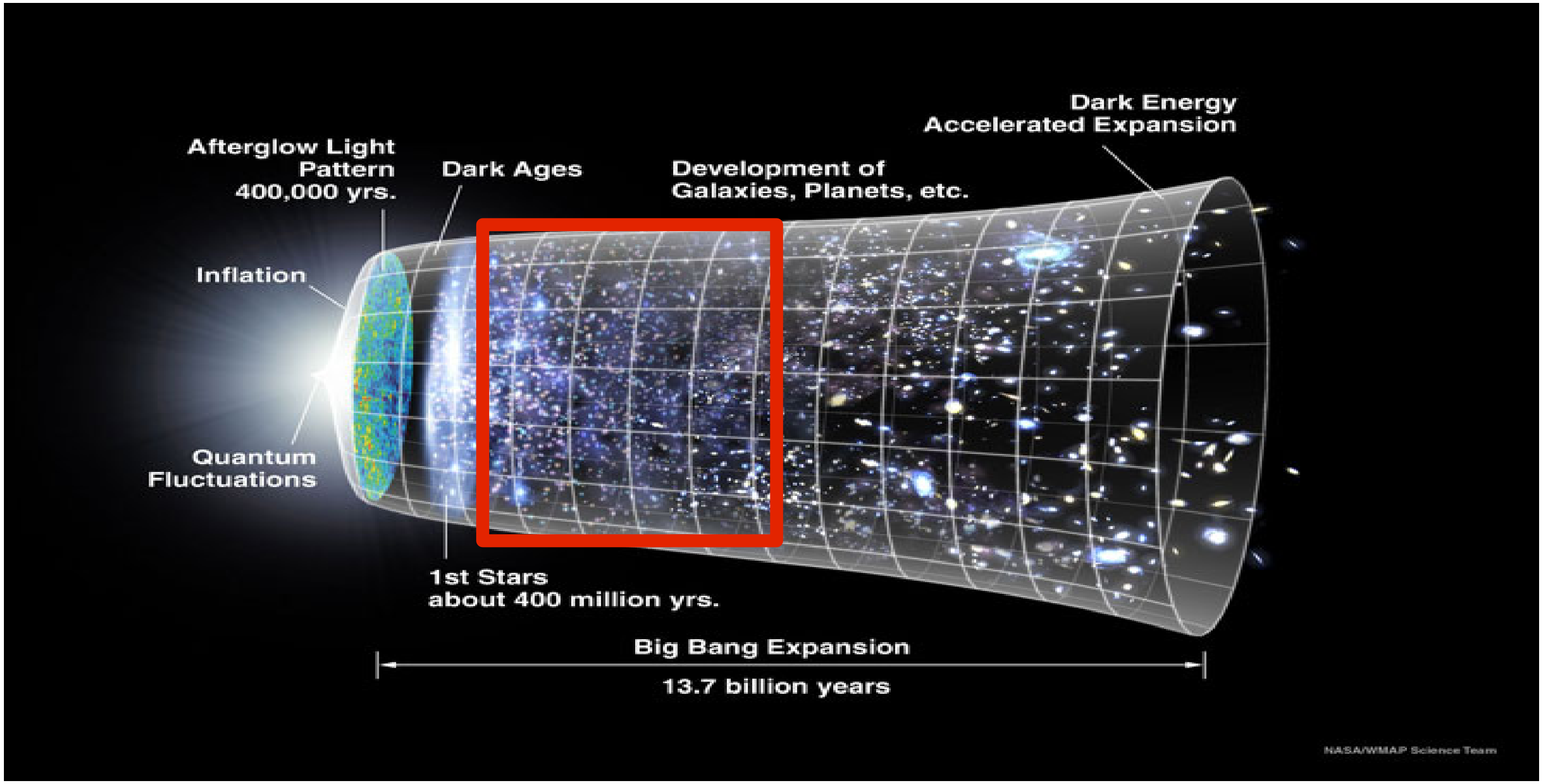
The first billion years of galaxy formation in cold and warm dark matter cosmologies

Pratika Dayal



ICC Institute for Computational Cosmology

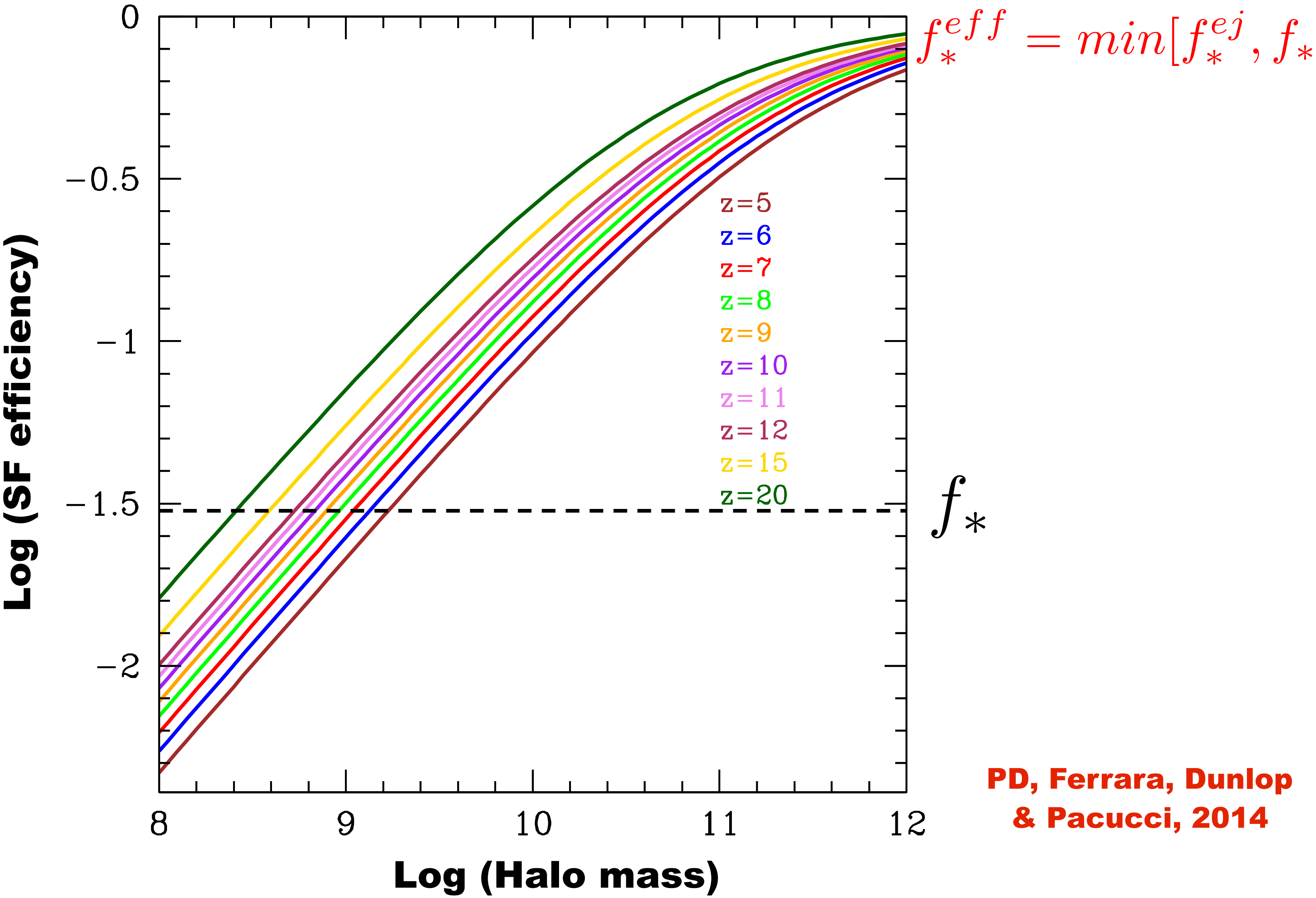
Institute of Advanced Study

Durham University

The main questions

- **What is the fundamental physics driving the evolution of early galaxies?**
- **How can we use them to constrain the nature of Dark Matter?**

The premise: maximum SFE limited by energy required to unbind rest of the gas and quench star formation - up to a certain maximum threshold



