ACT-DR6 Power Spectrum Foreground Model

… and validation on non-Gaussian simulations

Based on Beringue, Surao et al. (JCAP, 2025)

Benjamin BERINGUE
Oct 13th - CMB-France

SciPol
erc
cnrs
Science from the large scale cosmic
microwave background polarization structure

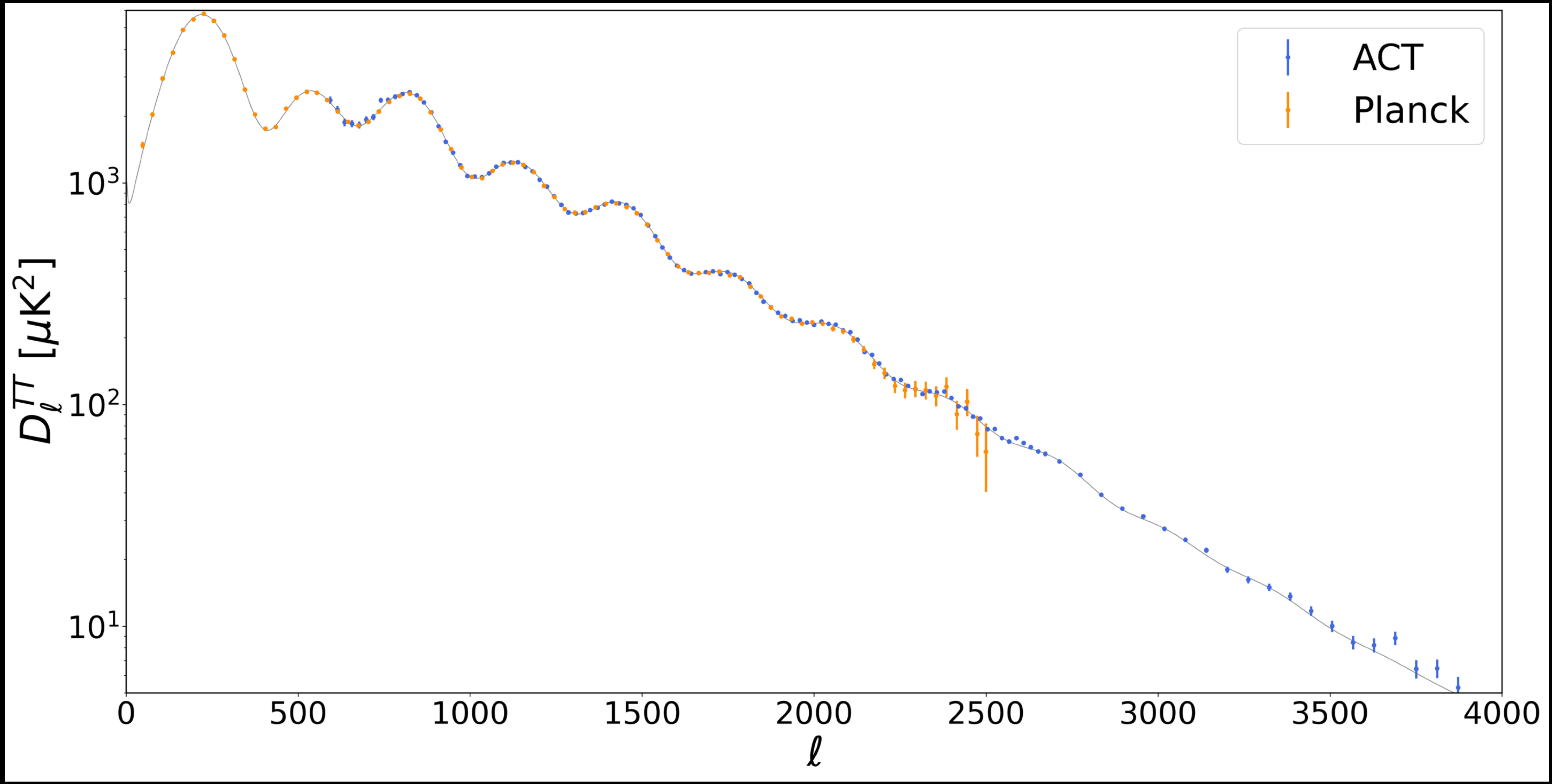
Outline

1. Modeling of the small scale angular power spectra
2. Testing DR6 model on Non-Gaussian simulations
3. Astrophysical constraints

Benjamin BERINGUE, APC
October 13th 2025

ACT *Data Release 6*

DR6 Power Spectra



ACT-DR6 data:

-Extend *Planck* measurement down to very small scales.

-Are consistent with *Planck* on overlapping scales.

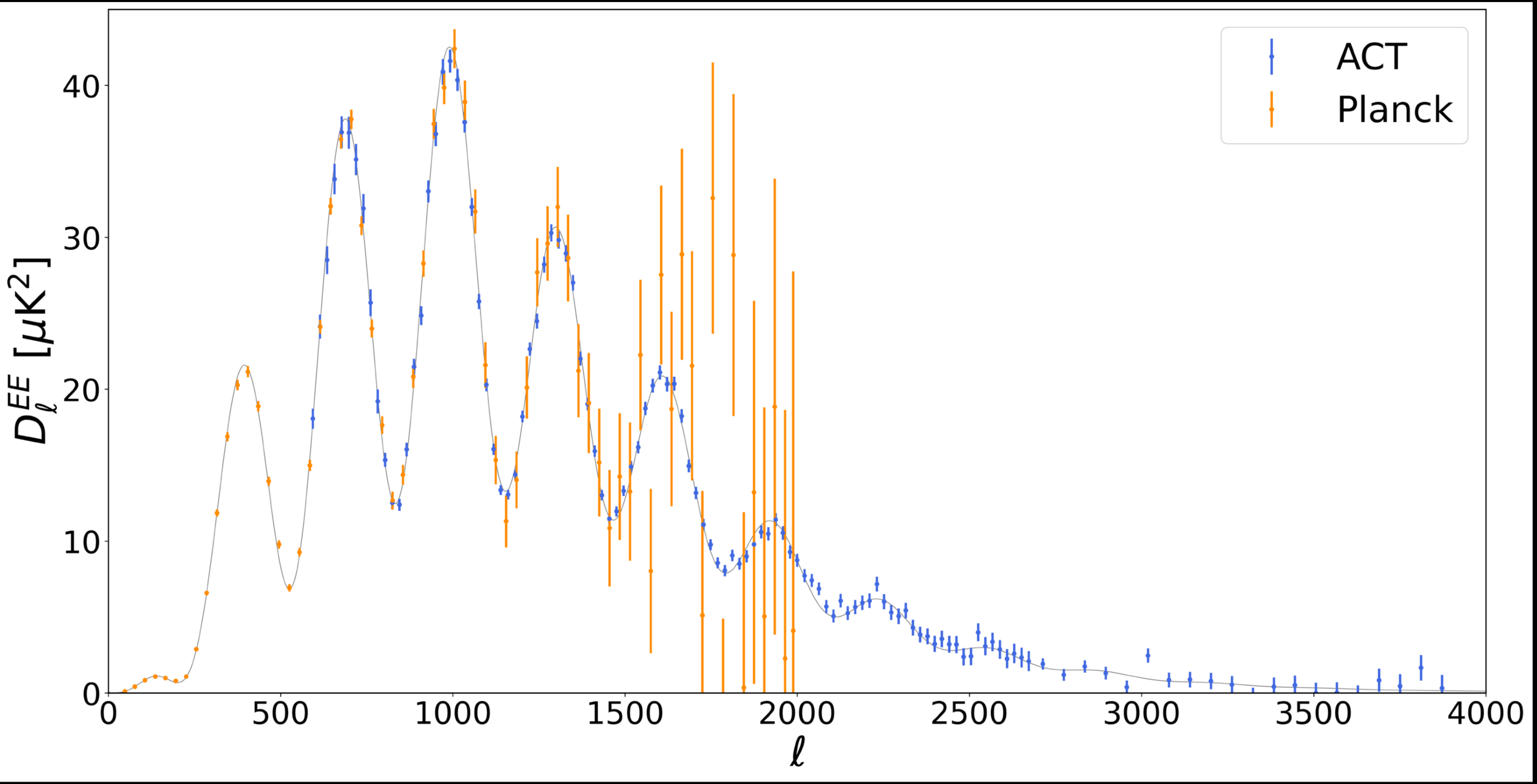
- ACT-DR6 EE is more sensitive than *Planck* for scales $\ell > 600$

-% precision cosmology with TE only.

[ACT-DR6 : *Louis et al.* 2503.14452]

ACT *Data Release 6*

DR6 Power Spectra



ACT-DR6 data:

-Extend *Planck* measurement down to very small scales.

-Are consistent with *Planck* on overlapping scales.

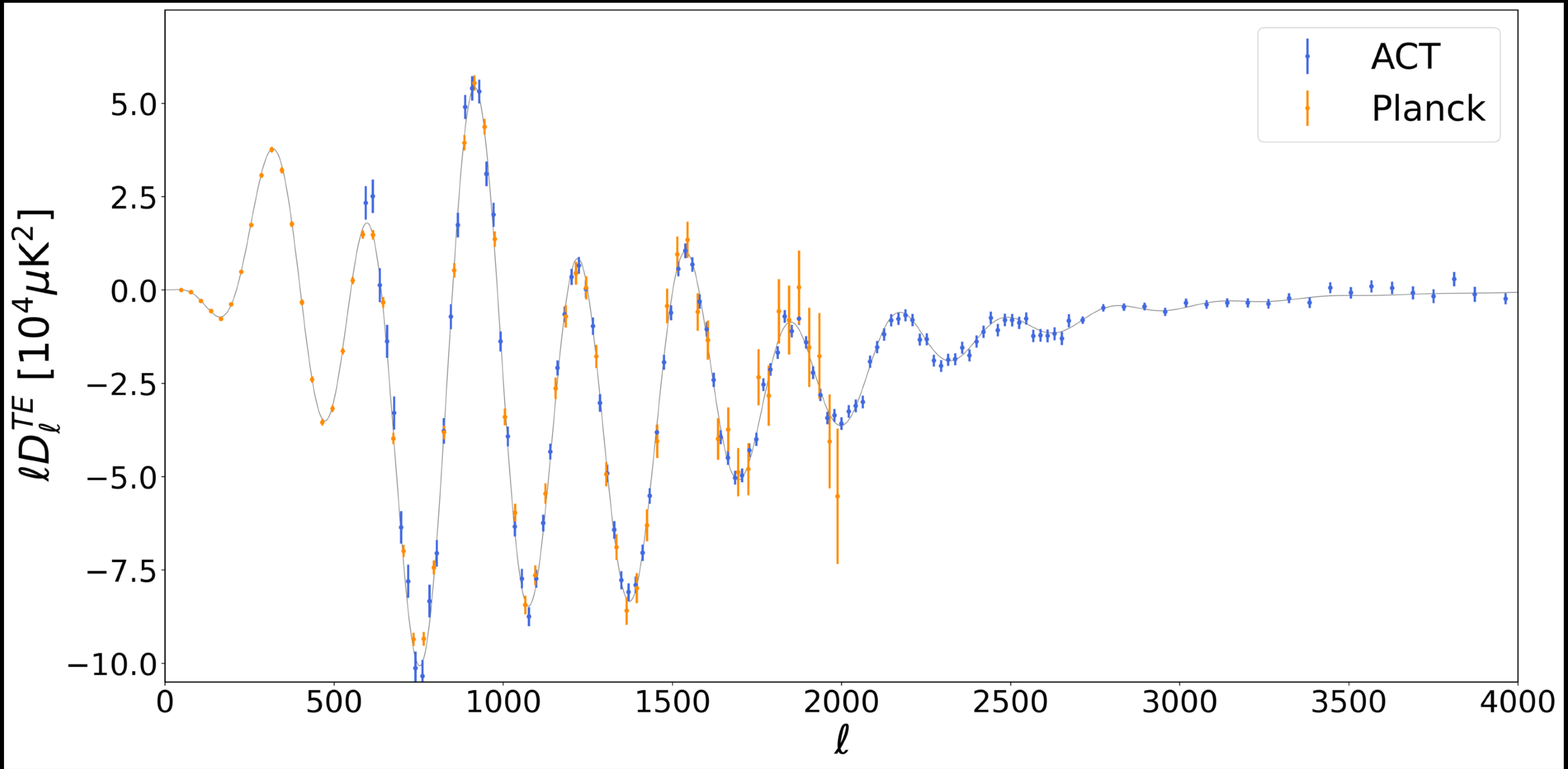
- ACT-DR6 EE is more sensitive than *Planck* for scales $\ell > 600$

-% precision cosmology with TE only.

[ACT-DR6 : *Louis et al.* 2503.14452]

ACT *Data Release 6*

DR6 Power Spectra



ACT-DR6 data:

-Extend *Planck* measurement down to very small scales.

-Are consistent with *Planck* on overlapping scales.

- ACT-DR6 EE is more sensitive than *Planck* for scales $\ell > 600$

-% precision cosmology with TE only.

[ACT-DR6 : *Louis et al.* 2503.14452]

Modeling of small scale power spectra

$$\hat{\mathscr{D}}_\ell^{\mathrm{obs.}}$$

$$\hat{\mathscr{D}}_\ell^{90\times220} \quad \hat{\mathscr{D}}_\ell^{150\times220}$$

$$\hat{\mathscr{D}}_\ell^{90\times90} \quad \hat{\mathscr{D}}_\ell^{90\times150}$$

$$\hat{\mathscr{D}}_\ell^{150\times150}$$

$$-2\ln L = (\mathscr{D}_\ell{}^{\mathrm{th.}} - \mathscr{D}_\ell{}^{\mathrm{obs.}})^T \Sigma^{-1} (\mathscr{D}_\ell{}^{\mathrm{th.}} - \mathscr{D}_\ell{}^{\mathrm{obs.}})$$

$$\Sigma_{\ell\ell'}$$

Atkins et al. [2025]

$$\mathscr{D}_\ell^{\mathrm{th.}}$$

Modeling of small scale power spectra

$$\mathscr{D}_\ell^{\text{th.}} = \mathscr{D}_\ell^{\text{CMB}} + \mathscr{D}_\ell^{\text{foregrounds}}$$

Modeling of small scale power spectra

$$\mathscr{D}_\ell^{\mathrm{fgs.,TT}} = \mathscr{D}_\ell^{\mathrm{tSZ}} + \mathscr{D}_\ell^{\mathrm{kSZ}} + \mathscr{D}_\ell^{\mathrm{CIB-c}} + \mathscr{D}_\ell^{\mathrm{CIB-p}} + \mathscr{D}_\ell^{\mathrm{tSZ\times CIB}} + \mathscr{D}_\ell^{\mathrm{radio,TT}} + \mathscr{D}_\ell^{\mathrm{dust,TT}}$$

[BB *et al.* 2506.06274]

