CONSTRAINTS ON GALAXY STAR FORMATION HISTORIES

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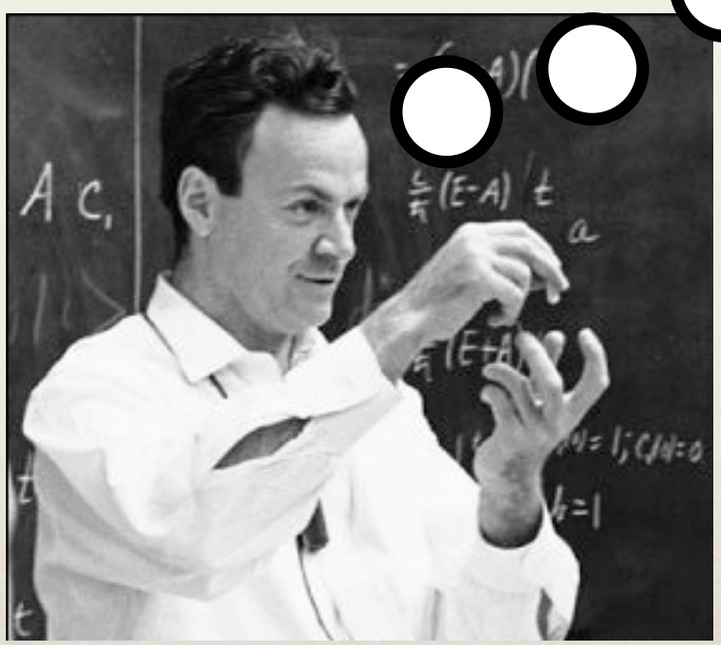
Santa Cruz Galaxy Workshop 2010

A Notorious Question

What do galaxy star formation histories look like, on average?



A Brief Reminder

In principle, it is possible to determine galaxy star formation histories just by looking at them.*

* e.g., Papovich 2010, Allanson et al. 2009, Aparicio & Hidalgo 2009, Tojeiro et al. 2009, and many others!

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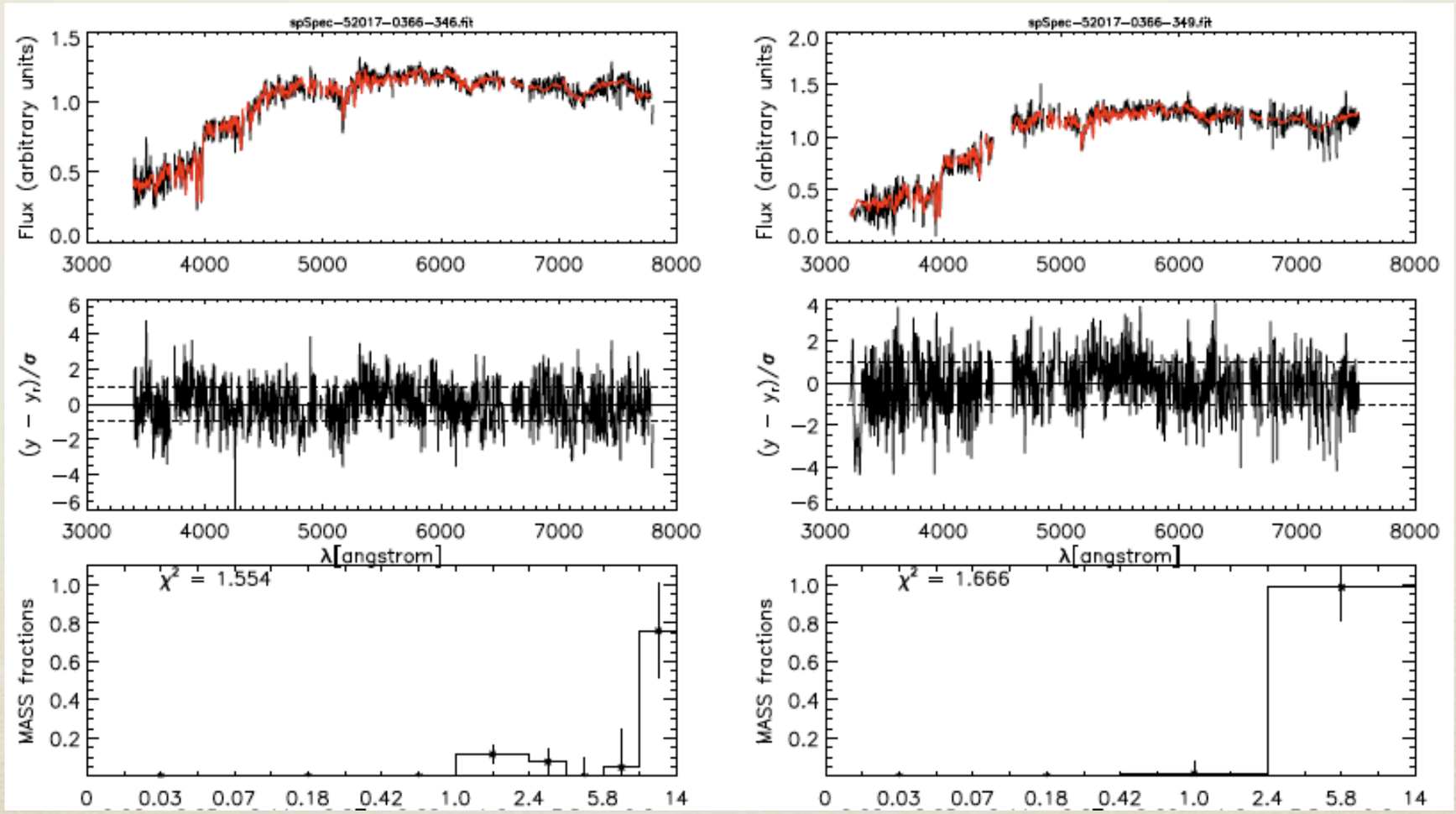
In practice, it is difficult to robustly estimate early galaxy star formation histories this way, except for nearby galaxies.



