A Next Generation CMB program

Description: The Cosmic Microwave Background (CMB) community is currently in the initial stages of discussions about a next generation CMB polarization experiment (NG-CMB). The experimental design is in a pre-conceptual stage, but would likely consist of one or more ground-based reflective telescopes optimized for a comprehensive survey of CMB polarization. NG-CMB would be designed to observe the CMB sky in two modes – a deep survey over ~1,000 deg^2 targeting inflationary gravitational waves, and a large-sky-area survey over a large fraction of the low-galactic foreground sky, possibly up to ~30,000 deg^2 optimized for precision cosmology from the gravitational lensing of the CMB. The focal planes for these telescopes would support detectors to enable multi-frequency measurements to provide good foreground rejection capability. The NG-CMB experiment could require 100,000 or more background-limited detectors to achieve 10% of the survey speed of a proposed CMB satellite mission (NASA's CMBPOL). At least an order-of-magnitude increase in sensitivity over current and proposed experiments would be targeted. Such an improvement would translate to unprecedented scientific gains in fundamental physics: the study of inflation, dark energy, and cosmic neutrinos.

Science: A NG-CMB experiment would constrain inflation-induced CMB polarization signals to r~0.005 (tensor-to-scalar ratio) through multi-frequency observations. Additionally, large sky surveys would enable the experiment to utilize CMB lensing for precision cosmology. Such a survey would constrain the sum of neutrino masses to $\sum m_\nu$~0.05 eV, either resulting in a detection of the absolute mass scale for neutrinos or greatly aid in distinguishing between normal and inverted hierarchies. The NG-CMB would also improve the constraints on cosmological parameters such as mean spatial curvature to Ω_k~0.004 and scalar spectral tilt to n_s~0.003. Finally, the lensing data from such an experiment, when cross-correlated with those from other large-scale surveys such as DES, LSST and MS-DESI, would provide a uniquely sensitive probe of early evolution of dark energy in our universe. The science case outlined here will be explored and developed for Snowmass in summer 2013.

Collaboration: A number of current generation experiments with DOE lab involvement can be considered pathfinder instruments for the NG-CMB. These include: POLARBEAR a 2m off-axis telescope deployed by UC Berkeley/LBNL and collaborators in the Atacama desert in Chile, with 2 additional telescopes funded and under construction; SPT-POL, a polarimeter deployed on the 10m South Pole Telescope by U Chicago/ANL and collaborators, and SPT-3G, its planned focal plane upgrade; and POLAR-1, a 1.6m crossed-Dragone telescope being developed by Stanford/SLAC and collaborators. After this initial round of discovery experiments, we anticipate convergence on an optimized configuration of the NG CMB leading to a proposal for a single, coherent program. At the moment, members from four DOE national laboratories (ANL, FNAL, LBNL and SLAC) and their associated university groups (UC Berkeley, Caltech, Case Western Reserve, Colorado, Chicago, Harvard, McGill, Minnesota and Stanford) are discussing paths toward such a consolidated program. This informal coalition is envisioned to become the core of an NG-CMB collaboration.

Costs: The estimated construction cost for the NG-CMB is crudely estimated to be ~$50 - 100M depending on the total size of the number of elements, sites and detector technology, in addition to R&D for instrument development and data analysis.

Science Classification and Readiness: All technical and programmatic elements of the NG-CMB program come from the field-tested, decade-long lineage of successful CMB experiments.

However, the development, fabrication, testing, and quality assurance of the large detector arrays vastly exceed the capabilities of current CMB groups based at universities. Therefore, the participation of detector groups at DOE laboratories will be essential to scaling up these pioneering experiments, realizing corresponding efficiencies, and managing an investment of this scale. Successful operation of the current generation of experiments will also greatly reduce the majority of challenges and technical risks to pursuing a full NG-CMB program. The construction of such a facility would likely take 3-4 years after the prototyping phase (2 or more years), followed by 5 years of observations.