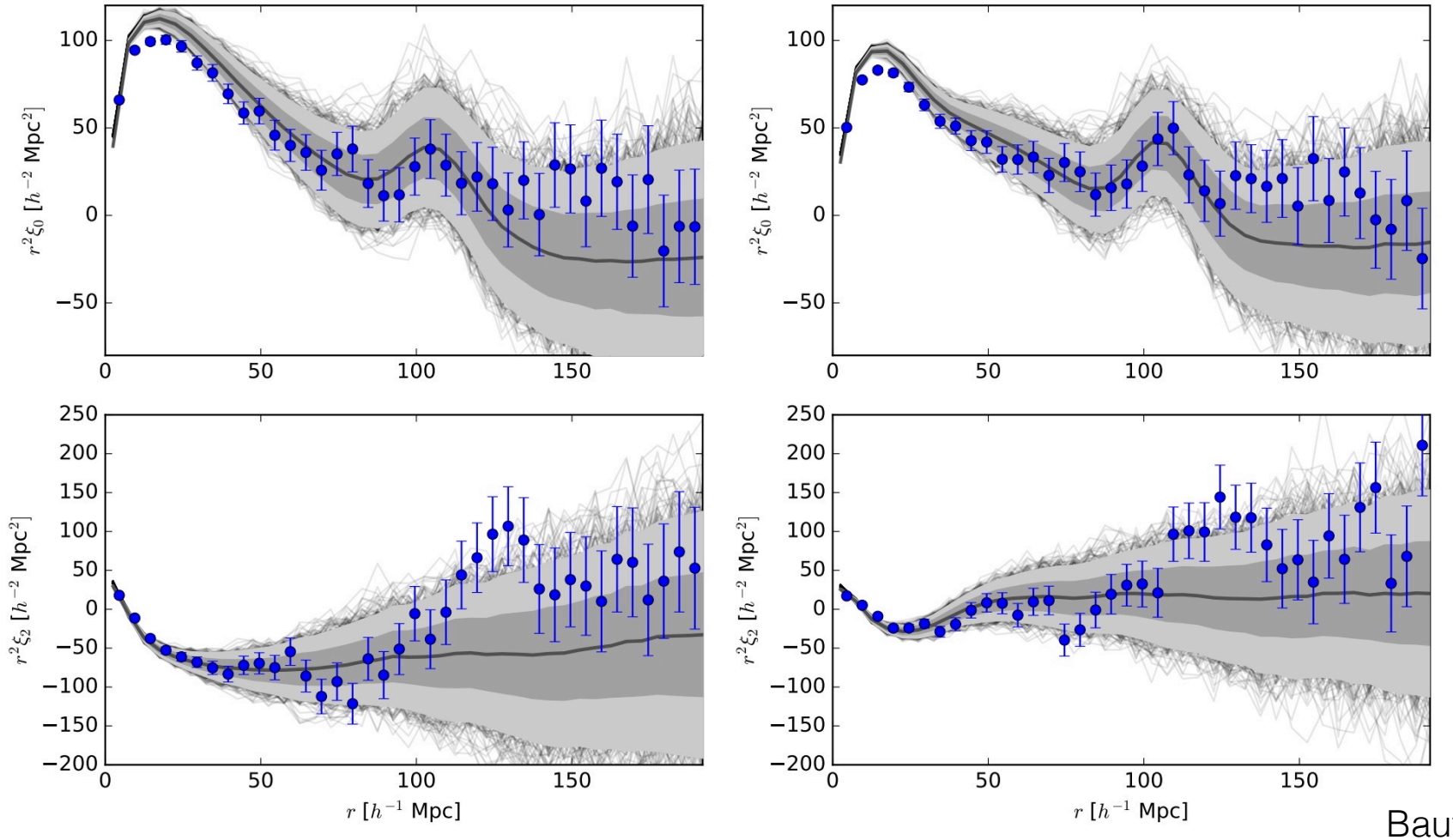
Galaxy clustering at small scale and measurement of structure growth

Zhongxu Zhai（翟忠旭）
Department of Astronomy, SJTU

Oct 30th –Nov 3rd , 2023
The 2nd Shanghai Assembly

Galaxy 2-point correlation function



Bautista+2018

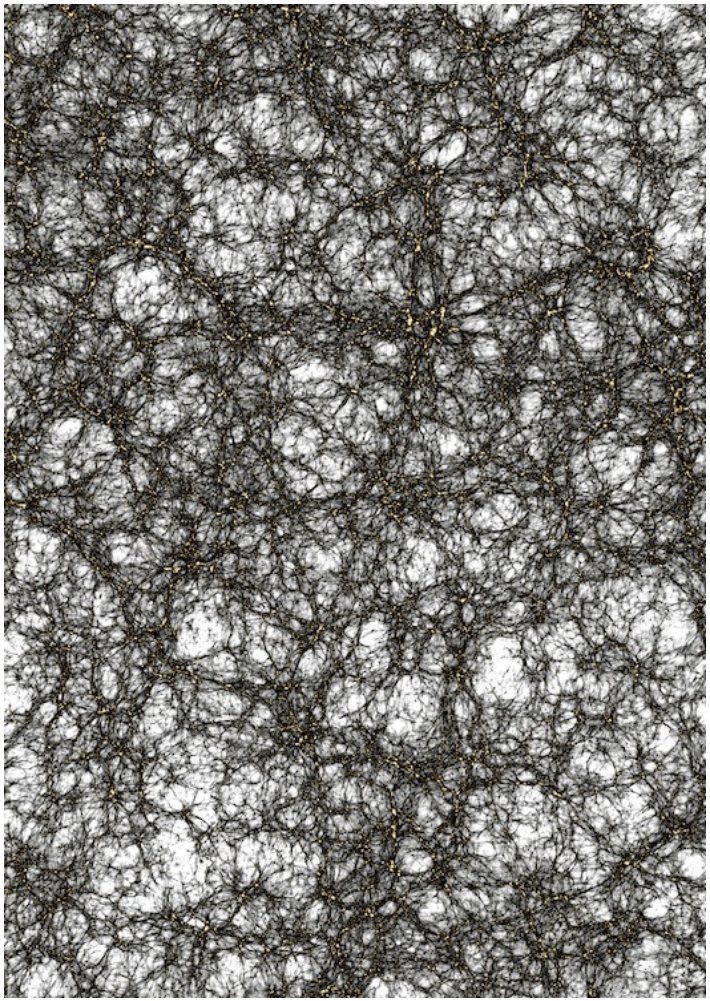
The Aemulus (alpha) Project

* Multi-institution collaboration

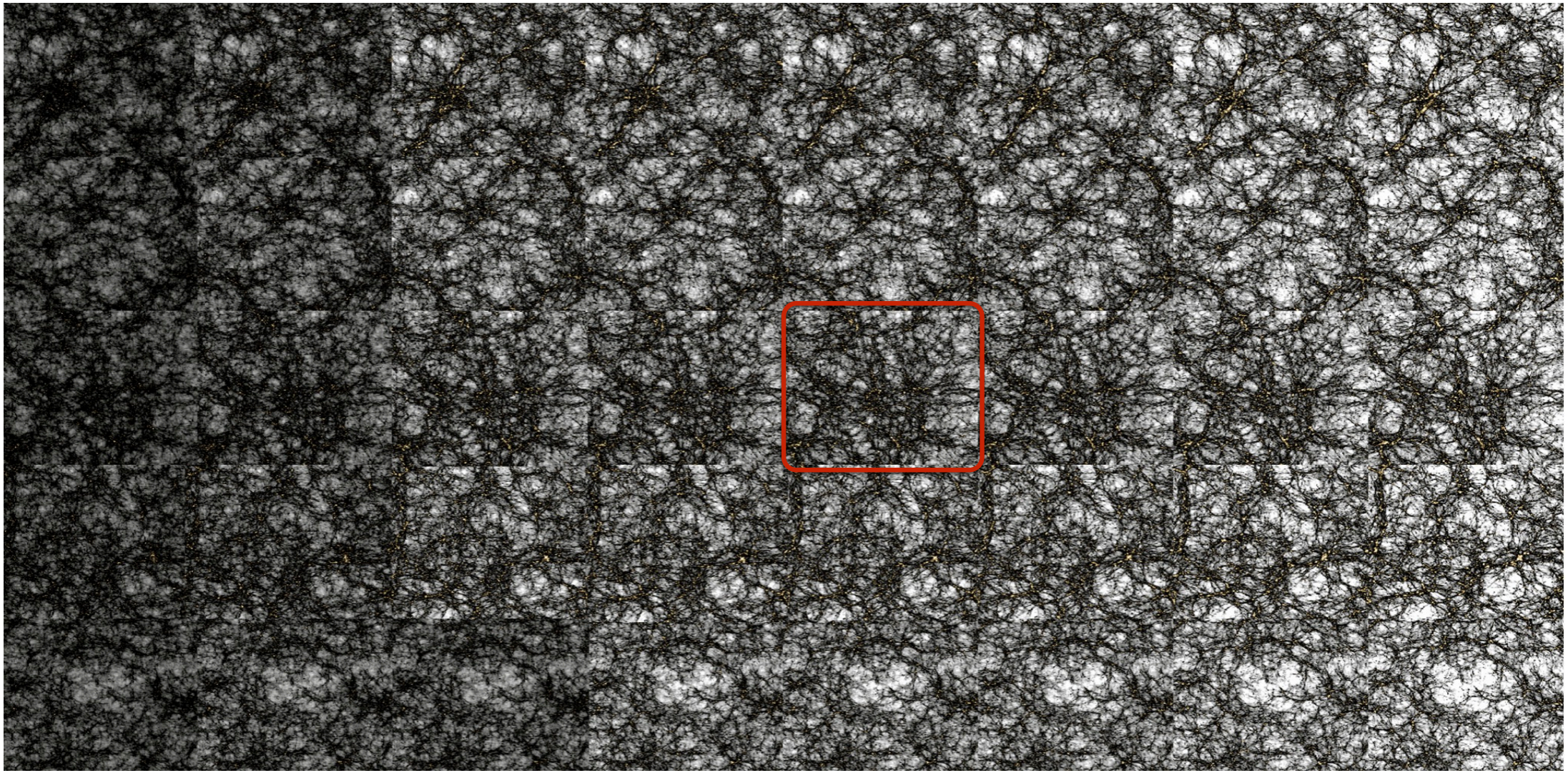
* Results: Suite(s) of high-resolution N-body simulations spanning currently-allowed cosmological parameter space

