Simons Observatory Large Aperture Telescope : Initial Science Observations

Merry Duparc
on behalf of the SO collaboration

2 June 2026 - GdR CoPhy episode 4

Simons Obervatory

- **CMB/mm observatory located in Atacama desert, Chile**
- **Two components :**

Small Aperture Telescopes (SATs)

Large angular scales

Large Aperture Telescope (LAT)

Small angular scales

Site : Cerro Toco

- 5200m altitude
- Very low humidity
- Large part of the sky accessible

→ Perfect for micro wave domain observations !

LAT Science cases

Cosmology

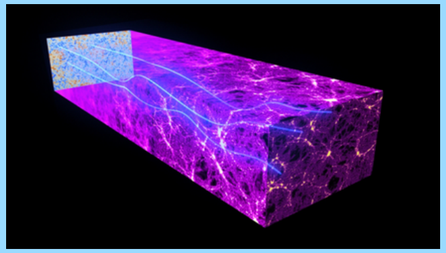
Dark matter

Dark energy

Growth of structure

Cosmic birefringence

Reionization

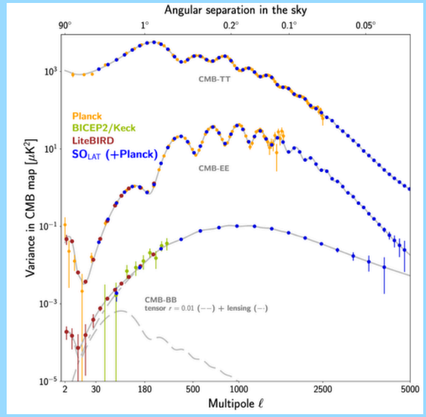


Primordial perturbations

Inflation parameters (ns)

Tensor to scalar ratio

Primordial non-gaussianities



Time-domain astrophysics

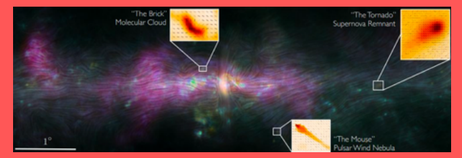
Gamma ray bursts, interacting supernovae, ...

Galactic science

Interstellar dust

molecular clouds

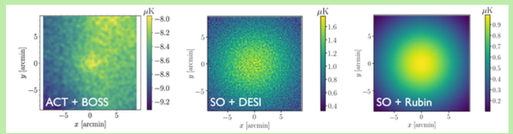
AGNs



Cluster physics

Galaxy feedback

Cluster evolution



Stellar system science

Star formation

Planet 9

Asteroid regoliths

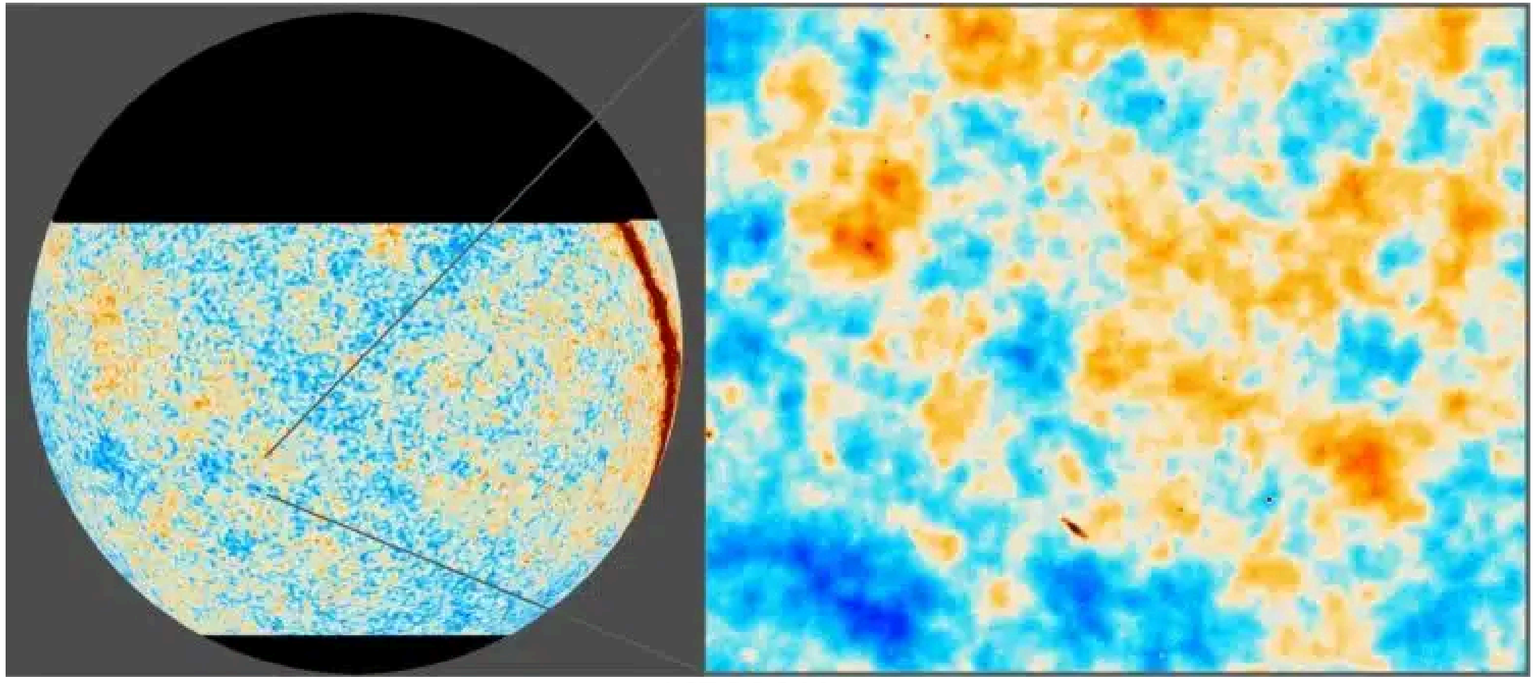
Particle physics

Number of relativistic species

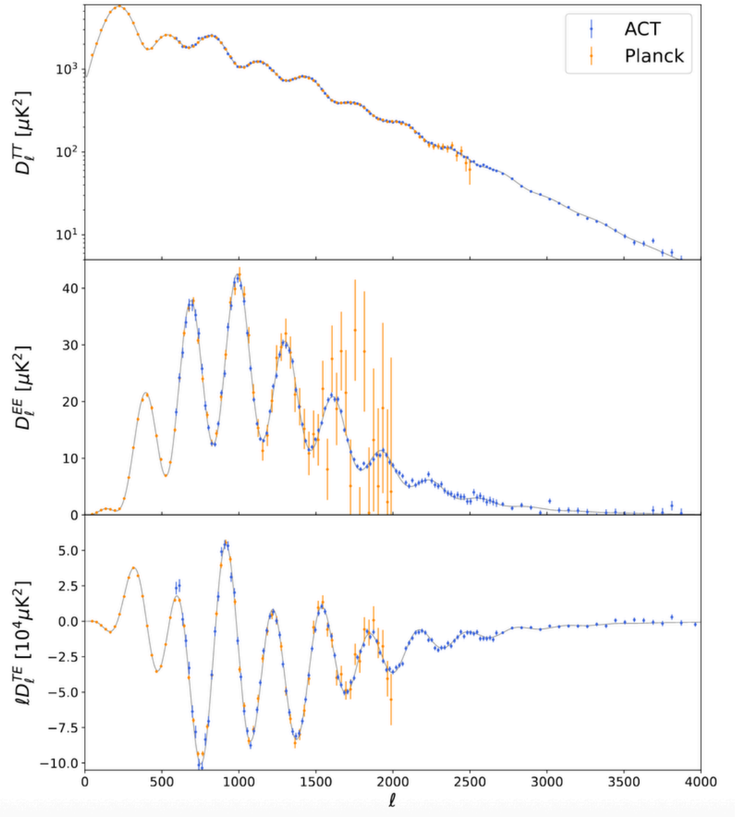
Neutrinos masses

The Simons Observatory: Science Goals and Forecasts for the Enhanced Large Aperture Telescope arXiv:2503.00636

SO LAT predecessor :
Atacama Cosmology Telescope (ACT)

