Assembly bias in simulations and observations

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Workshop on Galaxy Bias

ICTP, Trieste, October 2013

OUTLINE

Introduction: assembly bias

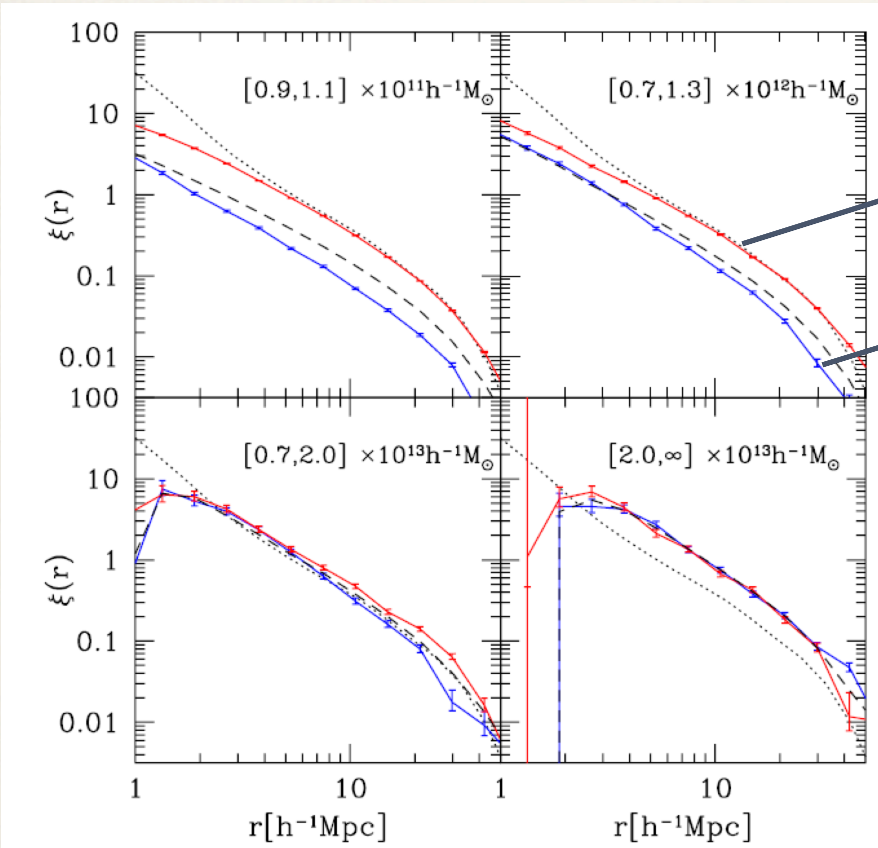
Model for peak height for assembly through age and spin

Assembly bias in observations

Summary

Lacerna & Padilla 2011, 2012, Walker-Soler et al. 2012, Lacerna, Stasyszin & Padilla 2013

Assembly bias



"oldest" haloes

"youngest" haloes

Dependence is strong for haloes
M ≤ 10^12 h-1 Msun

detectable but weak at 10^13 h-1 Msun

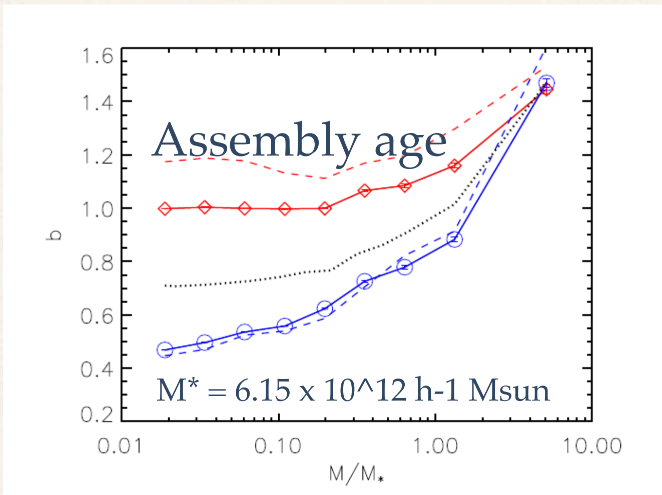
Undetectable for M > 2 x 10^13 h-1 Msun

Gao et al. 2005

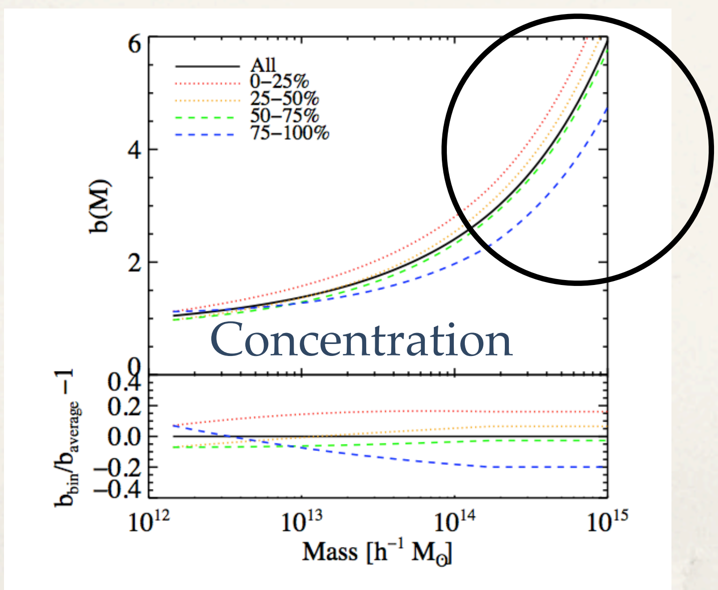
Consequences: several! HOD models with dependence on halo mass alone need to be revised (see for instance Gil-Marín, Jimenez & Verde 2011)

Assembly bias

Gao et al. (2005)



Wu et al. (2008)



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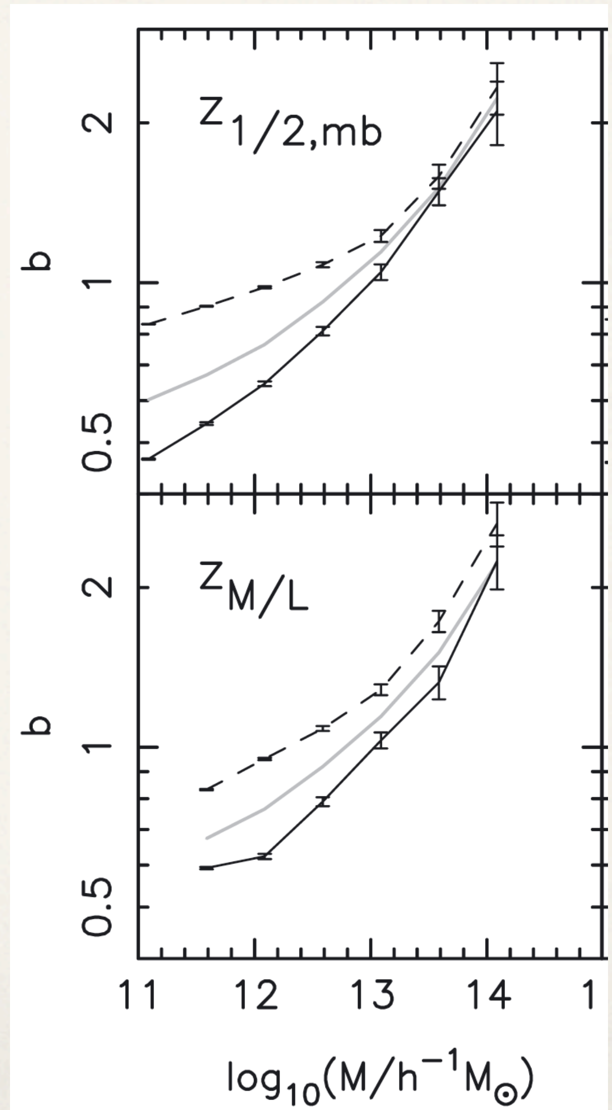
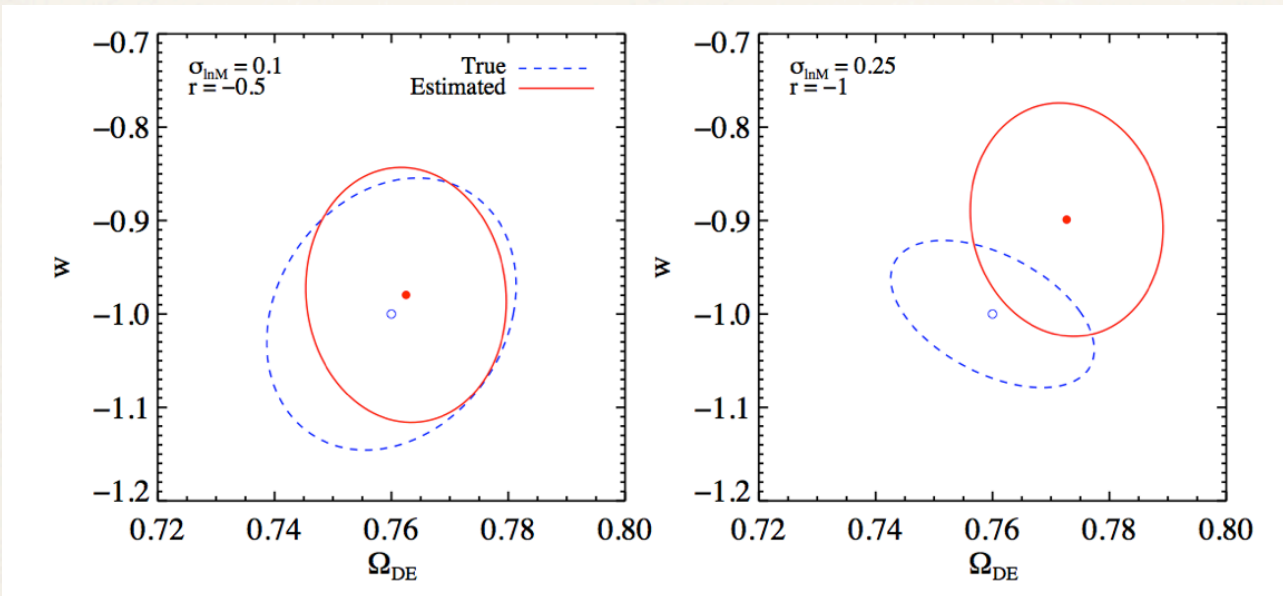


Assembly bias

Wu et al. (2008)



~1σ for ΩDE (DES)
~2σ for w (LSST)

Dark Energy Survey (DES) and
Large Synoptic SurveyTelescope (LSST):
both can infer significantly biased cosm. parameters.

