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A Muon Trigger Upgrade with High Transverse Momentum Resolution for the ATLAS Detector at the High-Luminosity LHC

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The Level-1 trigger for muons in ATLAS is based on trigger chambers (RPCs, TGCs) with excellent time resolution which are able to identify muons coming from a particular beam crossing. It is proposed to use precision tracking chambers (MDTs) for improving the transverse momentum resolution at the Level-1 trigger for the phase II of the LHC, the so-called High-Luminosity LHC. We present the new trigger algorithm and the architecture of the electronics as well as a prototype test. We demonstrate the performance for a transverse momentum threshold of 20 GeV using experimental data.

Summary

The trigger of the ATLAS experiment at the Large Hadron Collider (LHC) uses a three-level trigger system. The Level-1 trigger for muons is based on trigger chambers (RPCs, TGCs) with excellent time resolution which are able to identify muons coming from a particular beam crossing. The limited momentum resolution of the trigger chambers weakens the selectivity of the Level-1 trigger for high transverse momentum muons above a predefined threshold, for example 20 GeV. As a result, muon candidates below the threshold are allowed to cause "fake'' triggers, mostly corresponding to event signatures without physics interest.

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. A way to control these rates would be to improve the spatial resolution of the triggering system resulting in a drastically sharpened turn-on curve of the Level-1 trigger with respect to the transverse momentum. This is a future proposed upgrade of the Level-1 trigger for muons in ATLAS. It is possible without the installation of new trigger chambers by complementing the position measurements of the existing trigger chambers with the more precise position measurements of the monitored drift-tube (MDT) chambers.

In this concept, the trigger chambers will be used to define regions of interest (RoI), inside which high transverse momentum muon candidates are identified. MDT hits in the RoI are used for an accurate estimate of the track momentum, leading to an efficient suppression of sub-threshold muon triggers. 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 read-out chain, independent of the standard and asynchronous read-out. An encouraging response has been obtained from a prototype test at the Gamma Irradiation Facility at CERN for accomplishing a required position resolution with the priority read-out chain.

The muon data recorded by the ATLAS experiment in 2012 were used to determine the trigger rate with the proposed MDT Level-1 trigger scheme. The trigger rate is estimated to reduce to about half for a transverse momentum threshold of 20 GeV.

A major difficulty in the ATLAS muon system is the presence of large background of thermal neutrons and gamma rays causing occupancies of up to 10% in the MDT chambers. Monte carlo simulation is used to prove that the proposed MDT Level-1 trigger scheme can cope with these high background rates.

In our contribution, we present the new trigger algorithm and the architecture of the electronics together with a prototype test performed at the Gamma Irradiation Facility at CERN. We also show the performance obtained

with experimental data and monte carlo simulation, which demonstrates an excellent rejection efficiency for muon candidates below a transverse momentum threshold of 20 GeV.

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