# Search for SUSY in the 1-Lepton Channel with ATLAS at the LHC

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Supersymmetry (SUSY) is a well-motivated extension of the Standard Model which predicts new particles yet to be discovered. With the start-up of the Large Hadron Collider (LHC), the quest for SUSY will be allowed new opportunities: supersymmetric particles could be discovered using the ATLAS detector. The typical SUSY events at LHC would be the production of gluinos and squarks in the $pp$ interactions followed by quark-emitting decays into lighter supersymmetric particles. If R-parity is conserved, the Lightest Supersymmetric Particle (LSP), usually the lightest neutralino, is stable: the neutralinos emitted at the end of the supersymmetric decay chains would escape the detector. Typical supersymmetric decay chains would hence lead to a multi-jet, large missing transverse energy signature. The requirement of one lepton in the analysis, coming from a chargino or a heavy neutralino decay in the cascade for example, can further differentiate the signal from the expected Standard Model background.

The 1-lepton channel cut-based analysis has been performed on samples for the SUSY signal and the Standard Model backgrounds that were produced using the full simulation of the ATLAS detector (in GEANT). In the following, $p_T$ is the transverse momentum, $\not\!\!E_T$ is the transverse missing energy and $S_T$, the transverse sphericity. Moreover, the effective mass is defined as:

$$M_{eff} = \sum_{i=1}^{4} p_T^{jet,i} + p_T^{lep} + \not\!\!E_T. \qquad (1)$$

and the transverse mass, as:

$$M_T = \sqrt{2 p_T^{lep} \not\!\!E_T (1 - cos\phi(\vec{\not p}_T, \vec{p}_T^{\,lep}))} \qquad (2)$$

An event is selected if it has:

1. only one isolated lepton (electron or muon) with $p_T > 20\,GeV/c$
2. at least four jets: one with $p_T > 100\,GeV/c$ and three with $p_T > 50\,GeV/c$
3. $\not\!\!E_T > \max(100\,GeV, 0.2 M_{eff})$
4. $S_T > 0.2$
5. $M_T > 100\,GeV/c^2$
6. $M_{eff} > 800\,GeV/c^2$

| | SU3 | $t\bar{t}$ | W+j | Z+j | Diboson | QCD |
|---|---|---|---|---|---|---|
| Total | 27680 | 450000 | 19190 | 15110 | 55940 | 1644146 |
| Cut 1 | 4000 | 183994 | 5909 | 3448 | 29332 | 3937 |
| Cut 2 | 1491 | 15897 | 1206 | 473 | 31 | 1024 |
| Cut 3 | 995 | 2030 | 422 | 22 | 7 | $< 113$ |
| Cut 4 | 768 | 1549 | 316 | 16 | 5 | $< 113$ |
| Cut 5 | 451 | 132 | 14 | 1 | 1 | $< 113$ |
| Cut 6 | 363 | 36 | 5 | 0.2 | 0 | $< 113$ |

Table 1: Results of the 1-lepton analysis, in events for 1 $fb^{-1}$ of data, for the SUSY benchmark point SU3 and for the main backgrounds. The QCD sample being statistically limited, an upper limit at 95% C.L. is given when there is no event left: this is a pessimistic approach since the cuts 4 to 6 should also reduce this background.

Table 1 shows the number of events passing in turn each analysis cut for 1 $fb^{-1}$ of data (i.e. one month at low luminosity) for the SUSY benchmark point SU3 ($m_0 = 100$ GeV, $m_{1/2} = 300$ GeV, $A_0 = -300$ GeV, $tan\beta = 6$, $sign(\mu) = +$) and the main backgrounds. Using the upper limit on QCD events (see Table 1), one nevertheless obtains a high significance of $S/\sqrt{B} \approx 29$. Figure 1 shows the distribution of $M_{eff}$ for the signal and backgrounds after applying cuts 1 to 5.

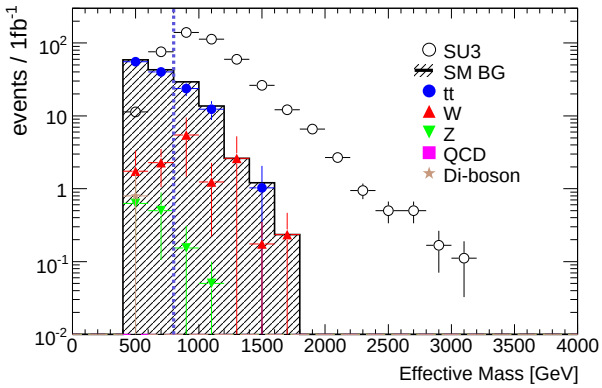


Fig. 1: $M_{eff}$ distribution for the SUSY benchmark point SU3 and for the main backgrounds after applying all cuts but the one on $M_{eff}$. The vertical line indicates the cut value chosen.

The trigger efficiency for the signal events selected by the analysis has been evaluated using the $10^{33}$ cm$^{-2}$s$^{-1}$ trigger menu from the HLT TDR [1]. Table 2 shows the triggers considered and their efficiency after applying the 1-lepton analysis to the point SU3. From this Table, one can see that a near 100% trigger efficiency can be reached with the J70_XE70 trigger, while jet triggers have low efficiencies. A trigger based only on missing transverse energy, XE120, has also been introduced and shows good efficiency, but the rate issue remains to be addressed. A possible alternative to the triggers based on missing transverse energy could be to use a combination of lepton and jet triggers, such as 4J1LEP.

| Trigger | Level 1 Threshold [GeV] | Level 1 Rate [kHz] | High Level Trigger Threshold [GeV] | High Level Trigger Rate [Hz] | Efficiency SU3 [%] |
|---|---|---|---|---|---|
| EM25I | 25 GeV | 12 | 25 GeV | 40 | |
| MU20 | 20 GeV | 0.8 | 20 GeV | 40 | |
| 1LEP | | | | | 79.9 |
| J400 | 200 GeV | 0.2 | 400 GeV | 10 | 9.7 |
| 3J165 | 90 GeV | 0.2 | 165 GeV | 10 | 15.0 |
| 4J110 | 65 GeV | 0.2 | 110 GeV | 10 | 22.1 |
| 4J1LEP | | | | | 84.4 |
| XE120 | 100 GeV | - | 120 GeV | - | 93.0 |
| J70_XE70 | 60 GeV | 0.4 | 70 GeV | 20 | 98.9 |

Table 2: Unprescaled triggers at $10^{33}$ cm$^{-2}$s$^{-1}$ and their efficiency for SU3 events passing the event selection. "J" stands for jet transverse energy, "XE" for missing transverse energy and "I" for isolated. 1LEP is defined as EM25I OR MU20 and 4J1LEP as 4J110 OR 1LEP.

## References

[1] ATLAS High-Level Trigger, Data Acquisition and Controls Technical Design Report, ATLAS TDR-016 (2003)