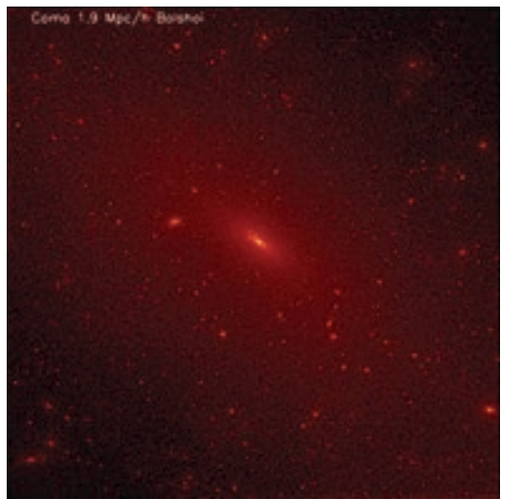
ETH zürich

Simon Birrer

A simple model linking dark matter and galaxy evolution



Speaker: Simon Birrer
ETH Zurich, Cosmology Group (Lead A. Refregier)
in collaboration with Simon Lilly

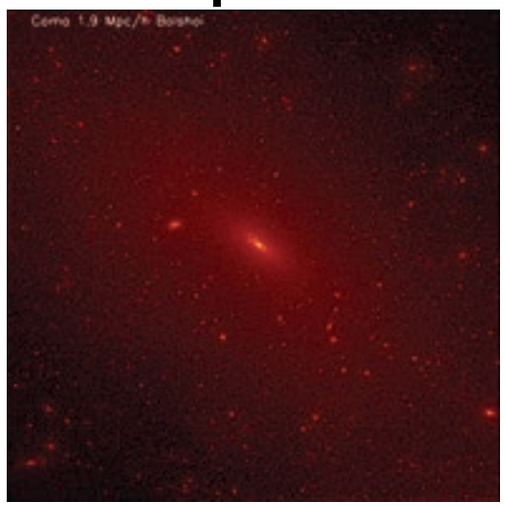
August 12th 2014, Santa Cruz

arXiv:1401.3162, accepted
Simon Birrer, Simon Lilly, Adam Amara, Aseem Paranjape, Alexandre Refregier

A "phenomenological" approach

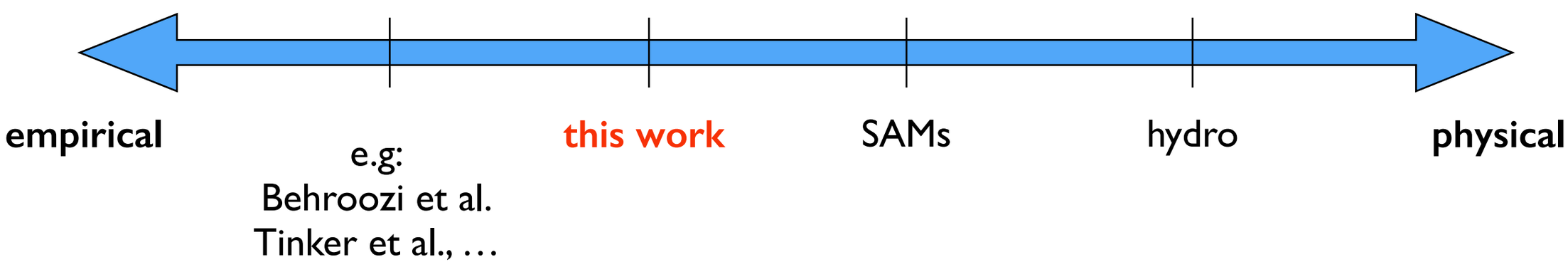
How far can we get with...

...simplified...

