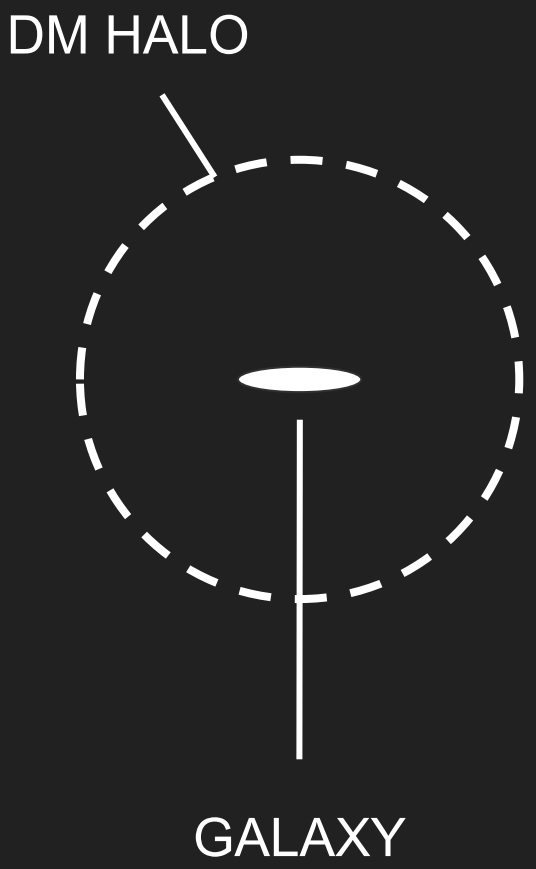
HOW DO GALAXIES TRACE THE LARGE SCALE STRUCTURE?



Author: Anna Durkalec anna.durkalec@ncbj.gov.pl **Marseille, 06.07.2022**

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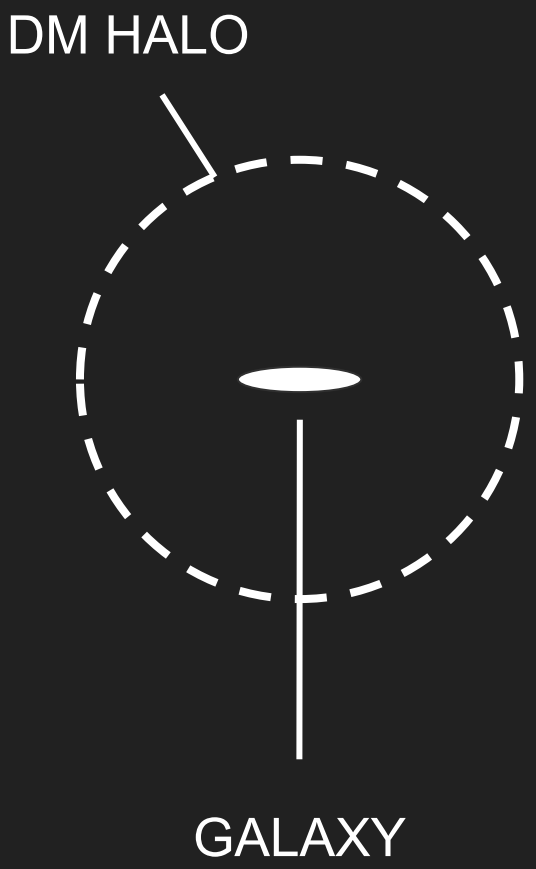

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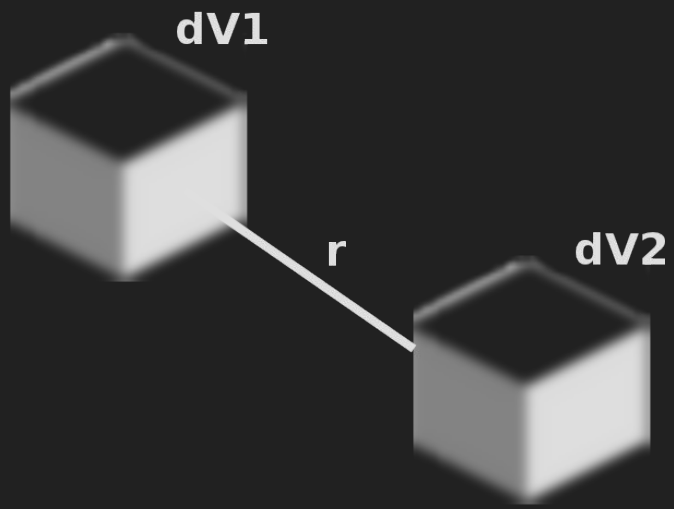
WELL…. IT’S COMPLICATED

GALAXY CORRELATION FUNCTION

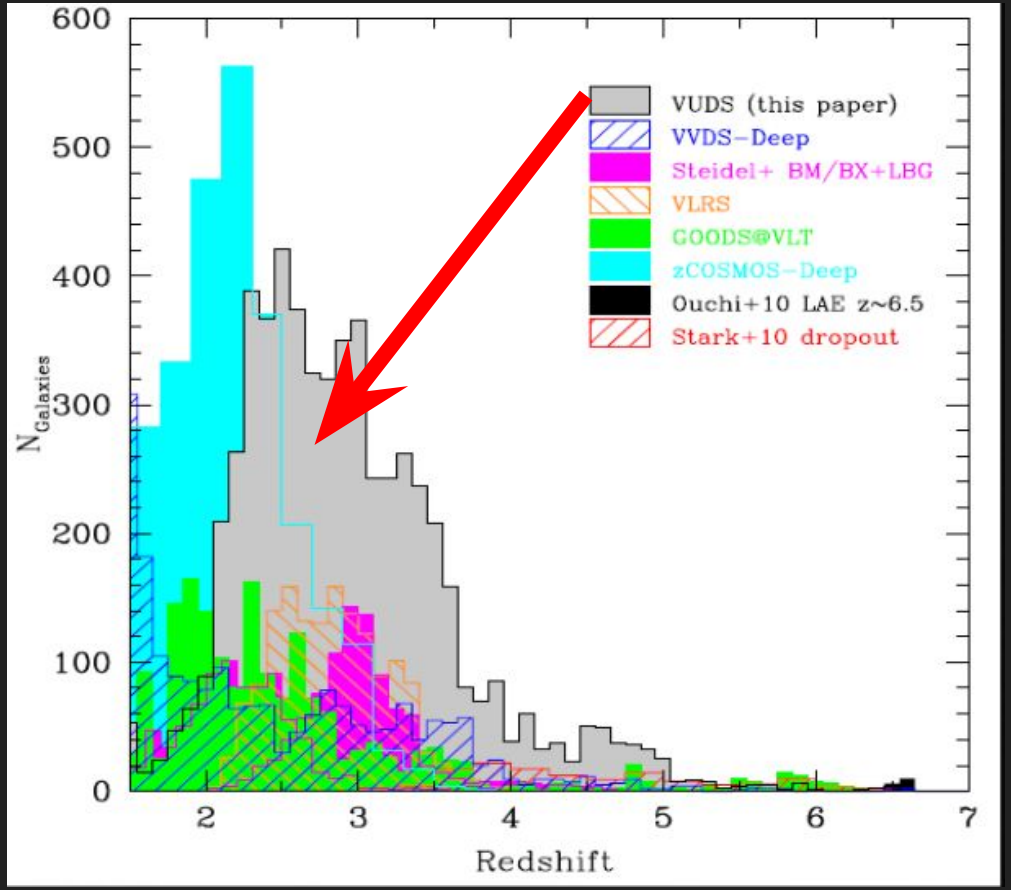


Excess number of pairs separated by r over the random distribution

BUT IT HAS REQUIREMENTS

GALAXY SAMPLE VIMOS ULTRA DEEP SURVEY (VUDS)

VIMOS ULTRA DEEP SURVEY (VUDS)

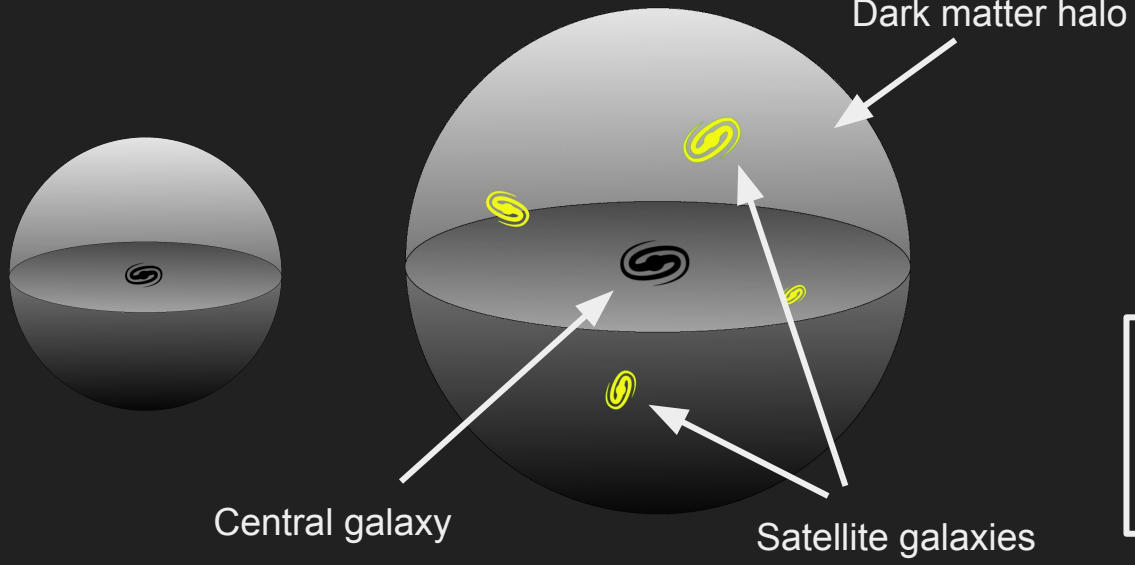


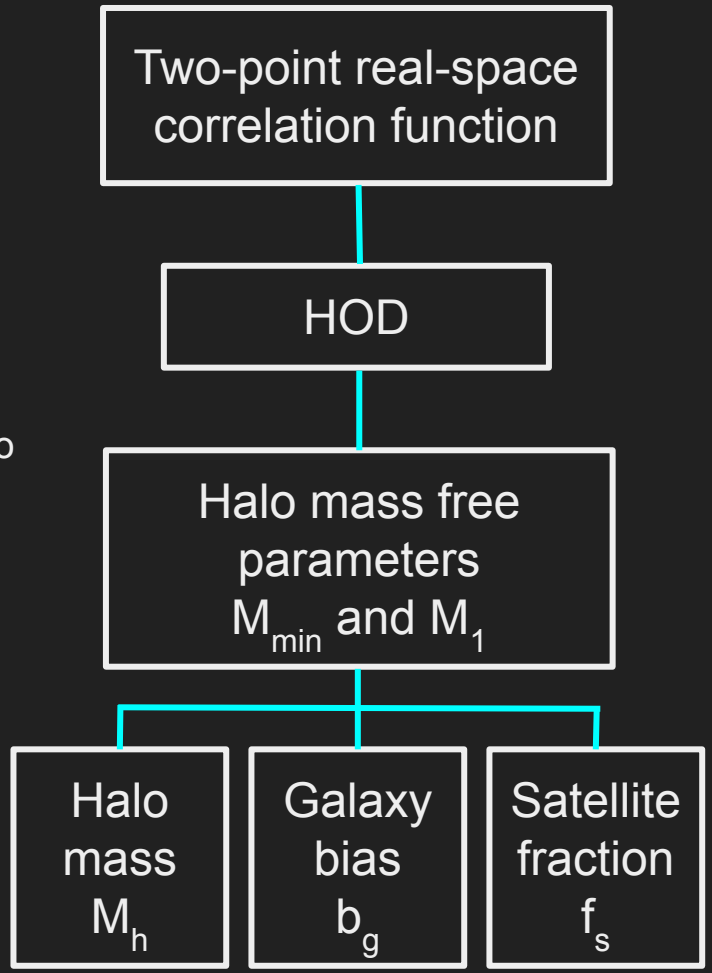
HALO OCCUPATION DISTRIBUTION MODELLING (HOD)

THE HOD FRAMEWORK

Assumptions:

