Development of Precision Time-Of-Flight Electronics for LHCb TORCH

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on behalf of the TORCH Collaboration,
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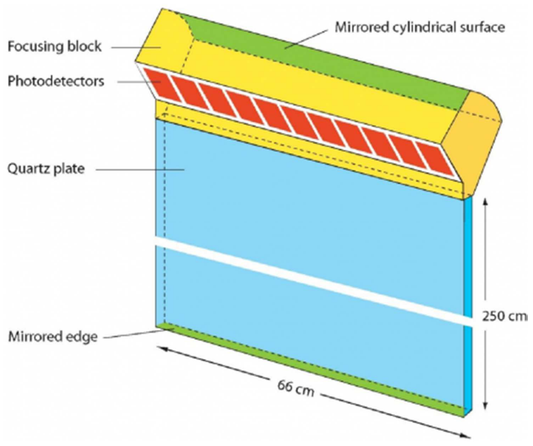
Introduction

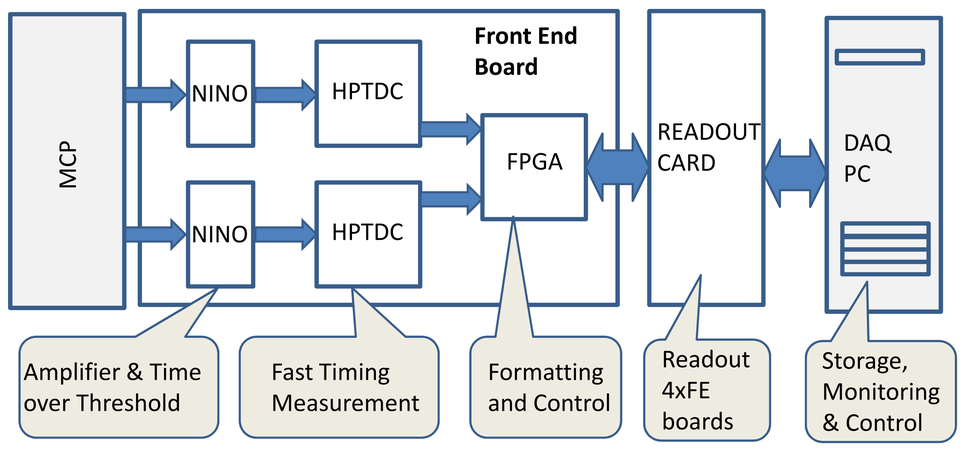
*TORCH— **T**ime **O**f internally **R**eflected **CH**erenkov light*

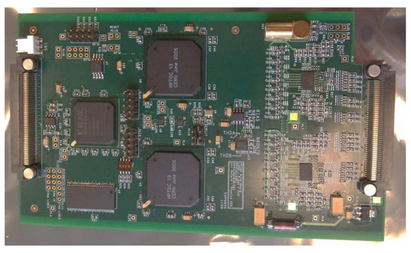


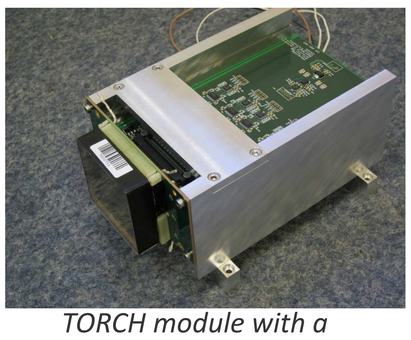
- TORCH is a high-precision time-of- flight system suitable for large areas.
- The aim is to achieve a timing resolution of 15 ps per incident particle, corresponding to a resolution of 50ps for single photons.
- TORCH will allow particle identification in the momentum region up to 10 GeV/c.
- Cherenkov 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.
- Time-of-flight is measured by custom electronics.
- Work with industrial partner (Photek) to develop customised MCPs.

Electronics Development

Data Flow




The Front-End board

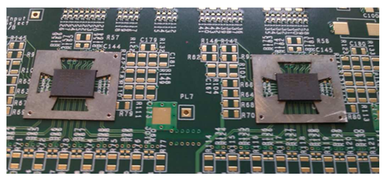

TORCH module with a commercial MCP

Electronics Design:

- 16 channels per board,
- Laboratory and test-beam firmware have been developed,
- Low jitter clock distribution,
- Delay matched PCB tracks across all channels,
- On board test signal injection,
- Giga-bit Ethernet-based readout for up to 4 Front-End boards ,
- Readout system also provides NINO threshold control and HPTDC configuration.