PD, Ferrara, Dunlop & Pacucci, 2014

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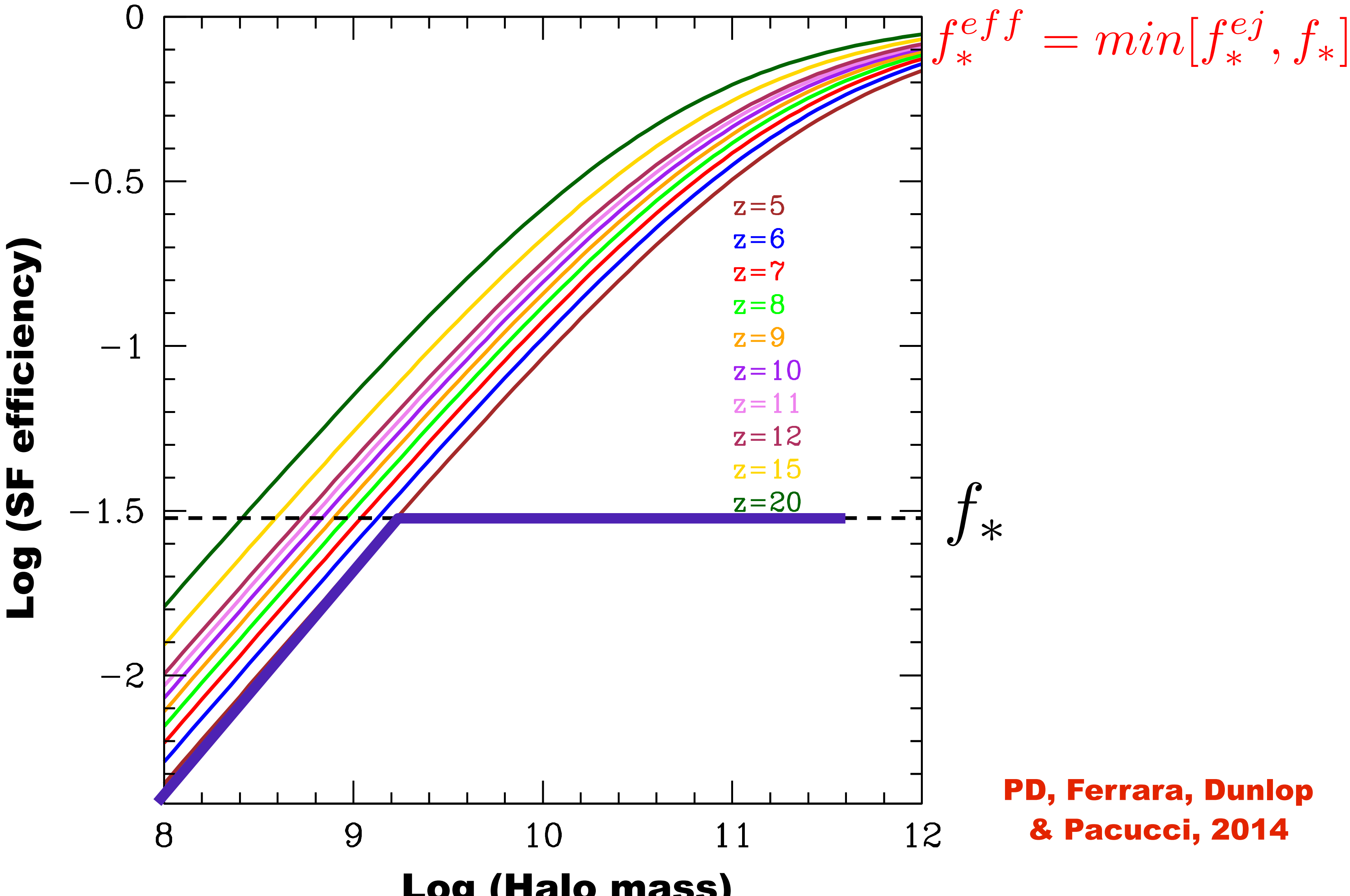

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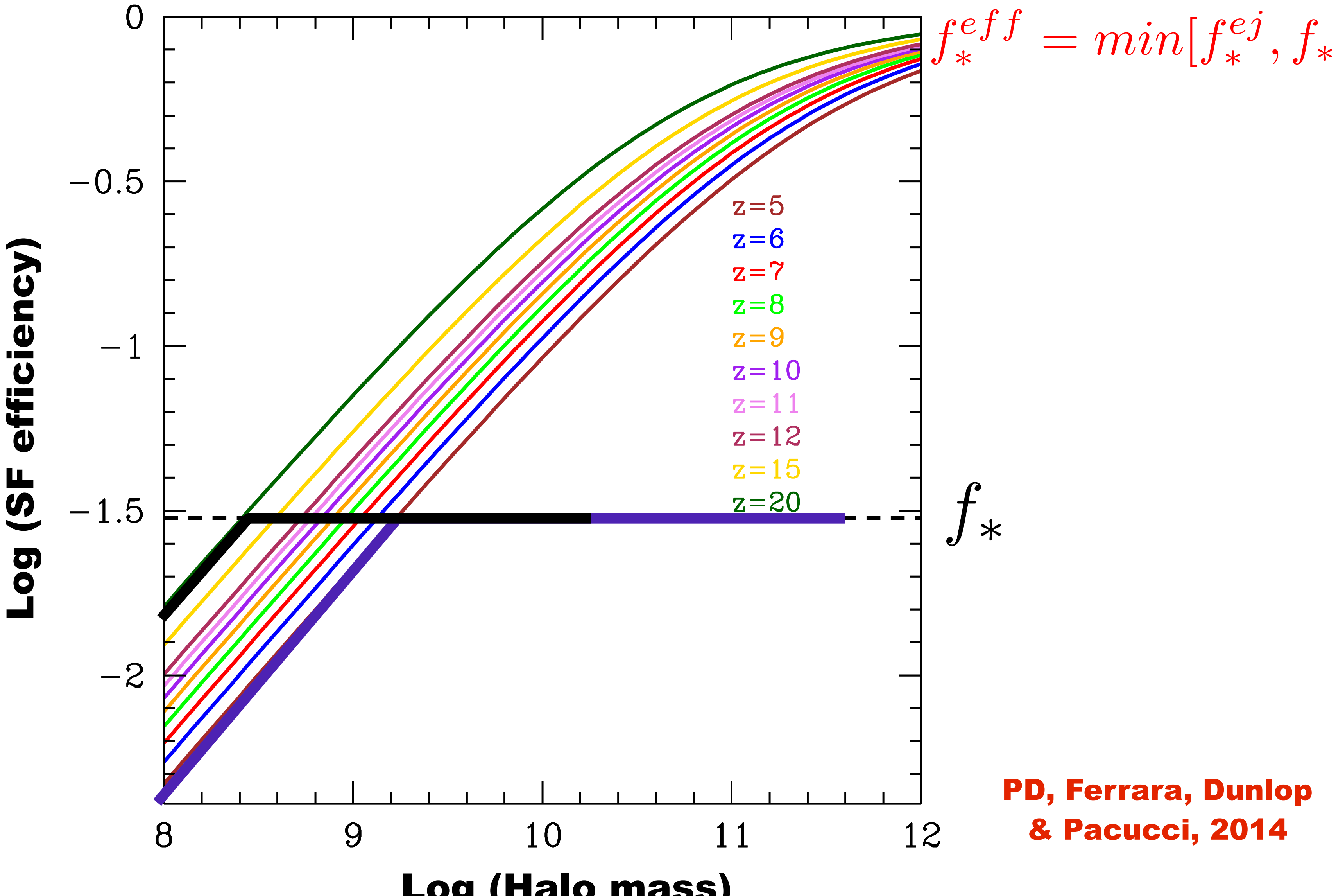
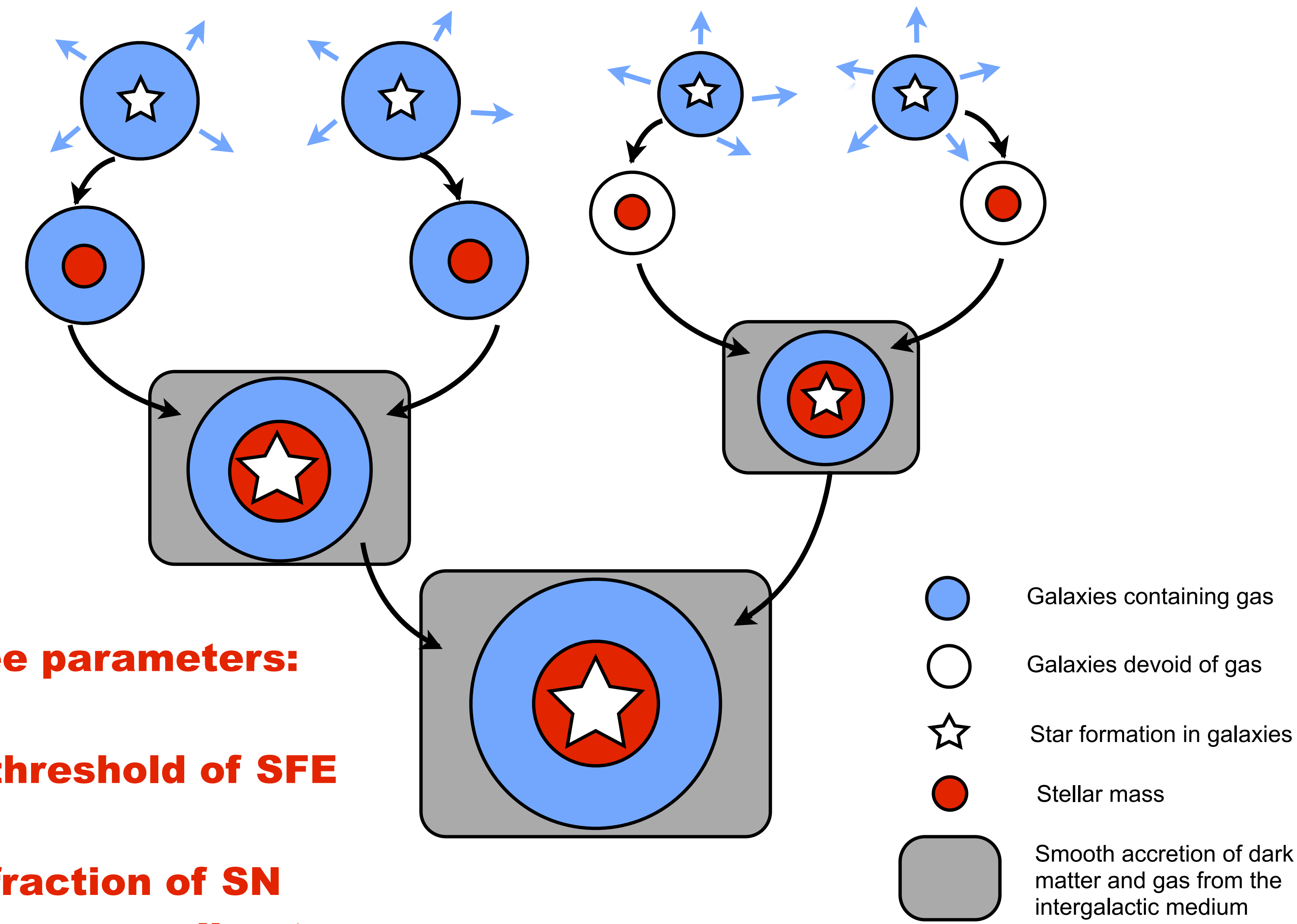


