WBS 1.08 Data Acquisition Overview

Laura Newburgh

CMB-S4 DAQ Conceptual Design Review
July 24, 2023

Who Am I

Name: Laura Newburgh

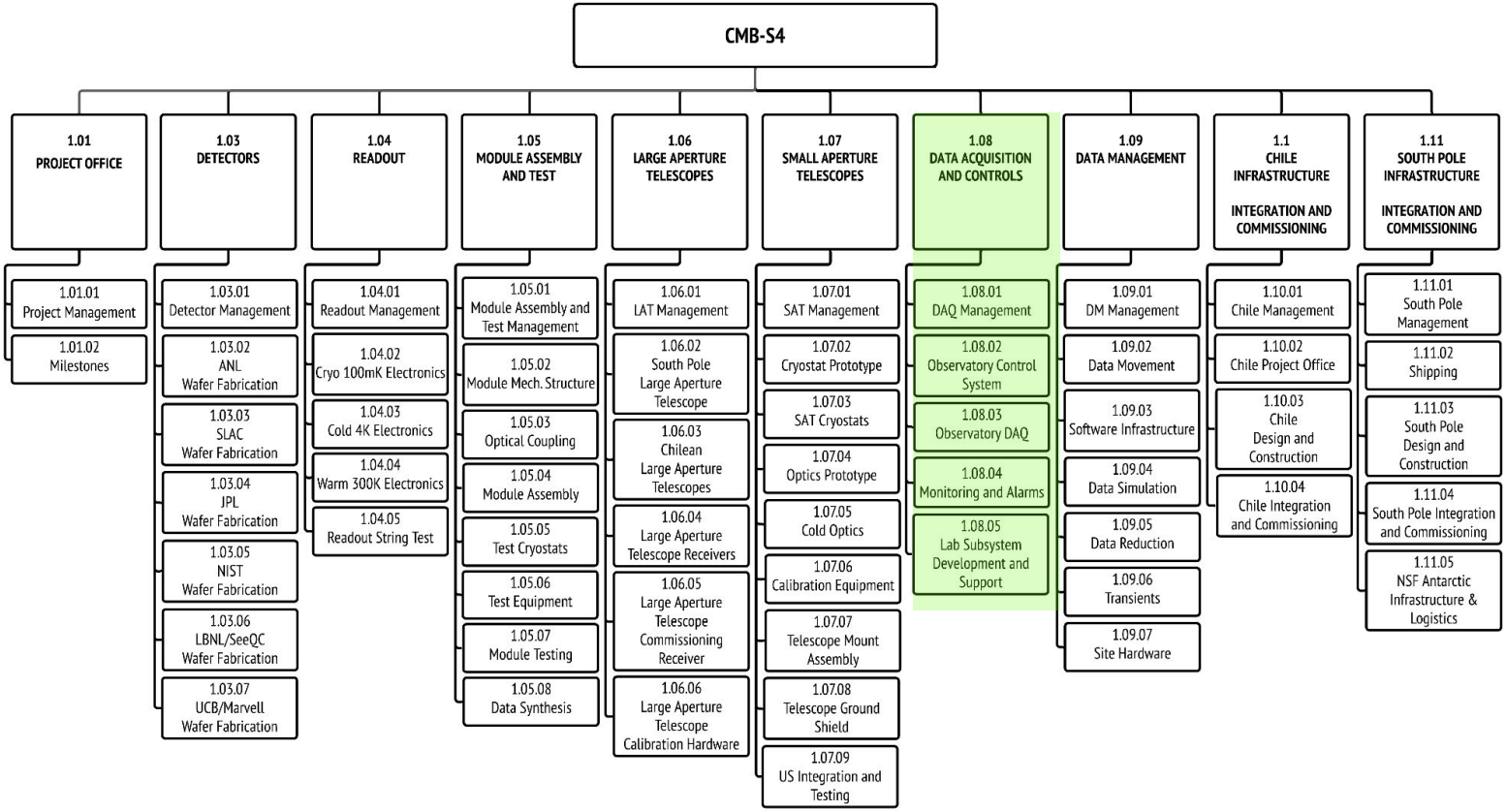
Role: CMB-S4 DAQ Science L2

- Assistant Prof. at Yale
- DAQ lead for Simons Observatory
- 17 years of experience on CMB experiments, 8 years on 21cm experiments

