

What Does Scatter Tell Us?



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Outline

- Observational constraints (and why is it so small?)
- The quenching mechanism for high mass galaxies.
- The duty cycle of star formation in SFMS.
- AOB...

Observational Constraints (and, why are they so small?)

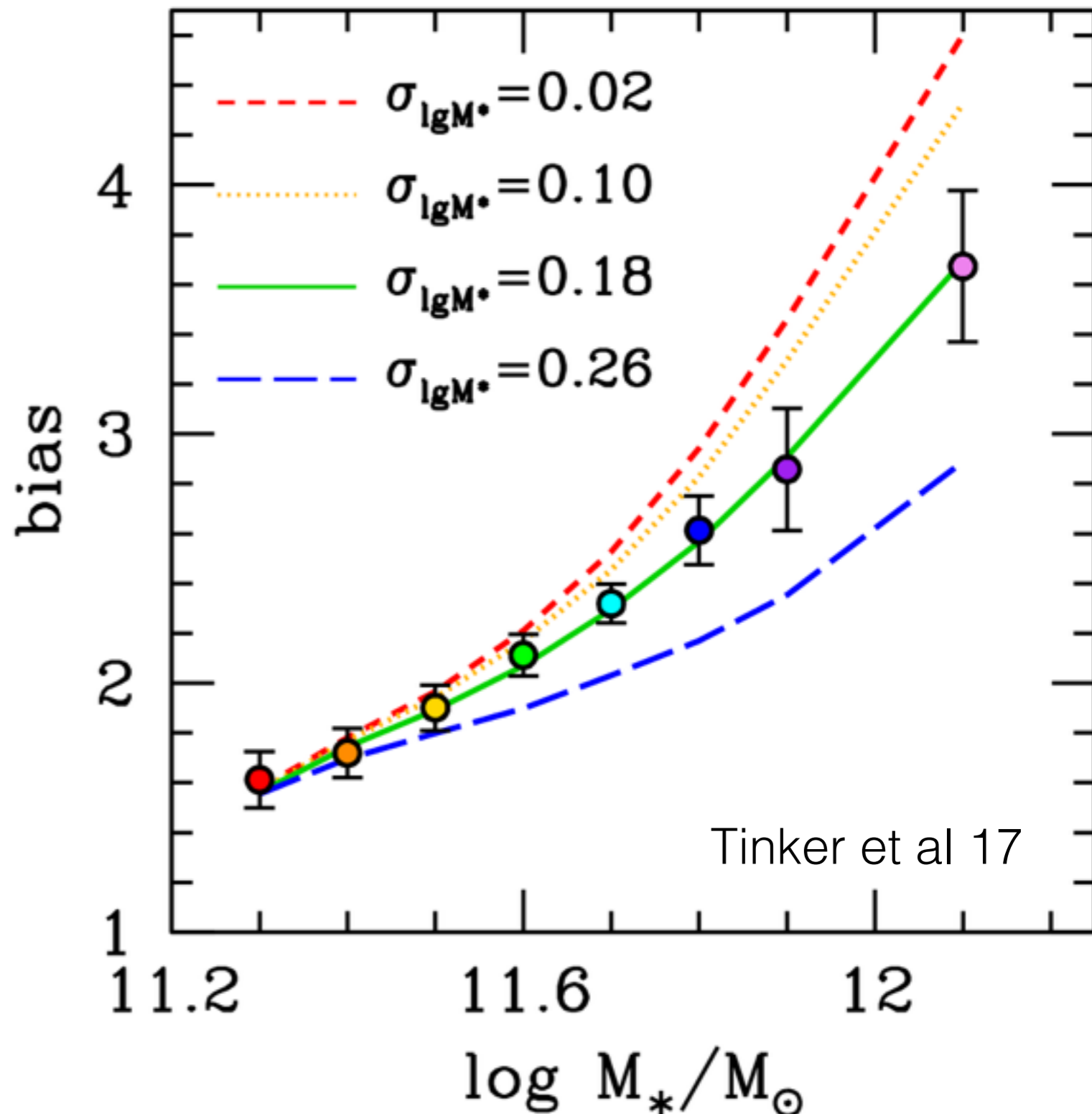
Tinker, Brownstein, Guo et al (the BOSS Galaxy Science Team)
2017, ApJ, 839, 121

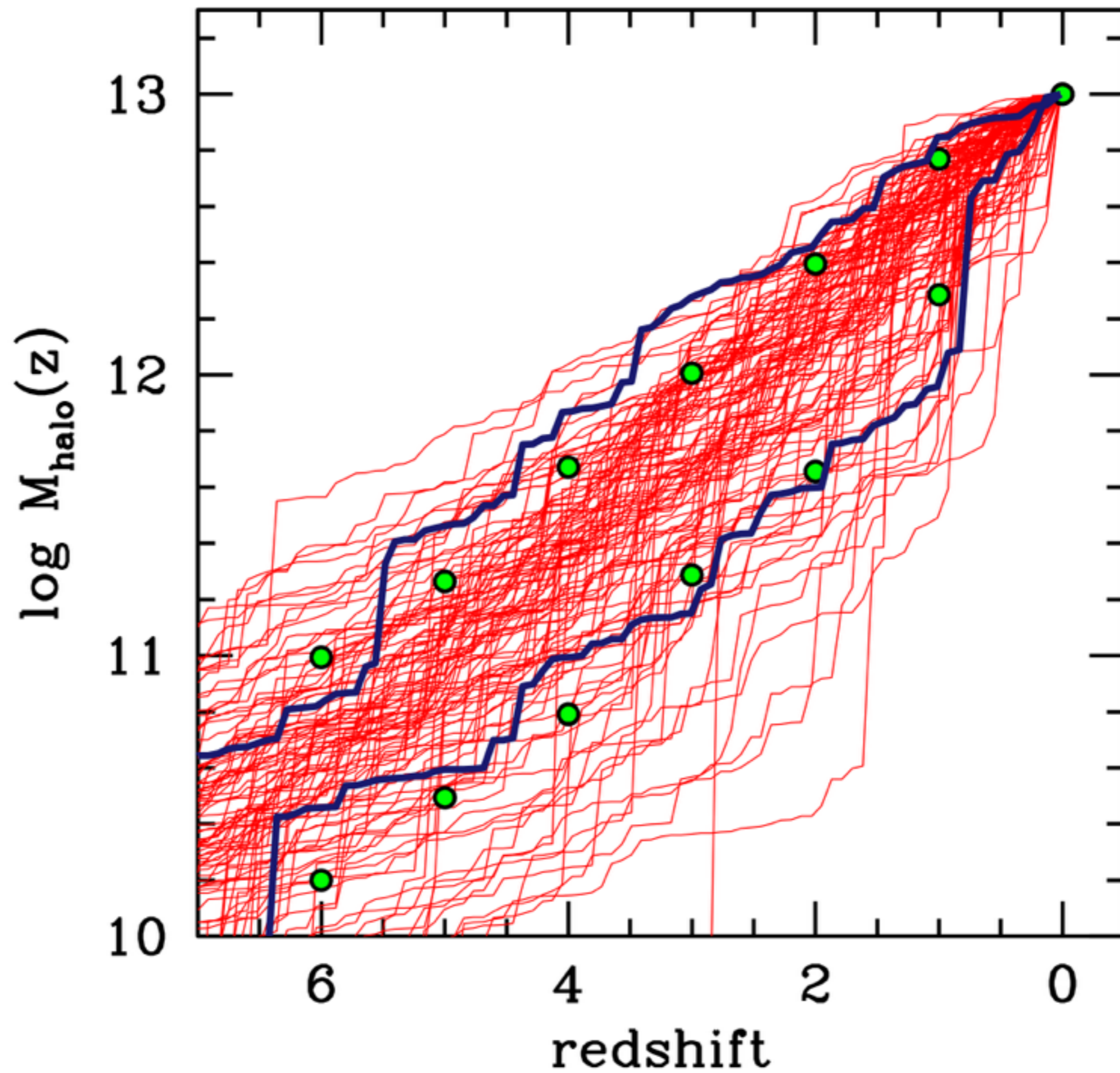
Constraints on the Scatter

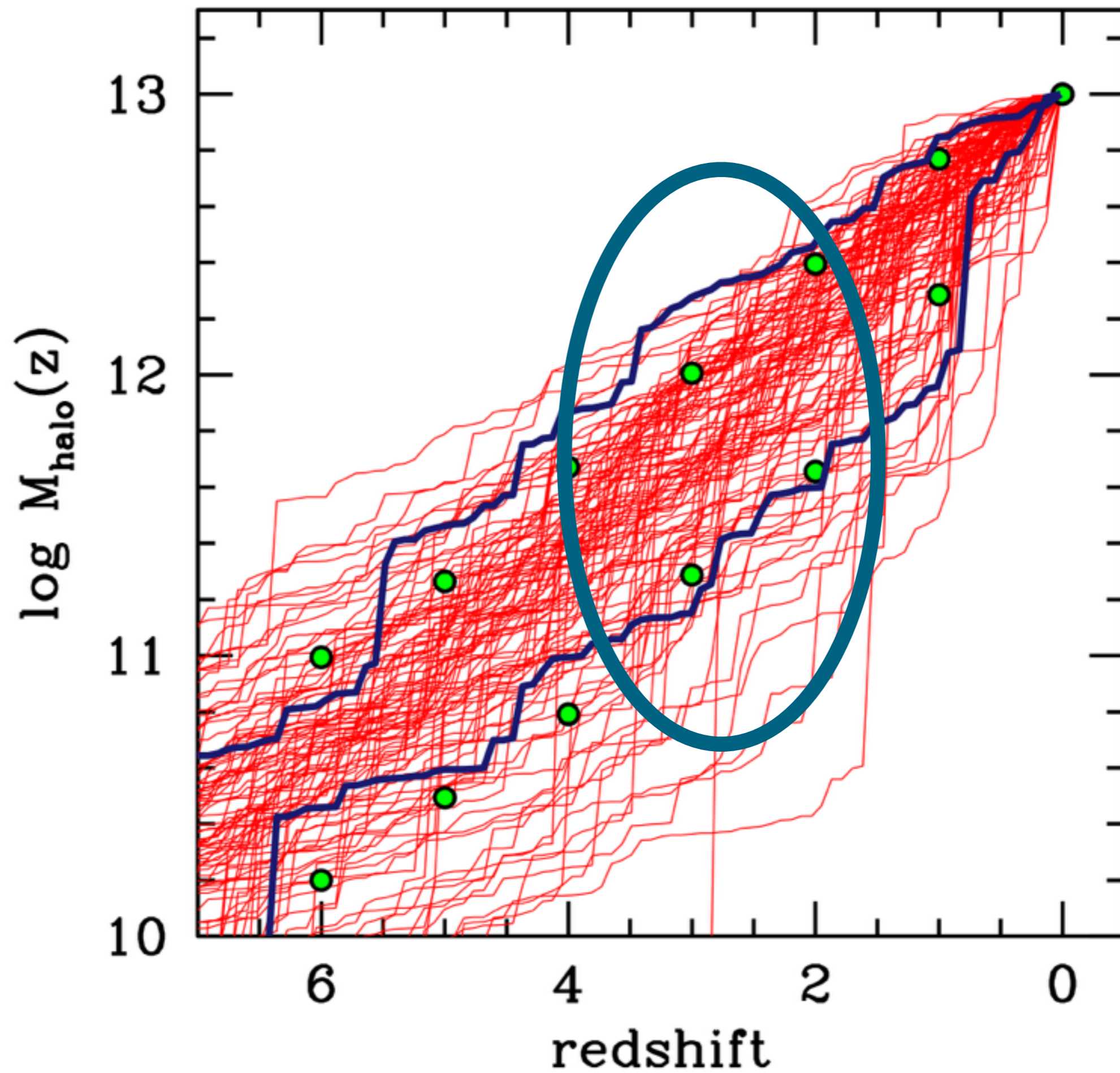
- Strong constraints obtained from the clustering of galaxies.
- BOSS results offer best sample of high-mass galaxies.
- Results here are quadrature sum of intrinsic and measurement scatters.

