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Physical properties of extreme emission-line galaxies at z~4-9 from the JWST CEERS survey

Mario Llerena

Postdoc INAF-OAR

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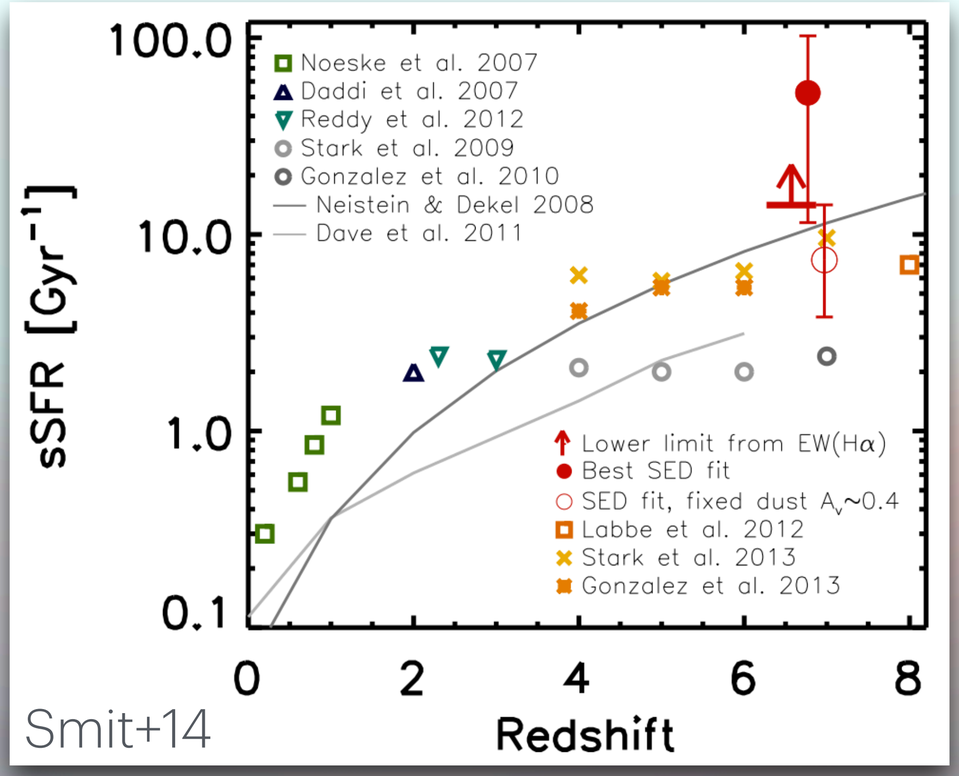
Cosmic Dawn at High Latitudes

Extreme emission-line galaxies (EELGs)

Strong star formation events.

High equivalent widths (EWs) driven by elevated specific star formation rates (sSFRs) up to 10-100 Gyr^{-1}

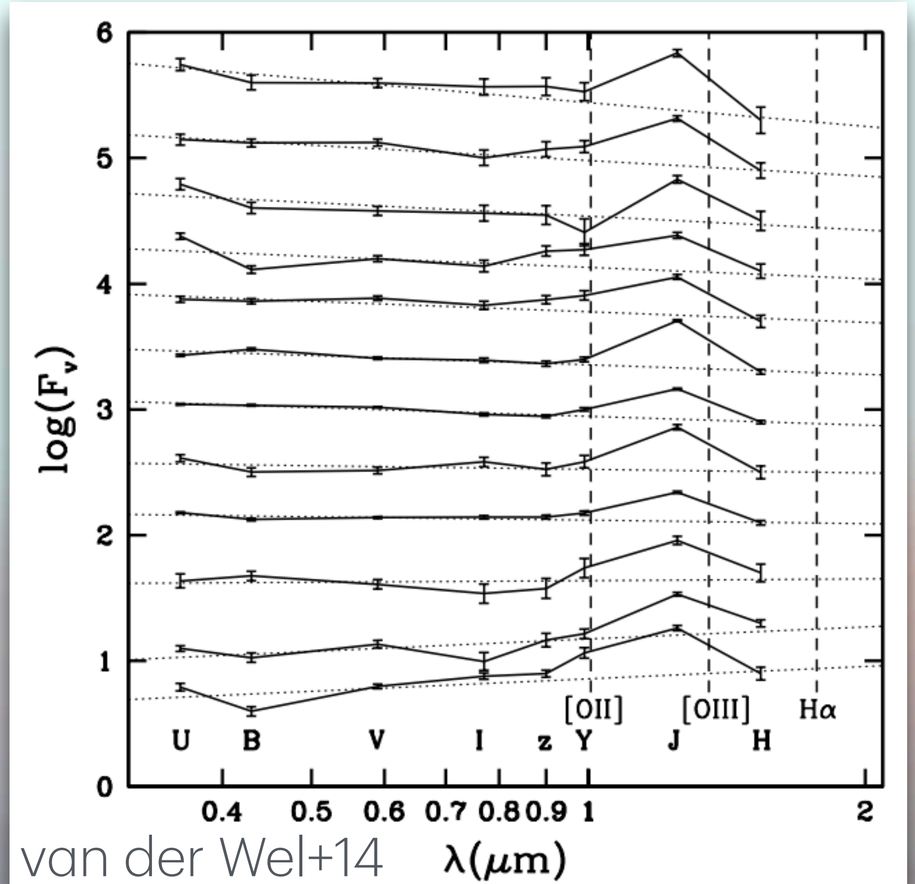
Galaxies with stellar masses $\lesssim 10^9 M_{sun}$, with subsolar metallicities and little dust (van der Wel+11, Maseda+14, Amorin+15, Forrest+17)



In large numbers, main contributors to reionization of the IGM

Extreme emission-line galaxies (EELGs)

Many of the searches for EELGs select samples using either **narrow**- (e.g. Sobral+2013; Iglesias-Páramo+2022;Lumbreras-Calle+2022) **broad**- (e.g. van der Wel+2011;Onodera+2020; Kojima+2020; Chen+2023; Davis+2023) or **medium**-band photometry (e.g. Cohn+2018;Withers+2023; Simmonds+2023), and **slitless** spectroscopy (e.g. Maseda+2018; Kashino+2023).



van der Wel+14

Large samples to understand their physical properties

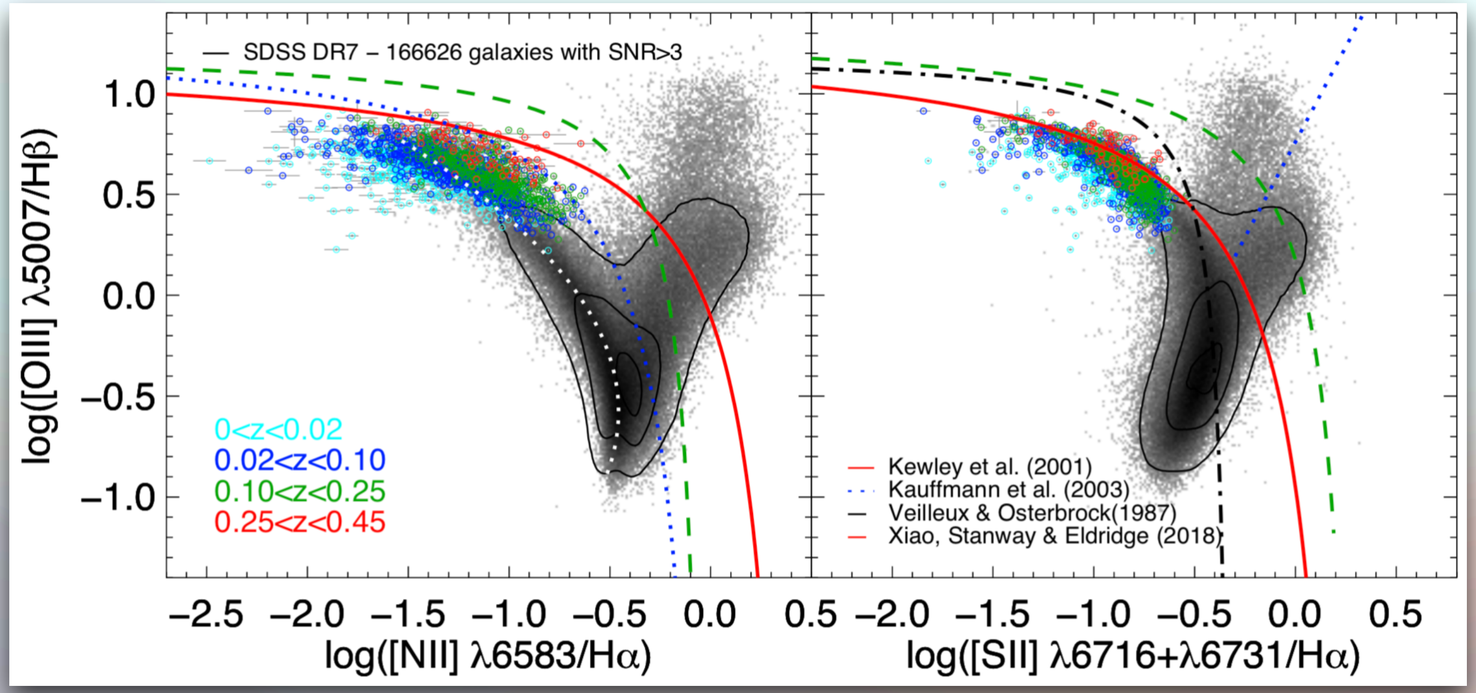
Empirical templates

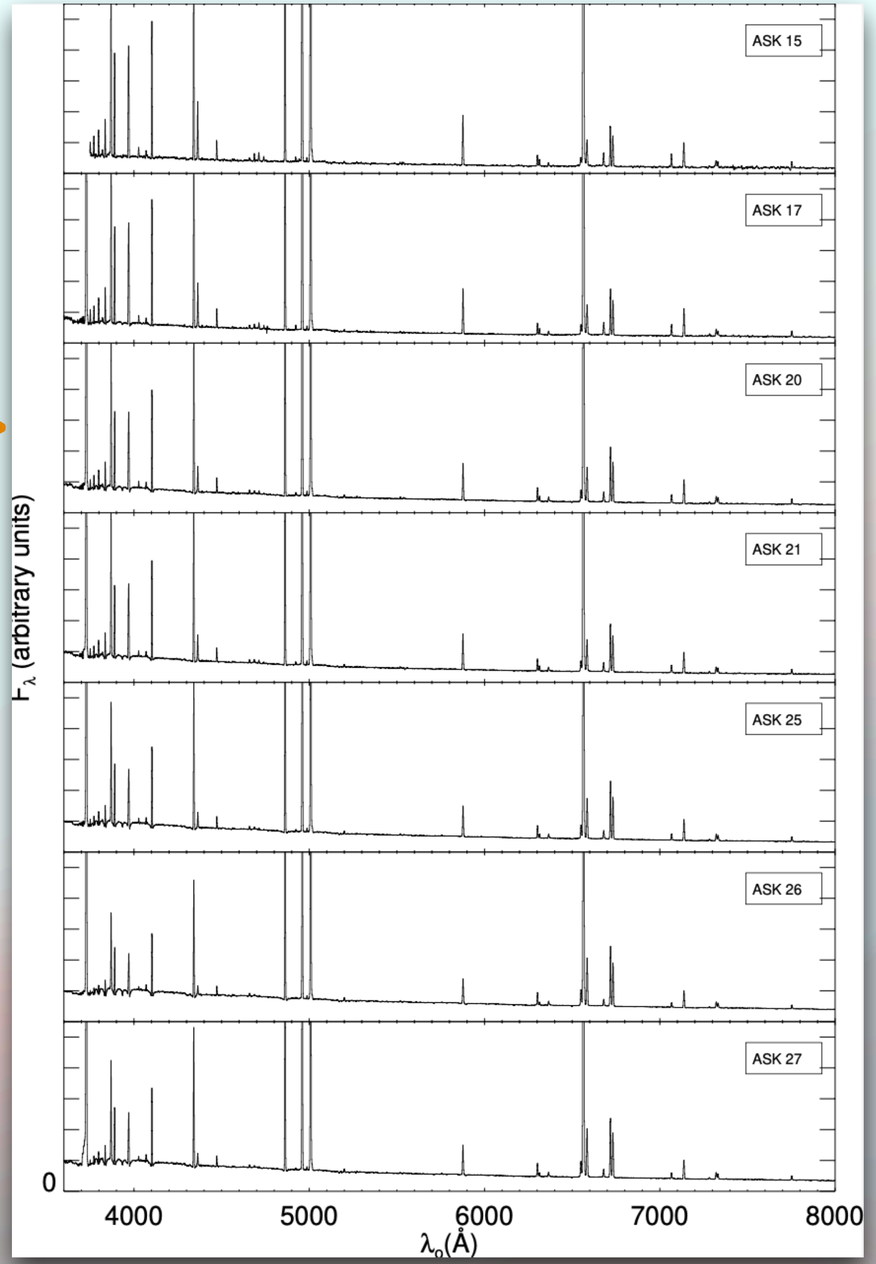
Synthetic NIRCam observations

Automated Spectroscopic K-means-based (ASK) classes presented in Sanchez-Almeida+2010.