* Goal: precision emulation of statistics of dark matter halos and galaxies:
  Halo mass function
  Halo bias function
  Galaxy correlation function
  Galaxy-galaxy lensing

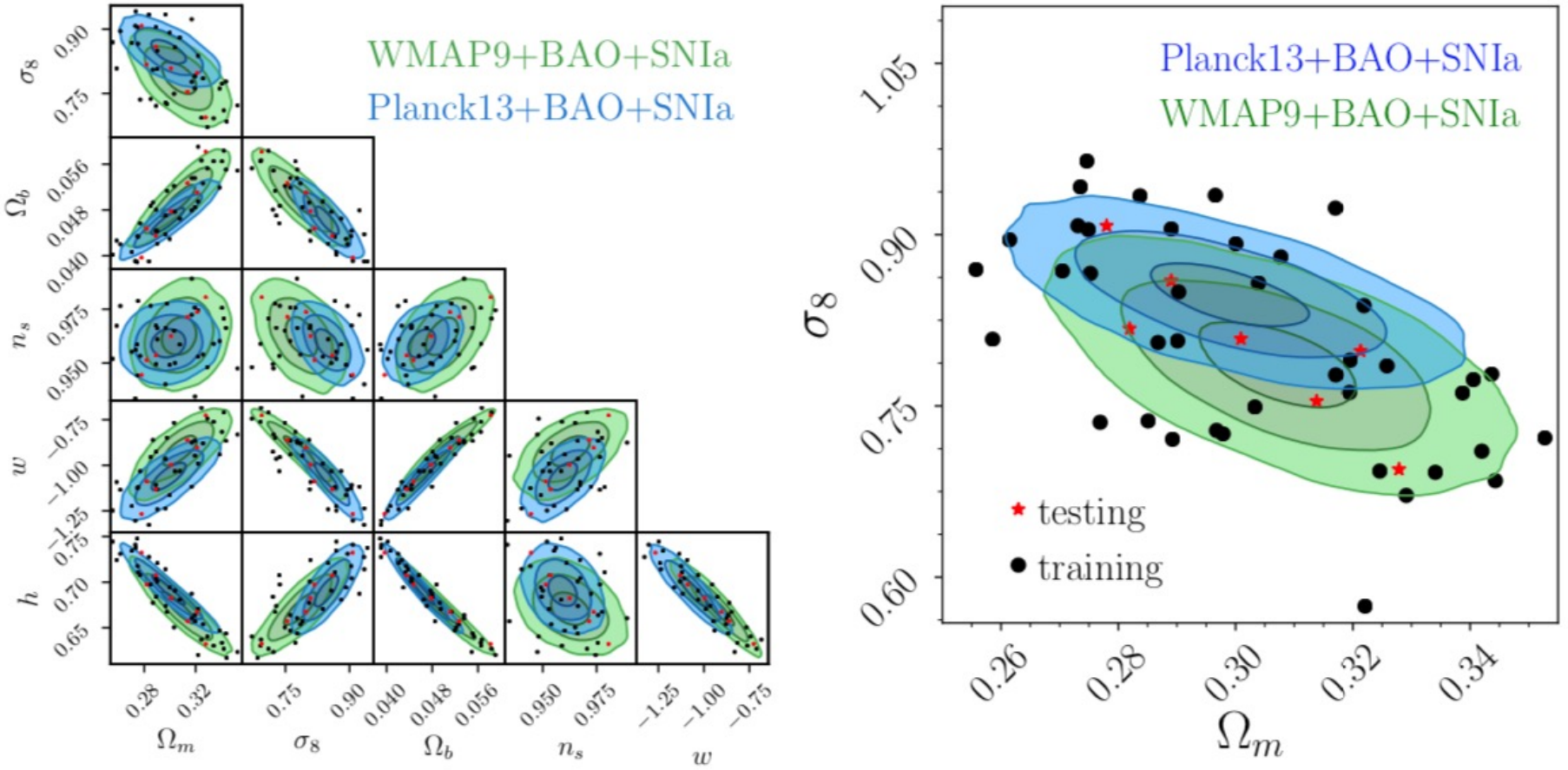
https://aemulusproject.github.io/



The Aemulus (alpha) Project

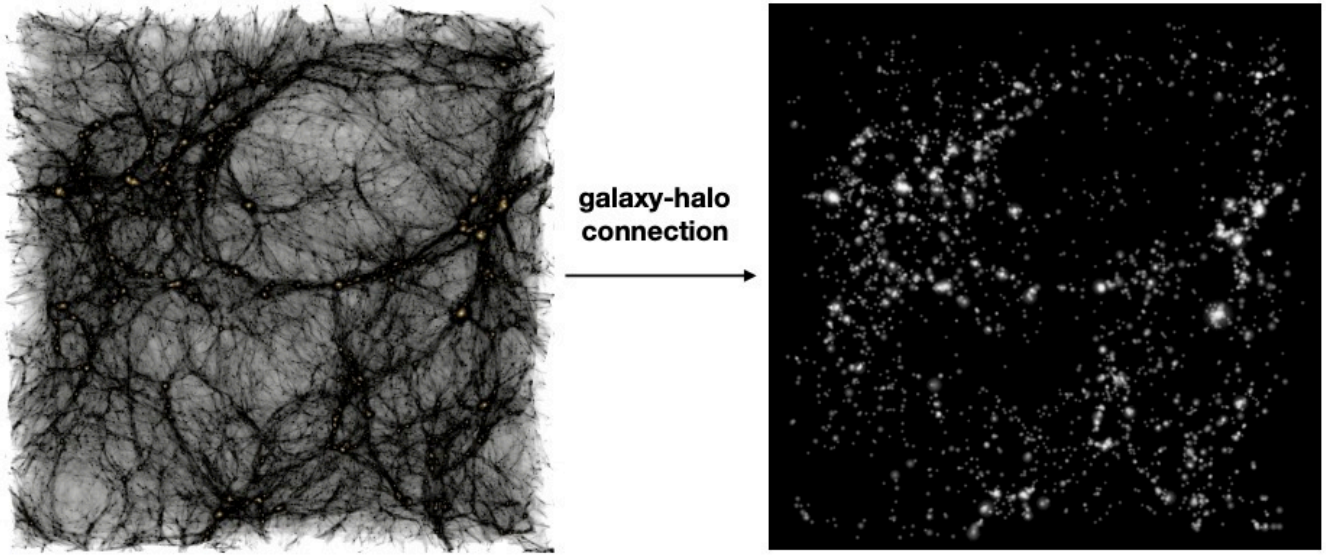


Aemulus I: cosmological models



Aemulus I

From Halos to Galaxies

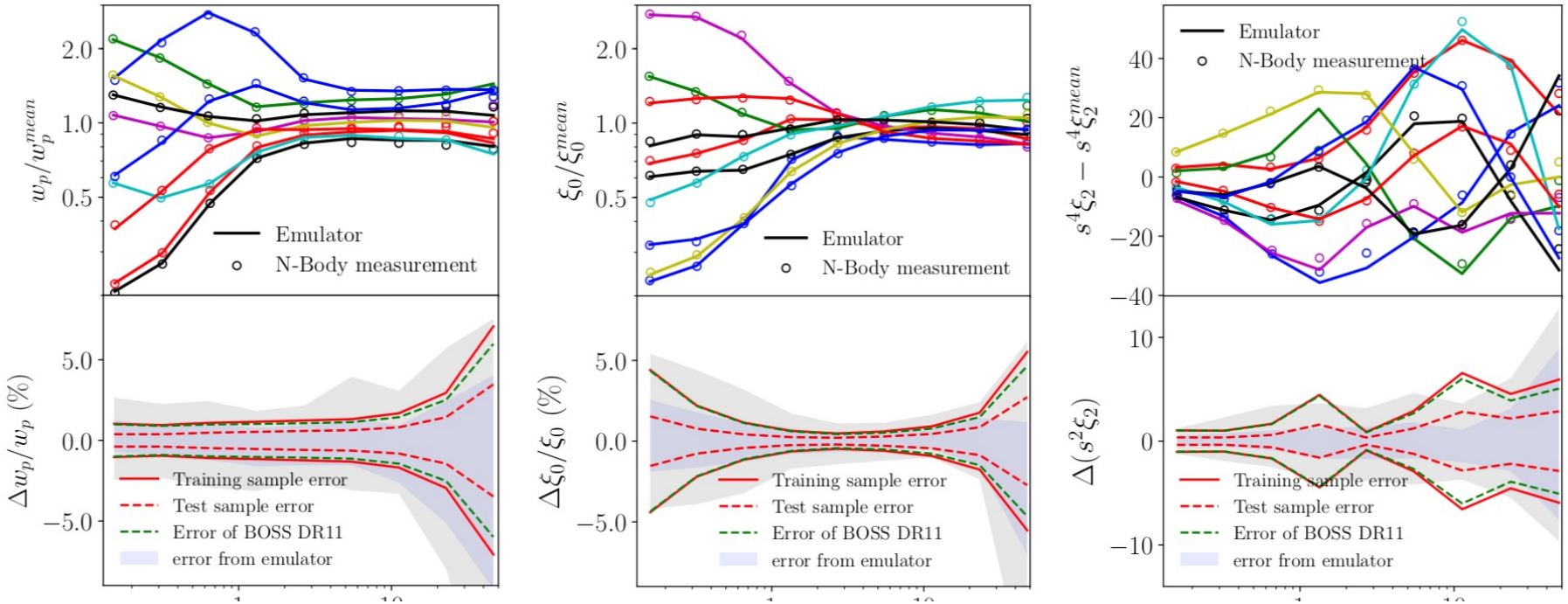


Approaches to modeling the galaxy-halo connection

← physical models			empirical models →	
Hydrodynamical Simulations	**Semi-analytic Models**	**Empirical Forward Modeling**	**Subhalo Abundance Modeling**	**Halo Occupation Models**
Simulate halos & gas; Star formation & feedback recipes	Evolution of density peaks plus recipes for gas cooling, star formation, feedback	Evolution of density peaks plus parameterized star formation rates	Density peaks (halos & subhalos) plus assumptions about galaxy—(sub)halo connection	Collapsed objects (halos) plus model for distribution of galaxy number given host halo properties

