GALAXIES REIONISING THE UNIVERSE

Journées SF2A 2015 – Session JWST

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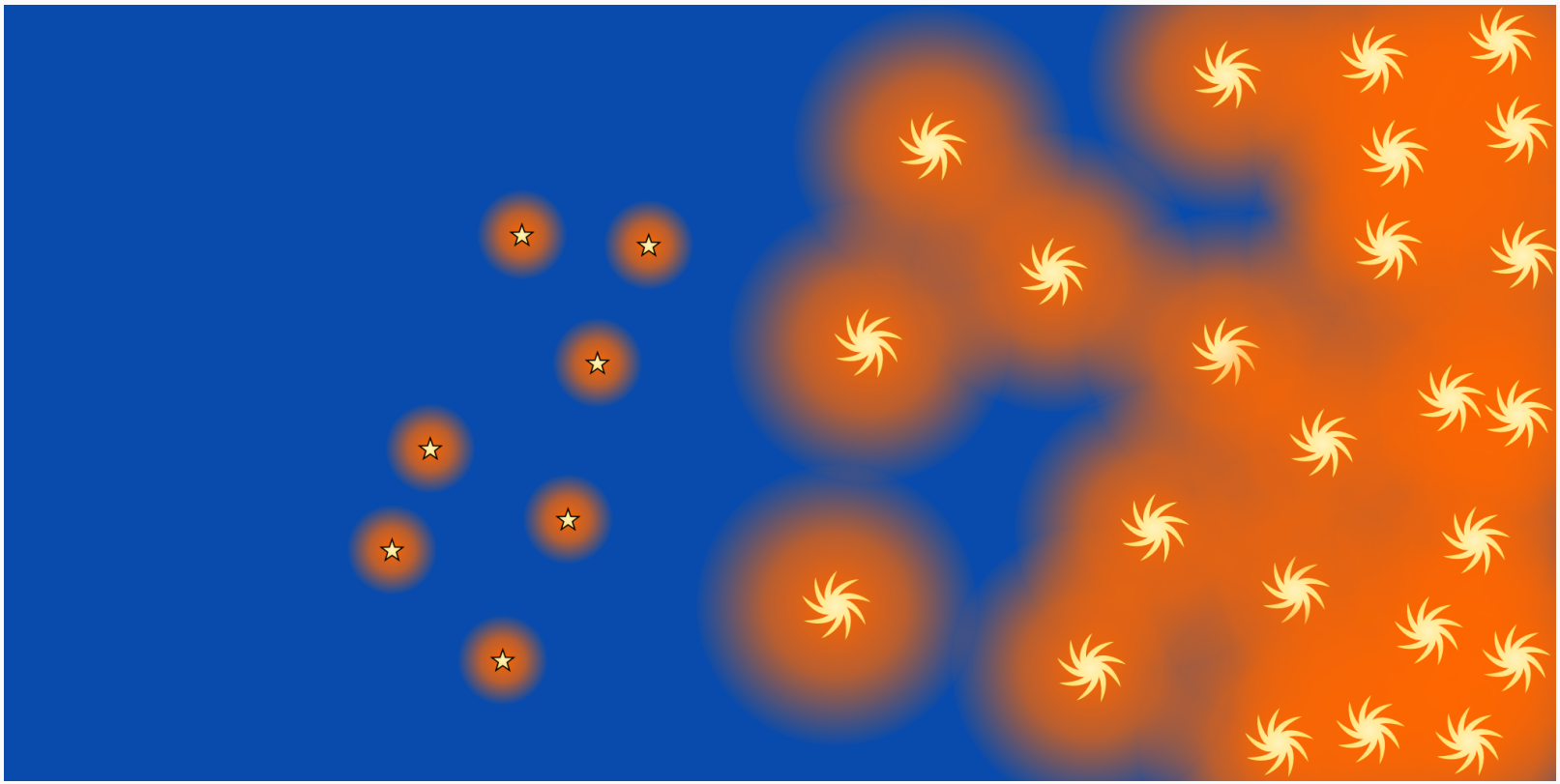
INTRODUCTION: THE EPOCH OF REIONISATION

Reionisation by the first galaxies



UNDERSTANDING THE REIONISATION

- Are there enough photons emitted to sustain reionisation?
- How do the ionising photons escape the galaxies?
- How do the ionised bubbles grow and overlap?

UNDERSTANDING THE REIONISATION

- Are there enough photons emitted to sustain reionisation?

→ How do galaxies form their stars?

- How do the ionising photons escape the galaxies?

→ How do the ionising f_{esc} evolves?

