COSMOLOGICAL RESULTS FROM THE ACT DR6 POWER SPECTRUM

Adri Duivenvoorden
Max Planck Institute for Astrophysics

mm-Universe 2025, Chicago
23-06-2025

ATACAMA COSMOLOGY TELESCOPE

2007–2022

image credit: Mark Devlin

ATACAMA COSMOLOGY TELESCOPE

Altitude of 5200 m in the Atacama desert in northern Chile

- Access to ~70% of the sky (ACT mapped ~40%)

6 meter telescope

- ~5 times *Planck* resolution

PI: Suzanne Staggs, Co-Director: Mark Devlin

image credit: Debra Kellner

ATACAMA COSMOLOGY TELESCOPE

2022 collaboration meeting, Princeton

ATACAMA COSMOLOGY TELESCOPE

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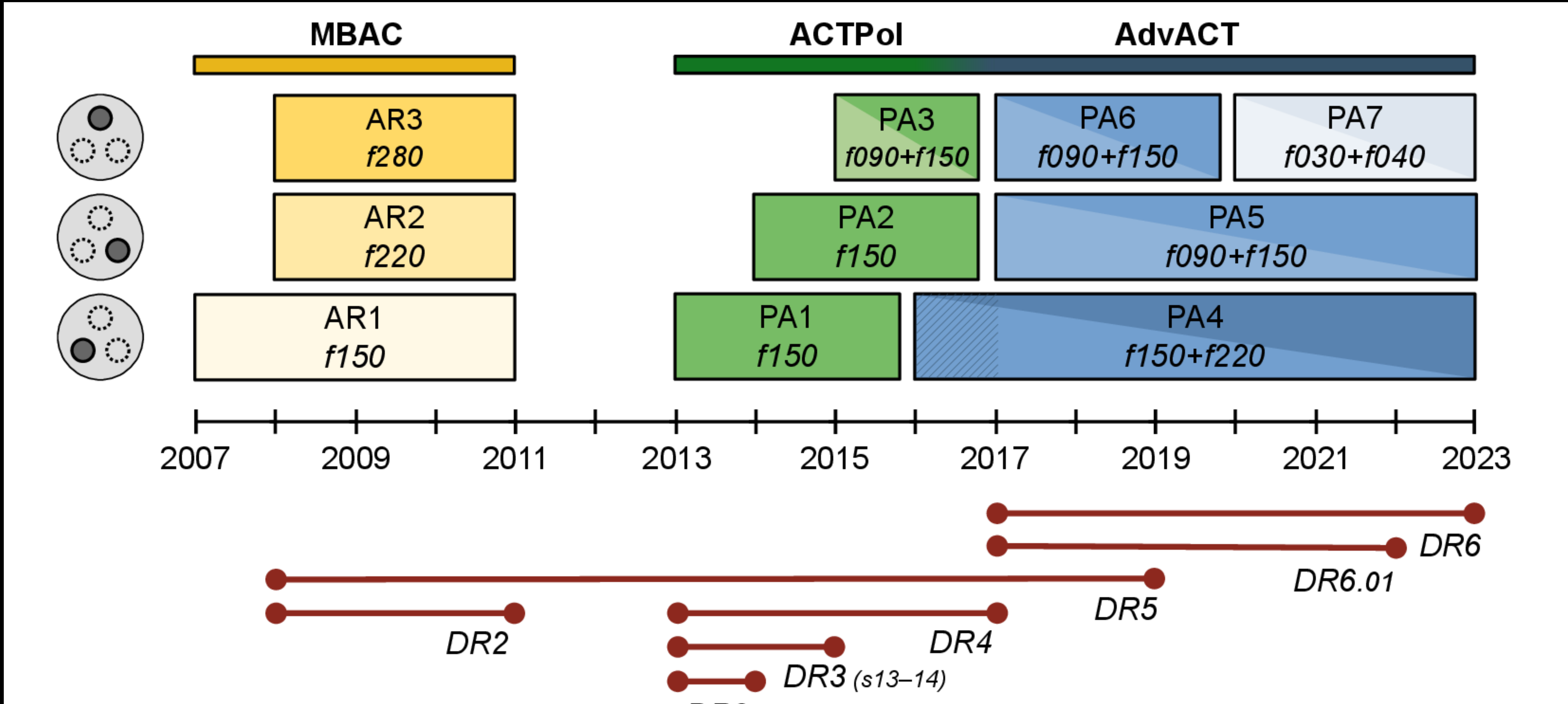
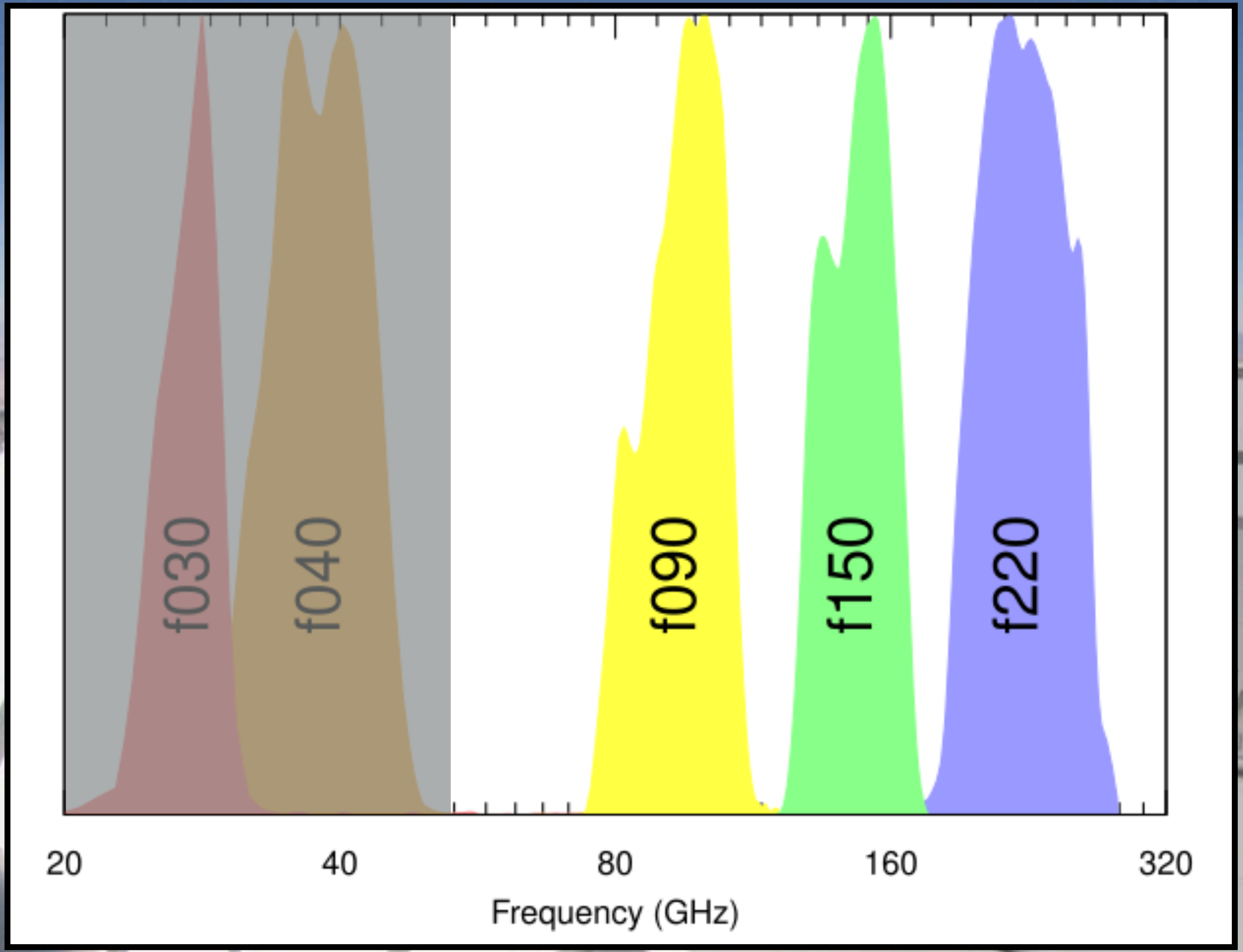
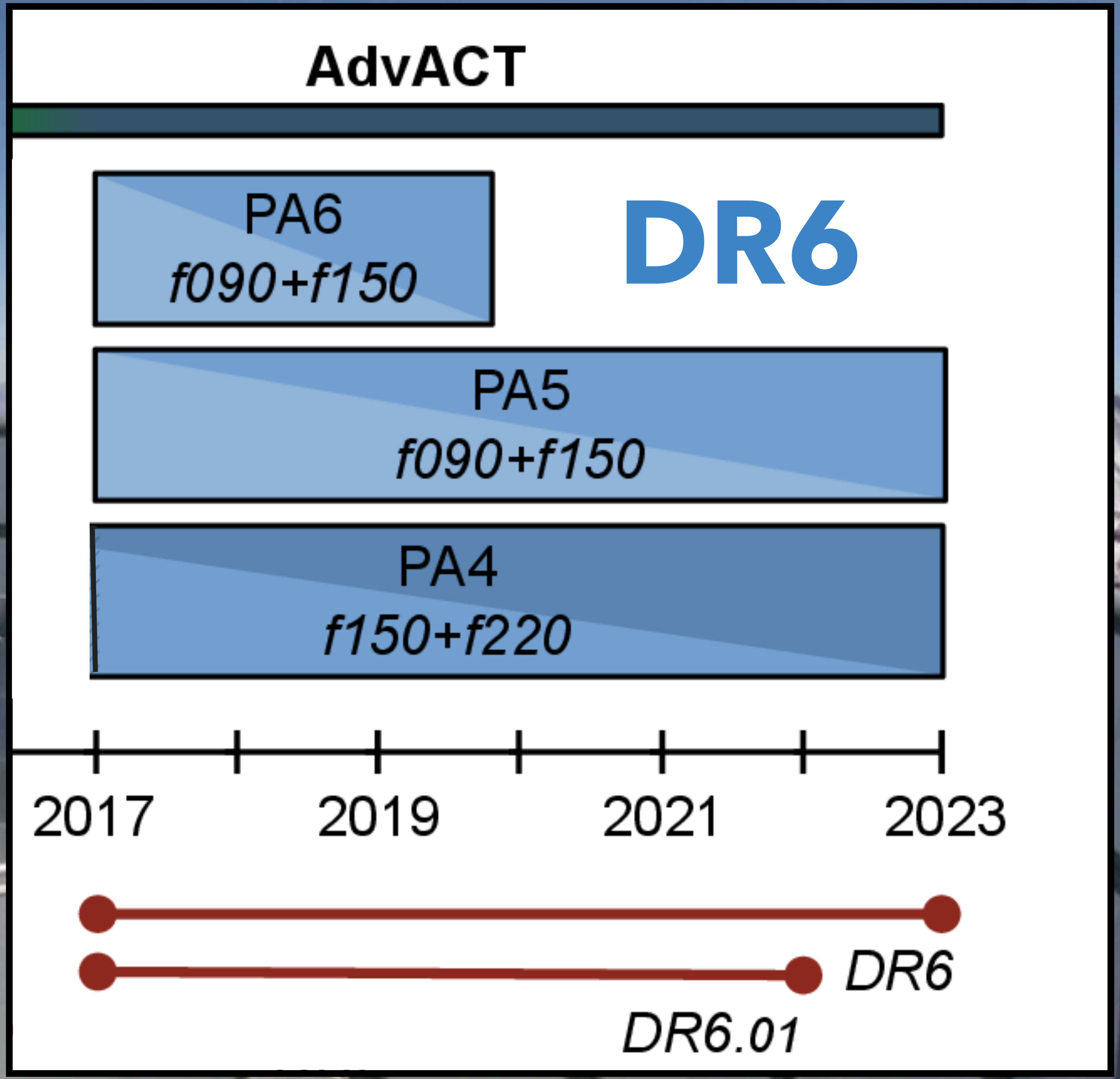


Figure: Adam Hincks

ATACAMA COSMOLOGY TELESCOPE, DR6





PAPERS

Naess et al. 2025 (2503.14451)

- Description of the frequency maps, the data reduction pipeline and derived maps

Louis et al. 2025 (2503.14452)

- Power spectra, measurements of foreground parameters and cosmological constraints on ΛCDM

Calabrese et al. 2025 (2503.14454)

- Constraints on extended cosmological models

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Colin Hill's talk on Thursday

Beringue et al. 2025 (2506.06274)

- Detailed discussion of foreground modeling choices

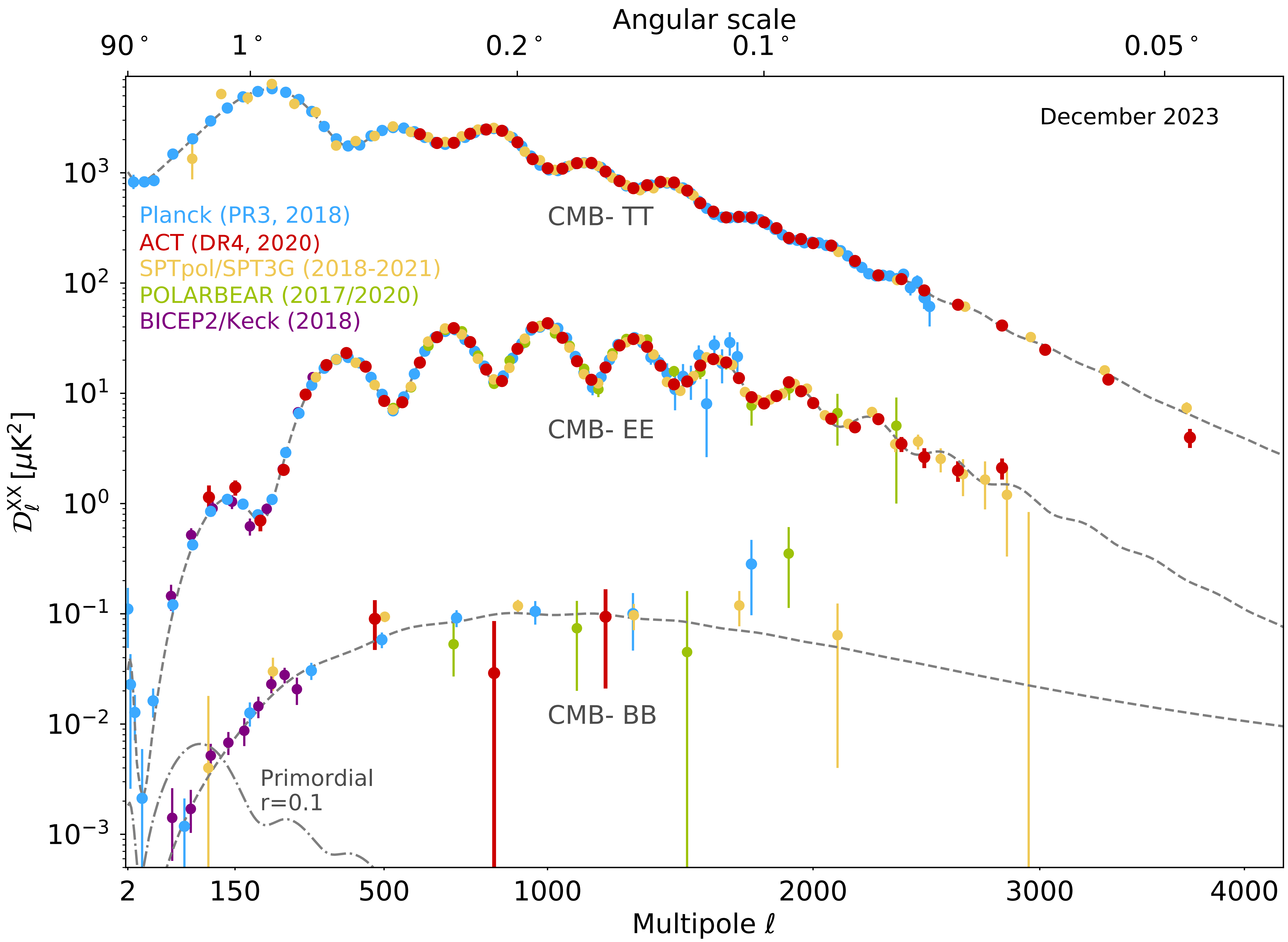
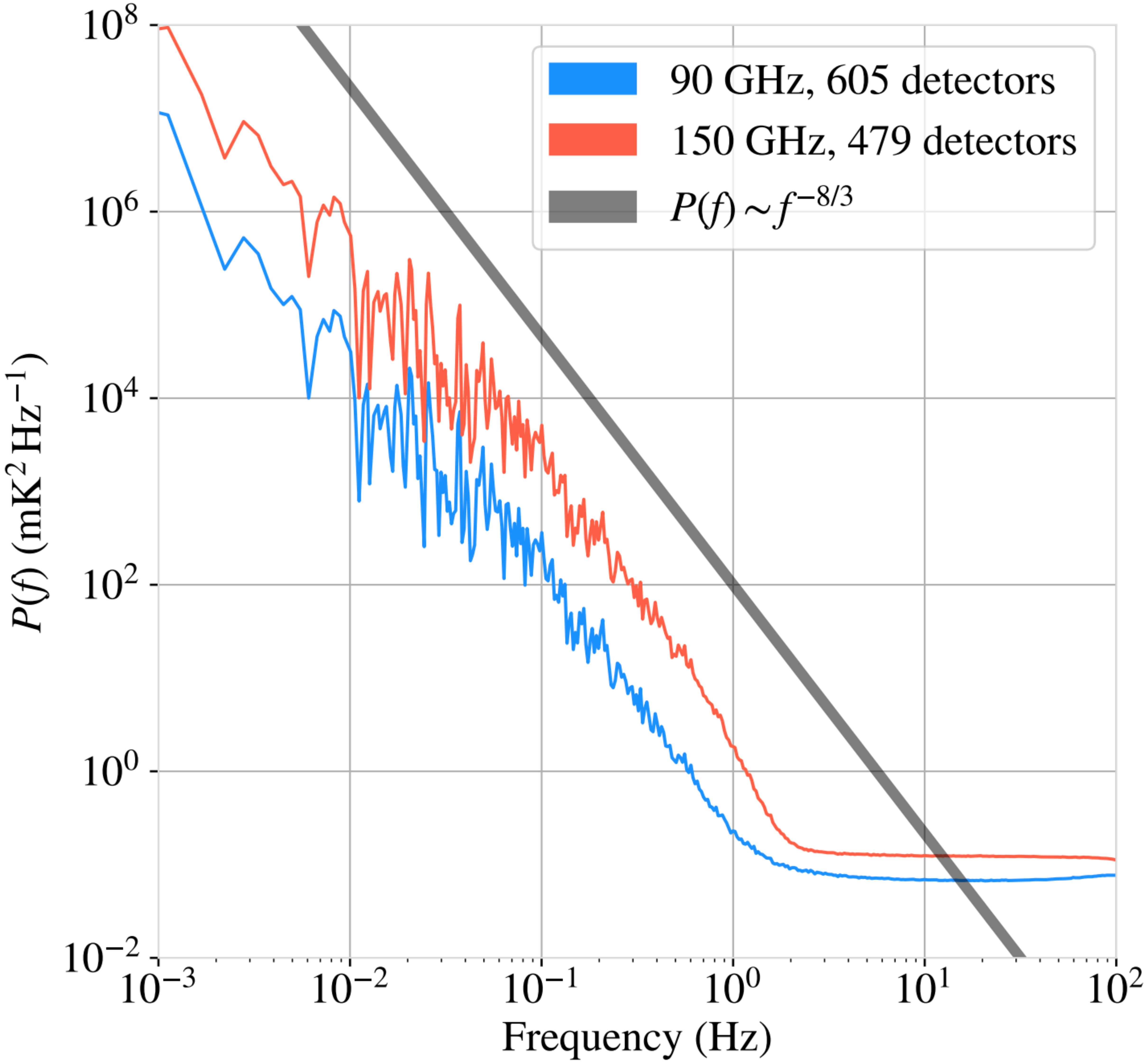


Fig by E. Calabrese

OBSERVING FROM THE GROUND



33 minutes of stare data for PA6

Morris et al. (2022), 2111.01319

MAPMAKING STRATEGY

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Solve for sky with iterative mapmaking
using all data simultaneously

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- Use cross-linking and detector-detector noise correlation structure to "optimally" suppress noise

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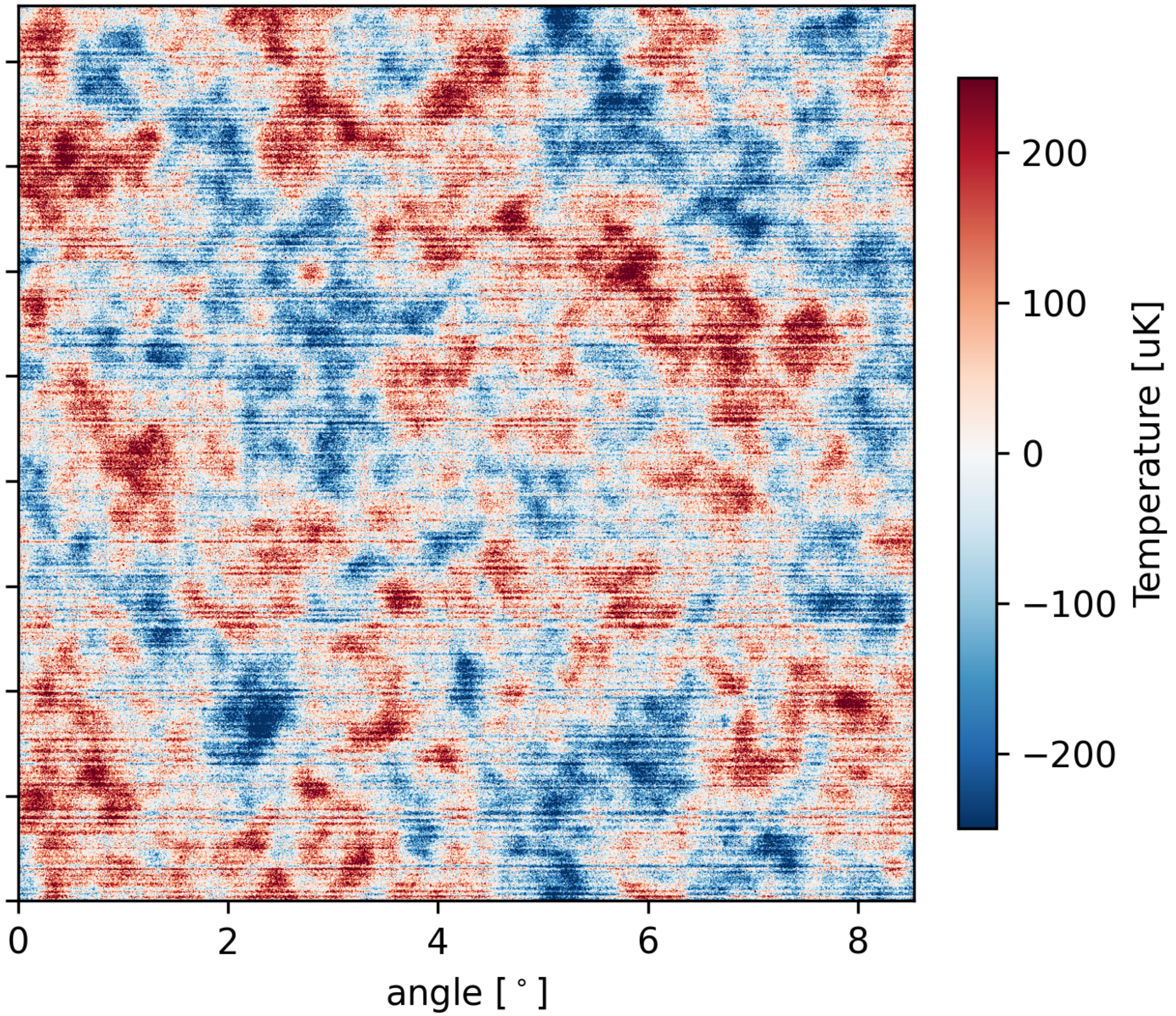

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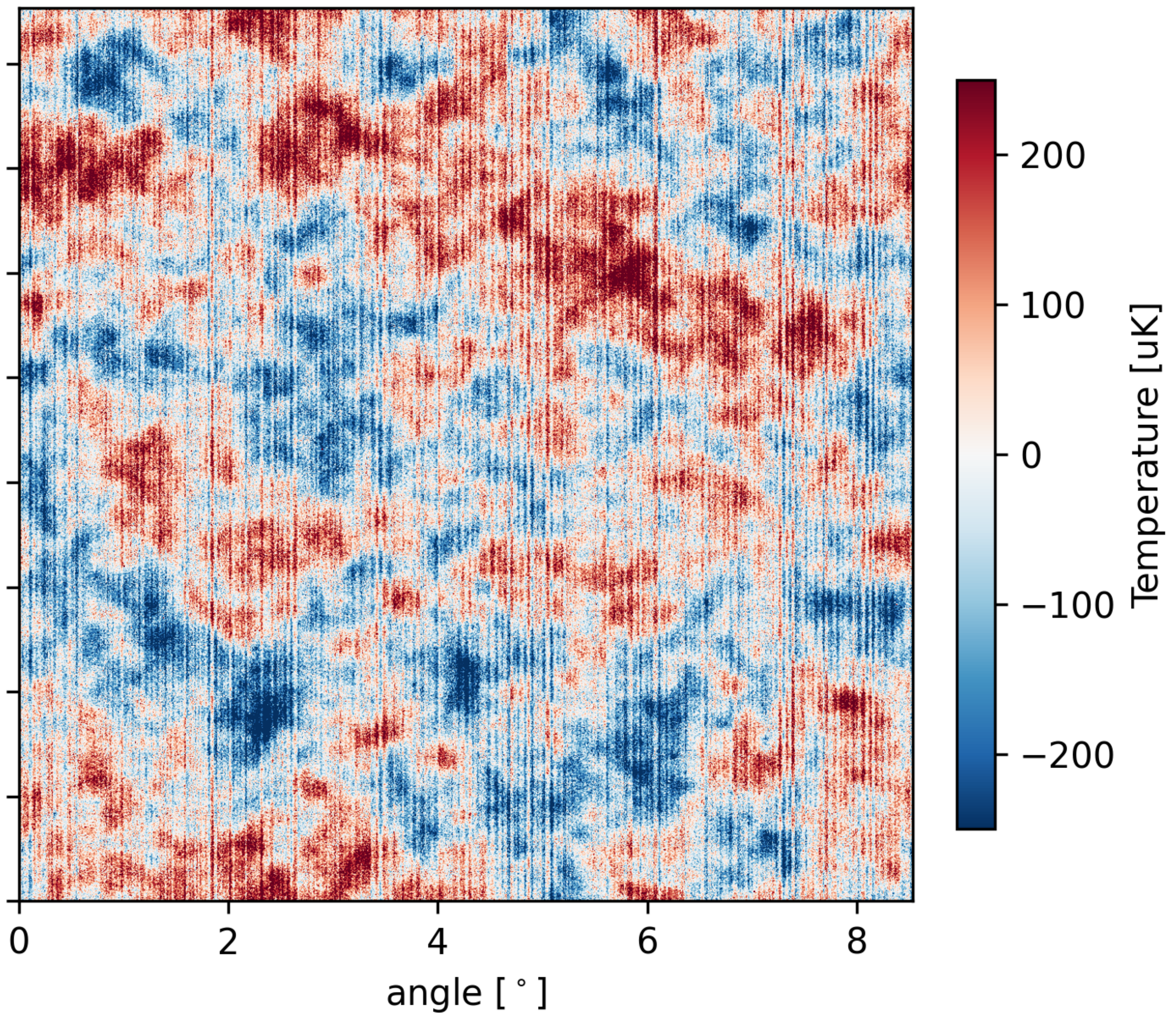

