Study of muon performance in SUSY events with ATLAS detector

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Since many of the SUSY analysis at ATLAS detector [2] focus on events with one or more high energetic leptons, the knowledge of the efficiencies and fake rates of these leptons is a crucial point. Monte Carlo based study of muon performance in mSUGRA and background events is described in this report. SU3 point which is covering the bulk region of mSUGRA parameter space, SU1 point in the stau-coannihilation region and SU4 point in the low-mass region were analysed. Leptonically decaying top quarks constitute a major background for analysis with leptons in the final state. The T1 sample with at least one top quark decaying leptonically was used. Pile-up and cavern background simulations were not included in the mentioned signal and background samples.

Muons obtained by the STACO software were used. They were reconstructed with Muonboy, combining Inner Detector and Muon Spectrometer tracks. Muons produced by the MuTag algorithm, dedicated to the identifications of very low-p_T muons, were discarded. The track segment match χ^2 was loosely required to be smaller than 100. If more than one Inner Detector track matched one track from the Muon Spectrometer, only the one with best match (smallest distance ΔR) was kept. Muon identification criteria were chosen in such a way to get the best possible efficiency and minimal probability of misidentification as different types of objects in a given SUSY environment. Reconstructed and truth muons are selected if having $|\eta| < 2.5$ and calorimeter isolation $E_T^{isol} < 10$ GeV in a cone $\Delta R < 0.2$ (later not applied on truth muon when calculating fake rates). Transverse momenta of reconstructed muon were required to be $p_T > 15$ GeV ($p_T > 20$ GeV) for efficiency (fake rate) studies and vice versa for truth muons. Truth and reconstructed jets with $p_T > 20$ GeV and $|\eta| < 2.5$ were selected.

A reconstructed jet was removed from studies if a reconstructed electron was found to be at a distance $\Delta R < 0.2$ from this reconstructed jet. If there was a truth electron (with $p_T > 20$ GeV, $|\eta| < 2.5$ and calorimeter isolation in $\Delta R < 0.2$ less than 10 GeV) at a distance $\Delta R < 0.2$ from a truth jet, then the truth jet was discarded. If a reconstructed muon was found at a distance $\Delta R < 0.4$ from a reconstructed jet, then the muon was excluded from studies. Studies of efficiencies and fake rates were performed both before and after applying $\Delta R(\mu, jet) > 0.4$ cut.

Muons in the event can originate from several sources. They are produced in the decays of "heavy" particles, like SUSY particles, Z and W bosons, τ leptons, or they can come from heavy and light flavours decays. There is also the possibility that muons are radiated by other muons in Bremsstrahlung processes (so called G4 muons). According to the origin of muon, three collections of truth muons were used for efficiencies and fake rate analysis:

- muons from decays of "heavy" particles like SUSY, Z, W and τ (Def1),
- muons from decays of all particles (SUSY, Z, W, τ, heavy and light flavours) apart from G4 muons (Def2),
- muons from decays of all particles including G4 muons (Def3).

Efficiency was defined as the ratio of the number of truth muons matched with a reconstructed muon within a distance $\Delta R < 0.02$, divided by the total number of truth muons. Truth muons described by the first two definitions (Def1 and Def2) were used. The efficiencies as a function of p_T and of η for STACO muons from SU3 sample before applying $\Delta R(\mu, jet) > 0.4$ cut are shown on Figure 1 and Figure 2 for truth muons described by Def2. Obtained average values of efficiencies before and after applying $\Delta R(\mu, jet) > 0.4$ cut are reported in Table 1.

Fake rate was defined as the number of reconstructed muons without matching truth muon at a distance $\Delta R < 0.02$, divided by the total number of truth jets. Truth muons from all three definitions (Def1, Def2, Def3) were analysed. Fake

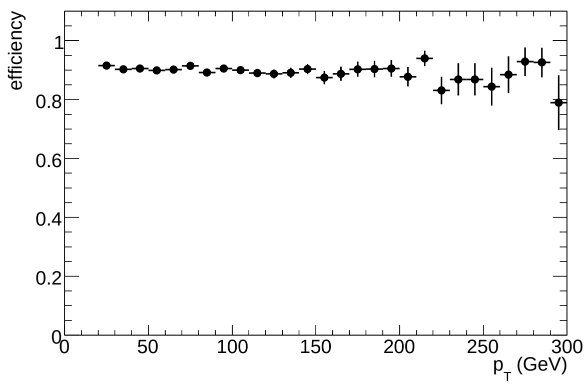

Figure 1. STACO muon efficiencies as a function of pT for the SU3 sample calculated with respect to truth muons described by Def2.

