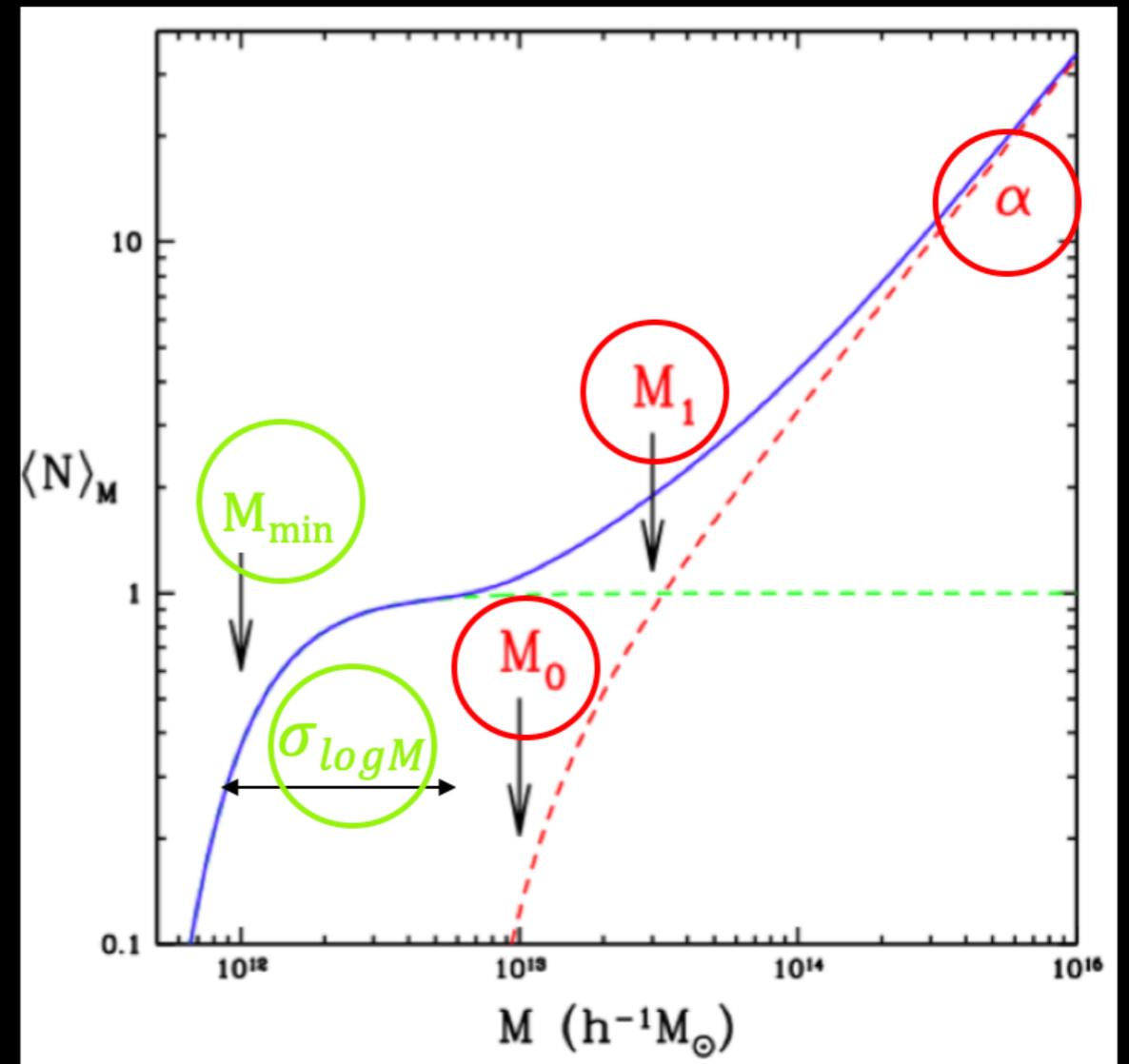
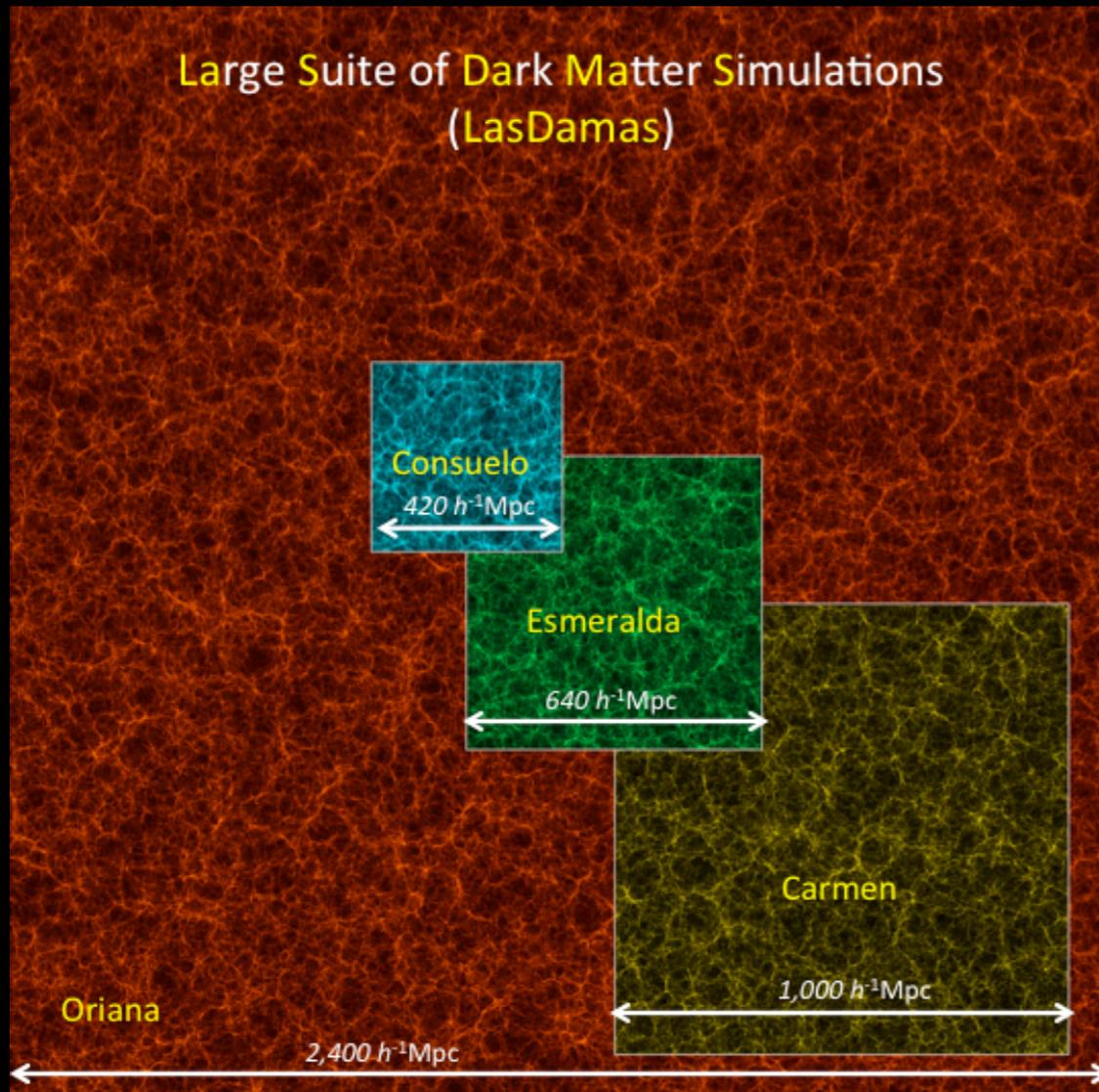


