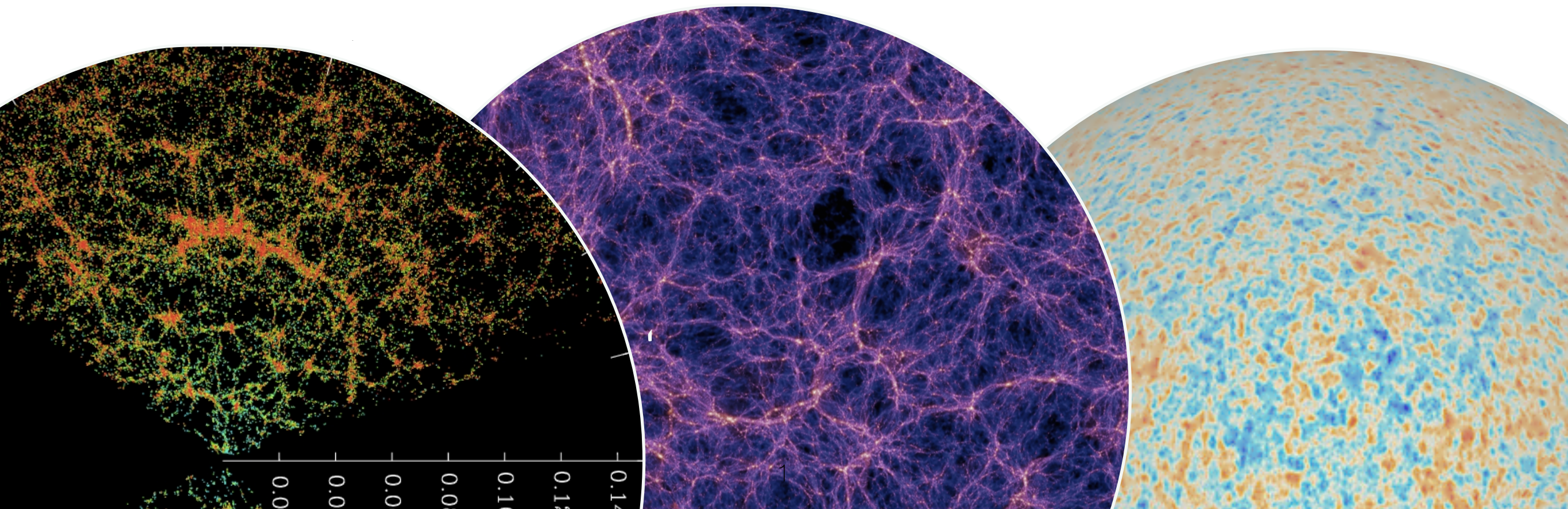


Robust Cosmology from Combining **Galaxy Surveys** and **CMB Lensing**

Chihway Chang (UChicago), Yuuki Omori (UChicago), Eric Baxter (UHawaii)
for the DES & SPT Collaborations

Based on: [2203.12439](#), [2203.12440](#), [2206.10824](#)



