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Modeling the growth of massive galaxies via mergers: A Semi Empirical approach

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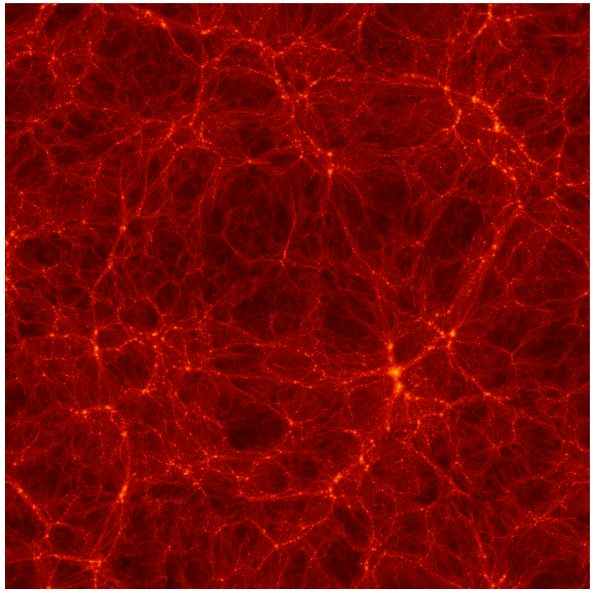
Outline Of Talk

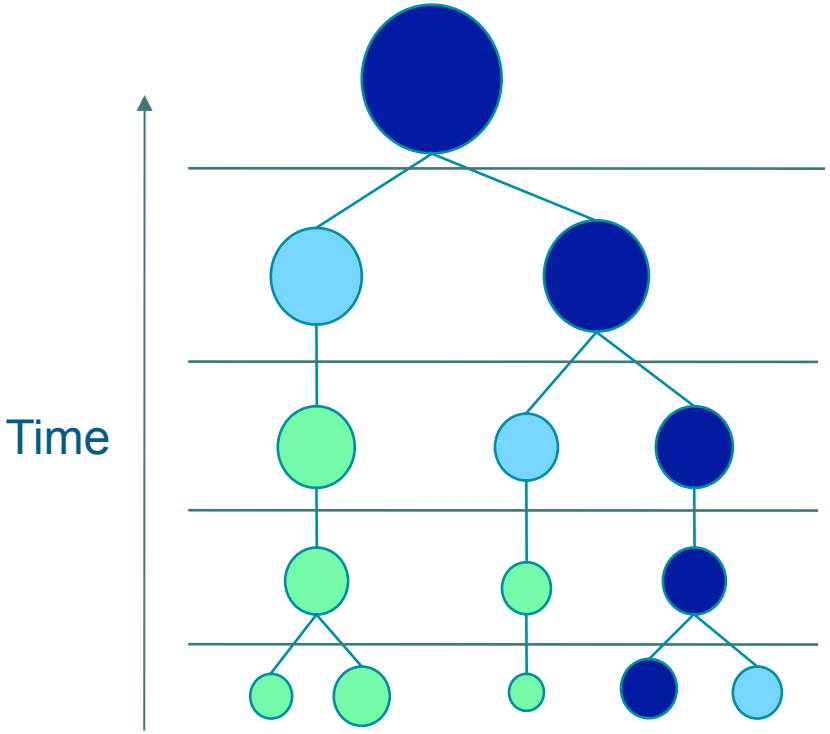
- Semi Empirical Approach
- Merger Driven Morphological Change
- Empirical Advantages

What is Semi Empirical Modelling

- Complementary to Semi-Analytic and Hydro
- Informed by observation reducing parameters
- Flexible modelling