Tojeiro et al. 2009

A Brief Reminder

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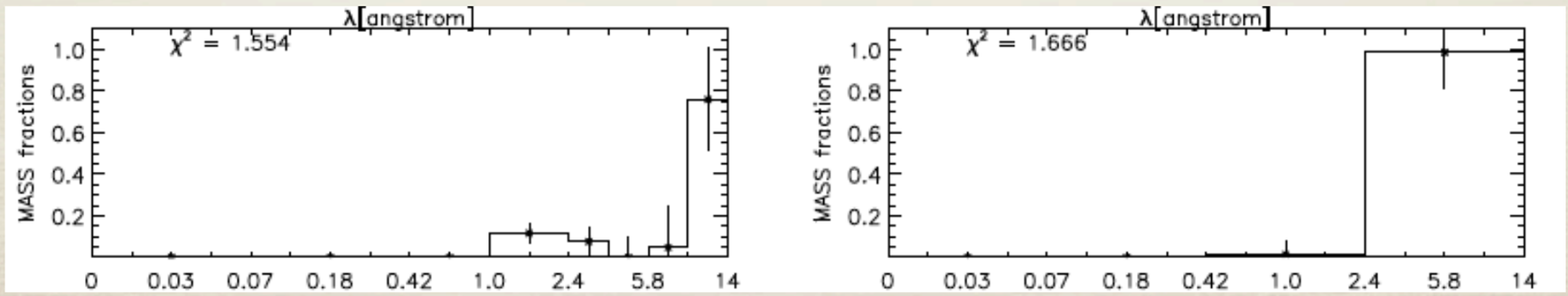
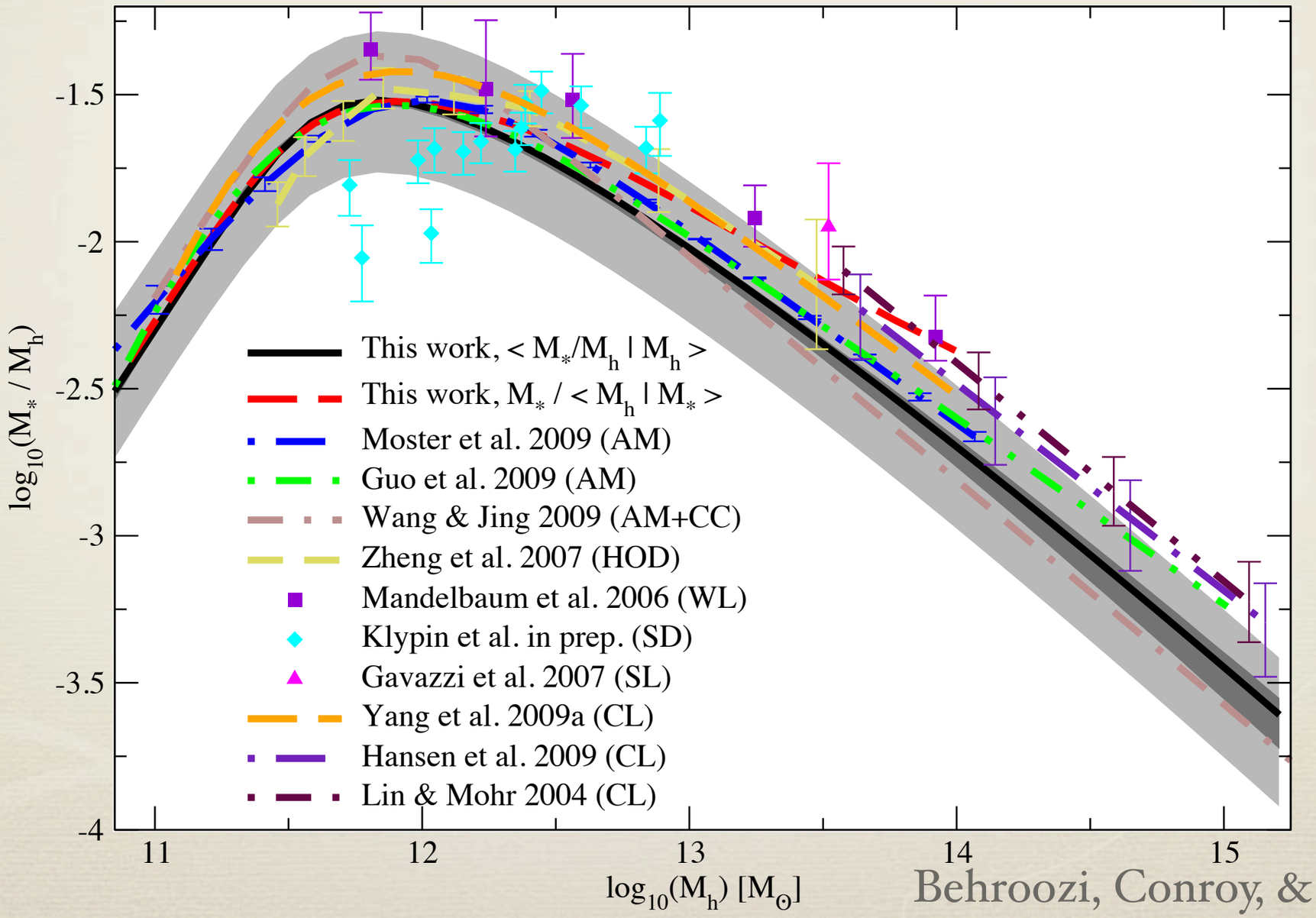
In general, there is little information about ancient stellar histories, as the colors of stellar populations more than two billion years old rapidly converge.



