The Characterization and Calibration of the Simons Observatory Small Aperture Telescope: Status and future plans

Nicholas Galitzki

University of California San Diego

Fulbright Scholar - Pontificia Universidad Católica de Chile

The University of Texas at Austin

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FULBRIGHT Chile

@AstroDrNick

How do we build and calibrate an experiment to maximize return on CMB science goals?

Experimental Parameters

CMB primordial B-modes

+ galactic foregrounds

+ atmosphere,

instrumental nois

systematics

Systematic mitigation and characterization

Calibration

Control of instrumental systematics is one of the most important challenges fo next gen CMB instruments

Experimental Parameters

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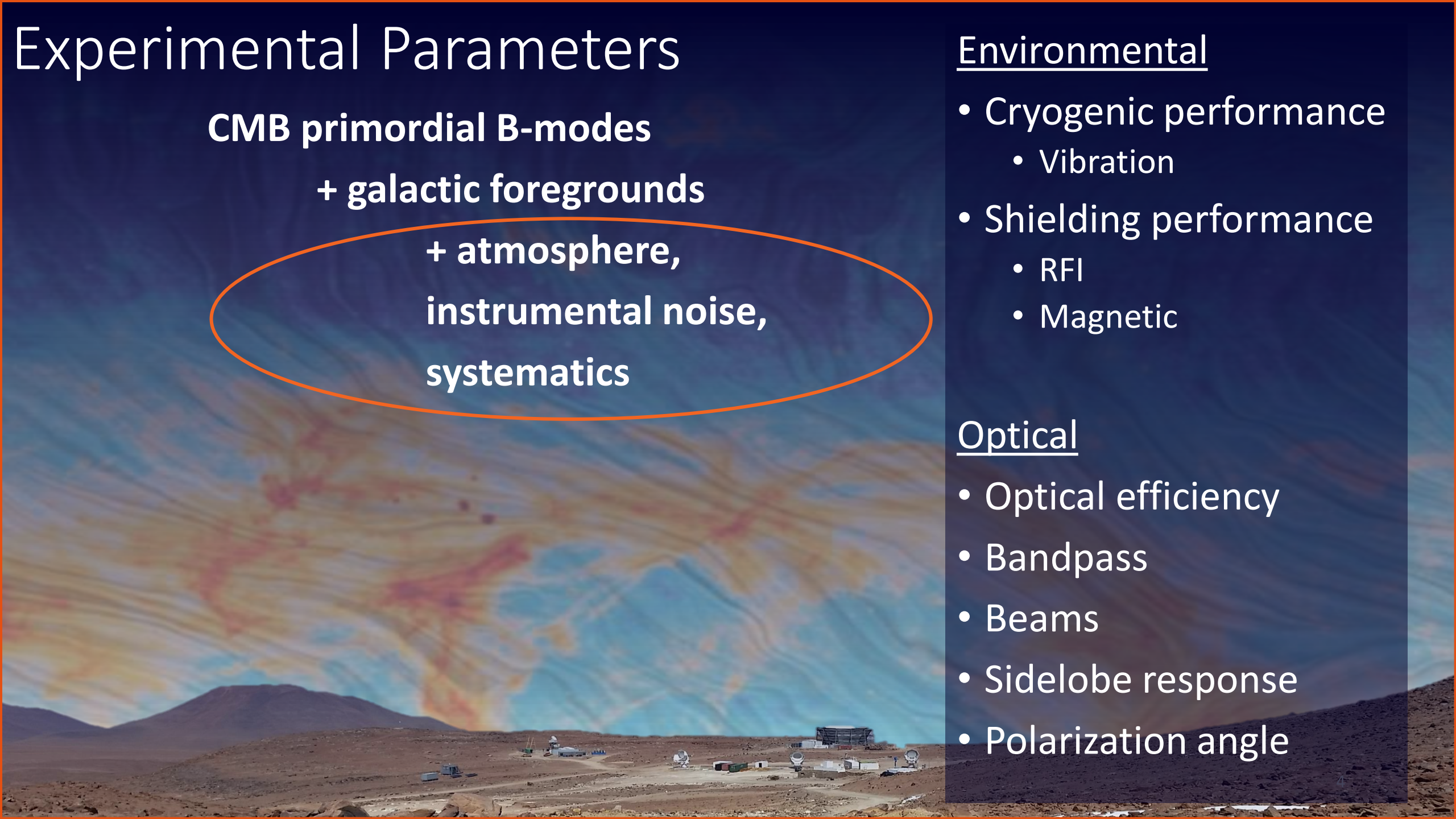


Environmental

- Cryogenic performance
  - Vibration
- Shielding performance
  - RFI
  - Magnetic

Optical

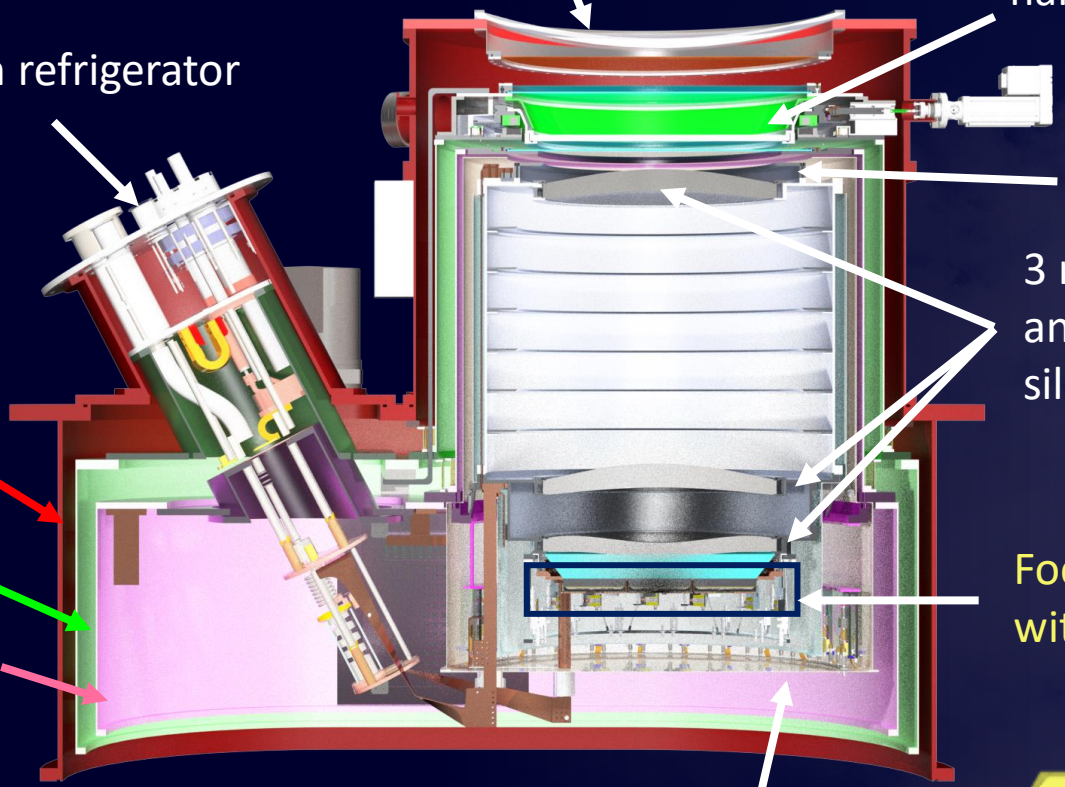
- Optical efficiency
- Bandpass
- Beams
- Sidelobe response
- Polarization angle