Outline

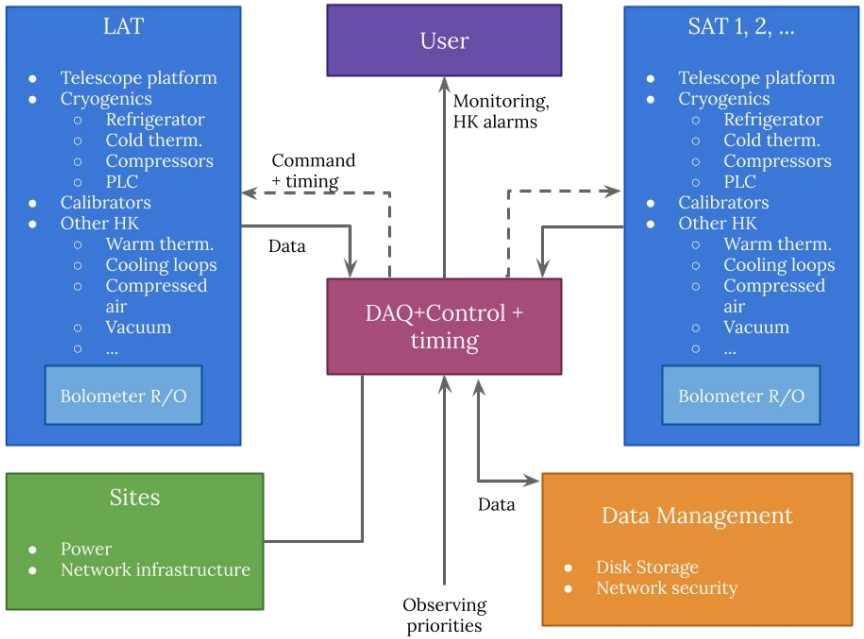
- Work breakdown structure
- Scope
- Team
- + ‘delta’ since last review
- + review responses
- System design overview
- System interfaces and requirements
- Schedule summary
- Cost summary
- Top-level risks
- Next steps towards CD-1
- Summary

Work Breakdown Structure



DAQ/Control Scope

- Acquire and aggregate high-speed data from detectors, slow data from housekeeping and meta-data into specified format, hand-off to data management
- Provide control framework (automated scheduling or more fine-tuned interaction) for commanding equipment in the labs, and at the observatories
- Browser-based live and historical monitoring of ‘housekeeping’ data and meta-data
- Hierarchical, **non-safety** alarms system based on housekeeping data
- Provide observatory-wide timing and frequency references to readout and telescope control hardware
- Provide support for running DAQ and Controls systems in development labs



(Example from the South Pole configuration)

Experienced DAQ Team

1.08
DATA ACQUISITION AND CONTROLS

Laura Newburgh (Yale)
Gregg Thayer (SLAC)

1.08.01
DAQ Management
Gregg Thayer (SLAC)

1.08.02
Observatory Control System
Brian Koopman (Yale)

1.08.03
Observatory DAQ
Nathan Whitehorn (MSU)

1.08.04
Monitoring and Alarms
Cosmin Deaconu (U. Chicago)

1.08.05
Lab Subsystem Development and Support
Abigail Crites (Cornell)

Delta from last review

- Context: last CDR was 2021
  - I was on maternity leave
  - L3 positions not assigned yet
  - Trade study just completed, no reason to depart from baseline Simons Observatory software.
  - SO software was being used in labs
  - No dedicated CAM
- Today:
  - SO is about to deploy, so we have:
    - Operation of a full SAT receiver+housekeeping in the lab
    - End-to-end software test system, most recently useful for testing data packaging and transfer
    - Working version of scheduling software
    - Working versions of ‘OCSweb’ (control and feedback from single hardware devices in a browser interface)
    - Commanded scheduled observations of just the telescope platform
    - Deployment of framework for 4 telescopes at the site (including control, acq, monitoring)
    - Prototype access control
    - Testing alarms system now
    - FYI: 2FA
  - AoA changed number of telescopes but no DAQ changes

Responses to review recommendations

- RT-186

  Recommendation

  Solidify the DAQ interface with regard to observing control and observing priorities. Present a credible observatory control scenario.

  This is essentially completed with the scheduler in place for SO

- RT-136

  Change how the trade study is presented. The study evaluated the baseline solution based on the Simons Observatory DAQ, found it to be adequate and that none of the other options in the study provided clear advantages [before CD-1].

