22°57'31" SOUTH, 67°47'15"WEST ELEVATION: 17,027.6'

SIMONS OBSERVATORY

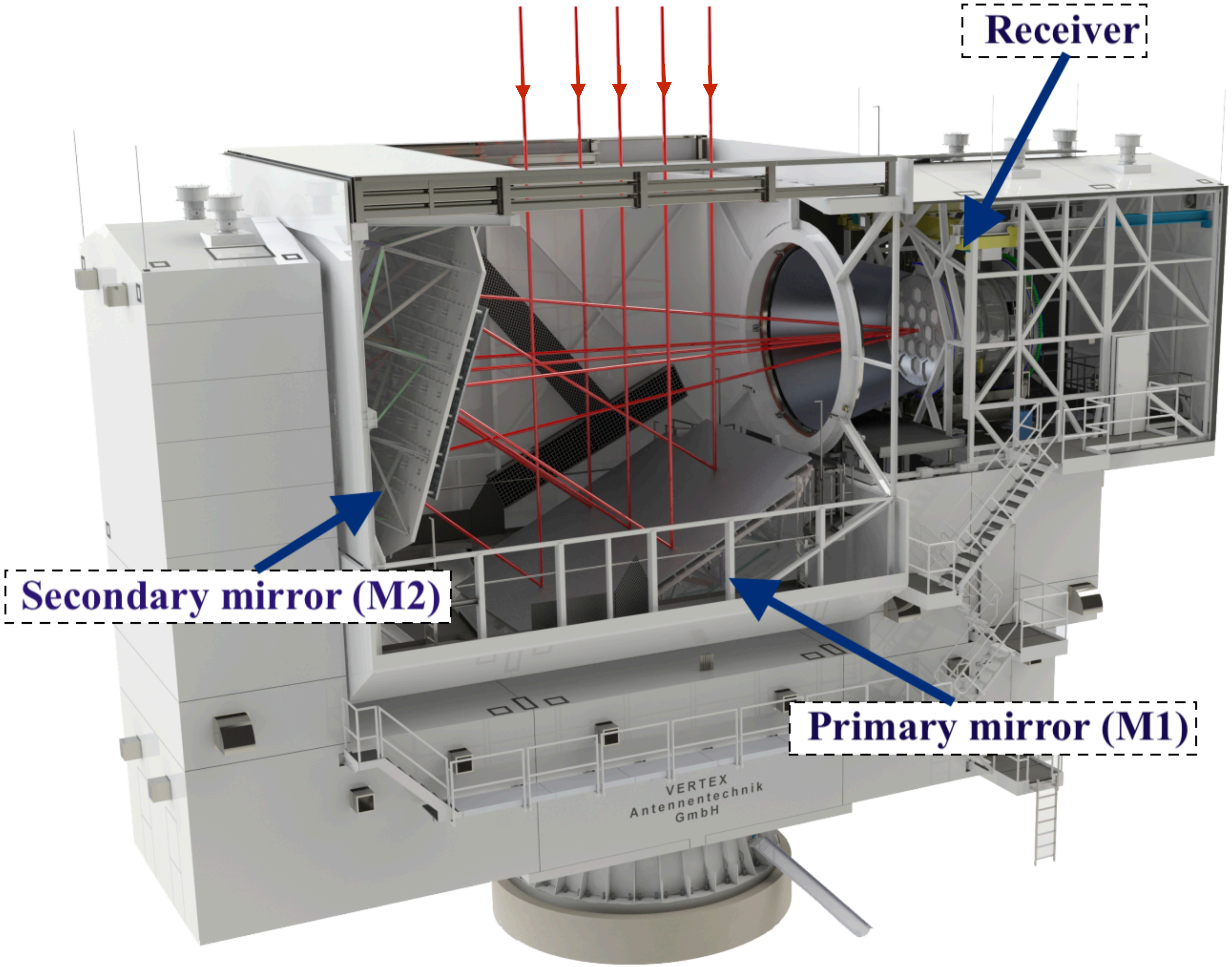
PARQUE ASTRONÓMICO ATACAMA, CHILE

Thibaut Louis
(For SO)

IJCLab
Irène Joliot-Curie
Laboratoire de Physique des 2 Infinis


CPI Vertex

Large Aperture Telescope



6m primary mirror in cross Dragone configuration

Large Aperture Telescope Receiver

2.4 m in diameter, can host a total of
60 000 detectors in 13 optics tubes

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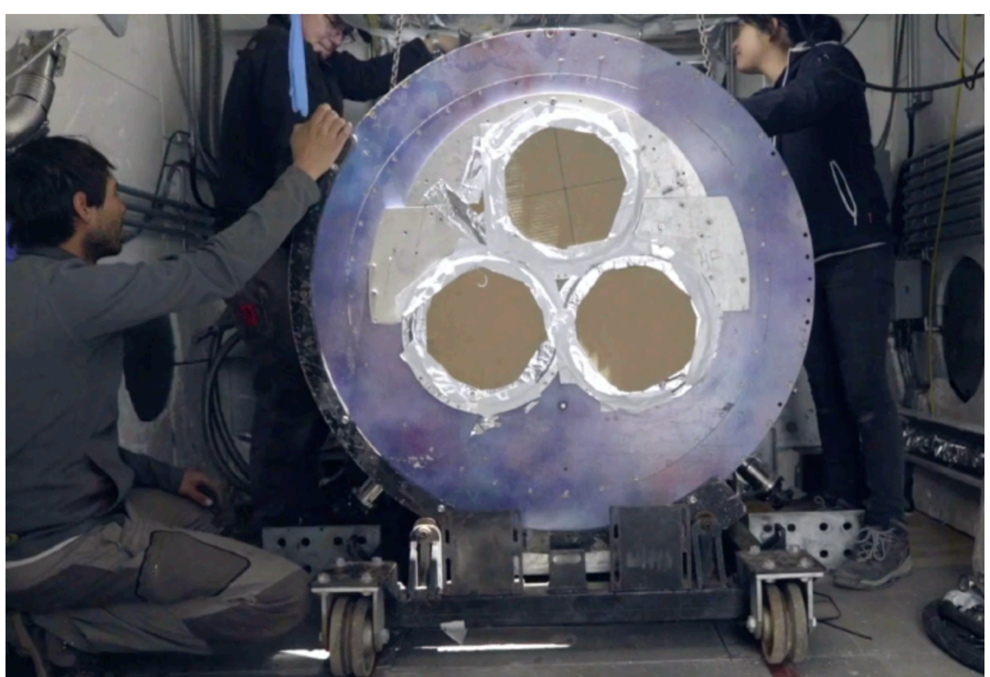
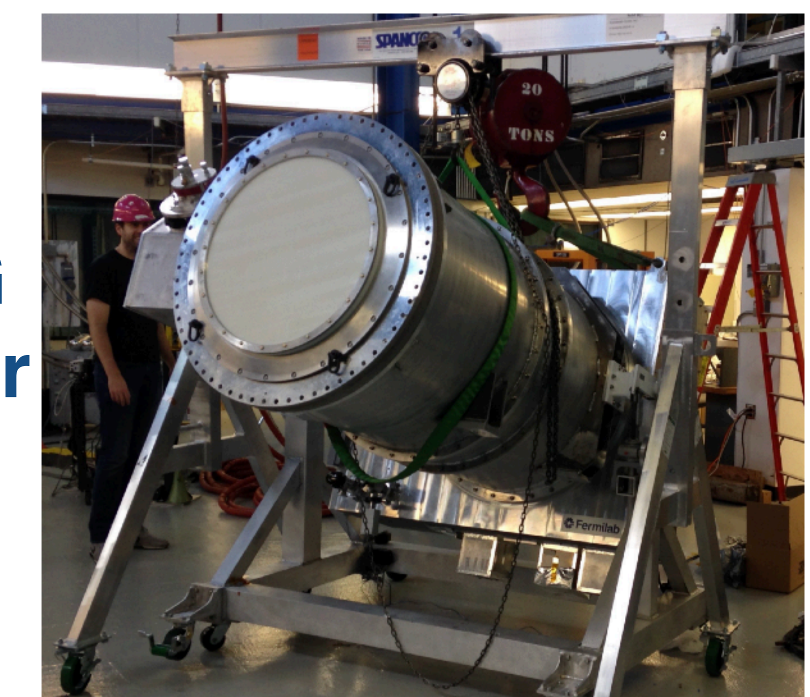
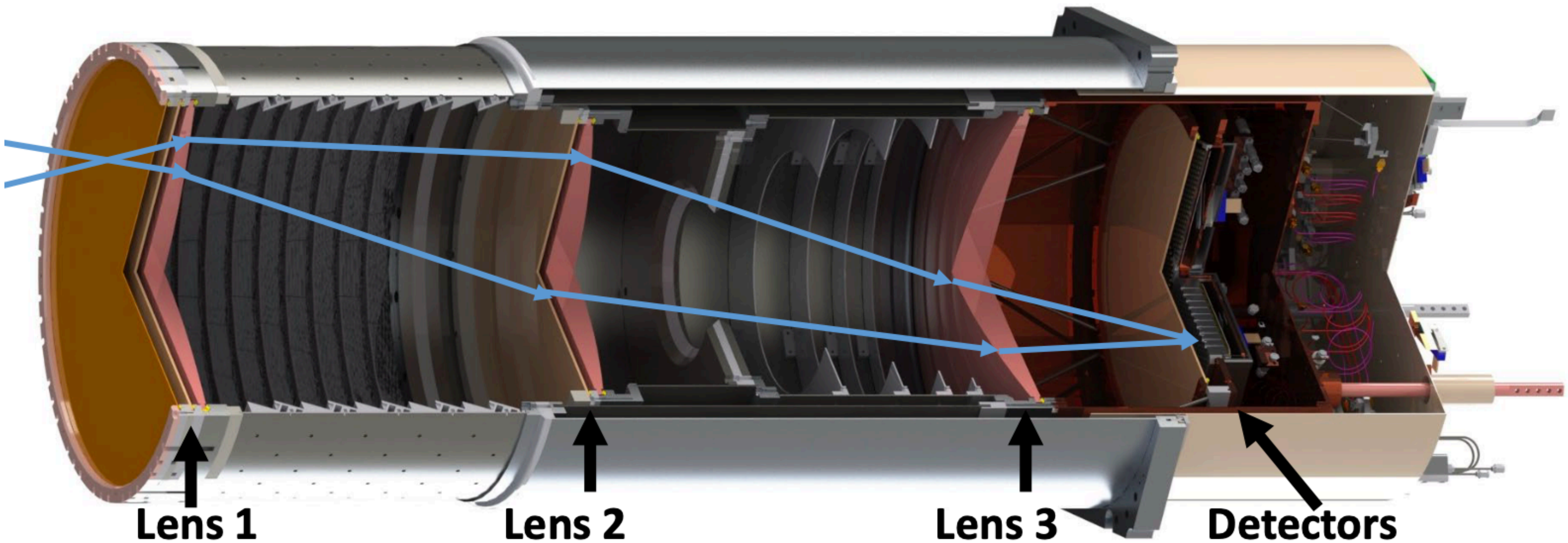
ACT Receiver

