COSMOLOGICAL CONSTRAINTS FROM GALAXY–GALAXY LENSING AND GALAXY–GALAXY CLUSTERING WITH THE HSC AND BOSS DATA

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ON BEHALF OF HSC SSP COLLABORATION

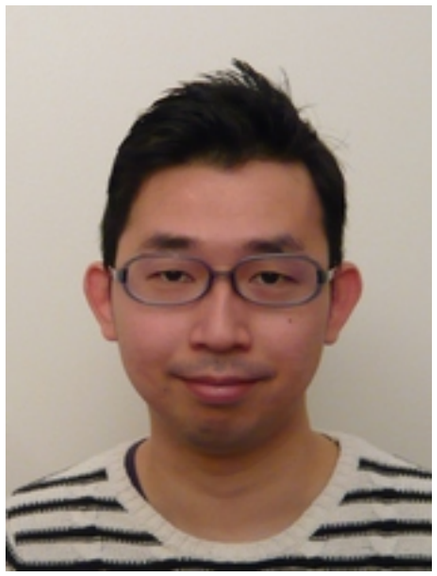
DISCLAIMER

NO "REAL" COSMOLOGICAL CONSTRAINTS IN THIS TALK

INSTEAD, I WILL PRESENT ROBUST MODEL BUILDING FOR G-G LENSING AND CLUSTERING ANALYSIS

OUR TEAM

Nishimichi+ (2018)

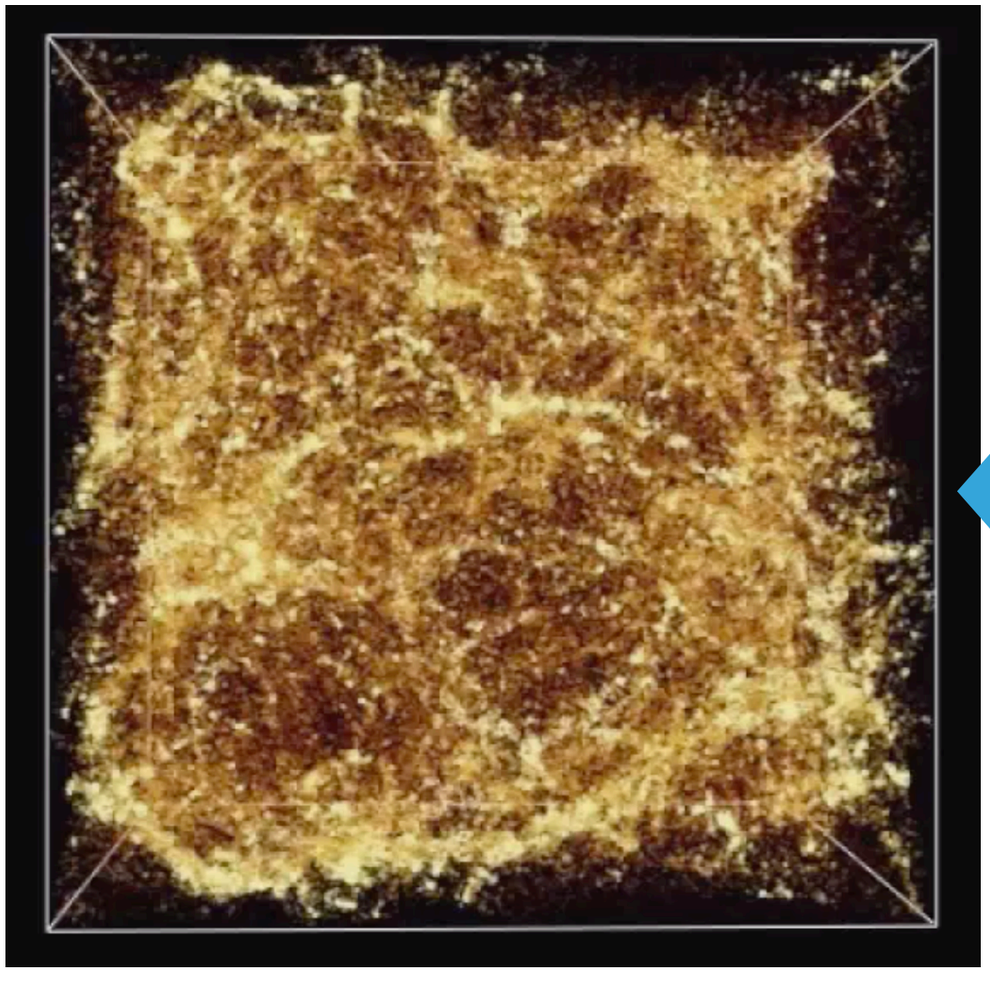


Takahashi+ (2017)

Shirasaki+ (2019)

SUMMARY STATISTICS: A TOOL TO EXTRACT COSMOLOGY

- We cannot make an apple-to-apple comparison between theory and data because of the difference in initial conditions.



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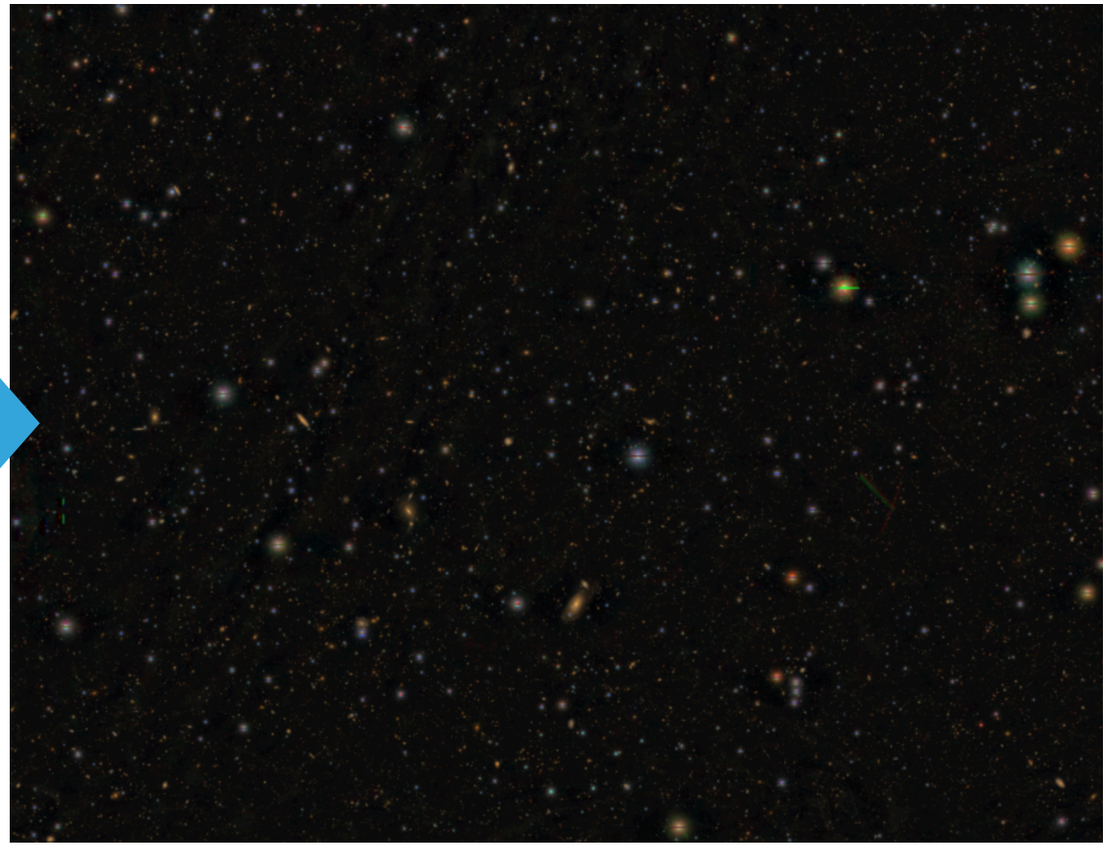
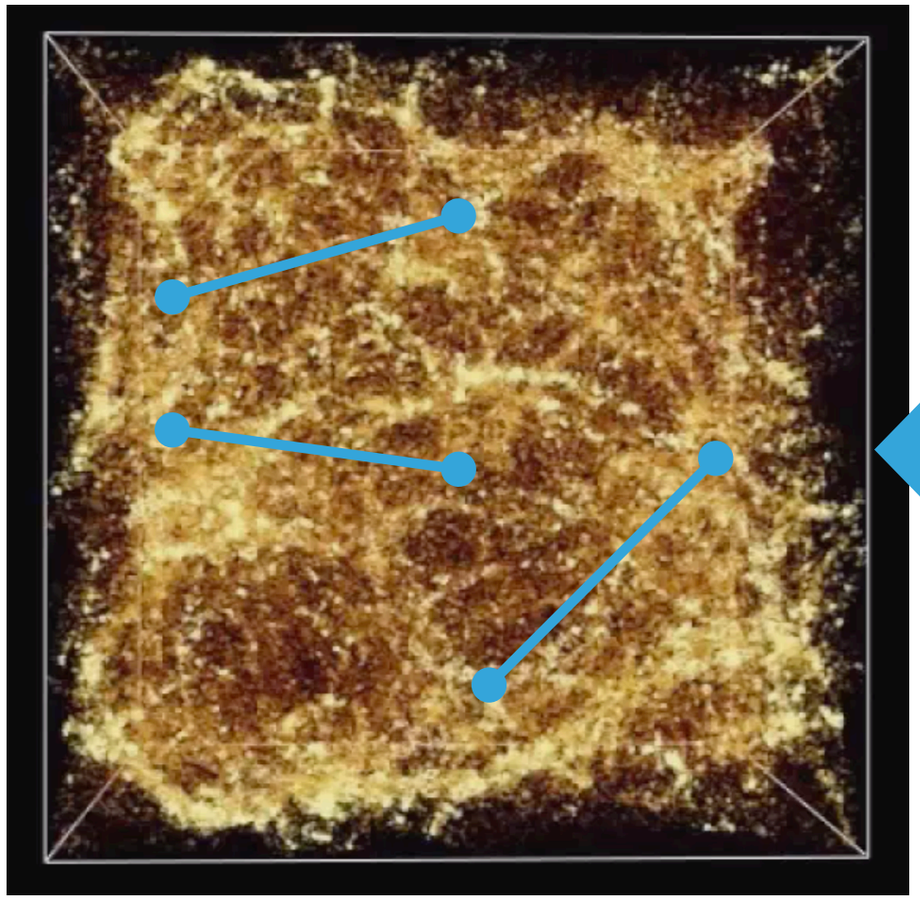
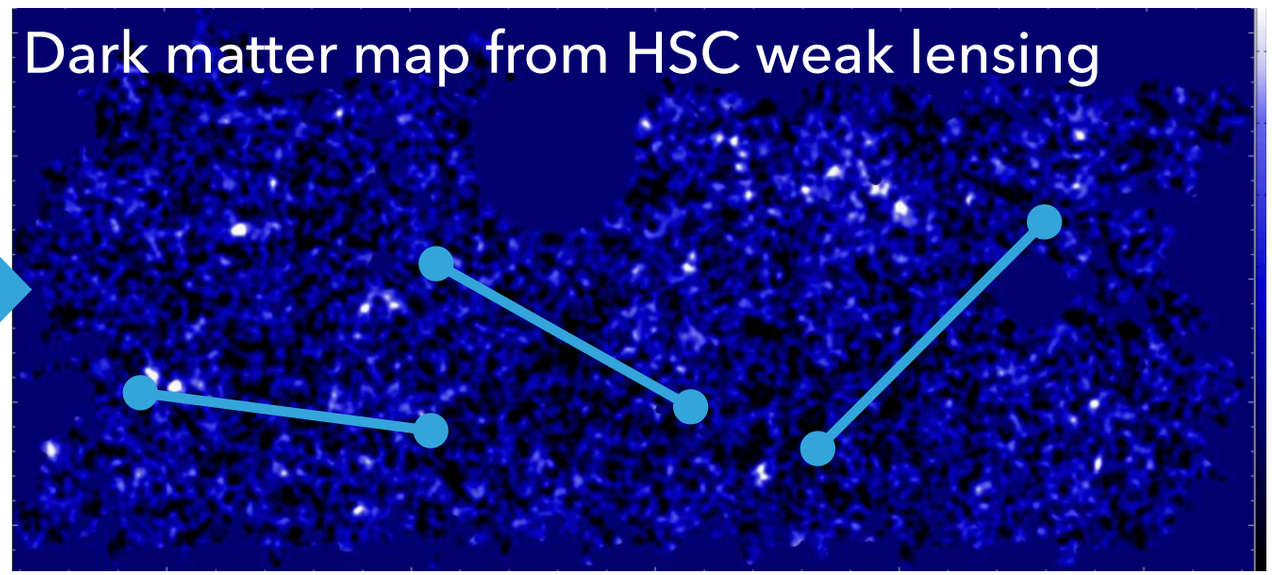


SUMMARY STATISTICS: A TOOL TO EXTRACT COSMOLOGY

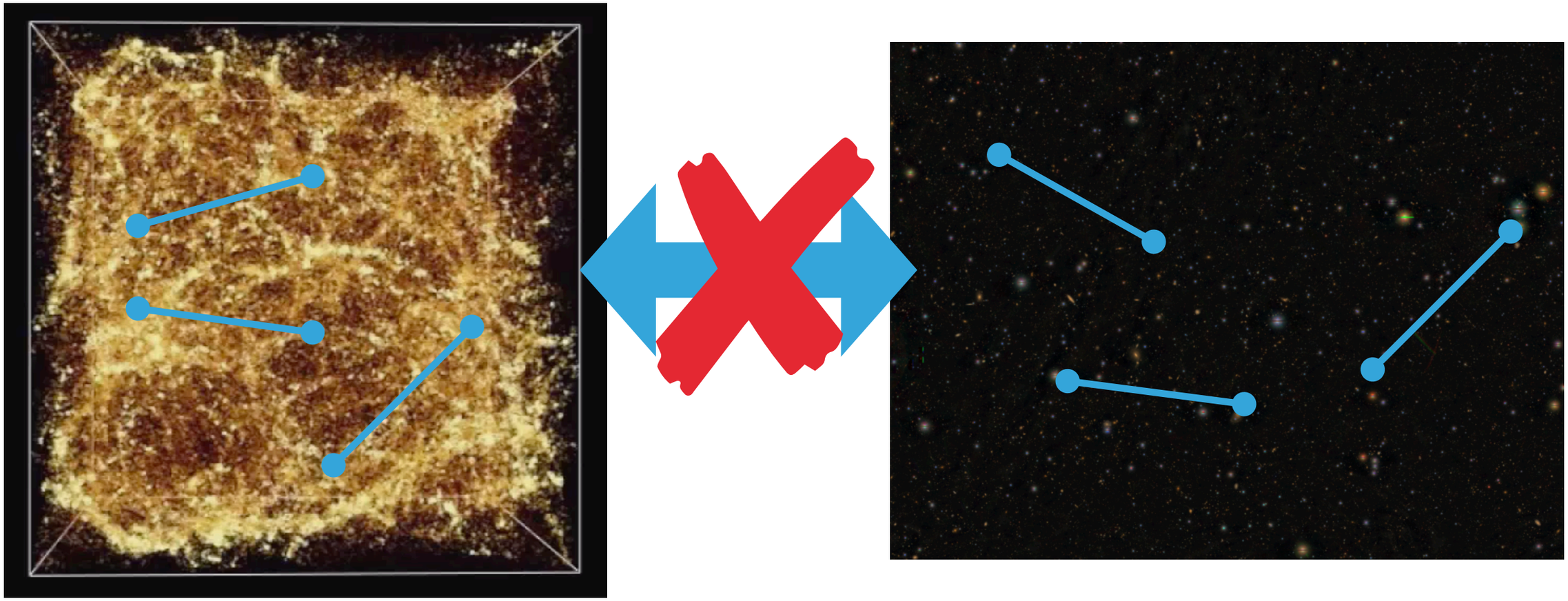
- We rely on **summary statistics**!
  - Cosmic shear: $\xi_{mm}(r) = \langle \delta_m(r' + r)\delta_m(r') \rangle_{r'}$
    - Compare dark matter distribution between data and theory.
    - **Weak lensing** enables direct measurement of dark matter distribution.