~one-million SDSS-DR7 galaxies with an apparent magnitude brighter than 17.8 can be classified in only 28 ASK classes based exclusively on the features and shape of their rest-frame

1% in 11 minor classes: metal-poor starbursts





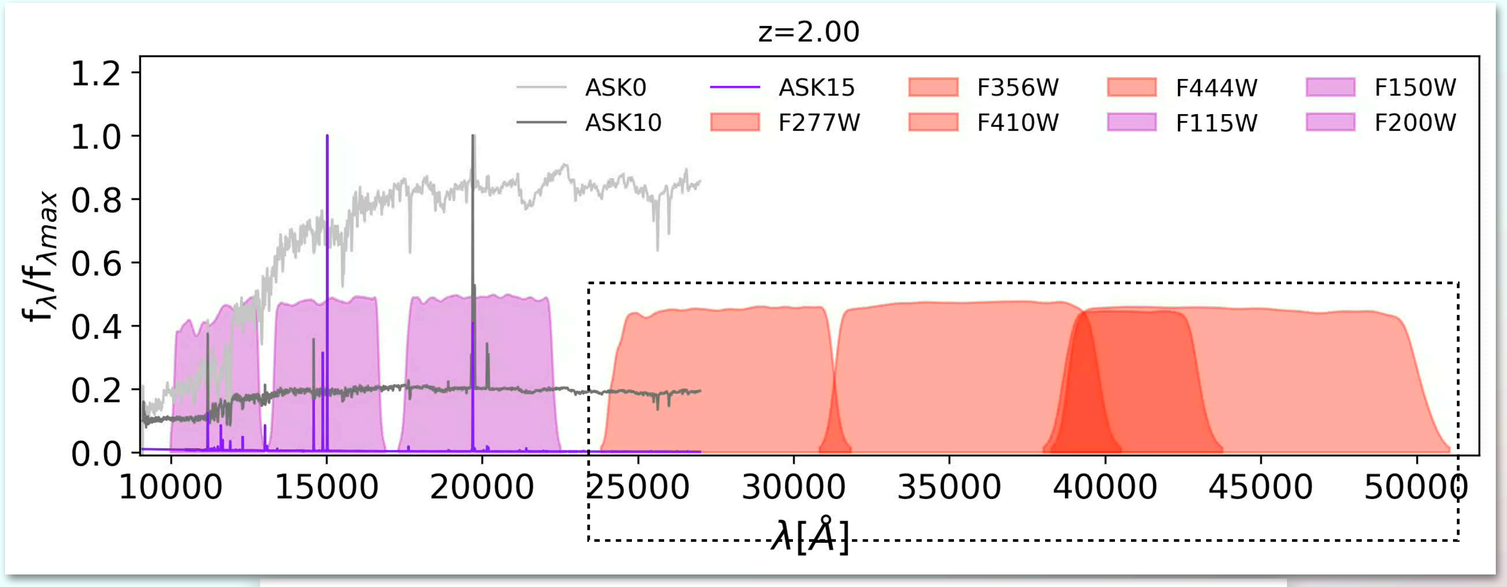
~1900 EELGs presented in Pérez-Montero+21

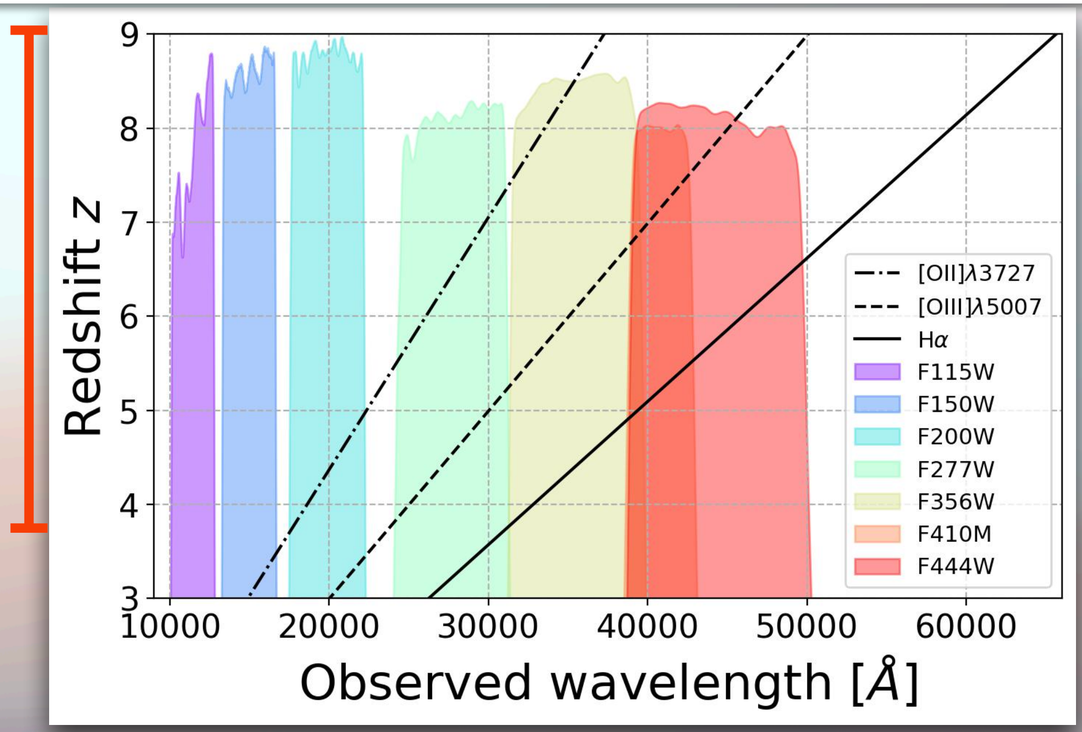
Synthetic NIRCam observations

1% in minor classes: metal-poor starbursts

ASK class	EW(Hβ) Å	EW([OIII]) Å	EW(Hα) Å
15	169.6	1097.9	918.3
17	144.9	874.3	782.3
20	92.3	496.2	484.9
21	85.9	460.1	457.5
25	63.9	298.1	334.4
26	45.1	172.8	232.0
27	57.4	234.1	302.4

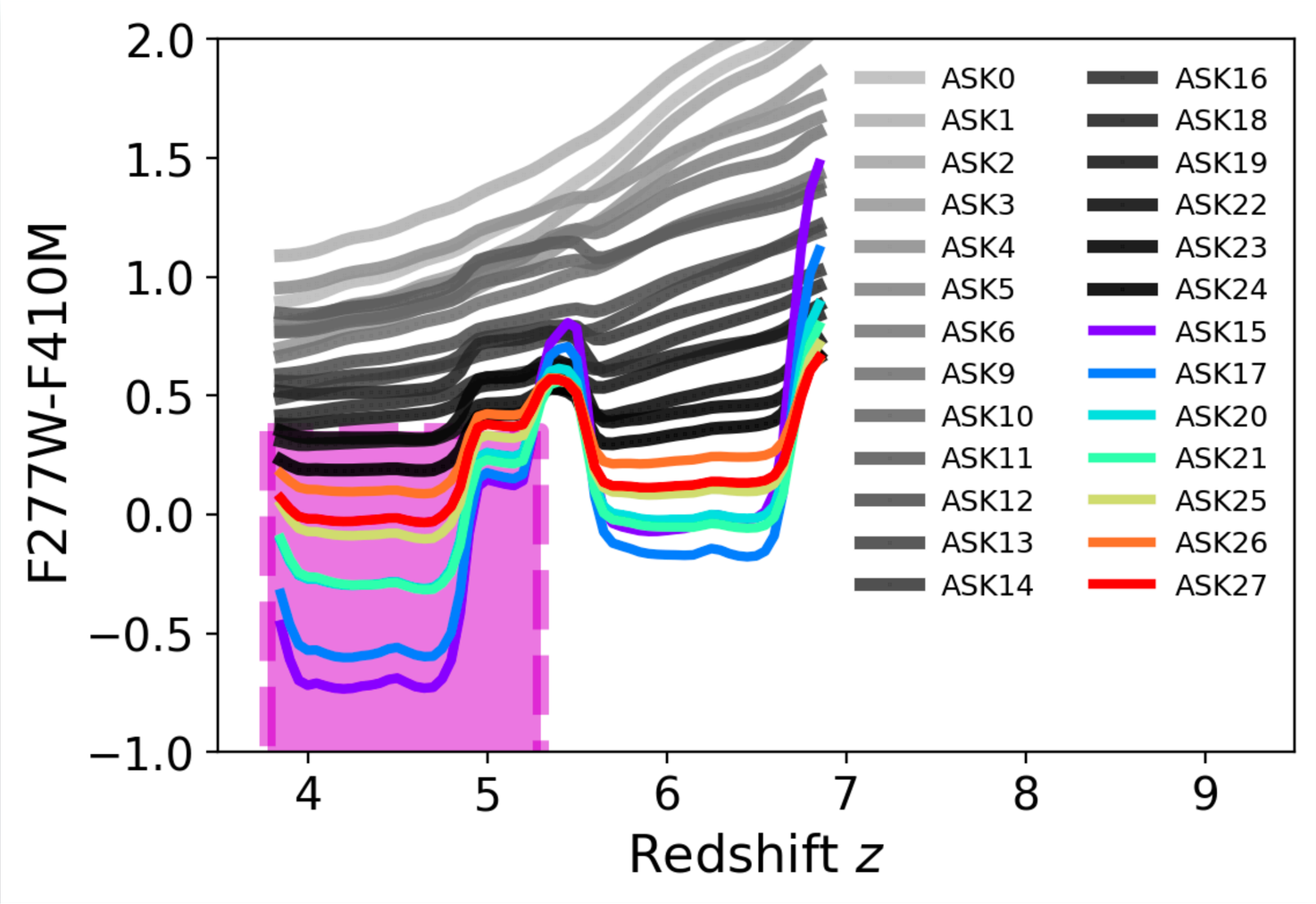
Templates ASK 15, 17, 20, 21: with EW([OIII])>460A

