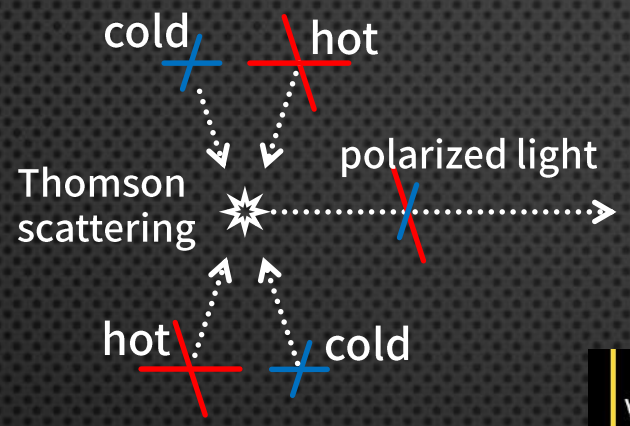
Recent progress of Simons Array experiment

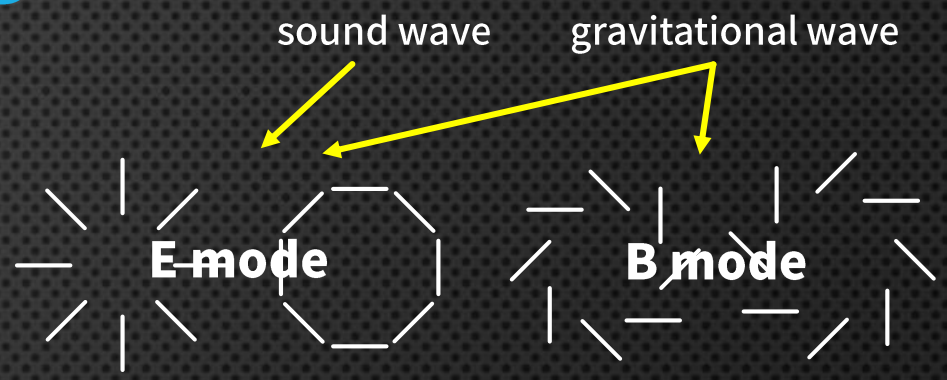
Daisuke Kaneko,

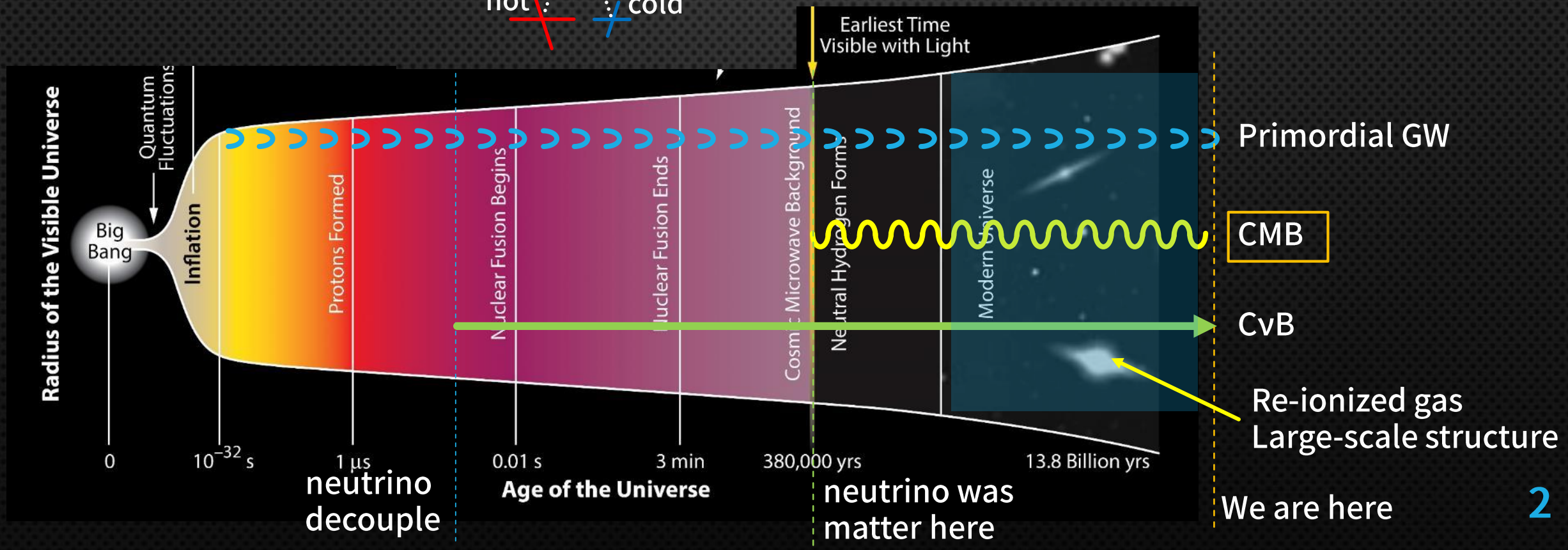
on behalf of POLARBEAR collaboration

Beginning of the universe and CMB

Both sound wave and gravitational wave make quadrupole temperature anisotropy.

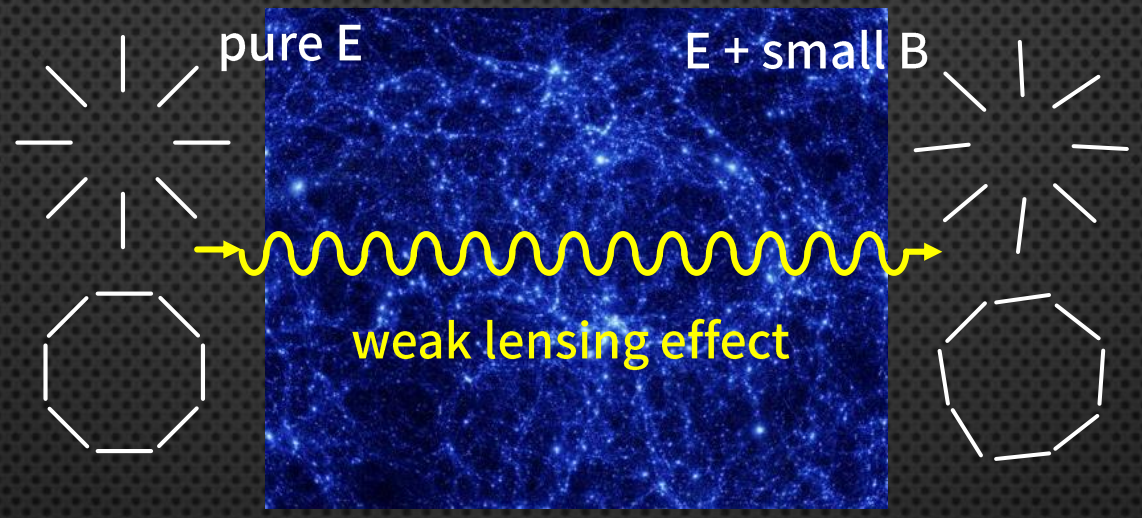




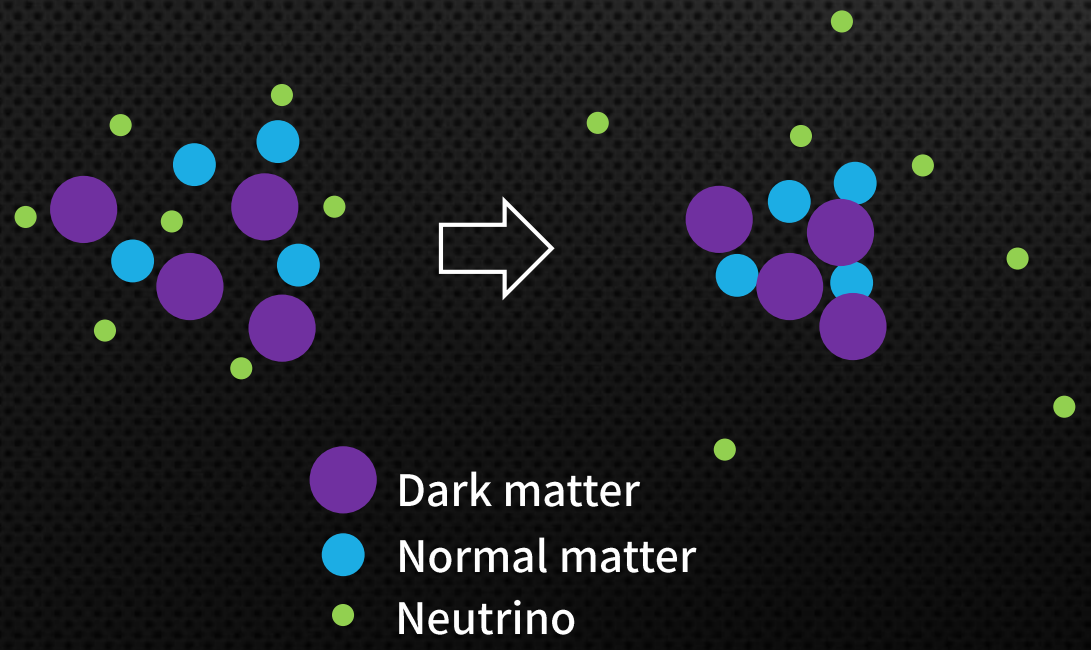


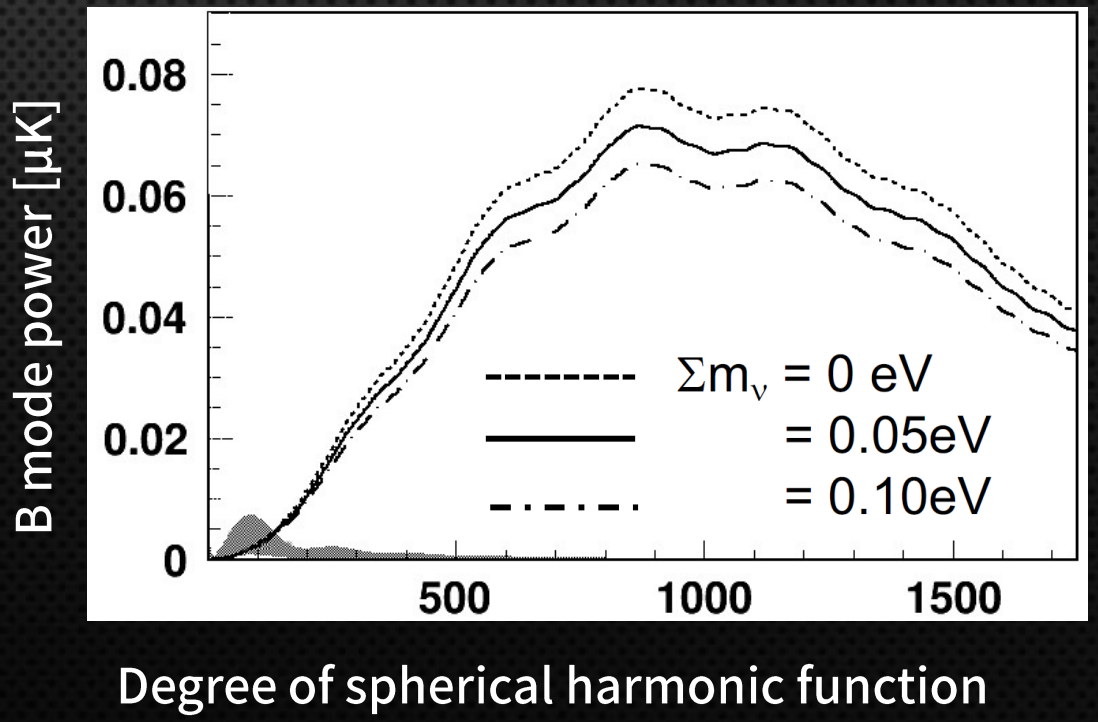
CMB observation and neutrino mass

Dark matter and normal matter concentrate to form largescale structure, but neutrino don't in small scale.

