Probing light neutralinos from pair produced sleptons with a displaced vertex at the LHC

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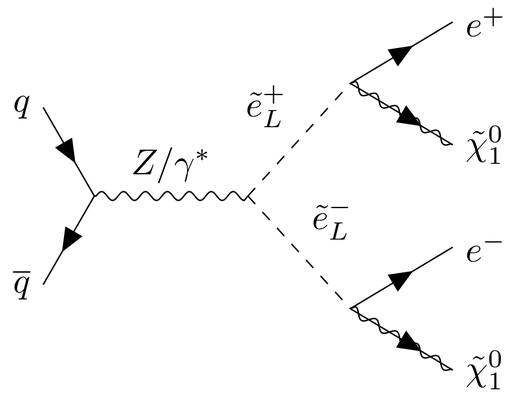
Model and phenomenology

In the RPV-MSSM , the MSSM lagrangian is supplemented with the superpotential

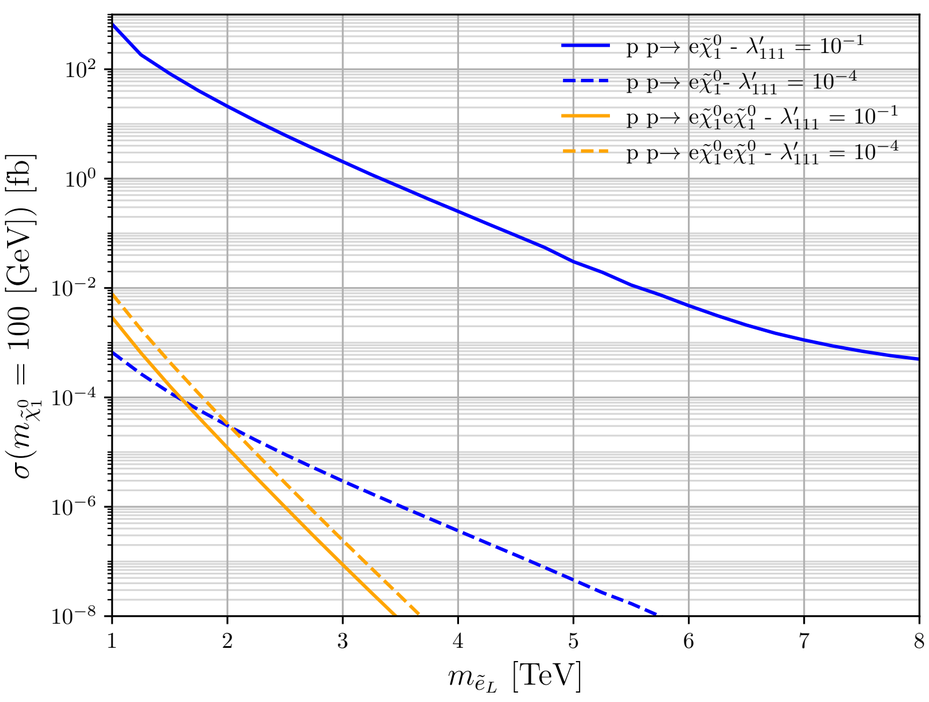
$$W_{\text{RPV}} = \sum_i \mu_i L_i H_u + \sum_{i,j,k} \left(\frac{1}{2}\lambda_{ijk} L_i L_j E_k^c + \lambda'_{ijk} L_i Q_j D_k^c + \frac{1}{2}\lambda''_{ijk} U_i^c D_j^c D_k^c \right), \tag{1}$$

The term LQD^c allows to produce a neutralino with a charged slepton and a prompt lepton, where if the RPV coupling is low enough, the neutralino will be a LLP with decay width

$$\Gamma_{\tilde{\chi}_1^0} \propto m_{\tilde{\chi}_1^0}^5 \left(\frac{\lambda'_{ijk}}{m_{\tilde{f}}^2} \right)^2, \tag{2}$$



Setting all the LQD^c to zero but λ'_{111}, the phenomenology scenario is controlled by this coupling and the neutralino and slepton masses $m_{\tilde{\chi}_1^0}$-$m_{\tilde{e}_L}$. The production cross-section is independent of the coupling in contrast as the single-production[2]. This allows to reach even lower values of λ'_{111}.

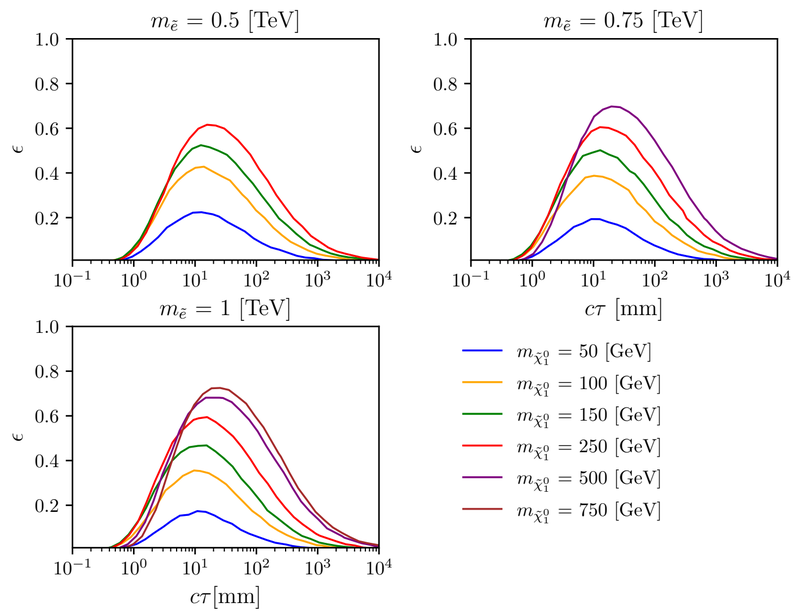


To study the DV phenomenology, 5 benchmarks were selected: 3 with a selepton mass fixed value $m_{\tilde{e}_L} = 0.25, 0.5, 1$ TeV, with focus on the λ'_{1111}-$m_{\tilde{\chi}_1^0}$ plane and 2 with a fixed coupling value $\lambda'_{111} = 10^{-4}, 10^{-6}$ targeting the mass plane.

