Inclusive searches for supersymmetric signatures with the ATLAS detector

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1 Introduction

A brief summary of recent results on inclusive searches for supersymmetry (SUSY) and of searches for SUSY signatures involving long-lived massive particles is presented. The reported results use up to 4.7 fb^{-1} of data from pp collisions at center-of-mass energy of $\sqrt{s} = 7$ TeV recorded in 2011 by ATLAS[1] at the LHC.

Strong SUSY production is searched in events with large jet multiplicities and large missing transverse momentum, with and without leptons. SUSY with $\tilde{\tau}$ as next to lightest SUSY particle (NLSP) is searched in events with one or more τ leptons and missing transverse momentum. SUSY with meta-stable charginos is searched in events with missing transverse momentum and a disappearing track. Table (1) lists the searches presented.

Signature	Model	$\int \mathcal{L}dt$	Ref.
0-lep + $E_{\mathrm{T}}^{\mathrm{miss}}$ +$\geq$ (2-6) jets	medium to large mass splittings	4.7 fb^{-1}	[2]
0-lep + $E_{\mathrm{T}}^{\mathrm{miss}}/\sqrt{H_{\mathrm{T}}}$ + $\geq$ (6-9) jets	long decay chains, $\tilde{g} \to t\bar{t}\tilde{\chi}^0$	4.7 fb^{-1}	[3]
$\geq$ 1-lep + $E_{\mathrm{T}}^{\mathrm{miss}}$ + $\geq$ (3,4) jets	decays with intermediate $\tilde{\chi}^{\pm}, \tilde{\chi}^0, \tilde{\ell}$	4.7 fb^{-1}	[4]
2-lep (S.S.) + $E_{\mathrm{T}}^{\mathrm{miss}}$ + $\geq$ 4 jets	$m_{\tilde{g}} \sim m_t + m_t + m_{\tilde{\chi}^0}$	2.1 fb^{-1}	[5]
$\geq$1-tau + $E_{\mathrm{T}}^{\mathrm{miss}}$ + jets	GMSB with $\tilde{\tau}$ NLSP	2.1 fb^{-1}	[6]
$\geq$2-tau + $E_{\mathrm{T}}^{\mathrm{miss}}$ + jets	GMSB with $\tilde{\tau}$ NLSP	2.1 fb^{-1}	[7]
Disappearing track	AMSB with meta-stable $\tilde{\chi}^{\pm}$	4.7 fb^{-1}	[8]

Table 1: SUSY searches performed by ATLAS. The word *lep* denotes an isolated electron or muon, *S.S.* denotes same-sign leptons, *tau* denotes hadronically decaying τ.

2 Searches with jets and $E_{\mathrm{T}}^{\mathrm{miss}}$

The (2-6) jets search [2] is motivated by strong SUSY production of gluinos and squarks that subsequently decay to quarks and neutralinos. Events are selected based on a jet+$E_{\mathrm{T}}^{\mathrm{miss}}$ trigger, applying a lepton veto, requiring from (2-6) jets, $E_{\mathrm{T}}^{\mathrm{miss}} > 160$ GeV, and azimuthal separation between the $E_{\mathrm{T}}^{\mathrm{miss}}$ and reconstructed jets to reject multi-jet backgrounds. Events are analysed in five signal regions, based on jet multiplicity, and in eleven channels based on the five signal regions and m_{eff}(incl.), defined to be the scalar sum of the transverse momenta of jets with $p_{\mathrm{T}} > 40$ GeV and $E_{\mathrm{T}}^{\mathrm{miss}}$. Fake $E_{\mathrm{T}}^{\mathrm{miss}}$ and $Z \rightarrow \nu\nu + jets$ backgrounds are estimated directly from data, other backgrounds are estimated using control regions to extrapolate Monte Carlo (MC) to the signal regions.

The (6-9) jets search [3] is motivated by SUSY models with long decay chains, and models with a gluino decaying to a top quark pair and a neutralino. To avoid overlap with the (2-6) jet search, the trigger used to select events for this search is based on multiple jets instead of $E_{\mathrm{T}}^{\mathrm{miss}}$. Events are selected using a lepton veto, requiring six to nine jets and $E_{\mathrm{T}}^{\mathrm{miss}}$ significance,$E_{\mathrm{T}}^{\mathrm{miss}}/\sqrt{H_{\mathrm{T}}} > 4$ GeV$^{1/2}$. Multi-jet backgrounds are estimated from data by extracting the shape of the $E_{\mathrm{T}}^{\mathrm{miss}}/\sqrt{H_{\mathrm{T}}}$ from a control region with lower jet multiplicity and normalising it according to a control region with the same jet multiplicity but $E_{\mathrm{T}}^{\mathrm{miss}}/\sqrt{H_{\mathrm{T}}} < 1.5$ GeV$^{1/2}$.