1. Galaxies reside in dark matter halos.
2. Number of galaxies inside the halo is the function of the mass of the halo.



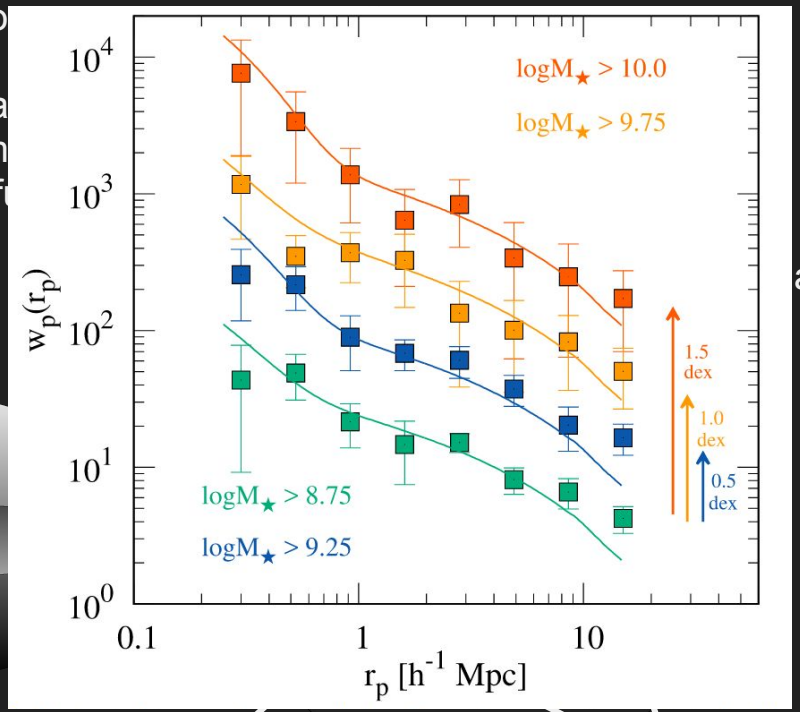


THE HOD FRAMEWORK

Assumptio

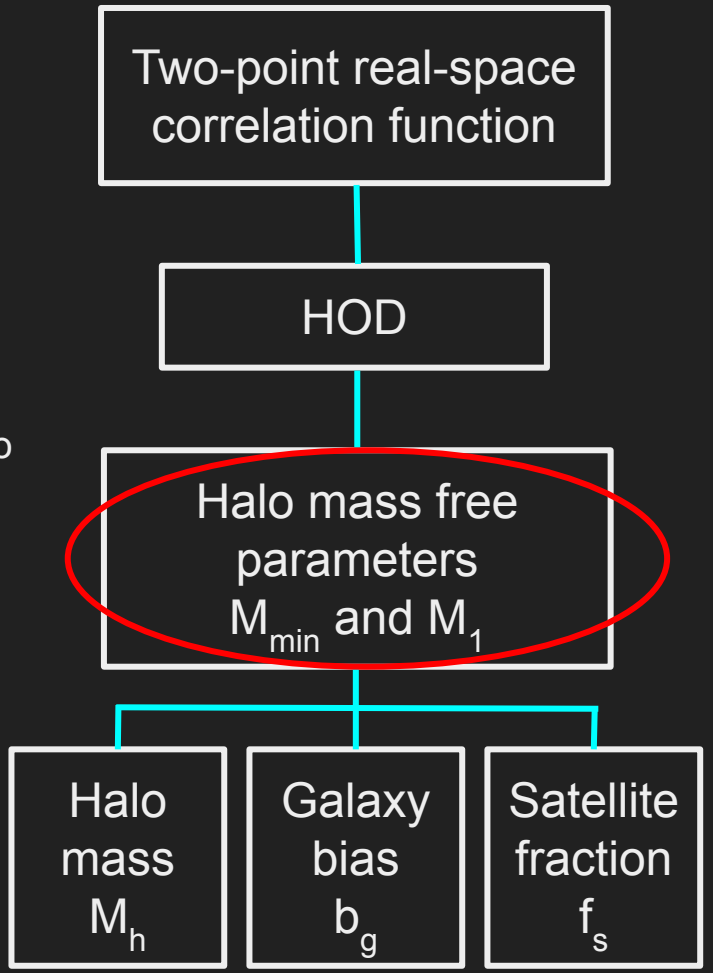
1. Gala
2. Num
   the f

atter halo



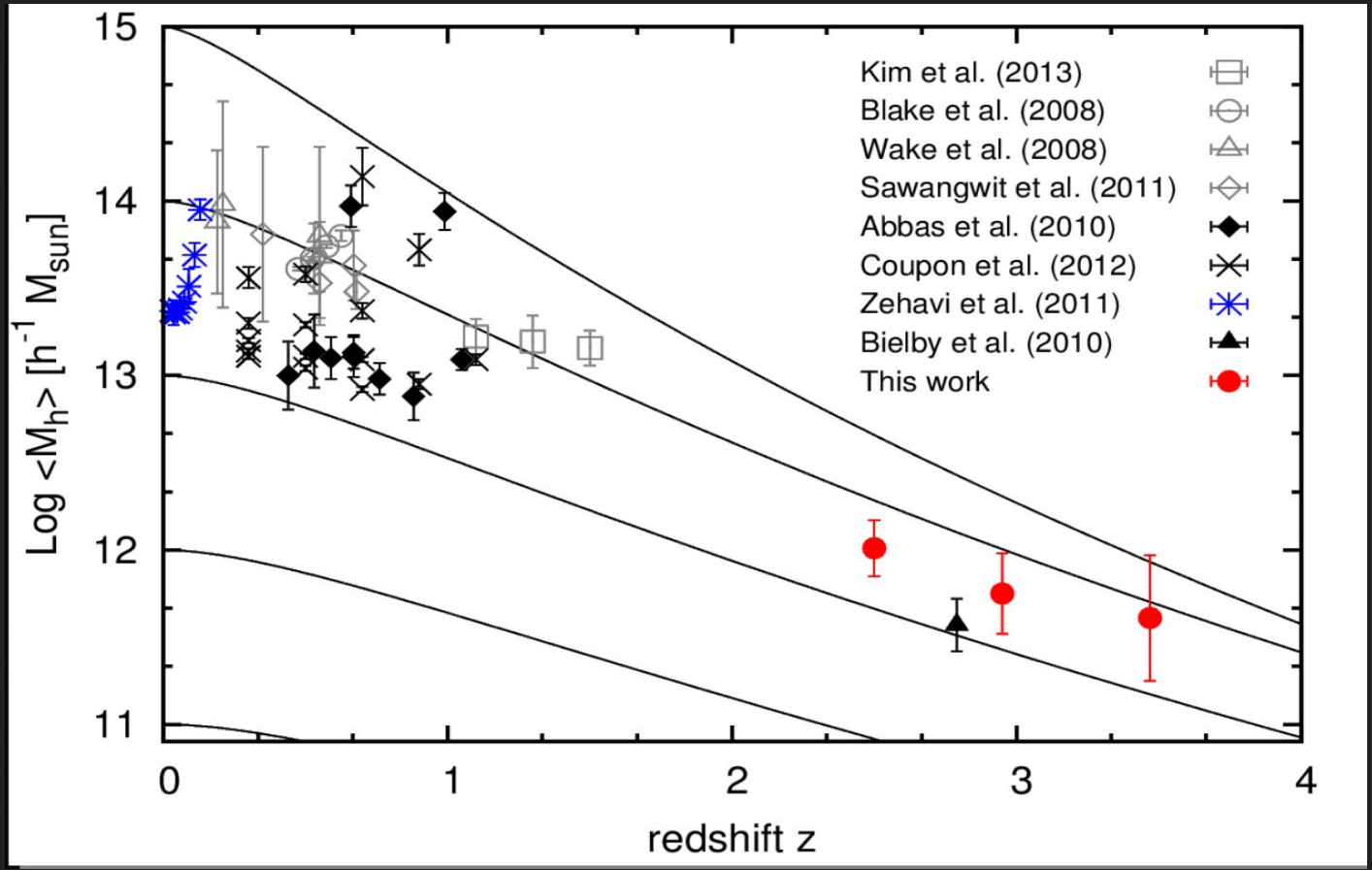
Central galaxy

Satellite galaxies



GENERAL GALAXY POPULATION AT Z ~ 3

HALO MASSES FOR GENERAL GALAXY POPULATION AT Z~3



Durkalec et al. 2015b

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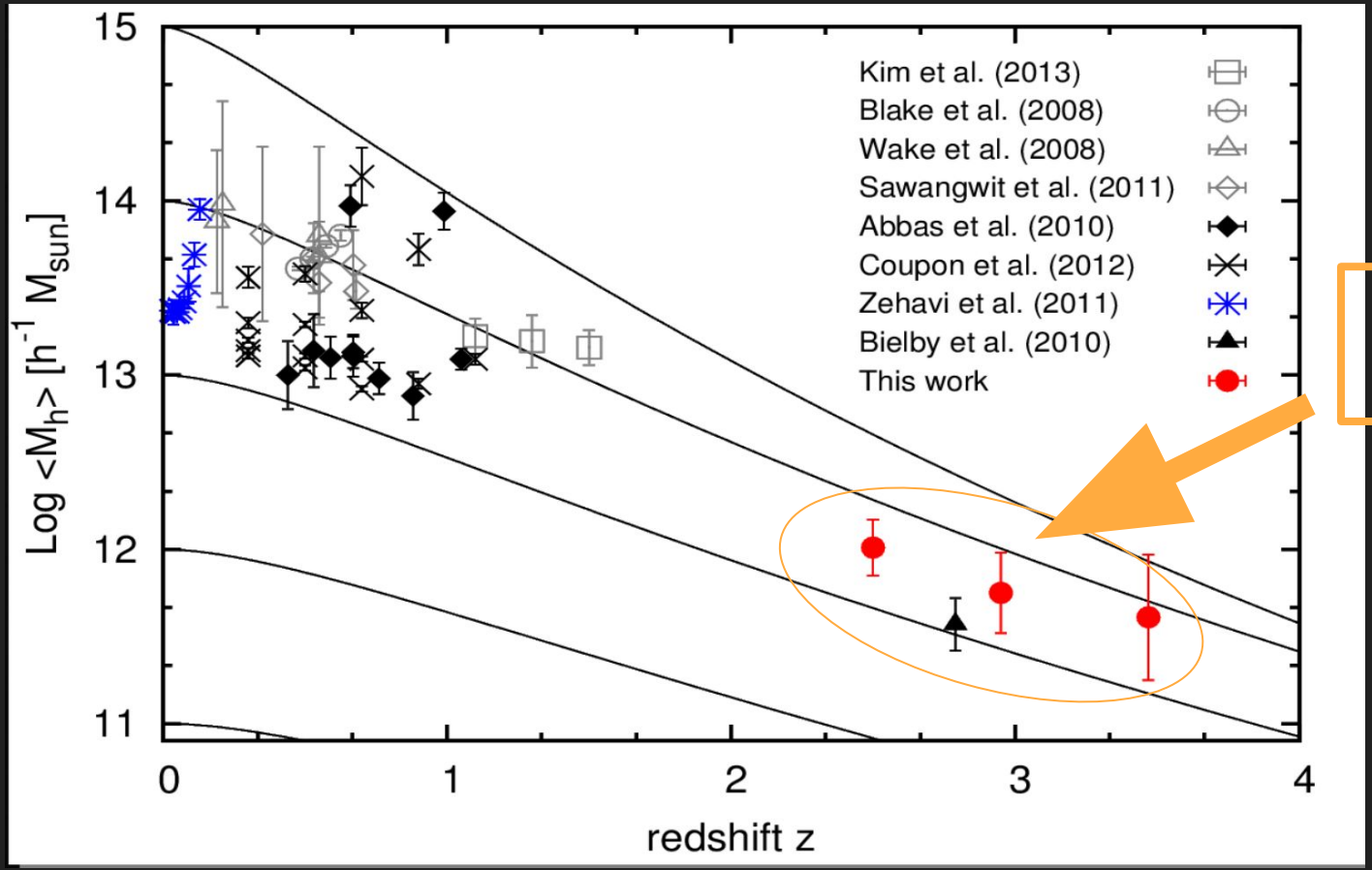

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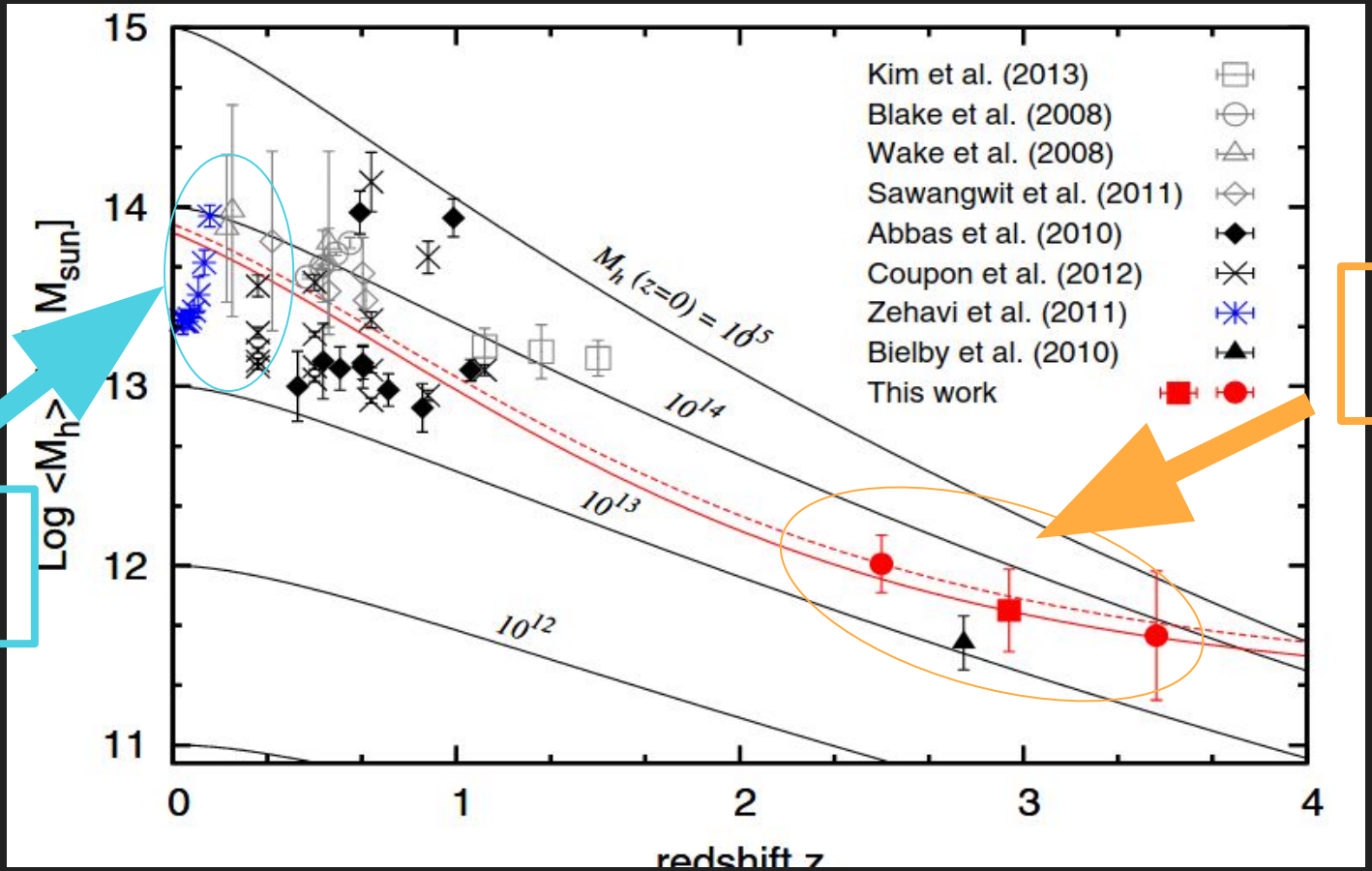
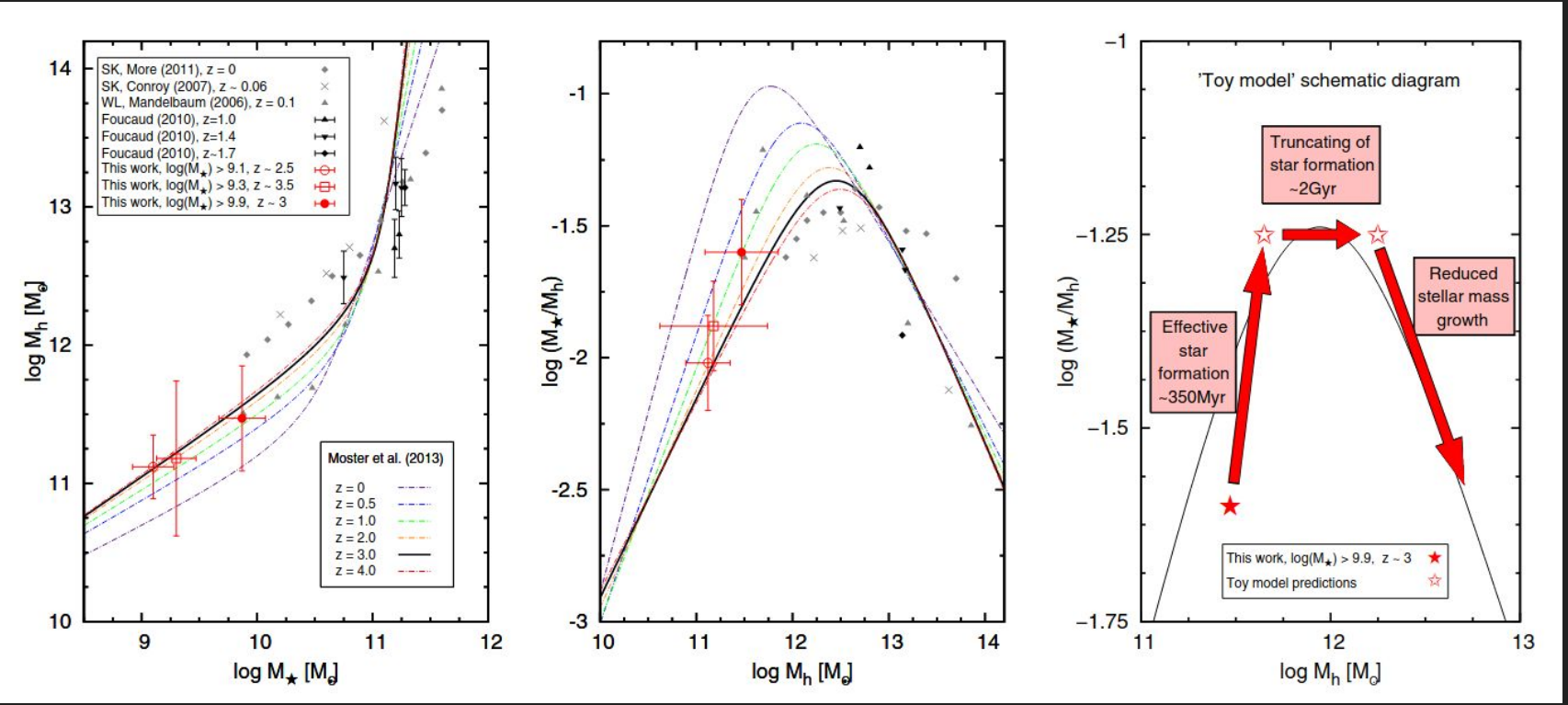


