ATLAS Results on SUSY

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DOI: http://dx.doi.org/10.3204/DESY-PROC-2011-04/demirkoz_bilge

High luminosity data collected at a center-of-mass energy of 7 TeV at the Large Hadron Collider by ATLAS experiment has allowed it to search for supersymmetry (SUSY) and SUSY signatures with an unprecedented statistical precision and mass reach. We here present searches for different signatures in many channels, including jets plus missing transverse energy (E_T^{miss}), optionally with leptons, di-leptons plus E_T^{miss}, B-jets plus E_T^{miss} as well as electron plus muon resonance and slow meta-stable particle searches.

1 Introduction

The Large Hadron Collider has been providing proton-proton collisions to the experiments since the end of 2009 and, since March 2010, has been operating at 7 TeV center-of-mass. The peak instantaneous luminosity delivered to ATLAS at the time of the Patras workshop was $1.26 \times 10^{33} cm^{-2} s^{-1}$ in 2011 while it was $0.21 \times 10^{33} cm^{-2} s^{-1}$ in 2010. Reduction in β^* to 1.5 as well as the increase in the number of bunches in the collider to 1236 bunches and the increase in the bunch charge to 1.4×10^{11} allowed for this increase in luminosity. The data taking efficiency for ATLAS remains above 95% since the start of data-taking.

The ATLAS detector is a multipurpose particle physics apparatus with a forward-backward symmetric cylindrical geometry and nearly 4π coverage in solid angle [1]. A thin solenoid provides a 2 T magnetic field in the volume of inner tracking detectors, consisting of silicon pixel, silicon microstrip detectors and a transition radiation tracker. The surrounding calorimeters are of particular importance to analyses involving the transverse missing energy observable. In the pseudorapidity region $|\eta| < 3.2$, high-granularity liquid-argon (LAr) electromagnetic (EM) sampling calorimeters are used. An iron-scintillator tile calorimeter provides hadronic coverage over $|\eta| < 1.7$. The end-cap and forward regions, spanning $1.5 < |\eta| < 4.9$, are instrumented with LAr calorimetry for both EM and hadronic measurements. The muon spectrometer (MS) surrounds the calorimeters and consists of three large superconducting toroids, a system of precision tracking chambers, and detectors for triggering.

2 SUSY searches

Here we present results from data taken in 2010 and in two cases, updated with data taken in 2011. As the SUSY parameter space is very large, the search results here are presented for representative models.

2.1 Searches using Missing Transverse Energy

In R-parity conserving SUSY models, missing transverse energy, E_T^{miss}, is a very important observable as stable, neutral and weakly-interacting particles predicted by SUSY can escape the ATLAS detector without leaving behind any track and energy deposition. Especially noteworthy, a dark matter candidate, the lightest supersymmetric particle, would have a E_T^{miss} signature. In ATLAS, E_T^{miss} is measured using calorimeter cells over the full range of $|\eta| < 4$ and corrected for the energy of reconstructed physics objects, such as muons. Here we now discuss searches employing this observable.

2.1.1 Jets plus Missing Transverse Energy Search

A search for squarks and gluinos in final states containing jets, missing transverse momentum and no electrons or muons was first presented, with $35pb^{-1}$ of data [2]. This analysis has been updated with data collected in 2011, with a total integrated luminosity of $165pb^{-1}$ and extends the sensitivity of the search by including final state topologies with at least 4 jets [3]. In a large number of R-parity conserving models, squarks, $\tilde{q}$ and gluinos, $\tilde{g}$ can be produced in pairs, decay through $\tilde{q} \rightarrow q\chi^0{}_1$ and $\tilde{g} \rightarrow qq\chi^0{}_1$ to weakly-interacting neutralinos, leading to decays with jets and E_T^{miss} in the final state.

As no excess above the Standard model background was observed, 95% confidence level limits were set: gluino masses below 725 GeV are excluded in simplified models containing only squarks of the first two generations, a gluino octet and a massless neutralino. The exclusion increases to 1025 GeV for equal mass squarks and gluinos. In MSUGRA/CMSSM models with $\tan\beta = 10$, $A_0 = 0$ and $\mu > 0$, squarks and gluinos of equal mass are excluded for masses below 950 GeV, as shown in Fig. 1. While being model dependent, this search provides the highest mass reach limits out of all the searches presented in this paper.

