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First RECAP collaboration  
meeting  
Garching 23-25 February 2026

Monday	Tuesday	Wednesday
9.00-9.30 welcome & introduction (Bene, Laura)	Talks - chair Kirsten:  9.00-9.15: Dario 9.15-9.30: Antonio 9.30-9.45: Aniket	9.00-10.30 tools/technical stuff
Talks - chair Bene:  9.30-9.45: Laura 9.45-10.00: Elie 10.00-10.15: Rahul 10.15-10.30: Seok-Jun	9.45-10.45 parallel discussions	10.30-11.00 coffee break
10.30-11.00 coffee break	10.45-11.15 coffee break	11.00-12.30 planning and wrap-up
Talks - chair Laura  11.00-11.15: Christian 11.15-11.30: Marta 11.30-11.45: Valentina 11.45-12.00: Louise 12.00-12.15: Lorenzo	11.15-12.15 parallel discussions	
12.15-13.15 lunch break	12.15-13.15 lunch break	
13.15-14.15 time for emails etc	13.15-14.00 time for emails etc	
14.15-15.15 parallel discussions	14.00-15.00 report/discussion	
15.15-15.45 coffee break		
15.45-16.45 parallel discussions	16.00-18.30 lasertag	
16.45-17.45 report/discussion		
19.00 dinner (Pls separate)	19.30 dinner	

### Properties of Lyalpha galaxies (Laura; room 006)

Elie - Aniket - Laura - Lorenzo - Rahul - Antonio - Seok-Jun - Dario - Bene - Ines (- Kirsten)

### IGM Evolution (Vale; 009)

Lorenzo - Valentina - Dario

### Mergers (Kirsten; room 027)

Louise - Laura - Kirsten

### Looking for dust and CII emission, ALMA proposal (Kirsten; room 027)

Kirsten - Aniket - (Rahul) - Ines - (Louise?)

### Absorption lines (Vale; room 006)

Katayani - Christian - Valentina - Seok-Jun - Bene - Marta

### LyC escape (Laura; room 006)

Antonio - Laura - Seok-Jun - Bene - Rahul - (Louise?)

### Simulations planning (Bene; room 006)

### AGN/quasars at high-redshift (room 009)

Lorenzo -

## AIM of the meeting:

- get to know each other in person!!
- share latest scientific results from each group
- discuss in detail specific observations-simulations synergies and identify what is needed from the simulations for each WG
- identify specific tasks within the various WGs and set up small sub-groups to work on them with a given timeline and aims - possibly also plan subgroups meeting
- distribute some duties (like update the webpages, manage the indico meeting pages, write pages for outreach etc)
- discuss dissemination activities
- more ....

## Objective A: Novel radiative transfer and large scale simulations of reionization

### WP-A1:

- new, fast, flexible code for radiative transfer in post-processing
- 3D non-equilibrium multi-frequency Monte Carlo approach
- propagation of Ly $\alpha$ , UV, X-ray photons through H, He and metals
- using Ly $\alpha$  RT to study properties of high-z galaxies

**Seok-Jun  
Elie**

### WP-A2:

- large scale hydrodynamic simulations of reionization with customized version of AREPO
- based on benchmark simulations of  $L=15$  cMpc (6-9 millions CPU)
- $L=60-300$  cMpc, with/out self-consistent RT, with/out BHs, various feedback

**Aniket**

## Objective B: Identifying cosmic ionizers and characterizing their nature

### WP-B1 ISM condition and UV-photon production in galaxies

Rahul, Ines

- Observations of  $z \geq 6$  galaxies with ALMA and JWST and detailed photoionization modeling to constrain the ISM physical conditions

### WP-B2 The Lyman continuum emission in $z=2-4$ galaxies

Antonio, Rahul, Ines

- Systematic study of properties of new sample to bridge gap between low- $z$  and EoR. Determine origin of UV-emission (young stars vs AGN/quasars).

### WP-B3 The Lyman continuum emission in AGN and QSOs

- Combining numerical modelling (from Obj A) with new spectroscopic data of  $z=3-5$  quasars to evaluate impact of BH feedback on stellar UV escape fraction.

### WP-B4 Early enrichment and the nature of the first sources

- New, very high-quality VLT spectroscopy of high- $z$  quasars to determining the enrichment of the intergalactic medium.
- Statistical properties of weak metal lines compared to theoretical predictions.

### WP-B5 The total ionizing budget in the epoch of Reionization

- Combining above results with new JWST and VLT/MOONS data to identify EoR galaxies similar to low- $z$  Lyman-continuum leakers.
- Evaluate the total ionizing budget of galaxies and AGN during EoR.

