Galaxy-Lensing Cross Correlations

Modeling and Measurements with SDSS

Sukhdeep Singh

BCCP

with

Rachel Mandelbaum, Uros Seljak and others

Galaxy-Lensing Cross correlations

- Robust to additive lensing systematics.
- Direct probe of galaxy-matter cross correlations
- Combined with clustering, provides matter-matter correlation function.
- A unique probe of galaxy-dark matter halo connection. (Next session)

Galaxy-galaxy lensing estimator

$$\Delta\Sigma(r_p) = \overline{\Sigma}(< r_p) - \Sigma(r_p)$$

Difficult to model

Contains information from small scales.

ADSD Estimator

Baldauf+ 2010

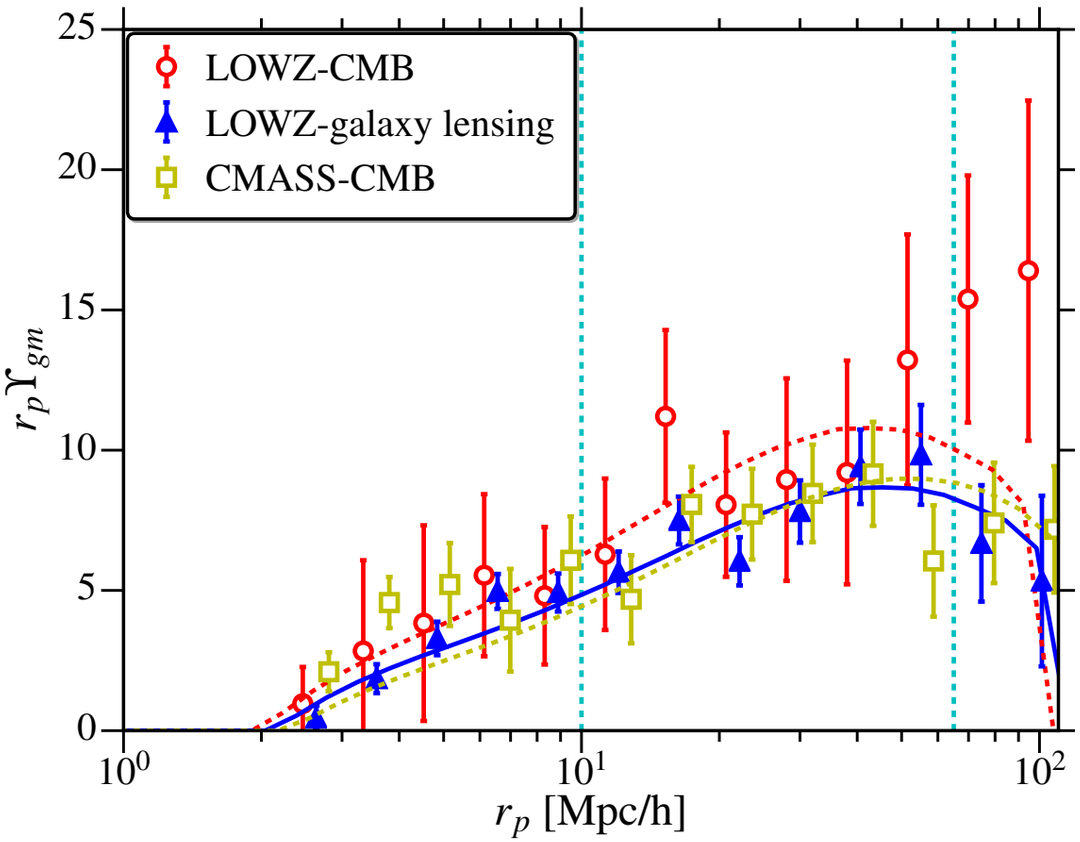
$$\Upsilon(r_p; r_0) = \Delta\Sigma(r_p) - \left(\frac{r_0}{r_p}\right)^2 \Delta\Sigma(r_0)$$

- Removes information from scales < $r_{0.}$
- Lowers impact of
  - non-linear bias and galaxy-matter correlation.
  - Baryon effects
  - RSD (projected clustering)
- **Cost:** Removing signal. Lowers S/N at small scales.