z ~ 0

z ~ 3

Durkalec et al. 2015b

STELLAR TO HALO MASS FUNCTION FOR GENERAL GALAXY POPULATION AT Z~3



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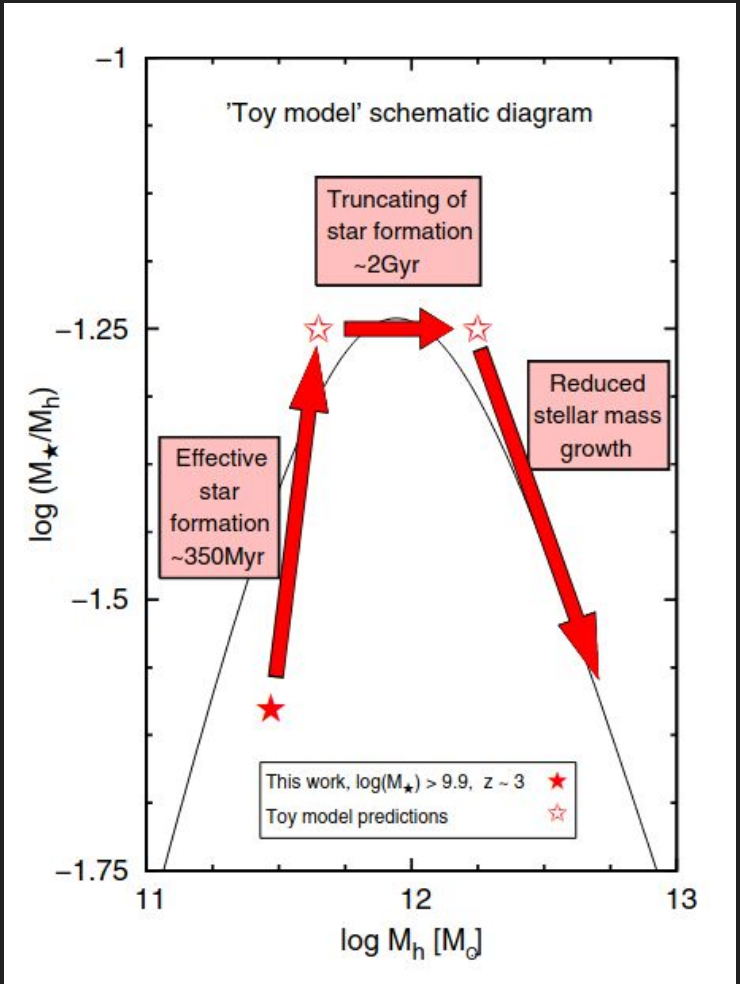


Durkalec et al. 2015a

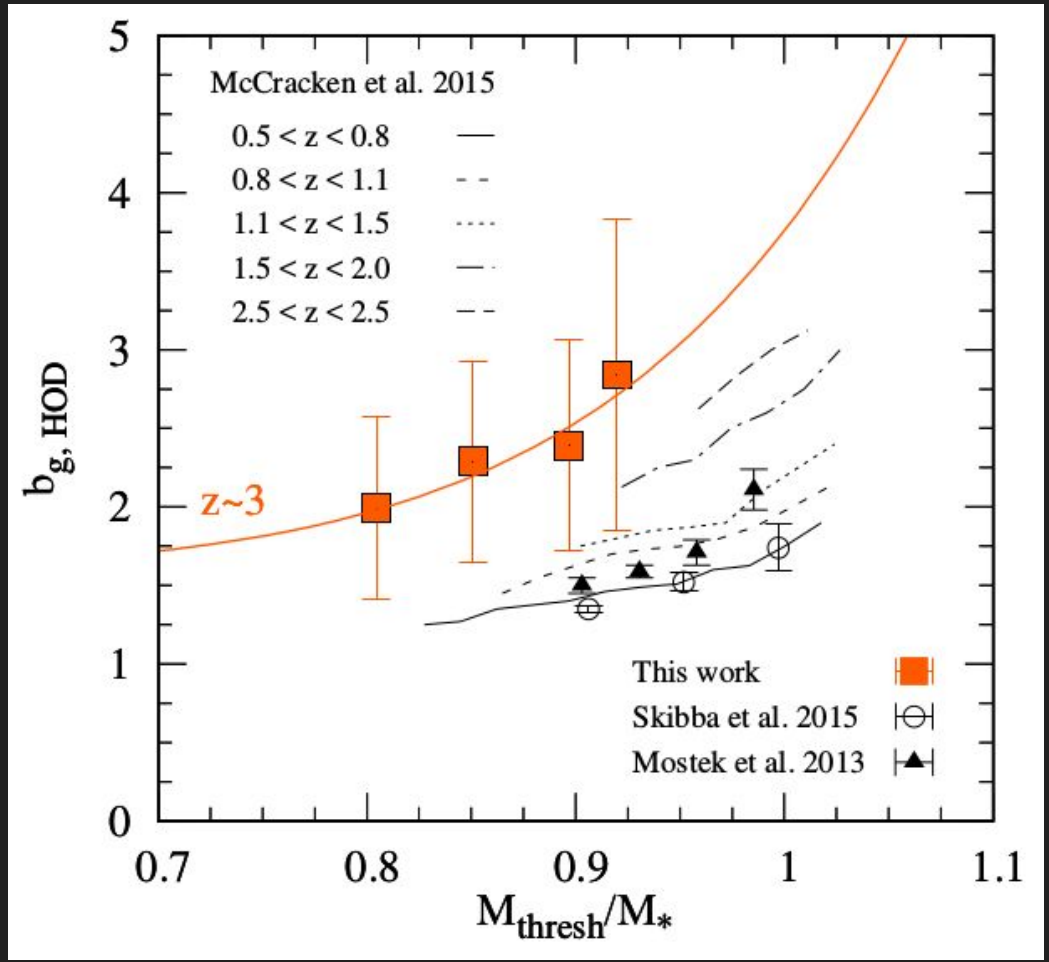
STELLAR TO HALO MASS FUNCTION FOR GENERAL GALAXY POPULATION AT Z~3

- Mass growth of DM haloes is described by a mean accretion taken from Fakhouri et al. (2010)
- Galaxies grow in M star formation using the median SFR for our sample (Tasca et al. 2014a), as well as through mergers with a constant accretion in stars of ~1 $M_{\odot}$/yr (Tasca et al. 2014b)

LUMINOSITY AND STELLAR MASS CLUSTERING DEPENDENCIES AT Z ~ 3

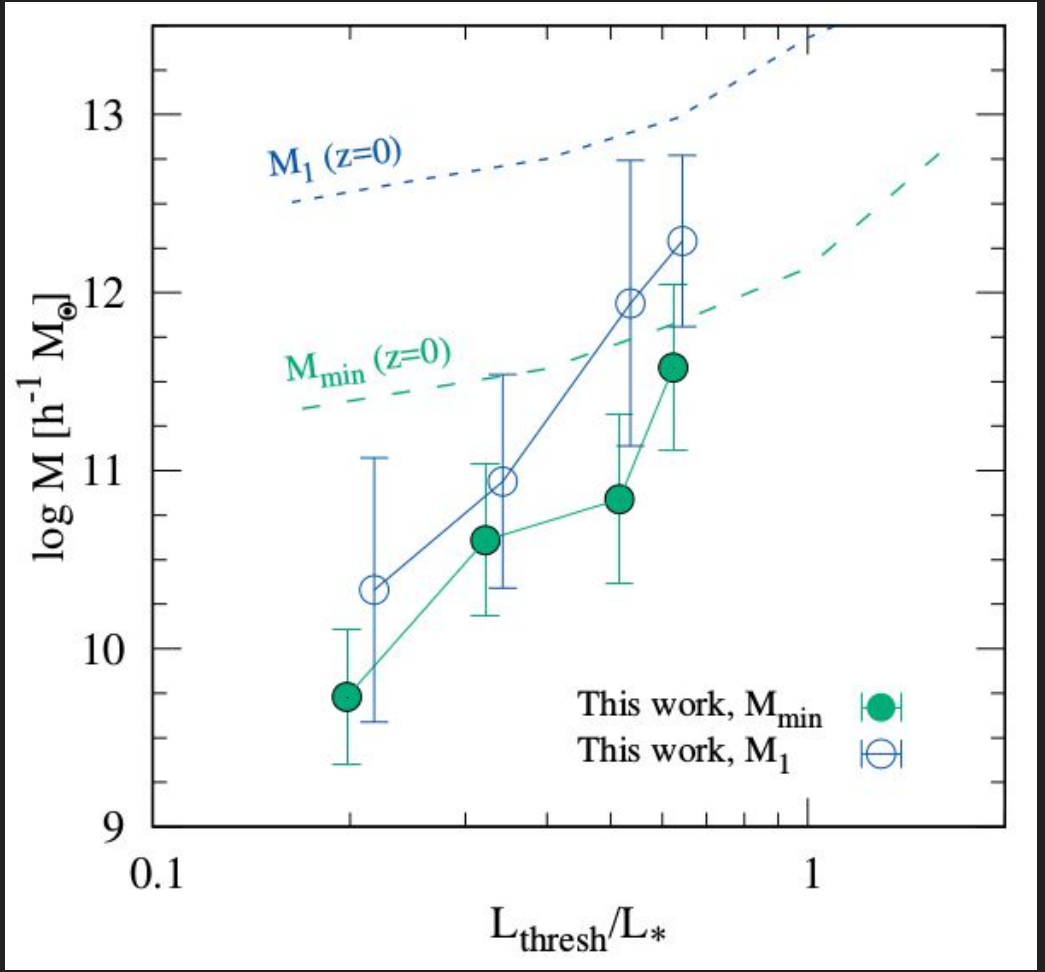
LARGE SCALE GALAXY BIAS

Redshift AND luminosity and stellar mass dependence



Durkalec et al. 2018, A&A 612A, 42D

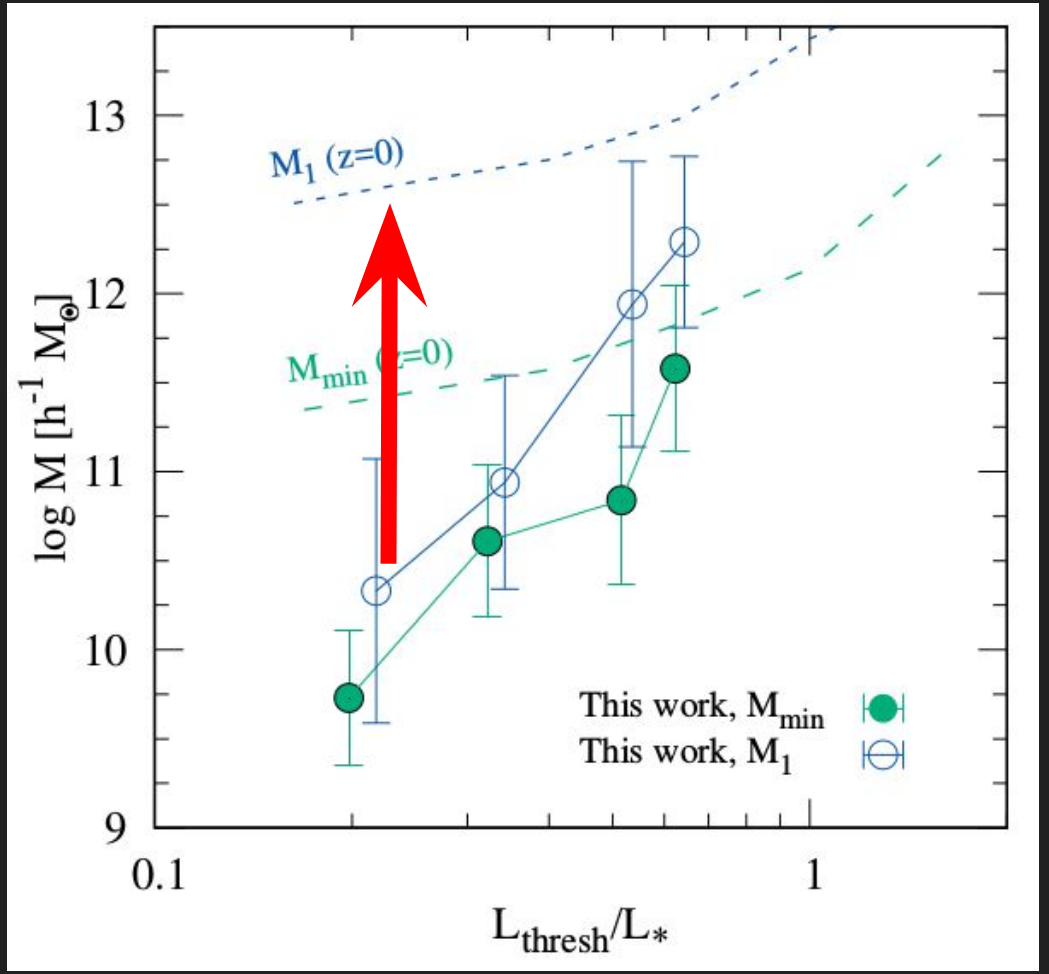
DARK MATTER
HALO MASSES



Durkalec et al. 2018, A&A 612A, 42D

DARK MATTER
HALO MASSES

Build up of dark matter haloes masses with cosmic time



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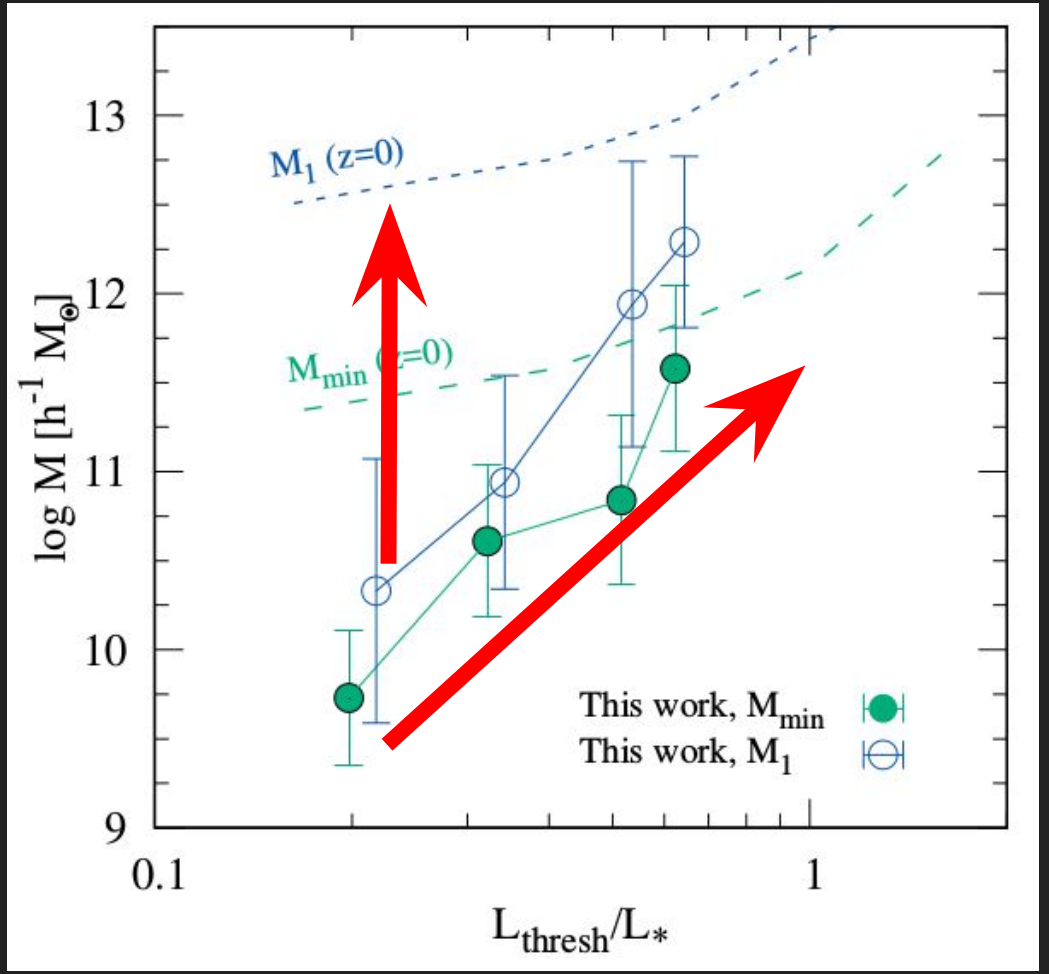
Build up of dark matter haloes masses with cosmic time

