PROCEEDINGS OF SCIENCE

Search for direct sbottom and stop pair production in final states with missing transverse momentum and two b-jets with the ATLAS detector

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We report on a search for pair production of the scalar partners of bottom and top quarks in 20.1 fb^{-1} of pp collisions at a centre-of-mass energy of 8 TeV using the ATLAS experiment at the Large Hadron Collider. The study focuses on final states with large missing transverse momentum, no leptons (electrons or muons) and two jets, each identified as originating from a b-quark. This final state can be produced in a R-parity conserving minimal supersymmetric scenario, when the scalar bottom decays into a bottom quark and a neutralino or the scalar top decays into a bottom quark and a chargino, with a small mass difference with the neutralino.

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1. Introduction

Collisions at the Large Hadron Collider might pair-produce coloured supersymmetric (SUSY) particles, e.g. the superpartner of the bottom or top quark. A search [1] in the full 2012 ATLAS [2] dataset (20.1 fb^{-1} at 8 TeV centre-of-mass energy) is presented, in which the two b-jets and missing transverse momentum final state is addressed. Such events arise in the first of the investigated simplified model scenarios, in which sbottom quarks are pair produced and each decays to the Standard Model b-quark and the lightest supersymmetric particle (LSP) with 100% branching ratio. Assuming R-parity conservation, the LSP is stable and non-interacting, giving rise to large transverse momentum imbalance ($E_{\mathrm{T}}^{\mathrm{miss}}$). Hard initial state radiation (ISR) may boost the sbottom pair system. A different model in which the results of this search are interpreted is that of stop pair production, with stop exclusive decay to b and lightest chargino. For small mass difference between the chargino and the LSP ($\Delta m = 5$ or 20 GeV), the chargino is assumed to decay to a virtual W and the LSP. Given the small mass difference, the off-shell W decay products may be soft and therefore below the thresholds required for efficient object reconstruction. The signature of such events reduces to a 2 b-jets + $E_{\mathrm{T}}^{\mathrm{miss}}$ final state. The main backgrounds are semi-leptonic $t\bar{t}$ and Z/W produced in association with heavy flavour (HF) jets.

2. Event Selection

Primary vertex and "cleaning" cuts are employed to reduce non-collision backgrounds, and events with isolated electrons or muons are vetoed. In order to ensure fully efficient triggers, the leading jet p_{T} is required to be above 130 GeV, while the $E_{\mathrm{T}}^{\mathrm{miss}}$ lower threshold is placed at 150 GeV. Given the expected signature, exactly 2 b-tagged jets are required. Two signal regions (SRs) are defined, SRA and SRB. In SRA, the two b-jets with $p_{\mathrm{T}} > 130, 50$ GeV are required to be the leading jets and serve as input to the kinematic variable m_{CT} [3, 4]. The m_{CT} variable is expected to have low values for background and high tails for signal. Several sub-regions are defined, requiring $m_{\mathrm{CT}} > 150, 200, 250, 300$ and 350 GeV, with higher threshold values targeting higher sbottom or stop masses. Following an optimisation procedure, an additional cut on the invariant mass of the two b-jets > 200 GeV was found to increase sensitivity. SRB exploits ISR by requiring one hard, non b-tagged leading jet with $p_{\mathrm{T}} > 150$ GeV, followed by the two b-tagged jets with $p_{\mathrm{T}} > 30$ GeV and high $E_{\mathrm{T}}^{\mathrm{miss}} > 250$ GeV. The leading jet and $E_{\mathrm{T}}^{\mathrm{miss}}$ are expected to be back-to-back, therefore their angular separation in the transverse plane must be $\Delta\phi > 2.5$. In both SRs, cuts are applied to limit further jet activity beyond that expected from sbottom decays and ISR. In the case of SRA, an event is vetoed if a 3rd jet with $p_{\mathrm{T}} > 50$ GeV is found; in the case of SRB, an upper limit is placed at 50 GeV on the sum of all jet p_{T}'s after the expected ISR jet and 2 b-tagged jets. In both cases, the vetoes refer to jets with $p_{\mathrm{T}} > 20$ GeV and $|\eta| < 2.8$. Both requirements are very efficient at suppressing $t\bar{t}$. Figure 1 shows discriminating distributions in the two signal regions.

