Galaxy Clustering in EAGLE Compared to GAMA and Illustris

María Celeste Artale

Instituto de Astronomía y Física del Espacio
(IAFE, CONICET-UBA)

In collaboration with
Peder Norberg, Tom Theuns, James Trayford (ICC, Durham)
Idit Zehavi (Case Western Reserve University)
Susana Pedrosa (IAFE)
Daniel Farrow (MPE), et al.

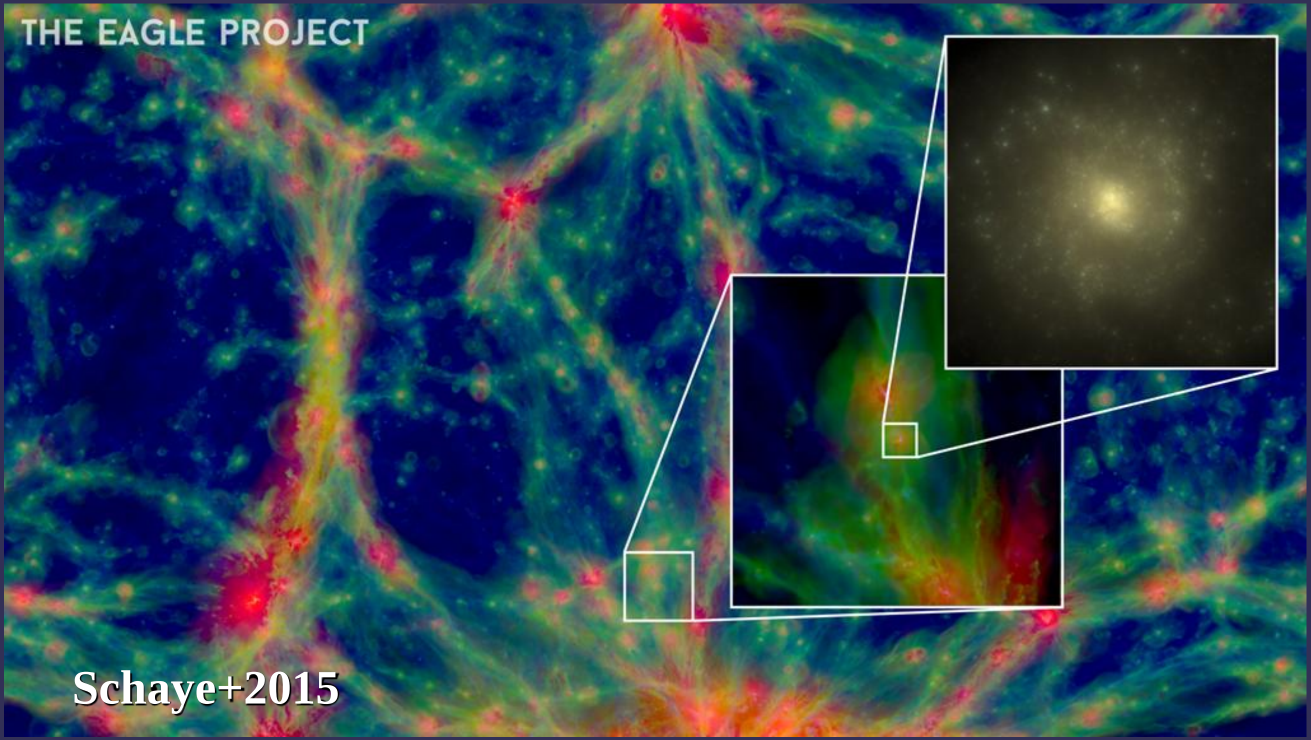
Motivation

Test whether galaxy clustering within EAGLE and its dependence on galaxy properties is compatible with galaxy clustering from GAMA.

Contrast EAGLE galaxy clustering with other galaxy formation models, e.g. Illustris-1 and GALFORM.

EAGLE Simulation

(Evolution and Assembly of GaLaxies and their Environments)