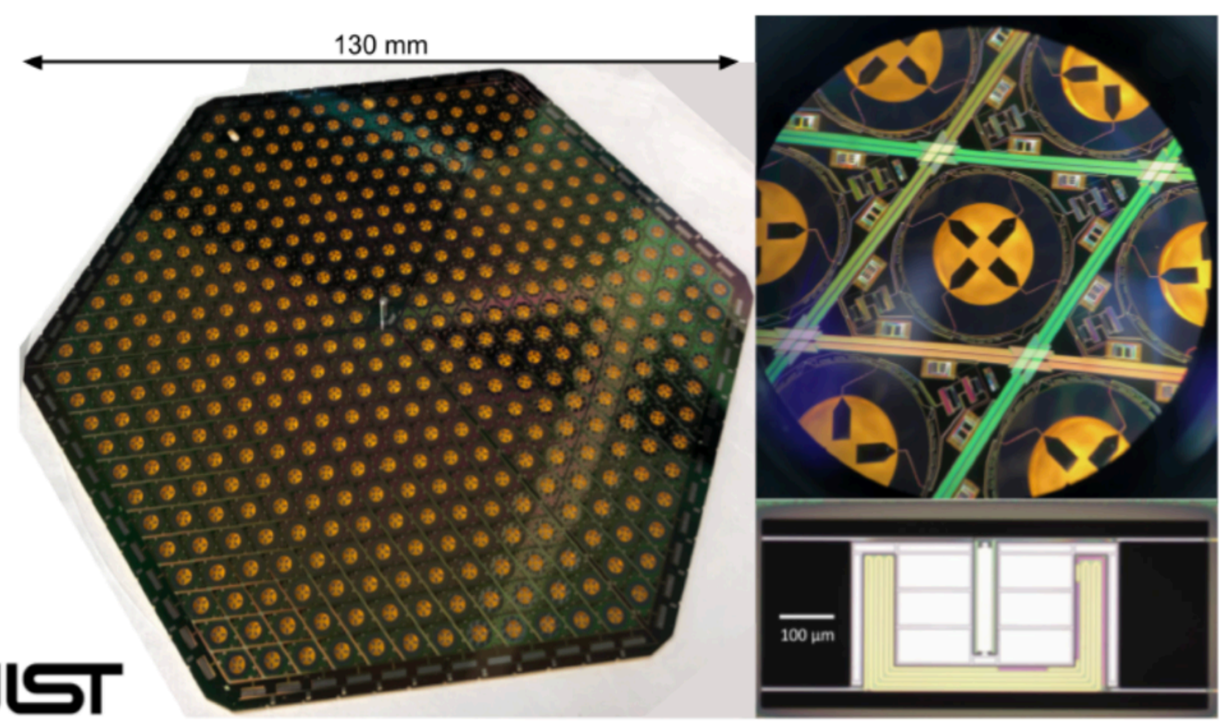


SPT-3G Receiver

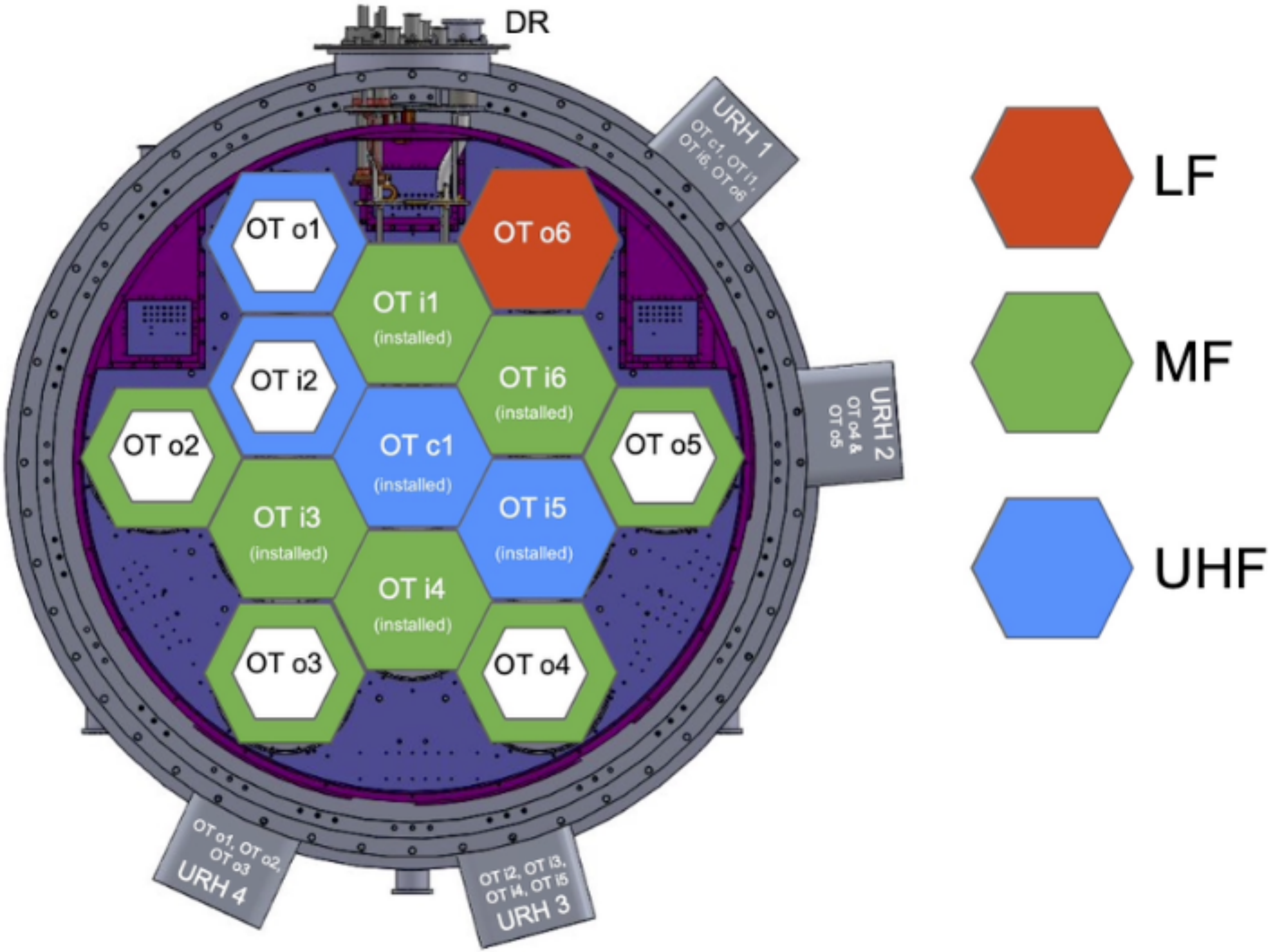


Large Aperture Telescope Optic Tubes



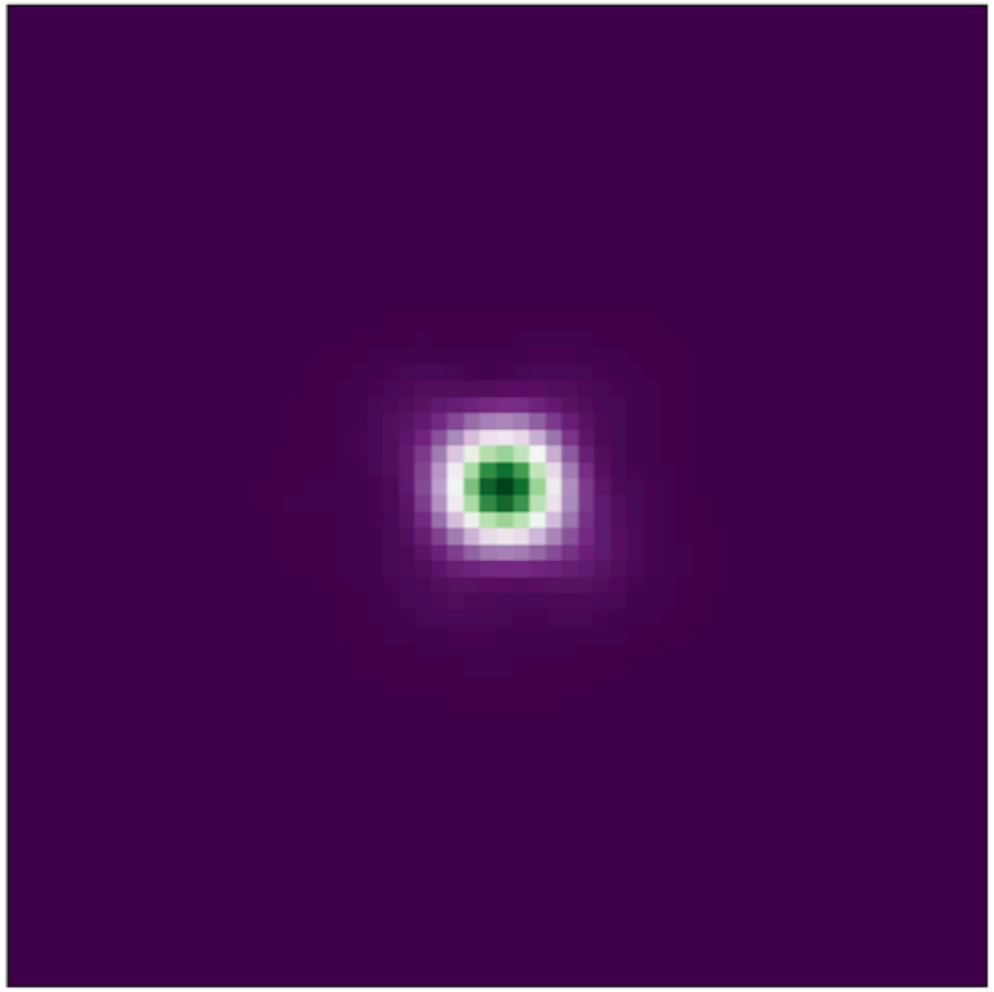


NIST



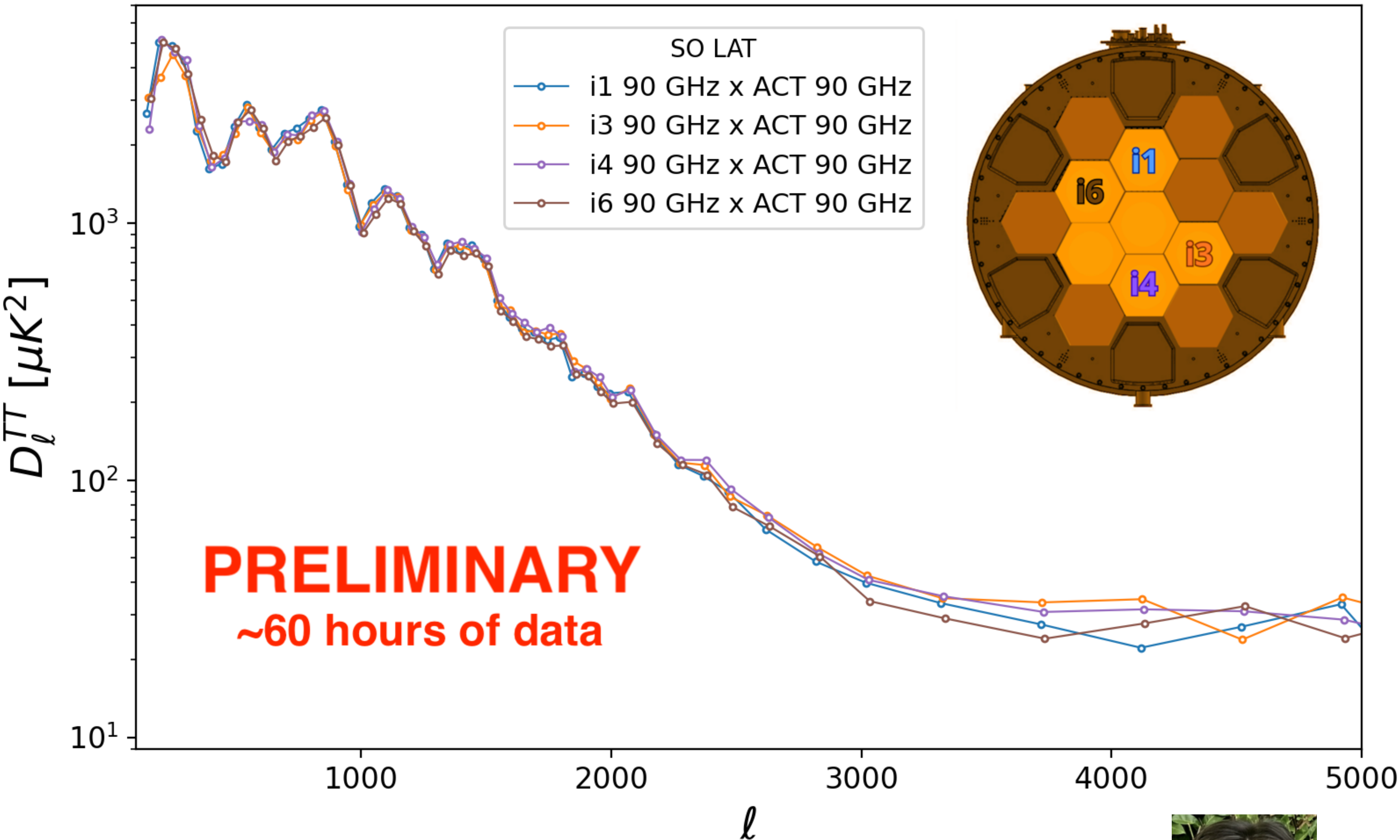
Each tube is expected to have a sensitivity comparable to ACT

Large Aperture Telescope – First Light February 2025!

