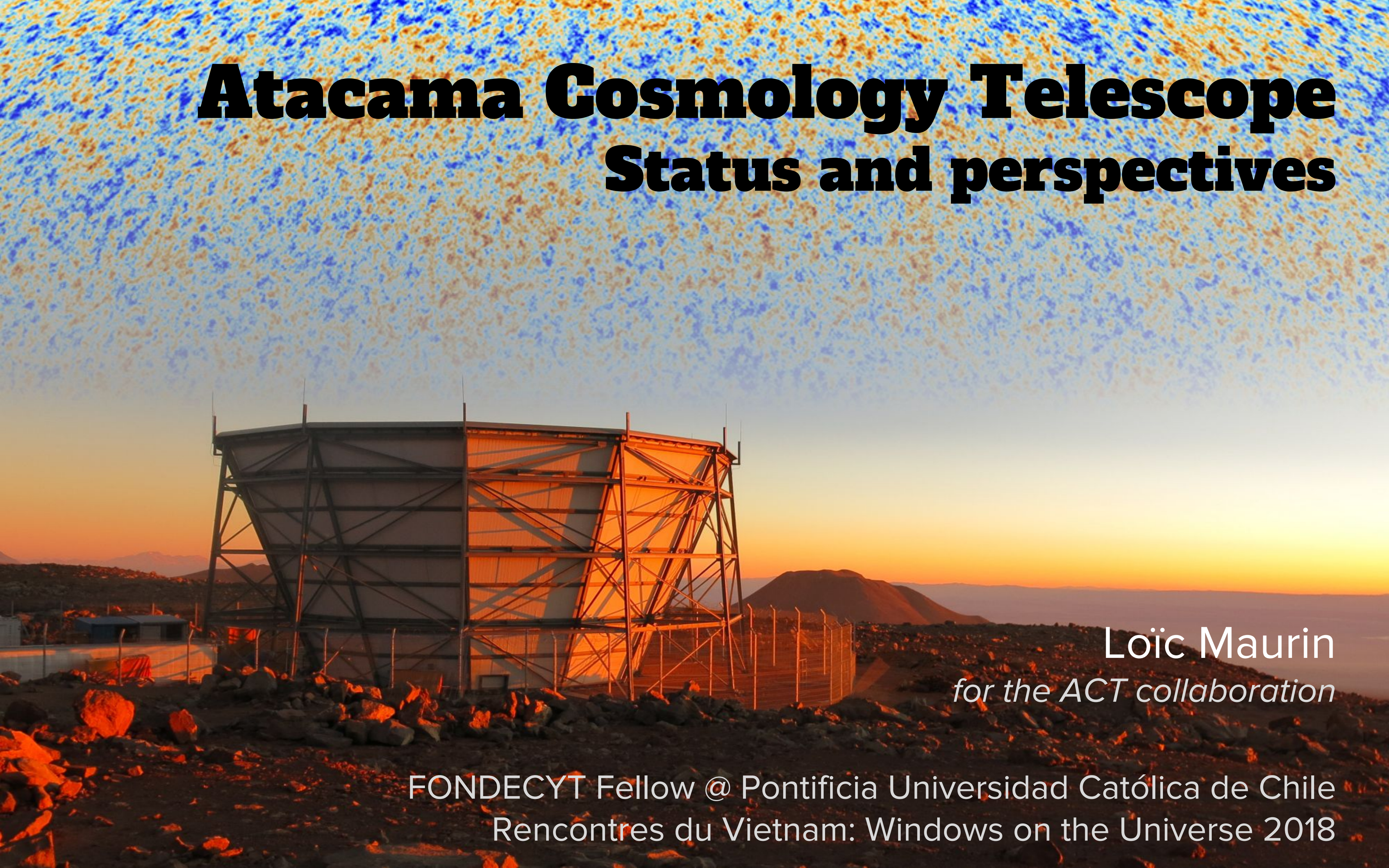
Atacama Cosmology Telescope

Status and perspectives



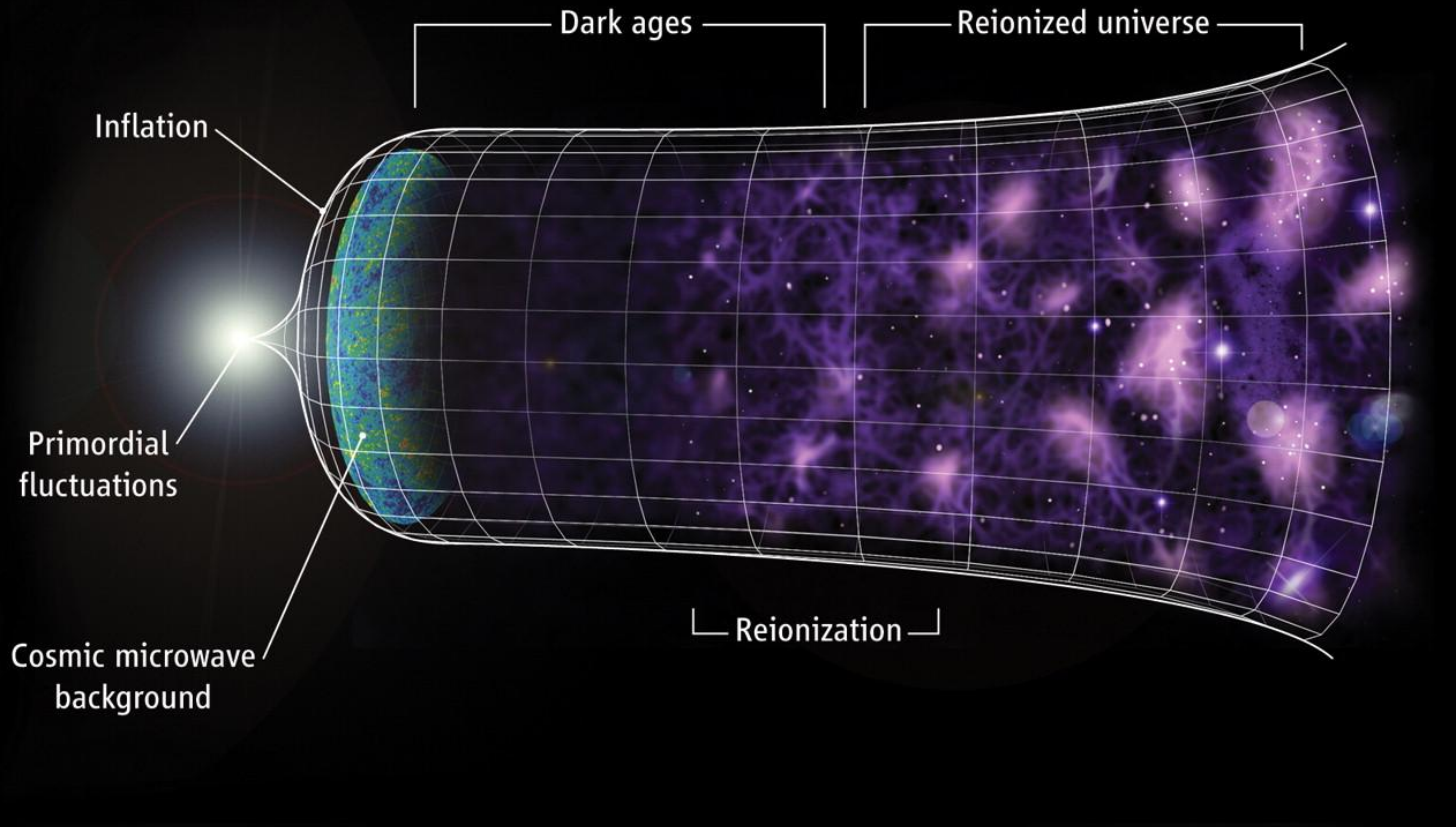
Loïc Maurin

for the ACT collaboration

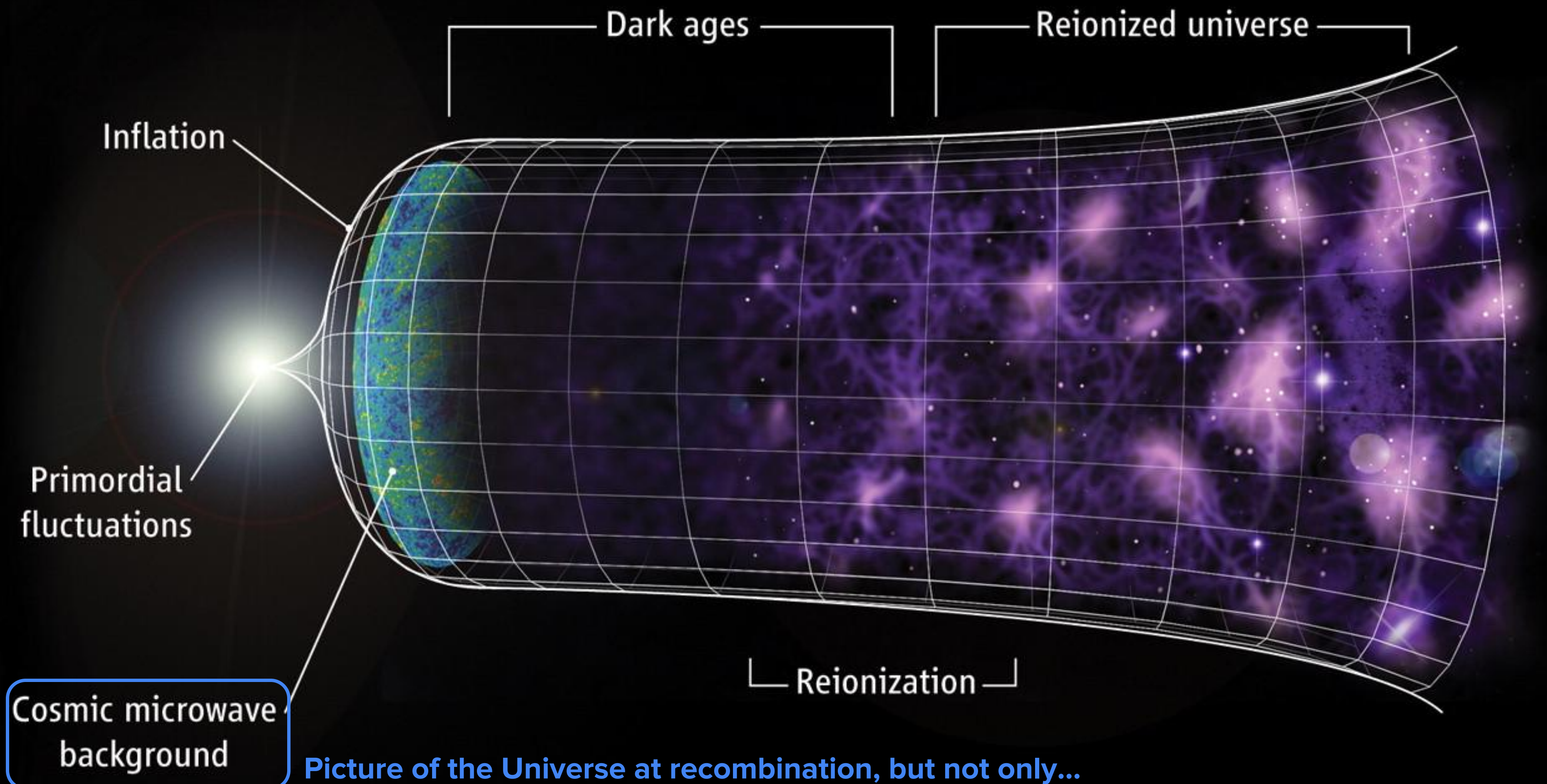
FONDECYT Fellow @ Pontificia Universidad Católica de Chile

Rencontres du Vietnam: Windows on the Universe 2018

Why do we look at the CMB?