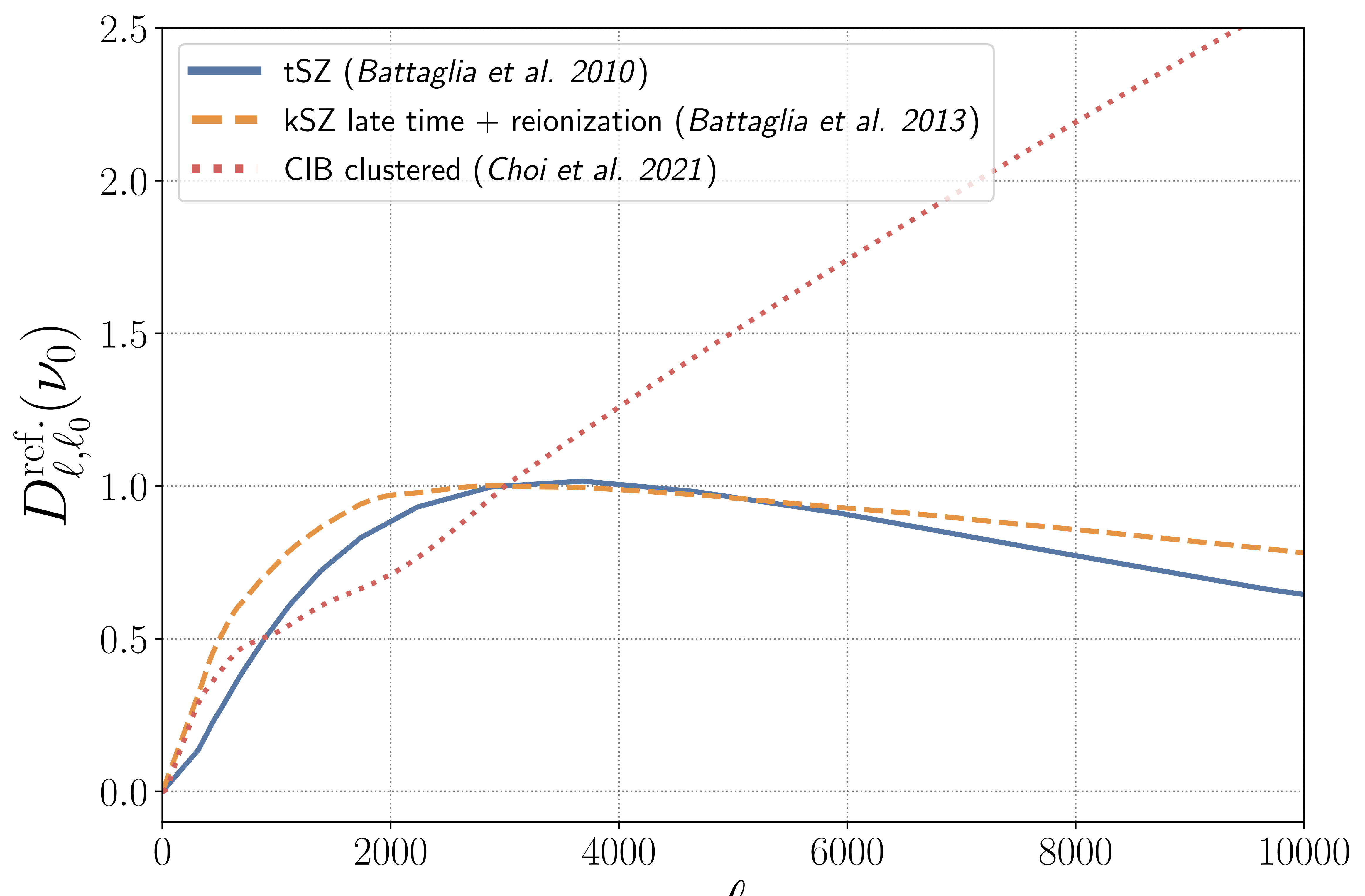
Modeling of small scale power spectra

$$\mathscr{D}_\ell^{\mathrm{fgs.,TT}} = \mathscr{D}_\ell^{\mathrm{tSZ}} + \mathscr{D}_\ell^{\mathrm{kSZ}} + \mathscr{D}_\ell^{\mathrm{CIB-c}} + \mathscr{D}_\ell^{\mathrm{CIB-p}} + \mathscr{D}_\ell^{\mathrm{tSZ\times CIB}} + \mathscr{D}_\ell^{\mathrm{radio,TT}} + \mathscr{D}_\ell^{\mathrm{dust,TT}}$$

Thermal Sunyaev-Zel'dovich effect

- Inverse Compton Scattering of CMB photons by hot electrons in clusters

$$\mathscr{D}^{T_iT_j}_{\ell,\mathrm{tSZ}} = a_{\mathrm{tSZ}} \mathscr{D}^{\mathrm{tSZ}}_{\ell,\ell_0} \left[\frac{\ell}{\ell_0}\right]^{\alpha_{\mathrm{tSZ}}} \frac{f_{\mathrm{tSZ}}(\nu_i) f_{\mathrm{tSZ}}(\nu_j)}{f^2_{\mathrm{tSZ}}(\nu_0)}$$



[BB *et al.* 2506.06274]

Benjamin BERINGUE, APC
October 13th 2025

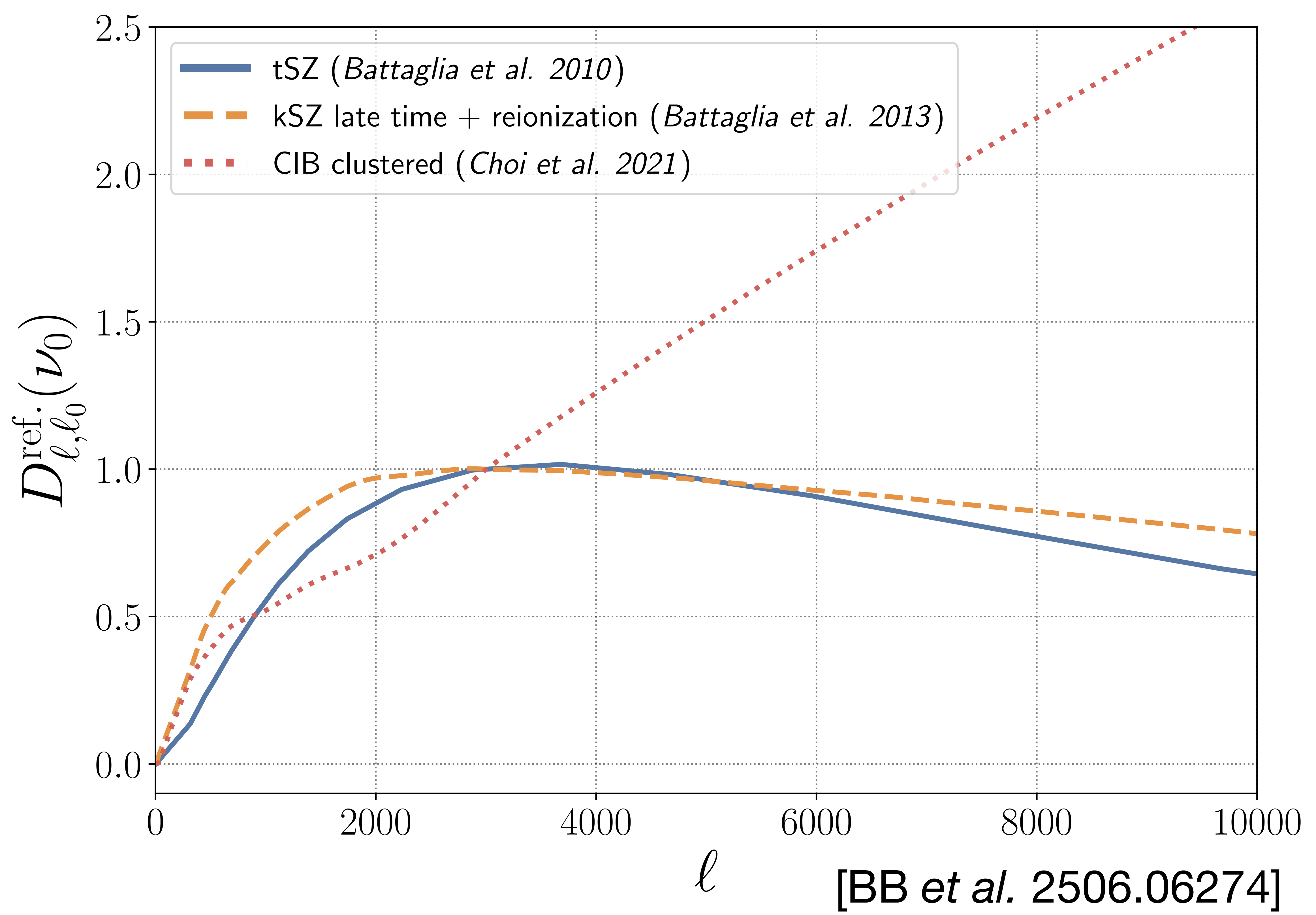
Modeling of small scale power spectra

$$\mathscr{D}_\ell^{\mathrm{fgs.,TT}} = \mathscr{D}_\ell^{\mathrm{tSZ}} + \mathscr{D}_\ell^{\mathrm{kSZ}} + \mathscr{D}_\ell^{\mathrm{CIB-c}} + \mathscr{D}_\ell^{\mathrm{CIB-p}} + \mathscr{D}_\ell^{\mathrm{tSZ\times CIB}} + \mathscr{D}_\ell^{\mathrm{radio,TT}} + \mathscr{D}_\ell^{\mathrm{dust,TT}}$$

Kinetic Sunyaev-Zel'dovich effect

- Inverse Compton Scattering of CMB photons by hot electrons in clusters with peculiar velocity

$$\mathscr{D}_{\ell,\mathrm{kSZ}}^{T_iT_j} = a_{\mathrm{kSZ}}\mathscr{D}_{\ell,\ell_0}^{\mathrm{kSZ}}$$



[BB *et al.* 2506.06274]

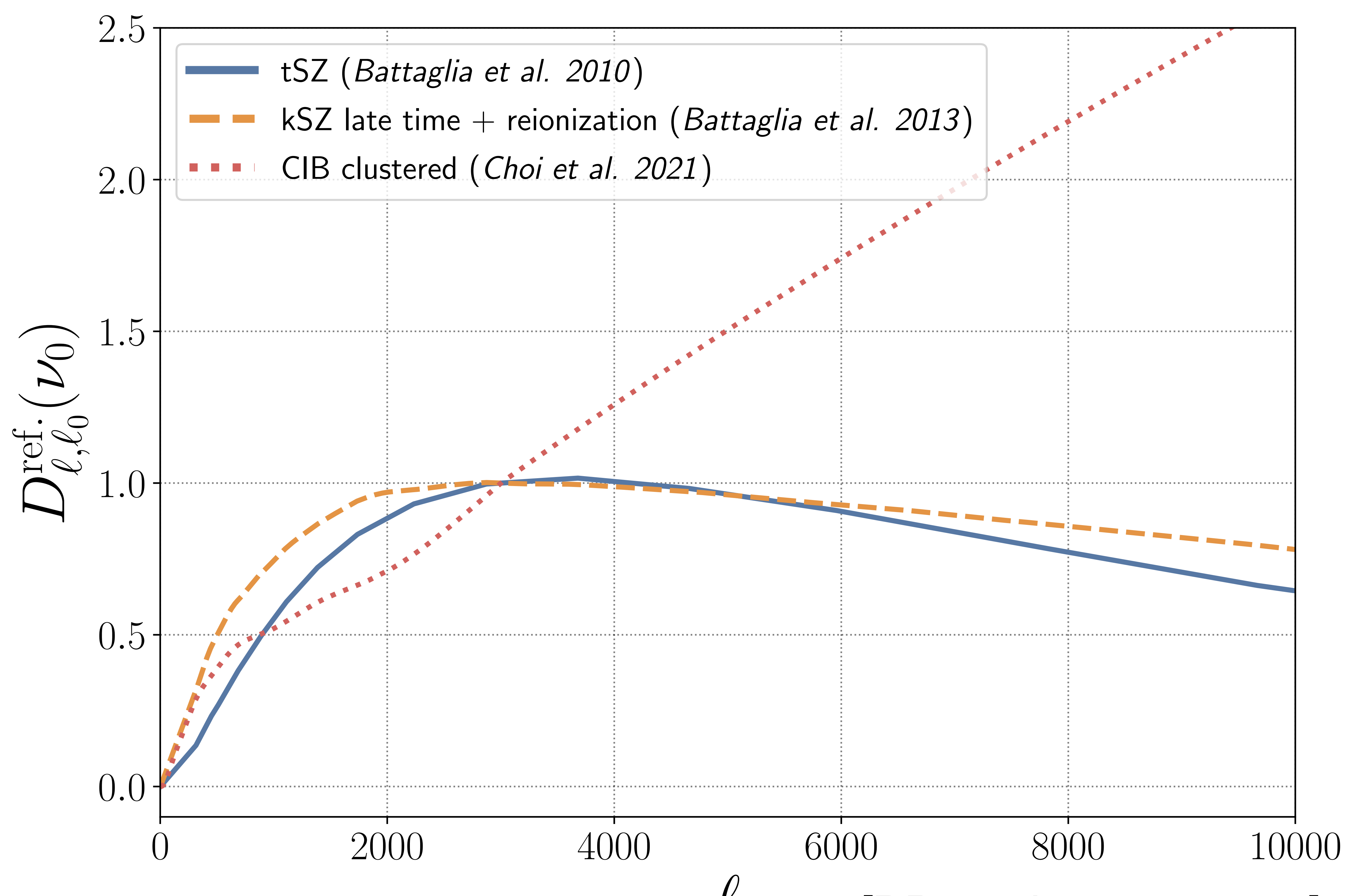
Modeling of small scale power spectra

$$\mathscr{D}_\ell^{\text{fgs.,TT}} = \mathscr{D}_\ell^{\text{tSZ}} + \mathscr{D}_\ell^{\text{kSZ}} + \mathscr{D}_\ell^{\text{CIB}-\text{c}} + \mathscr{D}_\ell^{\text{CIB}-\text{p}} + \mathscr{D}_\ell^{\text{tSZ}\times\text{CIB}} + \mathscr{D}_\ell^{\text{radio,TT}} + \mathscr{D}_\ell^{\text{dust,TT}}$$

Clustered Cosmic Infrared Background

- Redshifted thermal dust emission from distant galaxies.

$$\mathscr{D}_{\ell,\text{CIB}-\text{c}}^{T_iT_j} = a_c \mathscr{D}_{\ell,\ell_0}^{\text{CIB}-\text{c}} \frac{\mu(\nu_i;\beta_c,T_d)\mu(\nu_j;\beta_c,T_d)}{\mu^2(\nu_0;\beta_c,T_d)}$$



[BB *et al.* 2506.06274]