PD, Ferrara, Dunlop & Pacucci, 2014

A semi-analytic model implemented with this simple idea



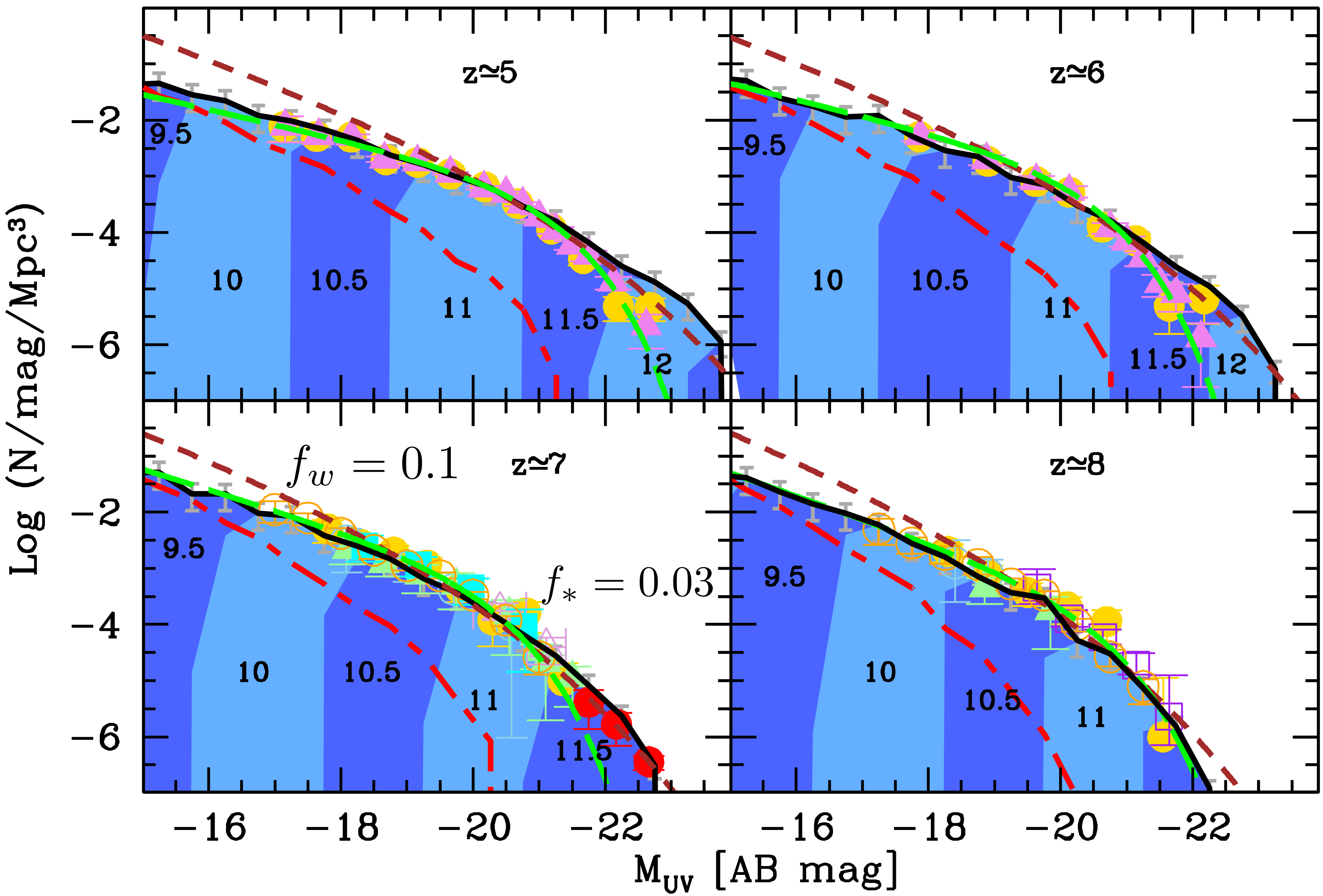
Free parameters:

f_* **1. threshold of SFE**

f_w **2. fraction of SN energy coupling to gas**

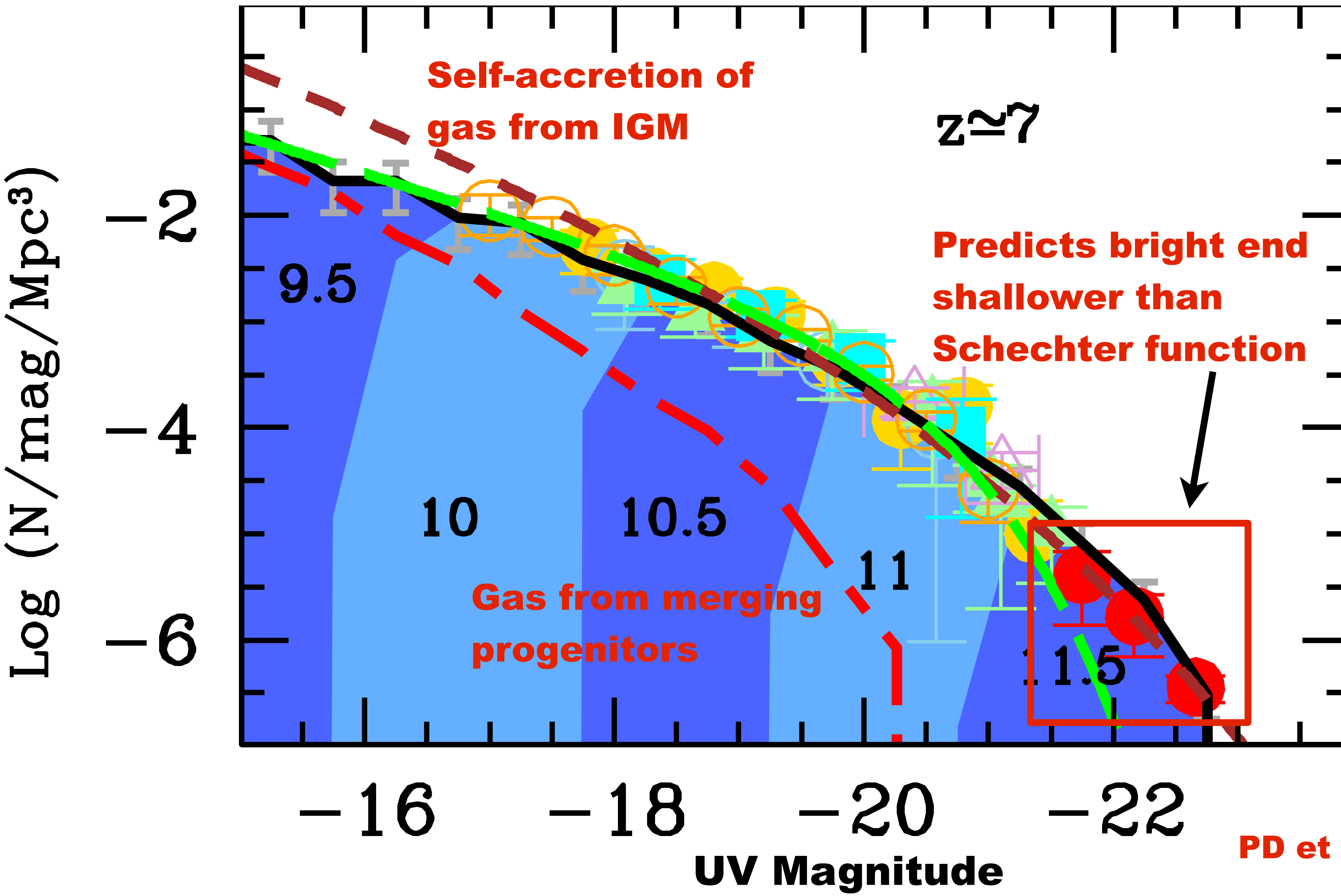
PD, Ferrara, Dunlop & Pacucci, 2014

The number counts of early LBGs (the UV LF)



