

Stellar mass dependent median galaxy size - halo radius relation

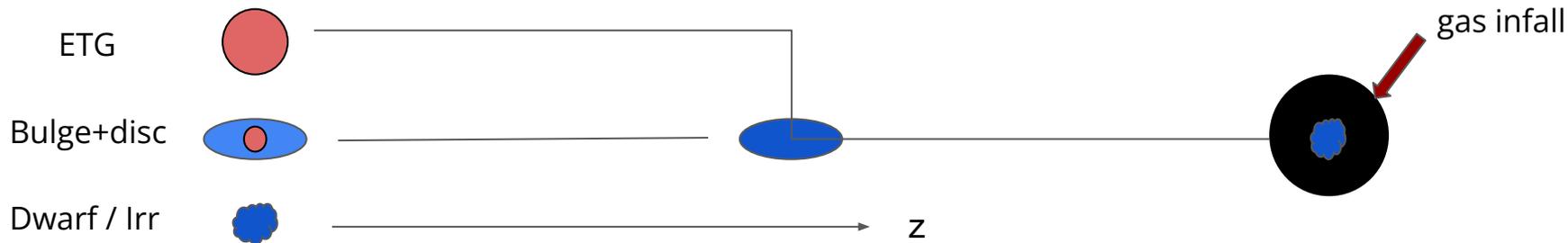
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GALAXY EVOLUTION
WITH THE ESA EUCLID MISSION AND ESO TELESCOPES

Galaxy formation in dark matter context

In Lambda-CDM universe, galaxies are formed within dark matter haloes.



Dark matter halo influential in setting **basic properties** of galaxies.

Galaxies : some amount of visible mass (M^), spread till some extent (size) in certain shape (morphology)*

Nearly all galaxy formation models predict connection between galaxy and halo properties.

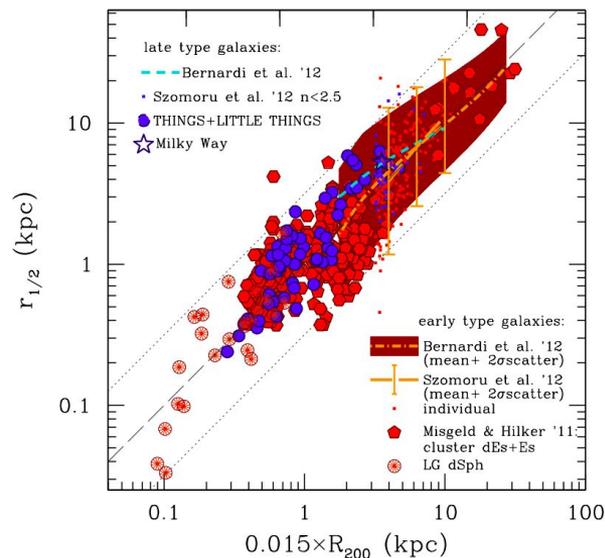
Studying galaxy-halo connection important for testing and refining existing models of galaxy formation.

Galaxy size - halo radius connection

Classic galaxy formation models predict galaxy size to be proportional to spin and size of haloes.

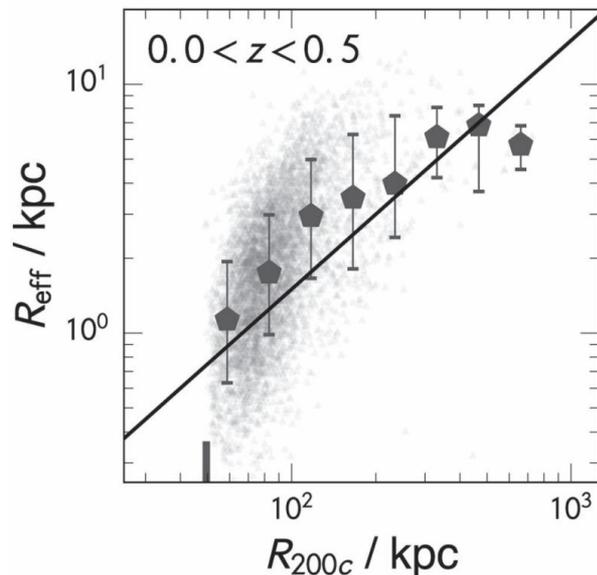
i.e. $R^* \sim \lambda_{\text{halo}} R_{\text{halo}}$ (Fall+1980, Mo+1998)

Kravtsov (2014)