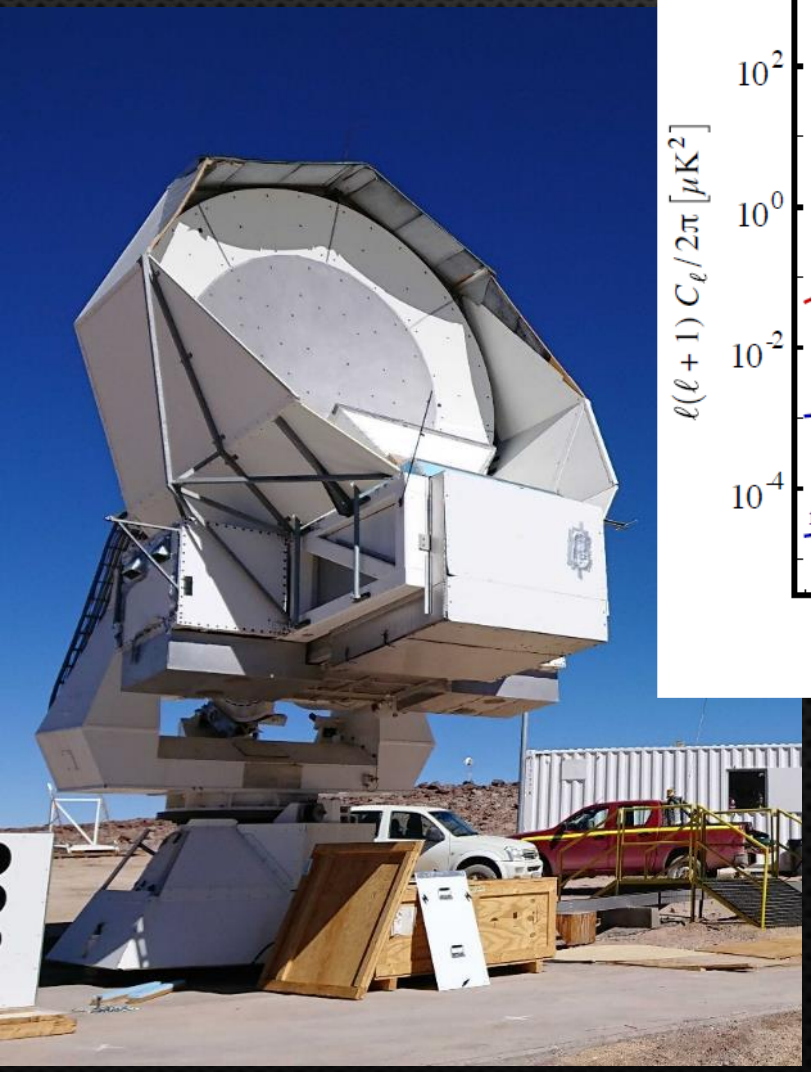


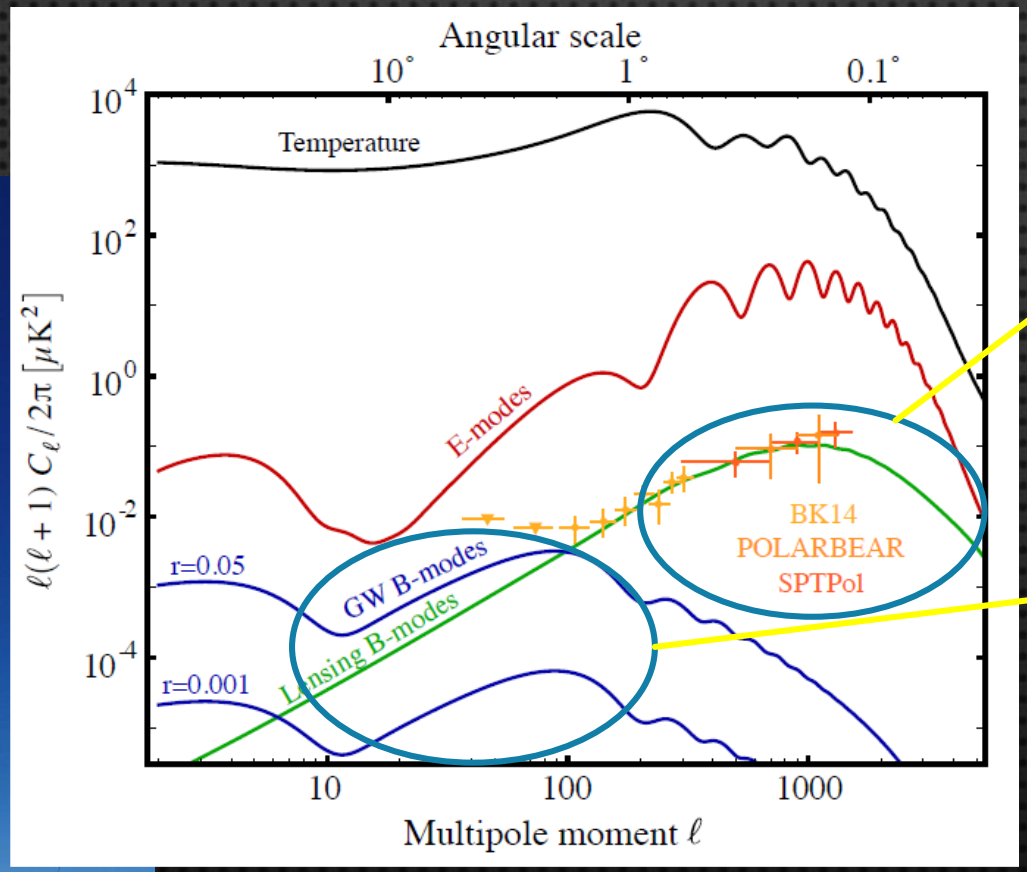
Sum of the neutrino mass can be measured as the height of B mode peak. Degradation with $\Omega_m h^2$ should be solved by galaxy survey (BAO).





What POLARBEAR / Simons Array aim at





After 3years observation with designed specification

☆ Neutrino mass
→ $\sigma(\Sigma m\nu) = 40$ meV
(w/ DESI BAO result)

☆ Inflation
tensor to scalar ratio: r
→ $\sigma(r)\,|_{0.1} = 0.006$

Expected sensitivity
90 GHz: 4.1 μK$\sqrt{s}$
150 GHz: 3.4 μK$\sqrt{s}$
220 GHz: 11.5 μK$\sqrt{s}$

