Cosmological Constraints from Galaxy-galaxy Lensing and Clustering with the Subaru HSC and SDSS BOSS Data

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Our Team


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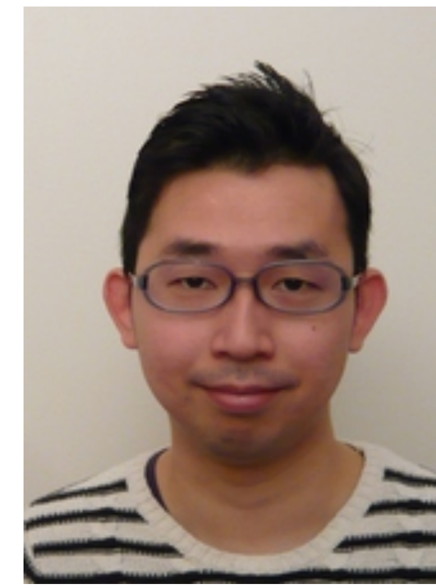
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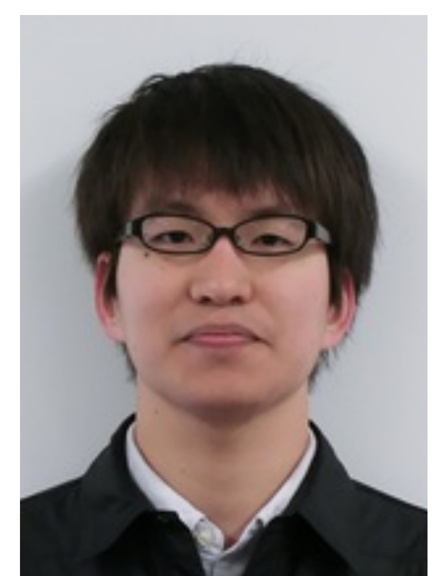
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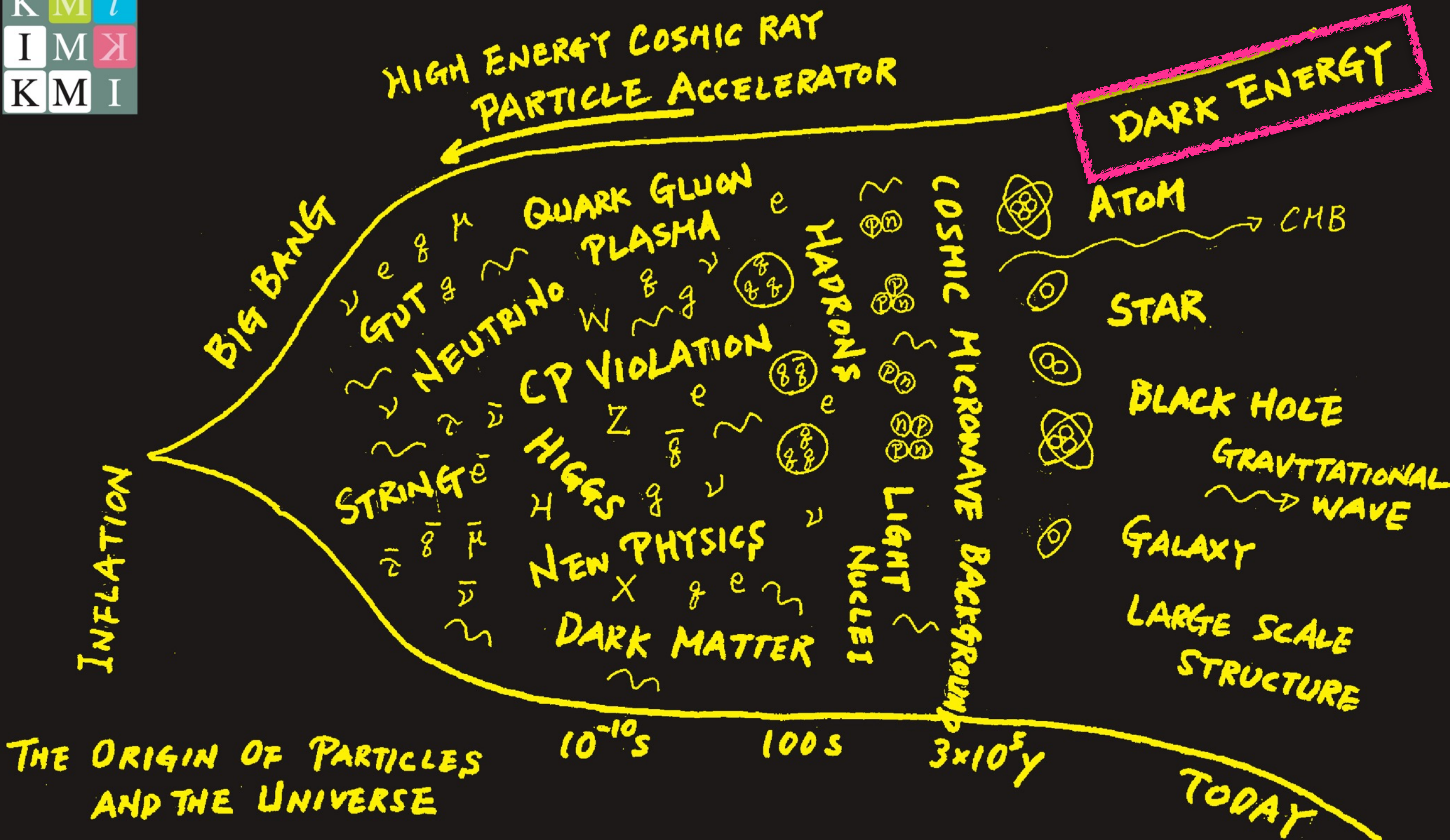
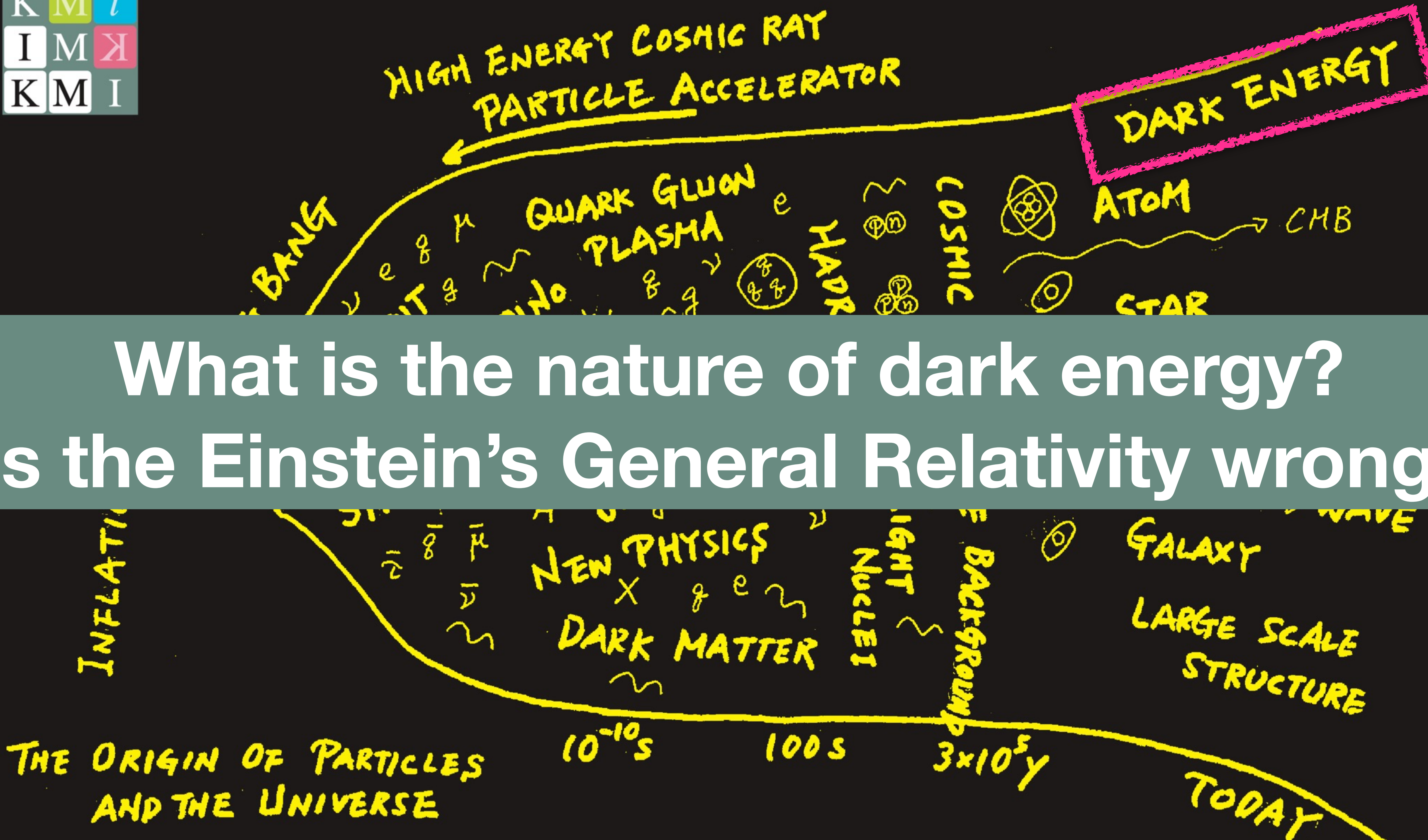
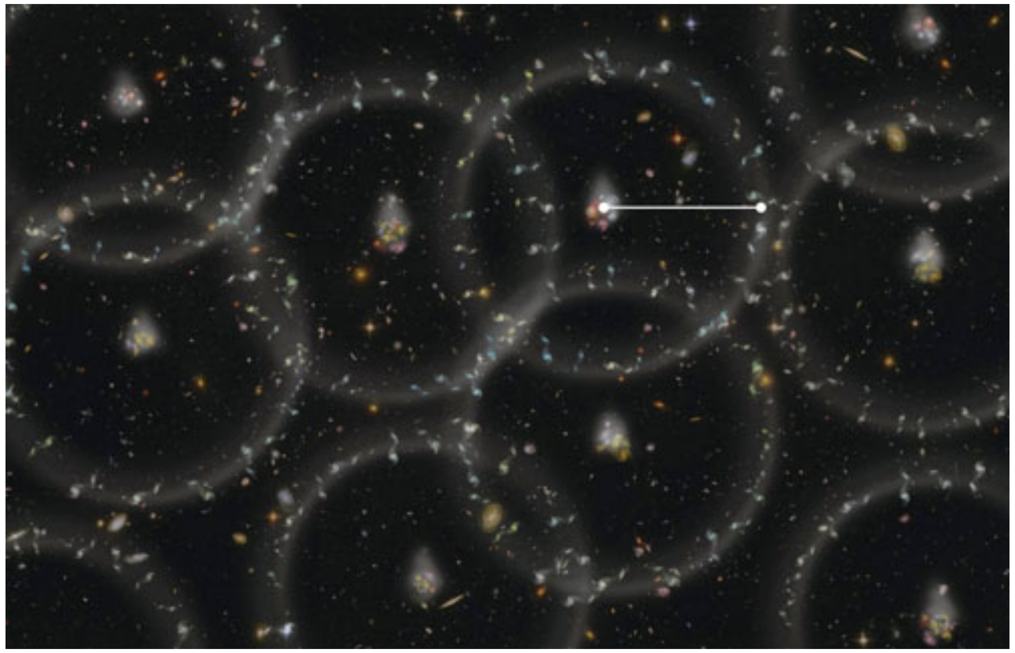


