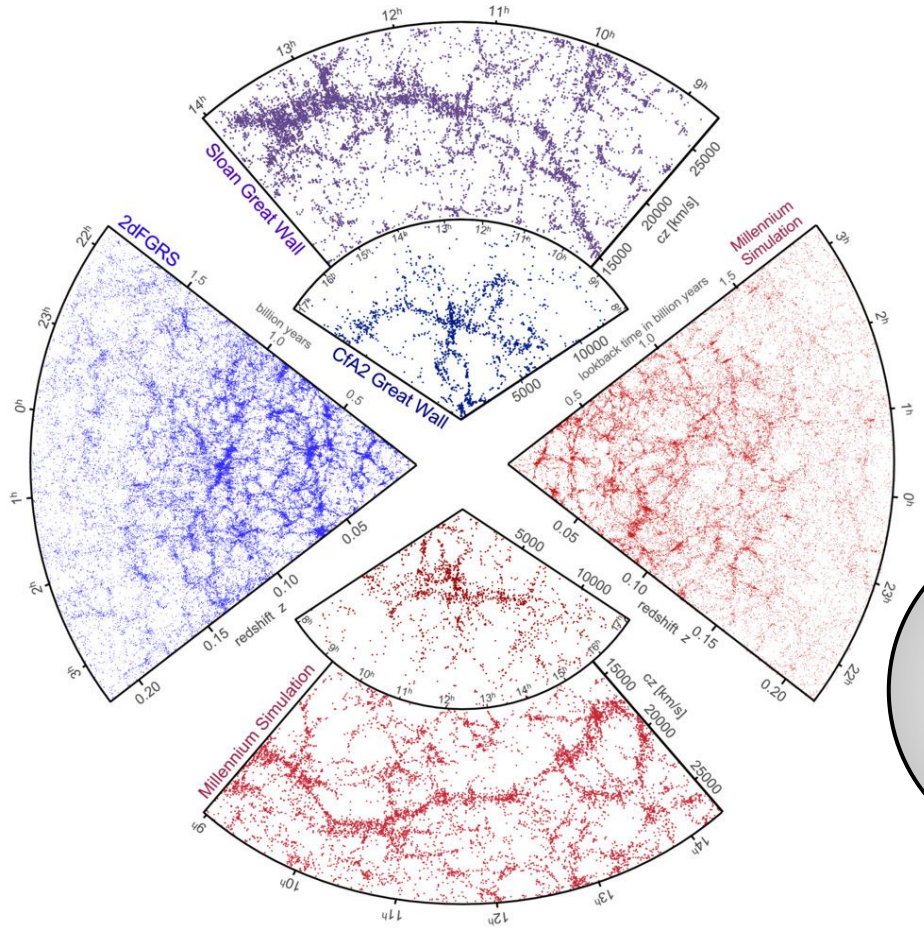
How well does galaxy clustering constrain cosmology and assembly bias?

By Sergio Contreras
With the collaboration of Raul Angulo

Introduction



Dark Energy

A few photons

Neutrinos?

Mass

~31%

Dark Matter

~26%

Baryons

~5%

Aim of the project

1. Constraint cosmological information from galaxy clustering

2. Constraint other galaxy formation-LSS properties from galaxy clustering, such as galaxy assembly bias

3. Determine which clustering statistics, and on which scales, continents cosmological and LSS information

Constraining cosmology and LSS information with galaxy clustering

Generate a dark matter simulation at a fix cosmology

Create a mock galaxy catalogue

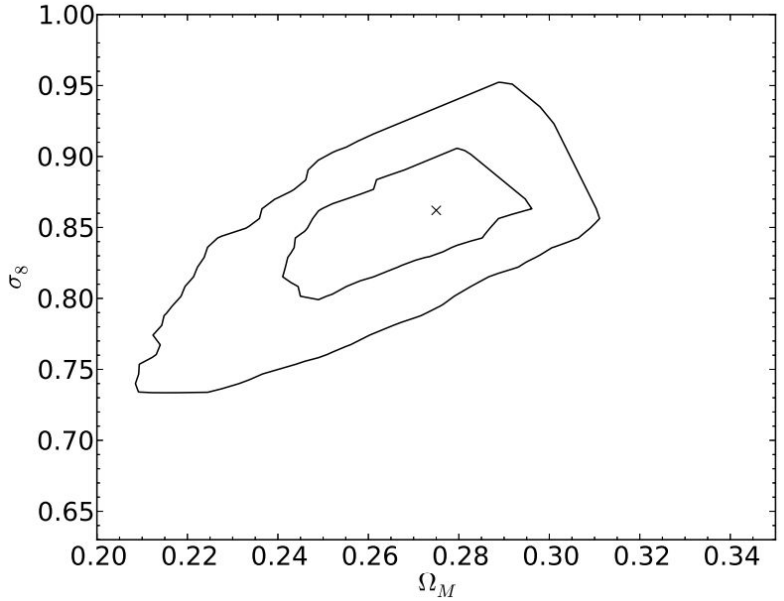
Compare it galaxy clustering to observations

It is similar (1σ)?

No

Yes

Valid Model(s)



Monte Carlo Approach

Plot from Simha & Cole (2013)