Taking Halo Modeling to the Next Level

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Mock Innsbruck 2020

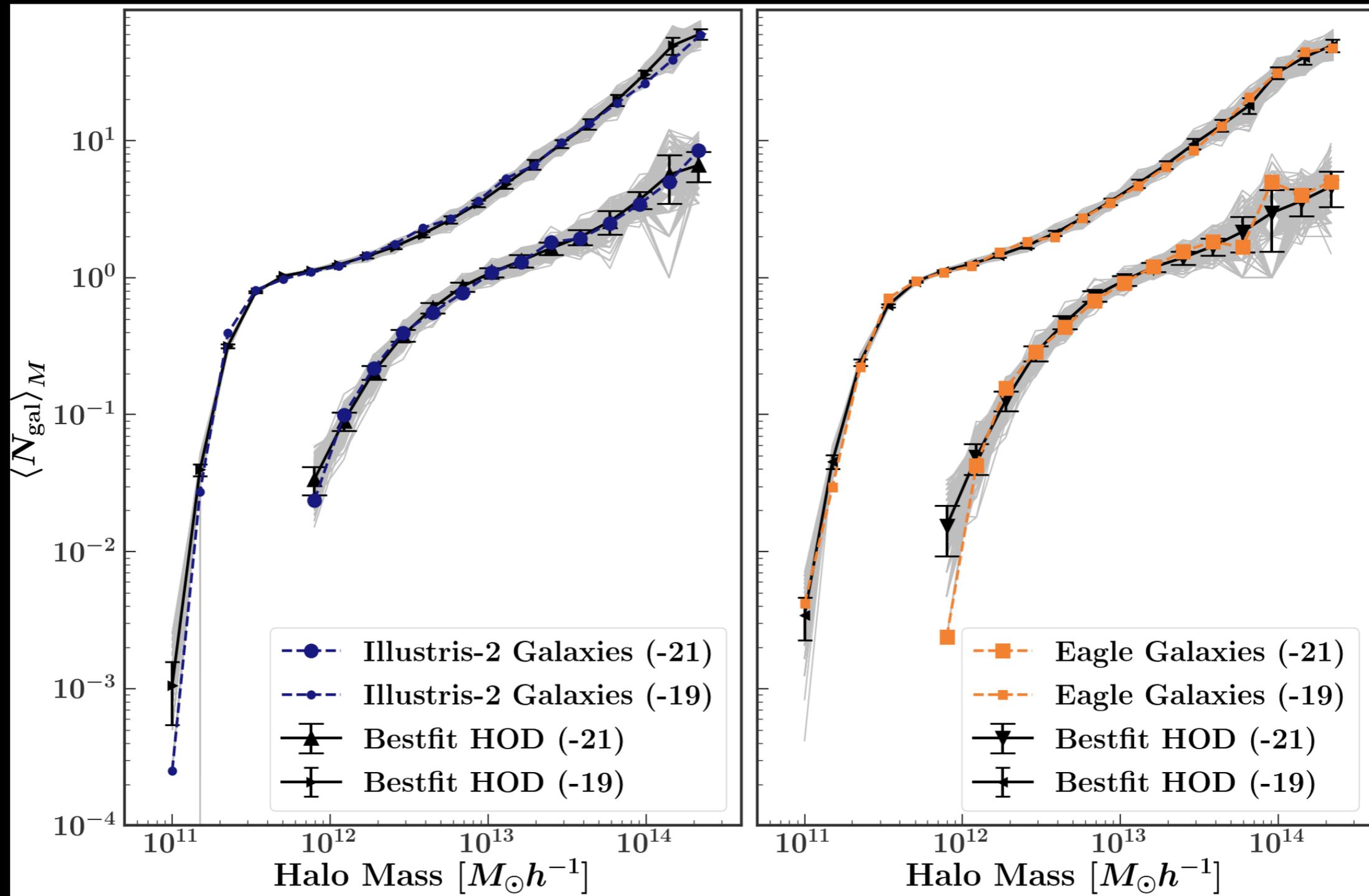
Motivation



Can we ignore baryonic physics? Do DMO simulations produce the correct halo population?

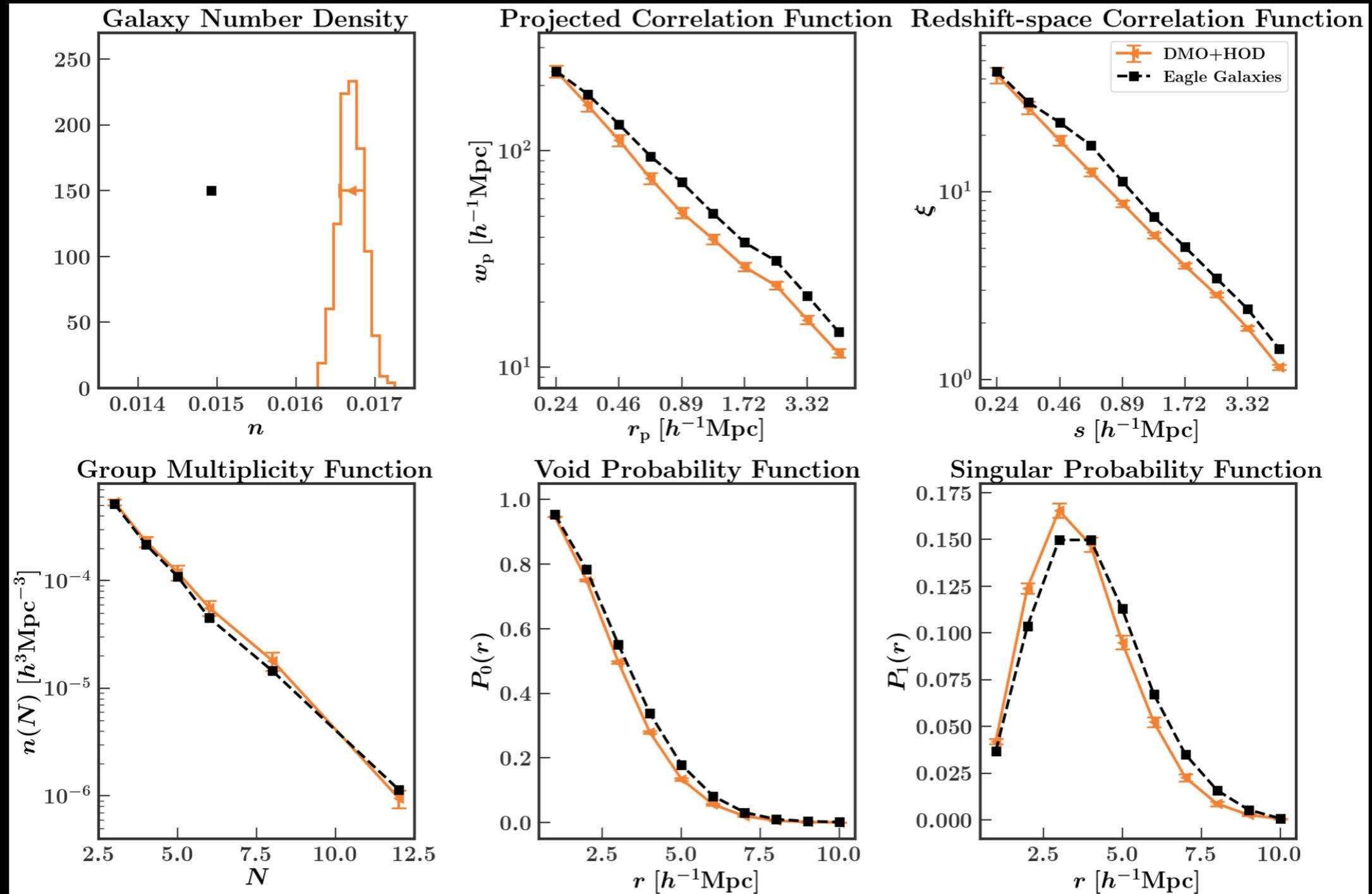
How do we need to expand the traditional HOD model?

