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Constraining the evolution of the most massive galaxies from their local abundances and ages

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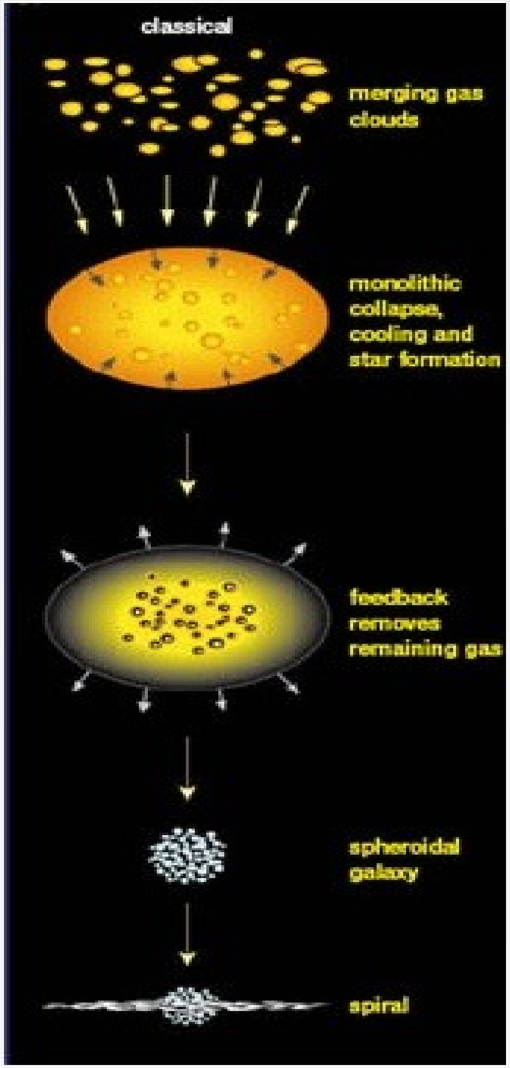
How do you grow a massive galaxy?

Mergers? In-situ?

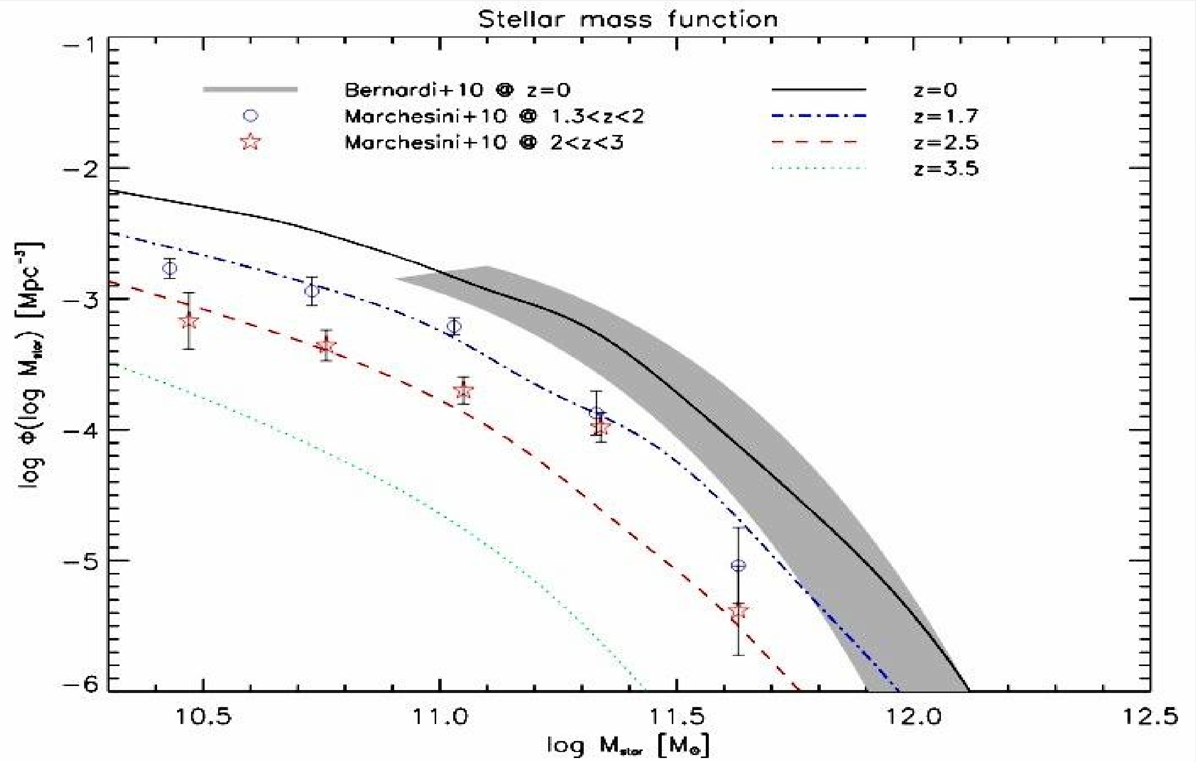
Very deep CFHT image
of Elliptical Galaxy NGC 474
Credit: P.-A. Duc



