Cosmology with KiDS-Legacy

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On behalf of the KiDS Collaboration

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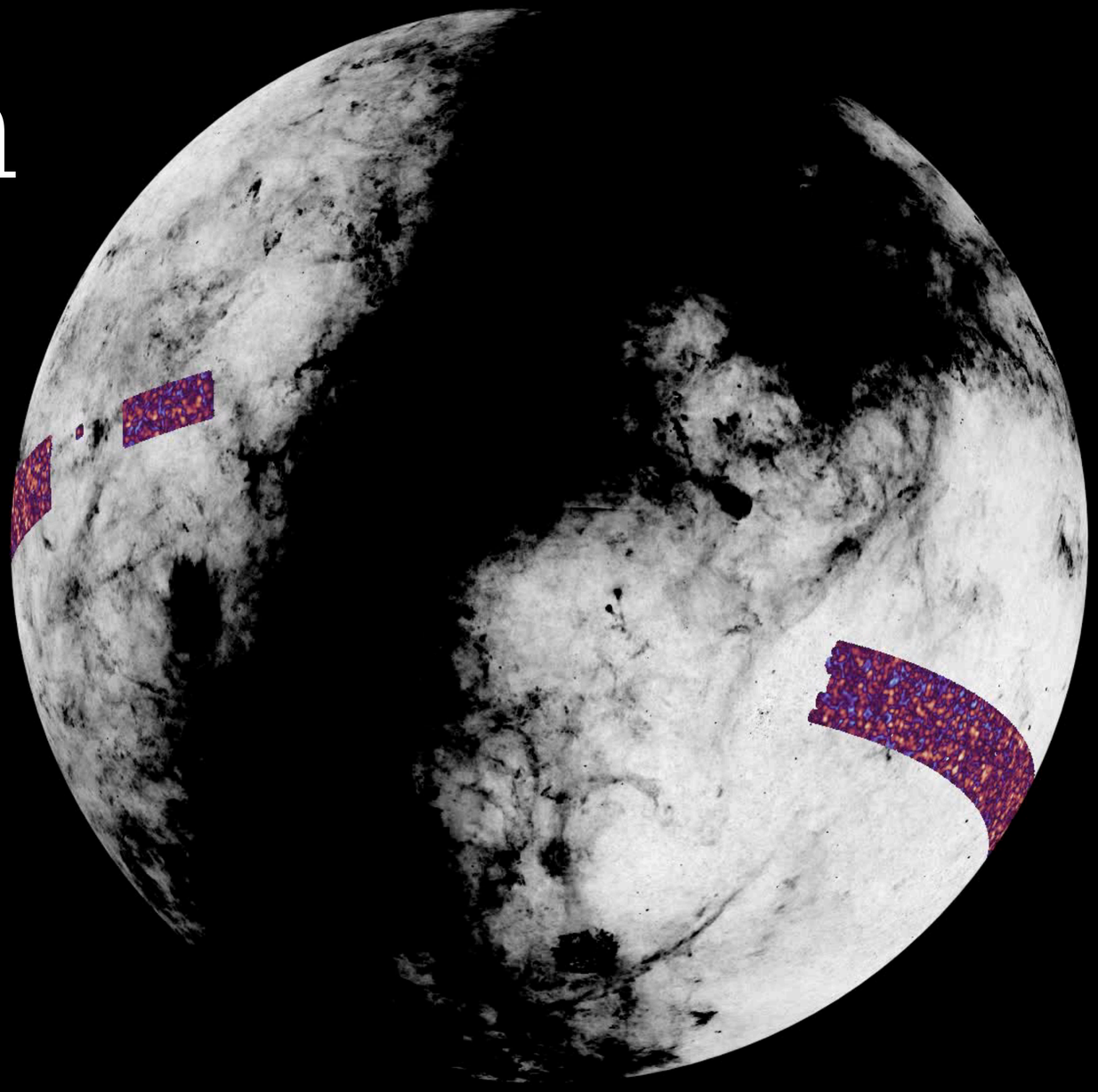
13.10.25



RUHR UNIVERSITÄT BOCHUM
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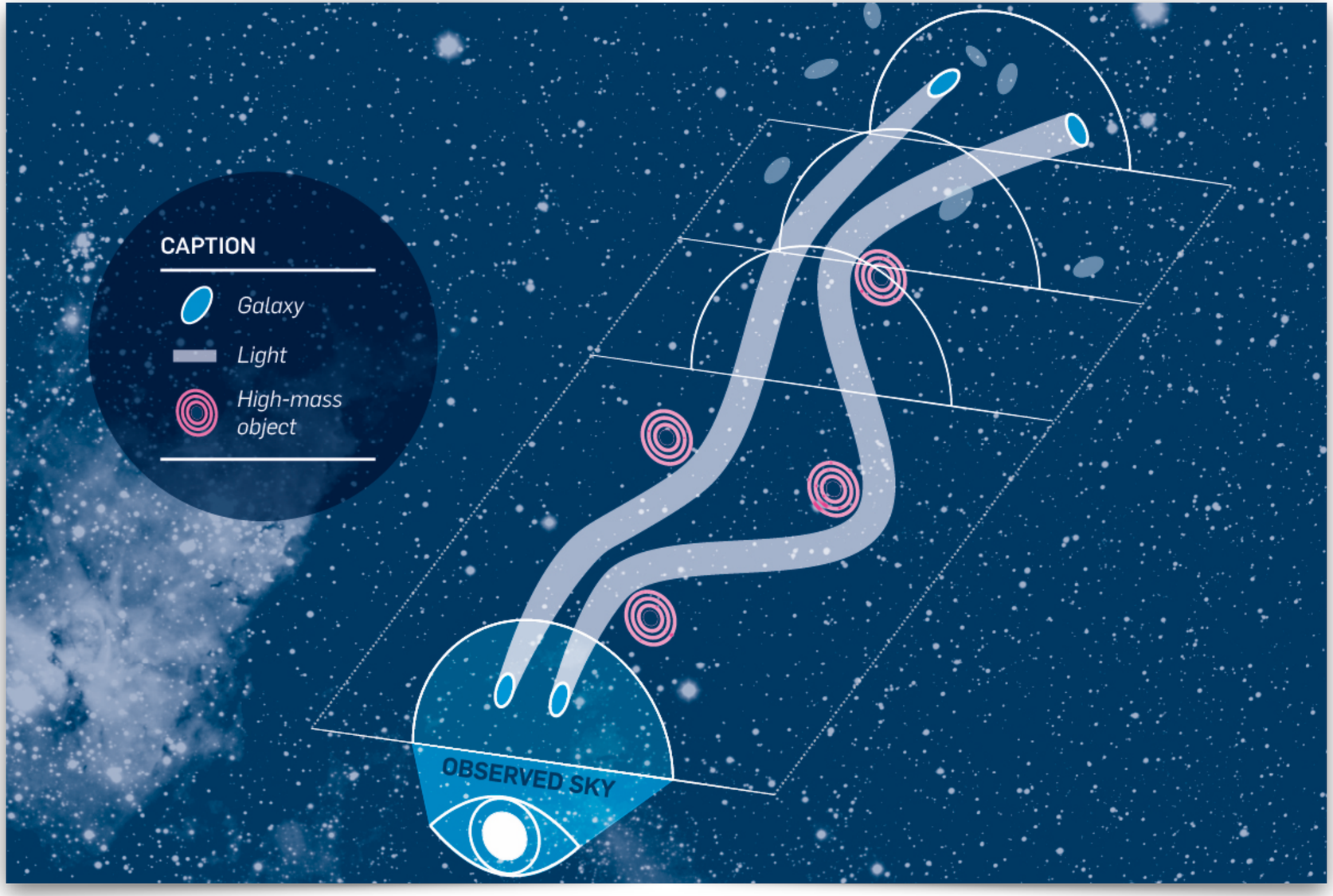
GERMAN CENTRE FOR COSMOLOGICAL LENSING

Fundamentals of Cosmic Shear

Lensing by large-scale structures



Galaxies in the distant universe have (mostly) randomly distributed shapes

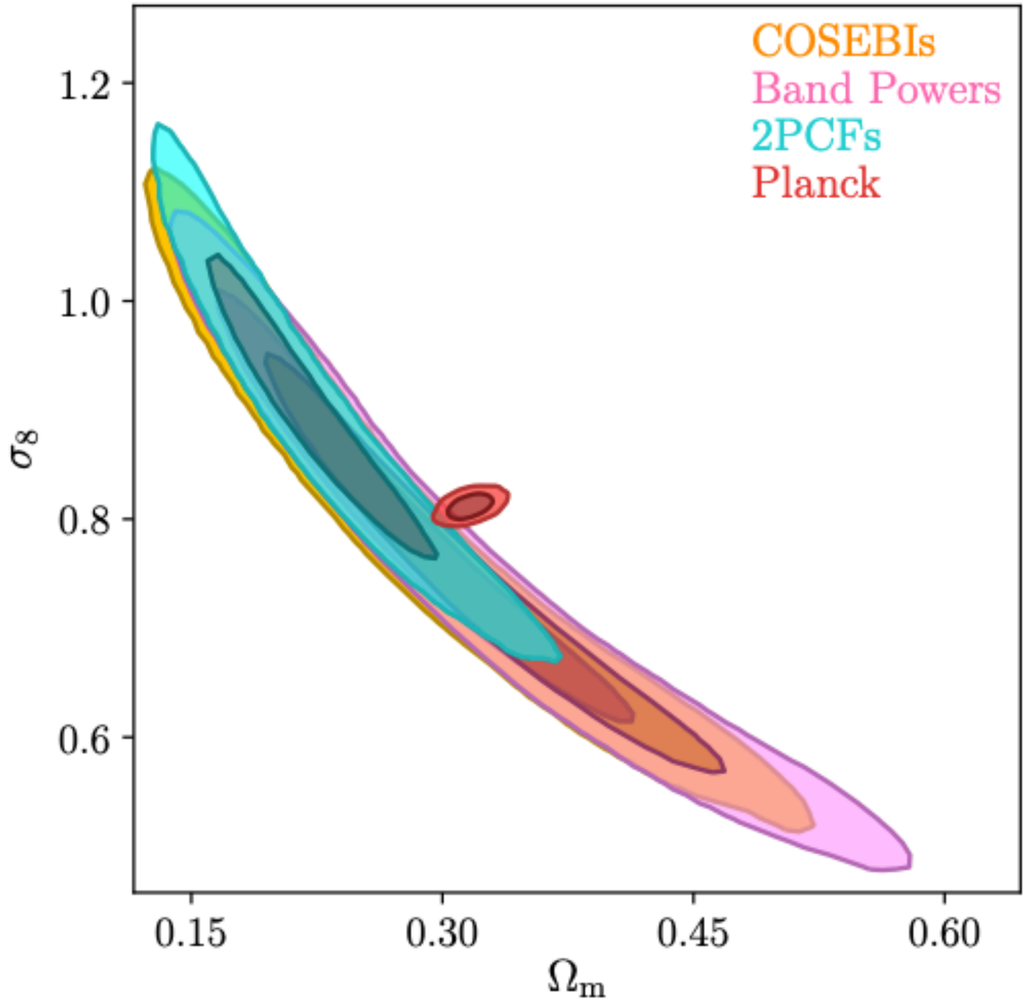
Light is distorted along the line-of-sight by massive structures

Propagation through similar structures imprints coherent distortions on galaxy shapes

Image Credit: Ruhr-University Bochum

Fundamentals of Cosmic Shear

Measuring Cosmological Parameters



Asgari et al. (2021)