SUMMARY STATISTICS: A TOOL TO EXTRACT COSMOLOGY

- Galaxy-galaxy clustering: $\xi_{gg}(r) = \langle \delta_g(r' + r)\delta_g(r') \rangle_{r'}$
  - Cannot be directly compared to theory because galaxies are **biased tracers** of underlying dark matter.



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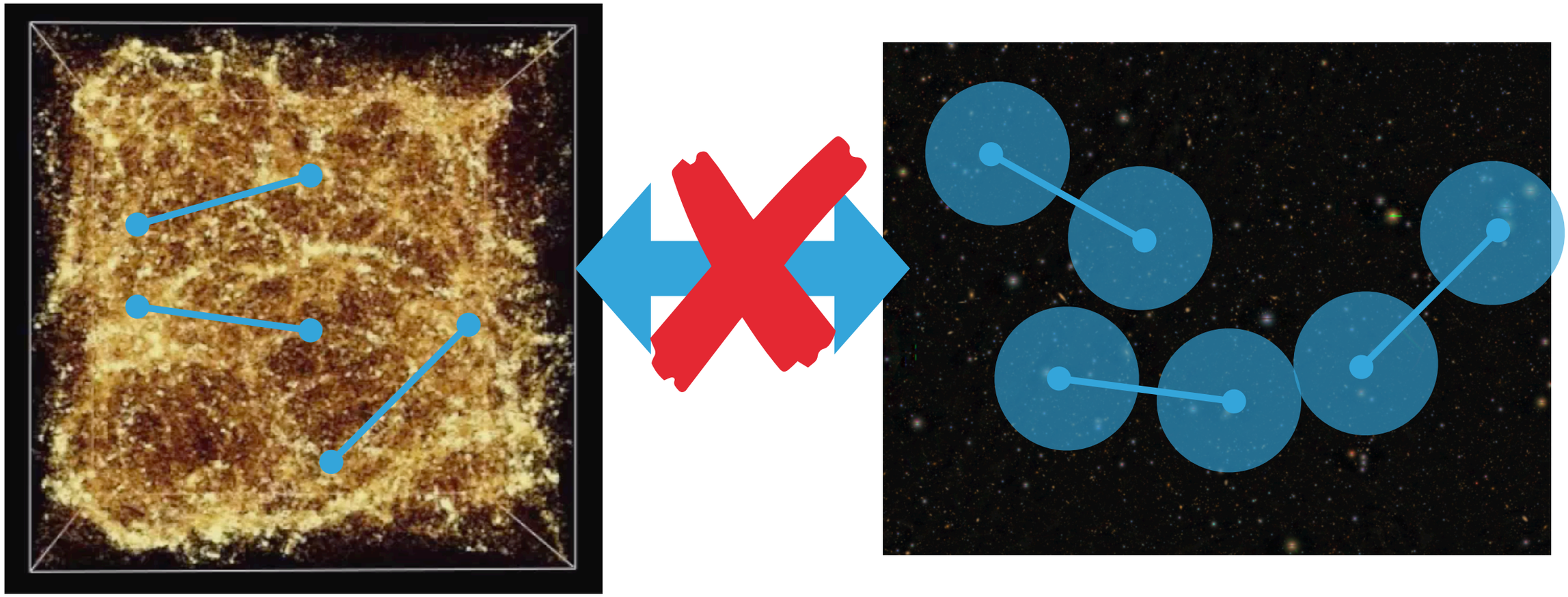
  - Can be used for **calibrating the bias**.



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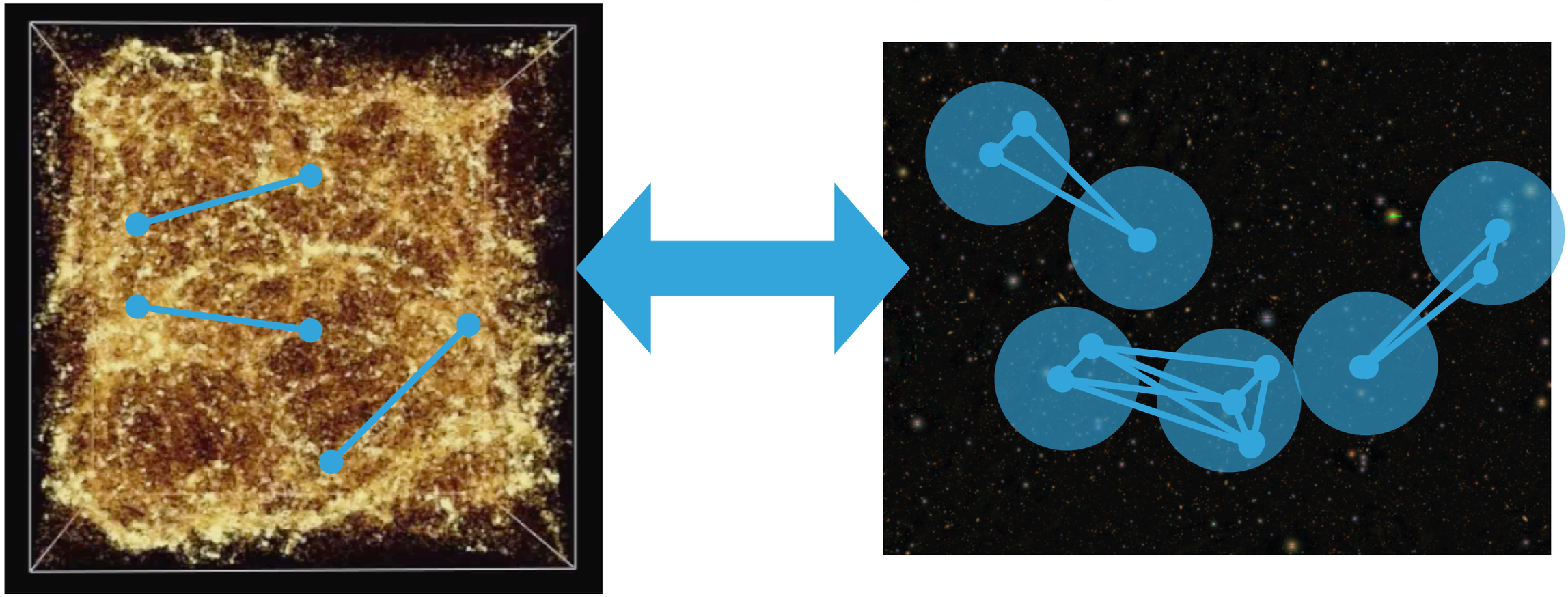
  - Can be used for **calibrating the bias**.
- We also need to take into account **how galaxies populate halos**.

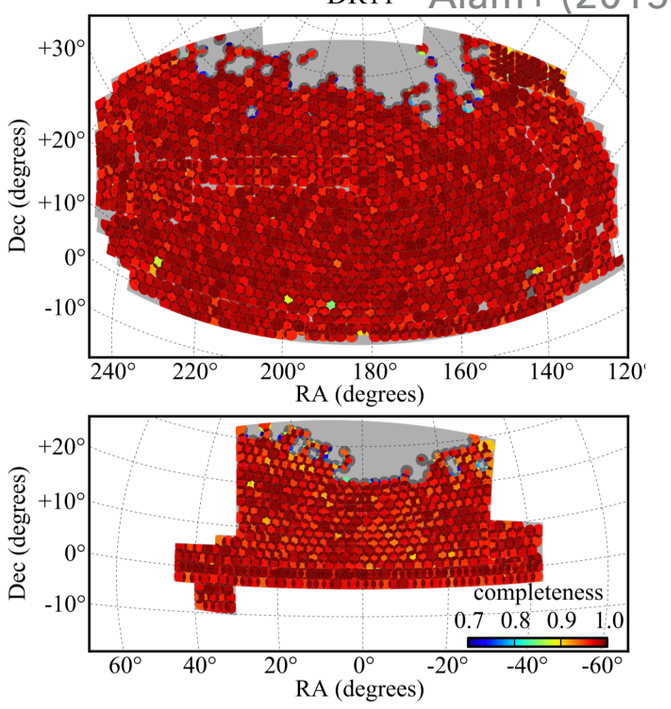


	Pros	Cons
Cosmic Shear	Clean theory	Prone to shear systematics and photo-z bias
G-G Lensing x Clustering	Less prone to shear systematics and **photo-z bias***	**Messy theory**

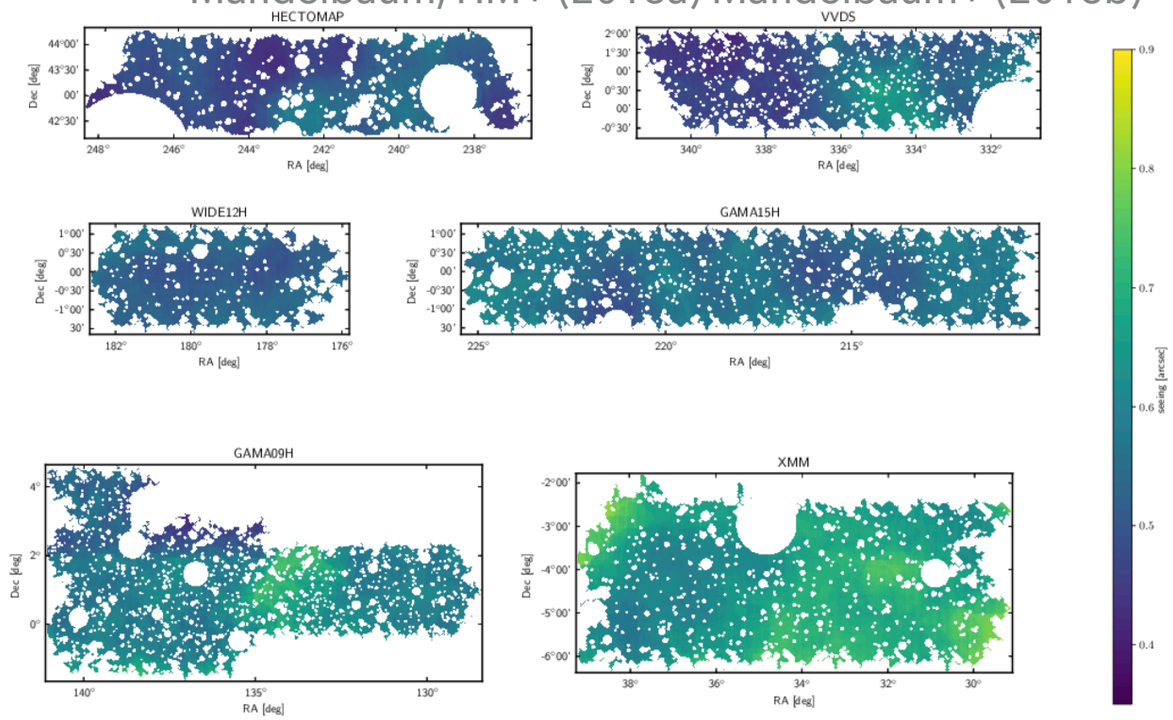
***Depending on analysis configuration**

DATA SET: BOSS FOR LENS GALAXIES, HSC FOR SOURCE GALAXIES

DR11 Alam+ (2015)



Mandelbaum, HM+ (2018a) Mandelbaum+ (2018b)



SDSS-III/BOSS DR11spec-z sample

- ~8300 deg^2
- 3 redshift bins: z = [0.15, 0.35], [0.47, 0.55], [0.55, 0.70]