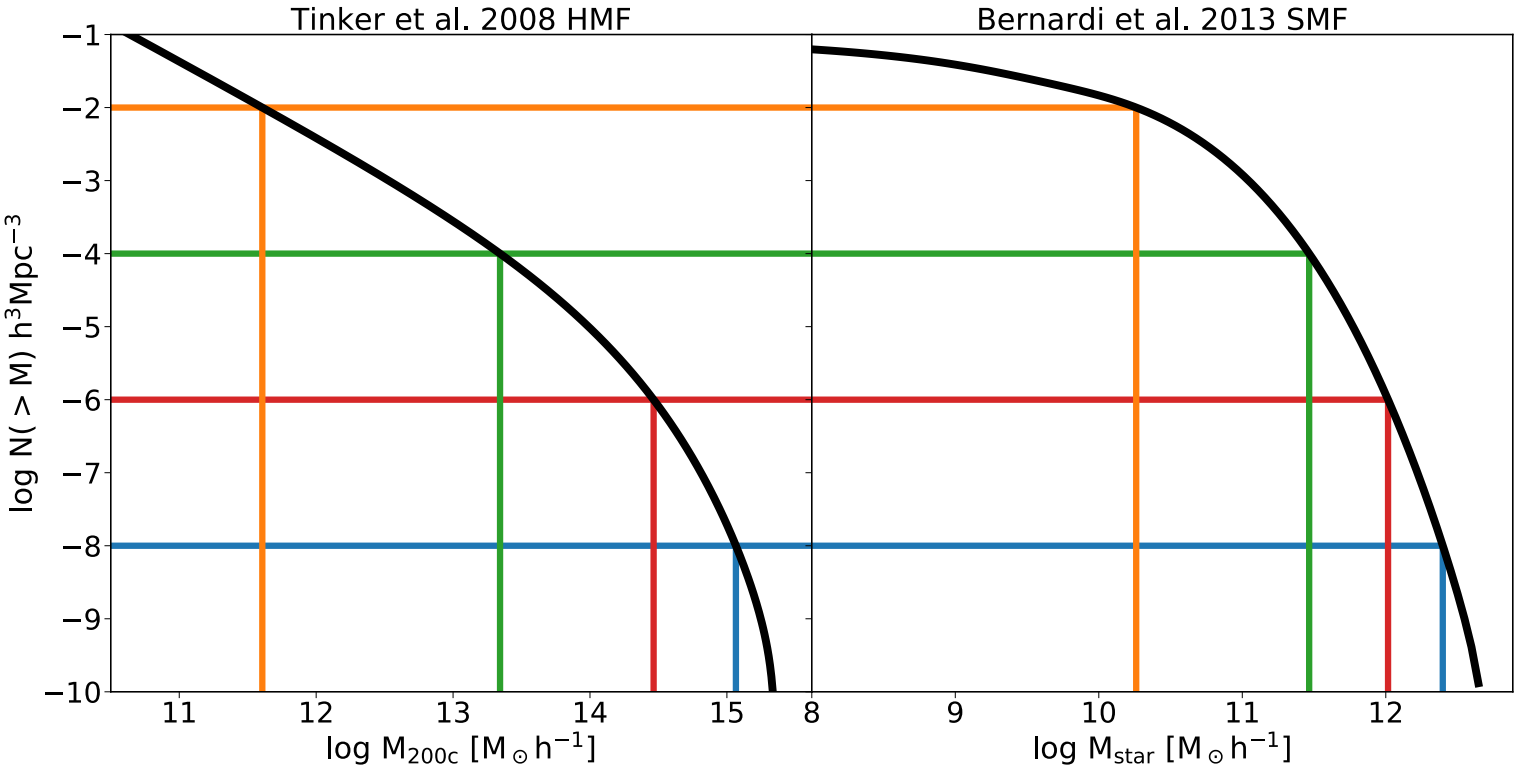
Our Model – 1:Halo Merger Trees





Bolshoi-Planck dark matter merger trees (Klypin et al. 2016)

