



Update on the IGM evolution from Ly α emitters in the JWST fields

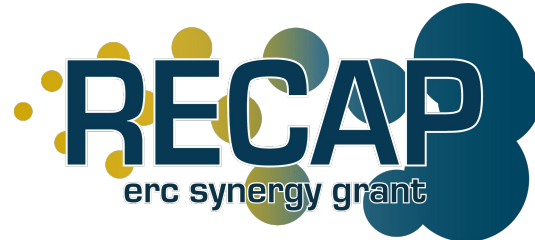
Lorenzo Napolitano (lorenzo.napolitano@inaf.it)



Funded by
the European Union

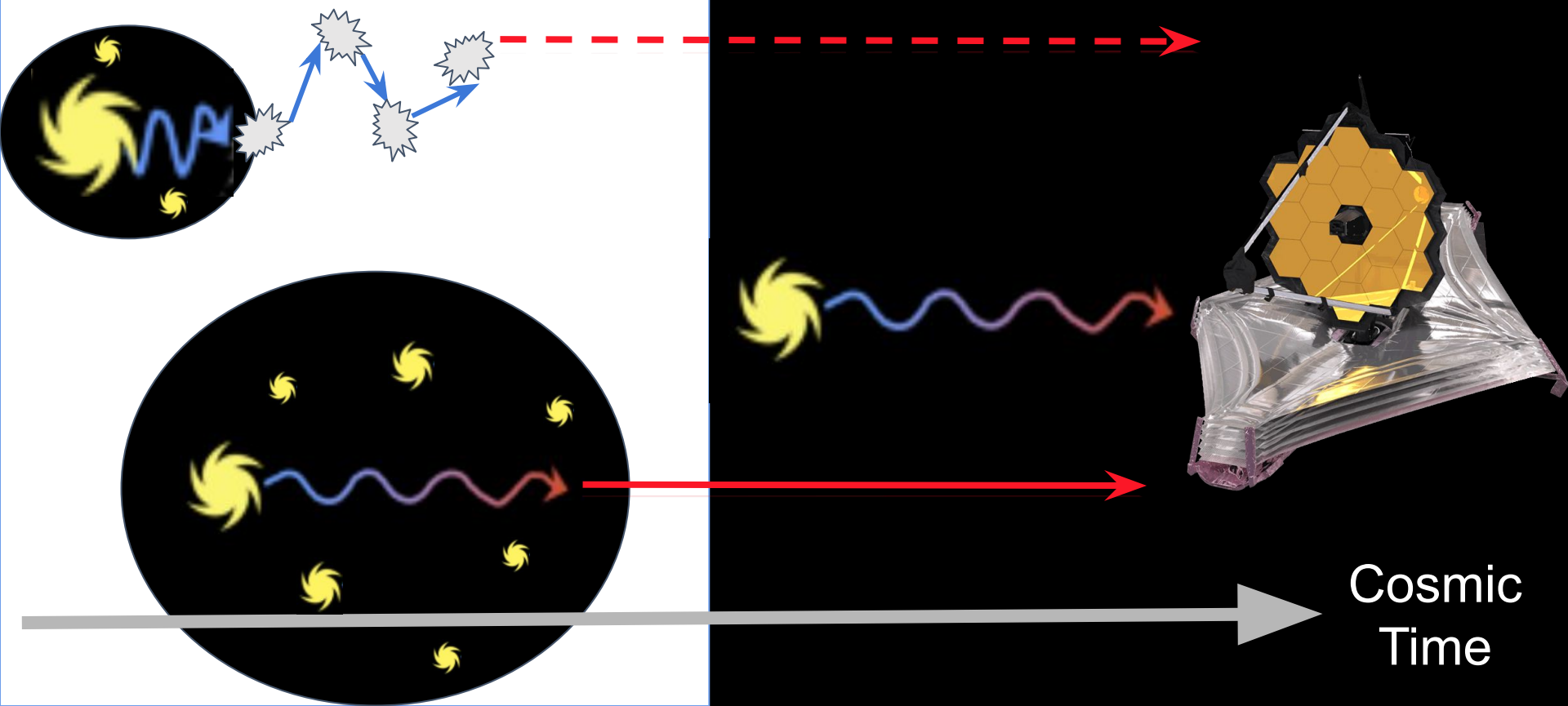


European Research Council
Established by the European Commission



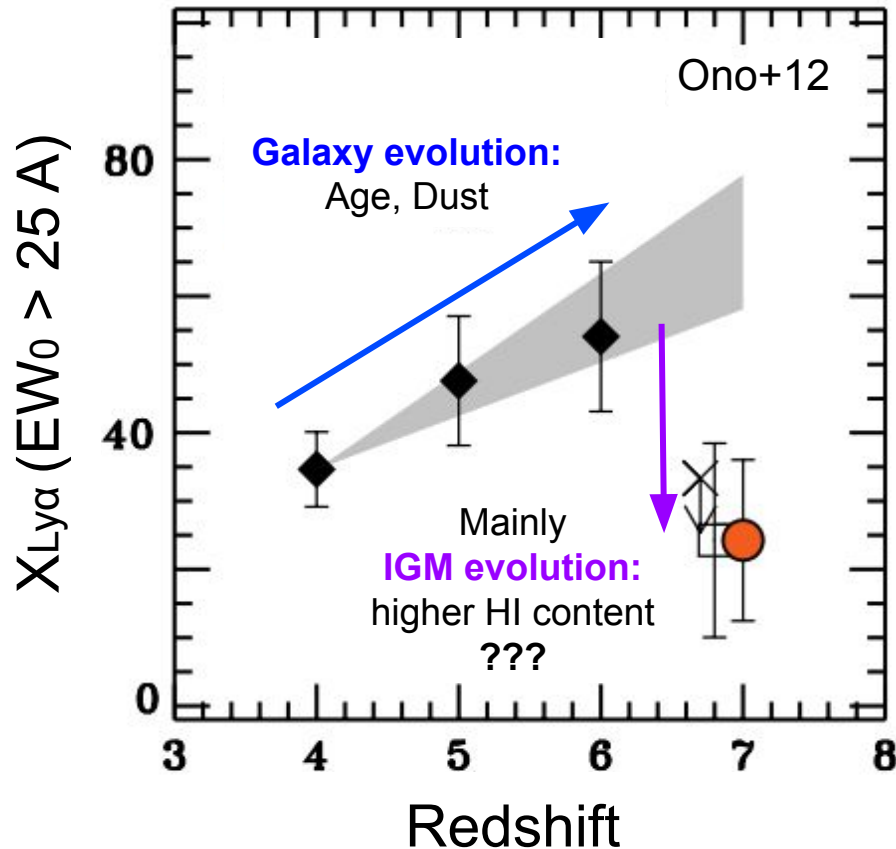
**Almost neutral
Intergalactic medium
(During reionization)**

