The Impact of Positive AGN feedback on Galaxy Formation

Emanuele Contini, Sukyoung K. Yi, Seyoung Jeon and Jinsu Rhee
(Yonsei University, Seoul)

2024 KIAS Workshop
Gyeongju 27/10-02/11/2024

Positive AGN feedback (Cresci+15)

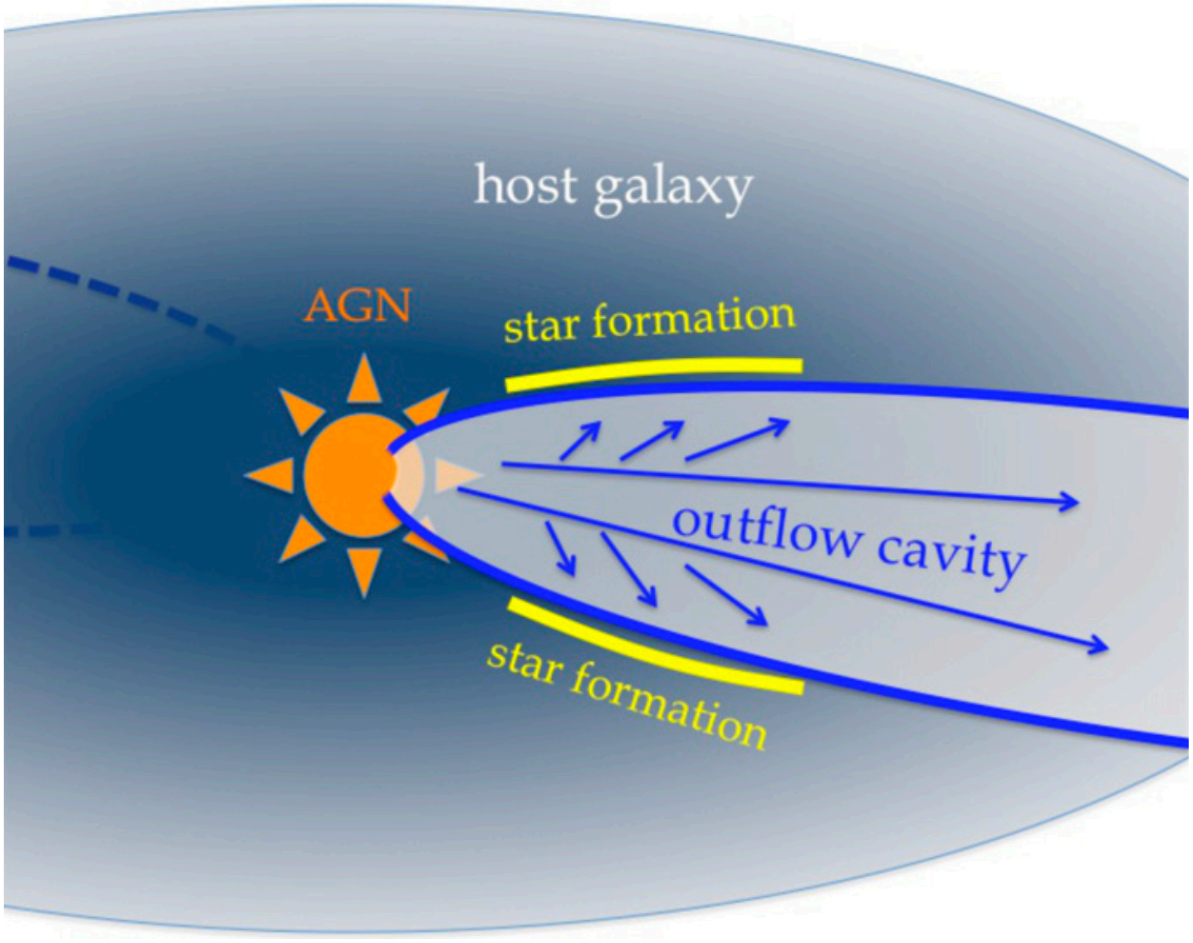


Figure 5. Schematic view of the geometry of the system. The high velocity material is sweeping the gas suppressing star formation in a cavity along the core of the outflow ("negative feedback"), but also triggering star formation by outflow induced pressure at the edges ("positive feedback").

FEGA (Contini+24)

- Infall and cooling of hot gas;
- Star formation (following the **extended Kennicutt-Schmidt relation**);
- Revised disk instability;
- Supernovae feedback;
- Gas stripping;
- Reincorporation of ejected gas;
- AGN feedback: negative and **positive**;
- Intracluster light: stripping of stars and mergers.

Calibrated using an **MCMC approach** on the observed evolution of the stellar mass function.