Constraining cosmology and LSS information with galaxy clustering

Generate a dark matter simulation at a fix cosmology

Create a mock galaxy catalogue

Compare it galaxy clustering to observations

Difficult

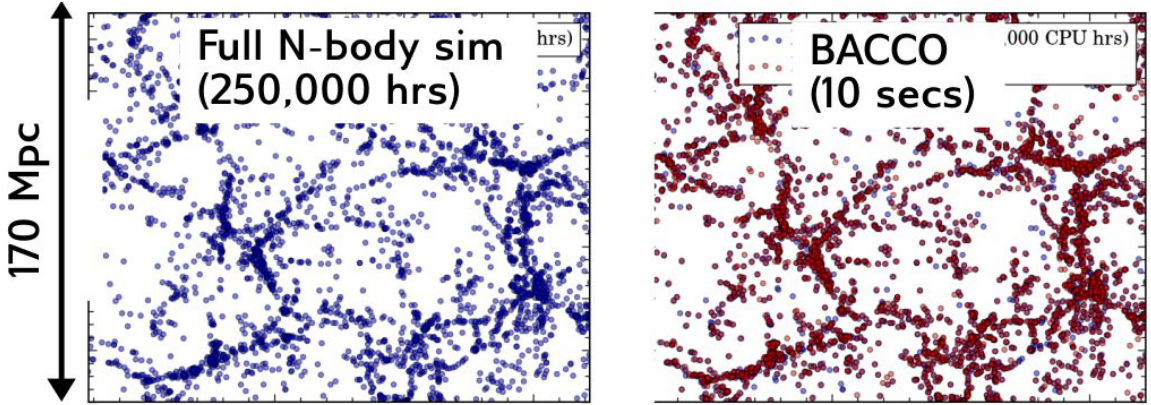
Simple

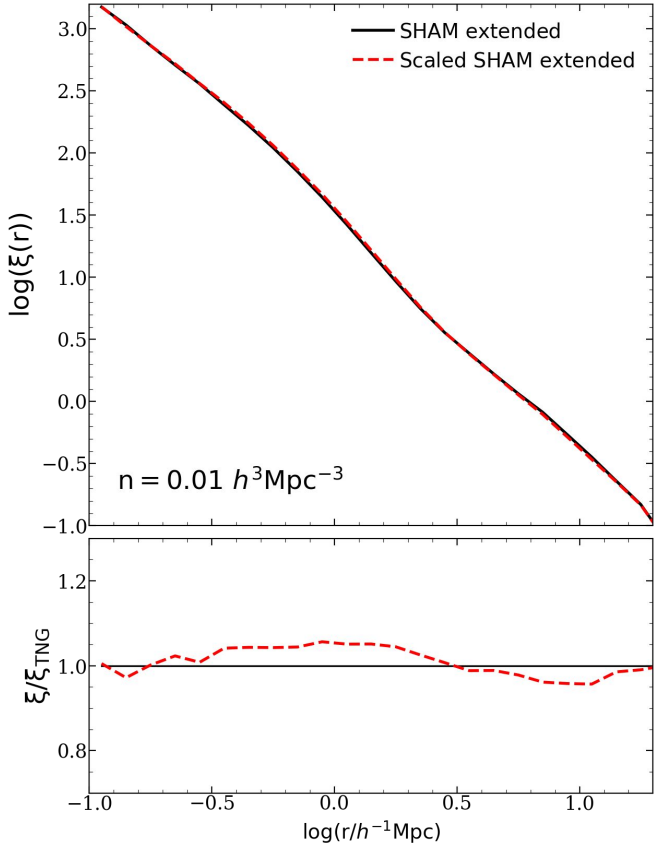
- Nested sampling
- Iterative emulator Pellejero-Ibañez+2020

- New public efficient clustering codes
- Public observational covariance matrices
- New alternatives to the classic MCMC