Fitting an HOD model to Hydro Simulations



- 2 simulations
- 2 samples
- 5 parameter HOD model

Clustering: Hydro vs **DMO+HOD**

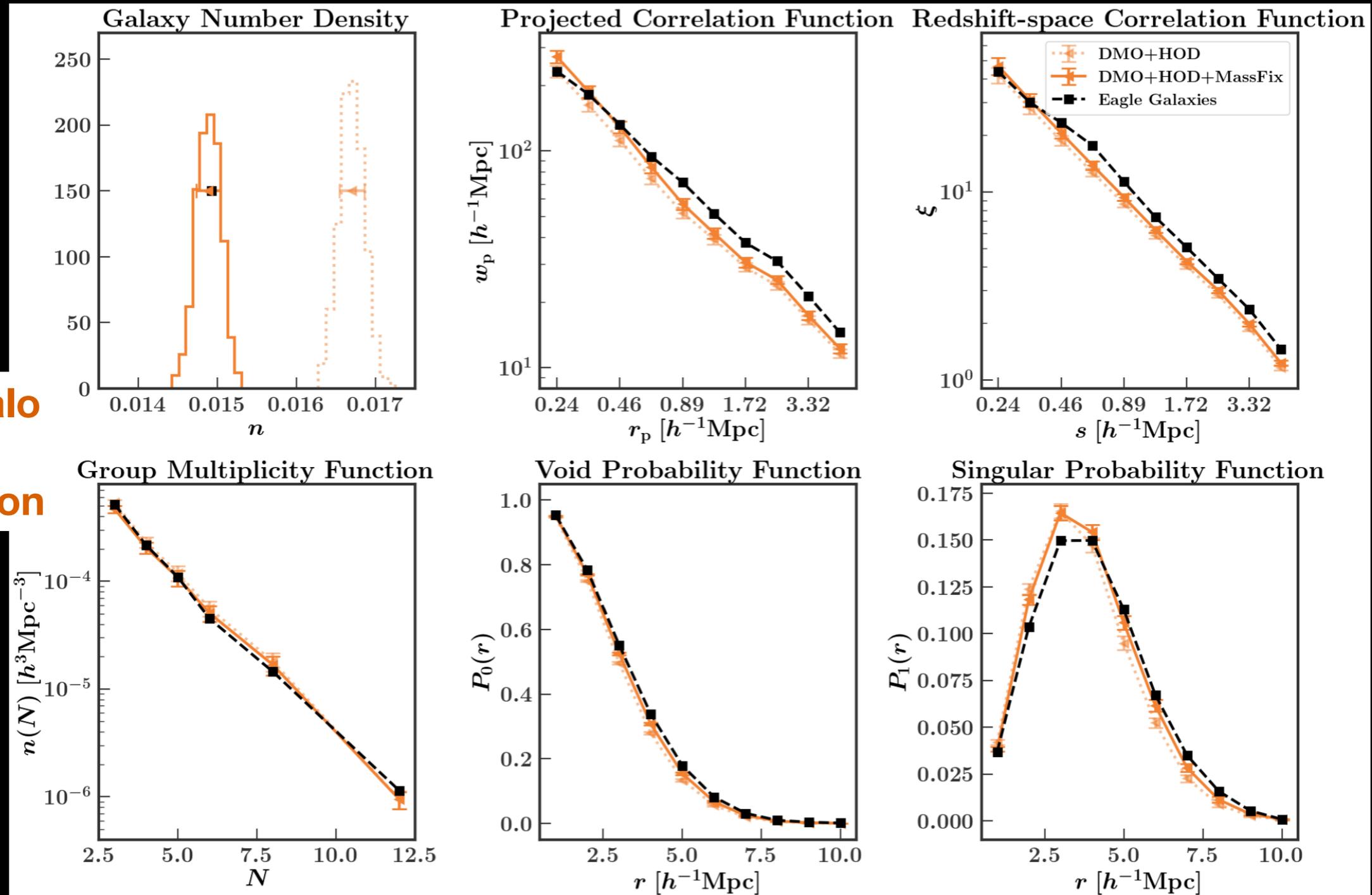


Original Eagle -19 Galaxies

VS

Eagle DMO + vanilla HOD model

Clustering: Hydro vs **DMO+Mass Correction+HOD**



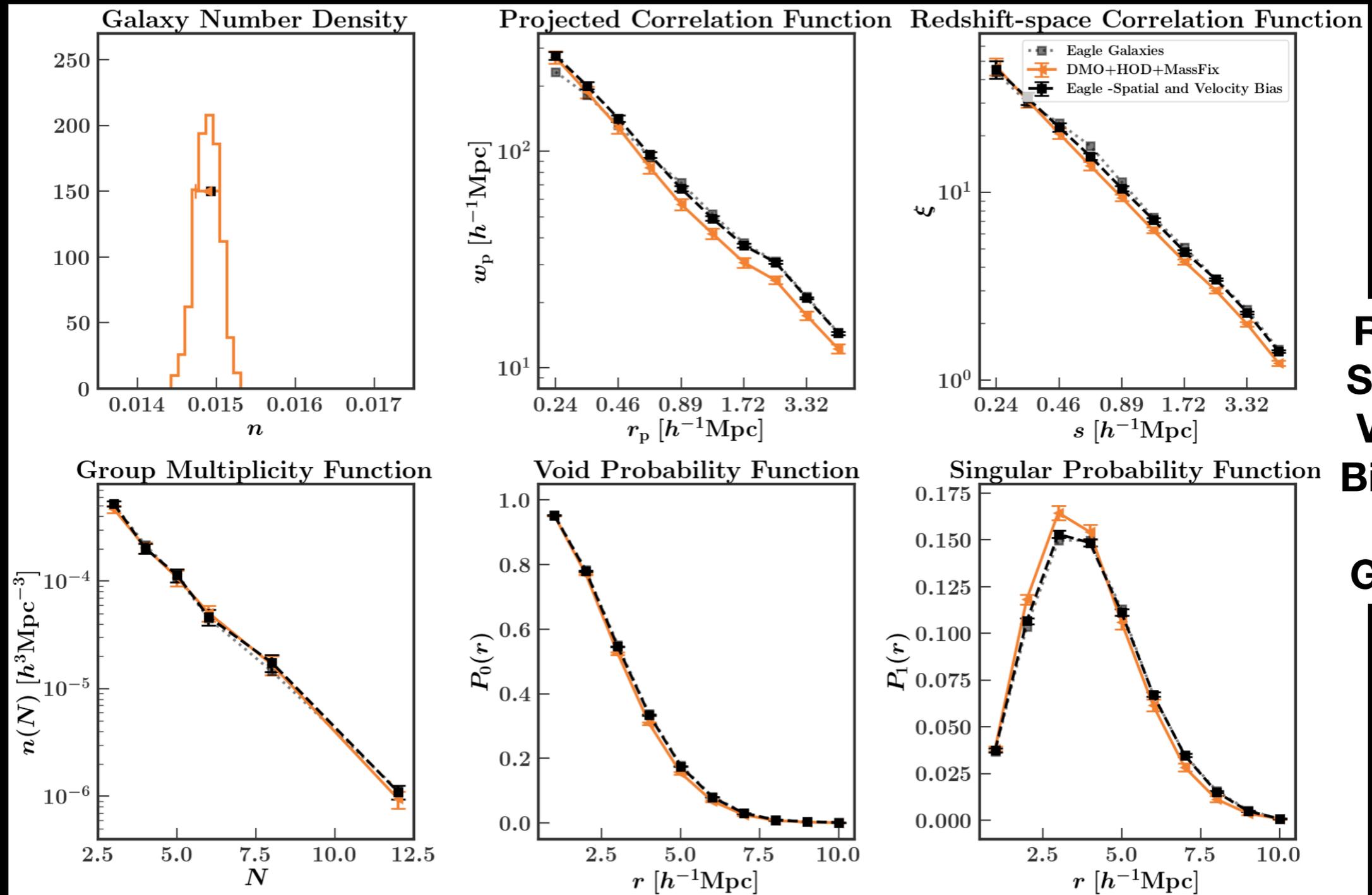
**DMO Halo
Mass
Correction**

Original Eagle -19 Galaxies

VS

Eagle DMO + Mass Correction + vanilla HOD model

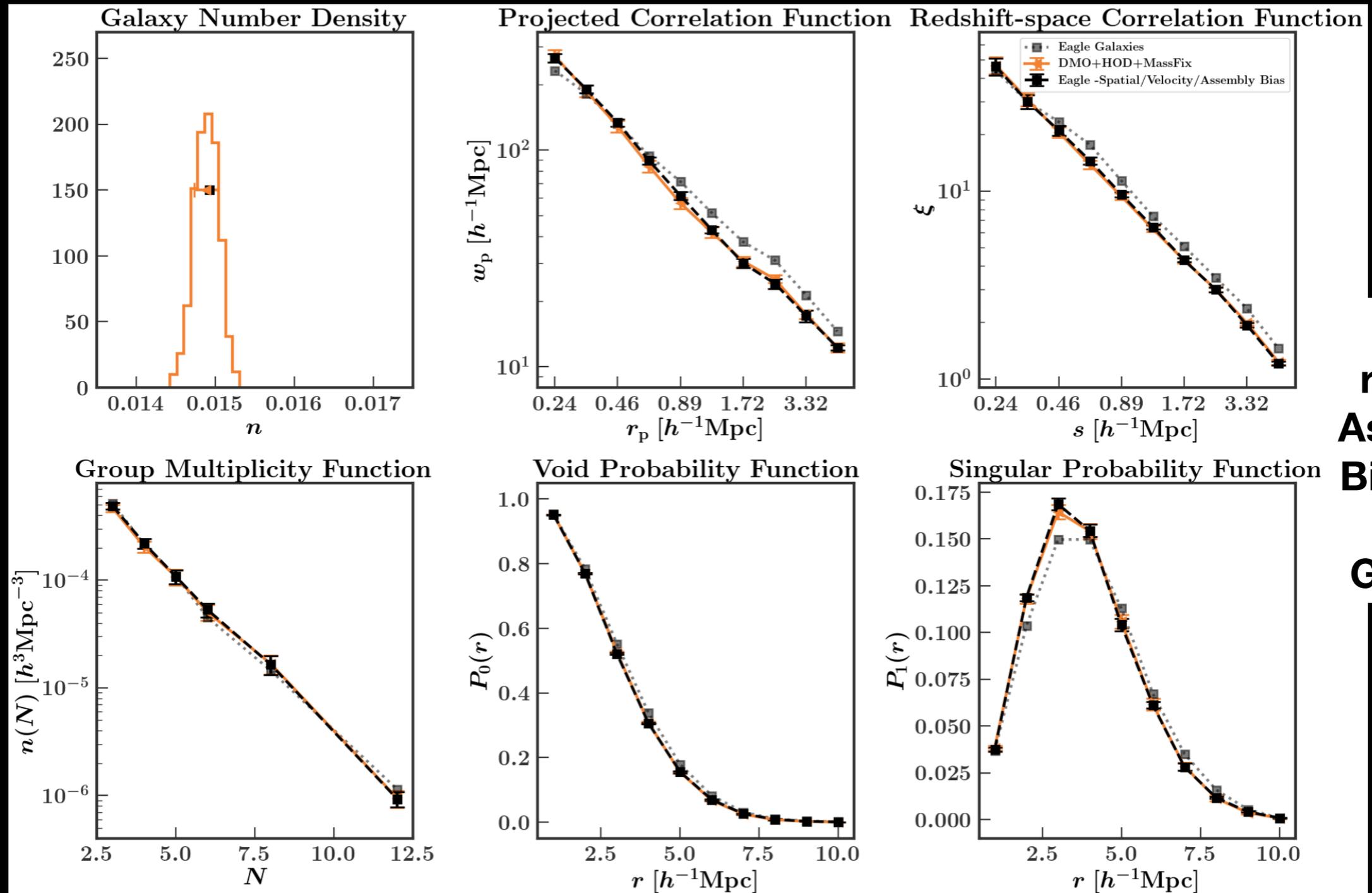
Clustering: Hydro vs **DMO+Mass Correction+HOD**



