

Searches for strong R-parity conserving SUSY production at the LHC with the ATLAS detector

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Searches for supersymmetric squarks and gluinos in events containing jets, missing transverse momentum, and one or zero lepton are presented. The results are based on the full data sample (5 fb^{-1}) recorded in 2011 at $\sqrt{s} = 7 \text{ TeV}$ centre-of-mass energy by the ATLAS experiment at the LHC.

1 Introduction

The search for physics beyond the Standard Model (SM) is one of the main tasks of Large Hadron Collider (LHC) experiments. SuperSymmetry (SUSY) is one of the most promising extensions of the SM. At a proton-proton collider, the strong production of supersymmetric particles (squark-squark, gluino-gluino, gluino-squark) is the preferred mechanism, if those particles are within the energy reach of the LHC. In R-parity conserving SUSY models [1, 2, 3, 4, 5, 6, 7, 8, 9], sparticles are produced in pairs, and the Lightest Supersymmetric particle (LSP) is stable and weakly interacting, therefore escaping detection. The experimental signature of such events is therefore several energetic jets and/or leptons, originating from the cascade decays of the initial squarks and gluinos, and large missing transverse momentum, E_T^{miss} coming from the LSP. Typical SM backgrounds to such searches are multi-jet, $t\bar{t}$, W , Z , and single top production. In this paper, a search for supersymmetry in events with several jets, large E_T^{miss} , and 1 or 0 lepton is presented, using the full data sample collected in 2011 by the ATLAS experiment [10] at the LHC in $p-p$ collisions at a center-of-mass energy of 7 TeV, corresponding to an integrated luminosity of $\sim 4.7 \text{ fb}^{-1}$ after the application of basic data quality requirements. Three analyses are presented, covering squark-squark and gluino-gluino production. In the first case, 1 (or more) jet is produced from each squark decay, therefore the analysis focuses on events with 2 or more energetic jets, and no lepton (see section 2). In the second case, longer decay chains are possible and a separate analysis focus on events with larger jet multiplicity (more than 5) and no lepton (described in section 3). The case where the squark or gluino decays producing one light (e or μ) lepton (and several jets) is presented in section 4.

2 The 0-lepton analysis

The effective mass m_{eff} (defined as the sum of E_T^{miss} and the transverse momentum p_T of all jets) is used in the 0-lepton analysis to discriminate SUSY signal from SM backgrounds. The background originating from multi-jet production is kept under control through a cut on the

minimum azimuthal angle ($\Delta\phi$) between the jets and the E_T^{miss} vector. In total, 11 signal regions with various jet multiplicities (ranging from 2 to 6) and different cuts on m_{eff} have been defined, in order to achieve maximal coverage in the squark-gluino mass plane, and to enhance sensitivity to models with compressed spectra (small mass splitting). The contribution in the signal regions from SM backgrounds from mismeasured multi-jet events, W and $Z(\rightarrow \nu\nu)+\text{jets}$, $t\bar{t}$ are estimated from background-enriched control regions through transfer factors taken from Monte Carlo (MC) or data (for multi-jet events). The 0-lepton analysis is described in [11]. No evidence is found for physics beyond the Standard Model. The results are interpreted in the context of a MSUGRA/CMSSM model with $\tan\beta = 10$, $A_0 = 0$ and $\mu > 0$ (see Fig. 1) and a simplified MSSM scenario with only strong production of gluinos and first- and second-generation squarks, and direct decays to jets and neutralinos (see Fig. 2). Gluino masses below 940 GeV, and squark masses below 1380 GeV (for gluino masses up to 2 TeV) are excluded at the 95% confidence level in the simplified model, whereas squarks and gluinos of equal mass are excluded for masses below 1400 GeV in the MSUGRA/CMSSM model.

