EUROPEAN ORGANISATION FOR NUCLEAR RESEARCH (CERN)

CERN-PH-EP-2013-119

Submitted to: JHEP

arXiv:1308.2631v1 [hep-ex] 12 Aug 2013

Search for direct third-generation squark pair production in final states with missing transverse momentum and two b-jets in $\sqrt{s} = 8$ TeV pp collisions with the ATLAS detector.

The ATLAS Collaboration

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The results of a search for pair production of supersymmetric partners of the Standard Model third-generation quarks are reported. This search uses 20.1 fb^{-1} of pp collisions at $\sqrt{s} = 8$ TeV collected by the ATLAS experiment at the Large Hadron Collider. The lightest bottom and top squarks ($\tilde{b}_1$ and $\tilde{t}_1$ respectively) are searched for in a final state with large missing transverse momentum and two jets identified as originating from b-quarks. No excess of events above the expected level of Standard Model background is found. The results are used to set upper limits on the visible cross section for processes beyond the Standard Model. Exclusion limits at the 95% confidence level on the masses of the third-generation squarks are derived in phenomenological supersymmetric R-parity-conserving models in which either the bottom or the top squark is the lightest squark. The $\tilde{b}_1$ is assumed to decay via $\tilde{b}_1 \to b\tilde{\chi}_1^0$ and the $\tilde{t}_1$ via $\tilde{t}_1 \to b\tilde{\chi}_1^{\pm}$, with undetectable products of the subsequent decay of the $\tilde{\chi}_1^{\pm}$ due to the small mass splitting between the $\tilde{\chi}_1^{\pm}$ and the $\tilde{\chi}_1^0$.

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Contents

1 Introduction

Supersymmetry (SUSY) [1–9] provides an extension of the Standard Model (SM) that solves the hierarchy problem [10–13] by introducing supersymmetric partners of the known bosons and fermions. In the framework of the R-parity-conserving minimal supersymmetric extension of the SM (MSSM) [14–18], SUSY particles are produced in pairs and the lightest supersymmetric particle (LSP) is stable, providing a possible candidate for dark matter. In a large variety of models, the LSP is the lightest neutralino ($\tilde{\chi}_1^0$). The coloured superpartners of quarks and gluons, the squarks ($\tilde{q}$) and the gluinos ($\tilde{g}$), if not too heavy, would be produced in strong interaction processes at the Large Hadron Collider (LHC) [19] and decay via cascades ending with the LSP. The undetected LSP would result in missing transverse momentum while the rest of the cascade would yield final states with multiple jets and possibly leptons.

A study of the expected SUSY particle spectrum derived from naturalness considerations [20, 21] suggests that the supersymmetric partners of the third-generation SM quarks are the lightest coloured supersymmetric particles. This may lead to the lightest bottom squark (sbottom, $\tilde{b}_1$) and top squark (stop, $\tilde{t}_1$) mass eigenstates being significantly lighter than the other squarks and the gluinos. As a consequence, $\tilde{b}_1$ and $\tilde{t}_1$ could be pair-produced with relatively large cross sections at the LHC.

Two possible sets of SUSY mass spectra are considered in this paper. In the first set of scenarios, the lightest sbottom is the only coloured sparticle contributing to the production processes and it only decays via $\tilde{b}_1 \to b\tilde{\chi}_1^0$. In the second set, the lightest stop is the only coloured sparticle allowed in the production processes and it decays exclusively via $\tilde{t}_1 \to b\tilde{\chi}_1^\pm$, where the lightest chargino ($\tilde{\chi}_1^\pm$) decays via a virtual W boson into the three-body final state $\tilde{\chi}_1^0 f \bar{f}'$. In the cases considered in this article, the fermions f and f' may have transverse momenta below the reconstruction thresholds applied in the analysis, as a consequence of a small value for $\Delta m \equiv m_{\tilde{\chi}_1^\pm} - m_{\tilde{\chi}_1^0}$.

In both scenarios, events are characterised by the presence of two jets originating from the hadronisation of the b-quarks and large missing transverse momentum. Results of searches for direct sbottom and stop production have been previously reported by the ATLAS [22–27] and CMS [28–30] experiments at the LHC, and by the Tevatron [31, 32] and LEP [33] experiments.

2 The ATLAS detector and data samples

The ATLAS detector [34] consists of inner tracking devices surrounded by a superconducting solenoid, electromagnetic and hadronic calorimeters and a muon spectrometer with a magnetic field produced by a set of toroids. The inner detector (ID), in combination with a superconducting solenoid magnet with a central field of 2 T, provides precision tracking and momentum measurement of charged particles in a pseudorapidity[1] range $|\eta| < 2.5$ and allows efficient identification of jets originating from b-hadron decays using impact parameter measurements and reconstructed secondary decay vertices. The ID consists of a silicon pixel detector, a silicon microstrip detector and a straw tube tracker ($|\eta| < 2.0$) that also provides transition radiation measurements for electron identification. The calorimeter system covers the pseudorapidity range $|\eta| < 4.9$. It is composed of sampling calorimeters with either liquid argon or scintillating tiles as the active medium. The muon spectrometer has separate trigger and high-precision tracking chambers, the latter providing muon identification and momentum measurement for $|\eta| < 2.7$.

The data sample used in this analysis was taken during the period from March to December 2012 with the LHC operating at a pp centre-of-mass energy of $\sqrt{s} = 8$ TeV. Candidate signal events are selected using a trigger based on a missing transverse momentum selection ($E_\mathrm{T}^\mathrm{miss}$), which is found to be 99% efficient for events passing the offline selection of $E_\mathrm{T}^\mathrm{miss} > 150$ GeV. The trigger efficiency variations over data-taking

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[1] ATLAS uses a right-handed coordinate system with its origin at the nominal interaction point (IP) in the centre of the detector and the z-axis along the beam pipe. The x-axis points from the IP to the centre of the LHC ring, and the y-axis points upward. Cylindrical coordinates (r, ϕ) are used in the transverse plane, ϕ being the azimuthal angle around the beam pipe. The pseudorapidity is defined in terms of the polar angle θ as $\eta = -\ln\tan(\theta/2)$. The distance ΔR in the η–ϕ space is defined as $\Delta R = \sqrt{(\Delta\eta)^2 + (\Delta\phi)^2}$.

periods are measured to be less than 1% after the offline requirements. After the application of beam, detector, and data-quality requirements, the total integrated luminosity considered is 20.1 fb^{-1}. The uncertainty on the integrated luminosity is ±2.8%. It is derived, following the same methodology as that detailed in ref. [35], from a preliminary calibration of the luminosity scale using beam-separation scans performed in November 2012. Events with final-state electrons or muons that satisfy single-lepton or dilepton triggers are used to define control regions in a total data sample of 20.3 fb^{-1}. A requirement on the transverse momentum $p_{\mathrm{T}} > 25$ GeV is applied to the highest-p_{T} electron or muon to ensure the trigger selection is fully efficient.

3 Simulated event samples

Simulated Monte Carlo (MC) event samples are used to aid in the description of the background and to model the SUSY signal. All SM MC samples utilised in the analysis are produced using the ATLAS Underlying Event Tune 2B [36] and are processed through the ATLAS detector simulation [37] based on GEANT4 [38] or passed through a fast simulation using a parameterisation of the performance of the ATLAS electromagnetic and hadronic calorimeters [39]. The effect of multiple pp interactions per bunch crossing (pile-up) is also taken into account.

The top-quark pair ($t\bar{t}$) background is simulated with POWHEG-1.0 [40] interfaced to PYTHIA-6.426 [41] for the fragmentation and hadronisation processes. The top-quark mass is fixed at 172.5 GeV, and the next-to-leading-order (NLO) parton distribution function (PDF) set CT10 [42] is used. Samples from ALPGEN-2.14 [43] and POWHEG each interfaced to HERWIG-6.520 for the fragmentation and hadronisation processes, including JIMMY-4.31 [44] for the underlying event description, are used to estimate the generator and fragmentation systematic uncertainties, while ACERMC-3.8 [45] interfaced to PYTHIA samples are used to estimate the showering uncertainties. Single top-quark production for the s-channel and Wt processes is simulated with MC@NLO-4.06 interfaced to HERWIG+JIMMY, while the t-channel process is simulated with ACERMC interfaced to PYTHIA and using the CTEQ6L1 [42] PDF set. Samples of $t\bar{t}+W/Z$ events are generated using the leading-order generator MADGRAPH-5.1.4.8 [46] interfaced to PYTHIA for the fragmentation and hadronisation processes. Samples of Z/γ^{*} or W production, both in association with up to five jets, are produced with SHERPA-1.4.1 [47]. MC samples of dibosons (ZZ, WZ and WW) are generated using SHERPA.