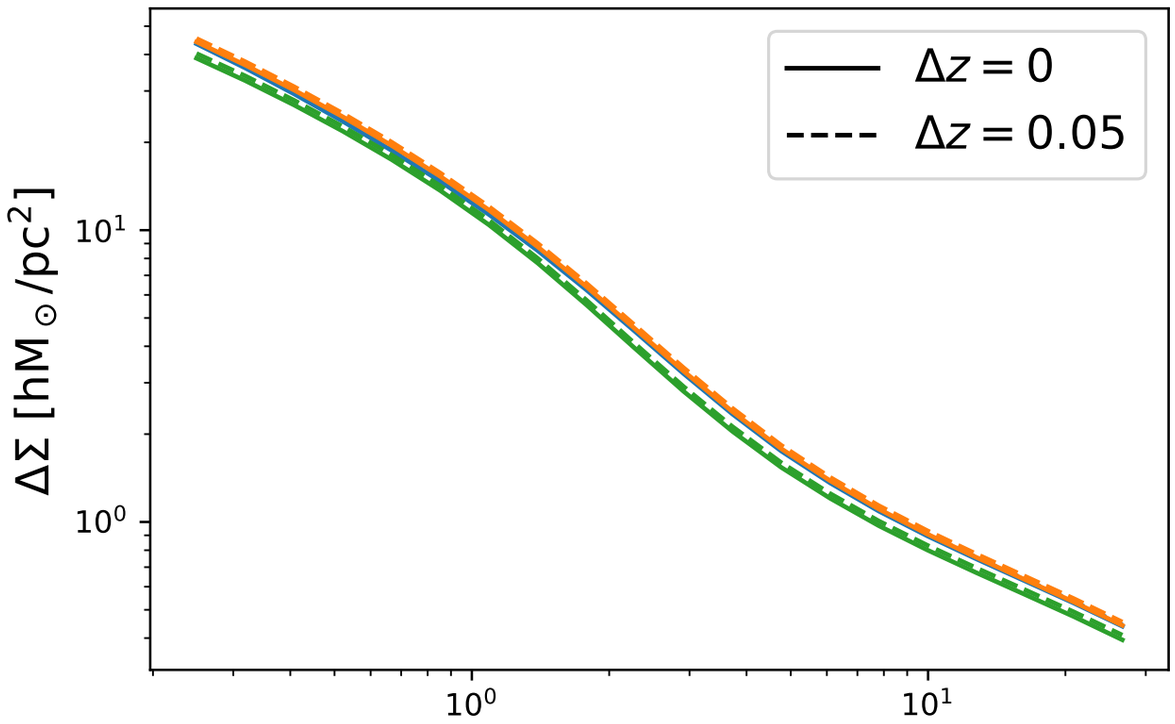
Clustering **Lensing**

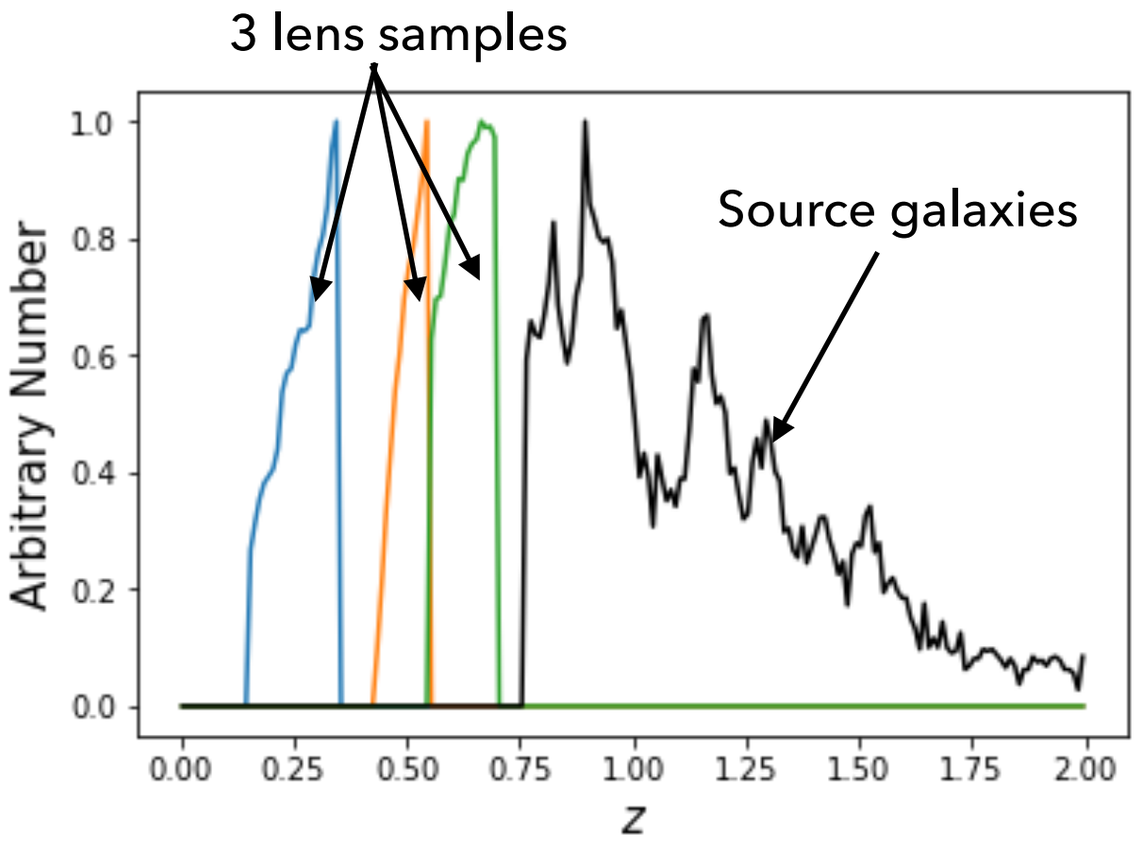
HSC first-year shape catalog

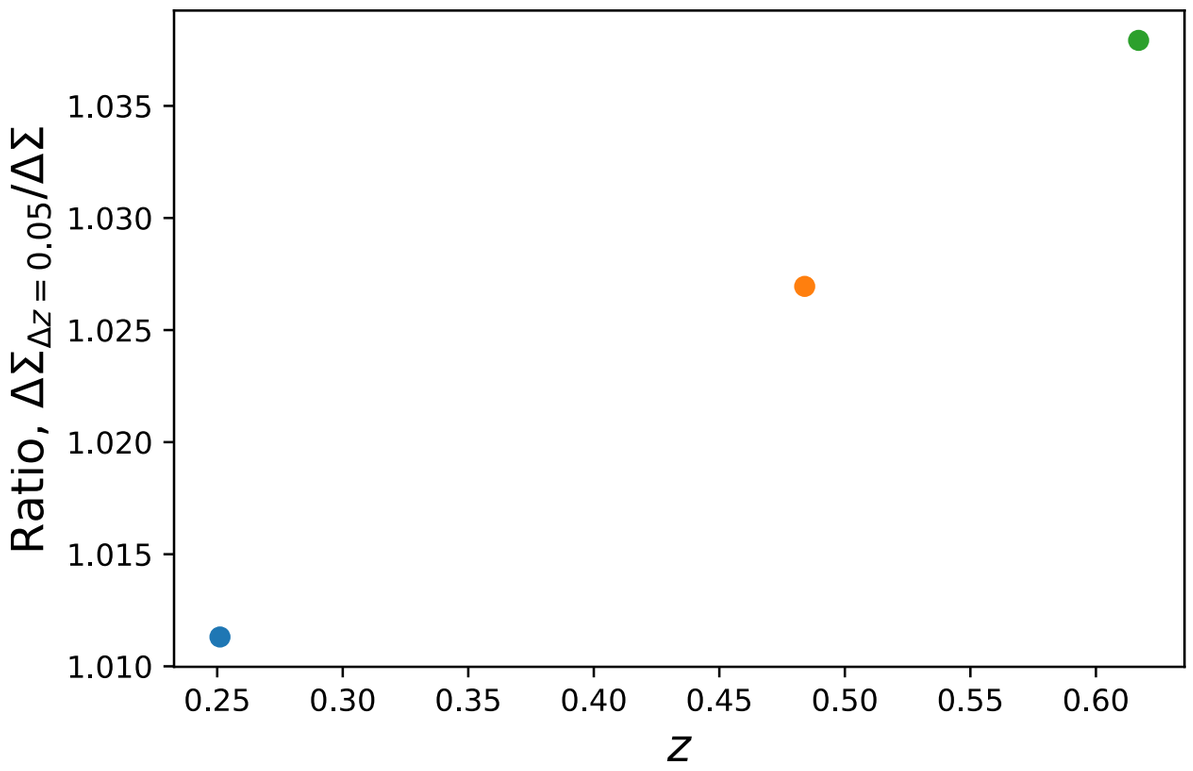
- 6 fields, in total 137 deg^2 (out of planned 1400deg^2)
- <z>~1.0, seeing=0.58", n_g~23gal/amin^2
- Use a single source population (z > 0.75) to self-calibrate photo-z bias (Oguri & Takada 2012).
- Multiplicative bias is blinded to avoid confirmation bias

PHOTO-Z SELF CALIBRATION

- The effect of photo-z systematics changes the amplitude of lensing signal at different redshirts by a different amount.
- If we use a single source population, we can break a degeneracy between σ_8 and photo-z bias, since σ_8 is constant across the redshift.







DIFFICULTIES IN MODELING LENSING AND CLUSTERING SIGNALS

- Cosmological systematics
  - Halo bias
  - Non-linear regime at R<~10 Mpc/h

→ **Emulator**

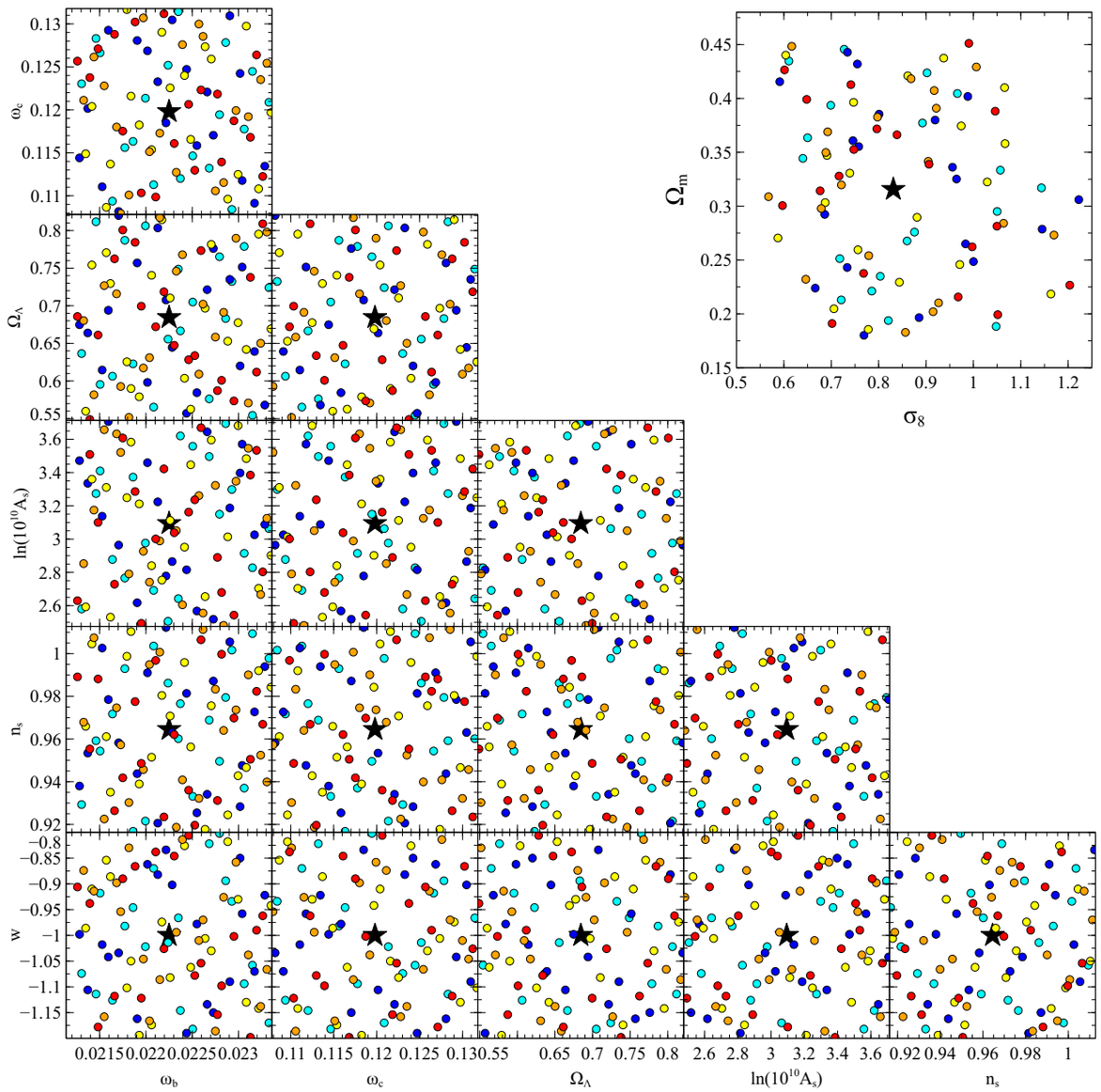
- Astrophysical systematics
  - How galaxies populate halos?
  - Baryonic effects
  - Assembly bias

→ **Cosmology Challenge**

DARK EMULATOR

- Dark Emulator provides
  - Halo mass function: dn/dM
  - Halo-matter correlation function: ξ_{hm}
  - Halo-halo correlation function: ξ_{hh}
- Measure summary statistics in 1 $[Gpc/h]^3$ and 2$[Gpc/h]^3$ simulations with 2048^3 particles for 101 cosmological parameter sets.
- Interpolate these measurements to a given cosmology using Gaussian process.
- **We don't have to care about halo bias!**

$\theta=(\omega_b, \omega_c, \Omega_\Lambda, A_s, n_s, w)$



Nishimichi+ (2018)

MODELING GALAXY-GALAXY LENSING AND CLUSTERING SIGNAL

Dark Emulator

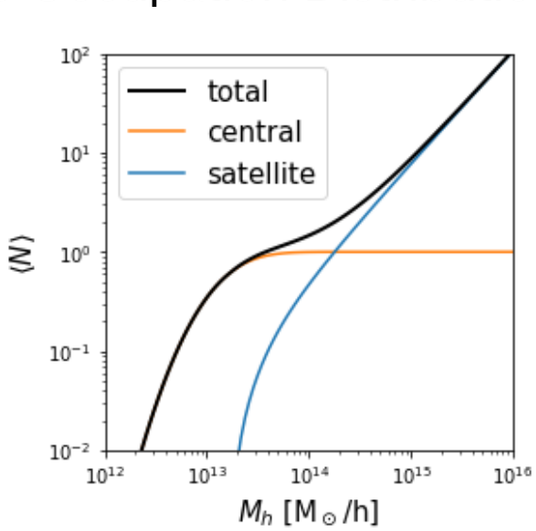
$dn/dz(M_h, z; \theta)$
$\xi_{hm}(r; M_h, z; \theta)$
$\xi_{hh}(r; M_h, z; \theta)$