PD, Ferrara, Dunlop & Pacucci, MNRAS, 2014

The gastrophysics of early LBGs

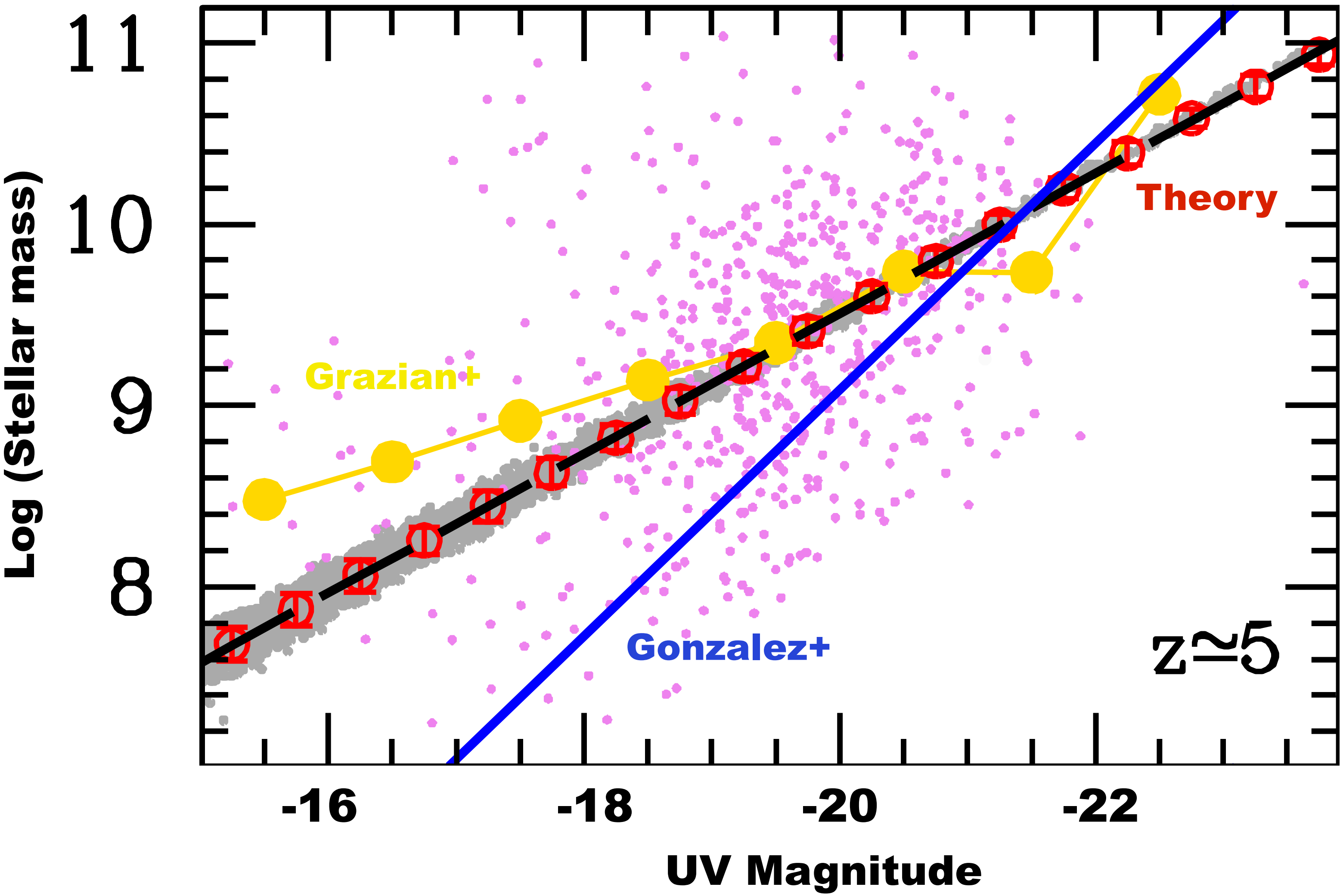


PD et al. 2014

Prediction for the frontier Fields and JWST: $\alpha = -1.75 \log z - 0.52$

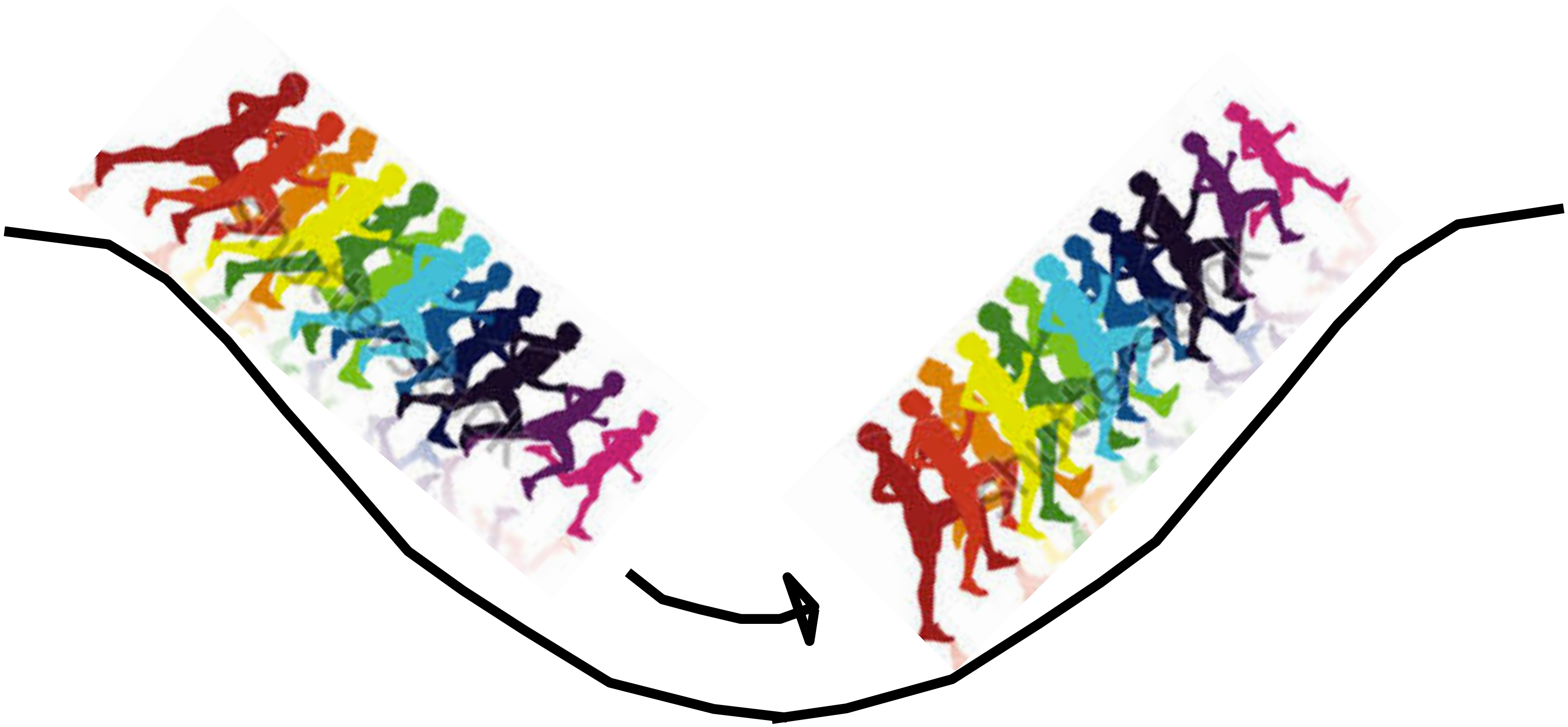
Light scales linearly with mass - but slope debated

