ACT DR6: Cosmology with the CMB from the Ground

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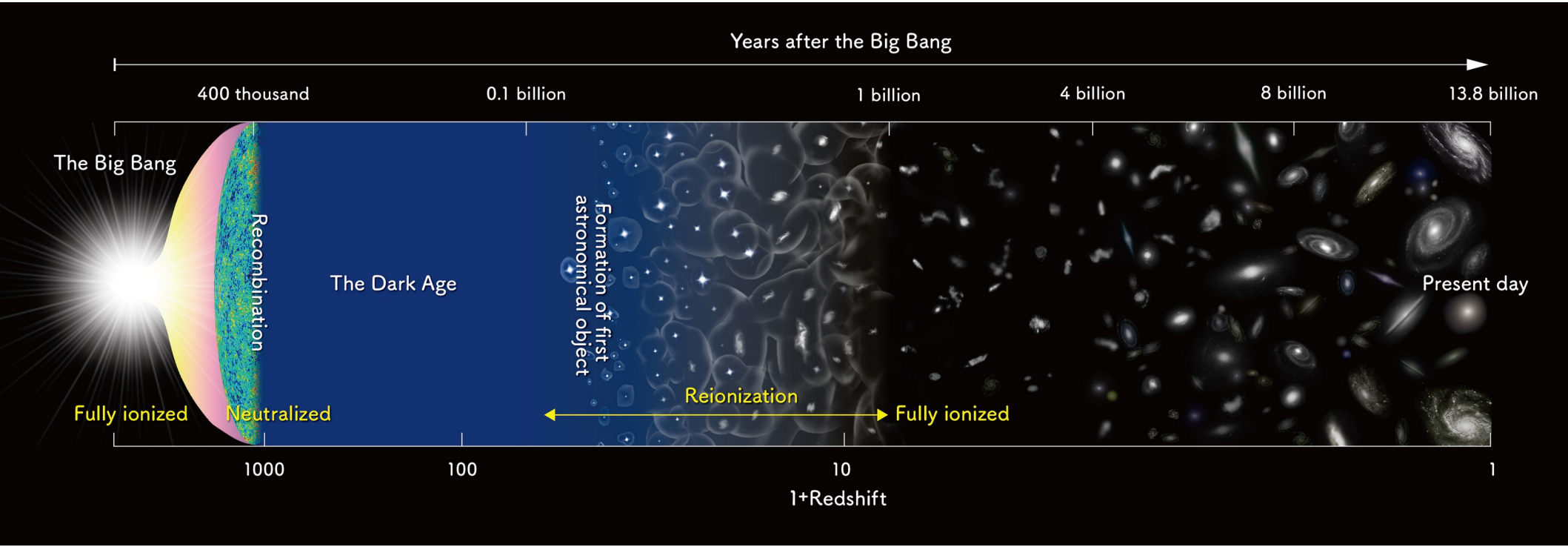
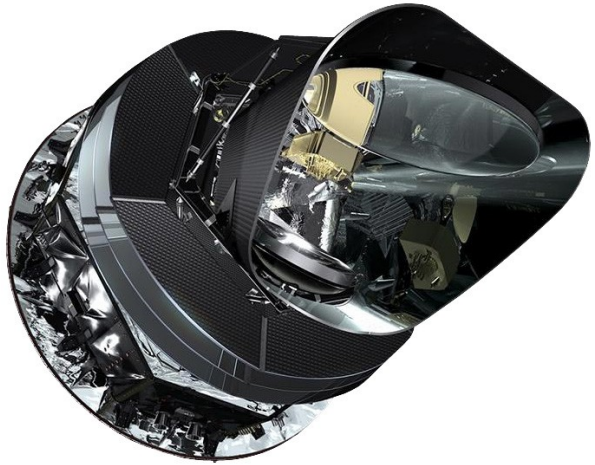
TeVPA, 2025