The background predictions are normalised to theoretical cross sections, calculated including higher-order QCD corrections where available, and are compared to data in appropriate control regions. The inclusive cross sections for Z+jets and W+jets processes are calculated with DYNNLO [48] with the MSTW 2008 next-to-next-to-leading-order PDF set [49]. Approximate NLO+NNLL (next-to-next-to-leading-logarithm) cross sections are used in the normalisation of the $t\bar{t}$ [50] and Wt [51] samples. Cross sections calculated at NLO are used for the $t\bar{t} + W$ and $t\bar{t} + Z$ samples [52] and for the diboson samples [53].

The SUSY signal samples are generated using MadGraph interfaced to Pythia (with PDF set CTEQ6L1) to ensure an accurate treatment of the initial-state radiation (ISR). Additional samples with different ISR parameter values are generated to evaluate the ISR systematic uncertainty. Polarisation effects due to the choice of left- and right-handed scalar sbottom or stop mixing were found to have a negligible impact on the analysis. Signal cross sections are calculated to next-to-leading-order in the strong coupling constant, adding the resummation of soft gluon emission at next-to-leading-logarithmic accuracy (NLO+NLL) [54–56]. The nominal cross section and its uncertainty are taken from an envelope of cross-section predictions using different PDF sets and factorisation and renormalisation scales, as described in ref. [57].

4 Physics object reconstruction

Jets are reconstructed from three-dimensional cell-energy clusters in the calorimeter using the anti-k_t jet algorithm [58, 59] with a radius parameter of 0.4. The measured jet energy is corrected for inhomogeneities and for the non-compensating nature of the calorimeter by weighting energy deposits arising from electromagnetic and hadronic showers by correction factors derived from MC simulations and validated with data. An additional calibration is subsequently applied to the corrected jet energies, relating the response of the calorimeter to the true jet energy [60]. The impact of additional collisions in the same or neighbouring bunch crossings is accounted for using corrections derived as a function of the average number of interactions per event and of the number of reconstructed primary vertices. Jets are required to have $p_{\mathrm{T}} > 20$ GeV, and are reconstructed in the range $|\eta| < 4.9$.

Events are rejected if they include jets failing the quality criteria described in ref. [60]. To further reject spurious jet signals originating from cosmic rays or detector malfunctions, additional criteria are applied to the charged p_{T} fraction (f_{ch}), defined as the sum of the p_{T} of all tracks associated with the jet divided by the jet p_{T}, and to the fraction of the jet energy contained in the electromagnetic layers of the calorimeter (f_{em}). Events are rejected if any of the two leading jets with $p_{\mathrm{T}} >$ 100 GeV and $|\eta| < 2.0$ satisfies either $f_{\mathrm{ch}} < 0.02$ or both $f_{\mathrm{ch}} < 0.05$ and $f_{\mathrm{em}} > 0.9$. To remove jets from additional pp collisions, all jets with $p_{\mathrm{T}} < 50$ GeV and $|\eta| < 2.5$ are required to have at least one track identified as coming from the primary vertex. The primary vertex itself is defined as the vertex with the highest summed track p_{T}^2.

Jets within the nominal acceptance of the ID ($|\eta| < 2.5$) and with $p_{\mathrm{T}} > 20$ GeV, are selected as originating from a b-quark (b-tagged) if they satisfy requirements on the impact parameter of the ID tracks, the secondary vertex reconstruction and the topology of b- and c-hadron decays inside the jet. The b-tagging algorithm [61] uses a multivariate technique and, for this analysis, is configured to achieve an efficiency of 60% for tagging b-jets in a MC sample of $t\bar{t}$ events with corresponding rejection factors of 580, 8 and 23 against jets originating from light quarks, c-quarks and τ-leptons, respectively.

Electrons are reconstructed from cell-energy clusters in the electromagnetic calorimeter matched to a track in the ID. Electron candidates are required to have $p_{\mathrm{T}} > 7$ GeV and $|\eta| < 2.47$ and must satisfy the “medium” selection criteria described in ref. [62] and reoptimized for 2012 data. Electrons used to define the control regions are selected using the “tight” criteria, $p_{\mathrm{T}} > 20$ GeV, and with an additional isolation requirement that the total transverse momentum of charged tracks within a cone of $\Delta R = 0.2$ around the candidate be less than 10% of the reconstructed p_{T}. Muon candidates are identified using a match between an extrapolated ID track and one or more track segments in the muon spectrometer [63], and are required to have $p_{\mathrm{T}} > 6$ GeV and $|\eta| < 2.4$. Muons used to define the control regions are also required to have $p_{\mathrm{T}} > 20$ GeV and less than 1.8 GeV deposited in the calorimeter within a cone of $\Delta R = 0.2$ around the candidate.

Following their reconstruction, candidate jets and leptons may point to the same energy deposits in the calorimeter. These overlaps are resolved by first discarding any jet candidate within $\Delta R = 0.2$ of an electron candidate. Then, any electron or muon candidate within $\Delta R = 0.4$ of any surviving jet is discarded.

The missing transverse momentum, $\boldsymbol{p}_{\mathrm{T}}^{\mathrm{miss}}$, with magnitude $E_{\mathrm{T}}^{\mathrm{miss}}$, is constructed as the negative of the vector sum of the transverse momentum of all muons and electrons with p_{T} >10 GeV, jets with p_{T} >20 GeV, and calibrated calorimeter energy clusters with $|\eta|$ <4.9 not assigned to these objects [64].

5 Event selection

Two sets of signal regions are defined to provide sensitivity to the kinematic topologies associated with different mass splittings between the sbottom or the stop and the neutralino. In all cases, the presence of at least one primary vertex (with at least five associated tracks with $p_{\mathrm{T}} > 0.4$ GeV) is required. Events are selected with $E_{\mathrm{T}}^{\mathrm{miss}} > 150$ GeV and no electrons or muons identified in the final state. For the signal region selections, jets within $|\eta| < 2.8$ are ordered according to their p_{T}, with n being their total number, and two jets are required to be b-tagged. The following event-level variables are defined:

- $\Delta\phi_{\mathrm{min}}$ is defined as the minimum azimuthal distance, $\Delta\phi$, between any of the three leading jets and the $\boldsymbol{p}_{\mathrm{T}}^{\mathrm{miss}}$ vector

  $$\Delta\phi_{\mathrm{min}} = \min(|\phi_1 - \phi_{\boldsymbol{p}_{\mathrm{T}}^{\mathrm{miss}}}|, |\phi_2 - \phi_{\boldsymbol{p}_{\mathrm{T}}^{\mathrm{miss}}}|, |\phi_3 - \phi_{\boldsymbol{p}_{\mathrm{T}}^{\mathrm{miss}}}|).$$

  Background multi-jet events are typically characterised by small values of $\Delta\phi_{\mathrm{min}}$;

- m_{eff} is defined as the scalar sum of the p_{T} of the k leading jets and the $E_{\mathrm{T}}^{\mathrm{miss}}$

  $$m_{\mathrm{eff}}(k) = \sum_{i=1}^{k} (p_{\mathrm{T}}^{\mathrm{jet}})_i + E_{\mathrm{T}}^{\mathrm{miss}},$$

  where the index refers to the p_{T}-ordered list of jets;

- $H_{\mathrm{T},3}$ is defined as the scalar sum of the p_{T} of the n jets, without including the three leading jets

  $$H_{\mathrm{T},3} = \sum_{i=4}^{n} (p_{\mathrm{T}}^{\mathrm{jet}})_i,$$

  where the index refers to the p_{T}-ordered list of jets;

- m_{bb} is defined as the invariant mass of the two b-tagged jets in the event;

