

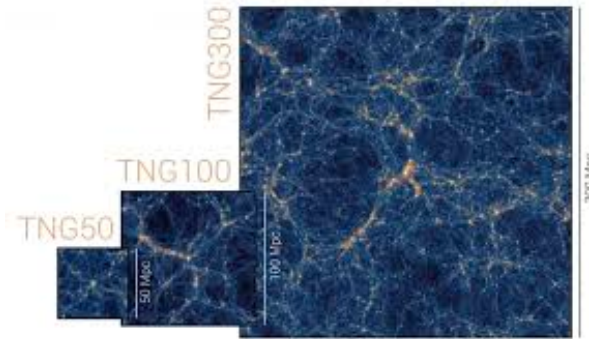
Inflows and outflows in cosmological simulations

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Cosmological simulations



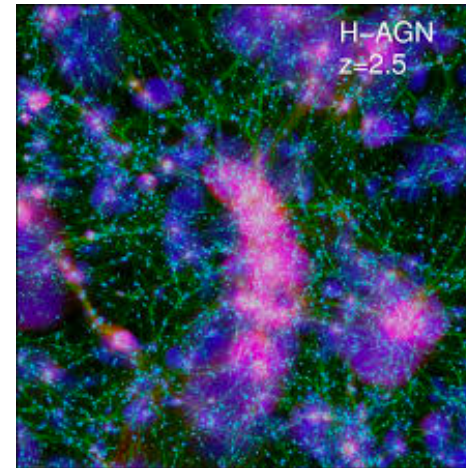
Eagle, Schaye et al. (2015)



TNG, Pillepich et al. (2018)



FIRE, Hopkins et al. (2014)



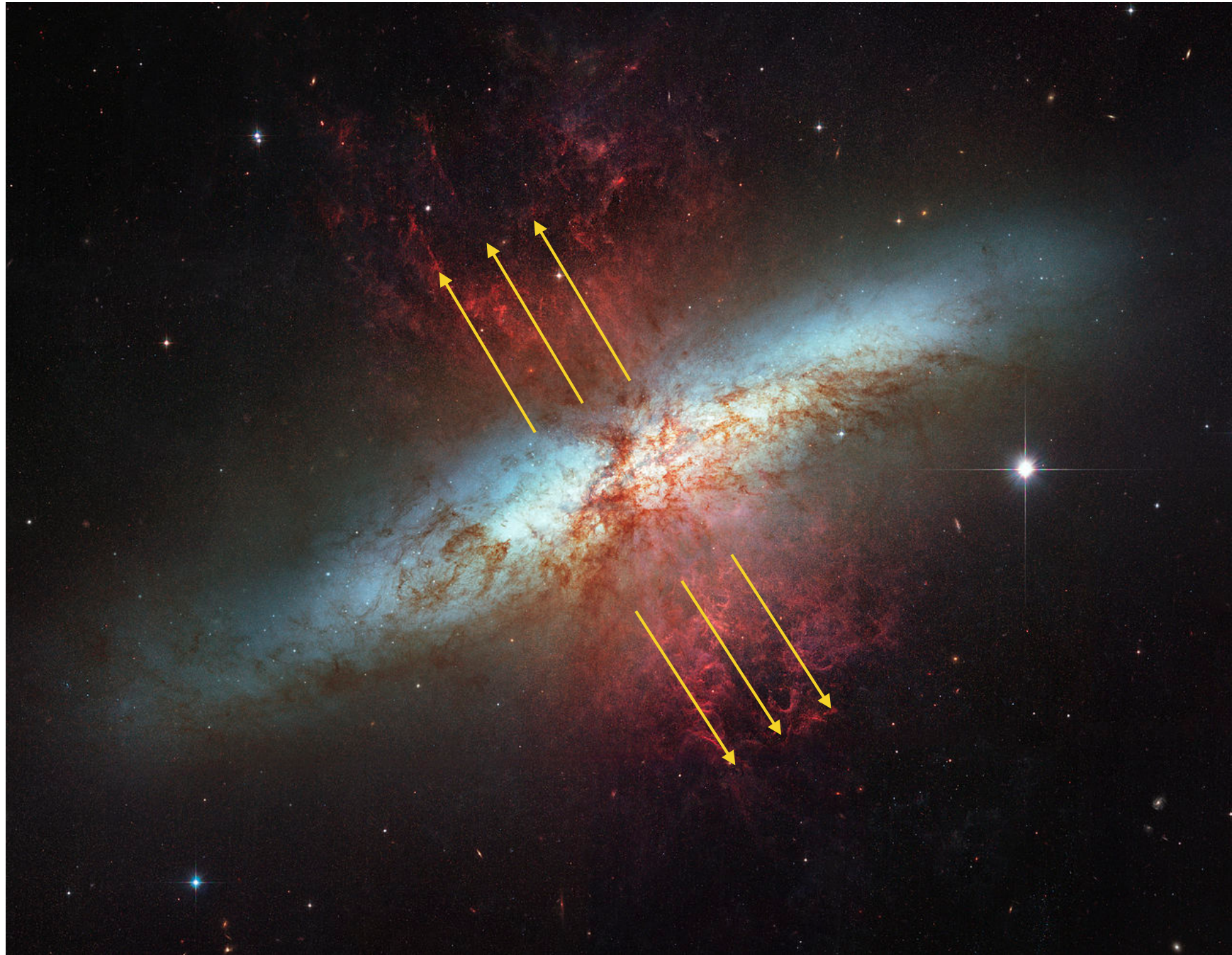
Horizon-AGN, Dubois et al. (2014)

Outline

- Is there any consensus on the galactic outflow and inflow rates from cosmological simulations?
 - Short answer: doesn't look like it - but it is not easy to tell
- How do the efficiencies of outflows and inflows scale as a function of dark matter halo mass?

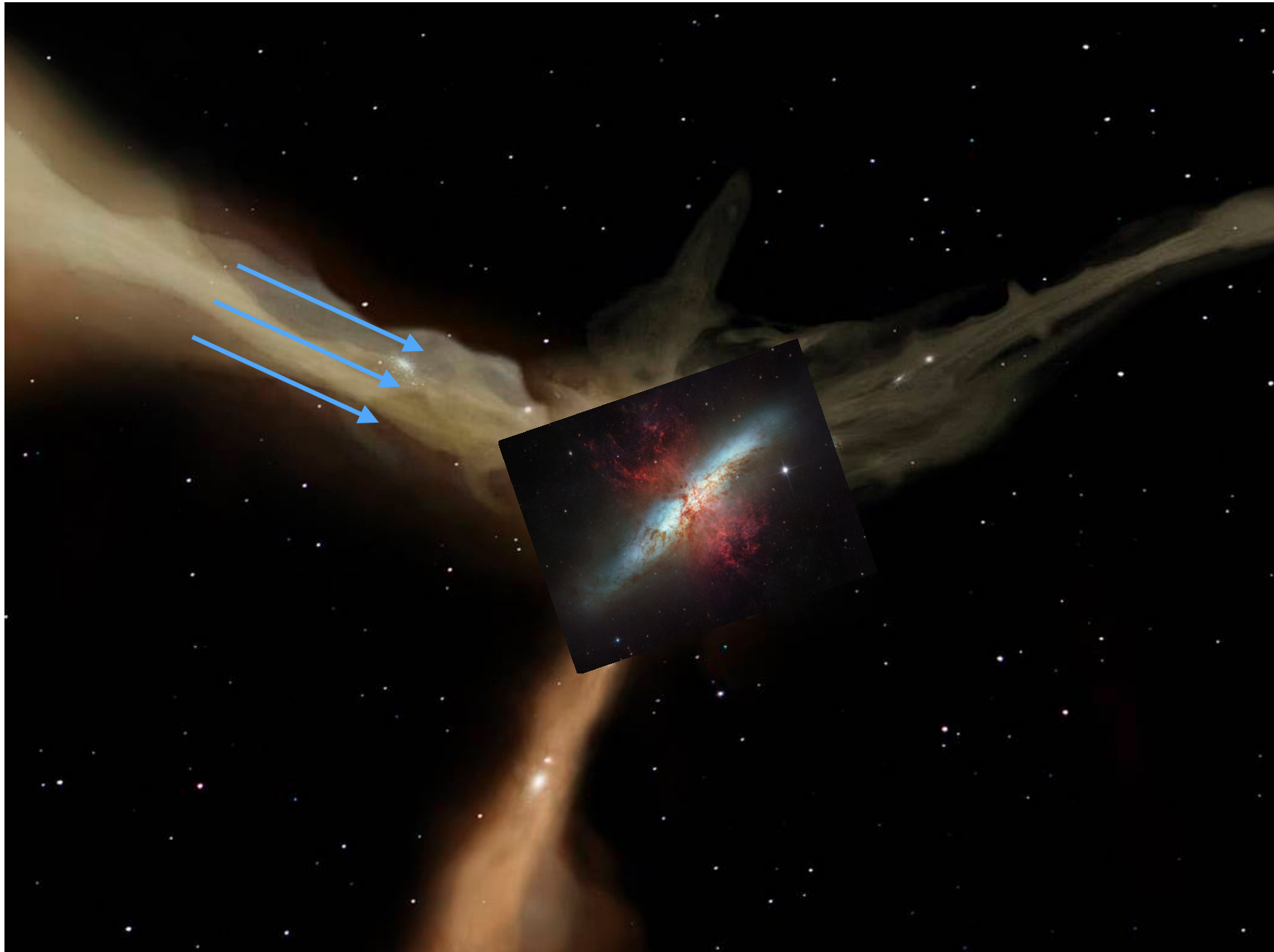
Outflow rates

1) How much gas is blown out galaxies?



