SuperCDMS SNOLAB

WBS 1.6: DAQ/Trigger

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Presentation Outline

- WBS scope and organization
- (Non)-technical overview and path to CD-2
- Cost and schedule
- Risk and mitigation

Scope of Work: WBS 1.6

DAQ software, and DAQ computer hardware downstream of the front end electronics (including network)

Associated systems: user interface, data quality, environmental monitoring, test facility DAQ tools

Software trigger, including trigger firmware for front-end electronics

Not included:

Front-end electronics itself (readout boards): WBS 1.5

Off-line data processing: WBS 1.8

WBS

- 1.6.1 (Hardware): DAQ computers, racks, and the experiment's internal underground network
- 1.6.2 (DAQ Software): device drivers, Level 2 software trigger, readout software, event builder
- 1.6.3 (User Interface): detector configuration tools, run control interface, and database
- 1.6.4 (Data Quality): online monitoring of data
- 1.6.5 (Environmental Monitoring): logging of experimental conditions to slow controls database
- 1.6.6 (Level 1 Trigger): trigger firmware running in front-end boards (DCRCs) that produces basic trigger primitives
- 1.6.7 (DAQ Tools for Detector Testing): software for tuning & testing detectors
- 1.6.8 (DAQ Integration & Test Facility Deployment): tests of DAQ tools at test facilities, deployment for project testing and SNOLAB

WBS Organization

- L2: Scott Oser
  Deputy: Dave Toback
  - Hardware: T. Lindner
  - Environmental Monitoring: Ben Loer
  - Software: B. von Krosigk
  - Level 1 Trigger: Jon Wilson
  - DAQ Detector Tools: Bruno Serfass
  - User Interface: Joel Sander
  - DAQ Integration: Anthony Villano
  - Data Quality: Amy Roberts

