

The Simons Observatory: Current status and Future prospects



Yoshinori SUENO
on behalf of the Simons
Observatory Collaboration

Credit: D. Boettger

Outline

- Overview of the Simons Observatory
- Preliminary results
- Future prospects (On-going/Future upgrade)
- Summary

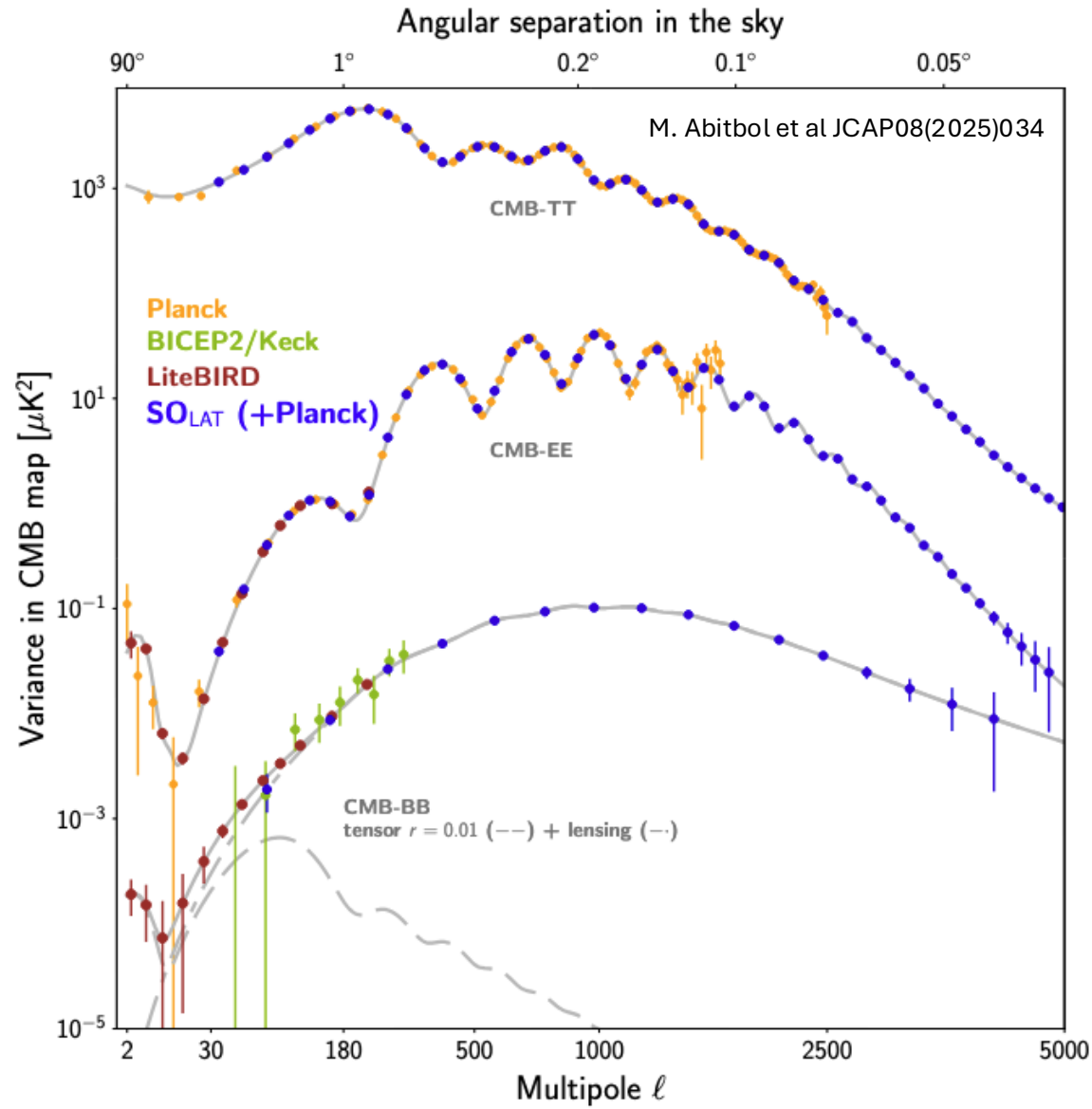
Overview of the Simons Observatory

The Simons Observatory Collaborations: 450+ researchers across 60+ institutions

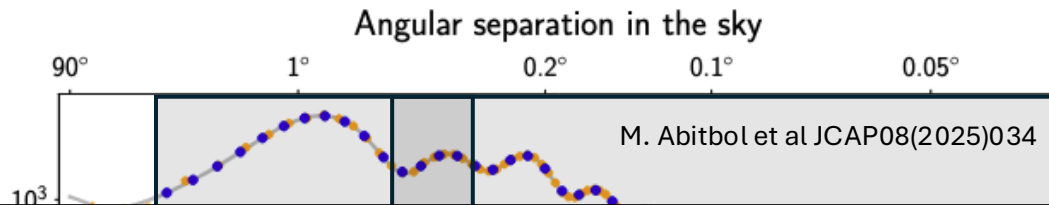


F2F at Chicago, 2024, July

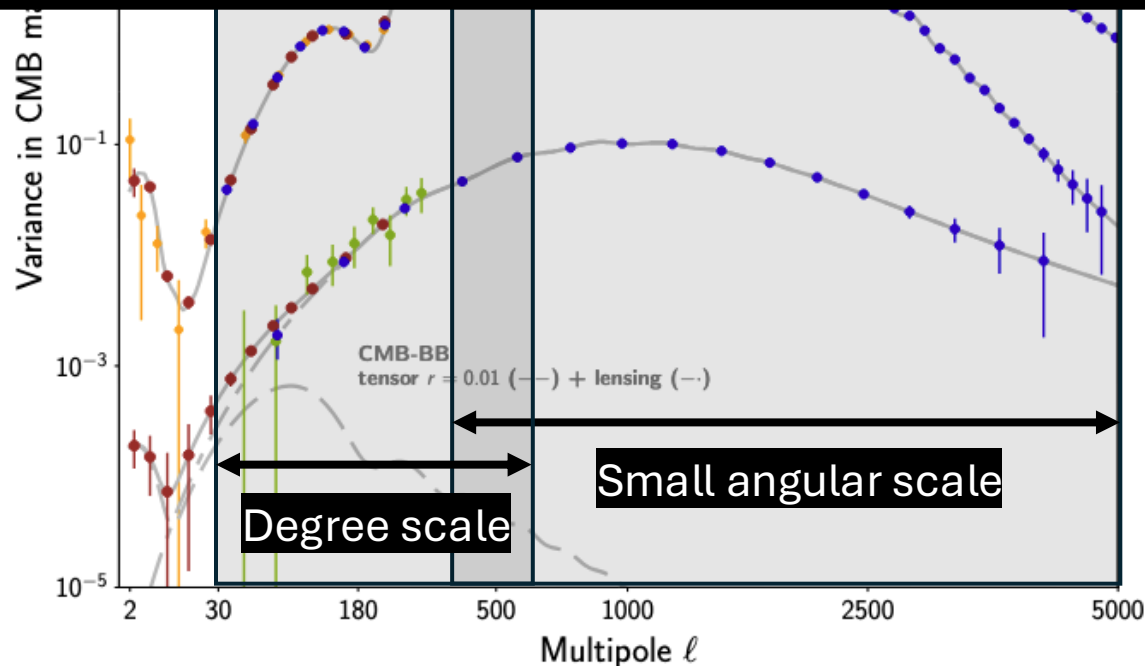
Science Targets (Survey Years: 2025-2034)



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The Simons Observatory measures very wide angular scale of CMB anisotropy with two types of telescopes at six frequency bands: LF(30/40 GHz), MF(90/150 GHz), UHF(220/280 GHz)

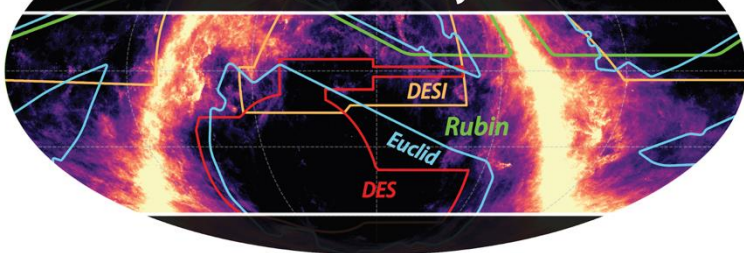


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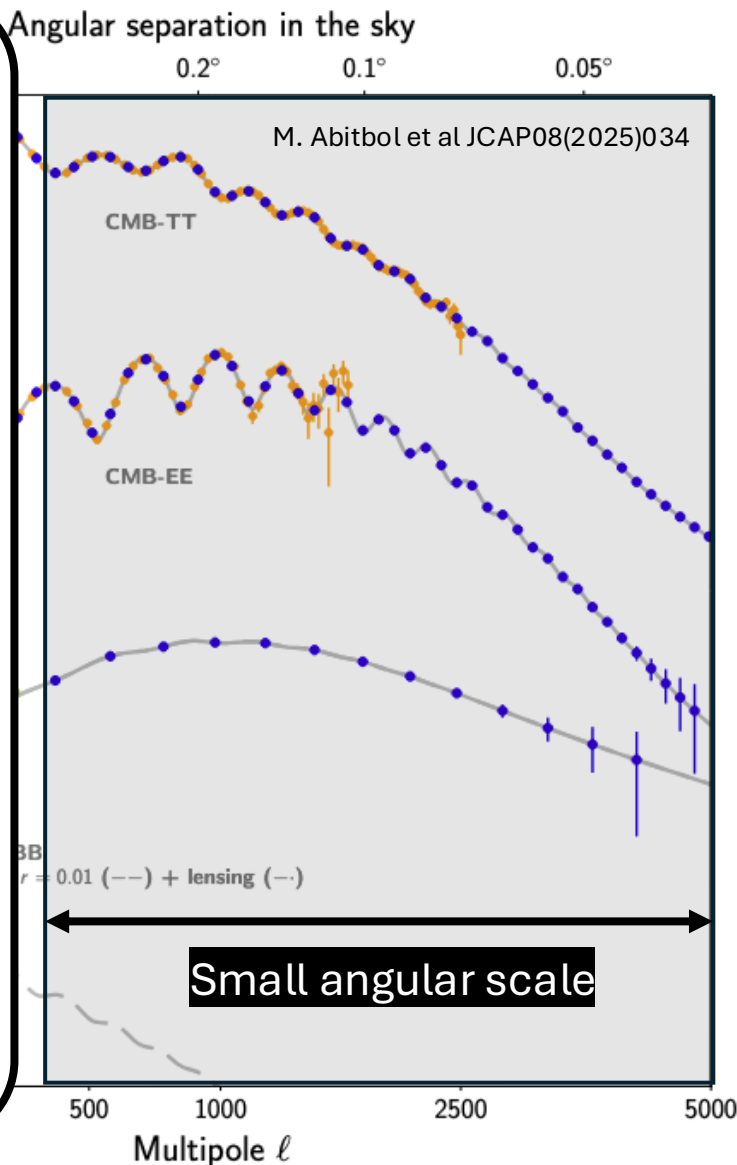
Large Aperture Telescope



Simons Observatory LAT Survey



- Wide range survey ($f_{sky} = 0.6$) with high angular resolution
- Co-added T map depth: $3.9 \mu\text{K-arcmin}$ (goal $2.6 \mu\text{K-arcmin}$).



