



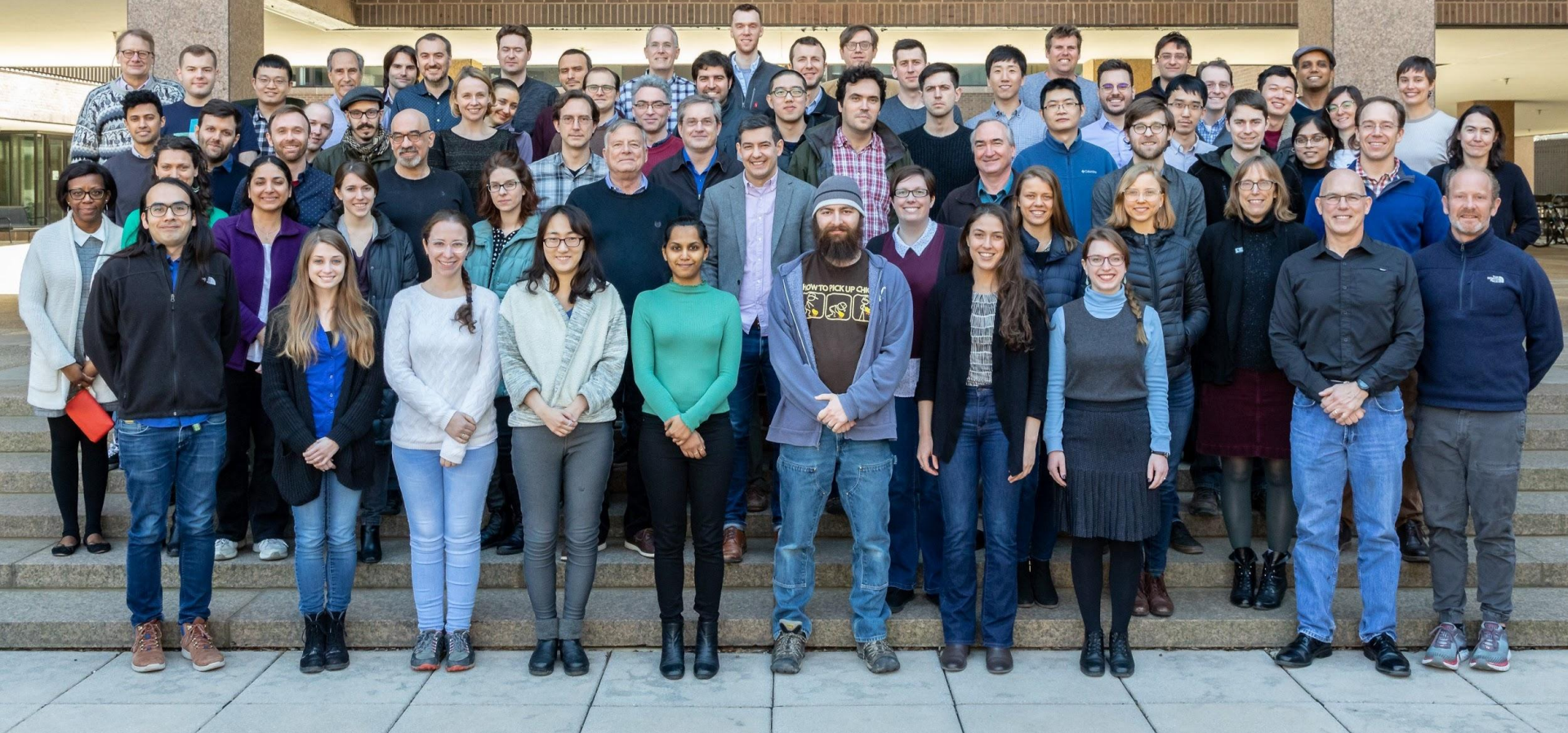
# Cosmological Parameters from ACT DR4 CMB Power Spectra

Simone Aiola (CCA)  
for the ACT Collaboration

August 14th 2020 – [act.princeton.edu](http://act.princeton.edu)

Follow us on Twitter @ACT\_PoI

# ACT Collaboration



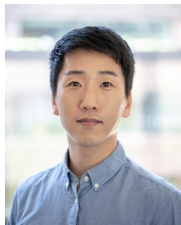
# ACT DR4 Papers

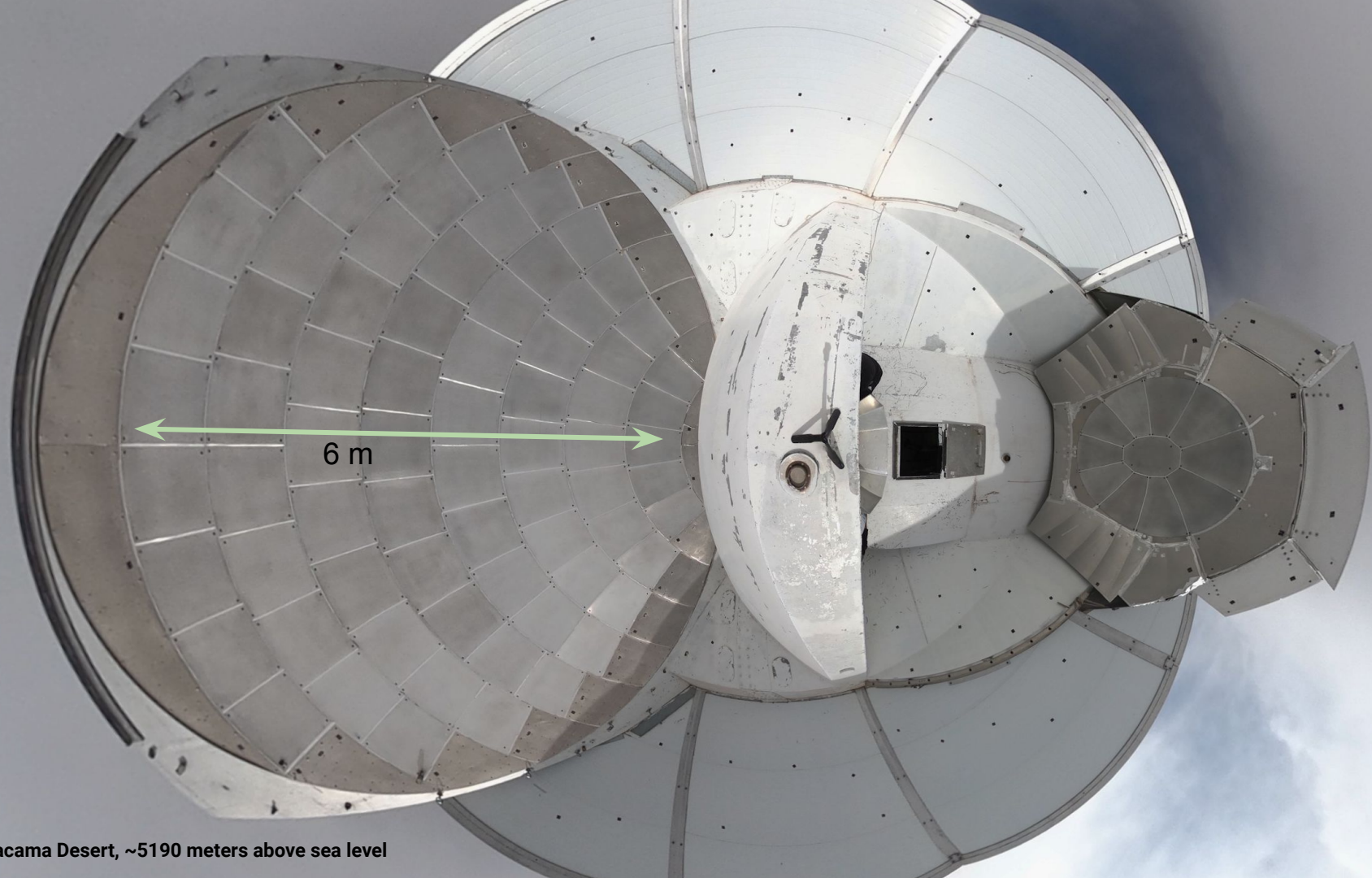
Material in these slides is presented in two connected papers

- Aiola, Calabrese, Maurin, Naess, Schmitt + **ACT** (arXiv: 2007.07288)



- Choi, Hasselfield, Ho, Koopman, Lungu + **ACT** (arXiv: 2007.07289)



