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CMS DT Chambers Read-Out Electronics

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Being close to completion of CMS installation, the three levels of the final read-out system of the Drift Tube (DT) chambers is presented. Firstly, the Read Out Boards (ROB), responsible for time digitalization of the signals generated by a charged particle track. Secondly, the Read Out Server (ROS) boards receive data from 25 ROB channels through a 240 Mbps copper link and perform data merging for further transmission through a 800 Mbps optical link.
Finally, the Detector Dependent Unit (DDU) merge data from 12 ROS to build an event fragment and send it to the global CMS DAQ through a S-LINK64 output at 320 MB/s. DDU also receives synchronization commands from the TTC system (Timing, Trigger and Control), perform errors detection on data and send a fast feedback to the TTS (Trigger Throttling System).
Functionality of these electronics has been validated in laboratory and in several test-beams, including the Magnet Test and Cosmic Challenge exercise that demonstrated proper operation and integration within the final CMS framework.

Summary

The CMS (Compact Muon Solenoid) detector is one of the four large experiments that will be installed in the new accelerator LHC (Large Hadron Collider) that is being built at CERN. A key point of CMS is its ability to trigger on and reconstruct muon tracks at high luminosities, as this will allow deeper exploring into matter, probing the Higgs mechanisms and other aspects of the Standard Model [1]. This task is performed by the various CMS sub detectors, among them, the Drift Tube chambers (DT), that provide muon identification and precise momentum measurement.

The read-out electronics of the CMS DT chambers is designed to perform time digitization of the signals generated by charged particle tracks and to do further data merging in order to achieve a read-out of the full detector (172,200 channels) at a Level 1 trigger rate of 100 kHz. The system is divided in three levels. First, the 1500 ROB (Read-Out Boards), placed inside the so-called Minicrates [2] attached to the DT chambers. Second, 60 ROS (Read-Out Server) boards located inside the CMS cavern in the balconies on both sides of the CMS wheels. And finally, 5 DDU (Detector Dependend Unit) boards which will operate in the underground counting room.

ROBs are built around an HPTDC (High Performance Time to Digital Converter) [3] ASIC developed by the CERN/EP MIC group. Inside each ROB, four HPTDC´s are connected in a token ring scheme for digitization of up to 128 chamber channels with a time resolution of 781 ps and further data transmission to the ROS through a 240 Mbps serial copper link.

ROS boards perform a data merging of 25 input ROB channels, reducing data overhead to achieve ˜ 8 kbytes per event in the whole detector. Data is serialized and transmitted to the DDU through an optical link at 800 Mbps. ROS boards also perform main tasks of data quality monitoring and event synchronization.

Each DDU merges data from 12 ROS in order to build an event fragment at the Level 1 trigger rate (up to 100 kHz) and send it to the global CMS DAQ through an S-LINK64 [4] output at 320 MB/s. One of the main tasks of the DDU is keeping synchronization with the whole detector. In order to do this, the DDU receives synchronization commands from the TTC system (Timing, Trigger and Control [5]), performs errors detection on data and sends a fast feedback to the trigger system through the TTS output (Trigger Throttling System [6]) to slow down the trigger rate or stop data acquisition in case of failures. In total the 5 DDU boards can manage event sizes up to ˜15 kbytes, at the trigger rate of 100 kHz, about the double of requirements.

In summary, the chosen architecture, as well as the dimension of the memories, links bandwidths, pooling mechanisms, failure detection circuitry, etc, fulfils the experiment requirements of trigger and data rate, radiation tolerance, limited supervision and power consumption.

The complete functionality of these electronics has been validated in laboratory and in several test-beams [7]. Moreover, Magnet Test and Cosmic Challenge exercise, has demonstrated full operation of the readout chain and integration within the final CMS framework. Right now, the read-out system is being installed and commissioned for CMS start up by fall 2007.

References

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