The ACT Collaboration

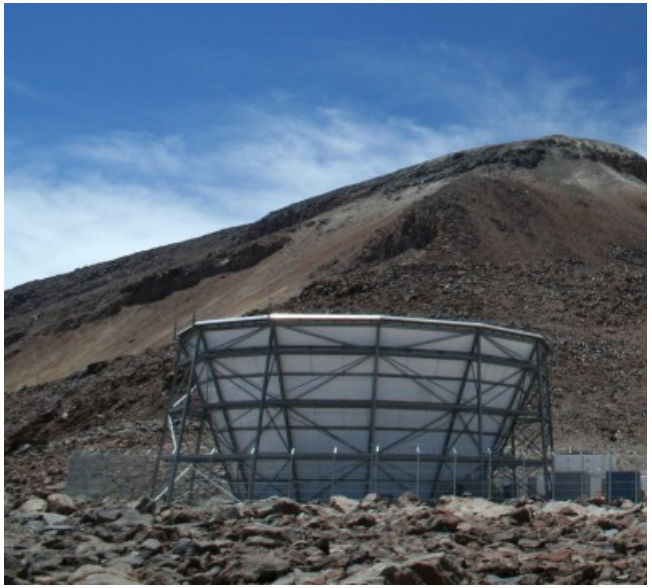
Cosmic History of the Universe



Planck vs ACT



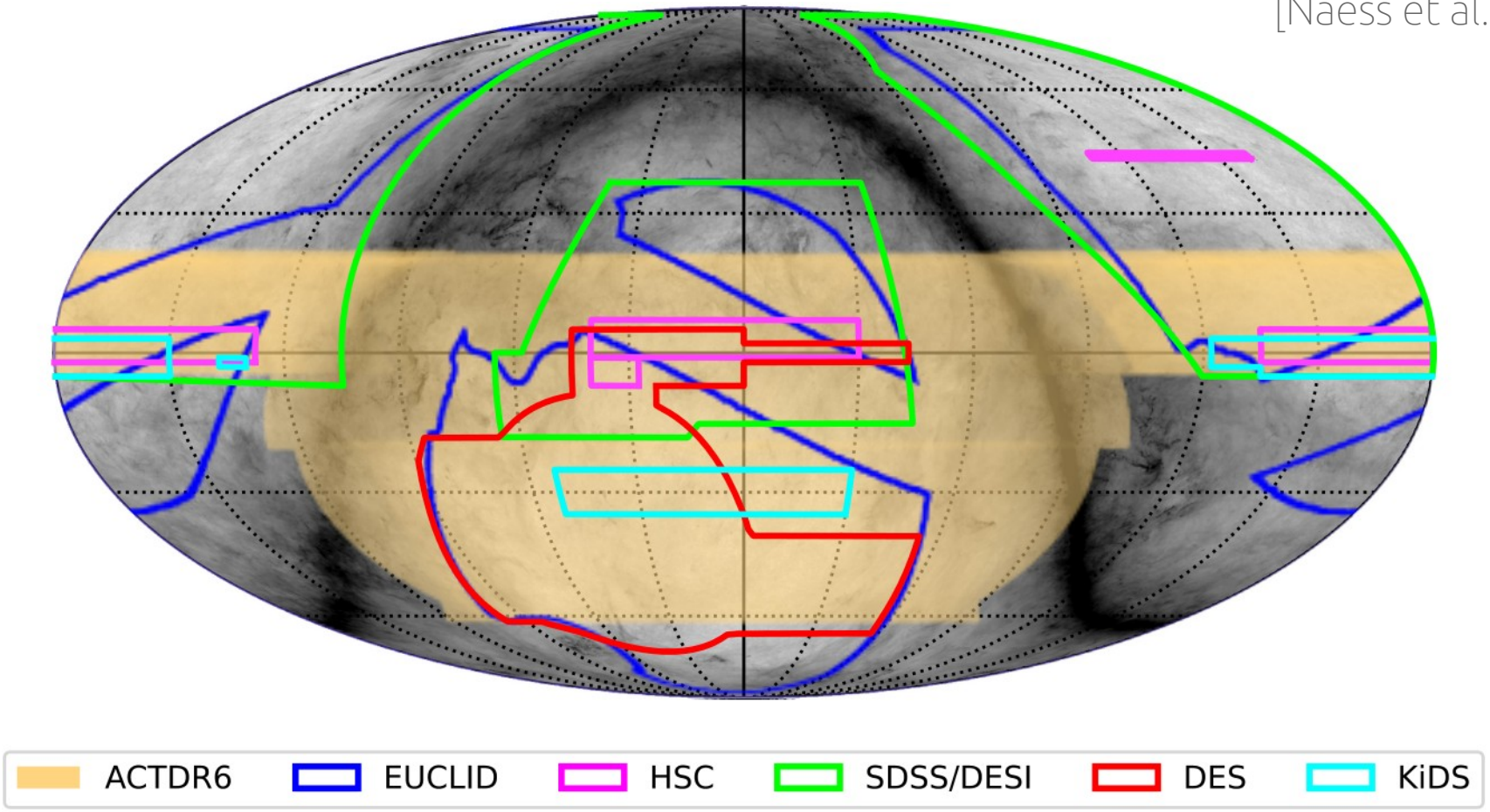
Planck
Last release 2018
70% sky coverage for science
5-10 arcmin resolution
9 bands 30-850 GHz