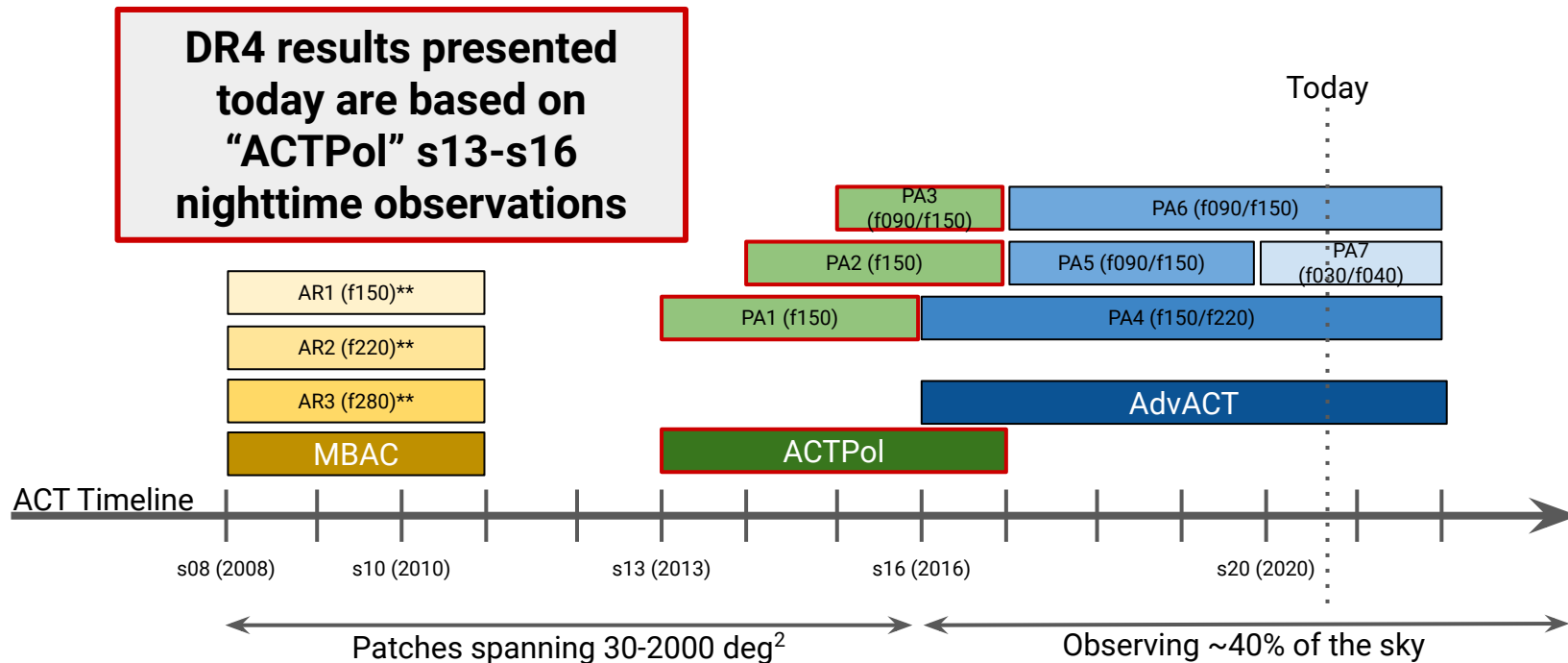


6 m

Atacama Desert, ~5190 meters above sea level

# ACT Datasets

A brief overview of past, current, and future ACT datasets



\*timeline is just indicative, observations do not start on Jan

\*\*no polarization

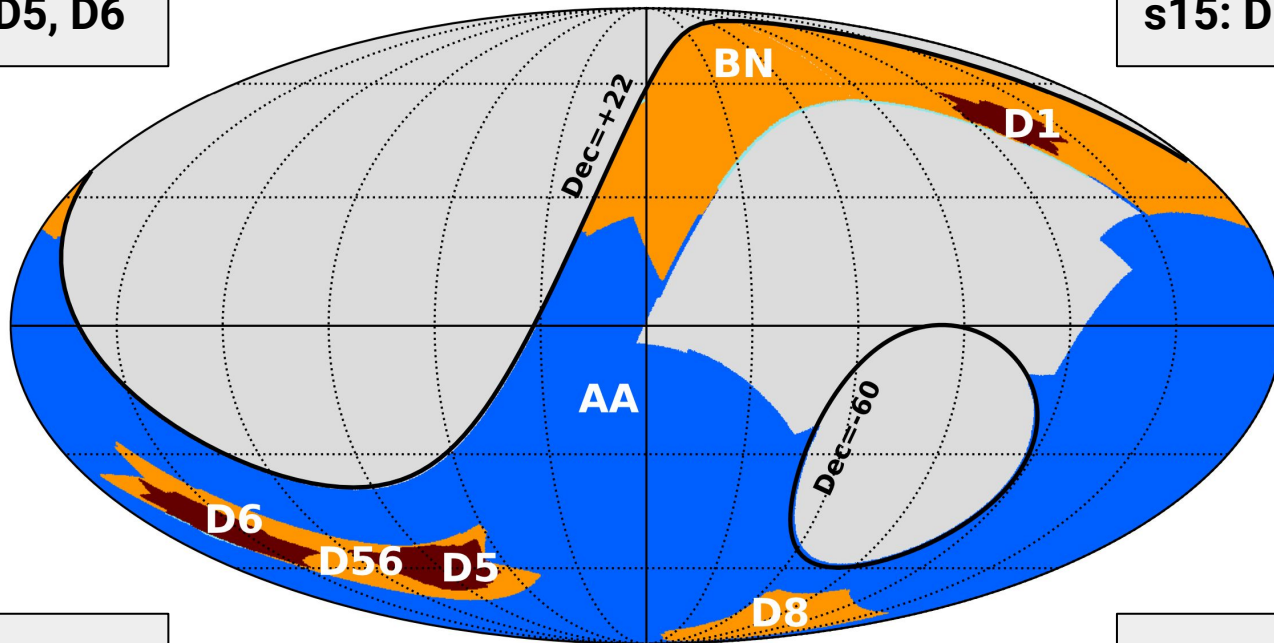
[SO and CMB-S4 baseline mode for Large-aperture telescopes in Chile]

# ACT DR4 Survey

A variety of patches were observed over the course of multiple seasons:

s13: D5, D5, D6

s15: D56, BN, D8



s14: D56

Layered “wedding cake” survey

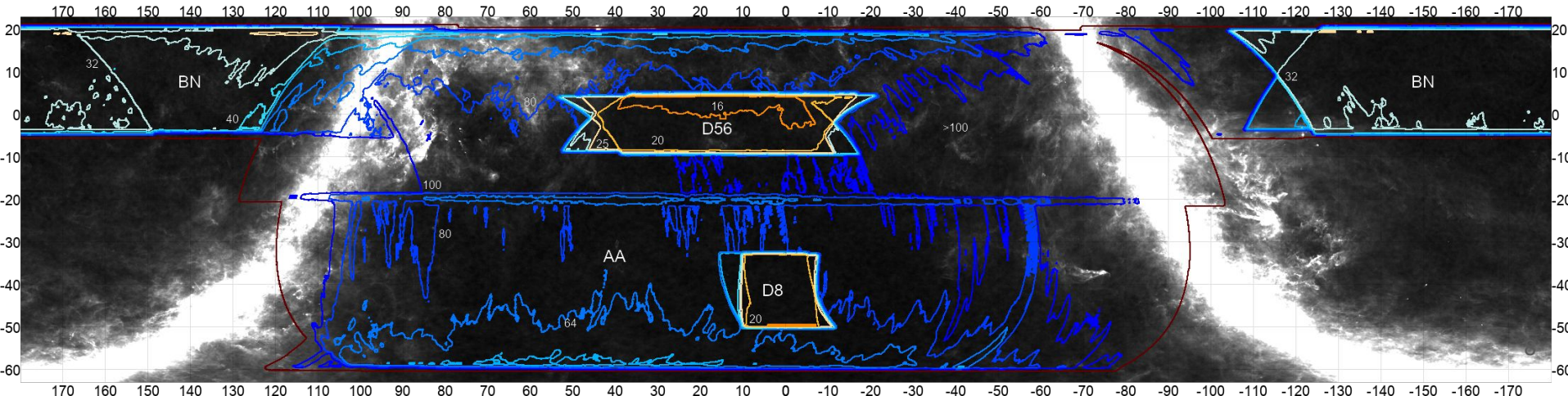
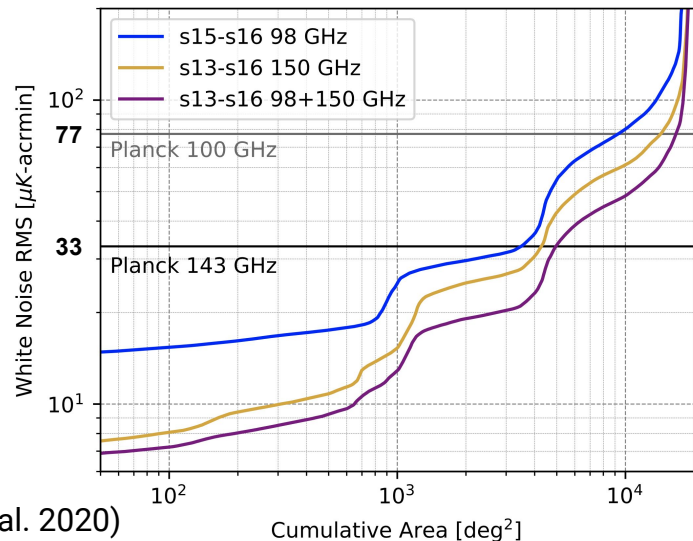
s16: AA