The Simons Observatory Collaboration

July 2019

Observatory Site

Small Aperture Telescopes



Small Aperture Telescope Array

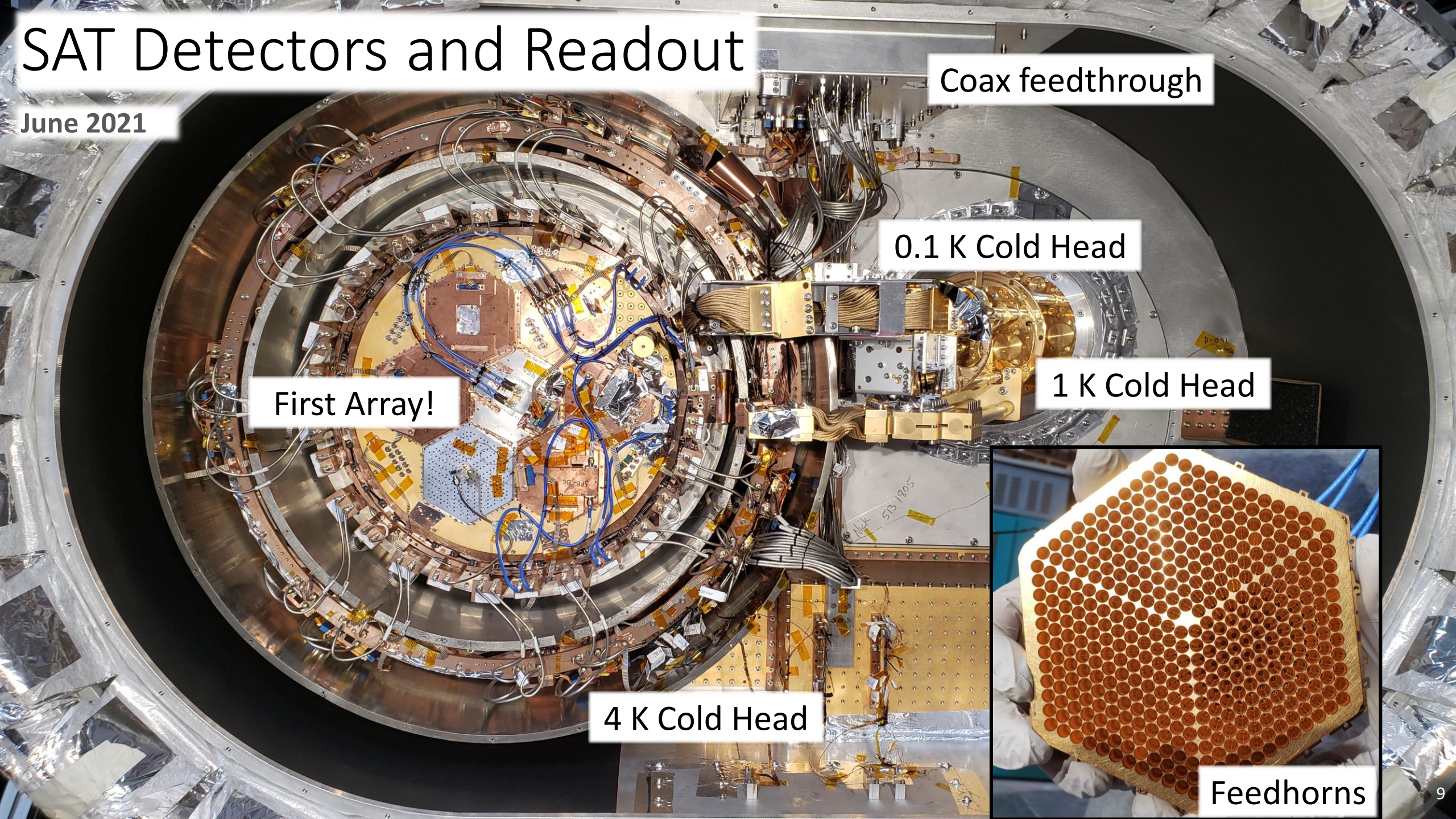
42 cm apertures

Dichroic pixels:

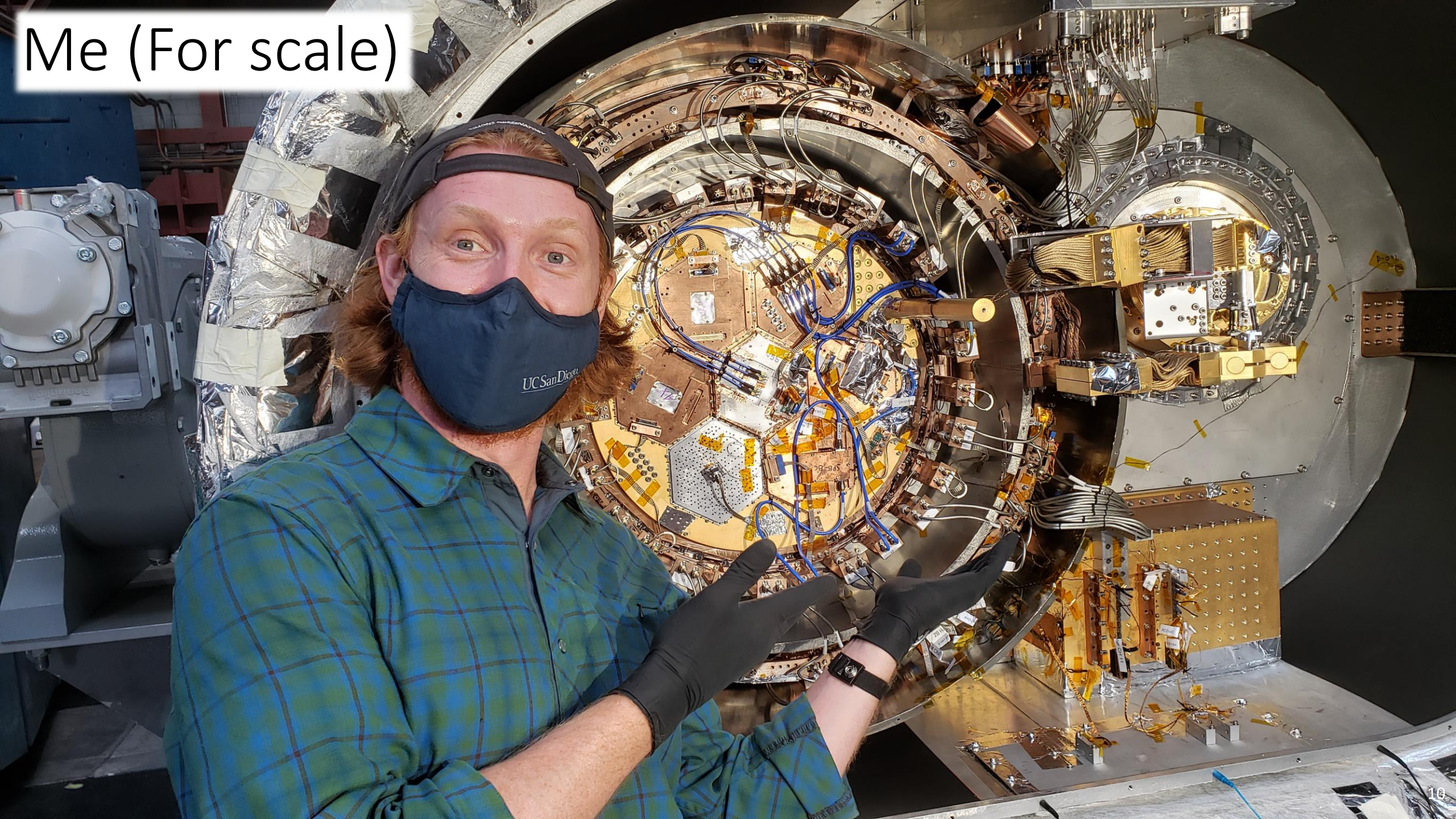
ν (GHz)	27/39	90/150	220/270
# detectors	1036	12096	12096