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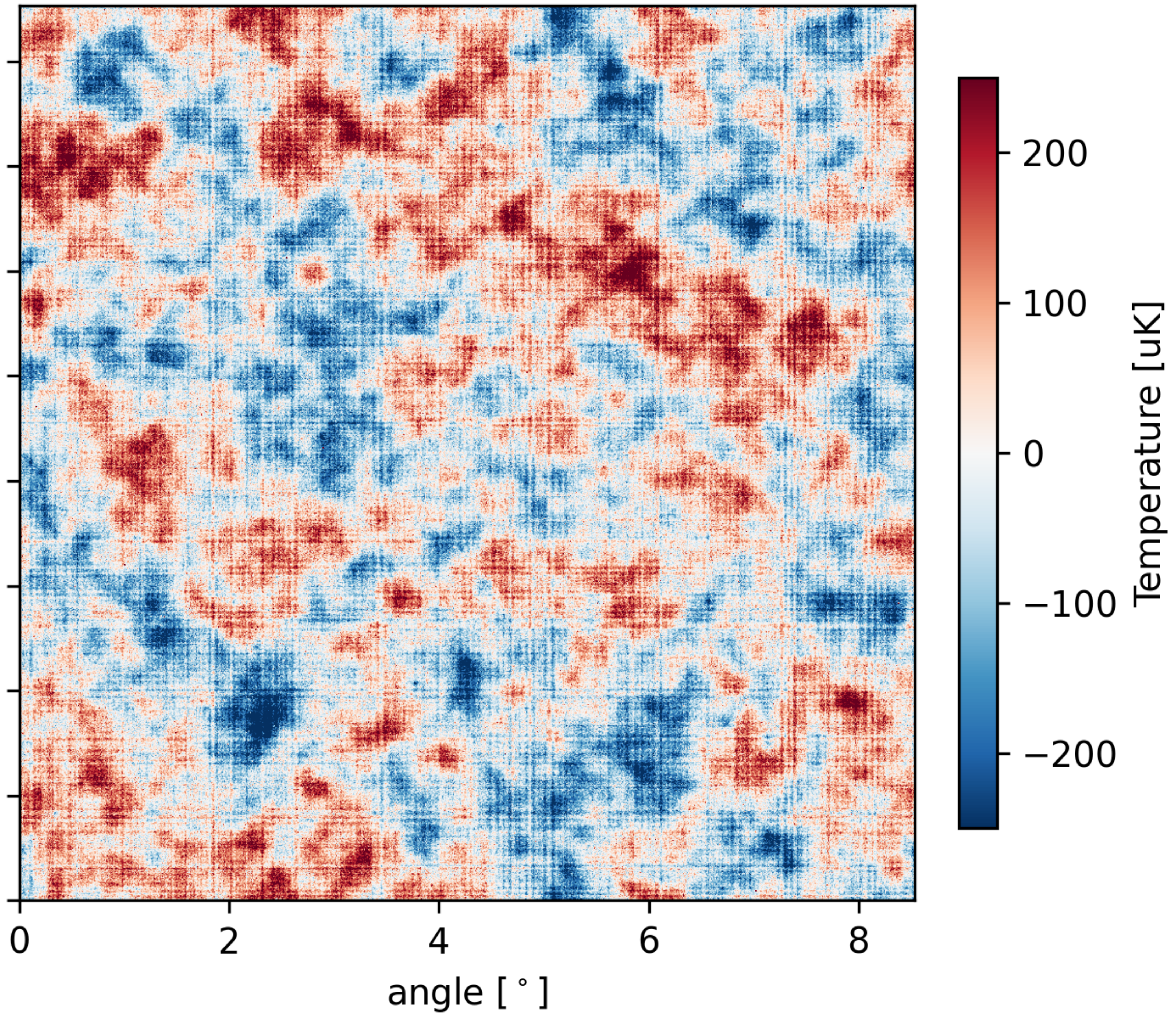

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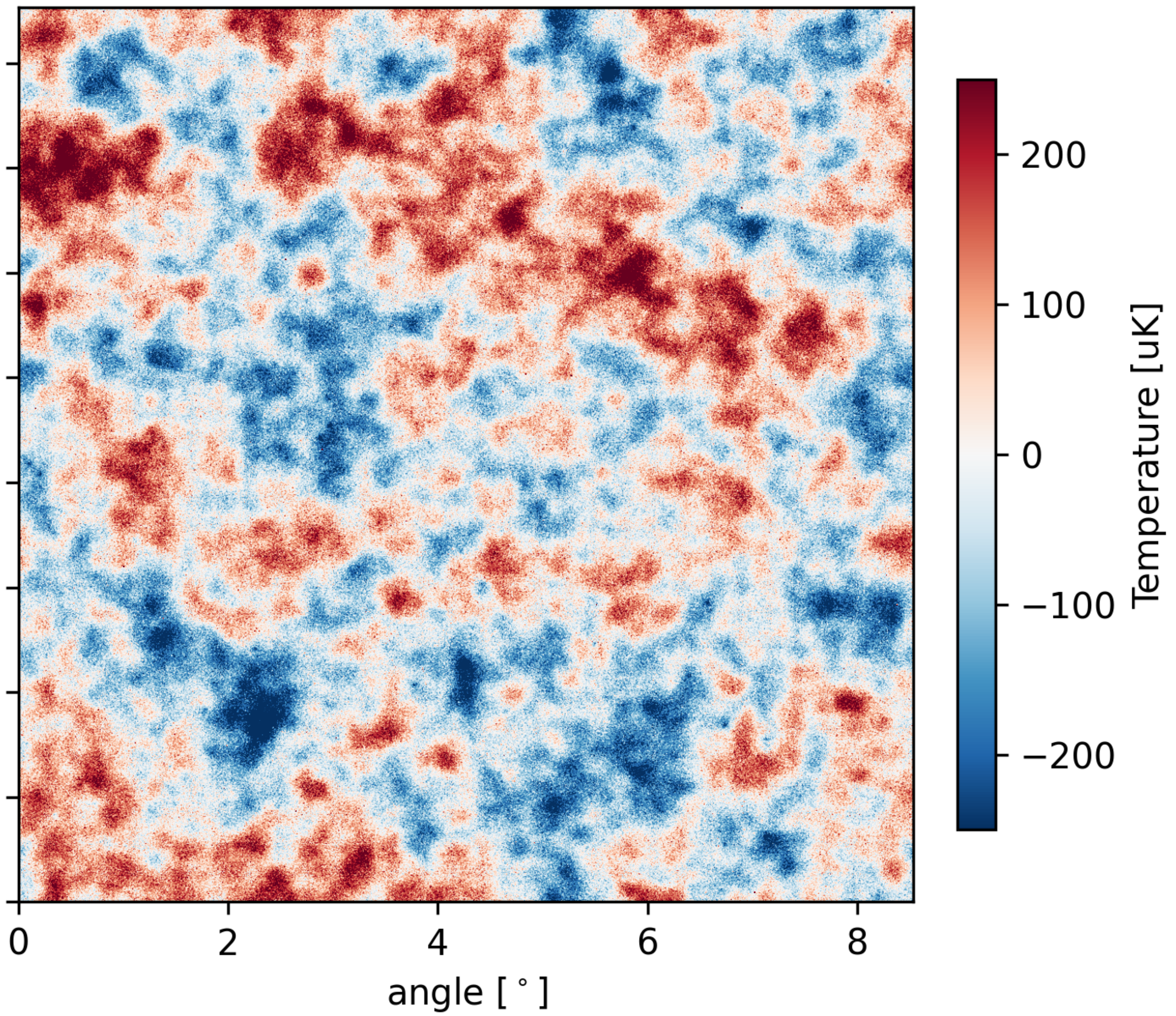
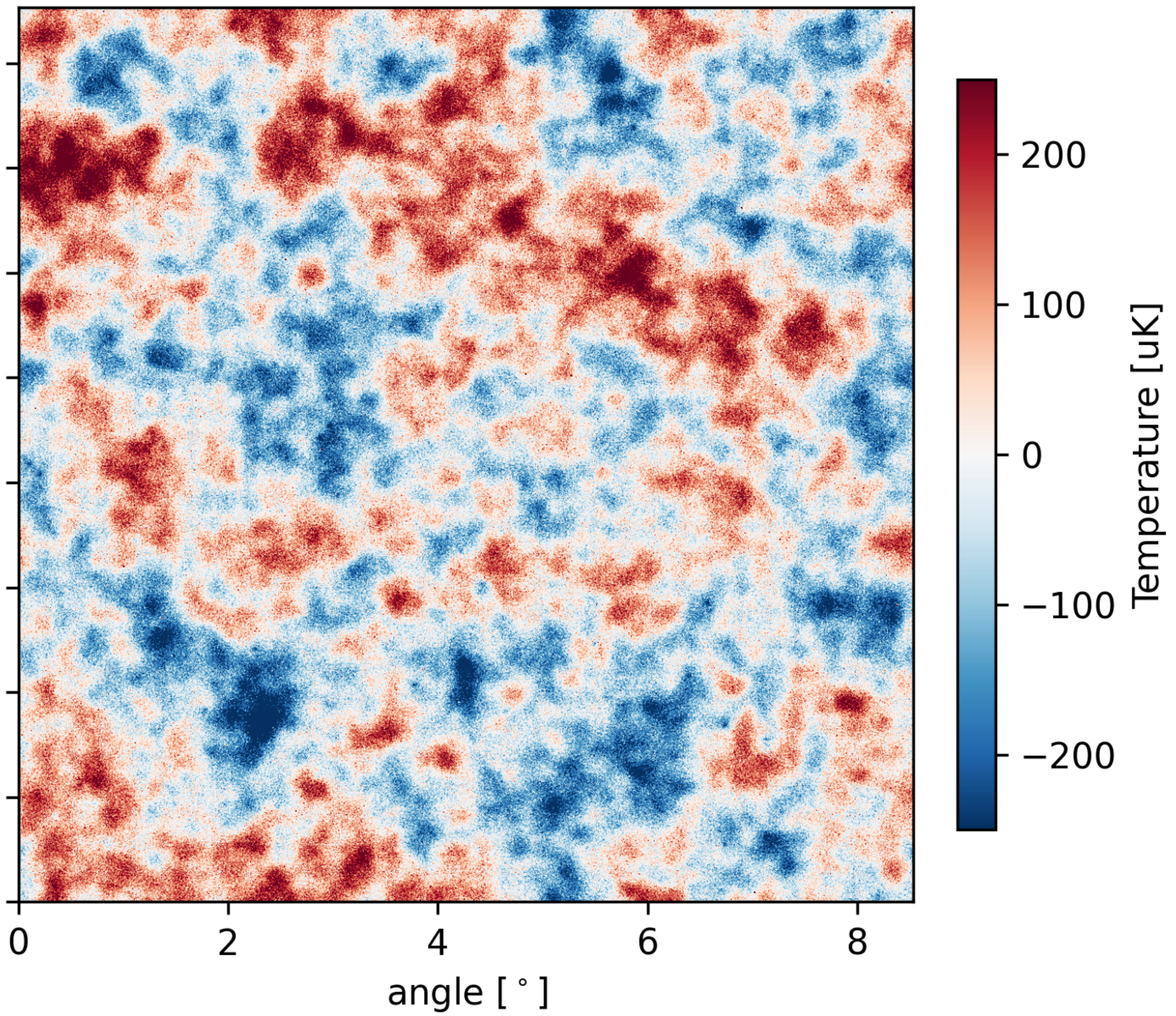


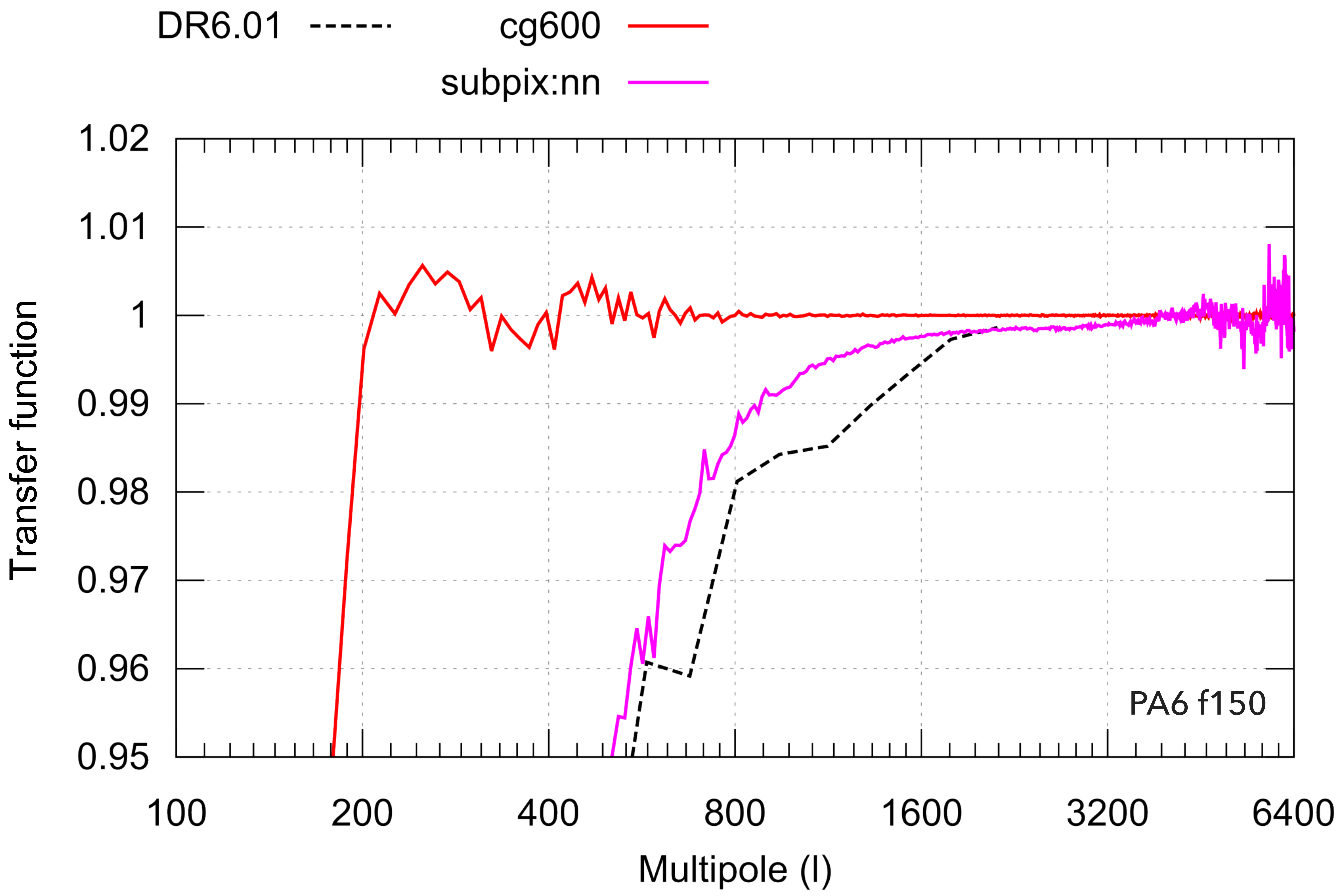
MAPMAKING STRATEGY

Solve for sky with iterative mapmaking using all data simultaneously

- Use cross-linking and detector-detector noise correlation structure to "optimally" suppress noise
- No ad hoc filtering: unbiased maps
- Not feasible to compute large sets of of end-to-end simulations
- Complicated noise in resulting maps



MAPMAKING SYSTEMATICS



Naess et al, 2025 (2503.14451)

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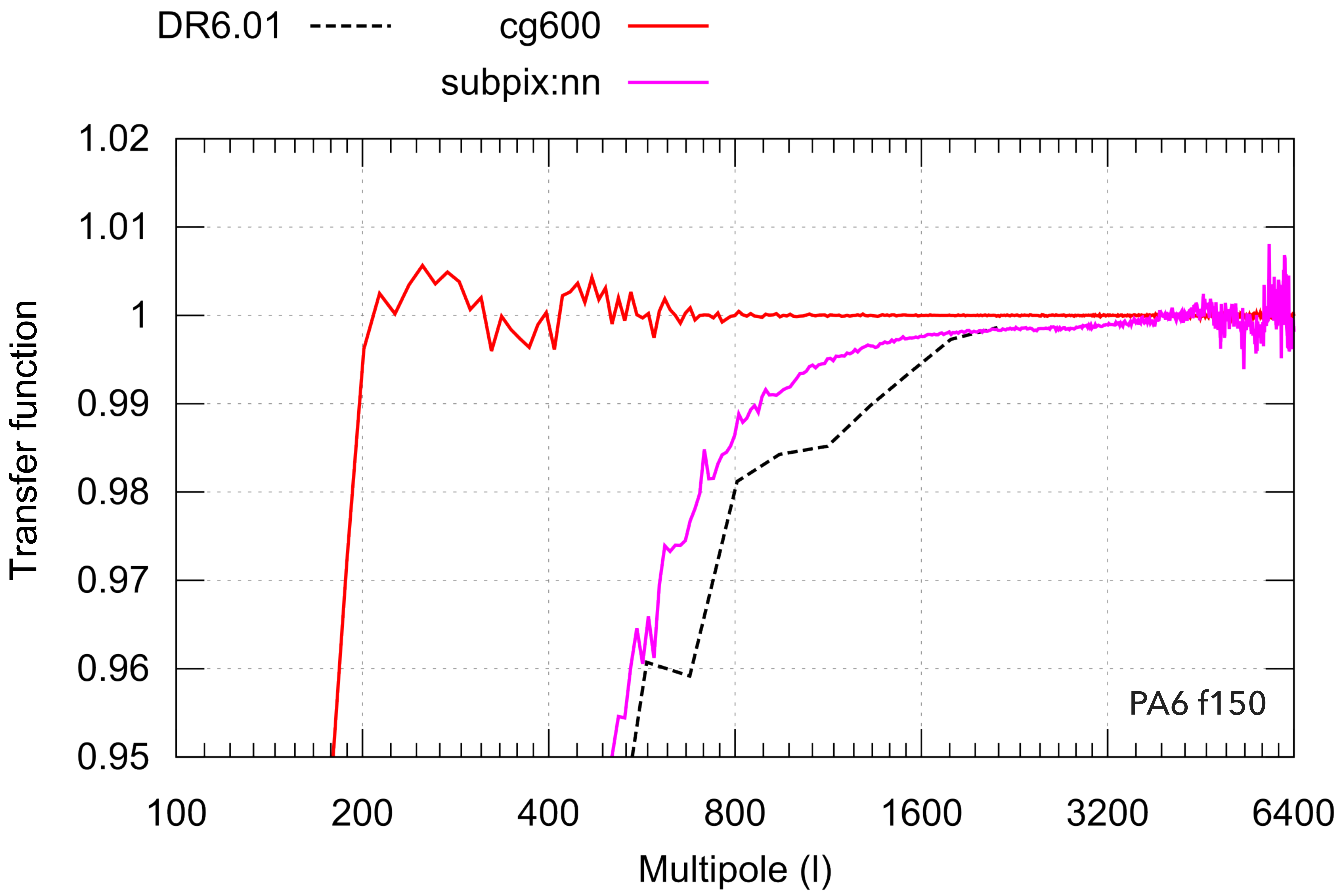

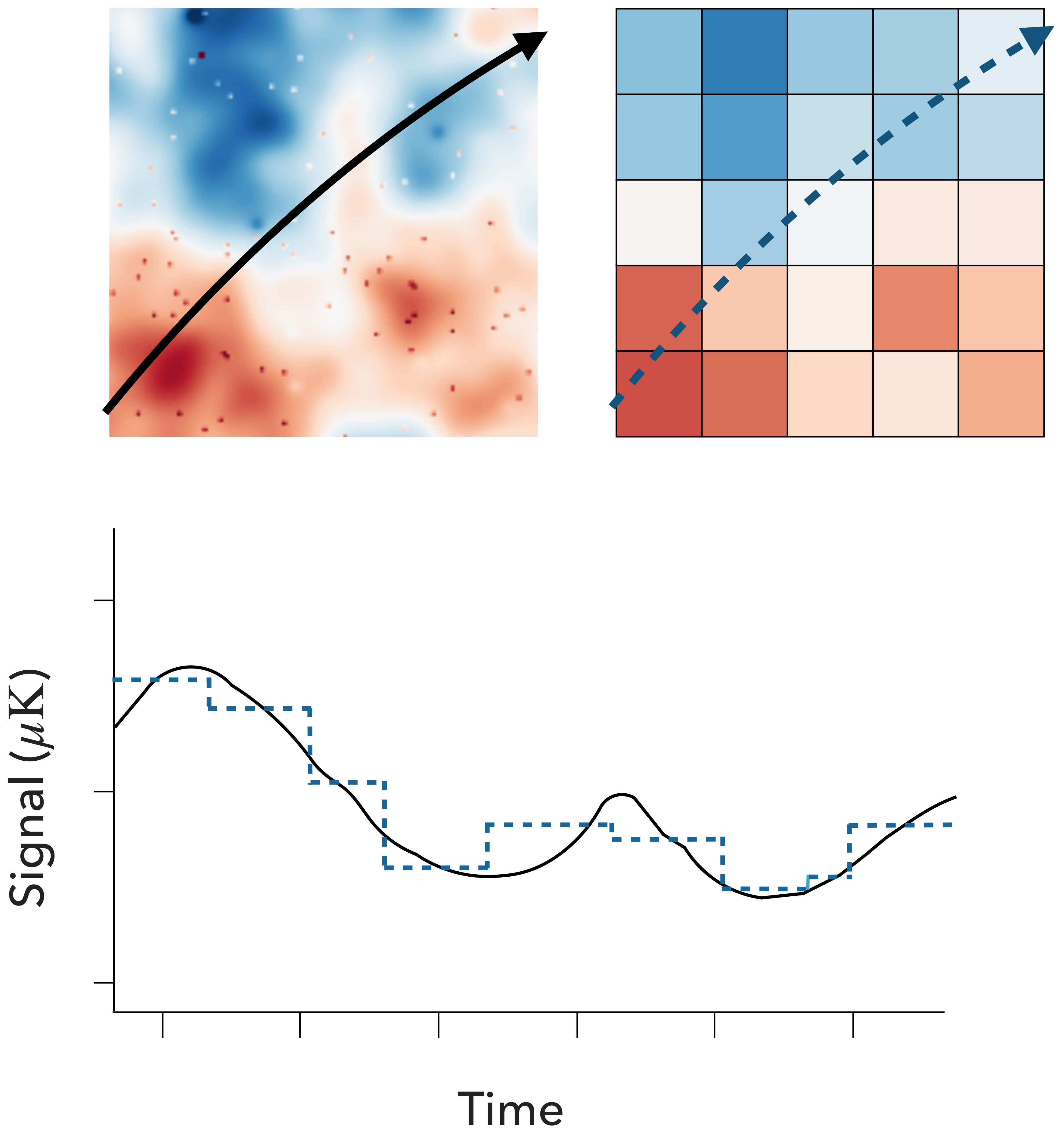

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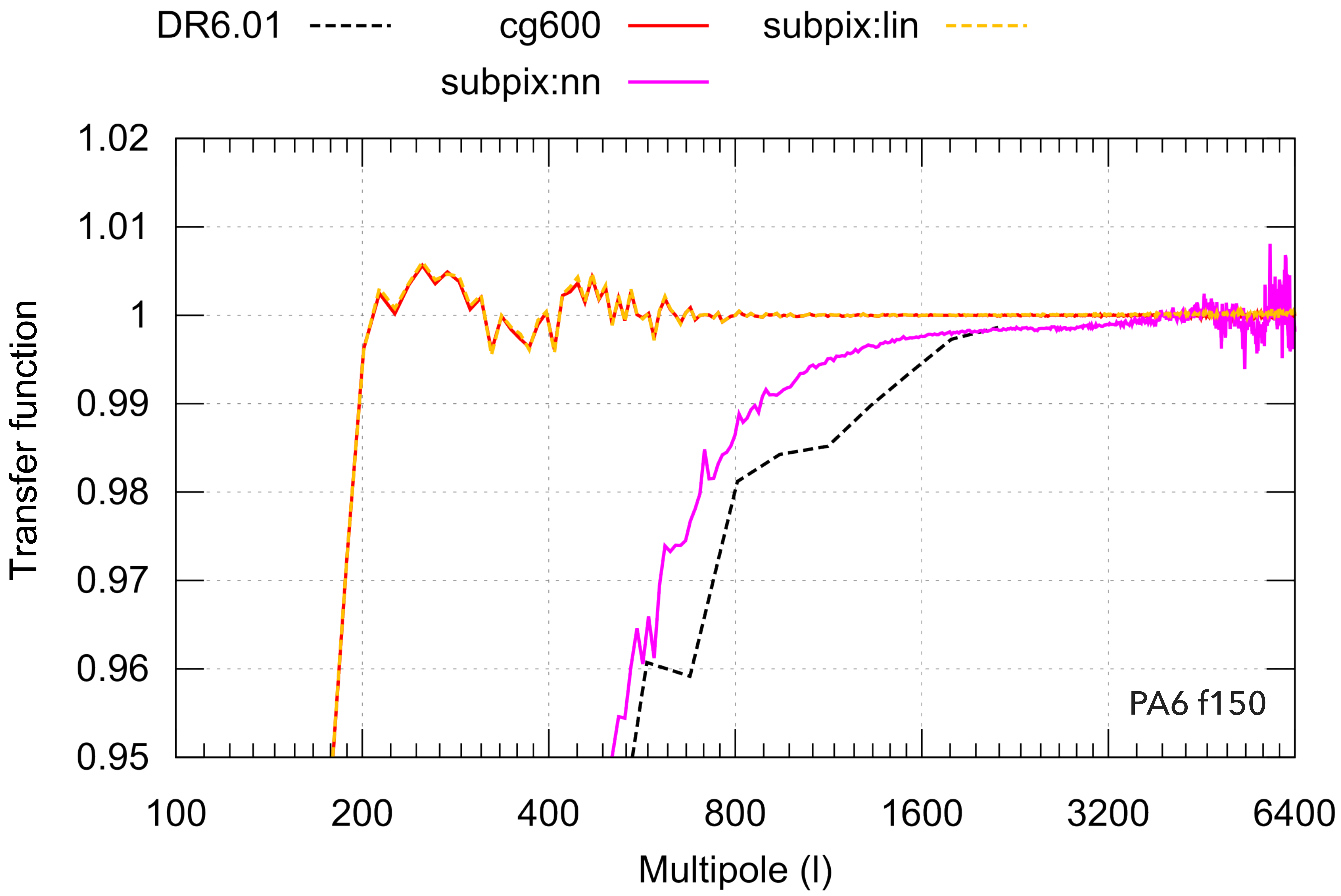