- m_{CT} is the contransverse mass [65] and is a kinematic variable that can be used to measure the masses of pair-produced semi-invisibly decaying heavy particles. For two identical decays of heavy particles into two visible particles (or particle aggregates) v_1 and v_2, and two invisible particles, m_{CT} is defined as:

  $$m_{\mathrm{CT}}^2(v_1, v_2) = \left[E_{\mathrm{T}}(v_1) + E_{\mathrm{T}}(v_2)\right]^2 - \left[\boldsymbol{p}_{\mathrm{T}}(v_1) - \boldsymbol{p}_{\mathrm{T}}(v_2)\right]^2,$$

  where $E_{\mathrm{T}} = \sqrt{p_{\mathrm{T}}^2 + m^2}$. In this analysis, v_1 and v_2 are the two b-jets from the squark decays and the invisible particles are the two $\tilde{\chi}_1^0$ particles or chargino decay products, depending on the assumption considered. The contransverse mass is an invariant under equal and opposite boosts of the parent particles in the transverse plane. For parent particles produced with small transverse boosts, m_{CT} is bounded from above by an analytical combination of particle masses. This bound is saturated when the two visible objects are co-linear. For $t\bar{t}$ events this kinematic bound is at 135 GeV. For production of sbottom pairs the bound is given by:

  $$m_{\mathrm{CT}}^{\mathrm{max}} = \frac{m^2(\tilde{b}) - m^2(\tilde{\chi}_1^0)}{m(\tilde{b})}.$$

  A similar equation can be written for production of stop pairs in terms of $m_{\tilde{t}_1}$ and $m_{\tilde{\chi}_1^\pm}$. A correction to m_{CT} for the transverse boost due to ISR is also applied [66].

The definition of the two signal regions is summarised in table 1. Signal region A (SRA) targets signal events with large mass splitting between the squark and the neutralino, identifying two b-tagged high-p_{T} leading jets as products of the two sbottom or stop decays. Events are rejected if any other central ($|\eta| < 2.8$) jets

Description	Signal Regions	
	SRA	SRB
Event cleaning	Common to all SR	
Lepton veto	No e/μ after overlap removal with $p_{\mathrm{T}} > 7(6)$ GeV for $e(\mu)$	
$E_{\mathrm{T}}^{\mathrm{miss}}$	> 150 GeV	> 250 GeV
Leading jet $p_{\mathrm{T}}(j_1)$	> 130 GeV	> 150 GeV
Second jet $p_{\mathrm{T}}(j_2)$	> 50 GeV,	> 30 GeV
Third jet $p_{\mathrm{T}}(j_3)$	veto if > 50 GeV	> 30 GeV
$\Delta\phi(\boldsymbol{p}_{\mathrm{T}}^{\mathrm{miss}}, j_1)$	-	> 2.5
b-tagging	leading 2 jets ($p_{\mathrm{T}} > 50$ GeV, $\lvert\eta\rvert < 2.5$)	2nd- and 3rd-leading jets ($p_{\mathrm{T}} > 30$ GeV, $\lvert\eta\rvert < 2.5$)
	$n_{b\text{-jets}} = 2$	
$\Delta\phi_{\mathrm{min}}$	> 0.4	> 0.4
$E_{\mathrm{T}}^{\mathrm{miss}}/m_{\mathrm{eff}}(k)$	$E_{\mathrm{T}}^{\mathrm{miss}}/m_{\mathrm{eff}}(2) > 0.25$	$E_{\mathrm{T}}^{\mathrm{miss}}/m_{\mathrm{eff}}(3) > 0.25$
m_{CT}	$> 150, 200, 250, 300, 350$ GeV	-
$H_{\mathrm{T},3}$	-	< 50 GeV
m_{bb}	> 200 GeV	-

Table 1. Summary of the event selection in each signal region.

are found with $p_{\mathrm{T}} > 50$ GeV. Multijet background is suppressed by selecting events with large $\Delta\phi_{\mathrm{min}}$ and $E_{\mathrm{T}}^{\mathrm{miss}}/m_{\mathrm{eff}}$. The requirement $m_{bb} > 200$ GeV is added to reduce backgrounds from production of top-quark (including top-quark pairs and single top-quark production processes), and Z-bosons in association with heavy-flavour jets. As a final selection criterion, five different thresholds on m_{CT} ranging from 150 GeV to 350 GeV are applied. For a signal point corresponding to $m_{\tilde{b}_1} = 500$ GeV and $m_{\tilde{\chi}_1^0} = 1$ GeV, 3% of the simulated events are retained by the SRA selection with $m_{\mathrm{CT}} > 250$ GeV.

Signal region B (SRB) is defined to enhance the sensitivity for a small squark–neutralino mass difference by explicitly selecting events with a high-p_{T} jet, which is likely to have been produced as initial state radiation, recoiling against the squark-pair system. High thresholds on the leading jet p_{T} and on the missing transverse momentum, which are required to be almost back-to-back in ϕ, are imposed. The leading jet is required to be not b-tagged, and two additional jets are required to be b-tagged. As for SRA, the multi-jet background is suppressed with appropriate selections on $\Delta\phi_{\rm min}$ and $E_{\rm T}^{\rm miss}/m_{\rm eff}$. A final upper requirement on the additional hadronic activity in the event, $H_{\rm T,3}$ <50 GeV completes the selection for SRB. For a signal point corresponding to $m_{\tilde{b}_1} = 300$ GeV and $m_{\tilde{\chi}_1^0} = 270$ GeV, 10% of the simulated events are retained by the SRB selection.

6 Background estimate

The dominant SM background processes in the signal regions are the production of W or Z bosons in association with heavy-flavour jets (referred to as W+hf and Z+hf) and the production of top-quarks. Events with Z+hf production followed by $Z \rightarrow \nu\bar{\nu}$ decay have the same signature as the signal and are the dominant background in SRA. Top-quark (dominant in SRB) and W+hf production satisfy the signal region selections when a charged lepton is produced but the event is not rejected, either because the lepton is a hadronically decaying τ, or because the electron or muon is not reconstructed. The dominant backgrounds are normalised in dedicated control regions (CRs) and then extrapolated to the signal regions using MC simulation. The control regions, detailed below, are defined by explicitly requiring the presence of one or two leptons (electrons or muons) in the final state together with further selection criteria similar to those of the corresponding signal regions. In particular, events with additional lepton candidates are vetoed applying the same lepton requirements used to veto events in the signal regions. The single top-quark contribution accounts for 5% to 20% of the total top-quark background contribution, depending on the signal region considered, and is added to the $t\bar{t}$ background contribution with a relative normalisation corresponding to that predicted by the MC simulation, as described in section 3.

The contributions from diboson and $t\bar{t} + W/Z$ processes are sub-dominant and they are collectively called "Others" in the following. They are estimated from MC simulation for both the signal and the control regions.

Finally, the background from multi-jet production is estimated from data using a procedure described in detail in ref. [67] modified to account for the flavour of the jets. The procedure consists of smearing the jet response in low-$E_{\rm T}^{\rm miss}$ seed events. The Gaussian core of the jet response function is obtained from dijet events, while the non-Gaussian tails are obtained from three-jet events, where the $E_{\rm T}^{\rm miss}$ can be unambiguously attributed to the mis-measurement of one of the jets. The contribution from multi-jet production in the control regions is found to be negligible.

For SRA, the contributions from top-quark, Z+jets and W+jets production are estimated simultaneously with a profile likelihood fit to three control regions. For SRB it is difficult to identify a control region that probes the W+jets background normalisation. Therefore, this contribution is estimated purely from MC simulation as described in section 3, and only control regions for top-quark and Z+jets are defined.

A set of same-flavour opposite-sign two-lepton control regions with dilepton invariant mass near the Z mass ($75 < m_{\ell\ell} < 105$ GeV) provides a data sample dominated by Z production. For these control regions, labelled in the following as CRA_SF and CRB_SF, the p_{T} of the leptons is added vectorially to the $\boldsymbol{p}_{\mathrm{T}}^{\mathrm{miss}}$ to mimic the expected missing transverse momentum spectrum of $Z \to \nu\bar{\nu}$ events, and is indicated in the following as $E_{\mathrm{T}}^{\mathrm{miss}}$ (lepton corrected). In addition, the p_{T} of the leading lepton is required to be above 90 GeV in order to further enhance the Z production contribution. In the case of CRA_SF, a $m_{bb} > 200$ GeV selection is also imposed.