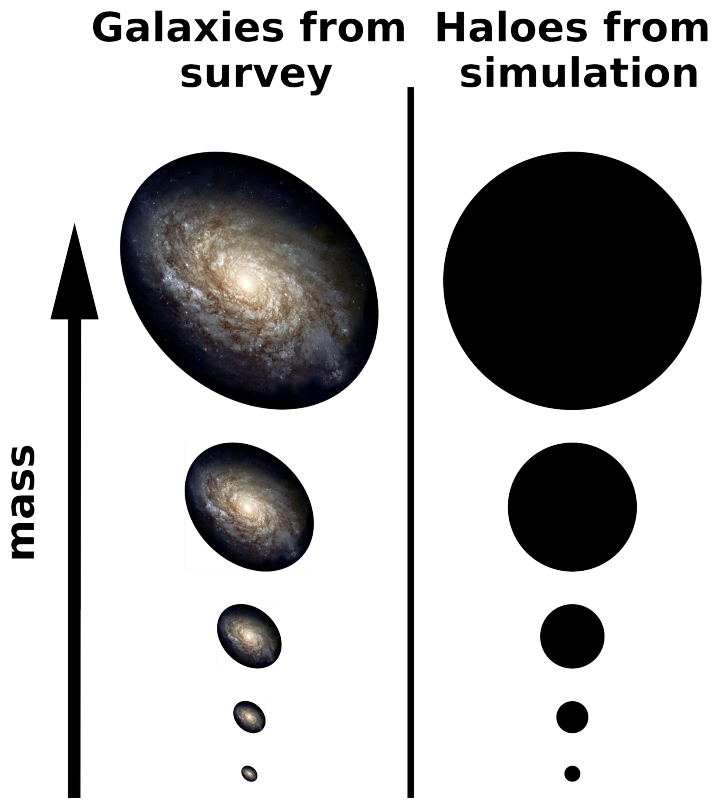
Our Model - 2:Abundance Matching



Our Model – 3:Assigning Galaxy Properties

Stellar Mass informs

- Star Formation Rate[1]
- Disk Size[2]
- Gas Fraction[3]



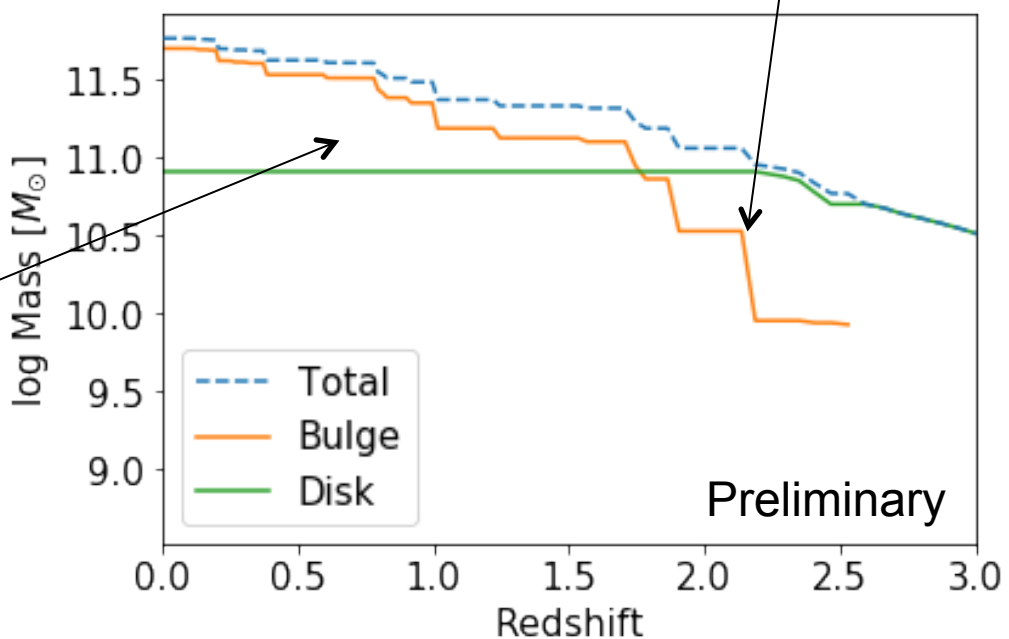
1. Tomzac 2016, 2.Shen 2003, 3.Upper Limit given by Stewart 2009

Mergers- Morphological drivers

- Starburst – Rapid conversion of gas to stars
- Distribution of gas and stellar mass*
- Major morphological change