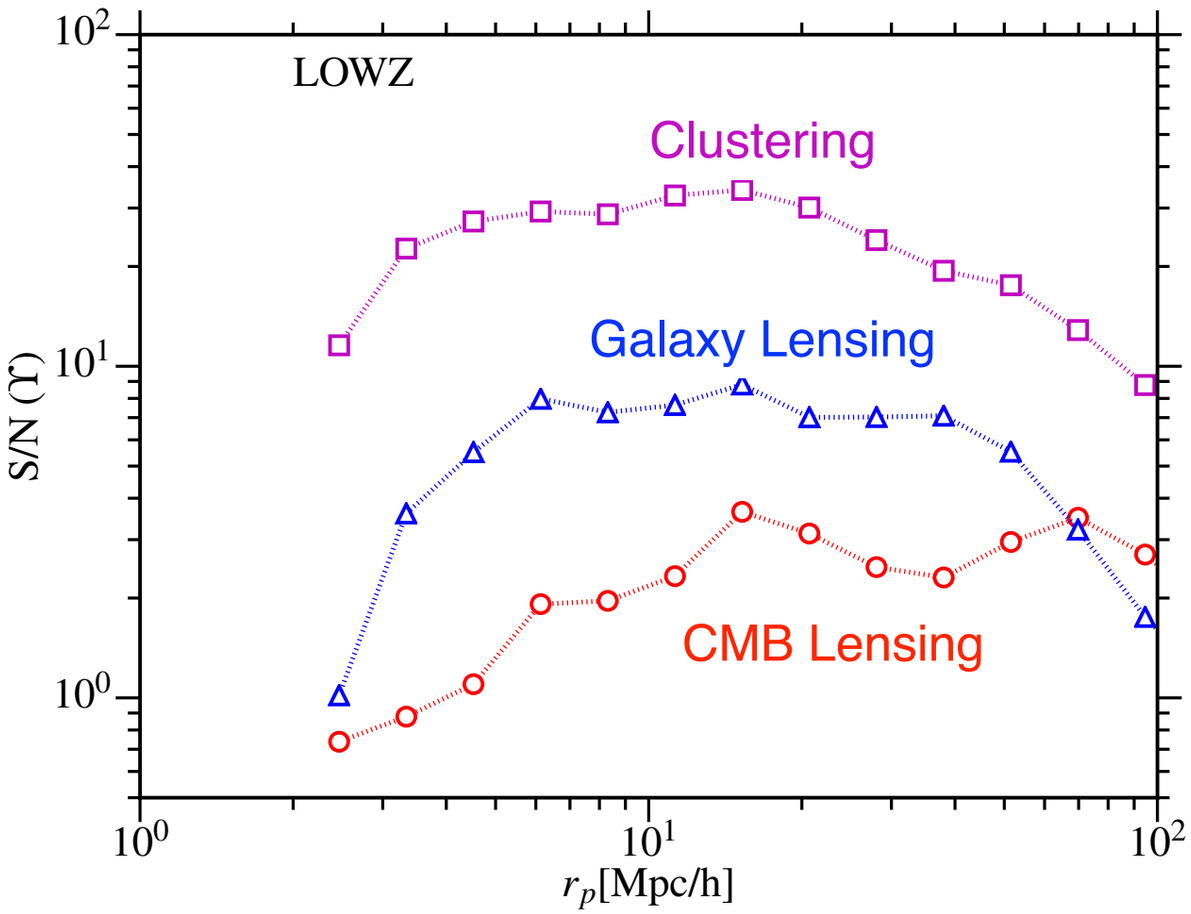
Measurements

Galaxy-Lensing Cross correlations

BOSS LOWZ X SDSS Lensing
BOSS CMASS X Planck Lensing



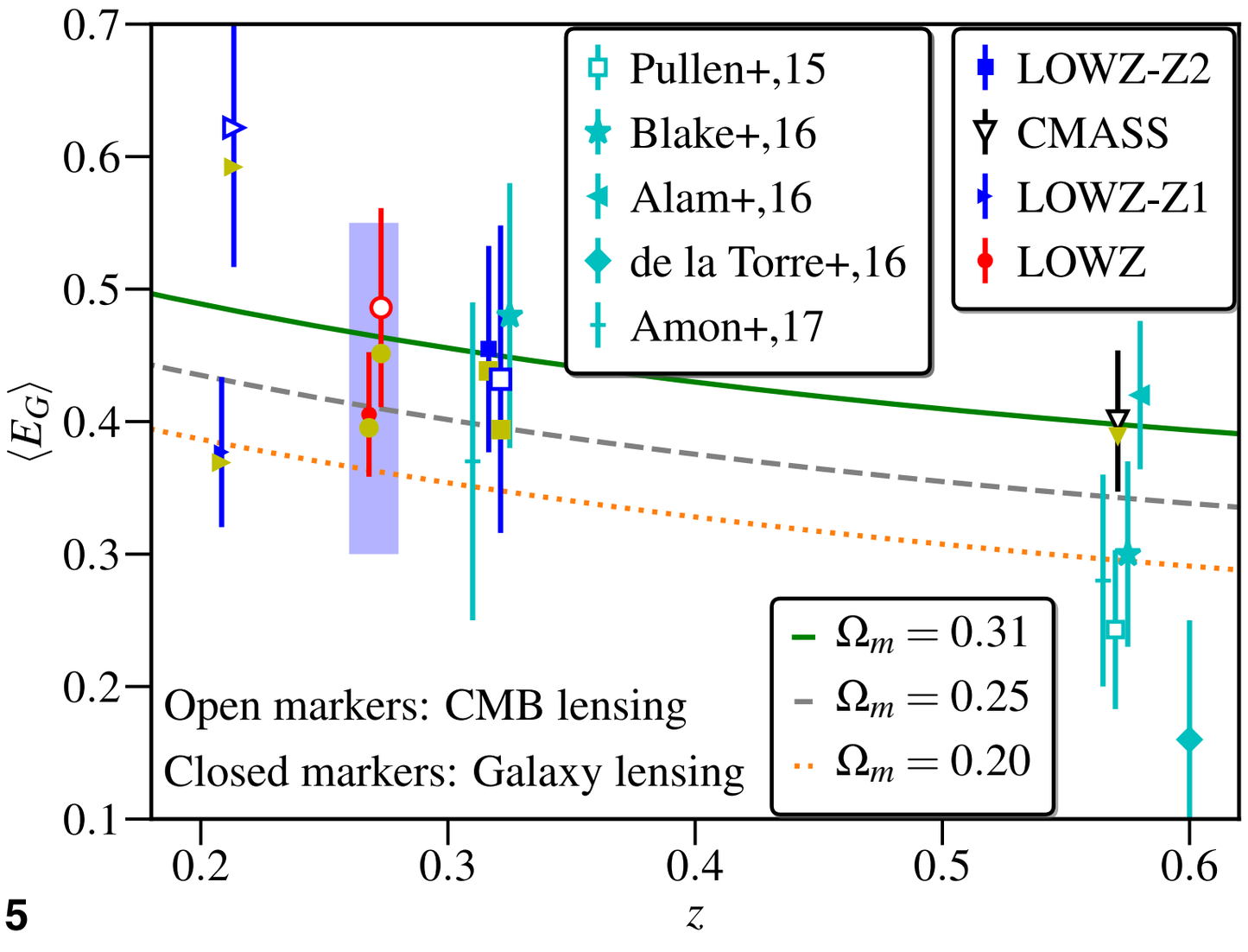
SS+ 2016
arXiv: 1606.08841



Measurements

Galaxy-Lensing Cross correlations

E_G Measurement



arXiv: 1803.08915

Cosmic Distance Ratio

$$\mathcal{R} = \frac{g\kappa_{\rm