LOI for development of bolometer readout for CMB-S4.
Submitted by Kam Arnold, UC San Diego.

Introduction: Scalable readout of bolometer arrays is one of the key developments necessary for CMB-S4. Existing readout technologies do not have the necessary multiplexing factor to reduce wiring complexity in the integrated camera and achieve high-yield readout of the detector arrays. This LOI covers two possible future technologies: microwave multiplexing (umux), the scheme currently being developed for Simons Observatory and BICEP Array, and Digital frequency-division multiplexing (DfMux) with sub-Kelvin SQUIDs, the scheme currently being developed for the LiteBIRD satellite project.

Participating Institutions: This LOI covers only work at UC San Diego. I expect to coordinate this work with SLAC (in the case of umux) and LBNL (in the case of DfMux).

The 3-year work plan would be discussed and coordinated with SLAC and DfMux. The goals below represent important goals in the readout development that UC San Diego has the expertise and resources to carry out.

Goal 1, umux: Demonstrate microwave performance of fully assembled detector wafer packages, ensuring that transmission ripple and reflections meet the specification. Simulate designs using electromagnetic simulation software to minimize reflections and optimize resonator coupling. Design and test an optimal wirebonding scheme, possibly using ribbon bonds.

Goal 2, umux and DfMux: Assess the temperature sensitivity of all the readout components, both warm and cold. Determine temperature stability requirements (cryogenic and room-temperature electronics). These are key requirements for engineering cameras with stable readout. Quantify data transmission requirements for both sites and carry out trade studies for each site on systems that can satisfy site requirements. *Develop a conceptual design for the data transmission system and a preliminary cost and schedule. Begin the detailed engineering design, refine the cost and schedule in preparation for CD-3a approval.*

Goal 3, umux and DfMux: Demonstrate crosstalk between multiplexed detectors and simulat observations with that level of crosstalk to ensure that it is low enough to achieve the CMB-S4 science goals.

Goal 4, umux: Demonstrate that the 4-8 GHz band umux is compatible with the lowest frequency bolometers for CMB-S4, which will be sensing radiation in the 20-30 GHz range.

Resources requested: The requested resources for each year are 50% support for a postdoctoral scholar and full support of a graduate student. This support is critical to bring in new resources and do new work dedicated to CMB-S4 while Simons Observatory cameras integrate and deploy to the Chilean site. We would also need support for the necessary microwave supplies to do the testing, and support to build custom mechanical housing parts and

printed circuit boards. We assume that we would be receiving hardware from NIST and SLAC as part of a coordinated effort.

Relevant Existing Effort: Kam Arnold's lab at UC San Diego has a BlueFors dilution refrigerator being used for testing Simons Observatory microwave multiplexing readout (umux). By the end of 2018 there will be a complete umux system operational in this dewar. This dewar is also being used to test sub-Kelvin squid implementations of DfMux. This lab is also integrating and deploying the POLARBEAR-2b camera, which is a camera using DfMux to read out 7000 detectors.