Growth with rising luminosity and stellar mass of galaxy population



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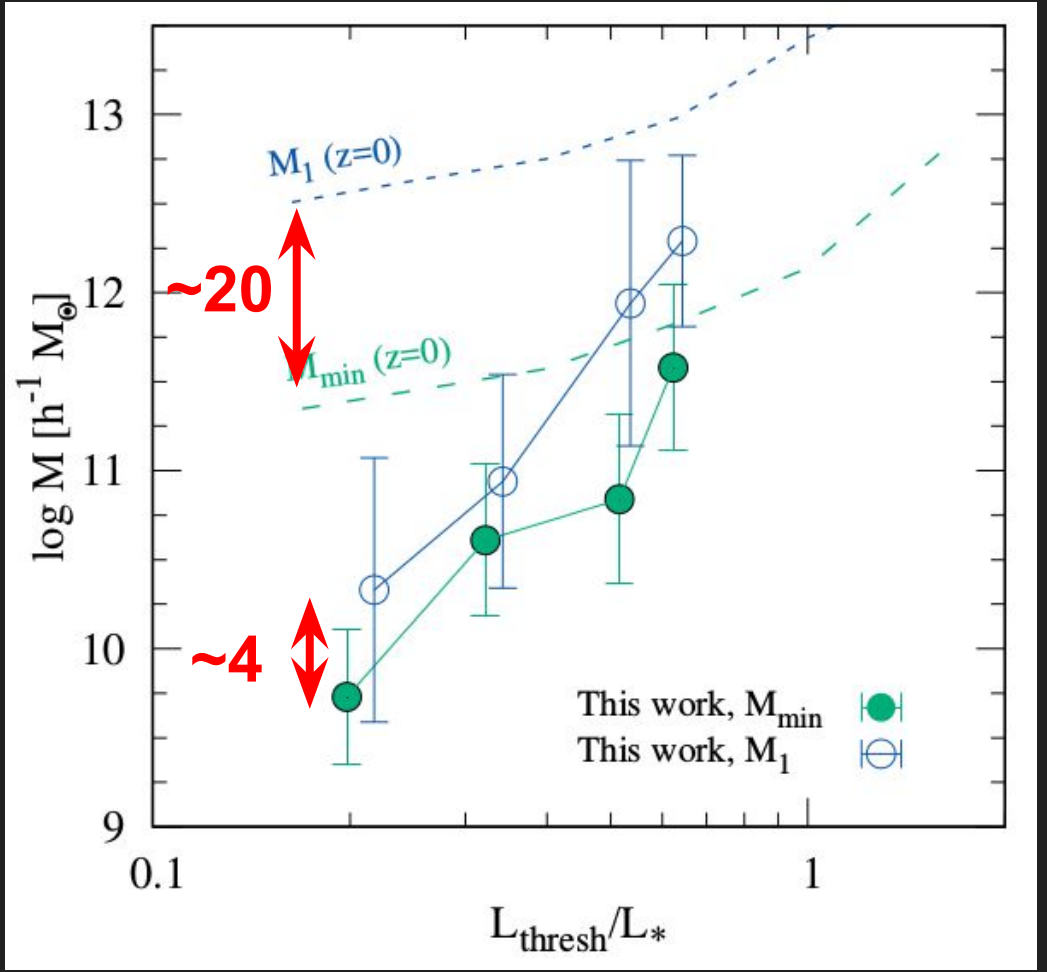
M_1/M_{min} ratio



Durkalec et al. 2018, A&A 612A, 42D

Halo mergers create satellites, galaxy mergers destroy them

WHAT DOES SMALL M_1/M_{min} RATIO MEAN?

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Small M1/Mmin ratio ~4, DM haloes full of recently acreated satellites

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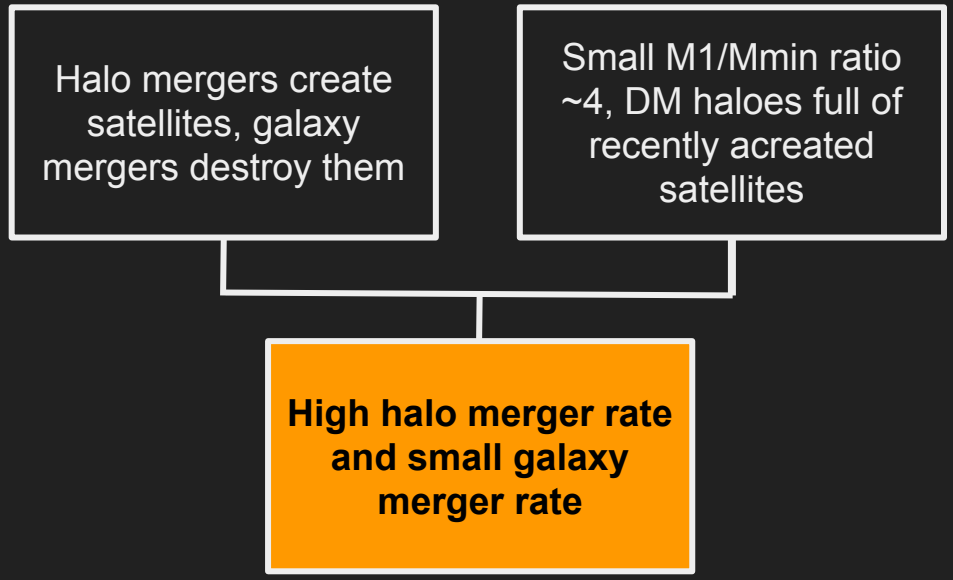

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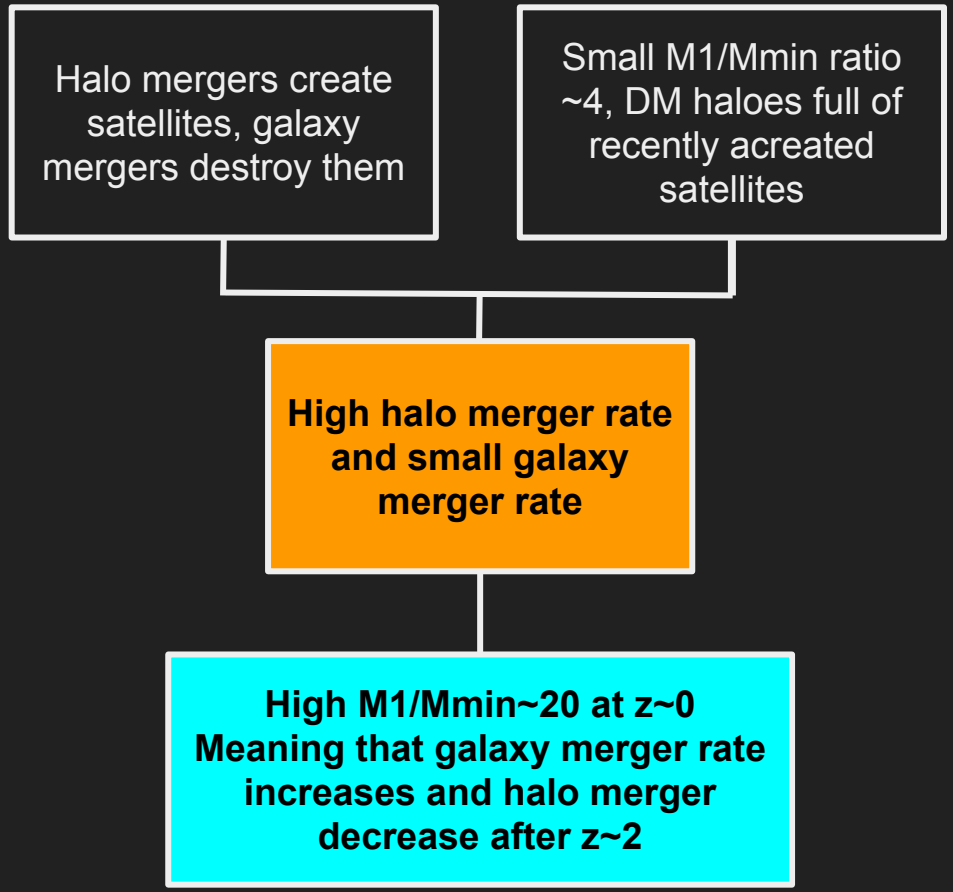
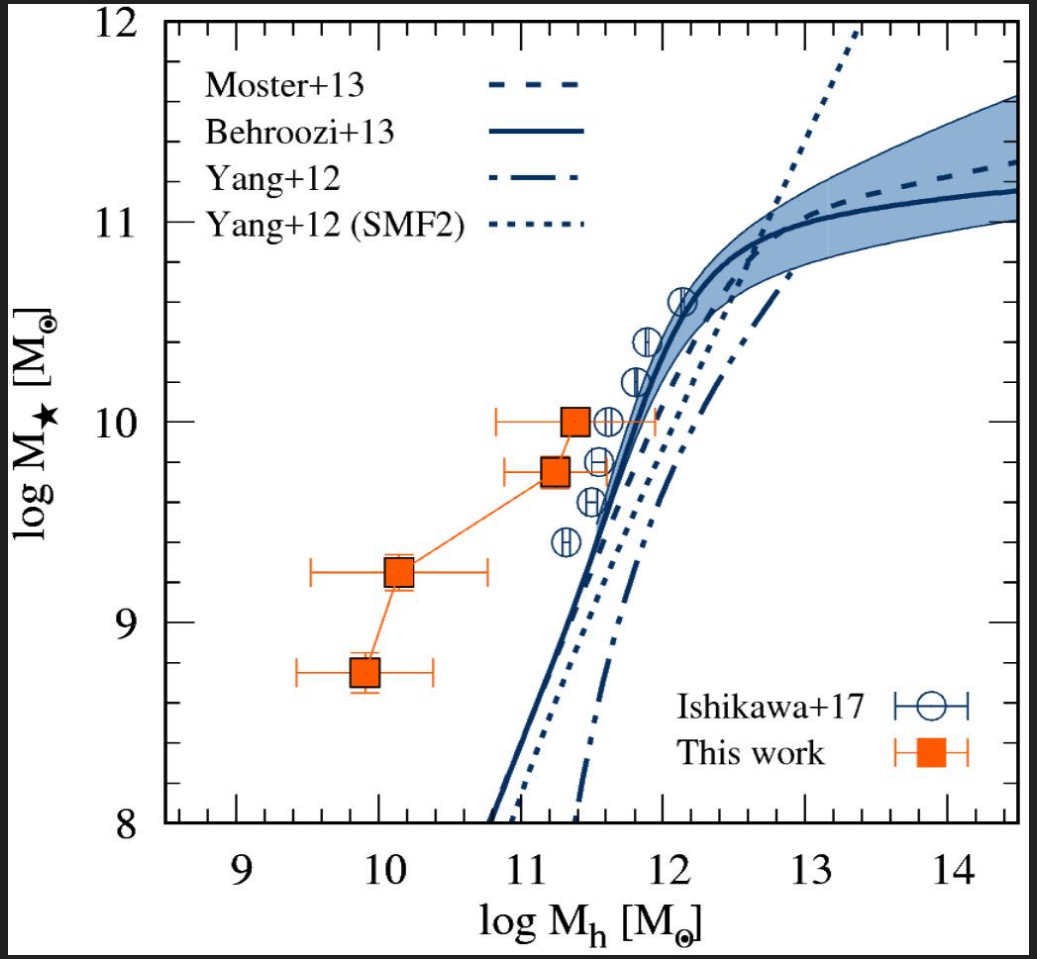


STELLAR TO HALO MASS FUNCTION Z ~ 3

STELLAR TO HALO MASS RATIO



Durkalec et al. 2018, A&A 612A, 42D

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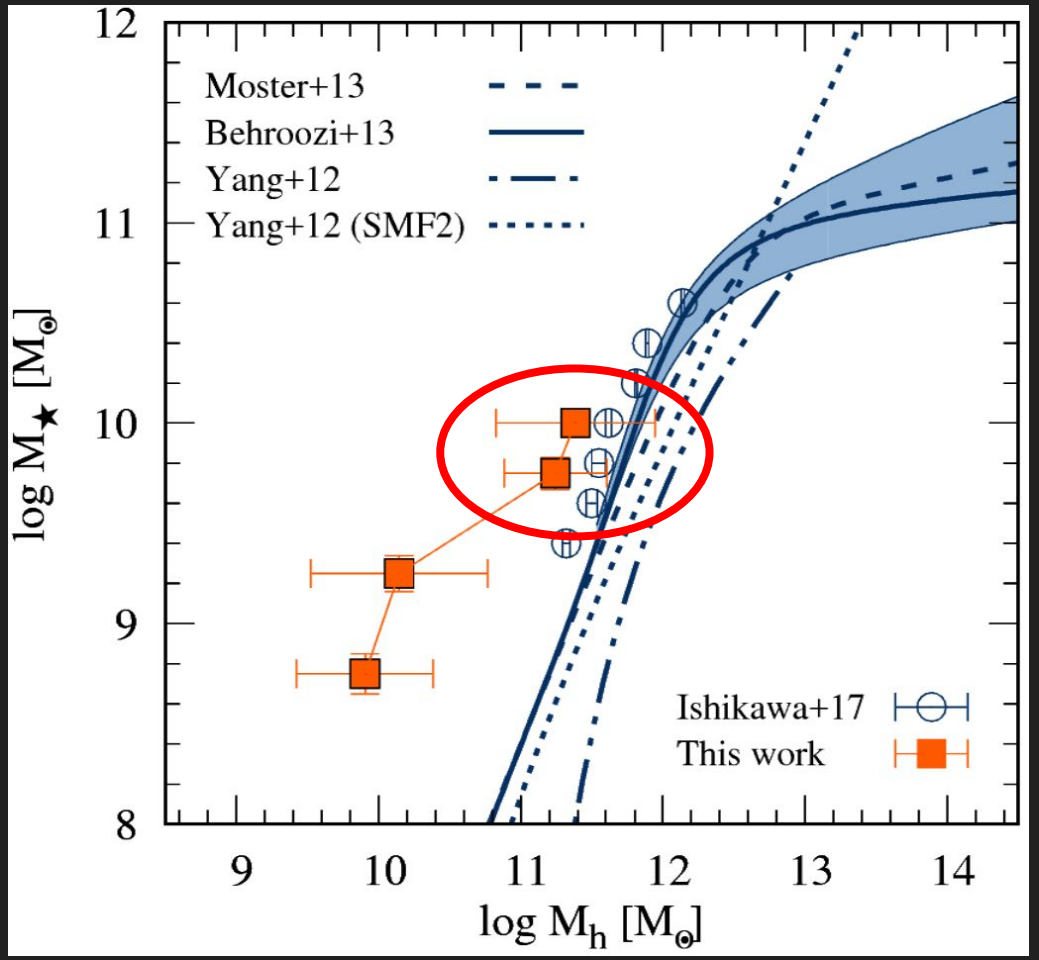
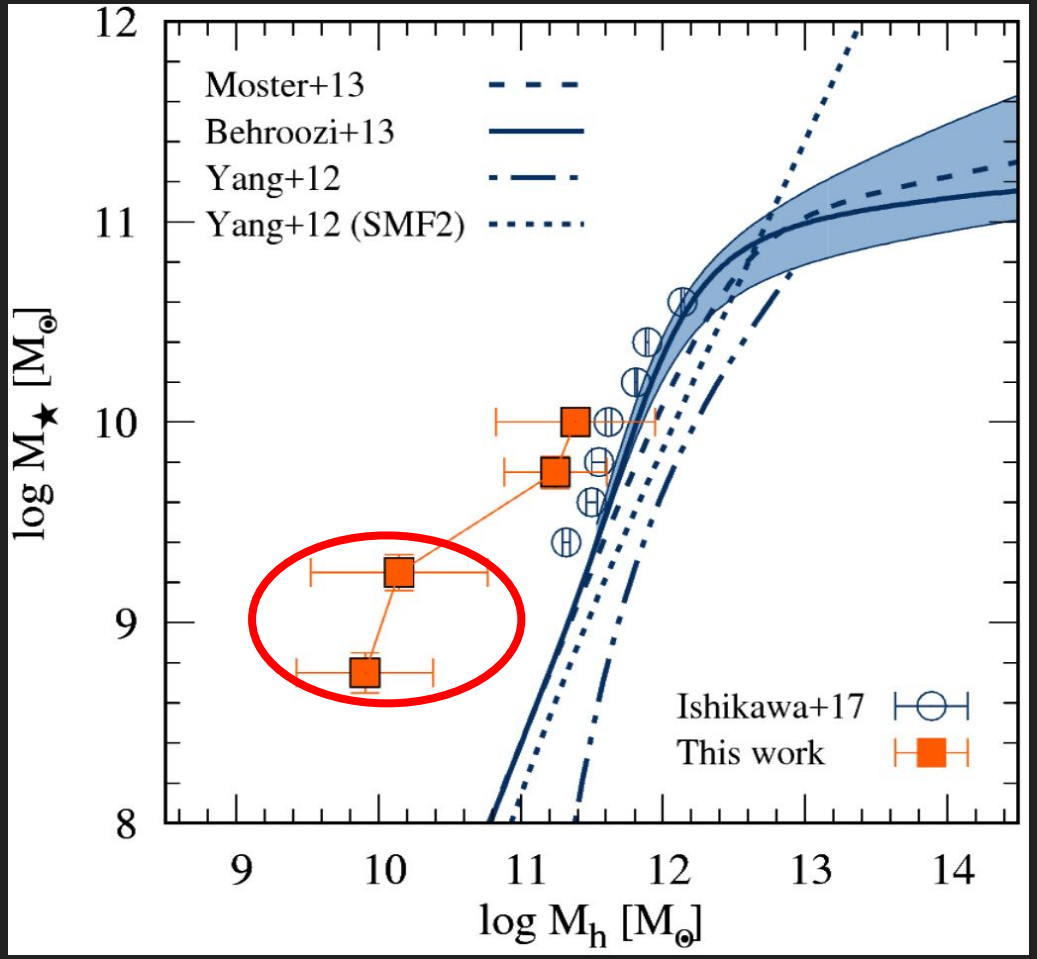


