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Prospects for electroweakinos at the HL-LHC

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EF Topical Groups:

■ (EF08) BSM: Model specific explorations
■ (EF09) BSM: More general explorations

Searches for weakly interacting particles are of particular interest for the High-Luminosity LHC (HL-LHC). The electroweak gaugino sector of the MSSM provides a well-motivated example of such particles with strong discovery potential at large luminosities. In this letter, we discuss two possible scenarios for electroweakino searches, the present constraints in each case, and discovery potential for the LHC running at 13 TeV and with integrated luminosity of L= 3 ab^{-1}.

I. THE WINO SCENARIO

The parameter space in the MSSM resulting from a Wino-like chargino, $\chi_1^\pm$, and Bino-like LSP, χ_1^0, gives the strongest potential at the LHC from the viewpoint of direct production. In this case, production of $\chi_1^\pm$ and χ_2^0 yields larger production cross sections compared to other scenarios where couplings to gauge bosons arise mostly from mixing. This is the traditional parameter space explored by the ATLAS and CMS collaborations [1–7] where, in the absence of scalar superpartners, the relevant search channels are either a trilepton plus missing energy final state or 1(0) leptons with $b\bar{b}$ and missing energy (theoretical analyses have also been presented in [8, 9]), coming from the decay of χ_2^0 to either a Z or SM h boson with maximal branching ratio.

The dynamics of the parameter space that determine the mass eigenstates, that being M_1, M_2, μ and $\tan\beta$. also determine the branching ratios to gauge and Higgs bosons. In particular, the coupling between the lightest neutralinos and the SM Higgs boson has a blind spot when $s_{2\beta} + (m_{\chi_1^0} + m_{\chi_2^0})/(2\mu) \sim 0$ [10]. Thus, apart from this blind spot region, the $\chi_2^0 \to \chi_1^0 + h$ channel is the more robust case for exploring the spectrum of electroweakinos at the LHC. The only exception here is in the compressed region where $m_{\chi_2^0} \simeq m_Z + m_{\chi_1^0}$ where the decay through the Z boson is always 100%. Though in this region kinematic signal efficiencies tend to be quite poor.

Not often emphasized, the squark spectrum also has a relevant effect on the direct production cross section, especially in the Wino scenario [10]. This dependence is most strongly correlated to the first two generation squarks, which contribute to the electroweakino direct production through t-channel exchange. In particular, varying the squark mass scale from $1 - 10$ TeV can achieve almost an order of magnitude boost in the Wino cross section, in certain regions of parameters [10].

Importantly, the sign of the Higgsino mass μ has a dramatic effect on the interpretation of different electroweakino search channels. In particular, trilepton searches will only have reach outside of the compressed region when the parameters are close to the blind spot region. Hence, this is only possible for $\mu < 0$. Recently, we have projected the discovery potential of the HL-LHC for electroweakinos in various scenarios of parameters mentioned here [10]. The HL-LHC will have strong discovery potential in a large region of masses. Such a region includes $m_{\chi_1^\pm} \gtrsim 800$ GeV, $m_{\chi_1^0} \gtrsim 300$ GeV in the most optimistic scenarios. The current bounds projected to L= 139 fb^{-1} would exclude $m_{\chi_1^\pm} \lesssim 600$ GeV, $m_{\chi_1^0} \lesssim 200$ GeV.

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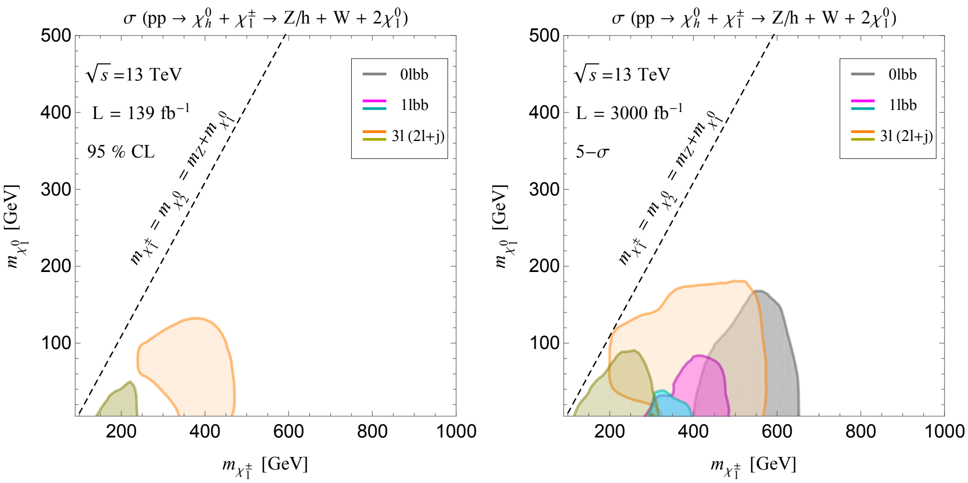

FIG. 1. **Left:** 95% confidence level bounds on the Higgsino-Bino scenario projected to integrated luminosity $L = 139$ fb^{-1}. **Right:** Projected $5 - \sigma$ discovery potential for the Higgsino-Bino scenario at integrated luminosity $L = 3$ ab^{-1}.

II. THE HIGGSINO-BINO SCENARIO

Recently, production channels of electroweakinos proceeding from the decay of heavy Higgs bosons have been studied as an alternative signature [11]. One advantage of this channel is that this search does not suffer from the kinematic deficiencies in the compressed region present in the direct searches. Further, this channel has the most promising signature in the Higgsino-Bino sector where branching ratios of heavys Higgses to electroweakinos can be sizable, unlike the Wino scenario. The Higgsino-Bino scenario is characterized by an electroweakino spectrum where the NLSPs, $\chi_1^{\pm}$ and $\chi_{2,3}^0$, are mostly Higgsino-like, and the LSP is almost purely Bino-like. Recently, we have explored the complementarity of both channels in this scenario at the 13 TeV LHC by recasting existing searches. While direct production searches, Fig. 1, are not as competitive as those of the Wino scenario, the heavy Higgs decay channel offers a promising reach in the compressed region. We discuss how dedicated analysis of both channels will give imperative information on the SUSY electroweak sector and heavy Higgses during the future runs of the LHC [12].

We plan to summarize existing studies, explore the scenarios further and possibly extend the search opportunities for electroweakinos at the HL-LHC and future colliders.

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