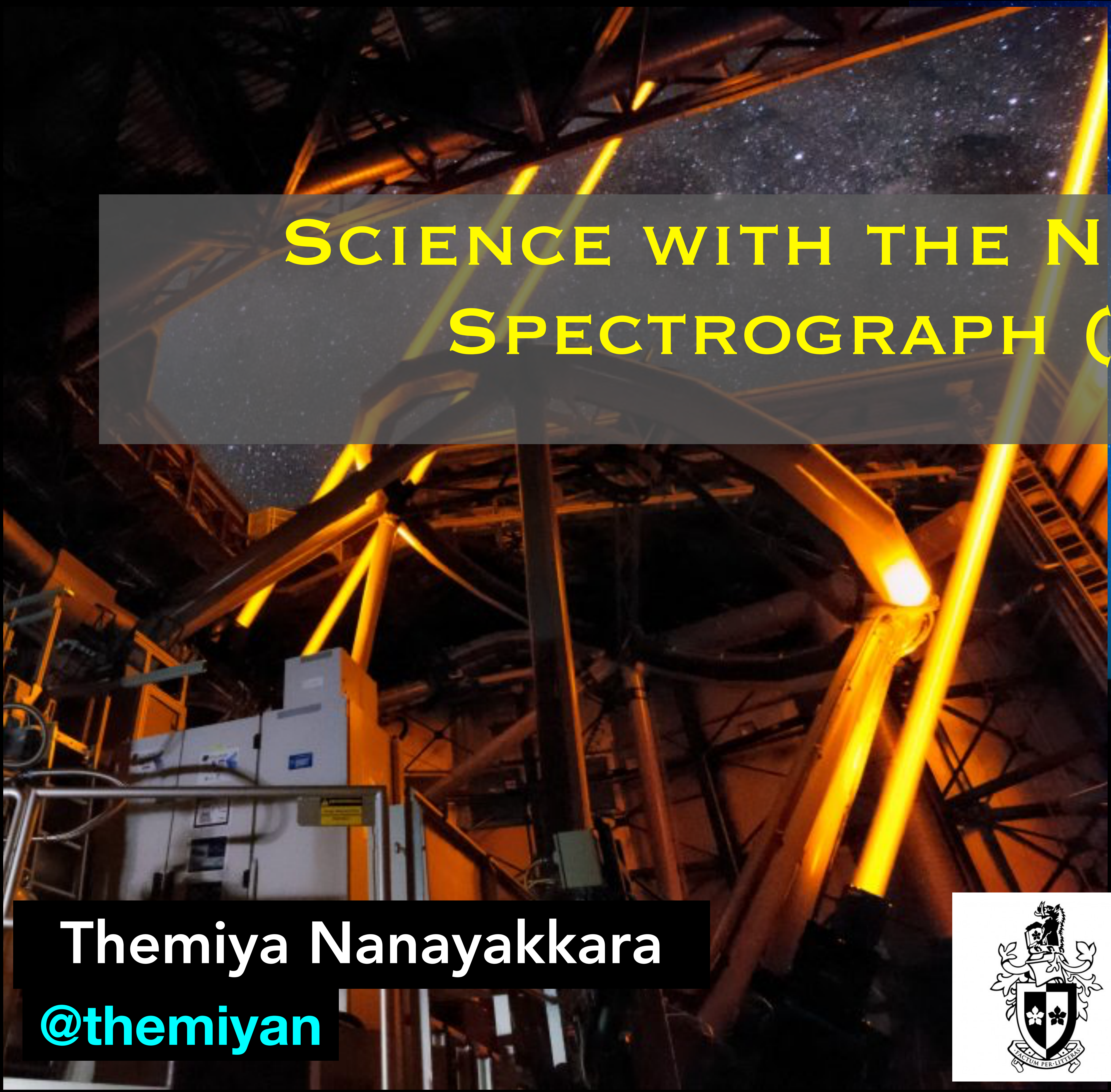
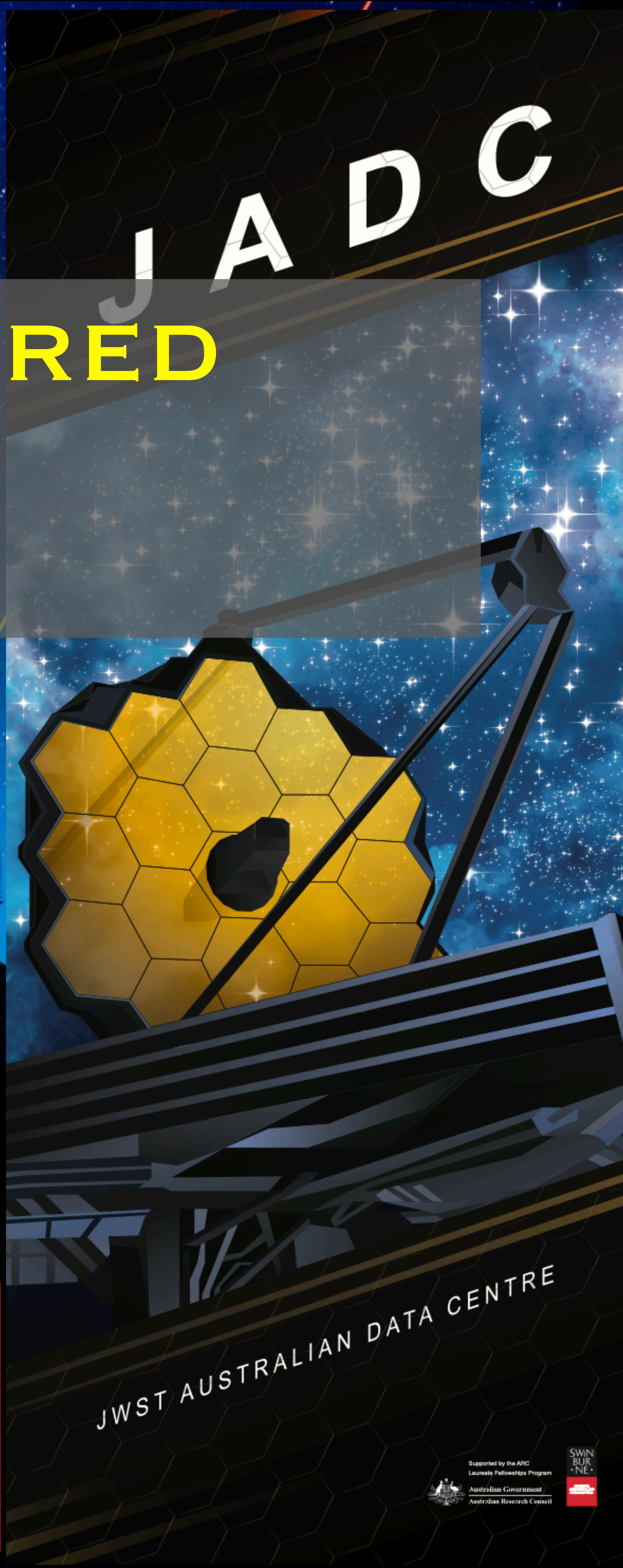
Science with the Near Infrared Spectrograph (NIRSpec)





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CENTRE FOR ASTROPHYSICS AND SUPERCOMPUTING

Recap of NIRSpec from week 1

Recap of NIRSpec from week 1

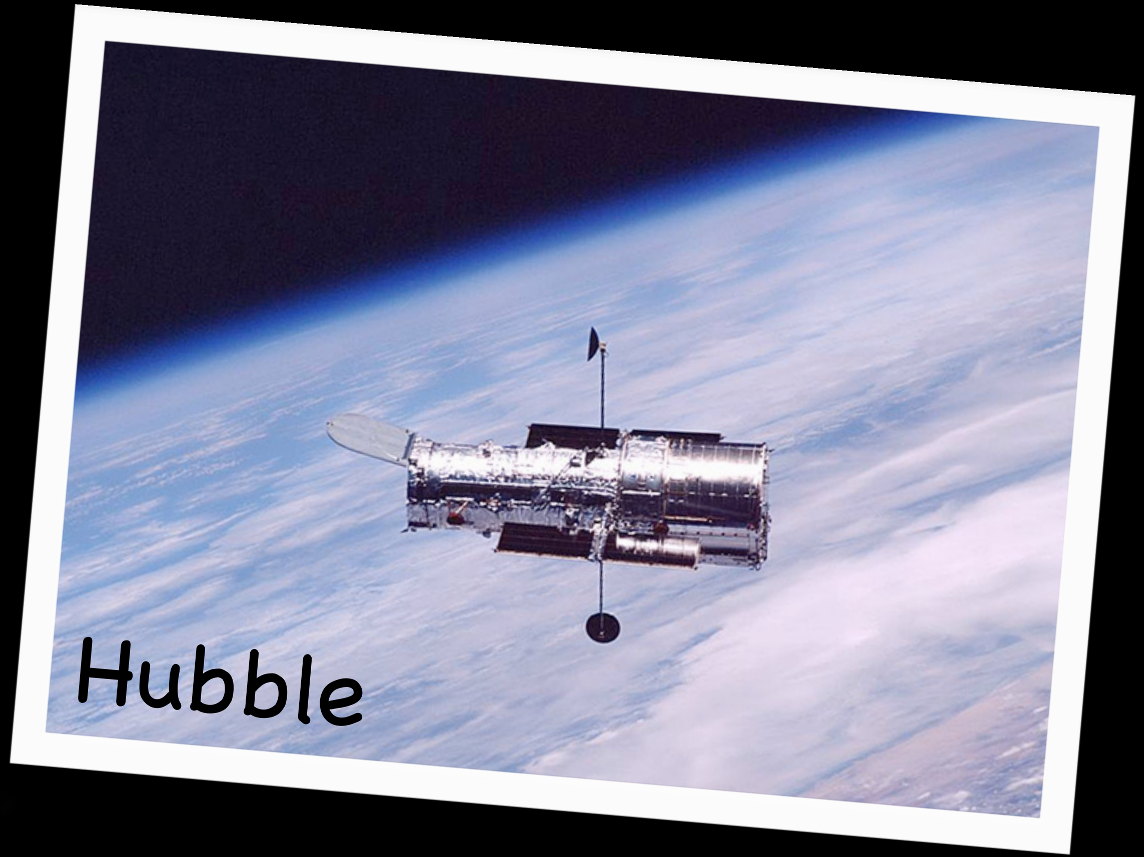
- 1. What is the redshift of the furthest galaxy spectroscopically confirmed by JWST/NIRSpec as of 1st of July 2024?

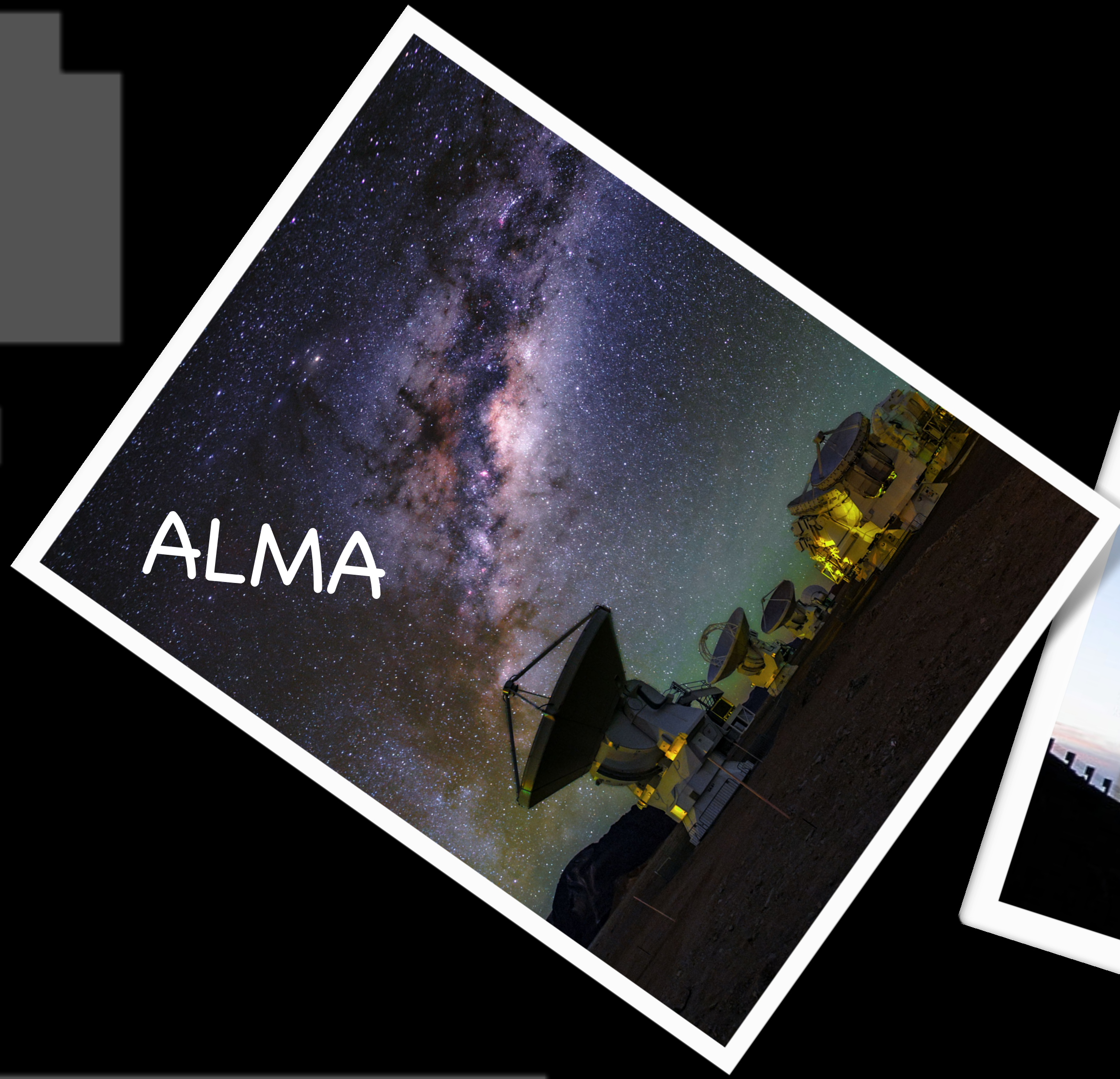
Recap of NIRSpec from week 1

- 1. What is the redshift of the furthest galaxy spectroscopically confirmed by JWST/NIRSpec as of 1st of July 2024?