Durkalec et al. 2018, A&A 612A, 42D

STELLAR TO HALO MASS RATIO

Dark matter halos less massive than expected

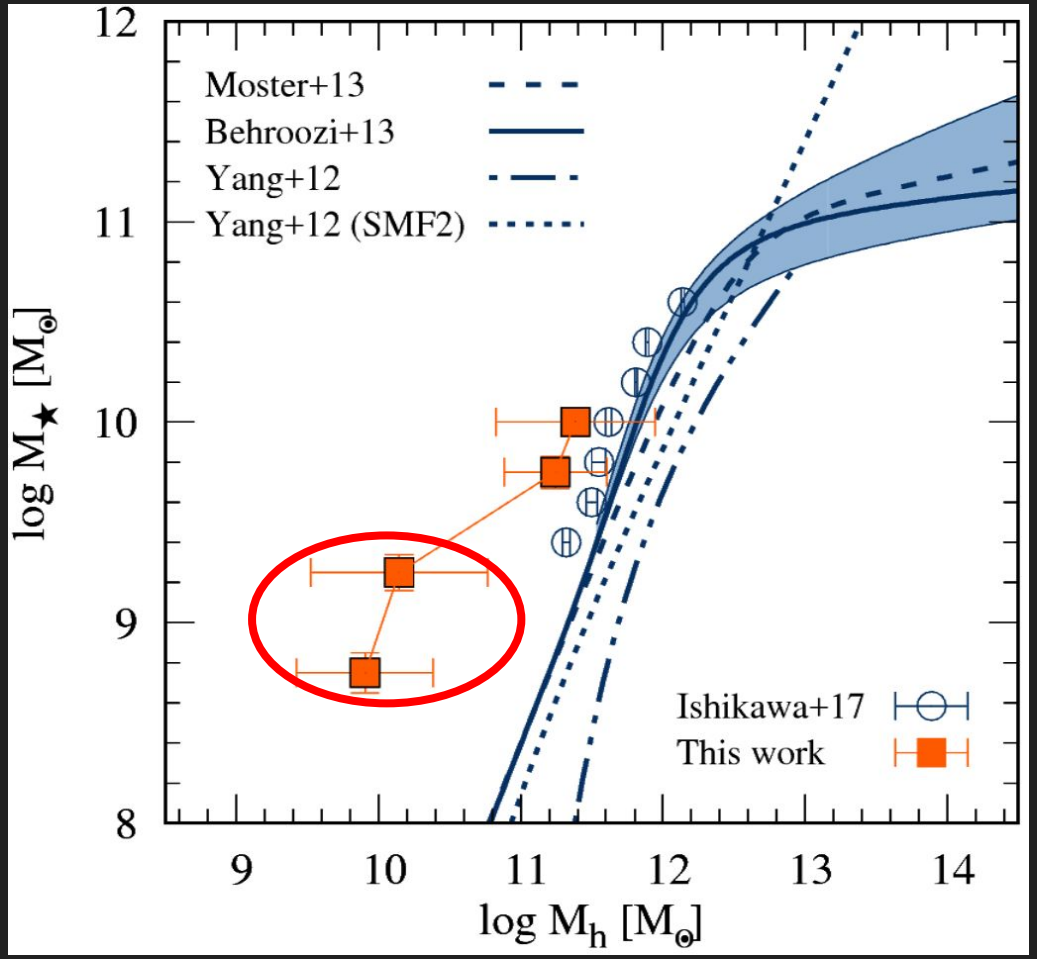


Durkalec et al. 2018, A&A 612A, 42D

STELLAR TO HALO MASS RATIO

Dark matter halos less massive than expected

Feedback?
Dark (empty) halos?



Durkalec et al. 2018, A&A 612A, 42D

DARK MATTER HALO ASYMMETRY

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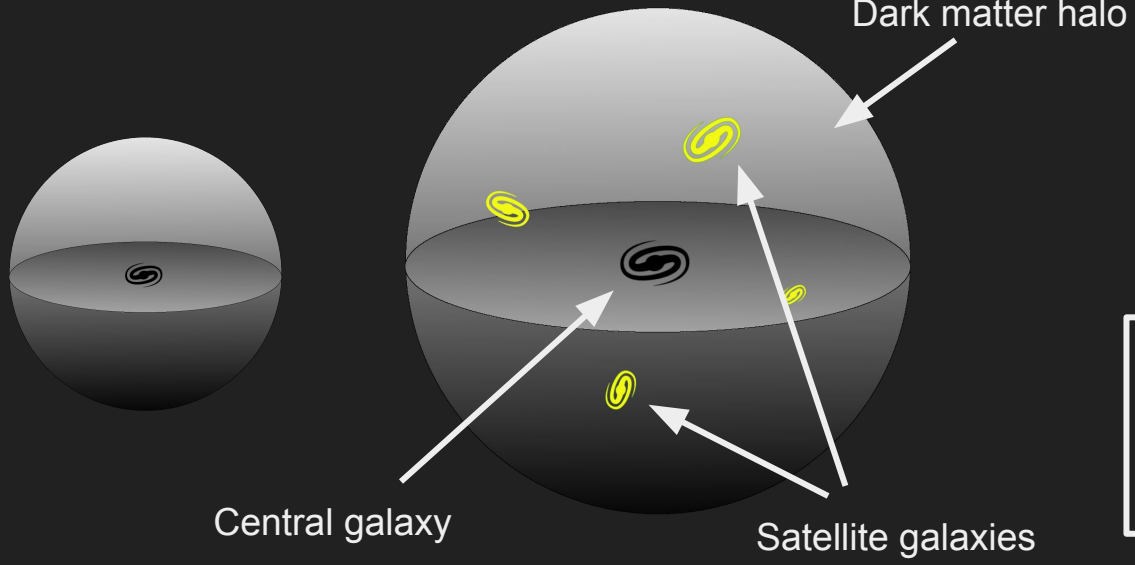

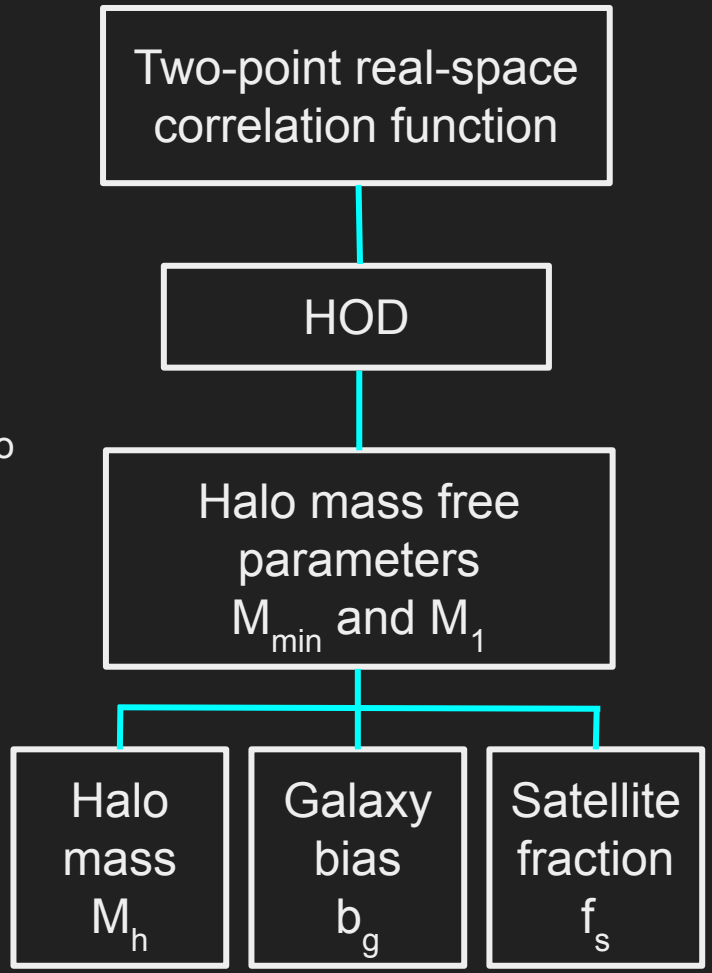

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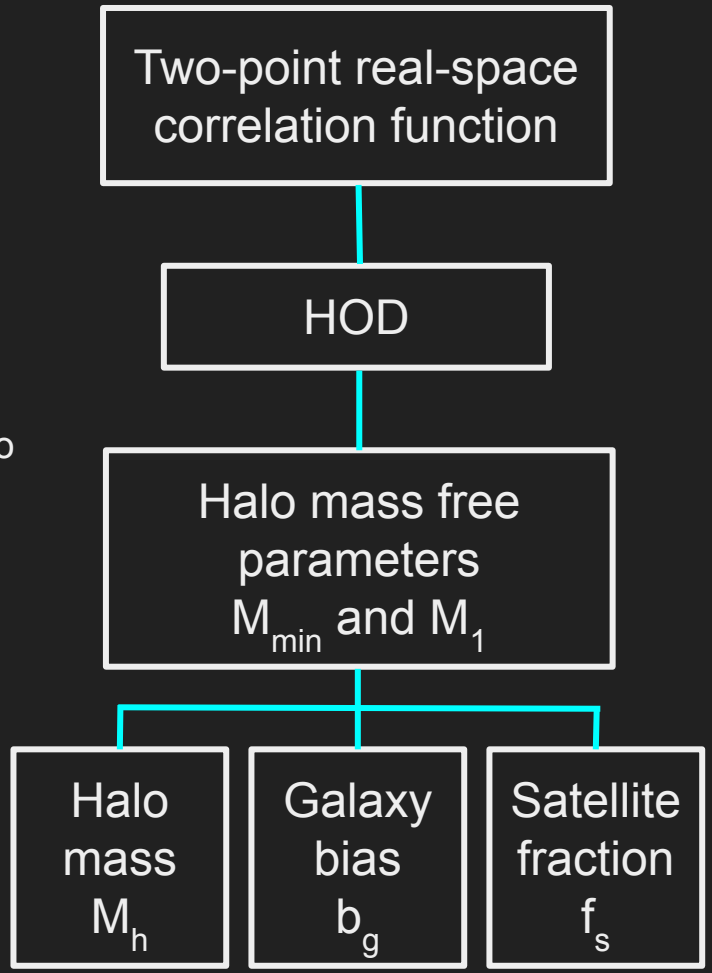
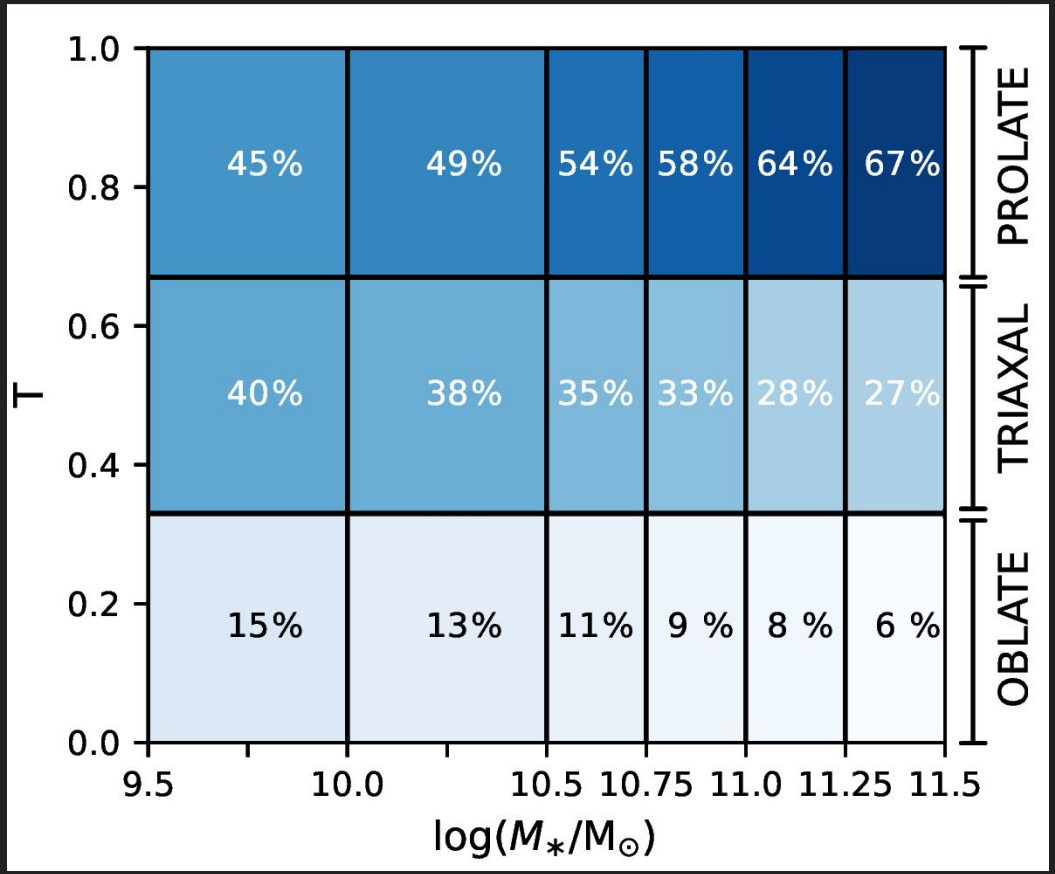


PROLATE

SPHERICAL

OBLATE



Mock catalogue populated in BolshoiP simulation, Durkalec et al. (in prep)