HIGH ENERGY COSMIC RAY
PARTICLE ACCELERATOR
DARK ENERGY
BIG BANG
INFLATION
QUARK GLUON PLASMA
GUT
NEUTRINO
CP VIOLATION
STRING
HIGGS
NEW PHYSICS
DARK MATTER
HADRONS
LIGHT NUCLEI
COSMIC MICROWAVE BACKGROUND
ATOM
CMB
STAR
BLACK HOLE
GRAVITATIONAL WAVE
GALAXY
LARGE SCALE STRUCTURE
10^{-10}s
100s
3×10^{5}y
TODAY
THE ORIGIN OF PARTICLES AND THE UNIVERSE



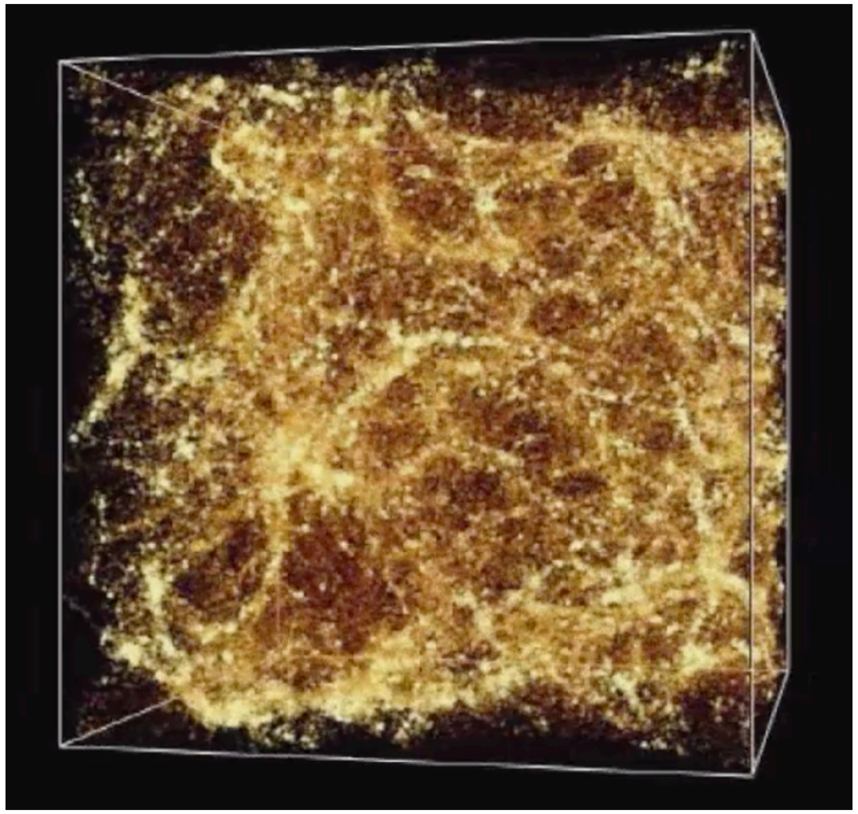
What is the nature of dark energy?
Is the Einstein's General Relativity wrong?

Cosmology Probes



Geometry of the Universe

- Type Ia supernovae
- Baryon Acoustic Oscillations



Growth of structure

- **Galaxy-galaxy clustering**
- **Weak gravitational lensing**
- Cluster number count
- Redshift space distortions

→ **sensitive to modified gravity**

Credit: SDSS/BOSS, ESA

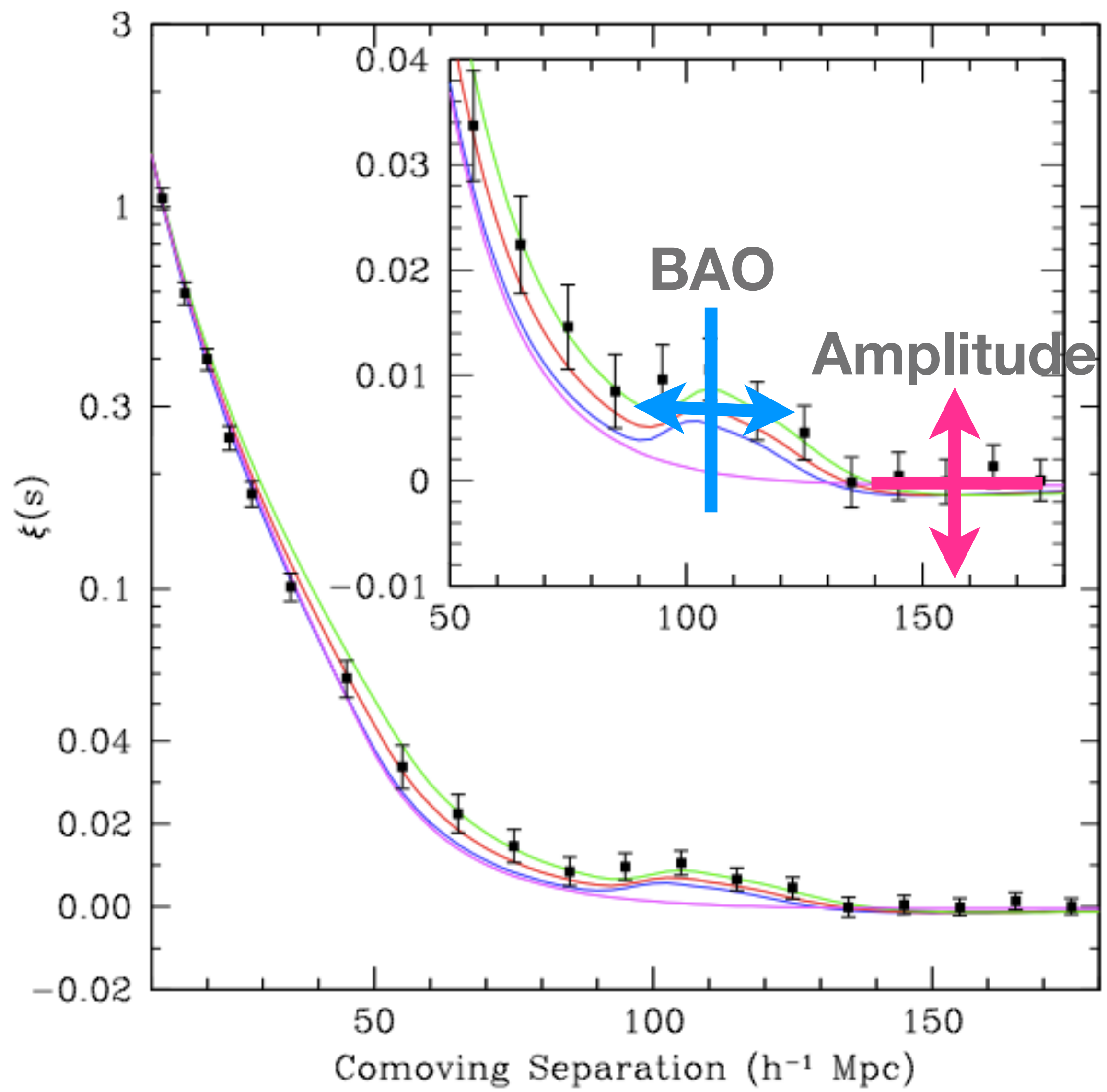
Galaxy-galaxy Clustering

Baryon acoustic oscillations (BAO)

