ATLAS Muon Trigger

Performance in *pp* collisions at √s=8 TeV

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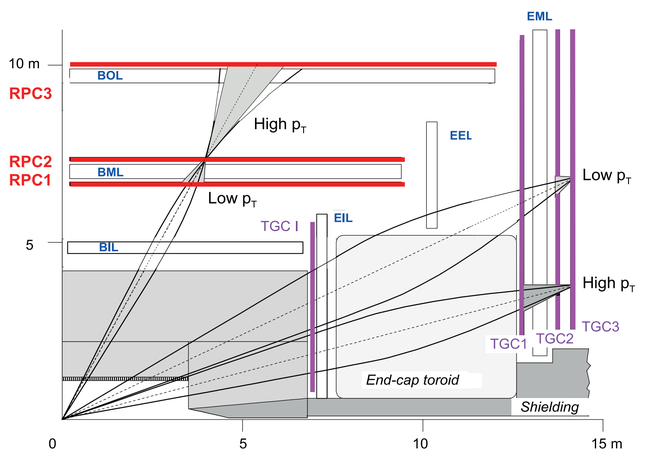
CHEP, Amsterdam, 14-18 Oct. 2013

Muons in the final state are distinctive signatures of many physics processes studied at the LHC, such as observation and measurements of a Higgs boson, searches for new phenomena, as well as the measurements of Standard Model processes. The precise determination of the muon trigger performance of the ATLAS detector is essential for muon-related physics analyses.

The ATLAS trigger reduces the LHC collision rate of 20 MHz to a rate of several hundred Hz of events recorded for physics analysis.
It does so in 3 steps. For the muon trigger the Level 1 hardware trigger creates regions of interest (RoI). The Level 2 fast software trigger uses only detector data in the RoI's. The Event Filter precise software trigger has access to the full detector data.



Longitudinal projection of one quadrant of ATLAS highlighting the chambers used to trigger muons at Level 1. The Resistive Plate Chambers (RPC) in the barrel are shown in red and the Thin Gap Chambers (TGC) in the end-cap in purple.

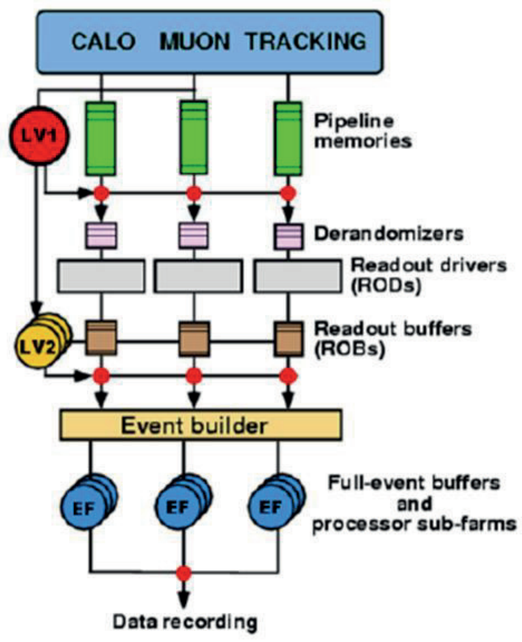
Input collision rate: 20 MHz

Level 1 (LV1): Hardware trigger
Uses only muon trigger chambers.
Muon trigger rate* for p_T>15 GeV: ~8 kHz.

Level 2 (LV2): Fast software trigger
Uses muon trigger chambers, muon precision chambers and the Inner Detector.
Average CPU time of muon trigger algorithm: ~13ms.

Event Filter (EF): Precise software trigger
Uses muon trigger chambers, muon precision chambers and the Inner Detector.
Average CPU time of muon trigger algorithm: ~260ms.
Total Muon Trigger rate*: ~200 Hz.

* Rates given for L=7 10^{33} $cm^{-2}s^{-1}$



Schematic overview of the 3-tiered ATLAS trigger system

Main muon triggers in 2012

Trigger name	Level 1	Level 2	Event Filter	Comment
mu13	p_T > 10GeV	p_T > 13 GeV	p_T > 13 GeV	for di-muon trigger 2mu13
mu18_tight	p_T > 15GeV	p_T > 18 GeV	p_T > 18 GeV	for di-muon trigger mu18_mu8
mu24i_tight	p_T > 15GeV	p_T > 22 GeV	p_T > 24 GeV, $\Sigma p_T^{track}(\Delta R<0.2) / p_T^{\mu} < 0.12$	lowest p_T isolated trigger
mu36_tight	p_T > 15GeV	p_T > 22 GeV	p_T > 36 GeV	lowest p_T non-isolated trigger
mu40_MSonly_barrel	p_T > 15GeV	p_T > 40 GeV, $\|\eta\| < 1.05$	p_T > 40 GeV, $\|\eta\| < 1.05$	only using muon spectrometer