Wechsler & Tinker 2018

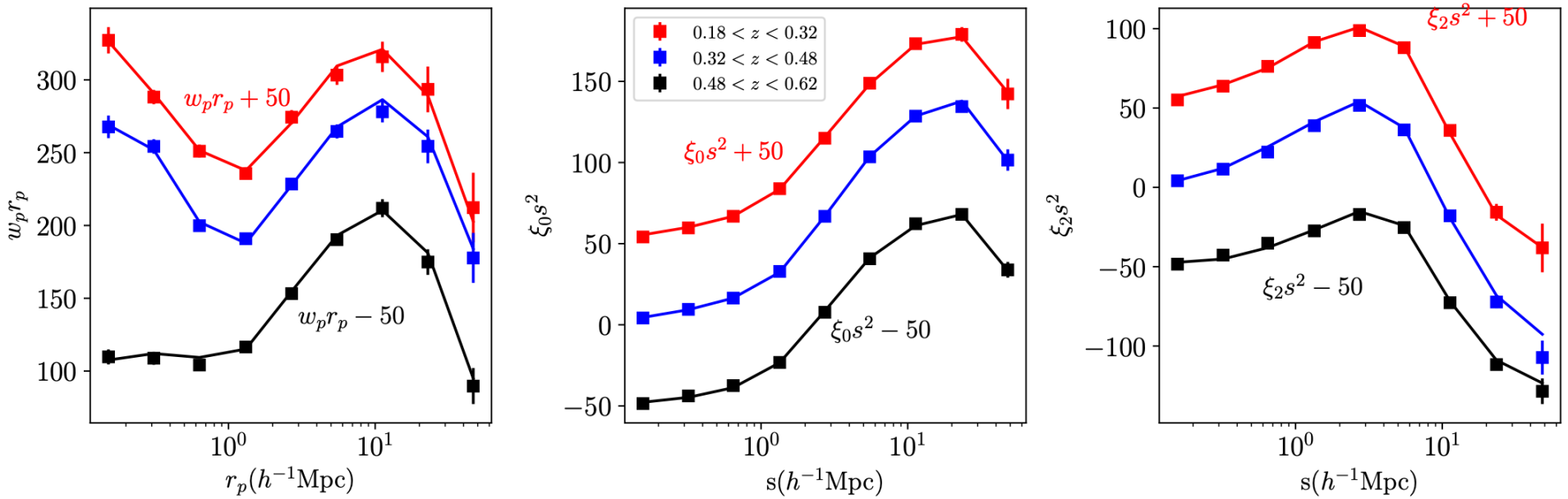
Aemulus III: Galaxy clustering



Construct the emulator for real and redshift space correlation function of galaxies at z=0.55, the accuracy is better than sample variance and reaches 1% at 1-10 Mpc/h

Aemulus III

Modeling SDSS-BOSS galaxies



Aemulus V

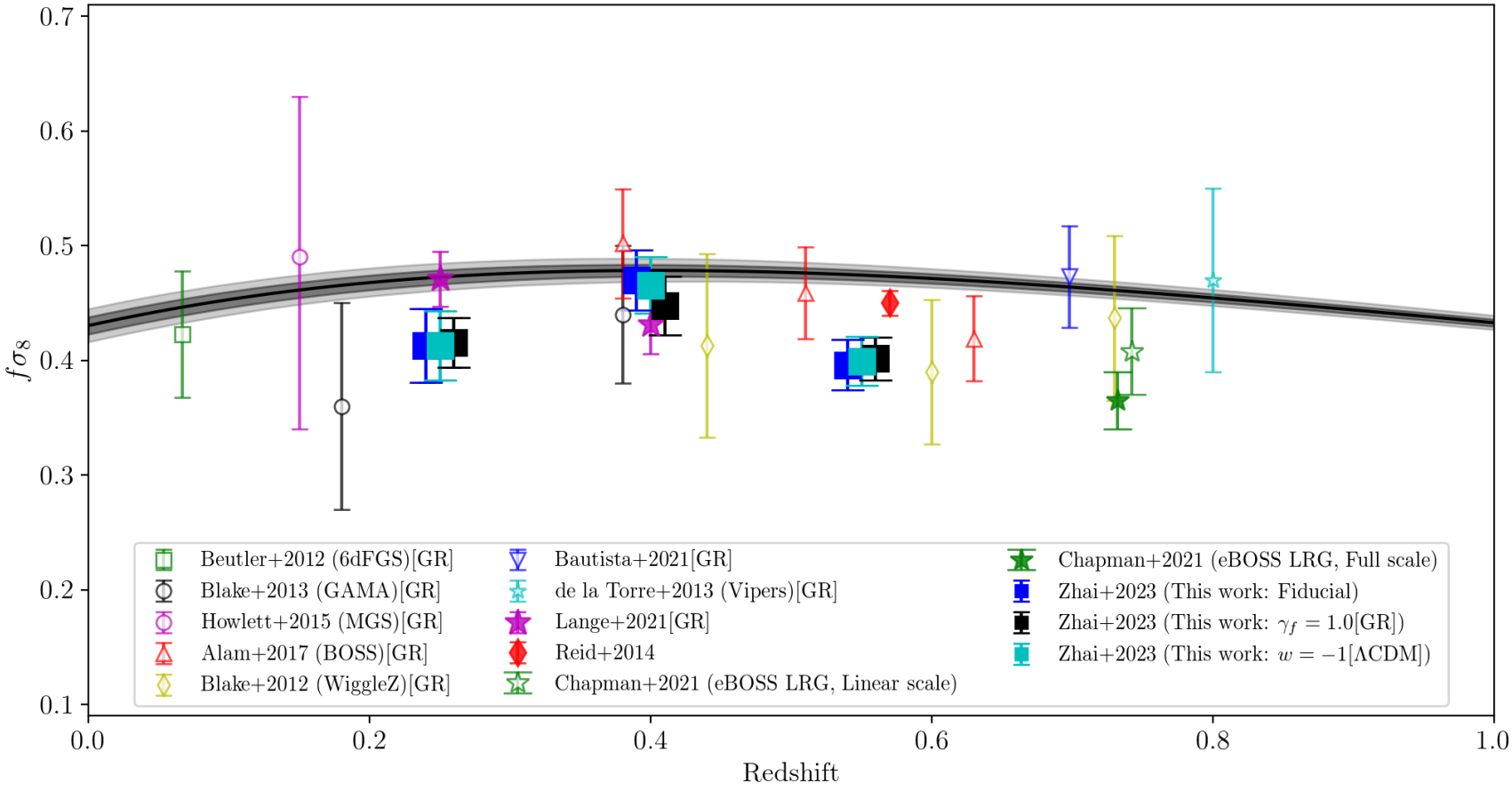
All simulations assume GR

Modeling of galaxies: velocity bias, concentration, assembly bias, etc.

Both real and redshift space clustering can match

Allows deviation from GR: velocity scaling parameter

Measurement of structure growth



Aemulus V

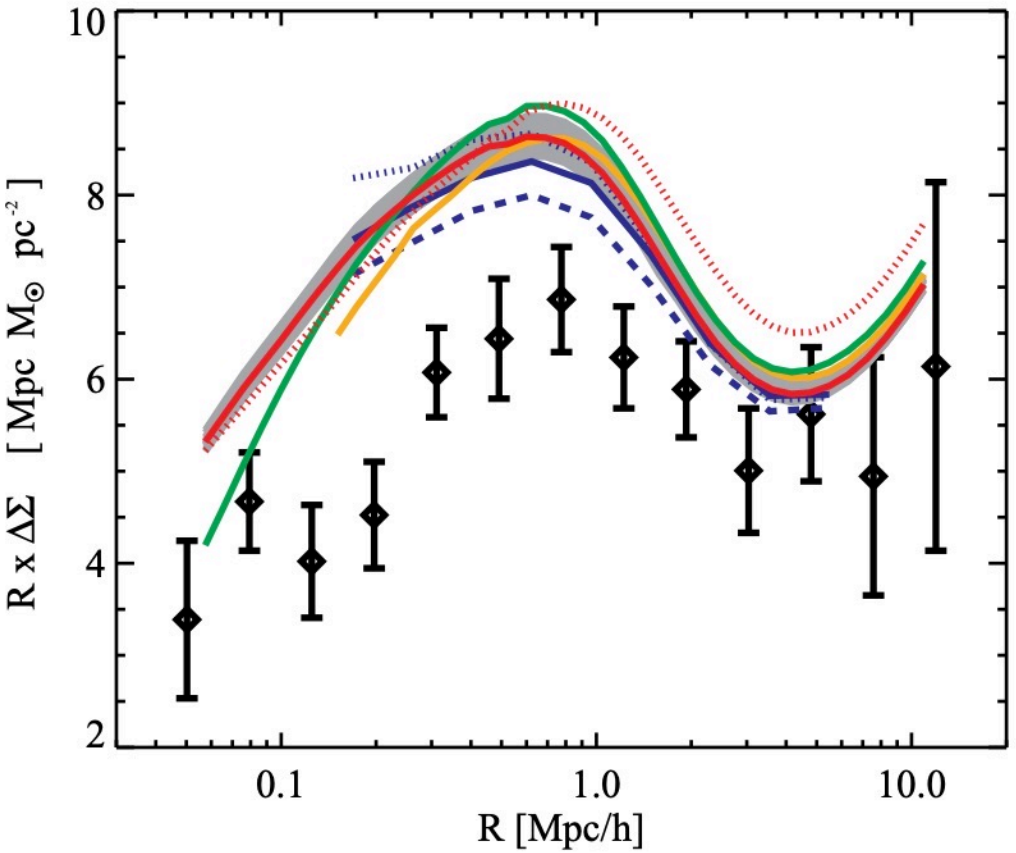
Astrophysics > Cosmology and Nongalactic Astrophysics