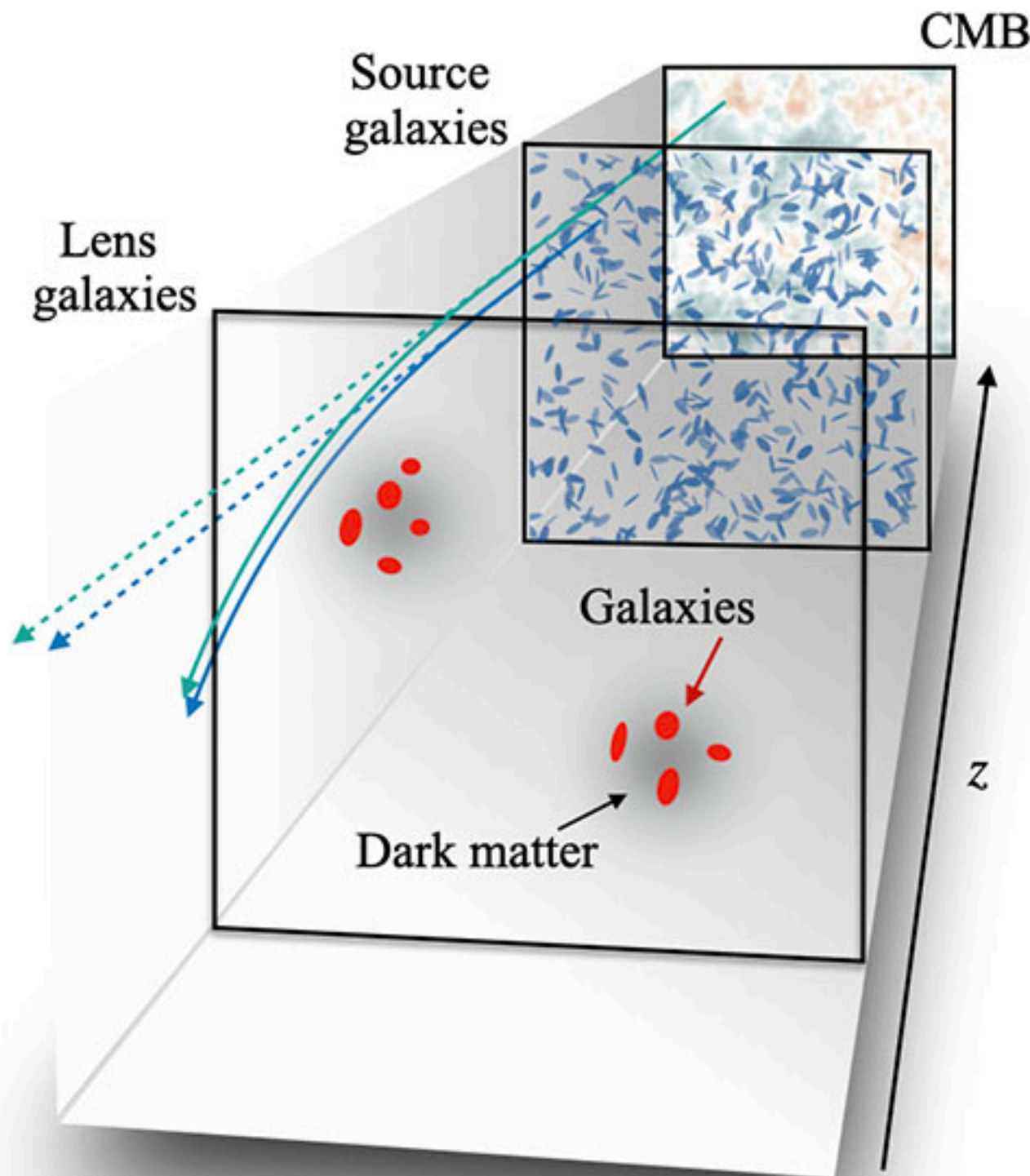
Cosmology today is not only about getting more statistics, but rather how we can actually **use** and **trust** the statistics we have. This will likely be true going forward into the CMB-S4 era.

Astrophysical and **observational systematic effects** are what keeps us up at night.

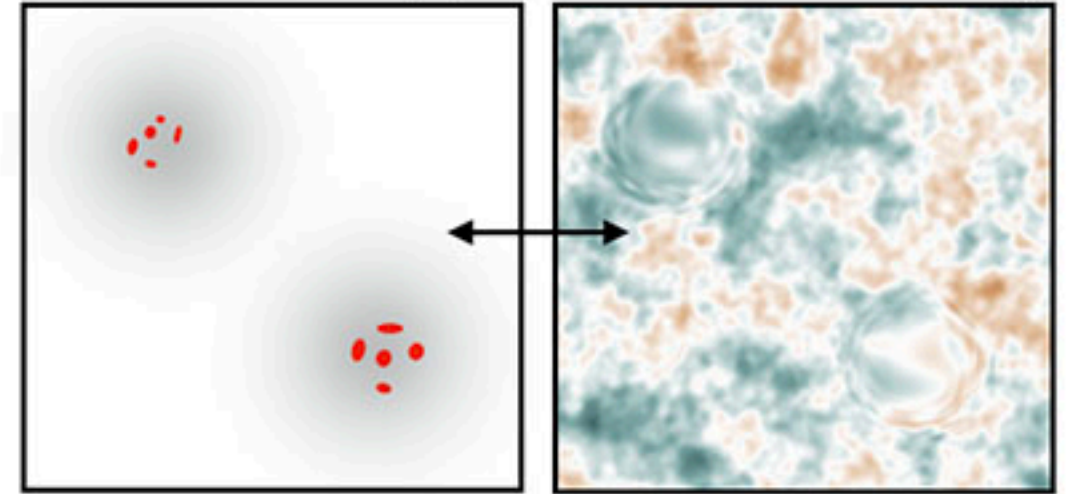
Combining datasets from **different wavelengths and instruments** is a good way to tackle these systematic effects.

We have the **Stage-III data** right now to test out these ideas.

