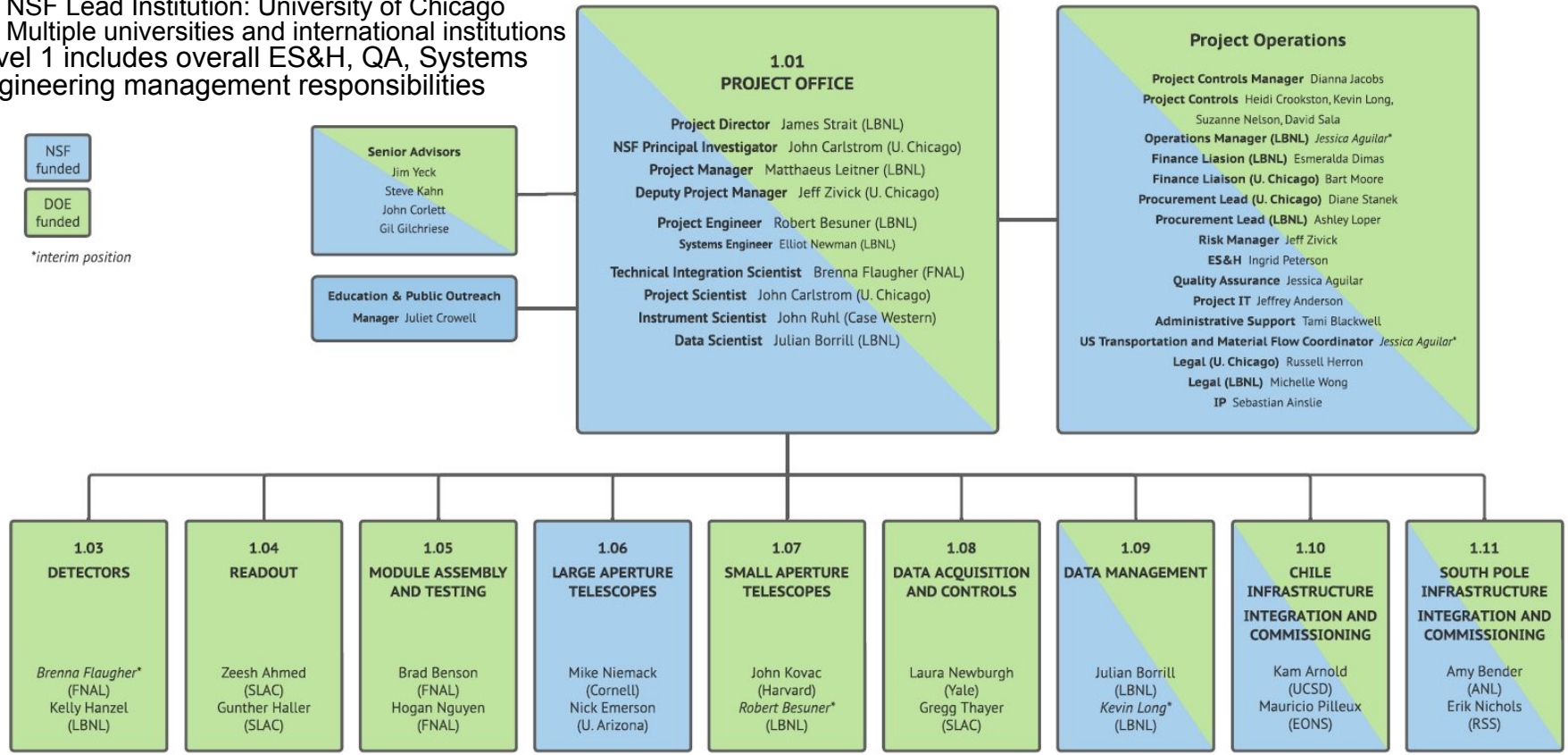
CMB-S4 Data Acquisition and Controls (DAQ) CDR

