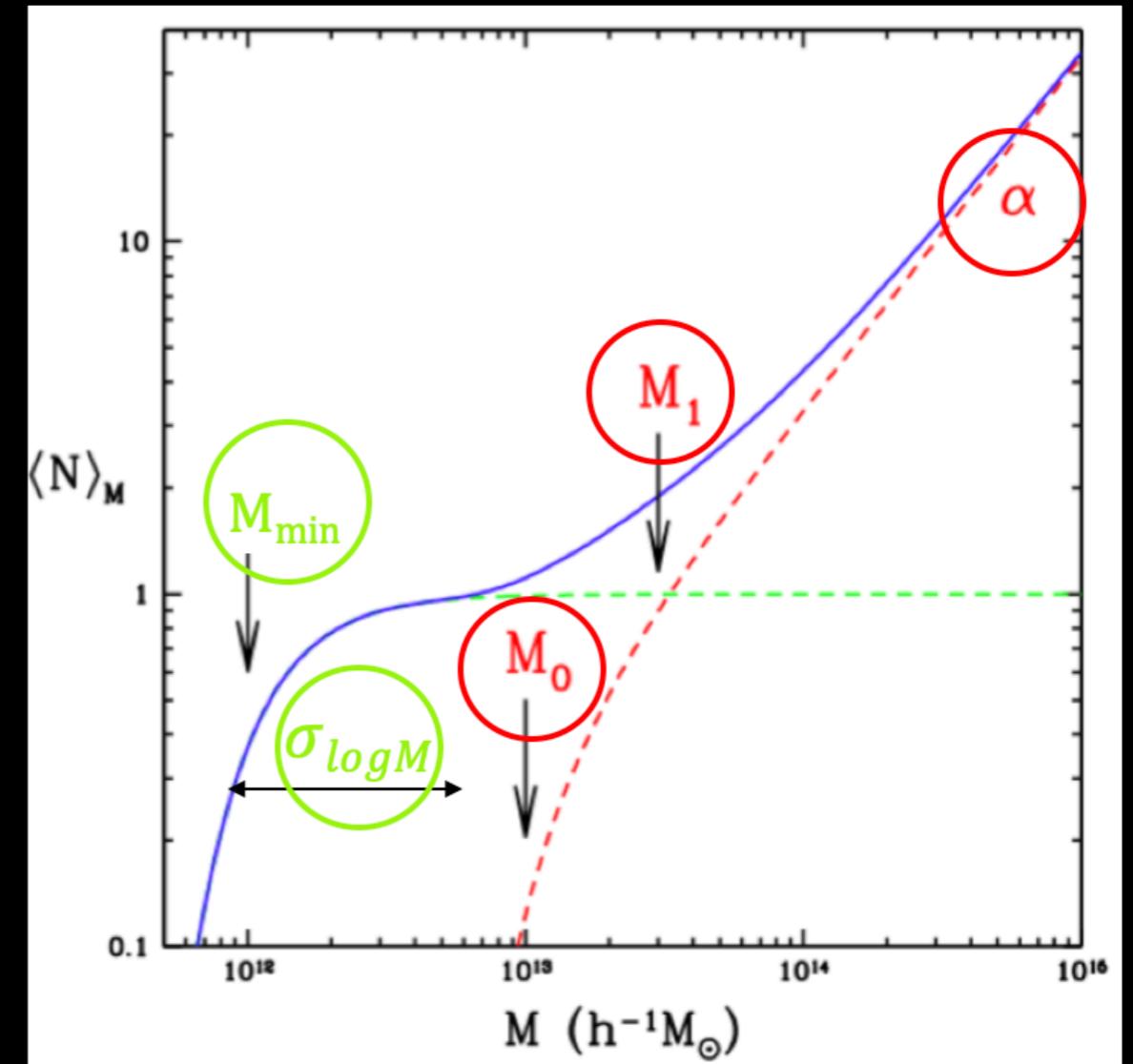
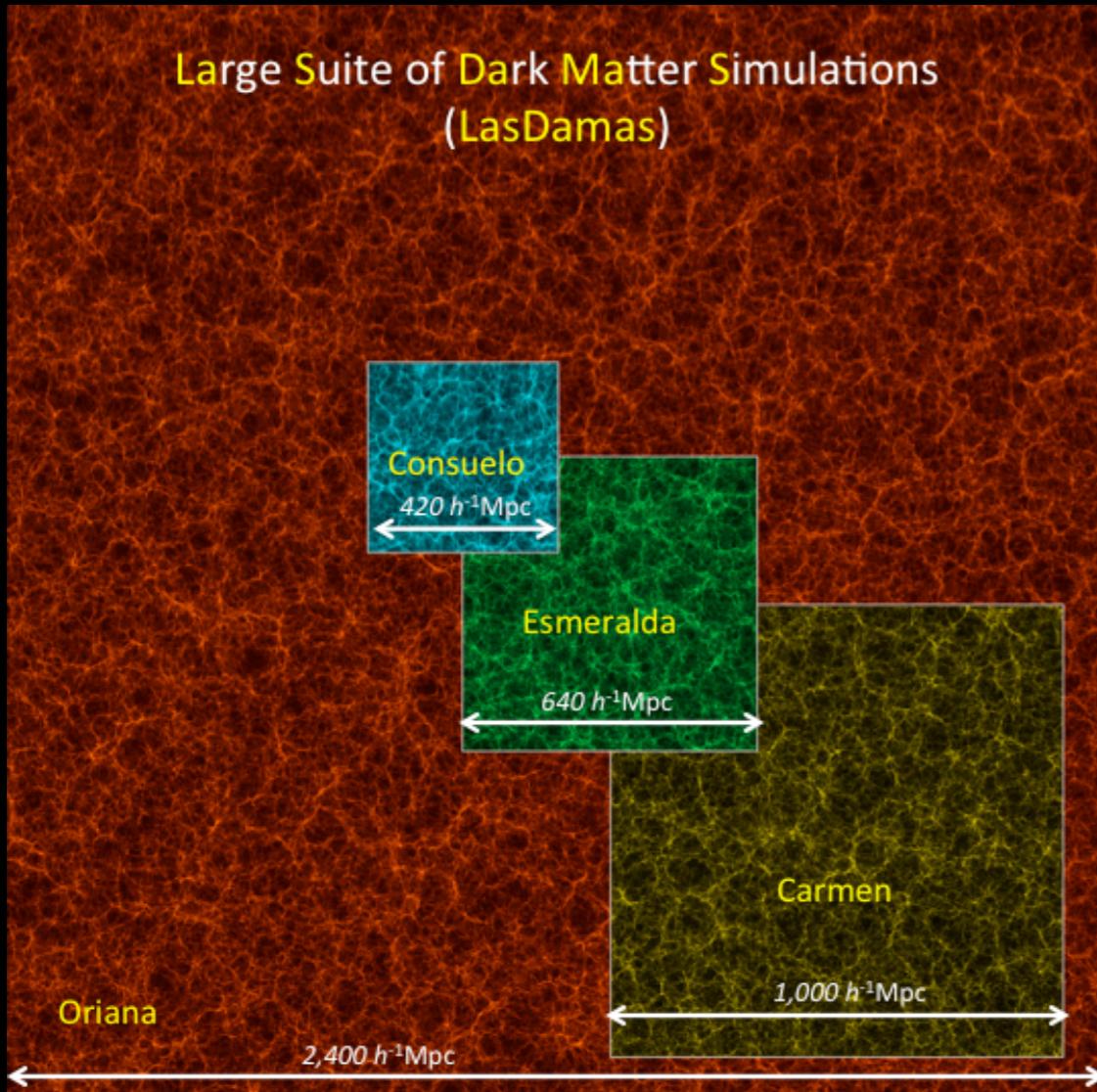