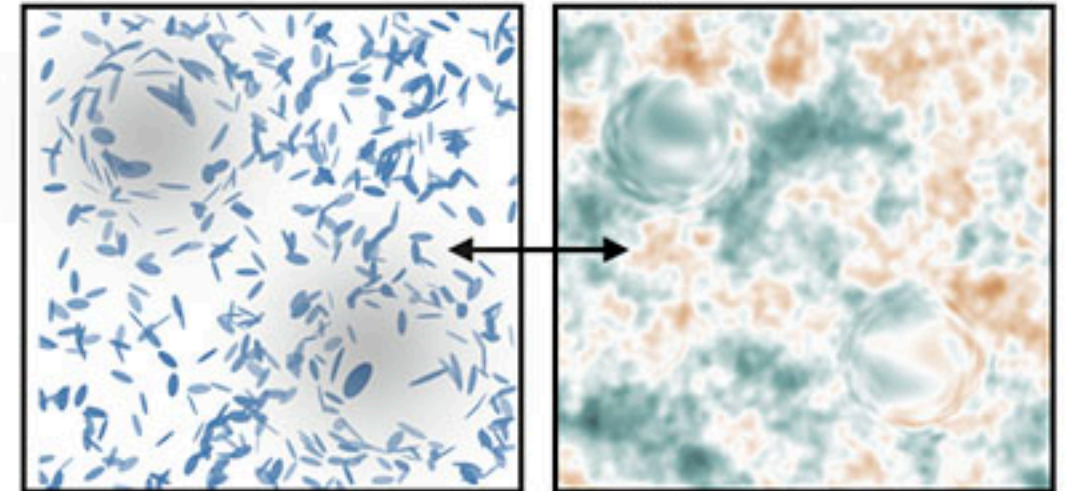
“6x2pt” = 3x2pt + CMB lensing



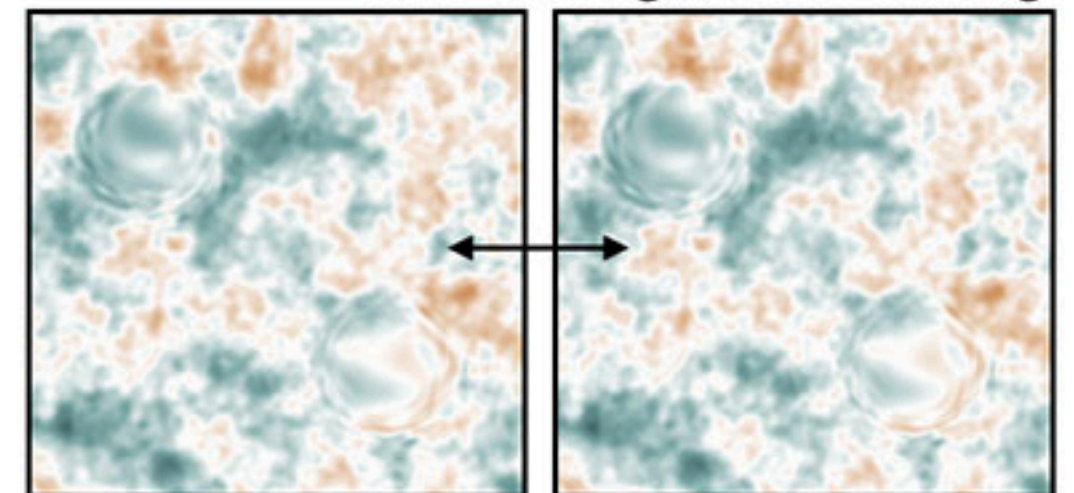
Galaxy positions \times CMB lensing



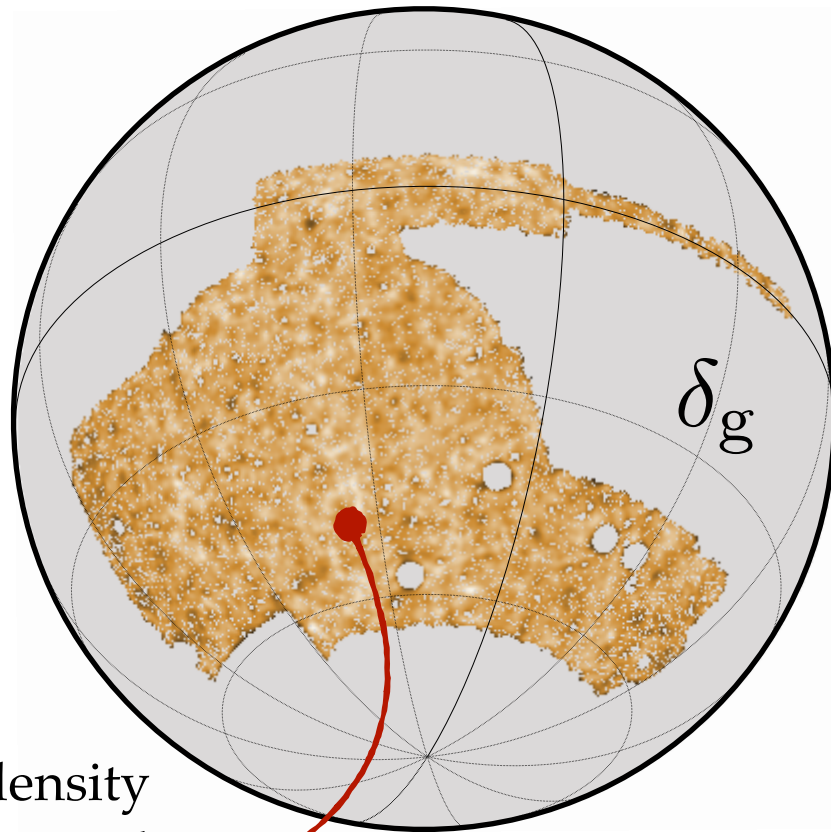
Galaxy lensing \times CMB lensing



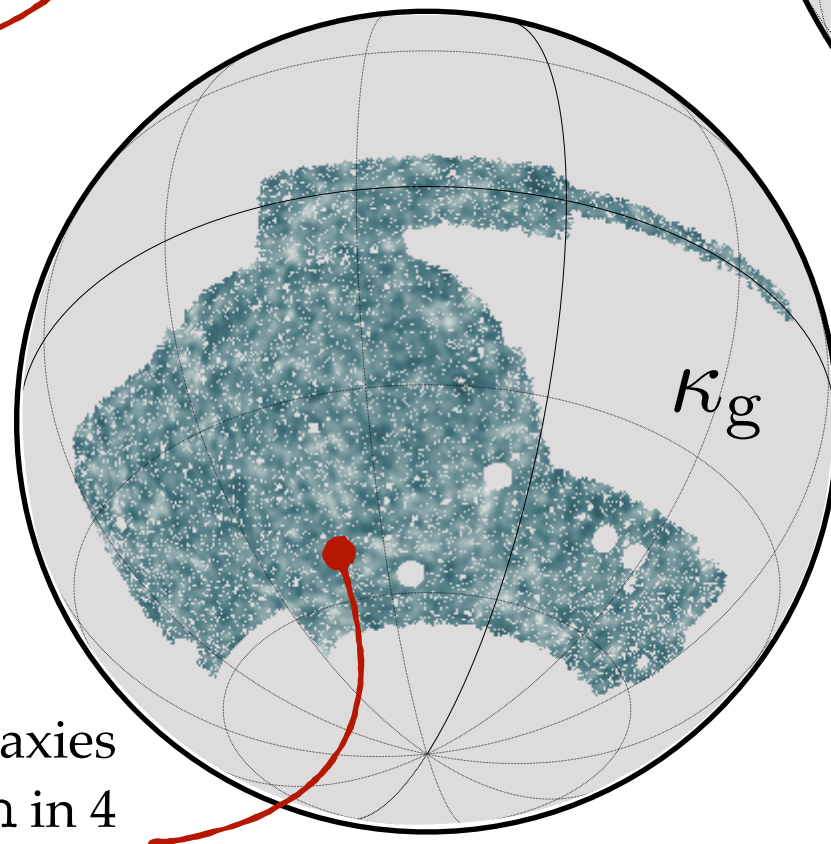