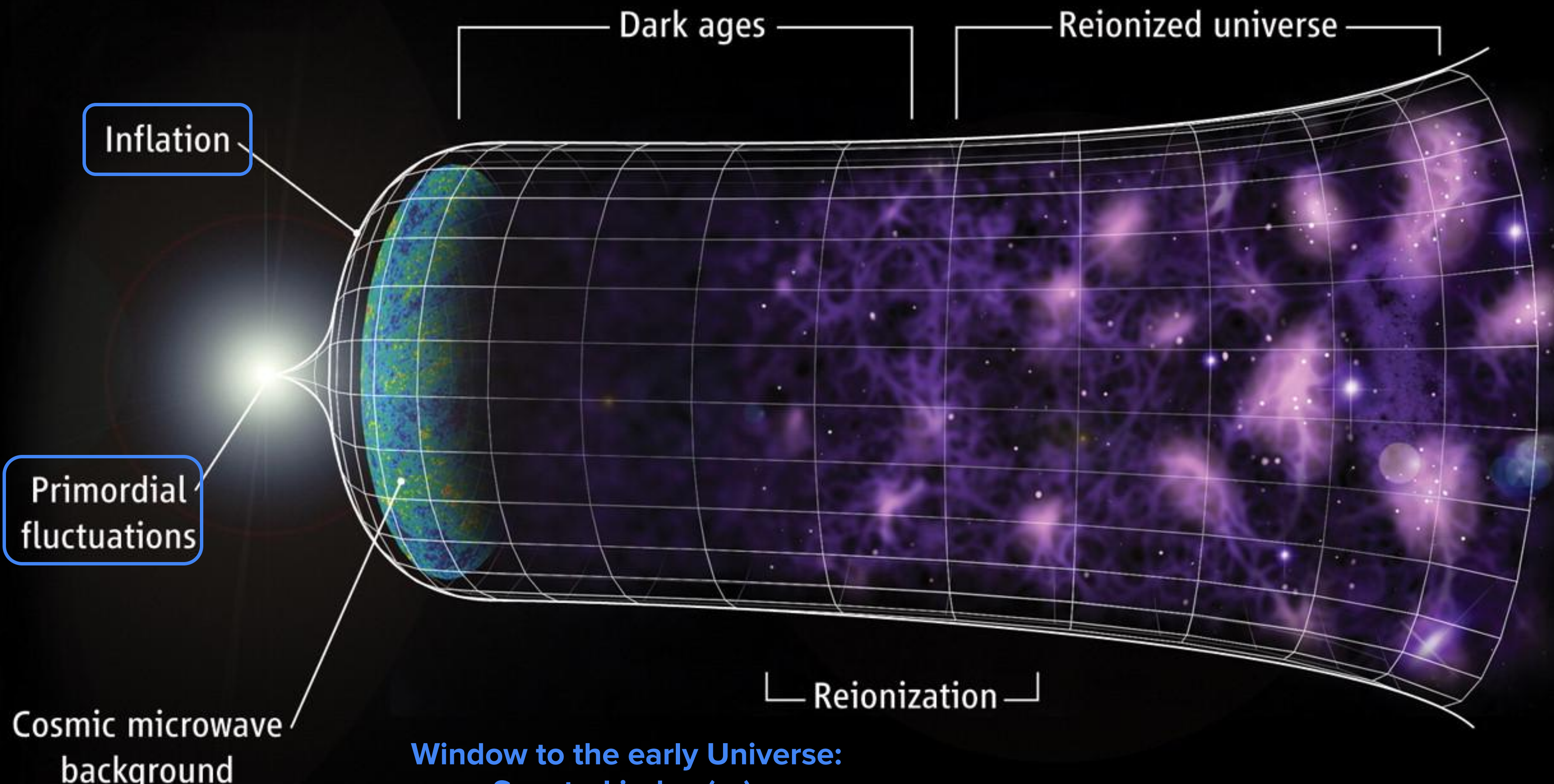


Why do we look at the CMB?



Picture of the Universe at recombination, but not only...

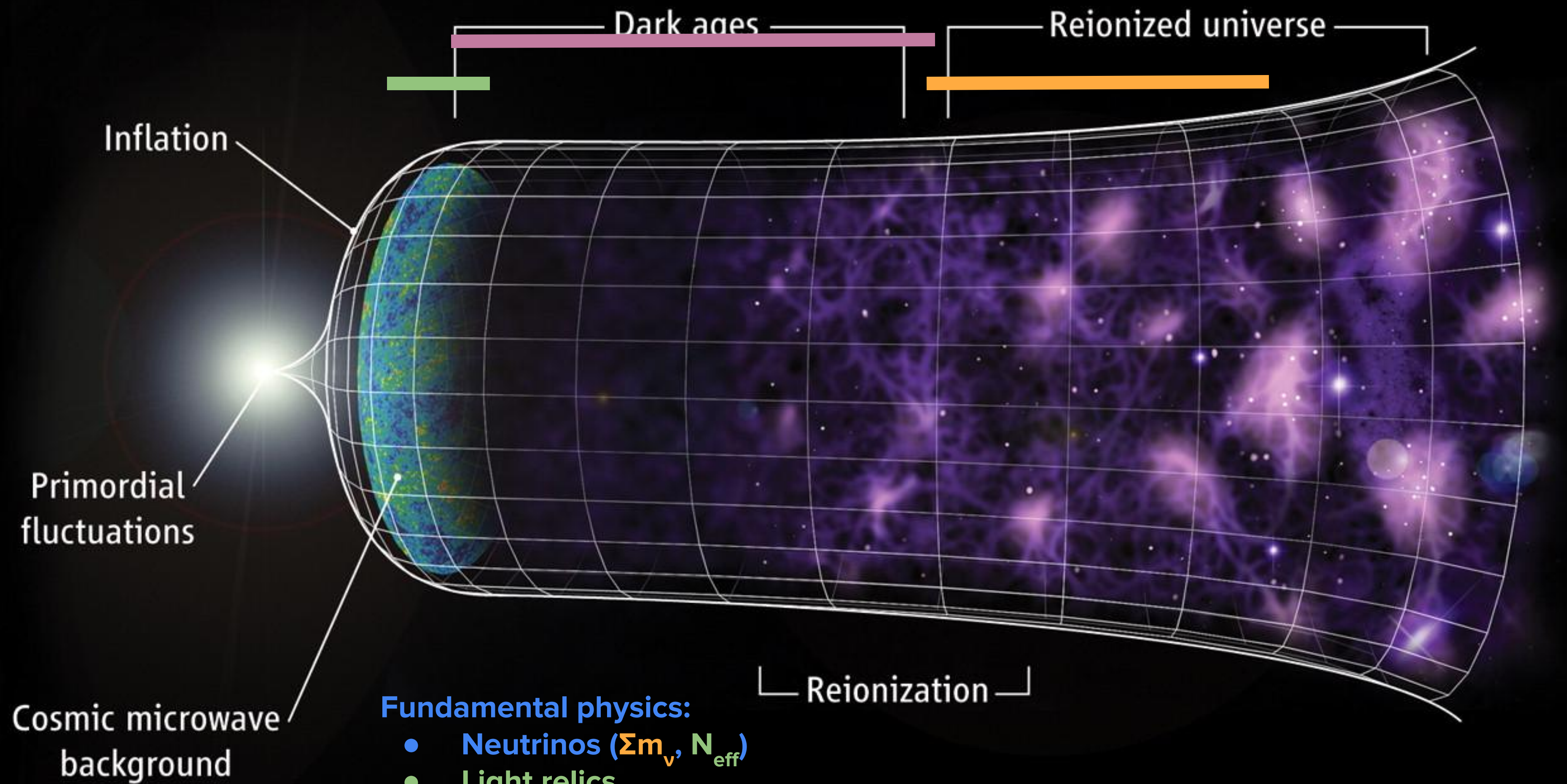
Why do we look at the CMB?



Window to the early Universe:

- Spectral index (n_s)
- Primordial gravitational wave (r)
- Non Gaussianity (f_{NL})

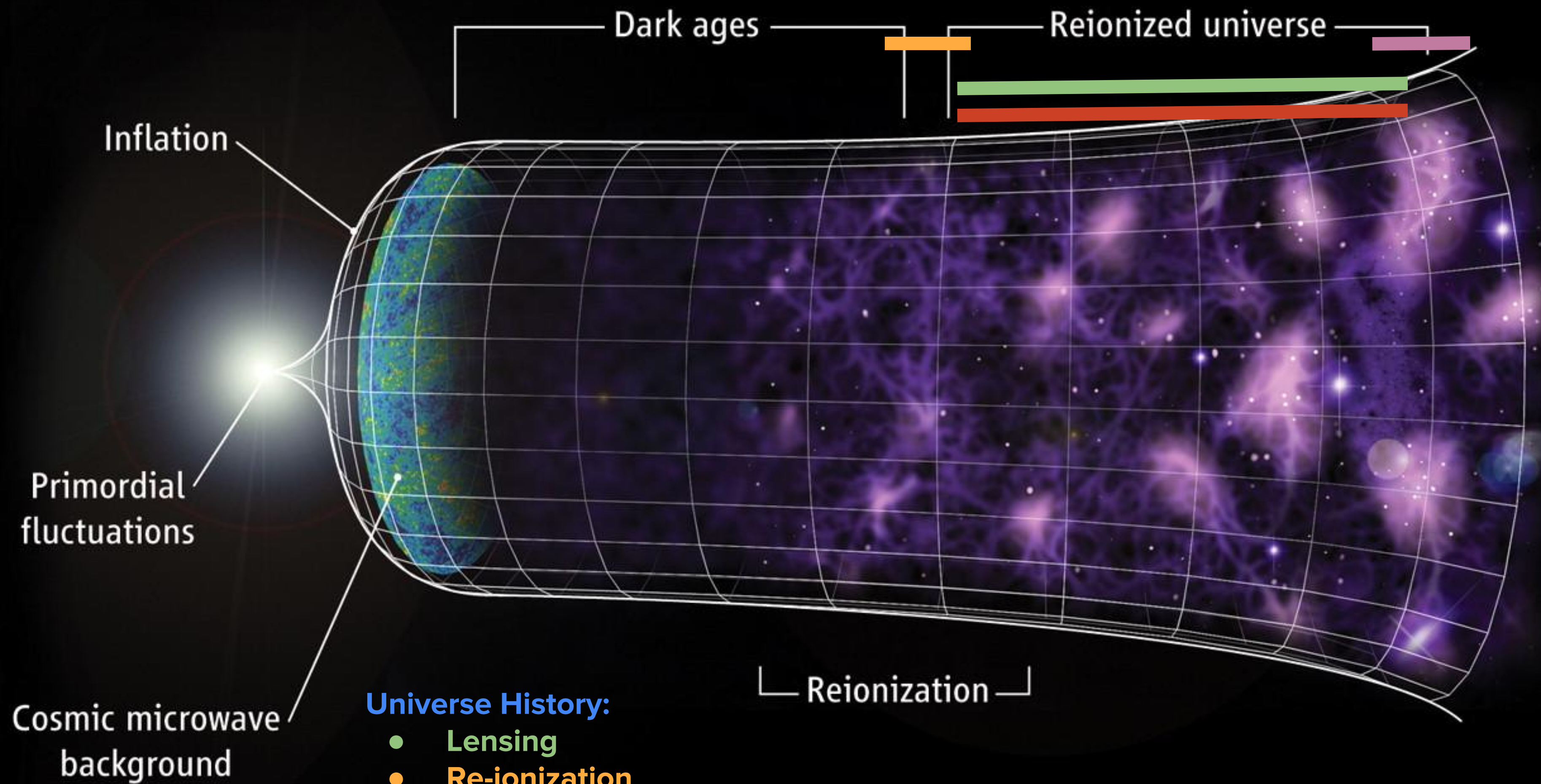
Why do we look at the CMB?



Fundamental physics:

- Neutrinos (Σm_ν, N_{eff})
- Light relics
- Dark Matter annihilation/interaction

Why do we look at the CMB?

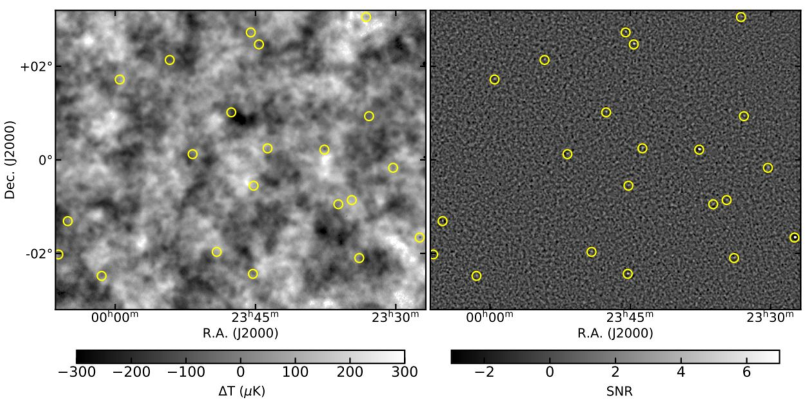


Universe History:

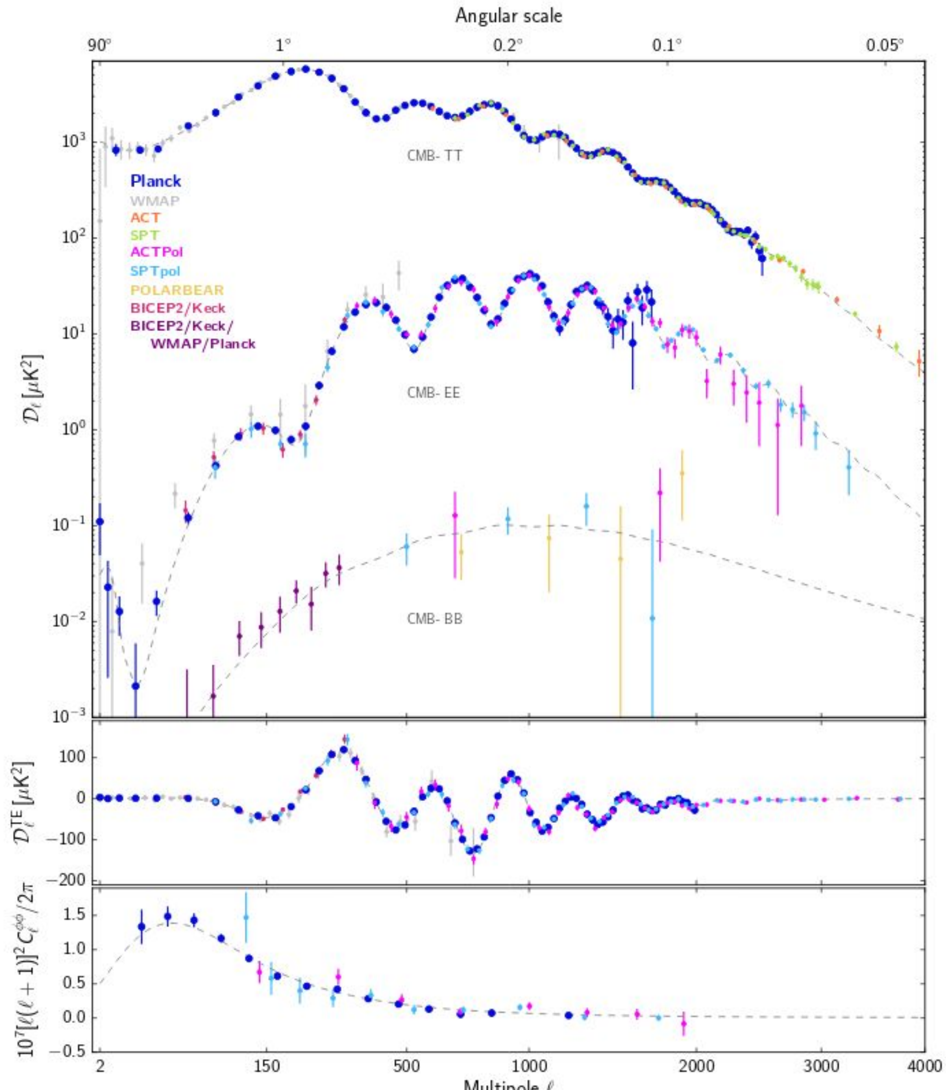
- Lensing
- Re-ionization
- Dark Energy
- Clusters, Galaxies, etc

How do we look at the CMB?

- Temperature
- Polarisation
- Power Spectrum/map
- Large scales/small scales



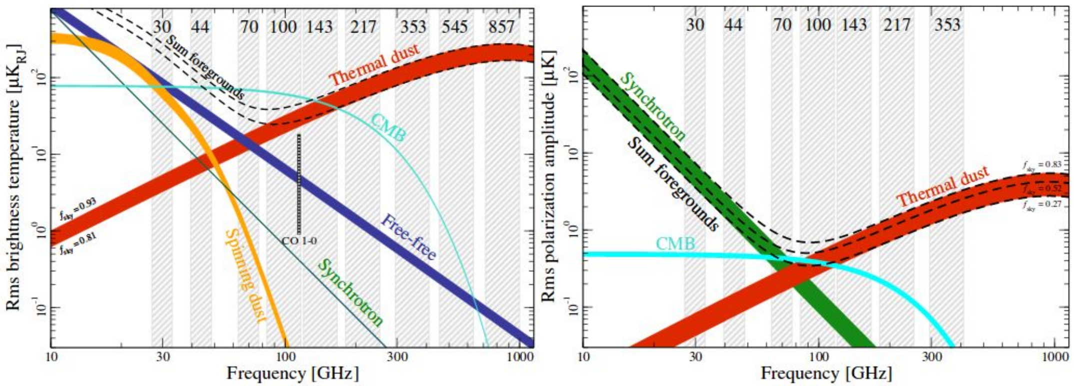
Hilton et al. (2018)



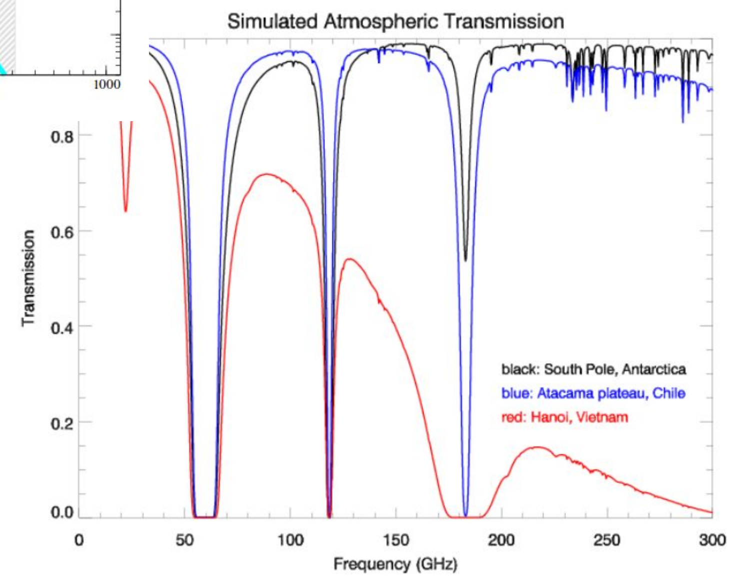
Planck collaboration (2018)

Ground based observations

Planck collaboration (2018)



JM Kovac
(Proceedings of the
6th Rencontres du Vietnam 2006)

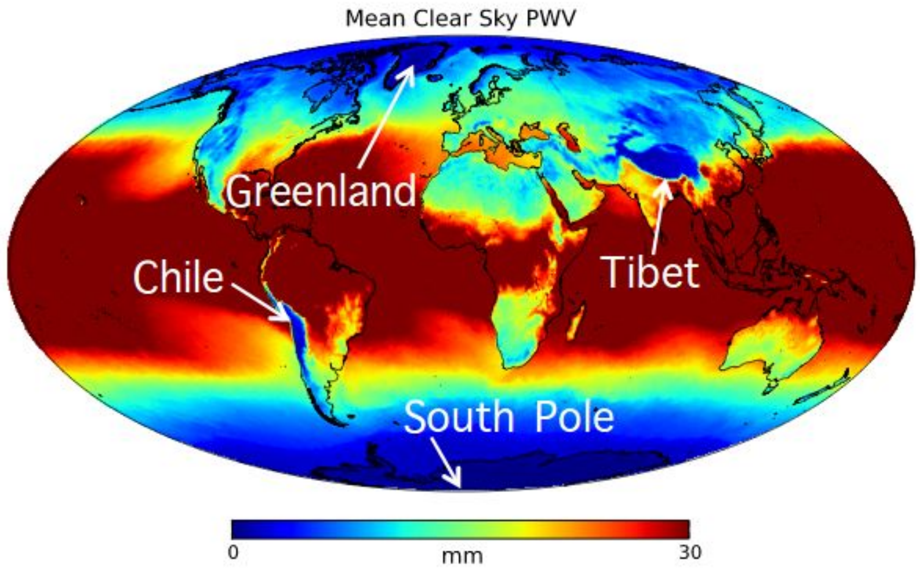


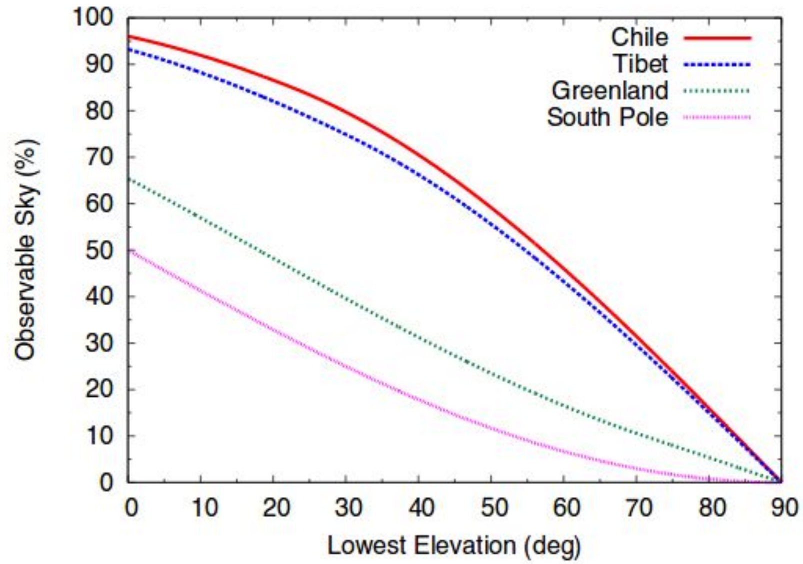
Trade-off between:

- signal
- foregrounds
- atmosphere transmission

Atacama Desert

Barron et al. (2018)





Great PWV conditions and high fraction of available sky


PERU
BO
Arica
Iquique
Atacama Desert
Antofagasta
Chañaral
Coquimbo
Valparaíso
SANTIAG
San Antonio
Rancagua
an
ARG
oncepción
Talcahuano
Lebu
Temuco

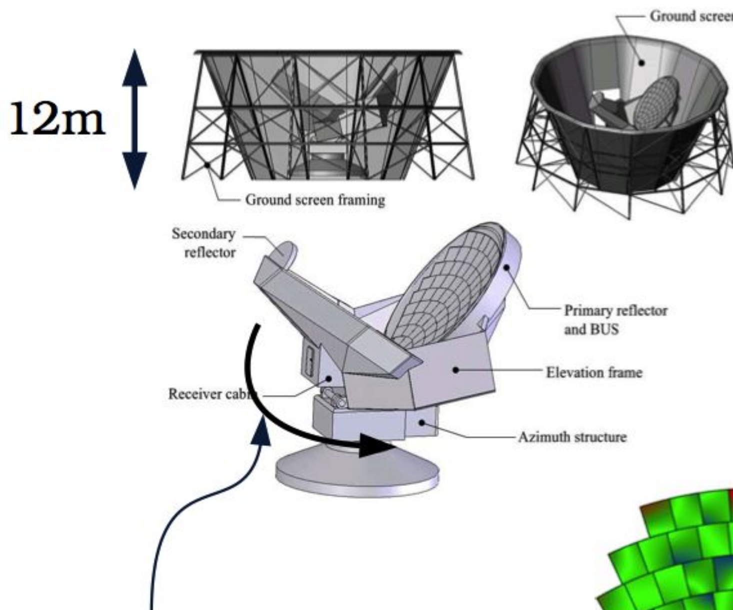

PERU
Arica
Iquique
Atacama Desert
Antofagasta
Chañaral
Coquimbo
Valparaíso
San Antonio
Rancagua
Talcahuano
Lebu
Temuco


Bolivia
Chile
Bolivia
Chile
Bolivia
Chile
Bolivia
Chile
27
ACT
Cerro Toco
ACT
Guayaques
Purico Complex
Atacama Large Millimeter Array...
ALMA
Monjes de La Pacana
Google


POLARBEAR/Simons Array
POLARBEAR
/ Simons Array
ACT
ACT
Cosmology Large
Angular Scale Surveyor
CLASS
Simons Observatory
Simons Observatory (soon)
Google

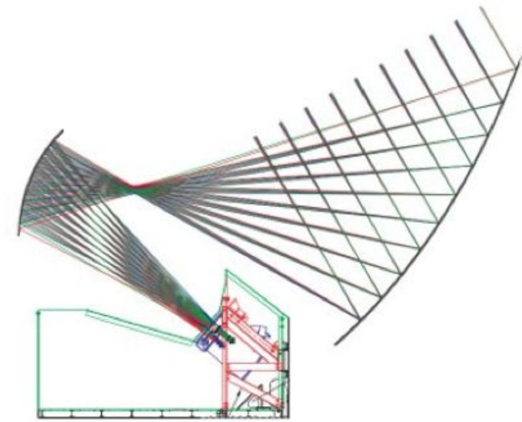
ACT Collaboration

The Atacama Cosmology Telescope

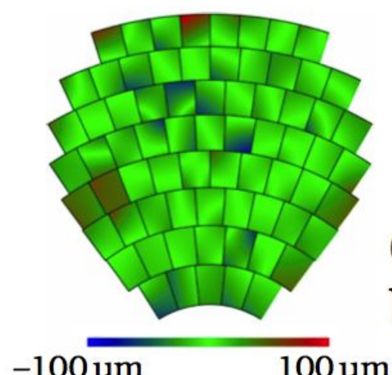


40 tonne azimuth structure rotates at up to 2 deg/s.