**Fully Ionized
Intergalactic medium
(After reionization)**



**Cosmic
Time**

The time evolution of Ly α emission (before JWST)



The fraction of Ly α emitters (LAEs) over the total number of star forming galaxies ($X_{\text{Ly}\alpha} = N_{\text{LAEs}} / N_{\text{SFGs}}$) mostly depends on:

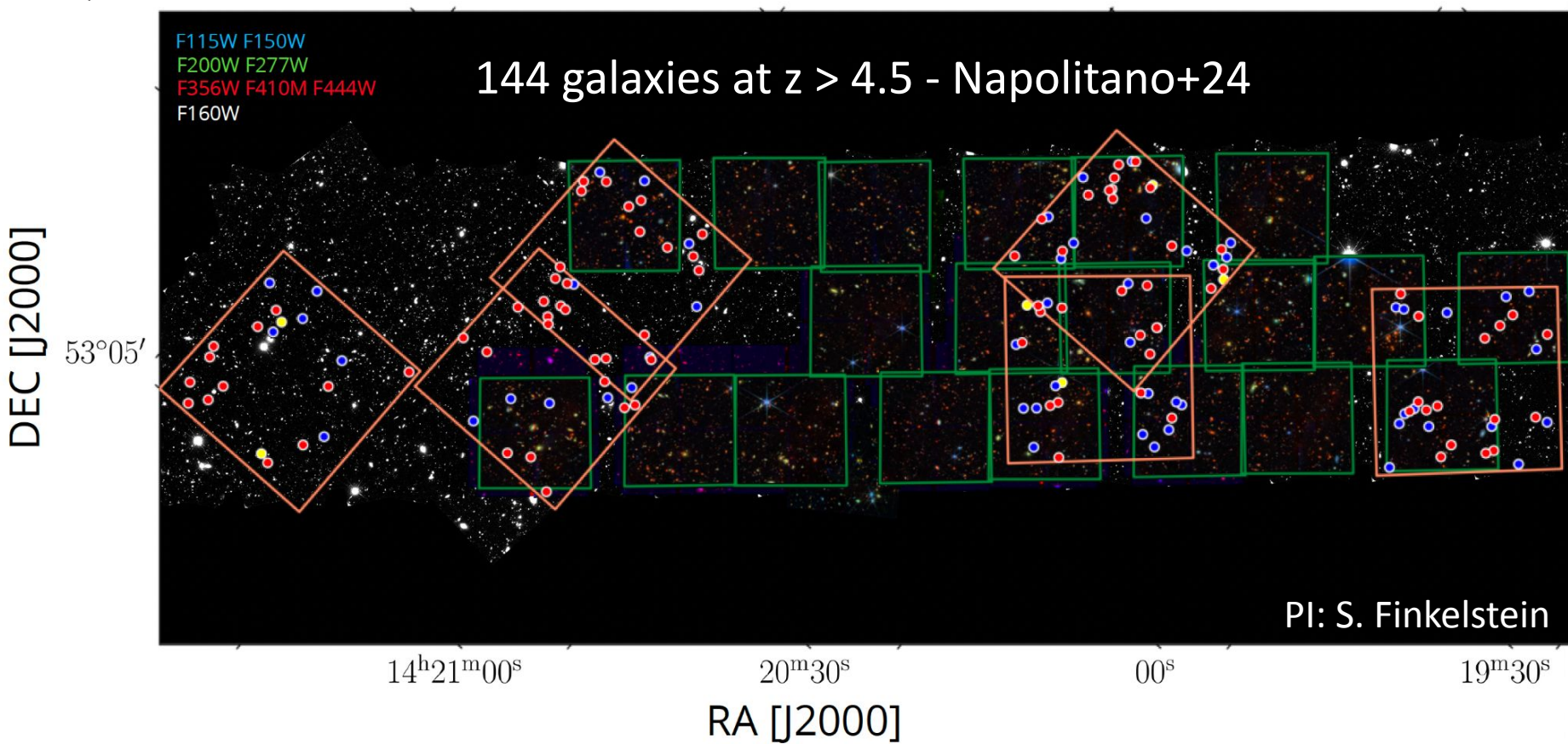
Galaxy evolution at $z < 6$

IGM evolution at $z > 6$

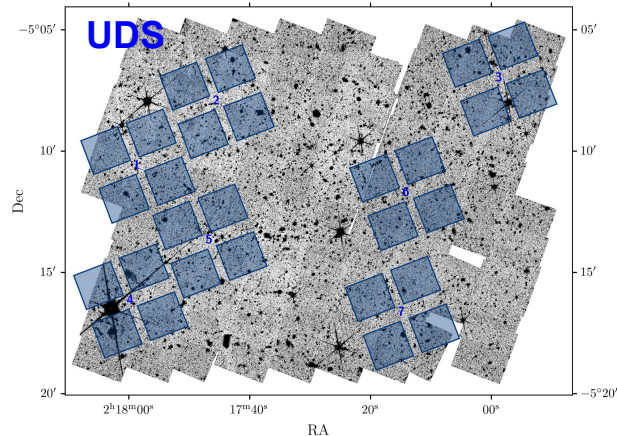
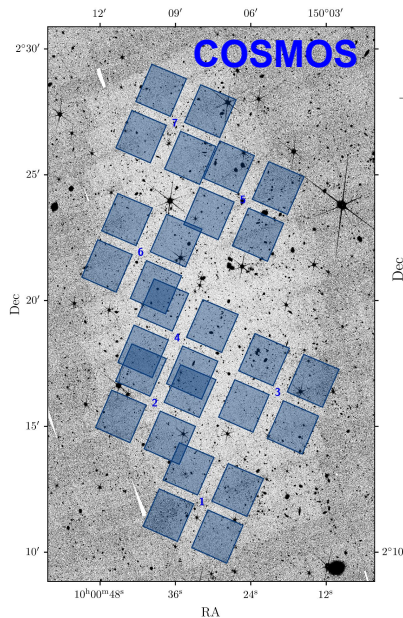
See also Stark+11, Tilvi+14, DeBarros+17, Pentericci+18, Mason+19