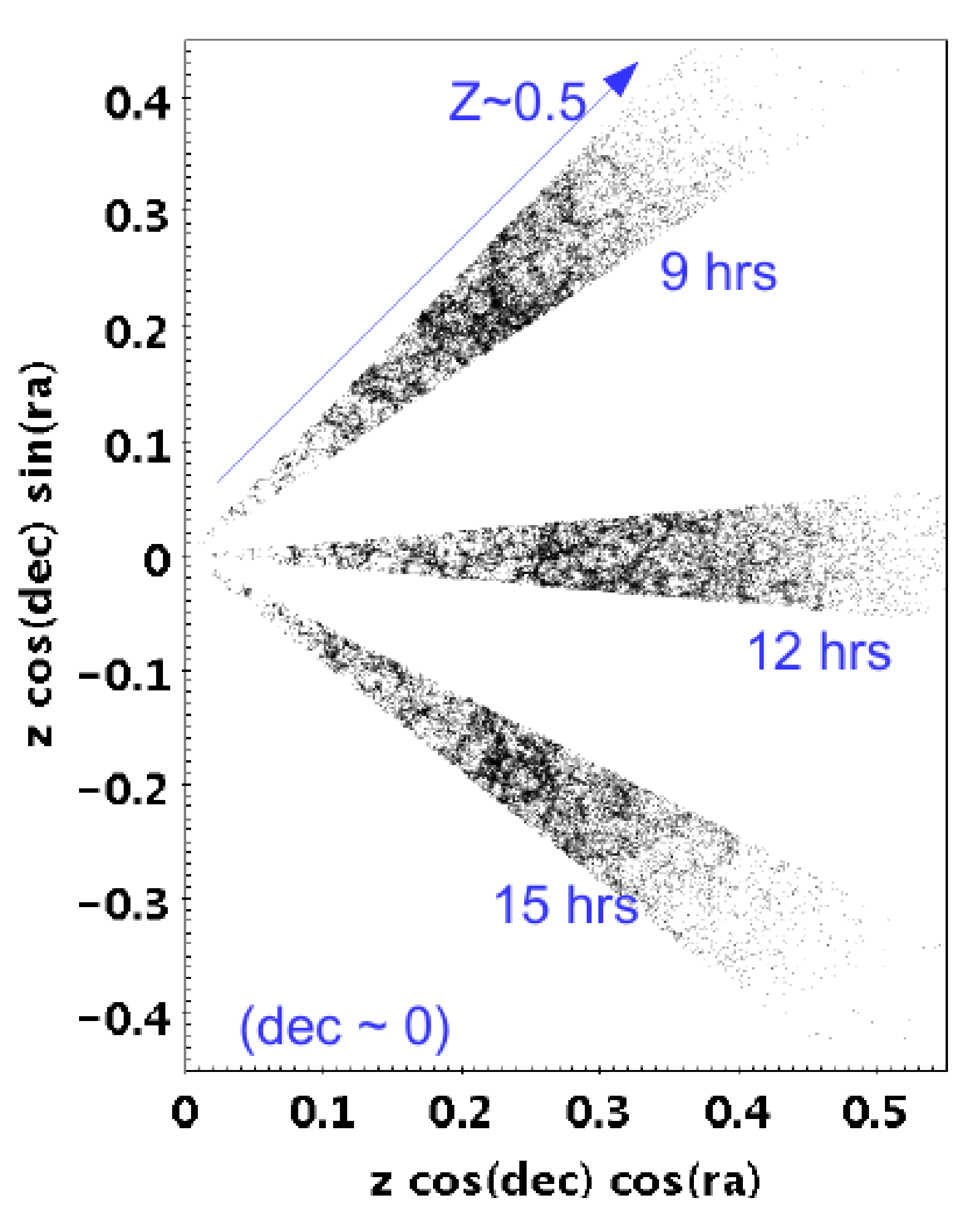
Sub-grid models for:
- radiative cooling
- star formation
- stellar mass loss
- metal enrichment
- energy feedback from star formation
- SMBH
- AGN feedback

* Cosmological parameters from Planck 2013
* We analyze the simulation of 100 Mpc of side
* We select galaxy populations by using the EAGLE Database

GAMA Survey

(Galaxy And Mass Assembly)

- Spectroscopic and multi-wavelength survey (UV to Far-IR)
- Three equatorial fields with a total area of ~180 deg^2
- Redshift survey to r_{petro} < 19.8
- Highly complete: >98%

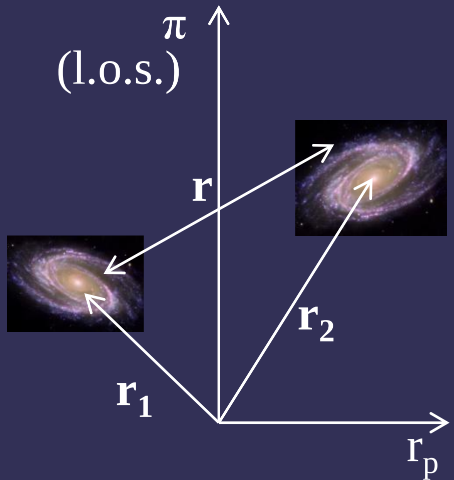


Farrow+2015 clustering:
- Volume and flux limited samples
- Our focus: $0.02 < z < 0.14$
- Investigate the 2PCF of galaxies as a function of their luminosity, stellar mass and colour

Real space clustering from redshift space

Projected correlation function:

$$w(r_p) = \int_{-\pi_{max}}^{\pi_{max}} \xi(r_p, \pi)\, d\pi$$



To 0th order, $w(r_p)$ is well described by a power-law

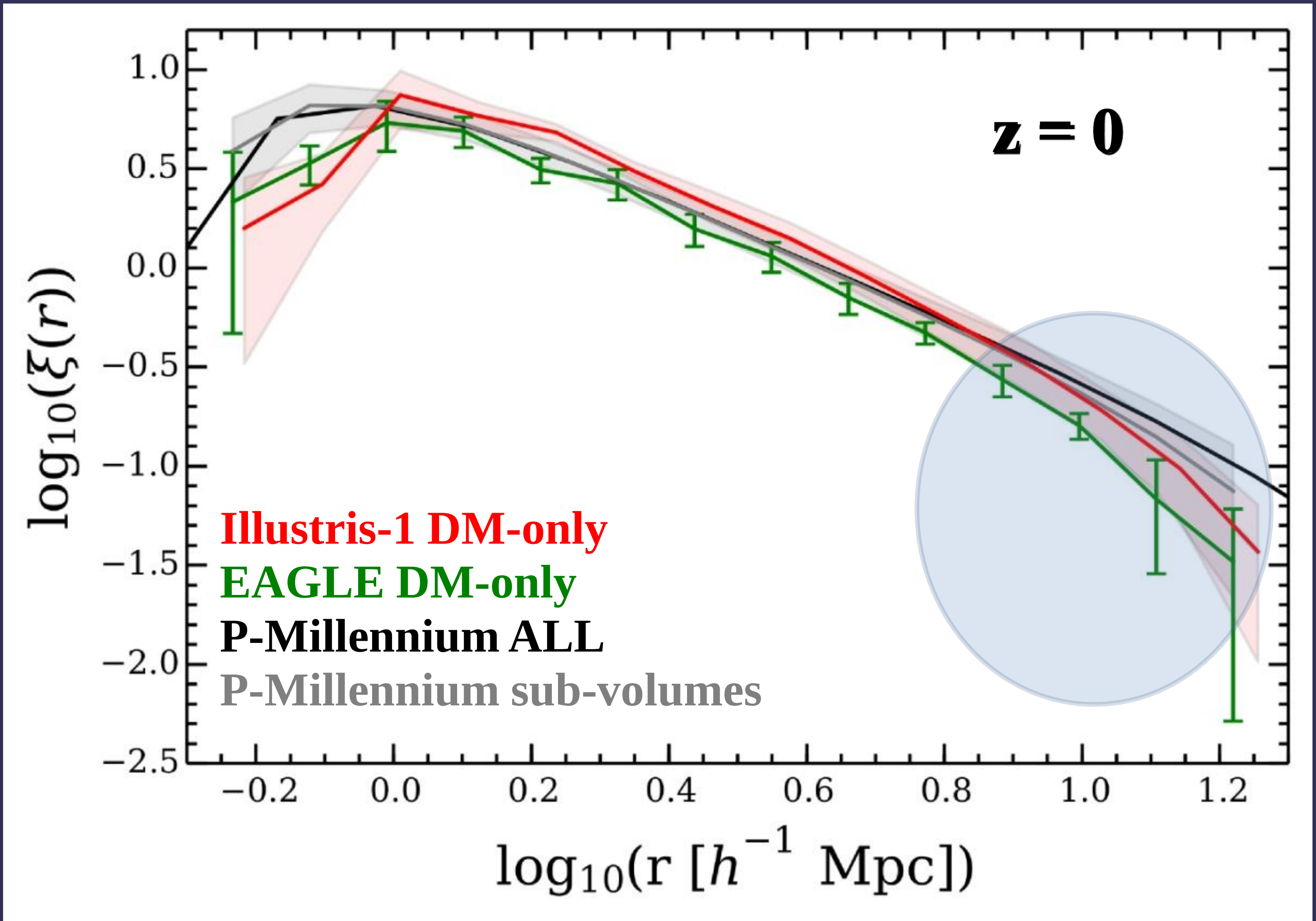
$$\xi(r) = \left(\frac{r}{r_0}\right)^{-\gamma} \xrightarrow[\pi_{max} \to \infty]{} w(r_p) = r_p \left(\frac{r_0}{r_p}\right)^{\gamma} \frac{\Gamma(1/2)\Gamma\left(\frac{\gamma-1}{2}\right)}{\Gamma\left(\frac{\gamma}{2}\right)}$$

