The impact of mergers on the Lyman Continuum photons escape in galaxies during the epoch of reionization

Sara Mascia, sara.mascia@inaf.it

Supervisor: L. Pentericci
Collaborators: A. Calabrò, L. Napolitano

26/02/2024, Cosmic Dawn at High Latitudes Conference

INAF ISTITUTO NAZIONALE DI ASTROFISICA
TOR VERGATA UNIVERSITÀ DEGLI STUDI DI ROMA
Finanziato dall'Unione europea NextGenerationEU
Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA

Ionizing budget during reionization

$$\dot{n}_{ion} = f_{esc}\,\xi_{ion}\,\rho_{UV}$$

[integrated on M_{UV}]

- We need to know **how many sources we are considering**
- We need to measure **how many LyC photons they are producing**
- What we still need to understand is **how many photons manage to escape**

Ionizing budget during reionization

$$\dot{n}_{ion} = f_{esc}\,\xi_{ion}\,\rho_{UV}$$

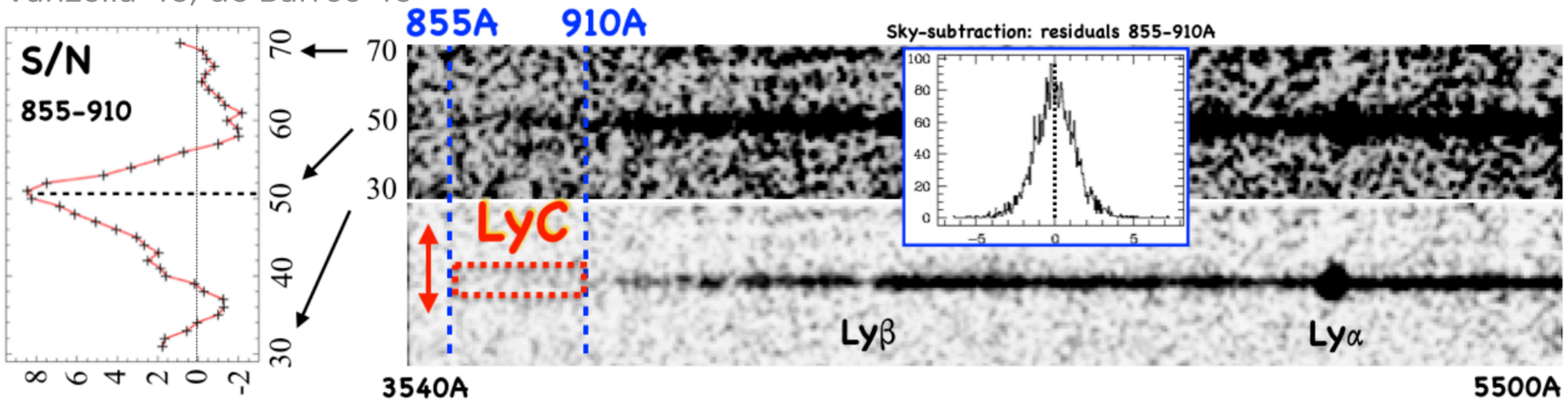
[integrated on M_{UV}]

- **Faint, low-mass galaxies** are thought to be responsible for cosmic reionization
- From empirical data and models, a **Lyman continuum (LyC) escape fraction of ~10-20% is needed**

Lyman Continuum emission

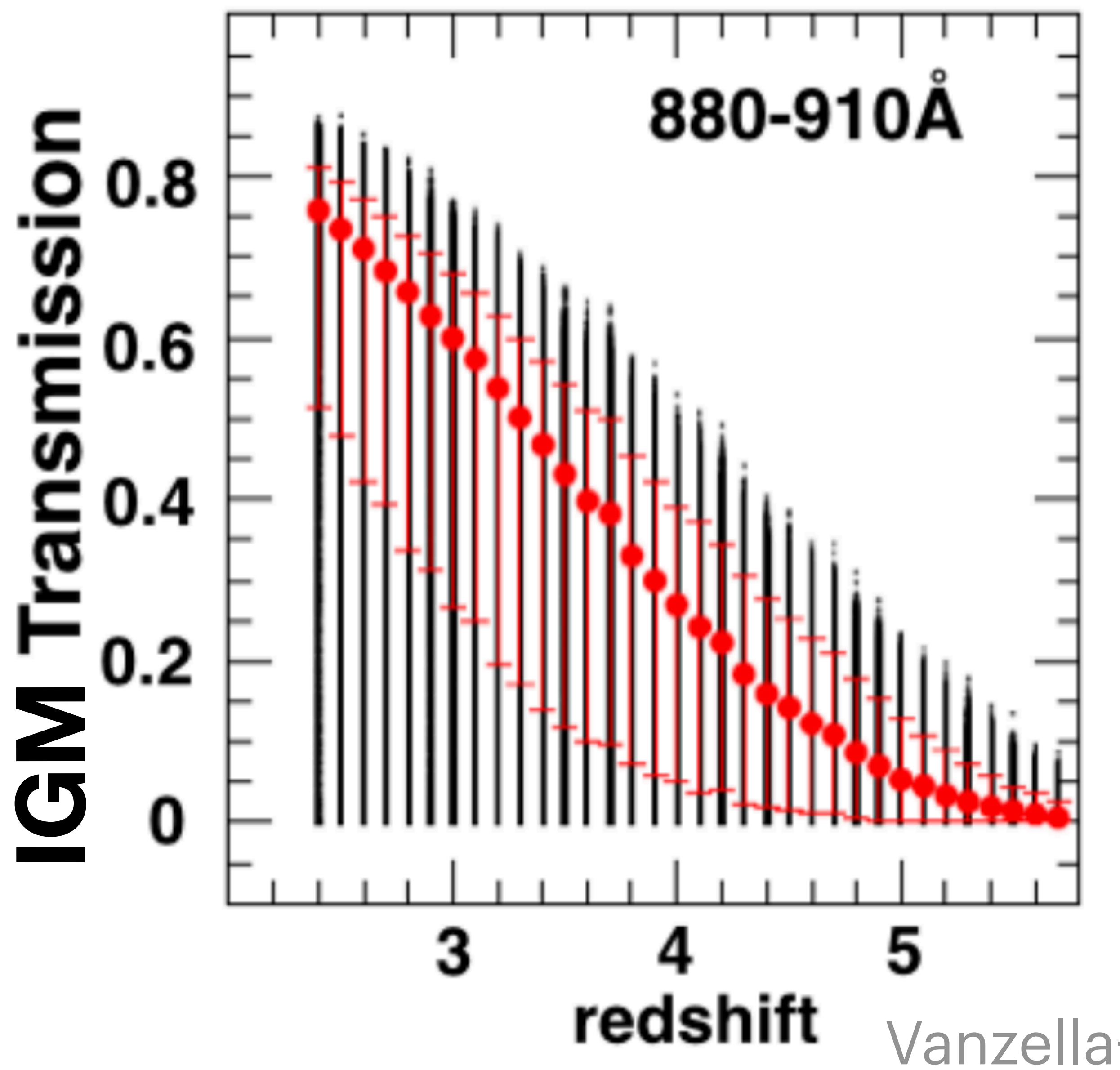
The LyC flux can be measured via photometry or spectroscopy at λ < 912 Å.

Vanzella+16, de Barros+16



Ion2, z=3.218, in GOODS-S/CANDELS, f_{esc} > 60%

However, at z ≥ 4.5
it is impossible
to detect LyC photons

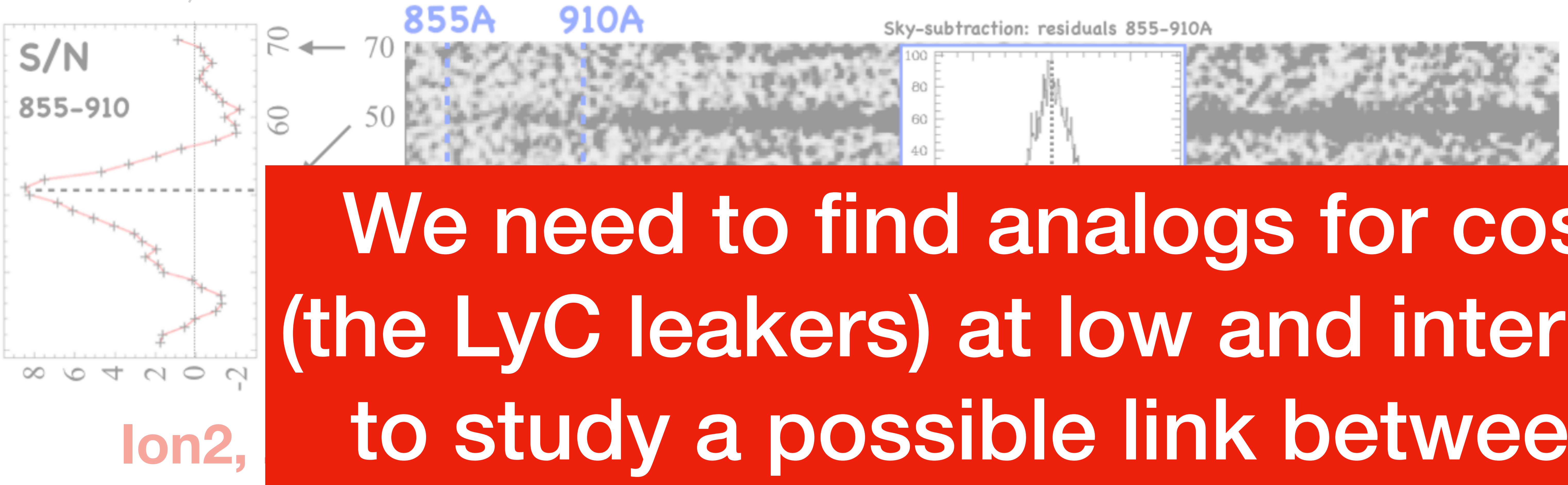


Vanzella+15

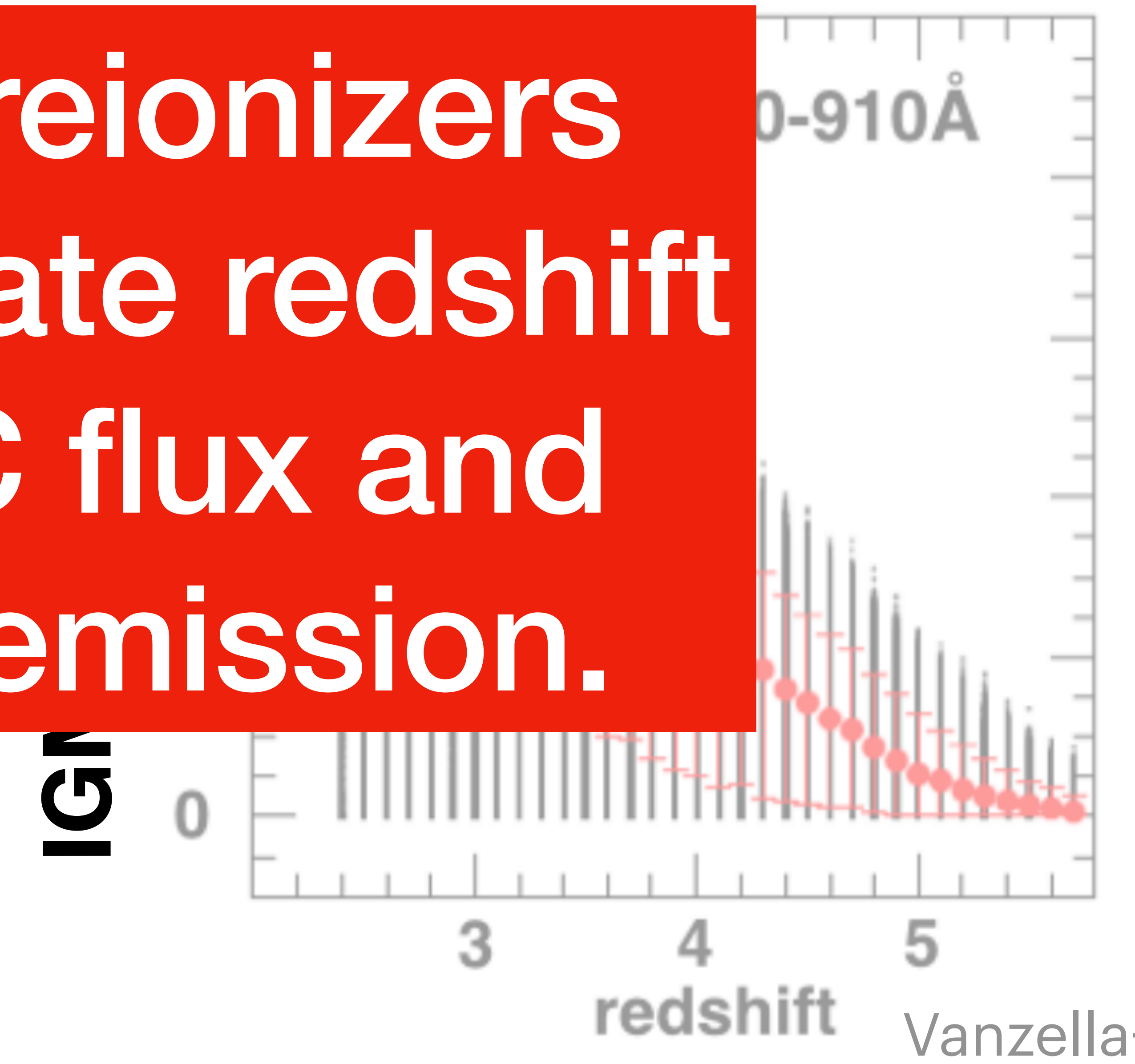
Lyman Continuum emission in the EoR?

