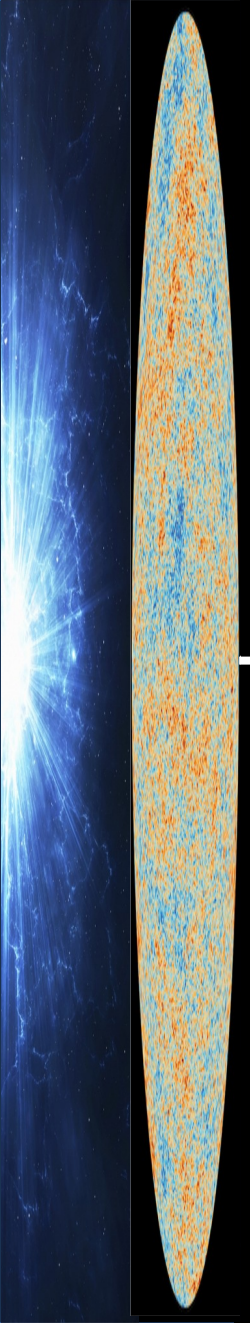

DAWN

The impact of an evolving IMF on galaxy evolution and reionisation

arXiv: 2312.12109

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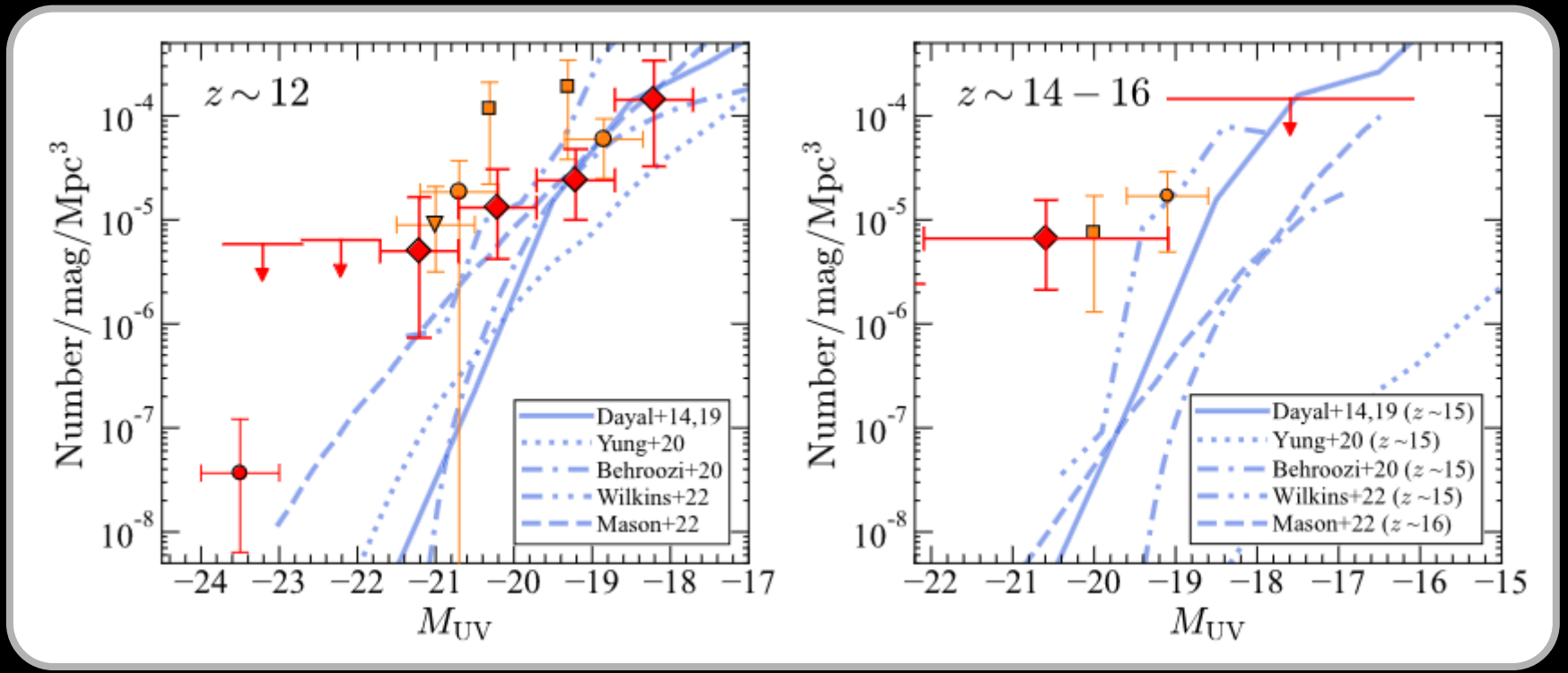
UNIVERSITY OF COPENHAGEN

Danmarks Grundforskningsfond
Danish National Research Foundation

Why do we see a high abundance of bright galaxies at z>10?