The set of control regions with exactly one lepton (e, μ) in the final state provides a data sample dominated by top-quark and W+jets production. A selection criterion is applied to the tranverse mass, 40 GeV $< m_{\mathrm{T}} <$ 100 GeV, where m_{T} is defined as:

$$\mathrm{m_T} = \sqrt{2p_{\mathrm{T}}^{\mathrm{lep}} E_{\mathrm{T}}^{\mathrm{miss}} - 2\mathbf{p}_{\mathrm{T}}^{\mathrm{lep}} \cdot \boldsymbol{p}_{\mathrm{T}}^{\mathrm{miss}}}$$

In the following, these control regions are labelled as CRA_1L and CRB_1L. CRA_1L is used to estimate the contribution of the W+jets background, which is enhanced by the selection criterion $m_{\mathrm{CT}} > 150$ GeV in SRA. CRB_1L is used to estimate the top-quark background in SRB.

To estimate top-quark production in SRA, a different-flavour opposite-sign two-lepton control region (CRA_DF) is defined requiring one electron and one muon in the final state with $m_{e\mu} > 50$ GeV and m_{CT} >75 GeV.

The definitions of the control regions are summarised in tables 2 and 3.

CRA_1L	CRA_SF	CRA_DF
One e or μ	$e^{\pm}e^{\mp}$ or $\mu^{\pm}\mu^{\mp}$	$e^{\pm}\mu^{\mp}$
Veto additional lepton candidates ($p_{\mathrm{T}}(e)$ >7 GeV $p_{\mathrm{T}}(\mu)$ >6 GeV)		
Only two reconstructed jets with $p_{\mathrm{T}} > 50$ GeV		
$p_{\mathrm{T}}(j_1) > 130$ GeV $p_{\mathrm{T}}(j_2) > 50$ GeV $E_{\mathrm{T}}^{\mathrm{miss}} > 100$ GeV	$p_{\mathrm{T}}(j_1) > 50$ GeV $p_{\mathrm{T}}(j_2) > 50$ GeV $E_{\mathrm{T}}^{\mathrm{miss}}$(lepton-corrected) > 100 GeV	$p_{\mathrm{T}}(j_1) > 130$ GeV $p_{\mathrm{T}}(j_2) > 50$ GeV $E_{\mathrm{T}}^{\mathrm{miss}} > 100$ GeV
Two reconstructed b-jets ($p_{\mathrm{T}} > 50$)		
40 GeV $< m_{\mathrm{T}} <$ 100 GeV	75 GeV $< m_{\ell\ell} <$ 105 GeV	$m_{\ell\ell} > 50$ GeV
$m_{\mathrm{CT}} > 150$ GeV	lepton $p_{\mathrm{T}} > 90$ GeV	$m_{\mathrm{CT}} > 75$ GeV
–	$m_{bb} > 200$ GeV	–

Table 2. Definitions of the three SRA control regions.

CRB_1L	CRB_SF
One e or μ	$e^{\pm}e^{\mp}$ or $\mu^{\pm}\mu^{\mp}$
Veto additional lepton candidates ($p_{\mathrm{T}}(e)$ >7 GeV $p_{\mathrm{T}}(\mu)$ >6 GeV)	
Only three reconstructed jets with $p_{\mathrm{T}} > 30$ GeV	
$p_{\mathrm{T}}(j_1) > 130$ GeV $E_{\mathrm{T}}^{\mathrm{miss}} > 120$ GeV	$p_{\mathrm{T}}(j_1) > 50$ GeV $E_{\mathrm{T}}^{\mathrm{miss}}$(lepton-corrected) > 100 GeV
j_1 anti b-tagged; j_2 and j_3 b-tagged	
40 GeV $< m_{\mathrm{T}} <$ 100 GeV	75 GeV $< m_{\ell\ell} <$ 105 GeV
–	Lepton $p_{\mathrm{T}} > 90$ GeV
$H_{\mathrm{T},3} < 50$ GeV	

Table 3. Definitions of the two SRB control regions.

The distribution of the m_{CT} variable in CRA_DF (before the m_{CT} selection) and of the leading lepton p_{T} (before the p_{T} selection) in CRA_SF are shown before the fit in figure 1. Similarly, the transverse mass distribution of the leading-lepton–$E_{\mathrm{T}}^{\mathrm{miss}}$ system in CRB_1L (before the m_{T} selection) and the invariant mass distribution of the two leptons in CRB_SF (before the $m_{\ell\ell}$ selection) are shown in figure 2. In these figures the data set used corresponds to an integrated luminosity of 20.3 fb^{-1} and the normalisations described in section 3 are assumed.

The observed numbers of events in the various CRs are used to generate internally consistent SM background estimates for each of the SRs via a profile likelihood fit. This procedure takes into account CR correlations due to common systematic uncertainties as well as contaminations from other SM processes and/or SUSY signal events, when a particular model is considered for exclusion. Systematic uncertainties, discussed in detail in section 7, are treated as nuisance parameters in the fit and are constrained with Gaussian functions taking into account correlations between sample estimates. The likelihood function is built as the product of Poisson probability functions, describing the observed and expected number of events in the control and (when excluding SUSY models) signal regions, and the constraints on the nuisance parameters. As a result, the impact of some of the systematic uncertainties that are correlated between the CRs and the corresponding SR is reduced.

The free parameters of the fit are the overall normalisation values of the top-quark, W+jets and Z+jets processes for SRA, and of the top-quark and Z+jets processes for SRB. The contributions from all other background processes are fixed at the values expected from MC. The fit results in the control regions are summarised

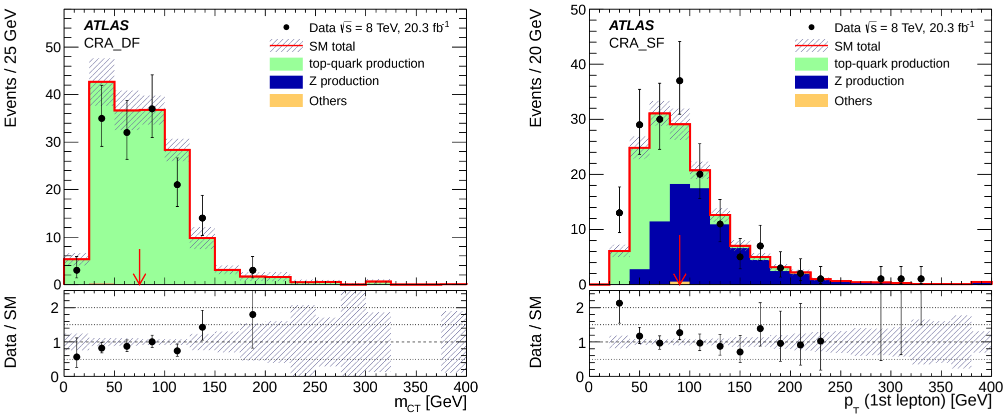

Figure 1. Left: m_{CT} distribution in CRA_DF omitting the requirement on the m_{CT} variable. Right: leading lepton p_{T} distribution in CRA_SF with all the selections applied except the requirement on this variable. The red arrows indicate where a selection on the corresponding variable is applied. The shaded band includes both the detector and theoretical systematic uncertainties. The SM prediction is normalised according to the MC expectations. The last bin in each histogram contains the integral of all events with values greater than the upper axis bound.

