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Measuring Galaxy Assembly Bias in IllustrisTNG

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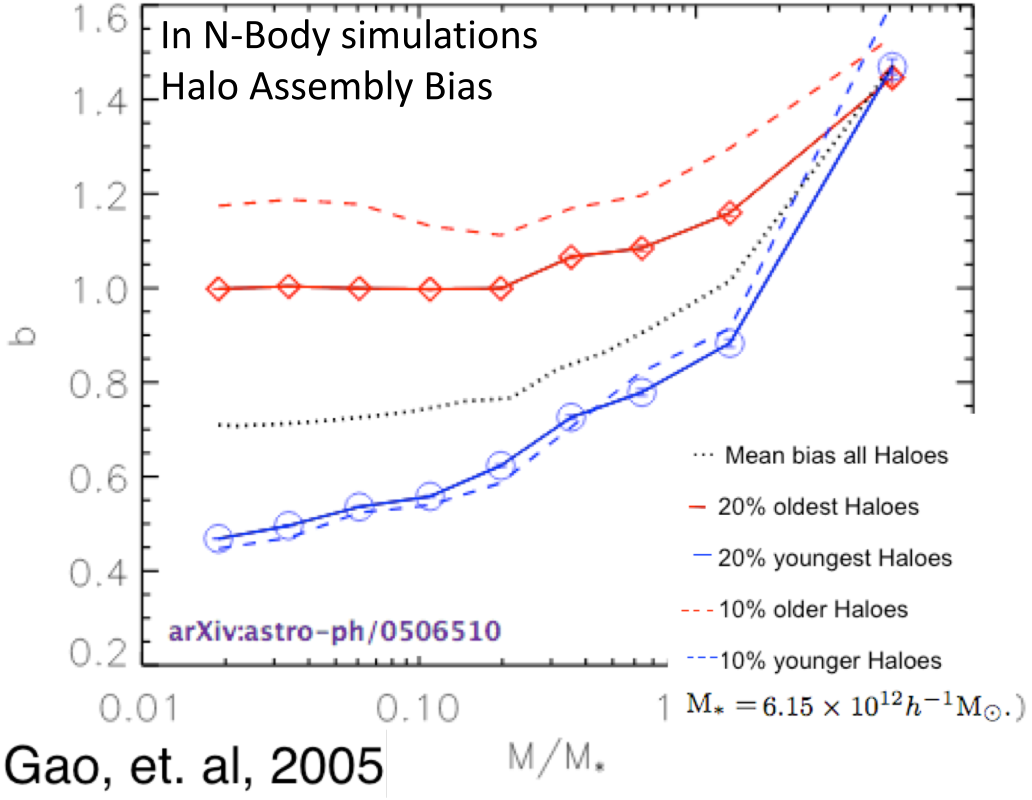
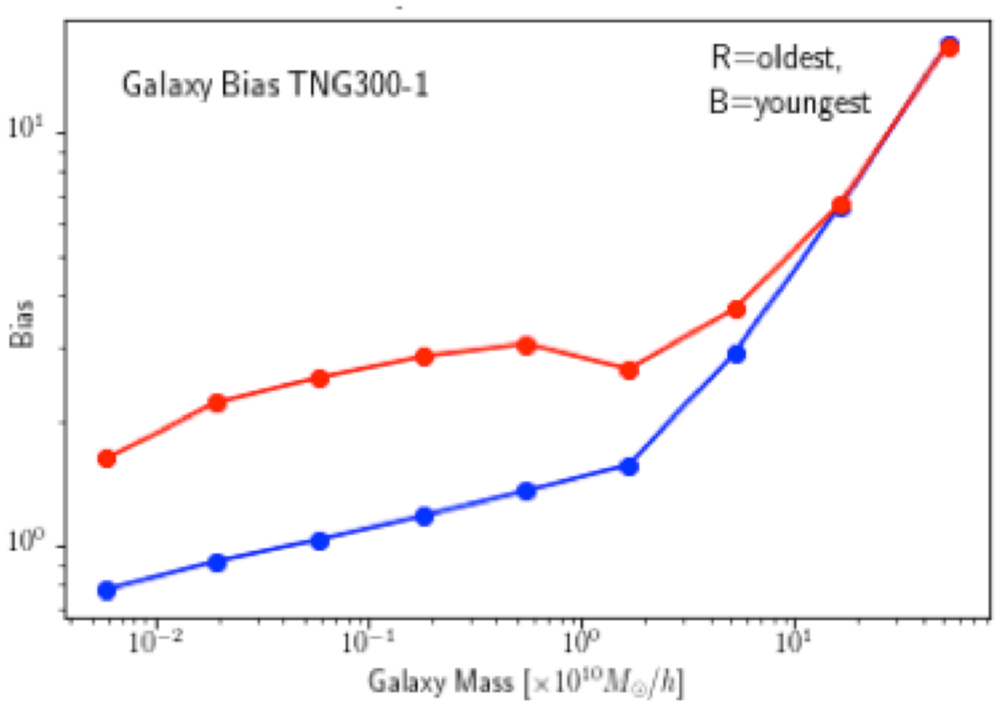
The galaxies are a window that connects us with the Dark Matter distribution, but the galaxies are not tracer completely the underlying matter distribution. This phenomenon is known as **Bias** and is related with the complex physical proccess in the Galaxy formation.



Gao, et. al, 2005



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- Halo Assembly Bias: The clustering properties of DM Halos depends on its assembly history and internal structure.

- Secondary Bias, secondary Assembly Bias: This influence of halo assembly bias on galaxy clustering

- Relative Bias between different galaxy populations can also be measured and is defined as the ratio of the clustering of one population relative to another

A.Coil 2012.

