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Upgrade of the ATLAS Level-1 Muon Trigger for High Luminosities Using the Precision Muon Drft Tube Chambers

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The upgrade of the LHC towards higher luminosity requires improved L1 trigger selectivity in order to keep the maximum total trigger rate at about 100 kHz. In the L1 muon trigger system this necessitates an increase of the pT threshold for single muons. Due to the limited spatial resolution of the trigger chambers, however, the selectivity for tracks above about 20 GeV/c is insufficient for an effective reduction of the L1 rate. We propose to used the precise track coordinates of the Monitored Drift Tube chambers in the ATLAS muon spectrometer for a decisive improvement of the L1 muon trigger pT resolution and selectivity. The implementation in the ATLAS trigger system, the fast track segment identification and the required latency will be discussed.

Summary 500 words

The upgrade plans for the Large Hadron Collider (LHC) at CERN foresee an increase of the peak luminosity beyond the nominal value of 10ˆ34 cm-2 s-1 by up to a factor of 5. As the total L1 trigger rate of the ATLAS experiment at the LHC cannot be significantly increased beyond 100 kHz, a higher selectivity of the L1 trigger for high-pT event signatures is required at the higher luminosities. One of the main inputs to the ATLAS L1 trigger are high-pT tracks identified in the muon spectrometer. As the rate of muon tracks is strongly decreasing with pT, the trigger rate is highly sensitive to the selected threshold. To keep the trigger rate for single muons at an acceptable level of about 10 kHz, a minimum pT threshold of 20-30 GeV/c has to be selected. Due to the limited spatial resolution of the trigger chambers and the corresponding pT error, however, a large fraction of tracks with pT below the selected threshold will be accepted, unnecessarily inflating the L1 rate.

We present a concept using the much higher spatial resolution of the Monitored Drift Tube (MDT) chambers of the ATLAS muon spectrometer for a better definition of the track momentum, improving the rejection of muons below the nominal pT threshold. This scheme requires a communication path between the trigger and MDT chambers to be established within each trigger tower. The coordinates of the high-pT tracks as determined by the trigger chambers are communicated to a newly implemented local processor ("TowerMaster") which determines the search path for MDT tubes to be read out (e.g. via a LUT) and sends this information to the readout service modules (CSM) on the MDT chambers from where they are transmitted to the front-end boards ("mezzanine cards"). At the front-end, a system of scalers is added to the existing readout logic (one scaler per tube) which determine the drift times with a relaxed time resolution of 25 ns. At this clock frequency the size of the drift time word is reduced to 6 bit, yet providing a spatial resolution of about 0,5 mm, about 20 times better than the resolution of the trigger chambers.

The scalers are started by the avalanche arriving at the MDT wires and stopped by a request from the trigger chambers due to a high-pT trigger. This request is timed to arrive a fixed number of beam crossings after the passage of the particle, the scaler reading thus corresponding to the absolute drift time of the primary electrons, i.e. to an absolute coordinate (apart from left-right ambiguity). The drift time readings of 6 tubes along a track in a MDT chamber (3 in each multilayer) contain redundancy and supply a robust measurement of the track coordinate. Combining the coordinates of the three MDT chambers in a tower along the muon trajectory yields the track sagitta and thus the muon transverse momentum. If it is below the selected high-pT threshold, a L1 veto is issued to the sector logic of the trigger tower. For this triggering scheme an additional L1 latency of 1-3 microseconds is required, depending on details of implementation.

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