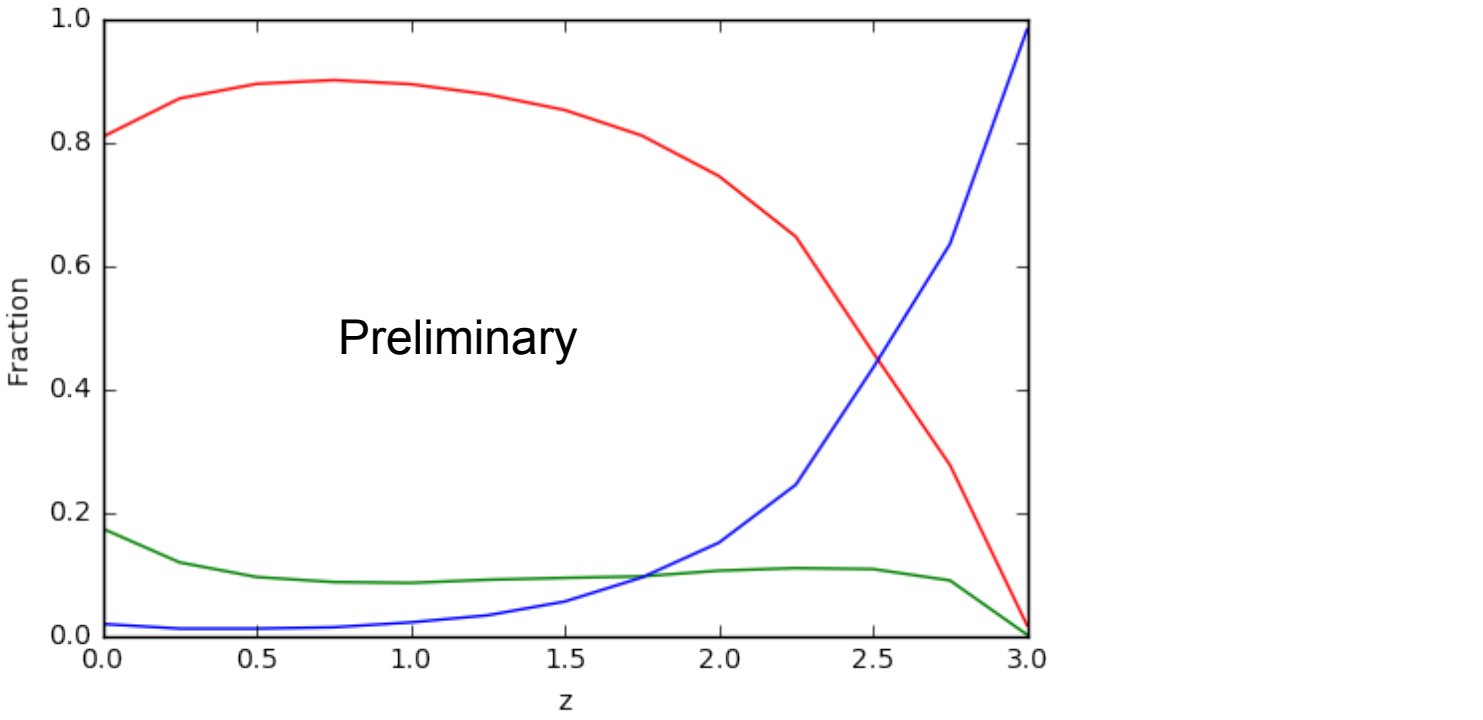
Minor mergers are driving a morphological change in the galaxy from a late type disk (low B/T) to an early type (high B/T)

We eventually see the galaxy growth is satisfied entirely by mergers.

