

KiDS x BOSS

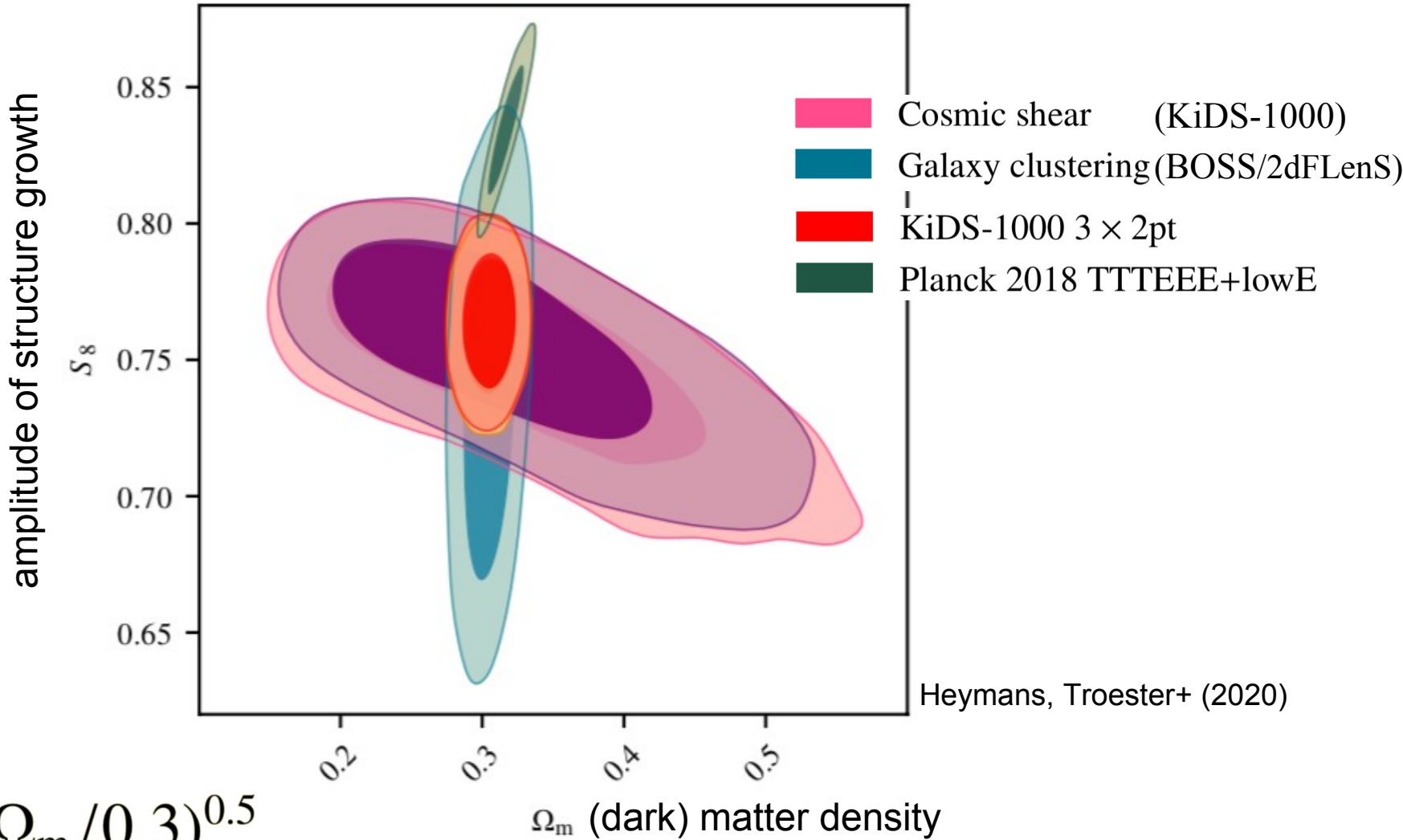
**A guide to precision cosmology
from combined galaxy surveys**

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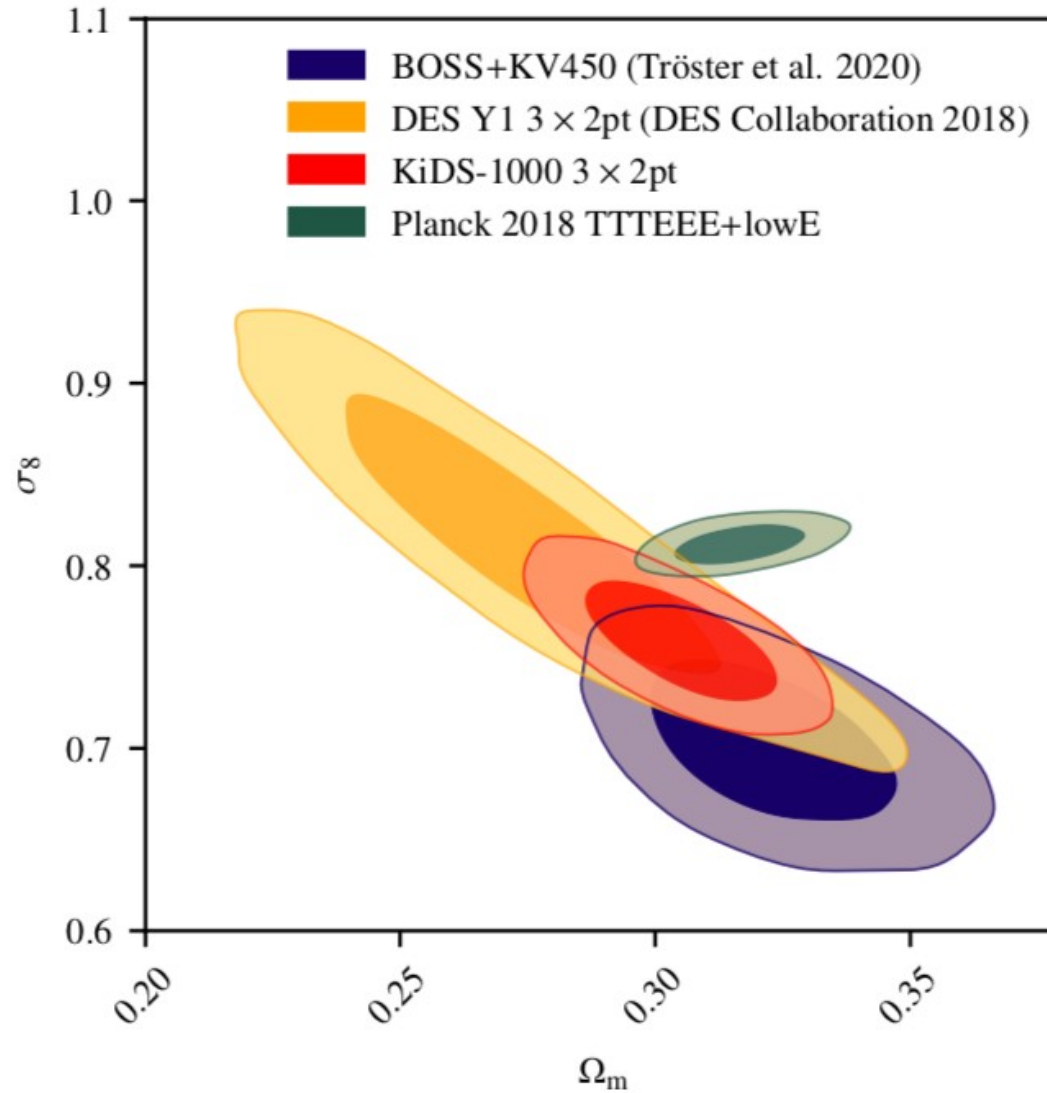
with Chieh-An Lin, Marika Asgari, Tilman Tröster, Catherine Heymans & the KiDS Team

The final result



$$S_8 = \sigma_8 (\Omega_m / 0.3)^{0.5}$$

The final result



Heymans, Troester+ (2020)