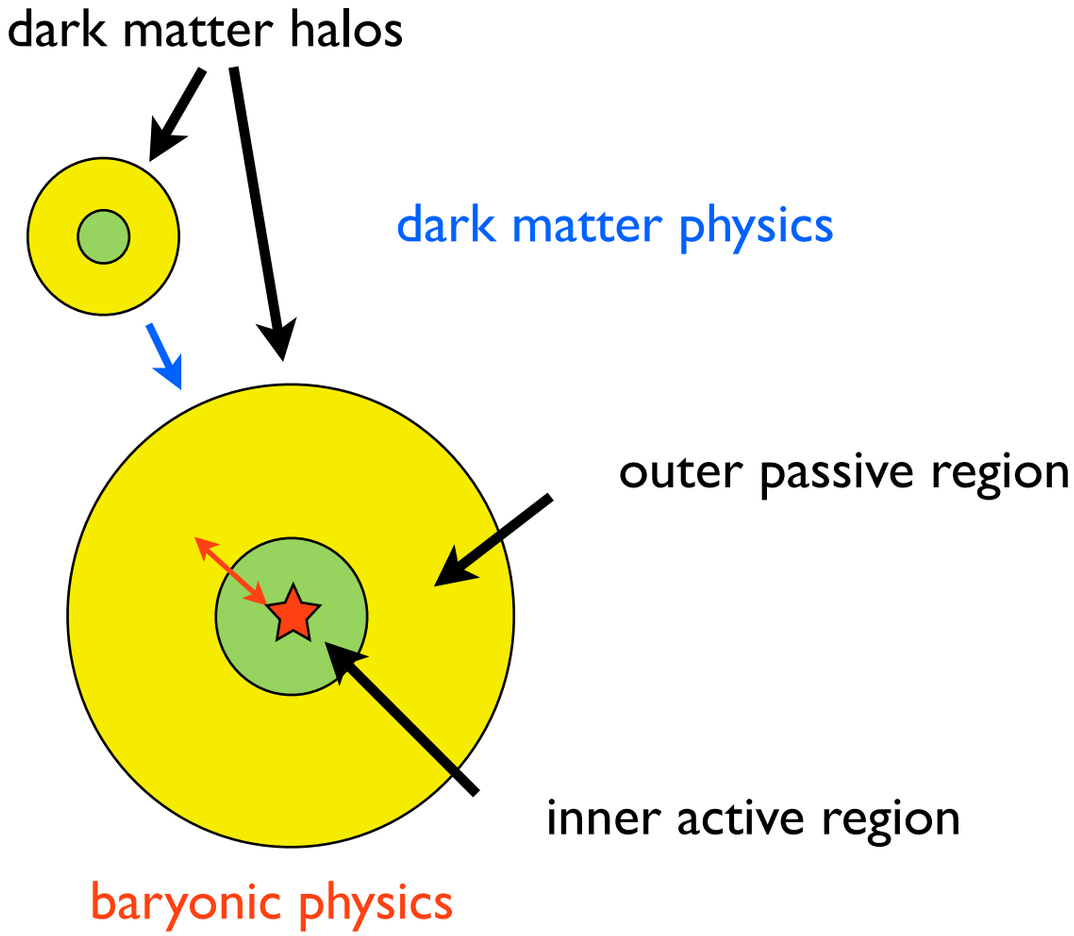


...simplified...

...in matching a set of observables over cosmic history?