Objective

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- Quantifying galaxy assembly bias using the cosmological hydrodynamical simulation IllustrisTNG simulation

- We measure directly the stellar mass assembly.

    We quantify the relative bias:

    Clustering-age depedence

    (g-i) colour

    specific Star Formation Rate

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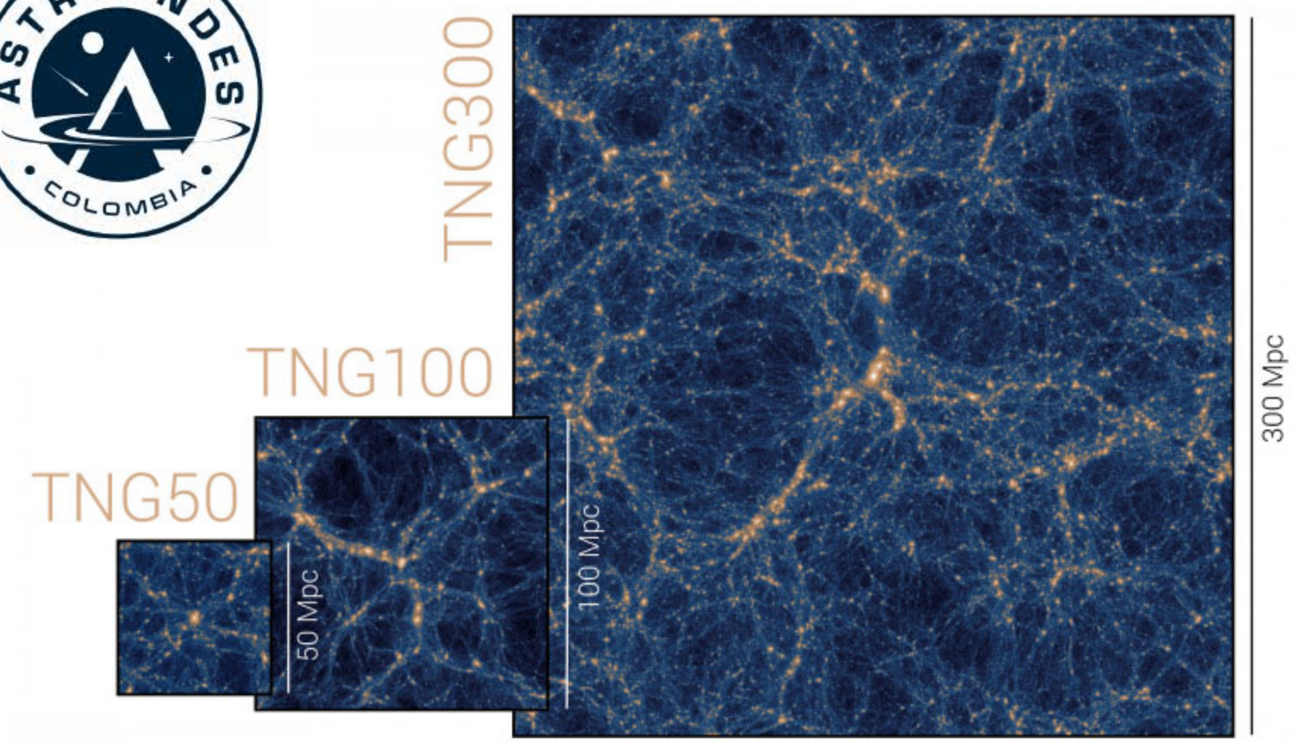
Z formation time: Redshift at which the galaxy in the branch has exactly half of its stellar mass at z=0