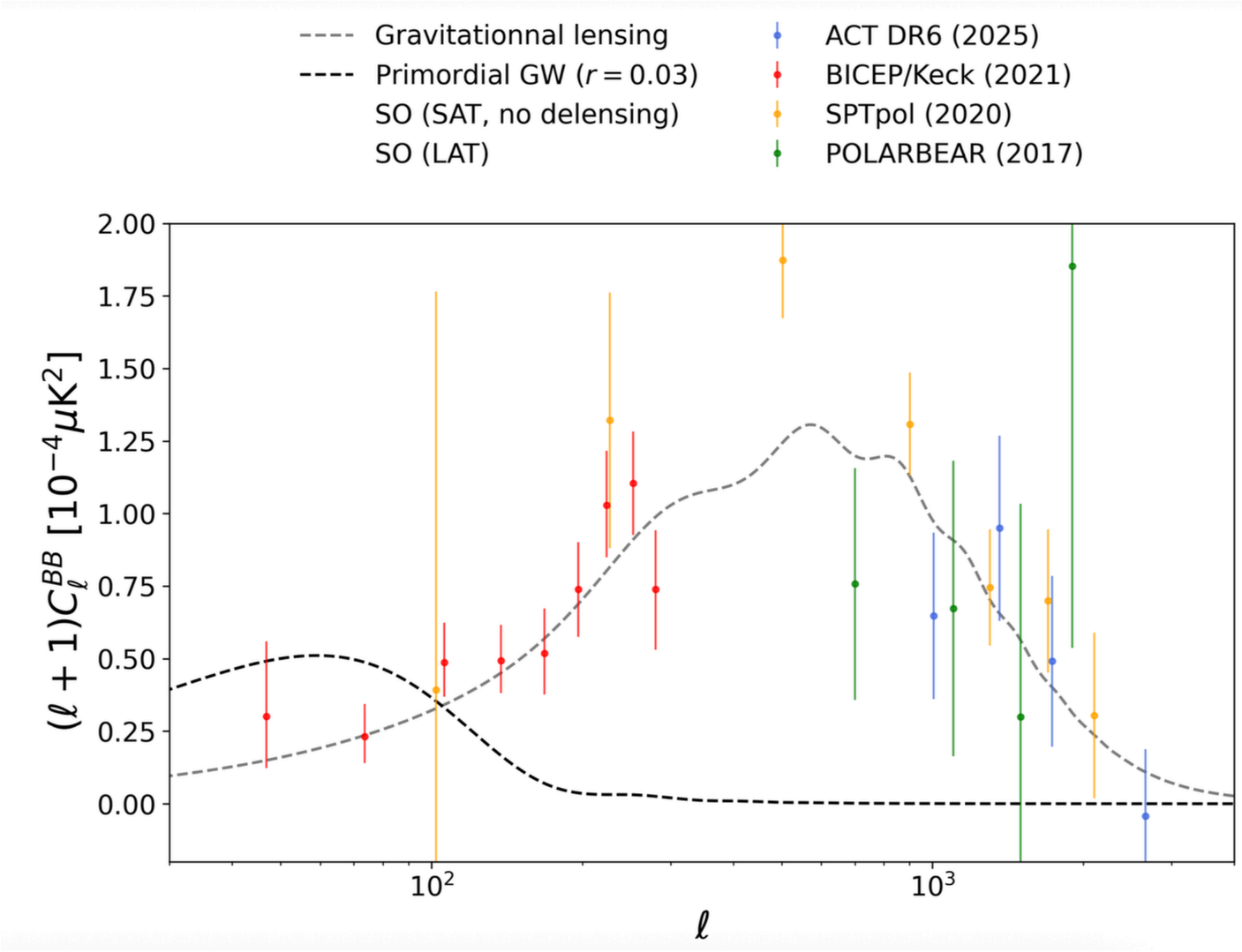


ACT DR6 Maps
Naess et Al. 2025

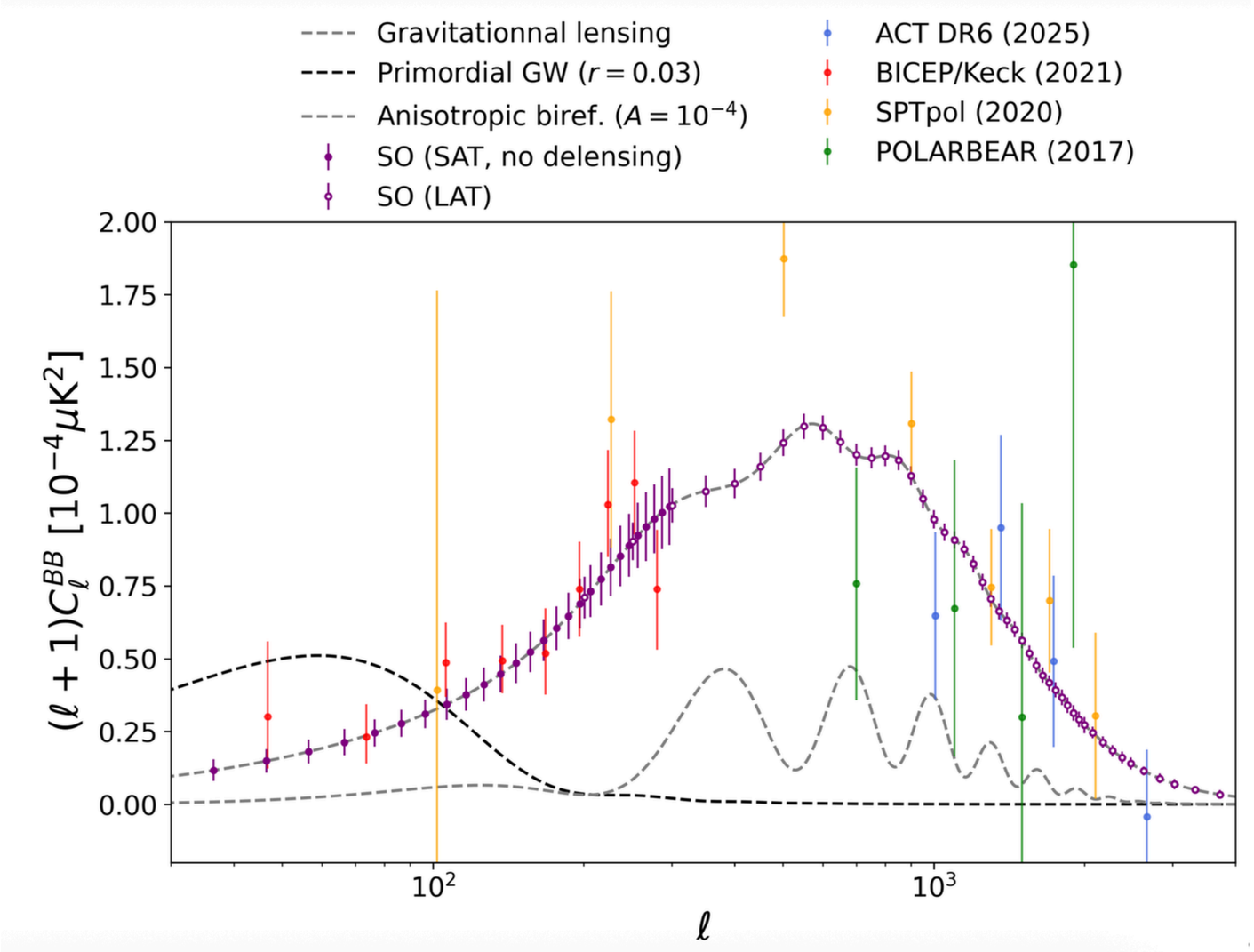


ACT DR6 Power Spectra, Likelihoods and ΛCDM parameters
Louis et Al. 2025

SO : Comparison to actual experiments

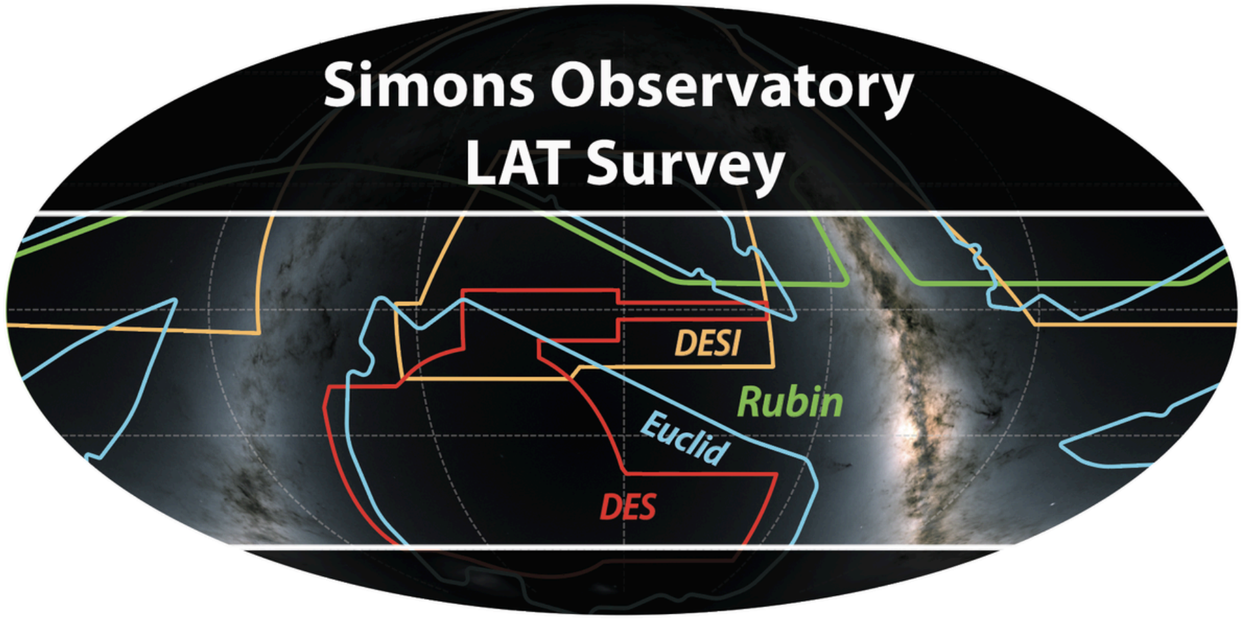


SO : Comparison to actual experiments



SO LAT

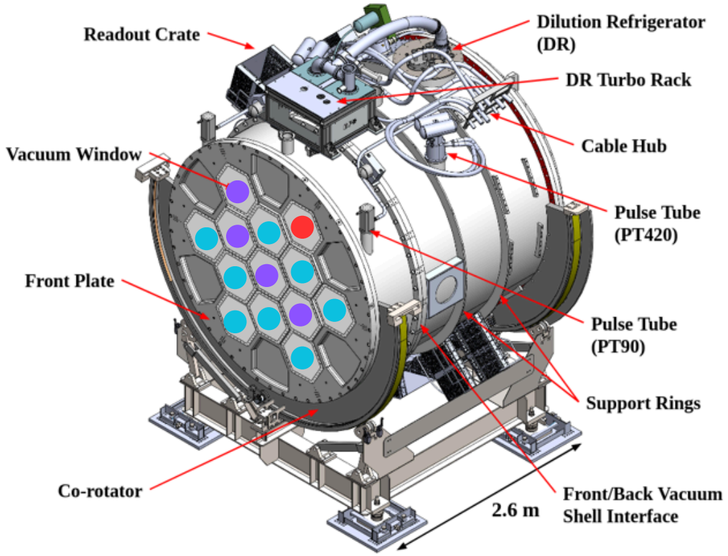

Credit : José Argañaraz

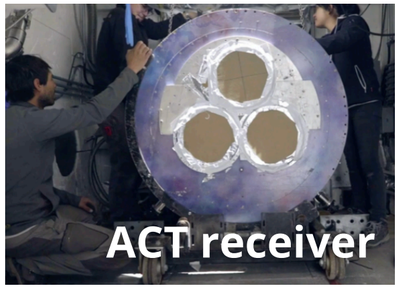


- 6 meter mirror
  - good angular resolution (~arcmin)
- 60 000 cryogenic detectors at 100mK
  - most detectors for a CMB telescope !