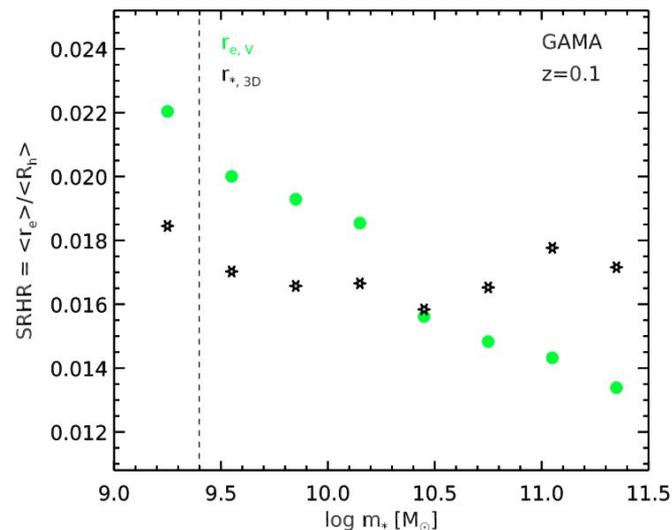
Linear relation: $r^* = 0.015 R_{\text{halo}}$

Huang+ (2017)



Linear relation + slight bent at high M^*

Somerville+ (2018)



r^*/R_{halo} roughly independent of M^*

Support classic galaxy formation models

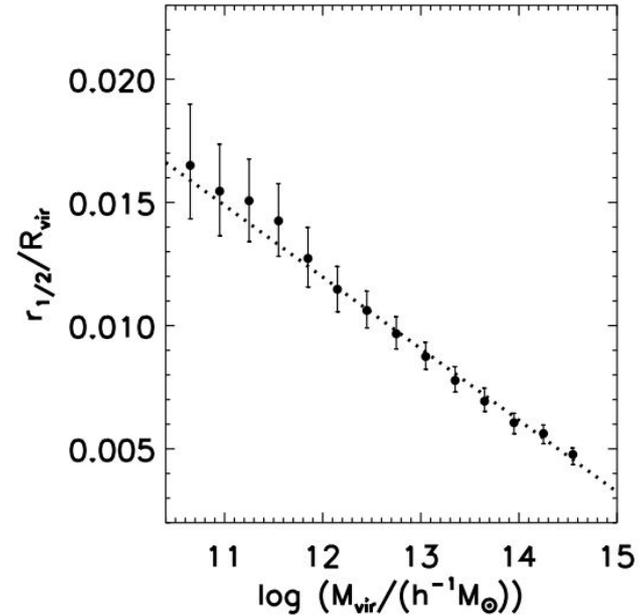
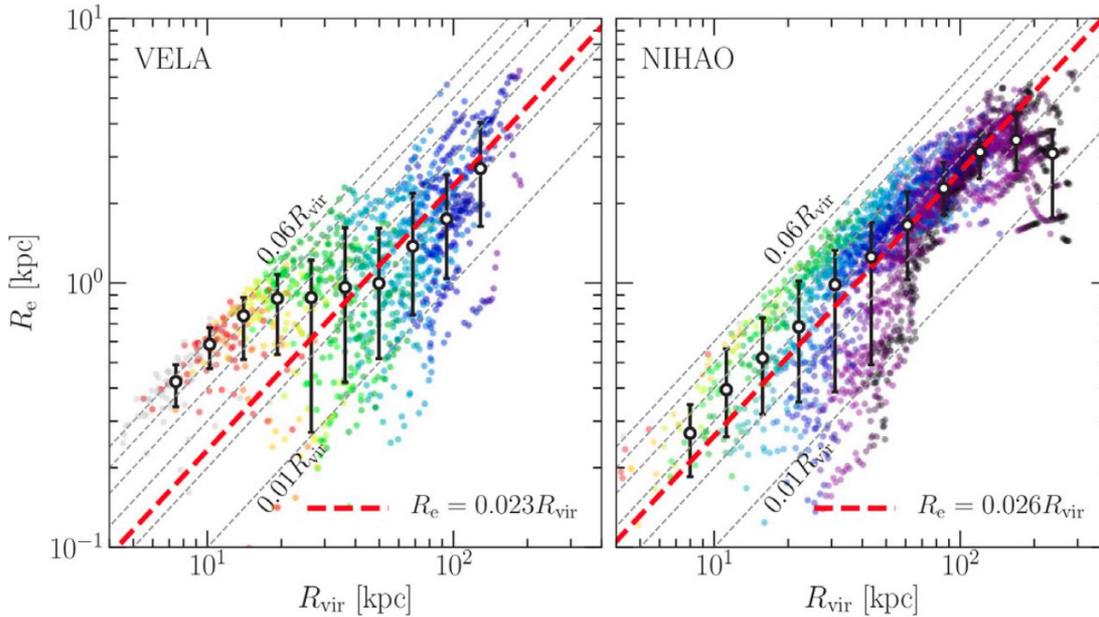
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Jiang+ (2019)