Rahul, Antonio

## Objective C: The impact of sources on their close environment

### WP-C1 Simulations of the CGM

- Zoom-in simulations of galaxies selected from large-scale simulations in WP-A2
- Single metals are followed and ionization state evaluated with CLOUDY and/or new RT code (WP-A1)

### WP-C2 Observation of the CGM through cosmic time

- Derive the mechanisms expelling metal

### WP-C3 Mapping the effect of galaxies on the IGM at $z \sim 6$

- Investigate the correlation properties between absorption lines in  $z \sim 6-7$  QSO spectra and galaxies close to the line-of-sight.
- Constrain size of enriched/ionized regions and refine constraints derived from comparison with the simulations.

**Manuela  
Christian**

### WP-C4 Comparison of the properties of $z > 6$ galaxies in different environments

- Investigate how properties of  $z > 6$  galaxies depend on nearby environment, especially based on ALMA and VLT/MOONS data.

**Ines**

## Objective D: Islands of Reionization: timeline and topology of Reionization

### WP-D1 Simulations of HII regions

- Simulate with new RT code (WP-A1) HII regions surrounding galaxies/BHs selected from WP-A2

### WP-D2 Onset of cosmic reionization: the first ionized bubbles

- Detailed follow-up studies of individual regions, as discovered in new large survey with VLT/MOONS.
- Measurements of properties and escape of ionizing photons will be compared to the simulations of Obj A.

Dario,  
Lorenzo

### WP-D3 Large ionized bubbles around quasars

- Map the density field at scales of 10's of kpc to several Mpcs around  $z \sim 6-7$  quasars.

Louise

### WP-D4 The evolution of the LAE visibility at $z > 6$ and its spatial variations

- With VLT/MOONS large-scale observations of high- $z$  galaxies study the timeline and topology of the reionization.

Lorenzo

### WP-D5 The final phases of reionization as seen from quasar spectra

- Determine the evolution of the HI content in  $z \sim 6-7$  based on the observed flux in the hydrogen absorption and comparative study combined with simulated mock catalogues (Obj A).



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- The new CAPERS dataset
- The collective voices of Ly $\alpha$  emitters: insight from JWST stacked spectroscopy

Roberta Tripodi, Lorenzo Napolitano, Laura Pentericci and OAR team

-Osservatorio Astronomico di Roma -

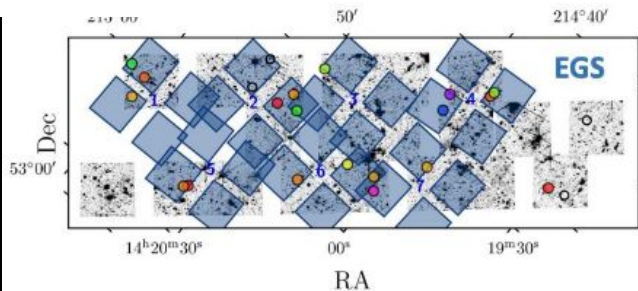


This work is supported by the ERC grant RECAP under grant agreement No 101166930



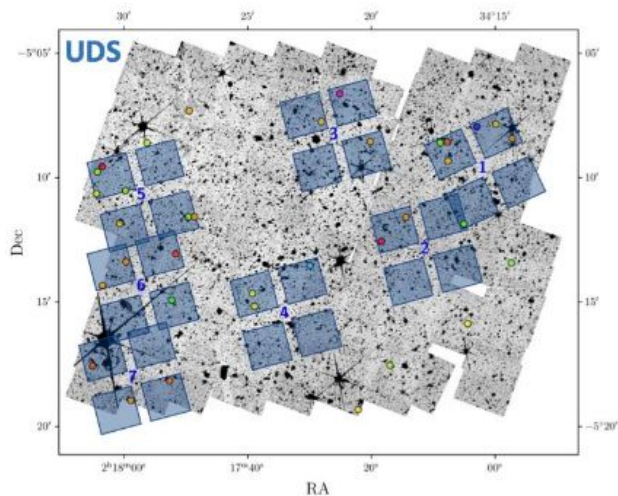
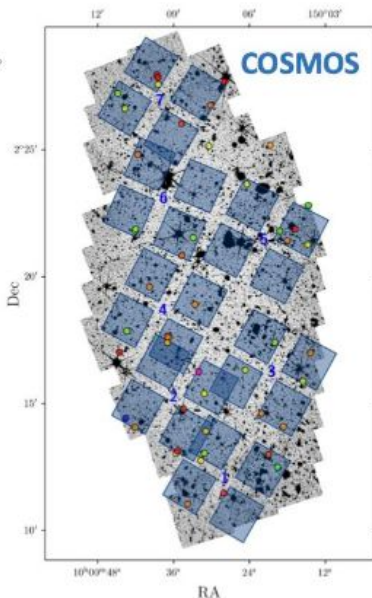
# The CANDELS- Area Prism Epoch of Reionization Survey (CAPERS)