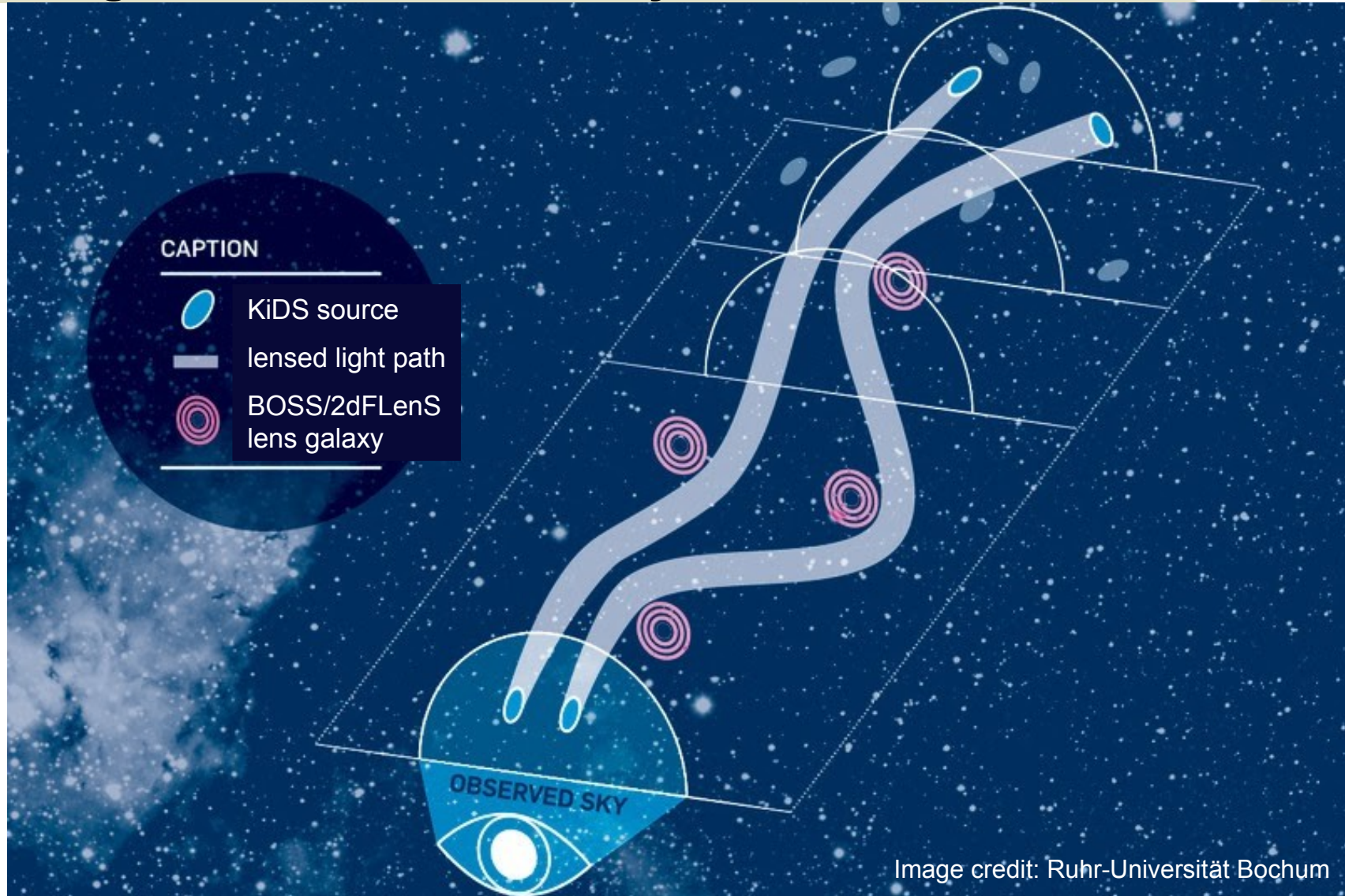
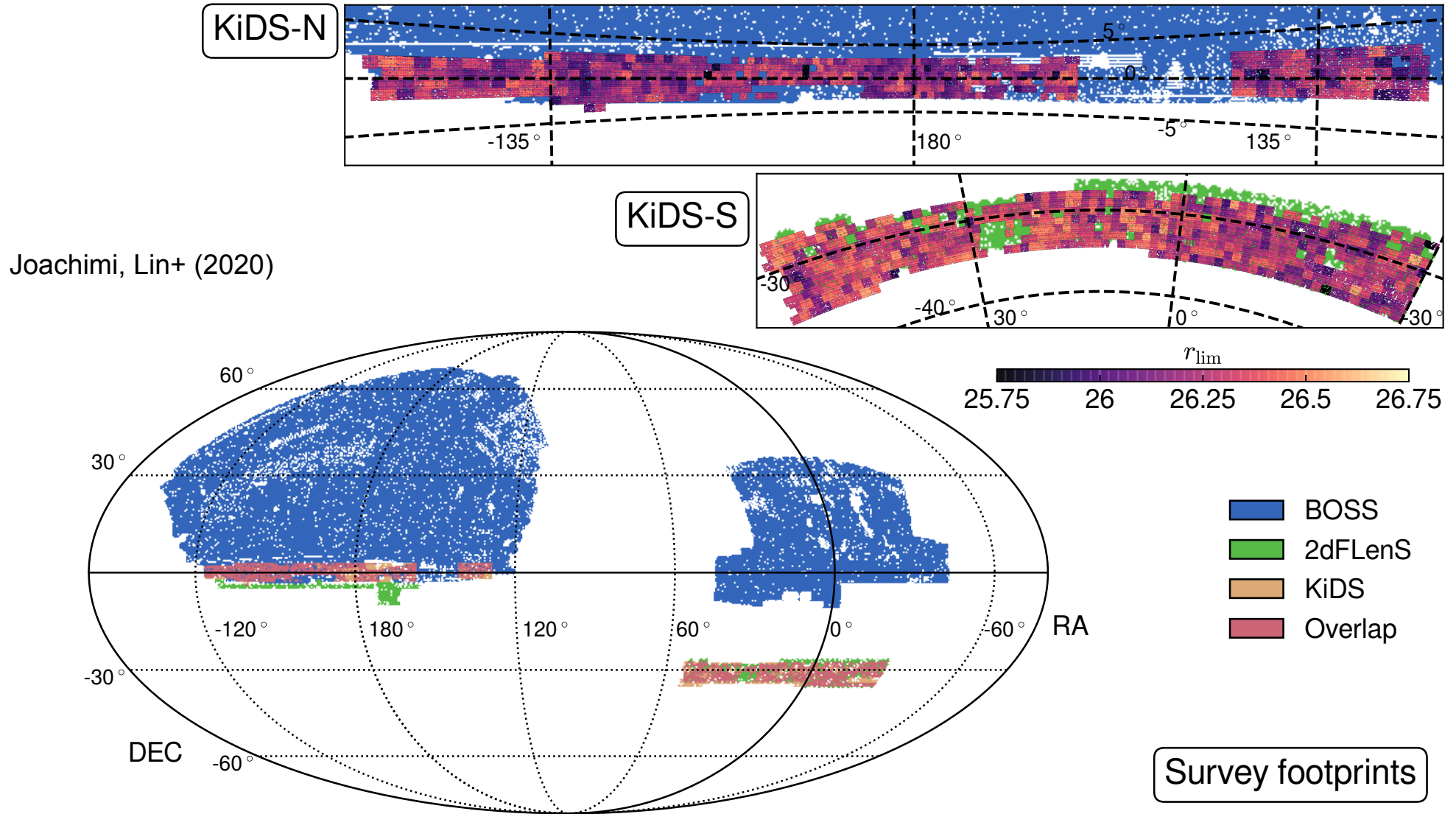
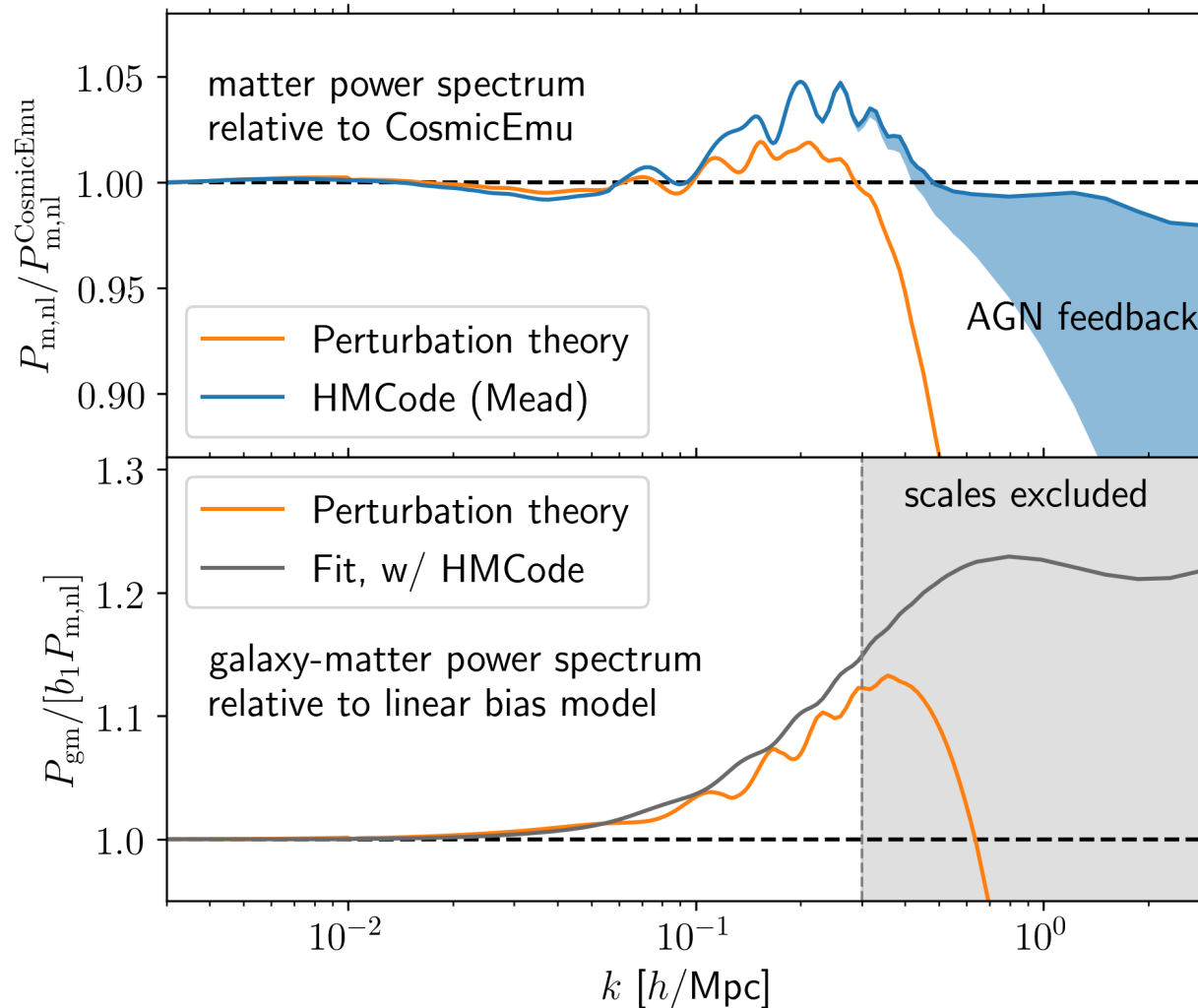


