SUSY and BSM Searches in ATLAS

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1 Introduction

A brief report on supersymmetry (SUSY) and other beyond-SM (BSM) searches in $\sqrt{s} = 7$ TeV pp collisions using up to $4.7\,\text{fb}^{-1}$of ATLAS [1] data at the LHC is presented. The shown results correspond to the status as of June 2012.

2 Supersymmetry searches

SUSY searches within ATLAS are grouped into R-parity conserving (RPC), and R-parity violating (RPV) together with long-lived particle models. Searches for RPC models are further divided into inclusive searches for strong production, searches for third generation squarks (direct and indirect production), and electroweak production ($\tilde{\chi}^{\pm}$, $\tilde{\chi}^{0}$, $\tilde{\ell}$). In the following, results with less than $1.0\,\text{fb}^{-1}$of data are omitted.

Table 1 lists the most relevant inclusive SUSY searches. Long cascade decays are searched for both with and without leptons. Exclusion limits of the all-hadronic search are shown in Fig. 1. The most stringent limits exclude squark and gluino masses up to 1.4 TeV (for $m_{\tilde{q}} \approx m_{\tilde{g}}$). The signature of GMSB models is to a large extent determined by the next-to-lightest-SUSY-particle (NLSP). Depending on its nature taus, photons, or Z bosons are emitted, which defines the corresponding searches.

Table 2 lists SUSY searches for third generation squarks. A light $\tilde{t}$ is motivated by naturalness arguments. Exclusion limits for a gluino-mediated $\tilde{t}$ model and a direct $\tilde{t}$ production scenario are shown in Fig. 2. In the first scenario gluino masses are excluded up to about 900 GeV for $m_{\tilde{\chi}^0_1} < 200\,\text{GeV}$, and a very-light $\tilde{t}$ is excluded by the second search up to a mass of about 135 GeV. [1]

Table 3 lists ATLAS searches for electroweak production. In a $\tilde{\chi}^{\pm}_1$-$\tilde{\chi}^{0}_2$ production model where each decay proceeds via a $\tilde{\ell}$ thus giving rise to large lepton mutliplicities, gaugino masses are excluded up to 300 GeV [15].

Table 4 lists searches for RPV and long-lived scenarios. These searches typically exploit experimentally challenging signatures, e.g. a displaced vertex, a disappearing track, or a stable massive particle, or energy deposits in unpaired bunches. The search for disappearing tracks [18] excludes non-prompt chargino masses up to 118 GeV.

[1] These values are derived from the $-1\,\sigma^{\text{SUSY}}_{\text{theory}}$ observed limit contours.

signature	model(s)	L	ref.
0-lep + $E_{\mathrm{T}}^{\mathrm{miss}}$+ $\geq$(2-6) jets	medium to large mass splittings	$4.7\,\mathrm{fb}^{-1}$	[2]
0-lep + $E_{\mathrm{T}}^{\mathrm{miss}}/\sqrt{H_{\mathrm{T}}}$ + $\geq$(6-8) jets	long decay chains, or multi-jets from e.g. $t\bar{t}$ decays	$4.7\,\mathrm{fb}^{-1}$	[3]
$\geq$1-lep + $E_{\mathrm{T}}^{\mathrm{miss}}$+ $\geq$(3,4) jets	decays with intermediate $\tilde{\chi}^{\pm}$,$\tilde{\chi}^{0}$,$\tilde{\ell}$	$4.7\,\mathrm{fb}^{-1}$	[4]
$\geq$ 1 tau + jets + $E_{\mathrm{T}}^{\mathrm{miss}}$	GMSB with stau NLSP	$2.1\,\mathrm{fb}^{-1}$	[5]
$\geq$ 2 tau + jets + $E_{\mathrm{T}}^{\mathrm{miss}}$	GMSB with stau NLSP	$2.1\,\mathrm{fb}^{-1}$	[6]
2-photons + $E_{\mathrm{T}}^{\mathrm{miss}}$	GMSB with bino-like neutralino	$1.0\,\mathrm{fb}^{-1}$	[7]
$Z \rightarrow \ell\ell$ + jets + $E_{\mathrm{T}}^{\mathrm{miss}}$	GMSB with higgsino-like neutralino	$1.0\,\mathrm{fb}^{-1}$	[8]

Table 1: Inclusive searches for RPC strong SUSY production. The word *lep* denotes an isolated electron or muon, and *tau* a hadronic tau decay.