SAT Detectors and Readout

June 2021



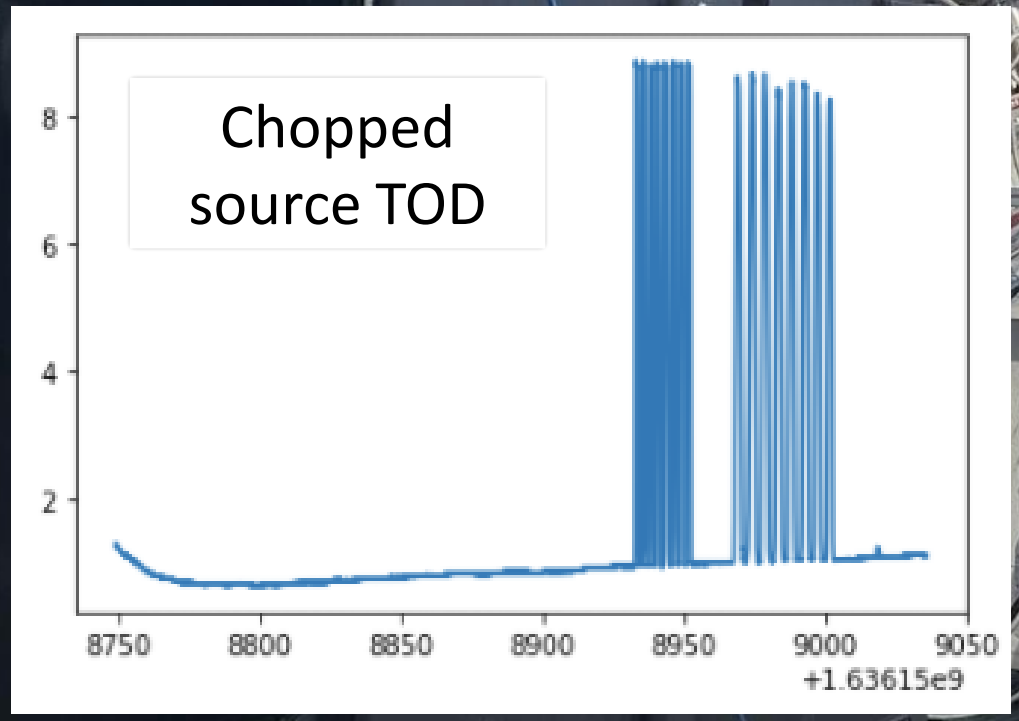
Me (For scale)



First Light! (Sort of)

November 2021

LN2 Cold Load



Characterized:

Cryo performance

Environmental shielding

End-to-end electronics

Software

(Galitzki et al. 2022 in prep.)

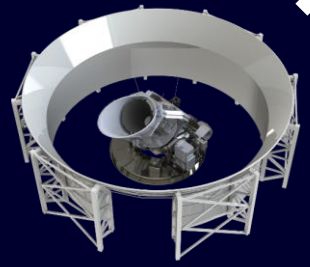
SAT Platform (SATP) –Factory Acceptance

<u>Characterized:</u>
Assembly
Vibration environment
Software
Pointing

SATP Site Acceptance (In progress!)

<u>To be characterized:</u>
Assembly
Vibration environment
Software
Pointing (star camera)

Simons Observatory



2018 2019 2020 2021 2022 2023

Small aperture telescope platform

Design	Manufacture	Validation	Ship and site testing

Small aperture telescope 1

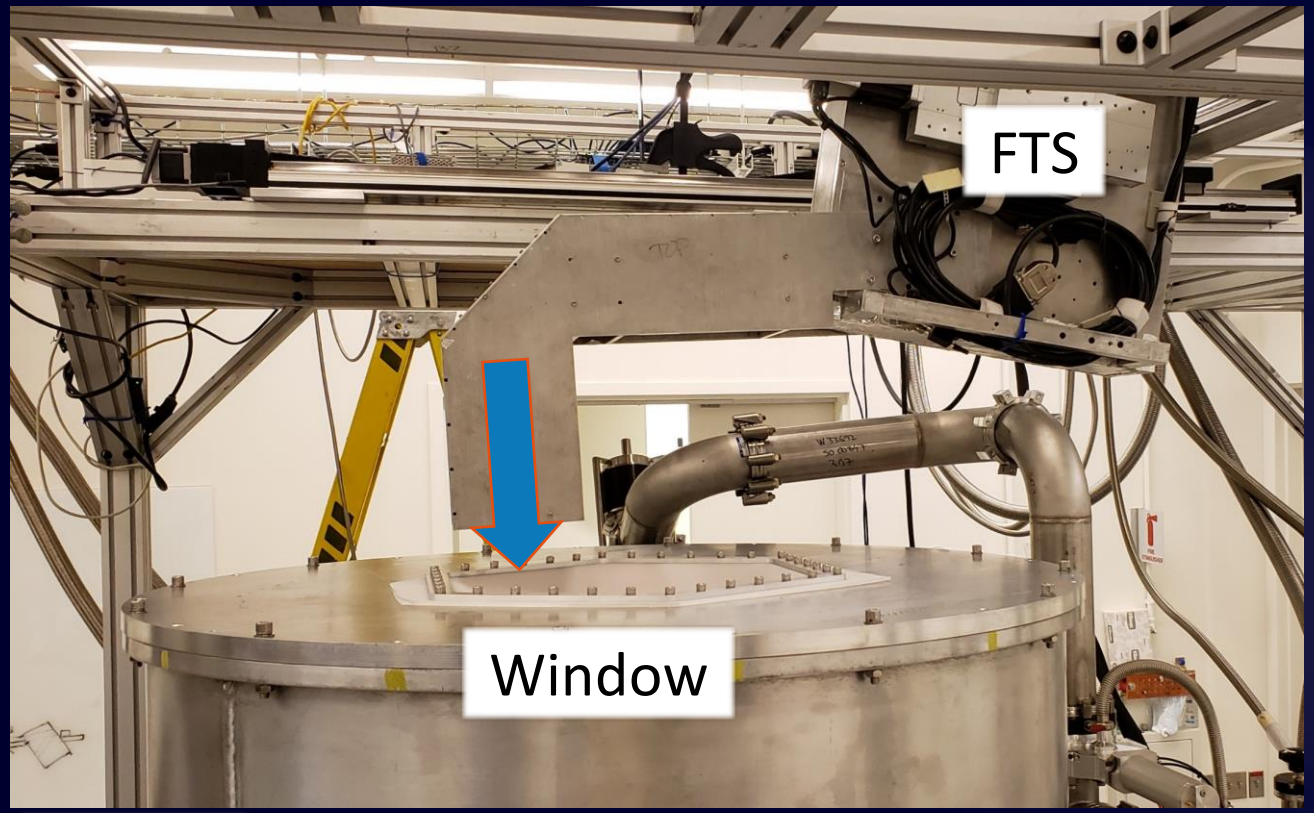
Design	Manufacture	Validation	Integration and testing	Ship and site testing