- 2. What is the highest redshift one can observe the Hα λ6564 line with JWST/NIRSpec?

Pre-JWST times





We have been probing the EoR in optical to sub-mm for a while now

The role of JWST

& JWST has accelerated our view into the depths of reionization

Why the early Universe?


tral IGM

UK Astrophysical Fluids Facility

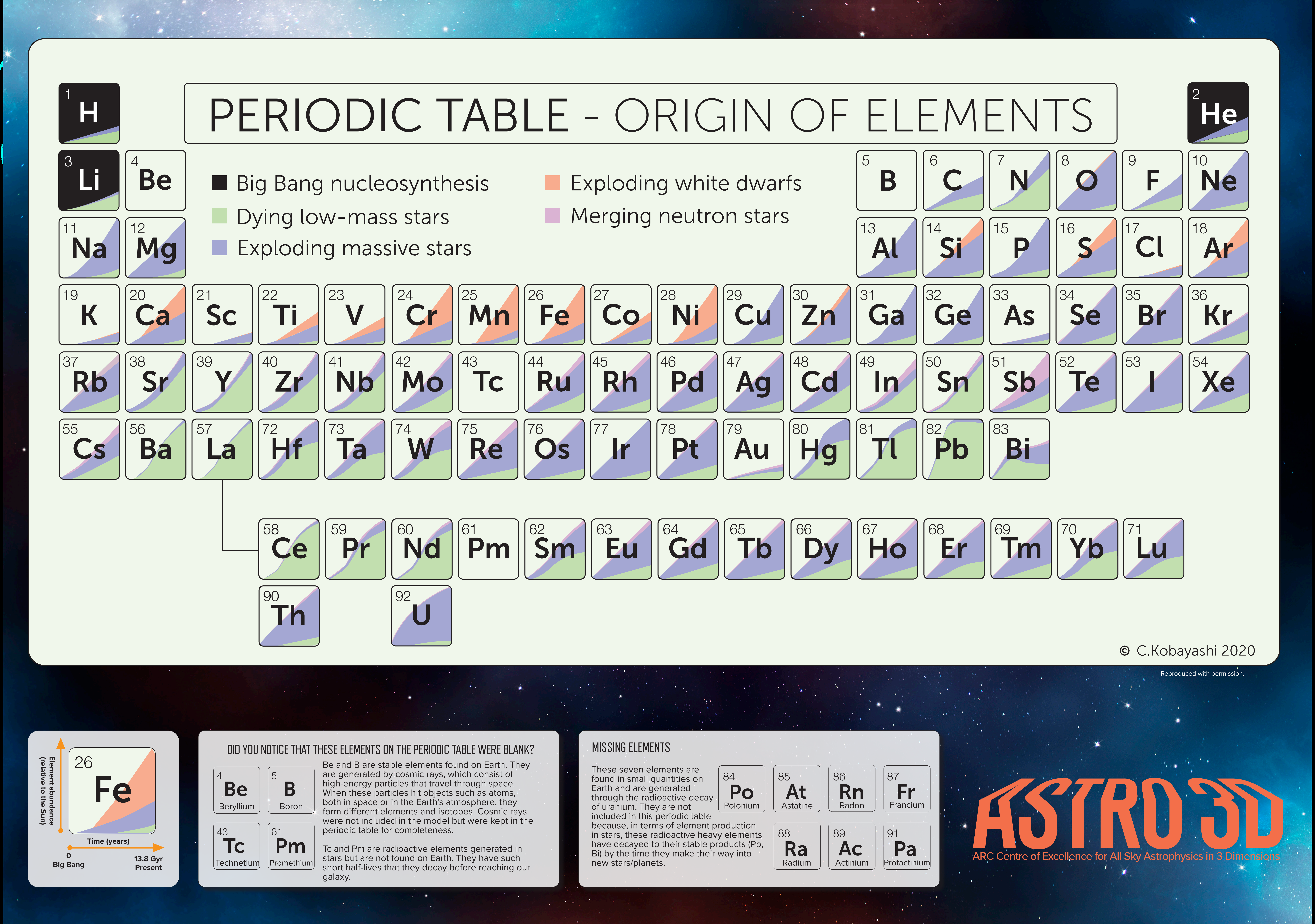
Matthew Bate

UNIVERSITY OF EXETER


Pop III
Stars
(Top heavy IMF)
E>54.4 eV

Cooling processes dominated by Ly-a and HeII

Cooli
domin
a



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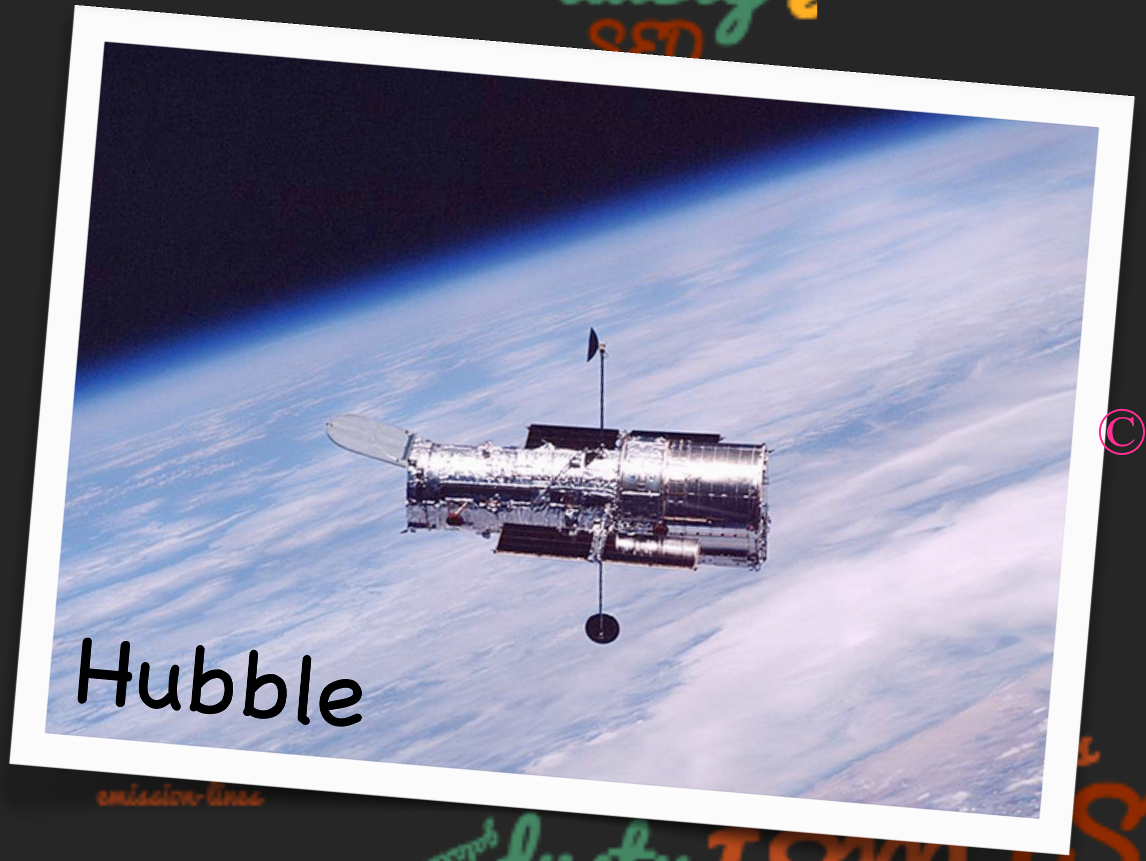
Cosmic MYSTERIES

I. Massive Quenched Galaxies at z~3-5

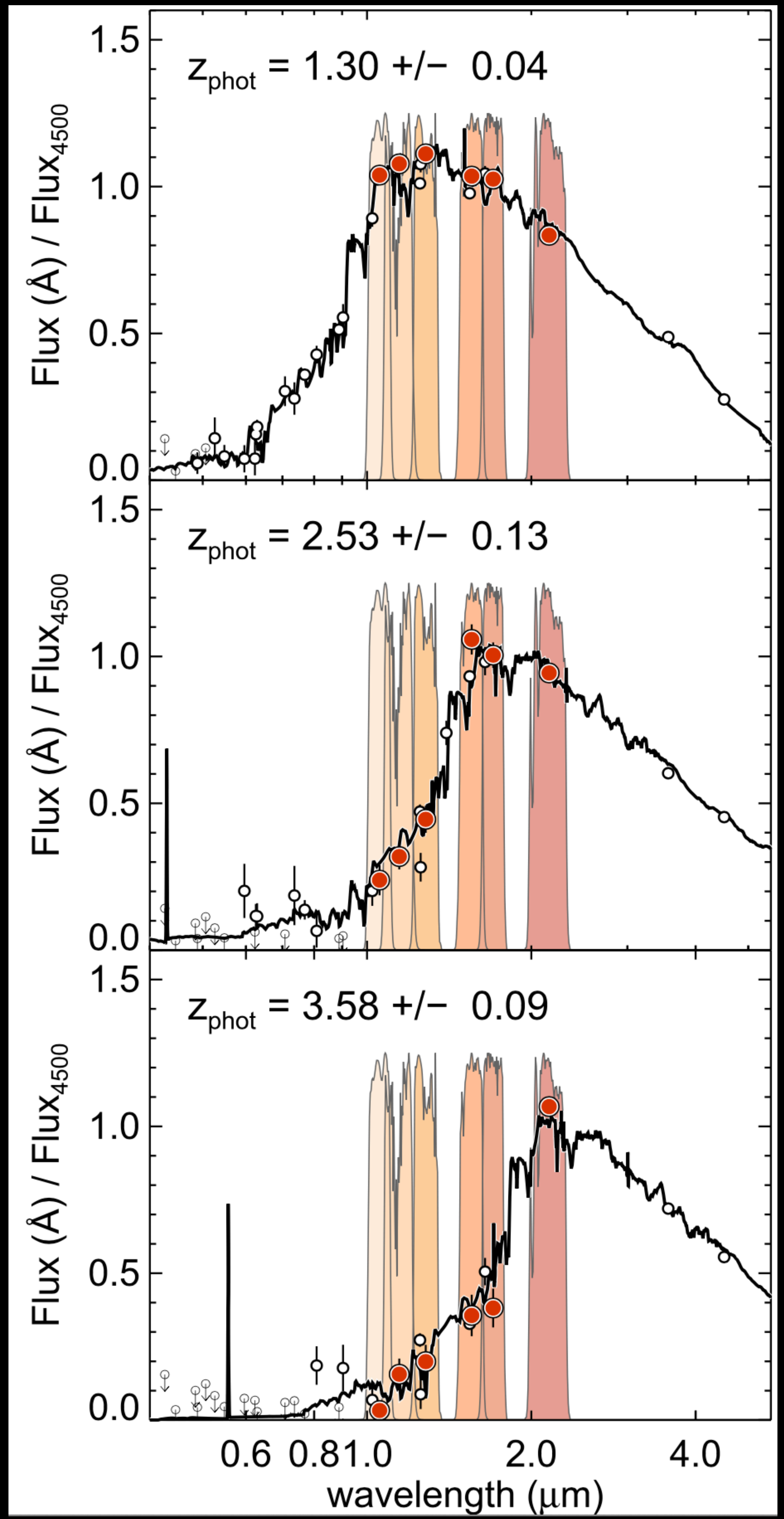
ZFOURGE

Fourstar Galaxy Evolution Survey



ZFOURGE
Fourstar Galaxy Evolution Survey
Subaru
Spitzer
Magellan
Herschel
Hubble
Keck
CFHT
©ADAM TOMCZAK
Redshift
0
1
2
3
4
Medium-Band
J_1 J_2 J_3 H_s H_l
Broad-Band
J H
Flux / Hz
wavelength (micron)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2

The J-H-K medium band filters gives tight constraints to the Balmer break at z~2-4