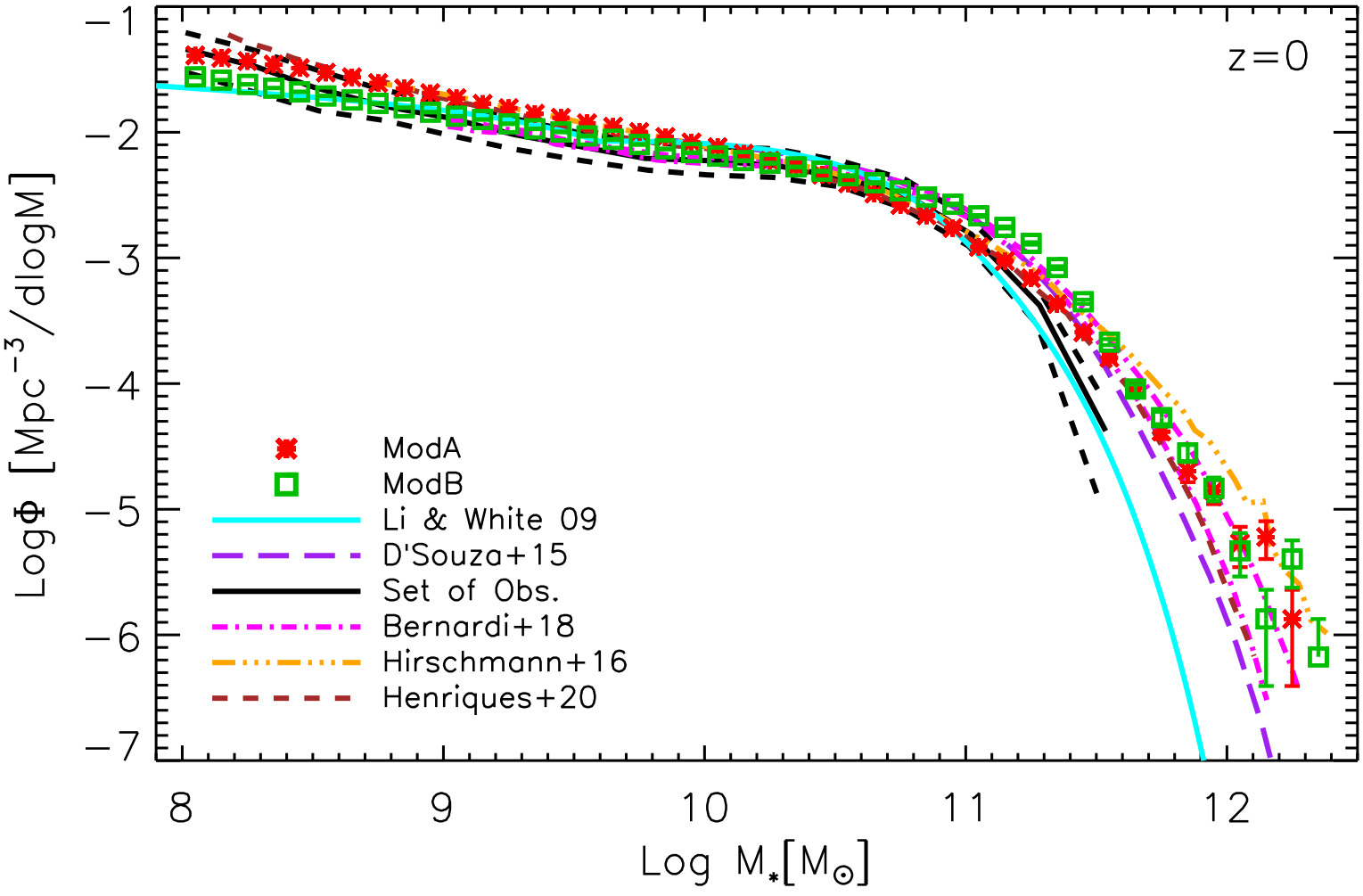
Positive AGN feedback Recipe

The model assumes a burst of star formation due to positive AGN feedback given by:

$$\dot{M}_* = \alpha_{\rm pAGN} \left(\frac{M_{\rm BH}}{10^8\, M_\odot/{\rm h}} \right)^{\beta_{\rm pAGN}} \dot{M}_{\rm cool}\,,$$

where $\dot{M}_*$, the rate of newly formed stars, is computed as a function of $\dot{M}_{\rm cool}$ and is proportional to the BH mass. The parameters $\alpha_{\rm pAGN}$ and $\beta_{\rm pAGN}$ govern the fraction of mass transformed into stars via burst.

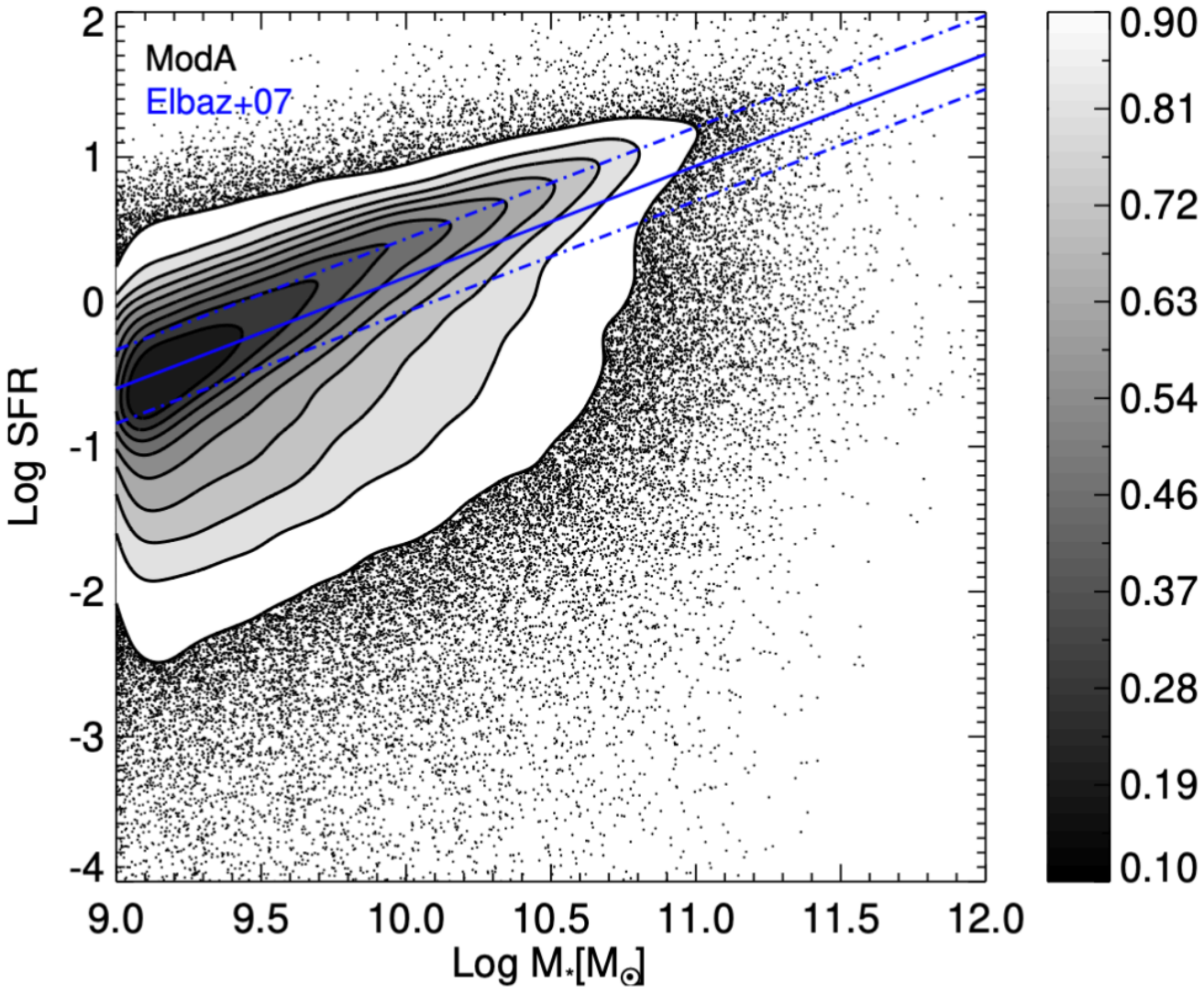
Stellar Mass Function at the present time