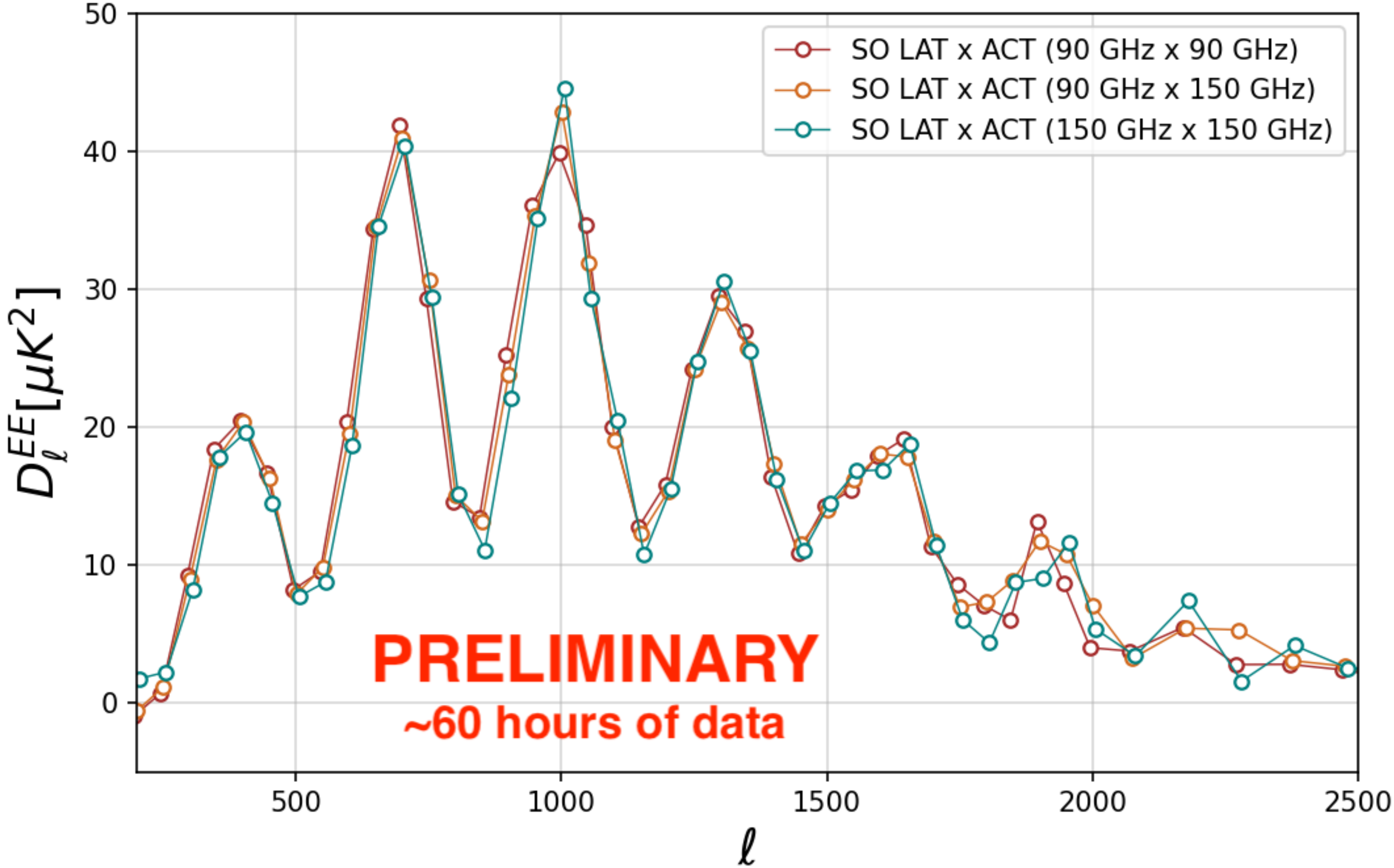


24,000 + Detectors on the Sky.

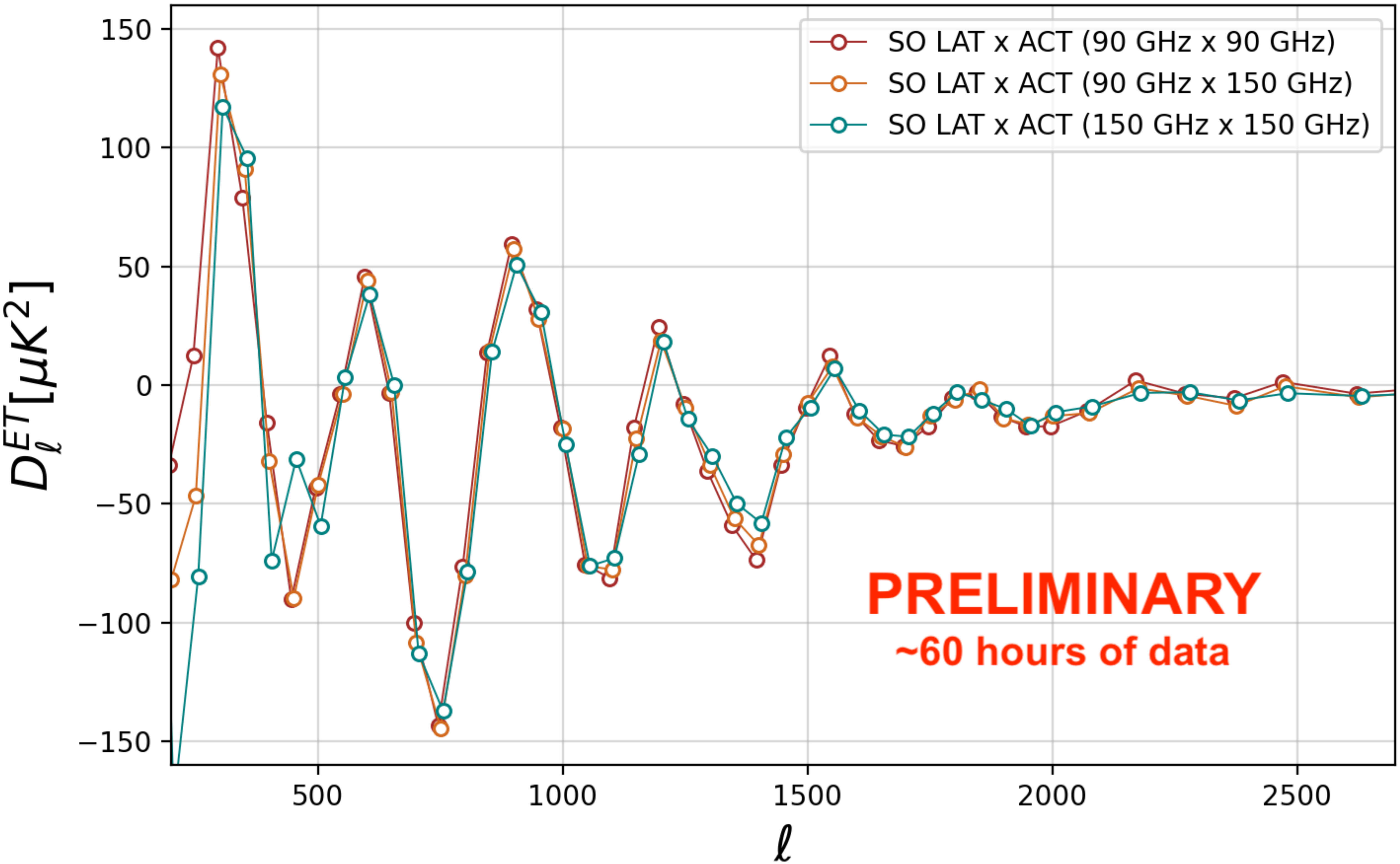
- Mirrors not yet aligned/focused.
- Signal to Noise of 4000+ per detector.
- 640 detectors used the Mars map.
- CMB maps are already being made.