The Scaling technique

Generate a dark matter simulation at a fix cosmology





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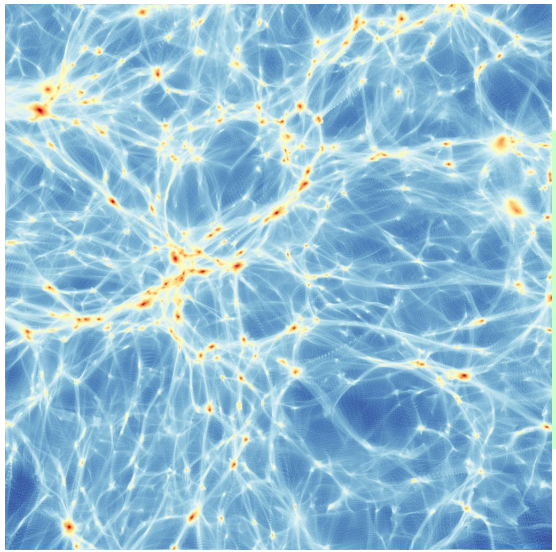
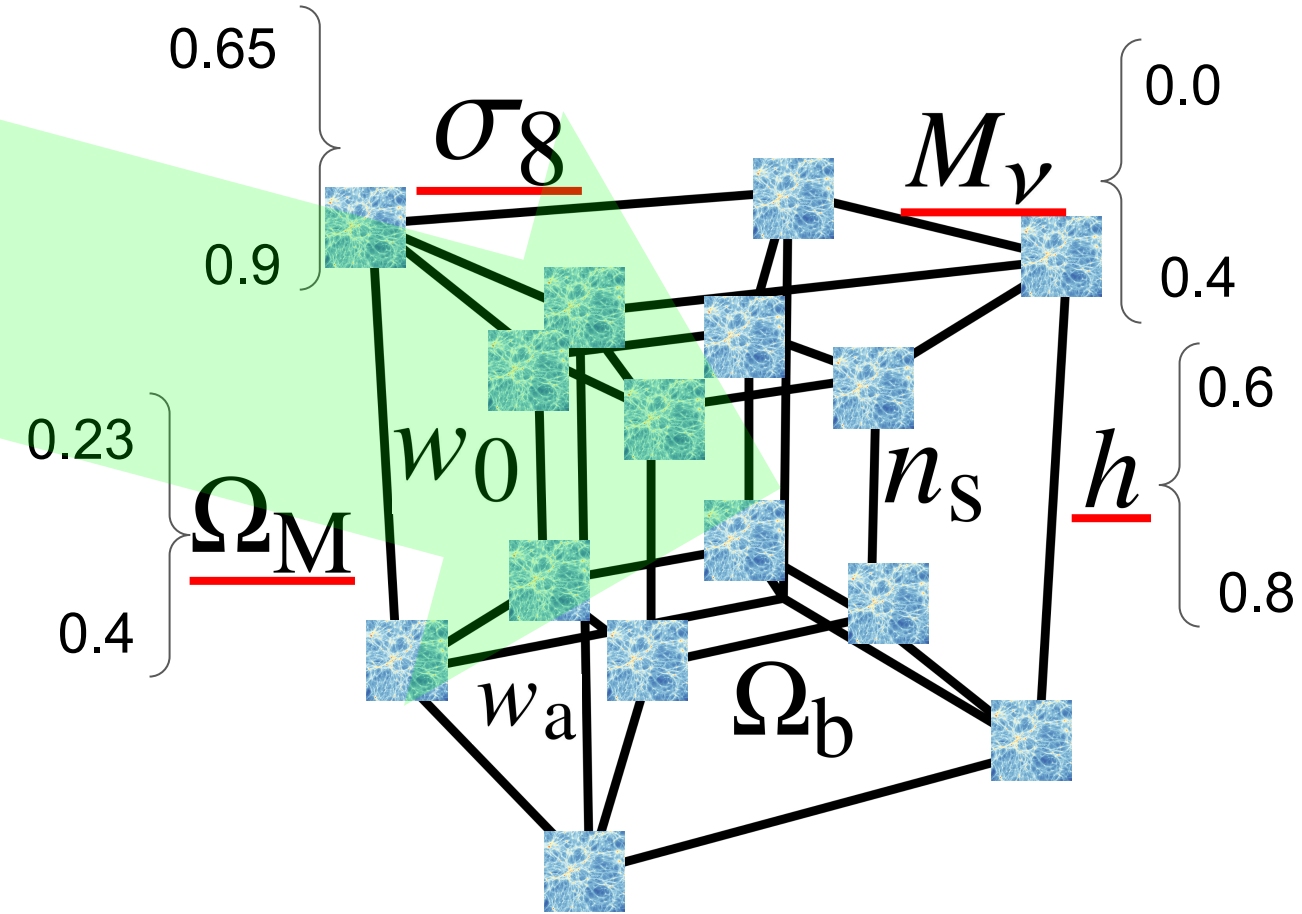
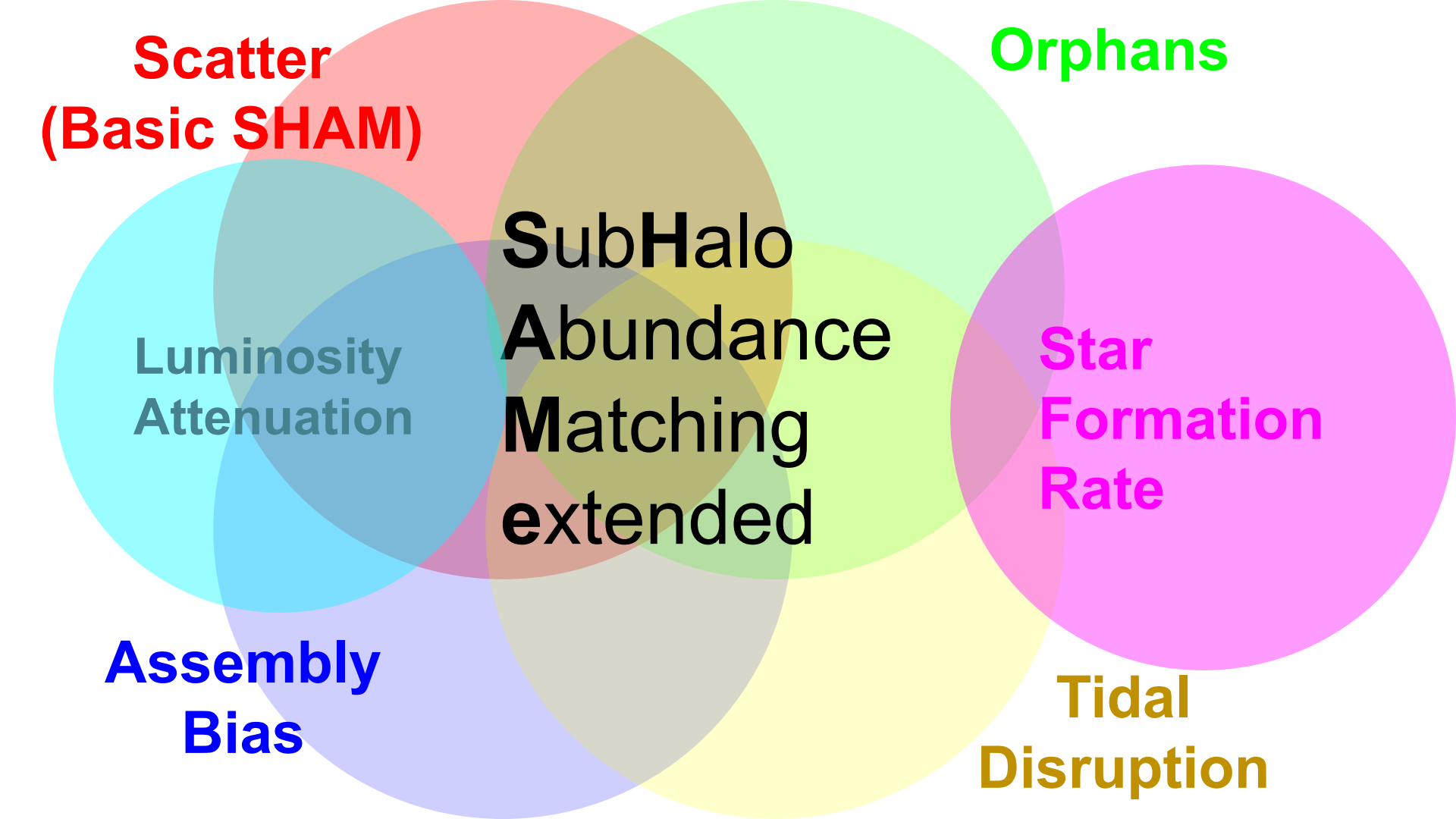





Scatter
(Basic SHAM)
Orphans
Luminosity
Attenuation
SubHalo
Abundance
Matching
extended
Star
Formation
Rate
Assembly
Bias
Tidal
Disruption