Tojeiro et al. 2009

Our Approach

We already have a robust understanding of the constraints on the galaxy - halo connection.



Behroozi, Conroy, & Wechsler 2010

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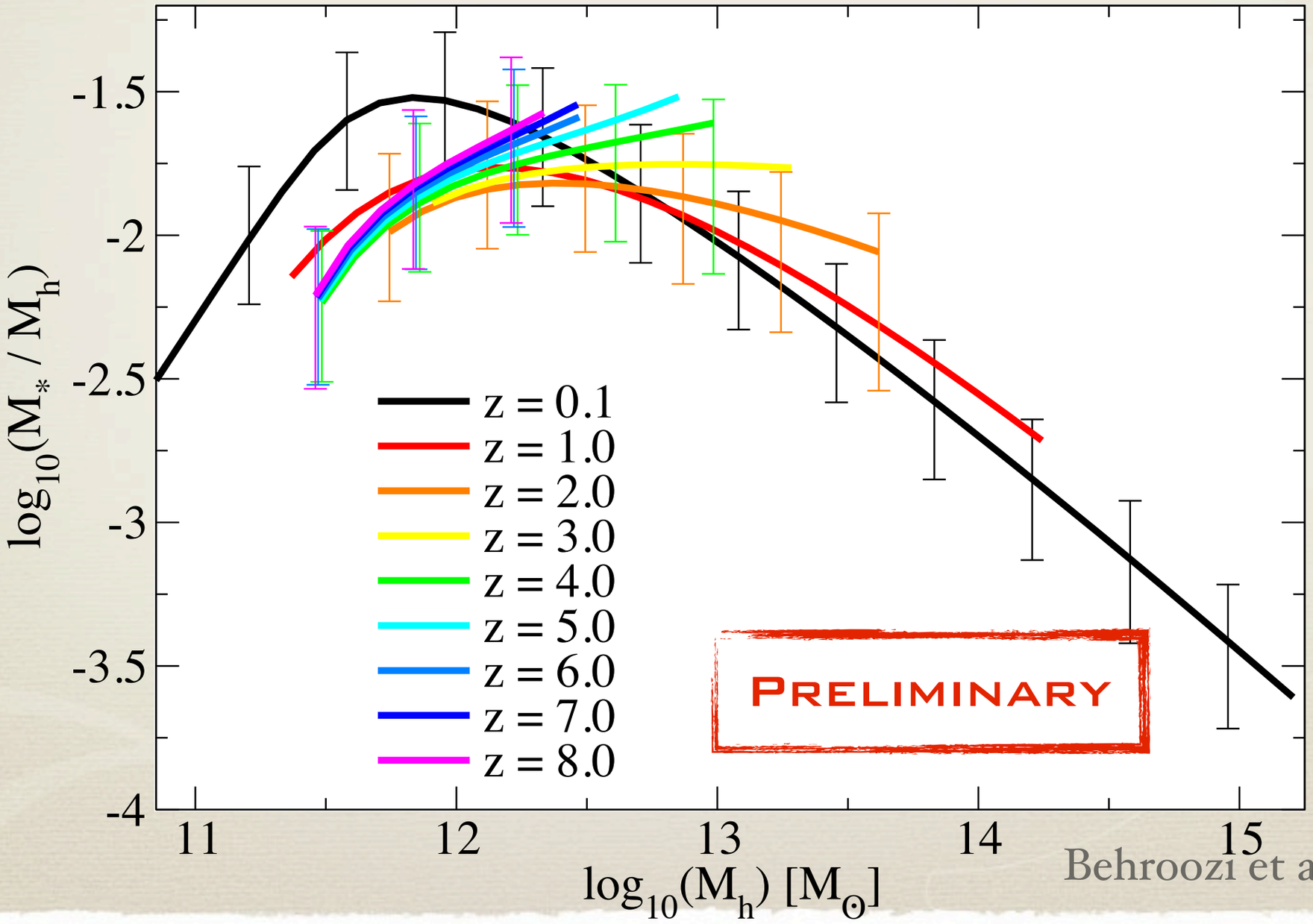
Since we only need to know halo and galaxy abundances, we can constrain the stellar mass in halos at any redshift.