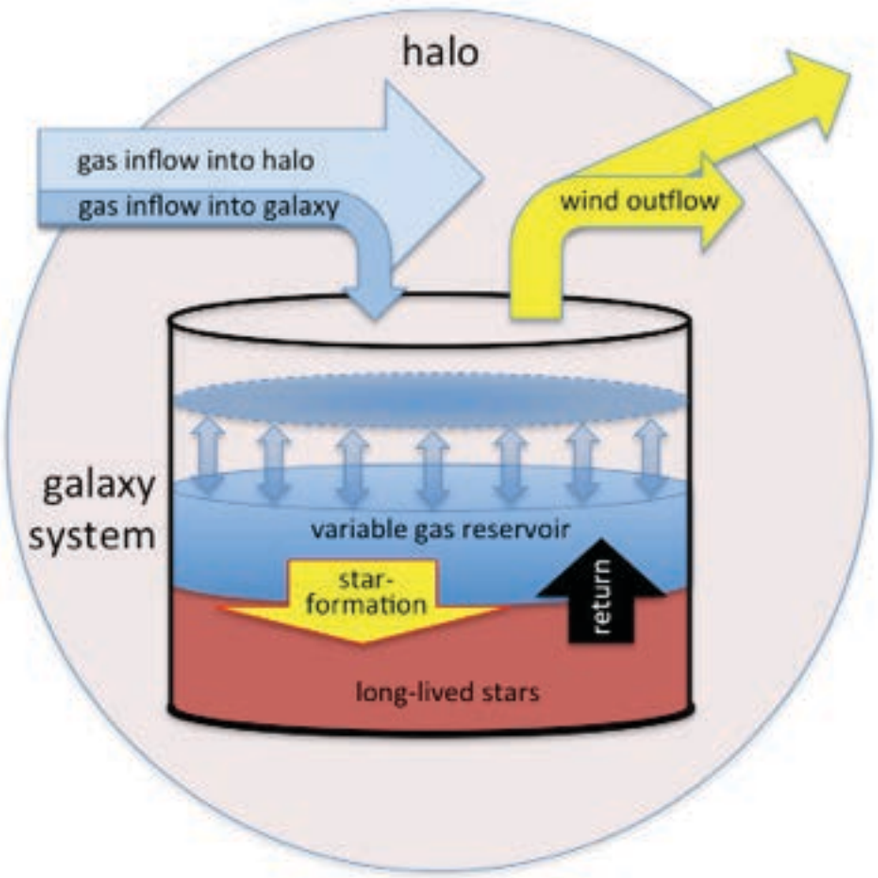


A galaxy - a simple picture



based on Lilly et al. 2013

A galaxy - a regulator system



from Lilly et al. 2013

gas within the regulator

$$SFR = \epsilon \cdot M_{\rm gas}$$

efficiency of the regulator

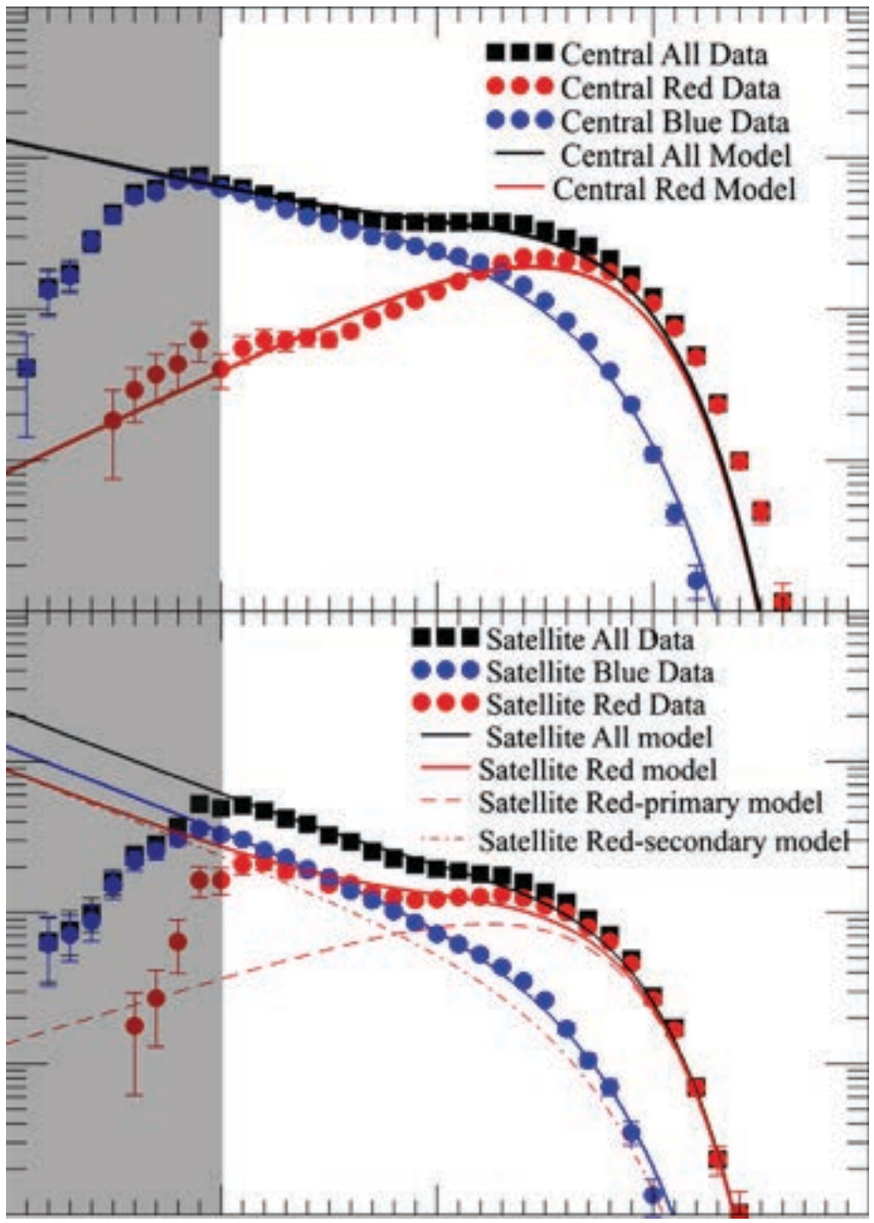
$$\dot{M}_{\rm gas,outflow} = \lambda \cdot SFR$$

outflow load

inflow of gas into regulator

$$\dot{M}_{\rm gas} = \Phi_b - \dot{M}_s - \dot{M}_{\rm gas,outflow}$$

Quenching formalism



from Peng et al. 2010/12

mass quenching:

quenching produces an exponential cutoff scale in the stellar mass function

$$\mathrm{d}p_{\mathrm{quench}} = \mu \mathrm{d}M_s$$

$$p_{\mathrm{quench}} = 1 - \exp\left[-\mu \Delta M_s\right]$$

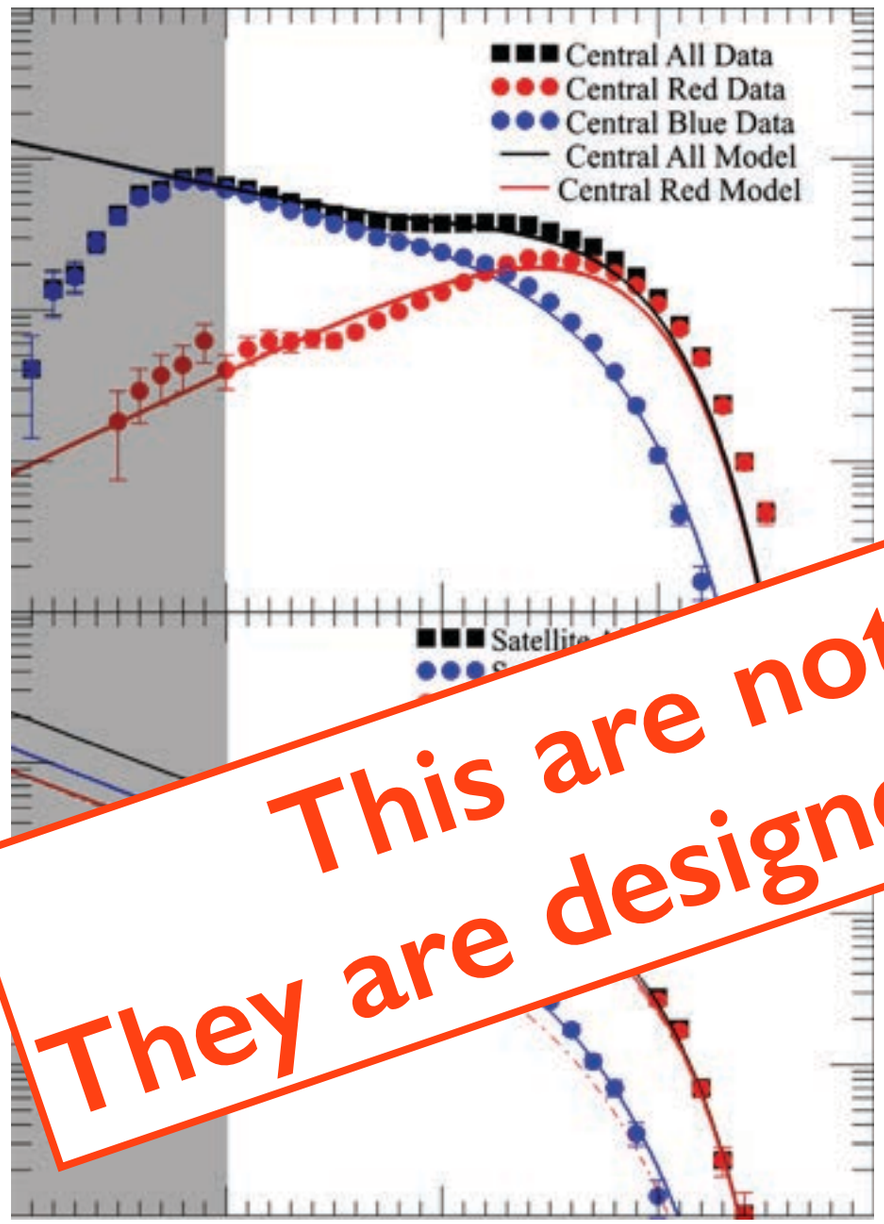
environment quenching:

satellite galaxies are more likely to be quenched

$$p_{\mathrm{sat}} = 0.5$$

e.g. Kovac et al. 2013 and Knobel et al. 2013

Quenching formalism



from Peng et al. 2010/12

mass quenching:

quenching pr…

exp…

$$1 - \exp\left[-\mu \Delta M_s\right]$$

environment quenching:

satellite galaxies are more likely to be quenched

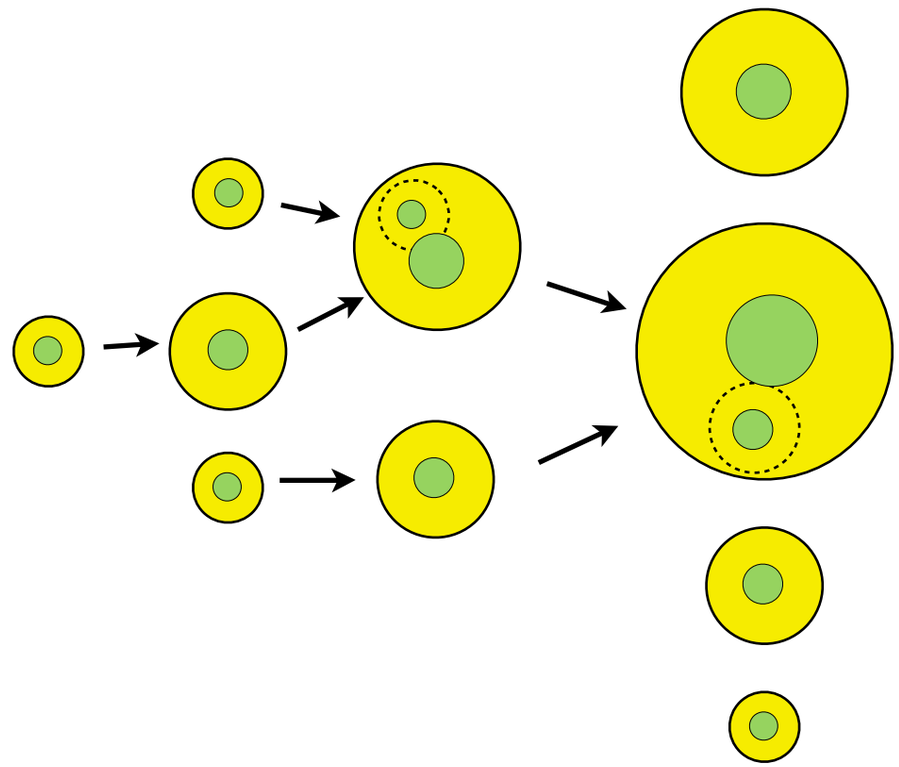
$$p_{\rm sat} = 0.5$$

e.g. Kovac et al. 2013 and Knobel et al. 2013

This are not physical descriptions! They are designed to match the observables.