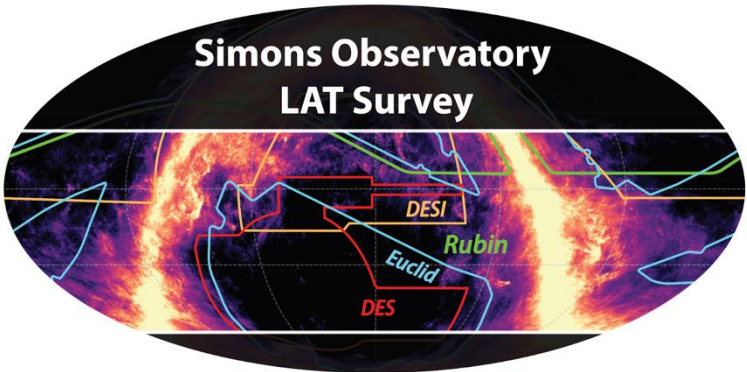
Science Targets (Survey Years: 2025-2034)

*Based on M. Abitbol et al JCAP08(2025)034

Large Aperture Telescope



Simons Observatory LAT Survey

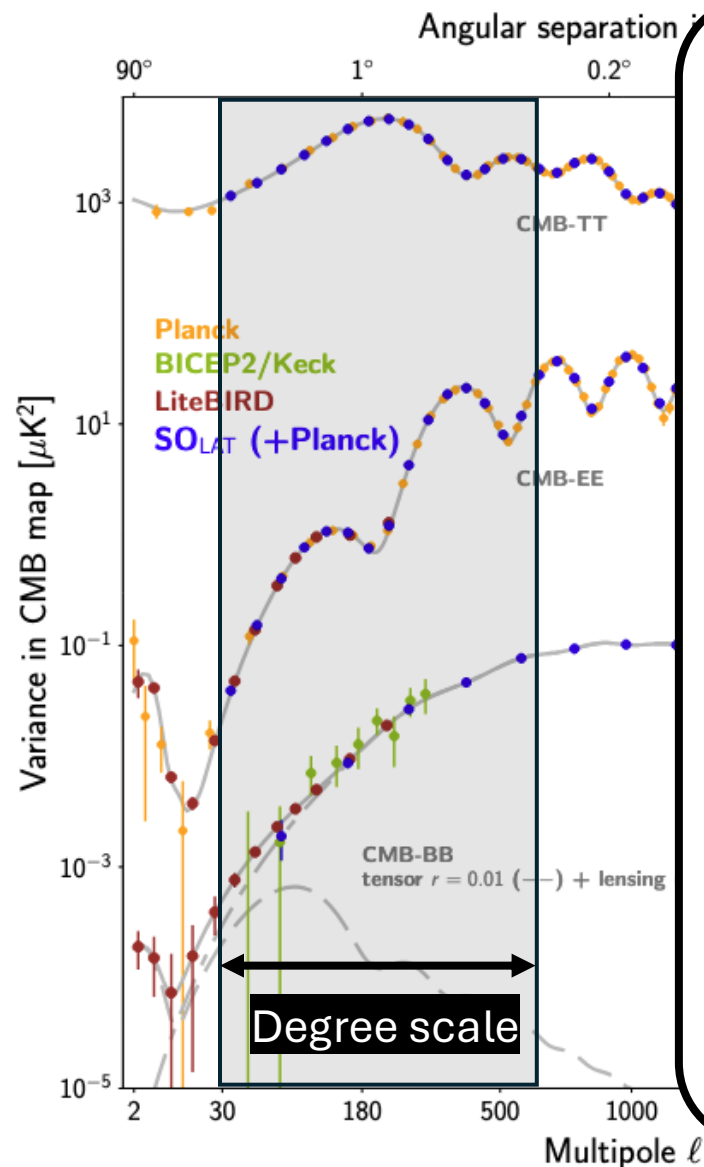


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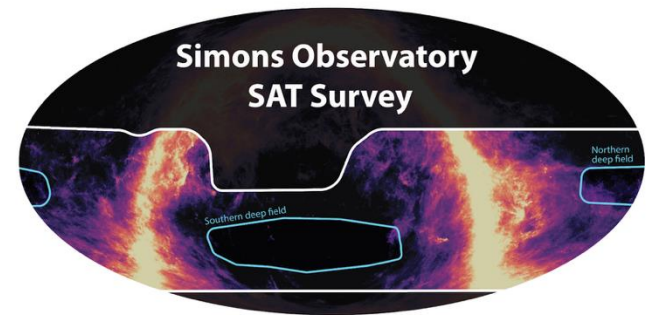
*Numbers are 1σ		Current	SO
Scalar spectral index	n_s	0.004	0.002
Non-Gaussianity	f_{NL}^{local}	5	1
Neutrino mass	Σm_ν	0.1	0.015-0.03
Relativistic species	N_{eff}	0.2	0.045
Amplitude of matter fluctuations	σ_8	7%	1%
Optical depth to reionization	τ	0.007	0.0035

Many others: Cluster, AGN, Transit...

Science Targets (~10-year survey)



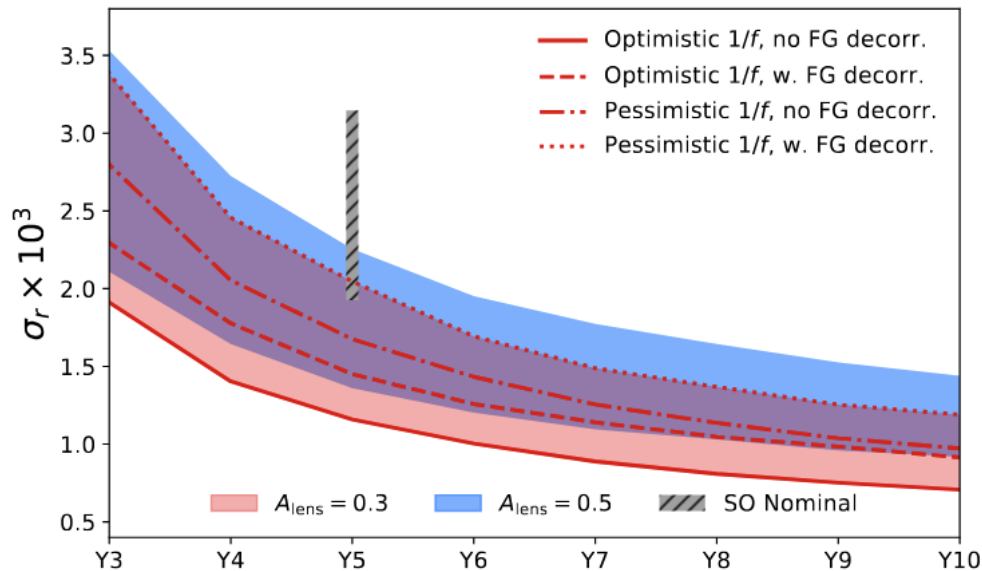
Small Aperture Telescope



- Degree scale with deep survey ($f_{\text{sky}} = 0.1$) to detect primordial gravitational wave signal
- Co-added P map depth: $1.3 \mu\text{K-arcmin}$ (goal $0.9 \mu\text{K-arcmin}$)

Science Targets (~10-year survey)

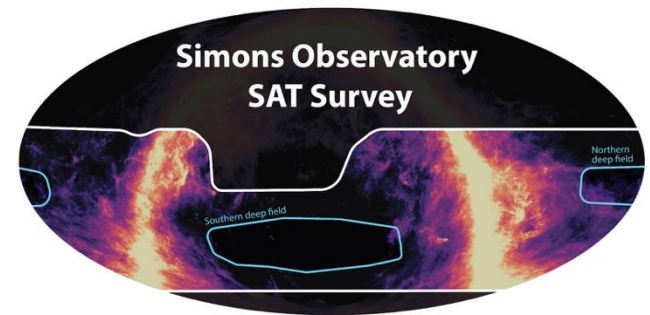
*Based on I. Abril-Cabezas et al JCAP04(2026)051



Primordial gravitational wave: r
0.009 (Current) $\rightarrow$ **0.001**

Degree scale

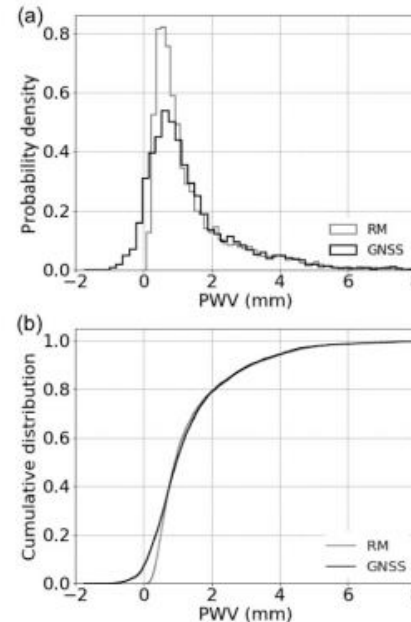
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Site: Cerro Toco, Atacama Desert, Chile

- Longitude: $67^{\circ} 47'$ West
- Latitude: $22^{\circ} 57'$ South
- Altitude: 5,200 m
- Typical PWV: $< 1\text{mm}$
- One Large Aperture Telescope (LAT)
- Three Small Aperture Telescope (SATs)
- Ongoing: Three more SATs and photovoltaic (PVA)



J. Sugiyama, et al., 2024MNRAS.528.4582S



LAT

Three SATs

(photovoltaic)

CLASS

(Three more SATs)

Credit: D. Boettger

New SAT(LF)

New 2 SATs (MF)

CLASS

SAT3(MF)

SAT2(UHF)

SAT1(MF)

LAT

Large Aperture Telescopes (LAT)



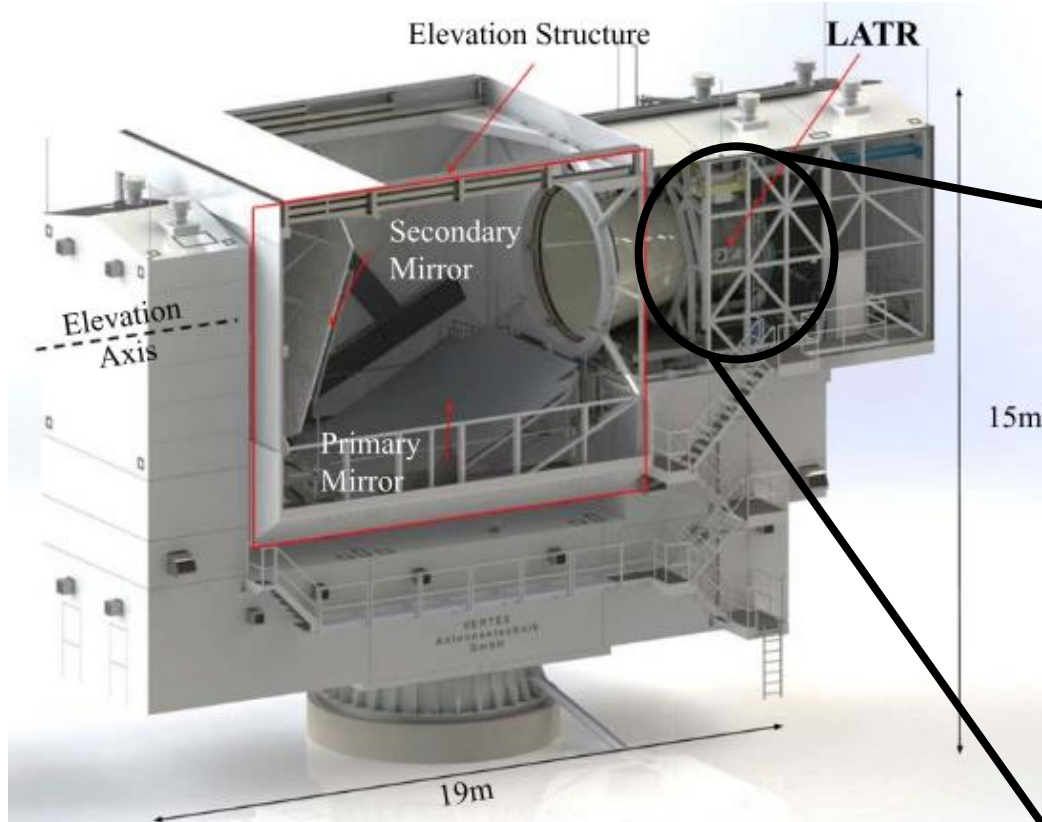
LAT

Credits: HoverCal & PoloCalC team

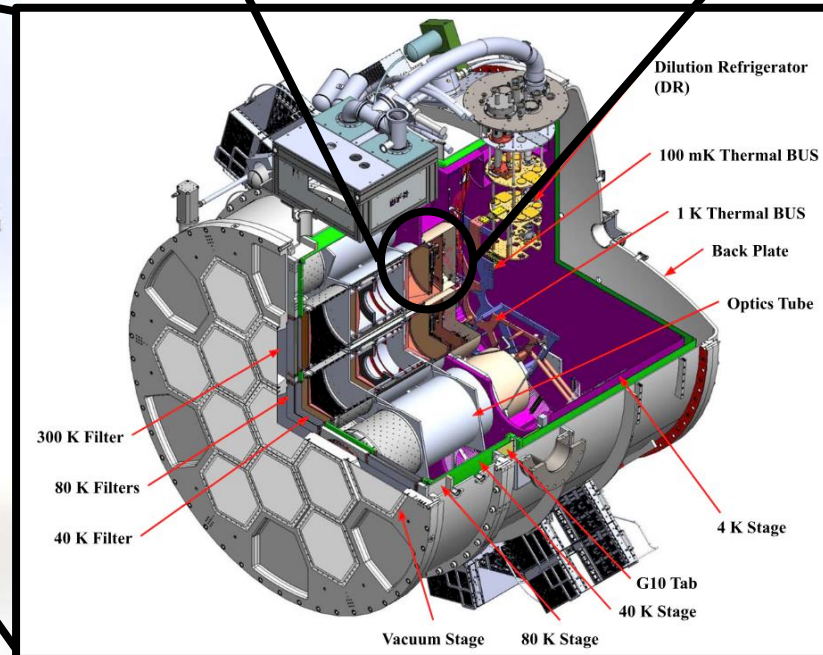
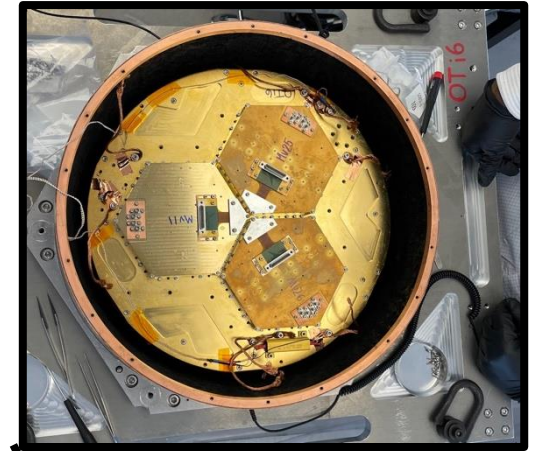
Large Apeature Telescope