Zehavi+2011: γ=1.8, r_0=5.33 h^{-1} Mpc

Clustering in Dark Matter Halos

DM-only simulations

Aim: to understand the limitations of using a 100Mpc box



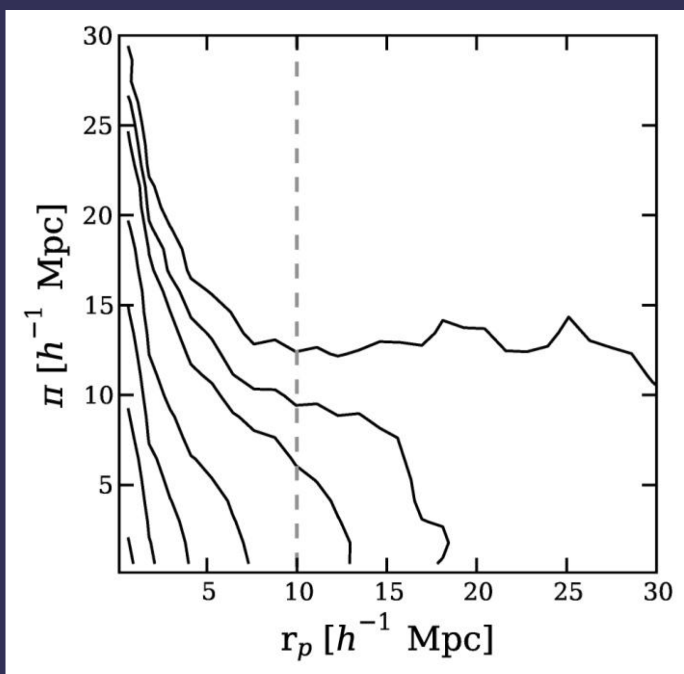
P-Millennium
- Planck 2013
- (800 Mpc)^3 box, i.e. 512x EAGLE !

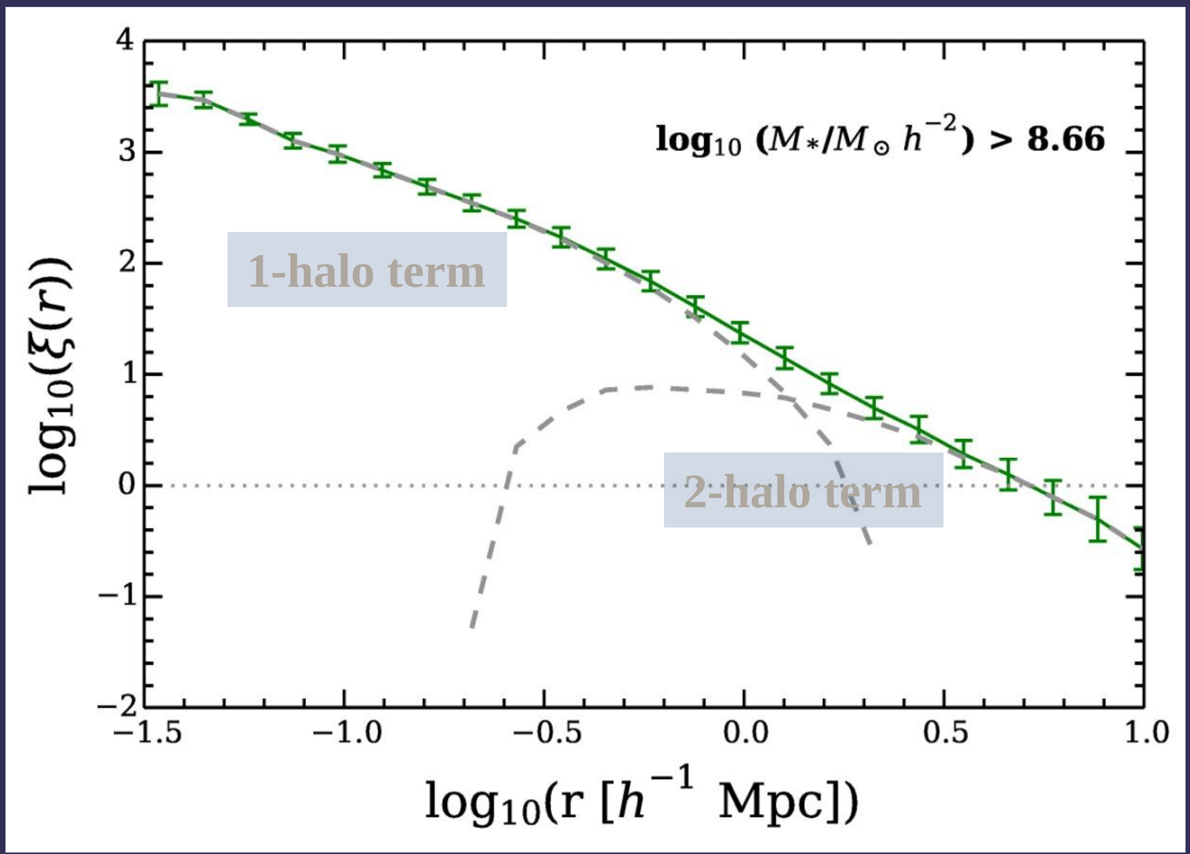
Illustris-1
- WMAP-9
- (106.5 Mpc)^3 box