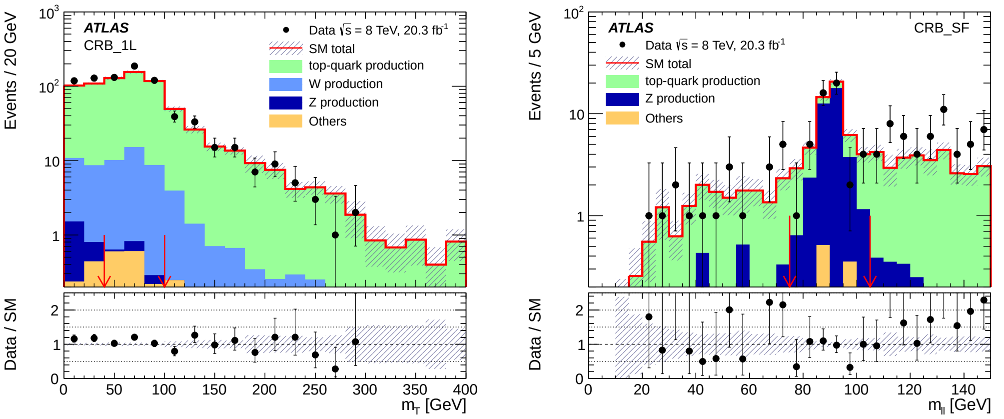

Figure 2. Left: transverse mass distribution of the leading-lepton–$E_{\mathrm{T}}^{\mathrm{miss}}$ system in CRB_1L omitting the m_{T} requirement. Right: dilepton invariant mass distribution in CRB_SF omitting the $m_{\ell\ell}$ requirement. The red arrows indicate where a selection on the corresponding variable is applied. The shaded band includes both the detector and theoretical systematic uncertainties. The SM prediction is normalised according to the MC expectations.

in tables 4 and 5 for SRA and SRB, respectively. These results are found to be compatible with MC yields predicted before the fit, which are also given in the tables.

The predictions from the fit are in good agreement with the MC estimates with a maximum discrepancy of two standard deviations observed in one of the control regions.

Channel	**CRA_1L**	**CRA_SF**	**CRA_DF**
Observed events	135	68	75
Fitted background events			
Total SM	135 ± 11	68 ± 8	75 ± 9
Top-quark production	91 ± 17	10.0 ± 1.3	75 ± 9
Z production	0.46 ± 0.12	58 ± 8	$0.07^{+0.10}_{-0.07}$
W production	40 ± 20	< 0.1	0.06 ± 0.03
Others	3.8 ± 2.0	0.44 ± 0.18	0.37 ± 0.13
MC expected events			
Top-quark production	100	11.0	82
Z production	0.44	54	0.07
W production	42	< 0.1	0.07
Others	3.8	0.44	0.37

Table 4. Results of the fit for the control regions adopted for SRA. Expected yields derived from MC simulation using theoretical cross sections are also shown. Uncertainties quoted include statistical and detector-related systematic effects. The central values of the fitted sum of backgrounds in the control regions agree with the observations by construction. The uncertainty on the total background estimate can be smaller than some of the individual uncertainties due to anticorrelations.

The reliability of the MC extrapolation of the SM background estimate outside of the control regions is evaluated in several validation regions. The first set of validation regions is defined with the same kinematic selection as the control regions but requiring only one jet to be b-tagged. They are used to verify the performance of the b-tagging algorithm in a larger sample of events. A second set of validation regions is defined with the same selection criteria as the signal regions, but with one of the requirements inverted. In all cases these validation regions are background-dominated with a potential signal contamination of less than 20% for the signal models considered. For SRA, two validation regions are explored by imposing either $m_{\mathrm{CT}} < 100$ GeV or $m_{bb} < 200$ GeV. To validate SRB, a validation region with the selection $H_{\mathrm{T},3} > 50$ GeV is defined as well as a second validation region with two leptons of different flavour to verify the normalisation of the top-quark background.

Good agreement is found in each case, with a difference of less than one standard deviation between the expectations and the number of observed events.

7 Systematic uncertainties

The dominant detector-related systematic effects are due to the uncertainties on the jet energy scale (JES) and resolution (JER), and on the b-tagging efficiency. The

Channel	**CRB_1L**	**CRB_SF**
Observed events	437	48
Fitted background events		
Total SM	437 ± 21	48 ± 7
Top-quark production	403 ± 27	16.2 ± 2.2
Z production	0.26 ± 0.15	31 ± 7
W production	32 ± 20	< 0.1
Others	1.4 ± 0.5	1.0 ± 0.5
MC expected events		
Top-quark production	370	15
Z production	0.32	38
W production	32	< 0.1
Others	1.4	1.0

Table 5. Results of the fit for the control regions adopted for SRB. Expected yields as derived from MC using theoretical cross sections are also shown. Uncertainties quoted include statistical and detector-related systematic effects. The central values of the fitted sum of backgrounds in the control regions agree with the observations by construction. The uncertainty on the total background estimate can be smaller than some of the individual uncertainties due to anticorrelations. The W production estimate is normalised using the nominal theoretical cross section and with the associated uncertainties discussed in section 7.

impact of these uncertainties is reduced through the normalisation of the dominant backgrounds in the control regions with kinematic selections resembling those of the corresponding signal region.

The JES uncertainty is determined using the techniques described in refs. [60, 68], leading to a slight dependence on p_{T}, η, jet flavour, number of primary vertices and proximity to adjacent jets. The JER uncertainty is obtained from in-situ measurements of the jet response asymmetry in dijet events [60]. These uncertainties on jets are propagated to the $E_{\mathrm{T}}^{\mathrm{miss}}$ measurement, and additional uncertainties on $E_{\mathrm{T}}^{\mathrm{miss}}$ arising from energy deposits not associated with any reconstructed objects are also included. The relative impact on the event yields from the JES (JER) uncertainty is between 1–5% (1–8%) in the different SRA regions and is 3% (8%) in SRB.

The b-tagging uncertainty is evaluated by varying the p_{T}- and flavour-dependent scale factors applied to each jet in the simulation within a range that reflects the systematic uncertainty on the measured tagging efficiency and rejection rates. The relative impact of this uncertainty on the final event yield is dominated by the uncertainty in the b-tagging efficiency. The uncertainty amounts to 2–10% in the different SRA regions and 2% in SRB.

In the case of SRB, an uncertainty is also associated with the requirement that jets with $p_{\mathrm{T}} < 50$ GeV have at least one track originating from the primary vertex.

It has a relative impact on the final event yields of 7%. Other detector systematic uncertainties like pile-up or trigger effects are found to have negligible impact on the analysis.

Theoretical uncertainties on the modeling of the $t\bar{t}$+jets background are assessed. The uncertainty due to the choice of the MC generator is estimated by comparing the predictions of the Powheg and Alpgen generators, both interfaced to the Herwig+Jimmy parton shower (PS) and hadronisation (HAD) calculations. The PS/HAD uncertainty is estimated by comparing samples generated with Powheg interfaced to either Pythia or Herwig+Jimmy. The uncertainty due to the ambiguity in the renormalisation and factorisation scales is estimated by individually doubling or halving them. The uncertainty in the ISR and final-state radiation (FSR) is estimated by comparing AcerMC samples generated with different amounts of ISR/FSR, as constrained by recent ATLAS measurements [69]. The PDF uncertainties are derived by varying the 52 PDFs in the CT10 NLO error set following the Hessian method and rescaling to the 68% confidence level. Since $t\bar{t}$ and single top-quark productions are treated together, these theoretical uncertainties are also assigned to the single top contribution and it was checked that they account for the difference in event kinematics between the samples. The final relative uncertainties on the yields due to theoretical uncertainties in top-quark production modeling are less than 0.7% in SRA and 4% in SRB, dominated mostly by PS/HAD and scale uncertainties.

Uncertainties in the W/Z+jets simulation are evaluated by comparing the predictions of the Sherpa and Alpgen generators and, by varying the Sherpa scales related to the matching scheme, the strong coupling constant, and the renormalisation and factorisation scales. The PDF uncertainties are evaluated following the same procedure as for the top-quark background. For SRB, W+jets production is estimated from MC simulation and an additional uncertainty of 26% due to the W+hf contribution is included [70]. The relative uncertainties on the yields are in the range 0.3–3.1% in SRA, mostly dominated by the difference between Sherpa and Alpgen. For SRB, a 3% uncertainty is assigned to Z+hf and 9% to W+hf, the latter uncertainty being dominated by the MC normalisation.

An uncertainty of 100% is derived for the multi-jet prediction by studying variations of the resolution function. Finally, uncertainties of 30% and of 50% are assigned to the cross sections of $t\bar{t} + W$ and of $t\bar{t} + Z$ production, respectively [52, 71].