Credit: F. Combes

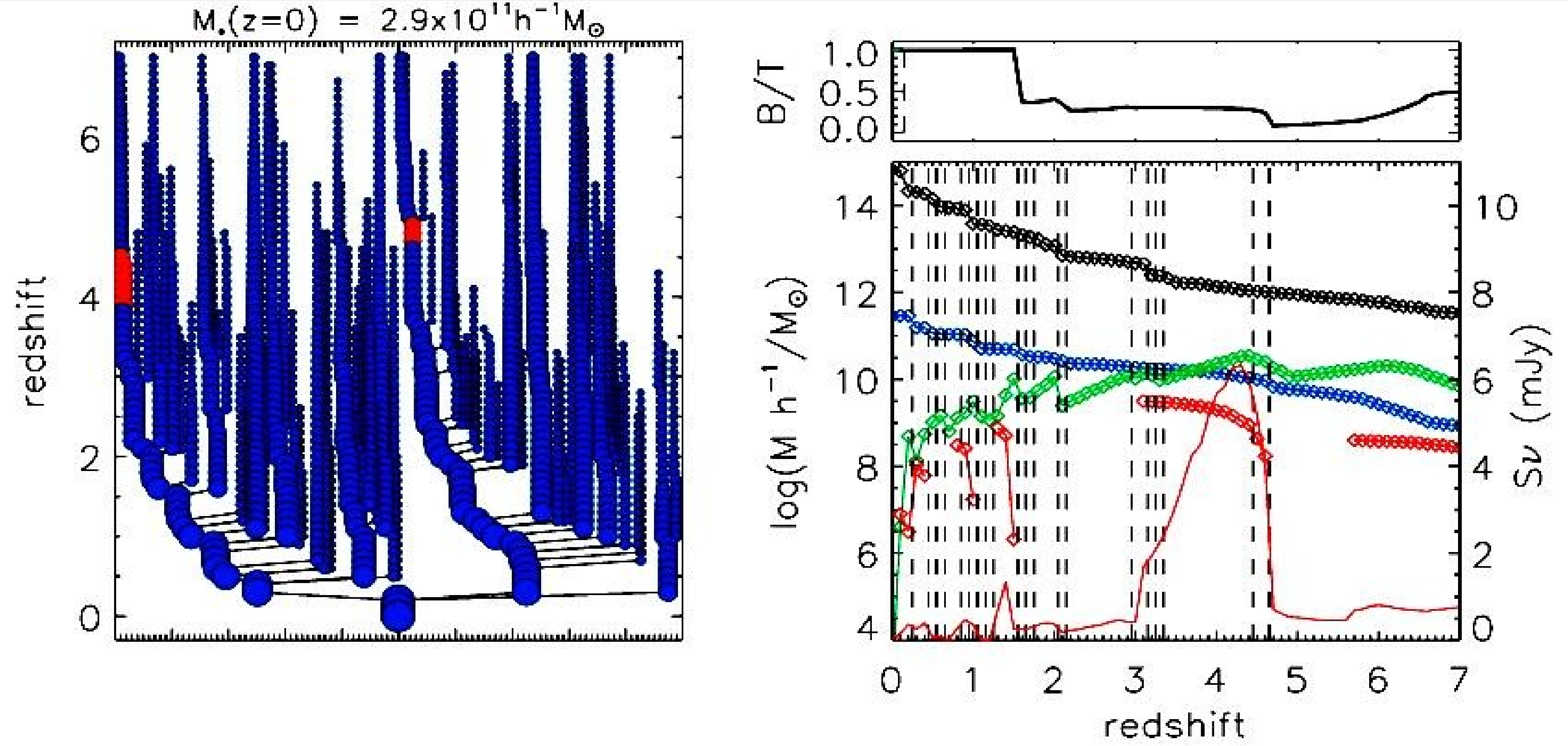
In-situ

…"the timescale of the main episode of the dust-enshrouded star formation in massive Haloes amounts to 7e8 yr. Given the SFR of 1e2-1e3 Msun/yr, this implies… final stellar Masses of 1e11-1e12 Msun. The corresponding stellar mass function matches the observed mass function of passive galaxy at z>1."
Lapi+11

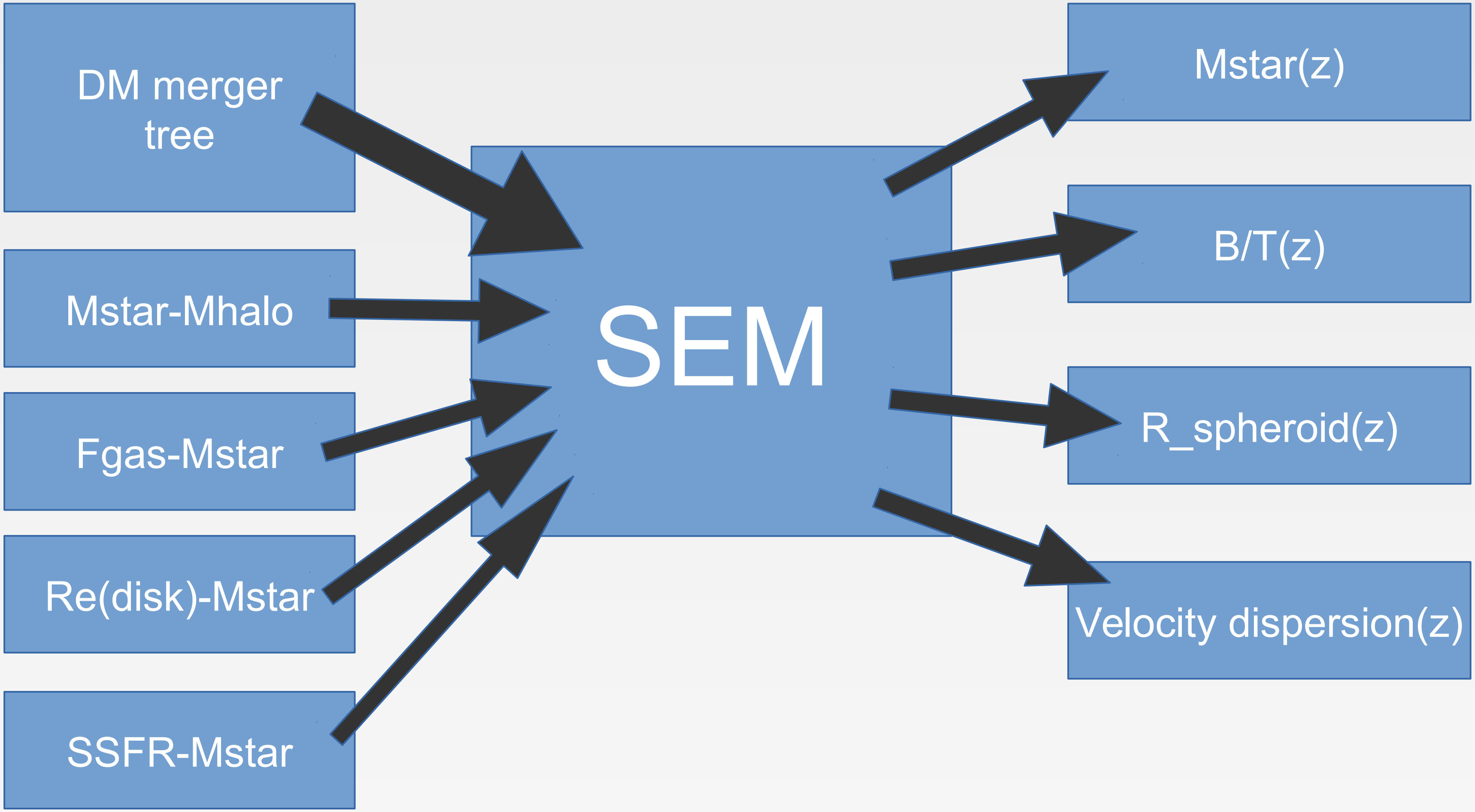


Mergers

…"our model predicts that SMGs are the progenitors of massive galaxies today. However, most of the stellar mass in these systems is built up by quiescent star formation and then assembled in galaxy mergers, making the contribution of long-lived stars formed during the SMG phase typically very small." Gonzalez+11