*JWST Cycle 3 Large Treasury Program (GO-6368) PI M. Dickinson*



## NIRSpec primary observations:

- NIRSpec MSA PRISM/CLEAR
- 3 survey fields
- 21 pointings
- 63 NIRSpec MSA configurations
- 1.68 unit exposure time / MSA =  $1.94 \times t_{\text{exp}}$  (CEERS)
- Targets can be repeated on (up to) 3 MSA configurations
- $\rightarrow t_{\text{exp}} = 5.04\text{h}$



## NIRCam coordinated parallels:

- Outside existing NIRCam: Broad bands
- Inside existing NIRCam: Medium bands



# The CAPERS spectroscopic targets

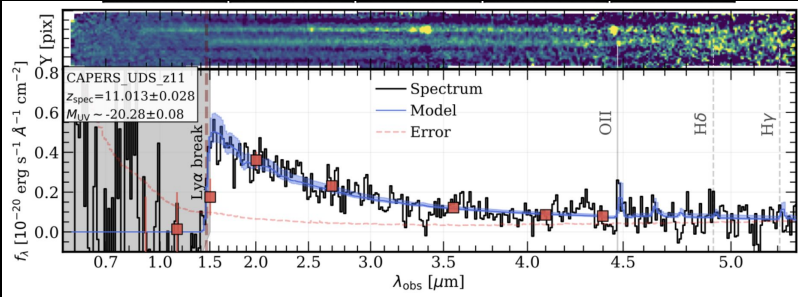
~10x CEERS NIRSpec prism sample size, and 2 to 6x deeper

- JWST NIRCам-selected\* [\*Except in CEERS NIRCам gaps]
  - Optical rest frame selection at  $z \lesssim 10$
  - UV rest frame selection at  $z \gtrsim 10$
- ~10,000 galaxies (all redshifts)
- ~2,000 at  $z > 4$
- ~100 at  $z > 9.5$ 
  - These drive the exposure time and MSA pointing placement
  - Most are repeated MSA x 3  $\rightarrow t_{\text{exp}} = 5\text{h}$
  - $m < 27.9 \rightarrow$  continuum SNR/pixel  $> 2$  at 1.05-2.40  $\mu\text{m}$  to detect the Ly $\alpha$  break



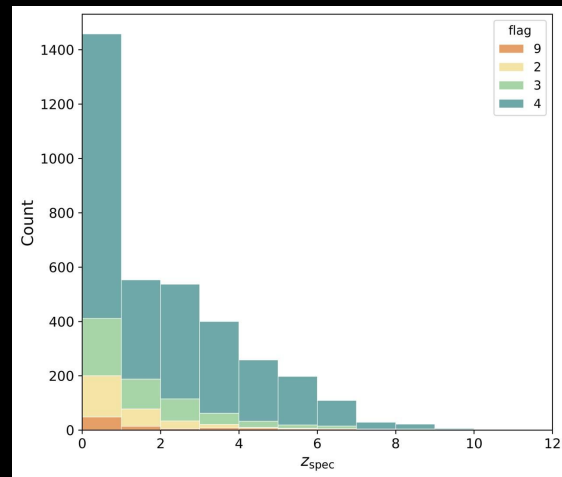
# The CAPERS scientific objectives

- Measure redshifts for  $>100$  NIRC*am*-discovered galaxy candidates at  $z > 9.5$
- Measure redshifts for  $\sim 2000$  galaxies at  $4 < z < 9.5$  selected by their rest-frame optical emission
- Assess the history of IGM reionization using statistics of Ly  $\alpha$  damping profiles, Ly  $\alpha$  emission, ionizing photon production and escape
- Measure stellar population properties and distribution functions
- Measure highly accurate galaxy luminosity and stellar mass functions
- Chart large-scale structure and its relation to galaxy properties
- **Create a legacy resource of spectroscopy to support research and follow-up observations (e.g., NIRS*pec* gratings, IFUs, MIRI, ALMA/millimeter, etc.)**