[Submitted on 25 Nov 2016]

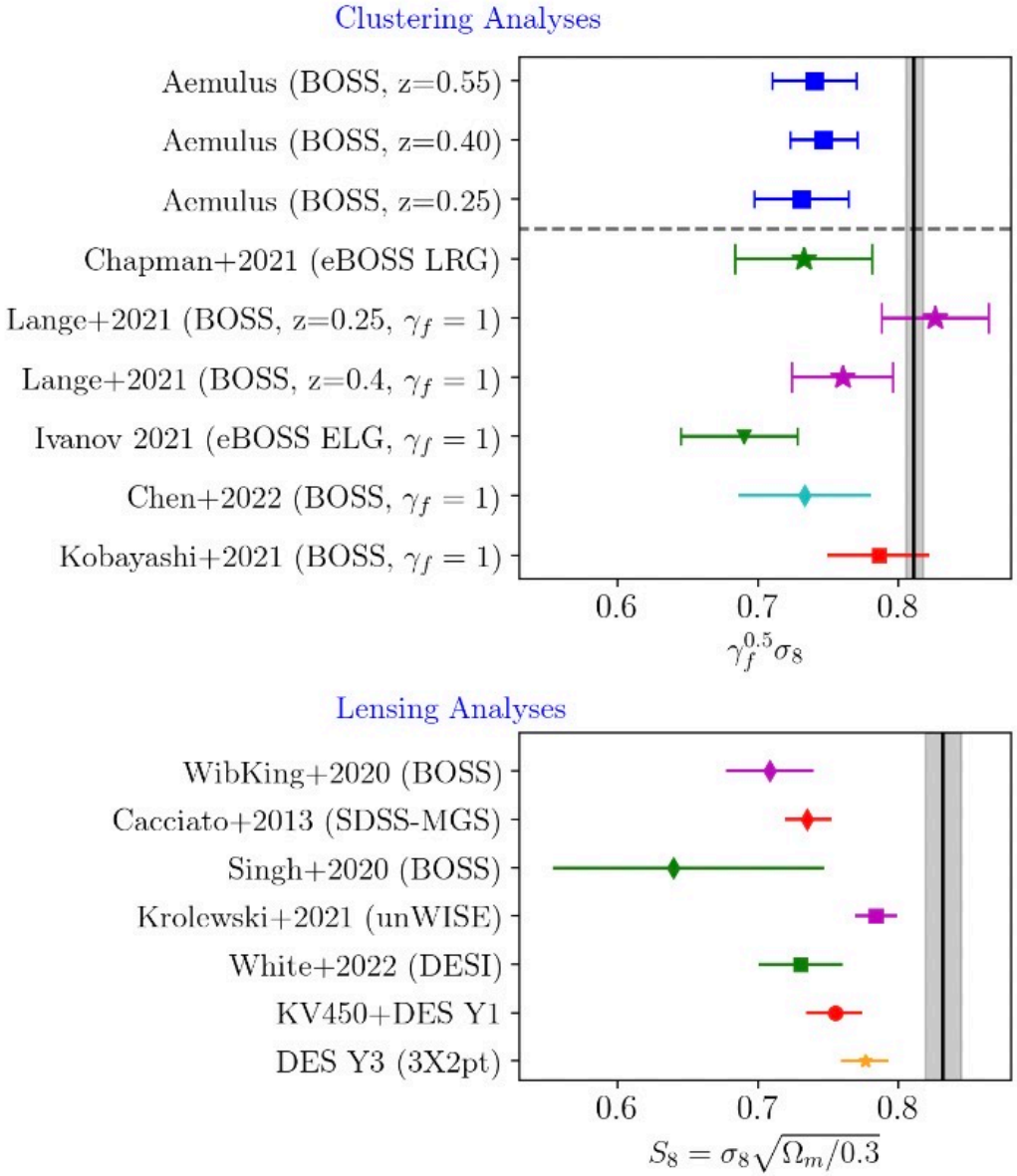
Lensing is Low: Cosmology, Galaxy Formation, or New Physics?

Alexie Leauthaud, Shun Saito, Stefan Hilbert, Alexandre Barreira, Surhud Mo
Kevin Bundy, Jean Coupon, Thomas Erben, Catherine Heymans, Hendrik Hil
Moraes, Maria E. S. Pereira, Sergio A. Rodriguez-Torres, Fabian Schmidt, Hu
Navarro

We present high signal-to-noise galaxy-galaxy lensing measurements of the BOSS CM
lensing data from CFHTLenS and CS82. We compare this signal with predictions from
the stellar mass function and the projected and two dimensional clustering of CMASS.
standard models of the galaxy-halo connection, robustly predicts a lensing signal tha
that our results are robust to a variety of systematic effects. Lowering the value of S_8
the lensing with clustering. However, given the scale of our measurement ($r < 10\ h^{-1}$
be taken into consideration. We explore the impact of baryon physics, assembly bias,
relativity on $\Delta\Sigma$ and show that several of these effects may be non-negligible given t
cosmological effects from the details of the galaxy-halo connection, the effects of ba
facing joint lensing and clustering analyses. This is especially true in the context of la
surveys with precise measurements but complex selection functions.