The LyC flux can be measured via photometry or spectroscopy at $\lambda < 912$ Å.

Vanzella+16, de Barros+16



However, at $z \geq 4.5$
it is impossible
to detect LyC photons

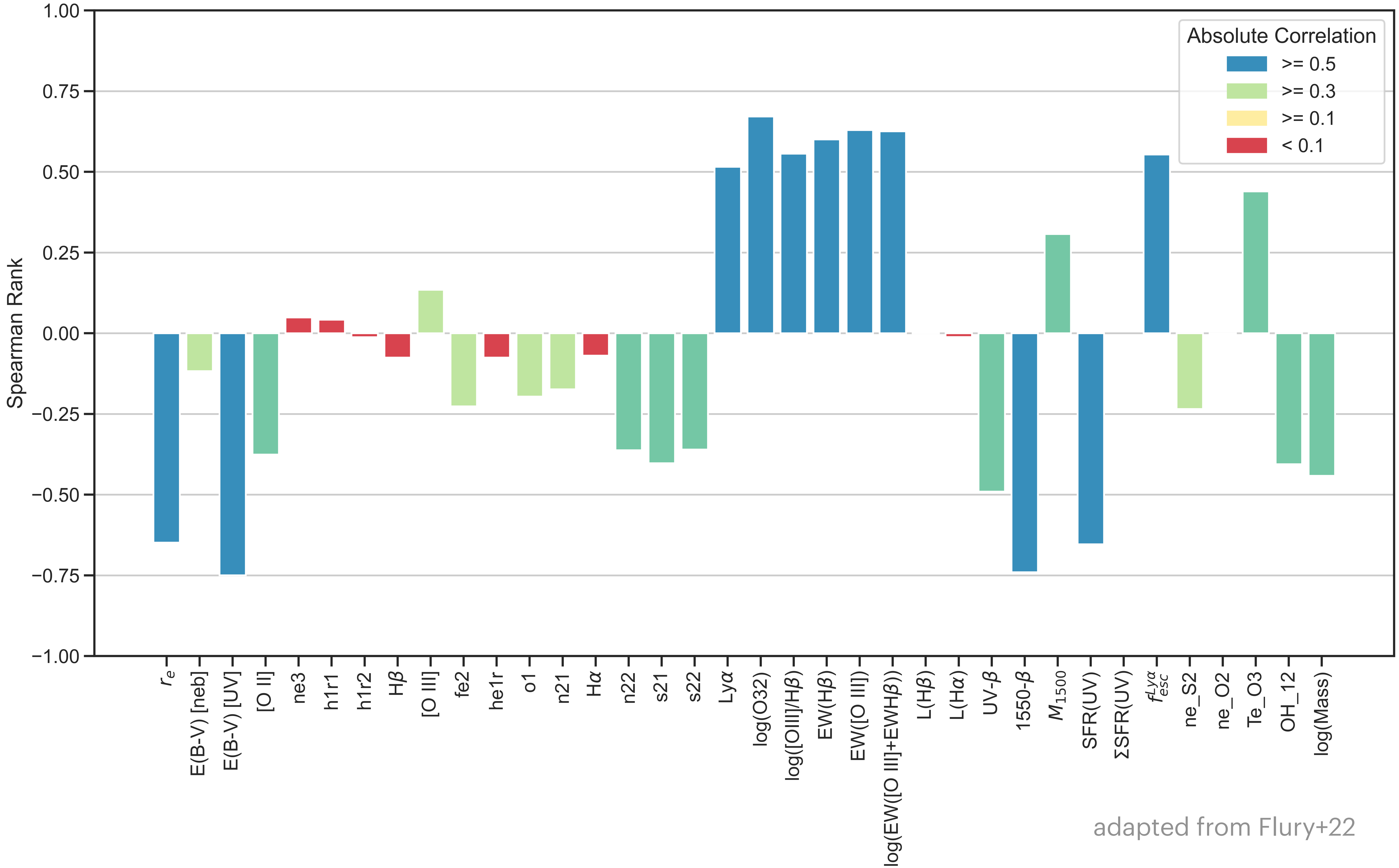


Vanzella+15

We need to find analogs for cosmic reionizers (the LyC leakers) at low and intermediate redshift to study a possible link between LyC flux and promising indirect indicators of this emission.

The Low-Redshift Lyman Continuum Survey

The most systematic and complete study of low redshift LyC leaking galaxies and indirect diagnostics comes from the Low-Redshift Lyman Continuum Survey (LzLCs, PI Jaskot)

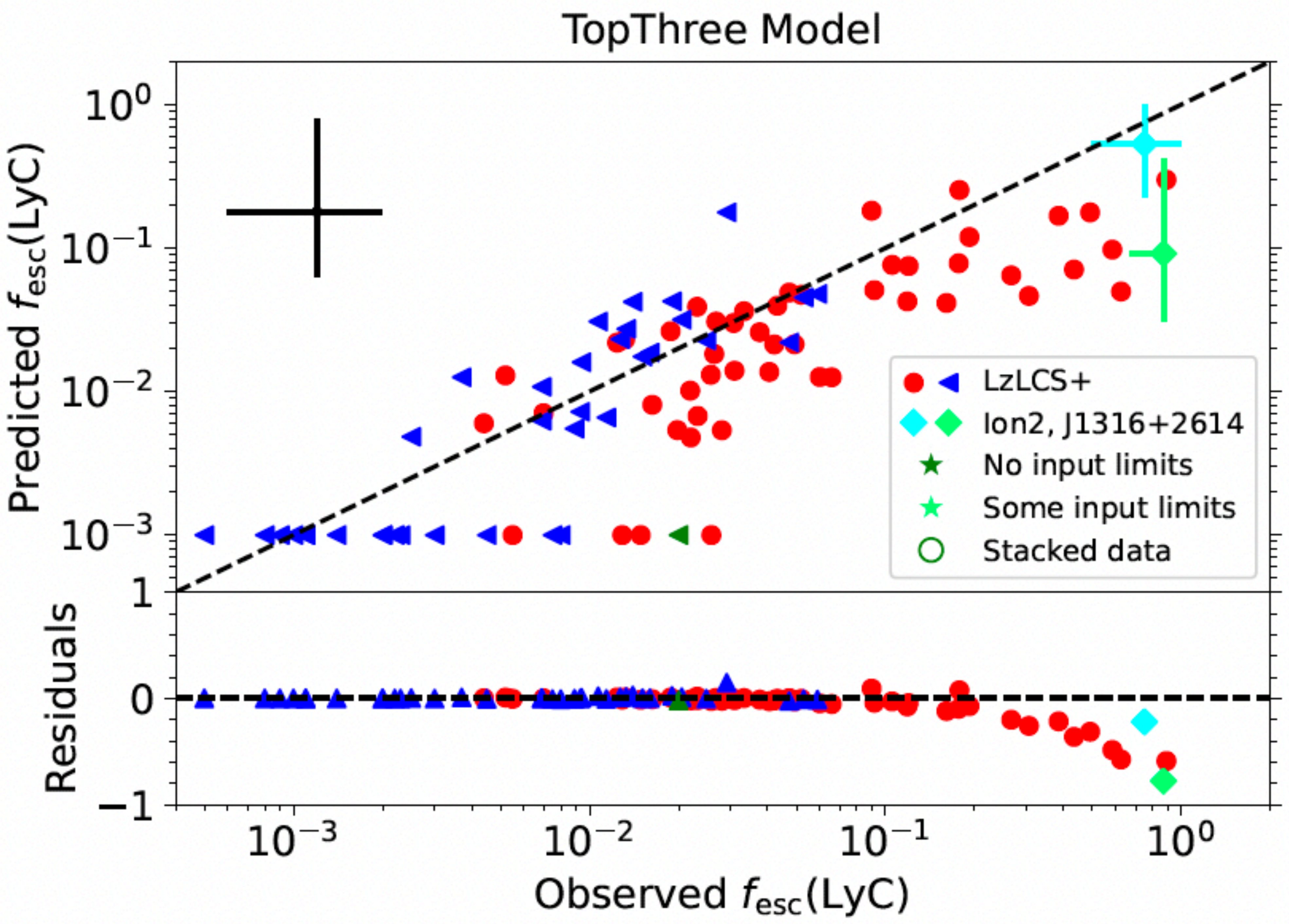


adapted from Flury+22

Predicting f_{esc} of EoR galaxies from multiple indicators

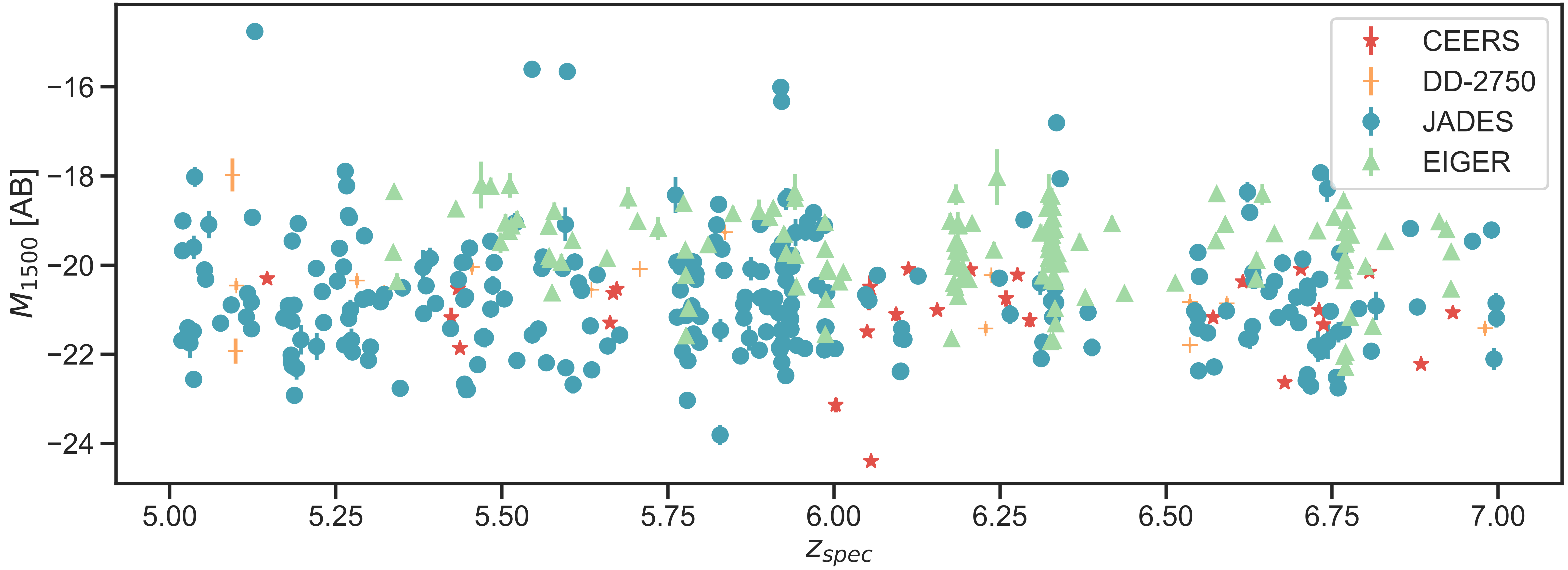
Significant efforts have been made to predict the f_{esc} values using the most promising indirect indicators from LzLCs (see Chisholm+22, Mascia+23b,24, **Jaskot+24a,b**)