8 Results and interpretation

The number of data events observed in each signal region is reported in table 6, together with the SM background expectation after the fit. Figures 3 and 4 show the comparison between the SM prediction and the observed data for some relevant kinematic distributions in SRA and SRB, respectively. An example of a SUSY pro-

Channel	**SRA, m_{CT} selection**					**SRB**
	150 GeV	200 GeV	250 GeV	300 GeV	350 GeV	
Observed	102	48	14	7	3	65
Total SM	94 ± 13	39 ± 6	15.8 ± 2.8	5.9 ± 1.1	2.5 ± 0.6	64 ± 10
Top-quark	11.1 ± 1.8	2.4 ± 1.4	0.44 ± 0.25	< 0.01	< 0.01	41 ± 7
Z production	66 ± 11	28 ± 5	11.4 ± 2.2	4.7 ± 0.9	1.9 ± 0.4	13 ± 4
W production	13 ± 6	4.9 ± 2.6	2.1 ± 1.1	1.0 ± 0.5	0.46 ± 0.26	8 ± 5
Others	4.3 ± 1.5	3.4 ± 1.3	1.8 ± 0.6	0.12 ± 0.11	$0.10^{+0.12}_{-0.10}$	2.0 ± 1.0
Multijet	0.21 ± 0.21	0.06 ± 0.06	0.02 ± 0.02	< 0.01	< 0.01	0.16 ± 0.16

Table 6. For each signal region, the observed event yield is compared with the background prediction obtained from the fit. Statistical, detector-related and theoretical systematic uncertainties are included, taking into account correlations.

cess with a large mass difference between the squark and the lightest neutralino is also shown for reference in each case.

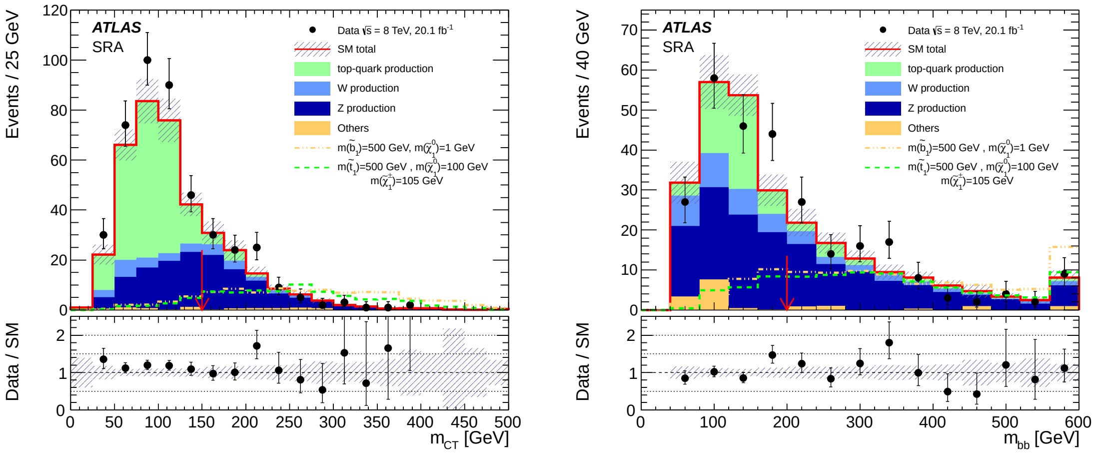

Figure 3. Left: m_{CT} distribution in SRA with all the selection criteria applied except the m_{CT} thresholds. Right: m_{bb} distribution in SRA with all selection criteria applied including $m_{\mathrm{CT}} > 150$ GeV. The shaded band includes statistical, detector-related and theoretical systematic uncertainties. The backgrounds are normalised to the values determined in the fit. The red arrows indicate where a selection on the corresponding variable is applied. For illustration the distributions expected for two signal models are displayed. The models correspond to $m_{\tilde{b}_1} = 500$ GeV and $m_{\tilde{\chi}_1^0} = 1$ GeV (orange dash-dot line) and $m_{\tilde{t}_1} = 500$ GeV and $m_{\tilde{\chi}_1^0} = 100$ GeV (green dash line). The rightmost bin in the figures includes the overflows.

No significant excess above the SM expectation is observed in any of the signal regions. The results are used to derive upper limits on the number of beyond the SM (BSM) events for each signal region, assuming no systematic uncertainties for these events and neglecting any possible contamination in the control regions. Scaling by the integrated luminosity, these can be interpreted as a corresponding upper limit

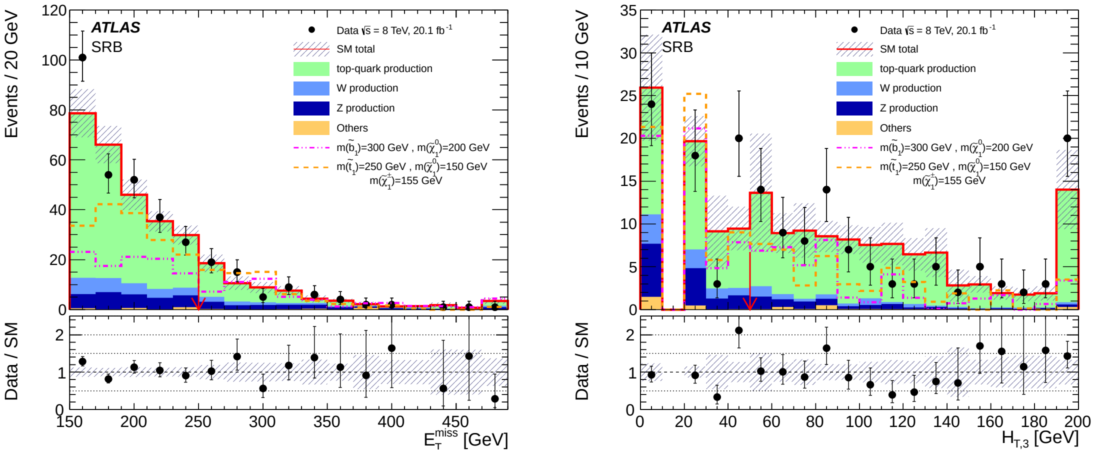

Figure 4. Left: $E_{\mathrm{T}}^{\mathrm{miss}}$ distribution with all SRB selection criteria applied except the final $E_{\mathrm{T}}^{\mathrm{miss}}$ requirement. Right: distribution of $H_{\mathrm{T},3}$ with all SRB selection criteria applied except the $H_{\mathrm{T},3}$ requirement. Since jets have $p_{\mathrm{T}} > 20$ GeV by construction, the leftmost bin contains events where no additional jets are present ($H_{\mathrm{T},3} =0$ GeV) while the second bin is empty. The shaded band includes statistical, detector-related and theoretical systematic uncertainties. The backgrounds are normalised to the values determined in the fit. The red arrows indicate where a selection on the corresponding variable is applied. For illustration the distributions expected for two signal models are displayed. The models correspond to $m_{\tilde{b}_1} = 300$ GeV and $m_{\tilde{\chi}_1^0} = 200$ GeV (purple dash-dot line) and $m_{\tilde{t}_1} = 250$ GeV and $m_{\tilde{\chi}_1^0} = 150$ GeV (orange dash line). The rightmost bin in the figures includes the overflows.

on the cross section, σ_{vis}, defined as

$$\sigma_{\mathrm{vis}} = \sigma \cdot A \cdot \epsilon$$

where σ, A and ϵ are, respectively, the production cross section, the acceptance and the selection efficiency for a BSM signal. The 95% confidence level (CL) limits are computed using the CLs prescription [72]. Table 7 summarises, for each signal region, the estimated SM background yield, the observed numbers of events, and the expected and observed upper limits on event yields from a BSM signal and on σ_{vis}.

The results are interpreted in various SUSY scenarios assuming a SUSY particle mass hierarchy such that the lightest third-generation squark decays exclusively via $\tilde{b}_1 \to b\tilde{\chi}_1^0$ or $\tilde{t}_1 \to b\tilde{\chi}_1^{\pm}$ for production of sbottom or stop pairs, respectively. For the latter case, two different values of Δm between the lightest chargino and neutralino are probed to assess the impact of the lepton and jet vetoes applied in the analysis.

Systematic uncertainties on the signal acceptance include experimental uncertainties, mostly dominated by b-tagging (20–30% in SRA, $\sim$ 15–30% in SRB) and JES (4–30% in SRA, 20–40% in SRB) uncertainties. These uncertainties are assumed to be fully correlated with those of the background.