Scientific Observations

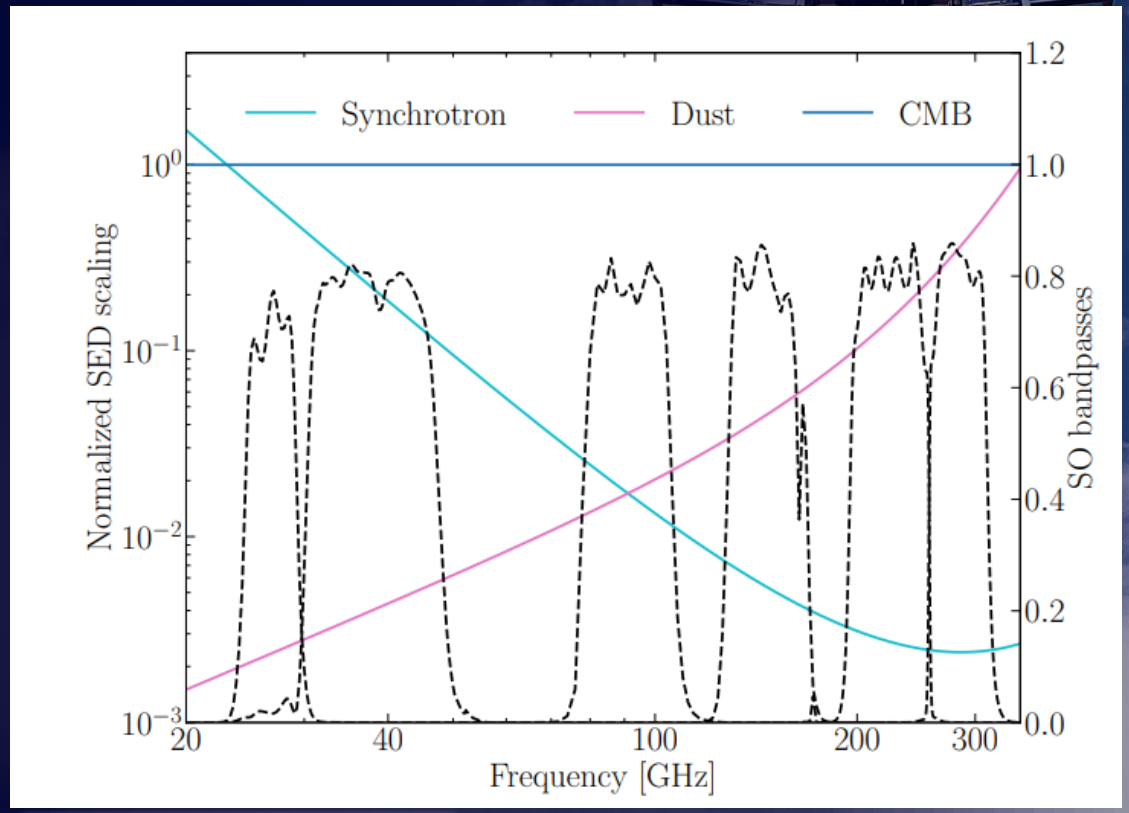
- Analysis pipeline development
- Calibration strategy