Zhang+ (2022)



r^* -Rhalo non linear. Proposed concentration dependence
 $r^* \sim 0.02 (c/10)^{-0.7} \times R_{\text{halo}}$

r^*/R_{halo} depends on M_h

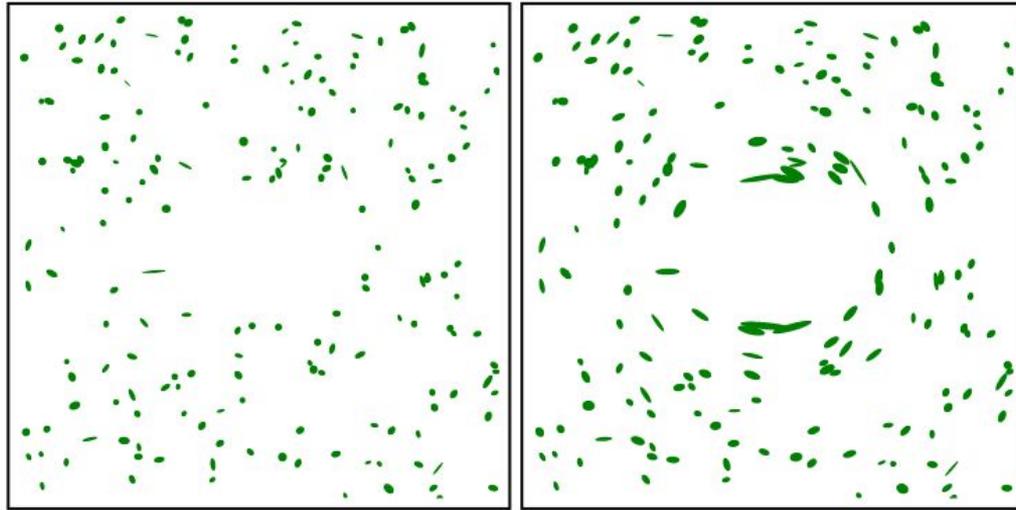
Oppose classic galaxy formation models

Galaxy size - halo radius connection

Conflicting galaxy size - halo connection came from abundance matching techniques or hydro-simulations.

These involve either inherent modelling assumptions or are purely theoretical.

We tackle this issue with weak gravitational lensing.



Source: wikipedia

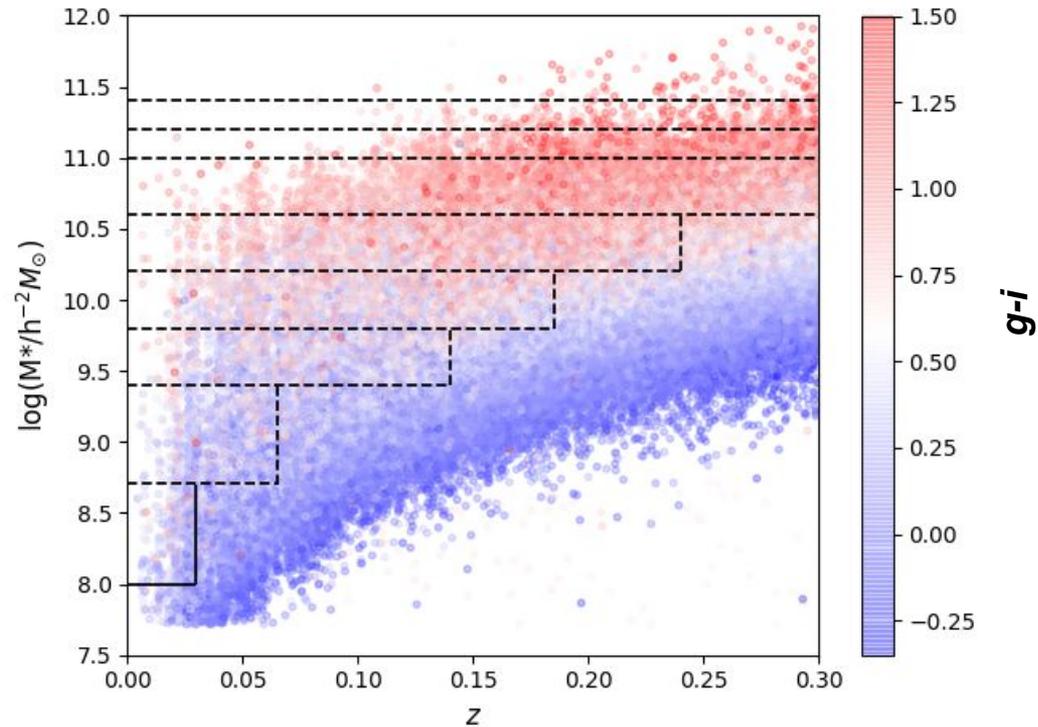
Foreground lens (matter) distorts background galaxies.

Distortion related to foreground lens mass (mostly dark matter). Need to stack lot of galaxies to see distortion

Average halo properties assigned to average galaxy properties in an observational manner.