Image credit: Ruhr-Universität Bochum

Survey footprints and overlaps





Weak lensing: halo model power spectrum (HMCode)

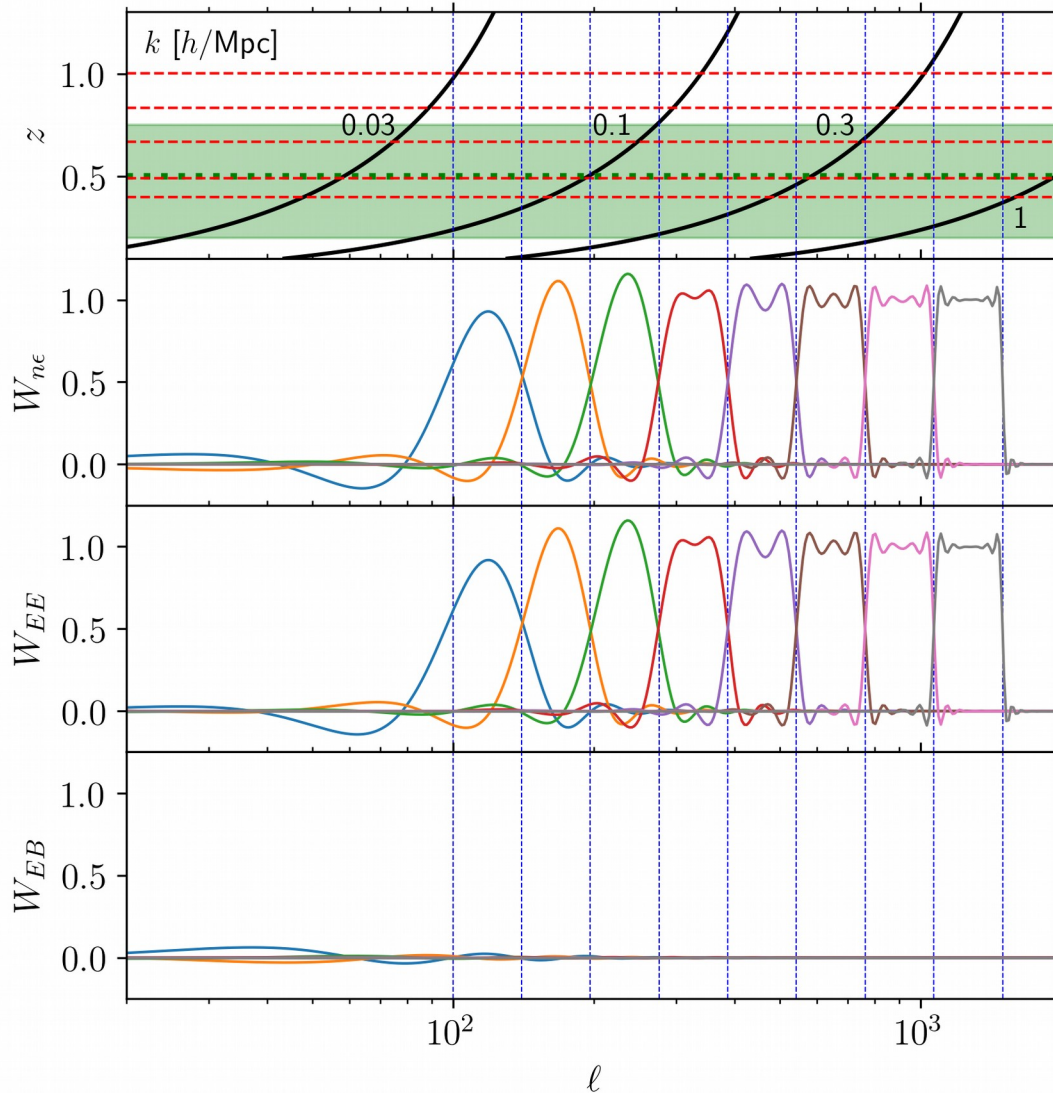
Clustering: perturbation theory + non-linear galaxy bias (gRPT)

Galaxy-galaxy lensing: hybrid approach w/ emulator + conservative scale cuts

Model includes:

- Baryon feedback
- Intrinsic alignments
- Magnification bias

Which summary statistics to use?



Correlation function-derived band powers:

- insensitive to survey footprint
- compact in harmonic space
- good E/B-mode separation
- Gaussian-distributed
- offer some data compression

For clustering we adopt the BOSS correlation function wedges.

20,000 realistic mock surveys



FLASK

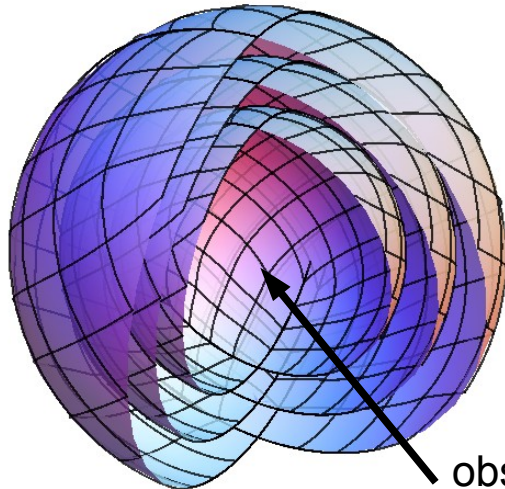
Xavier+ (2016)

+



SALMO

Lin+, soon on GitHub



observer

FLASK

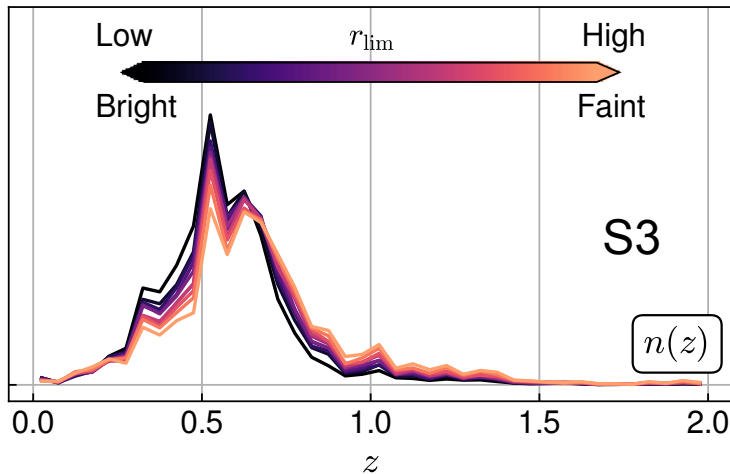
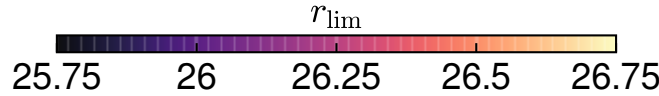
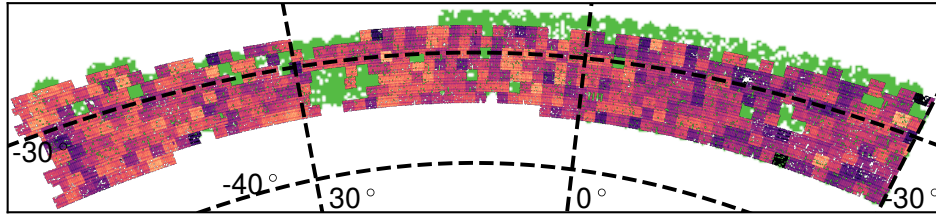
- generates lognormally distributed dark matter distribution in concentric shells
- resulting mock has pre-defined 2pt statistics
- determines weak lensing via integration along the line of sight