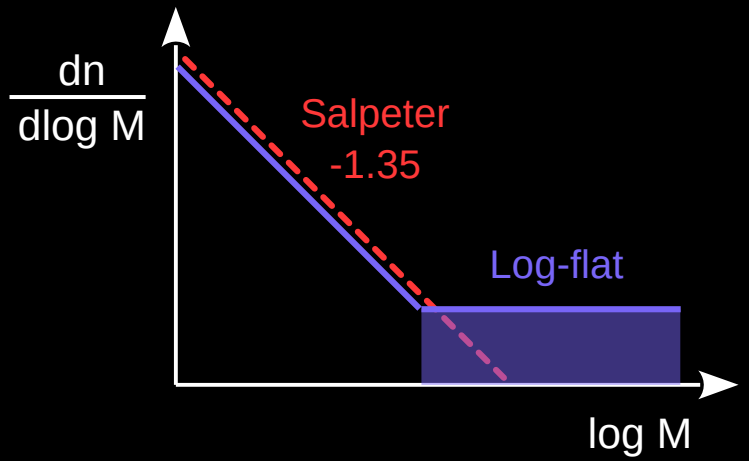
Harikane+2023



Due to bursty star formation, radiative feedback pushing dust from star forming region, feedback-free starbursts, and/or **top-heavier IMF**?

see e.g. Dekel+ 2023, Ferrara+2023, Mason+2022, Trinca+2023

Can a top-heavy IMF explain the bright z>10 galaxy abundance?



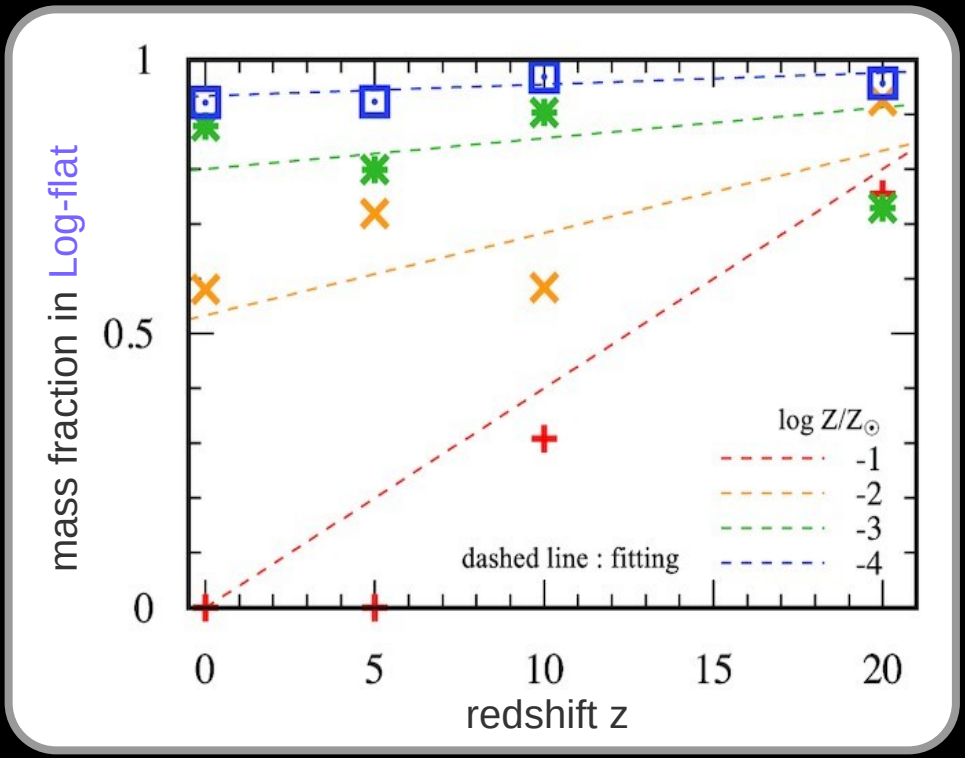
IMF depends on gas temperature

(metallicity, CMB temperature)