CMB}}{g\kappa_{gal}} = \frac{\Sigma_c(z_l, z_s)}{\Sigma_c(z_l, z_*)} \frac{\Sigma(z_l)}{\Sigma(z_l)}$$ Hu+ 2007b

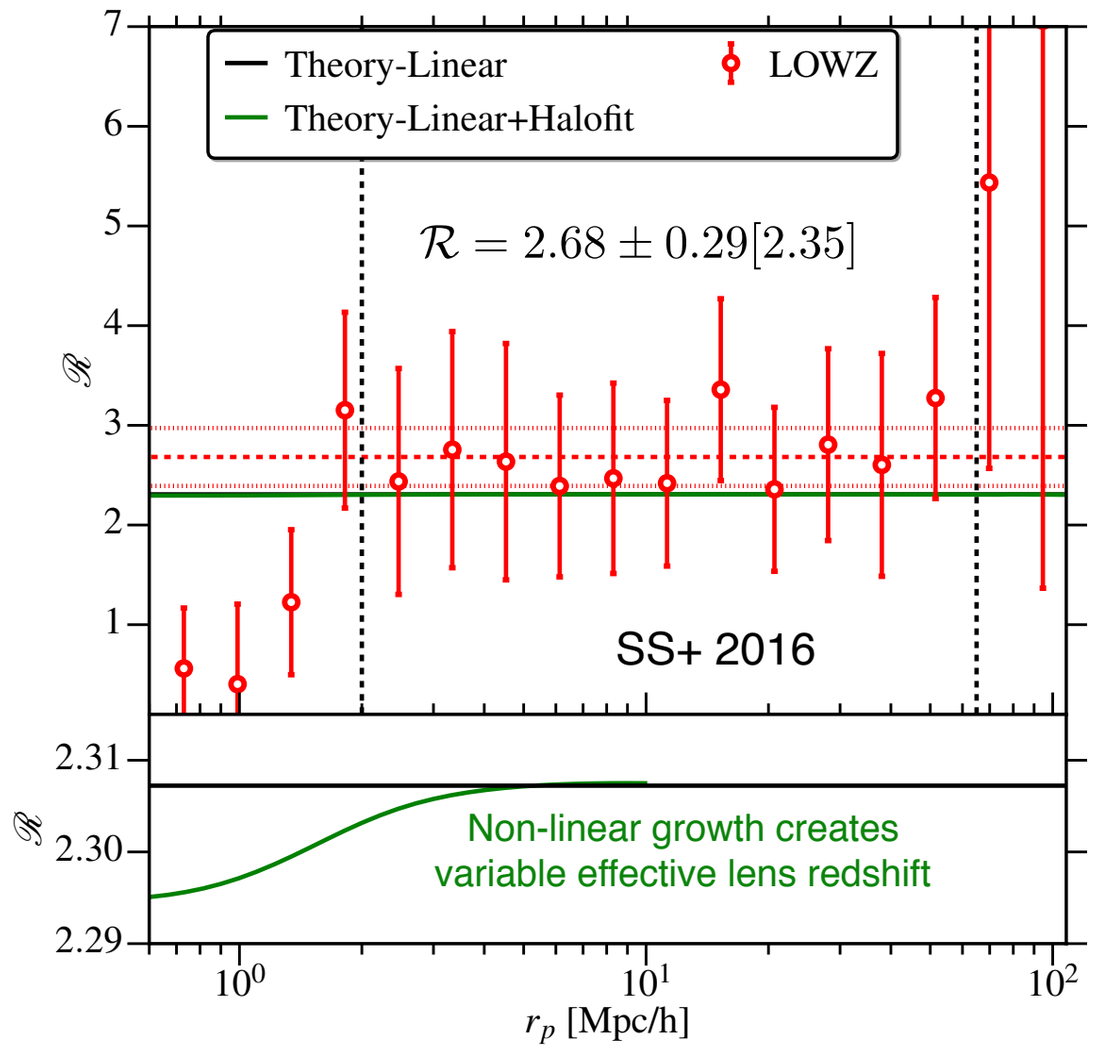
Geometric test, independent of power spectrum

Problems

- Not scale independent with non-linear growth.
  (work with narrow lens redshift bins)
- Weak dependence on cosmology

A good test for lensing systematics

$$\frac{\mathcal{R}_{\rm measured}}{\mathcal{R}_{\rm model}} \sim (1+m)_{\rm relative}$$

