MicroBooNE DAQ Status

Eric Church, Yale

LANL LArTPC Meeting

1-Feb-2013

Outline

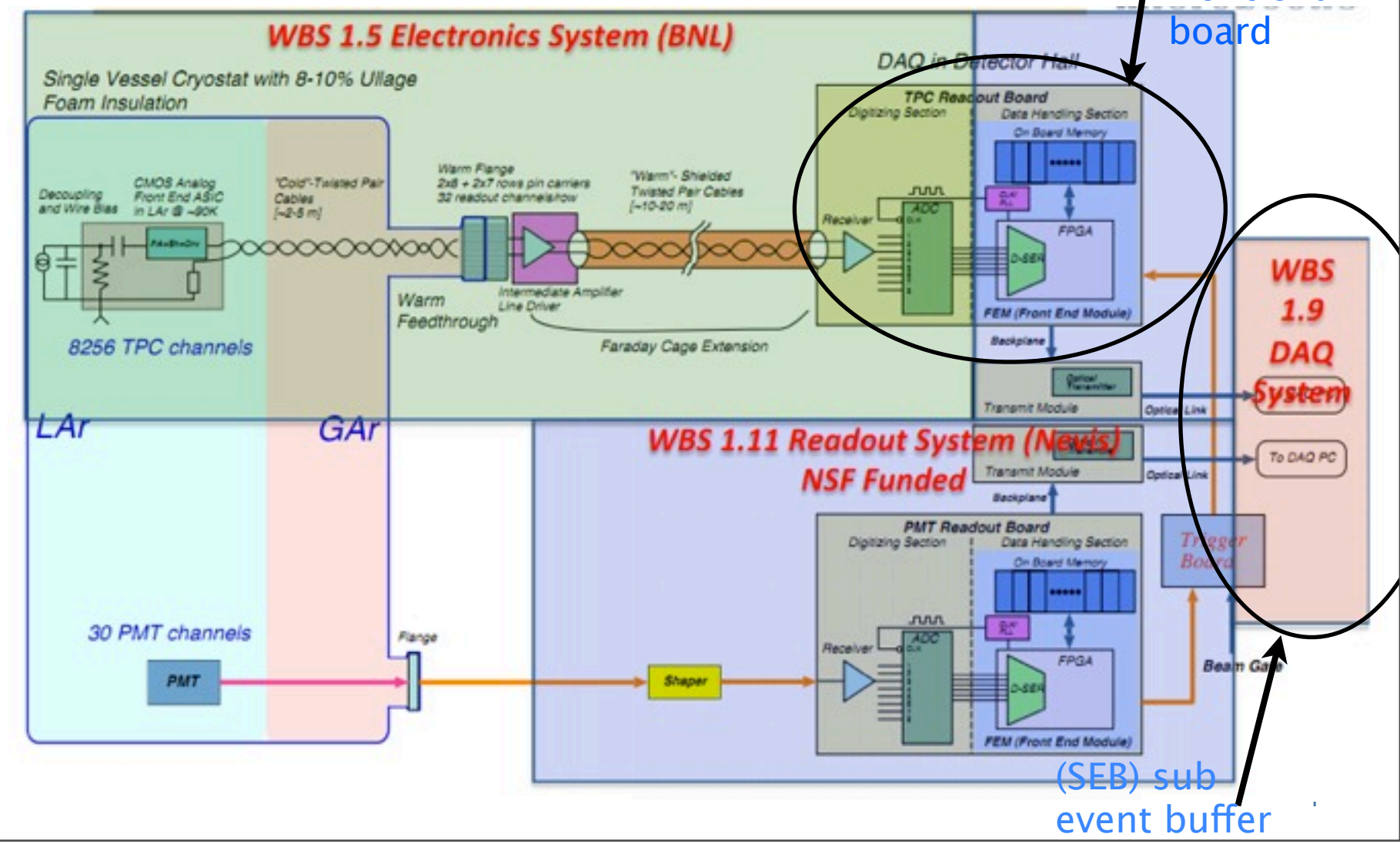
- Overview
- MicroBooNE DAQ Teststands
  - People/Institutions
- MicroBooNE DAQ System Overview
- System Components at DAB Teststand
- Progress so far
- Electronics Status
- Ongoing Work: stuff we're still building
- Charge Injection Calibration
- Schedule to completion
- Summary and Outlook
- Considerations for LANL LArTPC

MicroBooNE Status

- See Wes's talk
- CD3b March, 2012.
- CD4 in Summer, 2014
  - MicroBooNE collaboration and project hope to be ready much earlier.

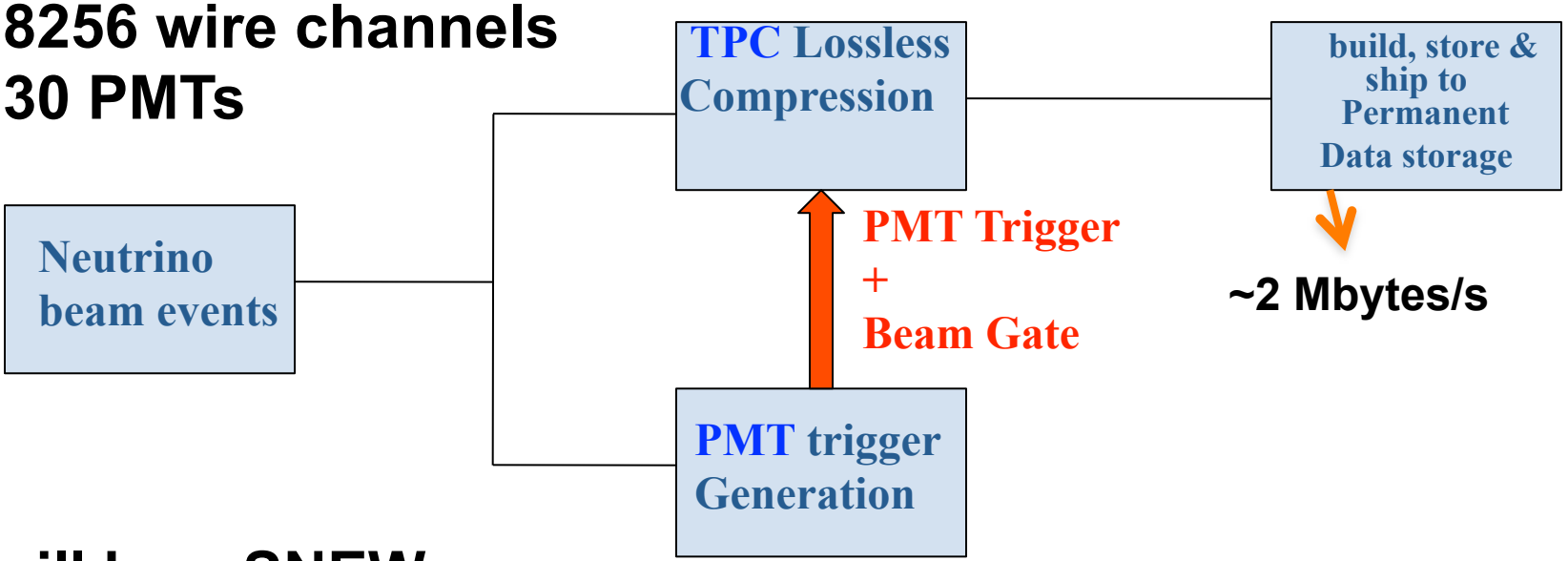
System Overview

- standard words/pictures



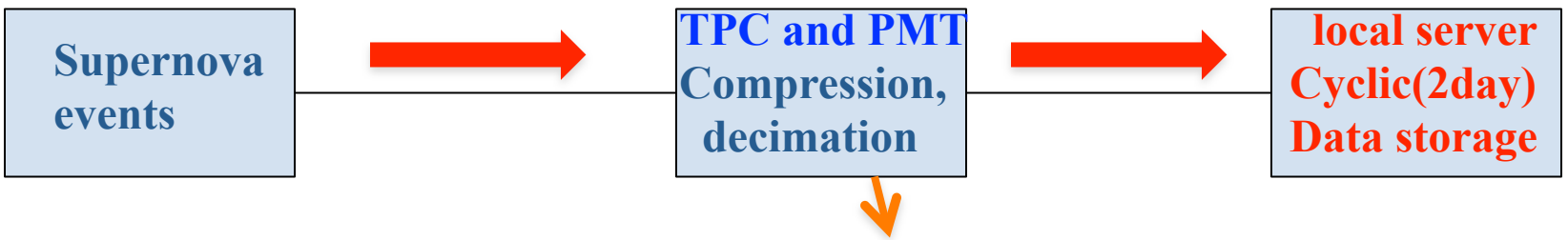
Digitizing Boards: MicroBooNE design

8256 wire channels
30 PMTs



We will be a SNEWs *consumer*.