Integrate into Astraeus

simulation framework

simulations of star-forming clouds *Chon+ 2022*

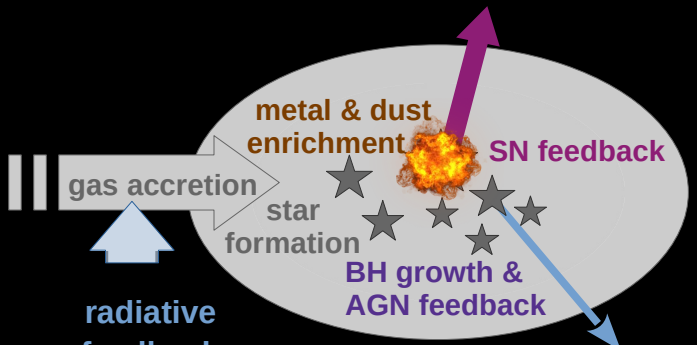


Elie Rasmussen Cueto
Master student

Cueto, Hutter et al. 2023
arXiv: 2312.12109

Astraeus framework: simulating the evolution of galaxies and the IGM

SEMI-ANALYTICAL GALAXY EVOLUTION MODEL

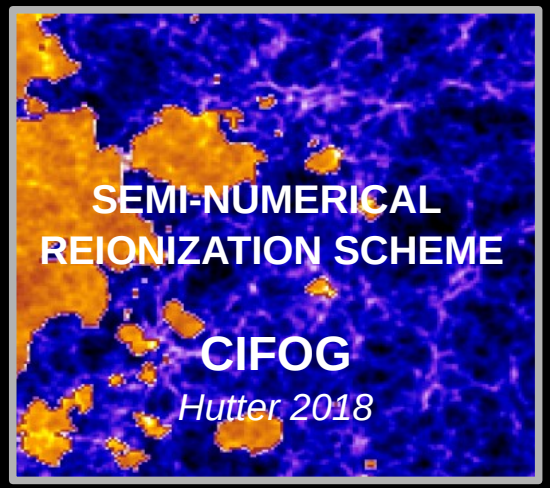


based on **DELPHI**
Dayal+ 2014

ionising emissivity distribution

COUPLING

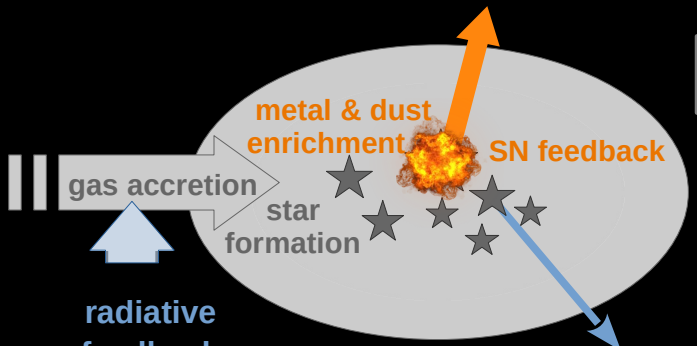
feedback from reionisation



Hutter+ 2021a, Ucci+2023, Hutter+ 2023a, Trebitsch+2023, Cueto+2023

Astraeus framework: simulating the evolution of galaxies and the IGM

SEMI-ANALYTICAL GALAXY EVOLUTION MODEL



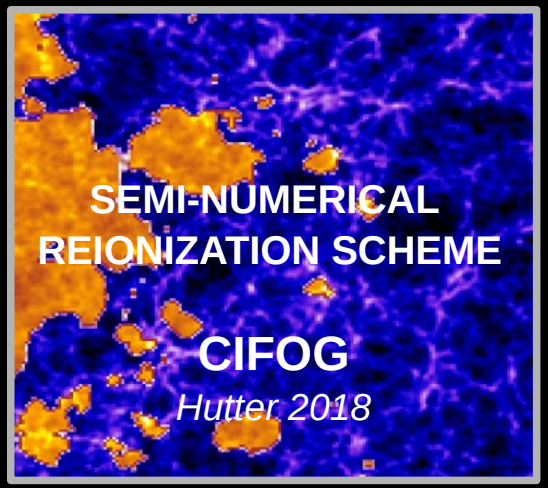
based on **DELPHI**
Dayal+ 2014

IMF dependent

ionising emissivity distribution

COUPLING

feedback from reionisation



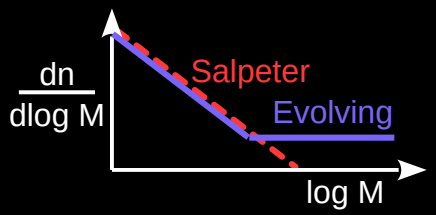
Hutter+ 2021a, Ucci+2023, Hutter+ 2023a, Trebitsch+2023, Cueto+2023