6 m Apeature, 7.8° FoV, FWHM $\sim 2.2'$ @ 90 GHz

- 13 optics tubes (Advanced SO)
 - Three modules in one optics tube
 - 1 LF, 8 MF, 4 UHF
 - Total > 60,000 Transition-Edge-Sensors (TESs)



One optics tube

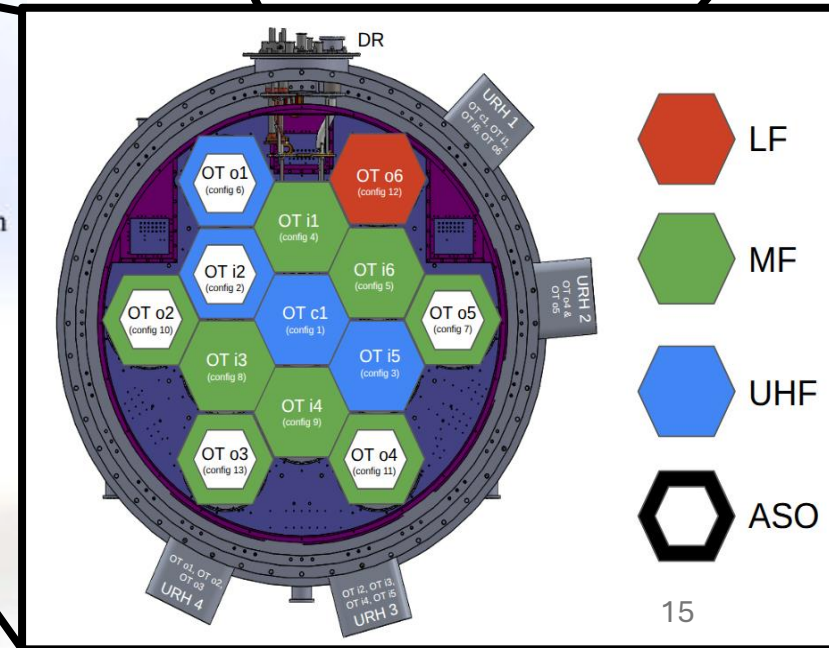
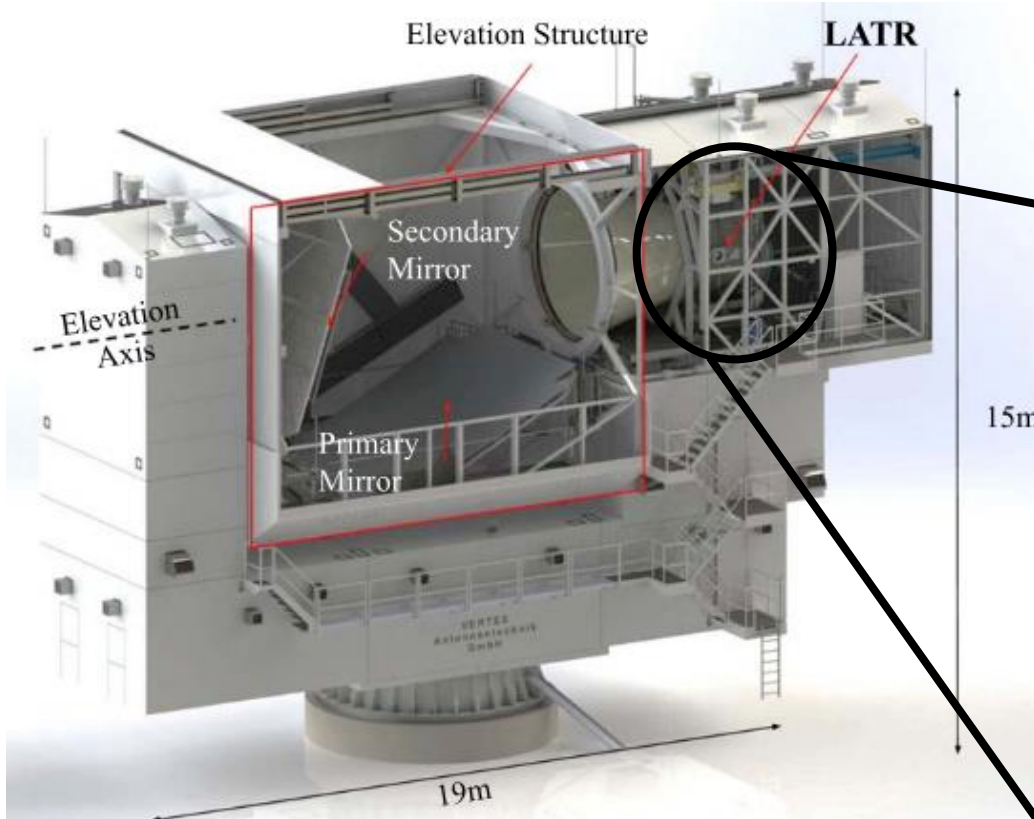
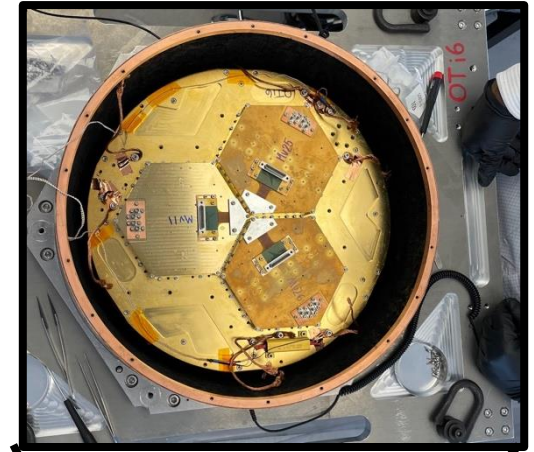


Large Apeature Telescope

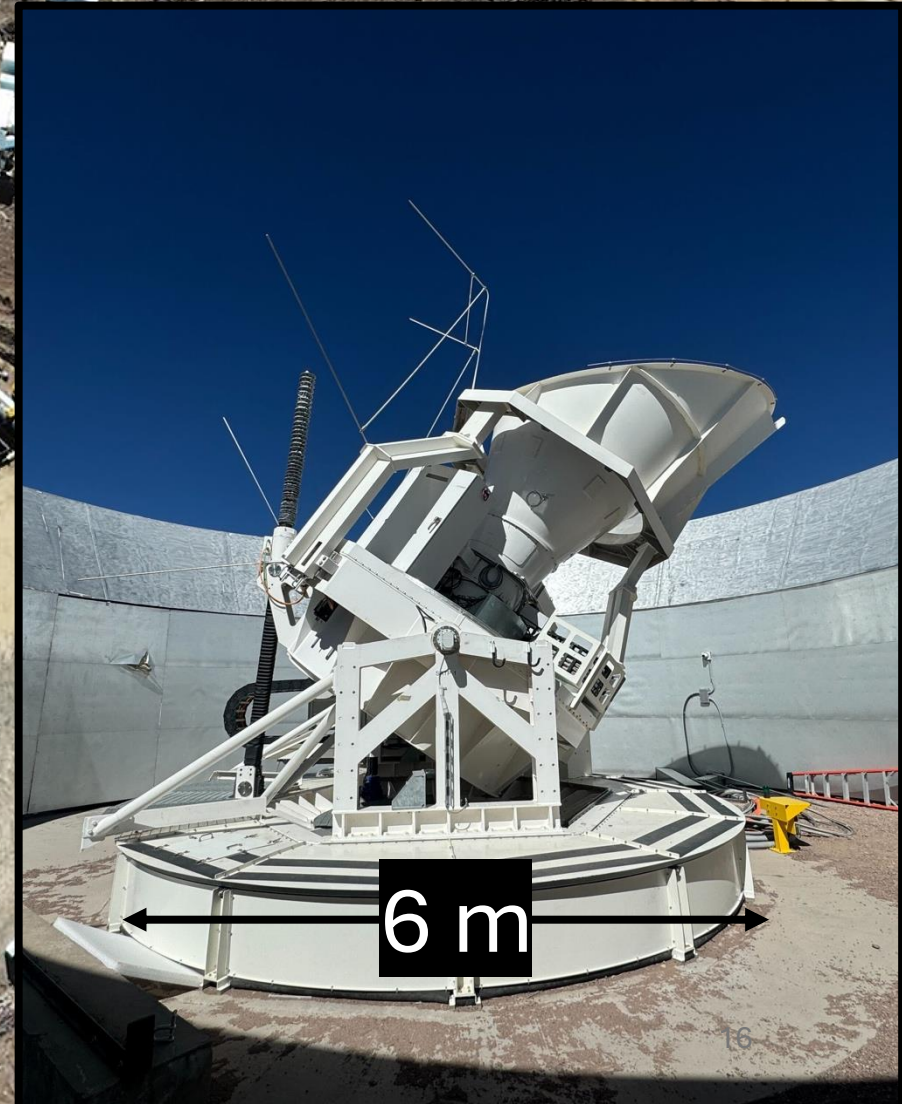
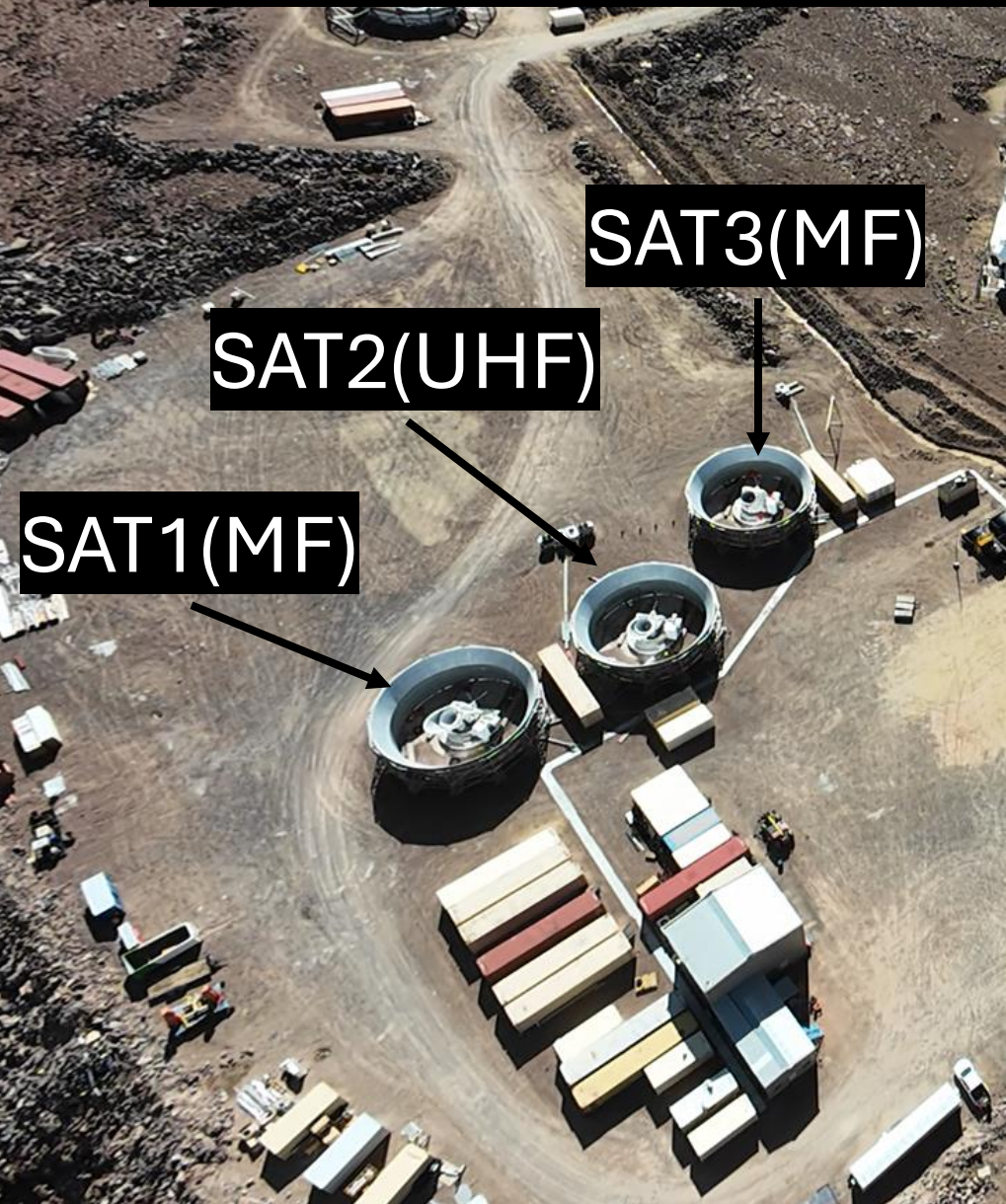
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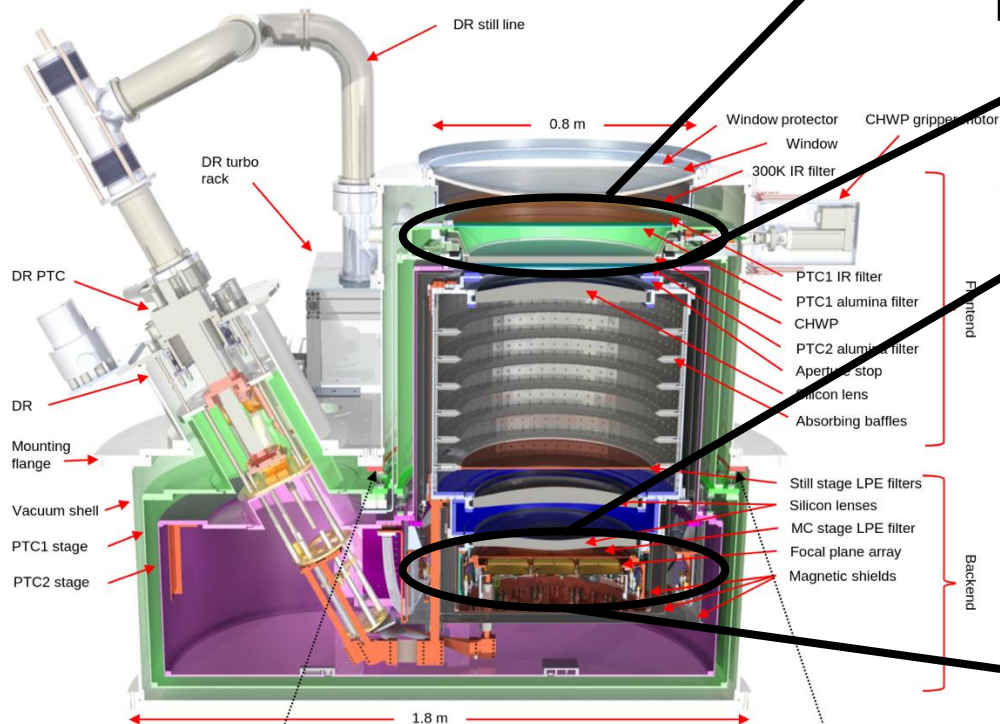
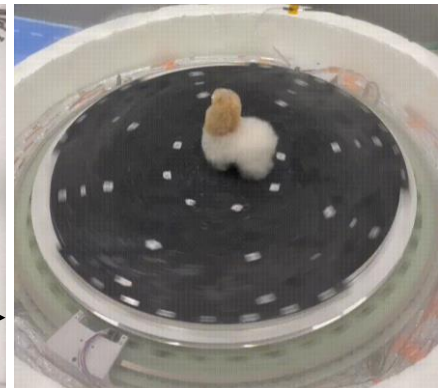
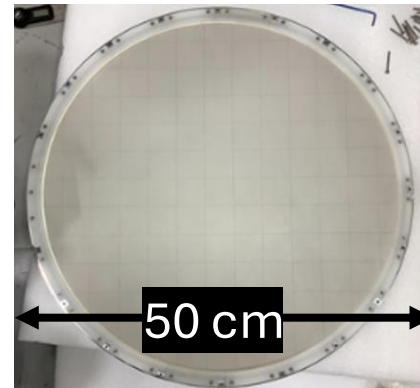
Small Aperture Telescopes (SATs)



