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SUSY RESULTS AT THE LHC WITH THE ATLAS DETECTOR

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Abstract
The data collected during 2011 with the ATLAS detector has been used to perform searches for signals due to R-parity conserving supersymmetry. The results of different analyses targeting jets, isolated leptons and missing transverse energy in the final state, a promising venue for the discovery of supersymmetry, are presented in some details in the following.

1. Introduction
Supersymmetry (SUSY) is one of the most popular extensions of the Standard Model (SM). SUSY relates each elementary SM particle of one spin to another particle named superpartner, from which it differs by half a unit of spin (fig. 1).

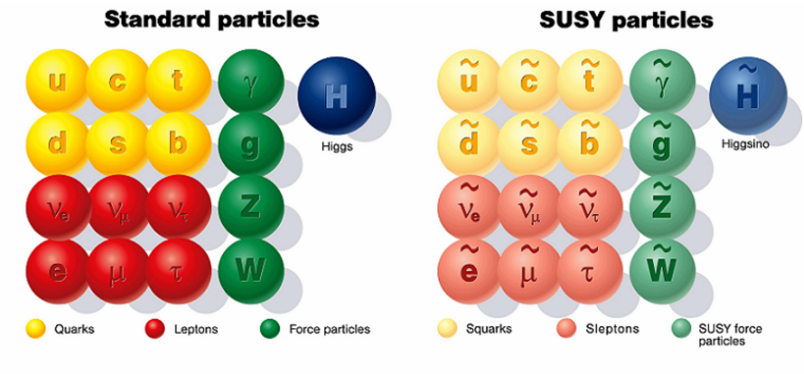

Figure 1: SM particles and their supersymmetric partners in the SUSY scenario

In case of R-parity[1] conservation, charginos and neutralinos[2] can be produced directly in pairs or in the decay chains of squarks and gluinos. Moreover, the Lightest Supersymmetric Particle (LSP) is stable and therefore escapes any detector, while charginos decay into LSPs can yield high-p_T leptons. A common signature for SUSY searches at high energy colliders is thus a high Transverse Missing Energy (E^T_{miss}) due to the LSPs, multiple high energetic jets from quark hadronization and eventually additional leptons coming from $\chi^{\pm}_1$ decay to the LSP (fig. 2).
The ATLAS Collaboration has searched these final states during the first year of proton-proton collisions at a centre-of-mass energy of 7 TeV, which have been delivered by the LHC in 2011.

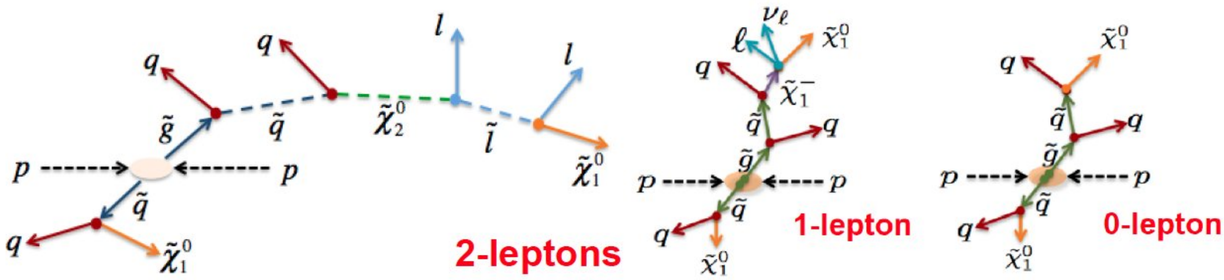

Figure 2: Example of proton-proton interactions where supersymmetric partners are produced in pairs: the final state includes E^T_{miss}, some jets and eventually one or more leptons.

[1] $R=(-1)^{3(B-L)+2s}$, where *B*,*L* and *S* are respectively the barionic number, the leptonic number and the spin.
[2] Charginos ($\chi^{\pm}_i$) and neutralinos (χ^0_j) are mass eigenstates of the superpartners of the bosons.

During this year, the ATLAS detector has worked remarkably well, recording around 5 fb^{-1} of collisions with an overall data taking efficiency of 94%. The proton run ended in October, when the LHC switched to heavy ions collisions[3].

2. 0-lepton final state

When squarks and gluinos decay directly to quarks and LSPs (fig. 2), leptons are not produced in the decay chain and therefore no electrons nor muons appear in the final state. This case is favoured when the squark and gluino masses are not heavy enough to decay into heavier neutralinos or charginos. With 1 fb^{-1} of ATLAS data, the number of expected SM events has been compared with the number of observed events in the 0-lepton final state, and no excess has been found over the expectation. The SM background processes, such as W/Z+jets, top pair production and QCD multijets, have been estimated by defining different Control Regions (CR) and by extracting the amount in the Signal Regions (SR) by means of transfer factors[4]. With no excess, it has been possible to set limits on the SUSY particle masses and subsequently to interprete the results within different theoretical models. Gluino and squark masses below 1000 GeV have been excluded at the 95% Confidence Level (C.L.) within the main models. The most important uncertainties taken into account in this analysis are Jet Energy Scale (JES), Jet Energy Resolution (JER), pileup effect, luminosity, Monte Carlo (MC) statistics and the uncertainty on cross sections.

