CMB-S4 Data Acquisition and Control (DAQ) CDR

L1 Introduction to Reviewers

Bobby Besuner - CMB-S4 Project Engineer

Science Goals

CMB-S4 will dramatically push forward our understanding of the history, evolution, and contents of the Universe by achieving four Science Goals:

GOAL 1: Test models of inflation by measuring or putting upper limits on r, the ratio of tensor fluctuations to scalar fluctuations.

GOAL 2: Determine the role of light relic particles in fundamental physics, and in the structure and evolution of the Universe.

GOAL 3: Measure the emergence of galaxy clusters as we know them today. Quantify the formation and evolution of the clusters and the intracluster medium during this crucial period in galaxy formation.

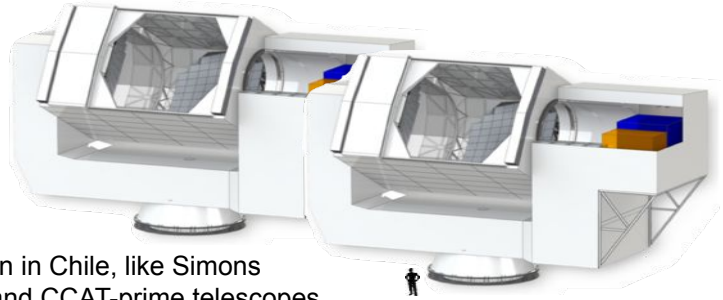
GOAL 4: Explore the millimeter-wave transient sky. Use the rate of mm-wave Gamma-Ray Bursts (GRB) to constrain GRB mechanisms. Provide mm-wave variability and polarization measurements for stars and active galactic nuclei.

(Ref. Program Level Requirements, CMBS4-doc-671)

Experiment Design

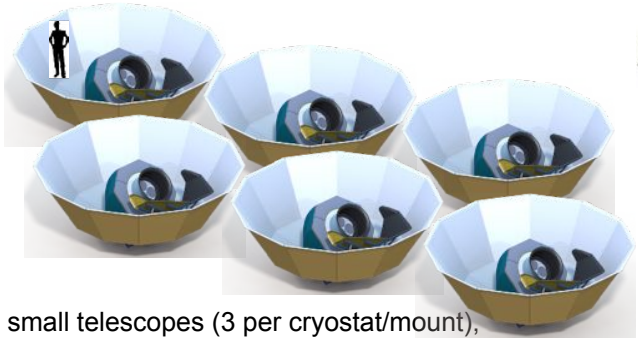
Flowdown from the science goals leads to an experiment with:

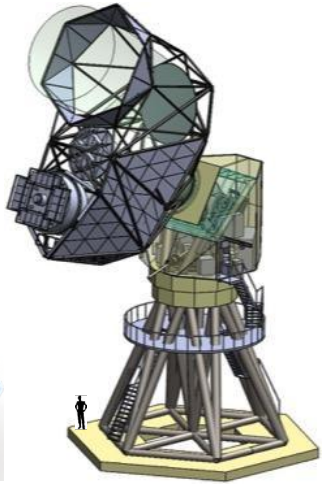
- A 7-year deep-wide survey targeting ~70% of sky from Chile using **2 x 6m telescopes** with **269,184 detectors** over **6 frequency bands**.
- A 7-year ultra-deep survey targeting ~3% of sky from the South Pole using **18 x 0.5m telescopes** with **154,560 detectors** over **8 frequency bands** and **1 x 5m telescope** with **126,360 detectors** over **7 frequency bands**.