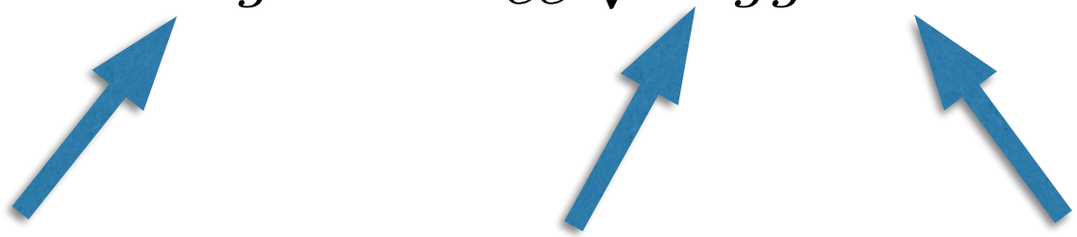


arXiv:1606.08841

Cosmological Parameter Estimation

Clustering+Lensing breaks bias-σ_8 degeneracy

$$\Upsilon_{gm} = r_{cc}^{\Upsilon}\sqrt{\Upsilon_{gg}\Upsilon_{mm}}$$



Galaxy-lensing measurement

Galaxy clustering measurement

Matter clustering model

Can also model $\Delta\Sigma_{gm}$

$$\Delta\Sigma_{gm}(r_p) = \Upsilon_{gm}(r_p) + \left(\frac{r_0}{r_p}\right)^2 \Delta\Sigma_{gm}(r_0)$$