# Taking Halo Modeling to the Next Level

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Mock Innsbruck 2020

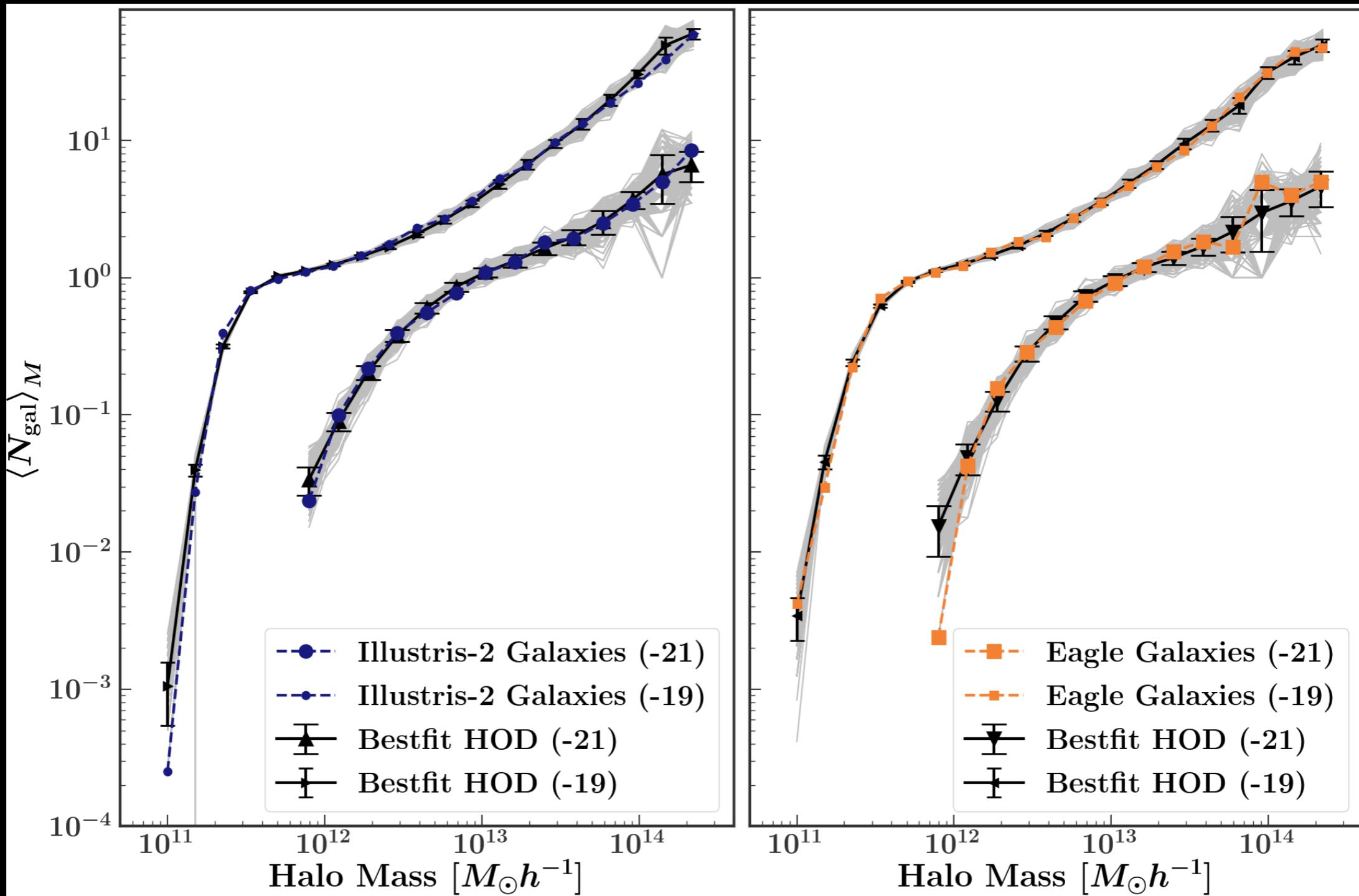
# Motivation



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

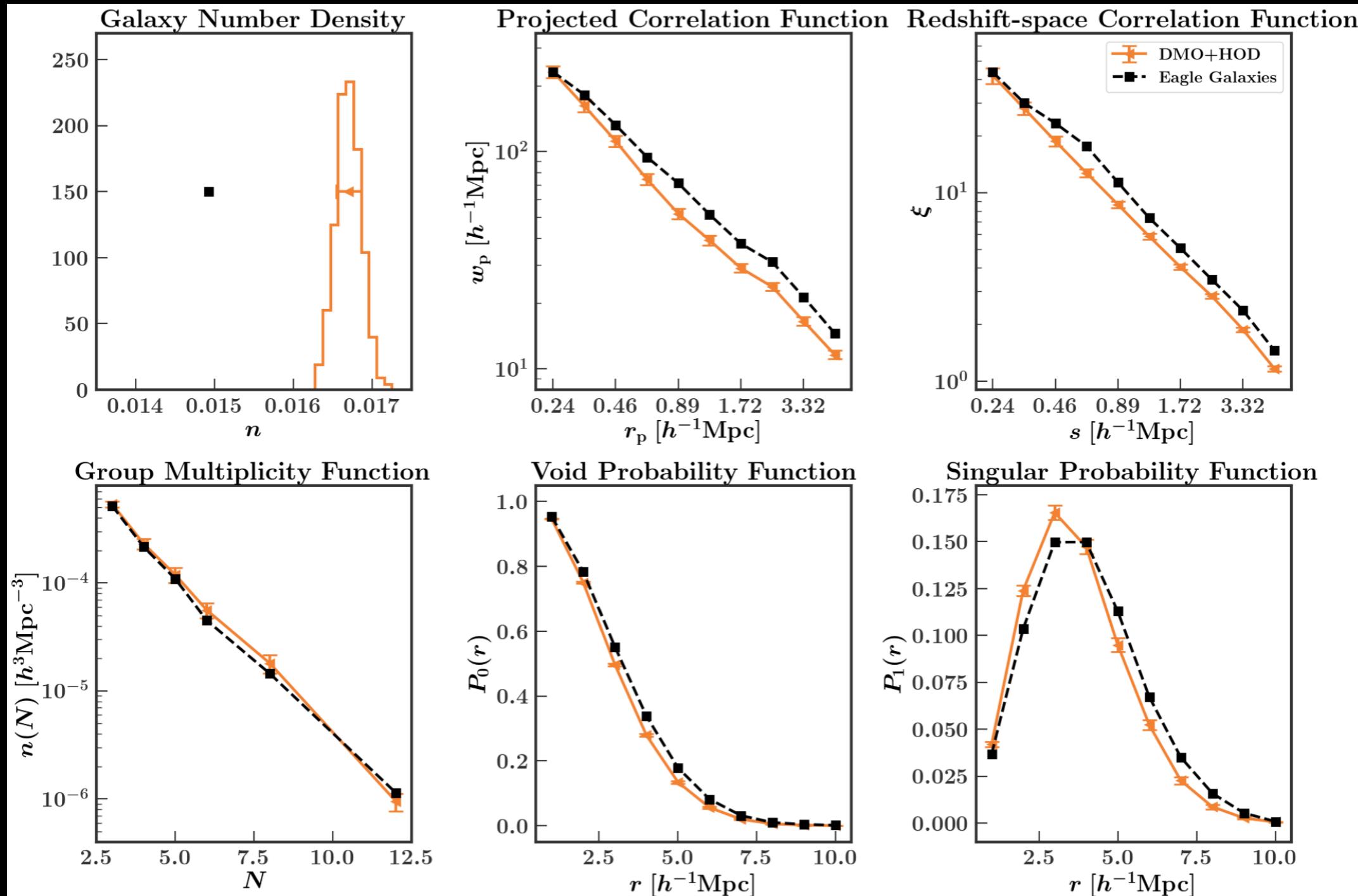
How do we need to expand the traditional HOD model?

