Beam instrumentation trigger input and readout

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DAQ Review

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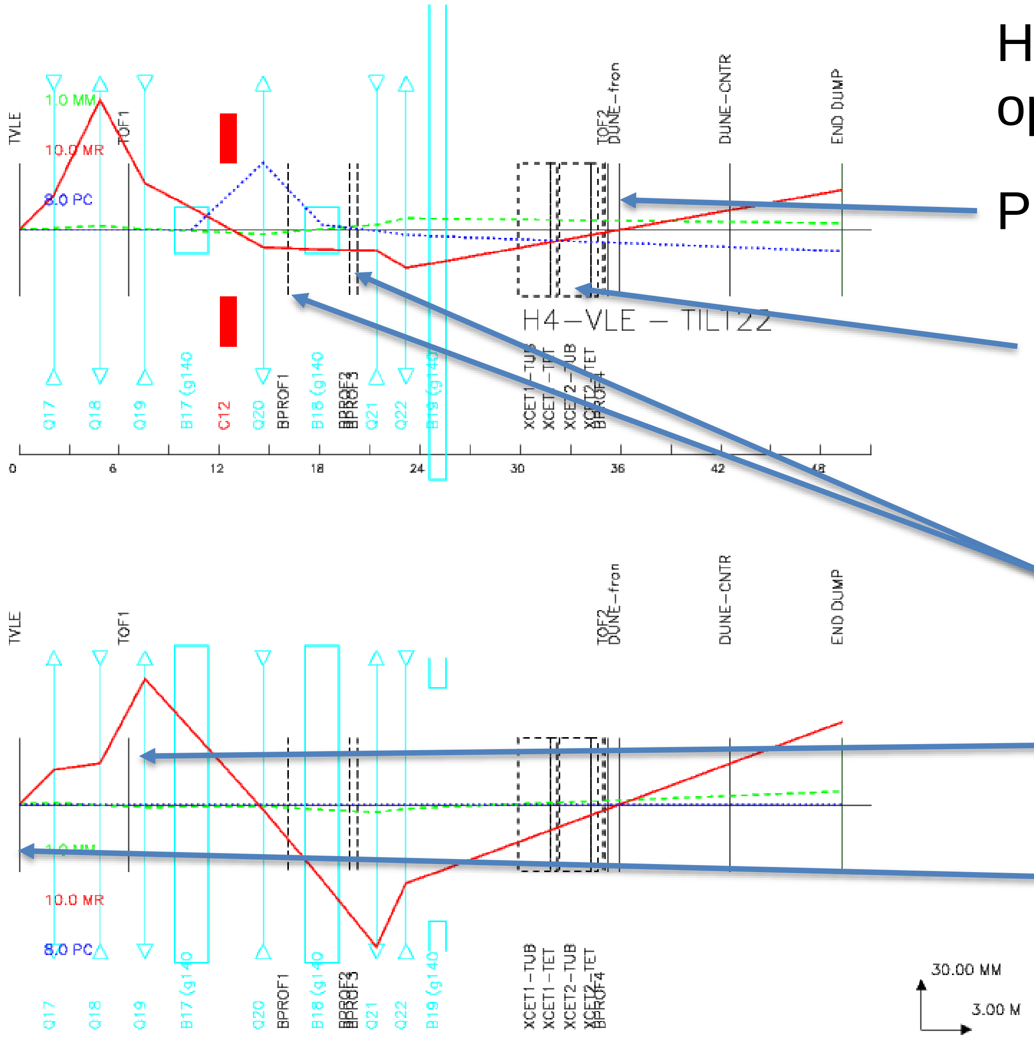
Introduction

- This presentation addresses the Interface between Beam Line Instrumentation and ProtoDune DAQ [DUNE-doc-1651-v2]
- The Beam Line Instrumentation (BLI) accomplishes different tasks and includes different detectors [see TDR]:
  - Beam Monitoring, Particle tracking, Momentum measurement
    - Scintillating fibres monitors (CERN BI group)
  - Particle Identification
    - Cherenkovs (CERN BI)
    - ToF from pLAPPD (FNAL) or scintillating fibres (CERN BI)
    - PiD actual configuration will change according to beam momentum
- Total length of the beam line 37m

Beam line schematics



H4 –VeryLowEnergy beam optics and detectors(draft)