Assembly bias

Walker-Soler, Gawiser, Padilla et al (2012)

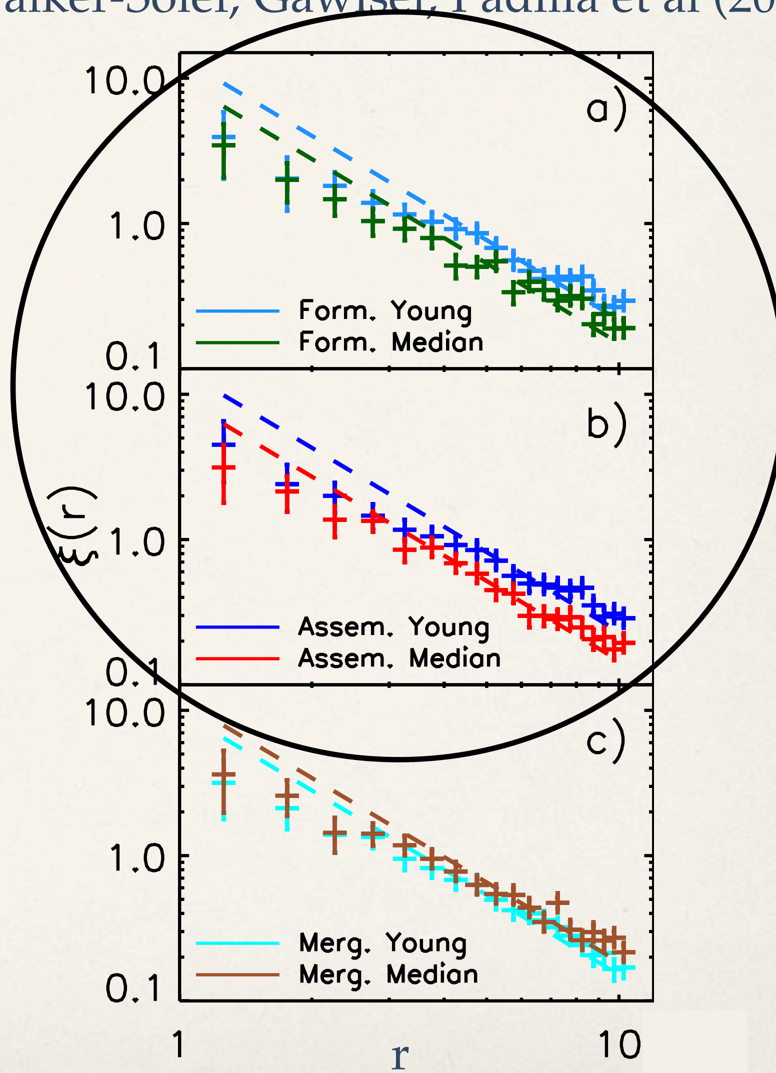
z=3 Ly-alpha emitter surveys:

DM hosts of 1e12Msun/h
Above nu=1

Ly-alpha emitters with young stellar populations.

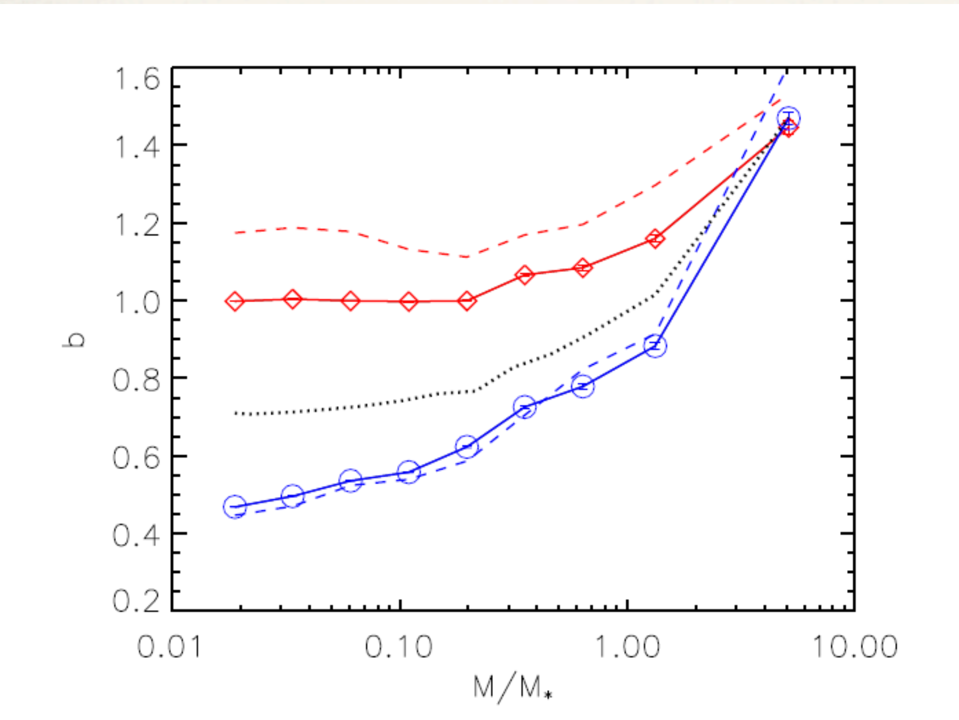
Does this imply young assembly age halos?

Possible consequences for the interpretation of HETDEX or Hyper SuprimeCAM surveys.



Assembly bias

Gao et al. (2005)



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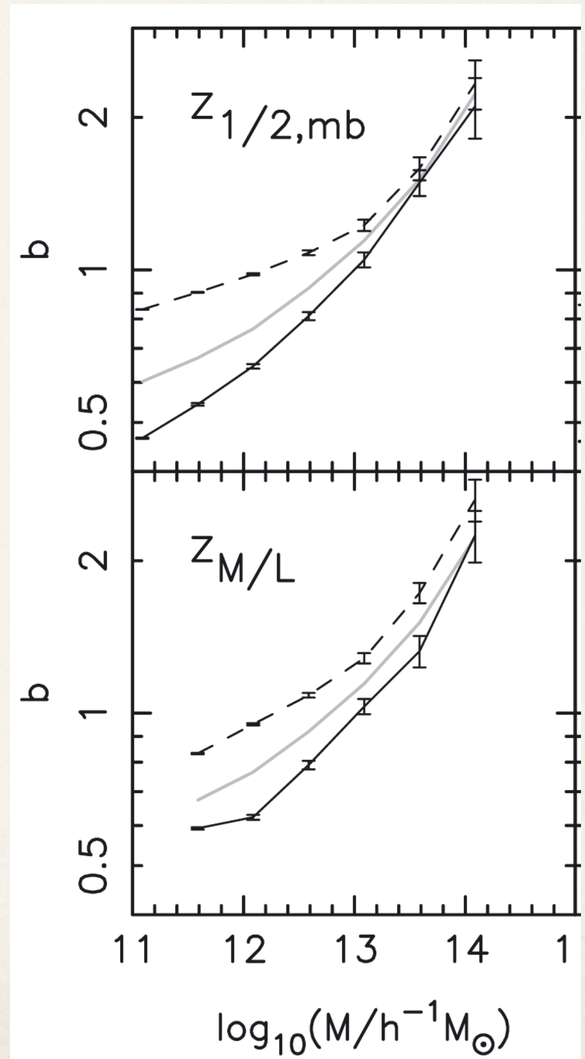
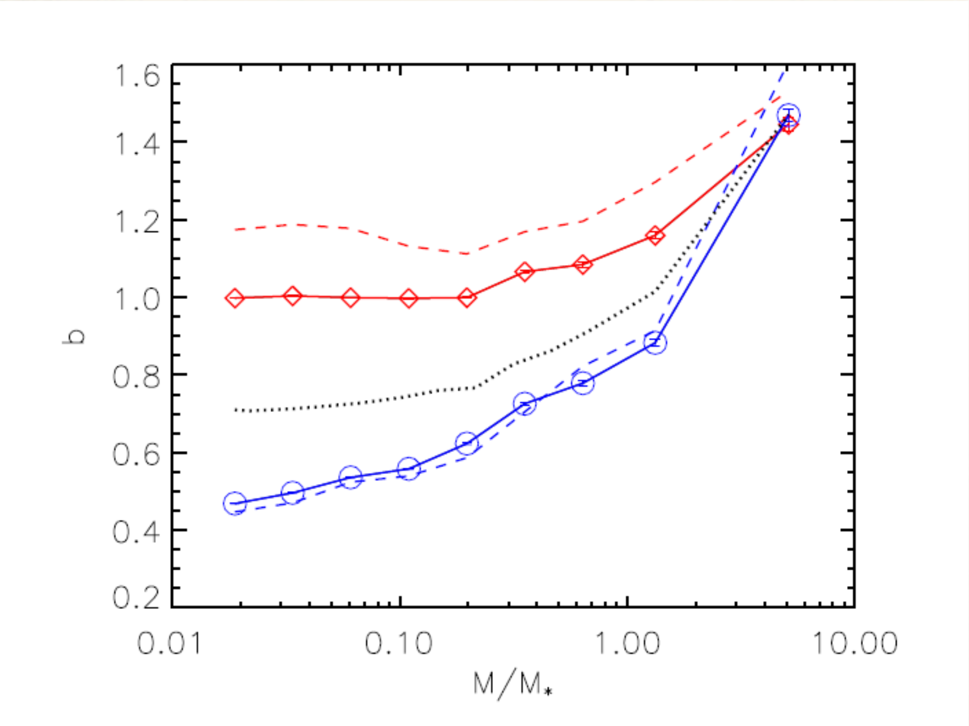


M* = 6.15 x 10^12 h-1 Msun

$$\xi_{\rm HH}(r, M) = b_{\rm H}^2(M)\xi_{\rm mm}(r),$$

Assembly bias

Gao et al. (2005)