Up next – In Lab Bandpass

FTS coupled to re-imaging optics



UChicago

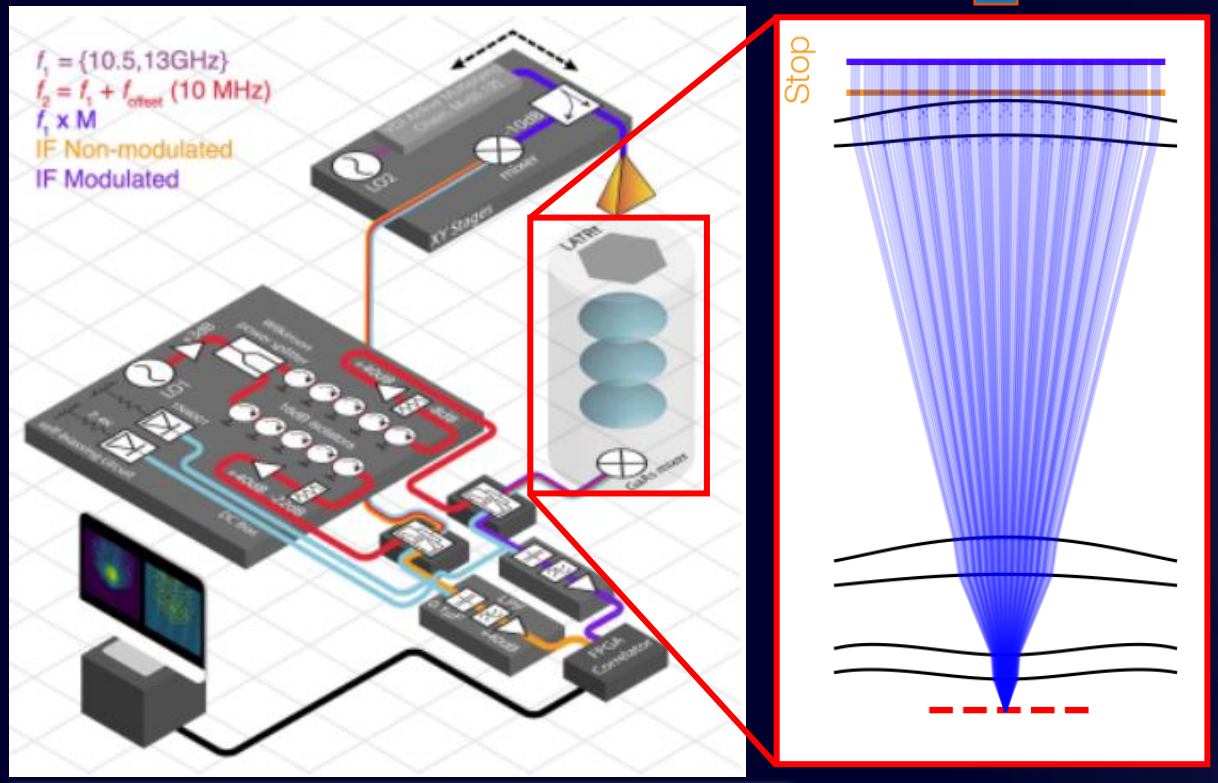


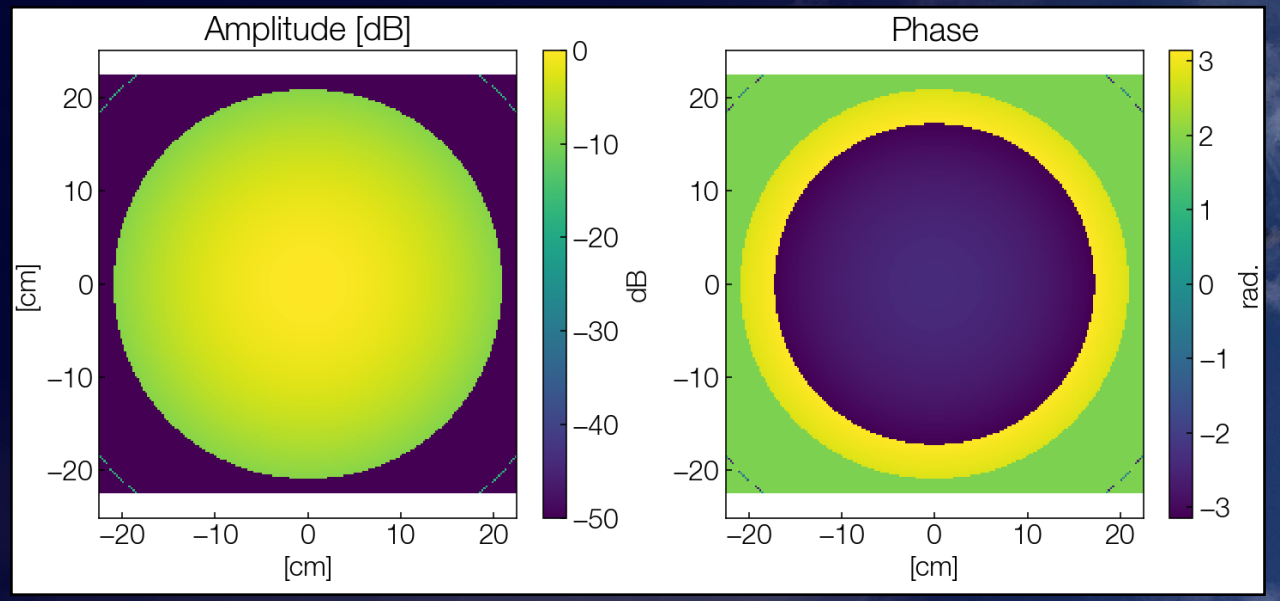
Abitbol et al. 2021

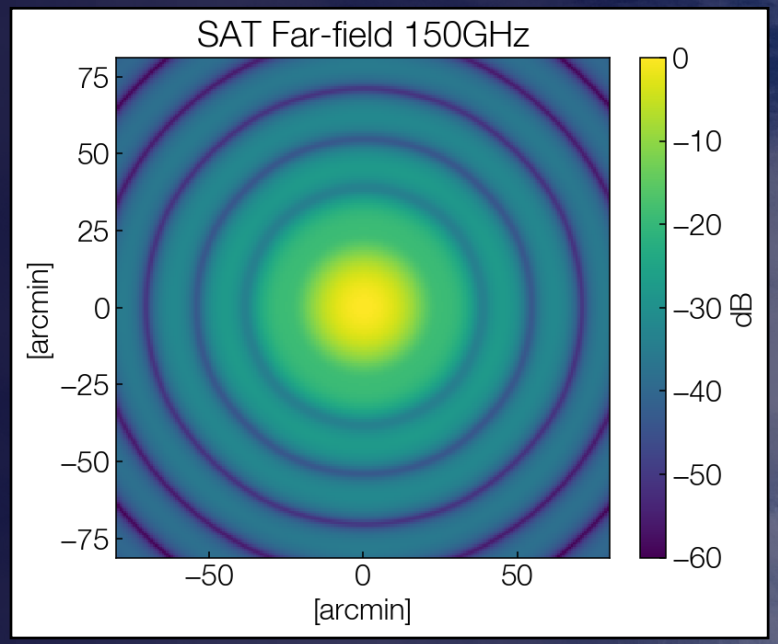
The Simons Observatory: gain, bandpass and polarization-angle calibration requirements for B-mode searches

Up next – In Lab Beam

Near-field holography







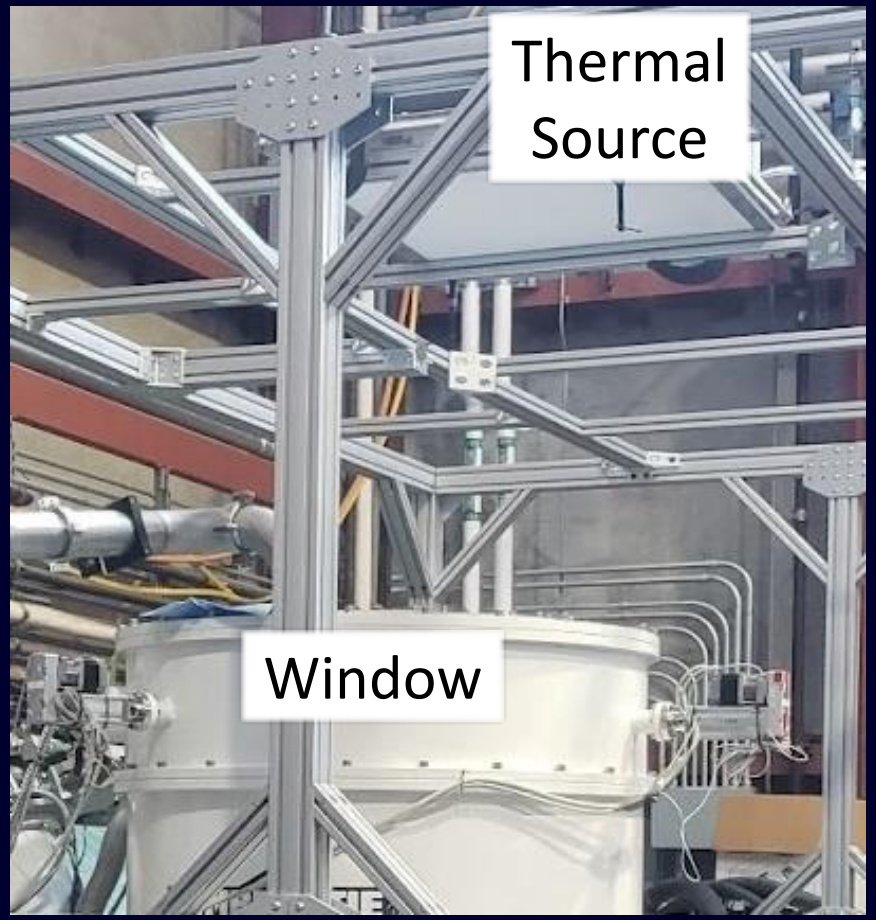
Chesmore et al. arxiv: 2107.04138

Chesmore et al. (2022 in prep)