Our Approach

1) Create hundreds of N-Body simulations

2) Populate them with galaxies

3) “Interpolate” between the different simulations

Use high resolution scaled simulations

~~Fewer simulations Smaller simulations~~

~~Less physical motivated mocks~~

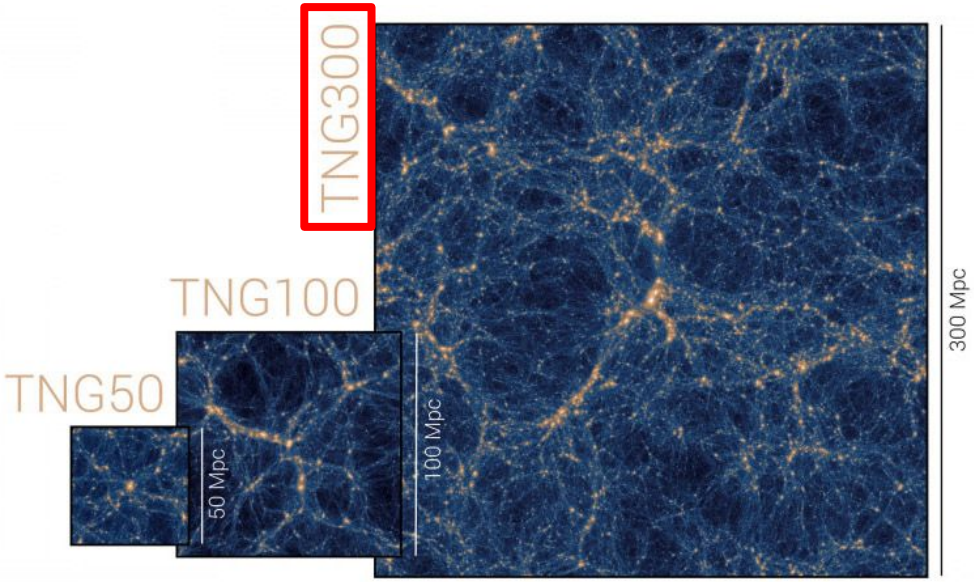
~~Difficult to interpolate~~

Many, MANY large simulations

State-of-the-art galaxy population model

Negligible interpolation errors

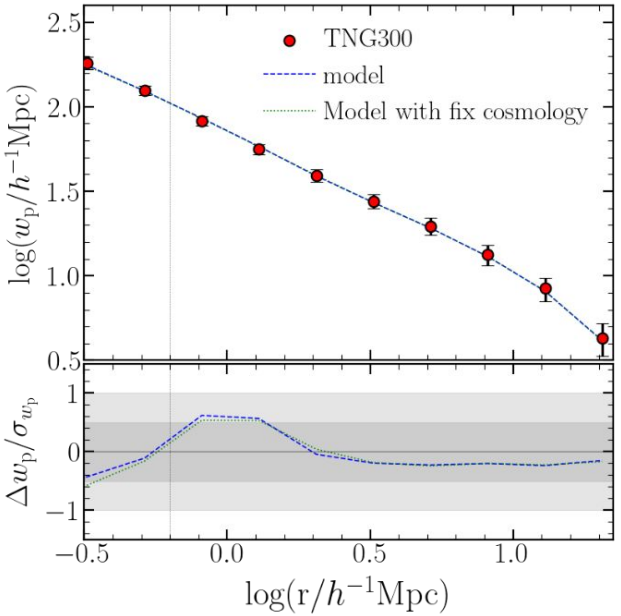
Target sample

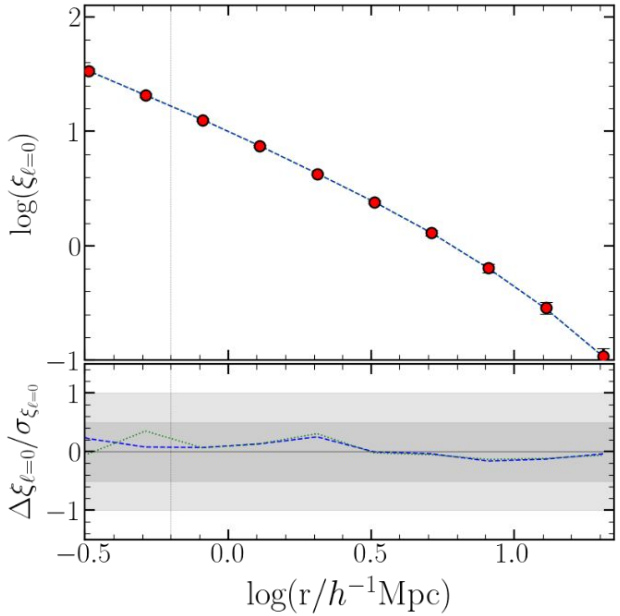


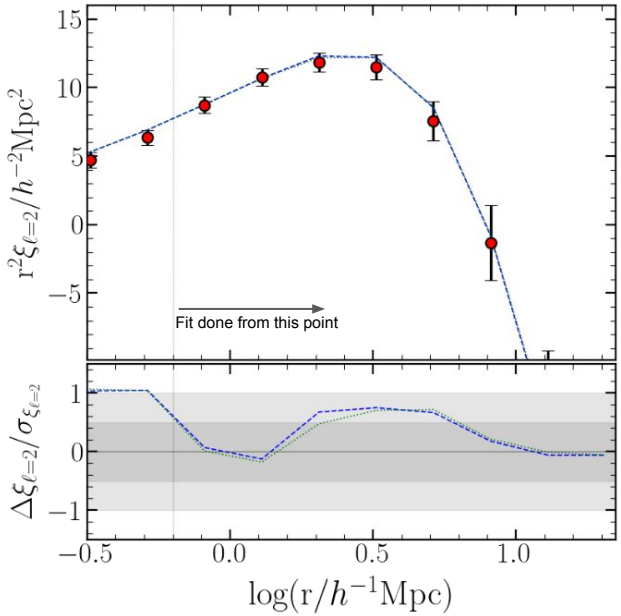
L - GALAXIES

- 500 Mpc/h (~740 Mpc), N=1536^3 particle simulations
- Fix IC
- TNG Cosmology
- Fiducial model based on Henriques et al. 2015
- 4 other extreme physical implementations