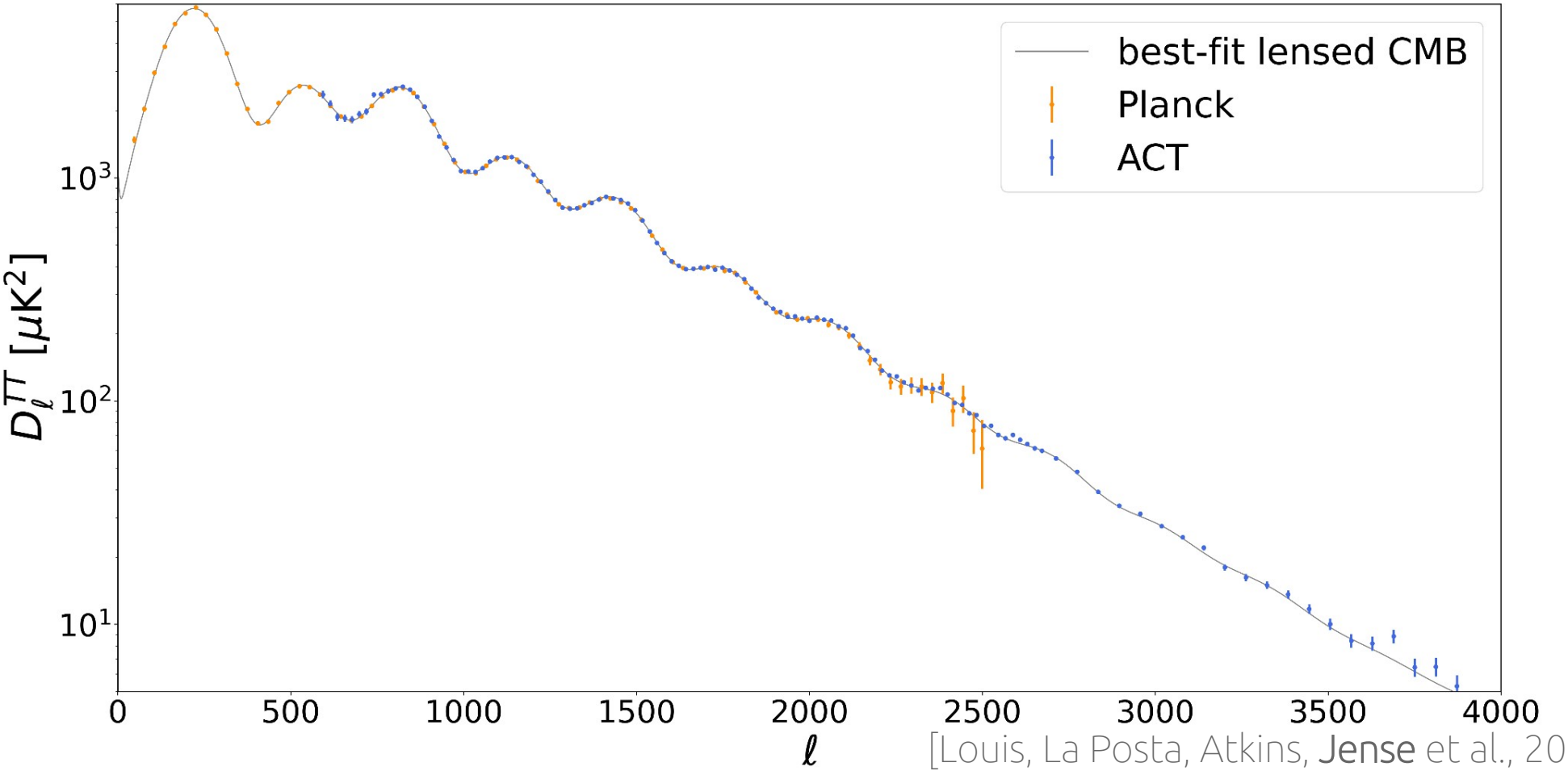
Atacama Cosmology Telescope
Observations 2008-2022
30% sky coverage for science
1-2 arcmin resolution
5 bands 30-220 GHz
Noise 3-6x lower than Planck

ACT DR6

[Naess et al., 2025]

