Direct probes of R-parity violation via single top-squark production at the LHC

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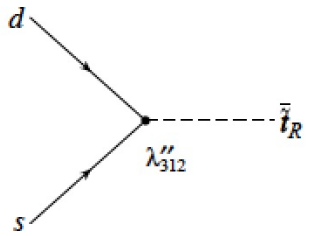
Outline

1. **R-parity violation — Why do we care?**
   - The Minimal Supersymmetric Standard Model
   - MSSM with Baryon number violation
2. **What do we need to see $t1$ at the TeV scale?**
3. **Results**

R-parity Violating Interactions

Why do we care about R-parity violation?

- *Haven't observed any supersymmetric partners.* **Need new signatures**
- *Why doesn't the proton decay?* **Lepton or Baryon numer are separately conserved**
- *R-parity conserving models only allow for pair production of sparticles.* **Single S-channel production affords more phase space**



Single top-squark production

$$R = (-1)^{3B+L+2s}$$

Particles have $R = 1$ and superpartners have $R = -1$

The dominant channels

We assume that the only R-parity violating term in MSSM Lagrangian is of the form $V_{R_p} = \lambda''_{ijk} U^c_i D^c_j D^c_k$

- U^c_i and D^c_i are right-handed-quark singlet chiral superfields,
- **Type-II**: λ''_{ijk} are antisymmetric in indices.
- For production of top squark the relevant couplings are λ''_{312}, λ''_{313} , λ''_{323}.
- Analysis on Z partial decay width to hadrons over leptons gives upper bounds of $\lambda''_{3jk} < 1$

We focus on R-parity conserving decays which include a superpartner in the final state.

Outline

Simulation

Matrix elements are calculated with MadEvent using superpartner masses and decay widths generated by SOFTSUSY within MSUGRA framework. Events from MadEvent are fed into Pythia to hadronize outgoing quarks and put through Delphes to simulate the ATLAS detector.

- SUSY Parameters are calculated for $tan(\beta) = 10$, $m_0 = 125 GeV$, $m_{\frac{1}{2}} = 500 GeV$, $A_0 = 0$, $sgn(\mu) = +1$.
- Events generated using PDF CETQ6l1.

Previous papers analyzed process at the Tevatron for $100\,GeV \leq M_{t1} \leq 300\,GeV$

- Dominant decay R-parity conserving mode was $\tilde{t_1} \rightarrow b + \tilde{\chi_1}^+$, with $\tilde{\chi_1}^+ \rightarrow l^+ + \nu_l + \tilde{\chi}_1^0$
- For $M_{\tilde{t_1}} > 800\,GeV$ the dominant decay mode is $\tilde{t_1} \rightarrow t + \tilde{\chi}_1^0$

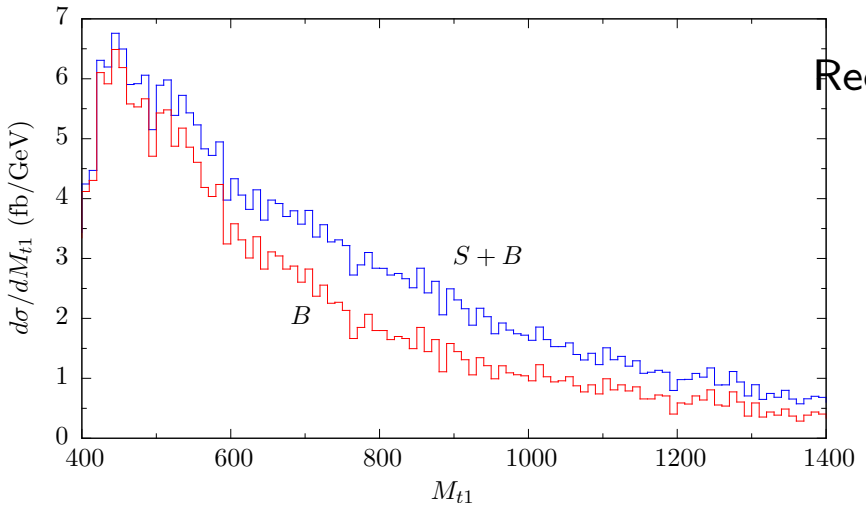
$\tilde{\chi}_1^0$ is sufficiently long-lived that it decays outside of the detector and is registered as missing energy