# ACT DR4 Survey

Total map-depth varies across the sky:

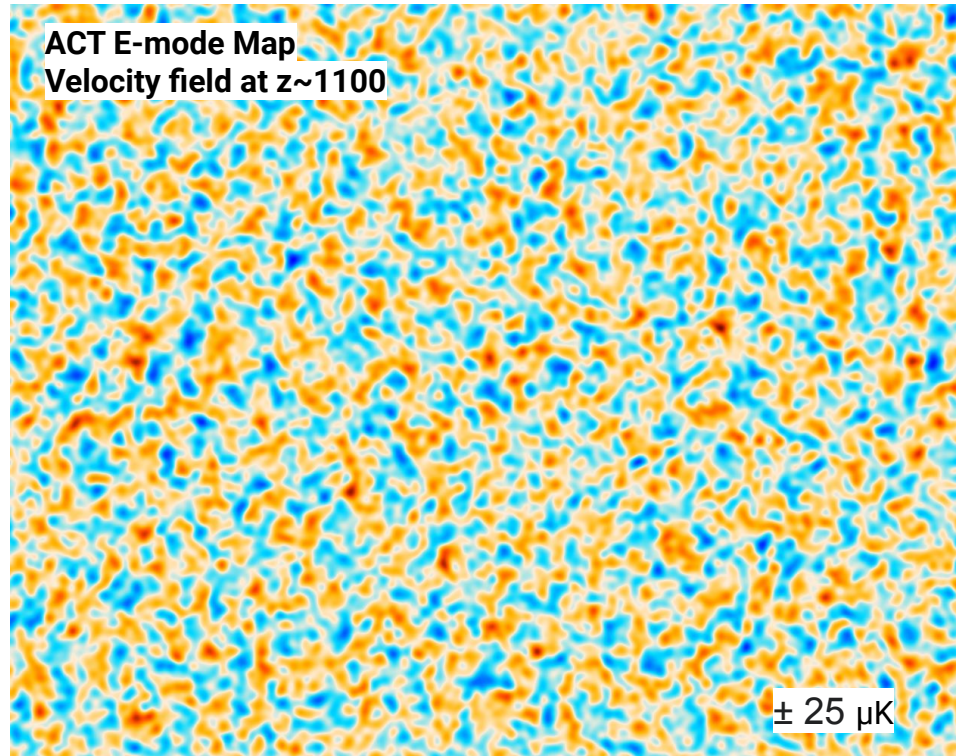
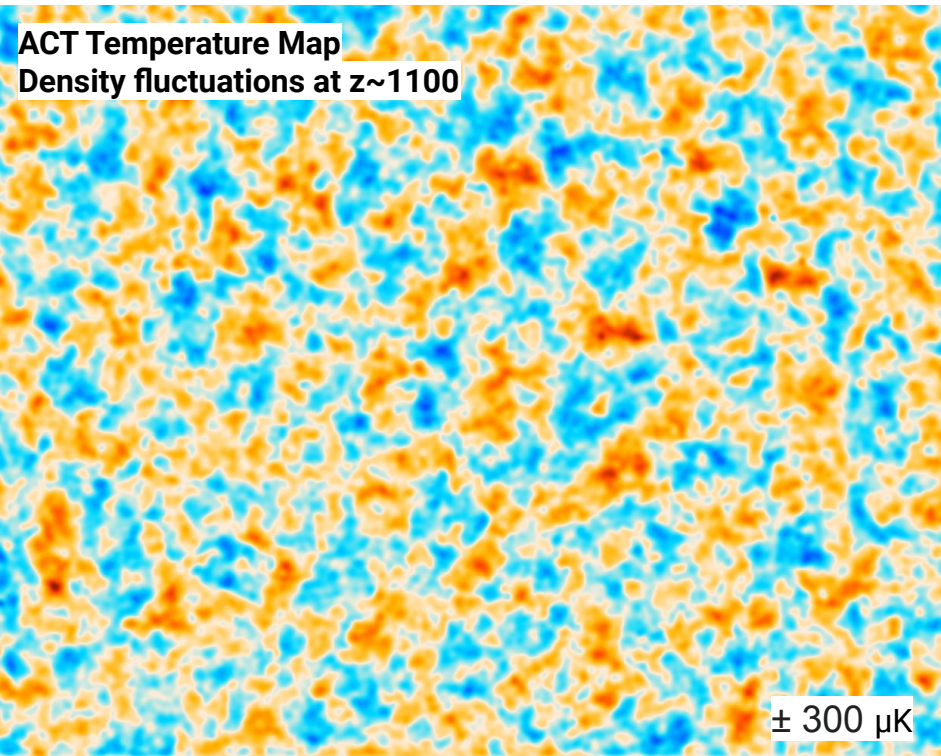
- At 150 GHz:  $\sim 4,000 \text{ deg}^2$  with noise < Planck's 143 GHz full-sky
- At 98 GHz:  $\sim 9,000 \text{ deg}^2$  with noise < Planck's 100 GHz full-sky
- 98 + 150 GHz:  $\sim 600 \text{ deg}^2$  with noise <  $10 \mu\text{K-arcmin}$

$\sim 2500 \text{ deg}^2$  when adding AdvACT data (Naess et al. 2020)



# ACT DR4 Measurement

Wiener filtered 150 GHz maps

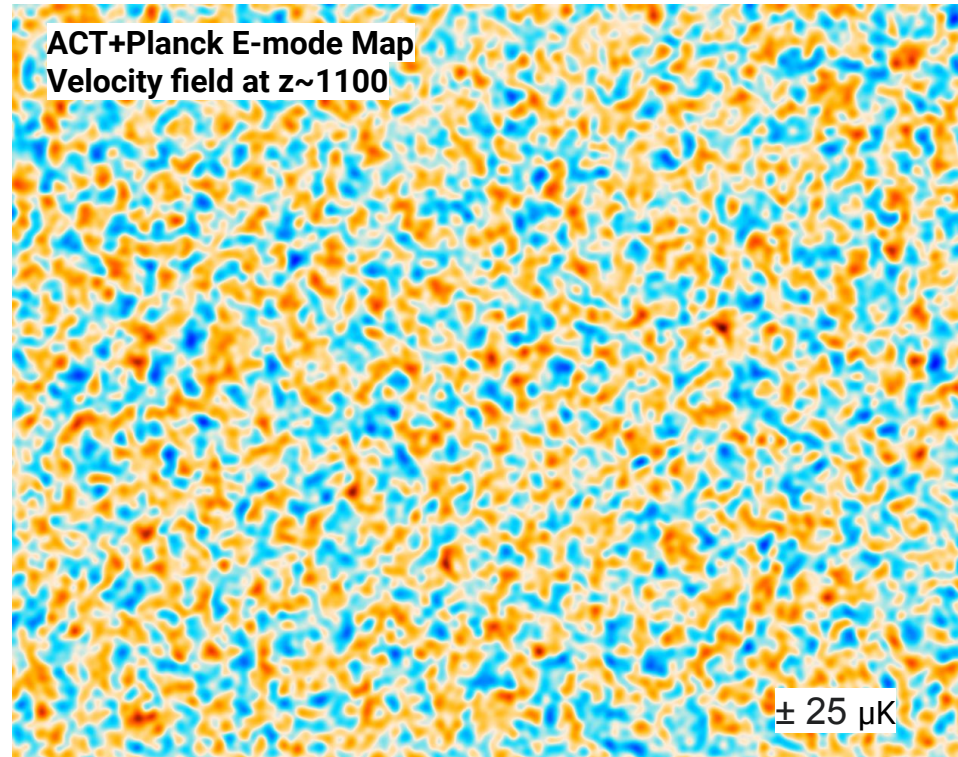
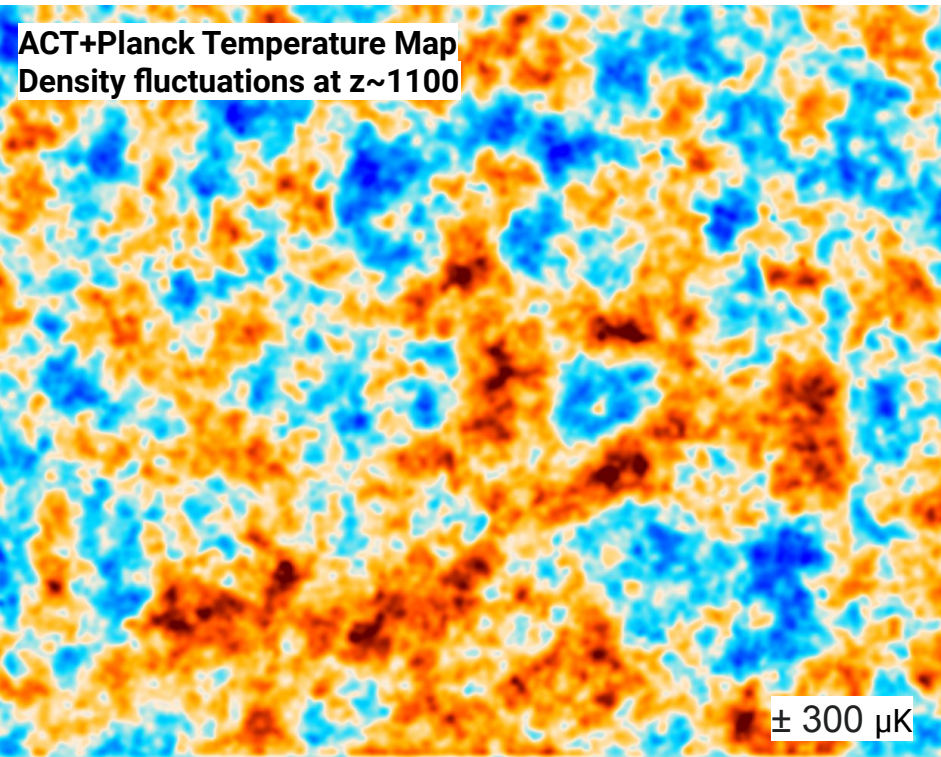


