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Precision Electronics for a System of Custom MCPs in the TORCH Time of Flight Detector

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The TORCH detector to provide low-momentum particle identification is an R&D project, combining Time-of Flight and Cherenkov techniques to achieve charged particle pi/K/p separation up to 10 GeV/c. The measurement requires a timing resolution of 70ps for single photons. Based a scalable design, a Time of Flight (TOF) measurement system has been developed to instrument a novel customized 512-channel Micro Channel Plate (MCP) device. A Gigabit Ethernet-based readout scheme that operates the TORCH demonstration unit consisting of ten such MCPs will be presented. The trigger and clock distribution will also be discussed.

Summary

TORCH has applications in experiments requiring low-momentum particle identification, for example to identify B-meson decay products in the upgrade of the LHCb experiment. The Time of Flight measurement requires a timing resolution of 70ps for single photons, which means that the electronics must provide better than 50ps time resolution.

The TORCH system uses 32-channel fast amplifiers/ Time-Over-Threshold (TOT) ASICs (NINO-32s), followed by High Performance Time to Digital Convertor ASICs (HPTDCs) coupled to a Micro-Channel Plate (MCP) detector for the fast timing measurement. In addition the system must measure charge division using the TOT digitization to improve the spatial accuracy of the MCPs by a factor of two. This system has been designed to read out a single MCP with 256 channels; later this year, a Phase 3 custom MCP will be procured with 512 channels. In order to read out such an MCP, a new NINO board has been designed to provide twice the channel count and offering improved cooling arrangement. The new board contains 4 NINO-32 ASICs (2 previously), and 2 HPTDC boards (64 channels each) are connected to such a NINO board to provide 128-channel digitisation. A Gigabit Ethernet-based readout board is connected to 8 HPTDC boards via a backplane to transfer data and provide clock, trigger and control signals. It connects to a PC with a signal Ethernet cable.

The final TORCH demonstrator will be instrumented with 10 MCPs. To read out such a system, a commercial Ethernet repeater is used to combine the 10 links into a single Ethernet cable to a PC. The readout system uses raw MAC protocol, to maximise efficiency. The PC can send control or configuration packets to a unique Ethernet address that is associated to a particular MCP. During operations, the PC will first configure the HPTDCs and NINOs, then instruct all HPTDCs to start measurement. The data are stored on HPTDC boards and readout board temporarily. The PC starts requesting data from the first MCP immediately, and once a fixed amount of data is received, then transferring on the first MCP is paused and a readout request is moved to the next MCP. During pause, the HPTDCs are still measuring but the data is not transferred over the Ethernet cable to avoid collation. A weighting factor is introduced in DAQ software to give priority to the MCP that has the higher occupancy. We have also implemented a time-out function, in case a faulty readout board blocks the readout the whole system.

A Trigger Logic Unit (TLU) is carried over from previous systems. A fan-out module is being prepared to distribute triggers and clocks to the 10 readout boards from a single TLU. The fan-out module also joins the busy signal via or-logic to indicate that a MCP modules cannot accept more triggers. The TLU will then stop issuing triggers to all readout boards. The TLU provides synchronisation to other systems, i.e. telescopes, Cherenkov counters, etc.

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