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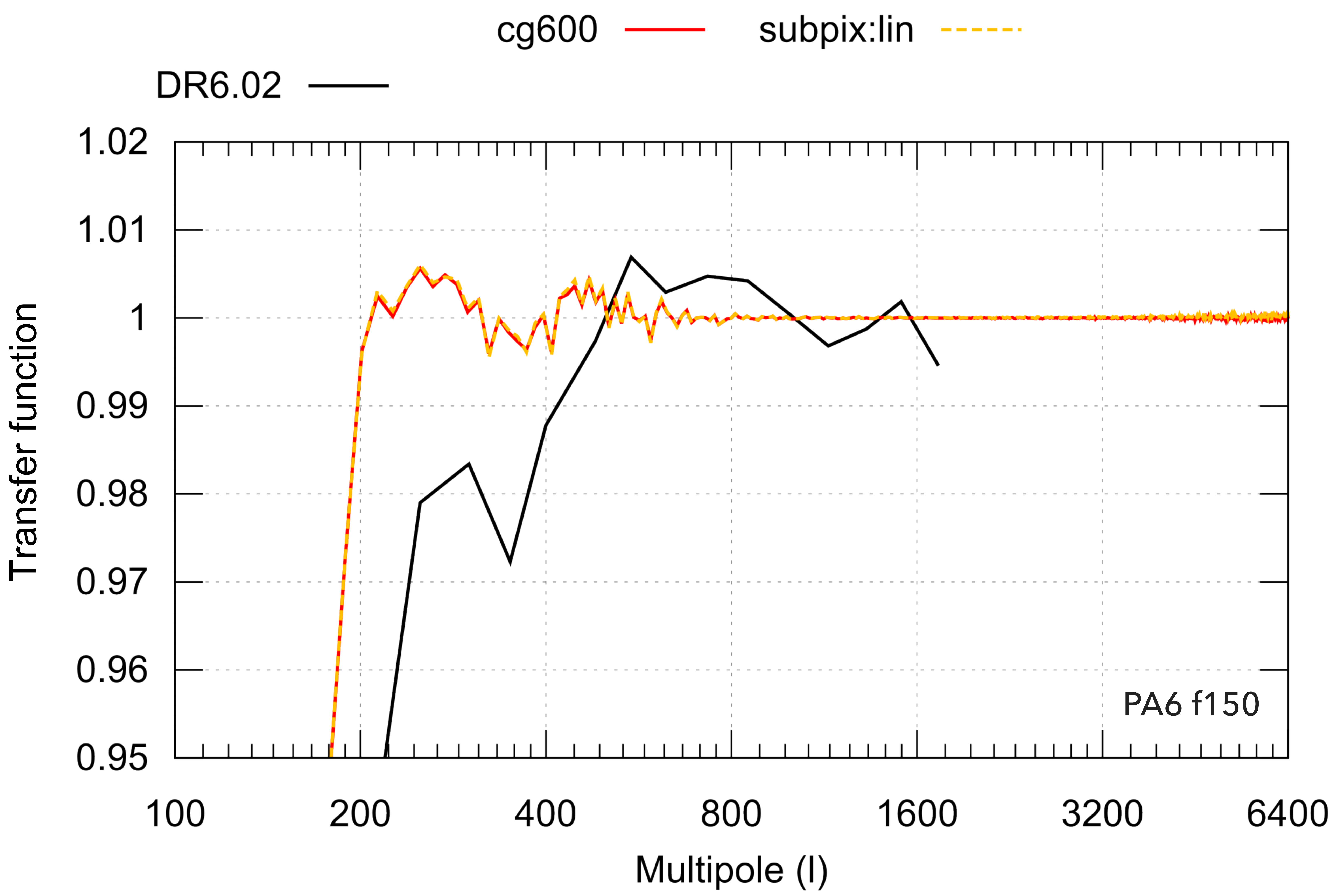

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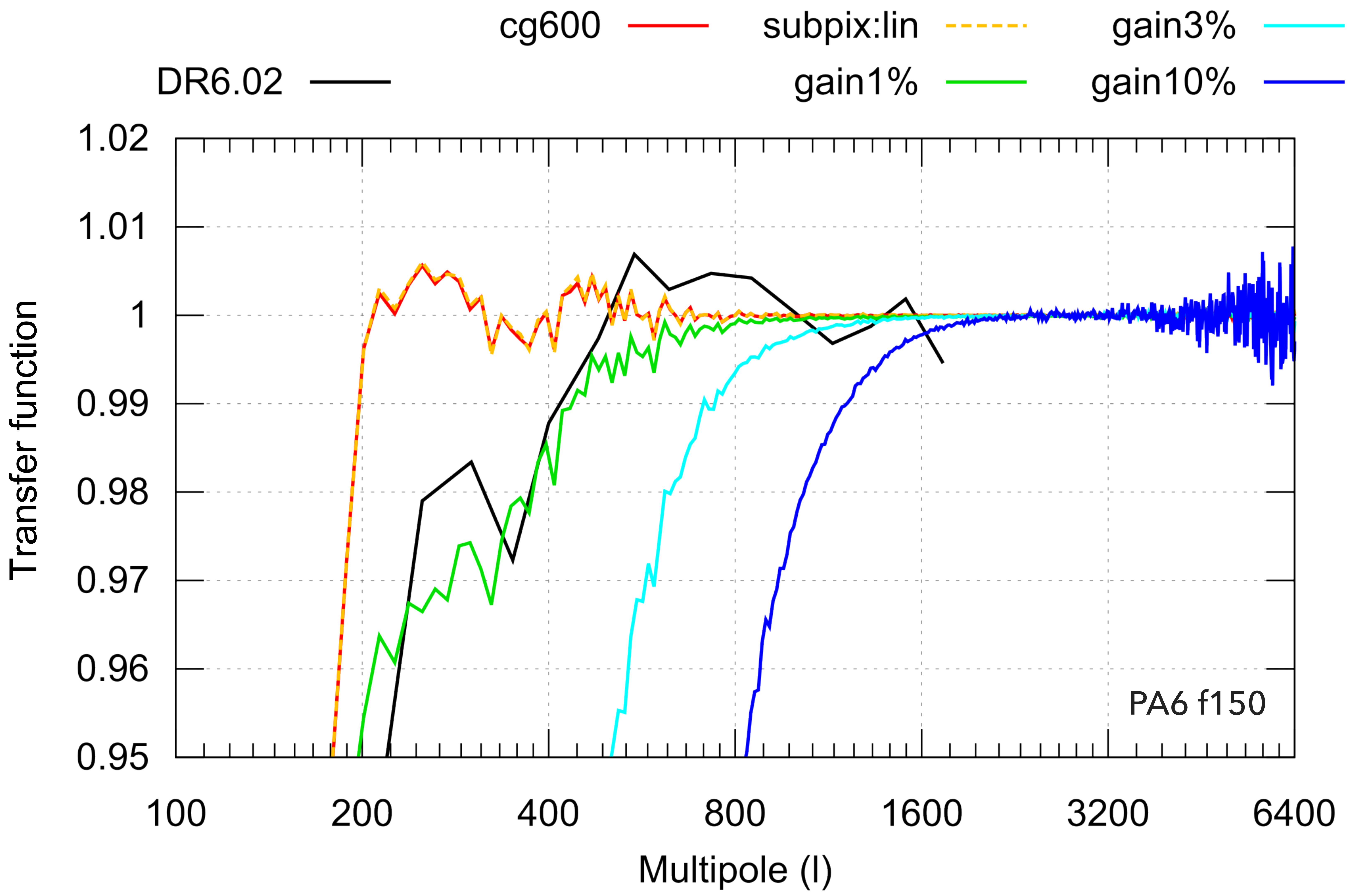

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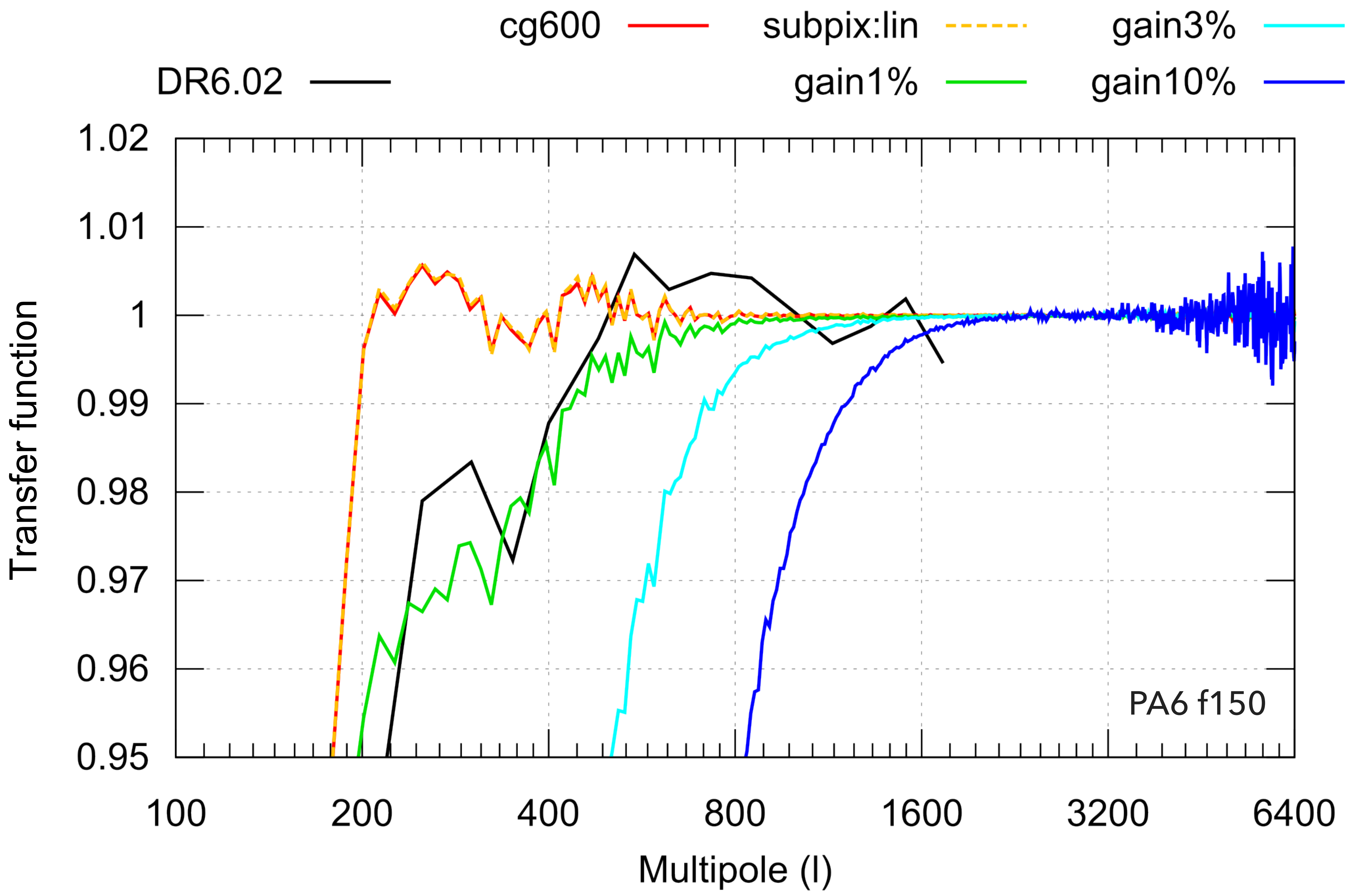

Final transfer function consistent with ~1% relative gain errors between detectors. Good enough for our science case

Improvements will likely require dedicated calibration hardware

Naess et al, 2025 (2503.14451)

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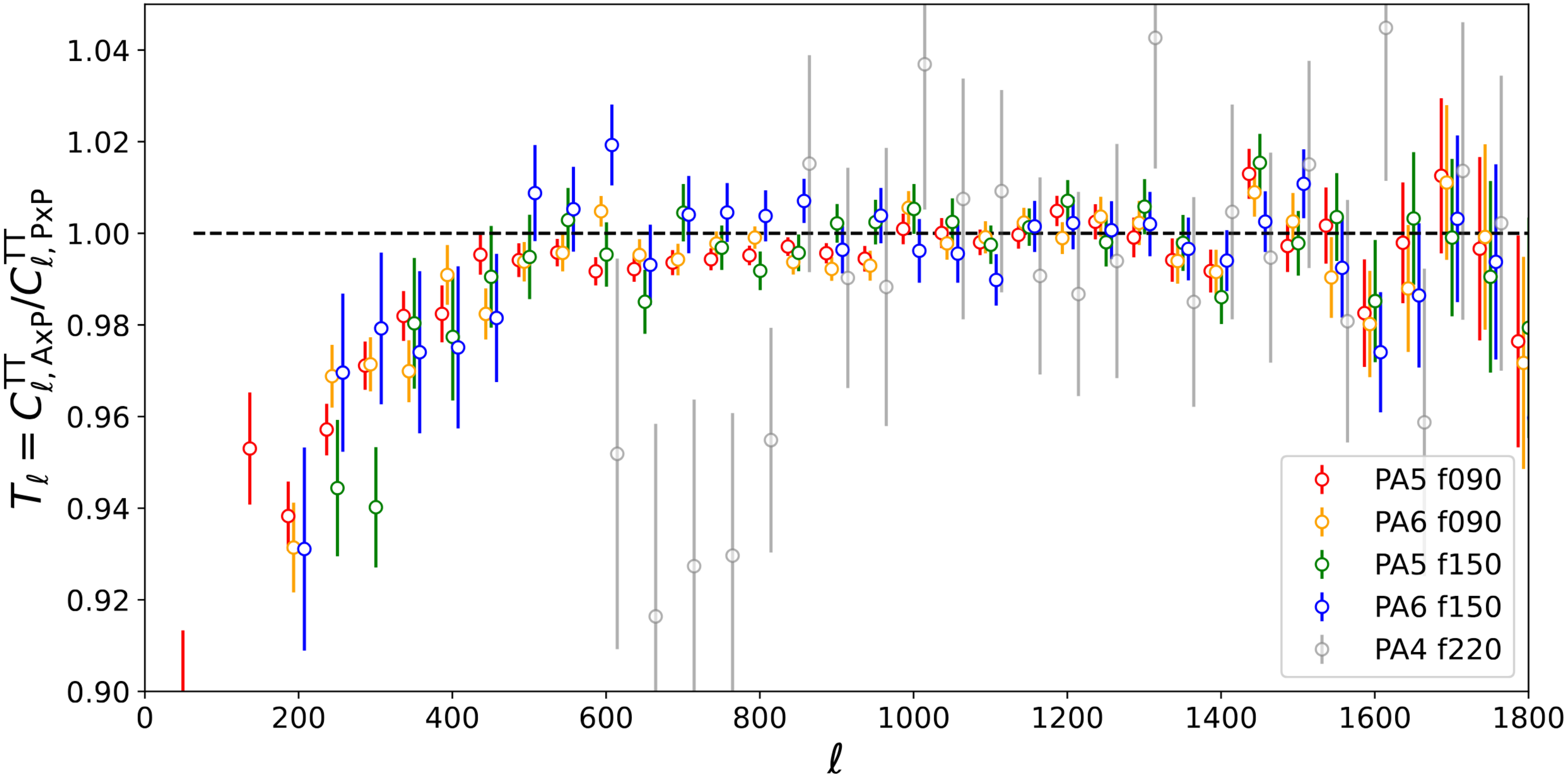
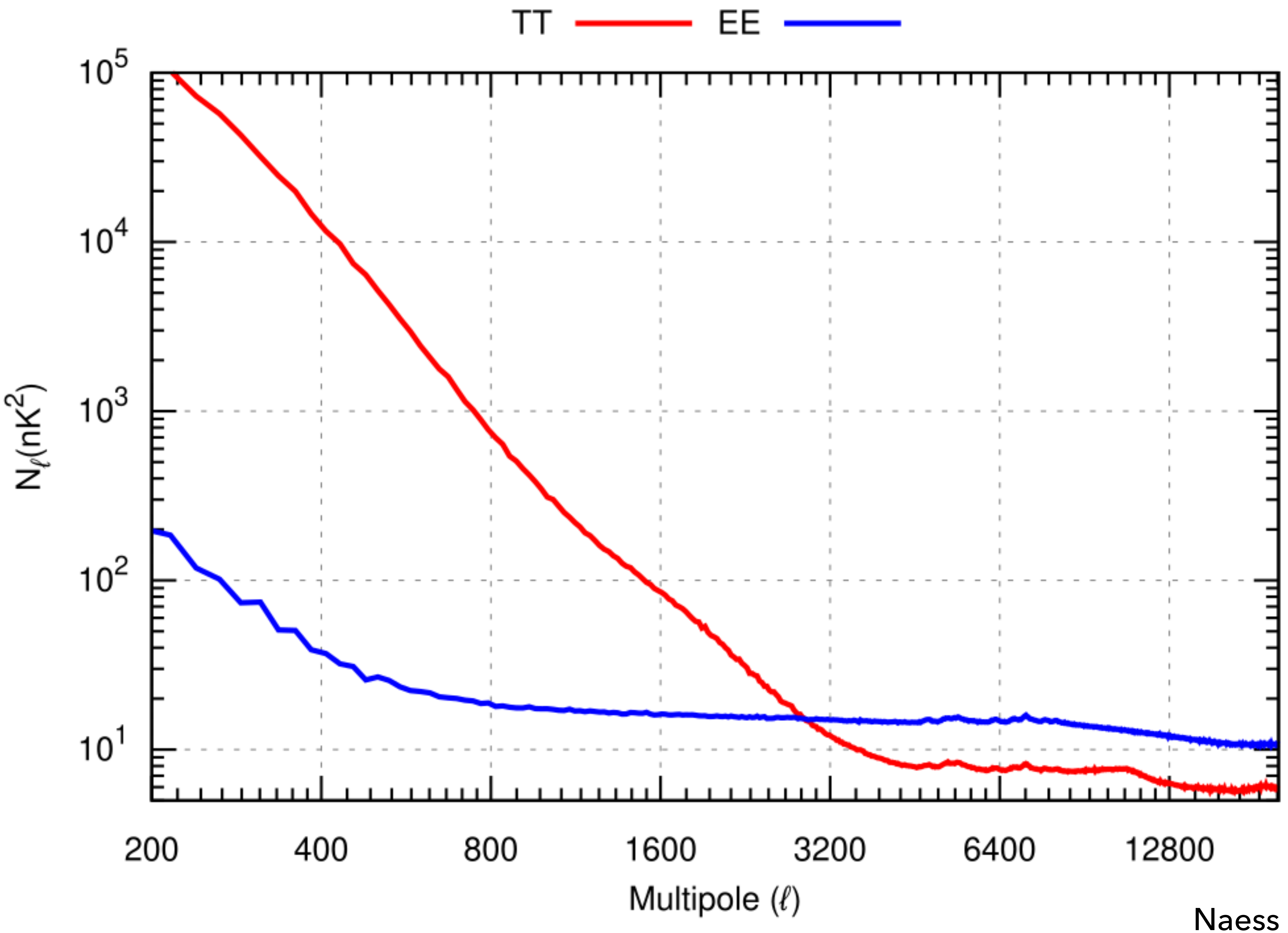


Louis et al, 2025 (2503.14452)

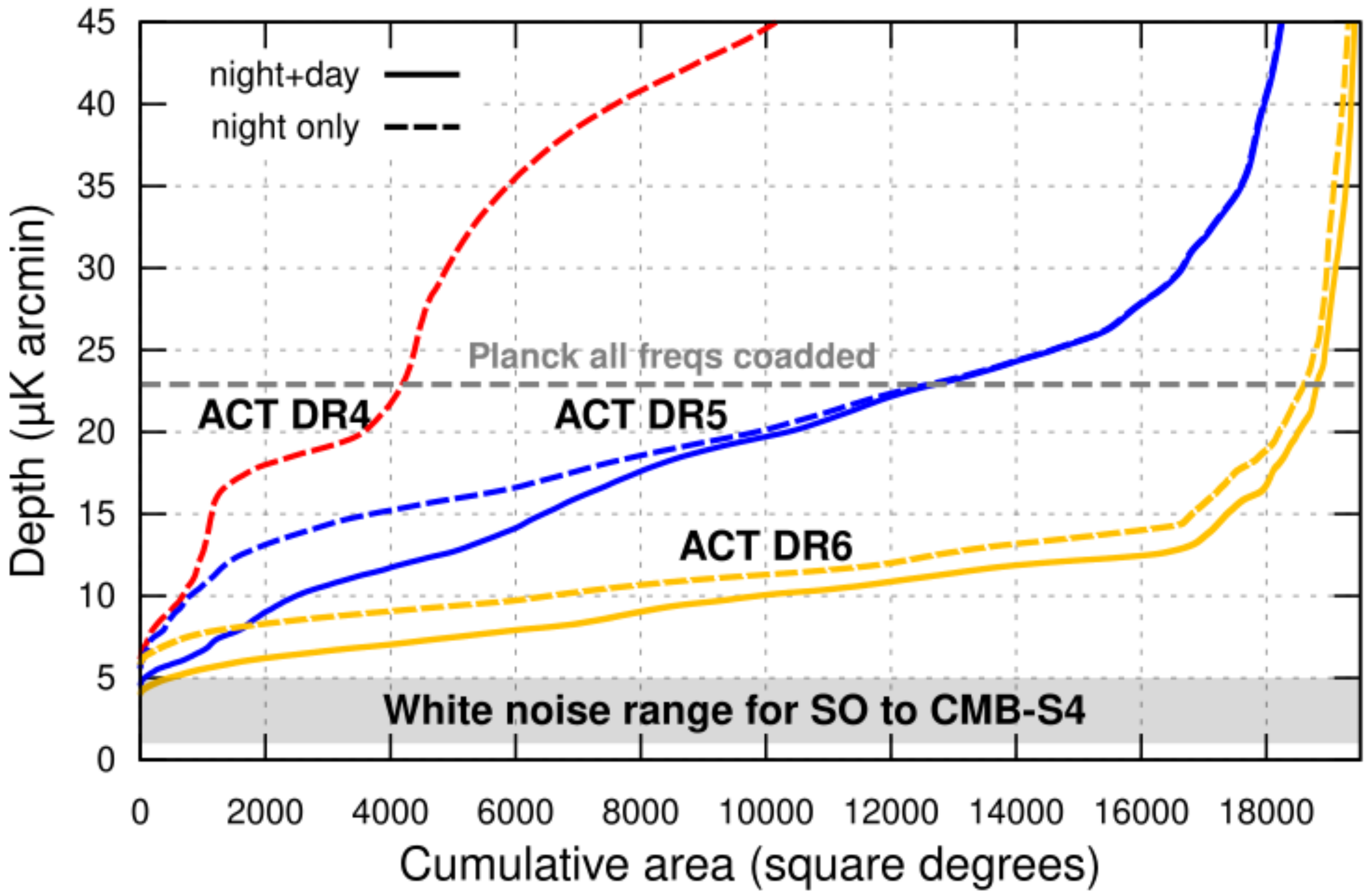
NOISE POWER SPECTRA



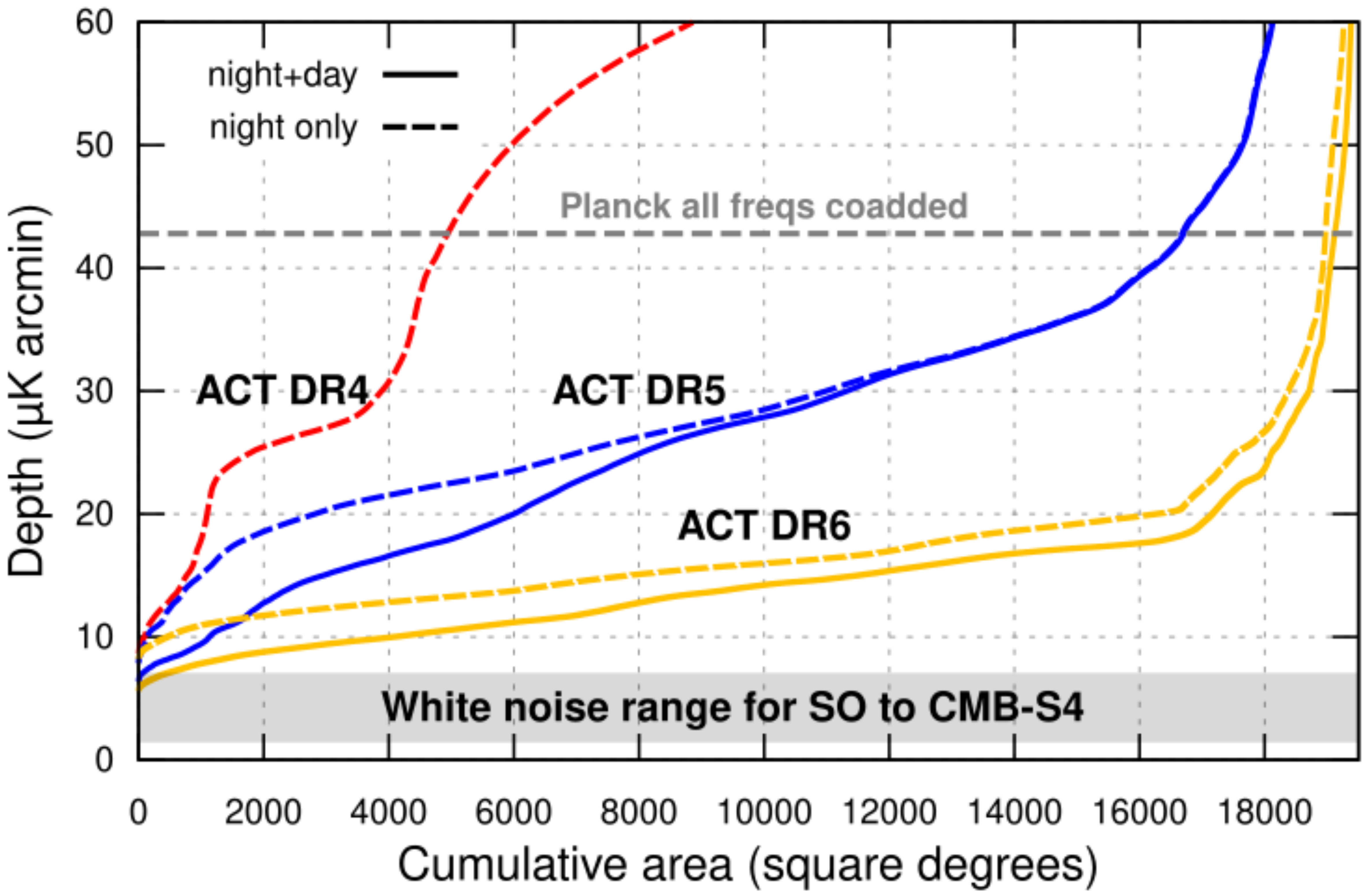
Naess et al, 2025 (2503.14451)