CMB lensing \times CMB lensing



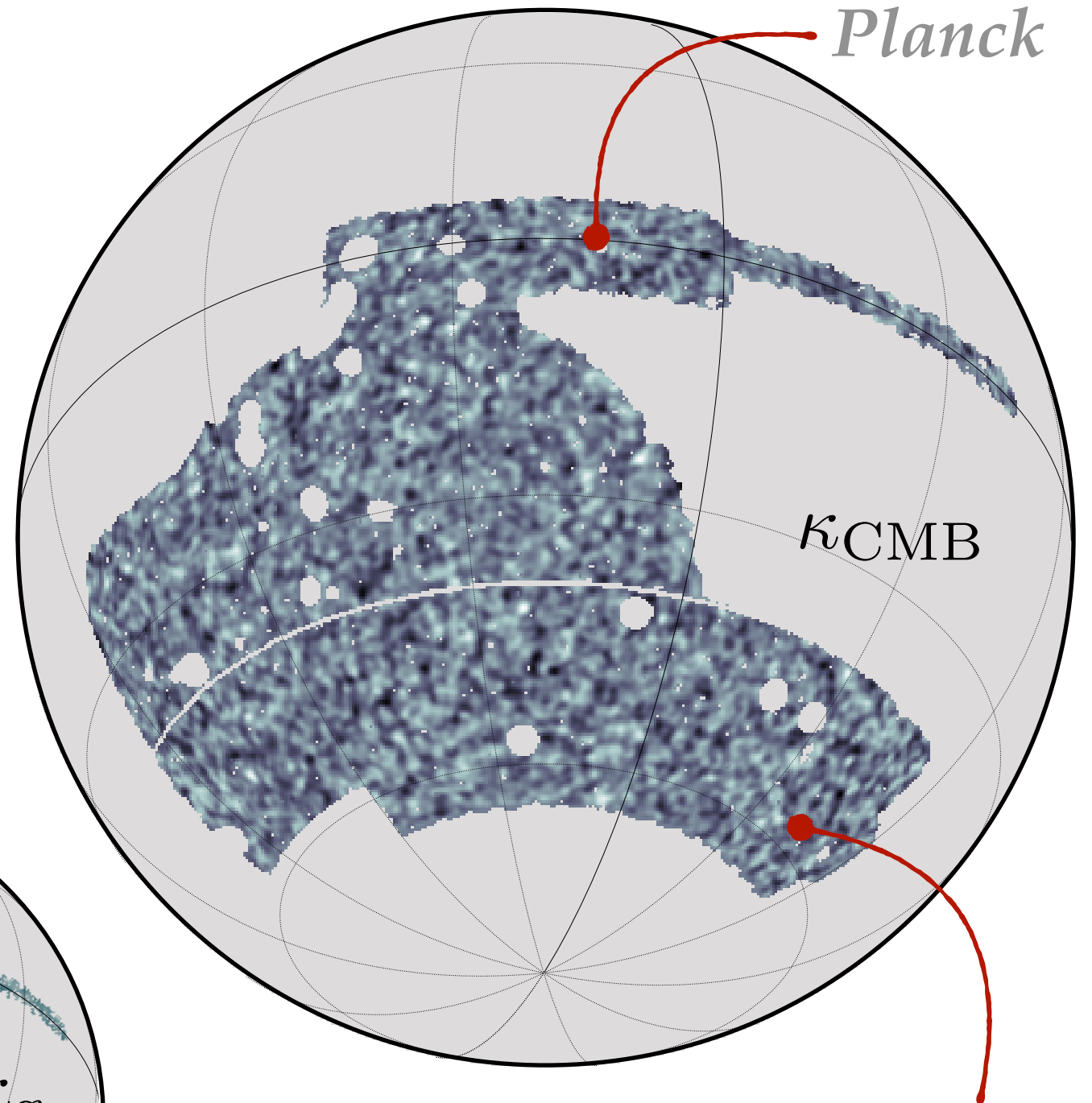
Dark Energy Survey (DES)



High density
magnitude-limited
galaxy sample in 4
tomographic bins.



100M weak lensing galaxies
via Metacalibration in 4
tomographic bins.



South Pole Telescope (SPT)

Omori et al. (2022) implemented method
proposed by Madhavacheril & Hill (2018)
to remove tSZ contamination. Allowing
small scale information to be used.

Cross-correlation only $\langle \delta_g \kappa_{\text{CMB}} \rangle + \langle \gamma_t \kappa_{\text{CMB}} \rangle$

