Data Acquisition for SBND

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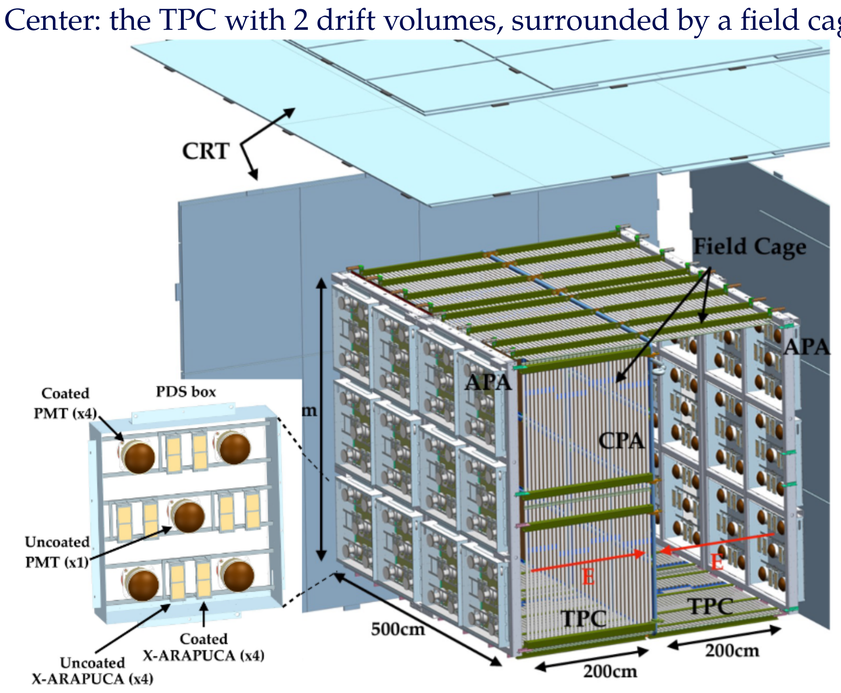
Short-Baseline Near Detector

- The Short-Baseline Near Detector is an 112 ton liquid argon time projection chamber (LArTPC) experiment based at Fermilab, in Batavia, IL, USA ~100m from the beam.
- The experiment consists of many detector subsystems and aspects of our data collection and readout system.
  - Time projection chamber (TPC) - 4mx 4m x 5m with wire plane readout
    - Signals digitized inside the cryostat and sent to warn readout electronics by Warm Interface Boards (WIBs)
  - Photon detection system
    - Photo-multiplier tubes (PMTs)
    - X-ARAPUCAs – SiPM based light detection
  - Cosmic Ray Tagger (CRT) – modules made of solid scintillator strips that surround the cryostat
  - Penn Trigger Board (PTB)
  - White Rabbit TDC – timing and synchronization system

Fig. 1: Diagram of the SBND detector, with views in and outside of the cryostat[1].

Center: the TPC with 2 drift volumes, surrounded by a field cage.



Bottom left: One photon detection system box containing PMTs and X-ARAPUCAs.

Top, back, far right: Some of the walls of the cosmic ray tagger. There are walls for all sides of the cryostat, with only the top CRT left to be installed.

Data Acquisition System (DAQ)

- SBND uses an **`artdaq`** based data acquisition system called **`sbndaq`** (also used by ICARUS).
- The Penn Trigger Board (PTB) is used to determine when a trigger should be sent out to all subsystems based on configurable parameters, beam signal inputs, and feedback from the PMTs and CRTs. This trigger causes a new event to be created and all detector components are read out.
- When the Nevis Trigger Board (NTB) receives an event trigger from the PTB, it creates a new `art` event, pulls data from the TPC readout electronics, and all of the other subsystems have their coincident data put into the same event[2].
- Due to close proximity to the beam we experience high data rates, with subsystem sampling rates of 2MHz, 500MHz, and 1GHz for the TPC, PMT and CRTs respectively.
- In order to end up with events which have data from the same real time activity its extremely important to make sure that all of the timestamps put on fragments by each subsystem agree with each other.
- Event builders create an event with the data from all subsystems and write them to disk.

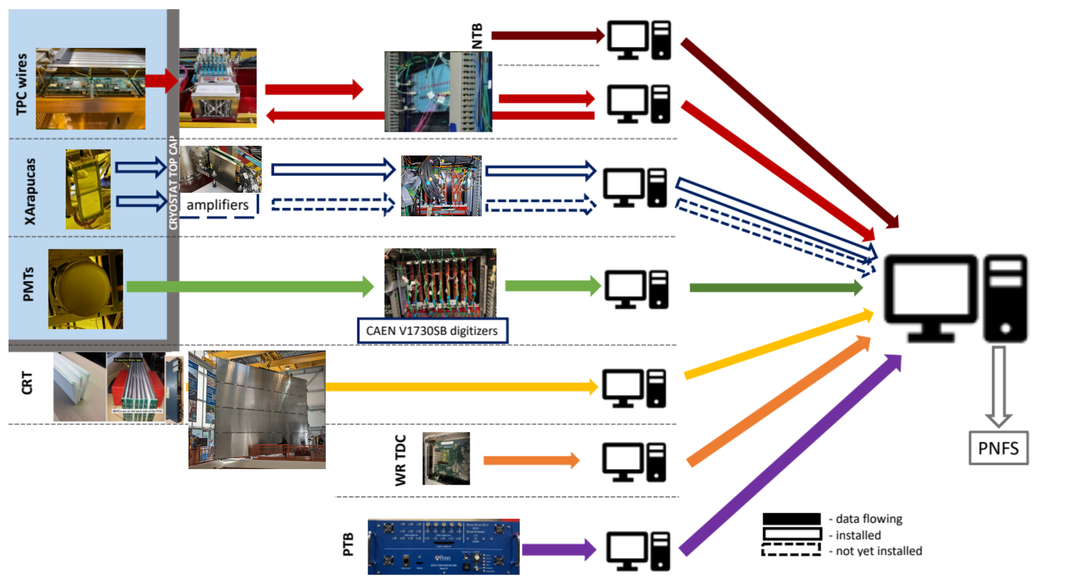


Fig. 2: A diagram of SBND's DAQ readout system. The components which are physically located within the cryostat are shown in the blue box on the top left. Arrows show the data flow from the data collection elements through digitizers to servers and event builders

