Radiative Corrections, p_T-Spectrum and Decay of Resonantly Produced Sleptons at Tevatron and LHC

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Outline

R-Parity in the MSSM

The Yukawa interactions in the MSSM are described by:

$$\mathcal{L}_W = \frac{1}{2}\frac{\delta^2 W}{\delta\varphi_i\delta\varphi_j}\overline{\psi^c_{L_i}}\psi_{L_j}$$

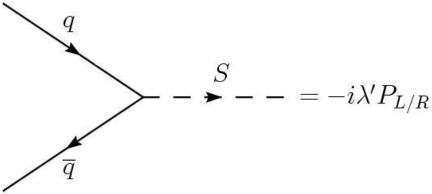
with the Superpotential:

$$W = (h^E)_{ij}\tilde{L}_i H_d \tilde{e^c_{R_j}} + (h^D)_{ij}\tilde{Q}_i H_d \tilde{d_{R^c_j}} + (h^U)_{ij}\tilde{Q}_i H_u \tilde{u^c_{R_j}} + \mu H_d H_u$$
$$+ \underbrace{\lambda_{ijk}\tilde{L}_i\tilde{L}_j\tilde{e^c_{R_k}} + \lambda'_{ijk}\tilde{L}_i\tilde{Q}_j\tilde{d^c_{R_k}}}_{\Delta L\neq 0} + \underbrace{\lambda''_{ijk}\tilde{u^c_{R_i}}\tilde{d^c_{R_j}}\tilde{d^c_{R_k}}}_{\Delta B\neq 0} + \underbrace{\kappa_i\tilde{L}_i H_u}_{\Delta L\neq 0}.$$

The lepton/baryon number violating terms, which lead to proton decay, can be suppressed by discrete symmetries like R-Parity.

Leading order

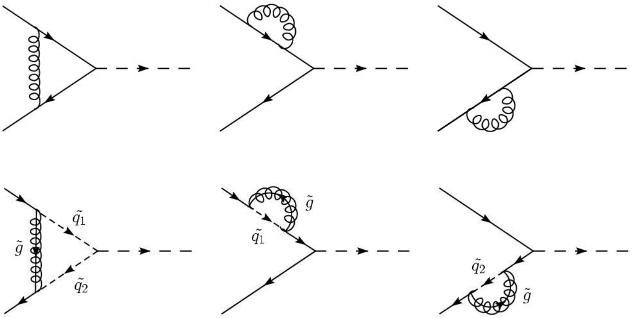
$$\mathcal{L}_{\lambda'} = \lambda'_{ijk}(\overline{d}_{R_k} d_{L_j} \tilde{\nu}_{L_i} - \overline{d}_{R_k} u_{L_j} \tilde{l}_{L_j}) + h.c. + \cdots$$



allows resonant single slepton production at hadron colliders.
(e.g. *Tevatron* or *LHC*)

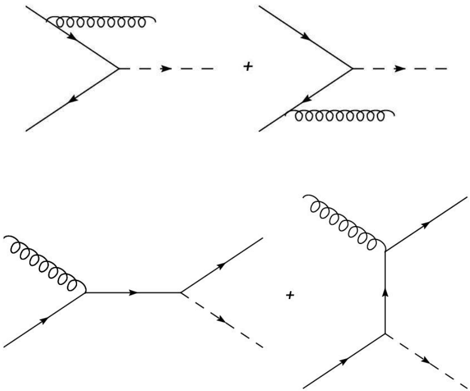
$$\Rightarrow \sigma_{LO} = \frac{\lambda'^2 \pi}{12s} \delta(1-\tau) \quad \text{with} \quad \tau = \frac{M^2}{s}$$

Virtual corrections



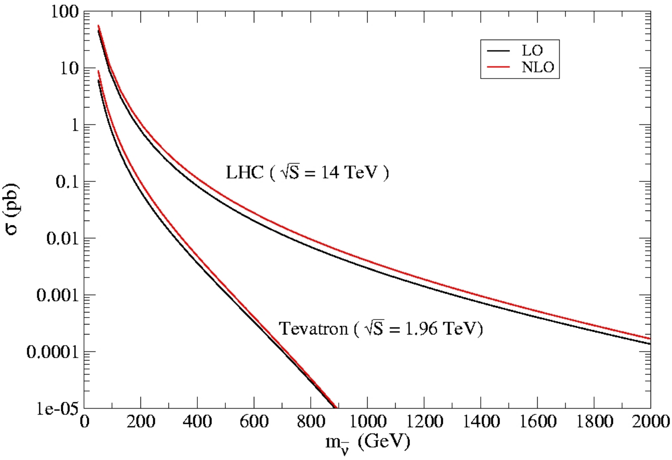
→ Renormalization scale μ_r and SUSY parameters are introduced.

