Contribution ID: **187** Type: **Poster**

Development and performance studies of TORCH readout electronics using custom MCPs in a test-beam

Wednesday, 30 September 2015 17:04 (1 minute)

The TORCH detector is an R&D project to provide low-momentum particle identification, combining Time-Of-Flight and Cherenkov techniques to achieve pi/K separation up to 10 GeV/c. Based-on an existing scalable design, we have undertaken production and testing of a system and have instrumented a novel customized Micro Channel Plate (MCP) device with 128-channels. The development and the performance of the system which has been used in a test-beam will be reported. The communication and data alignment between the TORCH system and the TimPix3 telescope for track reconstruction will also be discussed.

Summary

The TORCH detector is an R&D project to provide low-momentum particle identification, combining Time-Of-Flight (ToF) and Cherenkov techniques to achieve charged particle pi/K separation up to 10 GeV/c. TORCH has wide applications in experiments requiring low-momentum particle identification, for example for the upgraded LHCb experiment to identify B-meson decay products and for flavour tagging. The ToFmeasurement requires a timing resolution of 70ps for single photons and hence 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 the Micro Channel Plate (MCP) for the fast timing measurement [1]. The readout combination is a NINO-32 board containing two such ASIC chips, connected to a HPTDC board also with two ASIC chips, which in turn connected to a backplane coupled to a customised readout board. This system provides up to a 256-channel measurement for a 53 mm x 53 mm MCP. Laboratory measurements have been performed and a 26 ps intrinsic timing resolution has been demonstrated. A customised MCP has been developed in collaboration with industrial partners, Photek UK, and 4 x 32 channels of a demonstrator MCP has been instrumented with a pair of NINO-32 and HPTDC boards. The HPTDCs are currently run in High Resolution Mode and, with time-walk and INL calibrations, the system can provide up to 34 ps RMS timing resolution. We have produced two operational systems of NINO, HPTDC and readout boards and have developed tools and firmware to test the full integrity and performance of the readout chains.

The TORCH readout, which incorporates a Giga-bit Ethernet-based DAQ system, has recently been improved to configure the HPTDCs via a JTAG interface, thus no external programmer is required. This has made the system much more compact and robust. Testing functions have also been added to the system, e.g. internal triggers can now be generated to test the HPTDC functions without recourse to an external device. Trigger synchronisation and edge detection are also implemented to suit different environments. An interface to the AIDA Trigger Logic Unit has been development to work with external devices, in particular the TimePix3 telescope in the CERN SPS test-beam. Via this interface, timestamps between the TORCH detector and the telescope can be synchronised to identify tracks through the detector. If any one system has buffer overrun or other errors, triggers can be blocked, and data alignment can be maintained using the trigger number. An absolute time-stamp, which only resets at the beginning of a run, is also introduced in order to ensure trigger

matching if triggers are missed on one system.
New online displays have been developed to give users a visualised feedback of data quality in real time.

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Session Classification: Poster

Track Classification: Systems