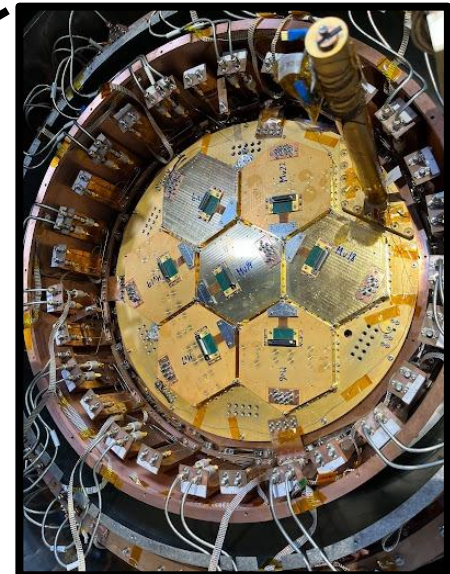
Small Aperture Telescope (SAT)

- 42 cm Aperture with $\sim 35^\circ$ FoV.
FWHM $\sim 27'$ @ 90 GHz
- 12,000 Transition-Edge-Sensor (TES) detectors in each SAT.
- Continuously rotating Half-Wave Plate to mitigate atmospheric $1/f$ noise

Rotating Half-Wave Plate (~ 2 Hz)



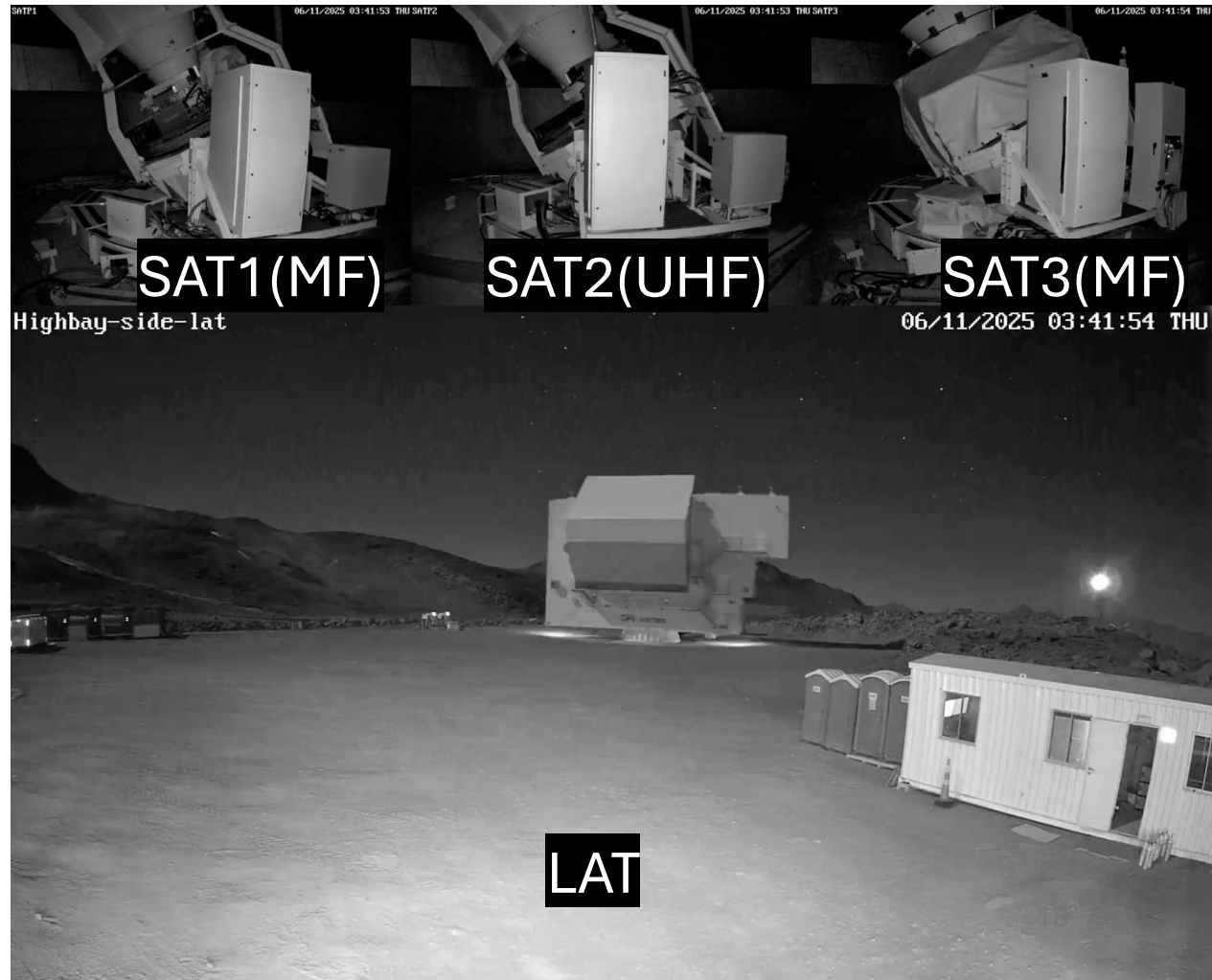
Seven modules = 12,000 detectors



Current status at site: Taking data with three SATs and ASO LAT!

Observation for one week

- Two MF-SAT (SAT1/SAT3)
 - conducting Initial Science Observation.
- UHF-SAT (SAT2)
 - Under Commissioning
- LAT
 - 13 optics tubes (Advanced SO)
 - Conducting commissioning and initial Science Observations



