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Operation and Monitoring of the CMS Regional Calorimeter Trigger

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The electronics for the Regional Calorimeter Trigger (RCT) of the Compact Muon Solenoid Experiment (CMS) have been produced, tested, and installed. The RCT hardware consists of 1 clock distribution crate and 18 double-sided crates containing custom boards, ASICs, and backplanes. 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 CMS Global Calorimeter Trigger (GCT) after processing. Integration tests with the TPG and GCT subsystems have been successful.

Installation is complete and the RCT is integrated into the Level-1 Trigger chain. Data-taking, triggered with cosmic ray muons, is now regular. Progressively, the operation and configuration of the RCT has moved from mostly hands-on to a completely automated process. The tools to monitor, operate, and debug the RCT are mature and will be described in detail, as well as the results from cosmic muon data-taking with the RCT.

Summary

The electronics for the Regional Calorimeter Trigger (RCT) of the Compact Muon Solenoid (CMS) Experiment have been produced, tested, and installed. The RCT has been integrated with the ECAL and HCAL Trigger Primitive Generators (TPGs) responsible for RCT input and the Global Calorimeter Trigger (GCT) that receives the RCT output. The hardware of the RCT consists of one 6U clock distribution crate with custom boards and eighteen 9Ux680mm double-sided crates containing a custom backplane and boards with custom ASICs. Including spares, almost 1800 boards of 9 different types have been produced. Included are a Clock Input Card (CIC), two Clock Fan-out Cards (CFCm and CFCc), backplane, Clock and Control Card (CCC), Receiver Mezzanine Card (RMC), Receiver Card (RC), Electron Identification Card (EIC), and Jet/Summary Card (JSC). This system receives 8000 calorimeter trigger tower transverse energies (ETs) and characterization bits from the ECAL and HCAL TPGs via 4 GBaud copper links. These ETs are summed over 4x4 tower regions for jet finding, missing ET, and total ET. Additionally, the individual tower energies and characterization bits are used to find electron candidates. These quantities are then forwarded to the GCT via their source cards for further processing and sorting.

The RCT crates, cables, and associated hardware have been installed underground and commissioned. The complete HCAL and barrel of the ECAL are fully installed and commissioned, resulting in the RCT's routine use as part of the CMS Level-1 Trigger chain. Simple pattern tests verified the chain and it's timing, and before the LHC turn-on, data has been taken using cosmic-ray muons to produce triggers. Progressively, the testing, configuration, and operation of the RCT has moved from command-line to a completely automated graphical user interface. Slow-control operations, such as power and temperature monitoring and control use the PVSS (Prozessvisualisierungs- und Steuerungs-System) SCADA (Supervisory Control and Data Acquisition) tool. RCT crate configuration and monitoring is done within the framework provided by the CMS Trigger Supervisor toolkit. As part of a Data Quality Monitoring (DQM) framework the RCT is checked both online and offline using a software Trigger Emulator (TE) for comparison. Finally, a set of custom offline crate tests using the TE and the RCT's self-test mode check inter-RCT connections and external links for possible problems. Details of the hardware, the implementation of these tools, and results from cosmic muon data-taking with the CMS Regional Calorimeter Trigger will be described in detail.

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