

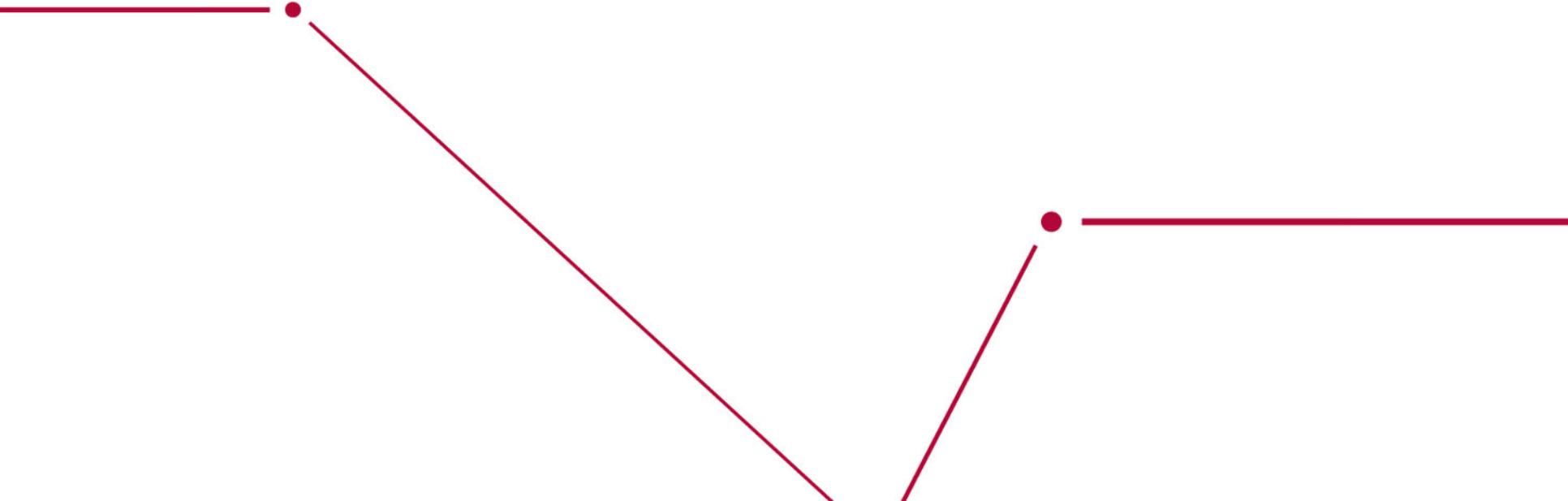


SuperCDMS SNOLAB

WBS 1.6: DAQ/Trigger

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July 19, 2016



Presentation Outline

- WBS scope and organization
- 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:

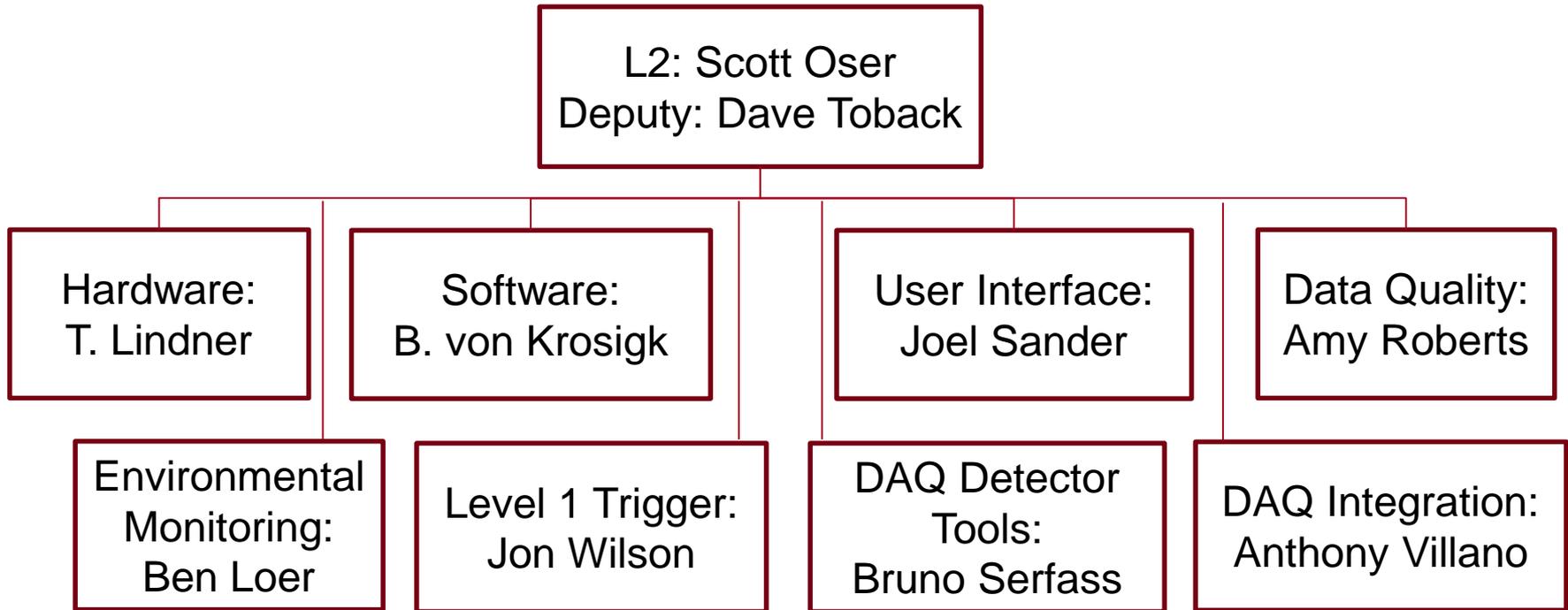
Front-end electronics itself (readout boards): WBS 1.5

Off-line data processing: WBS 1.8

WBS

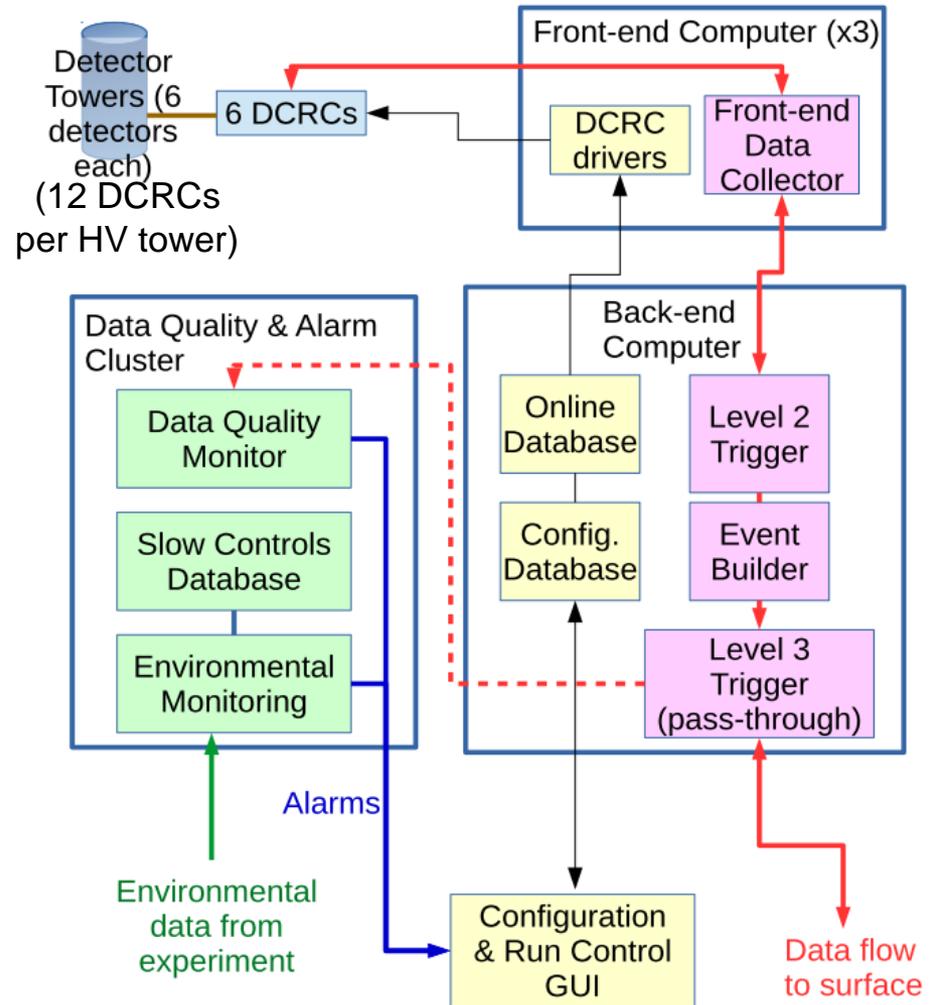
- 1.6.1 (Hardware): DAQ computers, racks, and the experiment's internal underground network
- 1.6.2 (DAQ Software): device drivers, Level 2 software trigger, readout software, event builder
- 1.6.3 (User Interface): detector configuration tools, run control interface, and database
- 1.6.4 (Data Quality): 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