SHAMe Performance



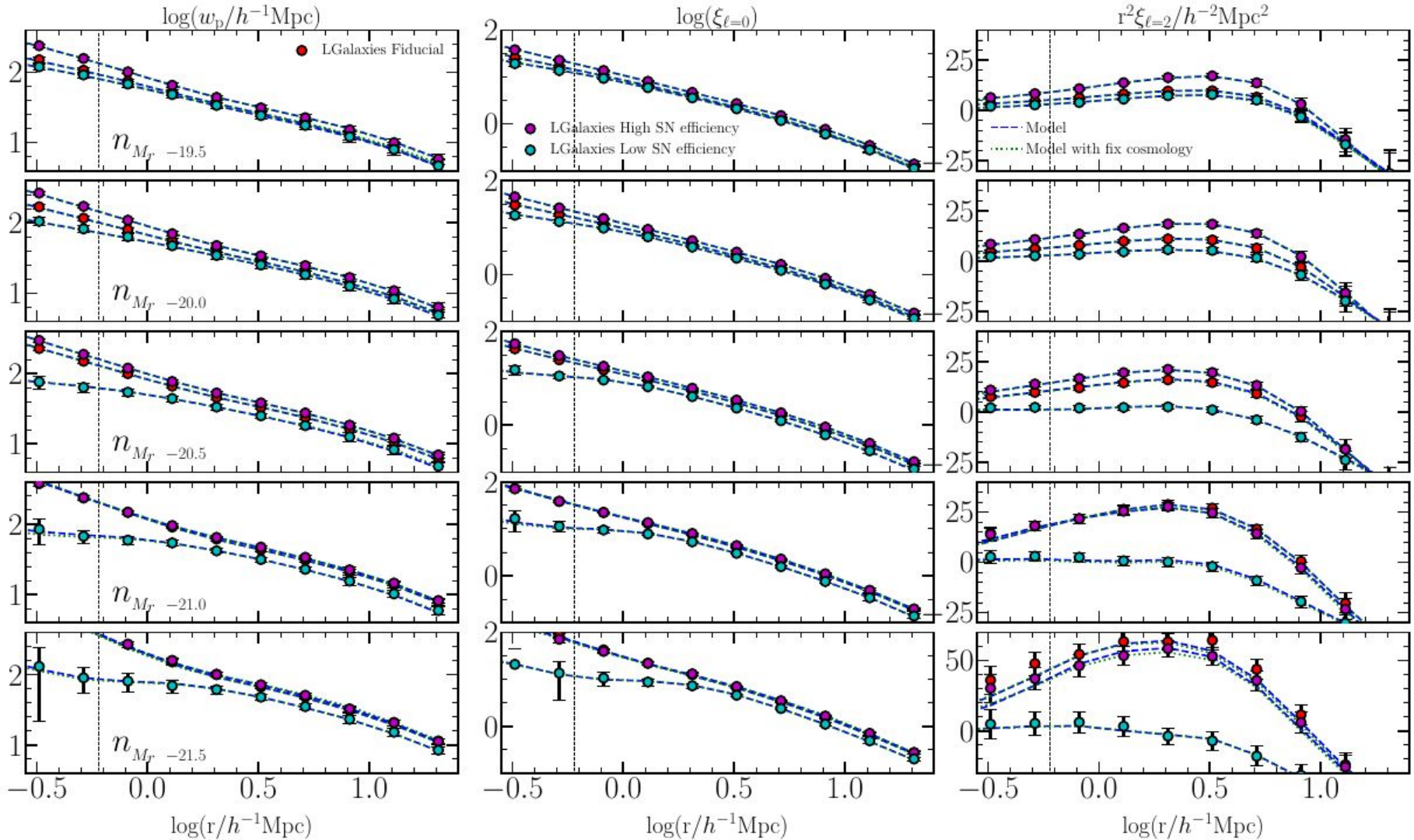




Best-fit model varying cosmological and astrophysical parameters

Model with cosmological parameters fixed at TNG cosmology

TNG at z~0.1


log(w_p/h^{-1}Mpc)
log($\xi_{\ell=0}$)
$r^2\xi_{\ell=2}/h^{-2}$Mpc^2
LGalaxies Fiducial
LGalaxies High SN efficiency
LGalaxies Low SN efficiency
Model
Model with fix cosmology
n_{M_r} −19.5
n_{M_r} −20.0
n_{M_r} −20.5
n_{M_r} −21.0
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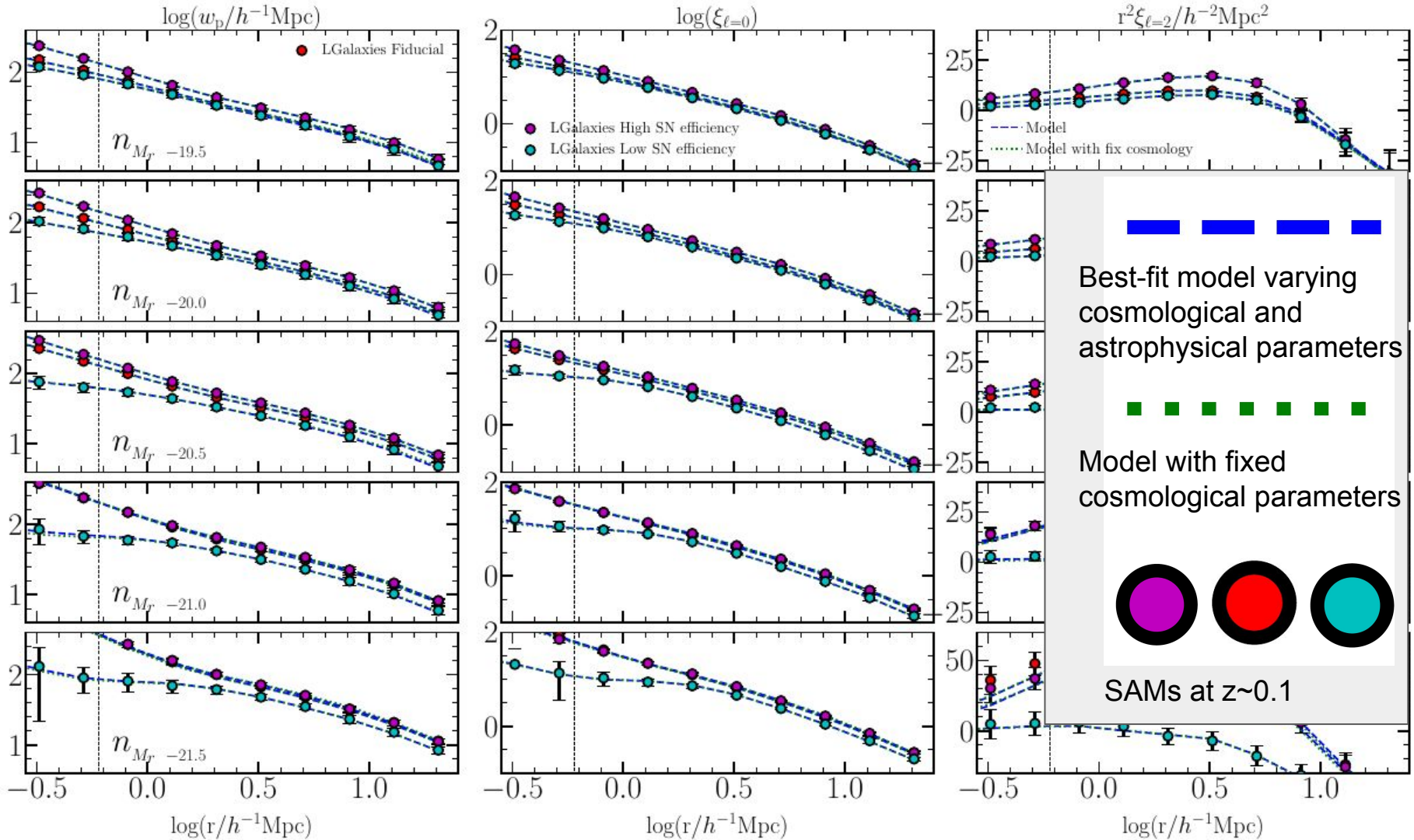