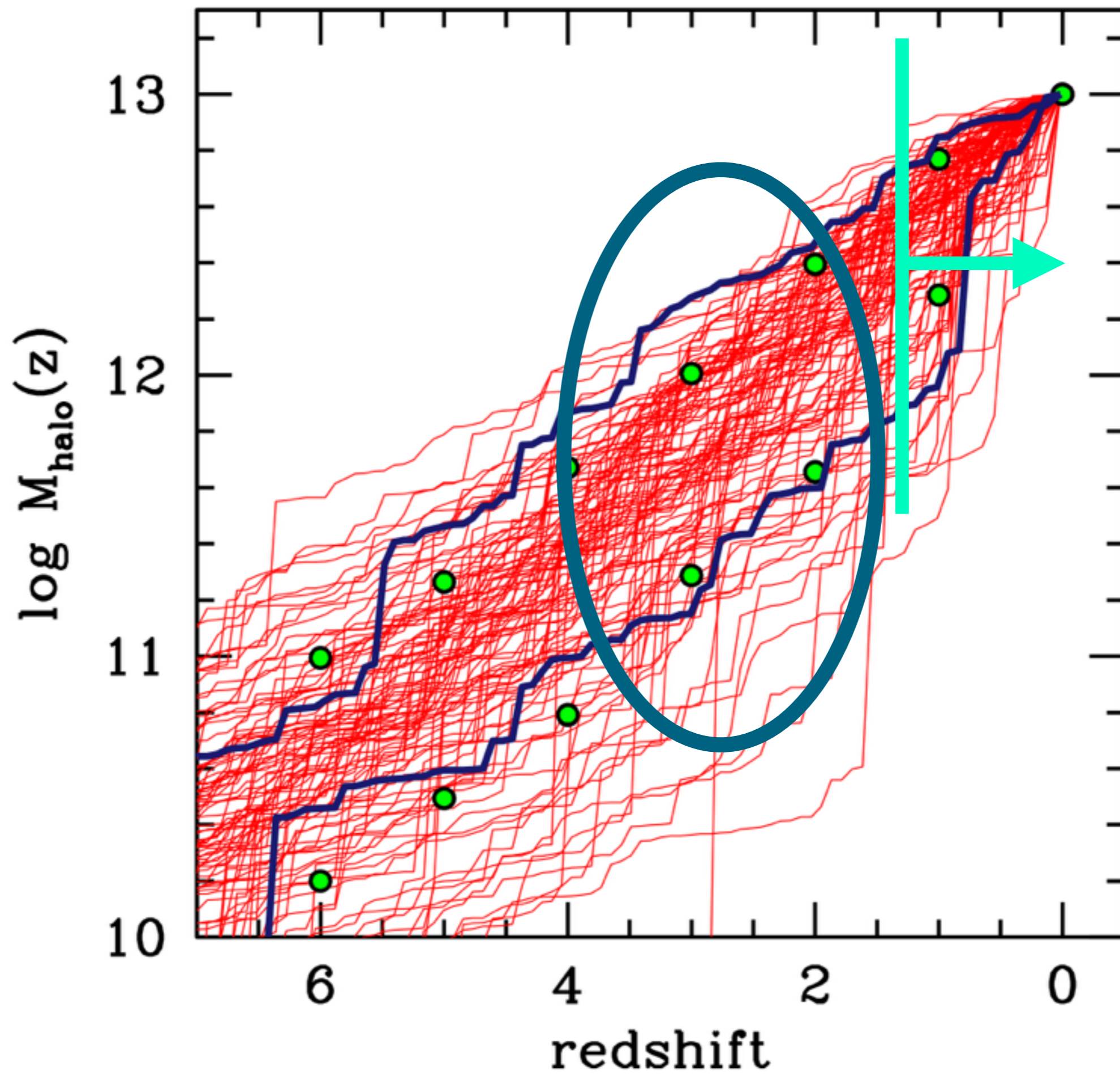
$$\sigma_{\log M_*} = 0.16 \text{ dex}$$

Zu & Mandelbaum 2015
Reddick et al 2013
More et al 2011
and others...



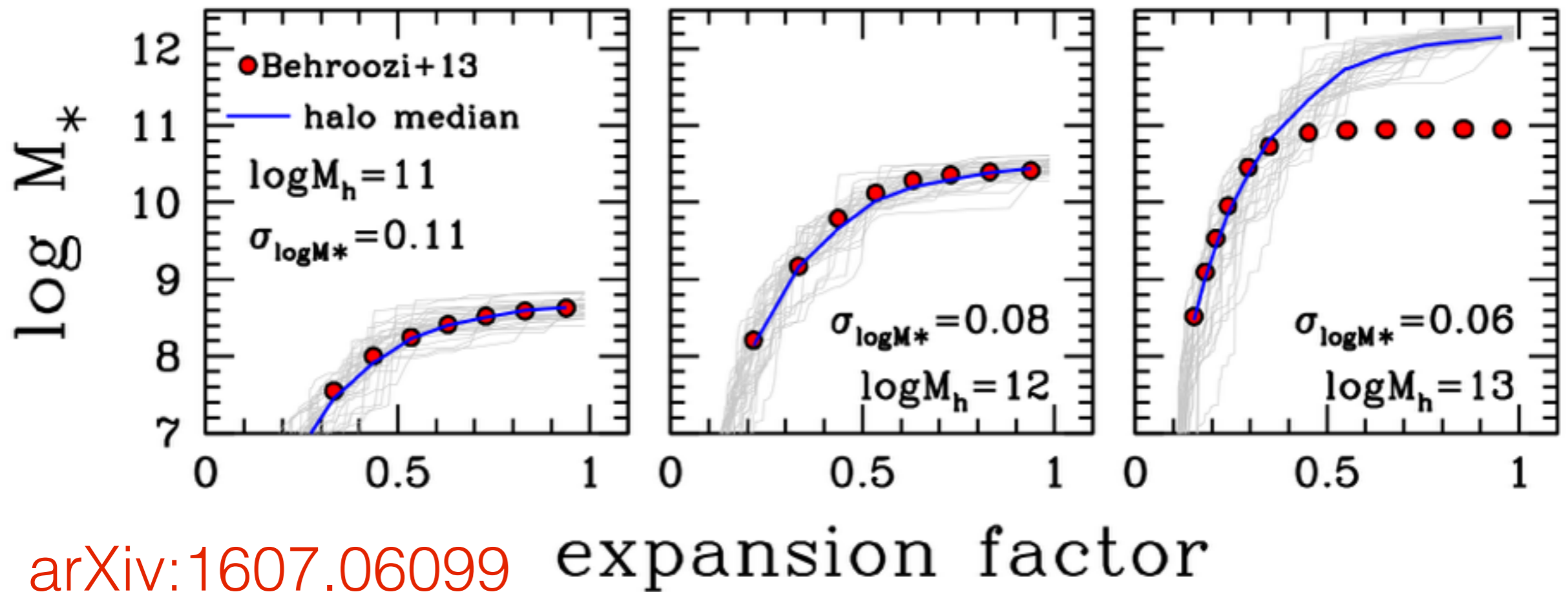






Scatter and Quenching of Massive Galaxies

Extending abundance matching to individual halos.



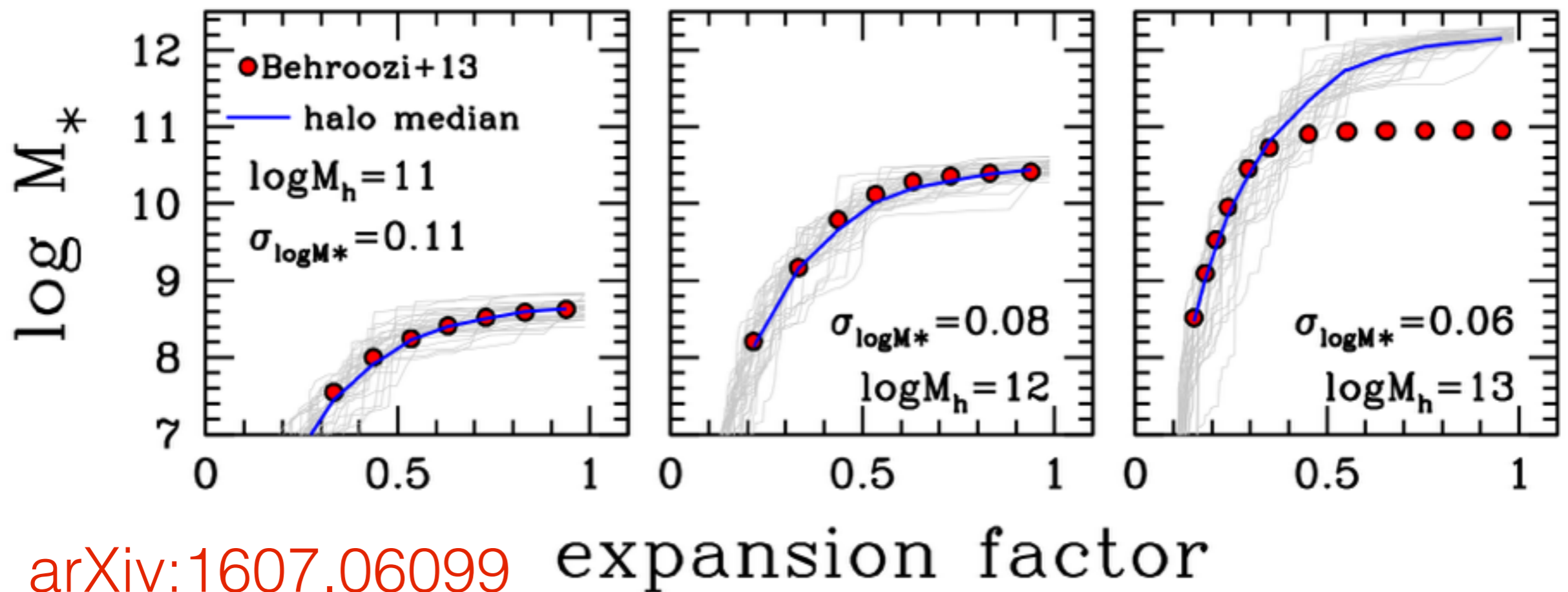
AM Ansatz:

$$f_{\text{con}} \equiv SFR \times \left[\frac{\Omega_b}{\Omega_m} \dot{M}_h \right]^{-1}$$

Simple Model:

$$M_*(z) = \int_0^{t(z)} SFR(t) dt = \int_{\infty}^z f_{\text{con}}(z') f_b \dot{M}_h \frac{dt}{dz'} dz'.$$

Extending abundance matching to individual halos.



AM Ansatz:

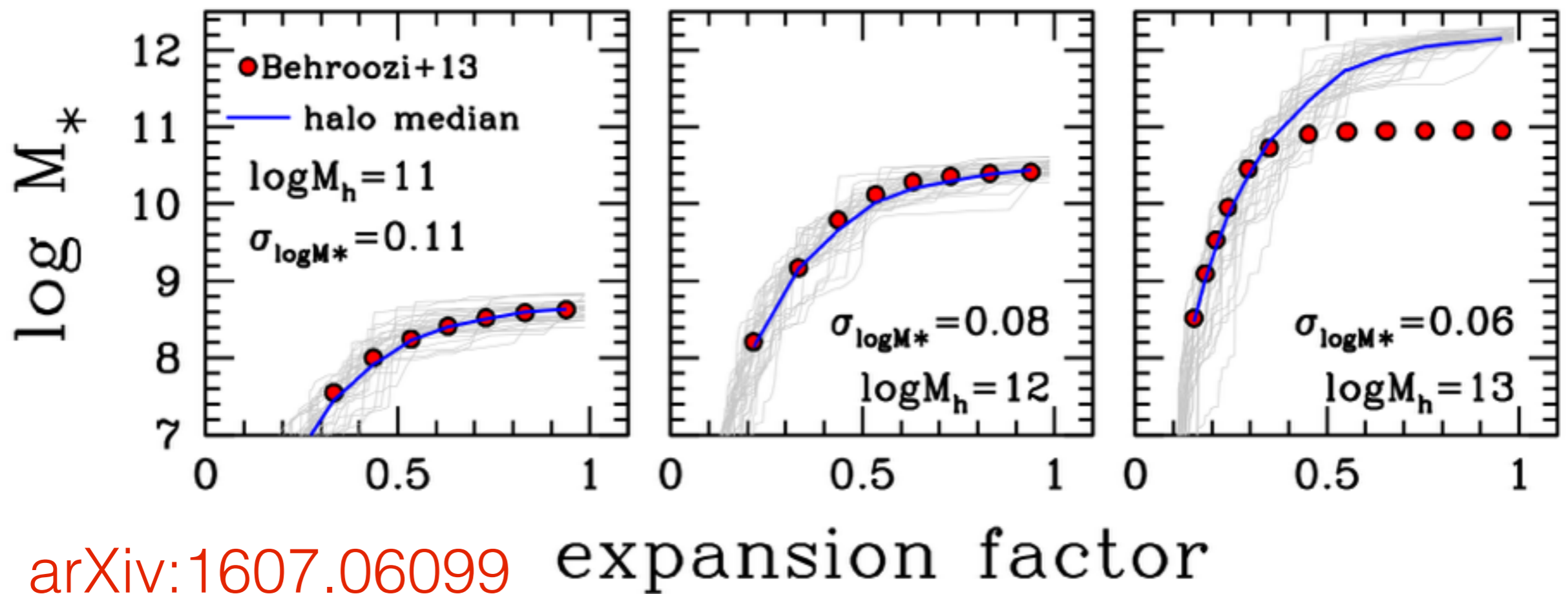
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Universal

Simple Model:

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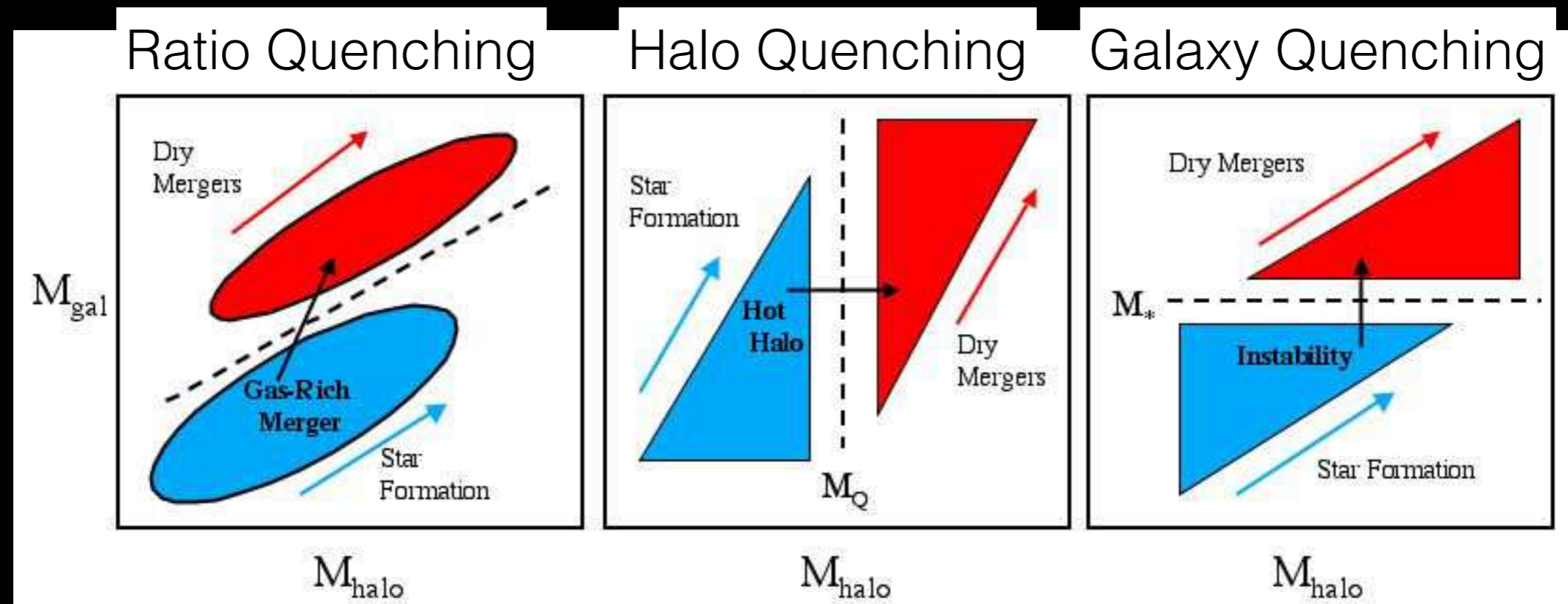
Universal