ProtoDUNE cryostat

Cherenkovs , last monitor, last ToF

Monitors for momentum measurement

First ToF station

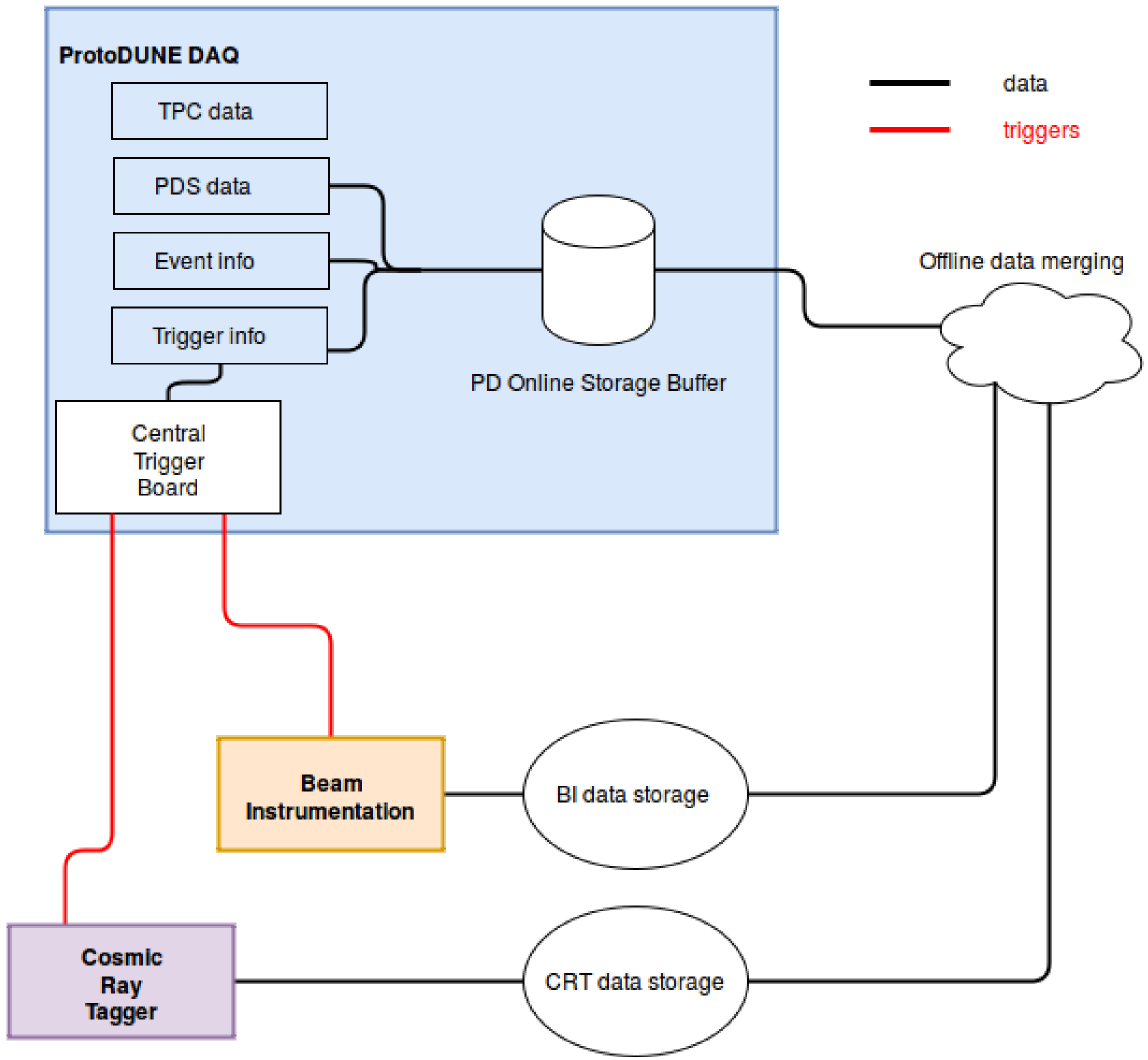
Secondary target

Introduction-II

- BLI will provide to PD
  - Trigger signals
  - Data fragments
- BLI data fragments will be included in PD events.

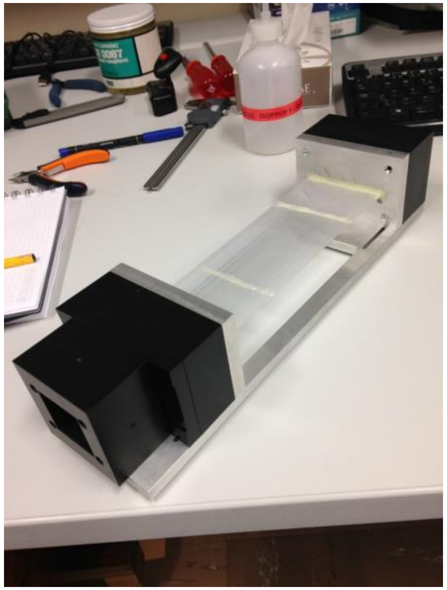
- BLI Data/trigger comes from two separate sources
  - BI Instrumentation, external to PD
  - FNAL pLAPPD, internal to Dune collaboration