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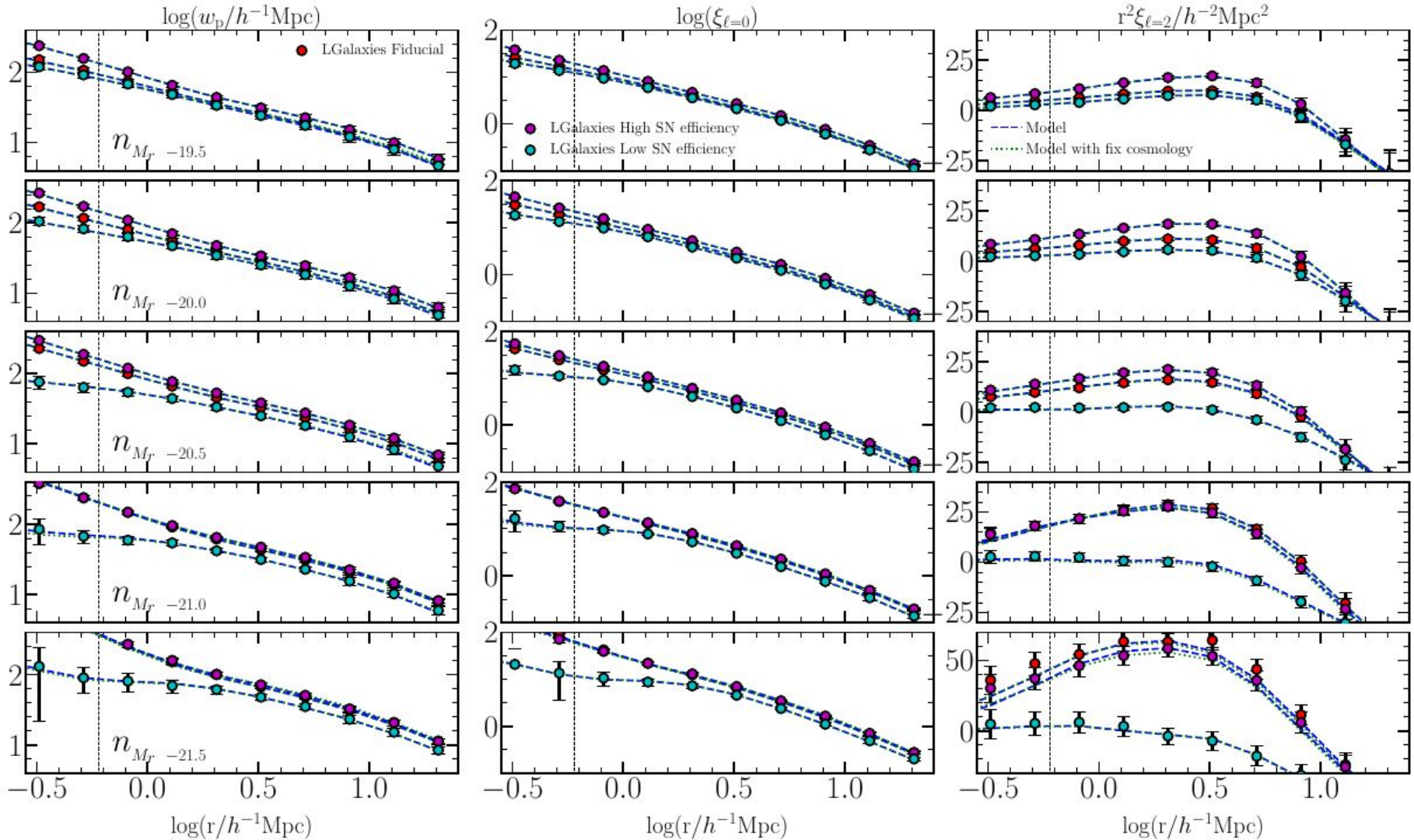
Best-fit model varying cosmological and astrophysical parameters
Model with fixed cosmological parameters
SAMs at z~0.1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log(r/h^{-1}Mpc)
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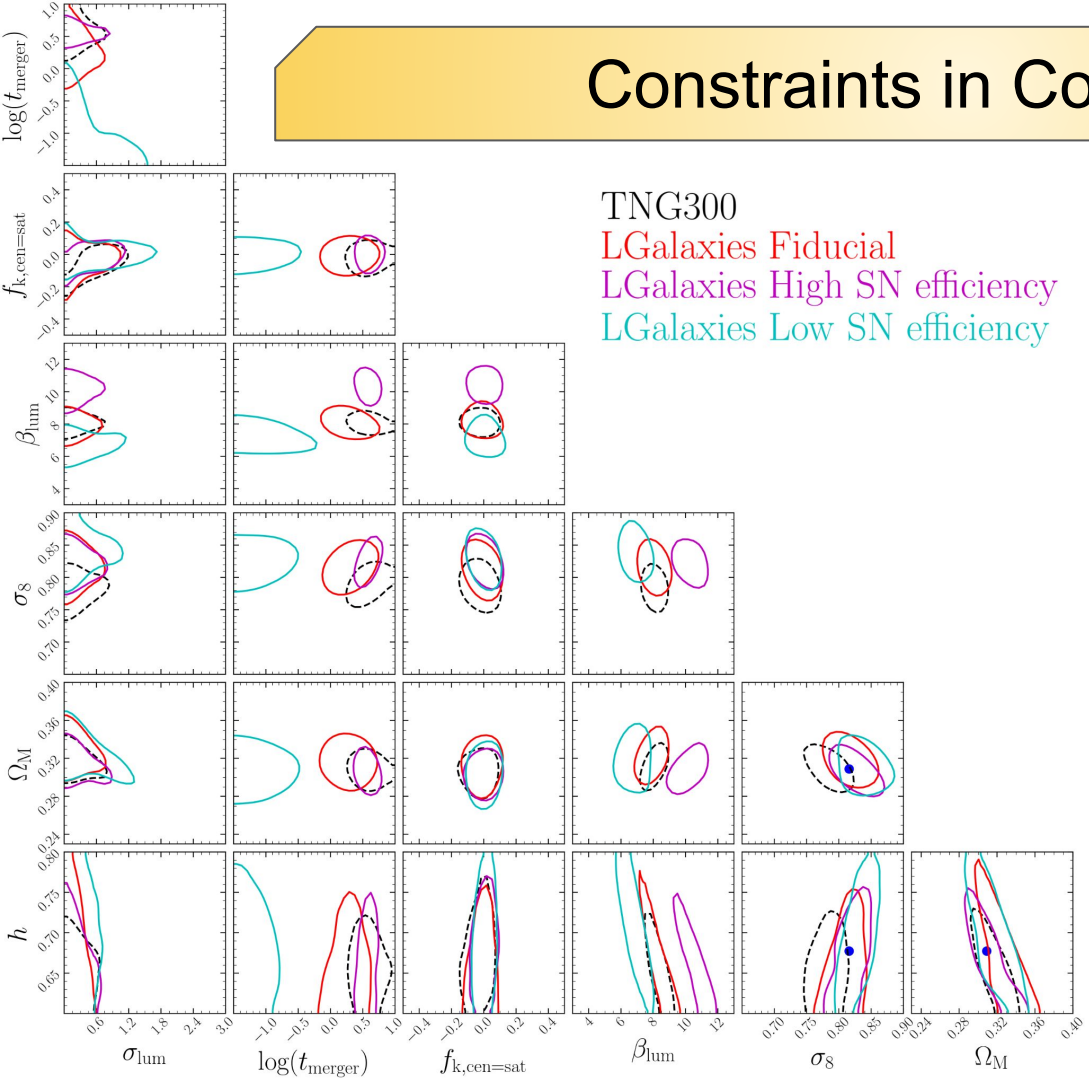
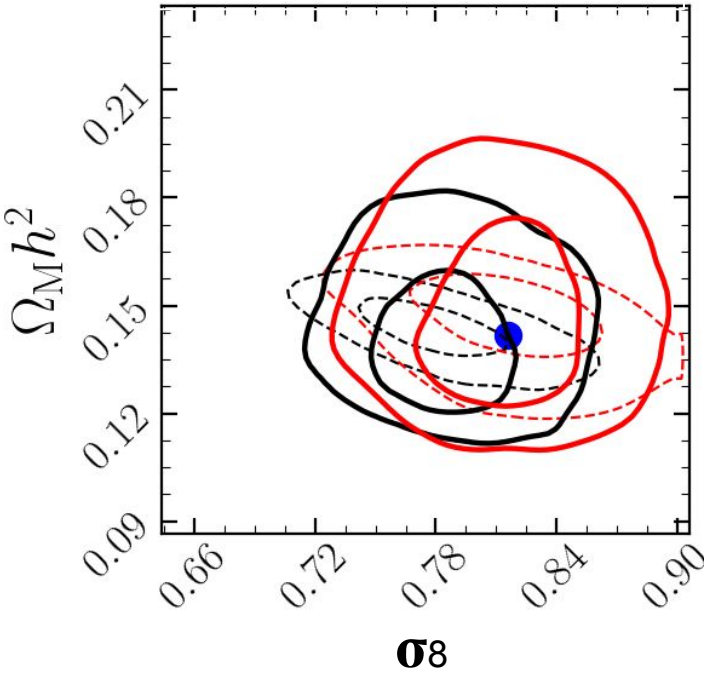
Constraints in Cosmology