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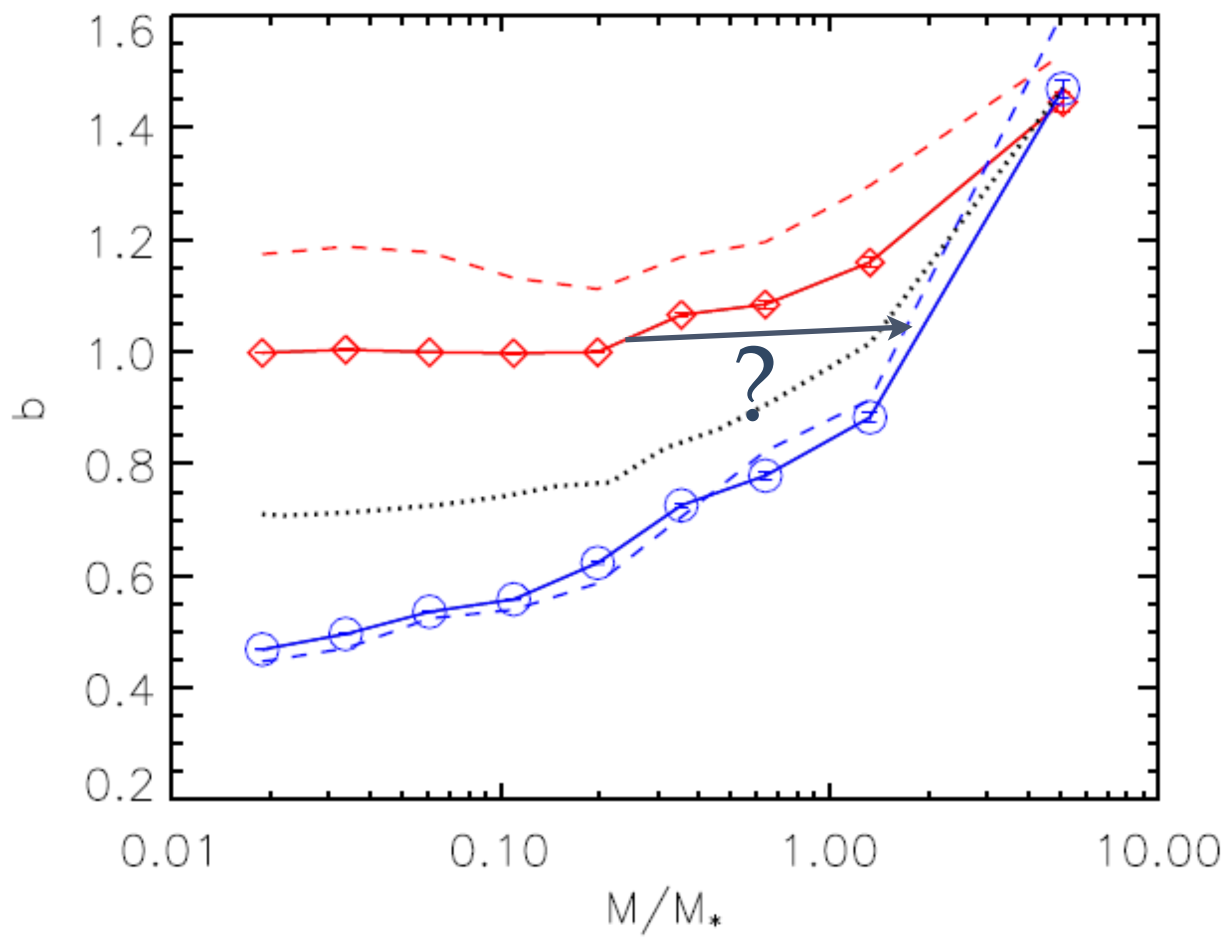
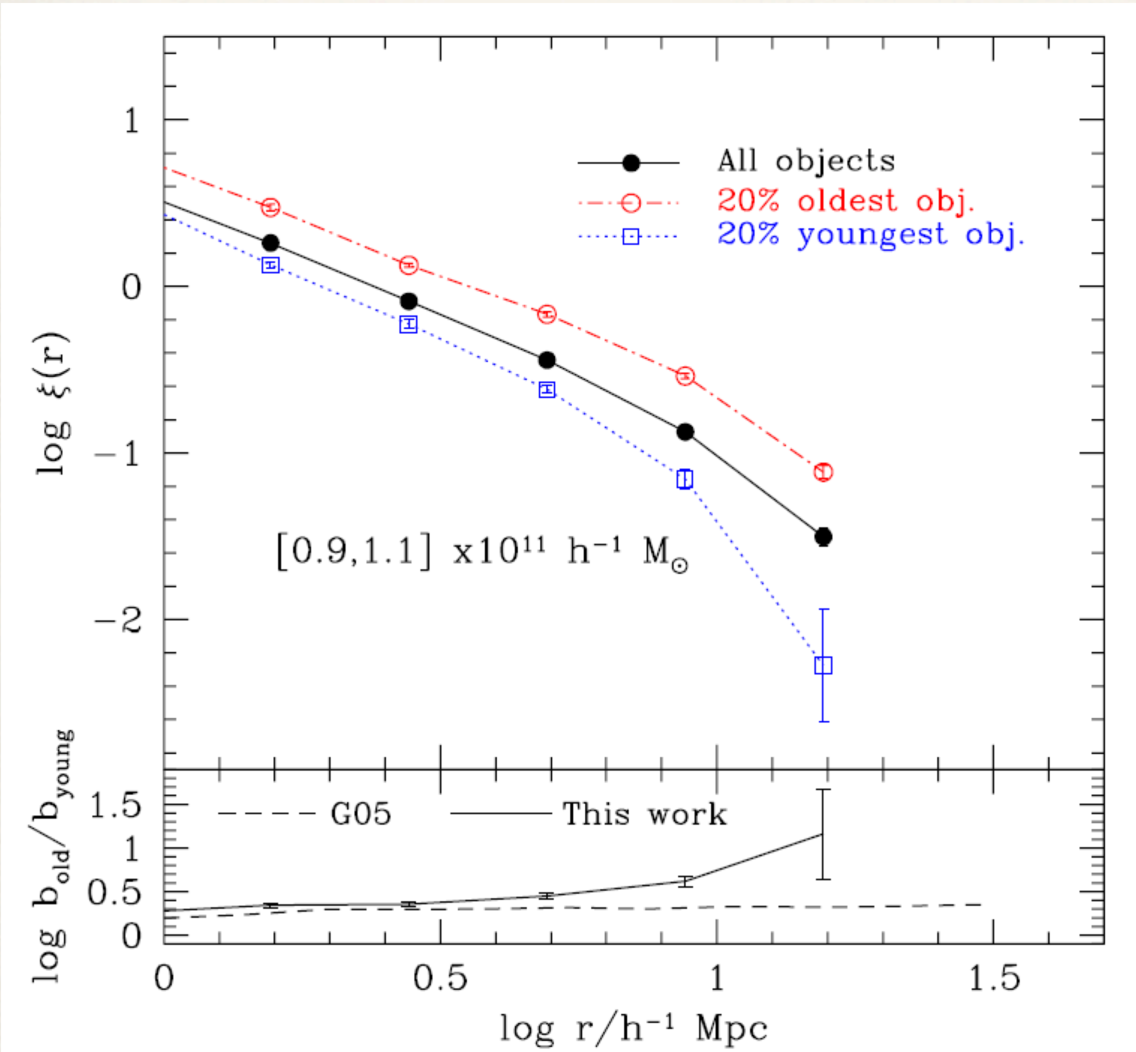
Assembly bias

Gao et al. (2005)



M* = 6.15 x 10^12 h-1 Msun

Two-point correlation function $\xi(r)$ for Haloes



Numerical Simulation:
SAG2 model
(Lagos et al. 2008)

Box of 150 Mpc/h on a side.

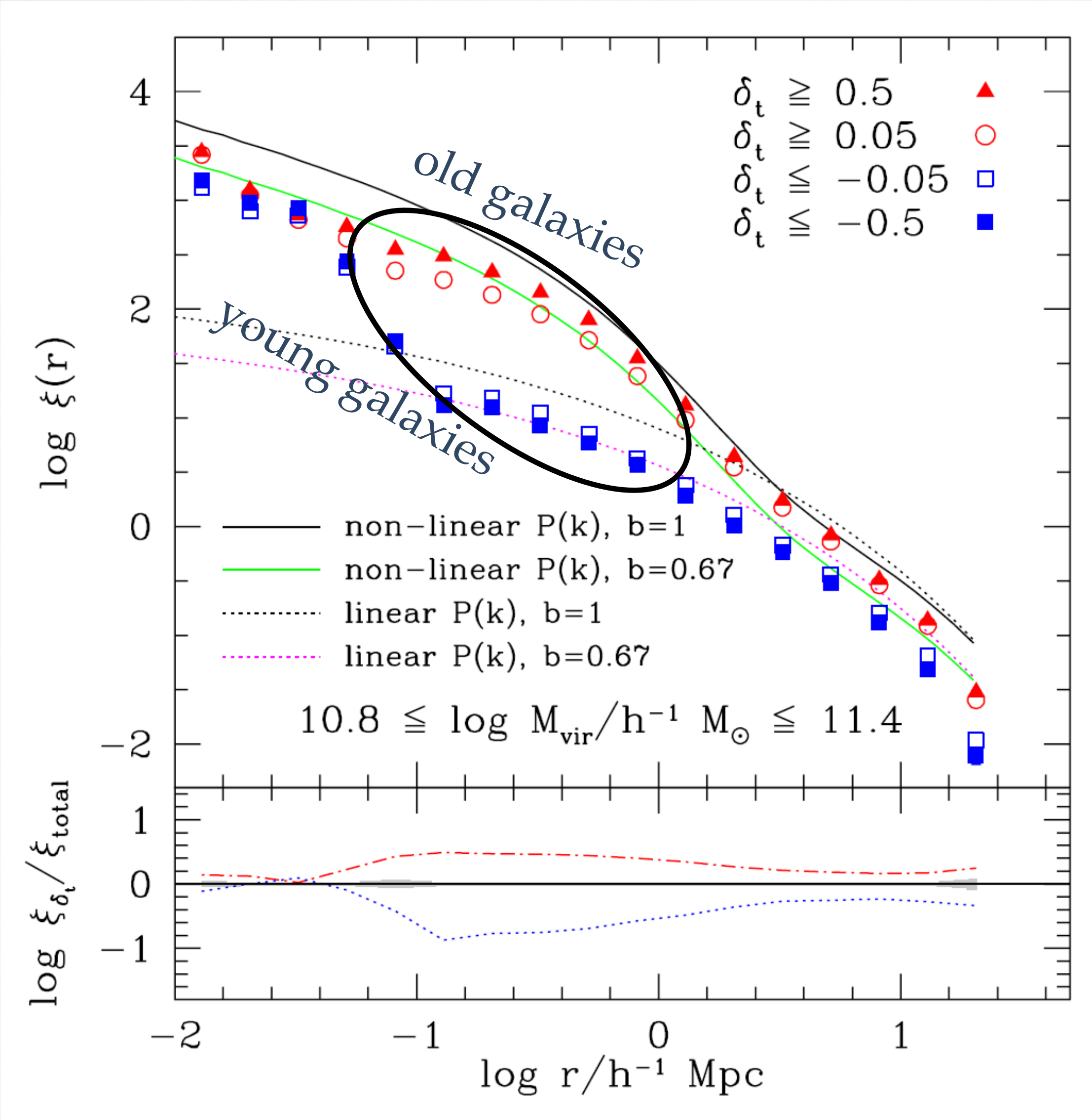
640^3 dark matter (DM) particles

Mass resolution ~ 10^9 h-1 Msun

The assembly bias effect is present with a high statistical significance

Lacerna & Padilla (2011)

