STAR FORMATION HISTORIES FROM Z=0 TO Z=8

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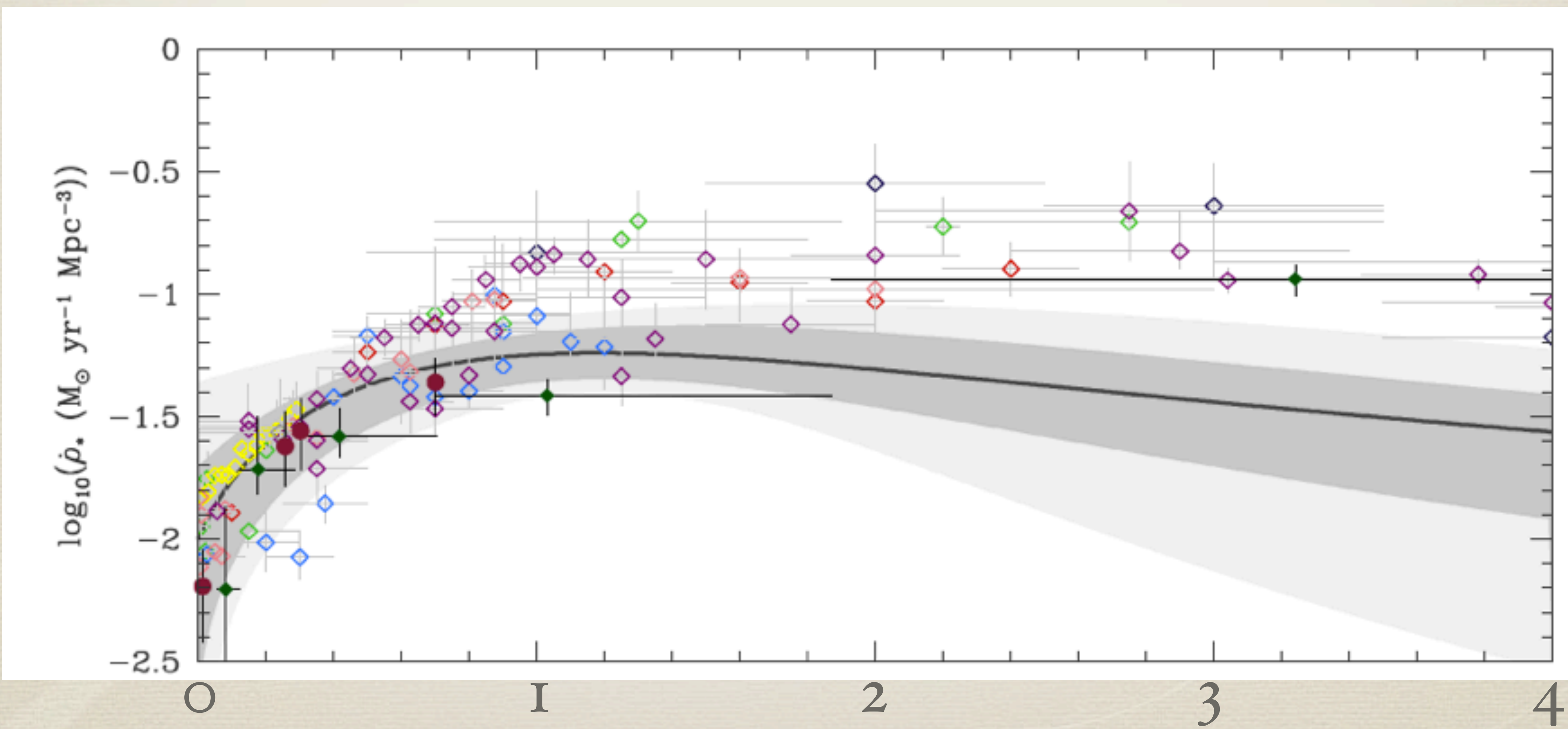
Major Questions

When did galaxies form their stars, as a function of their mass today? (Or their mass at an earlier redshift?)

LMC; Hubble Heritage Team

Major Questions

What's the solution to the discrepancy between the cosmic SFR and the cosmic SM density?



Wilkins et al. 2008

Approach

Parametrize the evolution of the stellar mass function;

Include nuisance parameters for
all conceivable systematic effects.*

Constrain using ALL available data, currently
including observations of the stellar mass function,
specific star formation rates,
and the cosmic star formation rate (all from z=0-8).

*see Behroozi, Conroy, & Wechsler 2010

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)

Talk to me about details!