θ: cosmology

⊗

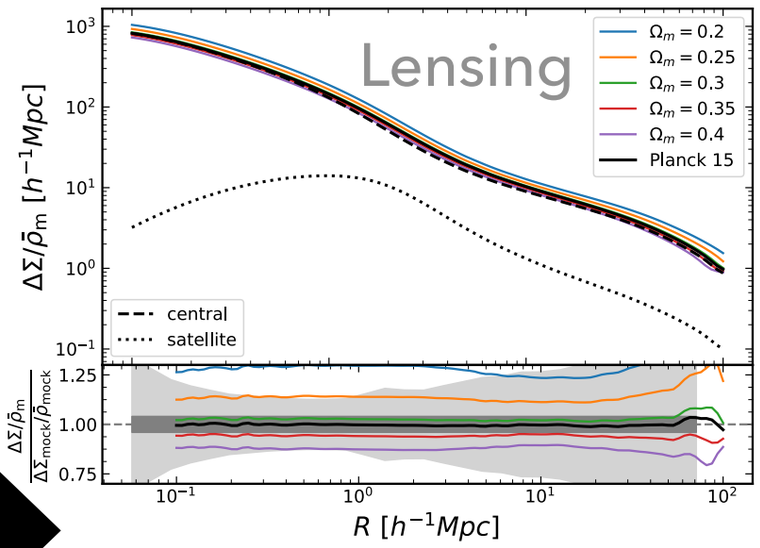
"Galaxy" parameters

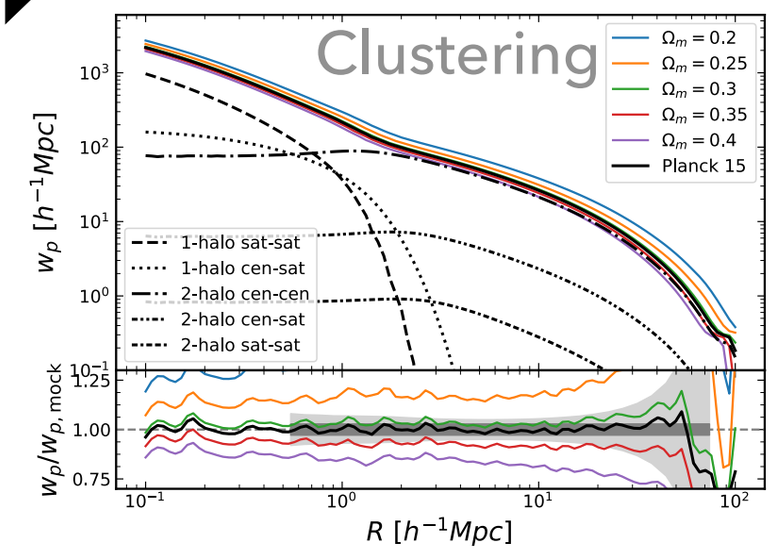
Halo Occupation Distribution



Satellite Distribution
Incompleteness

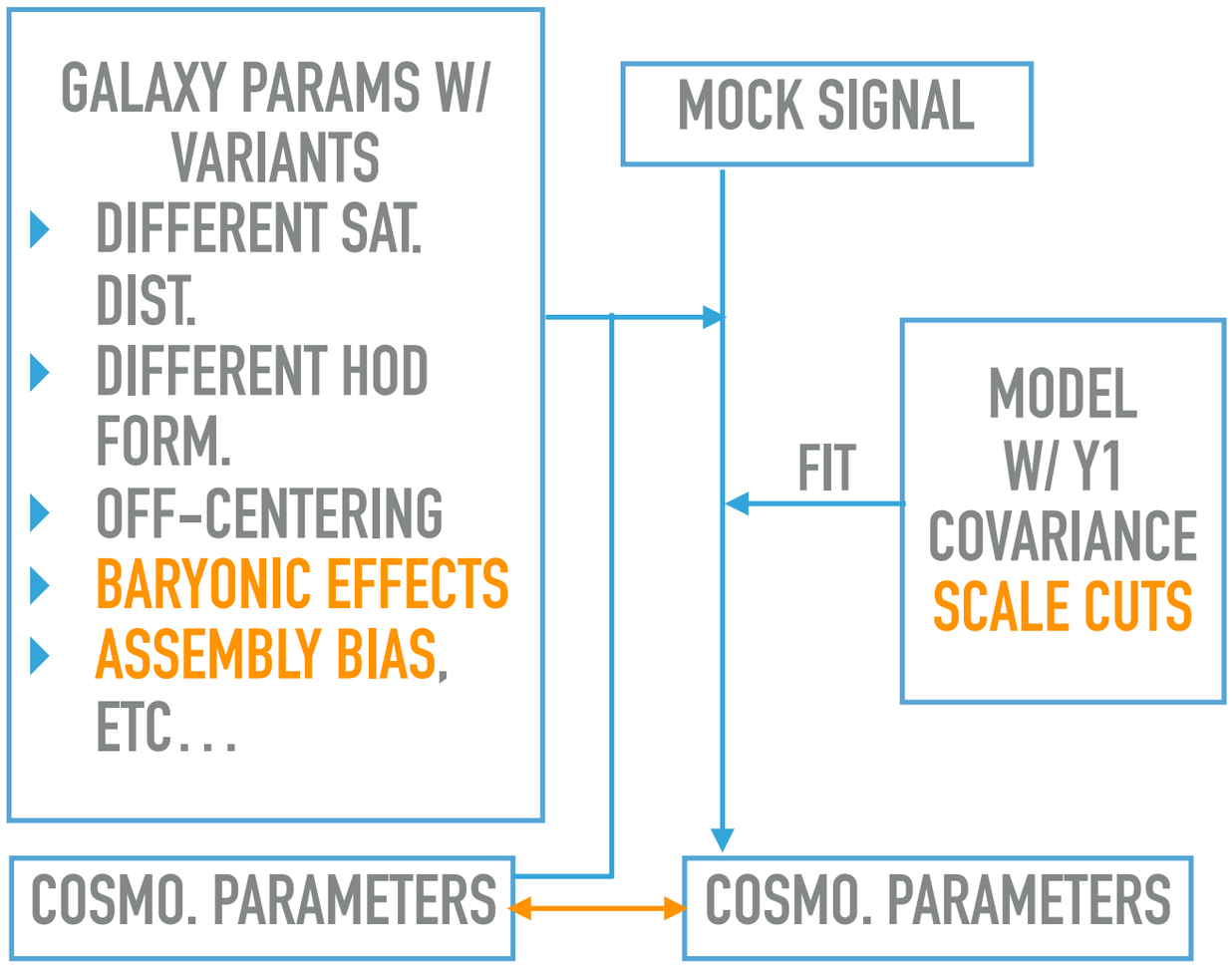
Nuisance parameters which will be marginalized over





COSMOLOGY CHALLENGE

Test the robustness of our model by fitting mocks with variants.



Our "fiducial" model

- "Standard" HOD (Zheng et al. 2005)
- Off-centering PDF: Gaussian
- Satellite distribution: NFW

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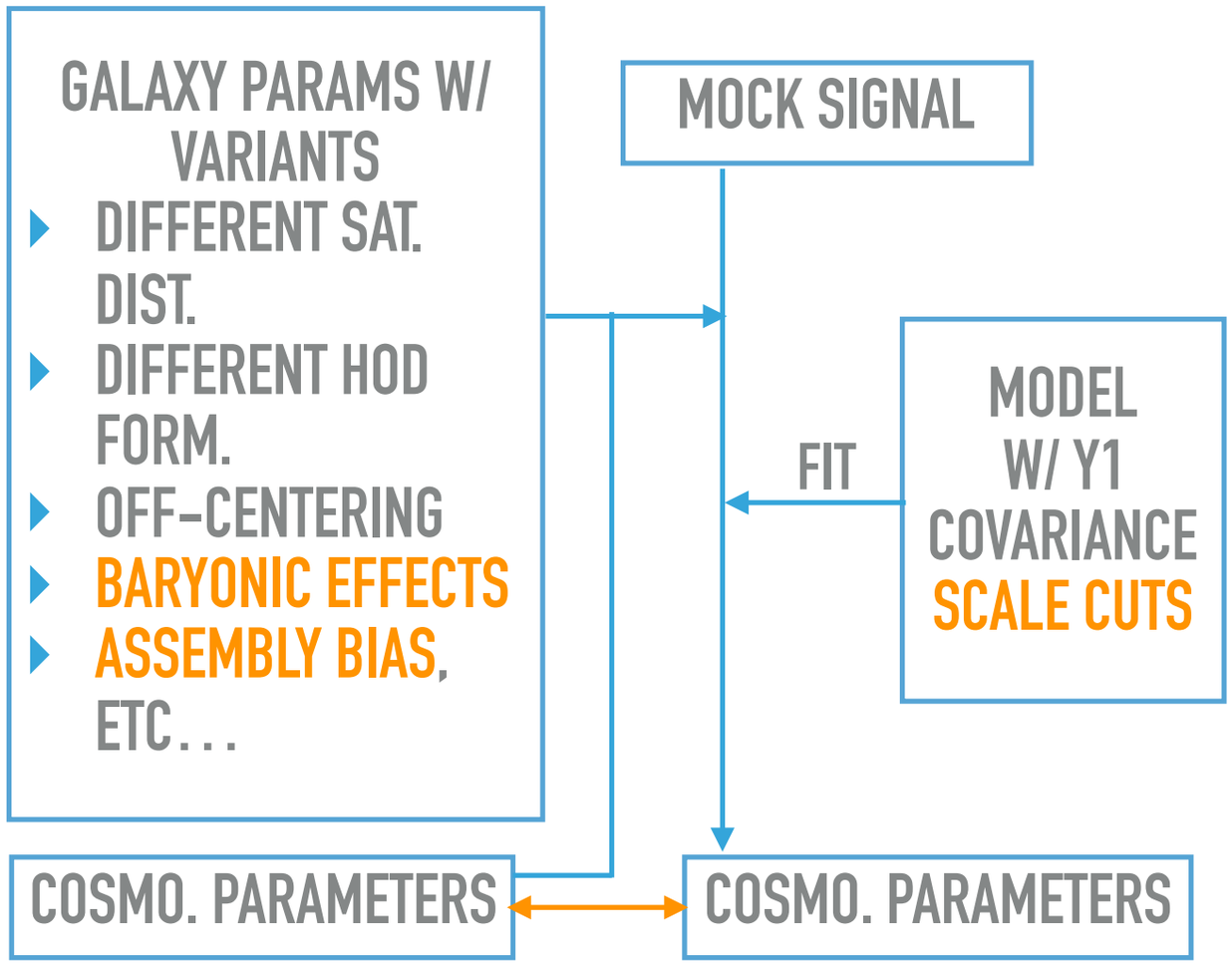