Technical Overview and Status

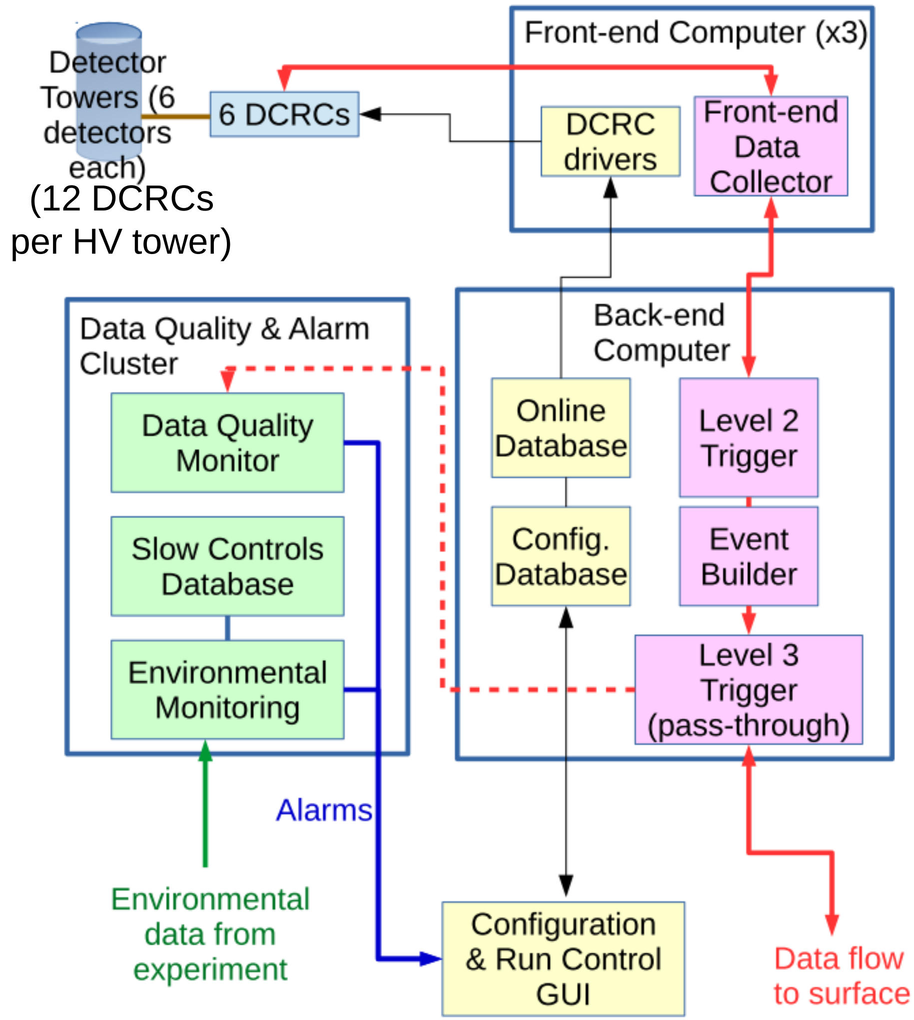
Basic DAQ architecture

DCRCs continuously digitize signals and apply detector-level trigger algorithm.

DAQ combines detector triggers to decide which waveforms to retrieve from DCRC memory.

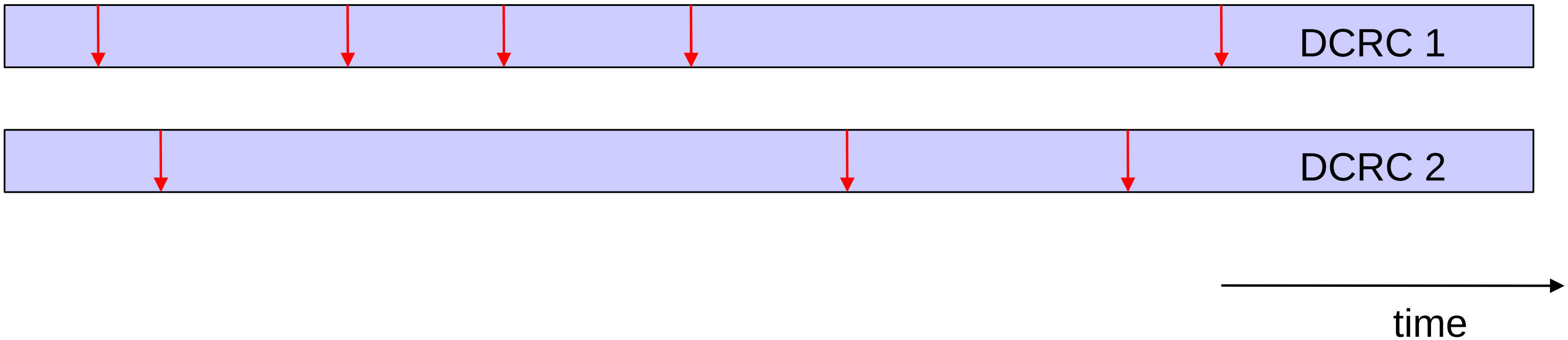
Tower-level processes collect detector triggers and read out waveforms.

Back-end processes run central trigger, configuration DB, event builder.



Deadtime-Free Trigger System

DCRCs continuously write digitized waveforms into memory, and an L1 trigger based on a finite impulse response filter running in firmware notes the times of potentially interesting signals (shown as red arrows).