WHITE NOISE LEVELS

Total intensity

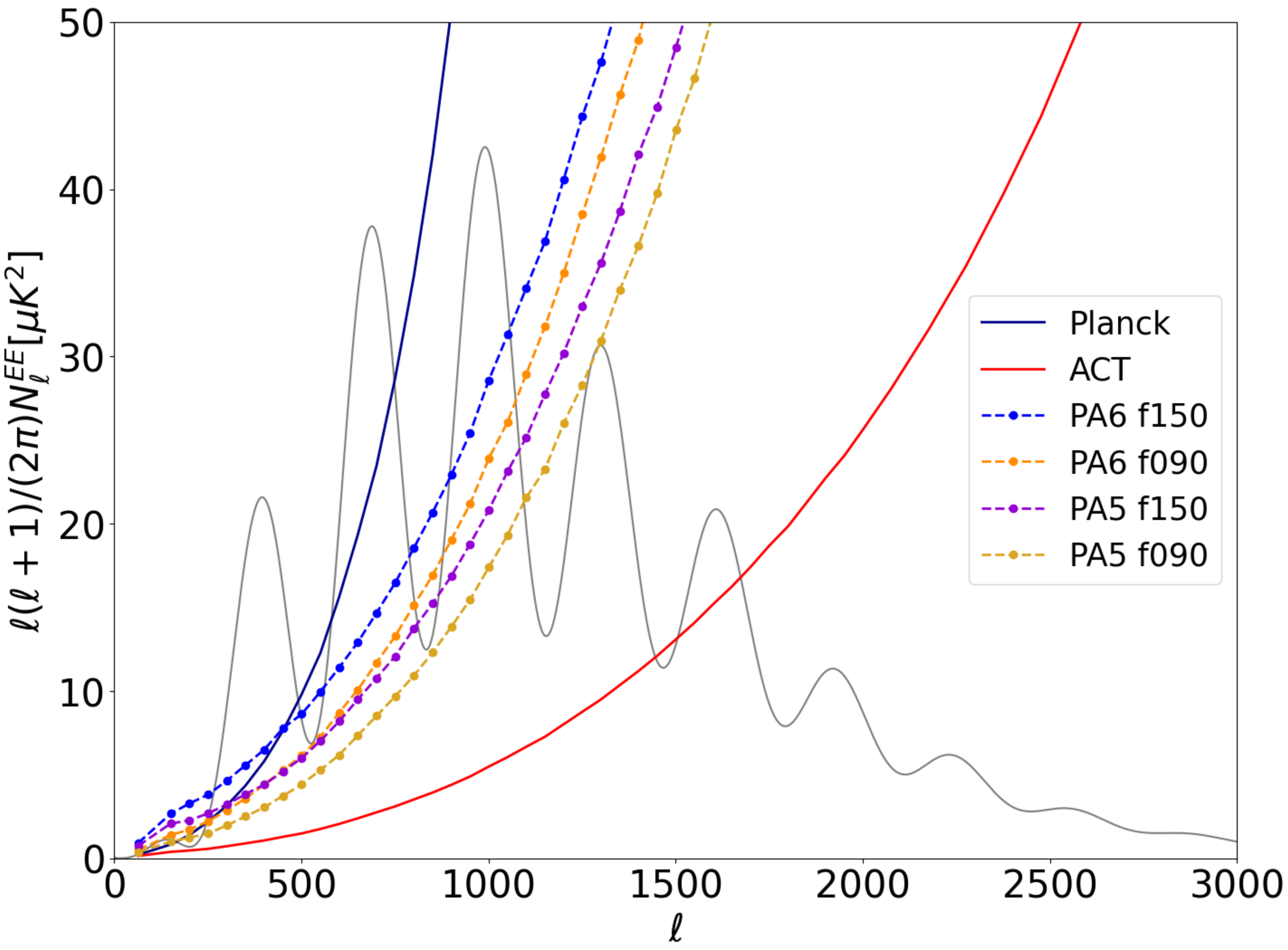


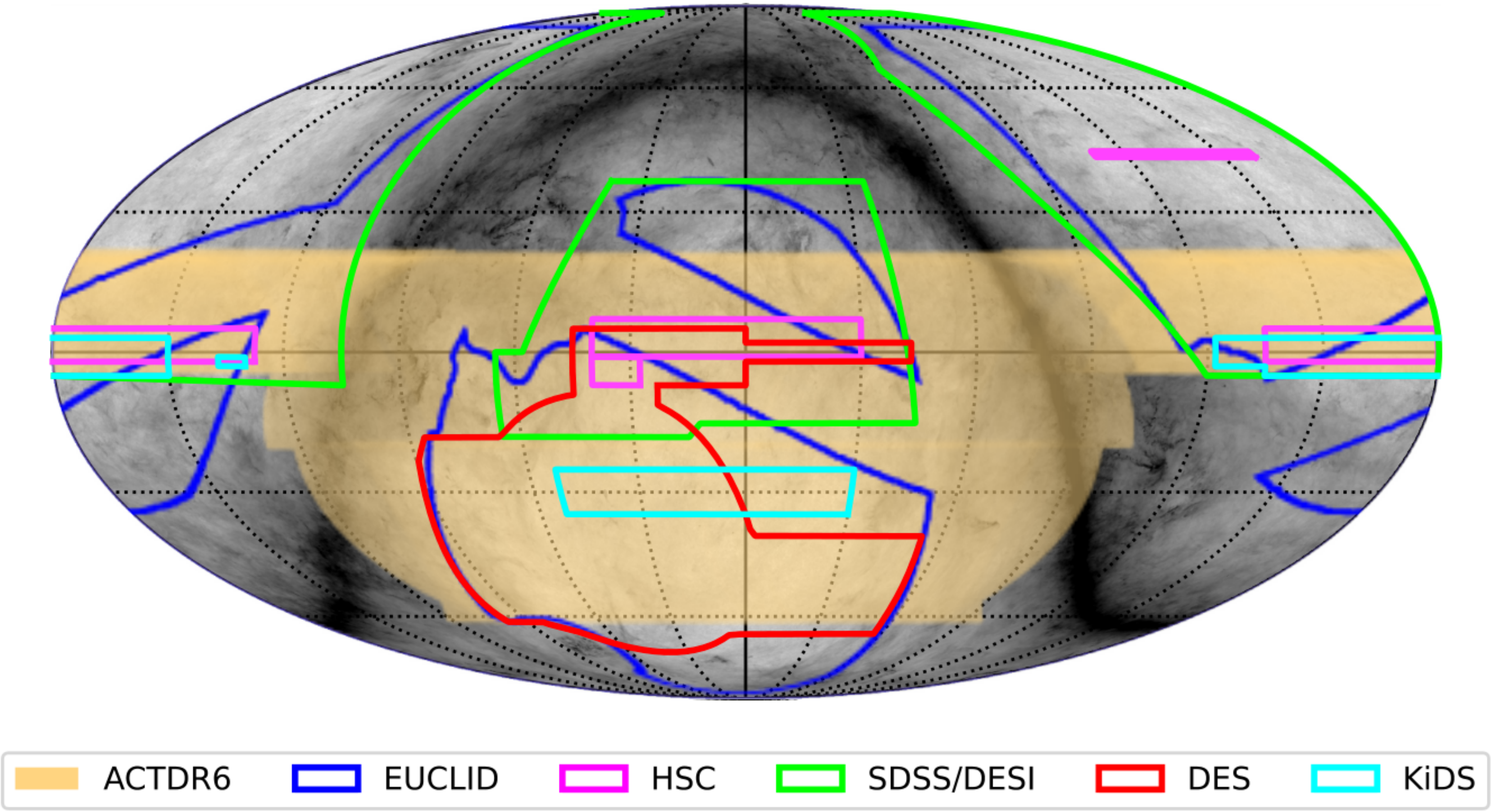
Polarization



Naess et al, 2025 (2503.14451)

POLARIZATION NOISE





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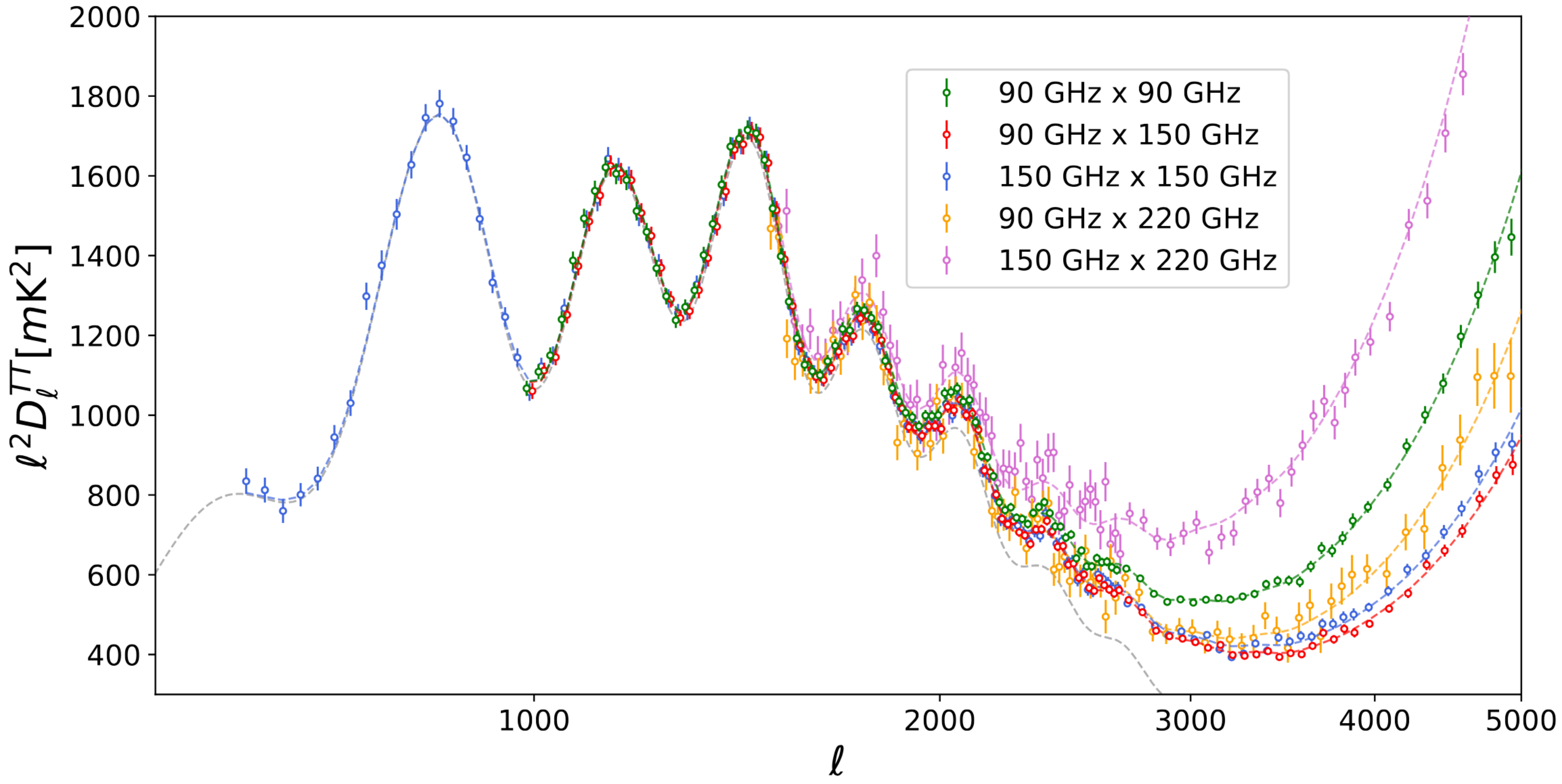

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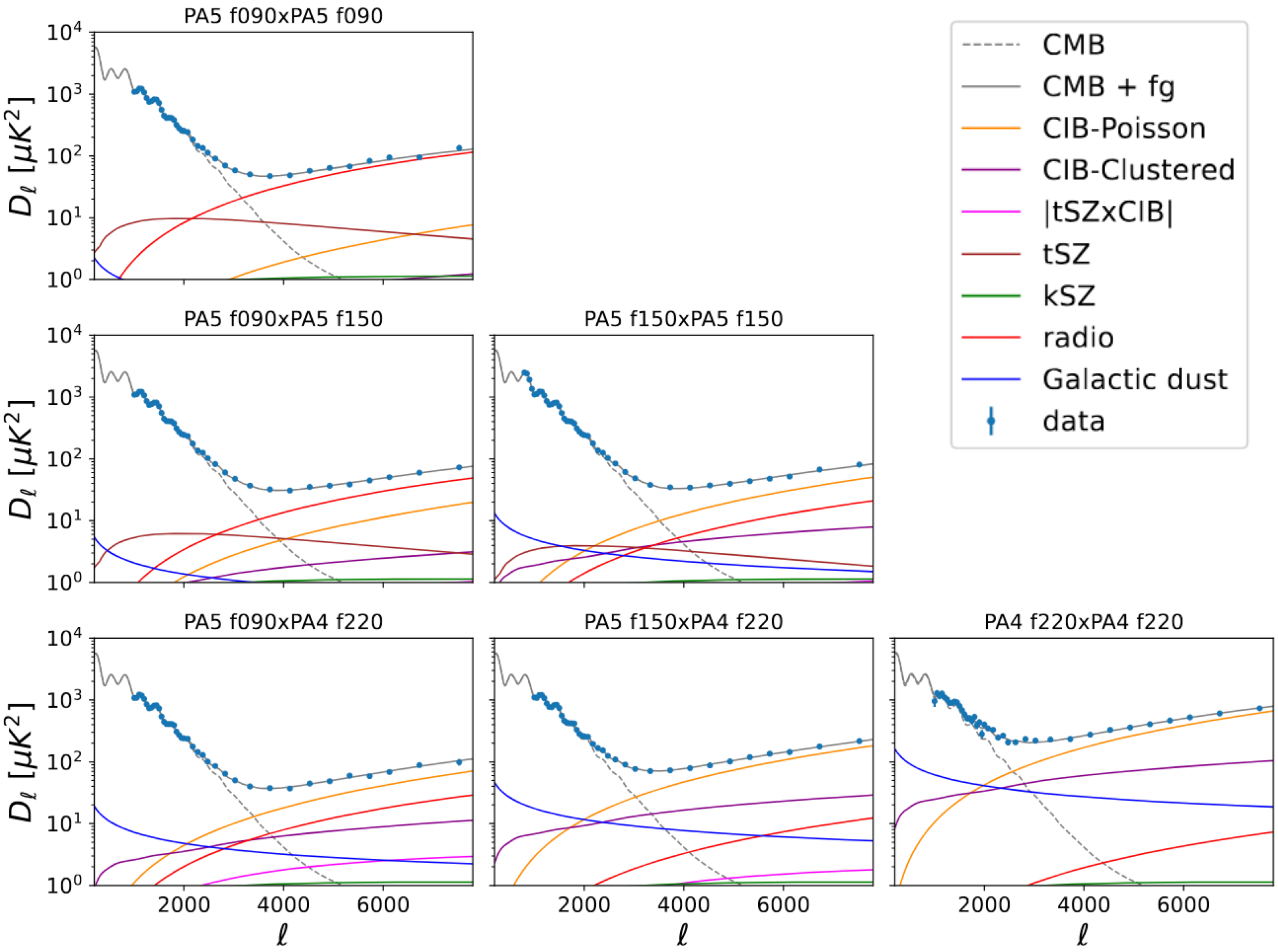

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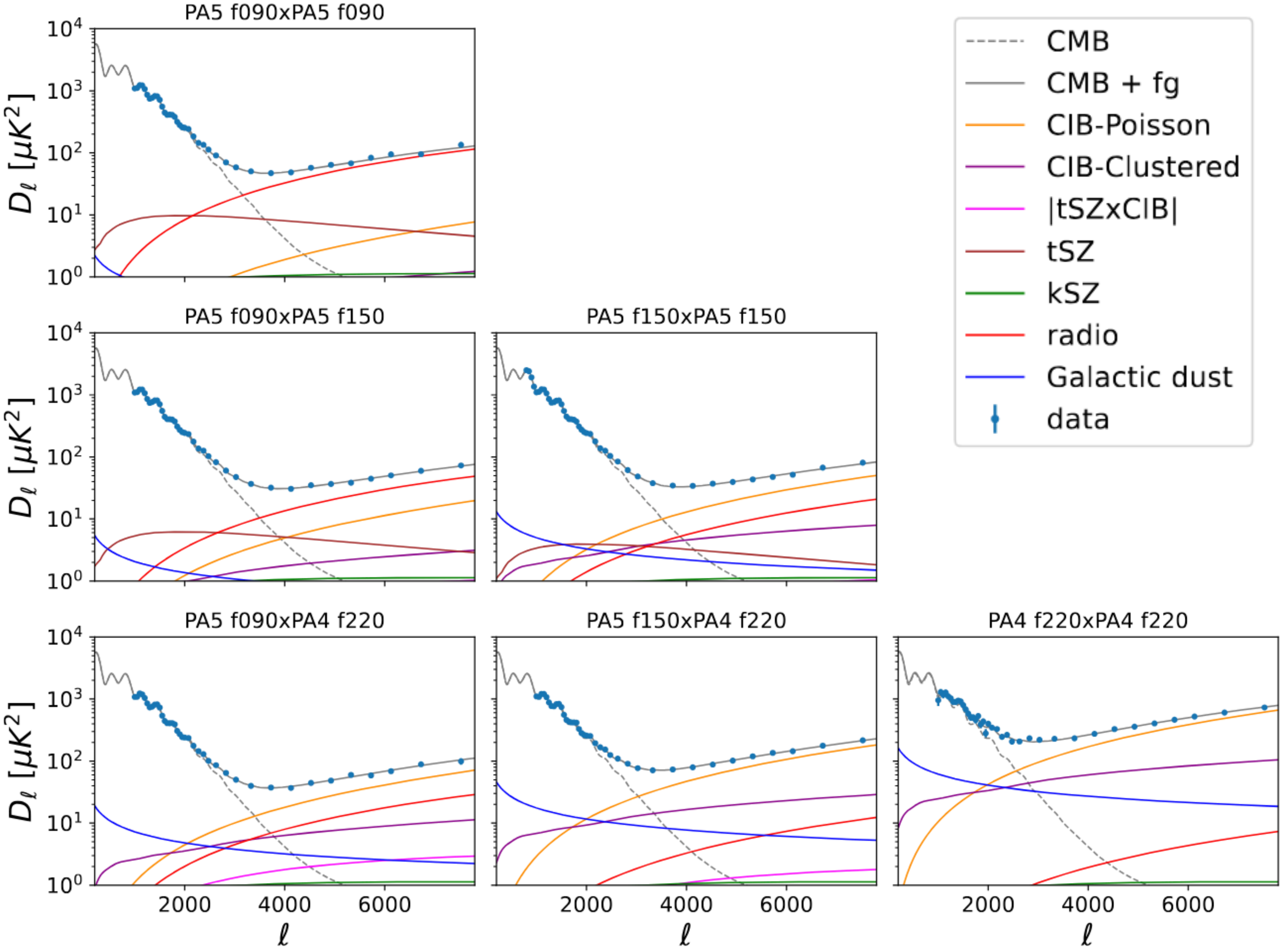
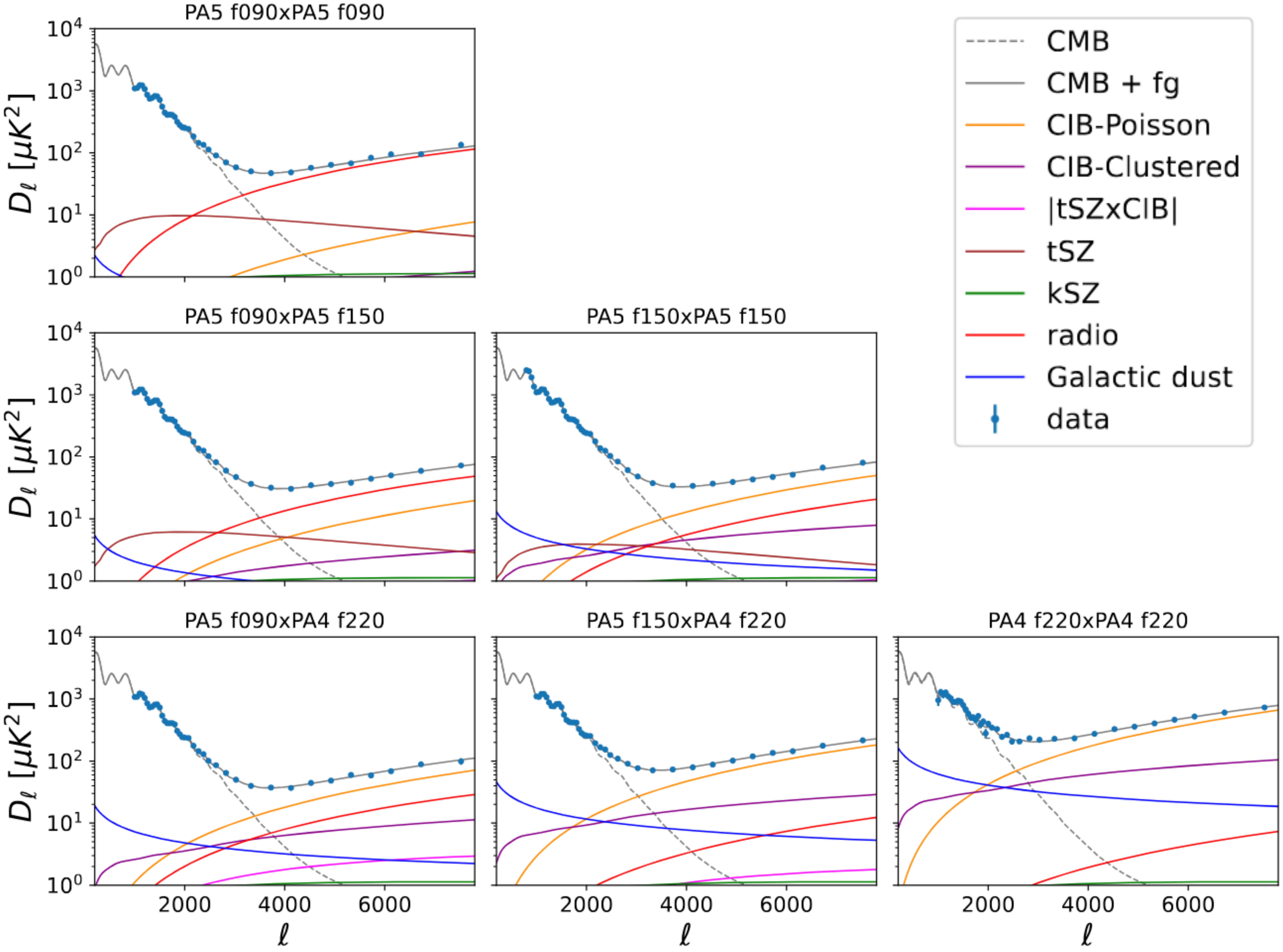


Foreground model with 14 free parameters

Louis et al, 2025 (2503.14452)



Foreground model with 14 free parameters

- TT: 9, EE: 2, TE : 2, common: 1

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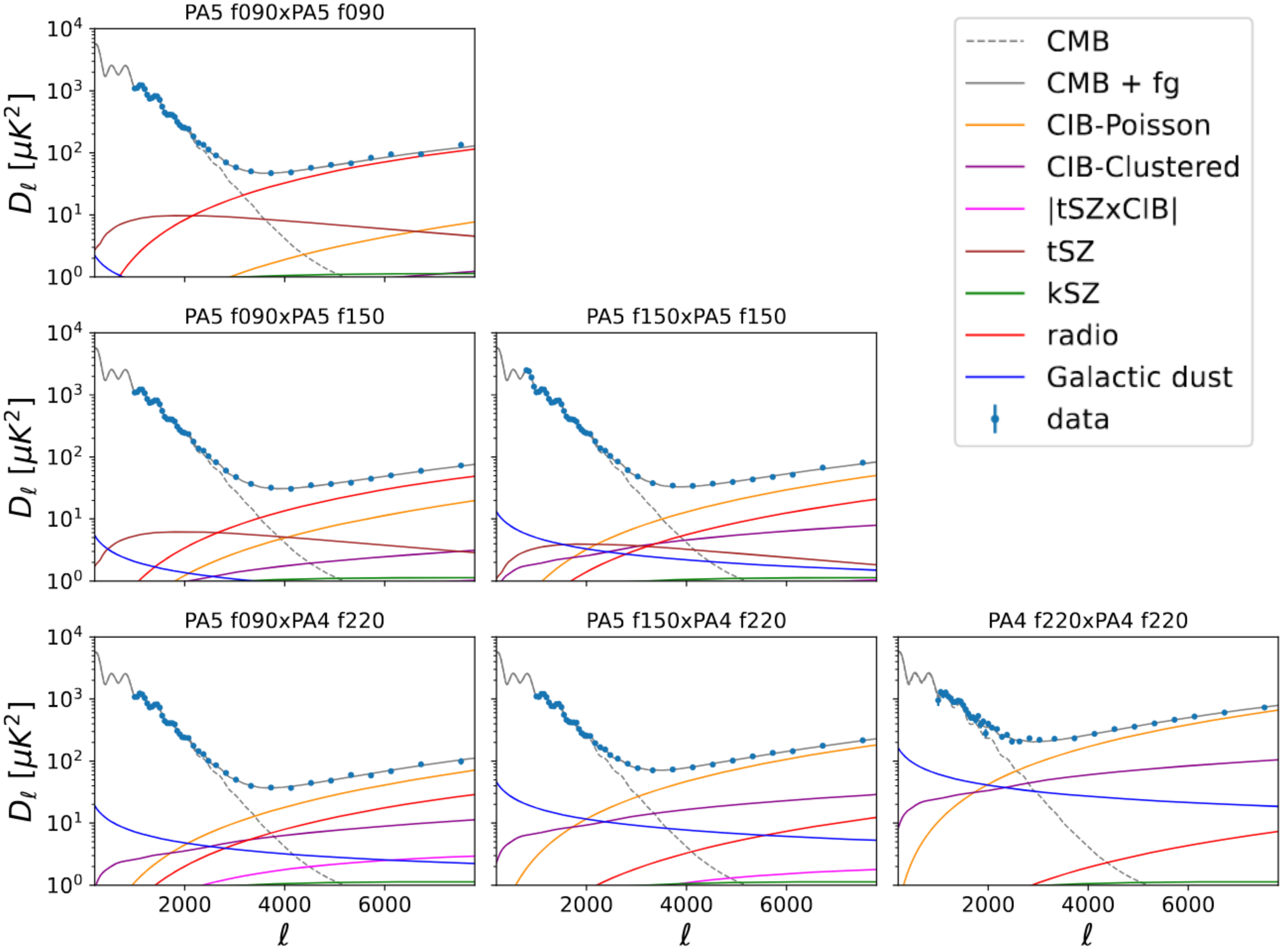