The 1-lepton search [4] is motivated by models with SUSY decay chains with intermediate $\tilde{\chi}^{\pm}, \tilde{\chi}^{0}, \tilde{\ell}$, for which an isolated lepton is a clean signature. Within this search ATLAS performs a soft-lepton analysis which enhances the sensitivity of the search (between twenty to thirty times) in the difficult kinematic region where the neutralino and gluino masses are close to each other. Events with an isolated lepton are selected according to jet multiplicity, $E_{\mathrm{T}}^{\mathrm{miss}}$, m_{eff}, and $E_{\mathrm{T}}^{\mathrm{miss}}/m_{\mathrm{eff}}$. Backgrounds are determined in a simultaneous Profile Likelihood (PL) fit with nuisance parameters, which allow the determination of some theoretical uncertainties directly from data. Notable uncertainties determined from data are: the relative normalization of W+jets and Z+jets MC samples with different parton multiplicities, the uncertainty in the cross section of the vector boson plus heavy flavor production, the uncertainty on the p_{T}^{Z} distribution, and the uncertainty in the normalization of the W +jets and Z +jets 0-1 parton MC due to uncertainties in renormalization and factorization scales.

The two same charge (hereafter called 'same sign') lepton search [5] is motivated by the equal probability of the majorana gluino to produce events with same sign and opposite sign leptons. A same sign lepton pair offers a clean signature, and enhances the sensitivity where the gluino mass is close to the combined mass of a top pair and the mass of the lightest neutralino. Events having two leading leptons with the same charge are selected based on jet multiplicity, $E_{\mathrm{T}}^{\mathrm{miss}}$, and m_{T} for one of the signal regions.

Limits for strong SUSY production are set in the absence of deviations from the

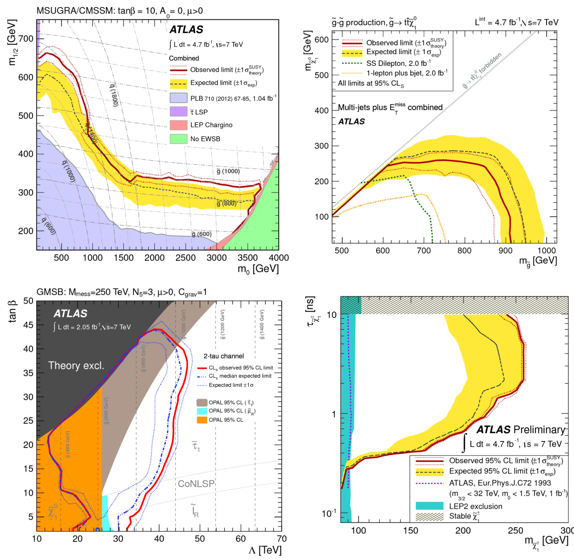

Figure 1: Top left - Exclusion plot in the MSUGRA/CMSSM [2]. Top right - exclusion plot for simplified model (6-9) jet search [3]. Bottom left - Limits on GMSB models based on ≥1,2 tau searches [7]. Bottom right - Limits on meta- stable charginos based on the disappearing track search [8].

Standard Model (SM) predictions. Figure (1 - top left) illustrates the limits set under the MSUGRA/CMSSM framework. Squarks with masses below 1.4 TeV are excluded, and gluinos are excluded with masses below 800 GeV. Results are also interpreted under simplified model assumptions, Figure (1 - top right) illustrates the interpretation of the 6-9 jets result under the assumption of a simplified model where $\tilde{g}\tilde{g}$ are always produced, and each $\tilde{g}$ decays to $t\bar{t} + \tilde{\chi}^0$.

3 Searches with tau leptons, jets and $E_{\mathrm{T}}^{\mathrm{miss}}$

Two SUSY searches motivated by GMSB models with a $\tilde{\tau}$ NLSP are performed. Events are selected based on hadronically decaying τ leptons identified using Boosted decision trees (BDTs). One search [6] selects events with at least one τ lepton. Another search [7] selects event with at least two τ leptons. Signal regions are defined according to $E_{\mathrm{T}}^{\mathrm{miss}}$, m_{eff}, and $m_{\mathrm{T}}(E_{\mathrm{T}}^{\mathrm{miss}}, \tau)$. Since no deviation from the SM is seen, limits on contributions from new phenomena are set. Figure (1 - bottom left) illustrates the interpretation of the result of these two searches under the assumption of GMSB with m_{mess} =250 TeV, $N_5 = 3$, $\mu > 0$, $C_{\mathrm{grav}} = 1$.

4 Search with a disappearing track

The search for SUSY with a disappearing track is motivated by AMSB models where the chargino can live long enough to be detected. The search aims at detecting a chargino that decays within the inner detector volume. Since the chargino and the neutralino are very close in mass in these models, the charged particle(s) from the decay of this chargino are too soft to be reconstructed, therefore a disappearing track is expected. Events are selected based on $E_{\mathrm{T}}^{\mathrm{miss}}$, jet multiplicity and a lepton veto. Chargino candidates are selected requiring a good track quality before the TRT (outer part of the inner detector with a radius between 56 to 108 cm) and less than five hits in the TRT's outer module. Charginos with masses between 90 and 120 GeV are excluded for lifetimes above 10^{-1} ns and below 10^{2} ns. Figure (1 - bottom right) illustrates the limits obtained for the chargino.

5 Conclusion

ATLAS has a thriving community with a strong and broad program searching for SUSY. No evidence for SUSY has been found by ATLAS in the 4.7 fb^{-1} recorded by ATLAS in 2011. ATLAS will continue to look for evidence of SUSY.

References

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