QCD Background Studies for Inclusive SUSY Searches in the 1-Lepton Channel

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Supersymmetry (SUSY) is a promising candidate to describe physics beyond the standard model and will be searched for with the ATLAS detector at the LHC. The 1-lepton SUSY analysis performed in the mSUGRA framework is one possible search mode being developed to look for hints of SUSY in events containing exactly one electron or muon in the final state [1]. Although in strong interactions no leptons are directly produced, a small fraction of the simulated QCD multijet events contain anyhow reconstructed electrons and muons, so-called fake leptons, and therefore represent one background component for this SUSY search channel.

The 1-lepton SUSY analysis, described in [1,2], comprises cuts on the leptons, the jets, the missing transverse energy, $\not\!\!E_T$, the transverse sphericity, S_T, the transverse mass, M_T, and the effective mass, M_{eff}. These cuts act very efficiently on the QCD background Monte Carlo samples, reducing the number of surviving events to zero. However, the rather low integrated luminosity of these samples caused by huge cross sections leads to a large statistical uncertainty on the cut efficiency. To reduce this uncertainty, a worst-case strategy was developed to estimate the QCD background cut efficiency based on neglecting correlations between more than two cut variables. Thereby, sufficient statistics allowed a direct application of the cuts on leptons and jets; the efficiencies of the cuts on $\not\!\!E_T$, S_T, M_T and M_{eff} were separately evaluated at 68.27% C.L. after applying only one of the proceeding cuts with respect to the cut order outlined in [1,2]. This procedure was done for all cuts that proceed the cuts on $\not\!\!E_T$, S_T, M_T and M_{eff}, respectively. Multiplying the worst upper limit on efficiency of each cut variable led to $\varepsilon_{combined}$, the combined cut efficiency for the cuts on $\not\!\!E_T$, S_T, M_T and M_{eff}. However, $\varepsilon_{combined}$ depends on the given cut order of $\not\!\!E_T$, S_T, M_T and M_{eff} as cut efficiencies can only be influenced by cuts that are imposed *before*. Therefore, $\varepsilon_{combined}$ was evaluated for all permutations of the cuts on $\not\!\!E_T$, S_T, M_T and M_{eff}. This method to evaluate the maximum QCD background predicts that the SUSY signal significance for the benchmark point SU3 could be improved by 30% with respect to [2].

Furthermore, the reconstructed electrons and muons contained in the QCD background samples were studied. A matching strategy was designed, assigning reconstructed leptons to a lepton or to a jet at generator level. If a reconstructed lepton is paired with a generated lepton of the same flavour, it is indicated as nonprompt since it originates from a heavy flavour decay following the initial strong interaction. A reconstructed lepton only matched by a generated jet is referred to as jet-faked lepton.

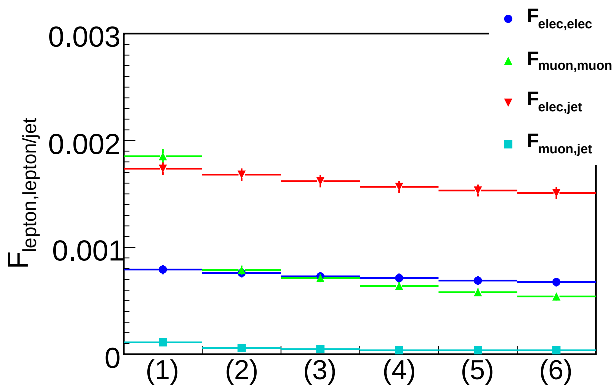

Fig. 1: $F_{elec,jet}$, $F_{muon,jet}$, $F_{elec,elec}$ and $F_{muon,muon}$ as a function of the $\Delta R(l,j)$ requirement. The bin labels (1) to (6) characterize different lepton isolations. For the bins (1) to (6) the energy isolation $etcone20 < 10$ GeV is applied. The bins (2) to (6) have to fulfill an additional $\Delta R(l,j)$ requirement that is tightened from $\Delta R(l,j) > 0.25$ to $\Delta R(l,j) > 0.45$ in steps of 0.05.

The integrated fake rates, $F_{reconstr.\ object,gener.\ object}$, defined as the ratio between the number of fake leptons ($p_T > 10$ GeV, $|\eta| < 2.5$) and reconstructed jets ($p_T > 20$ GeV, $|\eta| < 2.5$), were calculated for different combinations of the lepton energy isolation, $etcone20 = E_T^{(\Delta R<0.2)} - E_T^{(cluster)}$, and geometrical $\Delta R(l,j)$ requirement, which asks for a minimal distance between reconstructed leptons and jets. For the standard lepton isolation [1], $etcone20 < 10GeV$ and $\Delta R(l,j) > 0.4$, jet-faked electrons dominate the overall fake rate, whereas the contribution of jet-faked muons to the overall fake rate is marginal. Table 1 shows $F_{elec,jet}$ for different isolations of reconstructed electrons. Figure 1 depicts the different fake rates for $etcone20 < 10$ GeV and a $\Delta R(l,j)$ requirement which is tightened from bin to bin. The large decrease of $F_{muon,muon}$ from (1) to (2) in Figure 1 originates from an unprecise measurement of $etcone20$ in the transition region from the electromagnetic barrel to the electromagnetic end-cap calorimeter.

Moreover, the fake rates were analyzed as functions of kinematic variables and the probability of a generated jet or lepton to be reconstructed as a lepton was determined. More details are given in [3].

Table 1: $F_{elec,jet}$ for different isolations of reconstructed electrons. The fake rate in the first row, second column is missing as the $\Delta R(l,j)$ requirement is combined with $etcone20 < 10$ GeV.

$F_{elec,jet}/10^{-4}$	no $\Delta R(l,j)$ requ.	$\Delta R(l,j) > 0.4$
no $etcone20$ cut	40.4 ± 0.9	-
$etcone20 < 10$ GeV	17.4 ± 0.6	15.3 ± 0.6
$etcone20 < 5$ GeV	6.7 ± 0.4	5.9 ± 0.3

References

[1] The ATLAS Collaboration. Expected Performance of the ATLAS Experiment - Detector, Trigger and Physics. December 2008.
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[3] J. Will. QCD background studies for inclusive SUSY searches in the 1-lepton channel. Diplomarbeit. LMU. 2009.