# Fitting an HOD model to Hydro Simulations



- 2 simulations
- 2 samples
- 5 parameter HOD model

# Clustering: Hydro vs DMO+HOD



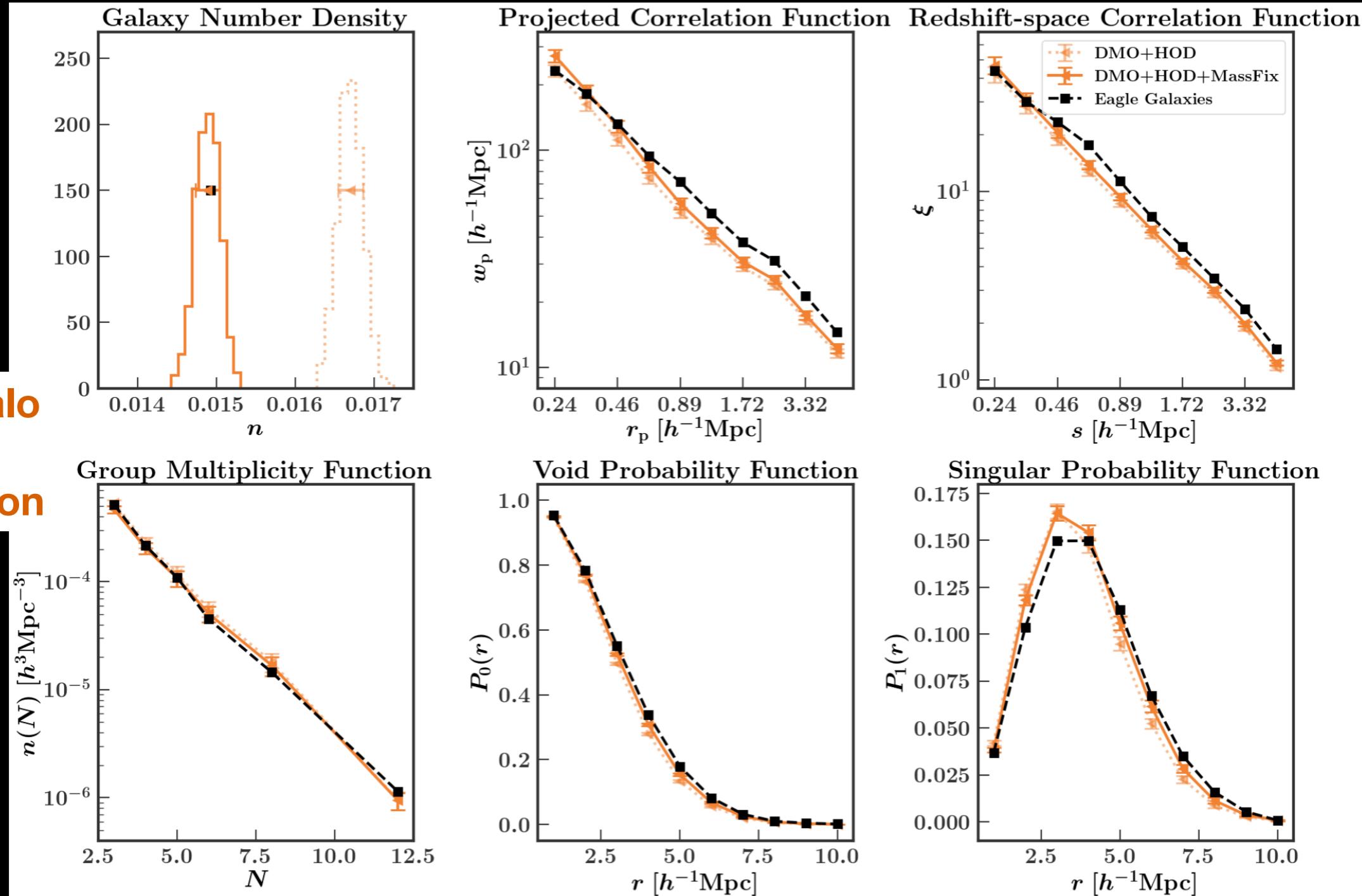
Original Eagle -19 Galaxies

vs

Eagle DMO + vanilla HOD model

# Clustering: Hydro vs DMO+Mass Correction+HOD

**DMO Halo  
Mass  
Correction**

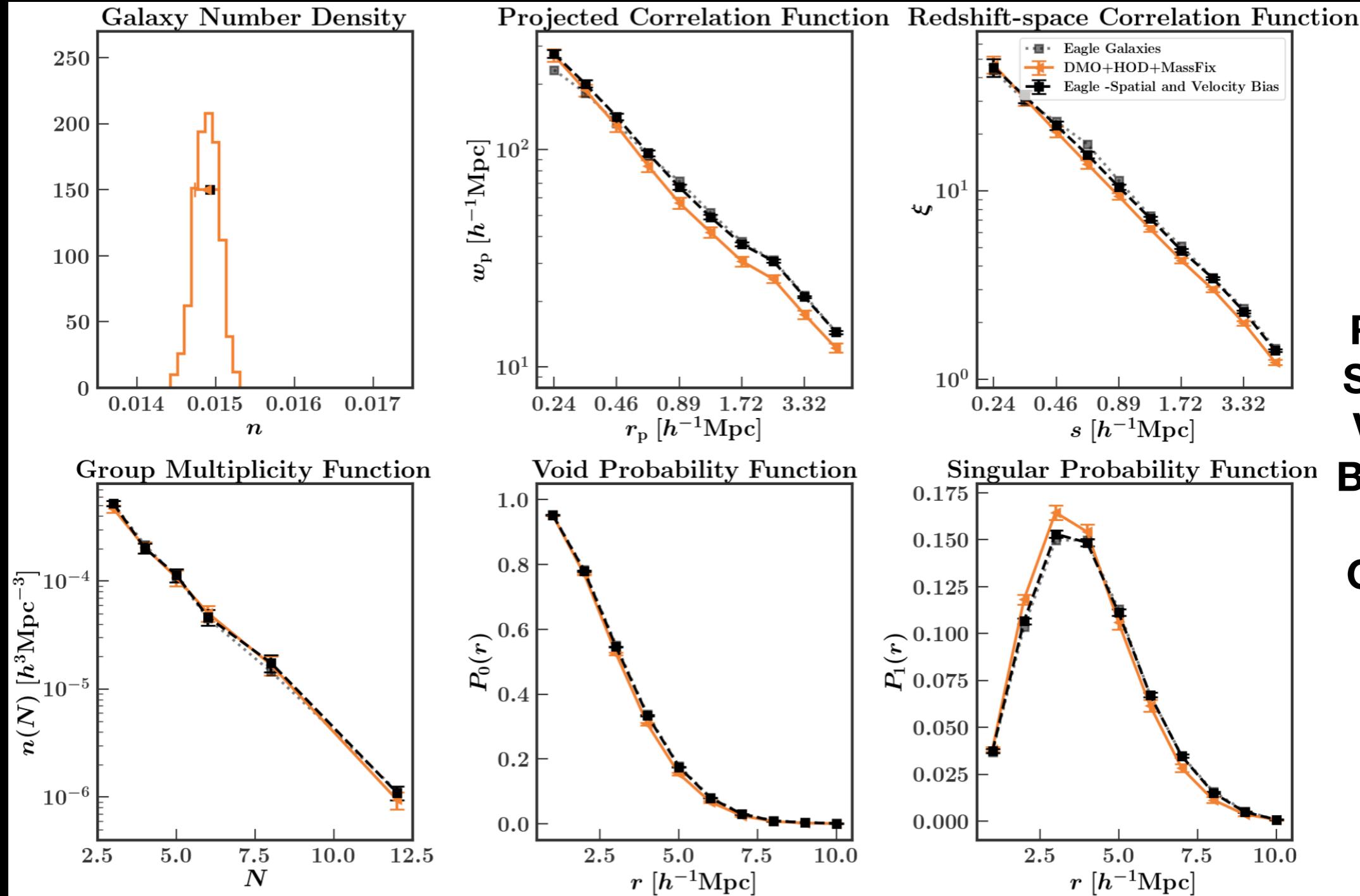


Original Eagle -19 Galaxies

vs

Eagle DMO + Mass Correction + vanilla HOD model

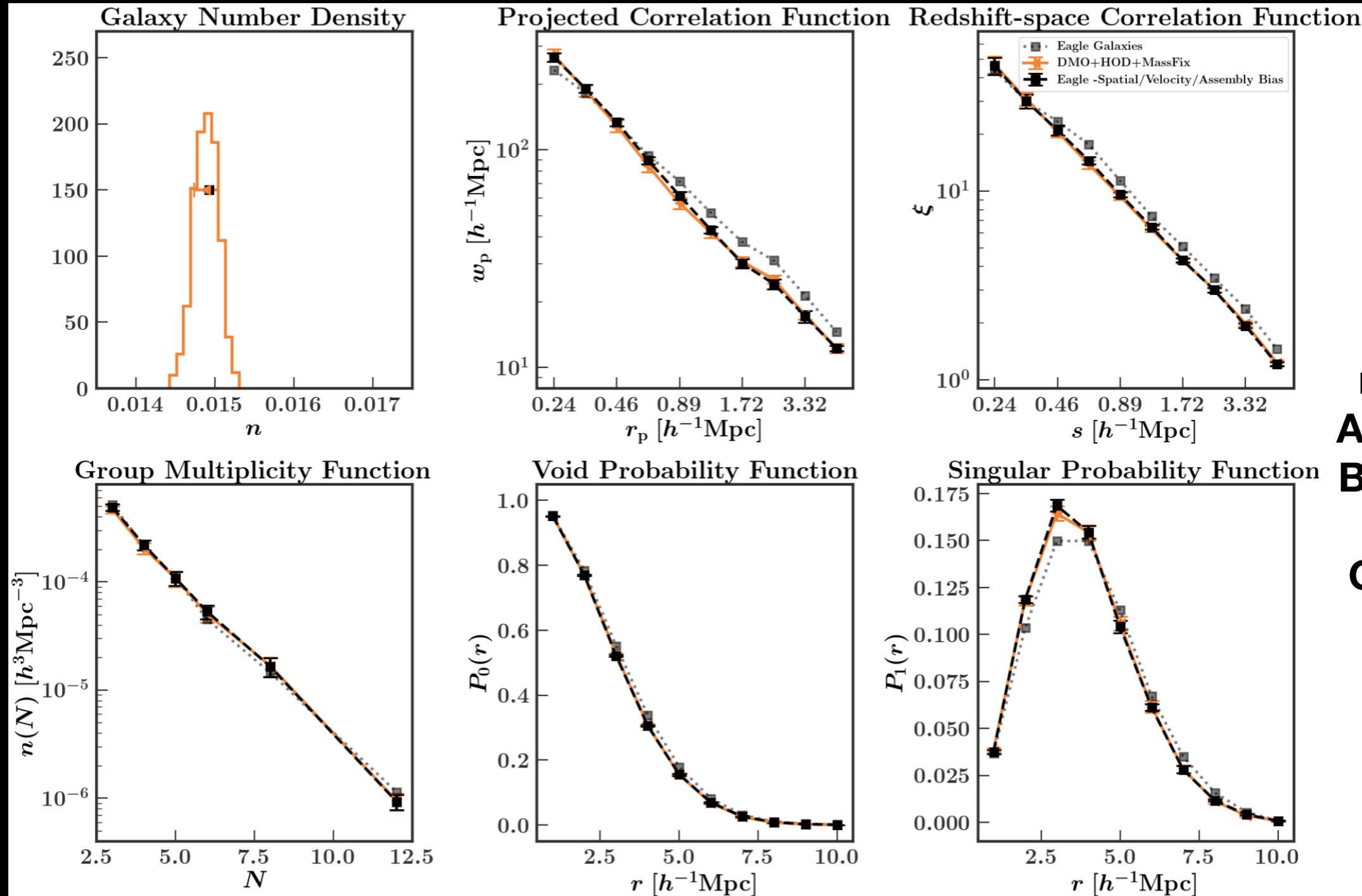