Model	Variables				
	Dust	Lyα	Nebular	Luminosity	Morphology
TopThree	E(B-V)$_{UV}$	—	$\log_{10}$(O32)	—	$\log_{10}(\Sigma_{SFR})$
LAE	E(B-V)$_{UV}$	EW(Lyα)	—	M_{1500}	—
LAE-O32	E(B-V)$_{UV}$	EW(Lyα)	$\log_{10}$(O32)	M_{1500}, $\log_{10}(M_*)$	—
LAE-O32-nodust	—	EW(Lyα)	$\log_{10}$(O32)	M_{1500}	—
ELG-EW	E(B-V)$_{UV}$	—	$\log_{10}$(EW([O III]+Hβ))	M_{1500}, $\log_{10}(M_*)$	—
ELG-O32	E(B-V)$_{UV}$	—	$\log_{10}$(O32)	M_{1500}, $\log_{10}(M_*)$	—
ELG-O32-β	β_{1550}	—	$\log_{10}$(O32)	M_{1500}	—
ELG-O32-β-Lyα	β_{1550}	$f_{esc,Ly\alpha}$	$\log_{10}$(O32)	M_{1500}, $\log_{10}(M_*)$	—
R50-β	β_{1550}	—	—	M_{1500}, $\log_{10}(M_*)$	$\log_{10}(r_{50,NUV})$
β-Metals	β_{1550}	—	12+$\log_{10}$(O/H)	M_{1500}, $\log_{10}(M_*)$	—



Jaskot+24b

High-redshift spectroscopic sample

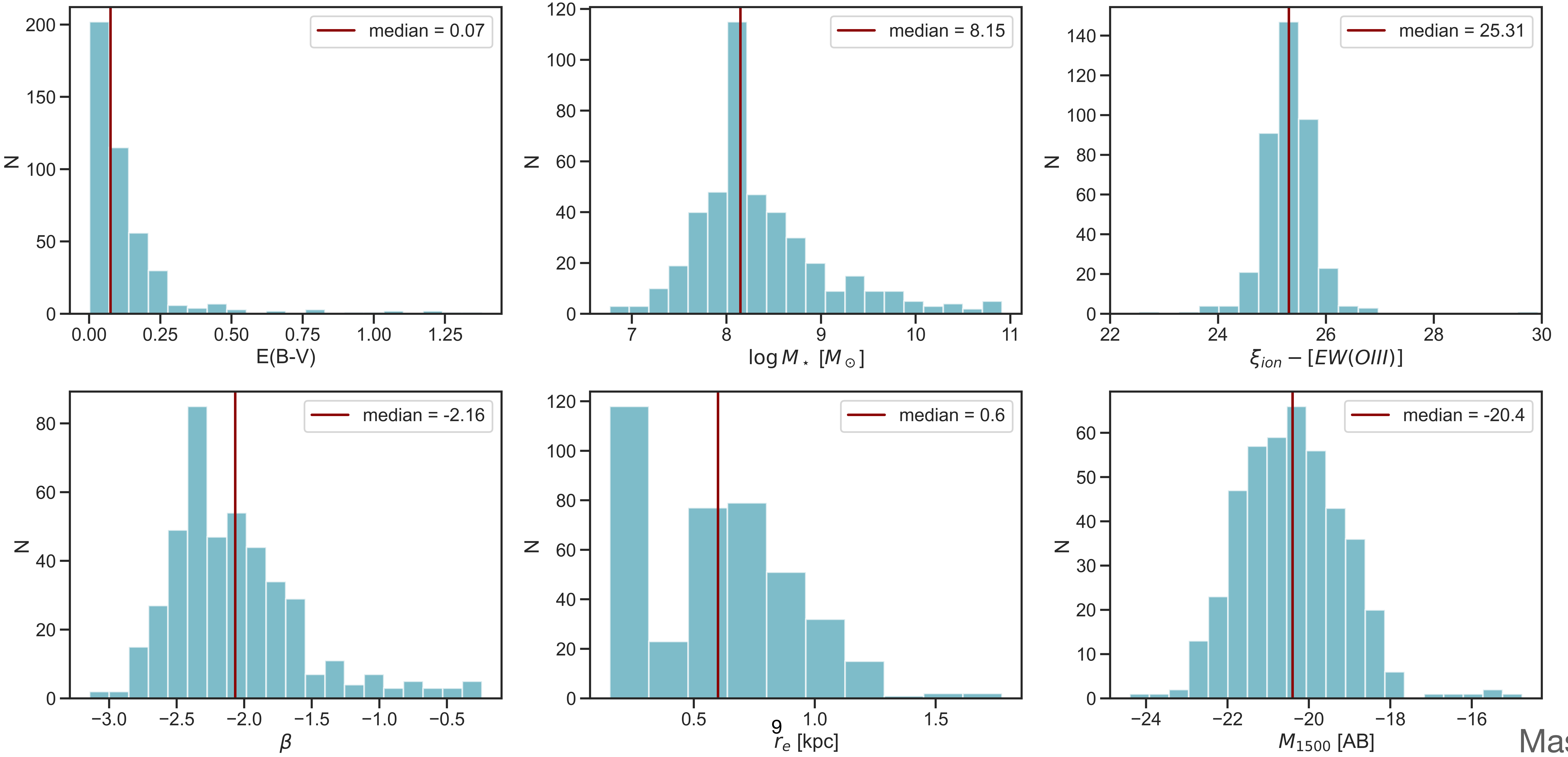


436 spectroscopically confirmed sources at z = 5-7 from JWST NIRSpec and NIRCAM/WFSS

Mascia+24(in prep.)

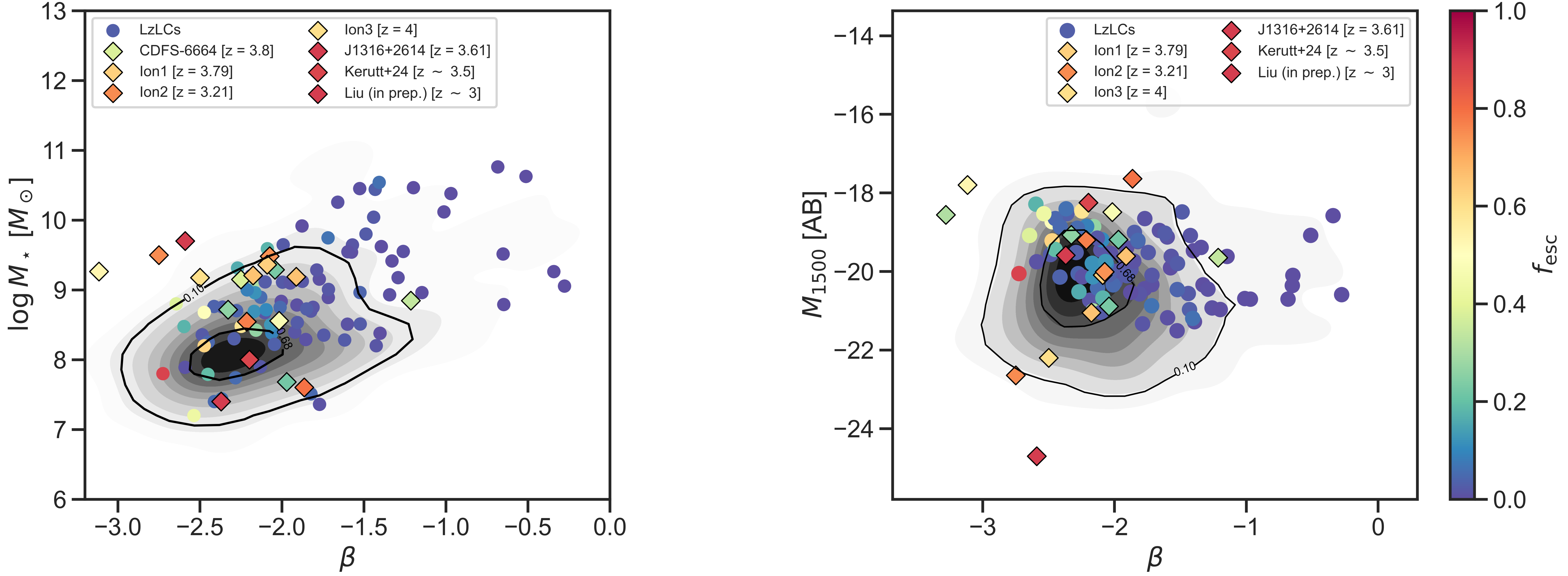
436 sources at z = 5-7

- stellar population properties using Prospector
- emission lines using LiMe
- re from F115W for z<5.5 and F150W for z>5.5 with galight



Mascia+24(in prep.)

Matching EoR galaxies and leakers at low and intermediate redshift



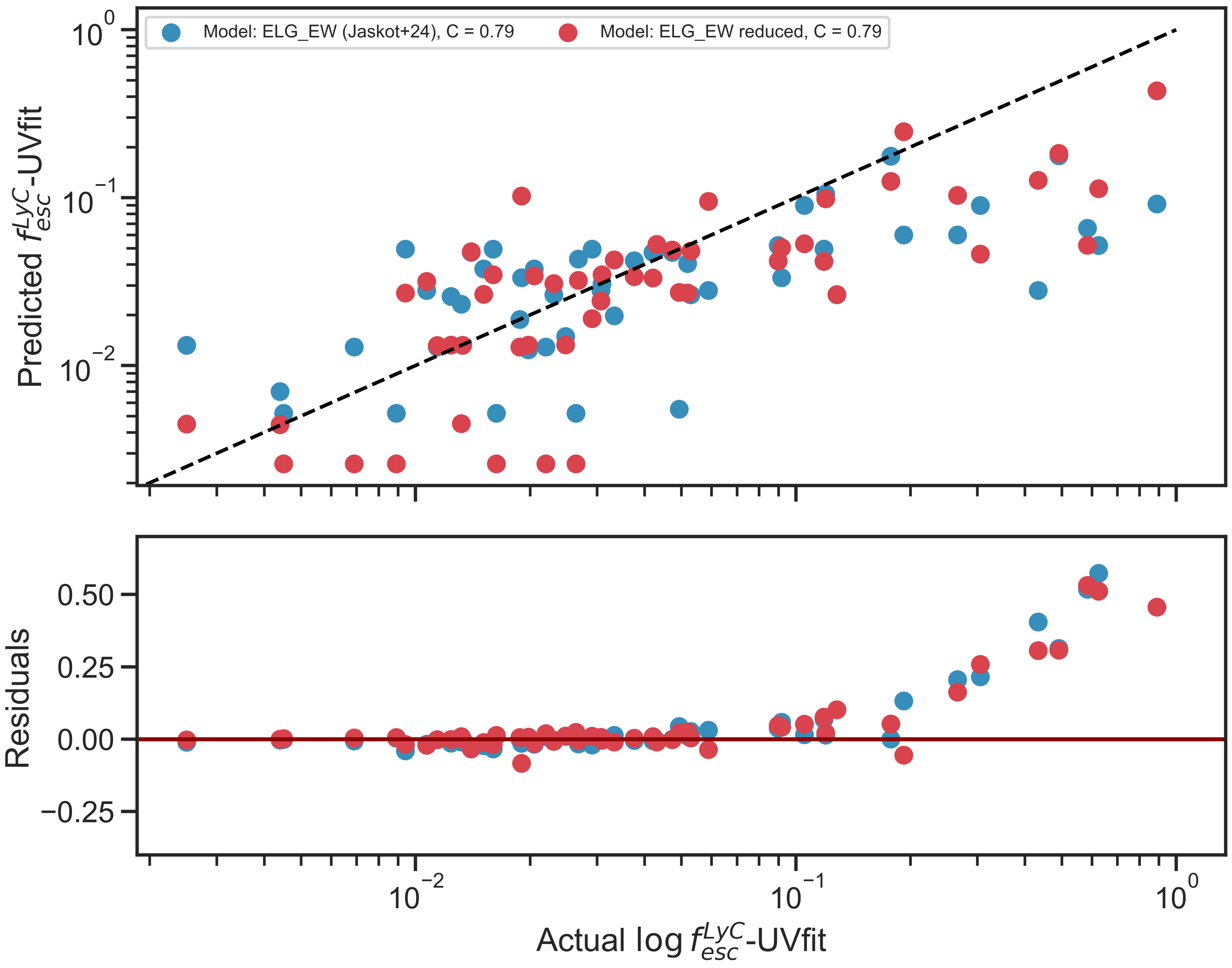
We selected a subsample of the ~50 LzLCs that are analogs of EoR sources

Mascia+24(in prep.)