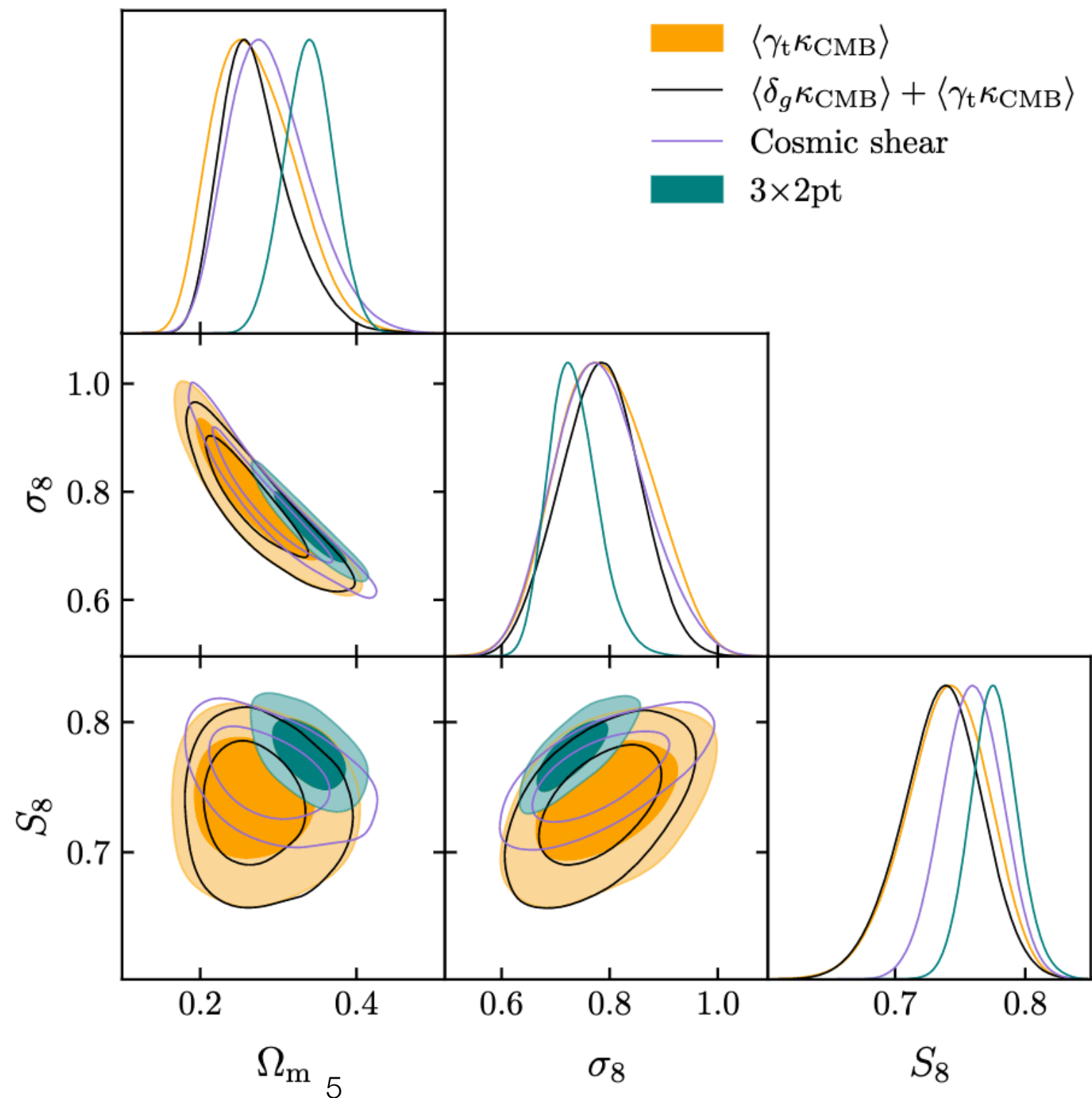
$$S_8 = 0.736^{+0.032}_{-0.028}$$

c.f. DES Y3 3x2pt

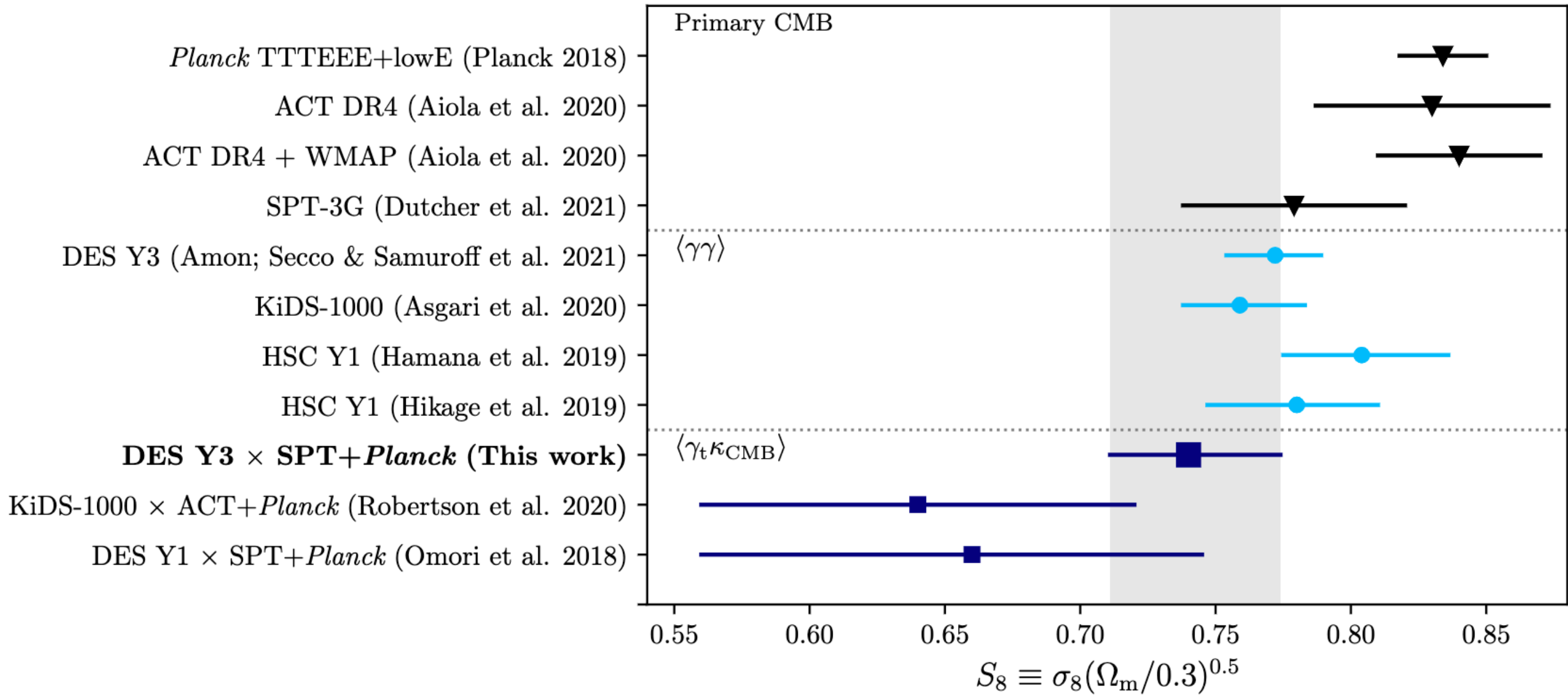
