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CMS Regional Calorimeter Trigger performance in 7 TeV data taking

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We report on the first operations of the CMS Regional Calorimeter Trigger (RCT) with collisions. Many first physics analyses at CMS have used calorimeter triggers. The RCT receives 8 bit energies and a data quality bit from the HCAL and ECAL Trigger Primitive Generators (TPGs) and sends it to the Global Calorimeter Trigger (GCT) after processing. The RCT hardware consists of 1 clock distribution crate and 18 double-sided crates containing custom boards, ASICs, and backplanes. Details will be presented on the physics performance, operational response to beam conditions, data quality monitoring, response to input detector problems, synchronization with beam collisions and overall control during operations from the initial data period for CMS

Summary

The Regional Calorimeter Trigger (RCT) is a key component of the Compact Muon Solenoid (CMS) experiment Level-1 trigger system. The first analyses at CMS that have electrons, photons, or hadronic jets in their signatures have relied on calorimeter triggers. The RCT collects trigger primitive information from the electromagnetic and hadronic calorimeters (ECAL and HCAL) and finds electron and photon (e/gamma) candidates and calculates regional energy sums that are sent to the GCT for further sorting and jet finding. This talk describes the design, calibration, and performance of the RCT during the initial data period for CMS during 7 TeV proton-proton collisions.

The RCT consists of one crate that distributes the clock signals and eighteen crates that perform algorithms to find trigger objects in a section of the CMS detector 5 eta by 40 degrees in phi. In each crate are 7 Receiver Cards (RC) that receive the TPGs, 7 Electron Identification Cards (EIC), a Jet Summary Card (JSC), and a Clock and Control Card (CCC). All of the boards were custom built for the RCT utilizing 5 different custom ASICs and high-speed integrated circuits.

The receiver card receives 8 bit energies and a data quality bit from the HCAL and ECAL Trigger Primitive Generators (TPGs). The CMS HCAL and ECAL send 4032 TPGs each to these boards. The ECAL TPGs consist of 5x5 lead-tungstate crystals in the innermost barrel. The HCAL TPGs correspond on a one to one basis to the HCAL towers. An additional 144 trigger primitives coming from the forward calorimeter are received by the JSCs.

The Receiver Cards add the ECAL and HCAL TPGs together over a 4x4 tower region. These regional sums are used to create Level-1 hadronic jet candidates in the Global Calorimeter Trigger (GCT). These regions are examined to evaluate the possible presence of a tau lepton inside the region. The GCT will use this information to calculate Jets based on 3x3 section of these regions, the total energy of an event, and the missing energy of the event.

The electron identification cards search for possible Level-1 electron and photon candidates. These objects are reconstructed by the addition of two adjacent ECAL trigger towers. Trigger towers that from adjoining EIC cards are shared by the custom made backplane. Information between adjoining crates is shared through cables to make sure the system is seamless. Electrons are divided into isolated and non-isolated electrons based on ratio of HCAL to ECAL energy and the noise level of the adjacent trigger towers.

The JSC summarizes the output of the RCT. This card aligns the regional sums and sends them to the Global Calorimeter Trigger and using a two-stage sort with 3 of our custom Sort AISCS, four of each of the most energetic isolated and non-isolated e/gamma candidates are found and sent to the GCT.

With some of the earliest data, a calibration of the e/gamma objects was preformed to insure high trigger efficiency. Photon energies measured using more precise non-trigger algorithms were compared to the measured Level-1 energies. A multiplication factor dependent on the azimuthally direction was applied to later measures. The method and results of this calibration are detailed.

Further details of the talk include the software controls of the system and its integration with the larger Level-1 operation, the monitoring of the data links of the TPGs to the RCT, and the storage and creation of the configurations of the system. The talk concludes with a report on the performance of the system compared to the emulated performance of the results.

Primary author: Dr EFRON, Jonathan Z (University of Wisconsin)

Presenter: Dr EFRON, Jonathan Z (University of Wisconsin)

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