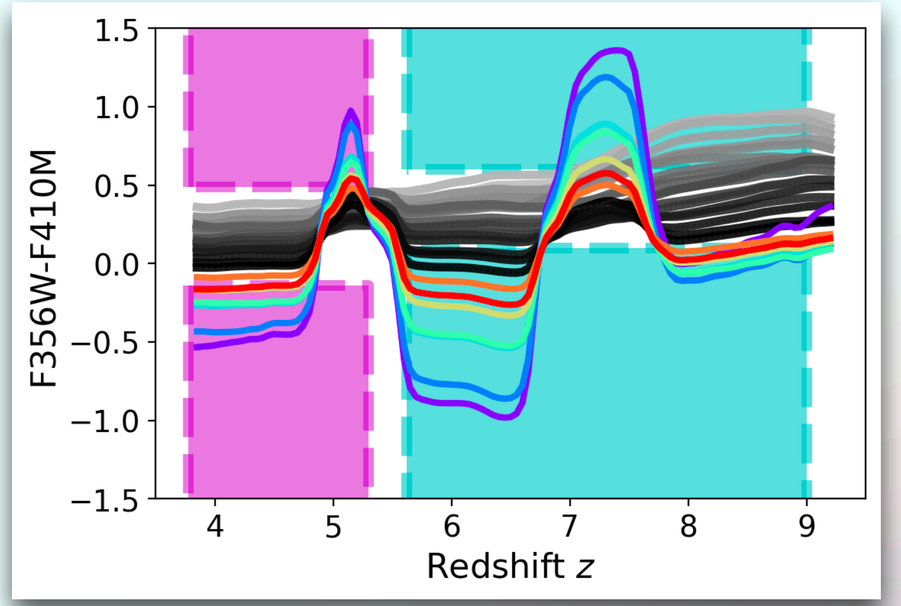


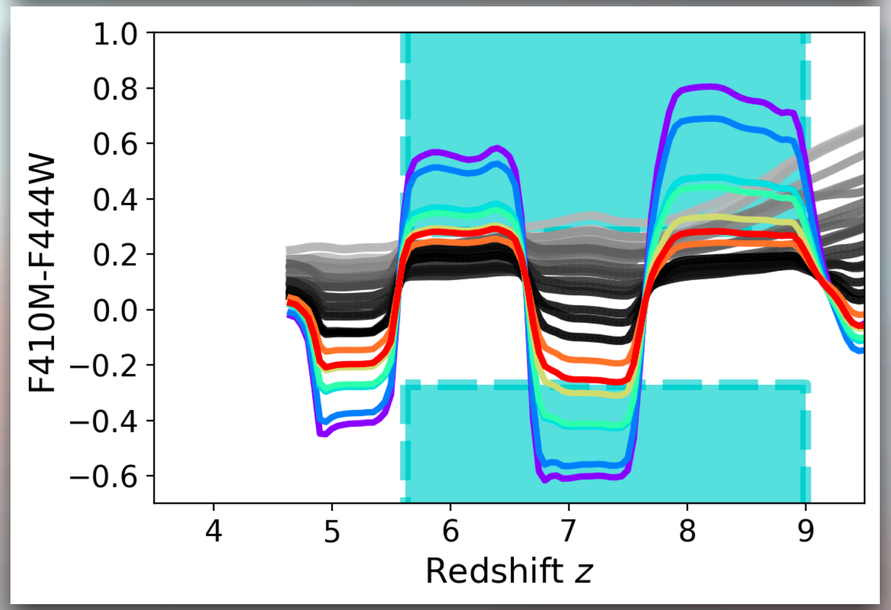


Color-Color diagrams

3.8<z<9.0: photo-zs from photometric catalogs





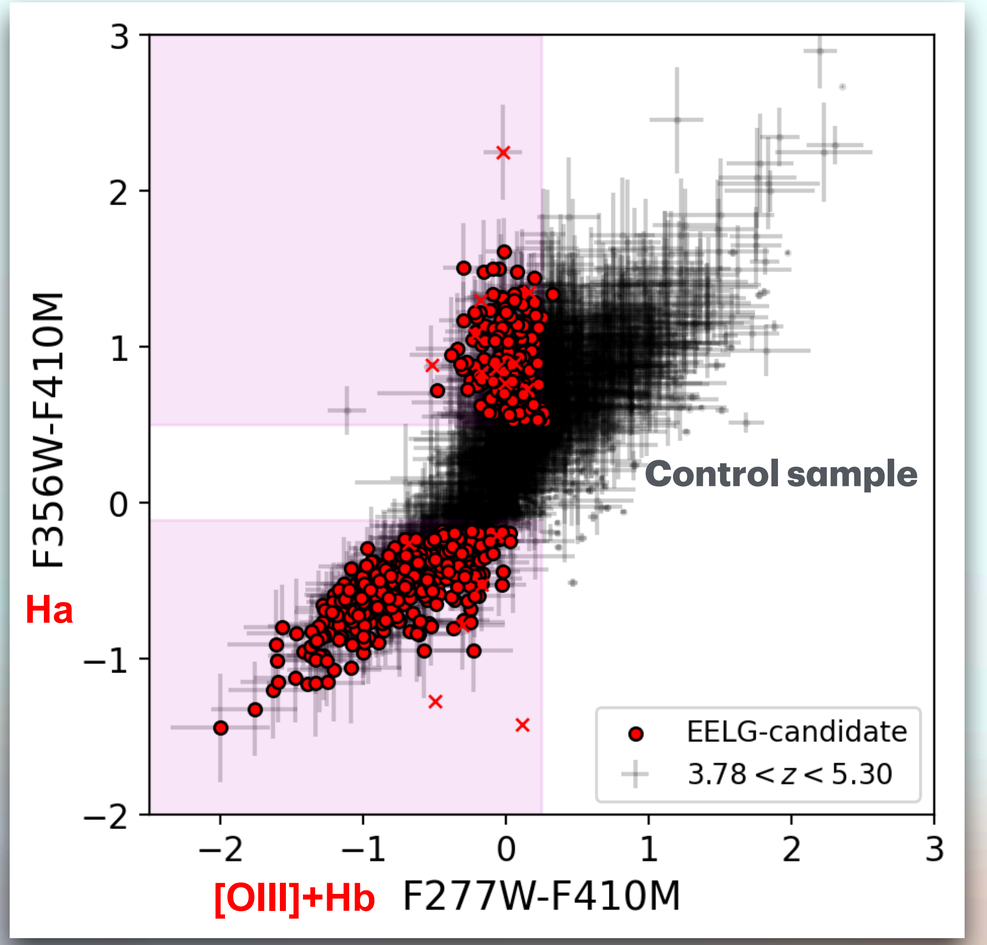


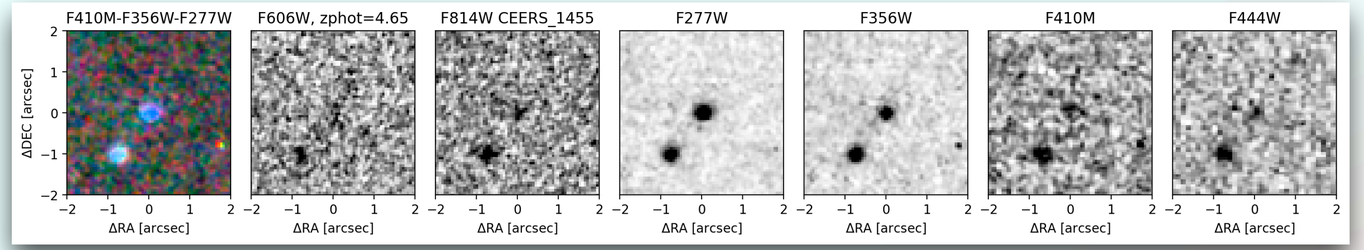
EELG candidates

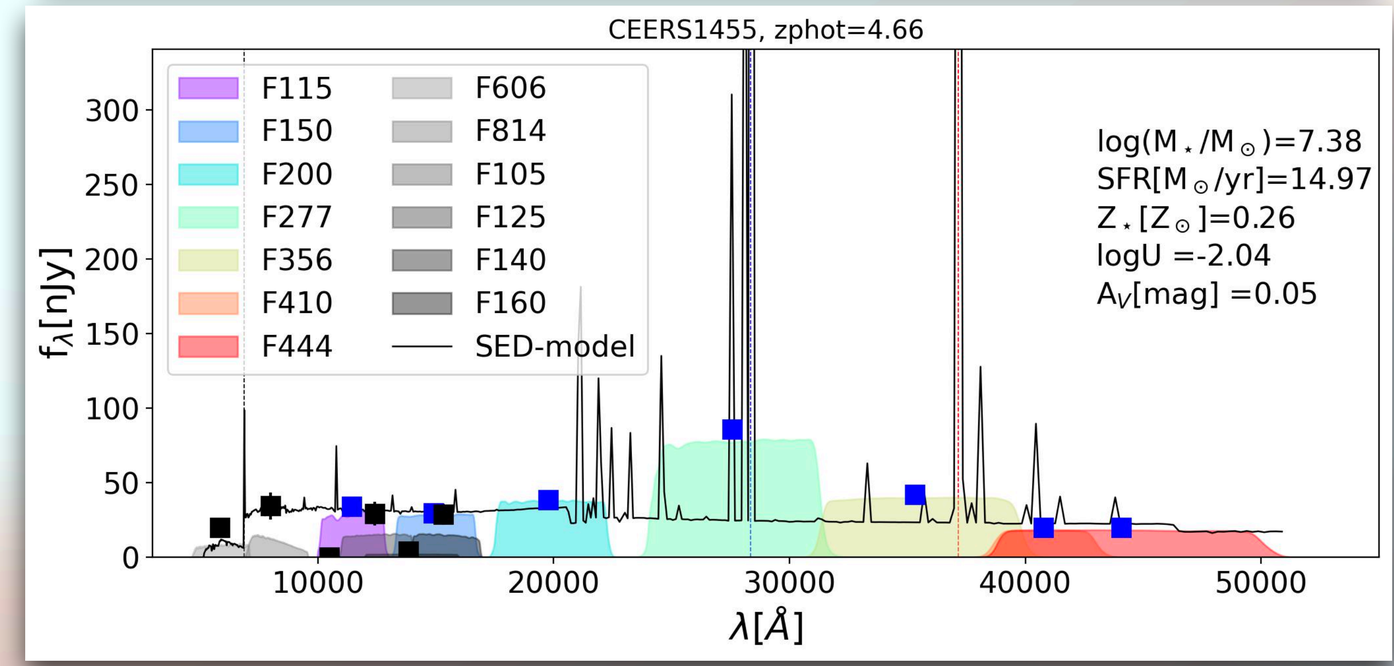
S/N>3

P(z>3)>50% (EAZY fit)

3.78<z<5.3







CEERS photometric catalogs v0.51.2
(Finkelstein et al. in prep.)

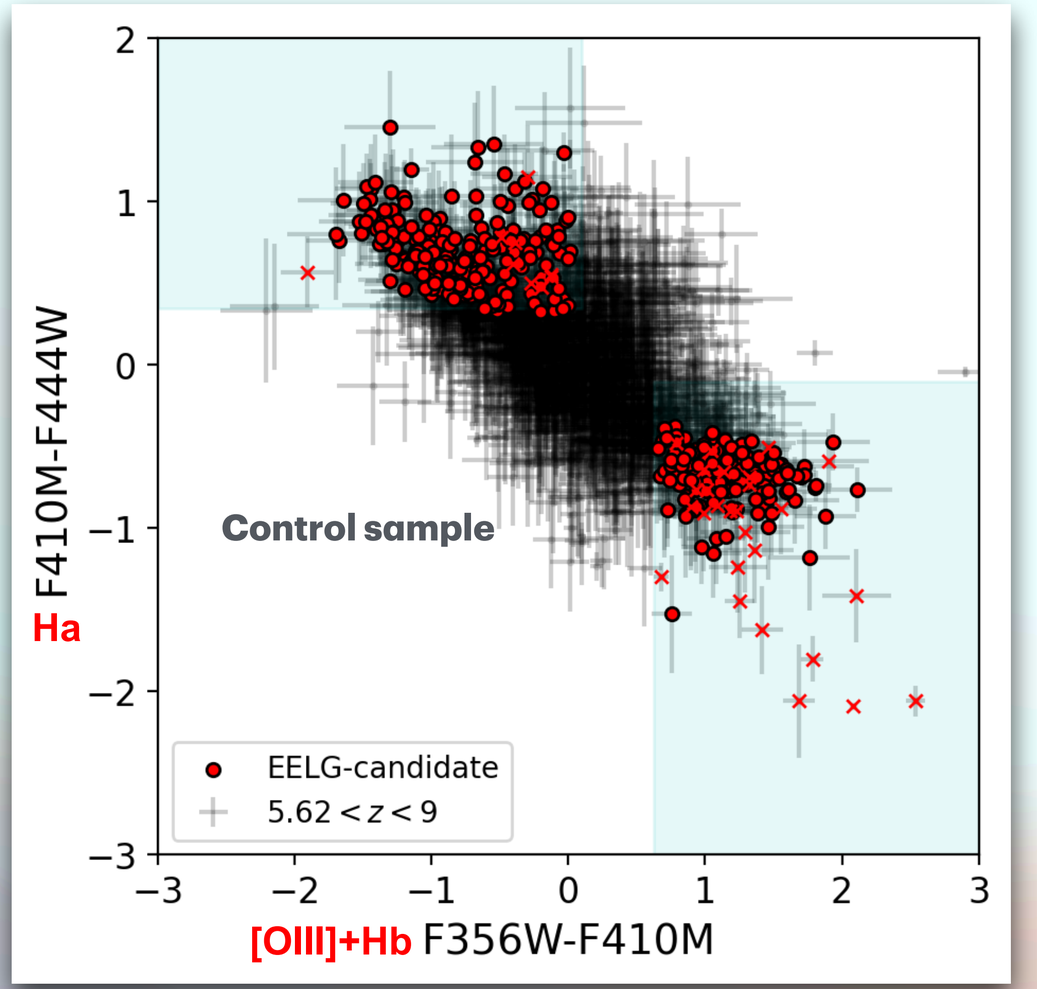
634 galaxies (~15%)

