CMB@60

L. Page

The important complementarity of space and ground/balloon CMB measurements.

Do from satellites only what cannot be done from the ground/balloons (at a reasonable cost/timescale.)

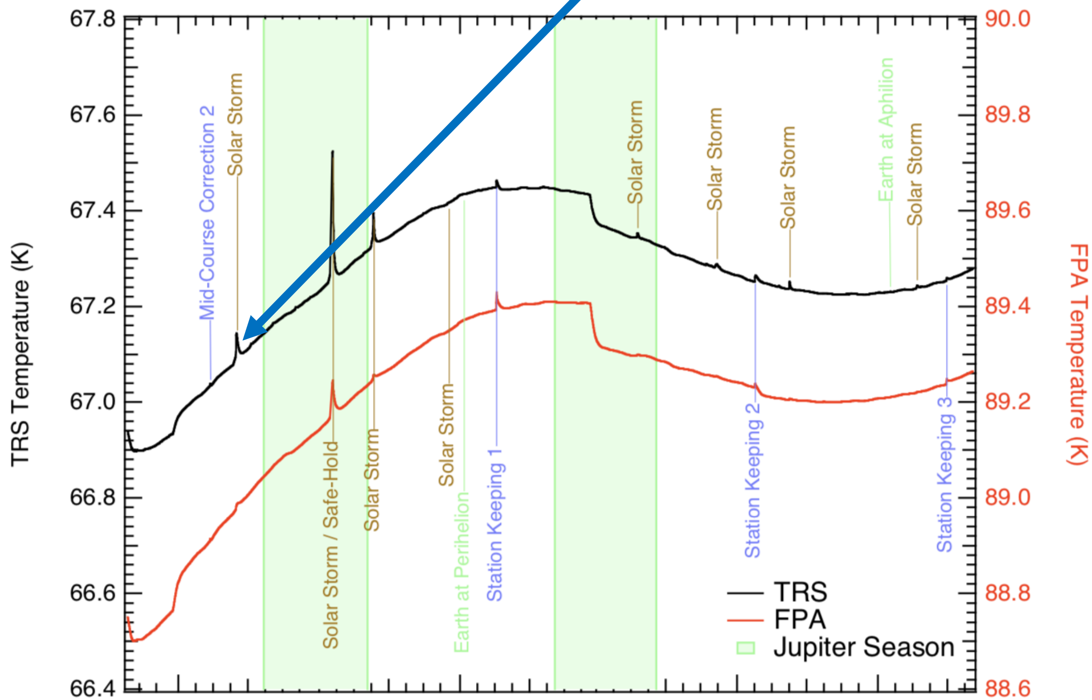
Use ground and balloon observations to mature technologies for space (in addition to the Science!)

Space has the advantage of stability, repeatability, long uninterrupted observing, continuous calibration on dipole, and all sky coverage.

Thermal stability

First (?) bolometric detection at L2!

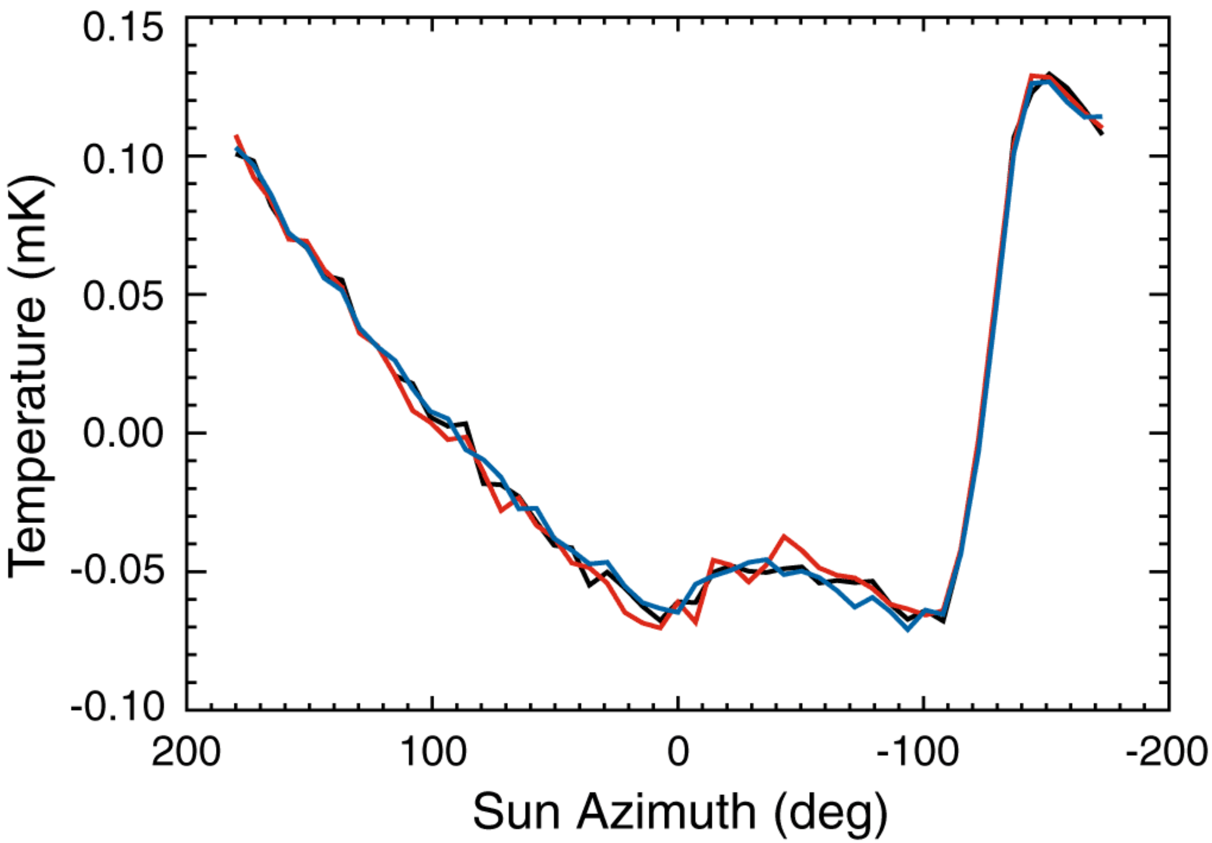
TRS: Thermal Reflector System (the primaries)