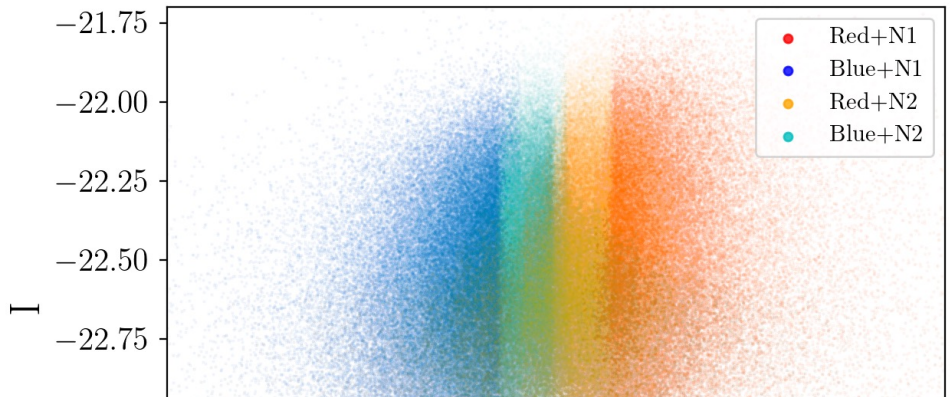


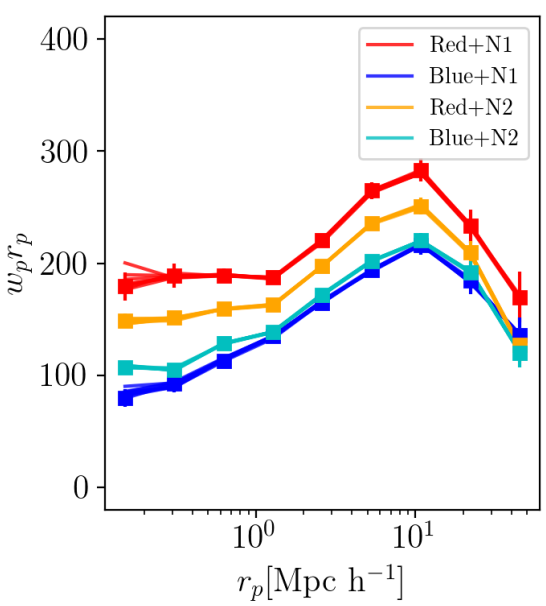
Clustering and Lensing

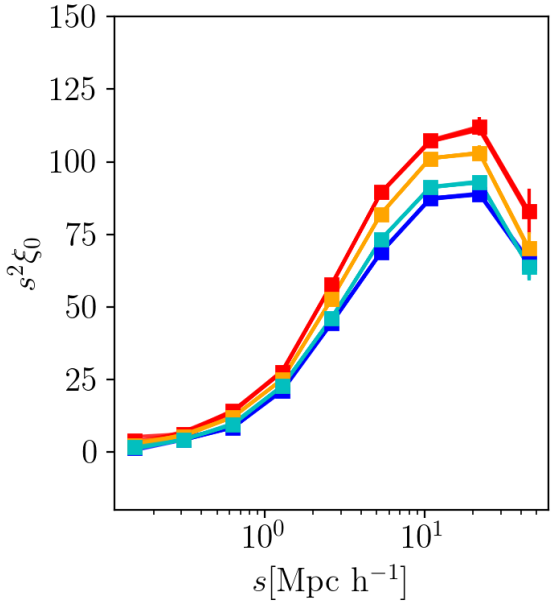


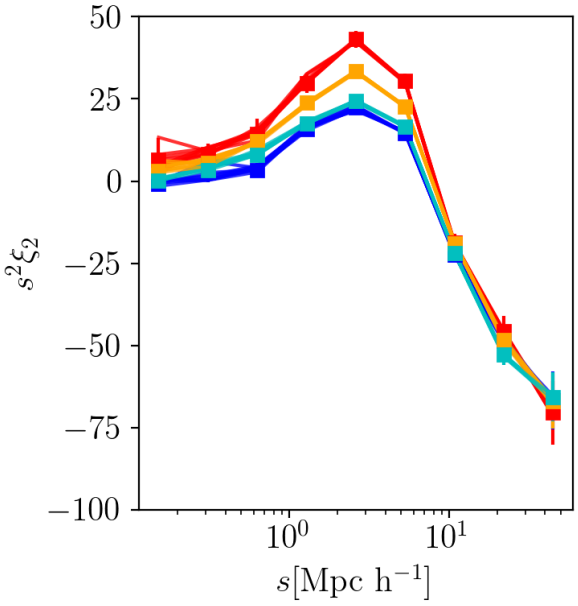
Aemulus V

Selections of galaxies

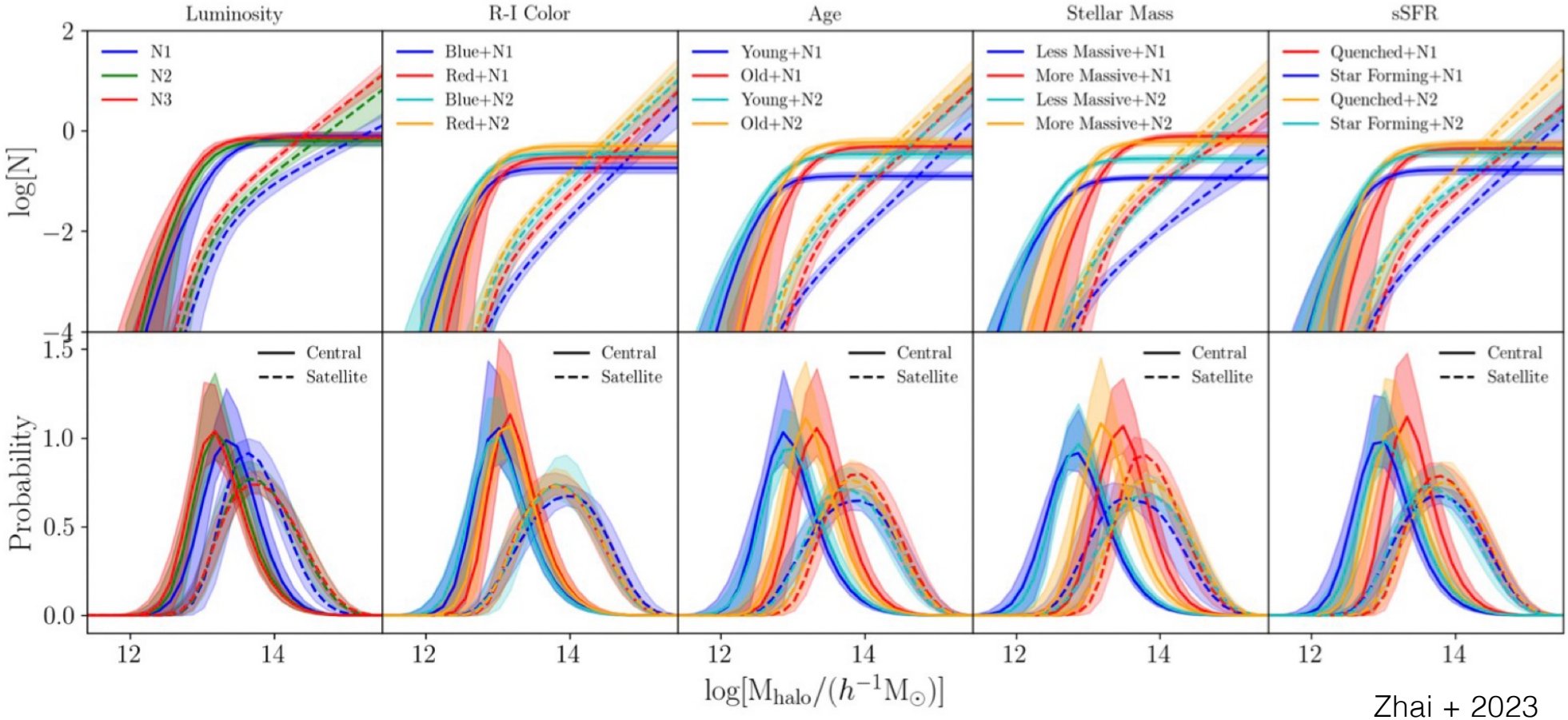