Degeneracy between amount of matter and strength of clustering

So we discuss cosmic shear in terms of the degeneracy:

$$S8 = \sigma_8 \sqrt{\Omega_m / 0.3}$$

or more generally:

$$\Sigma_8 = \sigma_8 (\Omega_m / 0.3)^{\alpha}$$

Fundamentals of Cosmic Shear

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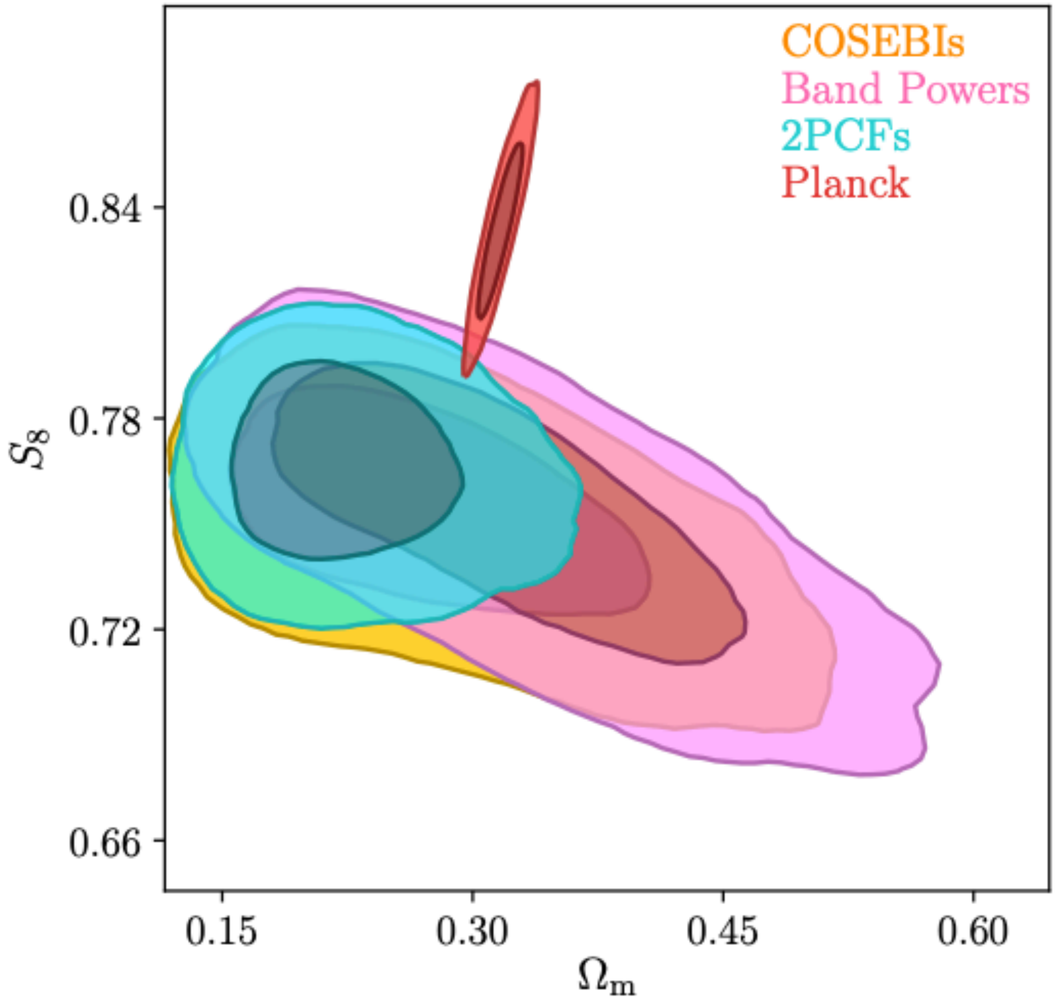

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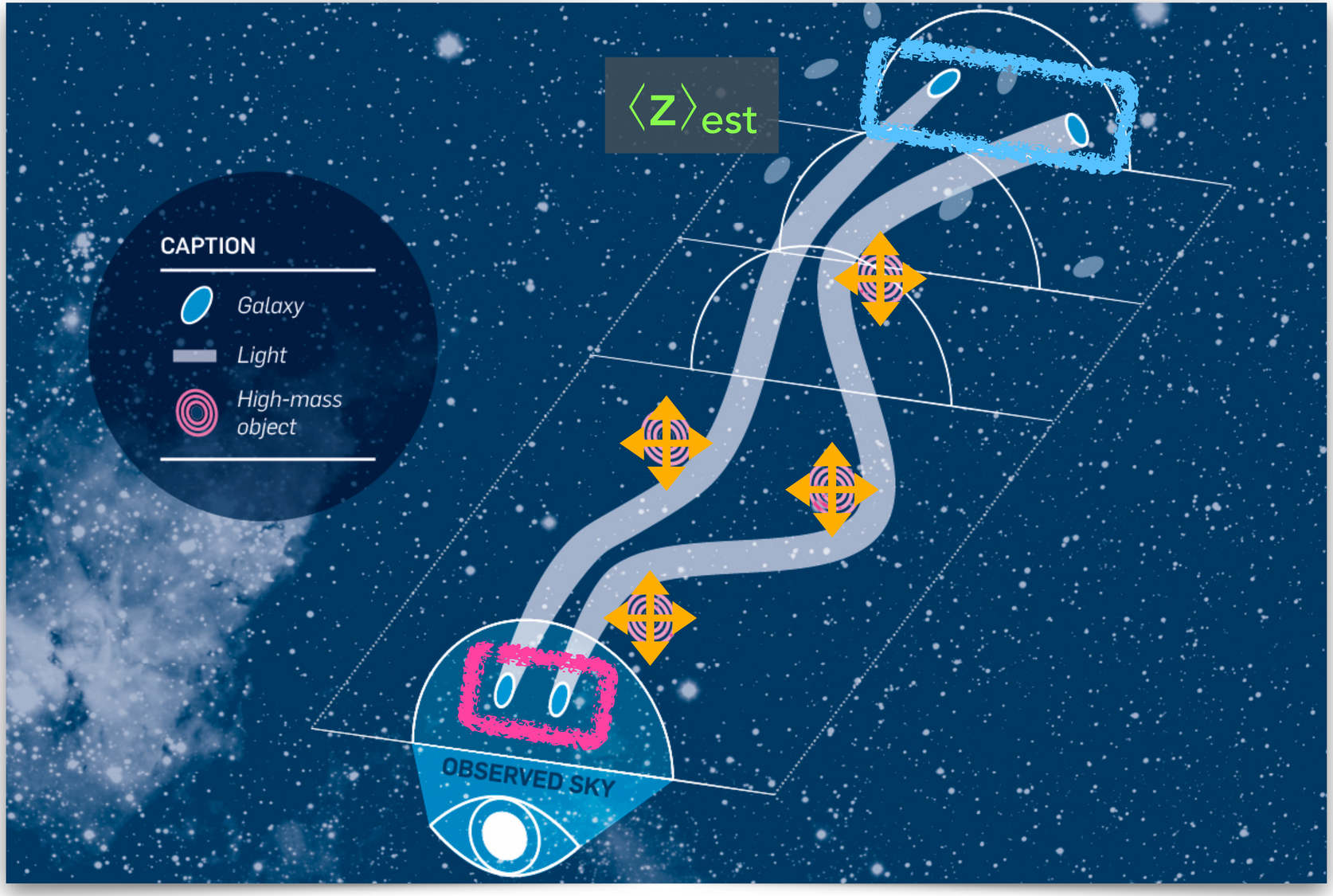
Robust Cosmic Shear Requirements

What do you need to get right?



Shape Measurements

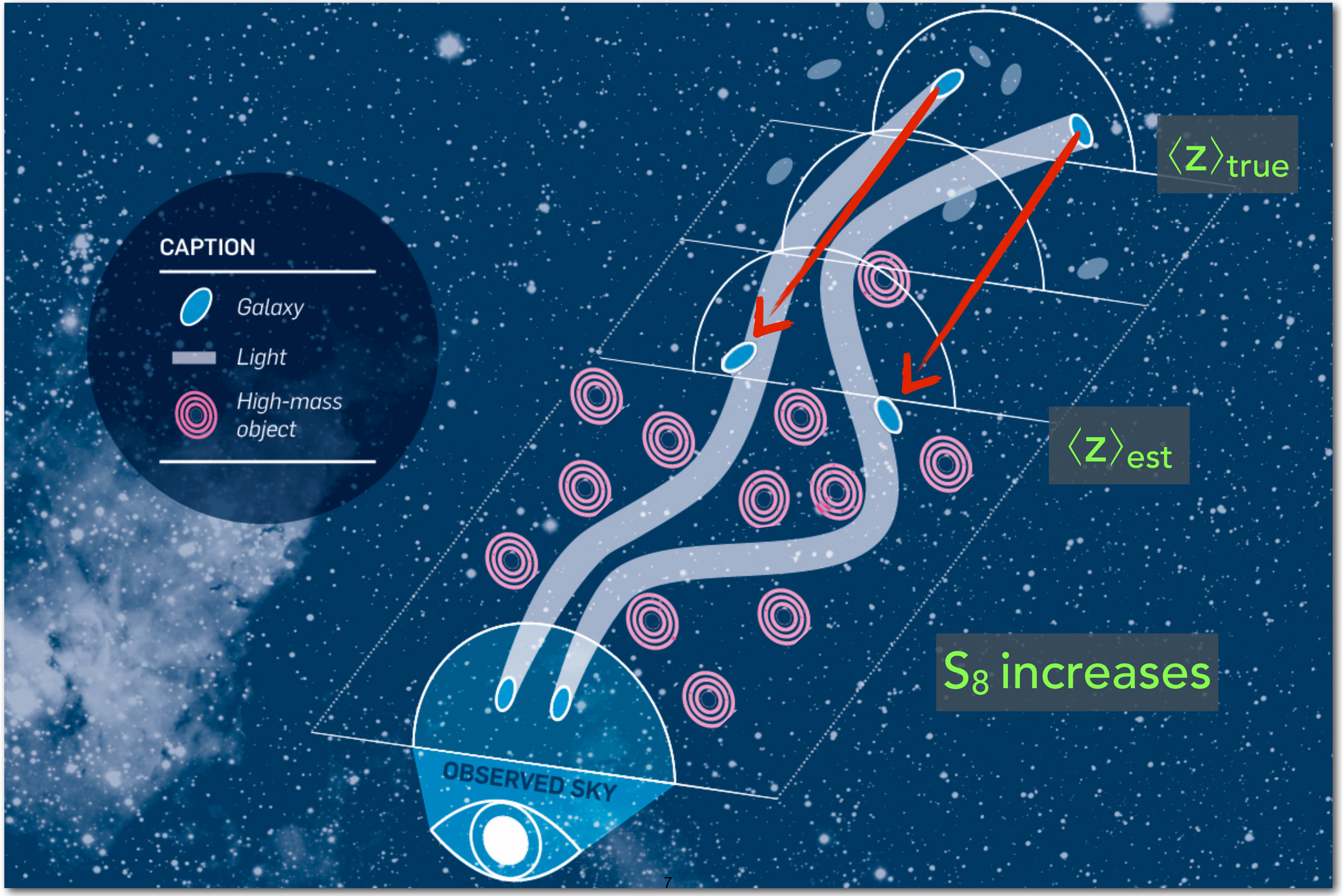
Source Redshift Distributions

Modelling of the Source galaxy population

Modelling of baryonic effects

Image Credit: Ruhr-University Bochum

Why is line-of-sight localisation (i.e. *redshift distribution calibration*) important for cosmic shear?