FPA: Focal Plane Assembly, where the amplifiers lived.

LiteBIRD will see solar storms in the HWP!

Limon et al. 2010. WMAP's first year thermal profile.



Temperature of primary binned in solar azimuth.

Year 1
Year 2
Year 3

Jarosik et al. 2007.

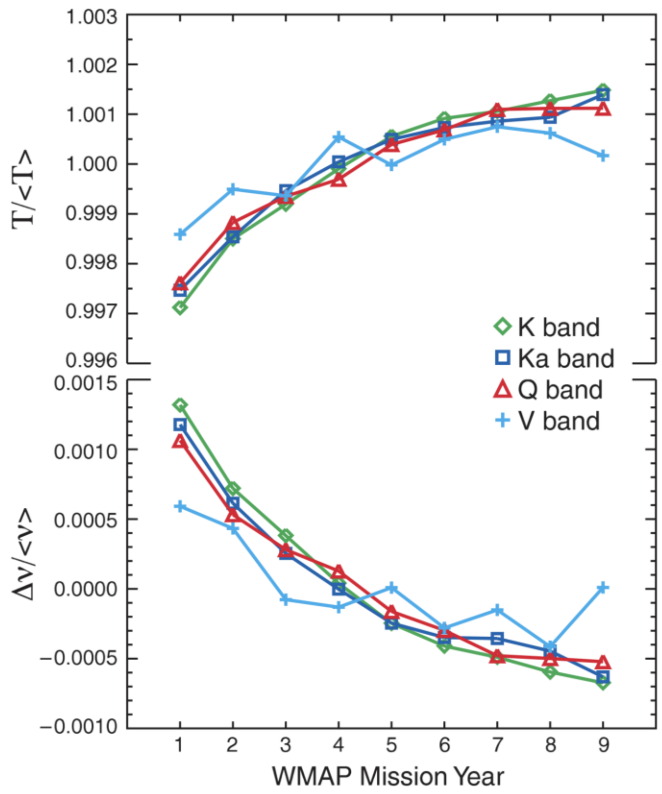


Fig. 44.— Top - Measurements of the year-to-year fractional brightness variation of the Galactic plane in *WMAP* skymaps, obtained by correlating Galactic plane signal in each single year map with Galactic plane signal in the nine-year map. There is a small dependence of these variations on spectral index, which shows that they are caused by variations in effective *WMAP* band center frequencies over the mission. Bottom - The year-to-year fractional variation of *WMAP* band center frequency derived from Galactic plane brightness variations measured for selected spectral index bins.

At a low level, lots of things change. They need to be checked. In this case, the central frequencies drifted.

Especially important for cleaning foregrounds.

Bennett et al. 2013.

