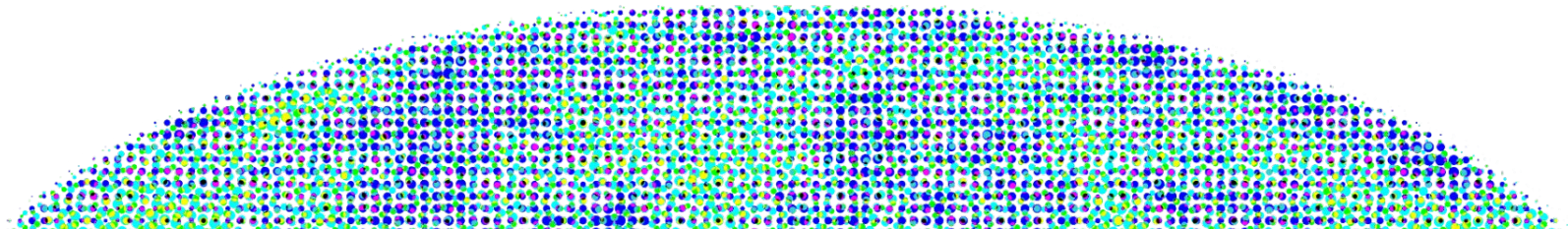
CMB S4

CMB-S4 Update

Committee on Astronomy and Astrophysics Fall Meeting

Jim Strait (he/him), LBNL, CMB-S4 Project Director
John Carlstrom (he/him), UChicago, CMB-S4 Project Scientist and NSF PI

8 November 2024



The Cosmic Microwave Background encodes vast information about the origin and evolution of the universe and about fundamental physics that has driven that evolution.

Subtle patterns in the CMB allow us to “see” processes that occurred in the first instants of our universe, revealing physics at energy scales far beyond any conceivable terrestrial experiment.

The CMB signal has been modified by the entire history of the universe through which it has traveled, providing a unique view of the structure of the universe and its building blocks.

Cosmological observations are crucial for understanding some of the greatest mysteries of particles and fields, notably understanding the nature of dark matter and dark energy, the quantum nature of gravity and the search for as-yet undiscovered particles and fields.