**Remove
Spatial &
Velocity
Bias from
Hydro
Galaxies**

**Original Eagle -19 Galaxies - Spatial & Velocity Bias
VS
Eagle DMO + Mass Correction + vanilla HOD model**

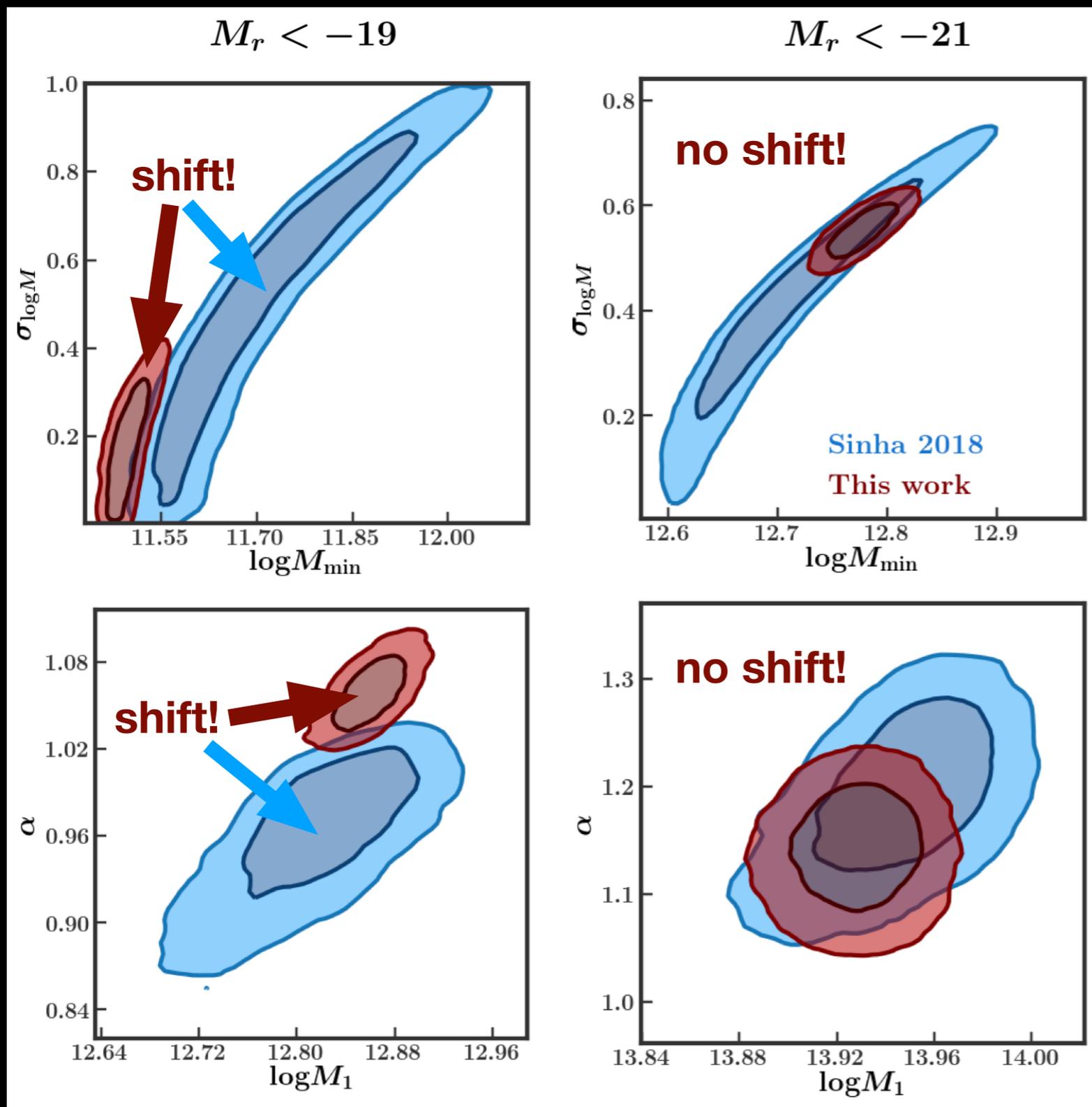
Clustering: Hydro vs **DMO+Mass Correction+HOD**



**Also
remove
Assembly
Bias from
Hydro
Galaxies**

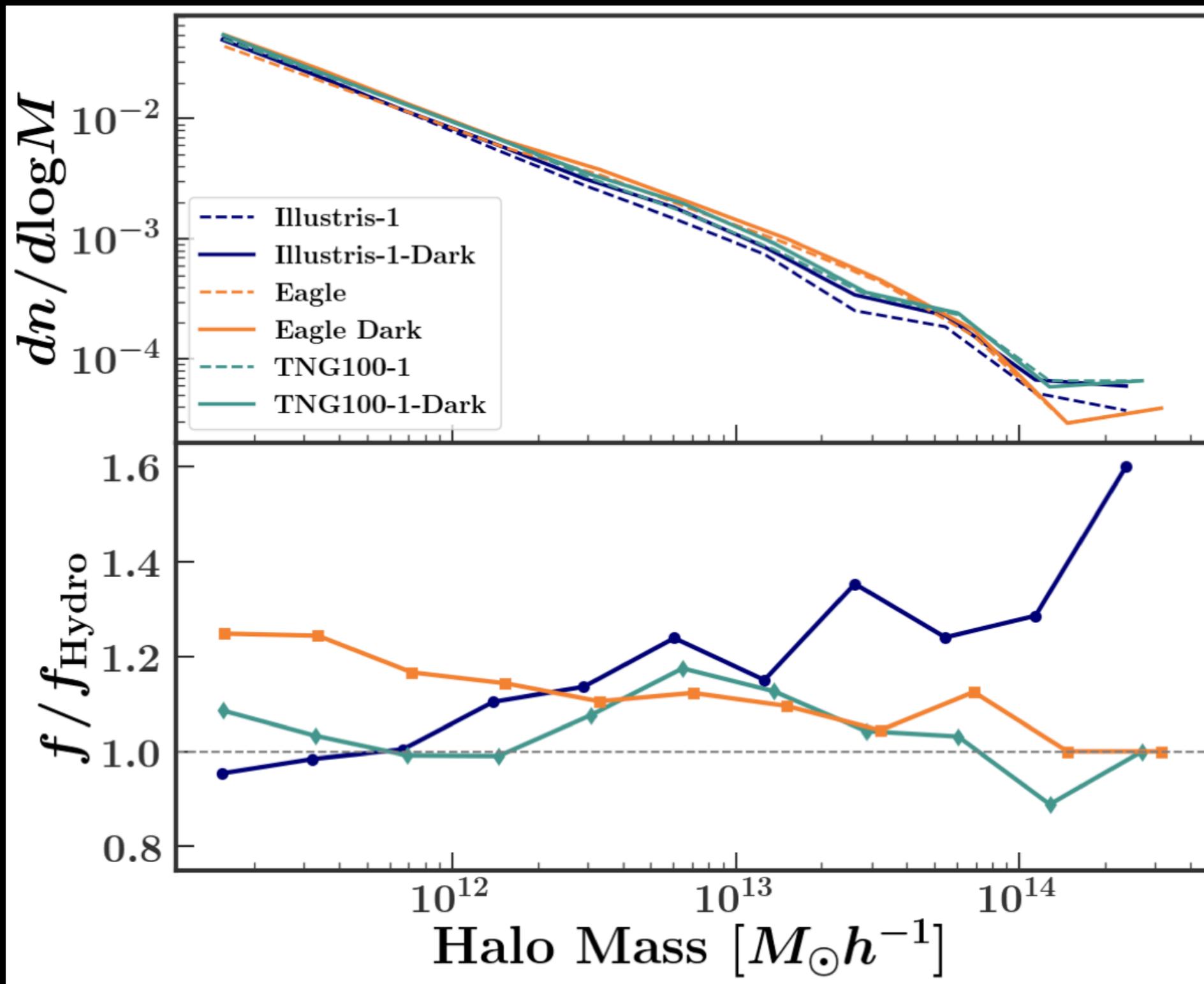
**Original Eagle -19 Galaxies - Spatial & Velocity & Assembly Bias
VS
Eagle DMO + Mass Correction + vanilla HOD model**

HOD modeling of SDSS galaxies



- The **addition of new clustering statistics** leads to a shift in HOD parameters for SDSS -19 galaxies, but not for -21 galaxies
- Analysis of Illustris and EAGLE galaxies showed that **spatial, velocity, and assembly bias** were present in the -19 samples but not in the -21 samples