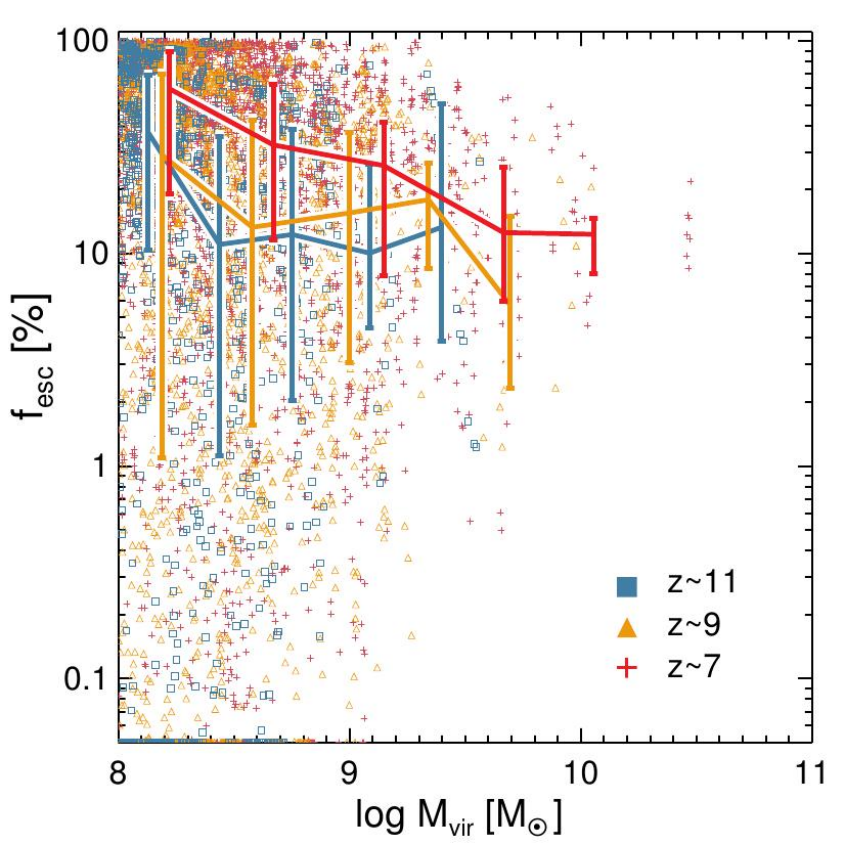
- How do the ionised bubbles grow and overlap?

We use numerical simulations to address these questions.

UNDERSTANDING THE REIONISATION

State of the art

- Ionising efficiency of galaxies quantified by f_{esc}
- So far, models favor reionisation by small galaxies
- ... but no strong constraints



Kimm+14

SIMULATION METHODOLOGY

METHODS: RHD ZOOM SIMULATIONS DOWN TO $z \sim 6$

What do we need to simulate small high-z galaxies?

- · Cosmological structure formation (DM+hydro)
- + Very high resolution to resolve the ISM
- + Physical model for star formation and supernova feedback
- + Follow the ionising radiation emitted by the stars