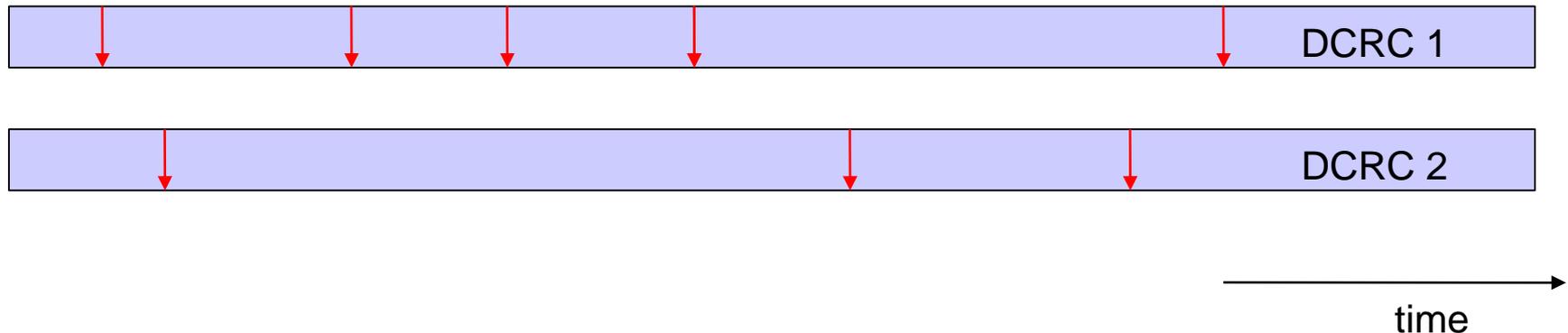
Basic DAQ architecture

- DCRCs (Detector Control & Readout Cards) continuously digitize signals and apply detector-level trigger algorithm.
- DAQ combines detector triggers to decide which waveforms to retrieve from DCRC memory.
- Front-end processes collect detector triggers and read out waveforms.
- Back-end processes run central trigger, configuration DB, event builder.