FEGA well reproduces the evolution of the SMF

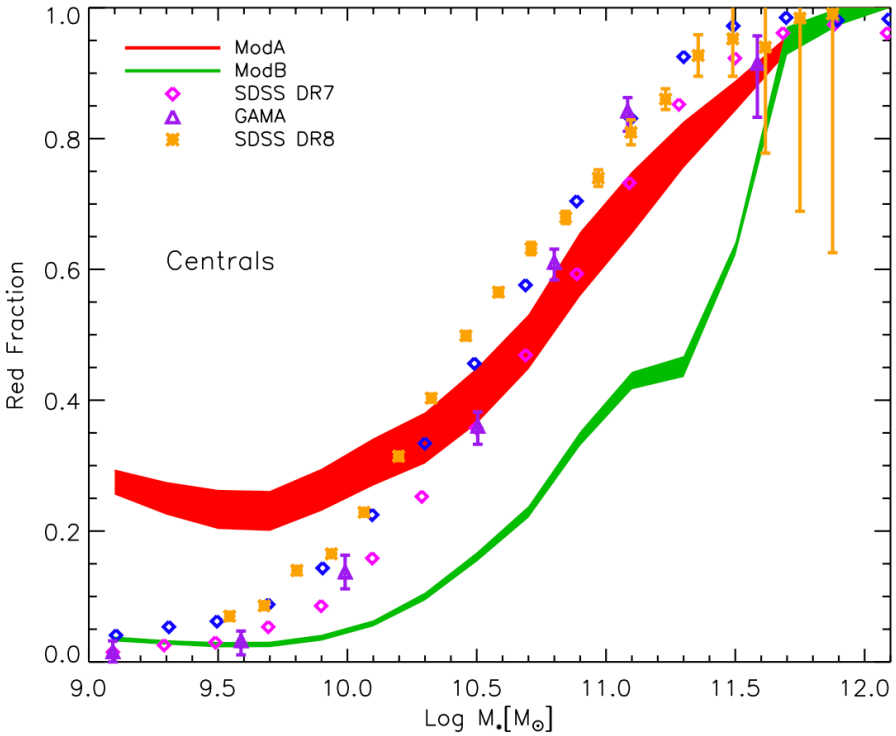
(I have the SMFs at higher redshifts if you want to see them...)

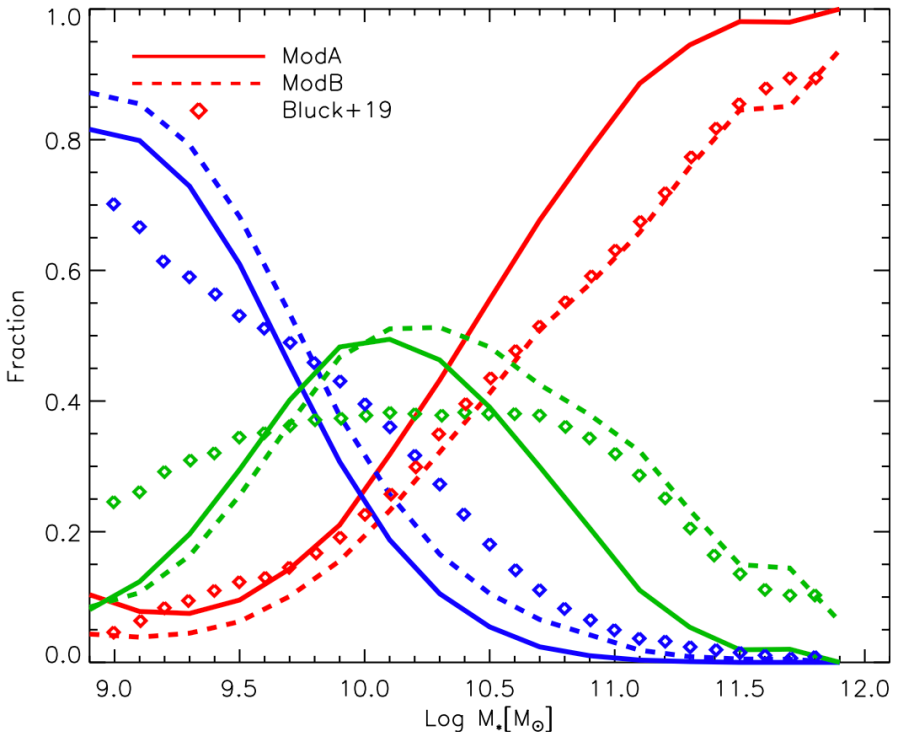
Star formation rate-stellar mass relation



Nice match with the observed blue sequence!

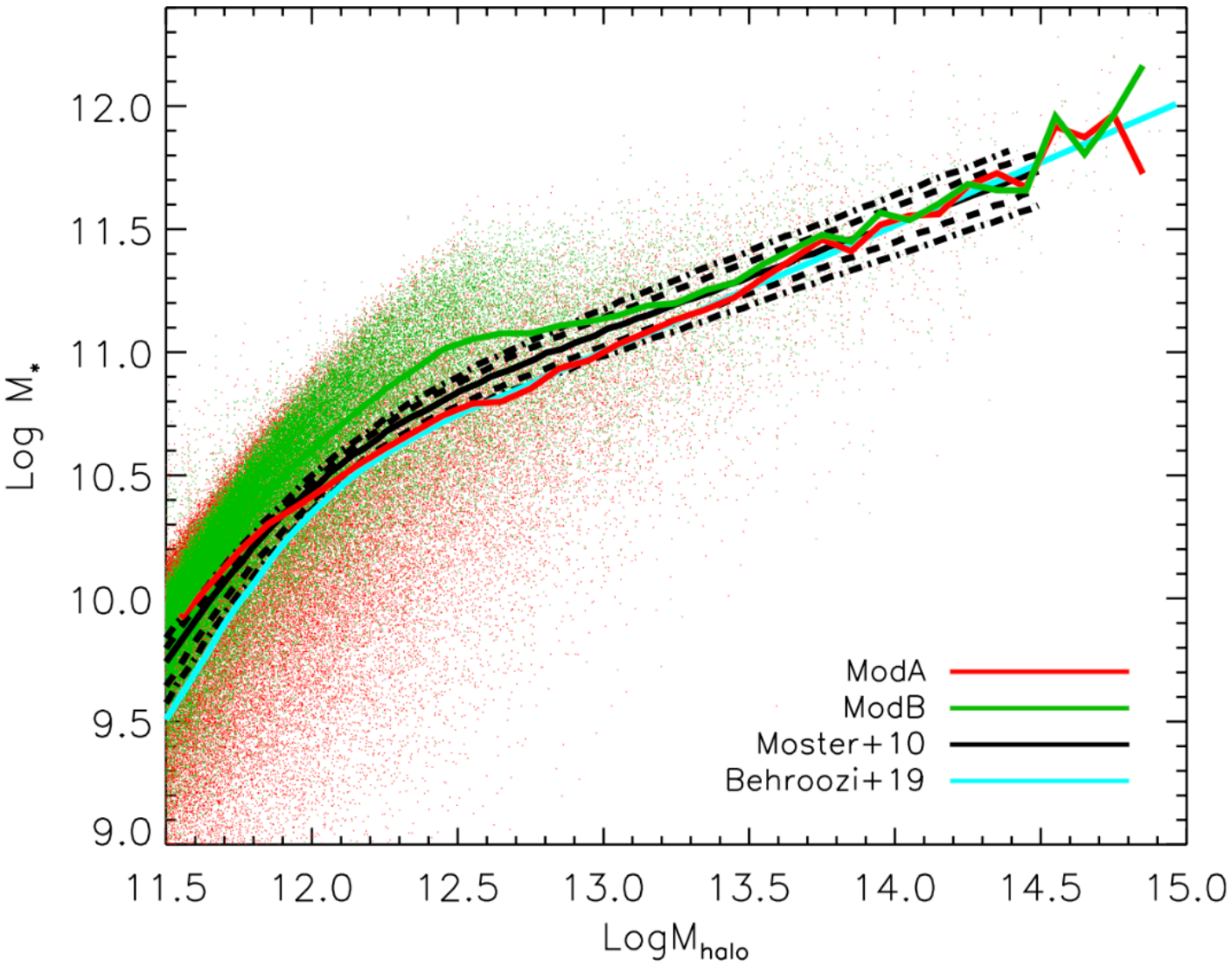
What about the morphology and red fraction?





