Recent results from New Physics searches using the ATLAS detector at LHC

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1 Introduction

The center of mass energy of the LHC (7 TeV) allows the experiments to test extensions of the Standard Model which foresee new phenomena at the TeV scale. Here, results from the searches for New Physics performed by the ATLAS collaboration with data collected in 2010 and in early 2011 are presented. In Section 2 searches for supersymmetry in final states with large missing transverse energy are discussed. In Section 3 searches for new long lived massive particles are presented. The remaining New Physics searches are divided according to their final states: fully hadronic (Section 4), leptonic (Section 5) and leptoquark searches (Section 6).

2 Searches for supersymmetry

The production via strong interaction of scalar quarks and gluinos, followed by their decay into a weakly interacting stable particle, would result in a final state characterized by high p_T jets and missing transverse energy. Leptons might also be produced depending on the mass hierarchy of the supersymmetric partners and the resulting decay chains. The lepton multiplicity, which strongly affects the background composition, is used to define search channels.

Signal is searched for by counting the number of events passing an appropriate set of selection cuts. The expected number of Standard Model events is determined using measurements performed in control regions and transfer functions which relate the expected rate in the signal region to that in the control samples. These transfer functions are obtained from data for the multijet background and from Monte Carlo simulation for other processes.

The 0 lepton final state analysis [1] uses 165 $pb^{-1}$of data collected in 2011. Events with large transverse missing momentum and two, three, or four high p_T jets in the final states are selected; the different jet multiplicity selections provide good sensitivity for different regions of the squark and gluino mass plane. For all the selections the observed rate is consistent with the background expectation. In Fig. 1 the limits are shown for a simplified model containing degenerate squark of the first two generations, a gluino octet and a massless neutralino. In such a model, gluino masses below 725 GeV are excluded at 95% confidence level, the limit increasing to 1025 GeV for equal mass squark and gluinos. This analysis has been recently updated with 1.04 $\text{fb}^{-1}$of data and submitted for publication [2].

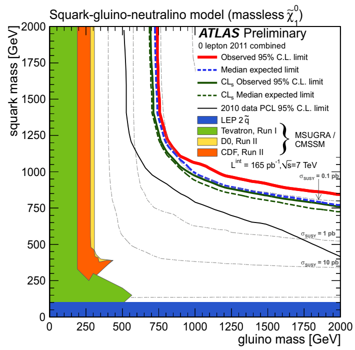

Figure 1: 95% exclusion limits in the gluino-squark mass plane for a simplified MSSM model with a massless neutralino. Comparison with existing limits should take into account that the present analysis assumes a massless neutralino.

The one lepton final state analysis [3], based on the full 2010 dataset (35 pb^{-1}), requires exactly one electron or muon with $p_T > 20$ GeV/c, three jets, and high values for the transverse mass m_T between lepton and neutrino and E^T_{Miss}. Events with two opposite or same sign leptons and large values of $E^T_{\text{Miss}}$are also used to search for evidence of New Physics [4]. In all channels the number of observed events is consistent with the Standard Model expectation, placing limits on the product of signal cross section, acceptance and selection efficiency between 0.063 pb and 0.22 pb, depending on the channel. The one lepton analysis has been recently updated with 1.04 $\text{fb}^{-1}$of 2011 data and submitted for publication [5].

Final states rich in b-jets can be produced by the decay of the gluino in sbottom or stop. A search for an excess of events with at least one b-tagged jets, further high p_T jets, transverse missing energy, and either no or one isolated lepton was thus performed with 35 $\text{pb}^{-1}$of 2010 data [6]. No significant excess over Standard Model expectation has been observed, which allowed to set limits in the plane defined by the gluino and the sbottom or stop masses. For models in which sbottoms(stops) are the only squarks present in the gluino decay cascade, gluino masses below 590 GeV

(520 GeV) are excluded at 95% C.L. Preliminary results with early 2011 data can be found in [7].

3 Searches for long lived particles

New heavy particles with long lifetimes appear in various extensions of the Standard Model. Here the results of three searches for these particles are reported.

The first search [8] looks for slow-moving electrically charged or strongly interacting (R-hadron) particles using timing measurements from the muon spectrometer and the hadronic calorimeter. No excess is observed above the estimated background. The electroweak production of long lived sleptons is excluded up to a mass of 110 GeV, while R-hadrons are excluded up to masses of 530 GeV to 544 GeV depending on the details of their production.

R-hadrons are also searched for by an analysis [9] which uses the dE/dx measured using the Pixel Detector and timing measurements from the hadron calorimeter to reconstruct the velocity of the candidates. Long lived scalar bottom lighter than 294 GeV, scalar top lighter than 309 GeV, and gluinos lighter than 562 to 584 GeV are excluded at 95% C.L.

Another analysis [10] looks for heavily ionizing particles. The signature is an high ionization measured in the Inner Detector, followed by a narrow energy deposit in the calorimeter. Production cross section limits are placed on particles with electric charge $6e < q < 17e$, mass $m < 1000$ GeV, and lifetime longer than 100 ns.