Deadtime-Free Trigger System

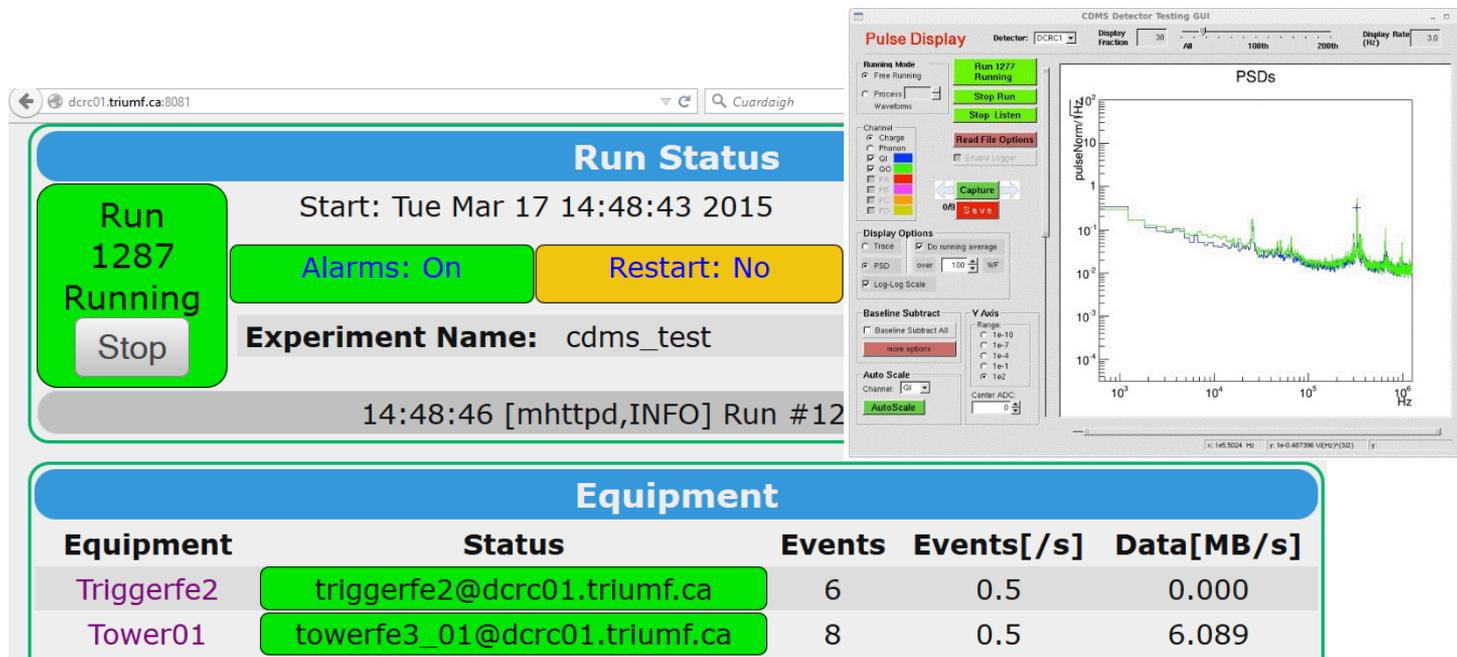
DCRCs continuously write digitized waveforms into memory, and an L1 trigger based on a finite impulse response filter running in firmware notes the times of potentially interesting signals (shown as red arrows).



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!



The screenshot displays the CDMS Detector Testing GUI. The 'Run Status' section shows 'Run 1287 Running' with a 'Stop' button. The start time is 'Tue Mar 17 14:48:43 2015'. Alarms are 'On' and 'Restart' is 'No'. The experiment name is 'cdms_test'. The equipment section is a table with the following data:

Equipment	Status	Events	Events[/s]	Data[MB/s]
Triggerfe2	triggerfe2@dcrc01.triumf.ca	6	0.5	0.000
Tower01	towerfe3_01@dcrc01.triumf.ca	8	0.5	6.089

The 'Pulse Display' window shows a log-log plot of PSDs (pulsesNorm/Hz) vs frequency (Hz). The plot shows a noisy signal with a peak around 10^5 Hz. The Y-axis ranges from 10^-4 to 10^0, and the X-axis ranges from 10^3 to 10^6 Hz.