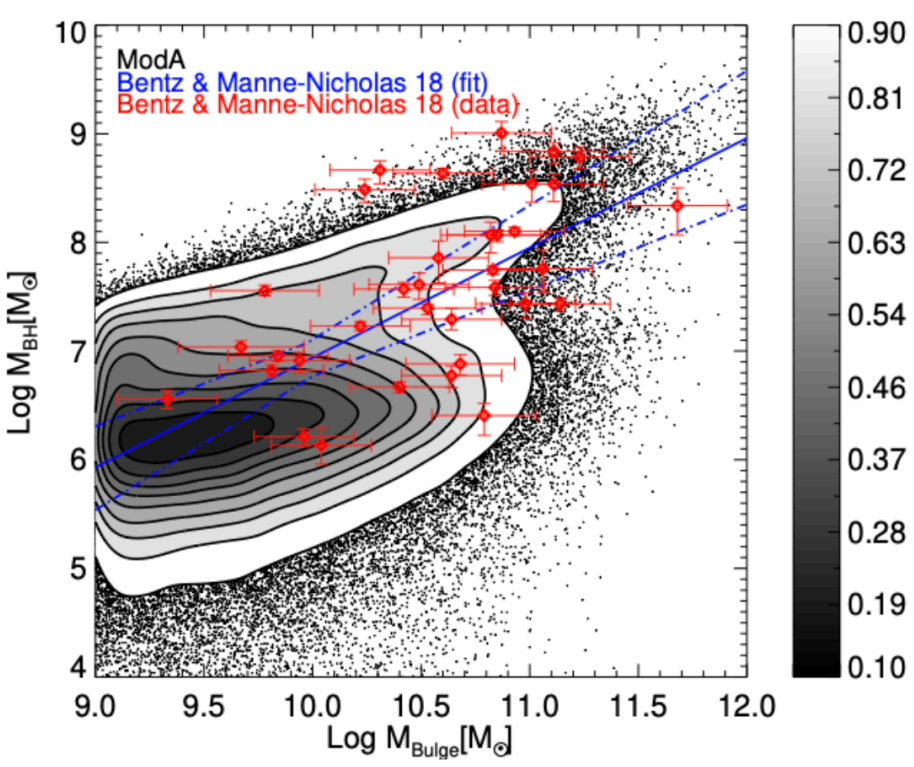
Amazing agreement with observations!
For the morphology, no SAM can do better.

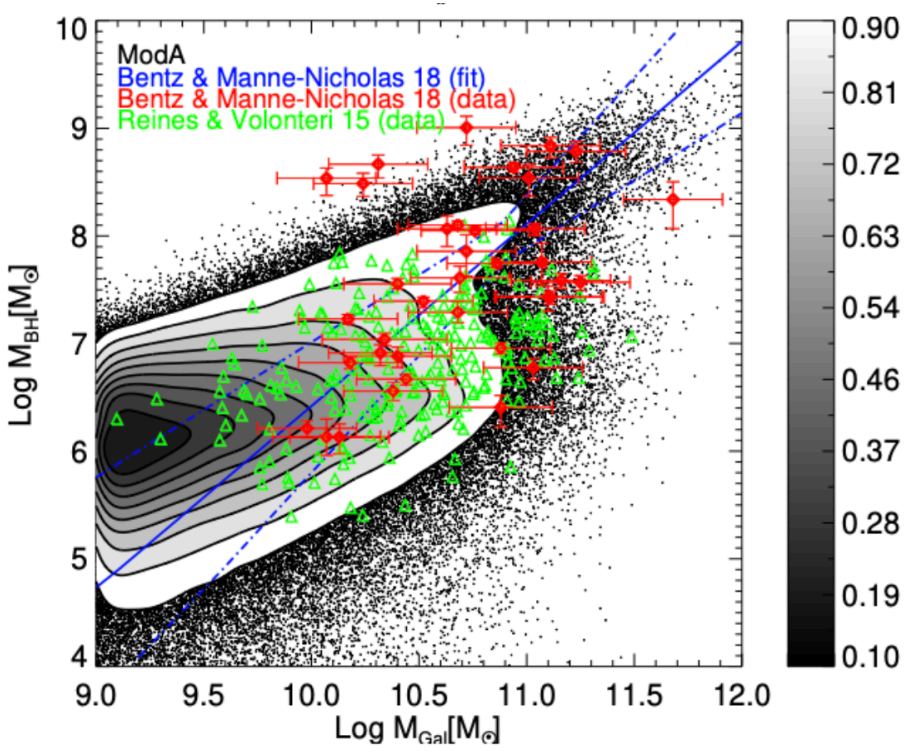
Stellar-to-Halo mass relation



Again, no SAM can do better than this!