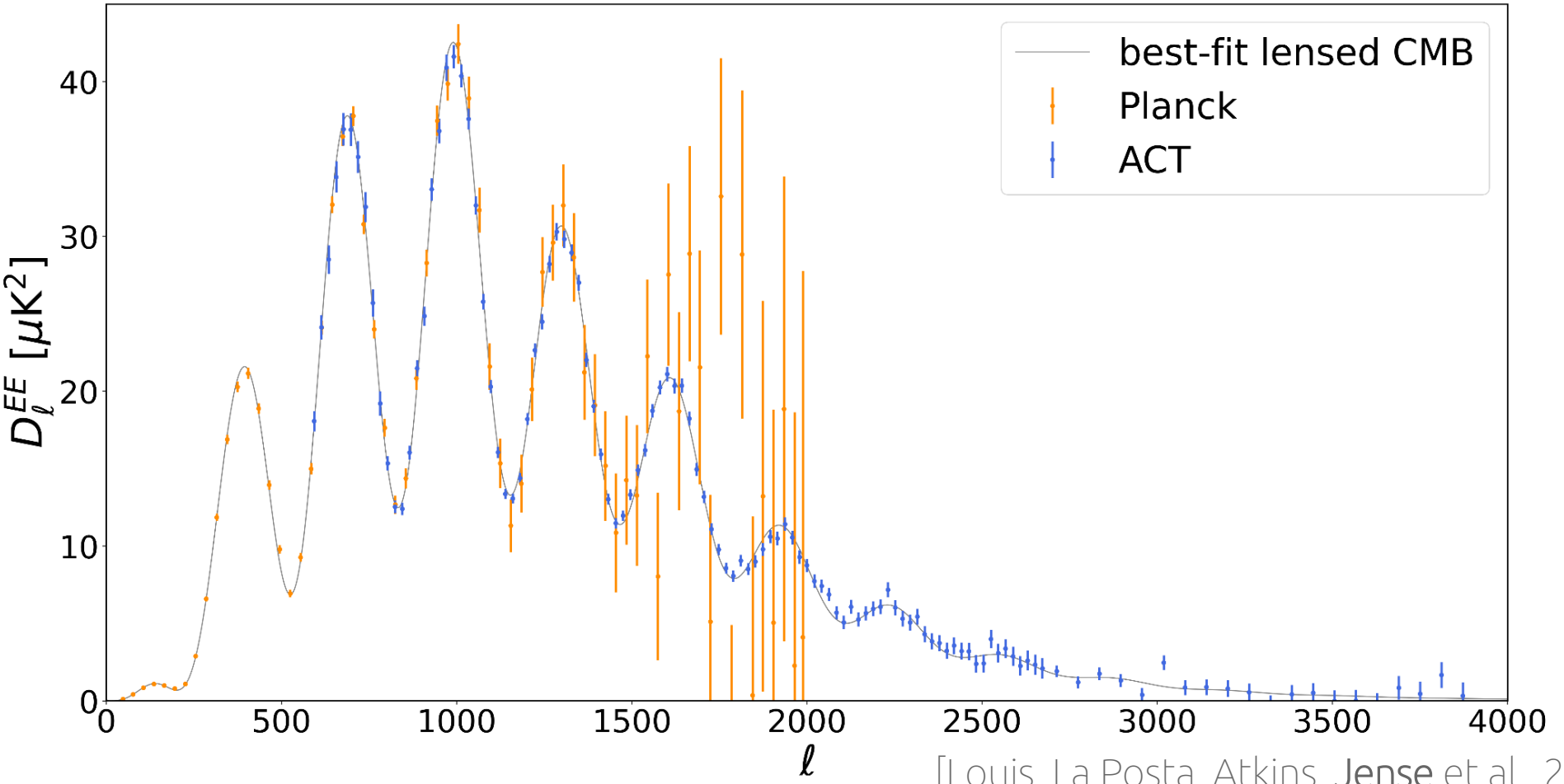


DR6 Power Spectra



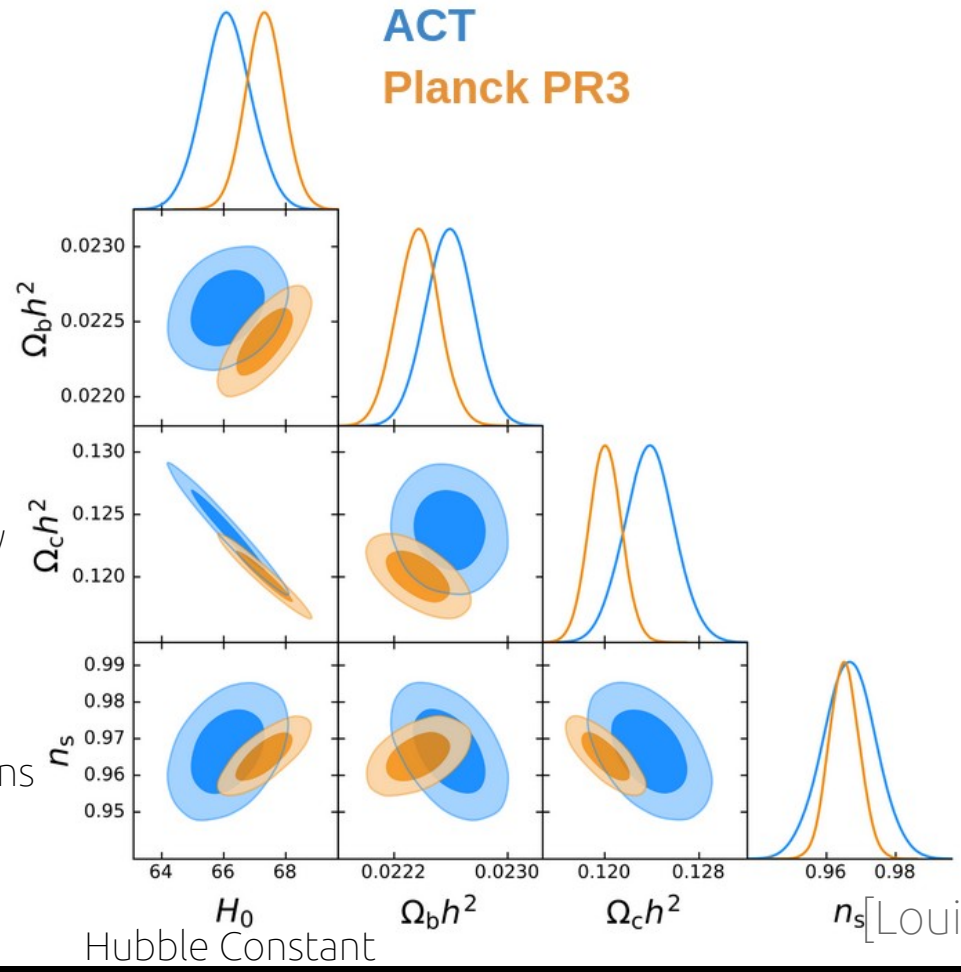
[Louis, La Posta, Atkins, **Jense** et al., 2025]