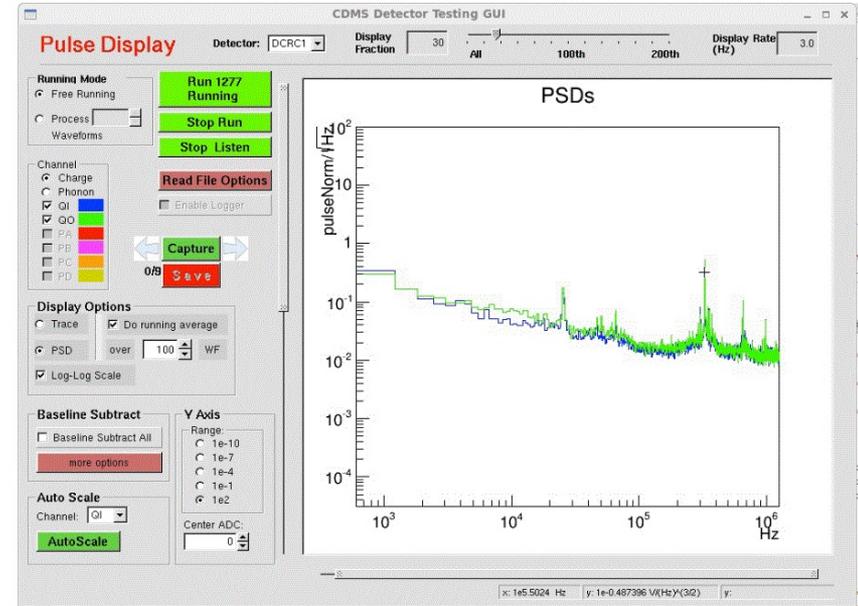
Summary Schedule

	FY16	FY17	FY18	FY19	FY20	FY21
Description	O N D J F M A M J J A S	O N D J F M A M J J A S	O N D J F M A M J J A S	O N D J F M A M J J A S	O N D J F M A M J J A S	O N D J F M A M J J A S
DAQ (prototype DCRC)	develop	debug				
Test w/ cold hardware						
Test with detector						
DAQ (pre-production)						
L1 trigger		develop		debug		
Test with detector						
Surface system test						
Data quality system						
Environ. Monitoring						
Install @ SNOLAB						

Recent Progress

New DAQ version for new prototype 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 prototype card and new data acquisition



Noise PSD collected from desktop tests of new DAQ from prototype DCRC



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

Near-term steps towards CD-2

Test of DAQ + prototype DCRC with prototype SNOLAB cold electronics at SLAC (August 2016)

- Exercise DAQ with cold hardware and dummy load (no detector)
- Use DAQ to measure noise of DCRC + cold hardware combination
- 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 prototype electronics (October 2016)

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

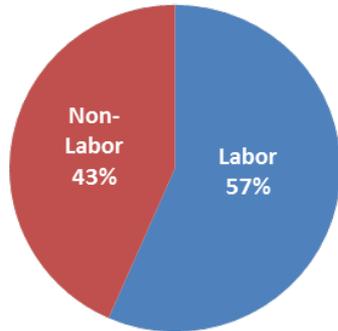
Develop new L1 trigger firmware (WBS 1.6.6)

- New trigger with FIR filtering to be implemented for pre-production DCRC

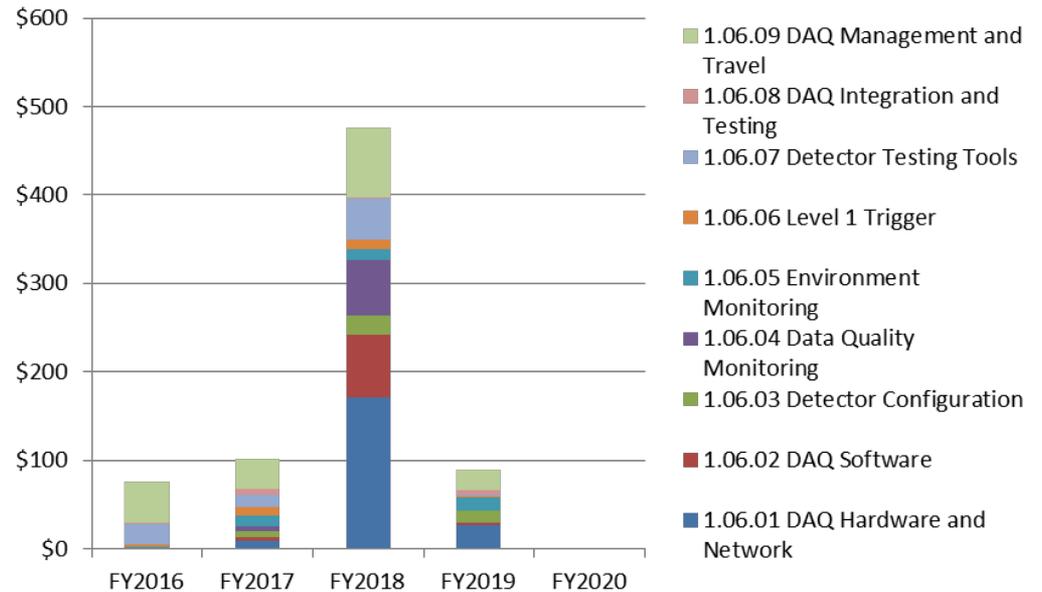
Finalize specifications of DAQ computers