Architecture

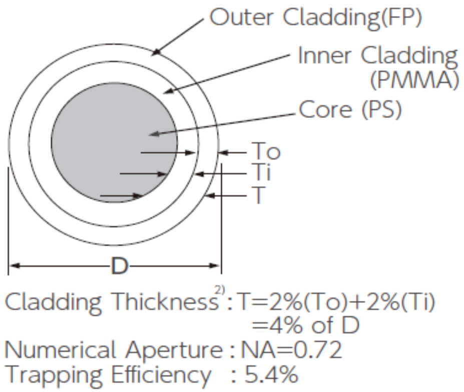


CERN-BI Beam Monitors

- Scintillating fibres, square section, double cladding, 1mm
- Light detected with SiPM, one per fibre
- 1 or 2 planes of fibres, 192 fibres per plane, 192x192 mm area==beam
- 3 planes for momentum measurement , 2x2 planes for tracking ➔ 7 planes in total



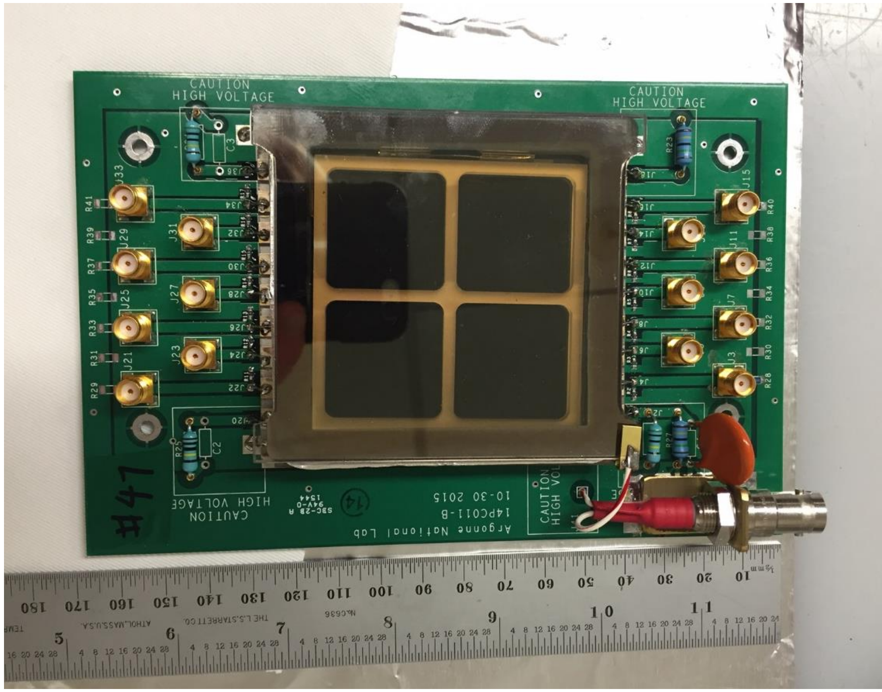
Example ofassembly



Prototypes tested in beam line, readout with CITIROC: an analogue front-end ASIC made by Omega Microelectronics (CNRS-IN2P3-Ecole Polytechnique) [I. Ortega et al, proceedings to be published]

Different ASIC under test for ToF application: STiC [JINST 9, C02003 (2014)]

FNAl pLAPPD ToF



- Plan to use two 6 cm x 6 cm MicroChannelPlate-based prototype Large Area Picosecond Photodetectors (pLAPPDs) from Argonne National Lab
- Split pulses, one stream to protoDUNE DAQ, the other copy going into a PID trigger board.

- The PID trigger board will look for coincidences between the two ToF detectors, do some fast analysis to measure a ToF (beam momentum is programmed into the board), and based on that provide "is consistent with a proton", "is consistent with a kaon" .. Signals
- pLAPPD data readout is managed by PD, not by CERN BI

Interfaces

- The instrumentation will be used by the CERN BI and EA (Experimental Areas) groups to commission, steer and monitor the beam
- BI/EA need data acquisition and trigger independently from PD
- Front-end readout is responsibility of the BI group and is separate, also physically, from PD readout
- → BI will provide NIM signals to PD i.e. for trigger
- Regarding access to data, for reliability reasons the Technical Network (TN) used by BI is not accessible from the General Network (GN).
- → BI will publish data on a public location where it can be retrieved by PD
- Data will be merged in offline prompt processing
- Note instead that the pLAPPDs data could be directly read out into the PD DAQ