Halos with $M_{200,c} > 10^{12}\ h^{-1}\ M_{\odot}$

Clustering in EAGLE Galaxies

Fingers-of-God



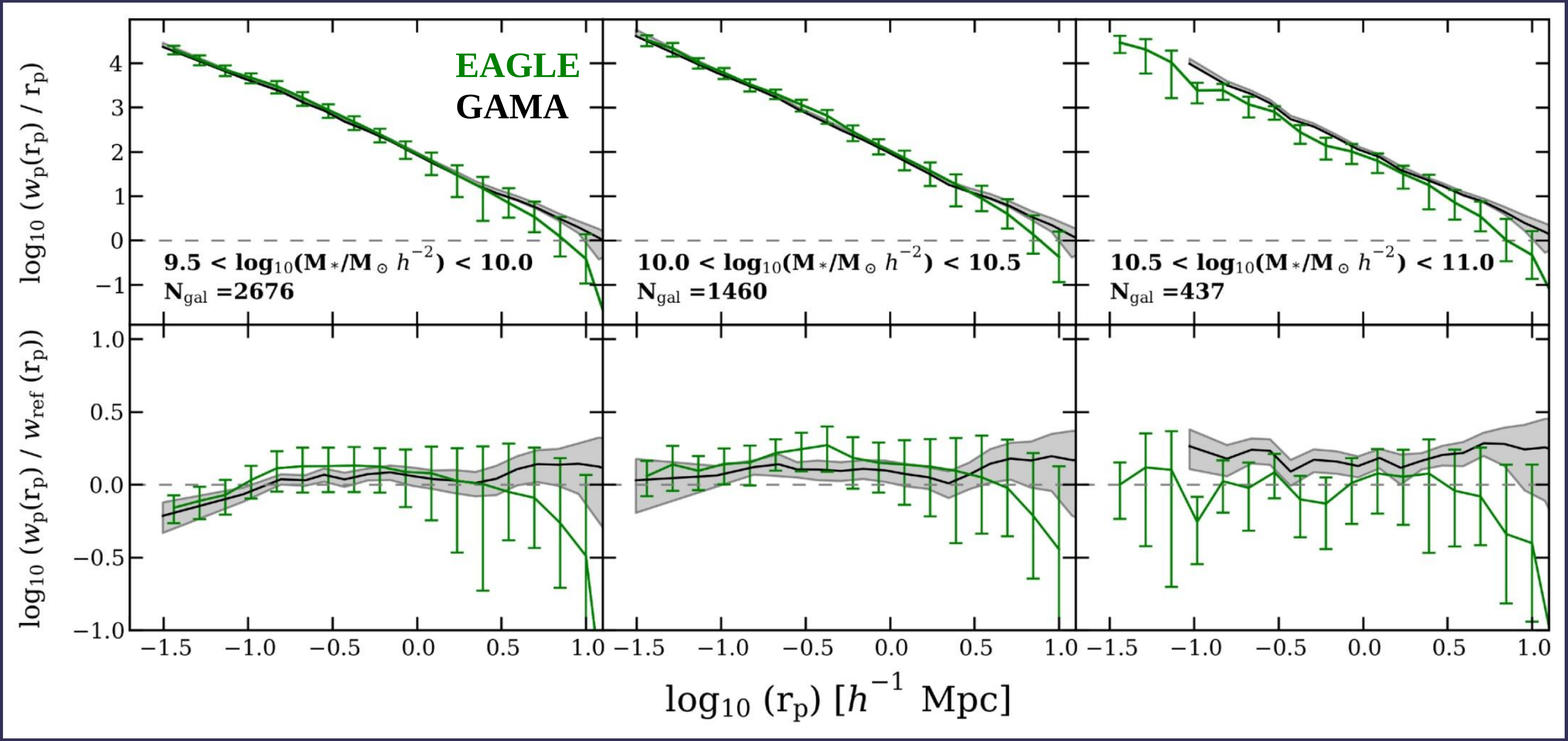


Contours represent

ξ = 5, 2, 1, 0.5, 0.2, 0.1, 0.01

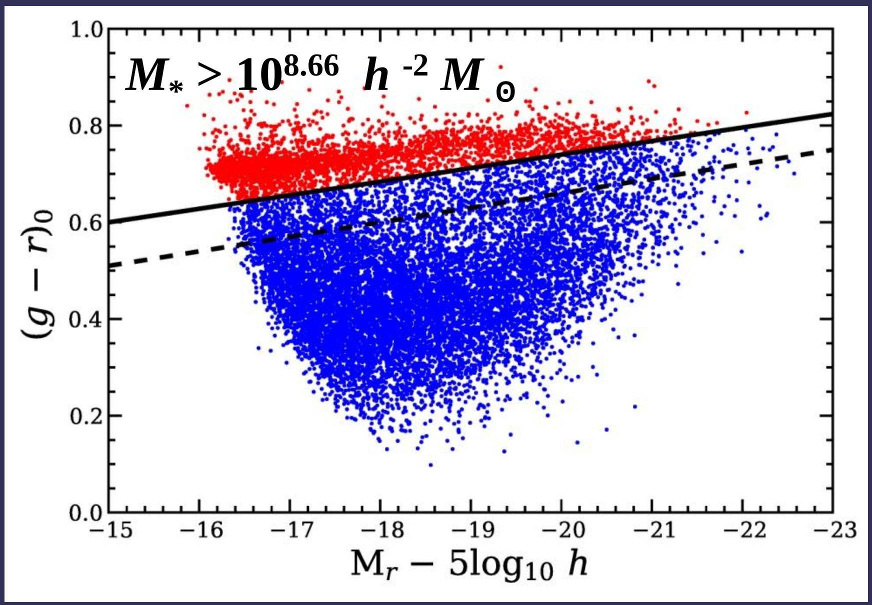
Galaxies with $\log(M_*/M_\odot\ h^{-2}) > 8.66$