Credit: Adam Hincks



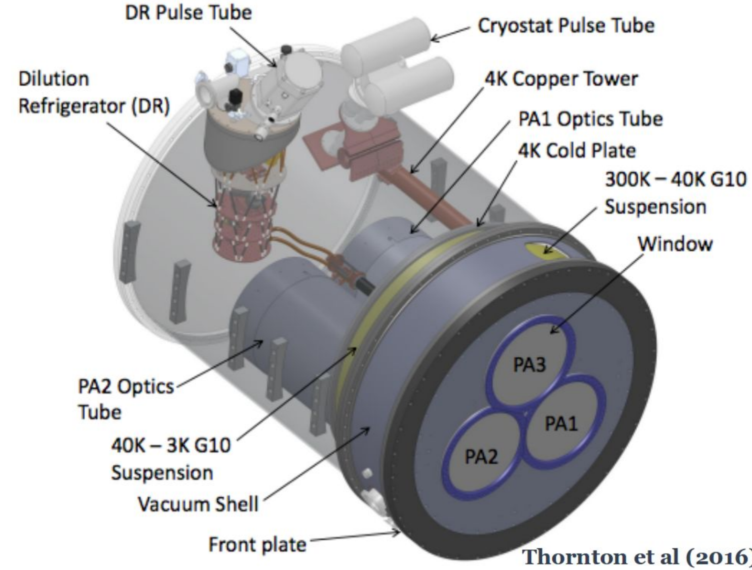
Off-axis, Gregorian telescope.

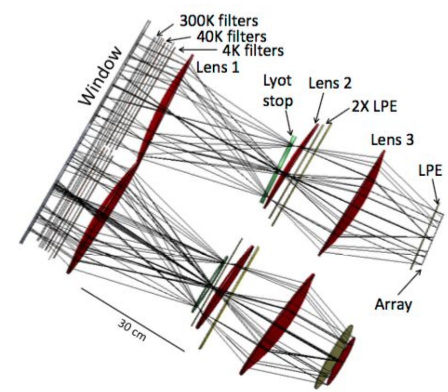


6 m primary → 1.3' beam @ 150 GHz

Thornton et al. (2016)

Cryostat

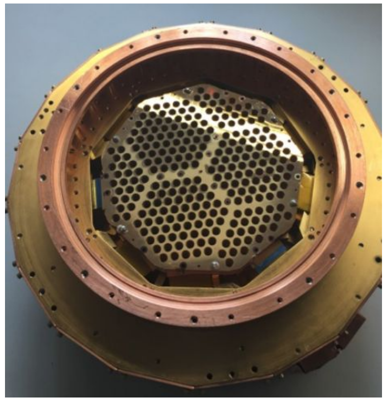


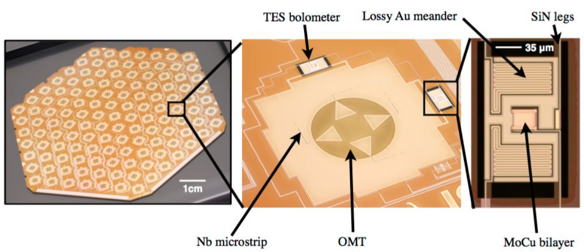


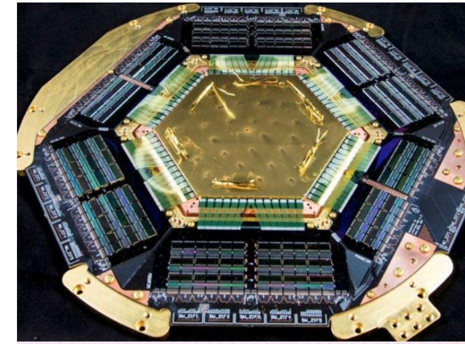
Thornton et al. (2016)