github.com/McMahonCosmologyGroup/sosat-optics

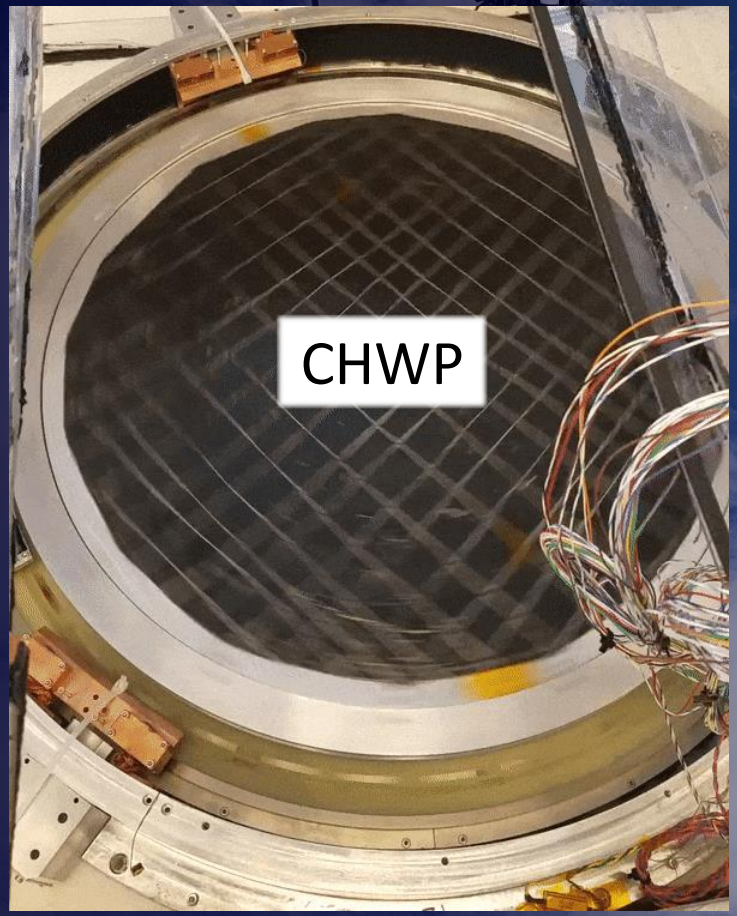
Up next – Other In Lab Tests

Optical Efficiency



Polarization Angle

Polarization Modulation



Up next - At site

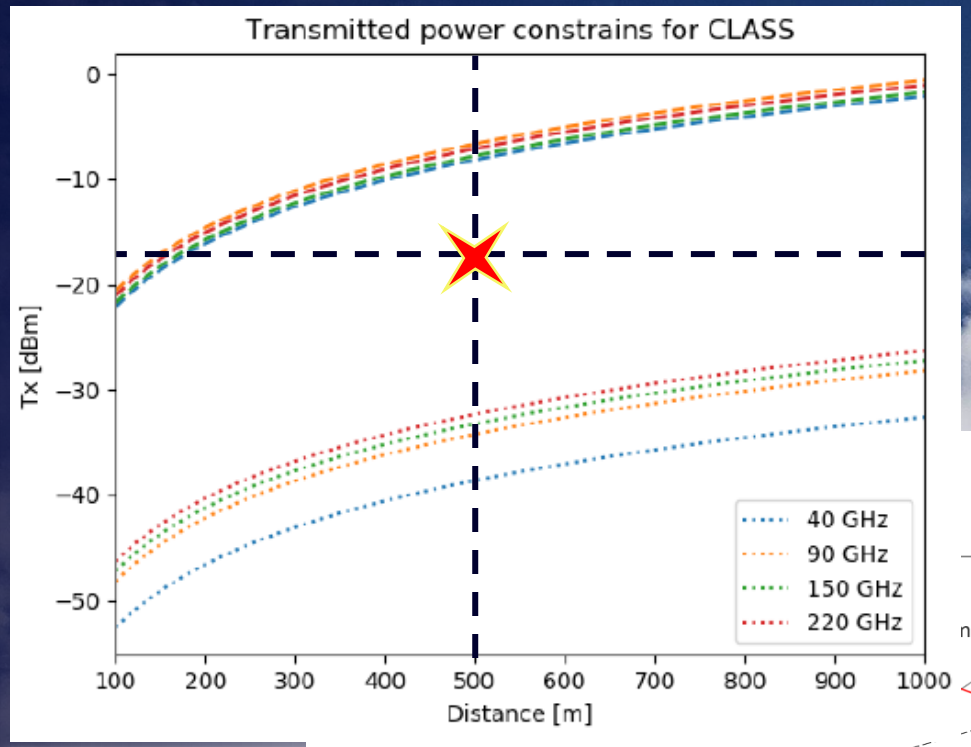
- Bandpass (FTS)
- Beam, Sidelobes, and Polarization
  - Sky sources
- Improved polarization
  - Wire grid
  - Artificial source