The model - the simple concepts

- simple differential equations embedded in a dark matter merger tree
- local continuity in stellar- gas- and DM mass
- quenching as a one-way description of stellar mass



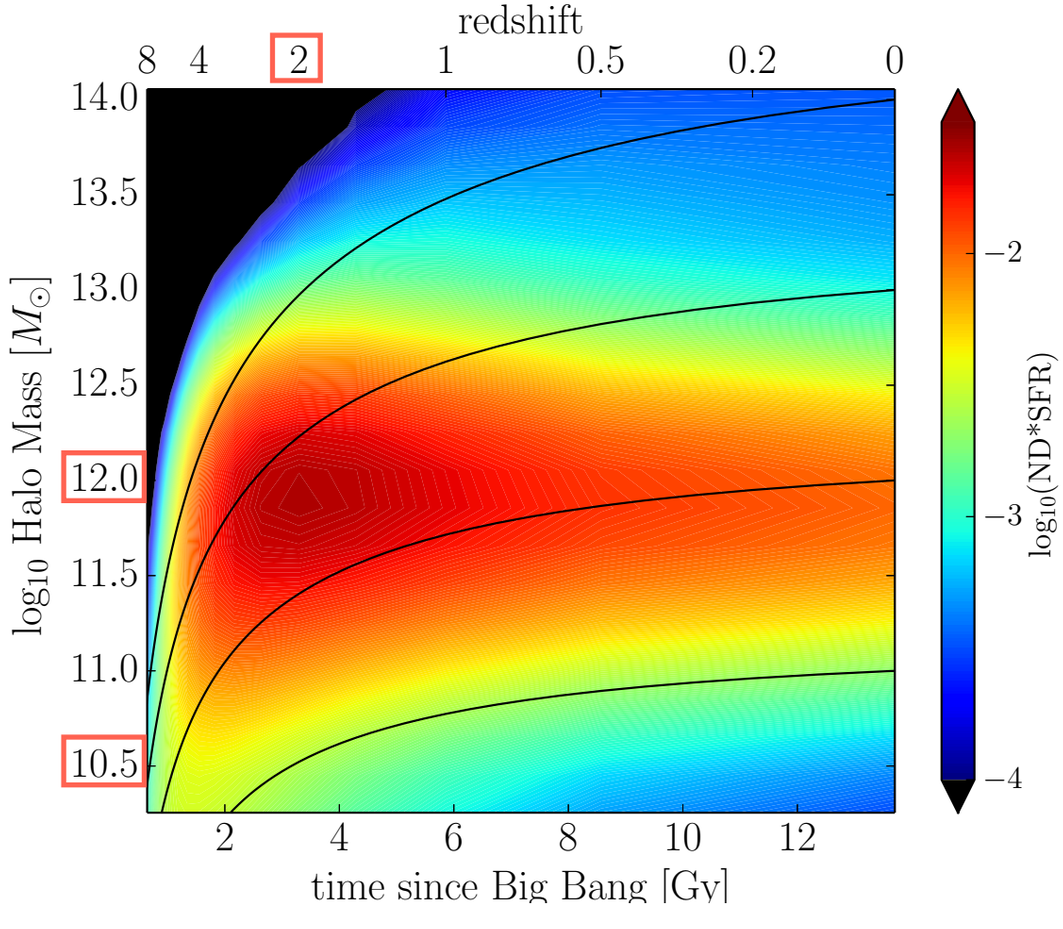
→ Prediction: Stellar-, gas-, DM mass and SFR for every single galaxy of a representative sample of the universe from z=8 to z=0.