3. Background estimation strategy

A partially data driven approach is taken, whereby Monte Carlo (MC) predictions of dominant backgrounds are normalised in control regions (CR). Two CRs for each SR are defined; they are similar in kinematics, but orthogonal to the SR and enhanced in the particular background. For the Z + HF jets CR, two leptons with opposite sign and of the same flavour are required, with their invariant mass constrained to be consistent with the mass of the Z. Here, the lepton p_{T}'s

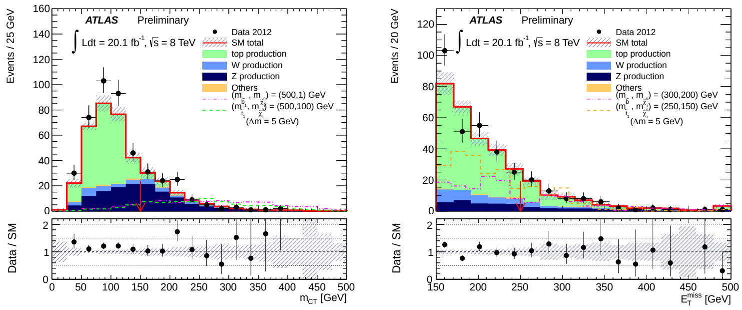

Figure 1: Left: $m_{\rm CT}$ distribution in SRA before the $m_{\rm CT}$ cut. Right: $E_{\rm T}^{\rm miss}$ distribution in SRB, $p_{\rm T}$ (j1) > 130 GeV; the red arrows indicate the final cuts used in the definition of the signal region.

are added vectorially to the $E_{\rm T}^{\rm miss}$ to mimic the $Z \to \nu\nu$ decay. The $t\bar{t}$, single top and W + HF jets CR has a one-lepton requirement. The transverse mass between the lepton and the $E_{\rm T}^{\rm miss}$ is required to be 40 GeV $< m_T <$ 100 GeV in order to reduce generic signal contamination. An additional $t\bar{t}$ - dominated CR is defined for SRA only by requiring two different-flavour leptons. Good agreement is found between the Monte Carlo prediction and data in all control regions. A combined profile likelihood fit of the MC expectation to data is performed in the control regions, with floating normalizations for $t\bar{t}$ + single top, Z + HF in both SRA and SRB and W + HF in SRA. Other, less significant backgrounds are estimated directly from MC. The normalizations are then applied to the MC expectation in the signal region. Goodness of fit is assessed in multiple, orthogonal validation regions.

4. Results and conclusions

The data is found to be consistent with the Standard Model prediction within 1σ, therefore exclusion limits can be set on simplified SUSY models (figure 2). For sbottom pairs decaying exclusively to $b\tilde{\chi}_1^0$, sbottom masses up to 620 GeV are excluded for neutralino masses below 150 GeV. 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).

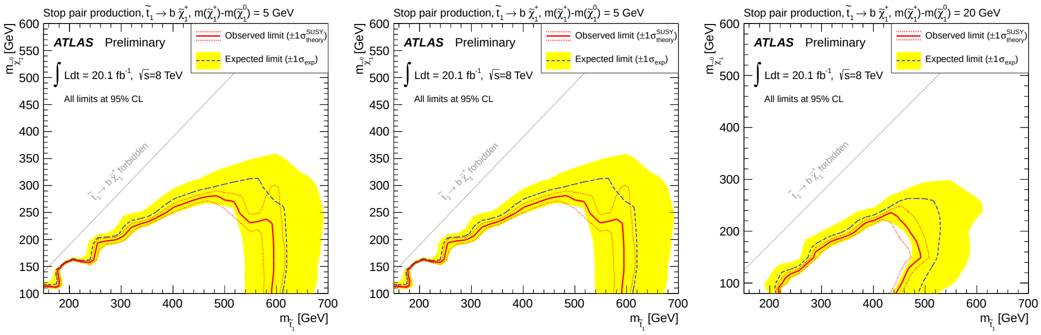

Figure 2: Expected and observed exclusion limits at 95% C.L. in the sbottom-LSP (left) and stop-LSP (middle, right) mass planes.

References

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