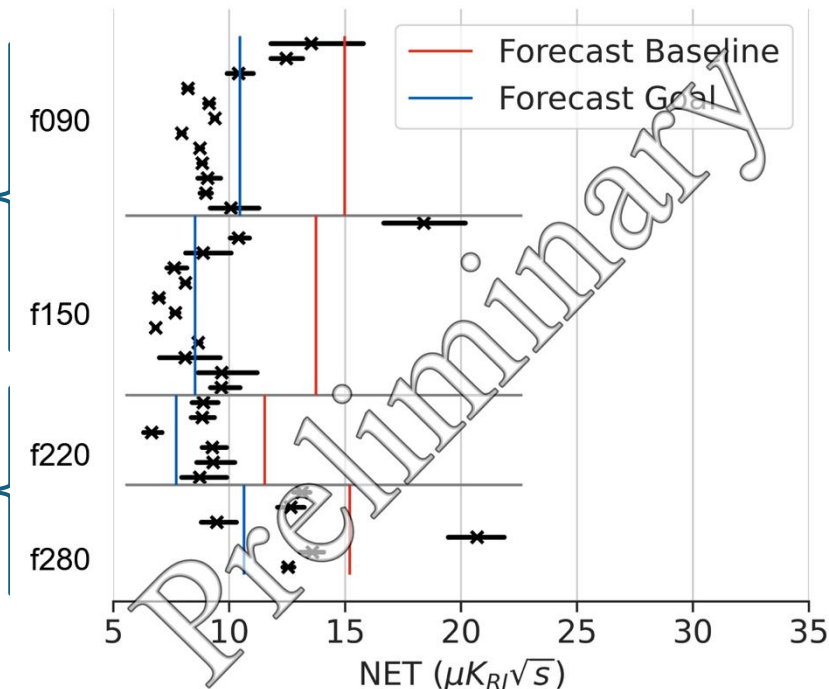
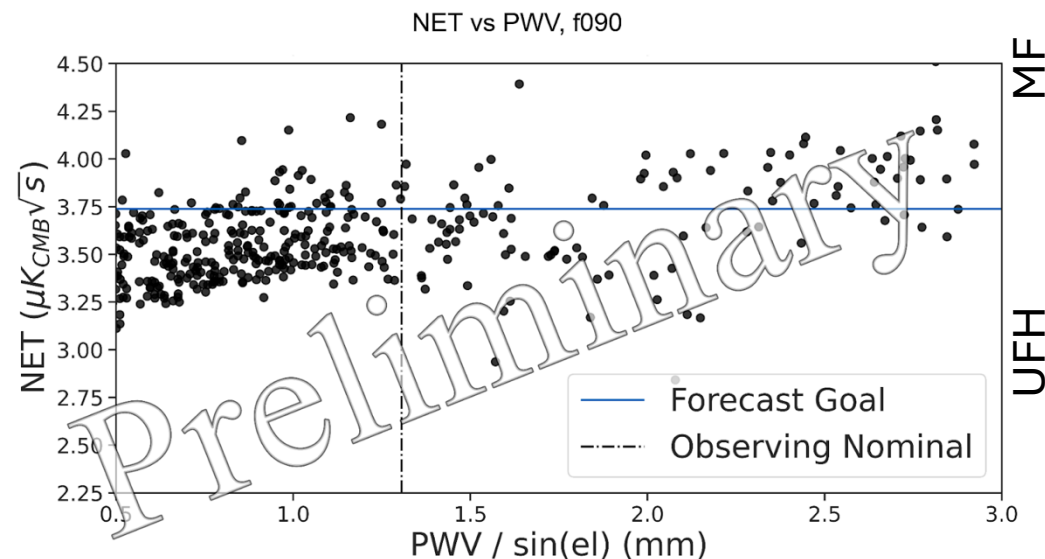
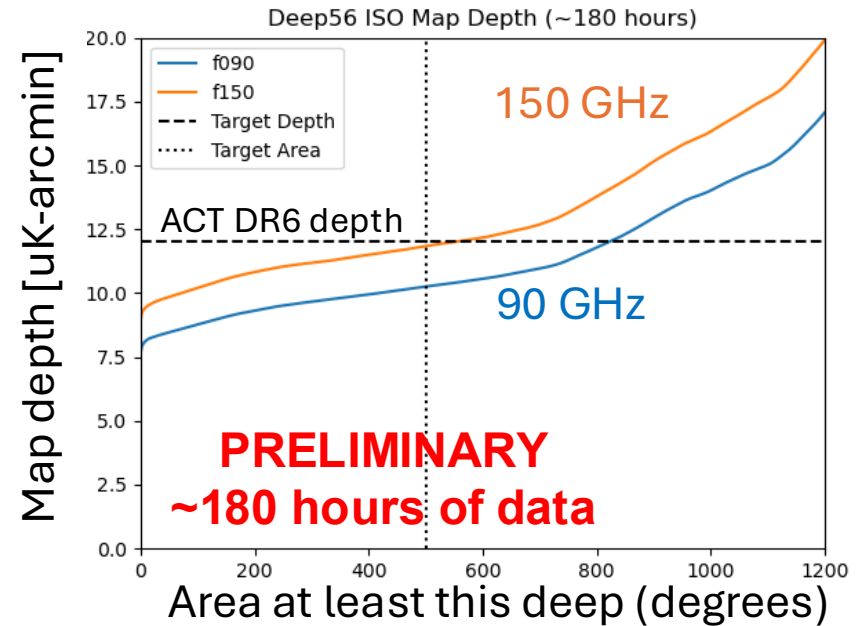
Preliminary results

Showing results of

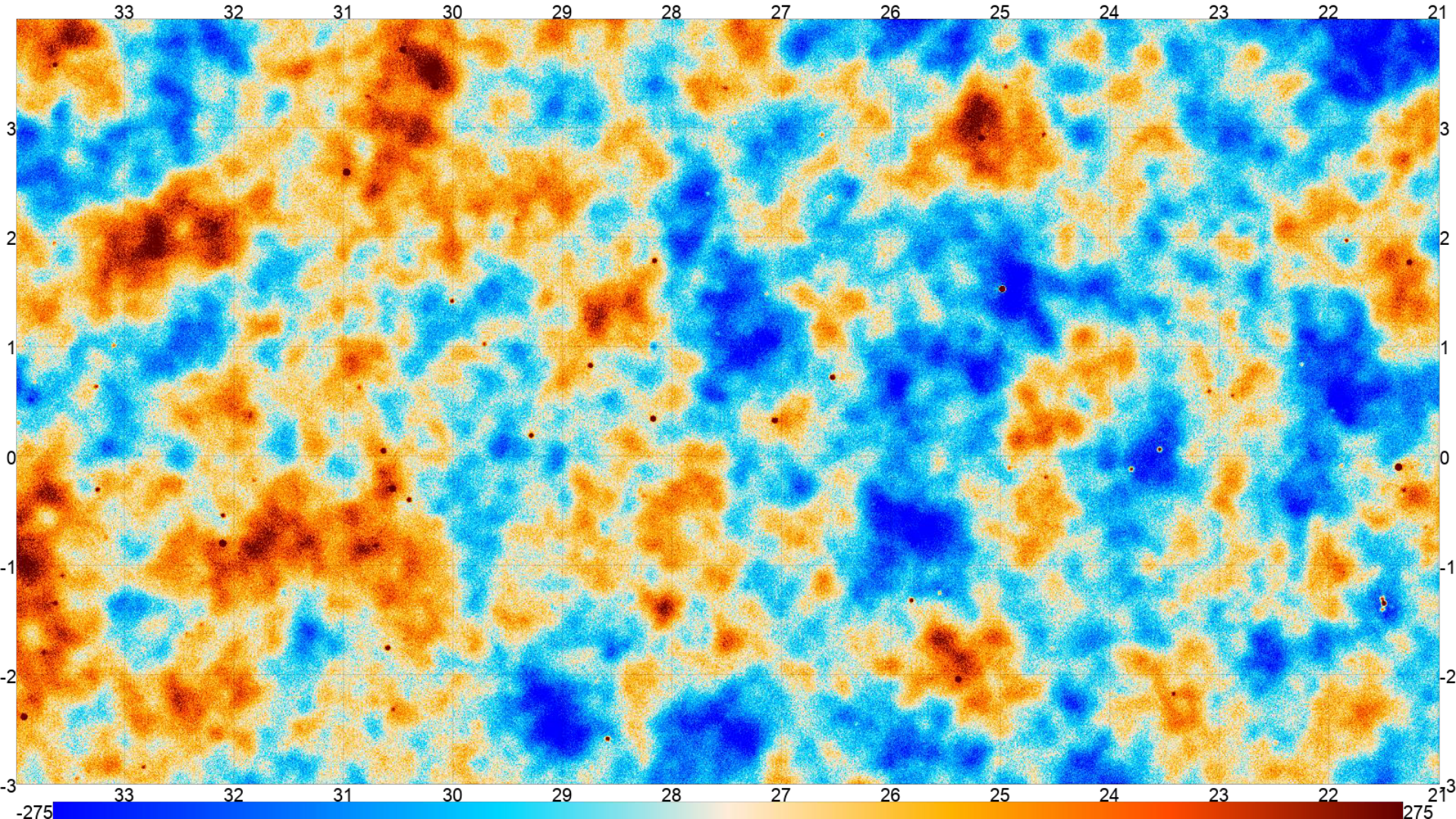
- LAT before the ASO upgrade (#optics tube is six: 4MF and 2UHF)
- MF-SATs (SAT1 and SAT3)

LAT: Sensitivity

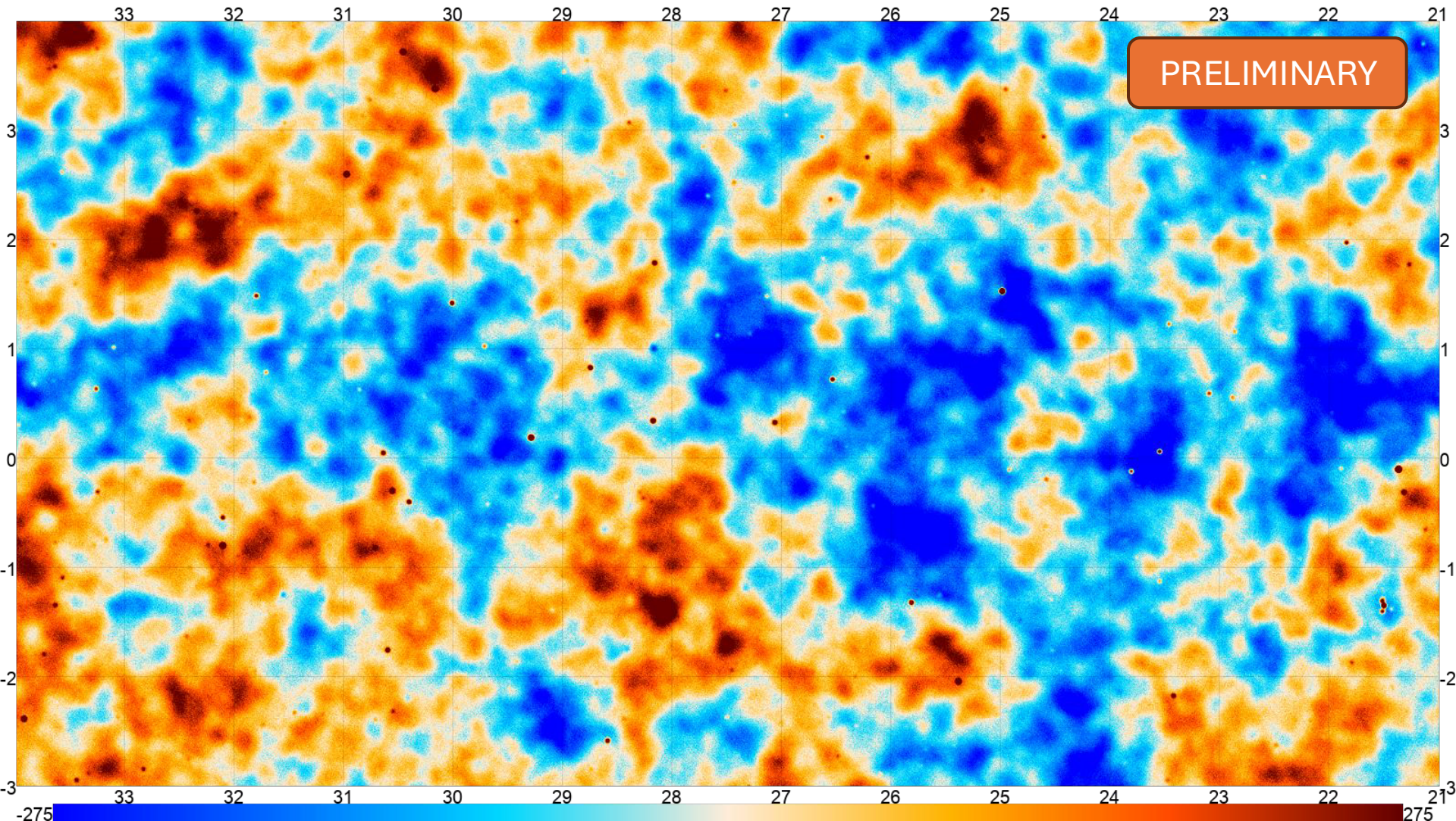
- Instantaneous sensitivity are exceeding the goal noise level at MF range.
- Achieved the same map depth as ACT achieved over 500sq. deg. with ~180 hours.