SALMO

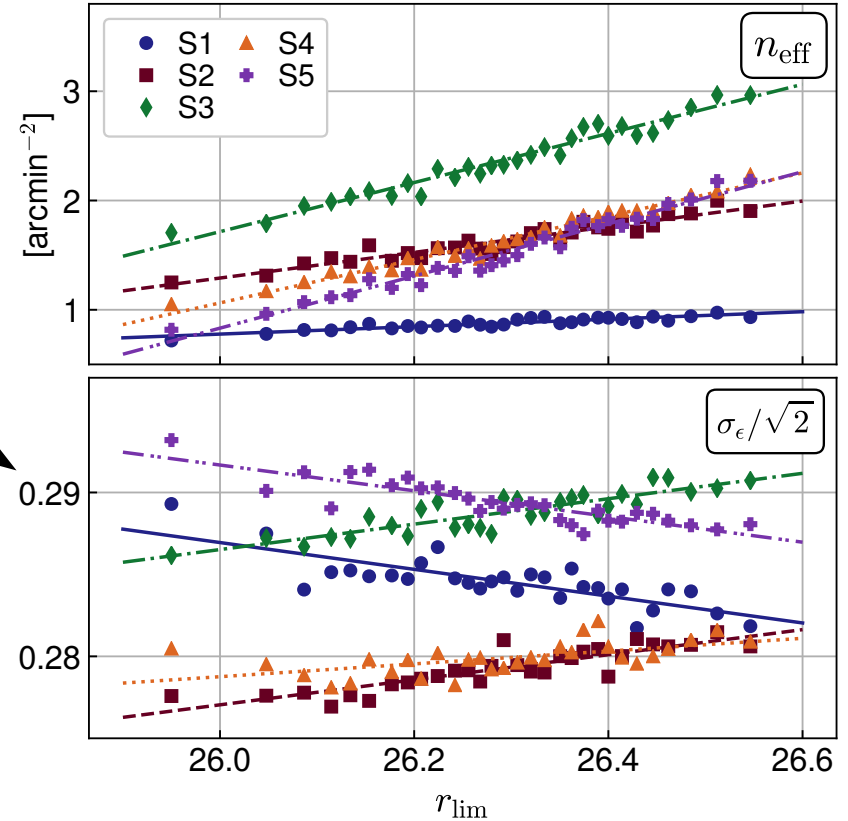
- populates matter distribution with lens and source galaxies
- applies realistic survey footprints
- allows for spatially varying galaxy sample properties

→ Mock analysis takes longer than mock creation!

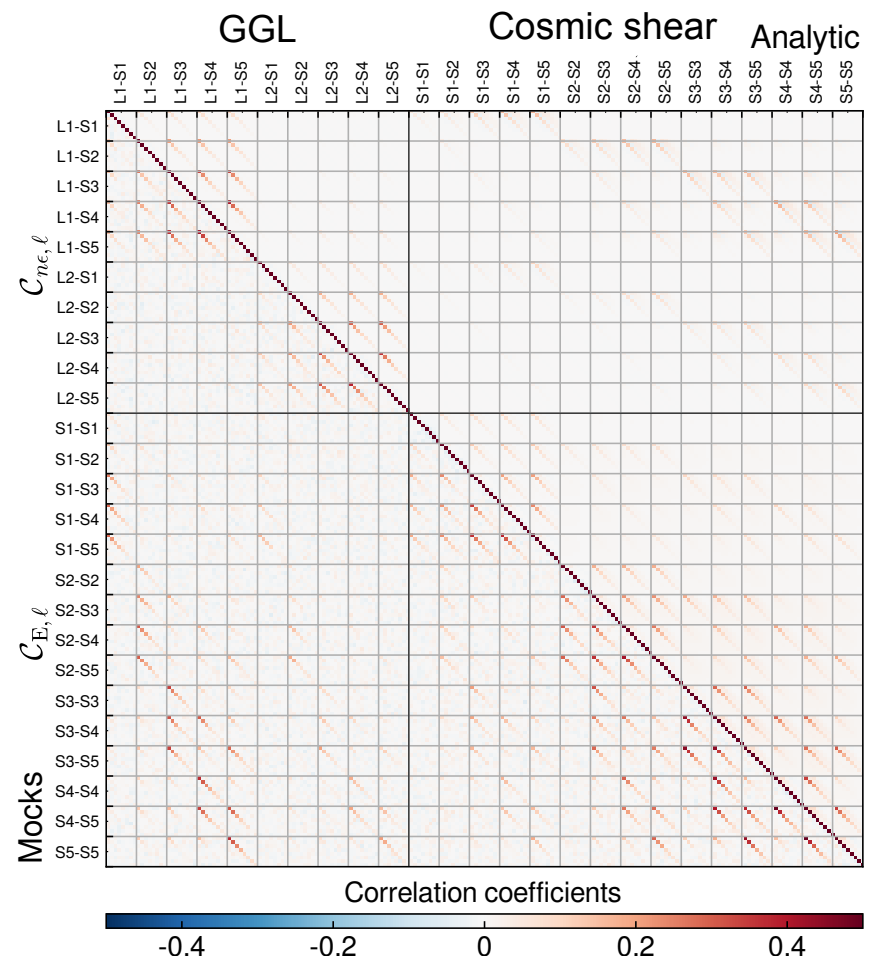
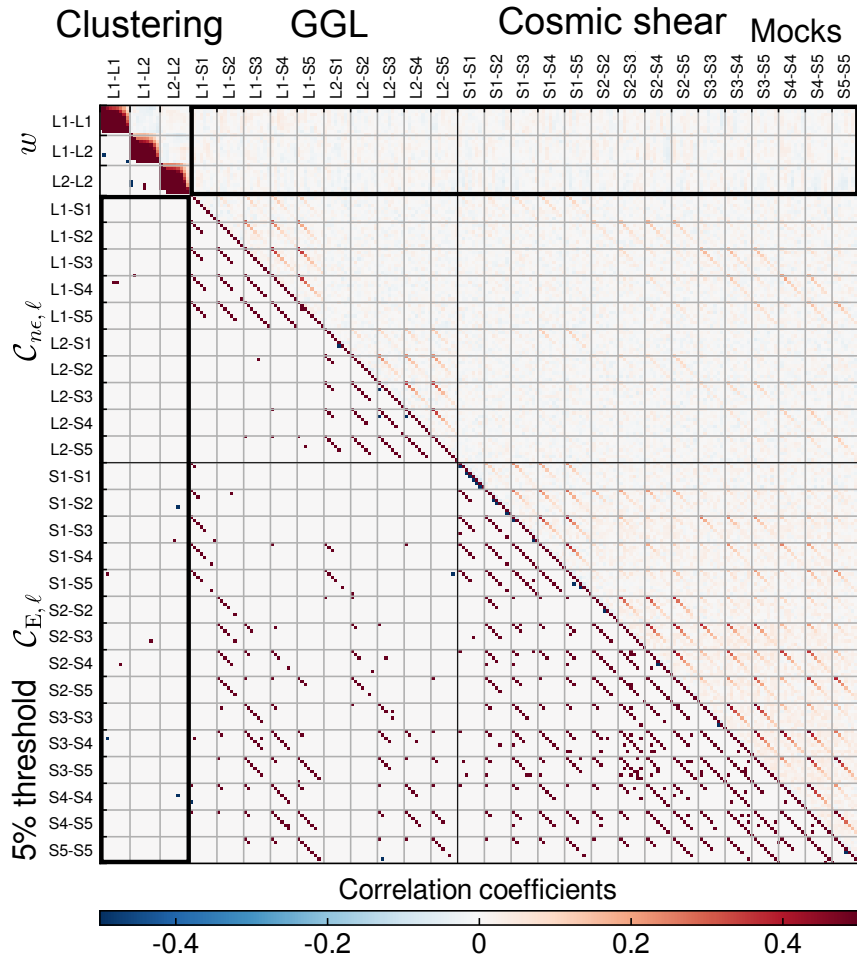
Spatial survey variability