Benjamin BERINGUE, APC
October 13th 2025

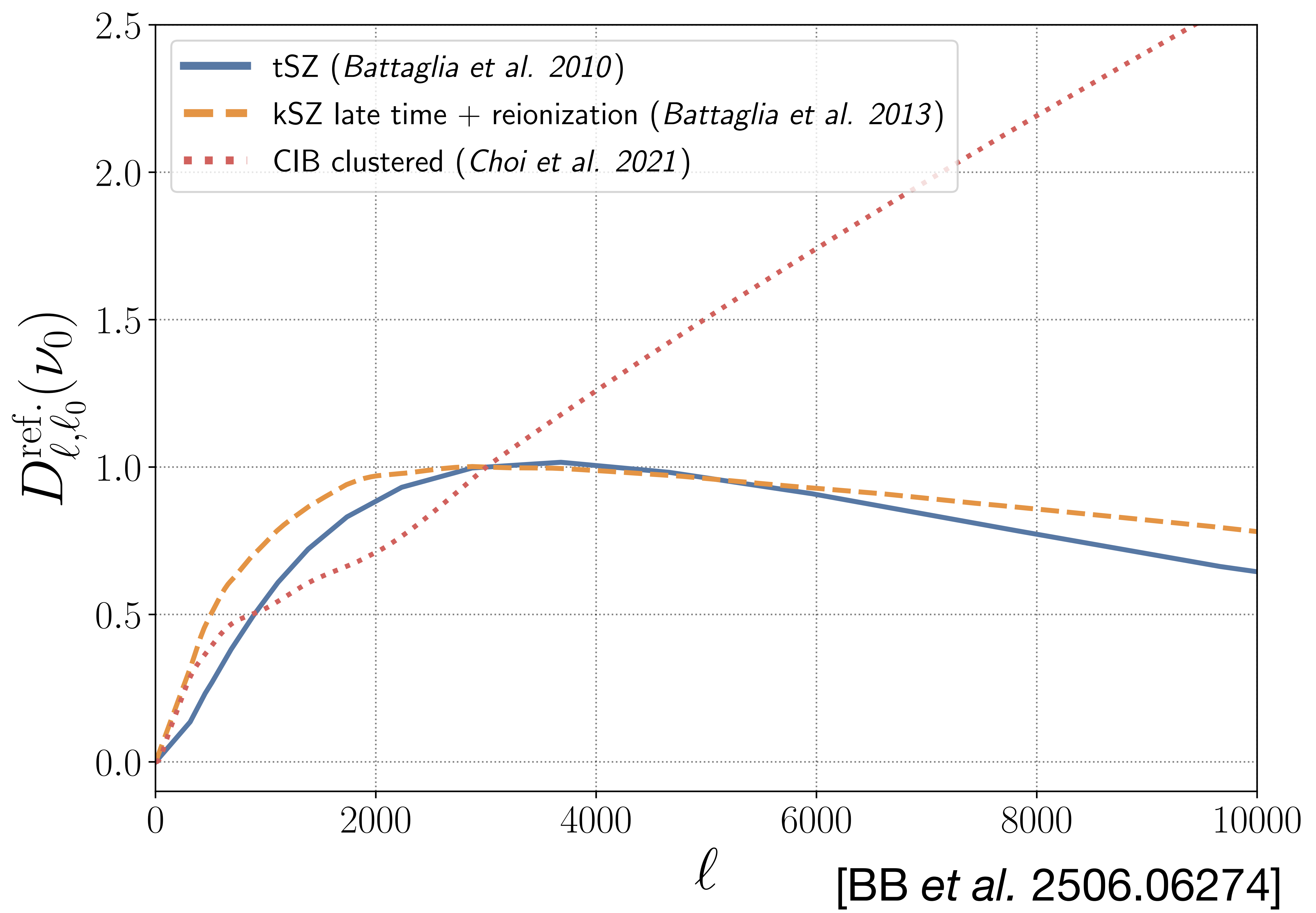
Modeling of small scale power spectra

$$\mathscr{D}_\ell^{\mathrm{fgs.,TT}} = \mathscr{D}_\ell^{\mathrm{tSZ}} + \mathscr{D}_\ell^{\mathrm{kSZ}} + \mathscr{D}_\ell^{\mathrm{CIB-c}} + \mathscr{D}_\ell^{\mathrm{CIB-p}} + \mathscr{D}_\ell^{\mathrm{tSZ\times CIB}} + \mathscr{D}_\ell^{\mathrm{radio,TT}} + \mathscr{D}_\ell^{\mathrm{dust,TT}}$$

Poisson Cosmic Infrared Background

- Redshifted thermal dust emission from distant galaxies.

$$\mathscr{D}_{\ell,\mathrm{CIB-p}}^{T_iT_j} = a_p \left[\frac{\ell(\ell+1)}{\ell_0(\ell_0+1)}\right] \frac{\mu(\nu_i;\beta_p,T_d)\mu(\nu_j;\beta_p,T_d)}{\mu^2(\nu_0;\beta_p,T_d)}$$

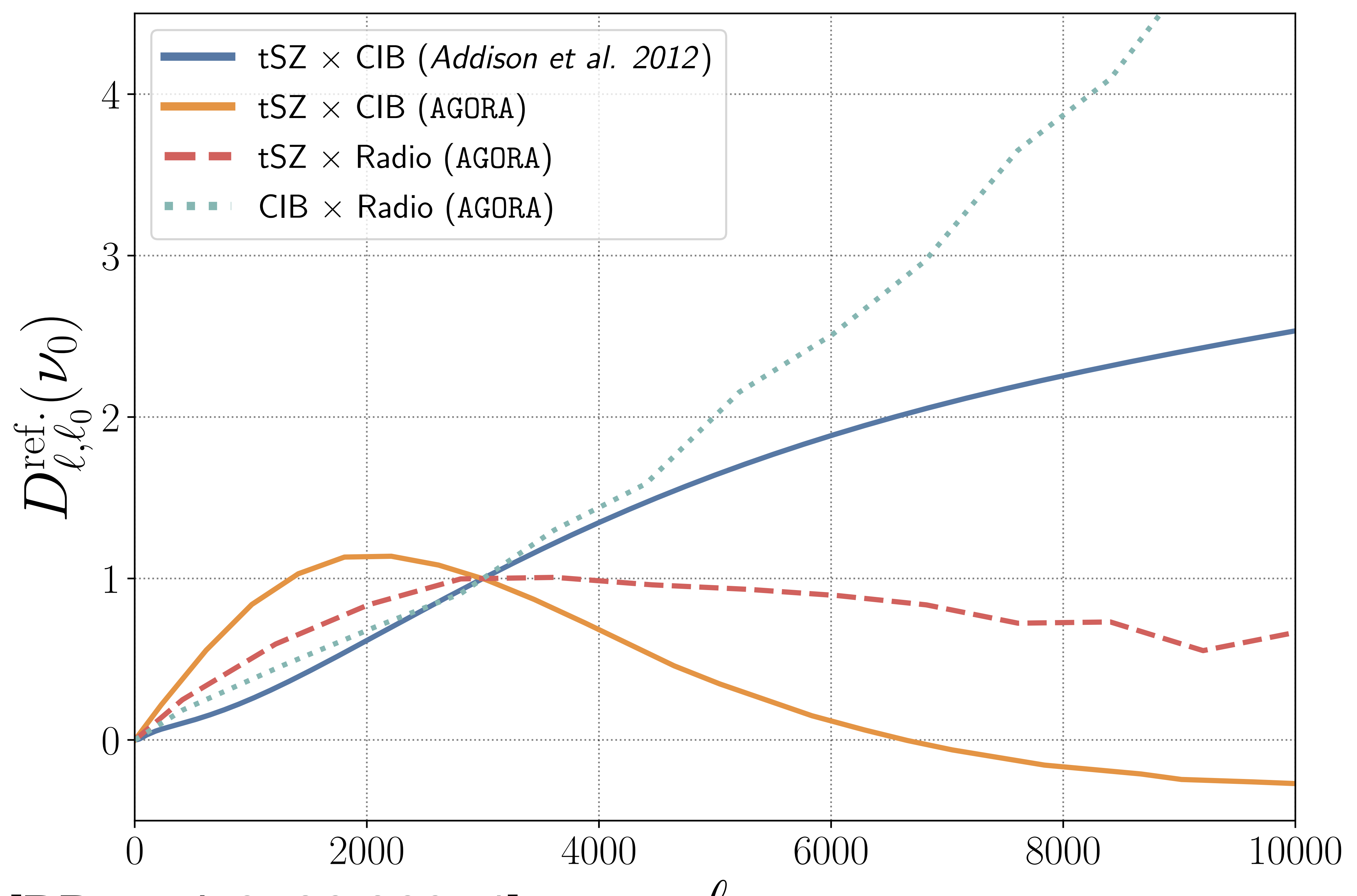


[BB *et al.* 2506.06274]

Benjamin BERINGUE, APC
October 13th 2025

Modeling of small scale power spectra

$$\mathscr{D}_\ell^{\mathrm{fgs.,TT}} = \mathscr{D}_\ell^{\mathrm{tSZ}} + \mathscr{D}_\ell^{\mathrm{kSZ}} + \mathscr{D}_\ell^{\mathrm{CIB-c}} + \mathscr{D}_\ell^{\mathrm{CIB-p}} + \mathscr{D}_\ell^{\mathrm{tSZ\times CIB}} + \mathscr{D}_\ell^{\mathrm{radio,TT}} + \mathscr{D}_\ell^{\mathrm{dust,TT}}$$



[BB *et al.* 2506.06274]

CIBxtSZ correlation

- tSZ and clustered CIB are sourced by the same clusters

$$\mathscr{D}^{T_iT_j}_{\ell,\mathrm{tSZ\times CIB}} = -\xi_{yc}\sqrt{a_c a_{\mathrm{tSZ}}}\,\mathscr{D}^{\mathrm{tSZ\times CIB}}_{\ell,\ell_0} \times \left(\frac{f_{\mathrm{tSZ}}(\nu_i)\mu(\nu_j;\beta_c,T_d) + f_{\mathrm{tSZ}}(\nu_j)\mu(\nu_i;\beta_c,T_d)}{f_{\mathrm{tSZ}}(\nu_0)\mu(\nu_0;\beta_c,T_d)}\right)$$

Benjamin BERINGUE, APC

October 13th 2025

Modeling of small scale power spectra

$$\mathscr{D}_\ell^{\rm fgs.,TT} = \mathscr{D}_\ell^{\rm tSZ} + \mathscr{D}_\ell^{\rm kSZ} + \mathscr{D}_\ell^{\rm CIB-c} + \mathscr{D}_\ell^{\rm CIB-p} + \mathscr{D}_\ell^{\rm tSZ\times CIB} + \mathscr{D}_\ell^{\rm radio,TT} + \mathscr{D}_\ell^{\rm dust,TT}$$

Poisson distributed Radio Galaxies

- Synchrotron emission from distant radio galaxies

$$\mathscr{D}_{\ell,\rm radio}^{X_iY_j} = a_{\rm s}^{XY} \left[\frac{\ell(\ell+1)}{\ell_0(\ell_0+1)}\right] \left[\frac{g(\nu_i)g(\nu_j)}{g^2(\nu_0)}\right] \left[\frac{\nu_i\nu_j}{\nu_0^2}\right]^{\beta_s+2}$$

[BB *et al.* 2506.06274]

Modeling of small scale power spectra

$$\mathscr{D}_\ell^{\mathrm{fgs.,TT}} = \mathscr{D}_\ell^{\mathrm{tSZ}} + \mathscr{D}_\ell^{\mathrm{kSZ}} + \mathscr{D}_\ell^{\mathrm{CIB-c}} + \mathscr{D}_\ell^{\mathrm{CIB-p}} + \mathscr{D}_\ell^{\mathrm{tSZ\times CIB}} + \mathscr{D}_\ell^{\mathrm{radio,TT}} + \mathscr{D}_\ell^{\mathrm{dust,TT}}$$

Residual galactic dust emission

- Thermal emission from galactic dust in the ACT footprint

$$\mathscr{D}_{\ell,g}^{T_iT_j} = a_g^{TT} \left[\frac{\ell}{\ell_0}\right]^{\alpha_g^{TT}} \frac{\mu(\nu_i;\beta_d,T_d^{\mathrm{eff}})\mu(\nu_j;\beta_d,T_d^{\mathrm{eff}})}{\mu^2(\nu_0;\beta_d,T_d^{\mathrm{eff}})}$$

Benjamin BERINGUE, APC
October 13th 2025

[BB *et al.* 2506.06274]

Modeling of small scale power spectra

$$\mathscr{D}_\ell^{\rm fgs.,TT} = \mathscr{D}_\ell^{\rm tSZ} + \mathscr{D}_\ell^{\rm kSZ} + \mathscr{D}_\ell^{\rm CIB-c} + \mathscr{D}_\ell^{\rm CIB-p} + \mathscr{D}_\ell^{\rm tSZ\times CIB} + \mathscr{D}_\ell^{\rm radio,TT} + \mathscr{D}_\ell^{\rm dust,TT}$$

$$\mathscr{D}_\ell^{\rm fgs.,EE} = \mathscr{D}_\ell^{\rm radio,EE} + \mathscr{D}_\ell^{\rm dust,EE}$$

$$\mathscr{D}_\ell^{\rm fgs.,TE} = \mathscr{D}_\ell^{\rm radio,TE} + \mathscr{D}_\ell^{\rm dust,TE}$$

[BB *et al.* 2506.06274]

Modeling of small scale power spectra

$$\mathscr{D}_\ell^{\mathrm{fgs.,TT}} = \mathscr{D}_\ell^{\mathrm{tSZ}} + \mathscr{D}_\ell^{\mathrm{kSZ}} + \mathscr{D}_\ell^{\mathrm{CIB-c}} + \mathscr{D}_\ell^{\mathrm{CIB-p}} + \mathscr{D}_\ell^{\mathrm{tSZ\times CIB}} + \mathscr{D}_\ell^{\mathrm{radio,TT}} + \mathscr{D}_\ell^{\mathrm{dust,TT}}$$

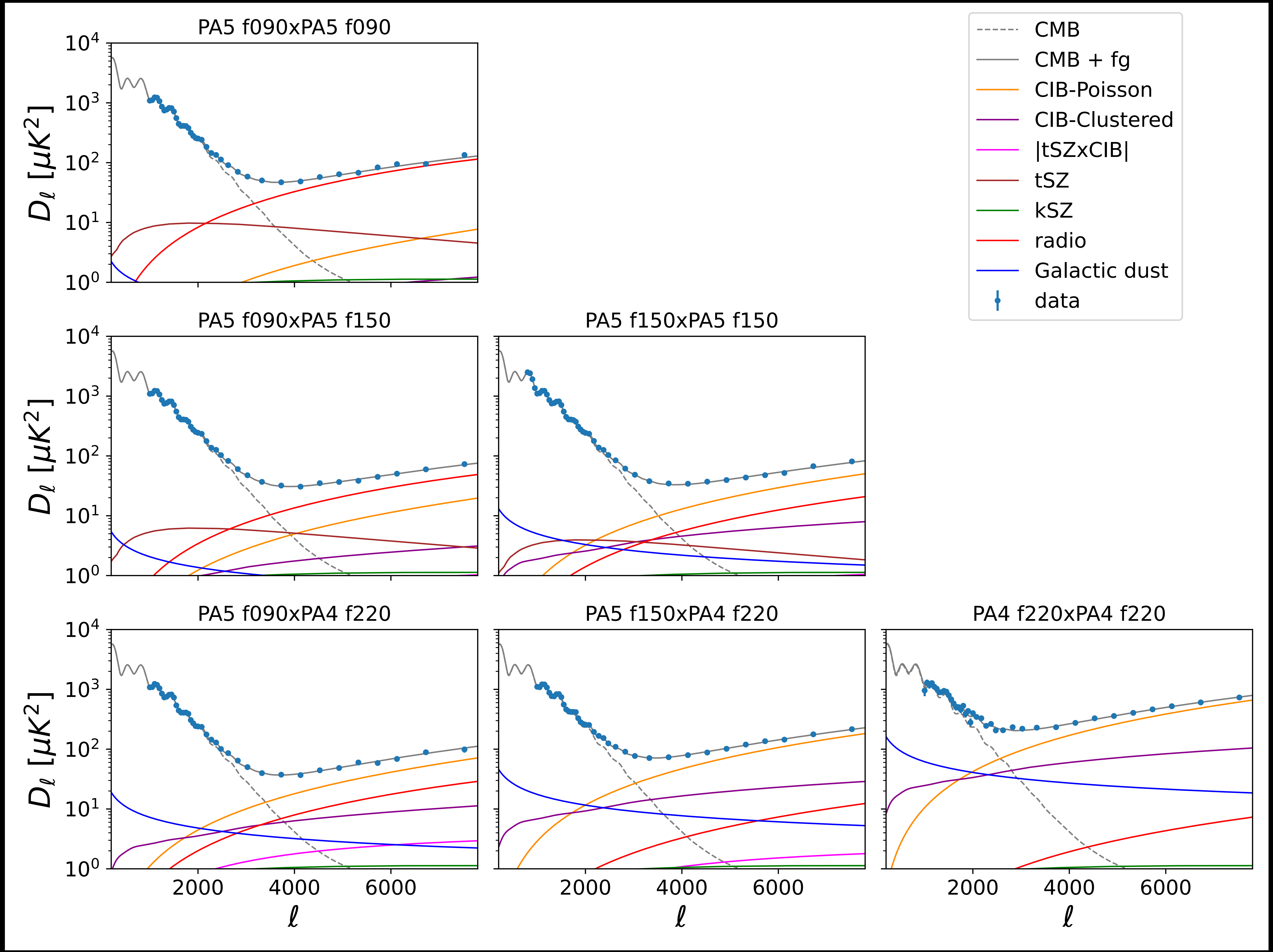
$$\mathscr{D}_\ell^{\mathrm{fgs.,EE}} = \mathscr{D}_\ell^{\mathrm{radio,EE}} + \mathscr{D}_\ell^{\mathrm{dust,EE}}$$

$$\mathscr{D}_\ell^{\mathrm{fgs.,TE}} = \mathscr{D}_\ell^{\mathrm{radio,TE}} + \mathscr{D}_\ell^{\mathrm{dust,TE}}$$