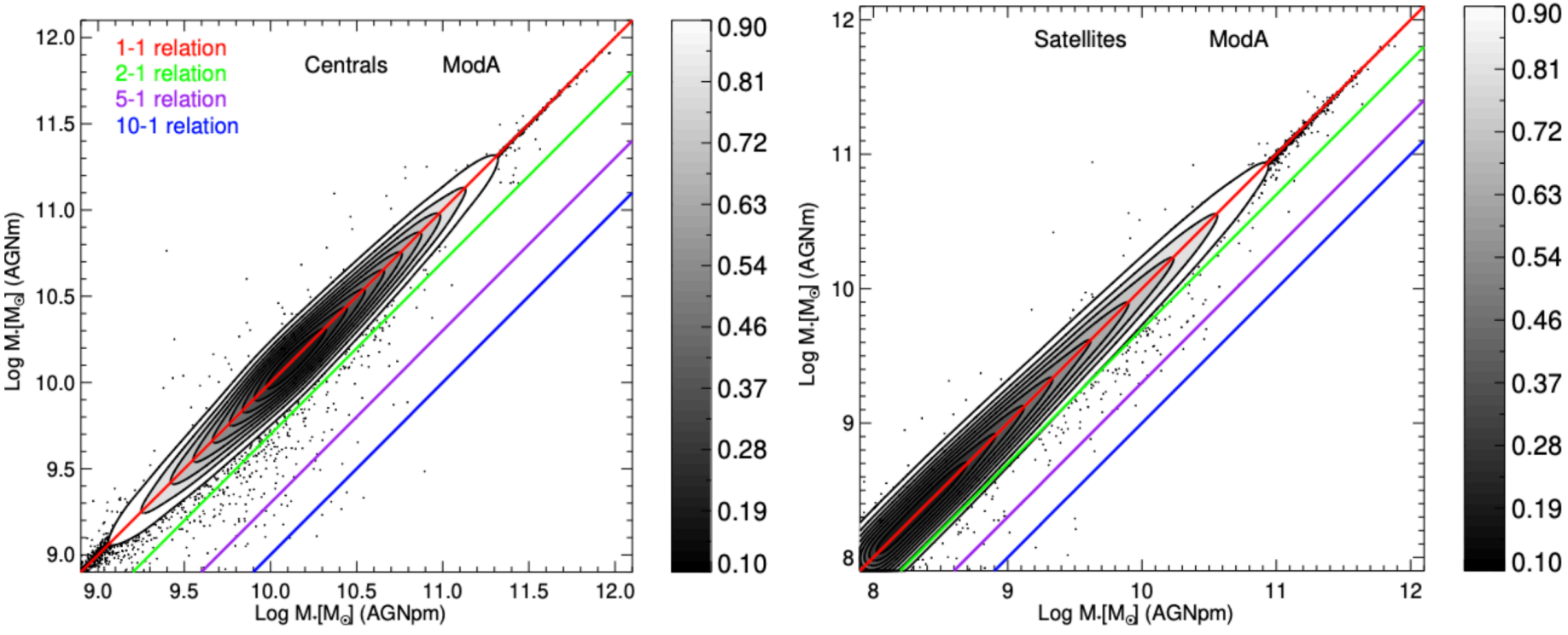
Black Hole-bulge/galaxy mass relation





Well reproduced, and both morphology-dependent
(I have the plots if you are curious...)

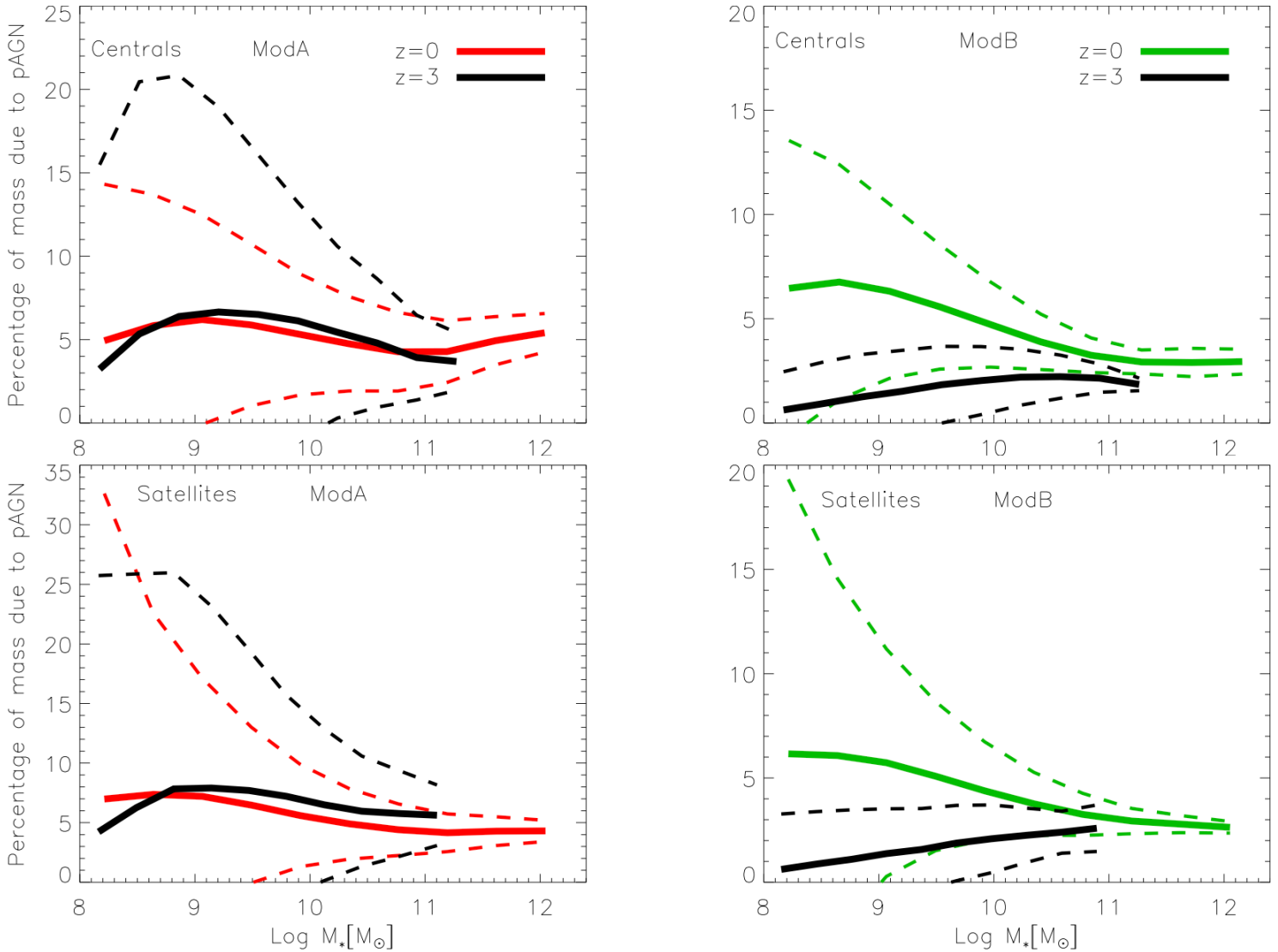
The importance of the positive mode of AGN feedback



Some galaxies grow a lot if the positive mode is on, some grow less!

Question: How do we quantify the growth due to positive AGN feedback?

