Fermilab

SBN DAQ Requirements Overview

Wesley Ketchum (FNAL), Eric Church (PNNL), Angela Fava (FNAL), Georgia Karagiorgi (Manchester)

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Overview

- Timescales
- Teststands
- Detector subsystems and channel multiplicity
- Data rates
- Trigger
- Event building
- Data flow
- Monitoring

A word about MicroBooNE

- MicroBooNE is part of the SBN program
- But won't discuss requirements for MicroBooNE much here
  - Running experiment
  - Existing DAQ meets basic experiment requirements
  - Complete upgrade path for MicroBooNE needs feedback from normal/ stable operations
  - SBND requirements match much of MicroBooNE
    - Will highlight differences

Timescales

- Both SBND and ICARUS plan to be operational ~2018
- Both experiments plan to have final hardware designs finalized ~Spring 2016
  - TPC hardware decisions largely already made
  - PMT + trigger hardware decisions still being finalized
  - Expect software architecture/framework decisions to be finalized on similar timescale

Teststands

- Both experiments need a DAQ operating on TPC test stands
  - ICARUS
    - Vertical slice with TPC, electronics, and DAQ PC at CERN exists
      - Could add switch and event builder
    - Development test stand with electronics and DAQ PC at INFN-Legarno
  - SBND
    - Vertical slice with (cold+warm) electronics, DAQ PC, network switch, and event builder PC at FNAL in development
    - Vertical slice with (warm) electronics, DAQ PC, switch, and event builder PC at PNNL in development
    - Development stand with readout electronics and DAQ PC at Nevis in development
    - CRT test stand with electronics and DAQ PC at Bern exists
- Plans for PMT, trigger, CRT (ICARUS), and laser (SBND) test stands to be developed with hardware decision
- Requirement: basic DAQ applications be able to operate on test stand in production-level mode

Detector subsystems: SBND

- TPC: ~11,500 channels
  - 64 channels per readout module, with 16 modules per readout crate
  - 2 MHz sampling, 3.84 ms readout → ~220 MB/event, uncompressed
    - ~20 MB/event per readout unit
  - Links: same as MicroBooNE (Nevis design optical links + PCIe card)
- PMT: ~100 channels
  - ~up to 1 GHz sampling → total data rate unknown, expected < TPC
- CRT: ~4000 channels
  - 32 channels per front-end board, with 18 FEBs per readout unit
  - About 6 MB/s data volume
- Laser
  - Readout of laser mirror positioning during calibration runs

Detector subsystems: ICARUS

- TPC: ~53,000 channels
  - 64 channels per readout module, with ~9 modules per readout crate
  - 2.5 MHz sampling, 1.64 ms readout → ~330 MB/event, uncompressed
    - ~3.4 MB/event per readout unit, though higher concentration possible
  - Links: presently deployed CAEN CONET-2 proprietary protocol
    - Used for testing, not final configuration
- PMT: ~400 channels
  - ~1 GHz sampling → total data rate unknown, expected < TPC
- CRT: ~? Channels
  - System still under design. Expected data rate << TPC

Total data rate requirements

- First, a note: next two slides report numbers from the collaboration per stated requirements
- Skip to slide 11 for a more honest side-by-side comparison in data rates

Total data rate requirements Front-End

- Assume just TPC data for now (as that is dominant, and designed)
- Maximum required instantaneous rate
  - Beam operation: ~15 Hz
  - Commissioning: 50 Hz (SBND),
    AFARA (as fast as reasonable achievable) (ICARUS)
- Expected average rate
  - Beam operation: ~5 HZ (ICARUS), ~5 Hz* (SBND)
    - *Assumes fully operational and commissioned trigger at start of data-taking
- Uncompressed data rates:
  - Instantaneous: 5 GB/s (ICARUS), 3.3 GB/s (SBND)
  - Average: 1.7 GB/s (ICRAUS), 1.1 GB/s (SBND)

Compression

- SBND
  - Assumes factor ~5 compression from Huffman scheme (similar to MicroBooNE)
  - No additional software compression assumed
- ICARUS
  - New scheme (compared to LNGS run) needed for new 12-bit ADCs
    - To be determined
  - Software compression factor ~2 from gzip of files (achieved at LNGS)
  - Additional compression could be implemented at FE PC or EventBuilder
    - Let's assume factor 4, like Nevis-style Huffman compression
- Total data rates with compression:
  - Instantaneous: 2.5 GB/s (ICARUS), 2 GB/s (SBND)
  - Average: 200 MB/s (ICRAUS), 220 MB/s (SBND)

What to make of all of that?