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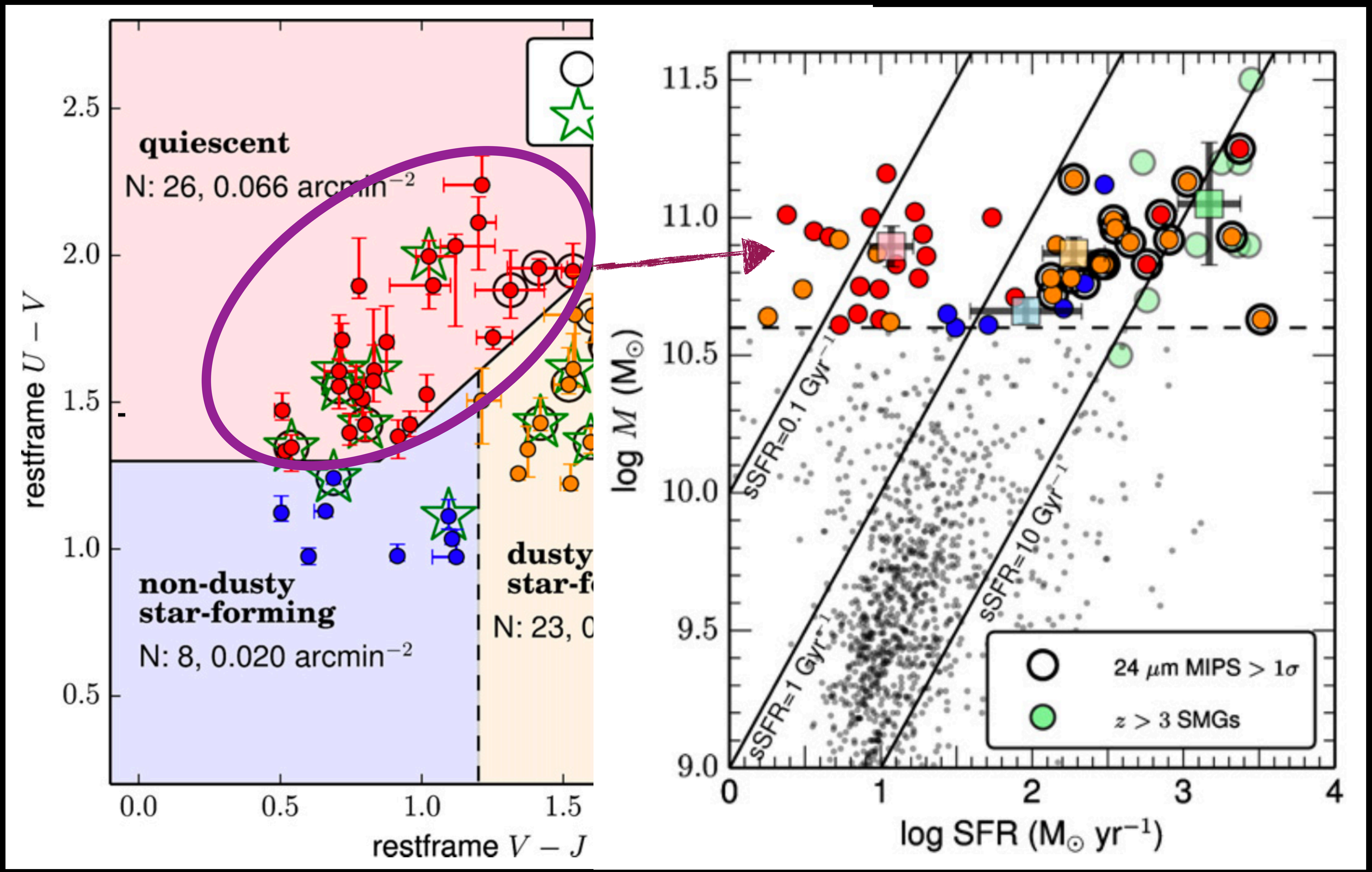

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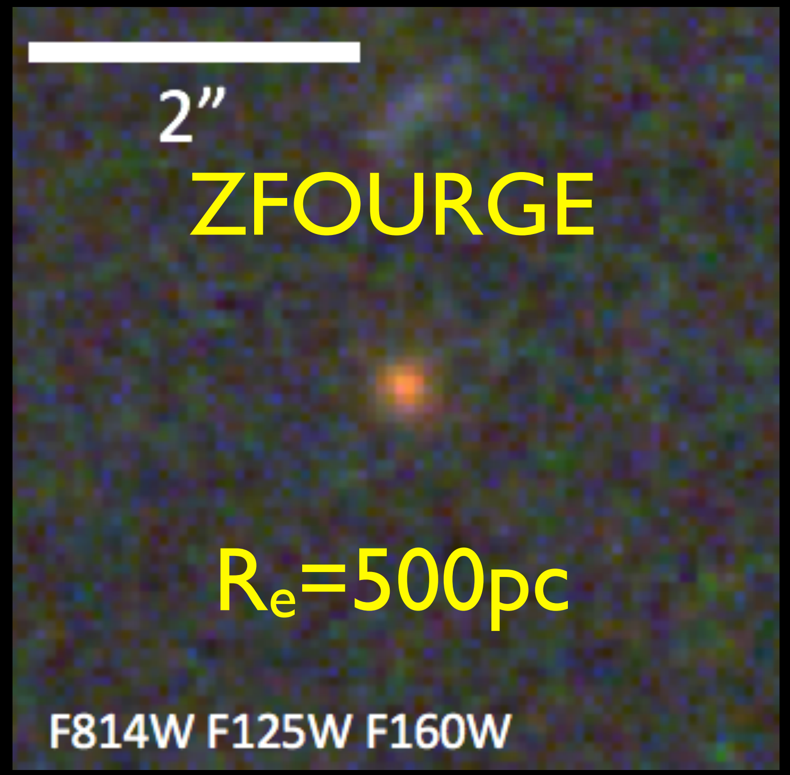
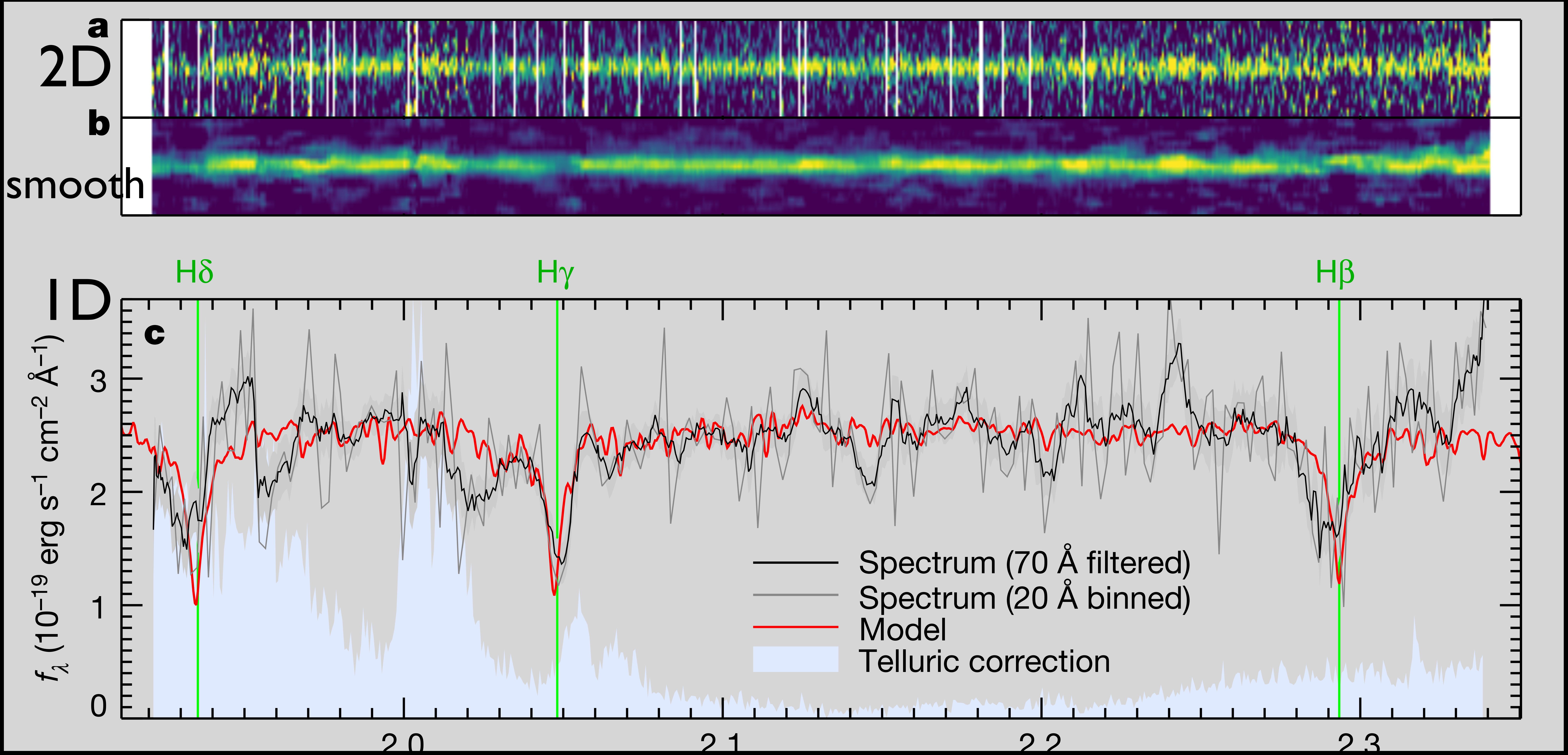
KECK/MOSFIRE was an efficient tool in providing spectroscopic confirmations for z~3-4 massive quiescent galaxies



z_{spec}=3.717 – Post-starburst spectrum! K(AB)=22.4



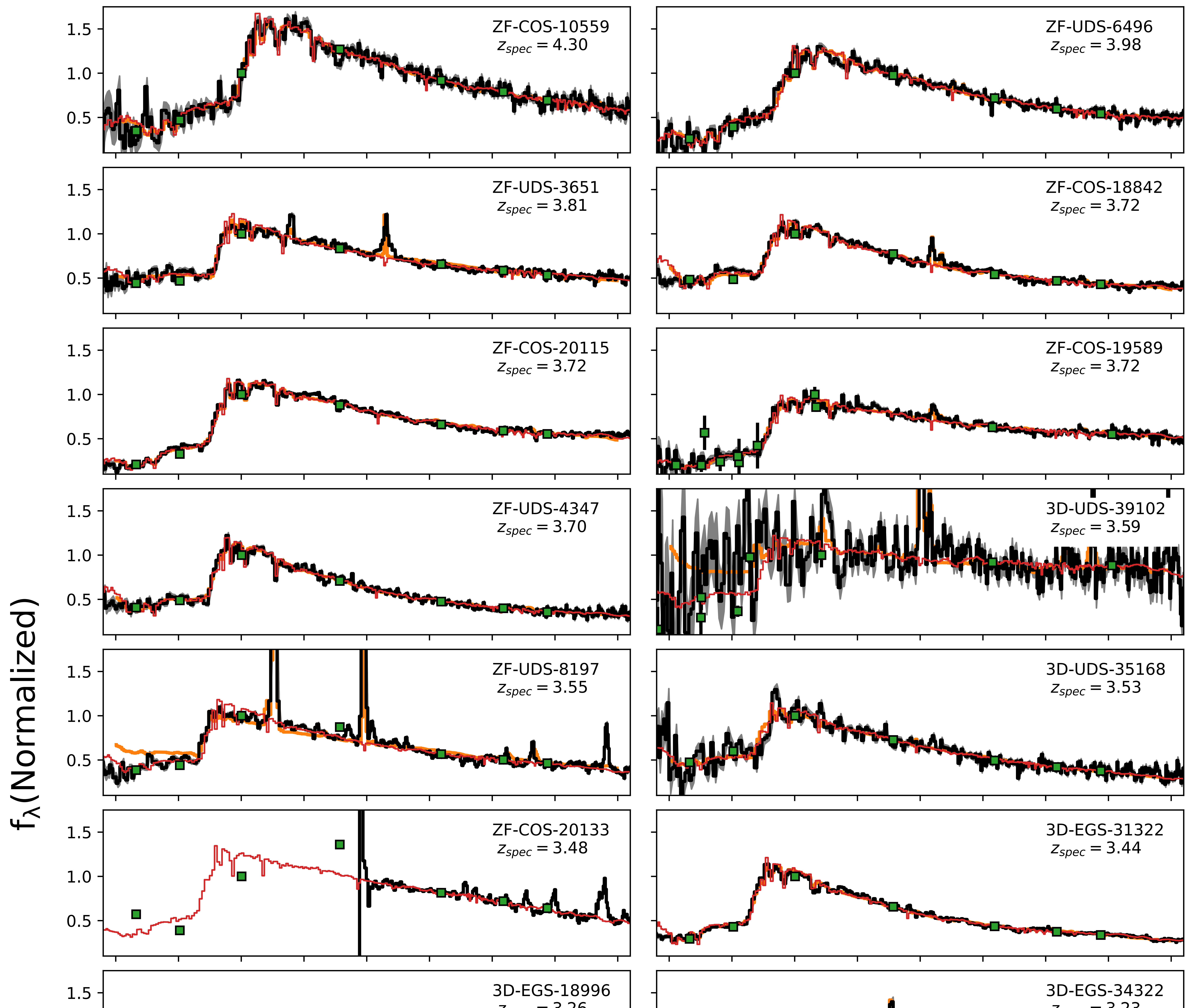
ZF-20115!