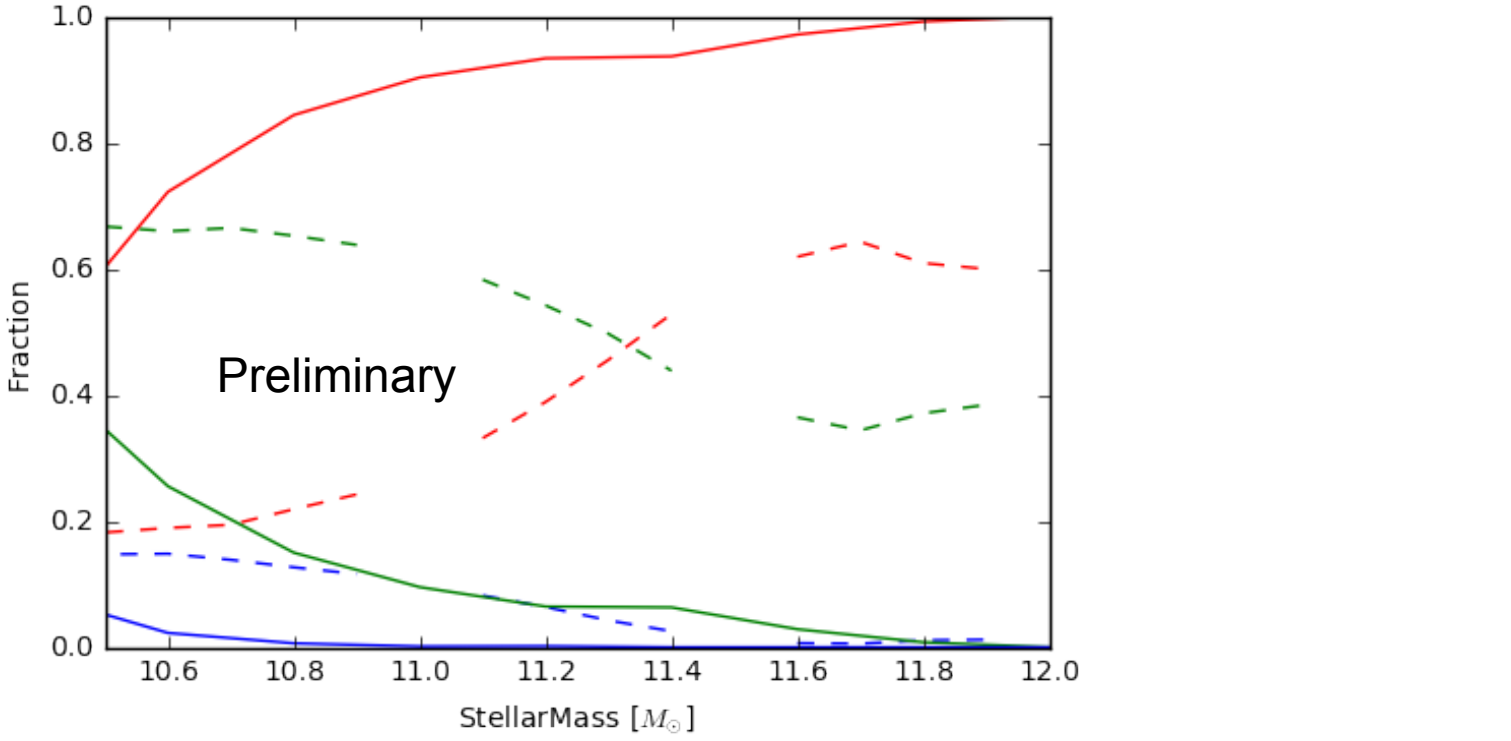


*Methods inspired by Hopkins et al 08 and Cole et al 2000

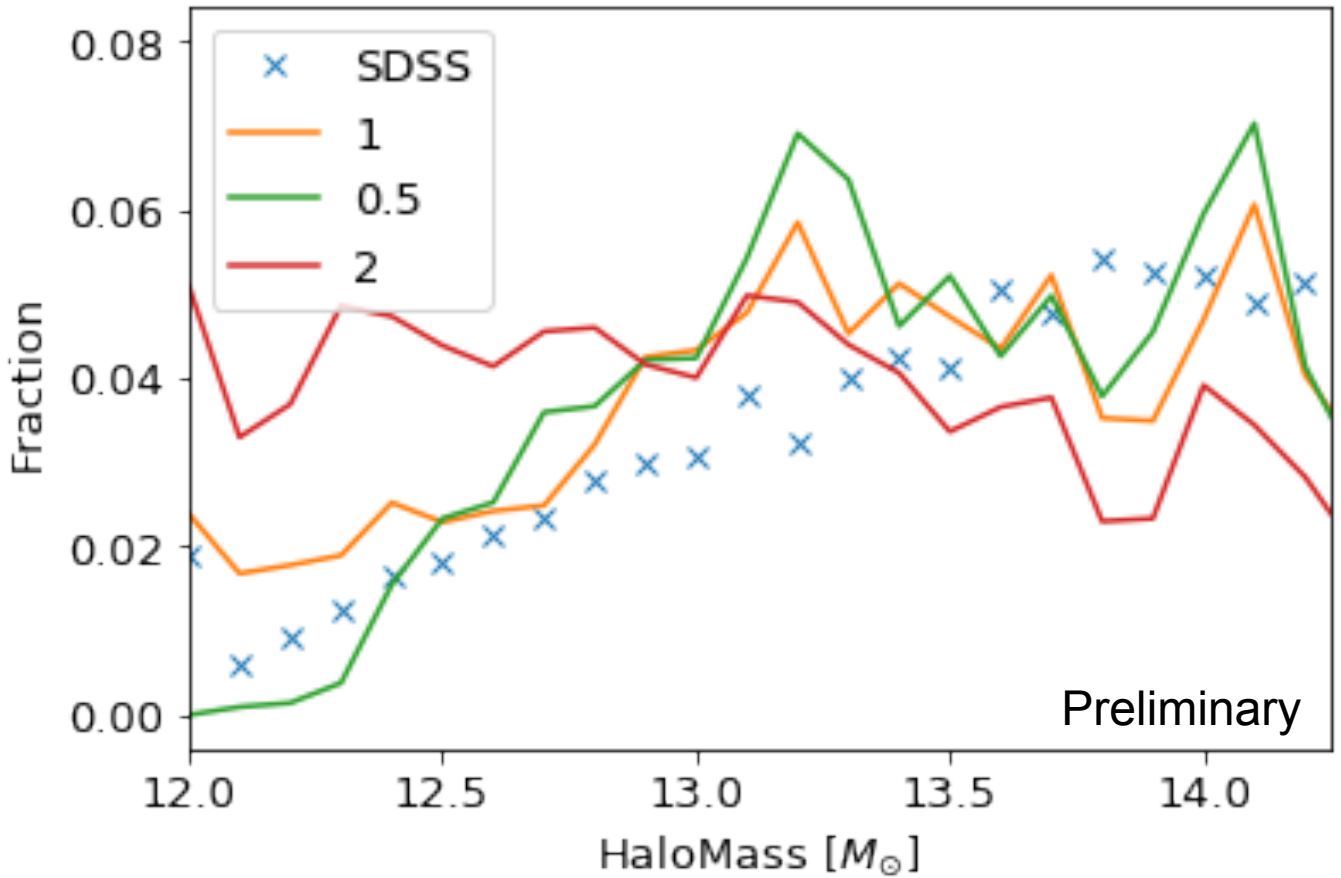
Results - Morphology by Redshift



Results - Morphology by Mass



Satellite Fractions



For satellites above 10^{10}

What do we gain through the empirical approach

- Avoid growing galaxies from first principles, lowering assumptions
- Our (re)initialization routine can ensure that we are probing the role of mergers exclusively
- We can be flexible to new data or new models without the need for significant retuning

Conclusions

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-We have developed a **flexible** lightweight model, facilitating **rapid development** and testing of new models.

-We test if **mergers alone** can create the observed morphology mix.

-Future work will test the impact of instability and disk regrowth.