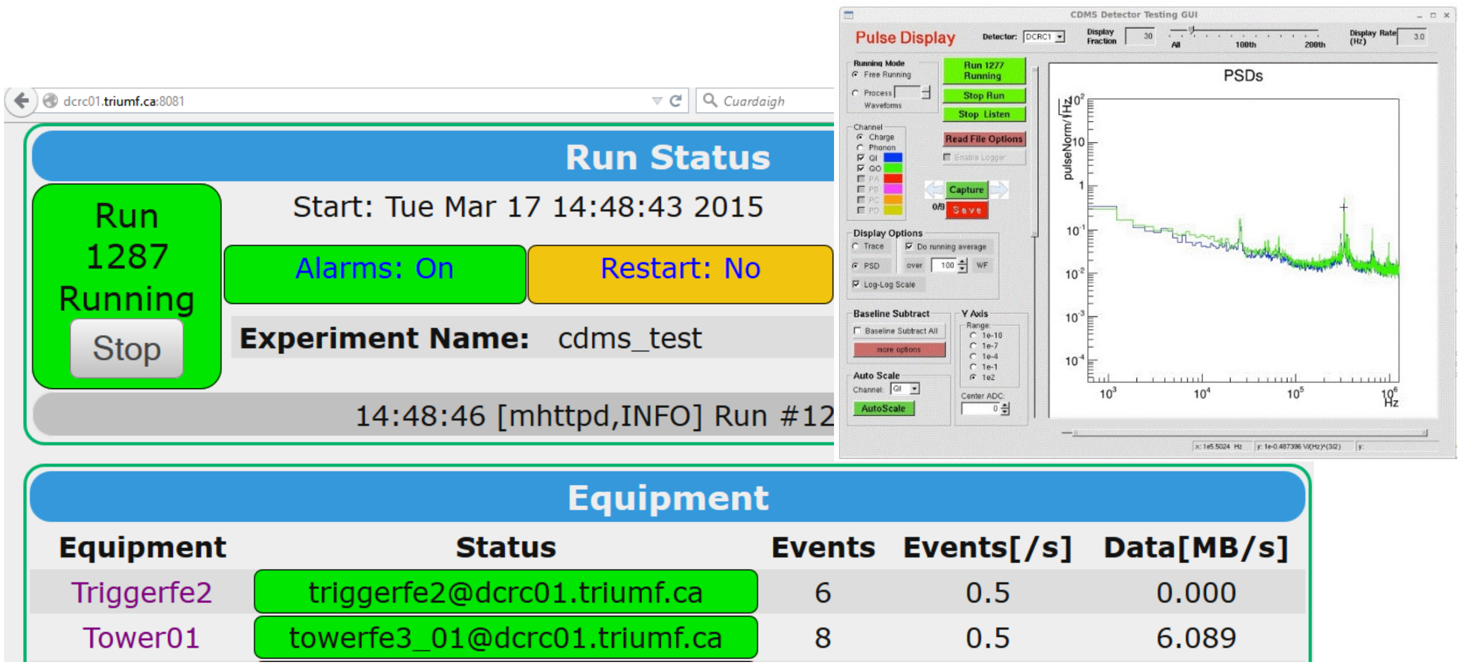


The L2 trigger system periodically collects the L1 trigger times from all DCRCs and decides what to do with them. This does not interrupt L1 trigger operation.