DR6 Power Spectra



[Louis, La Posta, Atkins, **Jense** et al., 2025]

Cosmological Concordance



Baryon density

Dark matter density

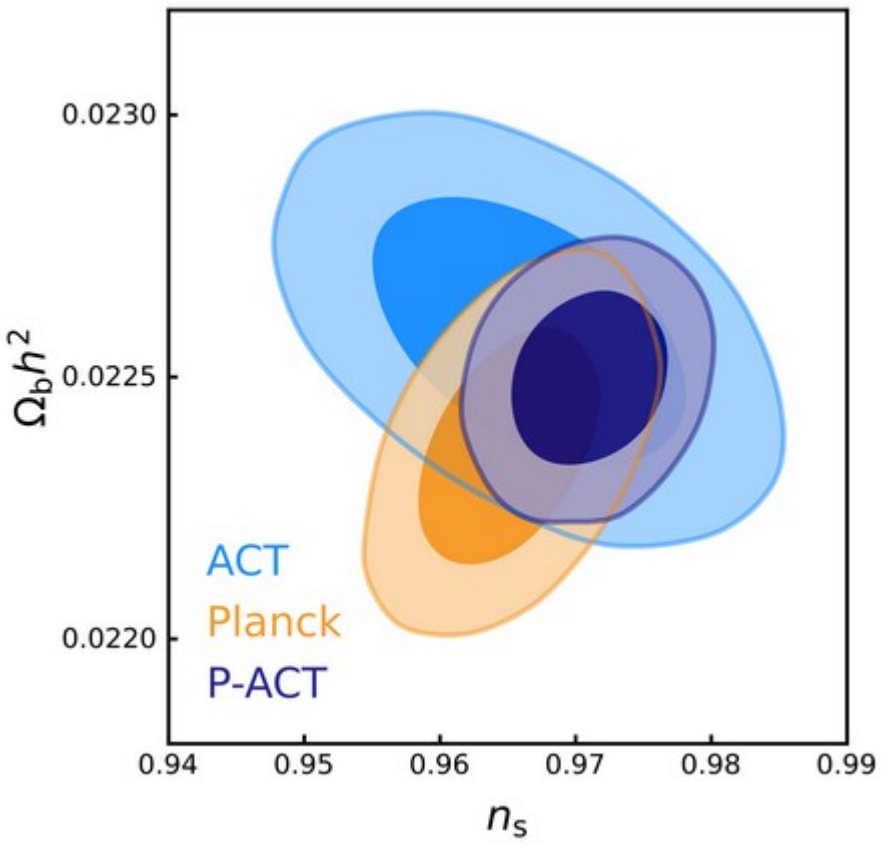
Spectral index of primordial fluctuations

Hubble Constant

Great agreement between ACT and Planck on ΛCDM: 1.6σ !

[Louis, La Posta, Atkins, **Jense** et al., 2025]

Cosmological Concordance



[Louis, La Posta, Atkins, Jense et al., 2025]