Simple Model:

$$M_*(z) = \int_0^{t(z)} SFR(t) dt = \int_{\infty}^z f_{\text{con}}(z') f_b \dot{M}_h \frac{dt}{dz'} dz'.$$

Changes halo-to-halo

Quenching Star Formation



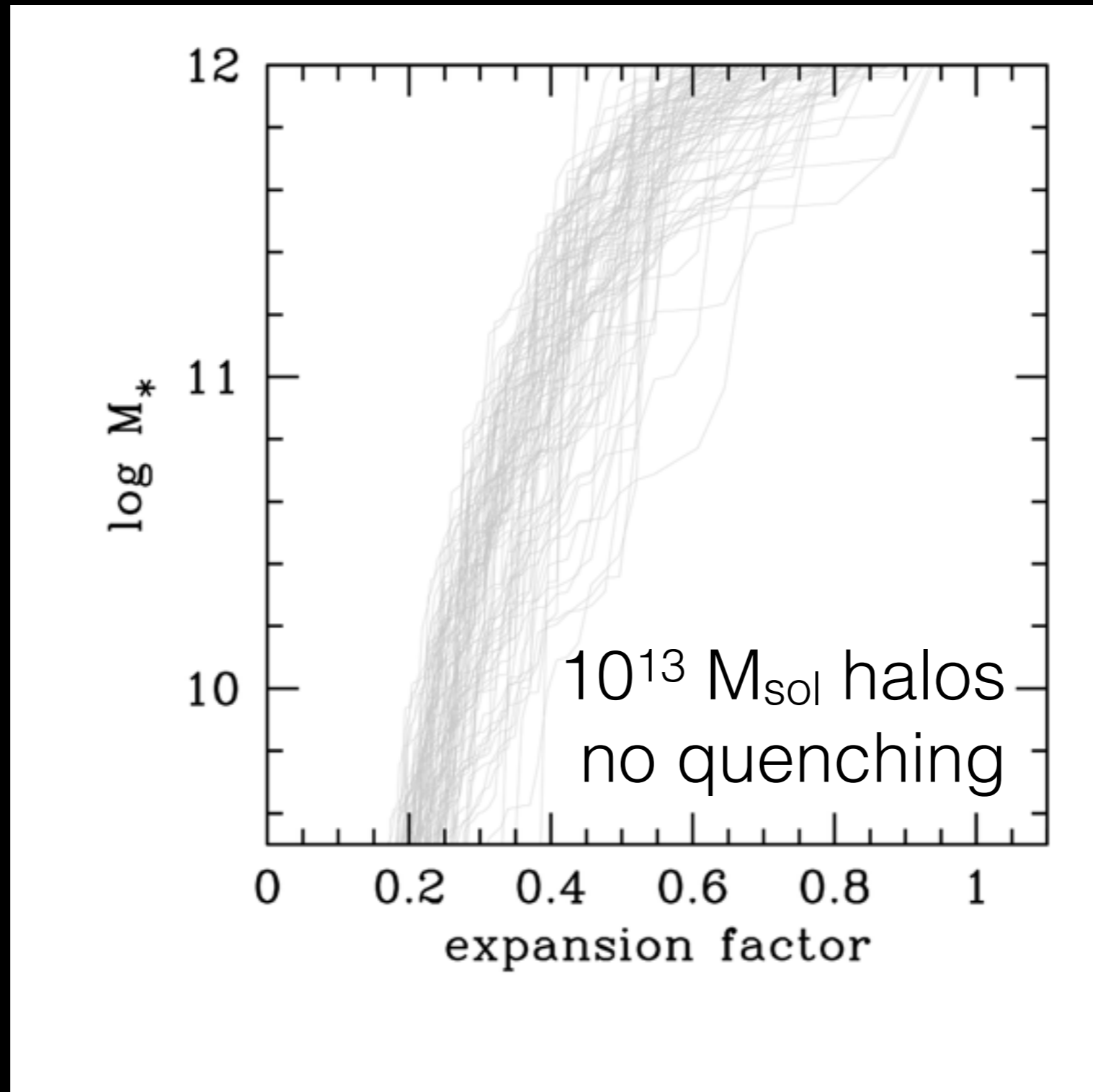
Hopkins et al 2008b

(Toy) Model: Quenching begins after a halo crosses a threshold in some physical quantity.

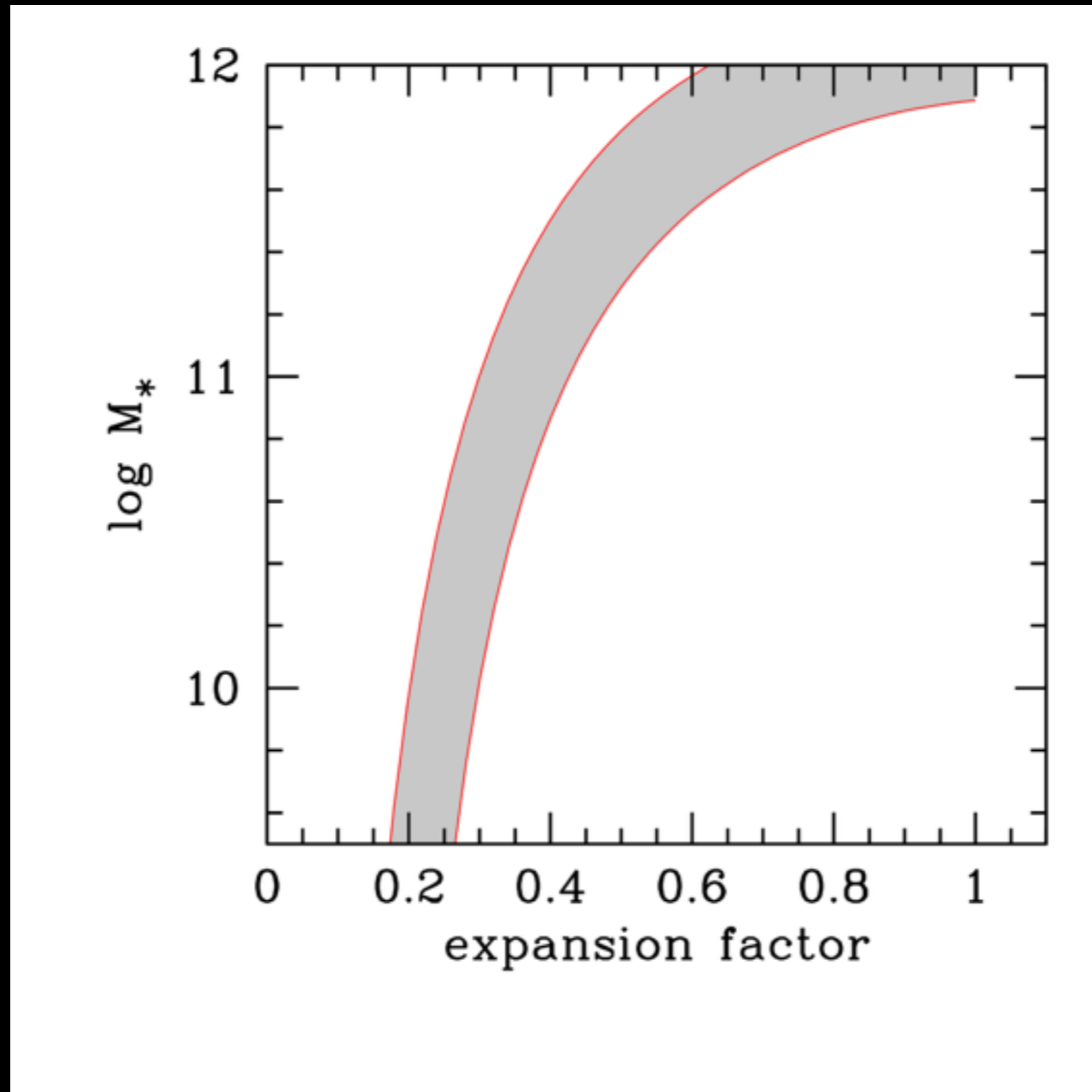
Details: Quenching can be fast or slow, but must match the mean $M_{\text{star}}(z)$.

Test: If a model yields a scatter smaller than 0.16 dex, leaving room for other sources.

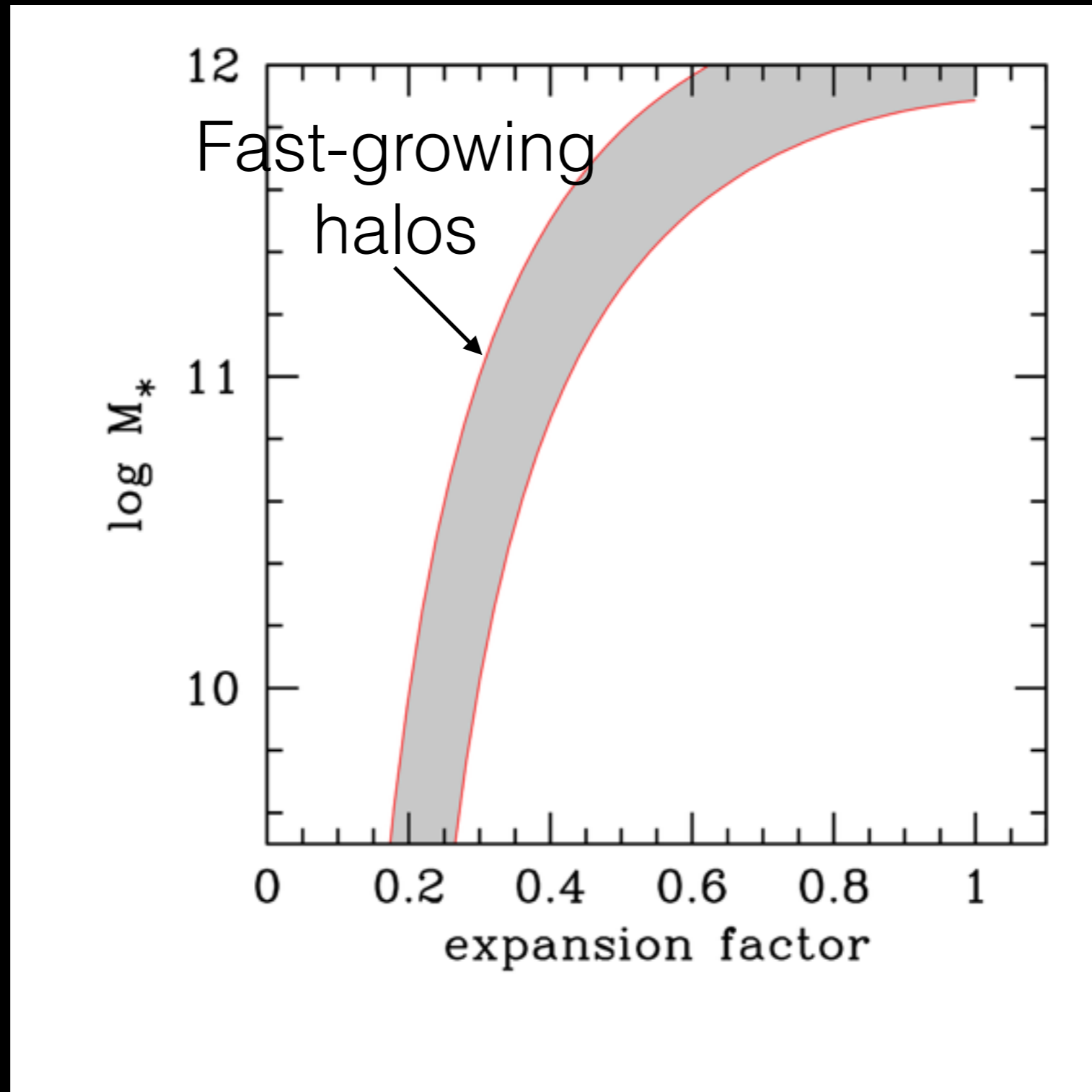
How does quenching affect scatter?