Sample

Overlapping galaxies (~38k) in surveys GAMA DR4 and Subaru-HSC data release S16a

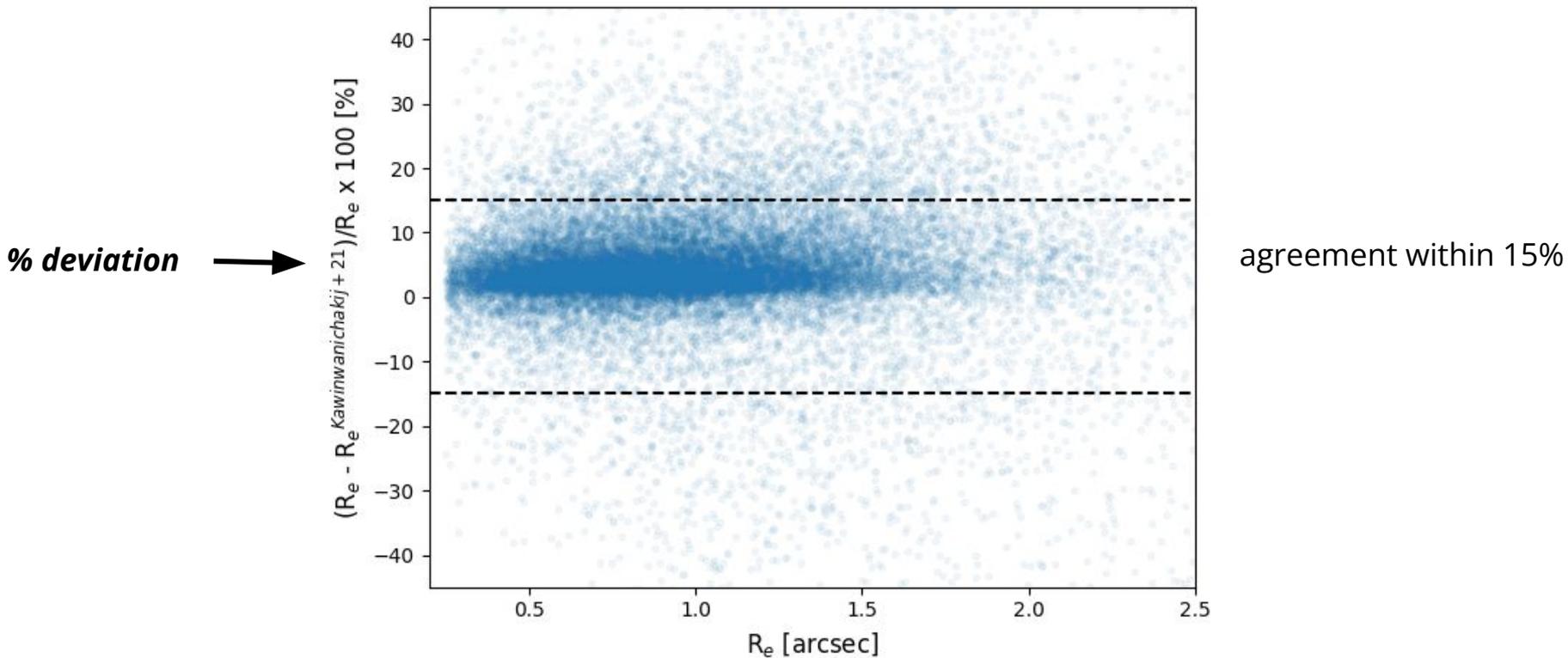


Stellar mass- redshift limited binning to ensure we are getting a fair mix red and blue galaxies.

Size measurements

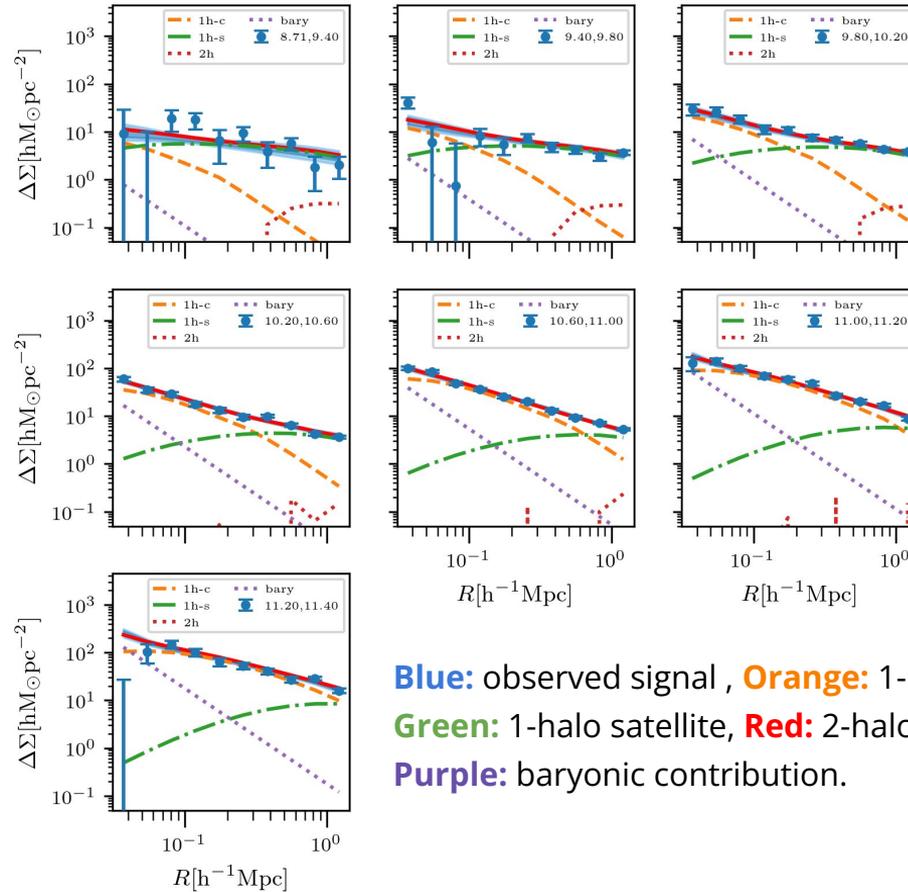
We fitted a single Sersic light profile to HSC i-band images to get the [half-light radius](#) for our sample galaxies.