8hr on MOSFIRE

Stellar mass 10^{11} $M_\odot$

JWST/NIRSpec is ideal to probe the quiescent galaxies at z>3

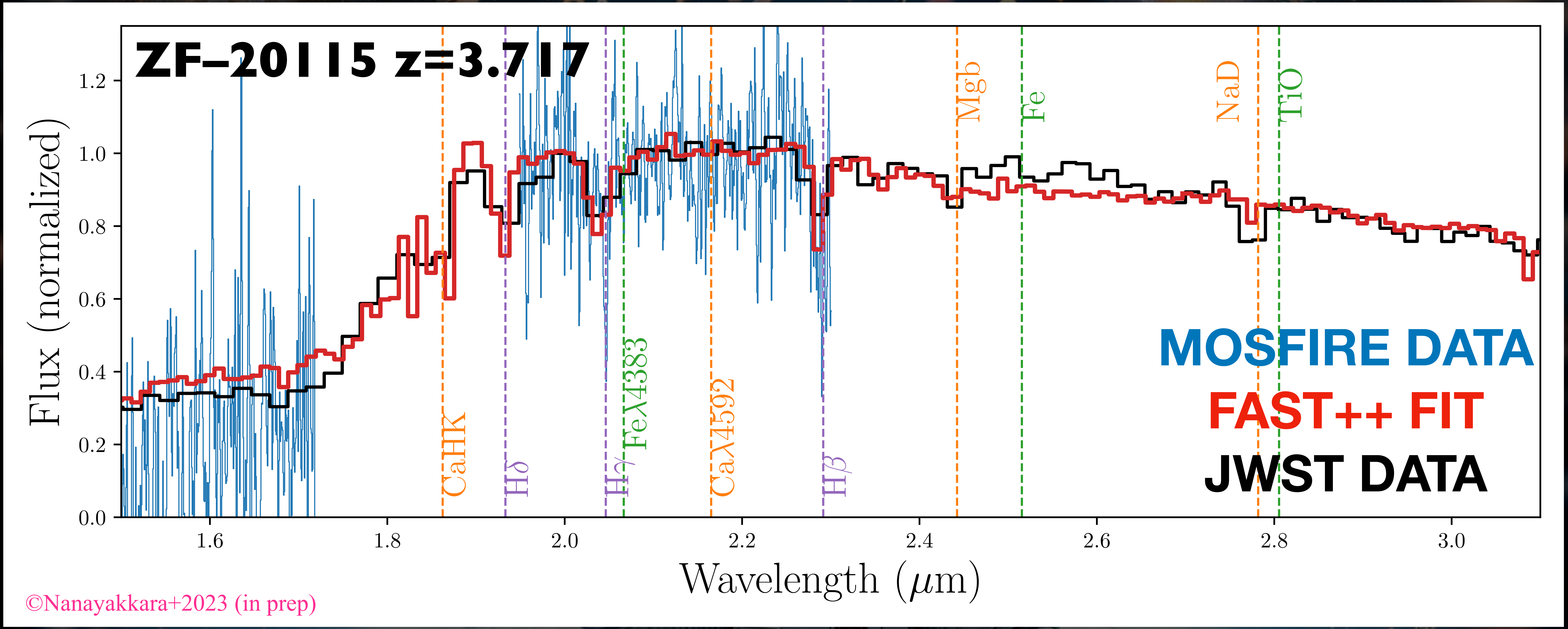
JWST/NIRSpec (in the CLEAR/PRISM mode) can be used as a redshift confirmation machine



Spec-z confirmed galaxies quiescence is confirmed via multiple tracers

- Based on photometry: shape of the SED
- Lack of star-formation based on spectra (some quiescence galaxies show AGN like emission lines)
- Lack of gas based on ALMA FIR detections

Initial indications are that some of these galaxies maybe α-enhanced, suggesting a quick buildup of stellar mass followed by rapid cessation of star-formation. It is likely features like NaD are driven by strong outflows in these early systems.



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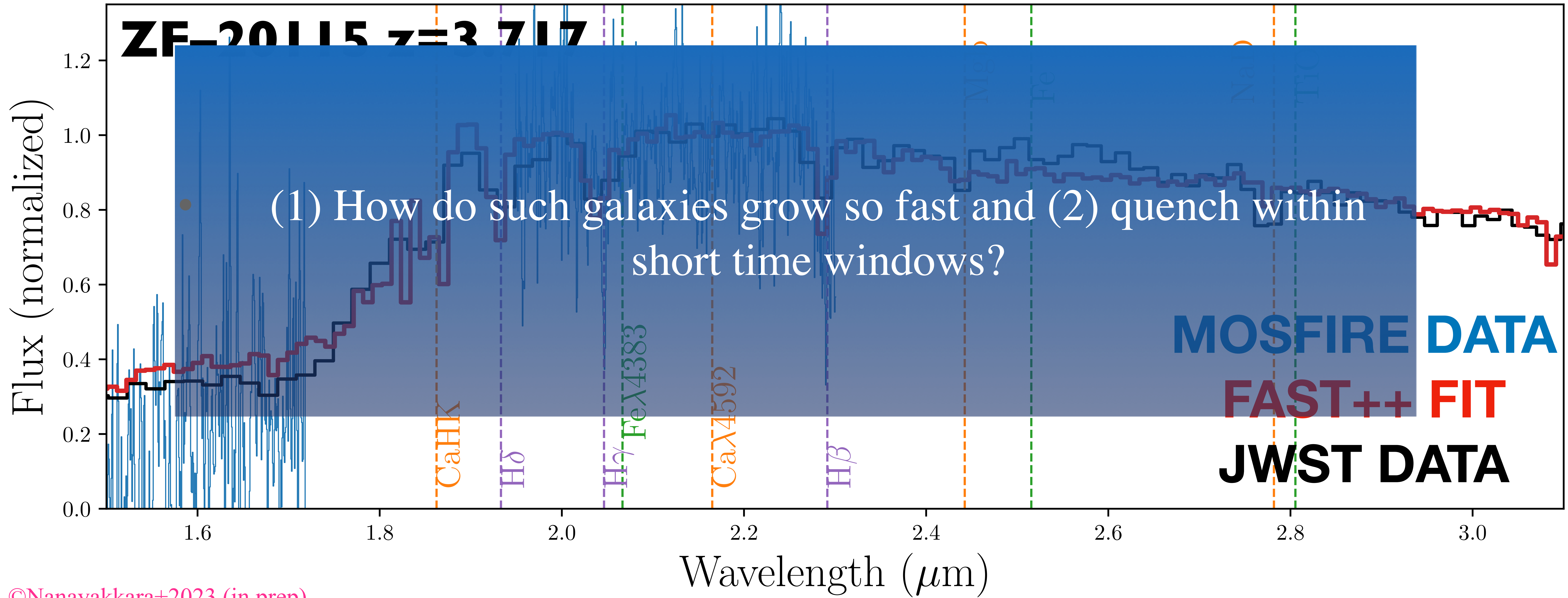

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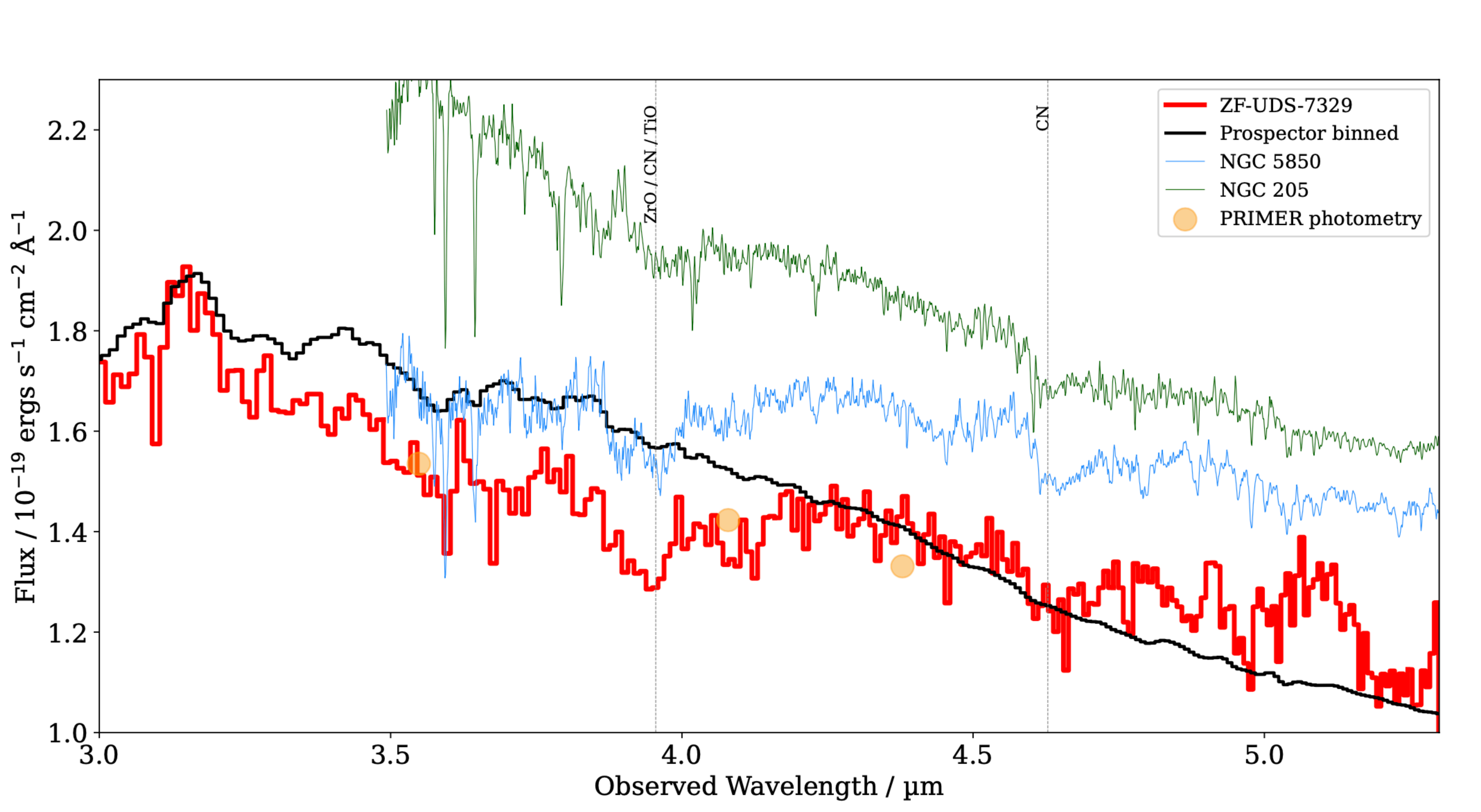
With JWST we are now entering the rest-NIR regime for z~3-4 galaxies. Limitations in spectral resolution and systemic biases due to optical/NIR normalisations of spectral libraries need to be well understood and propagated over



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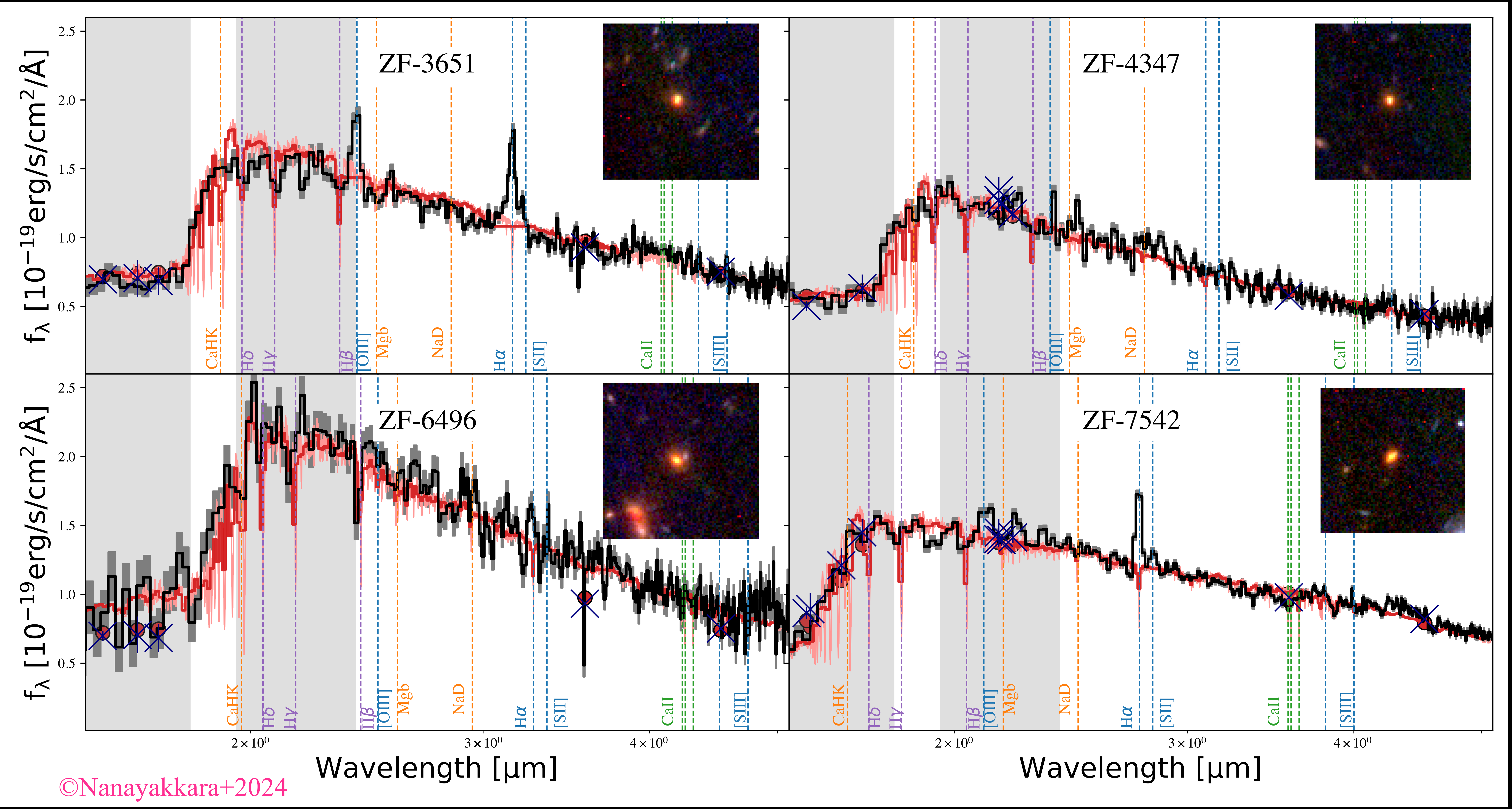
Cosmic MYSTERIES

II. AGN and exotic stars

The prominence of AGN in massive z>3 quiescent galaxies may start to form a picture of AGN driven galaxy quenching