Plot from Merry Duparc for the SO collaboration

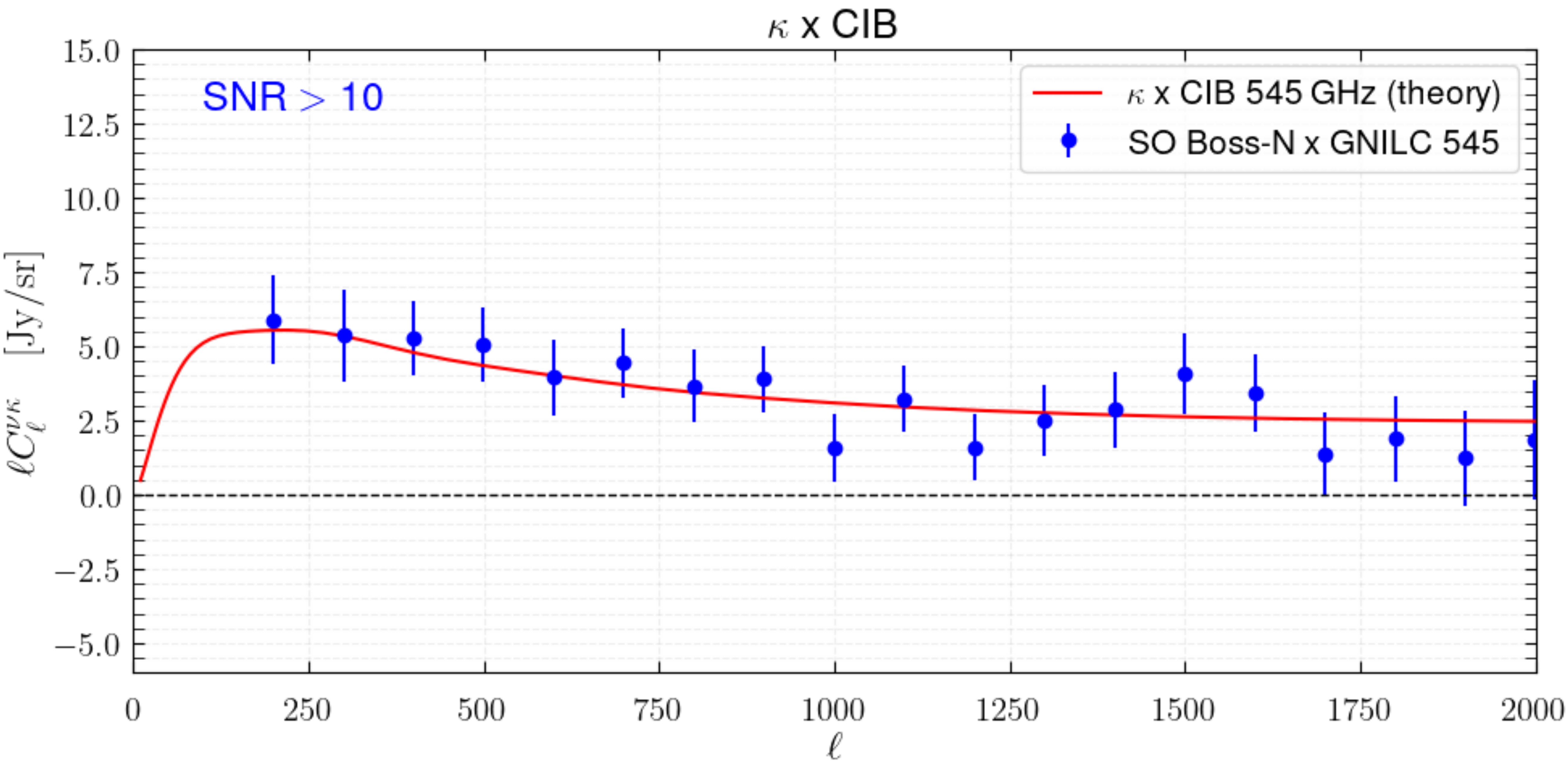


Plot from Merry Duparc for the SO collaboration

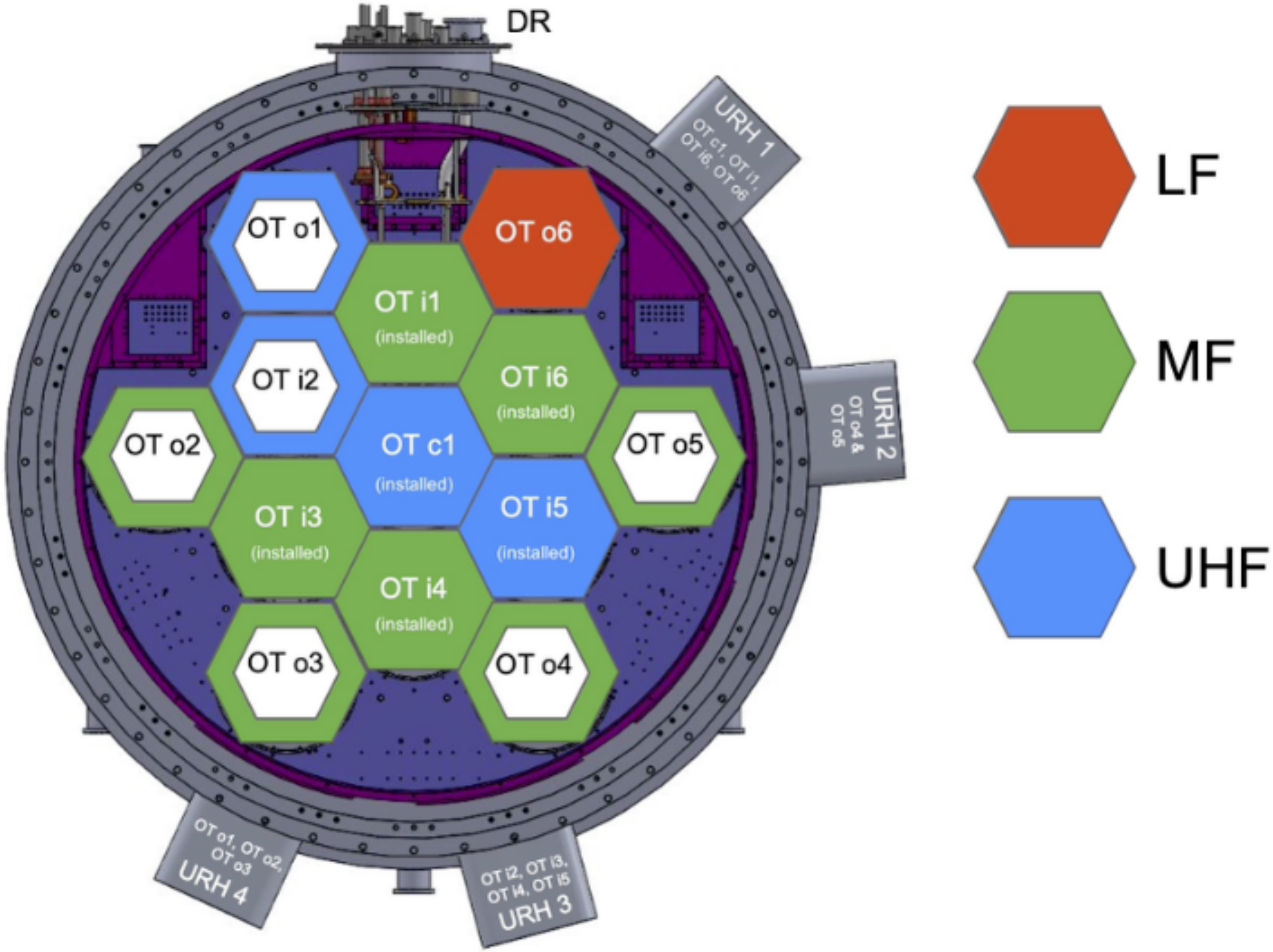


Plot from Merry Duparc for the SO collaboration

Preliminary

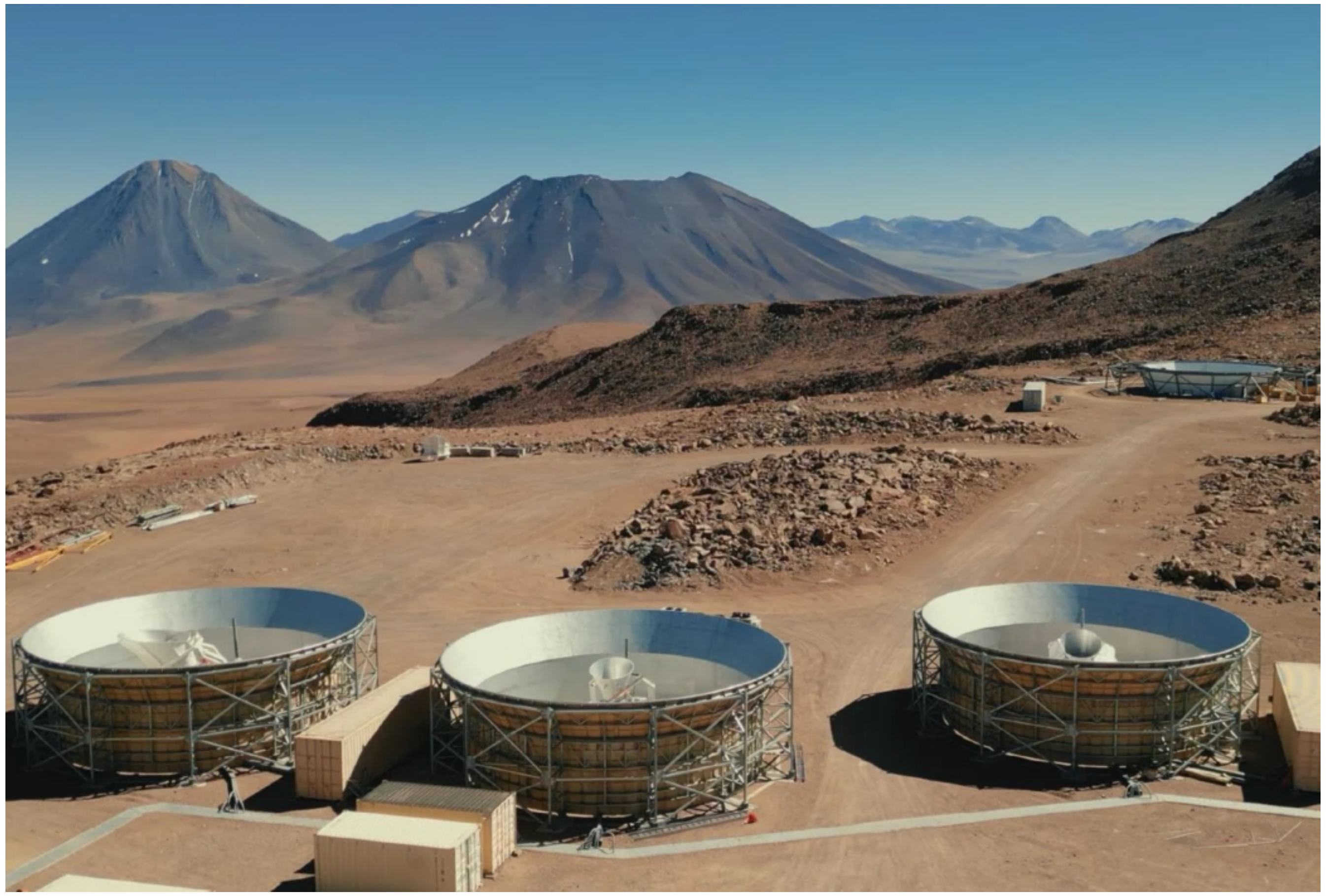


Plot from Ola Kusiak for the SO collaboration



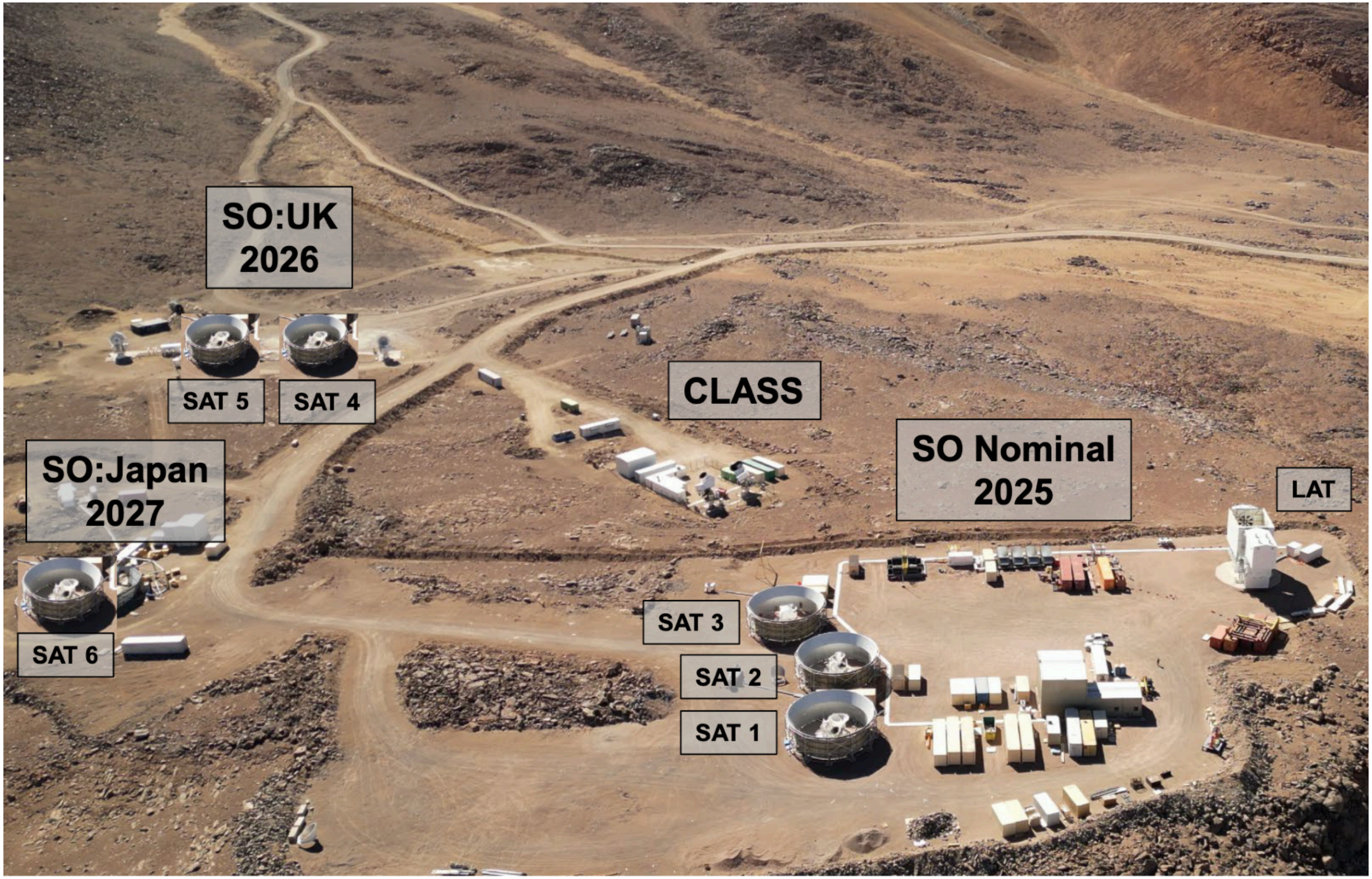
The full focal plane will be populated next year (2026),
13 tubes : 60 000 detectors on the sky expected

3 Small Aperture Telescopes (2 MF + 1 UHF) installed on site (10 k detectors each)



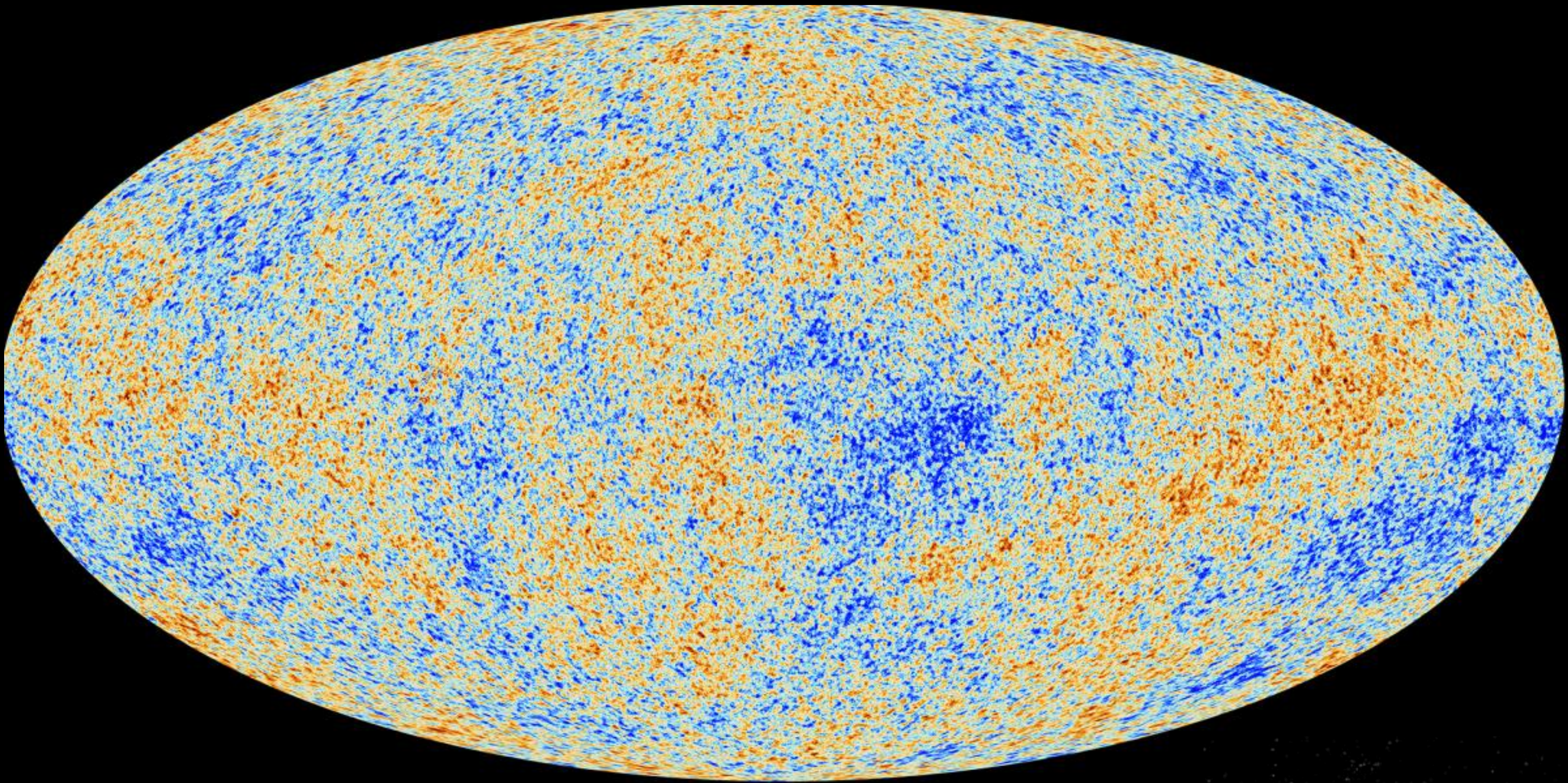
(See talk from Amalia & Pierre)