For B modes from space:

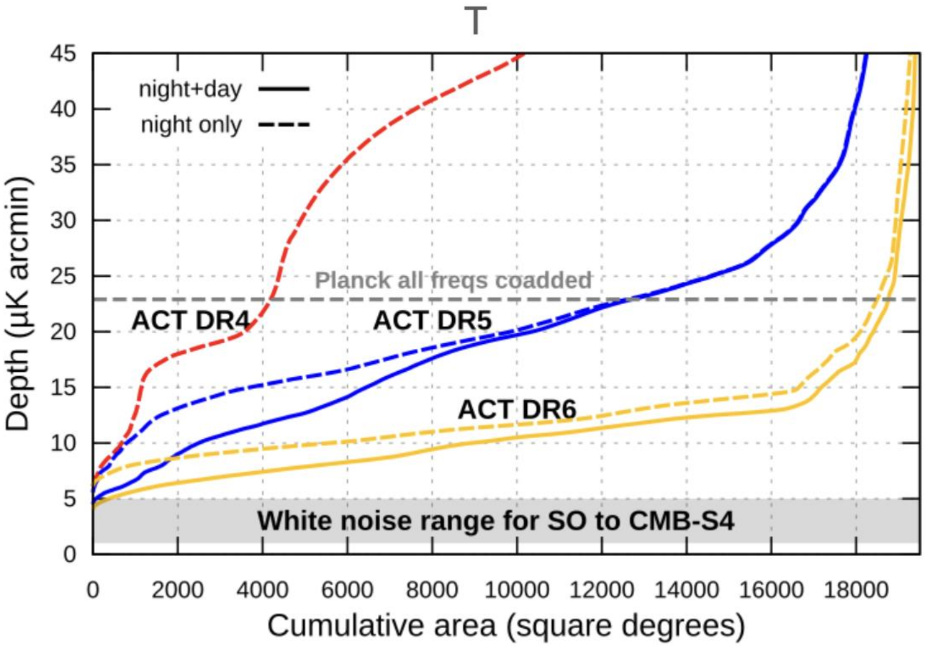
All sky measurements in frequency bands you cannot access from the ground with ~CMB photon limited detectors (with the usual science drivers.)

Complementarity from the ground:

For large area ground based measurements in P and T above l~500 we are already past Planck's sensitivity and, due in part to multiple observations of planets, ahead on some systematics.

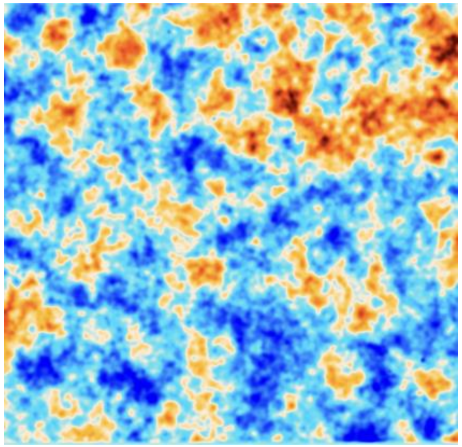
This is already being pushed to lower l with ever improving techniques.