The importance of the positive mode of AGN feedback II

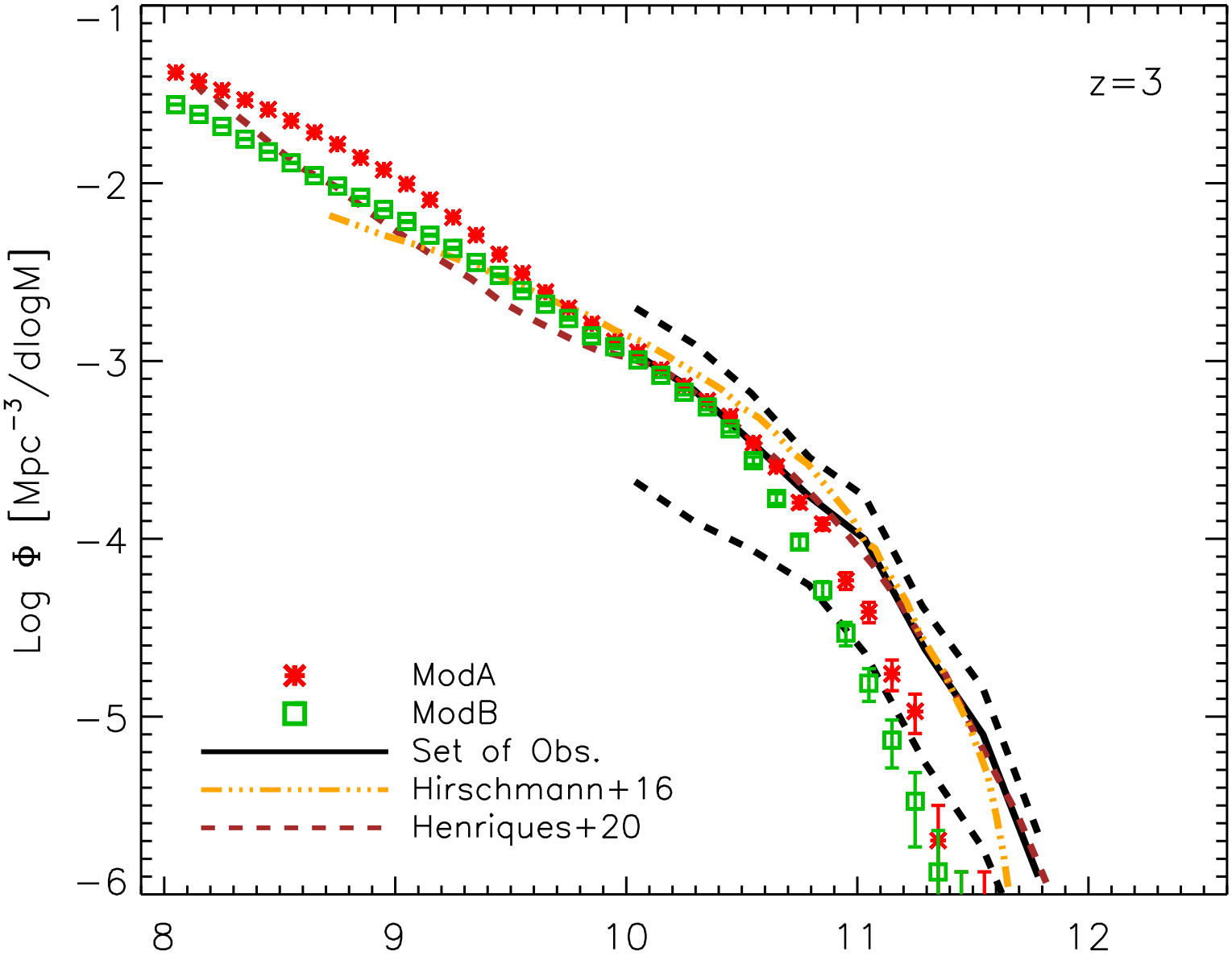


Both centrals and satellites grow, on average, around 5% due to pAGN feedback. Dwarfs show a larger scatter.