\*Only showing 150 deg<sup>2</sup>



# ACT DR4 Measurement

Wiener filtered 150 GHz maps

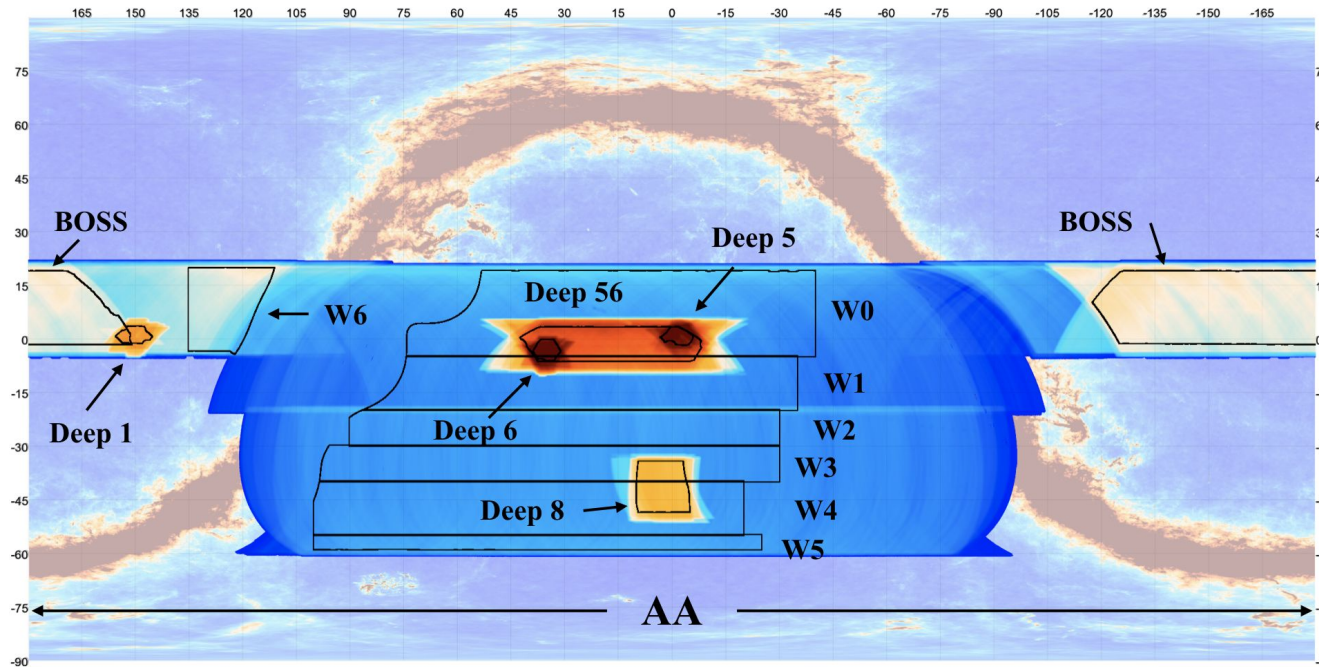


\*Only showing 150 deg<sup>2</sup>

# Regions for power spectra

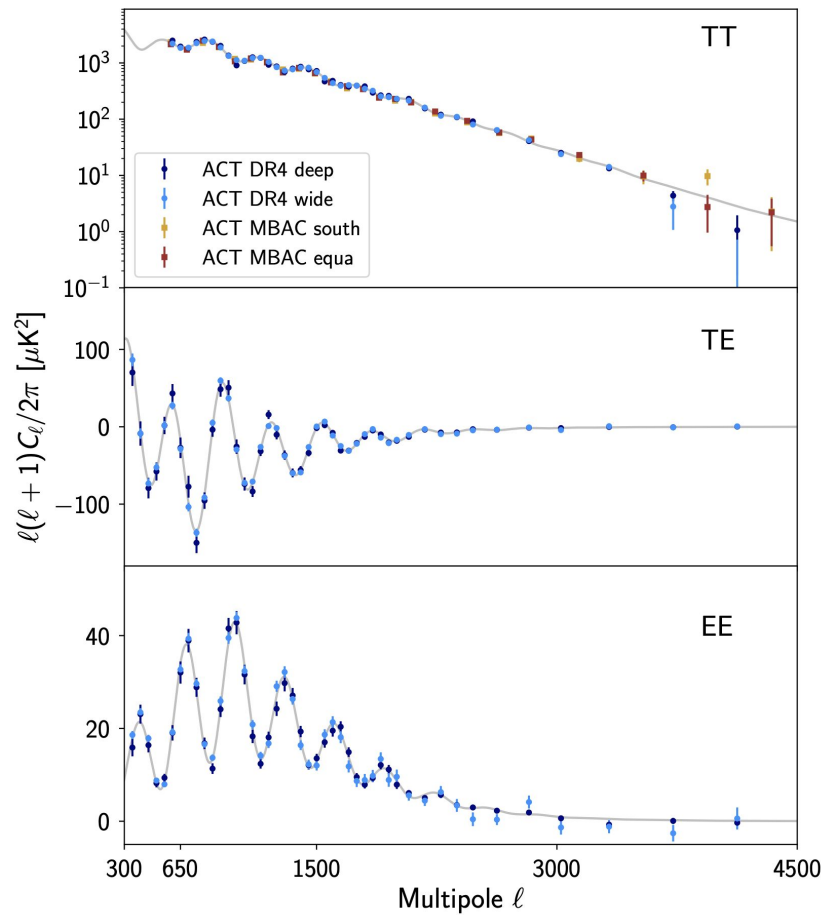
5,400 sq deg (effective area) used for PS;  
 ~17,000 sq deg observed