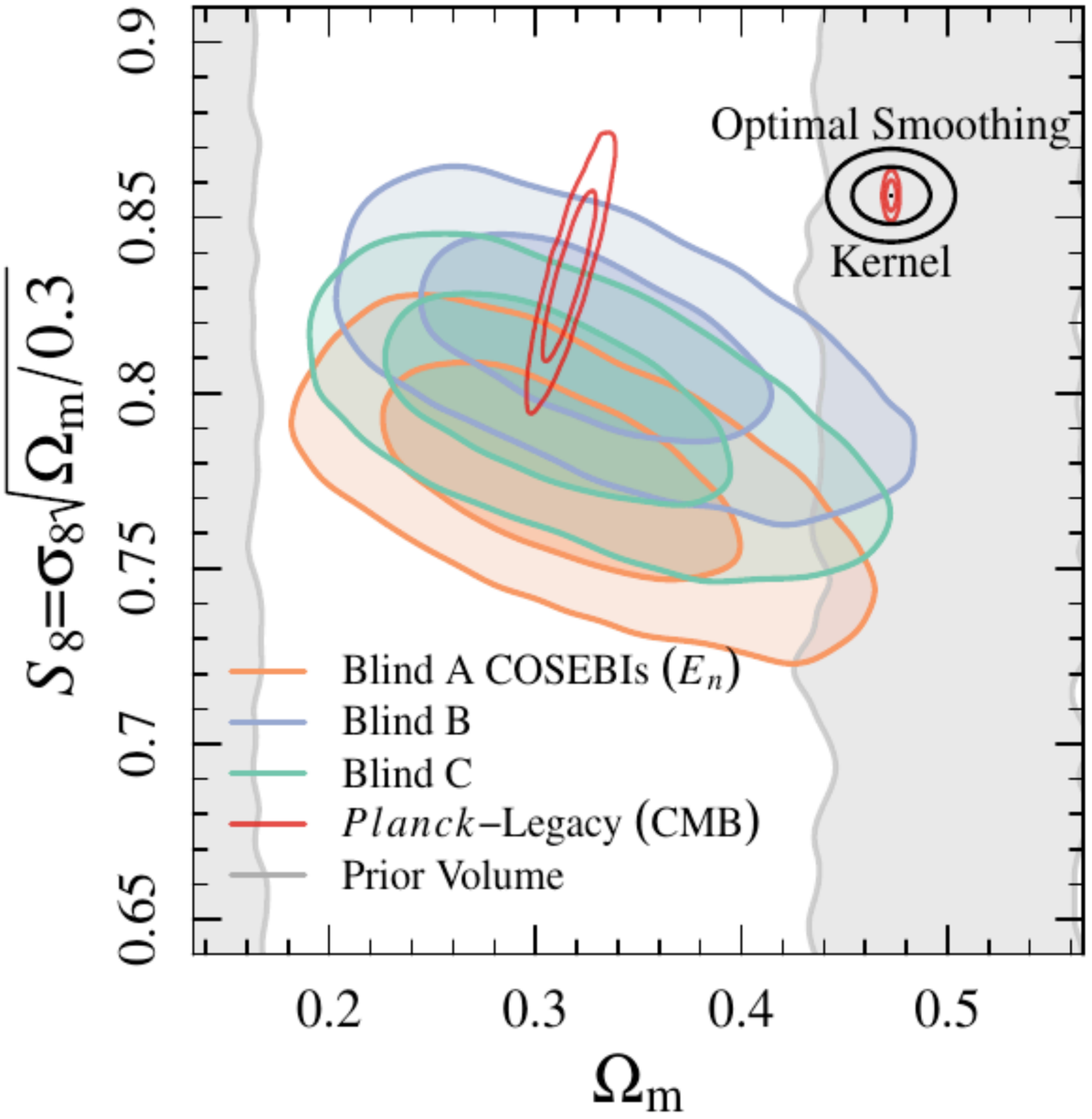

CAPTION
Galaxy
Light
High-mass object
⟨z⟩true
⟨z⟩est
S8 increases
OBSERVED SKY

Stage-III Cosmic Shear with the final release of KiDS

DR5 & KiDS-Legacy Analysis

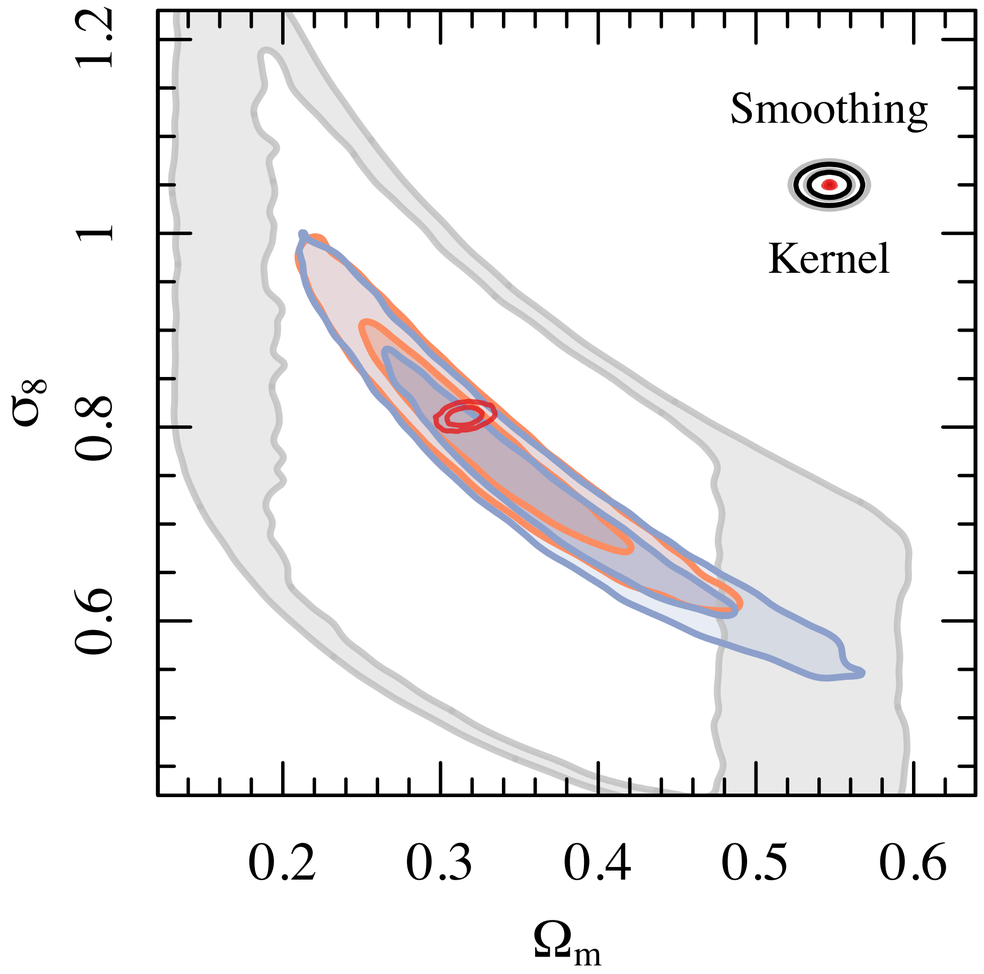
Photons to Blinded Cosmology

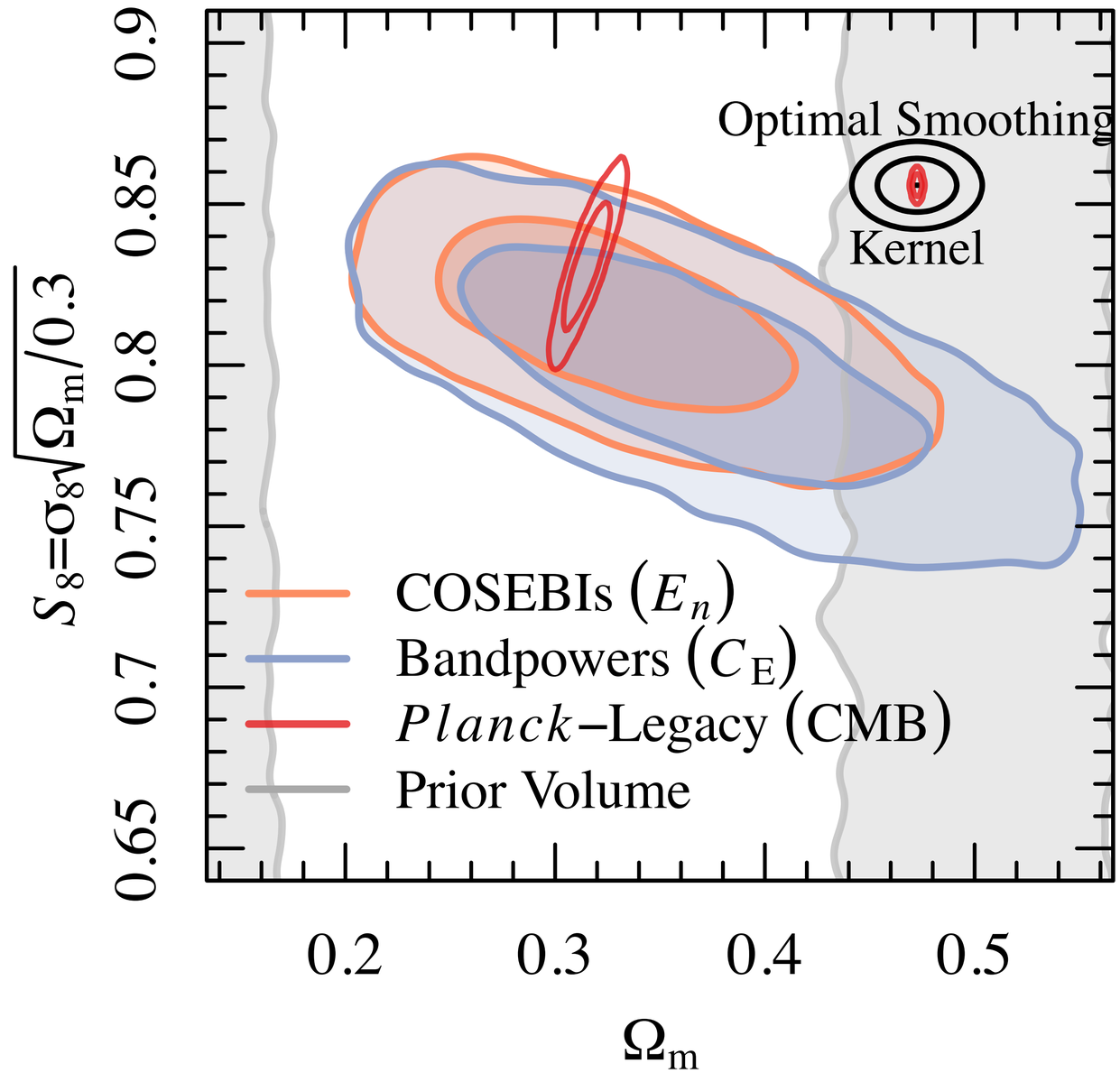
- 1347 sqdeg of optical & NIR data
- Complete re-reduction, including added depth
- Six bin tomographic analysis ($0.1 < z_{\rm B} \leq 2.0$)
- Multiple $N(z)$ estimates and calibrations
- Joint $N(z)$ and shear calibration simulations
- Updated covariance & IA modelling (NLA-M)
- New analysis infrastructure (*CosmoPipe*)
- Papers written with Blinded results



KiDS-Legacy cosmological constraints

Consistent with *Planck* (0.7σ)





Wright et al. (2025b)

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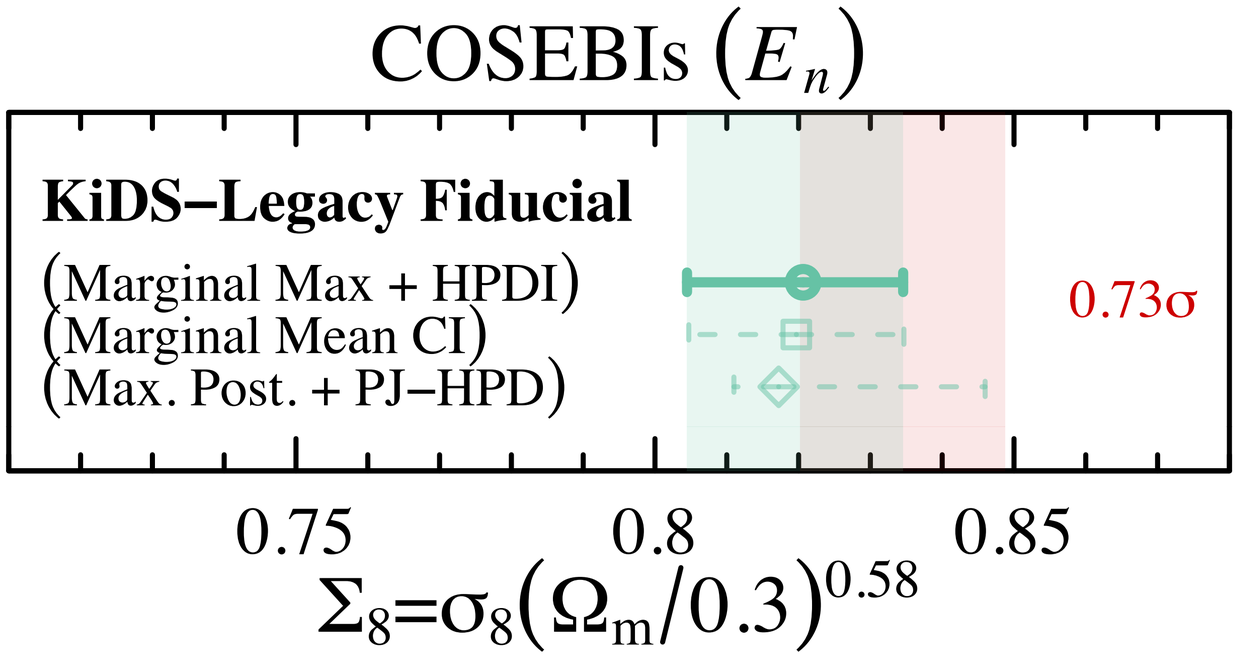
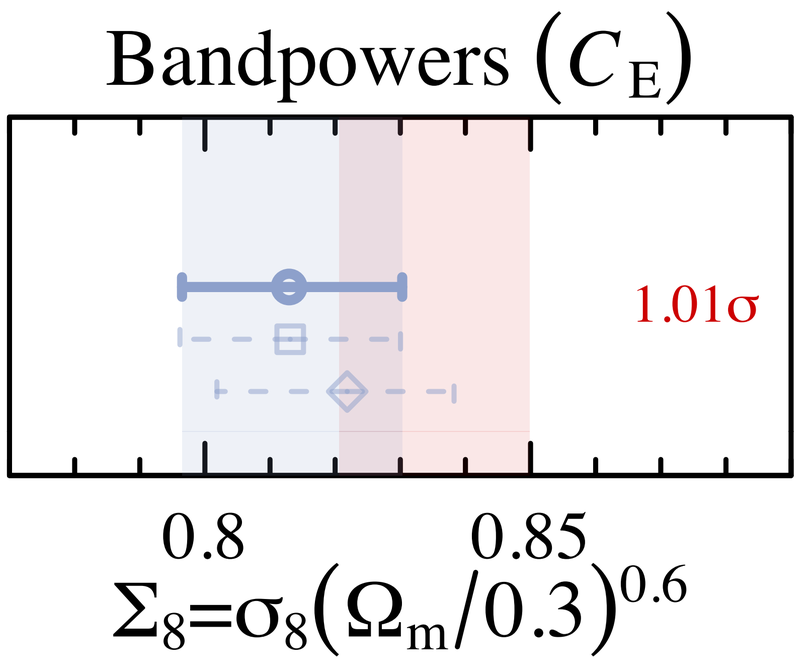
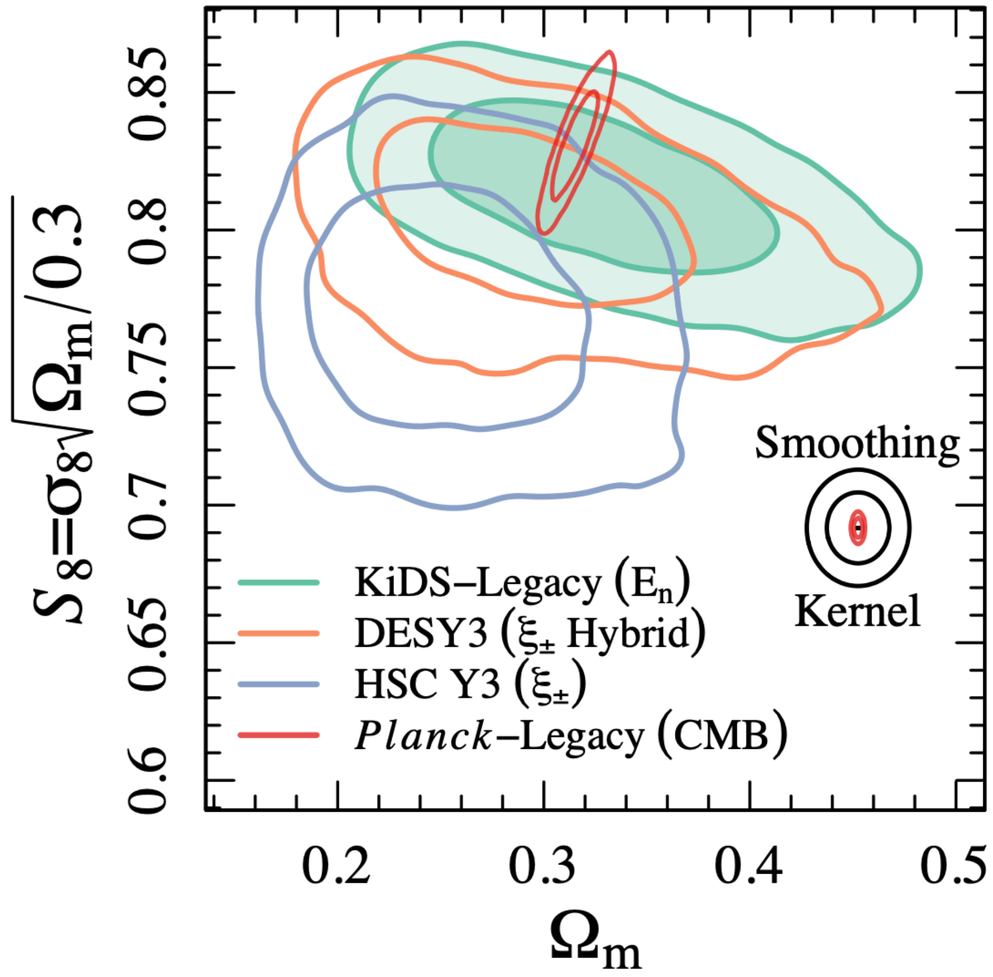