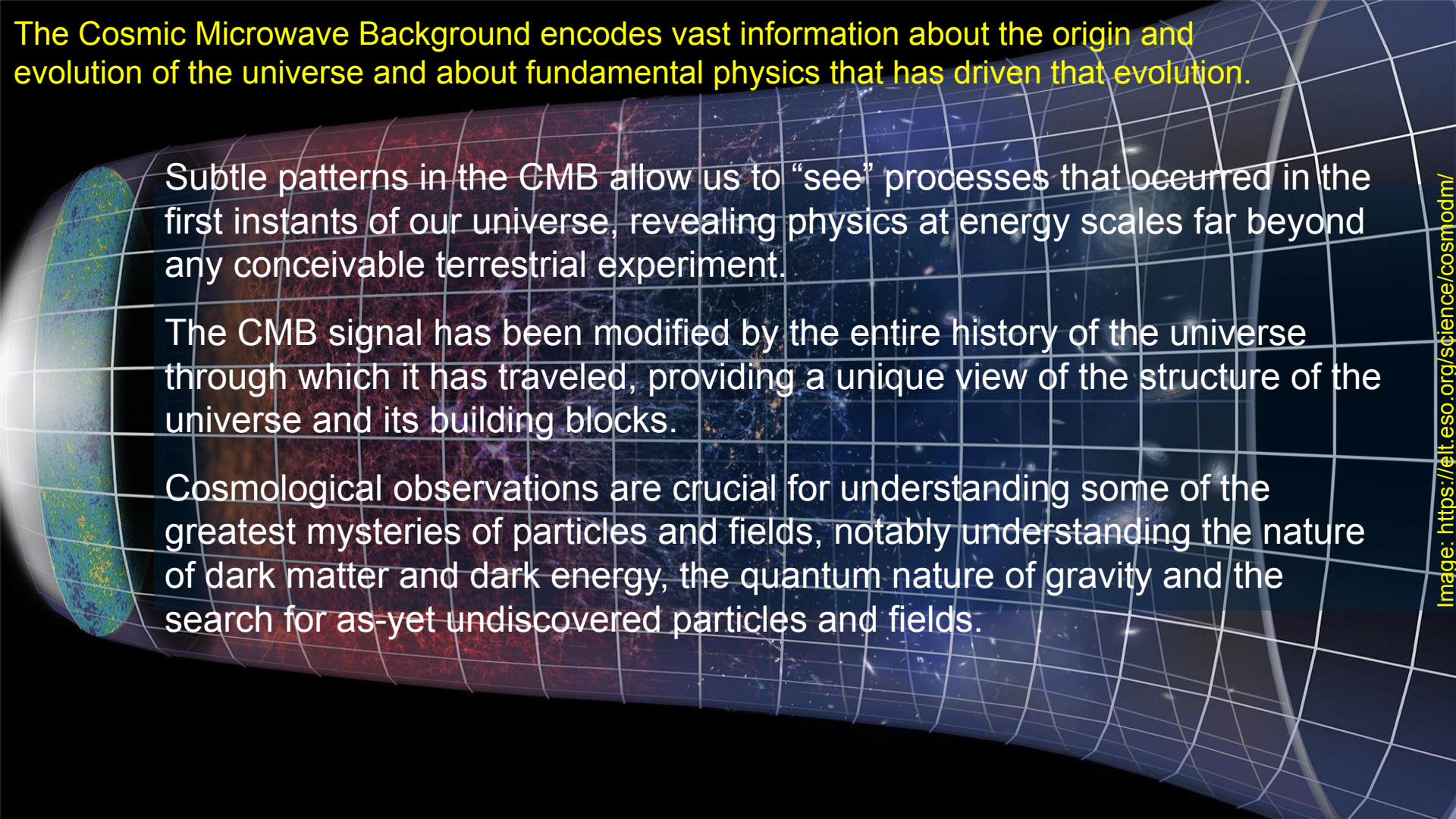


Image: https://elt.eso.org/science/cosmodm/

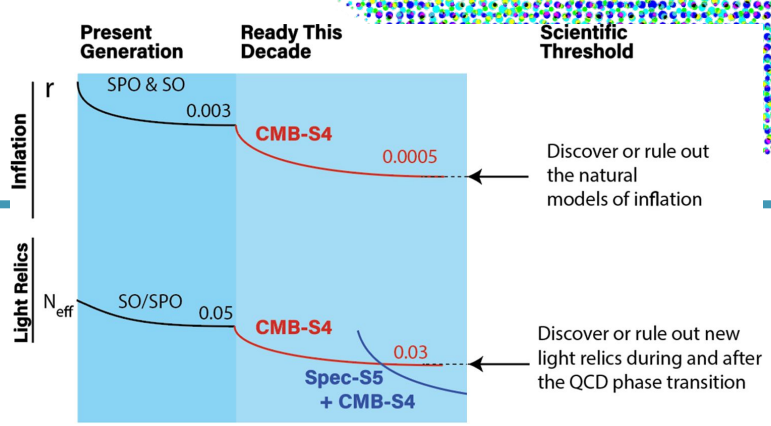
CMB-S4 will enable a major advance in our ability to study the CMB

- CMB-S4 will cross critical discovery thresholds in cosmology, astrophysics and fundamental physics and continue the groundbreaking history of US and DOE leadership in CMB research.
- It presents an exciting opportunity to discover gravitational waves produced by inflation in the extremely early universe, providing a direct window to this previously inaccessible epoch and the highest energy scales in the universe.
- The transformative science includes:
  - the search for primordial gravitational waves,
  - constraints on relic particles, setting the neutrino mass scale,
  - unique and complementary insights into dark energy and tests of gravity on large scales,
  - elucidating the role of baryonic feedback on galaxy formation and evolution,
  - opening up a window on the transient Universe at millimeter wavelengths.

CMB-S4 will have a profound and lasting impact on cosmology, astronomy, astrophysics and fundamental physics

- CMB-S4 will provide powerful synergies to surveys at other wavelengths,such as
  - DESI and potential follow-on surveys
  - the Vera C. Rubin Observatory Legacy Survey of Space and Time,
  - the Nancy Grace Roman Space Telescope and SPHEREx,
  - the proposed Spec-S5 and others yet to be imagined.
- CMB-S4 uses demonstrated technology to conduct two complementary surveys to address key science goals and test theories of cosmic inflation.
- The Astro2020 Decadal Survey recommended CMB-S4 as one of three large programs for NSF investment: “The NSF and the DOE should jointly pursue the design and implementation of the next generation ground-based cosmic microwave background experiment (CMB-S4).”
- 2023 P5 ranked CMB-S4 as the top priority for future Particle Physics construction projects.

Primary Science Goals



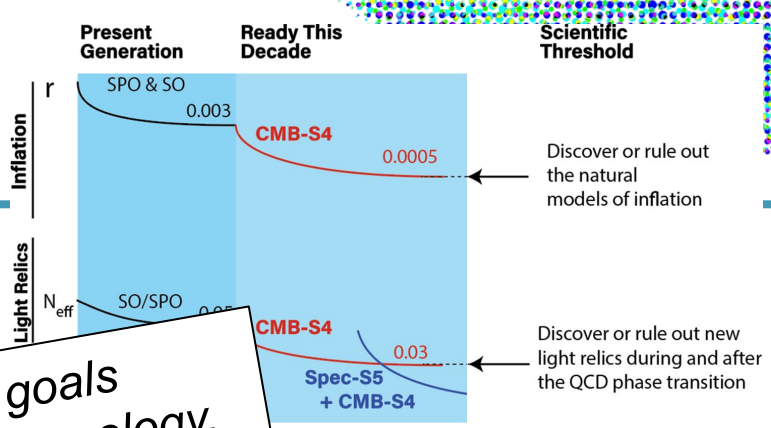
Inflation: CMB-S4 will cross a critical threshold ($\sigma_r < 0.0005$) to discover or rule out the natural models of inflation.

Relic Particles: CMB-S4 will cross a critical threshold to discover or rule out light relic particles that freeze out during and after the QCD phase transition extending our knowledge of relic particles by orders of magnitude in the freeze out temperature.

Matter Mapping: CMB-S4 will provide legacy maps that probe cosmology and astrophysics and that enable diverse new science including dark energy and dark matter studies and neutrino mass scale, complementing LSST DESC and DESI and the proposed Spec-S5.

Time Domain: CMB-S4 will provide ~hourly maps which detect millimeter wave transients relevant for wide range of astrophysics, e.g., solar system objects, stars, TDEs, SN, AGN, and multi-tracer studies with LSST, IceCUBE, and LIGO.

Primary Science Goals



Inflation: CMB-S4 will cross a critical threshold ($\sigma_r < 0.0005$) to discover or rule out the natural models of inflation.

Relic Particles: CMB-S4 will cross a criti… discover or rule out ligh… …he QCD phase transition exten… …agnitude in the freeze out temperature.

A design that achieves these driving goals enables broad and rich program of cosmology, astrophysics and physics research.

Matter Mapping: C… …rovide legacy maps that probe cosmology and astrophysics and that enable diverse new science including dark energy and dark matter studies and neutrino mass scale, complementing LSST DESC and DESI and the proposed Spec-S5.