PD, Ferrara, Dunlop & Pacucci, 2014

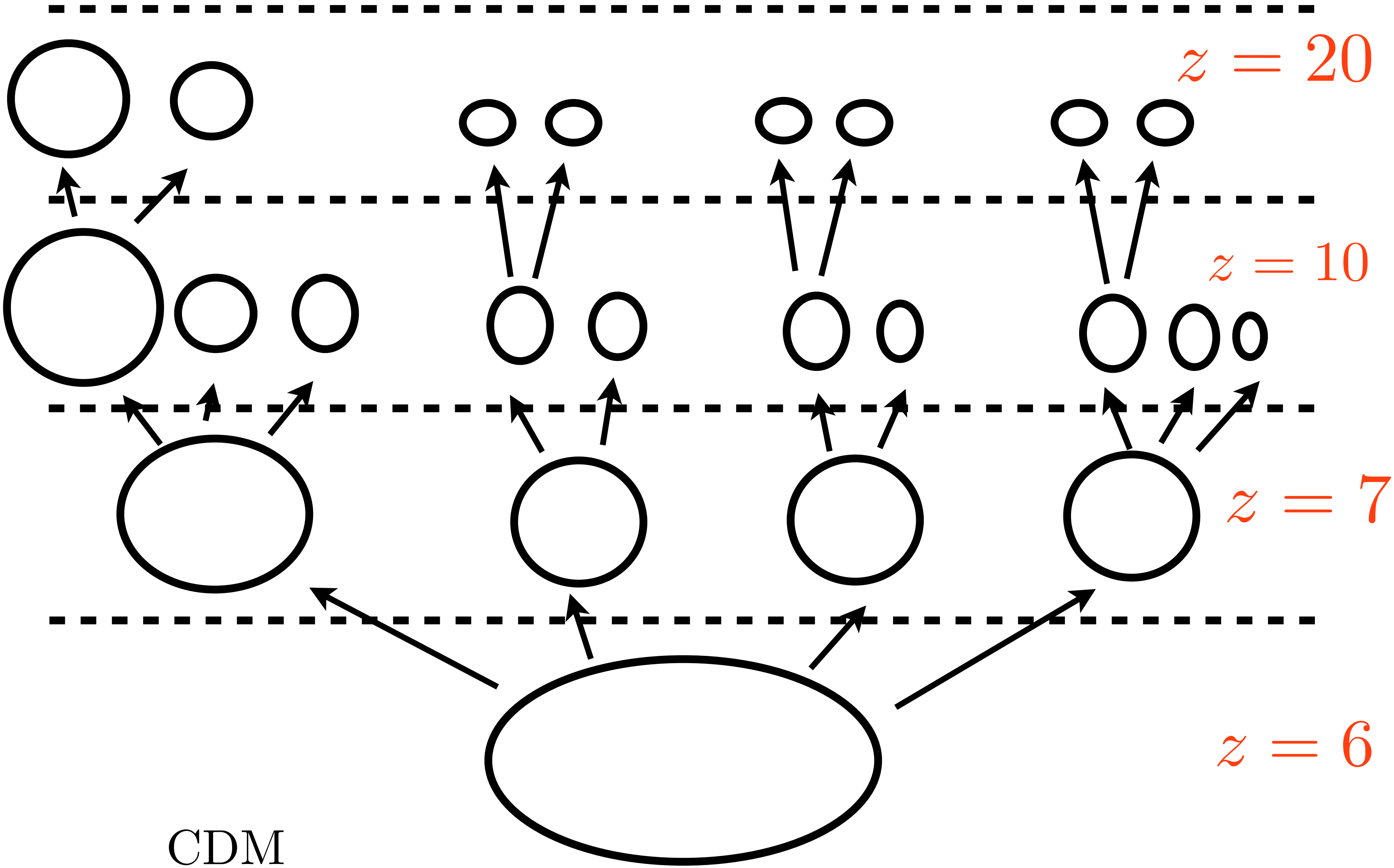


Testable prediction: $\log M_{*} \propto -0.38 M_{UV}$

Extending this framework to Warm Dark Matter Cosmologies

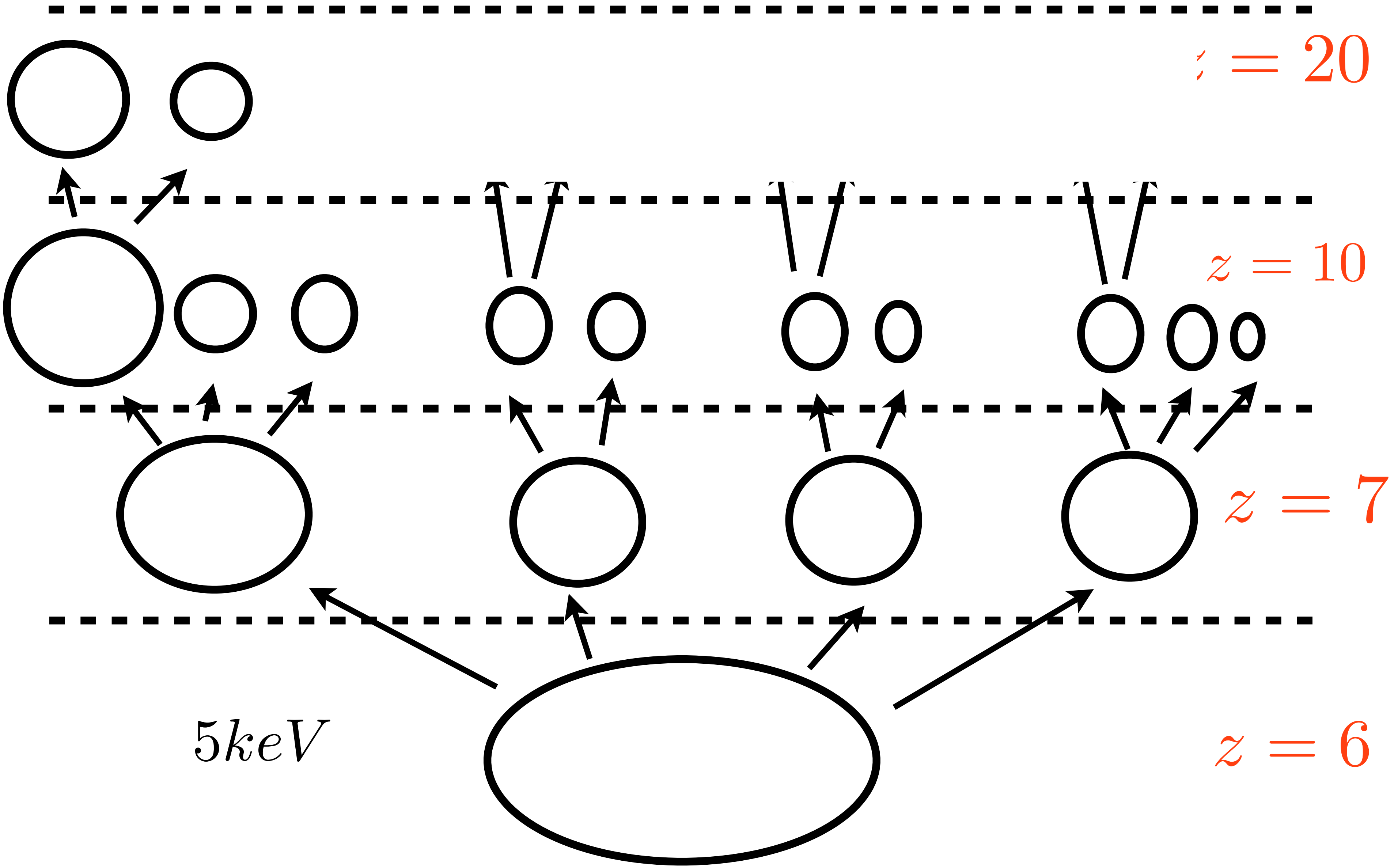


Hierarchical structure formation in CDM



Mass roughly 100 GeV

Lighter the WDM particle, more is the suppression of small scale structures



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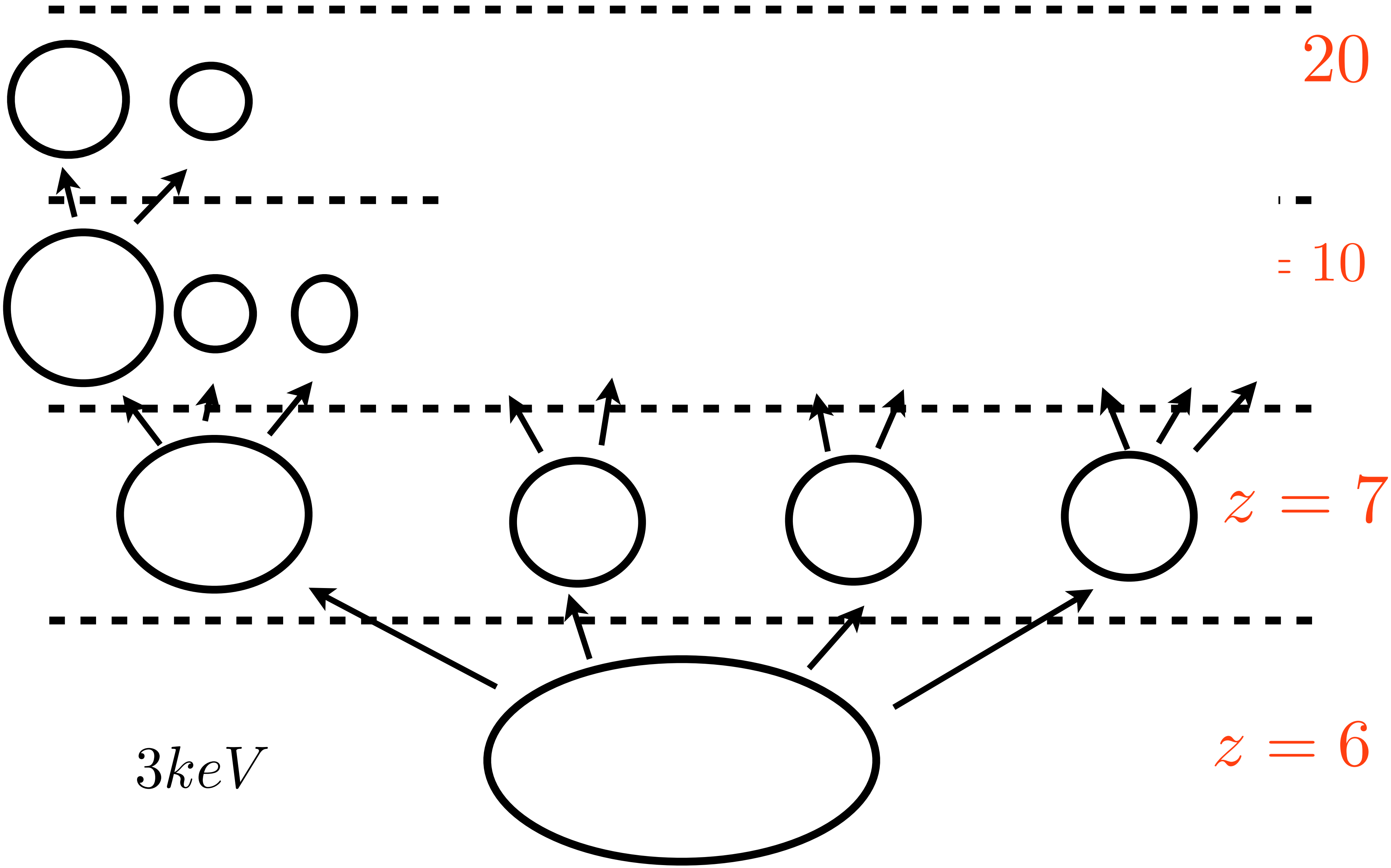