ACT+Planck DR6 f090 (5 years)



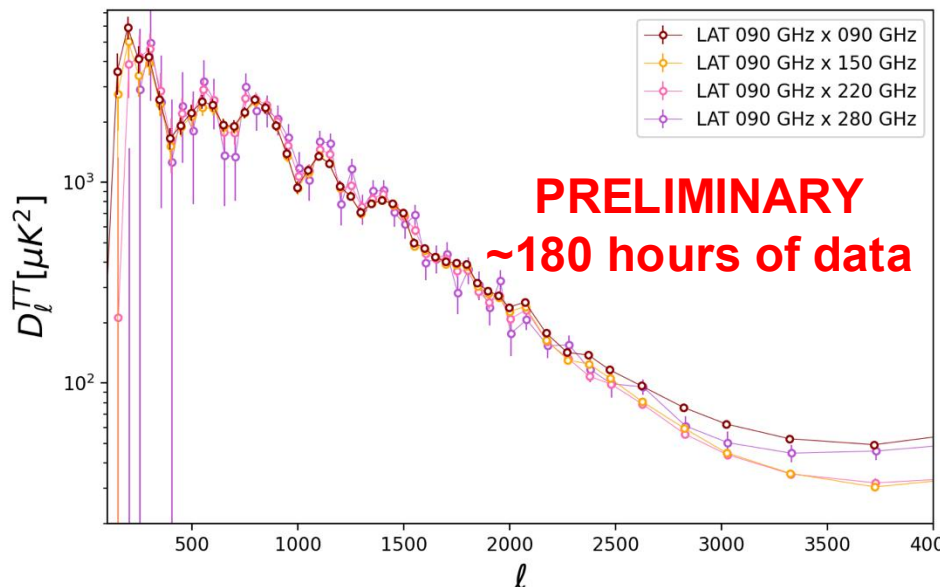
LAT f090 (~180 hours)



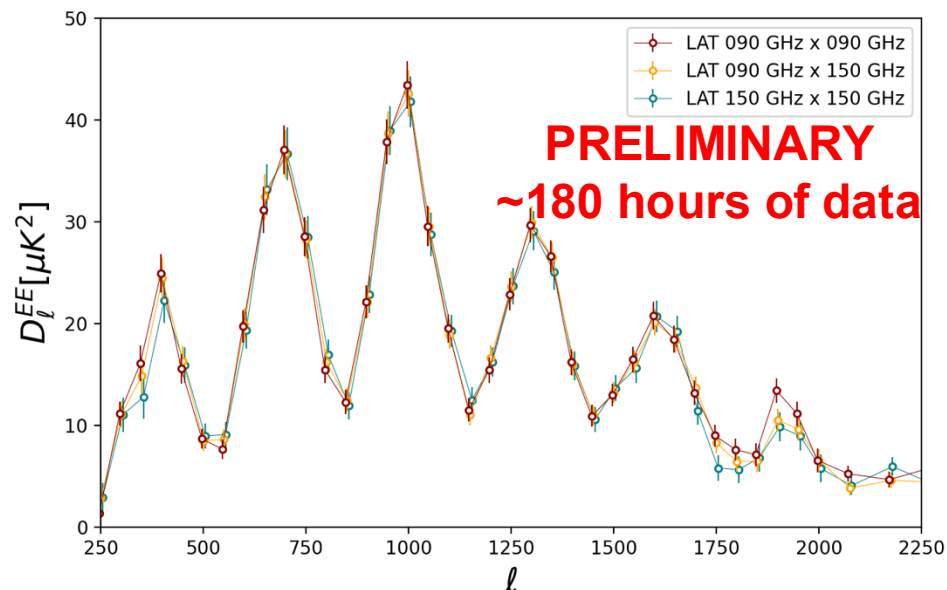
LAT: Power spectra

- Measured the acoustic oscillations in the TT and EE power spectra.
- Consistent between frequencies in both temperature and polarization.

TT power spectra

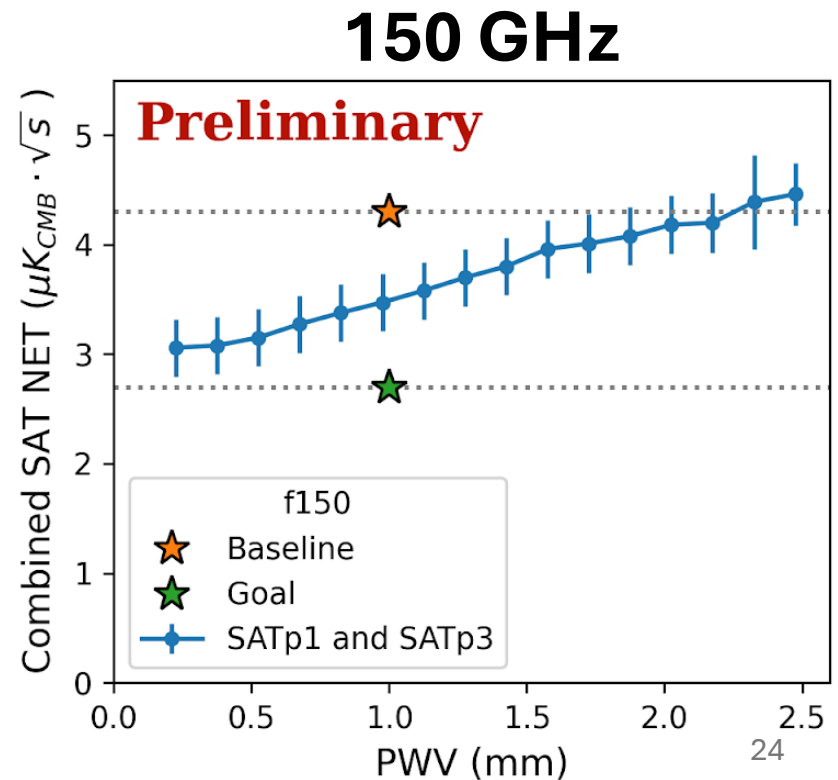
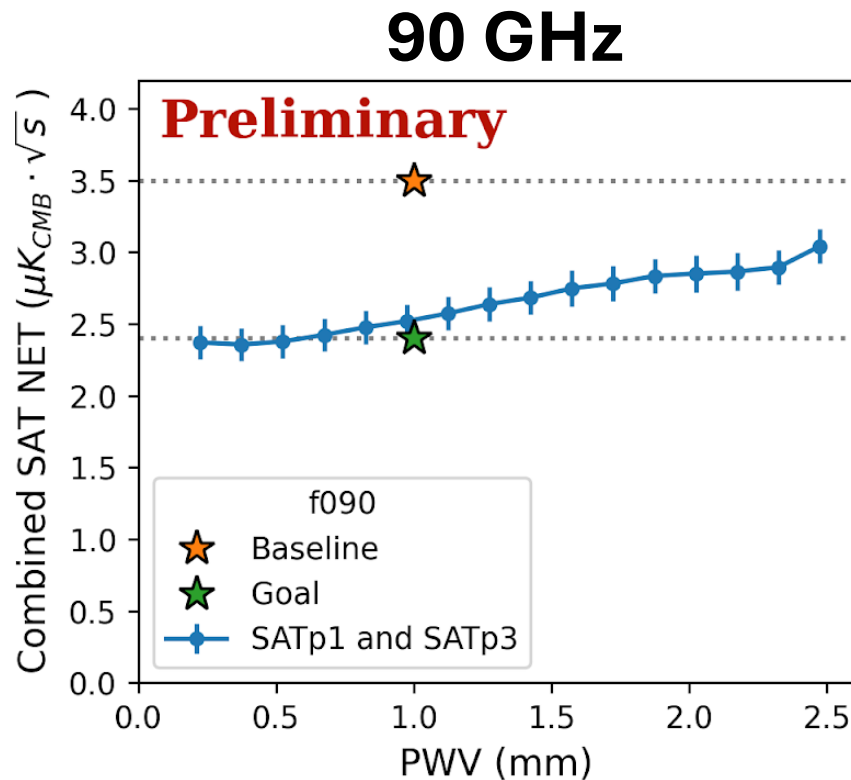


EE power spectra



SATs: sensitivity

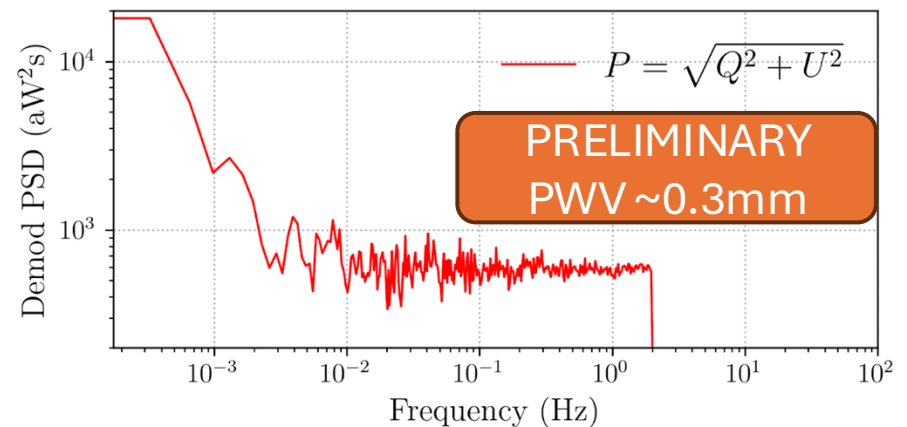
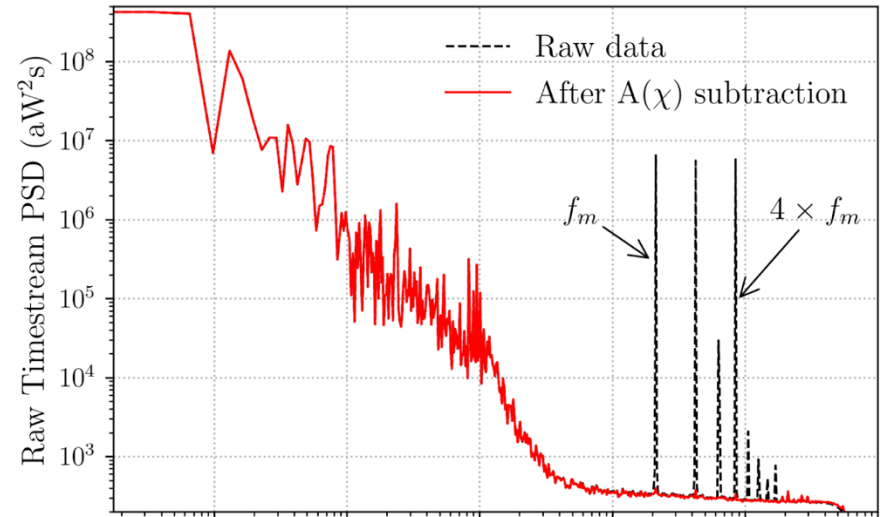
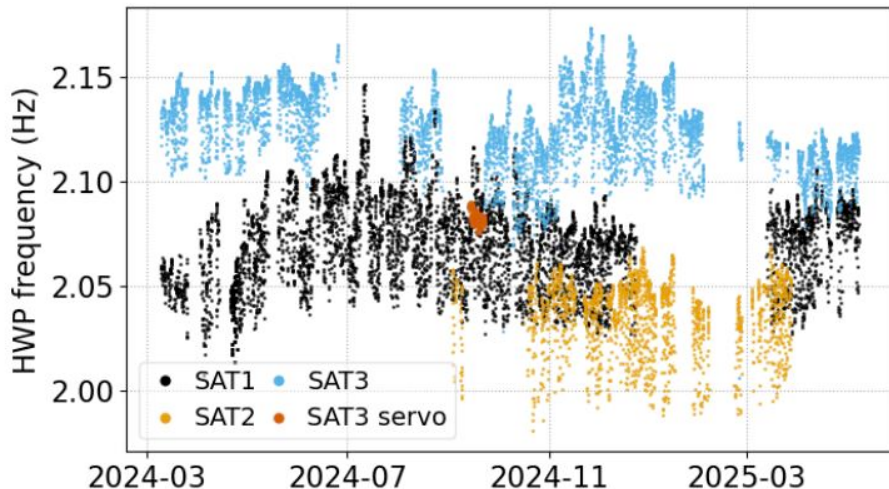
- Two MF-SATs combined instantaneous sensitivity is exceeding the baseline noise level in both bands!