- Sensitive to **geometry of Universe**

Amplitude of g-g clustering signal

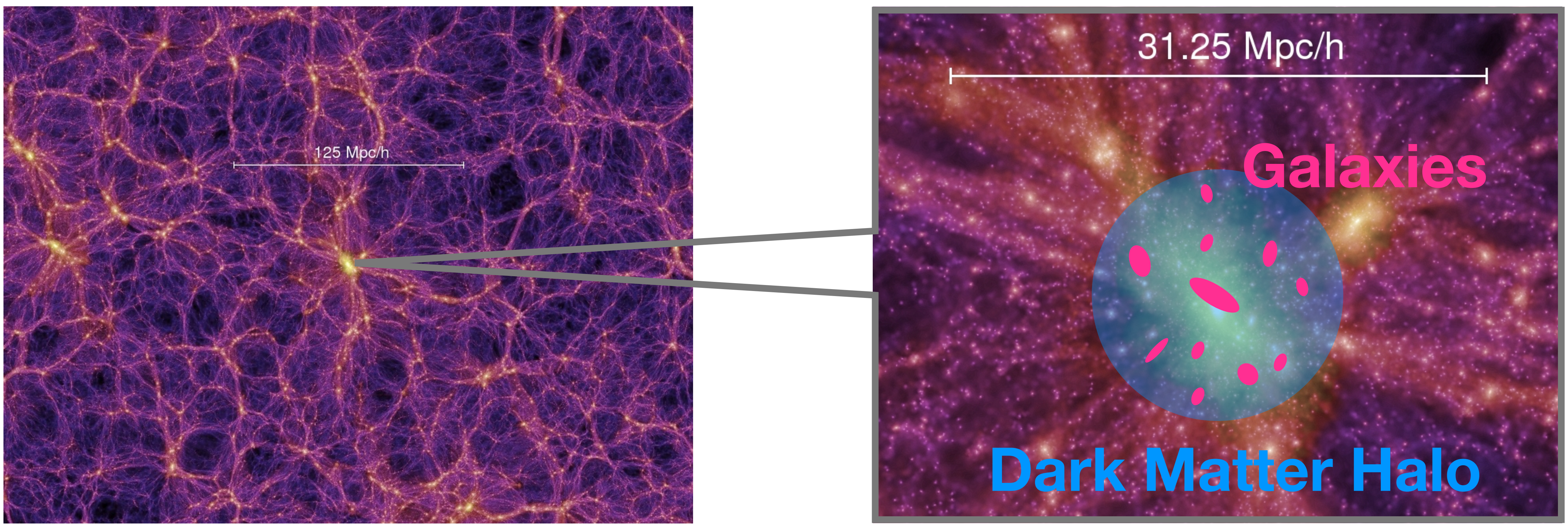
- Sensitive to **Growth of structure**
- **More signal-to-noise** than BAO :)
- **Biased** against underlying dark matter distributions :(



Eisenstein et al. (2005)

Calibration by Galaxy-galaxy Weak Lensing

Dark Matter Distribution



Dark matter halos are **the biased tracer** of the underlying dark matter distribution.

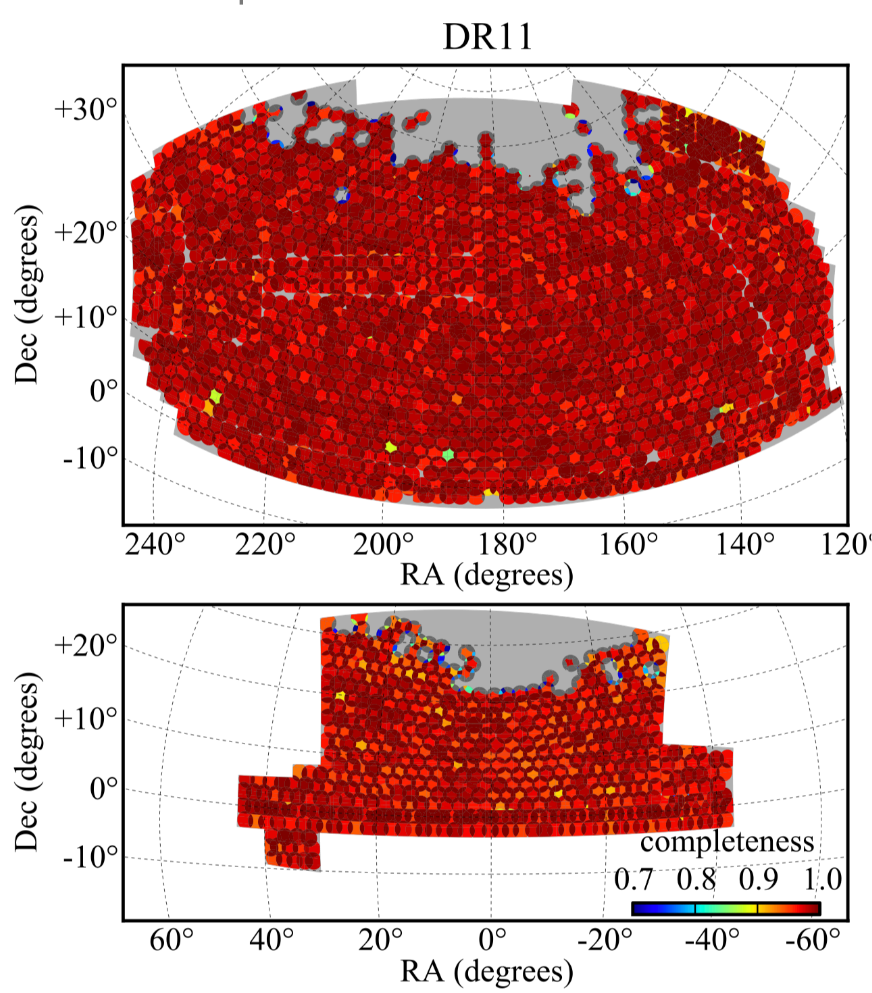
Weak lensing measurement around galaxies (= average dark matter distributions around galaxies) can be used to calibrate the connection between them.

Springel et al. (2005), Croton et al. (2006)

HSC x BOSS Measurement

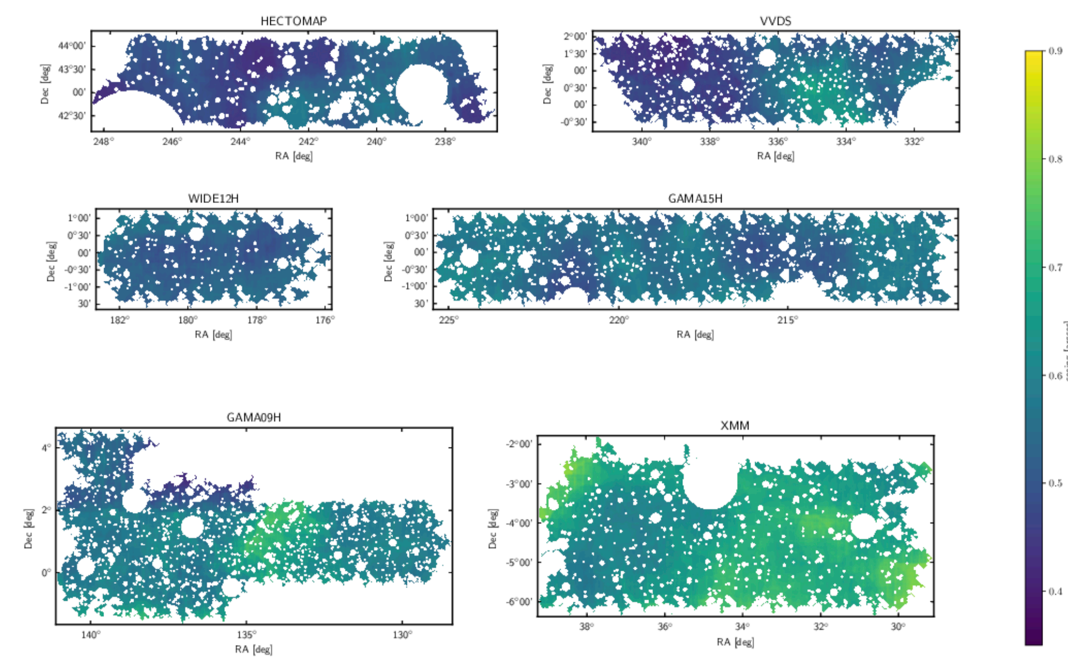
SDSS-III/BOSS spec-z sample

- Area ~ 8300 deg^2
- z = [0.15, 0.35], [0.47, 0.55], [0.55, 0.70]
- Luminosity cut is applied to obtain volume-limited sample.



HSC first-year shape catalog

- Area ~ 137 deg^2 in total
- <z>~1.0.
- Galaxy shapes are blinded.