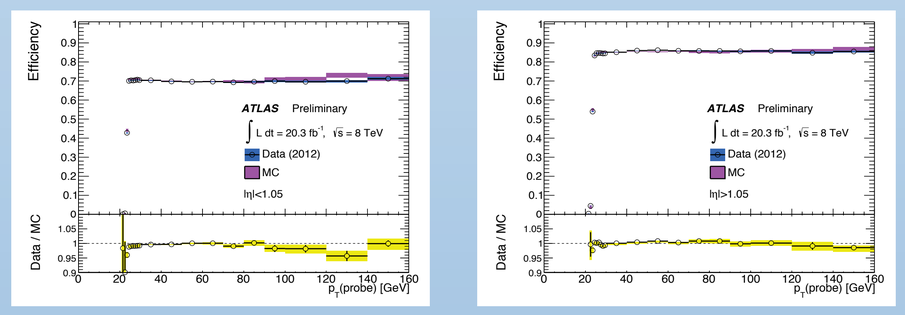
Measuring the trigger efficiency

Tag-and-Probe method

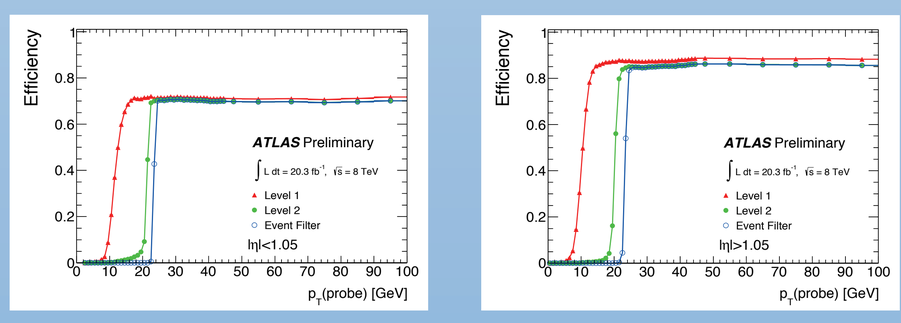
- Select events with isolated opposite-signed offline muon pairs with di-muon invariant mass close to the Z boson mass.
- Tag = offline muon matched to trigger muon.
- Probe = 2nd offline muon.
- Use probe to test for matching trigger muon.

Main Single Muon Trigger

In 2012 the main single muon trigger for use in physics analysis is a logical OR between triggers mu24i_tight and mu36_tight.

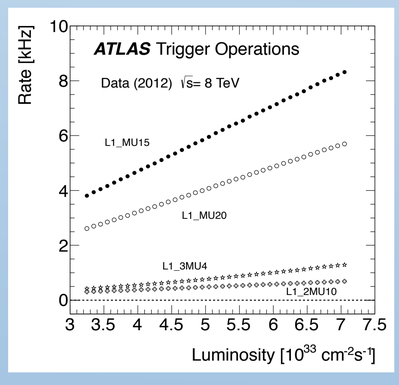


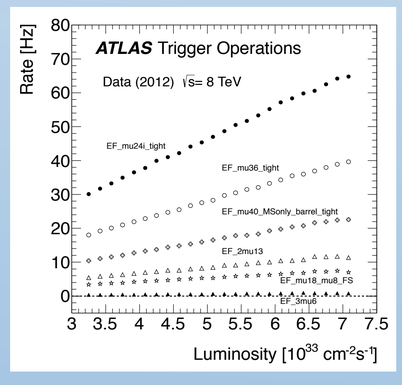
Efficiencies of the main single-muon trigger for physics analysis for muon barrel region (left) and end-cap regions (right). Both data and Monte Carlo simulation results are shown. Error bars include both statistical and systematic uncertainties.



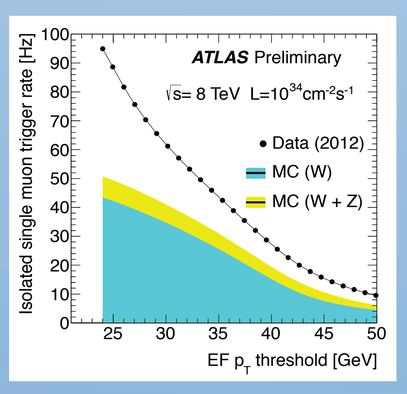
Turn-on curves of the 3 stages of the main single-muon trigger for physics analysis for muon barrel region (left) and end-cap regions (right). Error bars indicate statistical uncertainties.

Muon trigger rates



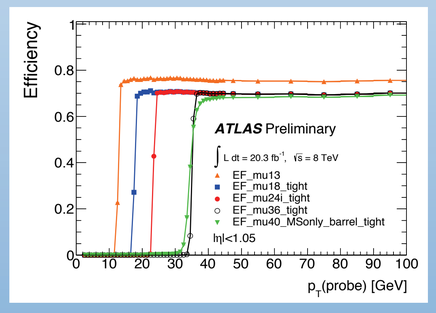


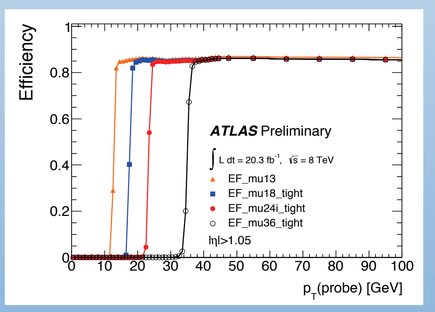
Level 1 (left) and Event Filter (right) trigger rates for the main muon triggers increase linearly with luminosity.



Rate of isolated single muon trigger as a function of p_T threshold extrapolated to instantaneous luminosity of 10^{34} $cm^{-2}s^{-1}$. The expected rate from Monte Carlo simulation from $W\rightarrow\mu\nu$ and $Z\rightarrow\mu\mu$ shows that at 24 GeV threshold these account for ~50% of the rate. The higher the threshold, the more the *W*+*Z* contributions dominate.

Turn-on curves for main muon triggers





Turn-on curves of the single muon triggers mu13, mu18, mu24i, mu36 and mu40 (muon spectrometer barrel only) for the muon barrel region (left) and endcap regions (right).

Summary and prospects

The ATLAS muon trigger has performed very well in run I. During the LHC shutdown the trigger is being upgraded, both on the hardware side and the software side, to be ready for an excellent performance in the much harsher conditions expected for run II.