Two-point correlation function
ξ(r) for galaxies



Different clustering between old and young galaxies

$$\delta_{t_i} = \frac{t_i - \langle t(M) \rangle}{\sigma_t(M)}$$

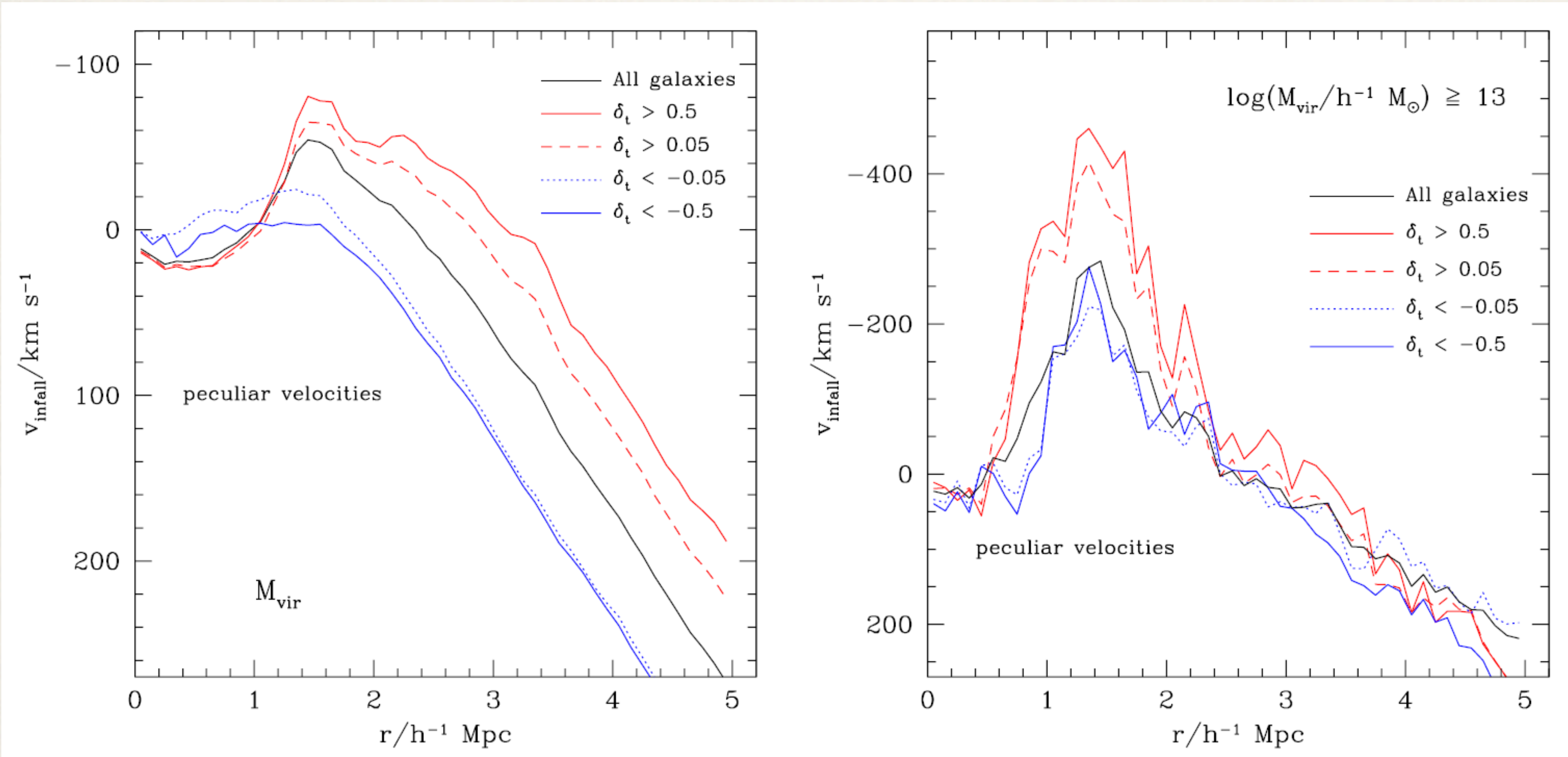
Particularly, for scales 80 kpc < r < 1.5 Mpc

mass in the infall region containing a halo ⇒ might show no dependence on age.

⇒ Virial mass is not a good enough overdensity peak height estimator.

Lacerna & Padilla (2011)

Infall Velocity Assembly bias



But, they have similar profiles when massive galaxies are selected.

⇒ Related with a smaller difference in clustering between them.

Lacerna & Padilla (2011)

Redefinition of an overdensity peak height

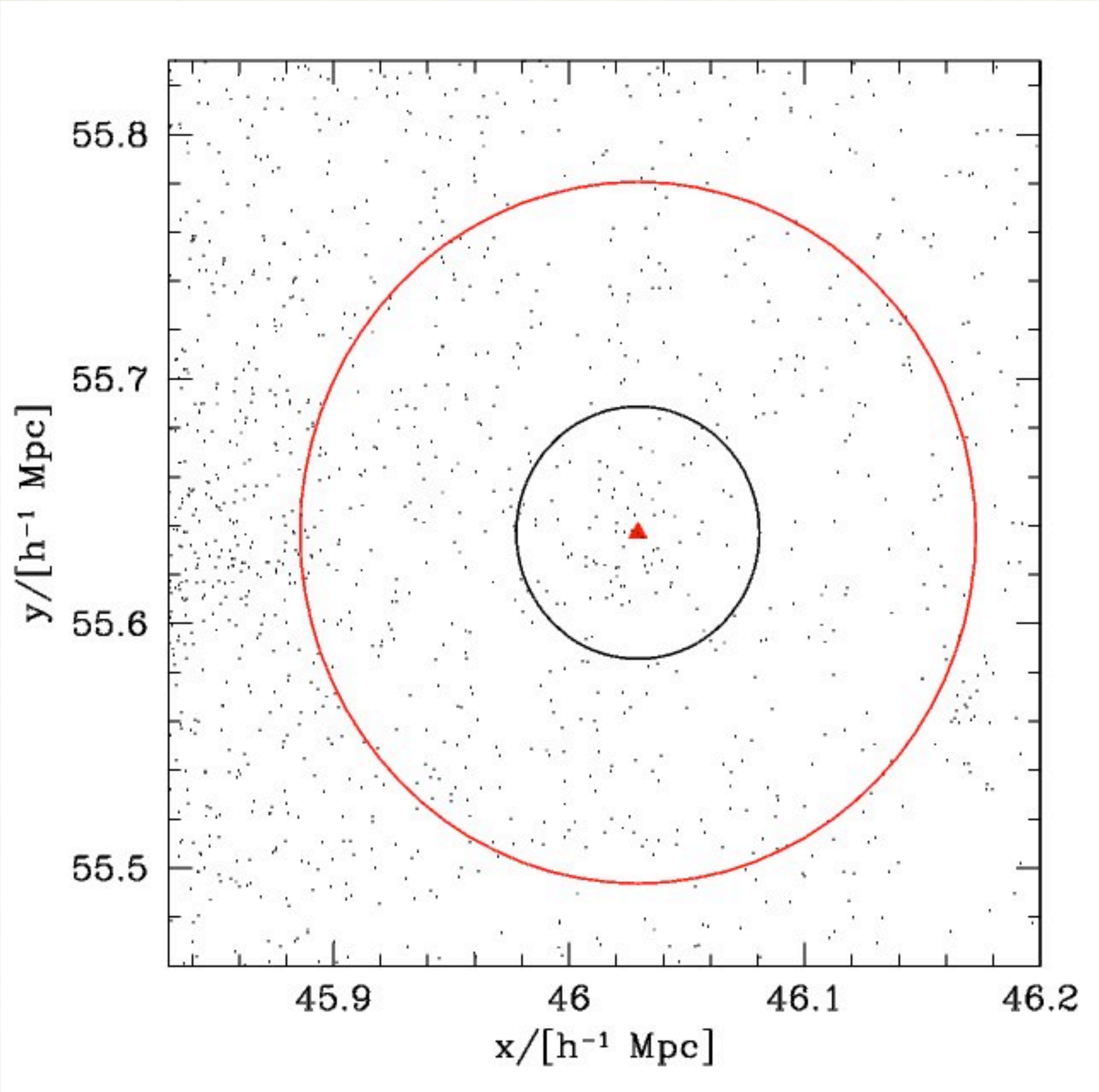
$$r = a\ \delta_t + b\ \log\left(\frac{M_{vir}}{M_{nl}}\right)$$

log(M_nl /h^-1 Msun) = 13.38

This radius defines a mass M for each galaxy.