The white noise level in ACT's DR6 **Temperature** maps



From Sigurd Naess

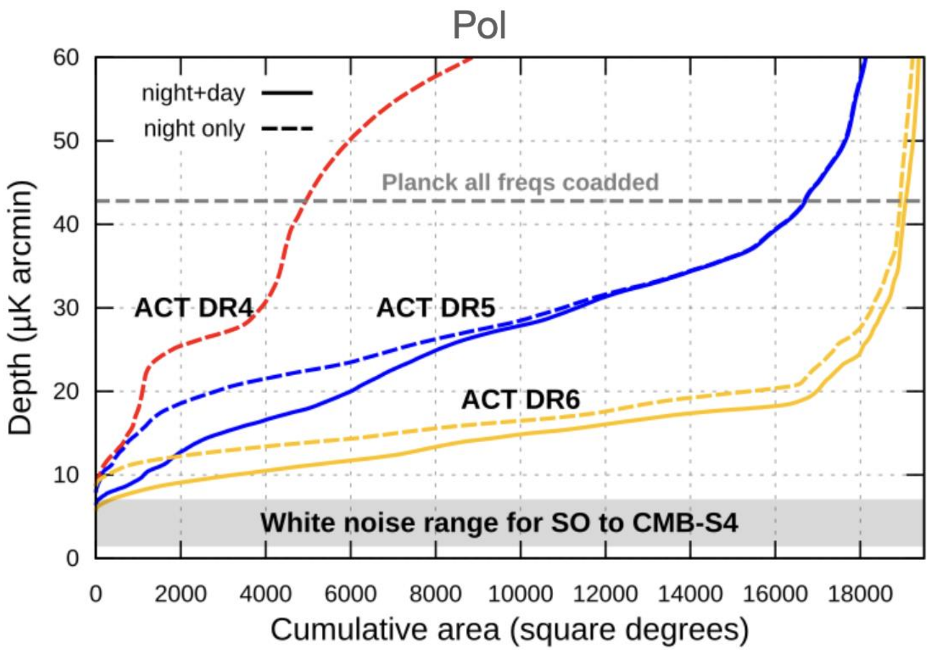
Temperature anisotropy



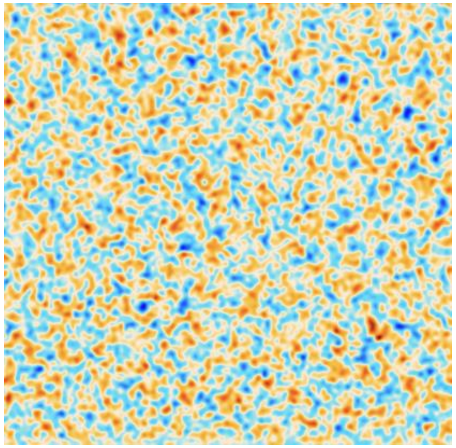
10 x10 degrees ±500μK

Credit: ACT Collaboration

The white noise level in ACT's DR6 **Polarization** maps

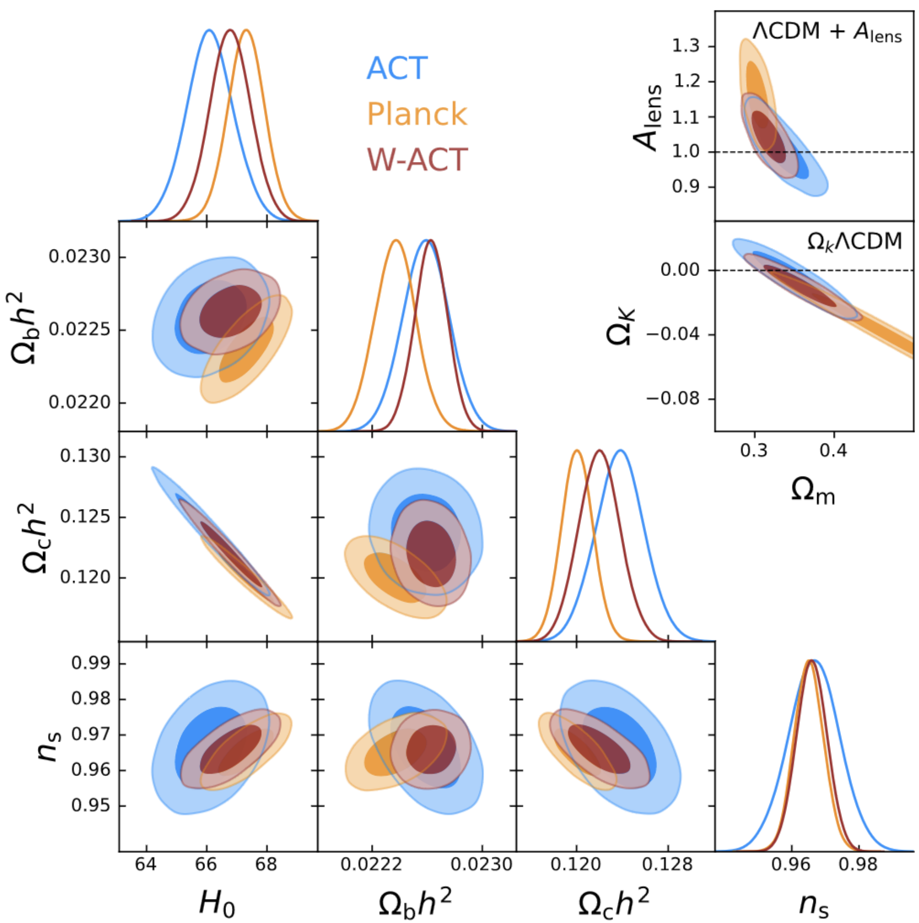


E-mode polarization



10 x10 degrees ±20μK

Credit: ACT Collaboration



Recent ACT results

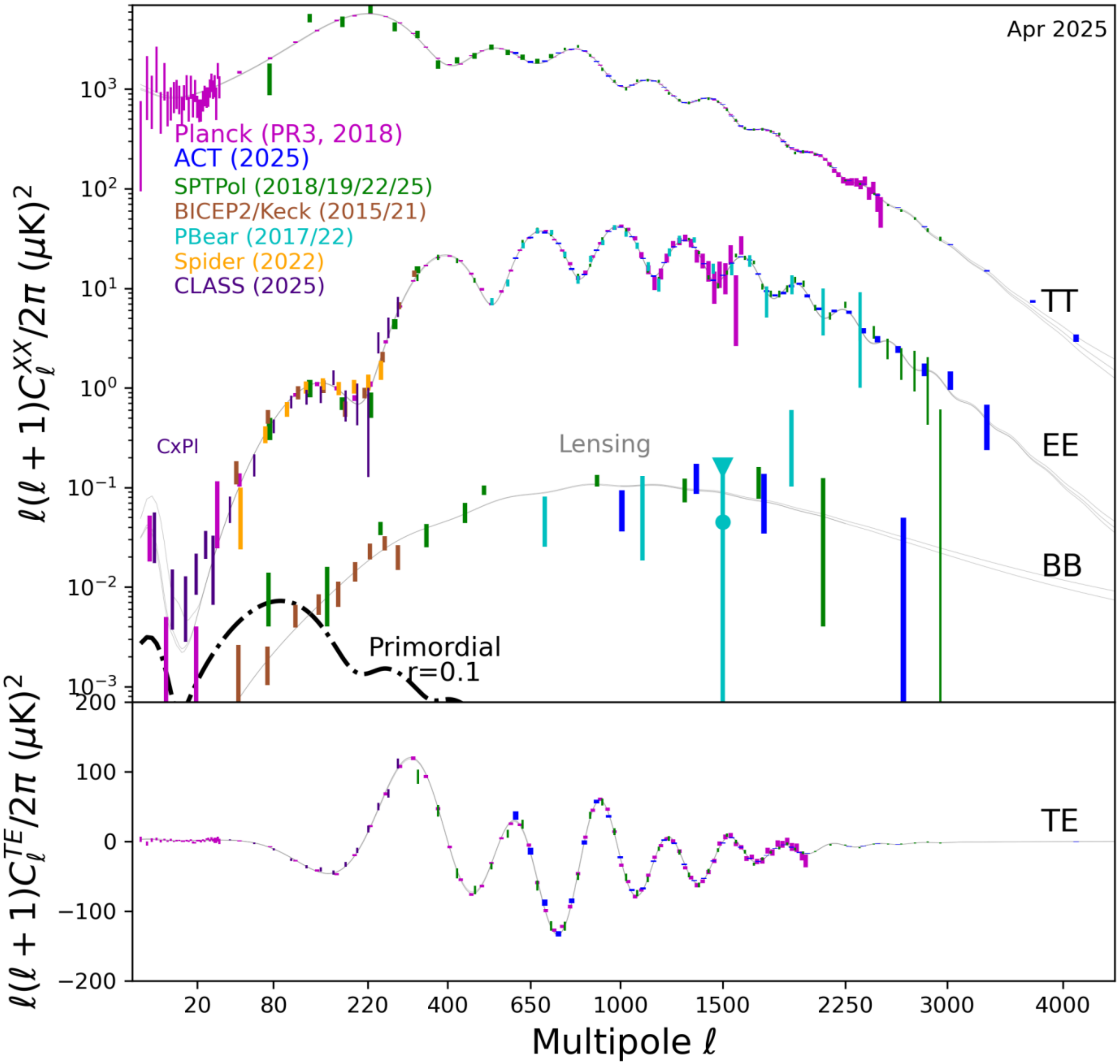
Louis et al 2025

Space

Ground

Parameter	ACT τ prior	Planck	W-ACT	P-ACT	P-ACT-LB
Sampled					