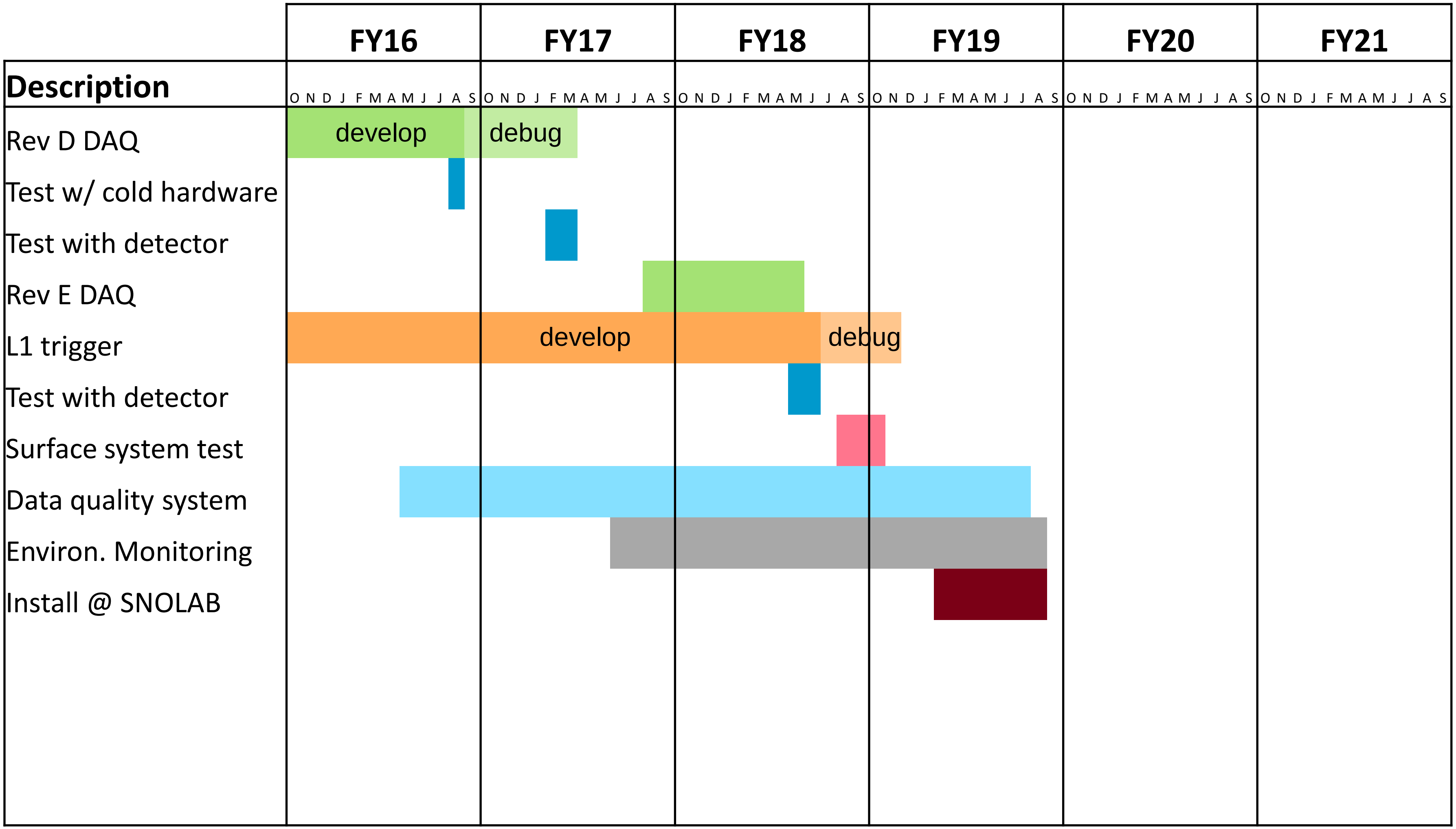
The Prototype DAQ

A working DAQ system has been written and used at test facilities. This includes a DCRC driver, front end, Level 2 trigger, pulse display, and simple configuration tools.

Throughput >100MB/s achieved!