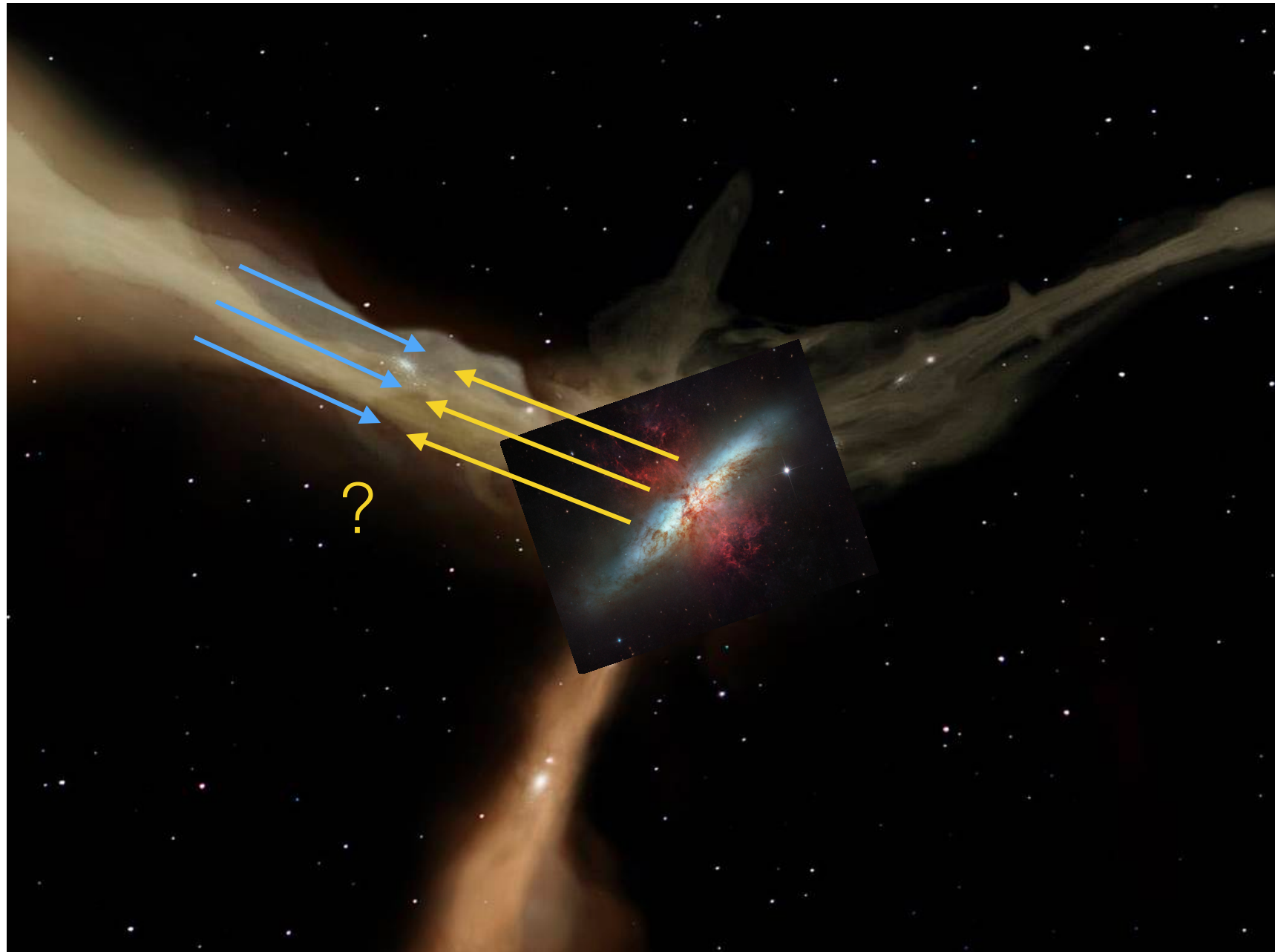
Inflow rates

2) How much gas is being accreted onto galaxies?



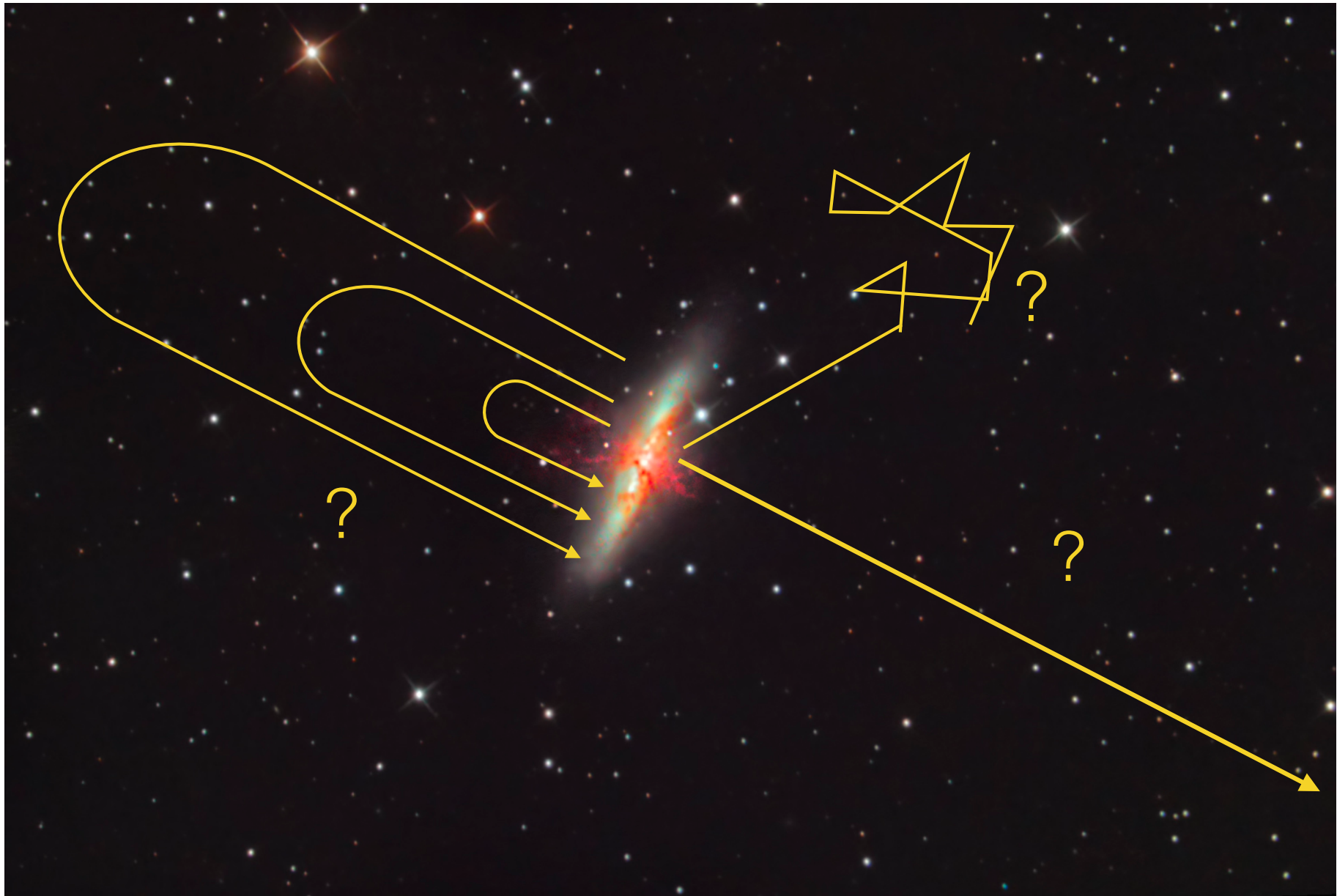
Inflow rates

3) Is there an interaction of inflows with outflows?