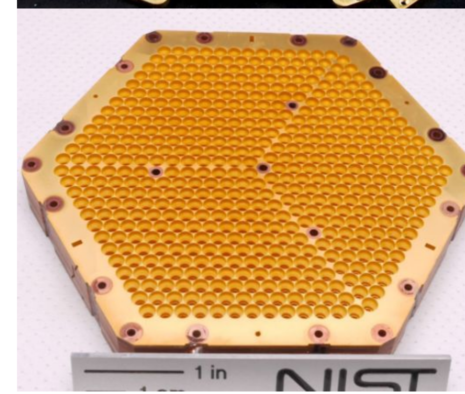
Cameras

ACTPol | **AdvACT**









s13
PA1 - 150GHz

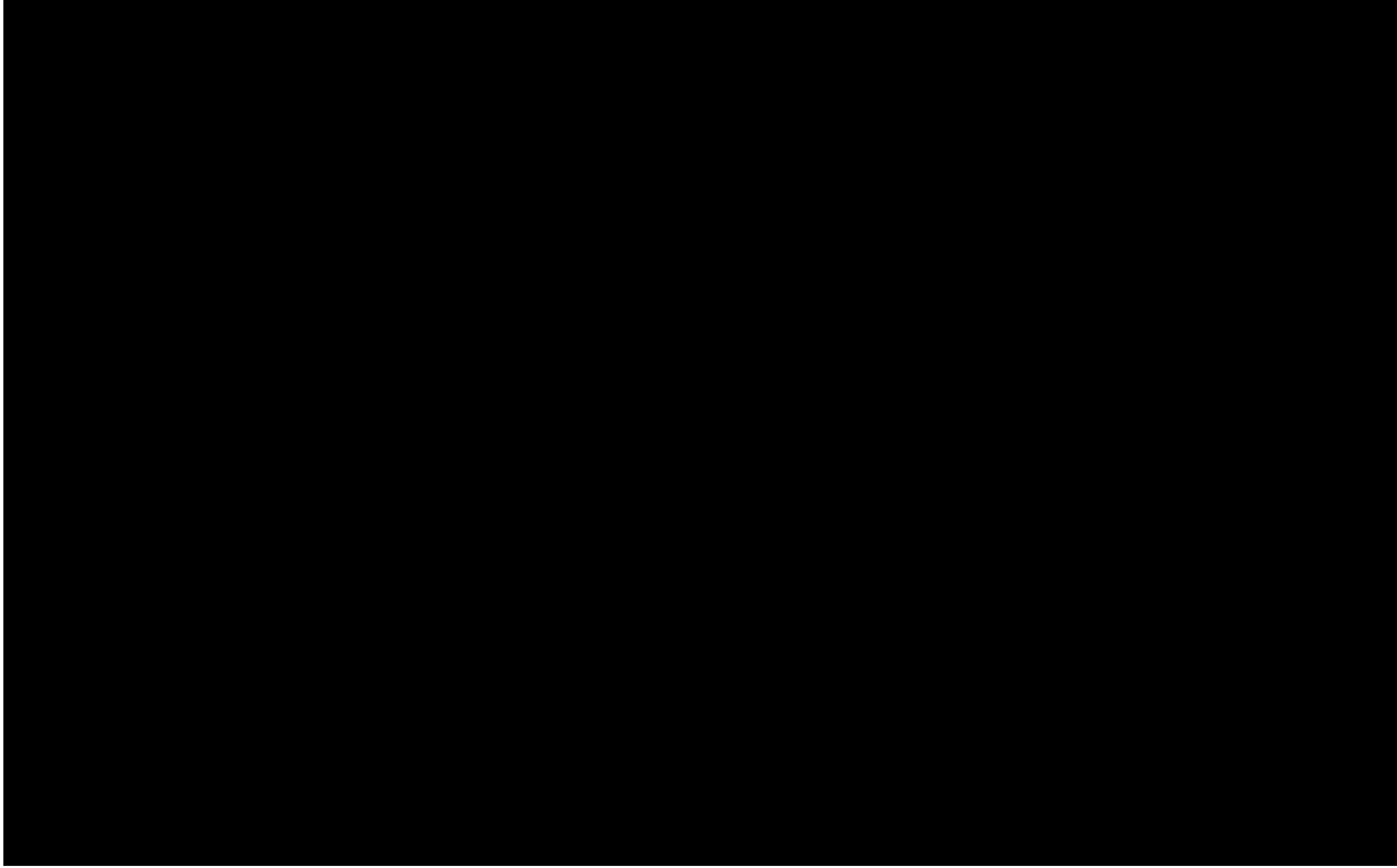
s14
PA1 - 150GHz
PA2 - 150GHz

s15
PA1 - 150GHz
PA2 - 150GHz
PA3 - 90/150GHz

s16
PA2 - 150GHz
PA3 - 90/150GHz
HF - 150/220GHz

s17
MF - 90/150GHz
MF - 90/150GHz
HF - 150/220GHz

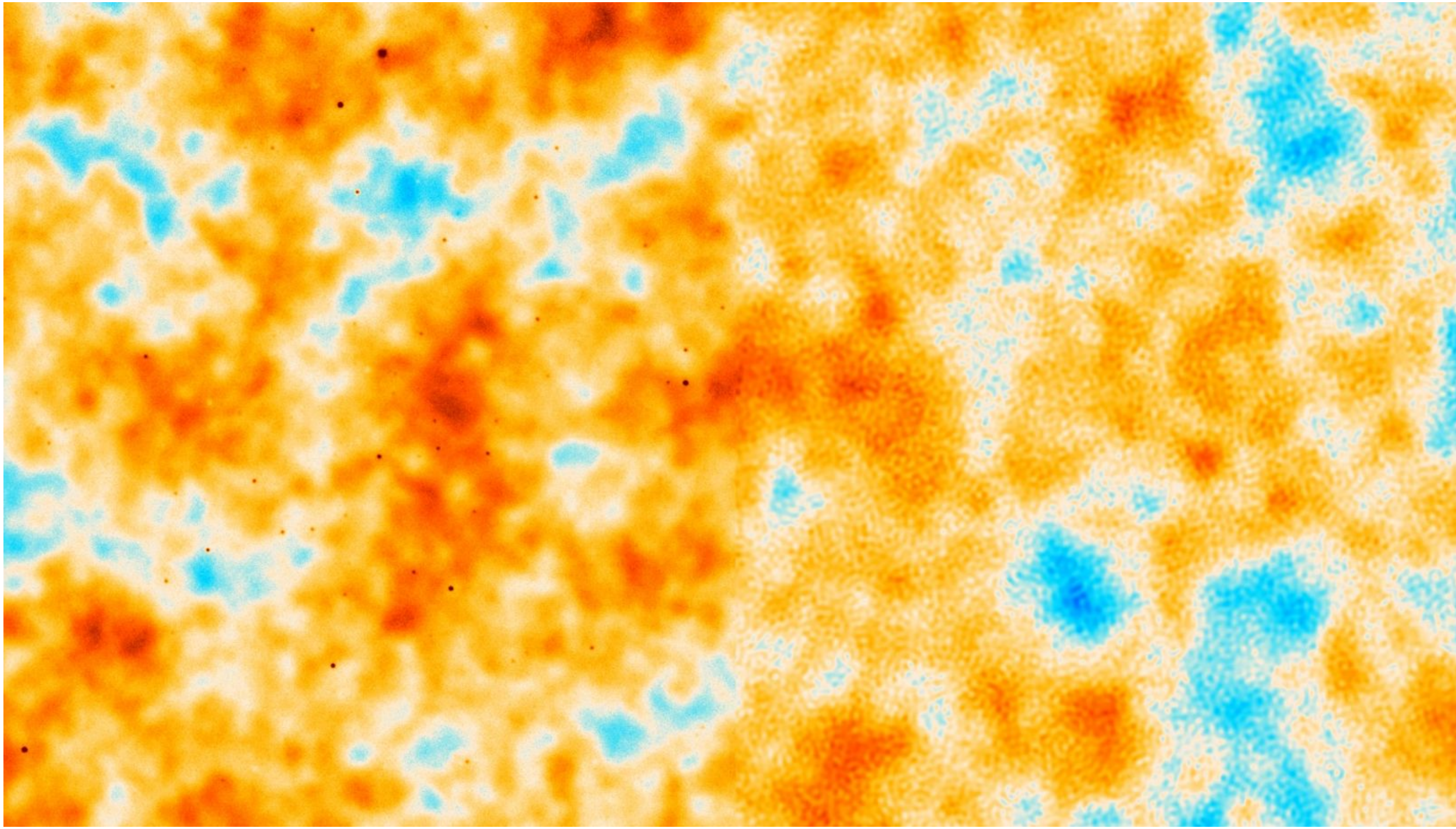
ACTPOL



PLANCK

Credit: Sigurd Naess

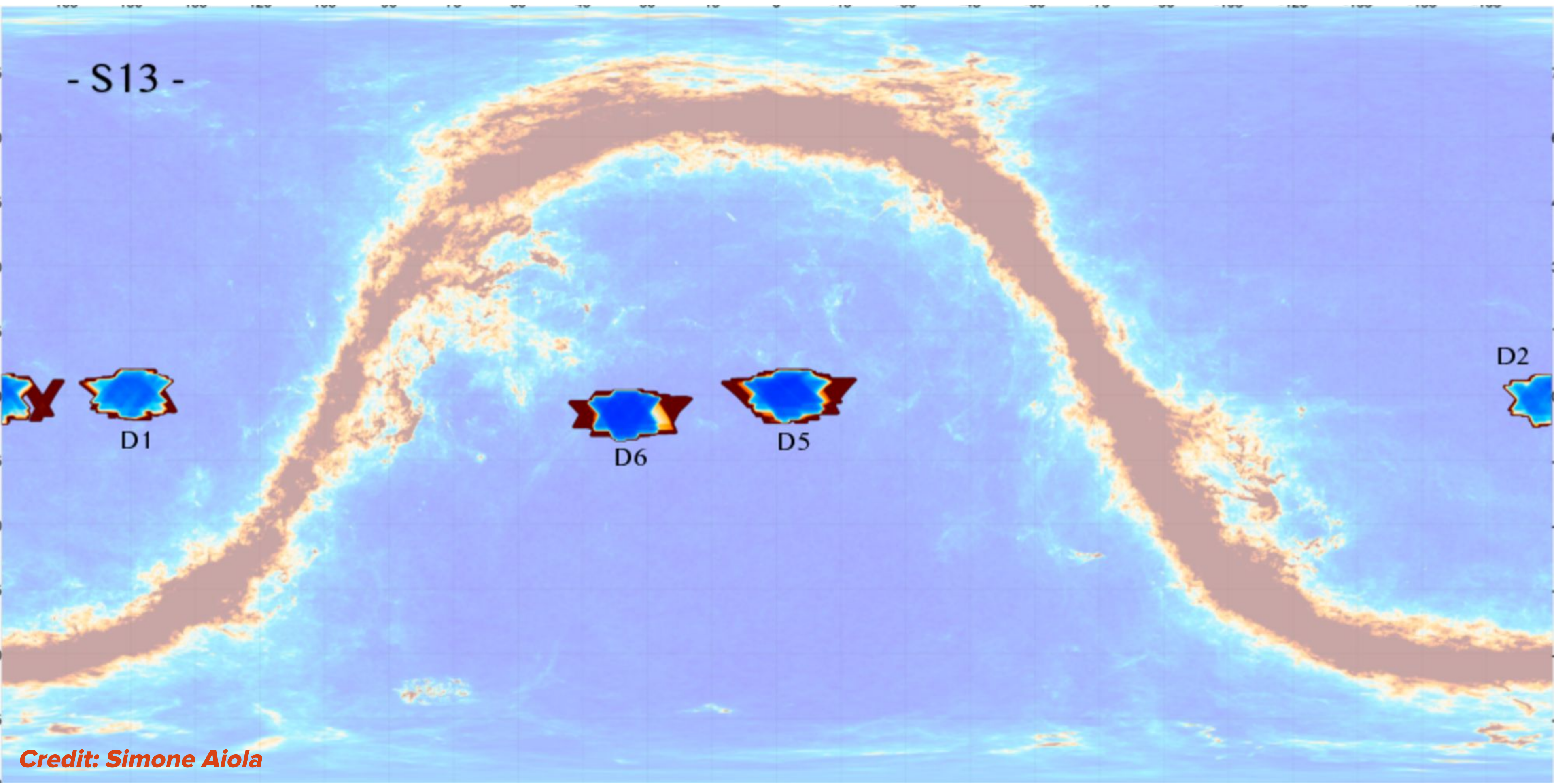
Note that small scale grainy structures in the Planck map comes from Planck noise being smoothed by upscaling to ACT resolution.



Credit: Sigurd Naess

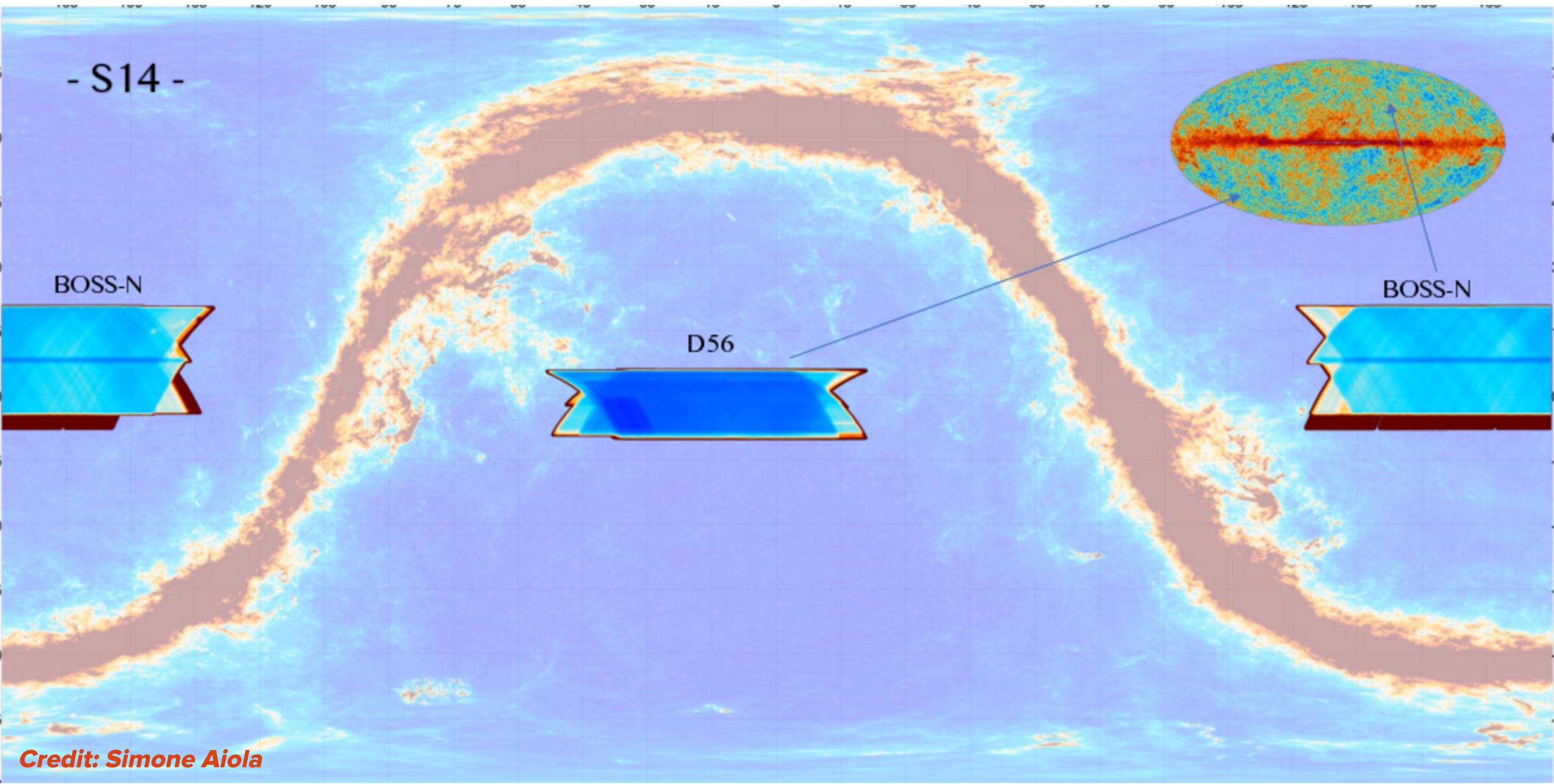
Note that small scale grainy structures in the Planck map comes from Planck noise being smoothed by upscaling to ACT resolution.

Observations (s13) - 150 GHz



Credit: Simone Aiola

Observations (s14) - 150 GHz

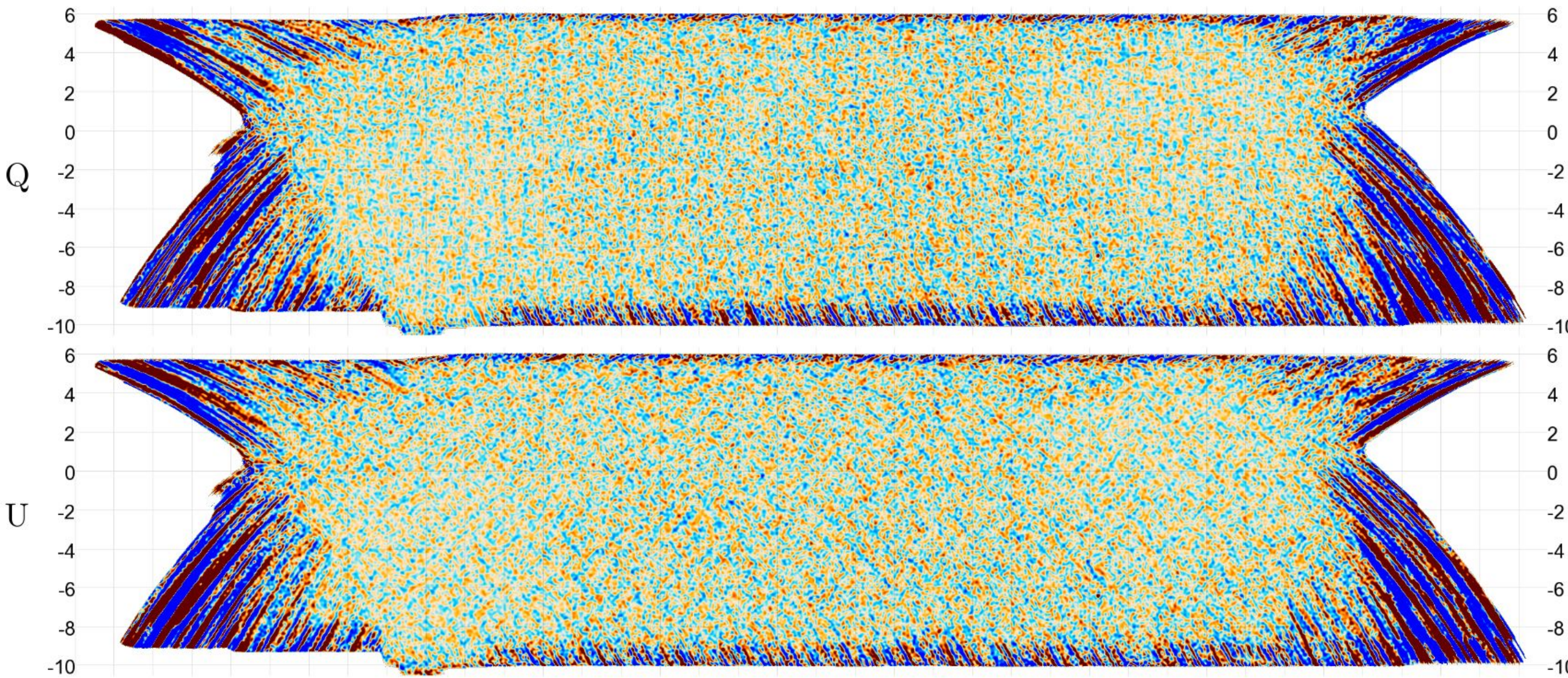


Credit: Simone Aiola

Analysis (s13-s14)

- Naess et al. (2014): PS and parameters
- Louis et al. (2017): PS and parameters
- van Engelen et al. (2015): Lensing from CIB
- Madhavacheril el al. (2015): Lensing by DM Halos
- Scherwin et al. (2017): Lensing PS
- Allison et al. (2015): Radio Galaxy Bias
- Schaan el al. (2016): kSZ ACTPol+BOSS
- de Bernardis et al. (2017): pairwise kSZ ACTPol+BOSS
- Hilton et al. (2018): SZ catalog
- Datta et al. (submitted): Polarized sources
- Coulton et al. (submitted): NG from secondary anisotropies

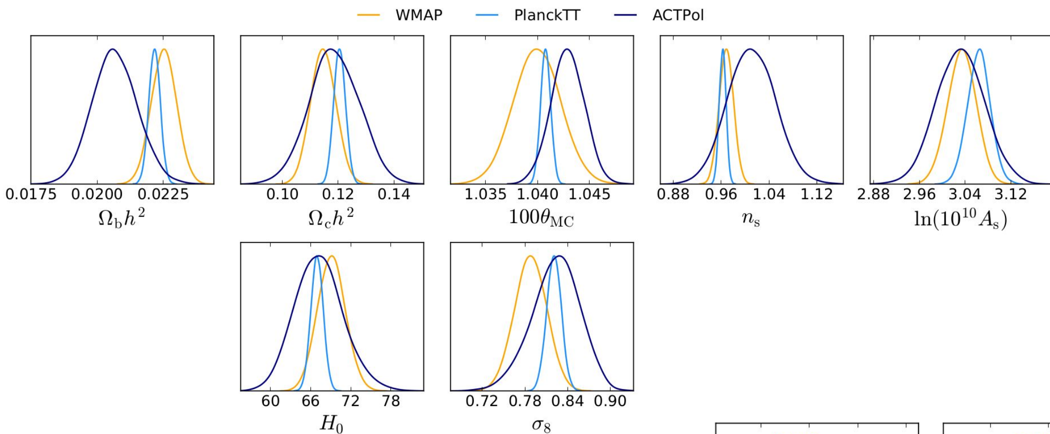
Polarization maps are signal dominated



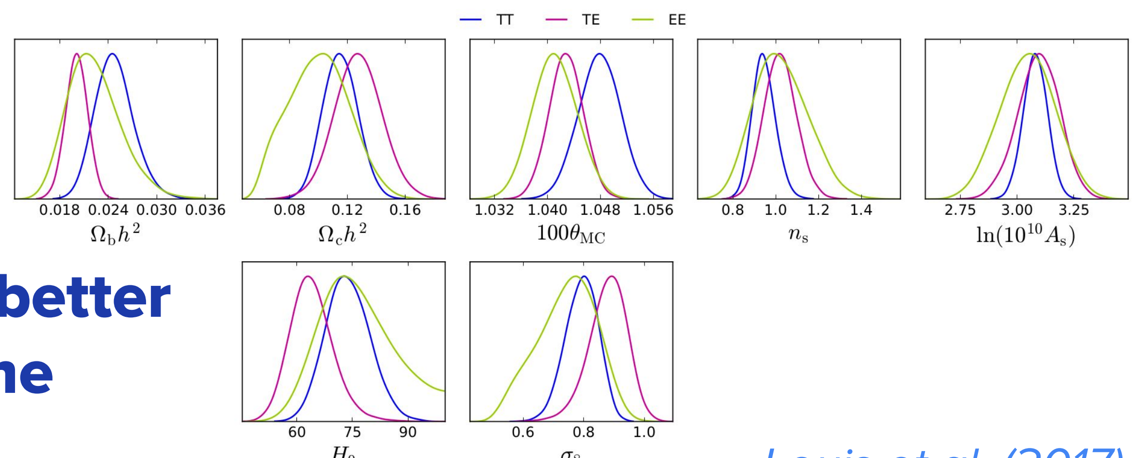
~600 sq-deg (filtered)