Our size measurement agrees well with published size estimation of HSC galaxies by Kawinwanichakij+ (21)



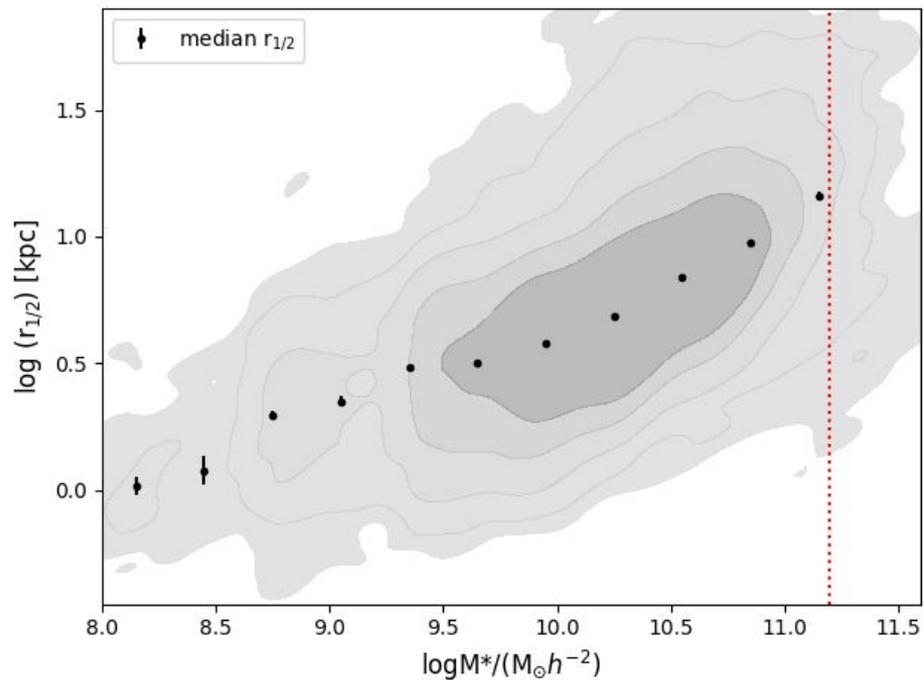
Halo mass estimates

Stacked weak lensing signals + conditional stellar mass function modelling. [Lead-Divya Rana, Surhud More]

