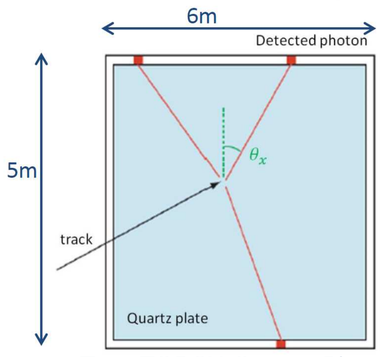
Precision electronics for a system of custom MCPs in the TORCH Time of Flight detector

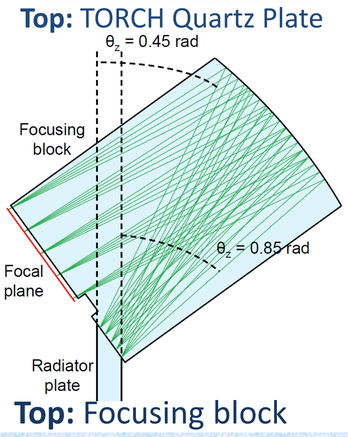
Rui Gao, University of Oxford ,
on behalf of the TORCH Collaboration,
TWEPP 2016, Karlsruhe Institute of Technology
Germany, 26th Sept. - 30th Sept. 2016

Introduction

*TORCH— **T**ime **O**f internally **R**eflected **CH**erenkov light*



Top: TORCH Quartz Plate

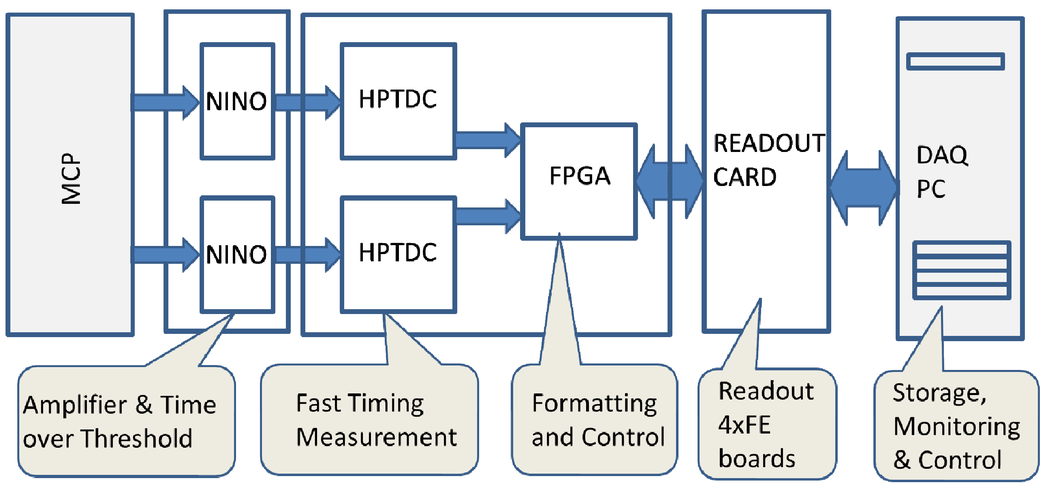


Top: Focusing block

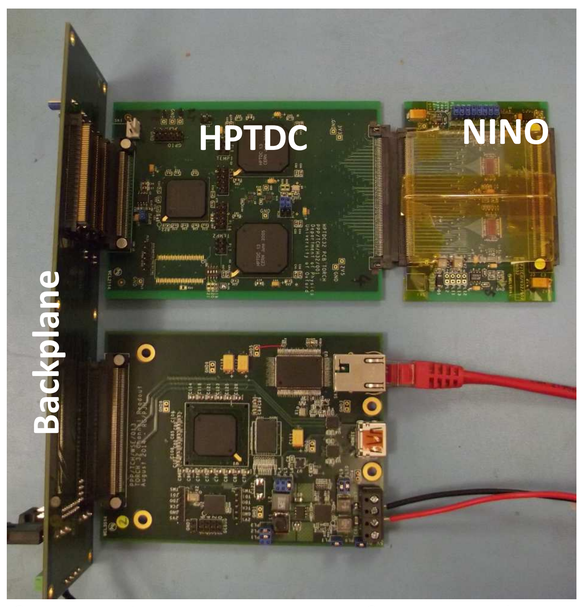
- TORCH is a high-precision time-of-flight detector suitable for large areas.
- The aim is to achieve a timing resolution of 15ps per incident particle, requiring a resolution of 70ps for single photons.
- TORCH will allow particle identification in the momentum range up to 10 GeV/c.
- Cherenkov photons 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.