Indirect indicators at low redshift for the “analogs”

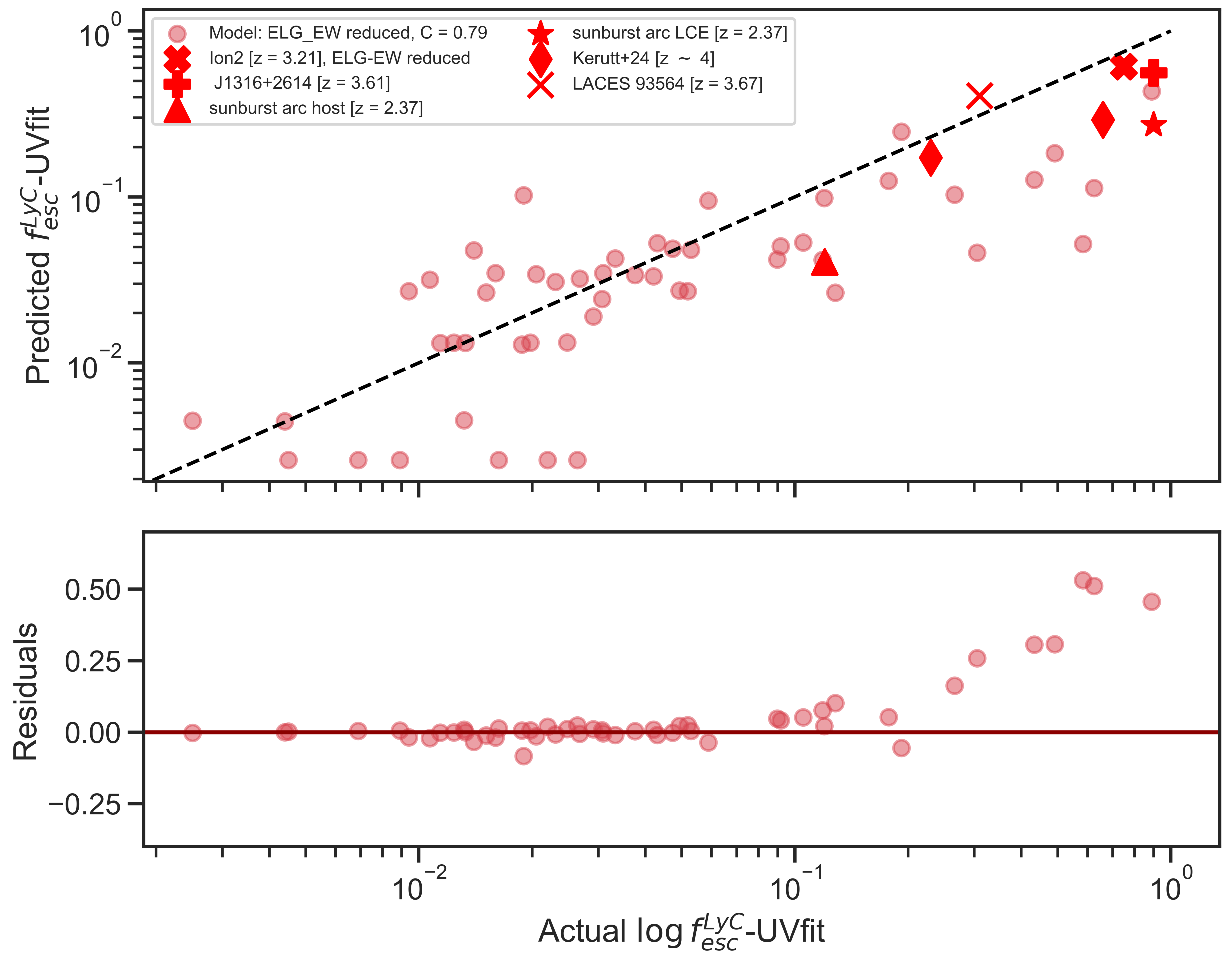
ELG-EW (Concordance=0.79):
- E(B-V)
- $\log_{10}$(O[III]+Hβ) EWs
- M_{1500}
- $\log_{10}(M_\star)$

ELG-O32 (Concordance=0.83):
- E(B-V)
- $\log_{10}$(O32)
- M_{1500}
- $\log_{10}(M_\star)$



Mascia+24(in prep.)

Predictions applied to z = 3 leakers



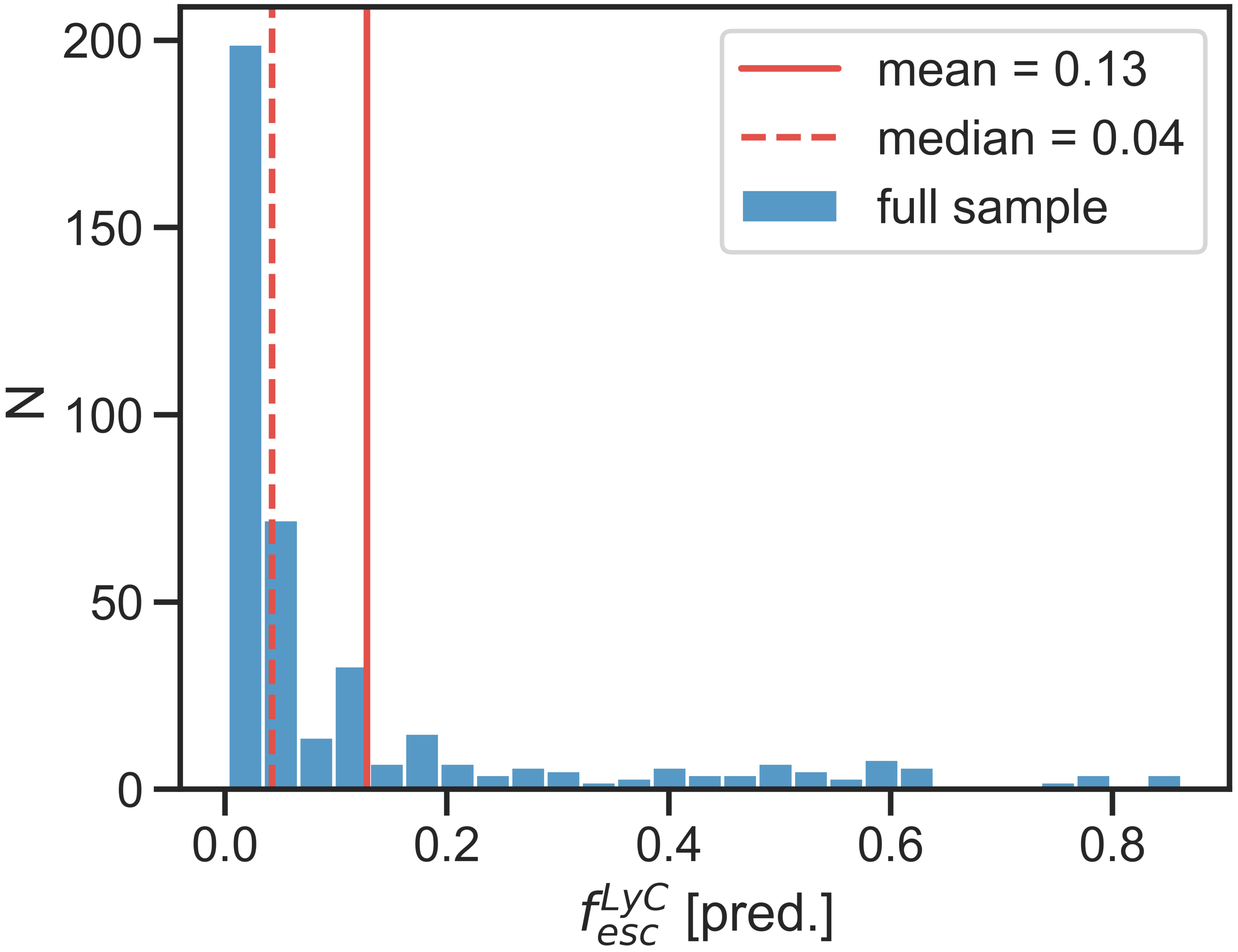
Predictions are effective

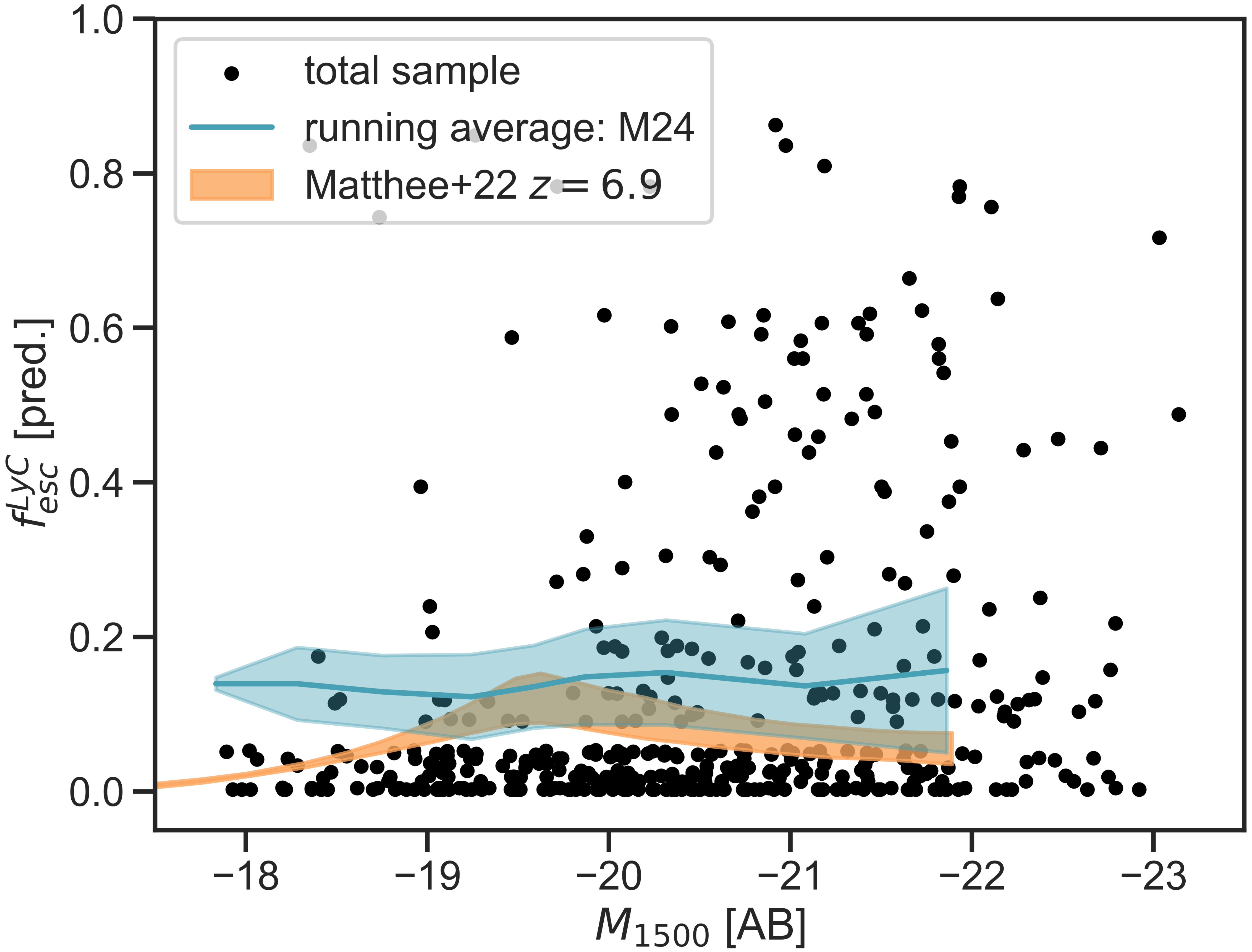
BUT

we still need to increase the statistics of known leakers at intermediate redshifts.