$\boxed{\text{14 parameters}}$

[BB *et al.* 2506.06274]

Modeling of small scale power spectra

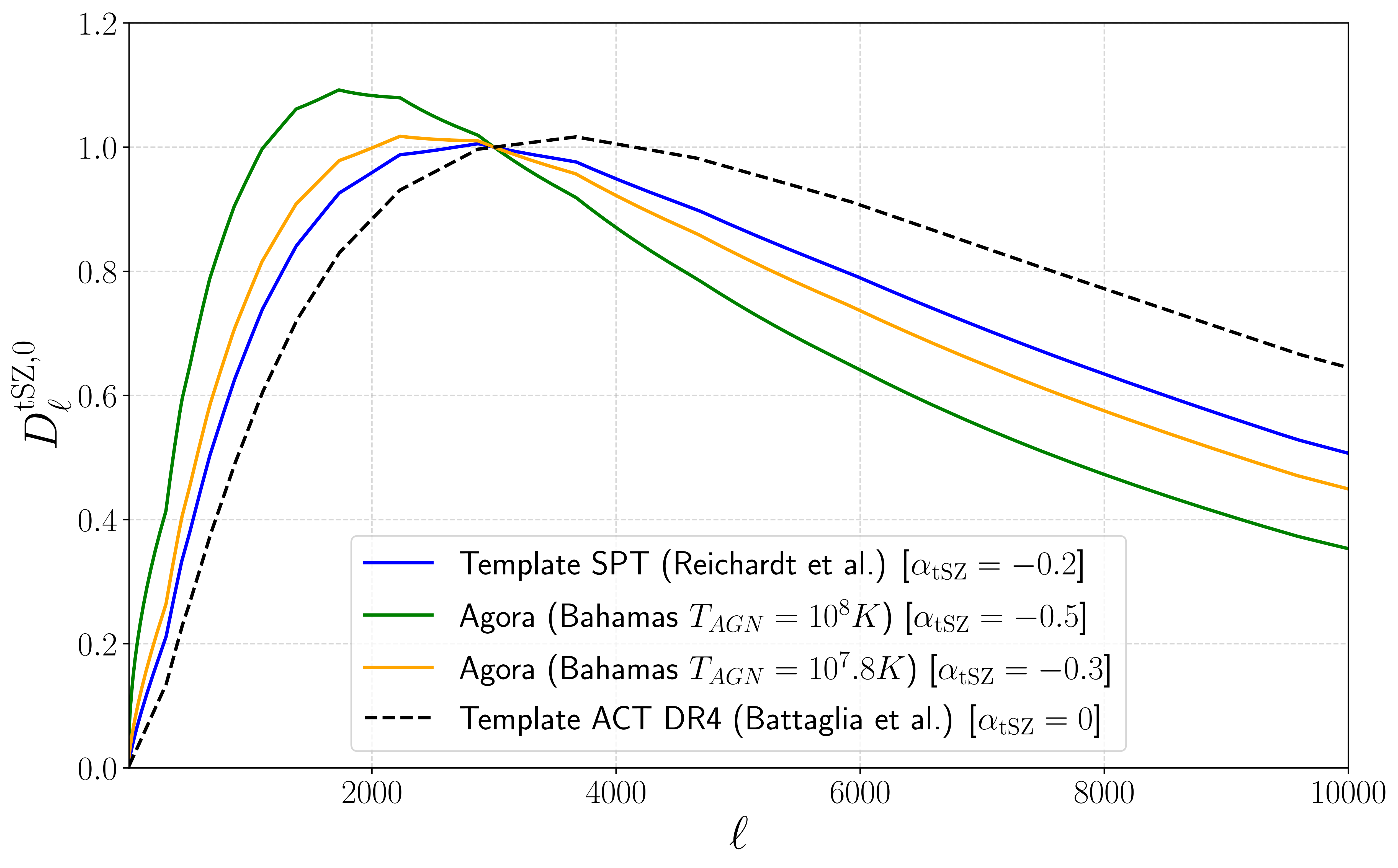


[ACT-DR6 : *Louis et al.* 2503.14452]

Modeling of tSZ signal

$$\mathscr{D}^{T_iT_j}_{\ell,\mathrm{tSZ}} = a_{\mathrm{tSZ}}\mathscr{D}^{\mathrm{tSZ}}_{\ell,\ell_0}\left[\frac{\ell}{\ell_0}\right]^{\alpha_{\mathrm{tSZ}}}\frac{f_{\mathrm{tSZ}}(\nu_i)f_{\mathrm{tSZ}}(\nu_j)}{f^2_{\mathrm{tSZ}}(\nu_0)}$$

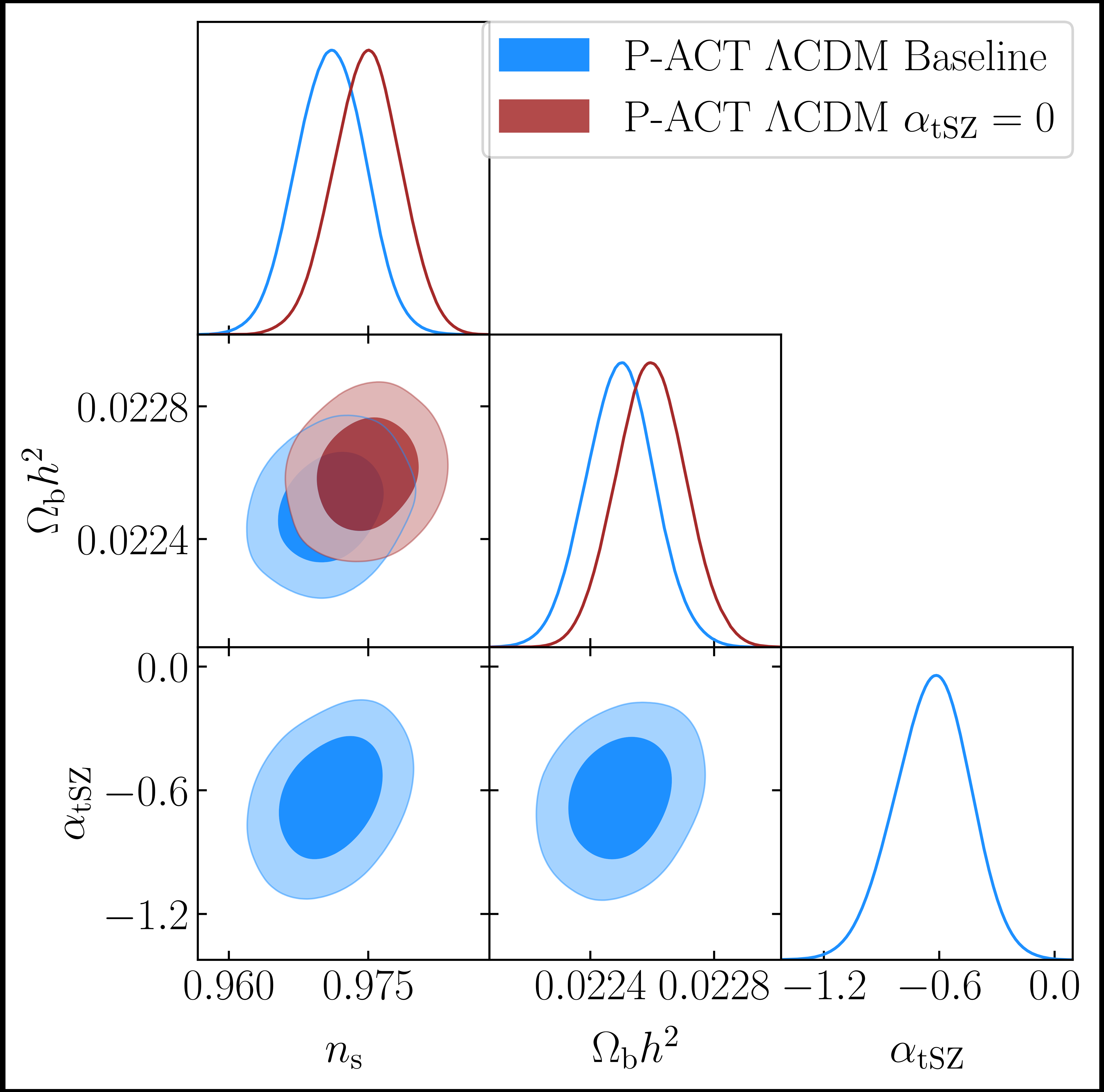
- Introduced new parameter : α_{tSZ} that empirically captures the scale dependence of the tSZ signal.
- Proxy for AGN temperature (in AGORA simulations). [Omori 2023].



Modeling of tSZ signal

- $> 0.5\sigma$ shift in cosmological parameters when $\alpha_{\rm tSZ} = 0$.

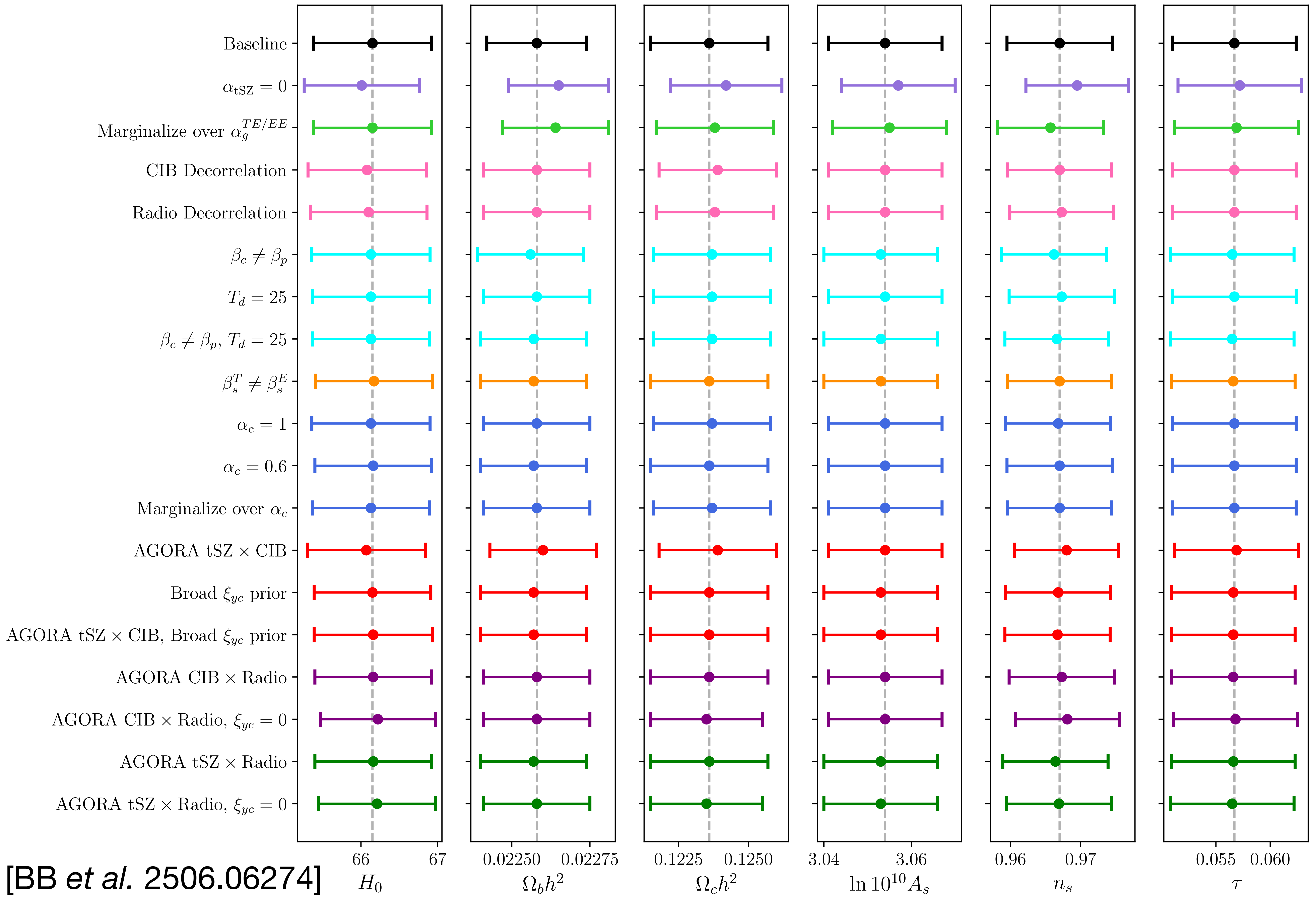
Parameter	ACT ΛCDM	ACT ΛCDM + $N_{\rm eff}$	P-ACT ΛCDM	P-ACT ΛCDM + $N_{\rm eff}$
H_0	-0.1	-0.3	0.3	-0.4
$\Omega_b h^2$	0.3	0.0	0.6	-0.2
$\Omega_c h^2$	0.2	-0.3	-0.2	-0.5
$\ln 10^{10} A_s$	0.2	0.0	0.3	-0.1
n_s	0.2	-0.2	0.8	-0.2
τ	0.1	0.2	0.3	0.1
$N_{\rm eff}$	–	-0.3	–	-0.5



[BB *et al.* 2506.06274]

Foreground model extensions

- Tested ~20 fg model extensions and assessed the impact on cosmological parameters.
- All changes below 0.1σ.
- No preference for any other model with ACT-DR6 data.