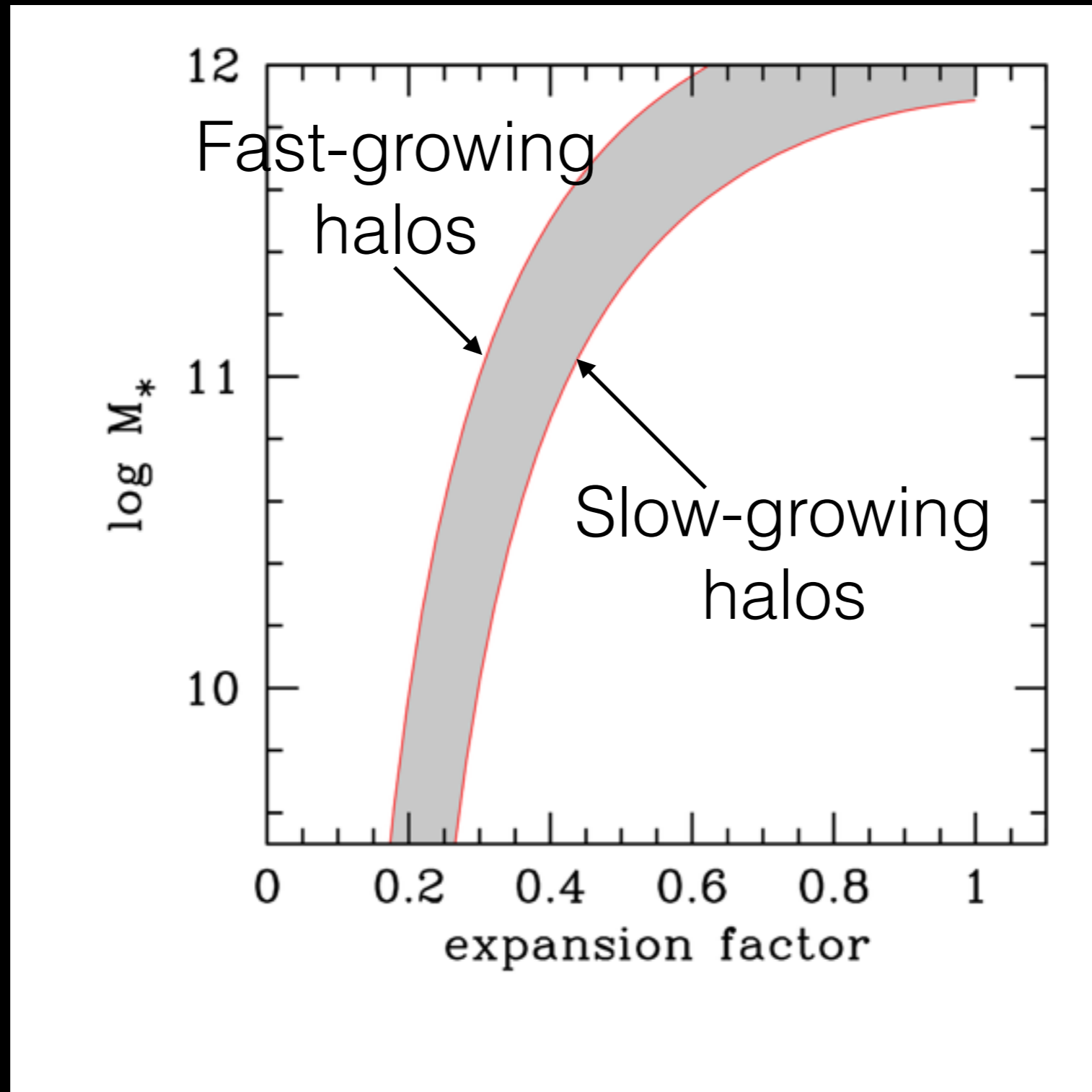
How does quenching affect scatter?



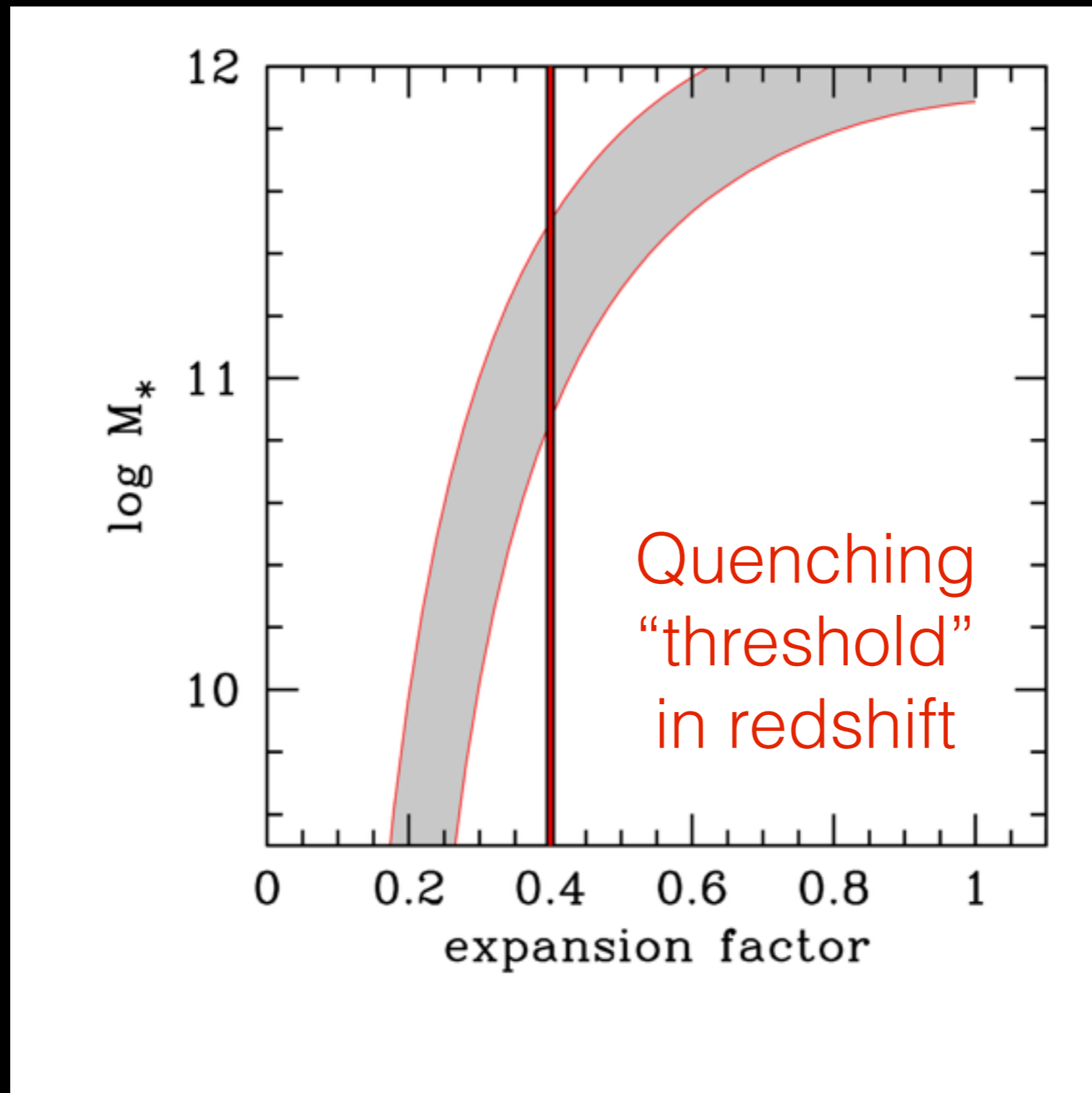
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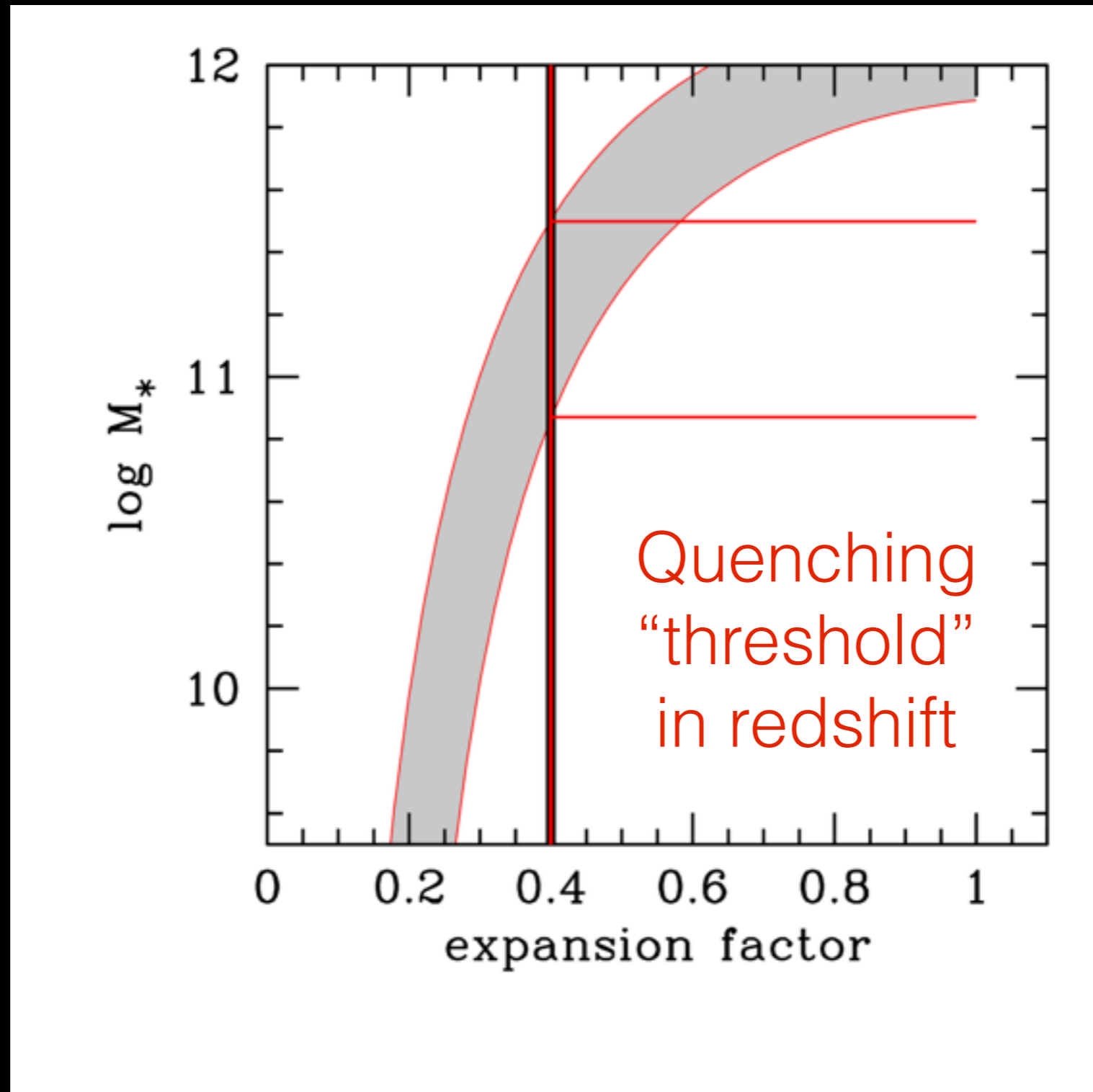
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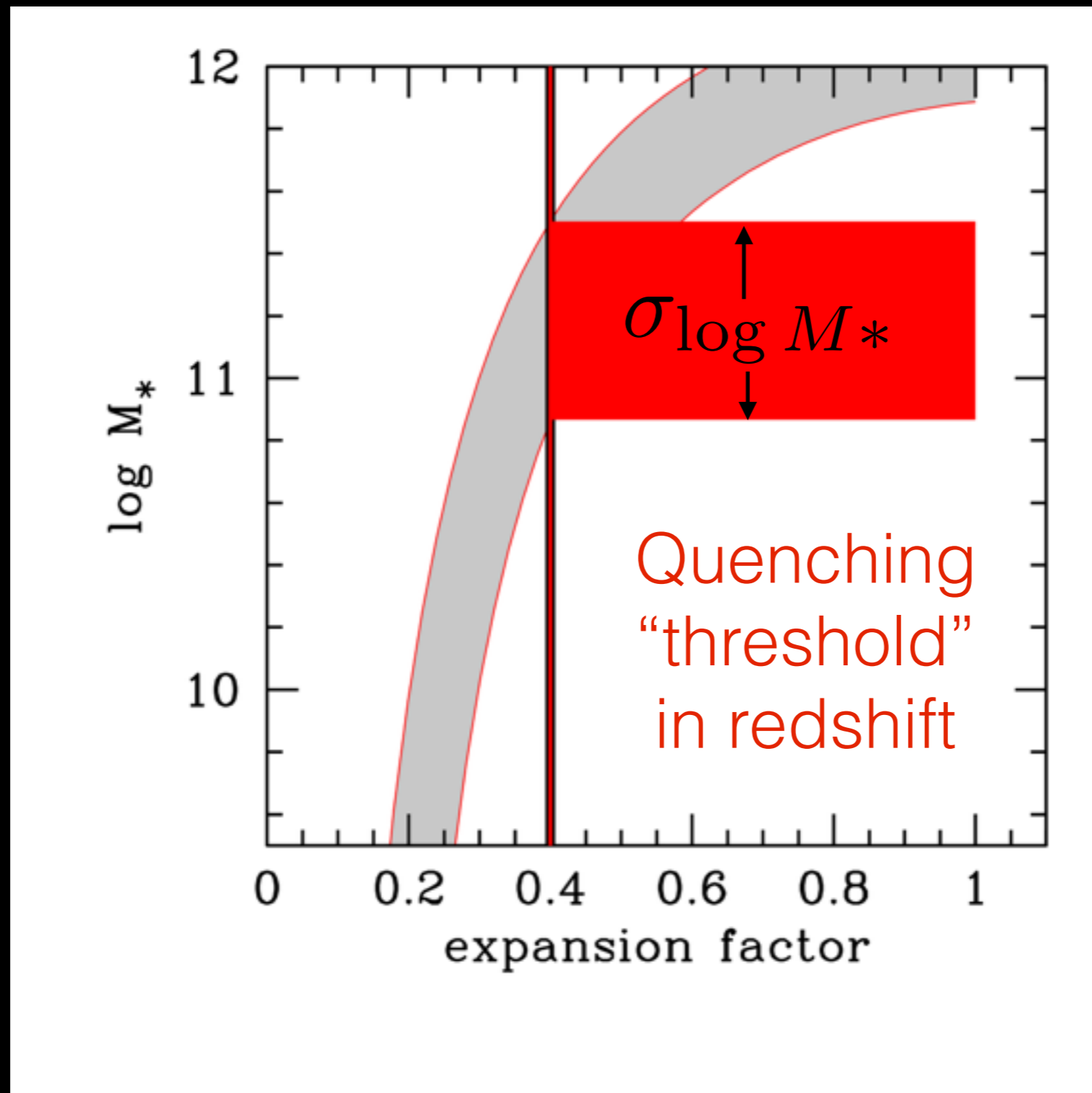
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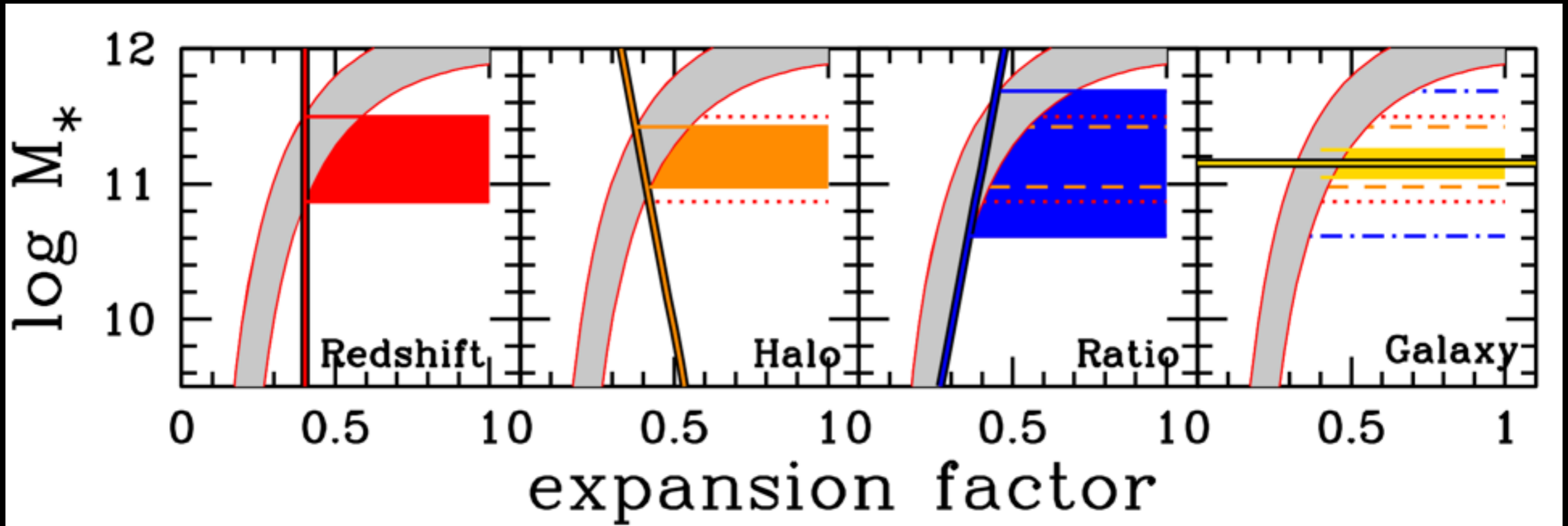
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How does quenching affect scatter?