Mascia+24(in prep.)

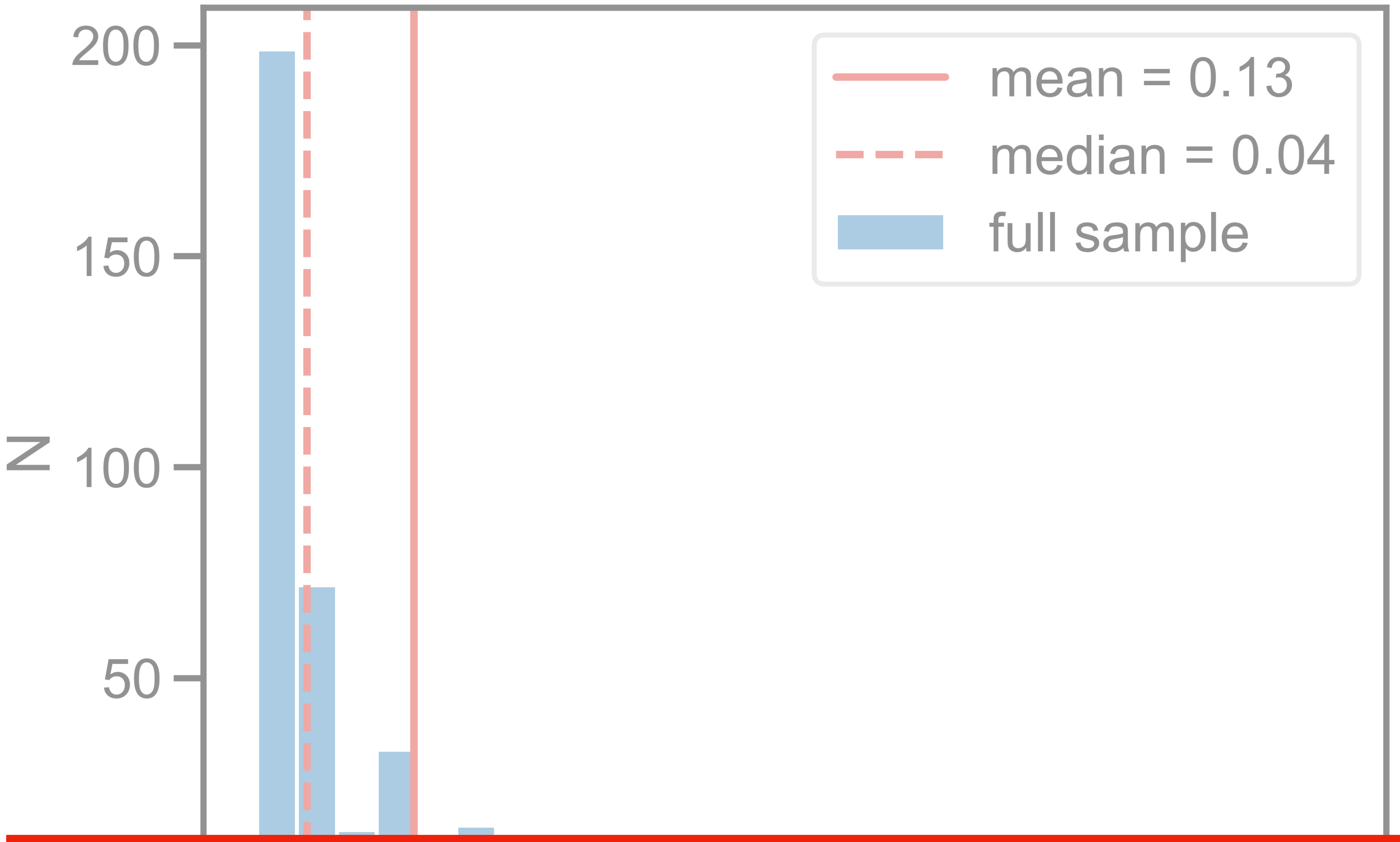
Predictions applied to our z = 5-7 sample

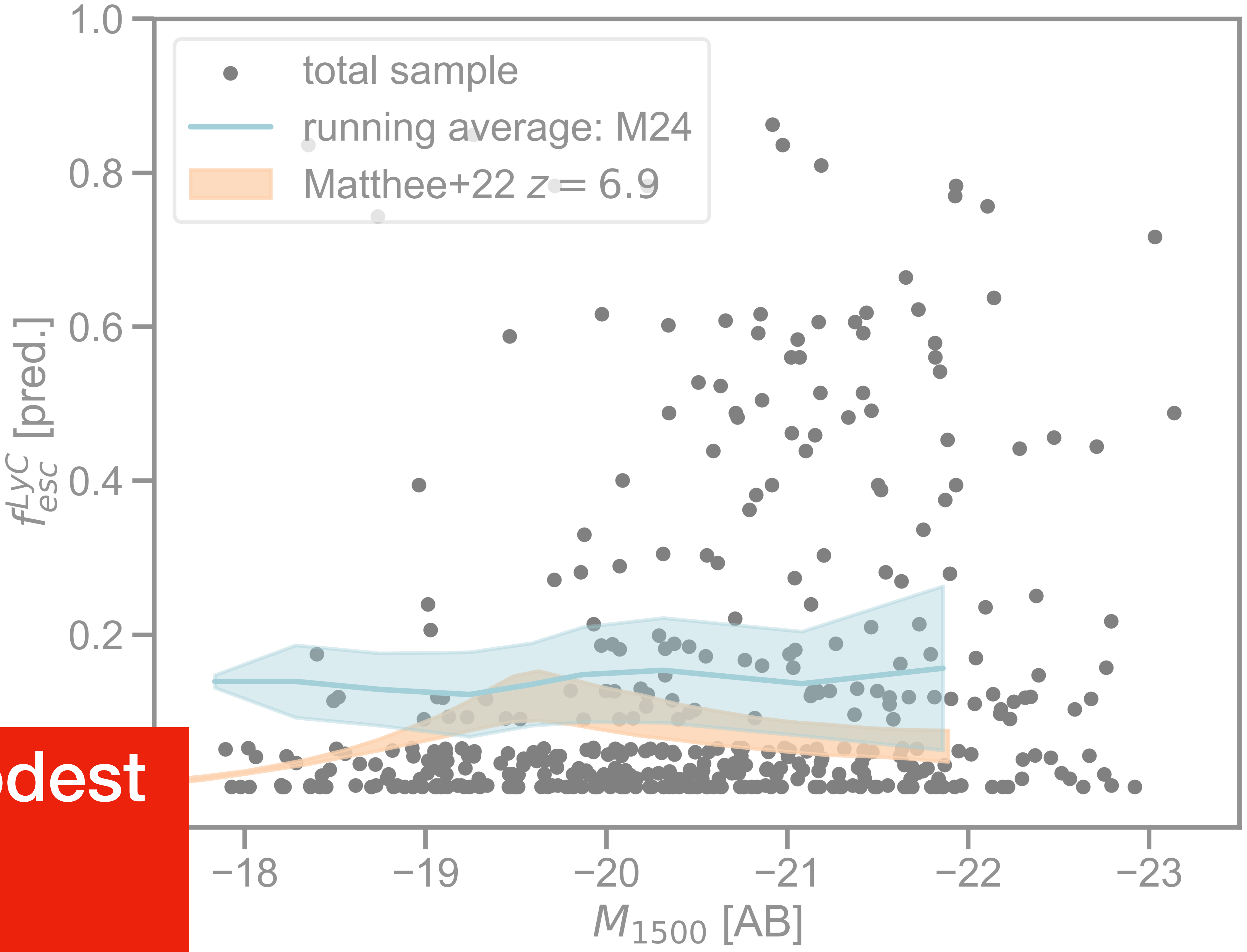




Mascia+24(in prep.)

Predictions applied to our z = 5-7 sample



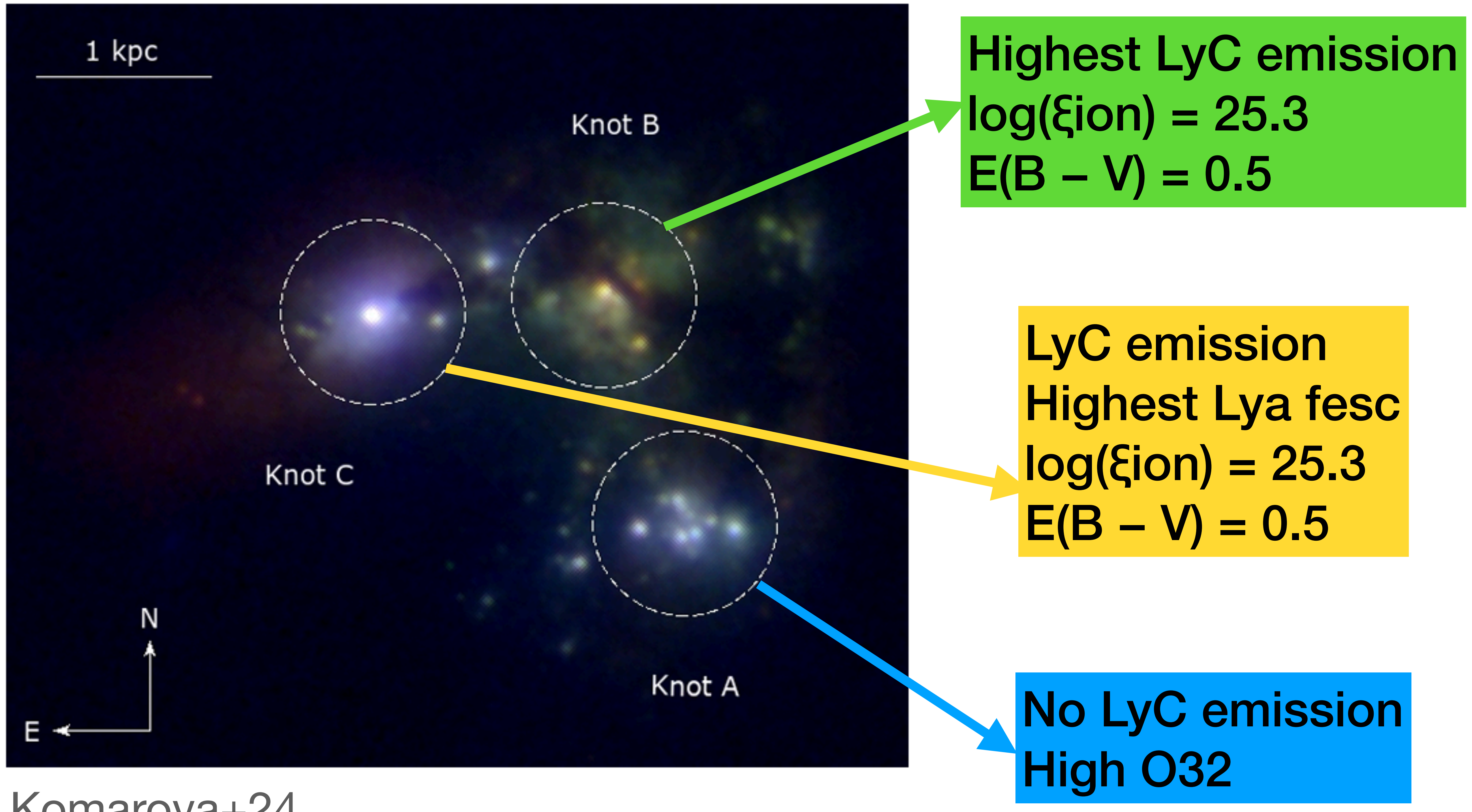


Most galaxies during the EoR have modest f_{esc} and there is no indication on a dependence with the M_{1500}

Mascia+24(in prep.)

