SUSY searches in early ATLAS data

Davide Costanzo

Dep. of Physics and Astronomy, University of Sheffield, Sheffield S3 7RH, UK

E-mail: davide.costanzo@cern.ch

Abstract. We review the SUSY searches strategy that will be adopted at the ATLAS startup. The Large Hadron Collider will deliver proton proton collisions at an unprecedented centre of mass energy of 14TeV, making it possible to expand the searches for SUSY well beyond the limit set by the present experiments at the Tevatron collider. Discovering SUSY may be possible using data accumulated during the first few months of running, but it will mostly depend on our ability to understand the experimental systematics, and to estimate the Standard Model background. The discovery reach for the first fb^{-1} of data collected by ATLAS is given for the case where the mSUGRA model is realised.

1. Introduction

The Standard Model is a very succesful theoretical framework which has been tested to an unprecedented level of precision by previous accelerator experiments. There are however both theoretical and experimental arguments suggesting that the Standard Model is not the ultimate theory and that some type of new physics is required to advance our understanding of particle physics. Two notable questions to which successful extensions of the Standard Model should provide answers are the stability of the Higgs mass and the nature of dark matter. Supersymmetry naturally answers both questions with the lightest SUSY particle (LSP) acting as Dark Matter candidate and SUSY particles possessing coupling to the Higgs that stabilise the theory.

The experimental sensitivity to supersymmetry is model dependent. Here we concentrate on the sensitivity to the gravity-mediated model (mSUGRA). The mSUGRA model assumes that at the GUT scale all bosons have a common mass m_0, all fermions have a common mass $m_{1/2}$, and all the trilinear Higgs-sfermion-sfermion couplings have a common value A_0. Thus, the model can be parametrised in terms of these three constants and of the ration of the HIggs expectation values, $\tan(\beta)$. Figure 1 shows the region of the $(m_{1/2}, m_0)$ parameter space which can be accessed by ATLAS for different luminosity scenarios, 1 fb^{-1} being the total integrated luminosity that we expect to collect during the first few months of operation. It can be noted as the region that can be explored with this "early" data largely extends the region covered by the previous LEP experiments and the current Tevatron experiments [1]. The understanding of the detector performance at its early stage of operation will be critical to allow the discovery of SUSY for most of the mSUGRA scenarios leading to sparticles with a mass below 1 TeV.

Instead of exploring all the allowed parameter space, several points are chosen to cover the main experimental signatures arising in the mSUGRA model and are simulated using a full Geant4 simulation of the ATLAS detector [2]. This strategy is tailored towards the preparation for understanding the experimental issues connected with SUSY searches, if a similar scenario is chosen by Nature the search strategy can easily be adjusted to it.

2. Searches in the multijet and Missing E_T channel

Cascade decays of SUSY particles will generate missing energy for the escaping LSP, but also multiple hadron jets. The SUSY mass scale, defined as $M_{\mathrm{SUSY}} = \min(\tilde{q}_R, \tilde{g})$, can be inferred by measuring the peak of the effective mass distribution M_{eff} defined as the sum of the missing transverse energy and the P_T of the four leading jets in the event. The expected distribution of M_{eff} in jet+$\not\!\!E_{\mathrm{T}}$+0 lepton events is plotted in figure 1(right) for SUSY and background events for a model that was studied using a full GEANT simulation of the ATLAS detector. It can be seen that the SUSY signal is more than one order of magnitude over the background for $M_{\mathrm{eff}} > 1$ TeV. From a fit to the M_{eff} distribution, the SUSY mass scale can be measured in a model independent fashion with an ultimate error $\leq 10\%$ [3]. The normalization of this distribution also provides a measure ofthe total SUSY production cross-section and together these two pieces of information can be used to contrain the SUSY breaking mechanism. The