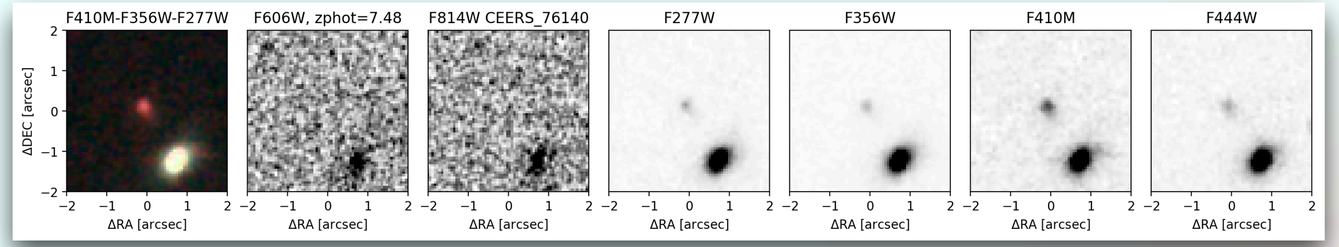
EELG candidates

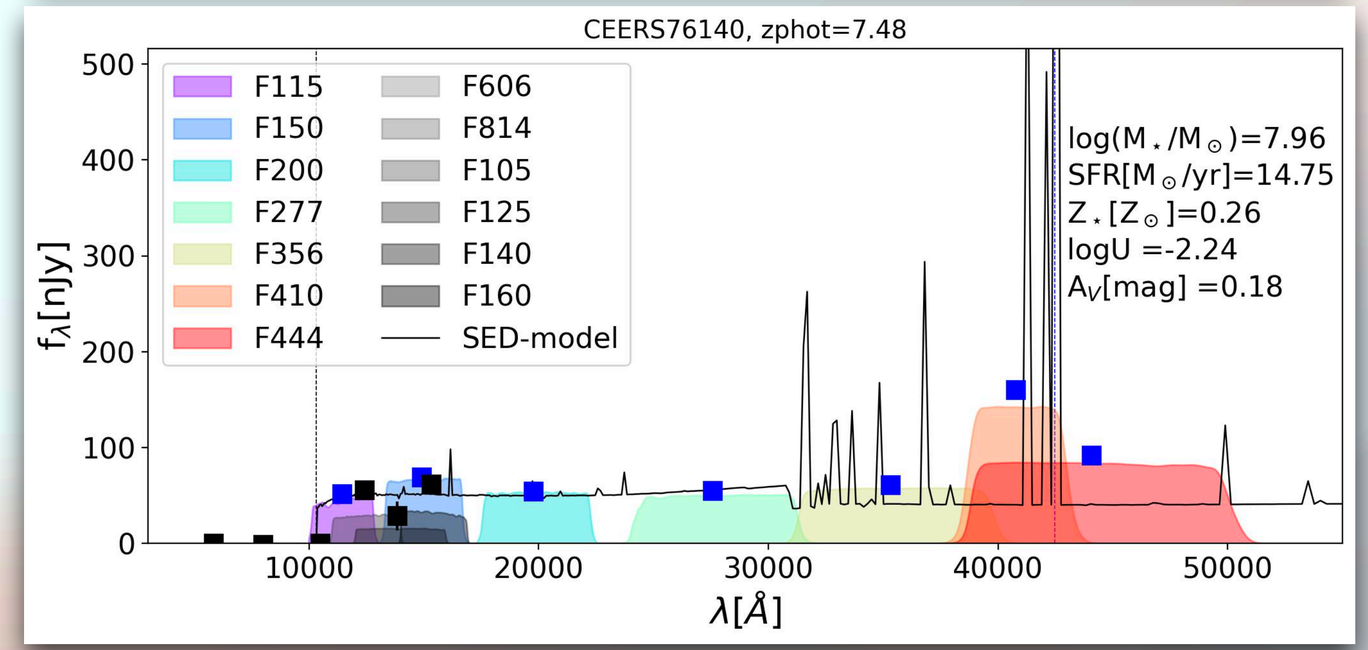
S/N>3

P(z>3)>50% (EAZY fit)

5.6<z<9







CEERS photometric catalogs v0.51.2
(Finkelstein et al. in prep.)

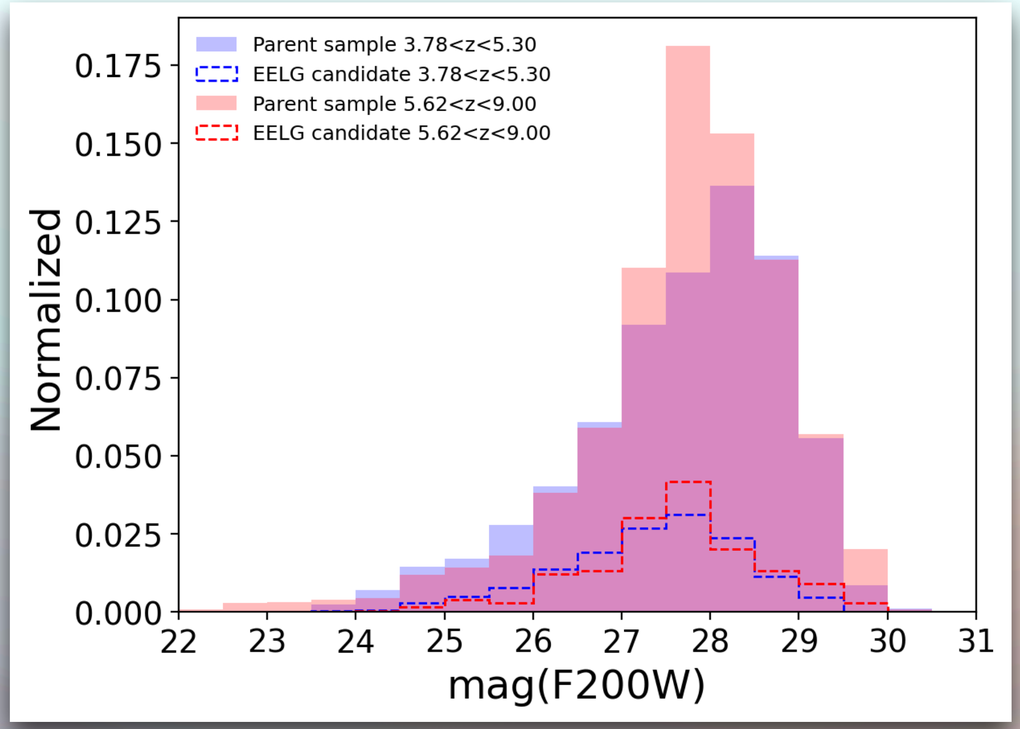
420 galaxies (~17%)

EELG candidates

By visual inspection, we clean the sample for saturated pixels, close to the edge galaxies.

Our final sample is made of 736 EELG candidates.

The control sample is made of ~1500 galaxies.