$10^4\theta_{\rm MC}$	104.056 ± 0.031 ...	104.088 ± 0.031 ...	104.066 ± 0.029 ...	104.073 ± 0.025 ...	104.086 ± 0.025 ...
$10^2\Omega_b h^2$	2.259 ± 0.017	2.237 ± 0.015	2.263 ± 0.012	2.250 ± 0.011	2.256 ± 0.011 .....
$10^2\Omega_c h^2$	12.38 ± 0.21	12.00 ± 0.14	12.20 ± 0.18	11.93 ± 0.12	11.79 ± 0.09 ....
$\log(10^{10}A_s)$ ..	3.053 ± 0.013	$3.054^{+0.012}_{-0.013}$	$3.057^{+0.010}_{-0.012}$	3.056 ± 0.013	$3.060^{+0.011}_{-0.012}$ ....
n_s	0.9666 ± 0.0077 ...	0.9651 ± 0.0044 ...	0.9660 ± 0.0046 ...	0.9709 ± 0.0038 ...	0.9743 ± 0.0034 ...
τ [%]	$5.62^{+0.53}_{-0.63}$	$5.90^{+0.55}_{-0.65}$	$5.71^{+0.54}_{-0.64}$	$6.03^{+0.55}_{-0.65}$	$6.32^{+0.55}_{-0.66}$ ....