Results - the "simplest" model

gas infall follows the DM accretion rate

$$\dot{M}_{\rm gas} = \Phi_b - \dot{M}_s - \dot{M}_{\rm gas,outflow}$$

Most stars form at $10^{12} M_\odot$ and about z = 2



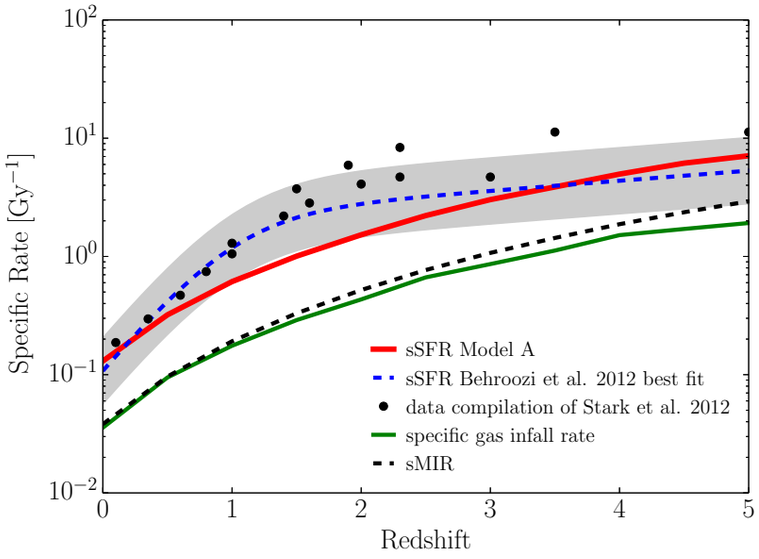
e.g, Behroozi et al. 2013

Results - the "simplest" model

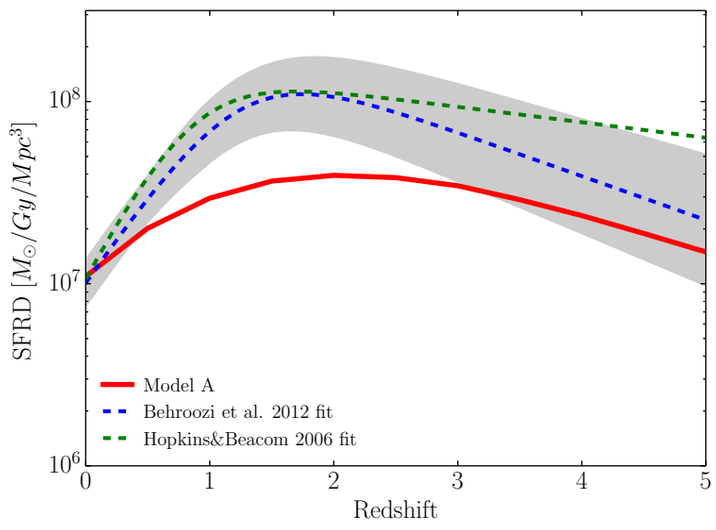
gas infall follows the DM accretion rate

$$\dot{M}_{\rm gas} = \Phi_b - \dot{M}_s - \dot{M}_{\rm gas,outflow}$$

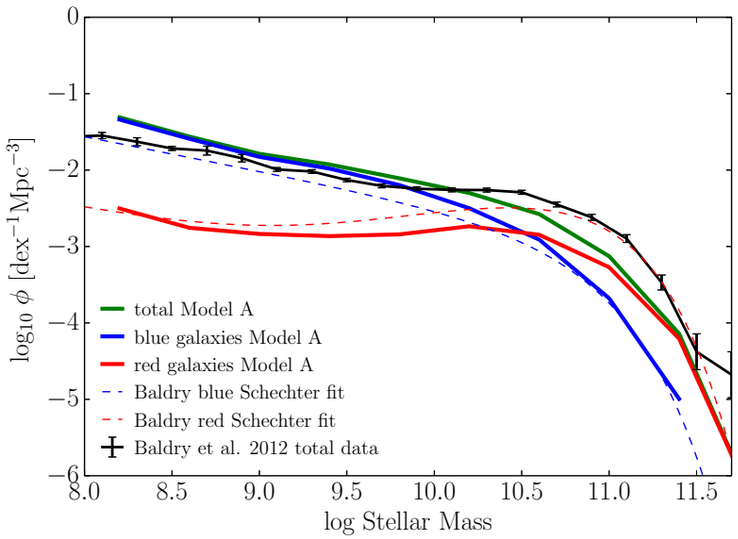
sSFR(z)



SFRD(z)



SMF(z=0)