Mergers in low redshift leakers

Haro11



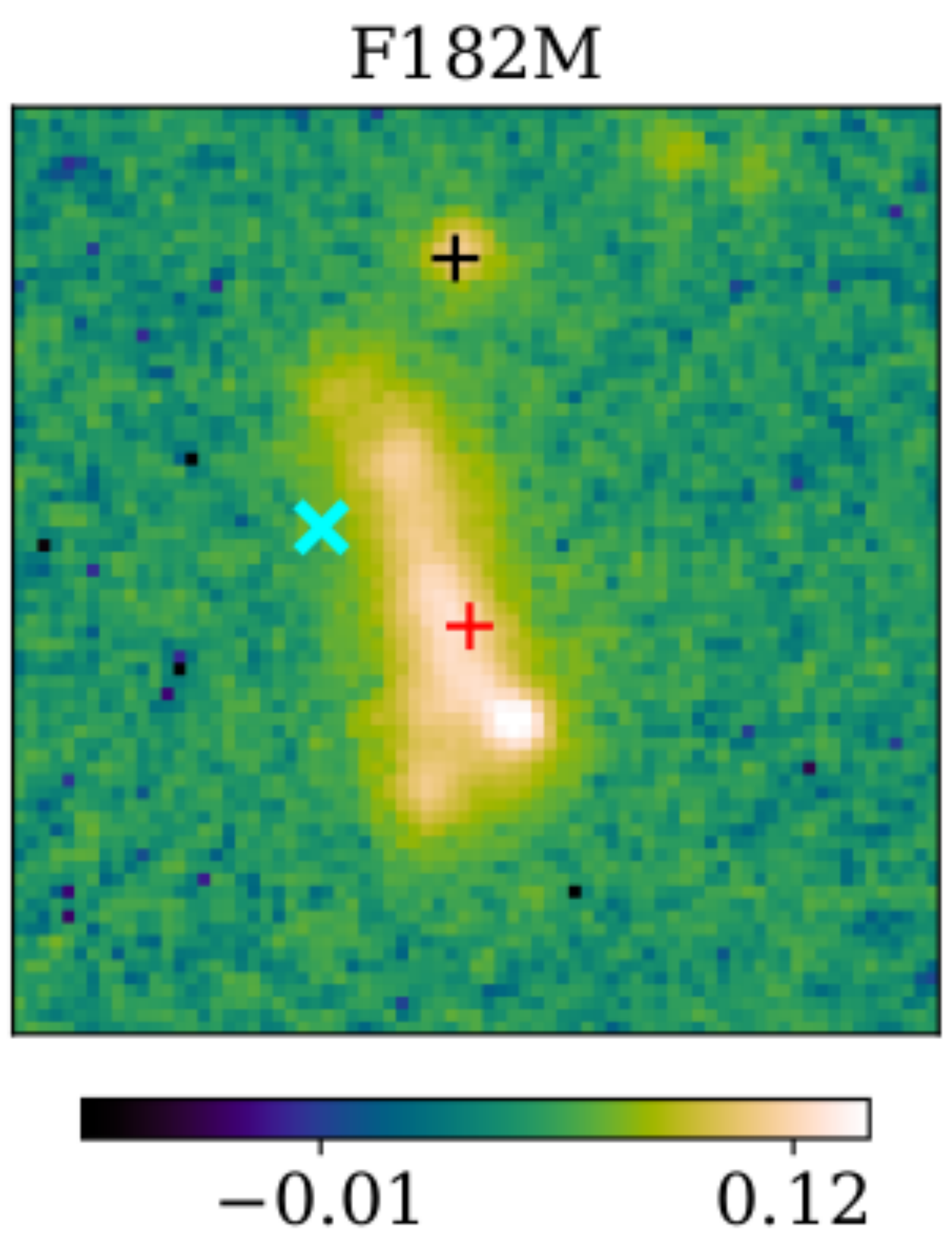
Komarova+24

Mergers and interactions could significantly influence star formation burst: the subsequent outflows can favour the formation of channels that allow the LyC radiation to escape.

Some low-z leakers appear indeed to be mergers (e.g., Haro11).

We aim to investigate whether this holds true during the EoR as well.

Mergers in low redshift leakers



Gupta+24

New confirmed leaker at z=3.088 with a spatially offset Lyman continuum emission.

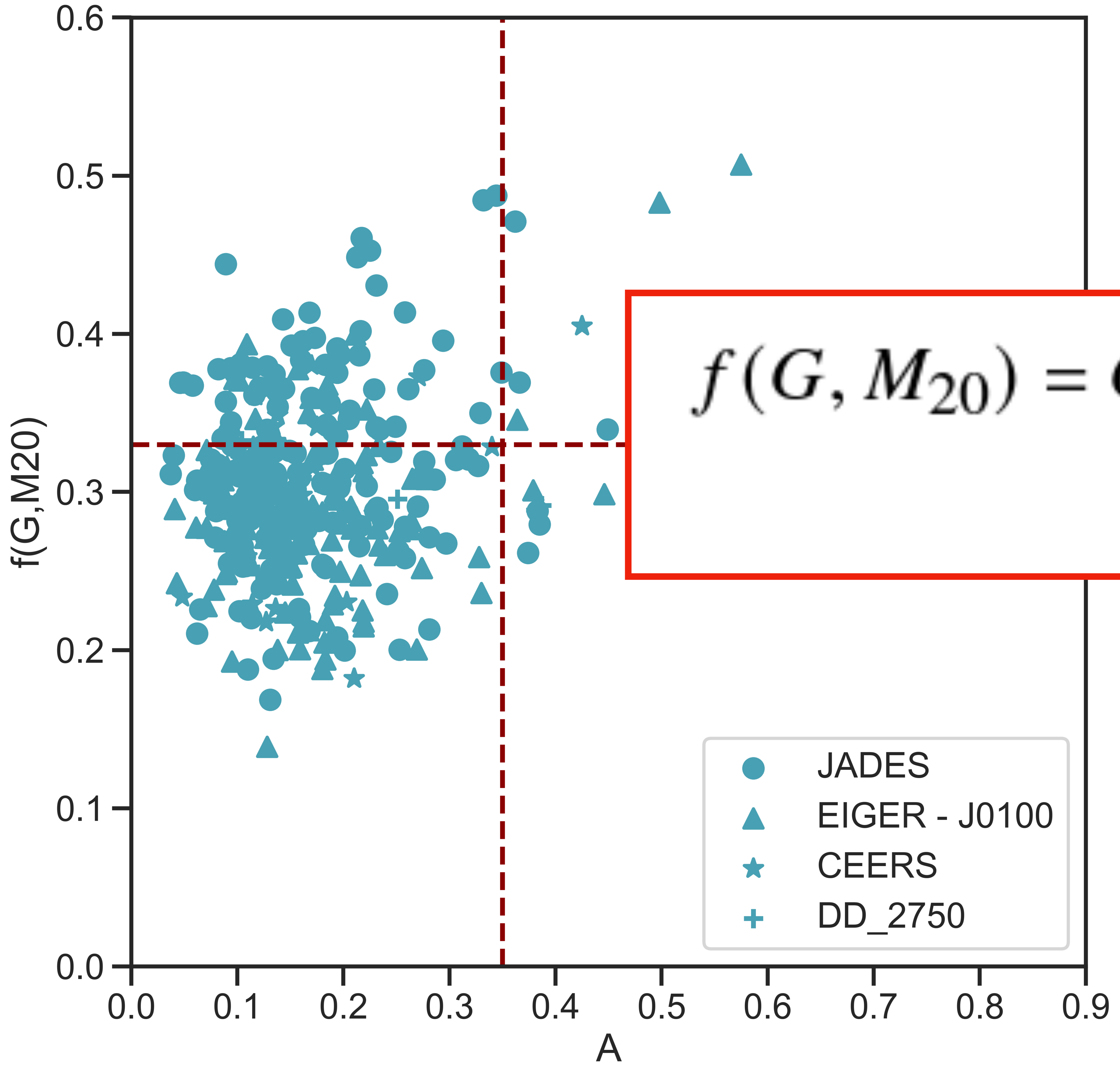
The Gini-M20 statistics (Lotz et al. 2008) classify z19863 as a merger based on the stellar emission (F182M)

See Anshu's talk on Friday!

Mergers during the EoR

From the F115W imaging, we are measuring:

- M20
- Gini structural parameter
- concentration of light (C)
- Shape asymmetry (A)
- clumpiness / smoothness parameter



Mergers identification following Dalmasso+24:

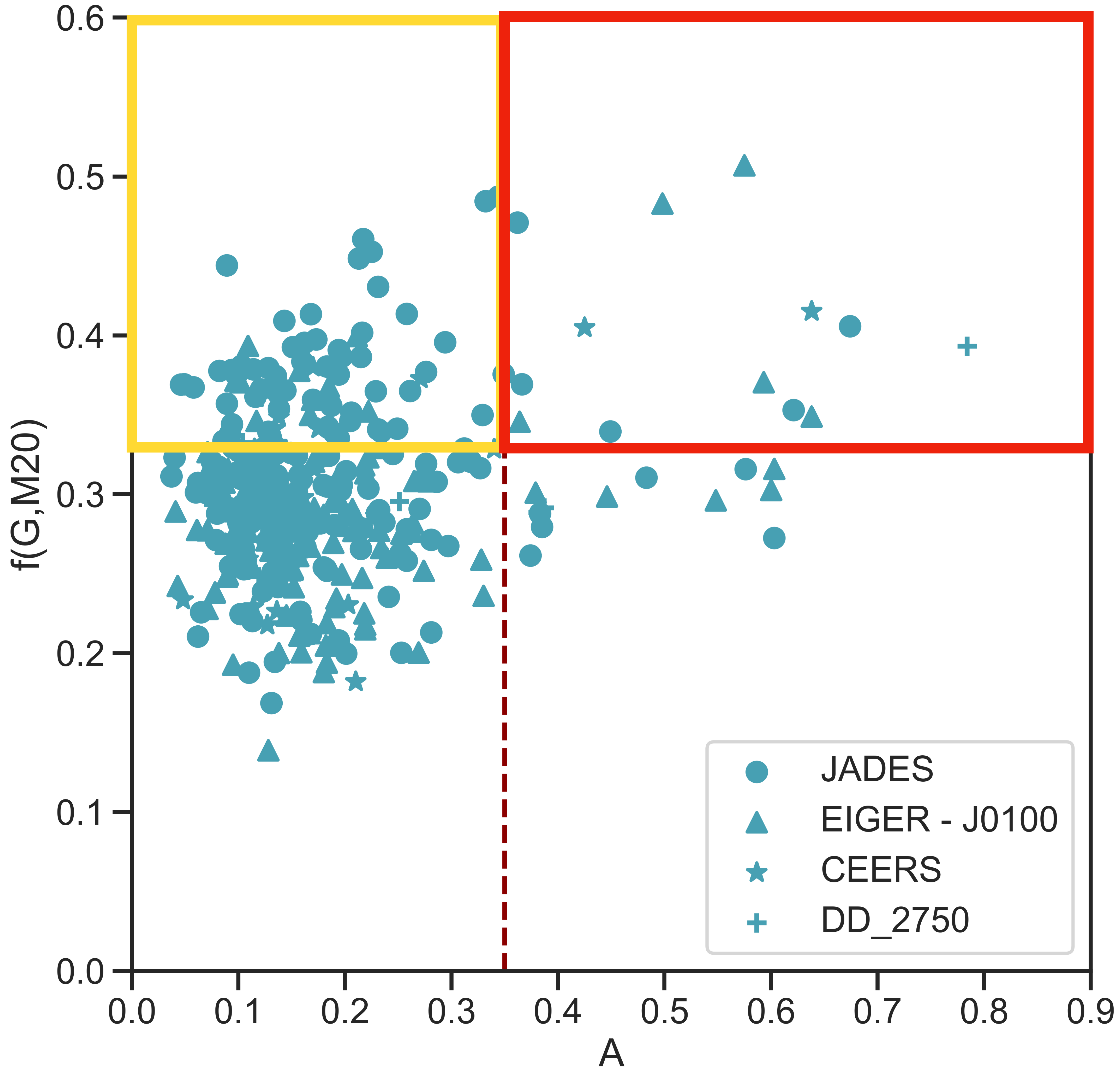
$$f(G, M_{20}) = G + 0.14 M_{20} > 0.33$$

$$A \geq 0.35$$

See also Treu+23

Mascia+24(in prep.)

