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Search for supersymmetry with a compressed mass spectrum in events involving soft leptons, jets and missing transverse momentum with an integrated luminosity of 20.1 pb^{-1} of $\sqrt{s} = 8$ TeV ATLAS data

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Supersymmetric scenarios characterised by a compressed sparticle spectrum represent an experimental challenge as they could be missed in inclusive searches. This poster describes a dedicated search for such models in final states with soft-lepton(s), jets and missing transverse momentum using an integrated luminosity of 20.1 fb^{-1} at $\sqrt{s} = 8$ TeV with the ATLAS detector [1].

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1. Introduction

Supersymmetry (SUSY) is one of the interesting theories of physics beyond the Standard Model (SM). Compressed SUSY refers to models where the mass splitting between the particles is small, and, as a result, the SM particles produced in their decays have low-momentum (are soft). Such spectra occur, e.g. in "natural" SUSY scenario [2, 3], where at least one top squark and the higgsinos are light, resulting in the lightest neutralino and chargino being almost degenerate in mass. A compressed spectrum is naturally realised also in the minimal Universal Extra Dimension (mUED) model [4]. In this model all the SM fields propagate in compactified extra dimensions (in this case only one extra dimension is assumed). The decay chains resemble the ones in SUSY.

2. Event selection

The analysis [5] is targeting pair production of colored SUSY or Kaluza-Klein particles, decaying in one or more steps to soft lepton(s), jets and missing transverse energy (E_T^{miss}) caused by the escaping dark-matter-candidate particle. Based on the target signal model, seven signal regions (SR) are designed (Table 1). Two SRs are optimised for inclusive squark/gluino pair production, four are targeting the "natural" scenario with direct stop production, and one is the dimuon SR optimised for mUED. In all cases the signal leptons are defined in the transverse momentum range 6 GeV < p_T < 25 GeV for muons and 10 GeV < p_T < 25 GeV for electrons. Second (third) lepton is vetoed in single(di)-lepton channel. The E_T^{miss} trigger with 80 GeV threshold is used.

	single-lepton one b-jet		**single-lepton two b-jets**		**single-lepton**		**soft dimuon**
	low-mass	**high-mass**	**low-mass**	**high-mass**	**3-jet**	**5-jet**	**2-jet**
Num. of jets	≥ 3		≥ 2		[3,4]	≥ 5	≥ 2
$p_T{}^{jets}$ (GeV)	$>$ 180,40,40	$>$ 180,25,25	$>$ 60,60 ($p_T{}^{3rd\,jet}$ <50)		$>$ 180,25,25		>70,25
Num. of b-tag jets	$\geq$ 1, but not the leading jet		2		–	–	0 (among 3 leading)
E_T^{miss}(GeV)	>250	>300	>200	>300	>400	>300	>170
m_T(GeV)	$>$ 100		–		$>$ 100		$>$ 80
m_{CT}(GeV)	–		>150	>200	–	–	–
channel specific	$E_T^{miss}/m_{\rm eff}^{\rm incl} > 0.35$		$H_{T,2}$ <50 GeV	–	$E_T^{miss}/m_{\rm eff}^{\rm incl} > 0.3$		$\lvert m_{\mu\mu} - m_Z \rvert > 10$ GeV
channel specific	$\Delta R_{\rm min}$ >1.0		$\Delta\Phi_{min} > 0.4$		$\Delta R_{\rm min}$ >1.0	–	$\Delta R_{\rm min}$ >1.0

Table 1: Overview of the main selection criteria for the seven soft-lepton signal regions. The transverse mass (m_T), the effective mass ($m_{\rm eff}^{\rm incl}$), the contransverse mass (m_{CT}), $H_{T,2}$, $\Delta R_{\rm min}({\rm jet},\ell)$ and $\Delta\Phi_{min}(E_T^{miss},{\rm jets})$ are defined in the Reference [5].