[BB *et al.* 2506.06274]

Outline

1. Modeling of the small scale angular power spectra

2. Testing DR6 model on Non-Gaussian simulations

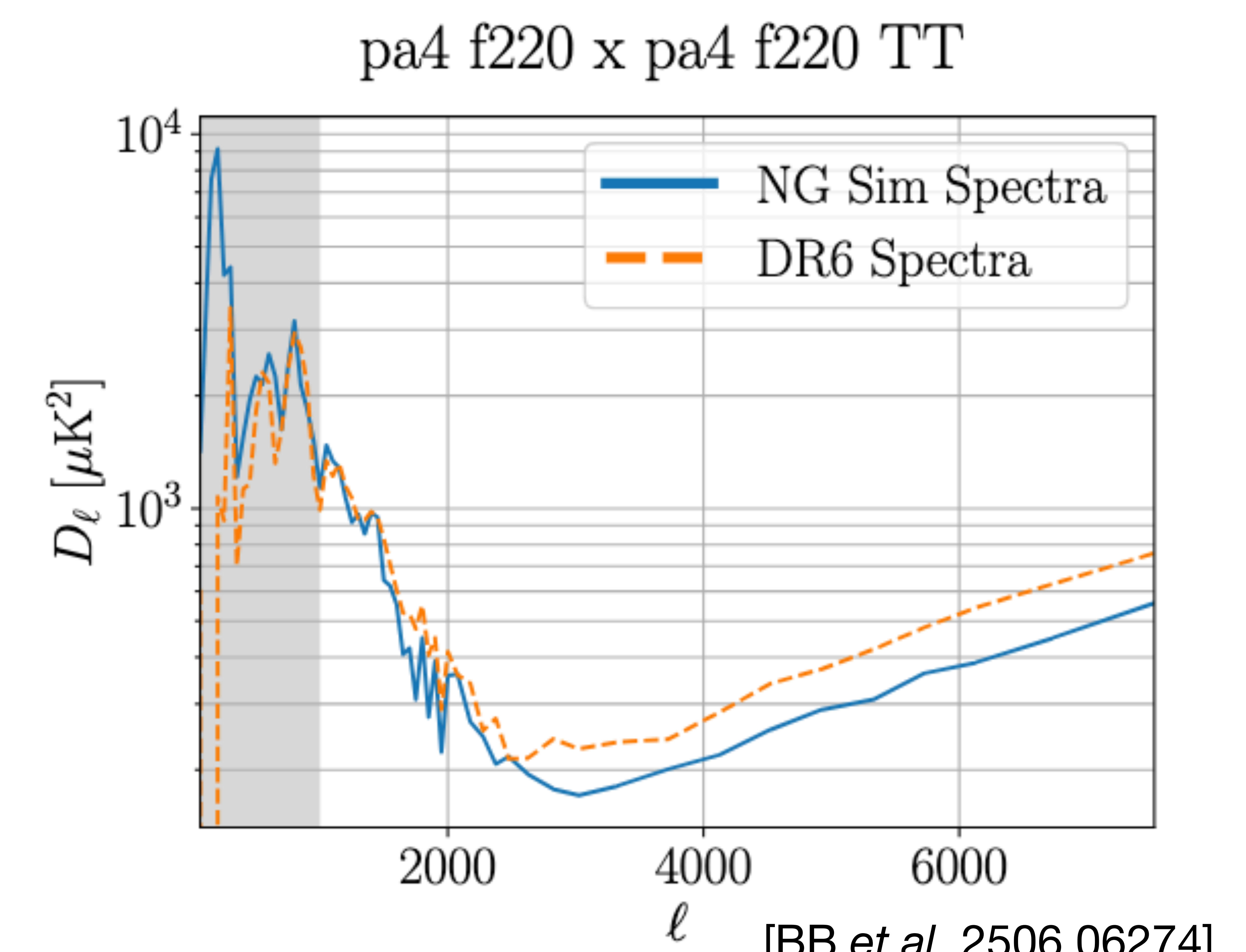
3. Astrophysical constraints

Benjamin BERINGUE, APC
October 13th 2025

Testing DR6 model on Non-Gaussian sims

- We used the AGORA simulations to produce 10 fully correlated non-gaussian simulations (CMB + foregrounds (galactic + extragal.) +noise).

- Processed through the DR6 pipeline.



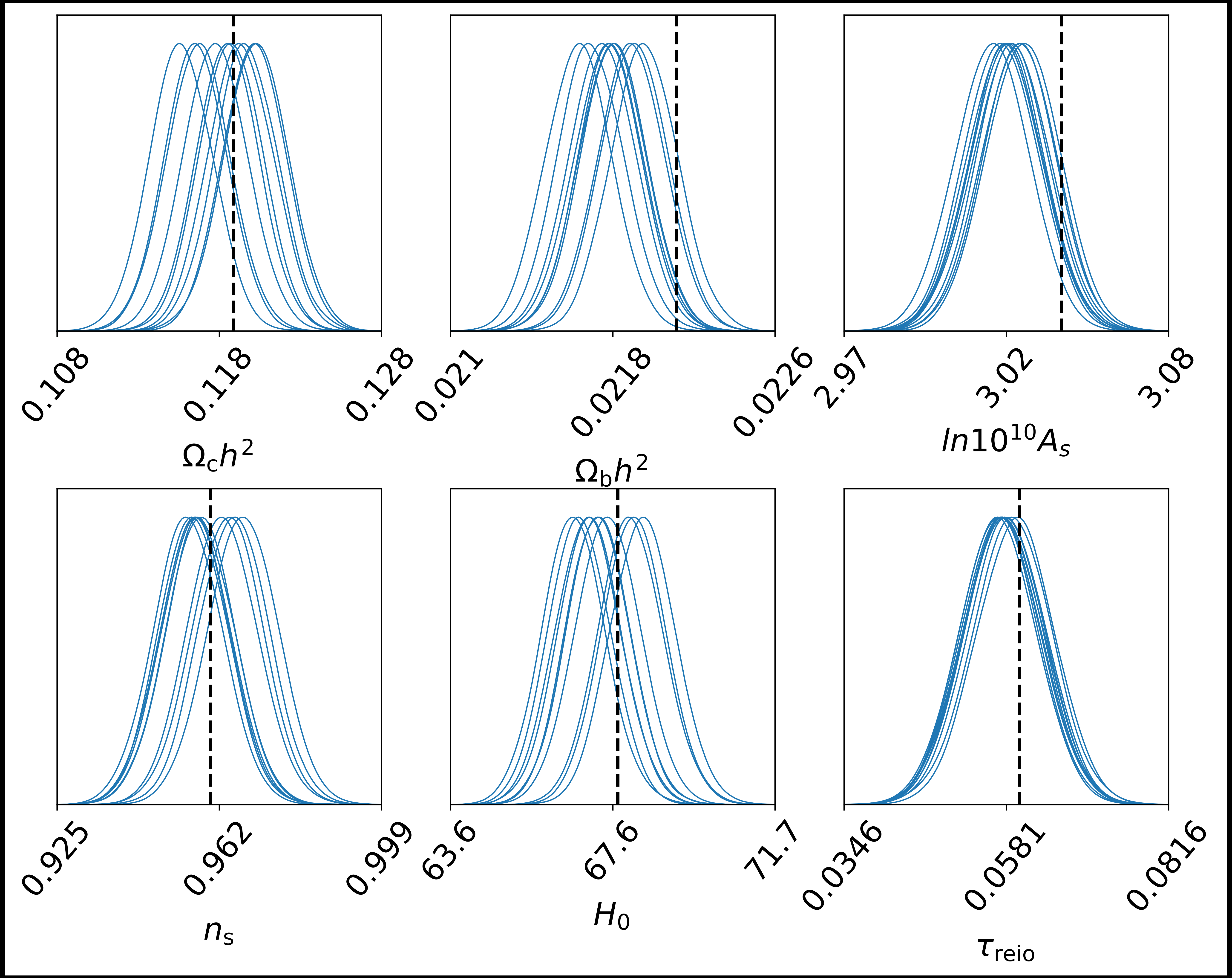
[BB *et al.* 2506.06274]

Benjamin BERINGUE, APC

October 13th 2025

Testing DR6 model on Non-Gaussian sims

- Recovered cosmo parameters are scattered as expected ($< 2\sigma$).
- Extremely challenging test of DR6 foreground model and pipeline.



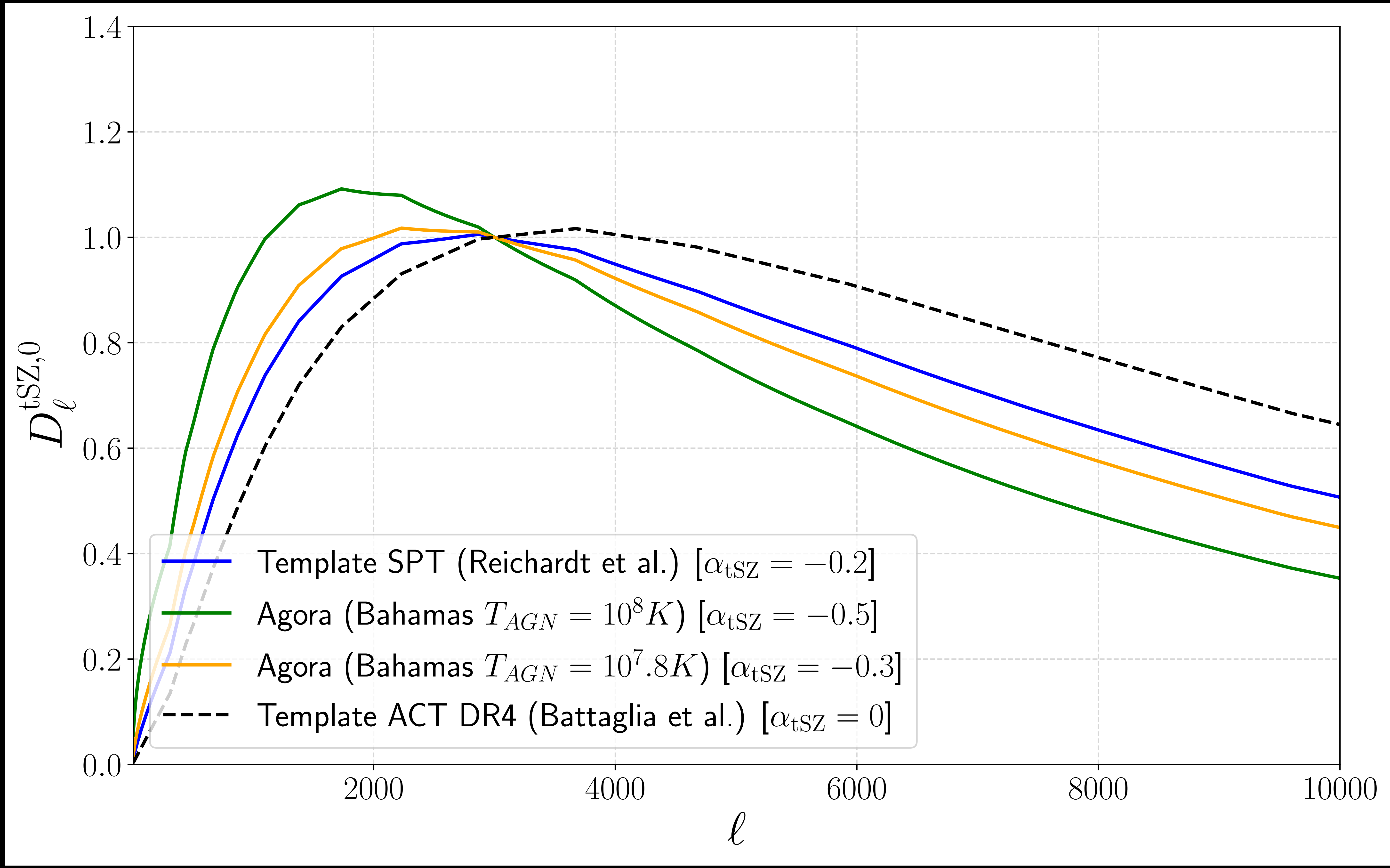
Benjamin BERINGUE, APC
October 13th 2025

Outline

1. Modeling of the small scale angular power spectra
2. Testing DR6 model on Non-Gaussian simulations
3. Astrophysical constraints

Constraints on tSZ spectrum

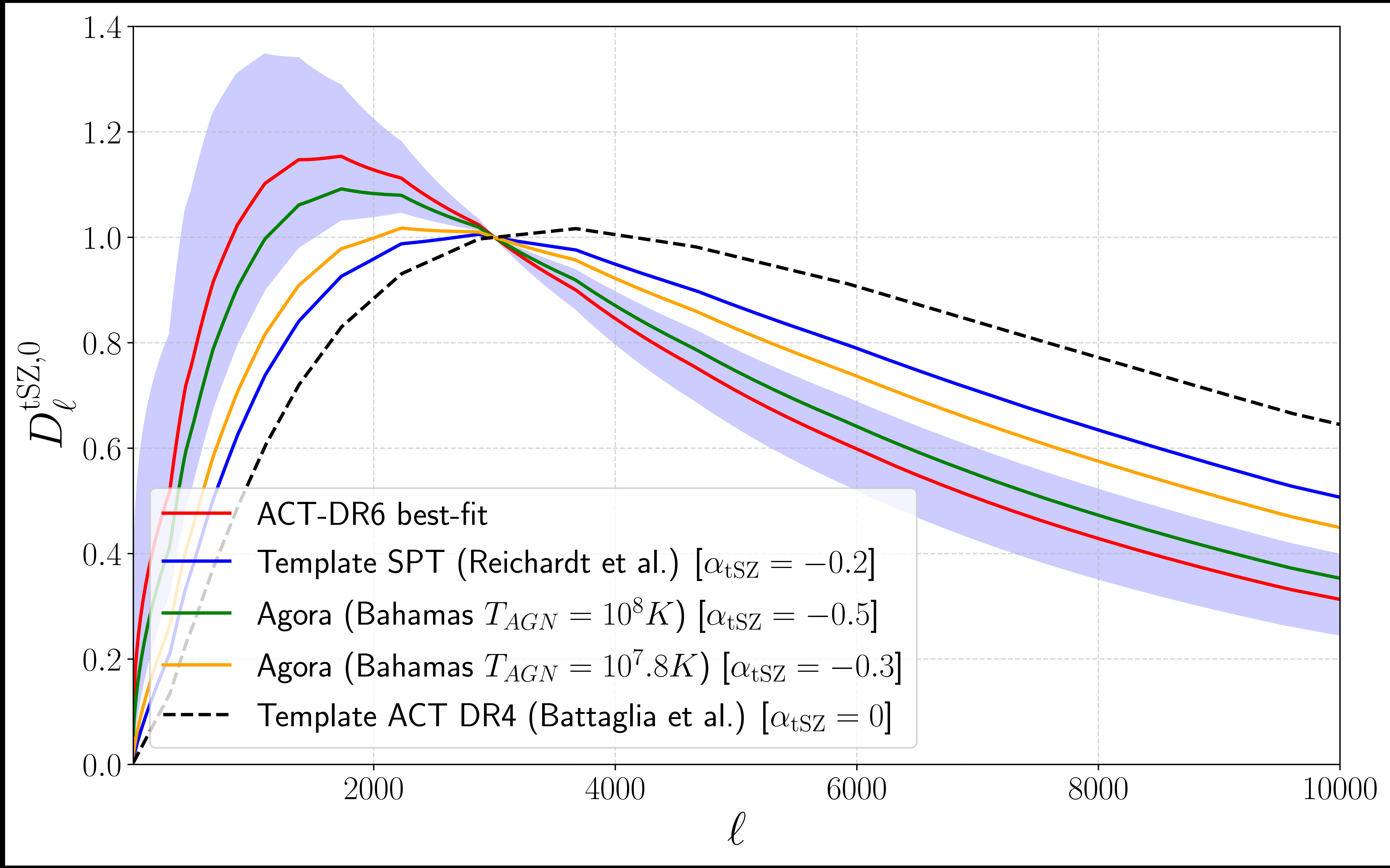
- $\alpha_{\rm tSZ}$ detected at 3σ in P-ACT: $\alpha_{\rm tSZ} = -0.6 \pm 0.2$.
- Higher AGN temperature than expected from AGORA/BAHAMAS simulations.
- Show sensitivity of multi-frequencies CMB data to tSZ modelling.



Benjamin BERINGUE, APC
October 13th 2025

Constraints on tSZ spectrum

- $\alpha_{\rm tSZ}$ detected at 3σ in P-ACT: $\alpha_{\rm tSZ} = -0.6 \pm 0.2$.
- Higher AGN temperature than expected from AGORA/BAHAMAS simulations.
- Show sensitivity of multi-frequencies CMB data to tSZ modelling.