The cut in S/N implies a cut in mag<29-30

No bias compared with the parent samples

Morphology

R: F410M

G: F356W

B: F277W

Compact, isolated

Morphology

R: F410M

G: F356W

B: F277W

Interacting systems

Morphology

R: F410M

G: F356W

B: F277W

Clumpy/Chains of clumps

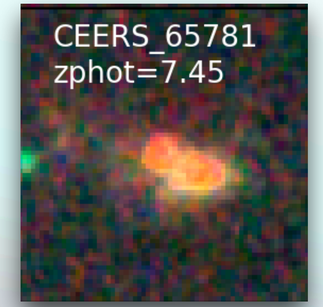
Morphology

R: F410M

G: F356W

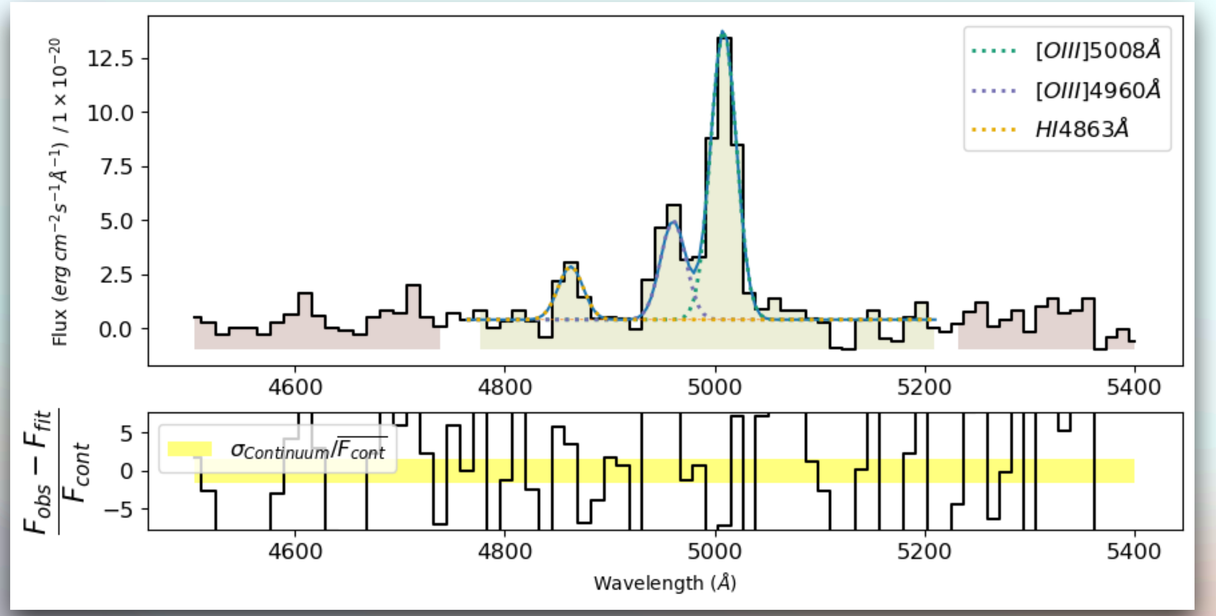
B: F277W

Major mergers

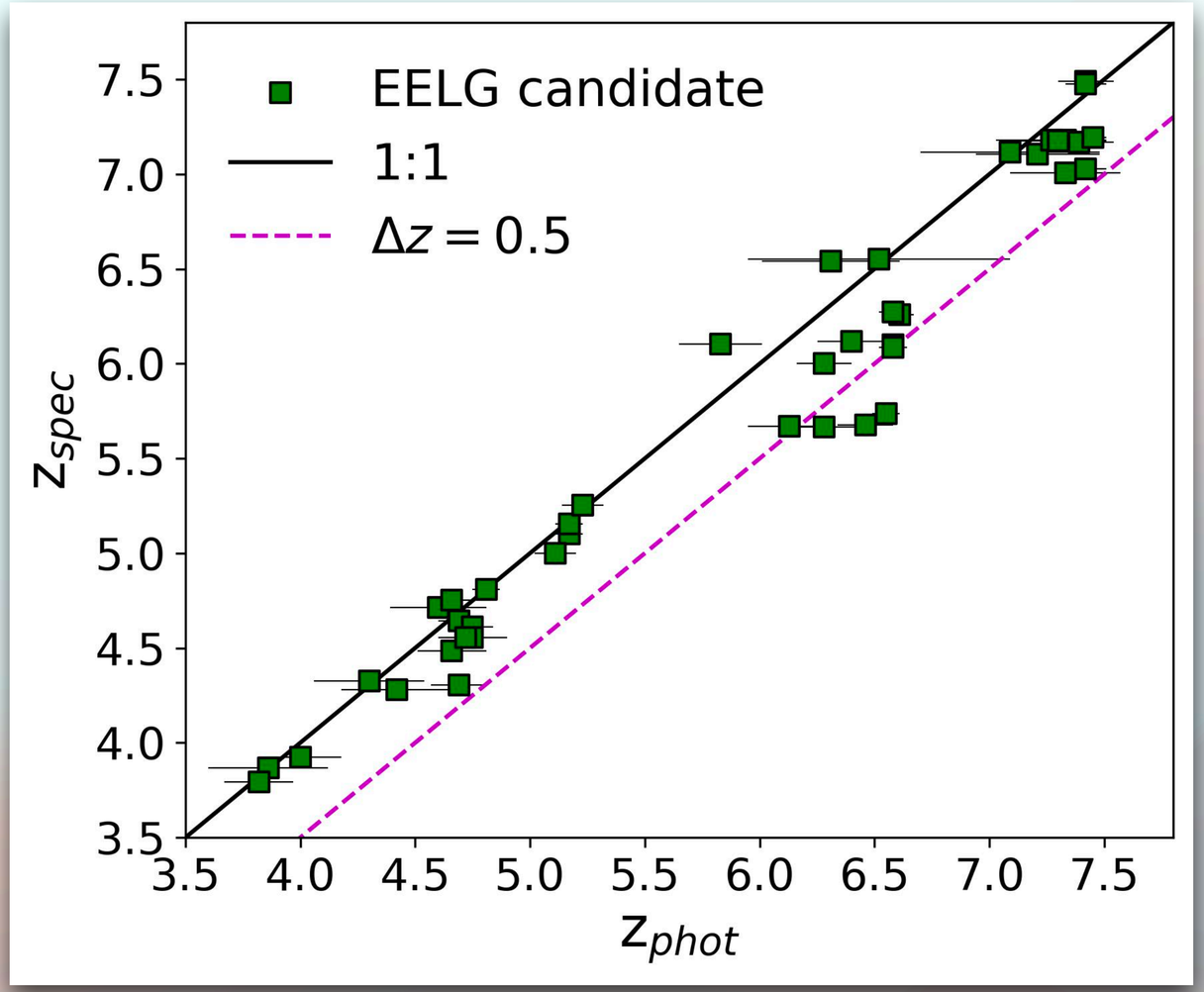


Validation of the selection

47 galaxies with NIRSpec observation -Prism or GM-
Arrabal Haro et al. (in prep)

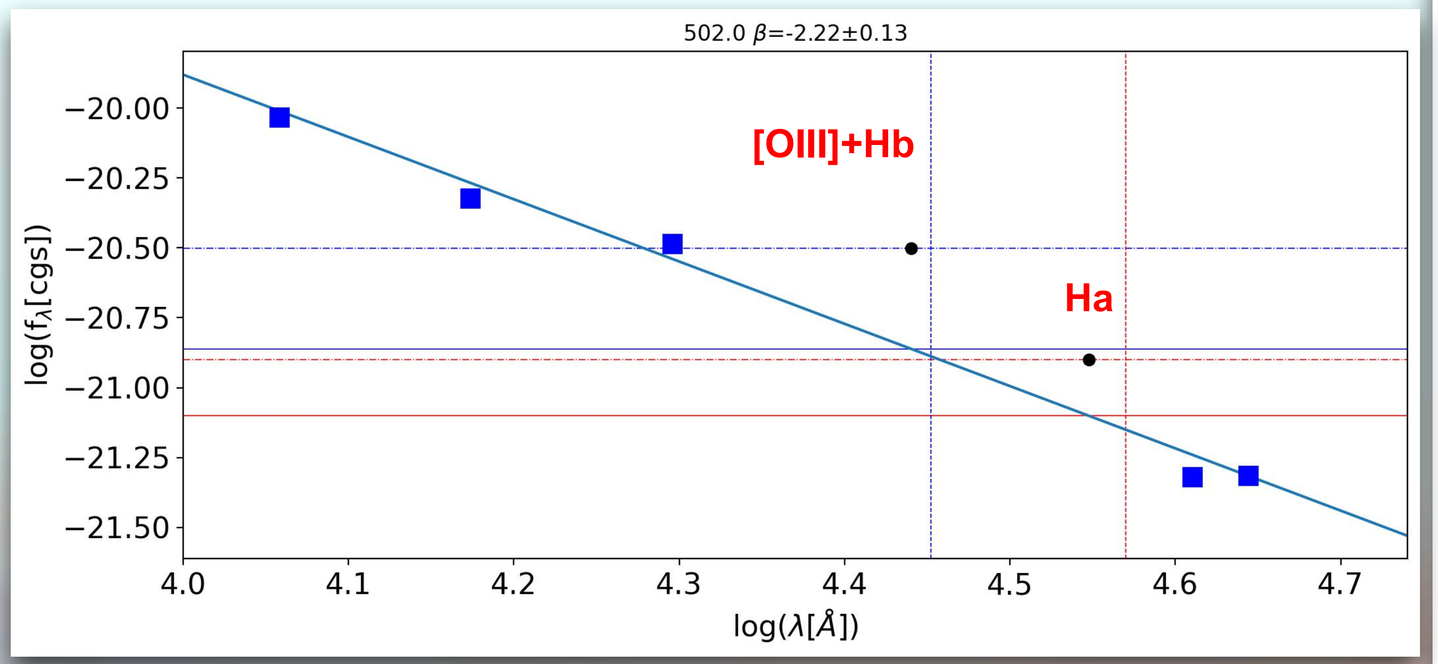


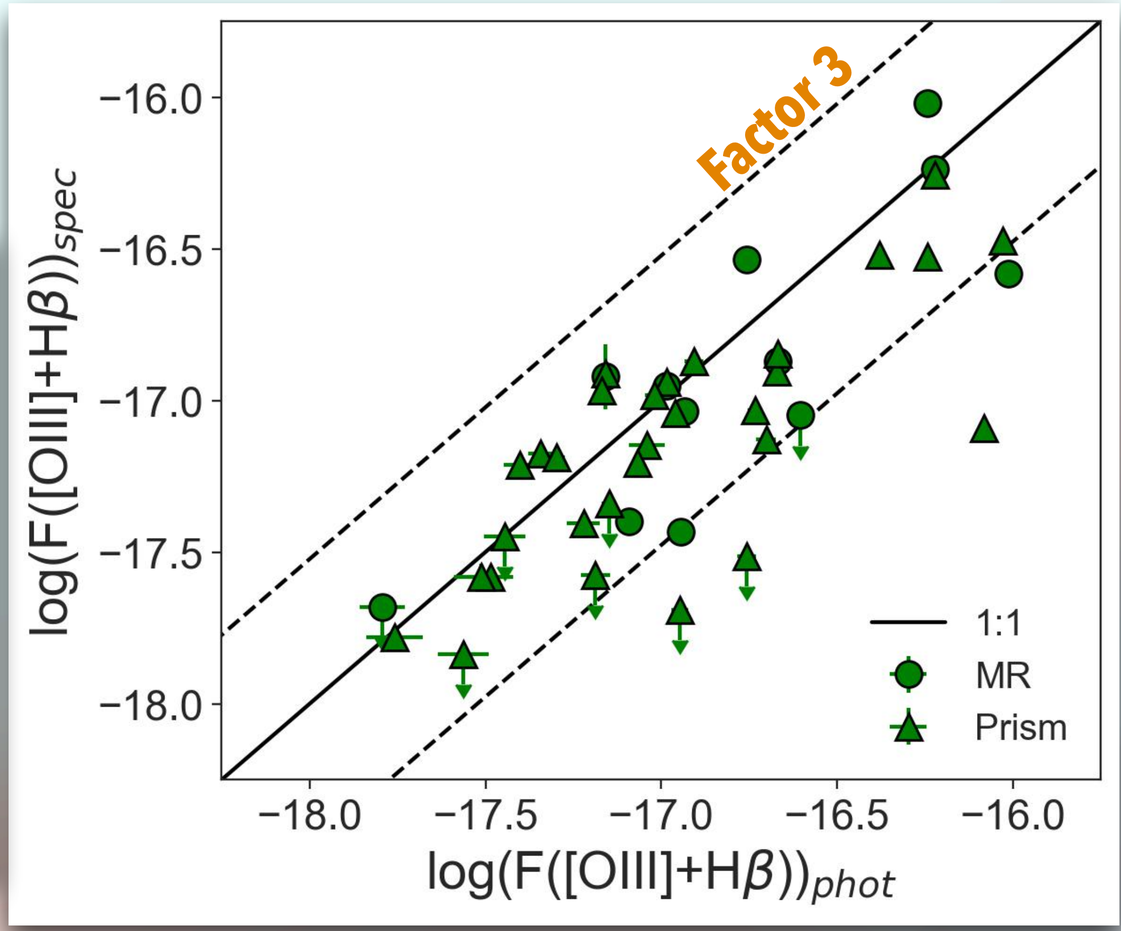
LiMe (Fernández+23)
https://ceers-data.streamlit.app/