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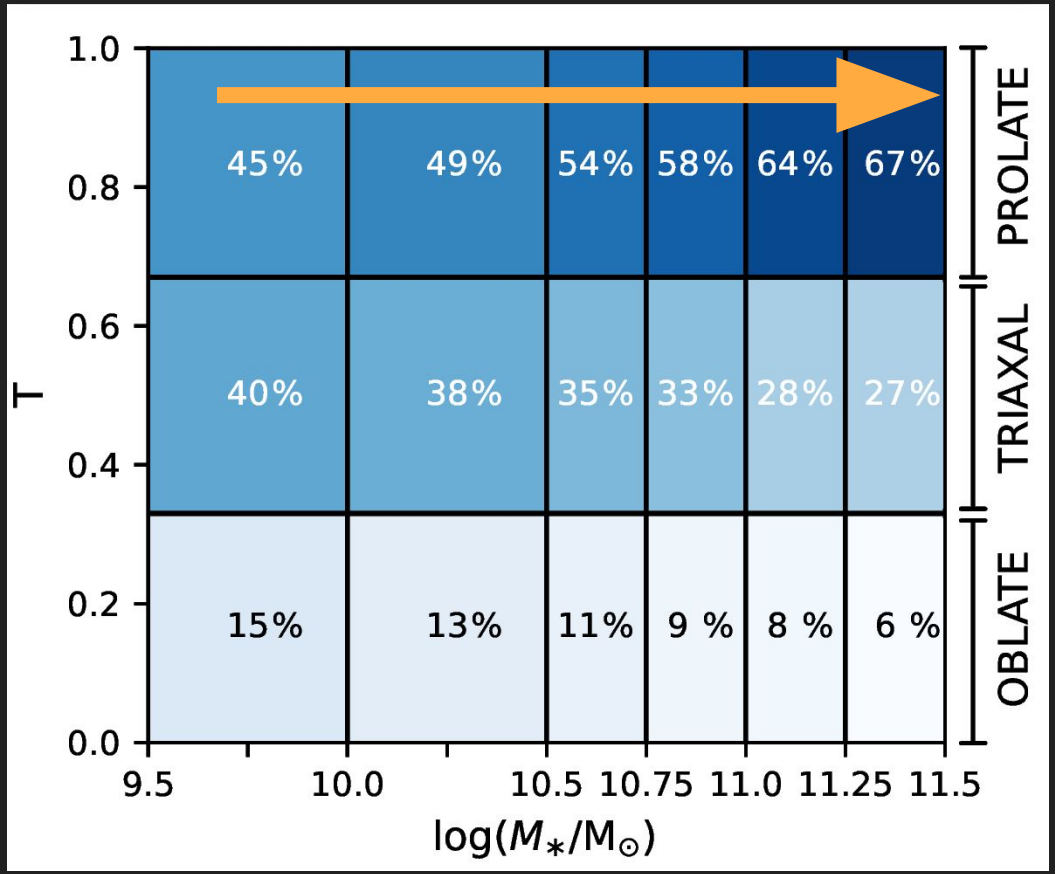


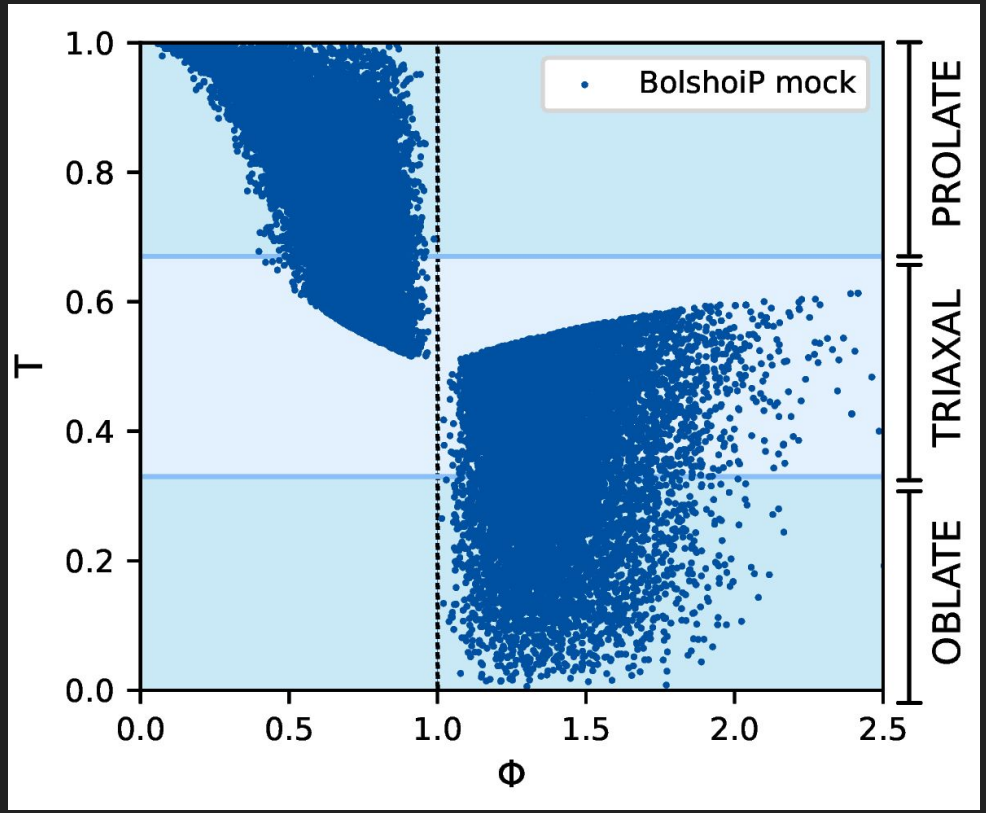
Mock catalogue populated in BolshoiP simulation, Durkalec et al. (in prep)

MODIFIED HOD (6 - PARAMETERS)

Additional parameter ϕ - constructed to measure how strongly the shape of the DM halo deviates from the spherical symmetry.

$$0 < \phi < \infty$$

$\phi = 1$
for a spherically symmetric haloes



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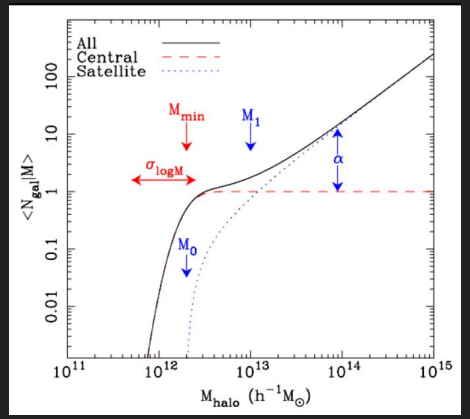
MODIFIED HOD (6 - PARAMETERS)

The core HOD stays the same:



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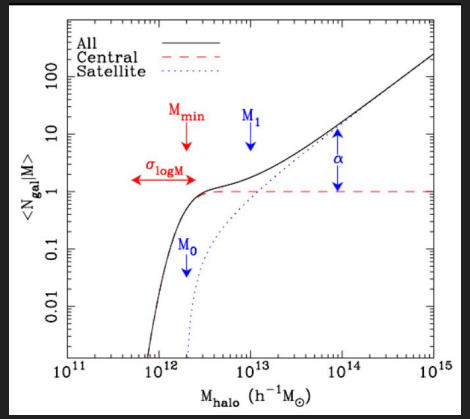

We modify (slightly) NFW profile:

NFW profile

$$\frac{\rho(R)}{\rho_{crit}} = \frac{\delta_c}{\frac{R}{R_S}\left(1+\frac{R}{R_S}\right)^2},$$

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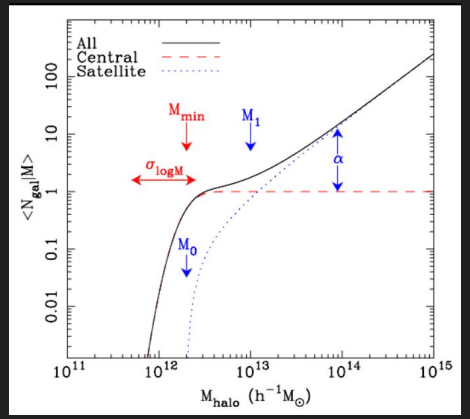

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$$R = \sqrt{\frac{x^2}{a^2} + \frac{y^2}{b^2} + \frac{z^2}{c^2}}.$$

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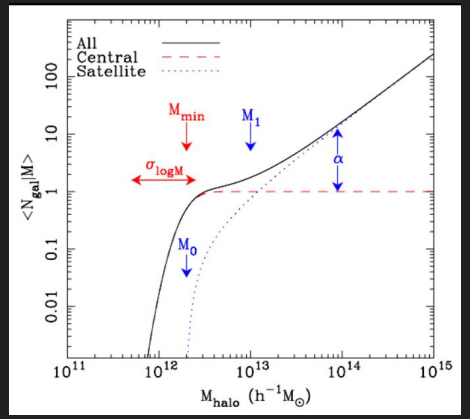

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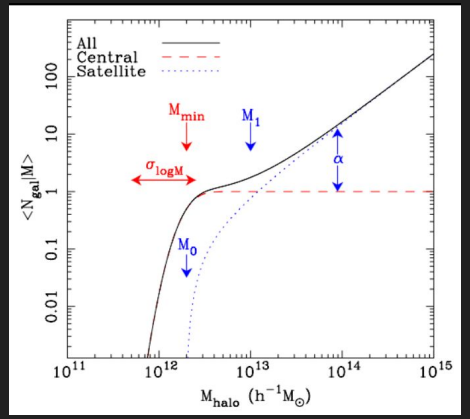

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$$R \approx \frac{r}{a\sqrt{2}}\sqrt{1+\phi^2} \sim \frac{r}{b\sqrt{2}}\sqrt{1+\phi^2}$$

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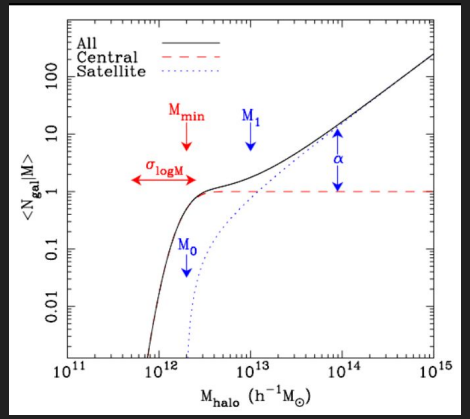

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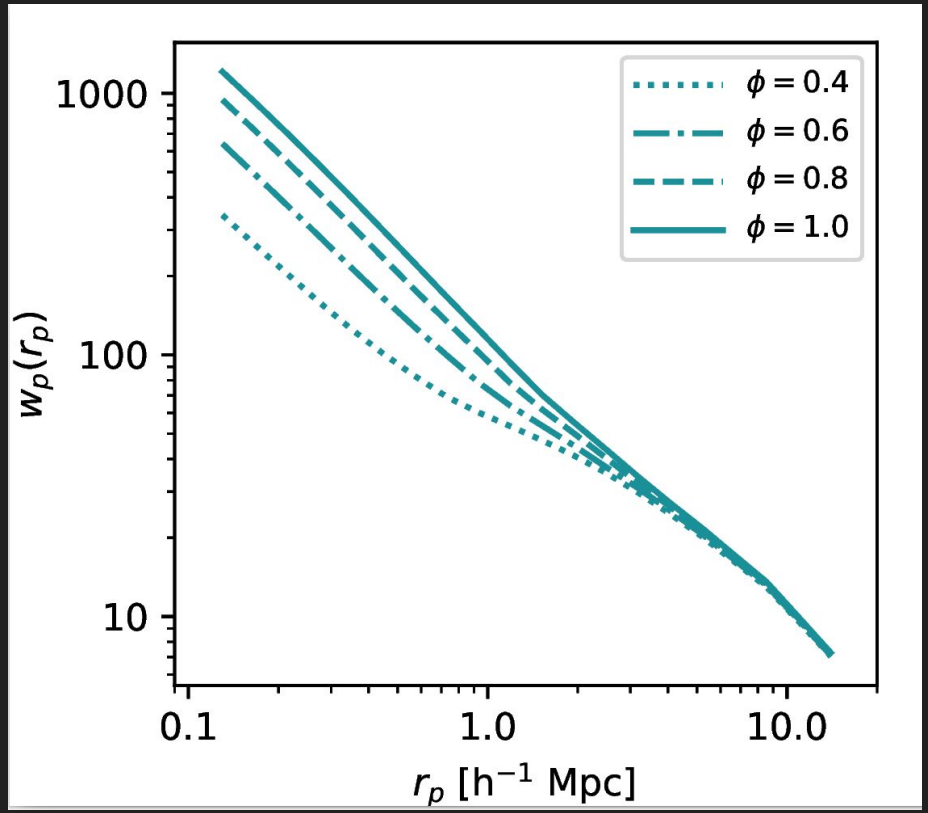
MODIFIED HOD (6 - PARAMETERS)

Modelled correlation functions for different ϕ and other parameters fixed at the same value

Only one halo term ($r_p < 1\ h^{-1}$ Mpc) is influenced



Durkalec et al. (in prep)

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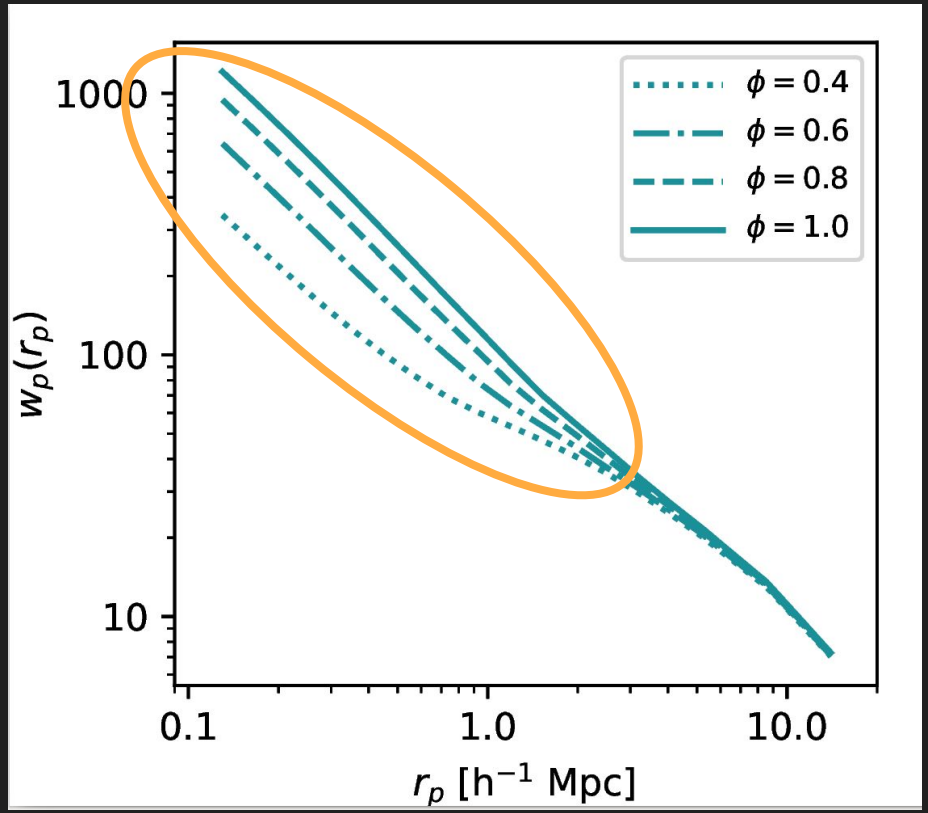