Behroozi et al. in prep

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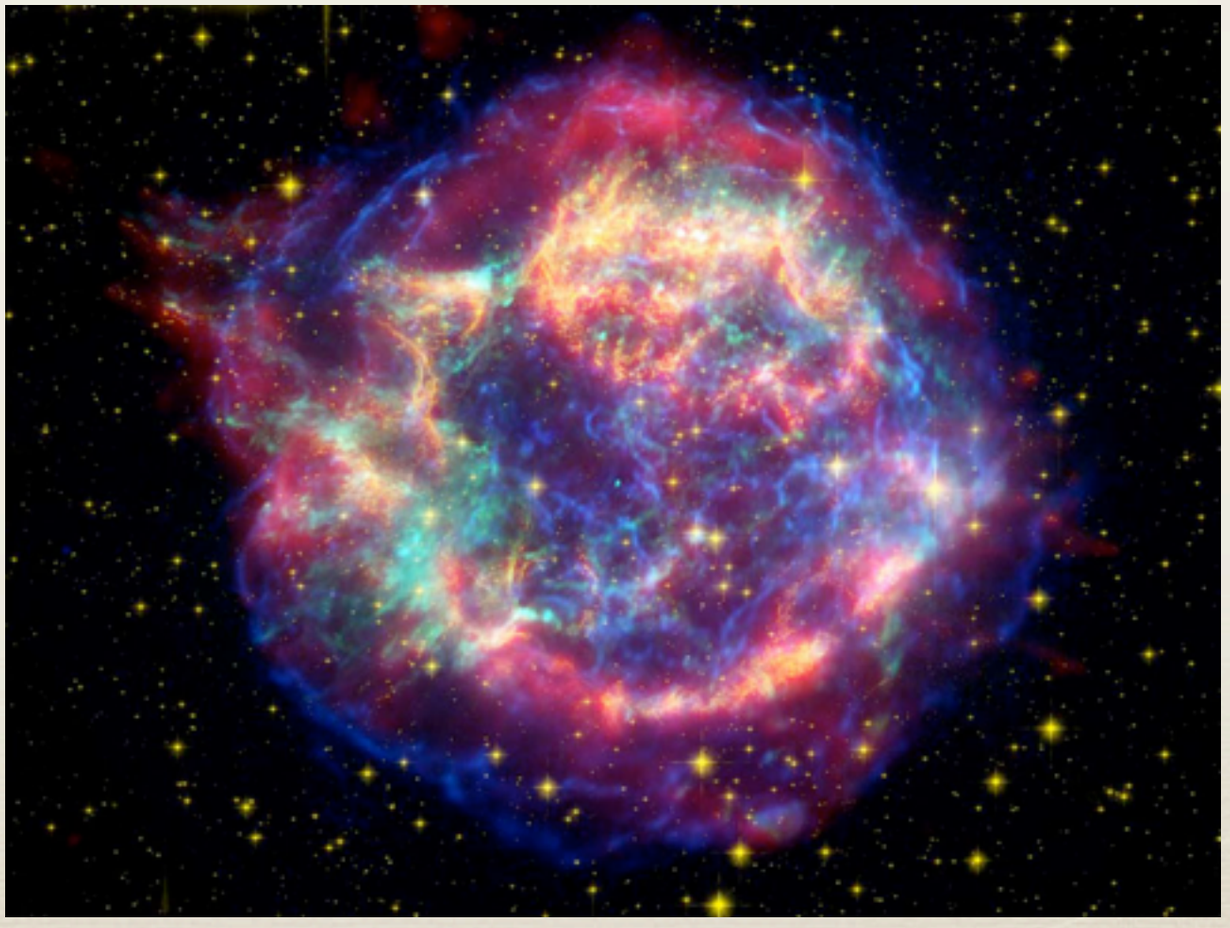