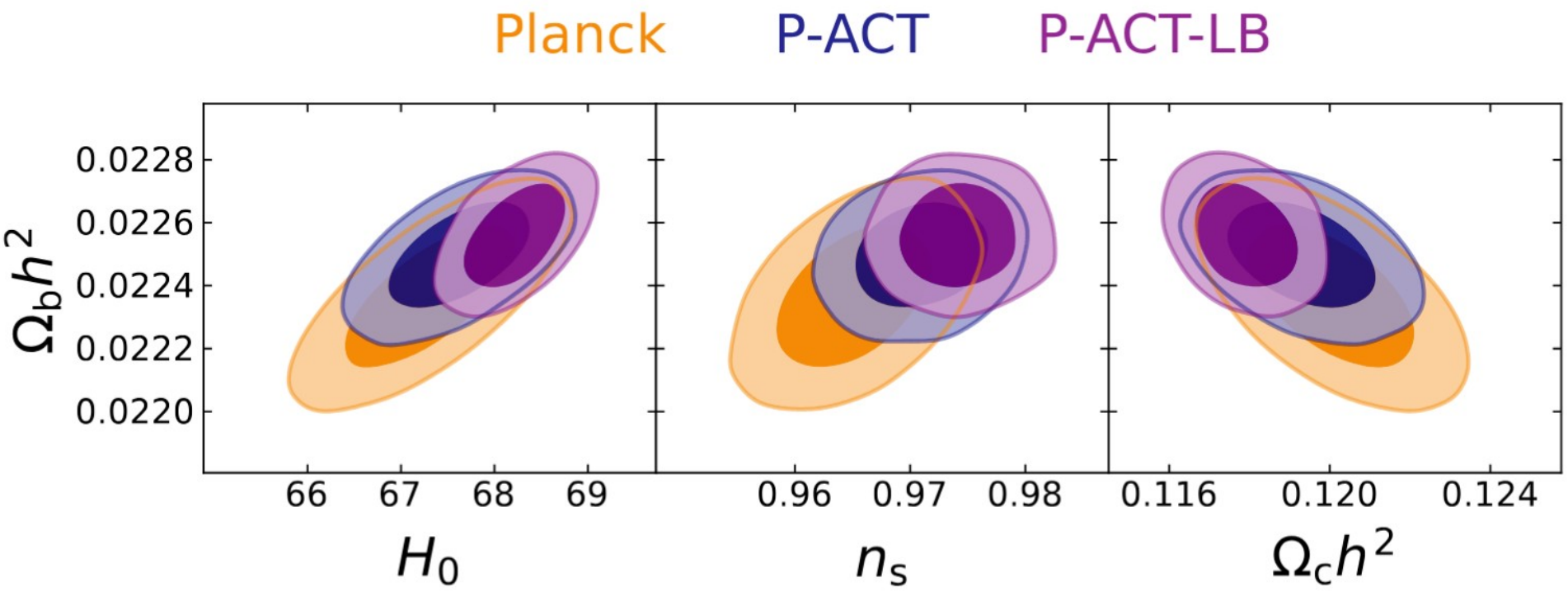
ACT and Planck operate at different scales, so parameters can be degenerate in different ways.

This means the combination of them can be **very efficient** in breaking these degeneracies.

Data Combinations:

- ACT — primary CMB from ACT
- P-ACT — primary CMB from Planck PR3 and ACT
- W-ACT — primary CMB from WMAP and ACT
- P-ACT-LB — + CMB lensing + BAO measurements (DESI DR1).
- P-ACT-LBS — + SNIa data

DR6 ΛCDM Cosmology



Combining P-ACT with lensing and BAO measurements from DESI gives the state-of-the-art constraints on cosmological parameters. We measure $H_0 = 68.22 \pm 0.36$ km/s/Mpc.

[Louis, La Posta, Atkins, **Jense** et al., 2025]

DR6 Beyond-ΛCDM Cosmology

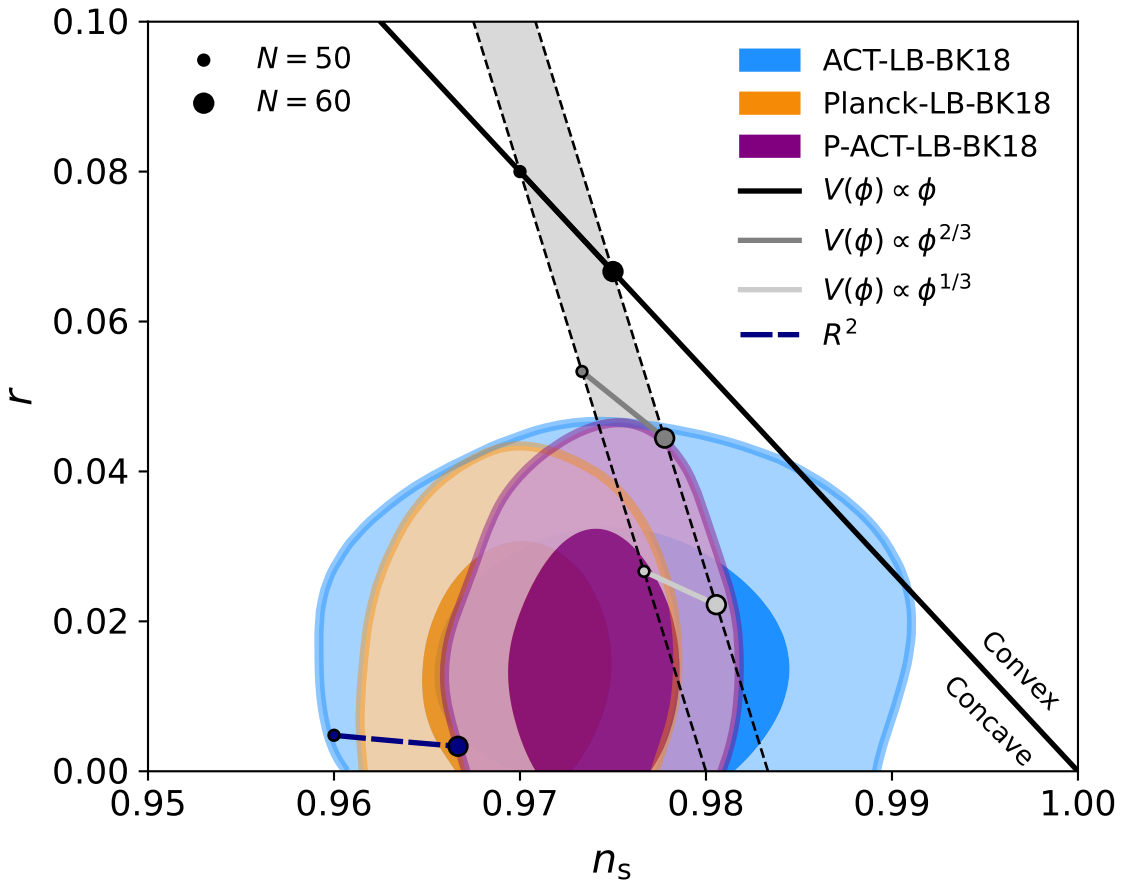
At this point, we tested a wide range of **extensions to the ΛCDM model**, looking for:

- Improvements thanks to ACT DR6;
- Models that are of interest (“tensions”).

We can measure a lot of different types of models with ACT DR6:

- Inflation physics
- Particle astrophysics
- Recombination physics
- Tests of Gravity and late-time physics

Inflation Physics



Tightened constraints on primordial perturbation power spectrum.

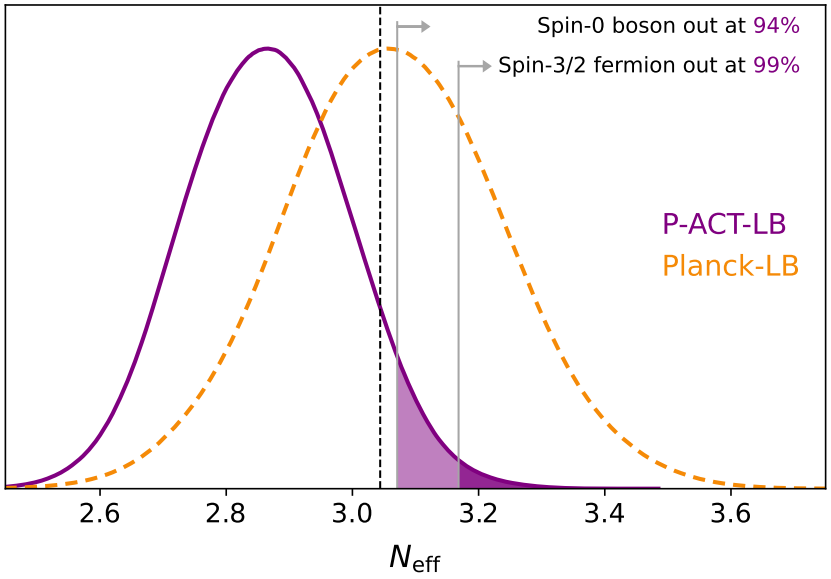
Planck: $n_s = 0.9651 \pm 0.0044$
P-ACT-LB: $n_s = 0.9743 \pm 0.0034$

No evidence of a departure from a simple power law.

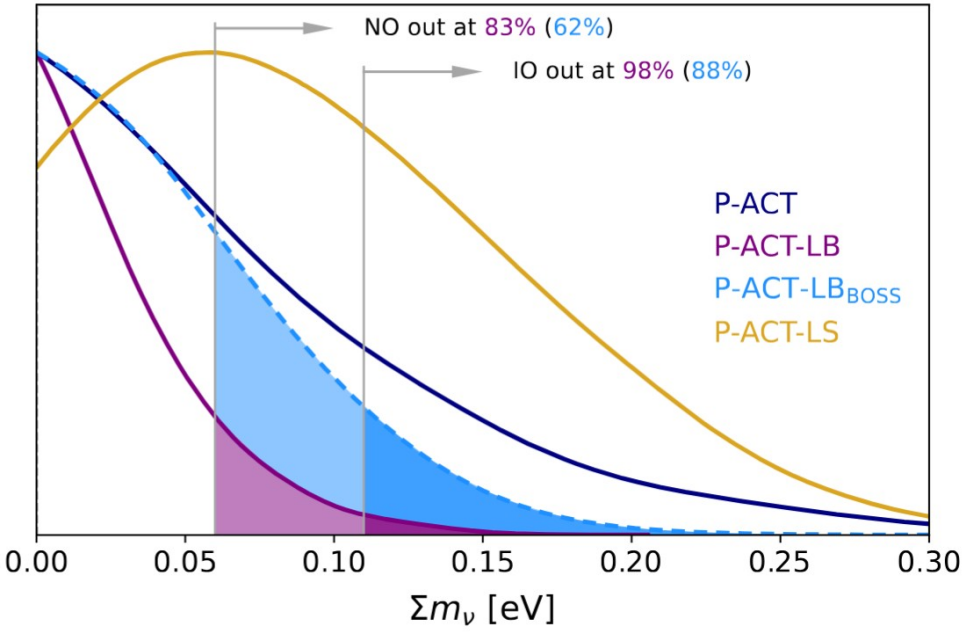
No deviation from adiabaticity detected.

