SUSY DM predictions for Direct Detection Experiments, the LHC and the ILC

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In this talk, results from the frequentist analysis of the parameter space for the supersymmetric models pMSSM10 [6] and mAMSB, done within the Mastercode collaboration, are reviewed. Among them, special attention is paid to the predictions concerning Direct Detection Experiments, the Large Hadron Collider [1] and the International Linear Collider [2]. Also, the Dark Matter candidate provided in each case is described.

1 Introduction

The Standard Model of Particle Physics (SM) is a very succcessful theory. Nevertheless, it fails to explain important things, such as the origin of dark matter and dark energy or the unification of the forces. Among the alternatives to the SM proposed in order to solve these, supersymmetry plays a major role.
The particle content of the minimal supersymmetrical extension of the SM (MSSM) [3] is made of the SM particles, their supersymmetric partners and 2 Higgs doublets. In this model the Lightest Supersymmetric Particle (LSP) is neutral and stable, which makes it a good Dark Matter candidate. It can be either a gravitino, the lightest neutralino (it can be a Bino, a Higgsino, a Wino or a combination of former), or a sneutrino. Nevertheless, sneutrinos are experimentally ruled out by direct detection experiments.
One of the main drawbacks of the MSSM is the fact that it has more than 100 free parameters, which makes it a very difficult model to confront with experimental data. In order to cope with this a purely phenomenological approach can be taken, like the pMSSM10, that has only 10 parameters. Also, a constrained model can be considered, where an assumption on the scenarios through which spontaneous SUSY breaking is achieved is made. An example of the latter is the mAMSB, with 3 free parameters and 1 sign.
To calculate the observables that go into our likelihood evaluation and perform Global fits of SUSY for these two models, the Mastercode framework is used, that interfaces several public and private code, linked using the SUSY Les Houches Accord (SLHA) [4], [5].

2 pMSSM10 Results

The best-fit point of the sampling provides the mass spectrum shown in Figure 1. It can be seen a clear-prediction for a Bino-like $m_{\tilde{\chi}_1^0}$. Its predicted mass is much lower than other GUT-based models. According to the mass range, the production of SUSY particles in this model would be possible at ILC, as long as the following condition is fulfilled for the mass of these particles: $m < \sqrt(s)/2$, where s$\sim$500 GeV for ILC. Plotting the DM candidate mass against the squark

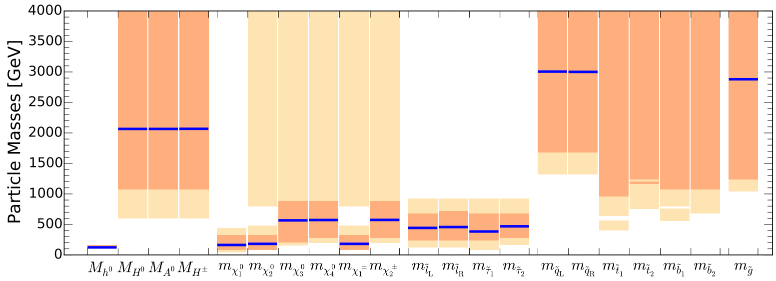

Figure 1: Mass spectrum for the best-fit point in pMSSM10 sampling

mass (left plot in Figure 2) it is shown that parts of the $\tilde{\chi}_1^{\pm}$ coannihilation region and the low-$m_{\tilde{\chi}_1^0}$ band are accessible to future LHC searches (especially if the gluino hass a mass of 4.5 TeV). Also, chargino coannihilation is proved to be the main production channel. In the right plot of this figure it is seen that most of the chargino coannihilation region would be accessible to future LZ searches.