Regions observed in 4  
 seasons (2013–2016)  
 with different arrays

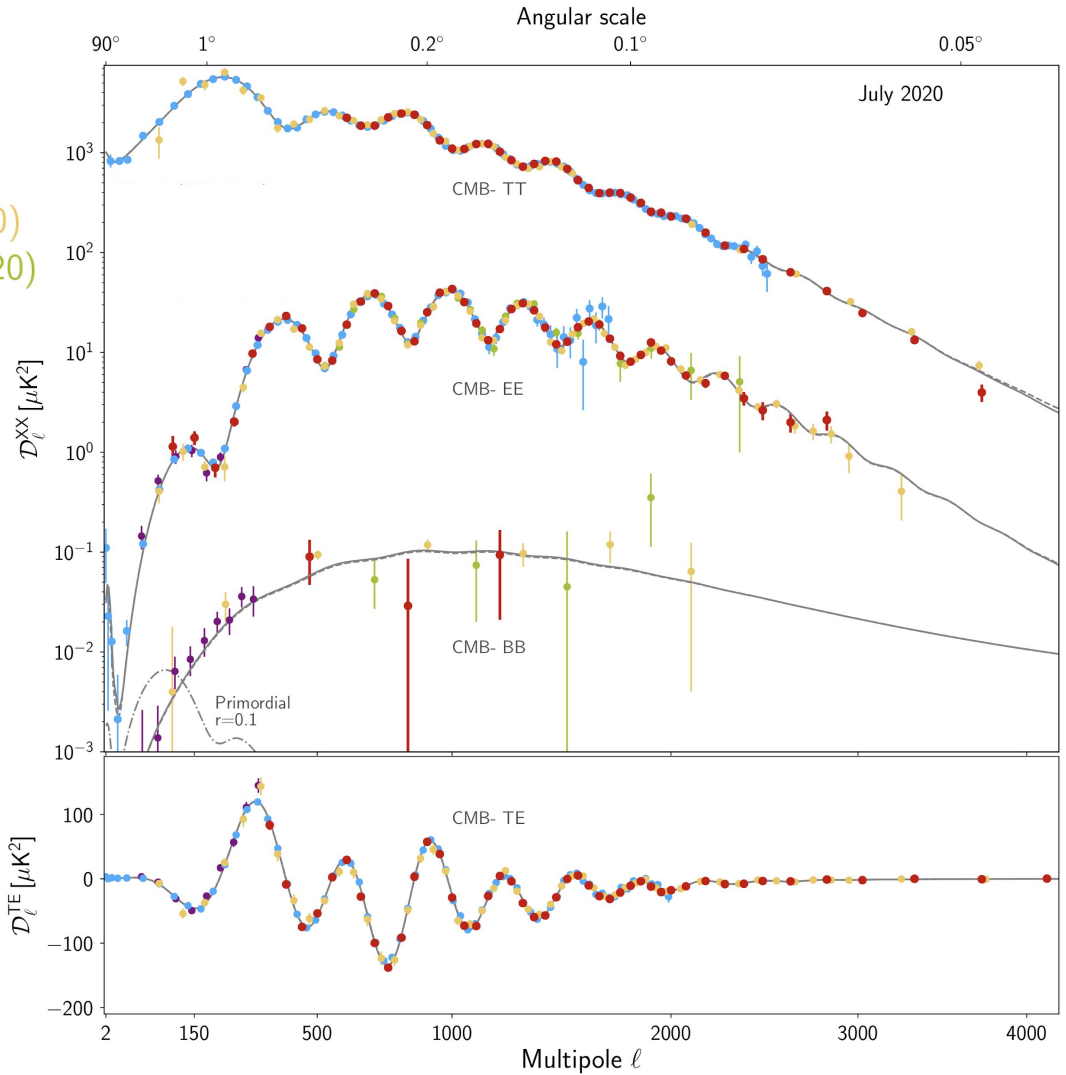


	s13	s14	s15	s16
PA1 150 GHz	D1 D5 D6	D56	D56 BN D8	
PA2 150 GHz		D56	D56 BN D8	AA
PA3 98/ 150 GHz			D56 BN D8	AA

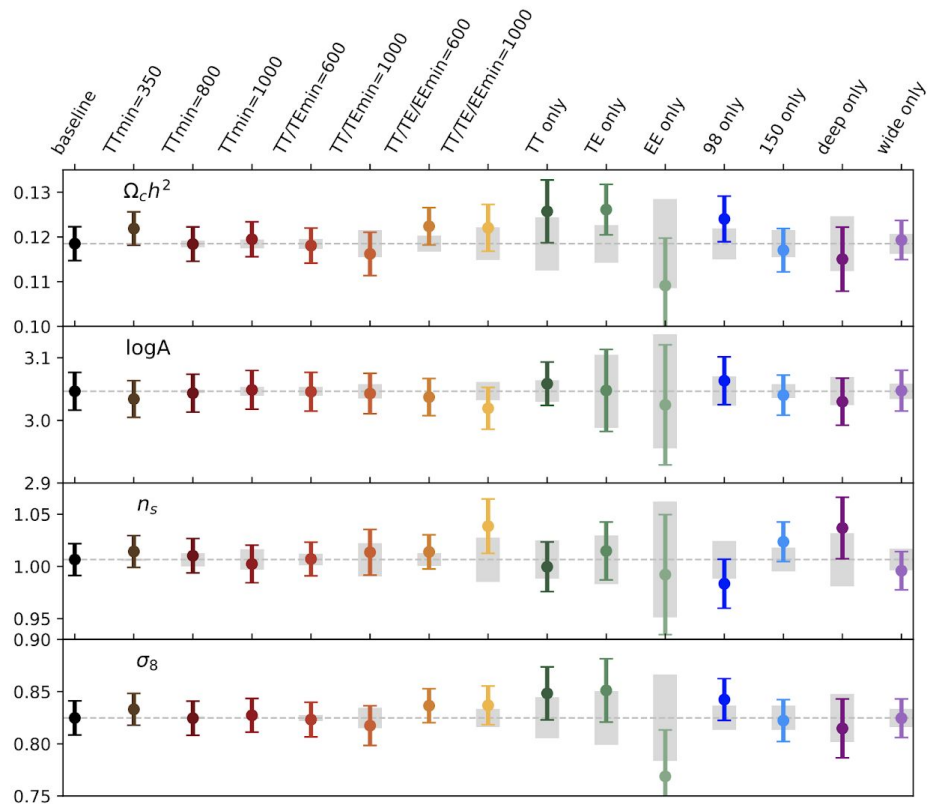
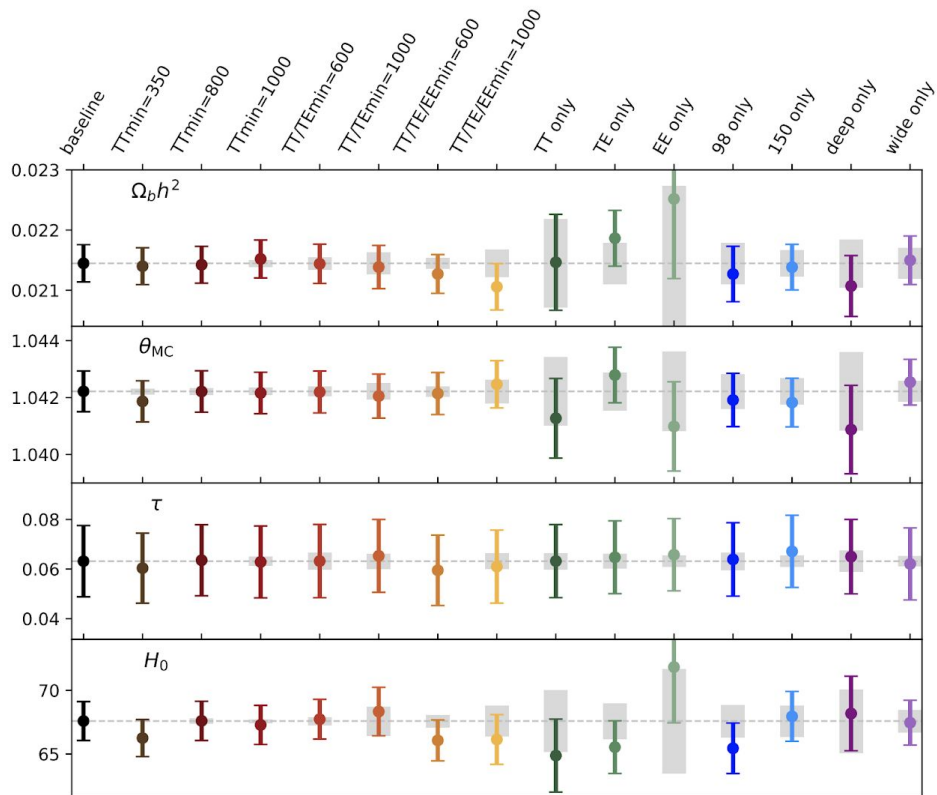
# CMB-only power spectra



Planck (PR3, 2018)  
ACT (DR4, 2020)  
SPTpol (2018/2019/2020)  
POLARBEAR (2017/2020)  
BICEP2/Keck (2018)