Real processes

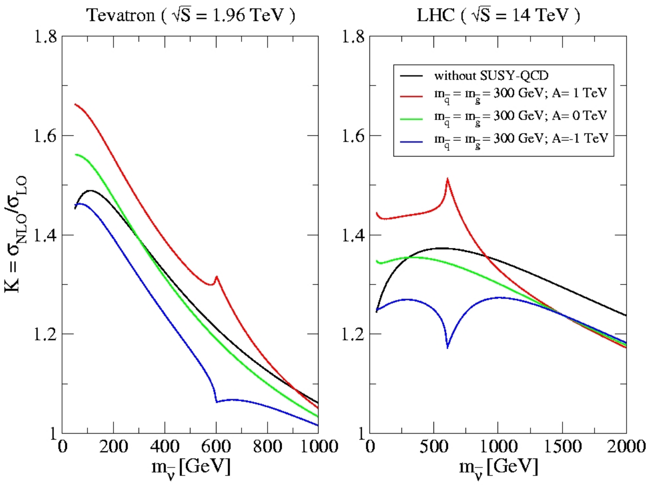


→ Factorization scale μ_f appears in the partonic cross section.

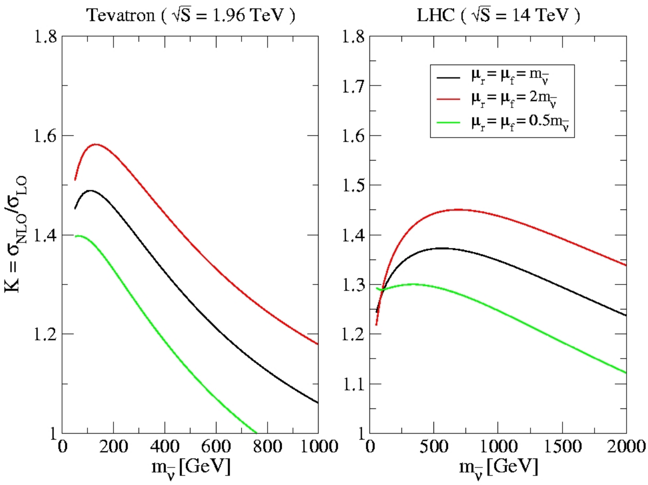
Hadronic cross section ($d\bar{d} \to \tilde{\nu}^*$; $\lambda' = 0.01$; $\mu_{r,f} = m_{\tilde{\nu}}$)



K-Factor ($d\bar{d} \to \tilde{\nu}^*; \lambda' = 0.01; \mu_{r,f} = m_{\tilde{\nu}}$)



Scale dependence ($d\bar{d} \to \tilde{\nu}^*$; $\lambda' = 0.01$)

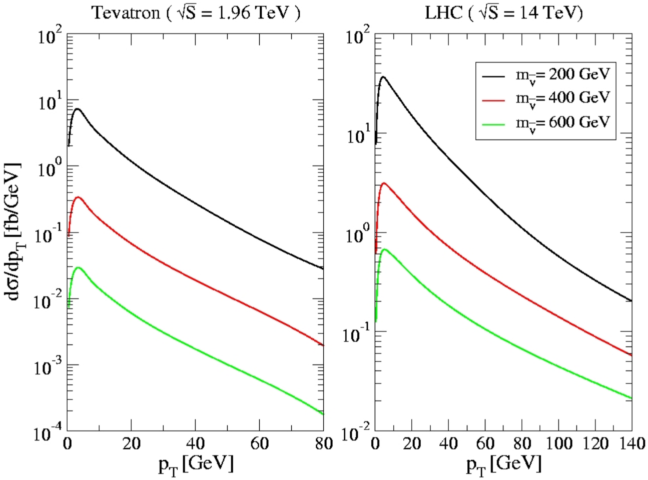


Transverse momentum spectrum

- Low p_T region is correctly described by $\frac{d\sigma}{dp_T}(resum)$.
- For higher p_T non singular terms get important, described by $\frac{d\sigma}{dp_T}(pert) - \frac{d\sigma}{dp_T}(asym)$.