L1 Introduction to Reviewers

Bobby Besuner - CMB-S4 Project Engineer

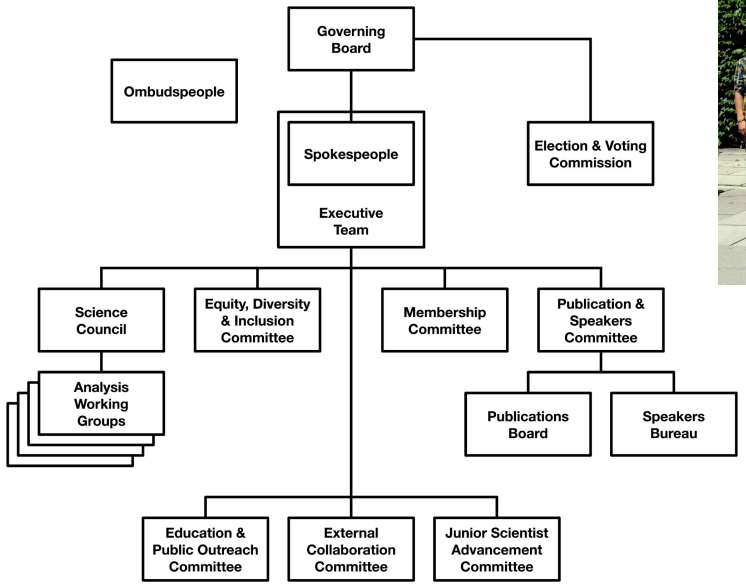
Project Organization

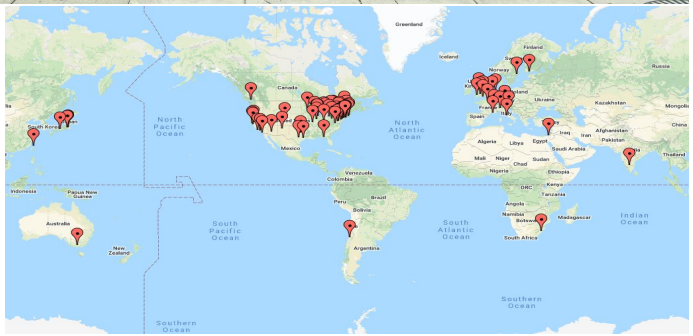
- Joint funding by DOE and NSF
  - DOE Labs: LBNL (lead lab), Argonne, Fermilab, SLAC
  - NSF Lead Institution: University of Chicago
  - Multiple universities and international institutions
- Level 1 includes overall ES&H, QA, Systems Engineering management responsibilities



Scientific Collaboration Organization

- 379 scientists at 113 institutions in 26 US states + 18 countries on 6 continents
  - 90 have collaboration governance roles
  - 66 have project roles





CMB-S4 Project Since Summer 2021

- November 2021 Director's Review of the Project
- Planned February 2022 OPA review canceled due to agency concerns about resource availability
- 2022 Analysis of Alternatives (AoA) conducted to re-optimize the experiment within updated resource constraints (next slide)
- 2023 Engagement with the P5 (Particle Physics Project Prioritization Panel) process
  - Presenting at P5 Town Halls
  - Submitting plans with technical, cost, and schedule details
  - Answering detailed questions from the P5 Cost Committee
- Two years of technical and programmatic work, including updating to the revised experimental configuration
- July-September 2023: Re-reviews of the Subsystem Conceptual Designs
- November 2023: Director's Review of the Project in preparation for future agency reviews
- Requirements and Interfaces are more mature and will be under configuration management before the November 2023 Director's Review of the Project

AoA process

- Experiment design space explored with a constraint on South Pole electrical power availability on the order of existing CMB experiments (SPT + BICEP Array)
  - Electrical Power needs scrubbed throughout the project
  - Alternative SAT cryostat configurations studied
  - Different distributions of SATs and LATs in Chile and South Pole
- Alternatives analyzed in detail
  - Site infrastructure needs
  - Science reach forecasts
  - Comparative lifecycle cost projections
  - Survey time required
  - Risk assessment
- Process and results reviewed by external reviewers in November 2022
  - Panel approved our process and concurred with our conclusion for the preferred Alternative
  - Agencies concurred after December 2022 briefing
- Result: Updated experiment is the same configuration as pre-AoA, but with half as many SATs deployed at the South Pole (minimal technical detail updates)

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.