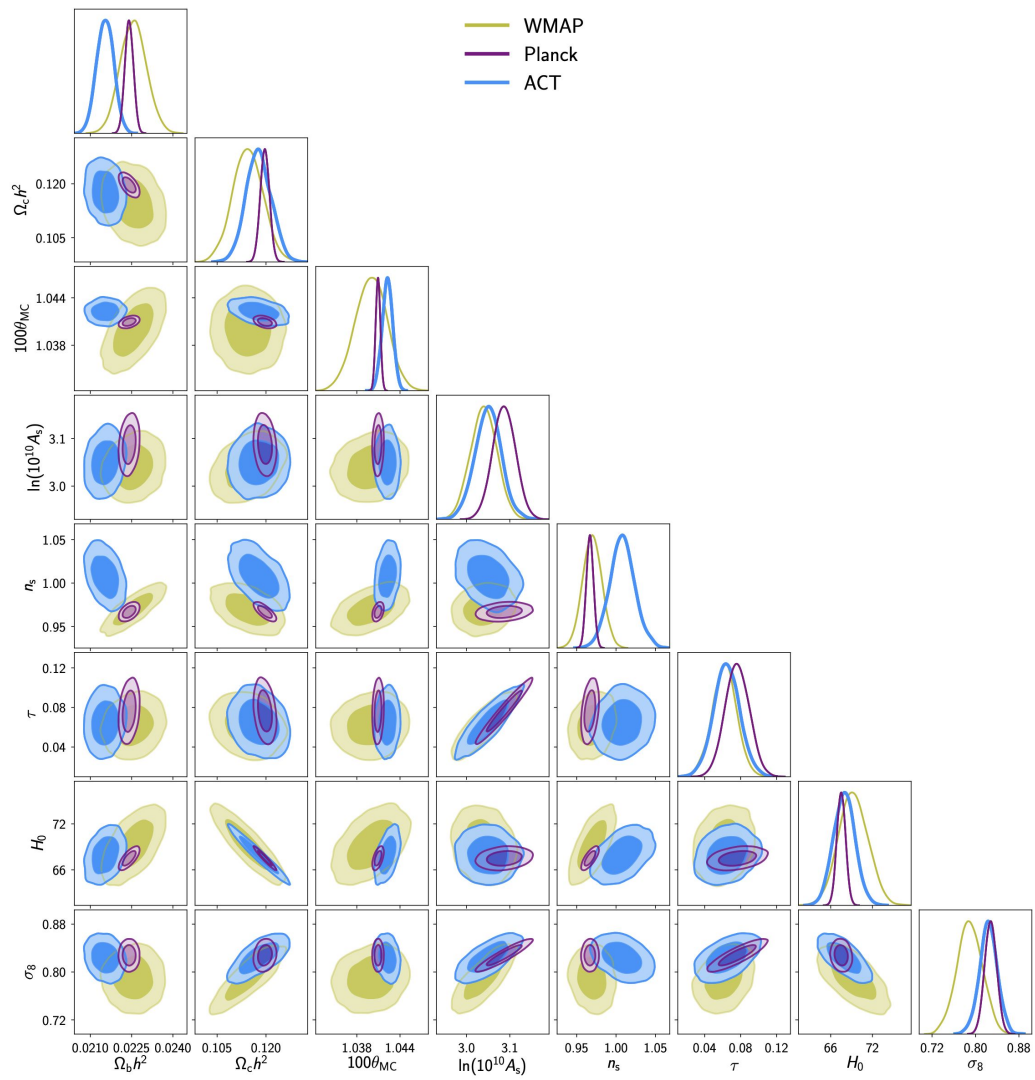


# Parameter-level tests

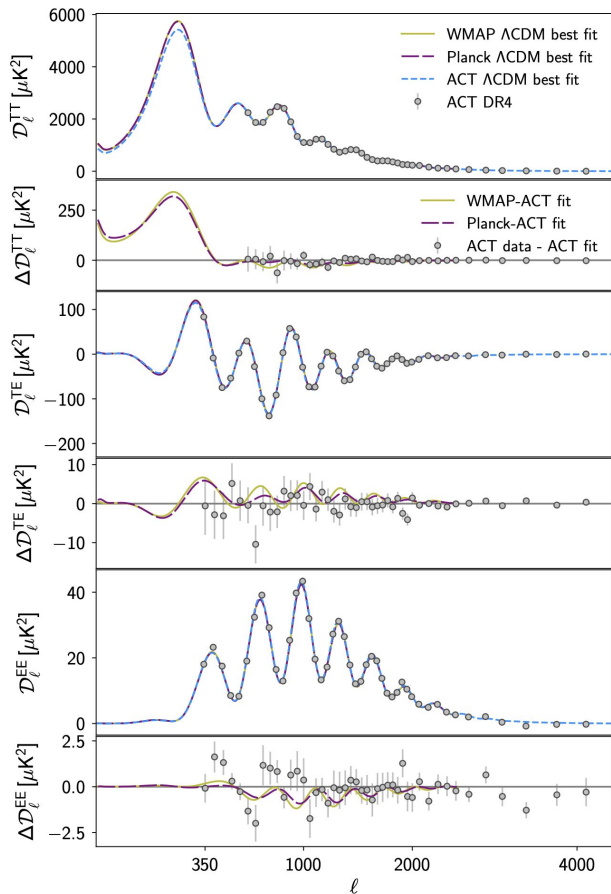


# ACT DR4 Cosmology

- $\Lambda$ CDM is a good fit to the ACT data
- Consistency 5D parameter space
  - ACT vs WMAP/Planck consistent at 2.3-2.7 $\sigma$

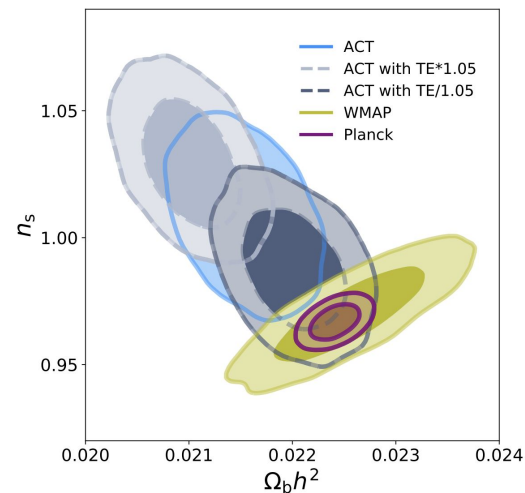
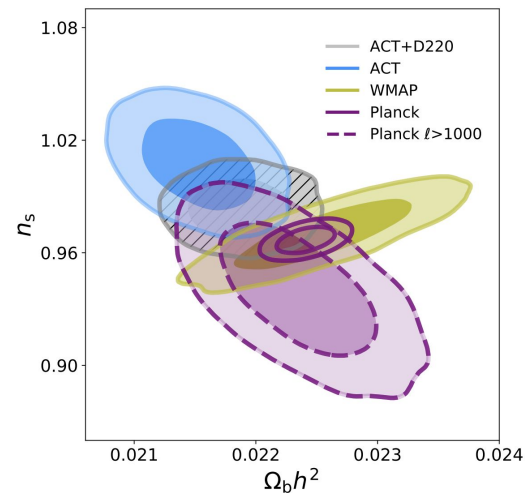


# ACT, WMAP, Planck



ACT prefers a  $2.4\sigma$  lower first peak in TT

Higher (lower) TE (EE)