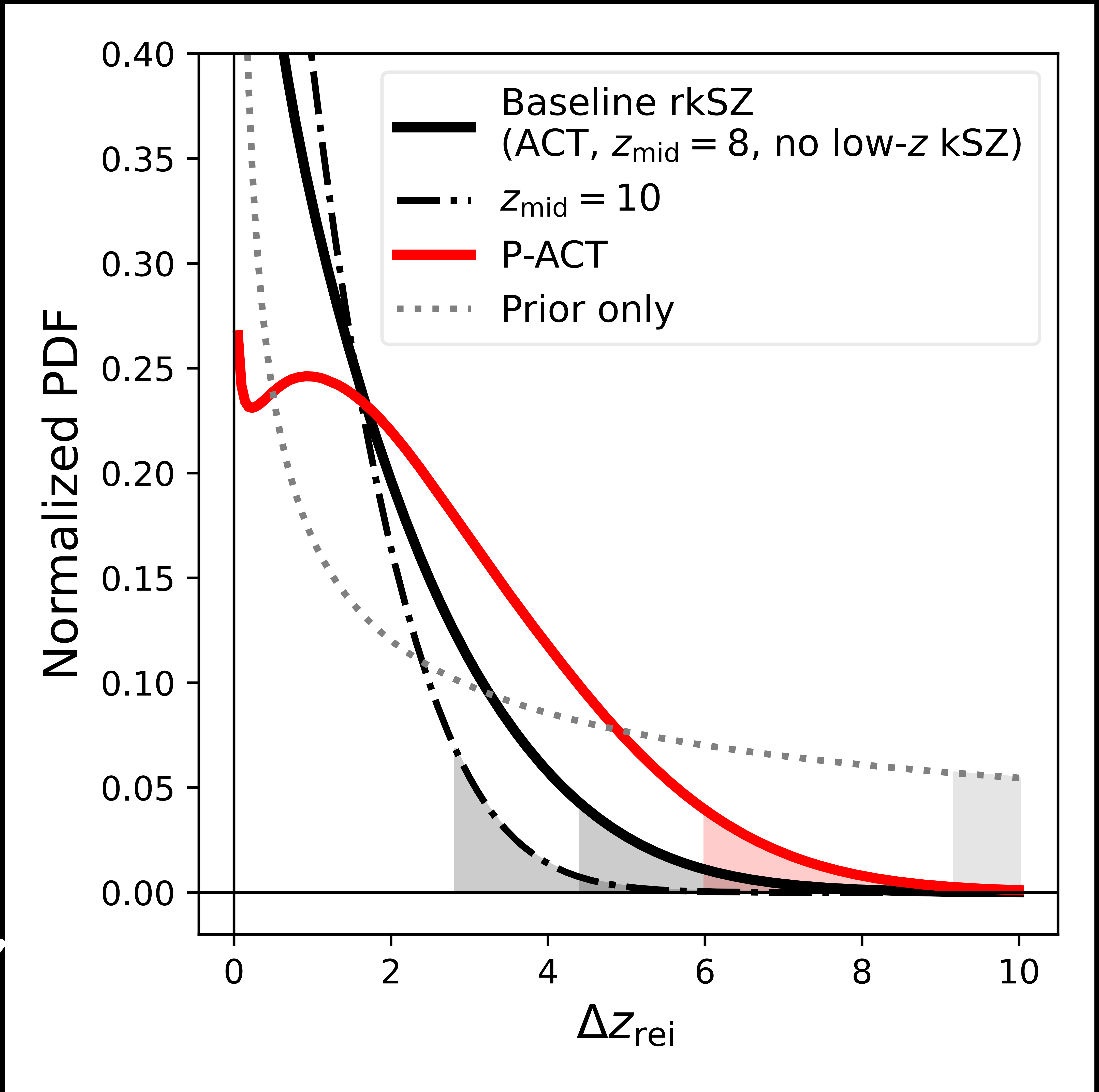


Constraints on reionisation

$$a_{\rm kSZ} = 1.48^{+0.71}_{-1.10}\ \mu{\rm K}^2$$

$$a_{\rm kSZ} = 2.03\left[\frac{1+z_{\rm mid}}{11} - 0.12\right]\left(\frac{\Delta z_{\rm rei}}{1.05}\right)^{0.51}$$

[Battaglia et al. 2013]



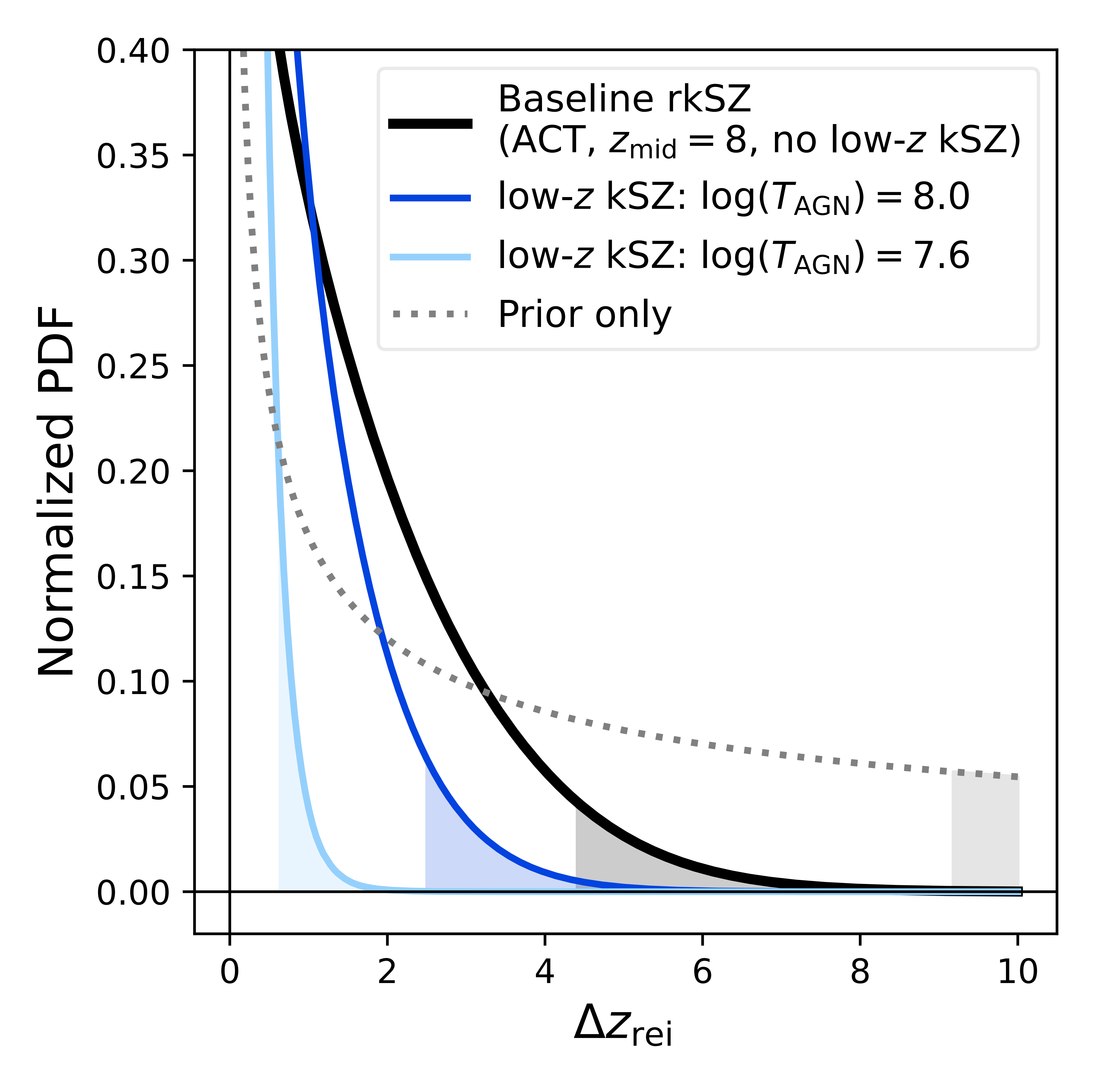
[BB *et al.* 2506.06274]

Constraints on reionisation

$$a_{\mathrm{kSZ}} = 1.48^{+0.71}_{-1.10}\ \mu\mathrm{K}^2$$

$$a_{\mathrm{kSZ}} = 2.03\left[\frac{1+z_{\mathrm{mid}}}{11} - 0.12\right]\left(\frac{\Delta z_{\mathrm{rei}}}{1.05}\right)^{0.51}$$

[Battaglia et al. 2013]



[BB *et al.* 2506.06274]

Constraints on reionisation

- Constraints on duration of reionisation for two different scaling relations.

Model	95% Upper Limit
Baseline rkSZ (ACT, B13 param., $z_{\rm mid} = 8$, no low-z kSZ)	$\Delta z_{\rm rei} < 4.4$
$z_{\rm mid} = 10$	$\Delta z_{\rm rei} < 2.9$
P-ACT	$\Delta z_{\rm rei} < 6.0$
low-z kSZ: $\log(T_{\rm AGN}) = 8.0$	$\Delta z_{\rm rei} < 2.5$
low-z kSZ: $\log(T_{\rm AGN}) = 7.6$	$\Delta z_{\rm rei} < 0.7$
Prior only	$\Delta z_{\rm rei} < 9.1$
`AMBER` param.	$\Delta z_{\rm rei,90} < 7.7$
`AMBER` param., $z_{\rm mid} = 10$	$\Delta z_{\rm rei,90} < 5.2$

[BB *et al.* 2506.06274]

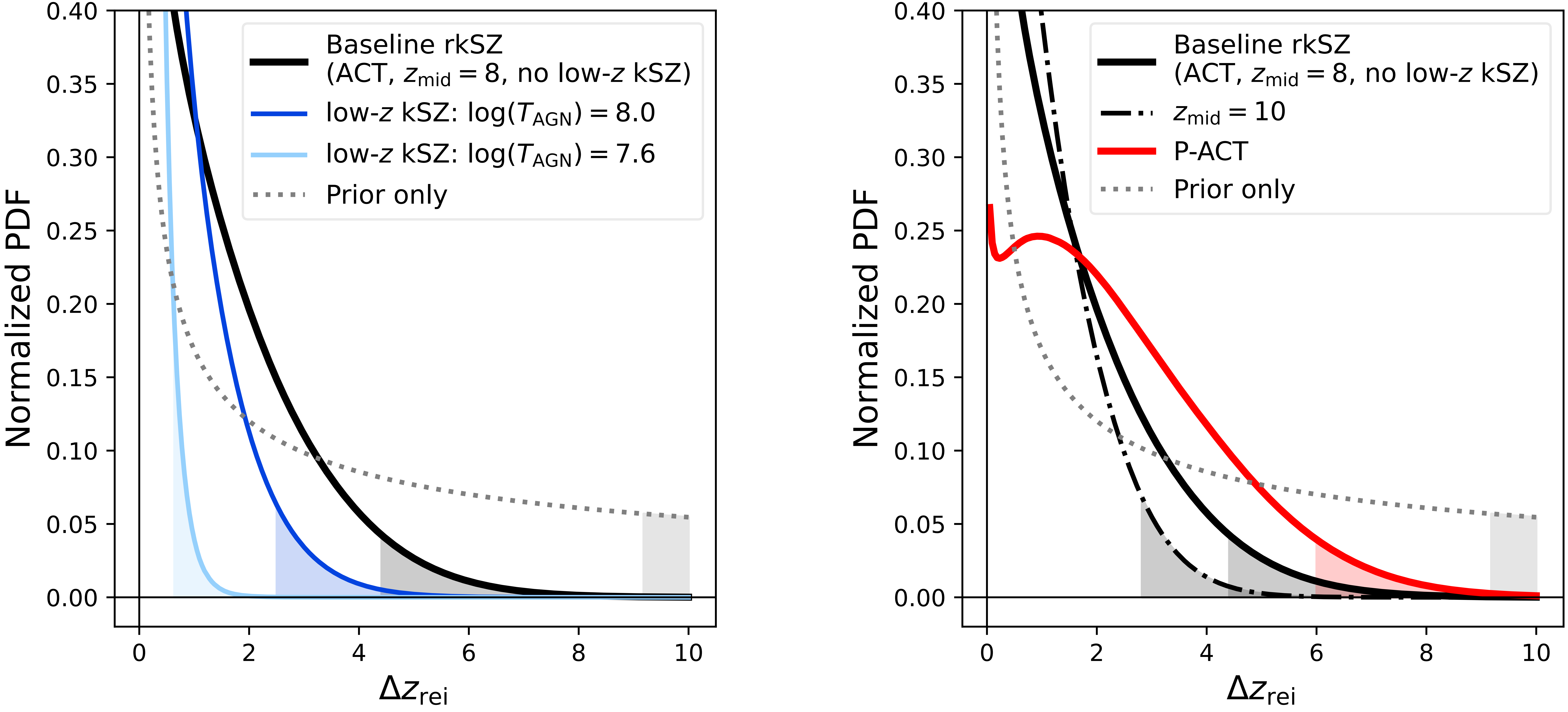
Thanks a lot for your attention !

beringue@apc.in2p3.fr
beringueb

Benjamin BERINGUE, APC
October 13th 2025

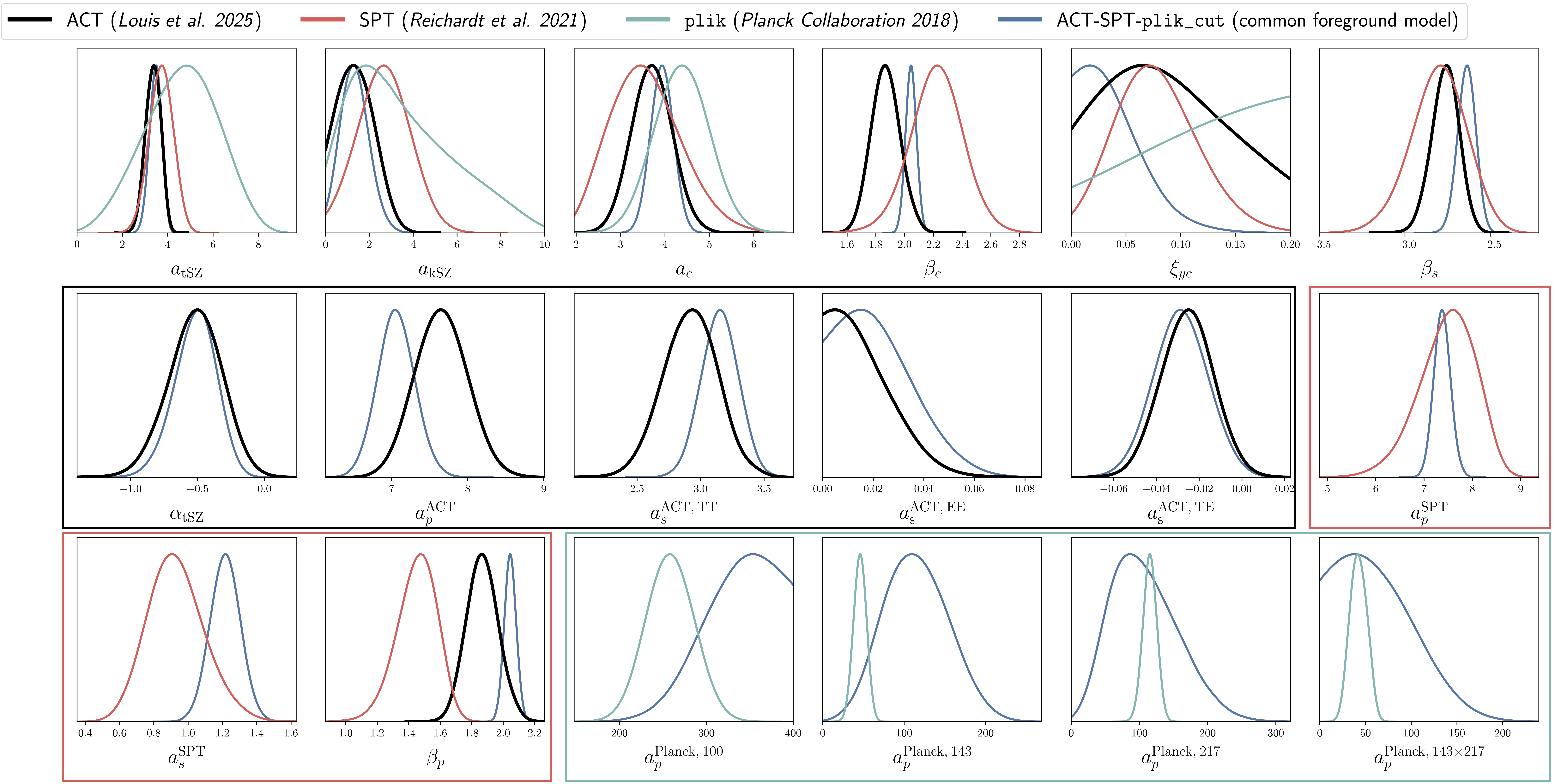
SciPol
Science from the large scale cosmic microwave background polarization structure