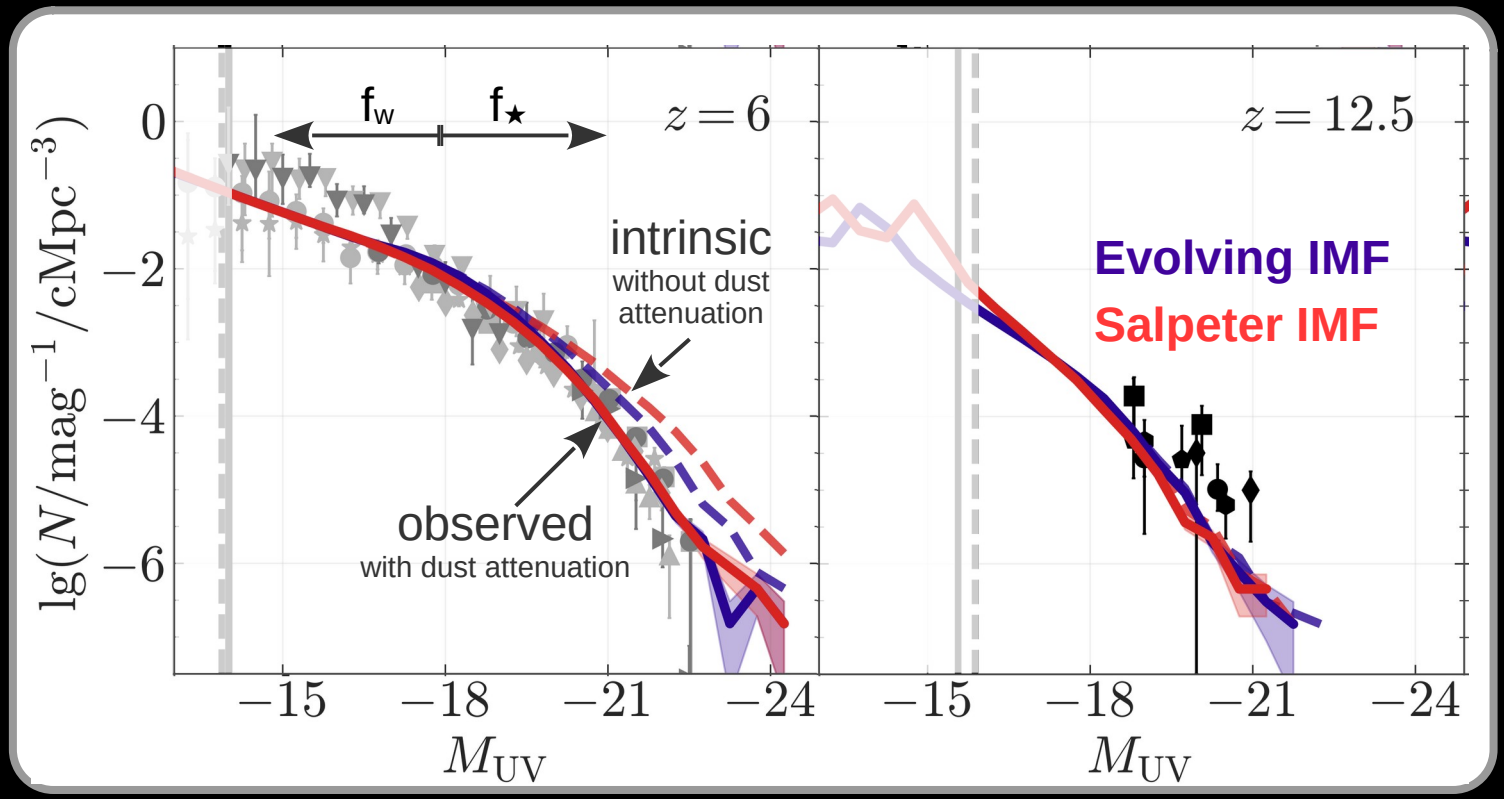
The evolution of the UV LFs at z=5-12 hardly changes!

Free parameters:

- $f_\star$ = 0.01 / 0.025 star formation efficiency
- f_w = 0.3 / 0.2 SN wind coupling efficieny
- f_{esc} = 0.038 / 0.31 ionising escape fraction

