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Search for supersymmetry in events with large missing transverse momentum, jets, and at least one tau lepton in 21 fb^{-1} of 8 TeV proton-proton collision data with the ATLAS detector

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Searches for Supersymmetry (SUSY) with tau leptons are of interest due to the enhanced branching ratio into taus compared to light leptons (e/μ) in many SUSY models. In this note a search for SUSY with the ATLAS detector at the Large Hadron Collider (LHC) in events with at least one hadronically decaying tau lepton, large missing transverse momentum, jets and no light leptons is presented. The results are based on 20.7 fb^{-1} of proton-proton collision data at a center-of-mass energy of 8 TeV collected during 2012. No excess above the Standard Model predictions has been observed. A limit on the SUSY breaking scale Λ of 51 TeV, independent of $\tan\beta$, is determined for a minimal gauge-mediated supersymmetry breaking (GMSB) model. In a natural gauge mediation (nGM) model limits are set on the gluino mass of 1140 GeV, independent of the $\tilde{\tau}$ mass, provided the $\tilde{\tau}$ is the next to lightest supersymmetric particle (NLSP). Limits are also obtained in the $m_0 - m_{1/2}$ plane of a mSUGRA/CMSSM model.

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1. Introduction

In many SUSY models the $\tilde{\tau}$ is the next to lightest supersymmetric particle (NLSP). Decays of heavier superpartners are thus often $\tilde{\tau}$ mediated, leading to final states with multiple taus. If squarks or gluinos from such models are produced at the LHC they will leave signatures in the ATLAS detector [1] containing missing transverse energy ($E_{\mathrm{T}}^{\mathrm{miss}}$) from the lightest supersymmetric particle (LSP) escaping detection, along with jets and taus produced in the decay of the initial sparticle.

This document reports on the search [2] designed to be sensitive to such SUSY signatures by requiring events with large $E_{\mathrm{T}}^{\mathrm{miss}}$, jets and at least one hadronically decaying tau lepton. The analysis has been performed using $20.7\,\mathrm{fb}^{-1}$ of proton-proton (pp) collision data at $\sqrt{s} = 8\,\mathrm{TeV}$ recorded with the ATLAS detector at the LHC during the 2012 run.

The results are interpreted in the context of three SUSY models – minimal gauge-mediated supersymmetry breaking (GMSB), minimal supergravity/constrained minimal supersymmetric standard model (mSUGRA/CMSSM) and natural gauge mediation (nGM). The mSUGRA/CMSSM model has the mass of the lightest Higgs boson compatible with the recently discovered Higgs boson, while in the nGM framework the values of the weak scale SUSY parameters are chosen to reduce the fine tuning in the Higgs sector.

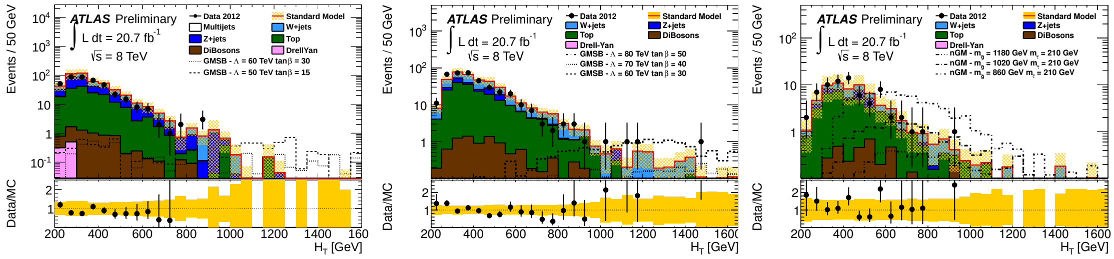
2. Event Selection and Background Estimation

Two mutually exclusive final states are considered, the first containing exactly one hadronically decaying tau and the second at least two. The event selection defining three signal regions (SRs) is shown in Table 1.