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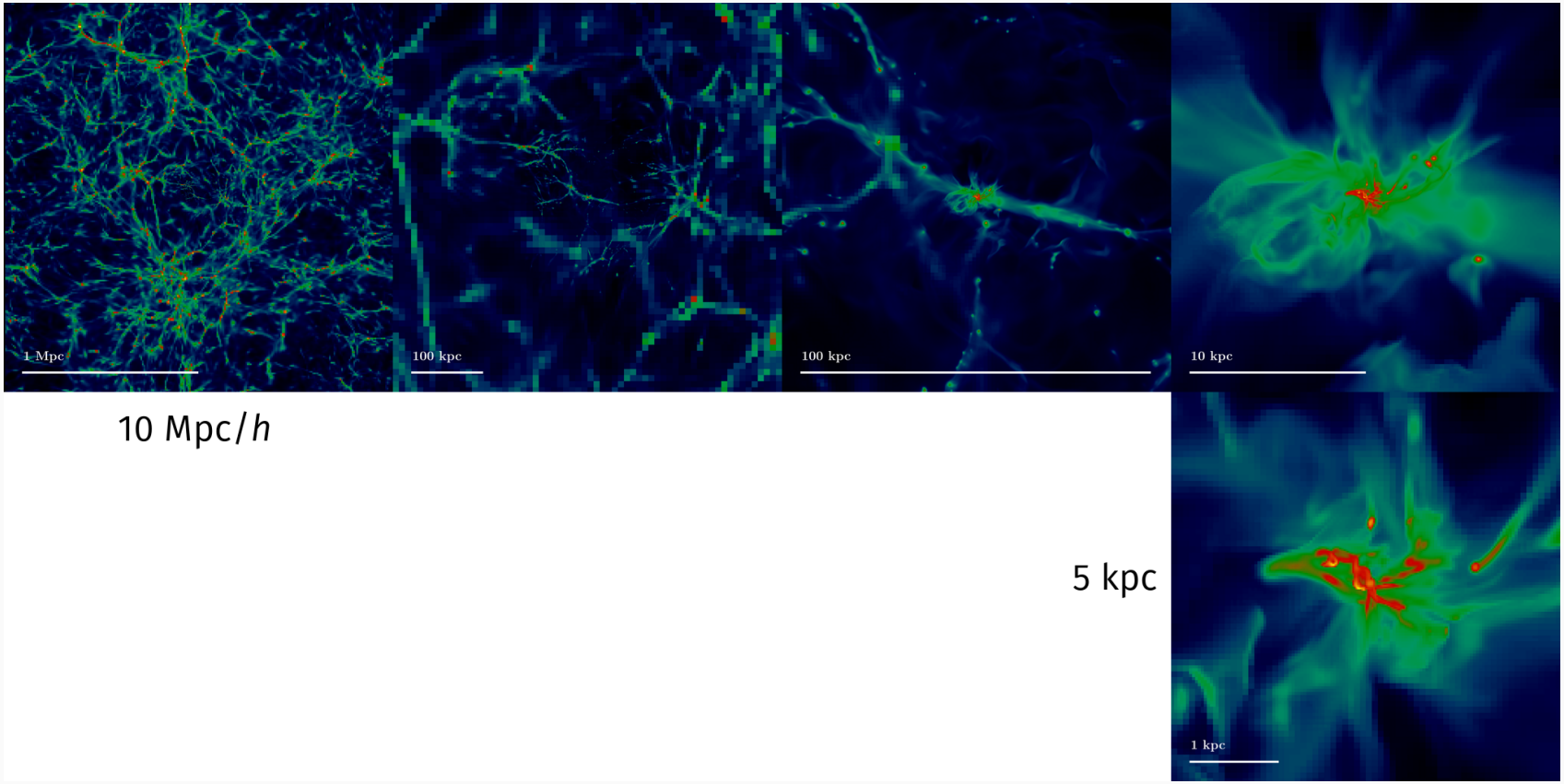
Our solution

- · RAMSES code with RHD = RAMSES-RT (Rosdahl+2013)
- · Cosmological zoom-in technique