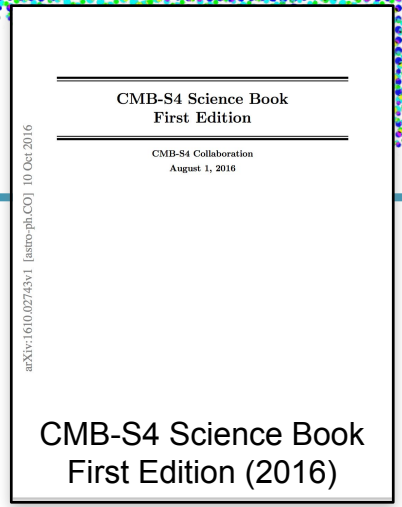
Time Domain: CMB-S4 will provide ~hourly maps which detect millimeter wave transients relevant for wide range of astrophysics, e.g., solar system objects, stars, TDEs, SN, AGN, and multi-tracer studies with LSST, IceCUBE, and LIGO.

Extremely Broad Science Program

Primary CMB Anisotropy: Inflationary gravitational waves • Inflation energy scale • Quantum Gravity • Light relics • BSM particles • Primordial power spectrum • Cosmic census (baryons-dark matter-dark energy) …

Secondary Anisotropy and using the CMB as a backlight: Neutrino mass • Dark Energy • Cosmic birefringence • Axion dark matter • Dark matter-baryon scattering • Sunyaev-Zeldovich scattering effects • Galaxy clusters • Galaxy evolution and feedback • Gravitational lensing • Cross-correlations with gas/mass/galaxies • Cosmological momentum field • Reionization/1st stars…

Time-domain, Deep, Wide-area, Millimeter-wave Surveys: Gamma ray bursts • Tidal disruption events • Fast blue optical transients • Supernovae • Time-variable active galactic nuclei • Multi-messenger correlations with time-domain observatories • Dusty star-forming galaxies • Stellar flares • Galactic black hole flares • Fast radio bursts • Interstellar medium • Galactic magnetic field • Exo-Oort Clouds • Planet 9 • Asteroids…



CMB-S4 Science Book First Edition (2016)

200 pages, >1400 citations

arXiv:1610.02743

Second Edition being drafted

CMB-S4 Has Been Supported By A Strong Heritage Of Community Endorsements

- 2024: HEPAP Facilities Subpanel: **CMB-S4's potential to contribute to world-leading science is "absolutely central."**
- 2023: P5: "***Plan and start the following major initiatives in order of priority: a. CMB-S4****, which looks back at the earliest moments of the universe to probe physics at the highest energy scales.*"
- 2023: AAAC: "*Coordination between NSF-OPP, NSF-AST, and DOE is critical* ***to ensure the success of CMB-S4 and enable the world-leading science and exciting discoveries that will be achieved with the project.***"
- 2021: Astro2020: "***The NSF and the DOE should jointly pursue the design and implementation of the next generation ground-based cosmic microwave background experiment (CMB-S4).***"
- 2015: NAS report recommended CMB-S4 science case as 1 of 3 strategic investments for Antarctic Research
- 2014: P5 recommended CMB-S4 under all budget scenarios

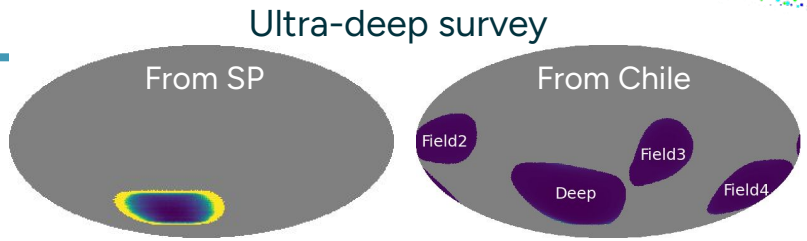
Astro2020's recommendation is based on the compelling science case for CMB-S4

"CMB-S4 … is designed to push CMB measurements across critical sensitivity and measurement thresholds to understand the origins of inflation, search for hidden fundamental particles, map out the distribution of mass and hot gas throughout the universe, and explore time-variable and static millimeter-wave sources." [Section M.4.1]

This science case is well aligned with CMB-S4's Science Goals [CMB-S4 Design Report 2023]:

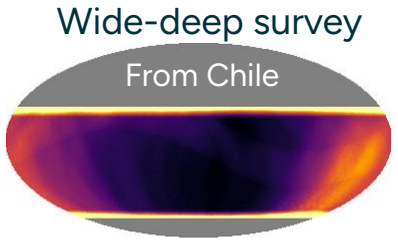
1) Test models of inflation by measuring or putting upper limits on r, the ratio of tensor fluctuations to scalar fluctuations.
2) Determine the role of light relic particles in fundamental physics, and in the structure and evolution of the Universe.
3) Measure the emergence of galaxy clusters as we know them today. Quantify the formation and evolution of the clusters and the intracluster medium during the crucial early period of galaxy formation.
4) Explore the millimeter-wave transient sky. Measure the rate of mm-transients. Use the rate of mm-wave GRBs to constrain GRB mechanisms. Provide mm-wave variability and polarization measurements for stars and active galactic nuclei.

CMB-S4 Site Selection



CMB-S4 Requires Two Complementary Surveys:

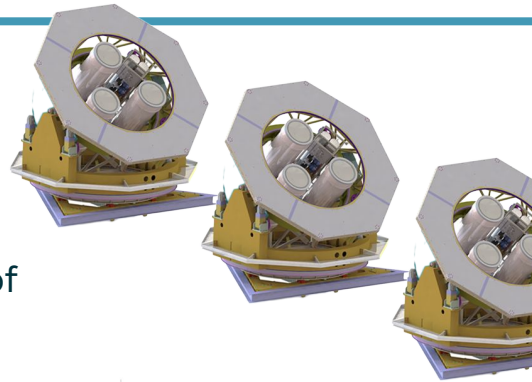
- **An ultra-deep survey** over a small fraction of the sky, mainly to address goal 1 - Test models of inflation.
- **A wide-deep survey** covering the largest possible fraction of the sky, mainly to address the other goals - light relic particles, formation and evolution of galaxy clusters, and transients.