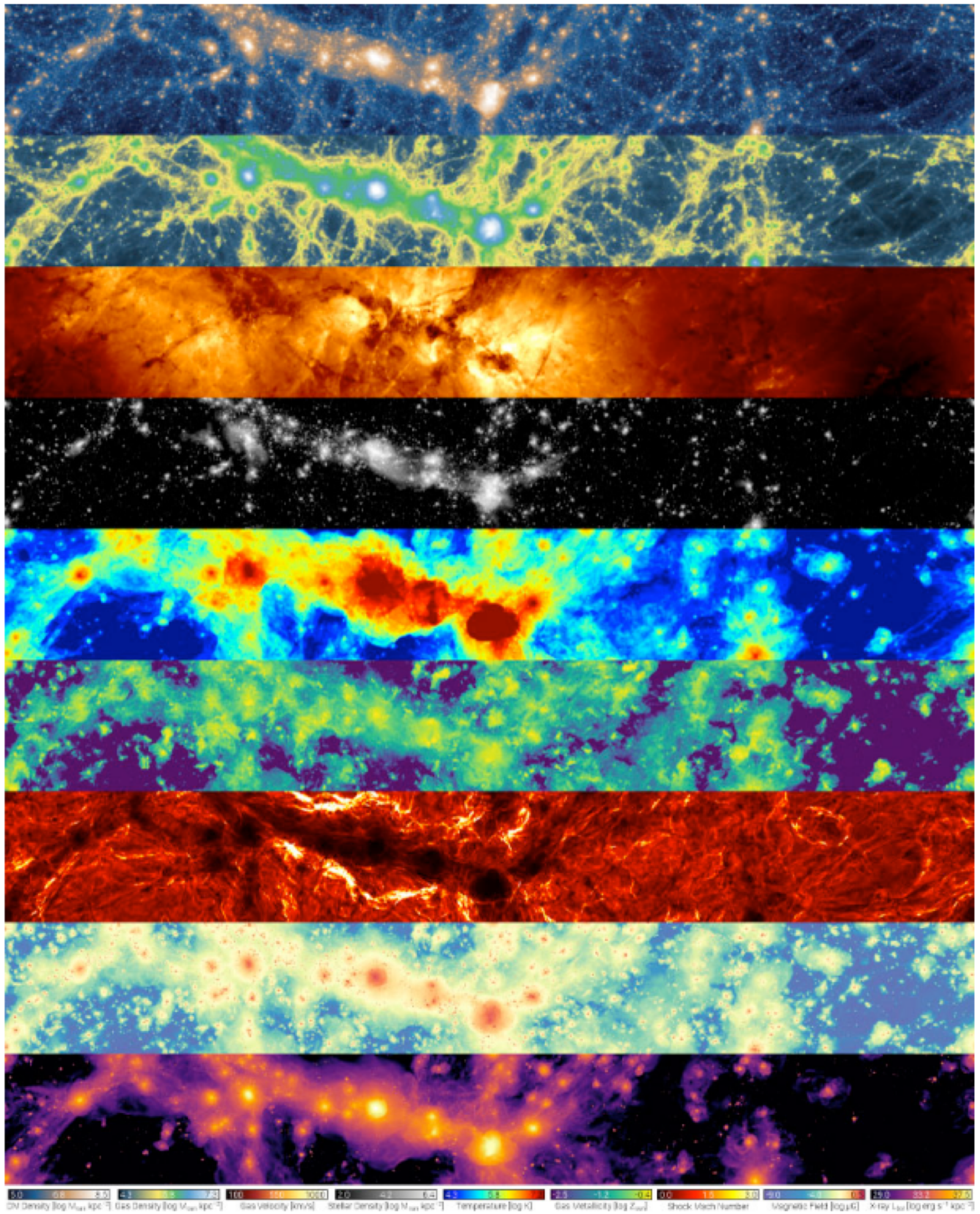
- Only use galaxies with stellar masses at Z = 0 greater than $10^9\,M_\odot\,h^{-1}$

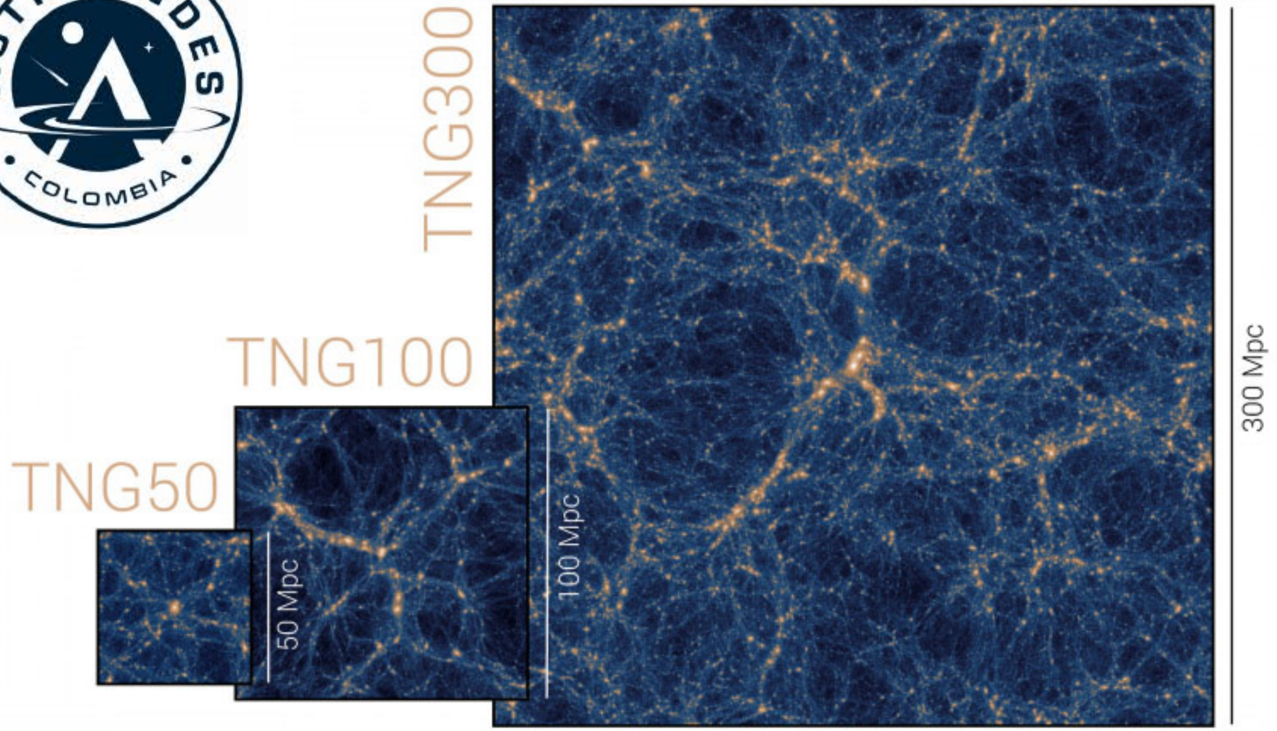


- Each simulation in IllustrisTNG evolves a large swath of a mock Universe from soon after the Big-Bang until the present day while taking into account a wide range of physical processes that drive galaxy formation

- TNG300, hydrodynamical simulations have reached a sufficient volume and resolution to study clustering of all matter components in The Universe on the relevant scales.

