Study of Muon Event Filter efficiencies on 2011 ATLAS data

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1. Introduction

During year 2011 the ATLAS experiment [1] has collected 4.9 fb^{-1} of proton-proton collisions at a centre-of-mass energy of 7 TeV at the LHC (Large Hadron Collider) [2].

All physics analyses requiring one or more hard muons selected events based on a single muon trigger condition. For periods B – I (the first half of the data taken in 2011), EF_mu18 is used as lowest unprescaled trigger, seeded by the loose $L1\_MU10$ Level-1 (L1) trigger. For the periods J – M, owing to the increasing instant luminosity and the consequent prescale of EF_mu18, the EF_mu18_medium trigger is chosen for the event selection. This trigger is seeded at L1 by $L1\_MU11$, which introduces an additional inefficiency, since it requires a 3- rather than a 2-station coincidence in the Muon Spectrometer. In order to avoid this inefficiency, the trigger EF_mu18_L1J10 can be used (a combined signature for events in which EF_mu18 trigger coexists with L1 item $L1\_J10$). The plateau efficiency of this last trigger is found to be comparable (to better than 1%) with EF_mu18 in events in which at least one offline jet with $p_T > 50$ GeV is found. Muon trigger efficiencies in SUSY analyses are studied by means of the "Tag & Probe" method applied to events in which the Z boson is selected in its $\mu\mu$ decay.

In order to achieve the highest possible statistics, events from the muon stream have been chosen during the periods from J to M of the 2011 ATLAS data taking [3].

2. Event selection

The offline references used to estimate trigger efficiencies are represented by the muon tracks reconstructed by the STACO offline algorithm satisfying some minimal requirements on trigger acceptance and isolation in addition to the cuts for the *loose* selection recommended by the Muon Combined Performance group:

- $p_T > 2.5$ GeV,
- $p > 4$ GeV,
- $|\eta| < 2.4$,
- $|z - z_{vtx}| < 10$ mm, where z_{vtx} is the z coordinate of the primary vertex in the event,
- sum of p_T of tracks in a 0.20 cone around the muon < 1.8 GeV,
- number of PIXEL hits > 1, and at least 1 hit in the b-layer, number of SCT hits > 5 and no more than 2 holes of the track [1] in PIXEL and SCT detectors,
  - for $|\eta| < 1.9$ the total number of hits has to be > 5 and the fraction of outlier hits to total hits < 0.9,
  - for $|\eta| > 1.9$, if the total number of hits is > 5, then the fraction of outlier hits to total hits is required to be < 0.9,

The primary vertex mentioned above is required to have at least 3 associated tracks and to be within 150 mm of the nominal position of the interaction point.

After the preselection of reference muons described above, the di-muons coming from Z boson production are finally selected by means of the following additional cuts:

- $p_T > 15$ GeV,
- at least two muons of opposite charge at a distance $\Delta R > 1$,
- invariant mass $m_{\mu\mu}$ of the di-muon system such that $|m_{\mu\mu} - m_Z| < 15$ GeV,

where $\Delta R = \sqrt{\Delta\eta^2 + \Delta\varphi^2}$, with $\Delta\eta$ and $\Delta\varphi$ defined as the difference in η and in azimuthal angle φ of the two muon tracks, respectively. Any of the two muon *candidates* defined so far is considered as a *tag muon* if a trigger object, found within $\Delta R < 0.15$, has fired the EF_mu18_medium trigger. Finally, the trigger is considered efficient on the other muon (called *probe muon*) if a trigger object is found within $\Delta R < 0.2$ from the probe muon itself.

To fit all efficiency curves, the function $f(p_T)$ has been used, defined as:

$$f(p_T) = \frac{p_0}{1 + 81^{\frac{p_1 - p_T}{p_2}}} \ ,$$

[1] A hole is defined as an unassigned measurement which was expected to belong to a given track trajectory.

where p_0 is the efficiency plateau value, p_1 represents the value of p_T at which the efficiency is half of its plateau, and p_2 is the p_T difference between the values at which the efficiency reaches 90% and 10% of the plateau value, respectively.