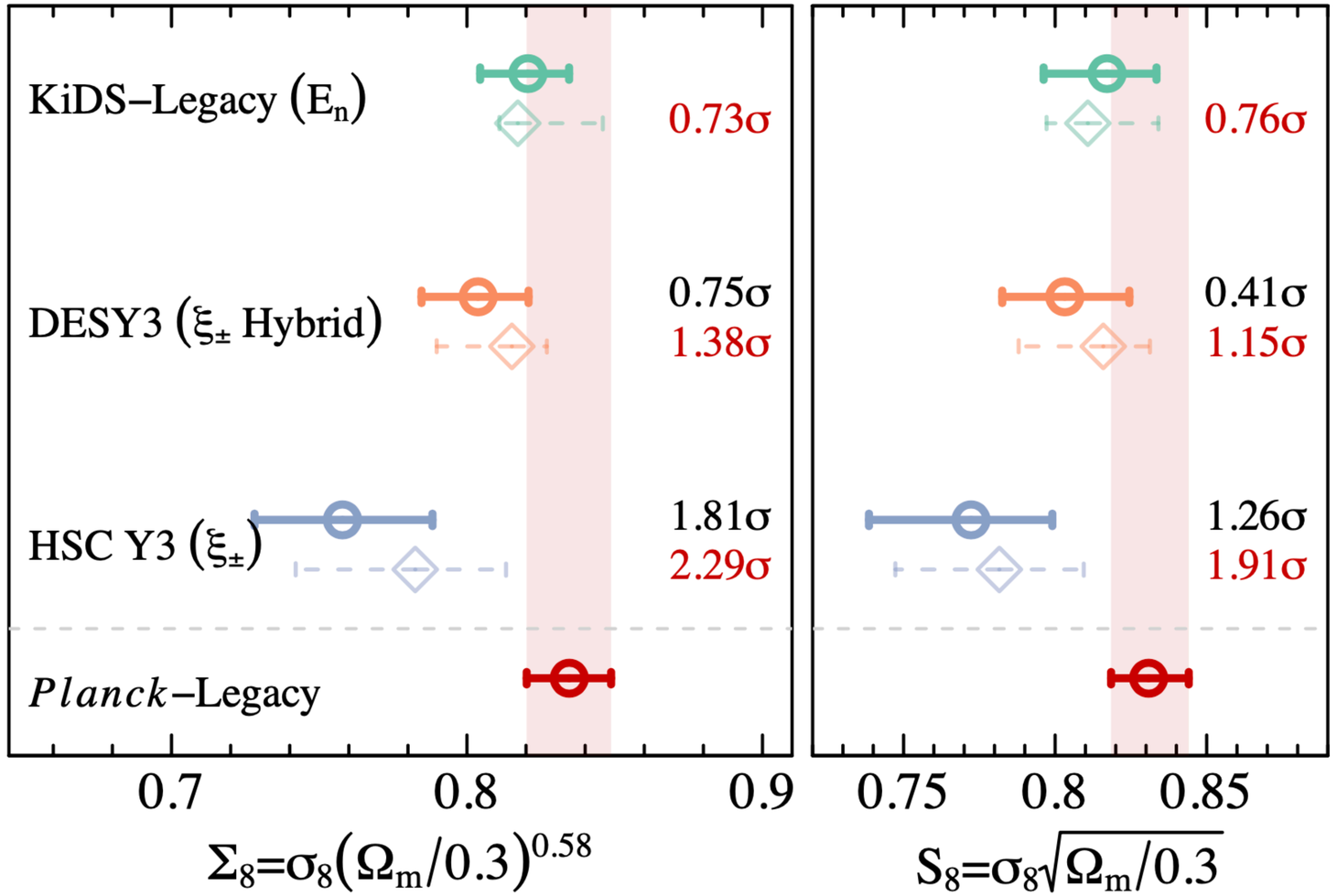


Wright et al. (2025b)

KiDS-Legacy cosmological constraints

Consistent with DES-Y3 Hybrid (0.8σ) & HSC Y3 (1.8σ)





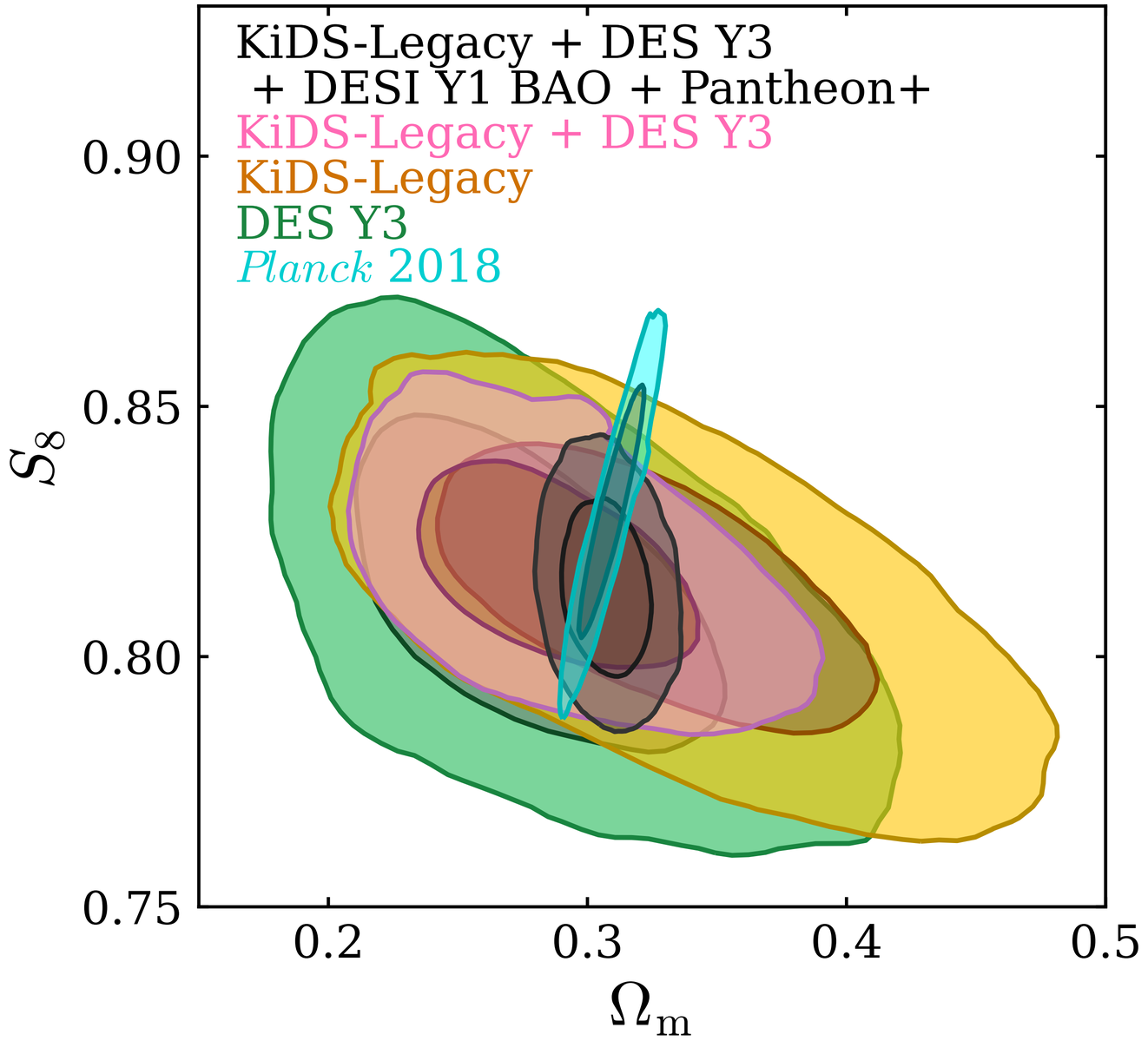
Wright et al. (2025b)

