PROCEEDINGS OF SCIENCE

Searching for supersymmetry with two same-sign leptons, multi-jets plus missing transverse energy in ATLAS at $\sqrt{s} = 10$ TeV

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A search for R-parity conserving supersymmetry using the ATLAS detector is presented. The final state under study includes two same-charge leptons, two jets, and missing transverse energy. We propose a data-driven method to estimate the number of Standard Model background events, and its discovery potential is assessed assuming an integrated luminosity of 200 pb^{-1} and a center of mass energy of 10 TeV.

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1. Introduction

Supersymmetry is one of the prime theories [1] for physics beyond the Standard Model. It predicts a super partner for every known elementary particle in the SM. In our study we consider an R-parity conserving scenario in which the lightest supersymmetric particle is stable. Searches for supersymmetry in the same-sign dilepton channel have been performed at Tevatron [2, 3].

2. Signal and Background Models

Our final state is composed of high P_T same-sign leptons, accompanied by at least two jets and $\not{E}_T$. SM processes that can mimic these final states are: $t\bar{t}$ pair production, W+light-quark jets and Wbb+jets, $b\bar{b}$ production, single top production, WW, ZZ, WZ, Wγ and Zγ production. As a potential signal for this analysis we have chosen the mSUGRA model.

3. Event Pre-Selection

The event pre-selection consists of the following cuts: Exactly 2 leptons with same charge, $P_{T,l1} > 20$ GeV and $P_{T,l2} > 10$ GeV. $(M_{ll}) > 5$ GeV. At least two jets with $P_T > 40$ GeV. $\not{E}_T > 50$ GeV. Transverse mass (M_T) to study the dominant background processes. It is defined as $M_T = \sqrt{2(P_{T,l1}\not{E}_T(1-cos\Delta\phi(l1,\not{E}_T))}$.

4. Background Estimation

After the event preselection cuts, $t\bar{t}$ and W+jets are the dominant processes among all of the SM background processes. In order to estimate the SM background in situ, we classify the events that survive the preselection into four different categories. We rely on four different variables that have power to discriminate between signal and background. These variables are: $\not{E}_T$, P_T of the second leading jet, P_T of the second leading lepton and M_T.

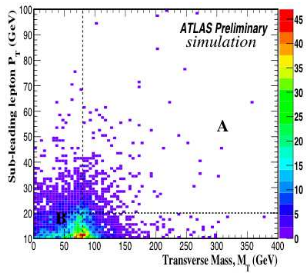

Figure 1: The small box (B), big box(A).

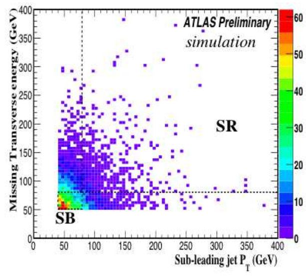

Figure 2: The small box (SB), big box (SR).

We define a signal-like region SR, a sideband region SB and regions A and B as follows: SR: $\not{E}_T > 80$ GeV and $P_{T,j2} > 80$ GeV; SB: $50 < \not{E}_T < 80$ GeV and $40 < P_{T,j2} < 80$ GeV. A: $P_{T,j2} > 20$ GeV and $M_T > 80$ GeV; B $10 < P_{T,j2} < 20$ GeV and $50 < M_T < 80$ GeV. If the correlation between the variables can be neglected, the following expresion holds $\frac{A_{SB}}{B_{SB}} \simeq \frac{A_{SR}}{B_{SR}}$ and $A'_{SR} \simeq \left(\frac{A_{SB}}{B_{SB}}\right) \times B_{SR}$. Here A'_{SR} is the estimated SM event rate in the signal region and A_{SR} is the expected MC event rate in the signal region. In Figures 1 and 2 we can see all these regions.

Process	A_{SR}	B_{SR}	A_{SB}	B_{SB}
W	-	0.7±0.4	0.9±0.5	2.2±0.7
Z	-	-	0.1±0.1	0.1±0.1
Wbb	-	-	-	0.4±0.2
Wt single top	-	0.3±0.3	-	-
t-chan single top	-	-	0.9±0.6	1.1±0.6
$t\bar{t}$	1.3±0.2	3.0±0.3	3.8±0.3	10.3±0.5
Total SM events	1.3±0.2	4.0±0.6	5.7±0.8	14.0±1.1
SU1	2.4±0.4	0.1±0.1	0.1±0.1	-
SU3	2.7±0.7	-	-	-
SU4	40.2±4.4	8.0±1.9	2.8±1.2	2.4±1.1
SU6	1.1±0.2	0.2±0.1	-	-

Figure 3: Expected number of events in 200 pb^{-1}.

Data Content	Expected Signal Events in A_{SR}	Expected Signal+SM events in A_{SR}	Estimated SM events in A'_{SR}
No SUSY(only SM)	-	1.3±0.2	1.6±1.1
SM+SUSY SU1	2.4±0.4	3.7±0.5	1.6±1.2
SM+SUSY SU3	2.7±0.7	4.0±0.7	1.6±1.1
SM+SUSY SU4	40.2±4.4	41.5±4.4	6.2±3.2
SM+SUSY SU6	1.1±0.2	2.4±0.3	1.6±1.2

Figure 4: Expected and estimated events of SM in signal region

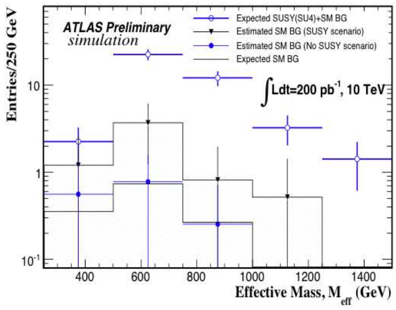

Figure 5: Effective mass distribution for leptons(same-sign)+jets+$\not{E}_T$ final state.

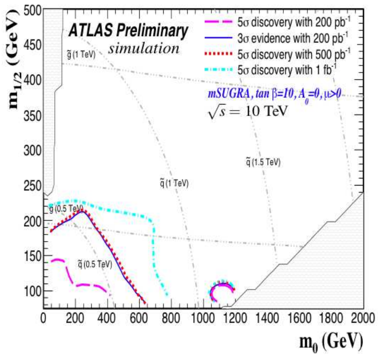

Figure 6: Discovery reach in the mSUGRA plane.

5. Discovery Potential

From table in figure 4 we conclude that if nature has chosen an SU4-like SUSY signal in data, we will be able to observe a clear signature with an integrated luminosity of 200 pb^{-1} at 10 TeV. Figure 5 shows the effective mass distribution for signal and background, defined as $M_{eff} = P_T^{lep} + \not{E}_T + \sum_{jets} P_T^j$. Figure 6 show the discovery reach for various luminosity scenarios in one of the mSUGRA parameter planes.

6. Conclusion

Same-sign dilepton production associated with jets and $\not{E}_T$ is an important channel to discover supersymmetry in the early LHC data. It is shown that we will be able to find evidence of gluinos and squarks of masses up to 500 GeV with a 3 σ significance with as little as 200 pb^{-1} of integrated luminosity and a center of mass energy of 10 TeV.

References

[1] H.Haber and G.Kane, "Phyis. Rept", (1985) 117-75

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