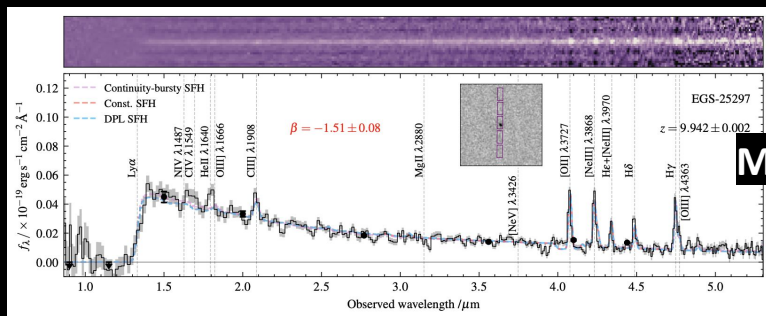


**Kokorev+2025**  
 **$z=11.0$  starburst**

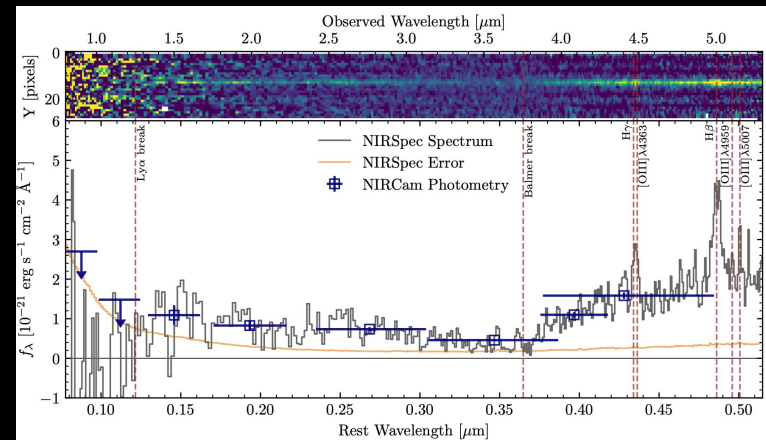
current spec-z determination



from S. Mascia



**Donnan+2025**  
**Most luminous, dustiest**  
**galaxy at  $z > 9$**



**Taylor+2025**  
 **$z=9.3$  Little Red Dot**

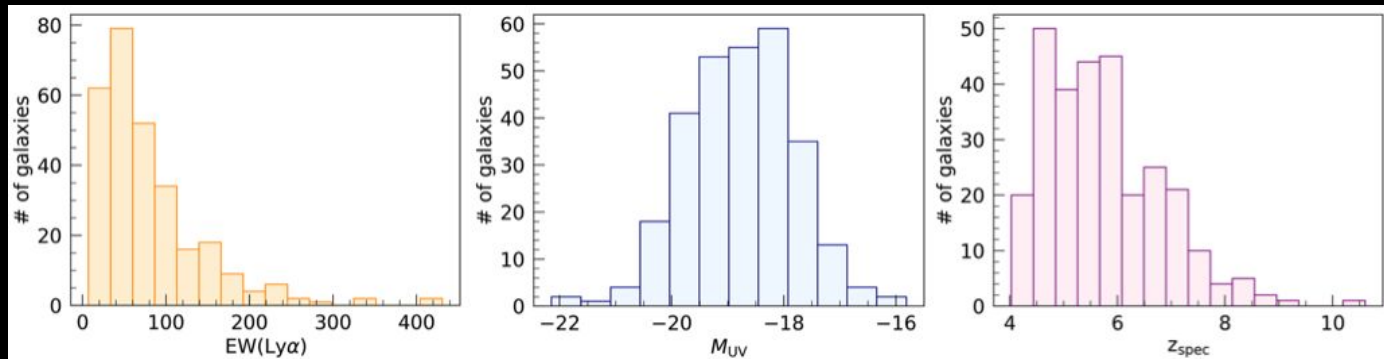
# The collective voices of Ly $\alpha$ emitters: spatial properties from stacked spectra