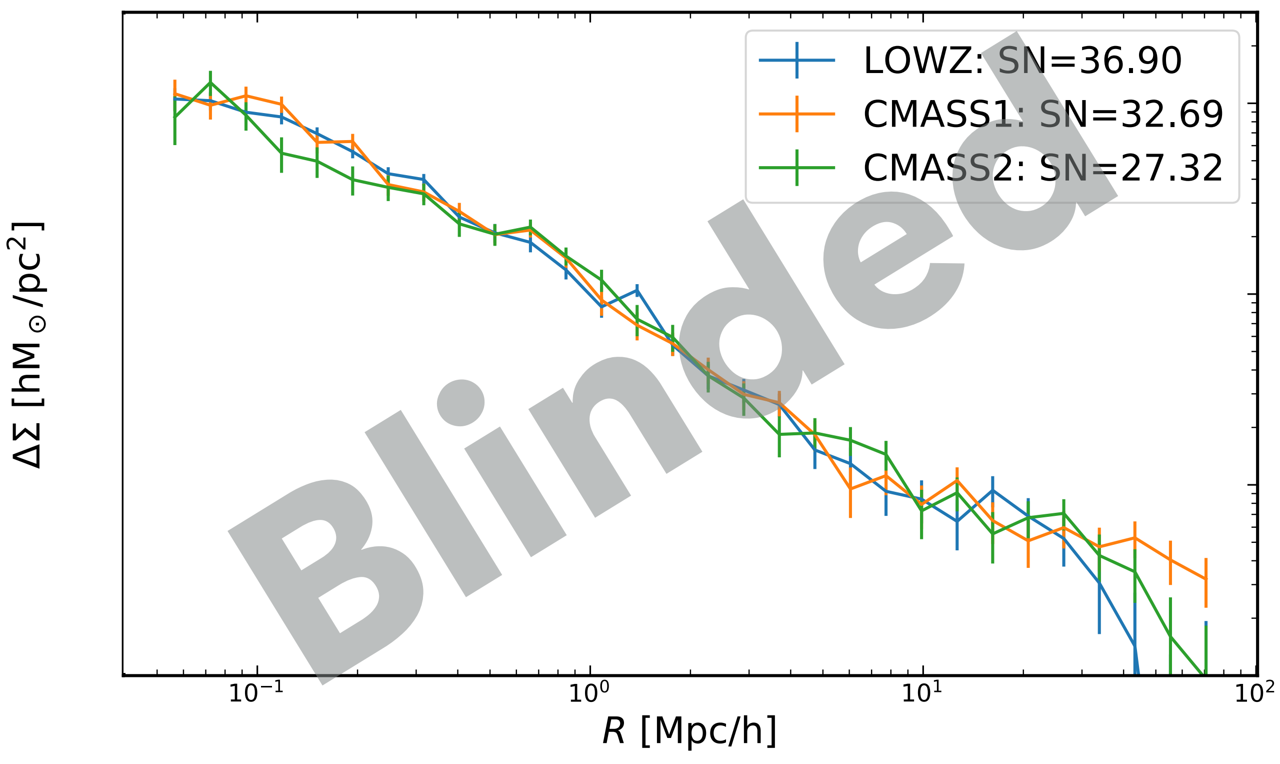


g-g lensing signal

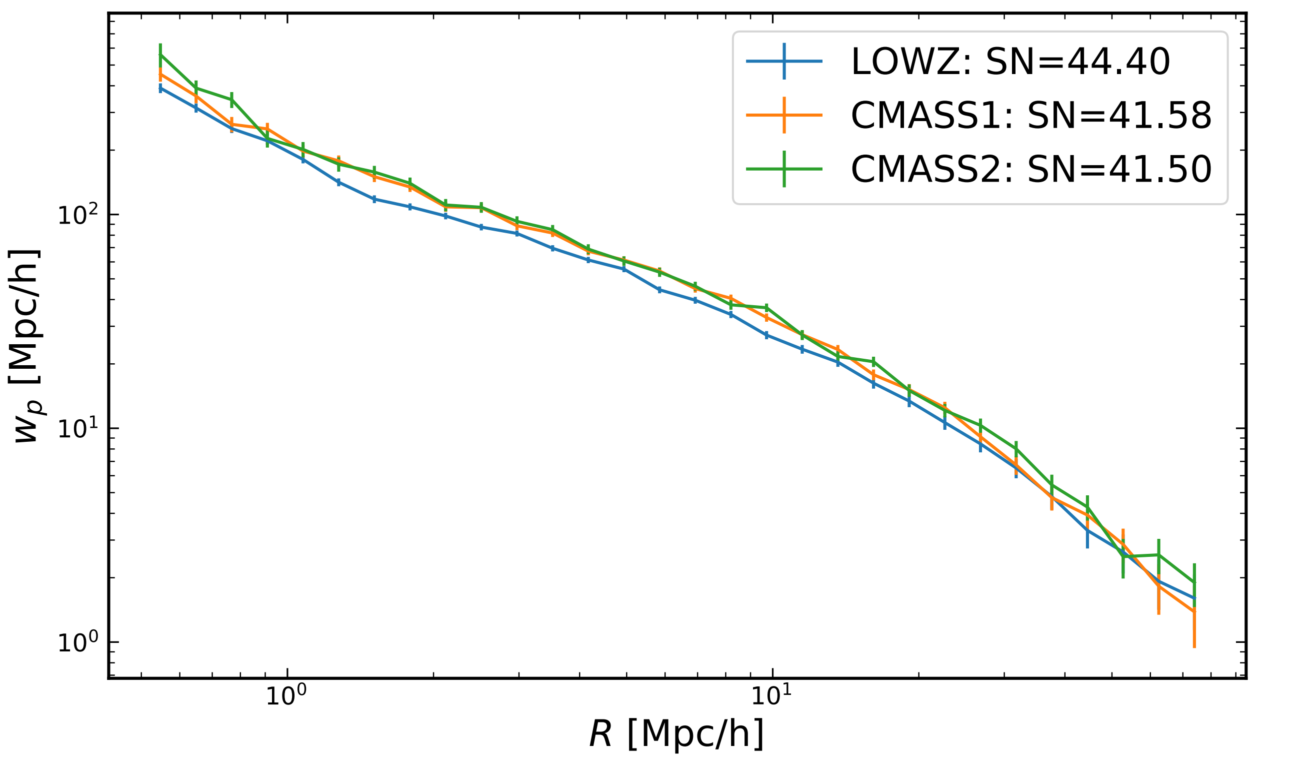
g-g clustering signal

HSC x BOSS Measurement

g-g lensing



g-g clustering



Challenges in Modeling Signals

Halo-halo correlation function

$\xi_{hh}(x; \vec{C})$

Halo-matter correlation function

$\xi_{hm}(x; \vec{C})$

$\otimes$

How galaxies occupy dark matter halos

$\Rightarrow$

Clustering Signal

Lensing Signal

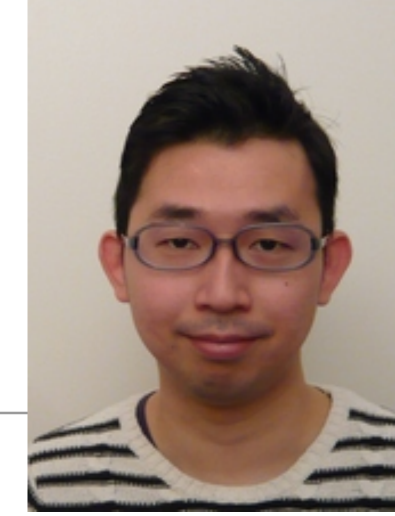
Modeling **correlation functions**

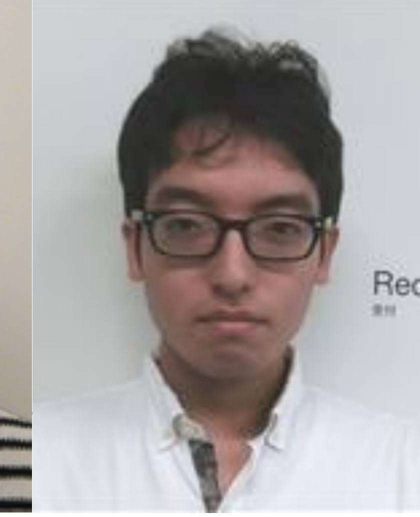
- Fitting formulae have been used for correlation functions, which leads systematics in the model.
- We use **Dark Emulator** to accurately model correlation functions.

Modeling **galaxy occupation in dark matter halos**

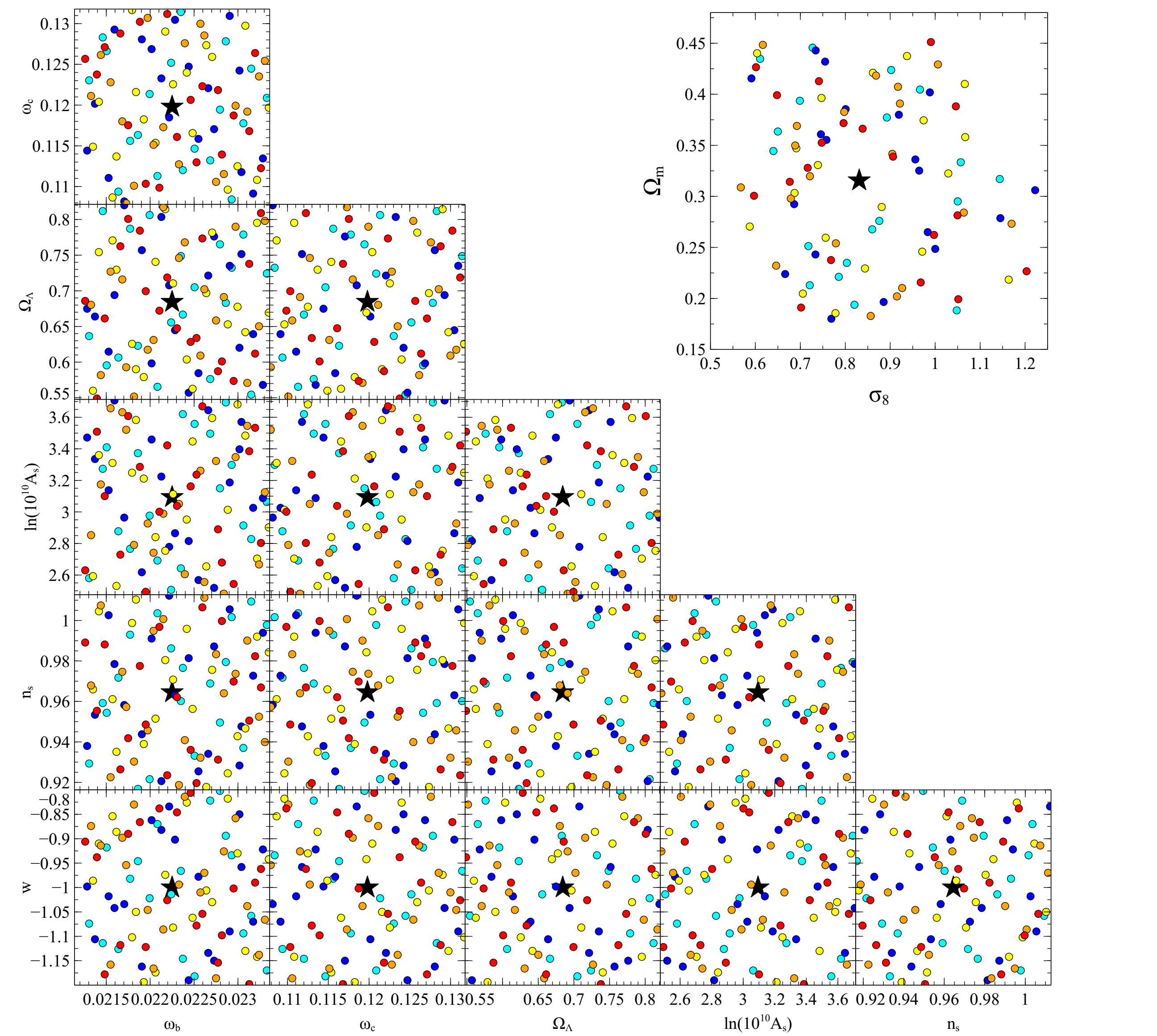
- Galaxy physics is not fully understood yet.
- We carry out **Cosmology Challenge** to test the robustness of our model against possible various galaxy occupation patterns.