tngproject.org

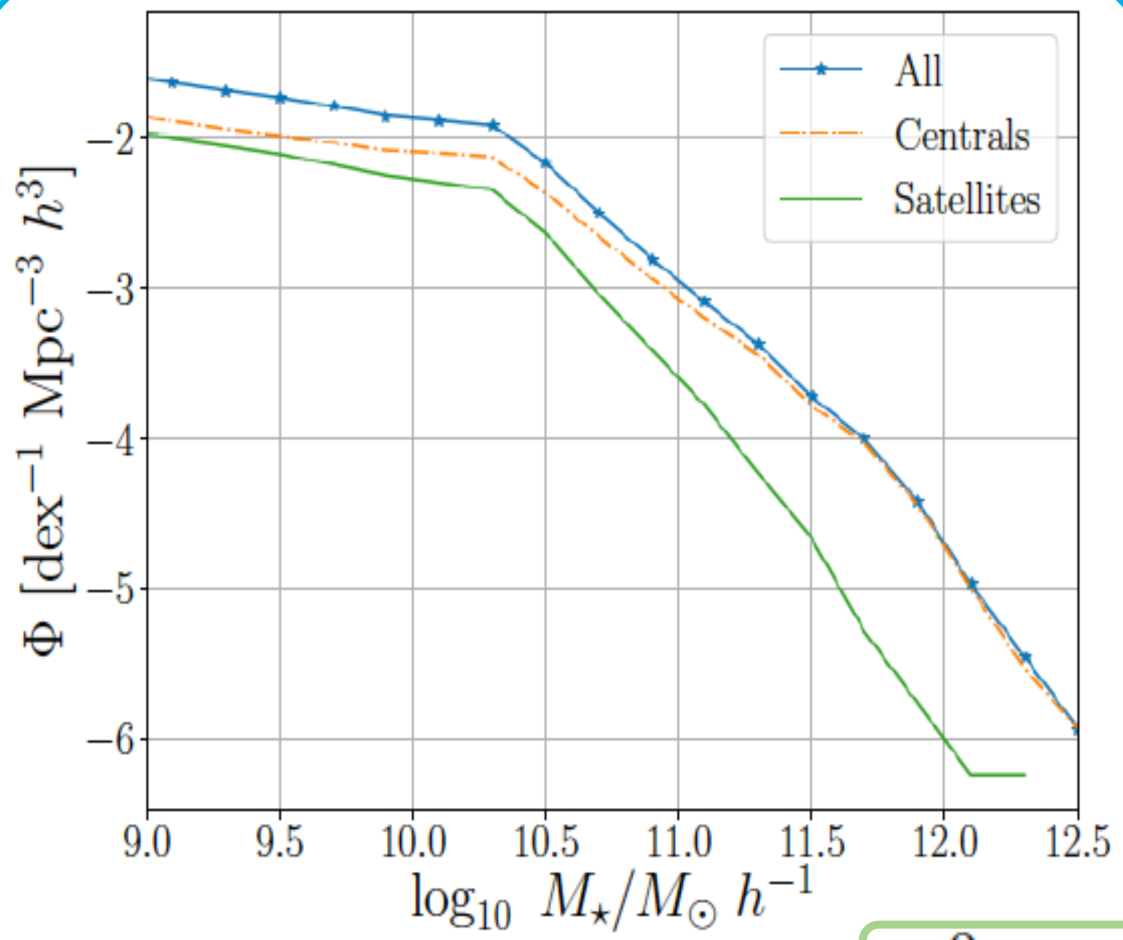


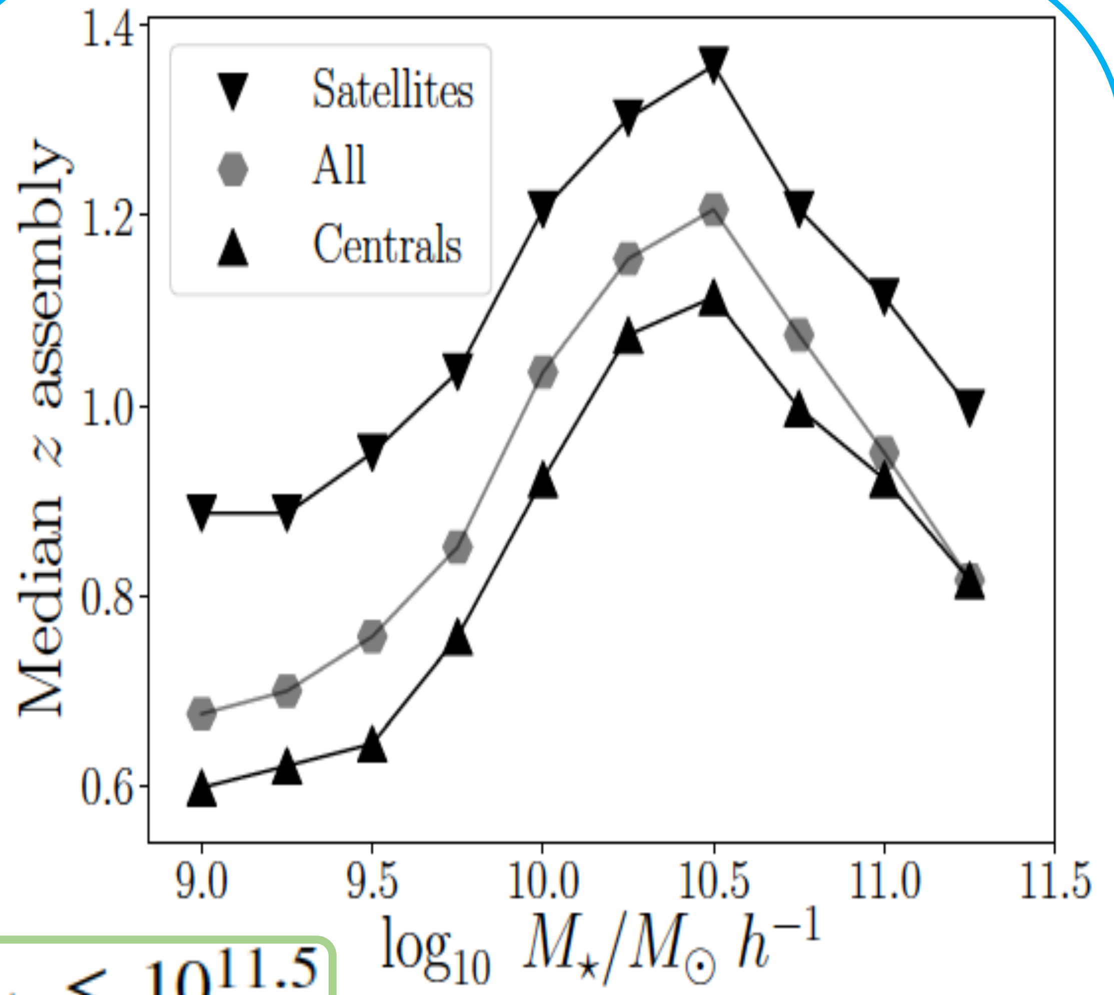


Illustris TNG:
$\Omega_m = 0.38089$, $\Omega_b = 0.0486$,
$\Omega_\Lambda = 0.6911$, $h = 0.6774$
(Planck Collaboration, et al. 2016).

		TNG300-1
Volume	[Mpc^3]	302.6^3
L_{box}	[Mpc/h]	205
N_{GAS}	-	2500^3
N_{DM}	-	2500^3
N_{TR}	-	2500^3
m_{baryon}	[$\mathrm{M}_\odot$]	1.1×10^7
m_{DM}	[$\mathrm{M}_\odot$]	5.9×10^7
$\epsilon_{\mathrm{gas,min}}$	[pc]	370
$\epsilon_{\mathrm{DM},\star}$	[pc]	1480

tngproject.org





$$10^9\ \mathrm{M}_\odot\, h^{-1} \leq M_\star \leq 10^{11.5}$$

Figure 1. Stellar mass functions for all galaxies and their partition into centrals and satellites. Although