Semi-Empirical Model (SEM)



Shankar et al. 2014a

Semi-Empirical Model (SEM)

Small number of free parameters

The main ones being:

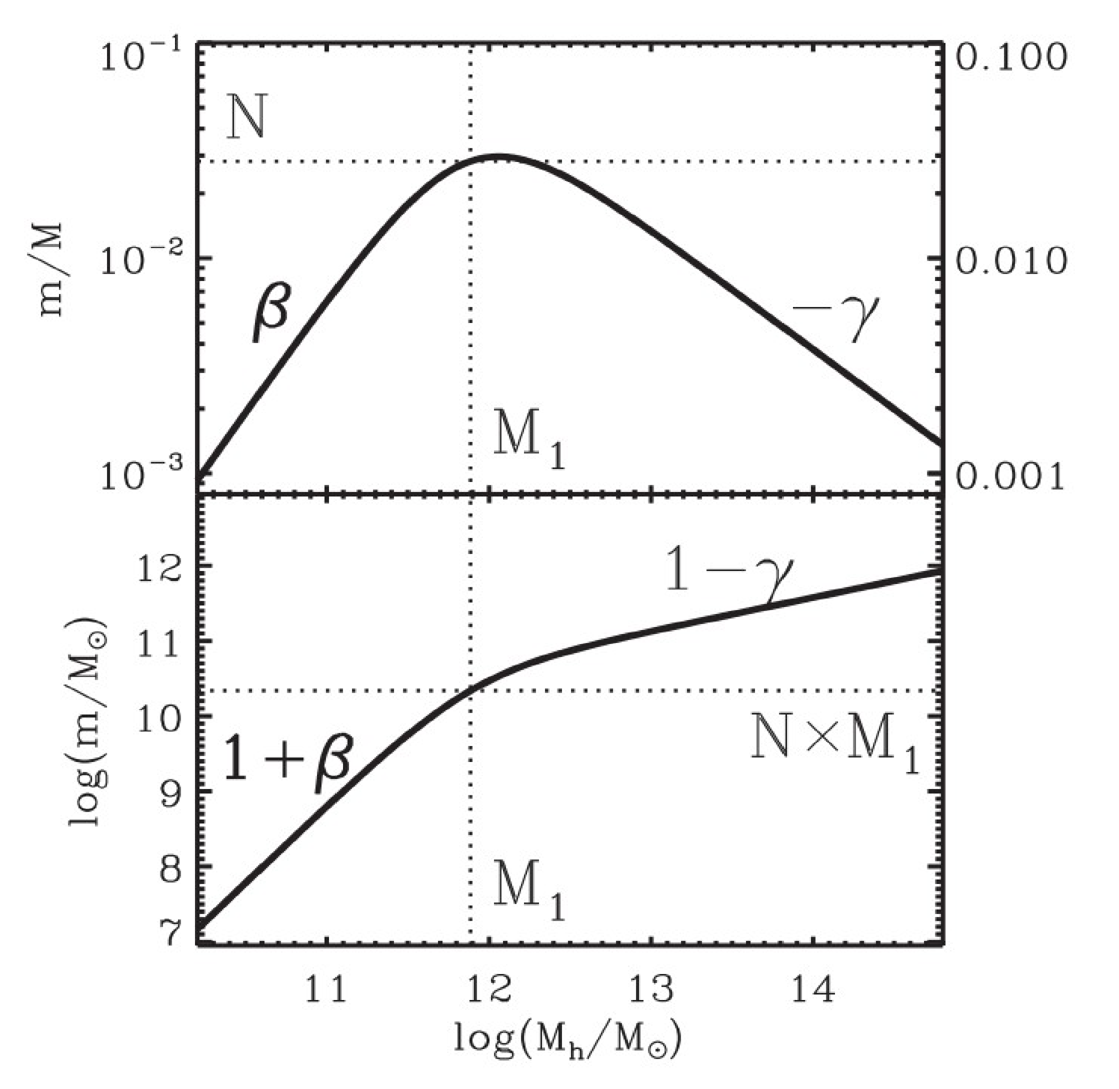
Forb (size growth efficiency of mergers)

Dynamical friction timescale

Extremely fast!