Modeling Correlation Functions by Dark Emulator



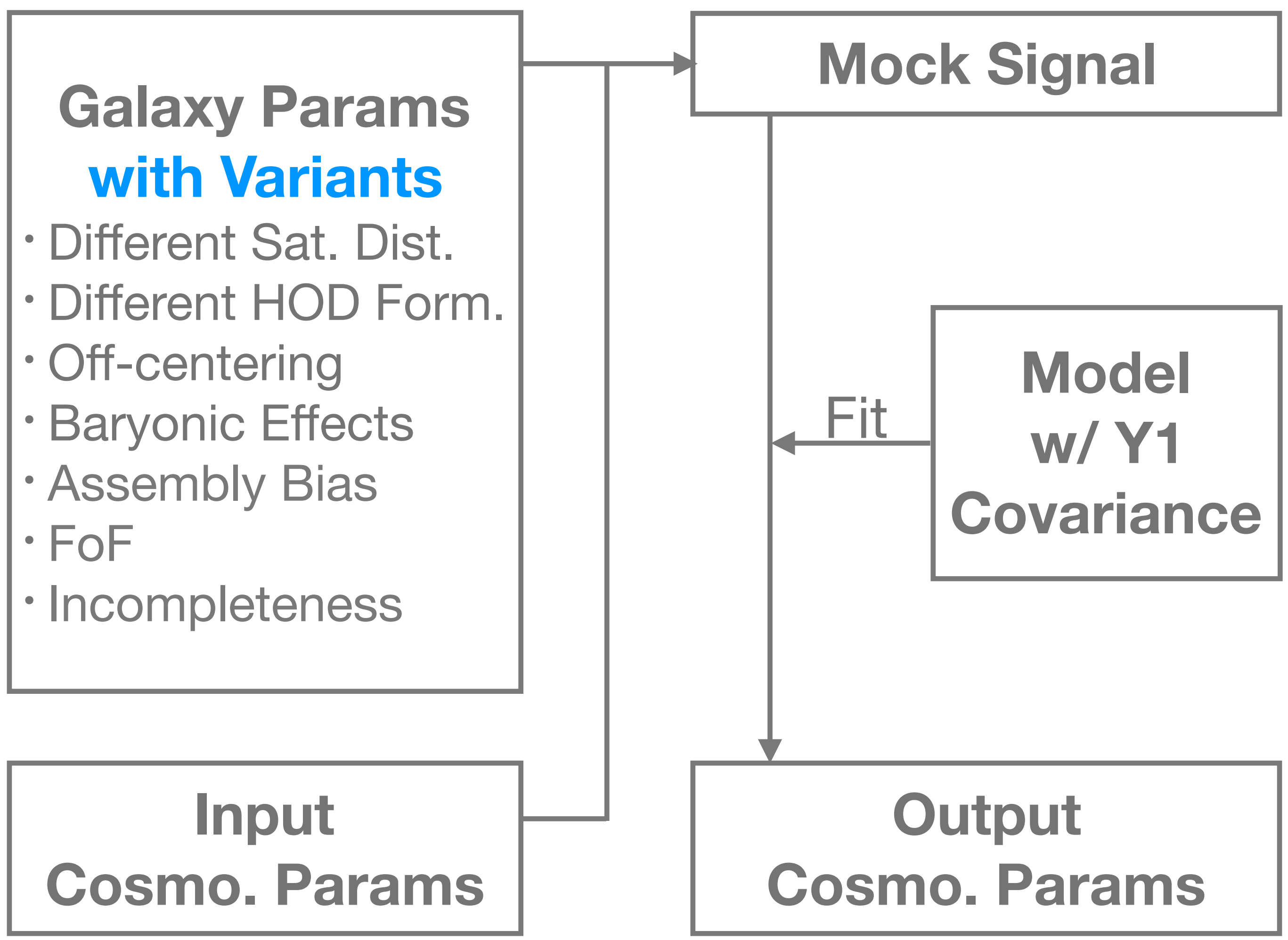


- Run N-body simulations under 101 sets of cosmological parameters. $\overrightarrow{C} = (\omega_b, \omega_c, \Omega_\Lambda, A_s, n_s, w)$
- Measure correlation functions, $\xi_{hh}(x; \overrightarrow{C})$ and $\xi_{hm}(x; \overrightarrow{C})$.
- Interpolate correlation functions across the cosmological parameter sets using a Gaussian process.
- Achieved an accuracy better than 2%.

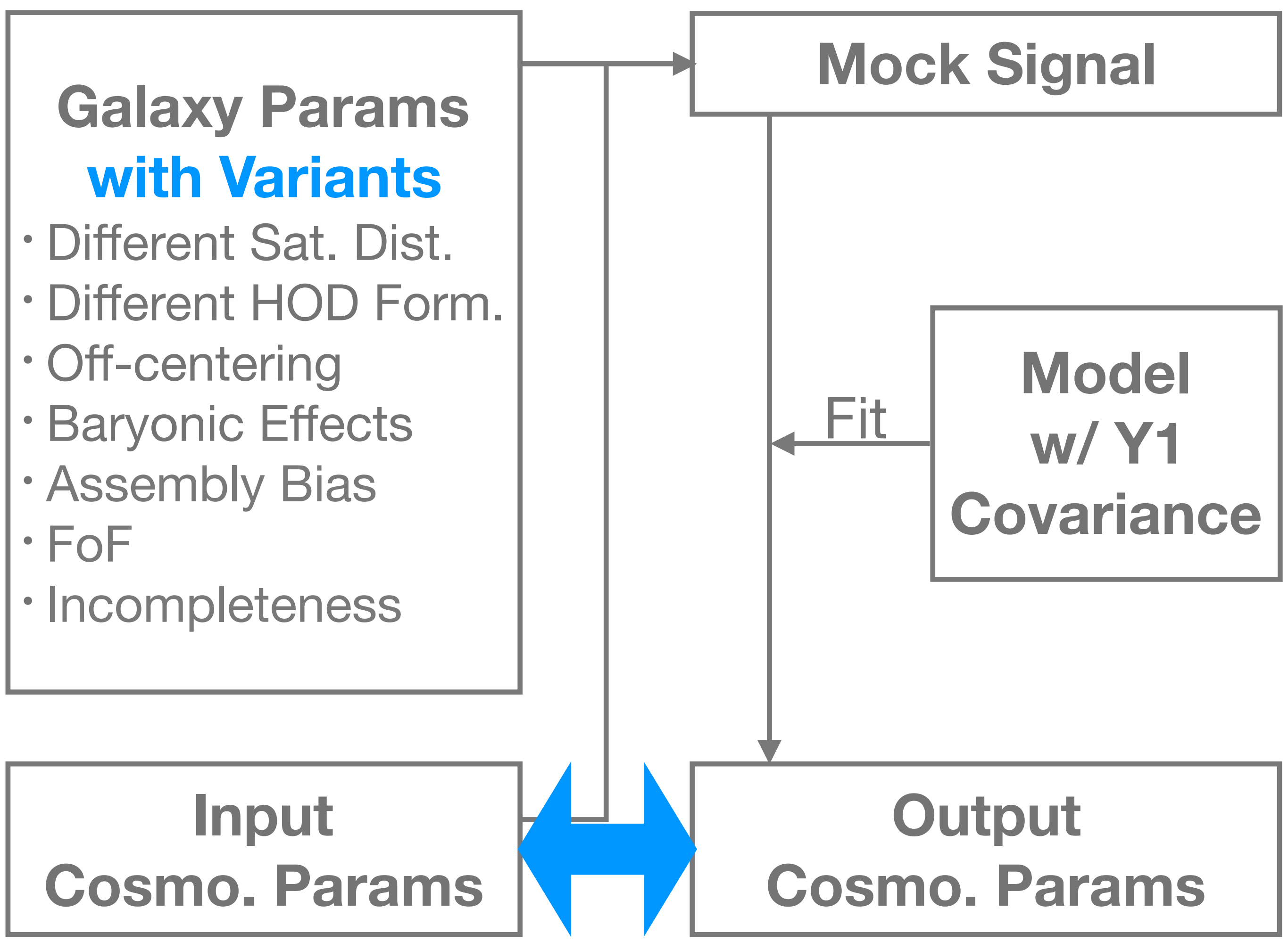


Nishimichi et al. (2019)