- Necessary for CD-3

1.06 Data Acquisition and Triggering (DAQ)



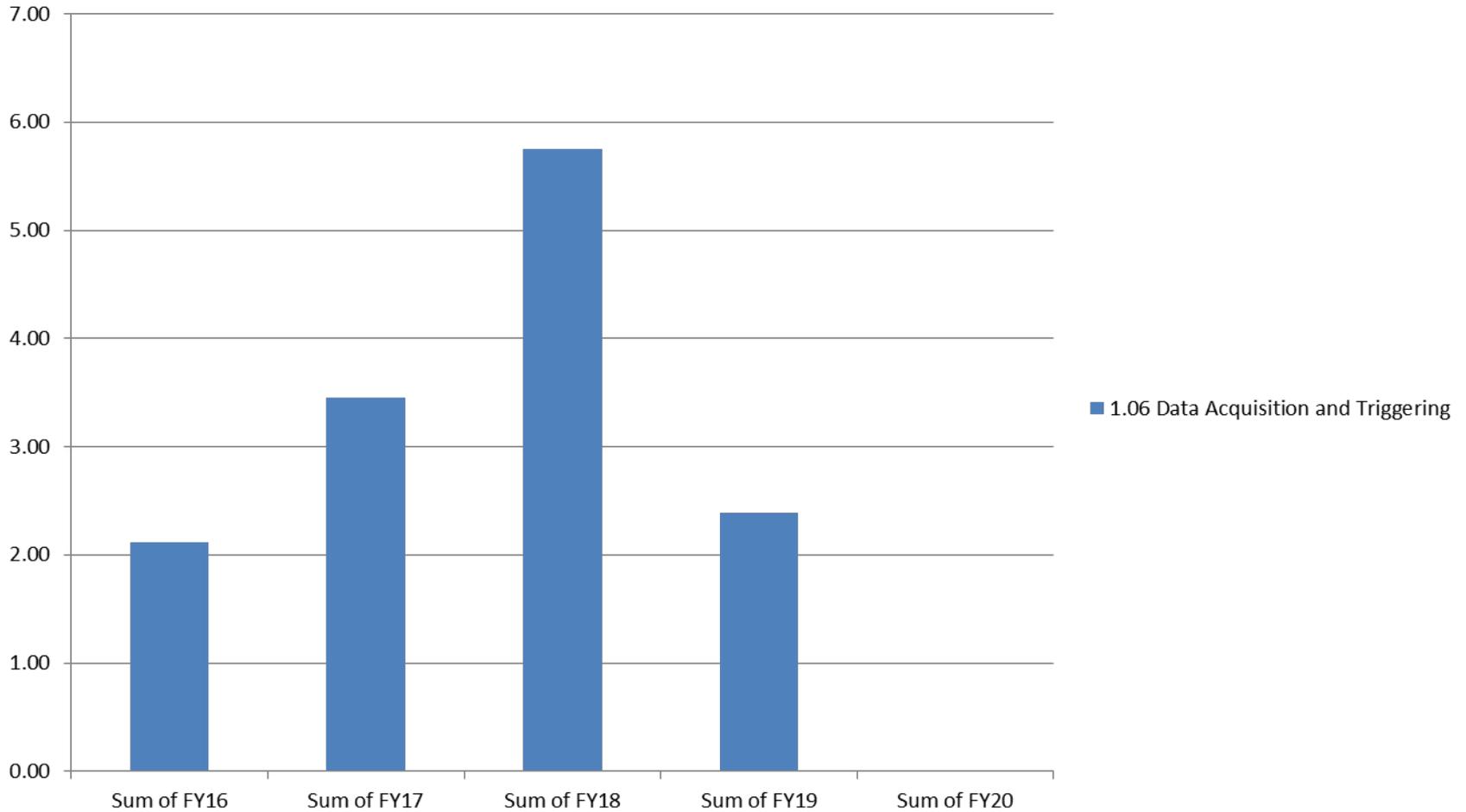
1.06 Data Acquisition and Triggering	
Resource Type	(\$K)
Labor	\$420
Non-Labor	\$323
Total BAC	\$743