SO LAT

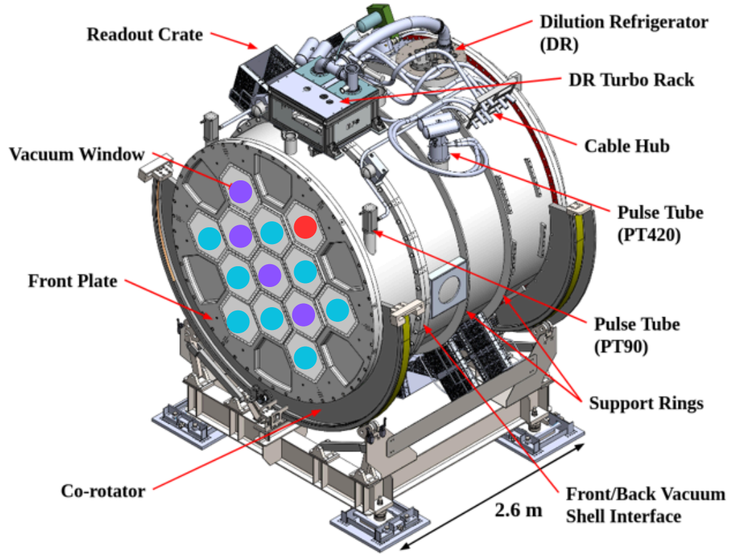
Credit : José Argañaraz





SO LAT

Credit : José Argañaraz

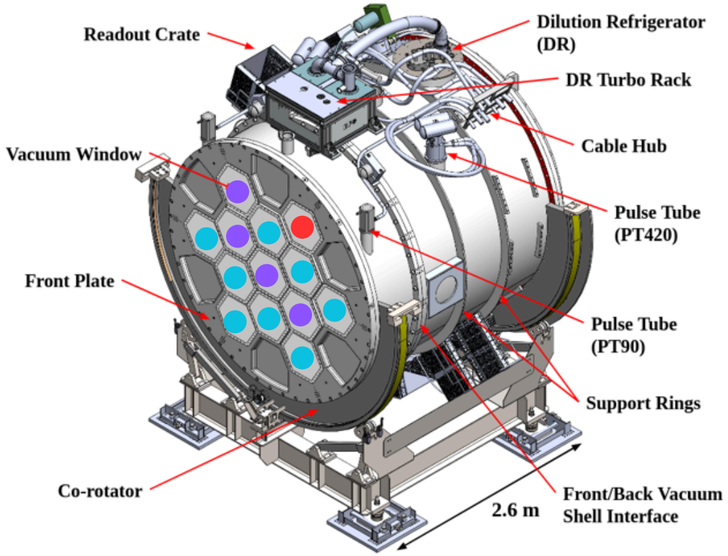


13 Optics tubes:

1 Low Freq	8 Mid Freq	4 High Freq
27 & 40 GHz	90 & 150 GHz	220 & 280 GHz

SO LAT


Credit : José Argañaraz

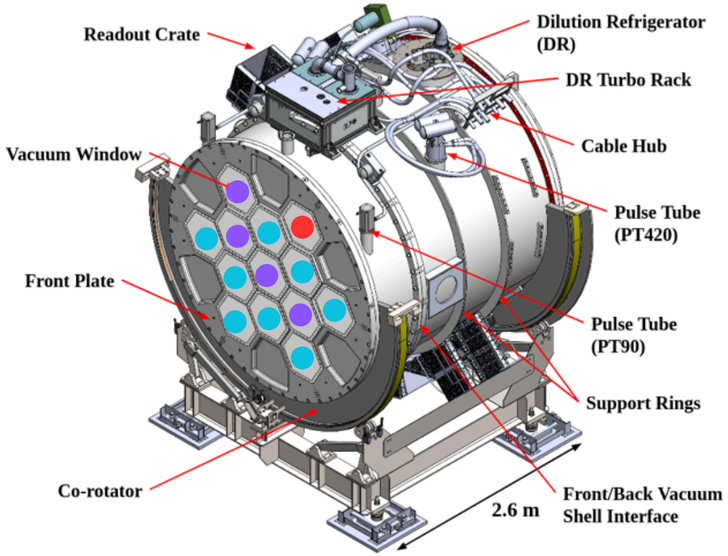


13 Optics tubes:

1 Low Freq	8 Mid Freq	4 High Freq
27 & 40 GHz	90 & 150 GHz	220 & 280 GHz
radio sources	CMB	**galactic dust**
synchrotron		**CIB**
and much more ...		**and much more ...**

SO LAT


Credit : José Argañaraz



1 Low Freq	8 Mid Freq	4 High Freq
27 & 40 GHz	90 & 150 GHz	220 & 280 GHz

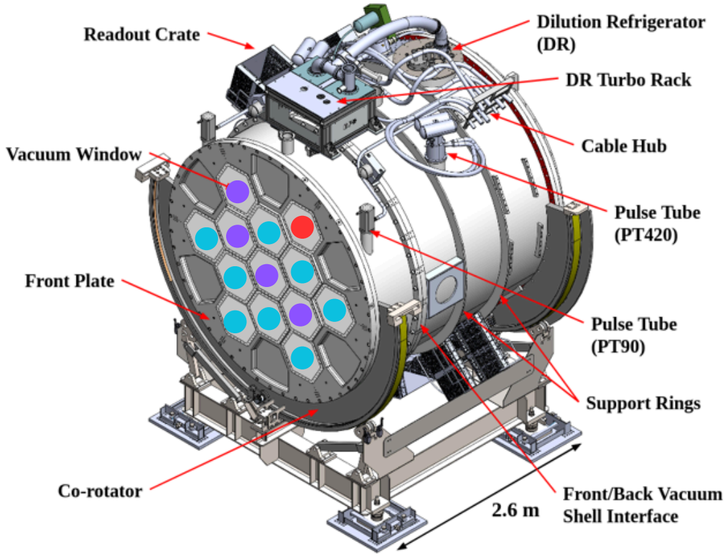
>10 times more detectors than ACT

much better **frequency coverage**

(3 → 6 bands)

SO LAT


Credit : José Argañaraz



1 Low Freq	8 Mid Freq	4 High Freq
27 & 40 GHz	90 & 150 GHz	220 & 280 GHz

- First light in march 2025, with half the tubes installed
- Rest of the tubes currently installed

SO LAT


Credit : José Argañaraz

Current status:

Initial Science Observations

- **Unblinded** analysis of 2025 data
- Aims to assess the **performance of the telescope** and **current state of the pipeline**

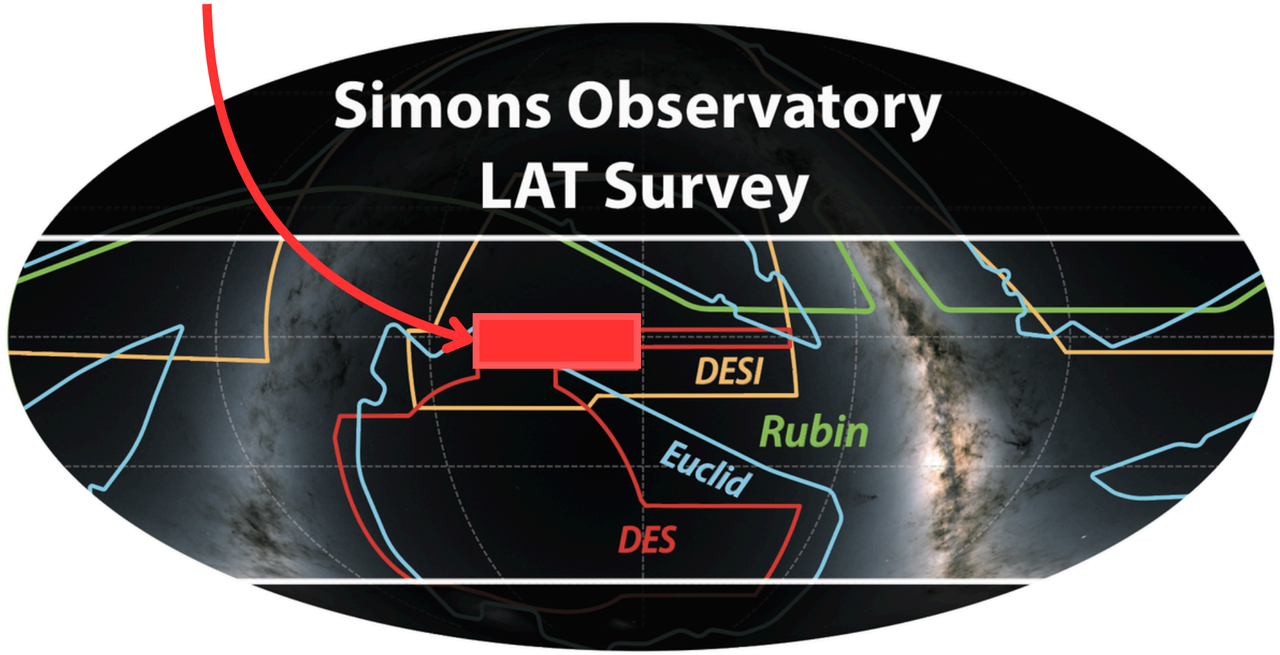
SO LAT


Credit : José Argañaraz

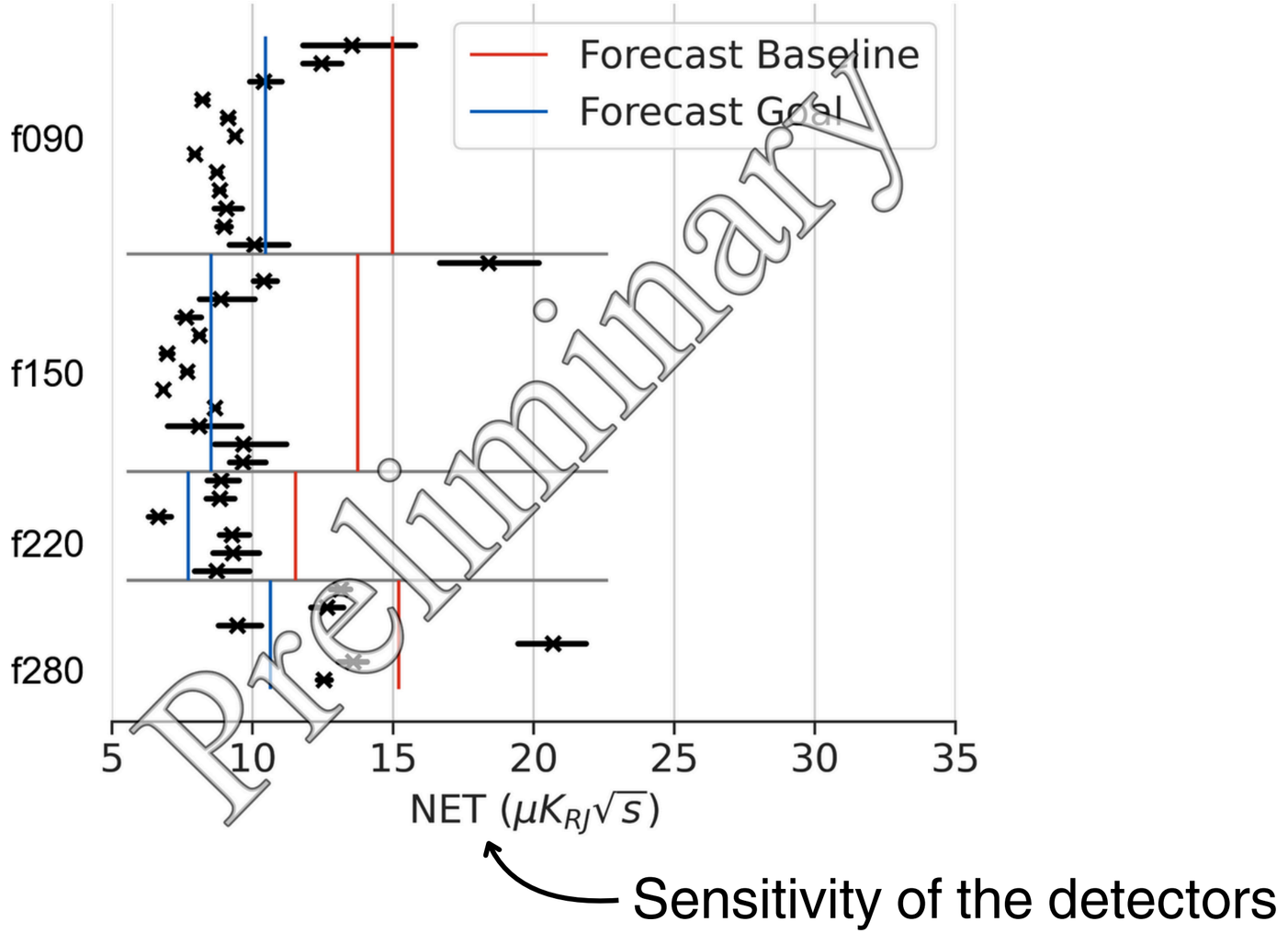
Current status:

Initial Science Observations

Results shown here: **~1%** of the sky with **similar depth as ACT**

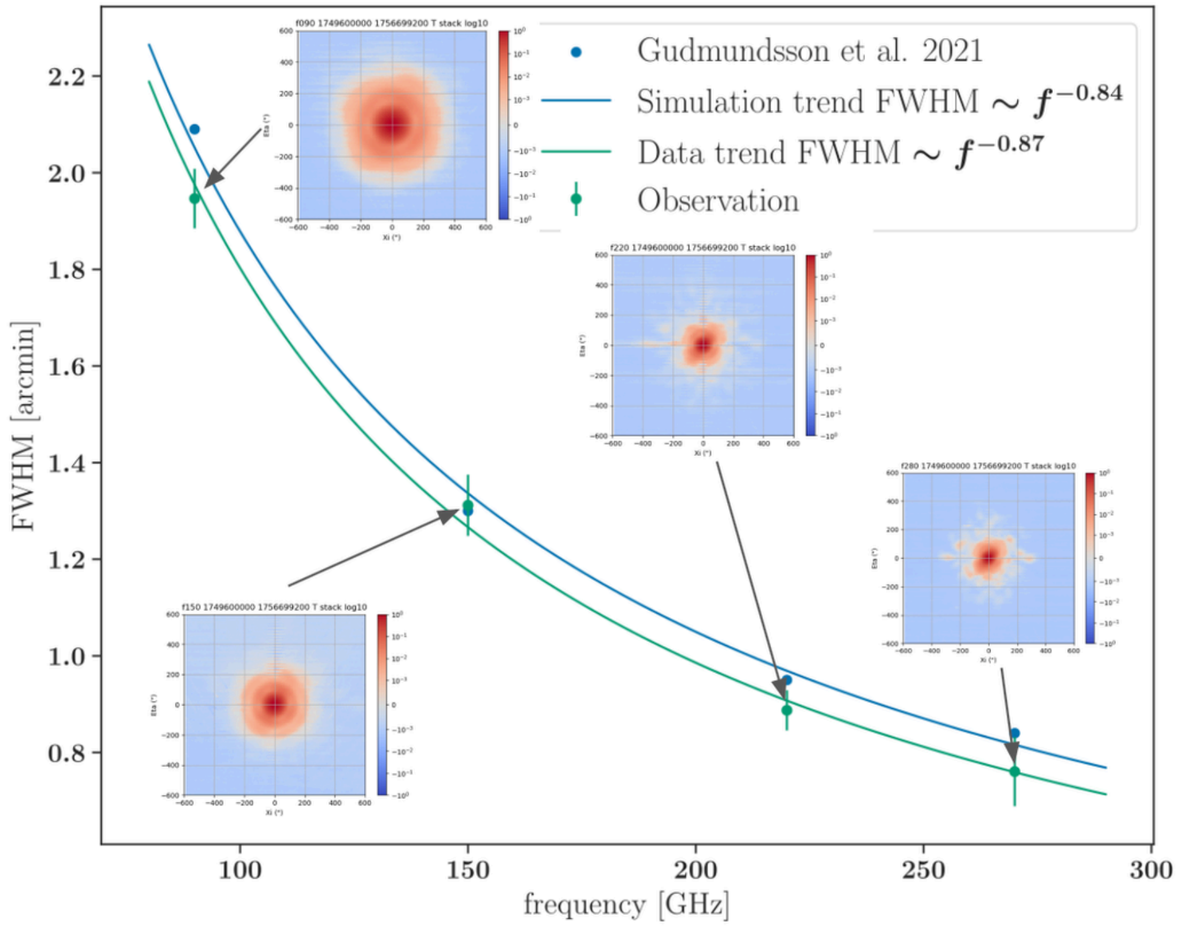


Detectors performance



Plot makers: Jack Orlowski-Scherer

Angular response of the telescope

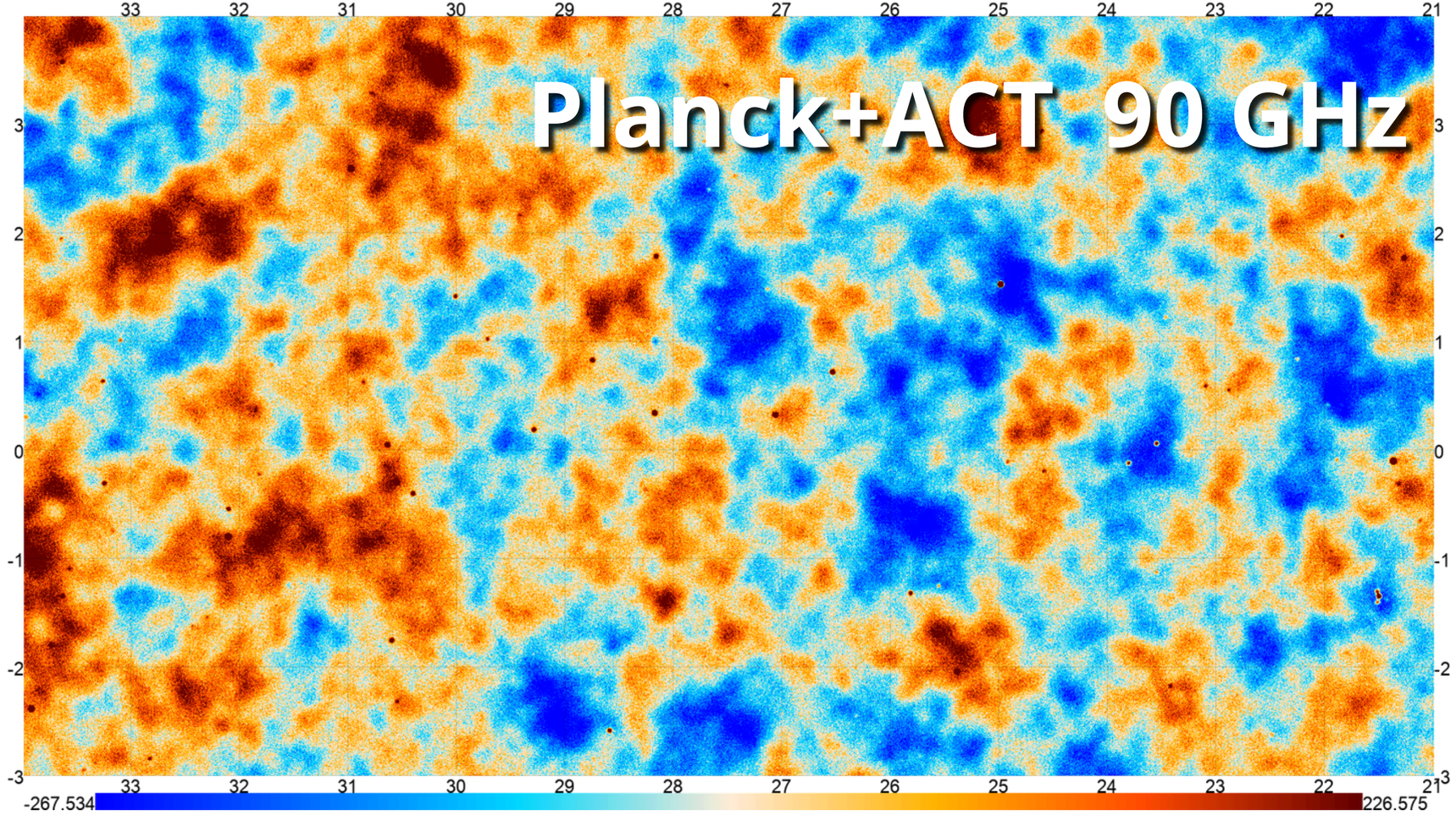


Blue line: simulations

Green line: trend from data

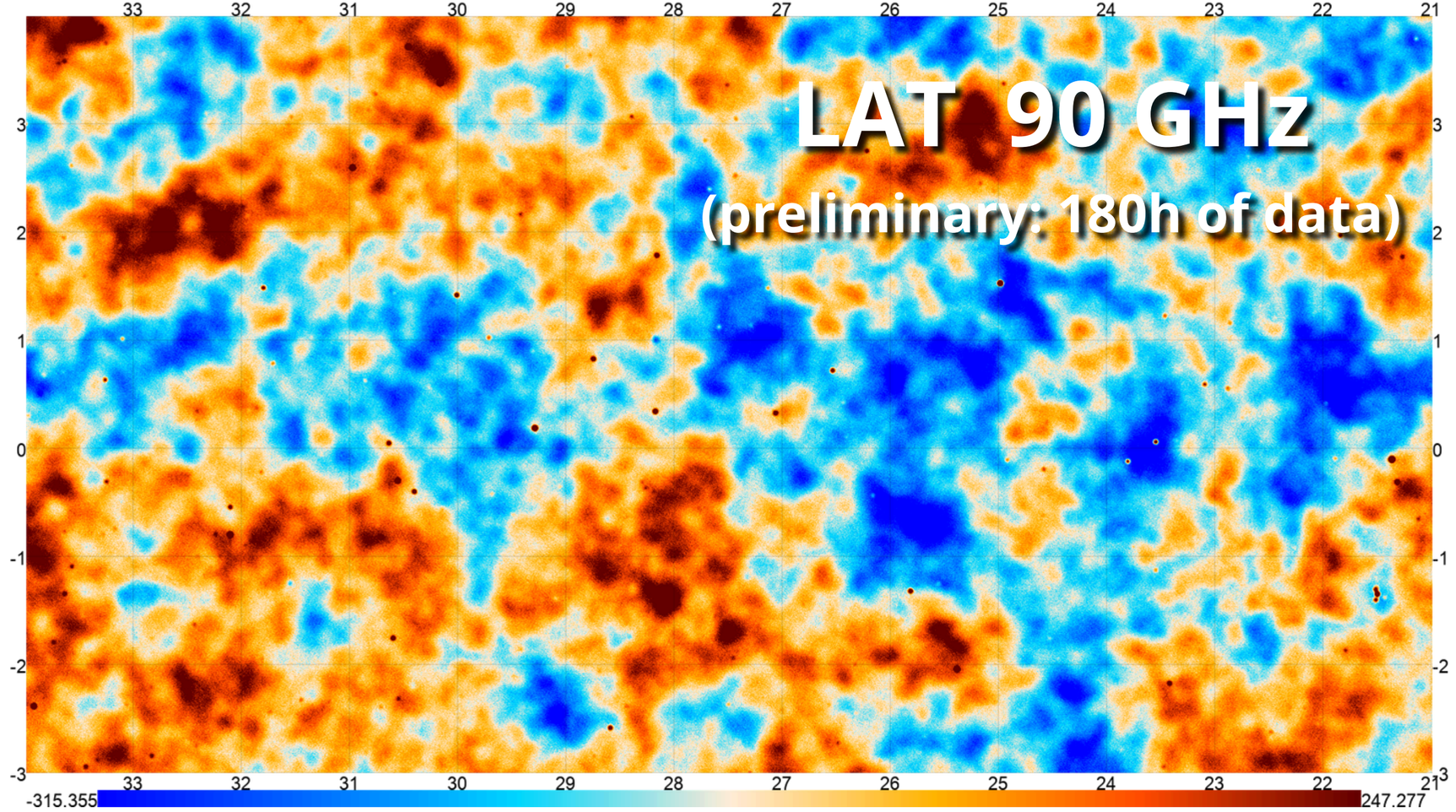
Plot makers: Saianeesh Haridas & Patricio Gallardo