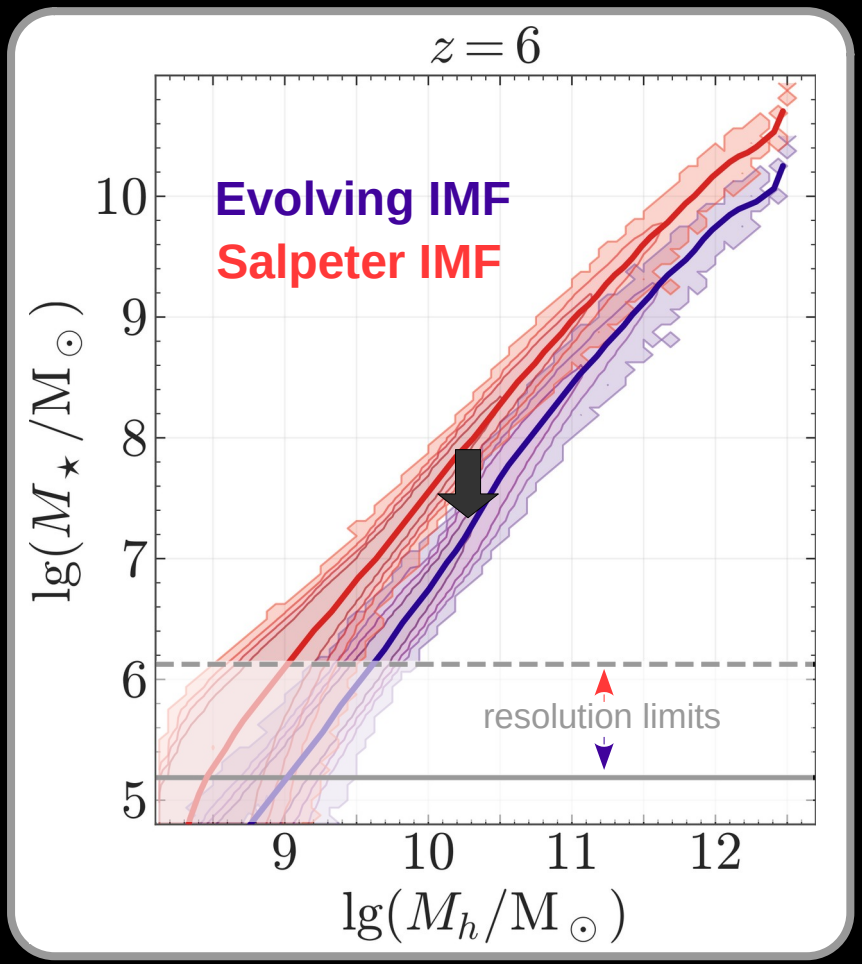
Values driven by z<10 UV LFs

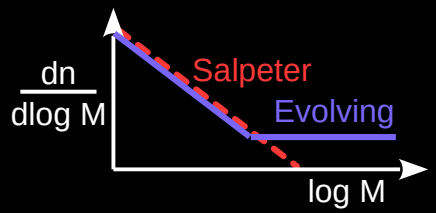




The evolving IMF's lower mass-to-light ratio requires assuming a smaller star formation efficiency and stronger SN wind coupling.

Evolving IMF: Lower star formation efficiency leads to stellar masses being ~0.5-1 dex lower in same z=6-12 halos