Deep56 area
Louis et al. (2017)

Constraining power from polarization



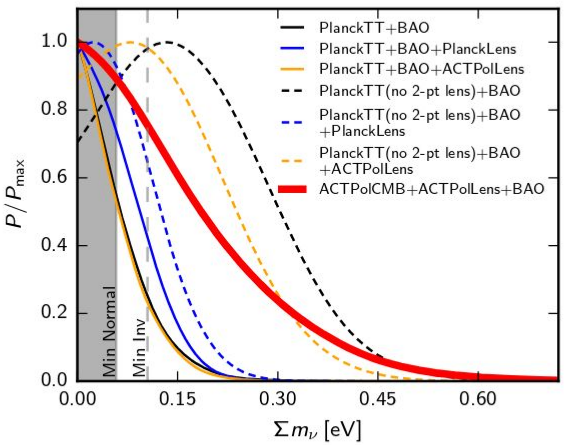
Not competitive alone for lack of large scales



But constraints from TE better than from TT for some parameters

Louis et al. (2017)

Lensing



7

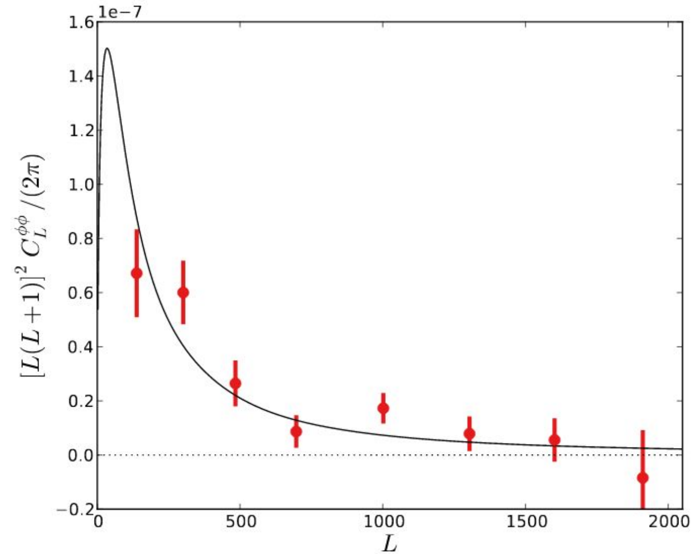
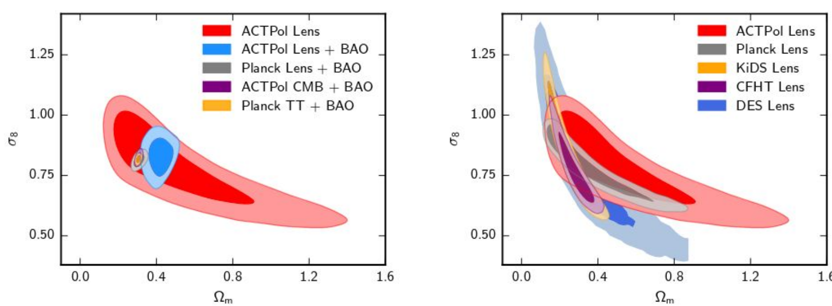


FIG. 2. Combined two-season ACTPol lensing power spectrum, coadded across all patches and estimators. The best-fit theory lensing power spectrum has an amplitude of $A_{\rm lens} = 1.06 \pm 0.15$ (stat.) ± 0.06 (sys.) relative to the *Planck* best-fit ΛCDM cosmology from the *Planck* temperature and polarization power spectra (which we define to have $A_{\rm lens} = 1$). The ACTPol best-fit is indicated with a black solid line, and the error bars just include statistical uncertainty. The χ^2 to the best-fit, scaled *Planck* ΛCDM theory model has a probability to exceed (PTE) of 0.32, suggesting a good fit to the standard ΛCDM cosmology.

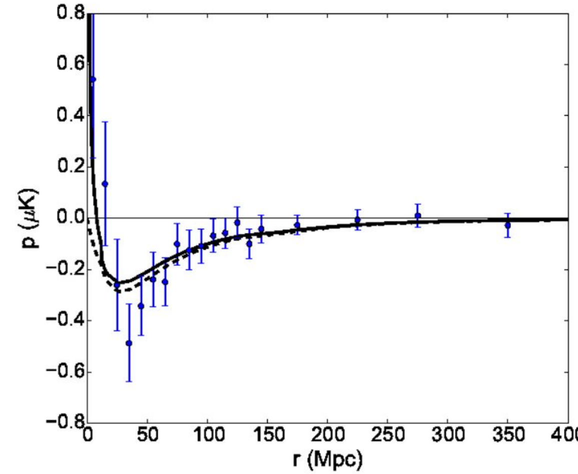


Constraining power on Ω_m, σ_8 and Σm_ν combining with BAO

Sherwin et al. (2017)

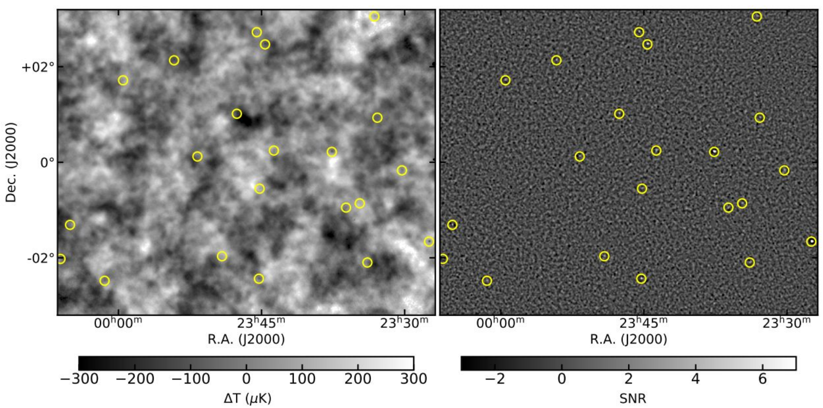
SZ Clusters

Pairwise kSZ (ACTPol+BOSS)



Bernardis et al. (2017)

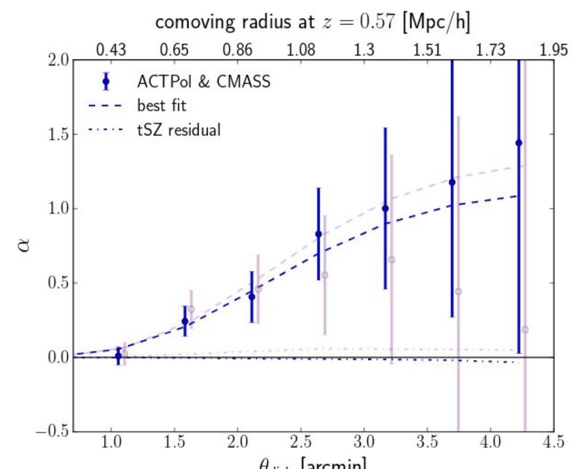
182 SZ clusters catalog + redshifts from follow-up



Hilton et al. (2017)

kSZ (ACTPol+BOSS)

Schaan et al. (2017)



Sources

Polarization for 181 extragalactic sources

Datta et al. (submitted)

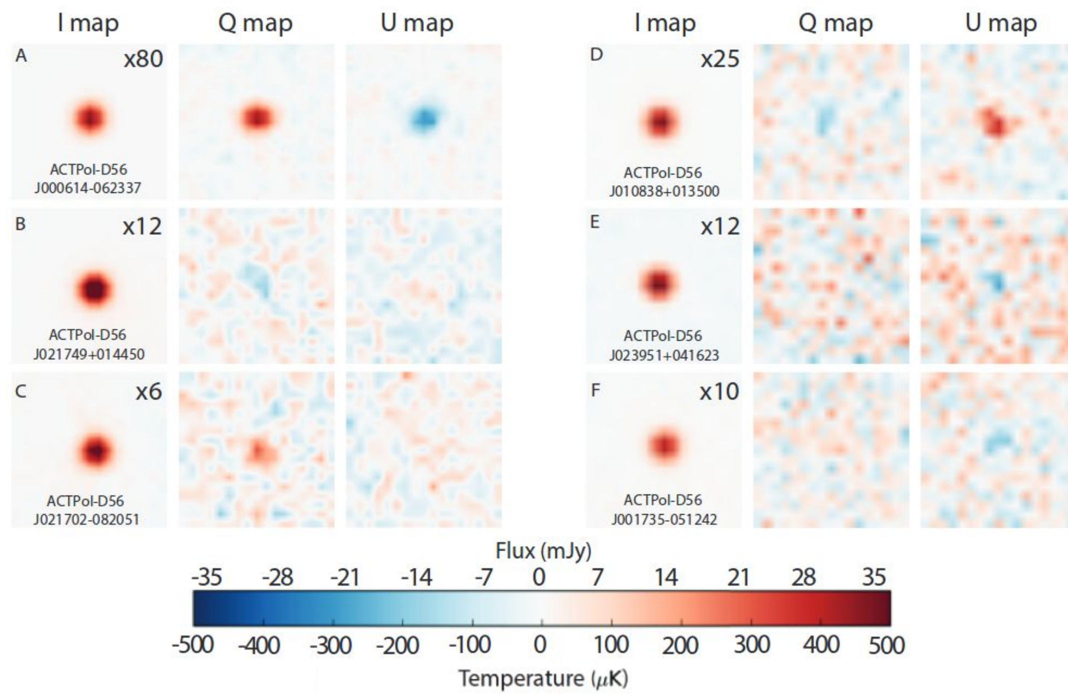


Figure 7. I, Q, and U thumbnails (0.02 deg^2 in area) of six intensity-selected sources that have the strongest signal in polarization. The intensity map temperatures have been scaled down by a factor noted in the top right corner of the I thumbnails so as to keep the color scale same for I, Q, and U. The color scale spans $\pm 500\ \mu$K for all but the brightest source in the top left panel ($\pm 2000\ \mu$K).

Non-Gaussianities from secondary anisotropies

ACTPol (resolution)

+

Planck (multifrequency)

Coulton et al. (submitted)

15

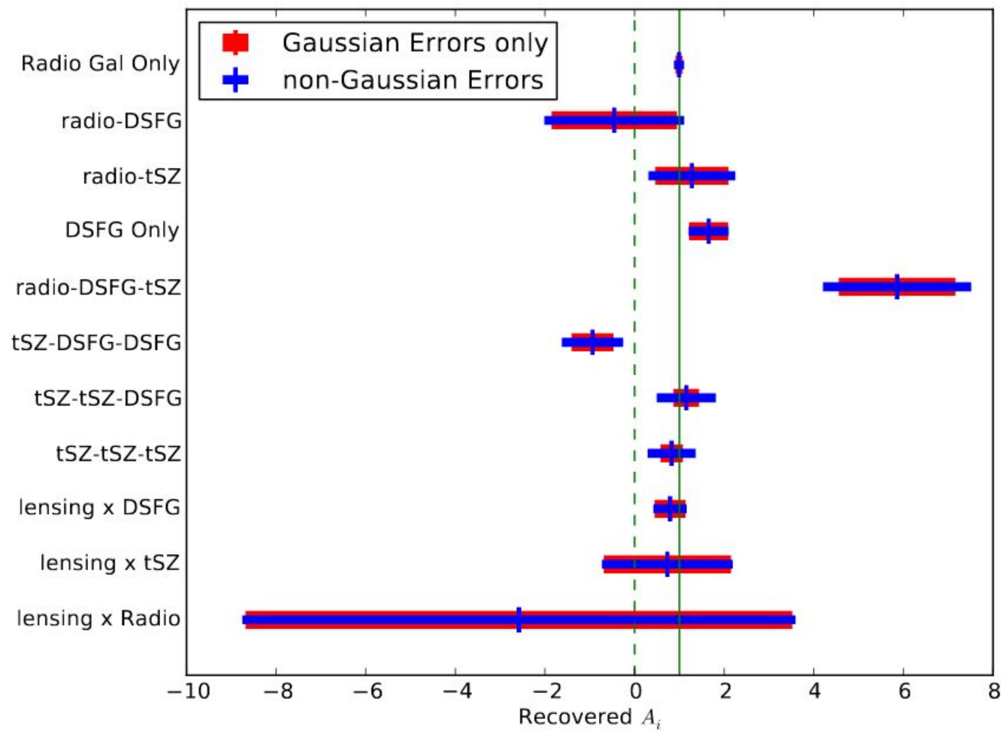


Figure 6. A graphical representation of our joint fit results from tables 1 excluding the lensing-ISW constraint in order to restrict the scales. The solid green line is the values predicted by our model and the dashed green is the null value.