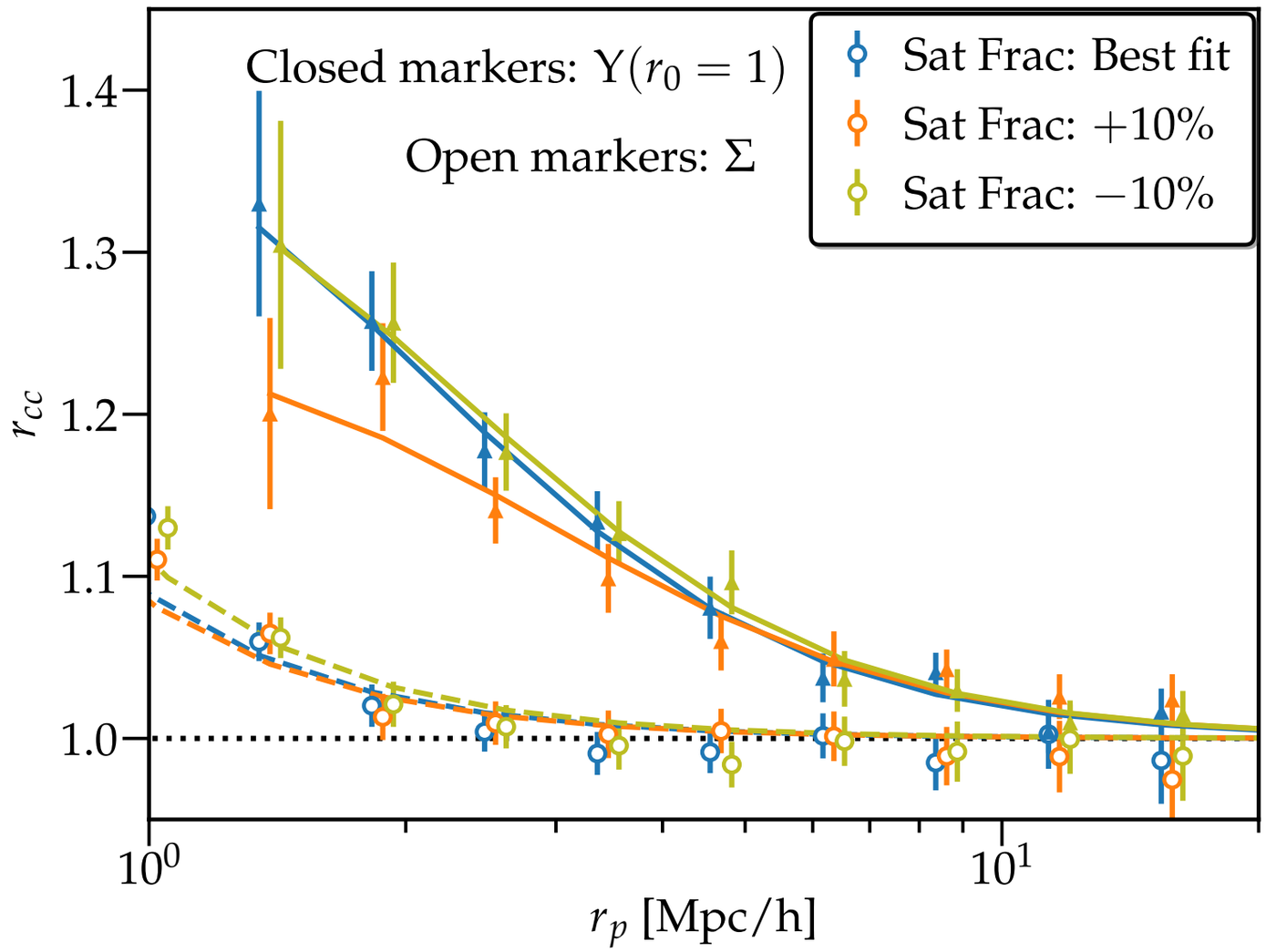
arXiv: 1811.06499

Cosmological Parameter Estimation

Clustering+Lensing breaks bias-σ_8 degeneracy

$$\Upsilon_{gm} = r_{cc}^{\Upsilon}\sqrt{\Upsilon_{gg}\Upsilon_{mm}}$$

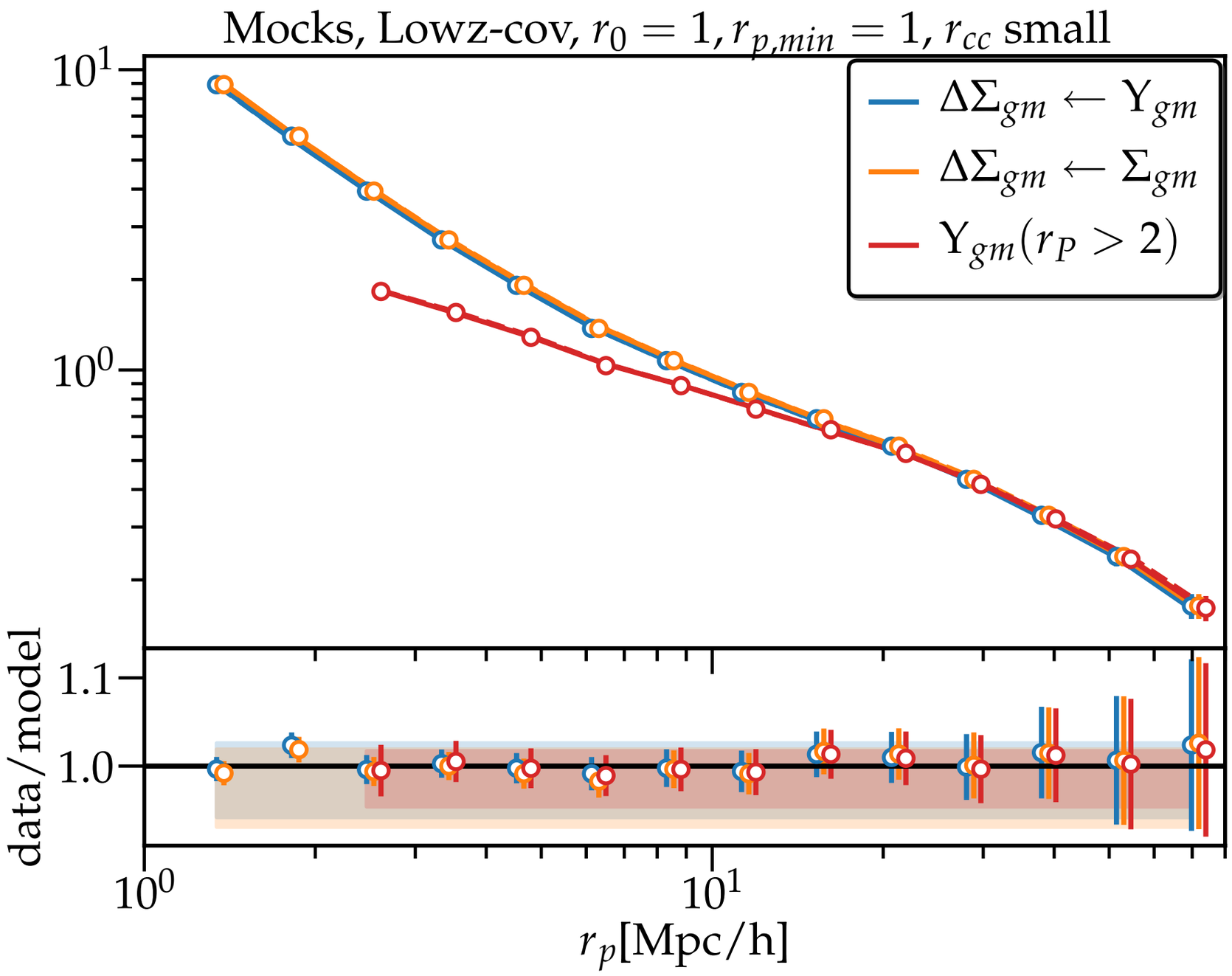
$$r_{cc} = 1 + \frac{a}{r_p^2 + b}$$



arXiv: 1811.06499

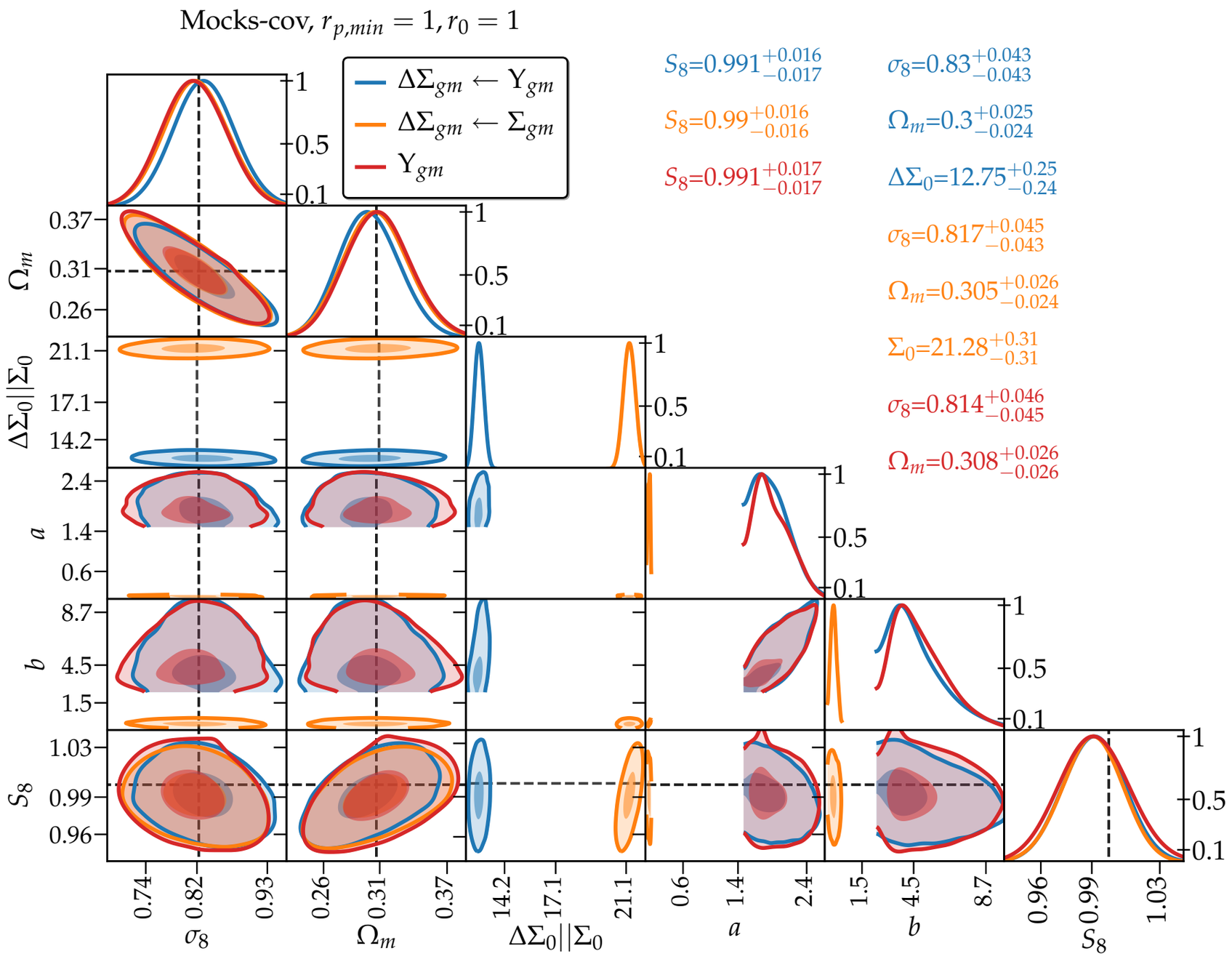