BACK UP

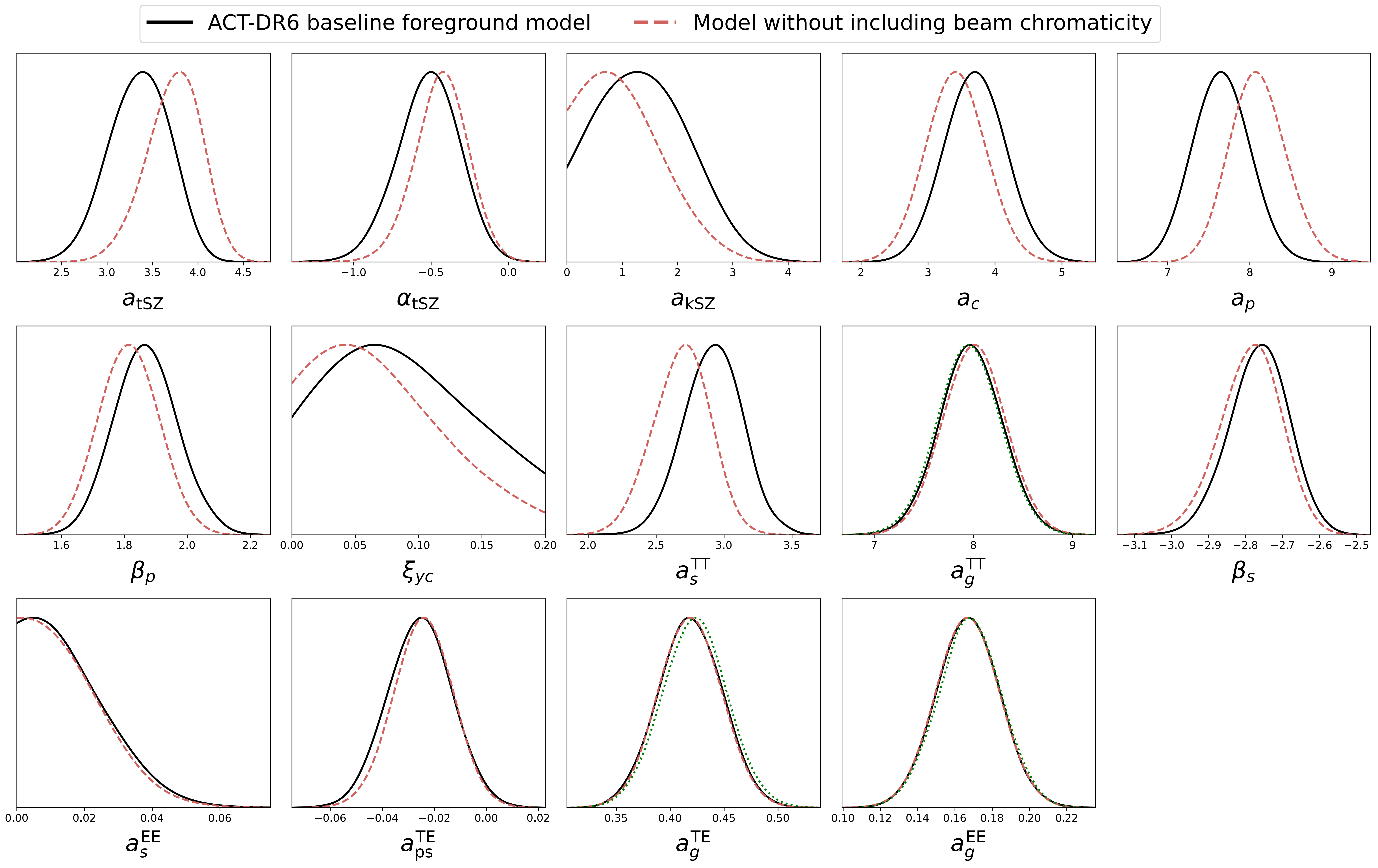


Baseline rkSZ
(ACT, $z_{\mathrm{mid}} = 8$, no low-z kSZ)
low-z kSZ: $\log(T_{\mathrm{AGN}}) = 8.0$
low-z kSZ: $\log(T_{\mathrm{AGN}}) = 7.6$
Prior only
Normalized PDF
Δz_{rei}
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0
2
4
6
8
10
Baseline rkSZ
(ACT, $z_{\mathrm{mid}} = 8$, no low-z kSZ)
$z_{\mathrm{mid}} = 10$
P-ACT
Prior only
Normalized PDF
Δz_{rei}

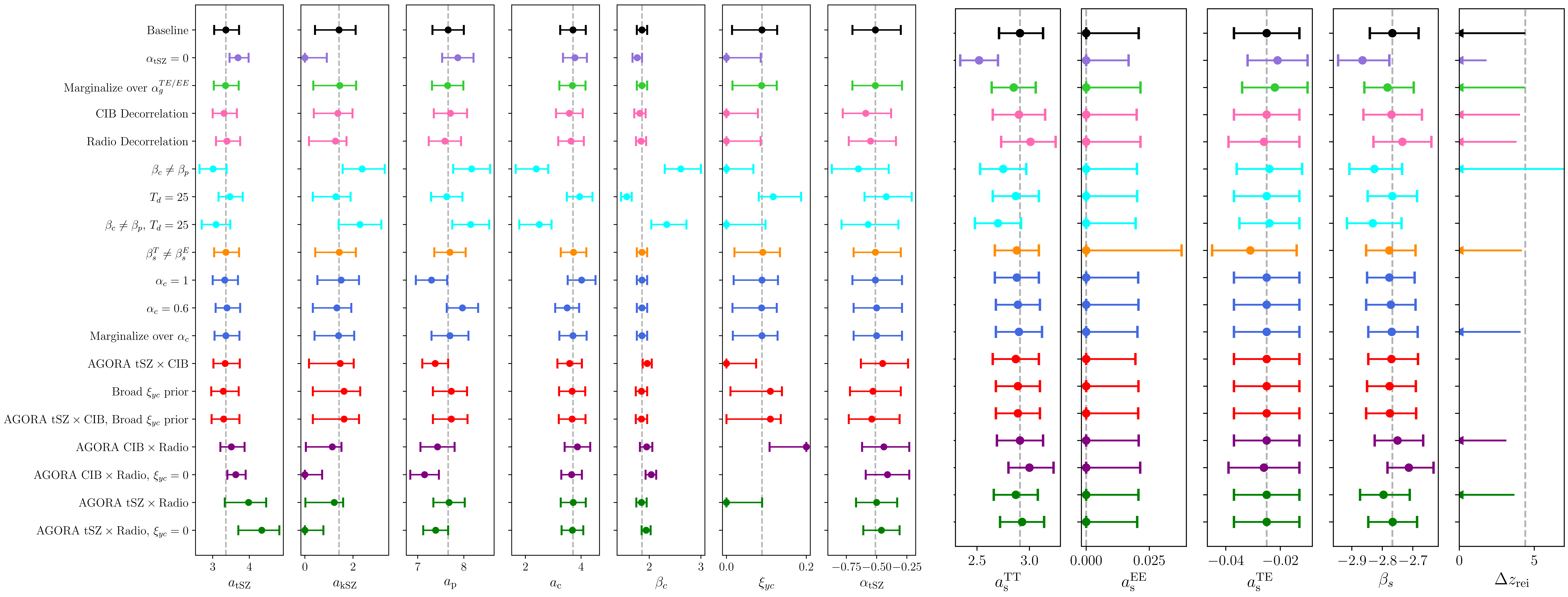
$$
\begin{aligned}
a_{\mathrm{tSZ}} &= 3.36\,^{+0.36}_{-0.32}\,(\mathrm{stat})\,^{+0.6}_{-0.4}\,(\mathrm{FG\ model\ sys}) \\
a_{\mathrm{kSZ}} &= 1.42\,^{+0.69}_{-1.00}\,(\mathrm{stat})\,^{+1.0}_{-0.2}\,(\mathrm{FG\ model\ sys}) \\
a_p &= 7.66\ \pm 0.34\,(\mathrm{stat})\,^{+0.5}_{-0.0}\,(\mathrm{FG\ model\ sys}) \\
a_c &= 3.71\ \pm 0.46\,(\mathrm{stat})\,^{+0.0}_{-1.3}\,(\mathrm{FG\ model\ sys}) \\
\beta_c &= 1.86\ \pm 0.10\,(\mathrm{stat})\,^{+0.7}_{-0.0}\,(\mathrm{FG\ model\ sys}) \\
\xi_{yc} &= 0.089\,^{+0.038}_{-0.075}\,(\mathrm{stat})\,^{+0.00}_{-0.09}\,(\mathrm{FG\ model\ sys}) \\
\alpha_{\mathrm{tSZ}} &= -0.51\,^{+0.21}_{-0.19}\,(\mathrm{stat})\,^{+0.0}_{-0.1}\,(\mathrm{FG\ model\ sys})
\end{aligned}
$$



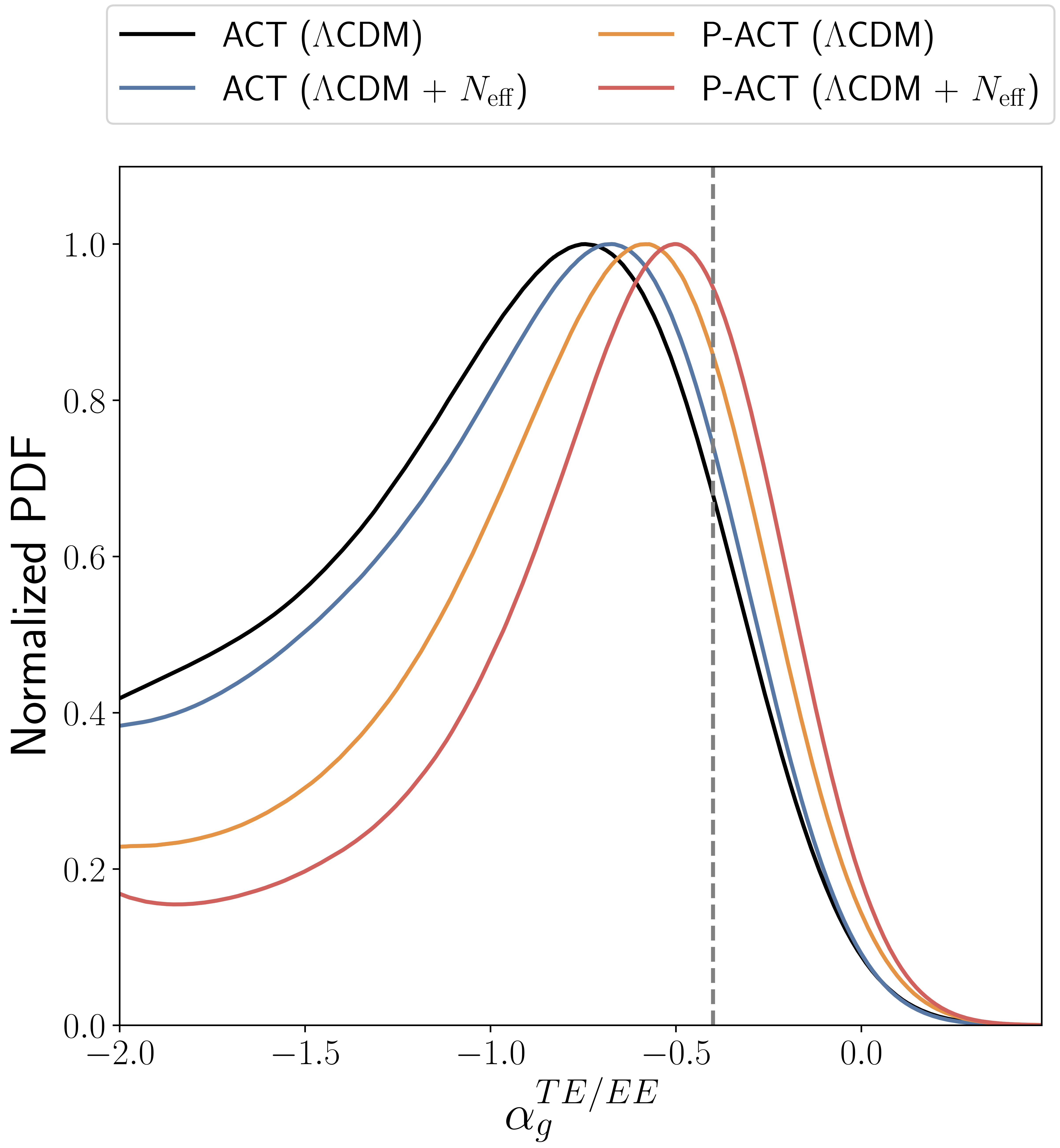
ACT (Louis et al. 2025)
SPT (Reichardt et al. 2021)
plik (Planck Collaboration 2018)
ACT-SPT-plik_cut (common foreground model)
$a_{\rm tSZ}$
$a_{\rm kSZ}$
a_c
β_c
ξ_{yc}
β_s
$\alpha_{\rm tSZ}$
$a_p^{\rm ACT}$
$a_s^{\rm ACT,\,TT}$
$a_s^{\rm ACT,\,EE}$
$a_s^{\rm ACT,\,TE}$
$a_p^{\rm SPT}$
$a_s^{\rm SPT}$
β_p
$a_p^{\rm Planck,\,100}$
$a_p^{\rm Planck,\,143}$
$a_p^{\rm Planck,\,217}$
$a_p^{\rm Planck,\,143\times217}$