*Roberta Tripodi, Lorenzo Napolitano, LP et al - ready for submission*

**AIM:** investigate the spatial properties of Ly $\alpha$  emitters and their connection to optical and UV properties

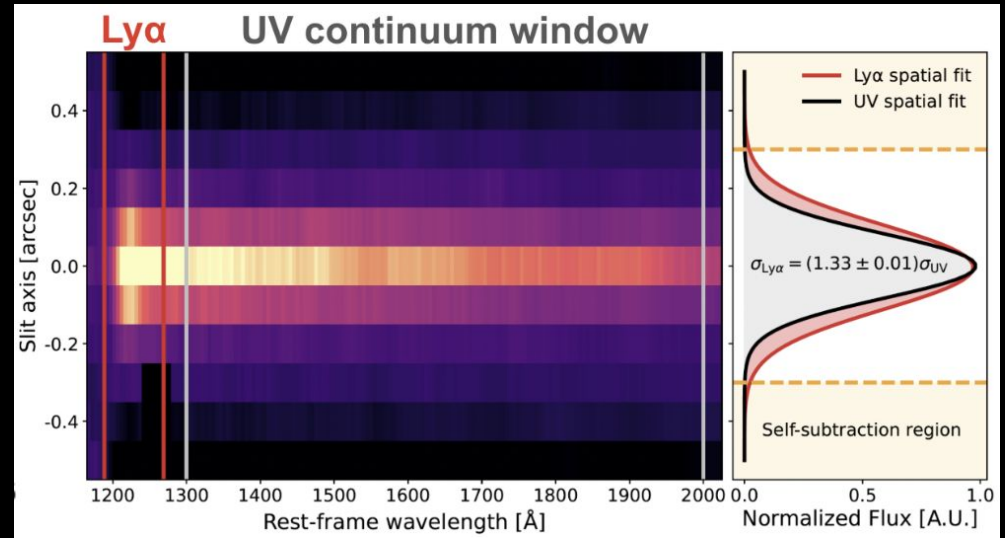
Selection of galaxies with:

- prism observations
- Ly $\alpha$  emission
- redshift  $4 < z < 11$
- no AGN signatures





As expected, the Ly $\alpha$  emission is more spatially extended than the UV continuum (see also Lorenzo's talk)

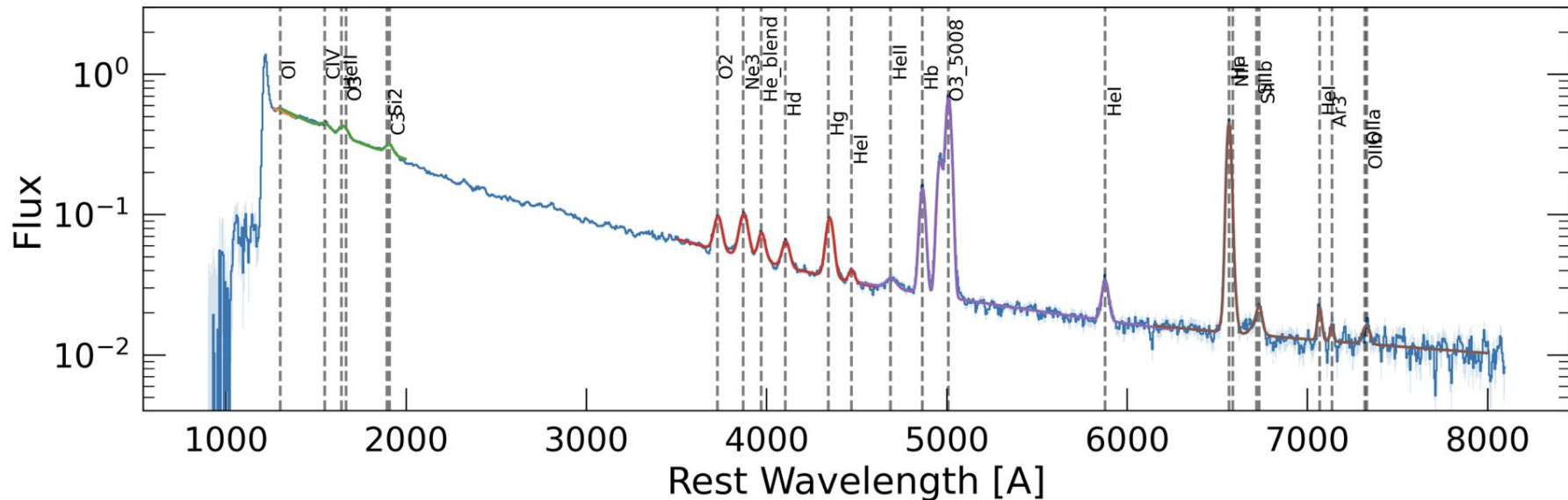


NB: this approach is limited by self subtraction in the outer regions (pixels  $\geq 3$ ) due to nodding background treatment



we would need a different background subtraction scheme (or IFU observations)