CLASS in Xcorr w/ Planck
Li, Eimer et al. 2025

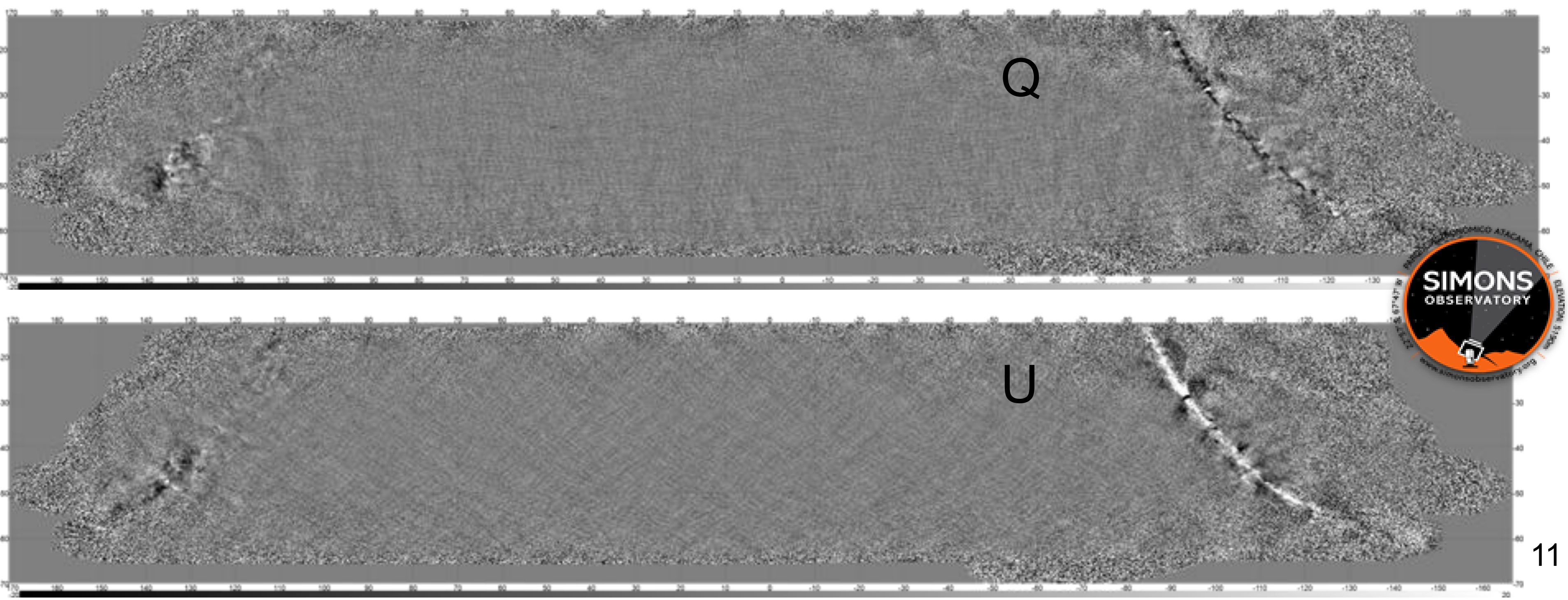


Measuring tau a top priority

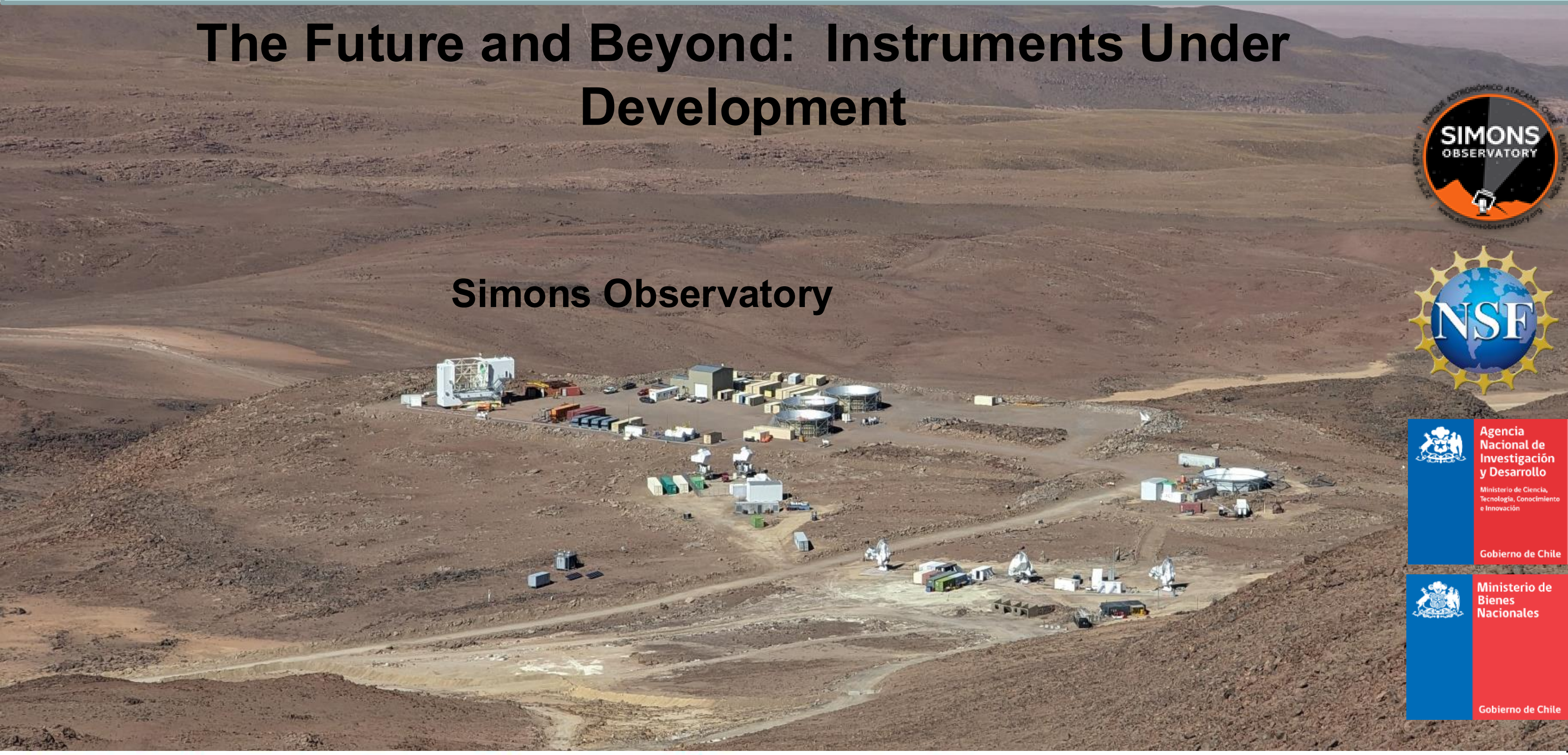
You can search for B-modes from Chile!