METHODS: RHD ZOOM SIMULATIONS DOWN TO $z \sim 6$

Zoom-in technique



10 Mpc/h

5 kpc

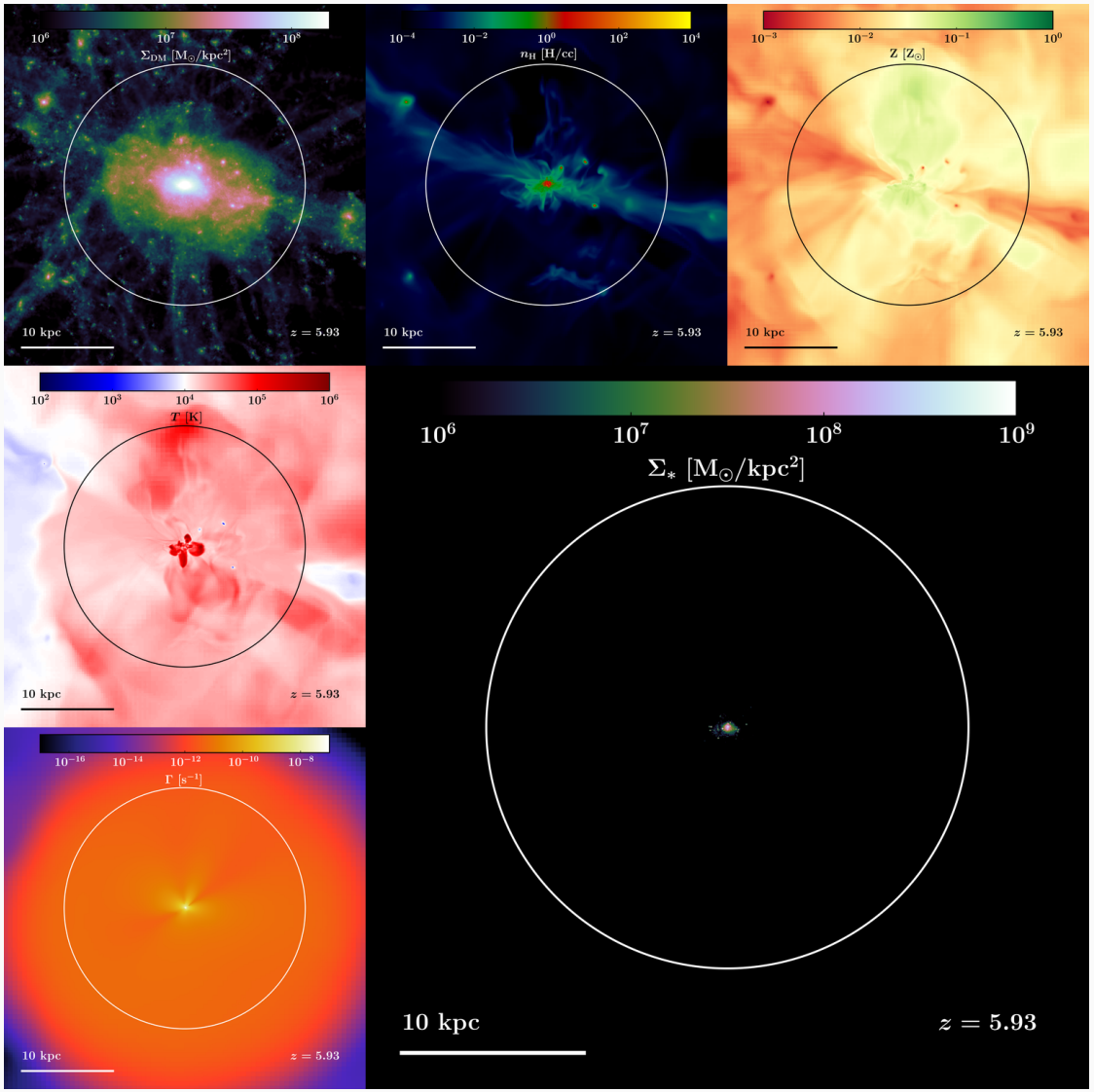
METHODS: RHD ZOOM SIMULATIONS DOWN TO $z \sim 6$