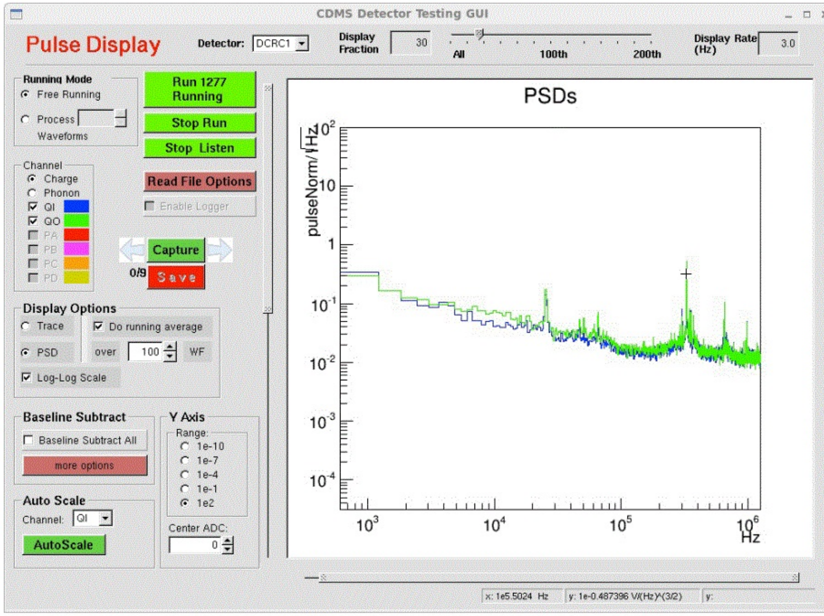
Summary Schedule



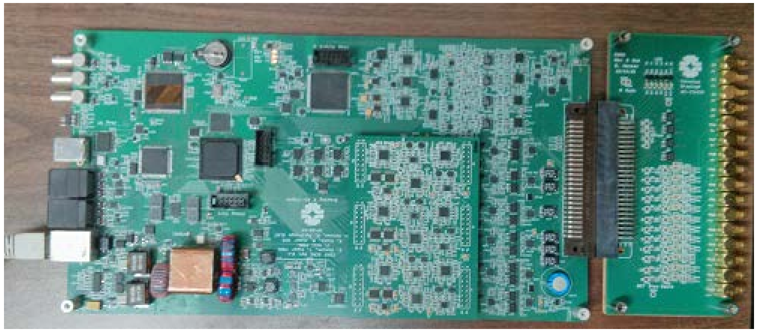
Recent Progress

New DAQ version for new Rev D DCRC:

- New prototype readout electronics capable of reading a full-sized SNOLAB detector: 12 phonon + 4 ionization channels
- Successfully have operated SQUIDs at UC-Denver using the Rev D card and new data acquisition



Noise PSD collected from desktop tests of new DAQ from Rev D DCRC



New prototype SNOLAB readout card (DCRC Rev D, May 2016)

Near-term steps towards CD-2

Test of DAQ + Rev D with prototype SNOLAB cold electronics at SLAC (1.6.8.3)

- Exercise DAQ with cold hardware and dummy load (no detector)
- Use DAQ to measure noise of Rev D + cold hardware combination
- Scheduled for August 2016
- This test will validate the completed preliminary design and is expected to be sufficient for DAQ/Trigger to proceed to CD-2

Produce HV-detector versions of existing DAQ code

Continue development of detector tuning tools

Medium-term plans

Operate prototype SNOLAB detector with Rev D electronics (1.6.8.4)

- Test triggering, ease of operations
- Verify DAQ functionality needed for detector testing
- Train users in use of new DAQ

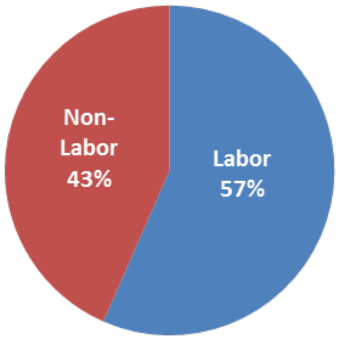
Develop new L1 trigger firmware (1.6.6)

- New trigger with FIR filtering to be implemented for Rev E DCRC

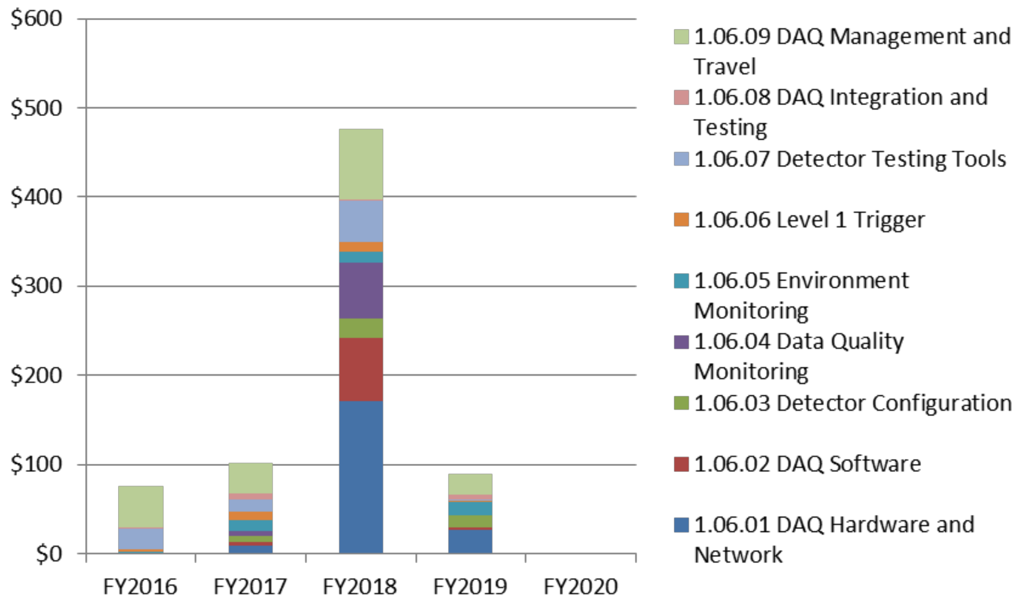
Finalize specifications of DAQ computers

