SUSY inclusive searches with jets, dileptons, and high missing transverse energy with the ATLAS detector

M.Bianco[1,2] , E.Gorini[1,2], M.Primavera[1], A.Ventura[1,2] (and the ATLAS Collaboration)

[1]Istituto Nazionale di Fisica Nucleare, sezione di Lecce, Italy

[2]Dipartimento di Fisica, Università del Salento, Italy

1. Introduction

Among a wide number of proposed theoretical models of physics beyond the Standard Model (SM), Supersymmetry (SUSY) is expected to be one of the most promising. SUSY models with "R-parity" conserved are particularly interesting, i.e. models in which SUSY particles are supposed to be produced in pairs and which determine decay chains ending with the Lightest Supersymmetric Particle (LSP), a neutral and stable particle which is a good candidate for cold dark matter.

If squarks and gluinos have masses of the order of a TeV, the Large Hadron Collider (LHC) [1] will be able to observe them thanks to its multipurpose experiments, like ATLAS (A Toroidal LHC ApparatuS) [2]. A few different benchmark points (*SUn* [3]) as well as *MSSMn* (Minimal Supersymmetric Standard Model n) have been considered within the framework of the Minimal Supergravity model (mSUGRA) [4].

2. Inclusive SUSY searches

At the LHC the typical SUSY event topology is dominated by high-p_T jets coming from the production of squark and gluino decays, together with large E_T^{miss} from undetected LSPs at the end of each sparticle decay chain. This provides the least model-dependent search for SUSY events with zero leptons in the final state.

The main background is represented by multi-jet QCD (especially in the low effective mass, M_{eff}, region) and by $t\bar{t}$ events with an unidentified lepton, but also W+jets and Z+jets give significant contributions at large M_{eff}. Also zero-lepton analyses based on less than 4 jets in the final state are possible: they are obtained by imposing higher p_T requirements to reduce the larger QCD background, with the result that the number of surviving events are approximately doubled for both signal and background (except for the low-mass *SU4* point), while the expected values of significance with 1 fb^{-1} don't change significantly.

A strong reduction of wrongly selected background from QCD multi-jet events can be obtained by requiring one or more isolated leptons in addition to multiple jets and E_T^{miss}. Although the background rejection is better with respect to the 0-lepton analysis, the yield is worse as the statistical significances with 1 fb^{-1} are in average lower [3].

Events with two leptons in the final state can be very relevant for inclusive searches and can be also exploited for exclusive studies involving measurement of SUSY parameters. The case of two leptons (electrons or muons) with opposite sign and same flavour can arise from neutralino decays, such as for $\chi_2^0 \to \ell^\pm \ell^\mp \chi_1^0$, directly or mediated by a slepton. Leptons can also come from independent decays, thus giving rise to dilepton pairs having same or different flavours. A clear evidence of new physics in this channel would be given by an excess of events containing same-flavour dileptons with respect to events with different flavour leptons (mostly coming from $t\bar{t}$ and W events).

Events with two prompt same-sign leptons are quite rare in SM, but in SUSY they should normally occur since the gluino is a Majorana particle. They represent a very clear event signature, but very small rates are expected (from 10 to 100 events/fb^{-1}). The main SM backgrounds are $t\bar{t}$, W+jets and Z+jets, though they are negligible.

3. Event selection

The search for SUSY in the two leptons final state presented here is based on the mSUGRA benchmark point *SU4*, which was chosen to be close to Tevatron bounds and is expected to be approximately in the sensitive region for analyses on 2010 data. This point is defined by the mSUGRA parameters [5]:

$$M_0 = 200GeV, M_{1/2} = 160GeV,$$
$$A = -400GeV, tan\beta = 10, \mu > 0$$

.

In Fig. 1 the invariant mass distribution for opposite sign muon pairs is shown after all analysis cuts in a data sample corresponding to an integrated luminosity of 15.7 pb^{-1}, together with the expected distribution for a simulated SUSY signal and the SM expected background.

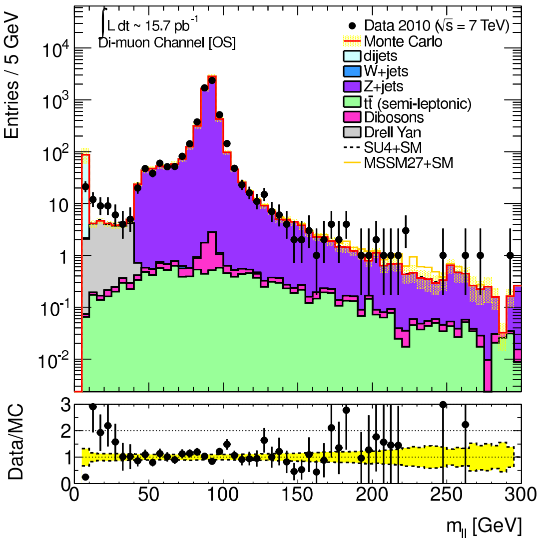

Figure 1. Invariant mass distribution of opposite sign muon pairs. The black points are data, while the histograms show the expected distributions from Monte Carlo samples normalized to the data integrated luminosity. The band indicates the uncertainty on the expectations coming from: finite statistics, cross section, luminosity, energy scales and resolutions.

In order to identify the SUSY signal and to reject the background, the following cuts have been applied in the analysis [6]:

- jets, reconstructed using the anti-kT clustering algorithm with R = 0.4, must have $p_T > 20$ GeV and $|\eta| < 2.5$. If a selected jet overlaps within $\Delta R < 0.2$ with an electron, it's removed, while the electron is retained.

- electrons must satisfy specific quality criteria, must be outside the calorimeter "Crack" region ($1.37 < |\eta| < 1.52$) and have $p_T > 20$ GeV and $|\eta| < 2.47$. If an electron overlaps with a jet ($0.2 < \Delta R < 0.4$), then the electron candidate is rejected. Electrons are finally requested to be isolated in a cone around their direction ($E_T(\Delta R < 0.20)/p_T < 0.15$).

- muons must pass several quality cuts applied on the number of measurements in the Inner Detector and to remove the contamination from light flavours in-flight decays, have $p_T > 20$ GeV and $|\eta| < 2.4$, be isolated in a cone of size 0.2 ($E_T(\Delta R < 0.20) < 1.8$ GeV). If a muon candidate overlaps with a jet ($\Delta R < 0.4$), it is rejected. A veto against cosmic rays has been also applied by requiring that the distance between the longitudinal (along the beam axis) muon position and the event Primary Vertex position was less than 10 mm.

Table 1 shows the results of the opposite sign SUSY dilepton search obtained with the selection described above on 34.3 pb^{-1} of data acquired in 2010 LHC run. Three different final cuts on E_T^{miss} have been considered, separately for ee, $e\mu$ and $\mu\mu$ channels.

Signal Regions	ee	eμ	$\mu\mu$
E_T^{miss} >100 GeV	4	13	13
E_T^{miss} >120 GeV	1	6	7
E_T^{miss} >150 GeV	1	4	4

Table 1
Results obtained with the ATLAS official selection applied in the opposite sign SUSY dilepton search on 34.3 pb^{-1} of data acquired in 2010 LHC run, separately for the ee, $e\mu$ and $\mu\mu$ channels.

The present statistics is not enough to claim for any evidence of SUSY with leptons in the final state; the work to extract the significance of these results is in progress. LHC 2011 run should provide enough statistics to perform sensitive tests over several points defined in *SUn* and *MSSMn* scenarios.

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