tomographic source galaxy bins



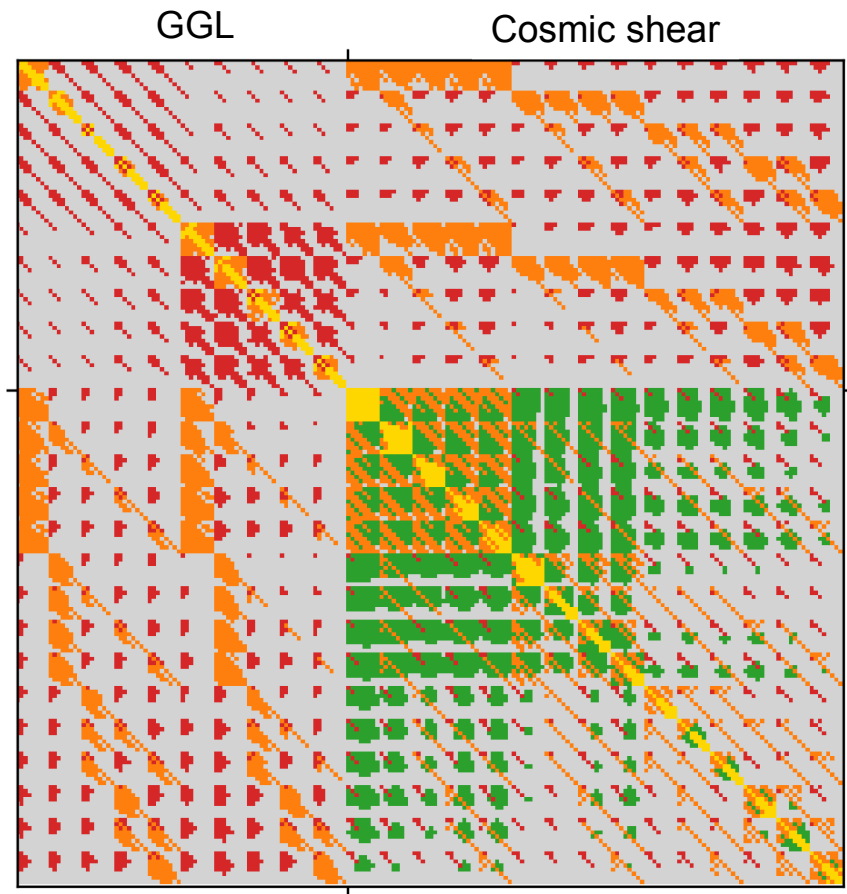
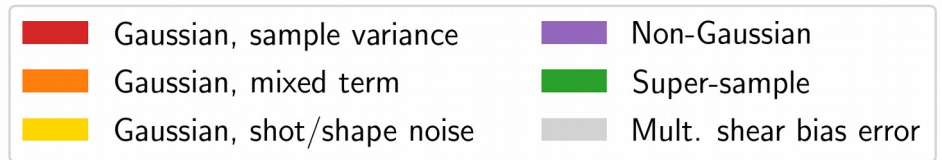
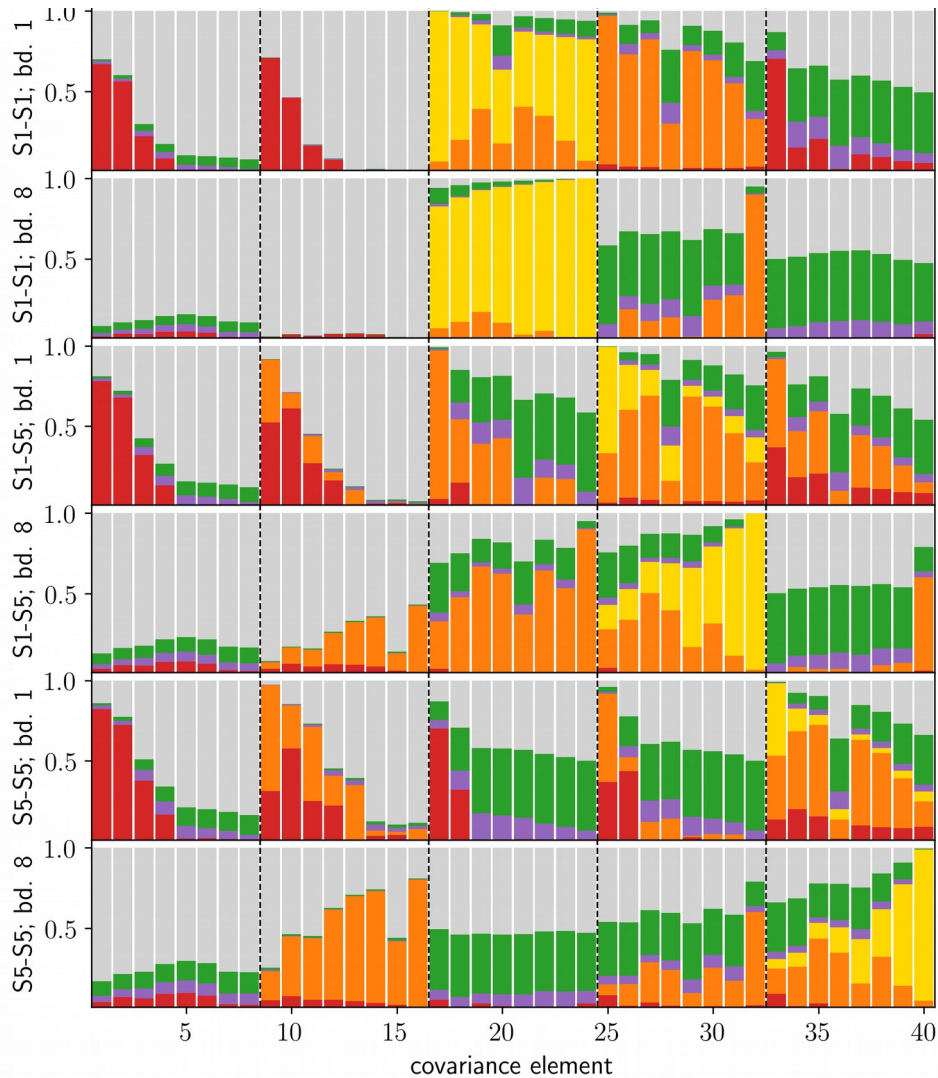
- Redshift distributions,
- galaxy number densities,
- ellipticity distributions
- ... vary across the sky.



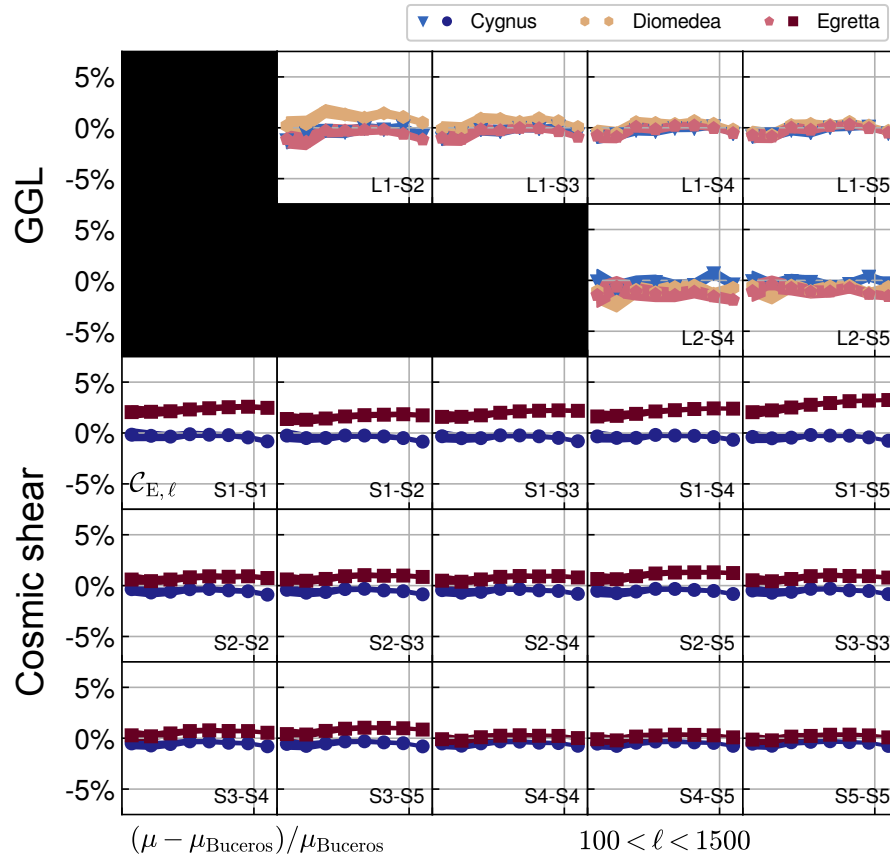
BOSS clustering is independent from KiDS.

Analytic and mock covariance agree very well.