Simulation and event selection

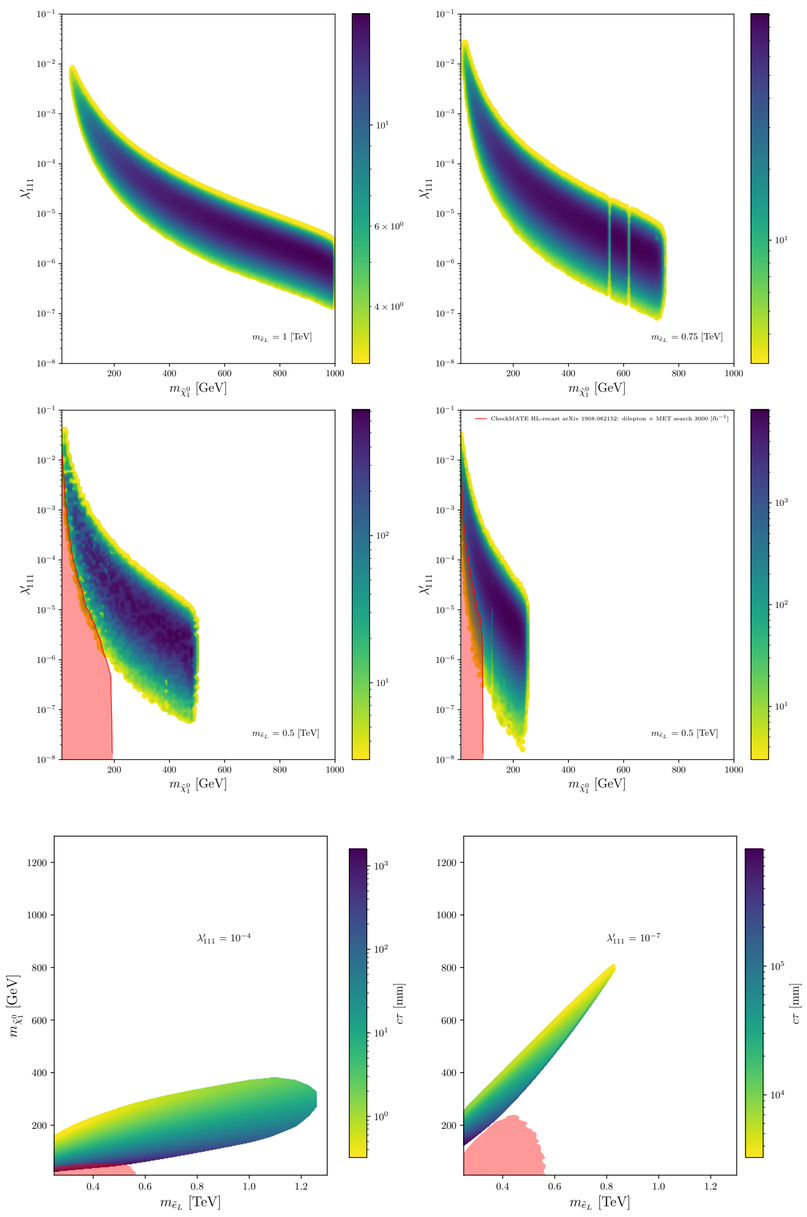
The strategy is based on identify the decay productos of the neutralino $\tilde{\chi}_1^0$ as displaced tracks [1]. Parton level LHE events were simulated for the process $pp \to \tilde{e}_L\tilde{e}_L \to e\tilde{\chi}_1^0 e\tilde{\chi}_1^0$ in MadGraph 5 with a the RPV-MSSM UFO model, and then passed to Pythia 8 complemented with a custume detector simulation.

1. Events an isolated, propmt electron as trigger, with $p_T > 25$ GeV and with $|\eta| < 2.47$.
2. DV are selected from tracks with $|d_0| > 2$ mm and $p_T > 1$ GeV.
3. Vertices are required to be within the inner tracker aceptance with r_{DV} between 4 and 300 mm and $|z_{\text{DV}}| < 300$ mm.
4. DV must have at least 5 tracks and have an invariant mass $m_{\text{DV}} \geq 10$ GeV



DV sensitivity

The number of events were computed with lower bound 3 events for the selected benchmarks. The sensitivity region were also compared with a reinterpretation of the ATLAS search of sleptons, which had a final state with 2 leptons + MET, where the neutralino is stable, made it with CheckMate2 [3], where we exclude the red region.



References

[1] Morad Aaboud et al. Search for long-lived, massive particles in events with displaced vertices and missing transverse momentum in $\sqrt{s} = 13$ TeV pp collisions with the ATLAS detector. *Phys. Rev. D*, 97(5):052012, 2018.

[2] Giovanna Cottin, Juan Carlos Helo, Nicolás A. Neill, Fabián Hernández-Pinto, and Zeren Simon Wang. Searching for light neutralinos with a displaced vertex at the LHC. *JHEP*, 10:095, 2022.

[3] Daniel Dercks, Nishita Desai, Jong Soo Kim, Krzysztof Rolbiecki, Jamie Tattersall, and Torsten Weber. CheckMATE 2: From the model to the limit. *Comput. Phys. Commun.*, 221:383–418, 2017.

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