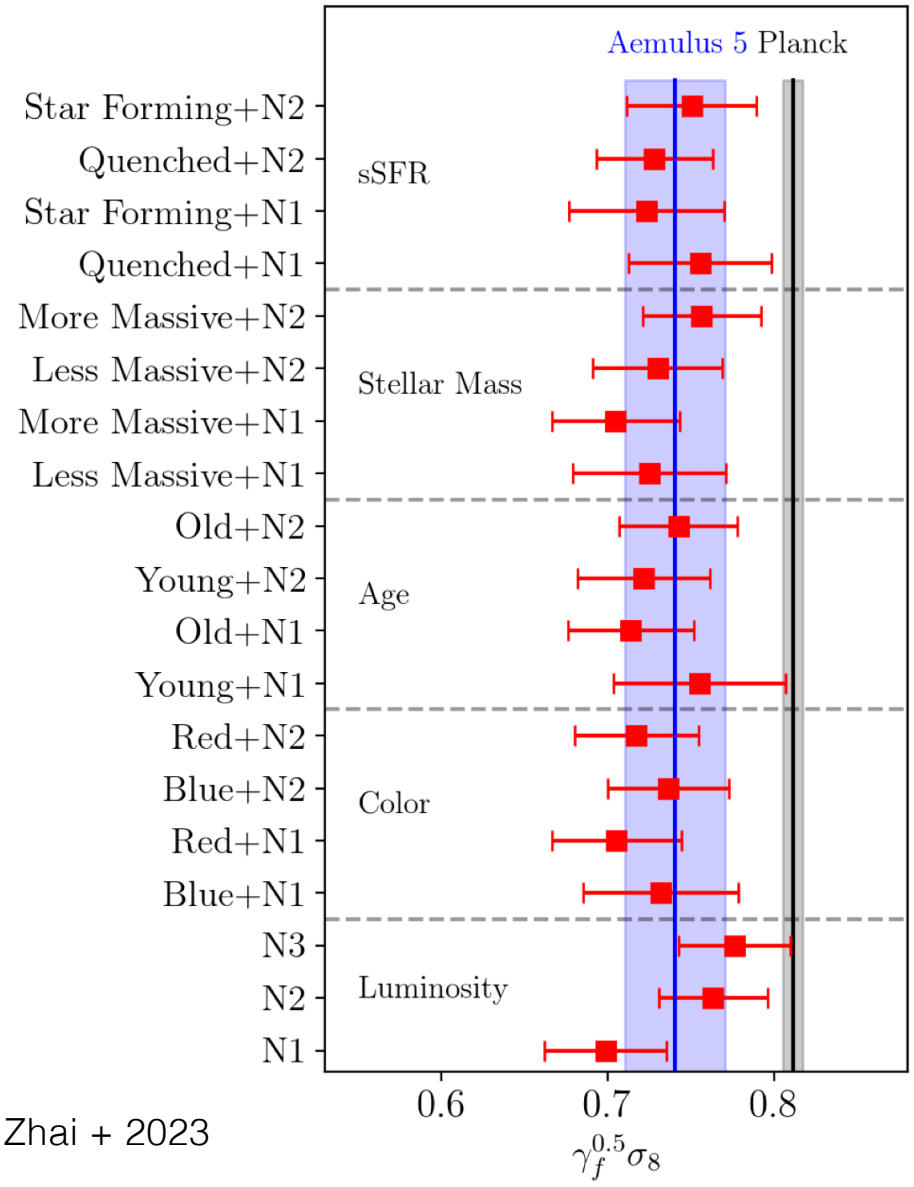


Halo Occupations



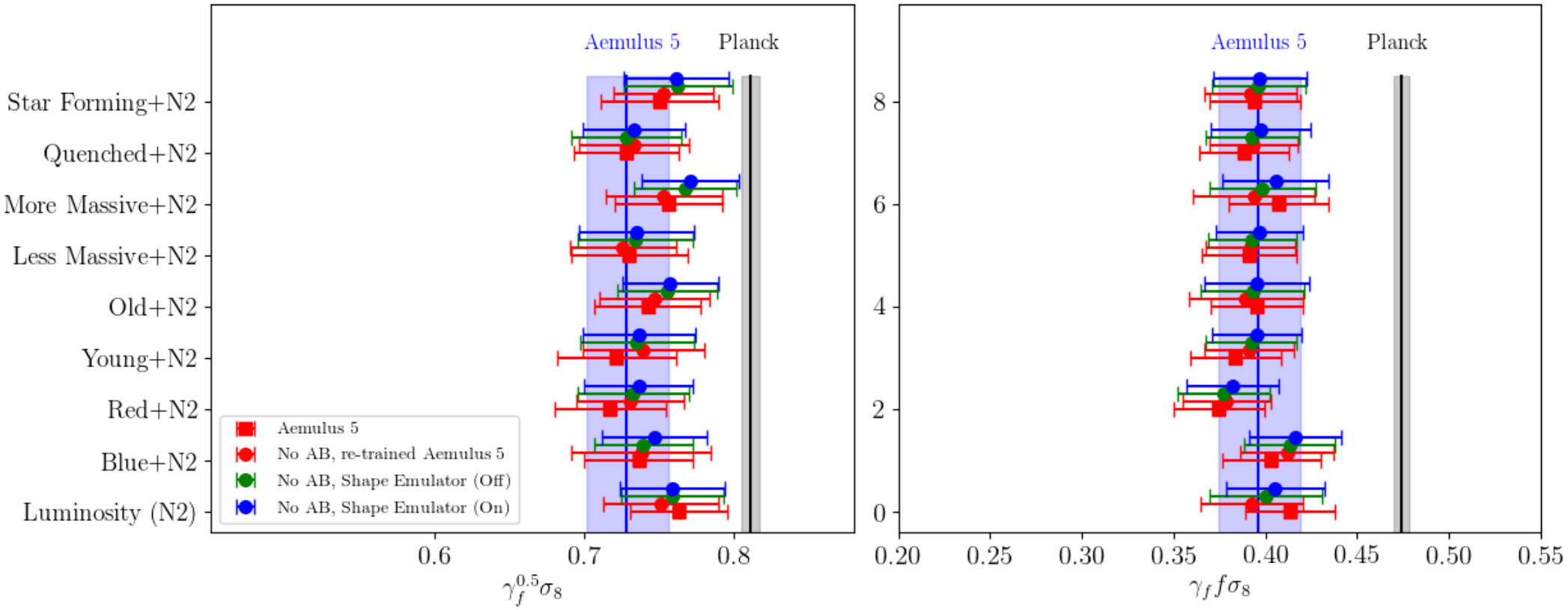
Zhai + 2023

Measurement of structure growth



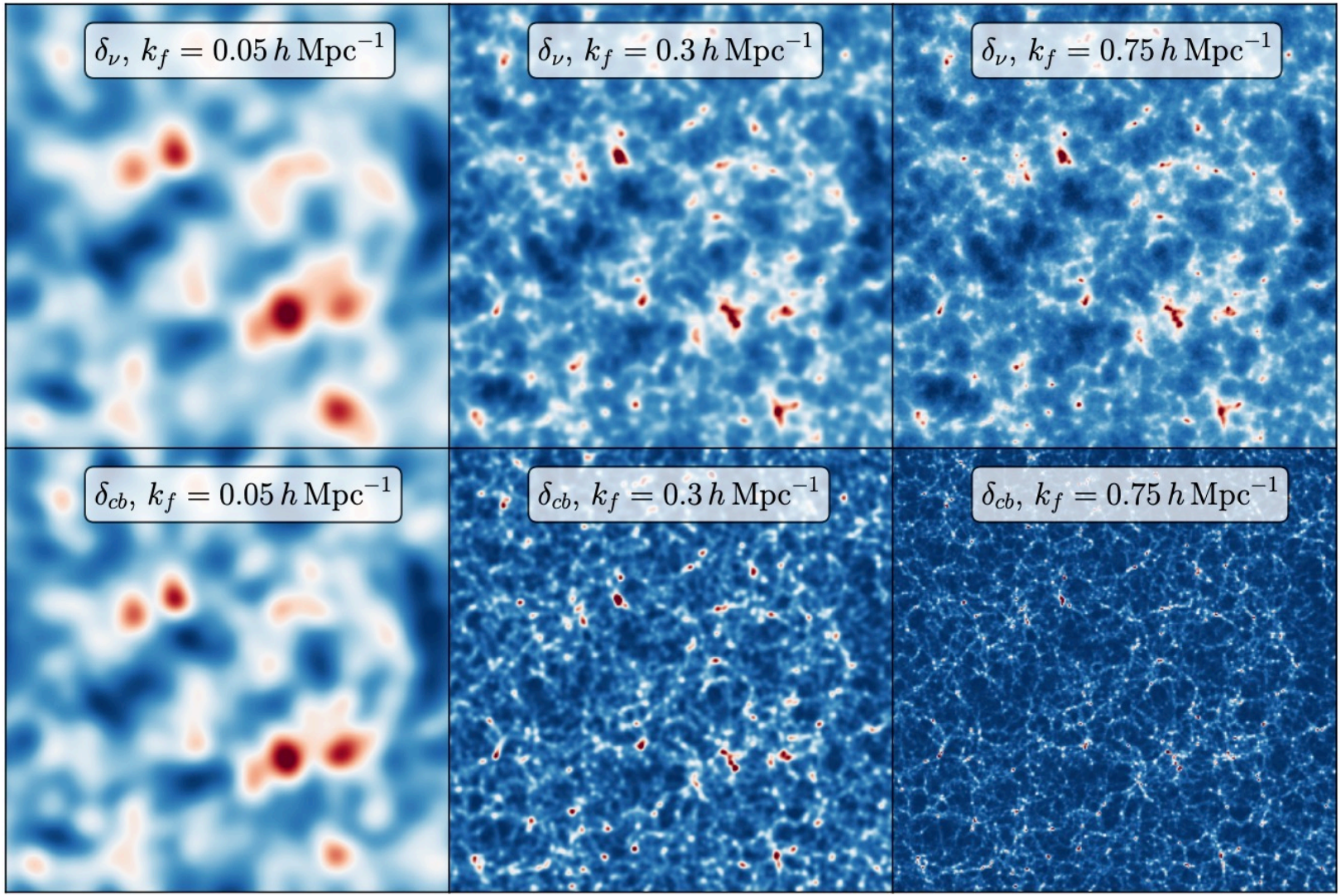
Zhai + 2023

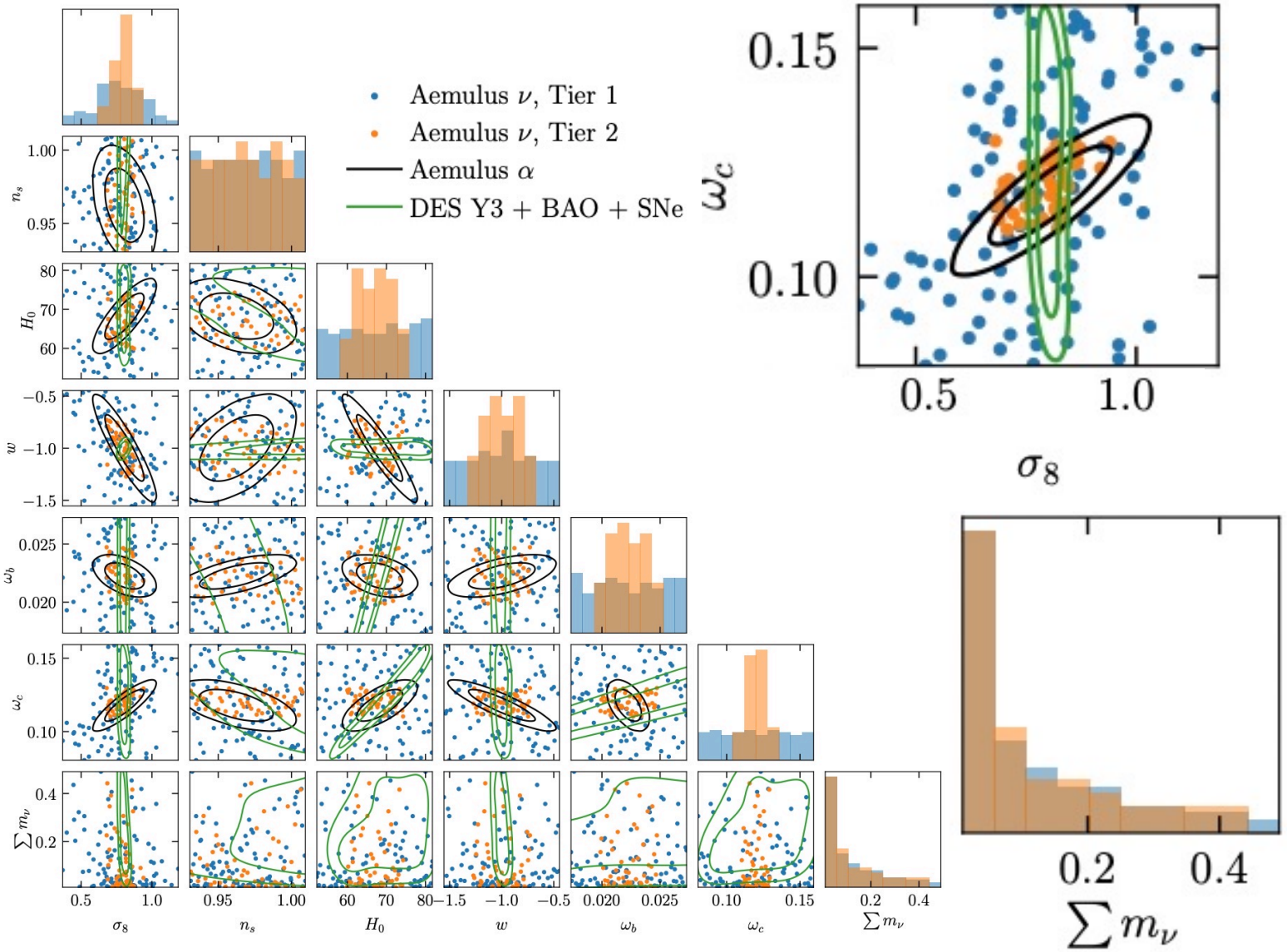
