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CMS Calorimeter Trigger Phase 1 Upgrade

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We present a design for the Phase-1 upgrade of the CMS calorimeter trigger system composed of FPGAs and Multi-GBit/sec links that adhere to the micro-TCA crate Telecom standard. The upgrade calorimeter trigger will implement algorithms that create collections of isolated and non-isolated electromagnetic objects, isolated and non-isolated tau objects and jet objects. The algorithms are organized in several steps with progressive data reduction. These include a particle cluster finder that reconstructs overlapping clusters of 2x2 calorimeter towers and applies electron identification, a cluster overlap filter, a particle isolation determination, jet reconstruction, particle separation and sorting.

Summary 500 words

The upgrade calorimeter trigger system will comprise up to 6 crates with up to 12 cards each. The goal is that the trigger processing cards will be uploaded with different versions of firmware each performing different processing tasks in the system. The proposed platform for the upgraded Calorimeter Trigger processing is an Advanced Mezzanine Card (AMC)-style micro-TCA module.

The Compact Calorimeter Trigger (CCT) design uses three card types. The Input Cards will receive the Trigger Primitive data from the ECAL, HCAL and Forward calorimeters and perform inter-region data sharing as needed. The Processing Cards will receive partial products from the Input Cards, perform second level sharing, complete the regional processing and deliver the output to the Summary Processing Cards that transmit their results to the Global Trigger.

Upgrade calorimeter trigger algorithms have been developed and demonstrated to achieve a factor of 4 rate reduction from the present calorimeter trigger algorithms with improved efficiency and much better position resolution for application in sophisticated topological triggers. To verify that the upgrade calorimeter algorithms are implementable, firmware has been developed in Xilinx tools for the improved clustering and filtering algorithms with increased position resolution. The initial indications are that about 8x16 trigger towers worth of information can be processed in a single Virtex 5 FPGA using a good fraction of its 6.5 Gbps GTX multi-gigabit transceivers and 50% of the available logic. The processing can be done at or above 200 MHz with a latency of 185 ns, which would keep this processing well within the latency envelope of the present calorimeter trigger calculations.

Demonstrators have been built and their test results will be reported. A system of four CCT prototype cards were integrated in a backplane fabric to demonstrate the running and data exchange of calorimeter trigger algorithms. Using TTC-based timing and synchronization, a system that links and auto-synchronizes 56 separate data channels has been demonstrated and its latency measured. The latency of the Xilinx GTP link I/O has been studied with various configurations, optimized and measured. An Intelligent Platform Management Interface (IPMI) Module Management Controller (MMC) has been developed and tested on an AMC card. Software has been developed to support the remote update of the FPGA flash over the micro-TCA GbE connection using a FPGA based server (Xilinx Microblaze).

The detailed mapping of the CMS HCAL and ECAL Front End readout electronics onto the new microTCA upgrade electronics has been developed and a design produced using optical links and signal splitting to permit operation of the present and upgrade calorimeter trigger electronics in parallel. The designs of the upgrade optical link TX/RX system and prototype processing cards for a parallel vertical slice test of the upgrade calorimeter trigger electronics will be shown.

This paper covers the Compact Calorimeter Trigger part of the CMS Calorimeter Trigger Upgrade program. The Time Multiplexed Trigger part is covered in a separate paper (G. Iles et al., submitted to TWEPP-11).

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