Search for Same-Sign Dilepton SUSY Events with ATLAS at the LHC

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Supersymmetry (SUSY) extends the Standard Model, predicting a set of new particles that only differ from the known SM particles by the spin, and - because SUSY is apparently broken - by the mass. In the following study, we assume that the R-parity is conserved, so that SUSY particles are produced in pairs and that the lightest supersymmetric particle (LSP) is stable. If the LSP is the lightest neutralino, it escapes ATLAS undetected and causes a missing transverse energy signature. The latter requires extensive calibration studies and a good understanding of the response of every ATLAS detector component before we can include it in our SUSY search.

A promising signature in superparticle search is the same-sign dilepton signal (SSD) for which a strong rejection of the Standard Model background is possible without the need to cut on the missing transverse energy. The final states of SUSY events can indeed contain two leptons (electrons or muons) with the same sign of charge. These leptons are not spatially related to a jet, so the SSD signal can be distinguished from the Standard Model background events by applying isolation criteria (e.g. cutting on the energy deposited around the tracks of the leptons).

A reliable identification of the charge of leptons is of great importance in this context. We have thus started performing an analysis of electron charge misidentification in the ATLAS detector. The overall magnitude of this effect is on the order of 0.5 percent according to Monte Carlo data. Bremsstrahlung and pair production processes are deemed to be predominantely responsible for the effect of charge misidentification. The energy of a particle is determined from its energy deposition in the calorimeter, while the charge is determined from the curvature of the particle track in the magnetic field of the detector. The energy measurement is thus less sensitive to bremsstrahlung and pair production than the charge identification, which suffers from the high track multiplicities and path deflections seen in such processes. Since bremsstrahlung and pair production only occur in matter the rate of charge misidentification will increase with the amount of material inside the tracking detector and therefore a higher charge misidentification rate is expected in the forward region around $|\eta| \approx 2$, where it reaches values of up to two percent.

In parallel, we have developed a SSD analysis and performed it on different points representing sets of allowed SUSY parameters, using the full simulation of the ATLAS detector. The study in the 'Bulk Region' shows that SUSY could be discovered within one year at low luminosity (10 fb^{-1}). We preselect our events by requiring two charged leptons (either electron or muon) with the same sign of charge, each having a minimum transverse momentum of 15 GeV.

Table 1 shows the background samples taken into account for this analysis; Table 2 summarizes the cut flow for different points of the mSUGRA-plane. Figure 1 shows the cut on the transverse momentum of the most energetic jet; the signal p_T-distribution clearly differs from the background samples.

Sample	σ (pb)	L(pb^{-1})
$t\bar{t}$	461	217
Zbb $\rightarrow$ llbb	43	3738
Zbb $\rightarrow$ 3l	5.2	2788
WW	24.5	851
WZ	7.8	3102
ZZ	2.1	11674

Table 1: Background samples used in this study along with their cross section and their integrated luminosity.

	cuts		
Sample	SSD	Isolation	1^{st} jet p_T
SU3	237	102	35
SU1	101	46	19
SU2	51	23	7
$SU2_{light}$	9	6	*(not applied)*
Background	5565	405	*(0)*

Table 2: Cut flow (number of events for 10 fb^{-1}) for different SUSY points (SU1 = Stau Coannhilation Region, SU2 = Focus Point Region, $SU2_{light}$ = SU2 without events containing squarks or gluinos, SU3 = Bulk Region) and for the background.

The analysis for the focus point region requires further improvement due to the small cross-section. In future analyses, different isolation cuts and W/Z-vetos will be tested. Since the strongest background is $t\bar{t}$, it has to be well analysed and understood.

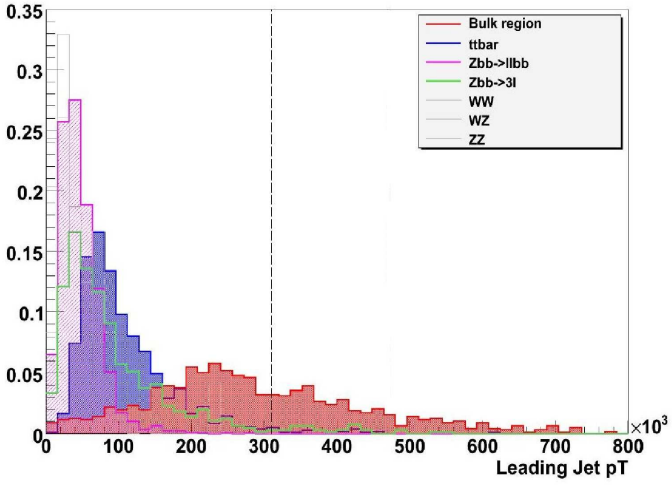

Fig. 1: Cut on the 1^{st} jet p_T, in MeV. The distributions are normalised to 1.