Validation of the selection

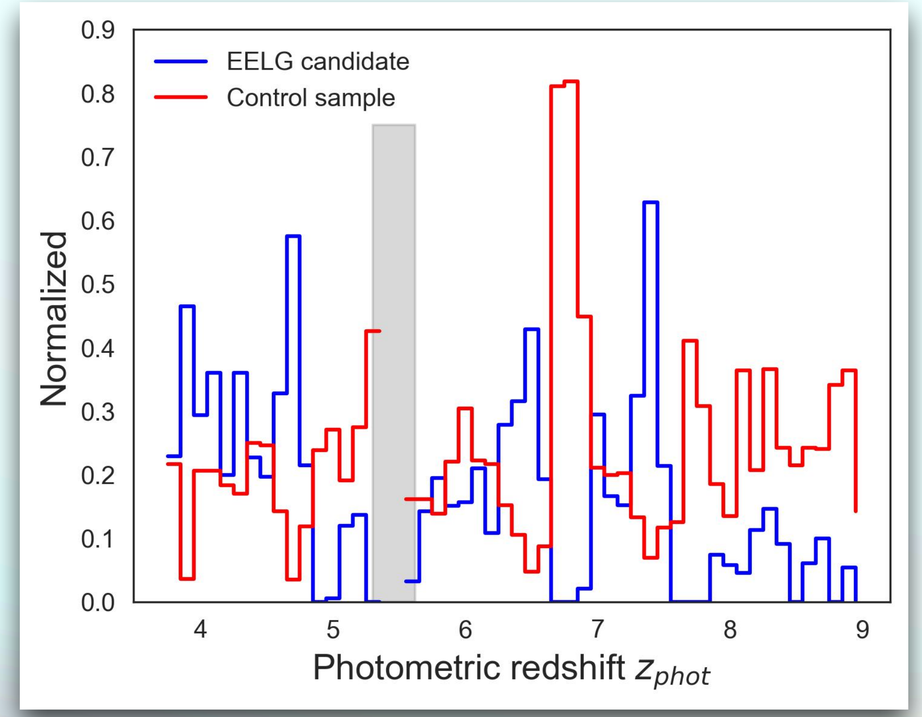
Photometric fluxes



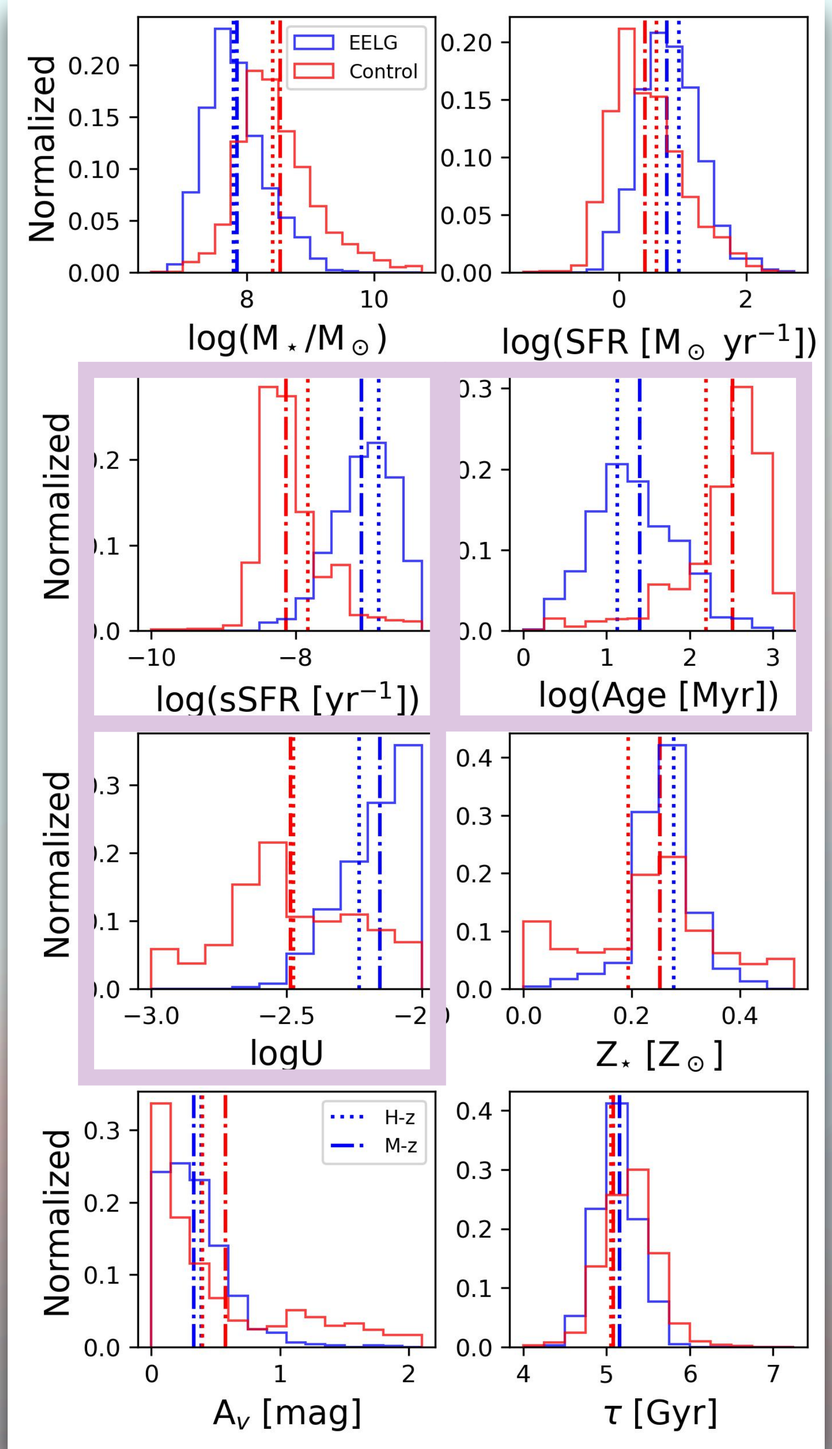


Differences due to: Overestimation of photometric fluxes, slit loss, flux calibration

Properties of EELG candidates (SED fitting)



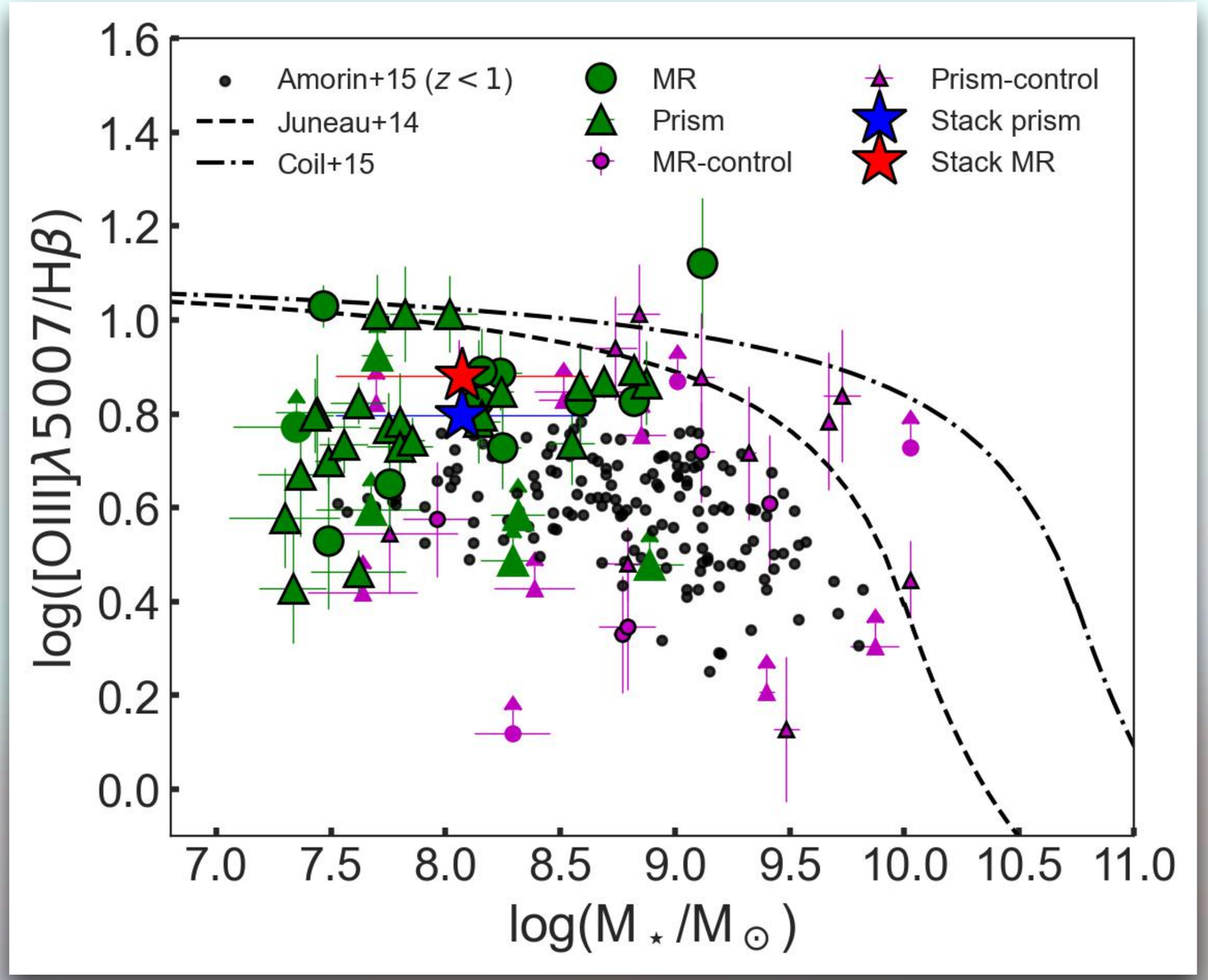
BAGPIPES: JWST photometry assuming delayed τ-model for the SFH