The CEERS NIRSpec PRISM sample

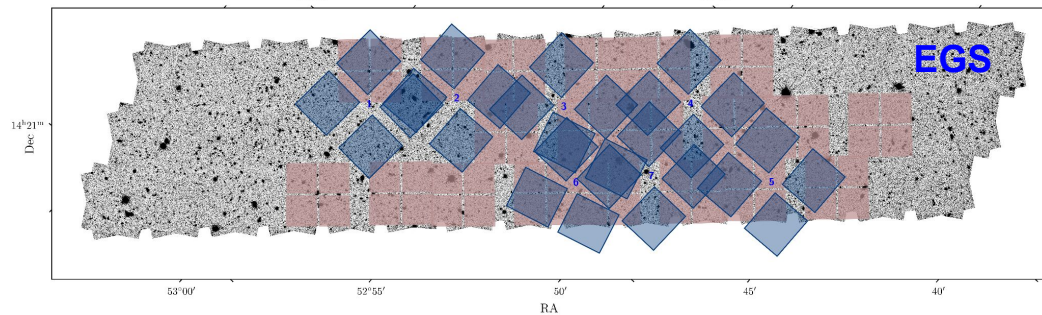


The CAPERS survey (GO-6368, PI: M. Dickinson)



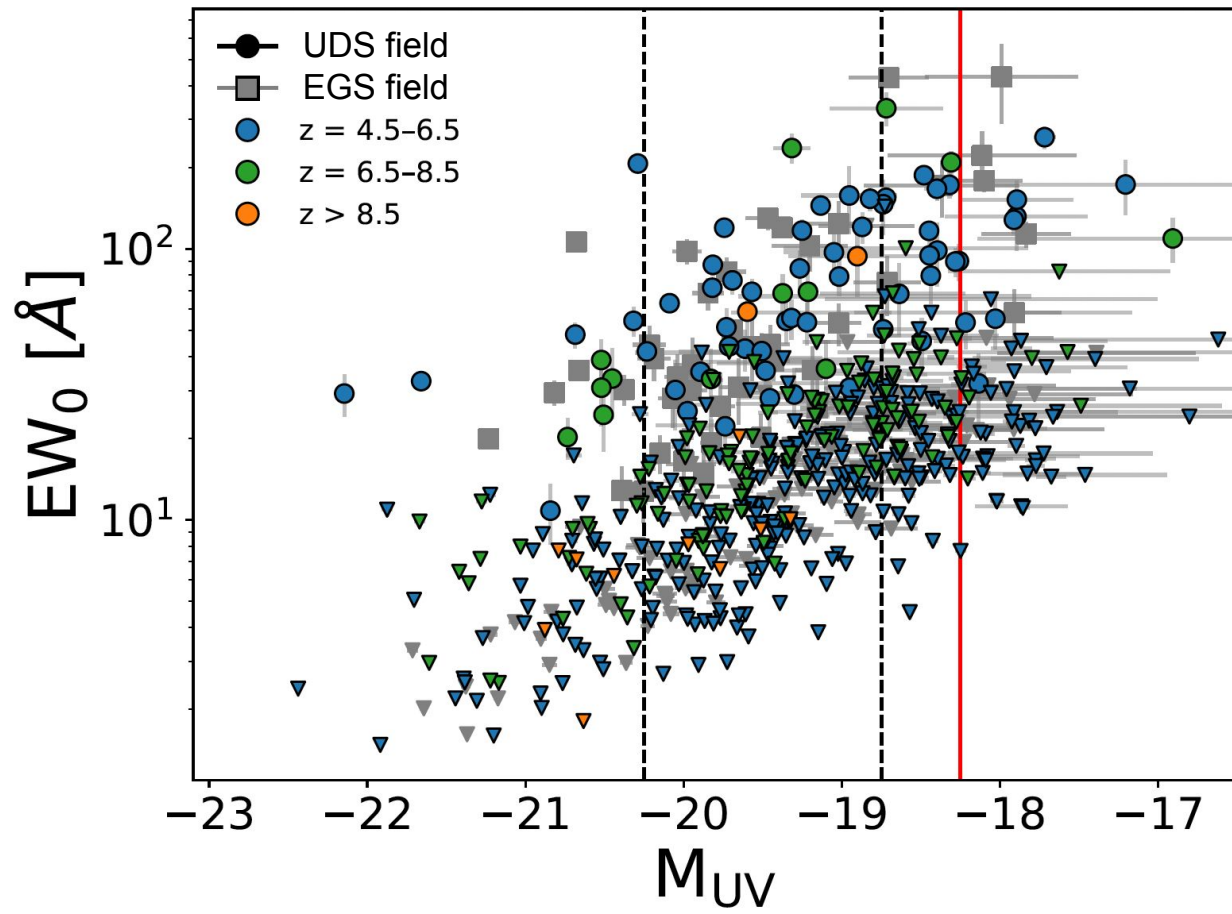
~4.5 hr per
pointing

Courtesy:
Mark Dickison



Napolitano+25c:
651 galaxies at $4.5 < z < 11$
from the CAPERS-UDS field
and DAWN JWST Archive
(v3, Heintz+24, de Graaff+25)