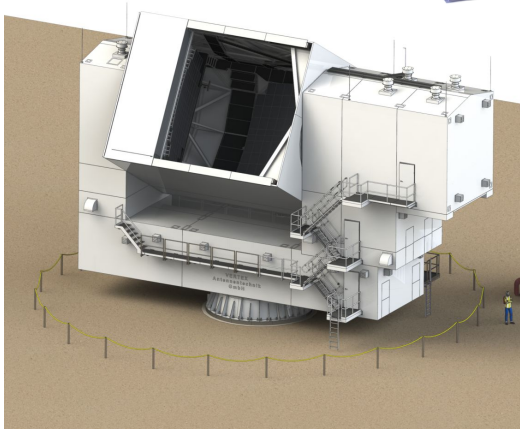


- CMB-S4 has conducted a rigorous Analysis of Alternatives (AoA) [CMBS4-doc-1004 and -1005], most recently documented for the 2023 Director's Review.
  - CMB-S4 had selected a two-site configuration with telescopes at the South Pole to conduct the ultra-deep survey and in the high Atacama desert in Chile to conduct the wide-deep survey.
  - The AoA also concluded that a configuration with all telescopes in Chile "could offer a way to make the measurements, if CMB-S4 is unable to access the Pole."

CMB-S4 Instruments

- The **ultra-deep survey** is conducted by:
  - Multiple small-aperture (~0.5m) telescopes (SAT) measuring degree-scale structures in the CMB
  - One or more large-aperture (6m) telescopes (LAT) for de-lensing, i.e., using CMB lensing reconstruction to remove the contribution of B-mode polarization caused by gravitational lensing of the CMB E-mode polarization by large scale structure
- The **wide-deep survey** is conducted by:
  - One or more additional LATs measuring small-scale structures over as large as possible an area of the sky
- The design of the LATs for delensing and for the wide-deep survey can be the same and the two surveys may be shared among the LATs to optimize efficiency.





Astro2020 prioritizes CMB-S4 second only to the ELT Program

"The survey recommends **phased NSF investment in three large programs** this decade. The **highest priority is participation in the U.S. extremely large telescope program**, because of its transformative nature, and because of the urgency of this investment to the projects' success. Next, **equal priority** is placed on **developing and implementing the CMB-S4 observatory** together with DOE, and on **beginning design, cost studies, and prototyping for the Next Generation Very Large Array (ngVLA)** radio telescope. Last, if these studies are successful, and if budgets allow, the survey recommends commencing construction of the ngVLA toward the end of the decade." [Section 7.6.1]

CMB-S4 is the only one of the top-rated projects not yet in the NSF MF Design Stage

- The US ELT Program is in the Preliminary Design Phase and is awaiting a decision by the NSF Director as to whether to advance either of the two candidate projects (GMT and TMT) into the Final Design Stage.
- The ngVLA project entered the Conceptual Design Phase in July 2023.
- In May 2024, "The NSF has made the decision **not to move the CMB-S4 project in its current form into the NSF Major Facility Design Stage at this time**" due to the need to "prioritize the recapitalization of **critical infrastructure at the South Pole**." [C.Smith, BPA, May 7,2024]

Following the NSF decision in May 2024 that excludes CMB-S4 from accessing the Pole, **CMB-S4 is developing the all-Chile option**, in which the ultra-deep survey is also conducted in Chile. The development of the revised configuration is **responsive to a Charge Letter from the DOE and NSF to the CMB-S4 Project** (more below).

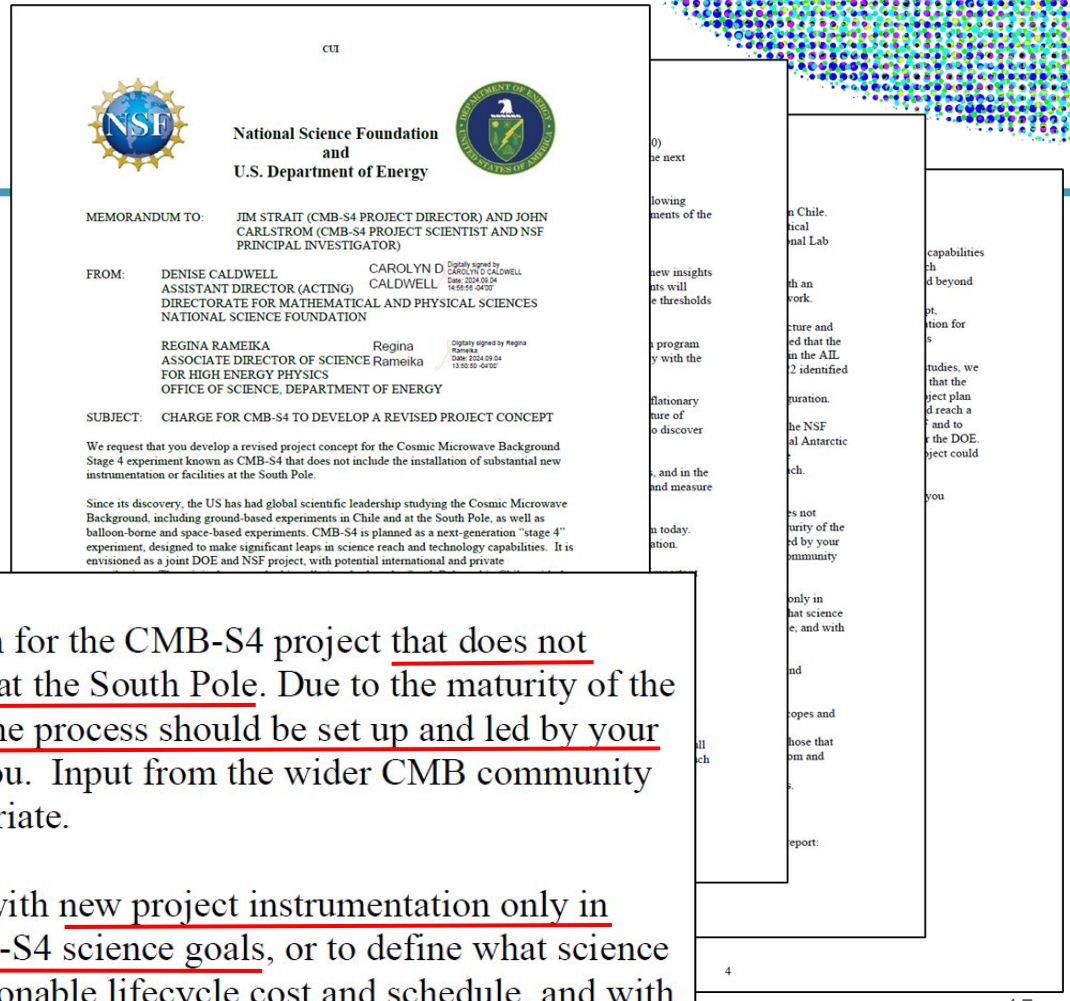
Developing a Revised CMB-S4 Configuration