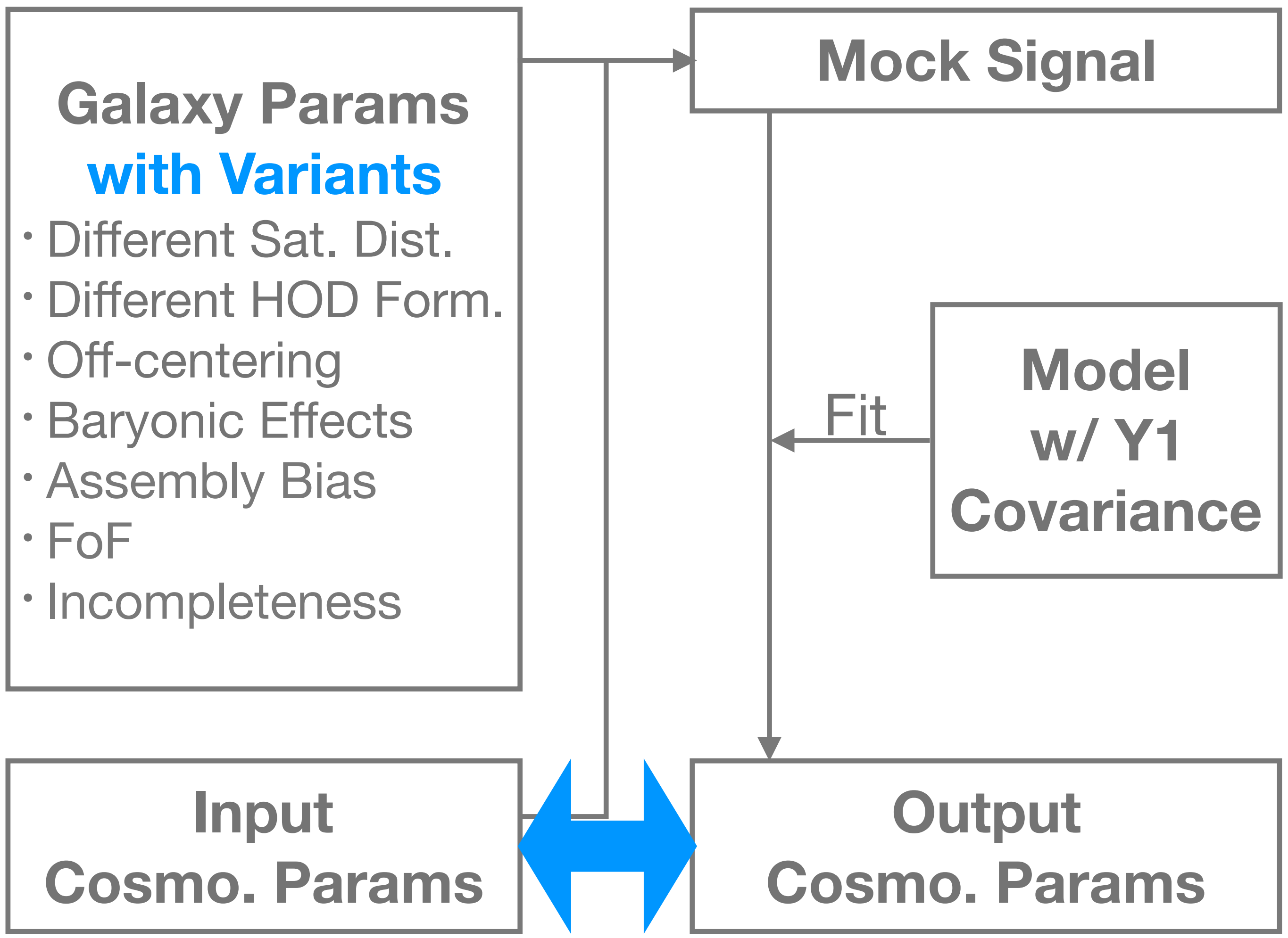
Testing Model Robustness: Cosmology Challenge