Analytical covariance modelling

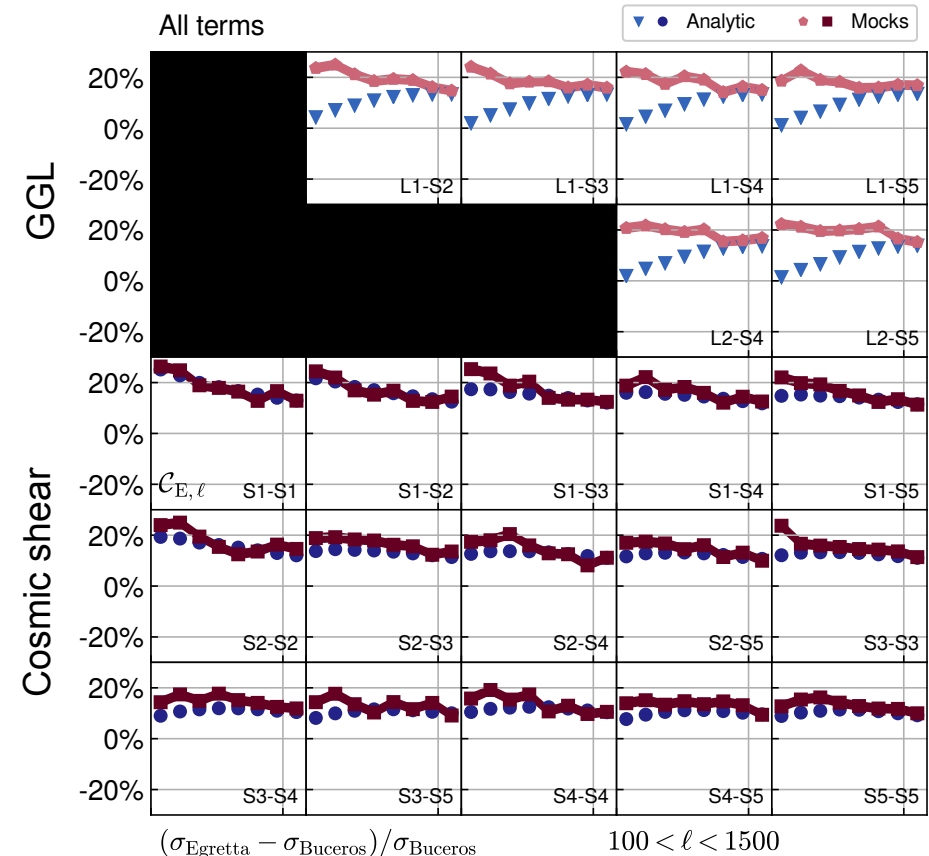


2pt statistics



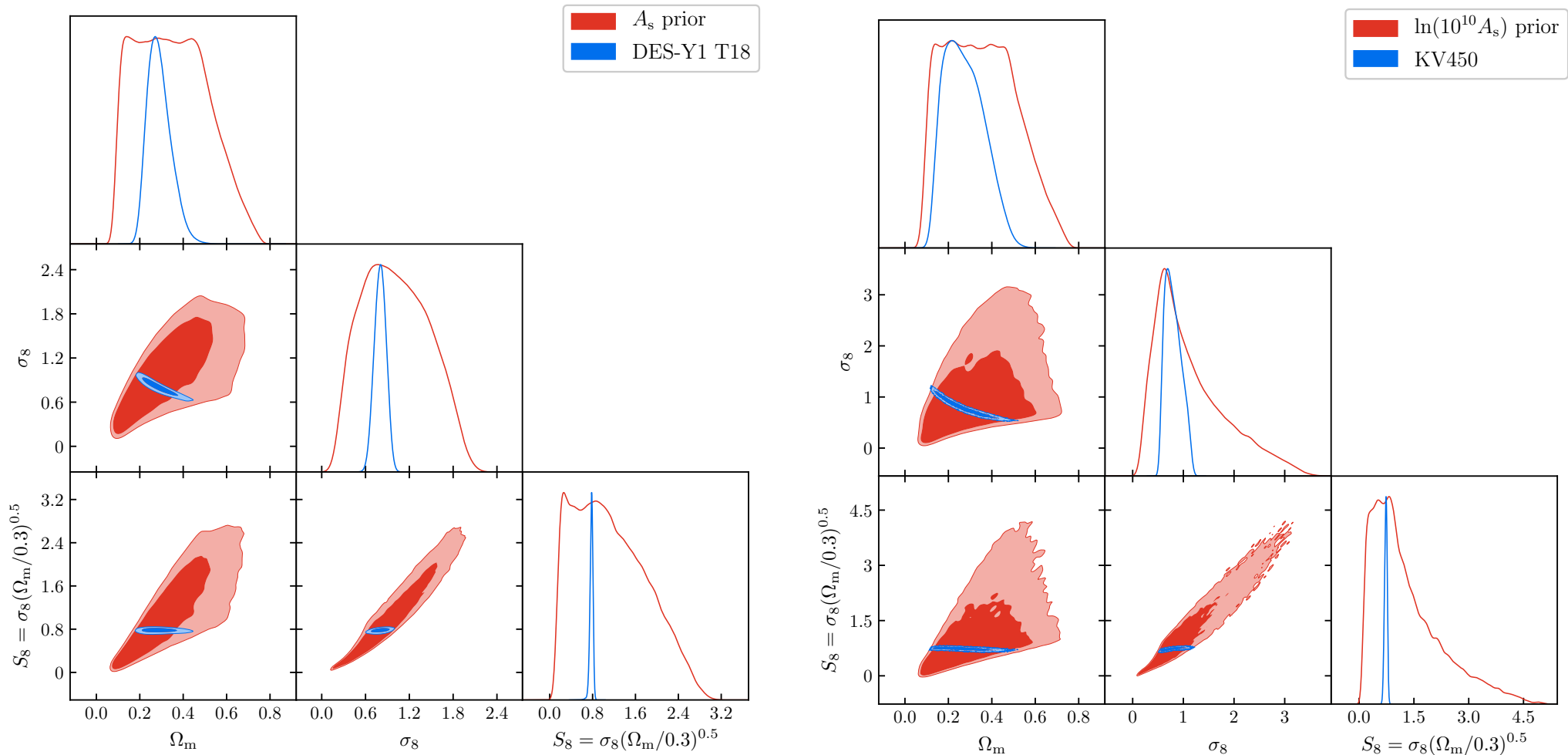
Few % effect (cf. Heydenreich+ 2020)

standard deviations



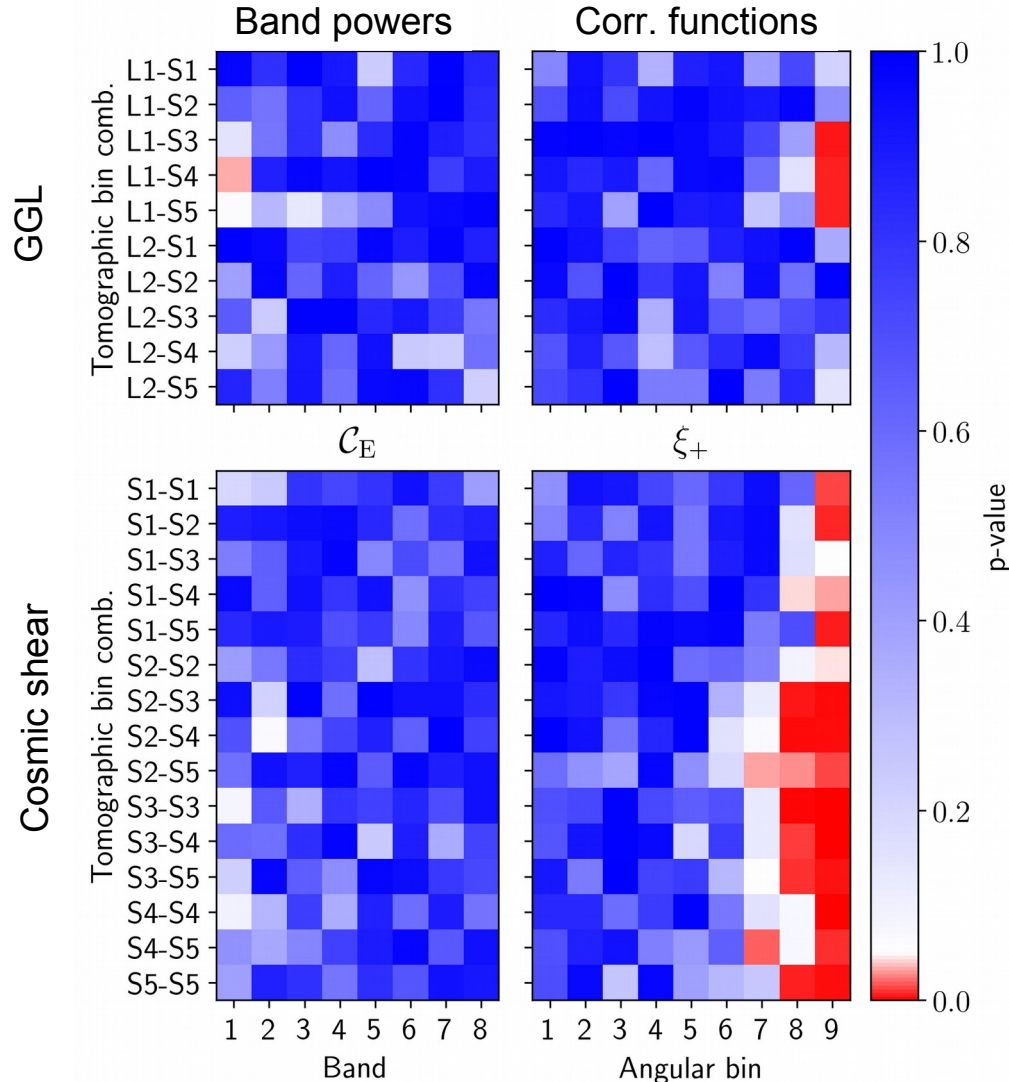
Up to 20% effect, but mostly captured by model

No such thing as uninformative priors



We impose a wide top-hat prior directly in S_8 .

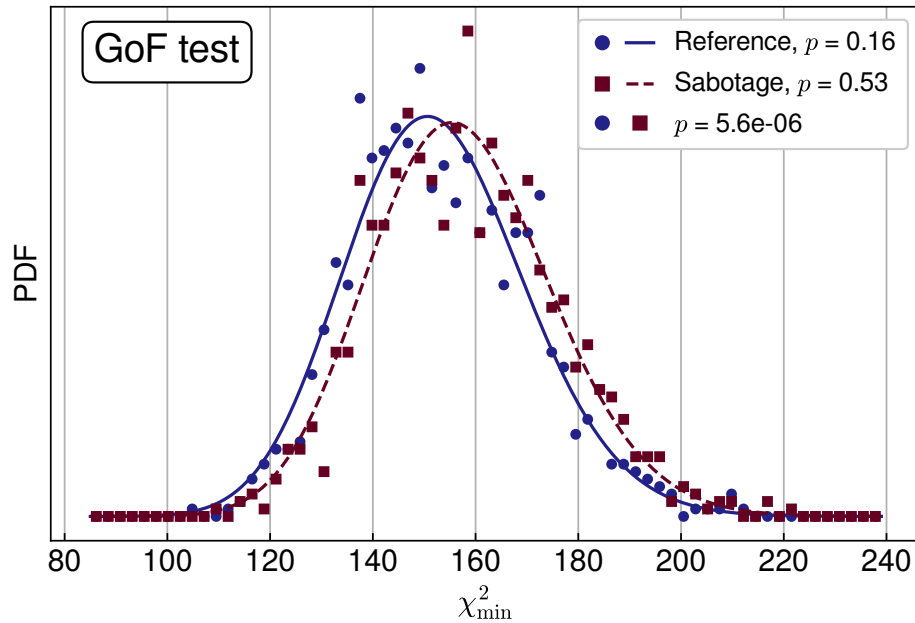
Can we use a Gaussian likelihood?