Radiative Hydrodynamics Simulations with RAMSES-RT of 3 haloes ($M_{\rm vir} = 10^8,\ 10^9,\ 2.5 \times 10^9 M_\odot$)

- High resolution
  - Dark matter: $m_{\rm DM} \simeq 10^3 M_\odot$
  - Gas: $\Delta x \simeq 10 - 20$ pc
  - Stars: $m_\star \simeq 120 M_\odot$
- State of the art subgrid models
  - Gravoturbulent star formation (Devriendt, Slyz, Kimm, in prep.)
  - Resolved mechanical feedback (Kimm & Cen, 2014)
- Ionising radiation propagated in 3 bins (HI, HeI, HeII)

METHODS: RHD ZOOM SIMULATIONS DOWN TO $z \sim 6$

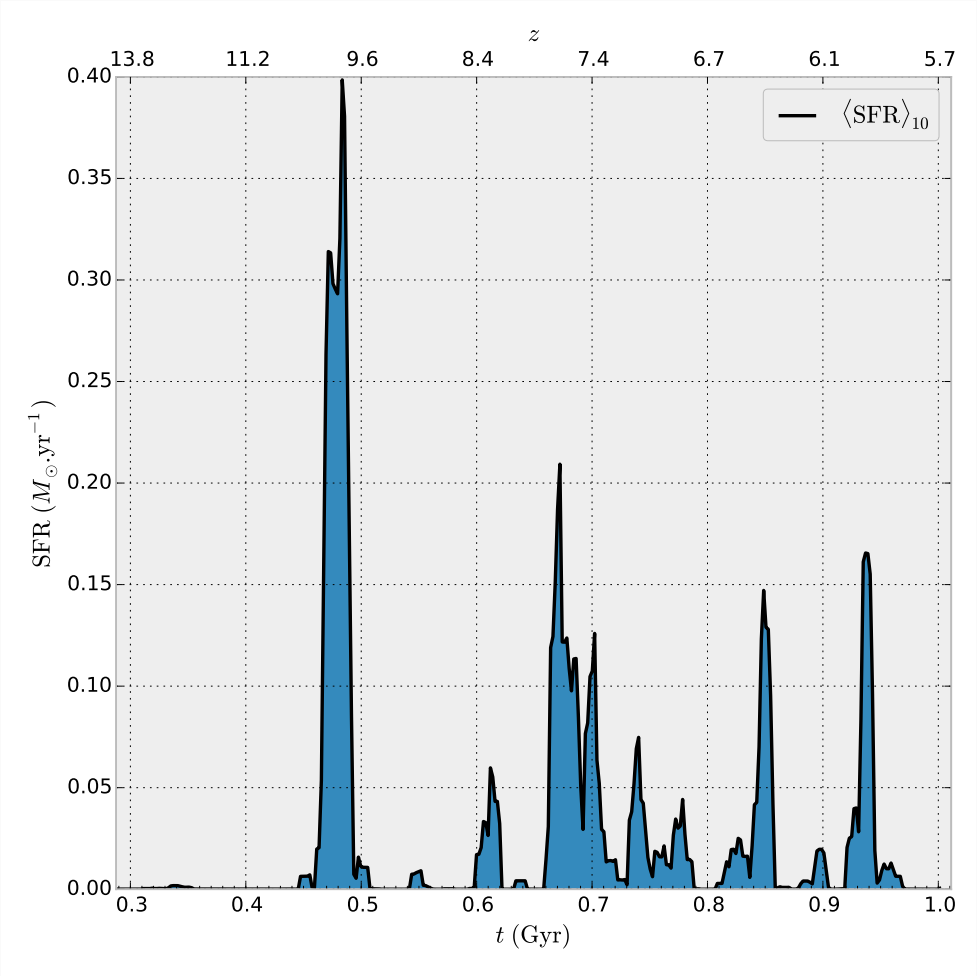
$2 \times 10^9 M_\odot$ halo at $z \simeq 6$