Joint constraint with DES/DESI/Pantheon+

Combined constraint is the most precise measurement of S_8 to date

$$S_8 = 0.814^{+0.011}_{-0.012}$$

$$\Omega_\mathrm{m} = 0.307^{+0.011}_{-0.011}$$



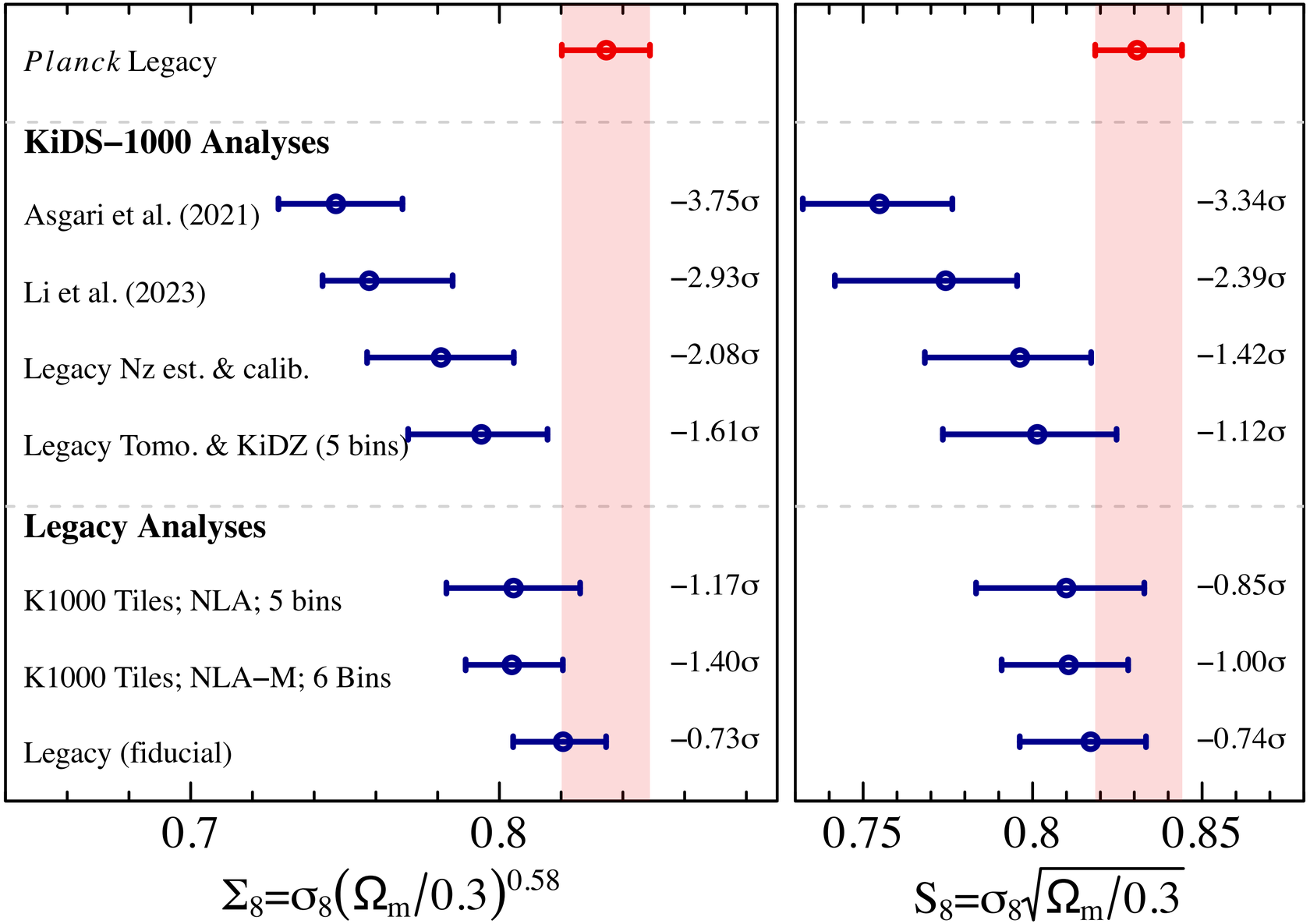
Stölzner et al. (2025)

From KiDS-1000 to KiDS-Legacy

What changed since 2021?

Updated Scale Cuts
New $N(z)$ methods
New calib. sample

New images/photo-z
Additional bin, new IA
Additional area



Wright et al. (2025b)

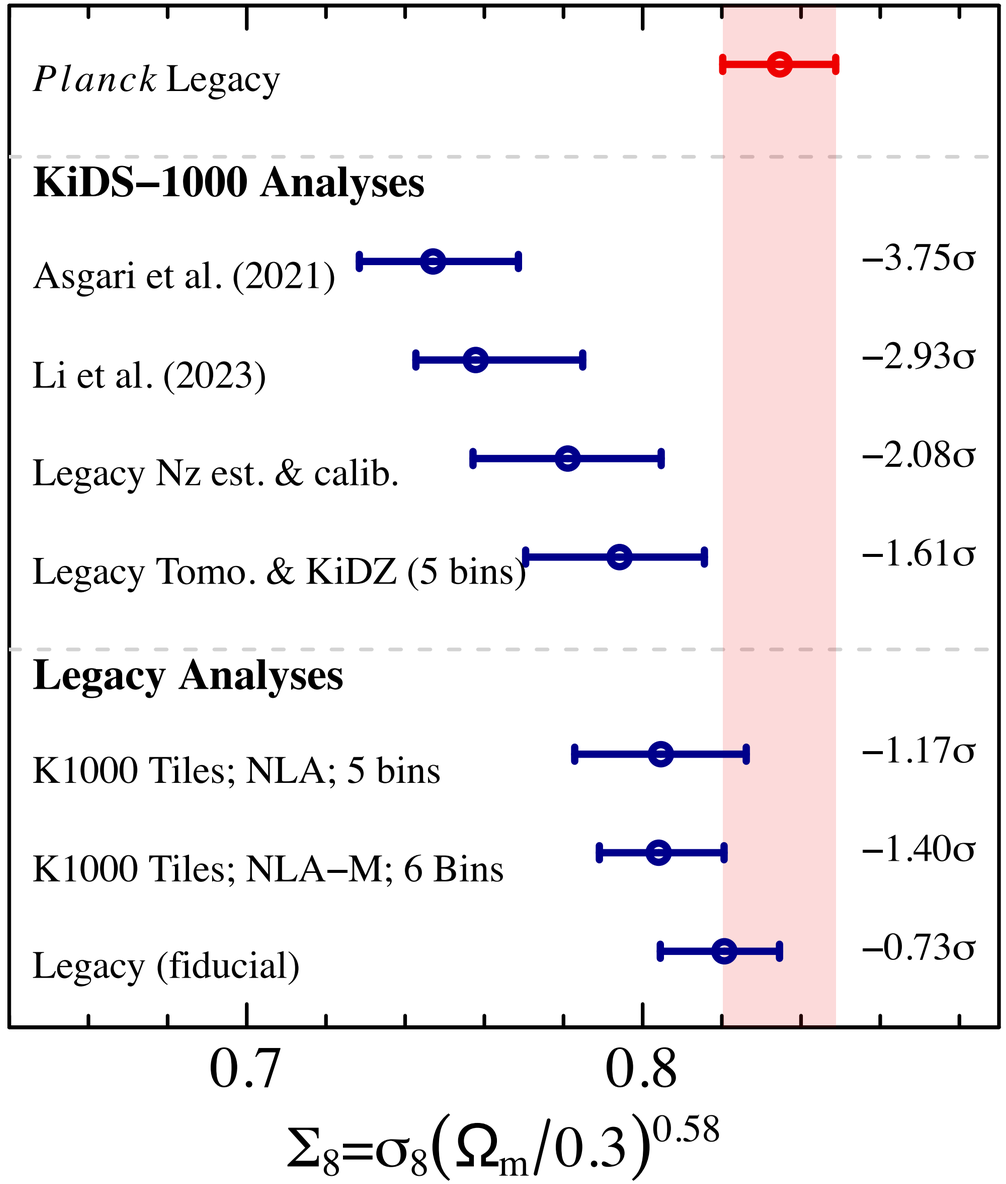
What changed since 2021?

Driving Factors

- New spectroscopic sample for $N(z)$ estimation
- Updated $N(z)$ calibration and estimation methods
- New imaging, new area

Further changes

- Revised scale cut
- New IA modelling
- New tomography
- New $P(k)$ emulation
- New sampler
- New analysis pipelines

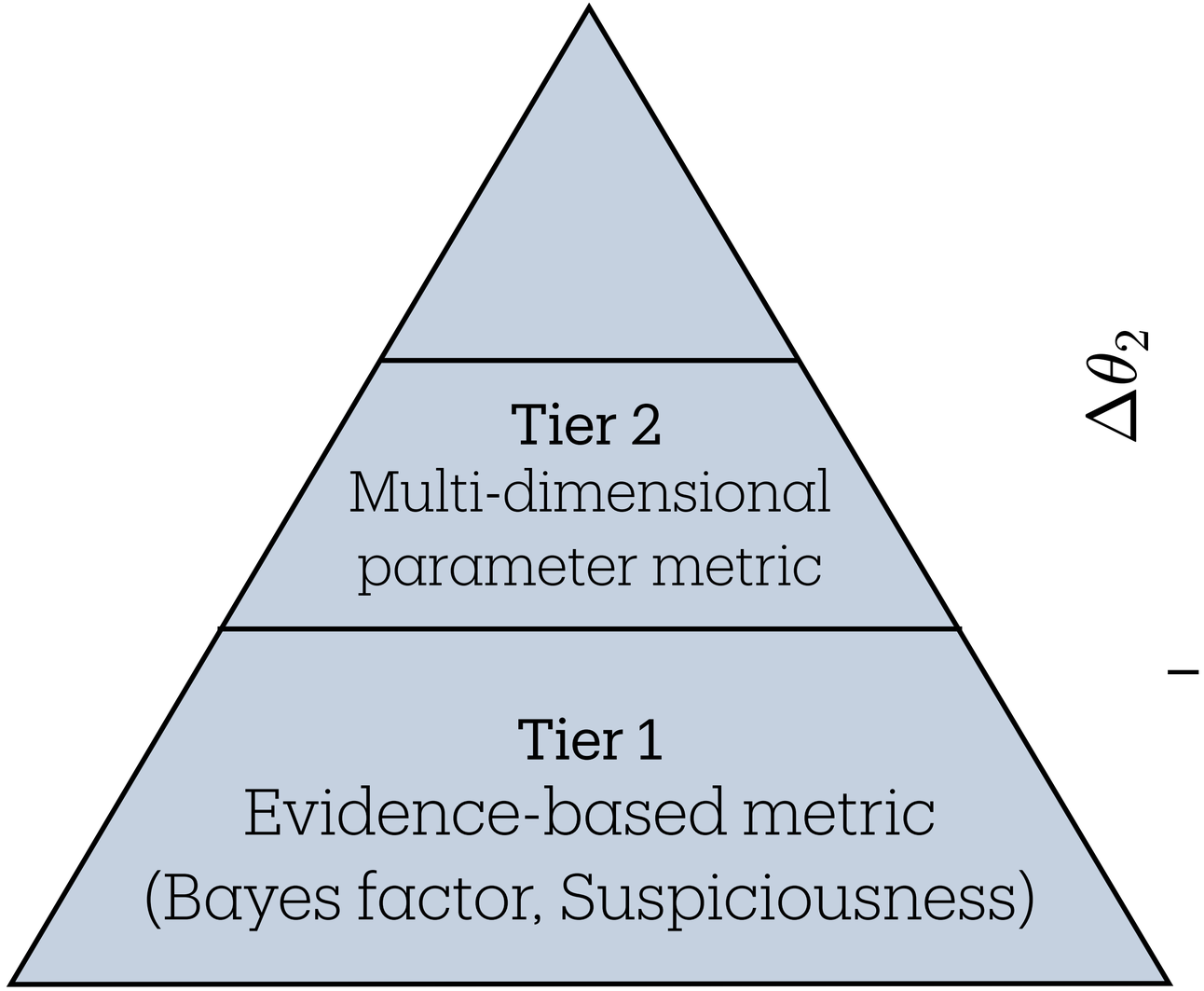


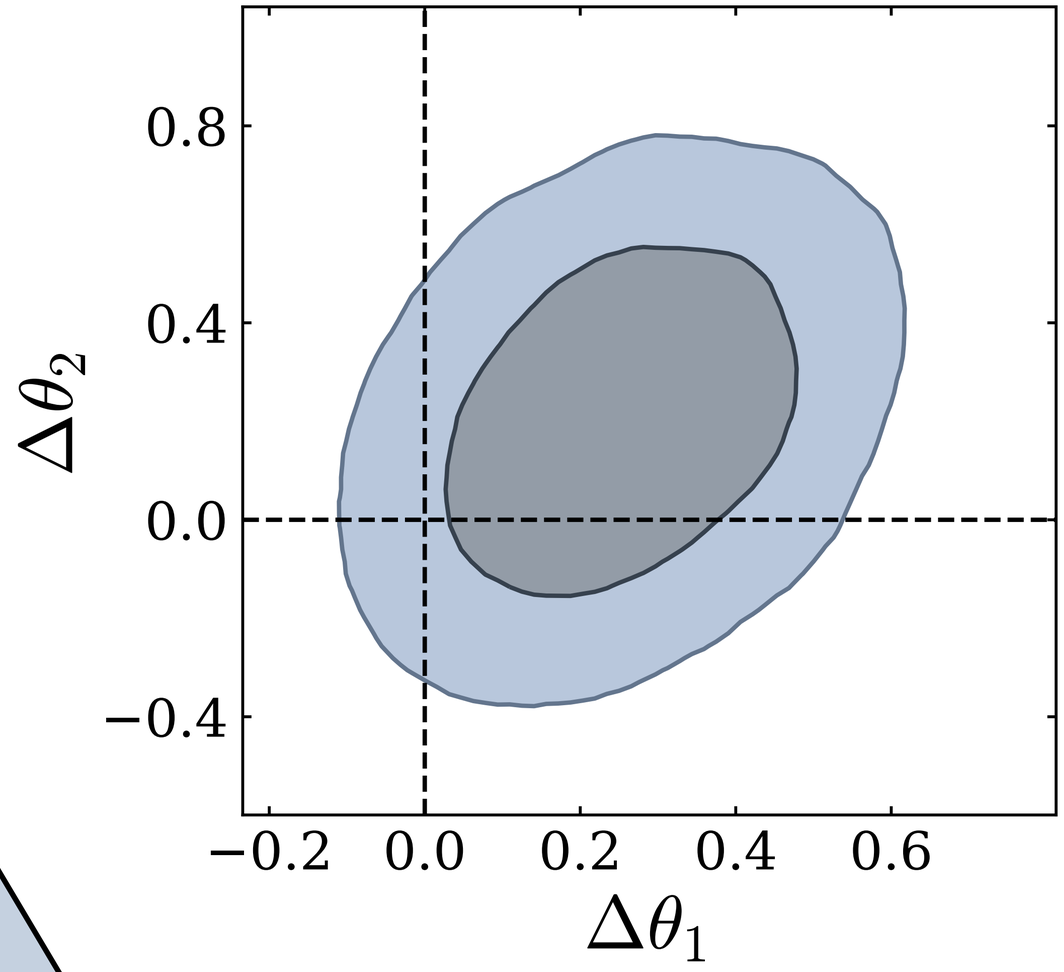
Wright et al. (2025b)

How do we know KiDS-Legacy is more robust?