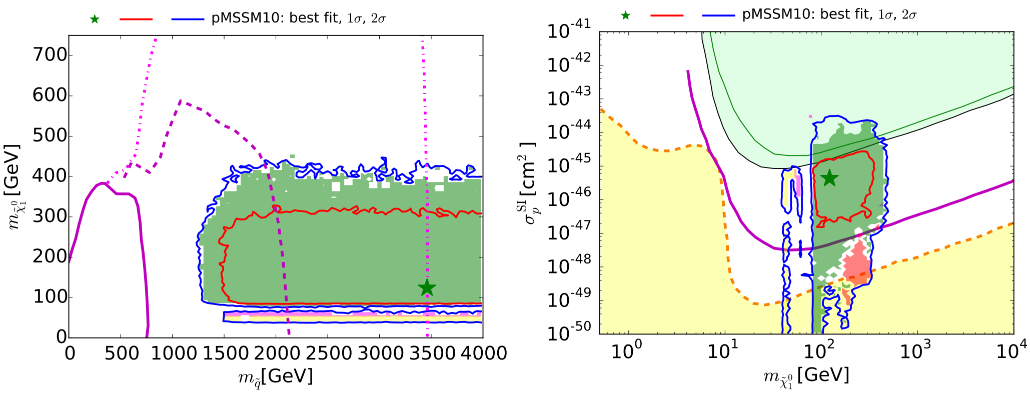

Figure 2: Left: $(m_{\tilde{q}}, m_{\tilde{\chi}_0})$ plane. The red and blue solid lines are the $\Delta\chi^2 = 2.30$ and 5.99 contours, and the solid (dashed) purple lines are the current and (projected) 95% exclusion contours for missing E_T searches at the LHC (with 300/fb of data at 14 TeV). The solid lines are almost identical with the contours for 5-σ discovery with 3000/fb. Right: $(m_{\tilde{\chi}_1^0}, \sigma_p^{SI})$ plane. The solid purple lines show the projected 95% exclusion sensitivity of the LUX-Zepelin (LZ) experiment [7]. The green and black lines show the current sensitivities of the XENON100 [8] and LUX [9] experiments, respectively, and the dashed orange line shows the astrophysical neutrino 'floor' [10], below which astrophysical neutrino backgrounds dominate (yellow region)

3 mAMSB Results

As it happened in the previous case, the LSP is a neutralino, almost degenerate with a chargino ($\tilde{\chi}_1^{\pm}$), as shown in the best-fit point mass spectrum (Figure 3). Because of their high masses, particles in this model are not directly detectable at LHC nor at ILC. The DM candidate can either be wino-like or higgsino-like. Nevertheless, the wino-like candidate, with mass ~ 3 TeV (common for all the wino DM models), is more favoured than the higgsino-like one. Notice that the preferred LSP mass is much bigger than the pMSSM10 prediction. Again, the main production mechanism of the DM candidate is the chargino coannihilation.

Concerning the $(m_{\tilde{\chi}_0}, \sigma_{SI})$ plane (Figure 4), wino-like candidate contour plots lie below the

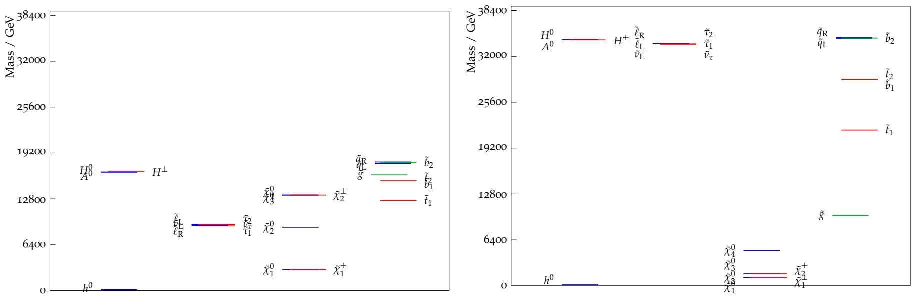

Figure 3: Mass spectrum for the best-fit point in mAMSB sampling, for the wino-like (left) and the higgsino-like (right) candidate

astrophysical neutrino floor, which would make it impossible to detect it with direct detection experiments. However, if the candidate is higgsino-like instead, LZ experiment would have accessibility to its measurement.

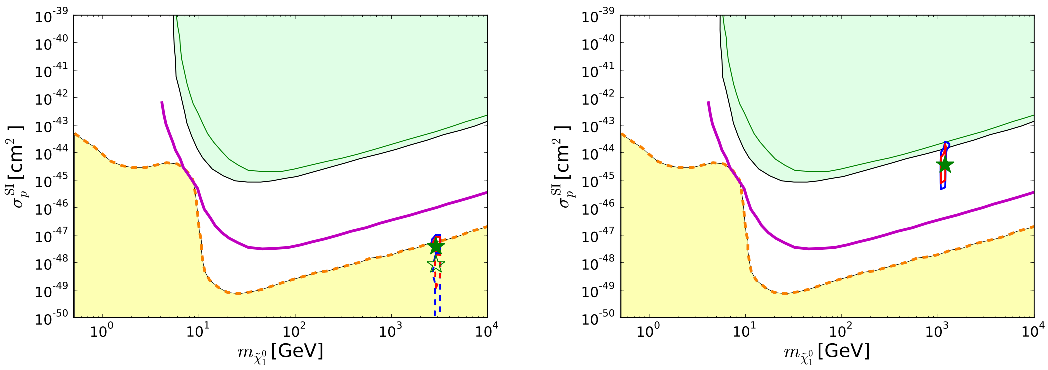

Figure 4: The $(m_{\tilde{\chi}^0_1}, \sigma_p^{SI})$ planes in the mAMSB framework. The plot on the left refers to the wino-like candidate, while the plot on the right corresponds to the higgsino-like one

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4 Conclusions

Supersymmetry is a good framework for explaining the origin of Dark Matter. Among the different models, both pMSSM10 and mAMSB have shown to provide good candidates. pMSSM10 candidate has much lower mass than other models (such as NUHM2,NUHM1,CMSSM), while mAMSB leads to a heavy wino-like candidate and a lighter higgsino-like candidate.

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