For SRB, the uncertainties due to the modelling of ISR processes are assessed by

Signal Regions	Background estimate	Observed data	95% CL upper limit on			
			BSM event yield		σ_{vis} (fb)	
			exp.	obs.	exp.	obs.
SRA ($m_{\text{CT}} > 150$ GeV)	94 ± 13	102	32^{+13}_{-9}	38	$1.6^{+0.6}_{-0.4}$	1.9
SRA ($m_{\text{CT}} > 200$ GeV)	39 ± 6	48	19^{+8}_{-5}	26	$0.94^{+0.40}_{-0.25}$	1.3
SRA ($m_{\text{CT}} > 250$ GeV)	15.8 ± 2.8	14	$10.2^{+4.6}_{-3.0}$	9.0	$0.51^{+0.22}_{-0.14}$	0.45
SRA ($m_{\text{CT}} > 300$ GeV)	5.9 ± 1.1	7	$6.5^{+3.3}_{-2.1}$	7.5	$0.32^{+0.16}_{-0.1}$	0.37
SRA ($m_{\text{CT}} > 350$ GeV)	2.5 ± 0.6	3	$4.7^{+2.6}_{-1.6}$	5.2	$0.23^{+0.13}_{-0.08}$	0.26
SRB	64 ± 10	65	26^{+10}_{-7}	27	$1.21^{+0.45}_{-0.35}$	1.3

Table 7. Expected and observed event yields with the corresponding upper limits on BSM signal yields and $\sigma_{\text{vis}} = \sigma \cdot A \cdot \epsilon$ for all the signal regions defined.

changing the strength of the parton shower controlled by PYTHIA and by doubling and halving the values of the following three parameters: (i) the factorisation and renormalisation scales; (ii) the matching distance between a parton and a jet; (iii) the scale at which α_S is evaluated at every parton radiation step. The relative changes due to each of these individual variations are assumed to be uncorrelated and are added in quadrature. The overall uncertainty due to ISR depends on the mass difference between the squark and the LSP, with a maximum value of 30% on the signal acceptance when the mass difference is on the order of 10 GeV and quickly dropping down to a plateau of 7–10% for mass differences above 25 GeV. This uncertainty has a negligible dependence on the squark mass for the mass range considered in this analysis.

Figure 5 shows the observed (solid lines) and expected (dashed lines) exclusion limits for the sbottom pair production scenario obtained by taking, for each signal mass configuration, the signal region with the best expected limit. These limits are obtained using a likelihood test which compares the observed numbers of events in the signal regions with the fitted background expectation and the ensuing signal contamination in the corresponding CRs for a given model. Sensitivity to scenarios with large mass difference ($>$ 100 GeV) between the $\tilde{b}_1$ and the $\tilde{\chi}_1^0$ is achieved with the successive m_{CT} thresholds used in SRA. Sensitivity to scenarios with smaller mass differences is achieved predominantly with the dedicated SRB selection. Sbottom masses up to 620 GeV are excluded at 95% CL for $m_{\tilde{\chi}_1^0} < 120$ GeV. Differences in mass above 50 GeV between the $\tilde{b}_1$ and the $\tilde{\chi}_1^0$ are excluded up to sbottom masses of 300 GeV. If the branching ratio of $\tilde{b}_1 \to b\tilde{\chi}_1^0$ is reduced to 60% and assuming that the analysis is not sensitive to other possible decays, the excluded upper limit on the sbottom mass for $m_{\tilde{\chi}_1^0} < 150$ GeV is reduced to 520 GeV. Similarly for

$m_{\tilde{b}_1} = 250$ GeV, the upper limit on $m_{\tilde{\chi}_1^0}$ is reduced by 30 GeV.

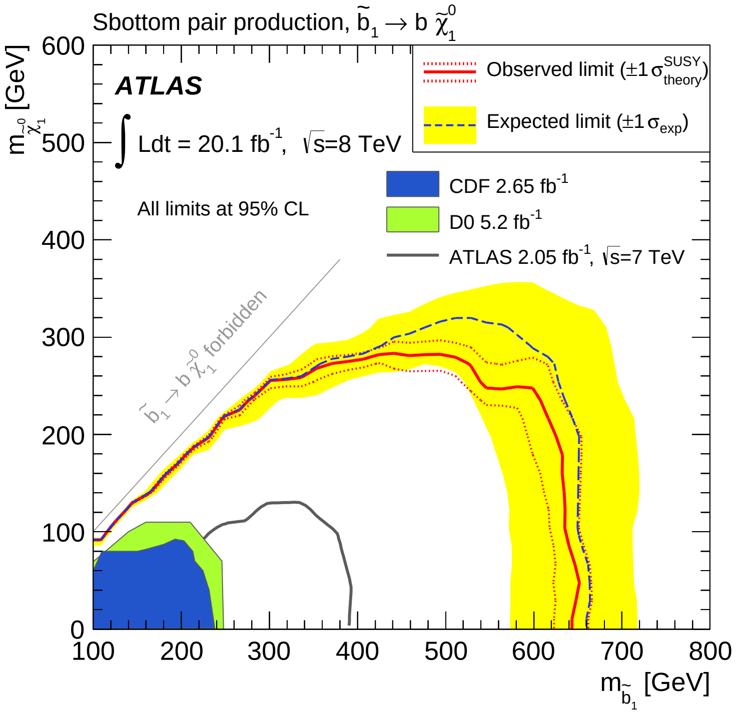

Figure 5. Expected and observed exclusion limits at 95% CL in the $(m_{\tilde{b}_1}, m_{\tilde{\chi}_1^0})$ mass plane for the sbottom pair production scenario considered. The signal region providing the best expected CLs exclusion limit is chosen at each point. The dashed (solid) lines show the expected (observed) limits, including all uncertainties except for the theoretical signal cross-section uncertainty (PDF and scale). The bands around the expected limits show the $\pm 1\sigma$ uncertainties. The dotted lines around the observed limits represent the results obtained when moving the nominal signal cross section up or down by the $\pm 1\sigma$ theoretical uncertainty. Previous limits published by ATLAS [22], CDF [31] and D0 [32] are also shown.

In the case of stop pair production with the stop decaying only into $b\tilde{\chi}_1^{\pm}$, the model depends on the masses of the three SUSY particles involved in the decay, $m_{\tilde{t}_1}$, $m_{\tilde{\chi}_1^{\pm}}$ and $m_{\tilde{\chi}_1^0}$. Limits are derived using the same procedure adopted for the sbottom pair production scenario and are presented in Figure 6 under the additional assumptions that $m_{\tilde{t}_1}$=300 GeV (upper left), $m_{\tilde{\chi}_1^{\pm}}$=150 GeV (upper right), or for a fixed value of the mass difference $\Delta m = m_{\tilde{\chi}_1^{\pm}} - m_{\tilde{\chi}_1^0}$ of 5 GeV (lower left) and 20 GeV (lower right). Stop masses up to 580 GeV (440 GeV) are excluded for $\Delta m = 5$ GeV (20 GeV) and for $m_{\tilde{\chi}_1^0} = 100$ GeV. For $\Delta m = 5$ GeV (20 GeV), neutralino masses up to 270 GeV (220 GeV) are excluded for $m_{\tilde{t}_1} = 420$ GeV. In the $\Delta m = 20$ GeV, a smaller fraction of the $(m_{\tilde{t}_1}, m_{\tilde{\chi}_1^0})$ plane is excluded since this scenario has a lower efficiency given that electrons and muons often have a p_{T} above the reconstruction threshold.