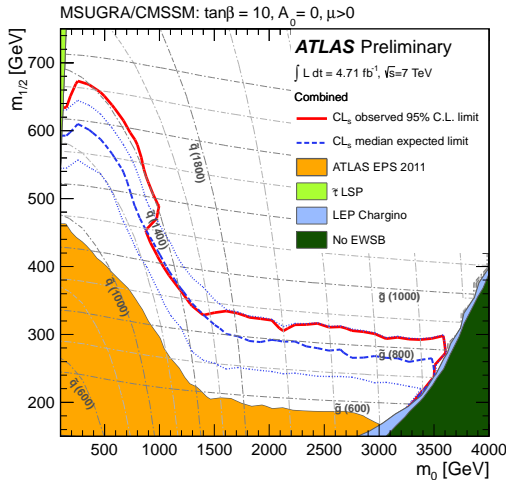


Figure 1: 95% CL_s exclusion limits in the MSUGRA/CMSSM model for the 0-lepton analysis [11].

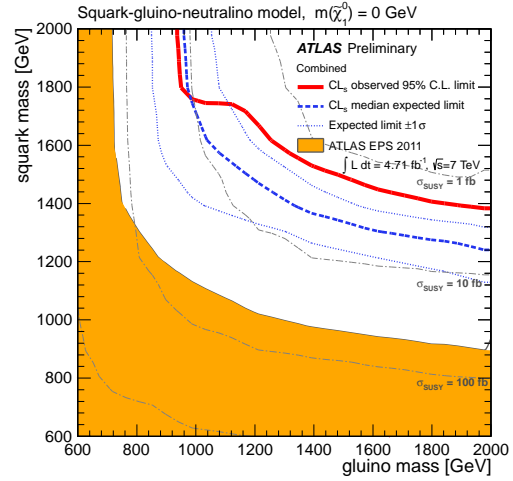


Figure 2: 95% CL_s exclusion limits in the simplified MSSM scenario for the 0-lepton analysis [11].

3 The 0-lepton multi-jet analysis

In the 0-lepton multi-jet analysis, searches for events containing from more than 5 to more than 8 jets are performed. The signal/background discriminating variable is H_T , defined as the scalar sum of the transverse momenta of all jets. 6 non-exclusive signal regions are defined according to various jet multiplicities and different cuts on the E_T^{miss} significance, defined as $E_T^{\text{miss}}/\sqrt{H_T}$. The main SM backgrounds are multi-jet processes (including fully hadronic $t\bar{t}$), estimated from data in control regions with lower jet multiplicities and E_T^{miss} , and *leptonic* processes in which the lepton is out of the detector acceptance or misidentified: $t\bar{t}$ (semi and full-leptonic) and $W/Z+\text{jets}$, estimated from data (when possible) in control regions, and extrapolated to signal

regions using MC (similar to the 0-lepton analysis). The 0-lepton multi-jet analysis is described in detail in [12]. A global fit for the normalisation of each background from the control regions is simultaneously performed in each signal region. No significant excess of data over SM prediction is found, therefore limits are set to a MSUGRA/CMSSM supersymmetric model where, for large m_0 , gluino masses smaller than 850 GeV are excluded at the 95% C.L (see Fig. 3). Within a simplified model containing only a gluino octet and a neutralino (and assuming that the gluino decays with 100% branching fraction to $t\bar{t}$ and a neutralino), gluino masses smaller than 880 GeV are excluded for neutralino masses less than 100 GeV (see Fig. 4).

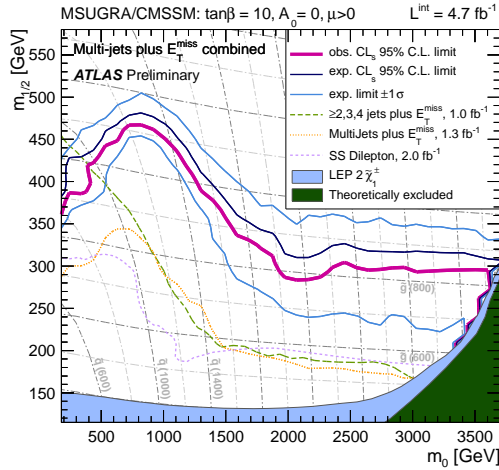


Figure 3: 95% CL_s exclusion limits in the MSUGRA/CMSSM model for the multijet analysis [12].

