Brightest group and cluster galaxies as indicators of relaxation

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Galaxy groups and clusters

Def.

"The most massive gravitationally bound structures in the Universe."

"Largest **relaxed/virialised** systems…"

Galaxy groups and clusters

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"The most massive gravitationally bound structures in the Universe."

Common misconception:

"Largest ~~relaxed/virialised~~ systems…"

Their dynamical state fluctuates during evolution!

Halo virialisation & relaxation

NB! virialisation $\in$ relaxation

Theoretical criteria for relaxation (Neto+07):

$$\frac{\mathrm{M_{sub}}}{\mathrm{M_{200}}} < 0.1, \quad \frac{r_p - r_{\mathrm{CM}}}{\mathrm{R_{200}}} < 0.07, \quad \frac{2T}{|U|} < 1.3$$

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centre of mass displacement

Aims

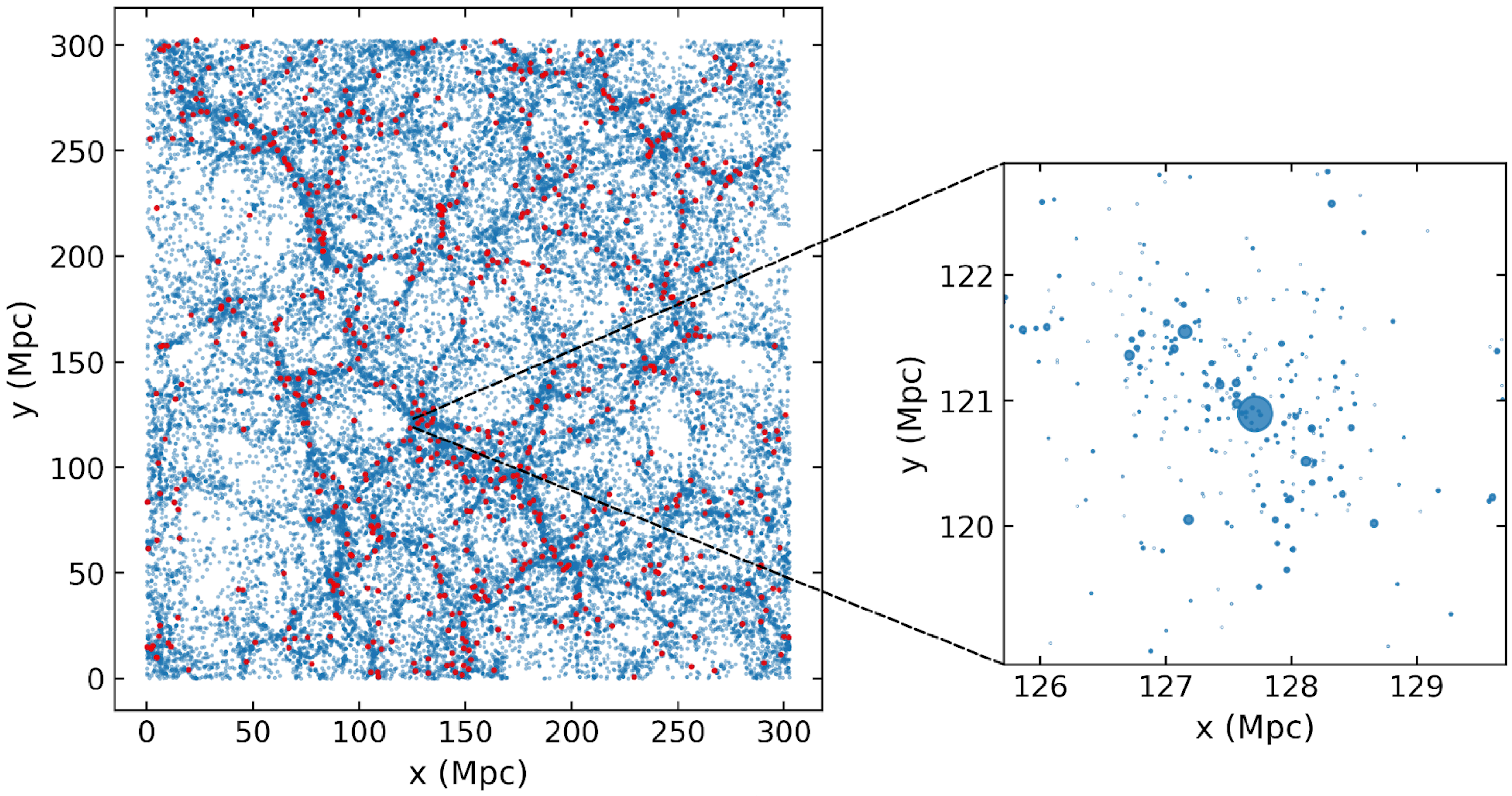
1) Find observable properties that correlate with relaxation.