Maps



Plot makers: Saianeesh Haridas & Sigurd Naess

Maps

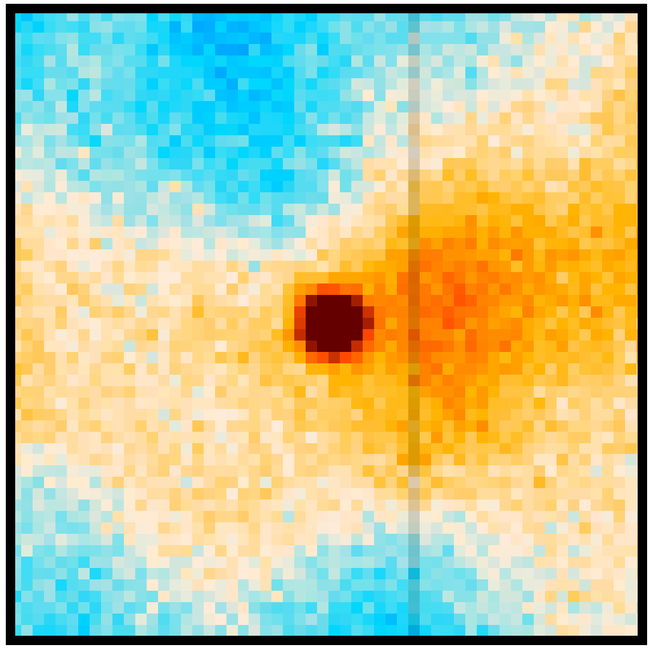


Plot makers: Saianeesh Haridas & Sigurd Naess

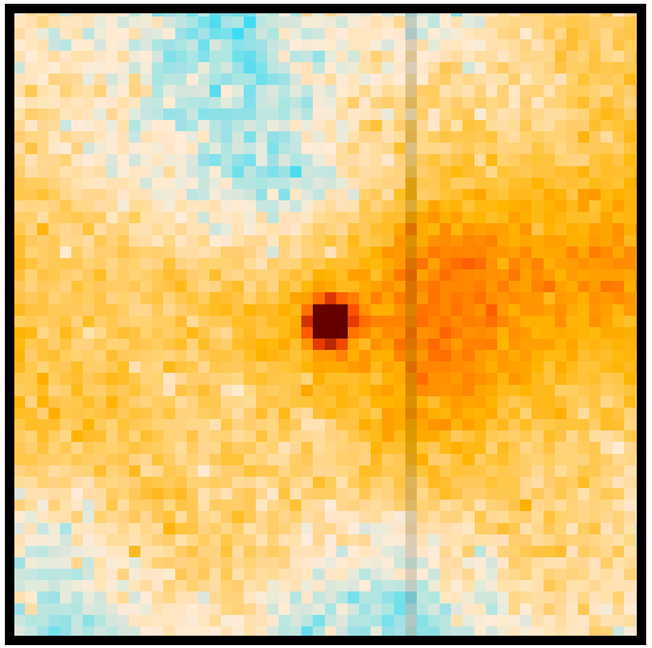
Maps

→ Zoom on a point source

90 GHz

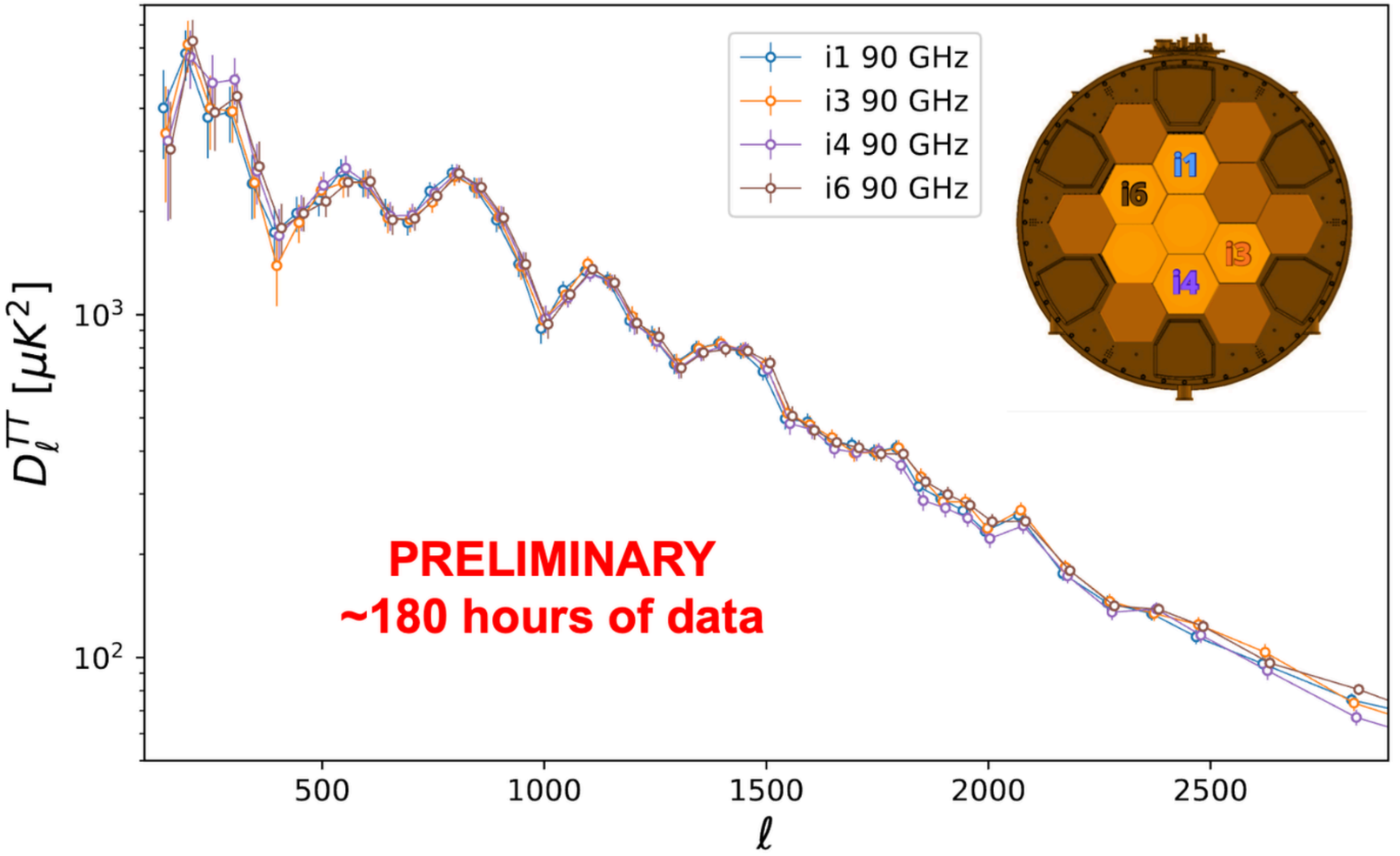


150 GHz



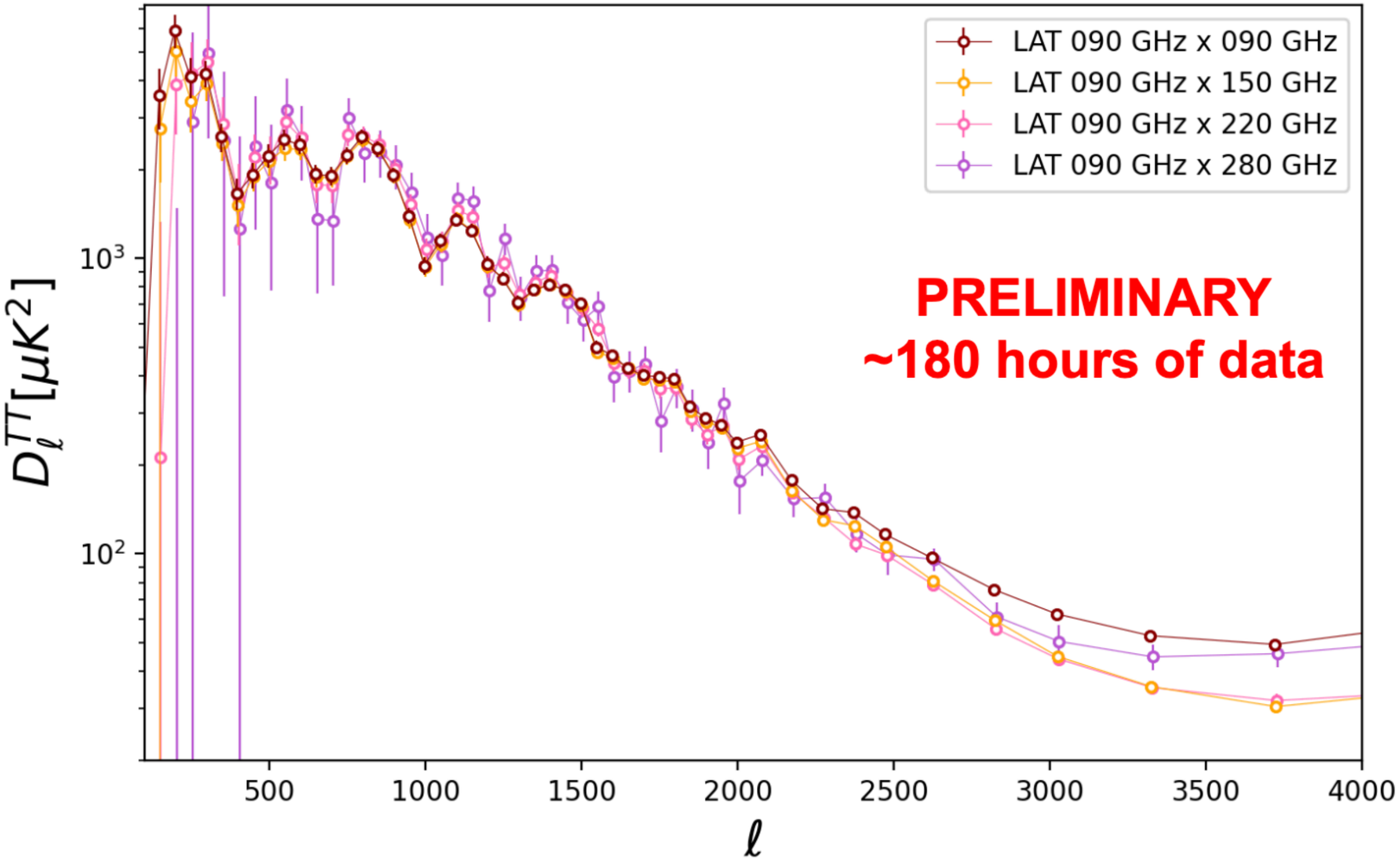
Plot makers: Saianeesh Haridas & Sigurd Naess