# Clustering: Hydro vs DMO+Mass Correction+HOD



Remove  
Spatial &  
Velocity  
Bias from  
Hydro  
Galaxies

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

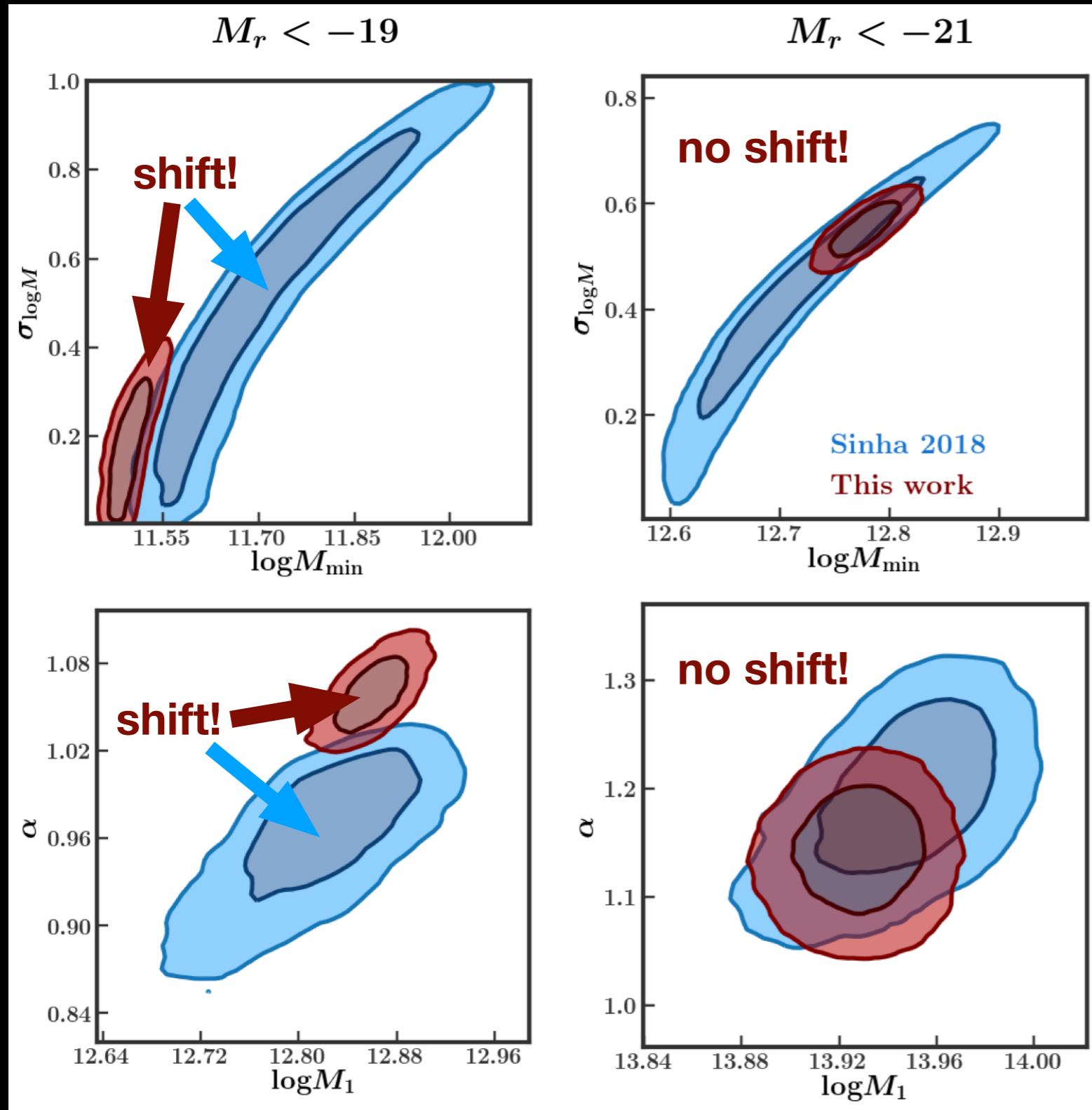
# Clustering: Hydro vs DMO+Mass Correction+HOD



Also  
remove  
Assembly  
Bias from  
Hydro  
Galaxies

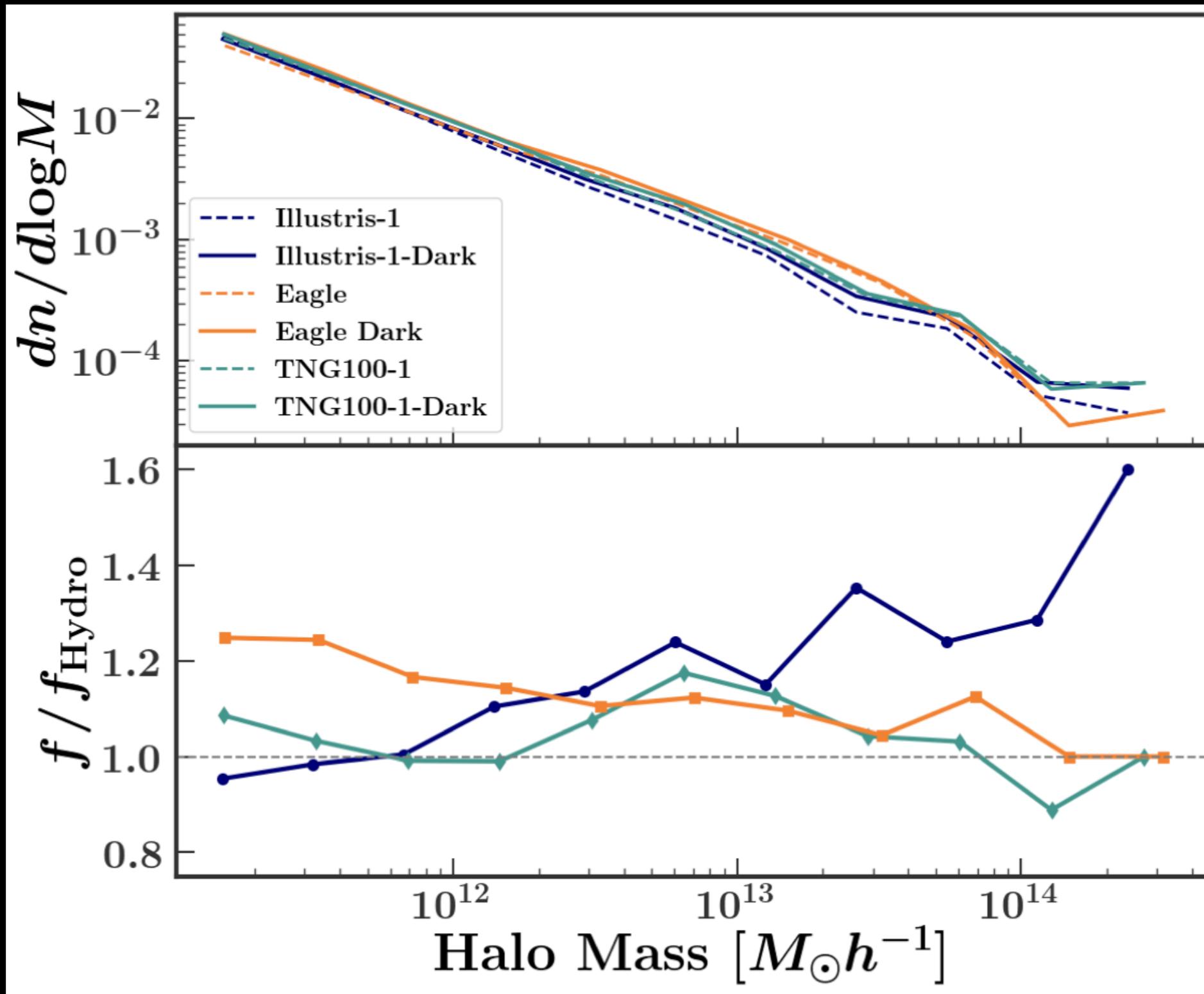
Original Eagle -19 Galaxies - Spatial & Velocity & Assembly Bias  
vs  
Eagle DMO + Mass Correction + vanilla HOD model