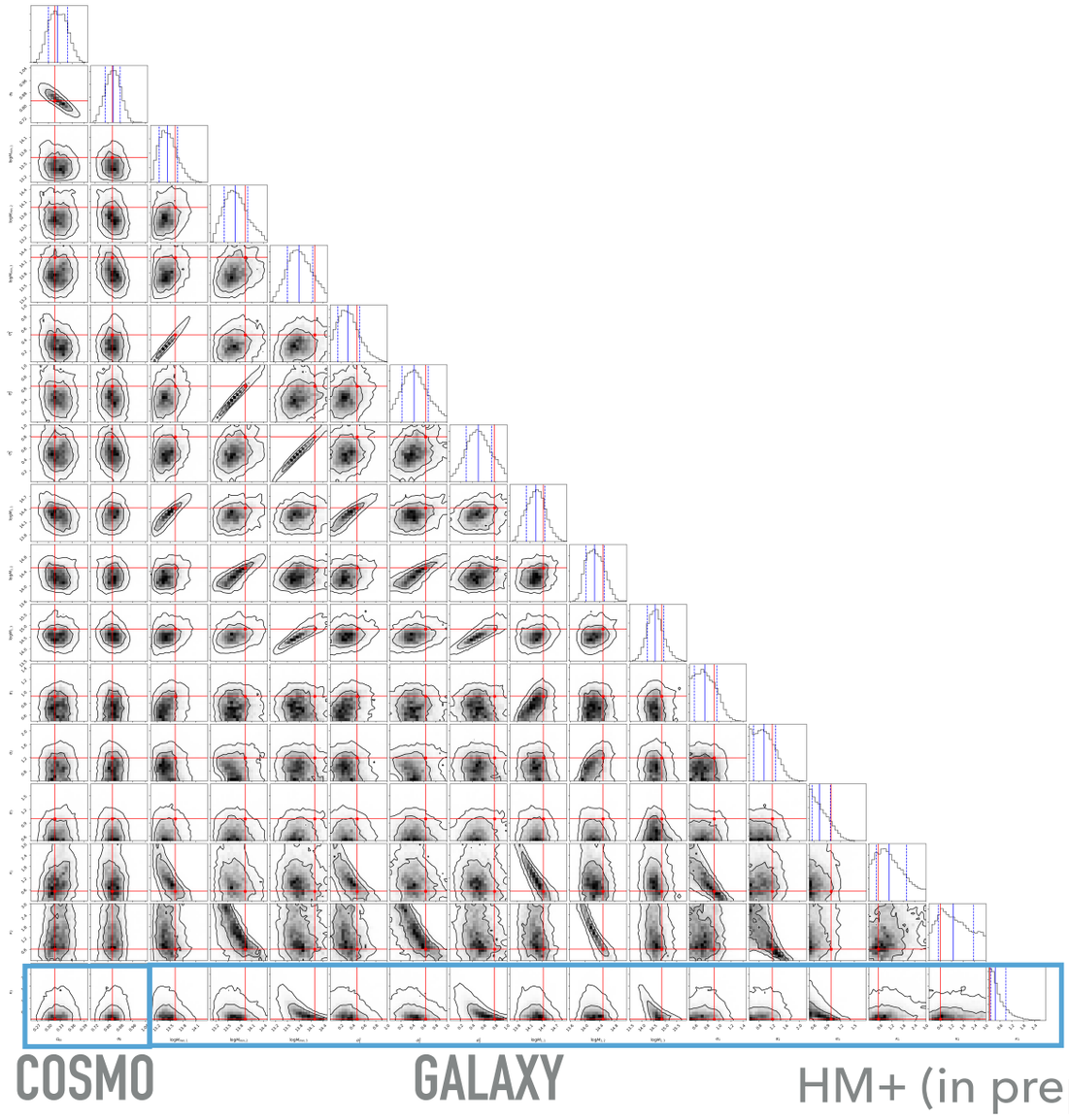

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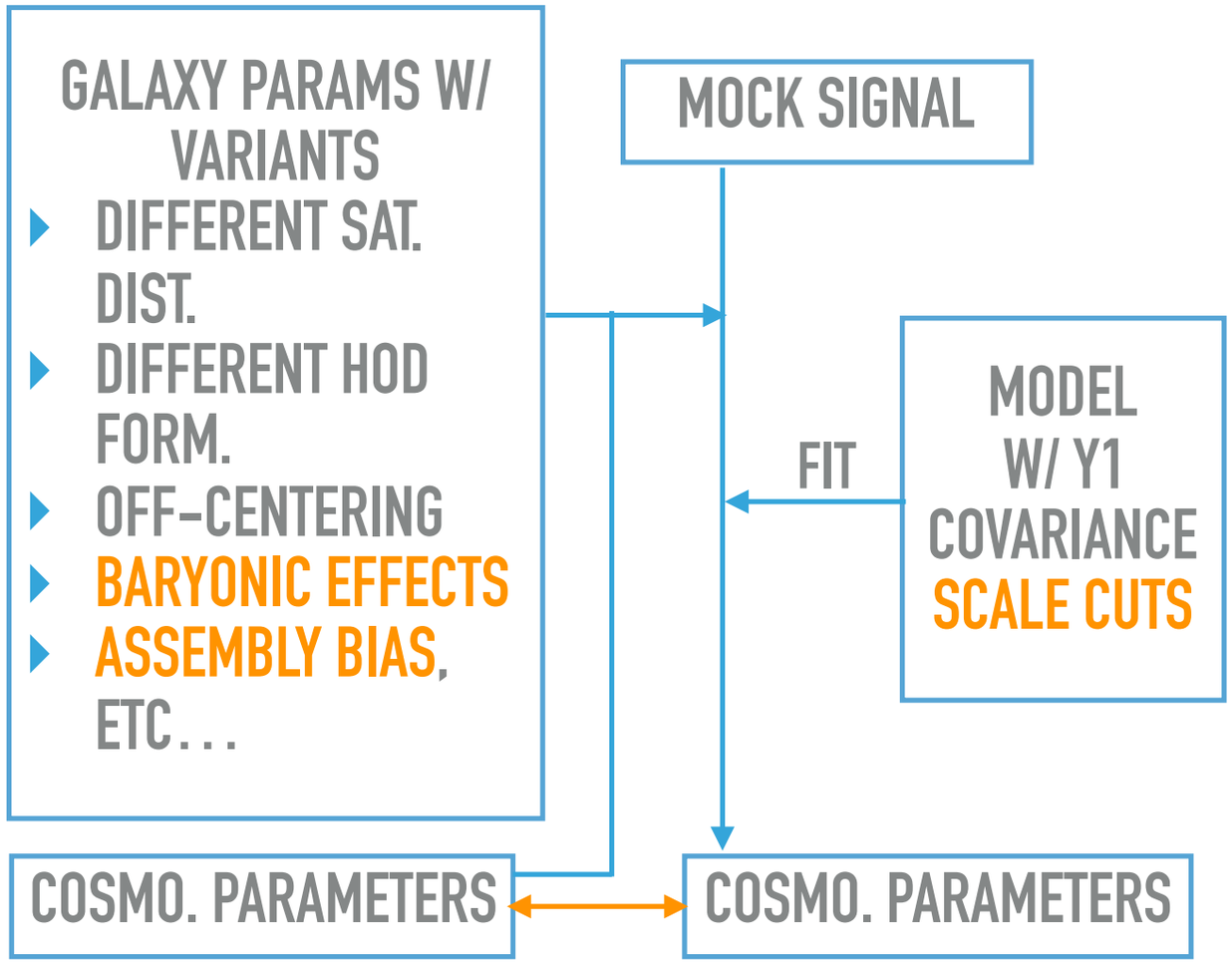
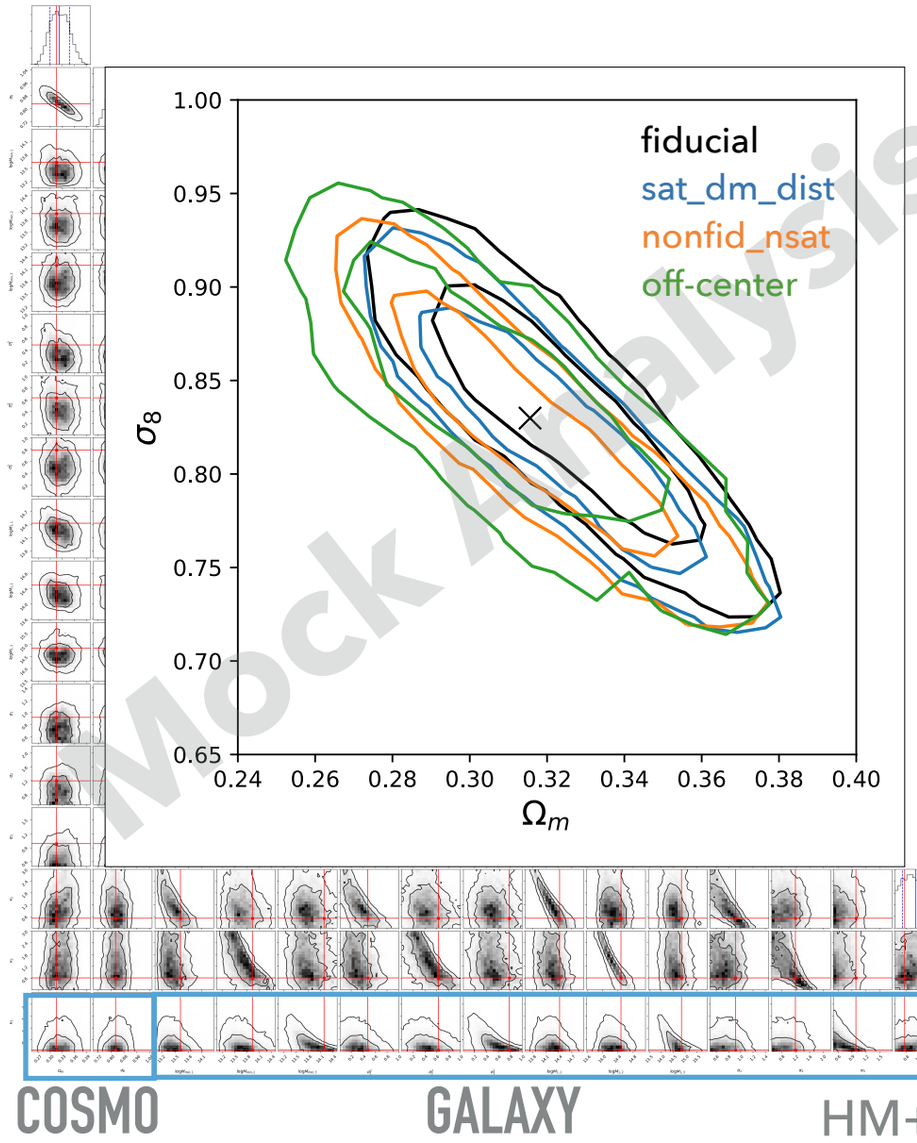
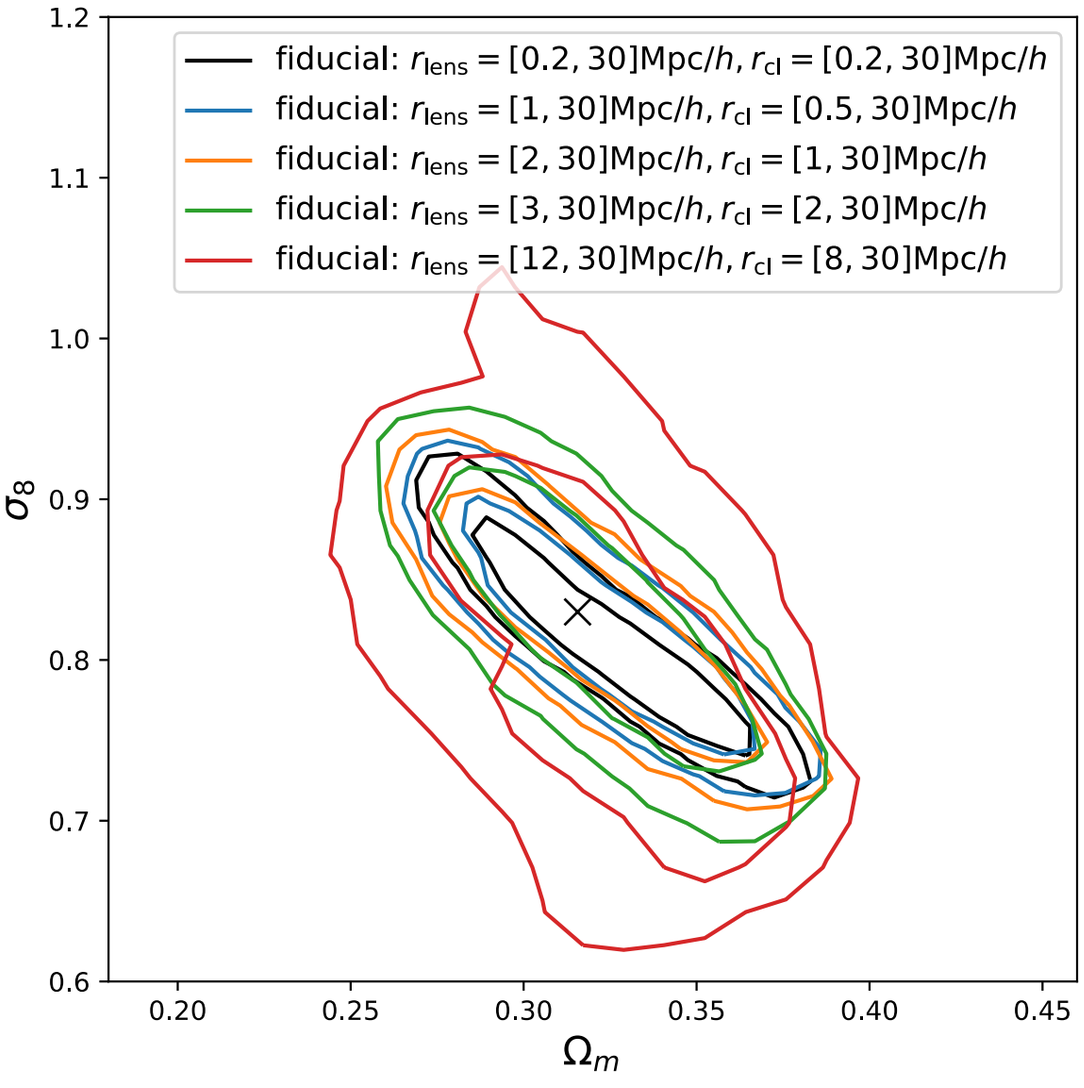
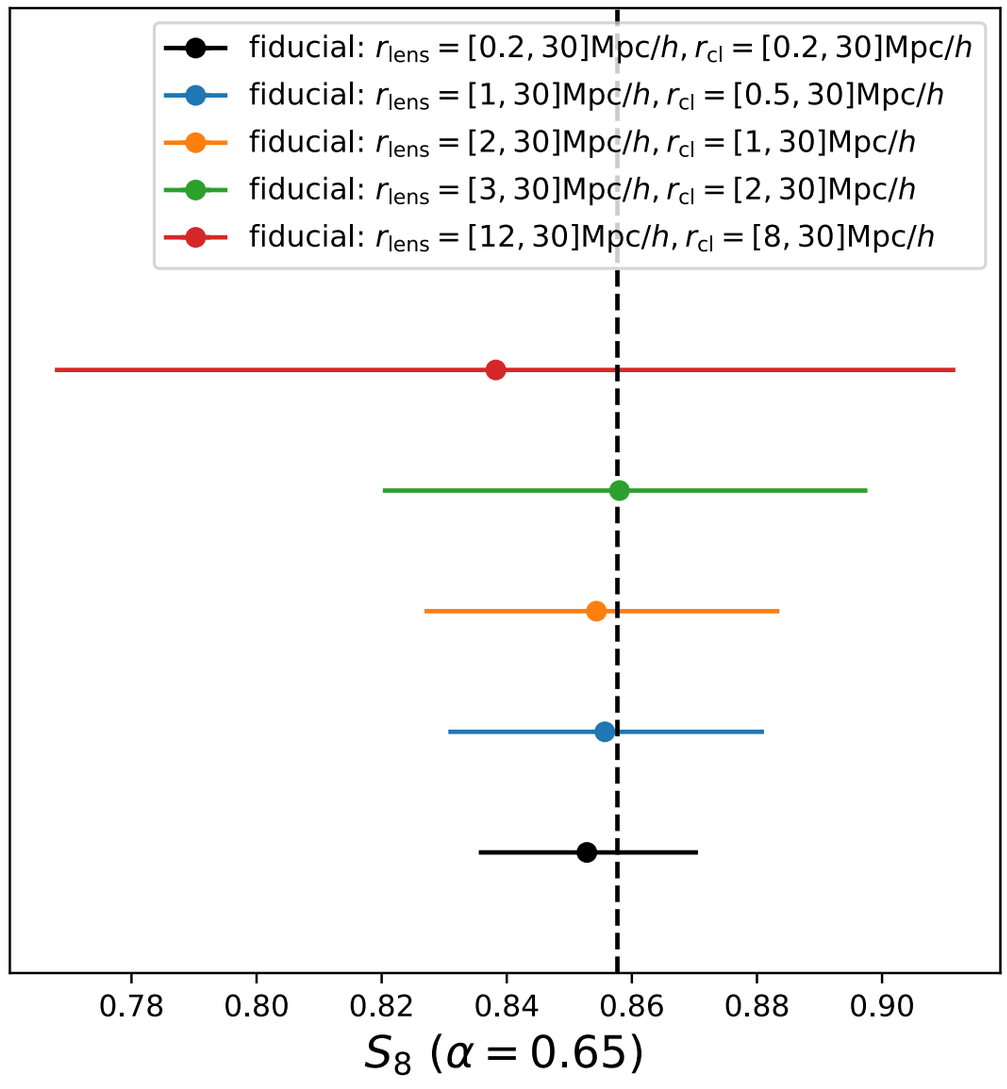