ANALYSIS

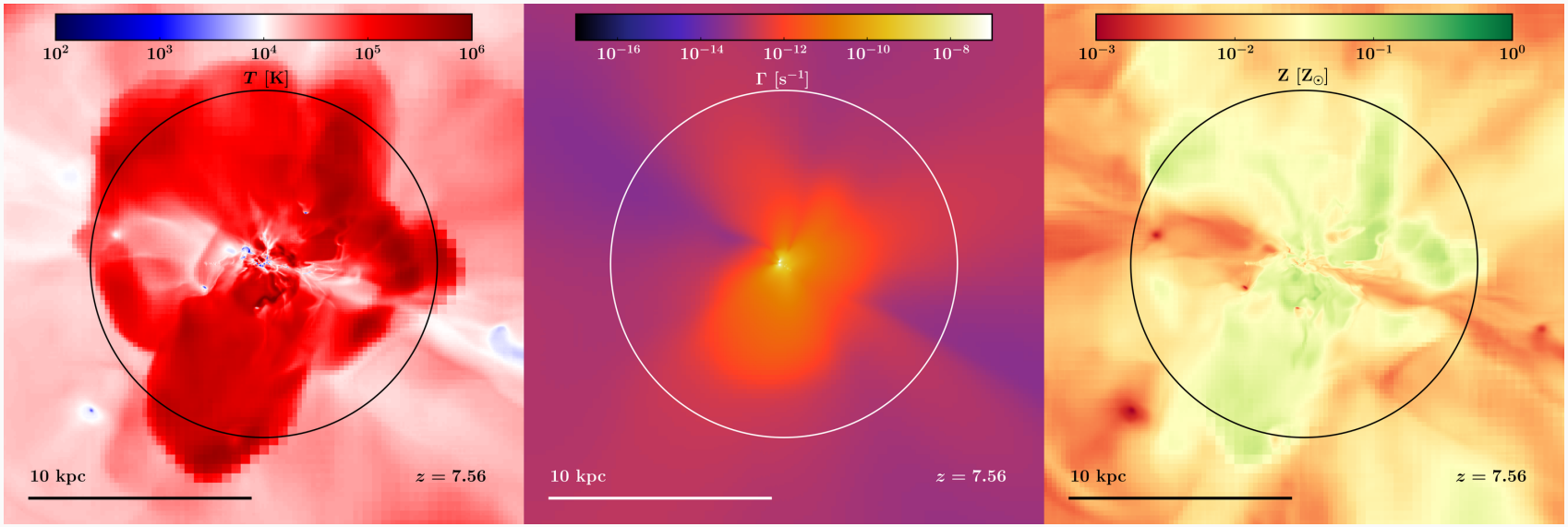
BURSTY ASSEMBLY OF SMALL GALAXIES

Star formation happens by bursts



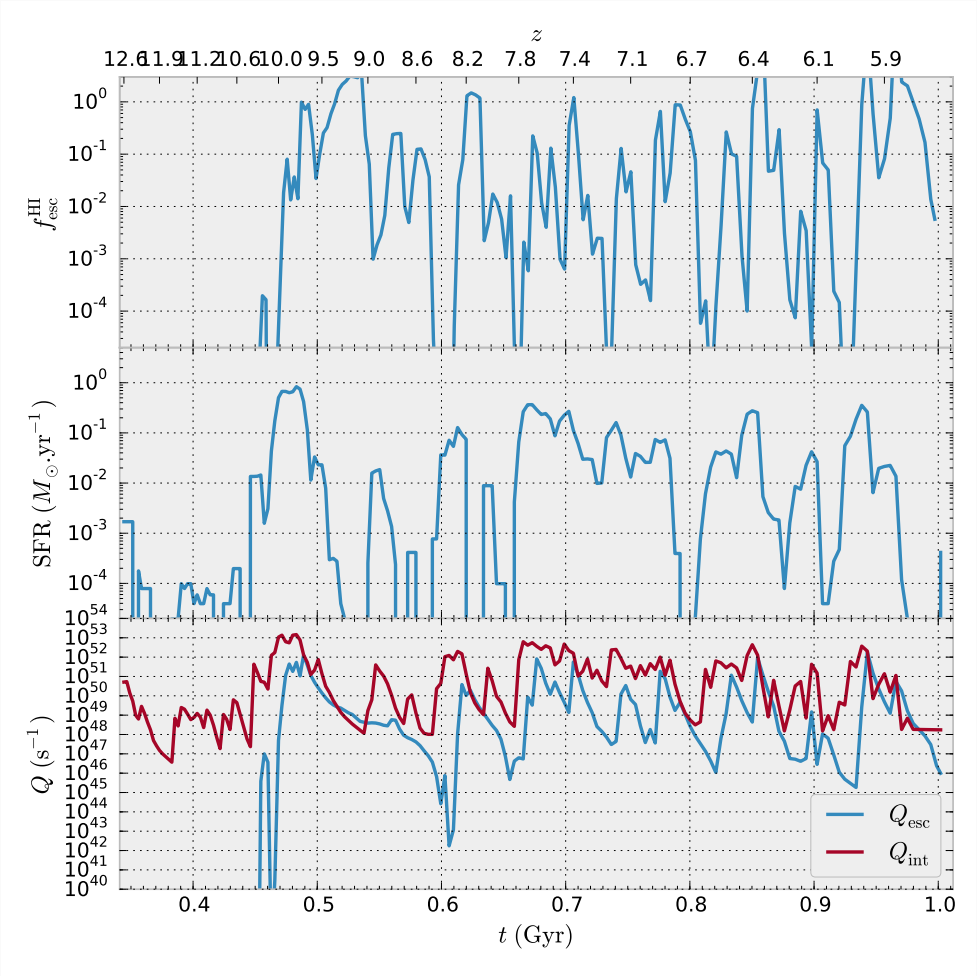
CONSEQUENCES ON THE IONISING EFFICIENCY

Correlation with the SN feedback events



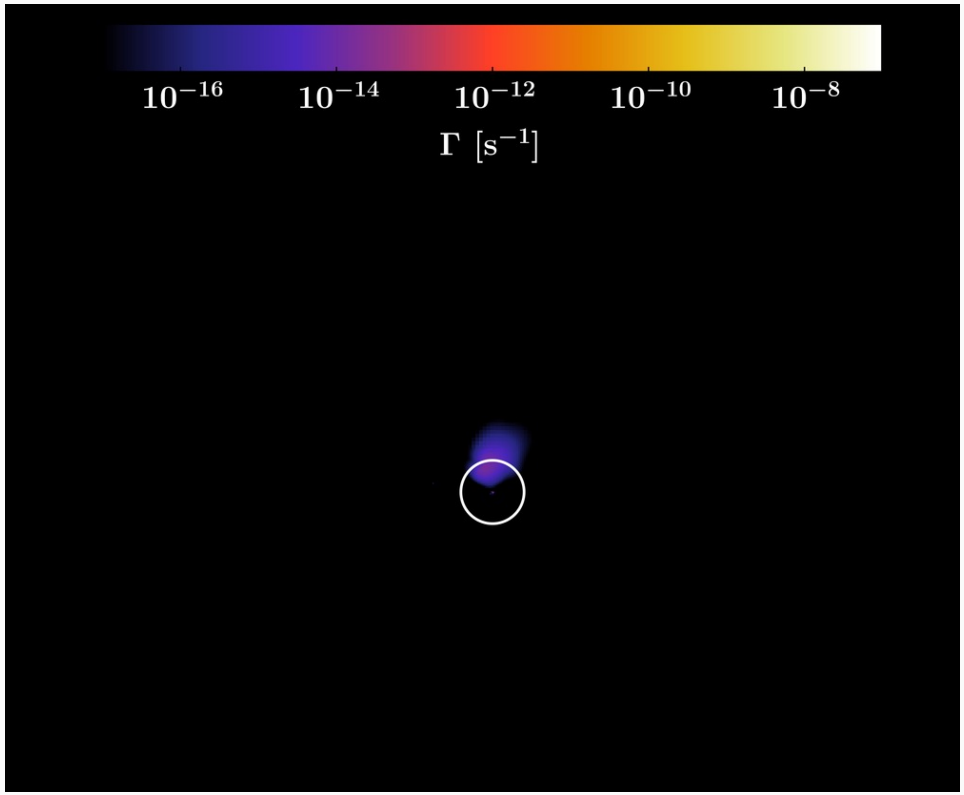