- Necessary for CD-3

1.06 Data Acquisition and Triggering (DAQ)

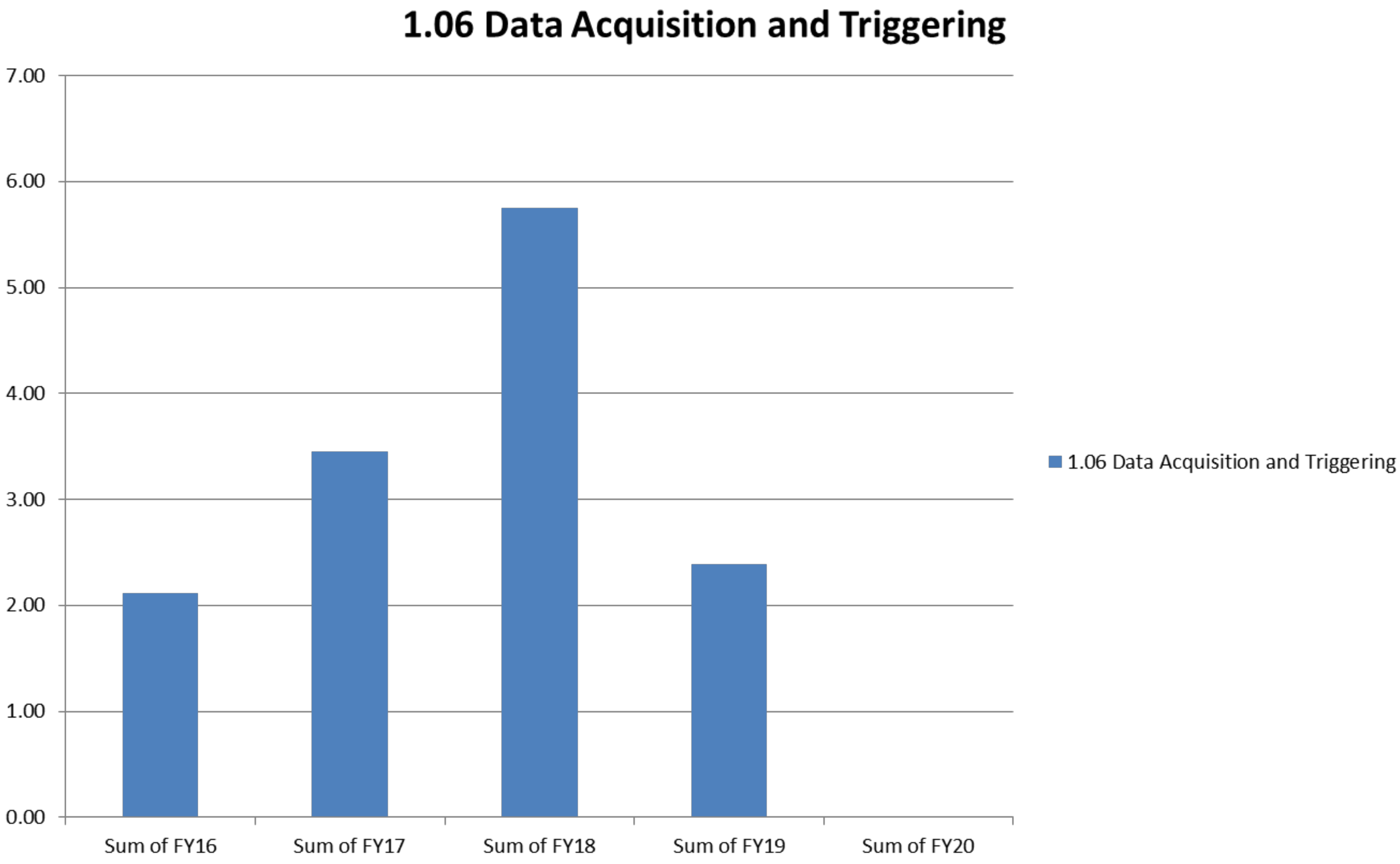


1.06 Data Acquisition and Triggering	
Resource Type	($K)
Labor	$420
Non-Labor	$323
Total BAC	**$743**



WBS	FY2016	FY2017	FY2018	FY2019	FY2020	Total
1.06.01 DAQ Hardware and Network	$1	$9	$171	$26	$0	$207
1.06.02 DAQ Software	$0	$4	$71	$3	$0	$79
1.06.03 Detector Configuration	$0	$7	$22	$13	$0	$42
1.06.04 Data Quality Monitoring	$0	$5	$62	$0	$0	$68
1.06.05 Environment Monitoring	$1	$11	$12	$15	$0	$39
1.06.06 Level 1 Trigger	$3	$10	$12	$1	$0	$26
1.06.07 Detector Testing Tools	$23	$14	$45	$2	$0	$84
1.06.08 DAQ Integration and Testing	$1	$7	$2	$4	$0	$15
1.06.09 DAQ Management and Travel	$47	$34	$79	$24	$0	$184
Grand Total	**$76**	**$101**	**$477**	**$89**	**$0**	**$743**

1.06 FTE



1.06 Data Acquisition and Triggering
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Sum of FY16
Sum of FY17
Sum of FY18
Sum of FY19
Sum of FY20
1.06 Data Acquisition and Triggering

Risks and Mitigation

Risk Title	IF/THEN	Risk Handling Plan (Mitigations)	Overall Impact Score
DCRC delays	If DCRC is delayed, there may be delays in DAQ development	Key Concern: Much DAQ work depends on DCRCs being made available early to DAQ group. Delays will slow DAQ development. Mitigations: plan as much of the work in advance, and maintain steady communications with readout electronics group	**Low**