the mass resolution in TNG300-1 resolves individual galaxies below 10^9 $\mathrm{M}_\odot$ h^{-1} we use this value as a threshold because galaxies above this mass has an appropriate resolution in the formation history to estimate their assembly time.

Figure 3. Median redshift of assembly as a function of stellar mass. Different symbols correspond to satellites, centrals or all galaxies. The stellar mass around $10^{10.5}$ $\mathrm{M}_\odot$ h^{-1} shows a transition between two regimes of *upsizing* and *downsizing*.

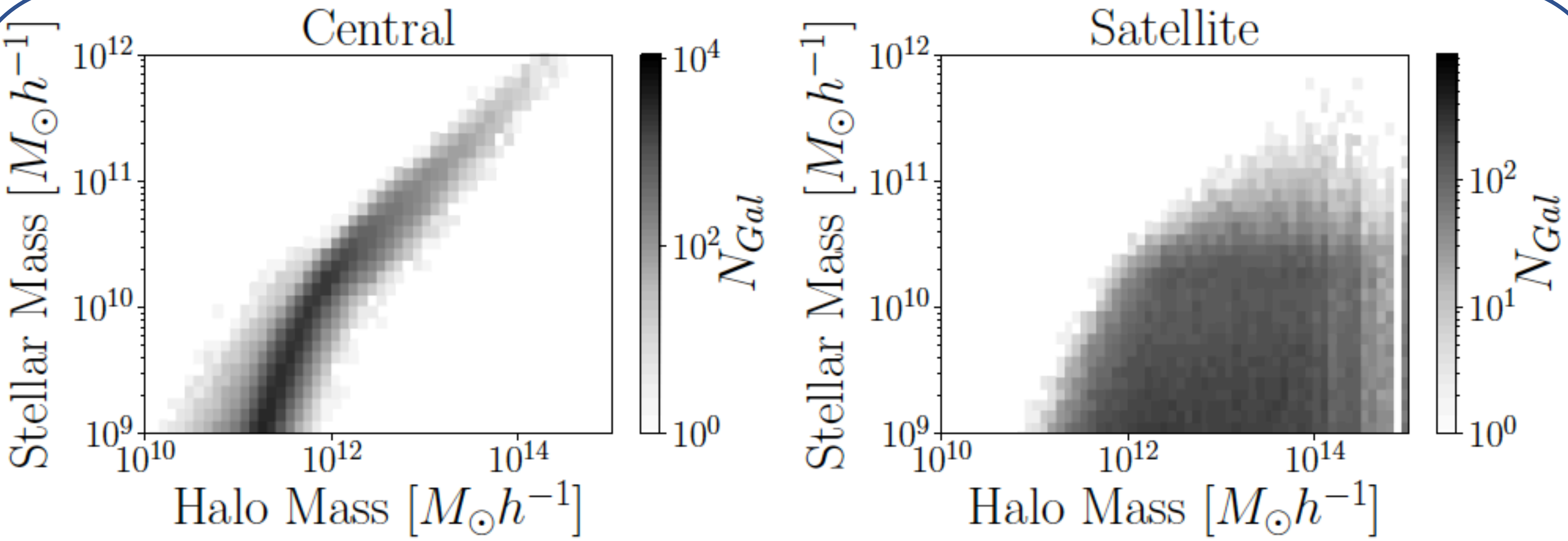


Figure 2. Relationship between stellar mass and the parent dark matter halo mass for central and satellite galaxies.

