Supersymmetry with Trilinear R-Parity Violation at the LHC

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Outline

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B and L Violating Couplings.

$$\lambda_{ijk} L_i L_j \bar{E}_k + \lambda'_{ijk} L_i Q_j \bar{D}_k + \lambda''_{ijk} \bar{U}_i \bar{D}_j \bar{D}_k + \mu_i H L_i$$

L_i, Q_i, H – lepton, quark, Higgs doublets
E_i, D_i, U_i – lepton, down, up quark singlets

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Bilinear Lepton number violating couplings; induces neutrino–neutralino mixing. Not our primary focus

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Trilinear Lepton number violating couplings

Trilinear Baryon number violating couplings

The Studied Scenario

- Neutralino NLSP
- (Gravitino LSP – for Dark Matter)
- Pair production of squarks and gluinos
- Cascade decay down to neutralino
- Three-body decay of neutralino
- Try to determine operator hierarchies

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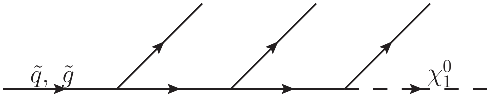

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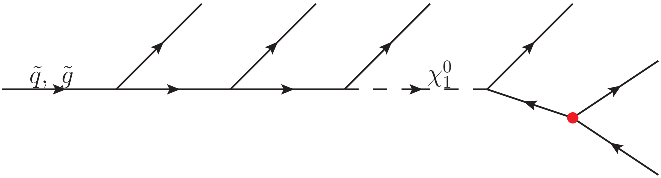

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Introduction

$LL\bar{E}$ Operators
- Final State Structure
- Invariant Mass Distributions
- Monte Carlo Studies

$LQ\bar{D}$ Operators
- Possible Final States
- Invariant Mass Distributions
- Monte Carlo Studies

$\bar{U}\bar{D}\bar{D}$ Operators

Conclusions

Final State Structure

- Lots of leptons → easy detection
- Some p_T^{miss} due to neutrinos
- Taus (depends on coupling)

Interesting questions:

- Which couplings dominate?
- What is the Neutralino mass?

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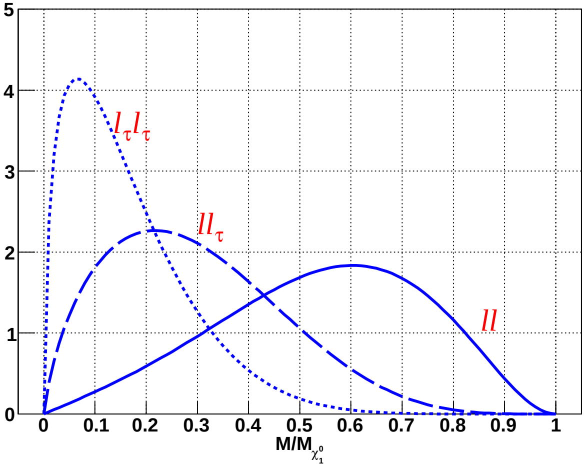
Theoretical Invariant Mass Distributions



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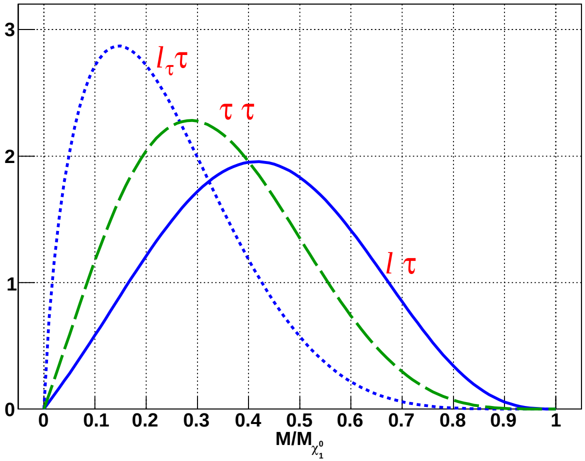

Event Selection

- At least three isolated leptons with $p_T > 20$ GeV
- At least one lepton with $p_T > 70$ GeV
- $p_T^{miss} > 100$ GeV

Take all opposite-sign lepton pairs and construct invariant mass distributions.
Subtract same-sign invariant mass distributions.

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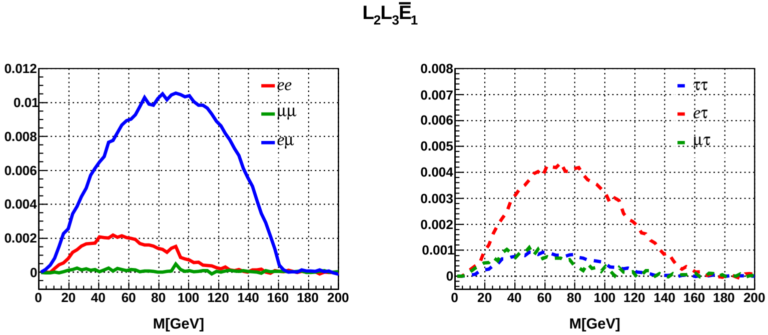