Approach

Include parametrized models for
all conceivable systematic effects:

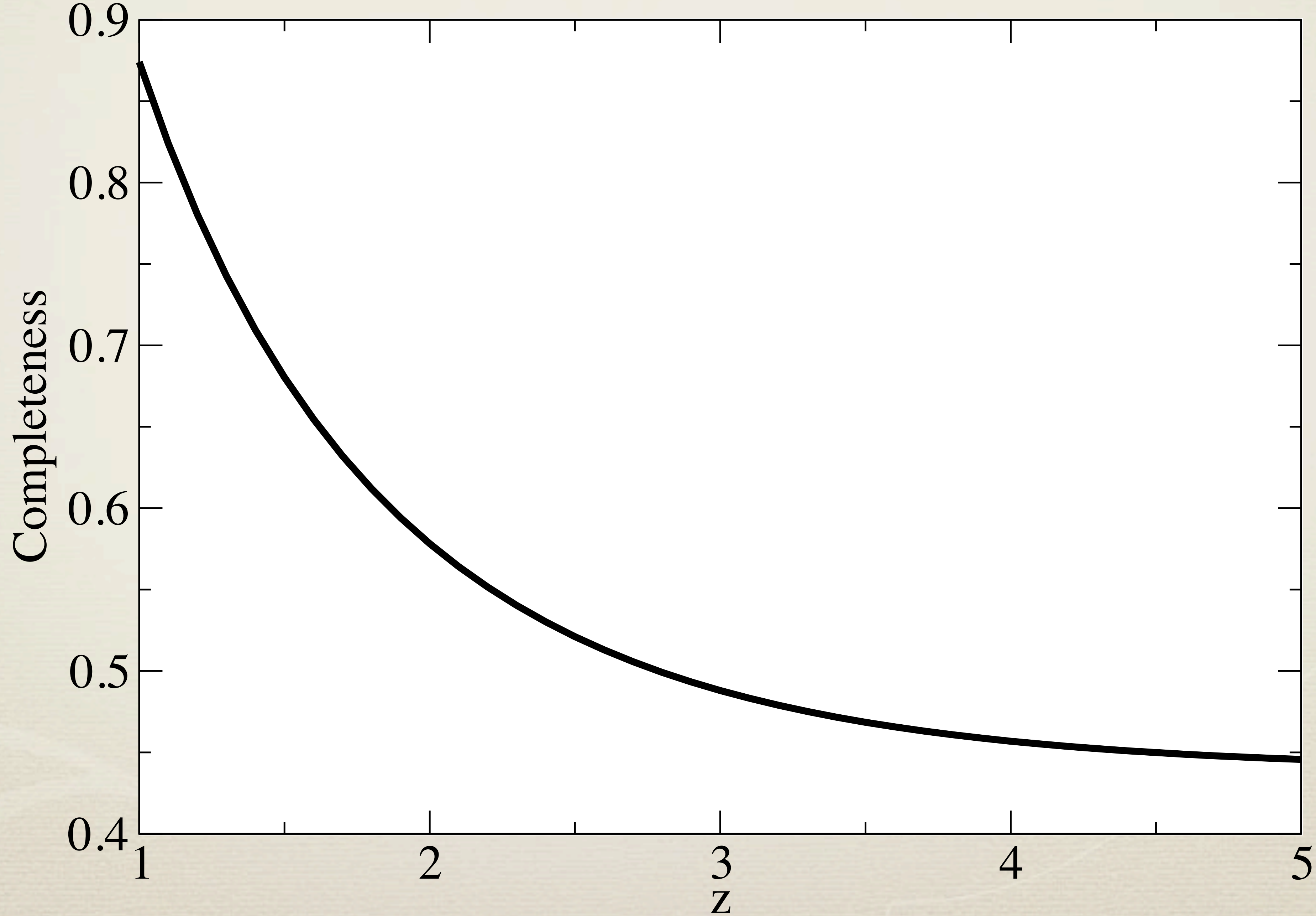
Many have suggested that high-redshift galaxies have bursty/dusty star formation,* but no-one's done a self-consistent check.

Let's try out a simple model!