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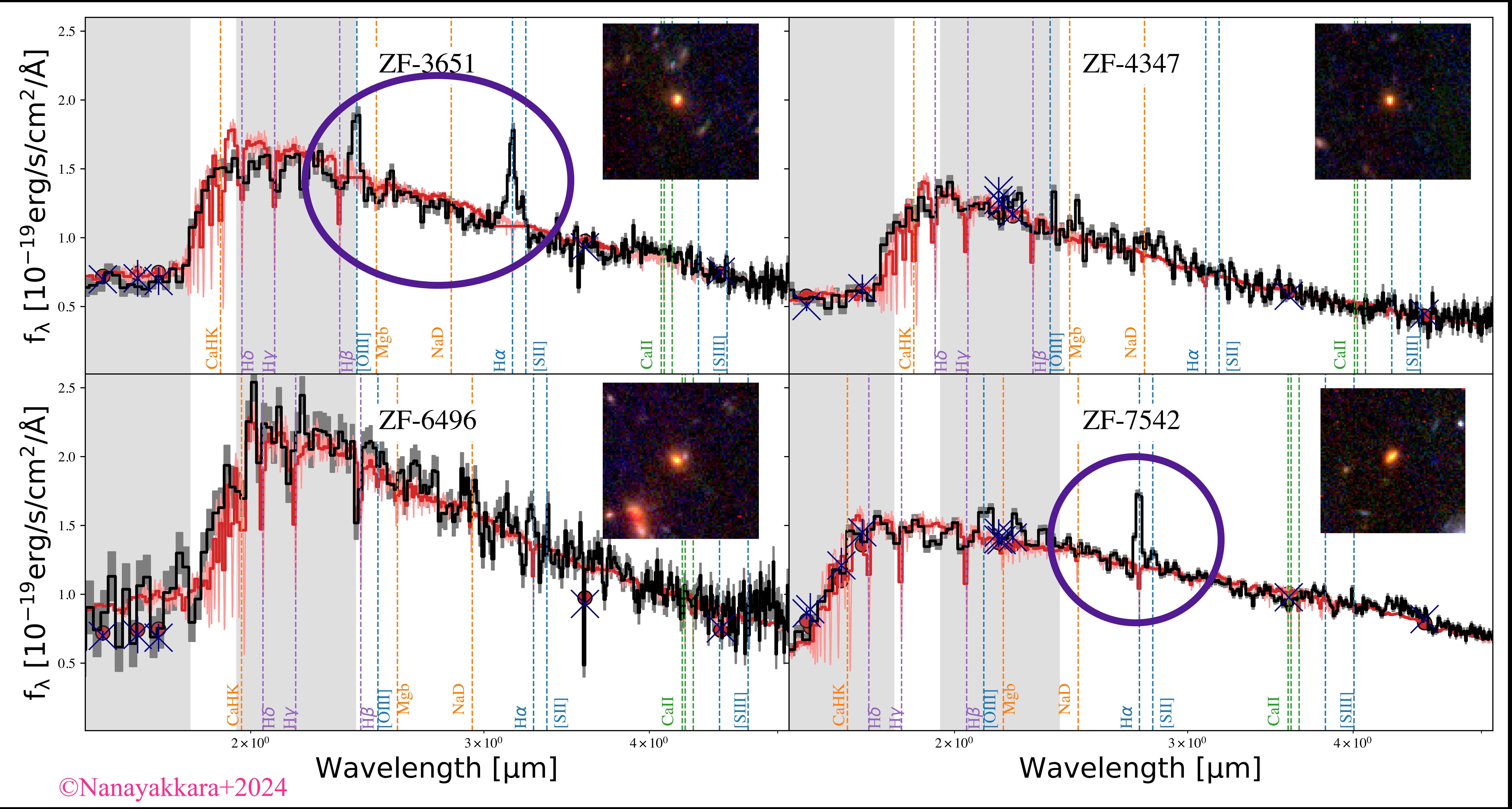

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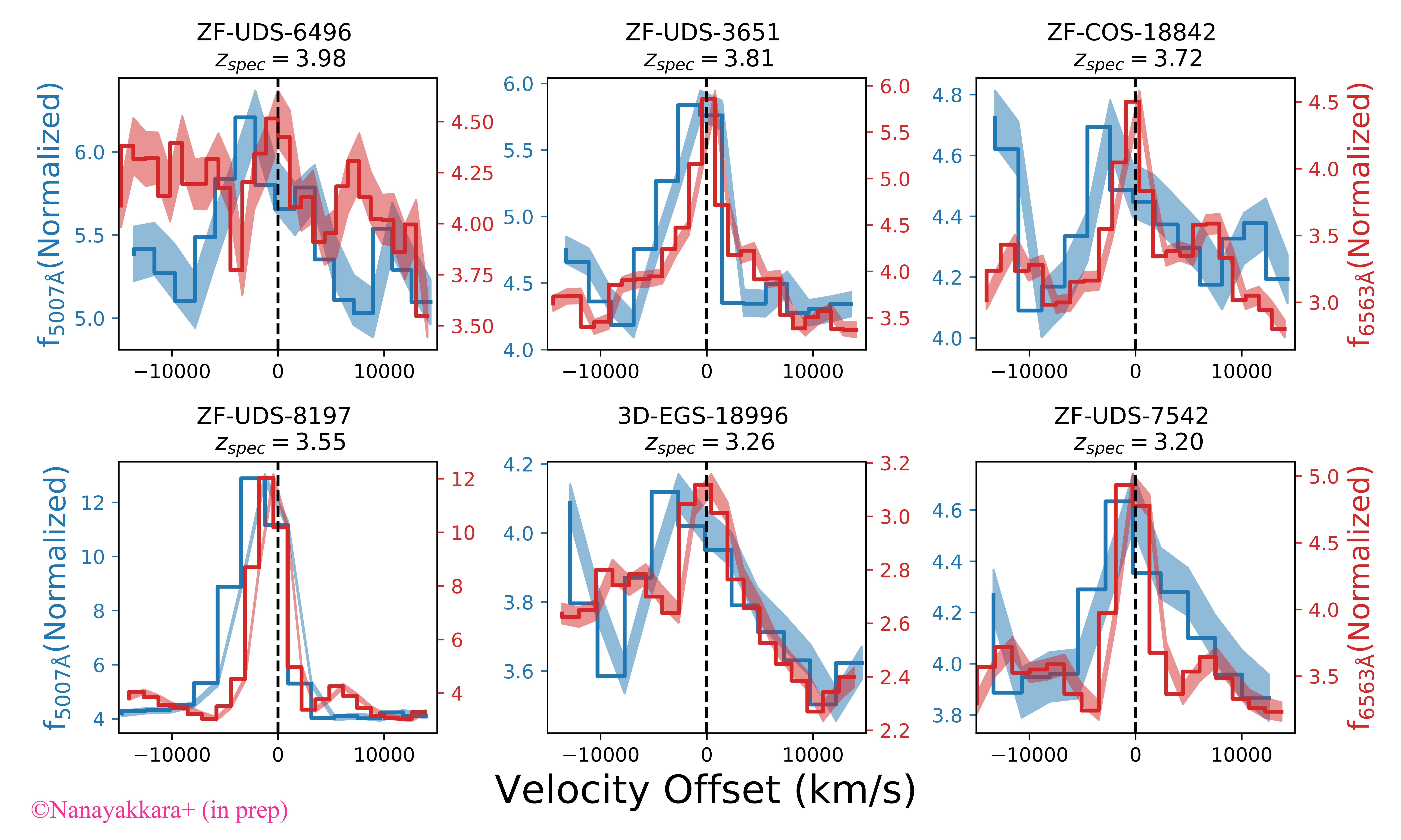
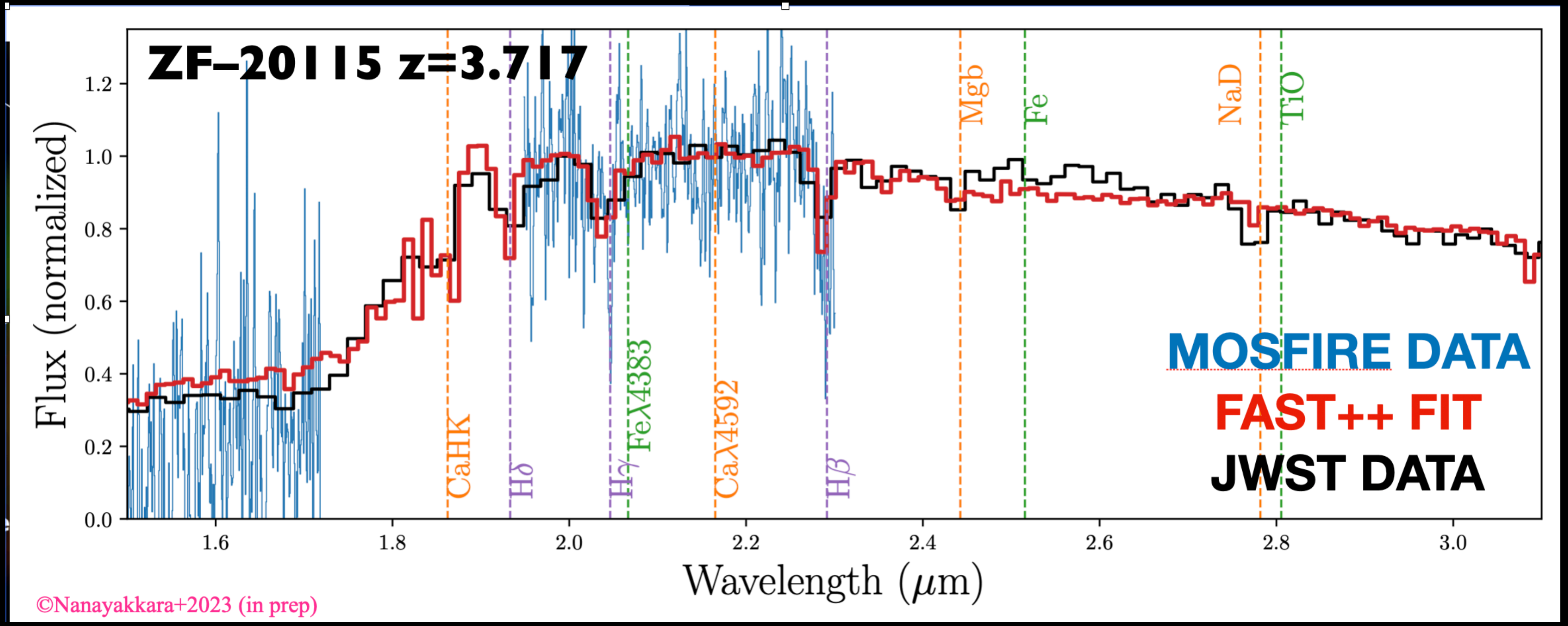
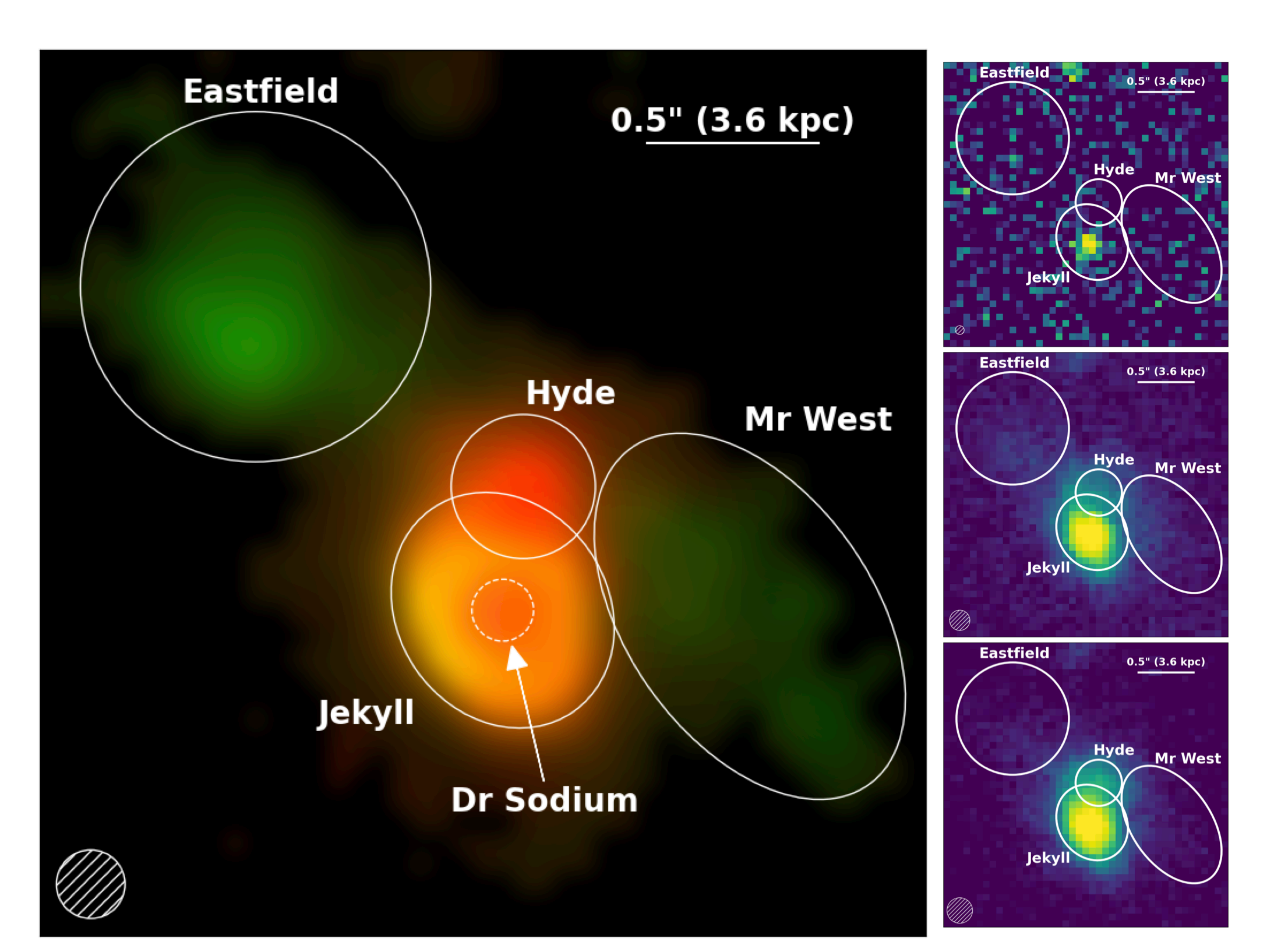
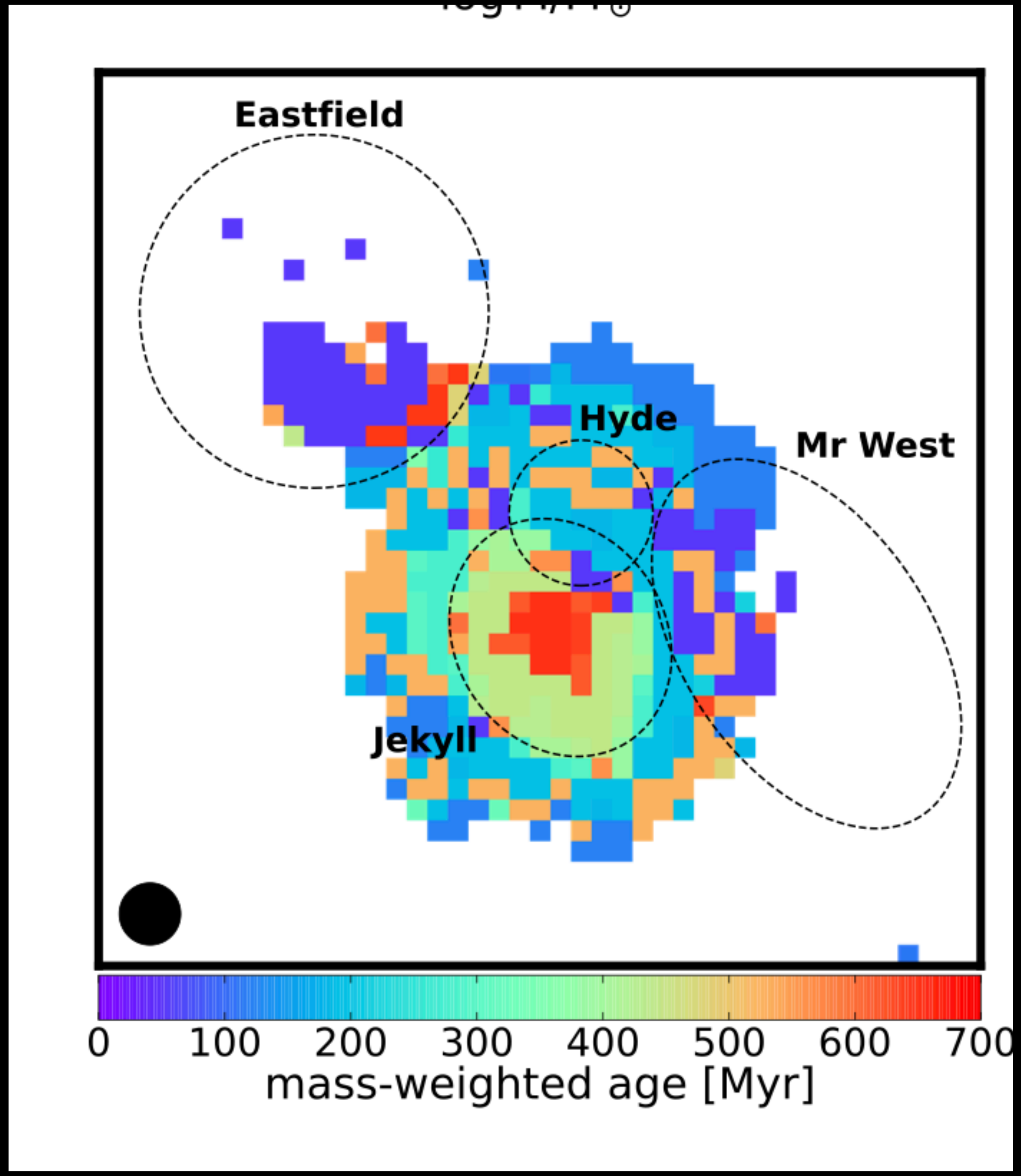