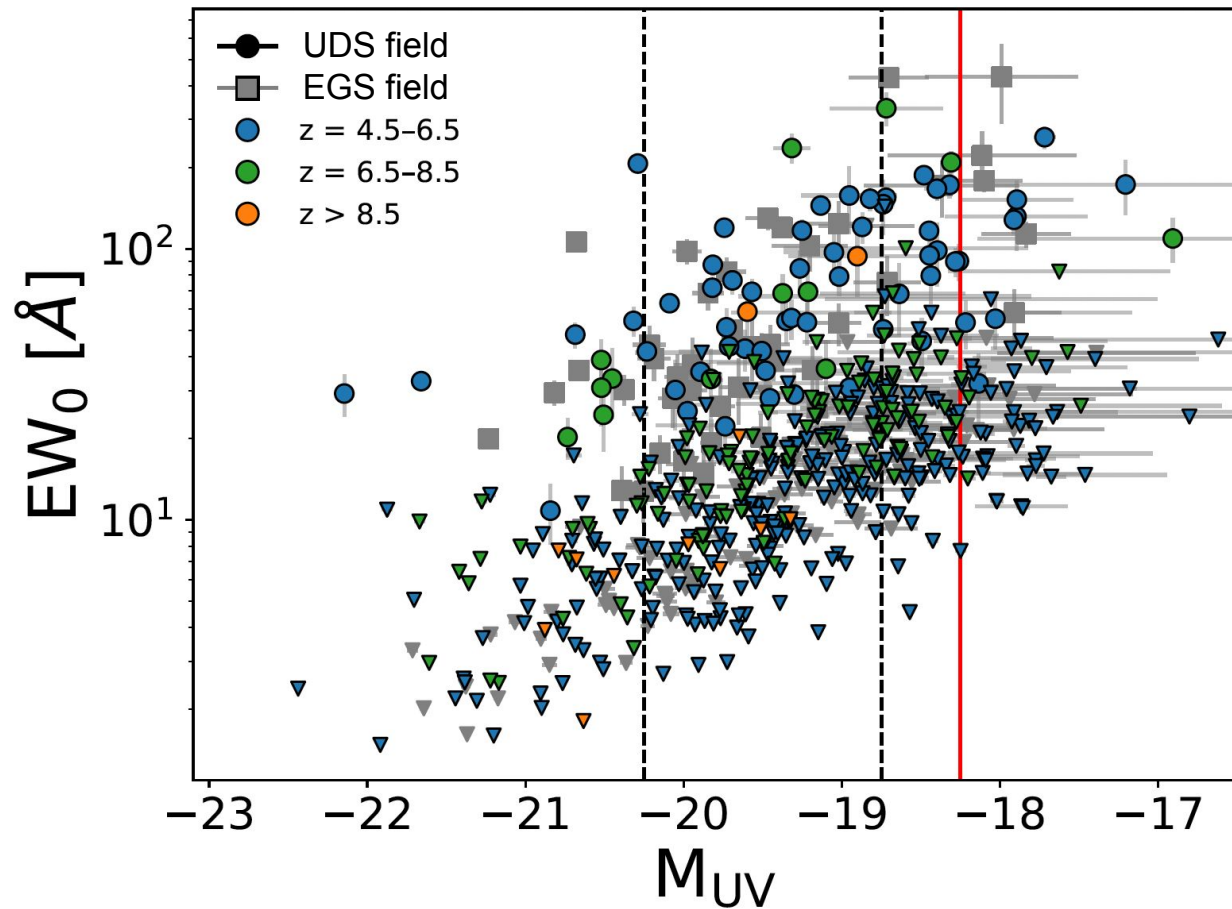
Ly α EW $_0$ and M $_{UV}$ relation



73 Ly α emitting galaxies with $S/N > 3$ in the UDS field

See also, e.g. Nakane+24, Napolitano+24, Jones+25

Ly α EW $_0$ and M $_{UV}$ relation



The fraction of Ly α emitters (LAEs) over the total number of star forming galaxies ($X_{\text{Ly}\alpha} = N_{\text{LAEs}} / N_{\text{SFGs}}$)

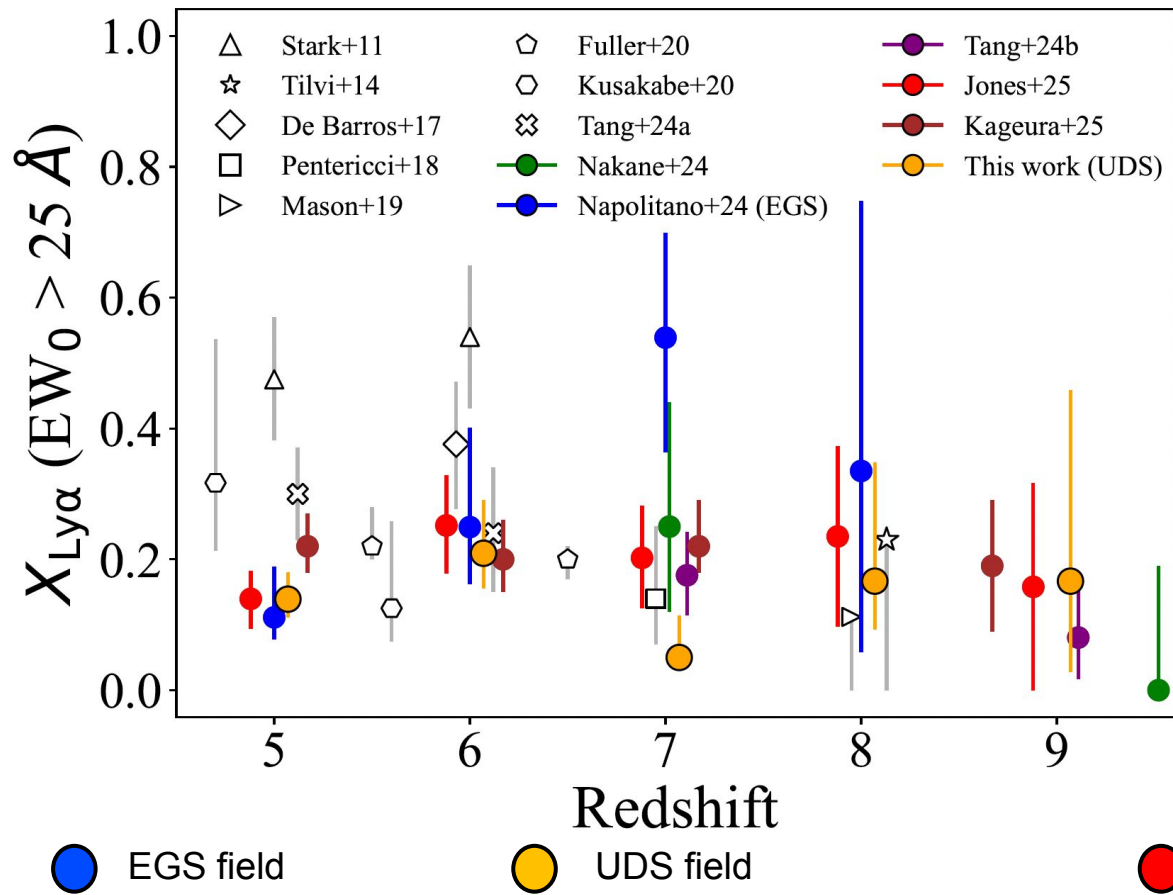
Adopted cut:

$-20.25 < M_{UV} < -18.75$

AGN excluded

$EW_{0,\text{lim}} < 25 \text{ \AA}$

Evolution of Ly α visibility across different line of sights



The fraction of Ly α emitters (LAEs) over the total number of star forming galaxies ($X_{\text{Ly}\alpha} = N_{\text{LAEs}} / N_{\text{SFGs}}$)

Adopted cut:

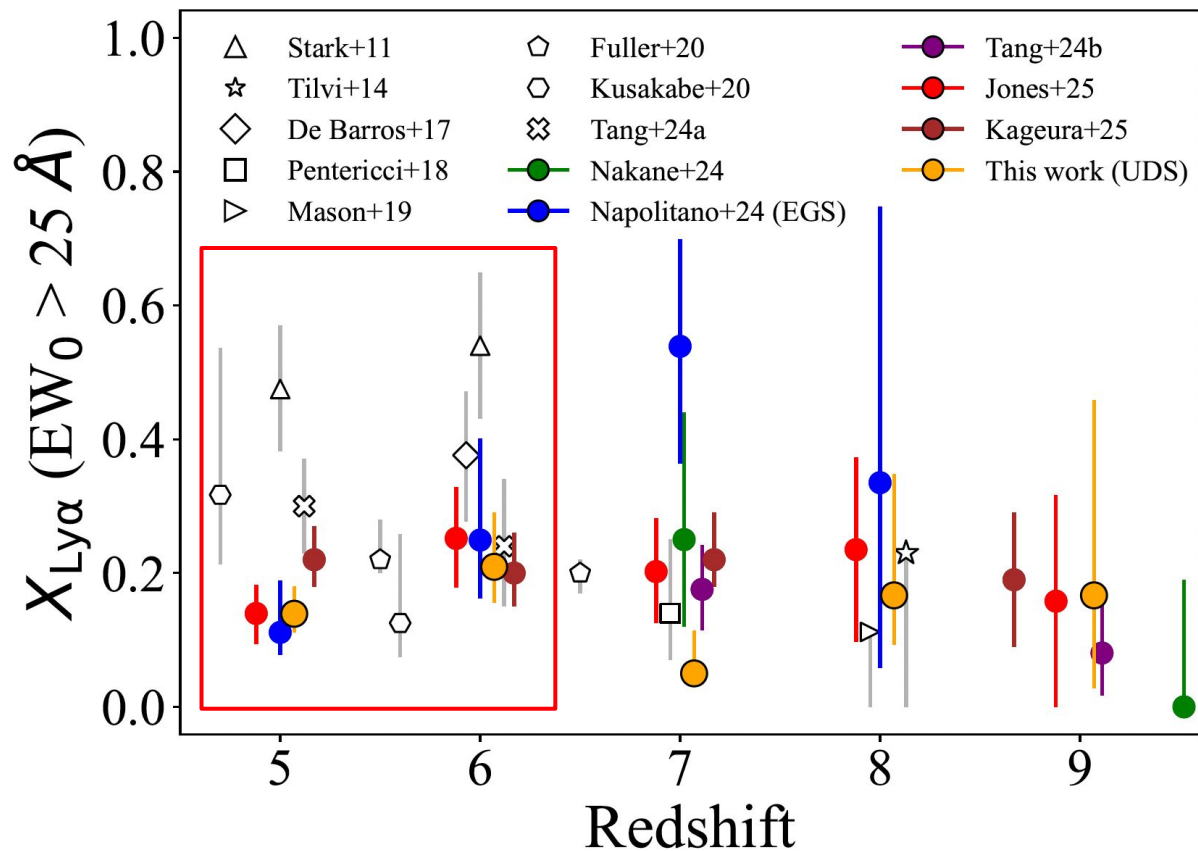
$$-20.25 < M_{\text{UV}} < -18.75$$

AGN excluded

$$\text{EW}_{0,\text{lim}} < 25 \text{ \AA}$$

Napolitano+25c

The evolution of Ly α visibility ...how to tackle possible systematics



In the post
Reionization Universe at
 $z < 6$

we find a discrepancy
between the JWST
and ground-based
results!

Napolitano+25c

...see also Nakane+24,
Napolitano+24, Jones+25,
Tang+24a,b, Kageura+25

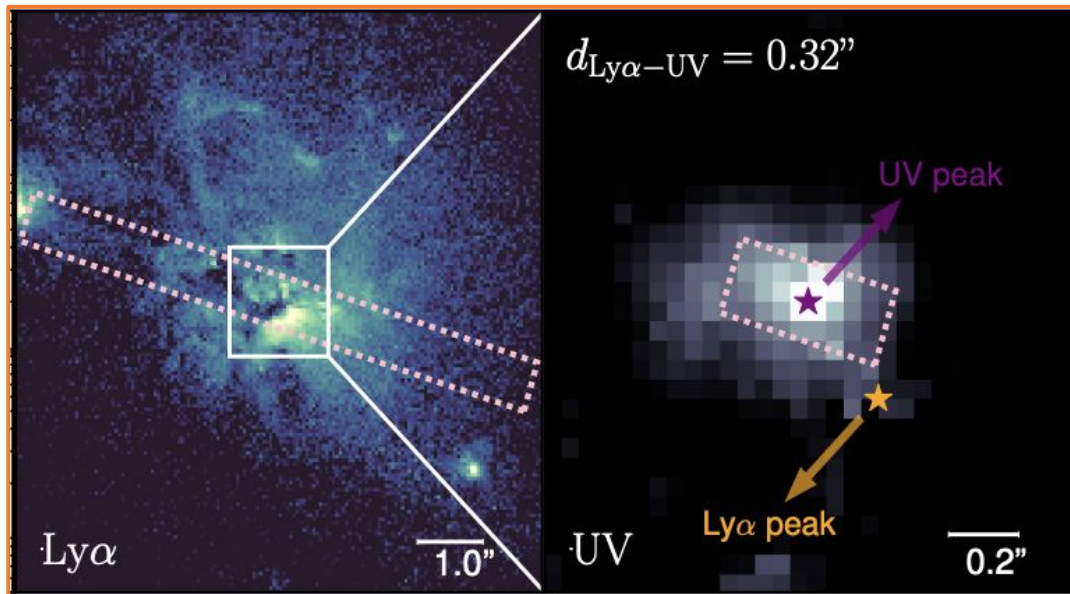
We explored this effect using the SPICE simulation