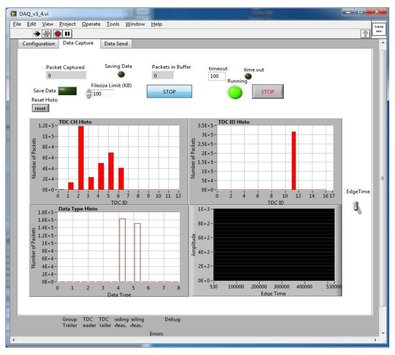
Electronics Production:

- Positioning tools have been developed to assist the assembly of NINO.
- Extra through-holes have been added to the foot print to allow reflowing large pads underneath NINO ASIC.
- Connectivity of NINO ASIC are tested before a board is fully populated.


Assembly of NINO ASICs

DAQ:

- Data transfer and storage,
- Online monitoring,
- Online control,
- HPTDC configuration.

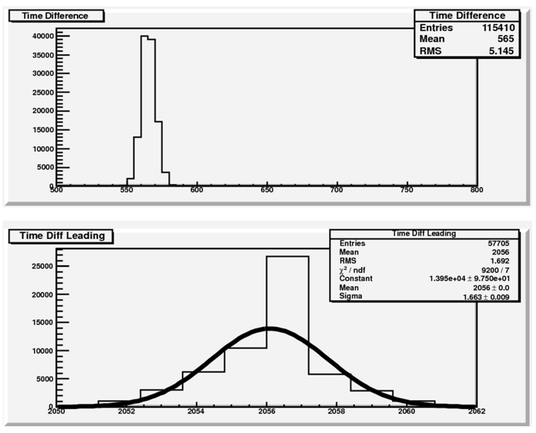

Screen shot of the DAQ Software

Laboratory and Beam Tests

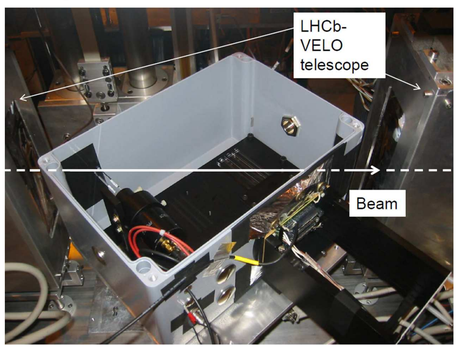
We measured 40ps intrinsic time resolution under lab testing conditions with an electrical test pulse, as shown in the picture on the right.

A commercial 8x8 MCP is connected to the system to demonstrate its performance.

A 90ps time resolution has been recorded with a fast pulsed laser and the MCP with a low gain of 100fC.



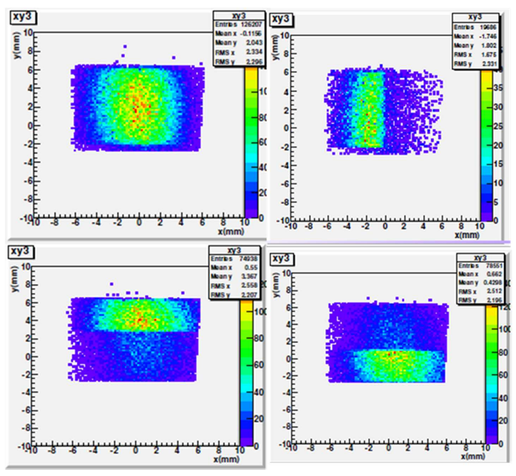
Time Resolution: Y-counts, X-bin in 25ps



Coincidence with LHCb VELO telescope hits has been observed, as shown in the picture on the right.

- A paper extensively reporting laboratory and test beam results will be published soon.

- The system on the left has been prepared for a beam test. Two borosilicate bars are used to produce photons from the beam. A single channel MCP is used to provide a reference signal.


The high-lighted area in green shows the coincident events with the LHCb VELO Telescope.

Future Work

- Designing 64-channel boards with NINO 32,
- Improving readout for higher throughput,
- Incorporating instrumentation control in DAQ software for automated testing,
- Incorporating CERN Giga Bit Transceivers,
- Planning for a test-beam next year.

TORCH is funded by European Research Council

The Collaborators are

For further information please go to our website: *http://torch.physics.ox.ac.uk*