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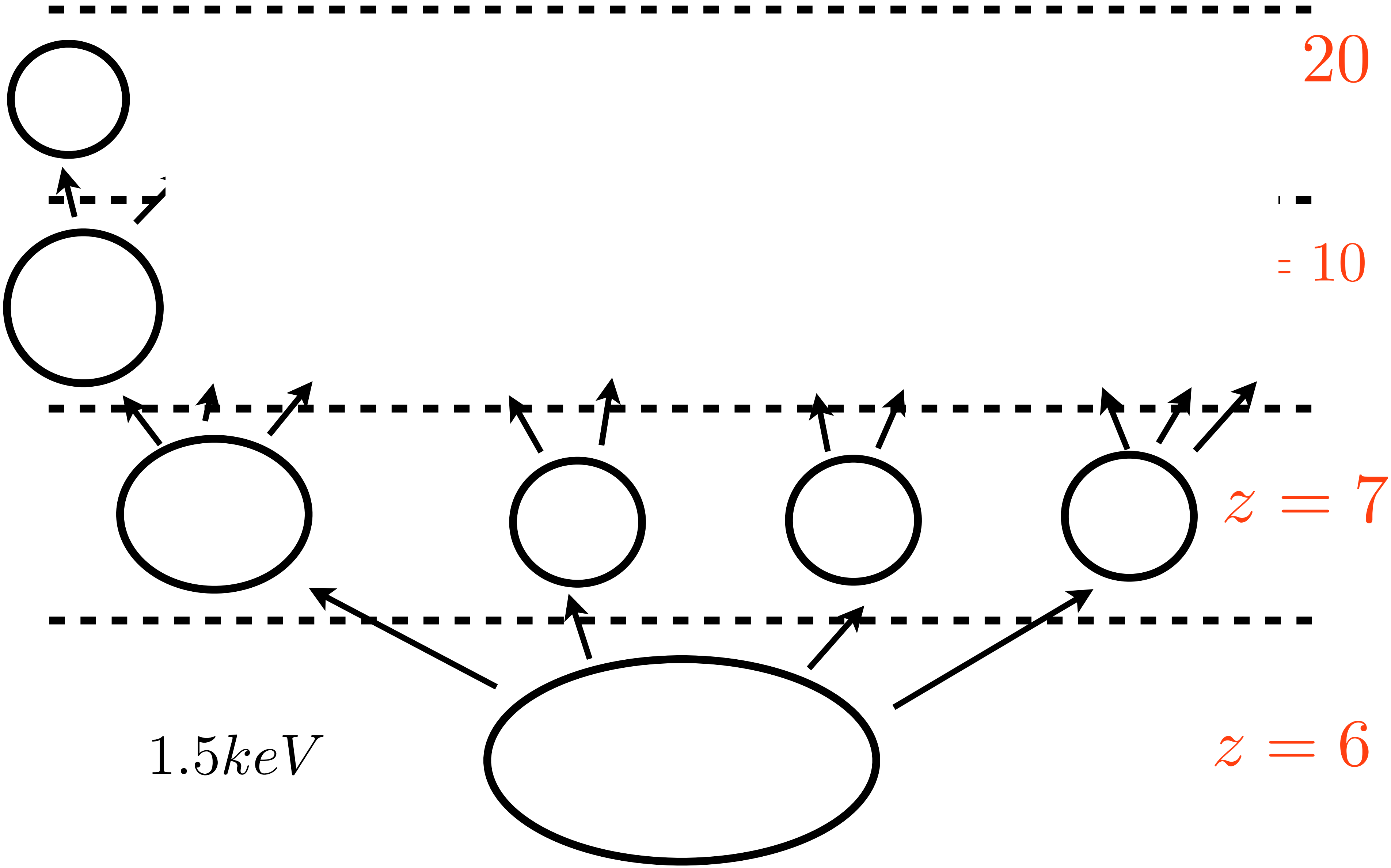
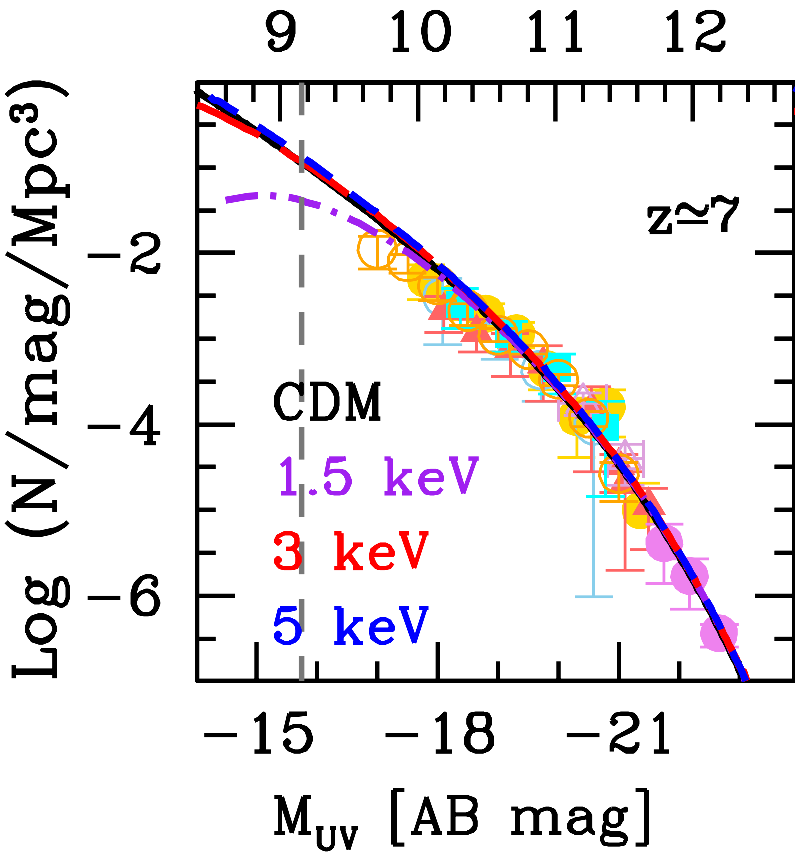
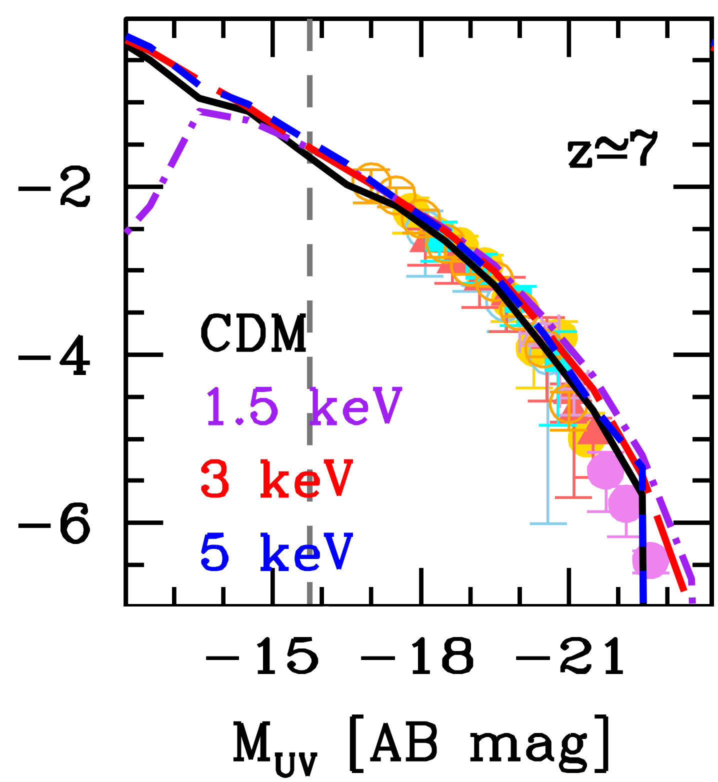