2) Replicate a halo mass function of relaxed groups/clusters.

Data – IllustrisTNG

- Planck 2015 cosmology
- TNG100-1, TNG300-1 & TNG-Cluster
- subhalos - galaxies; halos - clusters/groups
- BCG based on r-band absolute magnitude

Data – IllustrisTNG



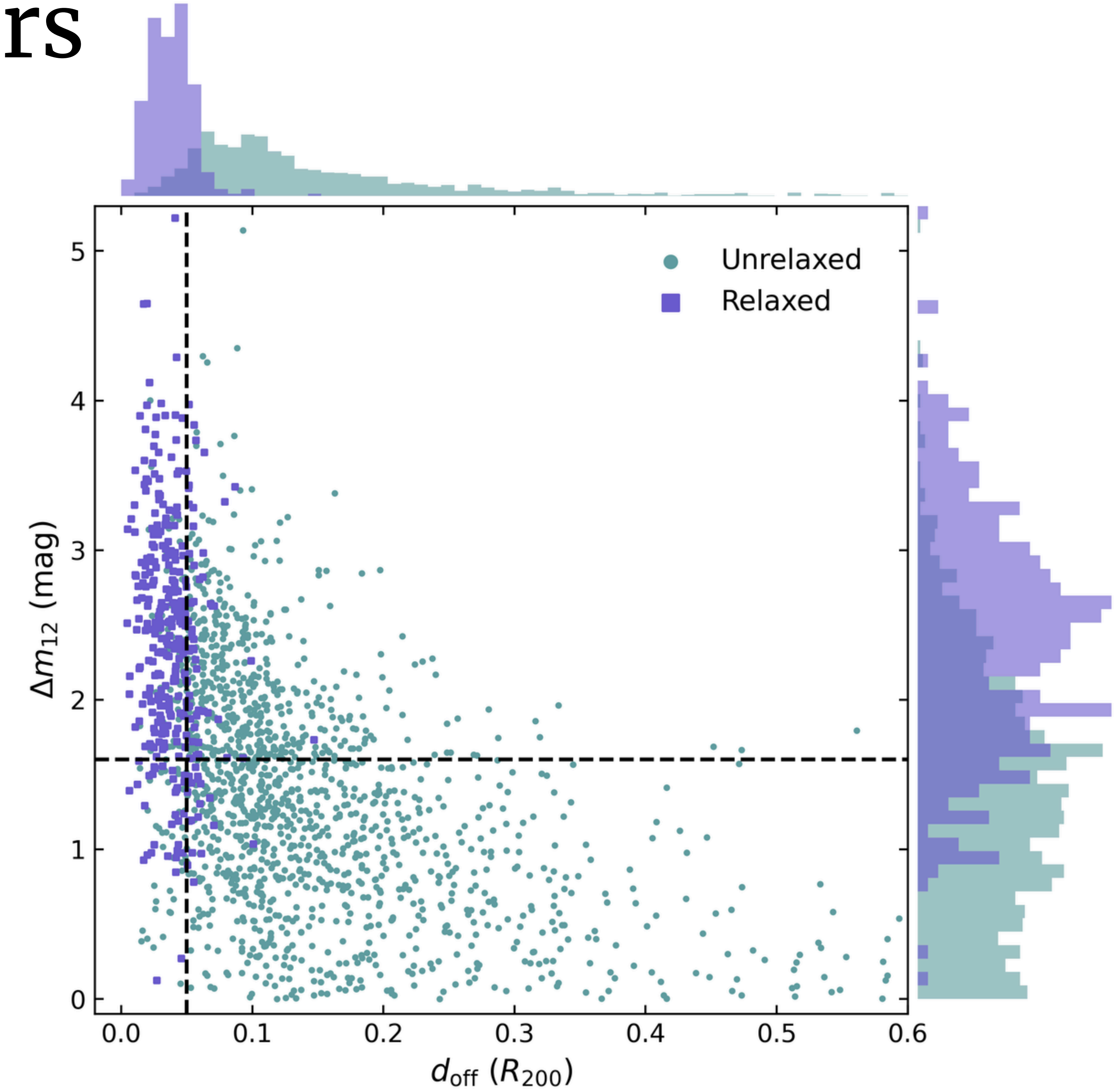
Results: Relaxation indicators

Dependence on halo size (R_{200})