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- In addition to 15 instrumental nuisance parameters (calibration, pol. eff., passband shifts)

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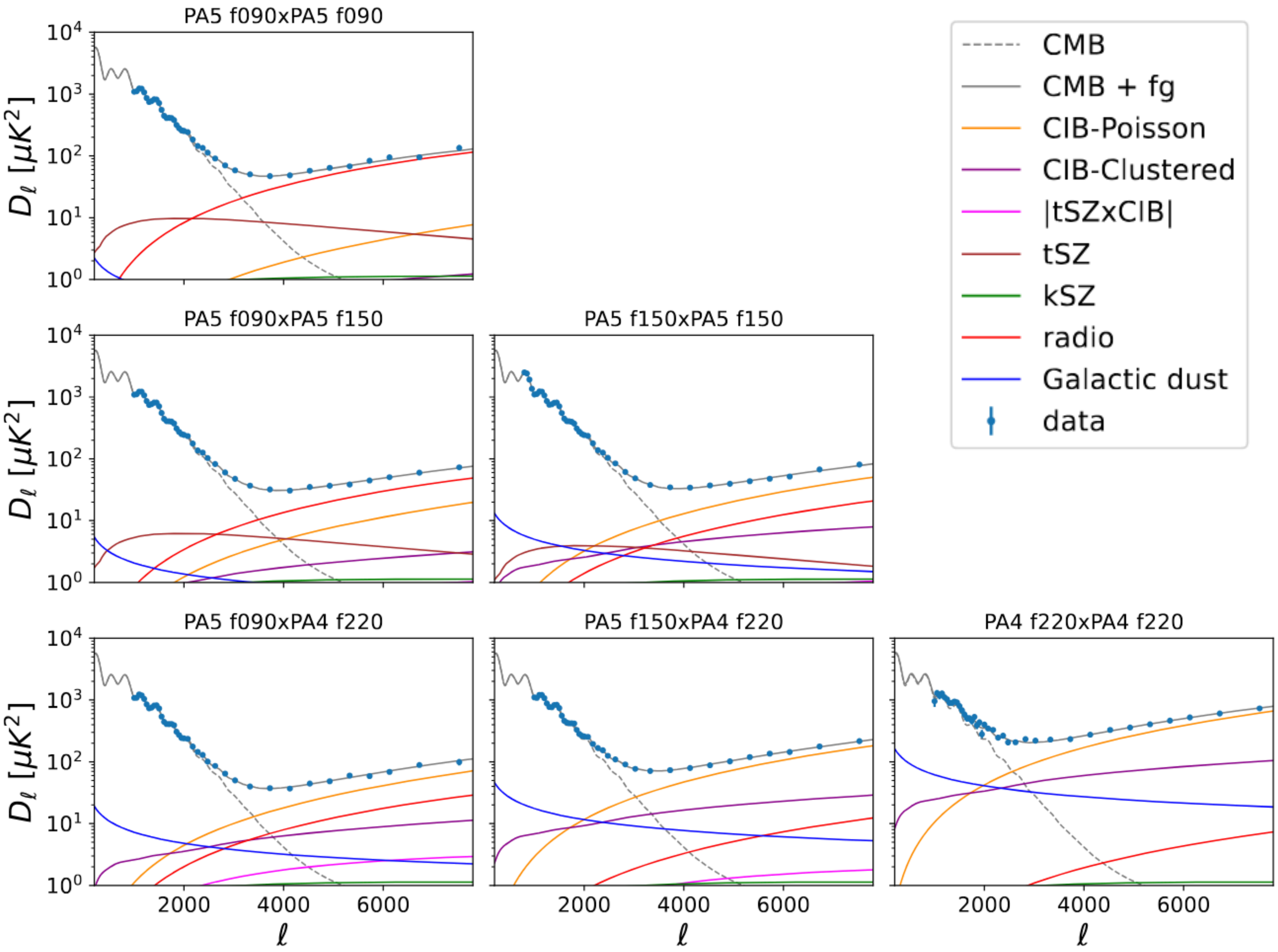
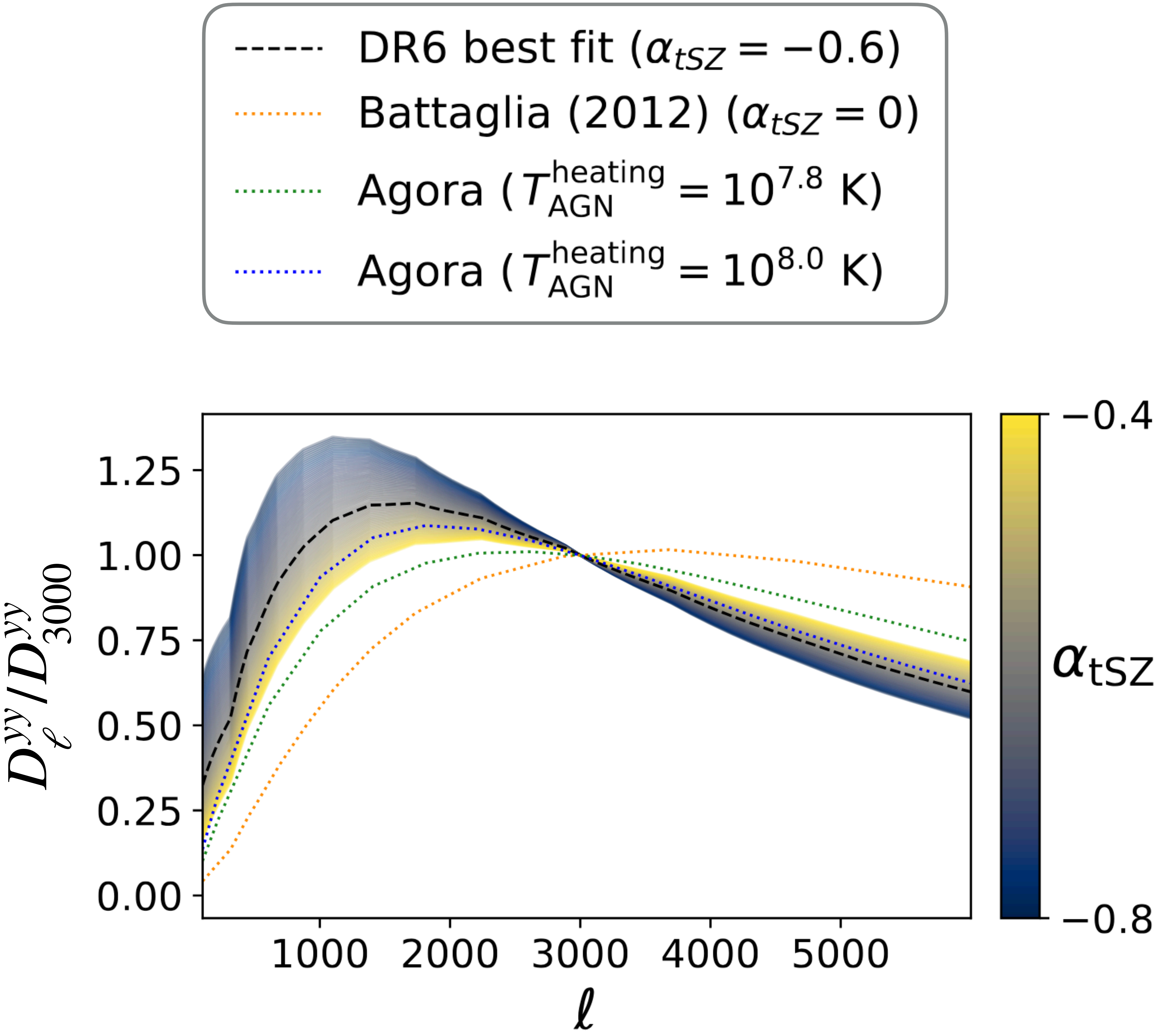


Foreground model with 14 free parameters

- TT: 9, EE: 2, TE : 2, common: 1
- In addition to 15 instrumental nuisance parameters (calibration, pol. eff., passband shifts)

- Necessary to use color-corrected beam per sky component

Louis et al, 2025 (2503.14452)



$$D_\ell^{yy} = a_{\rm tSZ} D_{\ell,\ell_0} \left(\frac{\ell}{\ell_0} \right)^{\alpha_{\rm tSZ}}$$

Louis et al, 2025 (2503.14452)

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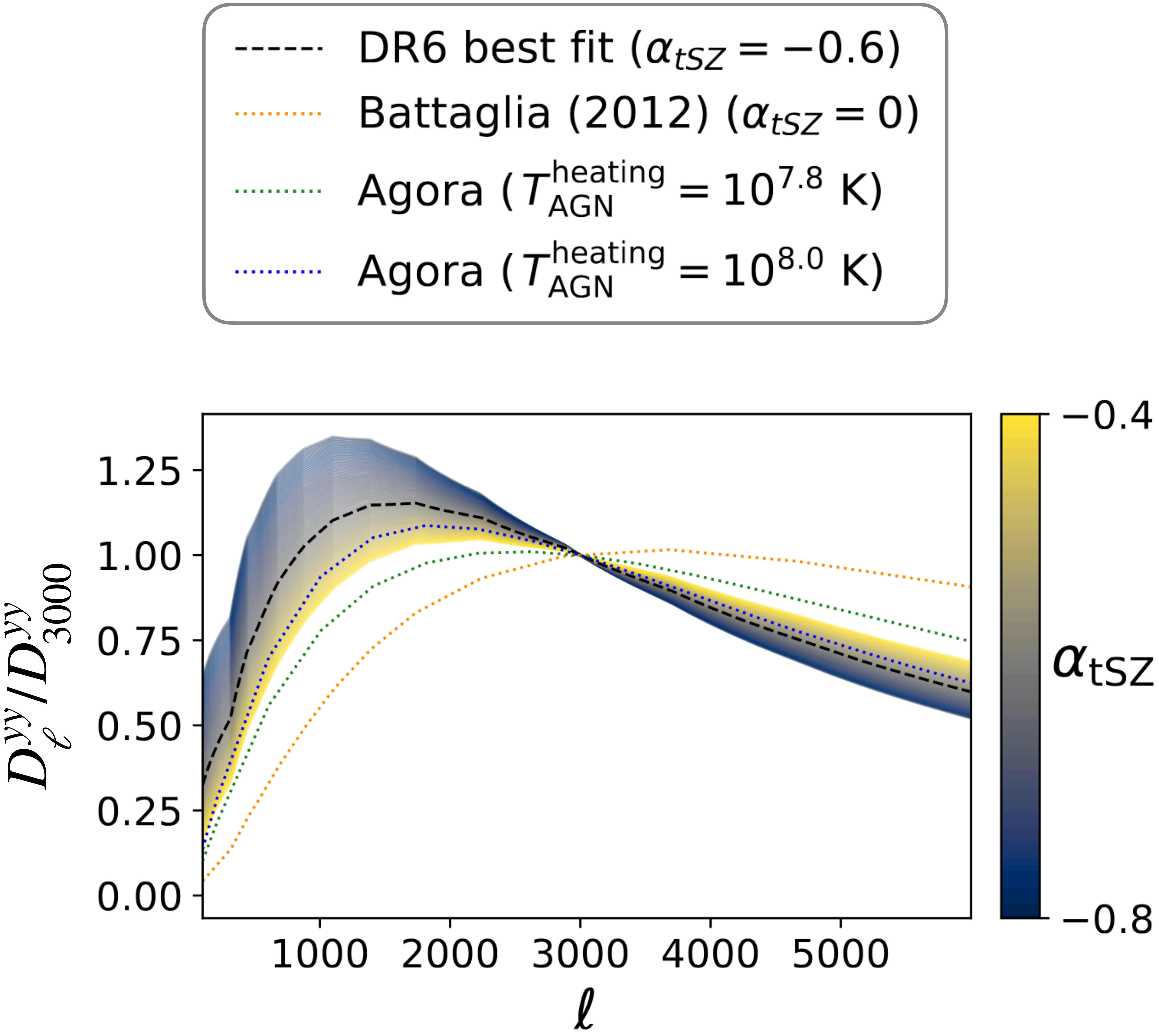
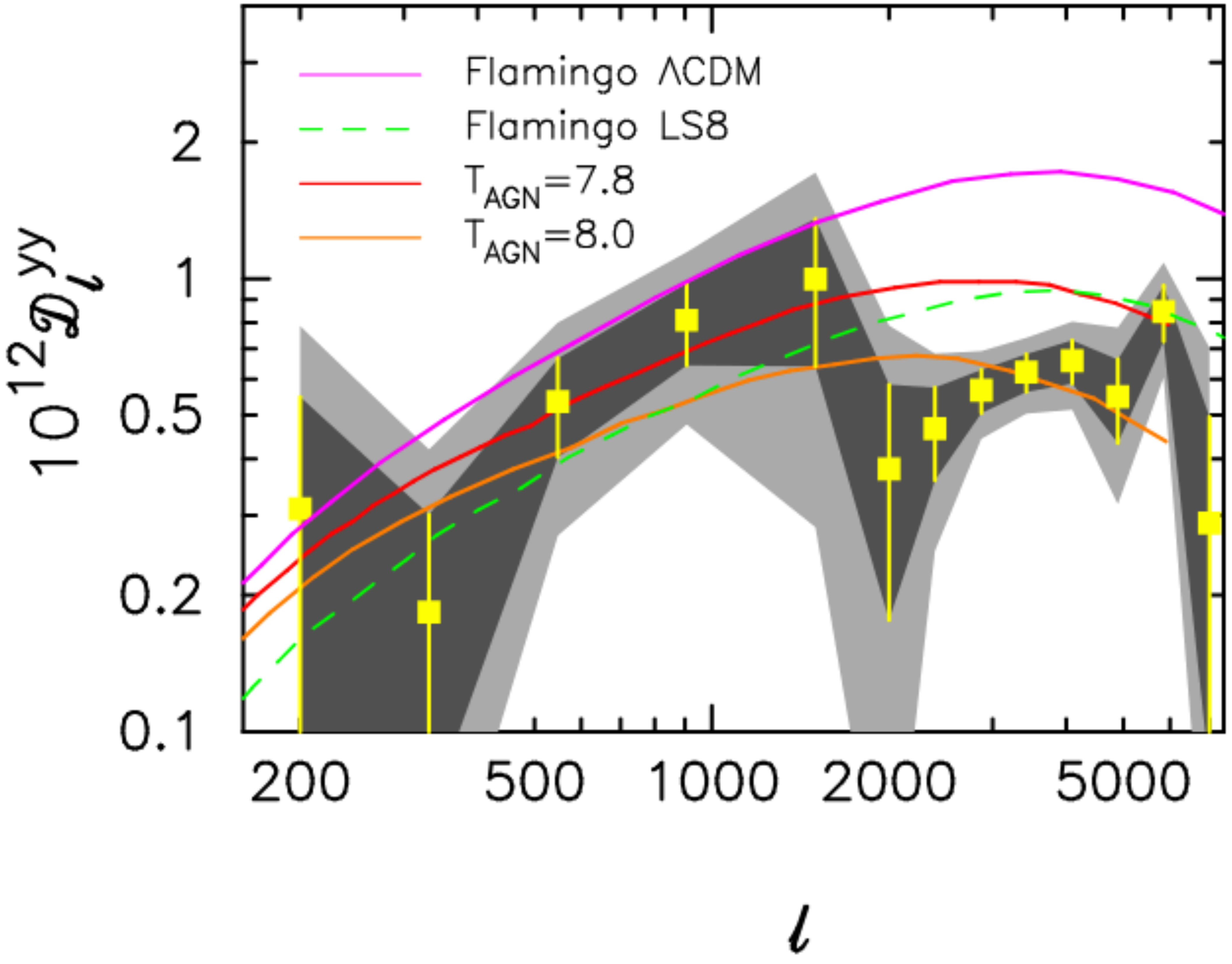
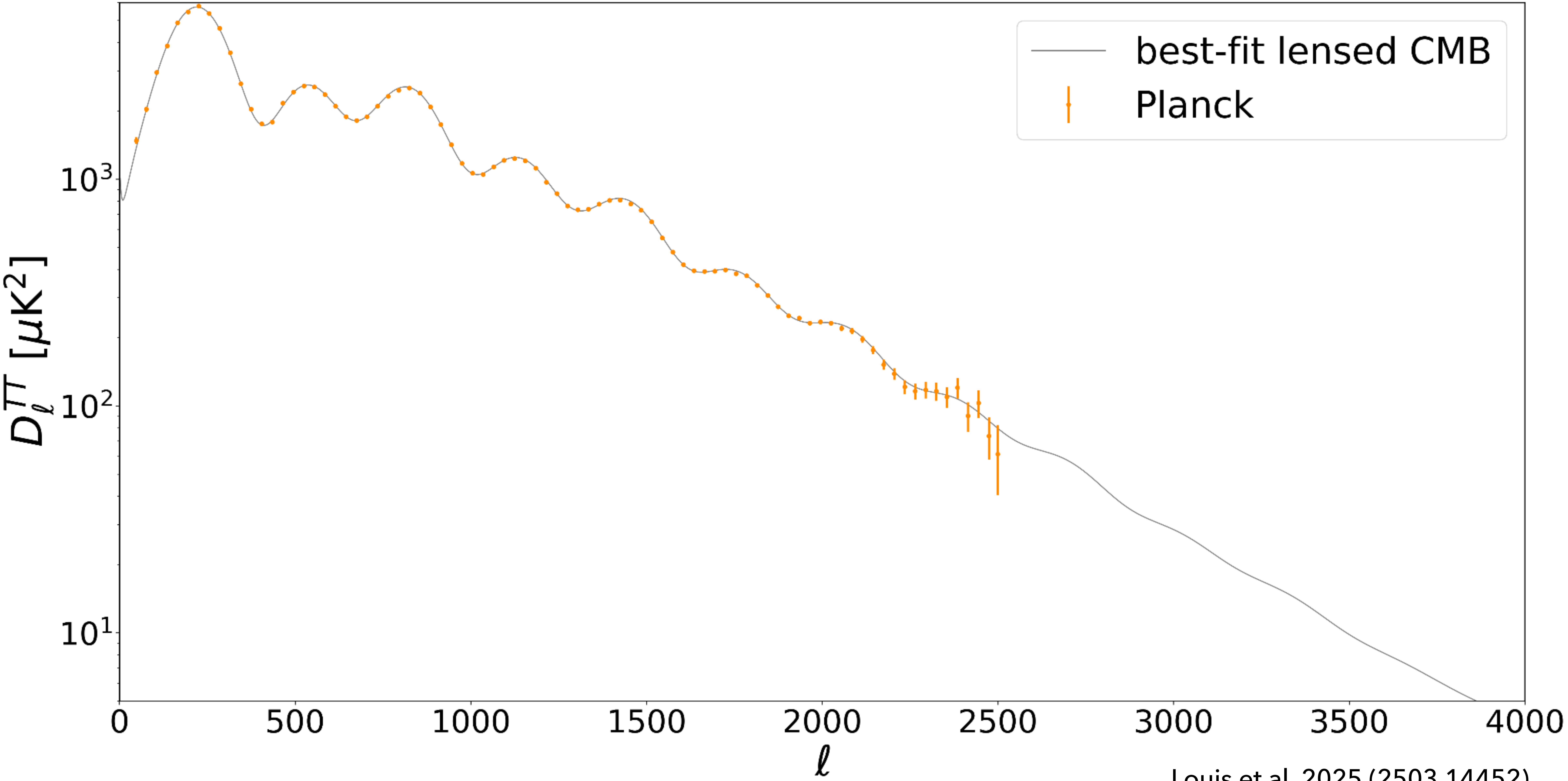


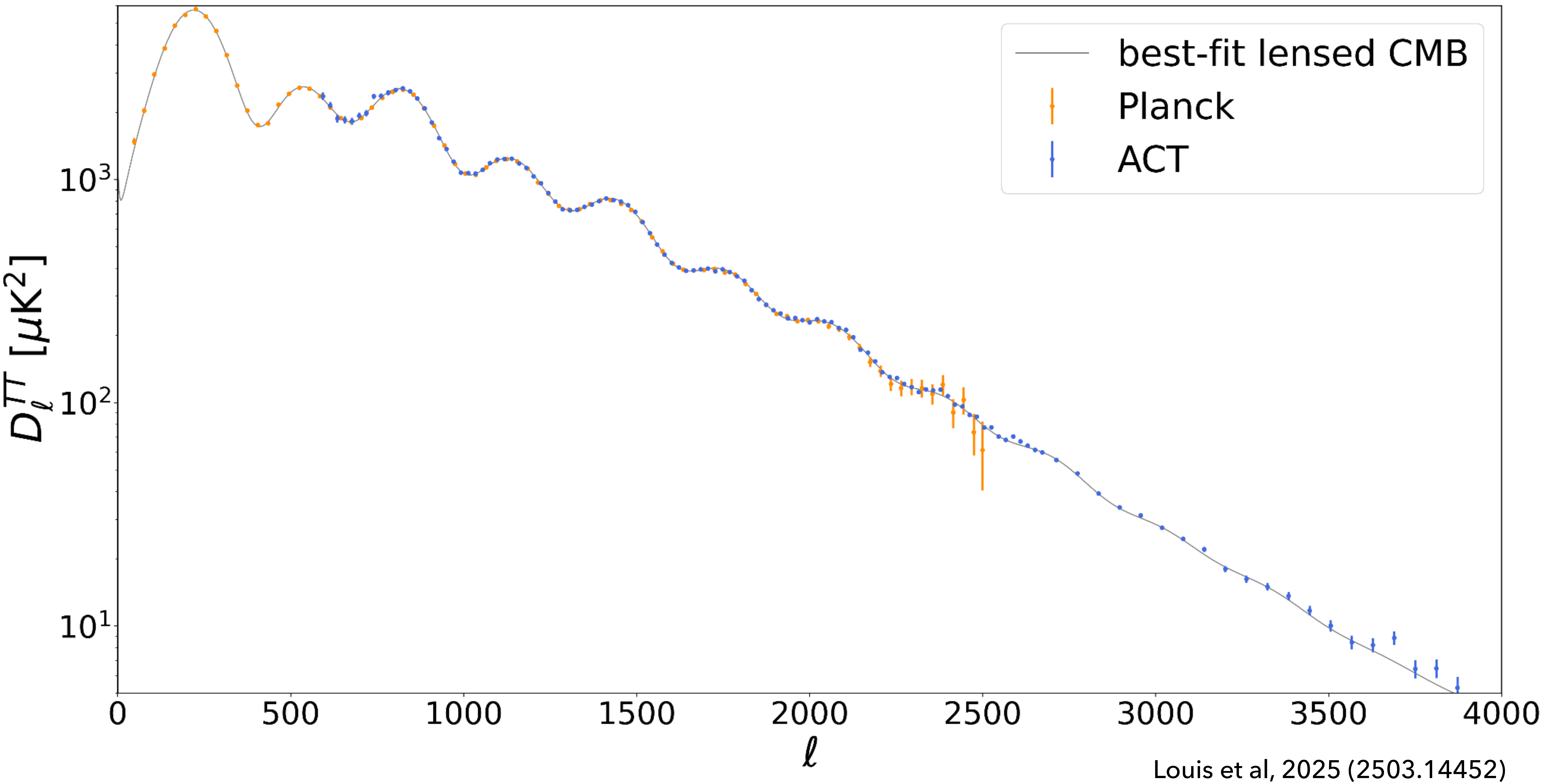
Louis et al, 2025 (2503.14452)



Efstathiou & McCarthy 2025 (2502.10232)