Mergers during the EoR

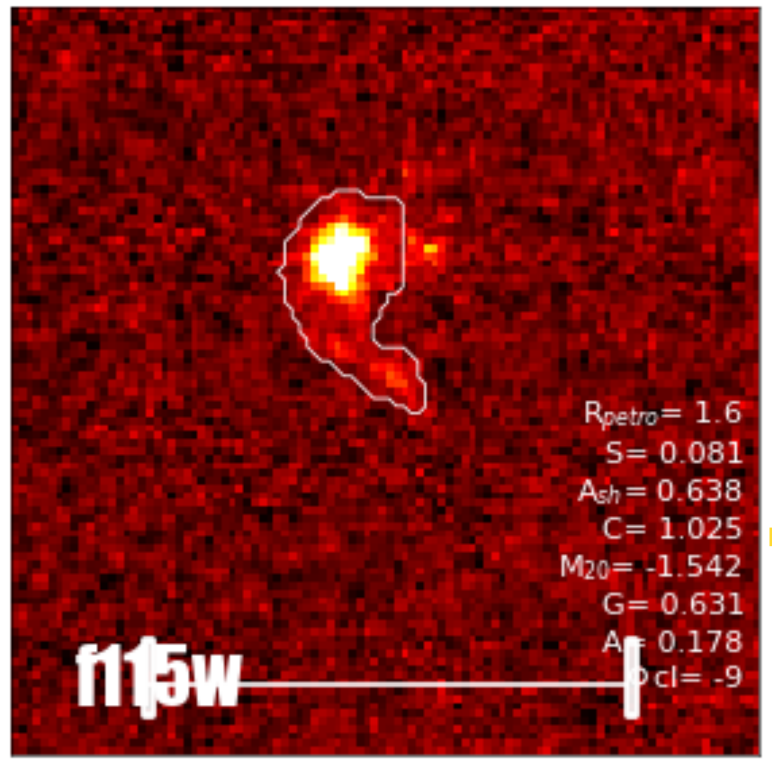


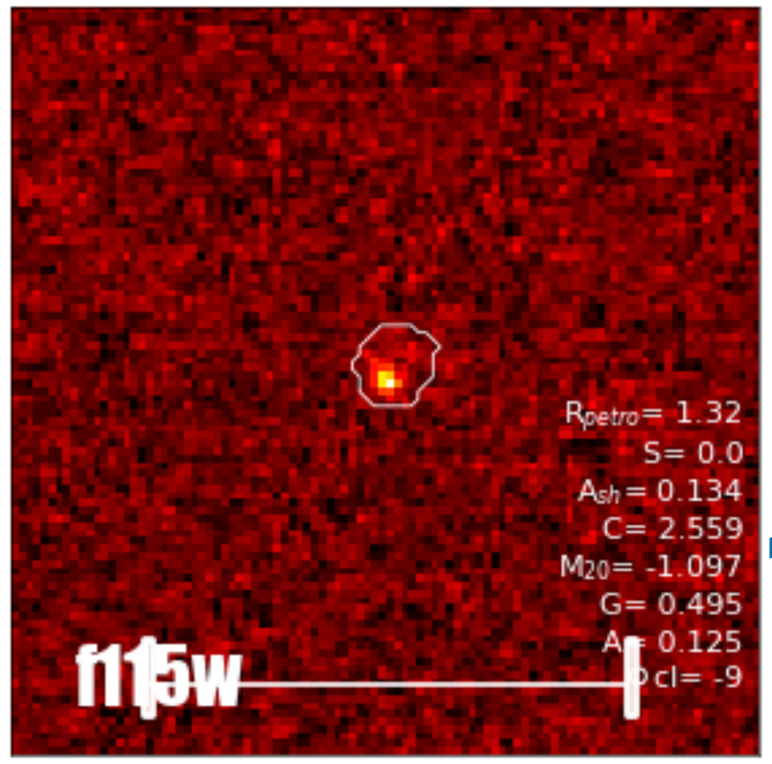
Mergers identification following Dalmasso+24:

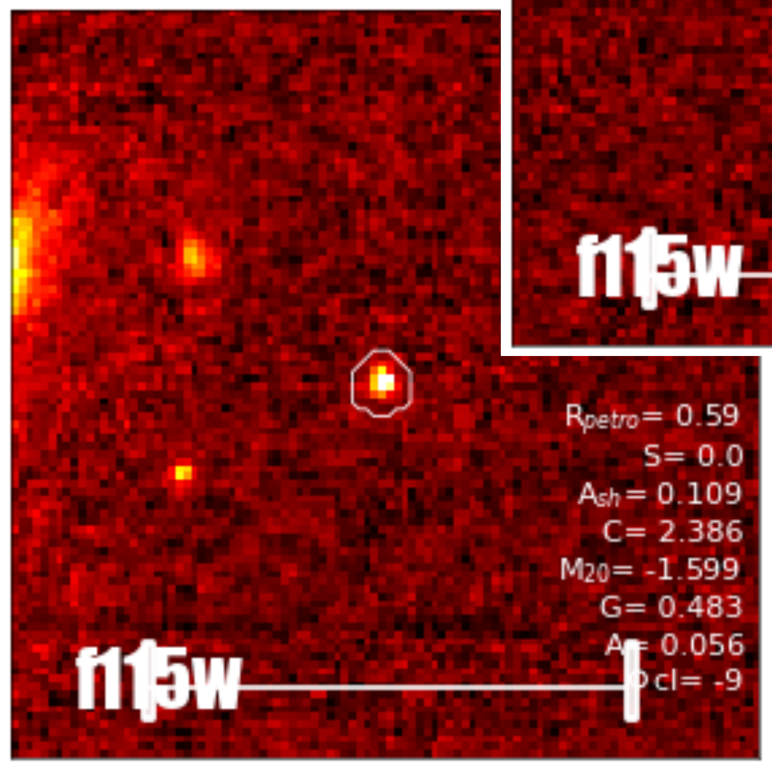
$$f(G, M_{20}) = G + 0.14M_{20} > 0.33$$
$$A \geq 0.35$$

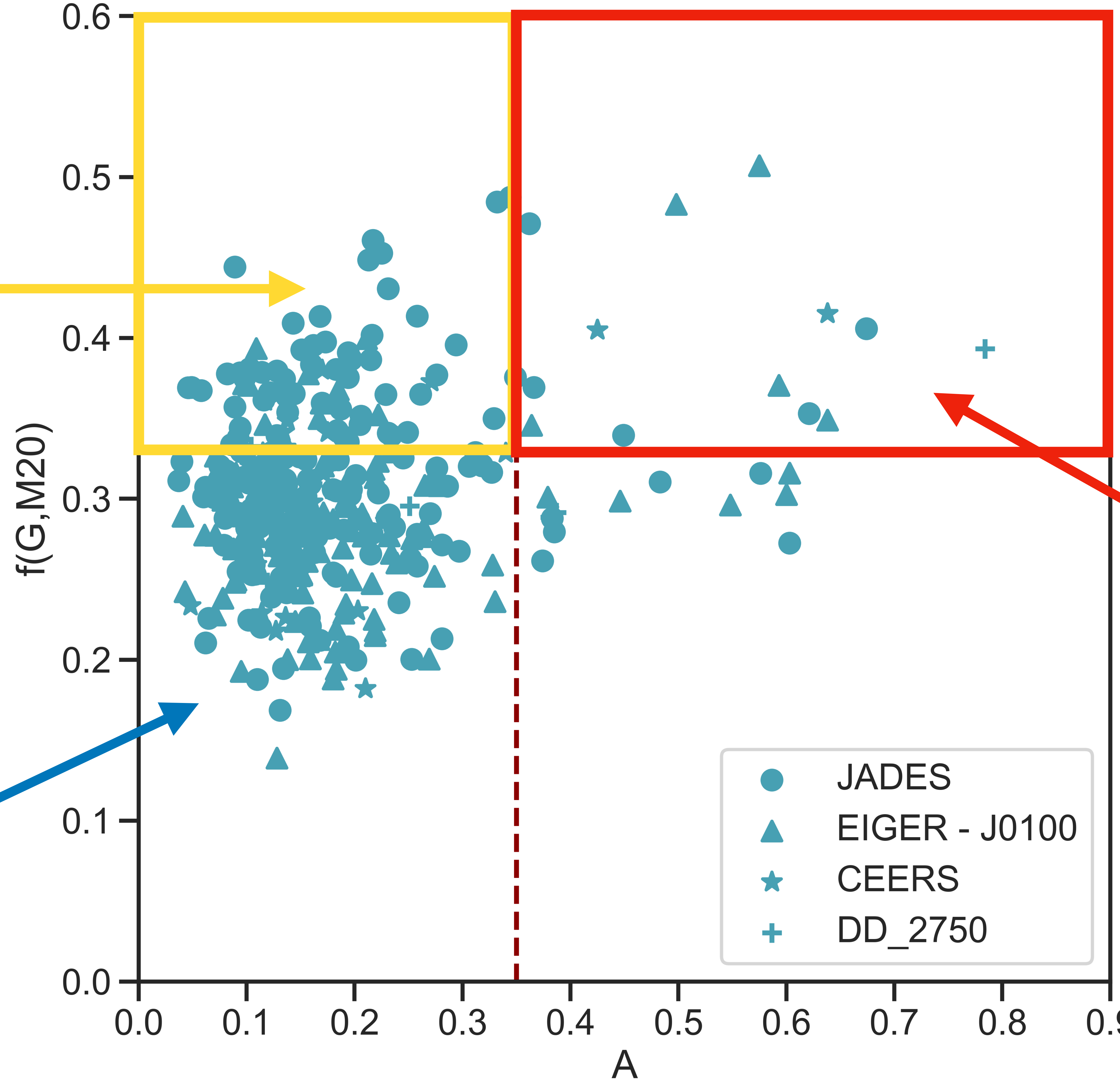
Mascia+24(in prep.)

Mergers during the EoR



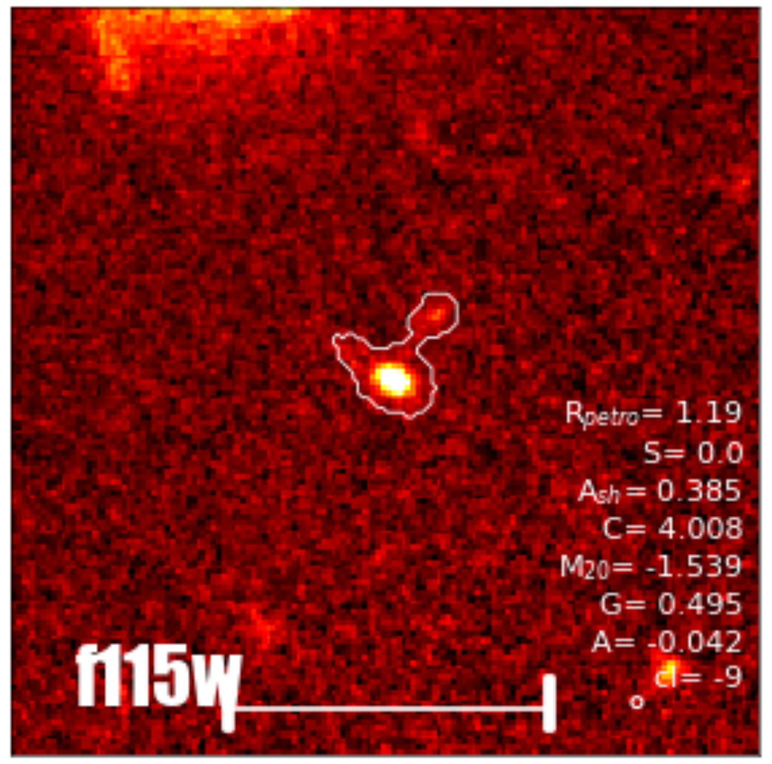






Mergers identification following Dalmasso+24:

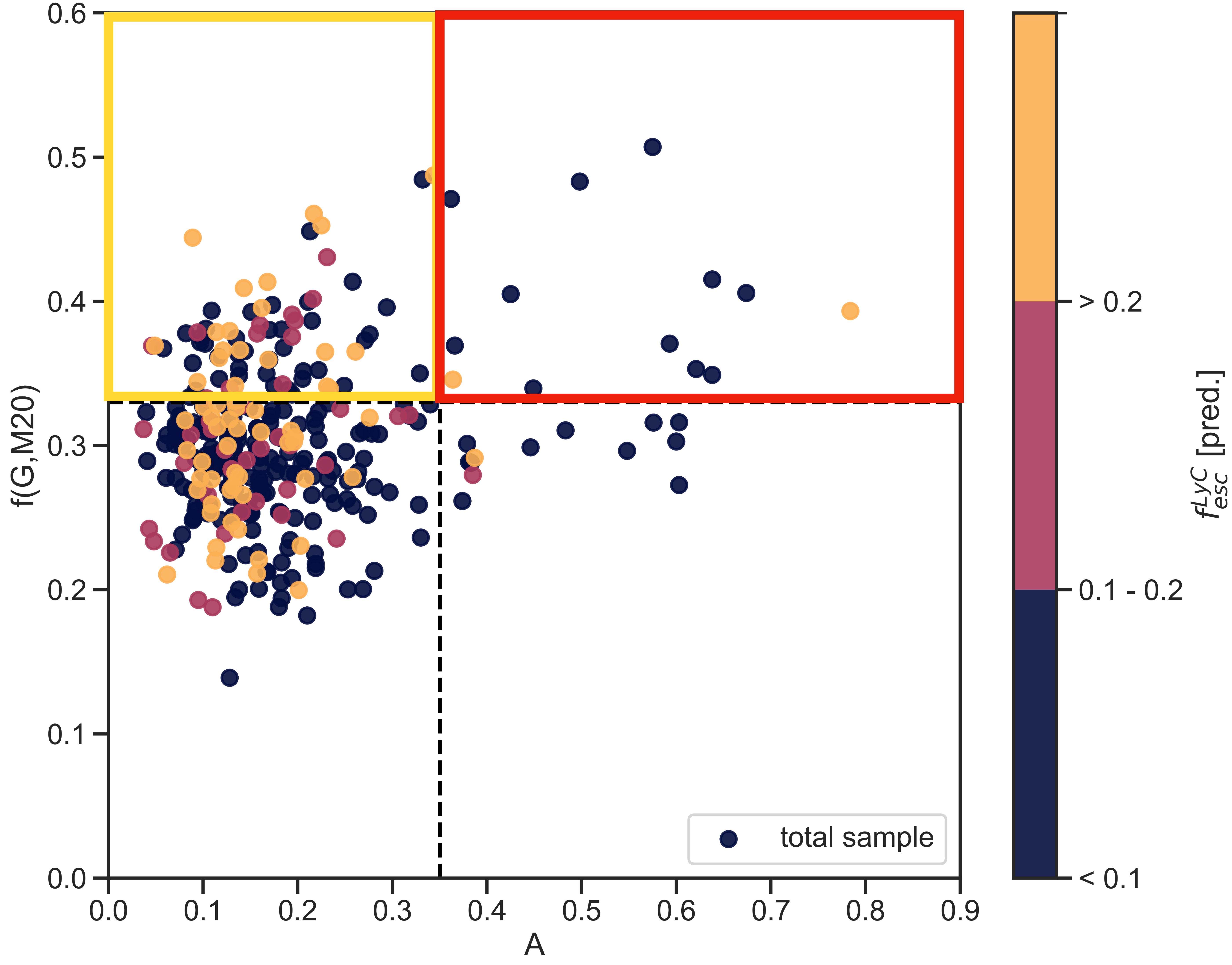
$$f(G, M_{20}) = G + 0.14M_{20} > 0.33$$
$$A \geq 0.35$$



Mascia+24(in prep.)

Mergers and fesc during the EoR

our sample now color coded by inferred f_{esc}

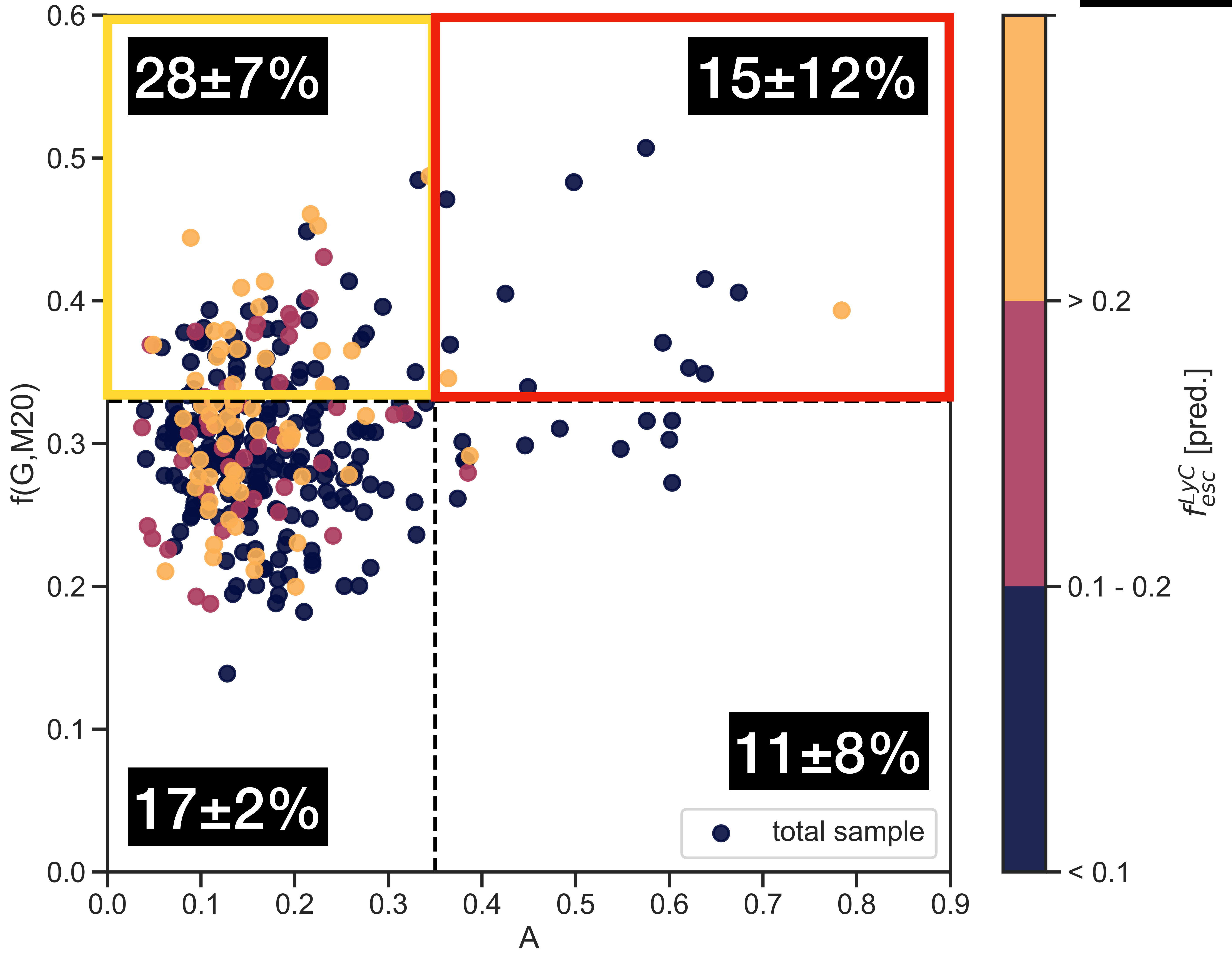


Mascia+24(in prep.)

Mergers and f_{esc} during the EoR

$$n\,\% = \frac{N_{gal}[f_{esc} \geq 0.2]}{N_{gal,TOT}}$$

The candidate leakers (f_{esc}>0.2) are evenly distributed in the f,A space

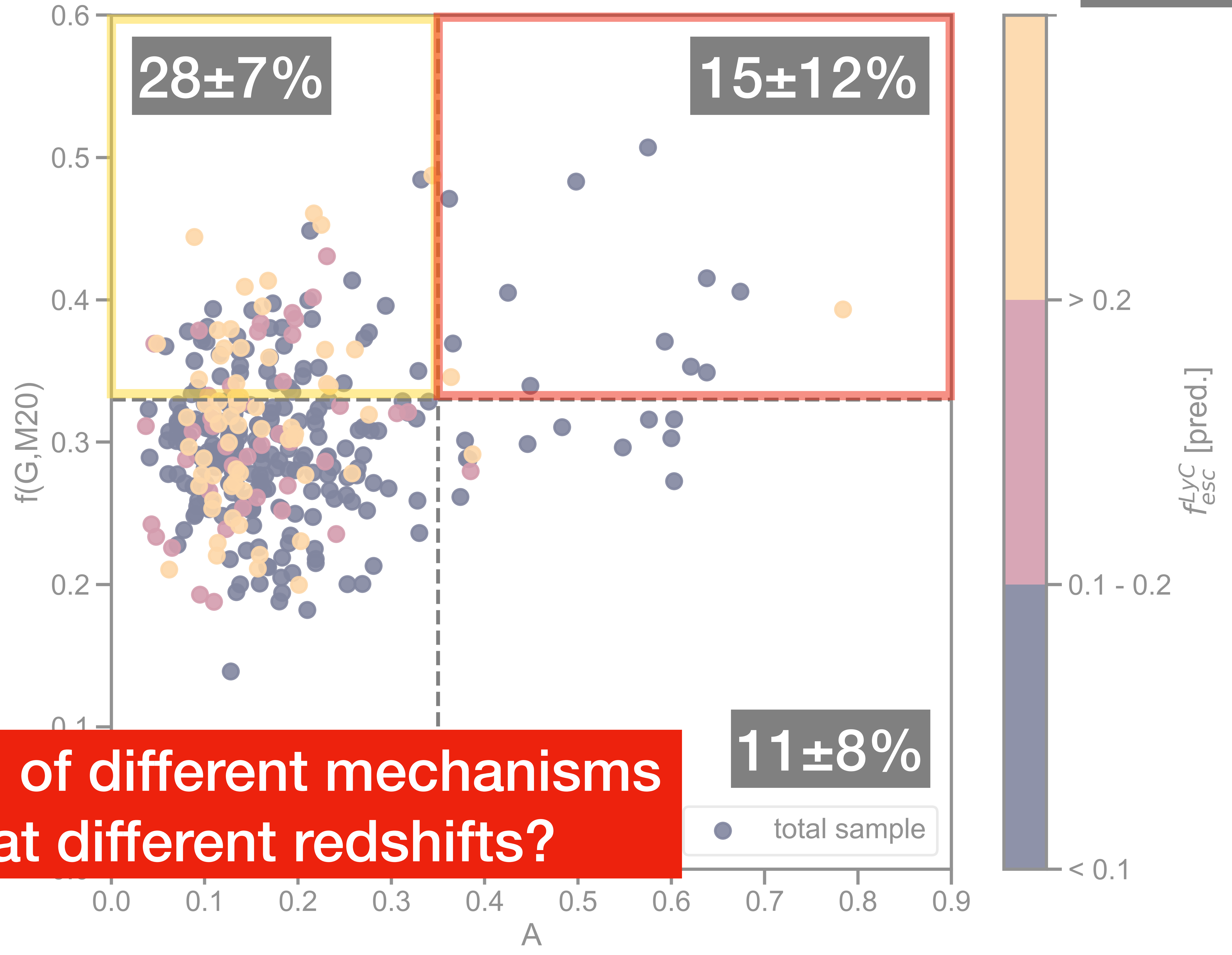


Mascia+24(in prep.)

Mergers and f_{esc} during the EoR

$$n\,\% = \frac{N_{gal}[f_{esc} \geq 0.2]}{N_{gal,TOT}}$$

The candidate leakers (f_{esc}>0.2) are evenly distributed in the f,A space



Is this an indication of different mechanisms of LyC escape at different redshifts?

Mascia+24(in prep.)

Key aspects we need to improve upon:

- Increase the sample of known leakers at low and intermediate redshift, and measure their physical and spectroscopic properties to infer diagnostics
- Refine the prediction models for escape fraction from the low and intermediate redshift leakers
- Use simulations to drive the interpretation of the multivariate diagnostics

Thank you!