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.

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.

Measuring the trigger efficiency

Tag-and-Probe method
- Select events with isolated opposite-sign 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.

Muon trigger rates

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: ~13 ms.

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

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

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.