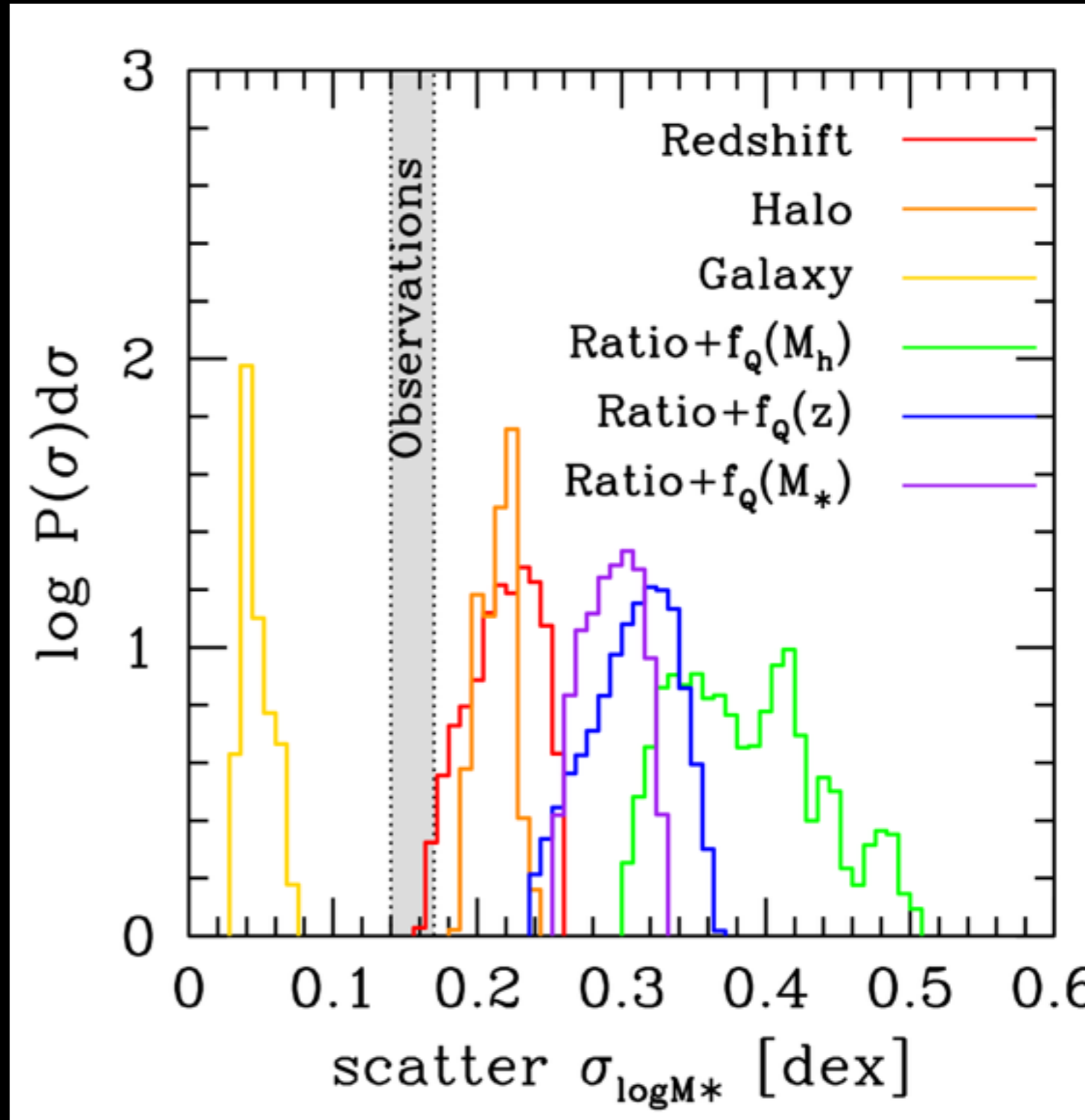


Testing all the models

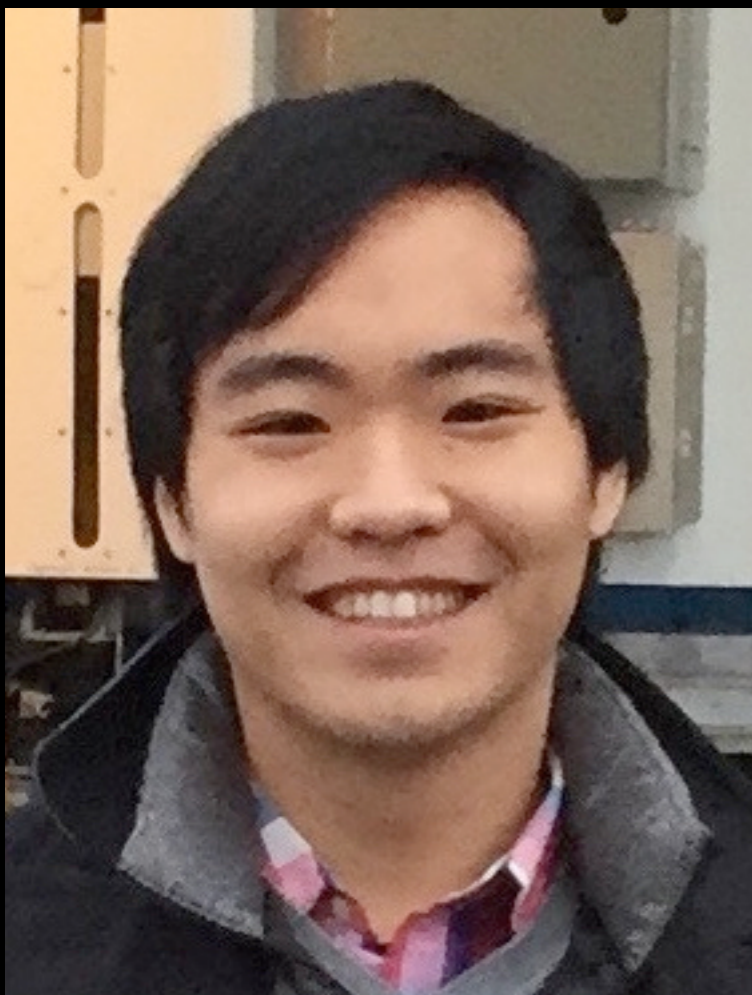


Comparing to the Data

- Only galaxy quenching yields scatter below the observed levels.
- Halo quenching can achieve lower scatter if the quenching threshold decreases with cosmic time.
- These models have no stochasticity, which only drives the scatter up.
- This is an idealized model, but results are worthy of exploring further.