COSMOLOGY CHALLENGE: SCALE CUTS

- Fit the fiducial mock signals varying scale cuts to see how S/N changes.
- Of course, going smaller scale yields higher S/N, but more prone to small scale systematics (like off-centering and baryonic effects)





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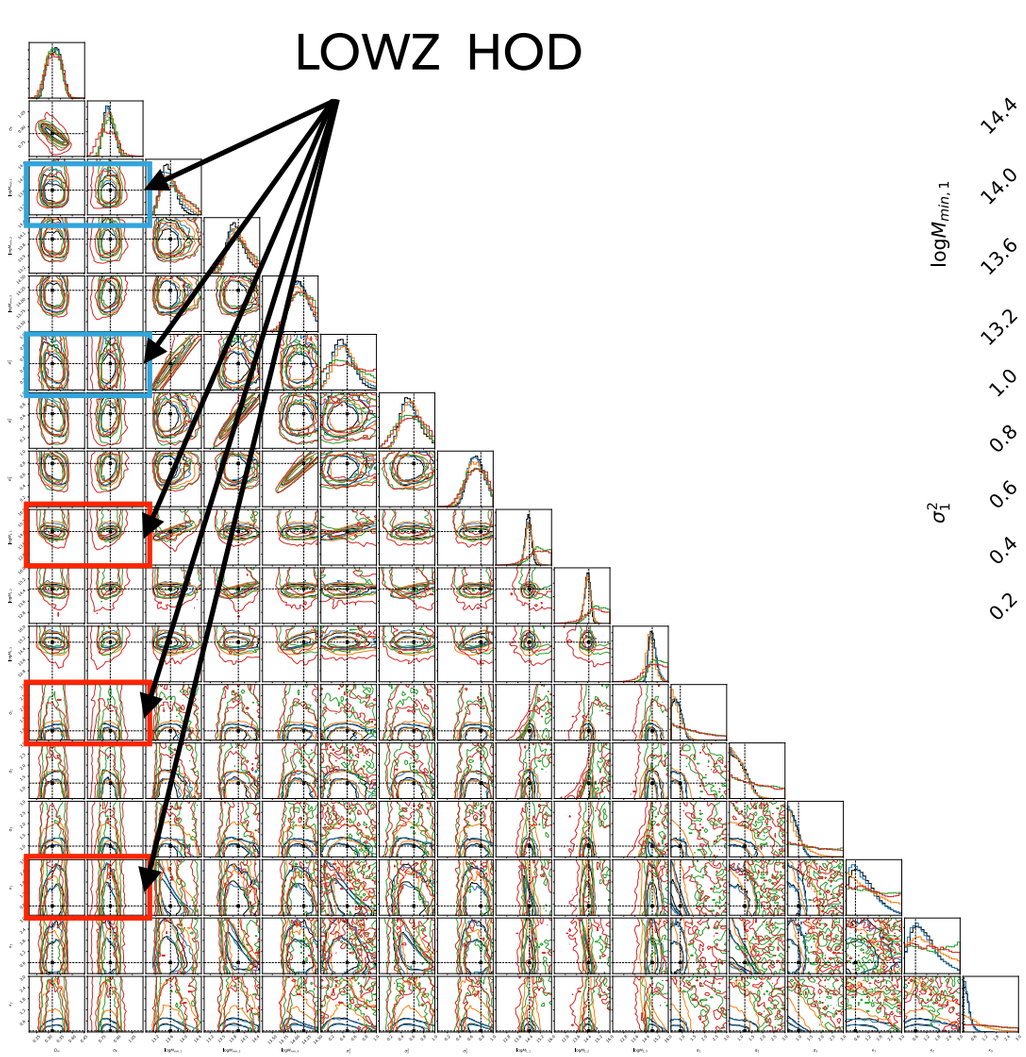
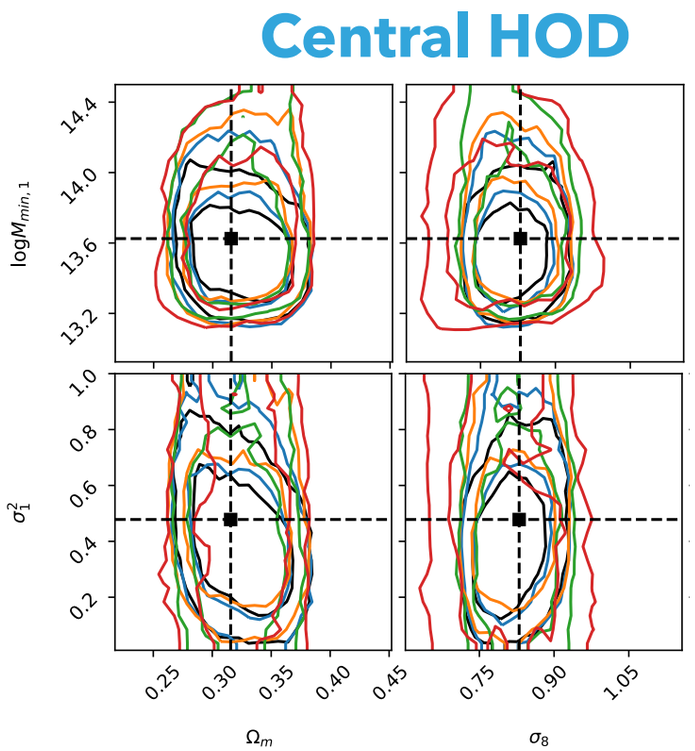
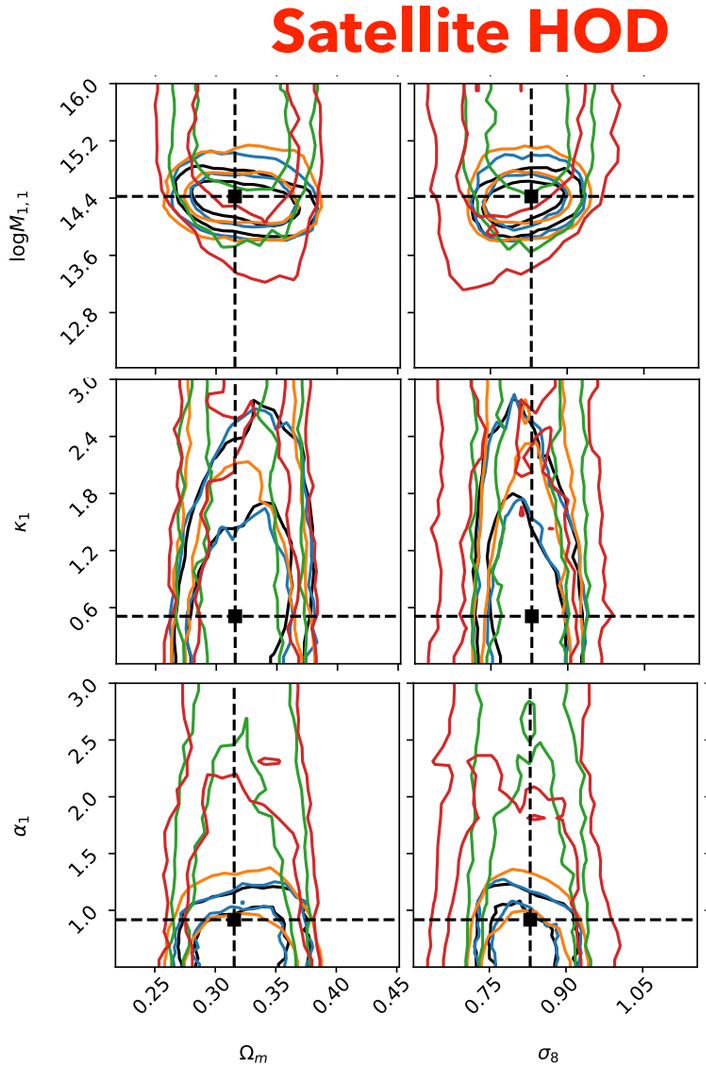
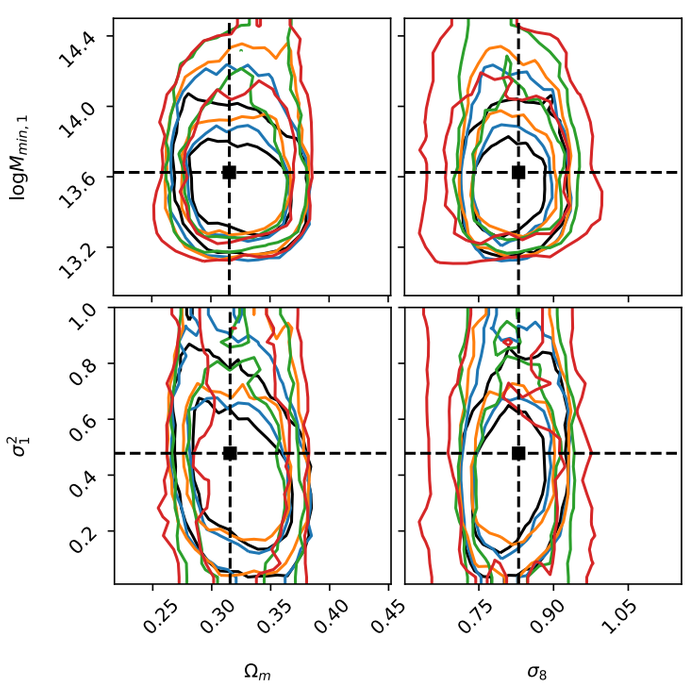