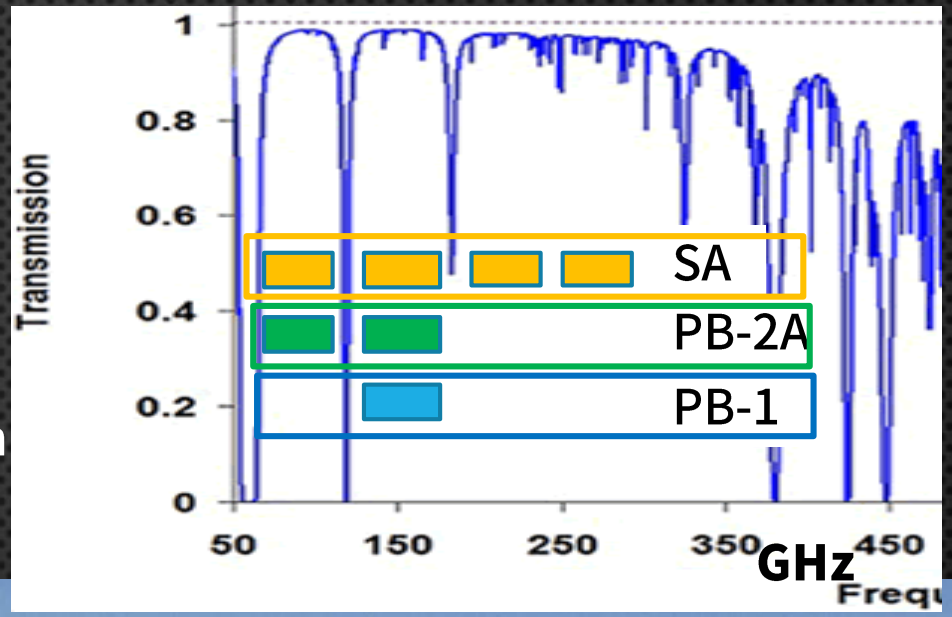
POLARBEAR-2 or Simons array

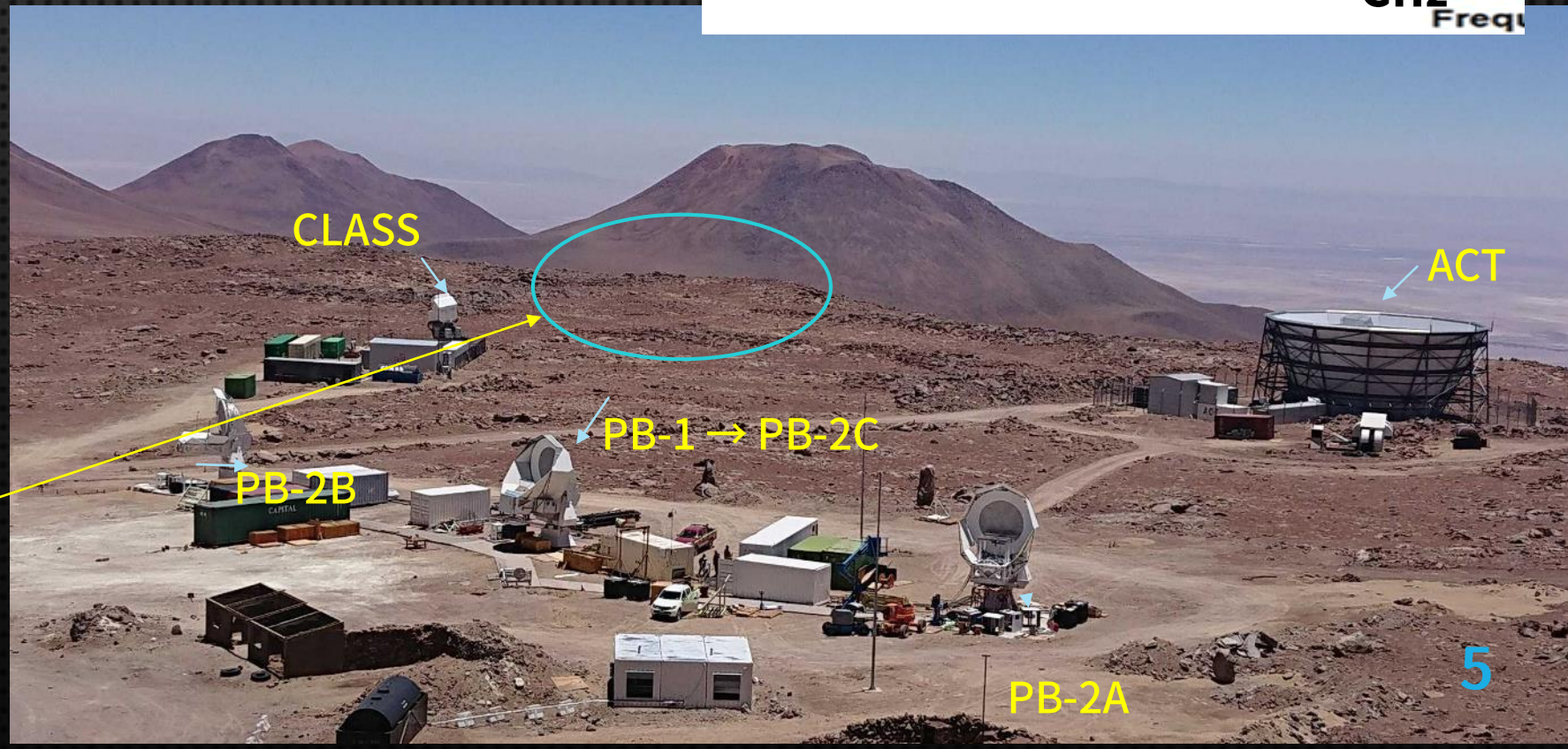
POLARBEAR
- CMB observation at Atacama, 2012 started observation

POLARBEAR-2
- Newly designed receiver for the same telescope with 6 times. more detectors. deployed in 2018