Ground-based

$\sim 1 \times 10 \text{ arcsec}^2$

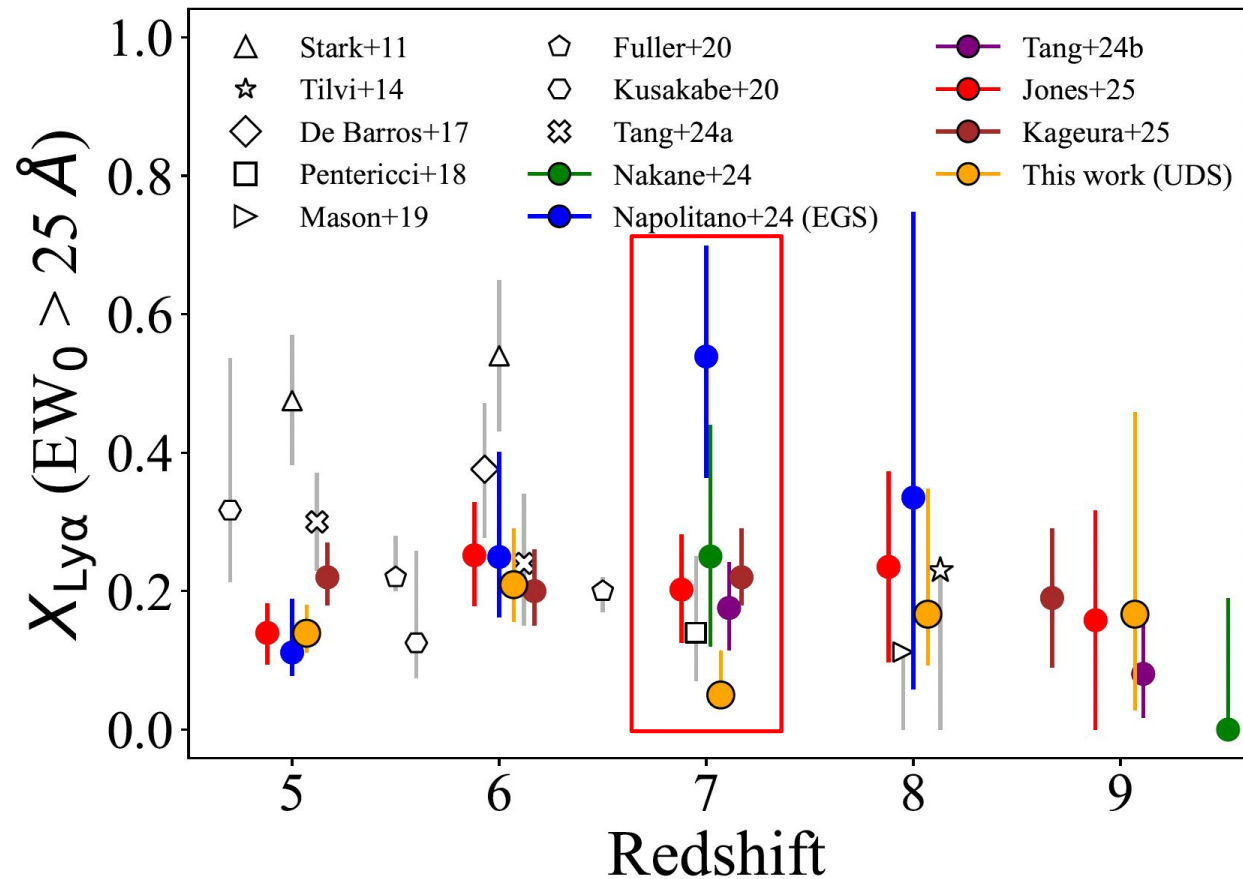
JWST NIRSpec

$\sim 0.2 \times 0.5 \text{ arcsec}^2$



Result: 26-37% of total Ly α flux is lost due to slit losses
Bhagwat+25

Evolution of Ly α visibility across different line of sights



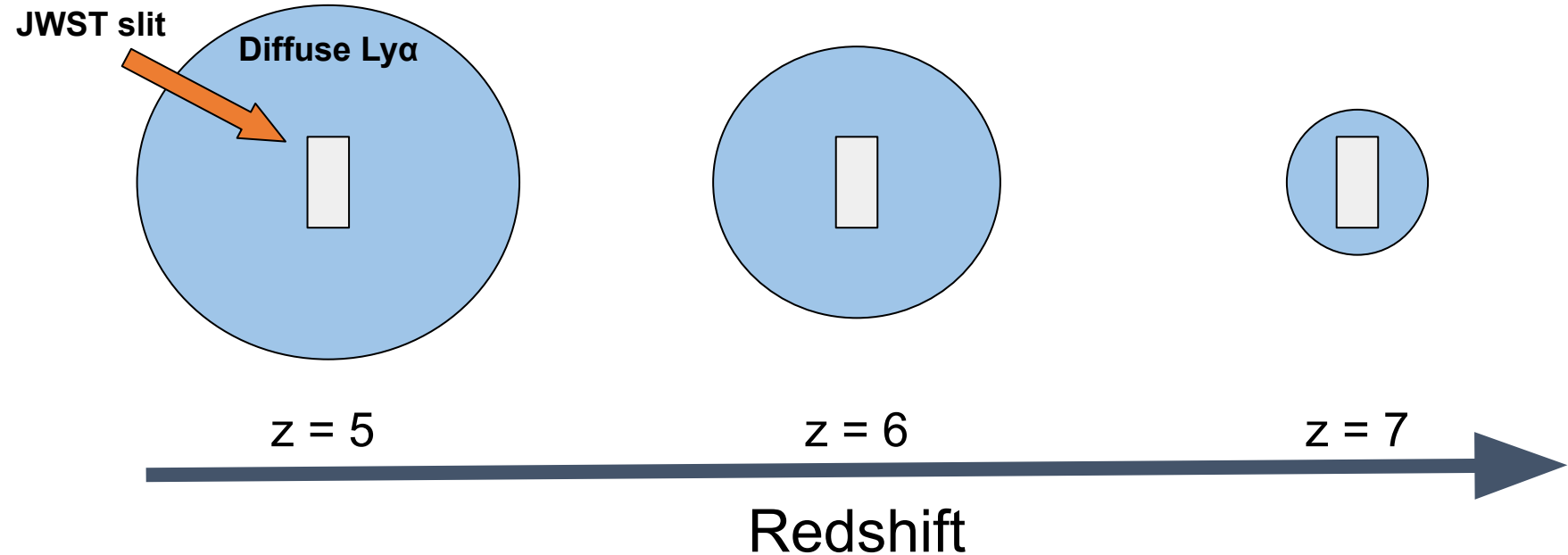
The fraction of Ly α emitters (LAEs) over the total number of star forming galaxies ($X_{\text{Ly}\alpha} = N_{\text{LAEs}} / N_{\text{SFGs}}$)

