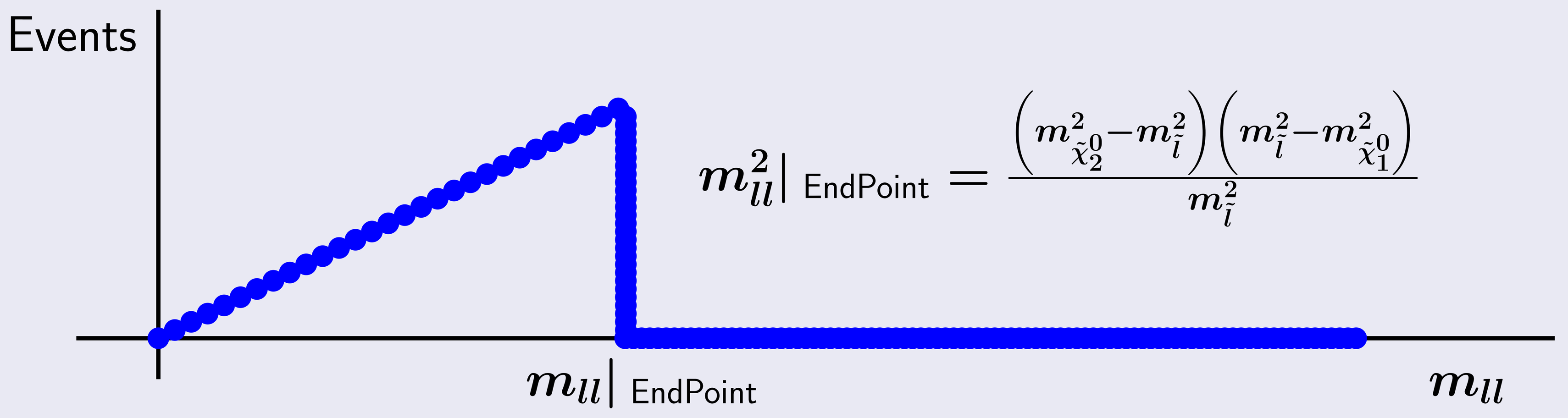
$$\Delta m_{\tilde{l}} = m_{\tilde{l}_2} - m_{\tilde{l}_1}$$

allowing for the cascade decay chain:



Measuring The SUSY Spectrum - The Kinematic Edge Technique

1. χ_1^0 is undetected $\Longrightarrow$ Edge Structure in distributions of kinematic observables.
2. The opposite-sign-dilepton EndPoint is the best studied case of a kinematic edge:



$$m_{ll}^2|_{\text{EndPoint}} = \frac{\left(m_{\tilde{\chi}_2^0}^2 - m_{\tilde{l}}^2\right)\left(m_{\tilde{l}}^2 - m_{\tilde{\chi}_1^0}^2\right)}{m_{\tilde{l}}^2}$$

3. Given sufficient measurements of Edge Structure$_j = f_j(\tilde{m}_k)$ the spectrum can in principle be calculated.

Flavor Blind Case (usually assumed)

1. $\tilde{l}_1$, $\tilde{l}_2$ degenerate $\Longrightarrow$ endpoints coincide.

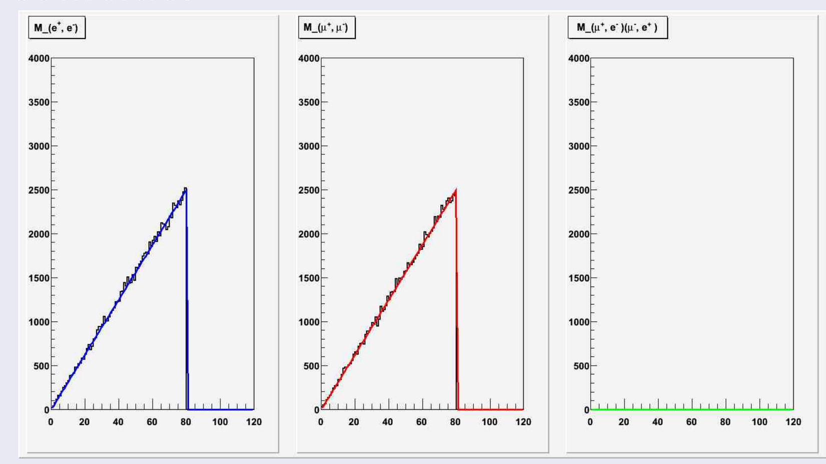


Figure: Predicted signal distributions for the flavor blind case.

2. No signal in $e\mu$ distribution.
3. "Flavor Subtraction" $\Longrightarrow$ high endpoint resolution.

$$m_{e^+e^-}/\beta + \beta m_{\mu^+\mu^-} - m_{e^{\pm}\mu^{\mp}}$$

with

$$\beta = \frac{e \text{ Efficiency}}{\mu \text{ Efficiency}}$$

Flavor Violating Case

1. $\tilde{l}_1$, $\tilde{l}_2$ non-degenerate $\Longrightarrow$ different endpoints with splitting Δm_{ll}.