Continuous TPC and PMT readout



Use the SN data stream to select and study K background events

Resources

- Work on the DAQ is ongoing at Nevis/FNAL through 2013. Moving to LArTF (MicroBooNE enclosure), we hope, end of 2013.
- The DAQ team is comprised of the following people :
  - Yale: Eric Church (TD), Andrzej Szelc (postdoc)
  - LANL: Wesley Ketchum and Zarko Pavlovic
  - Nevis: Georgia Karagiorgi, David Kaleko
  - Va Tech: Camillo Mariana and Leonidas Kalousis
  - KSU: Glenn Horton-Smith, David McKee and Sowjanya Gollapinni
  - FNAL:Bruce Baller (L2), Ron Rechenmacher, Gennadiy Lukhanin, Kurt Biery (FNAL CD CET group engineers)
  - MIT: Matt Toups, Ben Jones, Christie Chiu
  - UT-Austin: Rashid Mehdiyev

D0 (DAB) and Nevis Teststands

- This talk will mostly focus on the DAB (D0 Assembly Building) teststand, on which the MicroBooNE DAQ team is developing the DAQ.

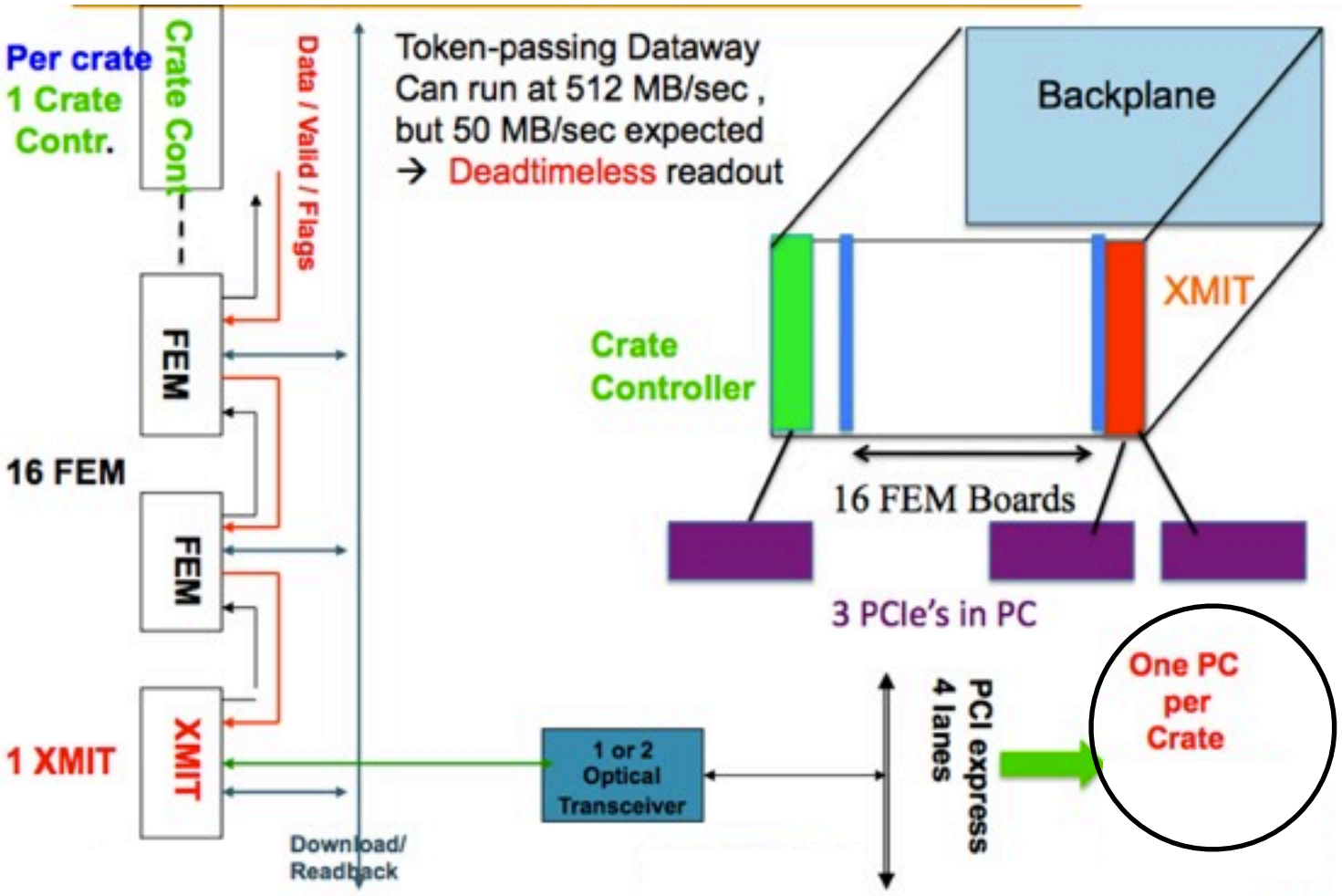
- Nevis runs its own test stand, where they run code and pass knowledge to us. And also, where they perform characterization of the electronics as it is fabricated and shipped to them.

Other uB-related Test Stands

- BNL maintains a front-end electronics test stand at which they test ASICS, motherboards, pre-amps, intermediate amplifiers, ...

- There is a Test Stand at PAB at FNAL that uses the control card (not XMIT) to read data from PMTs in liquid argon.
  - No wires, no E-field, reading out through Controller Card.
  - They are reading PMTs, and fitting to early/late light components
  - Doing dE/dx studies with an alpha source
  - Nitrogen impurity measurement
  - Shaking out PMT DAQ components, generally

Nevis TPC Crates (x9)



Wires are sampled@2MHz, 2 bytes

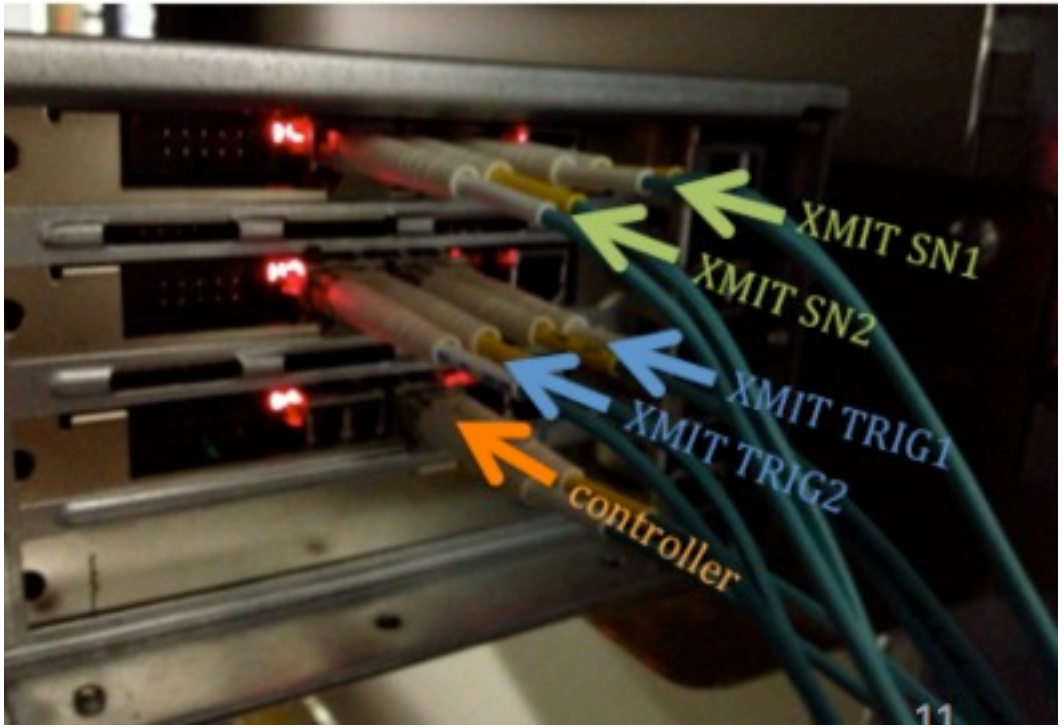
Fibers into SEB-computers

SEB == Sub Event Buffer <==> basically one crate.