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



Risks and Mitigation

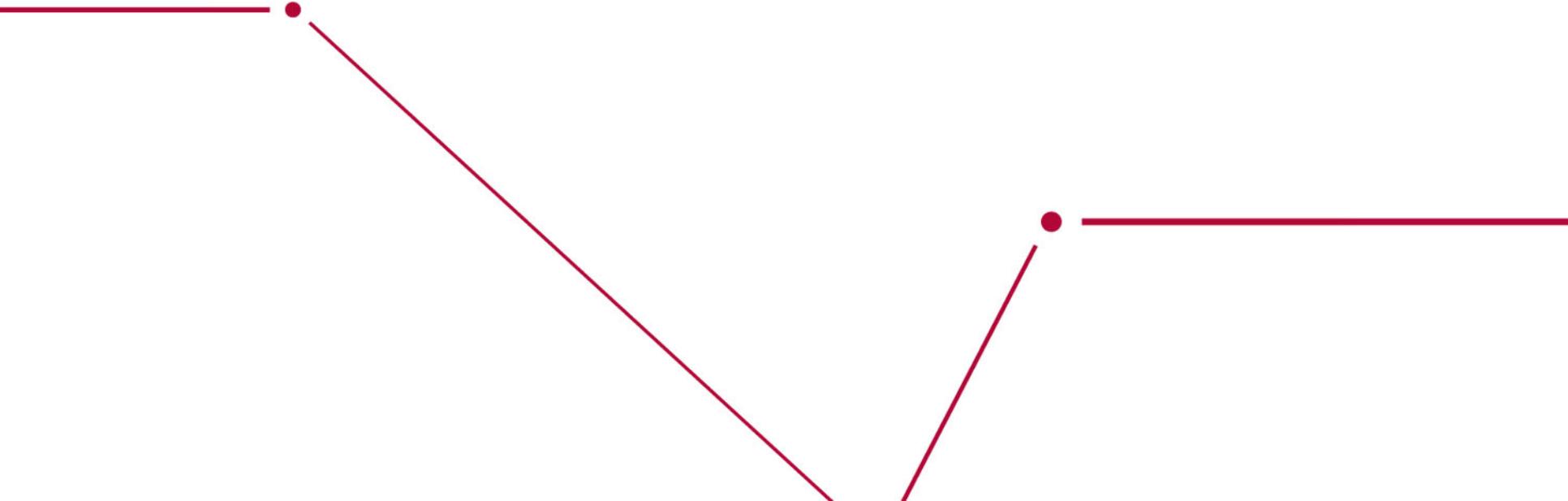
Risk Title	IF/THEN	Risk Handling Plan (Mitigations)	Overall Impact Score
DCRC delays	If DCRC is delayed, there may be delays in DAQ development	Key Concern: Much DAQ work depends on DCRCs being made available early to DAQ group. Delays will slow DAQ development. Mitigations: plan as much of the work 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

- **Design maturity:** a mature, tested design is already being used at test facilities. Remaining work is technically straightforward, and we are building on solutions that other experiments have successfully used.
- **Cost, schedule, and risk:** These have all been updated since CD-1, and are well understood. Risks are low.
- **Management:** L3 managers are in place and are producing monthly reports. Soon ready for earned value reporting.
- **Previous Review Recommendations:** none---WBS 1.6 was given no homework at CD-1



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.