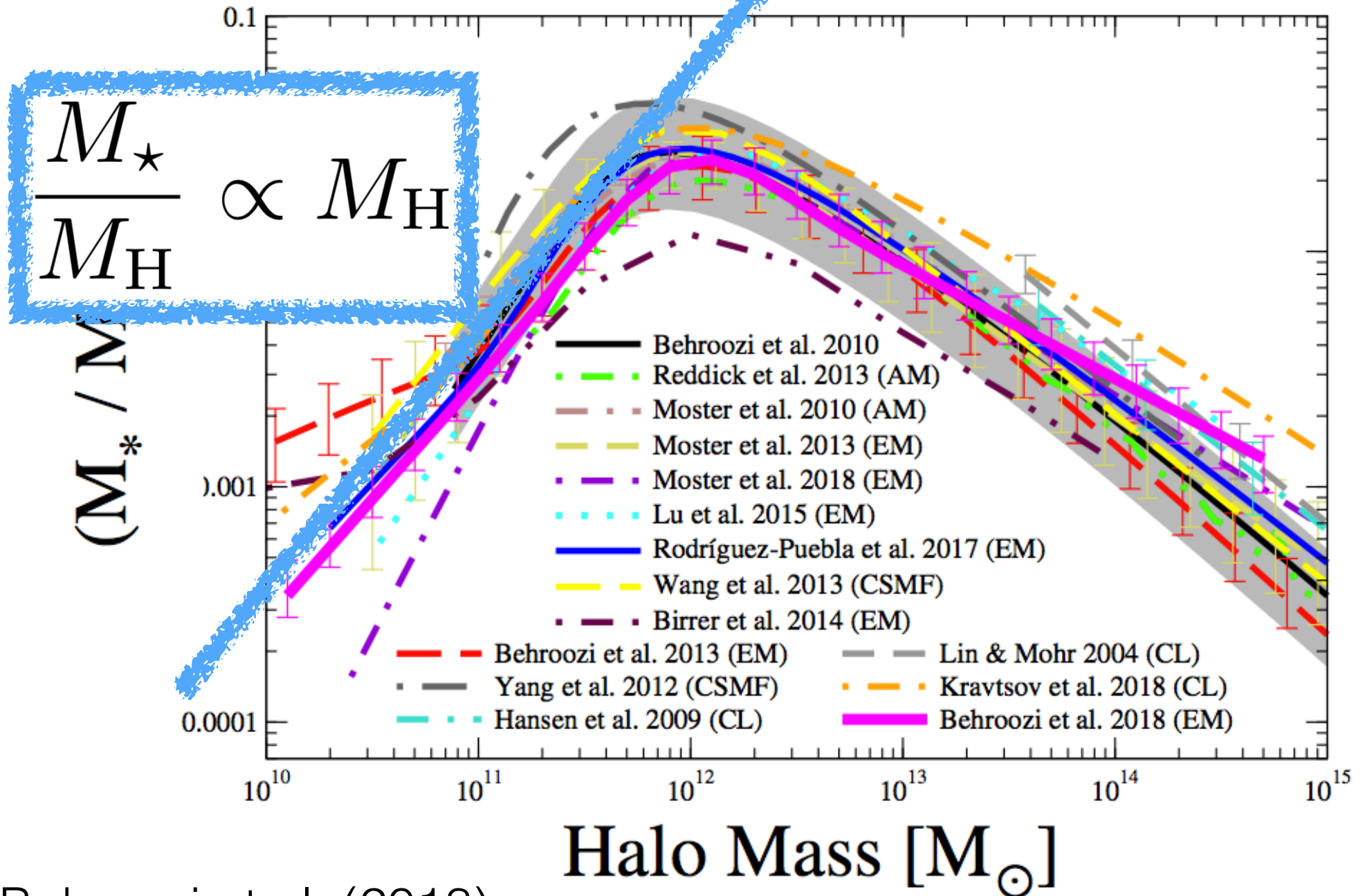


Recycling

4) What happens to the outflowing gas?



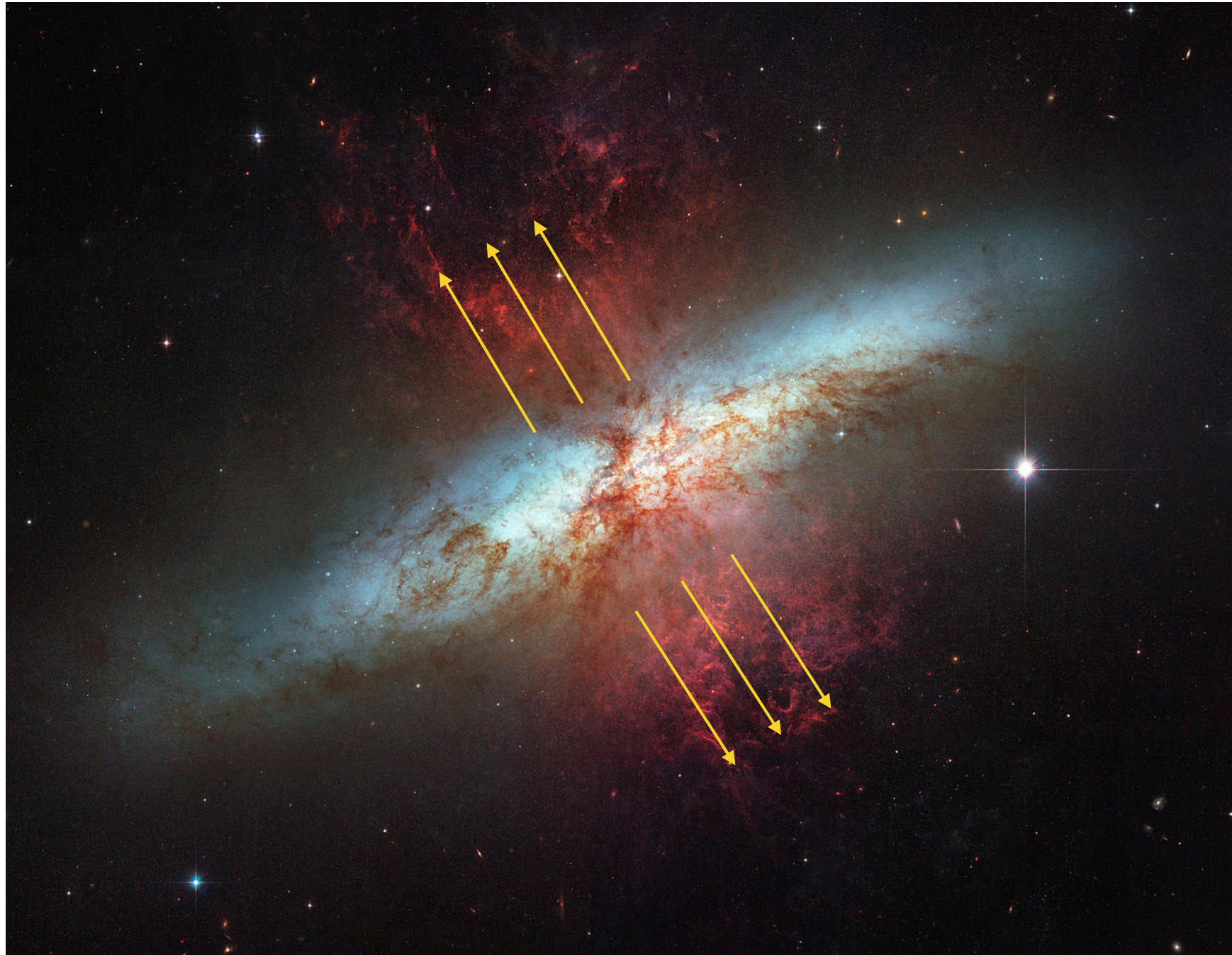
Stellar assembly efficiency



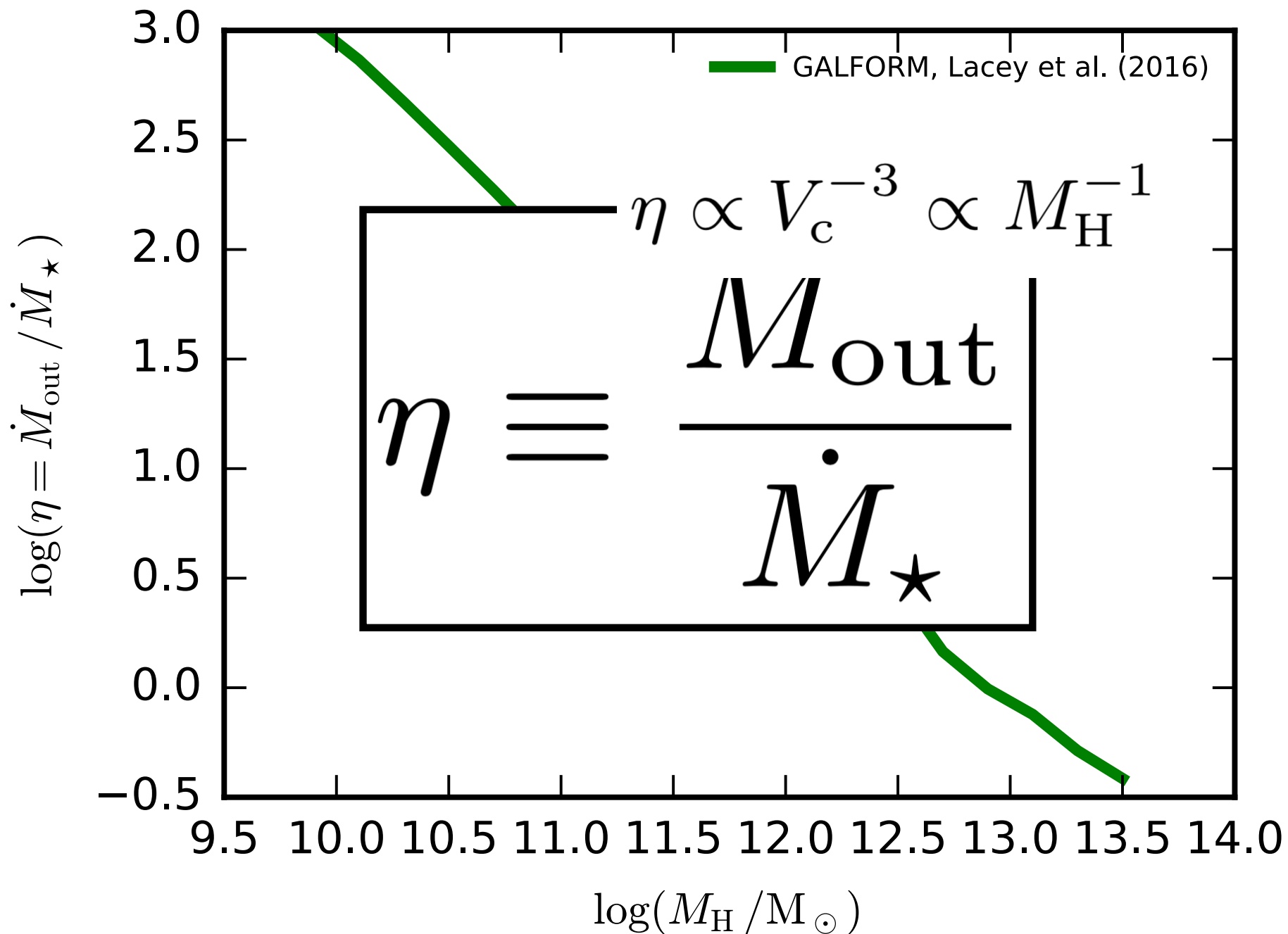
Behroozi et al. (2018)