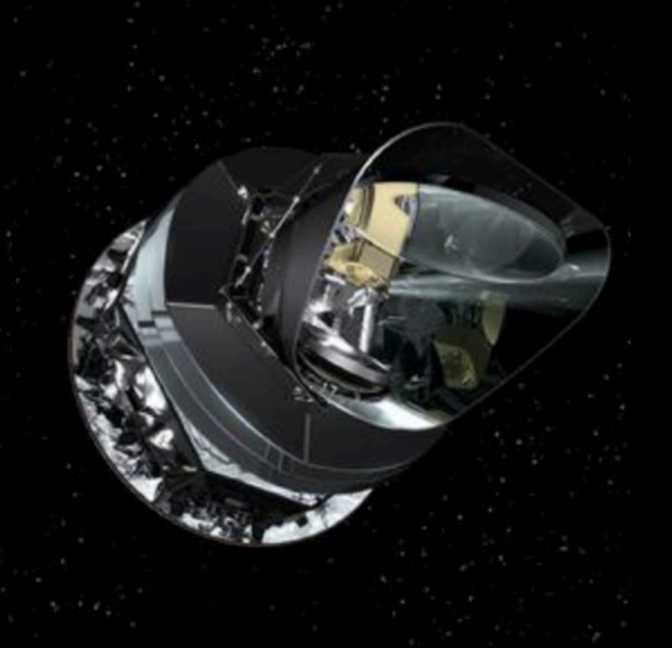
3 more SATs are being built (2 MF (with KIDs) UK, 1 LF Japan)



Discussion for a DOE contribution to SO (following the cancellation of S4)
+ a French contribution ? (See Josquin' talk)

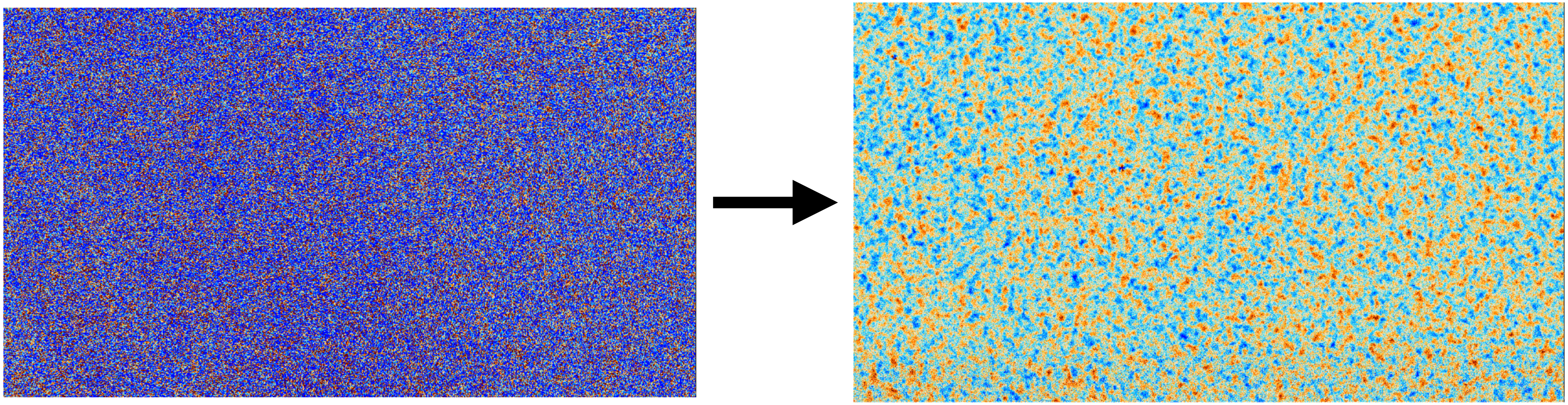
What are we trying to do ?





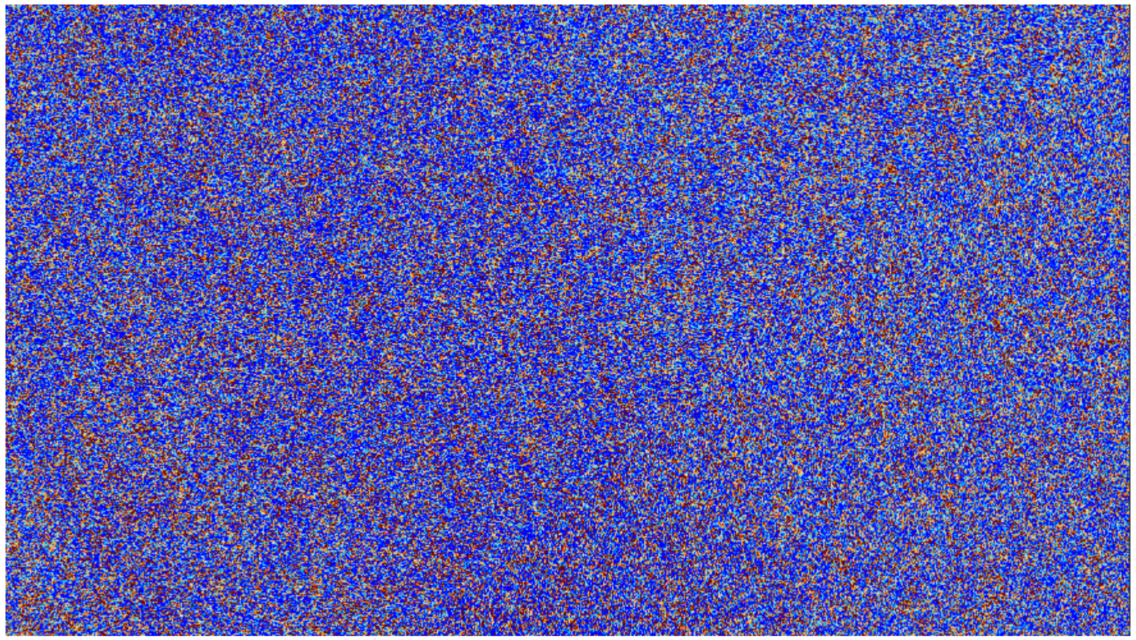
Color scale +/- 300 microkelvin

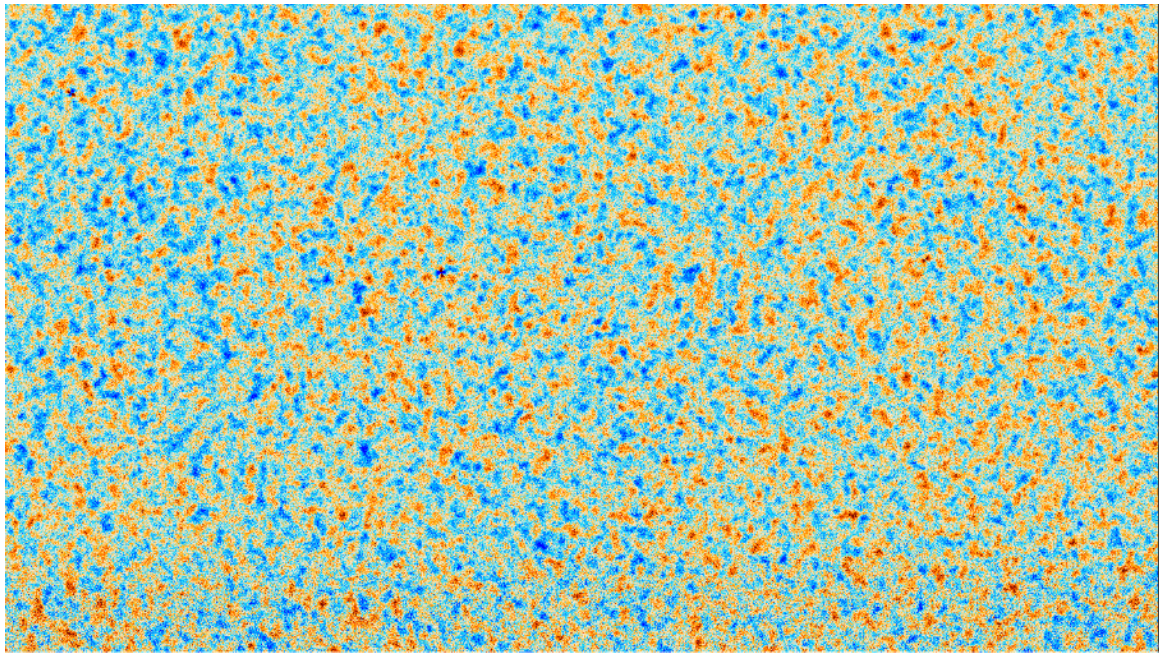
Planck E modes **ACT + Planck E modes**



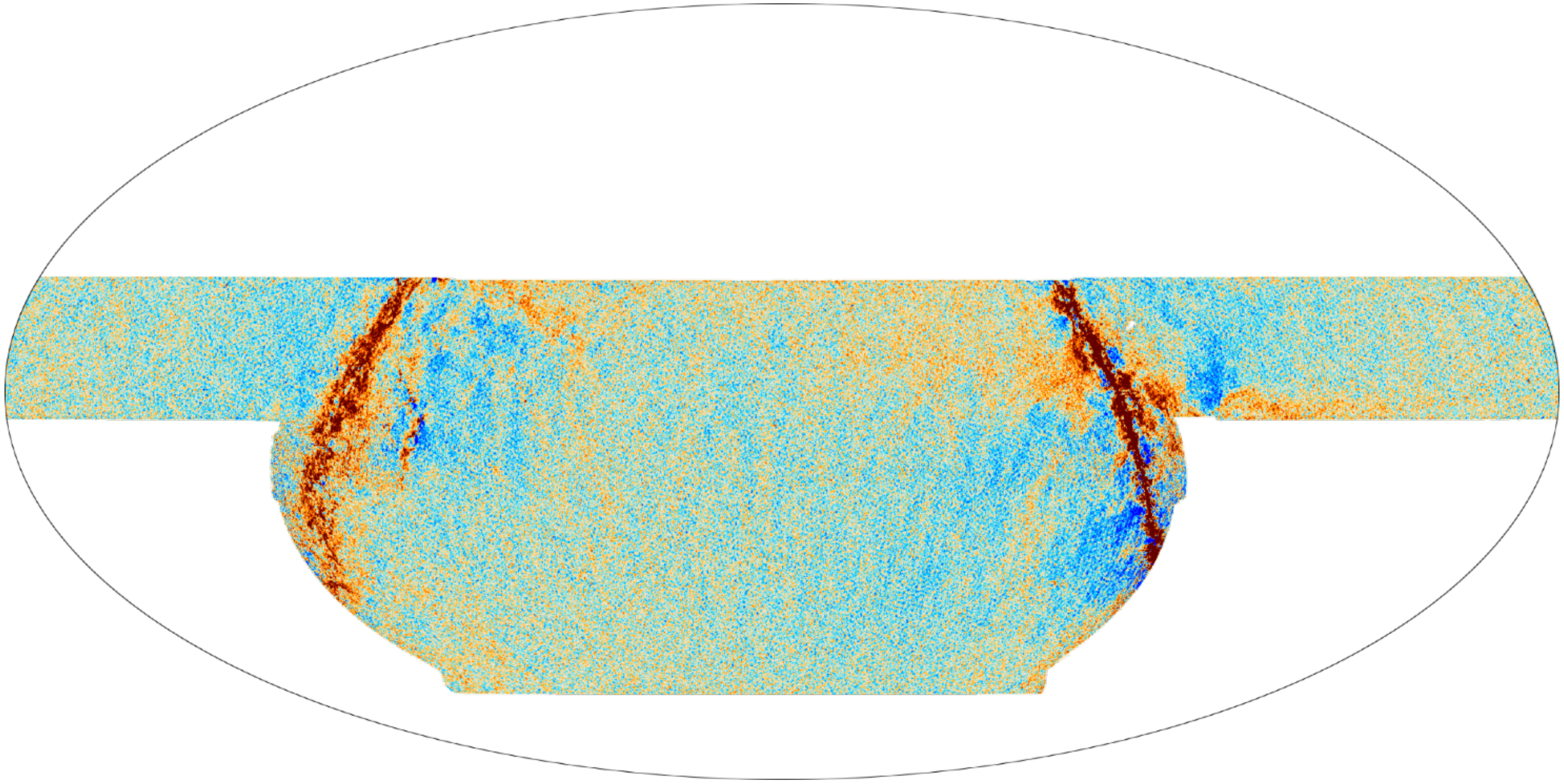
(color scale +/- 30 microkelvin)

