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The reach of the ATLAS experiment in SUSY parameter space

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With the very first LHC data, the ATLAS experiment will be sensitive to a SUSY signal well beyond the regions explored by the Tevatron. We present a detailed study of the reach of the experiment in the parameter space of different SUSY models, based on a parameterization of the results of a detailed detector simulation, and taking into account the expected uncertainties on background estimations in the first data.

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1. Introduction

The ATLAS experiment at the LHC will begin data taking in 2009. With a design centre-of-mass energy of 14 TeV the experiment has a large discovery potential for physics beyond the Standard Model (BSM physics). Supersymmetric extensions of the Standard Model (SM) are among the best motivated models of BSM physics and predict a large spectrum of new, unobserved particles with masses at the TeV scale. These particles are therefore expected to be produced at the LHC and so the search for supersymmetric particles will be an important task for 2009 and after.

This article concentrates on SUSY models in which the R-parity quantum number is conserved. SUSY particles are defined as having R-parity -1, and SM particles as having R-parity +1. Since R-parity is multiplicative its conservation results in three important phenomenological implications: SUSY particles are produced in even numbers in collider experiments; each SUSY particle can only decay into a state containing an odd number of SUSY particles; the lightest SUSY particle (LSP) is stable. The nature of the LSP affects the experimental signature of SUSY. This article concentrates on models in which the LSP is neutral and weakly interacting escaping the detector without detection leaving a signature of missing transverse energy (E_T^{miss}).

2. Inclusive searches

If their mass is in the TeV range, strongly interacting particles (squarks and gluinos), will dominate the SUSY production at the LHC. They will be produced in pairs and decay via cascade decay chains into states which include jets with high transverse momentum (p_T), a number of leptons or photons depending on the SUSY model, and E_T^{miss} from the LSPs. The general inclusive search strategy used by ATLAS concentrates on this signature of events with high p_T jets, a number of leptons and E_T^{miss}, and looks for an excess of events with respect to the Standard Model in datasets where SUSY events are expected. Detailed studies have been carried out for a broad spectrum of channels including channels with different jet multiplicities (1,2,3,4 jets), different lepton multiplicities (0,1,2,3 leptons), and also channels with taus and *b*-jets. The event selection cuts are documented in [1]. After applying the selection cuts a noticeable excess of events is observable above the SM background in distributions of the effective mass[1] (M_{eff}) for a number of points in the SUSY parameter space defined as the ATLAS benchmark points. One such point is SU3 defined as: m_0 = 100 GeV, $m_{1/2}$ = 300 GeV, $\tan\beta$ = 6, A_0 = -300 GeV, μ = +; with a cross-section of 28 pb at 14 TeV. Figure 1 shows the distribution of M_{eff} for the 4-jet 1-lepton channel (left) for these benchmark points with 1 fb^{-1} of integrated luminosity. It can be seen that an excess is already observable with this luminosity, which will be collected in the early phase of LHC running.

The main challenge in these searches is to reliably control the SM background. Since optimizing to one particular SUSY point (one particular region of the SUSY parameter space) is very restrictive, the event selection has been optimized to reduce the number of events from SM processes. For these studies, fully simulated Monte Carlo datasets with the detector response based on GEANT 4 were used for both signal and background. ATLAS has developed several data-driven

[1] The effective mass, M_{eff}, is defined as the scalar sum of the missing transverse energy and the p_T of the reconstructed objects (jets and leptons).

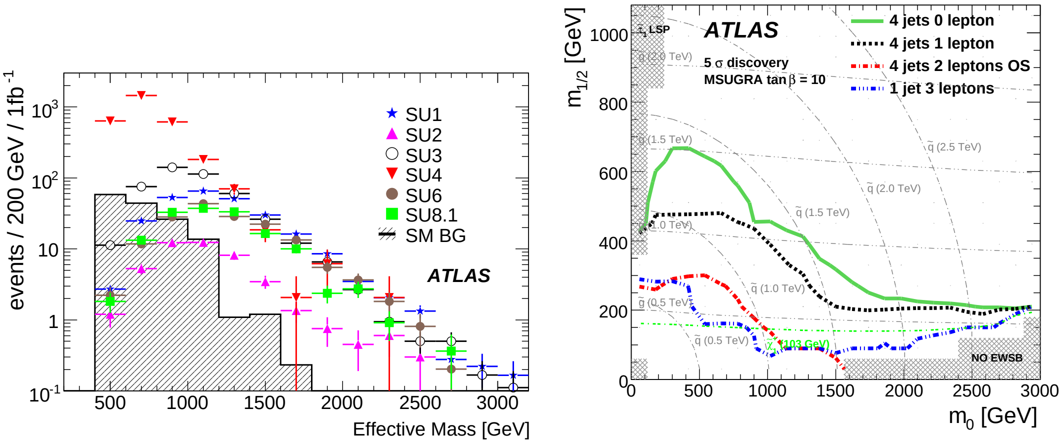

Figure 1: Left: The M_{eff} distributions for each of the SUn [1] ATLAS benchmark points, and for the sum of the Standard Model backgrounds with 1fb^{-1} for the 1-lepton analysis. Right: The 1fb^{-1} 5σ reach contours for a number of channels for mSUGRA as a function of m_0 and $m_{1/2}$ with $\tan\beta = 10$. The horizontal and curved grey lines indicate gluino and squark mass contours respectively in steps of 500 GeV.

methods to estimate and control the remaining background expectation with data. These methods are also documented in [1].

3. Scans

ATLAS has several SUSY benchmark points, chosen to give a variety of signatures, that it uses to test the inclusive analyses but there is no reason to believe that they are representative of what might be found at the LHC. In order to sample as wide a range of signals as possible, ATLAS also performs scans over hundreds of different SUSY points for several different models. The goal is to develop a general search strategy covering as wide a range of models as possible.

The scans are performed with a fast parameterization of the detector response for the signal. For each SUSY point, the same selection cuts are applied, apart from a cut on M_{eff} which is chosen to give the best significance. The scans have been used to determine the 5σ discovery reach for: the mSUGRA parameter space constrained from measurements including dark matter density; a model with non-universal Higgs masses (NUHM); an mSUGRA model with high $\tan\beta$ and a model with gauge mediated SUSY breaking (GMSB). These scans are documented in [1]. Figure 1 shows the 5σ discovery reach of several different channels in the $m_0 - m_{1/2}$ plane, for the mSUGRA model with $\tan\beta = 10$, $A_0 = 0$ GeV and $\mu = +$ (right).

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References

[1] ATLAS Collaboration, Expected Performance of the ATLAS Experiment, Detector, Trigger and Physics, CERN-OPEN-2008-020, Geneva, 2008, to appear.