Event Selection for SUSY search for heavy top partner in final states with two leptons with the ATLAS detector at LHC

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1. Introduction

The super-partners of third generation quarks are required to be lighter than approximately 500 GeV, and the existing LEP and Tevatron limits [2] for such particles are between 100 GeV and 200 GeV depending on the SUSY scenario.
Generic searches for SUSY particles look for squark and gluino production asking for events with large missing transverse momentum E_T^{miss} and jets plus possibly one or more leptons. Typical selection criteria require hard cuts on E_T^{miss} and on the transverse momenta of the jets, which have typically rather low efficiencies for sparticles lighter than 400 GeV. Therefore, it is important to perform dedicated exclusive searches of these particles.
An analysis searching for evidence of a heavy partner of the top quark (stop), where each of the stop partners decays into a b-jet, a lepton, and weakly interacting particles which escape detection, has been carried out. Two main criteria are used to separate the signal from the background: the request of b-tagged jets, which strongly suppresses the background from W/Z, and the presence of dedicated selection which exploit the differences between the kinematics of top decays and of the new particles.

The analysis is sensitive to the processes:

$$\tilde{t}\tilde{t} \to \tilde{\chi}_1^0 t \tilde{\chi}_1^0 \bar{t} \to \tilde{\chi}_1^0 b l^+ \nu \;\; \tilde{\chi}_1^0 \bar{b} l^- \nu \quad (1)$$

and

$$\tilde{t}\tilde{t} \to \tilde{\chi}^+ b \tilde{\chi}^- \bar{b} \to \tilde{\chi}_1^0 b l^+ \nu \;\; \tilde{\chi}_1^0 \bar{b} l^- \nu \quad (2)$$

where $\tilde{t}$ is the supersymmetric scalar top quark, $\tilde{\chi}_1^0$ is the lightest neutralino and $\tilde{\chi}^\pm$ are charginos. The first process requires $m(\tilde{t}) - m(\tilde{\chi}_1^0) > m(t)$ and the second one $m(\tilde{t}) - m(\tilde{\chi}^\pm) > m(b)$.

The analysis documented here is based on the selection of events with high values of the M_{T2} variable, which was introduced in the framework of SUSY measurement studies, which is exploited in the case where two identical particles ('legs') are produced, and both decay into an invisible particle. The vector sum of the transverse momenta of the two invisible particles is measured, and constitutes the $E_\mathrm{T}^{\mathrm{miss}}$ of the event.
The topology of event here discussed is illustrated in Fig. 1

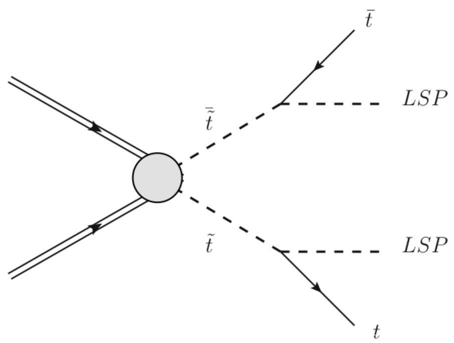

Figure 1. Diagram of pair production of stops with subsequent decay with 100% branching ratio to a top quark and the LSP (Neutralino).

The idea is to consider all possible decompositions of the $E_\mathrm{T}^{\mathrm{miss}}$ into two transverse vectors which are interpreted as the transverse momenta of the invisible particles in the two legs of the event. From the invisible momenta two transverse masses are built with the visible particles in the events and the maximum of the two values is taken. The minimum value over all possible decompositions of $E_\mathrm{T}^{\mathrm{miss}}$ of the variable thus calculated will be lower than the end point for the decay on a single leg. As an example, for WW production, M_{T2} will be below the end point for the W decay, which corresponds to the W mass. This variable has been already used in ATLAS [3] in the framework of a 0-lepton + jets search [4].

In case of full leptonic events such $t\bar{t}$, Wt, and WW the M_{T2} has an upper bound equal to the W-boson mass.
In our analysis, there is no upper bound, since even when the two leptons are generated by the decay of two W-bosons, $E_\mathrm{T}^{\mathrm{miss}}$ is the sum of the neutrino coming from W decays and from the

weakly interacting particles produced by the stop decay.