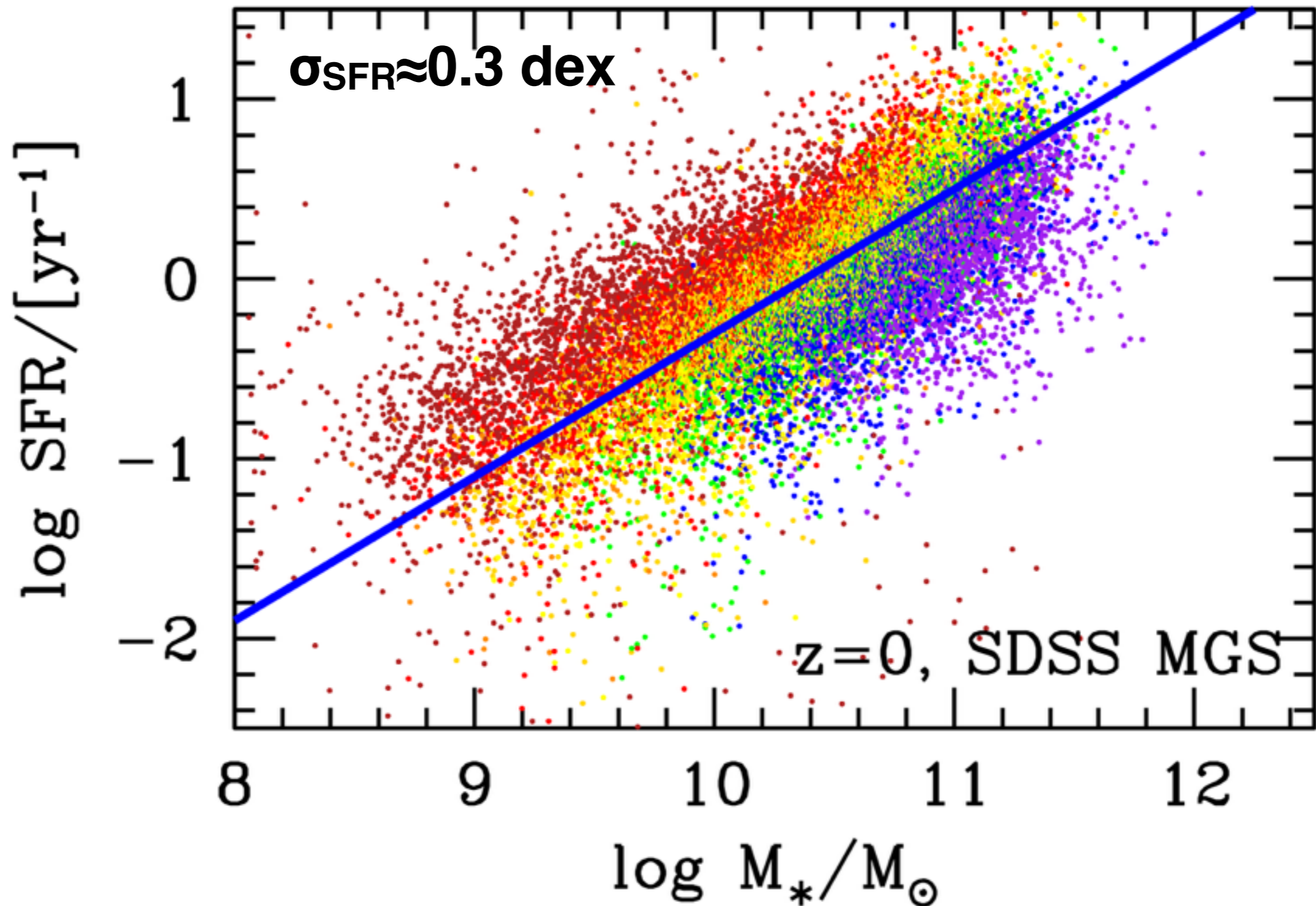


Scatter and Life on the Star Forming Main Sequence

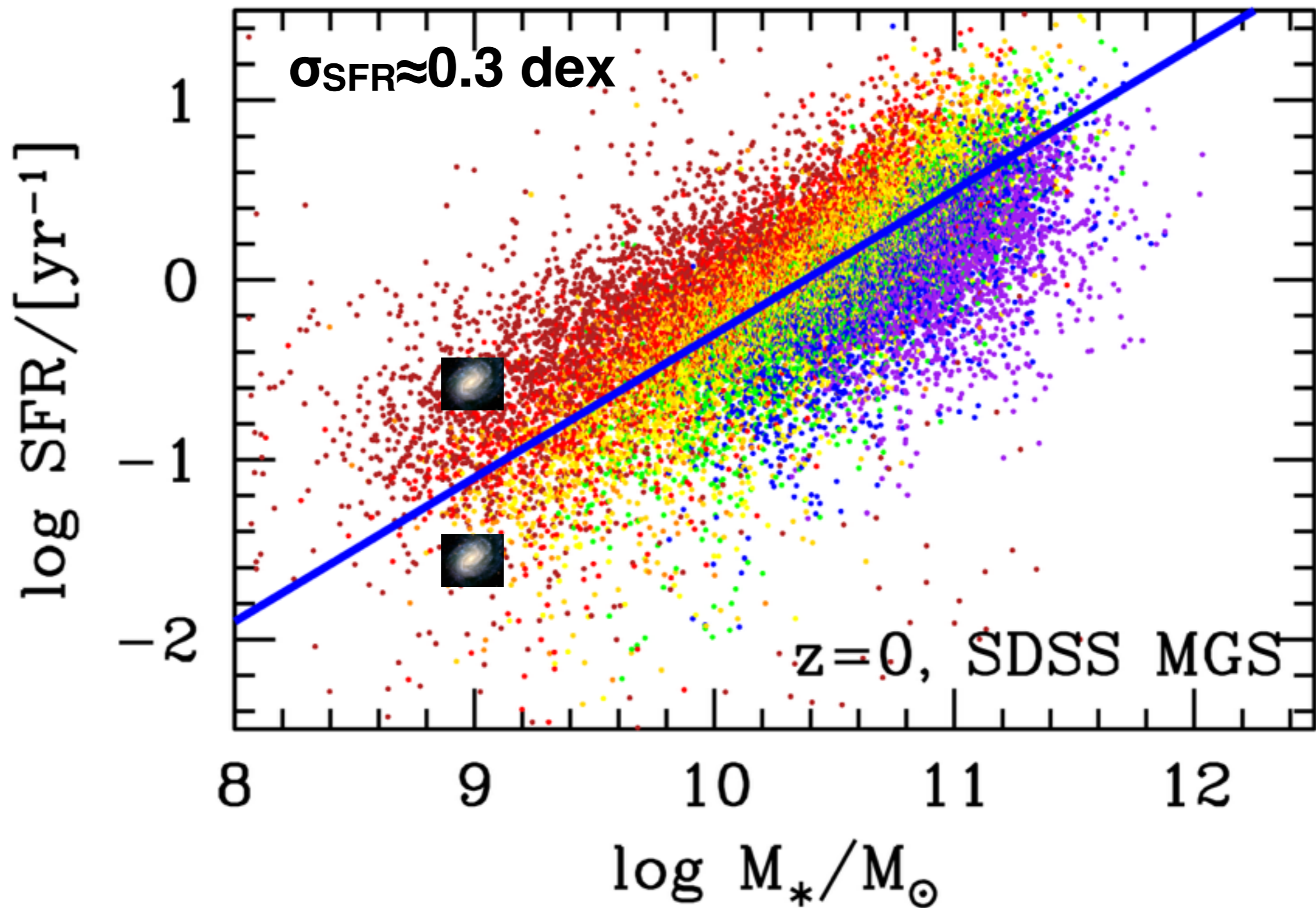


Hahn, Tinker, & Wetzel (in prep)