Hover-Cal

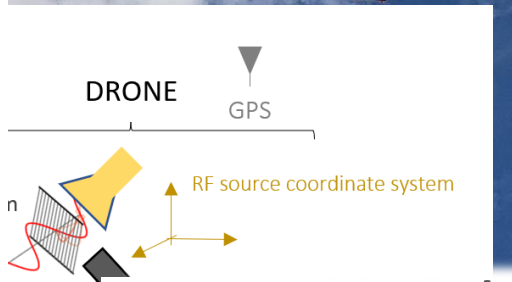
Absolute angle

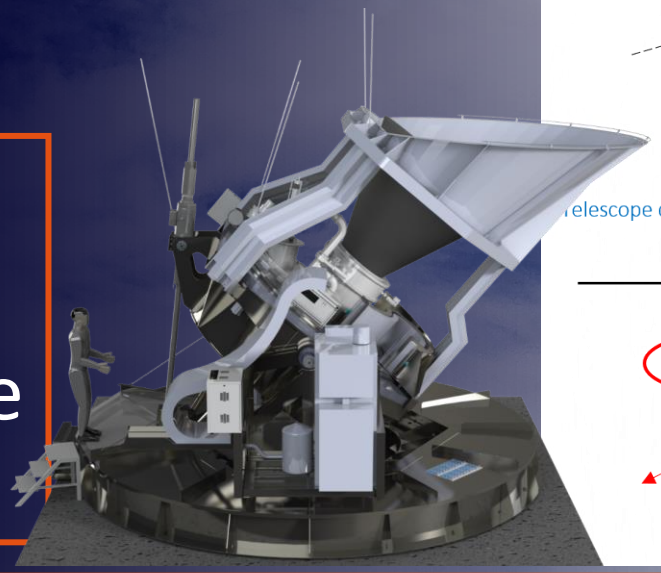
Polarized response

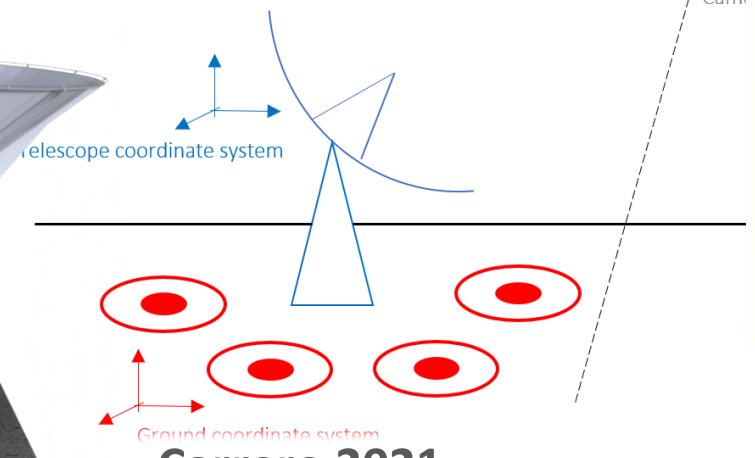
Shielding



Dünner 2020

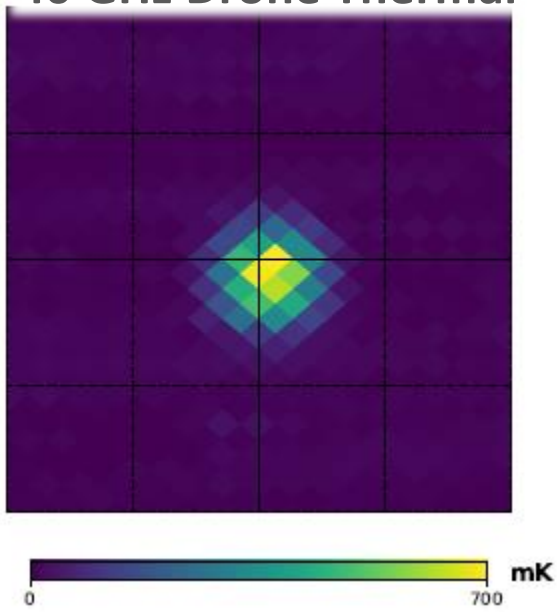






Carrero 2021

40 GHz Drone Thermal



Extended Science Potential

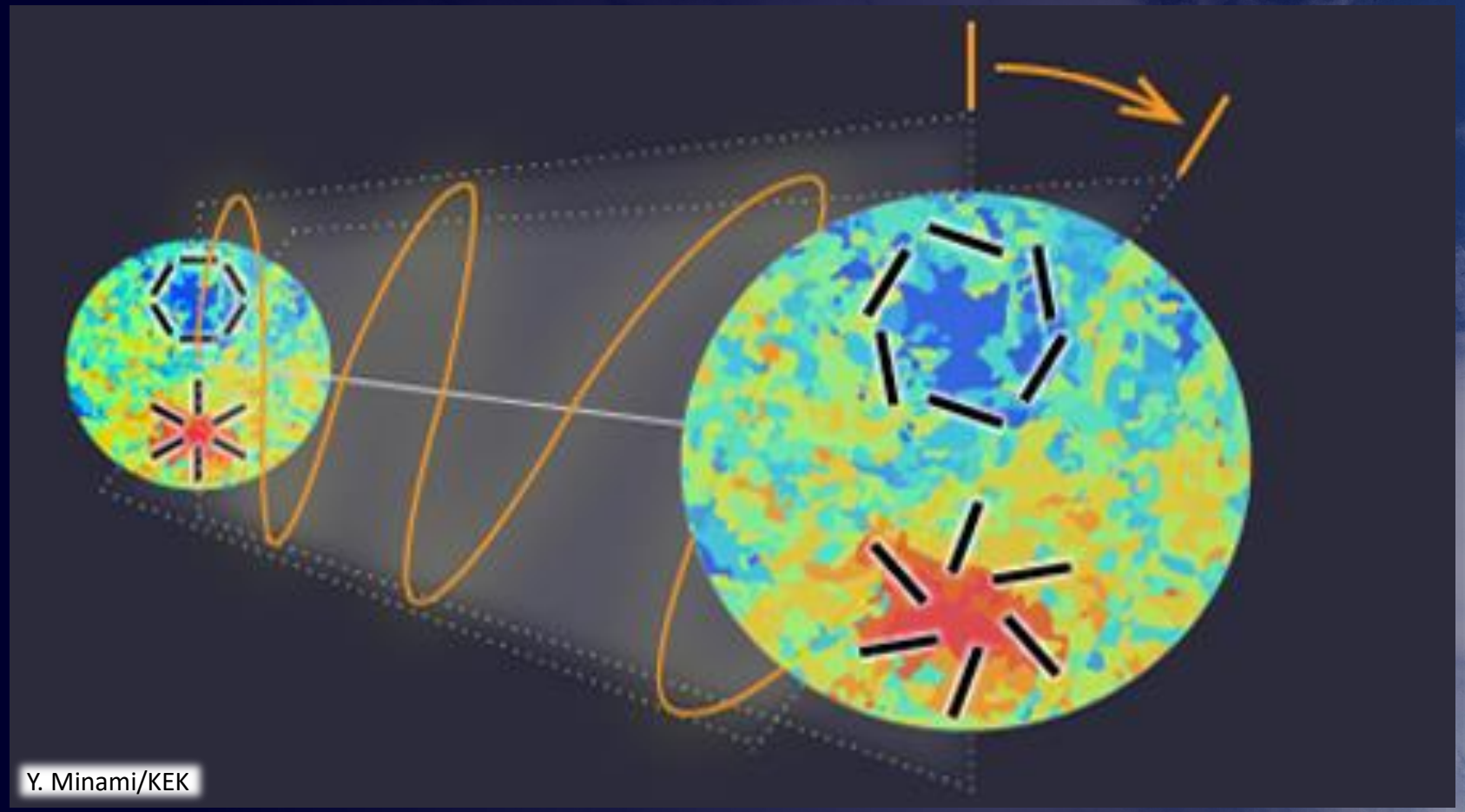
"To determine β, we must know the polarization-sensitive directions of detectors at the focal plane with respect to the sky coordinates. This requires accurate calibration of the polarization angles."

$\beta = 0.35 \pm 0.14$

(Minami 2020)

$\beta = 0.30 \pm 0.11$

(Diego-Palazuelos 2022)