	1τ SR	2τ GMSB SR	2τ nGM SR
Pre-selection	$p_{\mathrm{T}}^{\mathrm{jet1}} > 130$ GeV, $p_{\mathrm{T}}^{\mathrm{jet2}} > 30$ GeV $E_{\mathrm{T}}^{\mathrm{miss}} > 150$ GeV		
Taus	$N_\tau = 1$, $p_{\mathrm{T}}^{\tau} > 30$ GeV	$N_\tau \geq 2$, $p_{\mathrm{T}}^{\tau} > 20$ GeV	
Light leptons	$N_\ell = 0$		
Multijet rejection	$\Delta(\phi_{\mathrm{jet}_{1,2}-\mathbf{p}_{\mathrm{T}}{}^{\mathrm{miss}}}) > 0.3\,\mathrm{rad}$ $E_{\mathrm{T}}^{\mathrm{miss}}/m_{\mathrm{eff}} > 0.3$	$\Delta(\phi_{\mathrm{jet}_{1,2}-\mathbf{p}_{\mathrm{T}}{}^{\mathrm{miss}}}) > 0.3\,\mathrm{rad}$	
Signal cuts	$m_{\mathrm{T}}^{\tau} > 140$ GeV $H_{\mathrm{T}} > 800$ GeV	$m_{\mathrm{T}}^{\tau_1} + m_{\mathrm{T}}^{\tau_2} \geq 150$ GeV $H_{\mathrm{T}} > 900$ GeV	$m_{\mathrm{T}}^{\tau_1} + m_{\mathrm{T}}^{\tau_2} \geq 250$ GeV $H_{\mathrm{T}} > 600$ GeV $N_{\mathrm{jet}} \geq 4$

Table 1: Event selection criteria for the three signal regions with variables as defined in [2].

Backgrounds are estimated by Monte Carlo (MC) simulations, adjusted by process dependent scaling factors. These are derived from the ratio of data to MC event counts in dedicated control regions (CRs) for Top, W+jets and Z+jets. In the 1τ channel CRs are further split into regions with true and mis-identified tau leptons, while in the 2τ channel the composition of true and mis-identified taus are the same in CRs and SRs. This reduces the effects of possible mis-modelling of tau mis-identification probabilities and kinematics in the MC simulations.



(a) 1τ (b) 2τ GMSB (c) 2τ nGM

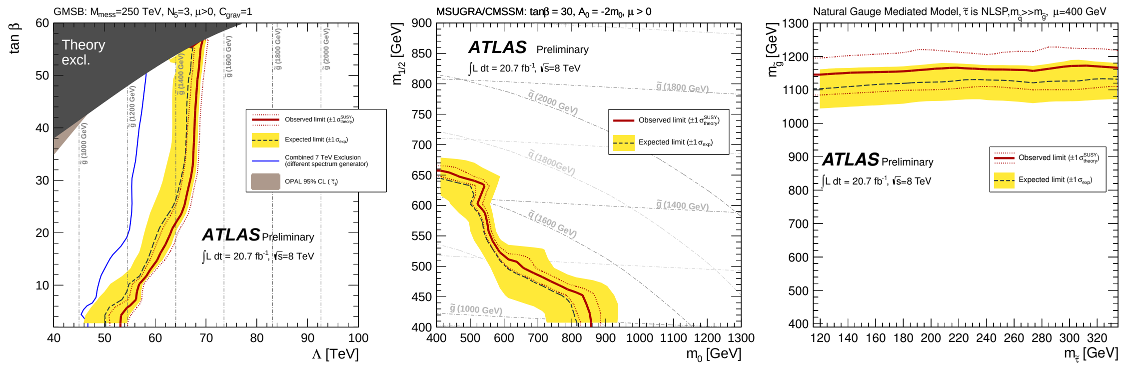
Figure 1: Distribution of H_T after all other requirements for the 1τ and 2τ GMSB and nGM signal region [2].

Correlations between backgrounds are taken into account by solving the matrix equation

$$\mathbf{N}^{\text{data}} = A\omega, \tag{2.1}$$

where the vector $\mathbf{N}^{\text{data}}$ contains the observed data events in the CRs, the matrix A contains the MC expectation for the CRs separated into the type of background process. The vector of scaling factors for each process, ω, is then obtained by inverting A. Figure 1 shows the H_T distributions after all other selections with the scaling factors applied. The small multijet contributions in the SRs are estimated by partly data driven methods.

3. Results and Conclusion



(a) GMSB (b) mSUGRA/CMSSM (c) nGM

Figure 2: Expected and observed 95% CL lower limits in the three SUSY models studied [2].

All results are found to be consistent with the SM expectations. Limits are set at 95% confidence level (CL) using the profile likelihood ratio method and the CL_S criterion. Model independent upper limits on the observed event yield and the visible cross section for each of the final states from any new physics contributions are set. Model dependent limits in the context of GMSB, mSUGRA/CMSSM and nGM are shown in Figure 2.

References

[1] ATLAS Collaboration, 2008 JINST 3 S08003.

[2] ATLAS Collaboration, ATLAS-CONF-2013-026, http://cds.cern.ch/record/1525882.

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