Public data

- Maps
  - s13 + s14
  - I, Q, U, hits, noise, lensing
- Beams
- Spectra
- Likelihood
  - CMB
  - Lensing
- Sources
  - masks
  - SZ catalog

ACTPol Data Products at LAMBDA

Show All Hide All

Two-season data products

Product Download Page	Description	No. Of Files/Size
Maps	These 128 FITS files are the two-year data from ACTPol and are the maps use to the results presented in Louis et al. (2016). More...	128 files, < 148 MB
Lensing Maps	This tarball contains CMB lensing data products from Season 2 of ACTPol observations associated with Sherwin et. al. 2016. More...	1 file, 33.58 GB
Masks	The point source masks are maps, in FITS format, with the same footprint and World Coordinate System as the associated ACTPol 148 GHz map. More...	1 file 148 MB
Beams	These files represent the beam transforms (Fourier space) and radial profiles (real space) for use with the ACTPol two-season data. The beams are described in Louis et al. 2016. More...	1 file, 7.7 MB

Two-season derived data products

Product Download Page	Description	No. Of Files/Size
SZ Cluster Catalog	The file E-D56Clusters.fits is a FITS table that combines the information from Tables A1-A3 in the ACTPol two-season cluster catalog paper. More...	1 file, 75 KB
Lensing Likelihood	This tarball contains the ACTPol lensing power spectrum likelihood More...	1 file 2.8 MB
CMB Likelihood	This is the software used by the ACTPol collaboration to compute the likelihood of cosmological models More...	1 file 15.8 MB
Total Spectra	The ACTPol EE, TT and TE power spectra More...	1 file 15.9 MB
CMB Spectra	The ACTPol TT, EE and TE CMB-only power spectra More...	1 file 4 KB

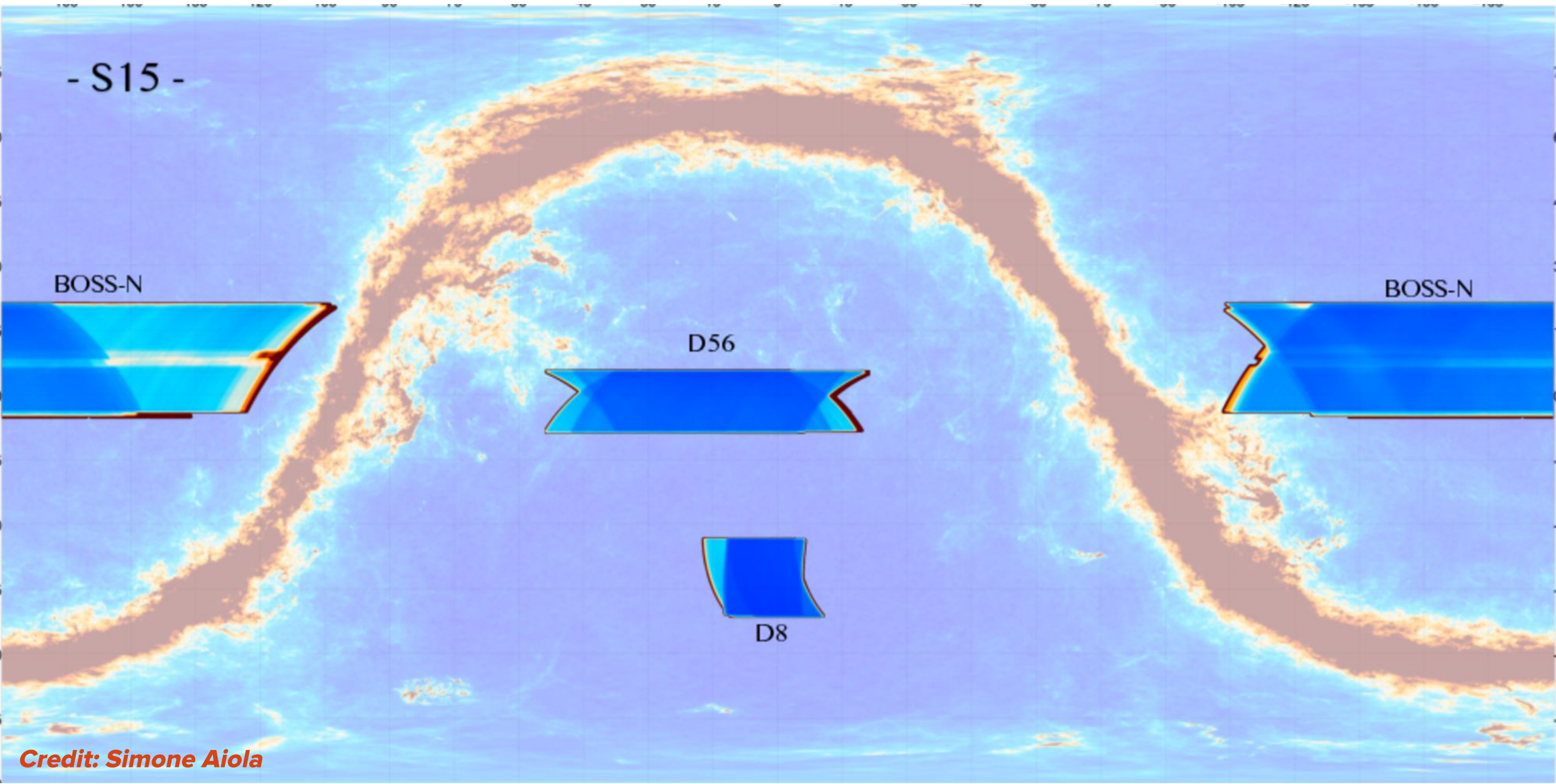
ACTPol Data Products

Product Download Page	Description	No. Of Files/Size
2014 Bandpowers	TT, TE, EE, BB, TB, and EB bandpowers from the first 3 months of ACTPol observations. More...	1 files, 8 KB
2014 Likelihood	Likelihood for TT, TE and EE bandpowers from the first 3 months of ACTPol observations. More...	1 file, 11.6 MB

Show All Hide All

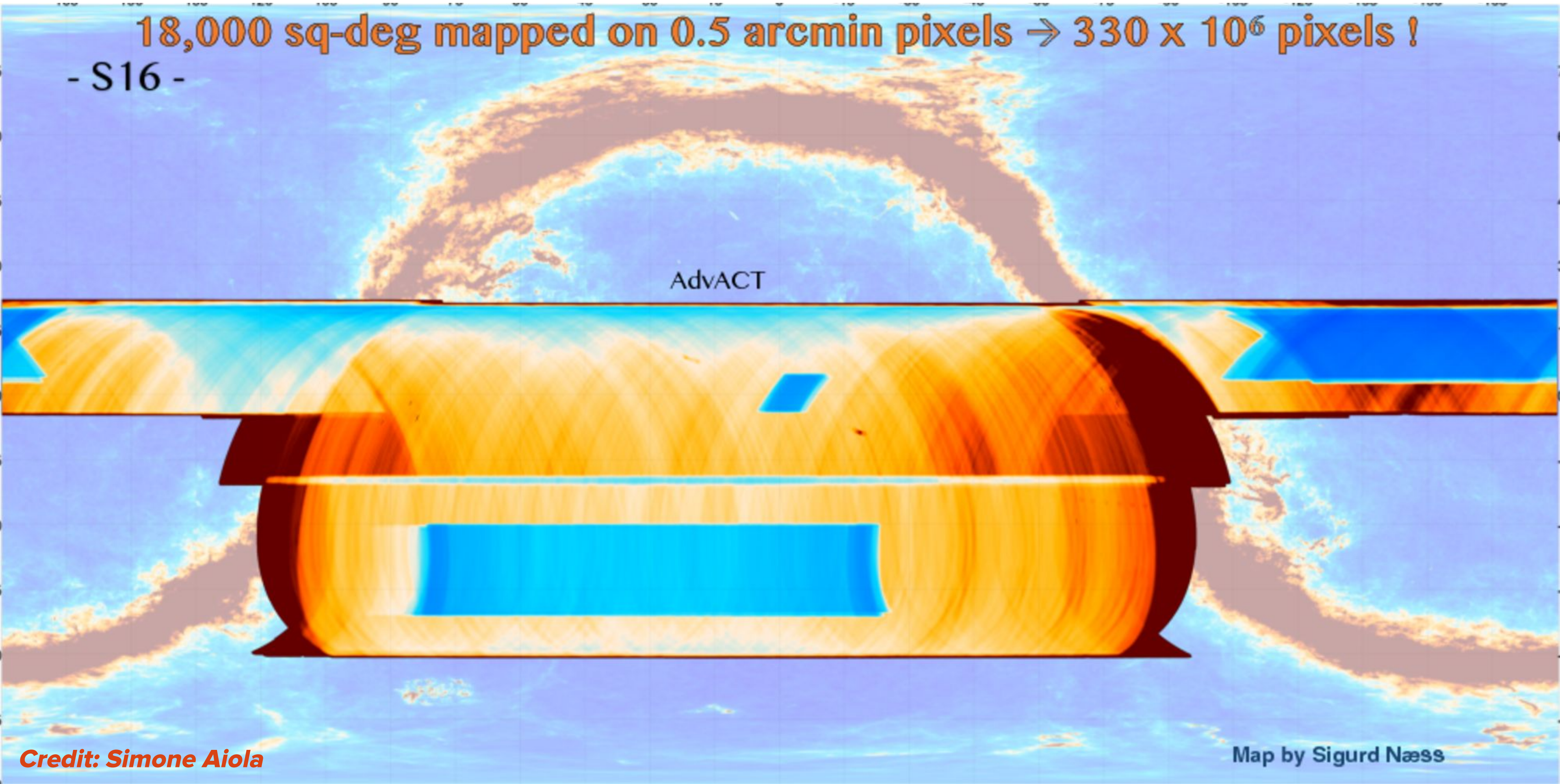
https://lambda.gsfc.nasa.gov/product/act/actpol_prod_table.cfm

Observations (s15) - 90/150 GHz



Credit: Simone Aiola

Observations (s16) - 90/150/220 GHz



Credit: Simone Aiola

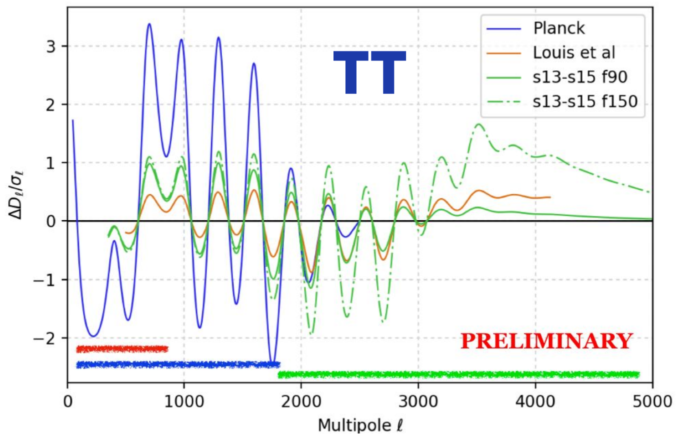
Analysis (s13-s16)

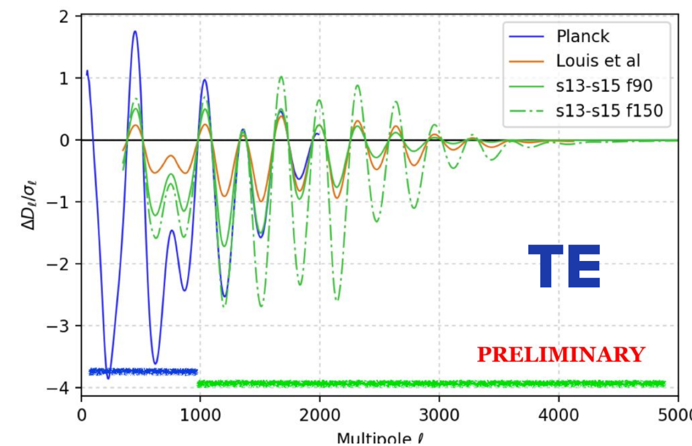
- More data
  - 20% more detectors for s13 and s14
  - s15
  - s16 (pa2 and pa3 only - no 220 GHz!)
- Improved noise model in the pipeline
- 90 GHz
  - consistency check with 150 GHz
  - better at large scale (atmosphere)