Simons Array
- 3 POLARBEAR-2 receiver

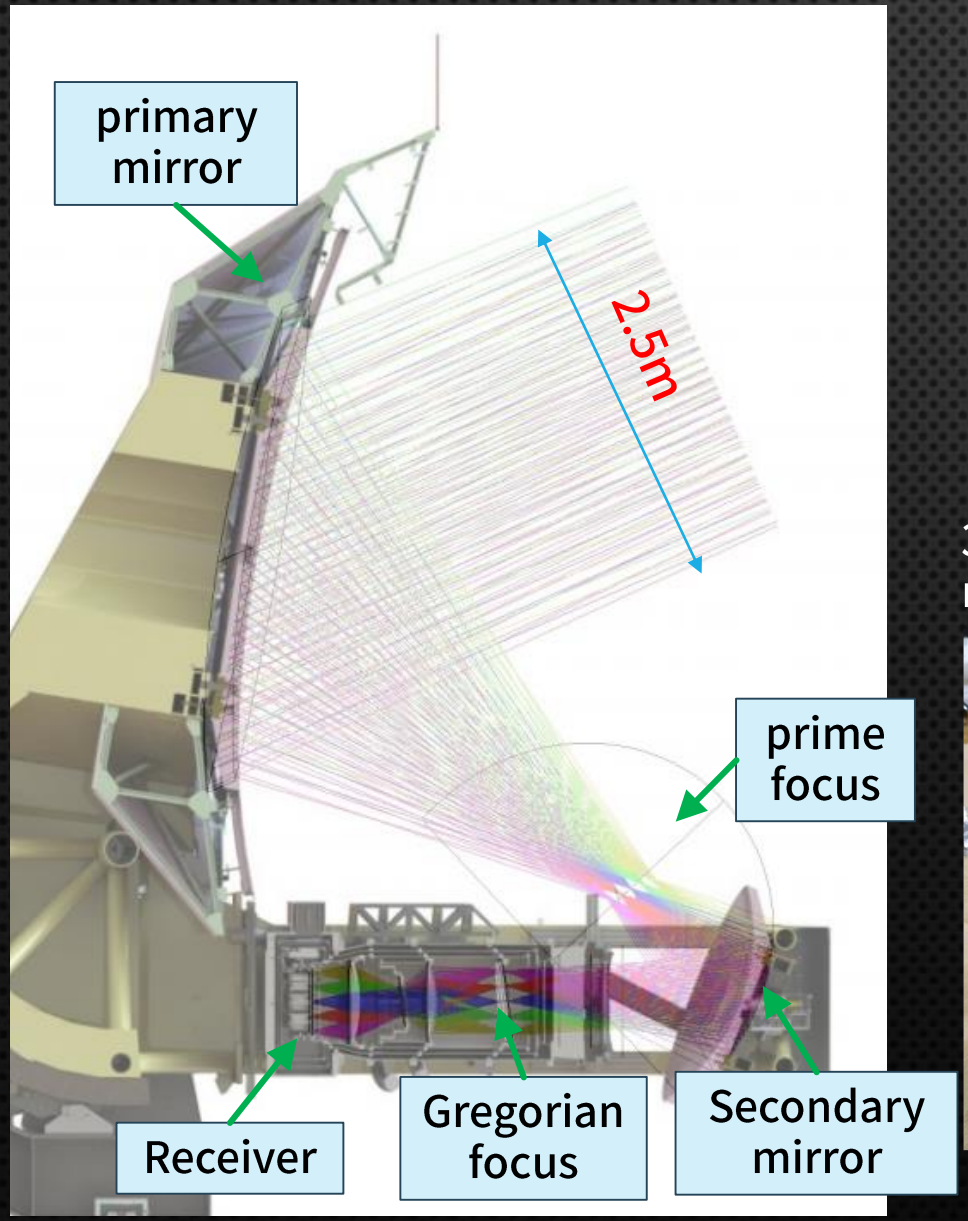
Observation bands →

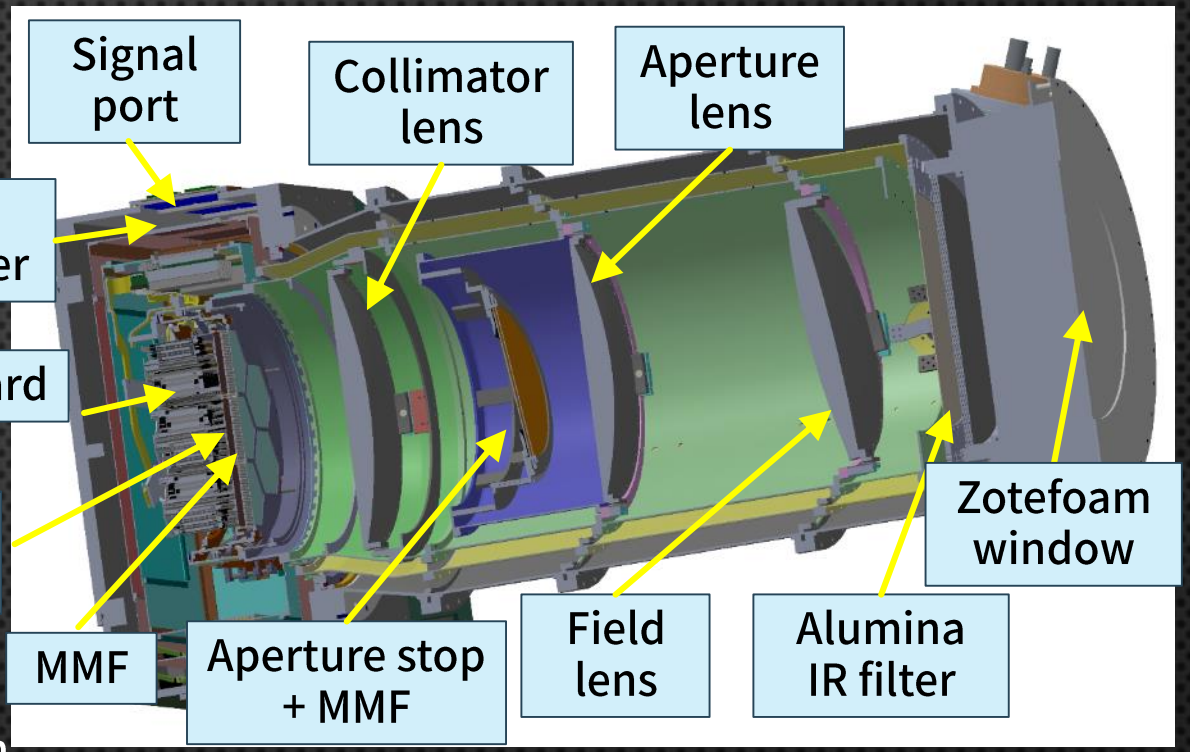




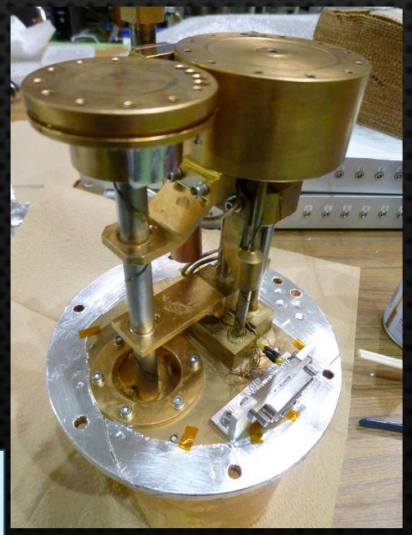
Simons Observatory around here

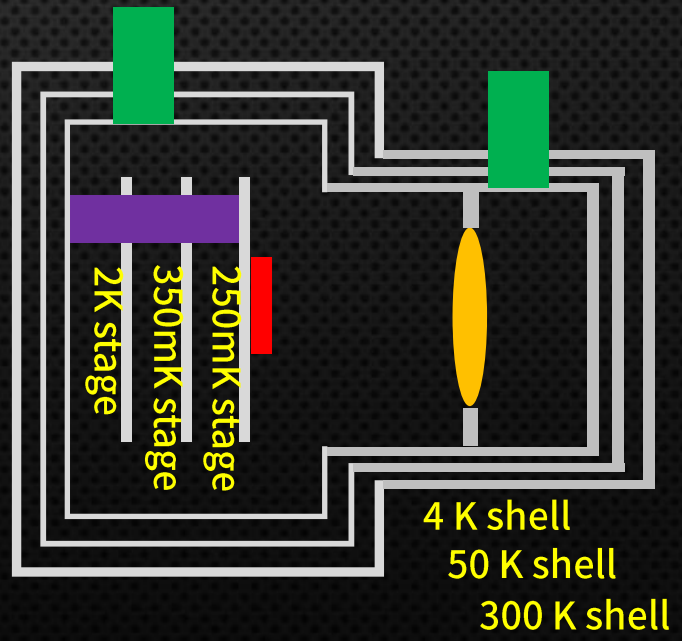
Design of PB-2A



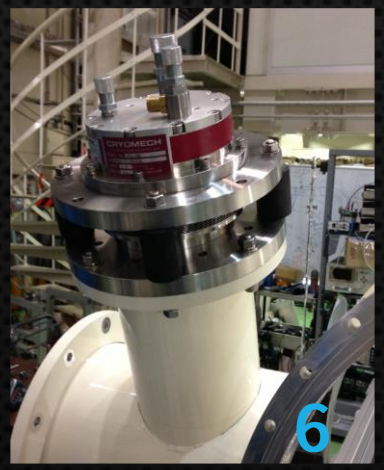


3 stage He sorption refrigerator



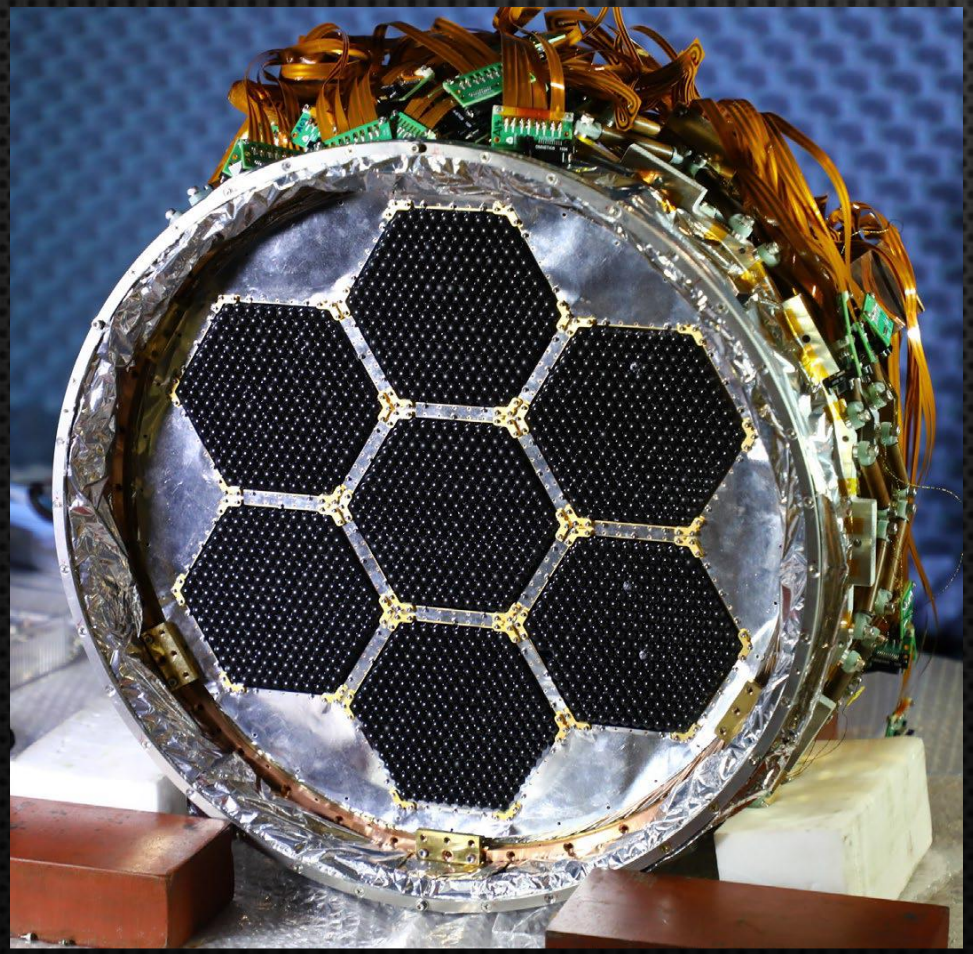


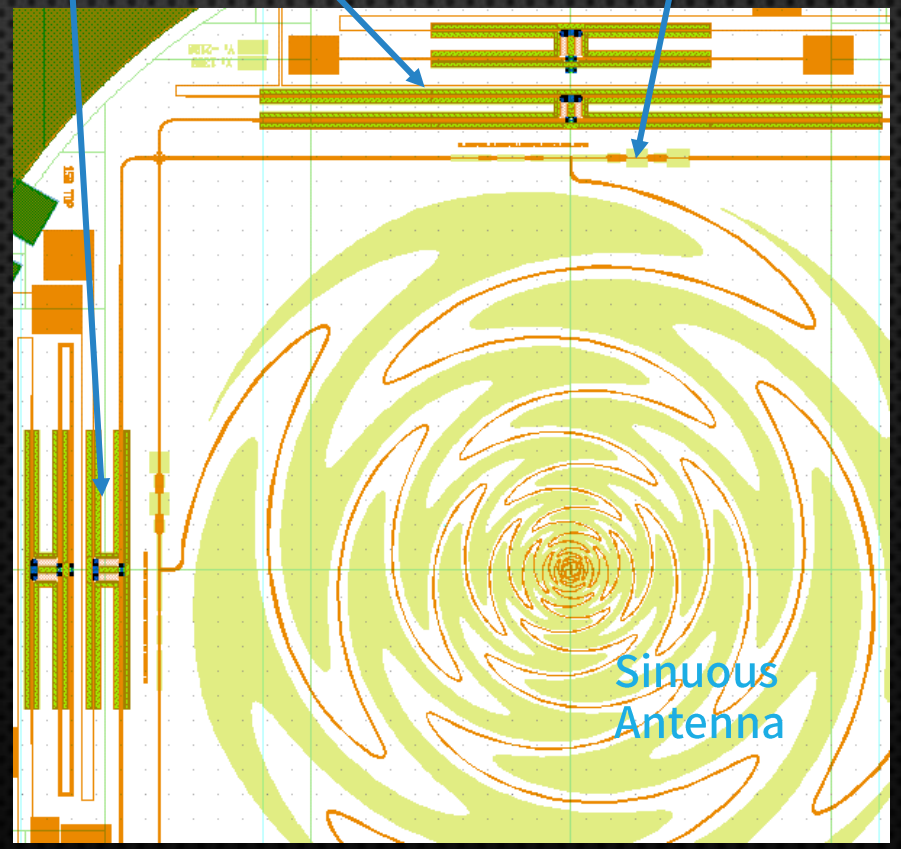
Pulse tube cooler cryomech PT415

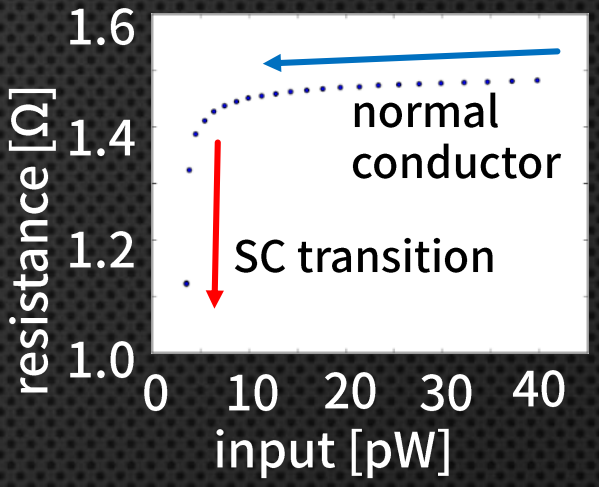


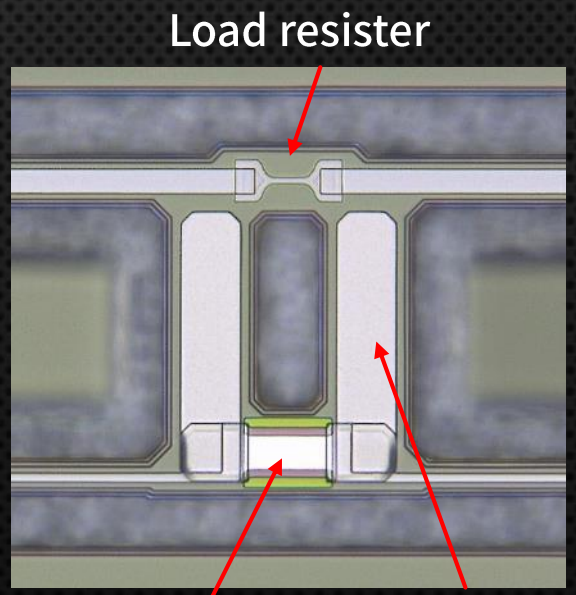
Focal-plane and detector design