# ACT DR4 Cosmology

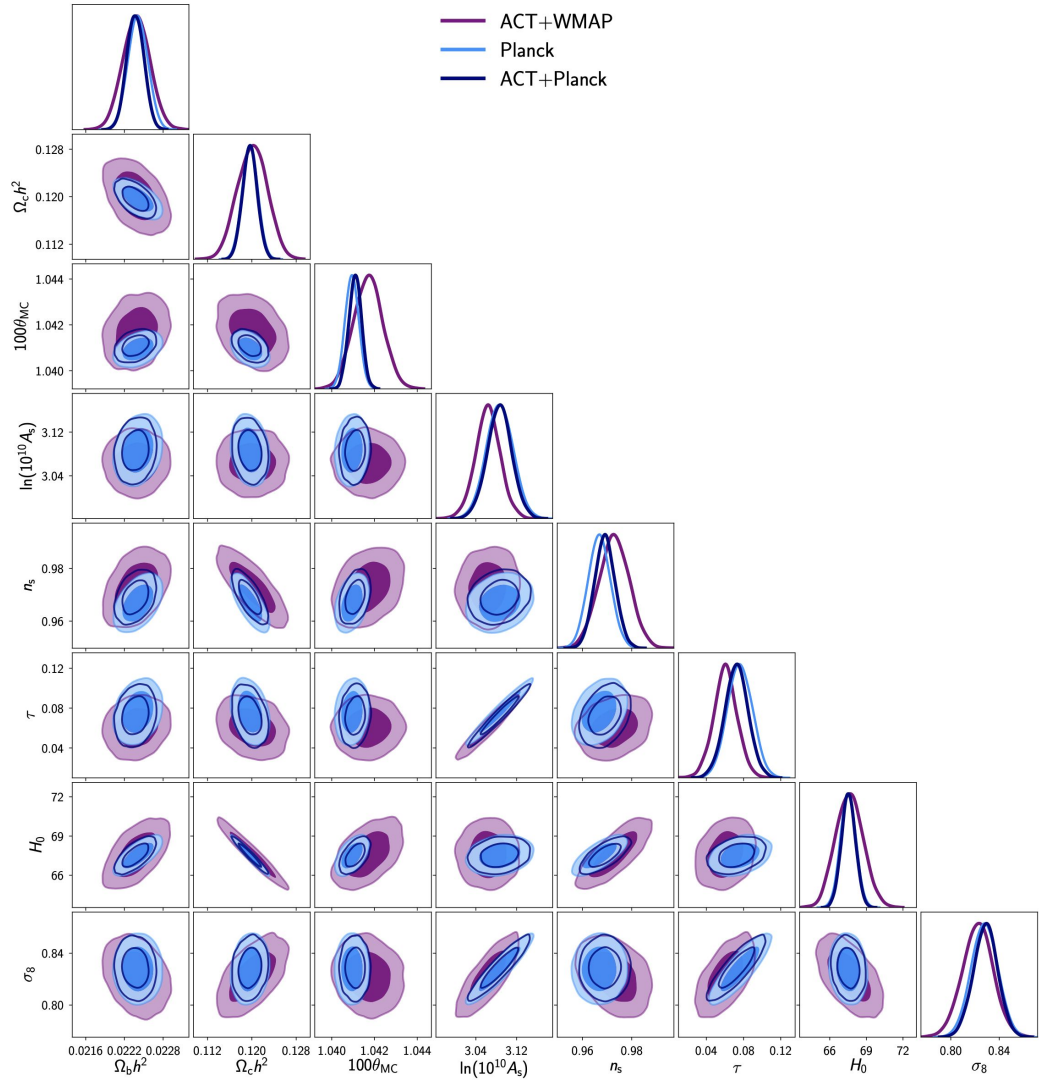
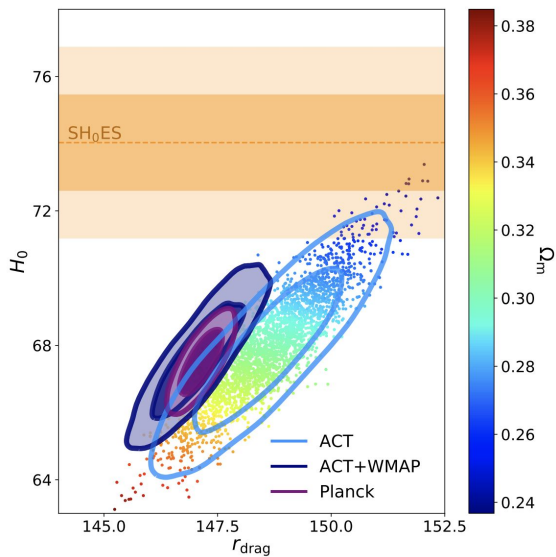
$$\theta^* = r_s^*/D_A^*$$

$$r_s^* = \int_0^{t^*} \frac{dt}{a(t)} c_s(t)$$

Early-time physics

$$D_A^*(z) = \frac{c}{H_0(1+z)} \int_0^{z^*} \frac{dz'}{E(z')}$$

Expansion history

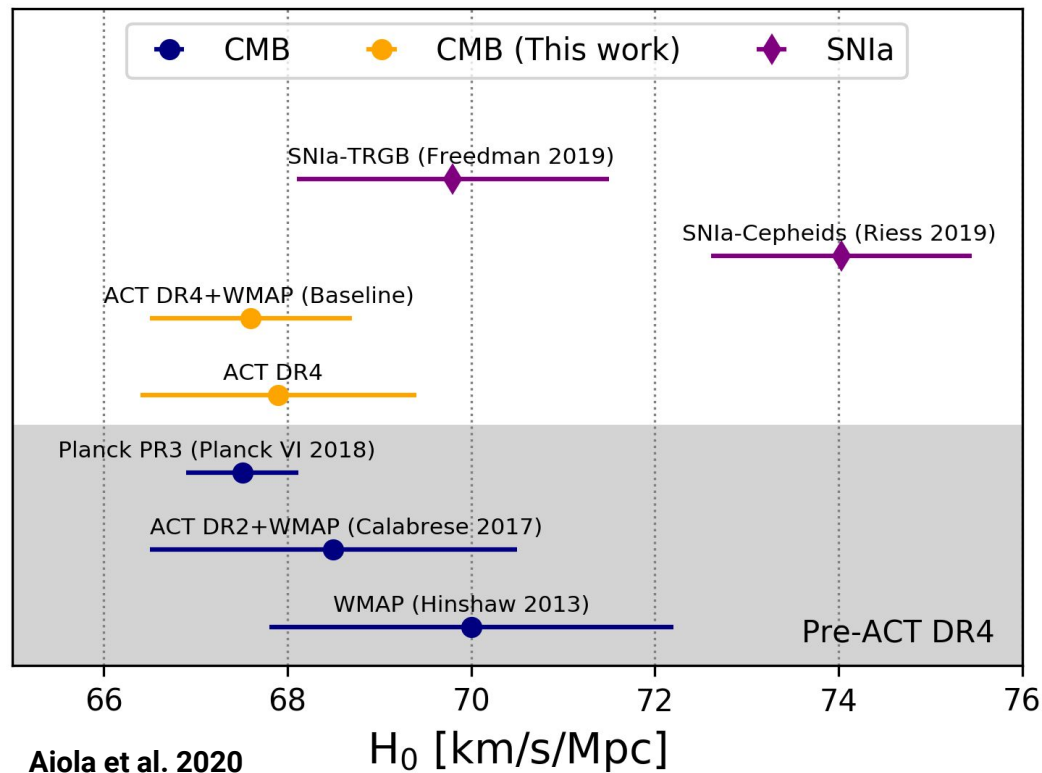




# ACT DR4 $H_0$ Estimate

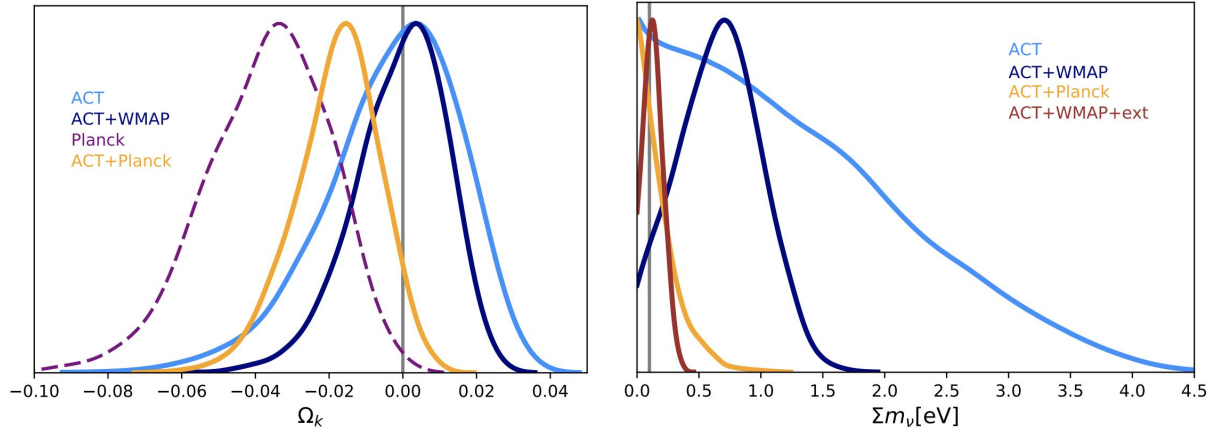
**ACT DR4 + WMAP:**  $H_0 = 67.6 \pm 1.1$  km/s/Mpc

- agrees with Planck within  $1\sigma$
- agrees with SNIa-TRGB within  $1\sigma$
- $\sim 4\sigma$  tension with SNIa-Cepheids