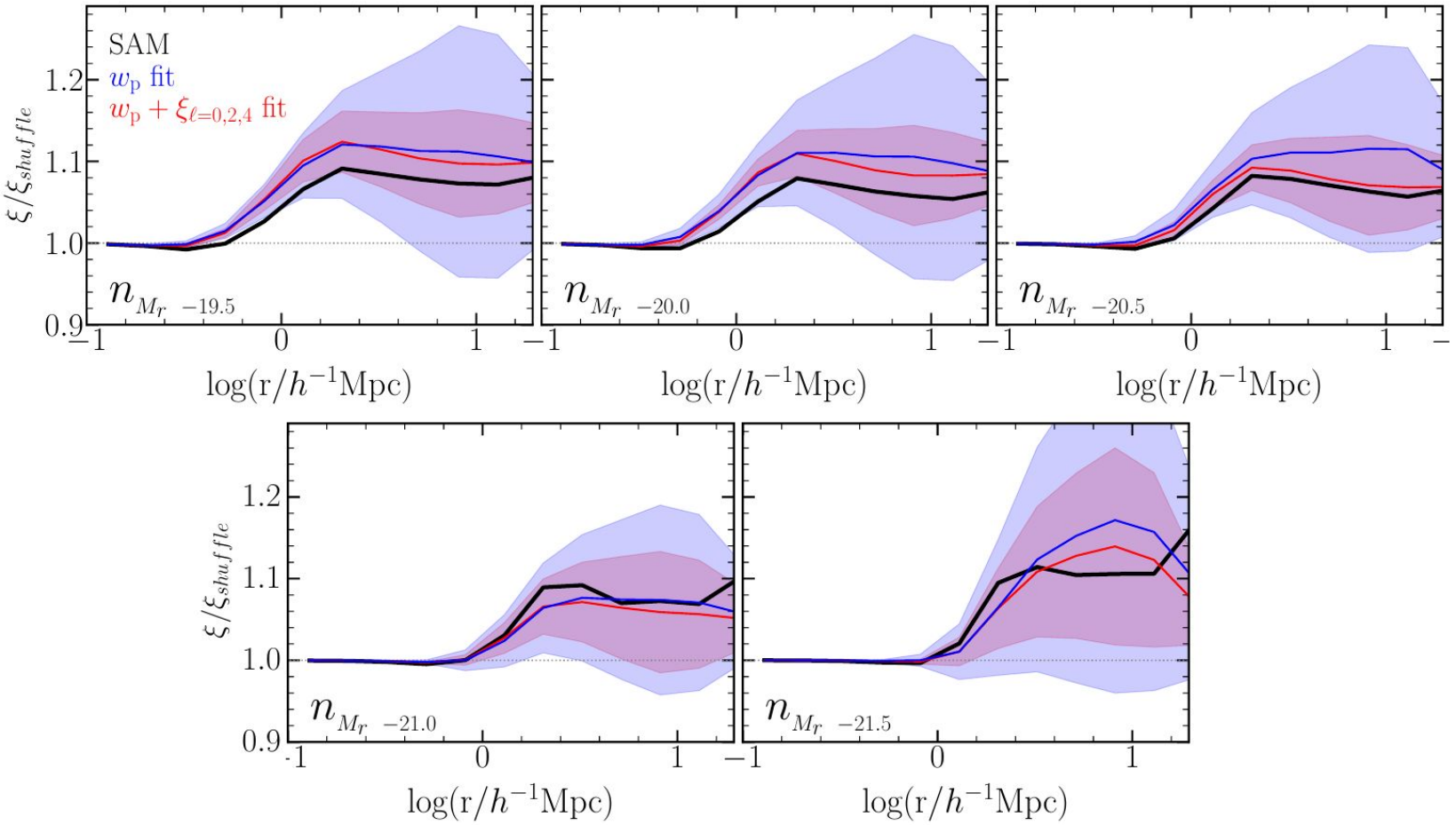
TNG300
LGalaxies Fiducial
LGalaxies High SN efficiency
LGalaxies Low SN efficiency