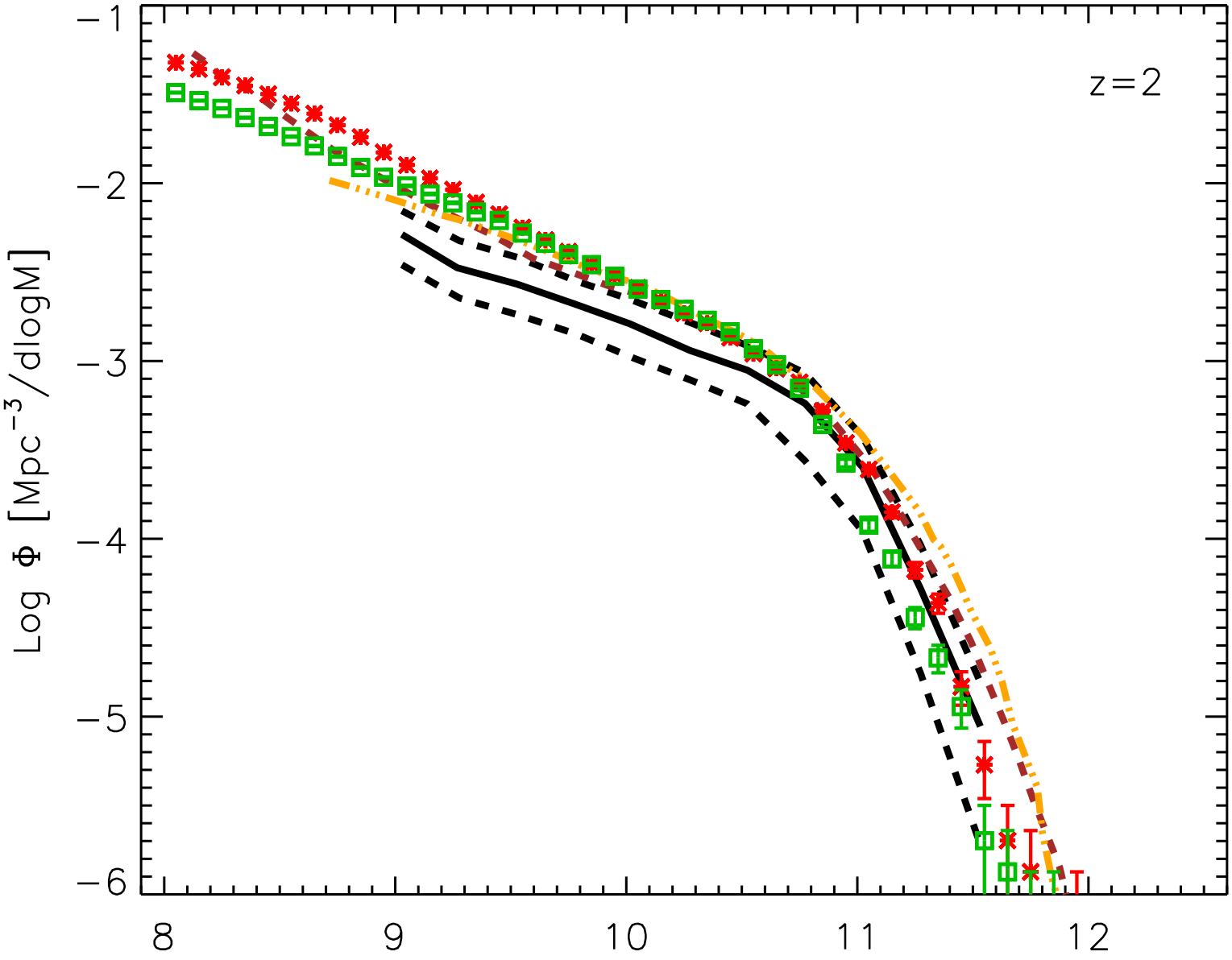
Take home messages

- FEGA is capable of reproducing the most important properties of galaxies, and their relations;
- **The positive AGN feedback can co-exist with its negative counterpart**;
- **The positive mode is stronger at higher redshift** and decreases with increasing stellar mass (as predicted by Silk's theory), if the scatter is included.

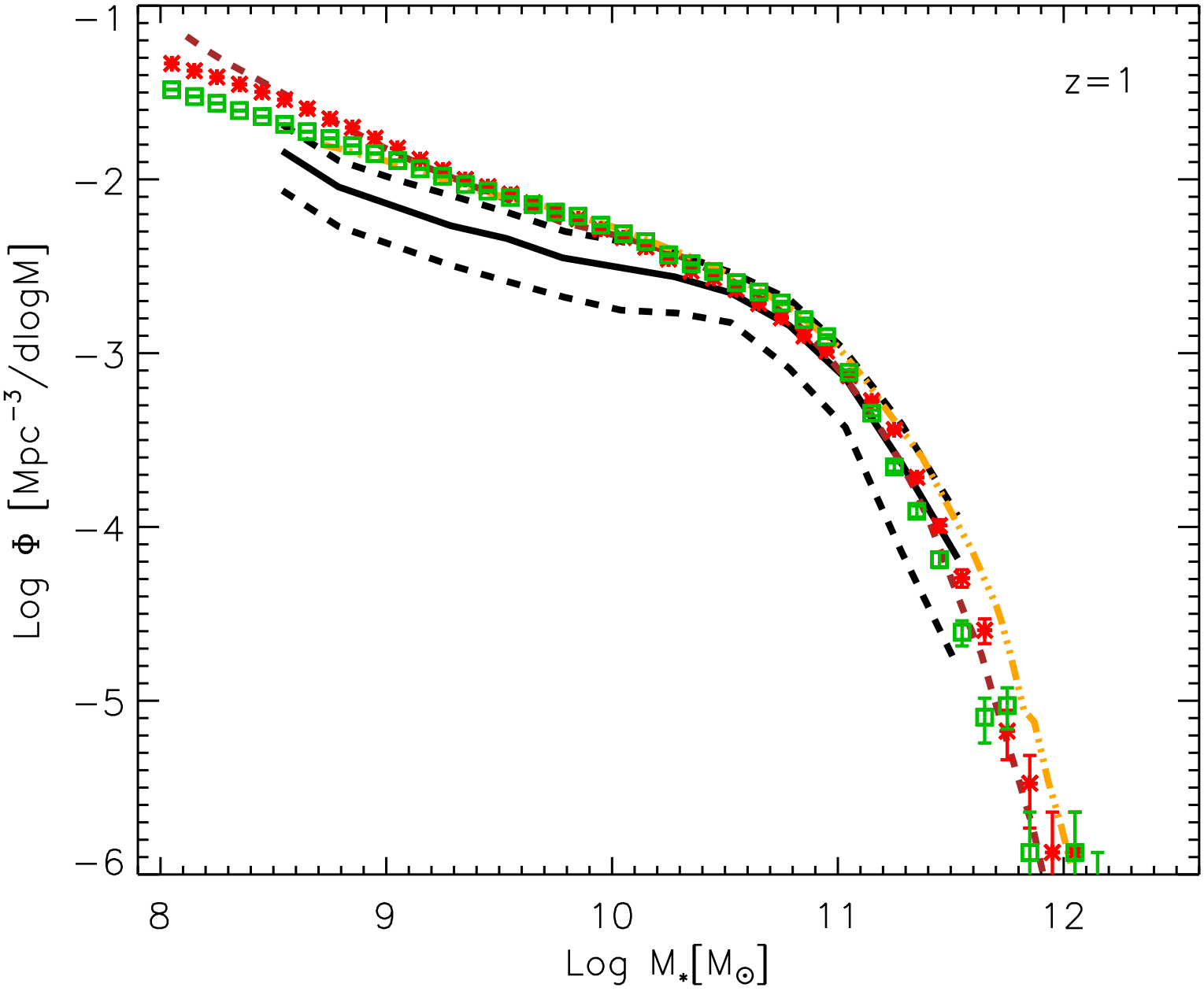
SMF $z = 3$


z=3
Log Φ [Mpc^{-3}/dlogM]
−1
−2
−3
−4
−5
−6
8
9
10
11
12
ModA
ModB
Set of Obs.
Hirschmann+16
Henriques+20