[Calabrese, Hill, **Jense**, La Posta et al., 2025]

Particle Physics



Tight constraints on the existence of beyond-standard model relativistic particles.



No evidence for non-zero neutrino mass.

$\Sigma m_\nu < 0.082$ eV (95%, P-ACT-LB)

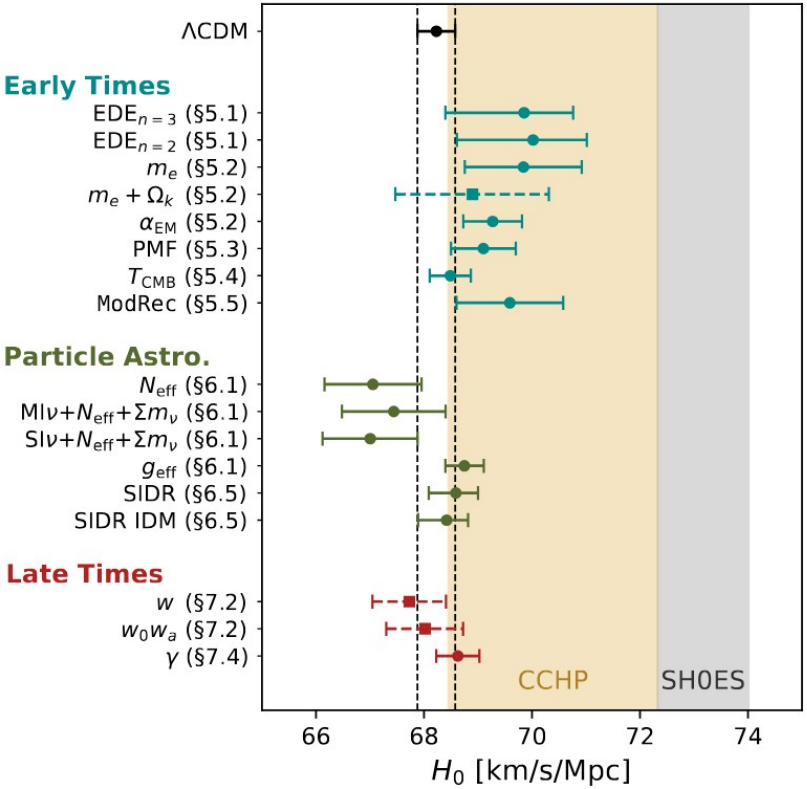
[Calabrese, Hill, Jense, La Posta et al., 2025]

Other models

Much more!
- No evidence for **neutrino interactions**;
- Concordance with **BBN models**;
- Tighter bounds on **axion** abundances;
- Constraints on **DM scattering** cross sections;
- Constraints on **DM annihilation rates**;
- Improved bounds on **Dark Radiation**;

[Calabrese, Hill, **Jense**, La Posta et al., 2025]

Hubble Tension



Standing problem in cosmology:

CMB: $H_0 = 68.22 \pm 0.36$ km/s/Mpc
Local: $H_0 = 73.17 \pm 0.86$ km/s/Mpc

None of the extensions we investigated (including models specifically targeting this tension) provide space to resolve this.

[Calabrese, Hill, Jense, La Posta et al., 2025]

Data Availability

LAMBDA legacy archive (lambda.gsfc.nasa.gov)

- Maps (frequency, coadd, ILC, null tests)
- MCMC chains, power spectra

NERSC (/global/cfs/cdirs/cmb/data/act_dr6/dr6.02)

In addition to all products on LAMBDA:

- Single-pass maps for time-domain studies
- Noise models and simulations
- Products to reproduce spectra and likelihood

PSpipe repository (Simons Observatory) (https://github.com/simonsobs/PSpipe)

- Code to reproduce spectra and likelihood

ACT DR6 Jupyter Notebooks (https://github.com/ACTCollaboration/DR6_Notebooks)

- Explanatory tutorials for DR6 data products