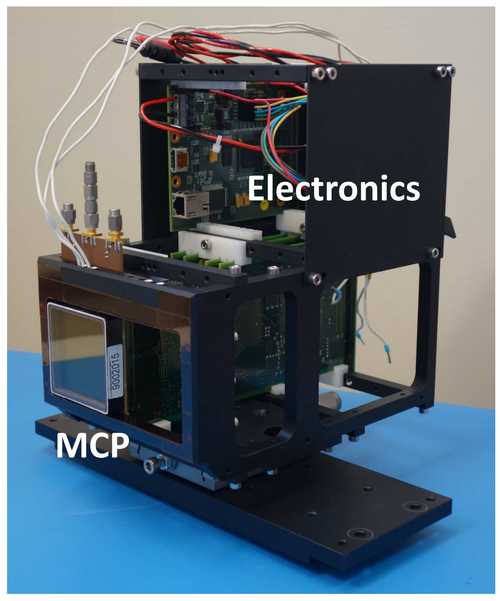
Electronics Development

Data Flow



Electronics Design Overview



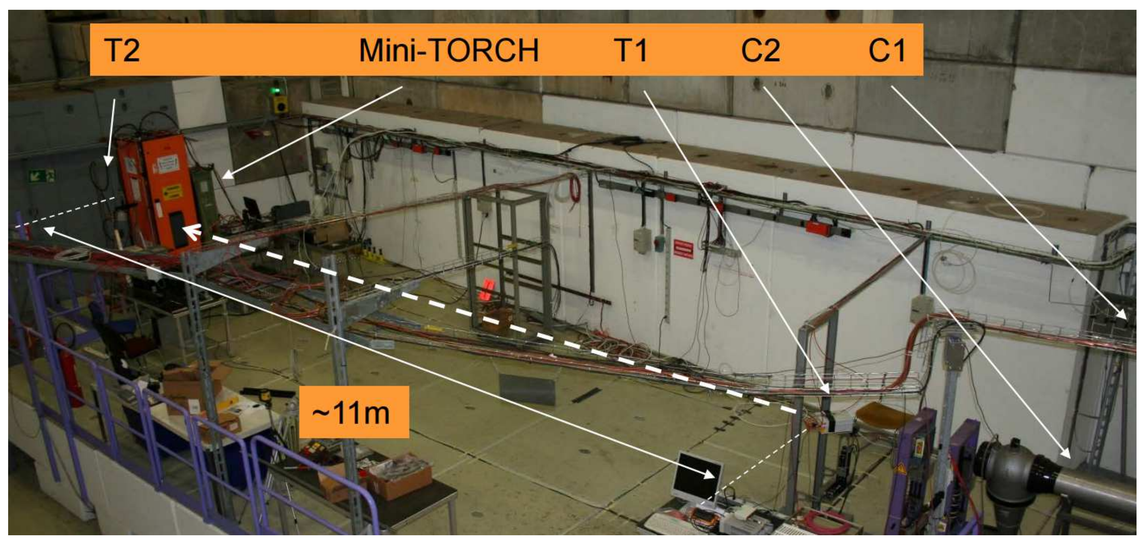


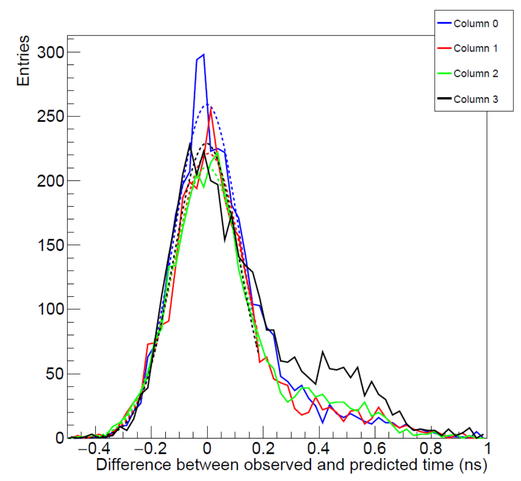
Left: Main components of TORCH electronics
Right: TORCH electronics fully instrumenting a commercial Planacon MCP with 8x32 channels, read out by 4 sets of NINO and HPTDC boards.

- 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

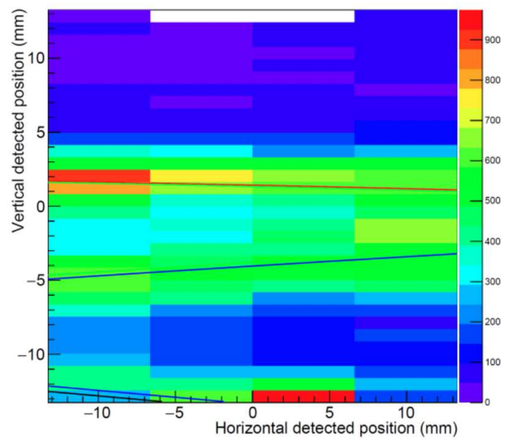
A small-sized quartz radiator plate and focussing block are exposed to a charged particle beam that generates Cherenkov light. The picture below shows this “Mini-TORCH” system installed in a light-tight rack in the PS-T9 beam test area at CERN. Two timing stations T1 and T2, and a small-size scintillator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





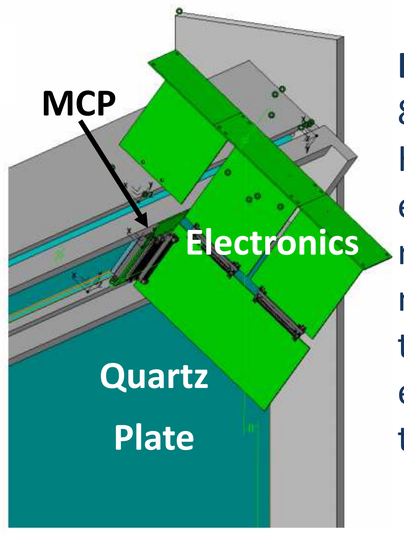
Top: Timing distribution (observed minus predicted) for 5Gev pion, demonstration a 117.2ps resolution.

Bottom: Hit-map of pion particles recorded with the 4x32-channel MCP. Solid lines show where the expected hits to be.



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)



Left: diagram of the future system for a 8x64-channel MCP. 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.

The TORCH project is funded by an ERC Advanced Grant under the Seventh Framework Programme (FP7), code ERC-2011-ADG proposal 299175.

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