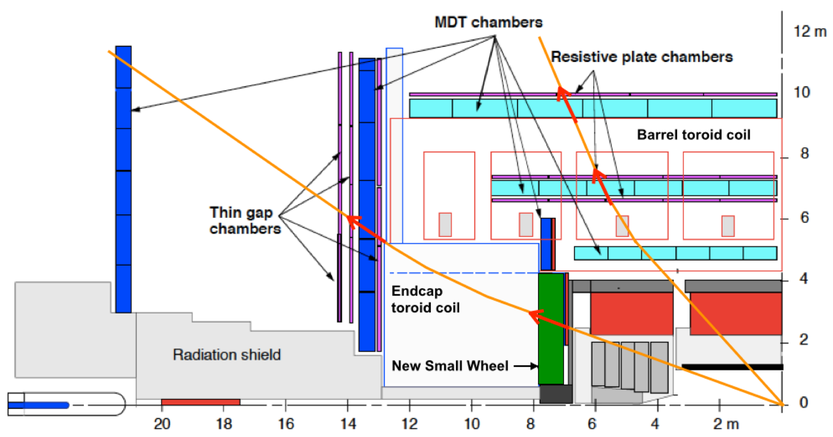
Concept of a Muon Trigger with High Transverse Momentum Resolution for the ATLAS Detector at the High-Luminosity LHC

Concept of a muon trigger upgrade

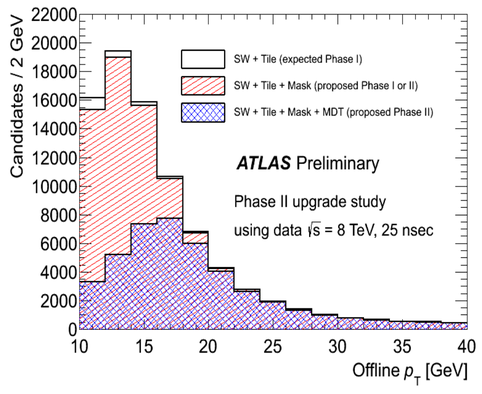
The phase II of the LHC, the so-called High-Luminosity LHC, is planned to start in 2025. The higher instantaneous luminosity, 5 x 10^{34} $cm^{-2}s^{-1}$, puts stringent constraints on the Level-1 trigger at the ATLAS experiment.

It is proposed to upgrade the Level-1 muon trigger system by introducing precise position measurements provided by the monitored drift-tube (MDT) chambers [1].



Expected trigger rate reduction

Based on a data sample recorded by the ATLAS detector in 2012, the rate for a single muon trigger with a transverse momentum threshold of 20 GeV is estimated to be reduced by about a factor of two by the proposed upgrade [2].

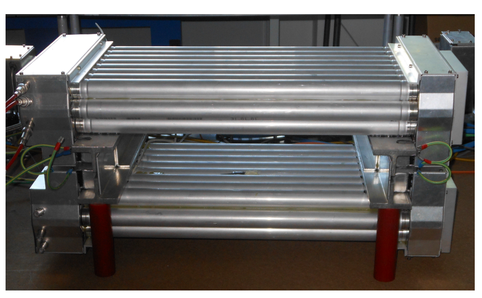


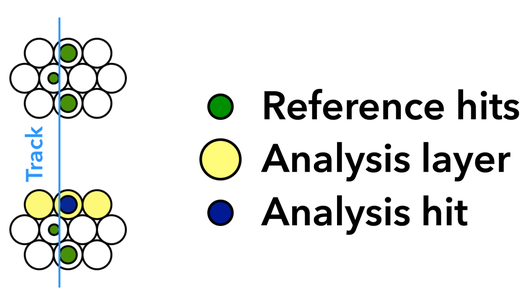
A proposed design of electronics

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 fast 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 track segments to be used for the trigger decision.

Test setup with a demonstrator

A demonstrator of the front-end electronics 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 with MDT chambers which has specifications similar to the ones installed in the ATLAS detector. Five layers, of the six layers in total, are used for reconstructing reference tracks. The remaining one layer is used to estimate the detection efficiency and the position resolution for single drift tube.

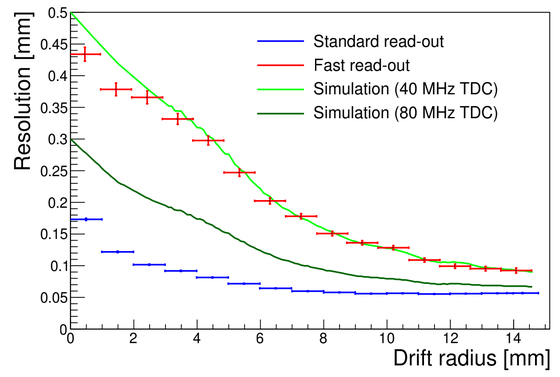




Preliminary test results

The efficiency of detecting a hit for single drift tube is measured to be > 99% for most of the region of drift radius.

The spacial resolution for single drift tube measured by the fast readout path is 0.1-0.5 mm depending the drift radius. The result is consistent with a simulation based on MDT's drift velocity.



Plan toward a full demonstration

Simulation study is ongoing for determining detailed algorithm of track segment finding and reconstruction. The algorithm will be implemented in FPGAs, and the efficiency and the angular resolution will be demonstrated.

A demonstration in a high-occupancy condition expected during the High-Luminosity LHC operation is also planned. The hits will be represented by the gamma rays from ^{137}Cs source at the CERN Gamma Irradiation Facility.

[1] ATLAS Collaboration, "Letter of Intent for the Phase-II Upgrade of the ATLAS Experiment", CERN-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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IEEE Nuclear Science Symposium, Seattle, WA USA, 8-15 November 2014