Often SEB refers to the computer servicing that crate.

There are two data streams.
(1) Triggered
(2) Supernova:
continuous stream

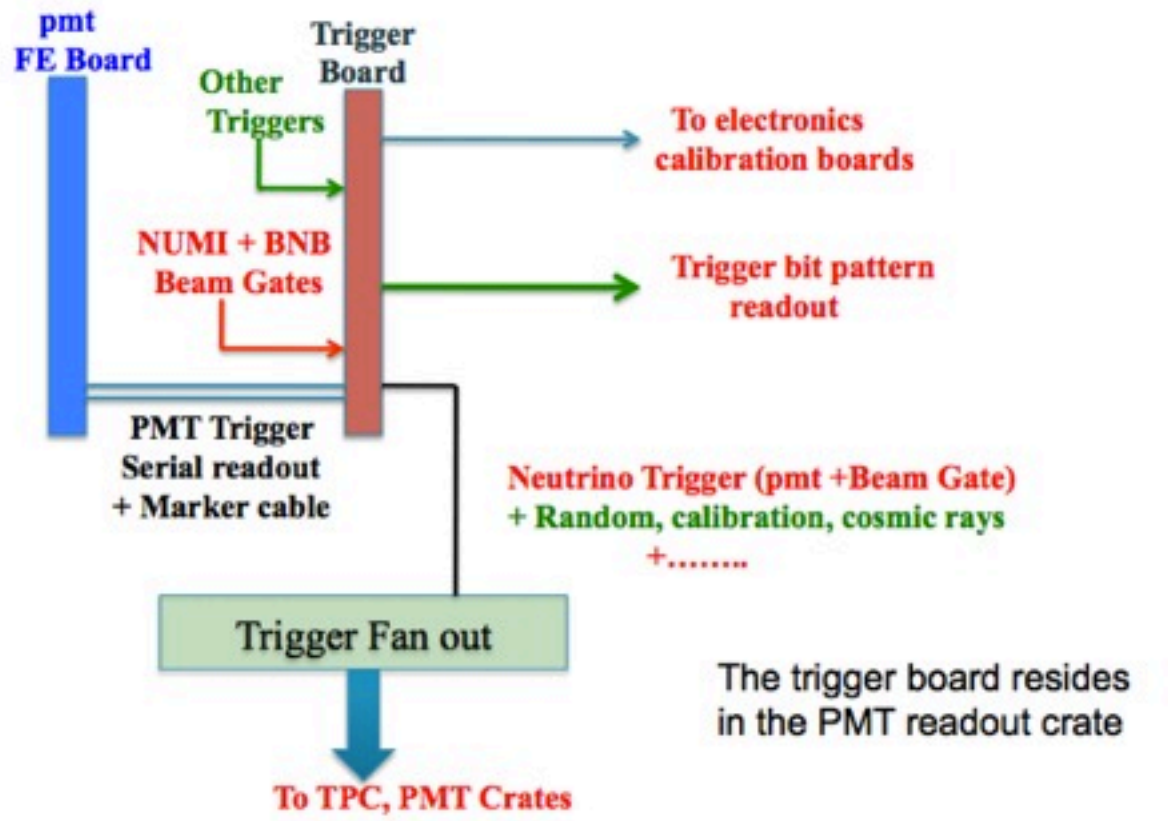
Both come through the "XMIT" card on duplex fibres.



Three NEVIS custom PCIe cards per SEB.