Outflow rates

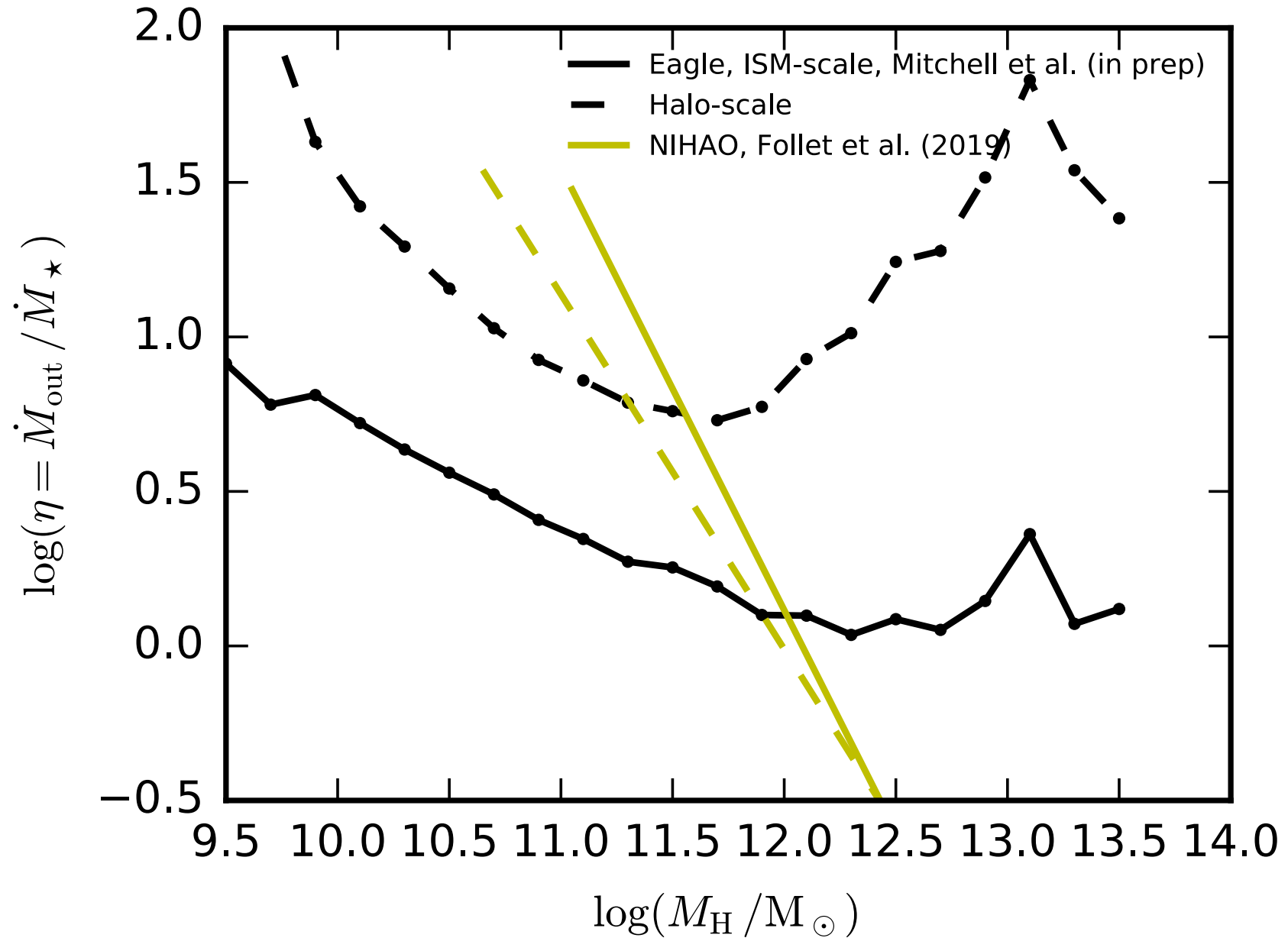
1) How much gas is blown out galaxies?