Power spectra



Plot makers: Merry Duparc

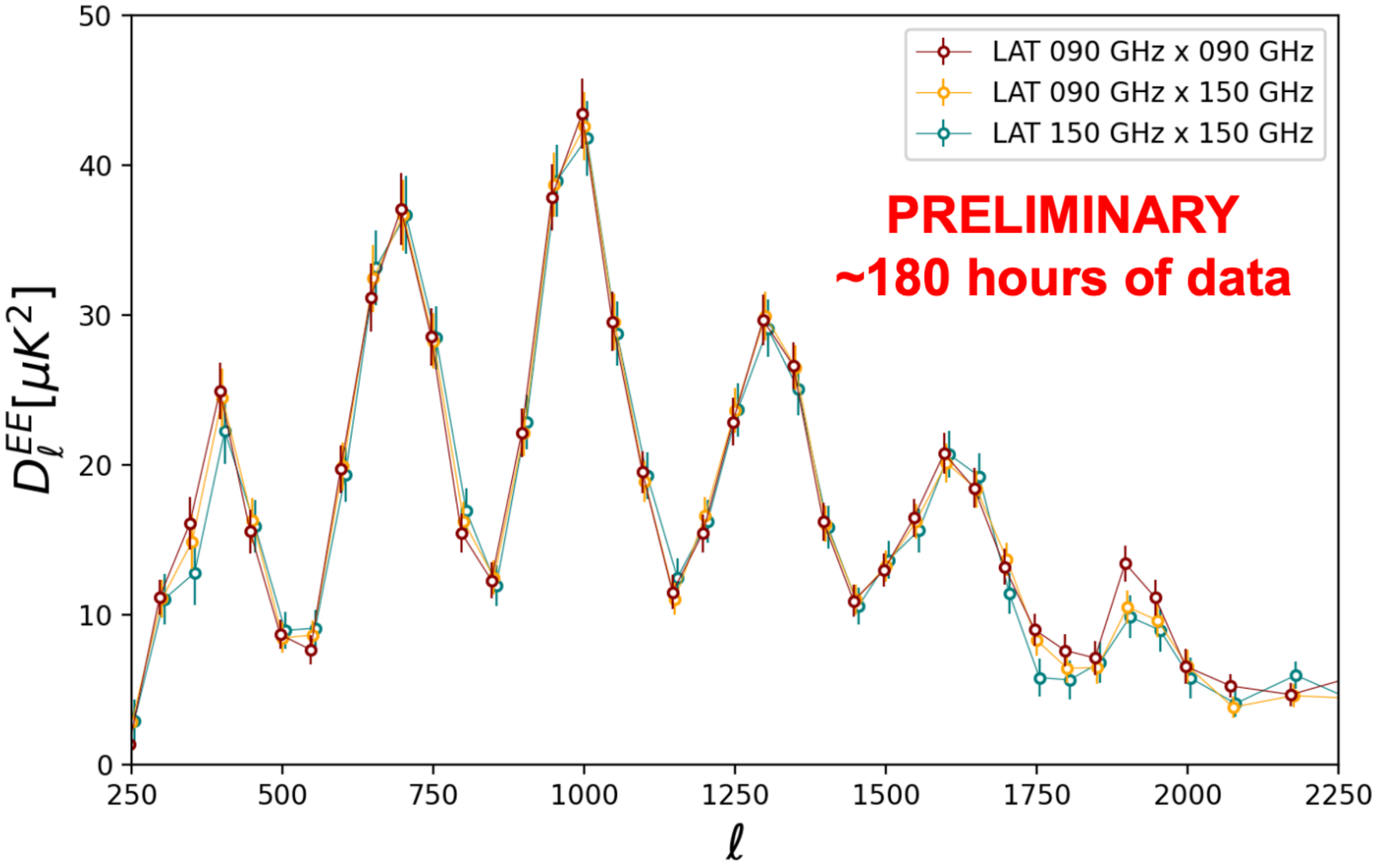
Power spectra



→We see the CMB in high frequency maps !