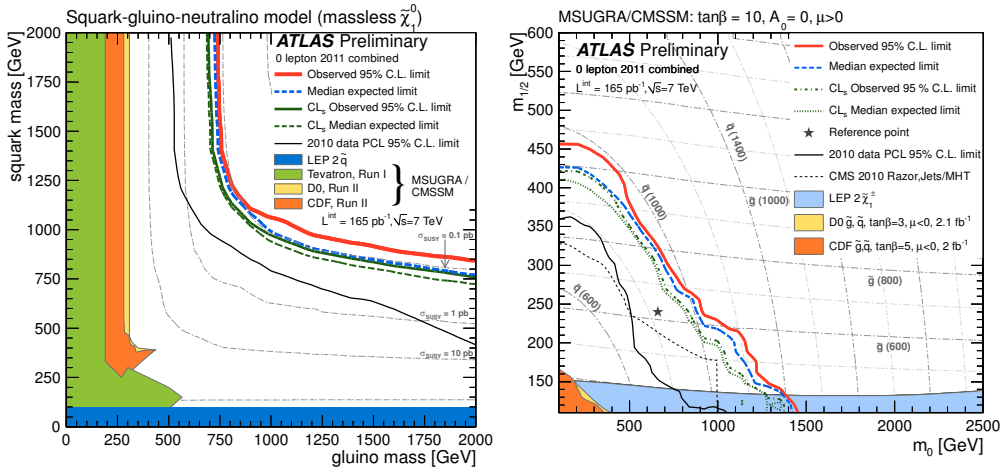

Figure 1: Results of the jets plus E_T^{miss} search. Left: Combined exclusion limits (solid red line) in the $(m_{\tilde{g}}$; $m_{\tilde{q}})$ plane for the simplified squark–gluino model with massless $\chi^0{}_1$. Right: Combined exclusion limits in the $(m_0$; $m_{1/2})$ plane of mSUGRA for which $\tan(\beta) = 10$, $A_0 = 0$ and $\mu > 0$.

2.1.2 Jets plus Missing Transverse Energy with Leptons Search

In R-parity conserving SUSY models, the chargino decay into the lightest supersymmetric particle can produce a high-momentum lepton. The search for SUSY with jets, E_T^{miss} with one isolated electron or muon, at least three high-p_T jets and significant E_T^{miss} was first performed with $35pb^{-1}$ of data [4, 5] and was later updated with $165pb^{-1}$ of data [6].

The search for SUSY with jets, E_T^{miss} and two leptons was performed with $35pb^{-1}$ of data [7, 8]. Different search strategies, based on identical sign or opposite sign electrical charges was employed. Specifically, a flavour subtraction technique has been used to search for an excess beyond SM expectations of high p_T^{miss} events containing opposite charge identical flavour lepton pairs. Based on specific bench-mark models, limits are placed on the squark mass between 450 and 690 GeV for squarks approximately degenerate in mass with gluinos, depending on the supersymmetric mass hierarchy considered. The search for SUSY with jets, E_T^{miss} and multi-leptons was also performed with $34pb^{-1}$ of data [9].

2.1.3 B-jets plus Missing Transverse Energy with leptons search

Final states rich in b-jets can be produced by the decay of the gluino to sbottom, $\tilde{b}$ or to stop, $\tilde{t}$. Search for supersymmetric particles in events with large missing transverse momentum and at least one heavy flavour jet candidate was performed using $35pb^{-1}$ of data [10]. No significant excess is observed with respect to the prediction for Standard Model processes. For R-parity conserving models in which sbottoms are the only squarks to appear in the gluino decay cascade, gluino masses below 590 GeV are excluded at the 95% confidence level. For stops, the limit is 520 GeV respectively.

2.2 Other searches

2.2.1 Search for electron plus muon resonance

Search for a heavy particle decaying into an $e^{\pm}\mu^{\mp}$ was performed, selecting an electron and muon with opposite signs with $p_T > 20$ GeV and requiring isolation, with $35pb^{-1}$ of data [11]. As no excess above the Standard Model background expectations was observed, 95% confidence-level limits were placed on two representative models. In an R-parity violating SUSY model, tau sneutrinos could produce such a signature and those with a mass below 0.75 TeV are excluded by this study, assuming single coupling dominance and the couplings $\lambda'_{311} = 0.11$ and $\lambda'_{312} = 0.07$. In a lepton flavor violating model, a Z'-like vector boson with masses of 0.70 to 1.00 TeV and corresponding cross sections times branching ratios of 0.175 to $0.183pb^{-1}$ is excluded.

2.2.2 Search for stable hadronizing squarks and gluinos

Coloured sparticles, predicted by SUSY, can hadronise into long-lived bound hadronic states, termed R-hadrons. A search for slow-moving charged particles was performed by triggering on E_T^{miss}, requiring isolation from jets in the event and a large ionisation energy loss in the pixel detector as well as requiring a long time-of-flight in the tile calorimeter, with $34pb^{-1}$ of data [12]. As no deviations from Standard Model background expectations was observed and 95% confidence-level limits can be set on the production cross-sections of squarks and gluinos. The influence of R-hadron interactions in matter was studied using a number of different models,

and lower mass limits for stable sbottoms, stops and gluinos are found to be at 294 GeV, 309 GeV and 562 GeV respectively.

2.2.3 Long-lived charged particle search

A search for heavy long-lived charged particles reaching the muon spectrometer, allowed by SUSY, specifically for meta-stable sleptons, squarks and gauginos, was also performed [13] with $37pb^{-1}$ of data. Requiring a late arrival time in the muon spectrometer, a well-measured Lorentz β factor and requiring it to be lower than 0.95, no excess above the estimated background was observed. Therefore, 95% confidence-level limits on $\tilde{\tau}$ and R-hadron production are set: Sleptons produced in electroweak processes are excluded up to a mass of 110 GeV. Stable $\tilde{\tau}$'s are excluded up to a mass of 136 GeV, in gravity-mediated SUSY breaking (GMSB) models with $N_5 = 3$, $m_{messenger} = 250$ TeV, sign(μ) = 1 and tan$\beta = 5$. Depending on the fraction of R-hadrons produced as $\tilde{g}$-balls, gluino R-hadrons in a generic interaction model are excluded up to masses of 530 GeV to 544 GeV.

3 Conclusion

The results presented here from ATLAS extend searches and provide more stringent constraints than the previous results from the Tevatron. The total integrated luminosity in 2011 by ATLAS was $5.25fb^{-1}$ and results are in the process of being updated. We would like to thank the LHC team for the excellent performance and the fast ramp of luminosity.

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