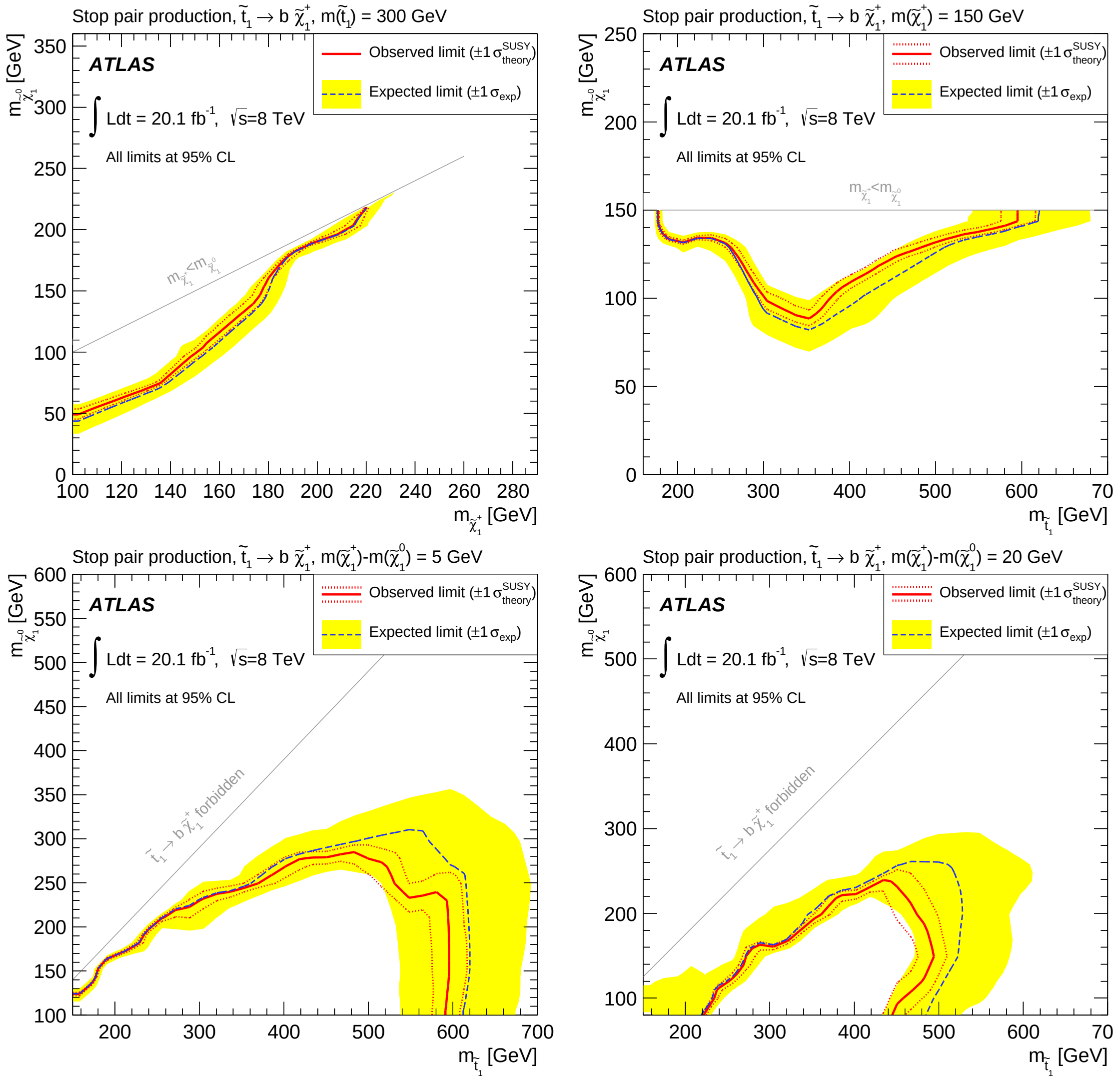

Figure 6. Expected and observed exclusion limits at 95% CL for the different stop pair production scenarios considered. Upper left: $(m_{\tilde{\chi}_1^\pm}, m_{\tilde{\chi}_1^0})$ mass plane with $m_{\tilde{t}_1} = 300$ GeV. Upper right: $(m_{\tilde{t}_1}, m_{\tilde{\chi}_1^0})$ mass plane with $m_{\tilde{\chi}_1^\pm} = 150$ GeV. Lower left: $(m_{\tilde{t}_1}, m_{\tilde{\chi}_1^0})$ mass plane with $m_{\tilde{\chi}_1^\pm} - m_{\tilde{\chi}_1^0} = 5$ GeV. Lower right: $(m_{\tilde{t}_1}, m_{\tilde{\chi}_1^0})$ mass plane with $m_{\tilde{\chi}_1^\pm} - m_{\tilde{\chi}_1^0} =$ 20 GeV. The signal region providing the best expected CLs exclusion limit is chosen at each point. The dashed (solid) lines show the expected (observed) limits, including all uncertainties except for the theoretical signal cross-section uncertainty (PDF and scale). The bands around the expected limits show the ±1σ uncertainties. The dotted lines around the observed limits represent the results obtained when moving the nominal signal cross section up or down by the ±1σ theoretical uncertainty. The excluded regions are above (below) the curves for the upper (lower) figures. For the bottom two figures, the lower bound of the vertical axis corresponds to the LEP limit of the lightest chargino mass, 103.5 GeV [33].

9 Conclusions

The results of a search for third-generation squark pair production in *pp* collisions at $\sqrt{s} = 8$ TeV based on 20.1 fb^{-1} of ATLAS data are reported. Events with large $E_{\mathrm{T}}^{\mathrm{miss}}$ and two *b*-tagged jets are analysed. The results are in agreement with SM predictions for backgrounds and translate into 95% CL. upper limits on the sbottom (stop) and neutralino masses in a given MSSM scenario for which the exclusive decay $\tilde{b}_1 \to b\tilde{\chi}_1^0$ ($\tilde{t}_1 \to b\tilde{\chi}_1^{\pm}$) is assumed. For sbottom pairs decaying exclusively to $b\tilde{\chi}_1^0$, sbottom masses up to 620 GeV are excluded at 95% CL for $m_{\tilde{\chi}_1^0} < 150$ GeV. Differences in mass above 50 GeV between the $\tilde{b}_1$ and the $\tilde{\chi}_1^0$ are excluded up to sbottom masses of 300 GeV. These limits significantly extend previous results.

For stop pairs decaying exclusively into $b\tilde{\chi}_1^{\pm}$, stop masses up to 580 GeV (440 GeV) are excluded for $\Delta m = m_{\tilde{\chi}_1^{\pm}} - m_{\tilde{\chi}_1^0} = 5$ GeV (20 GeV) and for $m_{\tilde{\chi}_1^0} = 100$ GeV. For $\Delta m = 5$ GeV (20 GeV), neutralino masses up to 270 GeV (220 GeV) are excluded for $m_{\tilde{t}_1} = 420$ GeV.

Acknowledgements

We thank CERN for the very successful operation of the LHC, as well as the support staff from our institutions without whom ATLAS could not be operated efficiently.

We acknowledge the support of ANPCyT, Argentina; YerPhI, Armenia; ARC, Australia; BMWF and FWF, Austria; ANAS, Azerbaijan; SSTC, Belarus; CNPq and FAPESP, Brazil; NSERC, NRC and CFI, Canada; CERN; CONICYT, Chile; CAS, MOST and NSFC, China; COLCIENCIAS, Colombia; MSMT CR, MPO CR and VSC CR, Czech Republic; DNRF, DNSRC and Lundbeck Foundation, Denmark; EPLANET, ERC and NSRF, European Union; IN2P3-CNRS, CEA-DSM/IRFU, France; GNSF, Georgia; BMBF, DFG, HGF, MPG and AvH Foundation, Germany; GSRT and NSRF, Greece; ISF, MINERVA, GIF, DIP and Benoziyo Center, Israel; INFN, Italy; MEXT and JSPS, Japan; CNRST, Morocco; FOM and NWO, Netherlands; BRF and RCN, Norway; MNiSW, Poland; GRICES and FCT, Portugal; MERYS (MECTS), Romania; MES of Russia and ROSATOM, Russian Federation; JINR; MSTD, Serbia; MSSR, Slovakia; ARRS and MIZŠ, Slovenia; DST/NRF, South Africa; MICINN, Spain; SRC and Wallenberg Foundation, Sweden; SER, SNSF and Cantons of Bern and Geneva, Switzerland; NSC, Taiwan; TAEK, Turkey; STFC, the Royal Society and Leverhulme Trust, United Kingdom; DOE and NSF, United States of America.

The crucial computing support from all WLCG partners is acknowledged gratefully, in particular from CERN and the ATLAS Tier-1 facilities at TRIUMF (Canada), NDGF (Denmark, Norway, Sweden), CC-IN2P3 (France), KIT/GridKA (Germany), INFN-CNAF (Italy), NL-T1 (Netherlands), PIC (Spain), ASGC (Taiwan), RAL (UK) and BNL (USA) and in the Tier-2 facilities worldwide.

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