If r < rvir $\Rightarrow$ M = Mvir

Our model: Radius for each galaxy is parametrized as

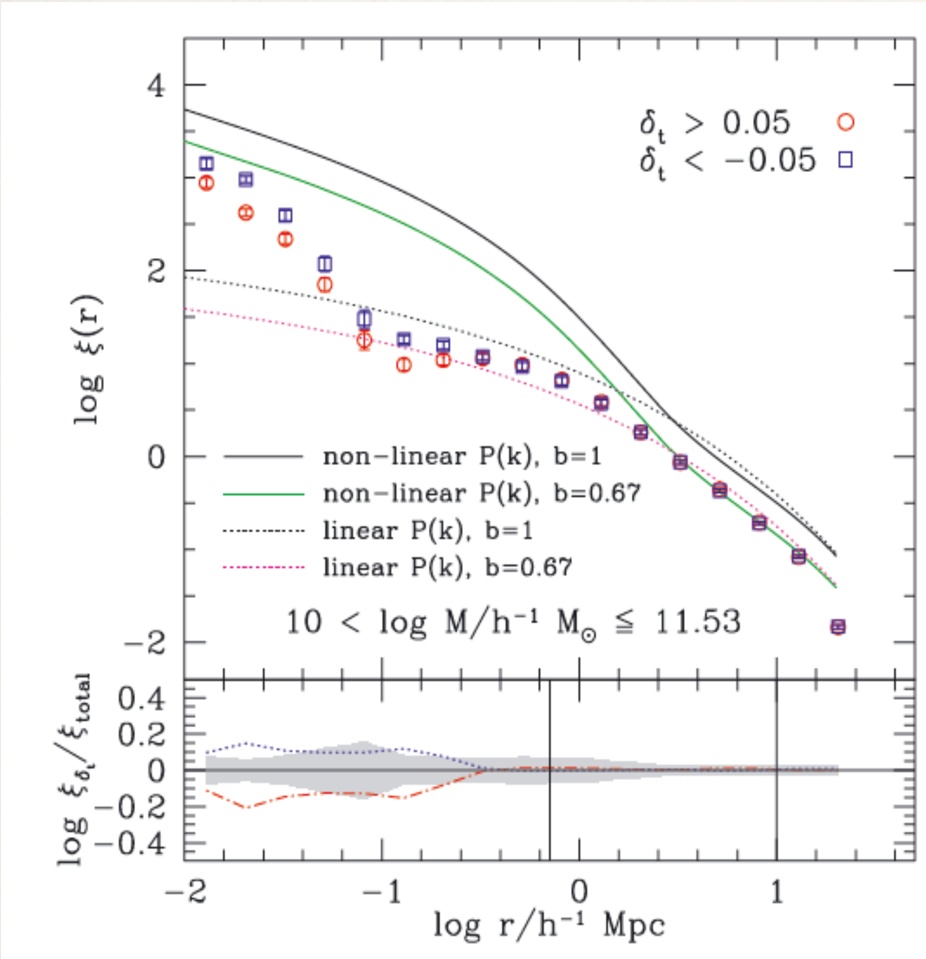


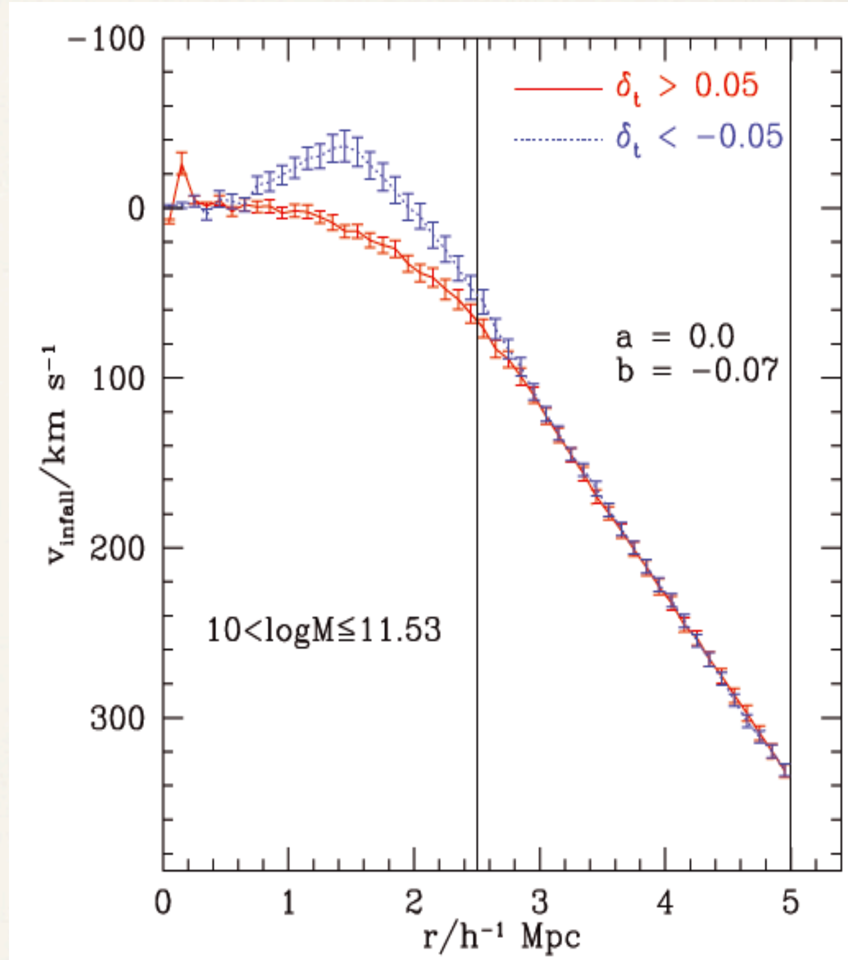
$$r = a\ \delta_t + b\ \log\left(\frac{M_{vir}}{M_{nl}}\right)$$

Rvir = 51.6 h-1 kpc

r = 143.4 h-1 kpc

Our model: assembly bias is not present at scales r $\geq$ 1 Mpc/h

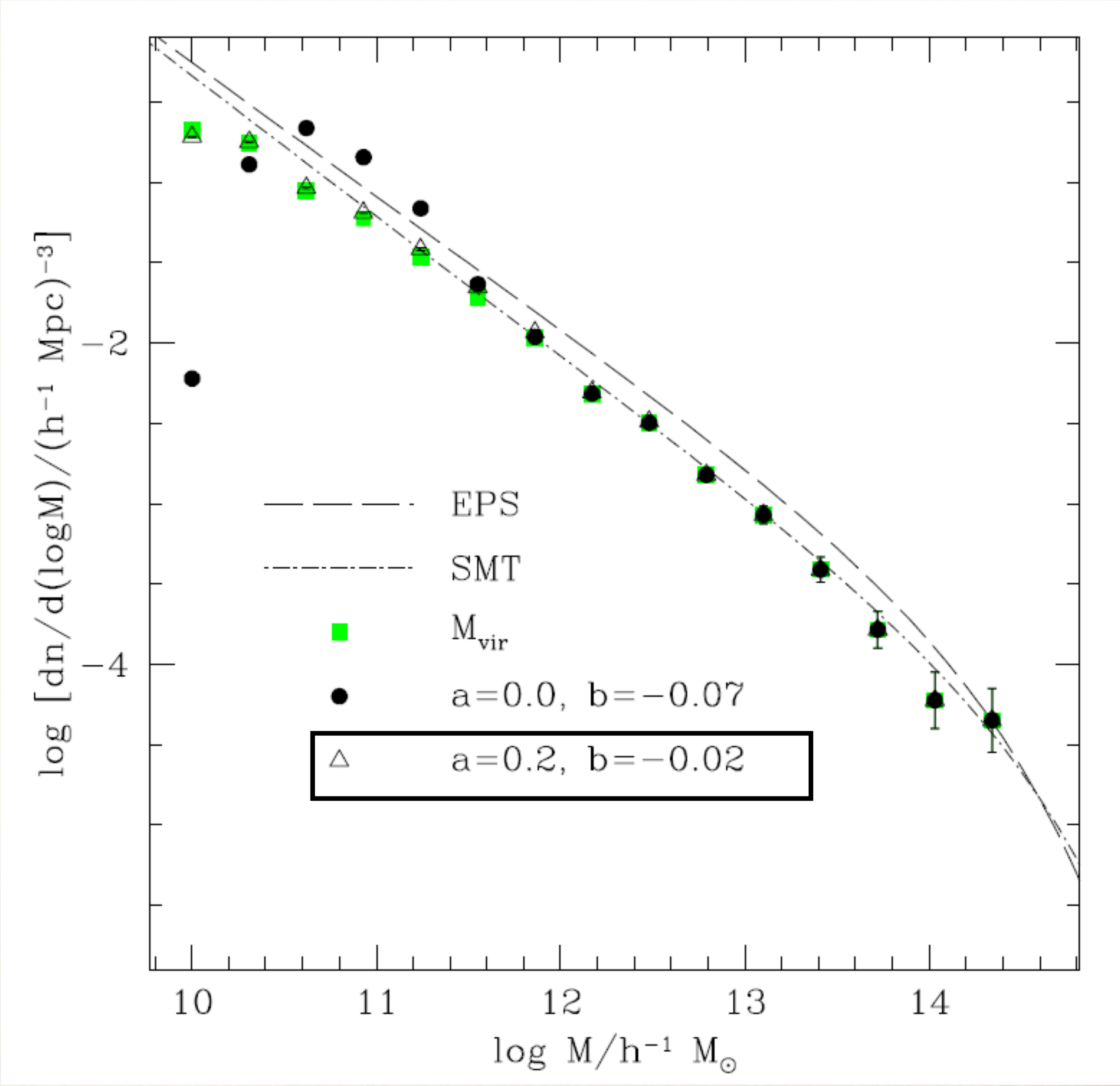




Lacerna & Padilla (2011)

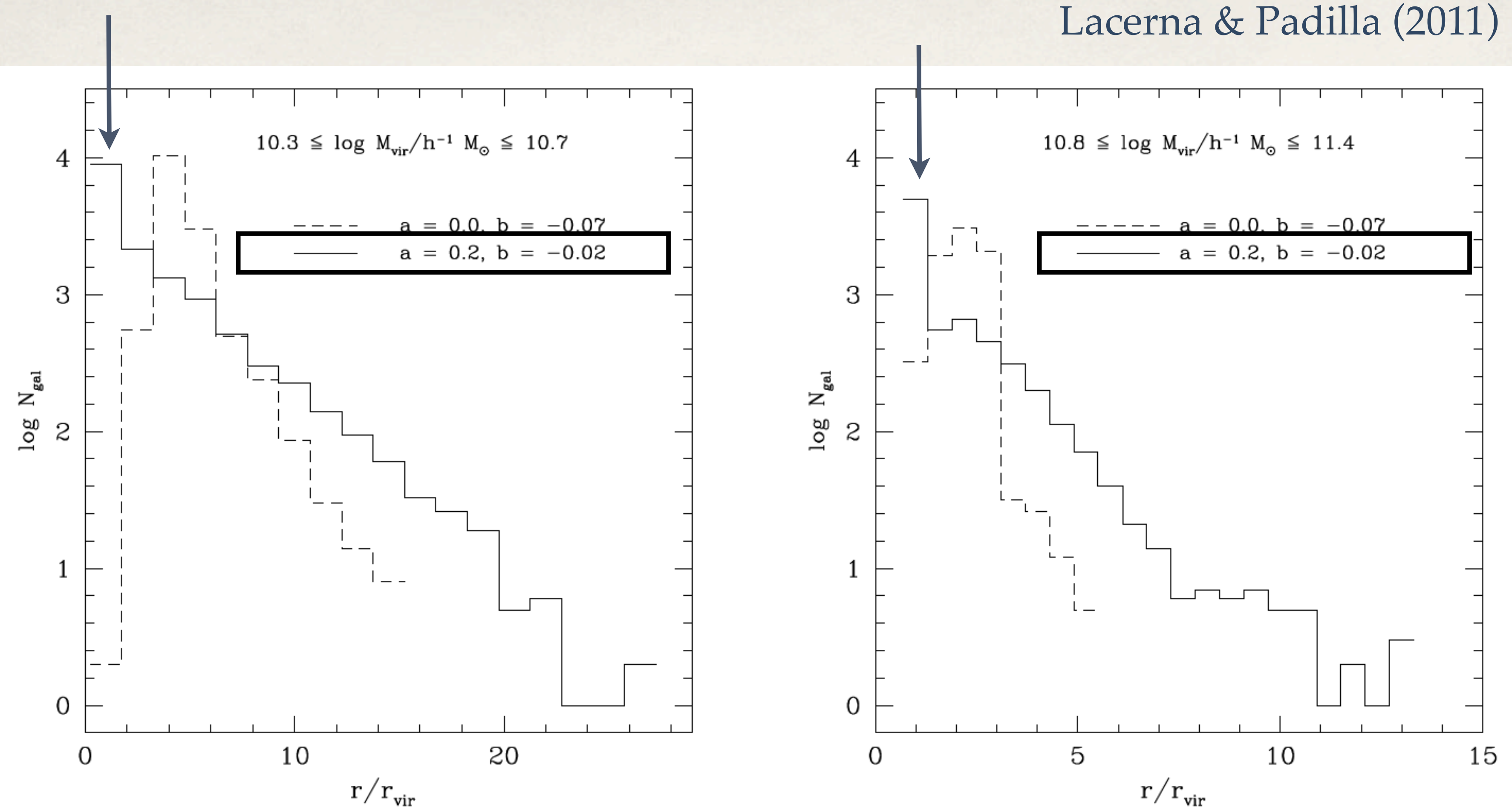
Mass Function

Lacerna & Padilla (2011)