Planck E modes **ACT + Planck E modes**

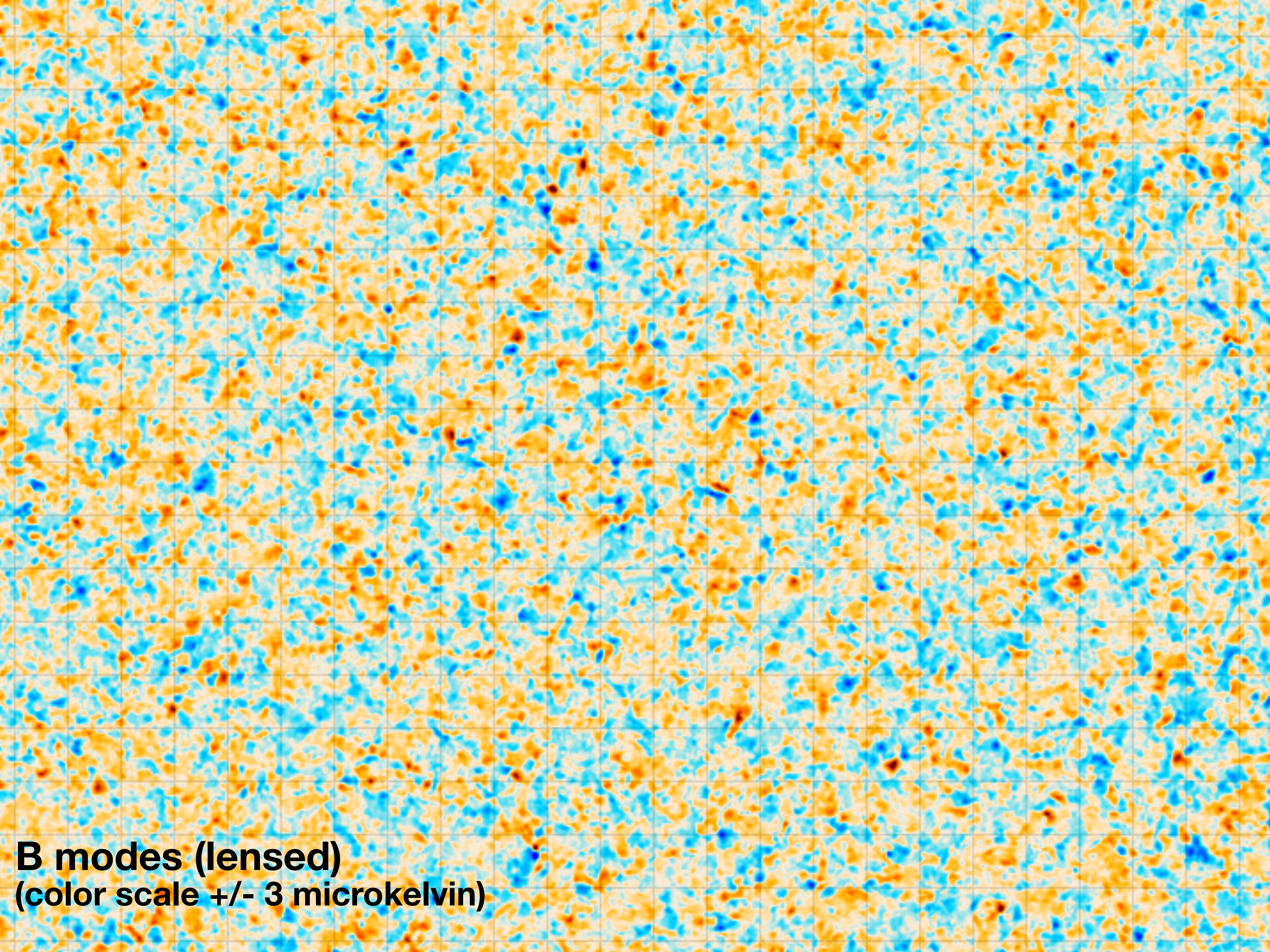


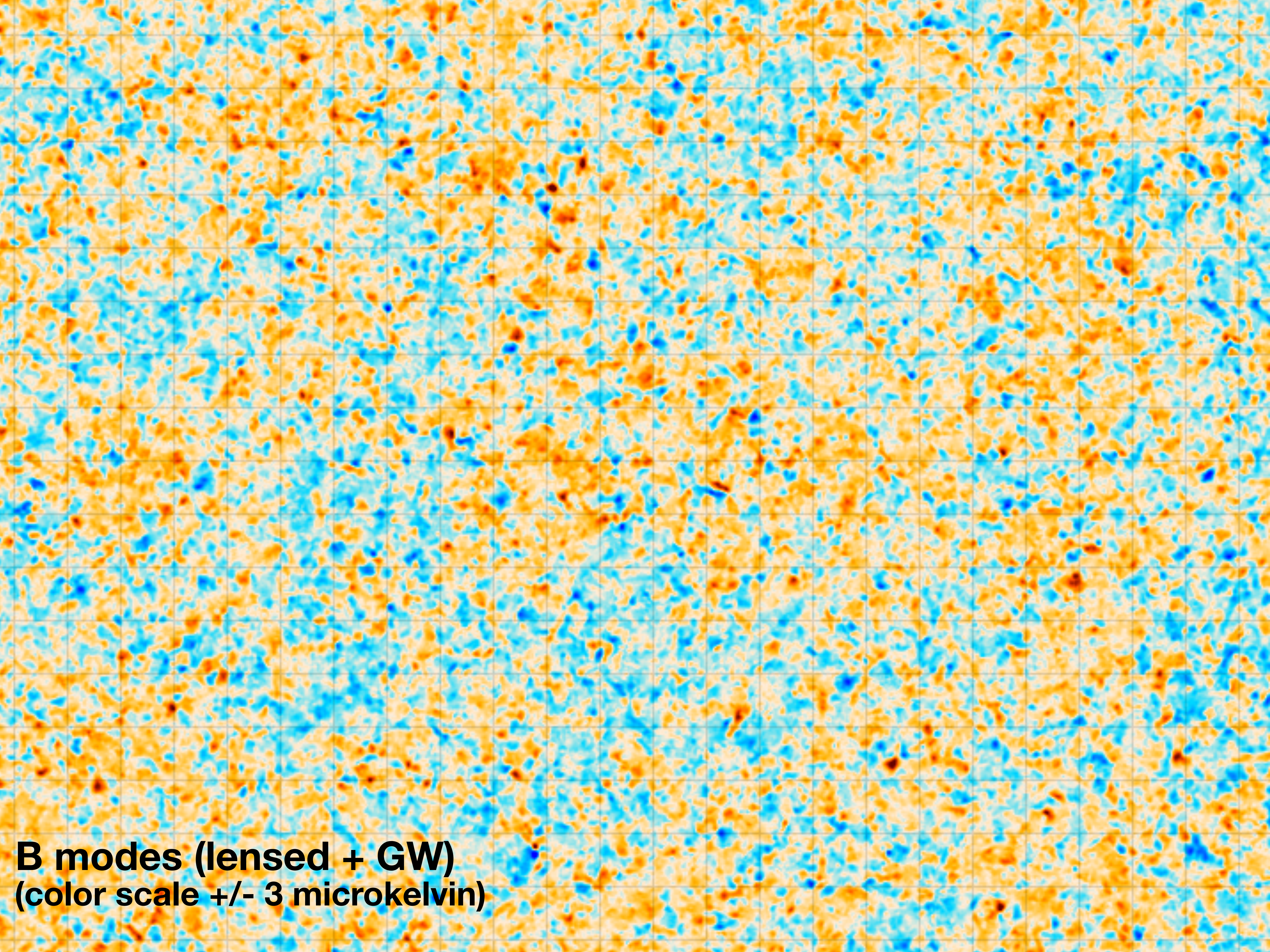


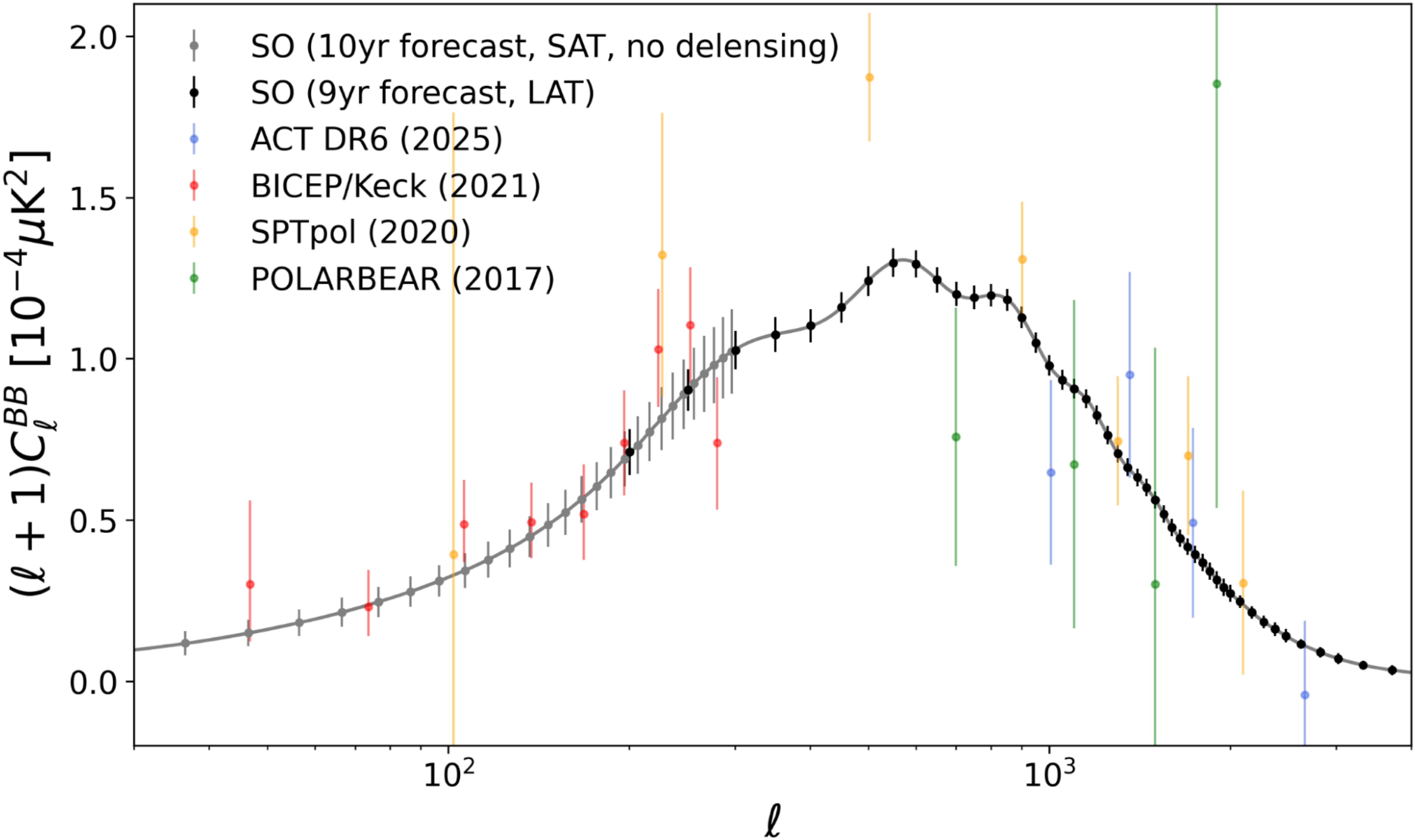
(color scale +/- 30 microkelvin)