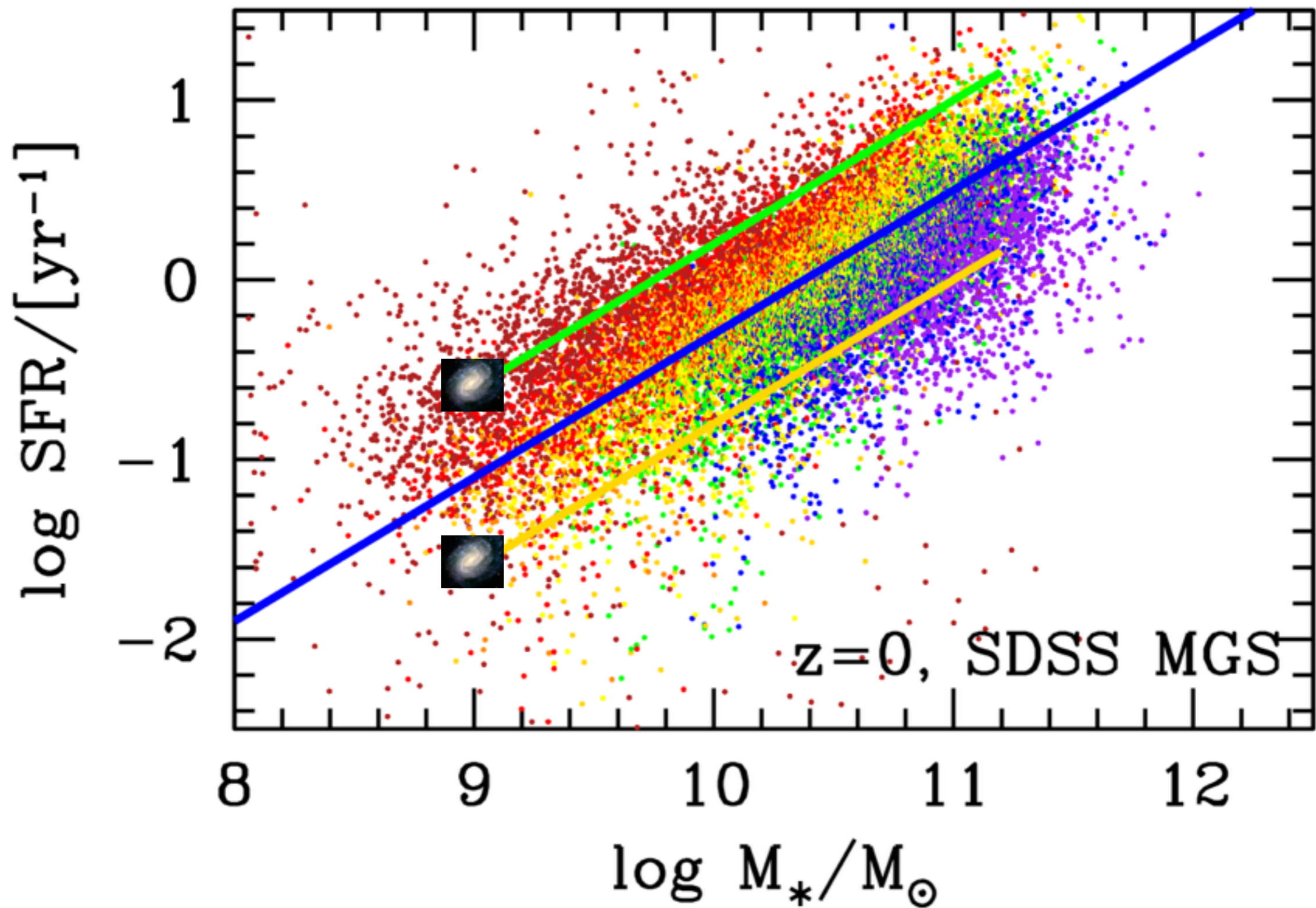
Scatter in the SFMS



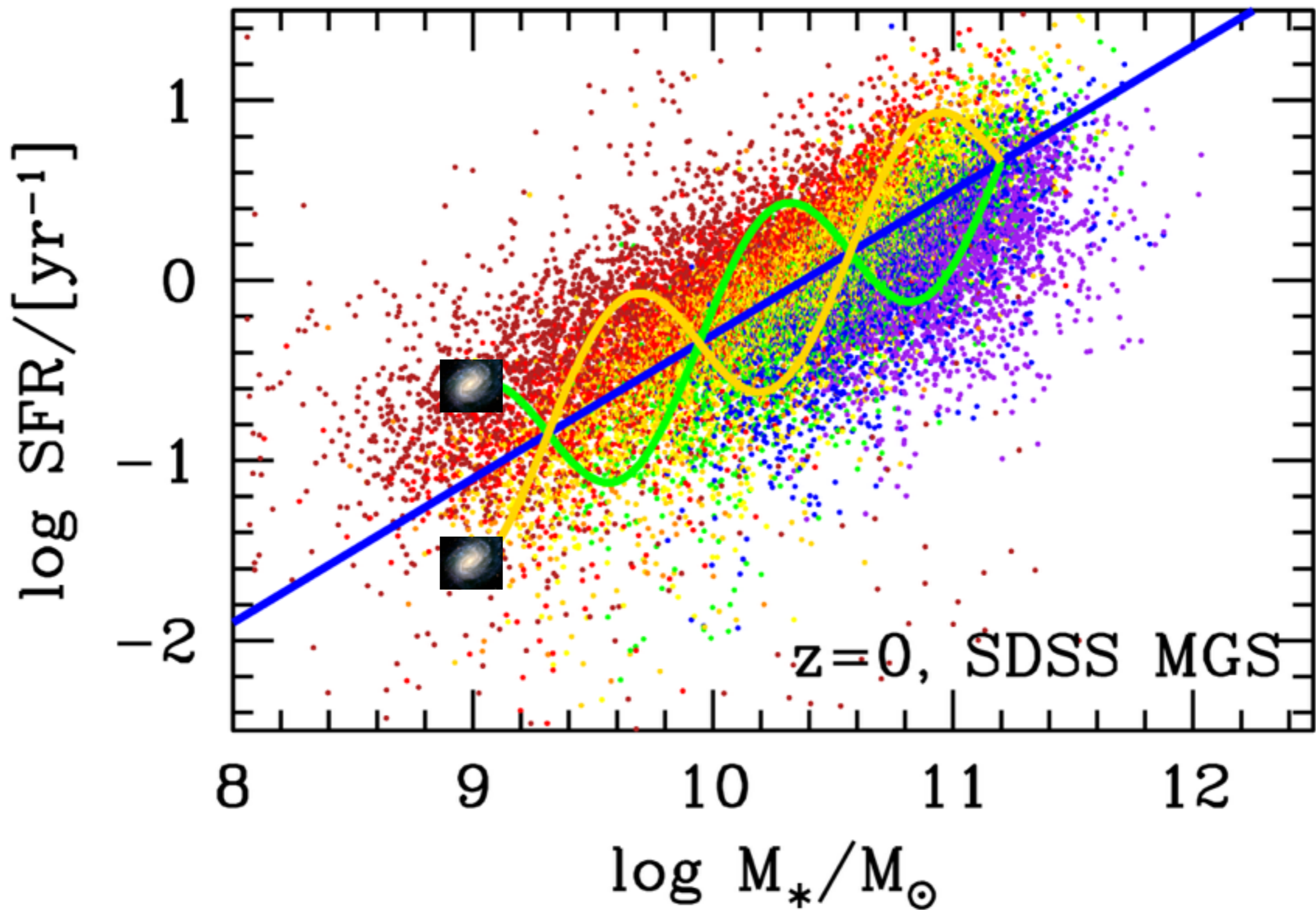
Scatter in the SFMS



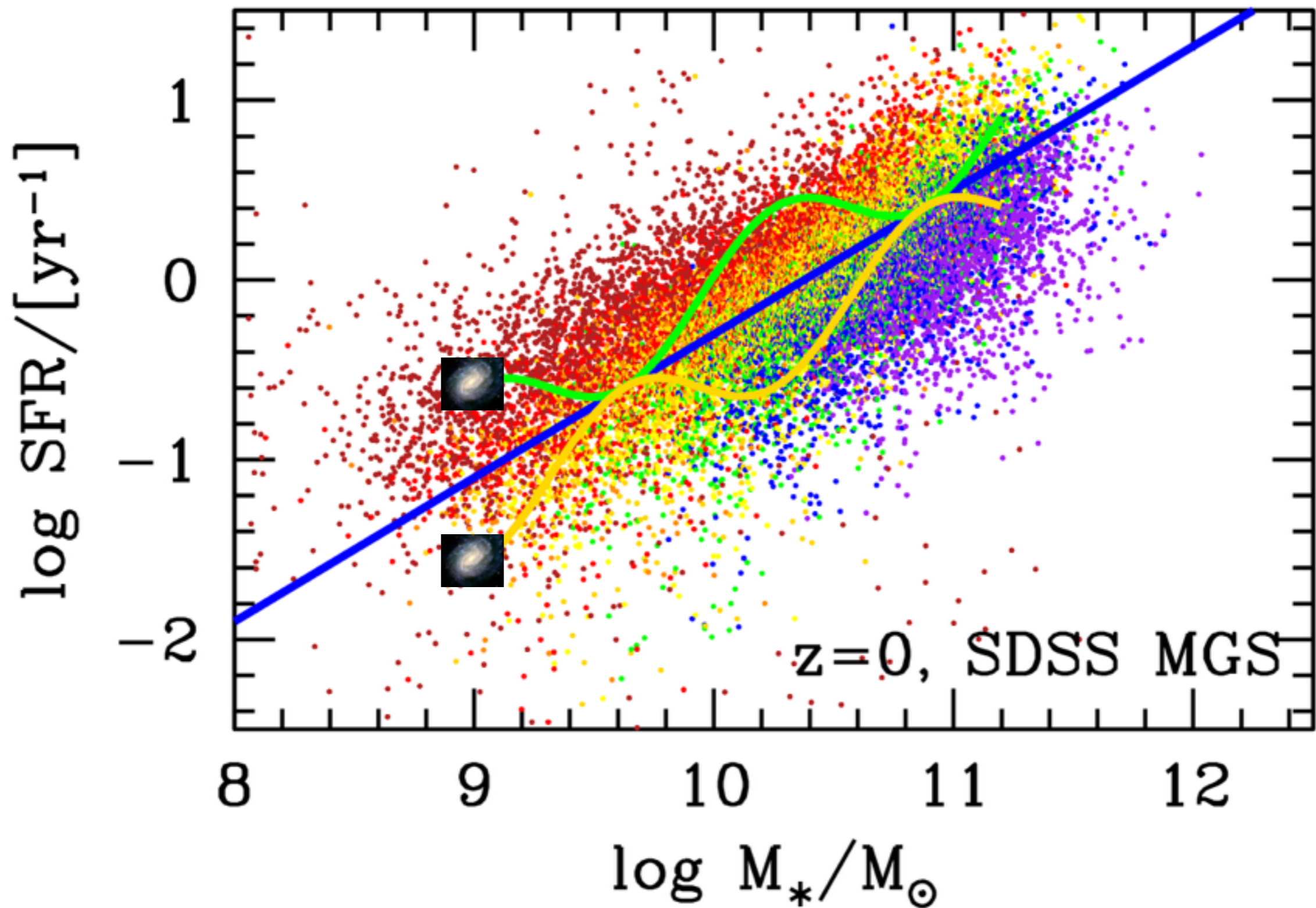
Scatter in the SFMS



Scatter in the SFMS



Scatter in the SFMS



QUESTIONS

- What is the timescale for star-formation duty cycle (about the mean)?
- What is the “intrinsic width” of the SFMS?
- How does halo growth impact the SFMS?

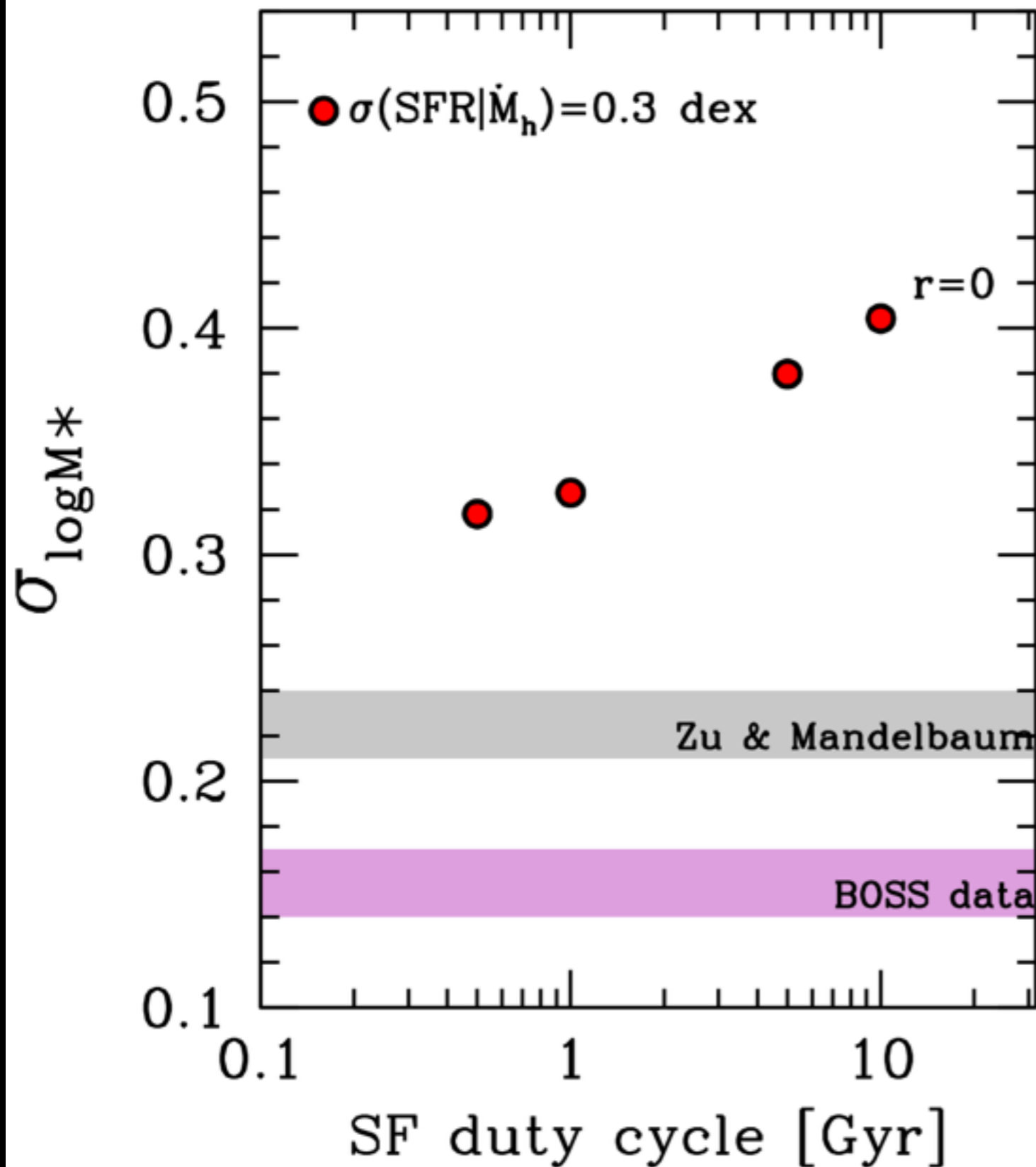
MODEL

- Initialize N-body simulation at $z=1$ with SHAM.
- Follow redshift evolution of mean SFMS.
- Individual halos fluctuate periodically around that mean.
- Match $z=0$ SMF, scatter in SFMS (0.3 dex), scatter in SHMR.

Results

PRELIMINARY!

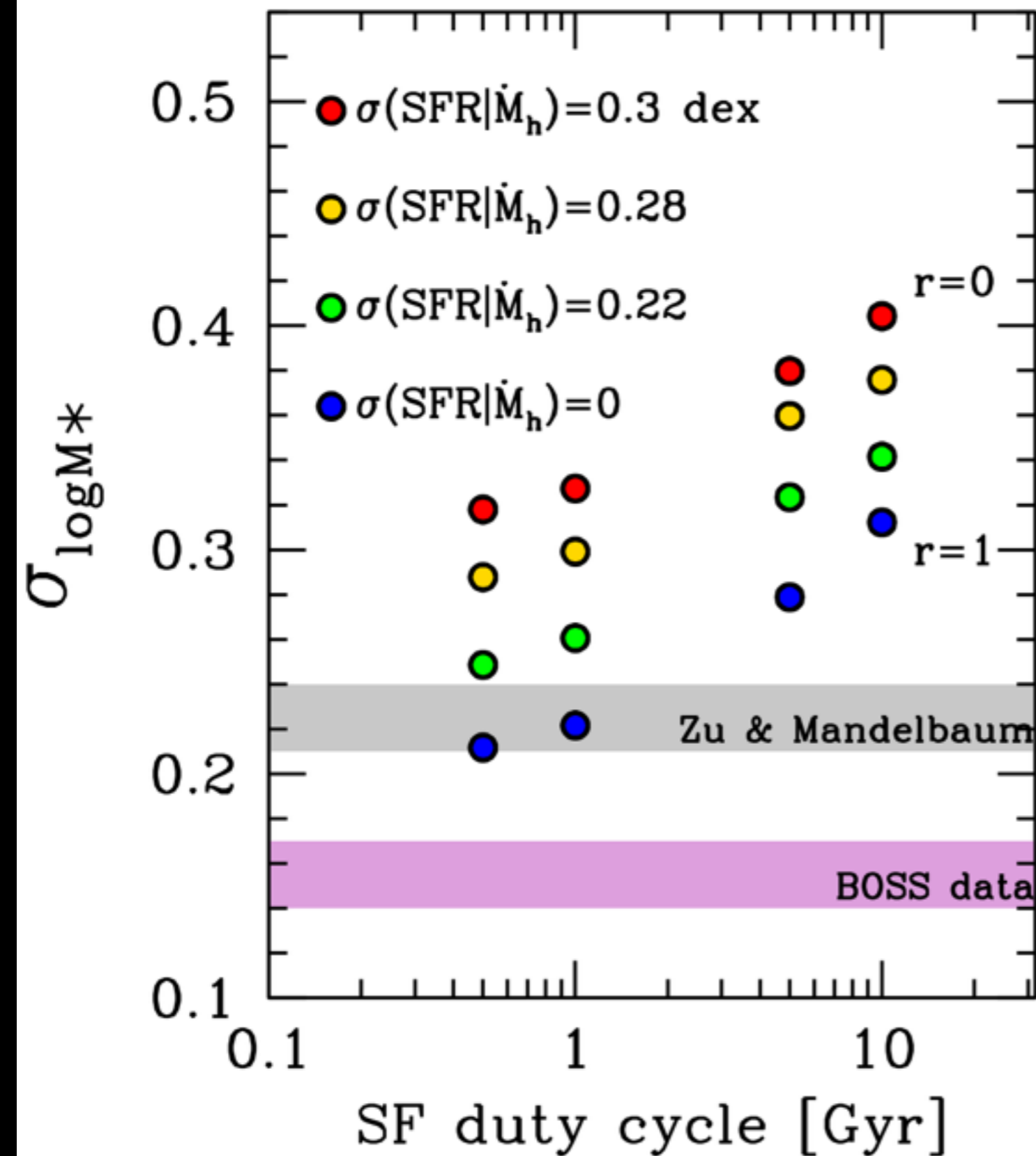
- Results where SFR is uncorrelated with halo formation rate.
- No duty cycle (or duty cycle too long) yields way too much scatter.
- Smaller duty cycle reduces scatter, but...
- No model can achieve small scatter seen in the data



Results

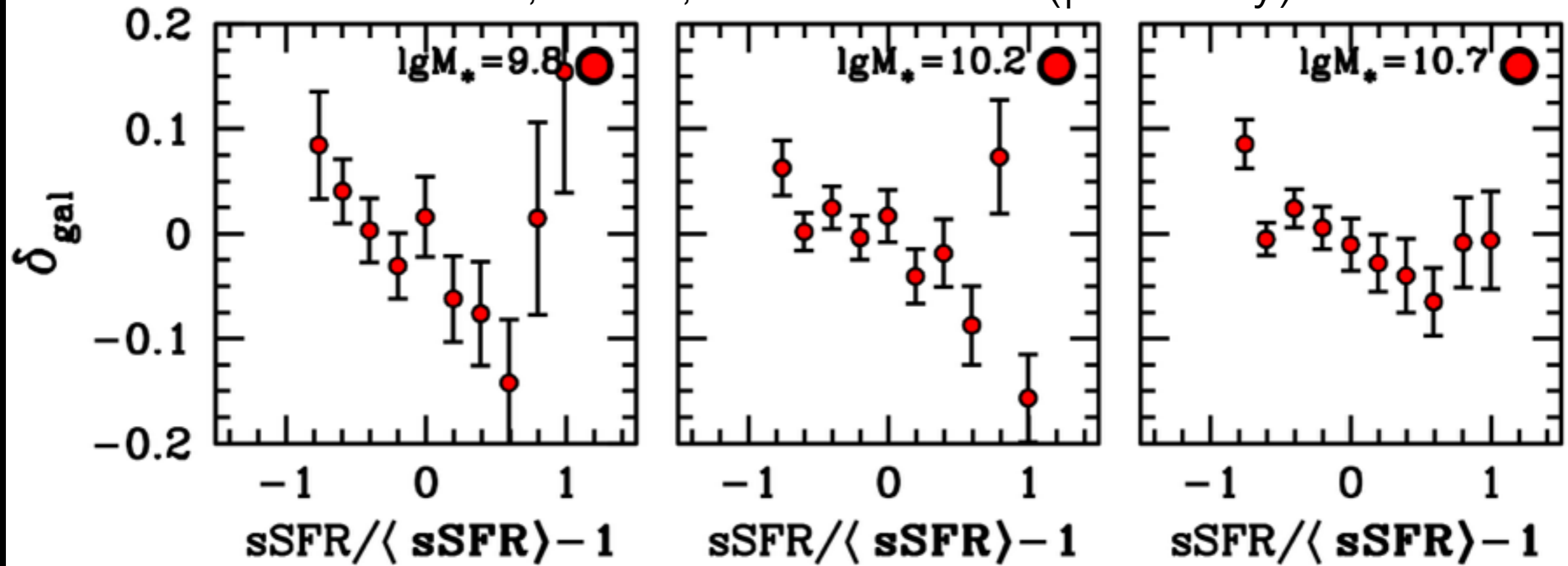
PRELIMINARY!

- Including correlation between SFR and halo growth rate.
- A duty cycle is required, regardless of assembly bias.
- Duty cycle required to be small, and assembly bias required to be high.



Is this seen in the data?