# HOD modeling of SDSS galaxies



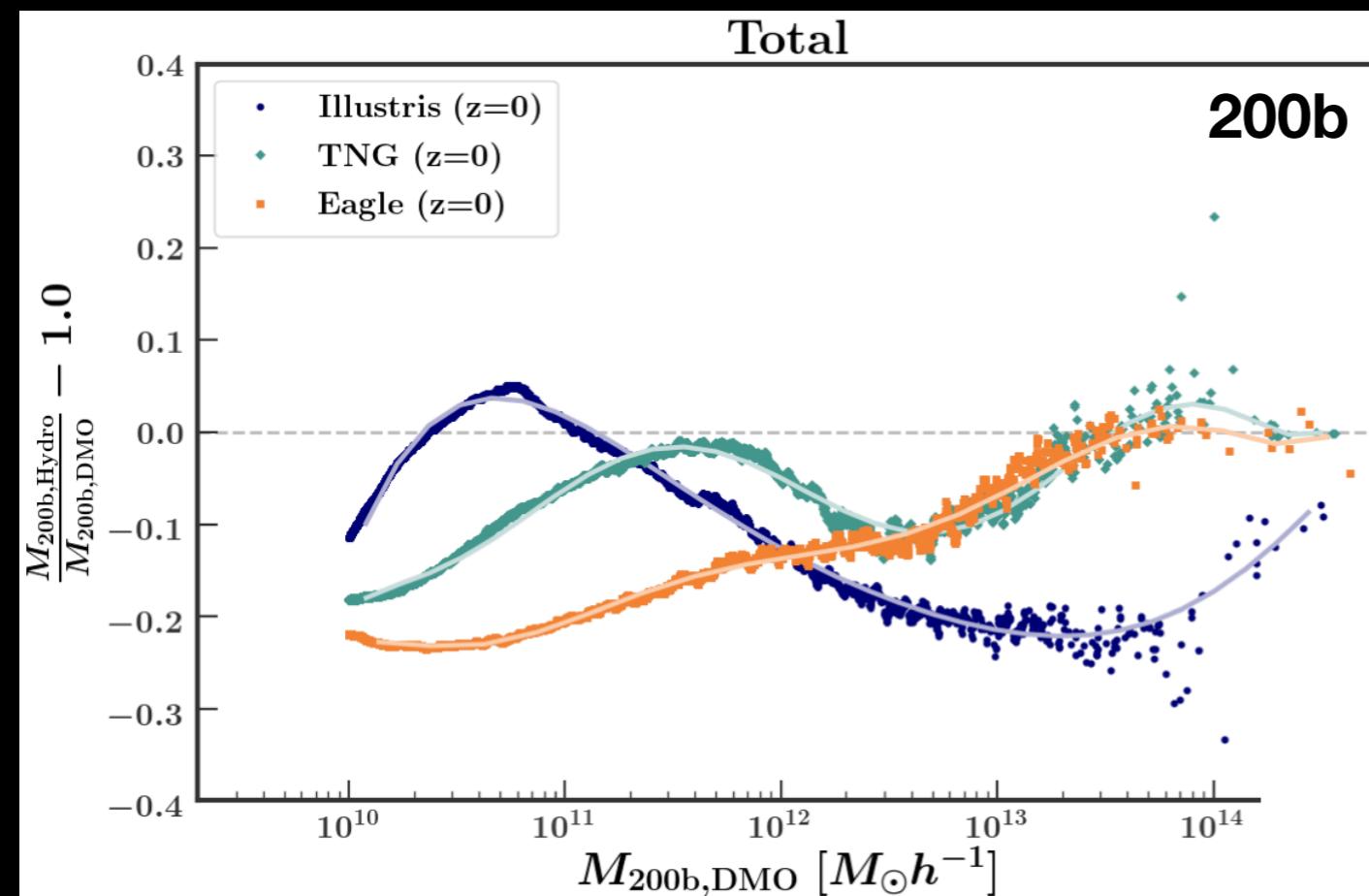
- The addition of new clustering statistics leads to a shift in HOD parameters for SDSS -19 galaxies, but not for -21 galaxies
- Analysis of Illustris and EAGLE galaxies showed that spatial, velocity, and assembly bias were present in the -19 samples but not in the -21 samples