4 Other searches in fully hadronic final states

A search for a resonance in the dijet invariant mass spectrum has been carried out with 163 pb^{-1} of data [11]. The measured distribution is shown in the left plot of Fig. 2. Since the data are found to be consistent with a smoothly falling distribution, 95% limits of 2.49 TeV and 2.67 TeV have been placed on excited squarks and axigluons respectively. Those limits have been raised to 2.99 TeV and 3.32 TeV respectively by a later analysis with 1.0 fb^{-1}, submitted for publication [12].

Another search in the multi-jet final state looks for an excess of events with high jet multiplicity and the scalar sum $\Sigma \mathrm{p}_T$ of their transverse momenta [13]. The production of quantum black holes would produce such a signature. The distribution of $\Sigma \mathrm{p}_T$ is measured for events with at least five jets with $\mathrm{p}_T > 50$ GeV/c and $|\eta| < 2.8$. Since the background $\Sigma \mathrm{p}_T$ shape is independent of jet multiplicity, it is measured in a control sample with less than five jets. An upper limit at the 95% C.L. on the cross section times acceptance of 0.29 pb for final states with more than four jets and $\Sigma \mathrm{p}_T > 2$ TeV is derived.

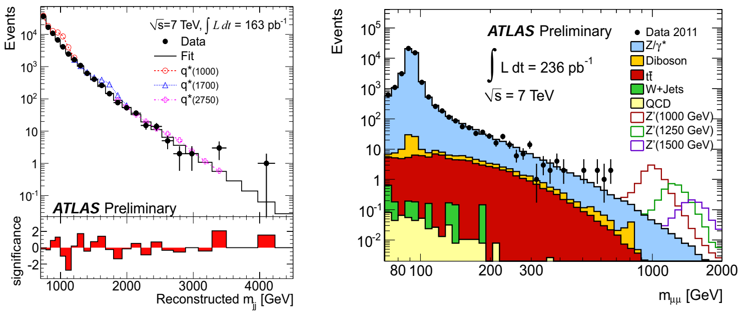

Figure 2: Left: measured di-jet mass spectrum (filled points) fitted with a binned background distribution (histogram). The predicted excited quark signals for masses of 1000, 1700 and 2750 GeV are superimposed. Right: dimuon invariant mass distribution after final selection, compared to the expected backgrounds, with three example SSM Z' signal superimposed.

5 Searches in leptonic final states

High mass electron and muon pairs have been examined in order to look for any evidence of a resonance [14]. The invariant mass distribution of muon pairs with 236 $\text{pb}^{-1}$of data is reported in the right plot of Fig. 2. No deviation from the expected contribution from Drell-Yan and other Standard Model processes has been observed. This allows to set 95% C.L. limits on the existence of new neutral gauge bosons; a Sequential Standard Model Z' is excluded for masses below 1.407 TeV while lower limits between 1.116 TeV and 1.259 TeV are placed on the gauge bosons of the E6 model. More stringent limits have been placed recently using a larger data set [15].

Events with one energetic muon and missing transverse energy have been used to probe the existence of heavy charged bosons [16]. Again, no evidence has been found and a 95% C.L. limit of 1.70 TeV on the mass of a Sequential Standard Model W' is placed. A recent update of this analysis [17] extends the limit to 2.15 TeV.

Another search looks for a new, light (order of 1 GeV) boson decaying into muons in a final state consisting of collimated leptons (lepton-jets). The analysis is performed with 40 pb^{-1} [18]. Events are required to contain at least two isolated lepton-jets, each of which must contain at least two muons. No signal candidate has been observed on top of a background of 0.21 ± 0.19 events. From this, 95% C.L. limits are set on the cross section for supersymmetric events with the lightest supersymmetric particle decaying to the new boson, as a function of the new boson mass.

6 Searches for leptoquarks

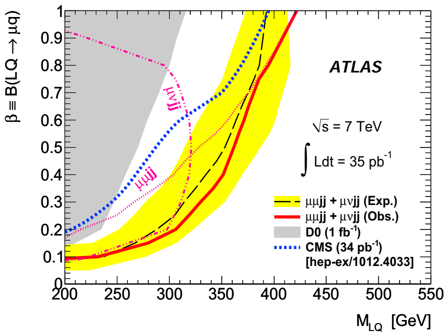

Figure 3: 95% C.L. limits from the muon channel searches on the plane defined by the branching ratio in muon quark of the leptoquarks and their mass.

Leptoquarks are hypothetical particles possessing both baryon and lepton quantum numbers; they have been searched for using the 2010 data sample, corresponding to 35 pb^{-1} [19]. Events with two oppositely charged electrons or muons and at least two jets, and events with one electron or muon, missing transverse momentum and at least two jets are selected. After event selection, rates are found to be consistent with the Standard Model prediction. Limits have been derived on the plane formed by the leptoquark mass and their branching ratios in charged lepton and quark (as opposed to neutrino and quark). The limits for second generation leptoquarks are reported in Fig. 3.

7 Conclusions

Evidence for new Physics has been searched for by the ATLAS experiment in many different channels. No new Physics signal has been found, and the exclusion limits presented in this report improve those obtained at LEP or the Tevatron.

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