

Protodune Cosmic Ray tagger (CRT)

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ProtoDUNE DAQ Review

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Introduction

- CRT motivations
 - System overview and trigger signals
 - CRT Readout
 - CRT Event Builder

ProtoDUNE CRT

System will be positioned in the front and back of the TPC

- identify muon present in beam halo
- tag this muon send trigger info to TPC

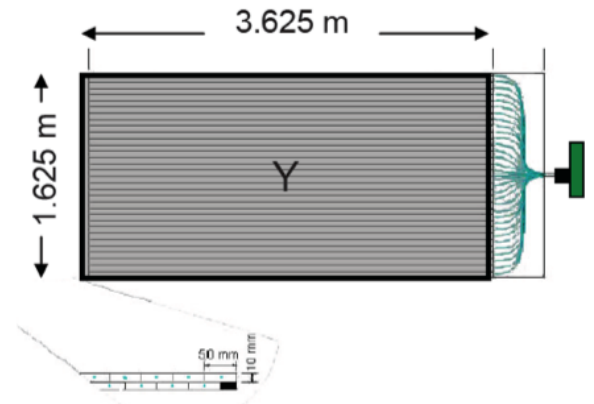
System will also have some panel on top of the TPC

- Muon veto, send trigger info to TPC

Trigger will be generated as an OR of the X and Y panels

Send to the TPC trigger board within 500 ns.

Hit info or ADC info in separate data stream.



- CRT modules consist of two layers of 64 scintillator strips with WLS fibers connected to a single multi-anode PMT

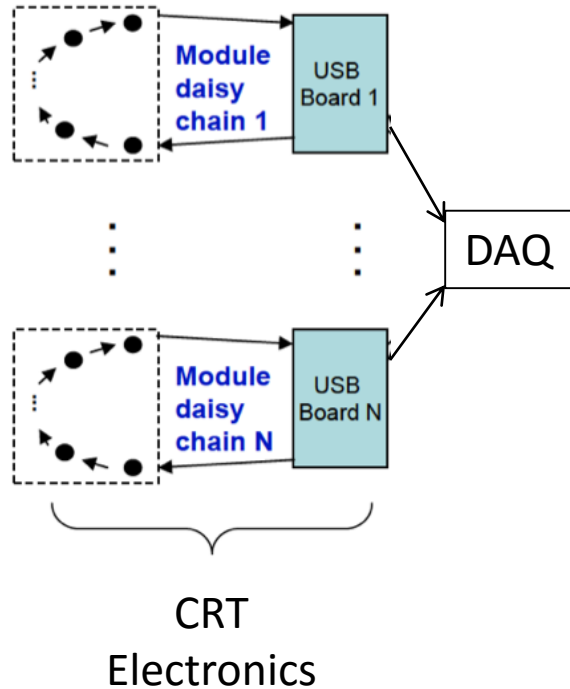


CRT Readout Electronics

- Multi-anode PMT (Hamamatsu M64)
- Multi-anode readout chip (Maroc2)
- Multi-anode front-end readout board (custom-made at Columbia / Nevis labs)
- USB board (custom-made at Columbia / Nevis labs)
- Fan-out / trigger boxes (custom-made at Columbia / Nevis labs)



System Overview and Trigger Signals

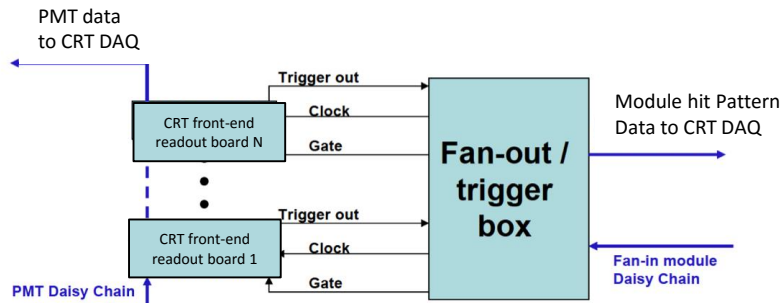


Each PMT board:

- Readout 64 channels - provide hits or ADC info
 - Hits processing require 120 ns
 - ADC processing require 32 μ s
- Board trigger does not know about other boards

Trigger board:

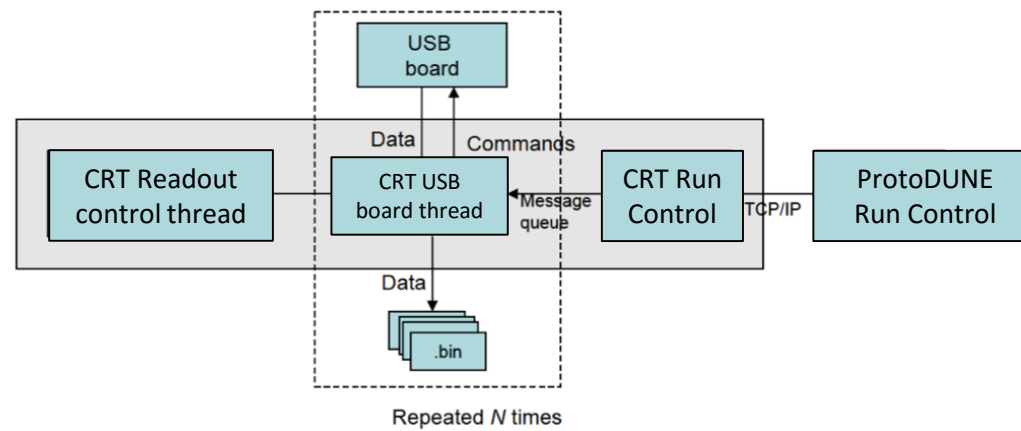
- Collect info from all PMT boards
- Provide hit info pattern (through DAQ)
- Form a trigger signal (based on single board info)
 - 2 trigger out available
 - Geometrical overlapping modules in < 500 ns
 - OR of all modules in < 500 ns



Data stream contains 32 bit timestamp can be used for data merging offline, only when a proper bit is asserted in the main data stream.

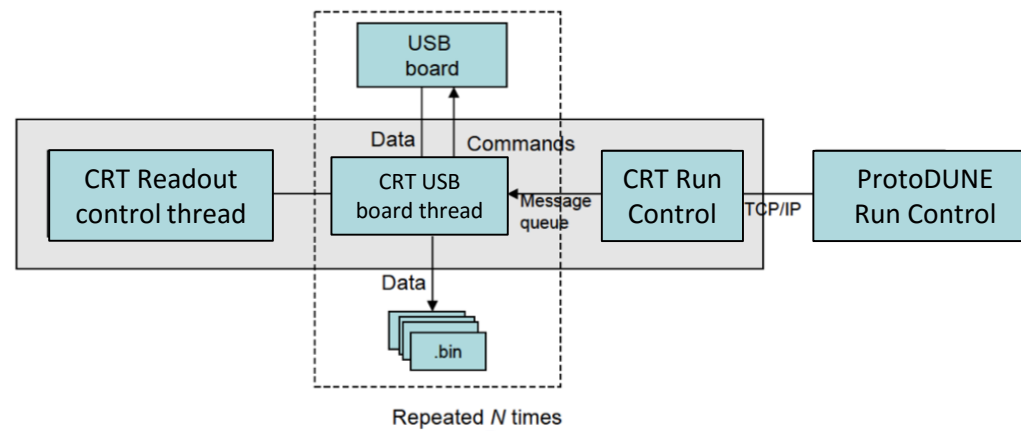
CRT Readout

- Launches independent threads (C++) to manage each USB board
 - USB communication using libusb
- Separate CRT run control process (perl/python) connect to the ProtoDUNE run control control via TCP/IP sockets
 - CRT run control communicate with the USB streams using message queues
- Binary data are written independently for each of the USB stream on disk



CRT Event Builder

- CRT Event Builder written in C++ and designed to:
 - Read raw data from the CRT DAQ
 - Independent, unsorted data stream for each of the USB, consisting of data packets from individual CRT modules
 - Compute and apply pedestal calculation
 - Apply offline thresholds
 - Time-order hits within individual data USB stream
 - Merge all USB data stream in time-order, grouping them into CRT events



Component testing

- All components tested already
- Component that need to be produced will be visually inspected after production and then tested
- Plan to have a full electronic test stand at Virginia Tech

Risks

- No risk identified for now

Conclusion

- System was used in 3 different experiments - did not cause major issues.
- Have years of running and extensive commissioning experience
- Full test stand planned
- Detector is very new to ProtoDUNE so lots of specific details of the system needs to be addressed
 - i.e. cable length need to be decided
 - location of the electronics boards for triggering
- We will use similar triggering and data margining schemes as the beam instrumentation.