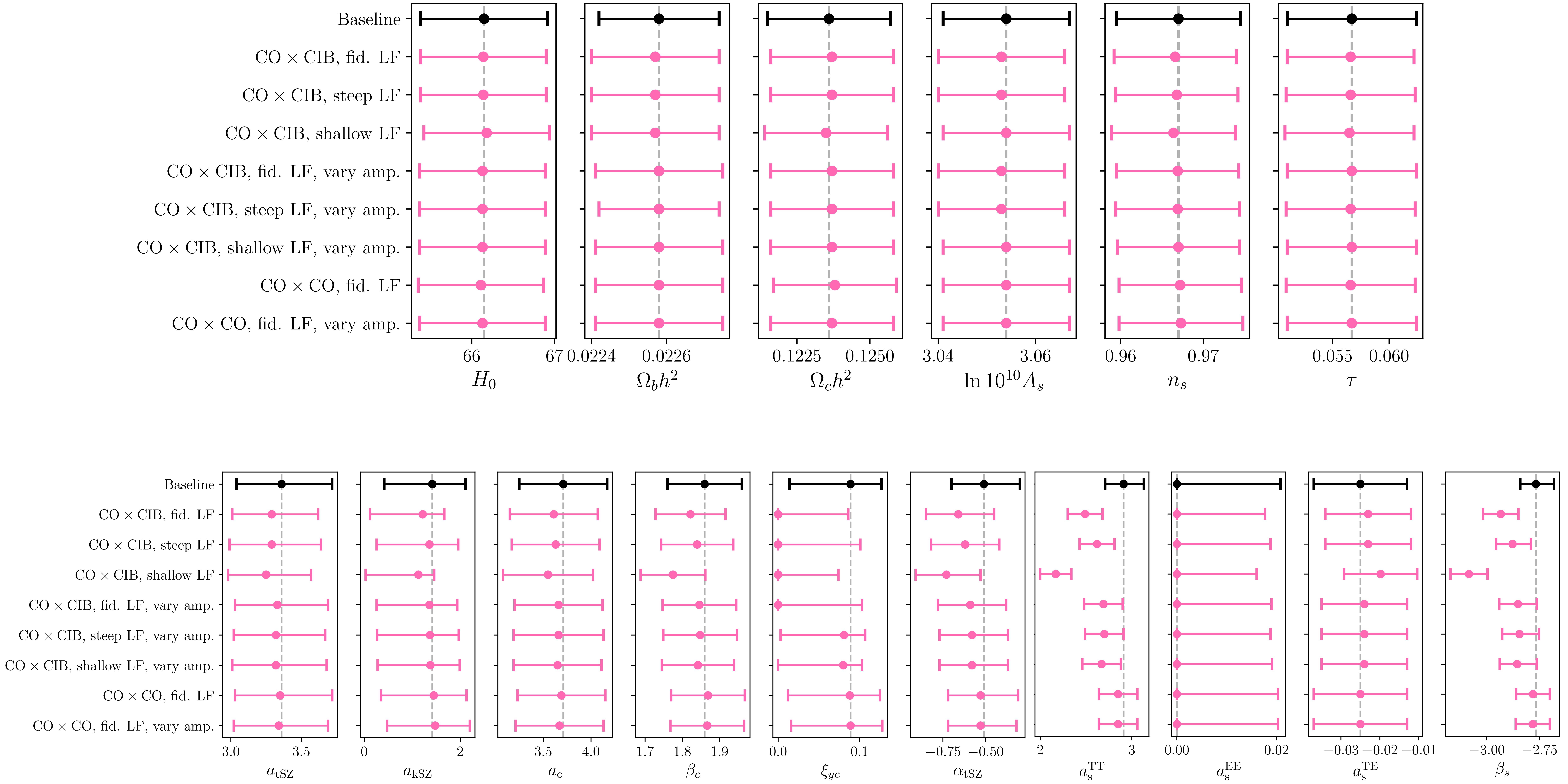


ACT-DR6 baseline foreground model
Model without including beam chromaticity
a_{tSZ}
α_{tSZ}
a_{kSZ}
a_c
a_p
β_p
ξ_{yc}
a_s^{TT}
a_g^{TT}
β_s
a_s^{EE}
$a_{\mathrm{ps}}^{\mathrm{TE}}$
a_g^{TE}
a_g^{EE}

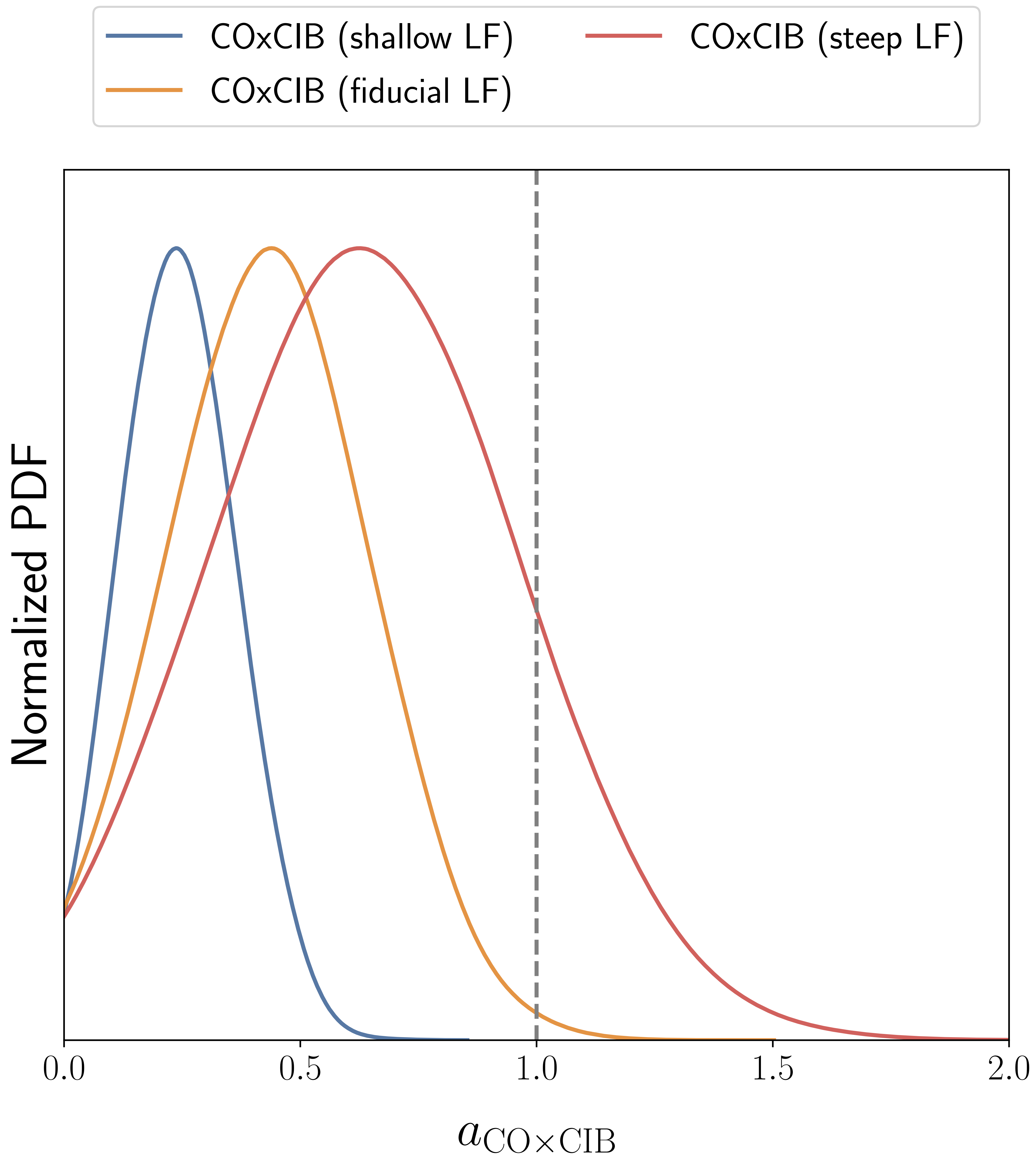


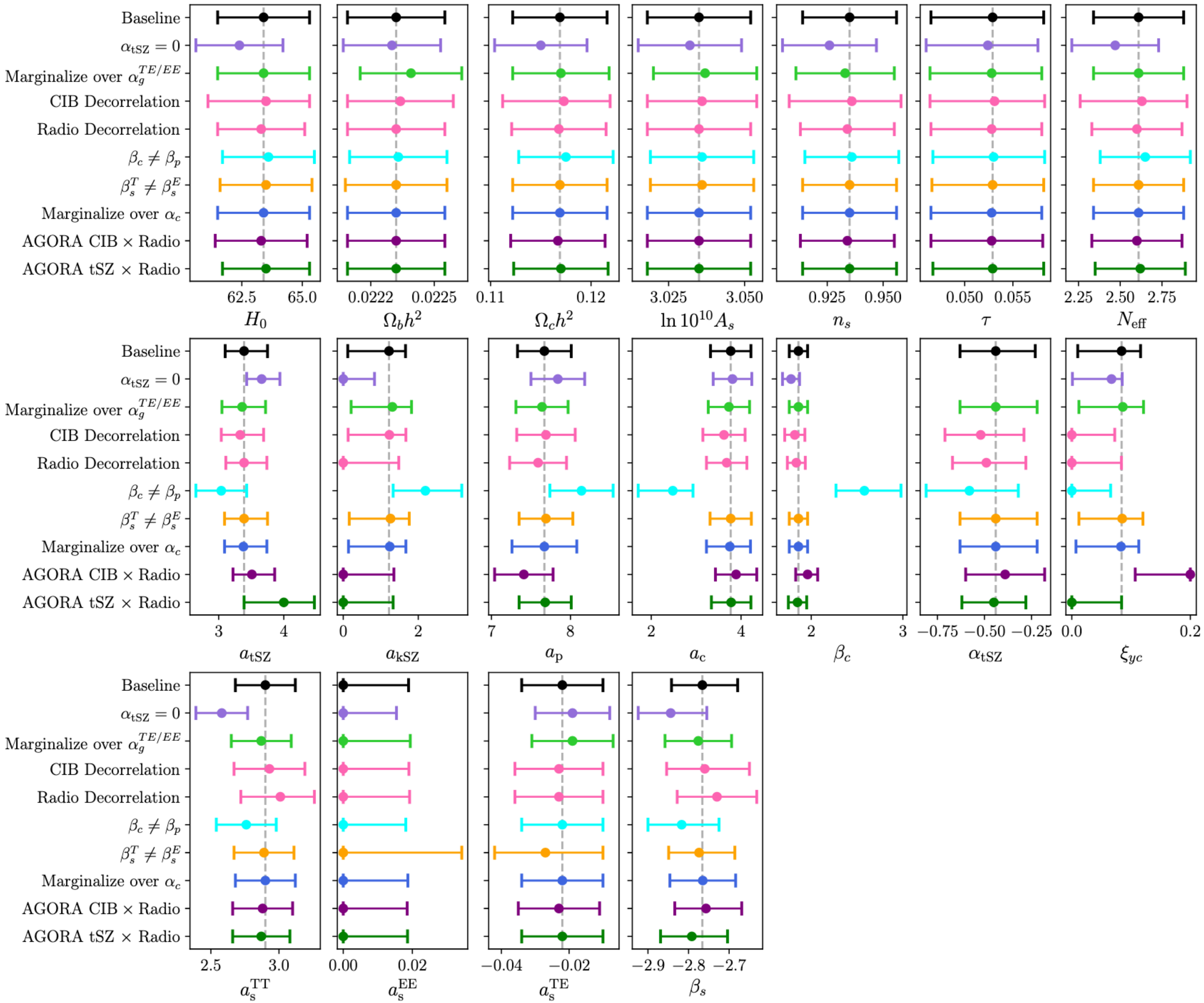
Baseline
$\alpha_{\rm tSZ}=0$
Marginalize over $\alpha_g^{TE/EE}$
CIB Decorrelation
Radio Decorrelation
$\beta_c \neq \beta_p$
$T_d = 25$
$\beta_c \neq \beta_p$, $T_d = 25$
$\beta_s^T \neq \beta_s^E$
$\alpha_c = 1$
$\alpha_c = 0.6$
Marginalize over α_c
AGORA tSZ × CIB
Broad ξ_{yc} prior
AGORA tSZ × CIB, Broad ξ_{yc} prior
AGORA CIB × Radio
AGORA CIB × Radio, $\xi_{yc}=0$
AGORA tSZ × Radio
AGORA tSZ × Radio, $\xi_{yc}=0$
$a_{\rm tSZ}$
$a_{\rm kSZ}$
$a_{\rm p}$
$a_{\rm c}$
β_c
ξ_{yc}
$\alpha_{\rm tSZ}$
$a_{\rm s}^{\rm TT}$
$a_{\rm s}^{\rm EE}$
$a_{\rm s}^{\rm TE}$
β_s
$\Delta z_{\rm rei}$


ACT (ΛCDM)
ACT (ΛCDM + $N_{\rm eff}$)
P-ACT (ΛCDM)
P-ACT (ΛCDM + $N_{\rm eff}$)
Normalized PDF
0.0
0.2
0.4
0.6
0.8
1.0
−2.0
−1.5
−1.0
−0.5
0.0
$\alpha_g^{TE/EE}$



Baseline
CO × CIB, fid. LF
CO × CIB, steep LF
CO × CIB, shallow LF
CO × CIB, fid. LF, vary amp.
CO × CIB, steep LF, vary amp.
CO × CIB, shallow LF, vary amp.
CO × CO, fid. LF
CO × CO, fid. LF, vary amp.
H_0
$\Omega_b h^2$
$\Omega_c h^2$
$\ln 10^{10} A_s$
n_s
τ
a_{tSZ}
a_{kSZ}
a_c
β_c
ξ_{yc}
α_{tSZ}
a_s^{TT}
a_s^{EE}
a_s^{TE}
β_s


COxCIB (shallow LF)
COxCIB (fiducial LF)
COxCIB (steep LF)
Normalized PDF
0.0
0.5
1.0
1.5
2.0
$a_{\mathrm{CO}\times\mathrm{CIB}}$



Baseline
$\alpha_{\rm tSZ} = 0$
Marginalize over $\alpha_g^{TE/EE}$
CIB Decorrelation
Radio Decorrelation
$\beta_c \neq \beta_p$
$\beta_s^T \neq \beta_s^E$
Marginalize over α_c
AGORA CIB × Radio
AGORA tSZ × Radio
62.5 65.0
H_0
0.0222 0.0225
$\Omega_b h^2$
0.11 0.12
$\Omega_c h^2$
3.025 3.050
$\ln 10^{10} A_s$
0.925 0.950
n_s
0.050 0.055
τ
2.25 2.50 2.75
$N_{\rm eff}$
3 4
$a_{\rm tSZ}$
0 2
$a_{\rm kSZ}$
7 8
$a_{\rm p}$
2 4
$a_{\rm c}$
2 3
β_c
−0.75 −0.50 −0.25
$\alpha_{\rm tSZ}$
0.0 0.2
ξ_{yc}
2.5 3.0
$a_{\rm s}^{\rm TT}$
0.00 0.02
$a_{\rm s}^{\rm EE}$
−0.04 −0.02
$a_{\rm s}^{\rm TE}$
−2.9 −2.8 −2.7
β_s

Foreground Model	New Parameter (ΛCDM+$N_{\rm eff}$ Cosmology)
Baseline (compare with $\alpha_{\rm tSZ} = 0$)	$\alpha_{\rm tSZ} = -0.44^{+0.21}_{-0.19}$
Marginalize over $\alpha_g^{\rm TE/EE}$	$\alpha_g^{\rm TE/EE} = -0.94^{+0.65}_{-0.37}$
CIB decorrelation	$r^{\rm CIB}_{90\times220} > 0.898$ $r^{\rm CIB}_{90\times150} > 0.874$ $r^{\rm CIB}_{150\times220} > 0.978$
Radio decorrelation	$r^{\rm radio}_{90\times220} = --$ $r^{\rm radio}_{90\times150} = 0.970^{+0.026}_{-0.011}$ $r^{\rm radio}_{150\times220} = --$
$\beta_c \neq \beta_p$	$\beta_c = 2.6^{+0.4}_{-0.3}$ $\beta_p = 1.8 \pm 0.1$
$\beta_s^T \neq \beta_s^E$	$\beta_s^T = -2.77^{+0.09}_{-0.08}$ $\beta_s^E > -3.15$
Marginalize over α_c	$\alpha_c = --$
AGORA CIB $\times$ radio	$\xi_{cs} = 0.06^{+0.02}_{-0.06}$
AGORA tSZ $\times$ radio	$\xi_{ys} < 0.13$