*Stark et al. 2009, K.S. Lee et al. 2009, Schaerer & Barros 2010

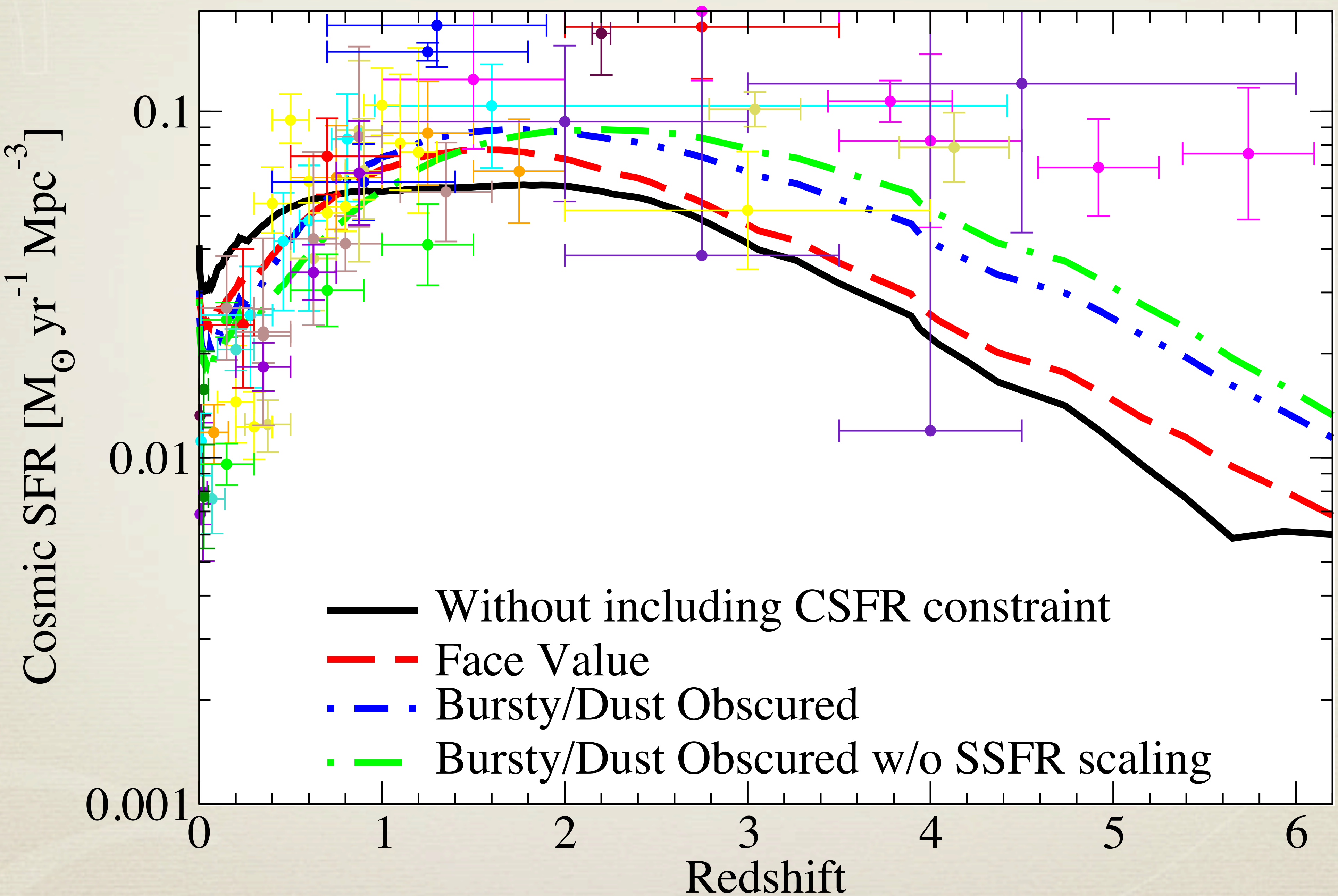
SFR / SM Tension

Incompleteness/burstiness: $\lambda(z) = \dfrac{A}{1 + \exp(B - z)}$



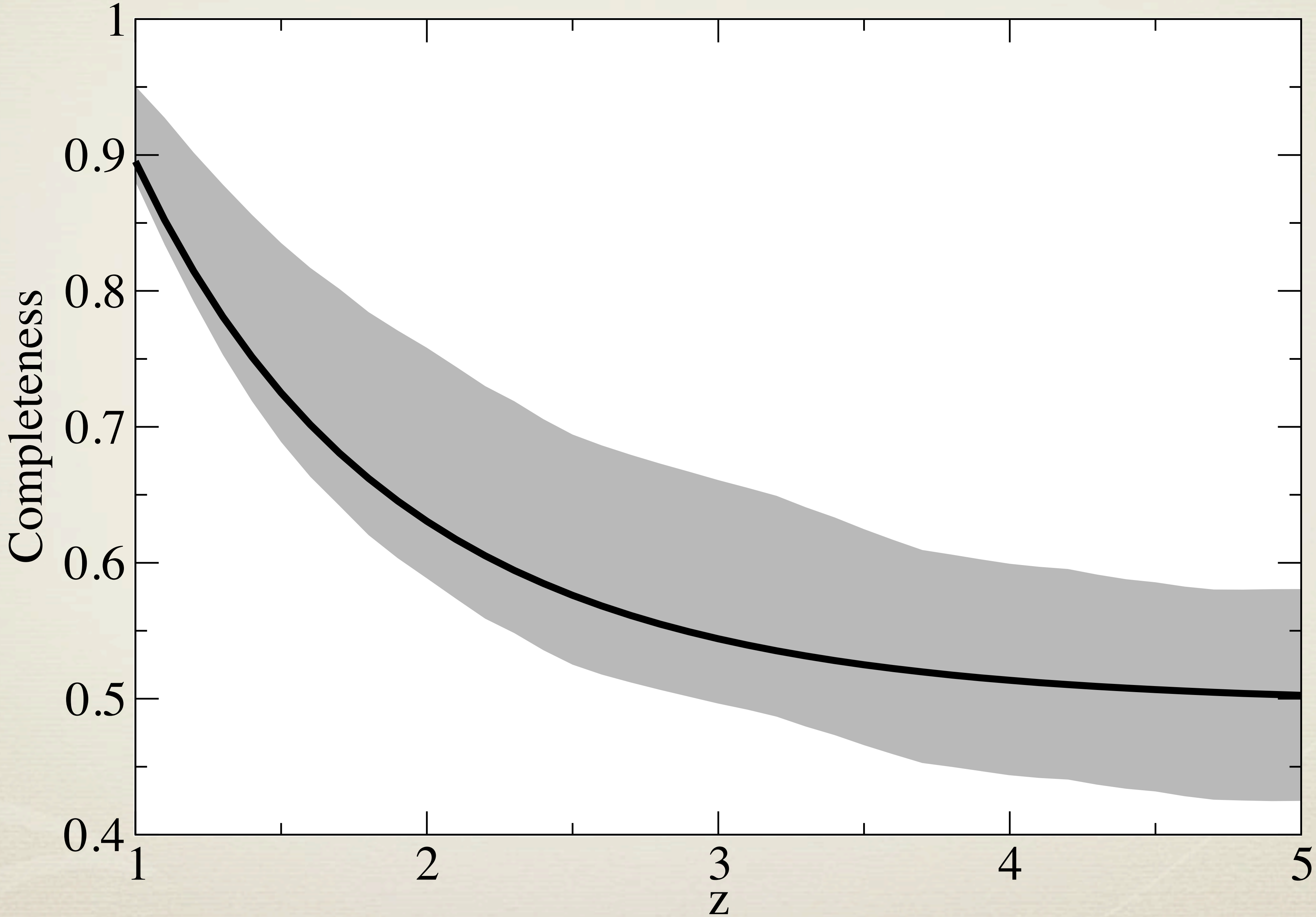