Map over 40% of the sky

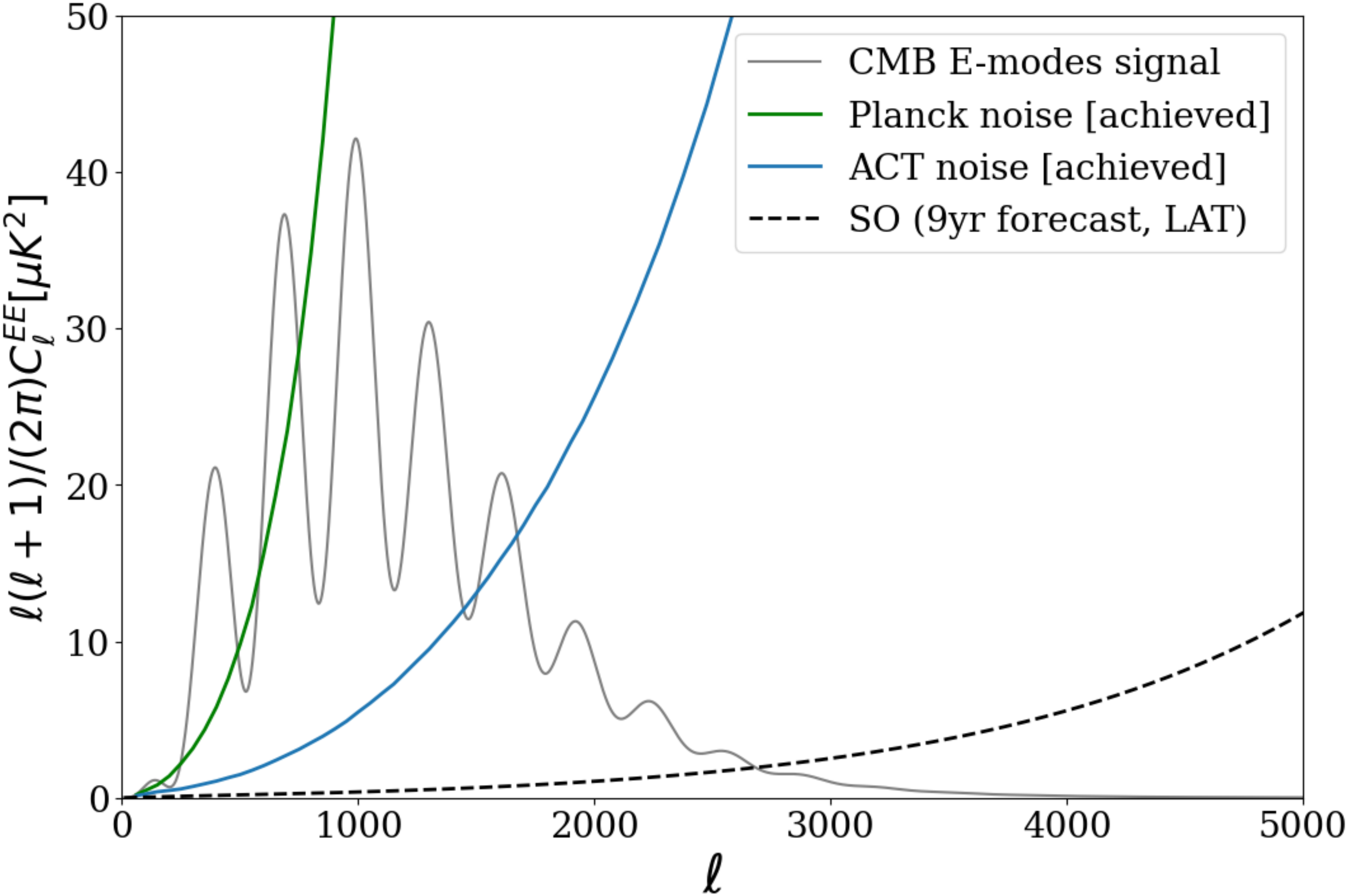

B modes (lensed)
(color scale +/- 3 microkelvin)

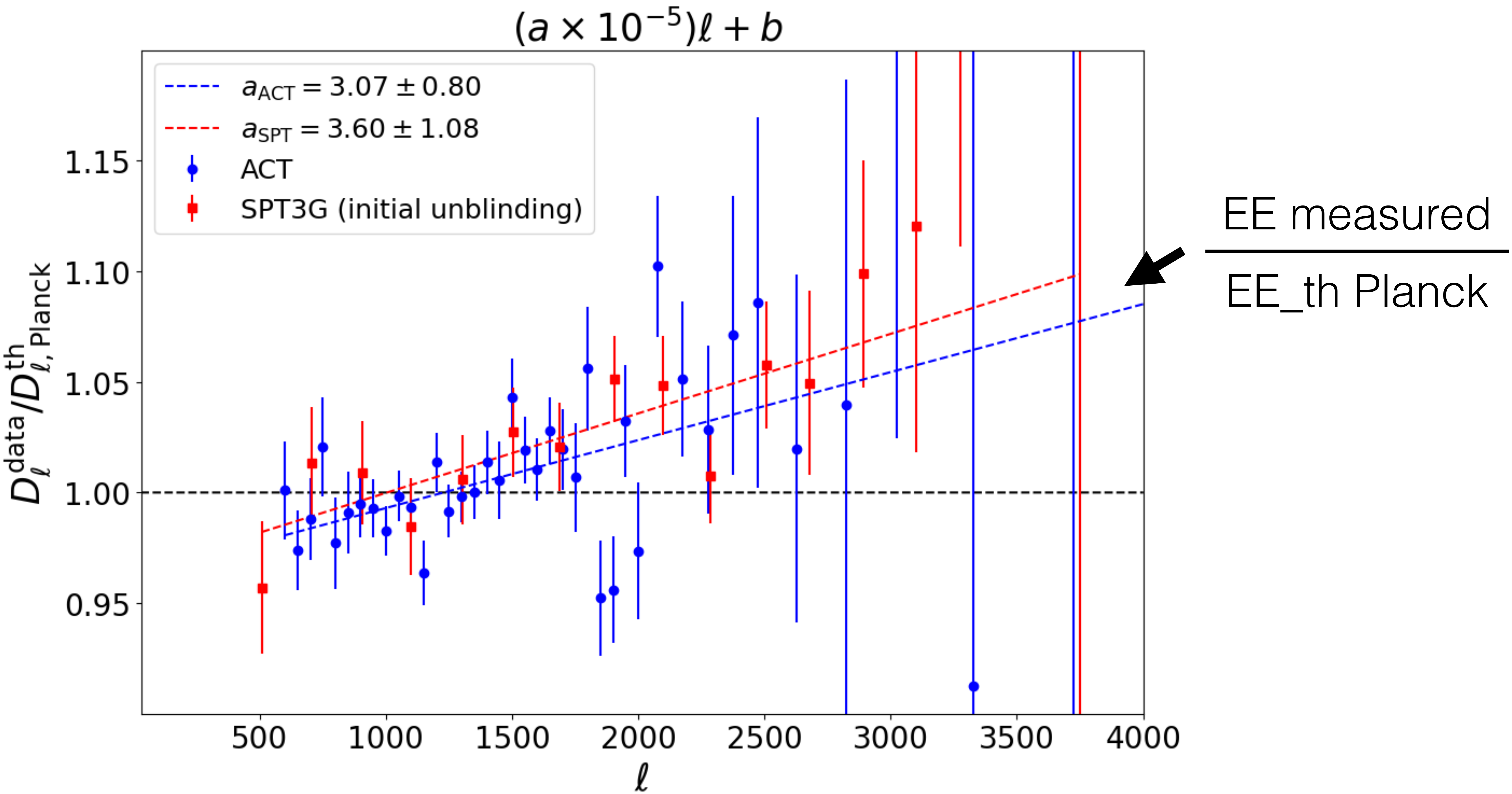

B modes (lensed + GW)
(color scale +/- 3 microkelvin)



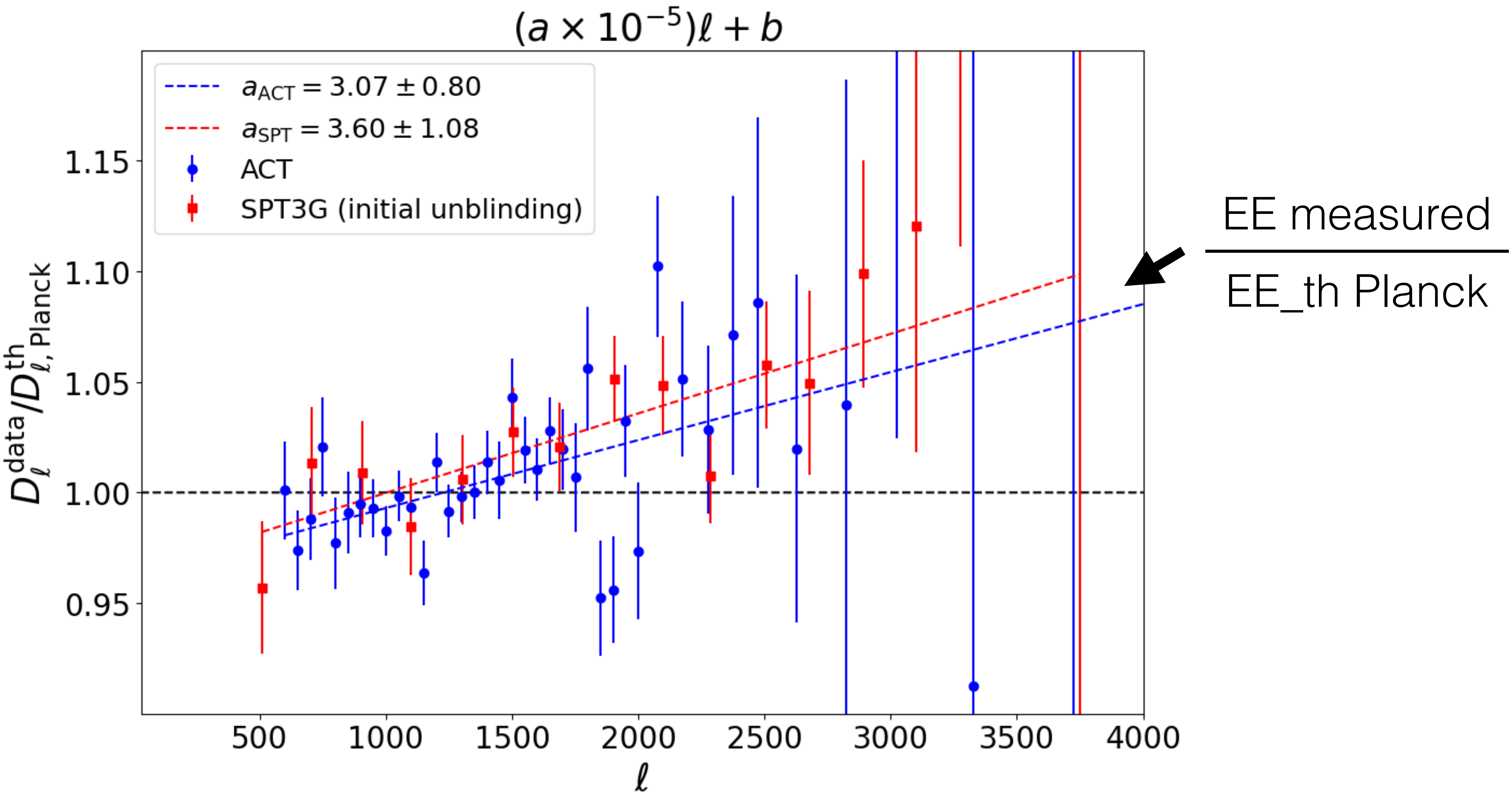
Target $\sigma(r) = 1 - 2 \times 10^{-3}$ after a 10 year survey

A very deep E mode measurement over 40% of the sky





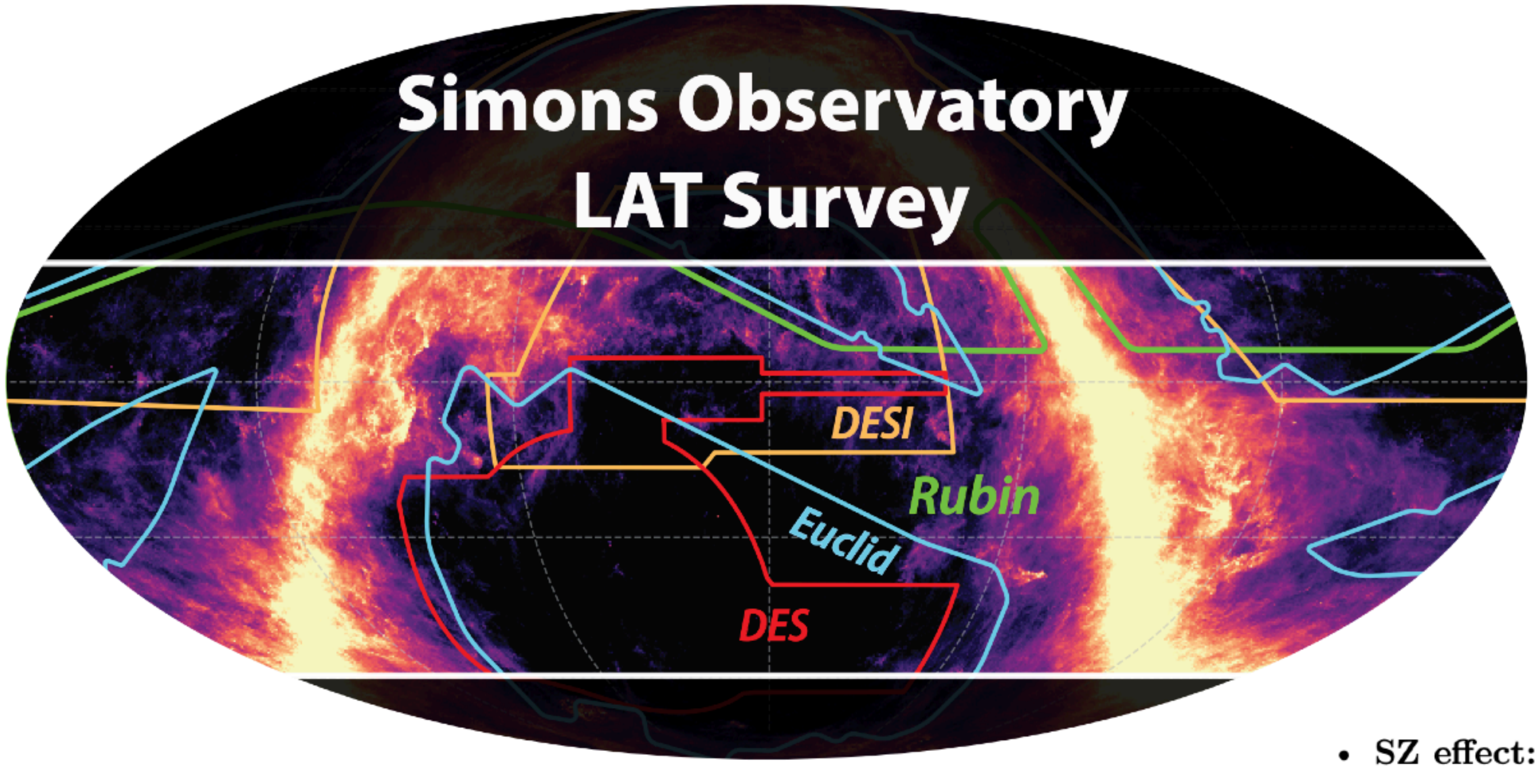
What I am interested in : Is the excess seen in ACT/SPT3G EE with respect to Planck best fit cosmology real ?