6m C-D design in Chile, like Simons Observatory and CCAT-prime telescopes

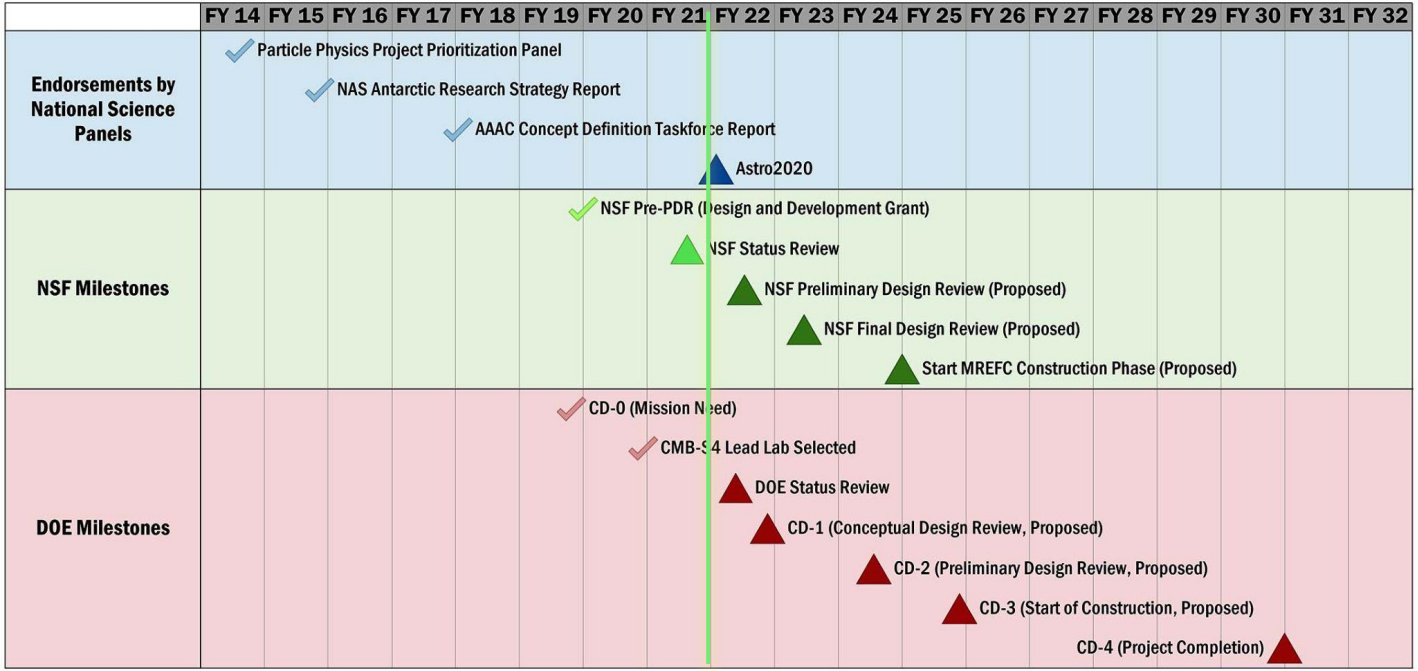
5m TMA design with monolithic mirrors and boresight rotation at South Pole





18 x 0.5m small telescopes (3 per cryostat/mount), heritage from BICEP Array & Simons Observatory

