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The performance of the ATLAS Level-1 Calorimeter Trigger with LHC collision data

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The ATLAS first-level calorimeter trigger is a hardware-based system designed to identify high-pT jets, electron/photon and tau candidates and to measure total and missing ET in the ATLAS calorimeters. After more than two years of commissioning in situ with calibration data and cosmic rays, the system has now been extensively used to select the most interesting proton-proton collision events. Final tuning of timing and energy calibration has been carried out in 2010 to improve the trigger response to physics objects. An analysis of the performance of the level-1 calorimeter trigger will be presented, along with the techniques used to achieve these results.

Summary

The ATLAS first-level calorimeter trigger (L1Calo) is a hardware-based system with a high degree of adaptability and configurability provided by widespread use of FPGAs. The real-time path of the trigger is subdivided into a Preprocessor, which takes analogue signals from the calorimeters and digitizes them, followed by two digital processor systems working in parallel: the Jet/Energy-sum processor and the Cluster Processor. It provides all the calorimeter based trigger information used by the Central Trigger Processor to make the final Level-1 trigger decision, and as such provides the majority of the individual inputs to this decision.

Along with the trigger decision path, L1Calo also provides read-out data and 'region-of-interest'(RoI) data on events accepted for further processing. The read-out data is used to monitor and understand the trigger decision, but the RoI data is used at a more fundamental level to guide the second level trigger. Much of the functionality of the system was verified before the LHC turn-on using calorimeter calibration systems and rare high-energy cosmic events. However, the final tuning of timing, energy calibration and signal processing required real proton-proton interactions from LHC beam to optimise the trigger response and sharpen the trigger turn-on curves.

LHC started to provide collision data in 2009. However, it was not until early 2010 that higher energies and luminosities were achieved, and these were necessary to gather enough statistics to be able to approach a final calibration. The first important step is to measure the timing of the input signals on a tower by tower basis. This is required to improve the association of the measured energy to the correct bunch-crossing (Bunch-Crossing Identification, or BCID). For a fully timed tower, the energy resolution is improved, and the efficiency of identifying the correct Bunch-Crossing is almost 100% down to energies as low as 2 GeV.

The next step is to improve the energy calibration itself based on collision data. An initial calibration based on calorimeter pulser runs provides a good basis, but the energy response for collision signals is not guaranteed to be exactly the same. The energy can first be improved by comparing against the detailed calorimeter data for collision events, but given enough statistics, can eventually be calibrated against well understood physics processes. It is not clear if the second step will be possible with the 2010 data, but the current status of the calibration will be presented.

Other factors, such as the digital filters used to process the signals, also influence the performance of the trigger. The status of the full system will be presented, along with results showing the achievement of the main goals of the calorimeter trigger, which is to provide sharp turn-on curves for

useful physics objects, and reliable RoI information to the High Level Trigger.

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