A precision Time of Flight readout system for the TORCH prototype detector

Rui Gao, University of Oxford , on behalf of the TORCH Collaboration,
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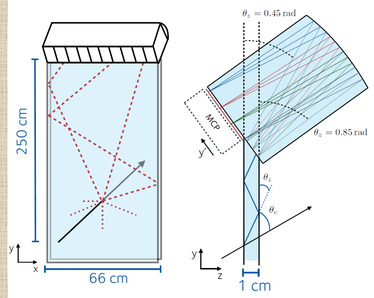
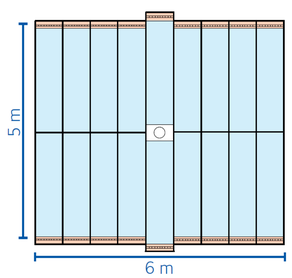
Introduction



Left: TORCH Module
Right: Focusing Block



Proposed TORCH detector

- TORCH— **T**ime **O**f internally **R**eflected **CH**erenkov light
- TORCH combines Time-of-Flight and Cherenkov techniques to achieve charged particle pi/K/p separation between 2 - 20 GeV/c.
- Cherenkov photons propagate by total internal reflection then 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.
- The TOF measurement requires a timing resolution of 70ps for single Cherenkov photon, which translates to the electronics contributing 50ps time resolution or better.
- We are working with industrial partner (Photek) to develop customised MCPs.
- A prototype "Proto-TORCH" has been developed with an 66cm × 125cm Quartz plate and a focusing block.

Future Work

- Prepare for future test-beams with fully instrumented Proto-TORCH in 2022.
- This will accommodate 11 MCPs, 44 NINO boards, 88 HPTDC boards, 22 readout boards and 11 back planes, in total 5632 channels.
- New generation of technologies such as PicoTDC, FastIC and lpGBT are being studied to improve resolution and performance in the future.

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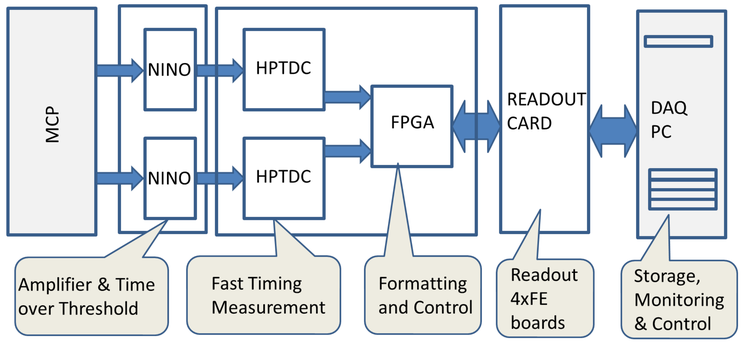
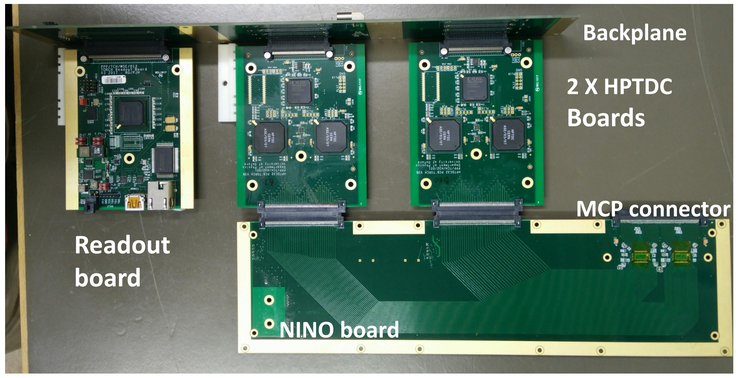
Electronics Development

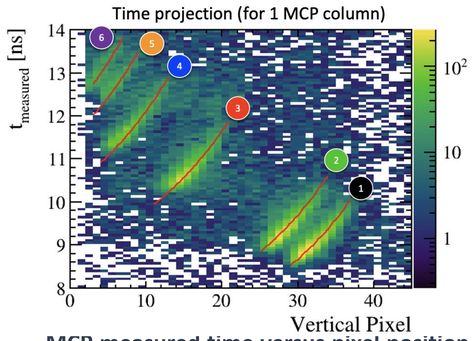


Data Flow



TORCH Electronics

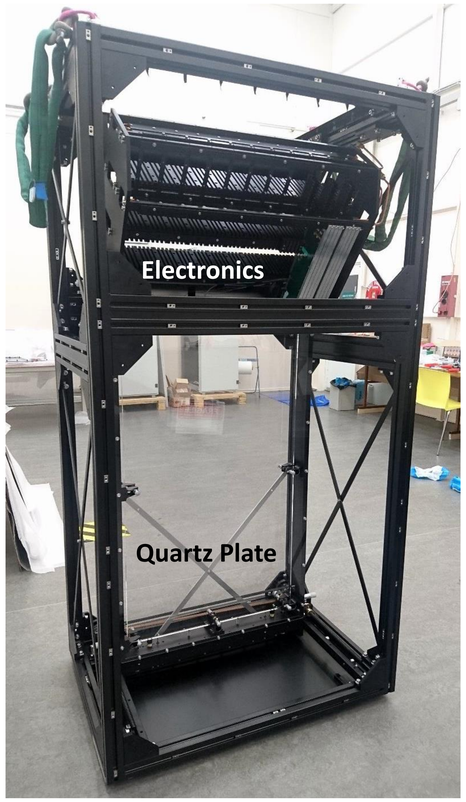
- The electronics is modular design providing up to 256 channels per system in a 8 X 64 arrangement.
- NINO board contains two 32-channel NINO ASICs utilising Time-Over-Threshold for amplitude measurement and time walk corrections.
- The HPTDC board contains two 32-channel HPTDC ASICs for fast timing digitisation.
- The readout board contains a custom Giga-bit Ethernet (GbE) based readout module.
- The GbE links from multiple readout boards connect to a commercial Ethernet switch with a 10 Giga-bit Ethernet uplink that connects to a DAQ PC.
- 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.
- A dedicated system is currently being commissioned at University of Bristol for the calibration of charge to pulse-width and integral nonlinearity.



MCP measured time versus pixel position from the test-beam, showing multiple reflections from the radiator

Test-beam

- A test-beam campaign has been carried out with a pair of MCPs in 2018.
- The plot on the left shows a measured time distribution recorded using Proto-TORCH.



Proto-TORCH – A prototype with a half-length TORCH quartz radiator