CONSEQUENCES ON THE IONISING EFFICIENCY

Strong correlation between f_{esc} and the SFR



FLICKERING OF SMALL HIGH-z GALAXIES

Out of the halo, IGM can recombine between two bursts



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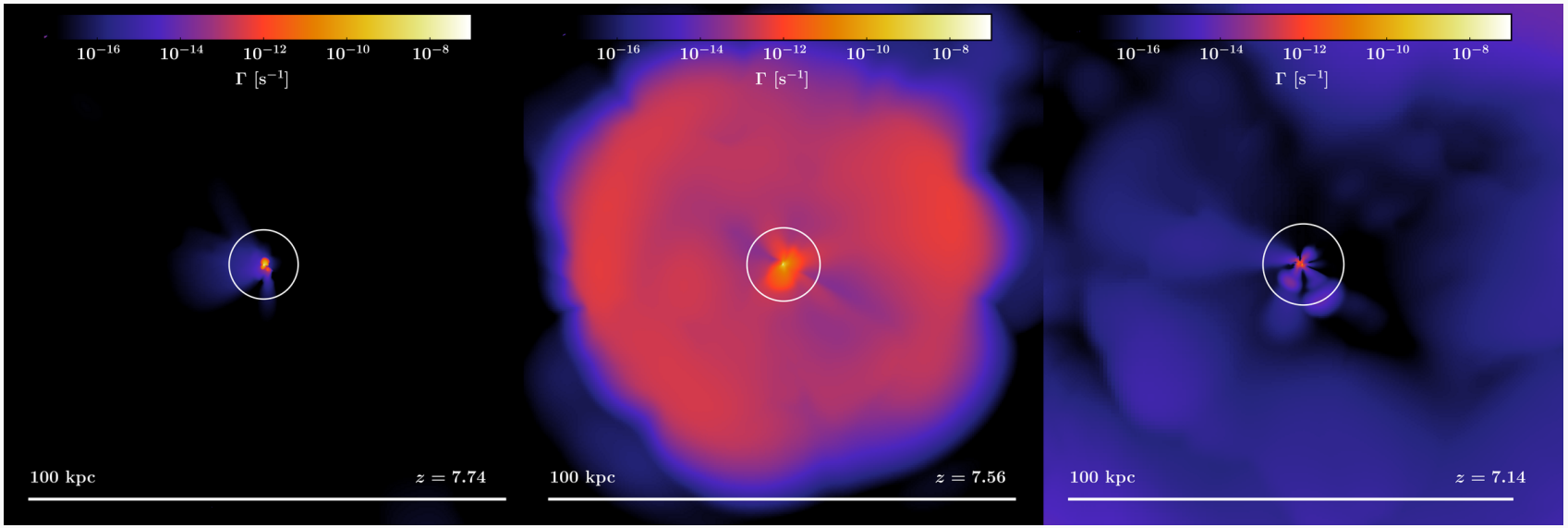