3. Background estimation

The dominant backgrounds in the analysis are $t\bar{t}$ and W+jets production, and misidentified lepton background. The $t\bar{t}$ and W+jets backgrounds are estimated in a semi-data-driven way with a combined fit to the data, based on the profile likelihood method. Overall normalisation factors for $t\bar{t}$ and W+jets processes are extracted from control regions (CR) where each of the backgrounds dominates. The CRs are made orthogonal to SRs by inverting some of the SR-defining requirements (transverse mass (m_T), lepton p_T, E_T^{miss} and number of b-jets, depending on the SR). The fit result is tested in validation regions, defined in "between" the signal and control regions. Good agreement is observed in the validation regions, mostly within one standard deviation. The misidentified lepton background is suppressed by requiring lepton to be well isolated. It is estimated in a fully data-driven way (the matrix method). Other minor backgrounds are estimated using the MC prediction.

4. Results

No significant deviation from the SM expectation is observed in the signal regions. The largest excess, corresponding to 2.3 standard deviations, is observed in the dimuon channel. Exclusion limits are set on the visible cross section and on specific models (Figure 1) at 95% CL.

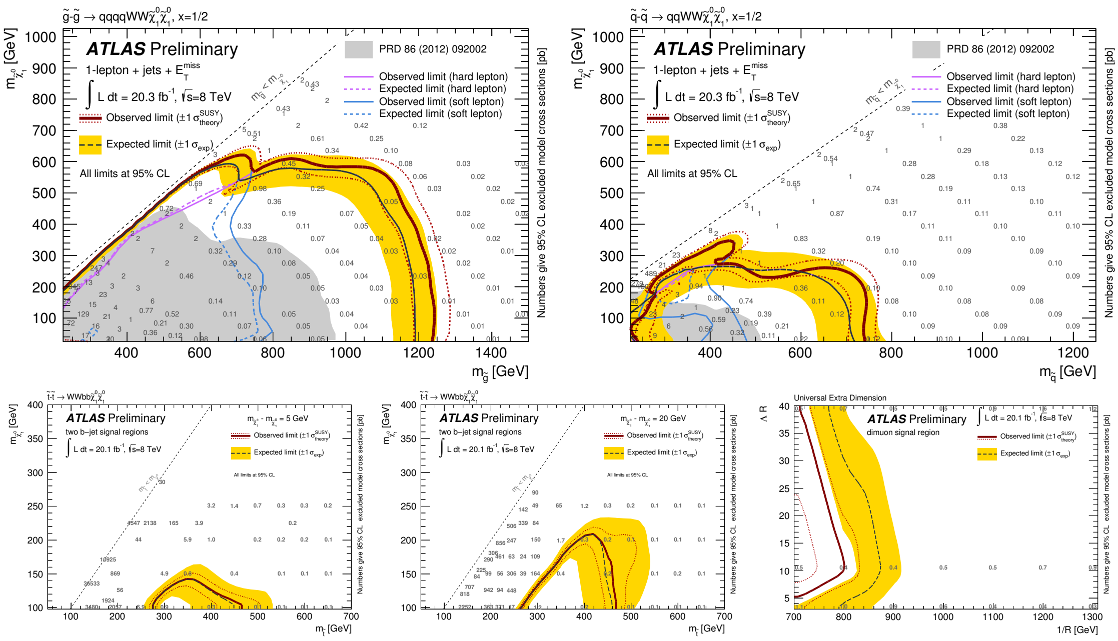

Figure 1: 95% CL exclusion limit from the single-lepton channels in the gluino simplified model and the first and second generation squark simplified model for the case in which the chargino mass is fixed at $x = 1/2$, where $x = (m_{\tilde{\chi}_1^\pm} - m_{\tilde{\chi}_1^0})/(m_{\tilde{g}(\tilde{q})} - m_{\tilde{\chi}_1^0})$, (top), from the 2-$b$-jets channels in the top squark pair production simplified model for the case in which the mass difference between the lightest chargino and the LSP is 5 GeV or 20 GeV (bottom left and center) and from the dimuon channel in the mUED model (bottom right). The blue and purple full (dashed) lines show the observed (expected) exclusion obtained from the soft (combined 3- and 5-jets channels) and the hard-lepton analyses [5], respectively, while the dark grey dashed (solid red) lines show the expected (observed) exclusion obtained by combining the soft and hard-lepton analyses (top). The observed limit set by the previous ATLAS analysis [6] using 7 TeV data is shown as a grey area.

References

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