Cosmological Parameter Estimation

Mocks fit



Cosmological Parameter Estimation

Mocks fit



S_8=0.991$^{+0.016}_{-0.017}$

S_8=0.99$^{+0.016}_{-0.016}$

S_8=0.991$^{+0.017}_{-0.017}$

σ_8=0.83$^{+0.043}_{-0.043}$

Ω_m=0.3$^{+0.025}_{-0.024}$

$\Delta\Sigma_0$=12.75$^{+0.25}_{-0.24}$

σ_8=0.817$^{+0.045}_{-0.043}$

Ω_m=0.305$^{+0.026}_{-0.024}$

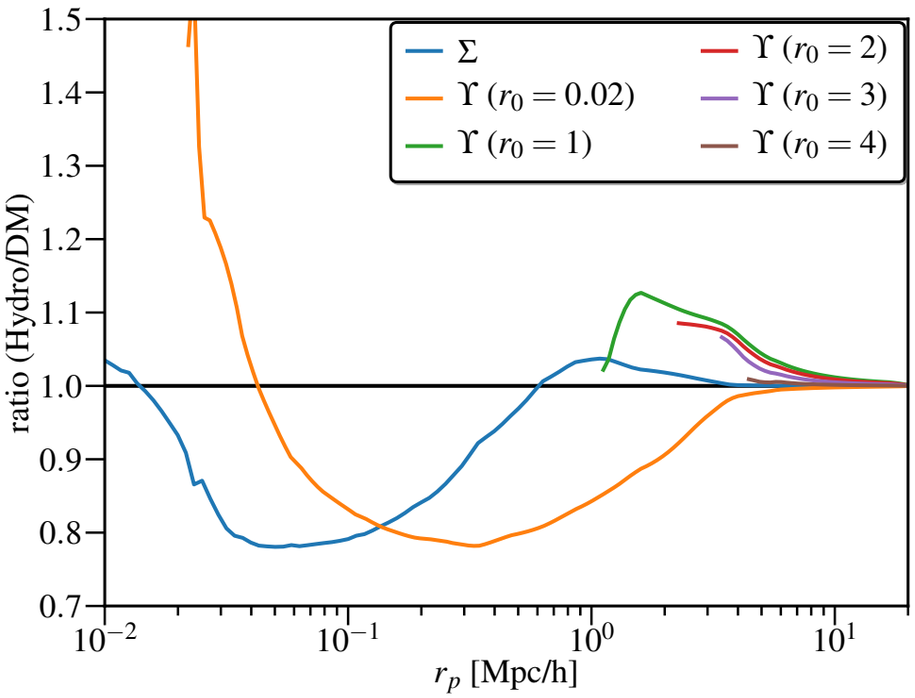
Σ_0=21.28$^{+0.31}_{-0.31}$

σ_8=0.814$^{+0.046}_{-0.045}$

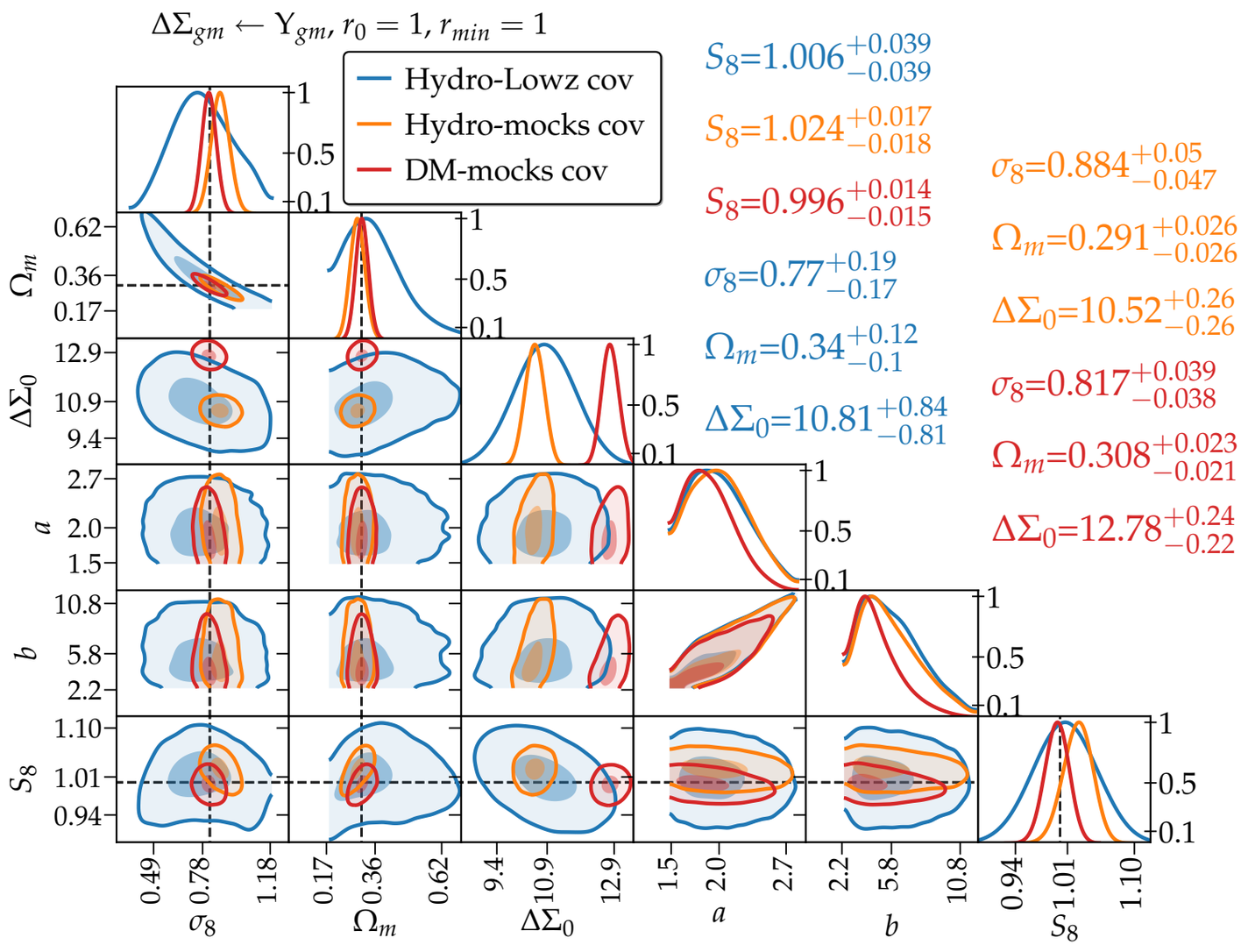
Ω_m=0.308$^{+0.026}_{-0.026}$

Cosmological Parameter Estimation

Effects of Baryons



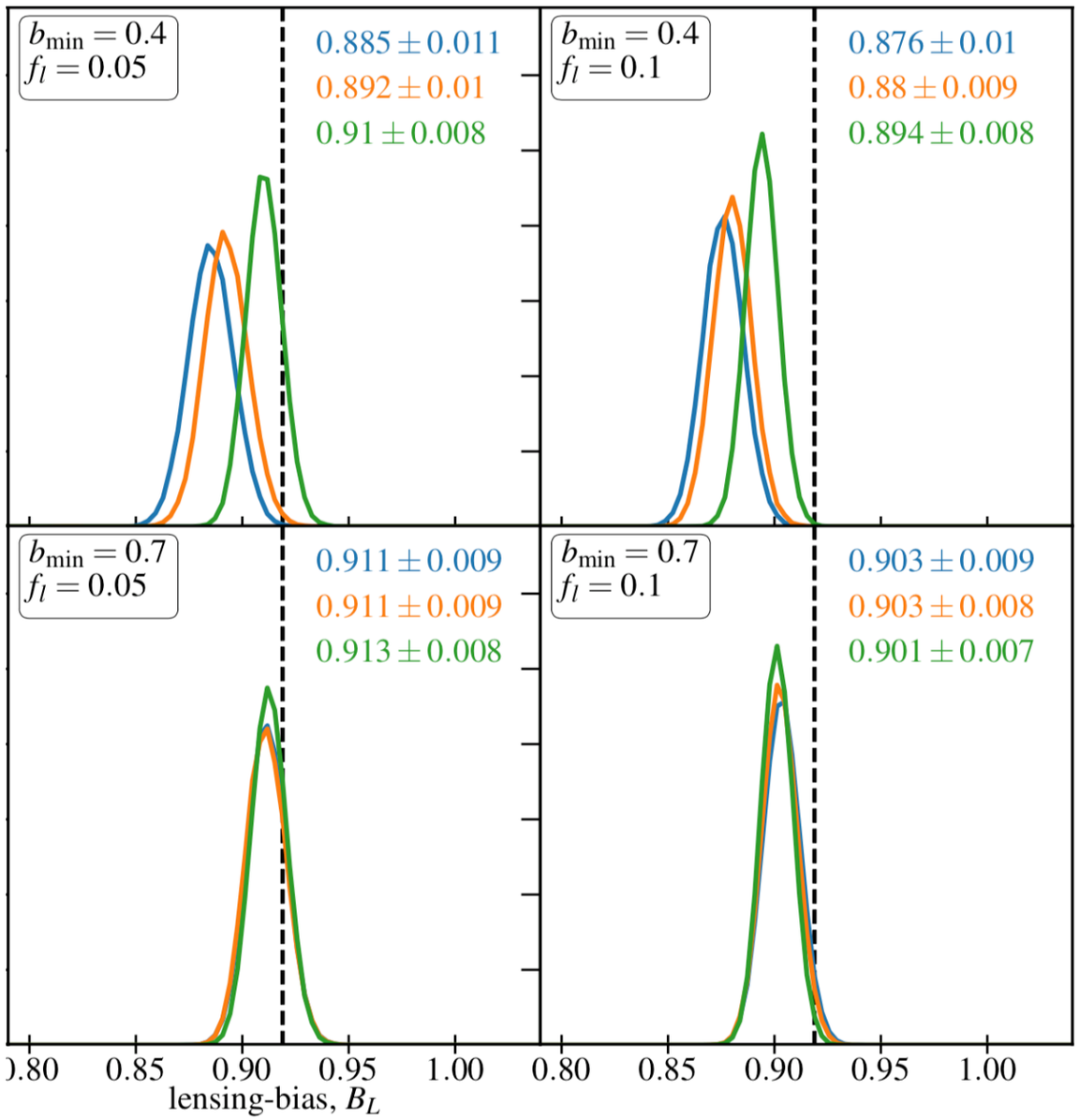
Modify $\Delta\Sigma$ based on Illustris simulation