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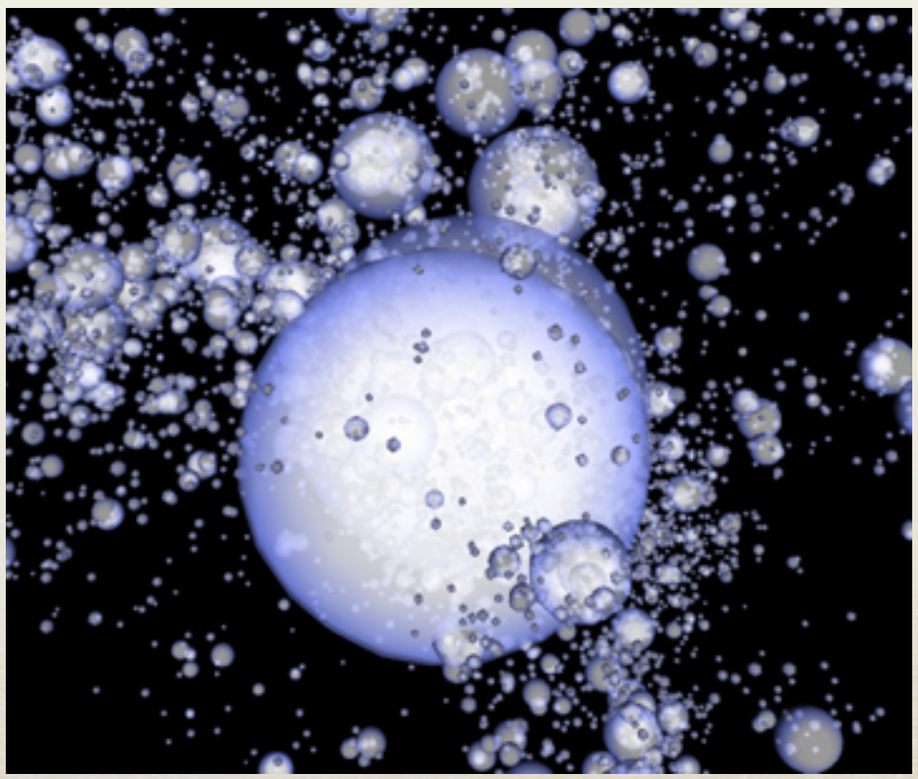

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All that's left to find the average star formation rates is to take the time derivative!

Our Approach

In equations:

$$(\Delta t) \cdot SFR_{m_d}(t_{now}) =$$

(new stars)

$$SM_{m_d}(t_{now})$$

(expected stellar mass)

$$- \left(MMP_{m_p,m_d} + SUBS_{m_p,m_d} \cdot (1 - ICL(m_p, m_d))\right)$$

(number of contributing progenitors, corrected for ICL losses)

$$\times\ SFH^{m_p,t}(t_{now})(1 - SL_t(t_{now}))$$

(stellar population of progenitors, corrected for stellar death)

Results

As such, we can recover both the average star formation rate *and* the average star formation history as a function of halo mass.*

* See also Conroy & Wechsler 2009

Results

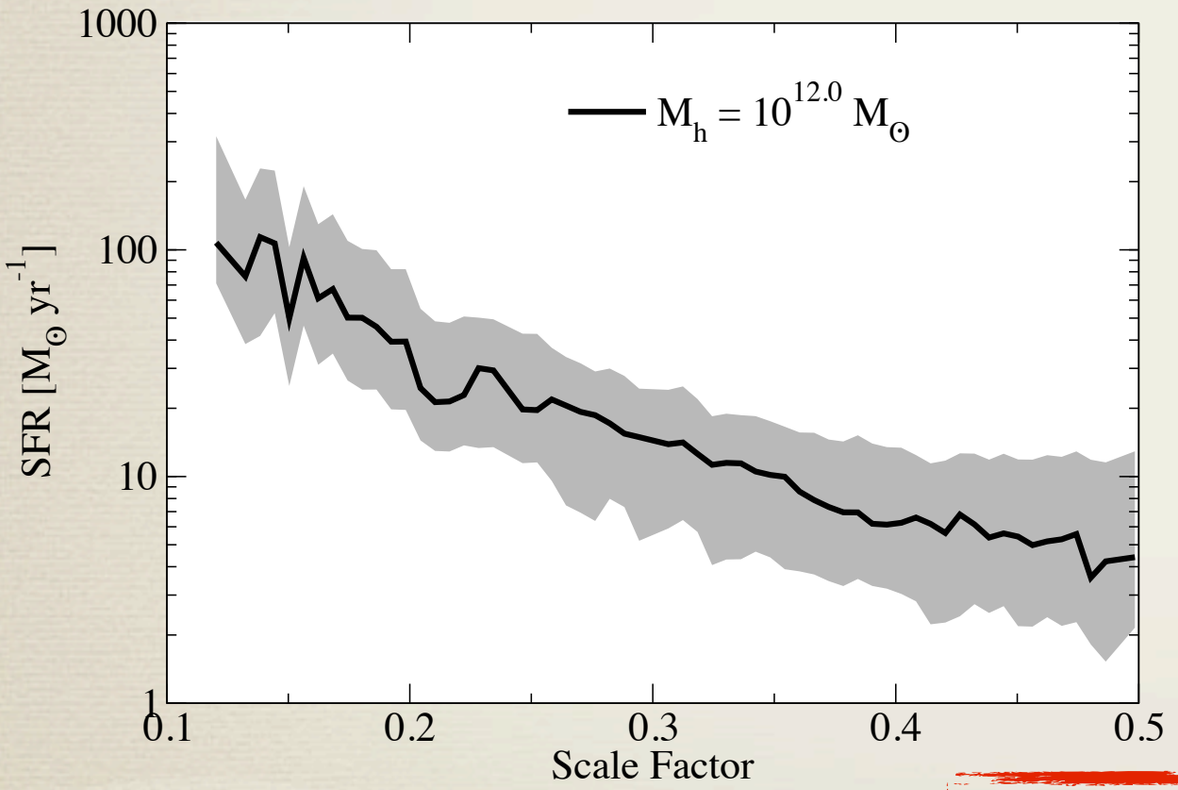
As such, we can recover both the average star formation rate *and* the average star formation history as a function of halo mass.*