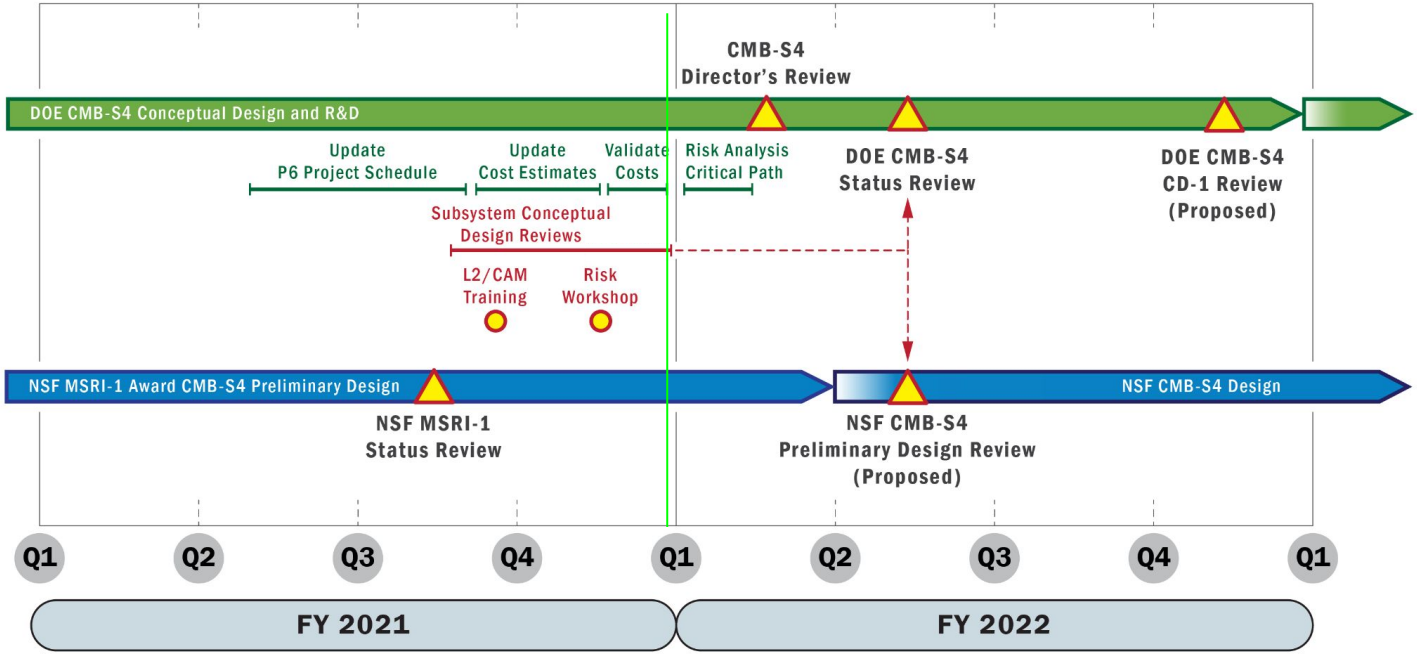
Top-Level Milestones



- Subsystem CDRs Completed Summer 2021
- DOE/OPA Status Review February 2022
- NSF PDR March 2022
- DOE CD-1 August 2022

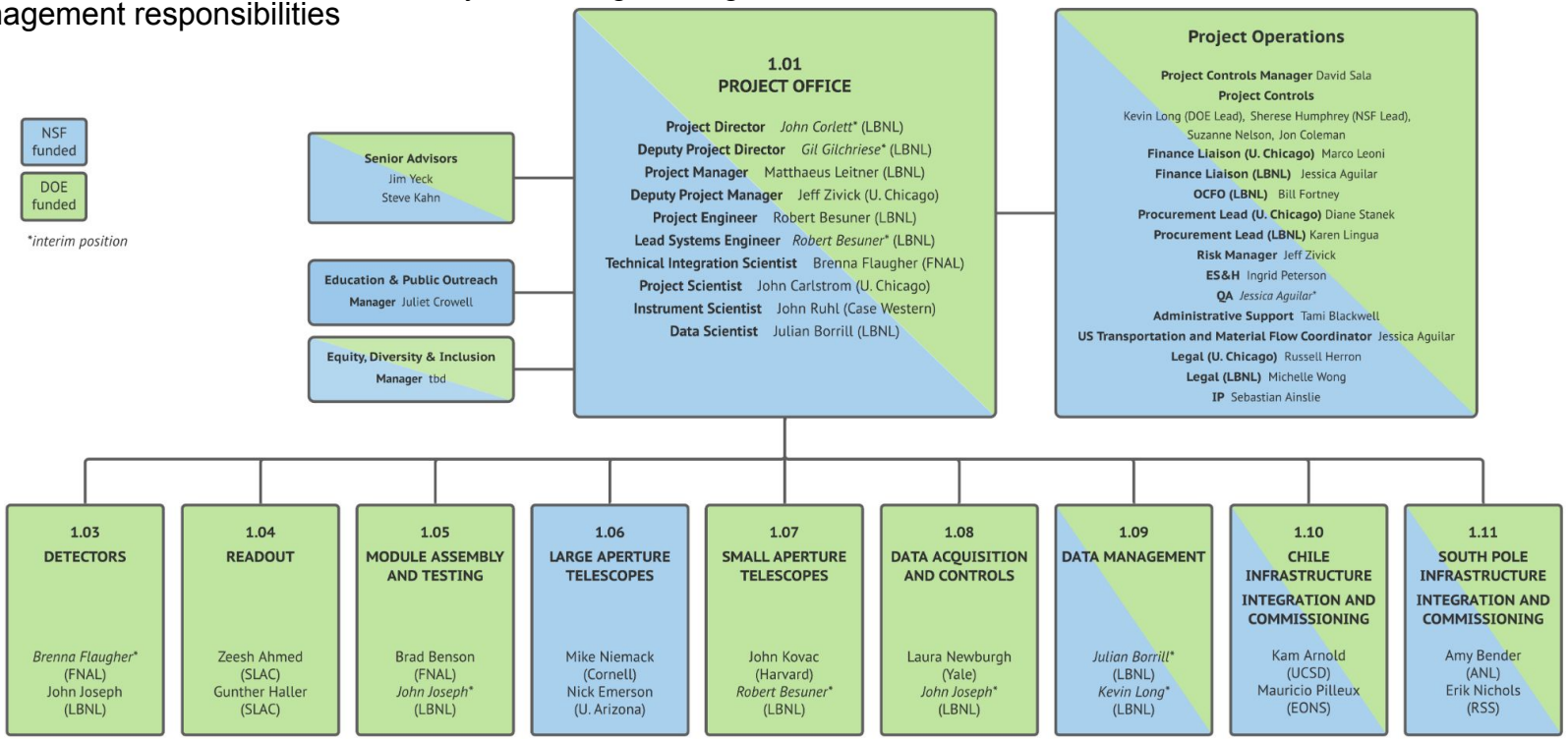
- Project Early Completion ~2030
- Project Late Completion ~2032
- Survey Completion ~2037