Timing

- Synchronization will be ensured by time stamping of data with the White Rabbit (WR) system [J. Serrano, ICALEPCS2009, http://www.ohwr.org/projects/white-rabbit]
- WR timestamps have a precision of +/-700 ps
- A common GPS signal will come from a WR master switch in the CCR (Cern Control Room), same GPS as for LHC
- The signal will be propagated to slave WR nodes, one for BI and one for PD.
- This will provide a 10 MHz clock and a 1 PPS output to both systems.
- PD will derive its primary 50 MHz clock from this 10 MHz
- Front-end digitizers of each BI and PD detector will time-stamp their buffer recording, corresponding to the time of the received trigger, with their internal clock, which is freestreaming
- Synchronisation is then ensured by time-stamping of trigger signals distributed to these detectors with WR
- Time stamping of the trigger signals is performed using FMC TDC mezzanines plugged onto a VME64x or PCIe WR-enabled carrier.

Trigger

- The primary trigger will come from the BI as a coincidence of beam scintillators or fibre trackers.
- In both cases, fast signals (<100 ns)
- BI will deliver this trigger as NIM signal to PD trigger box
- The present BI plan is to locate two VME crates (one for H2 and one for H4) in HNA394, that is at the border between old North Area and Extension. A barrack 30-40 meters further downstream could also be considered in order to gain 100 ns on the NIM trigger from BI.
- In any case, delivery of trigger signal will be within few hundreds of nanoseconds
- Reminder: requirement is beam rate < 100 Hz

Trigger-II

- Other logical signals will also be delivered to allow for PD trigger logic :
  - Cherenkov " above threshold " (2 signals)
  - Good event in all monitors (max 5, orthogonal planes will be in AND): NIM or TTL or LVDS
- pLAPPD ToF (max 3 signals)
- In total, the beam instrumentation needs max 11 inputs in the PD trigger box
- Warning Extraction (WE) and End of Extraction (EE) will be provided on a Lemo00 patch panel in PD

BI data volume

- Expected data volumes (excluding headers):
  - 7 fibres planes , 200 fibres each , one bit per fibre→ 1400 bits
  - 1 sci-fi ToF (3 words, TDC +2 ADCs)
  - 2 Cherenkovs (2 words)
  - For a total of about 200 Bytes +headers/event
  - To be added: pLAPPD ToF: waveform readout, 16 ADC samples + 1 TDC per channel, few channels per event → 200 values in 400 Bytes/events
  - For a total of about 600 Bytes +headers /event
- 60 kB /s at 100 Hz trigger rate

Data merging

- BI data fragments will be published at the end of each SPS cycle. Duration of the cycle is of the order of 40s. Each cycle can contain from zero to a few spills to NP04
  - PD DAQ will need a nearline merger
  - PD data will be written on local storage, and merged with BI data in the first, prompt, offline processing
  - BI data will be converted to standard artDAQ format
  - Complete PD+BI event will be sent to offline storage
- BI data will be aggregated to PD data based on GPS timestamps

Data - interface

- BI data will be published on the CERN *DIP and DIM* Servers https://wikis.web.cern.ch/wikis/display/EN/DIP+and+DIM immediately after the end of extraction
- DIP name servers are operated as a critical service, aiming for 100% availability through server redundancy.
- An API (Application Programming Interface) is available to publish and receive information.
- BI data will be also published to the CERN Accelerator Logging Service database (CERN-ATS-2009- 099, https://wikis.cern.ch/display/CALS/CERN+Accelerator+Logging+Service) for medium and long-term storge

Component testing

- Cherenkovs: in use since decades
- Scintillating fibres monitors
  - Prototypes of the fibers monitors have been already tested
  - Event-by-event readout under development
- WhiteRabbit
  - Modules commercially available
  - Widely used and tested (cite)
- Prototype of the full BI DAQ expected to be ready before summer 2017
- BI will be ready to be used with the PD trigger box in summer 2017
- pLAPPD DAQ under development.

Risks

- Trigger signals will be delivered on standard cables with <1μs latency . No risk is foreseen on this item
- Merging of BI data fragment with PD may fail if PD nearline/prompt processing cannot sustain the delay due to end-of-cycle BI buffering.
  - BI data are always logged on the CERN logging system. Offline retrieval of information is painful but possible
- The low event rate render the effect of jitters in time-stamping negligible

Conclusion

- The interface of Beam Instrumentation to PD DAQ has been defined
- Beam Instrumentation will provide a main trigger and auxiliary logic signals as NIM to PD trigger box with 100s ns latency
- Beam Instrumentation and PD will be synchronized through WhiteRabbit and a common GPS signal
- Data fragments from BI will be published and acquired at the end of each beam spill
- BI data converted to artDAQ format and merged to PD data
- pLAPPD DAQ and trigger under development
- A prototype of BI DAQ will be available for testing by summer 2017