7 detector wafers, 7588 TESs
on a focal plane



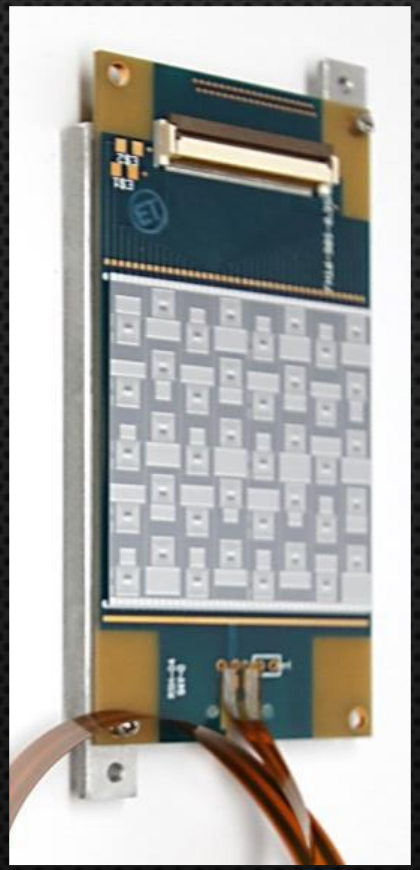


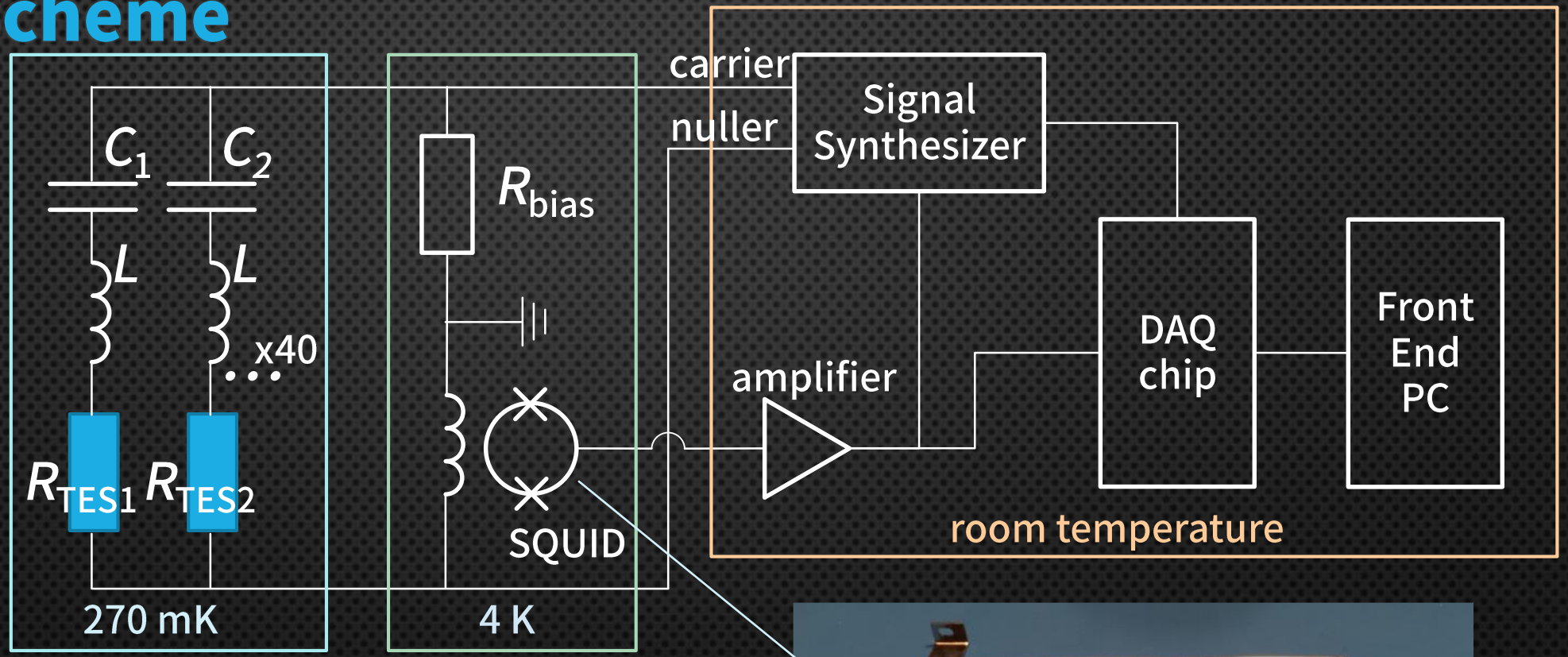


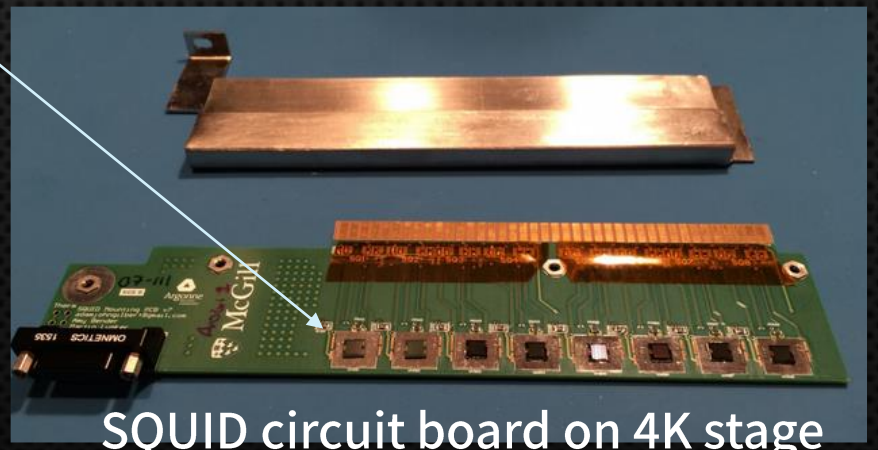


Readout scheme

LC circuit







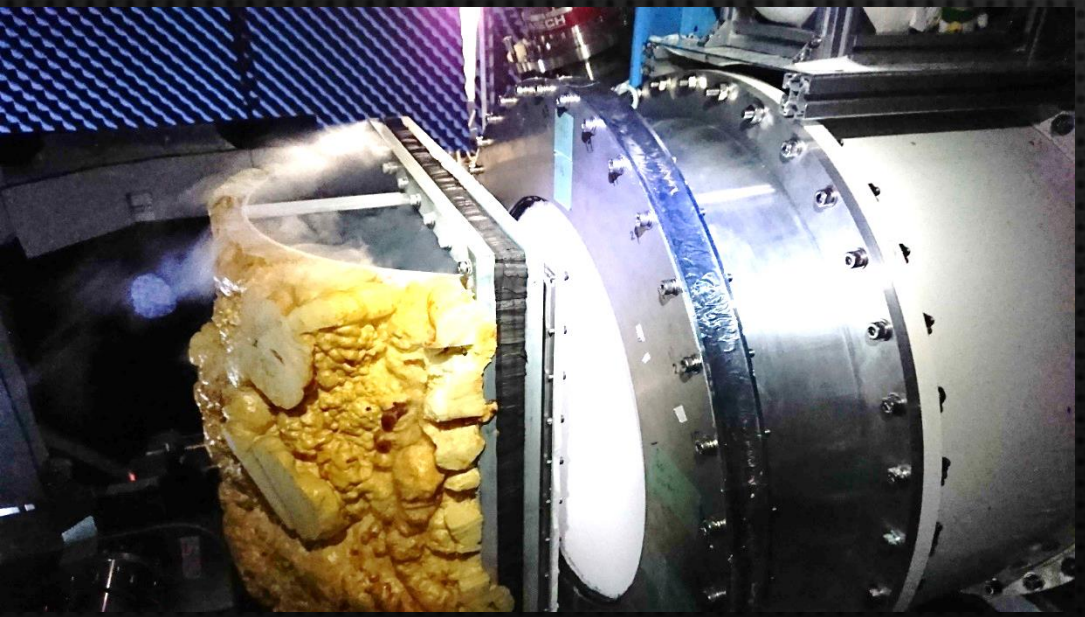
SQUID circuit board on 4K stage

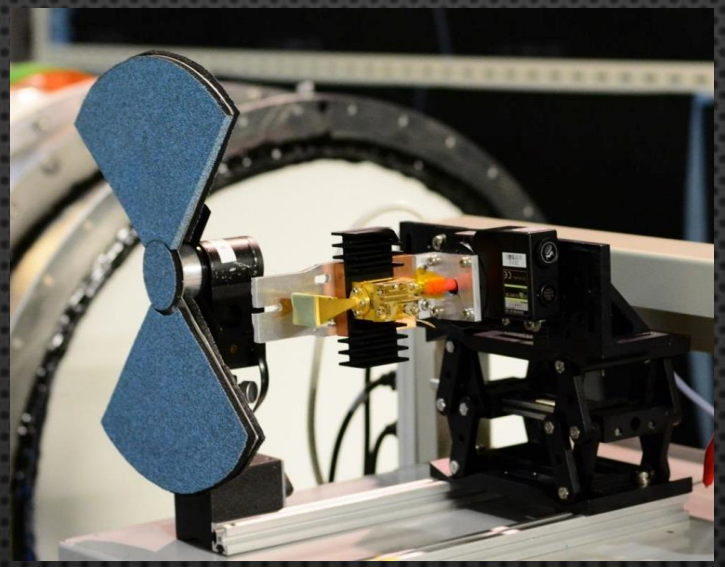
Capacitor and inductor are implemented as micro pattern

Lab Tests Finished

Liquid N2 bath

Optical yield
Optical efficiency



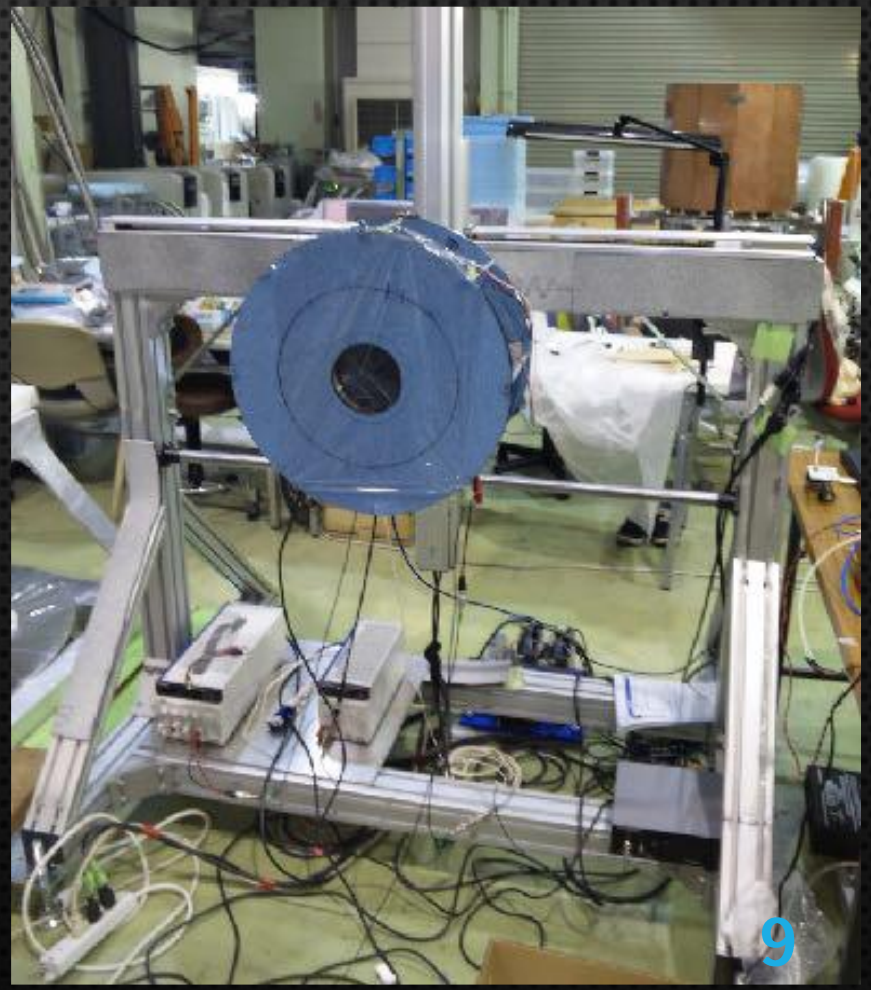


Coherent source

Channel assignment

Beam mapper
(movable thermal source)