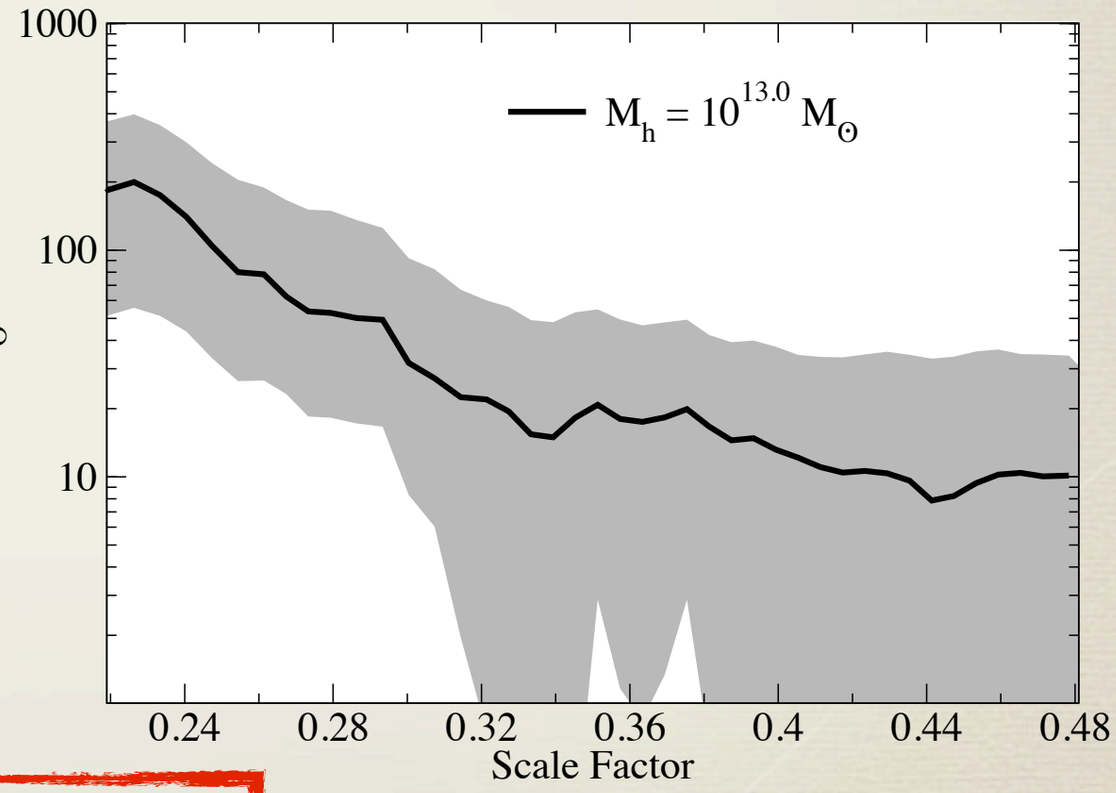
Plus, *full propagation of uncertainties* comes for free, from the work we have already done to calculate the uncertainties on the galaxy - halo connection.

* See also Conroy & Wechsler 2009

Star Formation Rates

Not unexpectedly, star formation rates at a given halo mass have always been decreasing.