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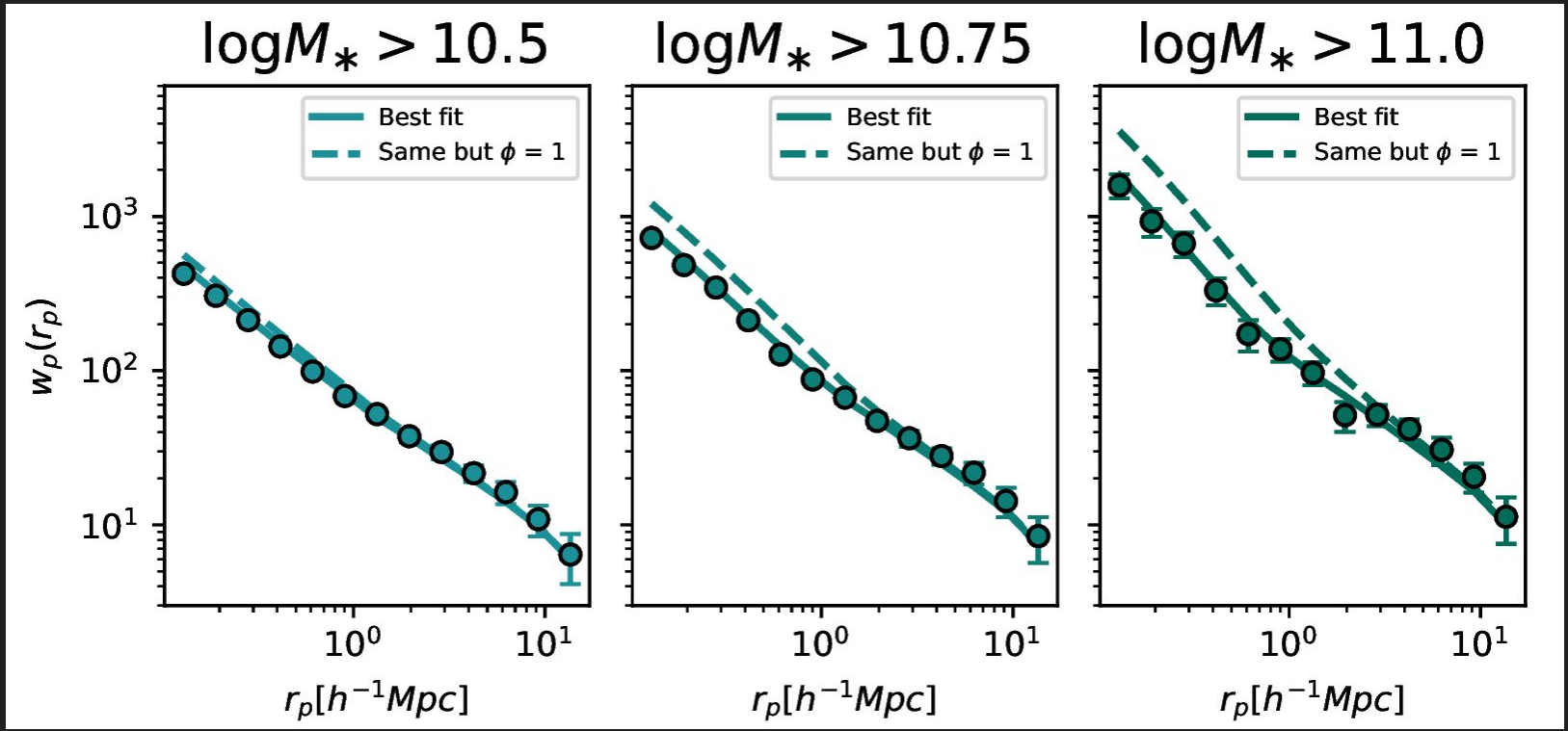
MODIFIED HOD (6 - PARAMETERS) FITS

BOLSHOIP MOCK RESULTS



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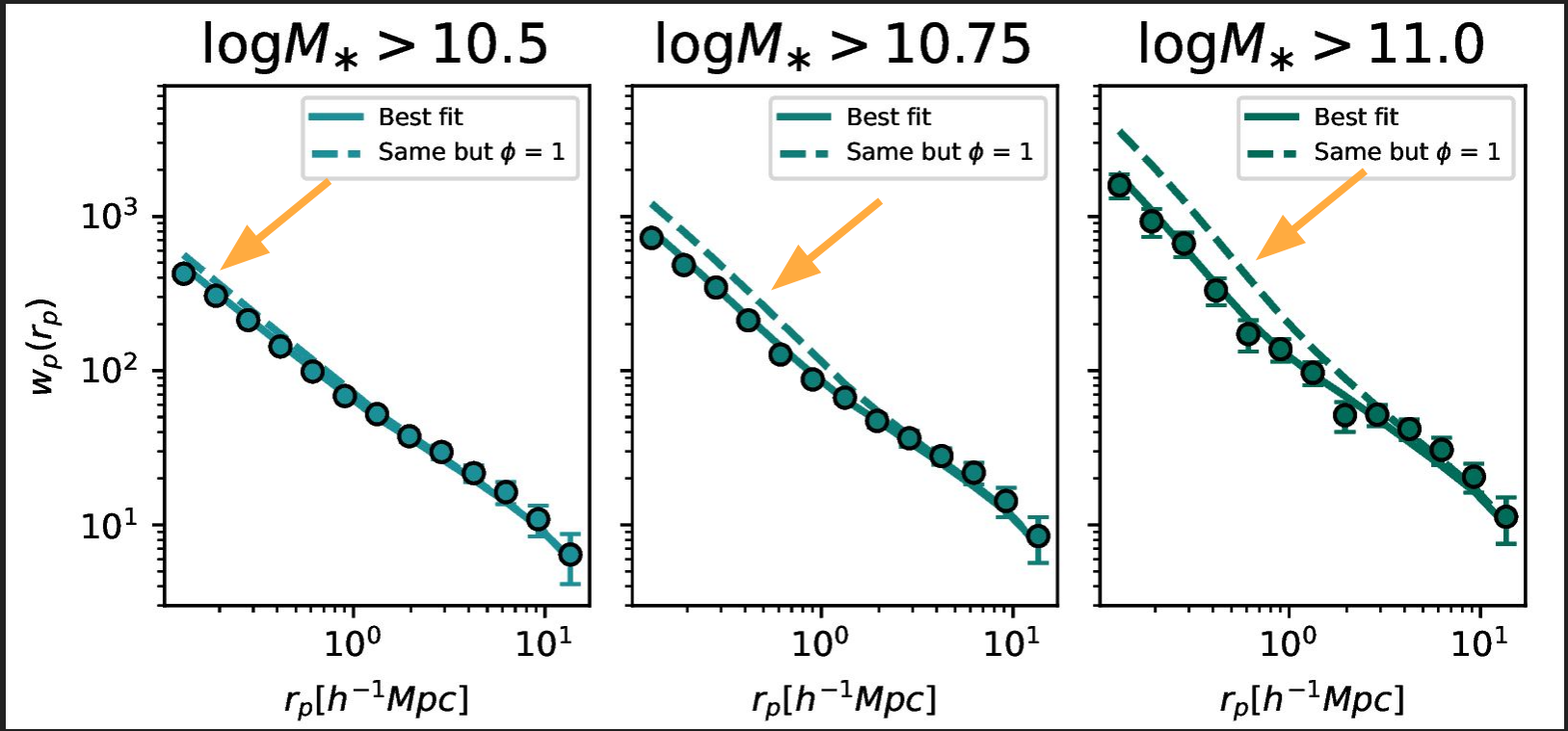

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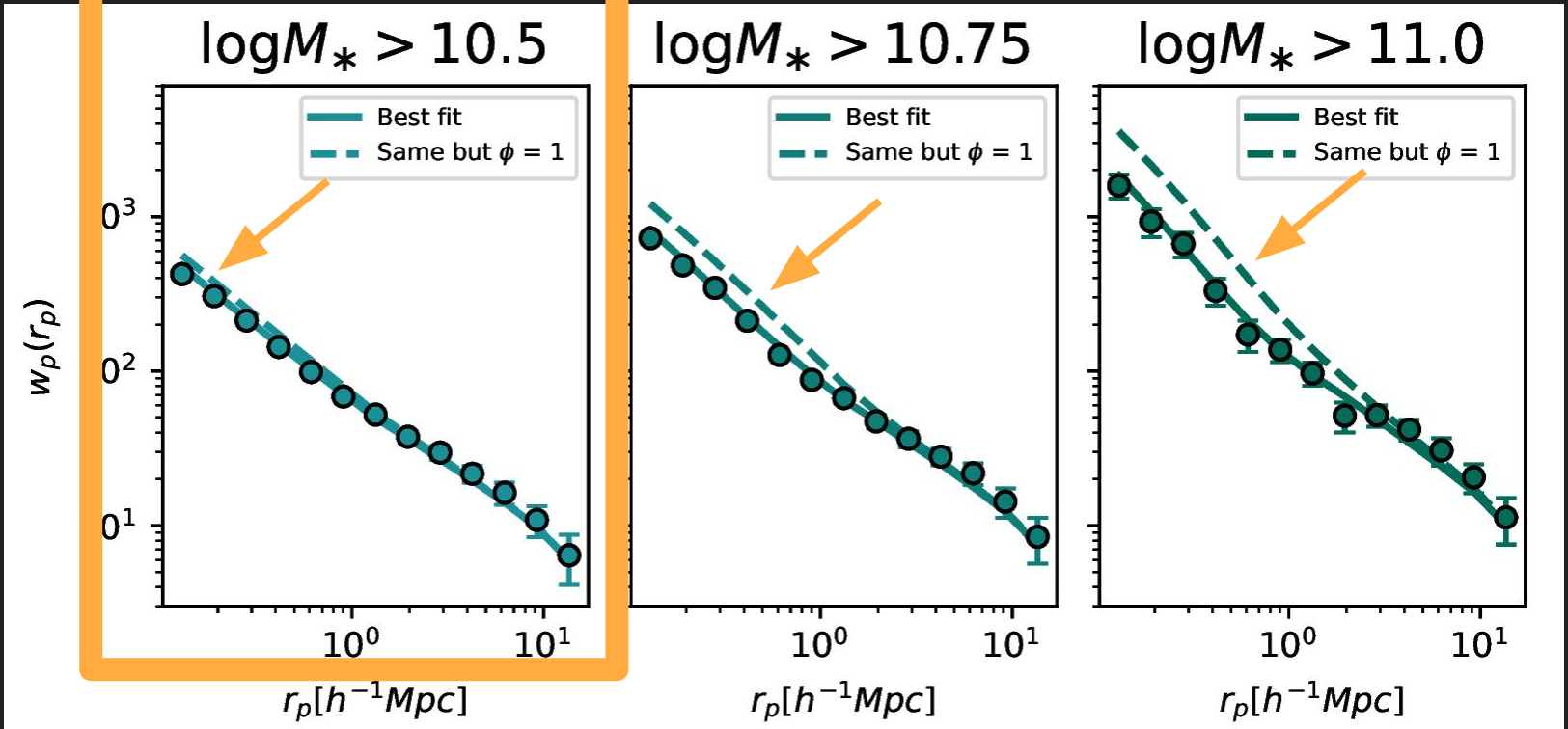

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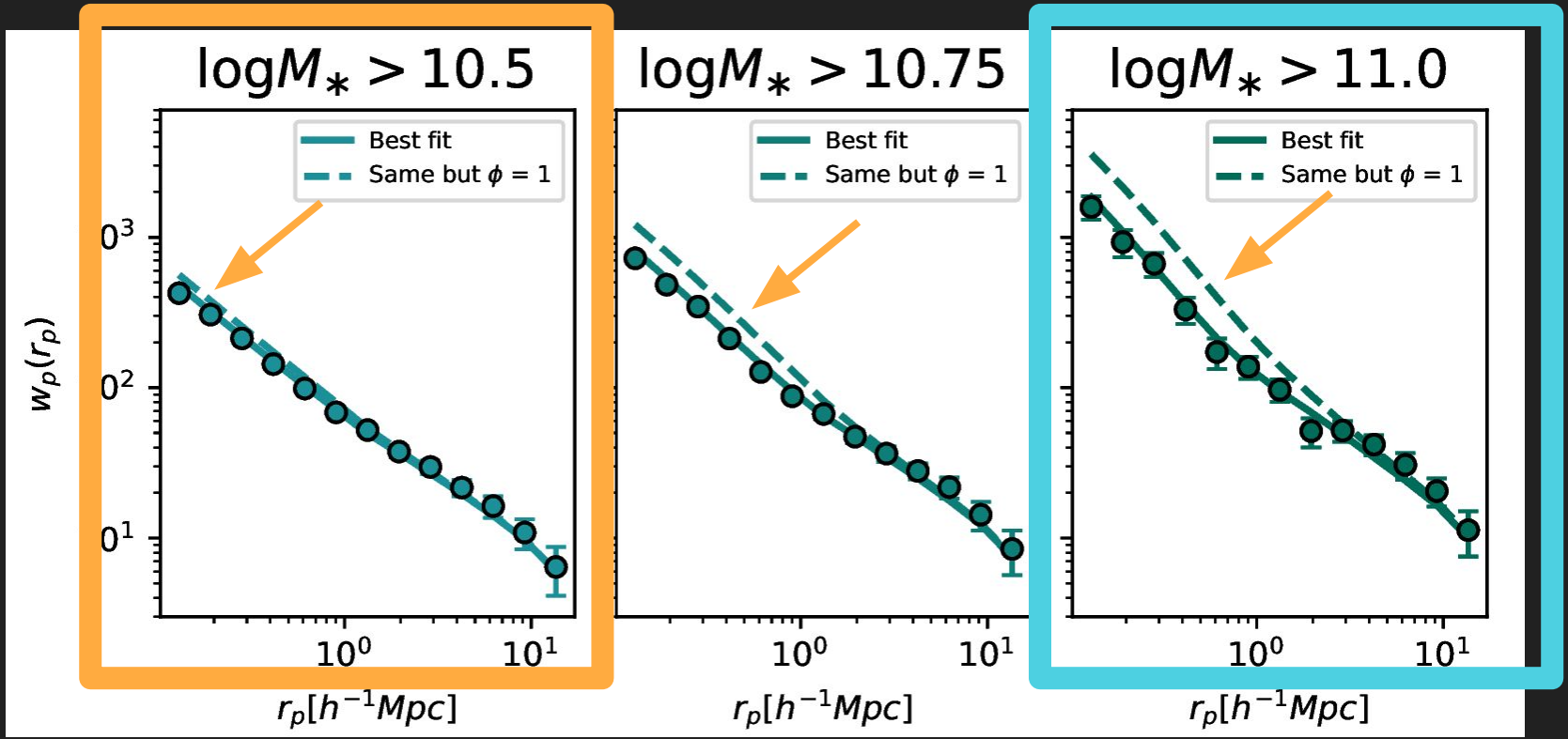