SAT: Rotating Half-Wave Plate

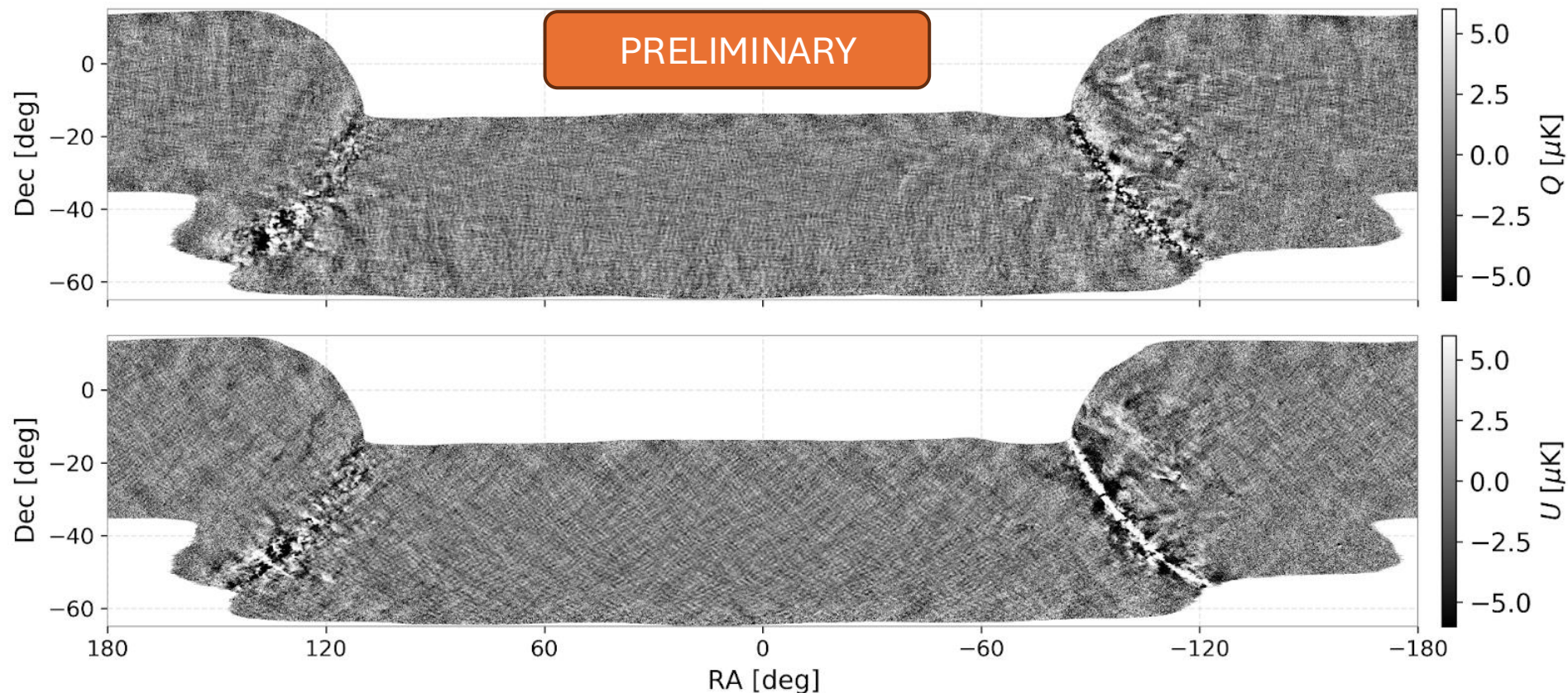
- Mitigate atmospheric $1/f$ noise well
- Rotation speed has been stable (<100 mHz) for all SATs, which is sufficient for SO-SATs.

K. Yamada et al., [arXiv:2605.27056](https://arxiv.org/abs/2605.27056)



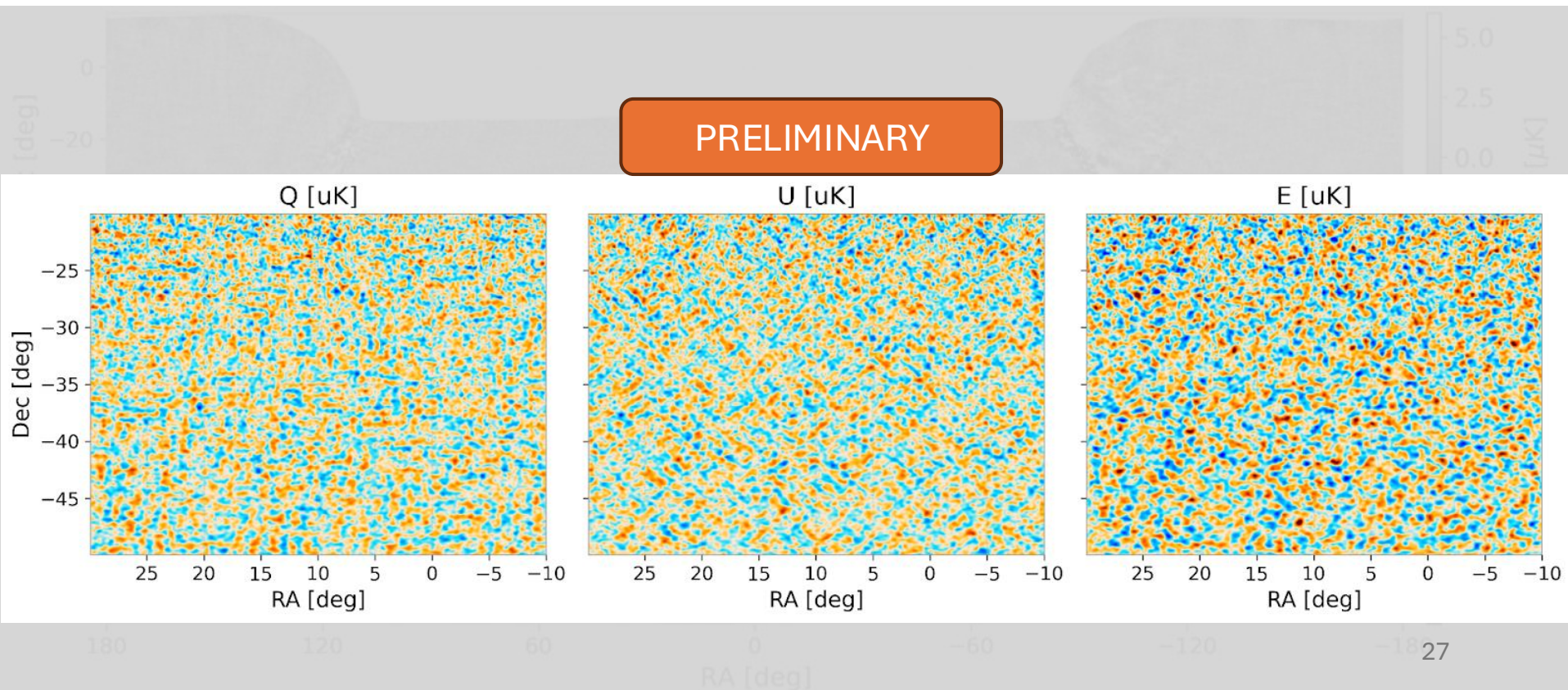
SAT: polarization maps

- Very promising Polarization maps!
- *E*-mode pattern are clearly seen.

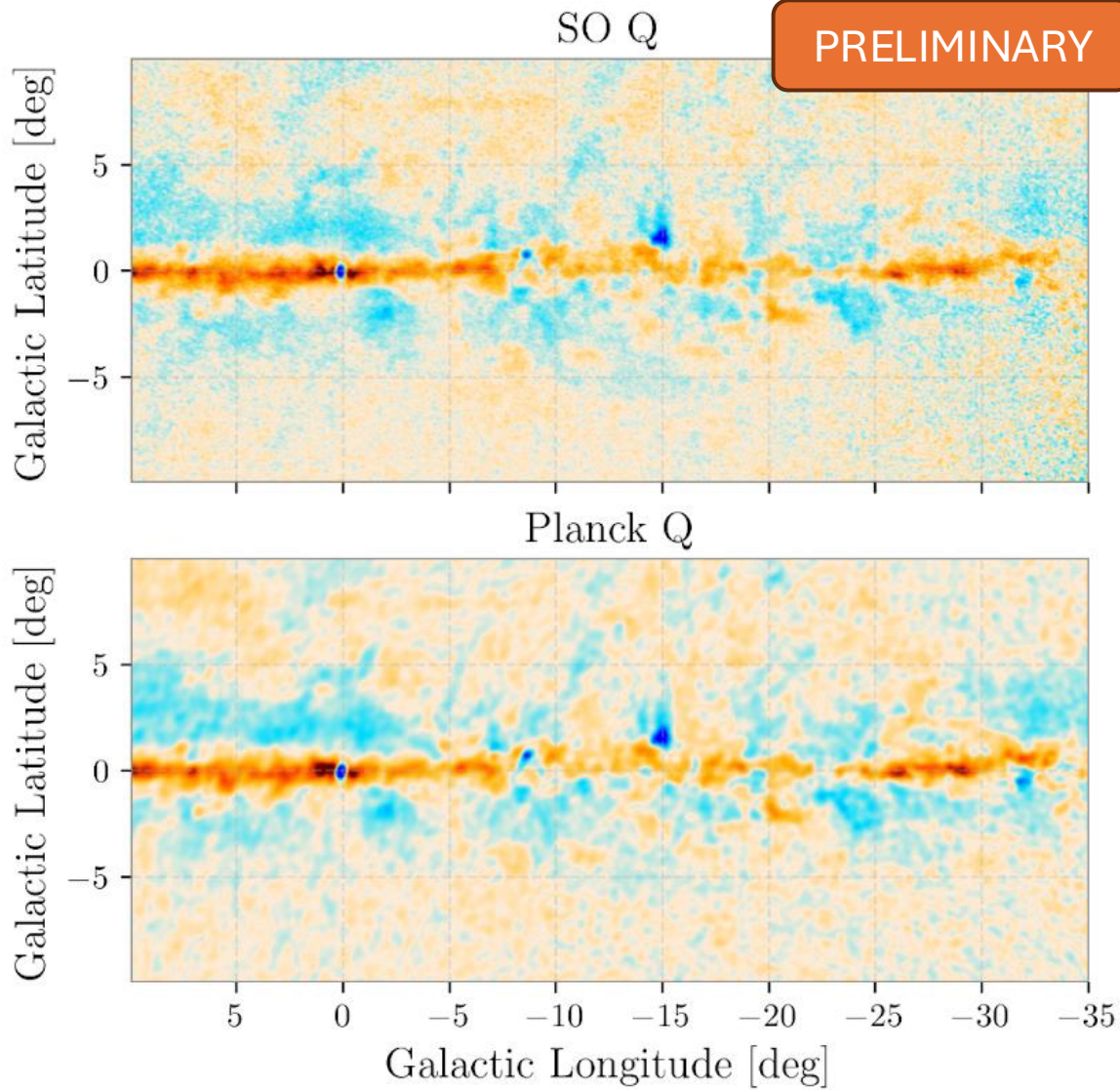


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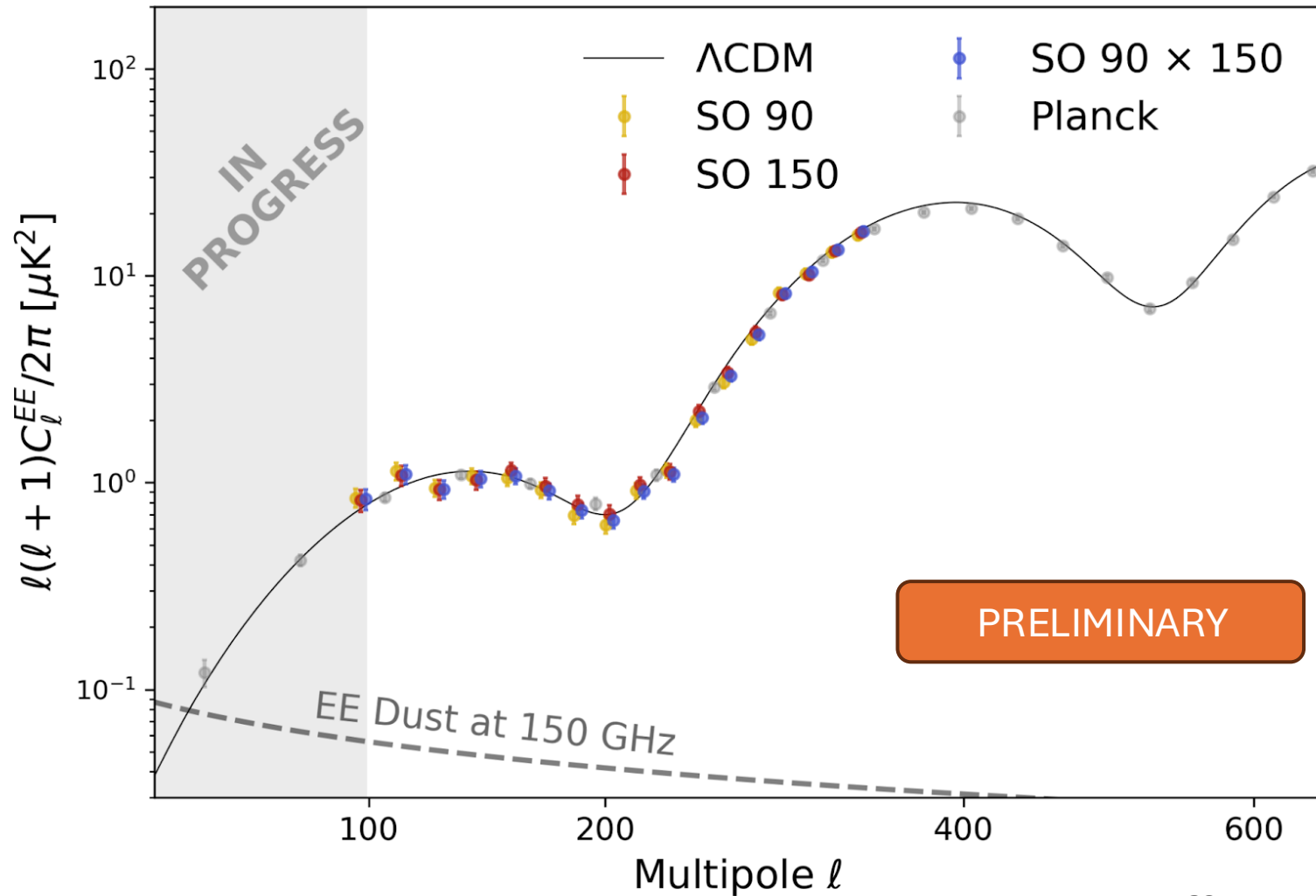


aps!