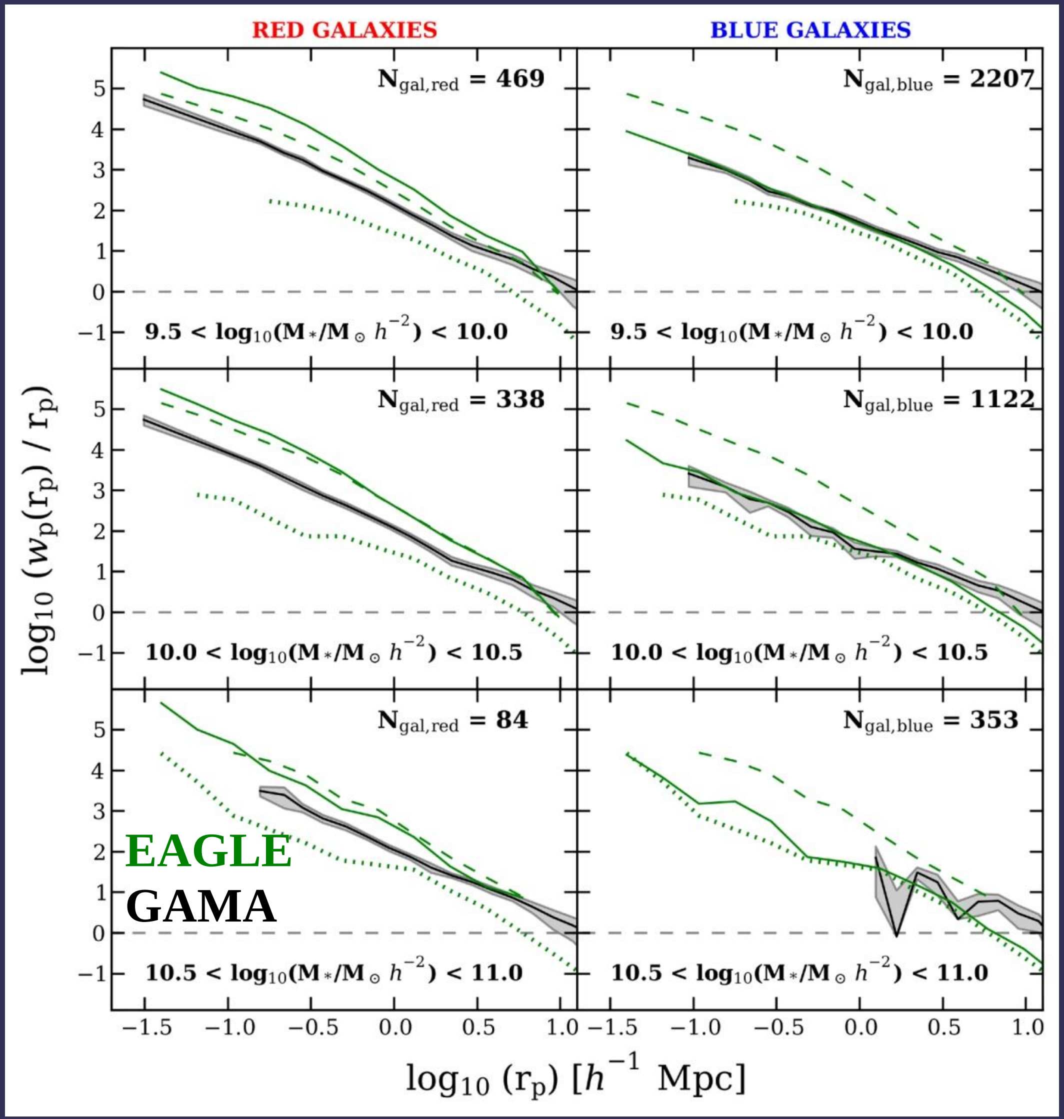
Stellar Mass Dependent Clustering



Good agreement between EAGLE and GAMA results

Color Dependent Clustering





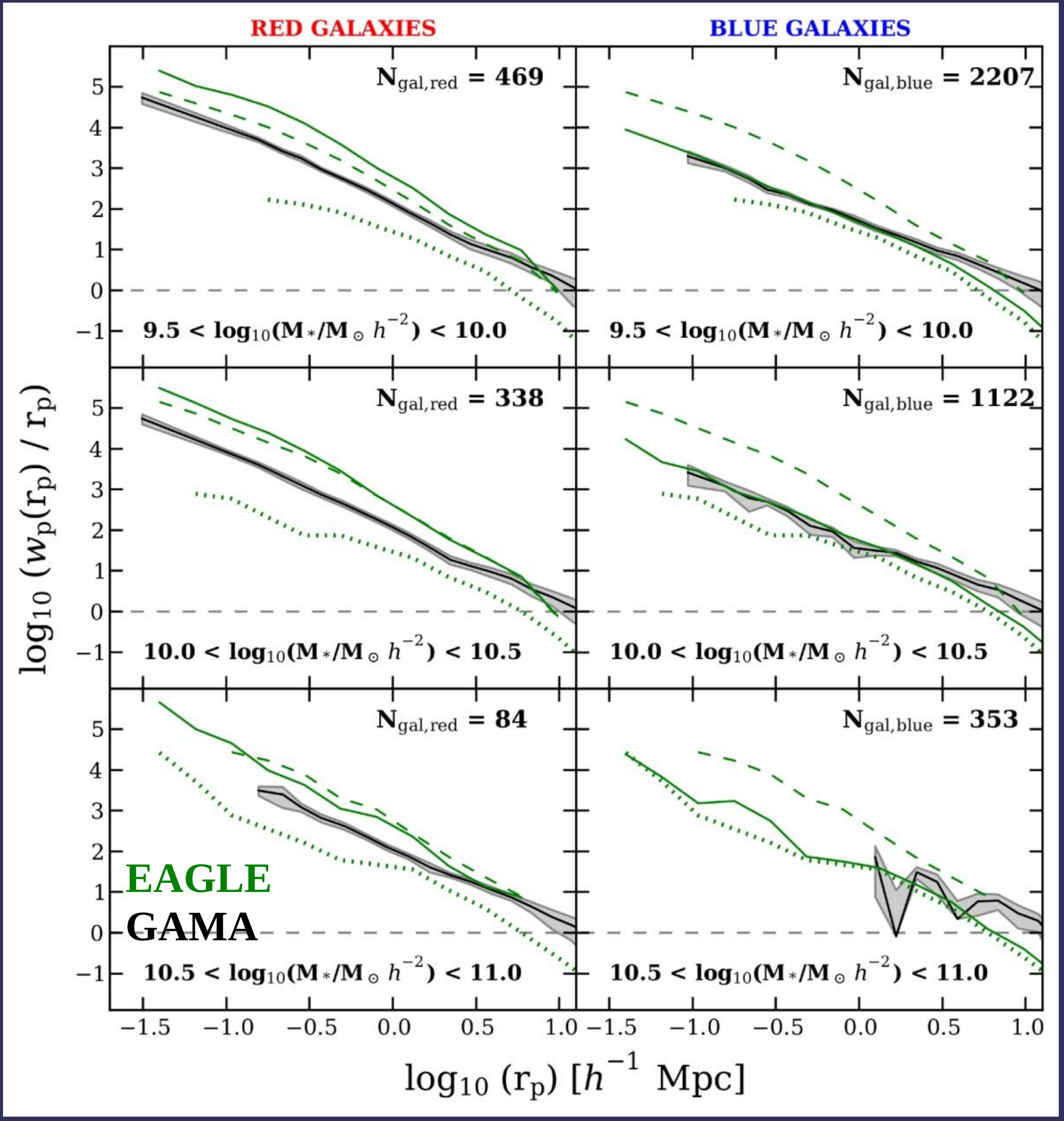
* Colour from Trayford+2015
* Red galaxies are more clustered than blue galaxies
* Red galaxies follow the same trend as satellite galaxies
* Clustering of EAGLE blue galaxies are in agreement with GAMA