Nevis Trigger Crate

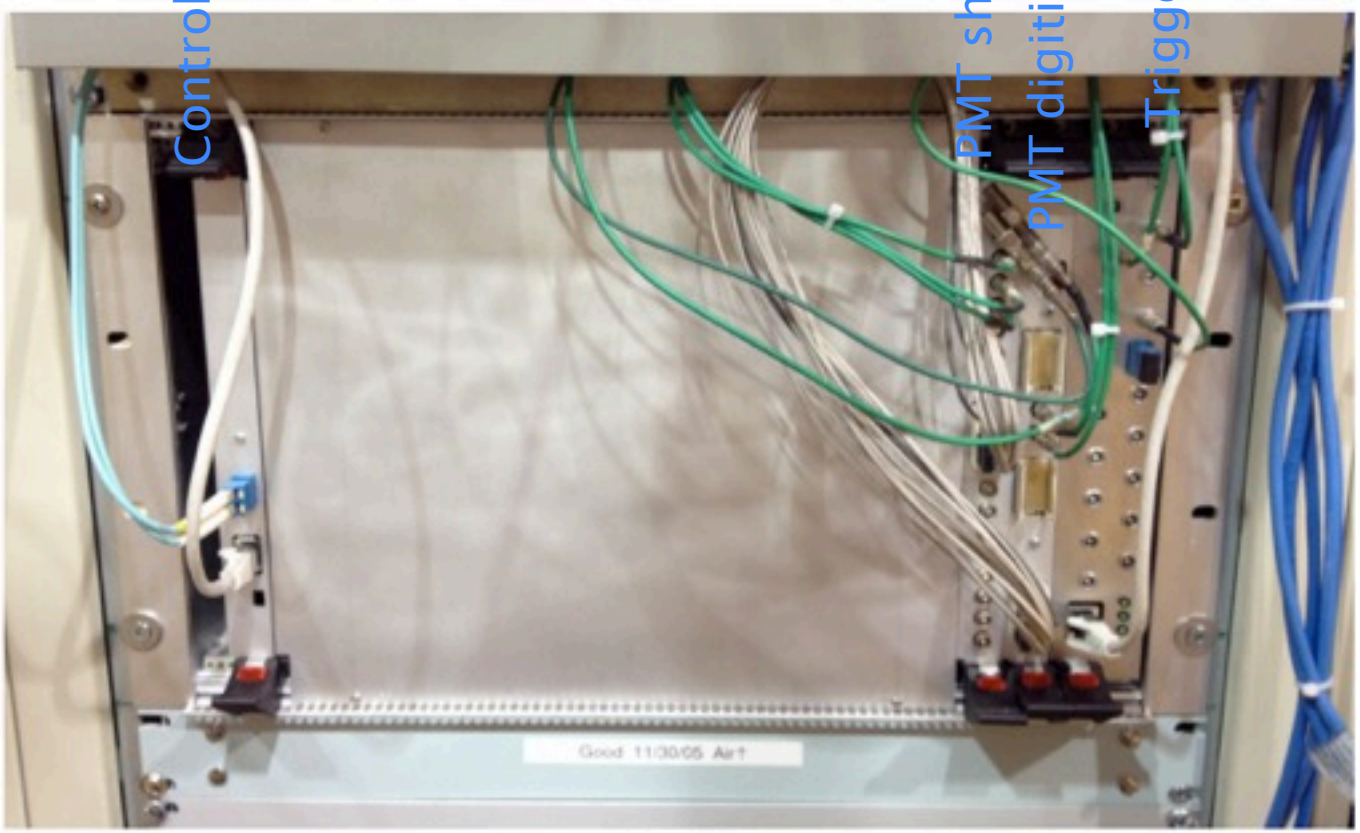
Overview: Trigger scheme



The trigger board resides in the PMT readout crate

PAB Teststand

Special, Trigger/PMT crate



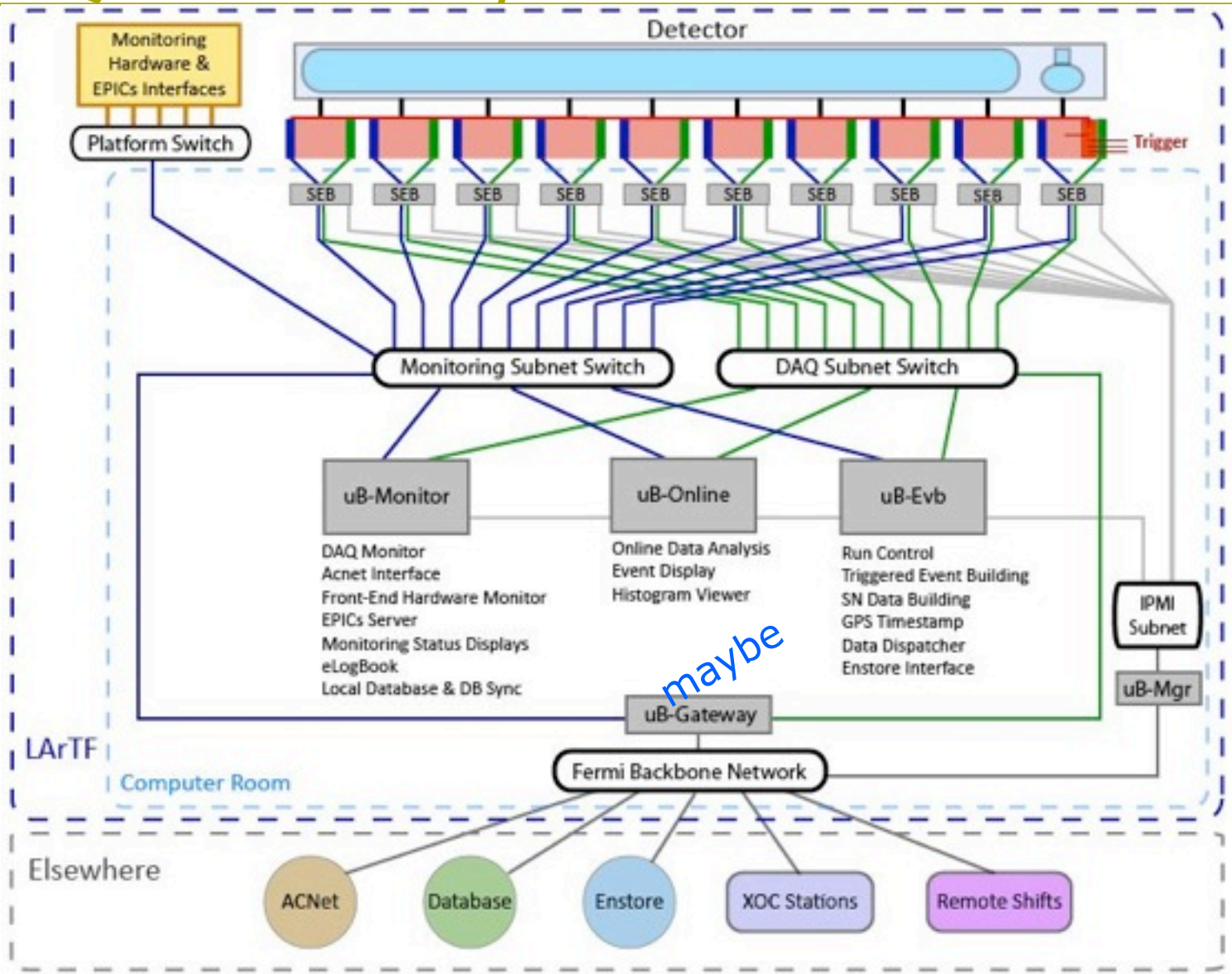
PMTs sampled@64MHz, 2bytes

Figure 2: PMT Crate Physical Setup (as of Oct. 10, 2012)

Overview of DAQ Project: WBS 1.9

- The MicroBooNE DAQ picks up where 1.11 (Nevis electronics) hands the data off: through the PCIe cards in the SEBPCs.
- DAQ is responsible for reading out, assembling events, writing them to file.
- But also:
  - Monitoring and Control,
  - Beam data concatenation,
  - Run stop/start: State Machine
  - Calibration runs, Laser Runs, ...
  - Online and Nearline processes,
  - File management, ...

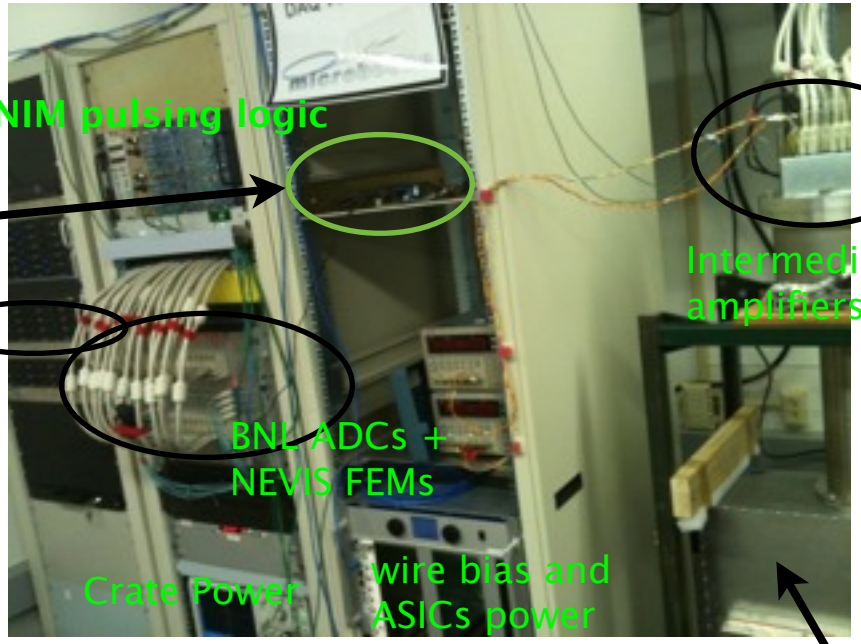
DAQ Network/Process Overview



Overview of DAQ writ small: the DAB TestStand

- BNL: ASICs through ADC

uboonedaq-seb-01.fnal.gov



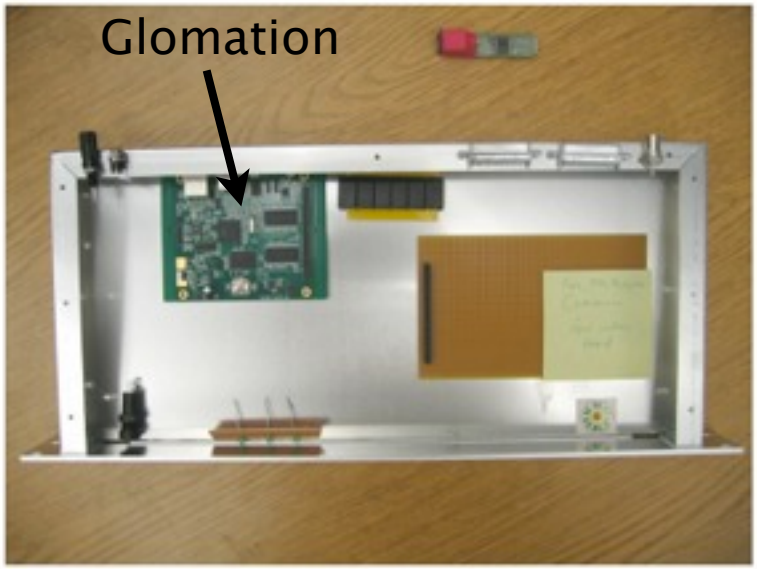
- Nevis readout:
  - Crate cards through PCIec ards
- DAQ: computers, software, glue

Technical Progress since CD-2

- Glomation SBC as the slow mon/control hub: one per rack.
- ACNET data, file management will come from supported CD IF Data Logging project and CD Enstore/ Sam solutions, respectively: Zarko!
- Readout established
- State Machine Built
- Code build specified
  - We have a very extensible model: ups'es where possible, git repository, CMake build system, C++ codebase

Glomation Single Board Computer GESBC-9G20

- SBC includes
  - Linux OS
  - Ethernet
  - RS232
  - USB
  - 40 digital I/O
  - 4 ADC
  - I2C and SPI bus



- Interfaces directly with
  - **Glassman Drift HV – RS232**
  - **Rack Temperature – I2C bus using Maxim DS1624**
  - **Rack Fanpack – digital I/O**

Glenn Horton-Smith, KSU

Technical Progress, contd

- EPICs IOCs (Input/Output controllers) accessing shared memory already demonstrated. SMNP to control/monitor most power supplies and monitor computer environment variables.