- In order to choose a revised configuration that we can confidently develop toward a full conceptual design, we are conducting **a rapid study of the design space** for CMB-S4 in Chile, including:
  - Numbers and types of telescopes, frequency bands and focal plane detector designs;
  - Survey strategies;
  - Site layout options and constraints.
- The goal is to be able to propose an all-Chile configuration that is able to address **all of the CMB-S4 science goals** and is optimized to meet the inflation science goal for an acceptable cost.
- We have set up a **Coordination Group** to oversee the rapid study of the design space to optimize the design concept for an all-Chile configuration for CMB-S4.
- We have also set up a Working Group to ensure that the design of CMB-S4 takes account of the **plans and capabilities of other experiments** that will be running between now and when CMB-S4 will begin observations, which is charged to collect and evaluate information regarding the plans and capabilities of current CMB experiments.
- The complete charges for the two Groups are included in the backup.

Funding Agency Charge

A formal charge, signed by the Directors of NSF/MPS and DOE/HEP, was sent to CMB-S4 on Sep 4.

The charge is consistent with the work that is already in progress.



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National Science Foundation
and
U.S. Department of Energy

MEMORANDUM TO: JIM STRAIT (CMB-S4 PROJECT DIRECTOR) AND JOHN CARLSTROM (CMB-S4 PROJECT SCIENTIST AND NSF PRINCIPAL INVESTIGATOR)

FROM: DENISE CALDWELL
ASSISTANT DIRECTOR (ACTING)
DIRECTORATE FOR MATHEMATICAL AND PHYSICAL SCIENCES
NATIONAL SCIENCE FOUNDATION

CAROLYN D CALDWELL Digitally signed by CAROLYN D CALDWELL Date: 2024.09.04 14:56:56 -04'00'

REGINA RAMEIKA
ASSOCIATE DIRECTOR OF SCIENCE
FOR HIGH ENERGY PHYSICS
OFFICE OF SCIENCE, DEPARTMENT OF ENERGY

Regina Rameika Digitally signed by Regina Rameika Date: 2024.09.04 13:50:50 -04'00'

SUBJECT: CHARGE FOR CMB-S4 TO DEVELOP A REVISED PROJECT CONCEPT

We request that you develop a revised project concept for the Cosmic Microwave Background Stage 4 experiment known as CMB-S4 that does not include the installation of substantial new instrumentation or facilities at the South Pole.

Since its discovery, the US has had global scientific leadership studying the Cosmic Microwave Background, including ground-based experiments in Chile and at the South Pole, as well as balloon-borne and space-based experiments. CMB-S4 is planned as a next-generation "stage 4" experiment, designed to make significant leaps in science reach and technology capabilities. It is envisioned as a joint DOE and NSF project, with potential international and private

Charge

The agencies request that you develop a revised plan for the CMB-S4 project that does not include significant new instrumentation or facilities at the South Pole. Due to the maturity of the CMB-S4 project team, collaboration, and concept, the process should be set up and led by your project team and collaboration, and co-chaired by you. Input from the wider CMB community should be included in developing the plan as appropriate.

The goal is to refocus on planning a configuration, with new project instrumentation only in Chile, that is capable of meeting the full set of CMB-S4 science goals, or to define what science goals can be reached, both within a reliable and reasonable lifecycle cost and schedule, and with an acceptable level of scientific risk. As part of your studies, you should:

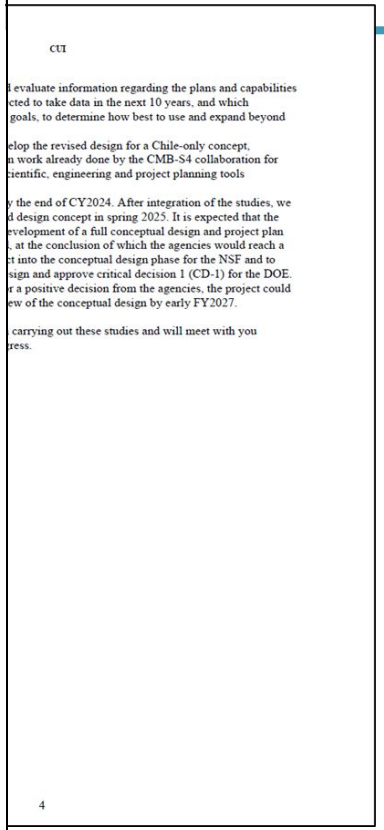
Funding Agency Charge

The study is envisioned as requiring two parallel efforts, to be combined into a final report:

1. Survey the Landscape: Collect and evaluate information regarding the plans and capabilities of CMB experiments that are expected to take data in the next 10 years, and which contribute to the CMB-S4 science goals, to determine how best to use and expand beyond those capabilities.
2. Optimize an all-Chile design: Develop the revised design for a Chile-only concept, incorporating the significant design work already done by the CMB-S4 collaboration for both sites, using well-developed scientific, engineering and project planning tools

We anticipate receiving draft reports by the end of CY2024. After integration of the studies, we expect to receive the report on a revised design concept in spring 2025. It is expected that the concept would form the basis for the development of a full conceptual design and project plan over an approximately two-year period, at the conclusion of which the agencies would reach a decision on whether to move the project into the conceptual design phase for the NSF and to fully develop the project conceptual design and approve critical decision 1 (CD-1) for the DOE. Within this timeframe, and allowing for a positive decision from the agencies, the project could be ready for a joint DOE and NSF review of the conceptual design by early FY2027.

We sincerely appreciate your efforts in carrying out these studies and will meet with you regularly to stay informed of your progress.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Chile Configuration Optimization

Immediate goal is to determine the scope, costs, and risks of an all-Chile configuration that is able to address all of the CMB-S4 science goals, and is optimized to meet the inflation science goal of $\sigma(r) \leq 5 \times 10^{-4}$ within a reasonable survey duration ($\lesssim$ 10 years).

Work is organized in five main areas, utilizing the existing Project and Collaboration structures as much as possible:

- Simulations and Forecasting
- Small-Aperture Telescope Design
- Large-Aperture Telescope Design
- Site Design
- Cost Modeling

Status:

- Full coordination group meeting weekly; many weekly sub-group meetings
- Progress is being paced by the Simulations and Forecasting, which have incorporated improved SAT models and scan strategies
- Cost and schedule impacts are being captured in the project plan, at a detailed level.
- Initial (partial) draft report in progress; final report in December.

CMB-S4 Strategy for Observing from Chile

Wide-deep “legacy” survey to be conducted by two 6-m LATs over 7 years (14 LAT-years), as in the previous 2-site configuration.

Ultra-deep survey for inflation science to be conducted by SATs covering the four cleanest patches of sky visible from Chile (the “Southern Hole” patch plus 3 others).

- Explore a range of configurations of the SATs:
  - Density of detectors on the focal plane
  - Number of frequency bands and bandwidths
  - Aperture (diameter of rotating half-wave plate)
- Optimize scan strategy
  - Choice and weighting of sky patches to minimize impact of galactic foregrounds
  - Solar and lunar avoidance
- Optimize siting of SATs (minimize ground pickup within reasonable cost)

CMB-S4 Strategy for Observing from Chile

Large-Aperture Telescope surveys:

- A de-lensing survey to support the B-mode search to be conducted by one or more 6-m LATs viewing the same sky patches as the SATs.
- De-lensing and legacy surveys may be shared/interleaved among all of the LATs to optimize efficiency and minimize cost.

We hope to collaborate with the Simons Observatory and the South Pole Observatory (SPT and BICEP Array) to combine analyses with them to reduce the total data required to be taken by CMB-S4.

Survey Of Current CMB Experiments

The purpose of the Current Experiments Working Group is to collect and evaluate information regarding the plans and capabilities of current CMB experiments that are expected to take data in the next 10 years and are able to address one or more of the CMB-S4 Science Goals, in order to inform CMB-S4 Project Management in planning the revised configuration of CMB-S4.

- Confidentiality: Meeting discussions, meeting notes and all other material except public reports is to be confidential to the WG. Outside subject experts invited to attend meetings are informed that the information they provide is confidential to the WG unless they grant permission to include information in the public report.

Status:

- They are collecting and evaluating information, concentrating on what they have determined are the most relevant experiments: SPO (BICEP + SPT), SO, LiteBIRD, plus a possible future satellite mission based on the PICO proposal.
- In consultation with forecasting experts, they have determined their methodology for comparing different experiments, including simulating the expected noise performance for each experiment.
- Preliminary (partial) report in progress; final report in December.

Steps Following the Conclusion of the Two Working Groups: Defining the Revised Configuration

- The combined results of the two working groups will be evaluated against the goals of the studies and will be used to define **a revised configuration** that, *building on the expected results of current experiments*, allows CMB-S4 **to achieve the goals set out in Astro2020, the 2023 P5 Report, and the CMB-S4 Program-Level Requirements**.
- The process for converging on a revised CMB-S4 configuration includes the following elements:
  - The Project and Collaboration leadership, working closely with the Project L1 Team and the Collaboration Science Council, will propose a revised configuration.
  - A draft document will be made available to the full Collaboration describing: the revised configuration; its science capabilities, risks, and cost; how it fits into the landscape of other experiments; and the rationale for choosing it.
  - The revised configuration will be vetted during the CMB-S4 Collaboration Meeting in March.
  - The report will be revised, if necessary, following the collaboration discussion.

Steps Following the Conclusion of the Two Working Groups: Funding Agency Approval

- The final report will be presented to the Funding agencies in Spring 2025, both as a written document and in an in-person briefing.
- Assuming a favorable outcome - in terms scientific capabilities, cost, schedule and risk - of the design studies carried out by CMB-S4, and following the briefing on the report, CMB-S4 will request that the Funding Agencies give the Project approval to proceed to develop the revised concept to the level required for NSF CDR and DOE CD-1 and will request that NSF propose to the NSF Director that CMB-S4 be placed into the Major Facilities Design Stage.
- Assuming adequate funding from the DOE and the NSF, the Project will fully develop the revised conceptual design and project plan to the level required for CDR and CD-1 by the end of FY2026, and the Funding Agencies will schedule a joint CDR / CD-1 Review to take place in early FY2027.
- A substantial increase in funding above current levels ($4.5M and $4.0M from DOE and NSF respectively this year) will be required in FY 2026 to achieve readiness for CD-1 and CDR in early FY 2027.