SFR / SM Tension

We can immediately better match the cosmic SFR.



SFR / SM Tension

And we can constrain the incompleteness (in this model):



SFR / SM Tension

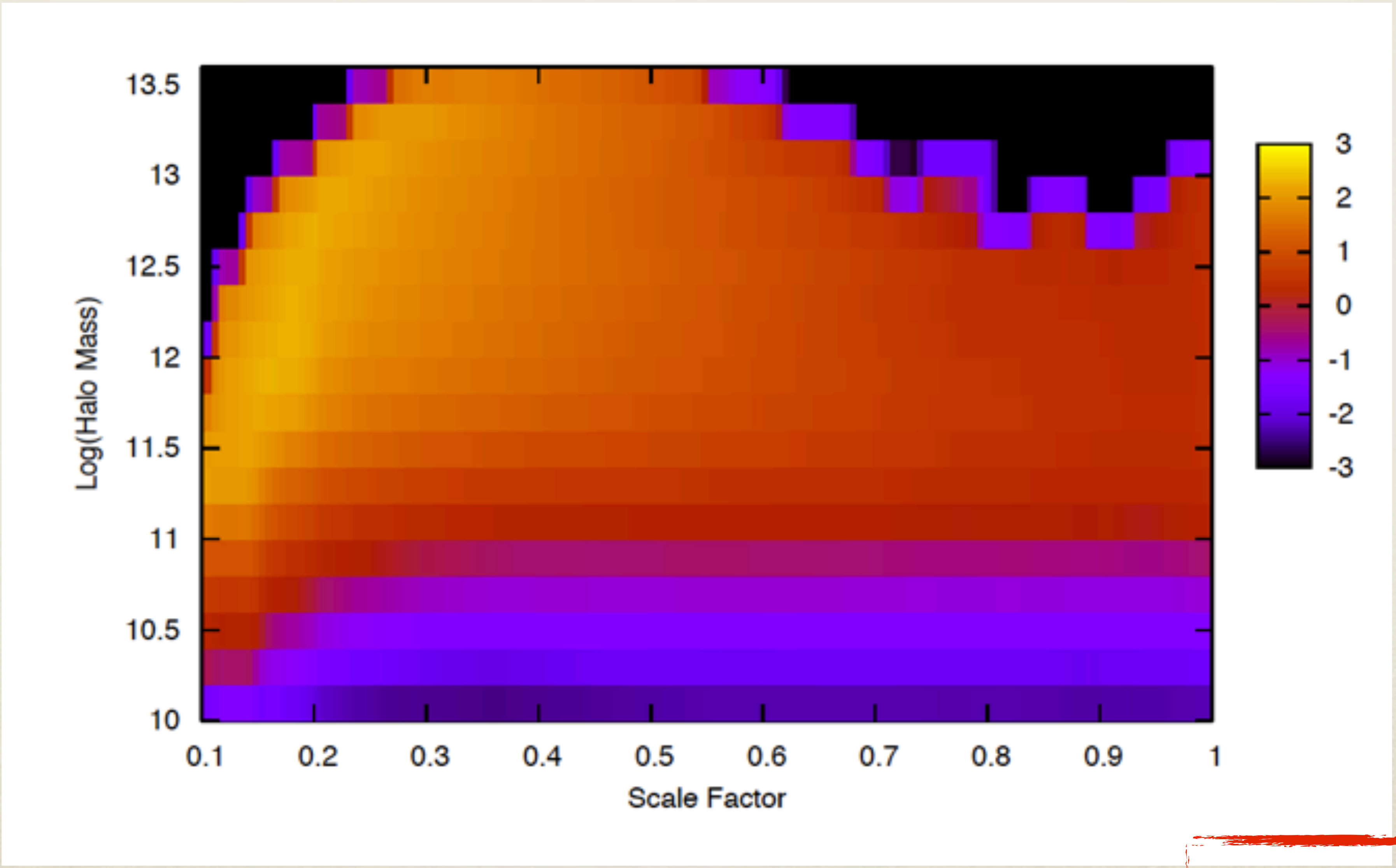
Result:

We have an extremely powerful framework for testing models to resolve the cosmic SFR / SM tension.

Burstiness / dust obscuration helps, but does not completely explain the cosmic SFR / SM tension at $z>4$.

Star Formation Rates

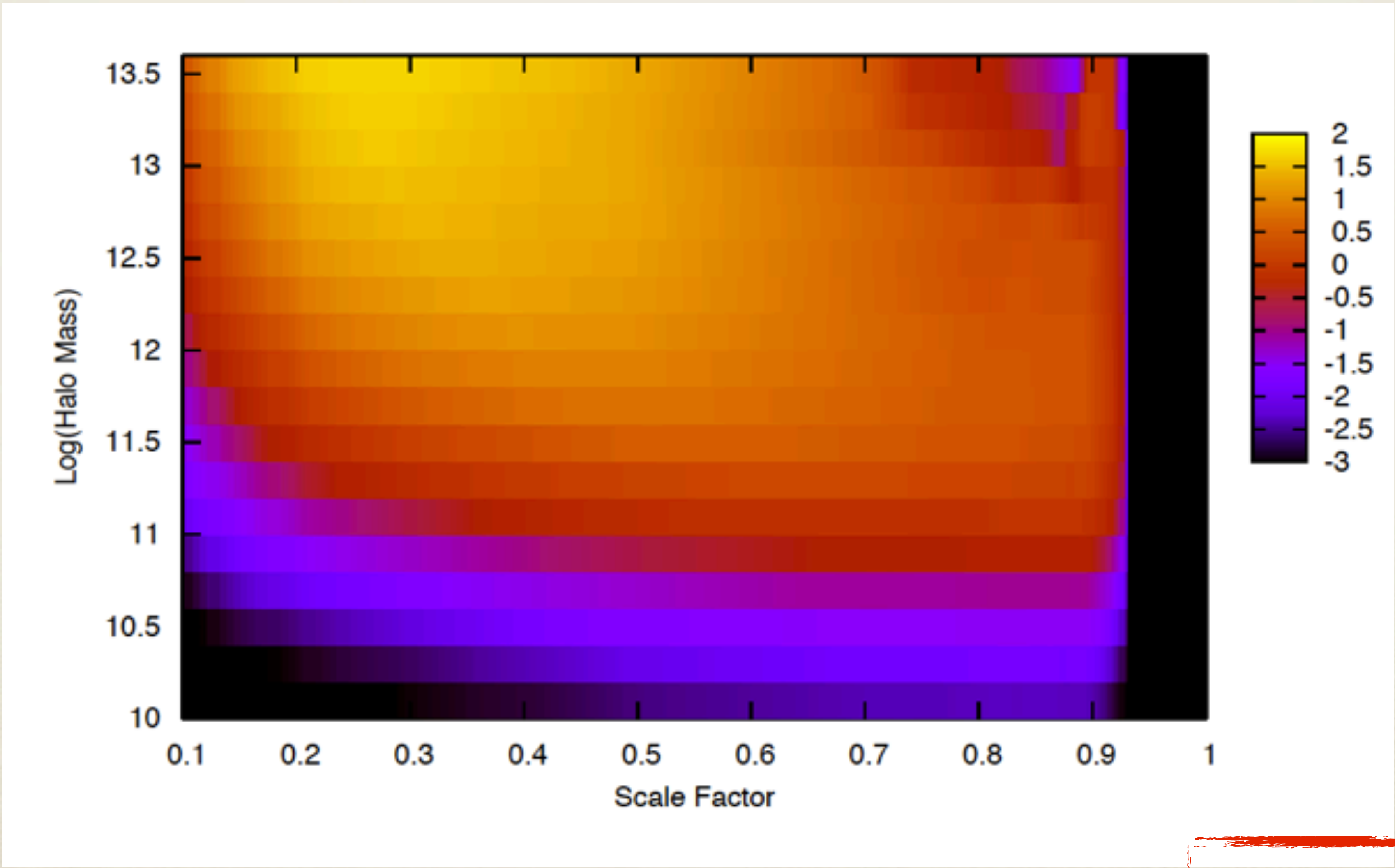
We've run our models to z=0, and found the same trends: strongly decreasing SFRs at fixed halo mass with redshift:



Preliminary

Star Formation Histories

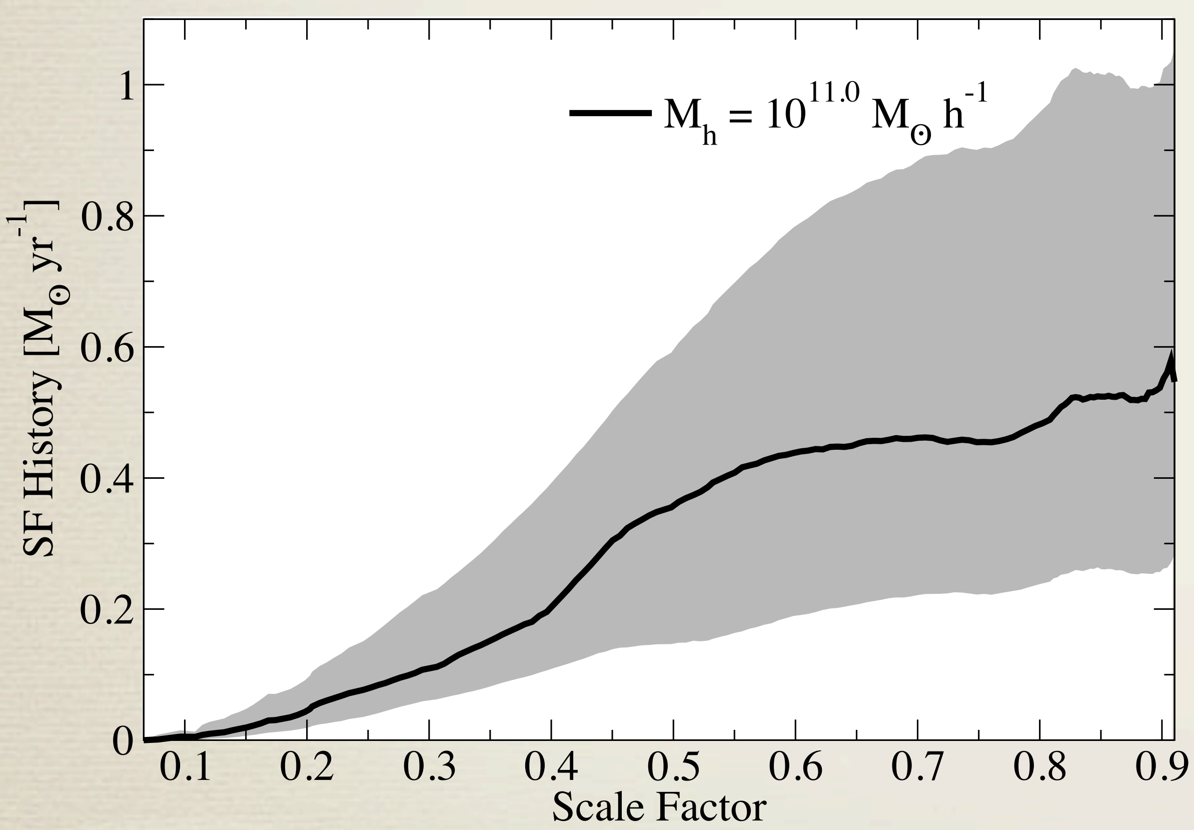
But, if we ask the complementary question about galaxy star formation histories, there's no single trend!