- Online data health via Ganglia: very powerful http-served monitoring tool. – Gennadiy L.
  - JSON plots, ala finance.google.com, etc
  - Easily scaled and intuitive
  - Simply, define the metric in the code. Time-series chart appears, nicely laid out. Layout is easily configurable.

Ganglia

Custom Metrics

For Online Monitoring of raw system, and also stuffed at the ~1Hz level into EPICS slowmon dB

Trig DMA Rate

Assem -bler write Rate

SN DMA Rate

Status of Work: recent accomplishments

- Event building finished (experience from mBooNE). Have even done it with uBooNE-specific DMA'd data files. A full, detailed fake data transport mode completed. -- Wes
  - it remains to exercise this on multiple actual crates, live -- Fall, 2013.
- Serialized/archived output data format defined. In a boost::serialized class
  - "serialized", "archived" meaning data laid out in order, with versioning that makes everything backward compatible as code evolves
  - Methods to write out binary chunks into file and read it back and unwind it to level desired -- Again, Wes.

Electronics Status

- Next few slides

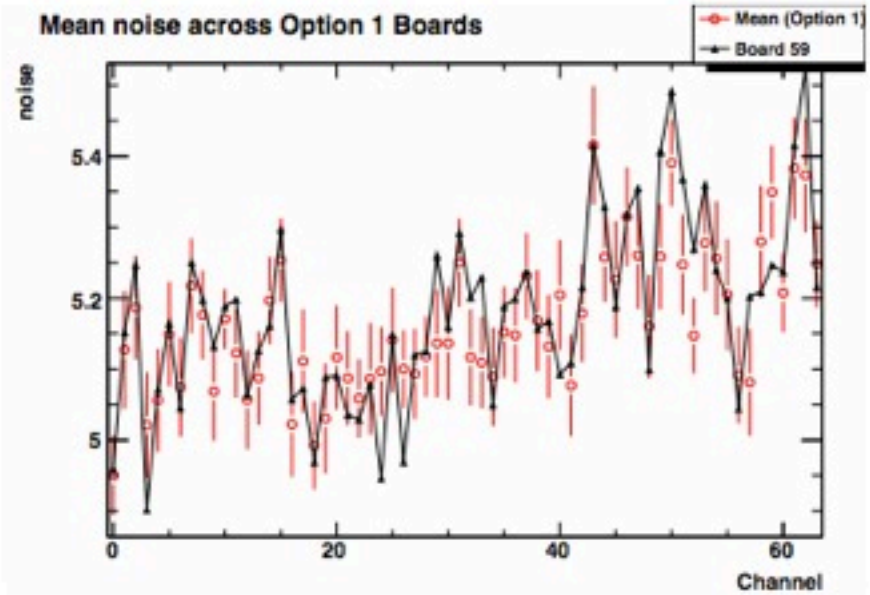
BNL fabrication and testing

These are so-called Cycle 4* ASICs. Final Cycle.

- CMOS Analog Front End ASIC
  - ASICs were delivered in early December
  - ASIC incoming test is ongoing at room temperature
    - 593 ASICs have been tested, 529 ASICs passed the test
    - Yield is ~89.2%
  - ASIC cold screening test is finished
    - 201 ASICs have been tested in LN_2, 195 ASICs passed the test
    - Very stringent criteria to screen chips in LN_2, for 6 chips that did not pass the test
      - 4 chips: each has a channel with slightly a reduced dynamic range
      - 2 chips: each has a channel with a slightly larger undershoot
    - **Cold/Warm Yield** is ~97%

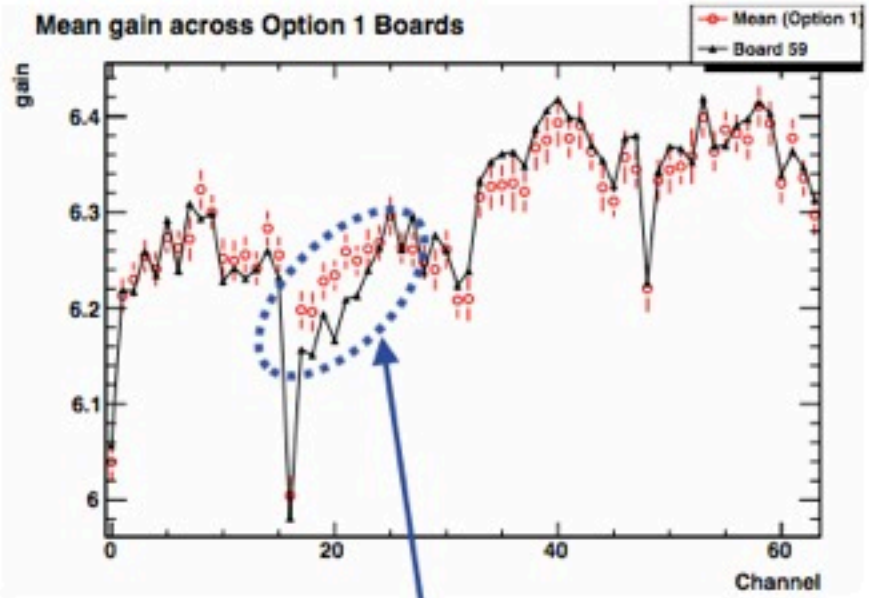
Electronics testing at BNL

ADC pedestals from reading signals with no input pulse.



Noise looks OK.

Calculated by pulsing multiple times at N~8 input amplitudes.



Gain in some channels significantly low.

BNL Nevis Electronics status

- Motherboard production fabrication starting next week. Received at BNL by end of March.
- ADC boards shipped/shipping now to NEVIS.
- Then, to DAB
- Into Racks in Spring

Nevis Status

- We now have >90% of boards in hand (from assembler):
  - All FEMs
  - All XMITs
  - All clock cards
  - All Controllers
  - All PMT shapers

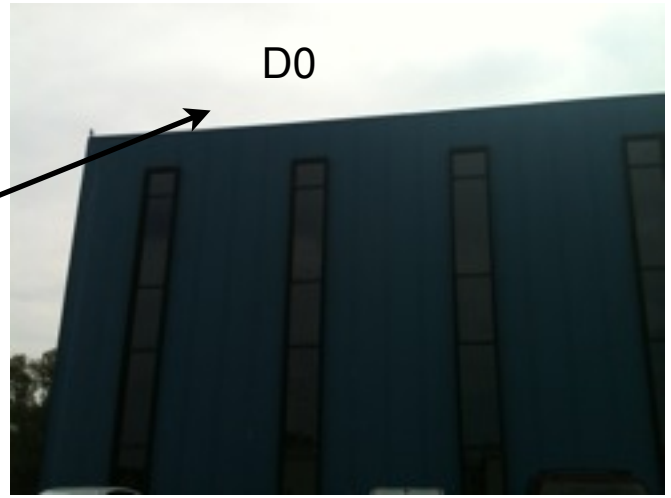
Status of Work: things in progress

- Absolute time into header: GPS card
  - Code in place to allow Pulse Per Second (PPS) interrupt to capture/synchronize DAQ clock to GPS.
- Configuration Database