~20% of systems are relaxed

Constraints:

$$d_{\rm off} < 0.05\ R_{200}$$
$$\Delta m_{12} > 1.6\ \text{mag}$$



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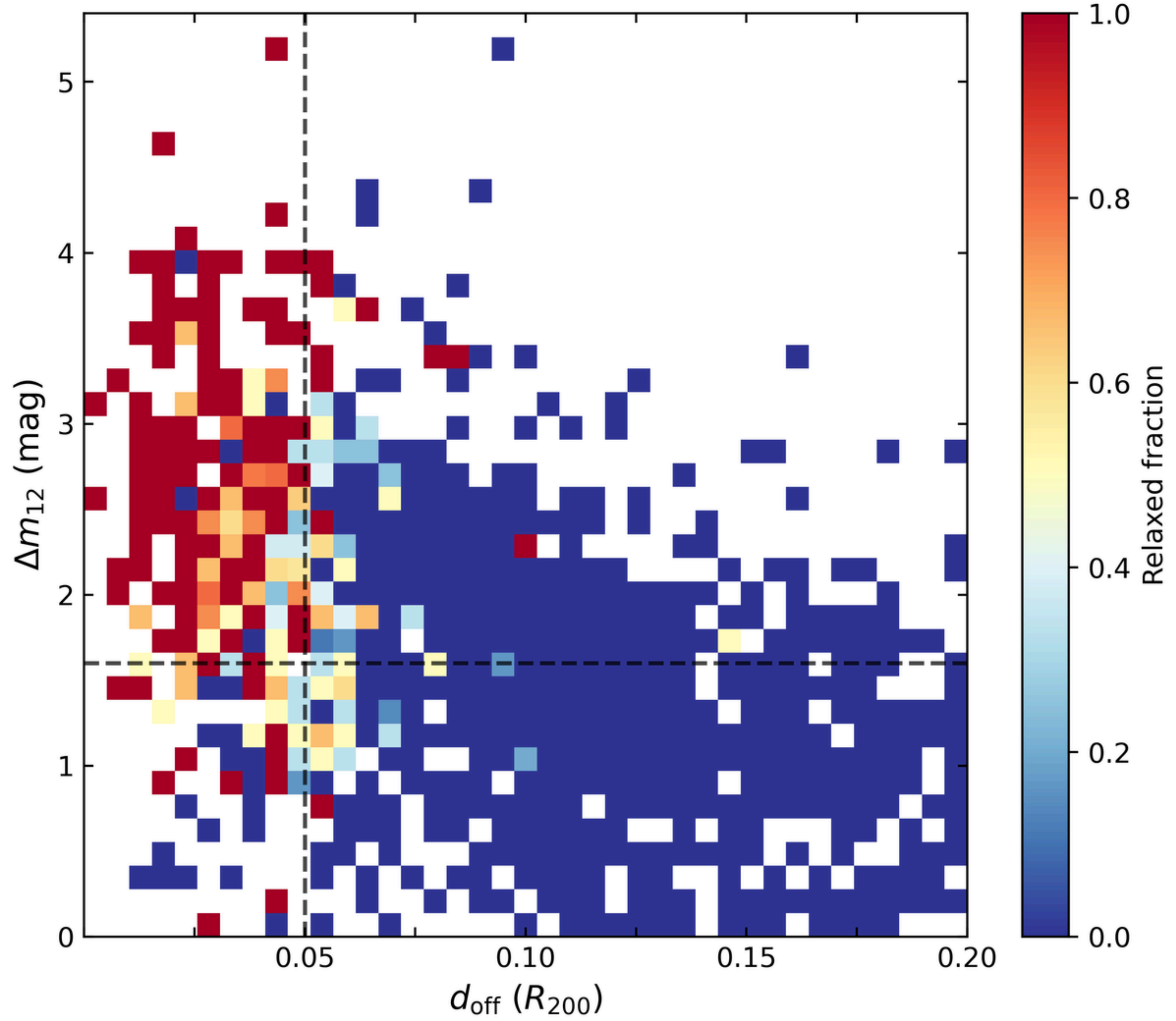
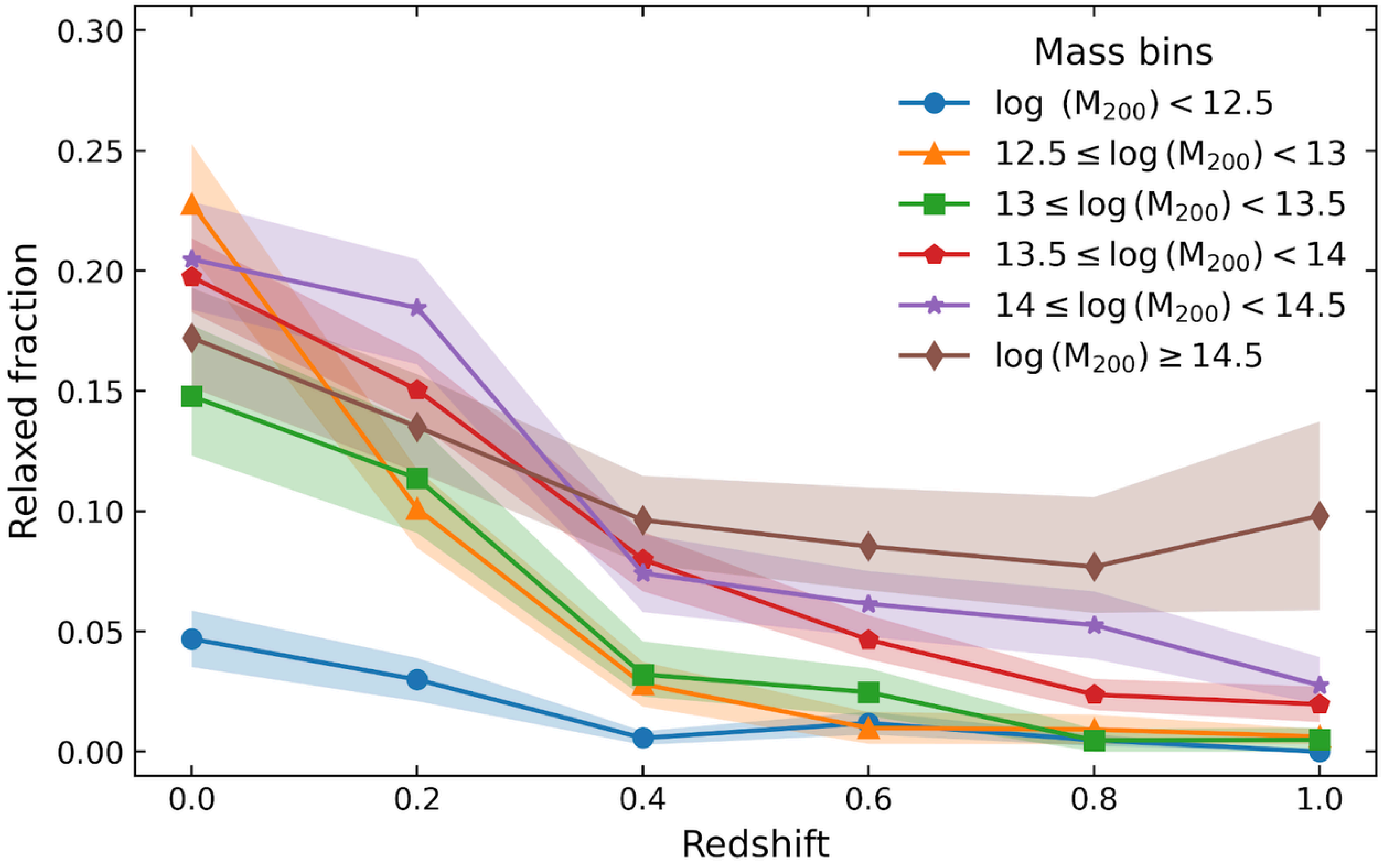