DAQ Commissioning status

- SBND has made significant progress in getting the DAQ ready for data taking.
- We are able to run with all of the different subsystems simultaneously at the desired design frequency of events at a 5 Hz rate, and a full sized data rate.
- We've been testing a wide variety of different trigger configurations, such as beam, a so called "off-beam" that can be used in conjunction with beam triggers in order to get concurrent sample of cosmic data, and using input data from the CRTs and PMTs to send triggers.
- The data flow paths have all been tested with all first phase physical components, which are all able to pass data to the event builder processes.
- By collecting data in coincidence with Booster Neutrino Beam spills (BNB) with the CRTs and PMTs, we can look for an excess in light from neutrino interactions.
- We see clear peaks in both the CRT and PMT data from the neutrino beam. Both neutrino interactions and in time beam products like rock muons would be included in these peaks.
- The peaks are each 1.6 μs wide – equal to the the duration of a beam spill

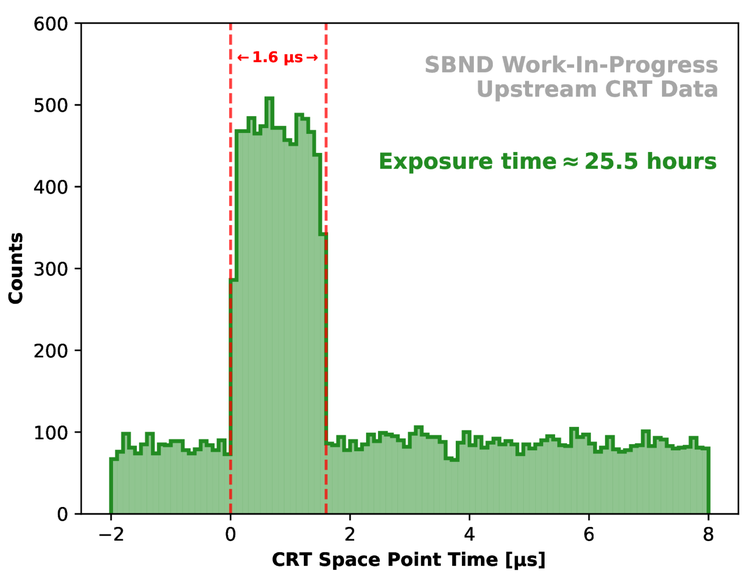


Fig. 3: Cosmic Ray Tagger event rates as a function of time referenced to the time of arrival of Booster Neutrino Beam. The excess above background is coincident with the arrival of the beam at the ND building.

DAQ Commissioning status cont.

- This is a great way to demonstrate that the timing and event triggers are behaving as expected, and that the beam acceptance window is correct.

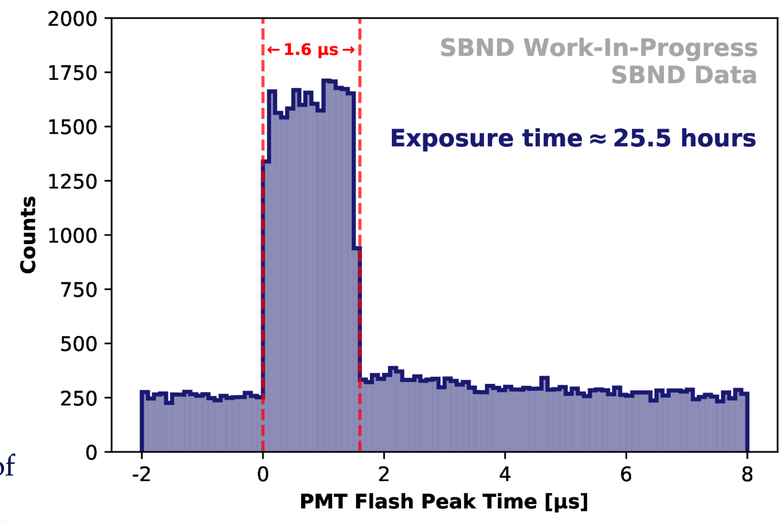


Fig. 4: The number of PMT flashes as a function of time referenced to the start of the Booster Neutrino Beam (BNB) spill. Over the full PMT readout waveform there is a steady background of flashes, with an increased rate during the neutrino beam spill.

Conclusion

- SBND is in the process of detector commissioning and development of our data acquisition system.
- SBND has made great progress towards commissioning our DAQ.
- We are able to handle a full data rate where we have all of the expected elements of detector readout included, and are running at a design frequency of ~5 Hz.
- A wide variety of different trigger configurations have been and continue to be tested, allowing for not just every beam spill data.
- By using PMT and CRT data we are able to see light from beam neutrinos.
- We'll continue working to improve the DAQ for steady data taking during this commissioning phase.

References
[1] P. Abratenko et. al. (SBND Collaboration). Scintillation Light in SBND: Simulation, Reconstruction, and Expected Performance of the Photon Detection System.
[2] H. Chen et. al. JINST 7 (2012) C12004 DOI: 10.1088/1748-0221/7/12/C12004

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