Halo shape effect



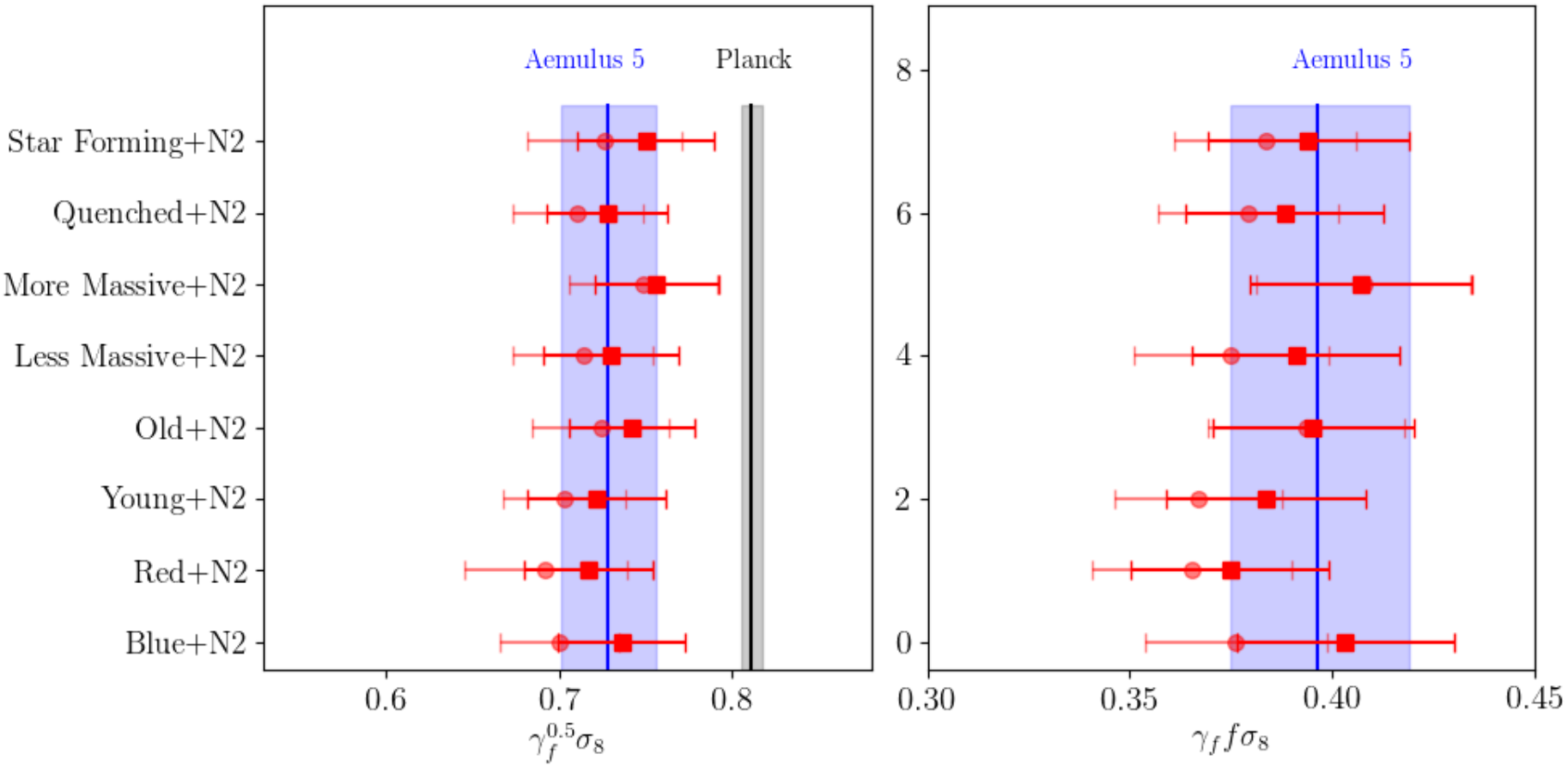
Zhai + in prep

The Aemulus nu Project



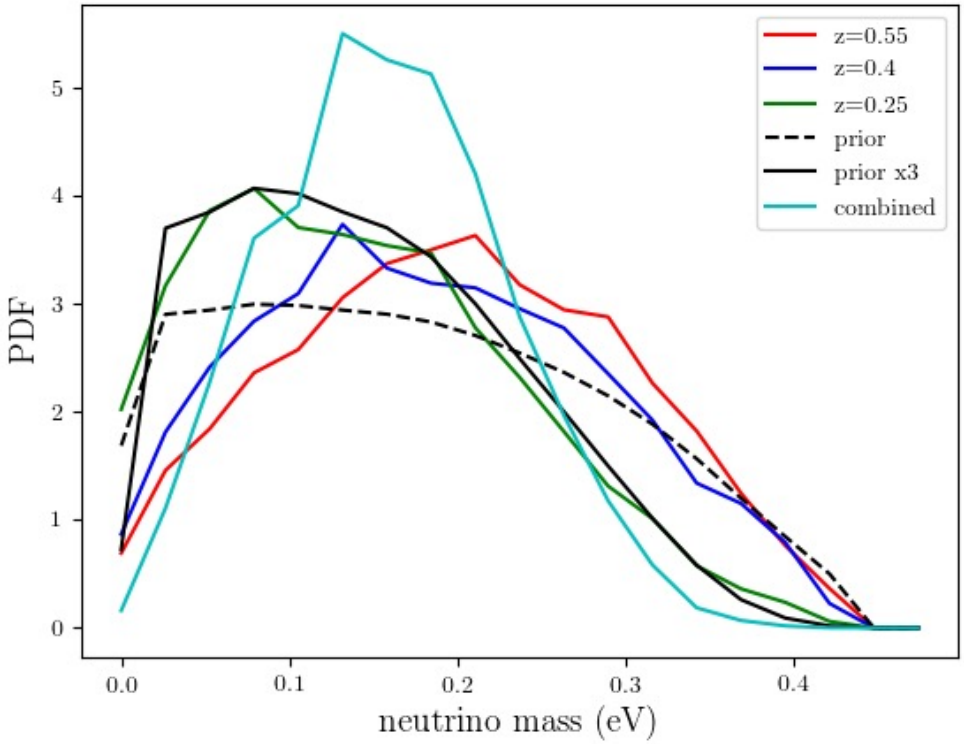

Aemulus ν, Tier 1
Aemulus ν, Tier 2
Aemulus α
DES Y3 + BAO + SNe
σ_8
n_s
H_0
w
ω_b
ω_c
$\sum m_\nu$