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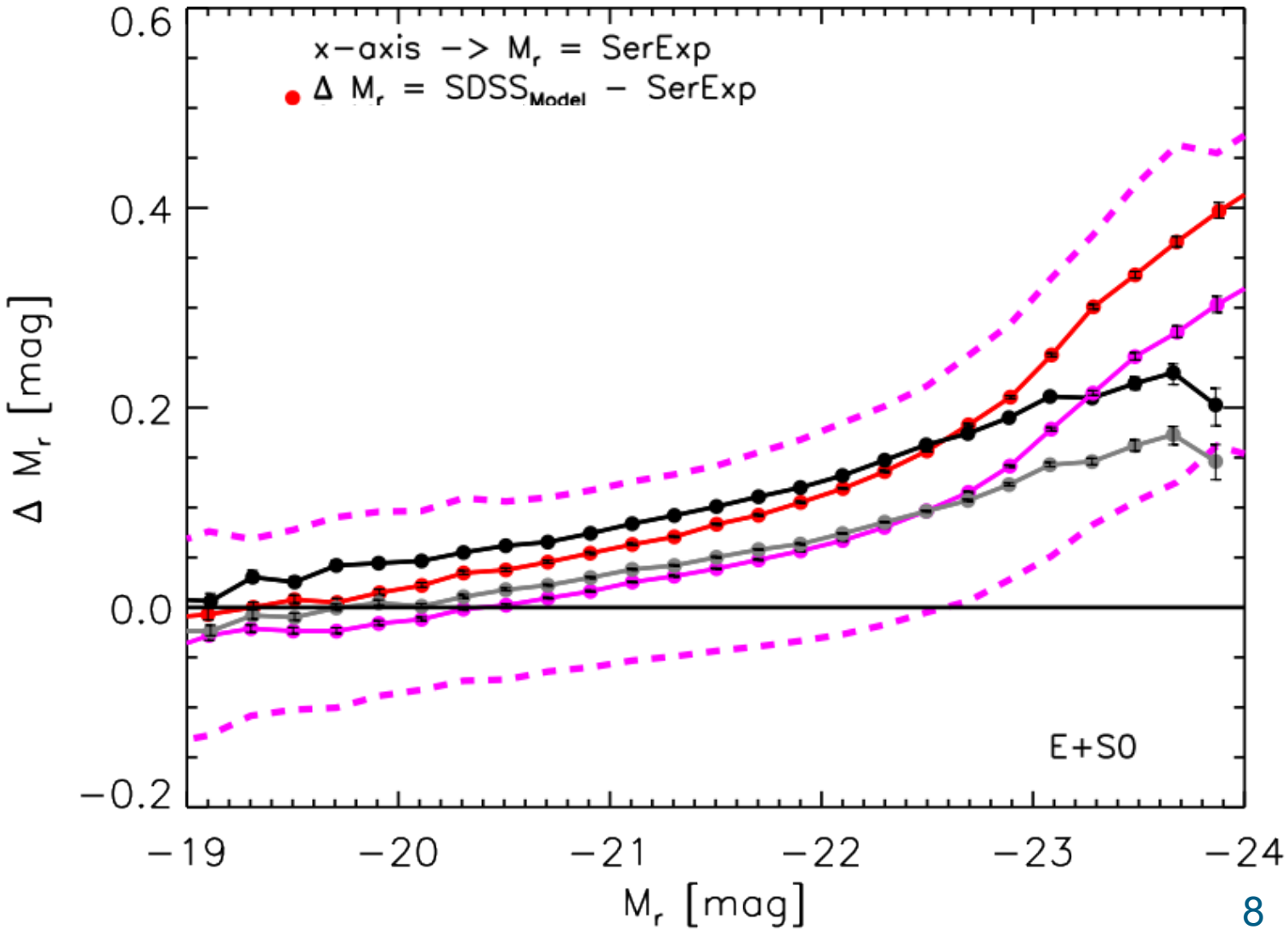
Our Model - SMF Tuning

Right:
Bernardi 2017 Fig4

Further:
Bernardi 2013 - 2017



Models:
Model 1: Cole 2000

Starburst: $e_{burst} = e_{1:1}\left(\frac{M_2}{M_1} - e_0\right)^{\gamma}$

Major, $M_{sat}/M_{cent} > 0.3$	Minor, $M_{sat}/M_{cent} < 0.3$
• Starburst as above.	• Starburst as above.
• Galaxy morphologies destroyed remnant is an elliptical.	• Gas added to the disk of the central.
• Mass of Central and Satellite added to the elliptical remnant.	• Satellite stellar mass adds to the bulge of the central galaxy.
• Remnant is quenched and can only grow via mergers.	• Galaxy is still considered to be on the star forming main sequence.

Models:
Model 2: Hopkins 2009

Starburst: $e_{burst} = e_{1:1}\left(\frac{M_2}{M_1} - e_0\right)^{\gamma}$

- Satellite causes a starbust as above.
- In addition the disk of the central galaxy is disrupted by the in falling satellite
- The mass of the bulge of the remnant is: Bulge of the central + SM of satellite + Starburst + Disrupted disk mass
- The mass of the disk of the remnant is: Disk of the central – Disrupted disk mass
- The gas reservoir of the remnant is: Satellite Gas + Central Gas – Starburst Mass