  Complete: (see next slide)

- RT-66

  DAQ: Complete the ICDs (which are currently more Interface Requirements Documents) - including requirements for a complete set of emulators. Include budget for emulator cluster. (later)

  Ongoing (we have interfaces with every L2, so this is not trivial)

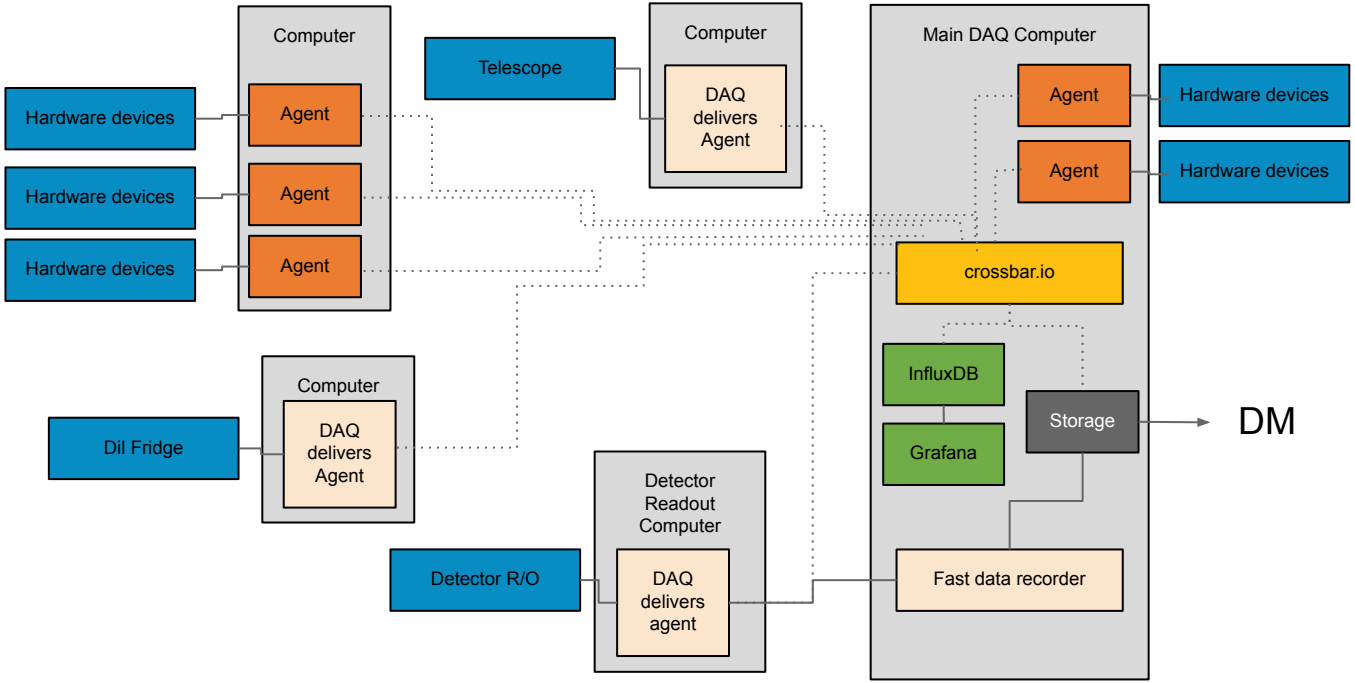
Trade study undertaken to identify whether any existing software met our needs

- Would prefer to use existing software rather than write something from scratch. Simons Observatory software package (OCS) identified as the preliminary baseline design.
- Steps:
  - Listed S4 DAQ requirements
  - Surveyed most likely candidates: Simons Observatory, LSST, ALMA, EPICS, GCP, CLASS, commercial (Ignition)
  - For any which we were available, we installed and tested the software against the requirements

Summary: **Found that Simons Observatory software met our needs and found no clear advantages for deviating from the baseline design.**

