Muon Trigger validation for 2015 ATLAS data taking

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1. Introduction

The ATLAS [1] experiment at the Large Hadron Collider (LHC) [2] has been taking data at a centre-of-mass energy between 900 GeV and 8 TeV during the period 2009-2013, also known as *Run I*. The LHC has delivered a total integrated luminosity of $\sim 20\ fb^{-1}$ in 2012, which has required specific strategies to obtain the highest possible physics output while trying to keep a reduced event rate. The ATLAS High Level Trigger (HLT) system has been successfully redesigned in order to adapt itself to the changing environment which have brought from a low luminosity in 2010 to the highest luminosities ever reached in 2012. During the Run I, the strategy for the muon trigger selection has been optimized for the different physics analyses in which muons in the final state are involved.

While getting ready for the next data taking period (*Run II*) a few hardware and software upgrades have been performed to the ATLAS Muon Trigger in order to deal with the higher and higher trigger rate expected due to the increased center-of-mass energy ($\sqrt{s}$ moving up to 13 and 14 TeV) and instantaneous luminosity (up to 10^{35} cm^{-2} s^{-1}). The most relevant design update concerning the trigger structure between the Run I and the Run II consists of a merging from a two-stage system (based on *Level 2* and *Event Filter* [3]) to a single HLT stage.

During the Run II it is expected that the number of collisions per bunch crossing will move from an average of ~ 25 (as obtained during Run I) up to more than 50, probably as high as 80. This aspect has been taken into account by properly adding such *pileup* effects over the simulated Monte Carlo (MC) events.

2. Trigger Validation framework

In order to get ready to the Run II data taking starting in spring 2015, the ATLAS Trigger environment has been equipped with a dedicated software framework to validate MC simulated samples at a center-of-mass energy of 13 TeV. Samples are organized in terms of *tags*, which contain information of the software release(s) used for:

- event generation
- detector simulation
- track/object reconstruction
- data analysis formattation.

The purpose of the ATLAS Muon Trigger Validation (MTV) is to provide a fast and complete response on the quality of the official software releases in order to make sure that these can be safely used for simulated MC samples and for real data taking. Results are provided in terms of the muon transverse momentum (p_T), pseudorapidity (η) and azimuthal angle (φ).

3. Efficiency and resolution studies

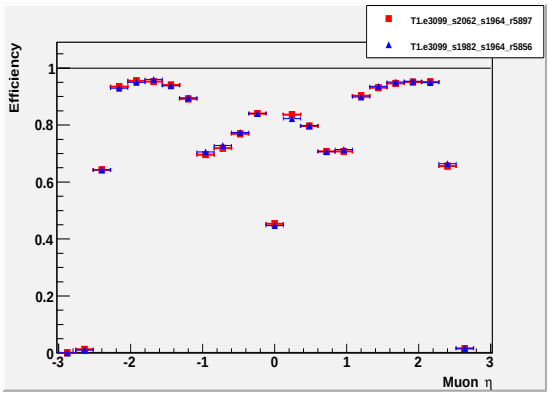

Figure 1. Efficiency of the Level 1 system with respect to simulated muons in the ATLAS Muon Spectrometer as a function of pseudorapidity η. The two different colors refer to two software tags: without (red squares) and with (blu triangles) pileup superimposed to simulated events, as expected during 2015 data taking.

The efficiency of the muon trigger system with respect to simulated muons (also called *true* muons, required to have p_T larger than 5 GeV/c and have pseudorapidity in the $|\eta| < 2.4$ range) is first tested at the hardware-based Level 1. In Fig. 1 the efficiency is shown as a function of η for all the muons in a set of $t\bar{t} \rightarrow W^+bW^-\bar{b}$ events in which at least one of the W bosons decays leptonically, thus producing one or two muons in the final state. Two scenarios are considered: one without the expected amount of pileup superimposed on events (red points) and one with the pileup (blue points). It is apparent that the efficiency is not significantly influenced by the presence of pileup.

The quality of the muon trigger objects can be verified by checking their resolutions in terms of kinematic and spatial reconstructed quantities. As the energy $\sqrt{s}$ in Run II is going to increase, it is particularly interesting to analyze muon resolution as a function of transverse momentum. The resolution on the spatial coordinates η and φ are shown in Fig. 2 for the EF algorithm combining ATLAS Muon Spectrometer and Inner Detector information.

In both plots of Fig. 2 the trigger spatial quantities η and φ are compared with the corresponding ones at MC truth level, but during the data taking period it will be possible to compare them with those obtained in the offline reconstruction framework. Similarly to what observed in Fig. 1, also in this case the performance is not affected by the presence of the expected pileup amount in the ATLAS detector. In particular, the η resolution is stably below $4 \cdot 10^{-4}$ for muons which exceed the lowest unprescaled single muon trigger threshold ($\sim$ 40 GeV), while the φ resolution requires at least 50 GeV muons in order to be as good as 10^{-4}.

The MTV system will be updated and maintained during the 2015 data taking period, with adequate upgrades and improvements as the LHC instant luminosity and the total trigger rate will be increasing.

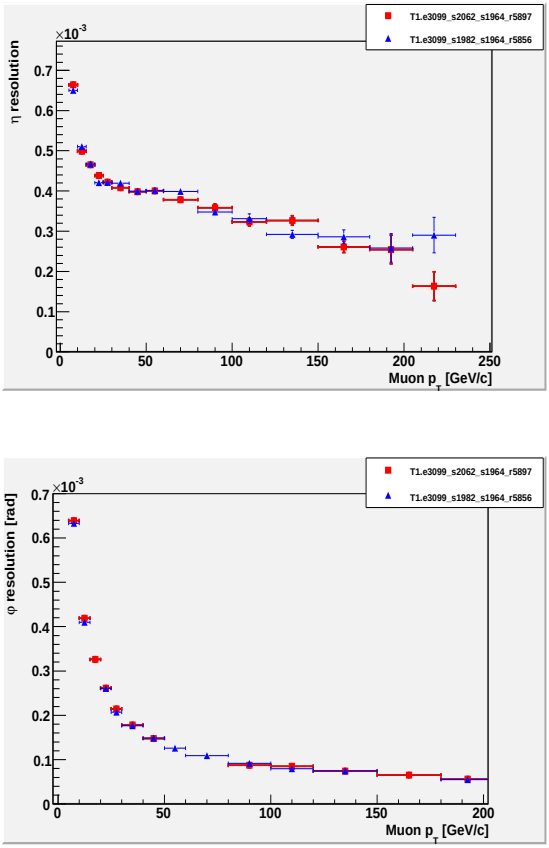

Figure 2. Resolution on muon EF pseudorapidity η (top) and on azimuthal angle φ (bottom) as functions of p_T. The two different colors refer to two simulated samples: without (red squares) and with (blu triangles) pileup superimposed to simulated $t\bar{t}$ events, as expected during 2015 data taking.

REFERENCES

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3. ATLAS Collaboration, *Performance of the ATLAS Trigger in 2010 running at the LHC*, Eur. Phys. J. C 72 (2012) 1849.
4. ATLAS Collaboration, *Performance of the ATLAS muon trigger in pp collisions at $\sqrt{s}$=8 TeV*, arXiv:1408.3179, accepted for publication on Eur. Phys. J. C.