GPS

In progress

D0

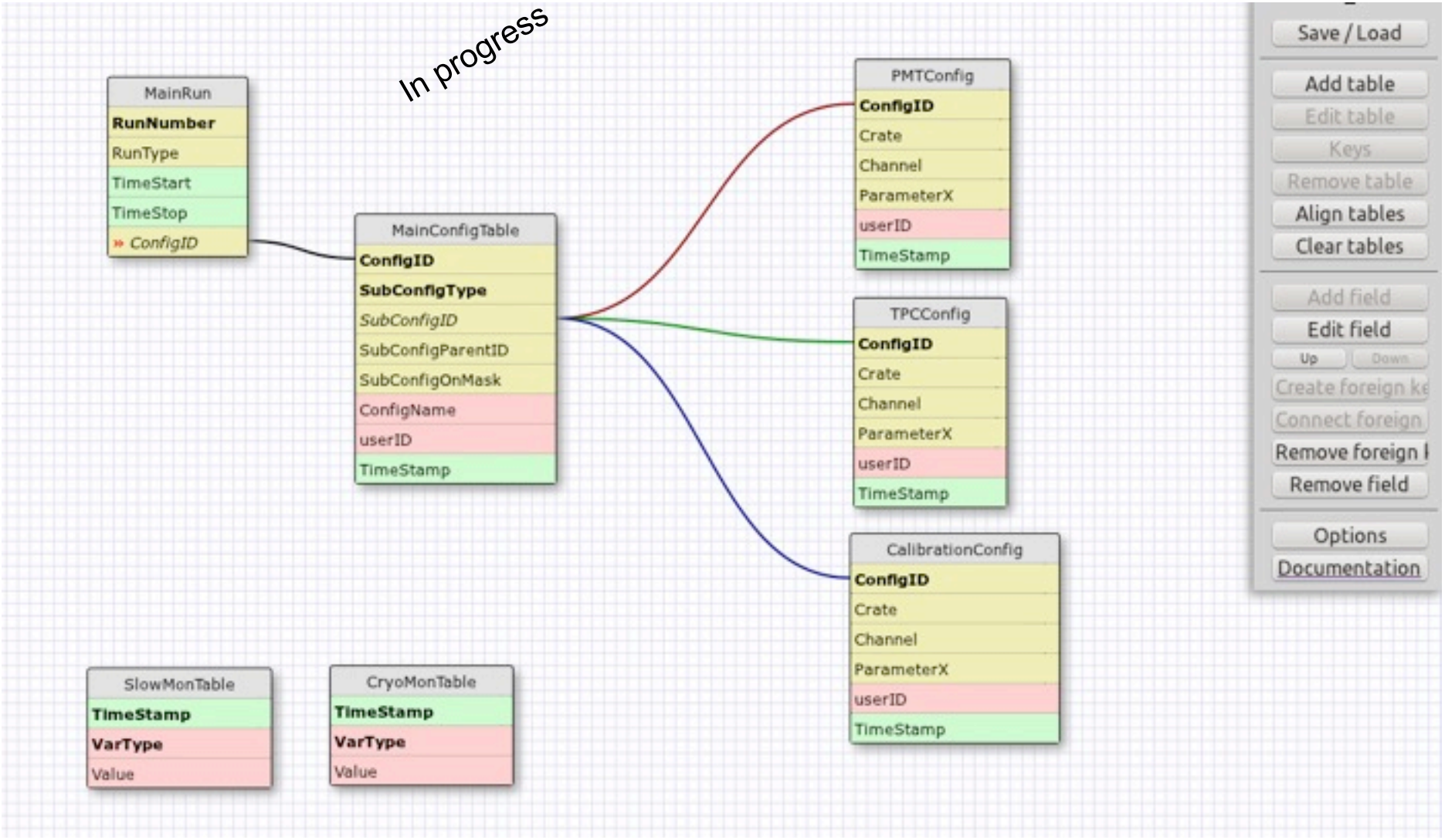


This $3k Symmetricom PCIe card advertises 170 nsec accuracy.

VA Tech taking this on. Trigger card in next couple months to store the DAQ clock value on each GPS's Pulse Per Second input. We then will grab that value and the GPS time and shove it into the trigger data header. Will propagate to the overall global header from there. All code already written.

PCIe card In uboonedaq-seb-10, works with new antenna, driver, code.

Configuration DB Scheme



Andrzej Szelc, Yale

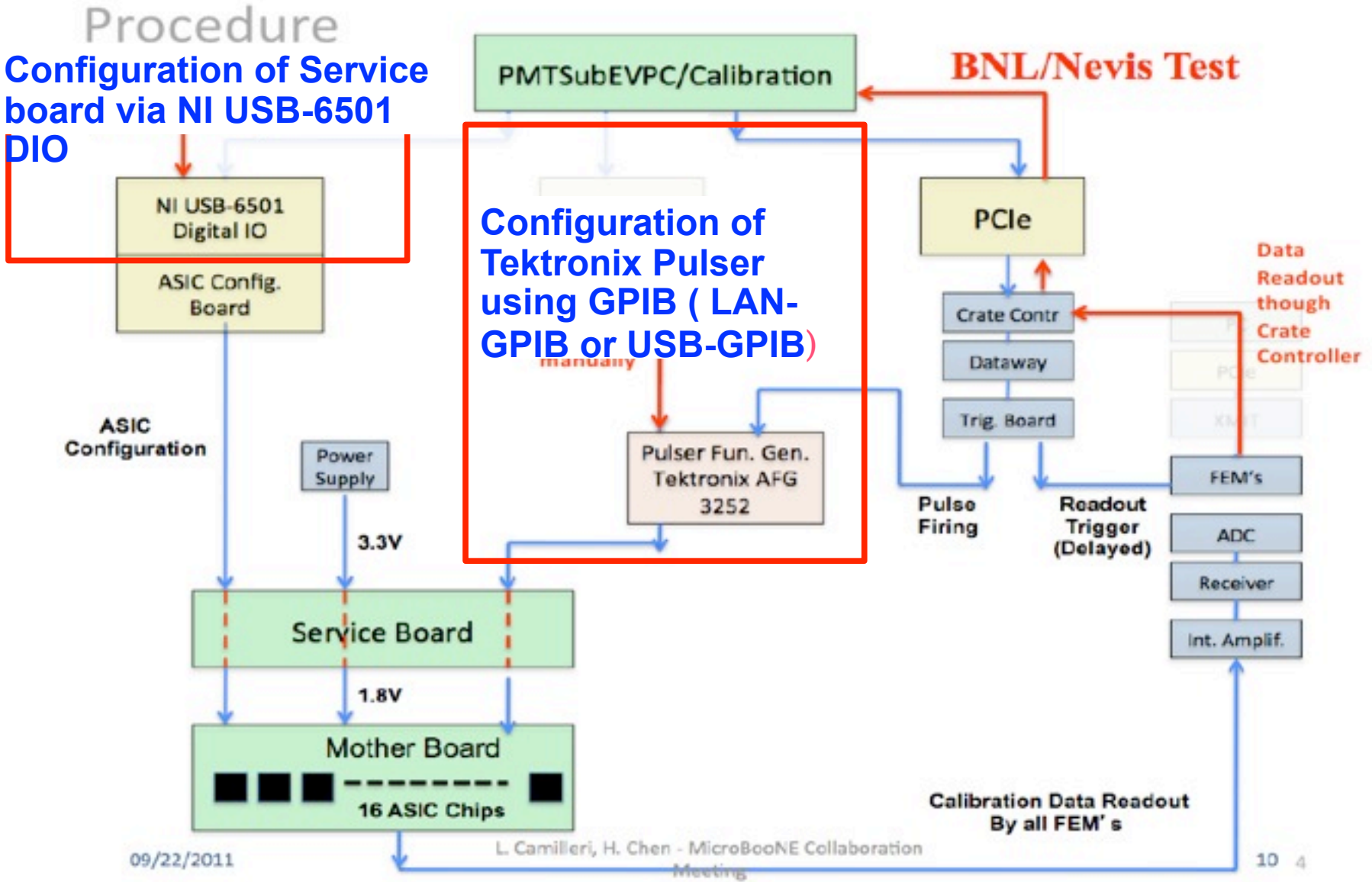
Status of Work: things in progress 2

- Processes for Nearline monitoring (LArSoft)
  - Swizzle from RawData
- EPICS, ongoing
  - Server imminently to be installed on its machine,
  - Alarming, Archiving, Control/Display GUI
  - IOCs reporting all data on list to EPICS dB
- Understanding nuances of Readout and FEM FPGA code ...
  - Interfacing with NEVIS