stellar mass as a function of the DM halo mass

CLUSTERING DEPENDENCE ON ASSEMBLY TIME

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$$b_r(r, S|A) = \frac{\xi_S(r)}{\xi_A(r)},$$

relative Bias:

- Clustering-age dependence
- sSFR
- (g-r) Colours

Montero-Dorta A. D., et al., 2020, MNRAS,

$\xi_S(r)$ → Correlation Function
Subsamples, first and last quartile redshift assembly distribution

$\xi_A(r)$ → Correlation Function
General sample in a fixed mass

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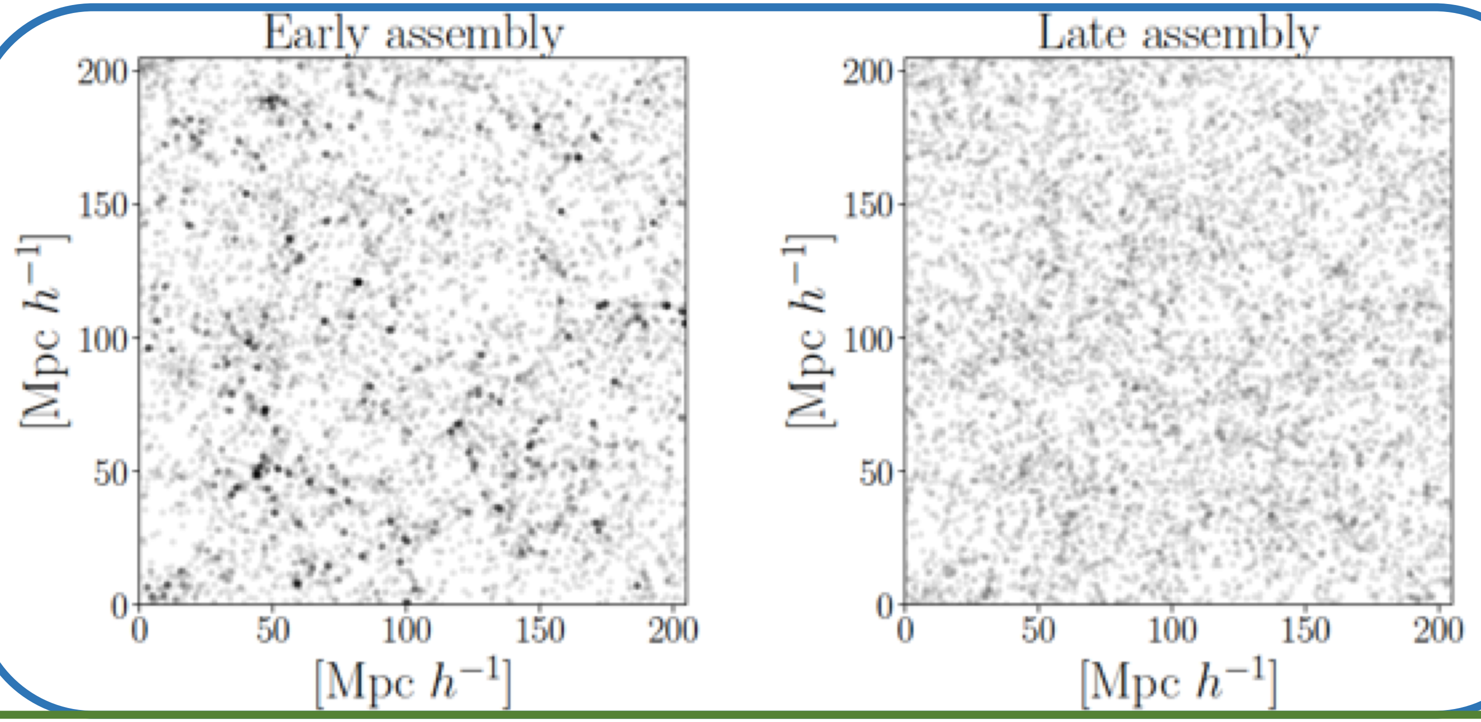
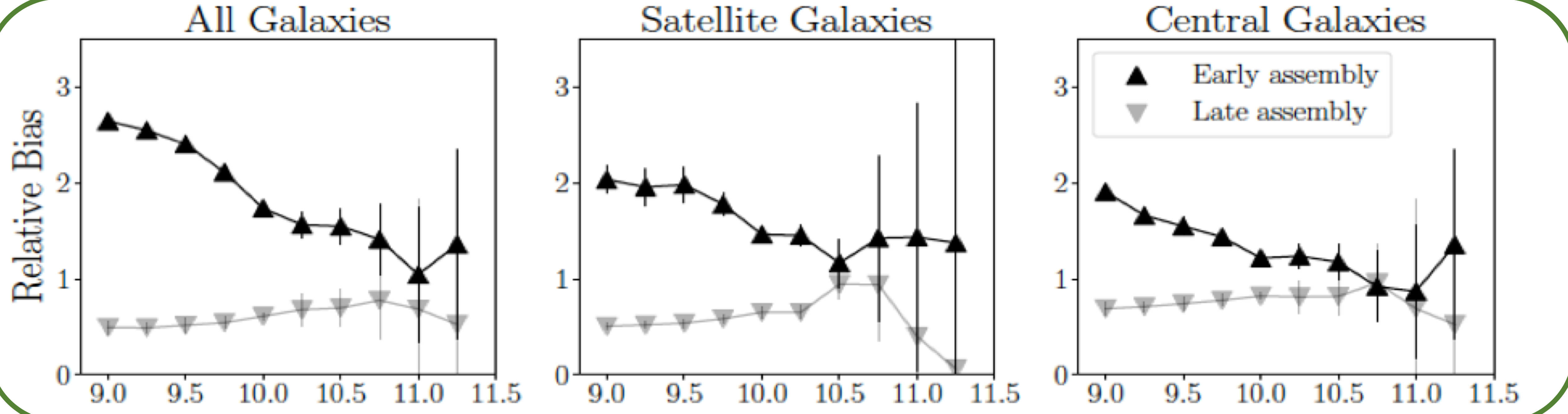


assembly time.