Tinker, Hahn, Mao & Wetzel (presently)

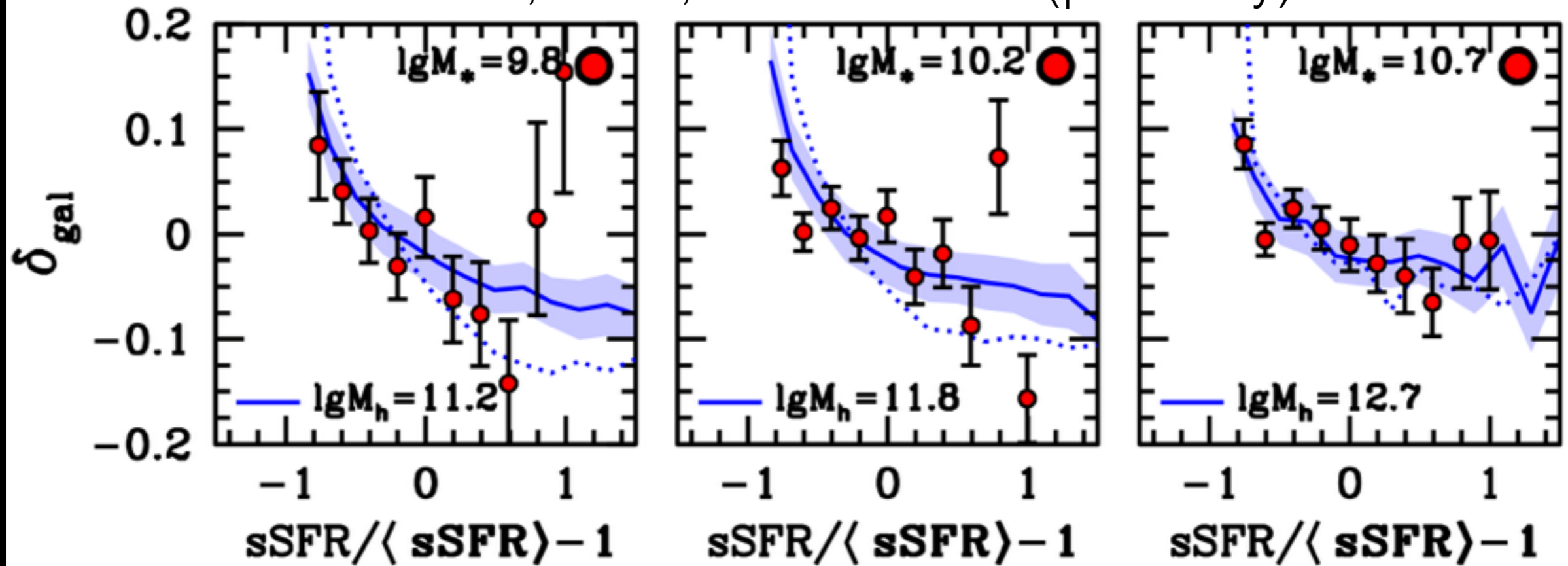


Data: Central galaxies on the SFMS from SDSS group catalog.

δ_{gal} is galaxy density in 10 Mpc/h spheres.

Is this seen in the data?

Tinker, Hahn, Mao & Wetzel (presently)



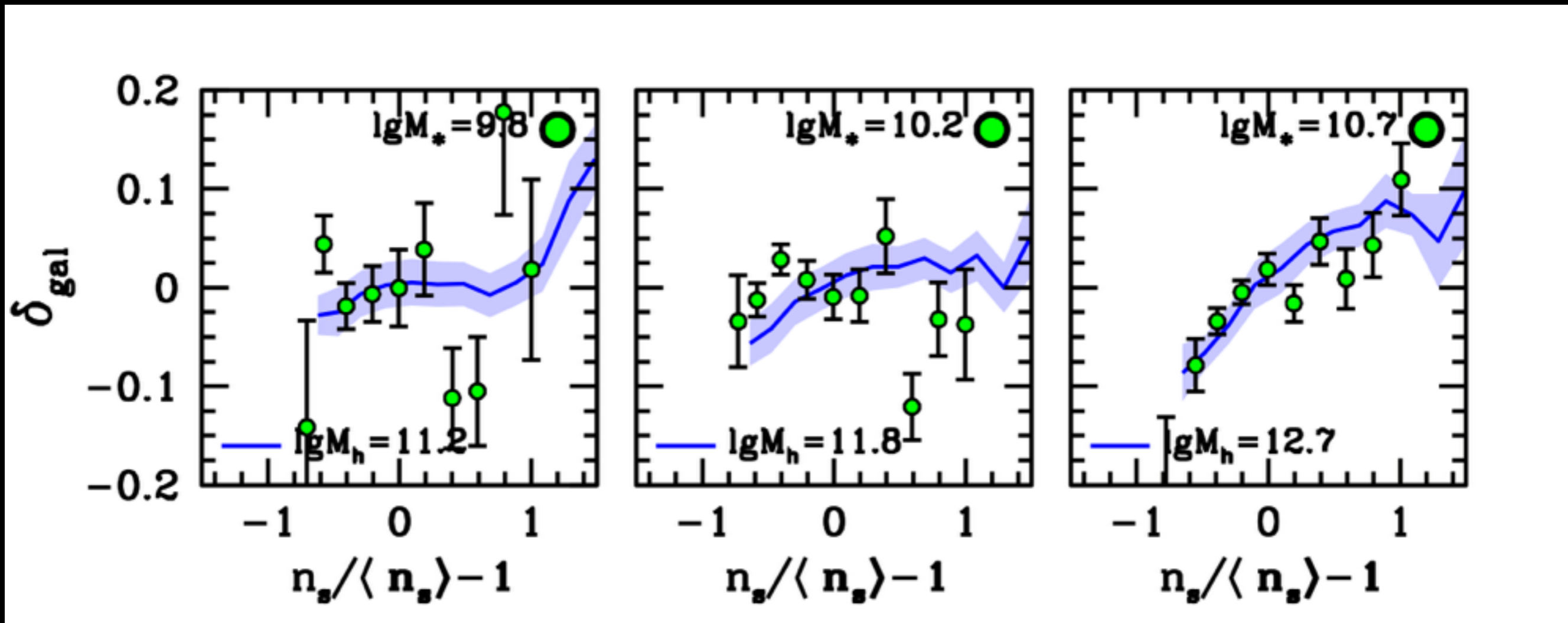
Model: Abundance match for $M_h - M_{\text{star}}$

$$\dot{M}_h / M_h \rightarrow \text{sSFR}$$

Dotted line has no scatter, solid line has 0.2 dex.

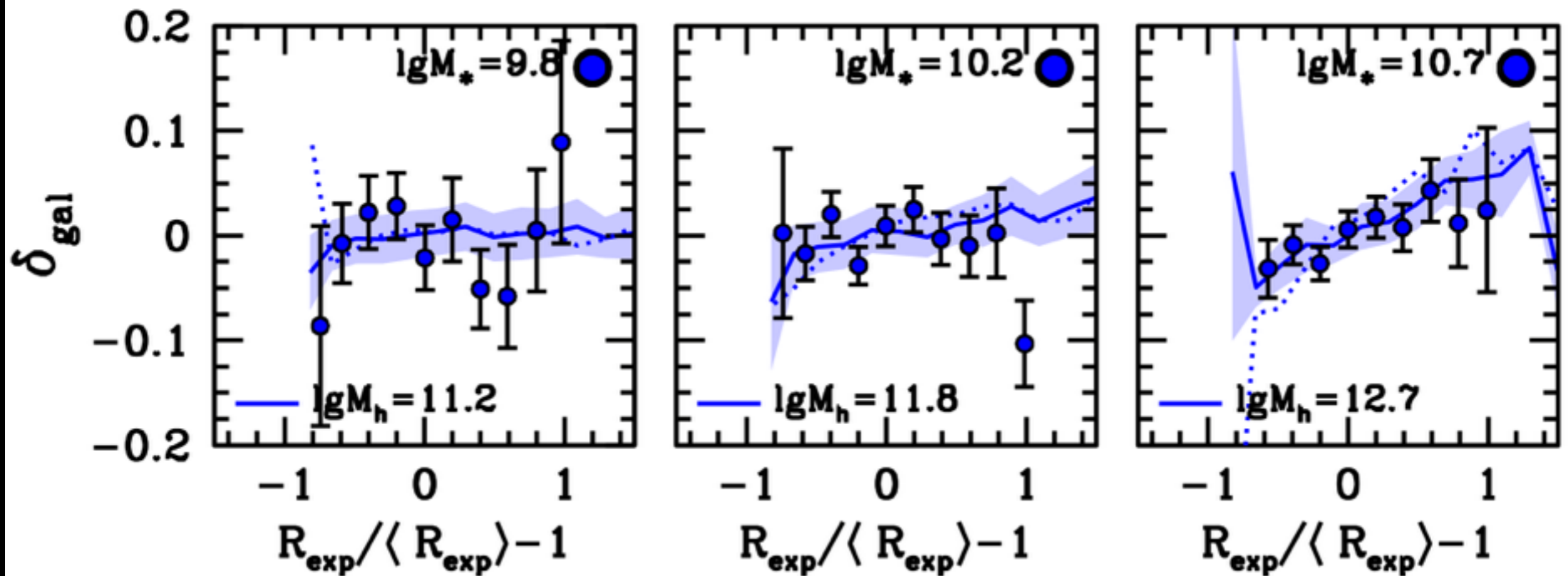
So, assuming we have
time...

What about halo spin?



Data: Same star-forming centrals as before.
Model: Abundance matching spin to Sersic index.

What about halo spin?

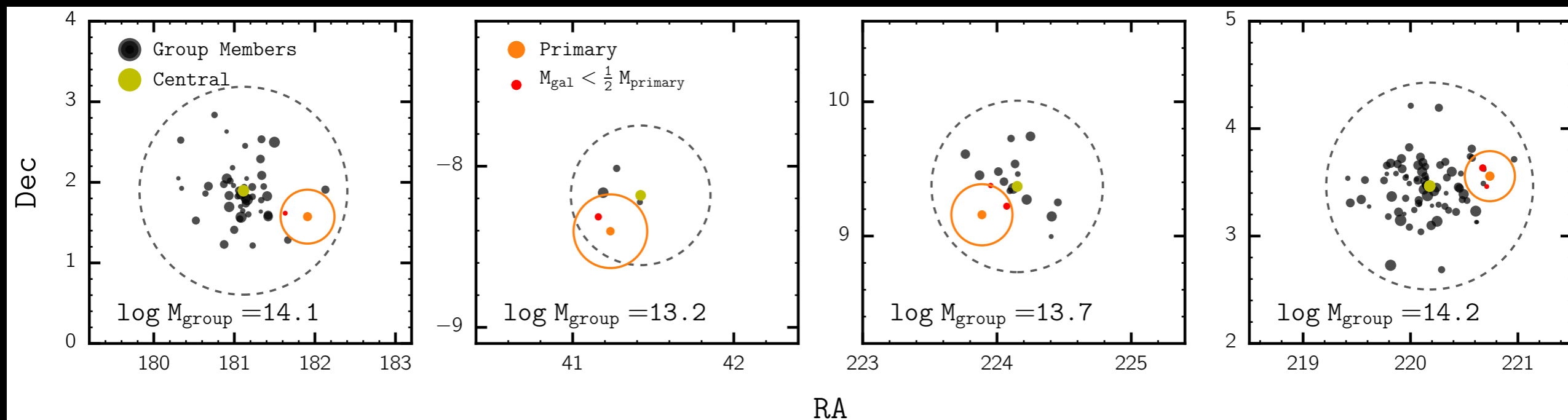
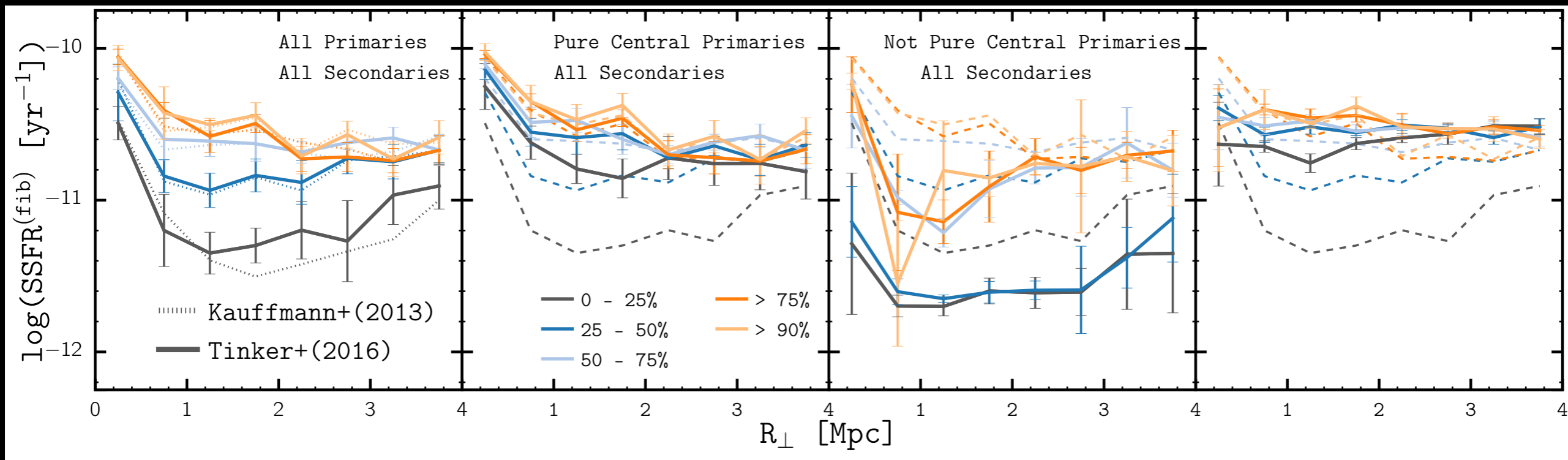


Data: Same star-forming centrals as before.
Model: Abundance matching spin to R_{exp}

So, do we still have
time?



Two-Halo Conformity



Two-Halo Conformity