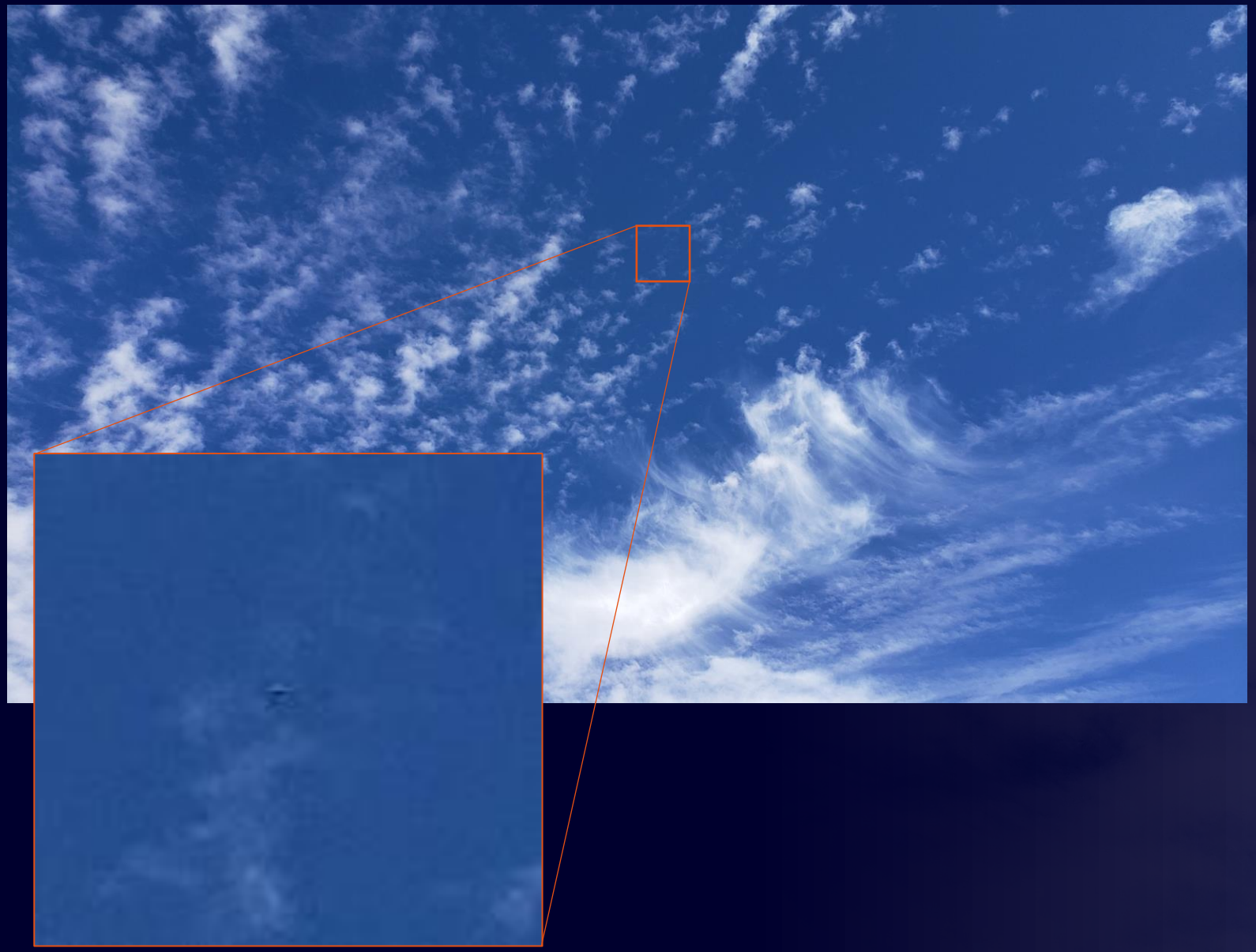
Hover-Cal Progress

April 2022

- 4 telescopes simultaneously!
- 19 total flights
- Over 2 hours in the air!
- 4 drone scan types
- 2 source payloads
  - 90 and 150 GHz

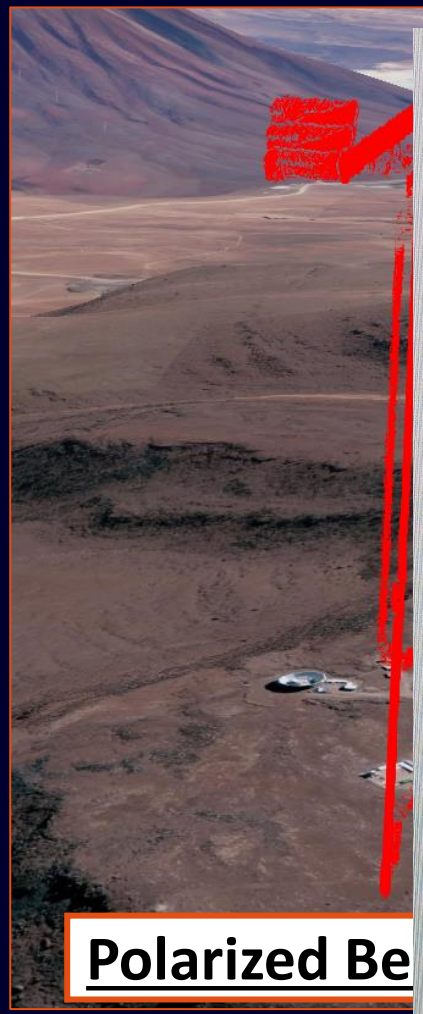
Felipe and drone (for scale)

Hover-Cal At 0.5 km

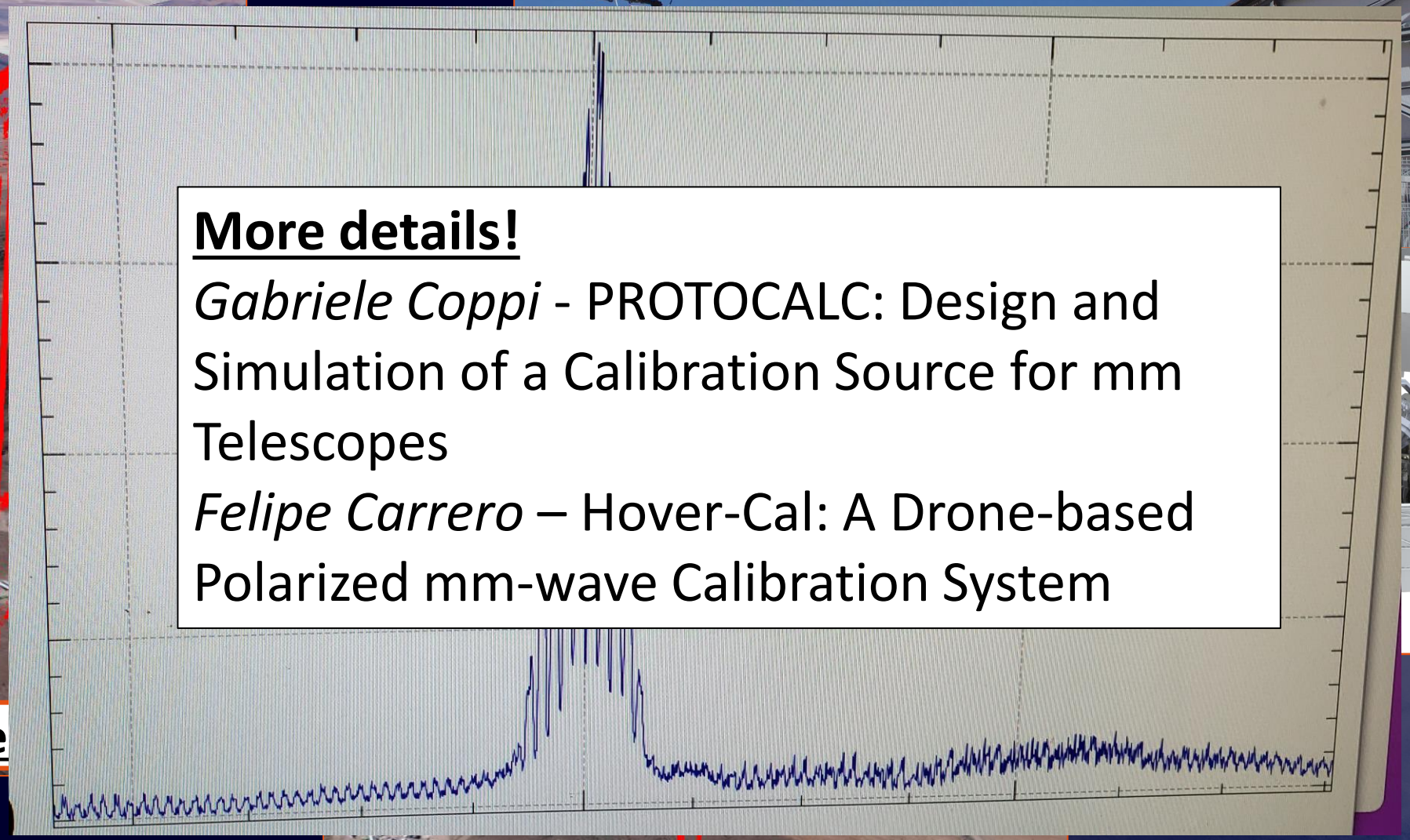


Hover-Cal Potential

Sidelobe & Optical Shielding Characterization



Polarized Be



More details!

Gabriele Coppi - PROTOCALC: Design and Simulation of a Calibration Source for mm Telescopes

Felipe Carrero – Hover-Cal: A Drone-based Polarized mm-wave Calibration System

Questions

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