In fact IFS of z>3 QUs demonstrate the complex nature of AGN and local environment in regulating the star-formation







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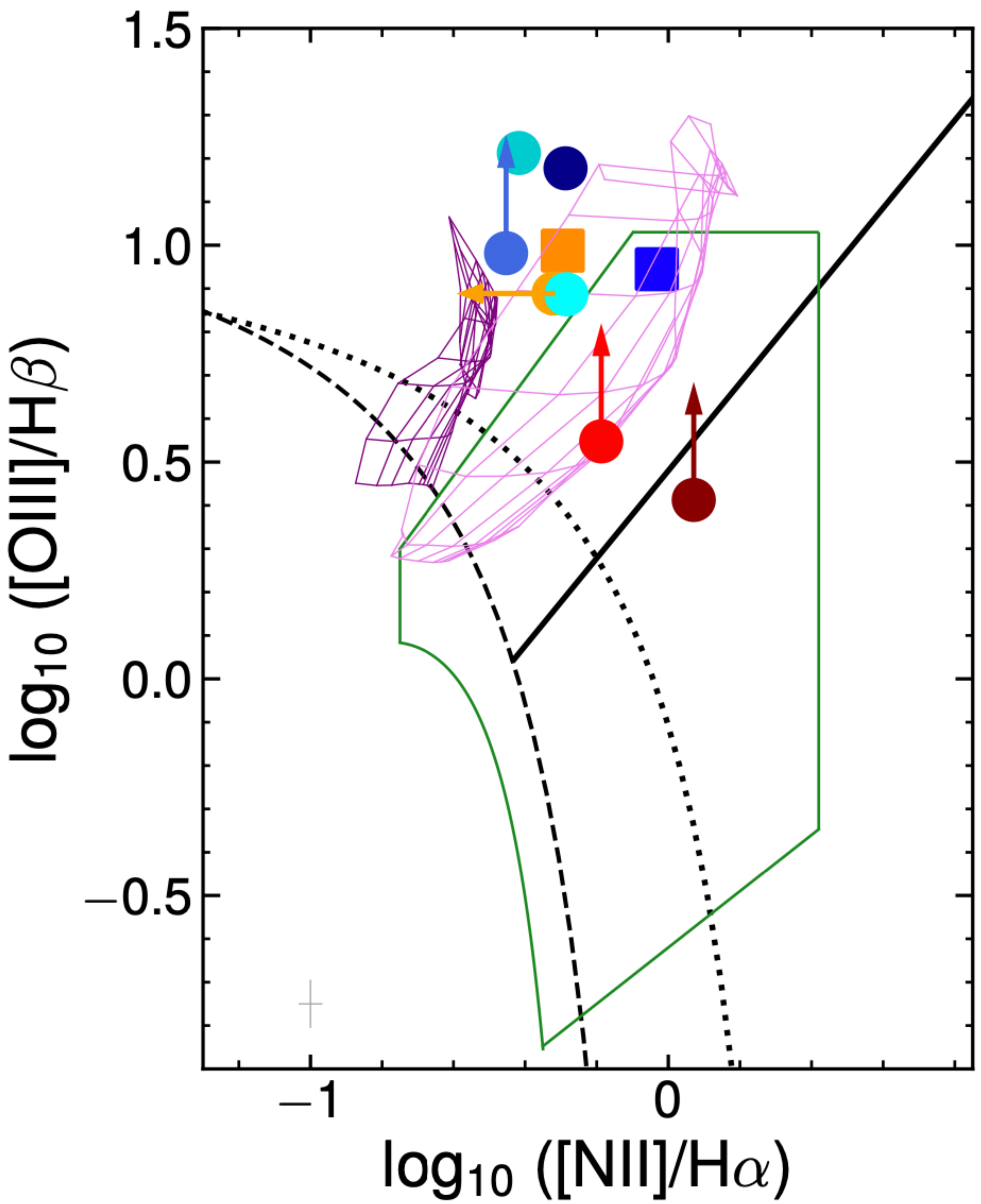