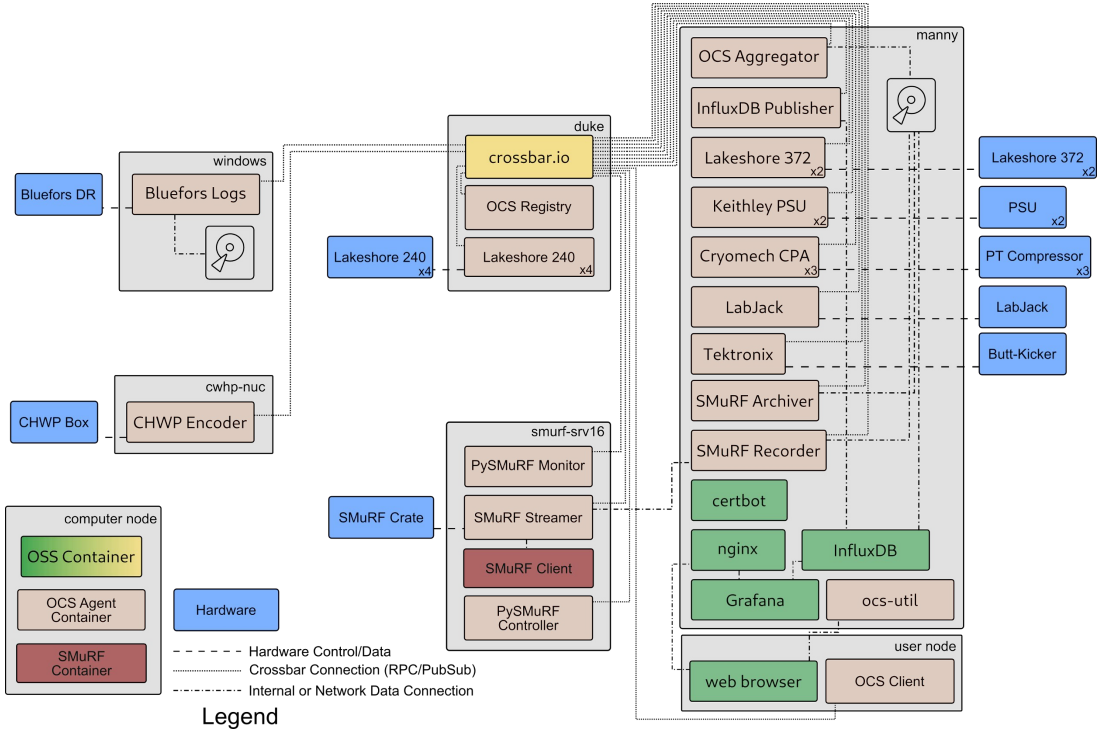
System Design Overview

- One agent per hardware device makes it :
  - Configurable
  - Modular
  - send data at different rates
- Enables hardware experts to determine what data/flags to acquire and command for their hardware component
- High Speed data: Detector R/O has dedicated data links
- ‘Commercial’ Grafana-based monitoring very flexible
- (Alarms not shown)



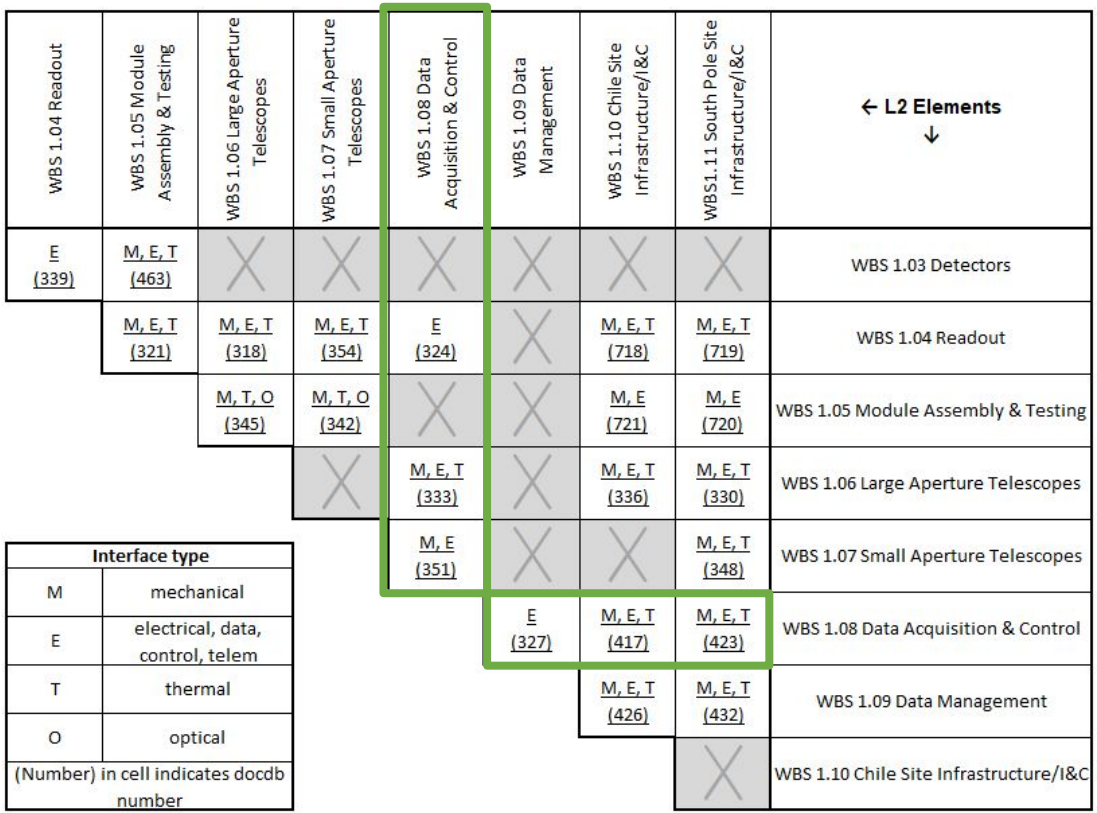
CMB-S4 Framework Based On Heritage (Simons Observatory)