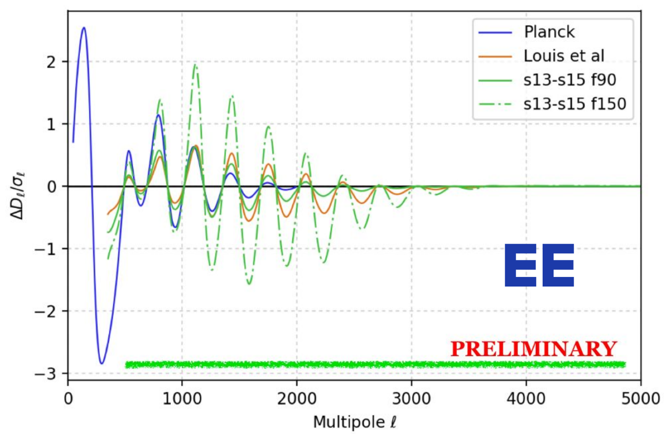
Aiola et al. (in prep)

Choi et al. (in prep)

Preliminary results: constraining power



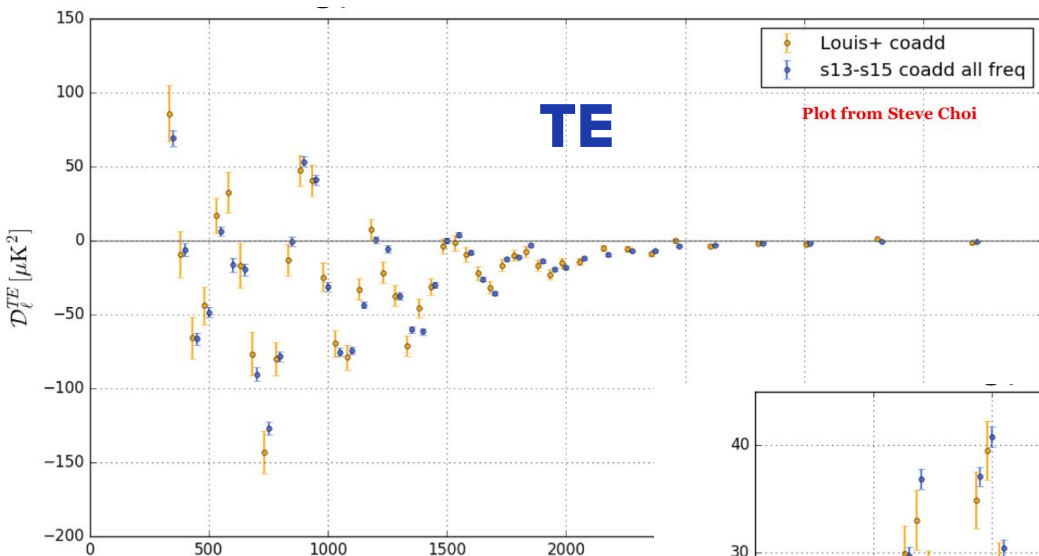




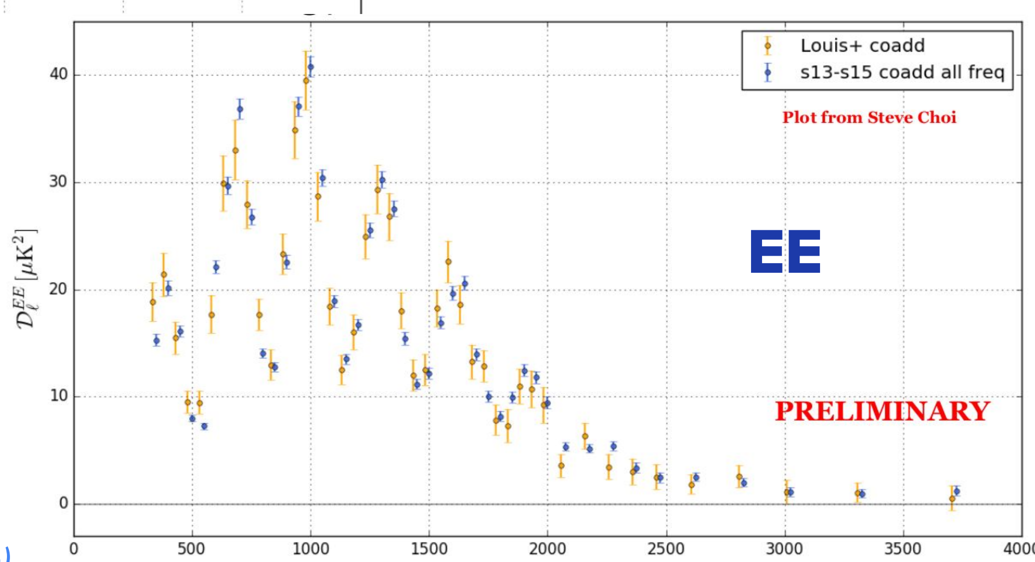
Figures from Simone Aiola

Aiola et al. (in prep) and Choi et al. (in prep)

Preliminary results: Power Spectrum

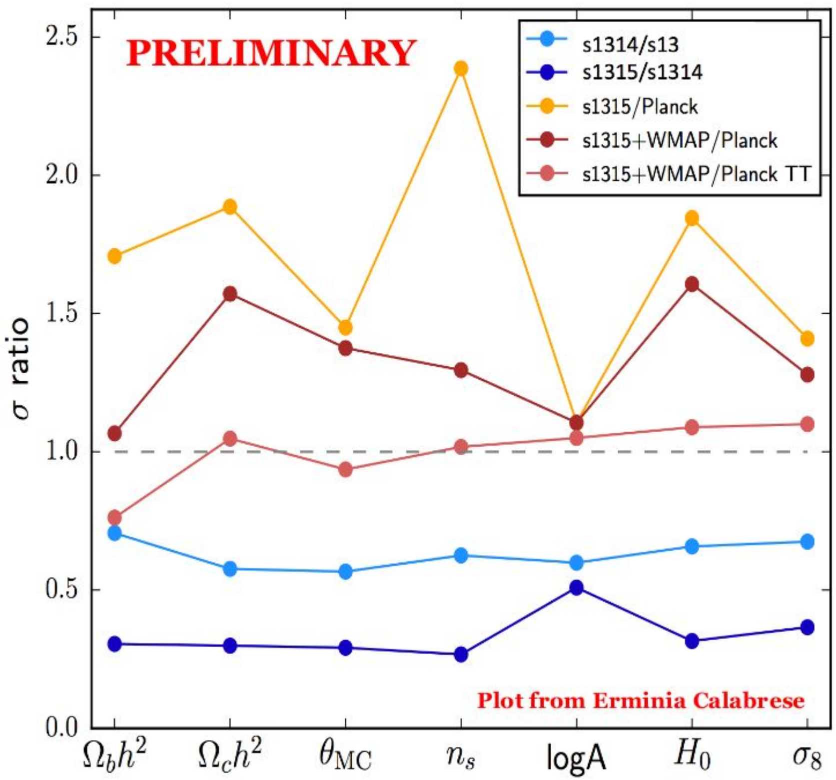


Figures from Steve Choi

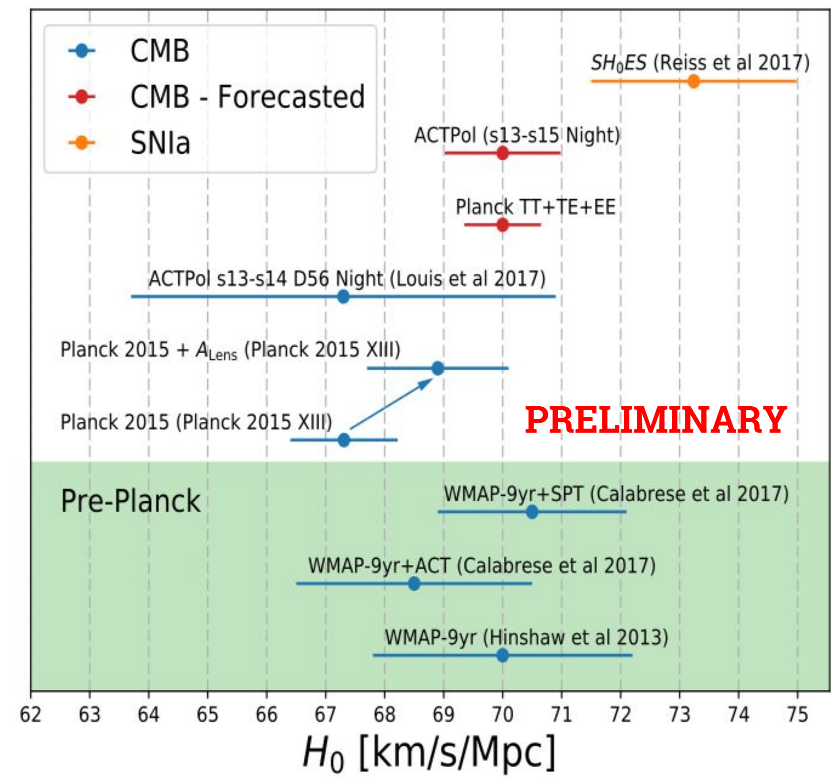


Aiola et al. (in prep) and Choi et al. (in prep)

Preliminary results: constraining power



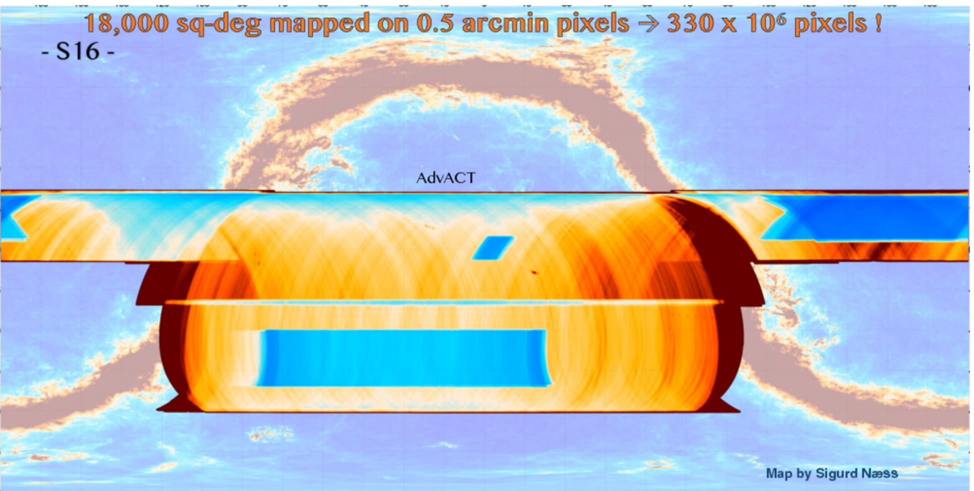
Figures from Erminia Calabrese, Steve Choi and Simone Aiola

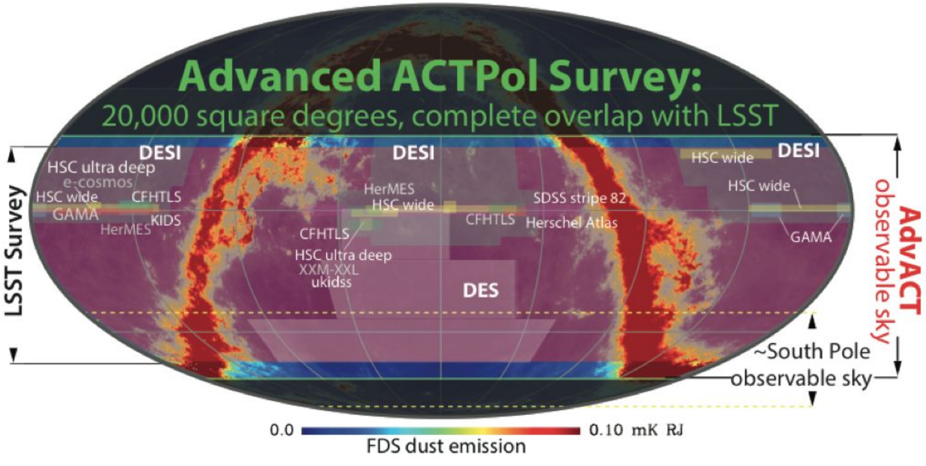


Aiola et al. (in prep) and Choi et al. (in prep)

Coming next:
Multi-frequency on 40% of the sky

s16	s17	s18	s19
PA2 - 150GHz	MF - 90/150GHz	MF - 90/150GHz	LF - 28/41GHz
PA3 - 90/150GHz	MF - 90/150GHz	MF - 90/150GHz	MF - 90/150GHz
HF - 150/220GHz	HF - 150/220GHz	HF - 150/220GHz	HF - 150/220GHz






Thank you!