EPS: extended Press-Schechter
SMT: Sheth, Mo, & Tormen (2001)

Lacerna & Padilla (2011)



< r > ~ 1 - 4 rvir

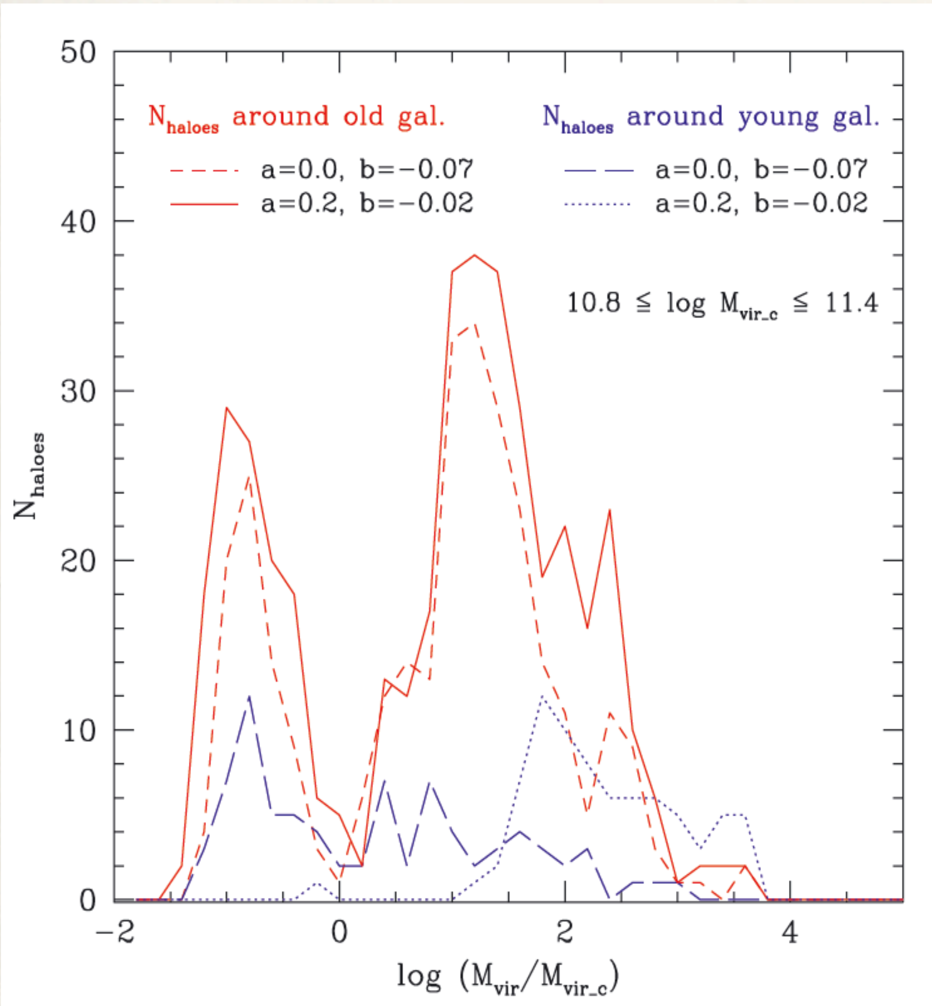
Most of the galaxies keep their original halo masses, Mvir (a=0.2, b=-0.02).

For higher values of Mvir, fewer objects change their halo masses.
All the galaxies with initially Mvir ≥ 6 x 10^12 Msun/h have M = Mvir

Peak height for old galaxies adds more haloes and mass than for young objects.

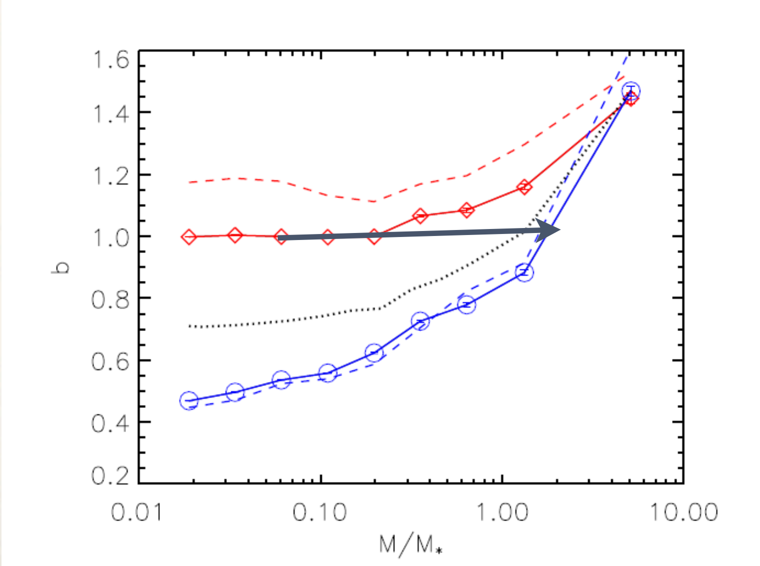
Lacerna & Padilla (2011)

Higher the virial mass, lower influence of other haloes inside the new peak height.



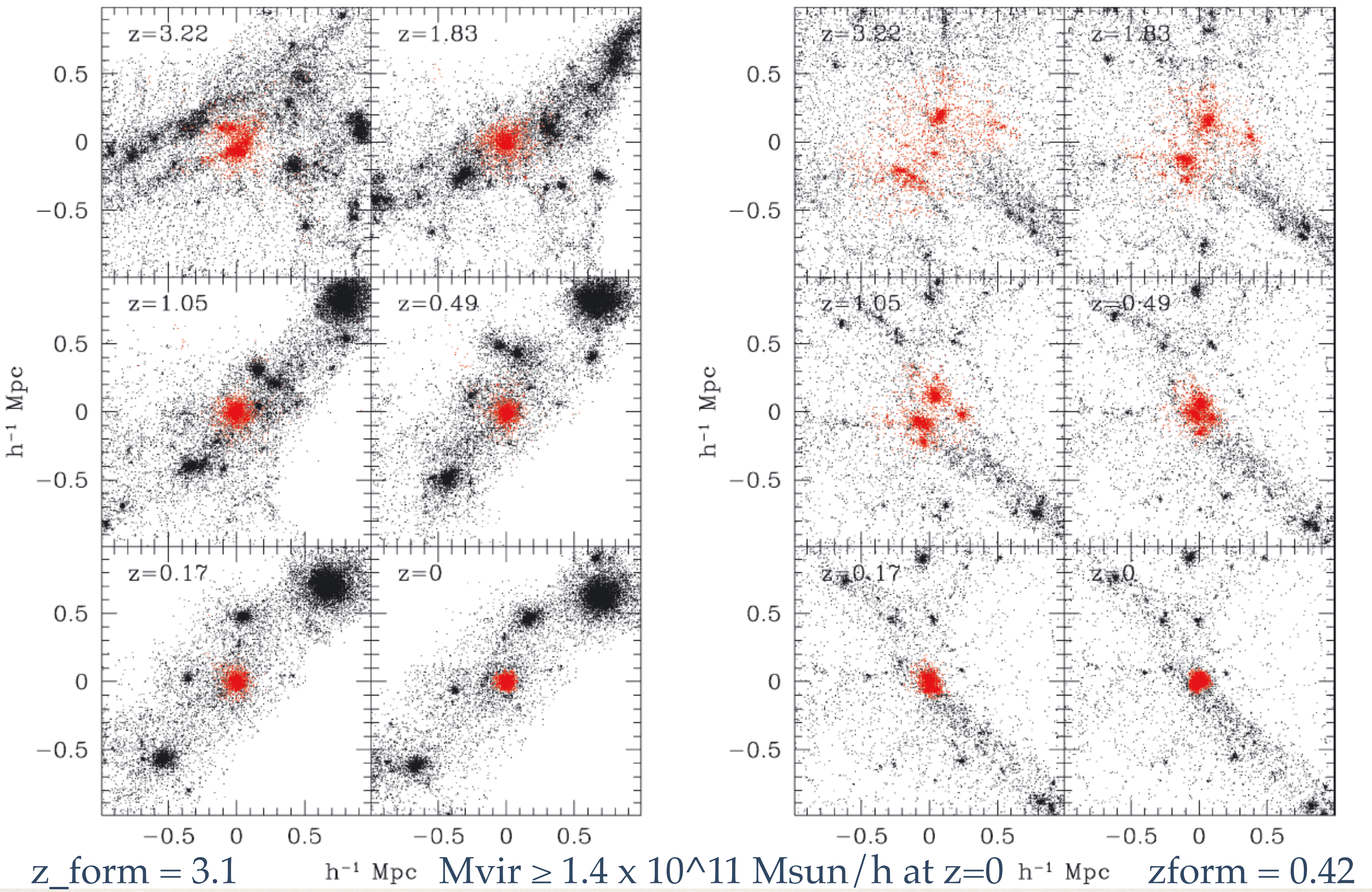
old, low virial mass objects surrounded preferentially by high-mass haloes.