- Worked example shows the framework allows:
  - heterogeneous computation structure
  - Scalability
  - Successful model: majority of agents written by ‘non-DAQ’ users
  - Useful feedback from early use



(Example from a SAT testbed at UCSD)

Project-Level Interfaces Are Identified And Being Developed For DAQ



WBS 1.04 Readout	WBS 1.05 Module Assembly & Testing	WBS 1.06 Large Aperture Telescopes	WBS 1.07 Small Aperture Telescopes	WBS 1.08 Data Acquisition & Control	WBS 1.09 Data Management	WBS 1.10 Chile Site Infrastructure/I&C	WBS1.11 South Pole Site Infrastructure/I&C	← L2 Elements ↓
E (339)	M, E, T (463)	X	X	X	X	X	X	WBS 1.03 Detectors
	M, E, T (321)	M, E, T (318)	M, E, T (354)	E (324)	X	M, E, T (718)	M, E, T (719)	WBS 1.04 Readout
		M, T, O (345)	M, T, O (342)	X	X	M, E (721)	M, E (720)	WBS 1.05 Module Assembly & Testing
			X	M, E, T (333)	X	M, E, T (336)	M, E, T (330)	WBS 1.06 Large Aperture Telescopes
				M, E (351)	X	X	M, E, T (348)	WBS 1.07 Small Aperture Telescopes
					E (327)	M, E, T (417)	M, E, T (423)	WBS 1.08 Data Acquisition & Control
						M, E, T (426)	M, E, T (432)	WBS 1.09 Data Management
							X	WBS 1.10 Chile Site Infrastructure/I&C

Interface type	
M	mechanical
E	electrical, data, control, telem
T	thermal
O	optical
(Number) in cell indicates docdb number	

DAQ contains interfaces to six WBS areas

- 1.04 Readout
- 1.06 LAT
- 1.07 SAT
- 1.09 Data Management (DM)
- 1.10 Chile Site Infrastructure
- 1.11 South Pole Site Infrastructure

DAQ to RO is driving interface: large data pipe and will evolve as R&D evolves

DAQ to DM is a driving interface: multiple handoffs and deliverables to define and track

Main DAQ Requirements/Drivers

- Acquire high speed data from detectors (400 Hz per detector, ~ 10 Gbit/s total)
- Acquire slow data from many, heterogeneous hardware devices at different rates
- Control system for scheduled observations to command telescope drive systems, readout boards, and other hardware in labs/site
- Enable use across labs and at observatory scale for early integration:
  - Scalable
  - Simple to add hardware integrators, so we can leverage hardware experts to write software for them
  - Use standard protocols, programming languages known to collaborators
- User-friendly, yet powerful, control and monitoring
- Timing system distributed across the site, allowing asynchronous data acquisition

Next Steps To CD-1

1. Continue working on management: Refining the schedule and completing ICDs.
2. Provide access, training, and development support for deployments in test labs.
3. First-draft DAQ/control for prototype warm readout boards.
4. Additional work:
    a. File formatting
    b. Determines what our proposed structure is for tracking files, associating them with observations, etc (and if this is our job)

Summary

An experienced and capable team is in place with clear roles and lines of authority

Trade studies have been completed to assess alternatives and selection Observatory Control System software

A design that will meet requirements is well-developed to conceptual / preliminary DOE maturity

Schedule designed to deploy software early