SAT: polarization maps

- Very
- E -mode

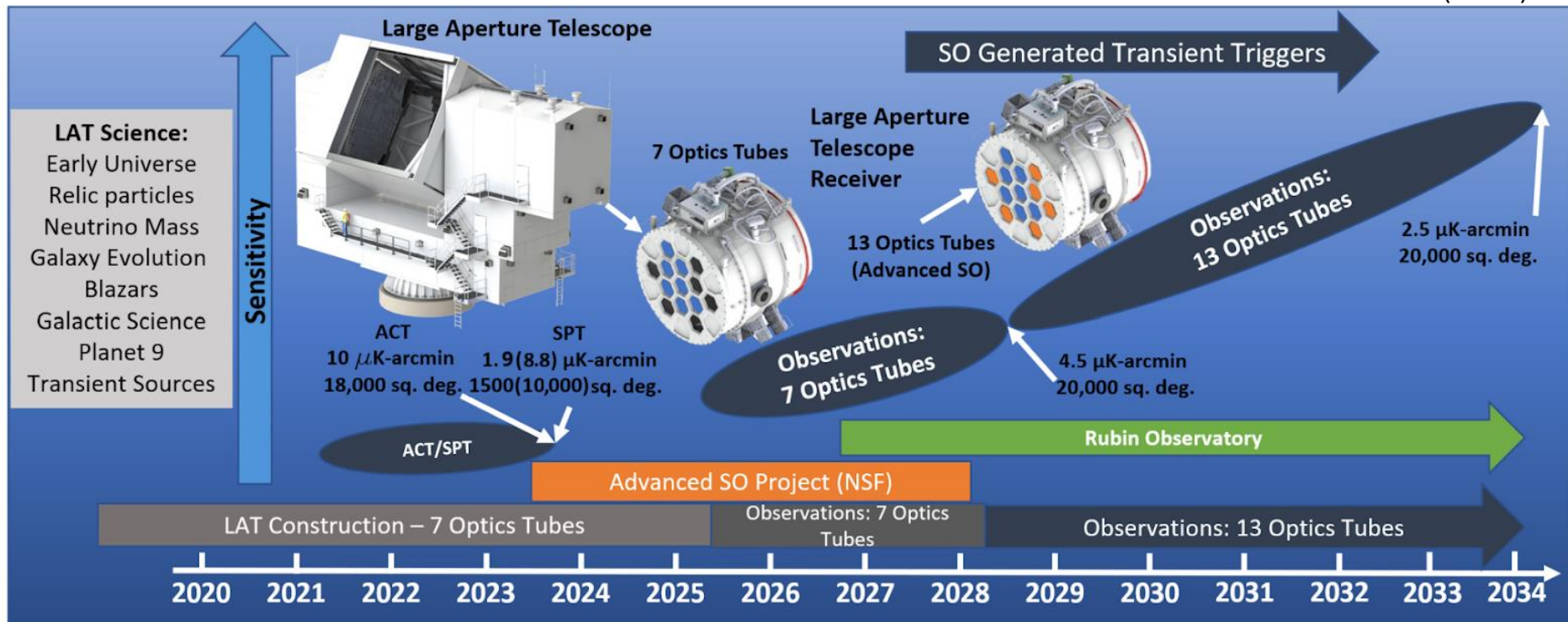


Future prospects

LAT prospect

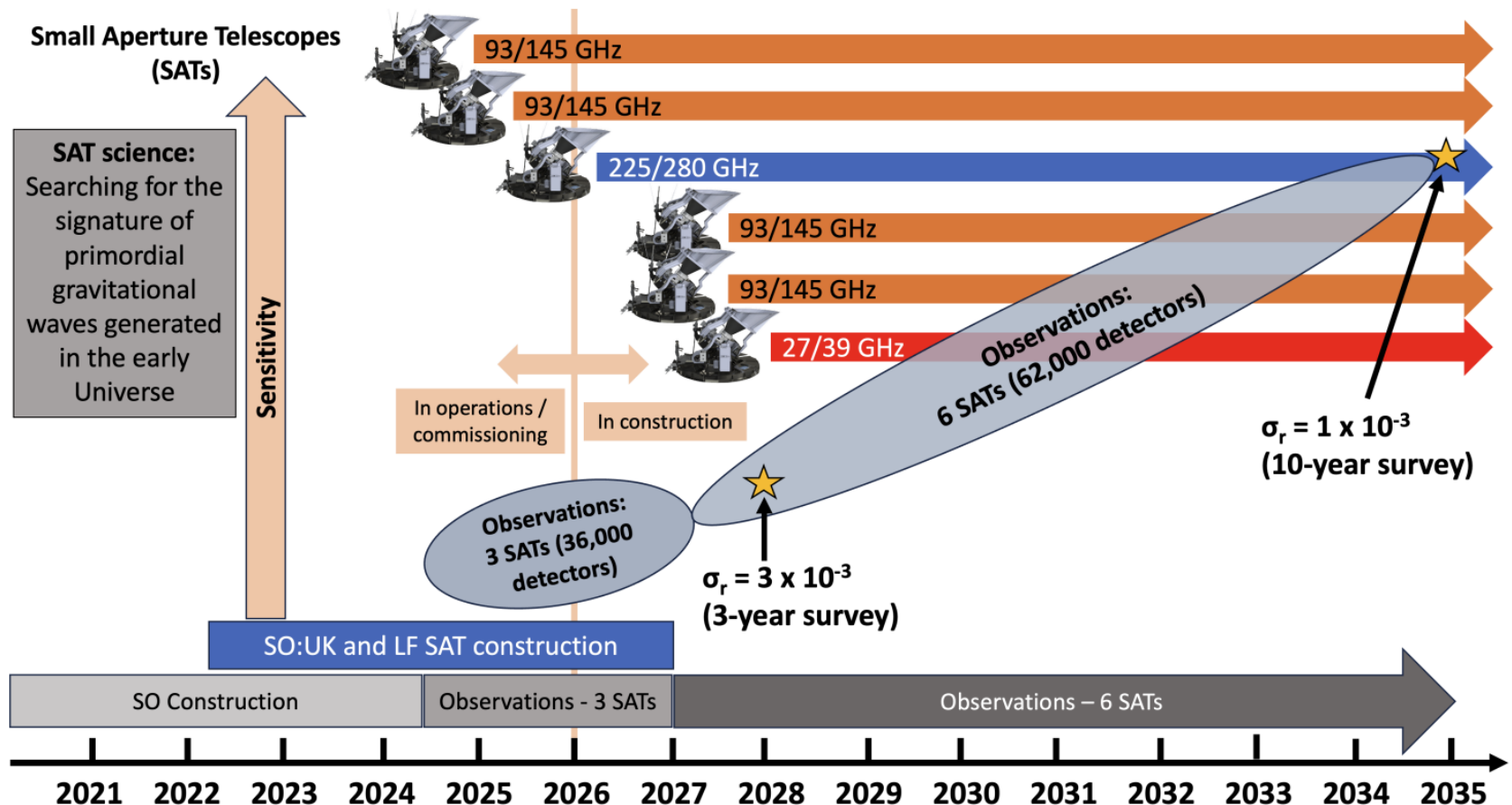
- We have already started taking data with 13 optics tube!
- Advanced SO project is 18 months ahead of scheule!

M. Abitbol et al JCAP08(2025)034



SAT prospect

- Additional three SATs: 2 MF(SO:UK), 1 LF(SO:JP)
 - Total number of detectors: >60,000



SAT prospect

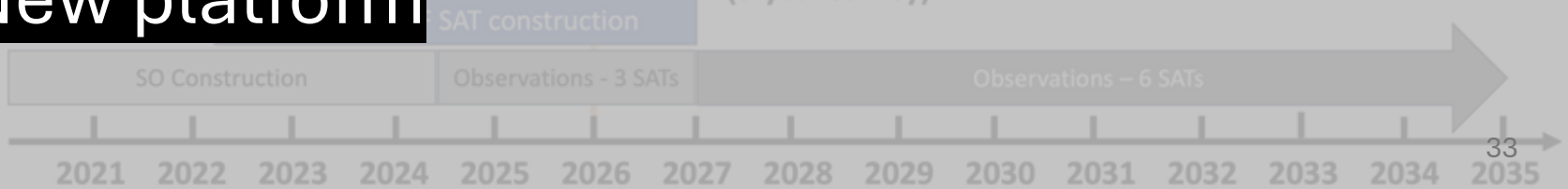
- Additional three SATs by 2027: 2 MF(SO:UK), 1 LF(SO:JP)
 - Total number of detectors: >60,000



New platform

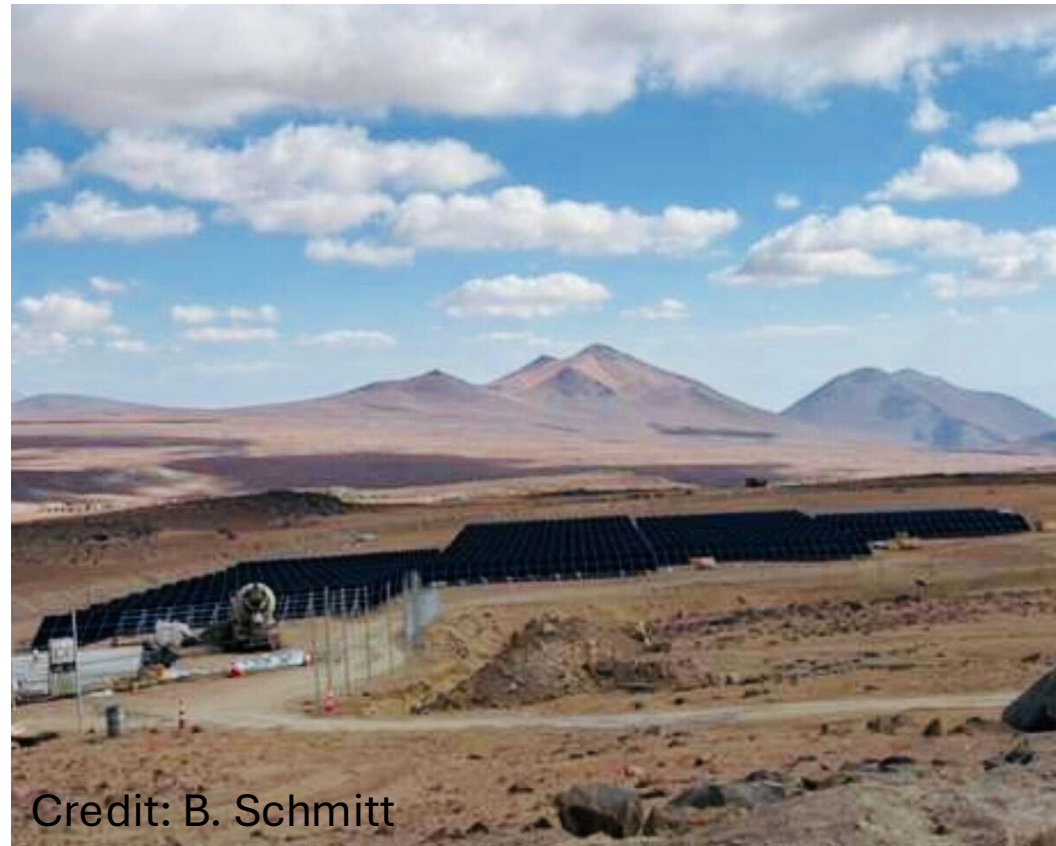


New cryostat



Site upgrade: photovoltaic(PVA)

- 1MW photovoltaic (PVA) array is underconstruction.
- Will generate power with PVA in addition to Diesel electric generators to ensure the energy security of this remote site.



Credit: B. Schmitt

Summary

- The Simons Observatory is observing from Atacama Desert with three SATs and LAT.
- Sensitivity of both MF-SATs and LAT are exceeding the baseline sensitivity.
- Three additional SATs will be deployed by 2027. The total number of detectors will be $>120,000$.
- Stay tuned for the first science results!