Old, low-mass galaxies would suffer truncation of matter by nearby massive objects



See also Firmani & Avila-Rees 2013

Consistent with Hahn et al. (2009)

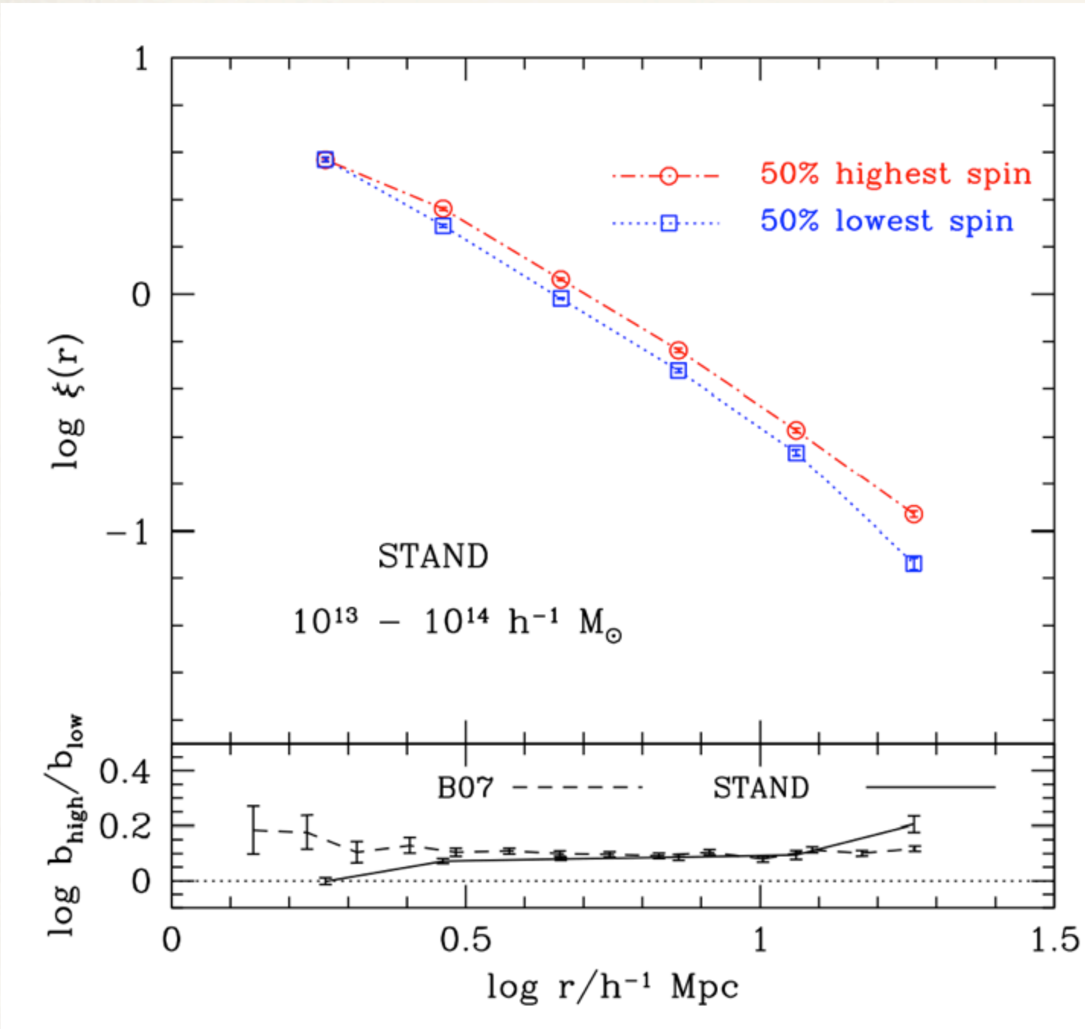


z_form = 3.1 Mvir ≥ 1.4 x 10^11 Msun/h at z=0 zform = 0.42

Tidal effects in the vicinity of massive haloes

Assembly bias as a result of different spin parameters

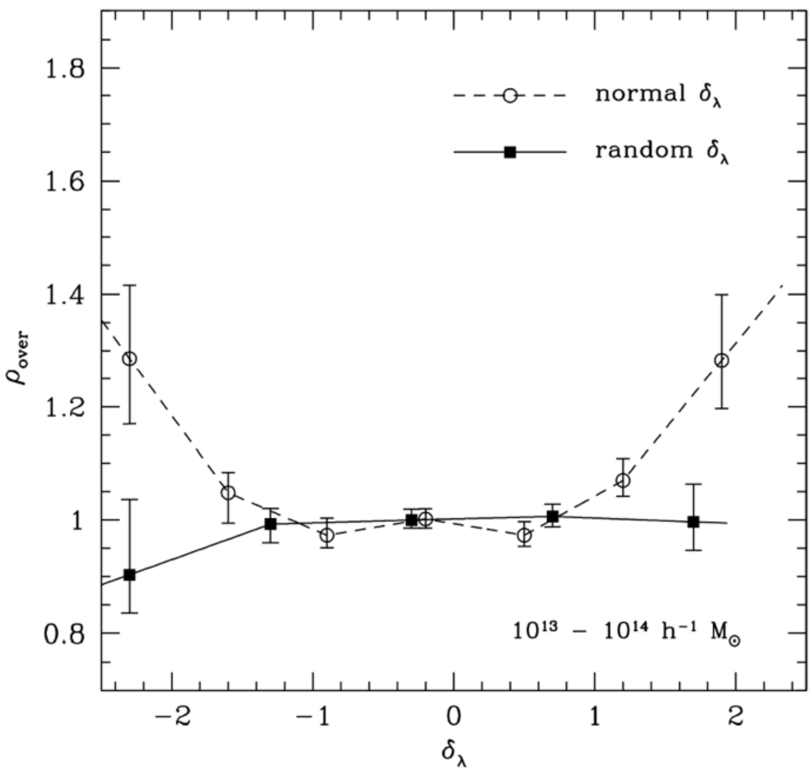
As reported in Bett et al., 2007



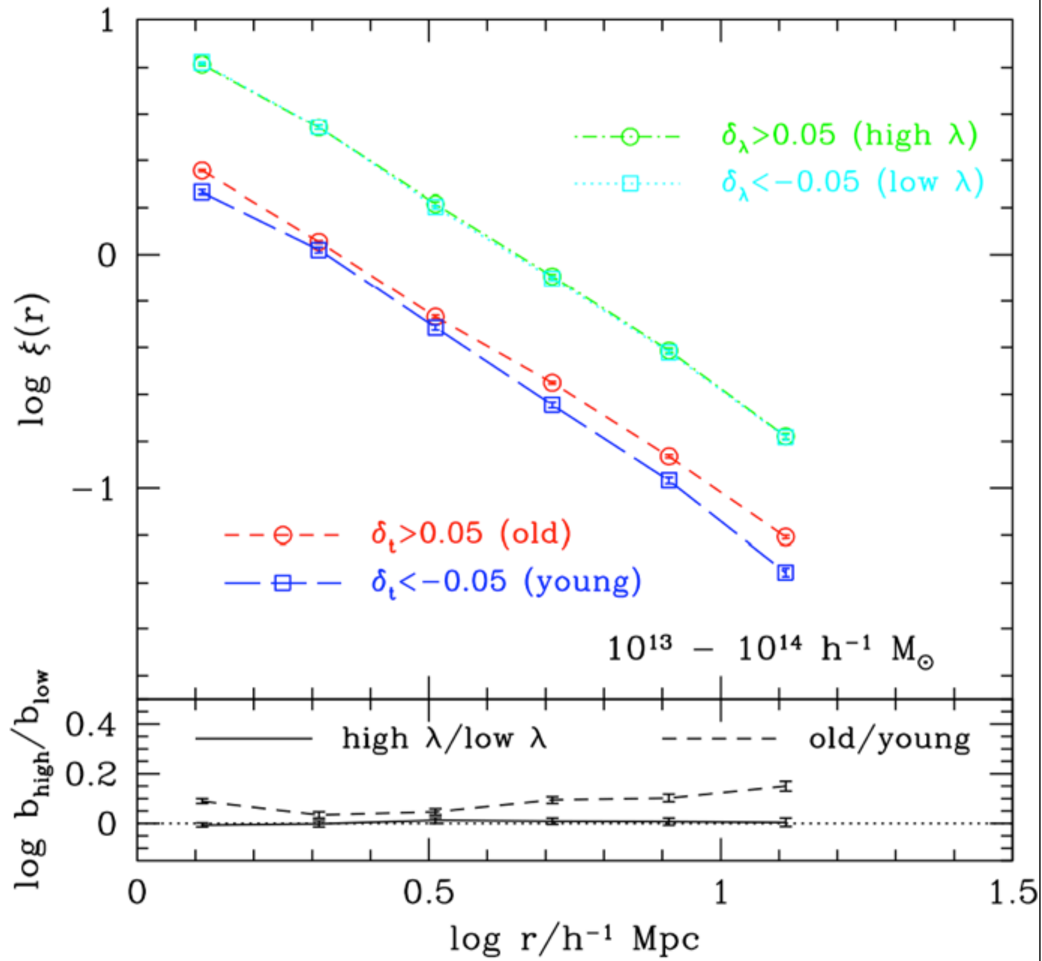
Only present in high masses (instead of low masses as age bias)

Lacerna & Padilla 2012

Assembly bias as a result of different spin parameters



$$\delta_{\lambda_i} = \frac{\lambda_i - \langle \lambda(M) \rangle}{\sigma_\lambda(M)}$$



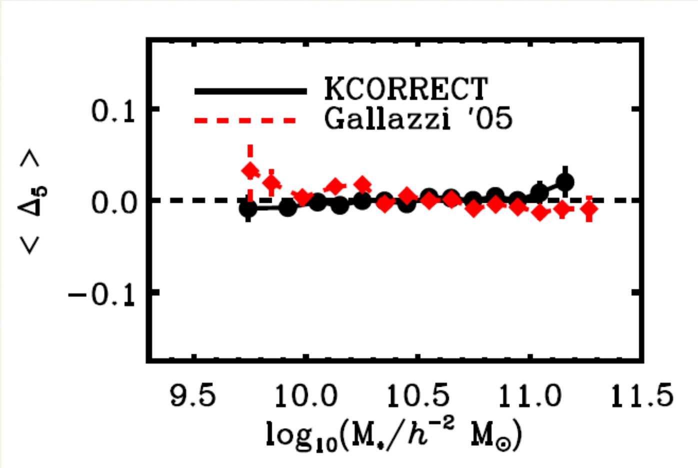
Use only haloes with
-Q<=2T/U+1<=Q,
Q=0.5

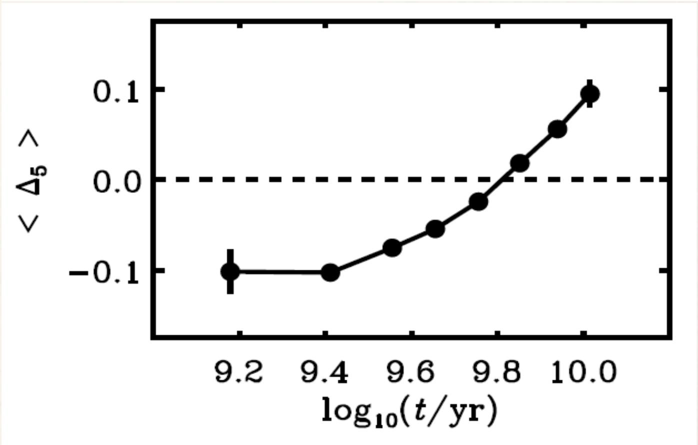
Lacerna & Padilla 2012

Assembly bias in Observations

Galaxies of similar color and luminosity show different ages in different environments.