# Halo Mass Function

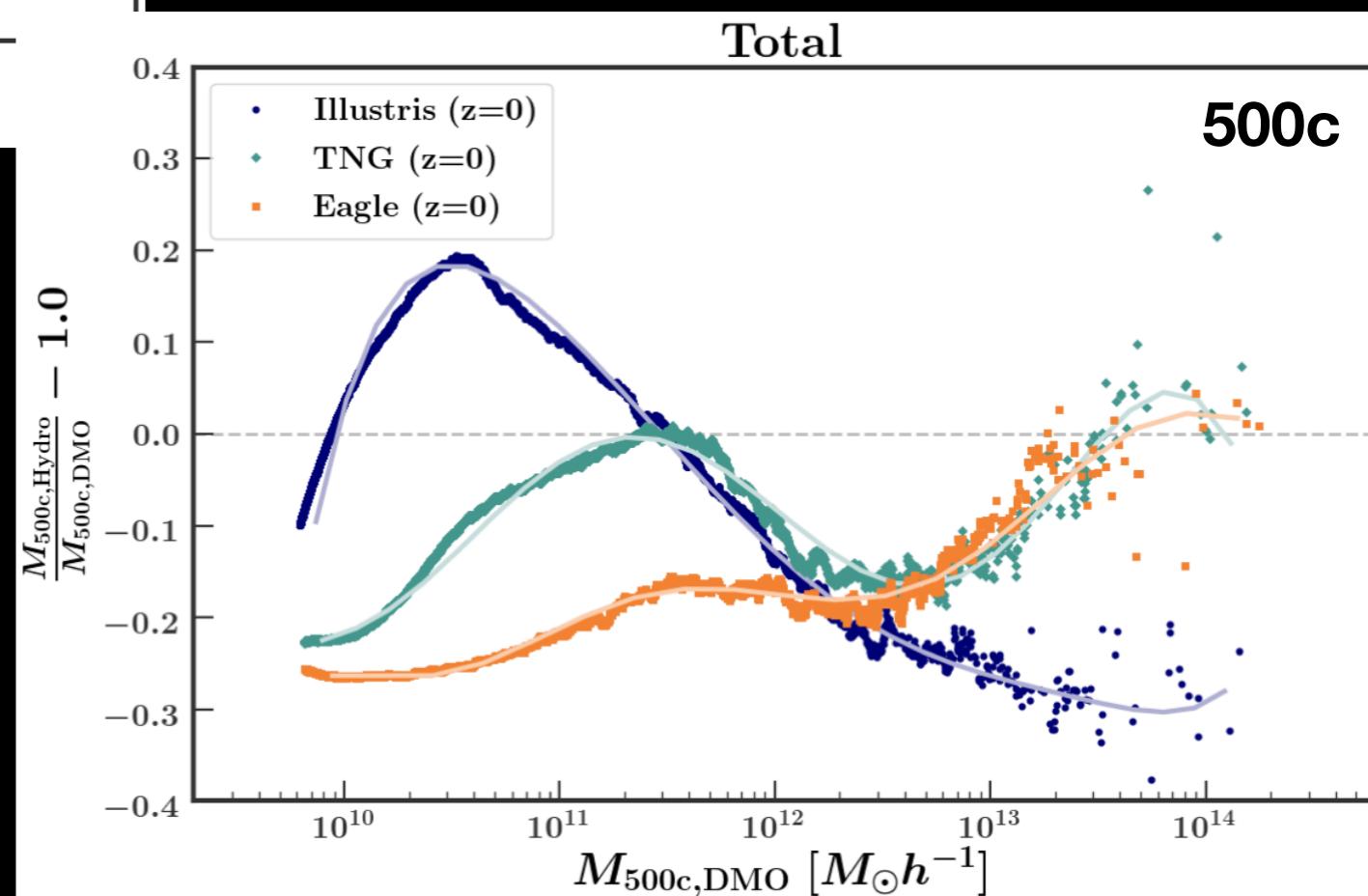


HMF is shifted to higher halo masses in DMO simulations compared to Hydro

# Halo Mass Correction

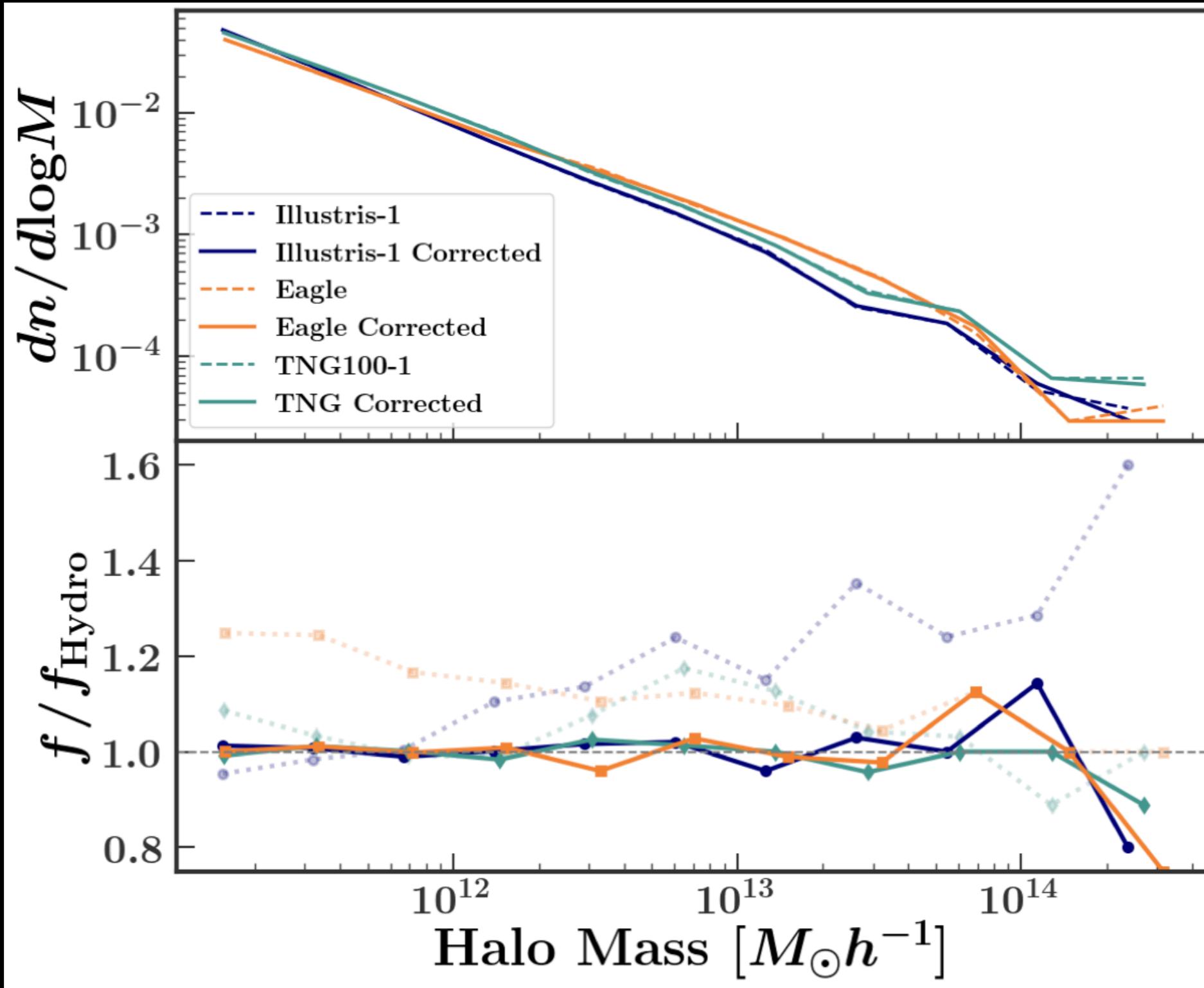


- Hydro and DMO halos are paired based on mass, i.e. abundance matched
- Complex relationship between hydro halo mass and DMO halo mass
- Three different simulations have different results due to feedback



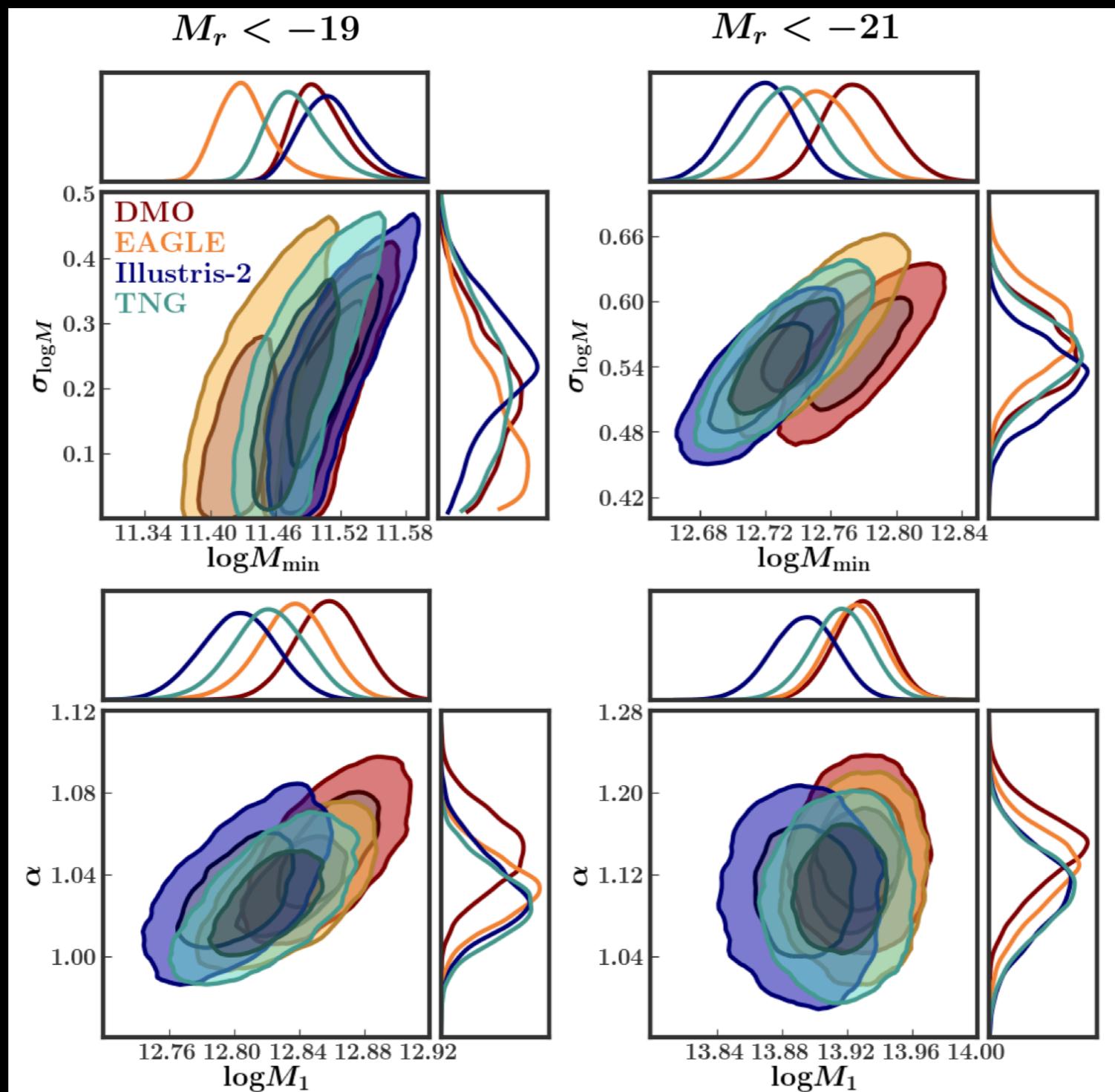
- Different relationships depending on redshift, halo definition
- Can fit the relationship in each simulation and use it to correct the halo mass function
- Fits coming in *Beltz-Mohrmann et al. in prep*