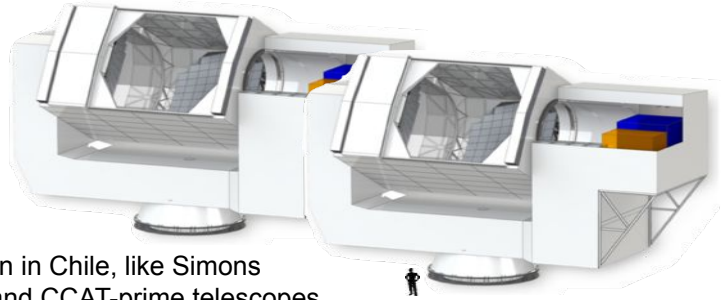
GOAL 4: Explore the millimeter-wave transient sky. Use the rate of mm-wave Gamma-Ray Bursts (GRB) to constrain GRB mechanisms. Provide mm-wave variability and polarization measurements for stars and active galactic nuclei.

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

Experiment Design (resulting from AoA)

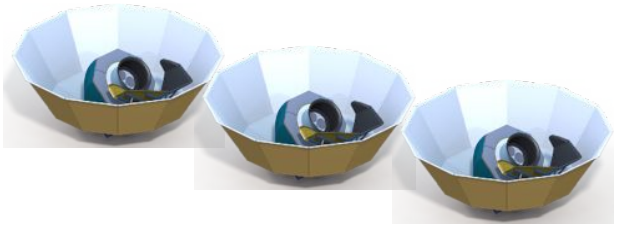
Flowdown from the science goals, within resource constraints, leads to an experiment with:

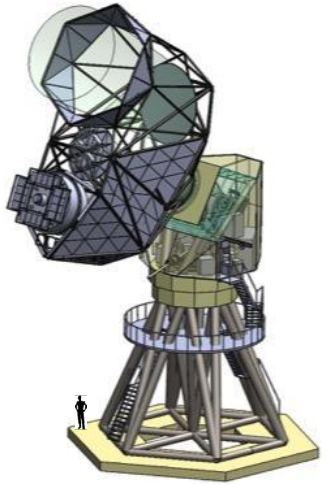
- A deep-wide survey targeting ~70% of sky from Chile using **2 x 6m telescopes** with **275,992 detectors** over **6 frequency bands**.
- An ultra-deep survey targeting ~3% of sky from the South Pole using **9 x 0.5m telescopes** with **90,816 detectors** over **8 frequency bands** and **1 x 5m telescope** with **129,024 detectors** over **7 frequency bands**.