Non-standard slow controls interface	If some monitoring hardware has non-standard communications interface that MIDAS cannot easily handle, we will need additional time and possibly special hardware or software to read out this hardware.	Key Concern: The communications interface for the various environmental monitoring equipment is not known. If these turn out to be non-standard, it may require significant investment of time and possibly modest costs to read them out. Mitigations: start communications early with all subsystems that will produce monitoring data to determine the likely kind of interface.	**Low**

Summary

- DAQ/Trigger design is quite advanced, with prototype version already in use at test facilities. Scope, cost and schedule are understood.
- Risks identified and mitigations are in place, although this is a low risk system overall.

Questions?

The MIDAS DAQ Platform

Free, open source C++-based DAQ framework written by TRIUMF and PSI. Used by T2K, DEAP, FNAL g-2, ALPHA, MEG,

Central Online Database (ODB) holds all experiment settings, and can be accessed by remote MIDAS clients.

Integrated http interface, Javascript support, ROOT interface, environmental monitoring, and electronic logbook.

Detector configuration and run control through web interface.

Chief Software Processes

DCRC Driver

Monitors ODB values for all DCRC settings, and writes new settings to DCRC when values are updated.

MIDAS server

Serves the ODB to MIDAS clients, provides run control, and logging. A pre-fab MIDAS process.

Tower Front-End

Reads L1 triggers from DCRCs upon request from L2 trigger. Reads waveforms as requested. One per tower.