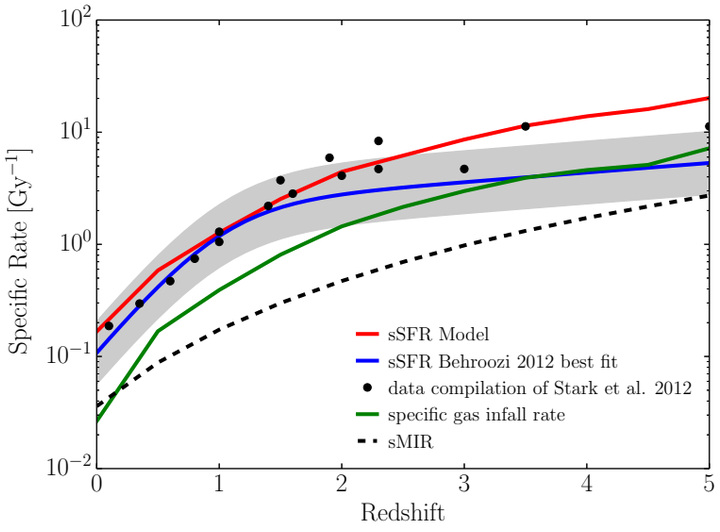


Results - the "tuned" model

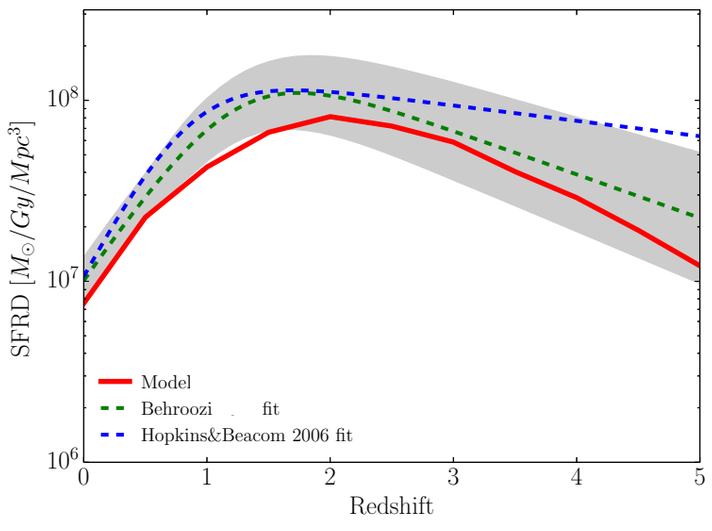
only further tuned description

$$\dot{M}_{\rm gas} = \Phi_b - \dot{M}_s - \dot{M}_{\rm gas,outflow}$$

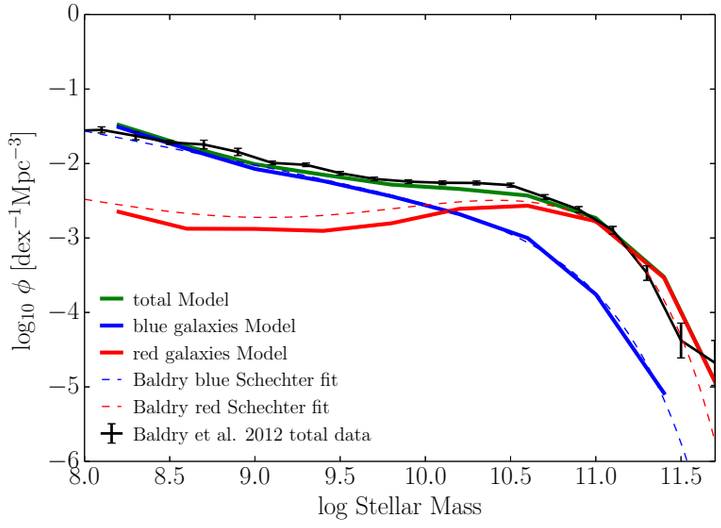
sSFR(z)



SFRD(z)

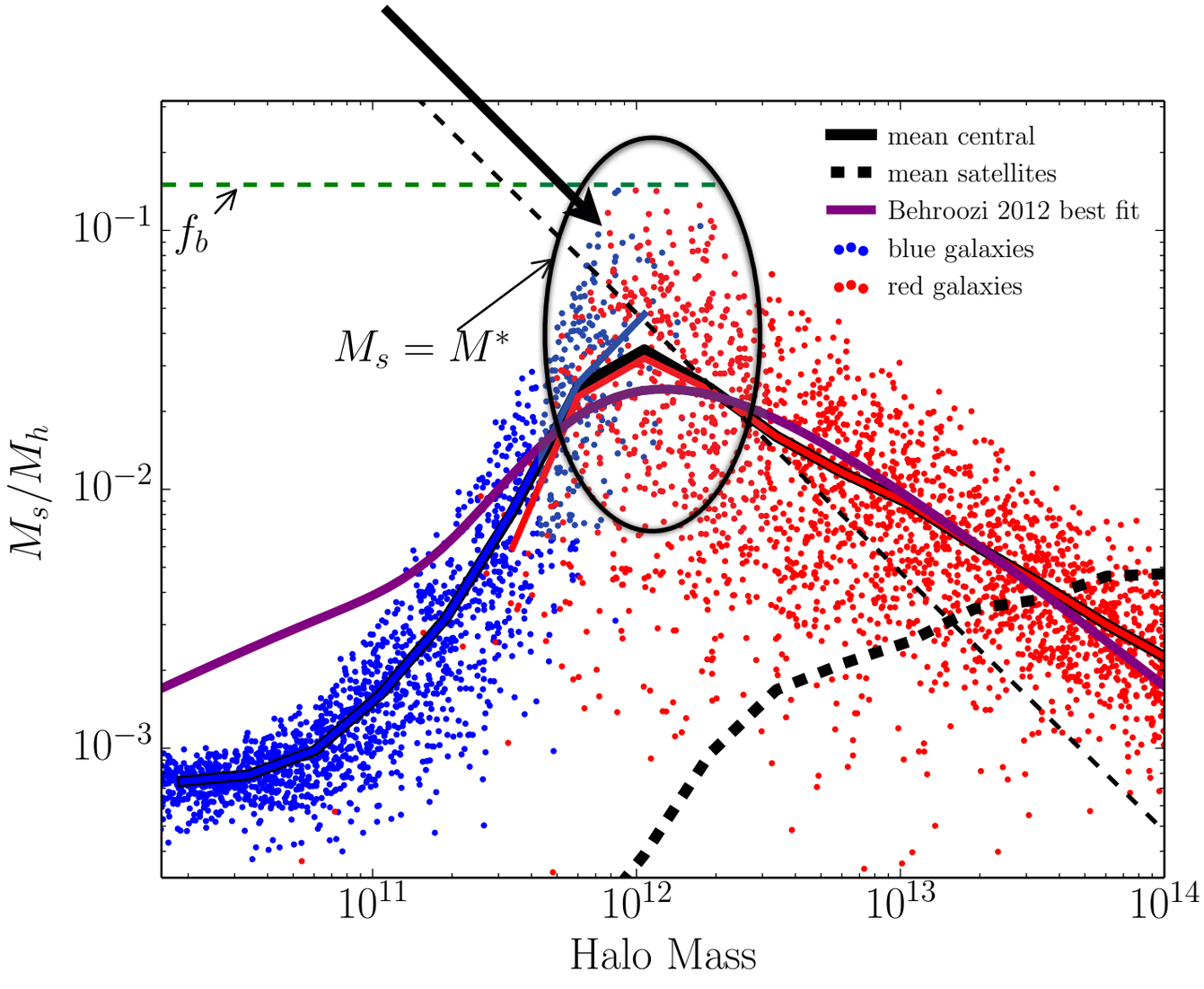


SMF(z=0)



Results (Halo Masses)

Is this a coincidence?