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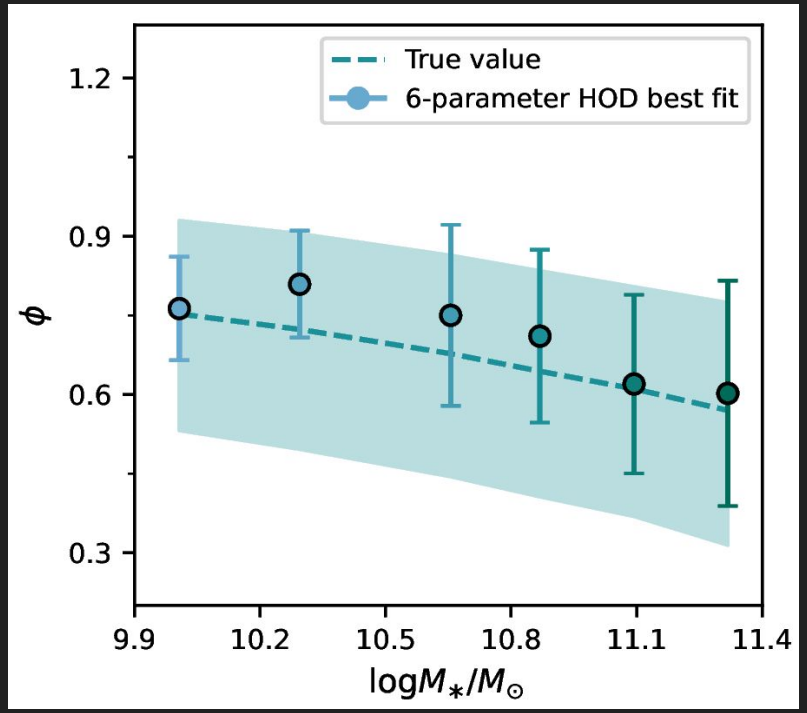
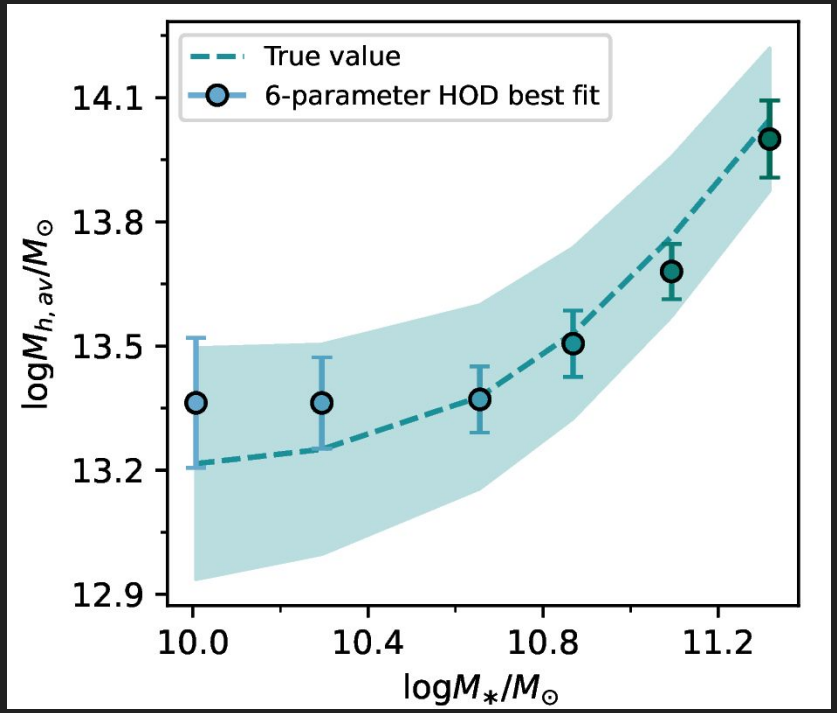
MODIFIED HOD (6 - PARAMETERS) FITS

BOLSHOIP MOCK RESULTS

ASYMMETRY



HALO MASS

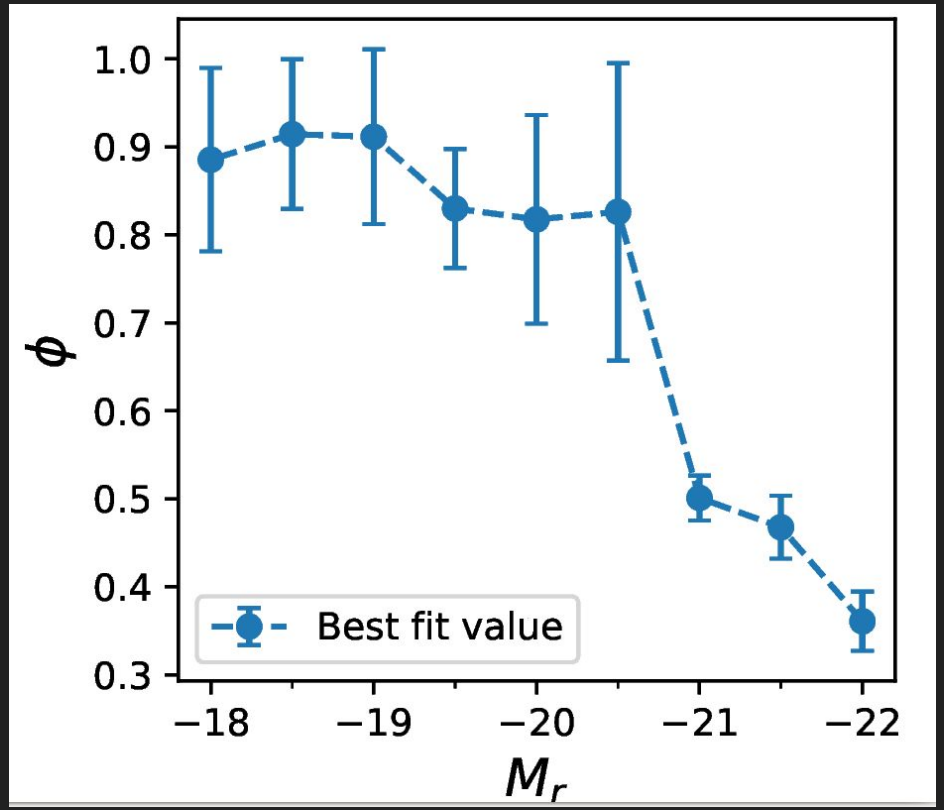


Durkalec et al. (in prep)

MODIFIED HOD (6 - PARAMETERS) FITS

MODEL FIT TO ZEHAVI ET AL. 2011 CF RESULTS (SDSS)

Halo asymmetry parameter for different M_r luminosity selected samples from SDSS - correlation function measurements from Zehavi et al. 2011.



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MODEL FIT TO ZEHAVI ET AL. 2011 CF RESULTS (SDSS)

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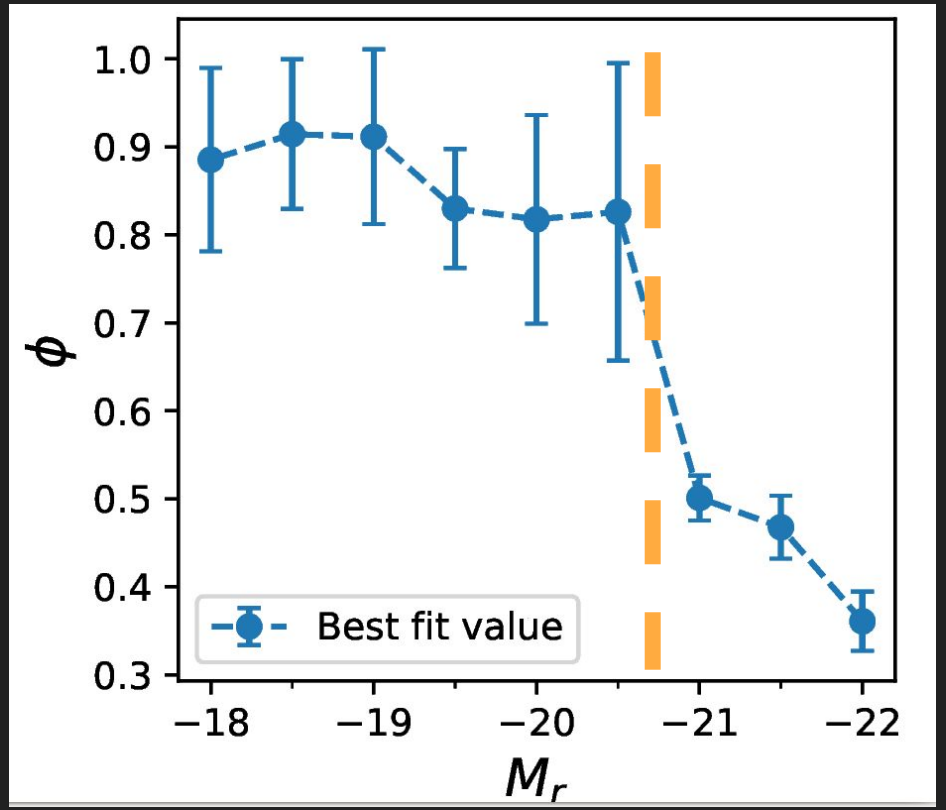
Halo asymmetry increases with luminosity of hosted galaxies. More luminous galaxies occupy more prolate DM haloes.



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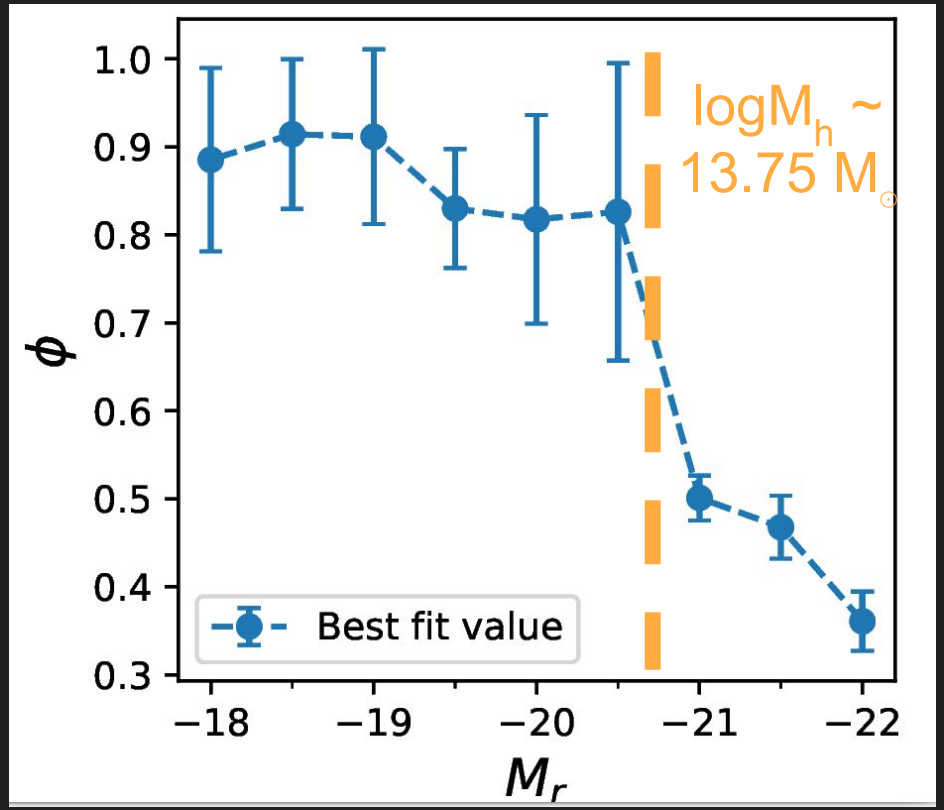
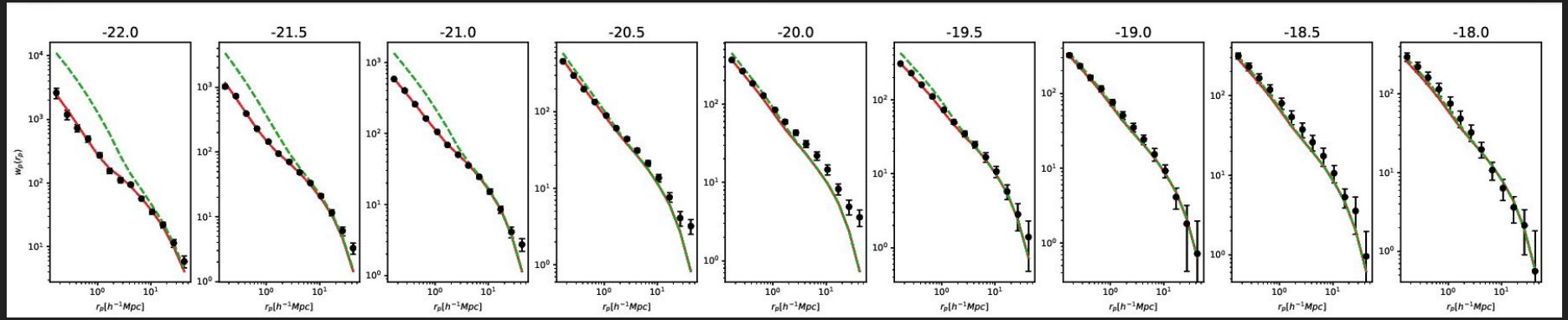
Why jump? Galaxy clusters? Model limitations - not sufficient signal in one halo term scales? Something else?

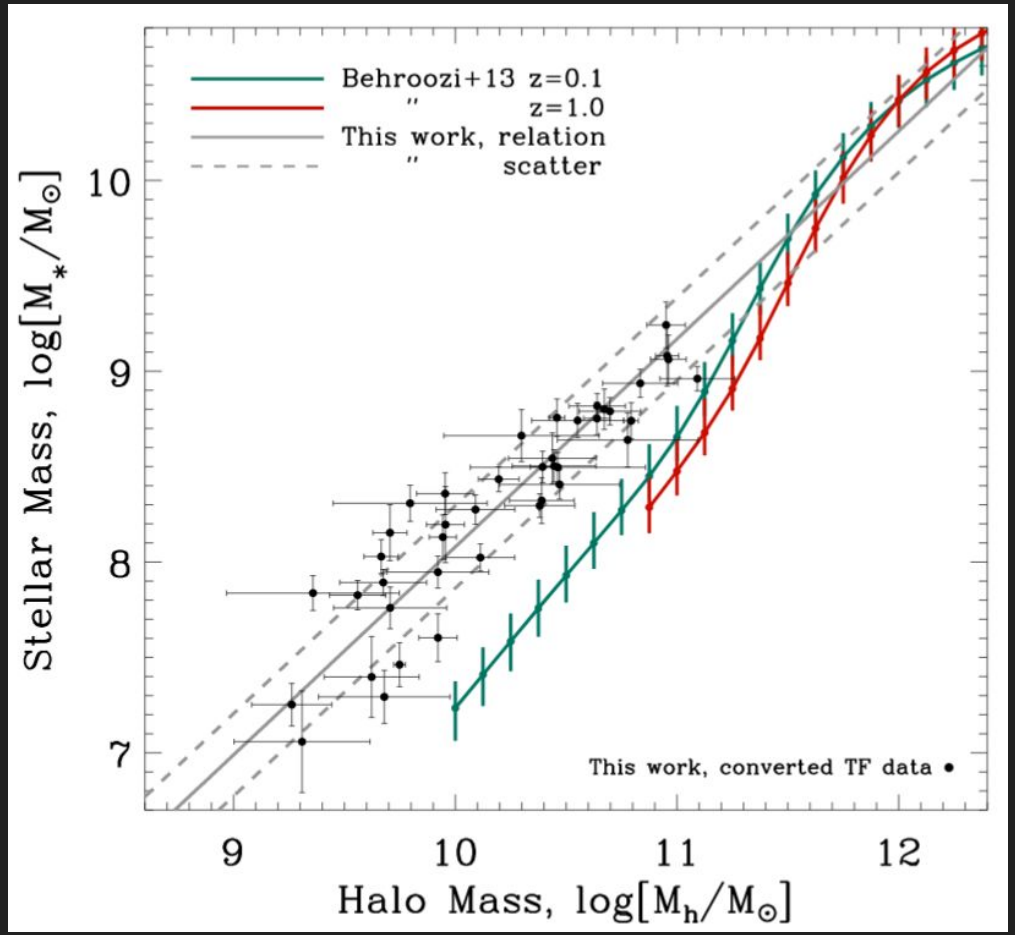


Durkalec et al. (in prep)

TAKE AWAY MESSAGES:

- We observe luminosity and stellar mass dependence of galaxy clustering at z~3.
- Large scale galaxy bias depend on luminosity and stellar mass and redshift.
- The same goes for dark matter halo masses.
- There is a lot of satellite galaxies at z~3.
- Stellar to halo mass relation might get complicated at z~3. Low mass galaxies can be found in unexpectedly low mass halos and they forming stars more efficiently.
- Halo asymmetry plays an important role in galaxy clustering, and needs to be included in HOD models, especially for massive and luminous galaxy samples.


-22.0
-21.5
-21.0
-20.5
-20.0
-19.5
-19.0
-18.5
-18.0
$w_p(r_p)$
$r_p[h^{-1}Mpc]$



Miller et al. 2014, ApJ, 782, 115M