Beam shape



Transportation to Chile

Documents for exports was tough work

← Special anti-shock palette with damper spring (patent of Nittsu)

Optics tube was disassembled for transportation.
↓

Seeing off crates to the site 2018 October 2nd ↓

Assemble at site

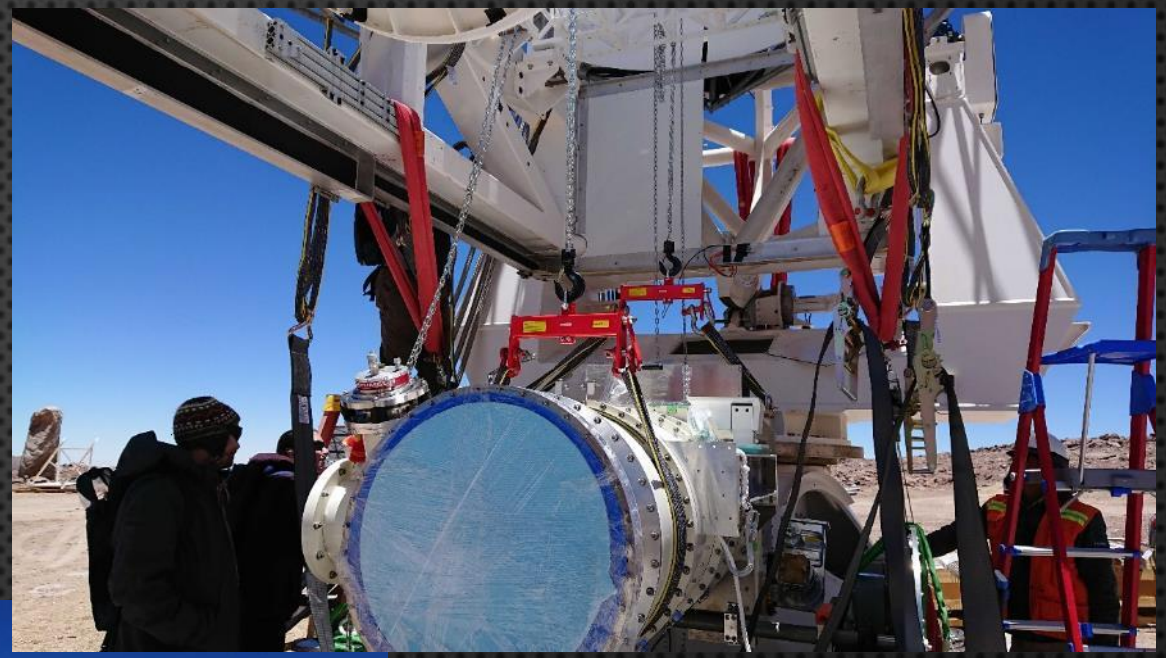
All crates arrived in end of October to the site.

We used ACT container for assembly.
The assembly work went smoothly, and was finished in 3 weeks.

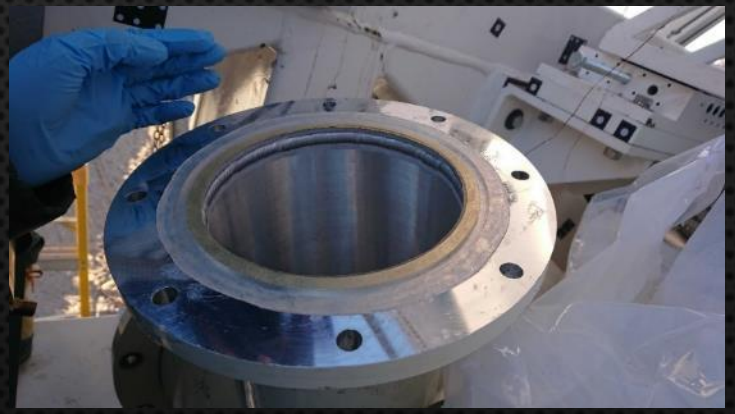
Mount to telescope

Temporary hoist system mounted on telescope
↓

Lifting receiver by hand. It took a half day →



Truck was hired for receiver transport
↓

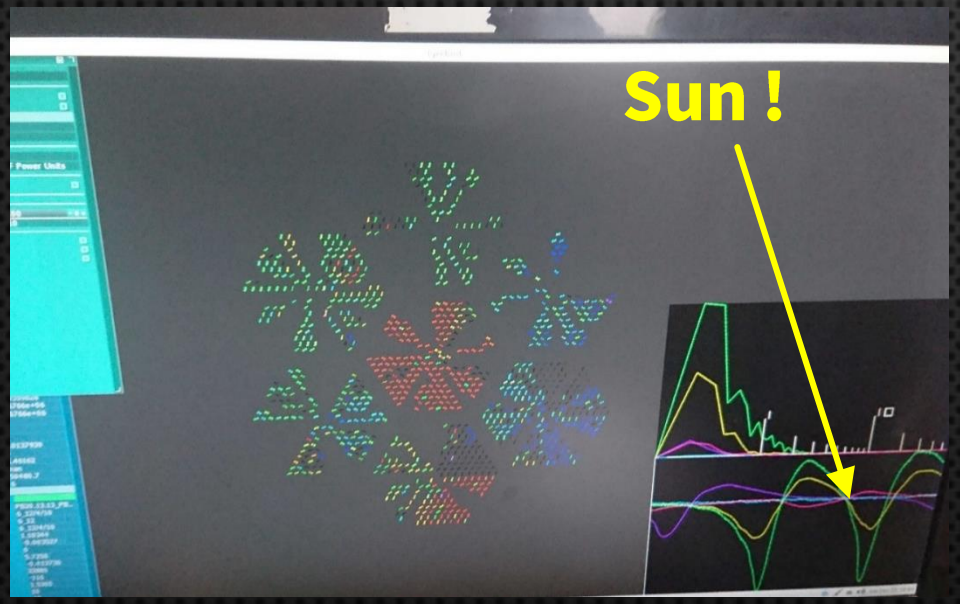


↑ Refrigerator's gasket replace on telescope, hardest work in my stay.

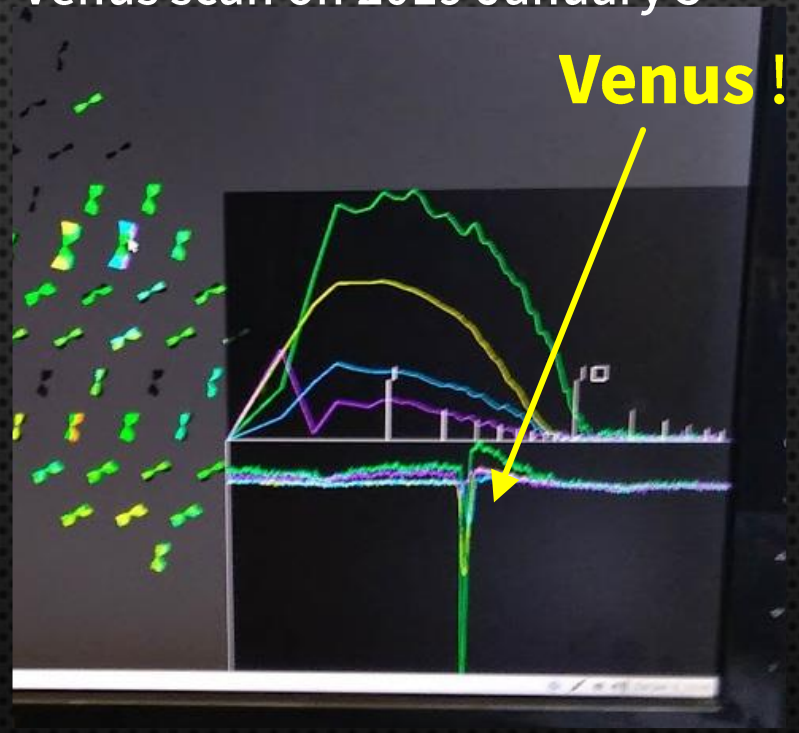
First observations

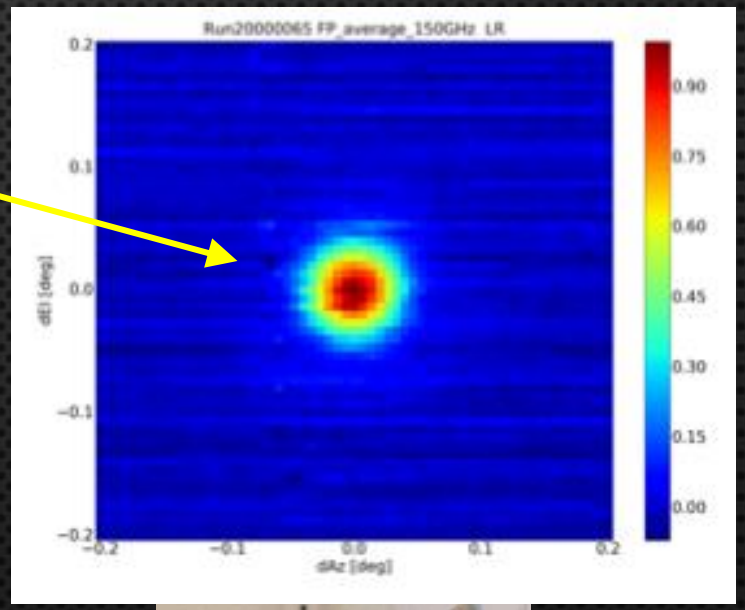
In the end of year 2019, all receiver cooling, telescope control and readout electronics got ready. First light was achieved in beginning of year 2019.