$$\frac{d\sigma}{dp_T}(total) = \frac{d\sigma}{dp_T}(resum) + \left[\frac{d\sigma}{dp_T}(pert) - \frac{d\sigma}{dp_T}(asym)\right]$$

p_T-spectrum $(d\bar{d} \to \tilde{\nu}, \lambda' = 0.01)$

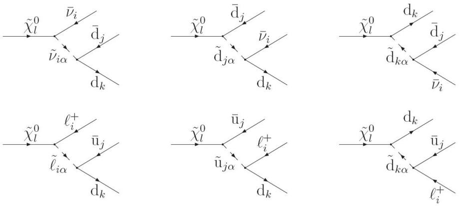


Slepton decay

$$\tilde{\ell}^* \longrightarrow \tilde{\chi}_1^0 + \ell^+$$

R-parity violation leads to $\tilde{\chi}_1^0$ decays:

$$\tilde{\chi}_1^0 \longrightarrow \ell^+ + \mathrm{q} + \overline{\mathrm{q}}$$



The decays with two like sign leptons have low SM background.

Events: $\tilde{\ell}^* \to 2\ell^+ + 2jets$ at Tevatron with $1fb^{-1}$ $(\lambda' = 0.01)$

scenario	$\tilde{\ell}$	$\sigma(u\bar{d} \to \tilde{\ell}^*)$	$BR(\tilde{\ell}* \to \tilde{\chi}_1^0 \ell^+)$	$BR(\tilde{\chi}_1^0 \to \ell^+ d\bar{u})$	events
SPS1a	$\tilde{e}_L, \tilde{\mu}_L$	165 fb	54,4%	15,8%	14,2
	$\tilde{\tau}_2$	145 fb	57,5%	24,6%	20,4
	$\tilde{\tau}_1$	47,8 fb	99,9%	24,6%	11,8
SPS3	$\tilde{e}_L, \tilde{\mu}_L$	45,3 fb	98,9%	20,4%	9,2
	$\tilde{\tau}_2$	43,1 fb	88,0%	34,5%	13
	$\tilde{\tau}_1$	8,05 fb	99,9%	34,5%	2,8
SPS5	$\tilde{e}_L, \tilde{\mu}_L$	70,8 fb	60,8%	19,9%	8,6
	$\tilde{\tau}_2$	65,9 fb	64,1%	23,6%	10
	$\tilde{\tau}_1$	12,4 fb	99,9%	23,6%	3

$\Rightarrow$ bound: $\lambda'_{i11} < 0.002 - 0.003$ for these scenarios.

Events: $\tilde{\ell}^* \rightarrow 2\ell^+ + 2jets$ at LHC with $100 fb^{-1}$ $(\lambda' = 0.01)$

scenario	$\tilde{\ell}^*$	$\sigma(u\bar{d} \rightarrow \tilde{\ell})$	BR($\tilde{\ell}* \rightarrow \tilde{\chi}_1^0 \ell^+$)	BR($\tilde{\chi}_1^0 \rightarrow \ell^+ d\bar{u}$)	events
SPS1a	$\tilde{e}_L, \tilde{\mu}_L$	1592 fb	54,4%	15,8%	13636
	$\tilde{\tau}_2$	1399 fb	57,5%	24,6%	19814
	$\tilde{\tau}_1$	401 fb	99,9%	24,6%	9883
SPS3	$\tilde{e}_L, \tilde{\mu}_L$	538 fb	98,9%	20,4%	10880
	$\tilde{\tau}_2$	514 fb	88,0%	34,5%	15601
	$\tilde{\tau}_1$	73 fb	99,9%	34,5%	2515
SPS5	$\tilde{e}_L, \tilde{\mu}_L$	771 fb	60,8%	19,9%	9345
	$\tilde{\tau}_2$	721 fb	64,1%	23,6%	10934
	$\tilde{\tau}_1$	114 fb	99,9%	23,6%	2703

$\Rightarrow$ LHC can improve bounds by two orders of magnitude.

Conclusion

- The R-Parity violating MSSM allows resonant single slepton production at hadron colliders.
- NLO contributions from SM-QCD are important due many new processes.
- Virtual SUSY-QCD contributions have to be considered, especially near squark-resonances.
- The p_T-spectrum of the slepton can be calculated through resummation of divergent terms .
- Decay of the slepton in two like sign leptons give clear signal.