Muon Event Filter resolution studies on 2011 ATLAS data

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1. Introduction

After having collected about 45 pb^{-1} of proton-proton collisions at a centre-of-mass energy of 7 TeV during year 2010 at the LHC [1] (Large Hadron Collider), the ATLAS [2] experiment has collected about 100 times more statistics (4.9 fb^{-1}) during 2011 at the same energy.

From the ATLAS muon trigger viewpoint [3,4], the first half of the data taken in 2011 (periods from B to I) was acquired with a primary trigger [1] called EF_mu18: this trigger is based on a cut at the last trigger level, called Event Filter (EF) asking for a muon transverse momentum (p_T) larger than 18 GeV and starting from a loose level-1 (L1) trigger selection ($L1\_MU10$), whose corresponding rate could be afforded up to luminosities of about 10^{33} $cm^{-2}s^{-1}$. With the increased luminosity achieved in summer 2011 (periods from J to M), a tighter primary trigger has been used for most physics analyses, EF_mu18_medium, seeded by the higher L1 p_T threshold $L1\_MU11$. The analysis performed here is based on 2011 ATLAS data collected during periods from J to M, corresponding to an integrated luminosity of $\sim$ 2.3 fb^{-1} [5].

2. Selection cuts

To study muon trigger performance, events from the muon stream (*physics_Muons*) have been considered. Muon tracks reconstructed by the "STACO" offline algorithm have been used as reference. At a first stage, these tracks have been required to satisfy specific quality cuts in order 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 < 1.8 GeV,
- number of PIXEL hits > 1,
- number of SCT hits > 5,
- number of TRT hits > 5,
- number of holes in PIXEL and SCT hits $<$ 3,
- $|z - z_{vtx}| < 10$ mm,

where η is the pseudorapidity, PIXEL, SCT and TRT are specific technologies of the ATLAS Inner Detector and z_{vtx} is the z coordinate of the primary vertex in the event, for which it has been required to be less than 150 mm distant from the nominal position of the interaction point and to composed of at least 3 tracks.

At a final stage, muon tracks have been asked to satisfy the "Tag & Probe" method in the hypothesis of $Z \to \mu\mu$ events, according to 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 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 η and in azimuthal angle φ of the two muon tracks, respectively. Any of the two muon *candidates* obtained in this way identifies a *tag* if a trigger track satisfying EF_mu18 or a higher threshold was found in the event within $\Delta R < 0.15$.

3. Resolution of muon Event Filter algorithms

The muon EF algorithms considered in this study are: *TrigMuonEF* (*Extrapolator* and *Combiner*) and *TrigMuGirl*. While the first one performs track reconstruction in two steps (only in the Muon Spectrometer, or *MS only*, and then combining information of the Inner Detector, or *outside-in*), the second one implements muon reconstruction in one step from Inner Detector toward the Muon Spectrometer (*inside-out*).

For each algorithm, the parameters p_T, η and φ are extracted and compared to the ones of the corresponding offline muon reference. In Figure 1 the resolution on $1/p_T$ (in GeV^{-1} units) is shown as a function of the muon offline p_T. This is obtained as the width parameter of a Gaussian fit

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

performed on the distribution of the differences between the quantity $1/p_T$ measured in the trigger and the corresponding one measured in the offline framework.

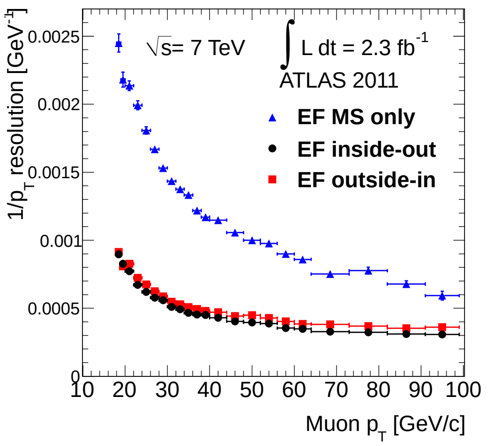

Figure 1. Transverse momentum resolution with respect to offline as a function of p_T for the three Muon Event Filter algorithms.

In general, the resolution improves as the muon p_T increases. The two combined EF algorithms show similar performance. They both take advantage of the combination of Muon Spectrometer and Inner Detector information to improve the $1/p_T$ resolution with respect to the *MS only* algorithm by a factor of 2 over the whole muon p_T spectrum.

This improvement is even more evident (by at least one order of magnitude) in the case of the η and the φ resolutions, as illustrated in Figure 2, thanks to the excellent accuracy allowed by the Inner Detector. The η resolution for each of the two combined EF algorithms has a small bump for p_T around 50 GeV. This effect (present also in the p_T and φ cases) can be explained by the different reconstruction performance in the barrel region ($|\eta| < 1.05$) and in the endcap regions ($1.05 < |\eta| < 2.4$), which are not separated in the plot and are characterized by very different p_T distributions.

The limited statistics collected in 2010 couldn't allow to study muon EF resolutions by means of the Tag & Probe method with an adequate statistical precision. A comparison between the present results and those obtained at that time [6] puts in evidence very relevant improvements, especially in the case of η and φ resolutions. The Tag & Probe method will be furtherly used to perform more and more accurate performance studies on the forthcoming 2012 ATLAS data taking.

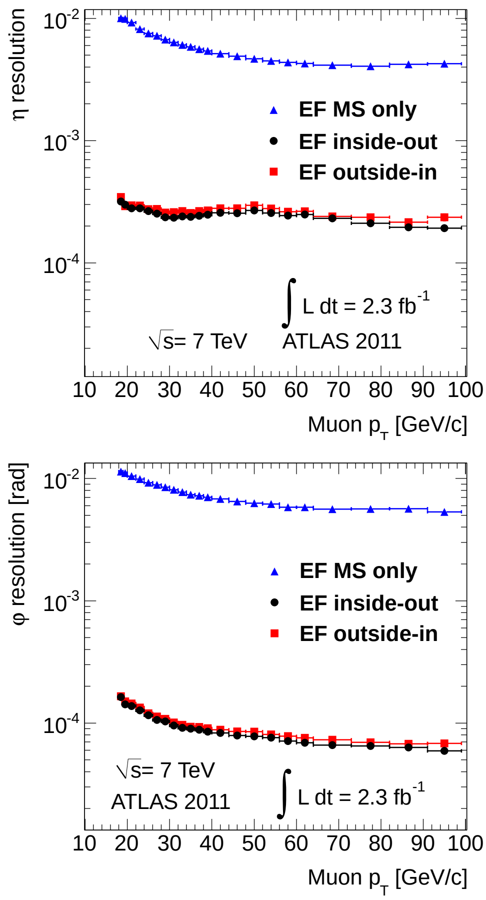

Figure 2. Spatial η and φ resolution with respect to offline as functions of muon offline tranverse momentum.

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