Status of Work: things in Progress 3

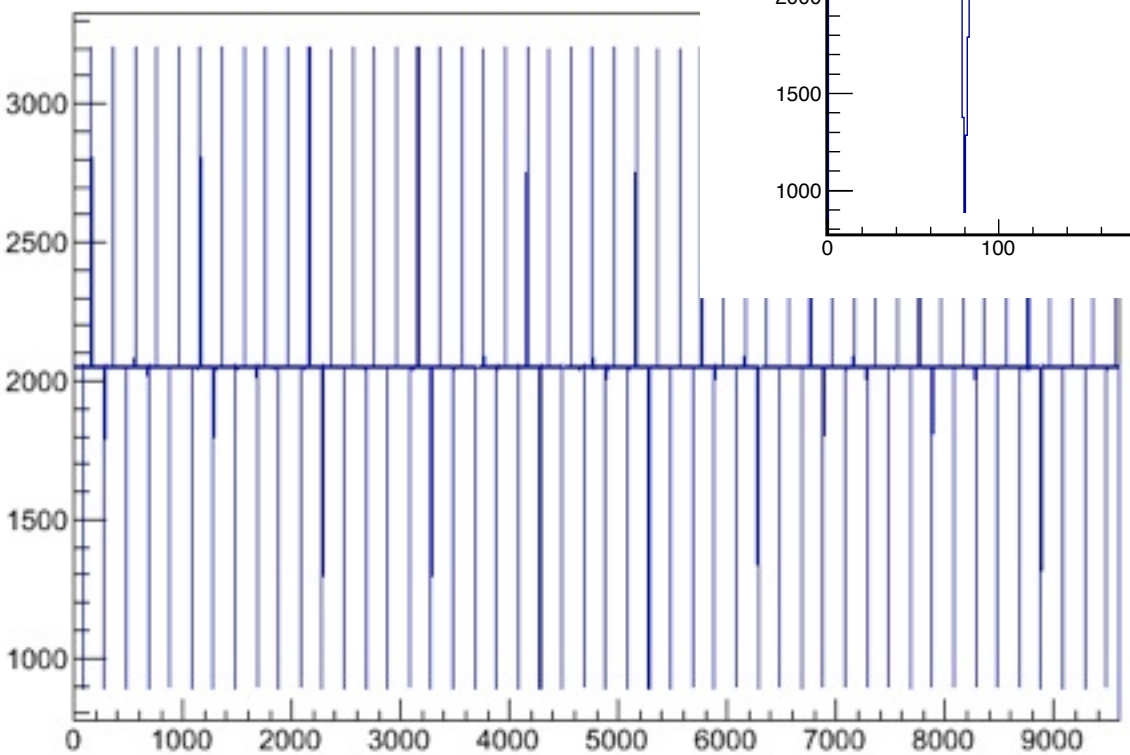
- Message Passing System to effect State Machine transitions: Configure, Connect, Run, Pause, Configure, Run, Stop, etc.
  - Code does not just fall through. This is a crucial step of sophistication that allows multi-mode running
  - Done to 0th order.
  - But now development for Calibration runs is needed: we want to run the special calibration trigger and configure hardware and pulse/read Nx1000 times all within one unambiguously labeled run with subruns: Pause, Re-config hardware, pulse/read, Pause, etc.

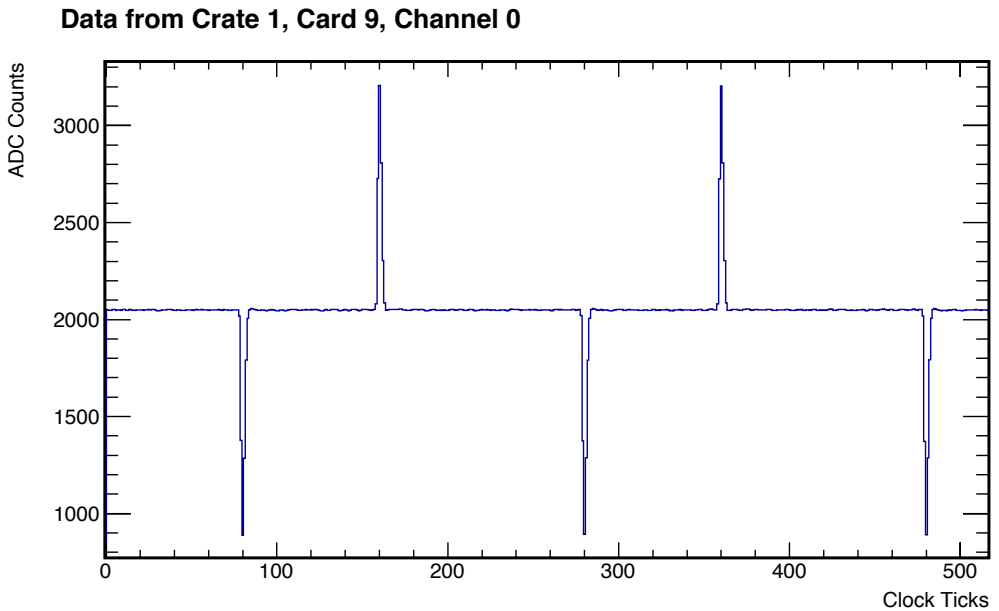
Calibration Hardware



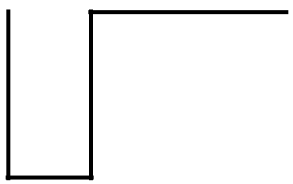
Calibration Run: we've done it

Continuous Pulse. Needs to be Burst



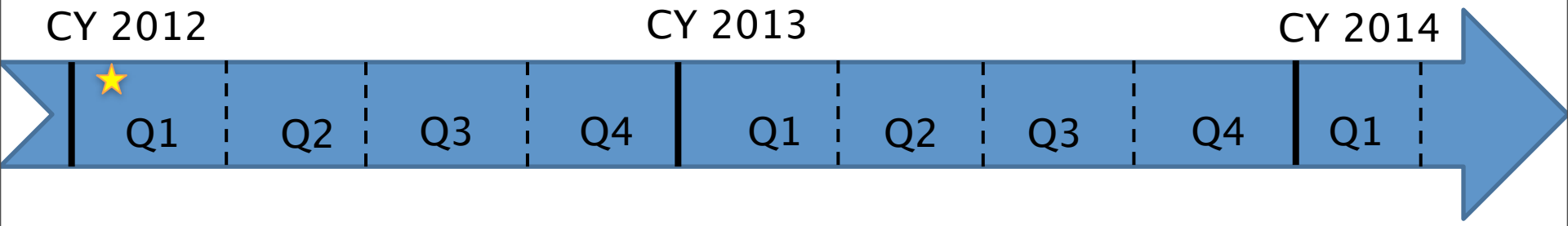


The input signal is 10 kHz.
It is a negative-, then positive-going square-wave signal, of width 40 usec.



Full 3x1.6msec frame read-out.

Schedule Highlights



- **Buy Pulser, get scope, PS's, test stand computers, start developing.** CD3b!
- **D0 Test Stand: Readout Testing**
  - **Buy Glomations**
  - **Buy switches**
  - **Buy servers (L2 Milestone)**
  - **Electronics from BNL, Crates from Nevis arrive at D0, tested on TPC**
  - **Set Up DAQ server racks**