Outflows & galaxy formation



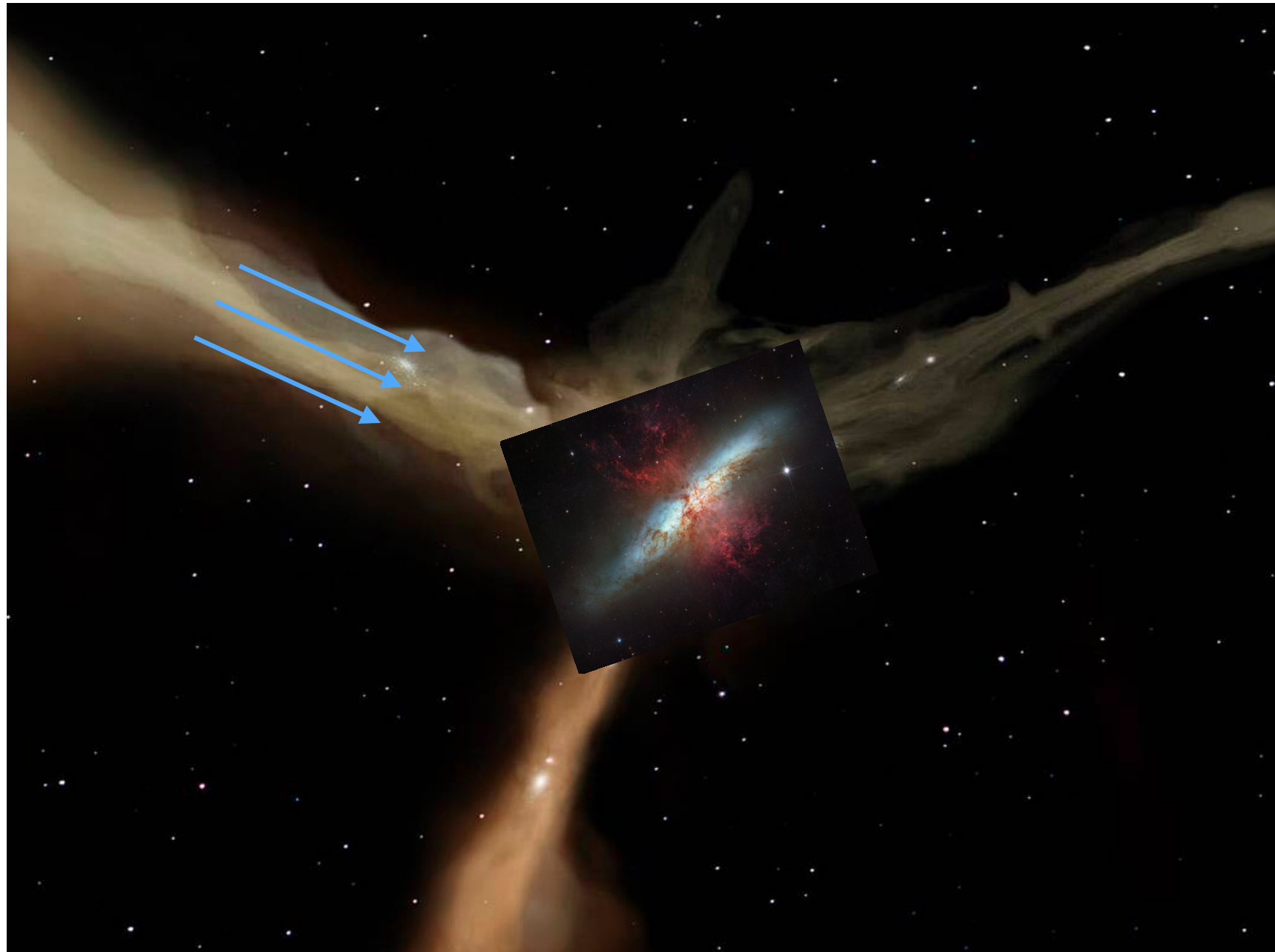
Outflows at different scales



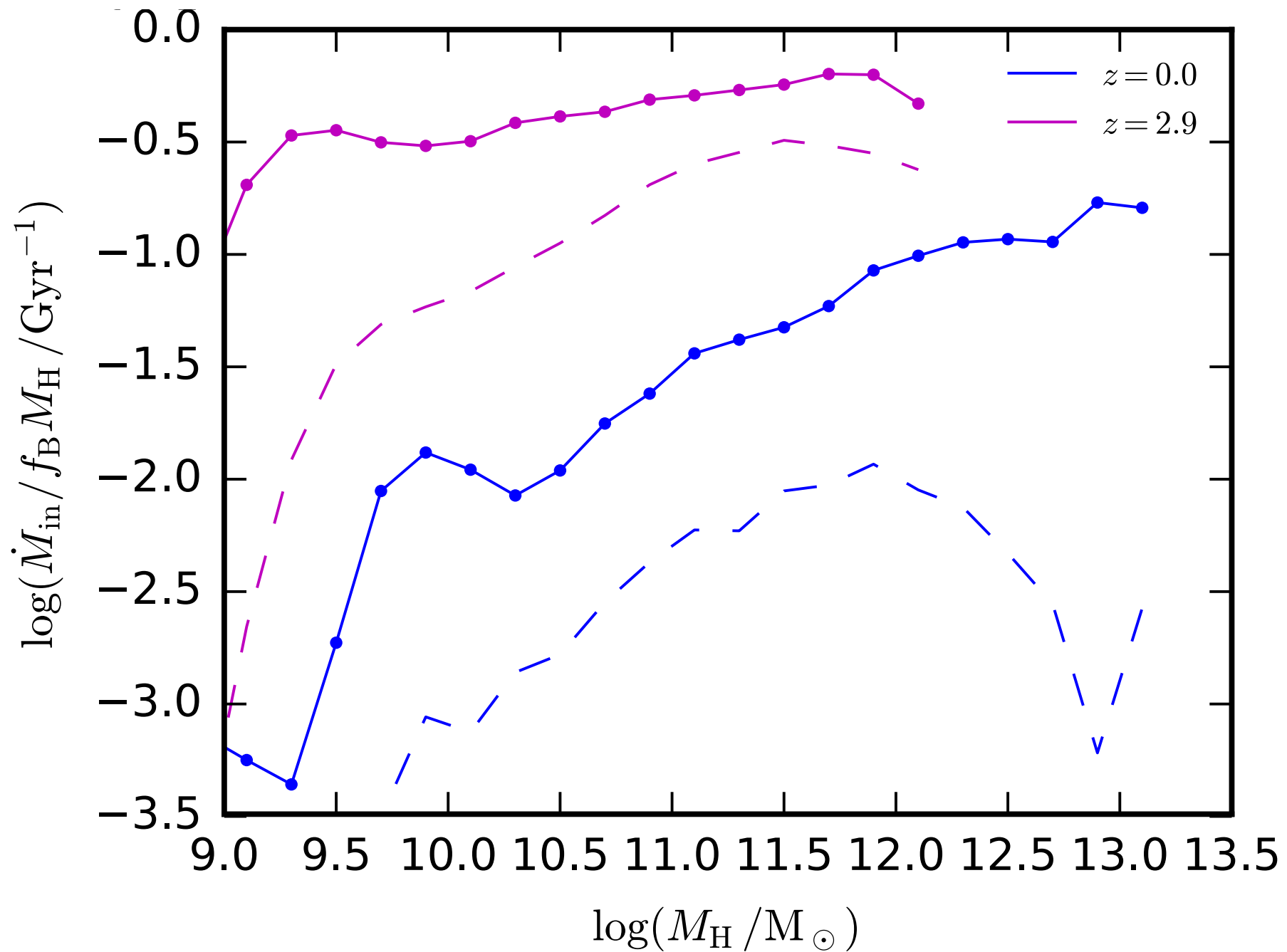
Outflow messages

- There is seemingly strong diversity in the scaling of outflow rates between different modern simulations
- The scaling is too shallow to entirely account for the relationship between stellar mass and halo mass inferred from observations (cue inflows)
- Substantial differences between ISM and halo-scale outflow rates (but no seemingly no consensus again)

What about inflows?



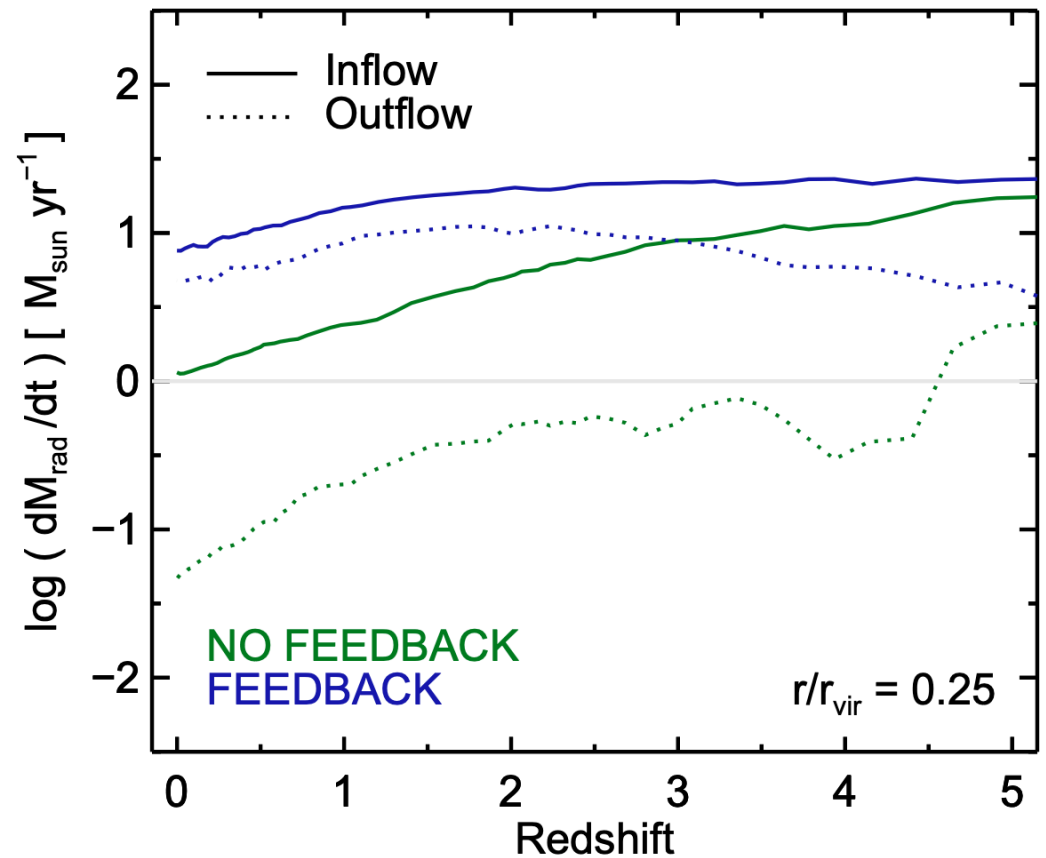
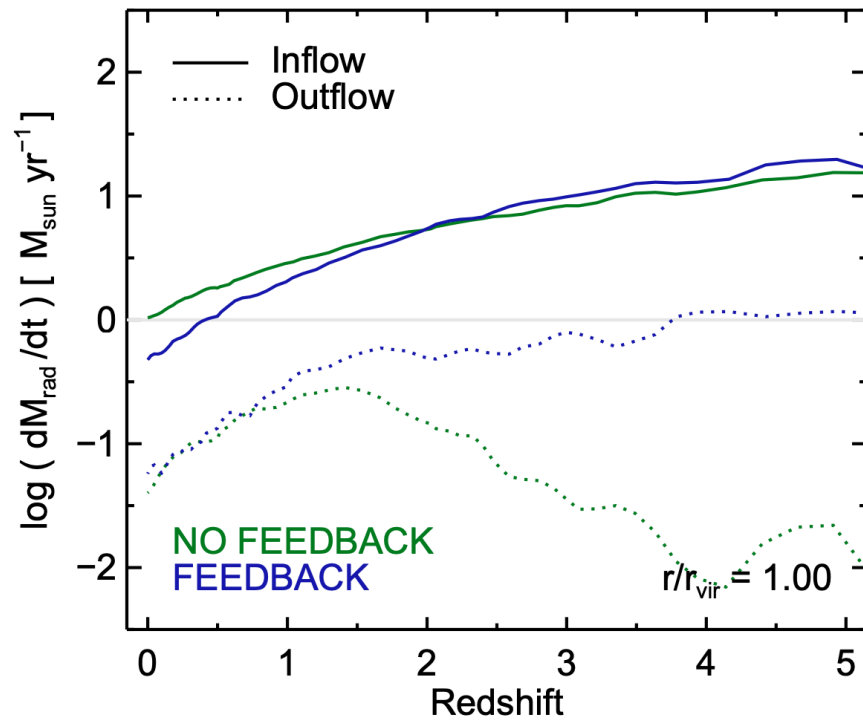
Inflow scaling in the Eagle simulations