UV LFs in WDM

Scaling Halo mass function



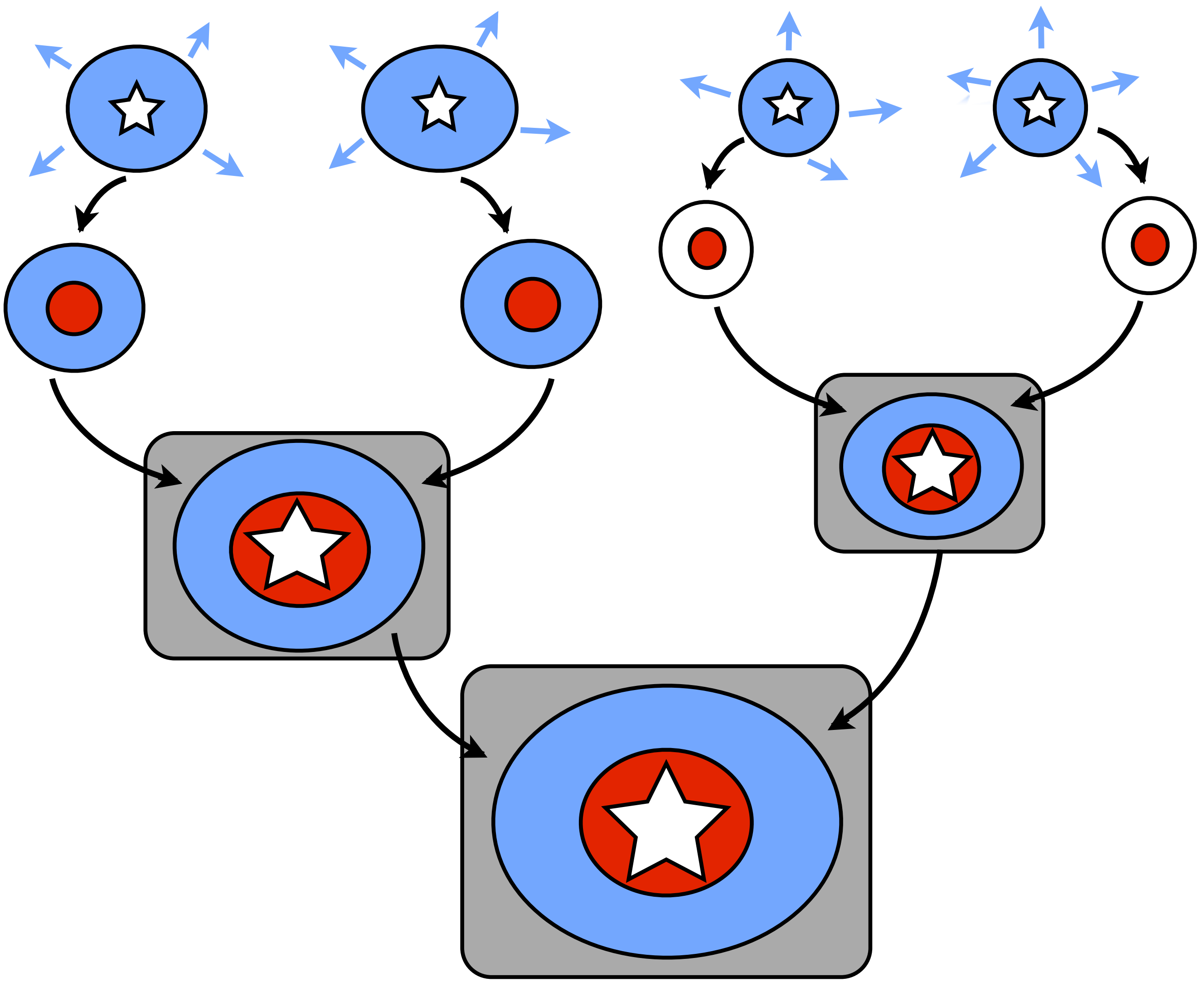
Fiducial model



Including baryons (and SF) decreases the difference between CDM and 1.5 keV WDM models

PD, Mesinger & Pacucci, 2015

Since the merger tree starts building up later in WDM models..



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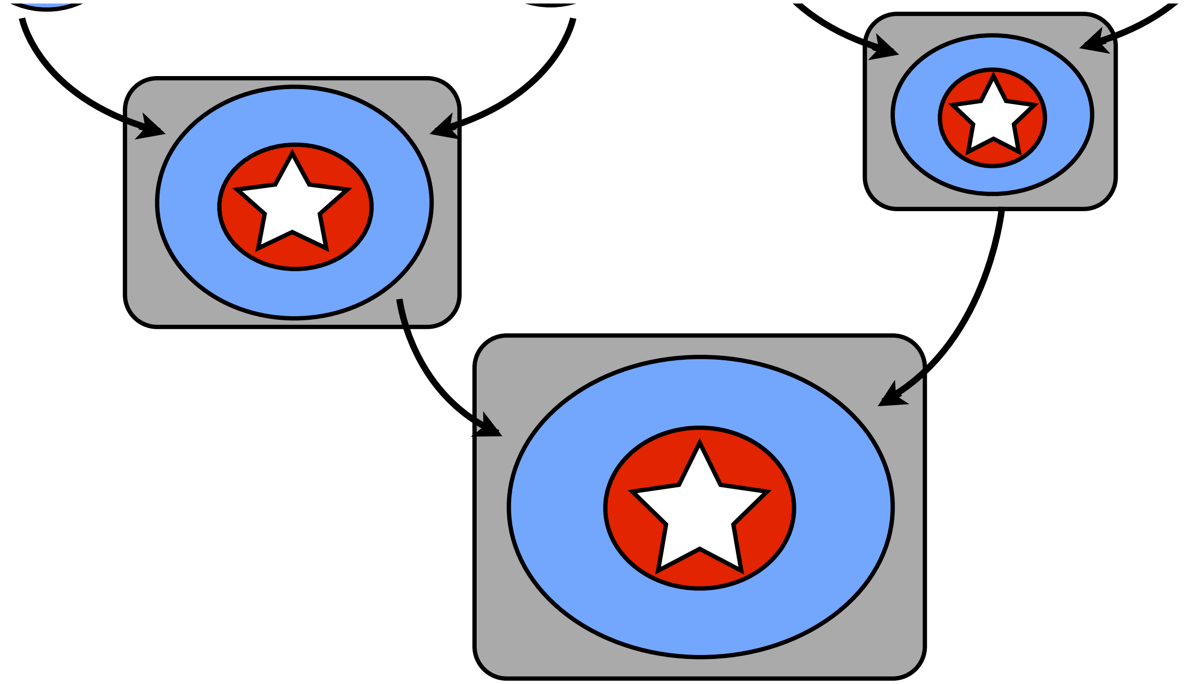
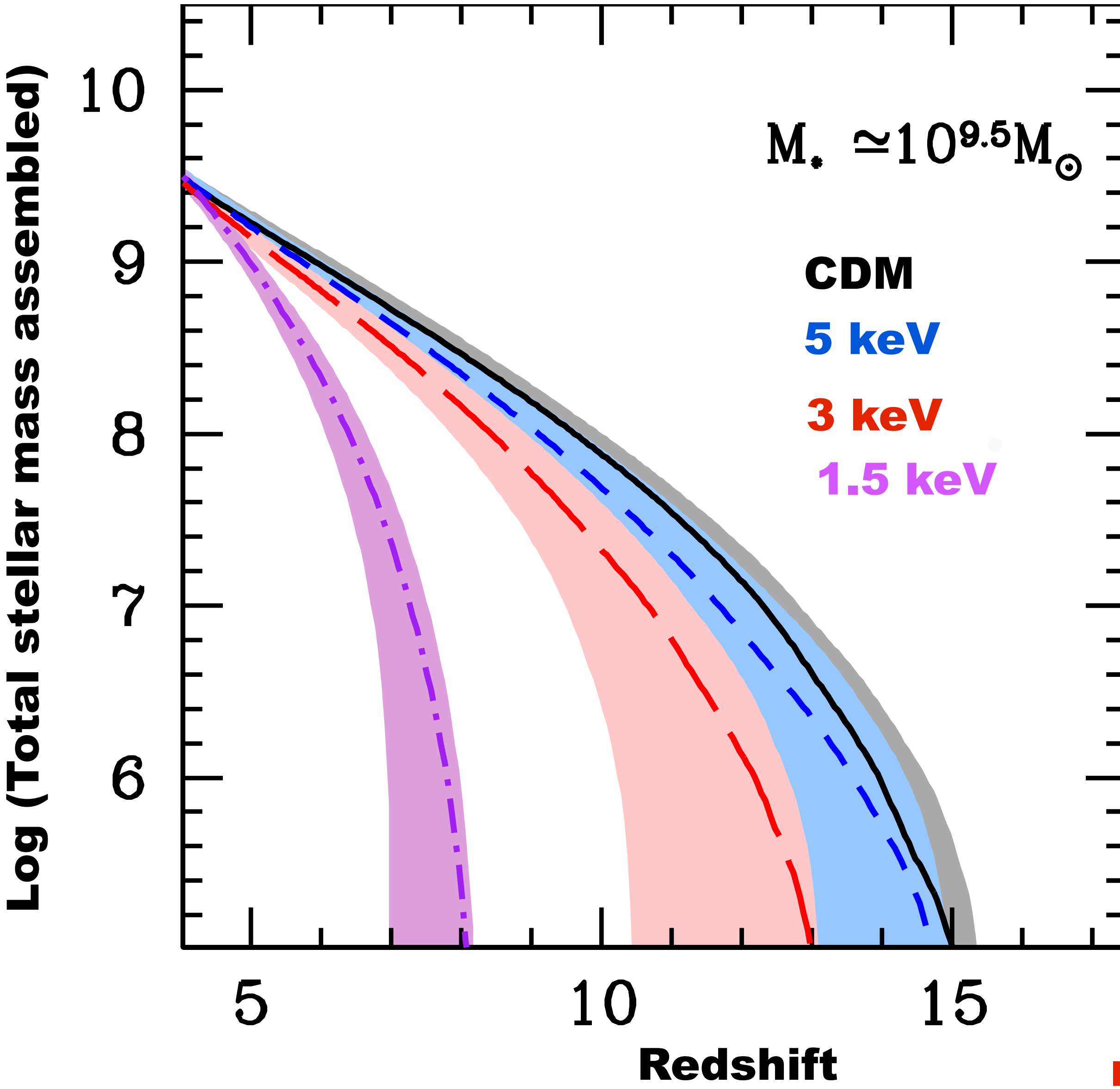