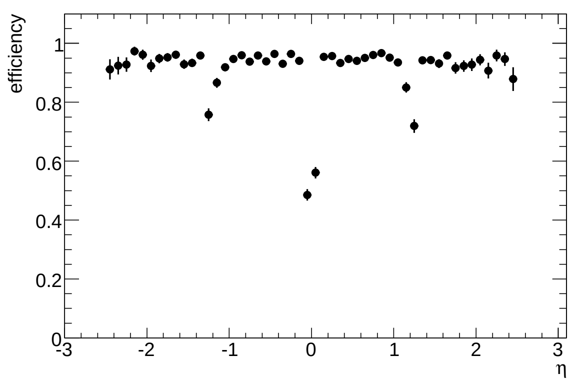

Figure 2. STACO muon efficiencies as a function of η for the SU3 sample calculated with respect to truth muons described by Def2.

	eff. (before)	eff. (after)
SU1, Def1	90.4(2)%	85.4(2)%
SU1, Def2	90.4(2)%	85.4(2)%
SU3, Def1	90.3(2)%	84.4(3)%
SU3, Def2	90.3(2)%	84.4(3)%
SU4, Def1	90.7(2)%	83.4(2)%
SU4, Def2	90.7(2)%	83.2(2)%
T1, Def1	91.46(7)%	87.06(9)%
T1, Def2	91.45(7)%	86.95(9)%

Table 1
STACO muon efficiencies for SU1, SU3, SU4 and T1 samples before and after applying $\Delta R(\mu, jet) > 0.4$ cut.

	f.r. (before)	f.r. (after)
SU1, Def1	$4.5(2) \times 10^{-4}$	$1.38(4) \times 10^{-4}$
SU1, Def2	$1.4(4) \times 10^{-5}$	$0.4(2) \times 10^{-5}$
SU1, Def3	$1.4(4) \times 10^{-5}$	$0.4(2) \times 10^{-5}$
SU3, Def1	$4.1(3) \times 10^{-4}$	$1.3(2) \times 10^{-4}$
SU3, Def2	$1.4(5) \times 10^{-5}$	$1.3(5) \times 10^{-5}$
SU3, Def3	$1.3(5) \times 10^{-5}$	$1.1(4) \times 10^{-5}$
SU4, Def1	$12.4(4) \times 10^{-4}$	$3.9(2) \times 10^{-4}$
SU4, Def2	$1.5(4) \times 10^{-5}$	$0.7(3) \times 10^{-5}$
SU4, Def3	$1.5(4) \times 10^{-5}$	$0.7(3) \times 10^{-5}$
T1, Def1	$17.2(3) \times 10^{-4}$	$5.4(2) \times 10^{-4}$
T1, Def2	$1.9(3) \times 10^{-5}$	$1.5(3) \times 10^{-5}$
T1, Def3	$1.5(3) \times 10^{-5}$	$1.0(2) \times 10^{-5}$

Table 2
STACO muon fake rates for SU1, SU3, SU4 and T1 samples before and after applying $\Delta R(\mu, jet) > 0.4$ cut.

rates are reported in Table 2 before and after applying $\Delta R(\mu, jet) > 0.4$ cut.

Goal of this study [3] was efficiencies and fake rates comparison between different SUSY samples and between SUSY and background T1 sample. Muon identification cuts were optimised with respect to the SUSY environment. Only statistical errors were considered. It can be seen from Table 1 that muon efficiencies are reasonably consistent for the different SUSY samples. Fake rates, with respect to muons coming from particles described by definitions Def2 and Def3, are statistically compatible in different SUSY and T1 samples and very low, of order 10^{-5}. With respect to muons described by Def1, fake rates are one or two orders of magnitude larger because they contain also the contribution of reconstructed muons coming from jets. T1 and SU4 events (Def1 truth muons) have larger fake rates than SU1 and SU3 events, because of their larger average number of b-jets. Cut $\Delta R(\mu, jet) > 0.4$ reduces fake rates (Table 2), especially in the case of highly isolated muons from heavy particles decays (Def1).

REFERENCES

1. ATLAS Collaboration is made of about 2500 Physicists coming from 167 Institutions of the following countries: Argentina, Armenia, Australia, Austria, Azerbaijan, Belarus, Brazil, Canada, Chile, China, Colombia, Czech Republic, Denmark, France, Georgia, Germany, Greece, Israel, Italy, Japan, Morocco, Netherlands, Norway, Poland, Portugal, Romania, Russia, Serbia, Slovakia, Slove-

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