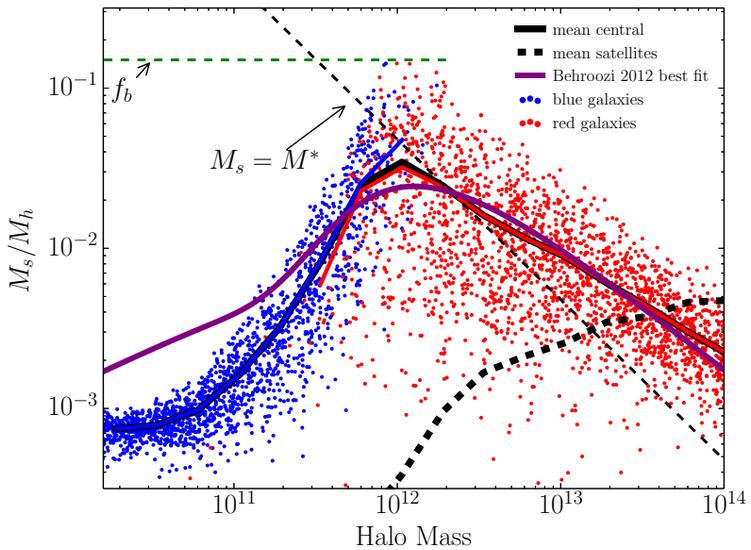


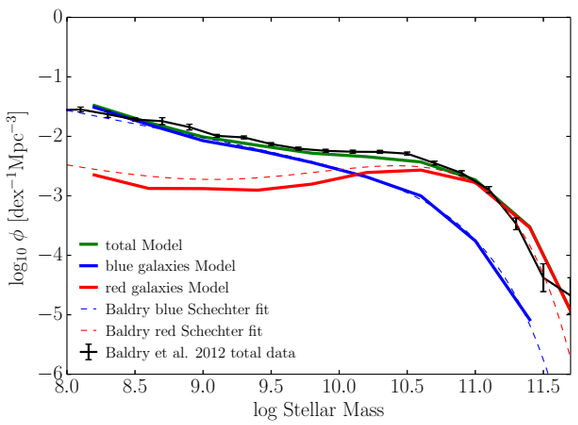
Conclusion

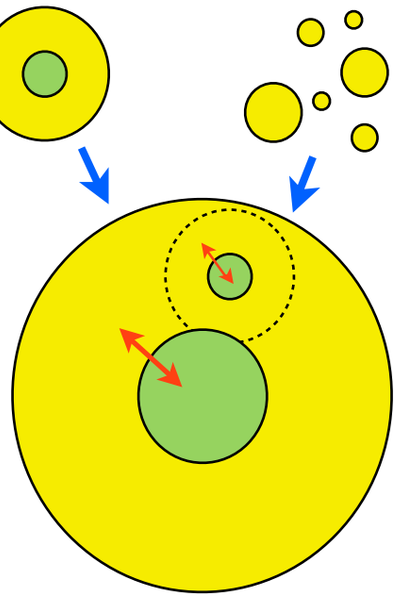
- Simple model (combination of regulation and quenching) gives remarkable consistencies with various observables
- Only gas inflow/re-injection has to be modified
- Quenching occurs just when galaxies approach the maximal conversion efficiency

Simon Birrer

Thanks! - Questions?

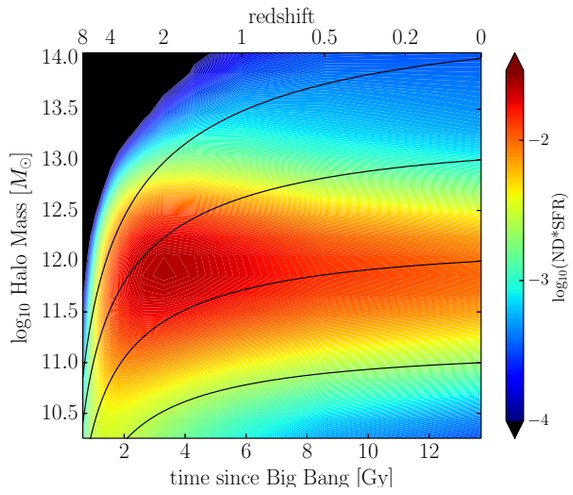






$$\dot{M}_{\rm gas,outflow} = \lambda \cdot SFR$$

$$SFR = \epsilon \cdot M_{\rm gas}$$



arXiv:1401.3162