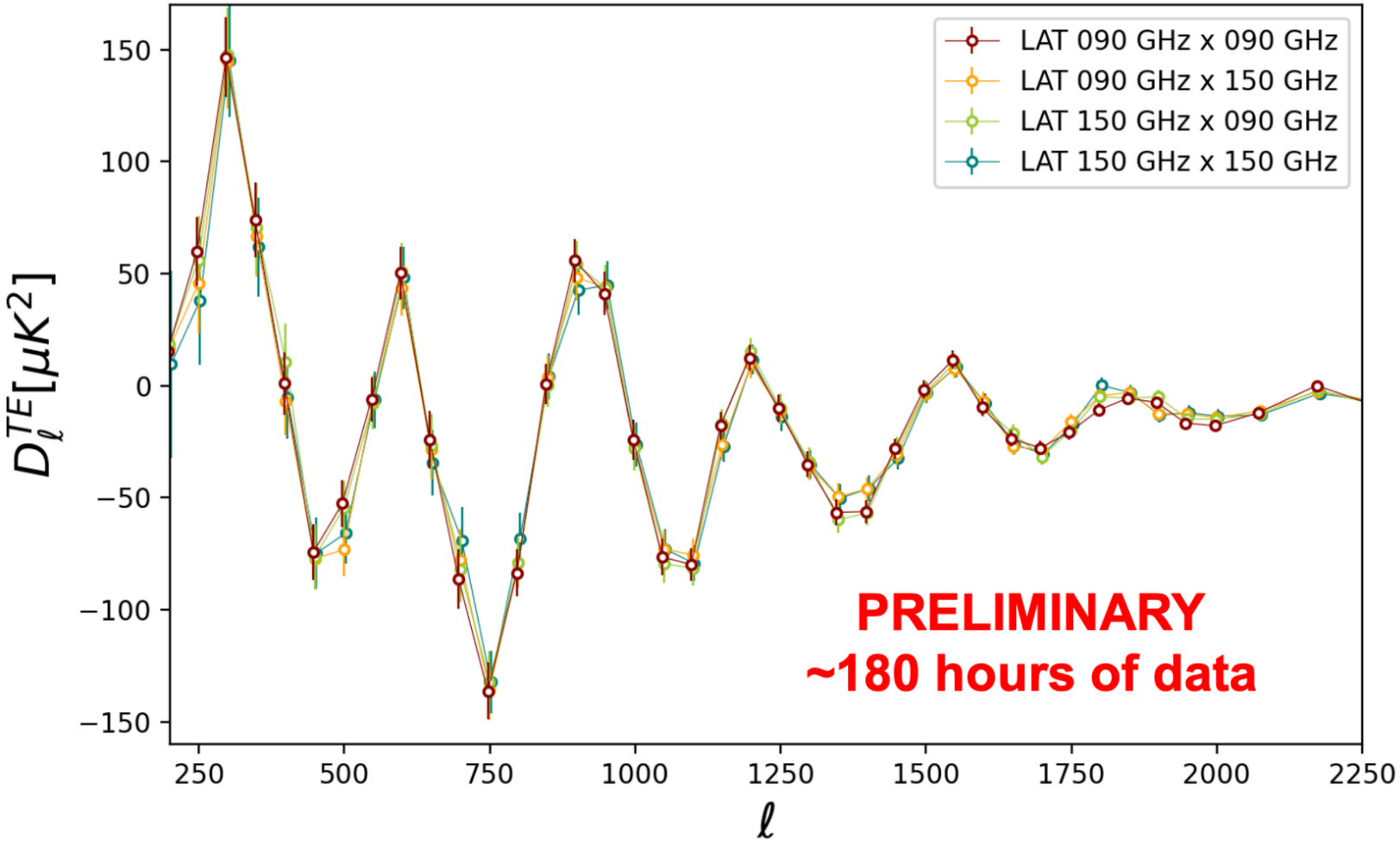
Plot makers: Merry Duparc

Power spectra



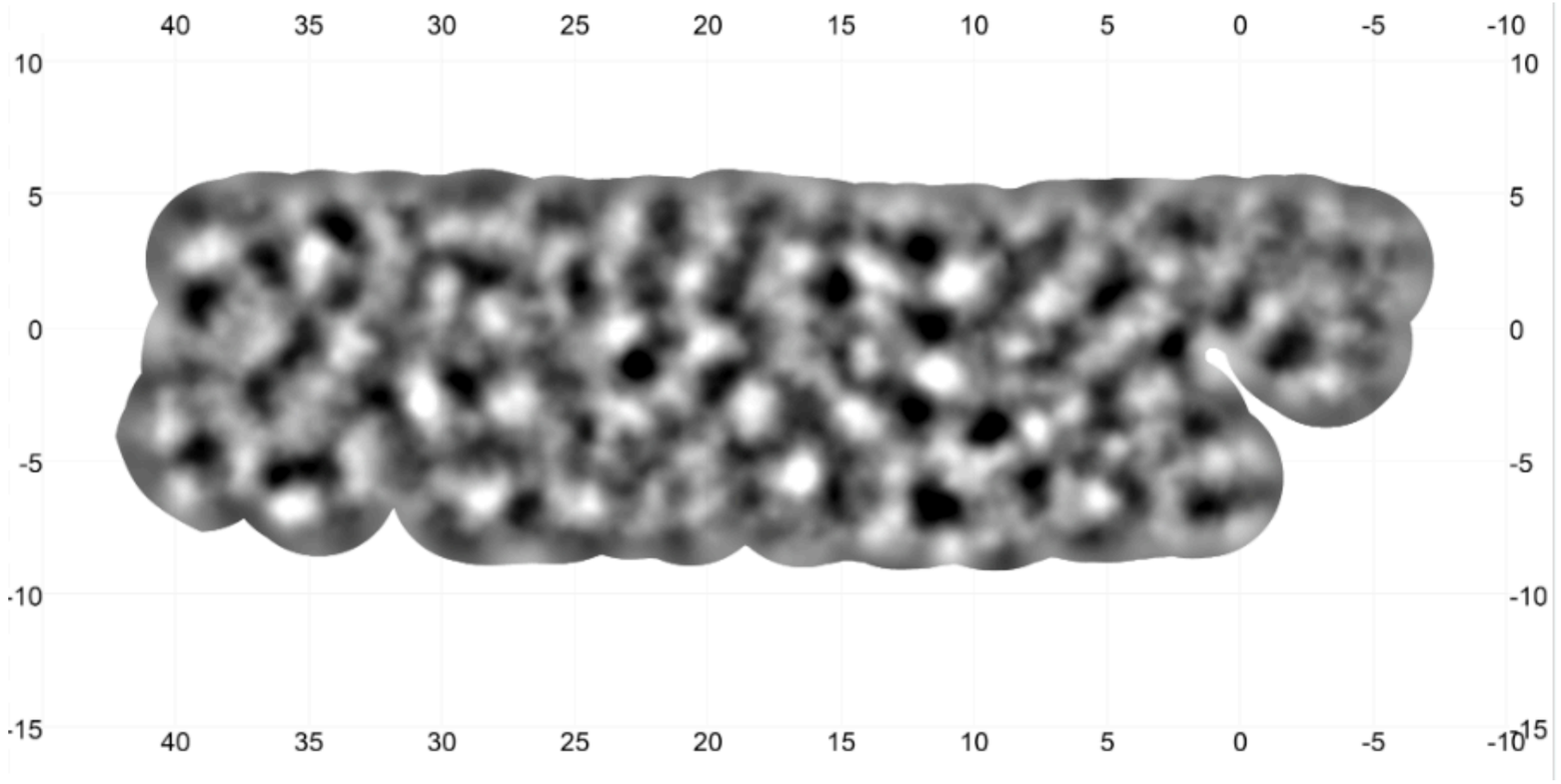
Plot makers: Merry Duparc

Power spectra



Plot makers: Merry Duparc

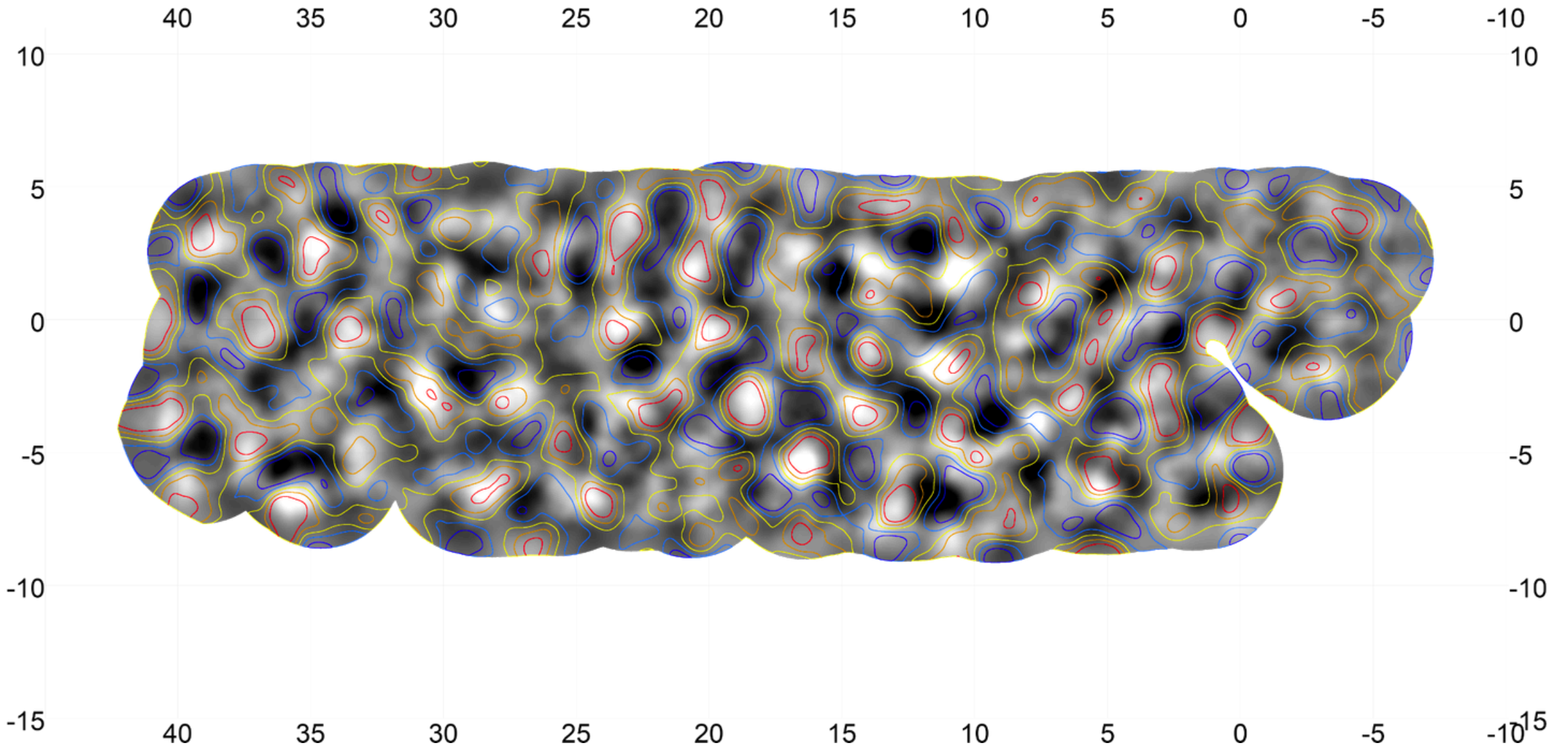
Lensing



Black and white:
mass map estimated with
LAT ISO data

Plot makers: Ola Kusiak & Karen Perez Sarmiento

Lensing



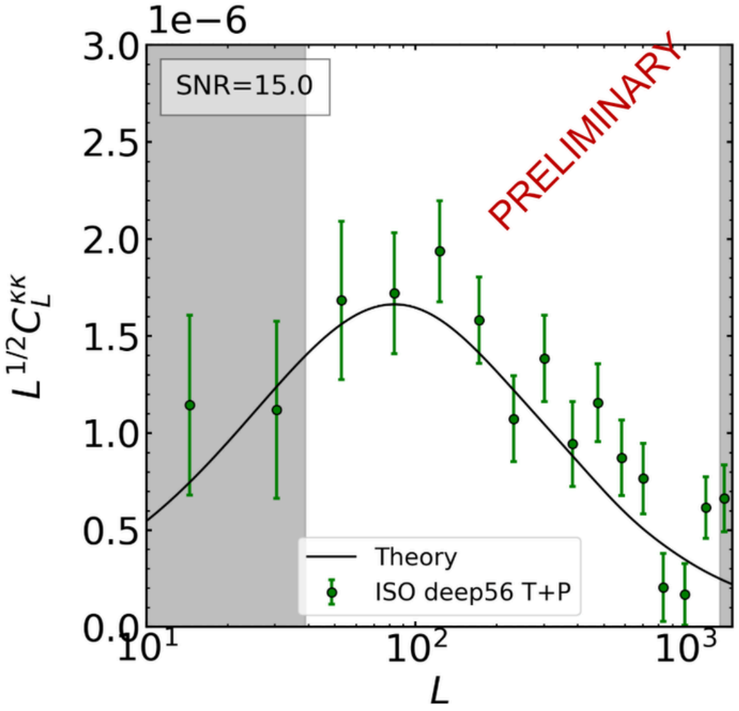
Black and white:
mass map estimated with
LAT ISO data

Blue/red **contours**:
CIB estimated from Planck
GNILC 545

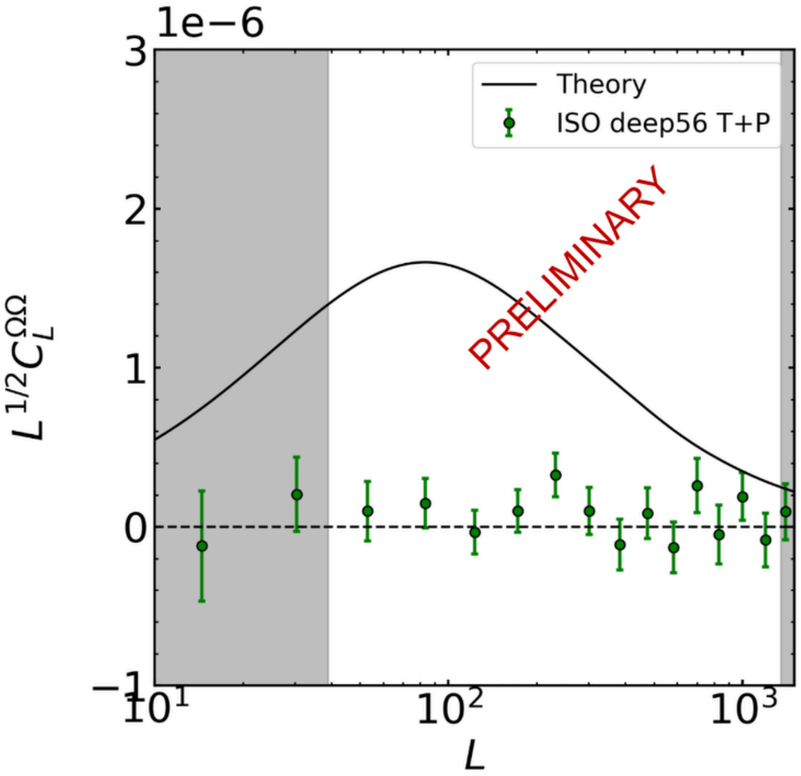
Plot makers: Ola Kusiak & Karen Perez Sarmiento

Lensing

Lensing auto power spectrum from LAT ISO Deep56 data
(~180h of observations on ~600 deg^2)



Curl null test



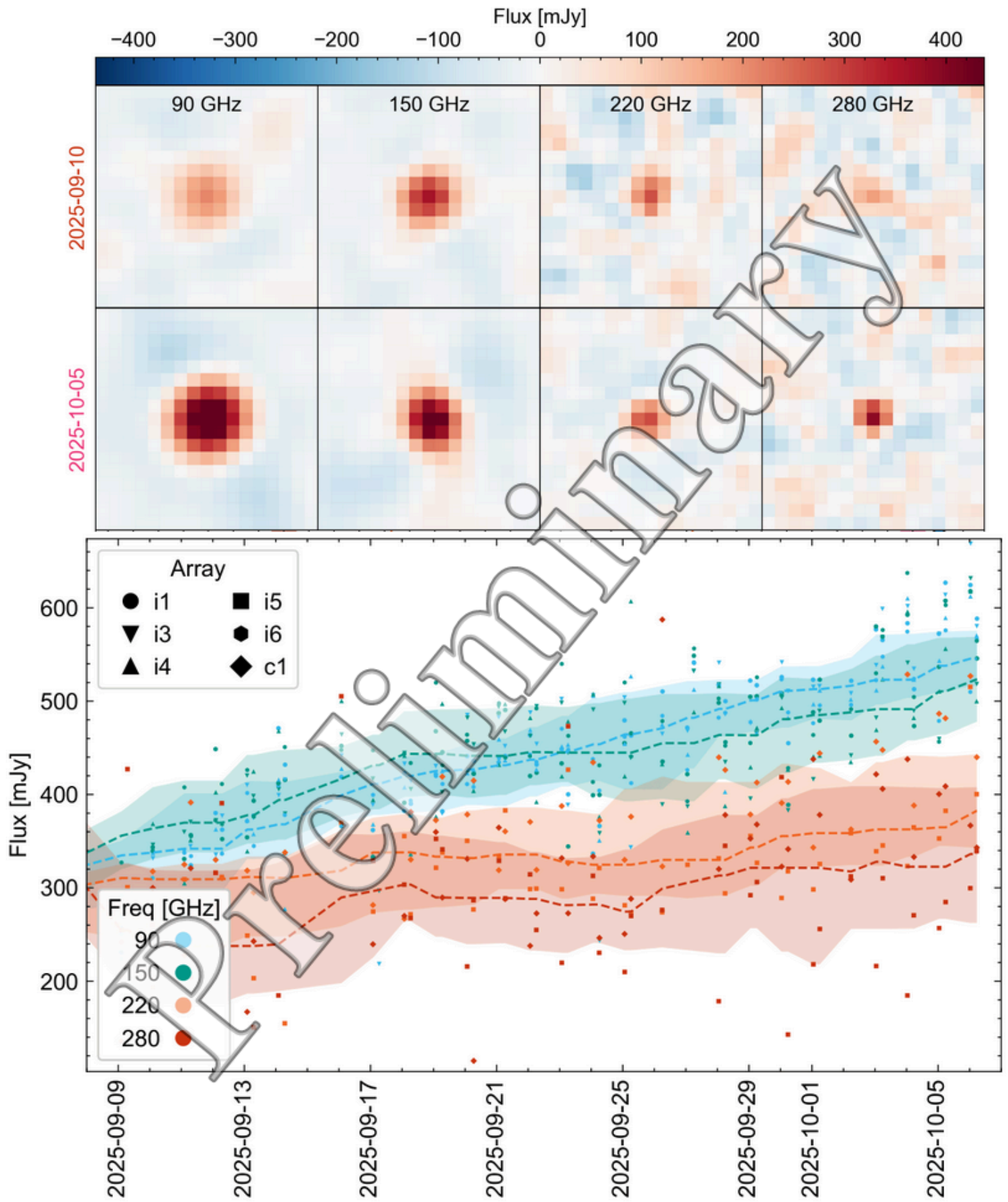
PTE=0.38

Plot makers: Ola Kusiak & Karen Perez Sarmiento

Time domain astrophysics

Fluctuating AGN, ACT J0017

arXiv:1608.06219



Plot makers: Josh Borrow

Thank you !