Inflows in the Eagle simulations

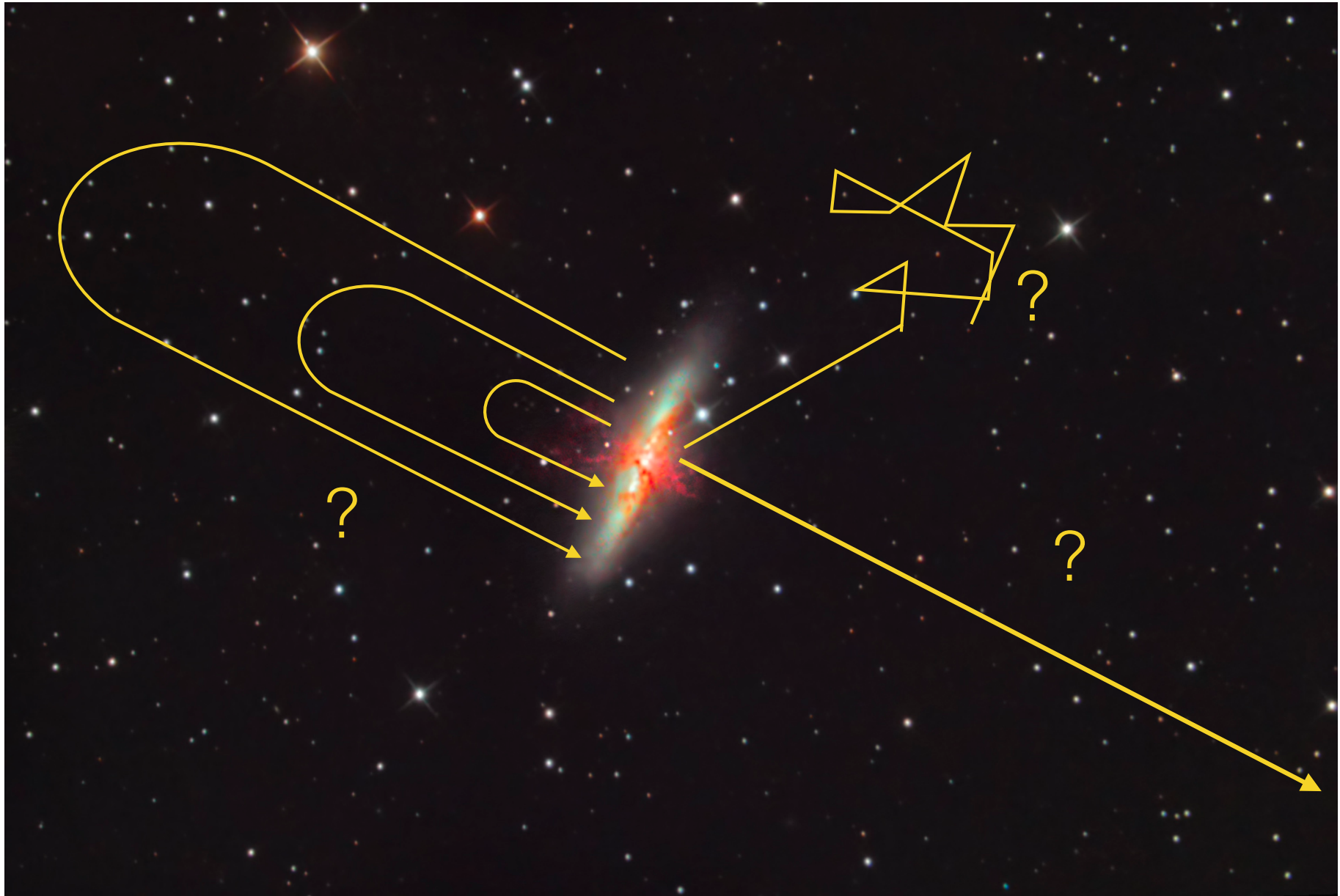
- The “efficiency” of inflows scale with halo mass, particularly at lower redshift, working with outflows to set the final scaling between stellar mass and halo mass.

Inflows in other simulations

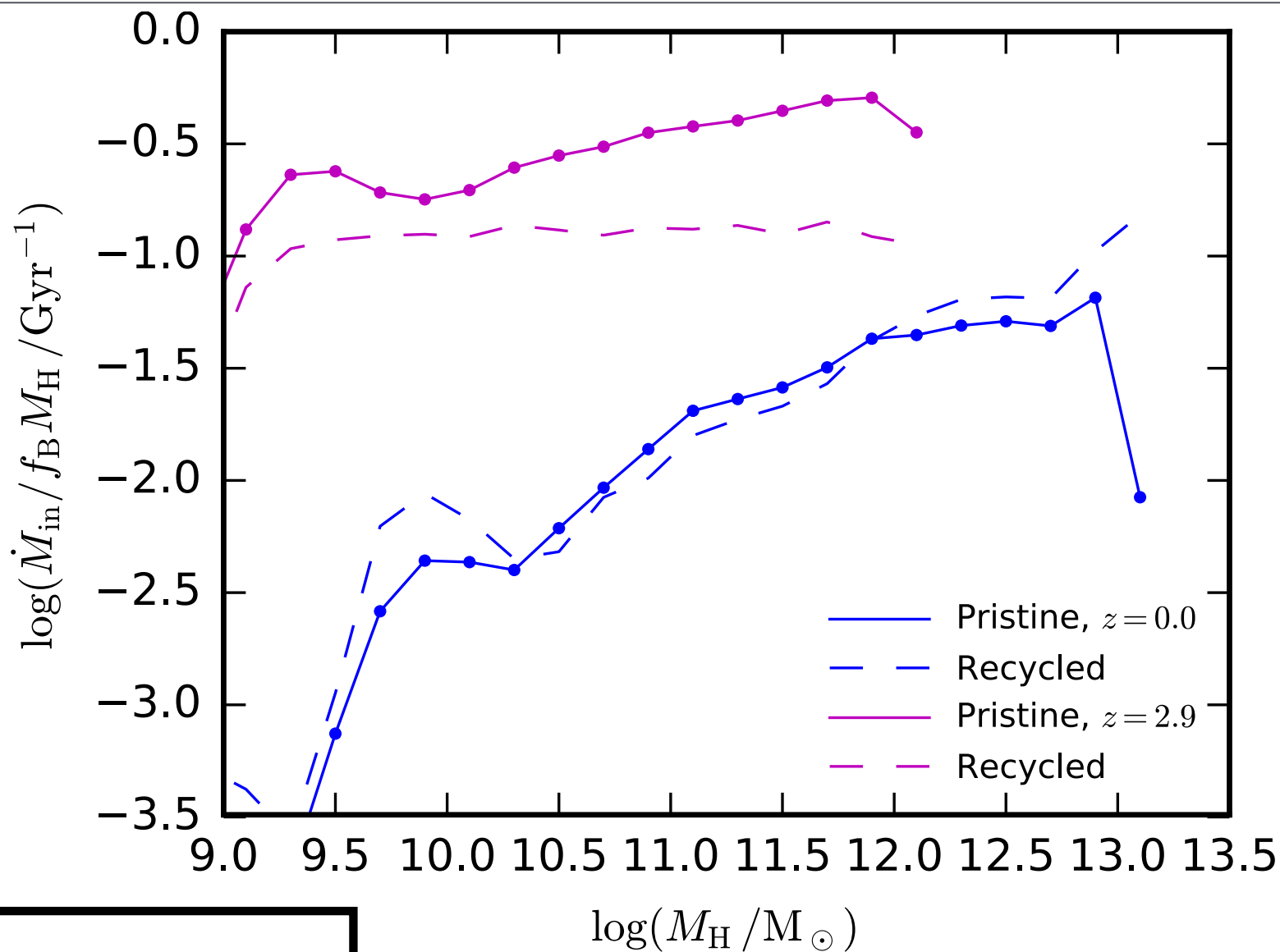


Nelson et al. (2015)

What about recycling?