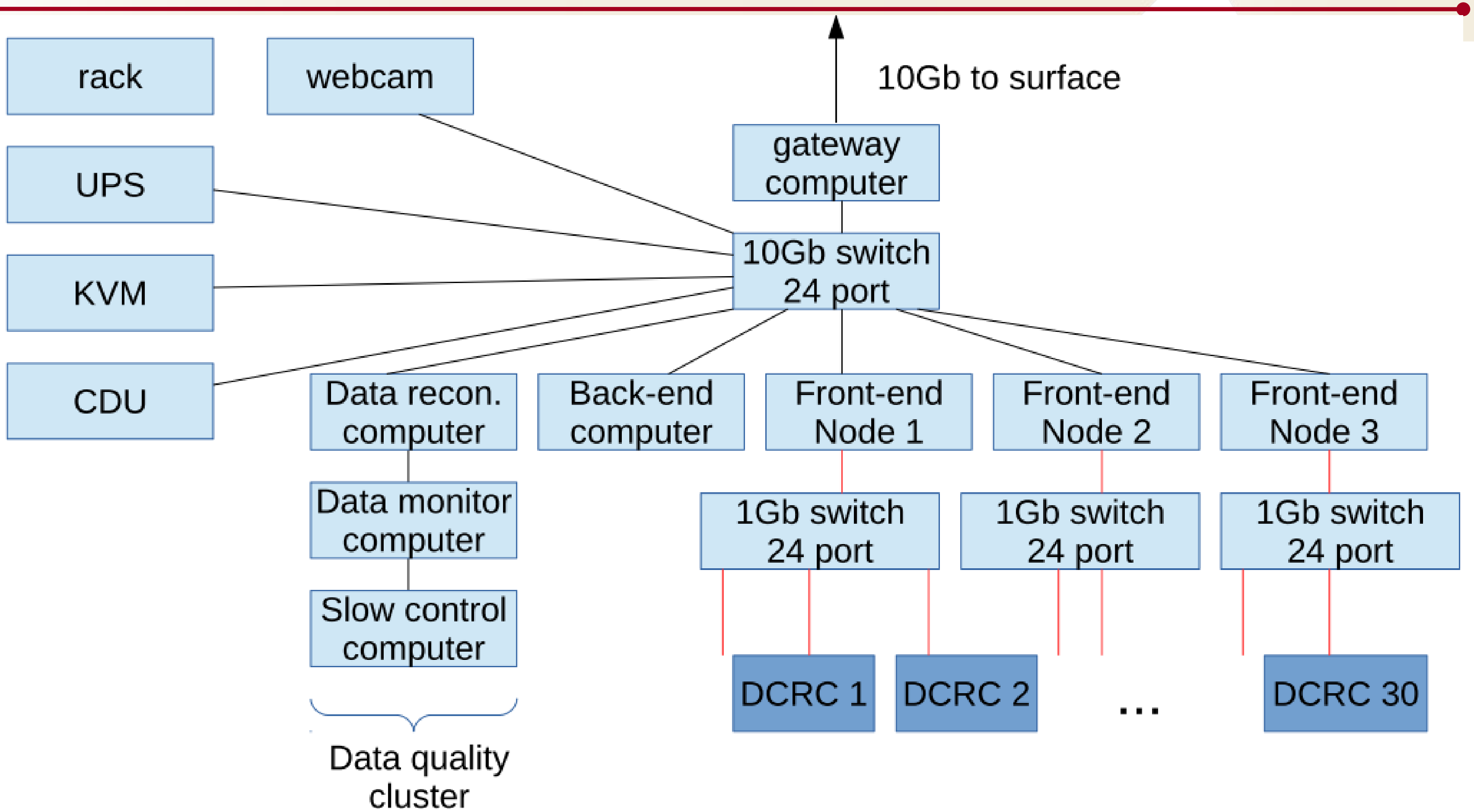
L2 Trigger

Collects L1 trigger information from all towers. Decides which waveforms should be read. Applies pileup cuts.

Event Builder

Collates waveforms from different towers and associates them with trigger info to form event. Tracks deadtime.

DAQ Hardware



Off-the-shelf hardware. Network configuration based on DEAP network already installed in SNOLAB.

DAQ/Trigger system design goals

- KPP: 50MB/s throughput (threshold), 100 MB/s (objective)
- Deadtime-free triggering
- Data volume within limits of SNOLAB network
- Capable of high trigger rates in calibration mode, to maximize livetime
- As low of a trigger threshold as possible
- Common DAQ solution for SNOLAB & test facilities
- Flexible, programmable software trigger
- Simple, intuitive detector configuration tools, to minimize operator errors
- integrated data quality and environmental monitoring, to maximize livetime and simplify analysis