Mstar-Mhalo relation

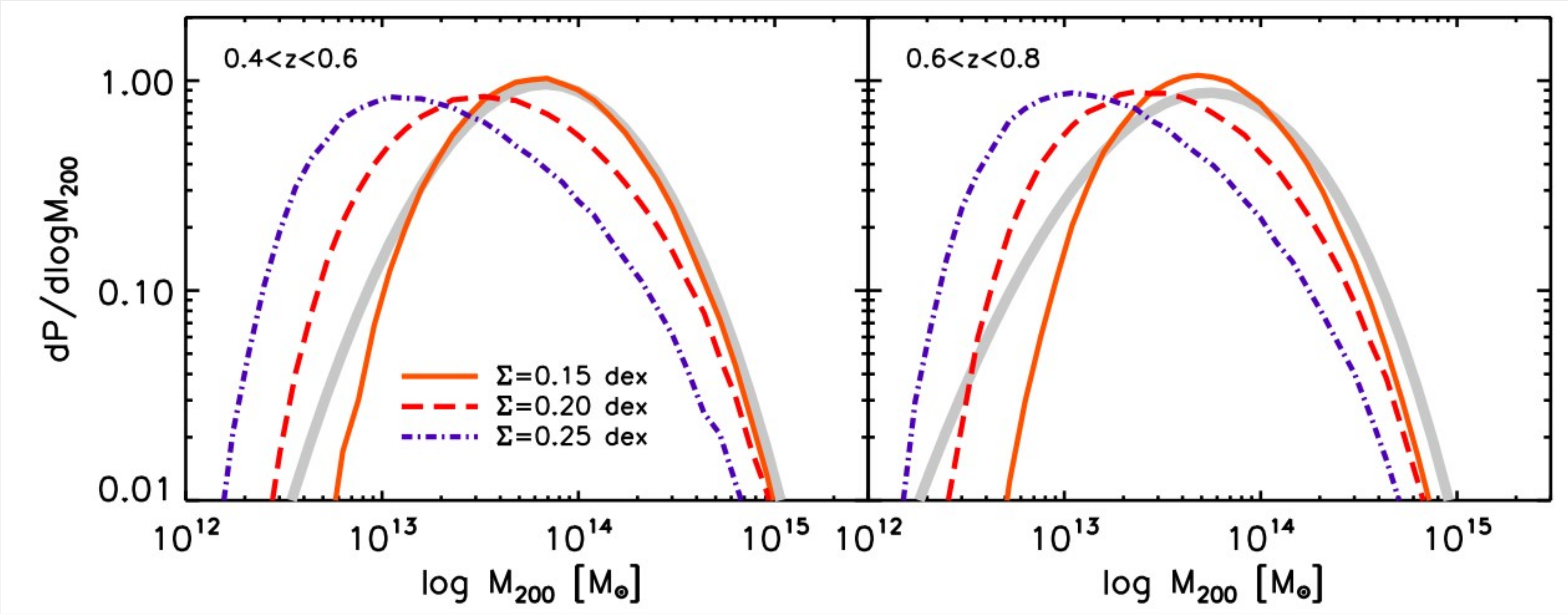
Very Important input to SEMs



Constructed using abundance matching

Moster et al. 2013

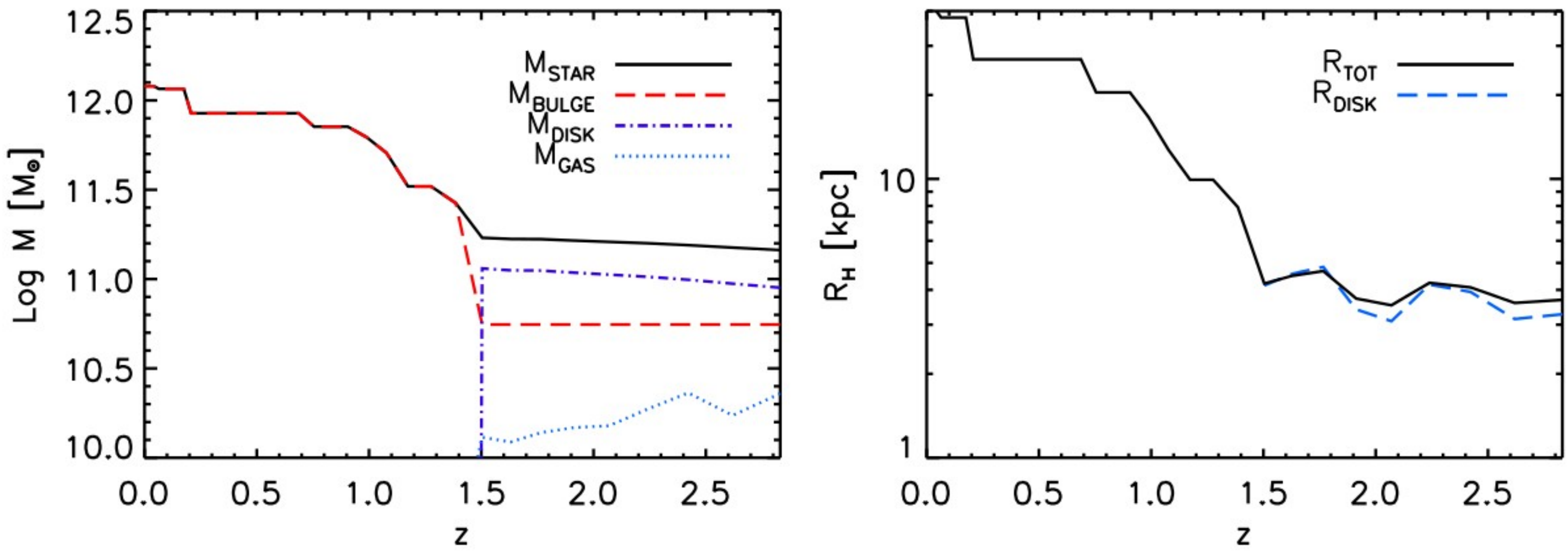
Scatter in SMHM



Predicted halo mass distributions compared to the BOSS clustering data from Guo et al. 2014