Testing Photo-z calibration

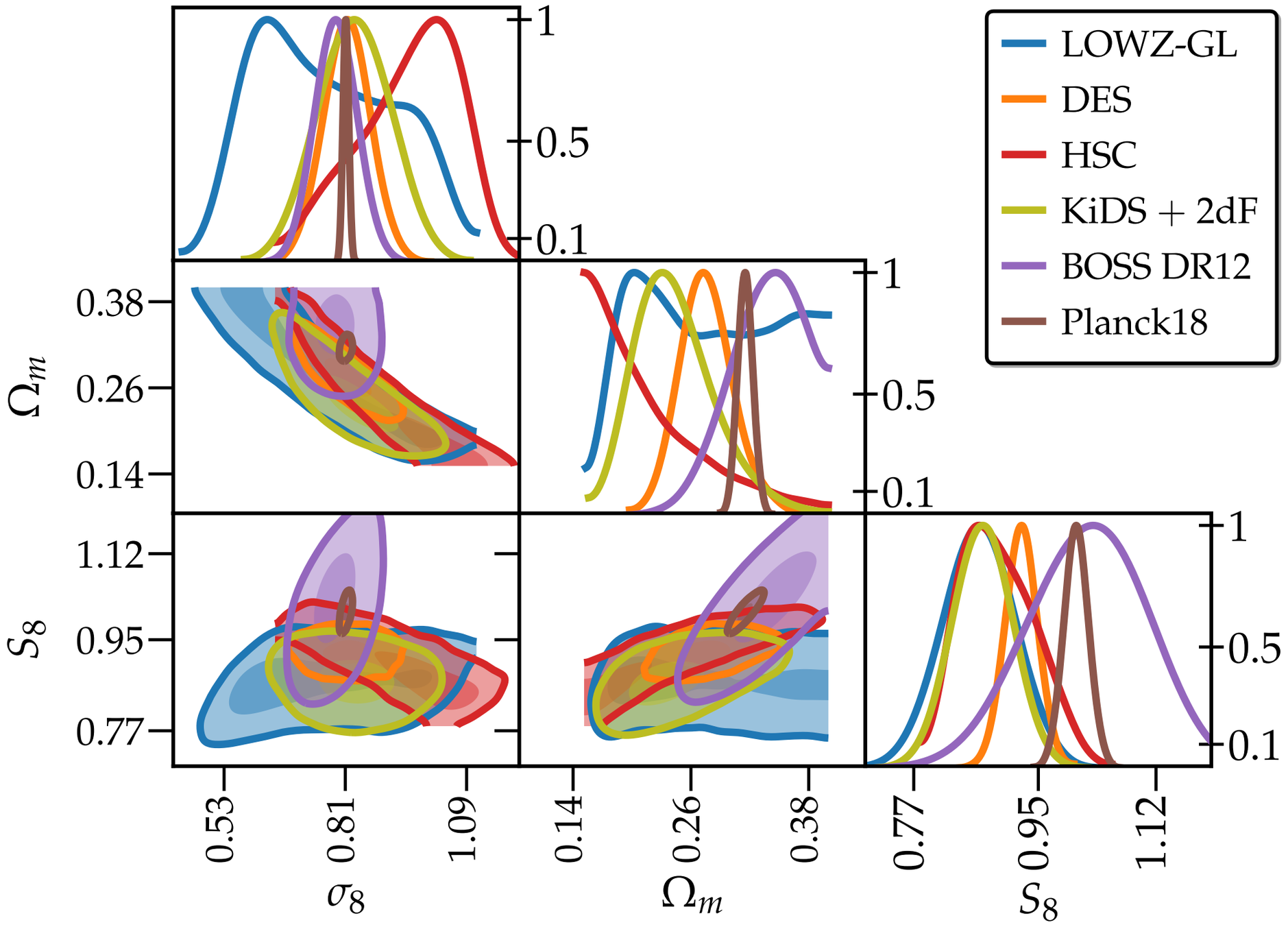
Clustering photo-z

Galaxy bias and lensing calibration



arXiv: 1803.08915

Cosmological Parameter Estimation



Summary

- Galaxy-Lensing cross correlations
  - Directly probe galaxy-matter correlations
  - Combined with clustering, breaks bias- σ_8 degeneracy
  - Combined with RSD, tests ΛCDM +GR

- Including CMB lensing constrains relative lensing calibration.
- BOSS X SDSS gives ~5-6% constraints on S_8
- Systematic uncertainties are approaching statistical errors.
- Extracting information from smaller scales. Halo model? Baryons?