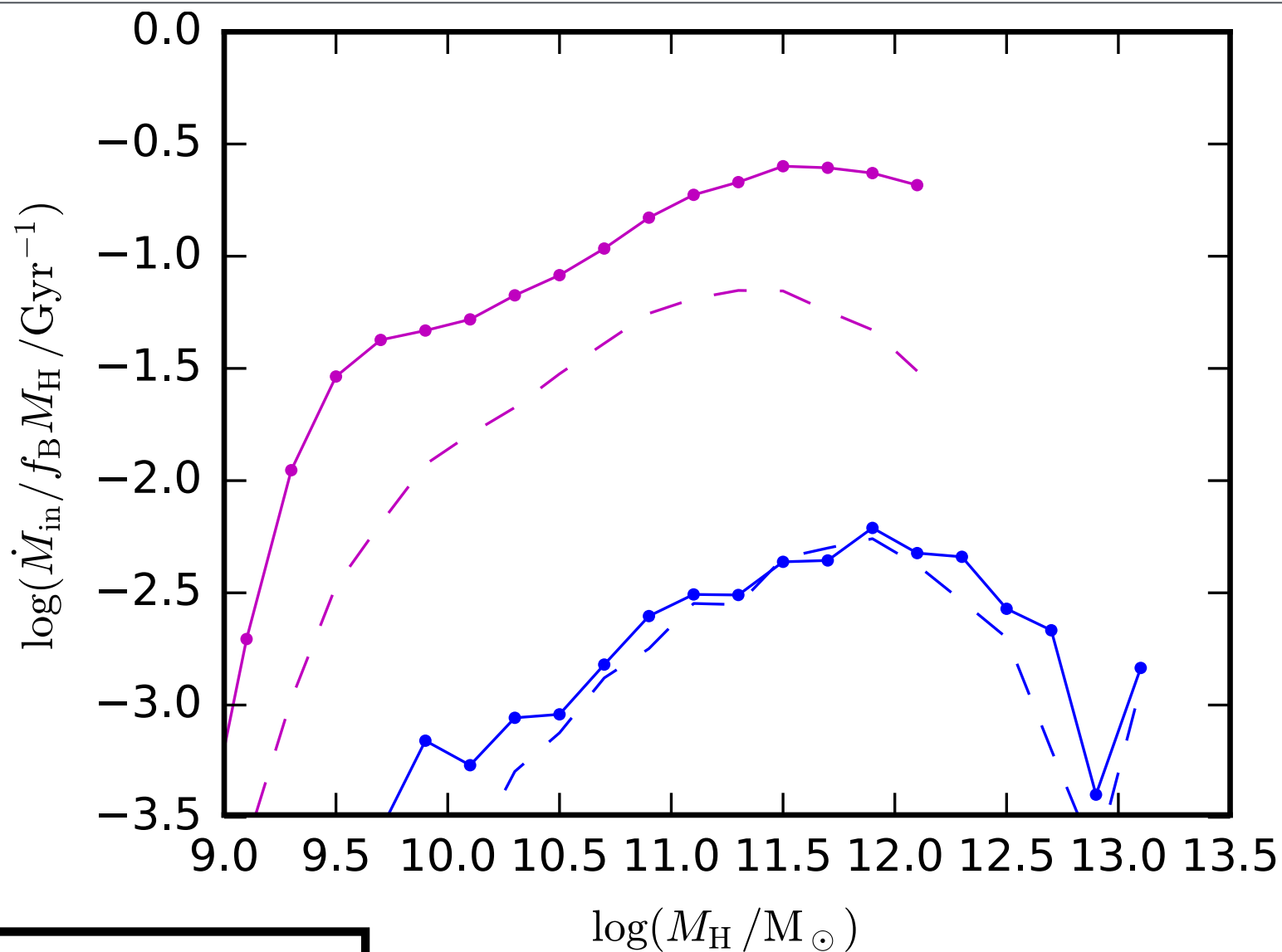


Recycling in Eagle



Halo scale

Recycling in Eagle

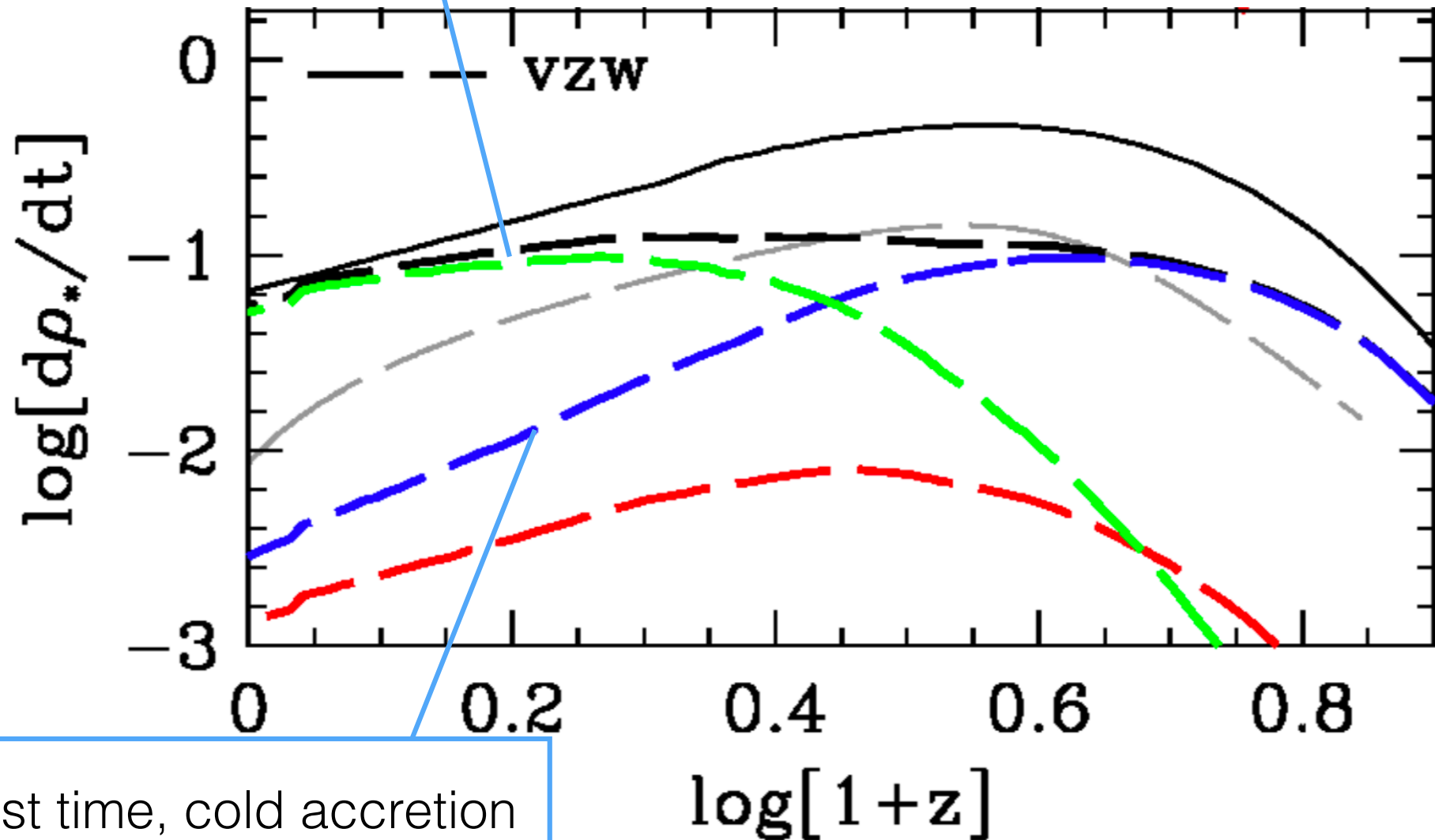


ISM scale

What about recycling?

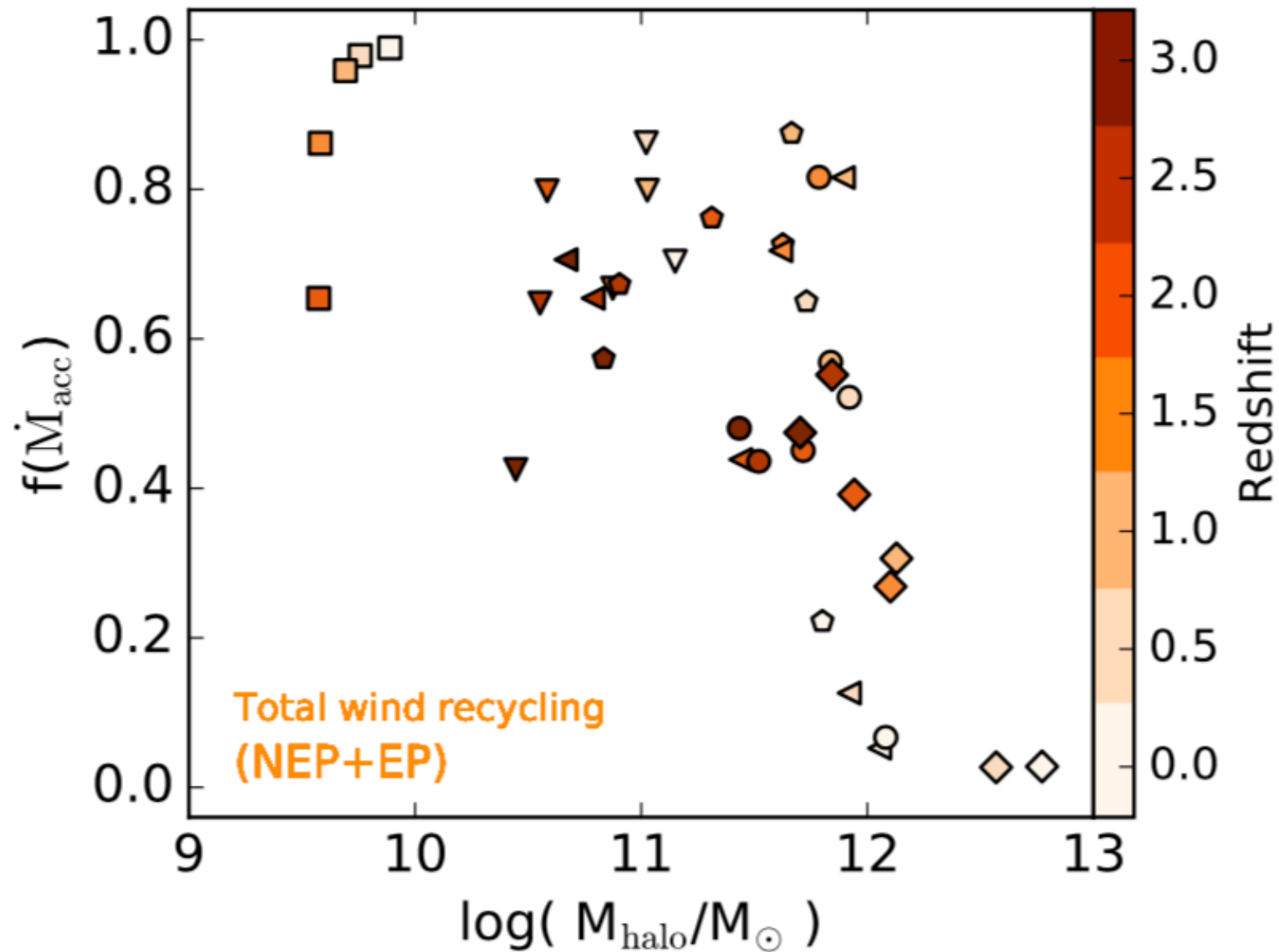
Recycled

Oppenheimer et al. (2010)