Shankar et al. 14b

SEM in action
An example BCG

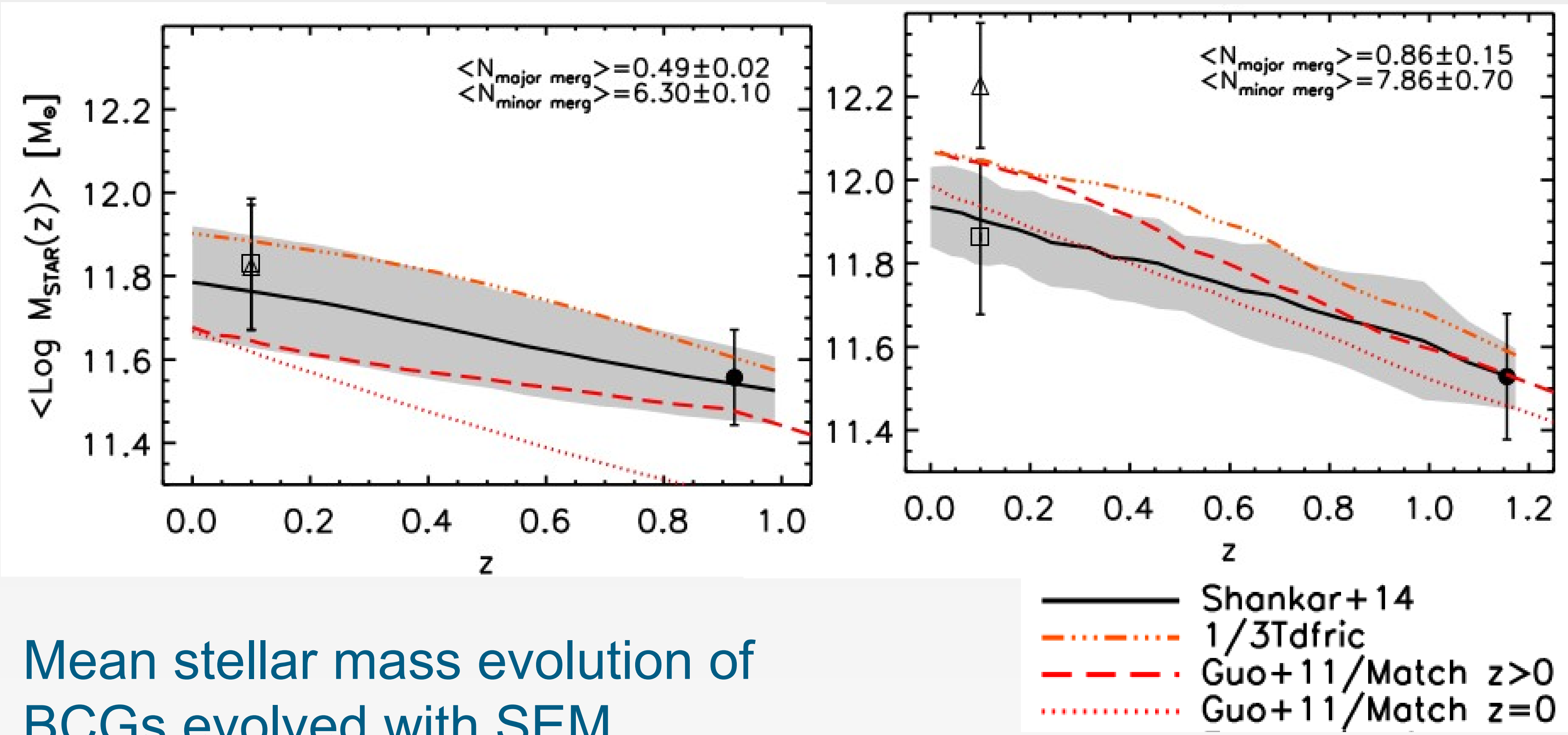


Predicted evolution of a central galaxy residing in a halo of mass $\sim 1.5 \times 10^{15} M_{\odot}$

Shankar, Buchan et al. 2015

SEM in action comparison with BCG data

log(Mhalo)=14 **log(Mhalo)=15**



Mean stellar mass evolution of BCGs evolved with SEM

Shankar, Buchan et al. 2015

A basic SEM supports a merger scenario for the most massive galaxies

However...

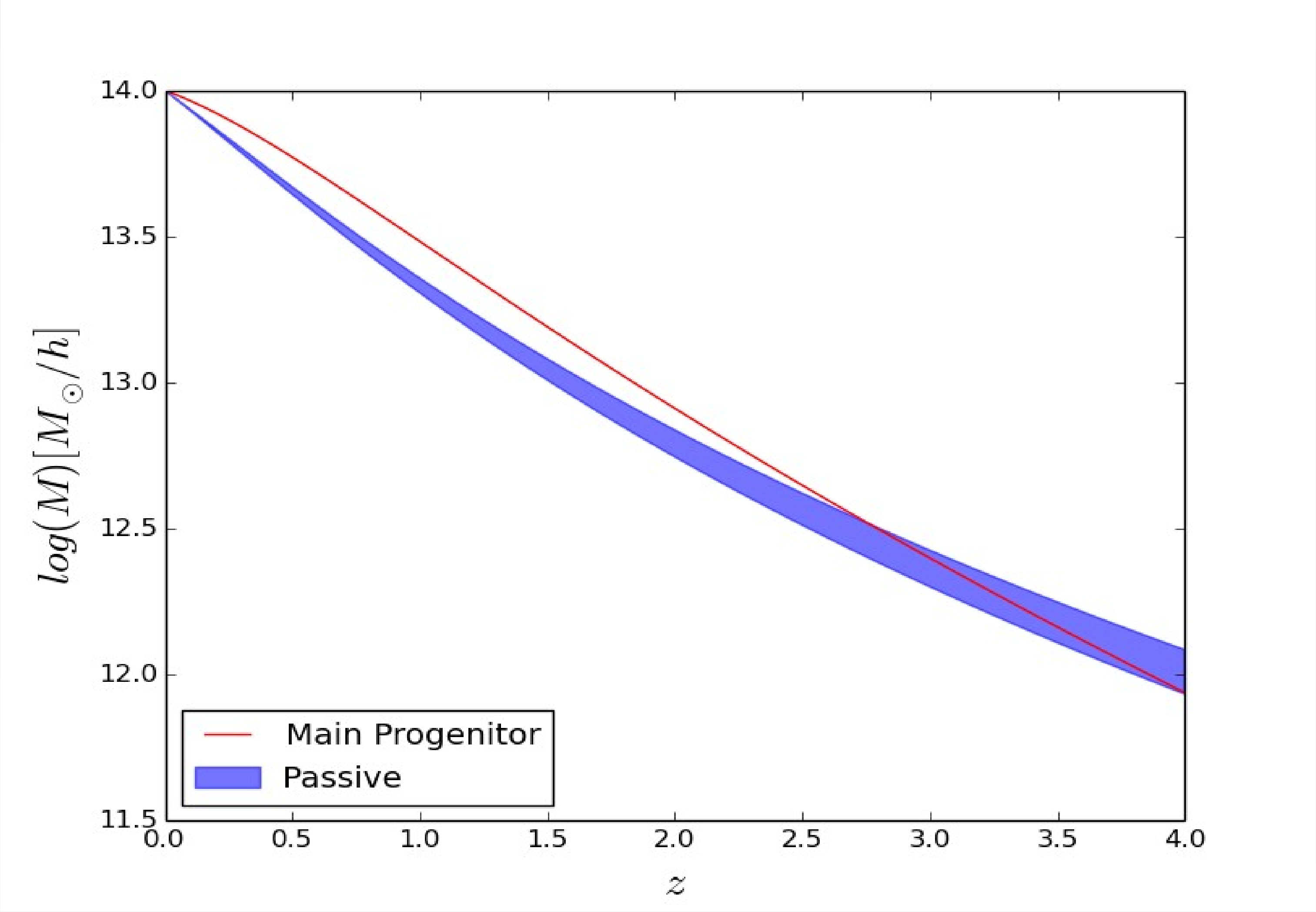
SEMs rely on having precise measurements from high redshifts which are still uncertain.

Surface brightness α $(1+z)^{-4}$?

Metallicity gradients?