OBSERVATIONAL PERSPECTIVES

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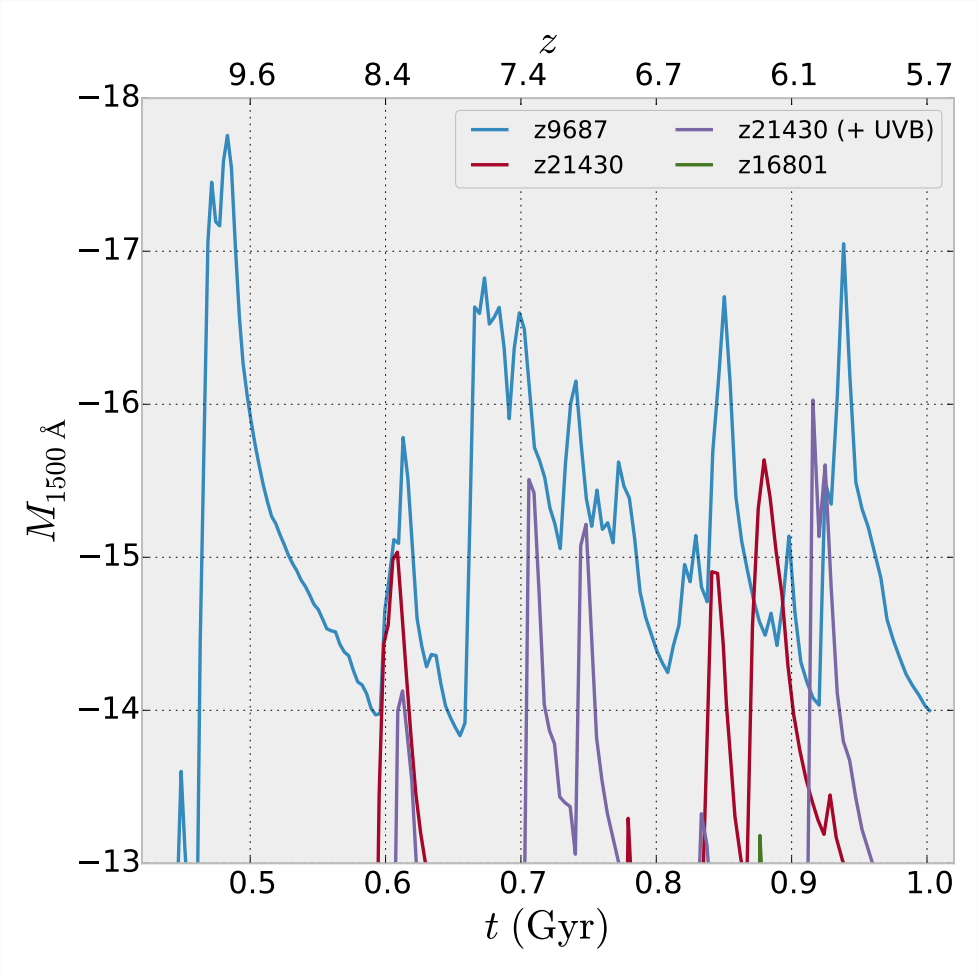
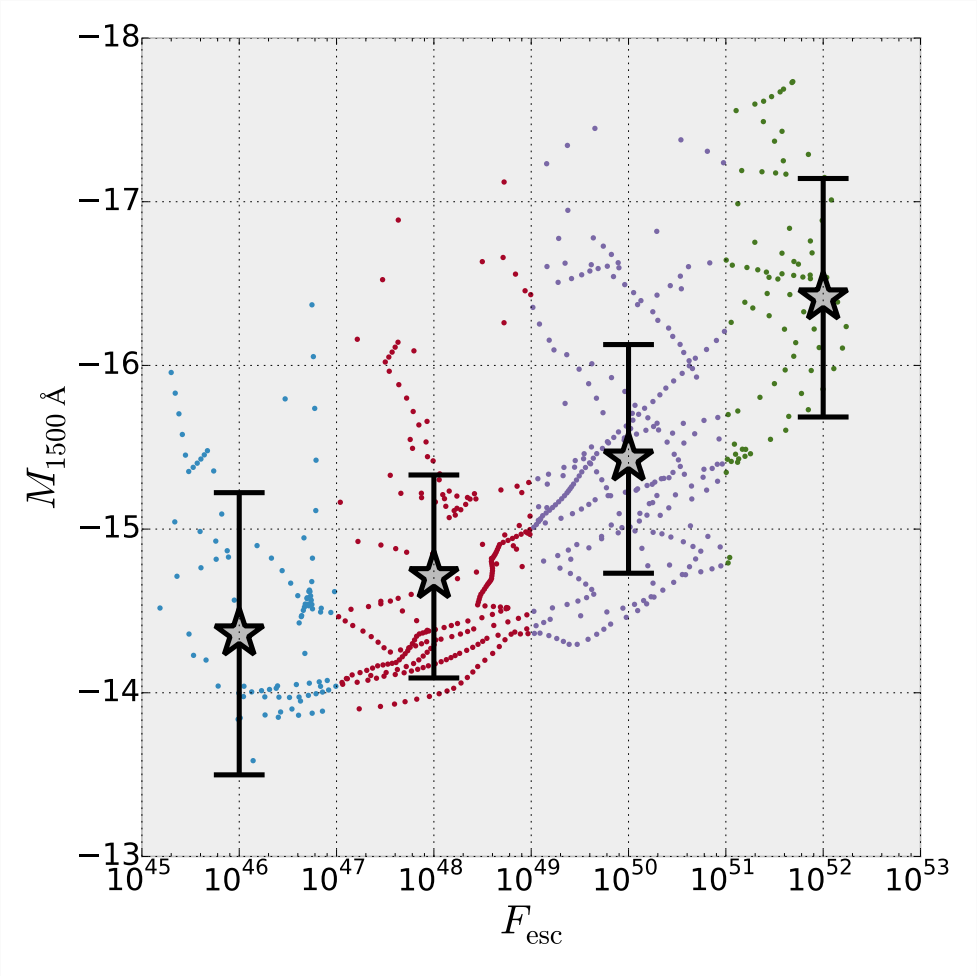
Small high-z galaxies might be observed by intermittence



OBSERVATIONAL PERSPECTIVES

Luminous galaxies are in a LyC-leaking phase



CONCLUSIONS

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- Simulating the sources of the reionisation is *hard* (high resolution + RHD needed), but can be done with RAMSES-RT.
- At high z, in the low mass regime, SF is very bursty.
- f_{esc} varies a lot, and is strongly correlated to SF and feedback.
- First (simplified) predictions for *JWST*: UV magnitude can reach $M_{1500} = -16$.