What I am interested in : Is the excess seen in ACT/SPT3G EE with respect to Planck best fit cosmology real ?

What other people care about: improvement of a factor 2 in ns and a factor 3 in Neff uncertainties

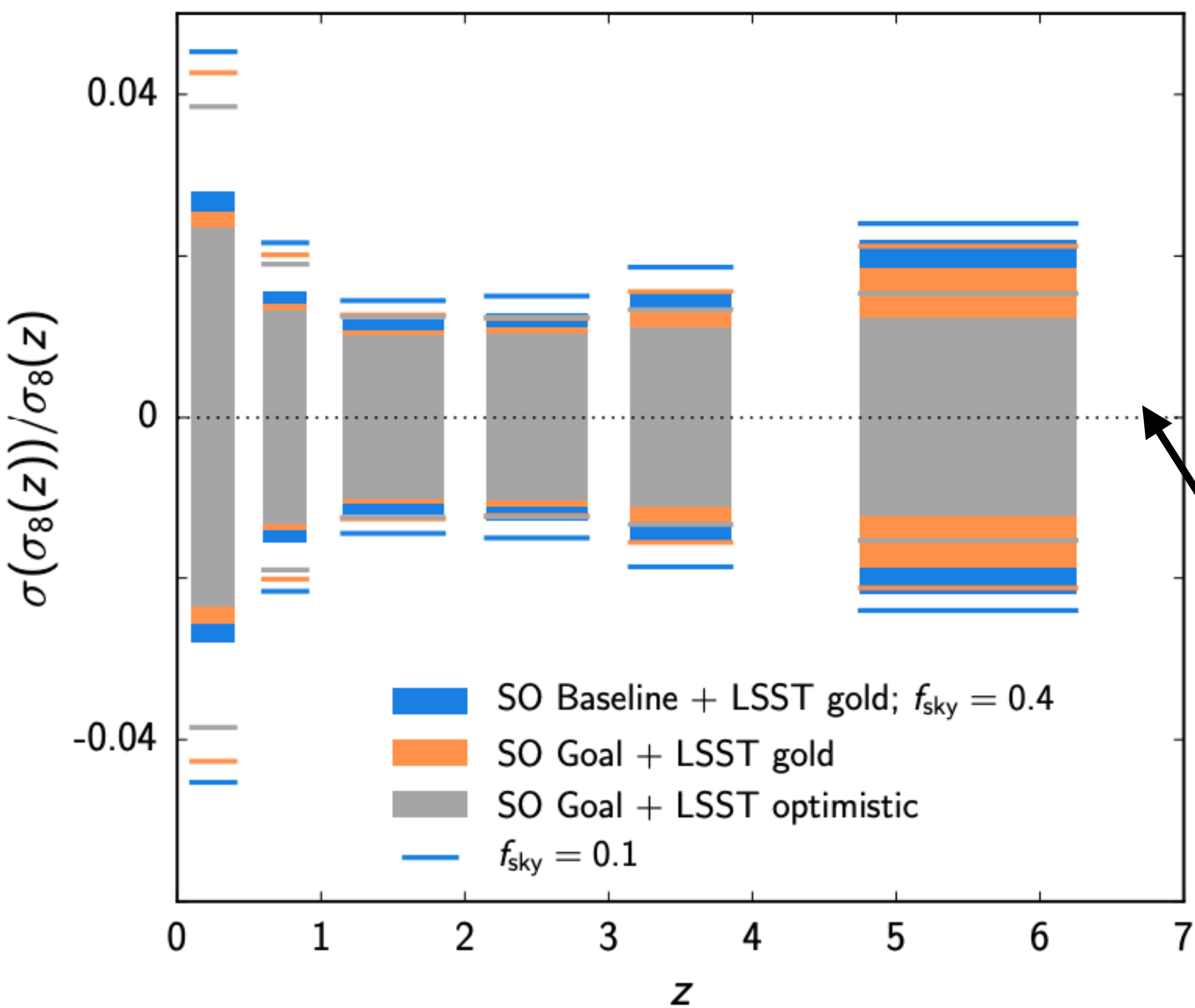
A wealth of cross correlation with large scale structure survey (Due to the unique location of SO)



- **Lensing:**
  - High-redshift measurement of structure growth from the cross-correlation of Quaia quasars and CMB lensing from ACT DR6 and Planck PR4 (Villagra et al., 2025)
  - Structure growth measurements from the cross-correlation of DESI Legacy Imaging galaxies and CMB lensing from ACT DR6 and Planck PR4 (Qu et al., 2024)
  - Multi-probe cosmology with unWISE galaxies and ACT DR6 CMB lensing (Farren et al., 2025)
  - Cosmological constraints from the cross-correlation of DESI Luminous Red Galaxies with CMB lensing from Planck PR4 and ACT DR6 (Sailer et al., 2025)
  - Structure formation over cosmic time with a measurement of the cross-correlation of CMB Lensing and DESI Luminous Red Galaxies (Kim et al., 2024)
  - DR6 Gravitational Lensing and SDSS BOSS cross-correlation measurement and constraints on gravity with the EG statistic (Wenzl et al., 2025)
  - Cosmology from cross-correlations of unWISE galaxies and ACT DR6 CMB lensing (Farren et al., 2024)

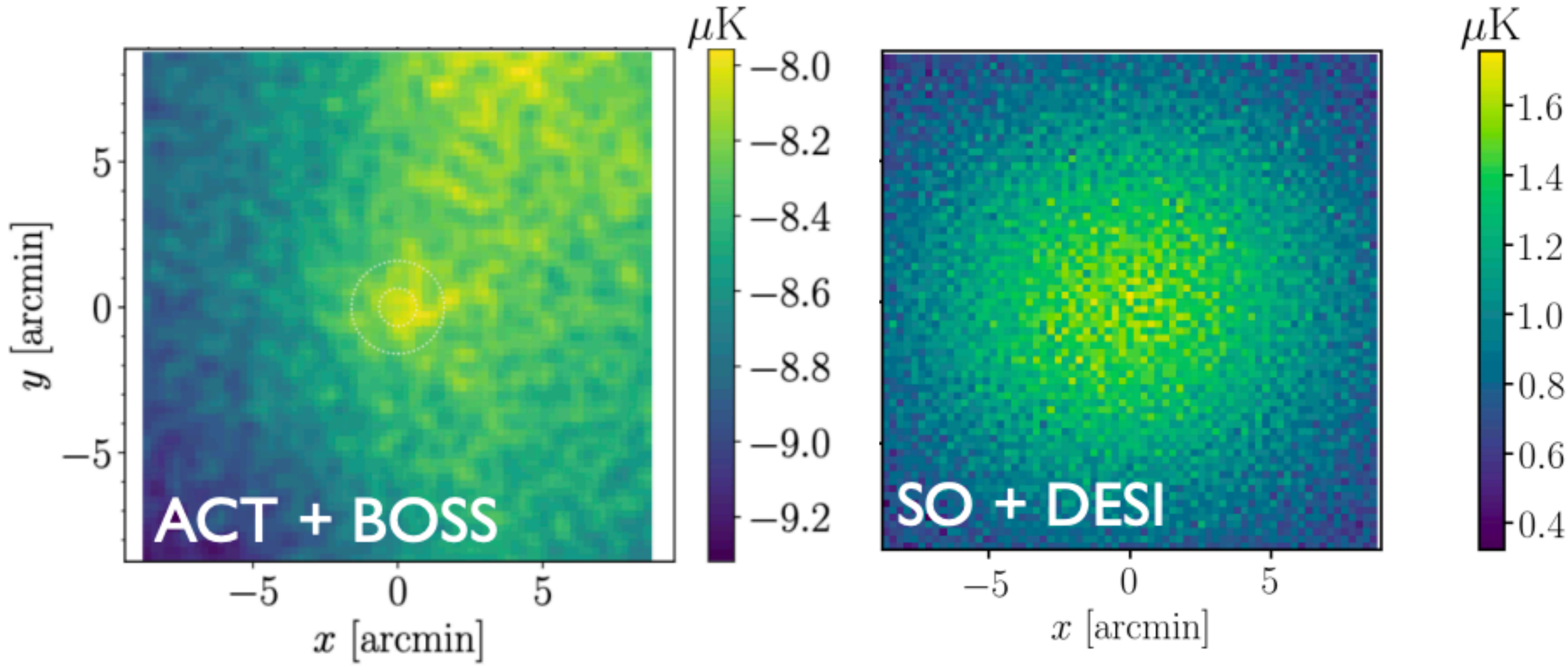
- **SZ effect:**
  - Large-scale velocity reconstruction with the kinematic Sunyaev–Zel'dovich effect and DESI LRGs (McCarthy et al., 2024)
  - Backlighting extended gas halos around luminous red galaxies: kinematic Sunyaev-Zel'dovich effect from DESI Y1 x ACT (Guachalla et al., 2025)
  - Measurements of the Thermal Sunyaev-Zel'dovich Effect with ACT and DESI Luminous Red Galaxies (Liu et al., 2025)
  - Evidence for large baryonic feedback at low and intermediate redshifts from kinematic Sunyaev-Zel'dovich observations with ACT and DESI photometric galaxies (Hadzhiyska et al., 2025)

Reconstruct the growth of structure as a function of redshift



Relative uncertainties on sigma8 as a function of z of order few %

Understand how baryons behaves in galaxies



$$T_{\mathrm{kSZ}} \propto n_e(\vec{v}.\hat{n})$$

Conclusions

-The Simons Observatory has started collecting data, and the initial results look very promising!

-Major upgrades to the Large Aperture Telescope are planned for next year, and three additional Small Aperture Telescopes are currently under construction. Discussions with the DOE are also underway

(+ Josquin's talk on KAIROS).

-The CMB remains a unique window into physics at the

highest energy scales, through parameters such as r, ns and Neff, and is crucial to interpreting any hints of new physics emerging at low redshift.

-Strong and growing synergies with large-scale structure surveys

from lensing and SZ effect.

In many cases we combine SO forecasts with DESI and LSST. For LSST we consider an overlap area of $f_{\rm sky} = 0.4$ and two possible galaxy samples. First is the 'gold' sample, which has galaxies with a dust-corrected $i < 24.5$ magnitude cut after three years of LSST observations. This corresponds to 29.4 galaxies arcmin^{-2} and $n(z) \propto z^2 \exp[-(z/0.27)^{0.92}]$ following LSST Science Collaboration (2009) and Chang et al. (2013). Second, we consider a more optimistic LSST galaxy sample with dust-corrected $i < 27$ and a $S/N > 5$ cut with ten years of LSST observation, following Gorecki et al. (2014). In that sample we include a possible sample of Lyman-break galaxies at z=4–7, identified using the dropout technique (see Dunlop 2012 for a review), with a number density estimated by extrapolating recent Hyper Suprime-Cam (HSC) results (Ono et al. 2018, Harikane et al. 2017, following Schmittfull and Seljak 2018).

For DESI we include projected measurements of the baryon acoustic oscillation (BAO) scale, by imposing a prior on r_s/D_V at multiple redshifts, as described in Levi et al. (2013). Here, r_s is the sound horizon at decoupling and D_V is the volume distance. We consider the DESI Luminous Red Galaxy (LRG) catalog as providing the target galaxies for the SZ studies described in Sec. 7. In these forecasts we assume an overlap area of 9000 square degrees between SO and DESI ($f_{\rm sky} = 0.23$).

Throughout the paper we will retain two significant figures in many of our forecast errors to enable comparison of different experimental configurations. In the summary table we restrict errors to one significant figure.