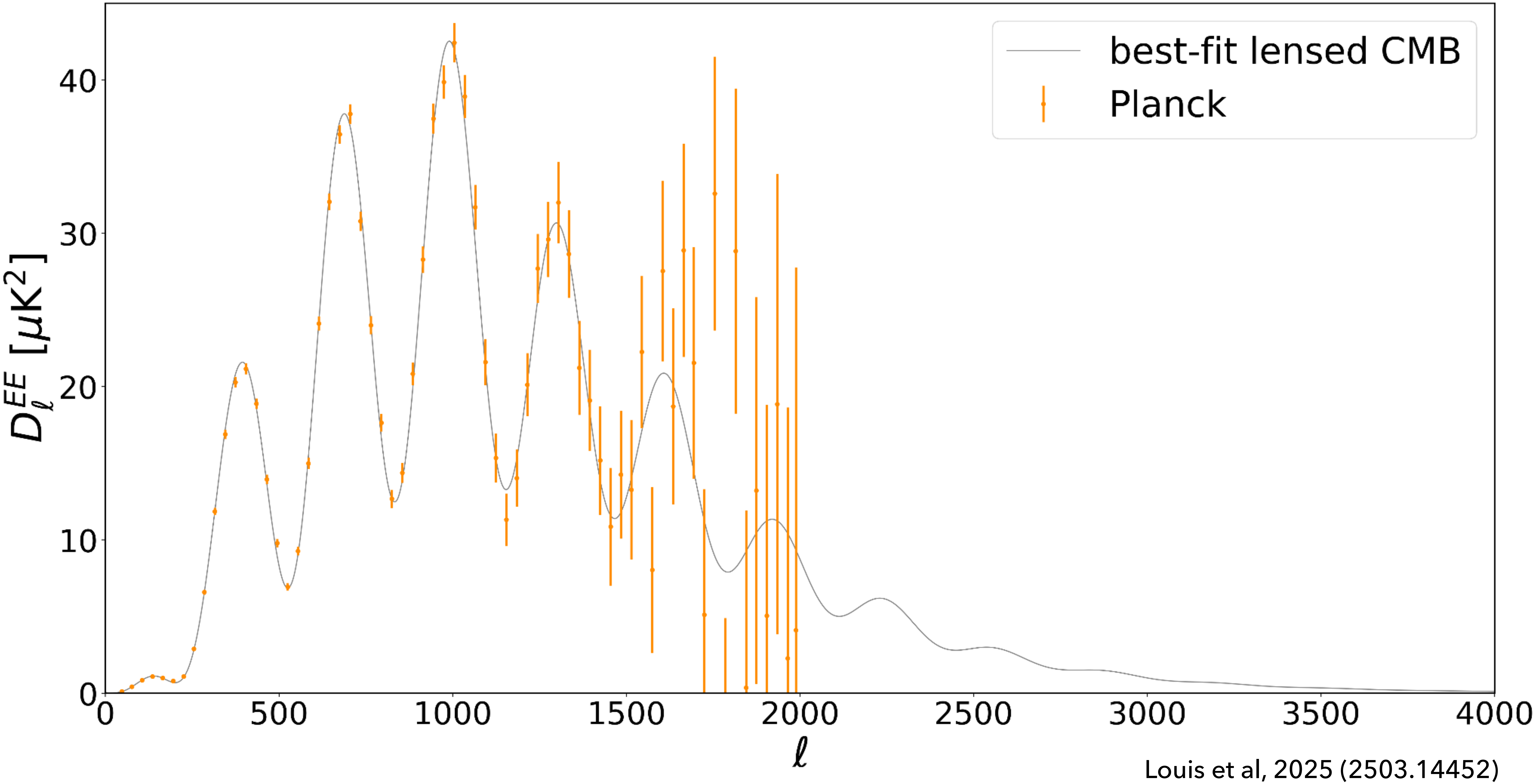


Louis et al, 2025 (2503.14452)

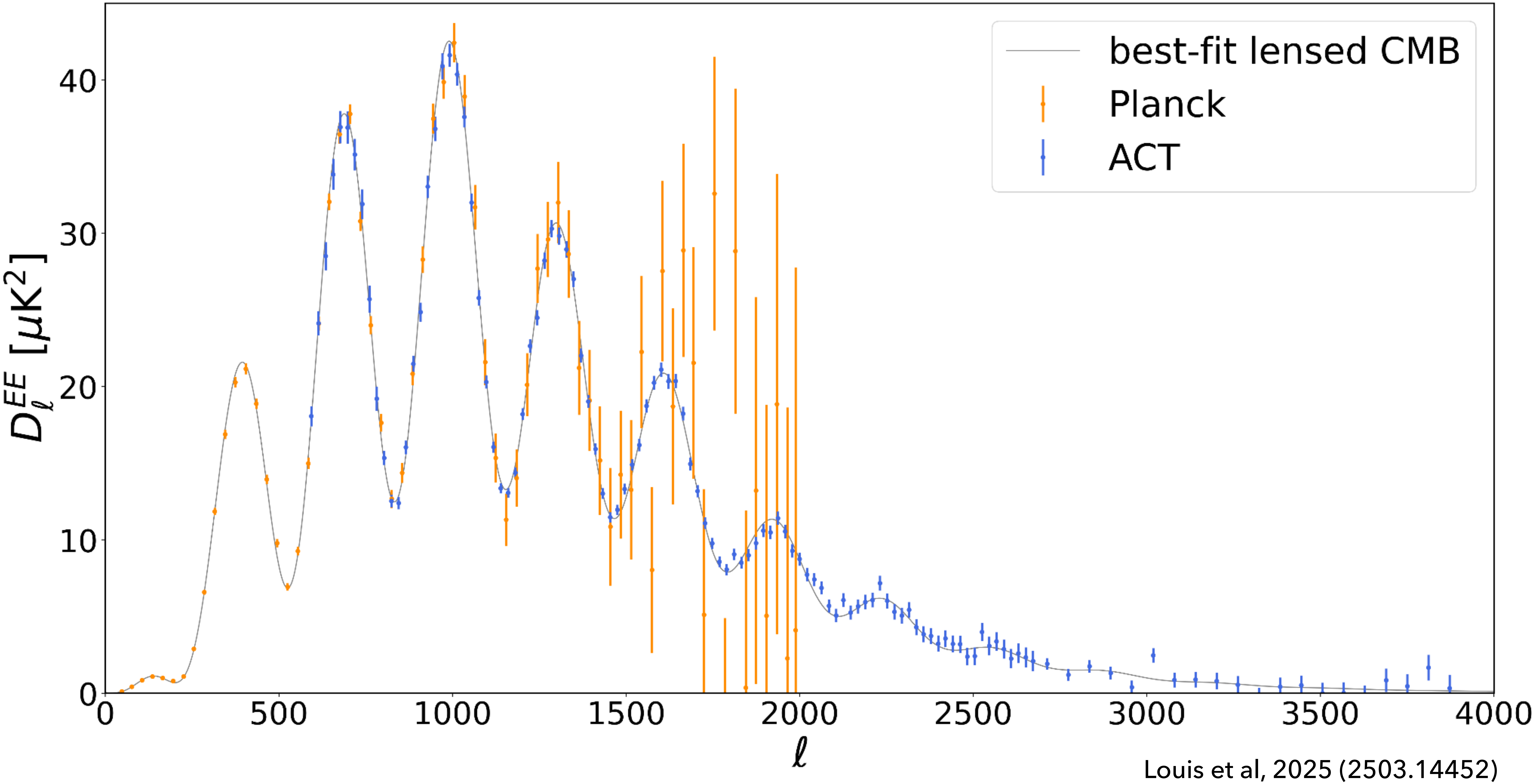


Louis et al, 2025 (2503.14452)

Combined with *Planck*: high S/N *E*-modes over the ACT patch



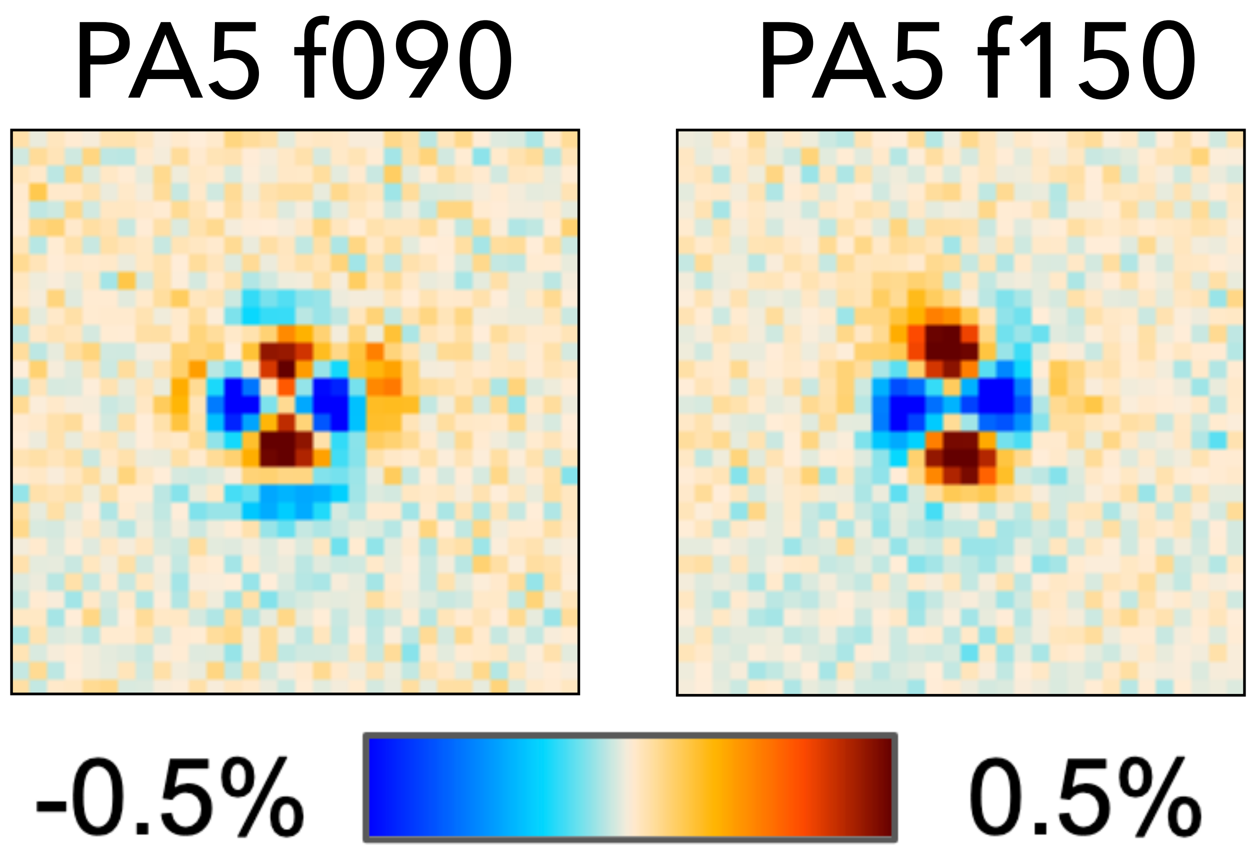
Louis et al, 2025 (2503.14452)



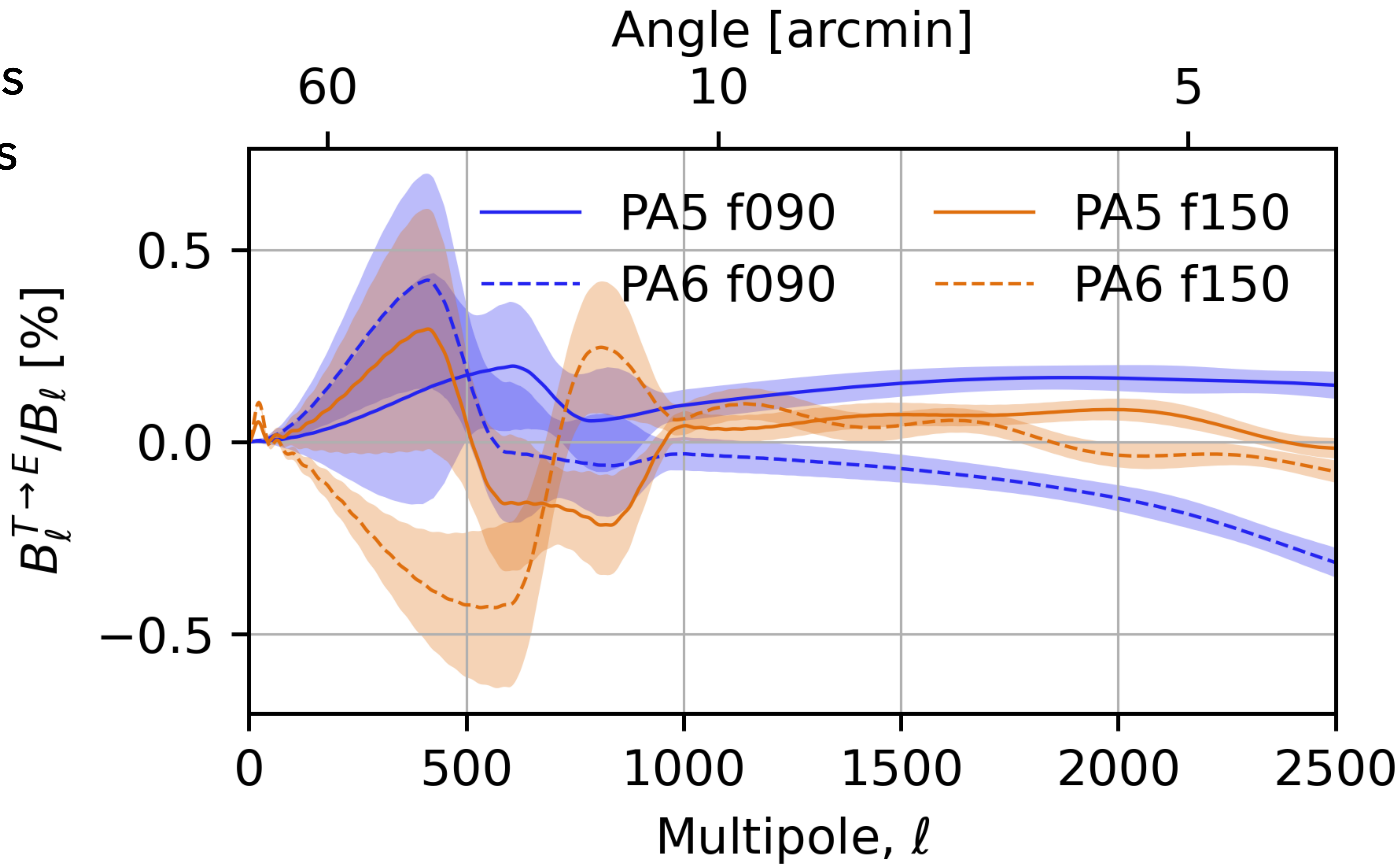
Louis et al, 2025 (2503.14452)

INTENSITY-TO-POLARIZATION LEAKAGE

Intensity-to-polarization leakage detected in TE array null tests. Matches polarized signal in planet observations



Spurious polarization in co-added Uranus observations (Stokes Q, 8′×8′)



Louis et al, 2025 (2503.14452)

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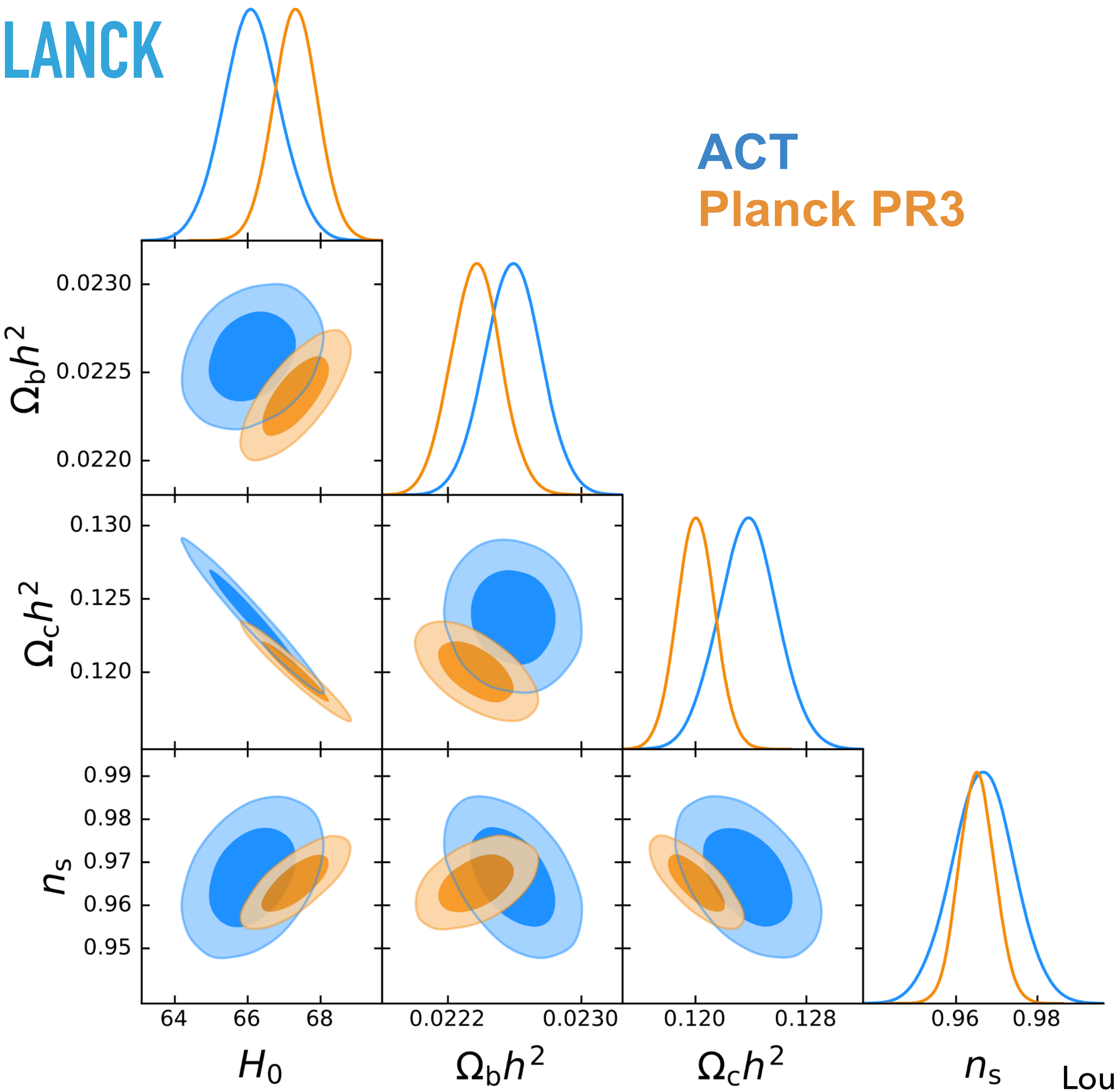
ACT COMPARED TO PLANCK

Consistent ΛCDM parameters at 1.6σ level



Using Planck Sroll2 low ℓ polarization for ACT

Louis et al, 2025 (2503.14452)

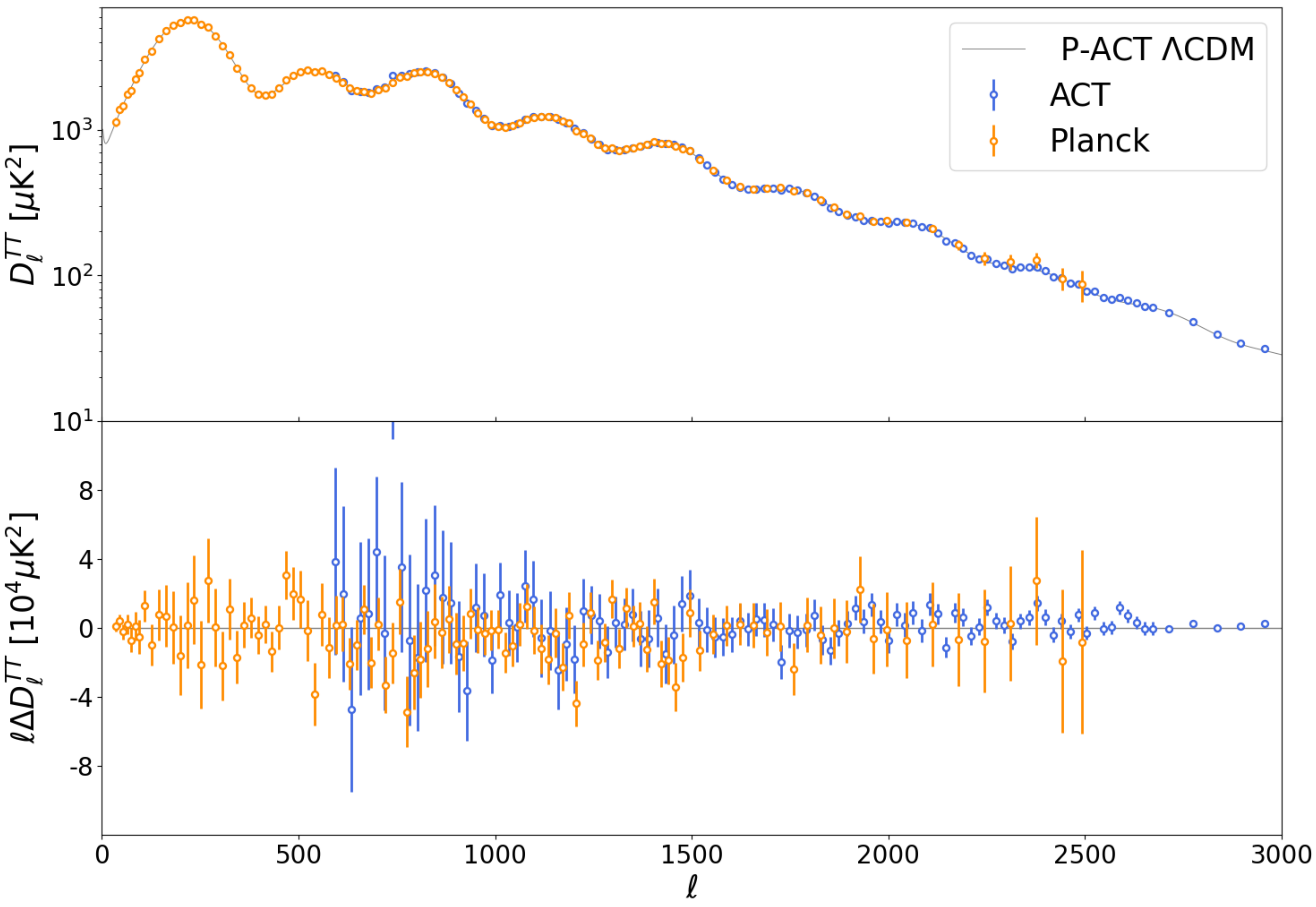
ACT + PLANCK

ΛCDM is a good fit to both ACT and ACT + *Planck*

χ^2(ACT) = 1598 / 1617 (63%)

χ^2(P-ACT) = 1842 / 1897 (81%)

P-ACT ≡ ACT + Plank PR3 (ℓ < 1000 for TT, ℓ < 600 for TE/EE) + low-ℓ temperature + Sroll2 low ℓ polarization



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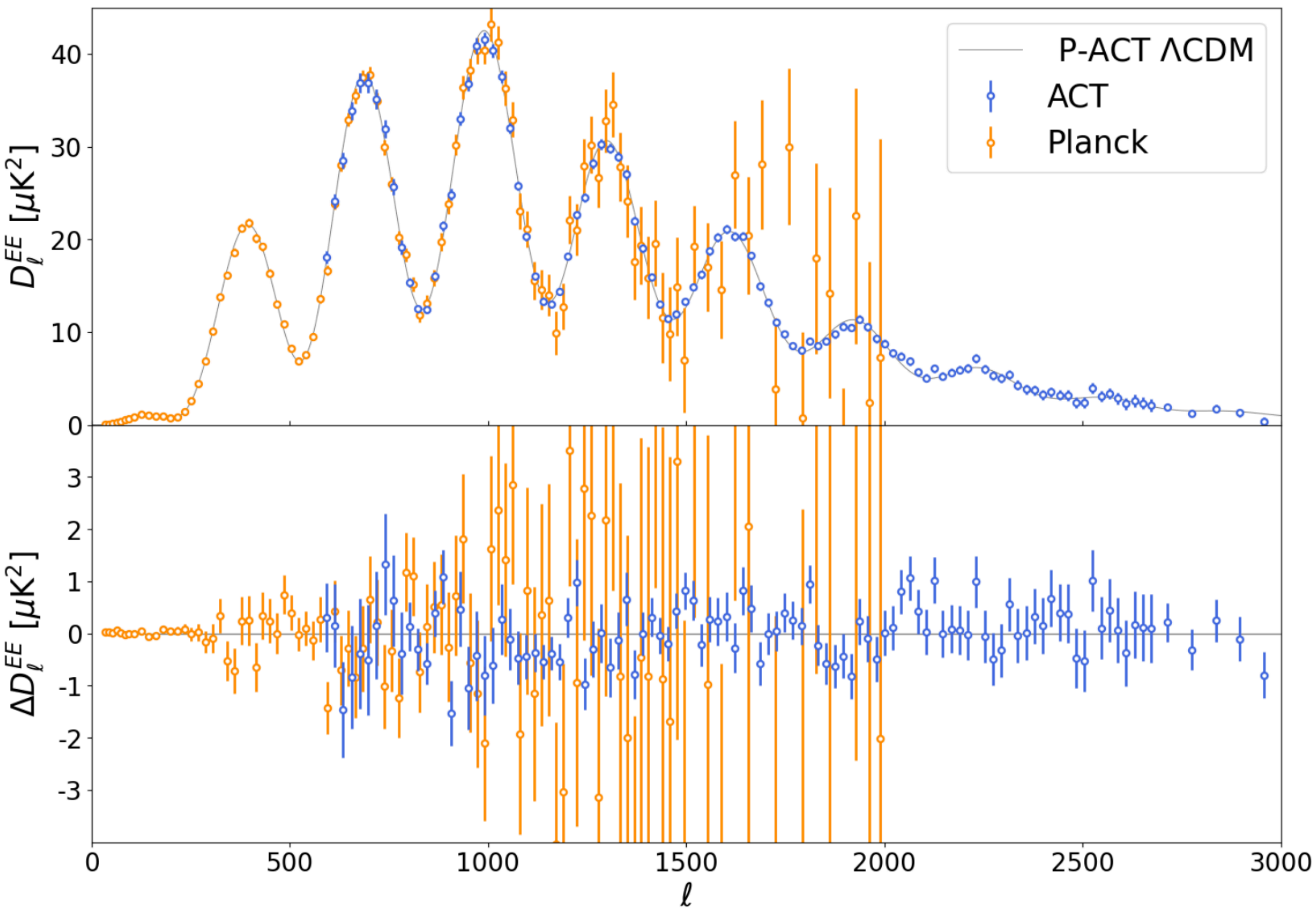