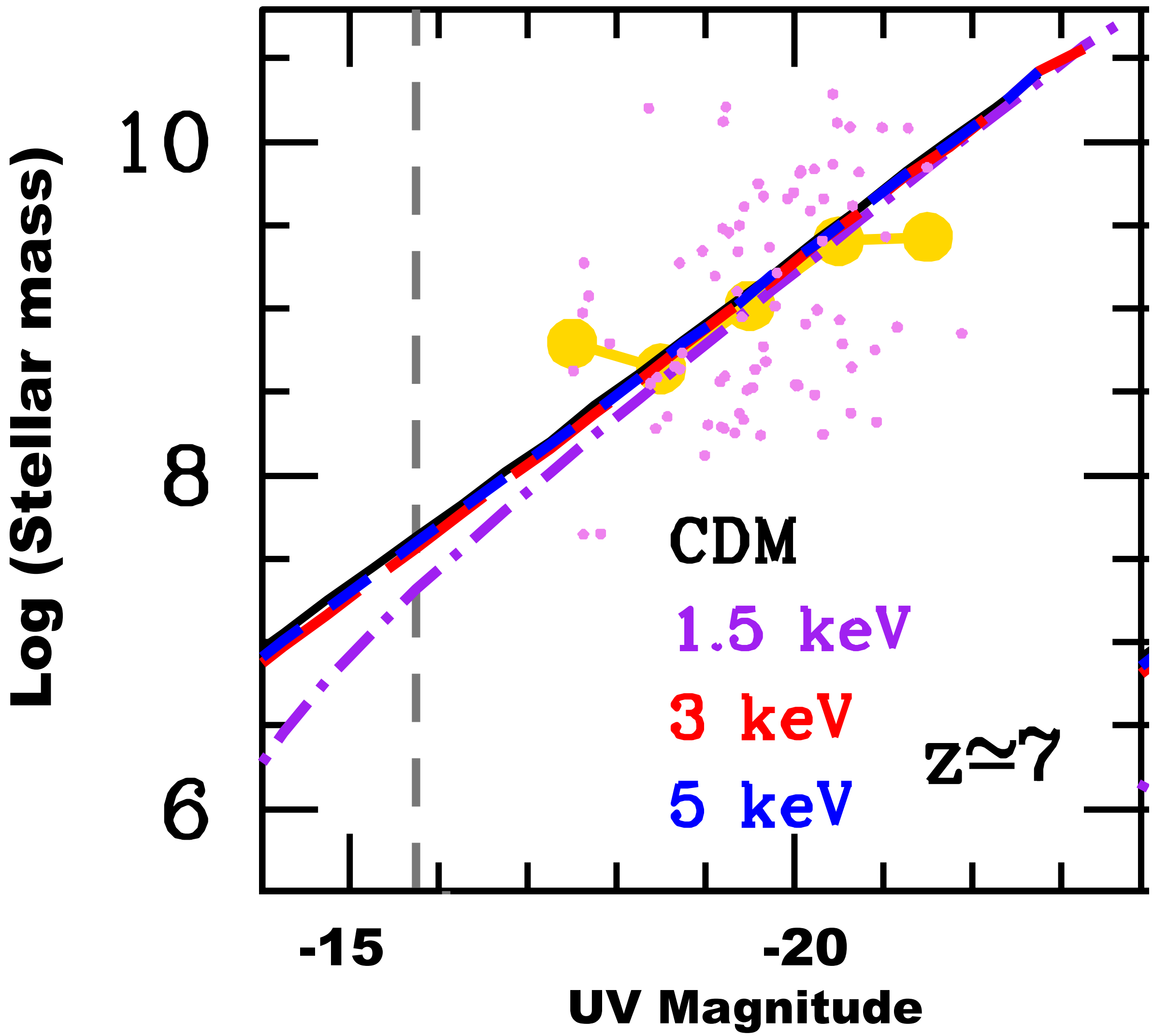
it leads to a delayed assembly of the stellar mass



Galaxies assemble faster in 1.5 keV WDM models compared to CDM. This is because they start off bigger and are less feedback limited as a consequence.

PD, Mesinger & Pacucci, 2015

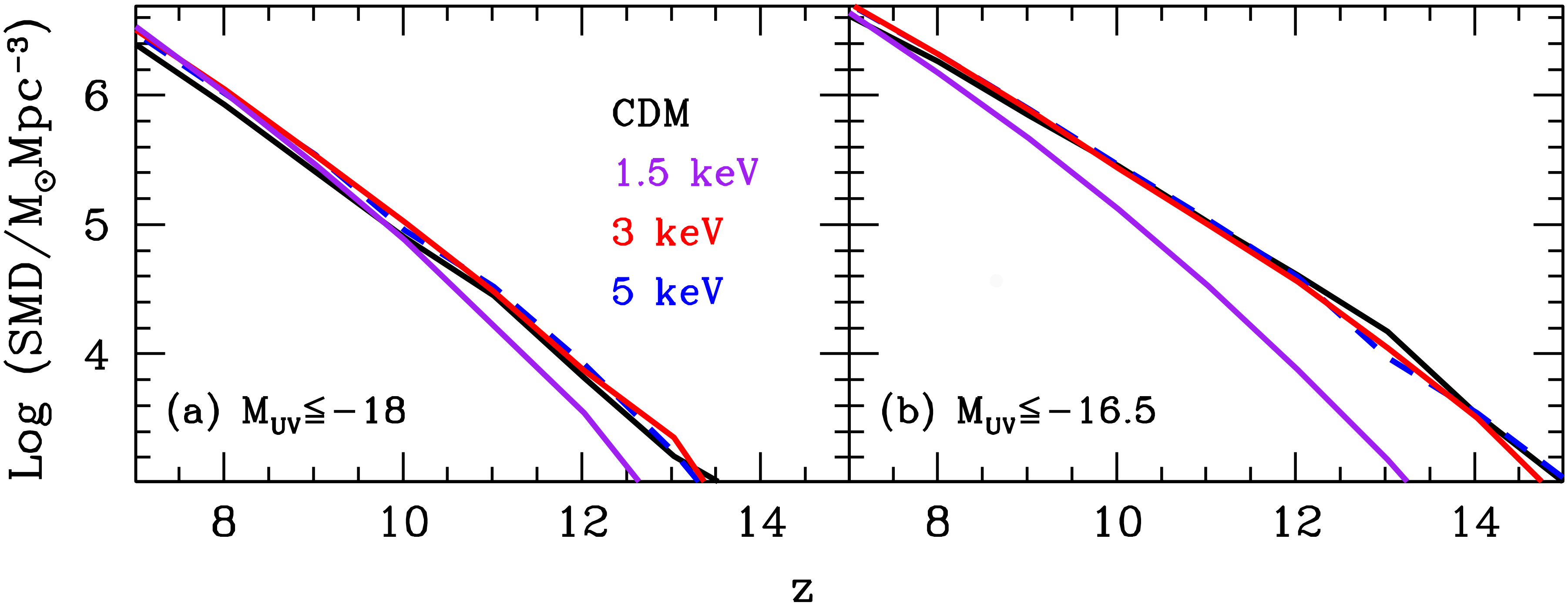
Mass-to-light ratios in different DM models



PD, Mesinger & Pacucci, 2015

Light WDM models show lower M/L ratios (i.e. more luminosity per unit stellar mass) compared to CDM

Observational imprints of light WDM particles: buildup of the cosmic stellar mass density



Redshift evolution of stellar mass density with JWST-detectable galaxies can allow constraints on WDM mass of about 2keV!

PD, Mesinger & Pacucci, 2015

Conclusions

- **The premise: galaxies form stars with a limiting efficiency that can unbind rest of the gas and quench star formation, up to a maximum threshold.**

- **This simple model reproduces the UV LF over 3.5 orders of magnitude in luminosity at z~5-8 and predicts evolution of the faint end (steepening with redshift), and a mass-to-magnitude relation (slope of -0.38).**

- **Gastrophysics depends on halo mass - self accretion (mergers) build up the gas mass for low mass (high mass) galaxies.**

- **Implementing the same baryonic physics into CDM and WDM models, we find UV LF, SMD, M/L ratios indistinguishable between CDM and >3 keV WDM. But JWST SMD measurements may help distinguish lower mass (~2 keV) WDM.**