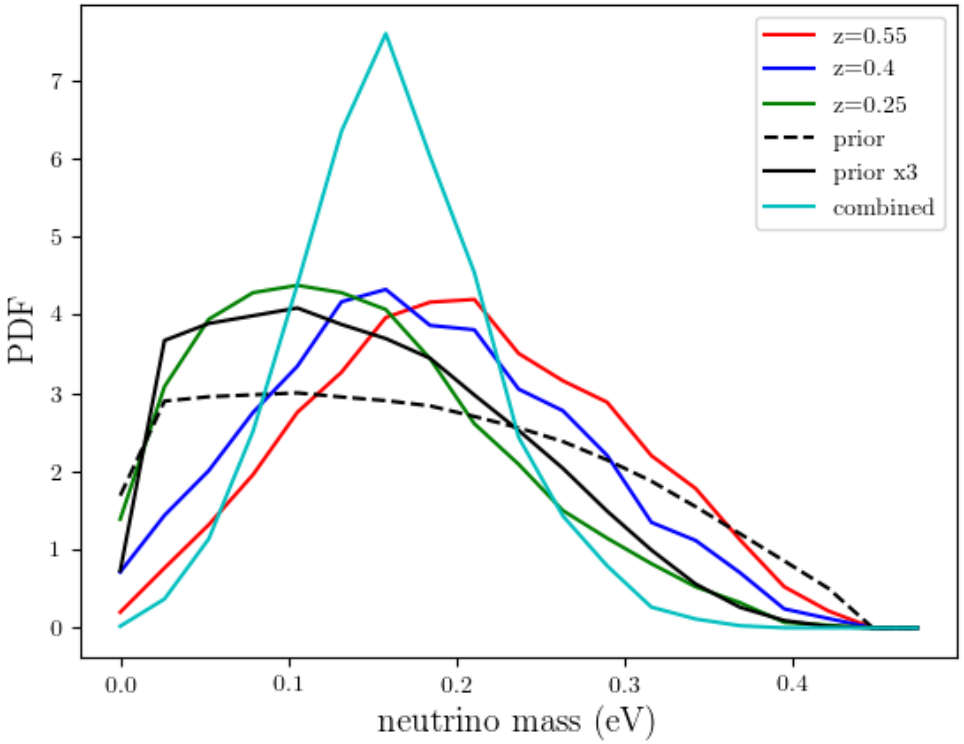
Re-analysis with massive neutrinos



Preliminary

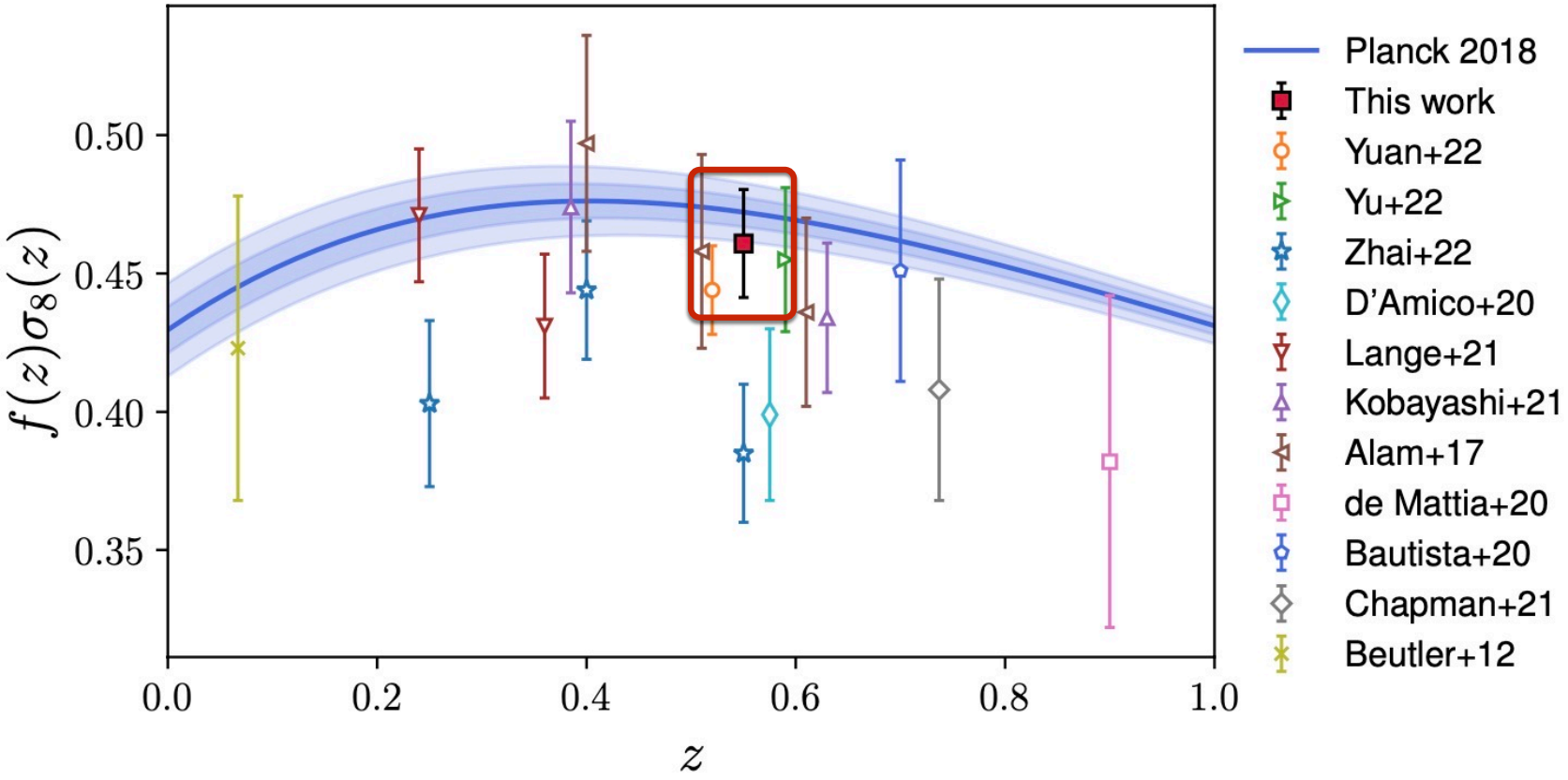
Constraints on neutrino mass





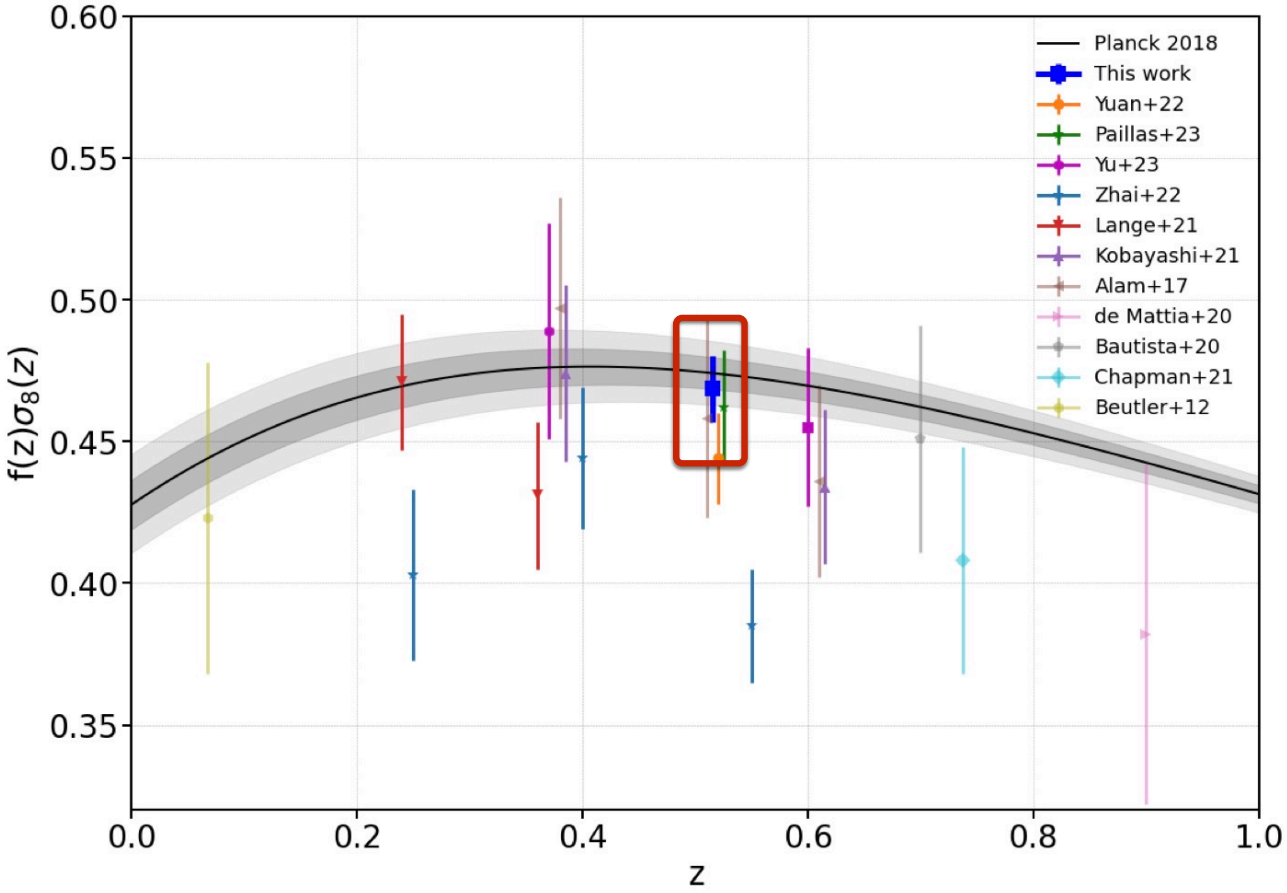
Preliminary

On the tensions



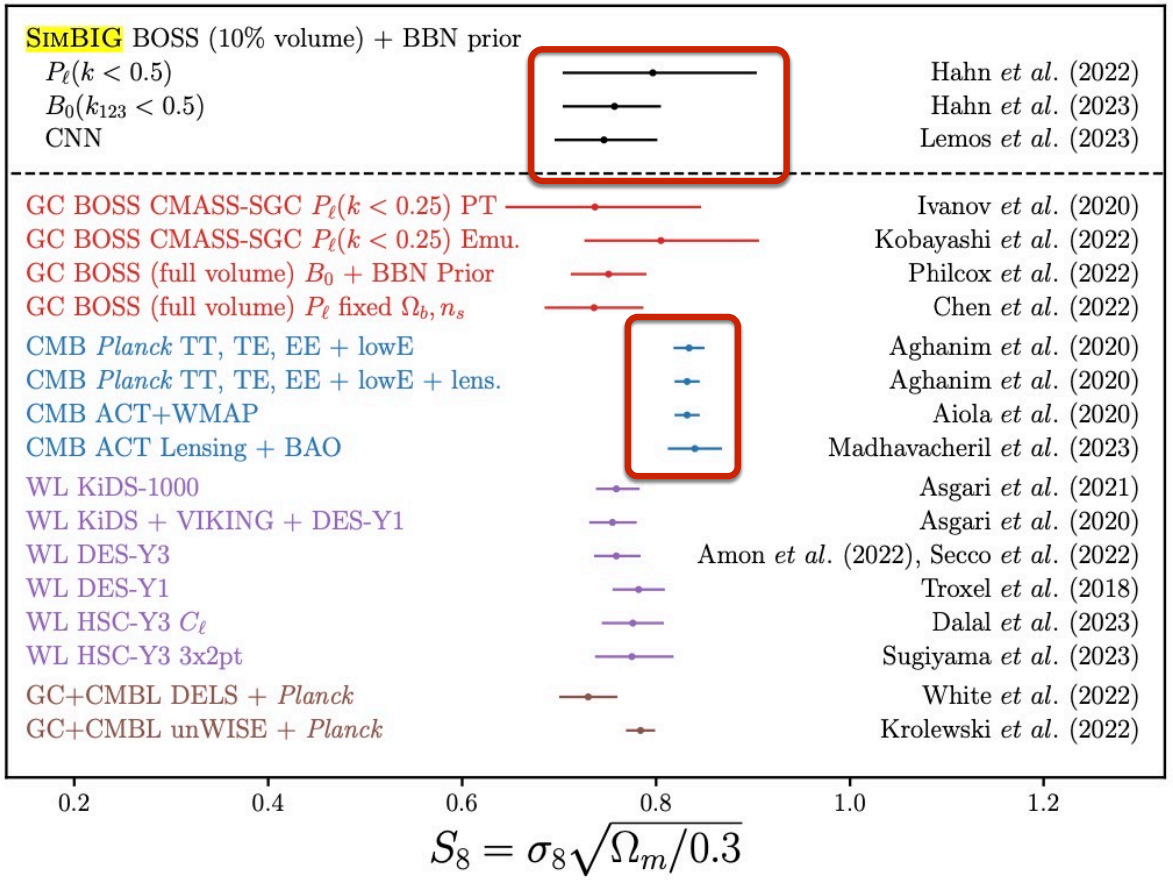
Density split analysis Paillas+2023

On the tensions



Wavelet scattering transform Valogiannis+2023

On the tensions



SIMBIG analysis Hahn+2023

Summary

* The emulator methodology is powerful and promising for both cosmology and galaxy science.

* Cosmological measurement at small scale reveals some tension with other experiments.

* It's possible that our model is not complete.

* *(possible) Future directions:*
* *Application to latest and future surveys: DESI/Euclid/Roman*
* *Cosmological simulations, e.g.* ***massive neutrinos (next generation of Aemulus suite)***
* *More summary statistics, e.g. galaxy-galaxy lensing*
* *Modeling methods, e.g. miscentering of central galaxies, sub/super Possionian of satellites, radial profile of dark matter halos, assembly bias (environment, orientation, anisotropic effect etc) and more.*

Thanks