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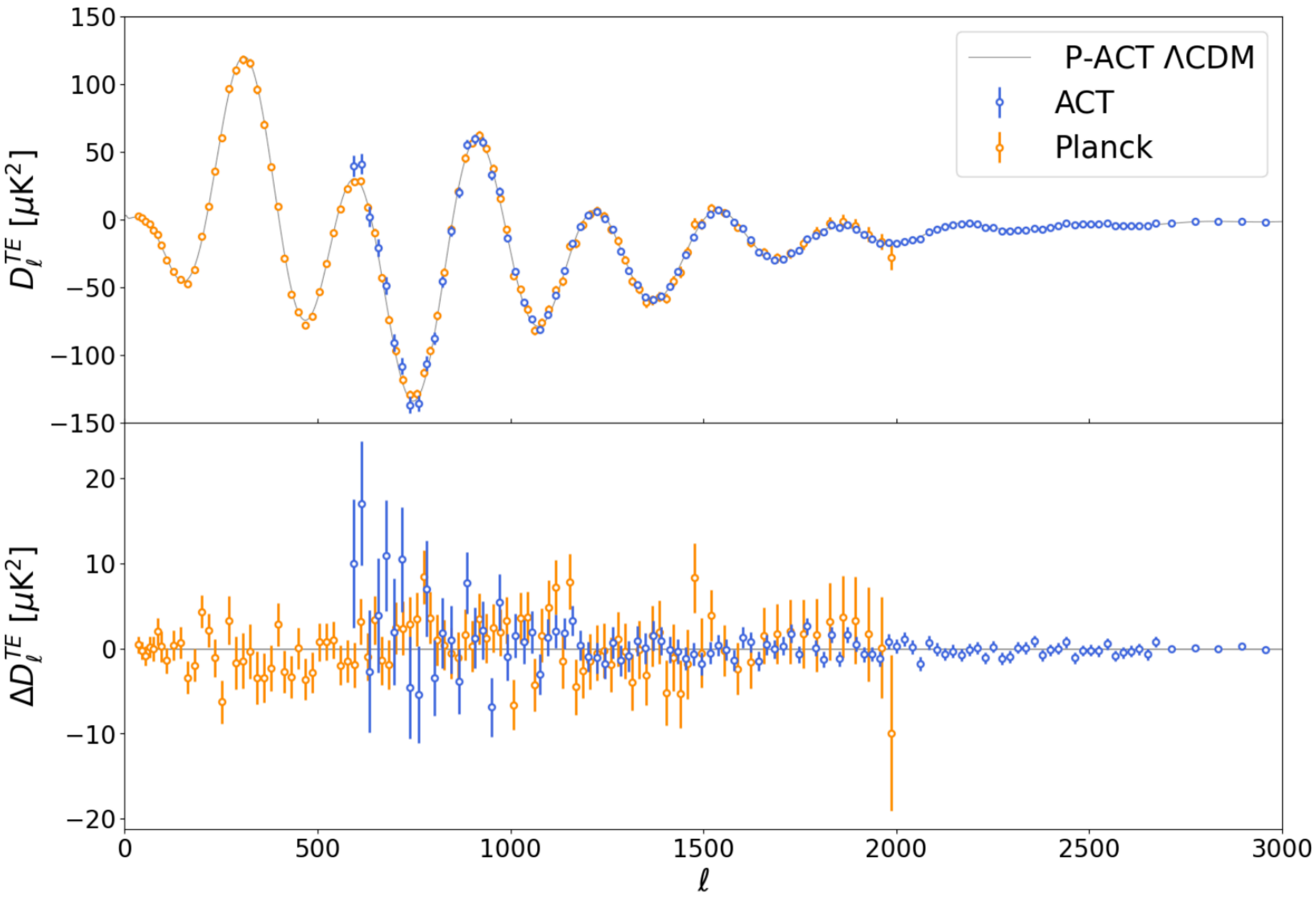

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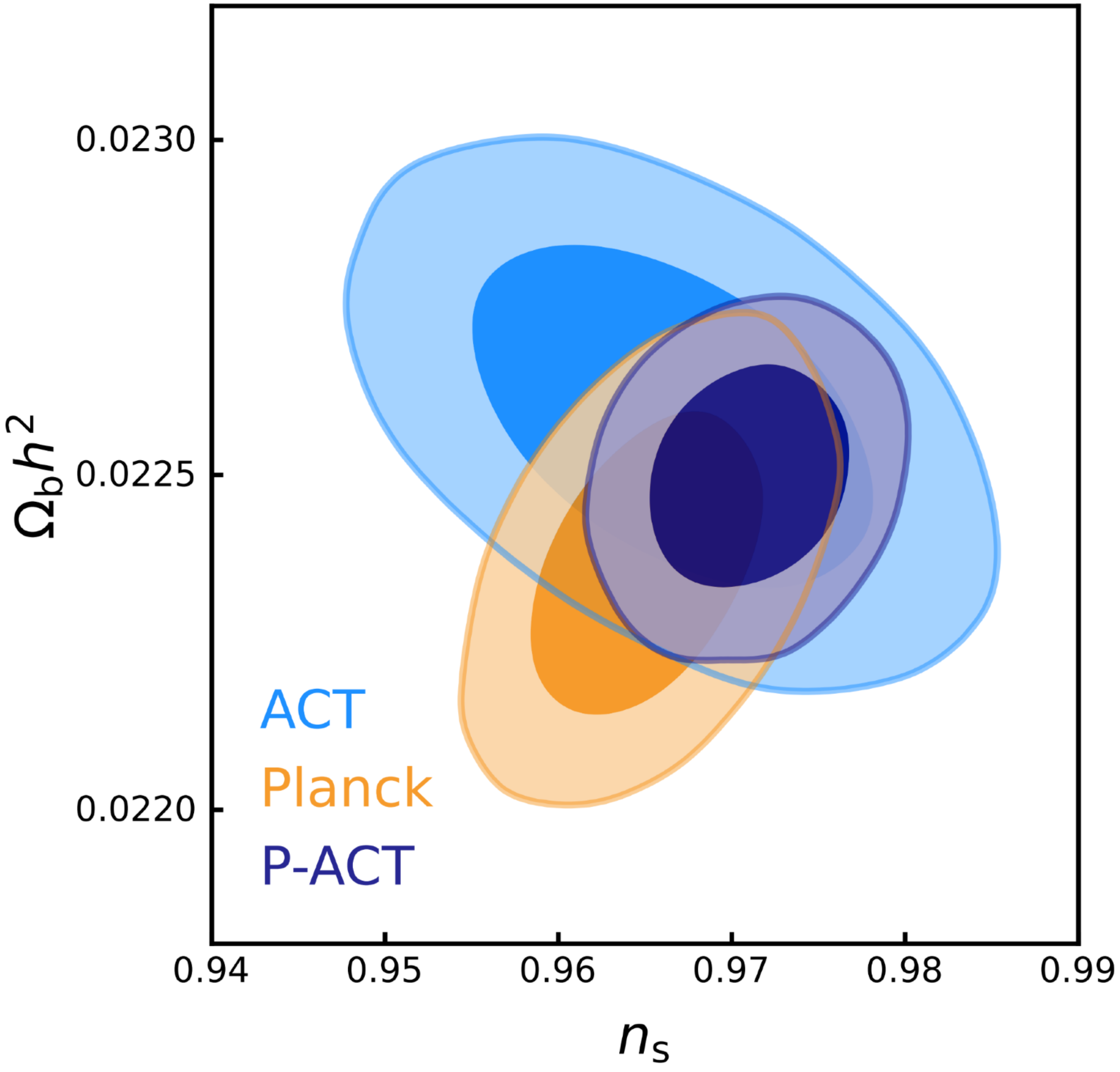
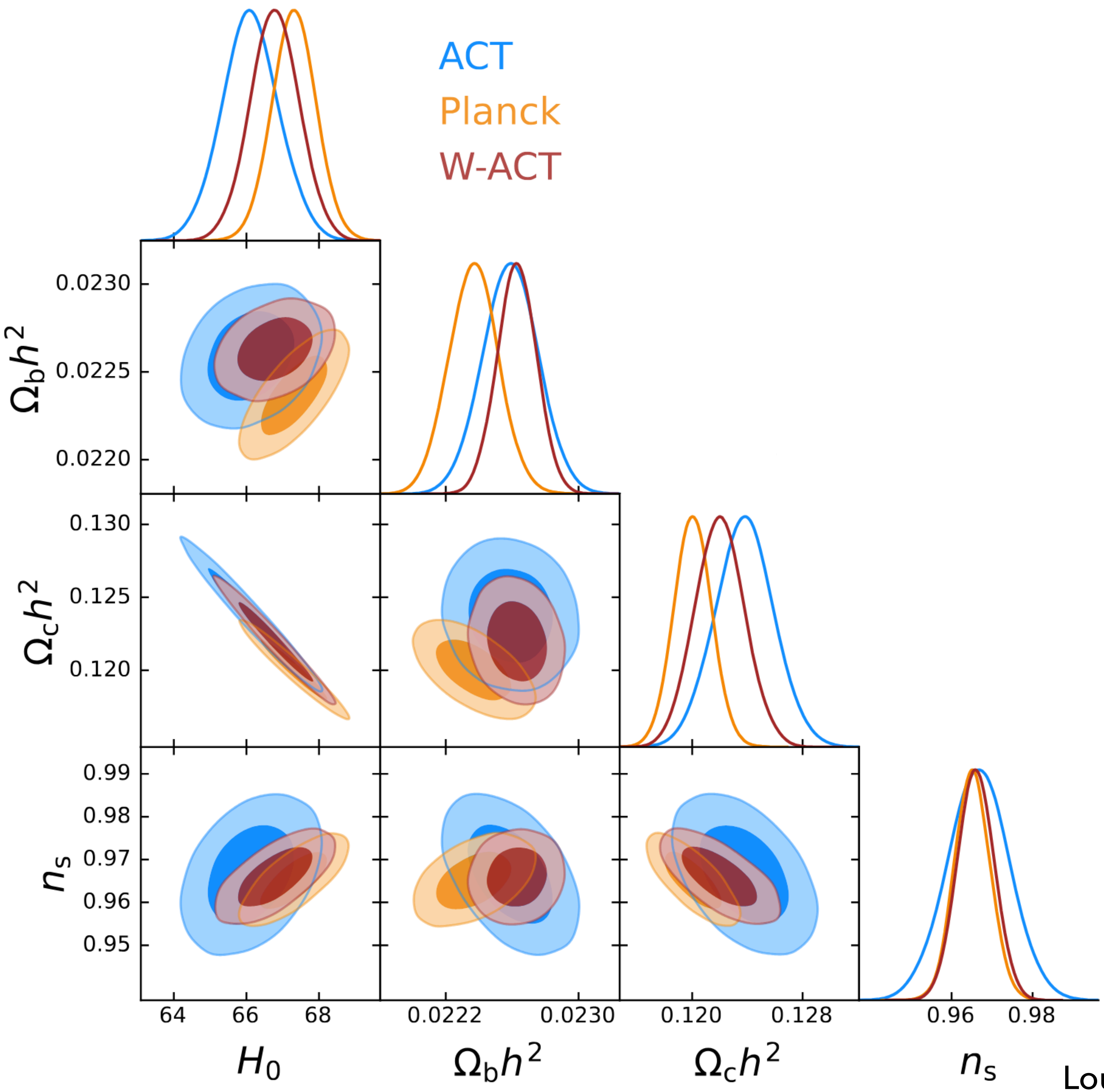


Louis et al, 2025 (2503.14452)

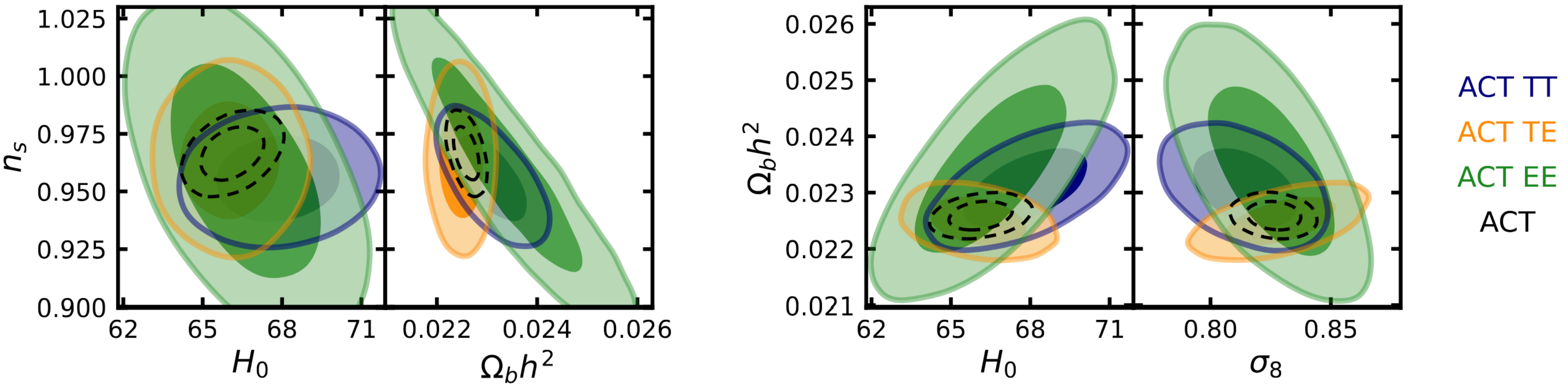
ACT + WMAP



W-ACT ≡ ACT + WMAP ($\ell > 23$ for EE) + Sroll2 low ℓ polarization

Louis et al, 2025 (2503.14452)

CONSISTENCY



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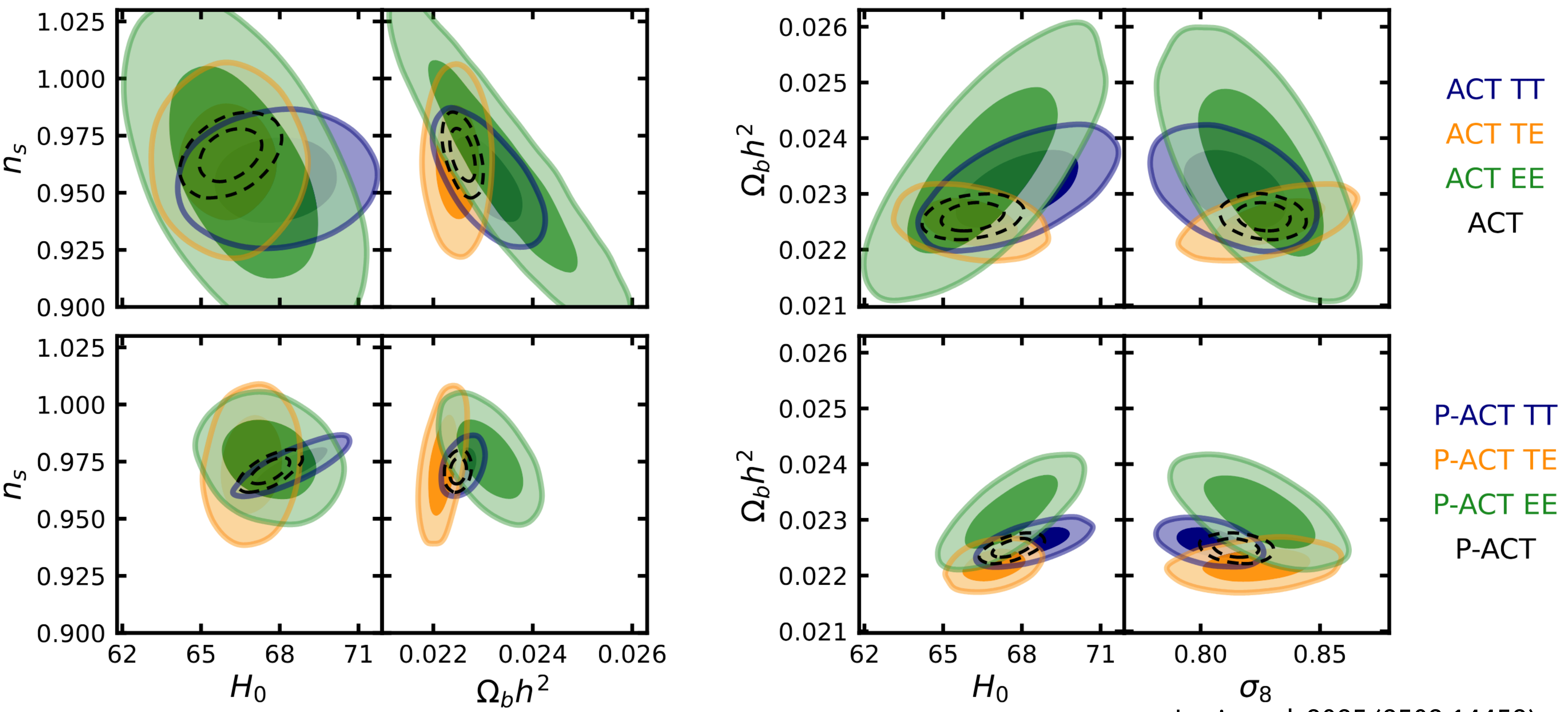

Louis et al, 2025 (2503.14452)

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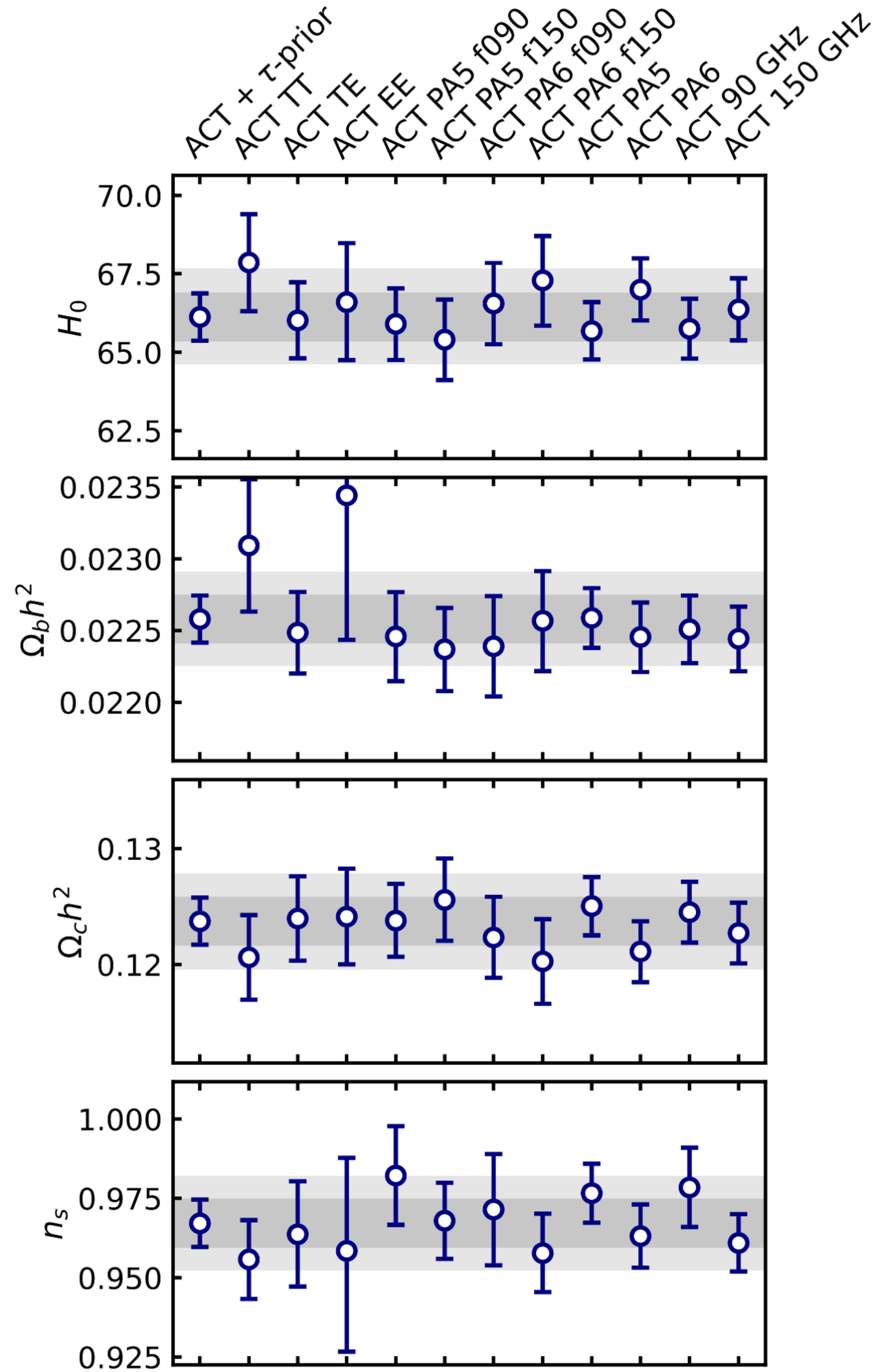
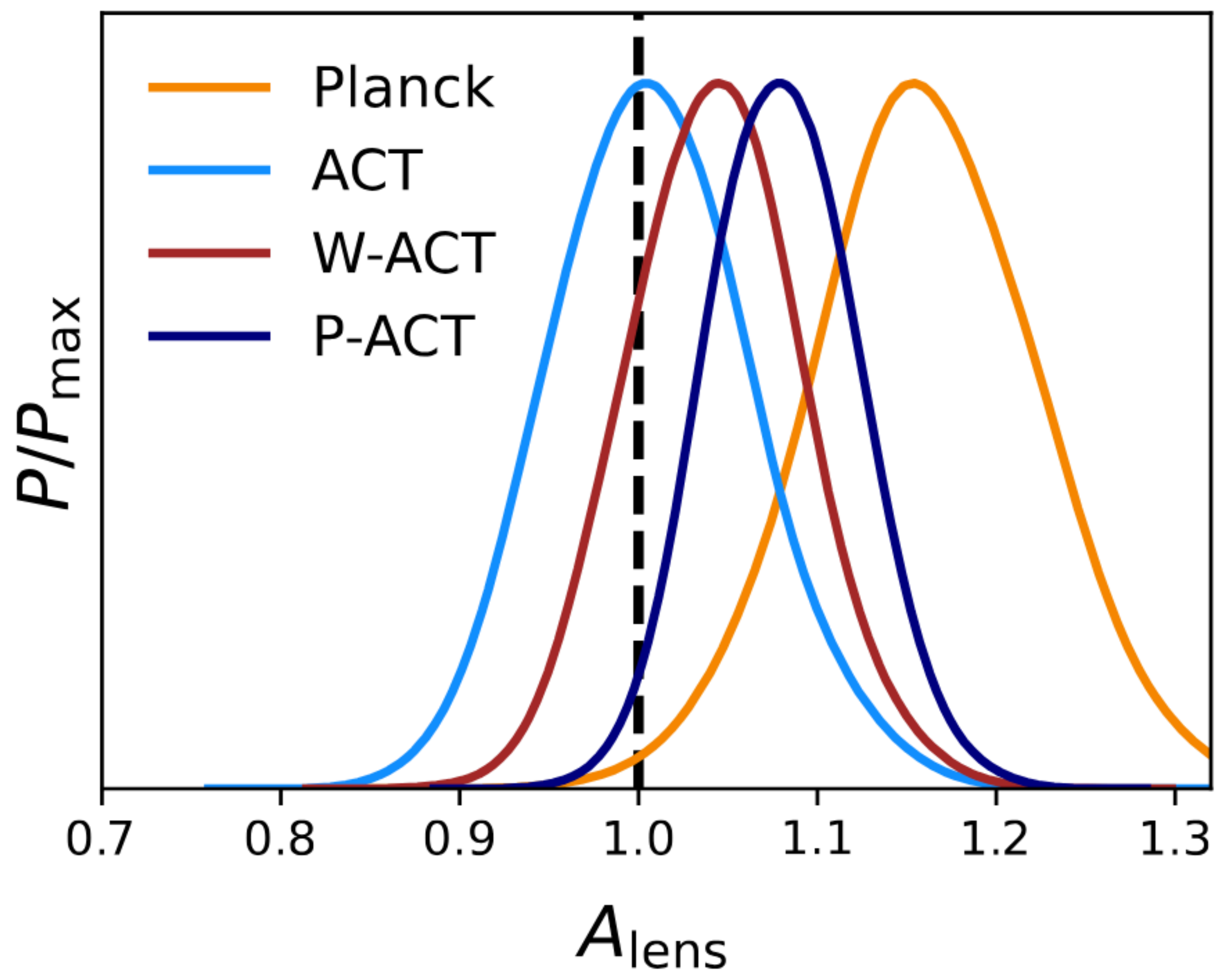


Louis et al, 2025 (2503.14452)

A_LENS OR CURVATURE



Note that Camspec & Hillipop analyses of *Planck* PR4 are closer to $A_{\rm lens} = 1$ and $\Omega_K = 0$

Louis et al, 2025 (2503.14452)

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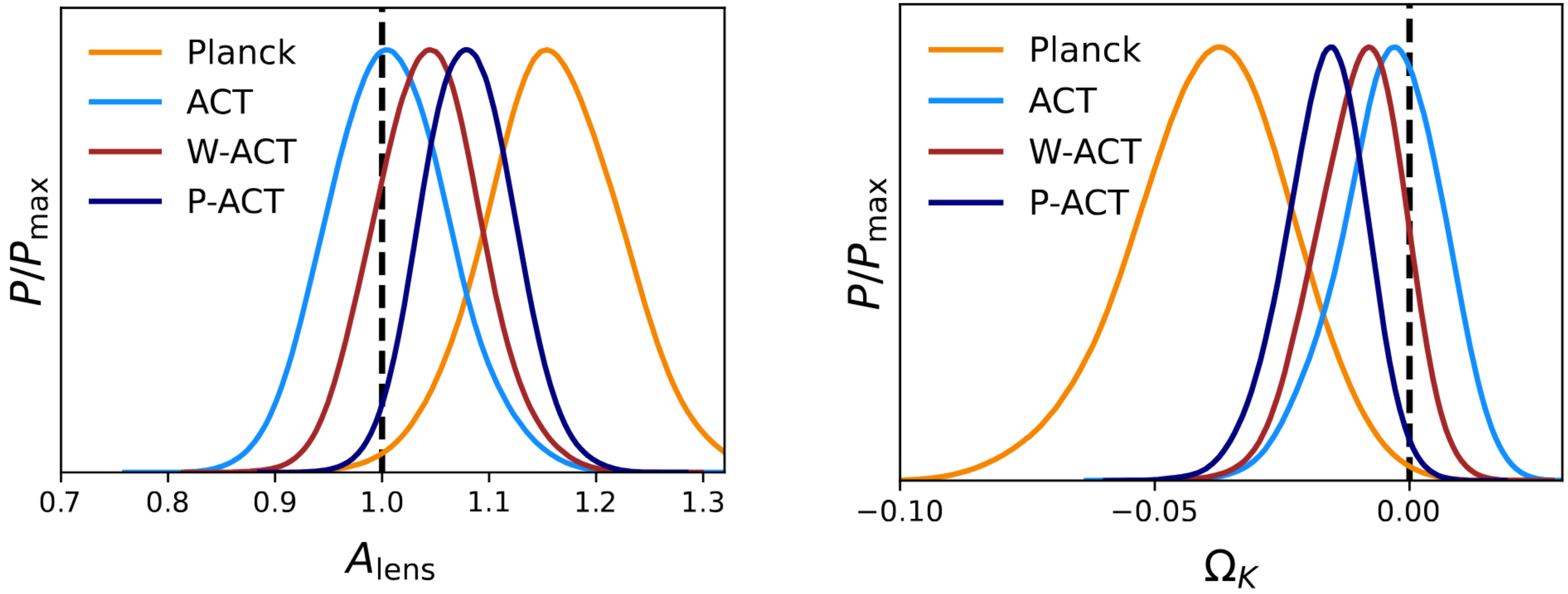