3. 1-lepton final state

In case a squark decays via chargino and a quark (fig. 2), then the chargino may produce a high-p_T lepton in the final state. Scenarios with large E^T_{miss}, jets and one electron or muon have been studied by ATLAS, but no excess has been found with respect to the SM predictions.
The main background processes for this final state are W+jets, top pair production with a semi-leptonic decay and QCD processes with a jet misidentified as a lepton. To measure them, the number of expected background events in the defined SR has been extracted with data-driven techniques from different CRs. Good agreement was also observed between predicted and observed events in every CR. Systematic uncertainties for this analysis are mainly due to theoretical uncertainties such as the prediction of cross section, scale factors and PDFs (20-30%), MC statistics (15%), JES and JER (1-10%), pileup (1-10%) and luminosity (3.7%).
Final results led to exclude masses of gluinos and squarks up to 875 GeV at the 95% C.L. (fig. 3).

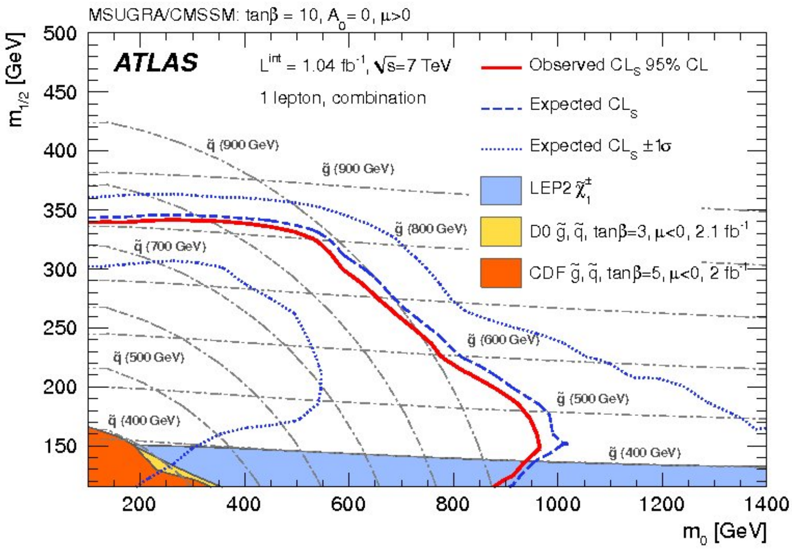

Figure 3: Observed and expected CL_s limits at 95% C.L., as well as the ±1 sigma variation on the expected limits, in the combined 1-lepton channel for an integrated luminosity of about 1 fb^{-1}.

[3] All the analysis presented in this paper apply to 1fb^{-1} of proton-proton collisions.
[4] A Control (Signal) Region is defined with loose (tight) cuts to enhance the presence of background (signal).

4. 2-leptons final state

The final state with two high-p_T, well-isolated leptons is a very promising venue to discover SUSY at the LHC. Two leptons can emerge either from the chargino decay into lepton-neutrino-neutralino in both legs or from a single chargino decay into two leptons plus a lighter chargino (fig. 2).
The SRs in this analysis have been optimized with studies on specific models and include final states with opposite sign leptons (OS), same sign (SS) and a flavour subtraction of events with same flavour and different flavour leptons. The major source of background for the OS SR comes from top pair production with a di-leptonic decay. SS leptons events have smaller SM background, but they suffer from low statistics. The estimate of all these processes has been handled with data-driven or semi data-driven techniques. In particular, the QCD misidentified leptons have been measured with a data-driven technique called Matrix Method. The total systematic uncertainty on the number of expected events for this channel ranges from 25% to 70%, depending on the cuts in the SR.
As for the other channels, no excess over SM background has been observed and limits on the masses and cross sections have been set. Charginos masses up to 200 GeV are excluded at 95% C.L.

5. Conclusions

A wide range of SUSY signatures has been investigated by ATLAS with 1 fb^{-1} of proton-proton collisions data. No hints for supersymmetry was observed in all channels and limits on the supersymmetric particles masses were set depending on the theoretical model.
At 95% C.L. squarks and gluinos masses up to 1000 GeV are excluded in most principal models.
For the year 2012, the ATLAS Collaboration is moving to study all the remaining range of SUSY signatures as well as to improve the existing analyses using the full 2011 statistics.
The parameter space where SUSY particles are hiding is being continuously reduced.

References

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