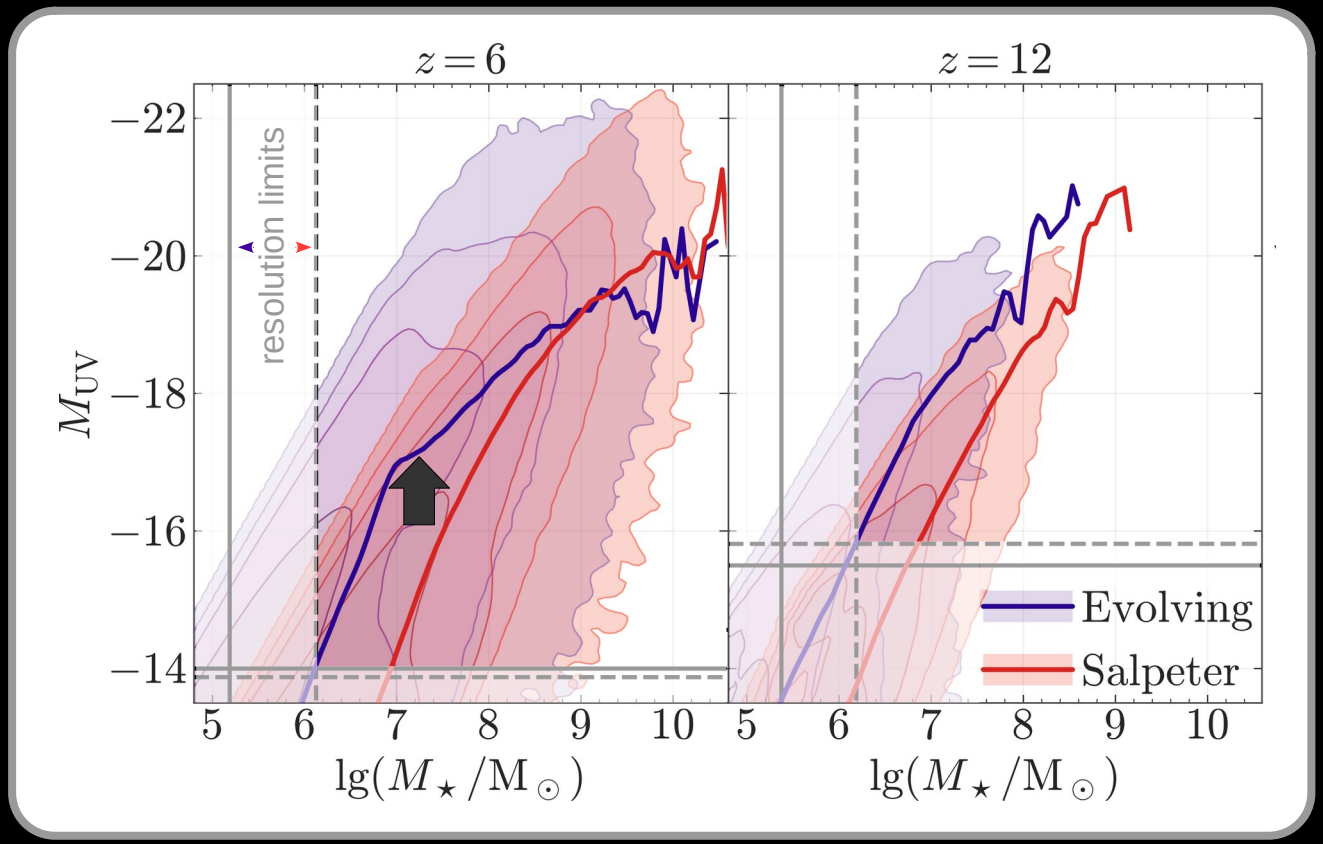


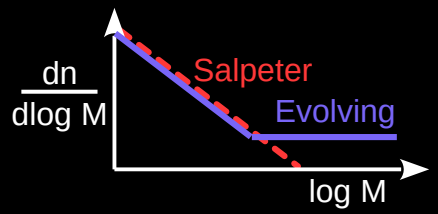


Main characteristics of the evolving IMF:

1. **slower build-up of stellar mass** due to lower star formation efficiency

Evolving IMF: Lower stellar mass-to-light ratio



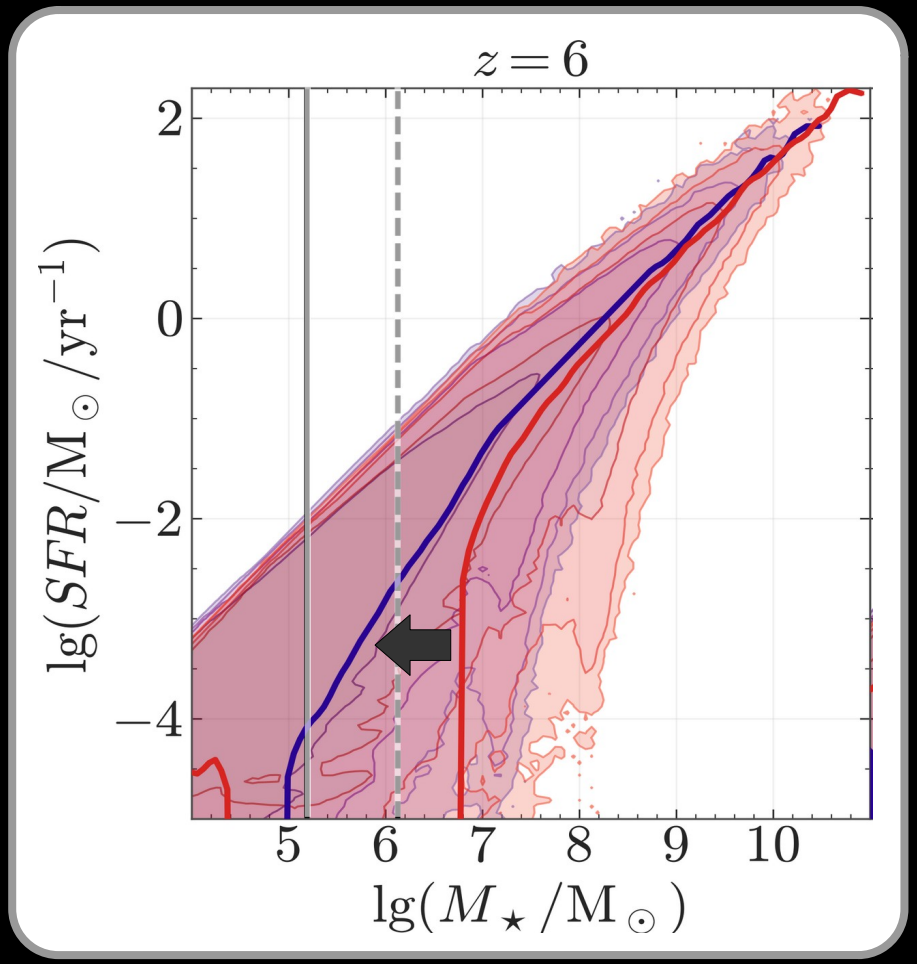


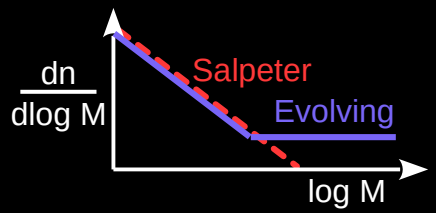
Main characteristics of the evolving IMF:

1. **slower build-up of stellar mass** due to lower star formation efficiency

2. **reduced mass-to-light ratio** due to a higher abundance of massive stars

Evolving IMF: star formation main sequence hardly changes



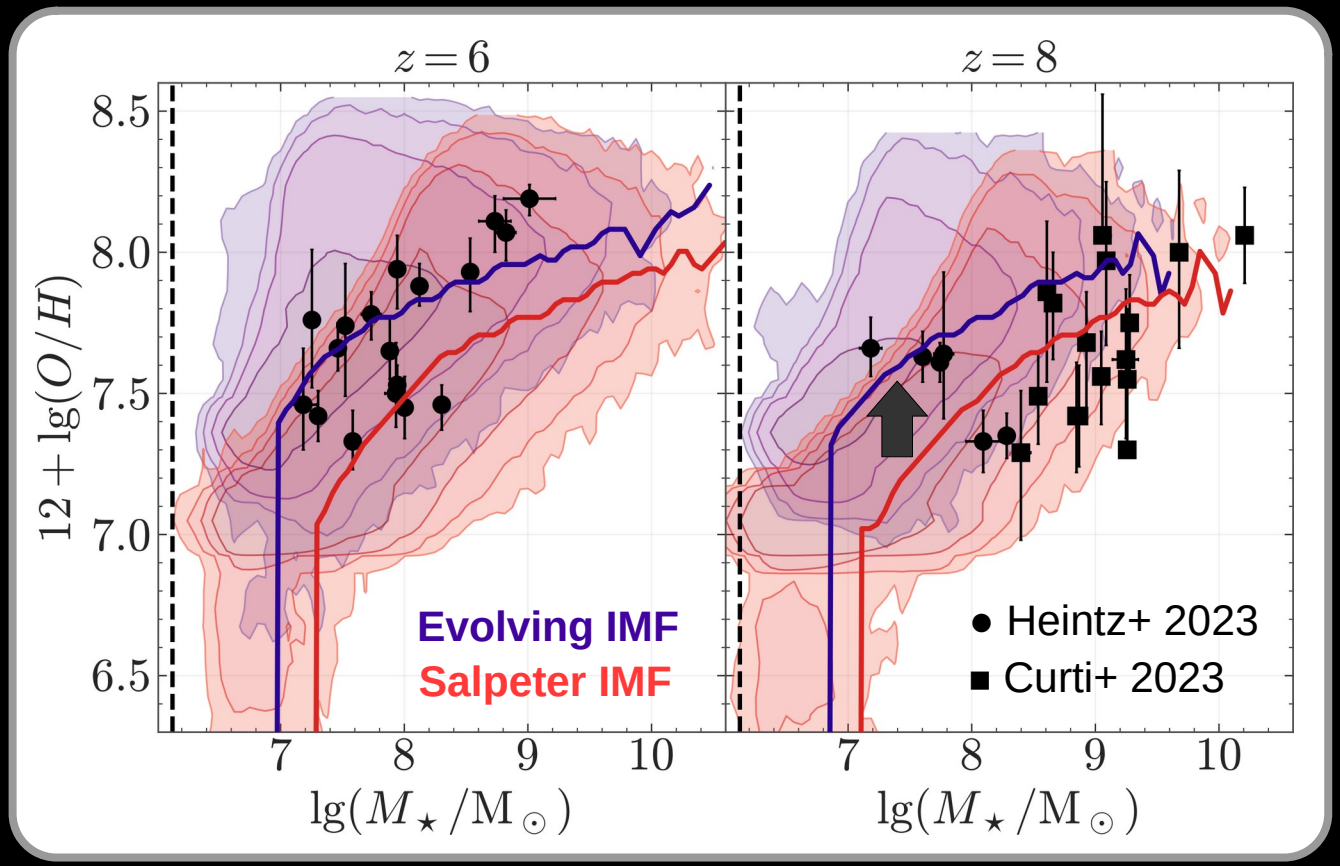


Characteristics of the evolving IMF:

1. **star formation main sequence unchanged** due to self-similar mass growth of halos

2. **higher SFR for low stellar mass galaxies** due to SN feedback being less delayed & located in more massive halos

Evolving IMF: mass – metallicity relation shifts to higher metallicities



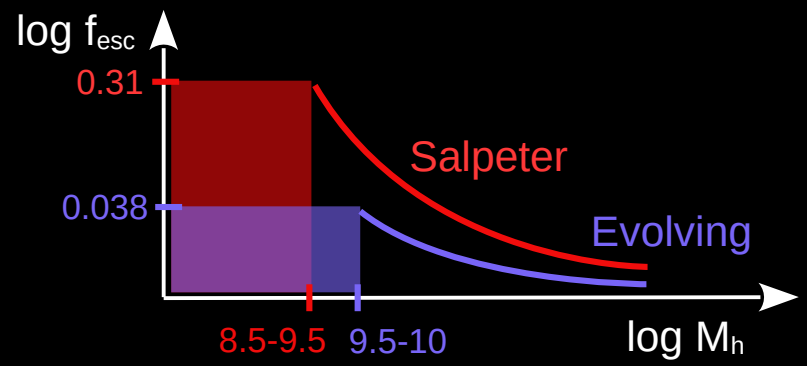
Characteristics of the evolving IMF:

1. **higher metallicities at same stellar masses** due to lower stellar-to-halo mass ratio & higher oxygen abundance

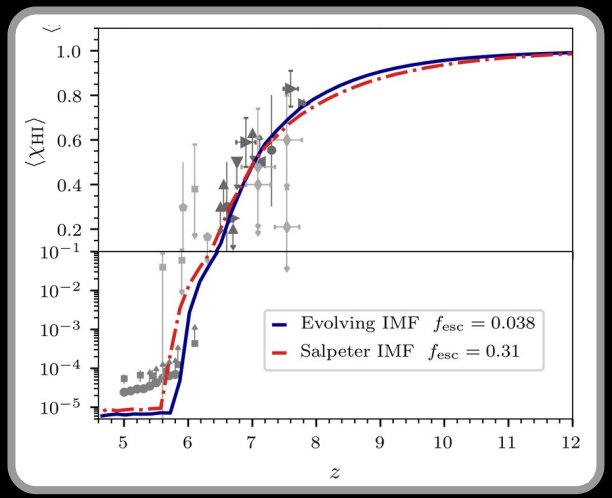
Note: metallicity-halo mass relation and metallicity-luminosity relation hardly change!

Evolving IMF: Only minor impact on reionisation topology

Assume: f_{esc} scales with ejected gas fraction

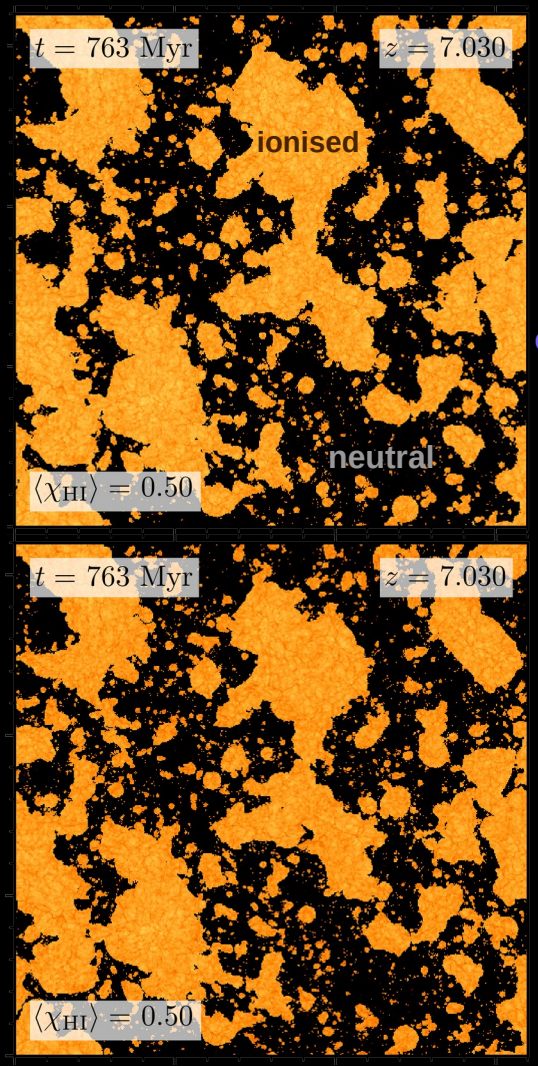


Adjust f_{esc} normalisation



similar ionisation history

only minor changes to ionisation topology



Conclusions

ASTRAEUS: self-consistent galaxy evolution model and reionisation:

- Semi-analytical galaxy evolution model fully coupled to a semi-numerical reionisation scheme
- Robust against mass and time resolution of underlying merger trees
- Publicly available at: *https://github.com/annehutter/astraeus*
- **Inlcudes now an evolving IMF!**

Effect of an evolving IMF compared to constant Salpeter IMF ...

… Galaxy evolution

- Slower build-up of stellar mass due to lower star formation efficiency and stronger SN feedback
- Lower stellar mass-to-light ratio
- Stellar mass – metallicity relation shifted to higher metallicities
- UV luminosity – dust mass relation shift to lower luminosities → Possibility to test with observations?

… Reionisation

- Stronger correlation between large-scale ionising emissivity and density distribution
- Reionisation history and topology change only minorly.

arXiv: 2312.12109