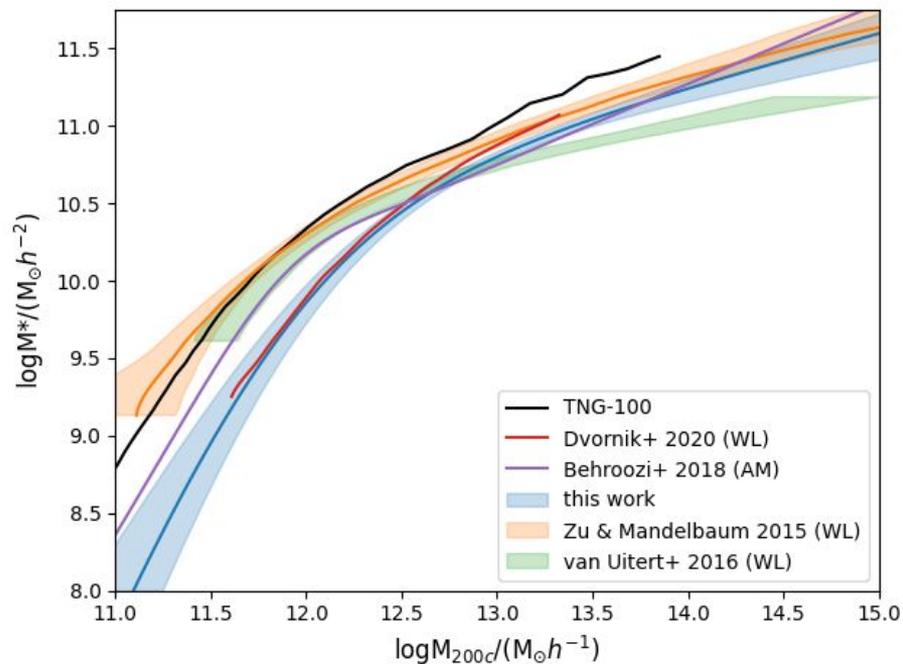


Results

galaxy size - stellar mass

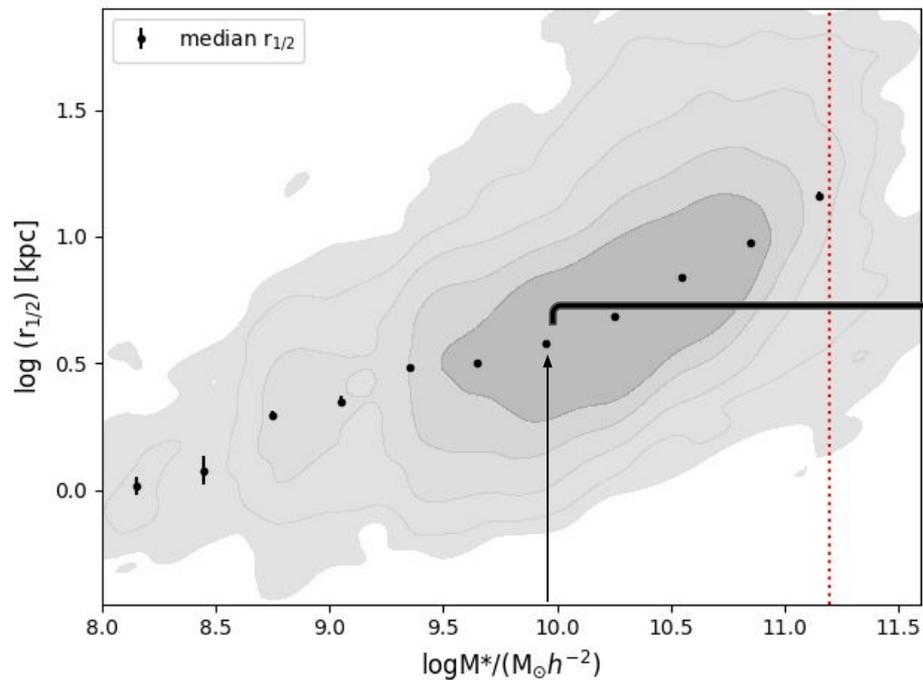


stellar mass - halo mass