Reconstructed Mass

Reconstruct longitudinally invariant mass M with Pythia and Delphes output

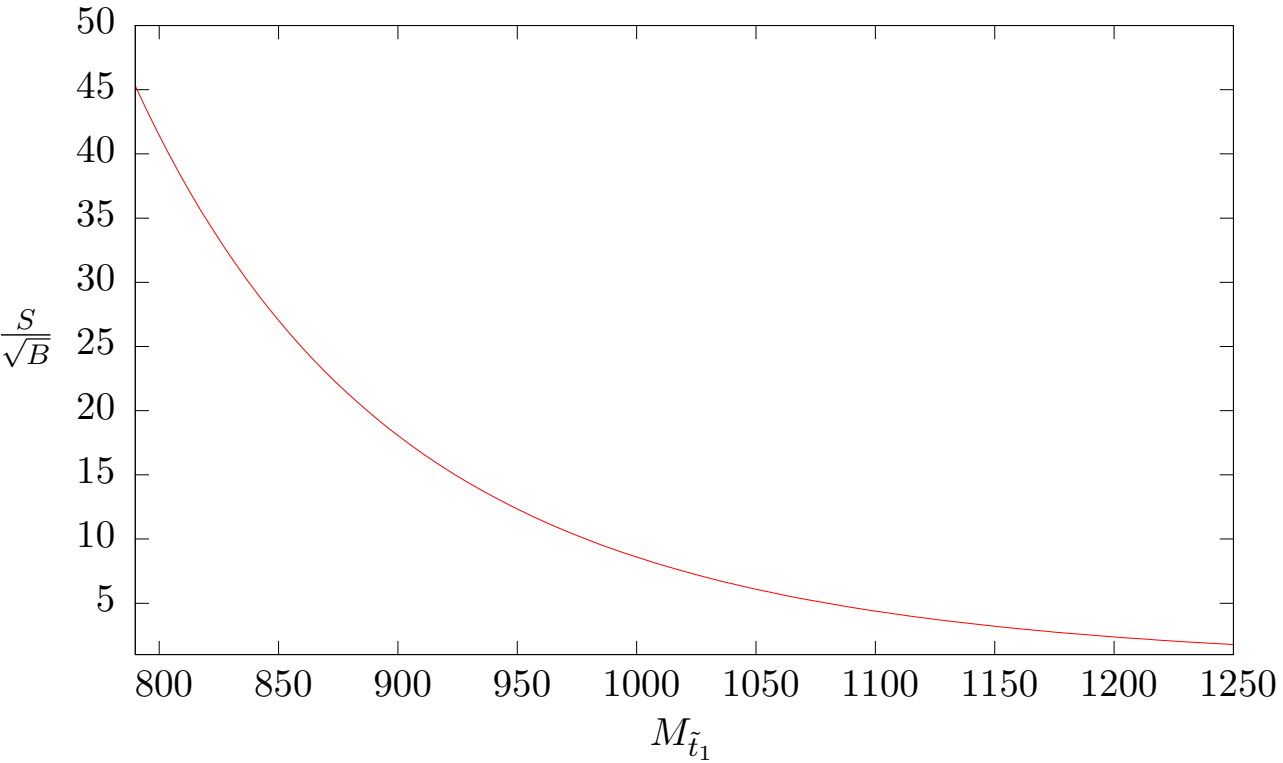
$$\boxed{|\eta| \leq 5} \qquad M^2_{\tilde{t}_1} = (p_t + p_{\tilde{\chi}^0_1})^2 \qquad \boxed{p_T^{\text{jet}} > 30\,GeV}$$

- $p_{\tilde{\chi}^0_1}$; given $\eta_{\tilde{\chi}^0_1} = -\eta_t$



Reconstructed mass M distribution for single-top-squark production (S) and back-grounds (B) at the LHC ($\sqrt{S} = 13\,Tev, 38.5 fb^{-1}$)

Significance of single-top-squark production over Background events for range of $M_{\tilde{t}_1}$ distribution for single-top-squark production (S) and back-grounds (B) at the LHC ($\sqrt{S} = 13\,Tev, 38.5 fb^{-1}$).



Thank you

Thank you for your attention!