Green dashed lines: satellite galaxies
Green dotted lines: central galaxies

Color Dependent Clustering

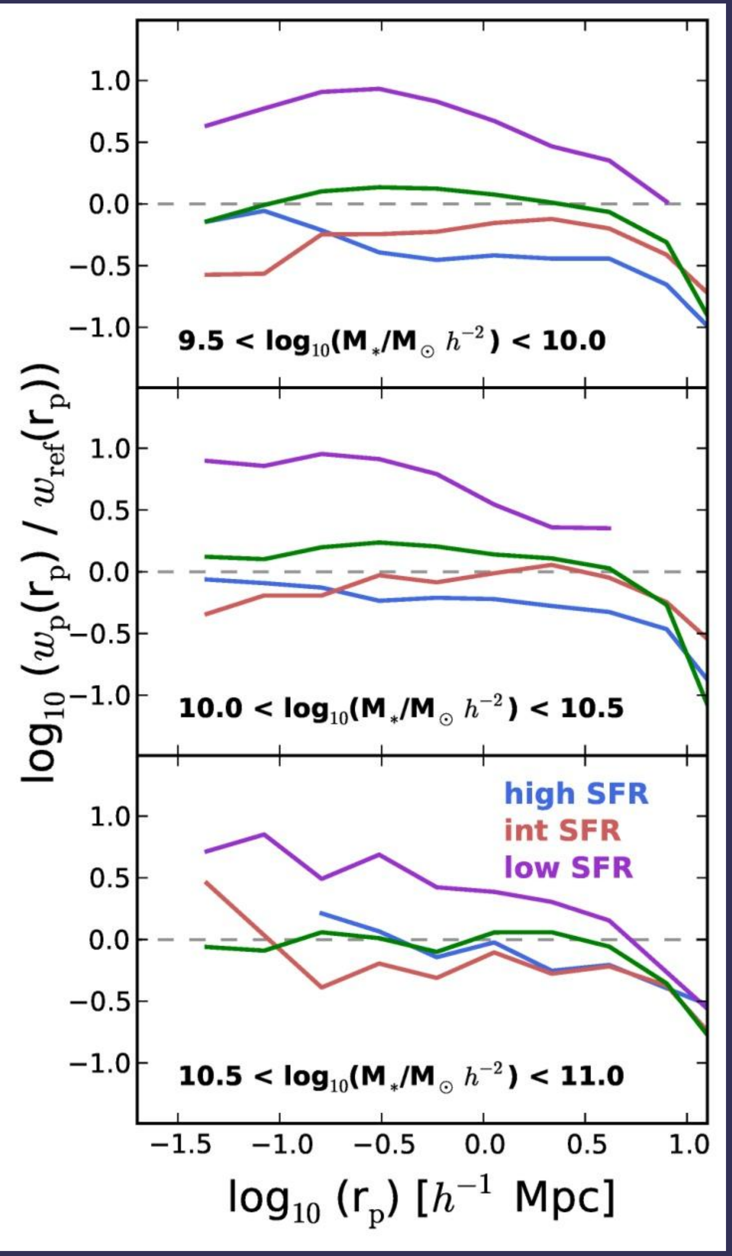
* Red galaxies are more clustered than blue galaxies
* Red galaxies follow the same trend as satellite galaxies
* Clustering of EAGLE blue galaxies are in agreement with GAMA
* Clustering of EAGLE red galaxies is not in good agreement with GAMA