PRELIMINARY

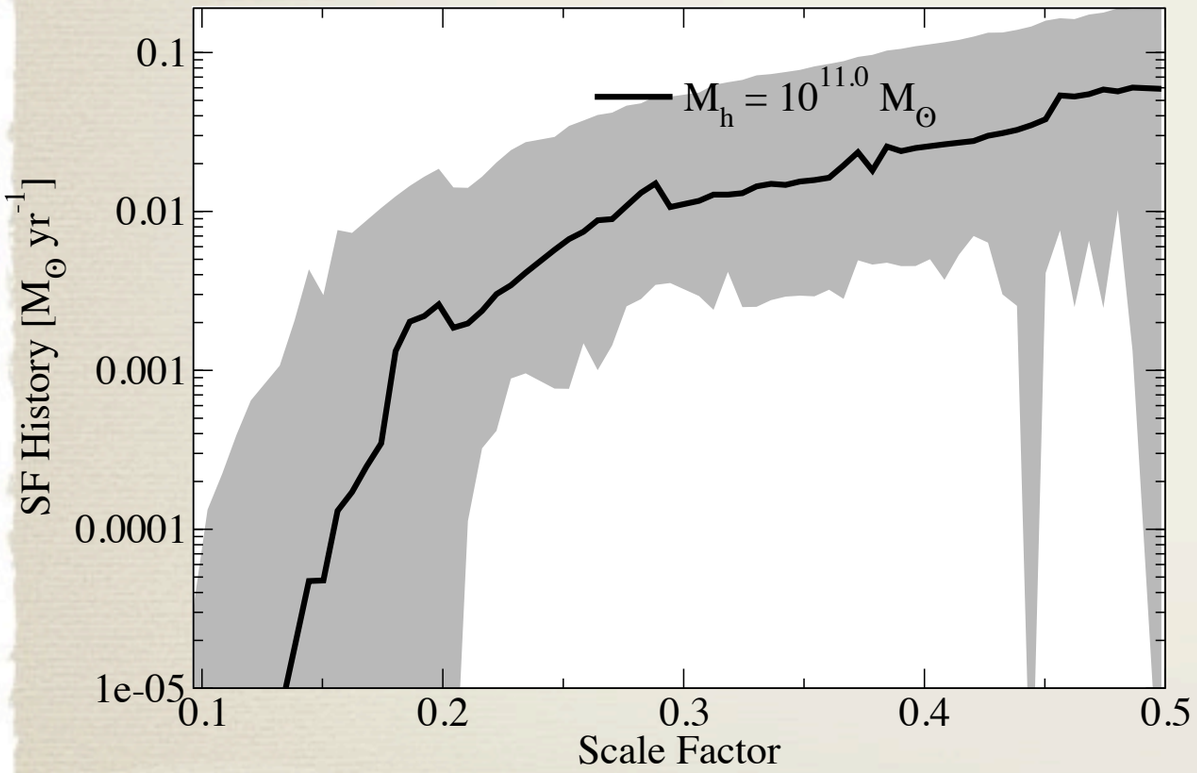
(Uncertainties on the order of 0.3 dex in SFR)

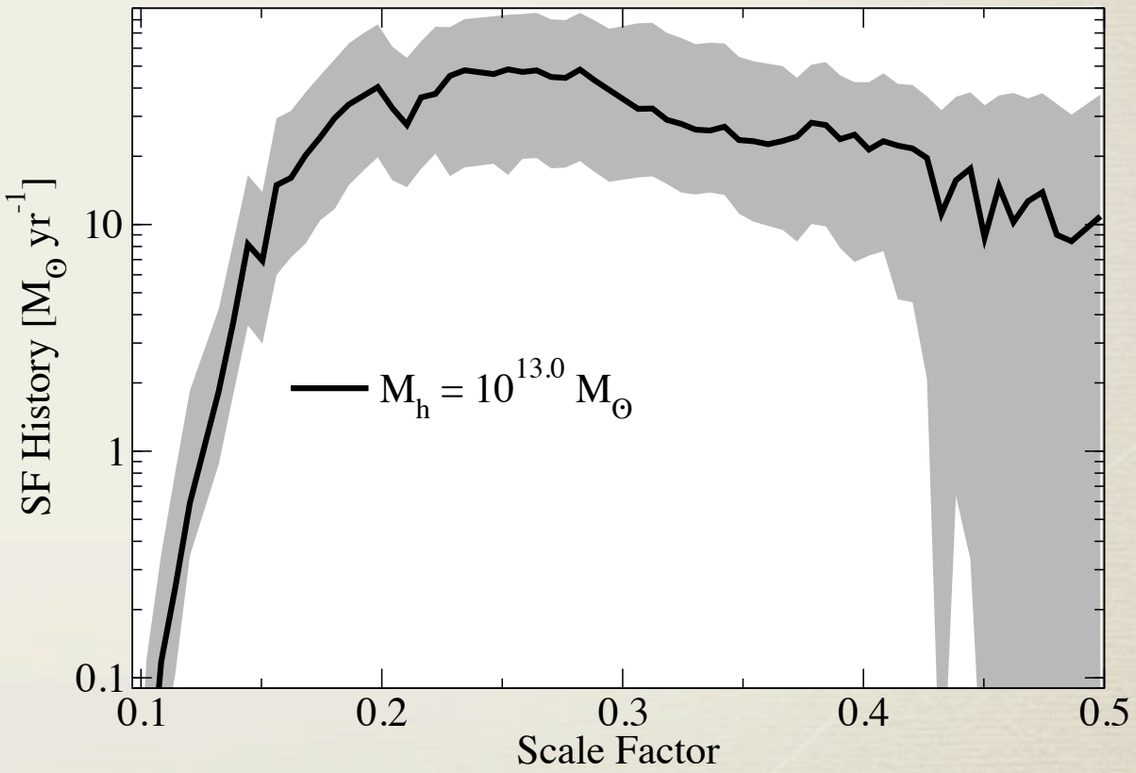
Star Formation Histories

But, if we ask the complementary question about galaxy star formation histories, there's no single trend!

Star Formation Histories

The rate at which the stellar population grew in low-mass galaxies has always been increasing; whereas for high-mass galaxies, the rate peaked at an early redshift and then declined.