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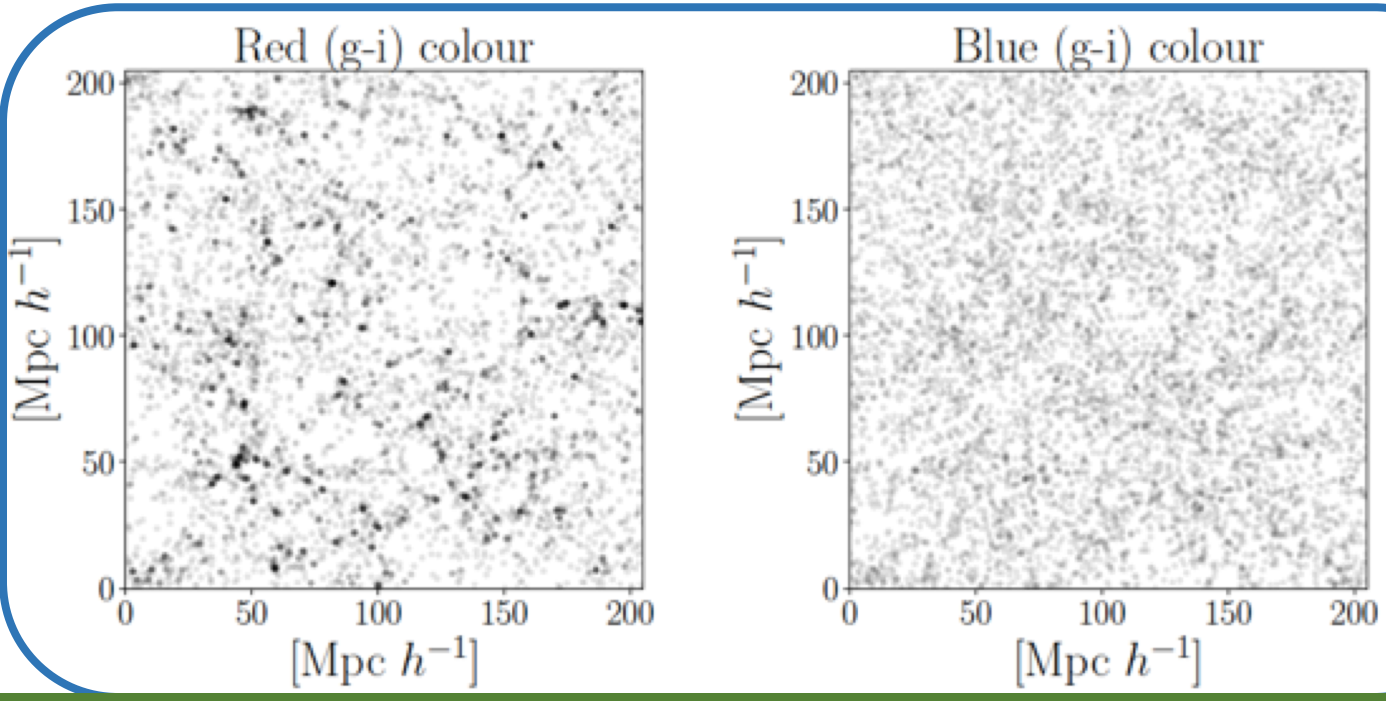
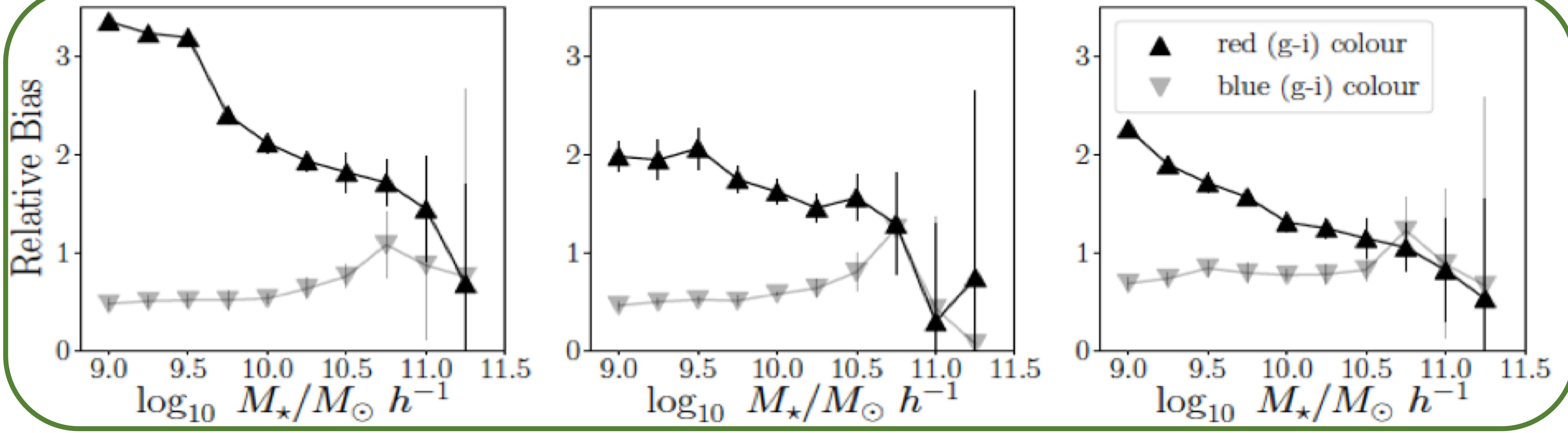
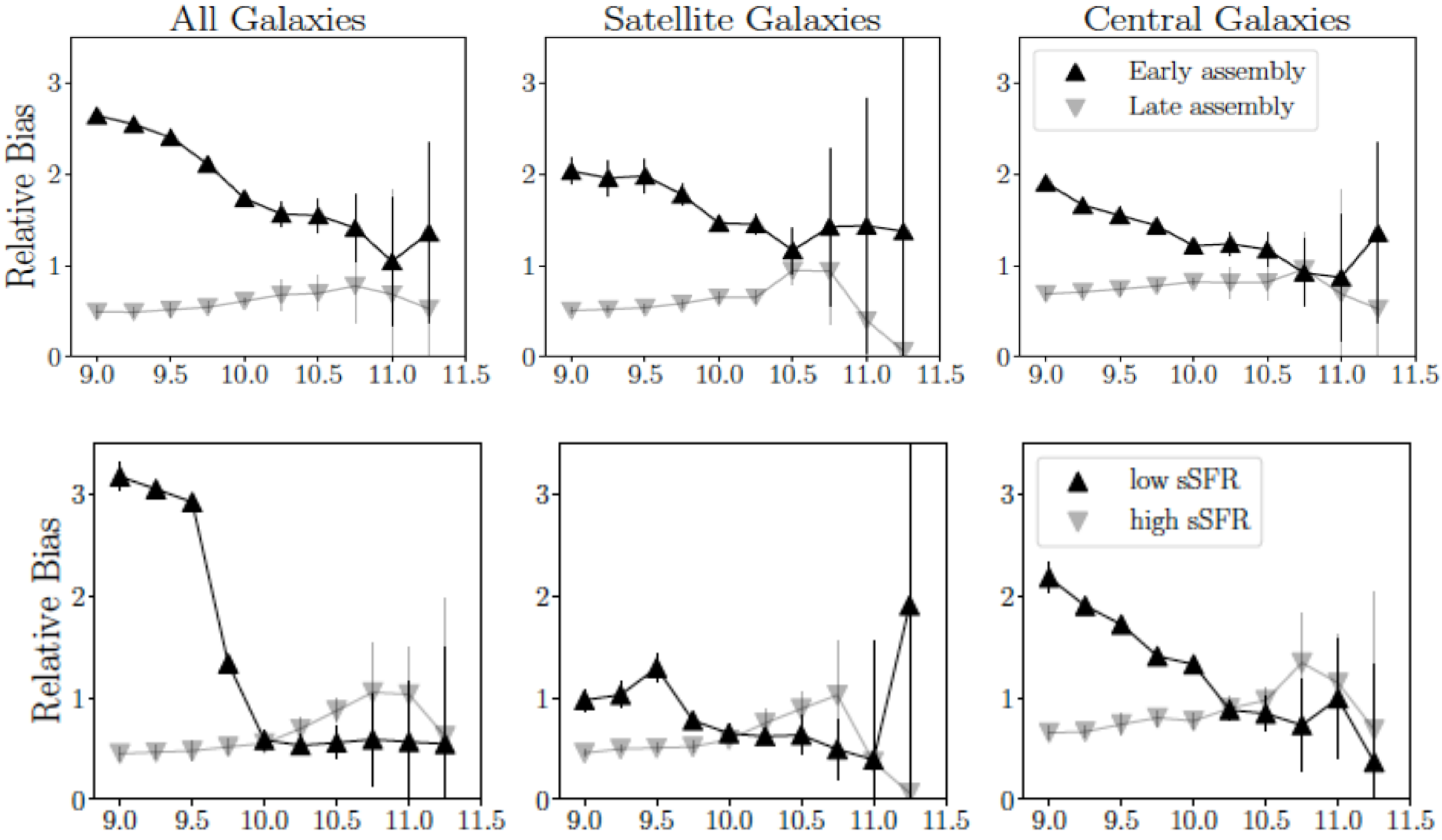


$(g - r)$ colours




All Galaxies
Satellite Galaxies
Central Galaxies
Relative Bias
Early assembly
Late assembly
low sSFR
high sSFR
0
1
2
3
9.0
9.5
10.0
10.5
11.0
11.5

Conclusions:

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- Early assembly galaxies tend to be more clustered than late-assembly galaxies. This trend is stronger towards lower stellar masses for $(6 \pm 1) \times 10^{10} \mathrm{M}_{\odot}\, h^{-1}$

- The assembly bias holds similar strength both for Satellites and Central Galaxies

- Using sSFR for the general galaxy population the assembly bias effect is noticeable for masses below $10^{10}\, \mathrm{M}_{\odot}\, h^{-1}$ this effect is weaker for satellite galaxies than it is for centrals

- The (g-r) colour produce results that closely follow the assembly time cuts in amplitude and mass trends

- An observational verification of our results could be achieved with the Dark Energy Spectroscopy Instrument (DESI)

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