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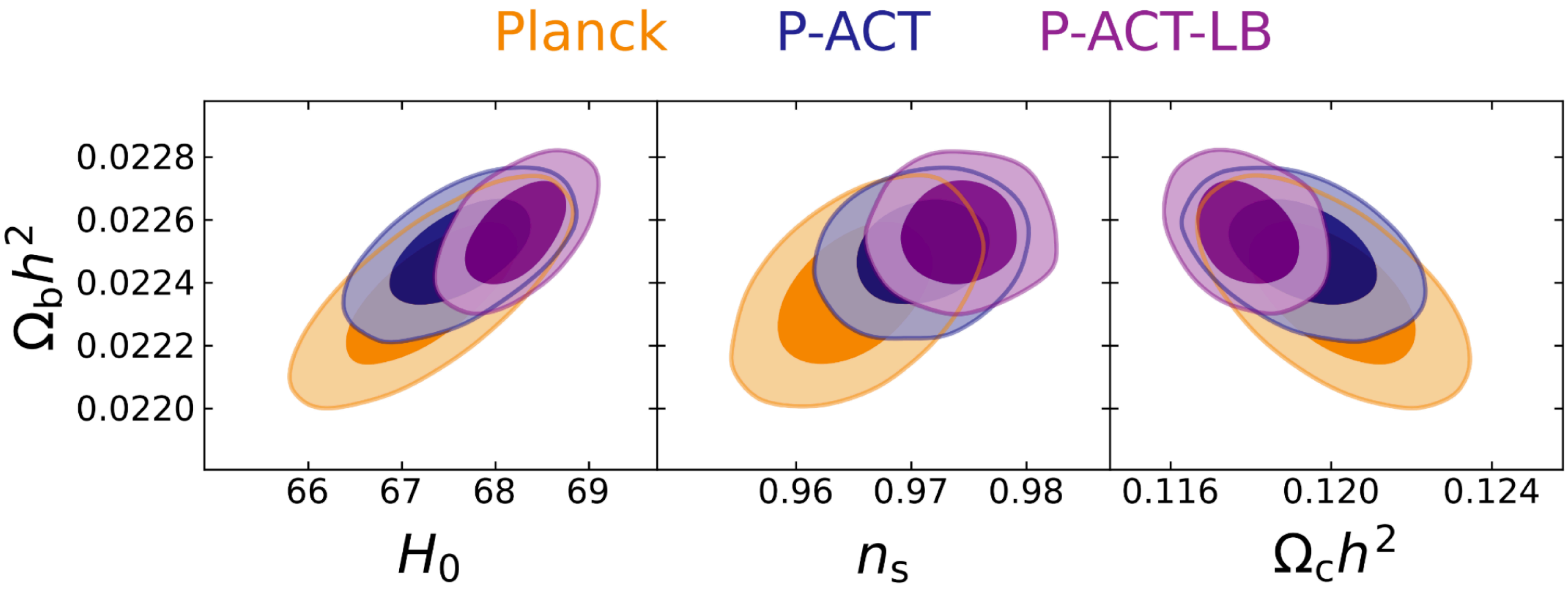
Louis et al, 2025 (2503.14452)

COMBINED WITH BAO

Addition of ACT DR6 + *Planck* PR4 CMB lensing (L) and BAO (B) from DESI Y1 significantly tightens constraints



Louis et al, 2025 (2503.14452)

DATA RELEASE

LAMBDA legacy archive (lambda.gsfc.nasa.gov/product/act/act_dr6.02)

- 600 raw frequency maps including null test maps
- 94 processed maps including Needlet-ILC maps of the CMB blackbody signal and thermal Sunyaev- Zeldovich signal
- MCMC chains, power spectra

NERSC (publicly available, see act.princeton.edu/ for globus link)

In addition to all products on LAMBDA

- 38 TB of short exposure maps used for time-domain analysis
- Noise models and noise simulations of the frequency maps
- All products needed to go from the maps to the power spectrum results

DR6_Notebooks Public Python notebooks with DR6 tutorials: github.com/ACTCollaboration/DR6_Notebooks

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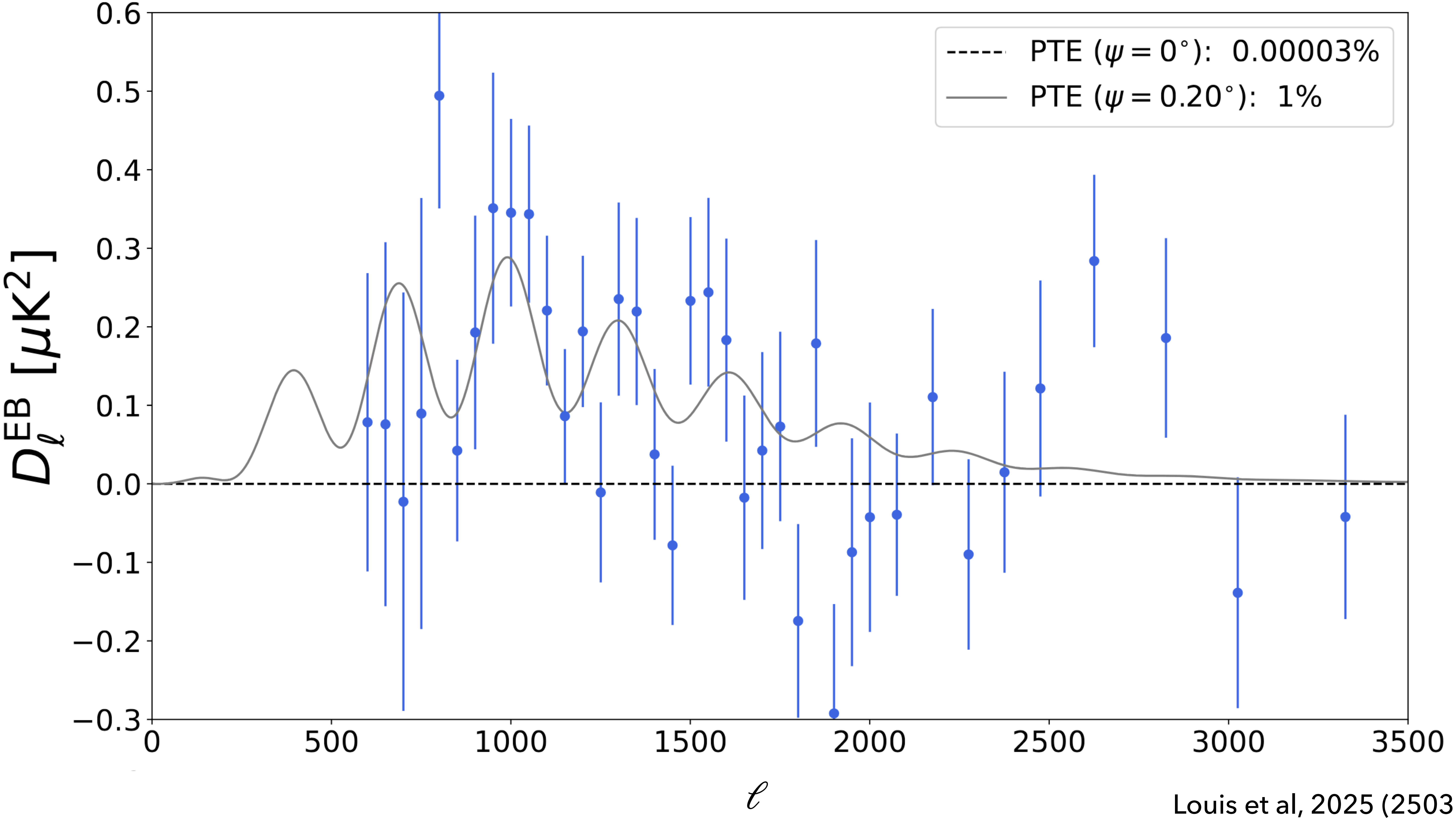
- High-resolution microwave sky observations enable a wide range of science topics: see many more ACT talks/posters this week!

BIREFRINGENCE



Louis et al, 2025 (2503.14452)

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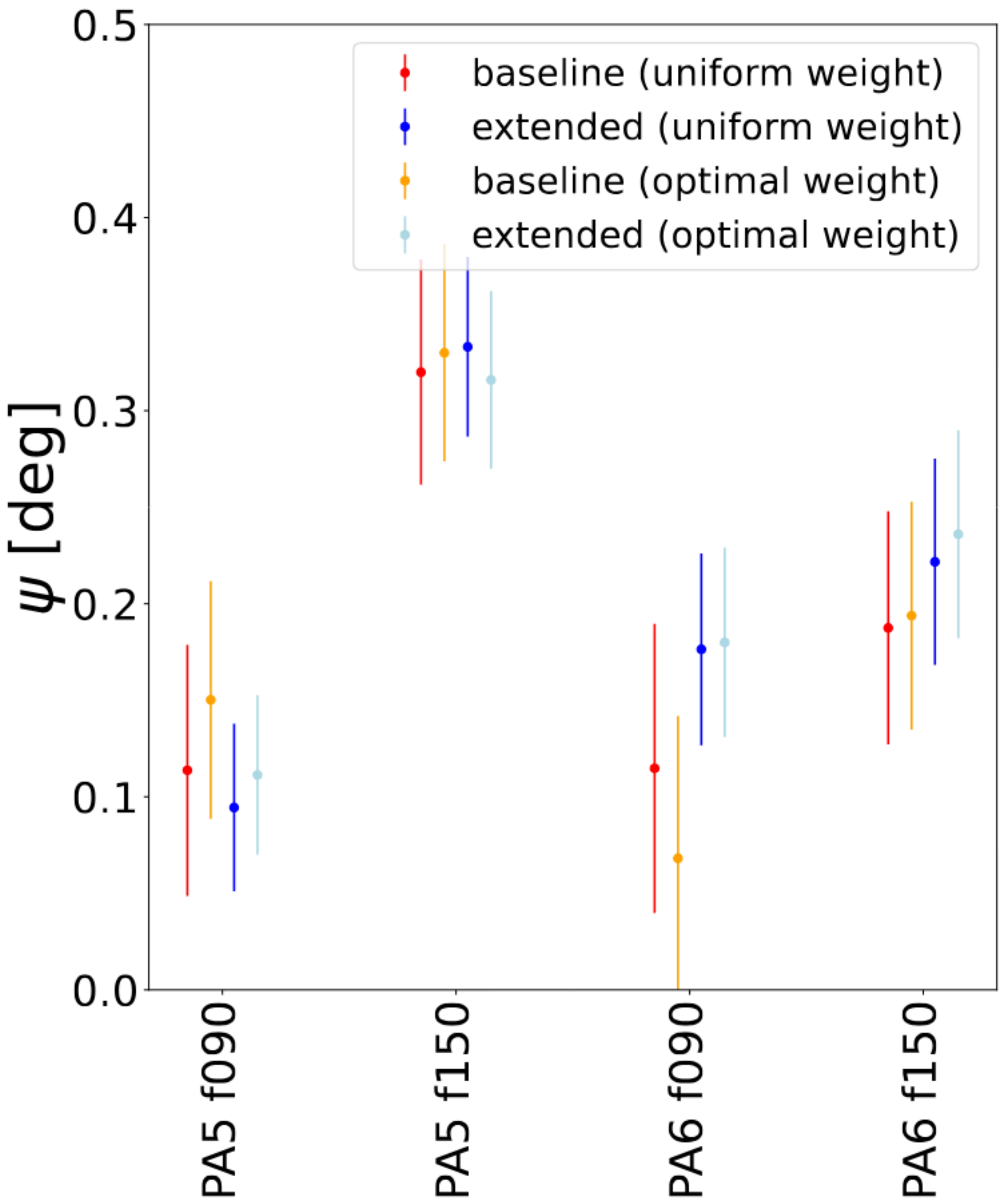

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ACT & PLANCK BEST FIT

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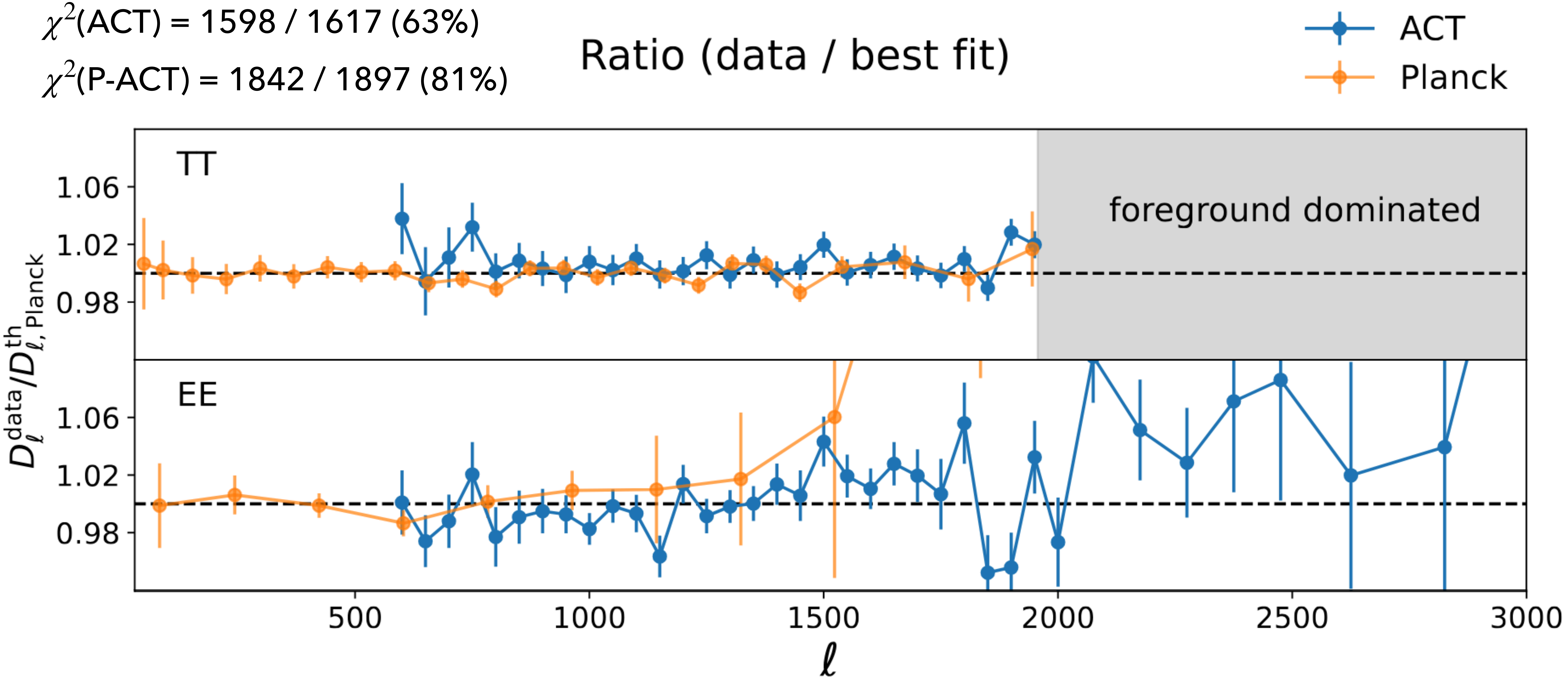

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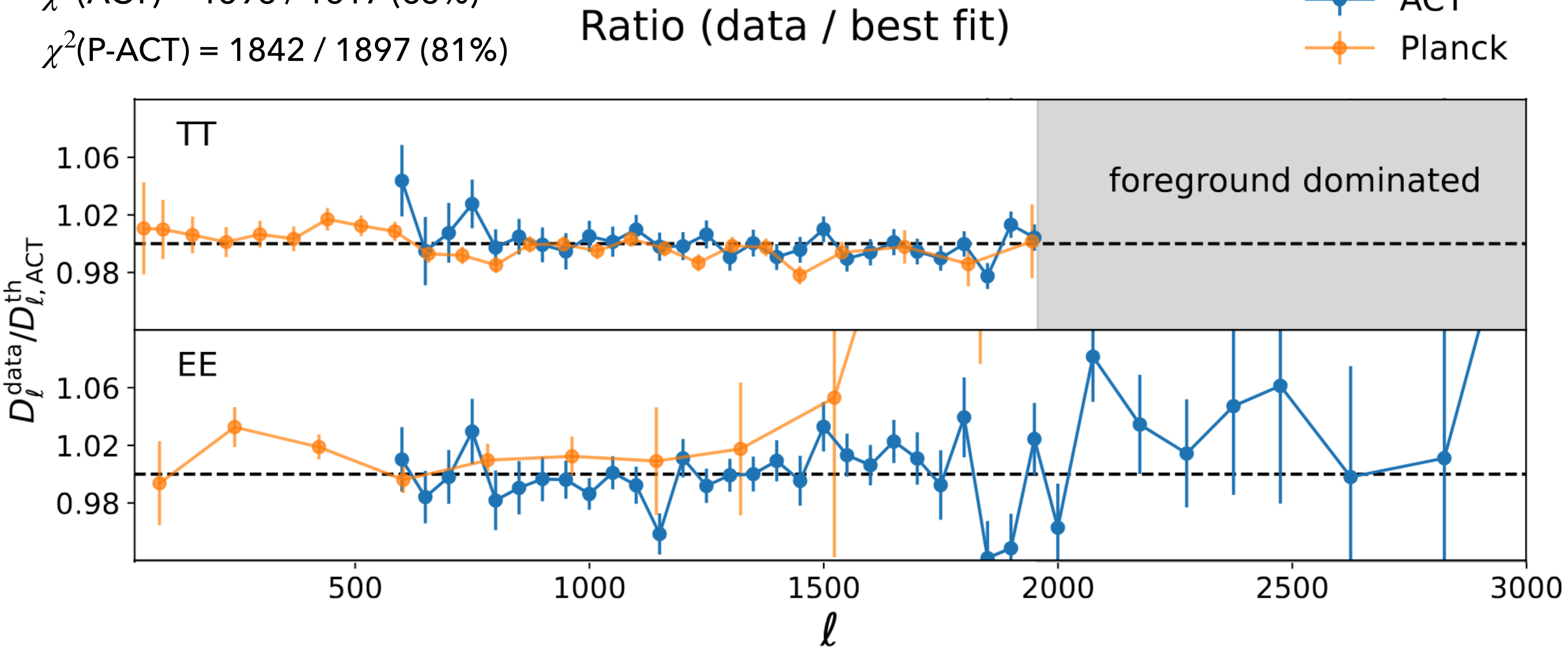

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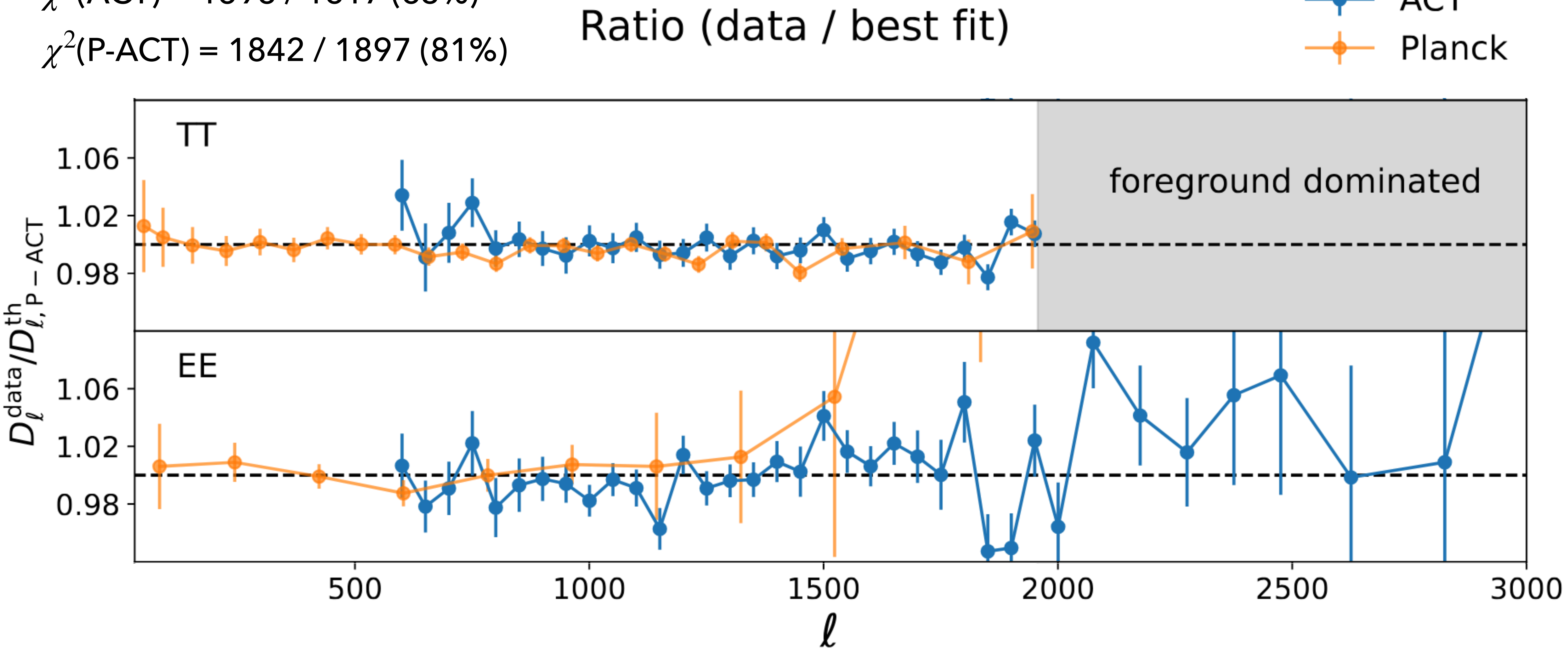

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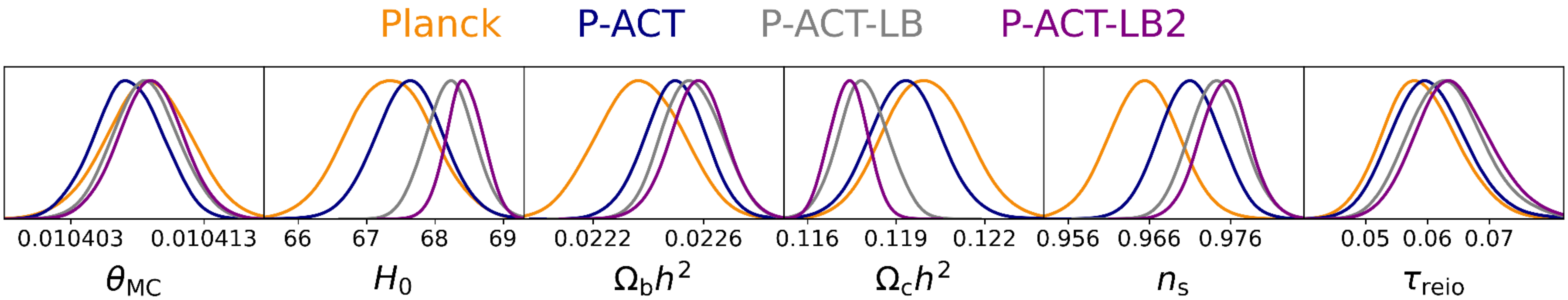
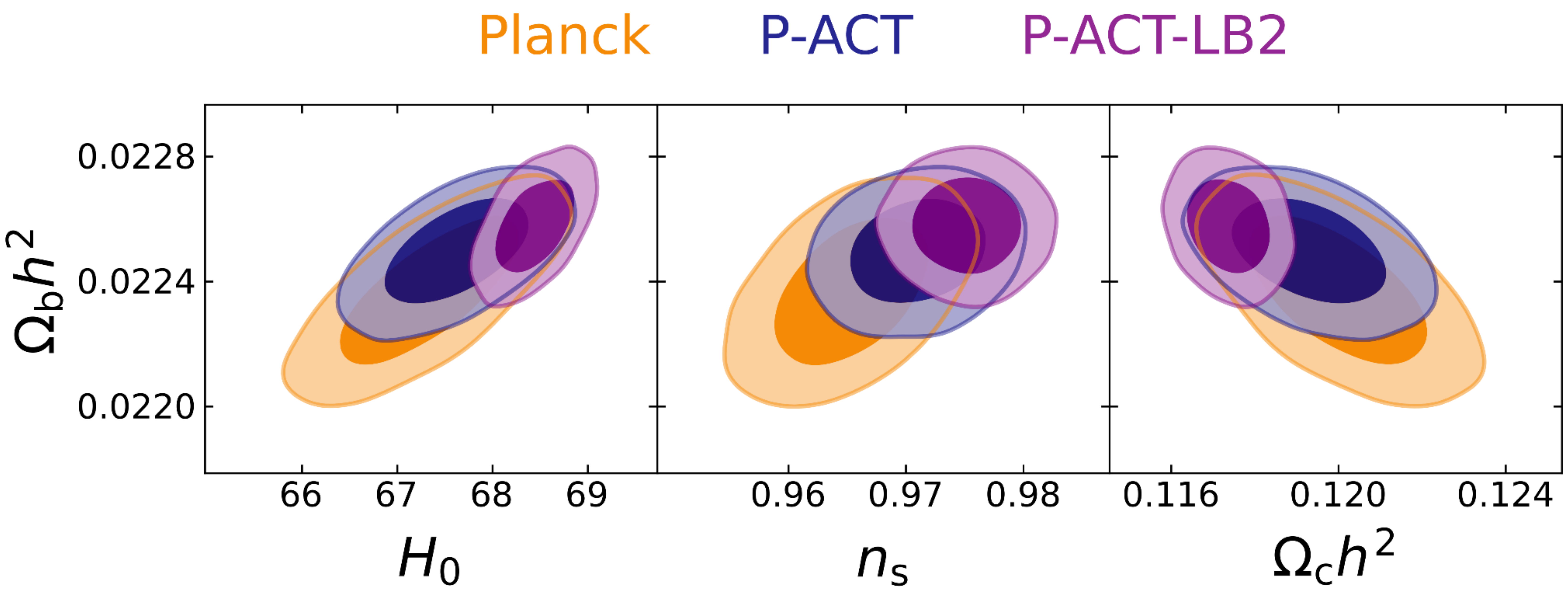
DESI BAO Y1 VS DR2





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