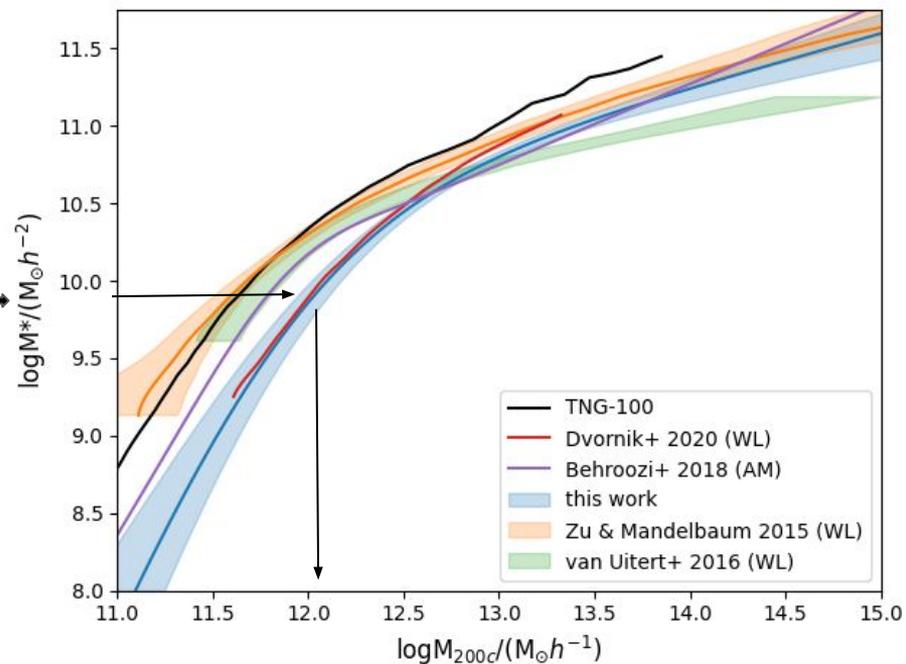


Results

galaxy size - stellar mass

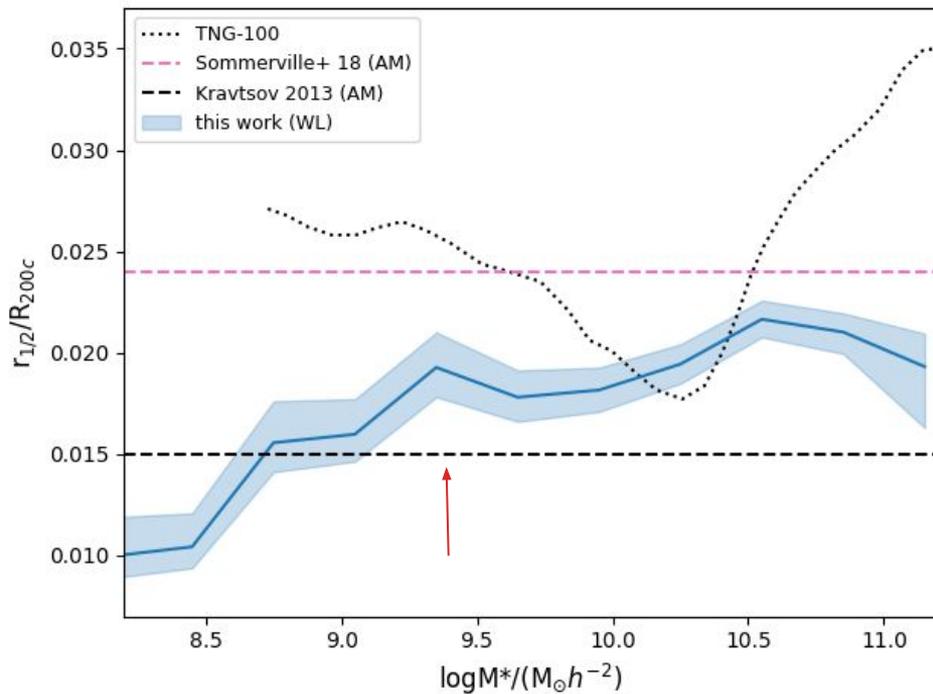
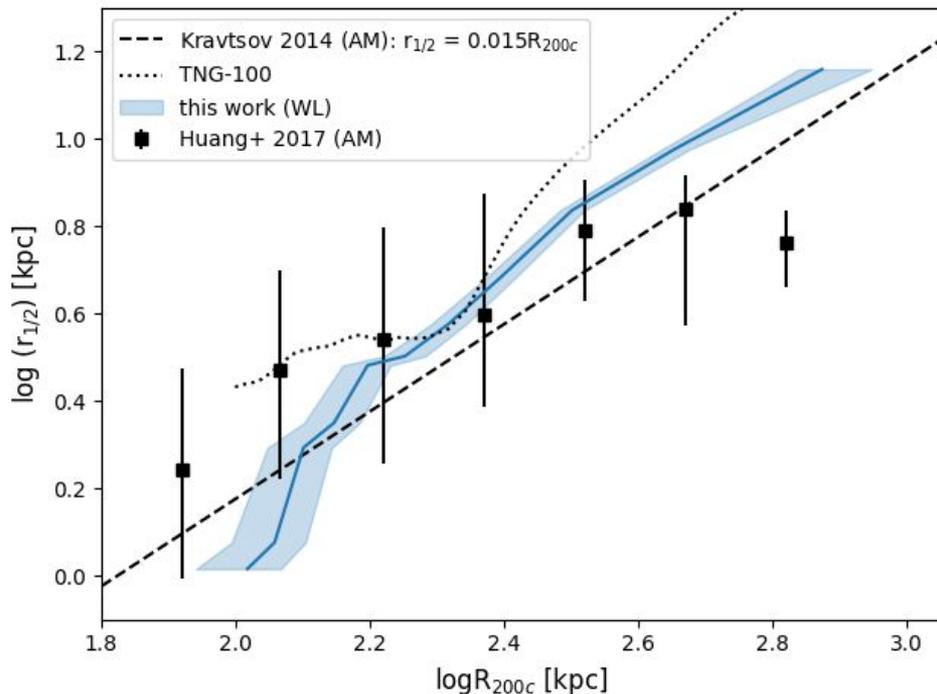