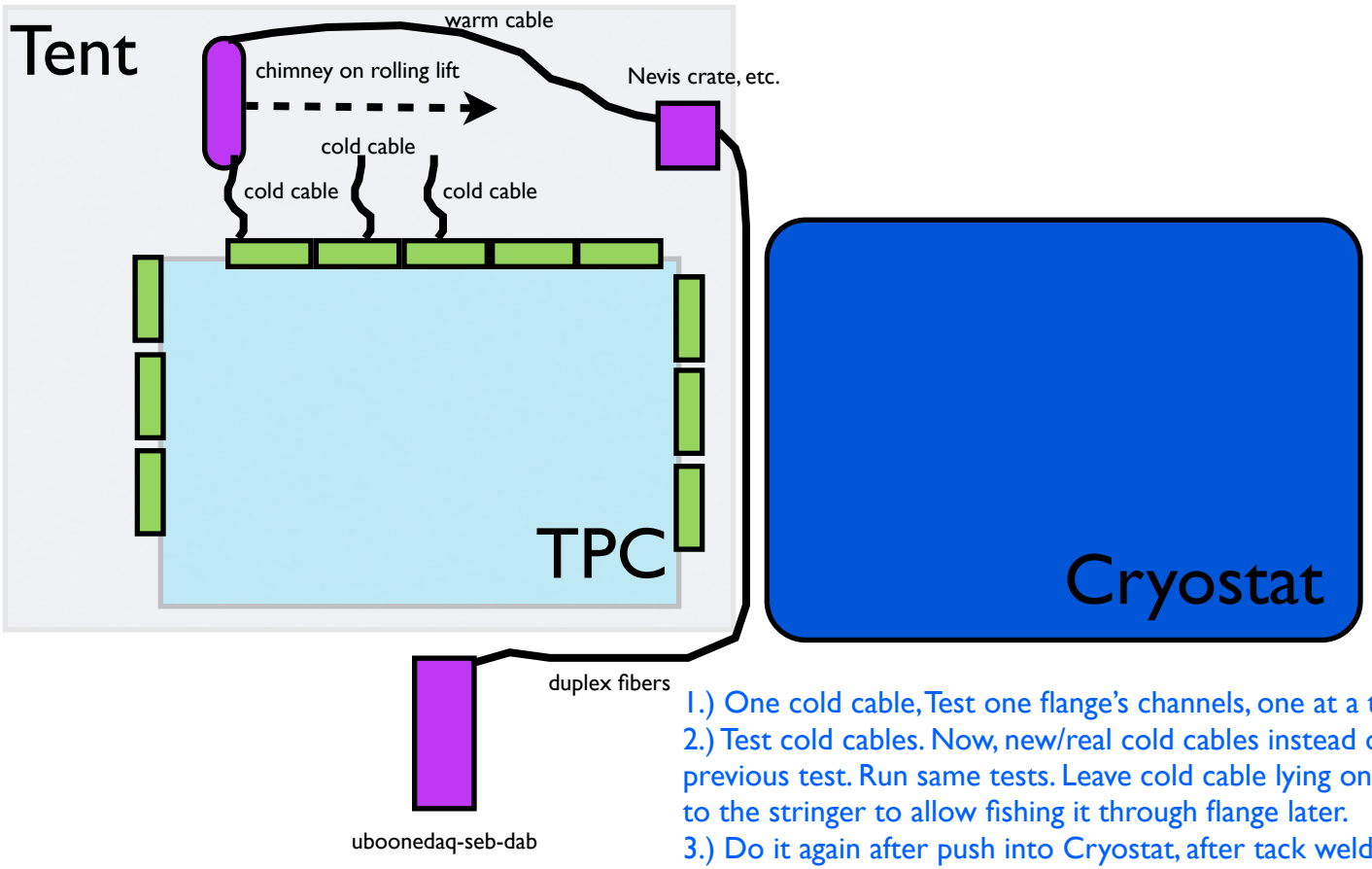
System Ready

Test Stands through 2013

- The Test Stand at DAB at FNAL will serve as an acceptance test station before buttoning-up, when/as all of the electronics boards are shipped to FNAL.

- 3-phase plan to test all Front End channels, keeping everything downstream fixed.

FNAL DAB Tests: 3 phases



1.) One cold cable, Test one flange's channels, one at a time.
2.) Test cold cables. Now, new/real cold cables instead of the one from previous test. Run same tests. Leave cold cable lying on top of TPC tied to the stringer to allow fishing it through flange later.
3.) Do it again after push into Cryostat, after tack weld, after real weld, after move to LArTF

MicroBooNE DAQ Summary and Outlook

- D0 Assembly Building test stand work is in full production, and ramping up further. Eye on everything becoming eventually the full DAQ.
- Move to FEE installation this Spring. Electronics Acceptance testing prior to buttoning up in Fall, move by Q1, 2014, perhaps earlier, with LAr Fill following (off project).
- Procurement of DAQ hardware ongoing: computers, switches, fibers, pulsers ... Major p.o.'s going out the door imminently.

LANL LArTPC considerations

- 900? channels: 64*16 channels in one Nevis crate.
- N TPC crates. Sounds like N=1
- Need to hold 3N PCIe cards, 4 in PMT/trigger crate
- 2U Koi SuperMicro boxes can hold 3 PCIe full height cards with a riser card and a RAID controller card.
  - 10 GbE network cards take another slot
  - GPS card may take another
  - 4U box can hold 6 slots with riser

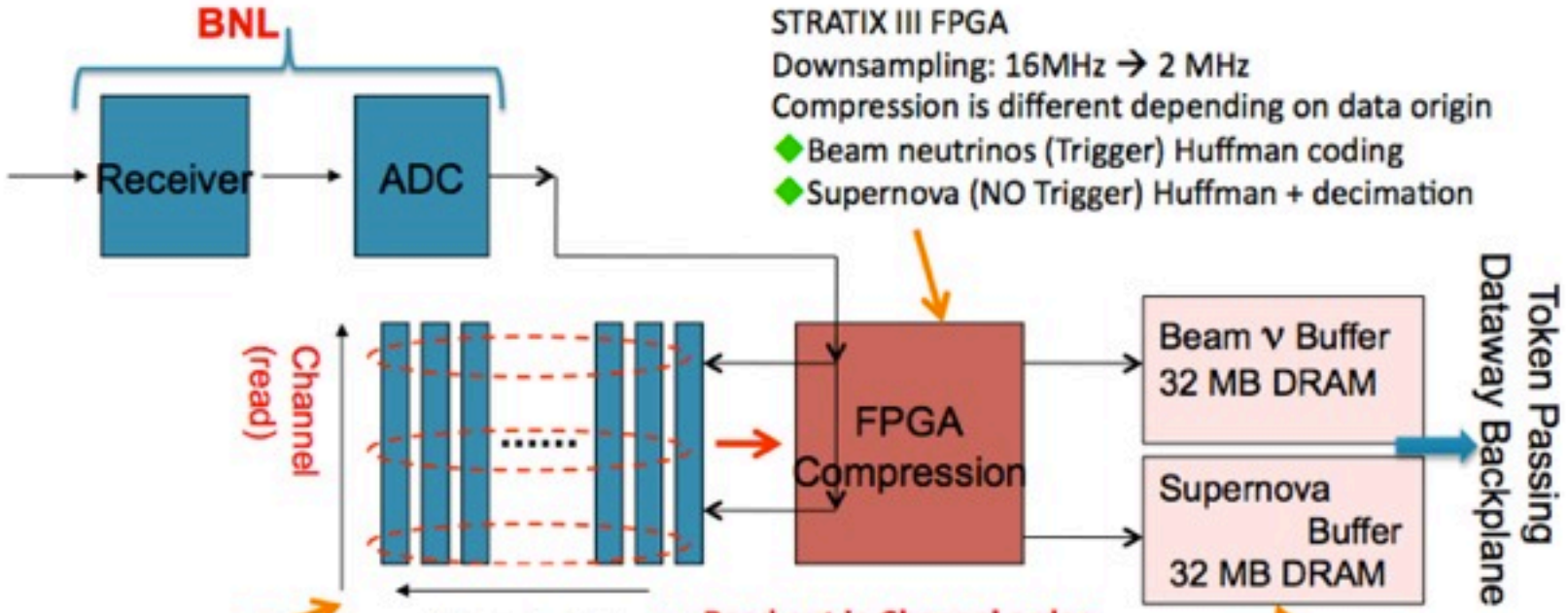
LANL LArTPC: Using the Codebase

- In principle, you just pull it down
  - `kinit -l user@FNAL.GOV`
  - `git clone ssh://p-uboonedaq@cdcvs.fnal.gov/cvs/projects/uboonedaq/`
  - `make -j32 # fast, parallel build on 32 cores`
- Certainly, it won't build right out of the box
  - We have some machine/environment specific things that will need reconfiguring
- But, one could be on one's way

Backup Slides

Overview: Digitizing Boards: Hardware and Tasks

Continuous Data rate per card: 64 wires x 2 MHz = 128 MHz 12 bit ADC words.



Procurement * ~1.3

Package	Preparer	Estimated Cost	Requisition	Purchase Order
Jungo WinDriver License	Eric Church	6500	15-March-2012	
Glomation 9G20	Eric Church	125	30-March-2012	
Tektronix AFG3000 pulser	Eric Church	3400	30-March-2012	
GPS PCI card	Eric Church	3500	30-March-2012	
DS1624 digital thermometers	Eric Church	800	30-March-2012	
PMT SEB computer	Eric Church	5400	30-March-2012	
Three network switches	Eric Church	15000	1-March-2013	
Ten SEB computers	Eric Church	59000	1-March-2013	
Event Builder Computer	Eric Church	8500	1-March-2013	
Two Online Monitoring computers	Eric Church	10800	1-March-2013	
Slow mon/control EPICs computers	Eric Church	5400	1-March-2013	
On-platform computer	Eric Church	3200	1-March-2013	
Three slide-out monitor/keyboards	Eric Church	1000	1-March-2013	
14 Glomation 9G20 SBCs	Eric Church	800	1-March-2013	
Two shift station computers and monitors	Eric Church	14000	1-March-2013	