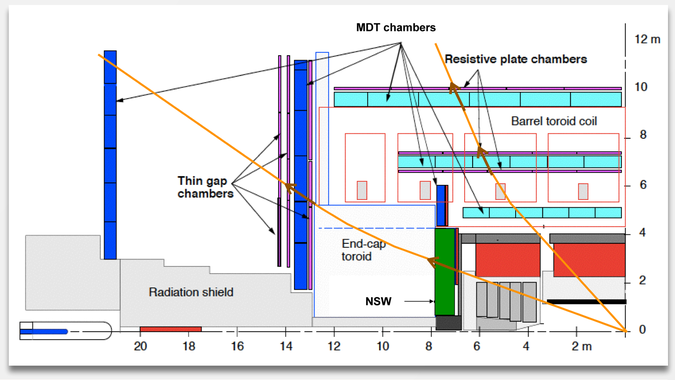
A muon trigger upgrade with high transverse momentum resolution for the ATLAS detector at the High-Luminosity LHC

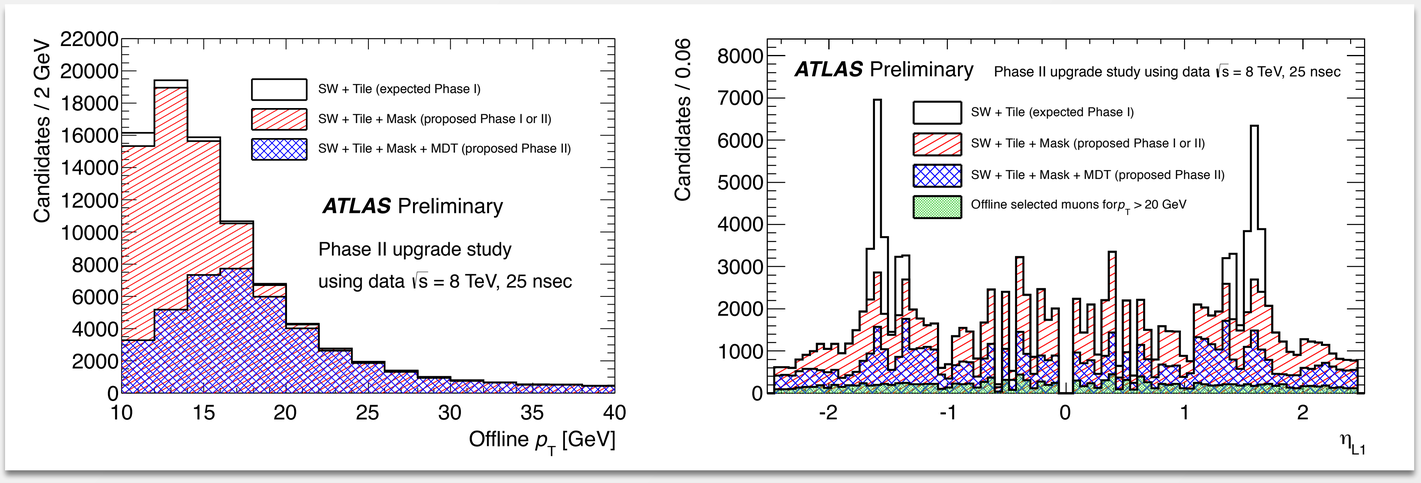
Concept of a muon trigger upgrade

The phase II of the LHC, the so-called High-Luminosity LHC, is planned to start in 2025 with a leveled instantaneous luminosity of 5 x 10^{34} $cm^{-2}s^{-1}$. The higher luminosity puts stringent limits on the Level-1 trigger rates at the ATLAS experiment. To control these rates, it is proposed to upgrade the Level-1 muon trigger system by complementing the position measurements of the existing trigger chambers with more precise position measurements of the monitored drift-tube (MDT) chambers [1].



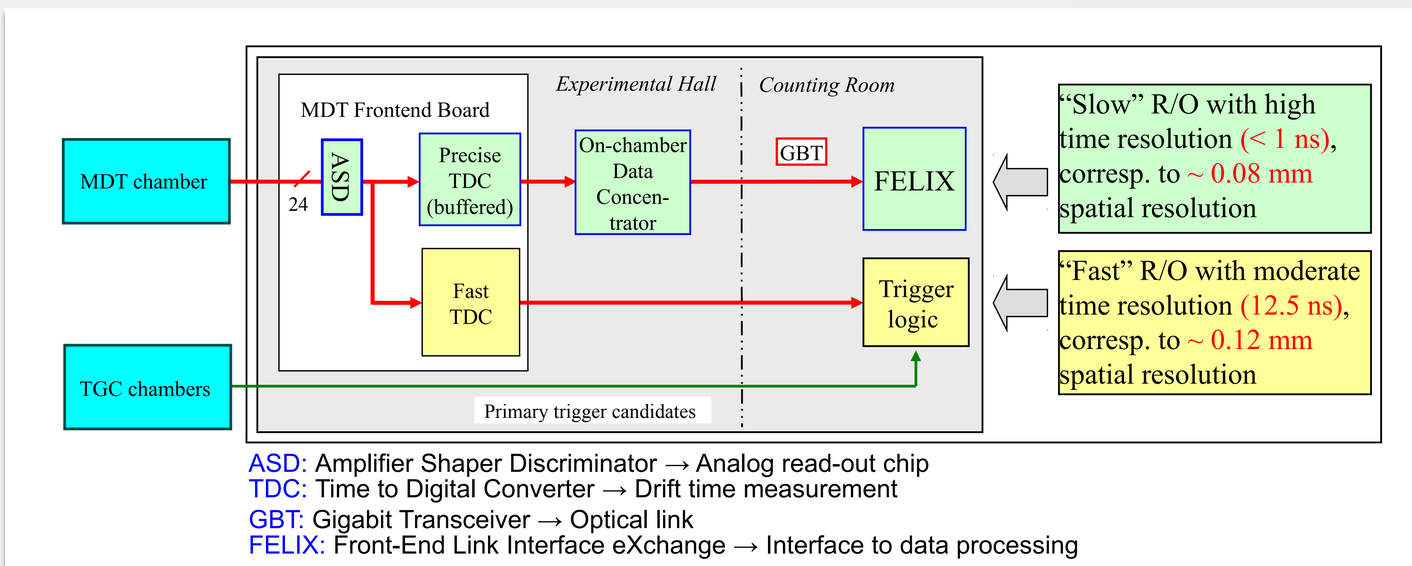
Trigger rate estimation using data taken in 2012

