Contribution ID: **67** Type: **Oral**

Level-1 jet trigger board for the ALICE Electromagnetic Calorimeter

Thursday 23 September 2010 11:00 (25 minutes)

The electromagnetic calorimeter (EMCAL) of ALICE is a large acceptance calorimeter that will enhance the capabilities for jet measurement. Based on the previous development made for the Photon Spectrometer (PHOS) level-0 trigger, a specific electronic upgrade was designed in order to allow a fast triggering on high energy jets (level-1). This development was made possible by the use of the latest generation of FPGA which can deal with the instantaneous incoming data rate of 26 Gbit/s and process it in less than 4 µs.

Summary

The ALICE experiment has been designed to study dense QCD matter produced in heavy ion collisions at the LHC. For this purpose, the ALICE detector has been upgraded with a large acceptance electromagnetic calorimeter EMCAL which will provide an efficient and unbiased trigger for high energy jets and the measurement of neutral portion of jet energy.

The calorimeter consists of 12672 towers of layered Pb-scintillator which are arranged in 2x2 towers (one module). Each tower features an avalanche photodiode (APD) that collects the light created during interaction and a charge sensitive preamplifier. The signal is sent to the front-end (FEE) card in order to be analogically summed over one module and fed through a shaper. After this stage, the 2x2 analogue sums are continuously digitized by 32 Trigger Region Unit (TRU) at the machine bunch crossing rate (40 MHz).

In each TRU, the 12 bit ADC values, associated to the 96 analogues sums of the 2x2 towers are integrated over a time-sliding window of 2 to 5 samples and are afterward space-summed over a sliding patch of 2x2 analogues sums (4x4 towers). The local L0-trigger (L0) is generated whenever this sum is above a threshold. In parallel to this processing, the modules'time-integrated values are stored in a circular buffer. Upon reception of a confirmed L0 from the Central Trigger Processor, all TRUs send the appropriate 96 time summed data to the Summary Trigger Unit (STU) via custom high speed LVDS links.

The data are transferred via 12 m of cat7 Ethernet type cables. Out of the 4 available differential pairs, one is dedicated to the transfer of a clean machine clock from STU to the TRUs, 2 to serially transfer the data to the STU at 2x400Mbps, and the last one to provide the local L0 to the STU.

Due to the foreseen jet patch size, the level-1 (L1) algorithm is subdivided in 2 stages. First, for each region, the 2x2 towers time-integrated values are space summed in order to build 8x8 towers sub-regions. Then the L1 jet trigger is generated whenever the integrated energy over a sliding window of n*n sub-region is above a multiplicity corrected threshold (n could be 2 or 3). The challenge is to have the whole data transfer and processing achieved in less than 5.2 µs.

The STU board features some additional functionalities such as remote control (FPGA reconfiguration, threshold settings), thanks to a magnetic less Ethernet interface board. It also has the possibility to insert the primitive triggering data in the data stream via the ALICE optical Dedicated Data Link upon reception of a level-2 accept trigger.

The feasibility of the high speed synchronous communication and its associated automated data synchronization mechanism has been demonstrated to work on prototype boards and in the detector. The L1 jet trigger algorithm has been conceptually designed and is currently in commissioning, the Ethernet magnetic-less board has been demonstrated to operate under a magnetic field of 0.5T.

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Session Classification: Trigger

Track Classification: Trigger