Halo Mass Function

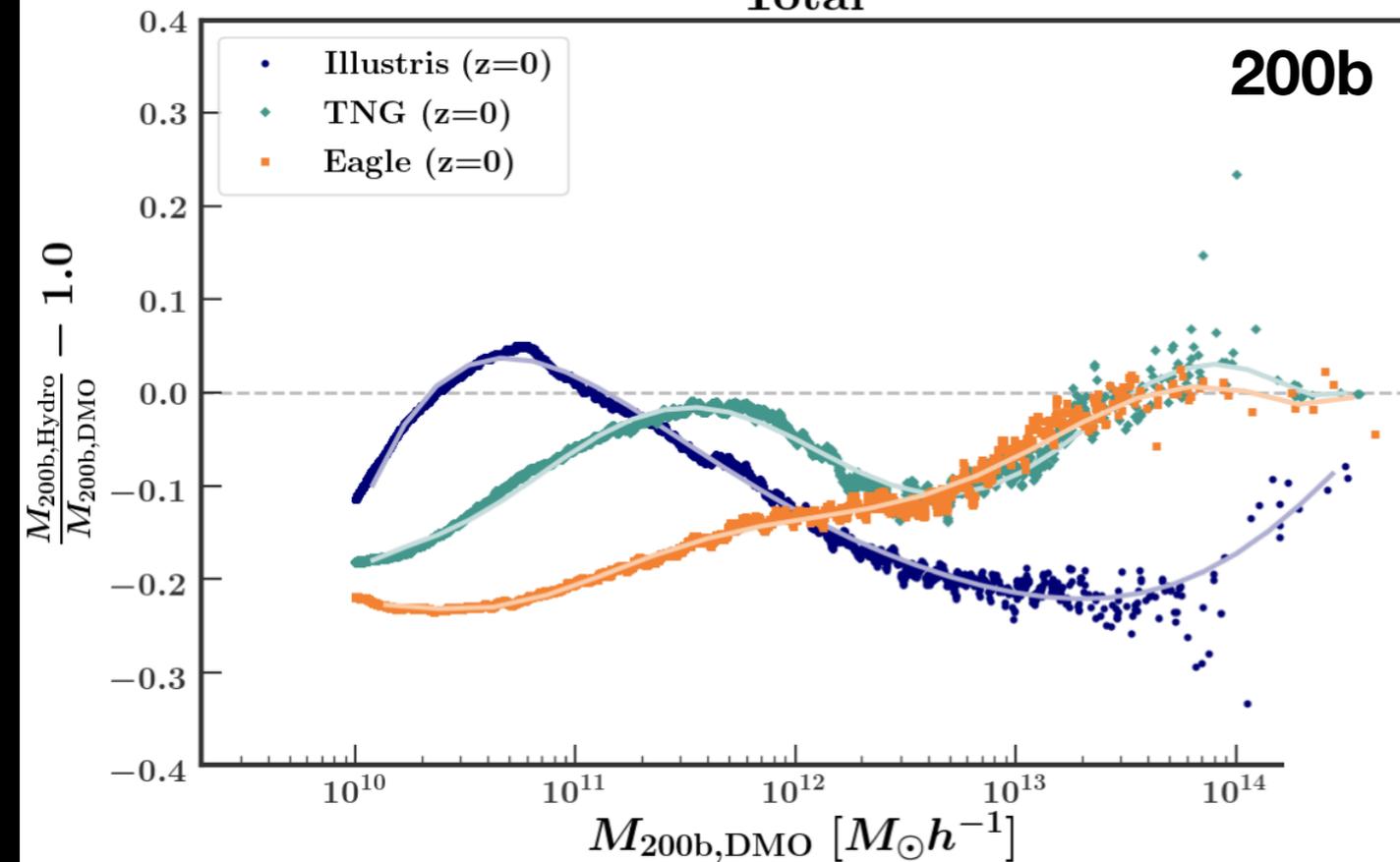


HMF is shifted to higher halo masses in DMO simulations compared to Hydro

Halo Mass Correction

Total

200b

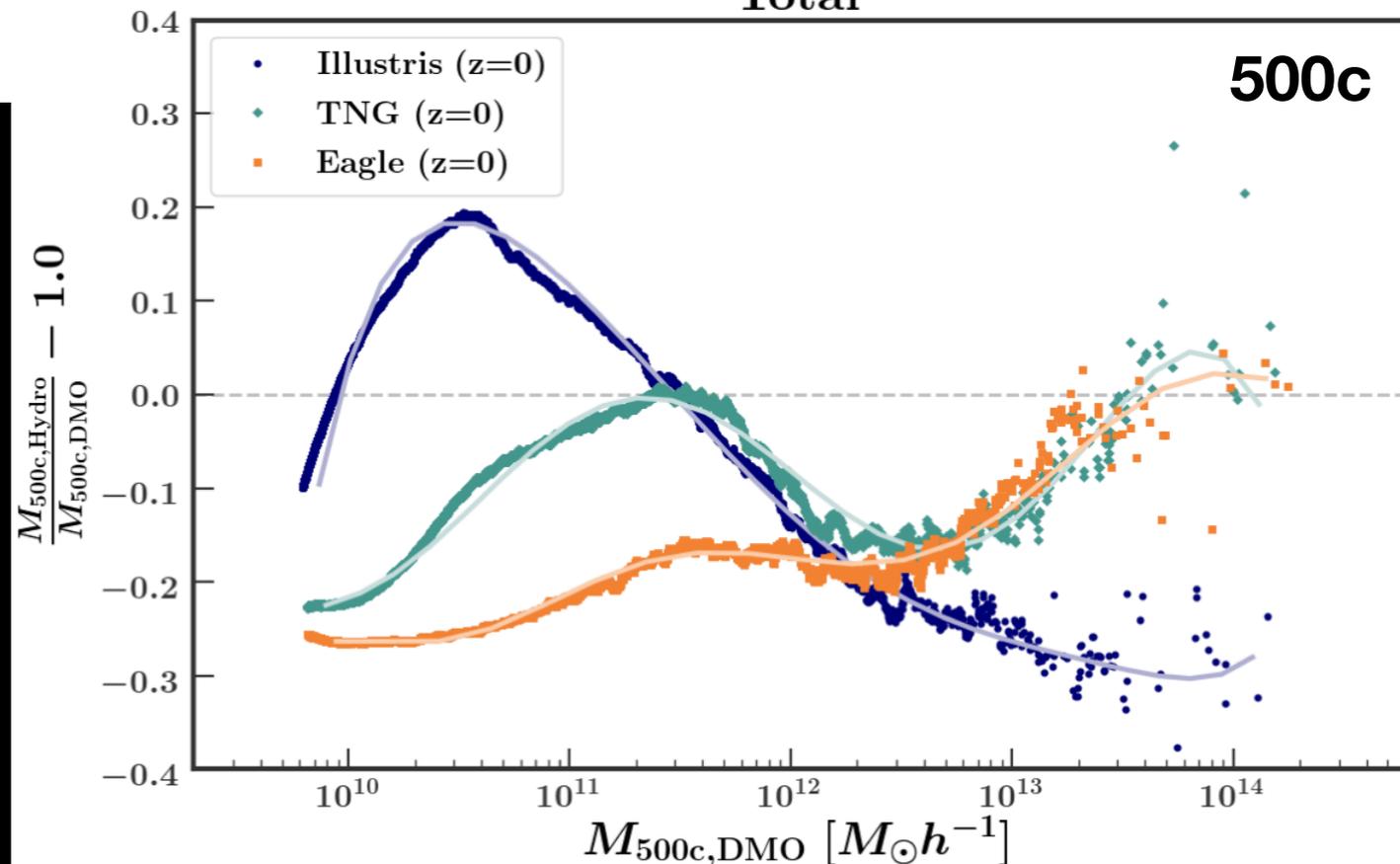


- Hydro and DMO halos are paired based on mass, i.e. abundance matched
- Complex relationship between hydro halo mass and DMO halo mass
- Three different simulations have different results due to feedback