- EGS field
- UDS field
- GOODS-S/N fields

2.7 σ discrepancy between the EGS and UDS results at $z = 7$

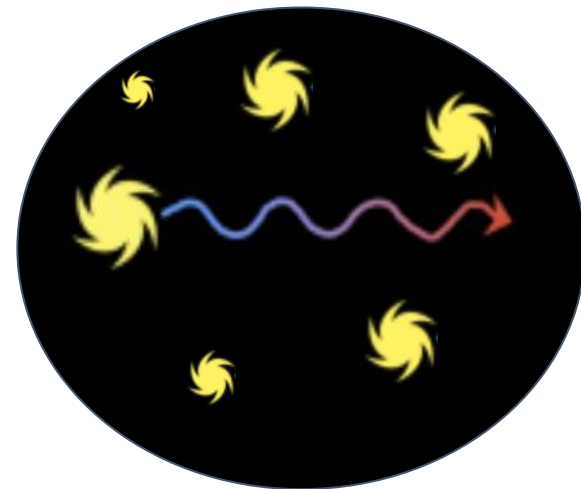
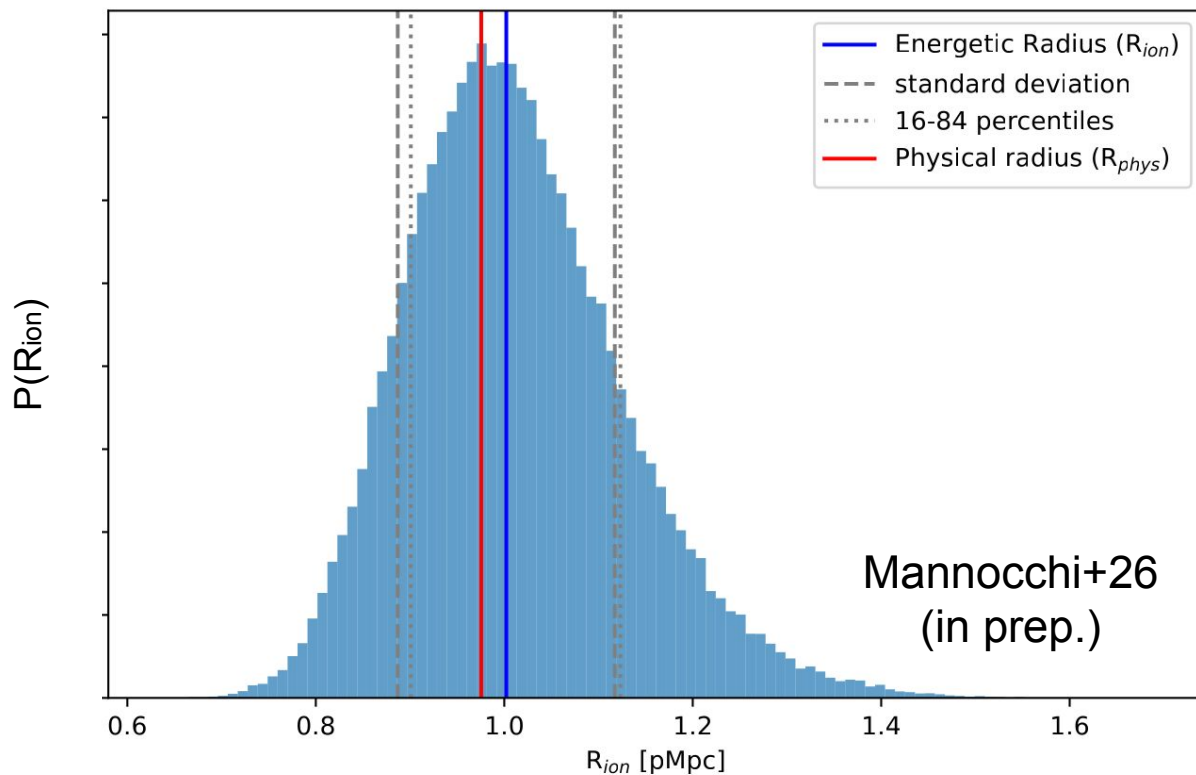
What's driving the lack of evolution for the Ly α visibility?

1. Observational bias due to size evolution on the sky plane
JWST NIRSspec slit: $\sim 0.2 \times 0.5 \text{ arcsec}^2$



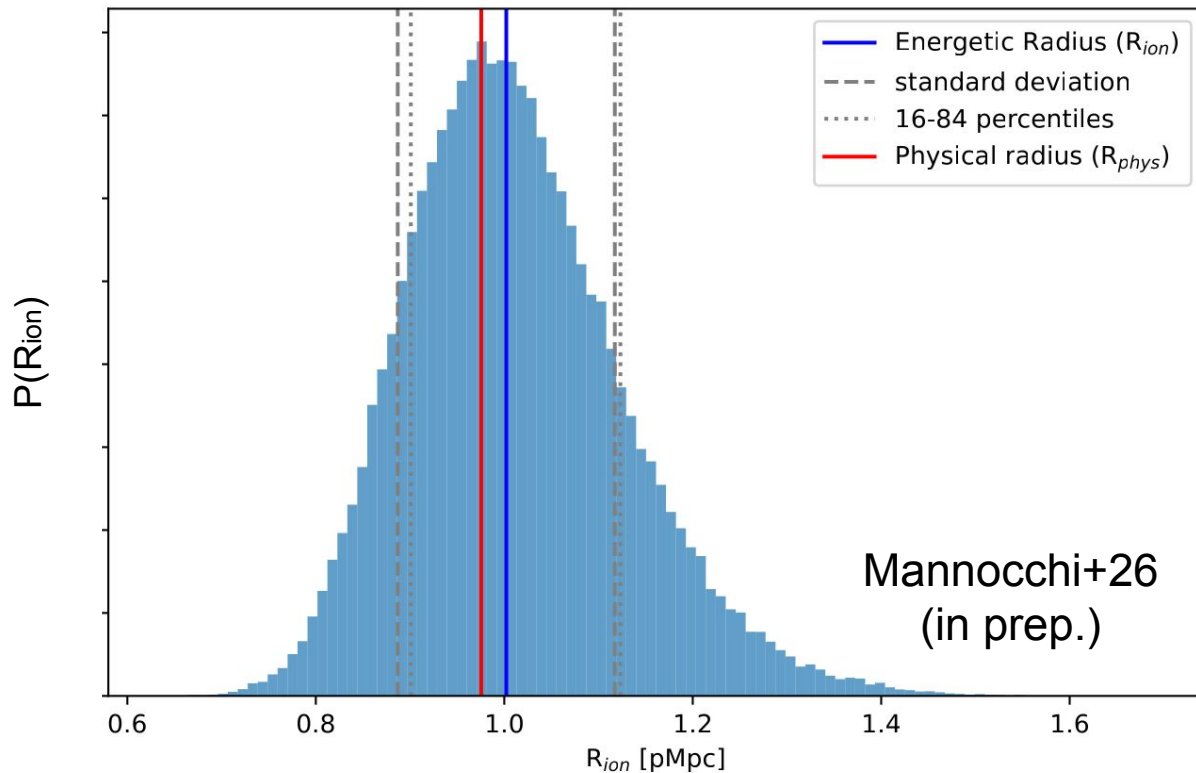
2. Ly α emitters at high-z are able to grow their own ionized bubbles