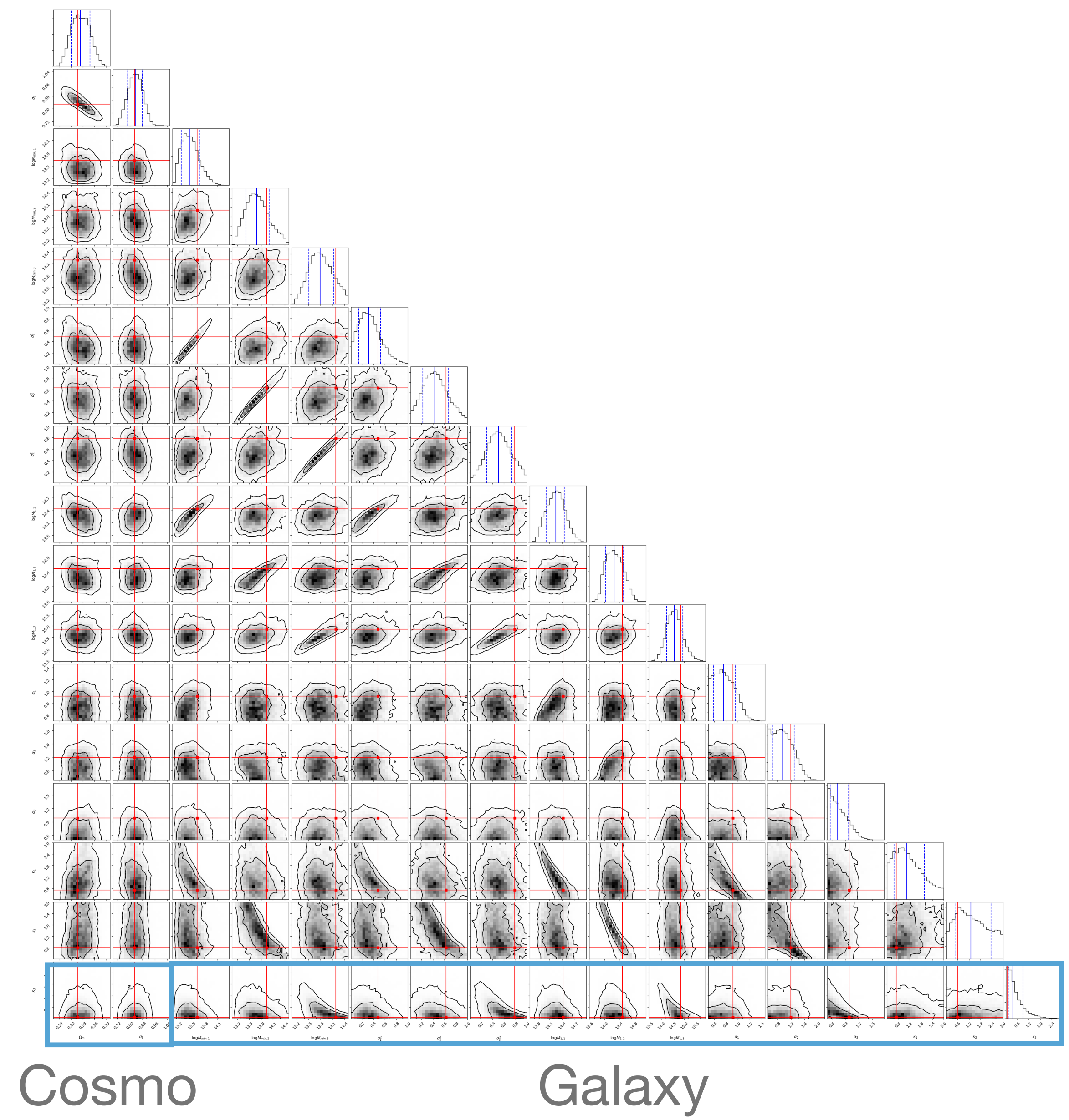


Testing Model Robustness: Cosmology Challenge

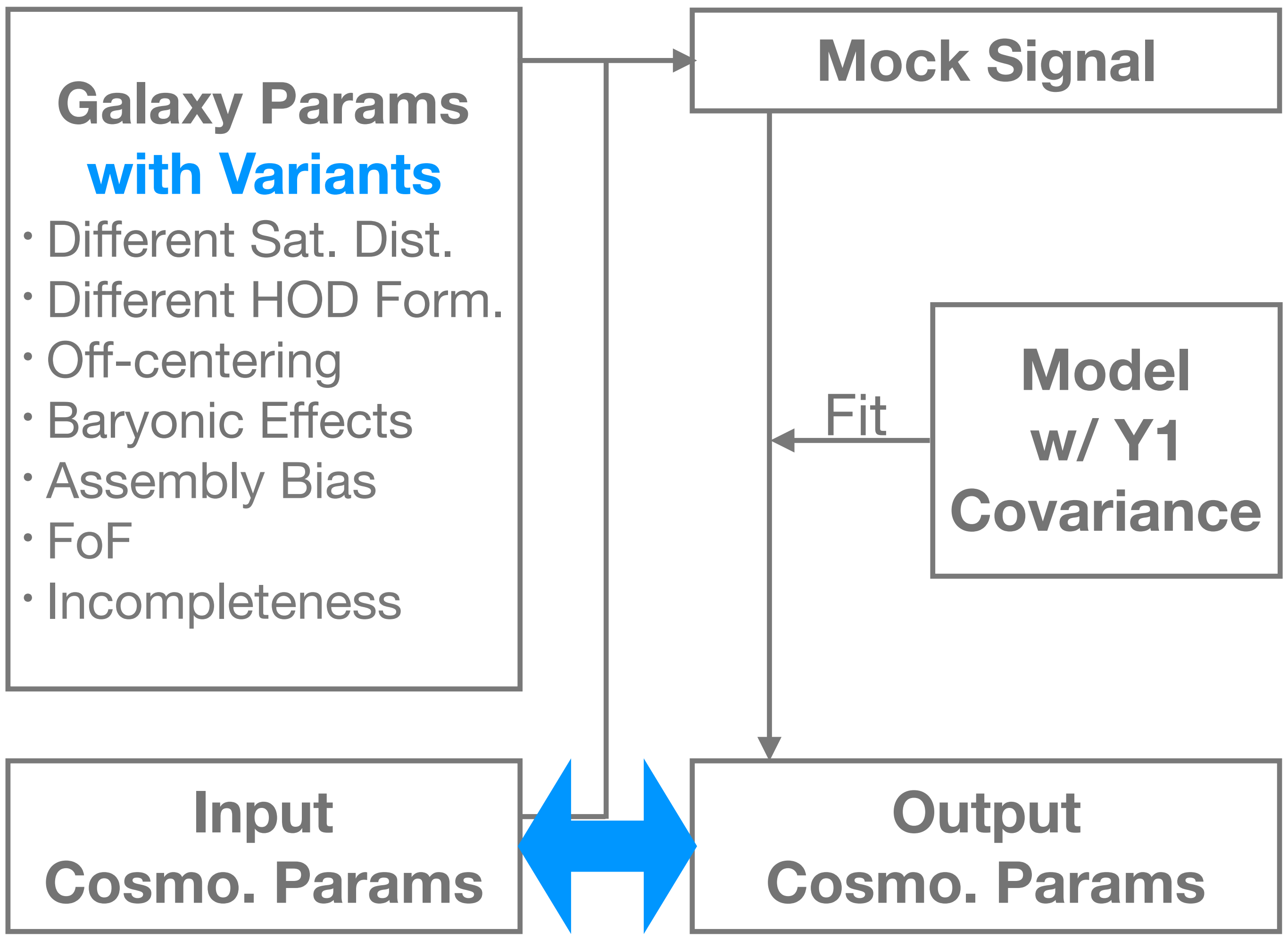


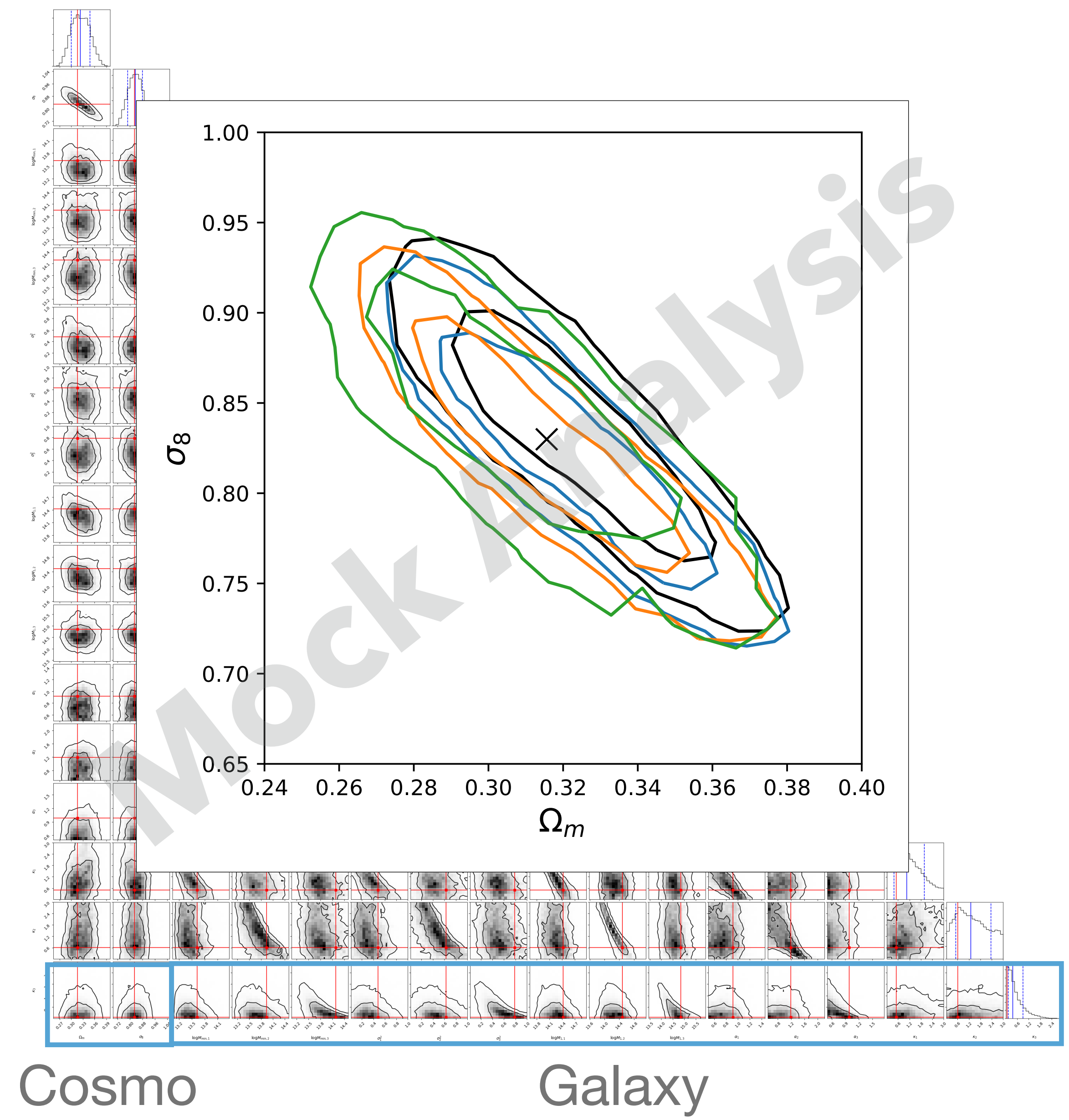
Testing Model Robustness: Cosmology Challenge