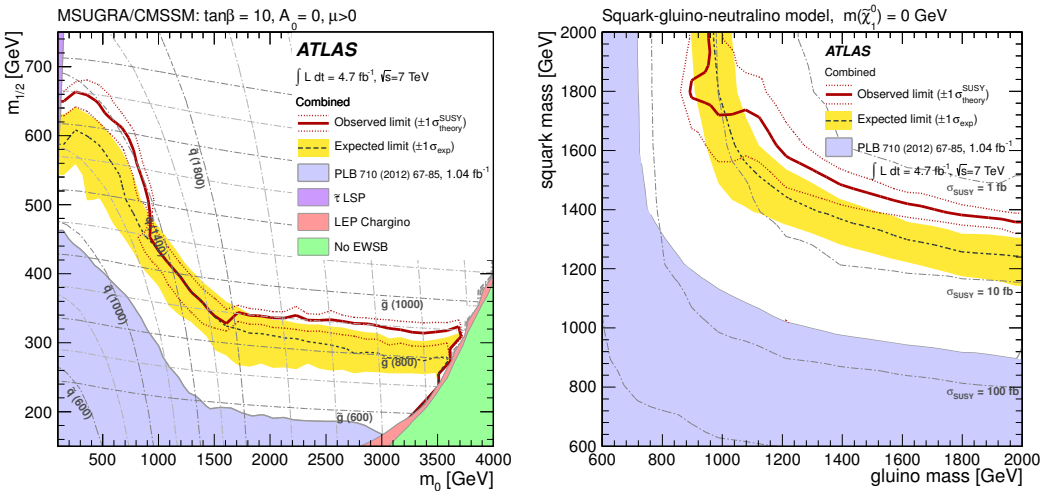

Figure 1: Exclusion plots in the MSUGRA/CMSSM (left) and squark-gluino-neutralino (right) models from Ref. [2].

signature	model(s)	L	ref.
0-lep + $E_{\mathrm{T}}^{\mathrm{miss}}$+ $\geq$(4,6) jets + $\geq$3 bjets	gluino-mediated $\tilde{b}$ or $\tilde{t}$	4.7 fb^{-1}	[9]
(0,1)-lep + $E_{\mathrm{T}}^{\mathrm{miss}}$+ $\geq$(3,4) jets + $\geq$(1,2) bjets	gluino-mediated $\tilde{b}$ or $\tilde{t}$	2.1 fb^{-1}	[10]
2-lep same-sign + $E_{\mathrm{T}}^{\mathrm{miss}}$+ $\geq$4 jets	gluino-mediated $\tilde{b}$ or $\tilde{t}$	2.1 fb^{-1}	[11]
2-lep + $E_{\mathrm{T}}^{\mathrm{miss}}$+ $\geq$1 jets	direct very-light $\tilde{t}$	4.7 fb^{-1}	[12]
$Z \rightarrow \ell\ell$ + $E_{\mathrm{T}}^{\mathrm{miss}}$+ $\geq$2 jets + $\geq$1 bjet	direct $\tilde{t}$ in GMSB	2.1 fb^{-1}	[13]
0-lep + 2 bjets + MCT	direct $\tilde{b}$	2.1 fb^{-1}	[14]

Table 2: Third generation searches for RPC strong SUSY production. The word *lep* denotes an isolated electron or muon, and *bjet* a b-tagged jet.

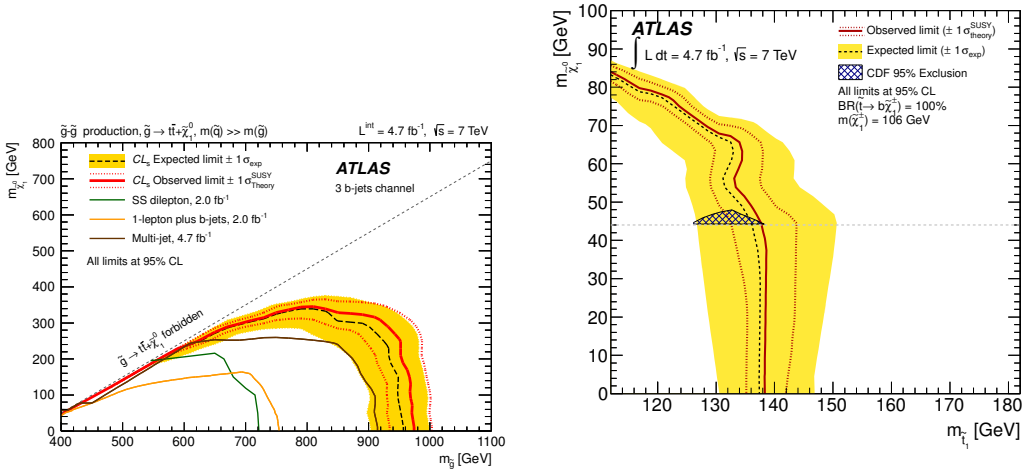

Figure 2: Exclusion limits in a gluino-mediated $\tilde{t}$ [9] (left) and a direct $\tilde{t}$ with $\tilde{t} \rightarrow b\tilde{\chi}^{\pm}$ [12] (right) model.

signature	model(s)	L	ref.
3-lep + $E_{\mathrm{T}}^{\mathrm{miss}}$+ Z rich/depleted	$\tilde{\chi}_1^{\pm}$-$\tilde{\chi}_2^0$, decay via $\tilde{\ell}$	2.1 fb^{-1}	[15]
4-lep + $E_{\mathrm{T}}^{\mathrm{miss}}$+ (Z depleted)	$\tilde{\chi}^{\pm}$-$\tilde{\chi}^0$, and RPV	2.1 fb^{-1}	[16]
2-lep + $E_{\mathrm{T}}^{\mathrm{miss}}$+ (jets)	$\tilde{\chi}_1^{\pm}$-$\tilde{\chi}_2^0$, decay via $\tilde{\ell}$	1.0 fb^{-1}	[17]

