PROCEEDINGS OF SCIENCE

Searches for heavy long-lived sleptons with the ATLAS detector in pp collisions at $\sqrt{s}$ = 8 TeV

Elisa MUSTO*
Technion - Israel Institute of Technology - Technion City, Haifa 32000, Israel
E-mail: emusto@cern.ch

A search for long-lived sleptons has been performed on a data sample of 16 fb^{-1} of pp collisions at a center of mass energy of $\sqrt{s}$= 8 TeV collected by the ATLAS detector at LHC in 2012. Long-lived sleptons are expected to interact as if they were heavy muons, charged and penetrating. Results are interpreted in the context of gauge-mediated supersymmetry breaking (GMSB) models where the $\tilde{\tau}_1$, supersymmetric partner of the τ lepton, is the next to lightest supersymmetric particle (NLSP) and decays outside the ATLAS volume. No excess is observed above the estimated background, therefore lower limits, at 95% confidence level, are set on the mass of the long-lived sleptons.

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*Speaker.

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1. Motivations and analysis strategy

Heavy long-lived particles are predicted by many Standard Model (SM) extensions.
In Supersymmetry (SUSY) [1, 2, 3], sleptons ($\tilde{l}$, superpartners of leptons), squarks and gluinos ($\tilde{q}$, $\tilde{g}$, superpartners of quarks and gluons, respectively) might have long lifetimes and decay outside the detector volume. Heavy sleptons produced at the Large Hadron Collider (LHC) could travel with velocity measurably lower than the speed of light; they would behave like heavy muons, releasing energy by ionisation as they pass through the ATLAS detector.

The ATLAS [4] search for long-lived sleptons [5] is performed by using 16 fb^{-1} of pp collisions collected by the ATLAS detector at LHC in 2012.
The long-lived particle (LLP) mass m is determined by measuring its velocity, β, and its momentum, p, using the relation $m = p/\beta\gamma$. The p is estimated from the measured track, while β is estimated by combining the β measurements obtained in the Muon Spectrometer and in the Calorimeters. In each sub-detector, β is obtained by averaging the time-of-flight (ToF) measurements of the different detector elements; a high timing accuracy, which reflects into a high β resolution, is obtained by calibrating the ToF of each detector element with a sample of muons found in the data.

The background is composed mainly of high-p_T muons with mis-measured β, and is estimated directly from the same data sample by convoluting the momentum and β distributions of the LLP candidates.

The events are selected online by muon triggers. The data sample is divided in two exclusive parts: events with two candidates, passing a loose selection (Signal Region, SR) or, if not, events with one candidate passing a tight selection[1] (Control Region, CR), used to assess systematic uncertainties. In both regions the candidates are required to have a combined β in the range $[0.2, 0.95]$; additional model dependent cuts are applied on the candidate mass.

Simulated signal samples in the framework of gauge-mediated SUSY breaking (GMSB) [7][2] are used to study the expected signal behavior and to set limits. In these samples hit times have been smeared in order to reproduce data, the smearing procedure is validated by using simulated (MC) $Z \to \mu\mu$ samples. Typical efficiencies for signal passing the mass cuts are 20% for the two candidate events and 15% for the one candidate events[3]; efficiency values are similar for all the LLP production processes.

The number of background and expected signal events above the mass cut in the two-candidate signal region and the different sources of systematic uncertainties are used to obtain the cross section limits, which are obtained using the CL_s prescription [6]. Mass limits are derived by comparing the obtained cross-section limits to the lower edge of the 1σ band around the theoretically predicted cross-section for each process.

[1] In the SR the two candidates are required to have a transverse momentum p_T above 50 GeV, to be outside the Z boson mass region, to pass quality cuts on the combined measured β. In the CR the p_T is raised to 70 GeV and the cuts on the combined β are tighter.

[2] The GMSB samples are generated with the following model parameters: number of super-multiplets in the messenger sector: 3, messenger mass scale: 250 TeV, sign of the Higgsino mass parameter: 1, scale factor for the gravitino mass (which determines the NLSP lifetime): 5000. The two Higgs doublets vacuum expectation values ratio, $\tan\beta$, is varied between 5 and 50, while the SUSY breaking scale Λ is varied from 80 to 160 TeV.

[3] In the one candidate region, the relative amount of signal with respect to background is very low with respect to the two candidate region, so it has been used to asses the systematic uncertainties on the background estimation procedure.

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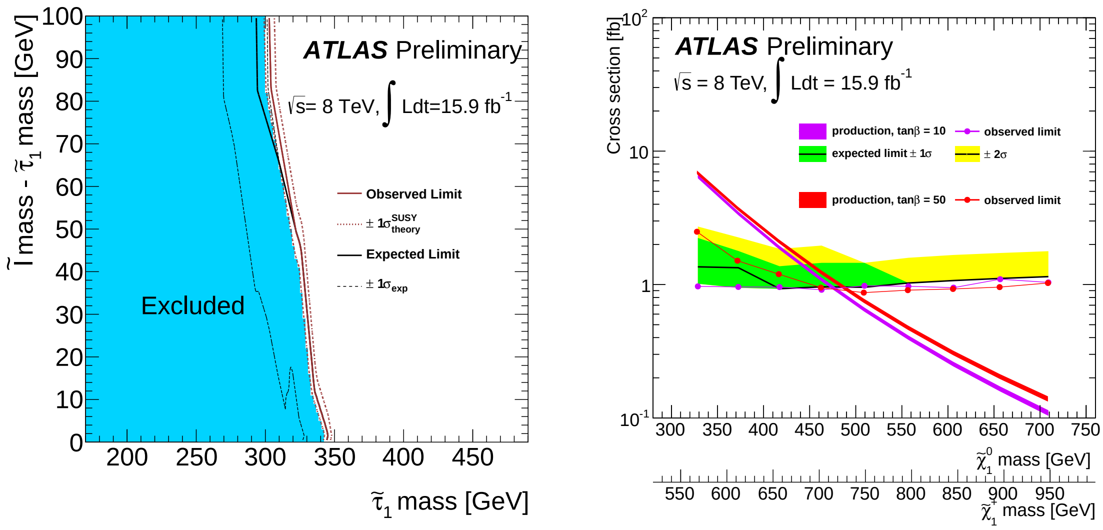

Figure 1: Left: excluded regions for directly produced sleptons in the plane m($\tilde{l}$)−m($\tilde{\tau}_1$) vs. m($\tilde{\tau}_1$). The excluded region is blue. Right: cross-section limits as a function of the $\tilde{\chi}$ mass for $\tilde{\tau}_1$s from chargino and neutralino production. Observed limits are given as solid lines with markers. Different colors represent models with different tanβ. Expected limits for tan$\beta = 10$ are drawn as black lines with ± 1 and $\pm 2\sigma$ uncertainty bands drawn in green and yellow respectively. The theoretical cross-section prediction (dominated by $\tilde{\chi}^0_1\tilde{\chi}^+_1$ production) is shown as a colored 1σ band. Both results can be found in Reference [5].

2. Results

No indication of signal above the expected background is observed. Results are interpreted in the GMSB context, where the lightest τ slepton ($\tilde{\tau}_1$) is the NLSP and is long-lived. Upper cross-section limits on model independent cross sections for direct $\tilde{l}$ (see Figure 1, right) and $\tilde{\tau}_1$ production have been obtained at 95%CL.
Exclusion limits are also set on directly produced $\tilde{\chi}^0_1$ and $\tilde{\chi}^{\pm}_1$, which afterwards decay directly or via heavier $\tilde{l}$ to $\tilde{\tau}_1$ (see Figure 1, left).

References

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