Similar underlying stellar population but younger starburst

Ionization source

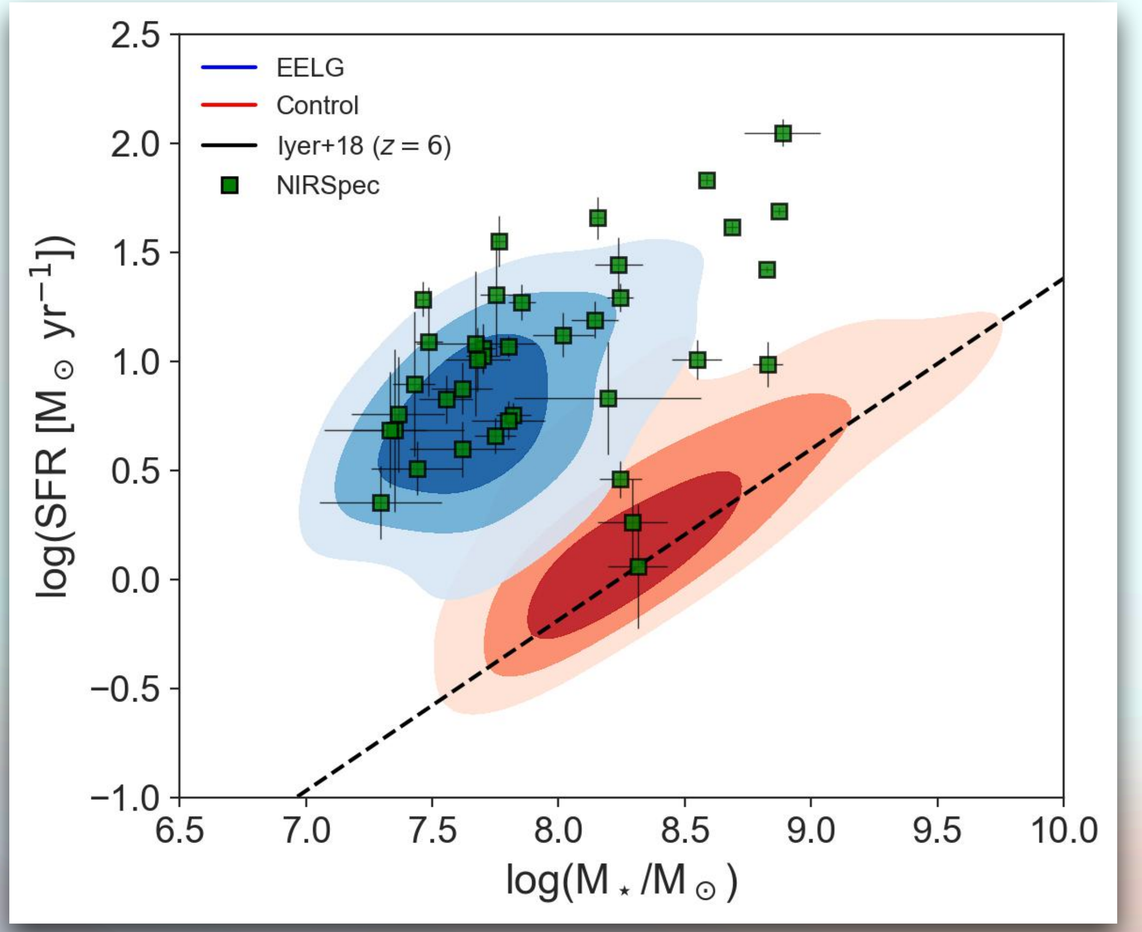
Spectroscopically observed sample



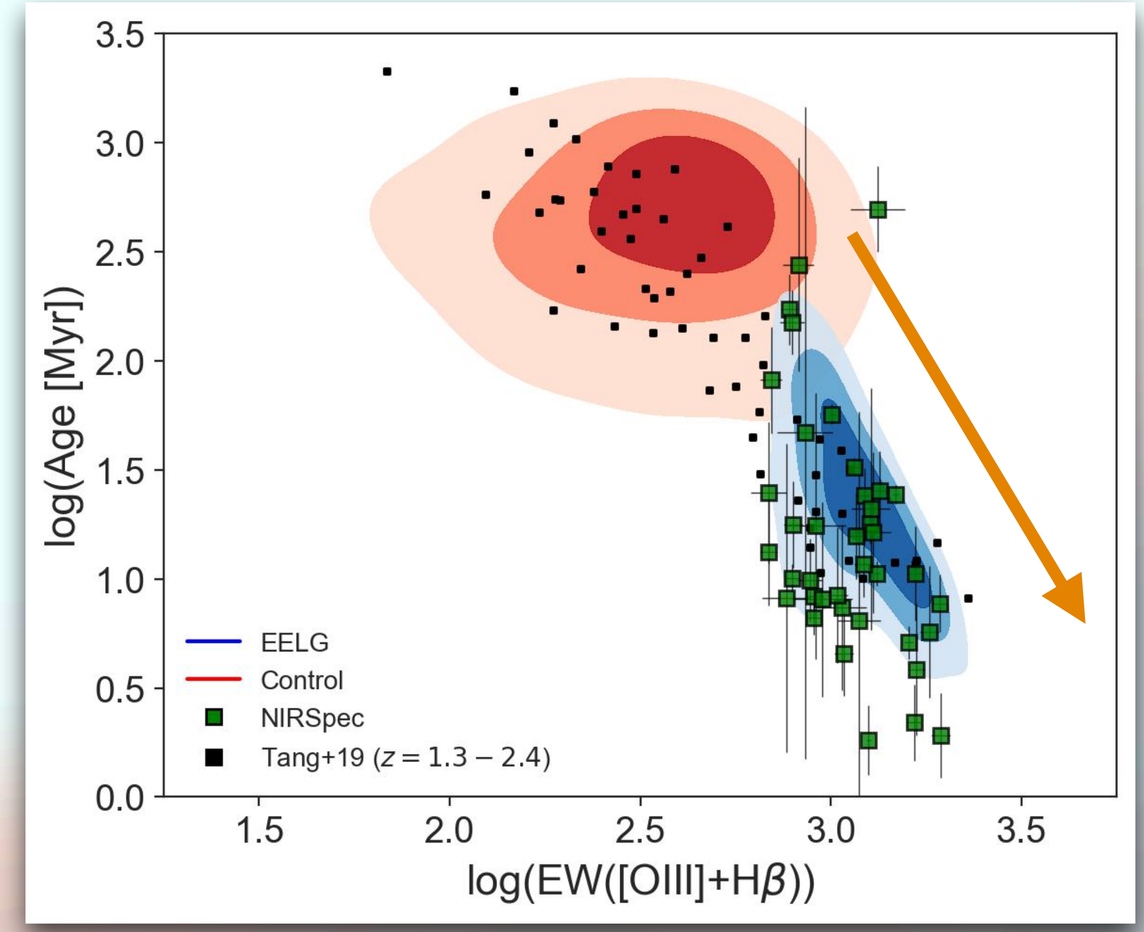
[OIII]/Hb~7

We can not rule out non-thermal sources for the entire sample

Young starbursts



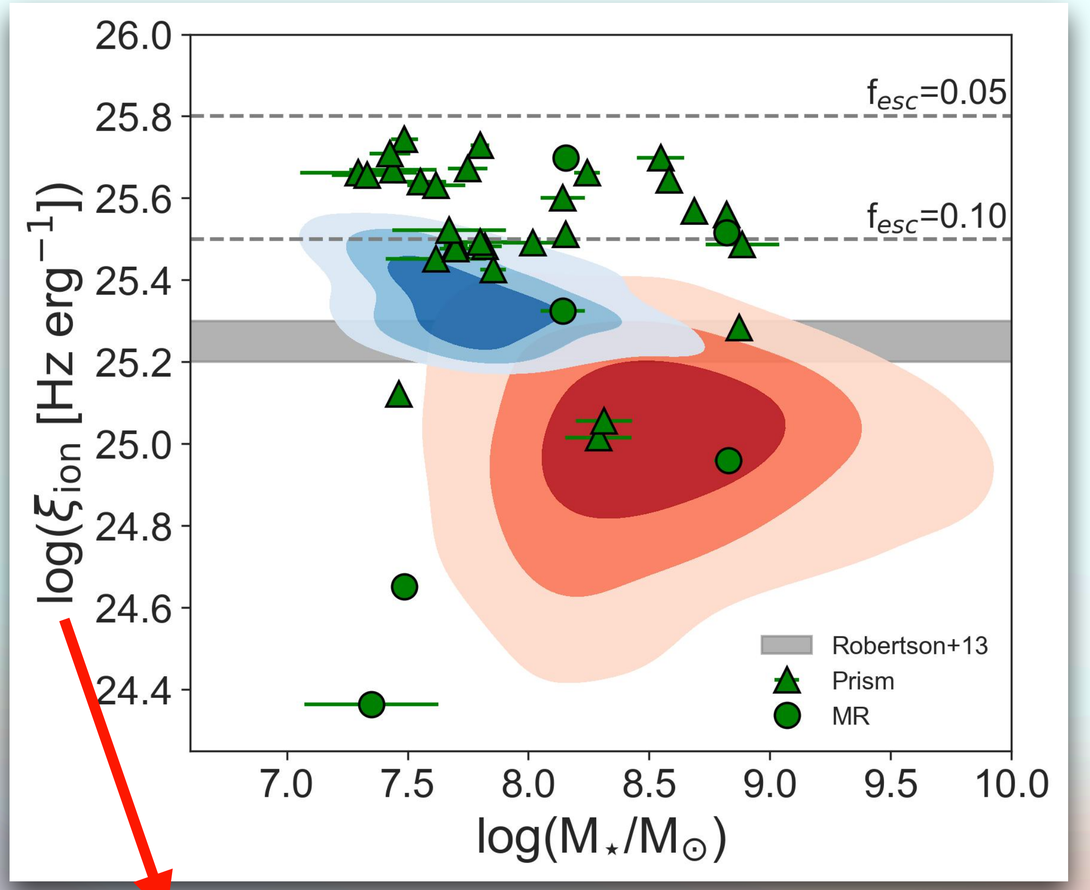
Above the main-sequence



Younger ages than the control sample

Escape of ionizing photons

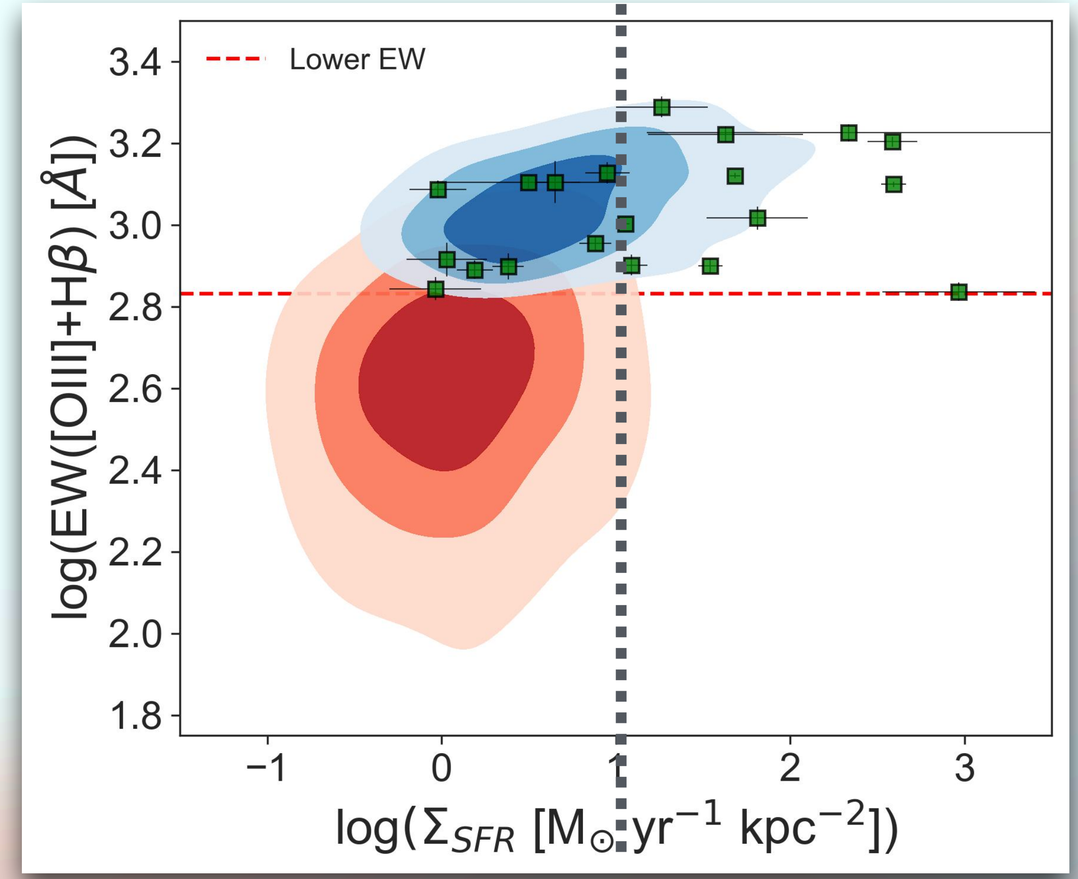
Mean EW([OIII]+Hb)~1000A



Chevallard+18, Tang+19

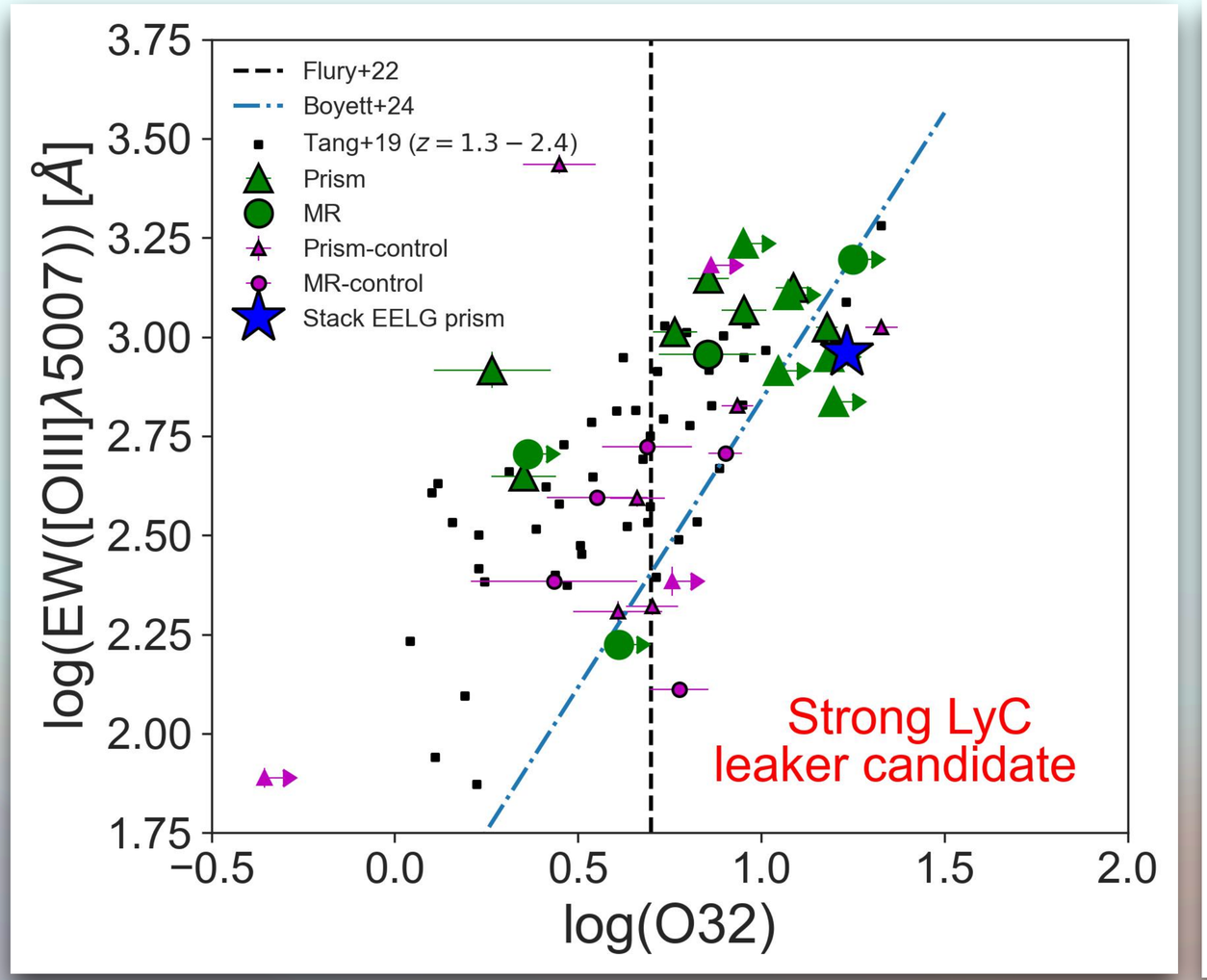
Half of EELGs shows higher values than range of canonical