Table 3: Searches for RPC electroweak SUSY production. The word *lep* denotes an isolated electron or muon, Z rich (depleted) describes a requirement (veto) on a lepton pair that has an invariant mass compatible with the Z boson.

signature	model(s)	L	ref.
Disappearing track + jets + $E_{\mathrm{T}}^{\mathrm{miss}}$	AMSB scenarios	$4.7\,\mathrm{fb}^{-1}$	[18]
el-mu continuum	t-channel exchange of RPV $\tilde{t}$	$4.7\,\mathrm{fb}^{-1}$	[19]
long lived particle	R-hadron (Pixel)	$2.1\,\mathrm{fb}^{-1}$	[20]
el-mu resonance	RPV $\tilde{\nu}_\tau$ (s-channel)	$1.1\,\mathrm{fb}^{-1}$	[21]

Table 4: RPV and long-lived SUSY searches.

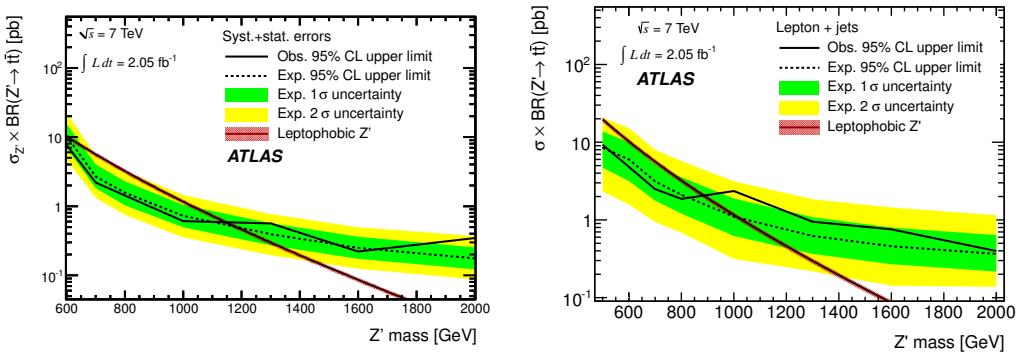

Figure 3: Comparison of exclusion limits in a leptophobic Z' model using the boosted (left) [23] and resolved (right) [24] $t\bar{t}$ resonance searches.

3 Other beyond-SM searches

There is some overlap between SUSY and BSM searches. However, many BSM final states are not covered by SUSY searches, including e.g. signatures with resonances, monojets, and in general signatures with small to medium $E_{\mathrm{T}}^{\mathrm{miss}}$. A complete list of non-SUSY BSM searches can be found in Ref. [22]. A few selected results are presented here.

A new search for heavy $t\bar{t}$ resonances specifically takes advantage of the boost by using "fat jets" to collect all collimated decay products in a single jet. Figure 3 shows the exclusion limits for one benchmark model (leptophobic Z'). The comparison with the corresponding resolved (not using "fat jets") search shows the gain for a heavy resonance.

Figure 4 shows results of the search for high-mass dilepton resonances. The sequential-SM Z' model is excluded up to a mass of 2.2 TeV.

Di-jet signatures are powerful probes of new physics, e.g. excited quarks (q^*) or contact interactions. q^* are excluded up to masses of 3.35 TeV [26].

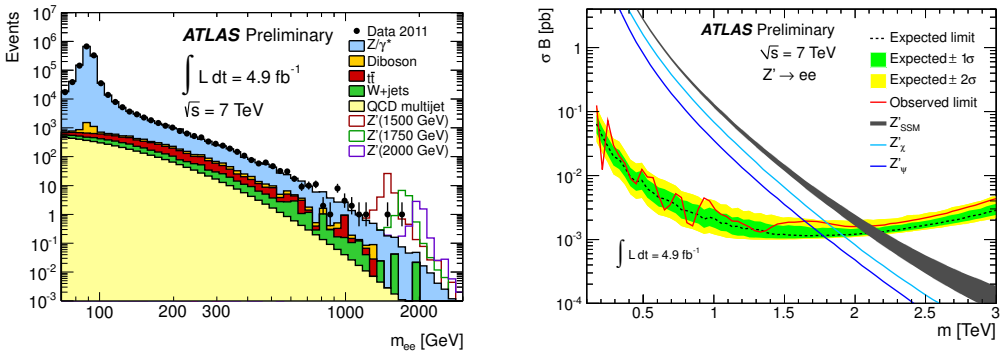

Figure 4: Invariant di-electron mass (left) and combined electron+muon exclusion limits for a sequential-SM Z' model using the di-lepton resonance search [25].

4 Summary

ATLAS is mining its data for the expected and unexpected. There is a strong and diverse program for BSM searches: SUSY and non-SUSY; generic and inclusive searches, as well as dedicated searches (e.g. direct $\tilde{t}$ production). New techniques are implemented (e.g. boosted top), and new phase-space is explored (e.g. 3-bjets). No excess has been observed. ATLAS will keep looking, thanks to the excellent LHC and detector performance.

References

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