Results: Redshift evolution

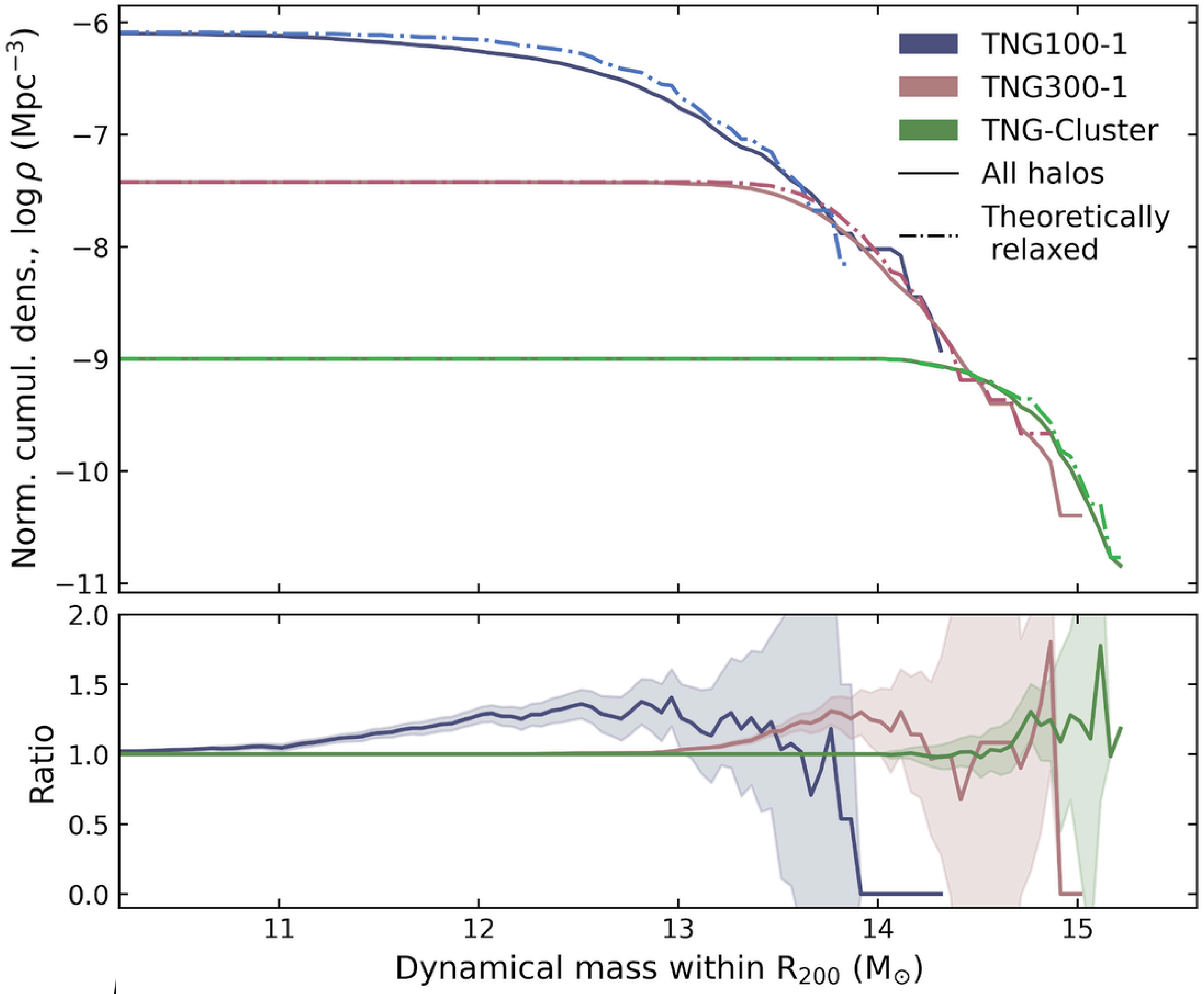
NB! The properties also evolve with redshift!