3. Muon Event Filter efficiencies

In Figure 1 the efficiencies are separately represented for barrel ($|\eta| < 1.05$, above) and for endcap regions ($1.05 < |\eta| < 2.4$, below) in case of the *EF_mu18_medium* corresponding to the Event Filter algorithm *TrigMuonEF*. As an example, the efficiency curves shown in the plots refer to data from period L5 (in black) and are superimposed to Monte Carlo (red). While some correction at the percent level are needed for the simulated events with muons in the barrel region (especially in the muon p_T region between 50 and 100 GeV), a good agreement is found between data and Monte Carlo in the endcap regions.

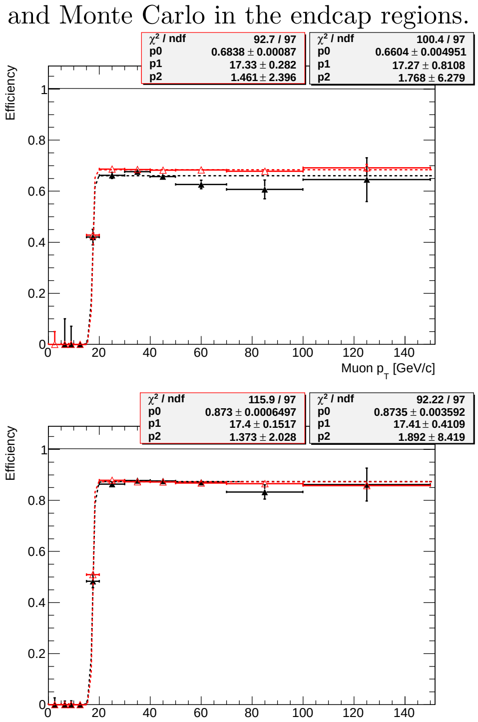

Figure 1. Efficiency vs. p_T for *EF_mu18_medium* in barrel (top) and in endcap regions (bottom), for data (filled symbols) and for Monte Carlo (empty symbols).

The large difference in the efficiency plateau values between barrel and endcaps is mostly due to the different L1 trigger acceptance of the Muon Spectrometer.

Similar plots can be obtained for the trigger *EF_mu18_L1J10* in events with at least one jet over a suitably high threshold[2]. The significant efficiency recovery allowed with respect to *EF_mu18_medium* justifies the use of *EF_mu18_L1J10* in analyses with at least one energetic jet in the event.

The study the *EF_mu18_L1J10* trigger efficiency on Monte Carlo samples requires the use of muon trigger scale factors. These correction factors are defined in each p_T bin as the ratio between the efficiency computed on real data and the one computed on $Z \to \mu\mu$ simulated events, both obtained by means of the "Tag & Probe" method. The muon trigger scale factors for *EF_mu18_L1J10* are shown in Figure 2 separately for barrel and endcap regions.

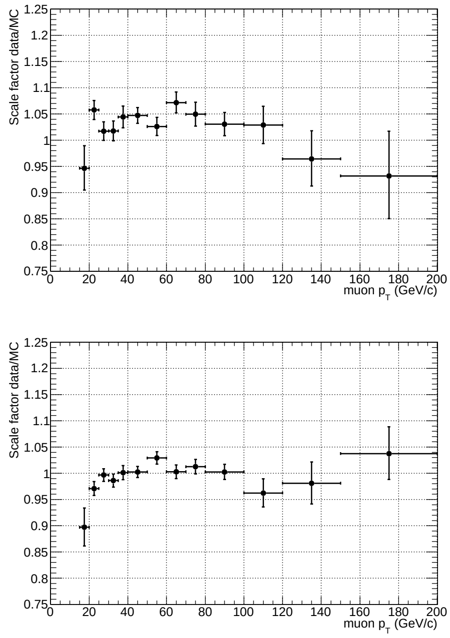

Figure 2. Muon trigger scale factors as functions of p_T for *EF_mu18_L1J10* in barrel (top) and in endcap regions (bottom).

[2] In order to obtain a plateu efficiency close to *EF_mu18* to better than 1%, an offline jet with p_T above 50 GeV has to be required in the event [4].

REFERENCES

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4. S. Asai et al., Search for Supersymmetry with jets and missing transverse momentum and one or more leptons at $\sqrt{s} = 7$ TeV, ATLAS supporting INT note, ATL-COM-PHYS-2011-1743 (2011).