Full Model
Fix h



Constraints in Assembly bias



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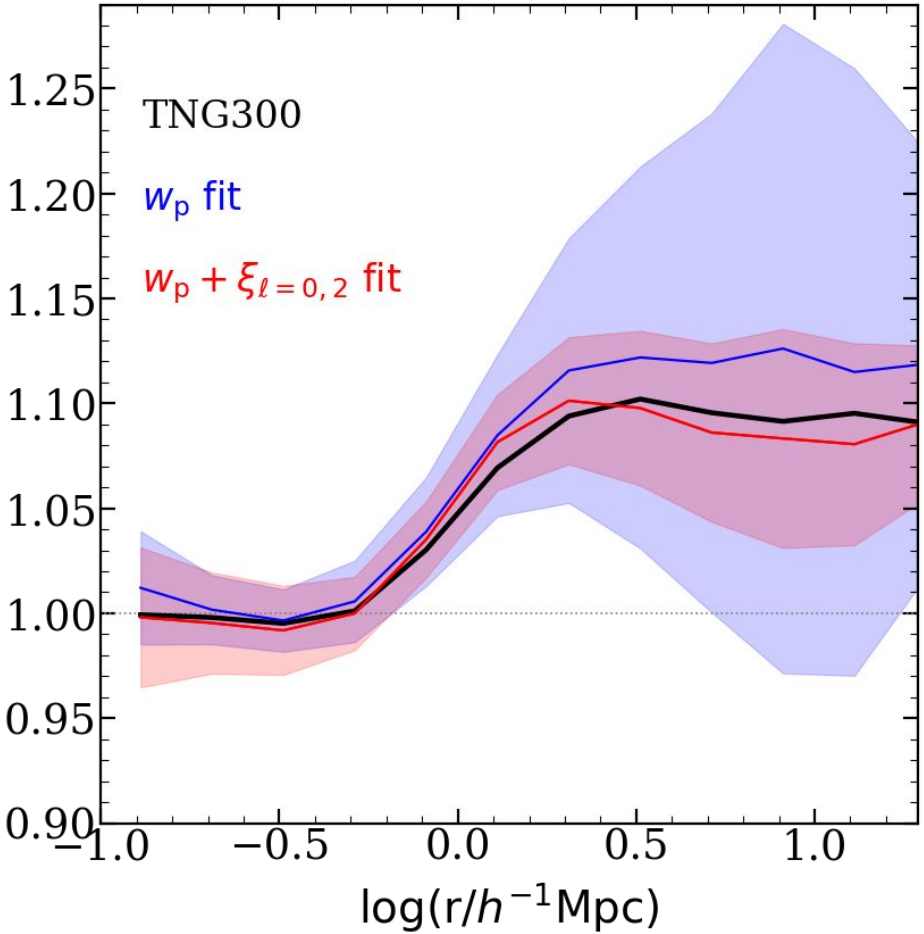

- We can correctly predict the right level of assembly bias for all models and number densities
- Wp alone can constrain the right level of assembly bias, but it can not discard a zero assembly bias level.
- Using the multipoles, we can constrain a positive level of assembly bias for all models

Take Away Message

- SHAMe galaxy population model can reproduce the expected galaxy clustering in real and redshift space at small scales and with a low number of free parameters.

- Combining the SHAMe model with the scaling technique, we can recover the cosmology and assembly bias from and hydrodynamic simulation & SAMs only using galaxy clustering.

- Observational constraints coming soon!