Precision electronics for a system of custom MCPs in the TORCH Time of Flight detector

**Introduction**

**TORCH—Time Of Internally Reflected CHerenkov light**

- TORCH is a high-precision time-of-flight detector suitable for large areas.
- The aim is to achieve a timing resolution of 15ps per incident particle, requiring a resolution of 70ps for single photons.
- TORCH will allow particle identification in the momentum range up to 10 GeV/c.
- Cherenkov photons propagate by total internal reflection.
- Photons are focused onto an array of Micro-Channel Plate (MCP) photon detectors at the periphery of the detector.
- Using custom electronics, the photon trajectory and time-of-propagation in quartz can be reconstructed.
- We are working with industrial partner (Photek) to develop customised MCPs.

**Aims**

- Prepare for instrumenting square 64x8-channel MCPs for the final-phase of Photek development.
- Prepare a readout system for 10 final-phase MCPs reading out a full-scale optics (66x125x1 cm$^3$)

**Electronics Development**

- A modular design providing up to 256 channels per system.
- NINO board contains two 32-channel NINO ASICs utilising Time-Over-Threshold for amplitude measurement and time walk corrections.
- The HPTDC board contains two 32-channel HPTDC ASICs for fast timing digitisation.
- The readout board contains a custom Giga-bit Ethernet-based readout module.
- The readout system is interfaced to an AIDA Trigger Logic Unit in order to integrate with external detectors (e.g. VELO Timepix Telescope, threshold Cherenkov counters).
- Labview-based DAQ software has been developed.
- The system has been used with both commercial and custom MCPs.

**Beam Tests**

A small-sized quartz radiator plate and focussing block are exposed to a charged particle beam that generates Cherenkov light. The picture below shows this “Mini-TORCH” system installed in a light-tight rack in the PS-T9 beam test area at CERN. Two timing stations T1 and T2, and a small-size scintillator are used for providing time references and beam location, respectively. Additionally, threshold Cherenkov counters C1 and C2 are used for particle selection.

**Future Work**

- Prepare for instrumenting square 64x8-channel MCPs for the final-phase of Photek development.
- Prepare a readout system for 10 final-phase MCPs reading out a full-scale optics (66x125x1 cm$^3$)

**Readout Board**

- Labview-based DAQ software has been developed.
- The system has been used with both commercial and custom MCPs.

**Electronics Design Overview**

- The system uses 8 HPTDC boards and 4 adapted NINO boards each with 4 NINO ASICs together with a readout module. The MCPs will be mounted along the horizontal direction on the supporting structure in grey. The electronics are mounted perpendicular to the line of MCPs.

**Data Flow**

- Prepare a readout system for 10 final-phase MCPs reading out a full-scale optics (66x125x1 cm$^3$)

**Top:** TIMING distribution (observed minus predicted) for 5 GeV pion, demonstrating a 117.2 ps resolution.