Λ CDM

$$S_8 = 0.776^{+0.017}_{-0.017}$$

$$\Omega_m = 0.339^{+0.032}_{-0.031}$$

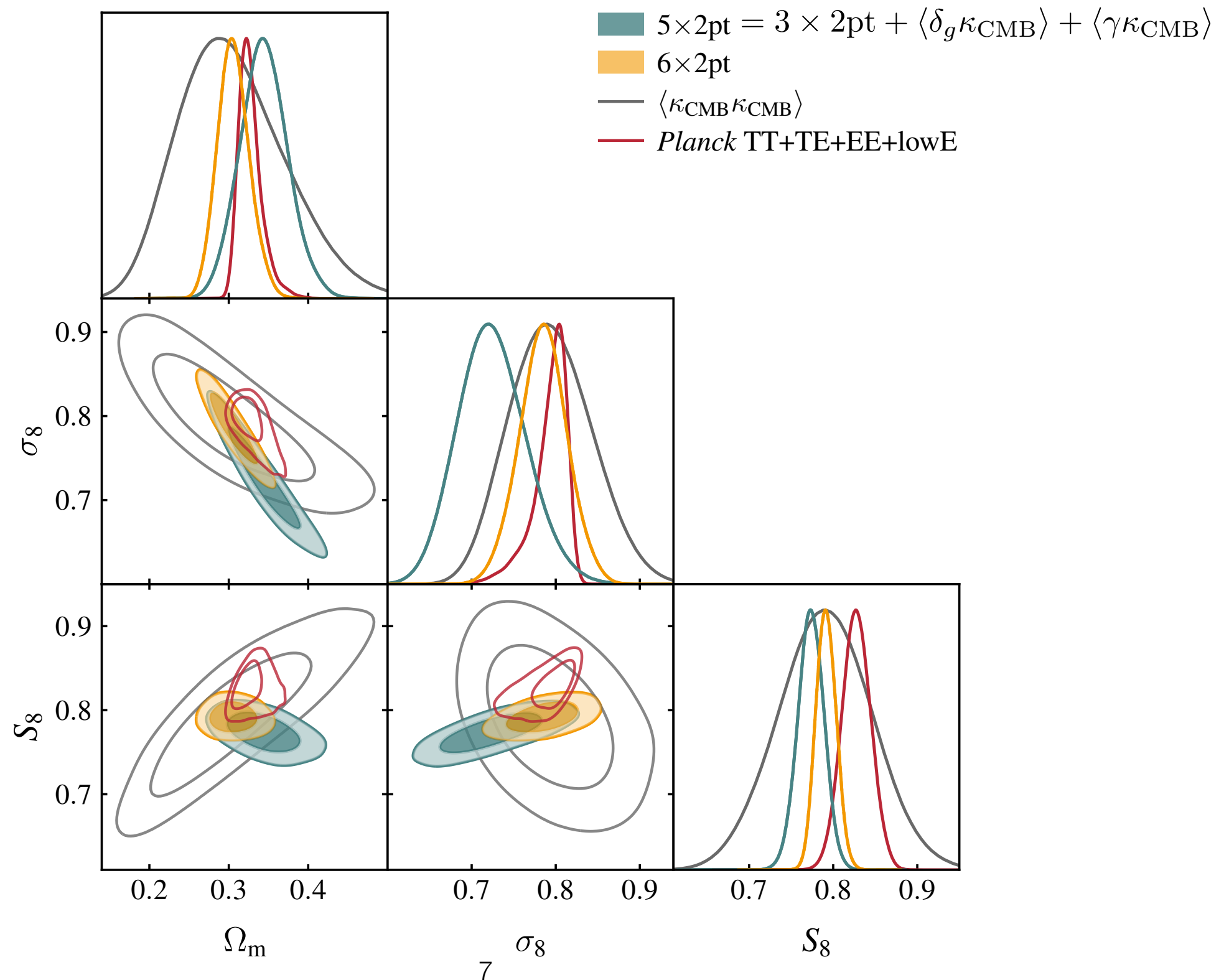


Tension?

