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Results on the Perfomance of the CMS Global Calorimeter Trigger for Electrons and Jets

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The CMS Global Calorimeter Trigger (GCT) is the device within the CMS Calorimeter Trigger system which is assigned the tasks of finding and sorting forward-, central- and tau-jet candidates, sorting isolated and non-isolated electron candidates, and reading out all the calorimeter trigger data. The GCT system is modular and uses 1.6 Gbps optical links to concentrate the calorimeter data in eight processing cards which accomplish the algorithm tasks by utilizing Virtex-II-Pro Xilinx FPGAs. The entire GCT system, including both electron- and jet-trigger hardware, has been installed and commissioned in the CMS underground cavern, USC-55. A sophisticated software package has been developed for controlling and configuring the GCT hardware and well as for monitoring the GCT status. Over the past one and a half years the GCT system has undergone detailed testing and its performance is well understood. The GCT design provides buffers at its inputs capable of holding 2048 events; these have been used to inject energy depositions corresponding to electrons and jets in order to test the GCT functionality by comparing its output with that of the GCT emulator. Entire SUSY, Higgs and QCD Monte Carlo background events that have a large number of jets in the final state have been used to validate the GCT performance. The results from all these studies are presented.

Summary

The CMS Global Calorimeter Trigger (GCT) is an integral part of the CMS trigger system. Its function is to receive and process data from all 18 Regional Calorimeter Trigger (RCT) crates and send the four highest-ranking electron and jet candidates to the Global Trigger, where they are used for generating the Level-1 Trigger Accept decision. This system has been designed to be modular. Due to a compressed development schedule, it borrows heavily from existing designs.

The primary requirements of the GCT are to sort electron candidates, and generate and sort jet candidates. The design has been optimized for these tasks. Other requirements include jet trigger counters, total jet transverse-energy trigger, total transverse-energy and missing transverse-energy triggers, luminosity monitoring, and RCT readout. The GCT is composed of four module types, the Source, Leaf, Wheel, and Concentrator cards.

The Source Cards receive their input data directly from the RCT crates, and transmit their output data via multi-gigabit optical links to the GCT main-processing crate. The Source Cards are located in the same racks as the RCT, and their main function is to convert the differential ECL RCT signals to high-speed serial optical format. In addition, the Source Cards provide the means for data capture and readout of the RCT data. Test data can be injected at the Source Card inputs using the 2048-event buffers implemented for each Source Card input channel. The Leaf Cards are configured to receive either electron or jet trigger data on high-speed optical fibres. Each Electron Leaf Card processes the electron data from nine RCT crates, selecting the four highest-energy candidates for further processing. Similarly, the Jet Leaf Cards process data from three RCT crates each, and forward the four highest-energy jets to the Wheel Cards. The jet-finding algorithm implements a sliding window. This requires data from adjacent RCT crates (corresponding to adjacent physical areas on the detector) to be exchanged; hence, Jet Leaf cards are linked to their neighbours in a corresponding fashion to facilitate this algorithm. The Wheel Cards are only used for processing jet data, and combine the output of three Leaf Cards each. These three Leaf Cards process the data from nine RCT crates, or half of CMS. The Wheel Cards sort the jets generated by the Leaf Cards, and forward the data from the four jet candidates with the highest transverse-energy to the Concentrator Card. The Concentrator Card accepts data from two Electron Leaf Cards and two Wheel Cards. It performs the final sorting of both electron and jet candidates, and sends the four highest-energy candidates of each type to the CMS Global Trigger. In addition, it provides a VME interface (slow control interface), and an S-Link64 data acquisition interface for the entire Calorimeter Trigger system.

At TWEPP 2007 we presented the first results from integrating the GCT in the CMS trigger system, as well as the first results from validating the Electron Trigger. The Electron Trigger has been used over the past year as the main CMS calorimeter trigger and has provided for stable operations and data taking. Using the experience for running the Electron Trigger, we have developed an extensive control and monitoring package to operate the GCT. This paper describes in detail the GCT software package and its performance. The running experience with the Electron Trigger resulted in upgrades of the Electron Trigger hardware. The final results on its performance are described here.

In the first half of 2008 the Jet Trigger was installed in USC55 and was integrated in the GCT system. The Jet Trigger was tested by injecting patterns and Monte Carlo events in the 2048-event input buffers of the Source Cards. Tests with events which had both electrons and jets were also performed and are presented. The Jet Trigger has been integrated in the GCT software framework. Results on the performance of the Jet Trigger are presented.

Over the past year the GCT group has received requests from CMS physics groups for triggers which were not included in the original GCT baseline design. The GCT group is in the process of implementing these upgrades and a short review of the progress achieved is also presented.

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