（別紙様式５）

変革を駆動する先端物理・数学プログラム（FoPM）

国外連携機関長期研修　報告書

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The purpose of this research trip was test of instruments for a telescope of the Simons Observatory (SO), which is a next generation's Cosmic Microwave Background (CMB) experiment. In this research trip, I have done the following things.

**Simons Observatory Collaboration Meeting**

In the first week, I attended the collaboration meeting of the Simons Observatory (Figure 1). The collaboration meeting in person was the first time in three years, and it was the first time for me to meet collaborators in the U.S. and Europe. In the meeting, we shared the status and test plans of the telescopes which will be deployed at the Atacama Desert, Chile in a year. I presented my analysis preparation for the beam calibration to the collaborators.

Figure 1. The photo of the collaboration

**The Final Test of the Small Aperture Telescope of the Simons Observatory**

The Small Aperture Telescope (SAT) is a telescope of the Simons Observatory for the investigation of the inflation of the universe. The final test of the SAT before the deployment will be conducted in UCSD in October. I have done some preparations for the final test of the SAT.

Setup of the Readout System

We use Microwave SQUID Multiplexing (μMUX), which read out superconducting detectors coupling to microwave resonators, as the readout of the detectors. I set up the readout system which is compatible to the deployment level one. The new things from before is (a) full seven readout boards, (b) setup of timing system for the data acquisition includes a timing master card and fanout boards which distributes the timing signal.

(a) We will use seven readout boards per telescope to readout over ten thousand of detectors. I setup these boards and tested simultaneous data streaming (Figure 2). One thing to watch for is the temperature of the boards. Boards are Field Programmable Gate Array (FPGA) ones, and such a high loading data taking dissipate much heat. Unlike the Atacama Desert, we need to cool the readout system in the testing at warmer San Diego so as not to damage the readout boards. Then I also setup a small tent and two air conditioners for cooling. Under this setup, I conducted full data streaming test with logging the temperatures of each readout board. I confirmed that the temperatures do not go up and got the readout system ready for the final test.

Figure 2. Cooling tent of the readout system for the final test

(b) Each readout board has each timestamps according to its internal clocks without external clock. It is enough for lab tests, but an external clock is necessary for the deployment. It is because we need more stable and universal timestamps for the demodulation of modulated signal and the simpler analysis. I setup the overall timing system with a timing master card which generate the timing signal and fanout cards which distributes the timing signal to each readout board via optical fibers (Figure 3). The hardware setting has been done, and I will setup the software from now on. Moreover, I am planning to overall timing test to confirm the timestamps of each board accurate and synchronized by sending pulse signals to the superconducting detectors during the final test.

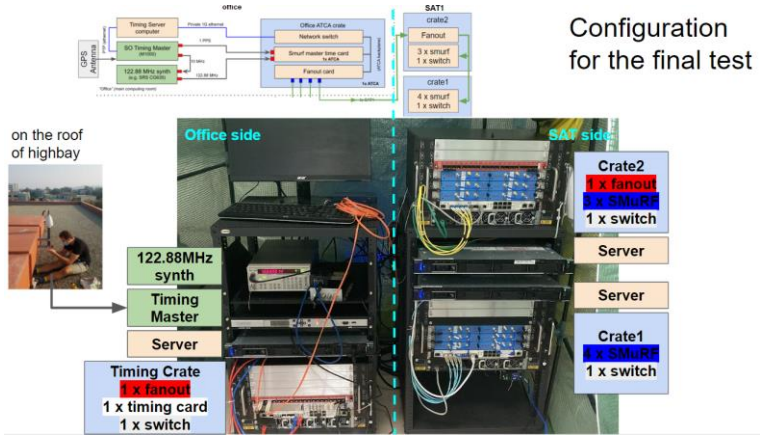


Figure 3. The whole readout system with the timing system. The upper schematics represents the lower picture of all readout system. The timing signal generated in the lower left timing card (white) is distributed to each readout boards (blue) via fanout (red).

SAT Installation

We started closing the cryostat of the telescope in the last a few weeks of my stay. The SAT consists of a vacuum chamber, an optics tube, cryogenic polarization modulator, a dilution refrigerator, and detector modules on the focal plane. The closing is ongoing, but I contributed to the preparation of the frame jigs to support different temperature stages with few thermal flows from high temperature stage to low temperature stage and installation of the dilution refrigerator unit into the vacuum chamber.

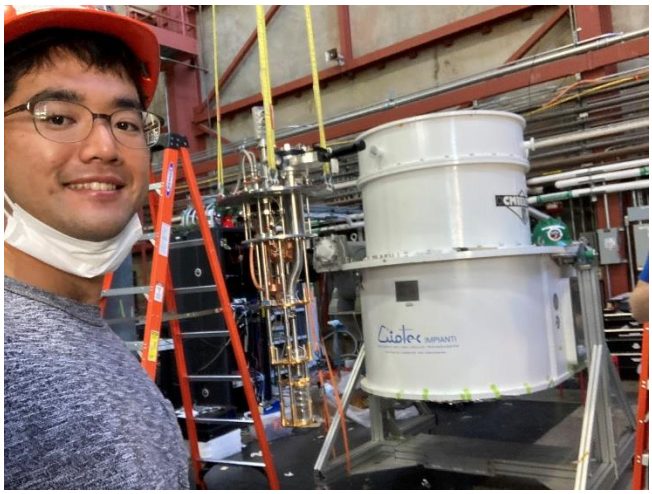

Figure 4. The picture of SAT with me. The right part is the vacuum chamber of the telescope. The refrigerator unit for cooling of the telescope is hanging at center. It was installed to the chamber after that.

Assembling Test of the Wiregrid

Wiregrid is a calibrator for the polarization angle of each detector. It mounts on the window of the telescope and generate polarized radiation with reflecting ambient radiation. I contributed to the assembling test of the wiregrid.

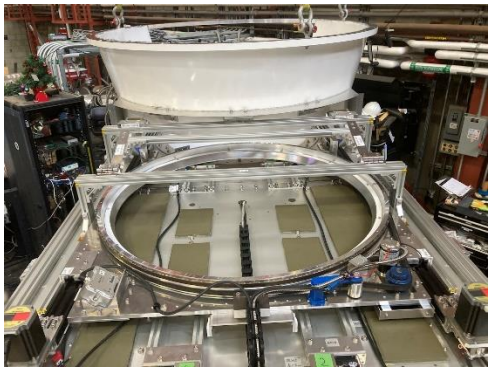

Figure 5. The picture of the wiregrid calibrator mounts on the window.

**Acknowledgement**

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