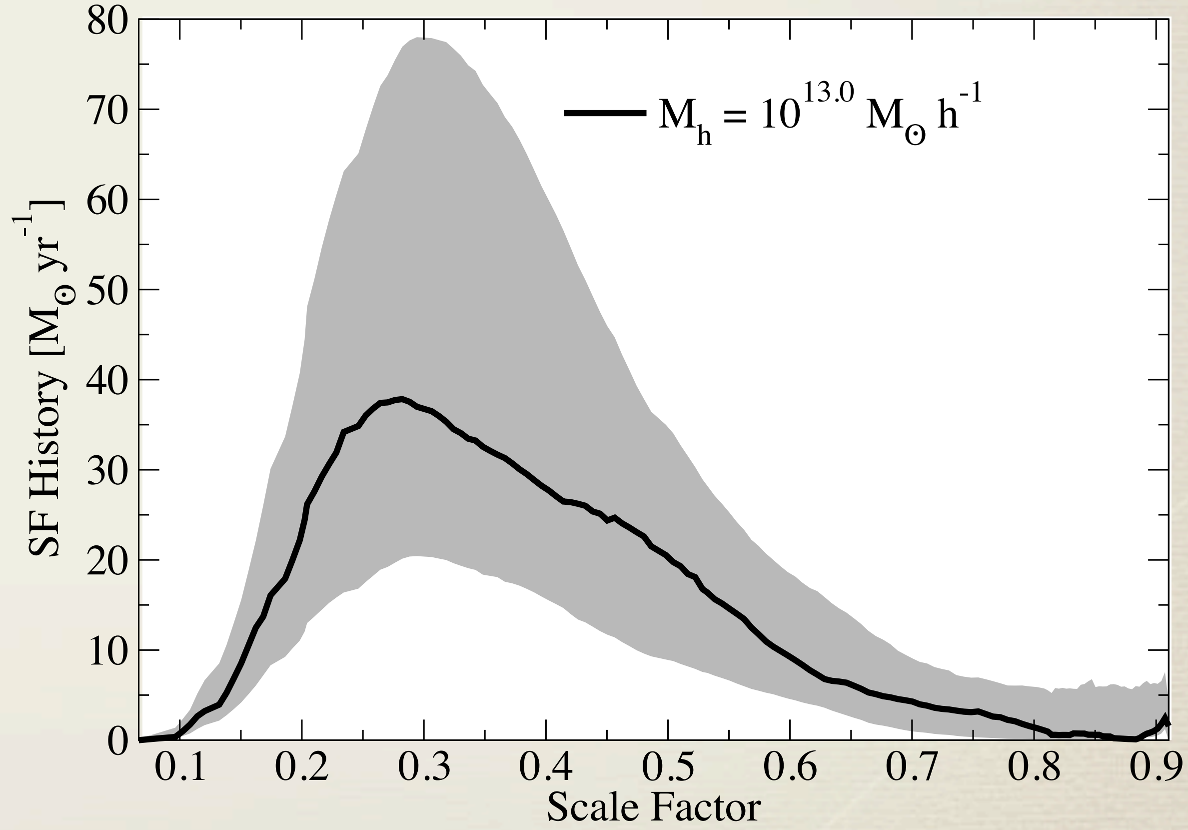


PRELIMINARY

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

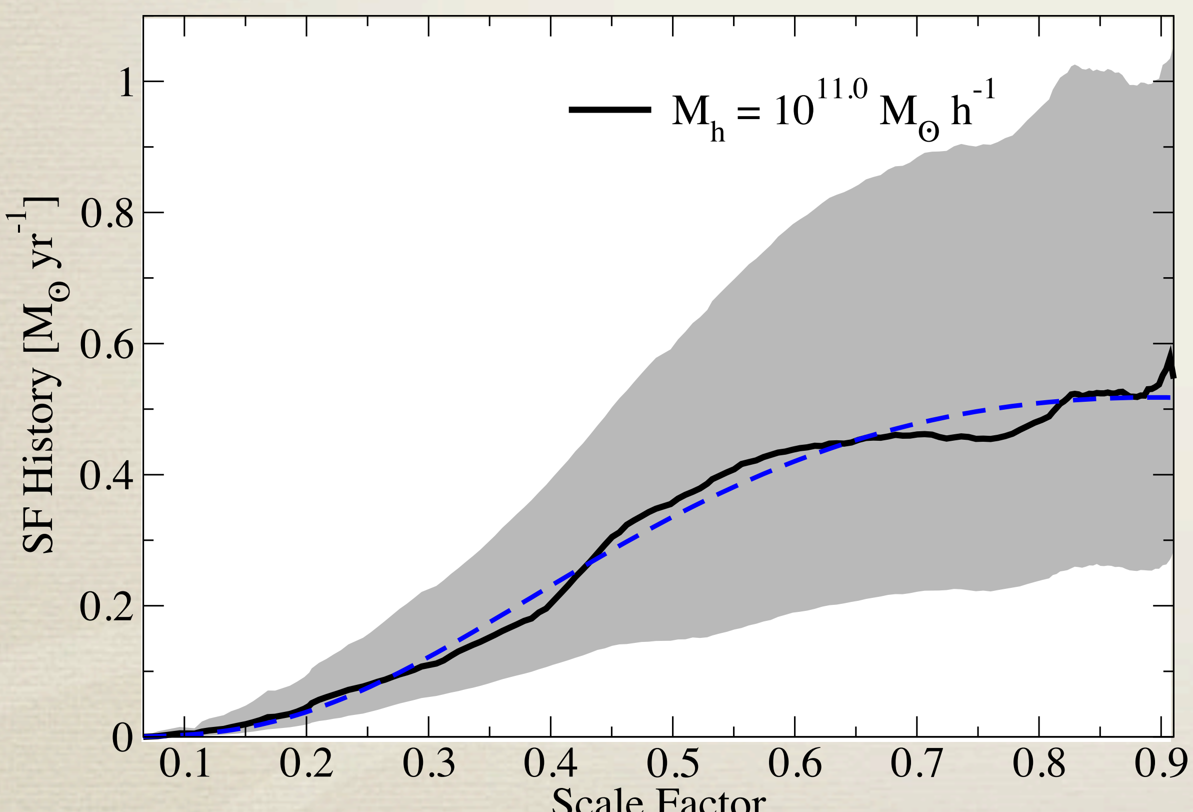
Star Formation Histories

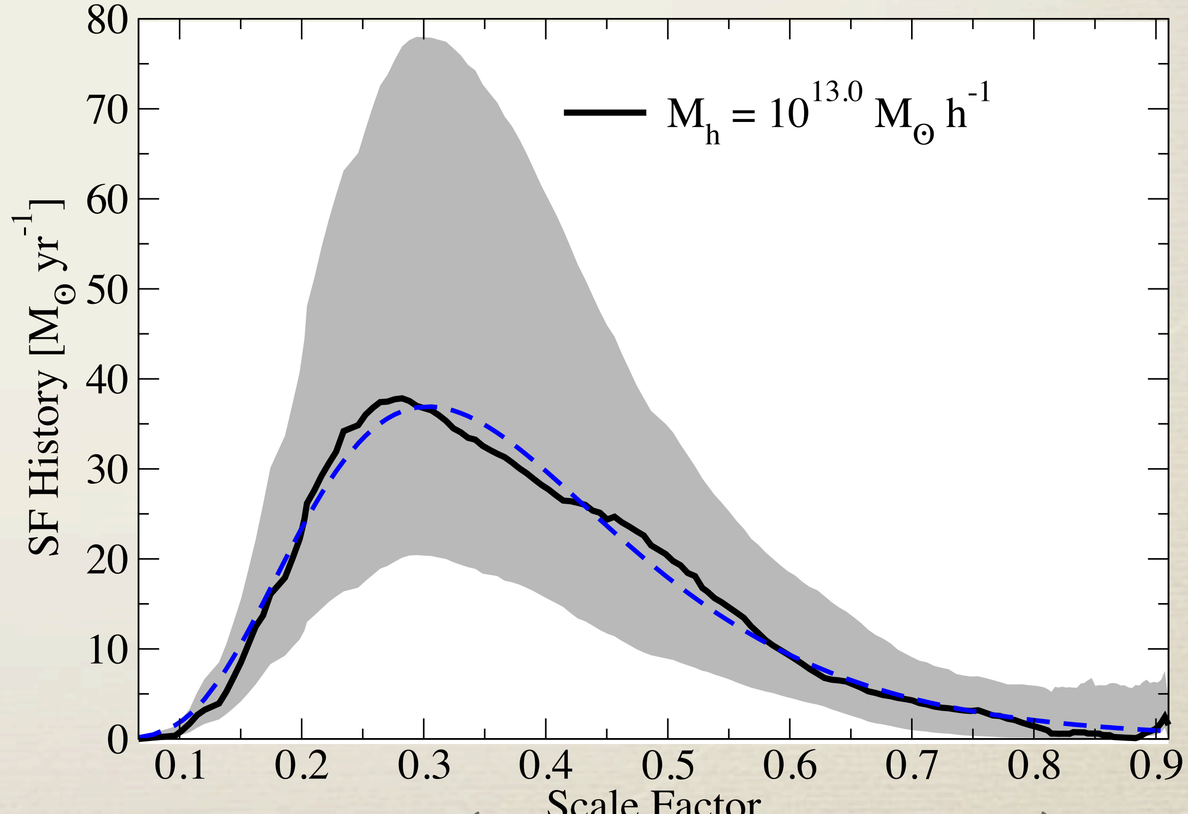
Best-fit model:

$$SFH(a) = Aa^B \exp[C(1-a)]$$

Even better in detail:

$$SFH(a) = Aa^B \exp[C(1-\sqrt[3]{a})]$$





Valid across a wide range of redshifts (0<z<4 at least).

Final Words

Still preliminary work, but:

Our approach combines constraints from the observed stellar mass function at all times, as well as the observed clustering of galaxies (through the galaxy-halo connection), as well as the cosmic SFR and specific SFRs.

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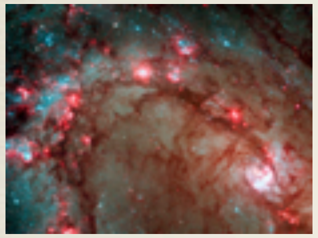
We can also start to constrain models for resolving the discrepancy between cosmic SFRs and SMs.

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

Image Credits



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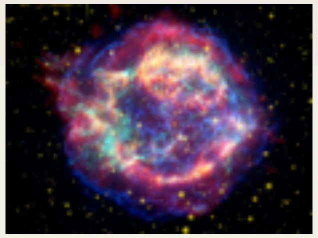

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