Other results:
- Zapata et al. (2011) find that similar galaxies in groups of equal mass but in isolated regions are redder.
- Luparello et al. (2013) show older stellar populations in galaxies in equal mass groups that lie in possible superclusters.
- Yaryura et al. (2013) show higher correlation functions for galaxies of equal properties and in equal mass groups that reside in superstructures.





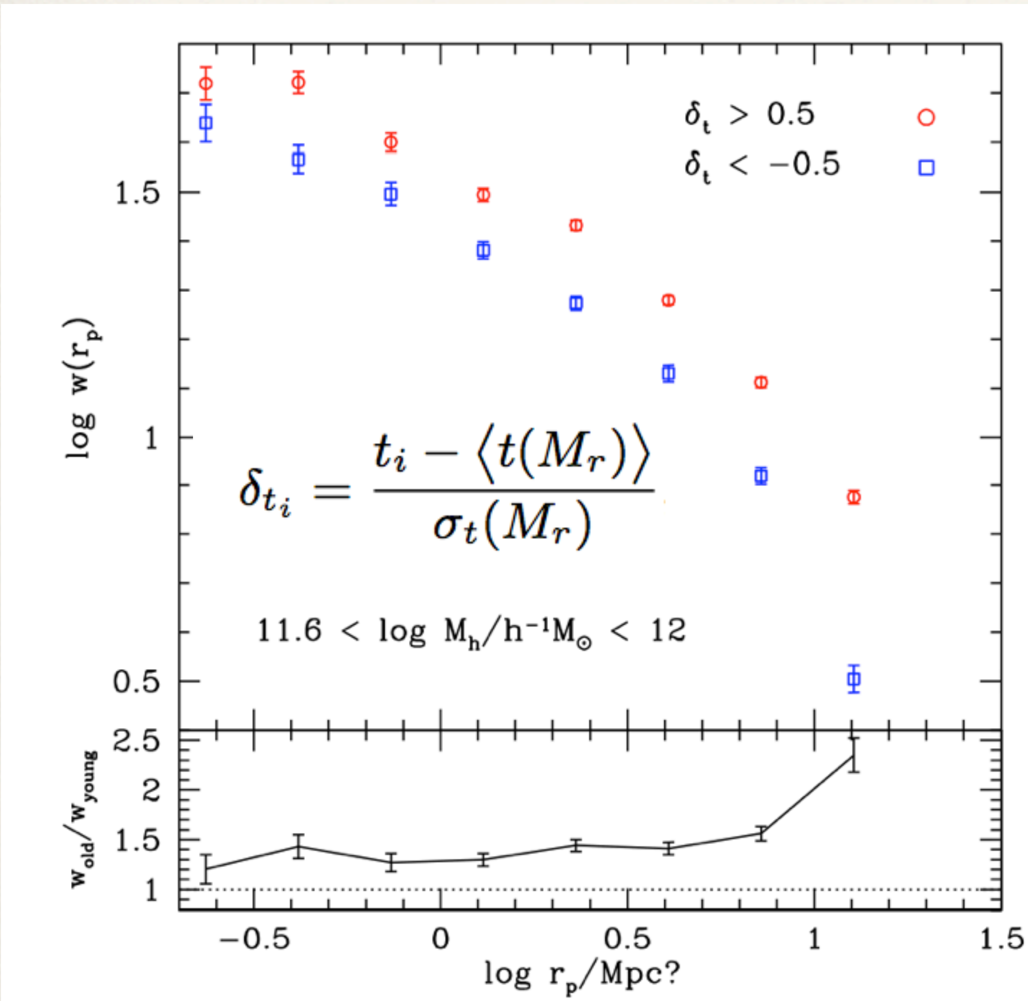
Cooper et al. (2010)

Possible additional test:

Li et al. (2013) study semi-analytic models and find that dwarfs of equal host halo mass can expected to be redder by 0.5 mags near clusters in comparison to the field.

Assembly bias in Observations

Lacerna, Stasyszyn & Padilla 2013



550,000 central SDSS galaxies in Yang et al. (2007) groups.

Ages from Dn4000 index.

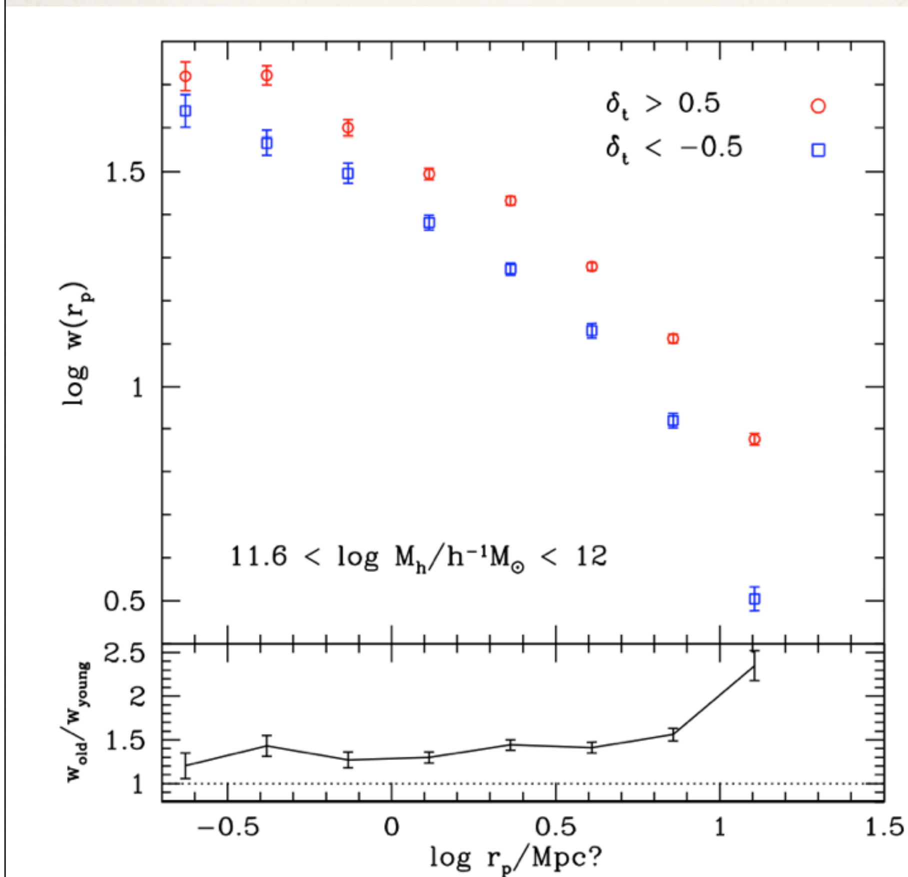
Clustering of old galaxies is typically fifty percent higher than that of young galaxies.

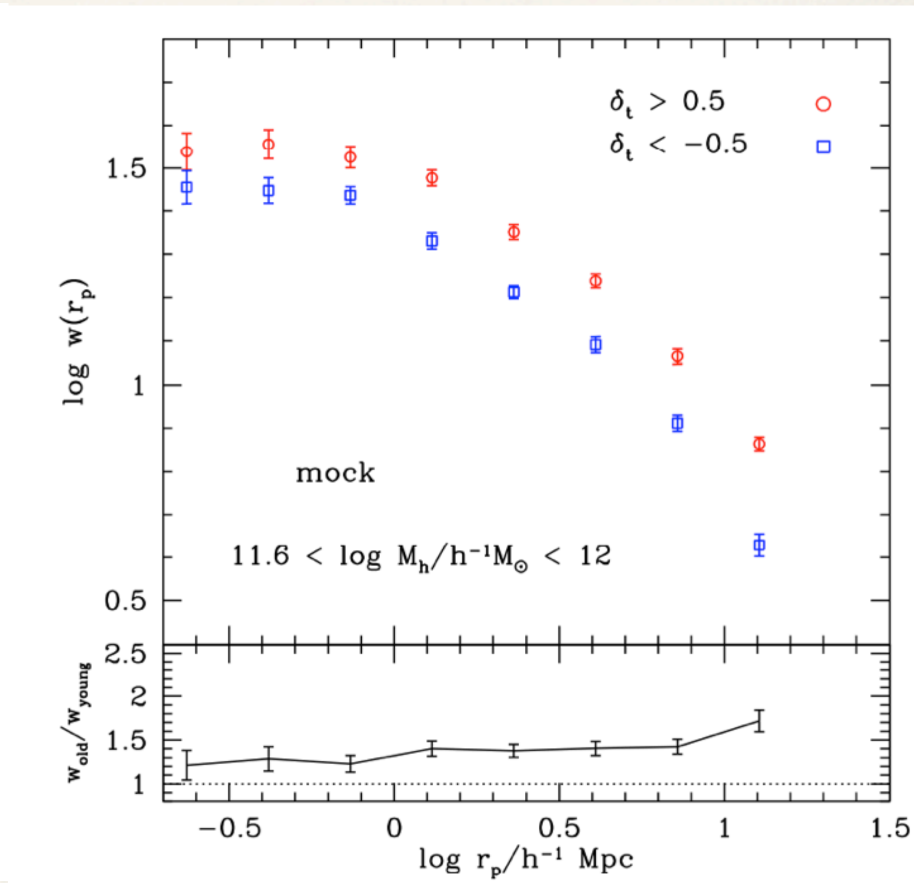
Assembly bias in Observations

Lacerna, Stasyszyn & Padilla 2013

SDSS galaxies

Mock FOF haloes





Stellar ages

Formation age

Summary

Redefinition of an overdensity peak height

Mass (luminosity) inside a sphere (cylinder) of radius r

assembly bias is not present at scales r $\geq$ 1 h-1 Mpc
for different ranges of mass.

Virial mass of low-mass objects is not an adequate proxy for peak height.
Equal virial mass objects can actually belong to initial density peaks of very different amplitude.
Necessary to include a more global environmental component.

Assembly bias possibly found in real galaxies in both direct and indirect ways.

Lacerna & Padilla 2011, 2012, Walker-Soler et al. 2012, Lacerna, Stasyszyn & Padilla 2013