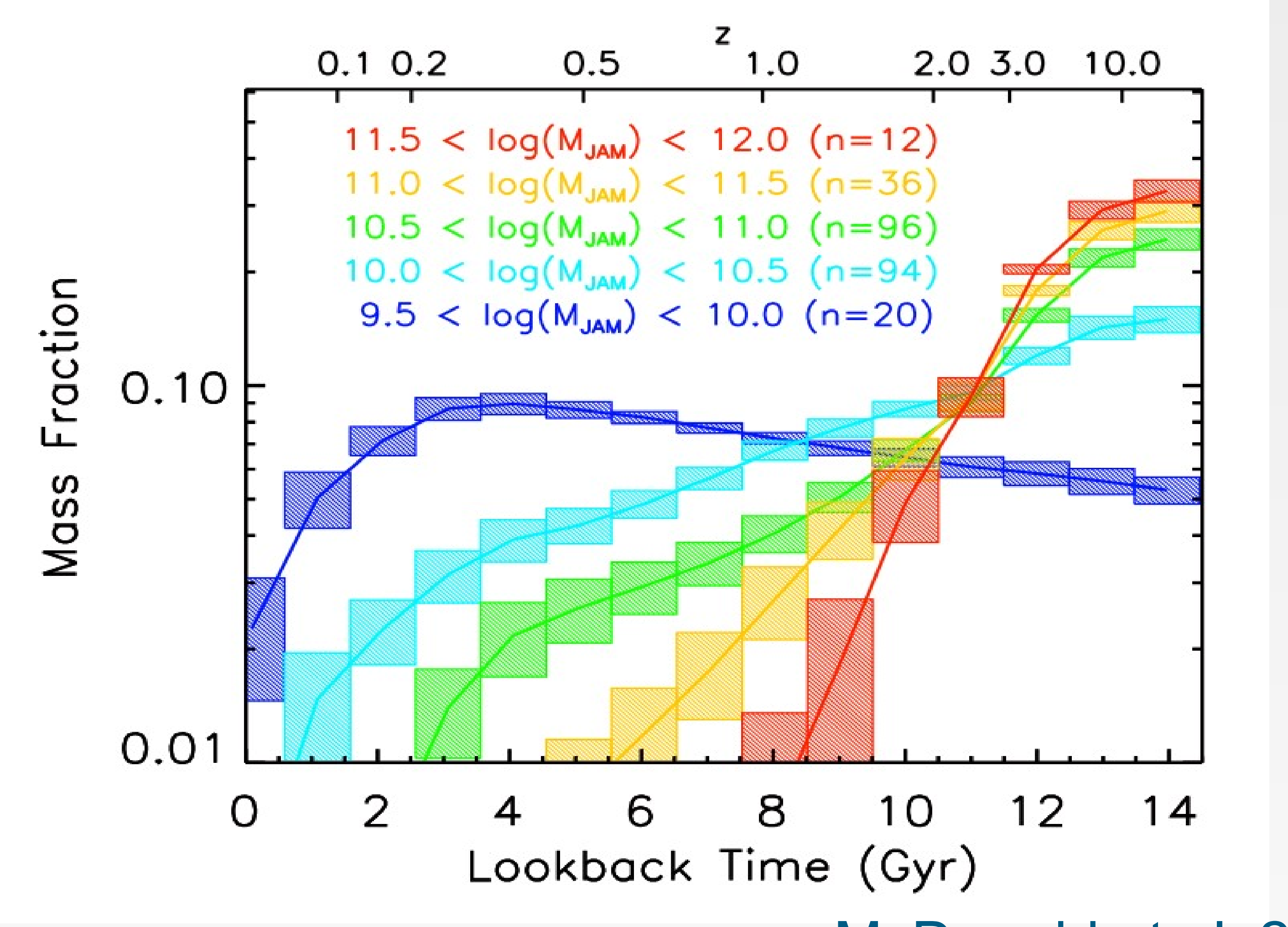
We can avoid these biases by combining constraints from local abundance matching and galaxy ages.