Correlation functions have sensitivity to small multipoles which are non-Gaussian.

Band powers have more compact kernel, thus avoiding non-Gaussian contributions.

How to assess the goodness of fit



Classic reduced χ^2 only applicable if:

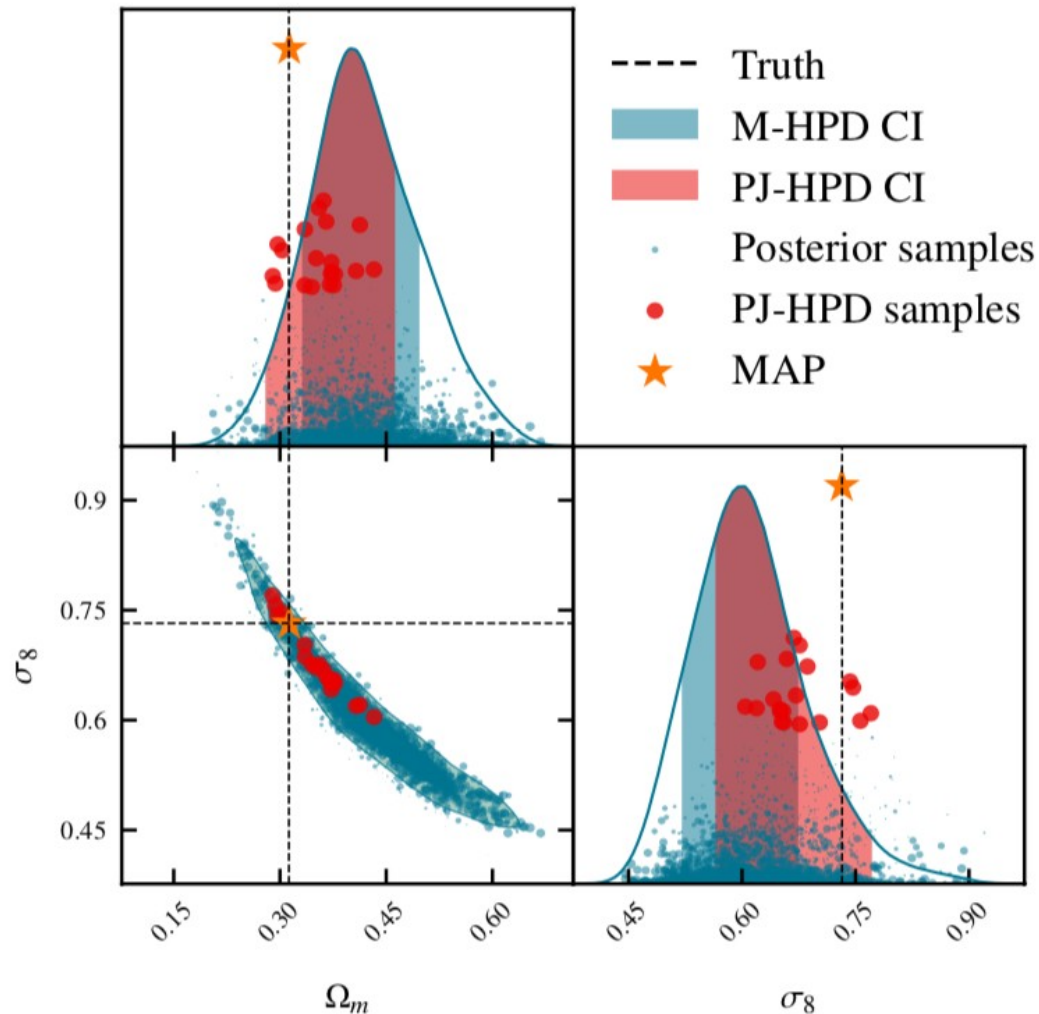
- Data are normally distributed
- Parameters are linear in the model
- Priors are uninformative

Our maximum log-likelihoods still follow a χ^2 distribution, but:

$$\langle \chi_{min}^2 \rangle = N_{data} - N_{par}$$

	Actual N_{par}	Effective N_{par}
Cosmic shear	12	4.5
All weak lensing	18	8.7

How to report parameter constraints?

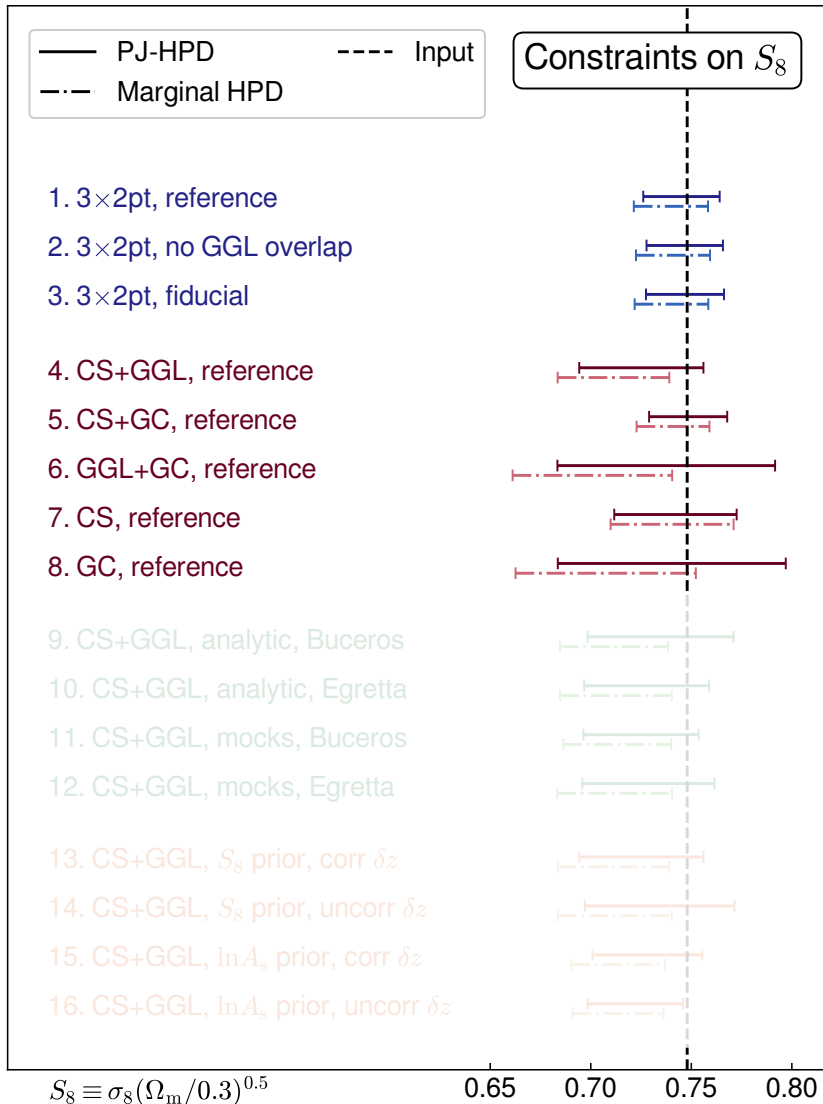


Standard is to report a best fit and credible interval derived from the marginal posterior (M-HPD).

We now also report the global maximum posterior (MAP) and a new credible interval (PJ-HPD):

- guaranteed to contain MAP
- reduces to standard for Gaussians and 1D distributions