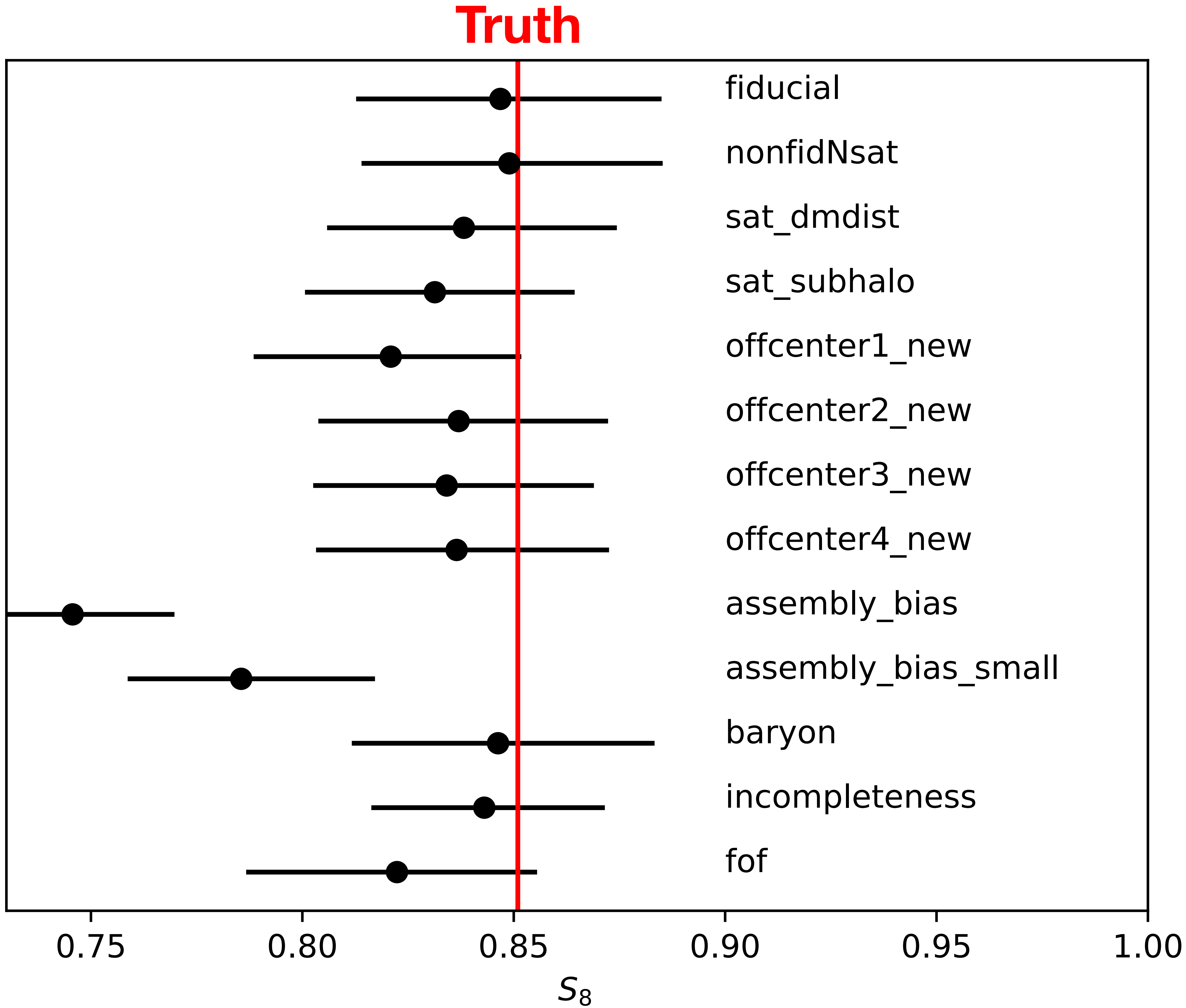




Testing Model Robustness: Cosmology Challenge

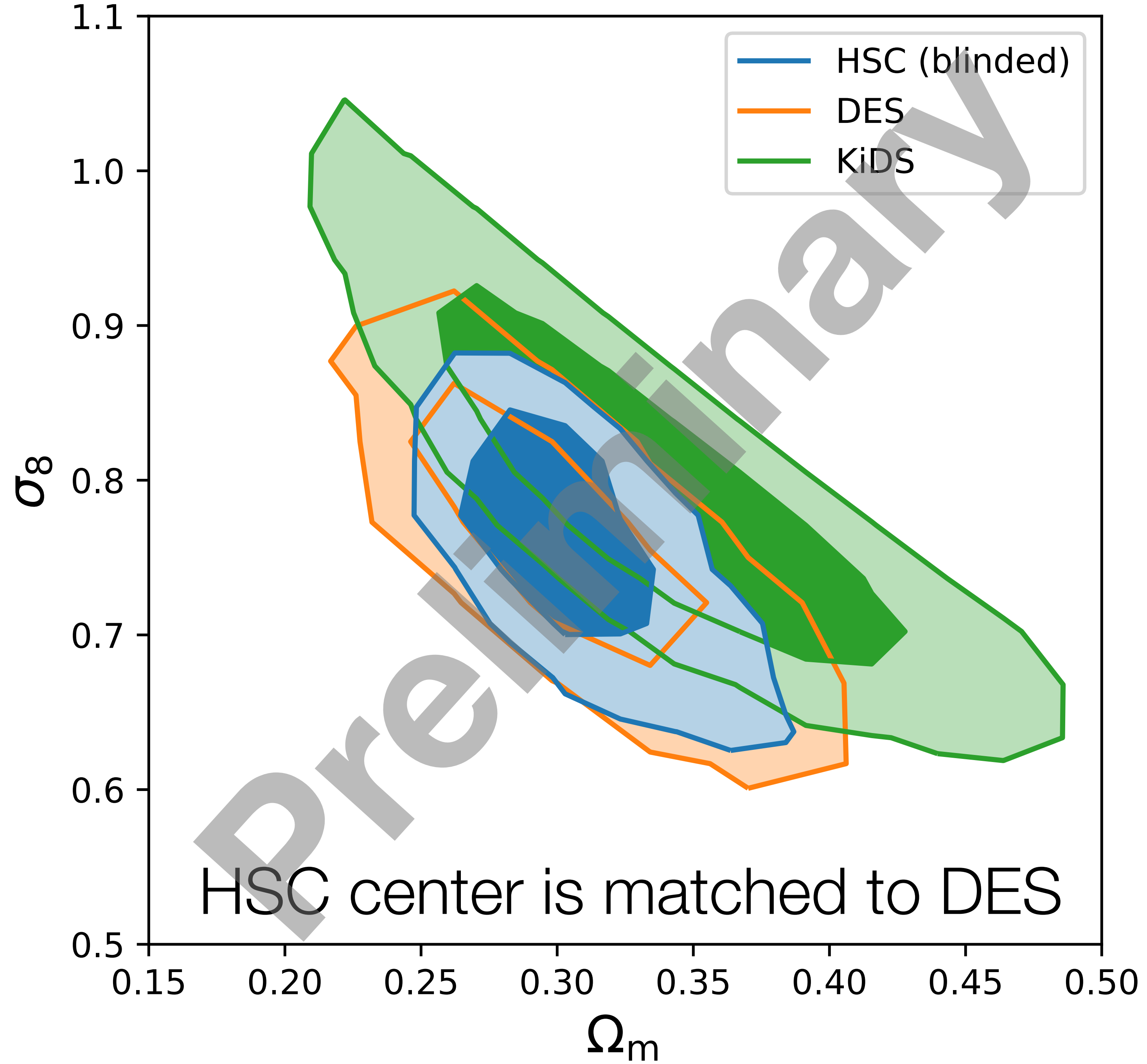






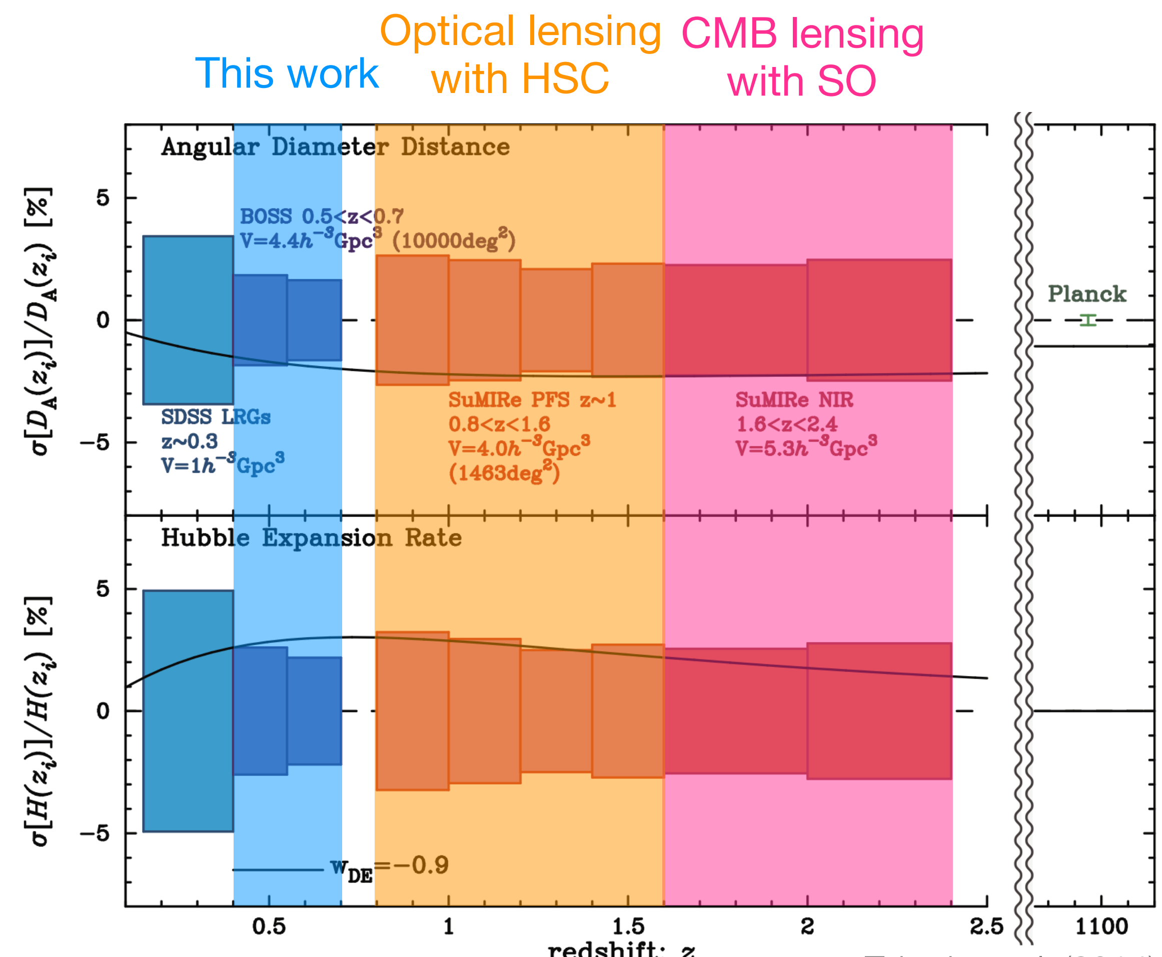
Truth
fiducial
nonfidNsat
sat_dmdist
sat_subhalo
offcenter1_new
offcenter2_new
offcenter3_new
offcenter4_new
assembly_bias
assembly_bias_small
baryon
incompleteness
fof
0.75
0.80
0.85
0.90
0.95
1.00
S_8

The cosmology challenge is done.
Stay tuned for cosmological constraints!

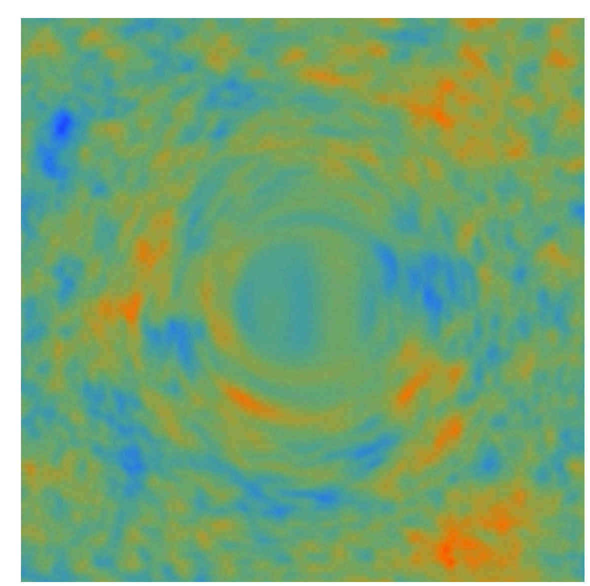


What Can Be Done with Prime Focus Spectrograph?

- PFS will enable us to push the redshift range from $z \sim 0.5$ to $z \sim 2.4$.
- Constraints on the evolution of w.
- HSC optical lensing can be used for ELGs at $z < 1.5$.
- Simons Observatory (SO) will enable CMB lensing measurement of ELGs at $z > 1.5$.



Takada et al. (2014)


Credit: W. Hu

Summary

- The combined probe of galaxy-galaxy clustering and lensing is a powerful cosmological probe.
- The combined analysis of SDSS-III/BOSS and HSC 1st year data is going on.
- We built a robust model of the clustering and lensing signal. Stay tuned for cosmology results.
- In the PFS era, we can cover the redshift range of $0.6 < z < 2.5$.