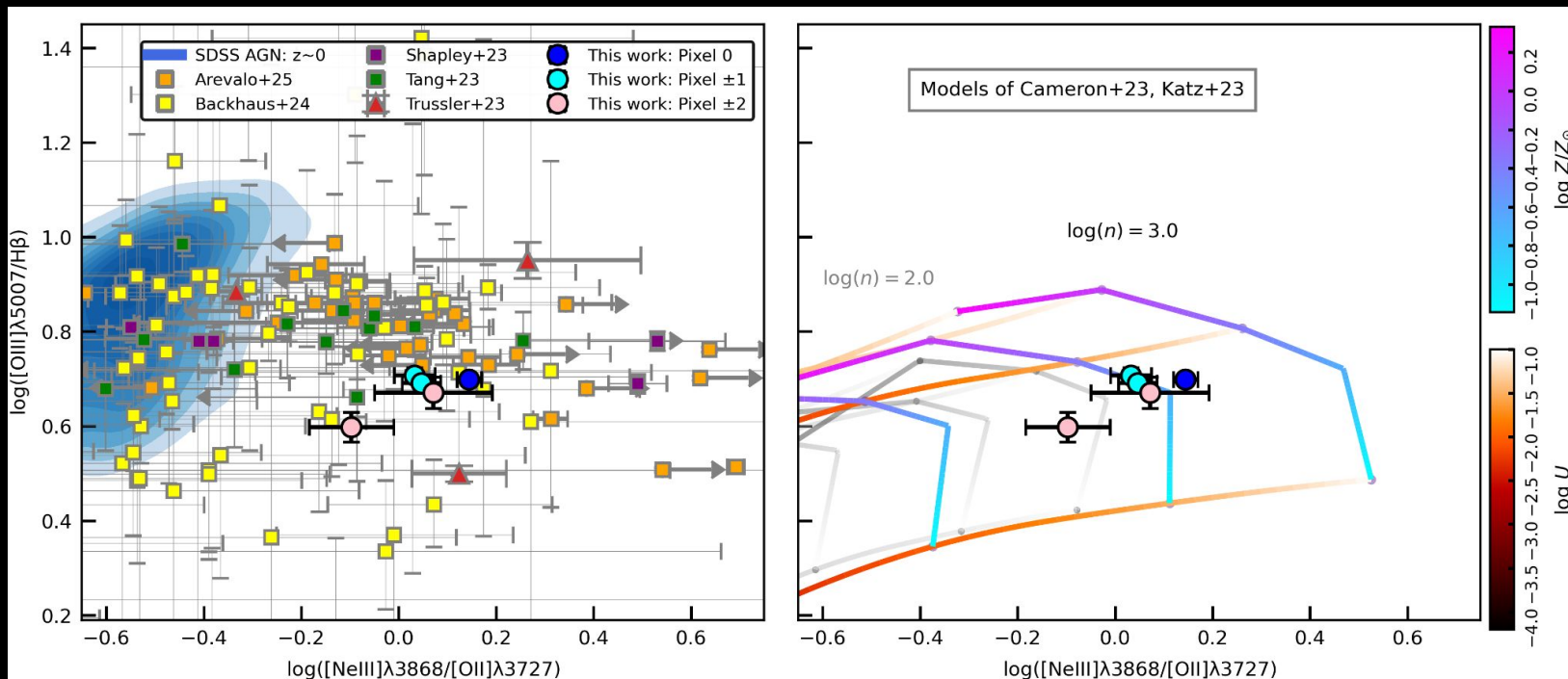
### Stack total, pix 0



the central pixel alone is 4x deeper than stack of Roberts-Borsani+24 for LAEs

# OHNO diagram (Backhaus+22)

- no metallicity gradients over the spatial range probed
- ionizing parameter gradient (higher at pixel 0)