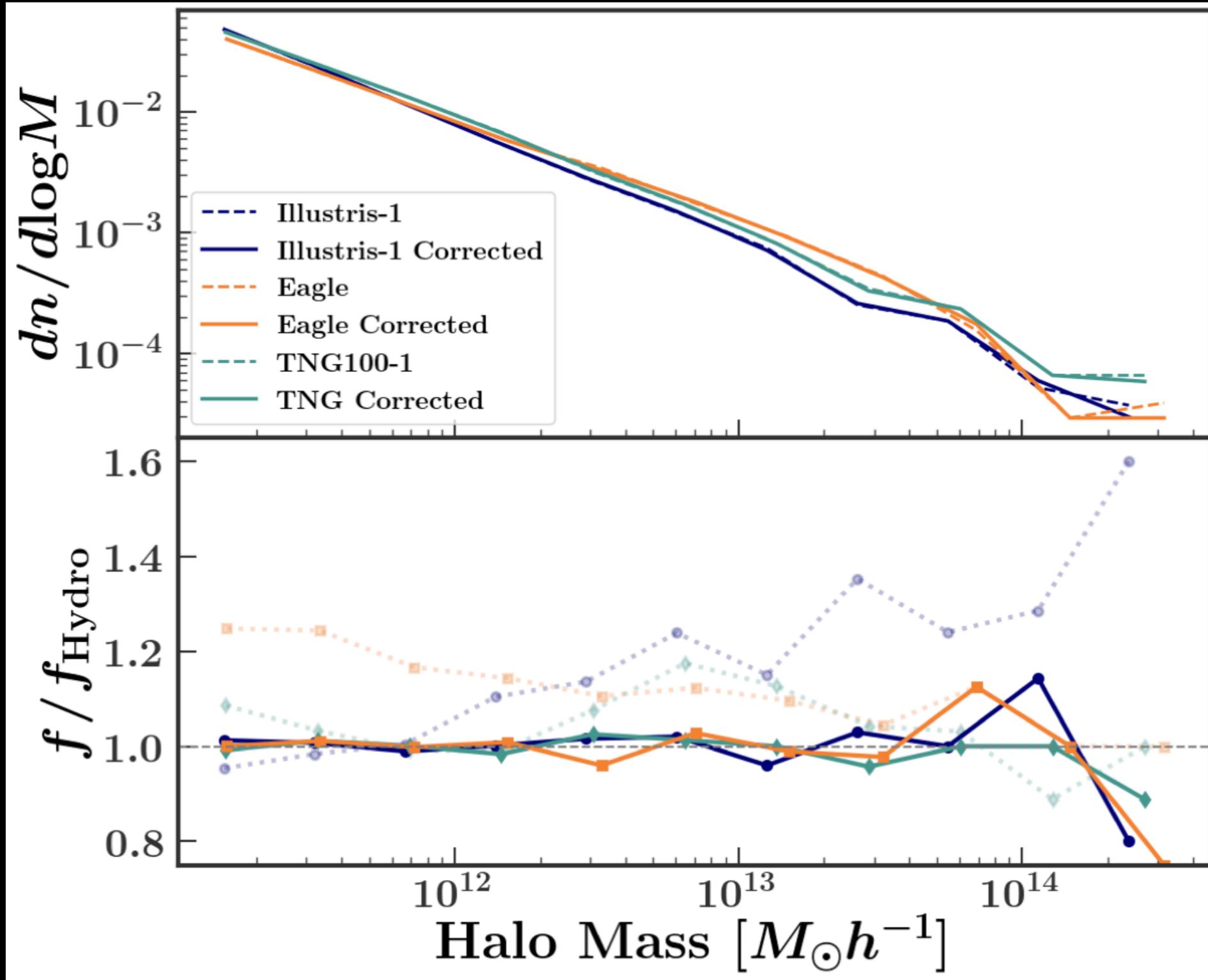
- Different relationships depending on redshift, halo definition
- Can fit the relationship in each simulation and use it to correct the halo mass function
- Fits coming in *Beltz-Mohrmann et al. in prep*

Total

500c

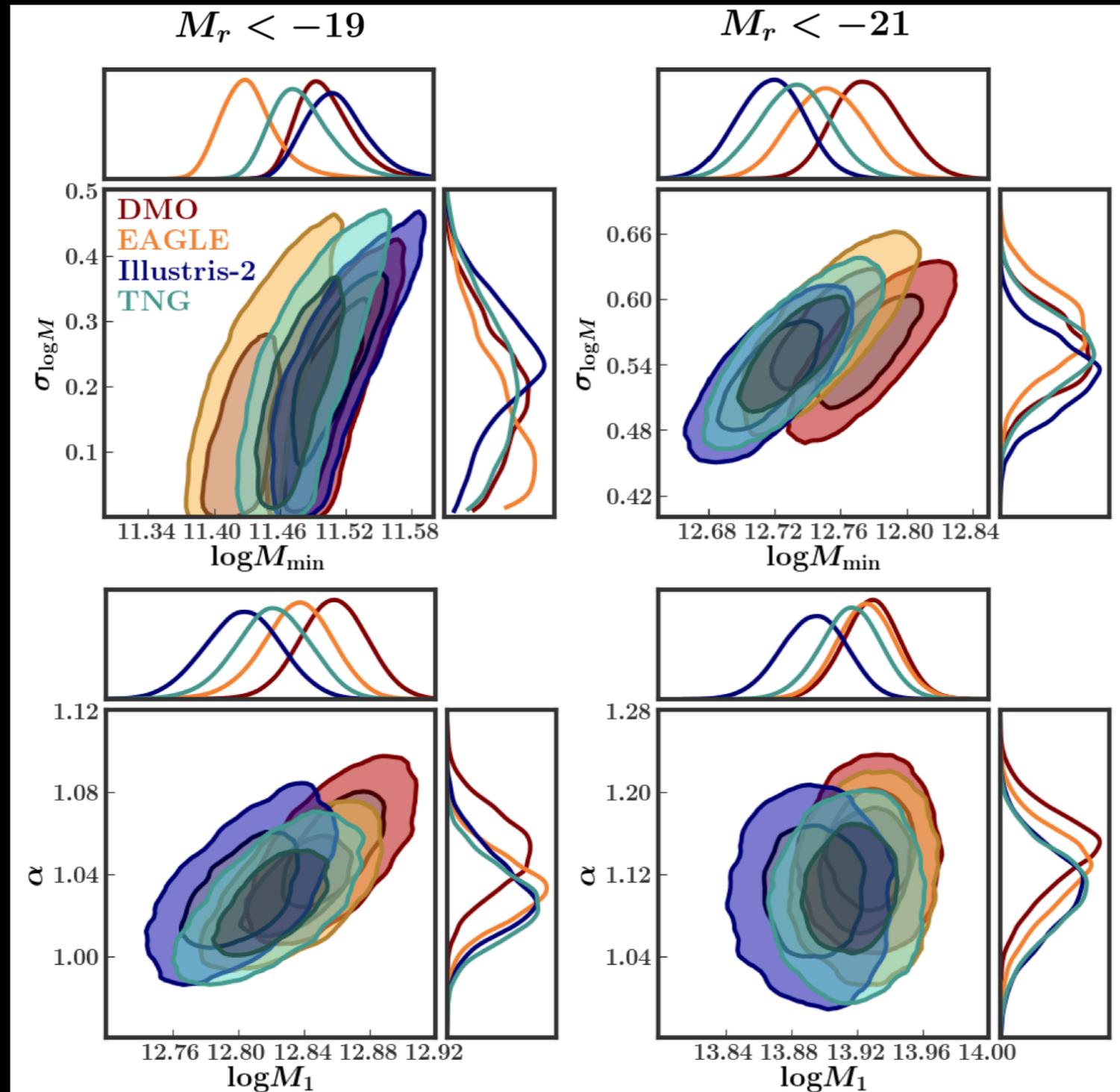


Halo Mass Function



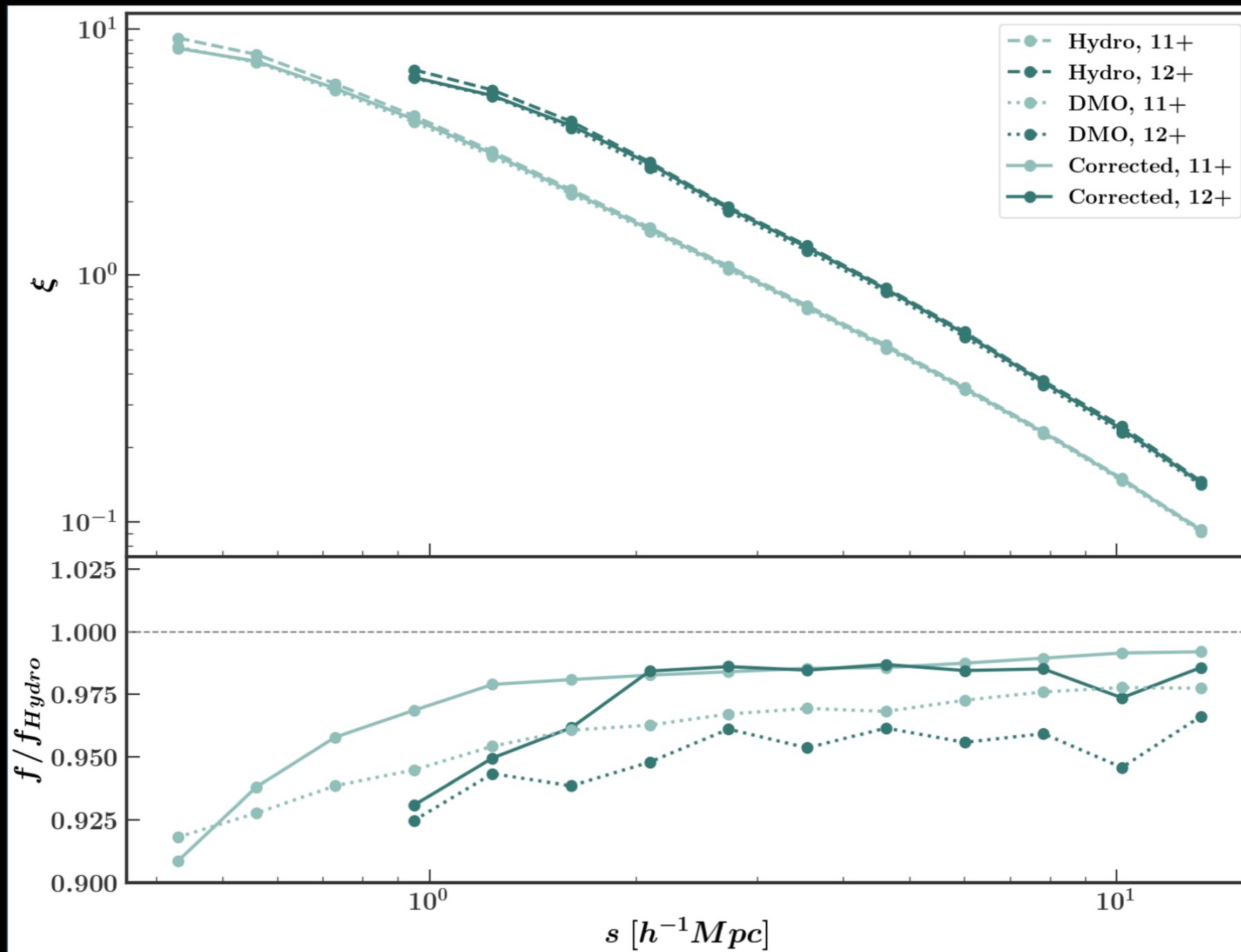
Using fits to correct DMO halo masses reproduces HMF from Hydro