Since the bound $M_{T2} < M_W$ for Standard Model events is quite sharp, by selecting events with $M_{T2} > M_W$ it is thus possible to dramatically enhance the signal over background ratio.

2. Event selection

The object (Jets, Electrons, Muons, $E_{\mathrm{T}}^{\mathrm{miss}}$) definitions used in this analysis are widely discussed in several ATLAS paper[5]: here we report the criteria used to identify the events falling in our Signal Region (SR).
Events are selected using the single lepton triggers. Different triggers are used for different data taking periods, in order to cope with the increasing instantaneous luminosity.
We apply the “smart LAr hole veto”, widely used in supersimmetry searches, to reject event with jet $p_T > 20$ GeV which falls in dead calorimeter cells. This is done both on data and MC, regardless of the data-taking period. No correction is done on $E_{\mathrm{T}}^{\mathrm{miss}}$ for the events which pass this selection, which defined as “LAr hole veto”.
In order to remove overlapping objects the following procedure is applied: a jet is rejected if the distance in ΔR between any baseline jet and any baseline electron is less than 0.2, than leptons (electrons and muons) are rejected if the distance in ΔR between surviving jets and lepots is less than 0.4.
A primary vertex of each event is required to contain at least 5 tracks: this cut reduces the chance of selecting a cosmic event since the d_0 and z_0 of the muons considered in the analysis are calculated using this first primary vertex.
In case of a cosmic muon, the event is rejected. Events which contain exactly two leptons are selected if at least one lepton satisfies the leading p_T requirement ($p_T > 25$ GeV for electrons and $p_T > 20$ GeV for muons), and if the dilepton invariant mass m_{ll} of same-flavour pairs is greater than 20 GeV.
In addition, events are retained only if they contain at least one jet with $p_T > 50$ GeV and a second jet with $p_T > 25$ GeV. Only for in case of Same Flavour analysis a Z veto and b-Jets tagging is applied. Finally the events in SR are identified by requiring $M_{T2} > 120 GeV$.
In Fig. 2 event distribution, at the end of event selection, as function of M_{T2} is shown.

Tab 1 shows results obtained with explained selection using 4.7 fb^{-1} of data acquired in 2011 LHC run.

Present statistics is not enough to claim for evidence of SUSY with leptons in the final state; work to extract estimate the backgrounds and the significance of results is in progress.

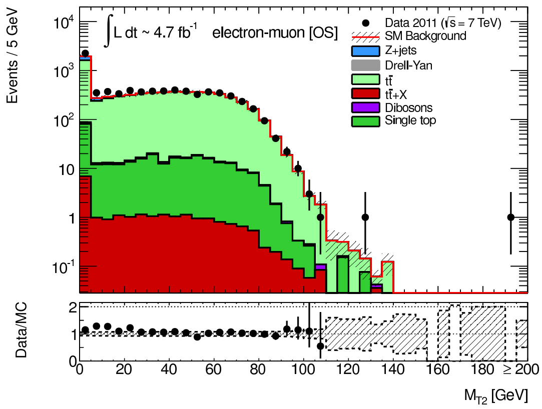

Figure 2. Event distibution as a function of the M_{T2} variable, for $e^{\pm}\mu^{\mp}$ channel, similar distributions are produced for $ee, \mu\mu$ channels. All signal selection cuts except that on M_{T2} have been applied.

Signal Regions	ee	eμ	$\mu\mu$
M_{T2} >120 GeV	1	2	0

Table 1
Results obtained with 4.7 fb^{-}1 acquired in 2011 LHC run, for OS SUSY analysis and separately for the ee, $e\mu$ and $\mu\mu$ channels.

REFERENCES

1. ATLAS Collaboration is made of about 3000 Physicists coming from 173 Institutions of the following countries: Argentina, Armenia, Australia, Austria, Azerbaijan, Belarus, Brazil, Canada, Chile, China, Colombia, Czech Republic, Denmark, France, Georgia, Germany, Greece, Israel, Italy, Japan, Morocco, Netherlands, Norway, Poland, Portugal, Romania, Russia, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Taiwan, Turkey, UK, USA, CERN, JINR.
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