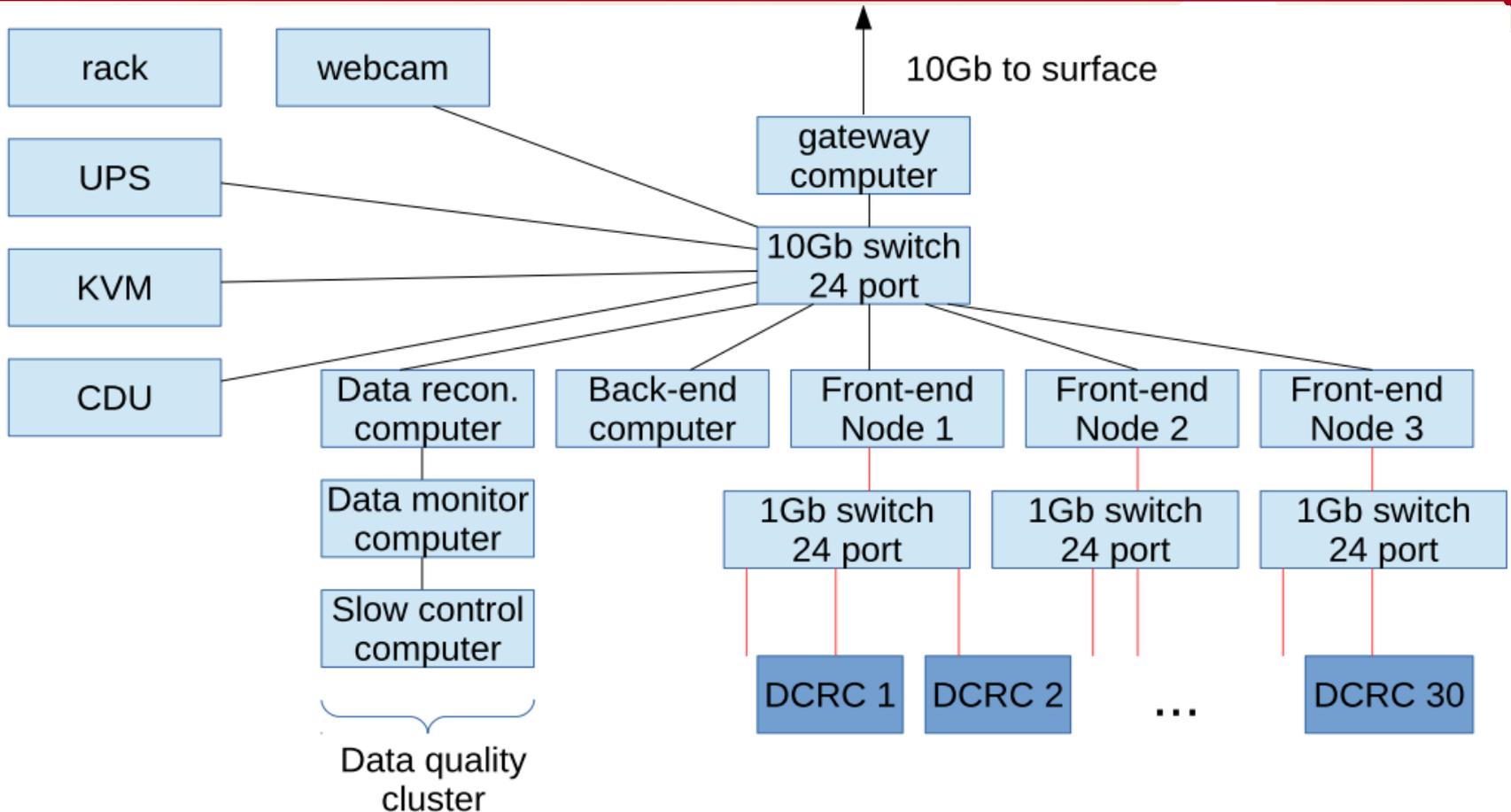
L2 Trigger

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