Effect of Mass Correction on HOD parameters



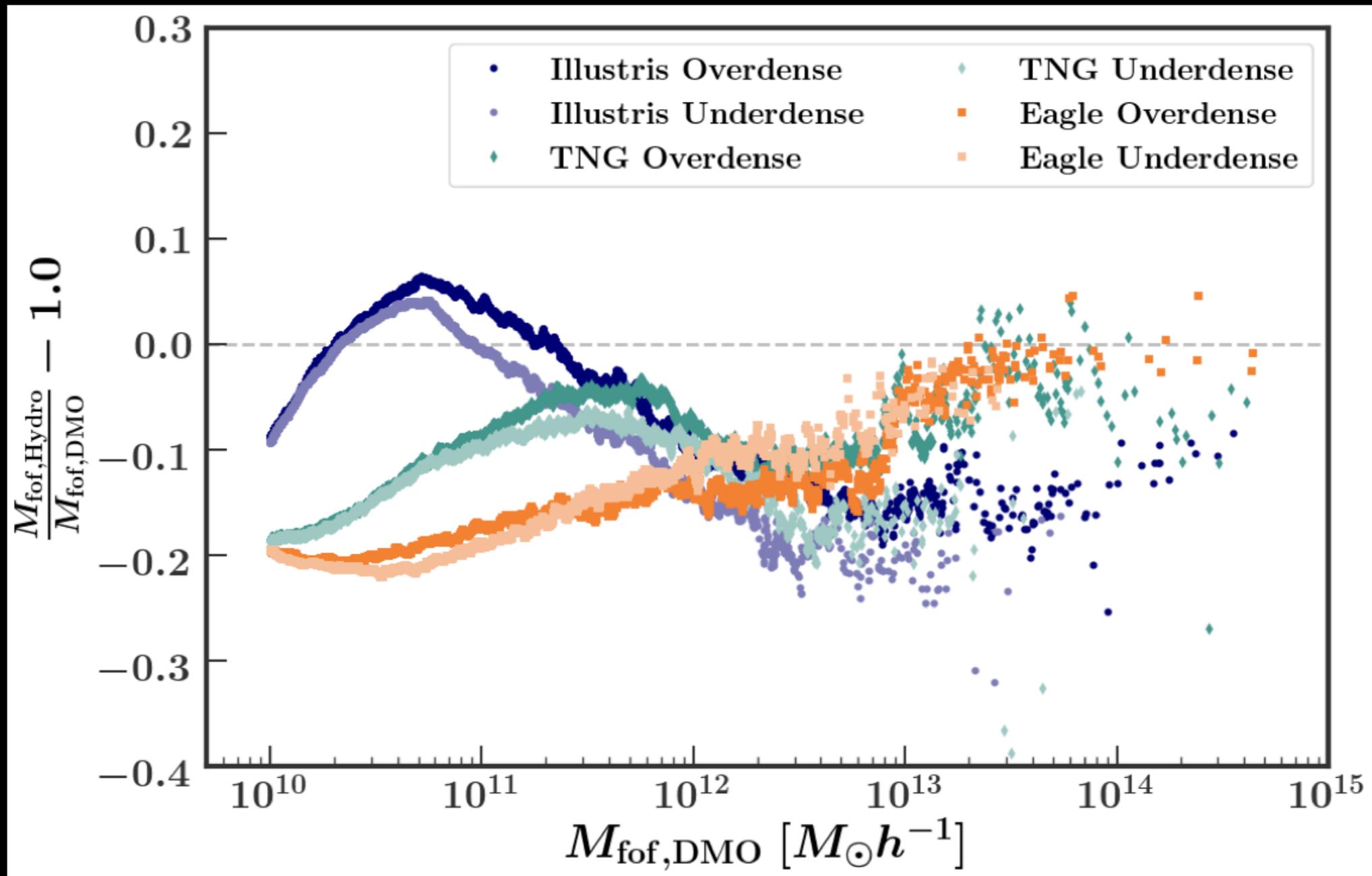
Applying the three different mass corrections to a large DMO simulation leads to different HOD parameter constraints when modeling the clustering of SDSS galaxies.

Halo Correlation Function: TNG300-1



- **~4% discrepancy without DMO mass correction**
- **~2% discrepancy with mass correction**
- **This correction was exact halo to halo correction; remaining discrepancy is not due to fit**

Environmental Dependence of Mass Correction

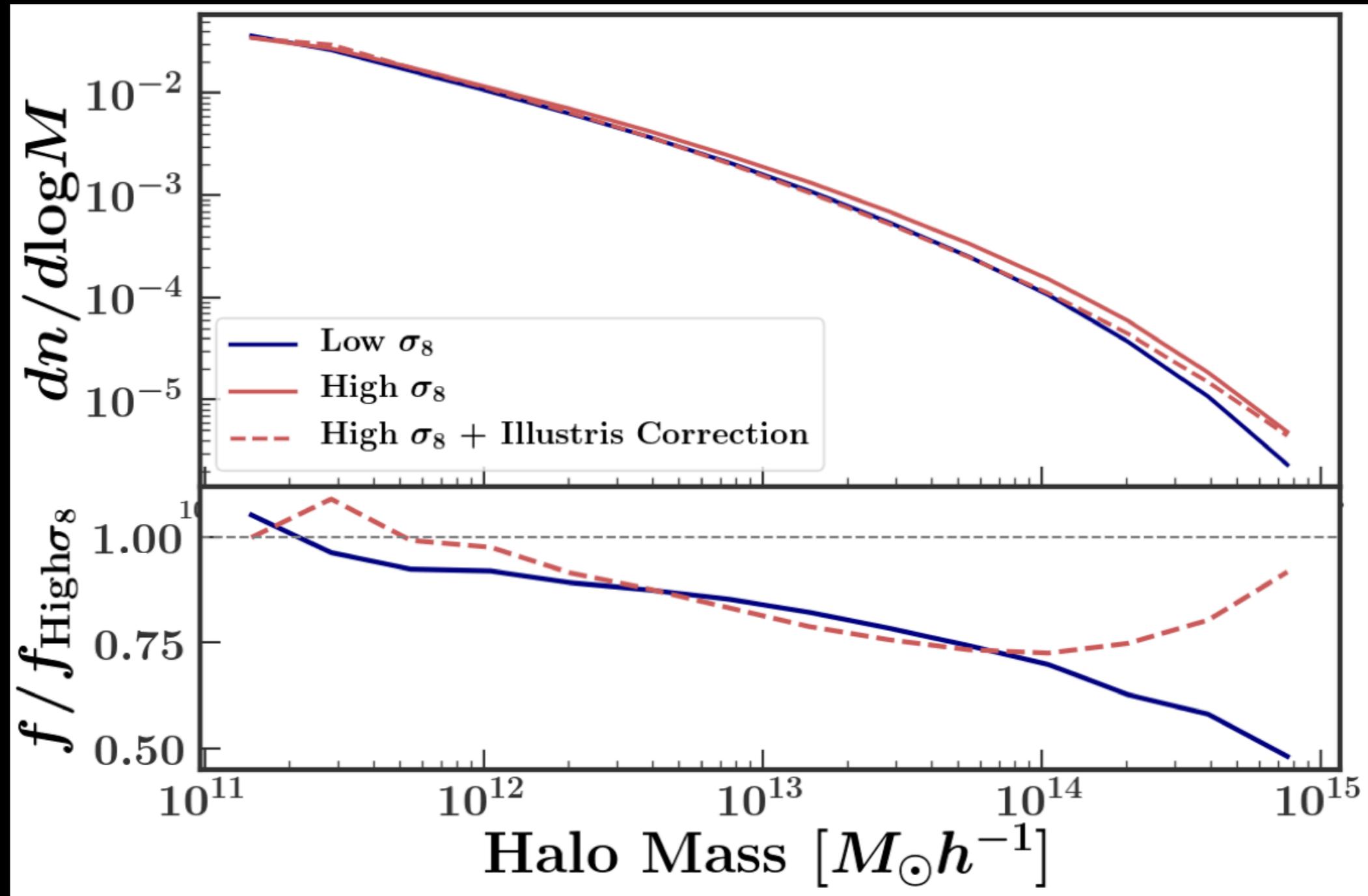


- Environment is measured as the mass within a 5 Mpc sphere around each halo.
- Environments are divided into high and low density based on the median environment across all halos
- Hydro and DMO halos are then paired within similar environments