# Halo Mass Function



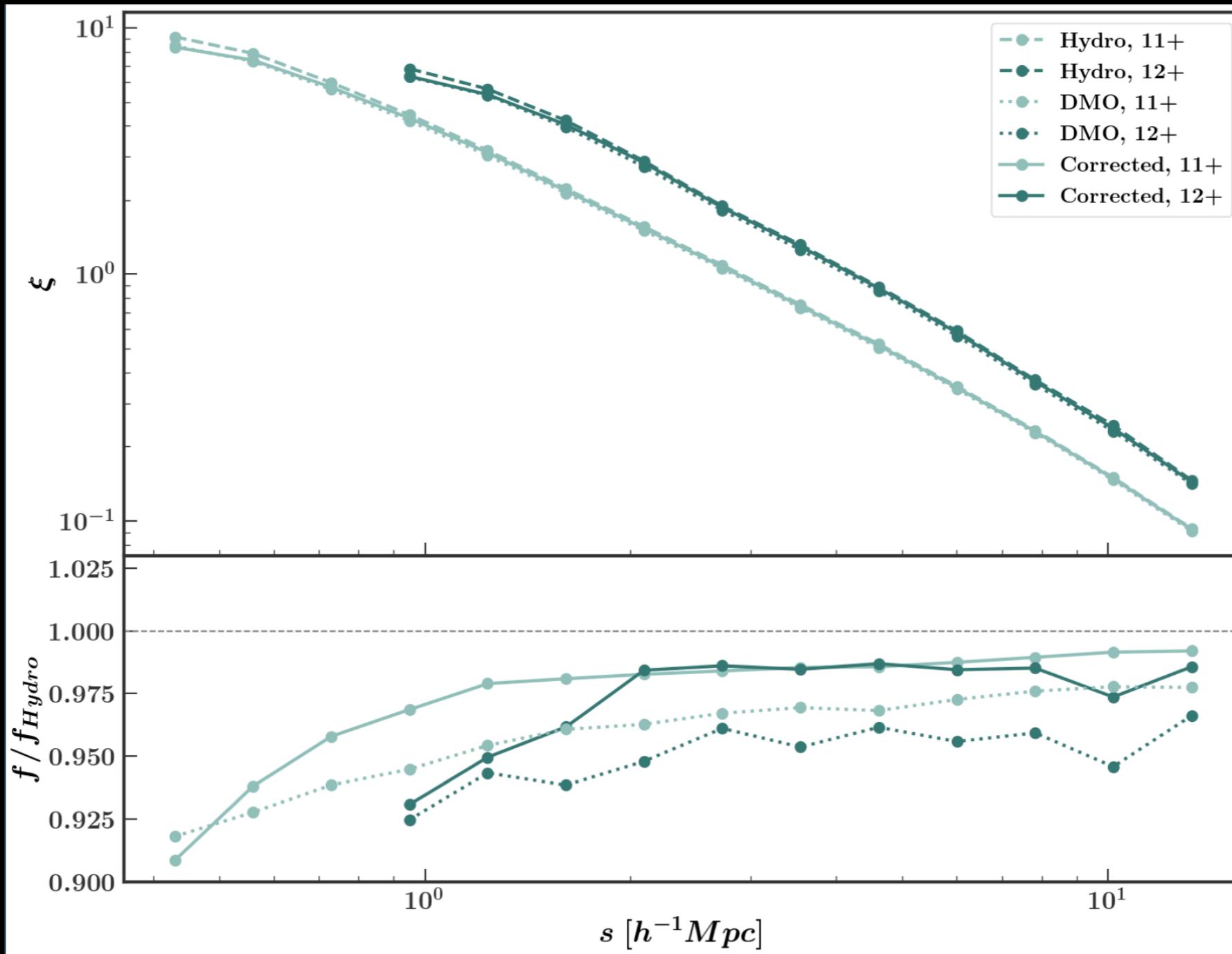
Using fits to correct DMO halo masses reproduces HMF from Hydro

# Effect of Mass Correction on HOD parameters



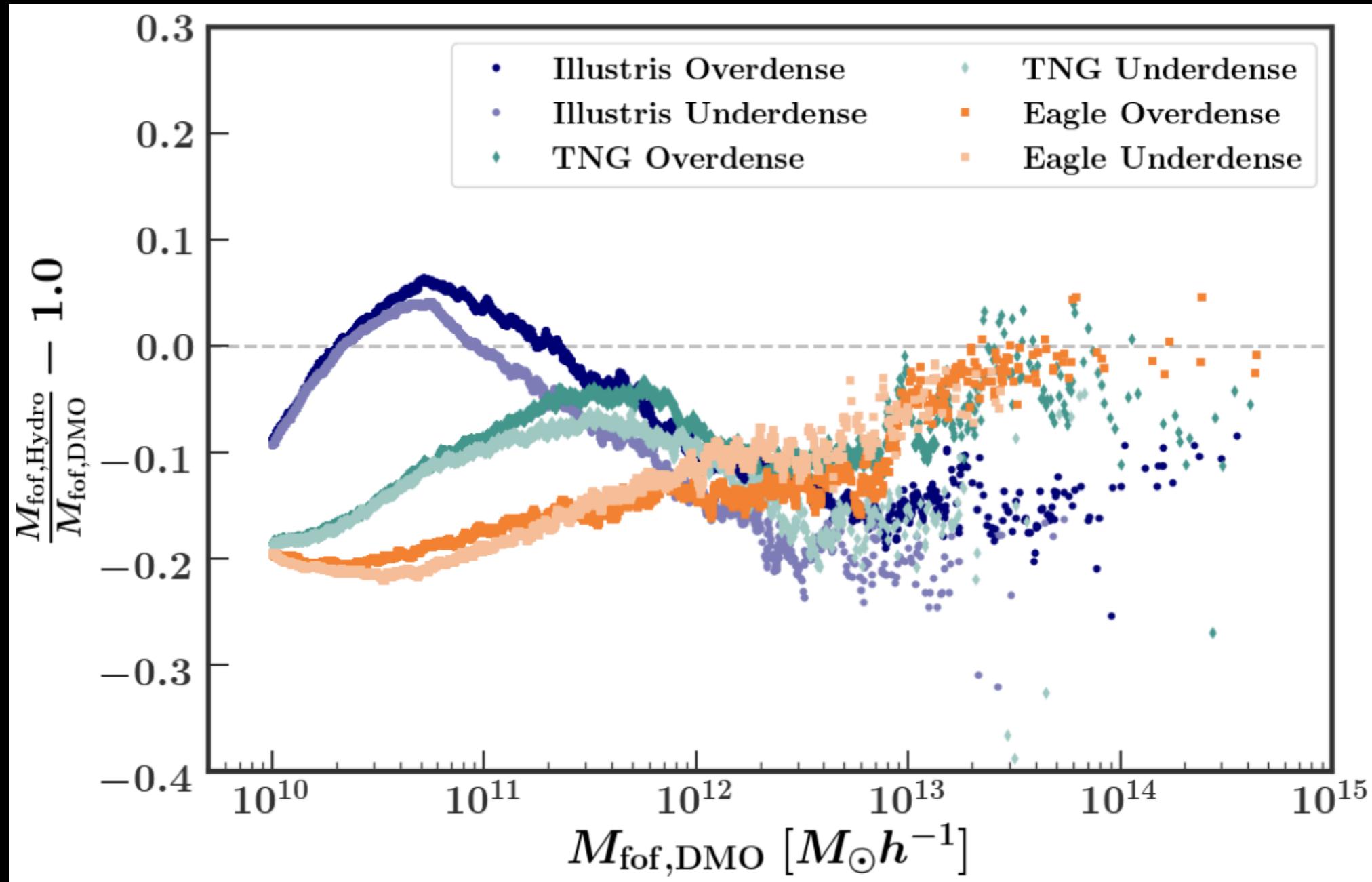
Applying the three different mass corrections to a large DMO simulation leads to different HOD parameter constraints when modeling the clustering of SDSS galaxies.