Sun scan on 2018 December 30



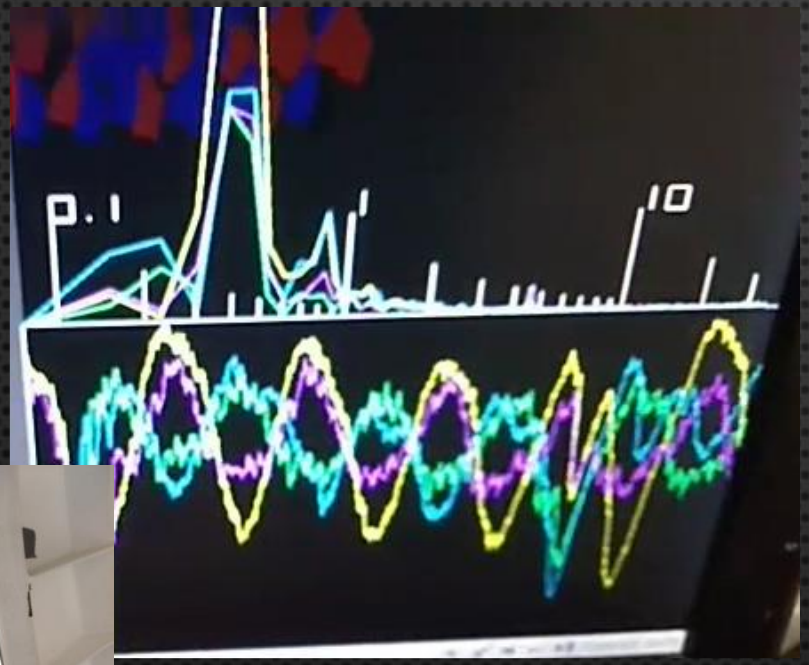
Venus scan on 2019 January 5





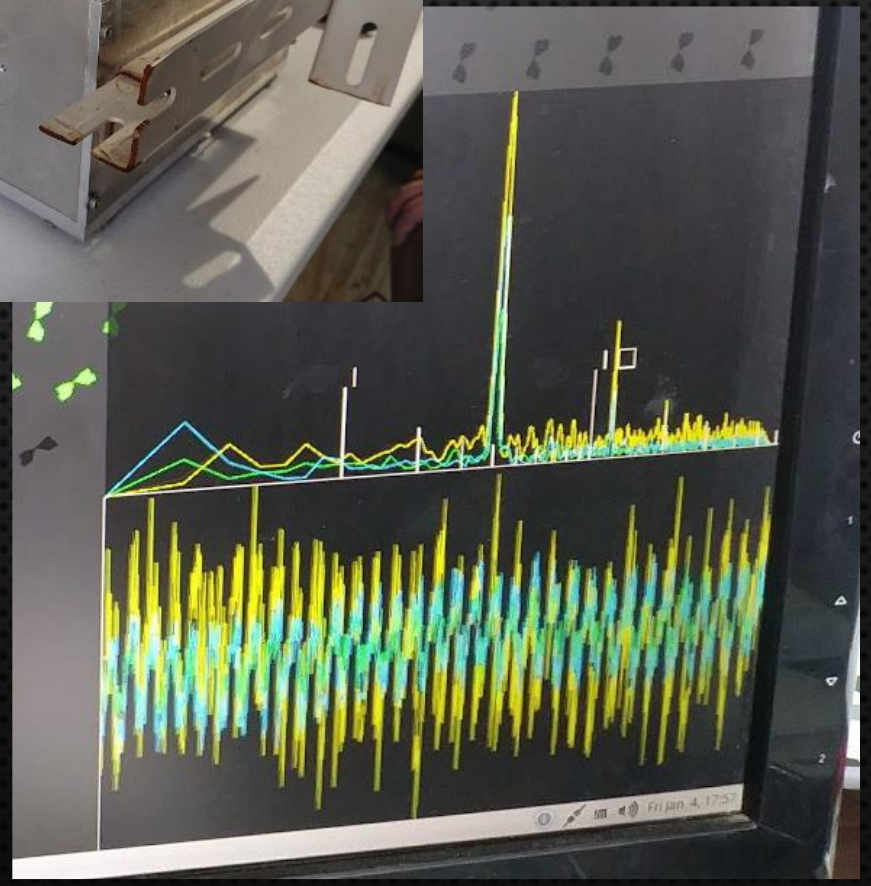
Early calibrations

Wire-grid calibrator in front of window
↓ →



↑ →

Stimulator: heater radiation source



Receiver operation and re-cooling

We opened receiver and repaired to mitigate vibration that generated heat, in order to achieve aimed temperature.

While temperature is going down, the readout electronics were also updated for more stable data acquisition. Grounding was also improved for lower noise environment.

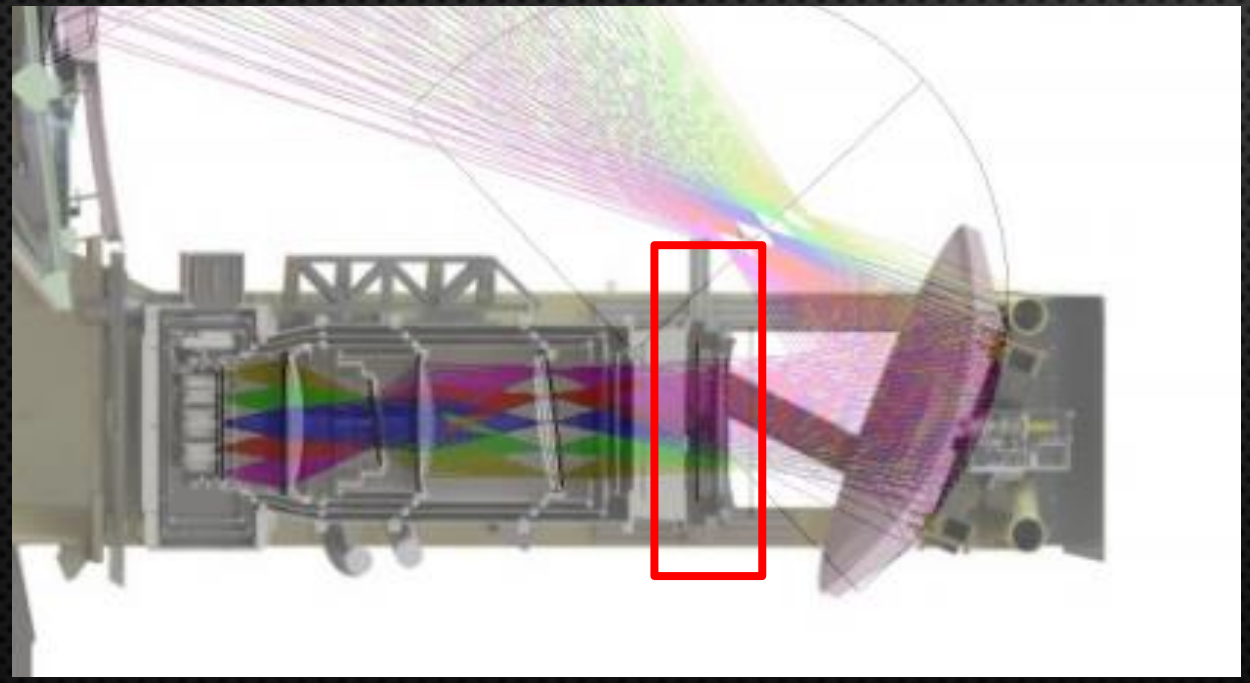
Focal plane detector viewed from back side

G10 insulator support plate
to remove ground loop

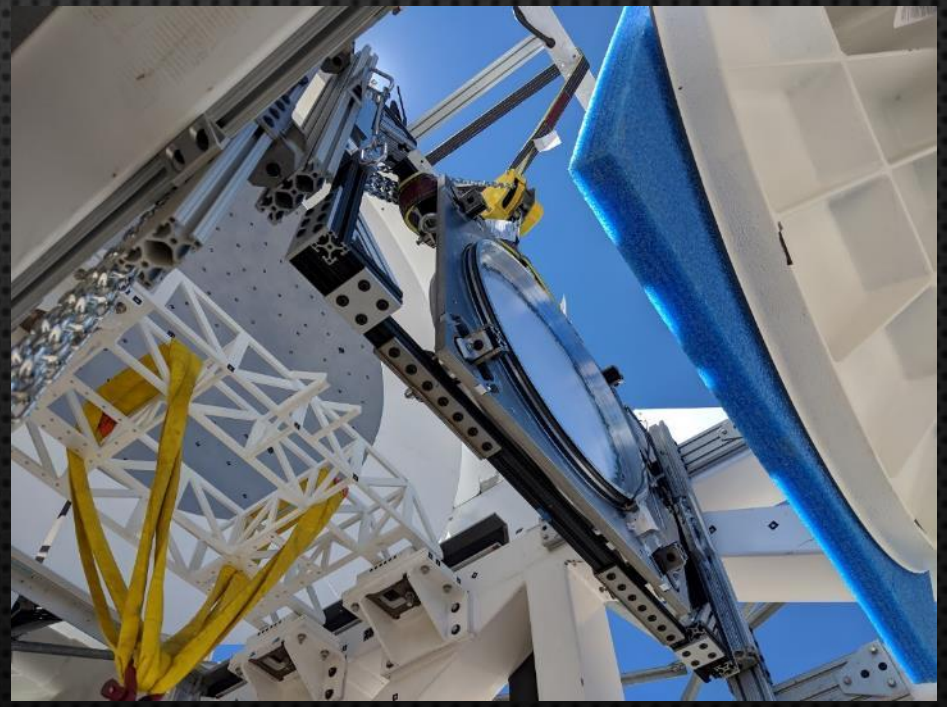
Continuous Rotating Half-Wave Plate(HWP)

HWP is an instrument to rotate polarization angle, and thus to reduce 1/f noise which comes from atmosphere and detector thermal fluctuation.

HWP is composed of 3 layer stacked 50cm sapphire plates.



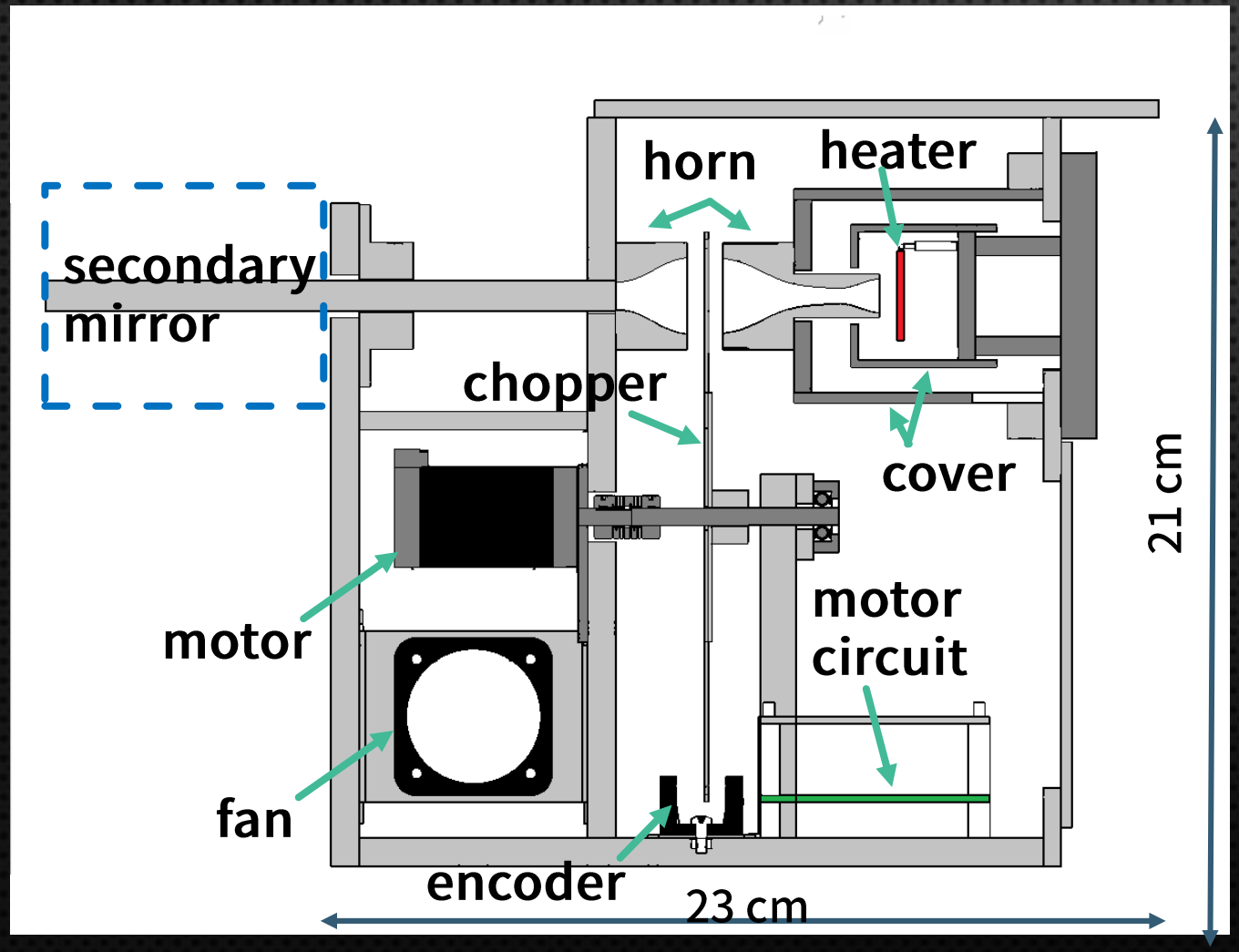
HWP is put just in front of receiver window