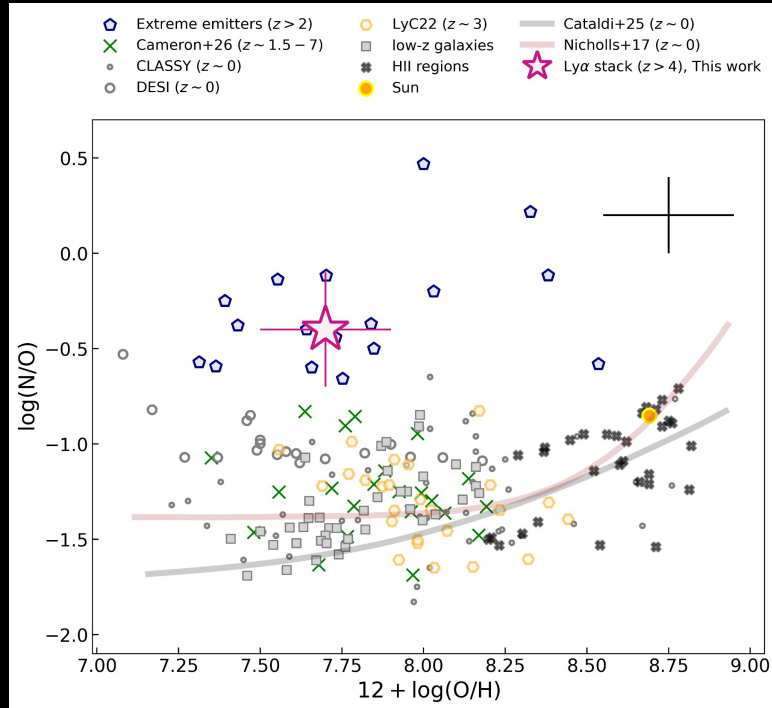


Metallicities can be derived in multiple ways:

- direct method (Te based) using NUVOLOSO (Perez-Diaz et al.)
- from OHNO diagram
- from HCM model
- from strong line method (Sanders+23 calibration)

	$\beta_{UV}$	$\log(Z_{\text{Sanders}}/Z_{\odot})$	$\log(Z_{\text{direct}}/Z_{\odot})$	$\log(Z_{\text{HCM}}/Z_{\odot})$	$\log(\text{N/O})_{\text{HCM}}$
Pix 2	$-2.5 \pm 0.1$	$-1.49 \pm 0.05$	$-1.20 \pm 0.03$	$-0.96 \pm 0.020$	N/A
Pix 1	$-2.07 \pm 0.02$	$-1.30 \pm 0.04$	$-0.85 \pm 0.02$	$-0.85 \pm 0.04$	$-0.3 \pm 0.2$
Pix 0	$-1.95 \pm 0.02$	$-1.32 \pm 0.03$	$-0.93 \pm 0.01$	$-0.91 \pm 0.02$	$-0.5 \pm 0.4$
Pix -1	$-2.32 \pm 0.01$	$-1.34 \pm 0.04$	$-0.80 \pm 0.02$	$-0.90 \pm 0.07$	$-0.8 \pm 0.4$
Pix -2	$-2.29 \pm 0.05$	$-1.37 \pm 0.05$	$-1.04 \pm 0.04$	$-1.00 \pm 0.05$	N/A

# Nitrogen-over-oxygen abundance vs metallicity in terms of $12 + \log(\text{O}/\text{H})$



Ly $\alpha$  emitters are N/O enhanced as many super-high redshift galaxies and AGN (Topping+24, Naidu+26, Zavala+24 etc etc)

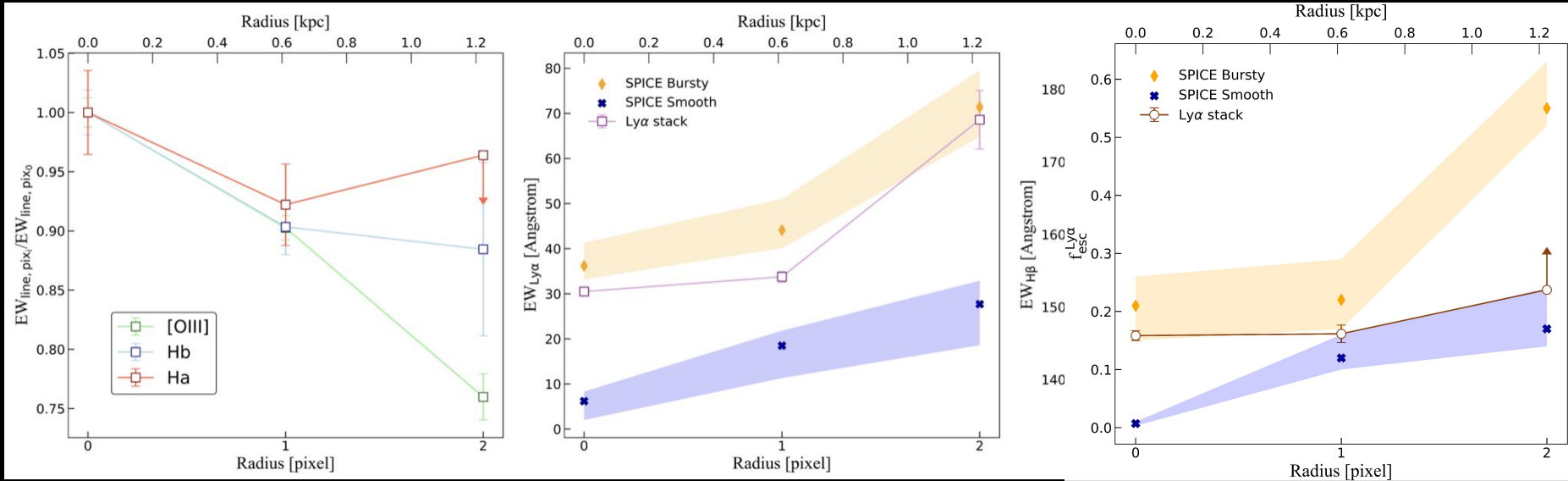
## General properties and trends:

- UV slopes are blue (-2.2), and become progressively bluer to outer radius
- gas density  $\approx \log(n/\text{cm}^{-3}) = 3$
- metallicity of  $\log(Z/Z_{\odot}) \sim -0.8 \pm 0.1$  (i.e.,  $12 + \log(\text{O}/\text{H}) = 7.89 \pm 0.10$ ) with no spatial gradients
- ionization parameter  $\log(U) \approx -1.5$  in the central regions, decreasing slightly to  $\log(U) \approx -1.75$  in outer pixels
- N/O enriched (just central pixels available)

EW(OIII)], EW(H $\alpha$ ),  
EW(H $\beta$ ) decreasing with  
distance from center

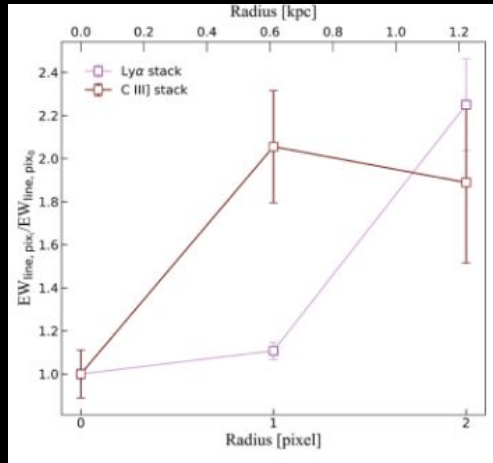
EW(Ly $\alpha$ ) and fesc(Ly $\alpha$ ) increasing  
with distance due to the resonant  
scattering nature of Ly $\alpha$

$$f_{\text{esc}}^{\text{Ly}\alpha} = \frac{F_{\text{obs}}^{\text{Ly}\alpha}}{F_{\text{int}}^{\text{Ly}\alpha}} = \frac{F_{\text{obs}}^{\text{Ly}\alpha}}{8.2 \times F_{\text{obs}}^{\text{H}\alpha}}$$



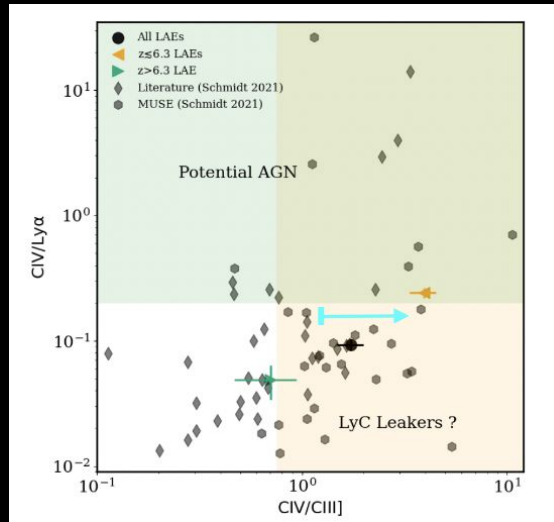
Comparison to SPICE simulations by Aniket:  
EW(Ly $\alpha$ ) and fesc(Ly $\alpha$ ) gradients show excellent  
agreement with the bursty feedback model

# The weird behaviour of CIII] emission



Contrary to all other emission lines, CIII] behaves like Ly $\alpha$  and increases as a function of distance

– but CIII] is NOT a resonant line  
????



CIV/Ly $\alpha$  vs CIV/CIII] is a diagnostic of AGN and possibly LyC leakage (Schaerer+23)

## Further work and thoughts for discussions

- comparison of other properties to SPICE simulations (e.g. metallicity)
- explore  $\text{Ly}\alpha$  properties as a function of  $\text{EW}(\text{Ly}\alpha)$ ,  $M_{\text{UV}}$ , redshift, morphologies and again compare to redshift evolution from SPICE

environment