stellar mass - halo mass



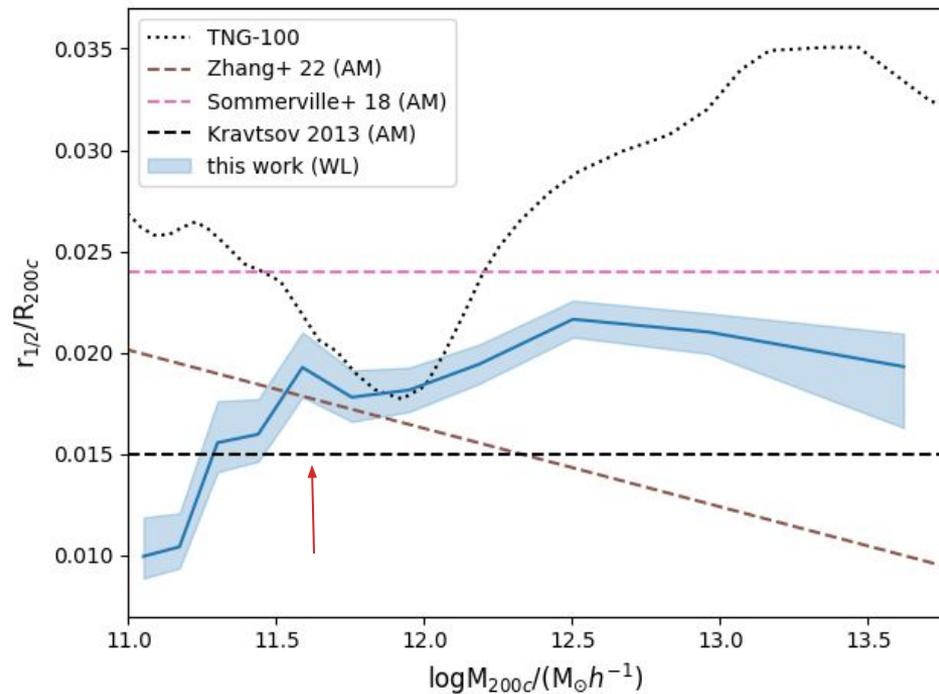
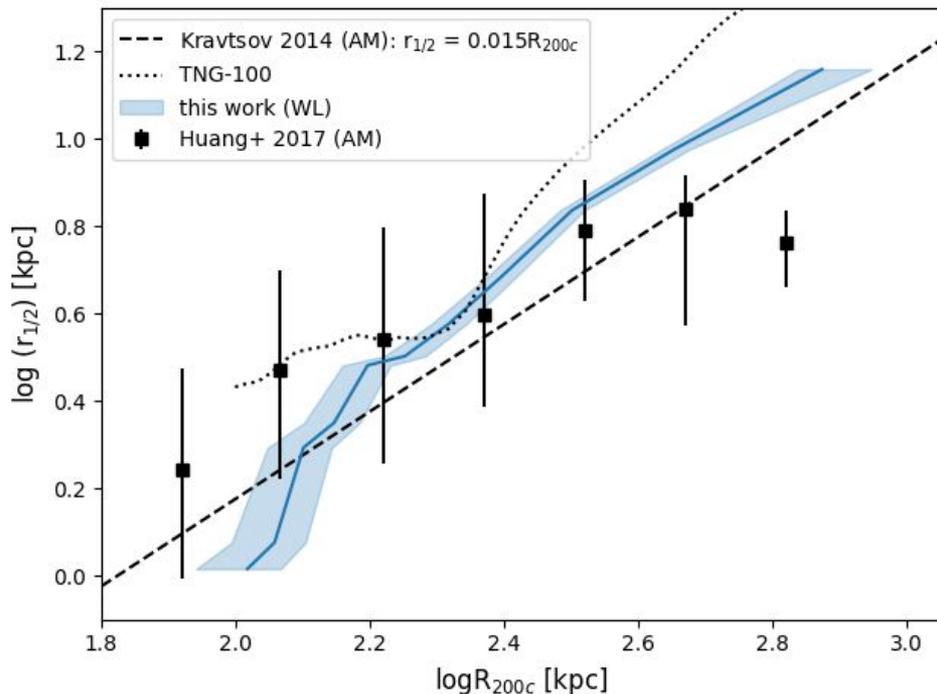
$r_{1/2}$ -----> M^* -----> M_{200c} -----> R_{200c}

Results: galaxy size - halo radius relation.



Galaxy size - halo radius relation seems linear **except** for low-mass / dwarf galaxies.

Results: Stellar mass dependent galaxy size - halo radius relation



Galaxy size - halo radius relation seems linear **except** for low-mass / dwarf galaxies.

Summary

- # Classic galaxy formation models predict galaxy size to be linearly related with halo radius.
- # No consensus on the form of galaxy size - halo radius relation in literature.
- # Cases for both linear and non-linear relation made by abundance matching or simulation work.
- # We connect galaxy size to their dark matter halo using weak gravitational lensing.
- # Galaxy size - halo radius relation fairly linear for galaxies more massive than $10^{9.5} M_{\text{sun}}$
- # The ratio of galaxy size/halo radius changes by a factor 2 as one moves from $10^{9.5}$ to $10^{8.5}$ in M^*
- # Dwarf / faint galaxy sector important for testing galaxy formation models.
- # Euclid — wider, deeper and farther — large number of faint galaxies + high resolution images.
- # Excellent data set for understanding the evolution of galaxy structure - dark matter halo connection.