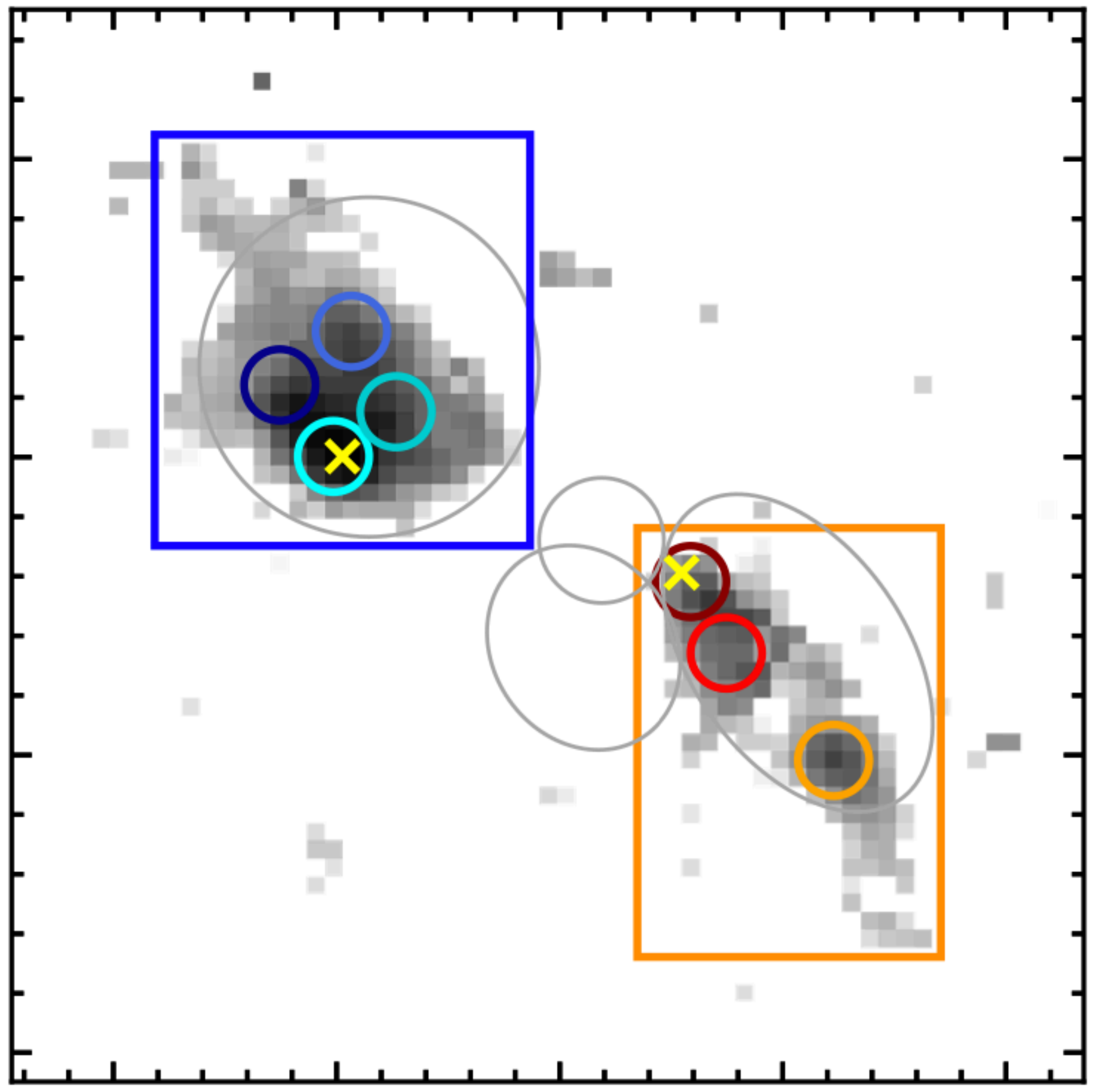

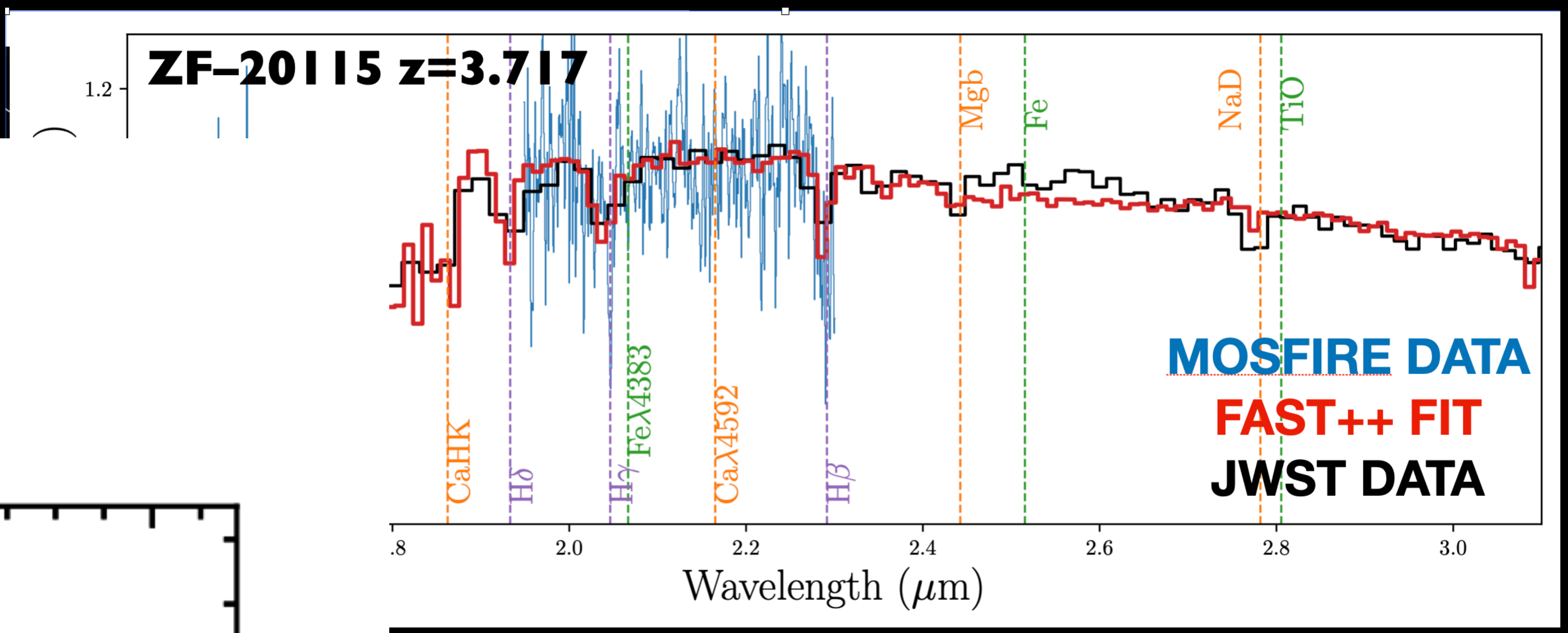

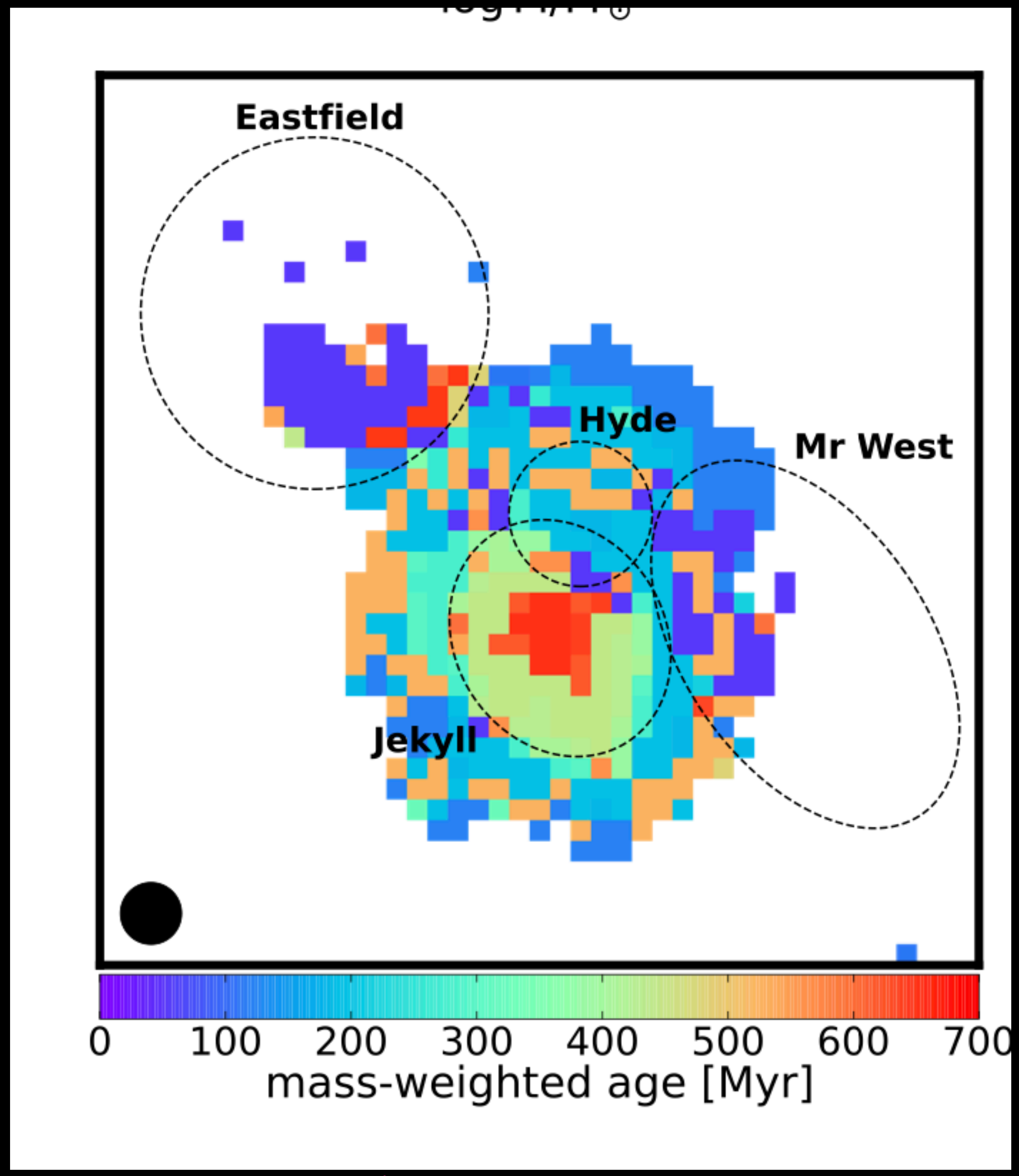

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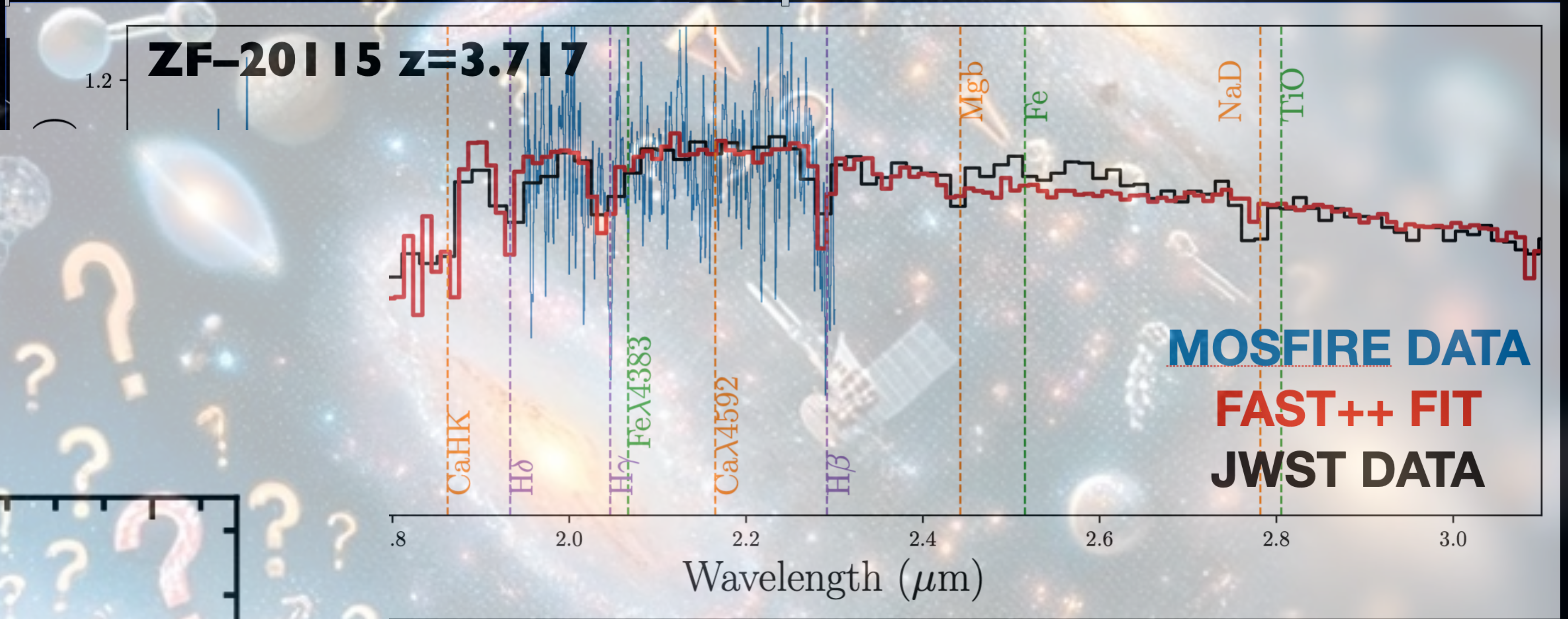
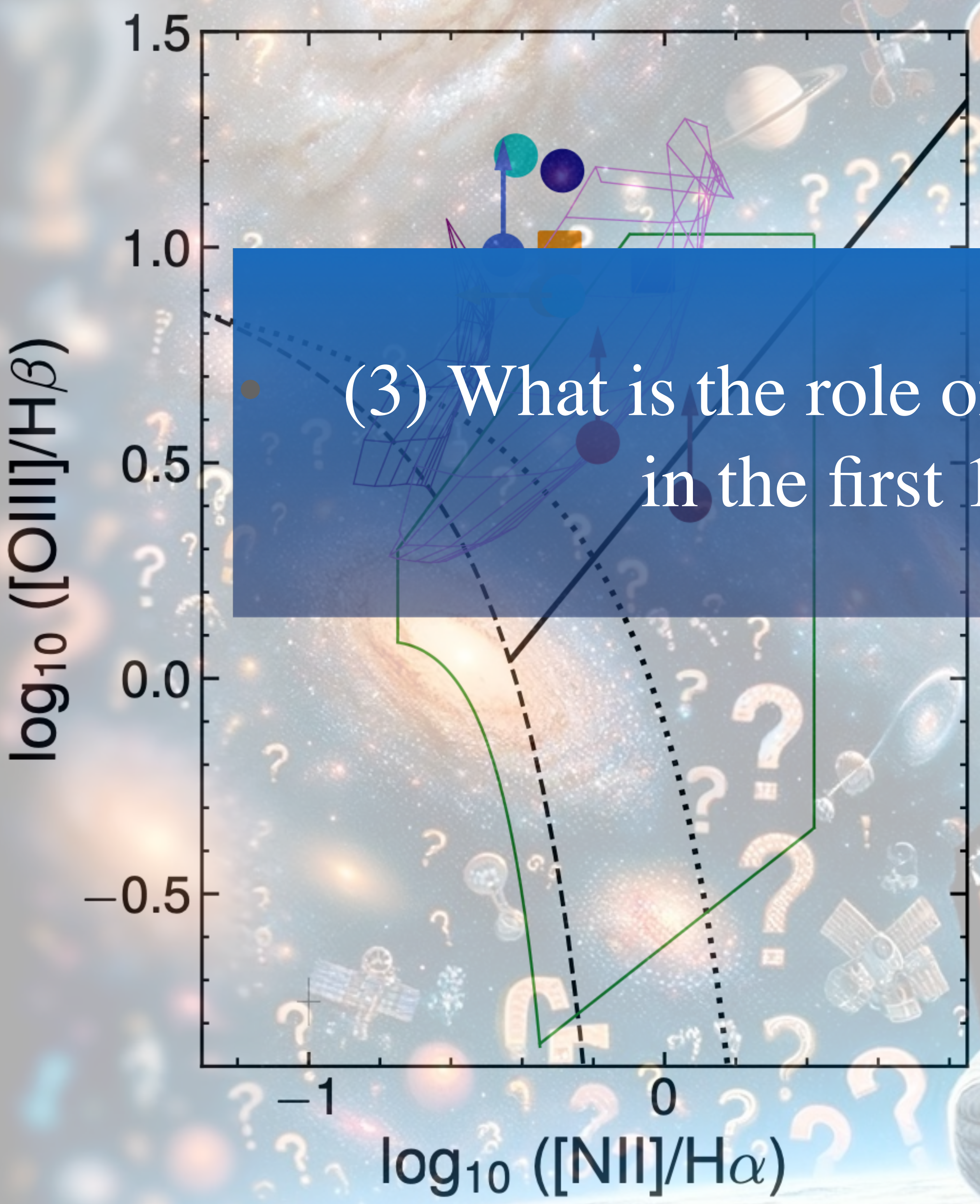
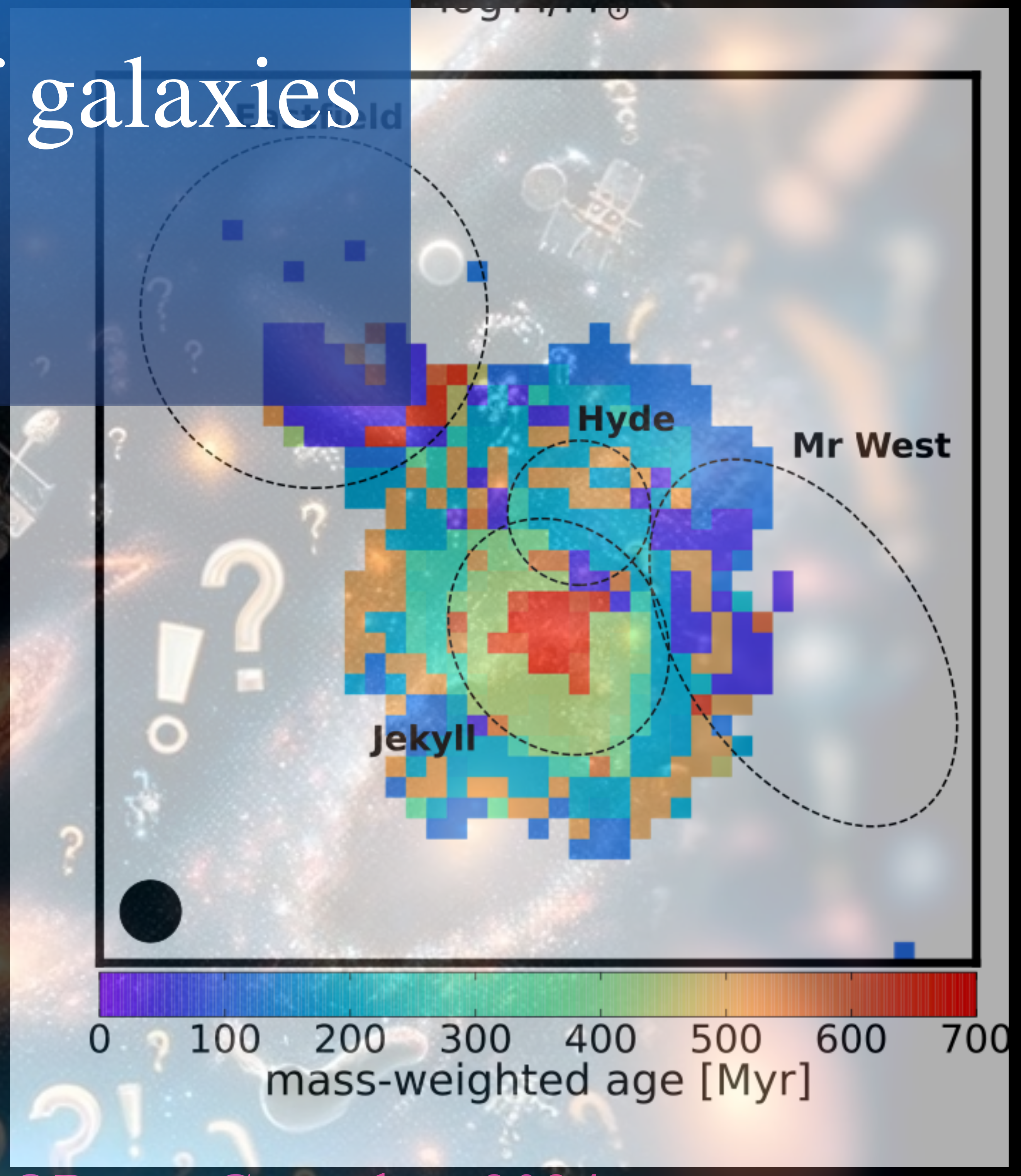
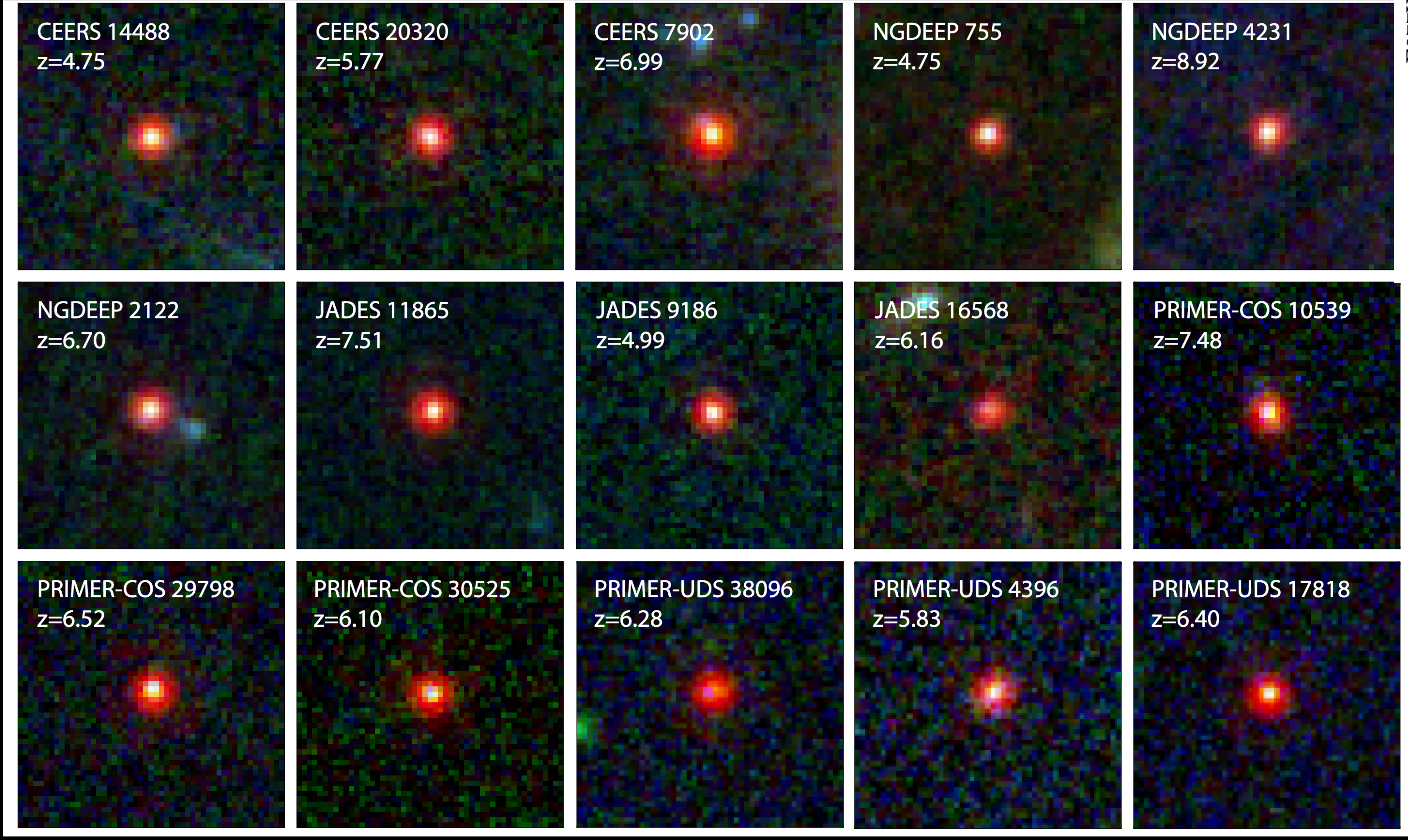




