Muon Event Filter efficiencies of ATLAS experiment

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1. Introduction

First proton-proton collisions at a centre-of-mass energy of 7 TeV have been taking place during year 2010 at the LHC [1] (Large Hadron Collider) and have been collected by the ATLAS [2] experiment for an integrated luminosity of about 45 pb^{-1}.

Different ATLAS data taking periods are considered, each one characterized by different primary [1] triggers. As far as muons are concerned, with the increasing luminosity, higher and higher muon transverse momentum (p_T) thresholds have been applied at the three-level trigger [3,4] of the experiment. Efficiencies shown here are computed at the last trigger level, called Event Filter (EF); results focus on a specific signature with the request of $p_T > 13$ GeV, which has been the primary trigger for large part of the 2010 collected data. Results shown here are of particular interest for SUSY inclusive searches with leptons in the final state [5].

2. Definition of muon trigger efficiency

To study muon trigger efficiencies, two different methods have been exploited: the first one, based on an "inclusive sample", uses a muon-independent data stream (to avoid any bias induced by the muon trigger itself), in which the logical OR of several muons + jets triggers was required; the other is the "Tag & Probe" method applied to the Z boson.

The efficiencies have been measured as functions of p_T using as references the muon tracks reconstructed by the official offline algorithm satisfying slightly different cuts depending on the period. These quality cuts are put in place to suppress fake tracks:

- $p_T > 5$ GeV,
- $|\eta| < 2.4$,
- sum of p_T of tracks in a 0.20 cone around the muon < 10 GeV,
- number of PIXEL hits > 0,
- number of SCT hits > 4,
- $|z - z_{vtx}| < 10$ mm,

where η is the pseudorapidity, PIXEL and SCT are specific technologies of the ATLAS Inner Detector, z_{vtx} is the z coordinate of the primary vertex in the event, for which it is required to be less than 150 mm distant from the nominal position of the interaction point. The requirement on muon isolation has been varied to check how actually trigger efficiency depends on it. In the case of the "Tag & Probe" method, the p_T cut has been increased to 10 GeV to improve the quality of the muon tracks.

All the efficiency curves shown in the following are fit to a function $f(p_T)$ defined as:

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

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

3. Efficiency studies with independent triggers

All efficiencies are separately studied for the barrel ($|\eta| < 1$) and the endcap regions ($1 < |\eta| < 2.4$). Similar results are obtained with the independent single muon trigger $EF\_mu13\_MG\_tight$, which runs an alternative EF algorithm. The difference between these triggers and the corresponding ones EF_mu13 and EF_mu13_MG consists in the fact that they are seeded at Level 1 by the tighter trigger item $L1\_MU10$ instead of the looser $L1\_MU0$. In Figure 1 the turn-on curves of EF_mu13_tight obtained using the inclusive sample are shown for the barrel and for the endcaps.

4. Efficiency studies with Tag & Probe method

As soon as ATLAS collected data increased during year 2010, the number of reconstructed $Z \to \mu\mu$ events has become large enough for a

[1]In this context, a single particle trigger is called *primary* when it represents the lowest unprescaled p_T threshold.

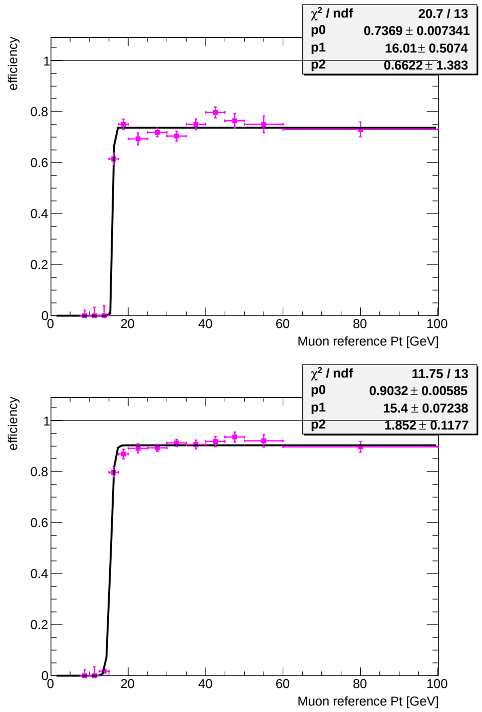

Figure 1. Efficiencies with respect to offline reference for EF_mu13_tight in barrel (top) and in endcap (bottom) regions in the periods in which this trigger was unprescaled.

study of muon trigger efficiencies at a % precision level by means of the “Tag & Probe” method. In this case no bias is directly induced by the choice of the triggered muon stream (*physics_Muons*), which is the one allowing the largest available $Z \to \mu\mu$ statistics. The event selection aims, in this case, at a clean *tag* sample with di-muons from Z boson production, applying to the previously selected muons the following additional cuts:

- $p_T > 10$ GeV,
- at least two muons of opposite charge at a distance $\Delta R > 0.5$,
- invariant mass $m_{\mu\mu}$ of two muons 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 pseudorapidity and in azimuthal angle of the two muon tracks, respectively. Any of the two muon *candidates* described so far identifies a *tag* if an EF_mu1X object is found within $\Delta R < 0.15$. About 88% of selected tags is found to satisfy this request. Finally, trigger is considered efficient on the other muon (*probe*) if a trigger object is found within $\Delta R < 0.5$ from the probe itself.

In Figure 2 the turn-on curves of EF_mu13_tight are shown for the same data taking period considered before. The plateau values of the efficiency are in very good agreement with the results found, in both barrel and endcap regions, using the method described in Par. 2.

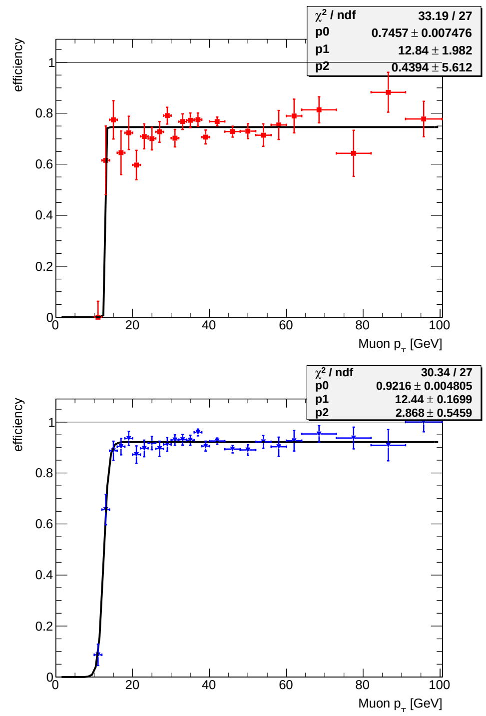

Figure 2. Efficiencies with respect to offline probes for EF_mu13_tight in barrel (top) and in endcap (bottom) regions using the “Tag & Probe” method.

Future plans during year 2011 will include muon trigger studies concerning higher p_T thresholds, such as EF_mu20 or EF_mu25, which will be used in the next data taking periods.

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