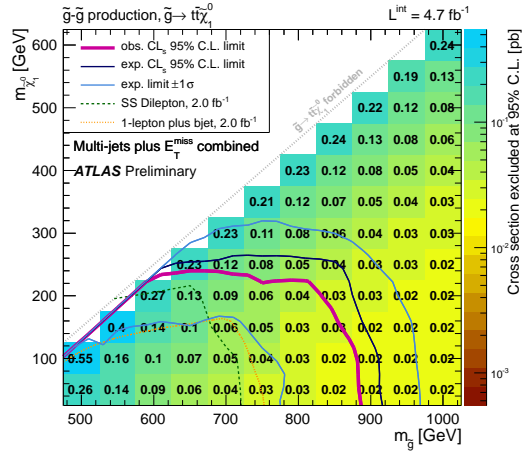


Figure 4: 95% CL_s exclusion limits in the simplified model scenario for the multijet analysis [12].

4 The 1-lepton analysis

The search for strong production of squarks and gluinos in events containing jets, E_T^{miss} , and one isolated lepton (e or μ) from chargino decays is the aim of the 1-lepton analysis. Three orthogonal signal regions are defined: one requiring one soft lepton (with transverse momentum smaller than 20 GeV for muons and 25 GeV for electrons) to enhance sensitivity to compressed spectra models, and two with one hard lepton and 3 or 4-jet multiplicities to probe higher SUSY mass scales. SUSY signal is separated from SM backgrounds (mainly multi-jet, $t\bar{t}$ and W) using m_{eff} . The background in the signal regions is estimated with an (over-constrained) simultaneous fit based on the profile likelihood method, with as inputs the contributions of the various background sources in appropriate control regions, and transfer functions to the signal regions taken from data or MC [13]. No hint of new physics is found, therefore limits are set in the MSUGRA/CMSSM model, where squarks and gluinos of equal masses below approximately 1200 GeV are excluded at 95% CL (see Fig. 5). In a simplified model with gluino-gluino pair production with several jets, W 's and neutralinos in the final state (where the gluino decays to the LSP via the intermediate step - one-step - of the lightest chargino, and with the chargino

mass set halfway, $x = 1/2$, in between the gluino and neutralino masses), gluino masses below approximately 900 GeV are excluded for LSP masses below 200 GeV. The soft 1-lepton search is more powerful along the diagonal region where the masses of the gluino and LSP become quasi-degenerate, while the hard-lepton analyses are more powerful in the rest of the phase space (see Fig. 6).

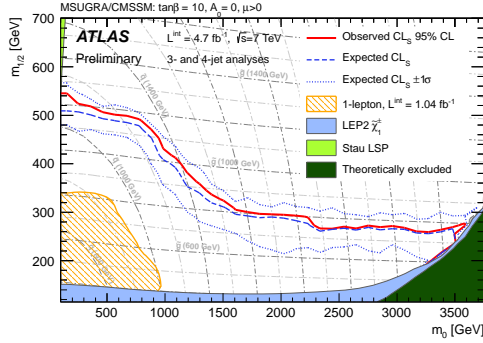


Figure 5: 95% CL_s exclusion limits in the MSUGRA/CMSSM model for the 1 (hard) lepton analysis [13].

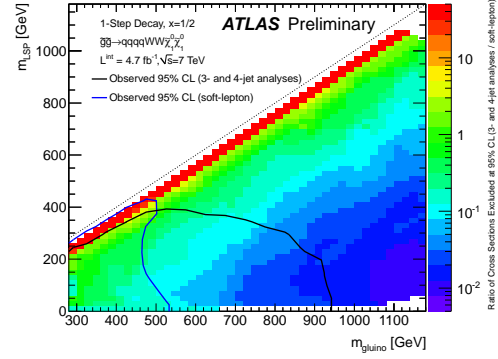


Figure 6: Ratio of the excluded cross sections by the hard-lepton (numerator) versus the soft-lepton (denominator) analyses, in the gluino production simplified model [13].

5 Conclusion

Three searches for strong production of SUSY particles using the ATLAS detector with the full 2011 dataset have been presented. No excess of data over SM expectation is found. Squarks and gluinos of equal mass are excluded up to 1400 GeV in the MSUGRA/CMSSM model. These limits considerably extend the exclusion limits by previous ATLAS measurements.

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