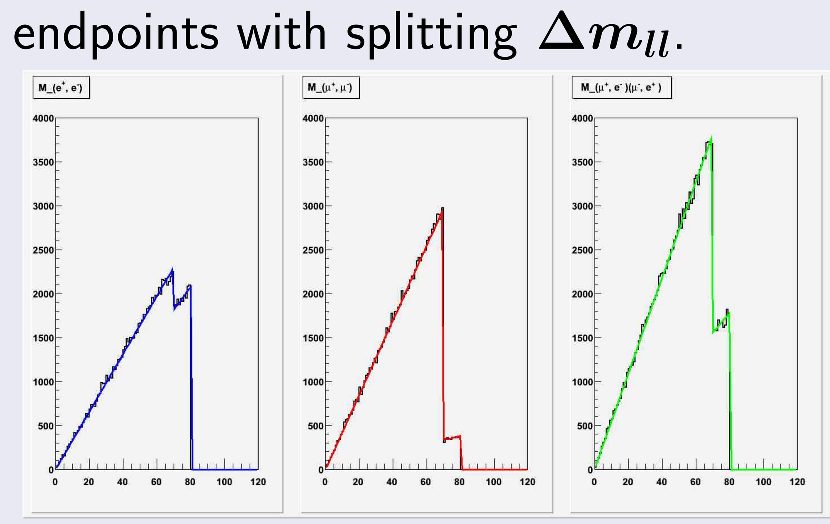


Figure: Predicted signal distributions for the flavor violating case ($\Delta m_{ll} = 4$GeV, $R = 0.9$, $\sin^2\theta = 0.7$).

2. #events: $N_{ll} \Leftrightarrow$ flavor parameters:

$$\frac{N_{e^{\pm}\mu^{\mp}}}{N_{e^+e^-}} = \frac{2(1+R)\cos^2\theta\sin^2\theta}{\cos^4\theta + R\sin^4\theta}$$

$$\frac{N_{\mu^{\pm}\mu^{\mp}}}{N_{e^+e^-}} = \frac{\sin^4\theta + R\cos^4\theta}{\cos^4\theta + R\sin^4\theta}$$

3. with

$$R = \left(\frac{m_{\chi_2^0}^2 - m_{\tilde{l}_2}^2}{m_{\chi_2^0}^2 - m_{\tilde{l}_1}^2}\right)^2$$

(Phase-Space Ratio of $\tilde{l}_2$,$\tilde{l}_1$ Decays.)

4. Signal in $e\mu \Longrightarrow$ mixing indication.
5. Binning affects the edge structure.

Results(Preliminary) - A Case With Small Mixing

Simulation results:

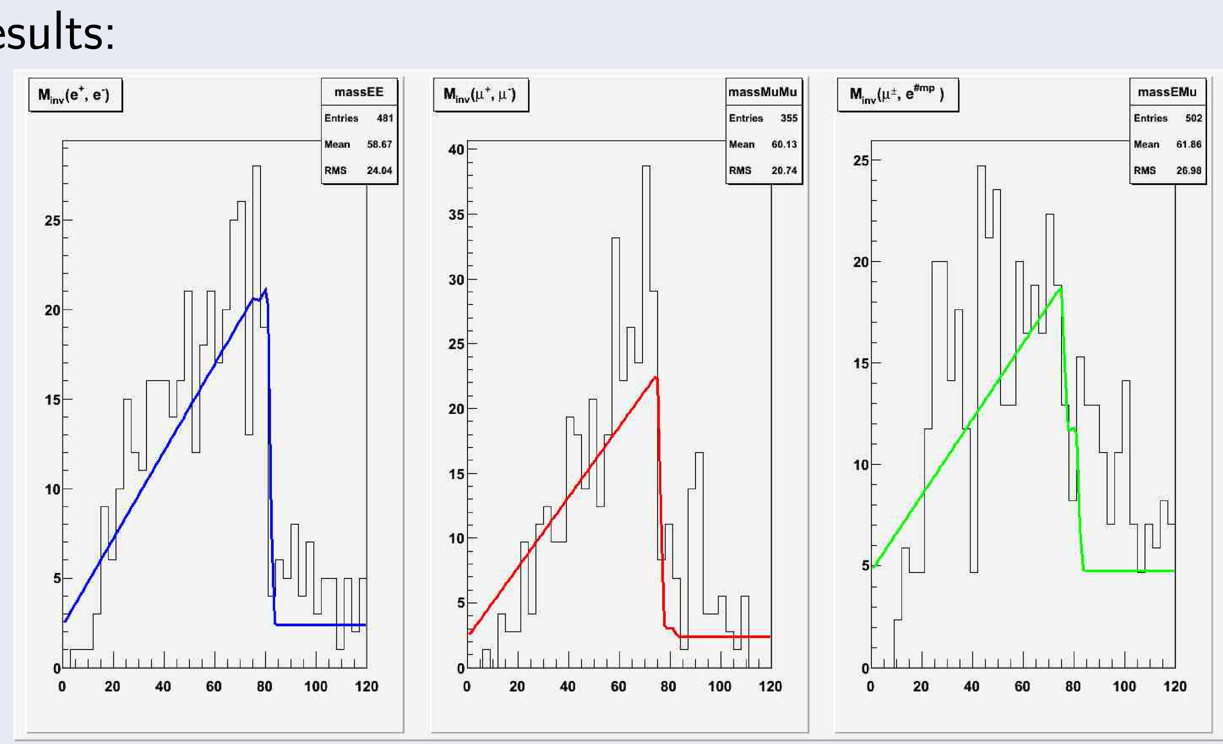


Figure: Simulation results for a model with small mixing ($\sin\theta \sim 0.95$) and $\Delta m_{ll} \sim 6$GeV

Main Conclusions:

- Different EndPoints can be resolved:

EndPoint	Truth [GeV]	Fit Result [GeV]
$\tilde{l}_1$ EndPoint	75.86	76.137 ± 0.242
$\tilde{l}_2$ EndPoint	81.87	81.881 ± 0.268

- $e\mu$ distribution contains signal $\Longrightarrow$ "Flavor Subtracion" fails.
- Small mixing $\Rightarrow$ one endpoint dominates each distribution $\Rightarrow$ better endpoint resolution.