- There's a lot of varying assumptions/ideas in those numbers, so let me give the three numbers I think are most relevant
- Max accelerator structure rate is 15 Hz
  - With conservative compression assumptions, this is 625 MB/s and 660 MB/s in ICARUS and SBND, respectively
- Likely beginning operational average rate is 5 Hz
  - → ~200 MB/s and 220 MB/s in ICARUS and SBND, respectively
- Incorporating a light-coincidence trigger will lower rates
  - Expected factors are approximate 1/40 and 1/15 in ICARUS and SBND, respectively
  - This leads end-data-rate assuming 5 Hz beam rate of 5 MB/s and 15 MB/s in ICARUS and SBND, respectively

Trigger

- Basic strategy is the same
  - Activity in light detection system in coincidence with neutrino beam spill
  - Both experiments require ability to trigger on neutrino beam spill alone
  - Both experiments require storage of trigger bits fired for each event
  - ***NOTE***: Neither experiment likely requires trigger-level veto from CRT system
    - To be determined with final decisions
  - Trigger signal broadcast to all TPC readout crates
    - PMT and CRT still under discussion for ICARUS
    - PMT not defined for SBND, but CRT will not see trigger signal
- Trigger hardware
  - Still being discussed for both experiments, along with PMT readout hardware
- Trigger backpressure from DAQ?
  - SBND: No requirement, readout electronics buffering sufficient
  - ICARUS: Required. DAQ must be able to issue temporary trigger inhibit

Synchronization

- TPC (both experiments)
  - All crates synchronized to each other
  - Crates synchronized to trigger clock
  - GPS time stamps
- PMT (both experiments)
  - Still undefined, but likely similar to TPC
- CRT
  - SBND: GPS time-stamps for each event, matched to time stamps from other fragments
  - ICARUS: still under discussion
- Beam (both experiments)
  - Online: trigger sees beam signal (properly timed in), and BNB RWM signal recorded
  - Offline: merge to beam data from IFDB based on GPS time stamps

Event-building

- Merge data from subsystems into one file online?
  - YES (both experiments)
    - Challenge for systems with only time-stamps to merge
- Additional information
  - YES (both experiments)
    - Run, event, timing info, trigger source, number of triggers dropped (ICARUS), etc.
- Format
  - SBND: Under discussion, but ROOT format likely sufficient
  - ICARUS: Under discussion, but probably ability to write binary (LNGS compatible) format alongside ROOT

SBND: Continuous stream

- SBND will have a “Supernova” stream for readout out data continuously
  - Expect total rate ~100 MB/s in each front-end crate
    - Requires zero-suppression in readout electronics
  - Data streamed to local DAQ PCs, and moved to permanent storage and processed only on receipt of external trigger (e.g. SNEWS alert)
    - Otherwise overwritten after 1-2 days
  - Should run simultaneously with triggered stream
- ICARUS does not currently have plans for a continuous data stream

Data flow

- See talks from MicroBooNE and ICARUS DAQ experience: these serve as the models for data flow
- In both experiments, fully built events can be moved towards offline storage after integration with beam data
- Both experiments plan to save raw (unprocessed) data, and (potentially) a processed data file
- Both experiments need 10 Gb links to offline storage
- Details on amount, features, and exact path towards permanent storage need to be defined
  - ICARUS: will be ironed out along with decisions on software
  - SBND: will follow MicroBooNE model
  - Both: will benefit from details of MicroBooNE's practical experience

Monitoring Tools

- Again, see talks from MicroBooNE and ICARUS DAQ experience
- ICARUS would like to retain database for tracking of files, data flow, and monitoring
  - Details of those to be discussed/depend on final software decisions
- SBND will use custom ganglia metrics for monitoring of DAQ quantities, and likely retain a database for monitoring data files after being fully built
  - Higher-level monitoring to be discussed, but can be accomplished through dedicated art modules running in an artdaq system
- System accessibility and maintenance
  - MicroBooNE heavily utilizes services of Scientific Linux and Architecture Management team: expect both ICARUS and SBND will do the same

Questions/Discussion

(And thank you!)