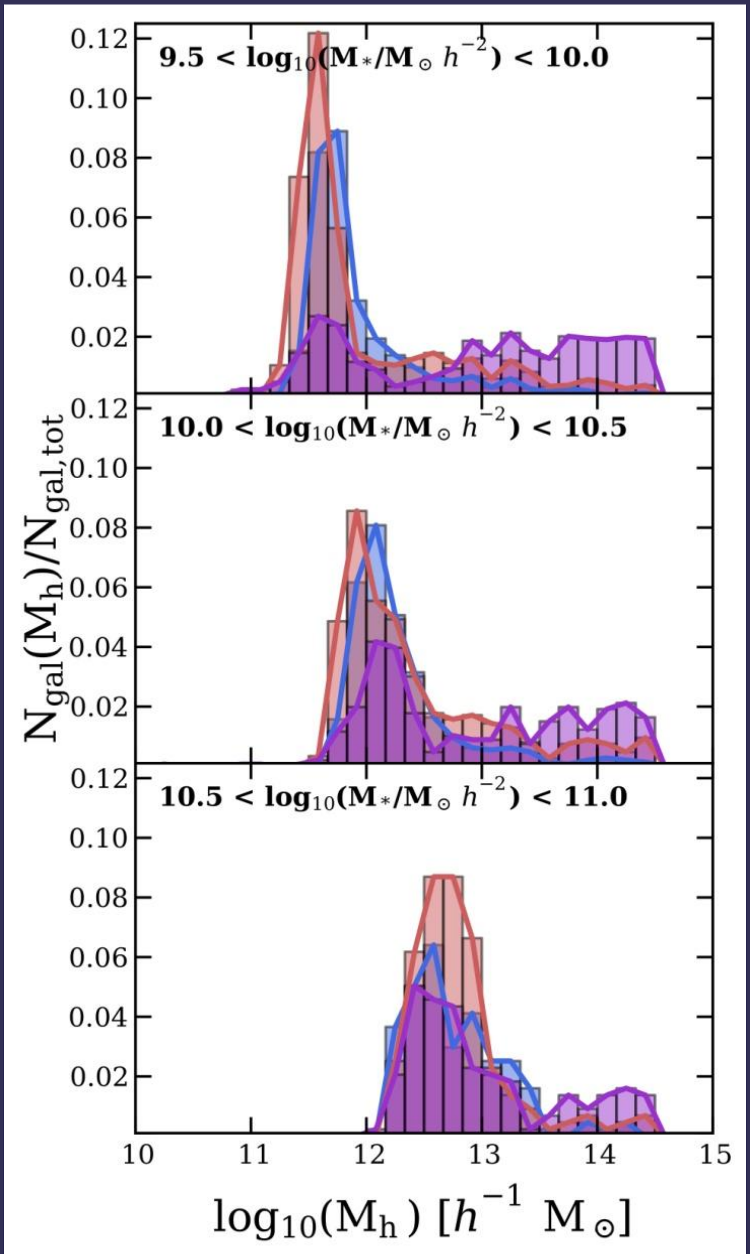
* Satellite galaxies are strongly clustered than centrals