The data recorded by the ATLAS experiment in 2012 were used to evaluate the trigger rate reduction by introducing the proposed upgrade [2]. The rate for a single muon trigger with a transverse momentum (p_T) threshold of 20 GeV is estimated to be reduced to ~50%. The muon candidates with p_T obtained by the offline analysis below 20 GeV are well rejected in an entire pseudorapidity region.



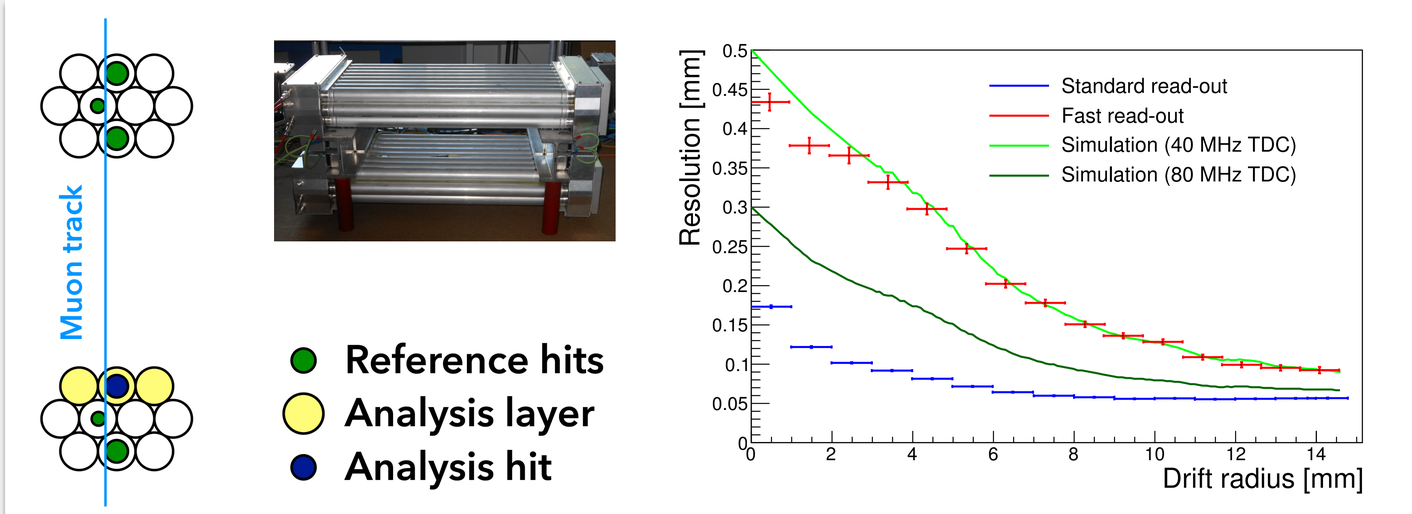
Technical implementation

In order to collect the MDT hit coordinates early enough for use in the Level-1 trigger logic, the relevant hits are read out through a priority readout chain, independent of the standard and asynchronous readout. The trigger chambers are used to define regions of interest (RoI) and to provide time origin for drift time measurements. MDT hits in the RoI are analyzed for finding and reconstructing the segments to be used for the trigger decision.



Hardware demonstrator and a preliminary test result

An electronics demonstrator has been developed by adding a fast readout path to the already existing standard MDT readout [3]. The fast TDC's frequency is 40 MHz while for the final implementation 80 MHz is foreseen. Cosmic-ray muon data are taken for evaluating the performance of the demonstrator. Measured single-tube spacial resolution is consistent with a simulation based on MDT's drift velocity.



Conclusion

We present a new muon trigger algorithm based on precision tracking chambers. The rate of a Level-1 single muon trigger with a p_T threshold of 20 GeV is estimated to be ~50% with respect to the rate without upgrades. In a proposed electronics scheme, a fast readout path is added to the standard readout. A test with a hardware demonstrator using cosmic-ray muons provides the spacial resolution consistent with an expectation. Further studies using the demonstrator are ongoing.

[1] ATLAS Collaboration, "Letter of Intent for the Phase-II Upgrade of the ATLAS Experiment", CERN-LHCC-2012-022, LHCC-I-023 (2012).
[2] ATLAS Collaboration, L1 Muon Trigger Public Results at https://twiki.cern.ch/twiki/bin/view/AtlasPublic/L1MuonTriggerPublicResults.
[3] R. Richter et al., "A Muon Trigger with high pT-resolution for Phase-II of the LHC Upgrade, based on the ATLAS Muon Drift Tube Chambers (MDT)", TIPP 2014.

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