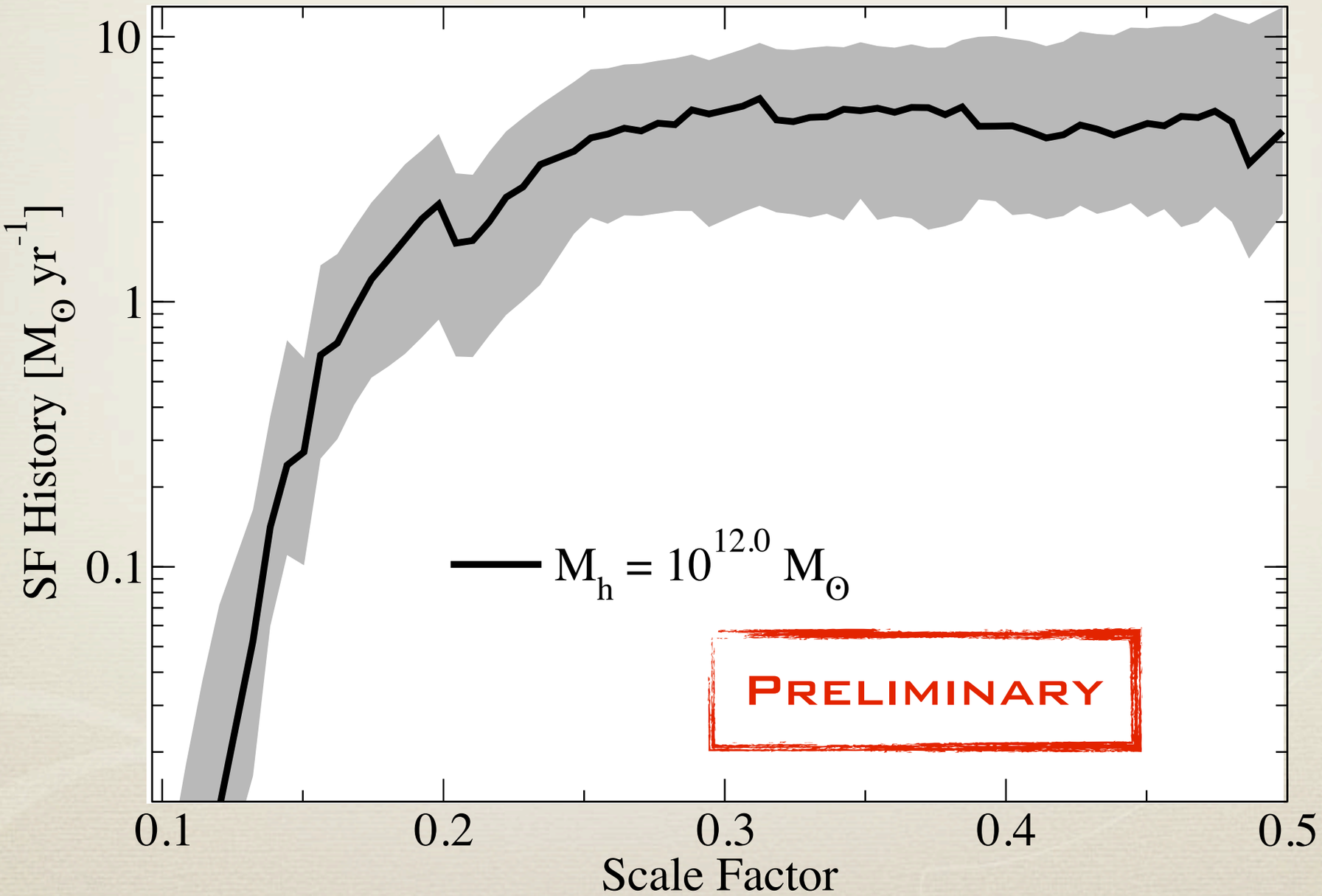




PRELIMINARY

Star Formation Histories

For intermediate galaxies, the stellar mass growth rate grew rapidly and then roughly stabilized.



Final Words

Still preliminary work, but:

By construction, our approach matches the observed stellar mass function at all times, as well as the observed clustering of galaxies (through the galaxy-halo connection).

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We've already obtained constraints on the functional form of *both* the star formation history and the star formation rate for galaxies.

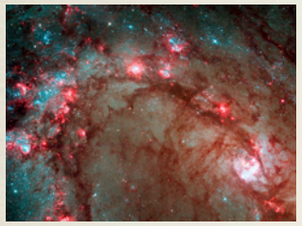
We've added to the growing body of evidence which suggests that exponentially declining stellar population models are not appropriate for most galaxies for z>1.

Future Work

Further work on modeling the fraction of stars which are ejected into the ICL will enable us to extend these results down to z=0.

Adding more data as constraints will help us understand deviations from the average star formation rates (e.g., scatter in SFR at fixed SM, SFR-density clustering, galaxy clustering by color).

Image Credits



http://spacefellowship.com/news/art15504/picture-of-the-day-the-birth-of-stars.html

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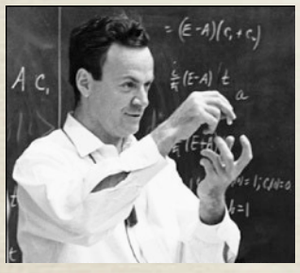
http://www.lionking.org/imgarchive/Act_2/Stargazing.jpg



http://www-scf.usc.edu/~kallos/images/Feynman.gif