Near-Term Schedule



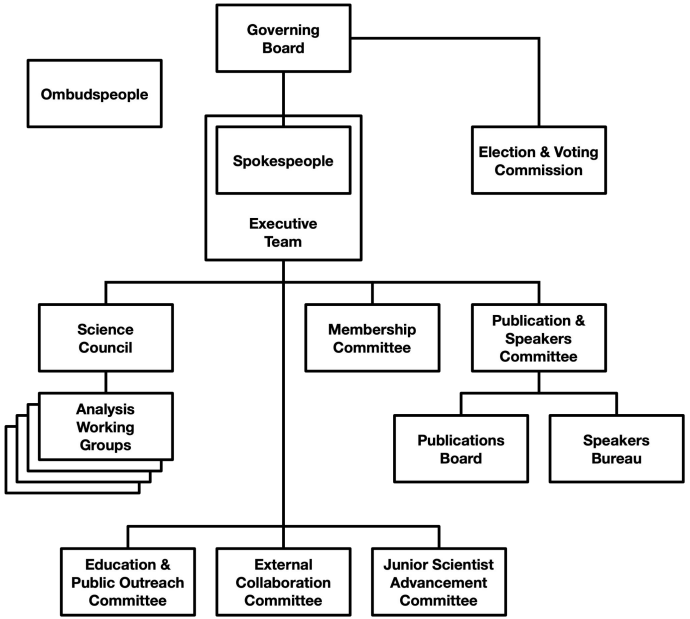
Project Organization

- Joint funding by DOE and NSF
  - DOE Labs: LBNL (lead lab), Argonne, Fermilab, SLAC
  - NSF Lead Institution: University of Chicago
  - Multiple universities and international institutions
- Level 1 includes overall ES&H, QA, Systems Engineering management responsibilities