Credit : Elle Shaw

Backup slides

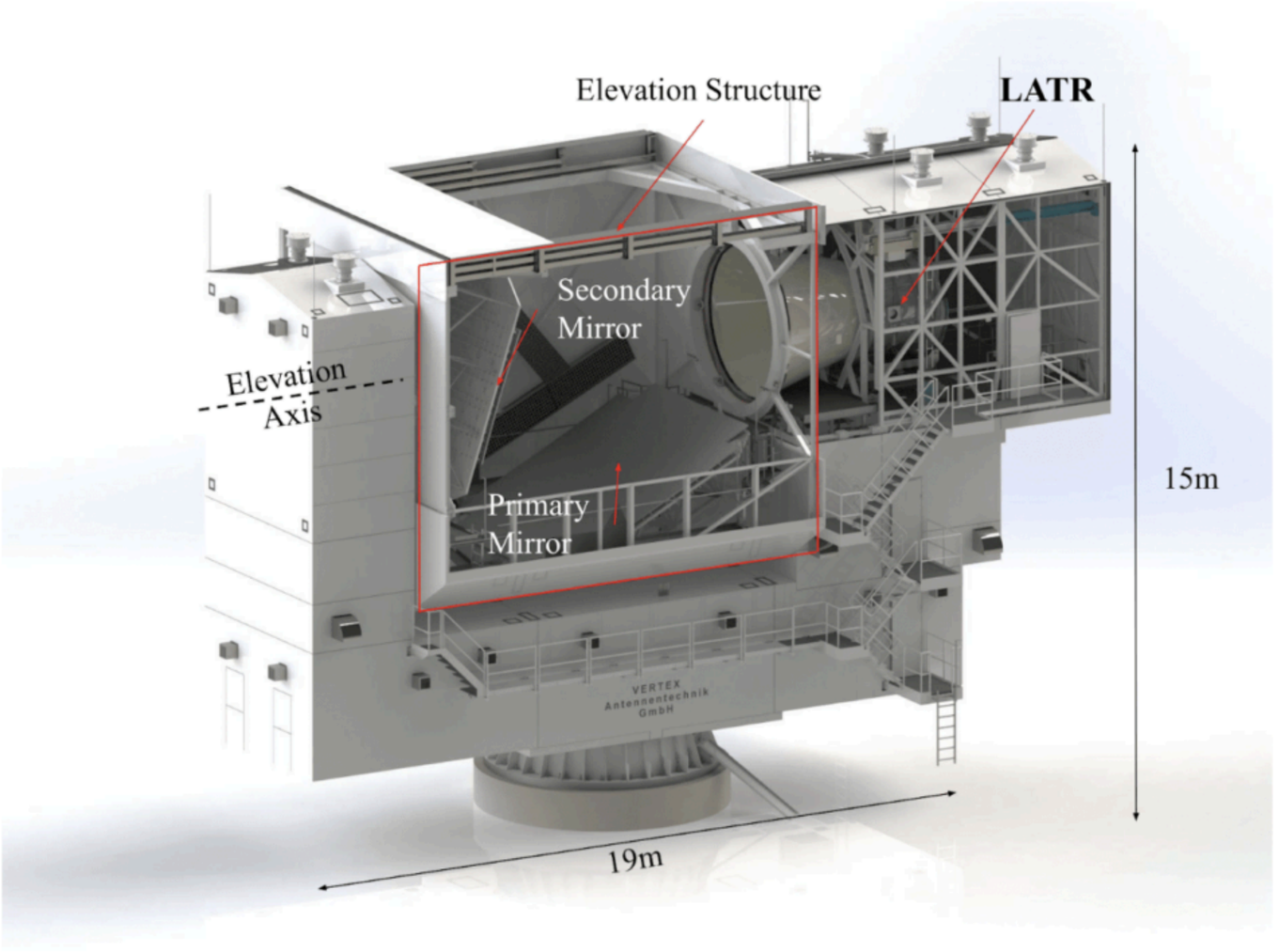
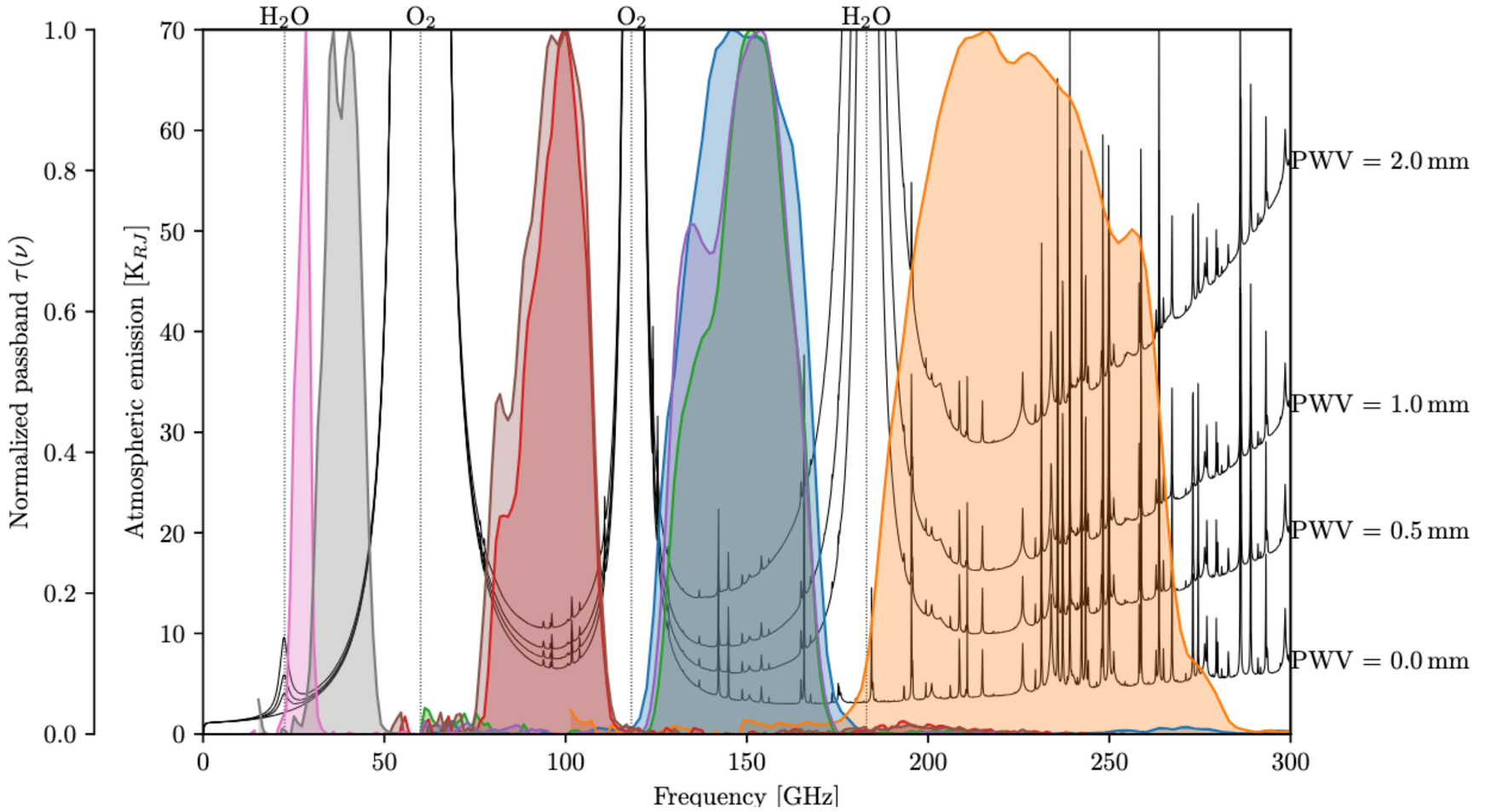


FIGURE 1: The Large Aperture Telescope and Receiver

Atmosphere emission



Morris et Al. 2025

Table 2. Summary of Enhanced Science Goals from SO LAT Survey[a]

	Current[b]	**SO 2025–2034**	Using Rubin, DESI, or *Euclid*	Reference
Primordial perturbations				
n_s	0.004	0.002	-	Shandera et al. (2019)
$e^{-2\tau}\mathcal{P}(k = 0.2\,\mathrm{Mpc}^{-1})$	3%	0.4%	-	Slosar et al. (2019b)
$f_{\mathrm{NL}}^{\mathrm{local}}$	5	1	✓	Meerburg et al. (2019)
Relativistic species				
N_{eff}	0.2	0.045	-	Green et al. (2019)
Neutrino mass[c]				
$\sum m_\nu$ (eV, $\sigma(\tau) = 0.01$)	0.1	0.03	✓	Dvorkin et al. (2019)
$\sum m_\nu$ (eV, $\sigma(\tau) = 0.002$)		0.015	✓	
Accelerated expansion				
$\sigma_8(z = 1 - 2)$	7%	1%	✓	Slosar et al. (2019a)
Galaxy evolution				
η_{feedback}	50–100%	2%	✓	Battaglia et al. (2019)
p_{nt}	50–100%	4%	✓	Battaglia et al. (2019)
Reionization				
Δz	1.4	0.3	-	Alvarez et al. (2019)
τ	0.007	0.0035	-	Alvarez et al. (2019)
Cluster catalog	4000	33,000	✓	
AGN catalog	2000	96,000	-	
Galactic science				
Molecular cloud B-fields	10s	> 860	-	Hensley et al. (2022)
$\sigma(\beta_{\mathrm{dust}})$	0.02	0.005	-	Hensley et al. (2022)
Solar System Science				
Distance limit for 5 $M_\oplus$ Planet 9	500 AU	900 AU	✓	Fienga et al. (2020)
Asteroid detections		$\sim 10,000$		
Transient detection distance				
Long GRBs, on-axis		1300 Mpc	-	
Low-luminosity GRBs		70–210 Mpc	-	
TDEs, on-axis		670 Mpc	-