Testing Internal Consistency

Greatly expanded suite of tests all indicate full consistency





Stölzner et al. (2025)

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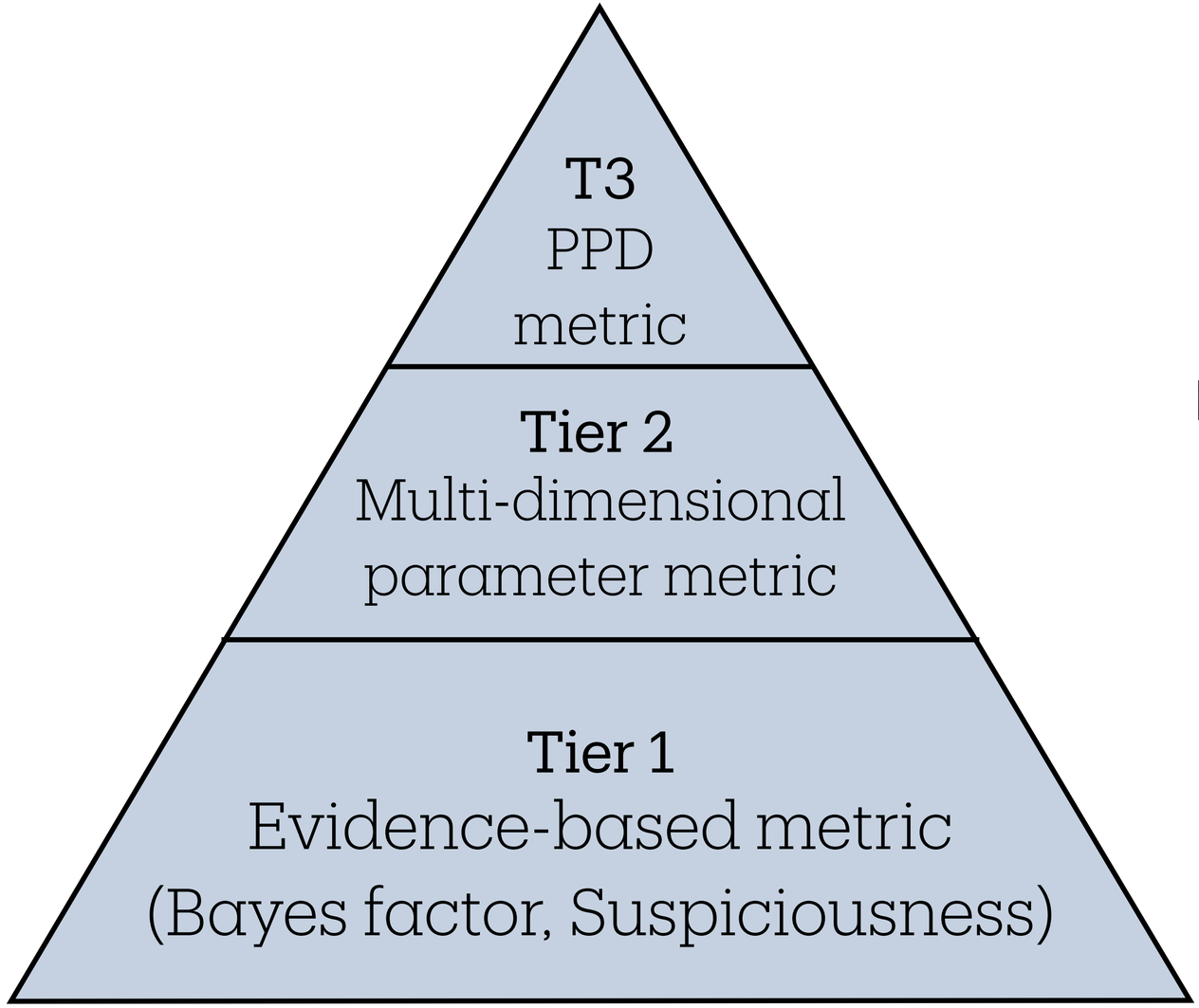
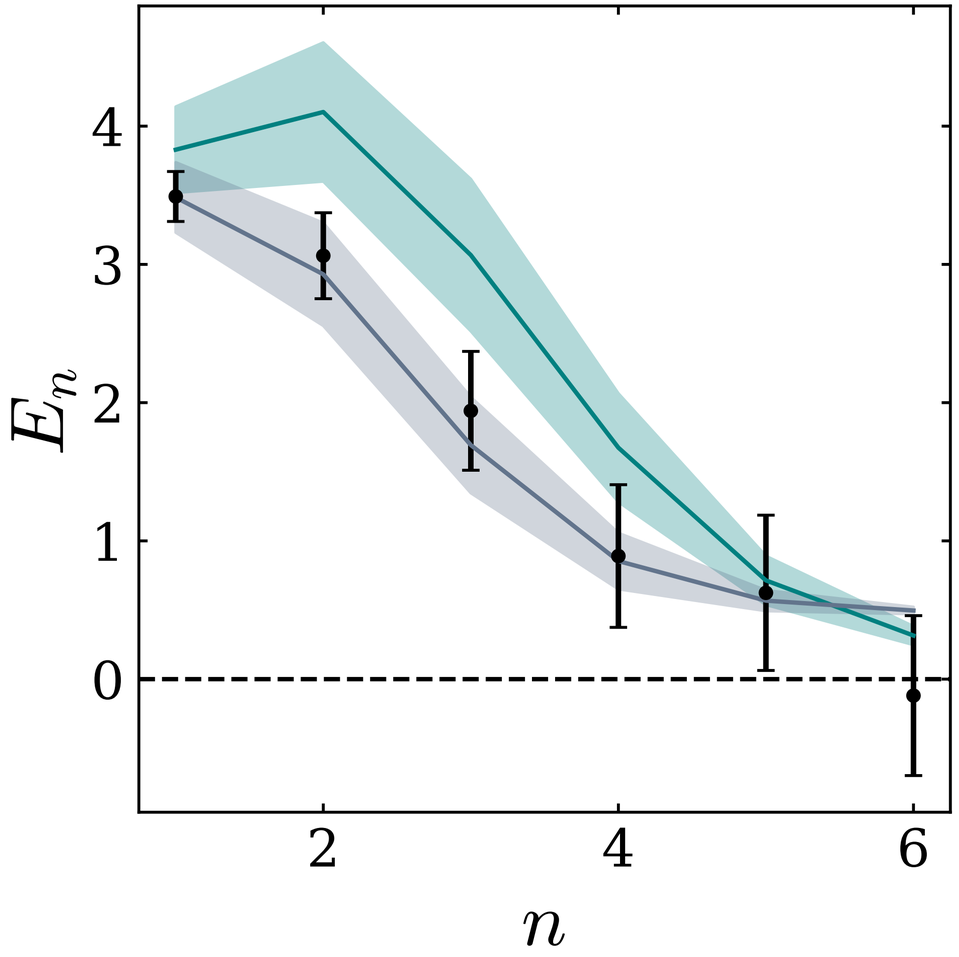




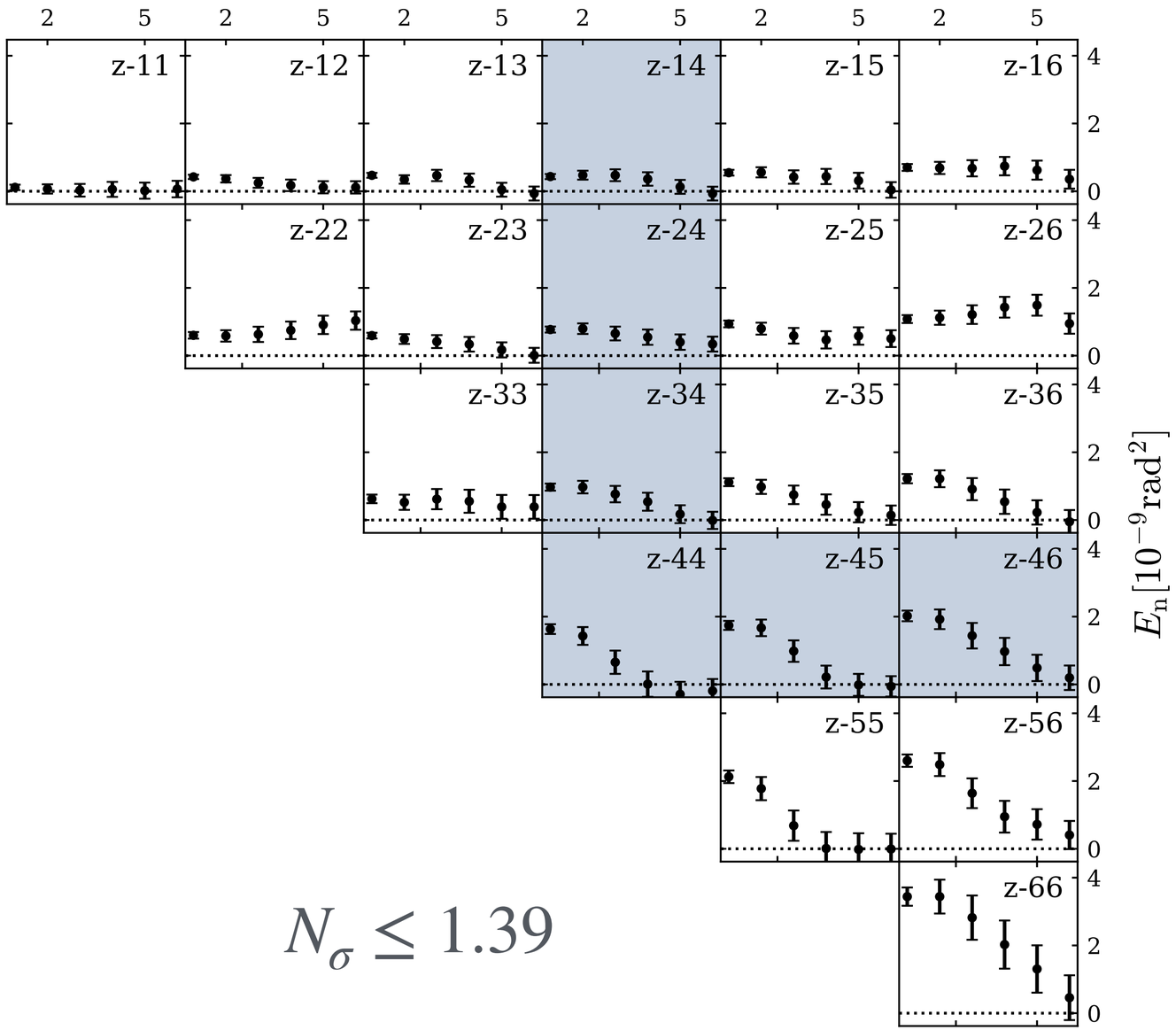
Stölzner et al. (2025)

Testing Internal Consistency

Wider range of internal splits

Data vector level:

- Redshift bins



$N_\sigma \leq 1.39$

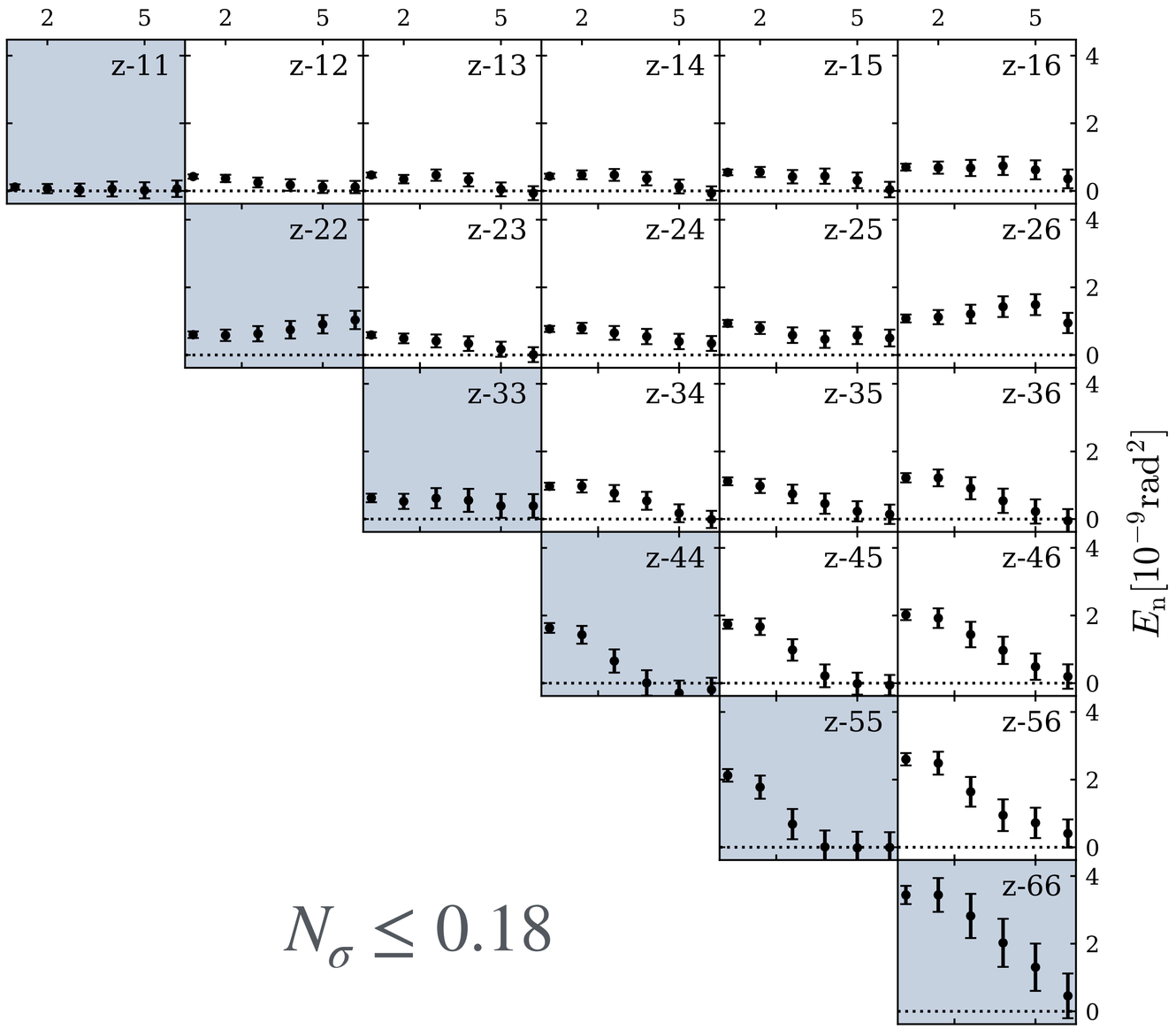
Stölzner et al. (2025)

Testing Internal Consistency $_n$

Wider range of internal splits

Data vector level:

- Redshift bins
- Auto- vs cross-correlation



$N_\sigma \leq 0.18$

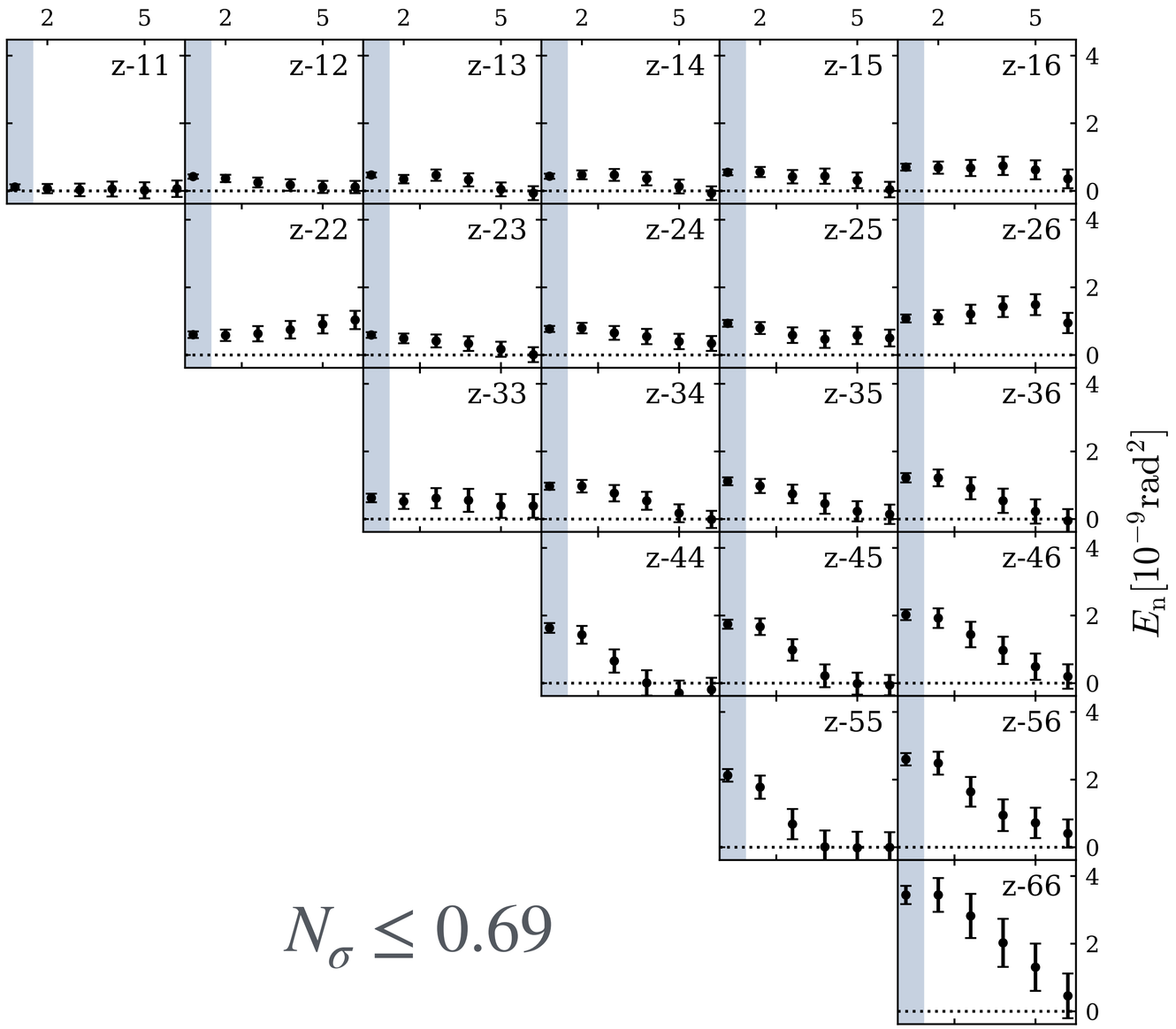
Stölzner et al. (2025)

Testing Internal Consistency $_n$

Wider range of internal splits

Data vector level:

- Redshift bins
- Auto- vs cross-correlation
- Scales/modes



$N_\sigma \leq 0.69$

Stölzner et al. (2025)

Testing Internal Consistency

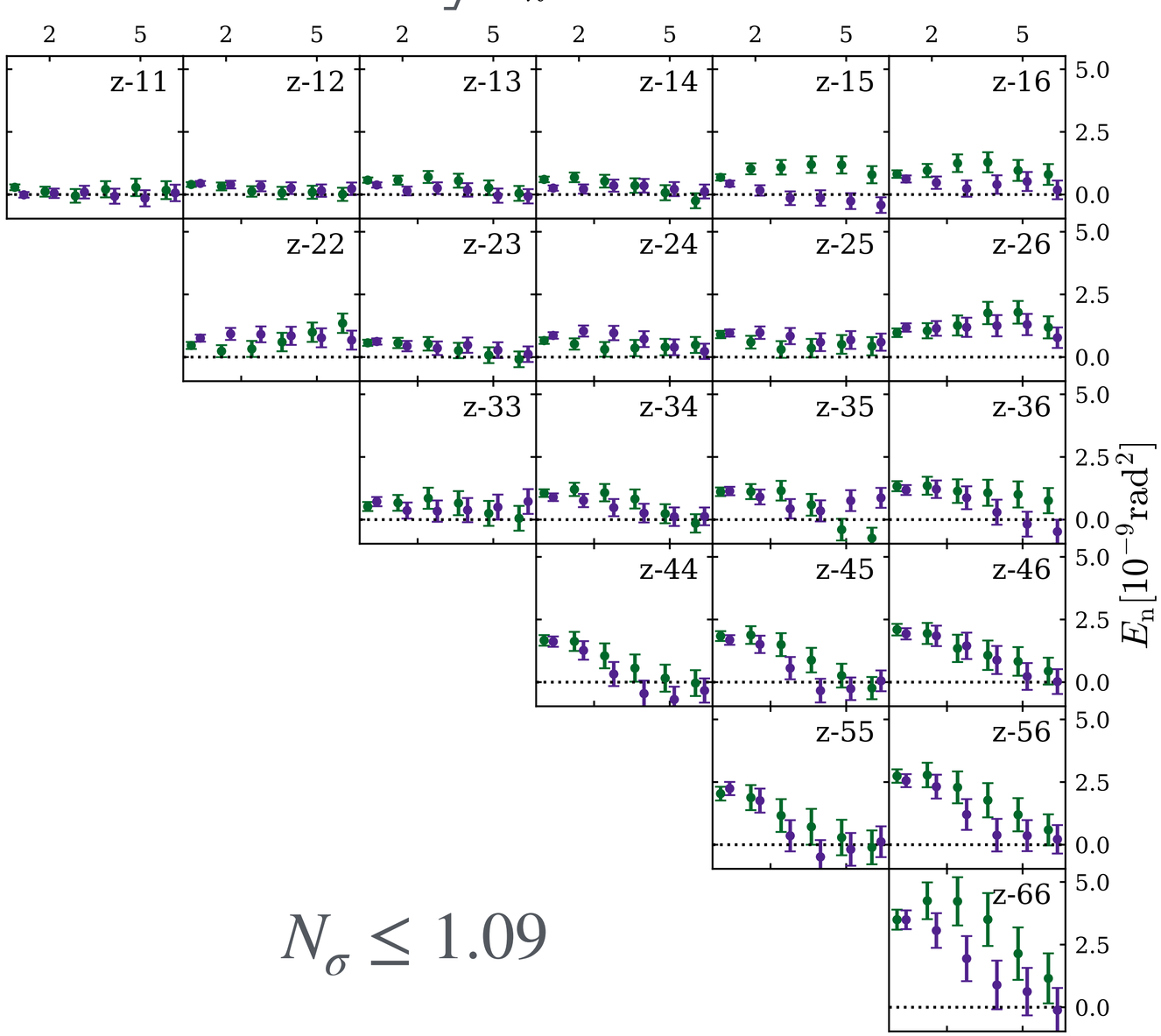
Wider range of internal splits

Data vector level:

- Redshift bins
- Auto- vs cross-correlation
- Scales/modes

Catalogue level:

- KiDS-North vs KiDS-South



$N_\sigma \leq 1.09$

Stölzner et al. (2025)

Testing Internal Consistency $_n$

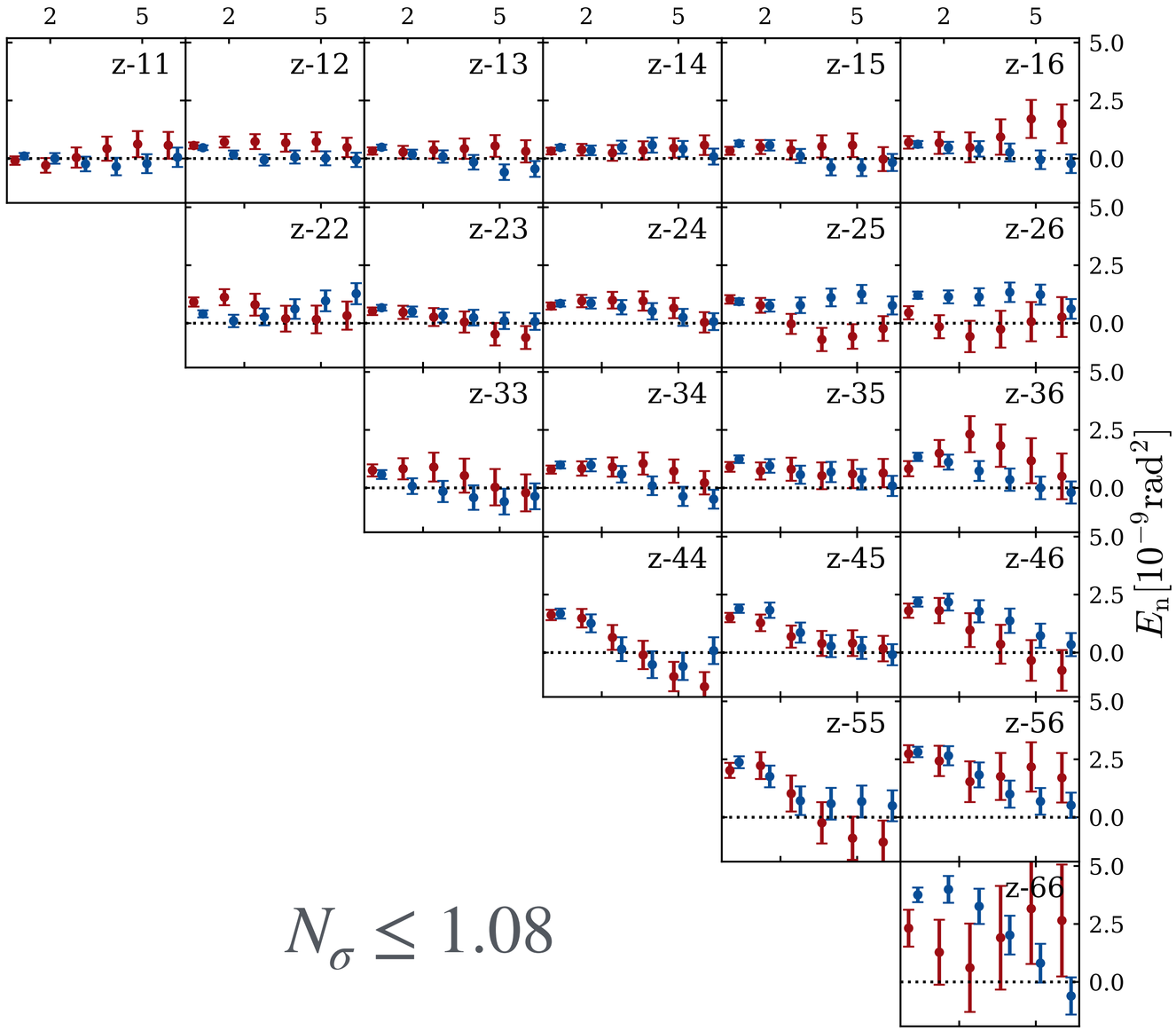
Wider range of internal splits

Data vector level:

- Redshift bins
- Auto- vs cross-correlation
- Scales/modes

Catalogue level:

- KiDS-North vs KiDS-South
- Red vs Blue



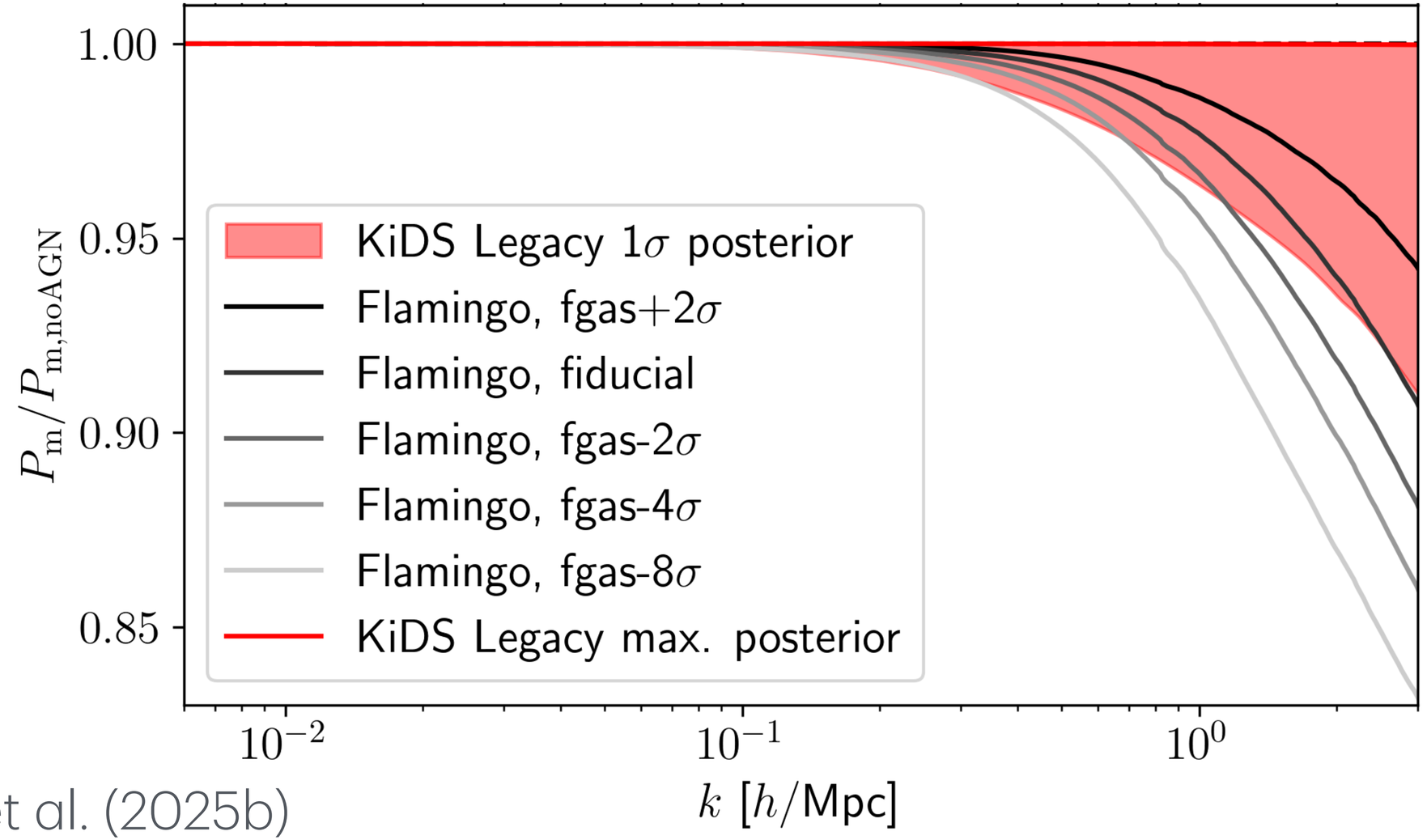
$N_\sigma \leq 1.08$

Stölzner et al. (2025)

Other Results from KiDS-Legacy Cosmic Shear

Baryonic Feedback Constraints

No evidence for significant feedback amplitudes from fiducial COSEBIs

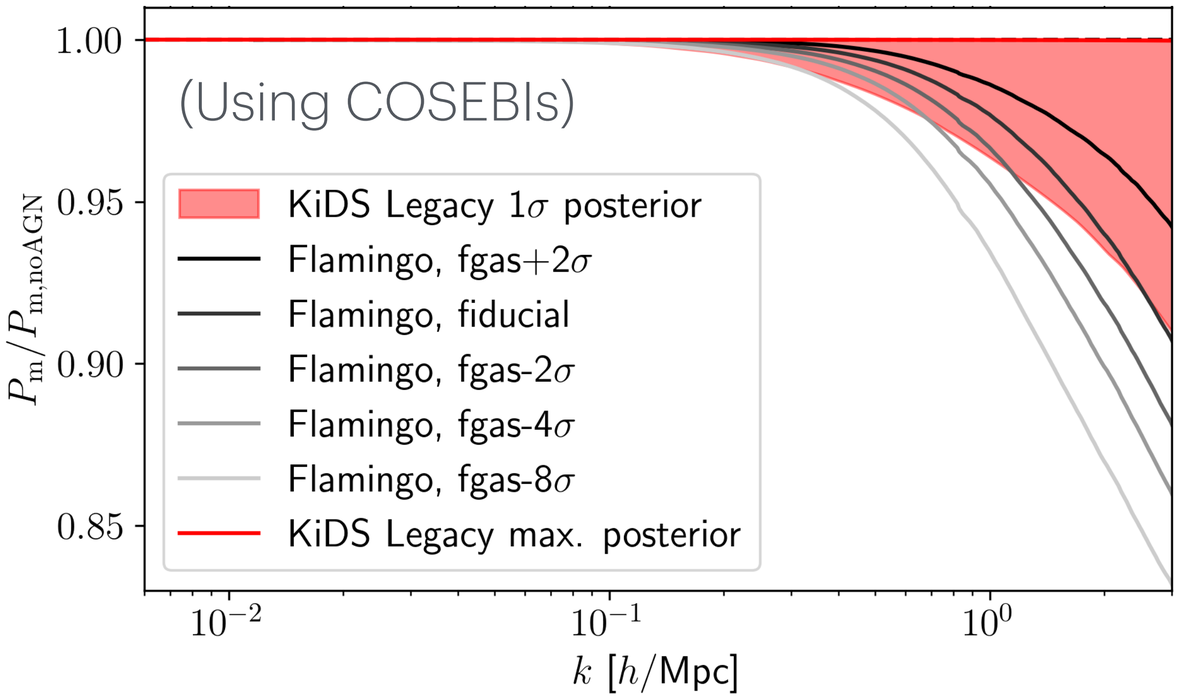


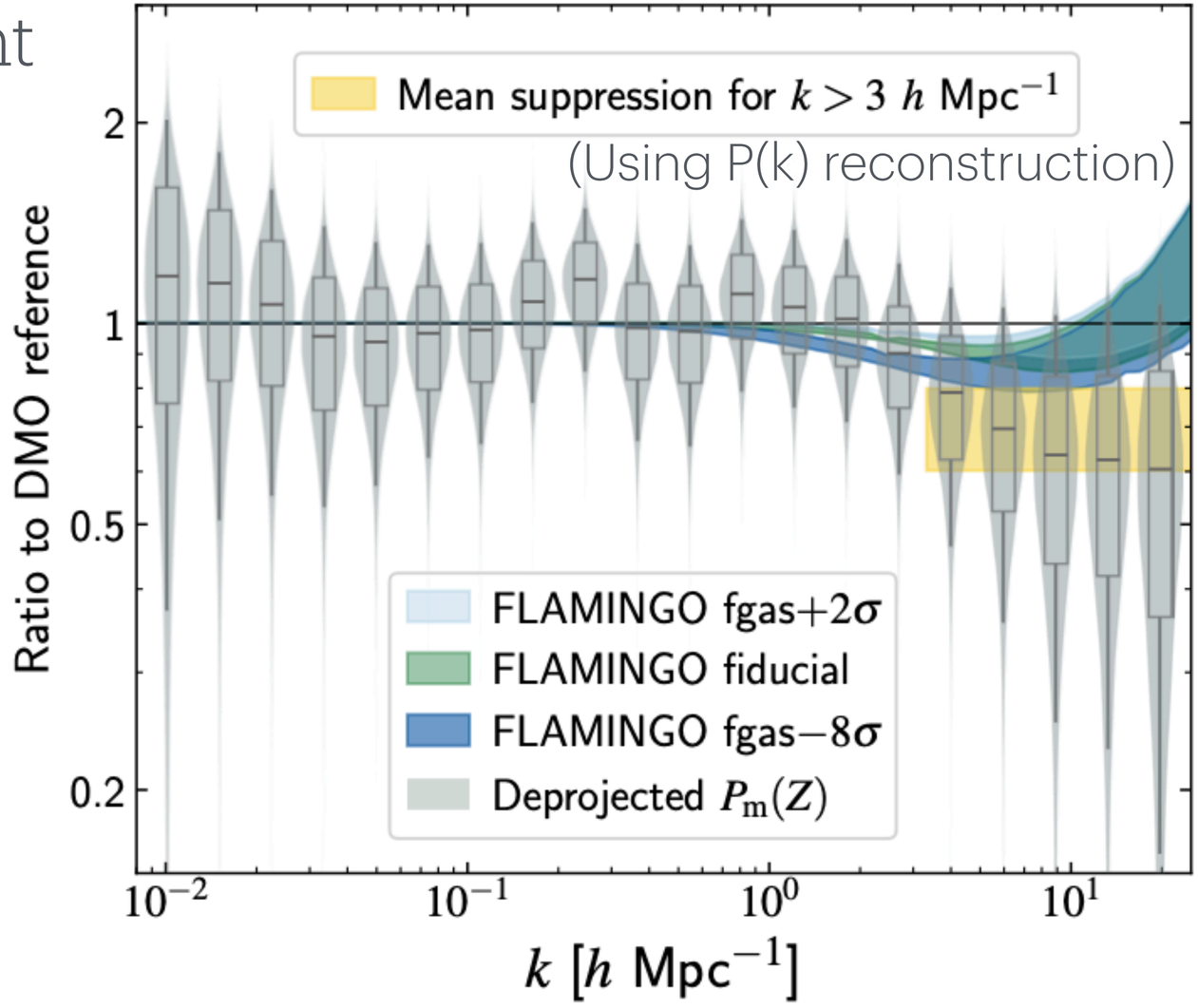
Wright et al. (2025b)

Baryonic Feedback Constraints

Using correlation functions at small scales & P(k) reconstruction:

more extreme feedback is evident





Broxterman et al. (2025)

Conclusions from KiDS-Legacy

- Data from the complete KiDS survey
  [Wright et al. (2024)]
- Improved calibration samples and methods
  [Wright et al. (2025a)]
- Consistent with *CMB*
  [Wright et al. (2025b)]
- No evidence for significant feedback
  [Wright et al. (2025b)]
- Most robust KiDS analysis to date
  [Stölzner et al. (2025)]