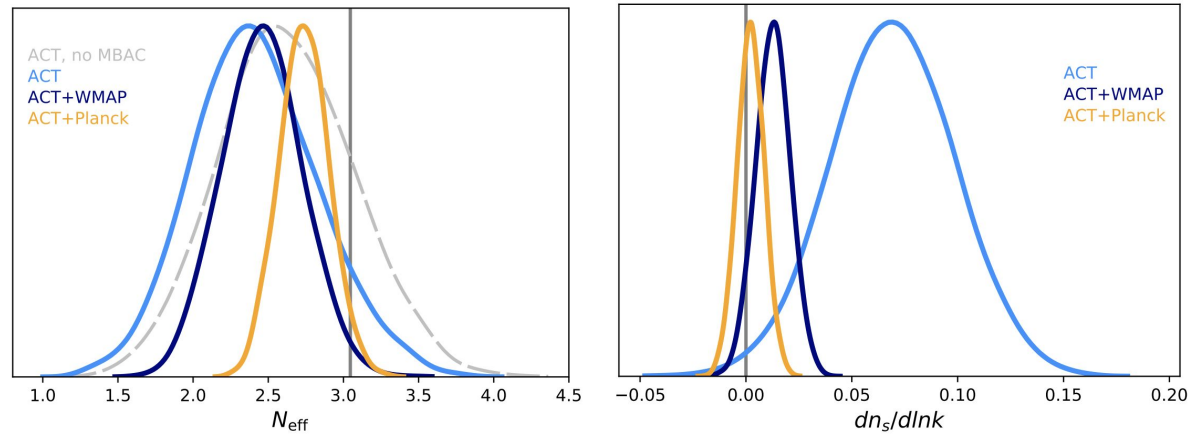


# ACT DR4 Cosmology beyond $\Lambda$ CDM

## Lensing Parameters

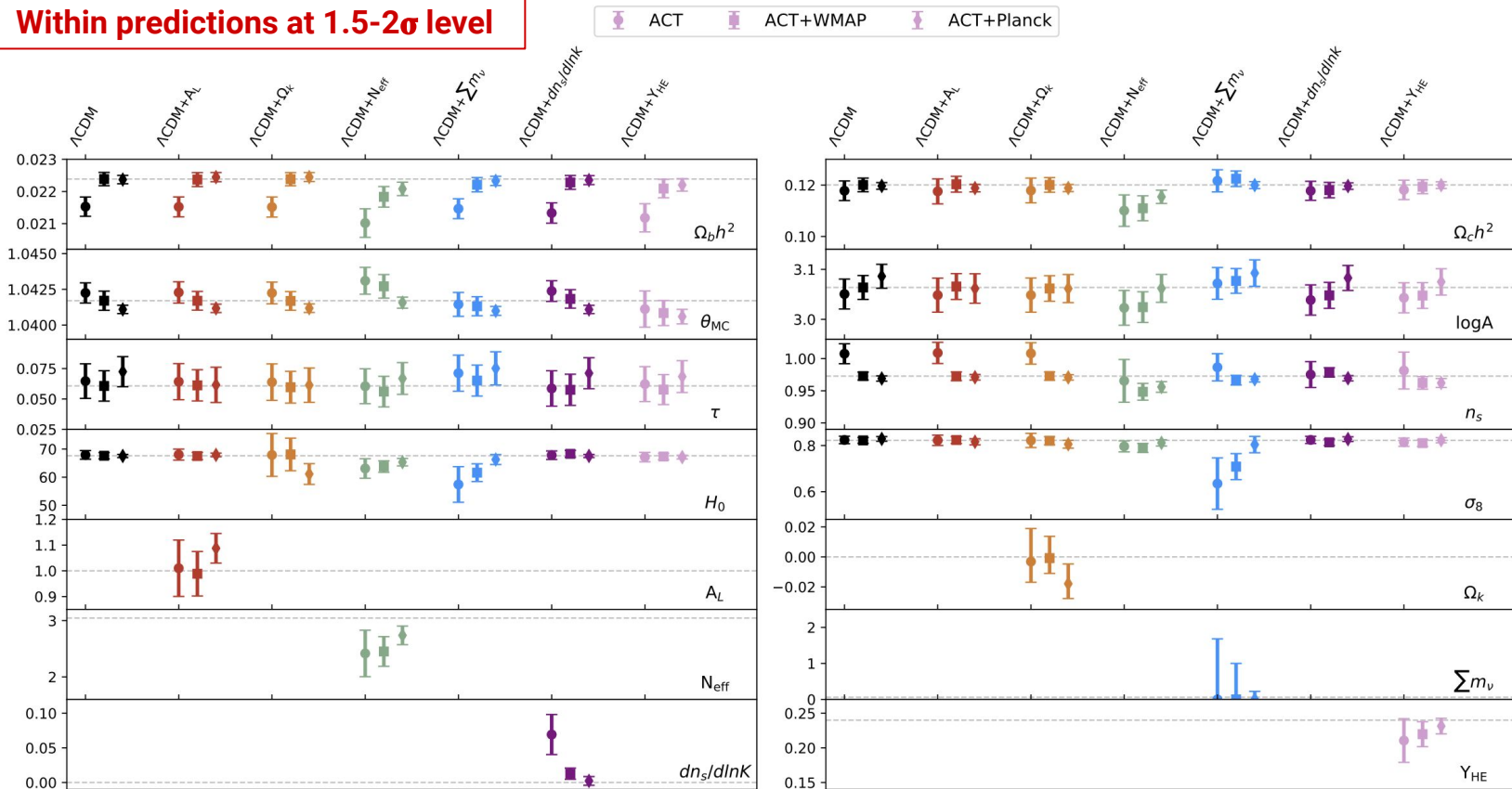


## Primordial Parameters



# ACT DR4 Cosmology beyond $\Lambda$ CDM

Within predictions at 1.5-2 $\sigma$  level



# ACT DR4 Publicly Released

Roughly 0.5TB of data products and 4.5TB of simulations made available to the community at [lambda.gsfc.nasa.gov](http://lambda.gsfc.nasa.gov)

DR4 2013-2016 Maps	
Product Download Page	Description
<a href="#">Season 13 Maps</a>	<a href="#">Frequency Maps at 98 and 150 GHz for Season 13 More...</a>
<a href="#">Season 14 Maps</a>	<a href="#">Frequency Maps at 98 and 150 GHz for Season 14 More...</a>
<a href="#">Season 15 Maps</a>	<a href="#">Frequency Maps at 98 and 150 GHz for Season 15 More...</a>
<a href="#">Season 16 Maps</a>	<a href="#">Frequency Maps at 98 and 150 GHz for Season 16 More...</a>

DR4 2013-2016 Derived Maps	
Product Download Page	Description
<a href="#">Coadd Maps</a>	<a href="#">s08-s16 Coadd Maps presented in Naess et al. 2020 More...</a>
<a href="#">Component Separated Maps</a>	<a href="#">TILE-C Component Separated Maps presented in Madhavacheril et al. 2019 More...</a>
<a href="#">Lensing Maps</a>	<a href="#">Lensing Maps presented in Darwish et al. 2019 More...</a>

DR4 2013-2016 Ancillary Products	
Product Download Page	Description
<a href="#">Masks</a>	<a href="#">Data Analysis Masks More...</a>
<a href="#">Window Functions</a>	<a href="#">Data Analysis Window Functions More...</a>

DR4 2013-2016 Derived Spectra	
Product Download Page	Description
<a href="#">Multifrequency Spectra</a>	<a href="#">Multifrequency Spectra presented in Choi et al. 2020 More...</a>
<a href="#">CMB-only Spectra</a>	<a href="#">CMB-only Spectra presented in Choi et al. 2020 More...</a>
<a href="#">Birefringence Spectra</a>	<a href="#">Cosmic-Birefringence Spectrum presented in Namikawa et al. 2020 More...</a>

DR4 2013-2016 Likelihoods	
Product Download Page	Description
<a href="#">Multifrequency Likelihood Software</a>	<a href="#">Baseline Multi-frequency Likelihood presented in Choi et al. 2020 More...</a>
<a href="#">CMB-only Likelihood Software</a>	<a href="#">Baseline CMB-only Likelihood presented in Aiola et al. 2020 More...</a>

DR4 2013-2016 Cosmological Results	
Product Download Page	Description
<a href="#">Likelihood Products</a>	<a href="#">Baseline CMB-only Likelihood Products presented in Aiola et al. 2020 More...</a>

DR4 2013-2016 Simulations	
Product Download Page	Description
	Simulations associated to the DR4 products will be available on NERSC.

DR4 2013-2016 Notebooks	
Product Download Page	Description
<a href="#">Data Notebooks</a>	<a href="#">Jupyter Notebook tutorials associated with ACT DR4 available on the ACT GitHub.</a>