Green dashed lines: satellite galaxies
Green dotted lines: central galaxies

Star Formation Rate Dependent Clustering

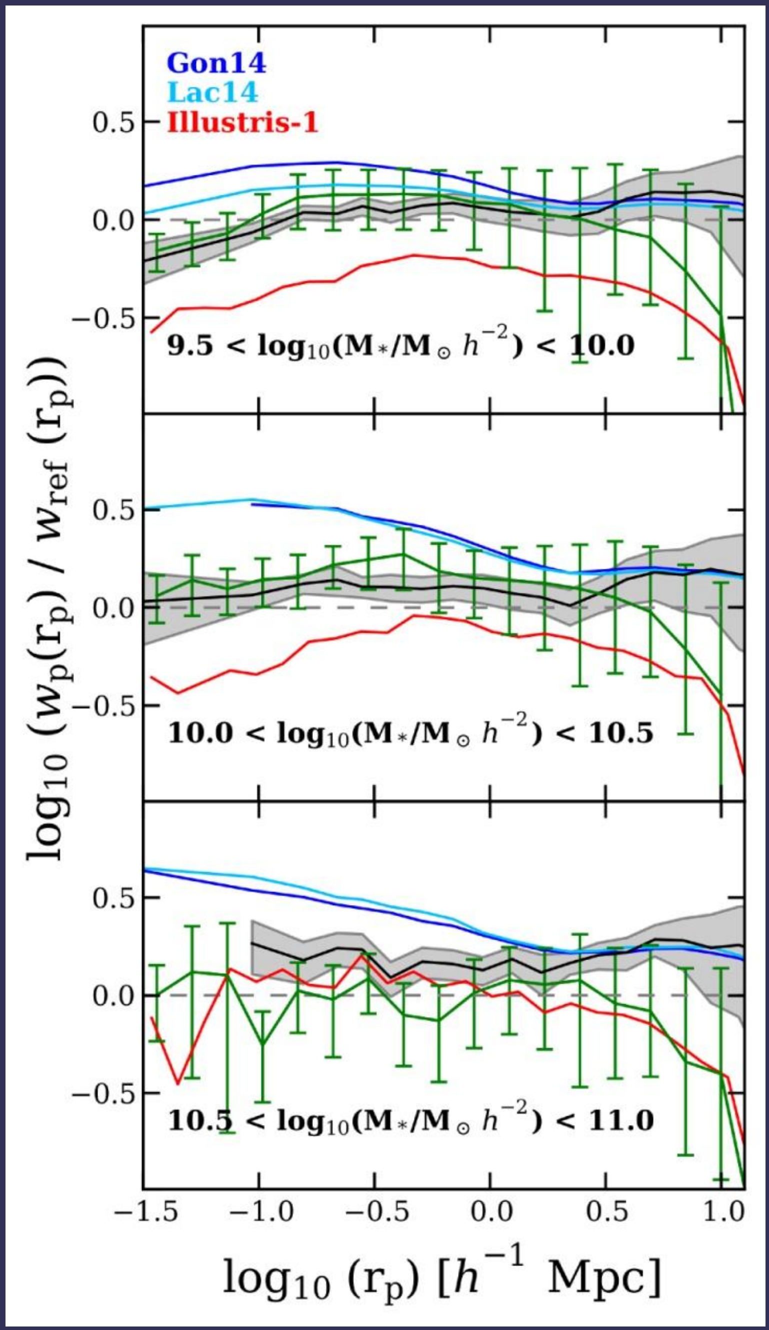


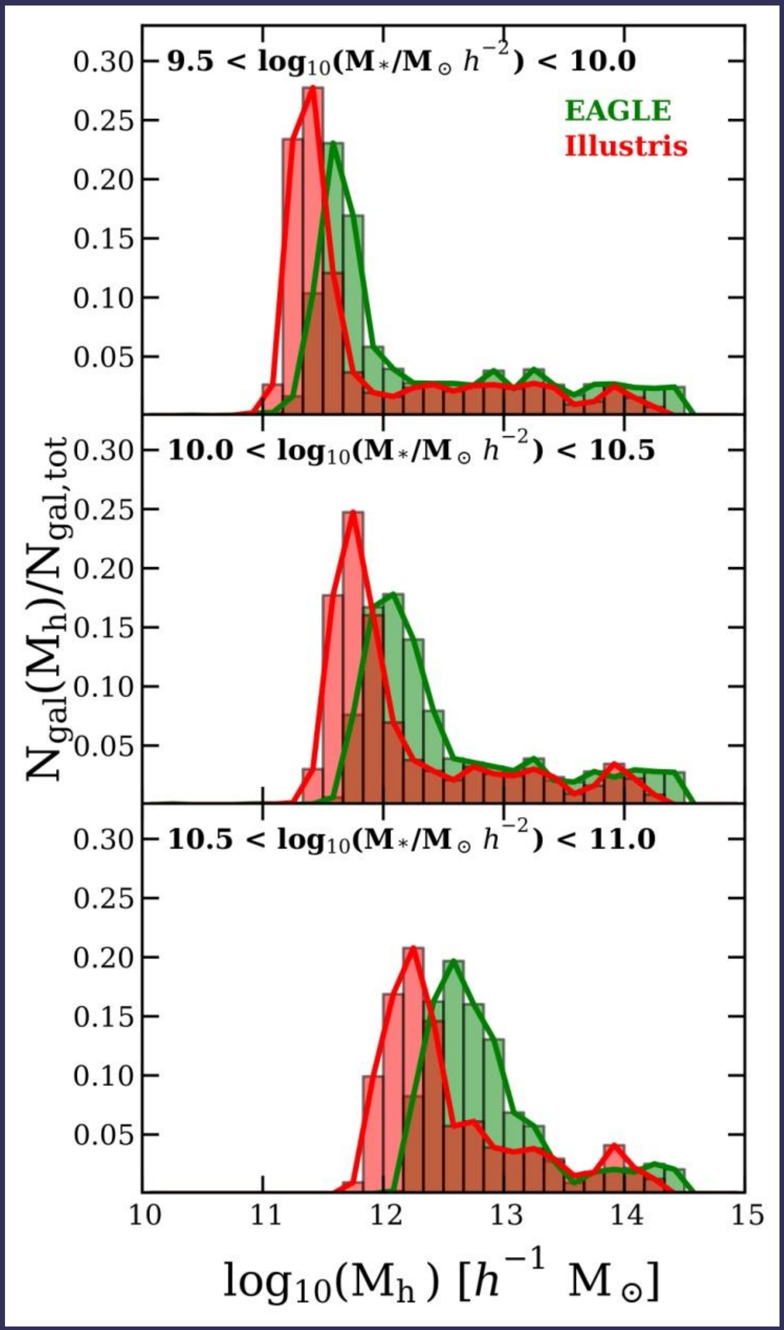


Low SFR population:
30% lowest SFR
High SFR population:
30% highest SFR

Low SFR:
- More clustered in the three stellar mass bins
- The most massive DM halos are more populated

Comparison with Other Galaxy Formation Models





- **Stronger clustering on small scales** for Gon14* & Lac14* semi-analytic models.

- Illustris-1 shows **consistenly a lower clustering** amplitude

- Galaxies from Illustris-1 reside in less massive halos, compared to EAGLE galaxies

Conclusions

* EAGLE galaxy clustering is in good qualitative agreement with GAMA clustering when split by stellar mass (or luminosity).

* EAGLE red galaxies more strongly clustered than blue

* EAGLE red galaxies seem to be more clustered than observations

* Low SFR galaxies are more strongly clustered than intermediate and high SFR galaxies

* Low SFR galaxies reside in a wide range of DM halo masses

* To provide stringent clustering constraints requires significantly larger volumes: typically a (200-300 Mpc/h)^3 box