A typical ionized bubble at $z = 7$: 2 LAEs and 12 non-LAEs

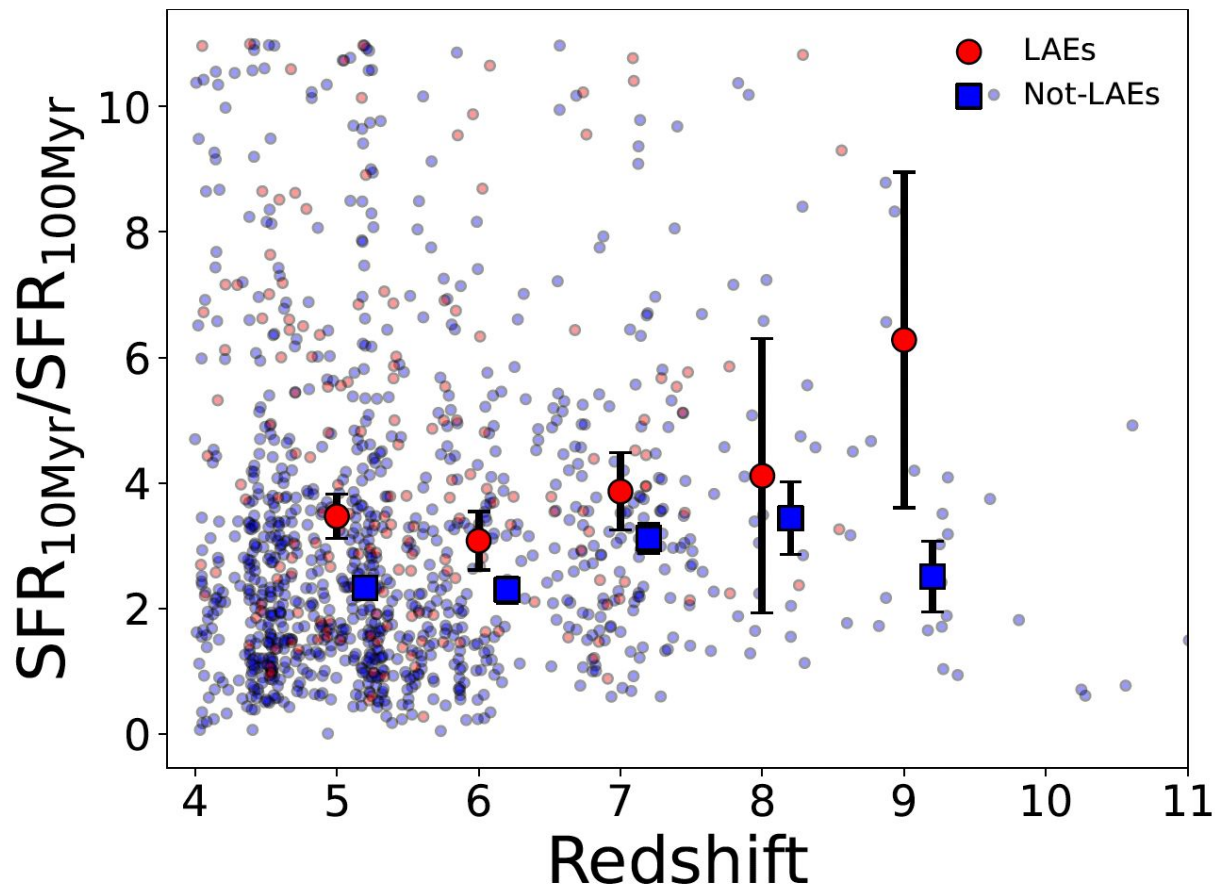


2. Ly α emitters at high-z are able to grow their own ionized bubbles

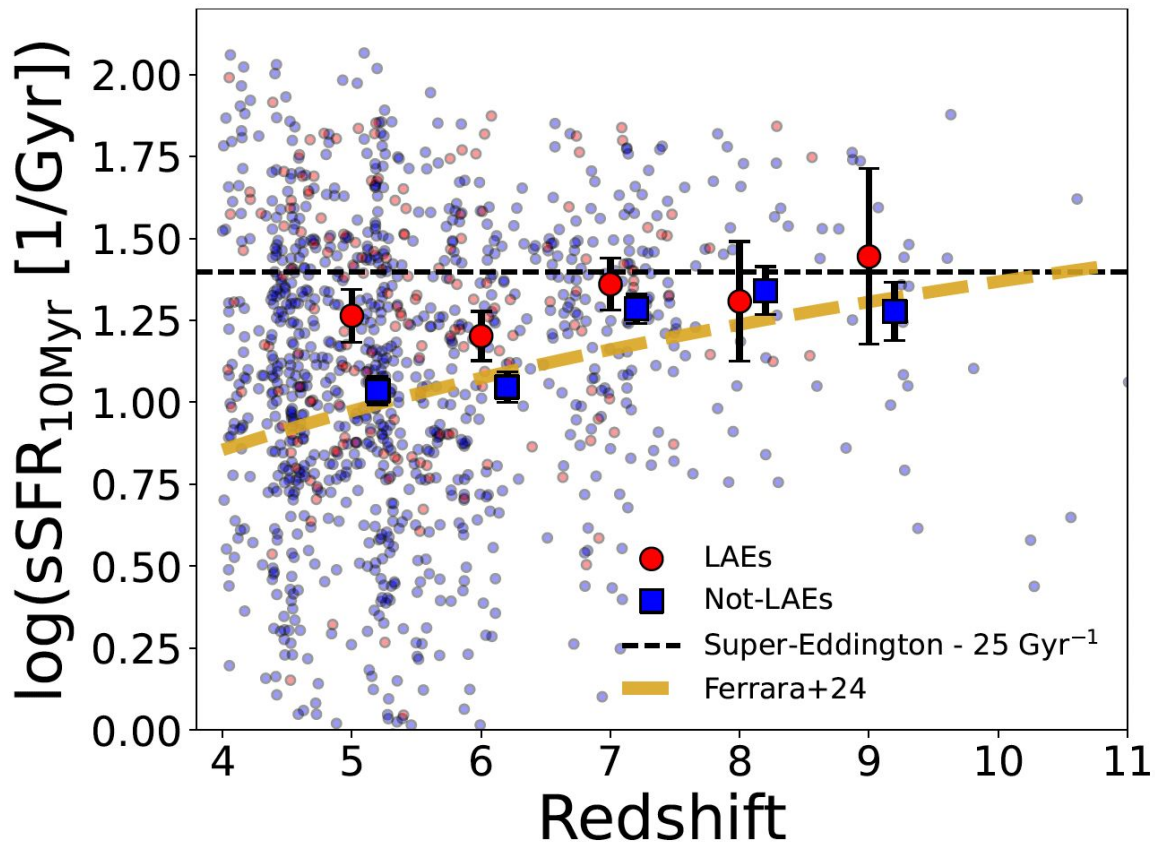
A typical ionized bubble at $z = 7$: 2 LAEs and 12 non-LAEs



3. Galaxy evolution can not be neglected: preliminary evidence of boosted Ly α emission at higher redshift



3. Galaxy evolution can not be neglected: preliminary evidence of boosted Ly α emission at higher redshift



Bursty galaxies introduce a velocity offset (redshift) between Ly α emission and the systemic redshift



Boosted Ly α transmission at higher z (Mason&Gronke2020)

Summary

- In the context of Cosmic Reionization $\text{Ly}\alpha$ is one of our best probes to trace the evolution of the neutral hydrogen fraction.
 - Synergy between models and observations can disentangle:
 1. Observational bias (i.e., $\text{Ly}\alpha$ slit loss, see Bhagwat+25, Napolitano+25c)
 2. Galaxy evolution (i.e., bursty $\text{Ly}\alpha$ emitters, see Ferrara+24)
 3. IGM evolution
 - Observations suggest a spatially inhomogeneous end of cosmic reionization characterized by ionized bubbles blown by ensembles of galaxies.