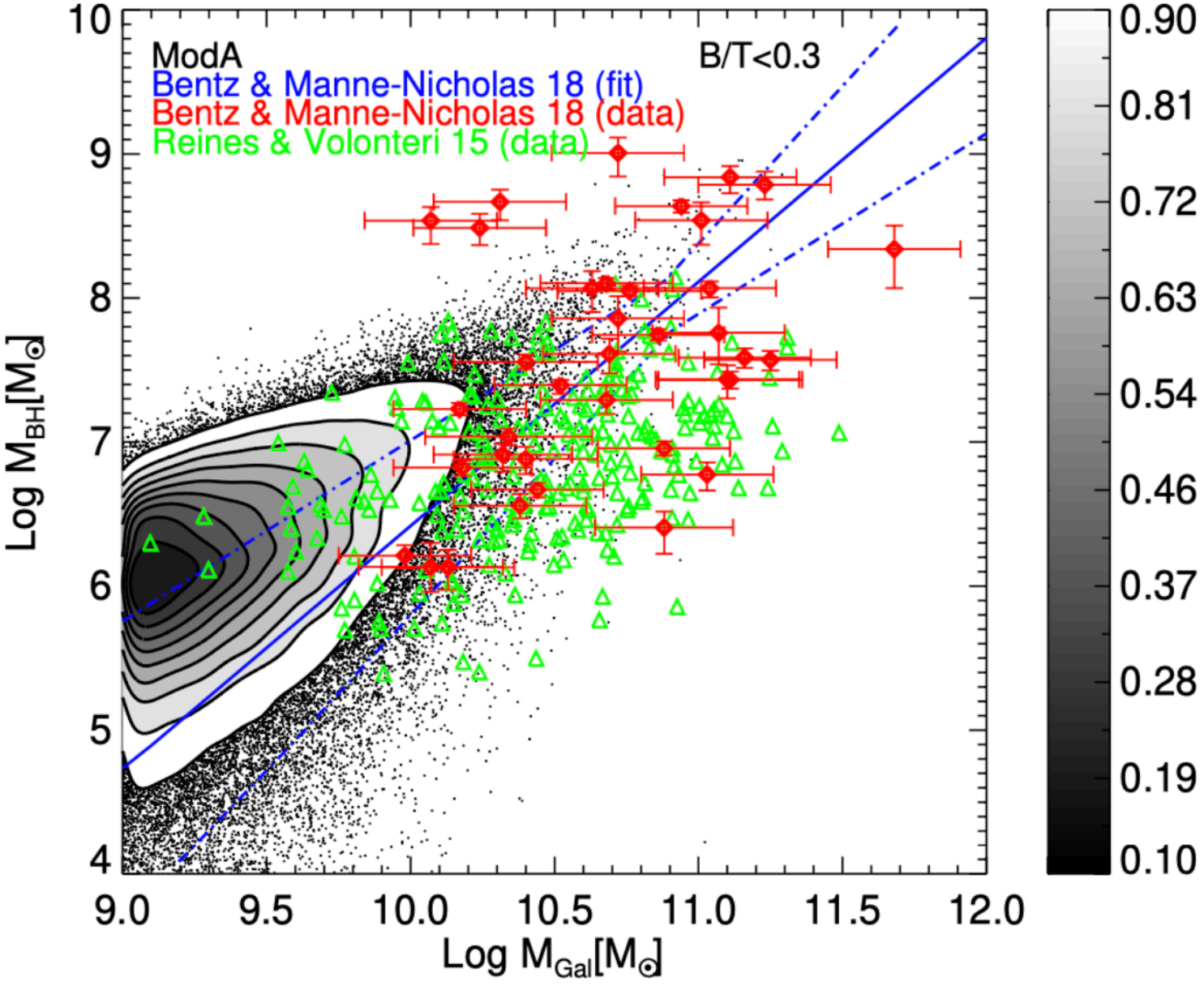
SMF $z = 2$



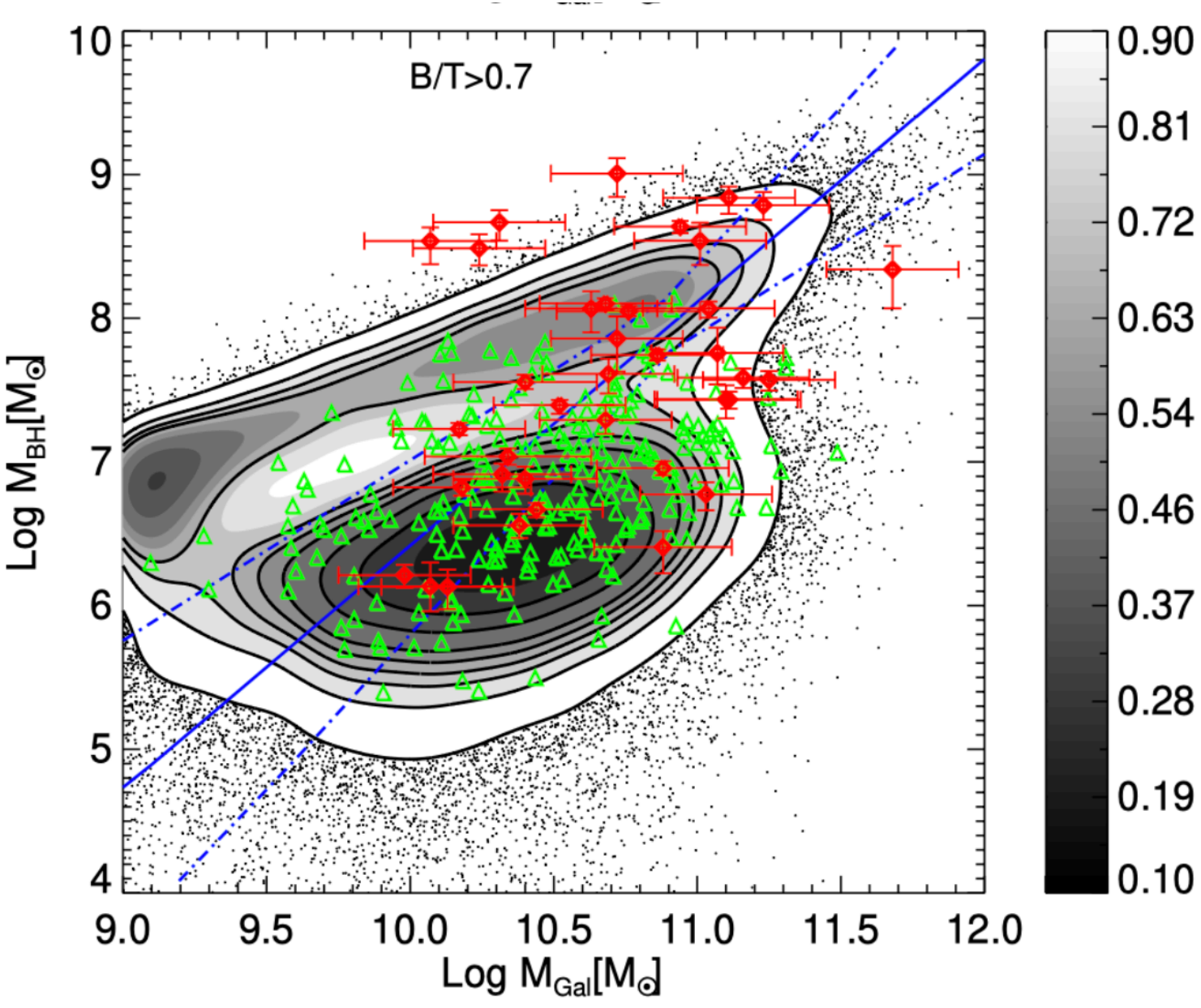
SMF $z = 1$



Spirals


ModA
B/T<0.3
Bentz & Manne-Nicholas 18 (fit)
Bentz & Manne-Nicholas 18 (data)
Reines & Volonteri 15 (data)
Log M_BH[M_⊙]
Log M_Gal[M_⊙]
10
9
8
7
6
5
4
9.0
9.5
10.0
10.5
11.0
11.5
12.0
0.90
0.81
0.72
0.63
0.54
0.46
0.37
0.28
0.19
0.10

Ellipticals



Lenticulars