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

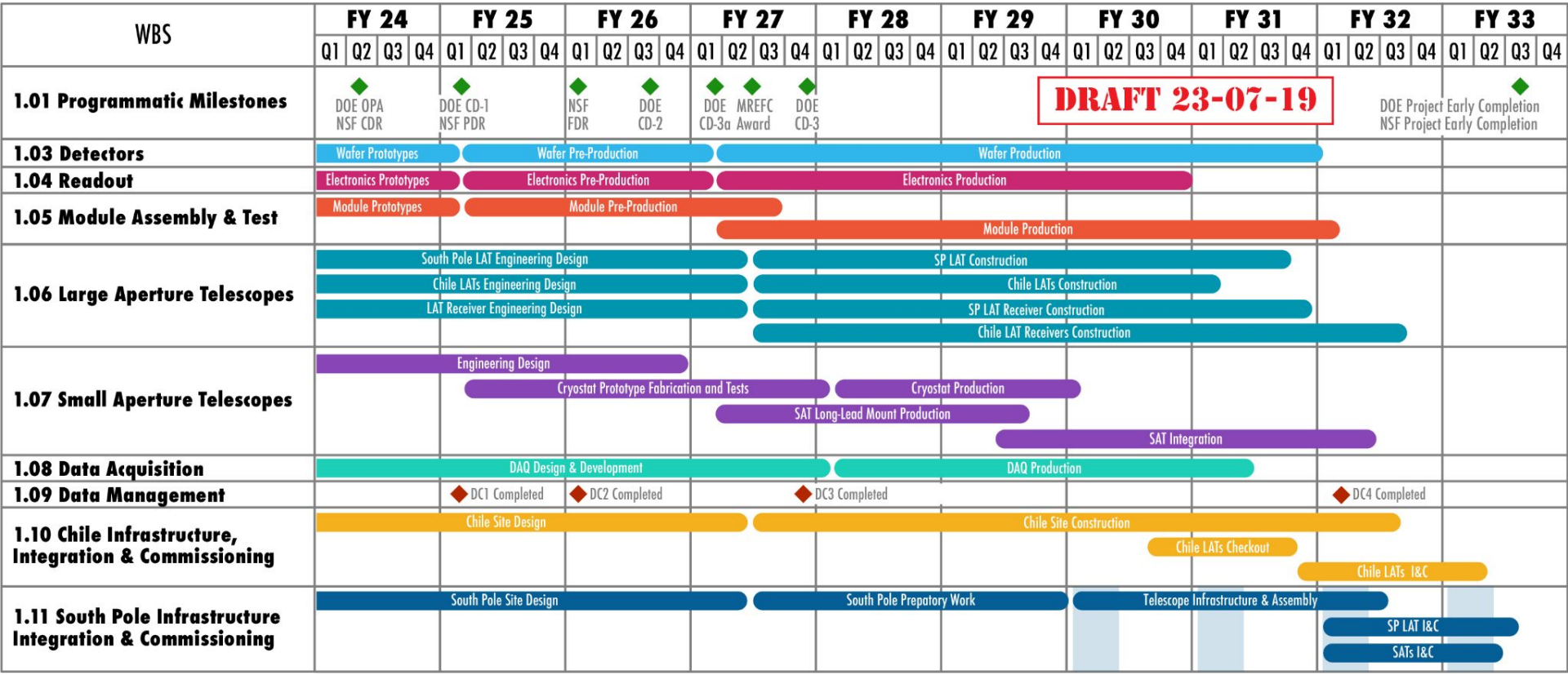
5m TMA design with monolithic mirrors and boresight rotation at South Pole





9 x 0.6 m small telescopes (3 per cryostat/mount), heritage from BICEP Array & Simons Observatory

Current CMB-S4 Project Timeline



Upcoming Director's Review

Previous comprehensive reviews

- NSF/MSRI-1 Review May 2021
- Director's Review Nov 2021
- The Project was fully prepared for a DOE/OPA progress review Feb 2022

Director's Review planned for November 14-17, 2023

- Assess the readiness for NSF CDR and DOE CD-1 reviews.
- A comprehensive and rigorous review of the full CMB-S4 Project with scope updated following last year's AoA.
- Conducted in a manner similar to a DOE/OPA Independent Project Review
- Gauge progress – technical, cost, schedule and management – since the previous Director's Review in November 2021
- Plan to utilize many of the same reviewers as in the 2021 review – a powerful, first-rate committee

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 CDR?
- **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

- We request that you present a slide deck at the closeout session
  - Draft Summary / overall assessment
  - Draft Answers to charge questions
    - Preferably Yes / No, with caveats / qualifiers / explanations
  - Draft Findings, Comments, and Recommendations
    - Emphasis on Comments and Recommendations

- Final report in the provided format requested one week from the end of the review (July 31)