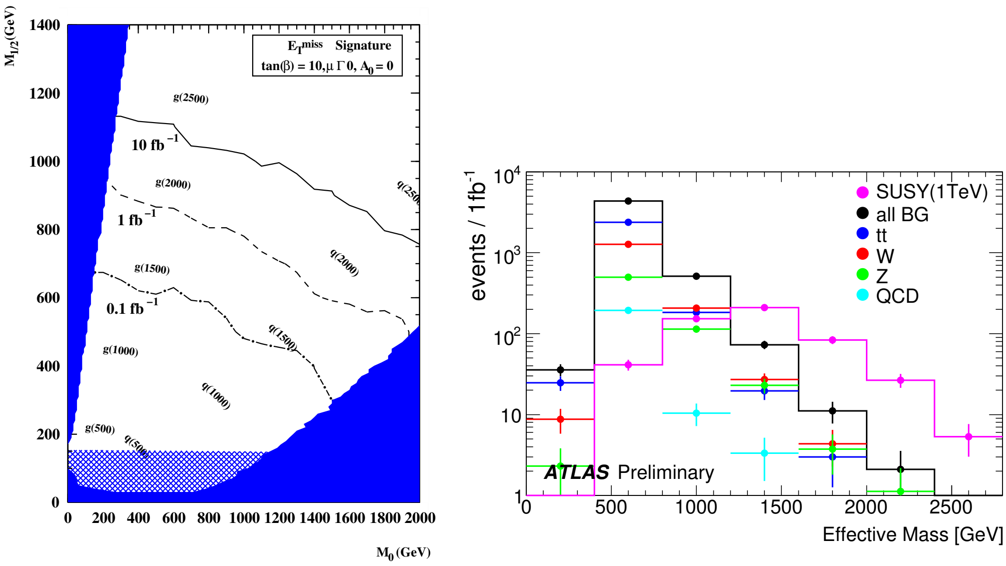

Figure 1. Left: ATLAS 5 σ discovery potential of the inclusive jets + $\not\!\!E_{\mathrm{T}}$ channel in the $m_0 - m_{1/2}$ plane for mSUGRA models with $\tan(\beta) = 10$, $\mu > 0$ and $A_0 = 0$ assuming $0.1\mathrm{fb}^{-1}$, $1\mathrm{fb}^{-1}$ and $10\mathrm{fb}^{-1}$ integrated luminosity. Full dark region are excluded by theory, htched regions by experiment (LEP2 and elsewhere). Right: Effective mass distribution for SM background channels and SUSY signal for a low mass mSUGRA point.

determination of the background cross section and shape should rely as much as possible on collider data to provide robust results. Techniques to estimate the main background from top production using LHC data are still being developed and will be presented later this year. The background from Z and W boson production can be estimated starting from the measurement of $Z \to l^+l^-$ events and rescaling them to account for $Z \to \nu\nu$ and $W^{\pm} \to l^{\pm}\nu$ decays. The background from multi-jet QCD production can be estimated by paremetrising the response of the detector to hadron jets in events with low jet multiplicity and then using this parametrisation for events with high jet multiplicity and low missing E_T to estimate the tails in $\not\!\!E_{\mathrm{T}}$.

3. Searches in the lepton + jets channel

SUSY searches can be conducted in a more exclusive way, by requesting the presence of electrons or muons in the final state together with jets and transverse missing energy. The total event yield in this case depends on the decay branching ratios of sparticles, but it constitutes a much cleaner signature generally producing a larger signal to background ratio. The distribution of the transverse missing energy for events with $\not{E}_T$ >100 GeV, four jets and two $e^{\pm}$ or $\mu^{\pm}$ in the final state is shown in figure 2 for a model in the “co-annihilation” regions of the mSUGRA parameter space. Only few events survive this selection for 1 fb^{-1} of data making it an useful tool for discovery, but demanding higher statistics for the measurement of the model parameters.

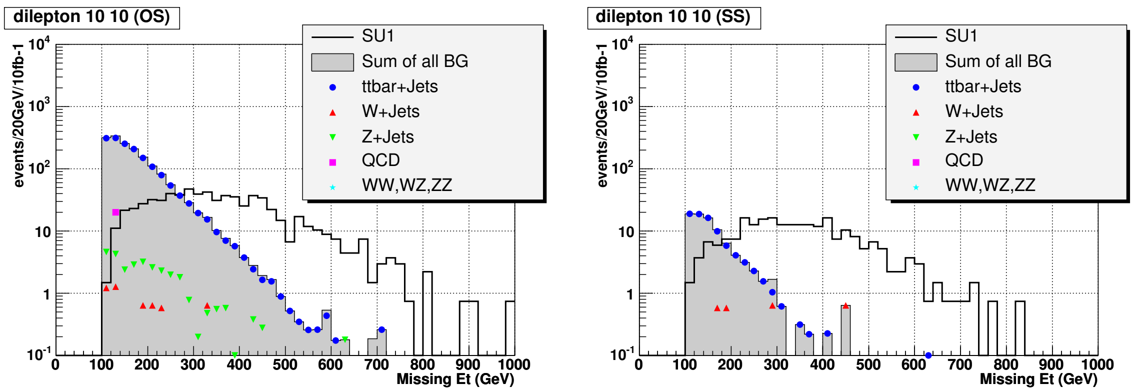

Figure 2. Missing transverse energy for events with two charged leptons (electrons or muons) in the final state for an mSUGRA model in the “co-annihilation” region. The plot on the left (right) is for events with like-sign (opposite-sign) charged leptons in the final state.

References

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