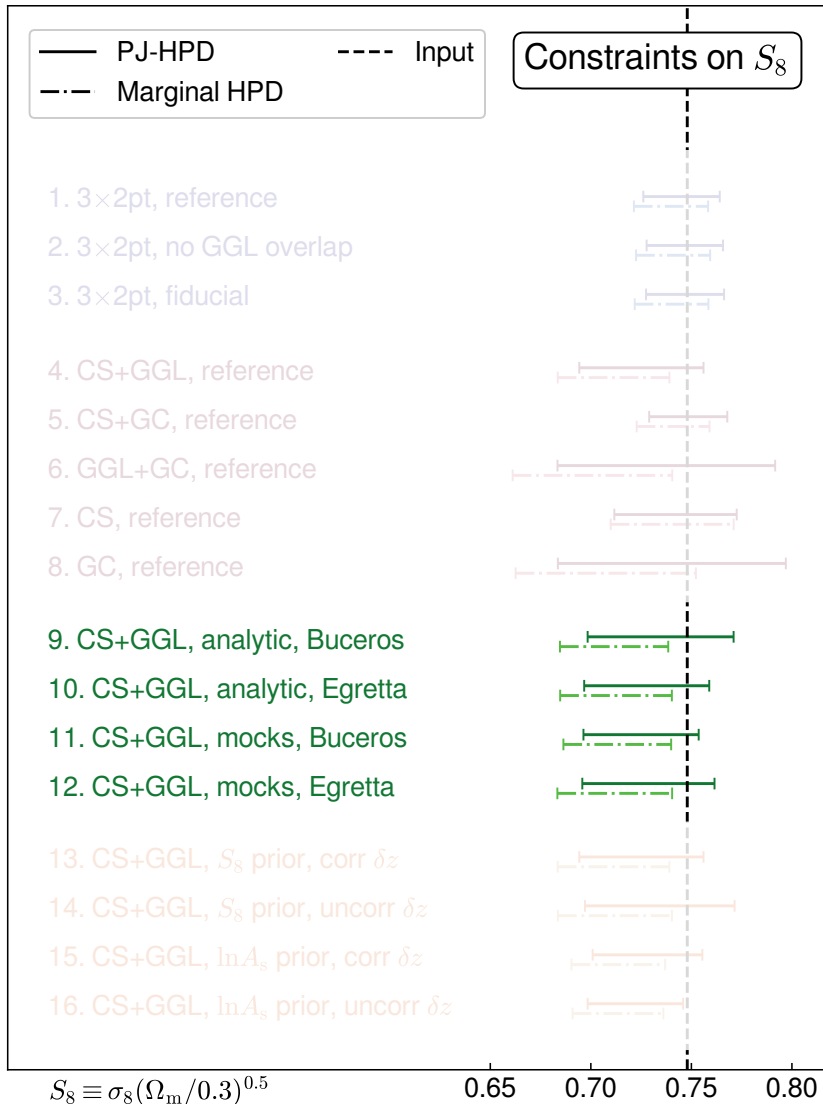
Validating analysis choices



Standard marginal credible intervals tend to report low values of S_8 .

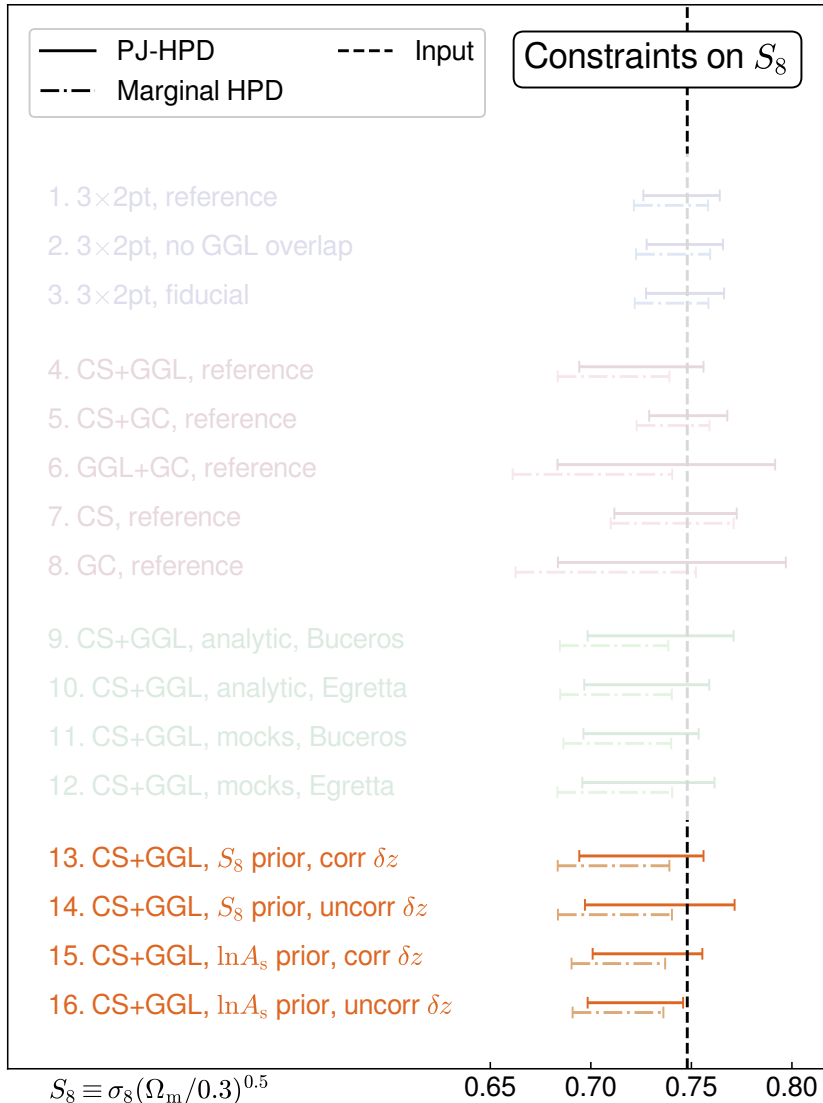
Galaxy-galaxy lensing adds little constraining power because of the large BOSS area.

Validating analysis choices



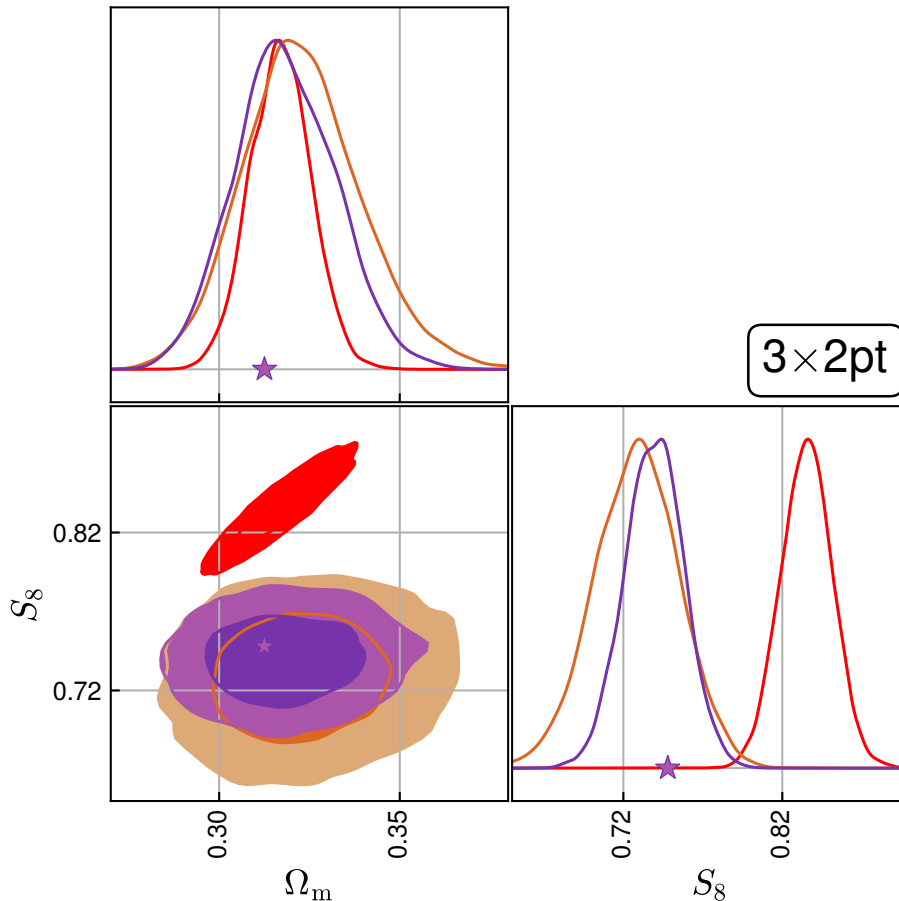
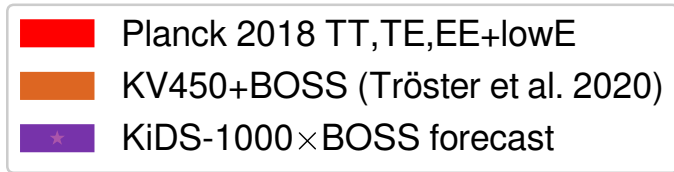
Our results are not sensitive to using a mock or analytic covariance, or to taking complex survey effects into account.

Validating analysis choices



Our S_8 prior is slightly more conservative than previous prior choices.

The analysis is robust to changes in the prior on the source redshift distributions.



The S_8 constraining power of our 3x2pt analysis matches that of Planck (2018).

Known systematic limitations are controlled to 0.1σ in S_8 .

What's next?

- further improve calibration of *redshift distributions* and push deeper
- better understand *intrinsic alignments* in relevant galaxy populations
- develop a comprehensive halo model of *non-linear cosmology and astrophysics*
- improve modelling of *spatial survey variations*
- *translate methodological insights* to the DESI/ Euclid/ LSST era

KiDS-1000 papers

- 3x2pt analysis – Heymans, Troester+; <https://arxiv.org/abs/2007.15632>
- 3x2pt methodology – Joachimi, Lin+; <https://arxiv.org/abs/2007.01844>
- cosmic shear analysis – Asgari, Lin, Joachimi+; <https://arxiv.org/abs/2007.15633>
- shear catalogues – Giblin, Heymans+; <https://arxiv.org/abs/2007.01845>
- redshift distributions – Hildebrandt, van den Busch, Wright+; <https://arxiv.org/abs/2007.15635>

KiDS survey info

<http://kids.strw.leidenuniv.nl/>

All data products will be available on this website after acceptance of the papers.