# 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

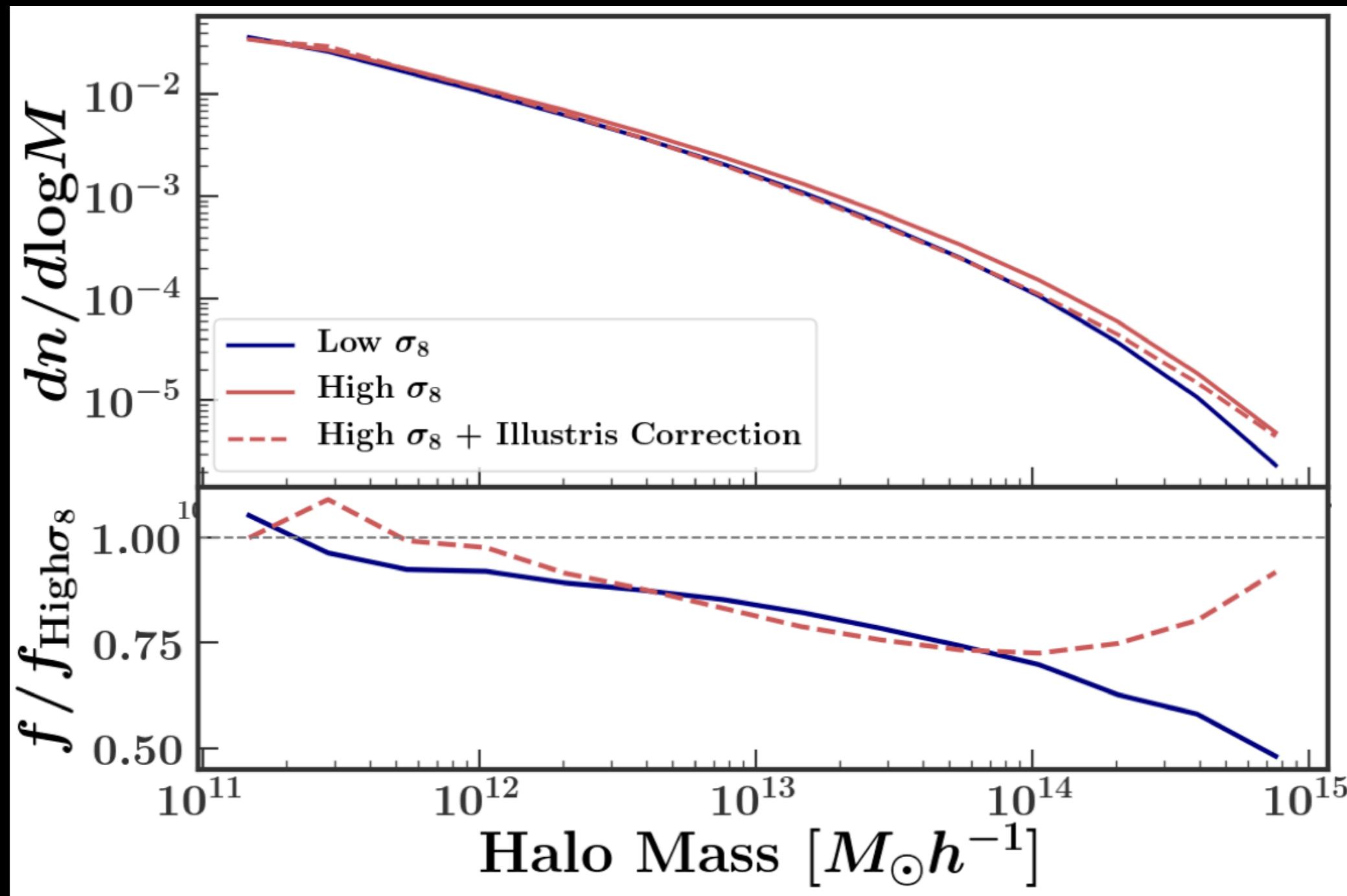


- Environment is measured as the mass within a 5 Mpc sphere around each halo.
- Environments are divided into high and low density based on the median environment across all halos
- Hydro and DMO halos are then paired within similar environments

# Conclusions

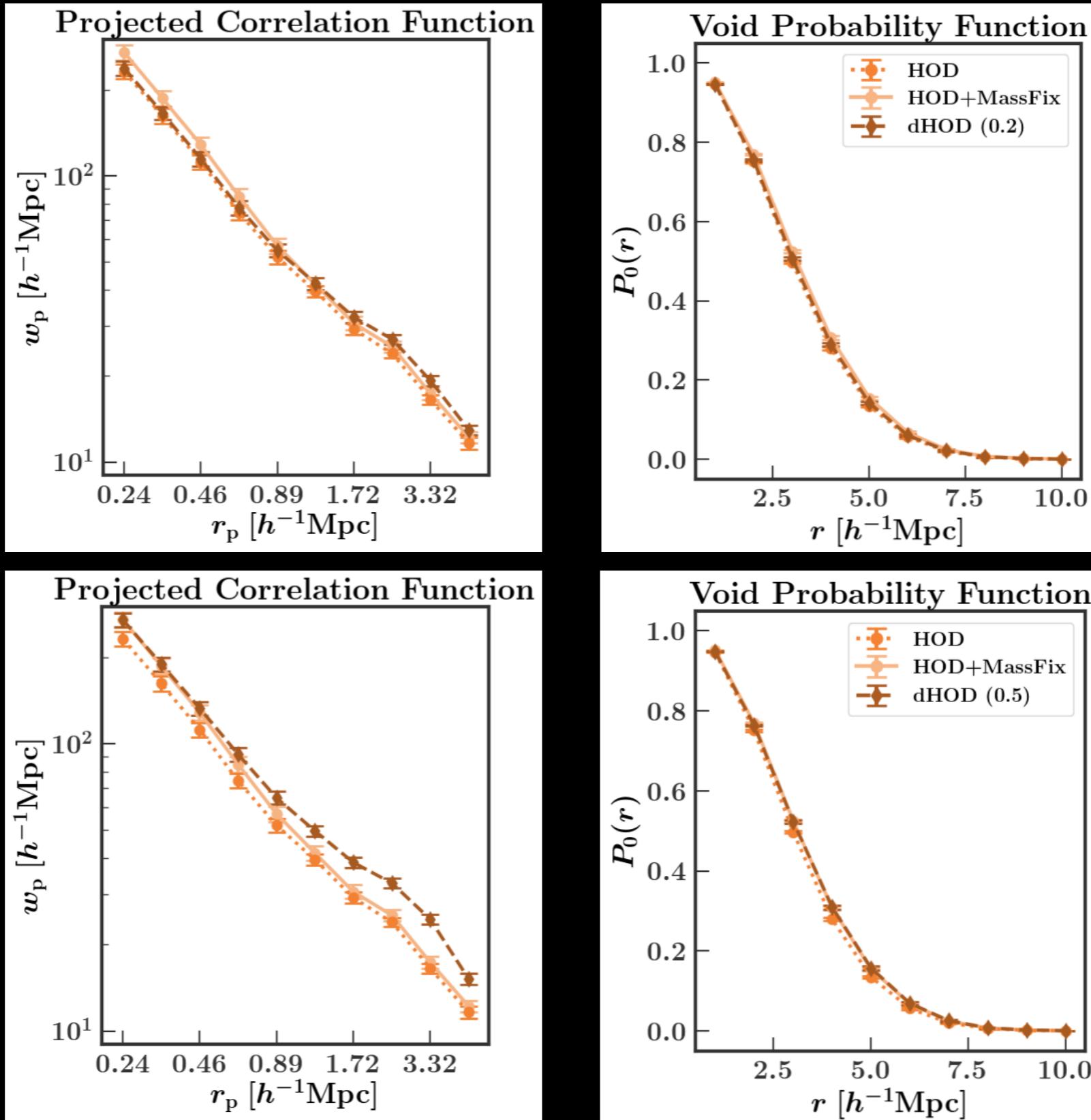
- Based on comparisons to hydro simulations, the vanilla HOD model needs to be expanded to include effects like spatial bias, velocity bias, and assembly bias
  - Using clustering statistics that are sensitive to these biases without including them in the model could lead to incorrect HOD parameter constraints
- 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.