Conclusions

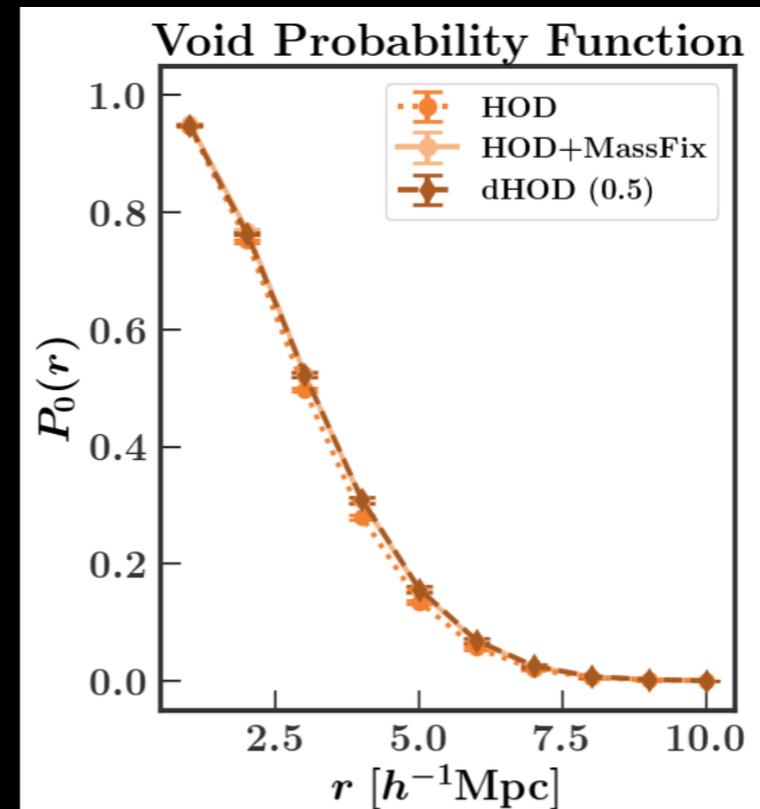
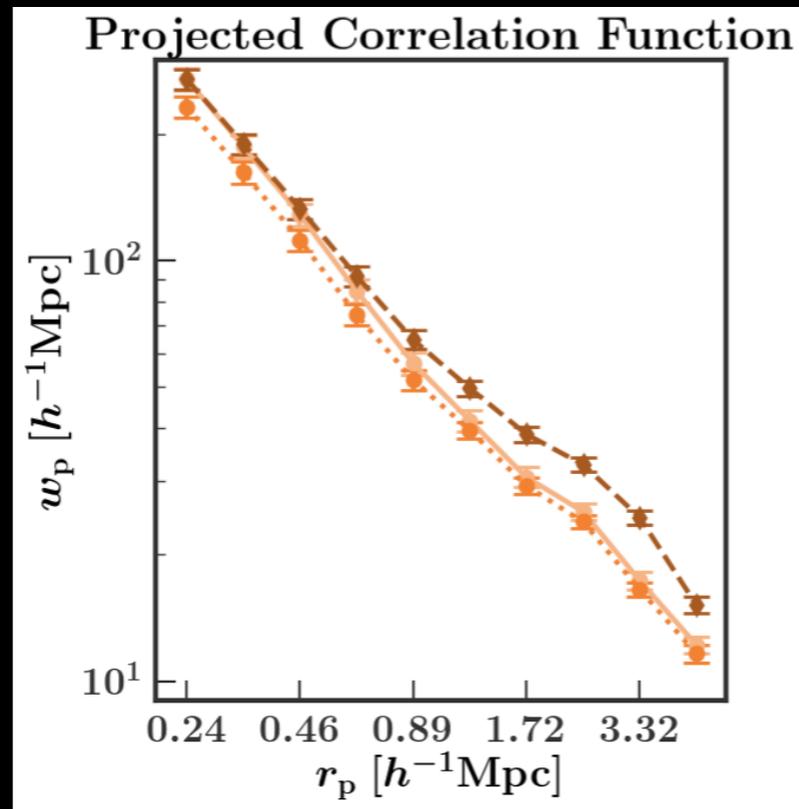
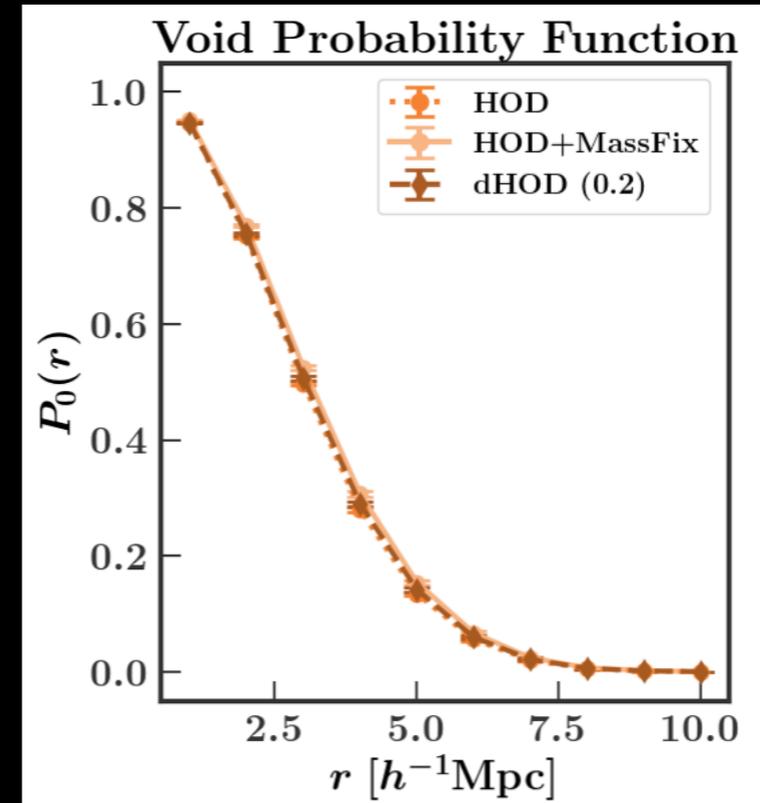
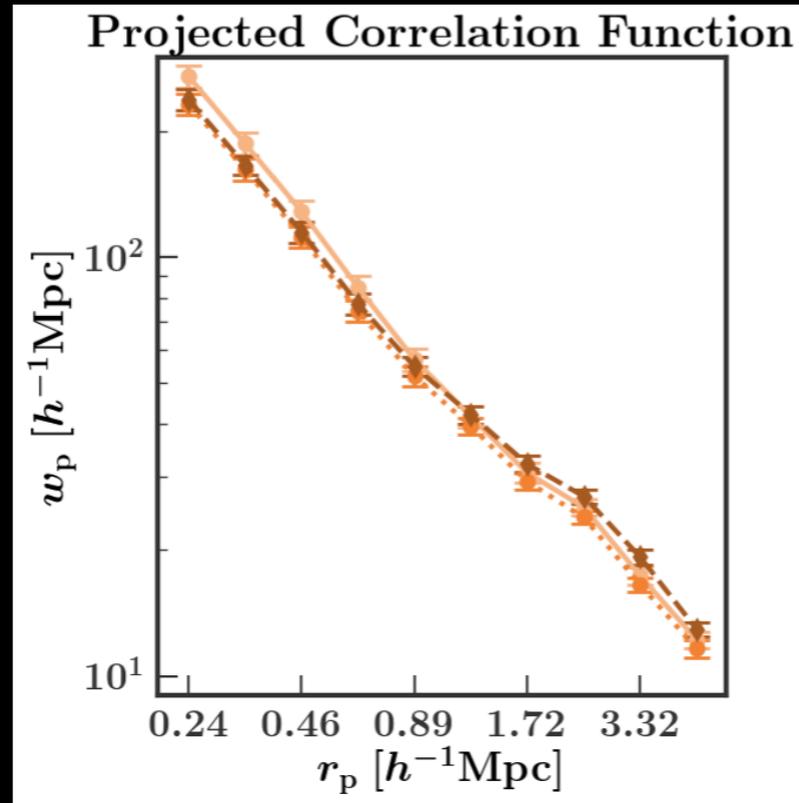
- **Based on comparisons to hydro simulations, the vanilla HOD model needs to be expanded to include effects like spatial bias, velocity bias, and assembly bias**
- **Using clustering statistics that are sensitive to these biases without including them in the model could lead to incorrect HOD parameter constraints**
- **DMO simulations produce a dark halo population that is different from hydro simulations due to the lack of baryonic physics**
 - **Using DMO simulations for HOD and other modeling could lead to incorrect results**
 - **The DMO halo mass function can be corrected, but the correction is different for different hydro simulations**
 - **There is some environmental dependence to this correction**
 - **Not applying a mass correction could lead to incorrect conclusions about HOD parameters, assembly bias, as well as cosmology**
 - **Mass corrections coming in *Beltz-Mohrmann et al. in prep***

Effect of Mass Correction on Cosmological Constraints



Not applying a mass correction could lead to the incorrect cosmology constraints.

Clustering: HOD+Mass Correction vs dHOD



For certain clustering measurements, not applying a mass correction might lead to the conclusion that assembly bias is present when it is not.