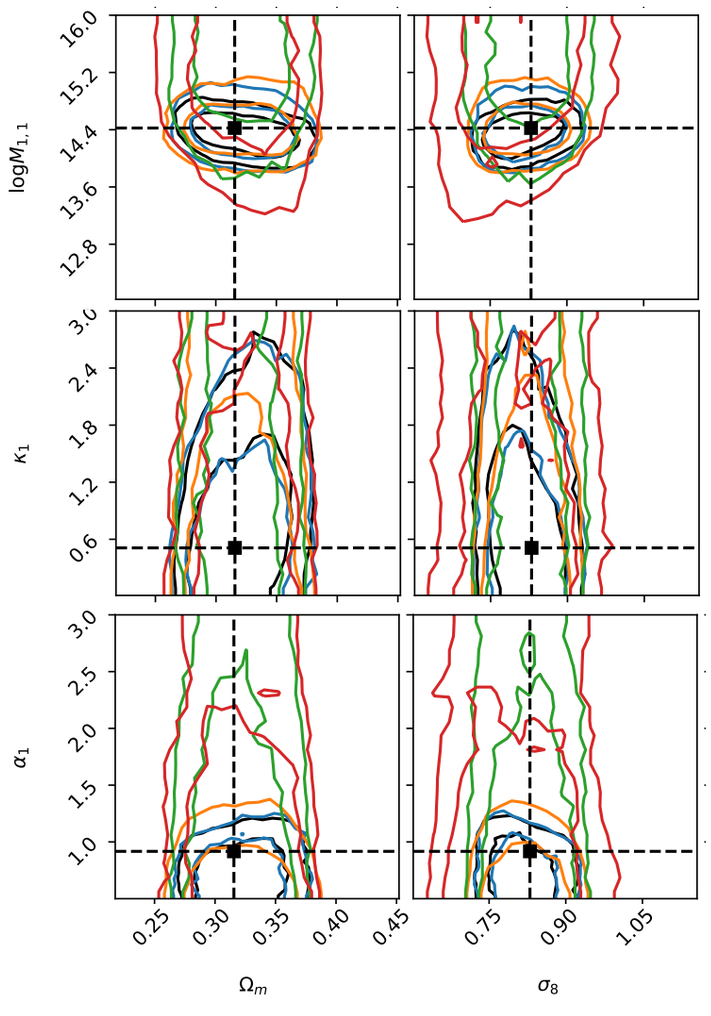


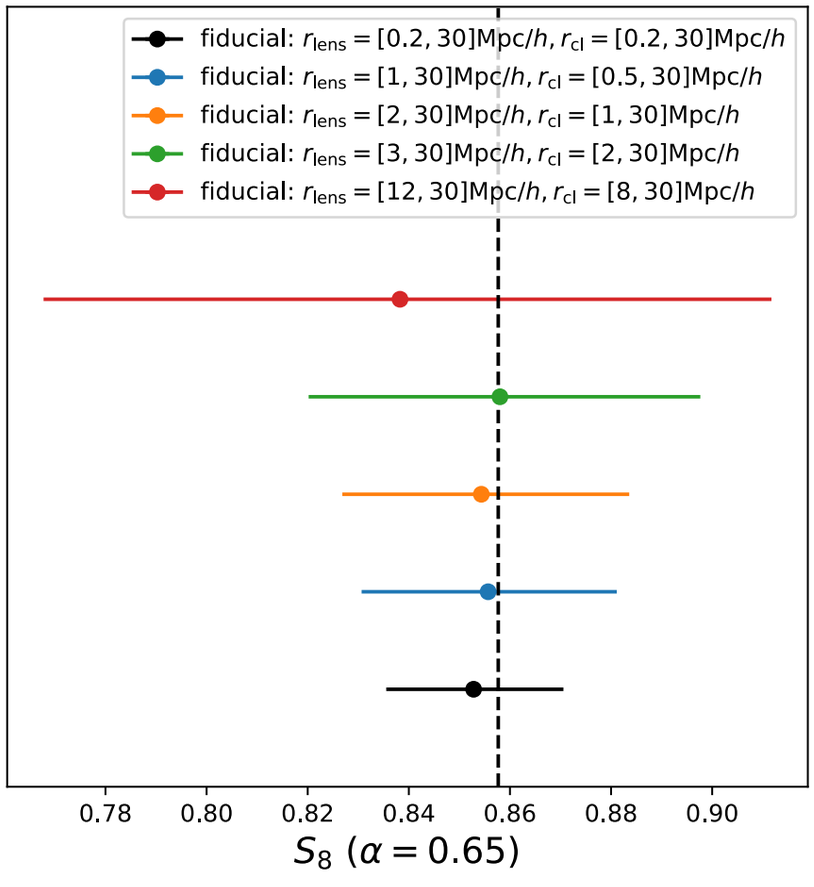
COSMOLOGY CHALLENGE: SCALE CUTS

Central HOD



Satellite HOD

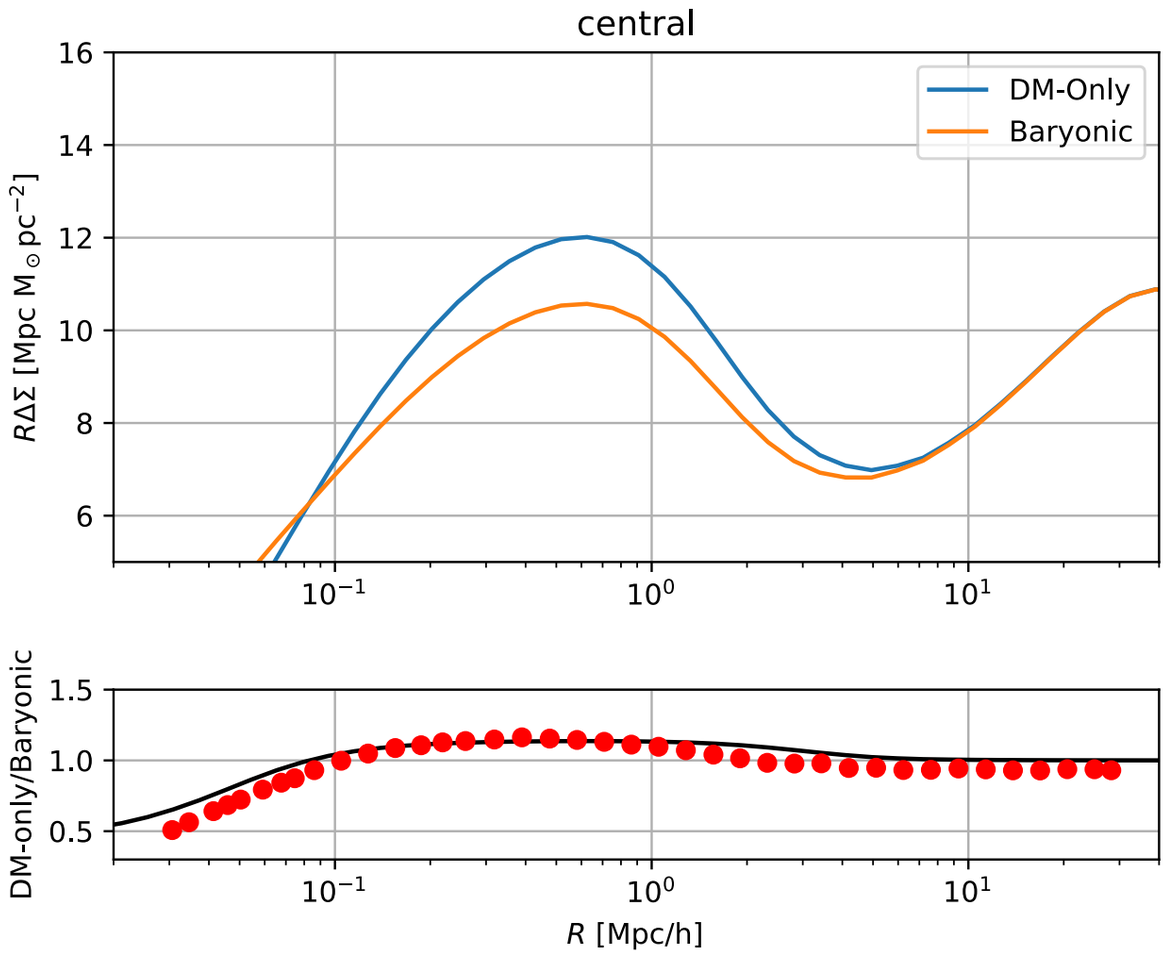




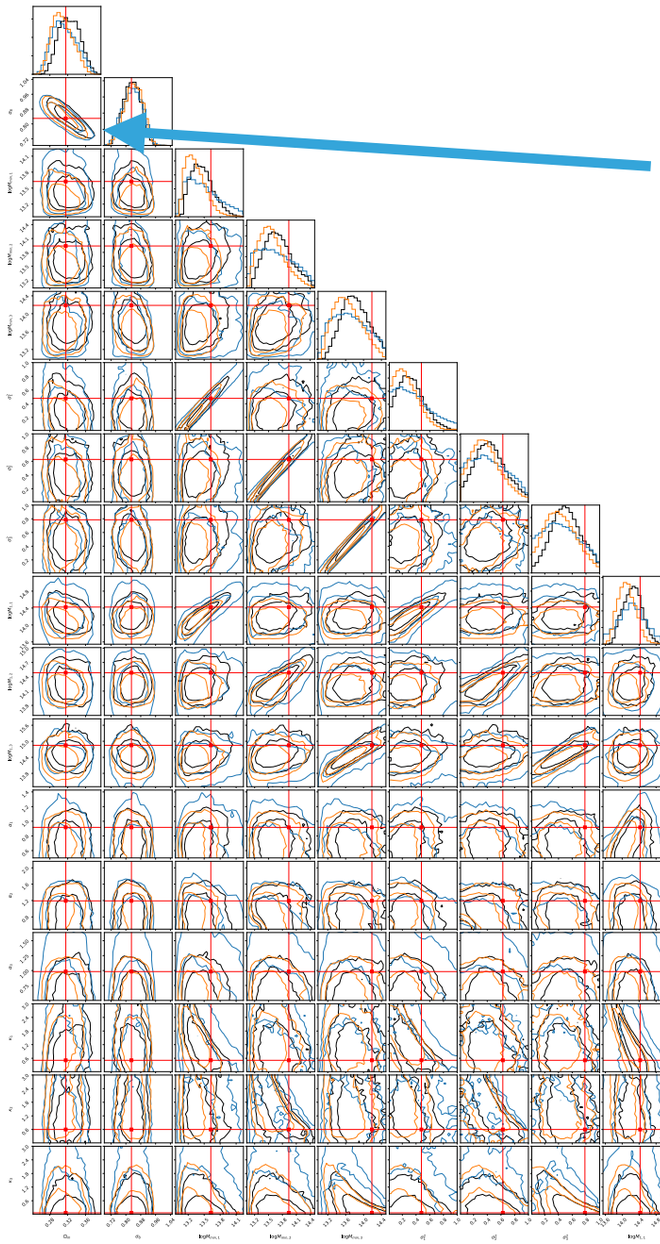
COSMOLOGY CHALLENGE: BARYONIC EFFECTS

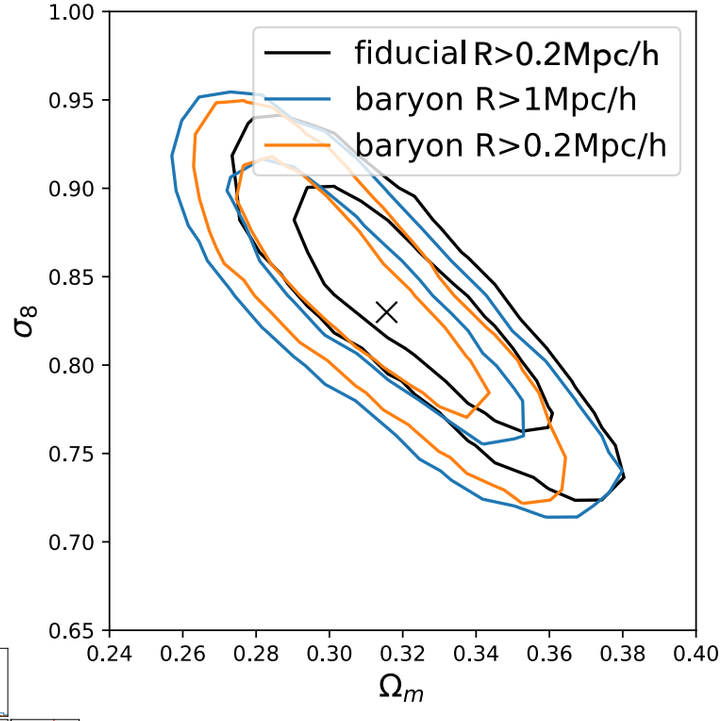
Generate mock signals

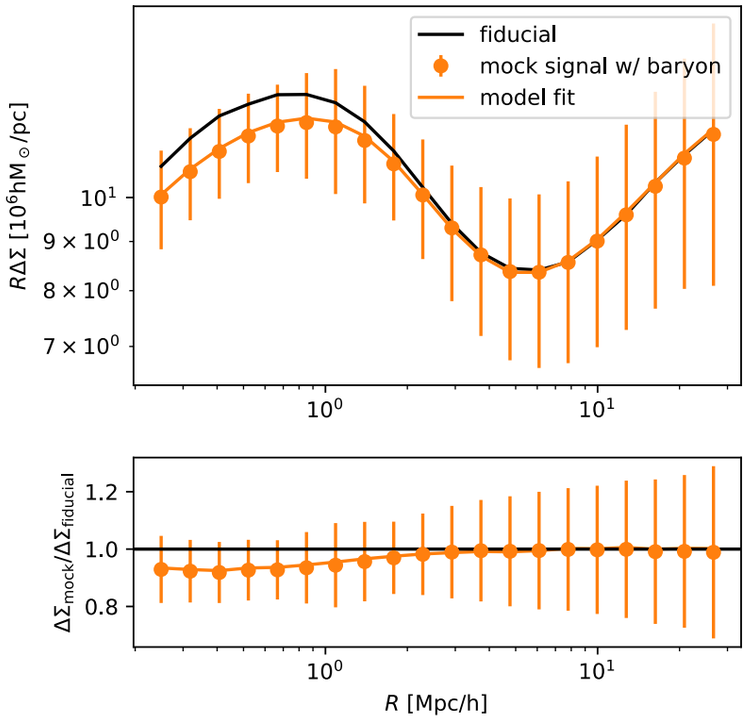
- Applied the prescription by Schneider & Teyssier (2016) to the halo-matter correlation function provided by Dark Emulator.
- Parameters were fixed to reproduce Leauthaud et al. (2017) which is based on the Illustris Simulations.
- Up to ~10% effect at ~1Mpc/h. No effect on the 2-halo term.



HSC-BOSS GALAXY-GALAXY LENSING AND CLUSTERING







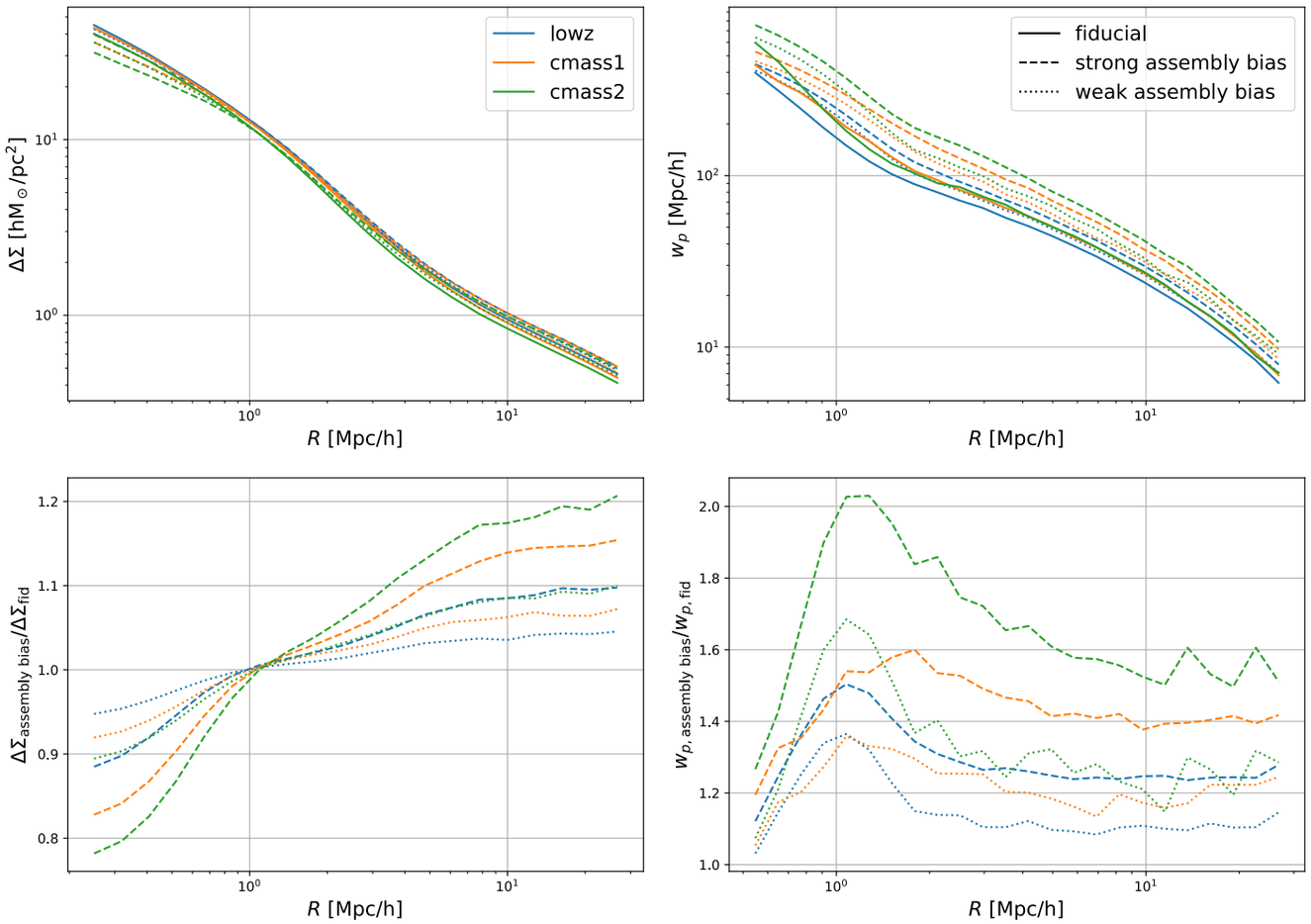
Baryonic effects won't significantly affect cosmology results in the HSC first year analysis.