Reliability limit z ~0.2



Results: Halo mass function replication

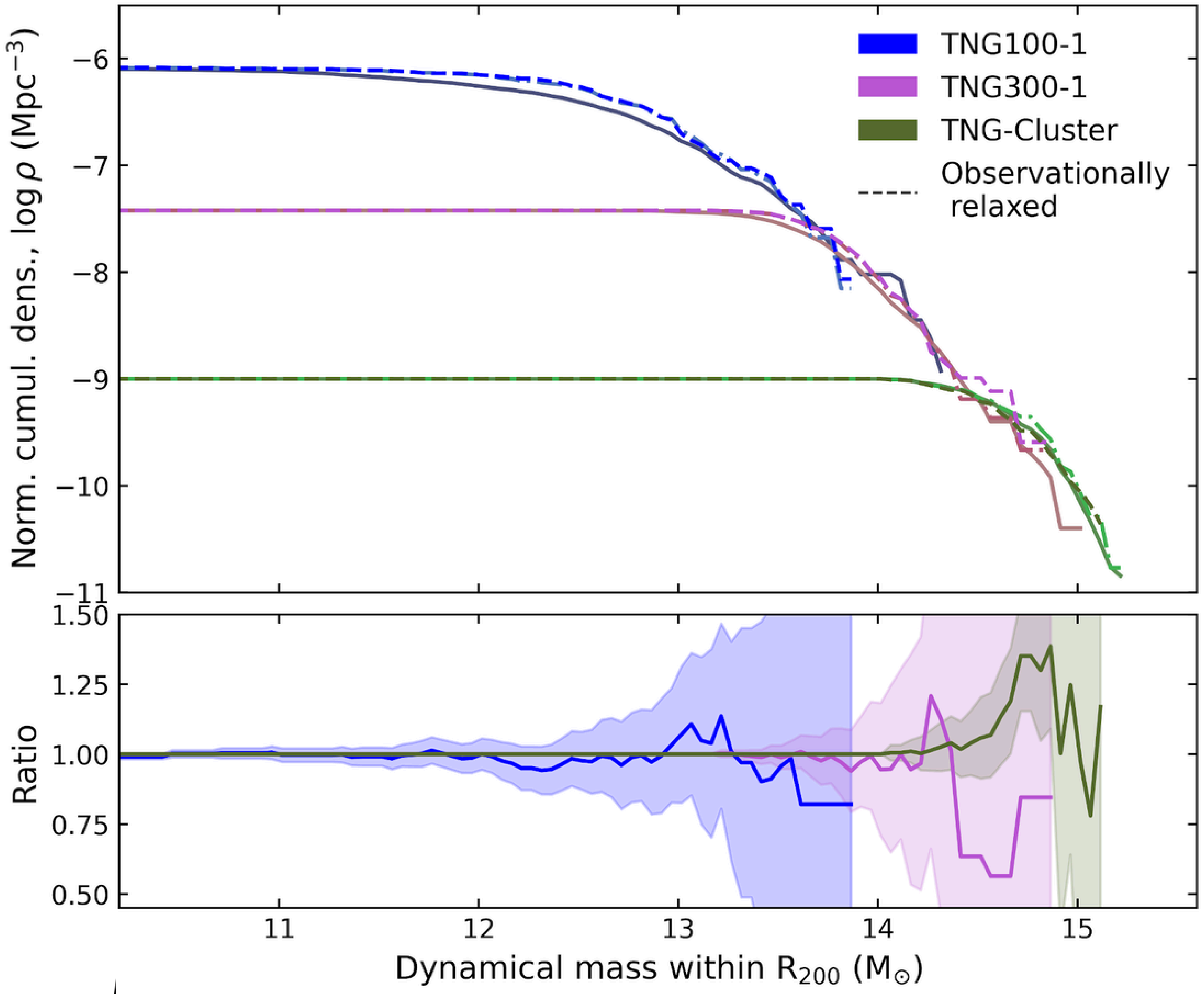
Relaxed halos tend to be more massive.



Results: Halo mass function replication

Relaxed halos tend to be more massive.

Observable proxy overlaps well with relaxed systems.



Summary

- The dynamical state of groups and clusters fluctuates during halo evolution.
  - Observable criteria are needed for determining it.
- The BCG central offset and magnitude gap are good proxies.
  - $d_{\rm off} < 0.05\ R_{200}$, $\Delta m_{12} > 1.6$ mag
- To be tested on observational data (GAMA, SDSS, WAVES)