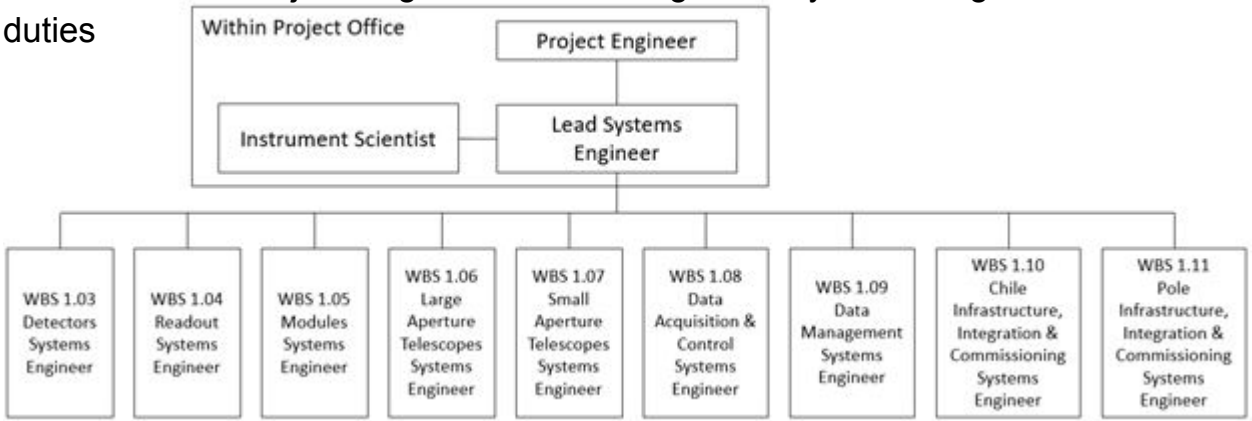
Collaboration Organization

- 300 scientists at 100 institutions in 17 countries on 6 continents
  - 77 have collaboration governance roles
  - 41 have project roles



CMB-S4 Systems Engineering

- The project is being developed using Systems Engineering processes, described in the CMB-S4 Systems Engineering Management Plan (CMBS4-doc-520):
  - Defines overall organization of the Systems Engineering team (org chart below)
    - Lead Systems Engineer (and likely future additional SysEs) at L1
    - Engineers in each L2 with Systems Engineering responsibilities for that L2
  - Defines Systems Engineering roles and responsibilities
  - Defines policies and processes for Systems Engineering areas (requirements, interfaces, budgeting of technical resources, verification plans, design value management)
    - L1 System-level and L2 Subsystem Technical Requirements flow down from Science Goals
- Current funding levels mean the L1 Project Engineer is the acting Lead Systems Engineer and L2 Leads are performing L2 SysE duties



Charge Questions

- **Technical scope**
  1. Are the requirements defined at a conceptual design level of maturity, and is the proposed design expected to meet them?
  2. Have the major interfaces been identified and appropriately incorporated into the design?
  3. Have alternatives been appropriately studied in developing the design?
- **Design management**
  4. Have the major subsystem risks been identified?
  5. Are procurements being planned and prepared for appropriately?
  6. Have major cost and schedule drivers been identified?
- **Quality Assurance**
  7. Is QA sufficiently incorporated into the design and execution planning?
  8. Are the necessary future QA documents identified and are plans at a level of maturity commensurate with a conceptual design?
- **ES&H**
  9. Is ES&H sufficiently incorporated into the planning and design?
- **Miscellaneous**
  10. Have all the previous review recommendations been addressed?
  11. Are there any other issues that have been identified that need to be addressed?
- **Overall readiness**
  12. Is the design maturity at a sufficient level for conceptual design review approval?

Yellow-filled text boxes on presentation slides denote Charge Question(s) addressed: CQ5

Conceptual Design Definition

Conceptual Design Review [~5-15% Design Maturity]

- The Conceptual Design Review (CDR) is held to assure that the objectives and requirements of the item being designed are understood and that the proposed approach will meet these requirements. The emphasis should be on the requirements, and how the proposed design will meet them.
- The CDR should occur early enough so that the concept can be modified without a major impact on the project. The review should present the major design alternatives considered, the relative risk for each and the reasons for the approach chosen by the design team.
- The output of the CDR is a baseline design (subject to the closure of any requests for action/recommendations resulting from the review). A successful CDR allows the design effort to proceed to the preliminary design phase.
- The CDR should address the following items:
  - Design Objective
  - Technical Requirements
  - Organizational Interfaces
  - Technical Interfaces
  - Safety Hazards (Design for Safety)
  - Risk Areas
  - Proposed Design Approach
  - Consideration of major design alternatives
  - Lessons learned from previous projects or experience
  - Preliminary Budget and schedule

Review Closeout

- Closeout plans to be discussed at the end of today's review
- Final report in the provided format requested by the end of next week (October 8)

Link to Agenda

Link to Review Report