Access to large-area low-foreground region.
Wonderful complementarity to space.

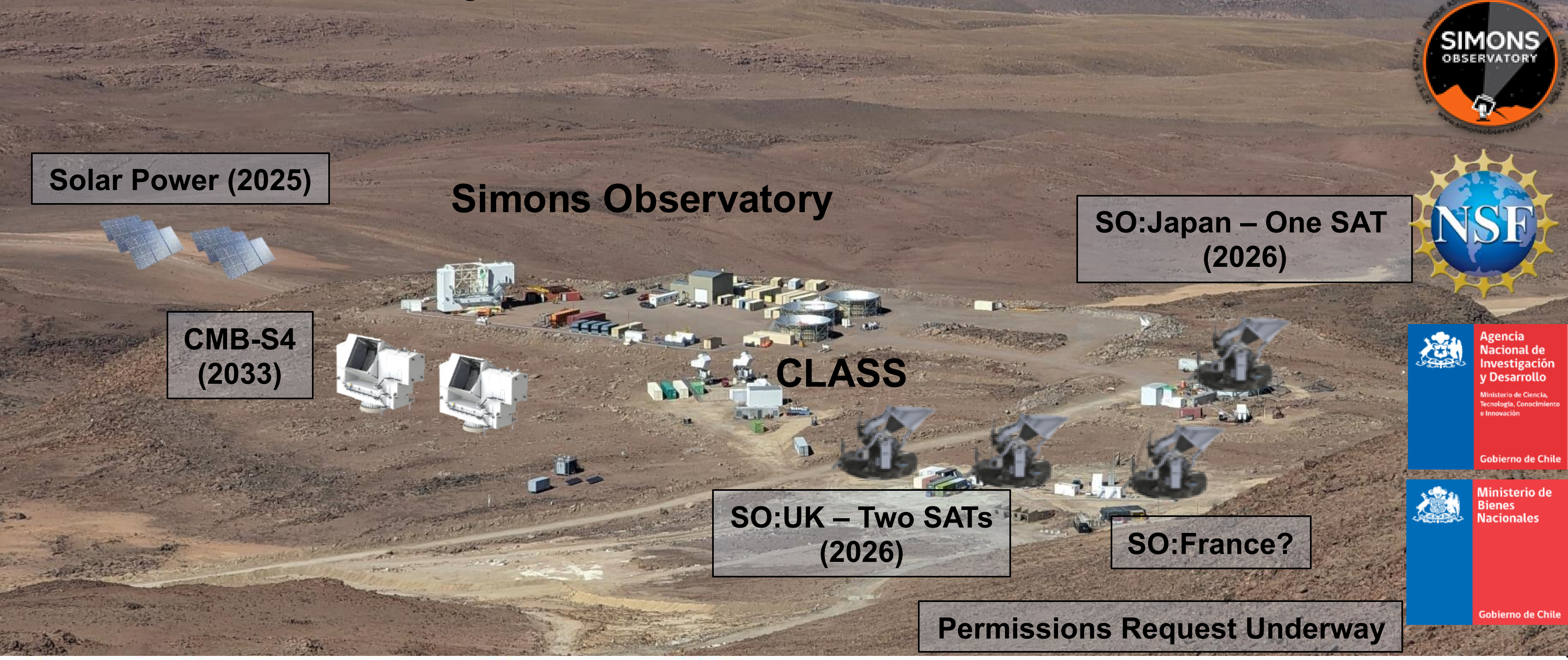
Preliminary SAT Maps: 90 GHz from one telescope