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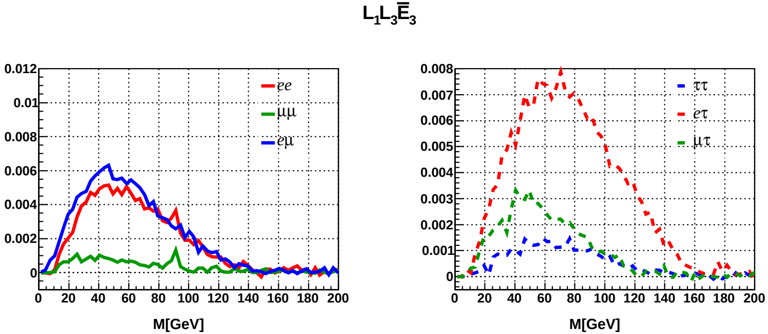

Outline

Possible Final States

Neutralino → lepton + 2 jets, neutrino + 2 jets

Neutralino boosted ⇒ jets are close in the detector

- $L_{1,2}Q_{1,2}\bar{D}_3$ ⇒ lepton + b-jet + light jet
- taus ⇒ loss of information (momentum) through neutrinos
- Q_3 ⇒ only neutrino + 2 jets (at least one b-jet)

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Interesting Invariant Mass Distributions

Lots of backgrounds/uncertainties ⇒ smooth signals drown
Look for peaks

- lepton – jet
- lepton – jet – jet
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Need to suppress $t\bar{t}$ background

- Transverse sphericity > 0.2,
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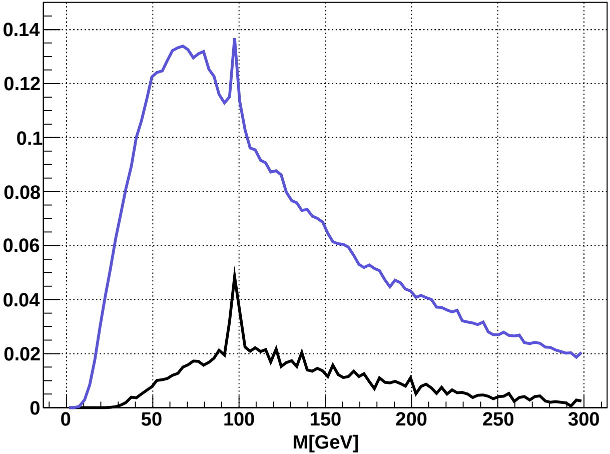
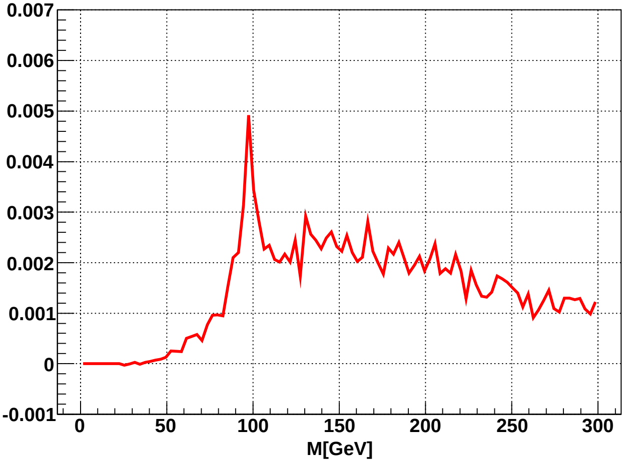
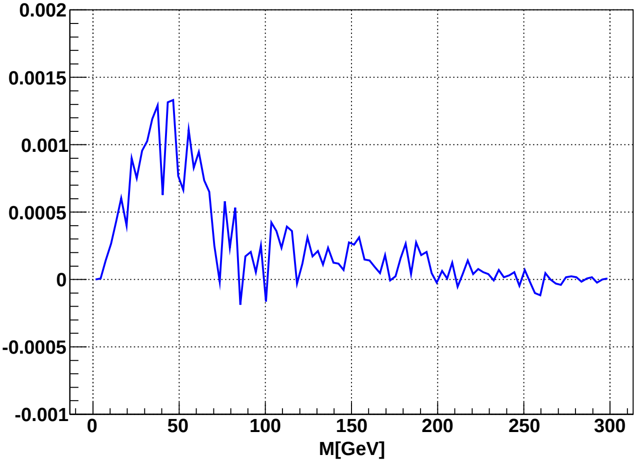
Invariant Masses – $L_1 Q_1 \bar{D}_2$: lepton - jet, lepton - 2 jets



Invariant Masses – $L_1 Q_1 \bar{D}_3$: electron - b-jet - jet



Invariant Masses – $L_3 Q_1 \bar{D}_3$: tau-jet - b-jet



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$\bar{U}\bar{D}\bar{D}$

Difficult!

Butterworth, Ellis, Raklev and Salam [hep-ph:0906.0728]:
Jet structure can do the job

b-tagging for studying flavour structure.

Exception: $\bar{U}_3 \Rightarrow \begin{cases} M_{\chi_1^0} < M_{top} & \Rightarrow \quad \chi_1^0 \; escapes \\ M_{\chi_1^0} > M_{top} & \Rightarrow \quad \chi_1^0 \to t(\bar{t}) + 2\;(soft)\;jets \end{cases}$

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- $LL\bar{E}$ operators allow precise measurements of flavour structure.
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