Summary of the Planned Timeline

FY24 Q4 - FY25 Q1:	Complete studies by the two Working Groups
FY25 Q2:	Analyze results and conclude on the revised configuration of CMB-S4
Spring 2025:	Brief the NSF and DOE on the revised configuration and seek concurrence
FY25 Q3-Q4:	Value engineering studies to optimize the revised configuration for cost while maintaining scientific capability
FY26:	Develop the conceptual design to readiness for CDR and CD-1, to the extent that funding permits
FY27 Q1	CDR and CD-1 Review (goal)

Conclusions and Future Prospects

- **We have a focused action plan for reconfiguring CMB-S4 in Chile**, which we are executing and which is consistent with a written charge jointly signed by the two funding agencies.
  - Developing and optimizing the all-Chile configuration
  - Surveying the landscape of CMB experiments to determine CMB-S4's role in it
  - Combining the two studies to determine a revised configuration that will form the basis for a complete conceptual design, in conjunction with expected capabilities other experiments.
  - Moving toward readiness for CD-1 and CDR by the end of FY 2026, if funding permits.
- The funding situation at least through FY25 is very challenging, but we are able to execute this plan, while continuing modest technical development in key areas.

- **CAA's continued strong support** for executing the science vision of CMB-S4 as one of the top priorities of the Decadal Survey is very important.
- **We seek your support** for a prompt decision to proceed toward CD-1 and CDR once our report is delivered in the spring, and for adequate funding to complete the revised conceptual design in a timely manner.

Backup

Full Charges for the Working Group Charges

CMB-S4 Project Coordination Group: Optimize an all-Chile CMB-S4 Configuration

Charge

Purpose The purpose of the Chile-Optimization Coordination Group is to coordinate studies to optimize the design concept for an all-Chile configuration of CMB-S4 that will form the basis for developing a full conceptual design and project plan. The Coordination Group is led by and reports to the CMB-S4 Project Director and to the NSF PI / Project Scientist.

Charge Starting from the point design represented by Alternative 3 in the Analysis of Alternatives that was reported to the Funding Agencies in December 2022 and to the Director's Review in November 2023, develop a more optimized configuration of CMB-S4 with all telescopes located in the high Atacama desert in Chile. The goal is to propose an all-Chile configuration that is able to address all of the CMB-S4 science goals, and is optimized to meet the inflation science goal of $\sigma(r) \leq 5 \times 10^{-4}$ within a reasonable survey duration ($\leq$ 10 years), for a reasonable total project construction cost (DOE TPC + NSF MREFC $\leq$ $1B), with an acceptable level of scientific risk. The estimated survey duration, cost, and scientific risk, as well as uncertainties in them, should be quantified to the extent possible.

The work of optimizing the all-Chile configuration will focus on four main topics:

- Science simulations and forecasting, including: numbers and types of telescopes; optimal frequency bands and survey strategies; foregrounds; delensing strategies; systematic errors for different telescope designs and configurations.
- SAT design options for Chile conditions.
- LAT design options to address both the wide-deep survey and de-lensing requirements.
- Site design development and constraints.

Areas where additional information is needed to advance the design or to quantify the scientific and technical risks should be identified and the means to obtain the information (e.g. focused R&D or data provided by other experiments such as the Simons Observatory) should be specified, together with a rough timeline for when sufficient information would be available.

Membership The Coordination Group consists of the leaders of working groups on each of the four topics listed above, which represent respectively the inflation science simulation and forecasting group, and the Project L2 organizations for SATs, LATs and the Chile Site. Additional members may be chosen by the Project Director and Project Scientist. The working groups will draw upon the expertise of the entire CMB-S4 Collaboration and Project to obtain and develop information needed to do their work.

Reporting The Chile-Optimization Coordination Group should provide regular reports to the CMB-S4 Collaboration and Project, including progress reports to the CMB-S4 Level 1 Team on August 28 and September 25. A preliminary written report should be delivered by October 31, 2024 and a final written report by December 20, 2024.

CMB-S4 Project Working Group: Survey of Current CMB Experiments

Charge

Purpose The purpose of the Current Experiments Working Group is to collect and evaluate information regarding the plans and capabilities of CMB experiments that are expected to take data in the next 10 years and are able to address one or more of the CMB-S4 Science Goals, in order to inform CMB-S4 Project Management in planning the revised configuration of CMB-S4. The working group reports to the CMB-S4 Project Director and to the NSF PI / Project Scientist.

Charge The Current Experiments Working Group is charged to collect and evaluate information regarding the plans and capabilities of CMB experiments that are expected to take data in the next 10 years and to be able to address one or more of the CMB-S4 Science Goals. Include experiments that are in operation, under construction, and realistically planned. Based on this information, provide projections regarding the expected science reach as a function of time for each experiment using relevant metrics for each science goal that can be used to compare the capabilities of each experiment relative to the CMB-S4 Science Goals. These projections should be based on those made by the proponents of each experiment. If the assumptions made by an experiment in making their projections differ significantly from those made by CMB-S4, provide an evaluation as to how the projections would differ if they were based on CMB-S4-like assumptions. Also, provide an evaluation of the risk regarding each experiment's ultimate capabilities. Identify and quantify gaps between the combined sensitivity of the experiments considered and the Science Goals of CMB-S4.

Experiments to be considered include:

- South Pole Observatory (BICEP + SPT)
- Simons Observatory
- CLASS
- CCAT Observatory
- LiteBIRD
- AliCPT
- Other experiments that the working group may identify in the course of its work

The Working Group should also comment on other relevant experimental programs that could be operational on the same timescale as CMB-S4.