Start with halo mass accretion history



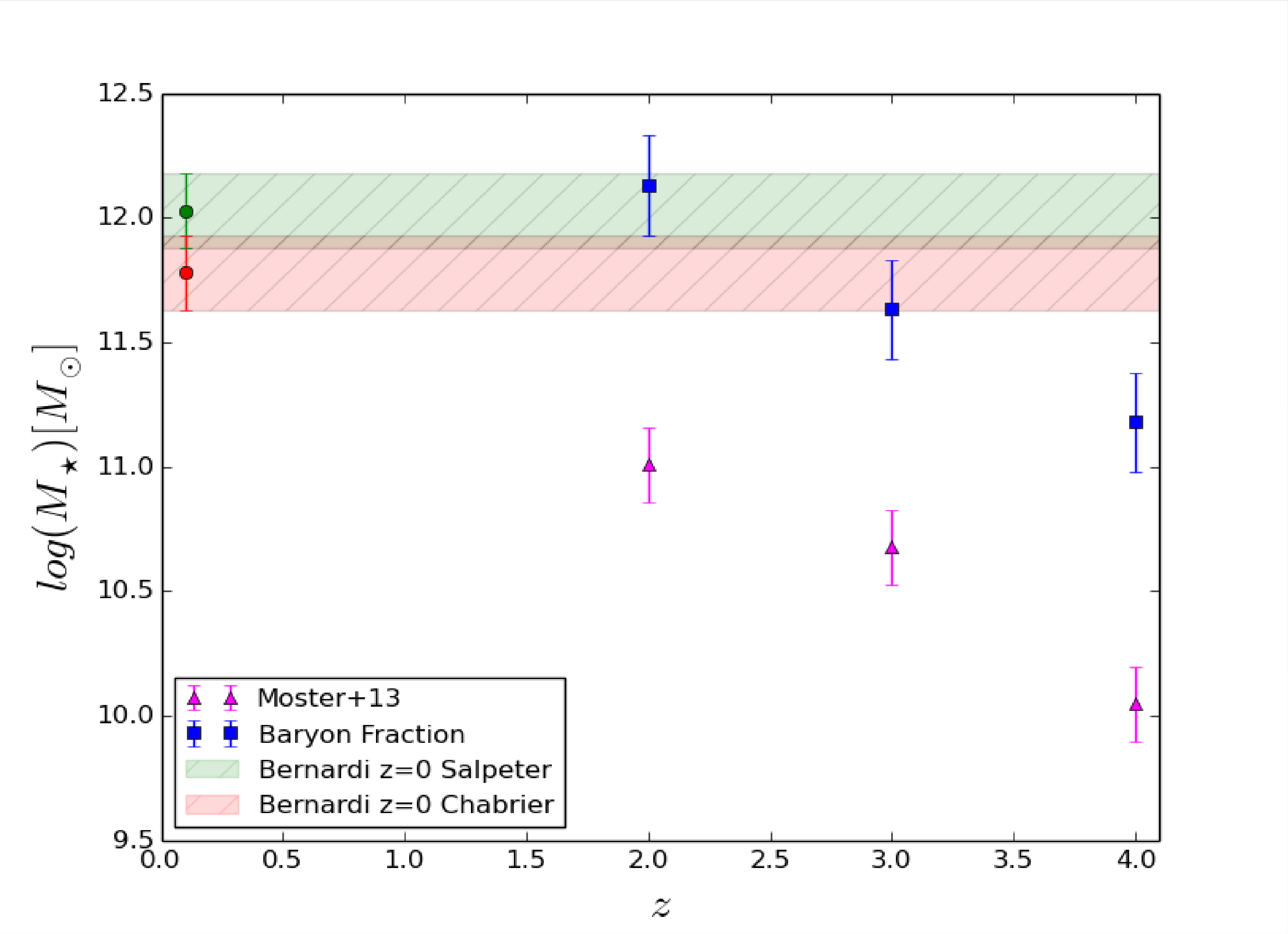
And the predicted ages of galaxies

Mass weighted age of stellar population



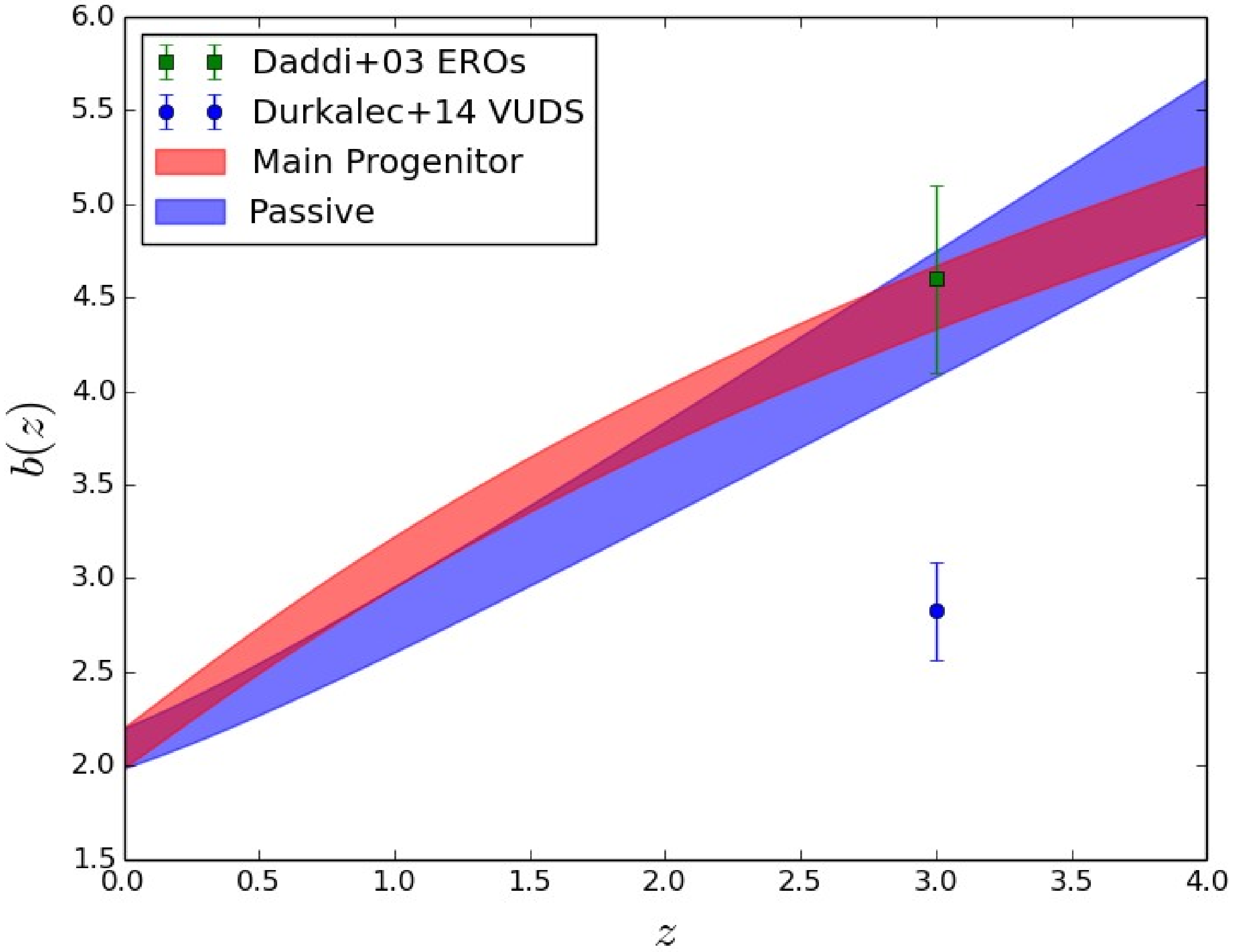
McDermid et al. 2015

Stellar mass of a $10^{14}M_\odot$ halo at z=0

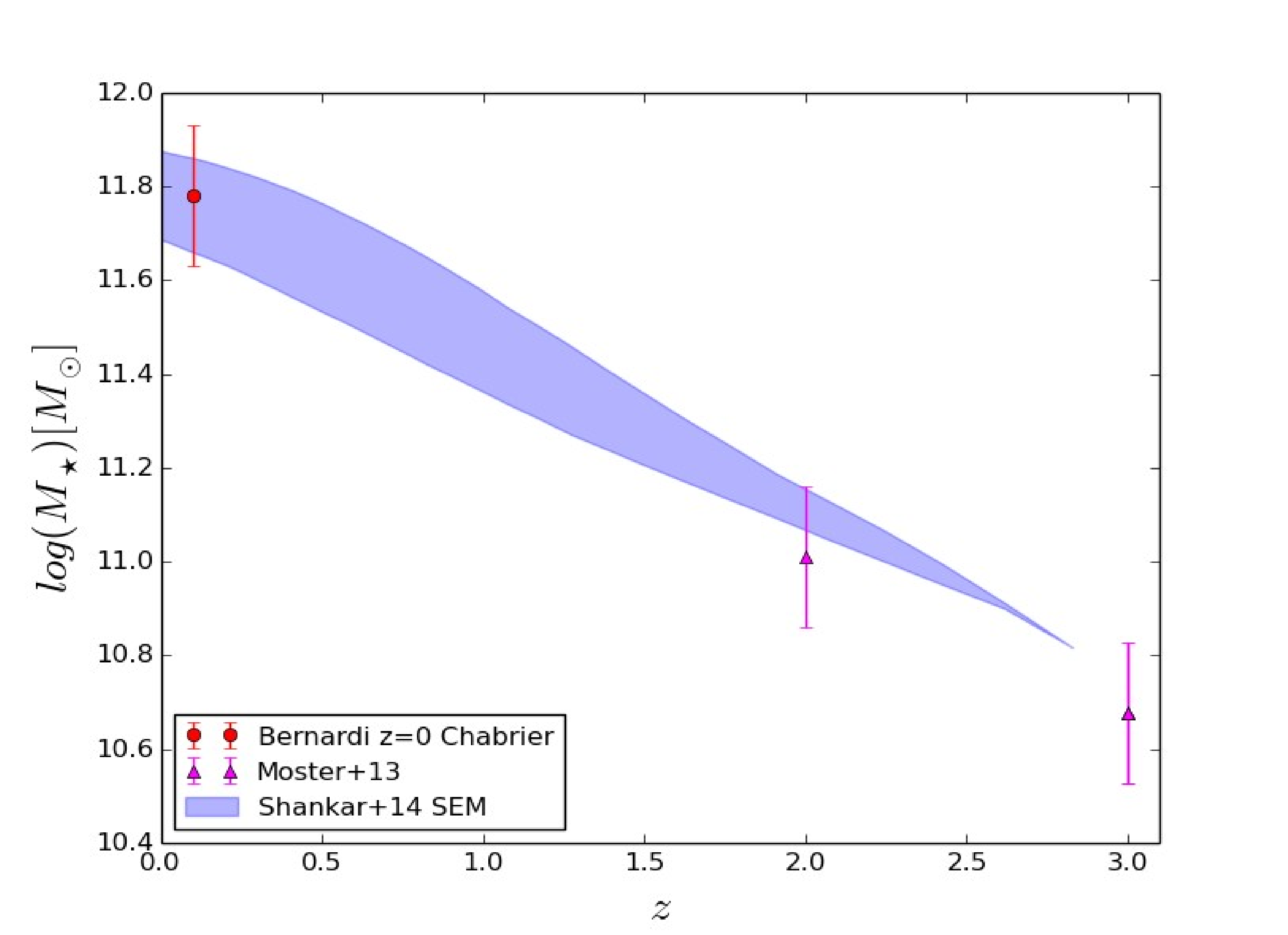


Buchan & Shankar in prep.

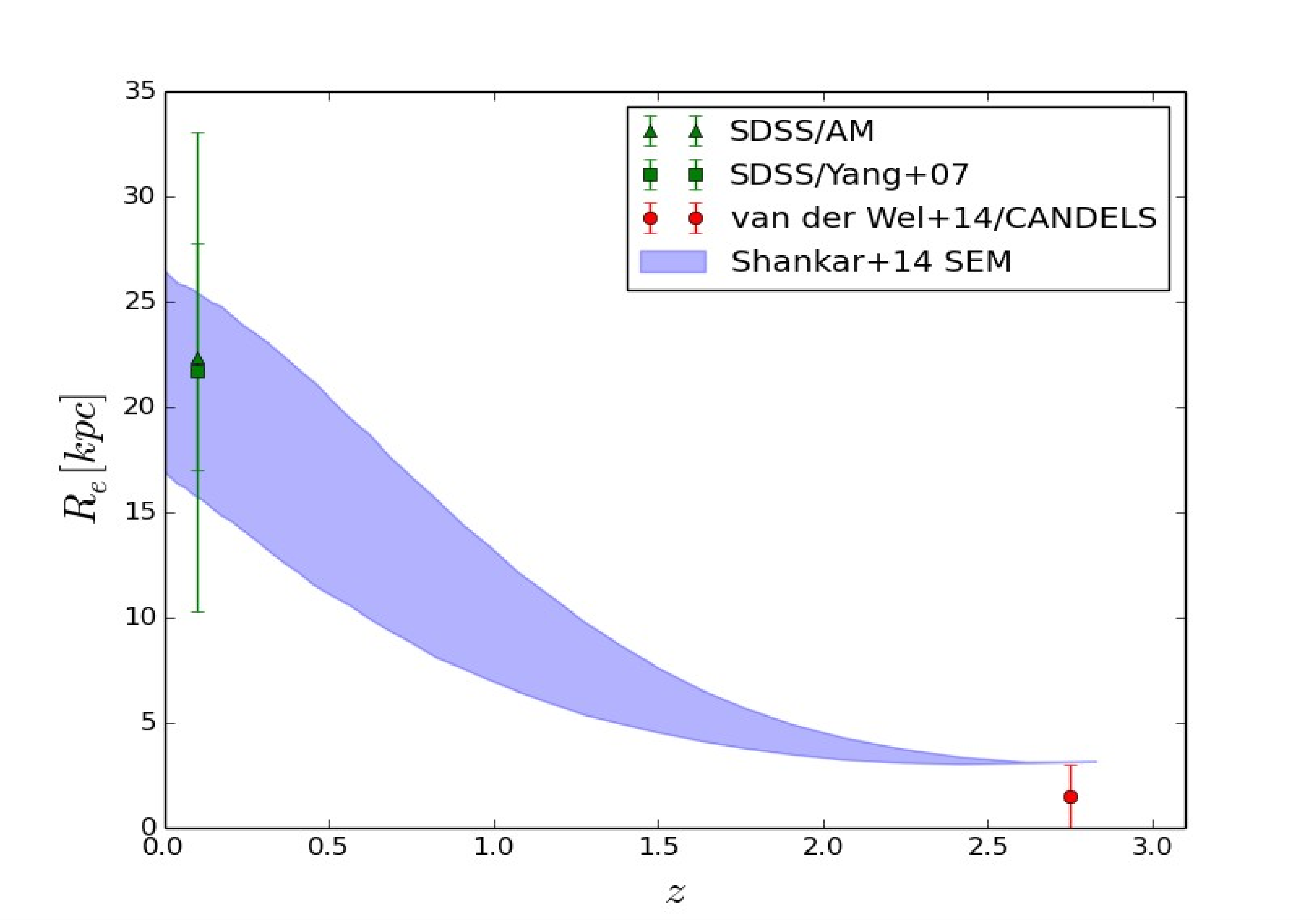
Comparing the halo bias to data



Galaxy grown with SEM through (mostly) mergers



Galaxy grown with SEM through (mostly) mergers



Summary

There is still degeneracy in the models:

How much in-situ vs mergers?

SEM based around mergers can reproduce mass and size evolution since z=1

Additional constraints from ages and local abundance matching favour a scenario where the stellar mass of BCGs increases dramatically since z=3

Progenitors of BCGs may be EROs.

This can be reproduced since z=3 in SEMs with mergers assuming moderately short tdyn and forb=0 although results are more tentative

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