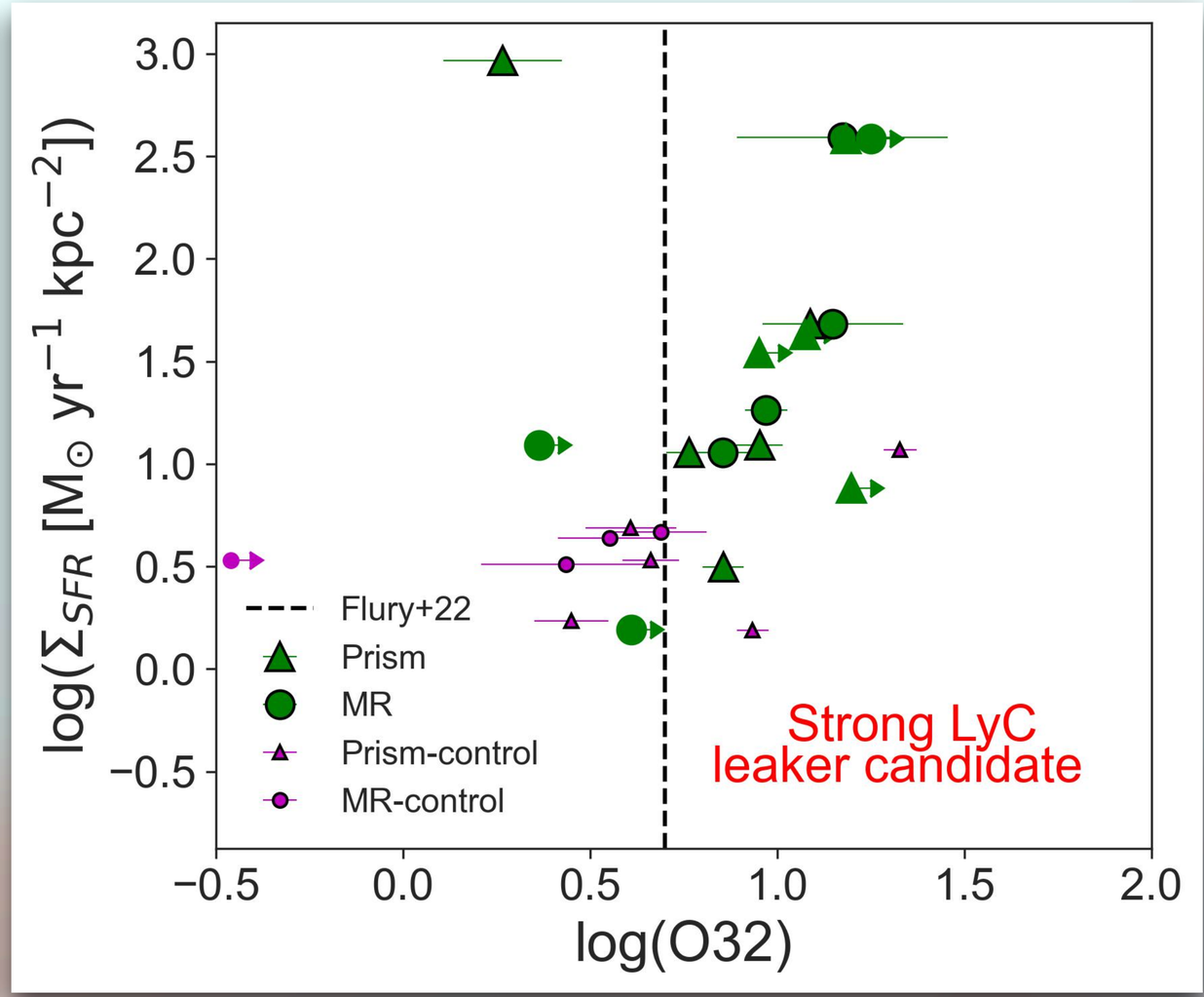
Flury+22: Higher fraction of LyC leakers



Higher EWs and concentrated SFR have the conditions that should facilitate the escape of LyC photons

Escape of ionizing photons





Summary

arXiv: 2403.05362

We use the broad-band filters F277W, F356W, and F444W and the medium-band filter F410M to select EELGs at z~4-9. We selected a sample of 736 candidates. 47 of them have already NIRSpec spectra. We define a control sample to compare the properties with the sample of EELGs. We use BAGPIPES to estimate their physical properties.We also use the F277W filter to estimate the physical size of the young stellar populations.

- Low mass, with high sSFRs and a mean age of 50Myr
- The larger differences are in the sSFR, ages and ionization parameter compared with control sample. This suggests they may have similar underlying stellar populations.
- Metal-poor starburst with high log([OIII]/Hbeta)~0.4-1 which indicates that star-formation may be the dominant source of ionization in these galaxies.
- Indirect LyC indicators (O32, SFR surface density) indicate they may have the conditions to facilitate the escape of ionizing photons.

Thanks!

RGB images

R: F410M

G: F356W

B: F277W

Blueish galaxies are at z~3.78-4.82 where [OIII] falls in F277W and Ha in F356W.

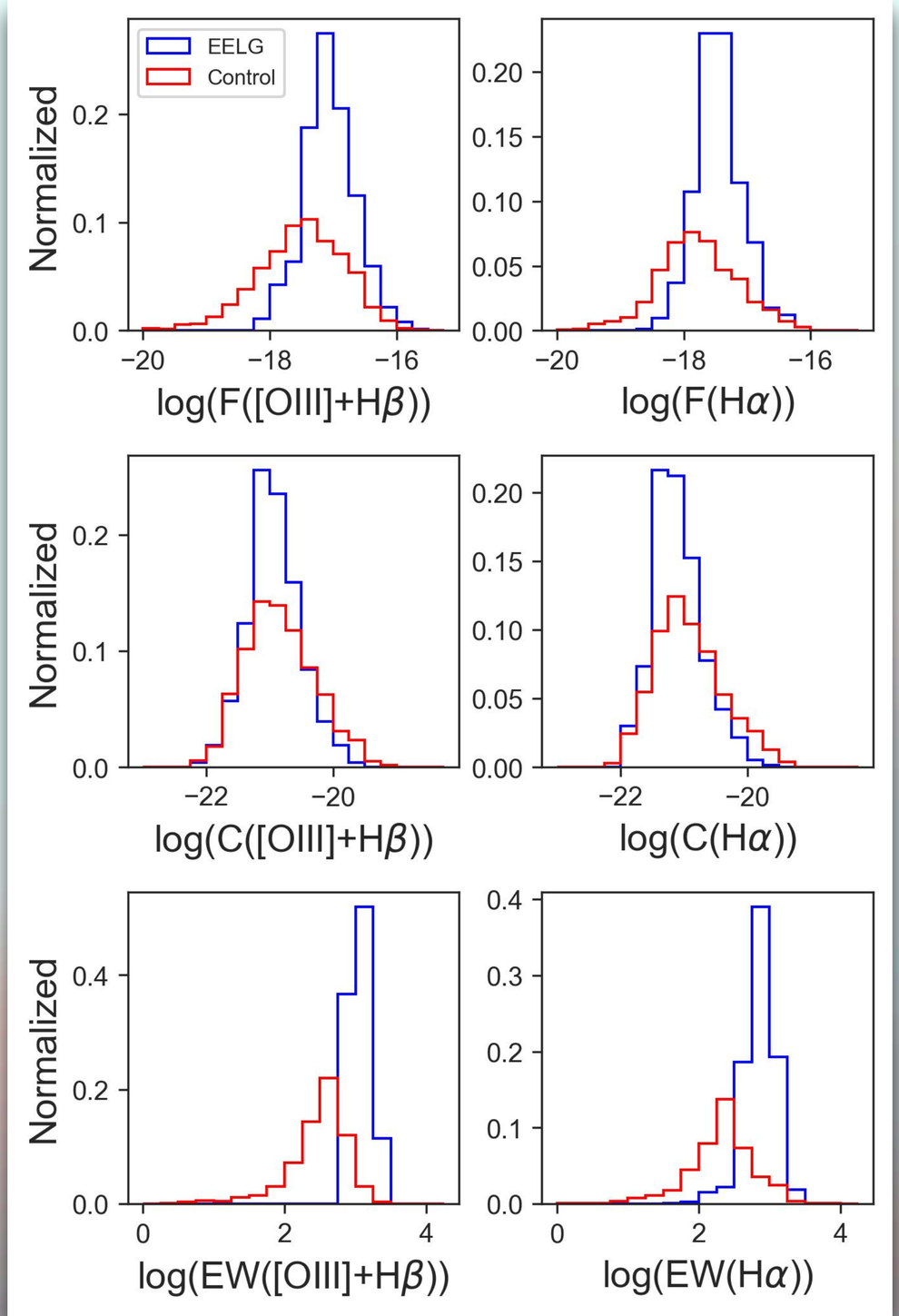
The colors in RGB images are associated with redshift ranges where bright emission lines fall within filters.

Redish galaxies are at z~ 6.63-7.68 where [OIII] falls in F410M.

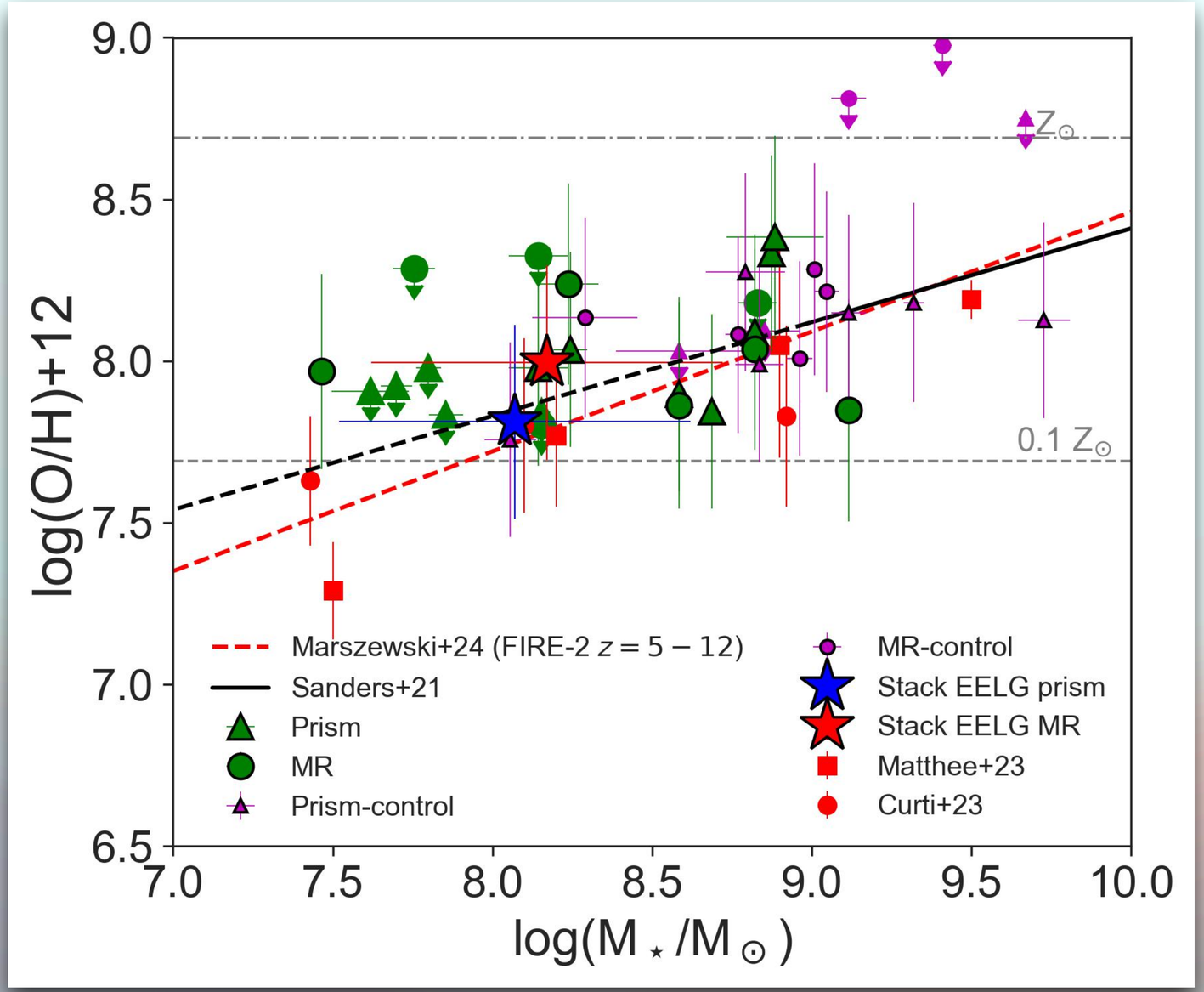
Control sample

We selected ~1500 galaxies that do not satisfy the color selection criteria with similar S/N. We clean the sample imposing than Kron radius >1.6 pix

Higher fraction of high EWs in the sample of EELGs



Gas-phase metallicity



We find sub-solar gas-phase metallicities for the sample of EELGs based on the O32 calibration with a mean value of **26% solar**.

They follow the MZR at z~3.3 which suggests they **do not show different gas-phase metallicities** than the general population of galaxies.

Properties of EELGs candidates (GALFIT)

From v0.52 galfit catalog (McGrath et al. in prep.)

We only consider 488 sources with good fit quality (so-called Flag=0).

F200W: <4680A (rest-frame)