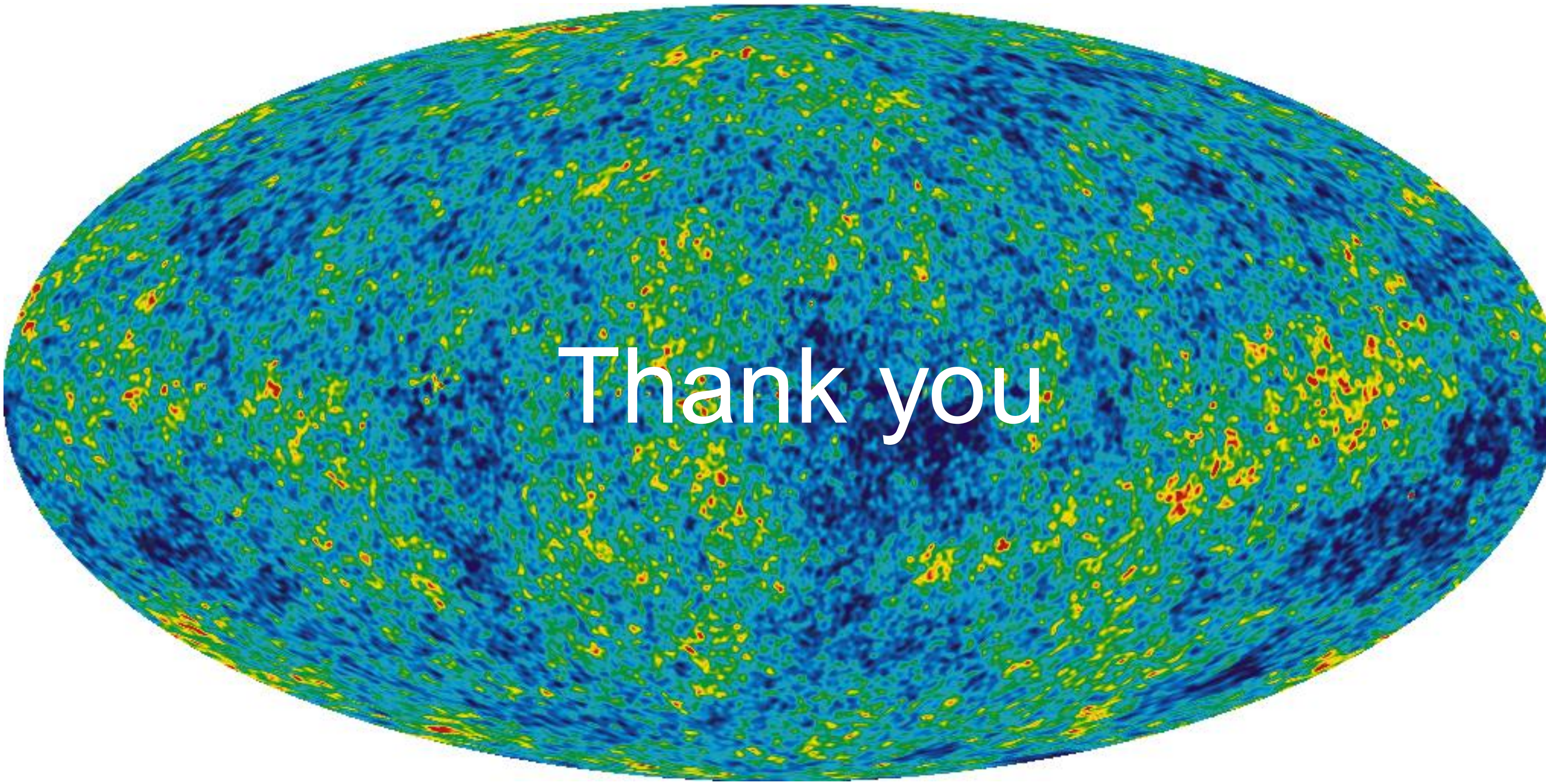
The Future and Beyond: Instruments Under Development



The Future and Beyond: Instruments Under Development



SIMONS FOUNDATION HEISING-SIMONS FOUNDATION


Thank you