Mount and rotation demonstration have been performed.

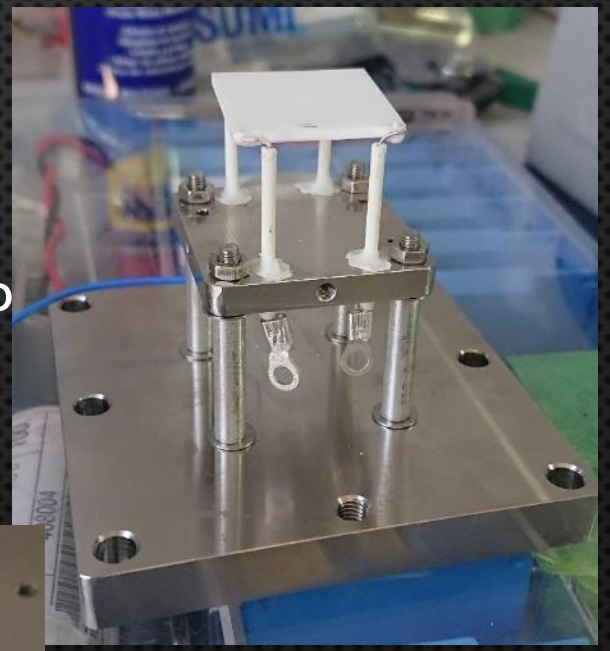
Stimulator : constant radiation source

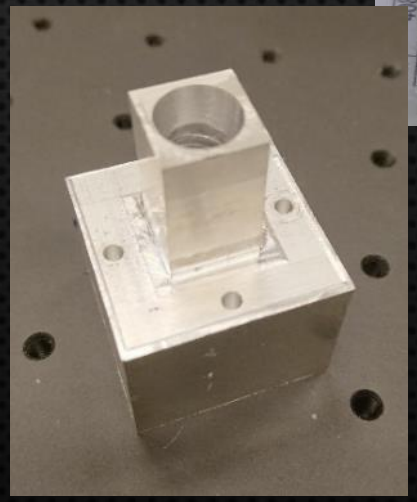
Stimulator is a regularly used calibrator which put behind secondary, it is used to calibrate relative gain and time-constant of detector.



Alumina heater rise up to 700°C.

Designed easy to replace when it is broken.





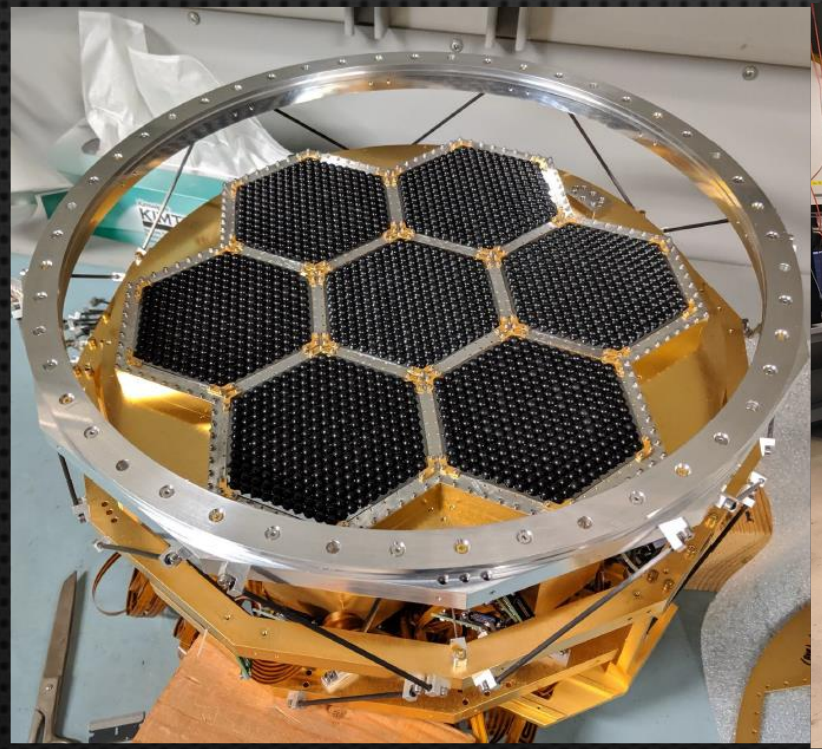
Optical horn is machined by ourselves.

New stimulator is available

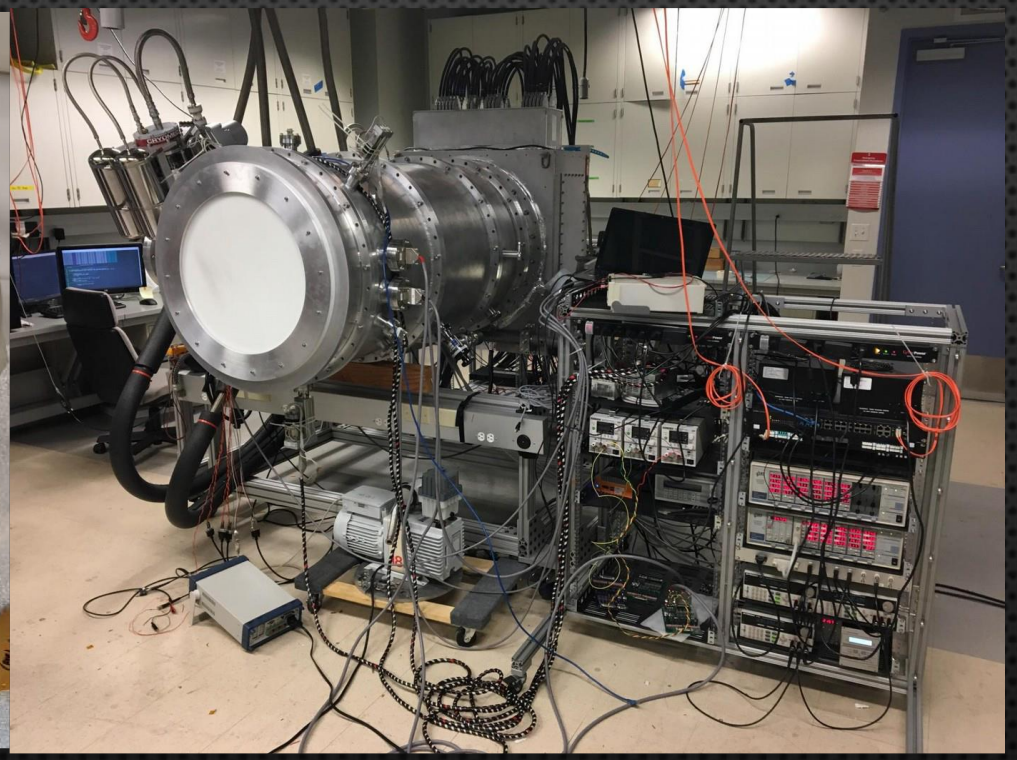
Although first package returned to Japan,
stimulator arrived to site (by my hand carry) and installed in the end of April 2019.

Currently working for commissioning jobs.

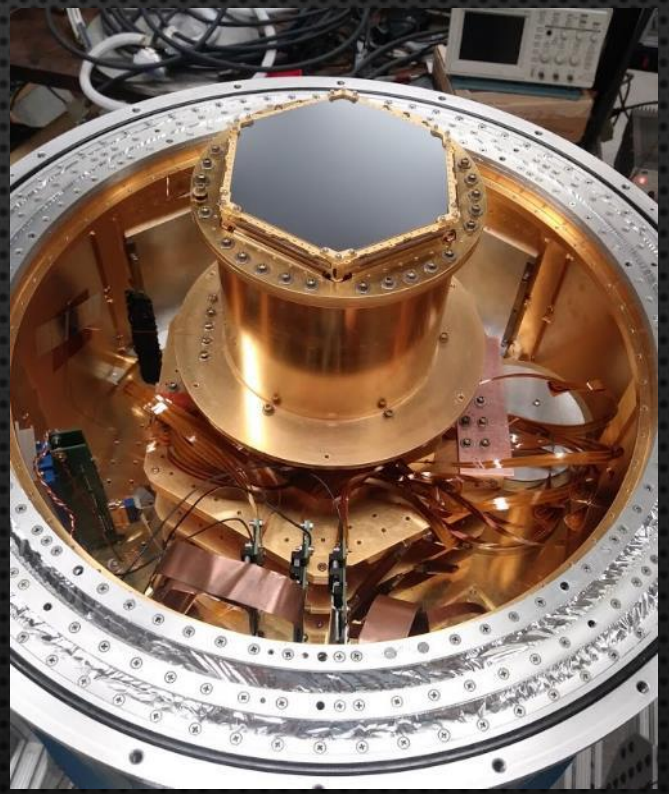
Development of PB-2B and PB-2C



Assembled PB-2B focal plane detector with wafer



PB-2B cryostat in test @ UCSD



Fabricated PB-2C wafer in dewer test

Summary and outlook

PB-2A receiver

Installed to telescope in November 2018
First light in January 2019
After modification in March, commissioning is continuing

Although still there are much tasks, this year we want start CMB observation

PB-2B

Now integration test in going in laboratory

PB-2C

Cryostat is made, making detector and optical components

Please wait results from Simons array.