Optimizing Tracklet-Based Searches for Higgsino-like DM

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1 Motivation

WIMPs have been among the most appealing DM candidates because a connection to the electroweak scale is implied, and since the correct relic abundance is obtained model independently. However, the viable parts of WIMP parameter space have been shrinking due to the null results from collider searches, direct and indirect detection experiments. With this in mind, a pseudo-Dirac electroweak doublet fermion is one of the few remaining minimal models of DM, and is theoretically well represented; for example the Higgsino-like LSP in the MSSM is a well-known example of this type of WIMP.

For the purposes of a collider search for this type of WIMP, the charged state is produced with electroweak cross sections, and decays to the nearly mass-degenerate neutral state (and a soft charged particle, usually a pion for EW splitting) with a lifetime that makes it challenging for the signal events to pass traditional displaced vertex selection cuts. A more promising way to search for this type of WIMP is the identification of 'disappearing' tracklets, where the charged state decays inside the inner tracker. The bounds obtained from tracklet-based searches currently extend to $m_{\chi^\pm} \sim 150$ GeV, and $\tau_{\chi^\pm}$ 0.04 ns [1].

The goal of this study is to seek an improvement in the sensitivity of tracklet-based searches by further optimization to the higgsino-like WIMP case.

2 Proposal

Reanalysis of LHC Run II data and searches at Run III: Current tracklet-based searches require one tracklet with four hits in the tracker, which only a small fraction of charginos can satisfy due to their short lifetime. We will investigate whether a 3-hit tracklet search may be viable. We propose to perform a detailed background estimate,

and study the effects of additional selection criteria in order to compensate for the increased background, such using the soft pion track and the charged-track momentum, in conjunction with a re-optimization of p_T and MET cuts. Since chargino pair production is an important contribution to this final state, we will also explore whether a search for a *pair* of tracklets with relaxed selection cuts may have sensitivity.

HL-LHC: The high pileup environment of the HL-LHC will result in significantly larger backgrounds, in particular for the background arising from track misreconstruction. We will investigate whether a dedicated disappearing track + MET trigger may provide sensitivity despite these challenges.

Future Colliders: Previous studies [2] indicate that the full mass range consistent with a thermal relic higgsino may in principle be fully probed at a 100 TeV collider if tracklets can be successfully reconstructed within 10 cm of the beam pipe. We will study benchmarks for detector design with detector coverage down to $r \sim 10$ cm and extending to the forward region, as well as dedicated trigger benchmarks, to study the sensitivity.

References

[1] M. Aaboud *et al.* [ATLAS], JHEP **06**, 022 (2018) doi:10.1007/JHEP06(2018)022 [arXiv:1712.02118 [hep-ex]].

[2] R. Mahbubani, P. Schwaller and J. Zurita, JHEP **06**, 119 (2017) doi:10.1007/JHEP06(2017)119 [arXiv:1703.05327 [hep-ph]].