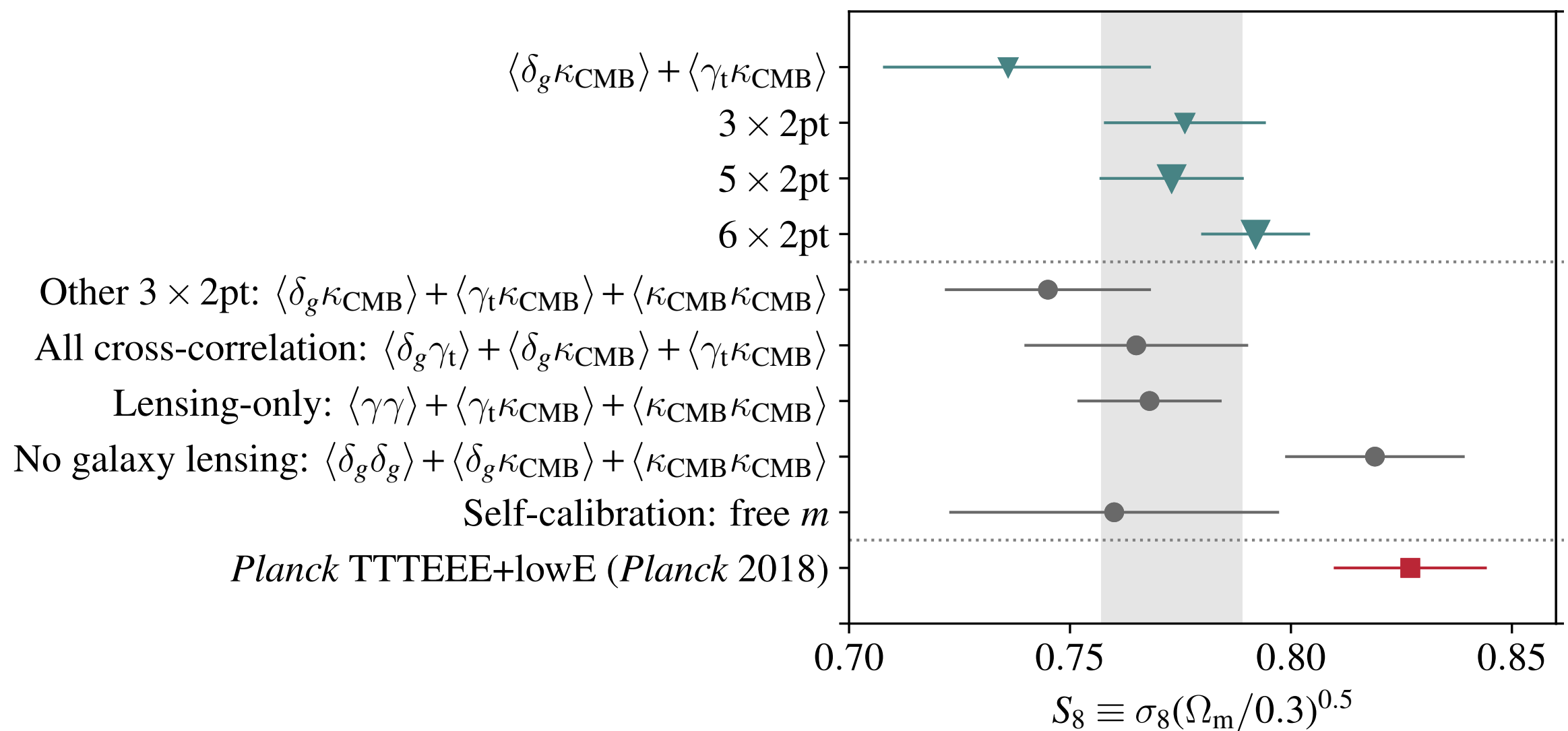


For the first time, cross-correlation probes are now constraining enough to say something meaningful about this tension!

Everything combined



Investigate different combinations



Adding CMB lensing allows us to examine the data in many different ways.

Overall our results show that the 3x2pt results is robust, and we are still consistent with *Planck* at the 1.4σ level.

Summary

- We have constructed a CMB lensing map from a combination of SPT-SZ and *Planck* that is **optimized for cross-correlation** (minimizing tSZ).
- We constrain cosmology using **6 two-point functions** combining galaxy position, shear, and CMB lensing.
- The cross-correlation of **galaxy shear and CMB lensing** is very powerful. This will be true for S4 as well.
- The combined cosmological constraints are **consistent with *Planck* primary constraints and very robust**.
- Working on using this pipeline for ACT x DES as well — building the cross-correlation community for S4.

Independent handles on systematics

The constraints on galaxy bias can be impacted by selection effects. We now have an additional way to test this.

We are more consistent with galaxy-galaxy lensing