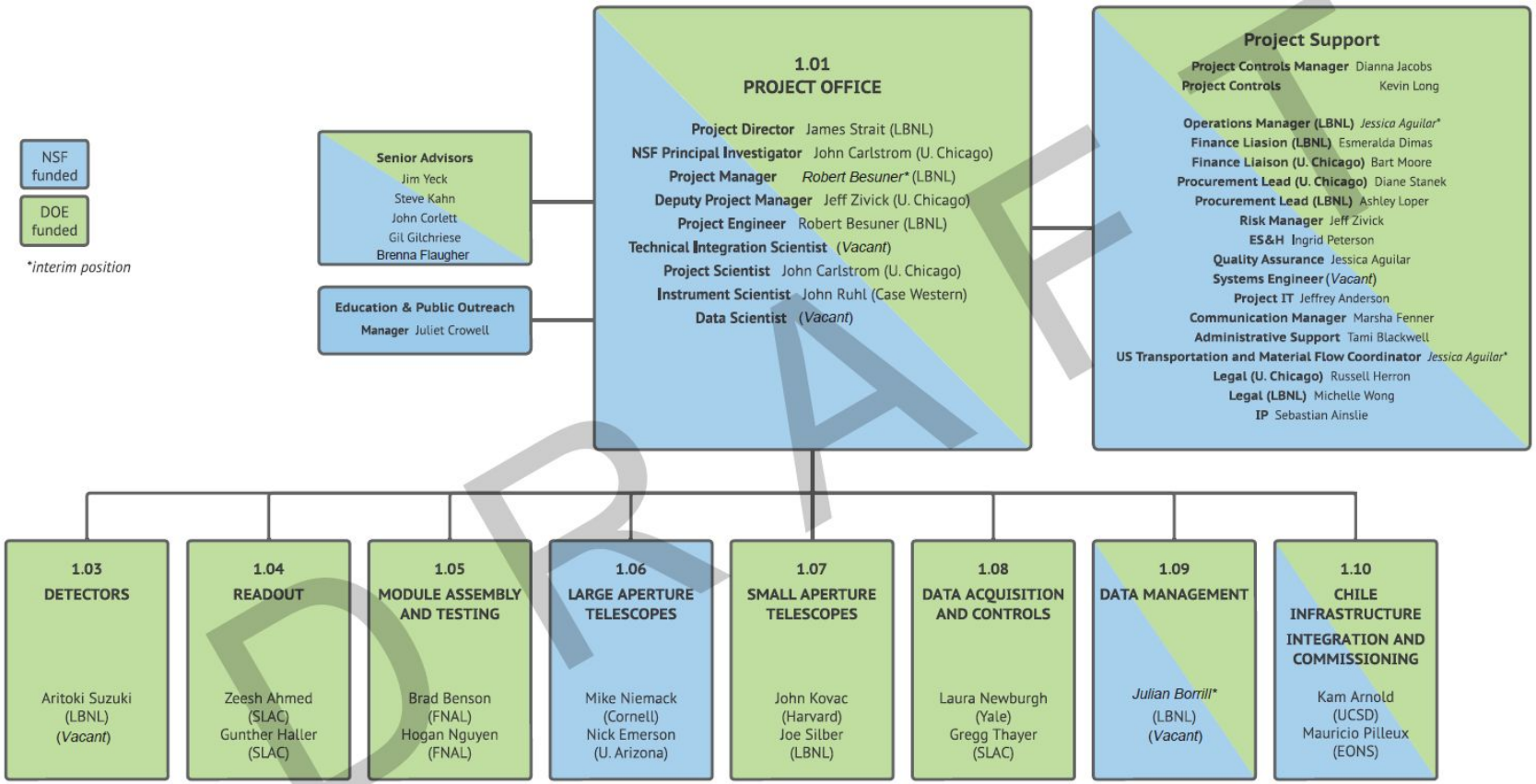
Membership The Current Experiments Working Group membership is mainly drawn from members of the CMB-S4 Collaboration and Project and includes members who are knowledgeable about each of the relevant experiments. The working group should draw upon the expertise of the entire CMB-S4 Collaboration and Project and that of the full CMB community.

Reporting The Current Experiments Working Group should provide regular reports to the CMB-S4 Collaboration and Project. It is asked to provide progress reports to the CMB-S4 Level-1 Team on August 16 and September 20, to submit a preliminary written report by October 15, 2024, for discussion at the L1 meeting on October 18 and a final written report by December 16, 2024.

A Strong and Enthusiastic CMB-S4 Science Collaboration

- CMB-S4 Science Collaboration is highly active and engaged
  - >500 members: primarily cosmologists, particle physicists, and astronomers (~⅓ international)
  - >115 institutions (>50 non-US)
  - >21 countries
  - >20 U.S. States
  - 2 major collaboration meetings/year
  - 1st collaboration meeting in 2015
  - Established a formal collaboration in 2018
- Laid the foundation for the Project:
  - Produced *CMB-S4 Science Book* (arXiv:1610.02743) and *CMB-S4 Technology Book* (arXiv:1706.02464); Second edition of the Science Book is in preparation.
  - Produced *CMB-S4 Science Case, Reference Design, and Project Plan,* for input to Astro2020 (arXiv:1907.04473)
- Next Collaboration Meeting will be the last week of March 2024.

CMB-S4 has a well developed organizational structure, staffed by experienced scientists, engineers and managers.



Funding

- Funding of $4.0 M for the second year of the NSF Continuing Design Cooperative Agreement was granted on August 27.
  - This is the level we had been told to expect.
  - It is 8% above the 1st year funding, but less than half the amount in the 3-year proposal.
- The President's Budget Request for CMB-S4 in FY 2025 is $4.5M from DOE. We have been assured by DOE that we can plan on this value.
  - This is flat-flat relative to FY 2024.
- A substantial increase in funding above these levels will be required in FY 2026 to achieve readiness for CD-1 and CDR in early FY 2027.