COSMOLOGY CHALLENGE: ASSEMBLY BIAS

Assembly bias: halo bias that depends on halo properties other than halo mass, e.g., concentration.

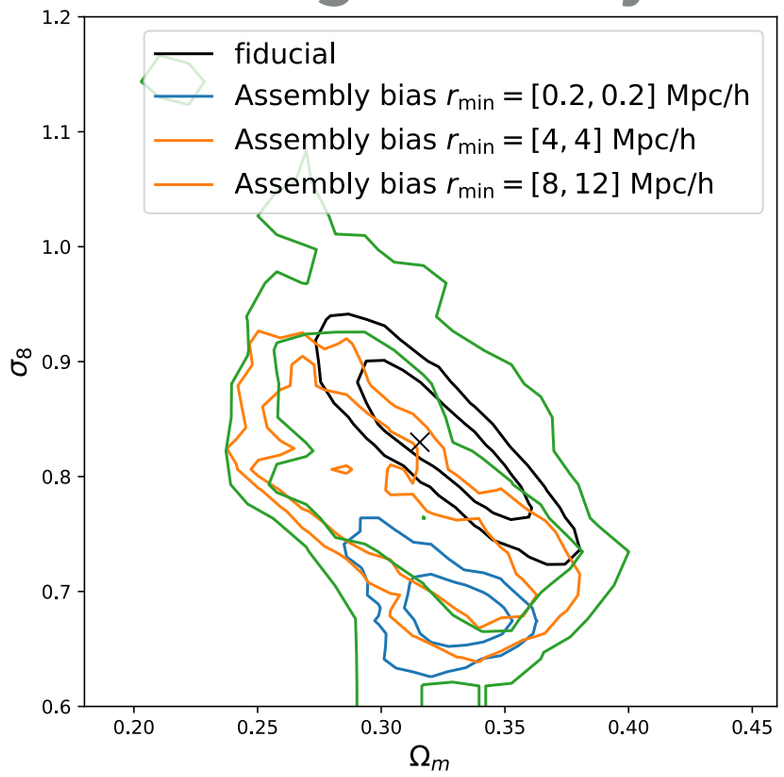
Generate mock signals

- Case 1: Assign central galaxies from halos with low concentration to $<N_{cen}(M)>$ → strong assembly bias $[b_{low\text{-}c}/b_{fid}]^2 \sim 1.5$
- Case2: Add stochasticity to the case 1 → weak assembly bias $[b_{low\text{-}c}/b_{fid}]^2 \sim 1.2$

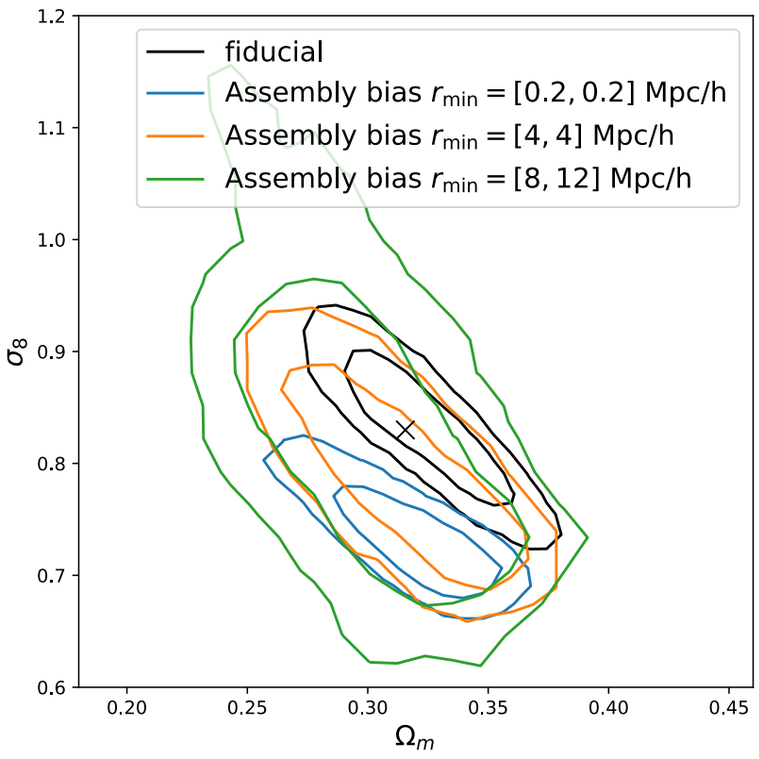


COSMOLOGY CHALLENGE: ASSEMBLY BIAS MATTERS!

Strong Assembly Bias



Weak Assembly Bias



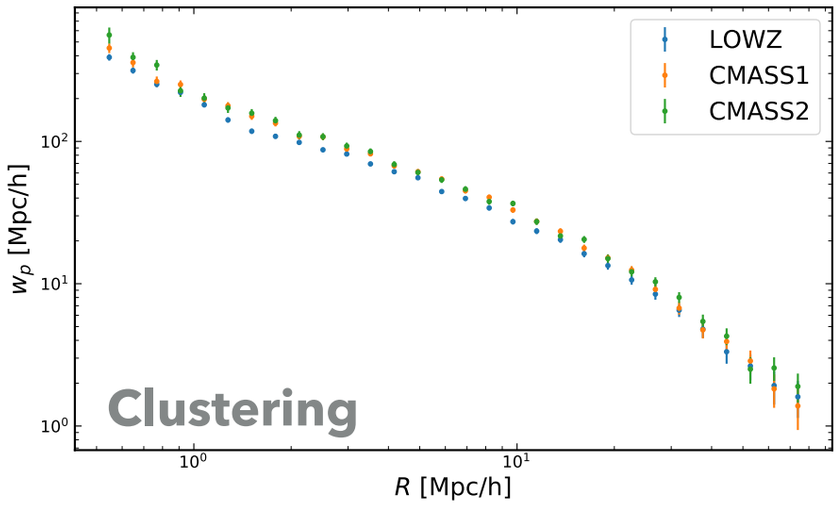
We can monitor if there is assembly bias by looking at the shifts in cosmological constraints.

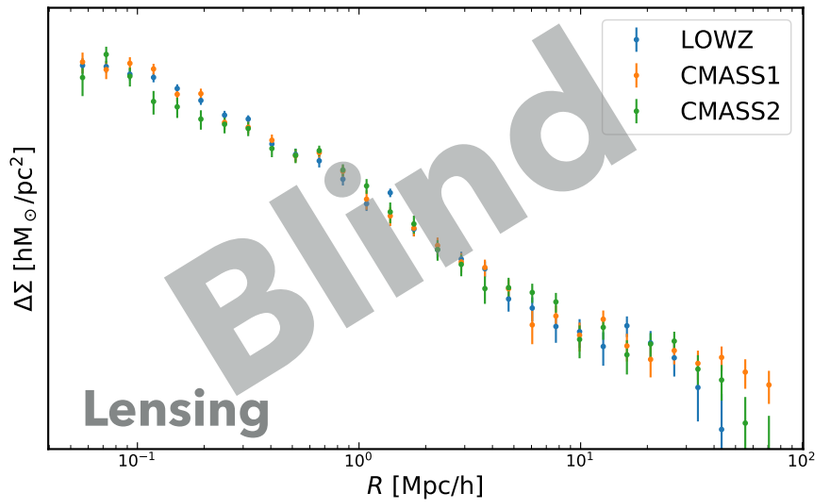
SUMMARY

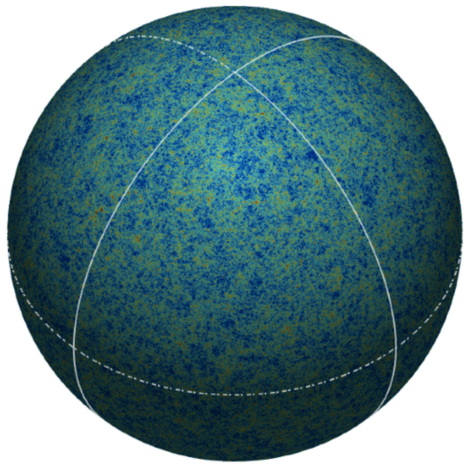
- We are working on cosmological constraints from combined galaxy-galaxy lensing and clustering with BOSS DR11 and HSC 1st year data.
- Robust modeling of g-g lensing and clustering signal.
  - Photo-z self-calibration.
  - Cosmology challenge: fit mock signals with variants by our fiducial model.
  - Baryonic effects will not have a significant impact on the first year analysis.
  - Assembly bias matters! We need to monitor how cosmological constraints shifts with the scales for fit.
- Stay tuned with the cosmological constraint from real data!

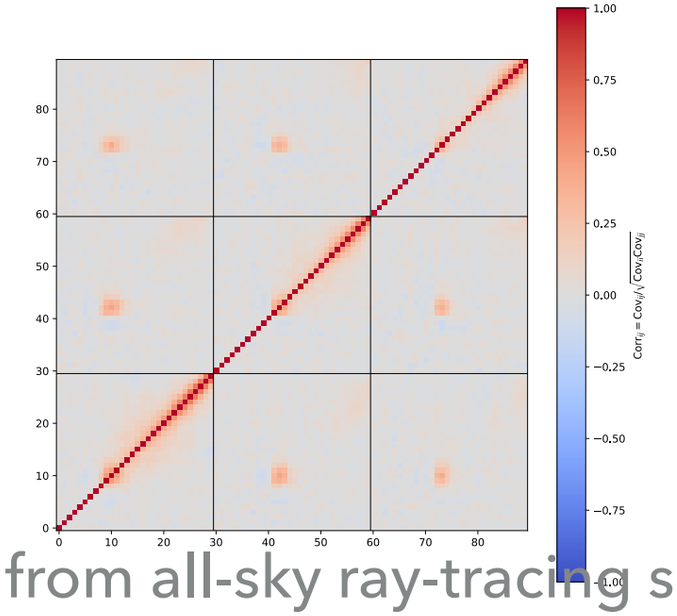
BACKUP SLIDES

CLUSTERING AND LENSING MEASUREMENTS AND COVARIANCE







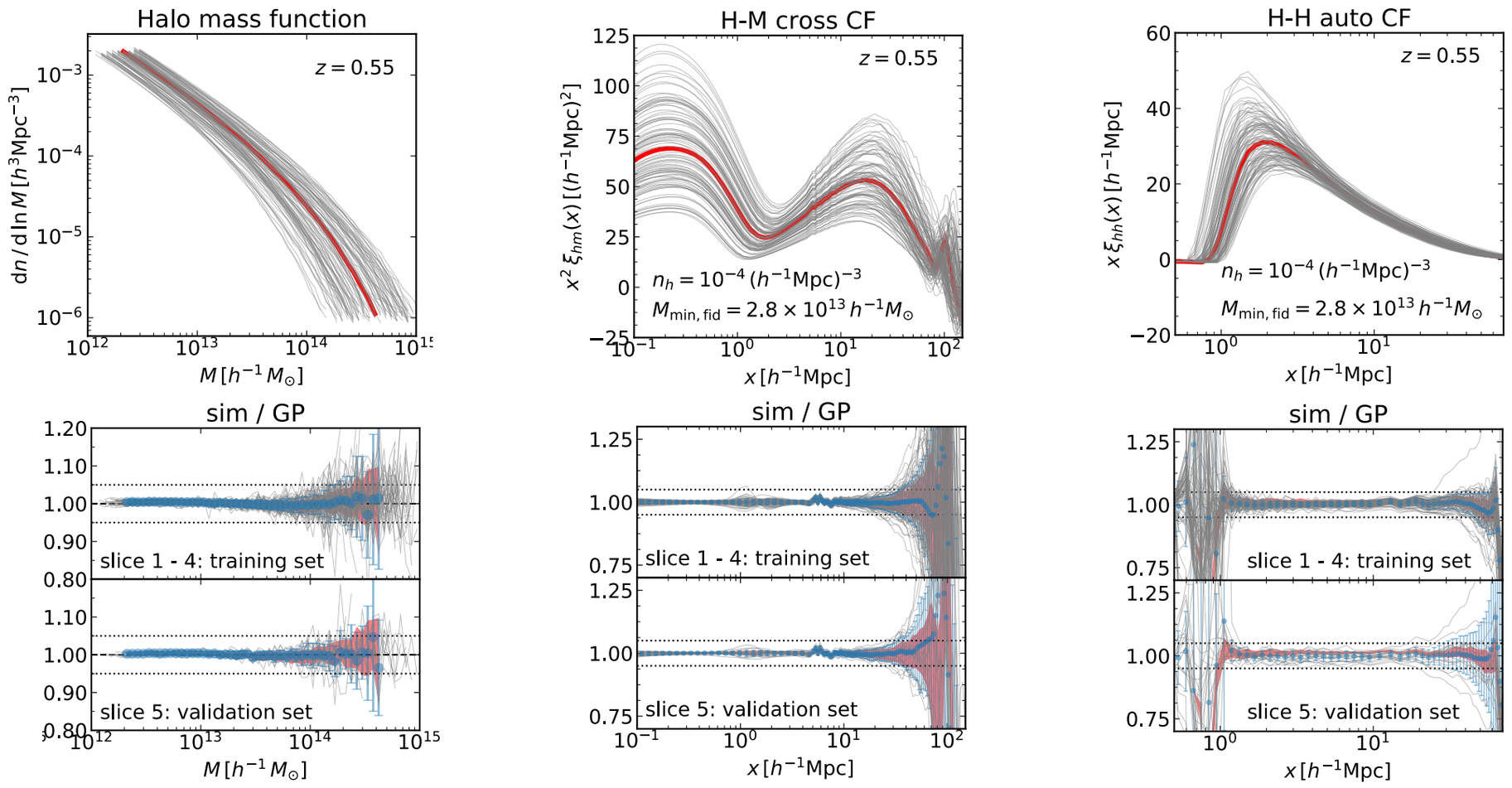


Covariance is computed from all-sky ray-tracing simula

(Takahashi+ 2017, Shirasaki+ 2019.)

- 108 realizations x 21 HSC first year fields.
- Naturally take into account survey geometry effects.

DARK EMULATOR: VALIDATION TESTS



A few % accuracy is achieved! Nishimichi+ (2018)