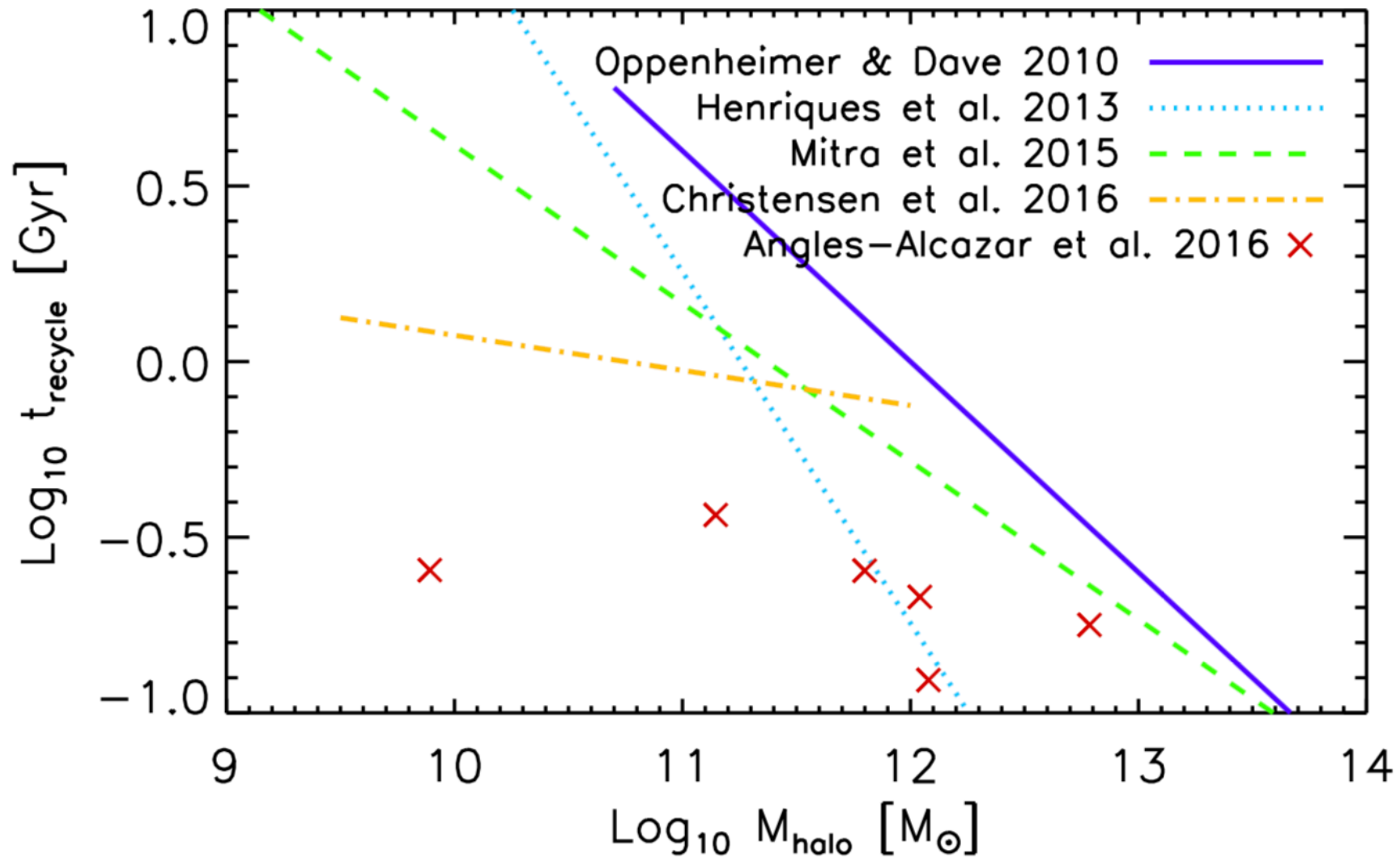
1st time, cold accretion

Recycling in the FIRE simulations



Angles-Alcazar et al. (2017)

Recycling time scales

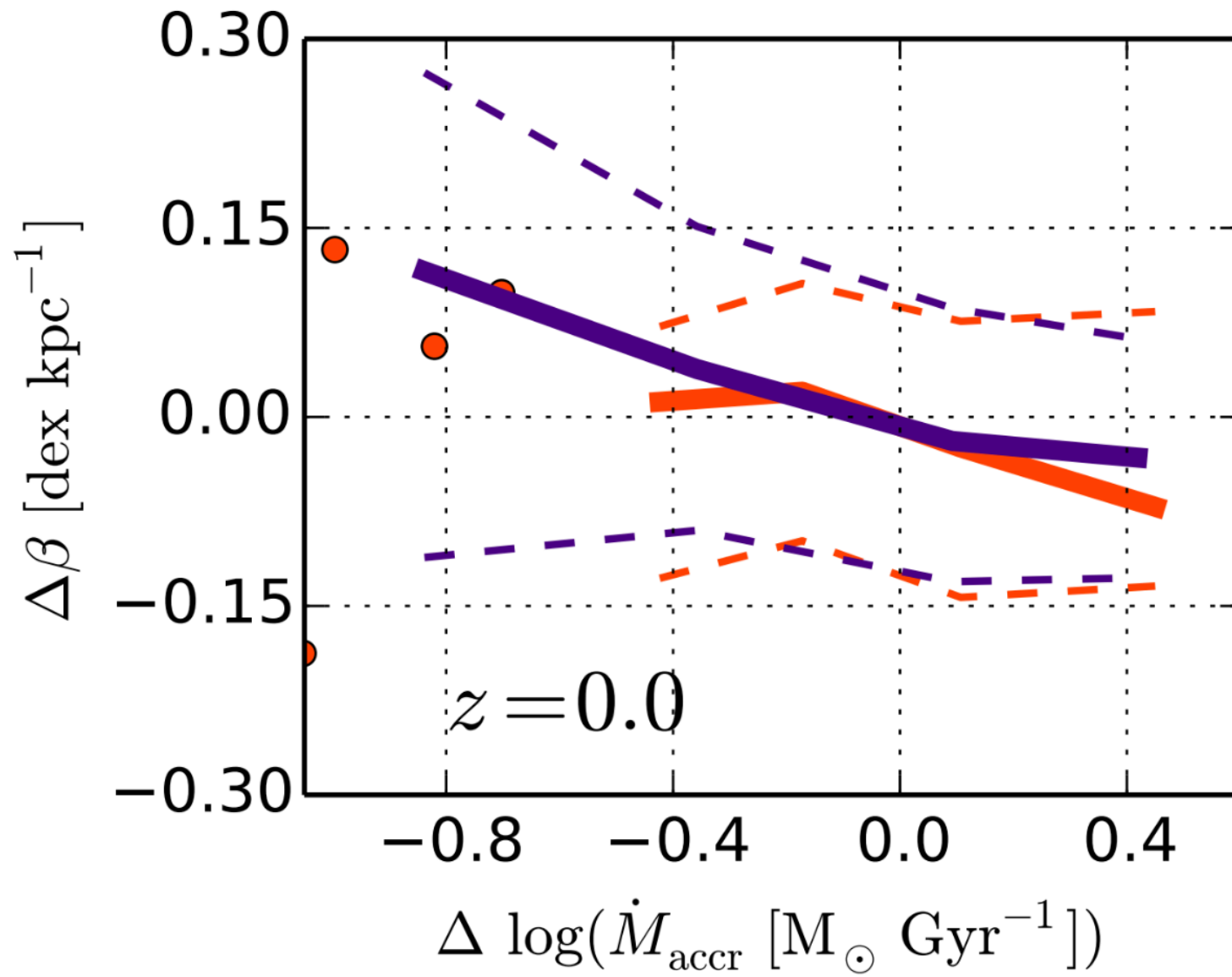


Compilation from Van de Voort (2017)

Recycling messages

- Again, there seems to be little consensus emerging from cosmological simulations.
- There is confusion on the definition of recycling and its efficiency.

Indirect tracers of inflows - metallicity gradients



Summary

- At face value, there appears to be little consensus on the inflow and outflow rates found in cosmological simulations.
 - This is not surprising!
- It seems likely that the efficiency of both outflows and inflows scales with mass to explain the observationally inferred relationship between stellar mass and halo mass.
- For Eagle, work is ongoing to make connections to different observational tracers of inflows/outflows.