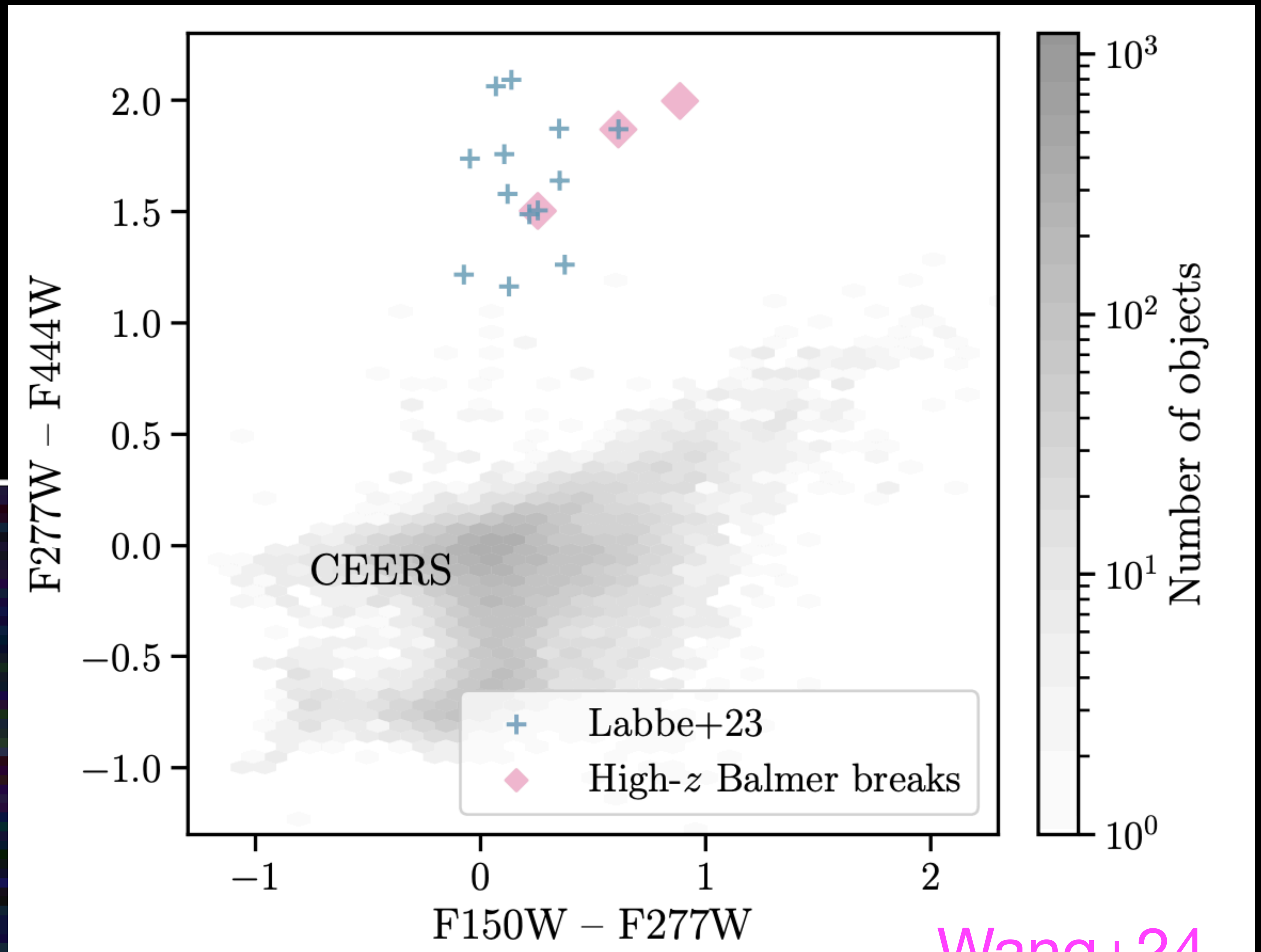
(3) What is the role of AGN in regulating the growth of galaxies in the first 1-2 billion years of the Universe?



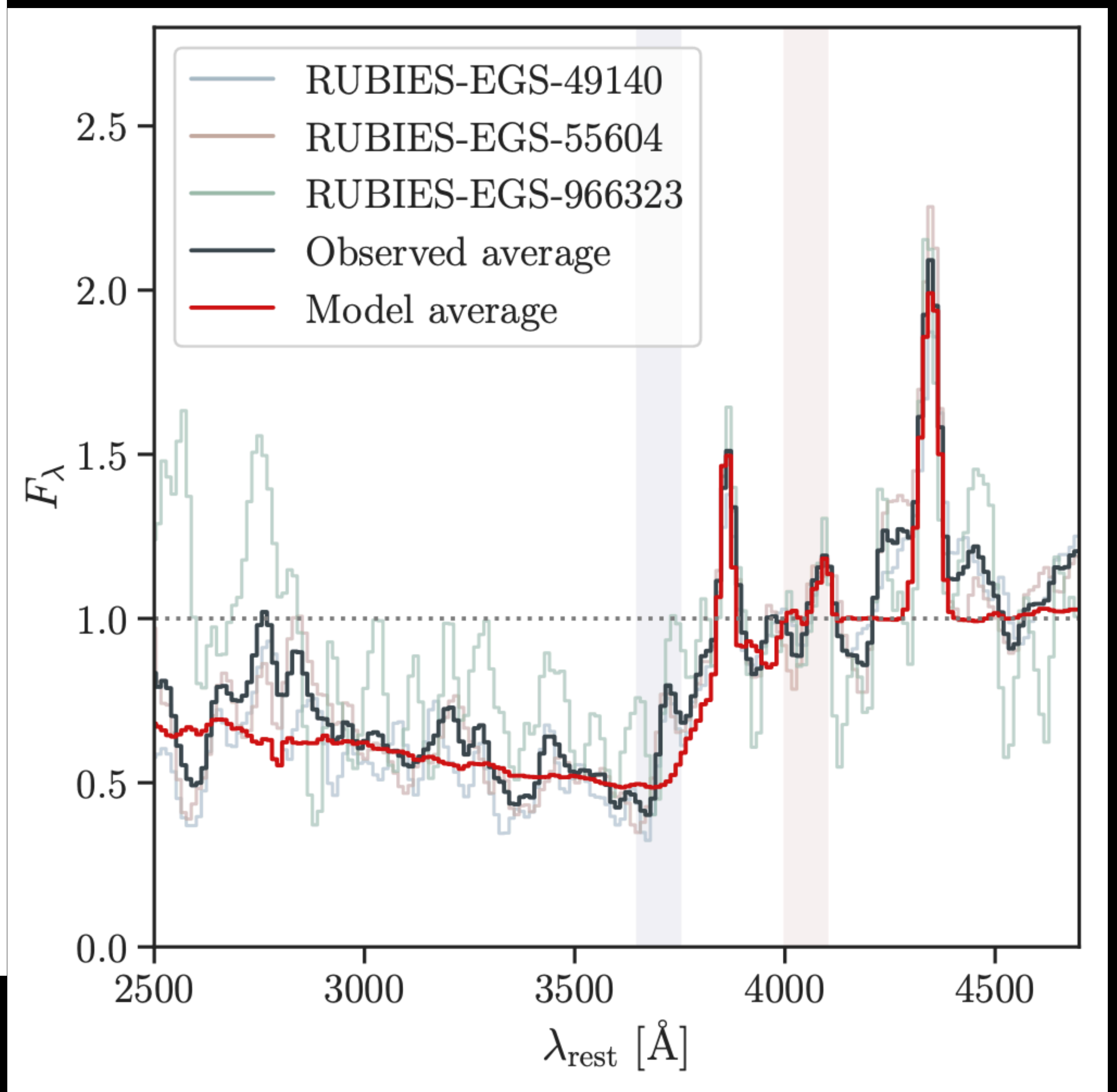
Little Red Dots: A previously unseen population of AGN?



Kocevski+24

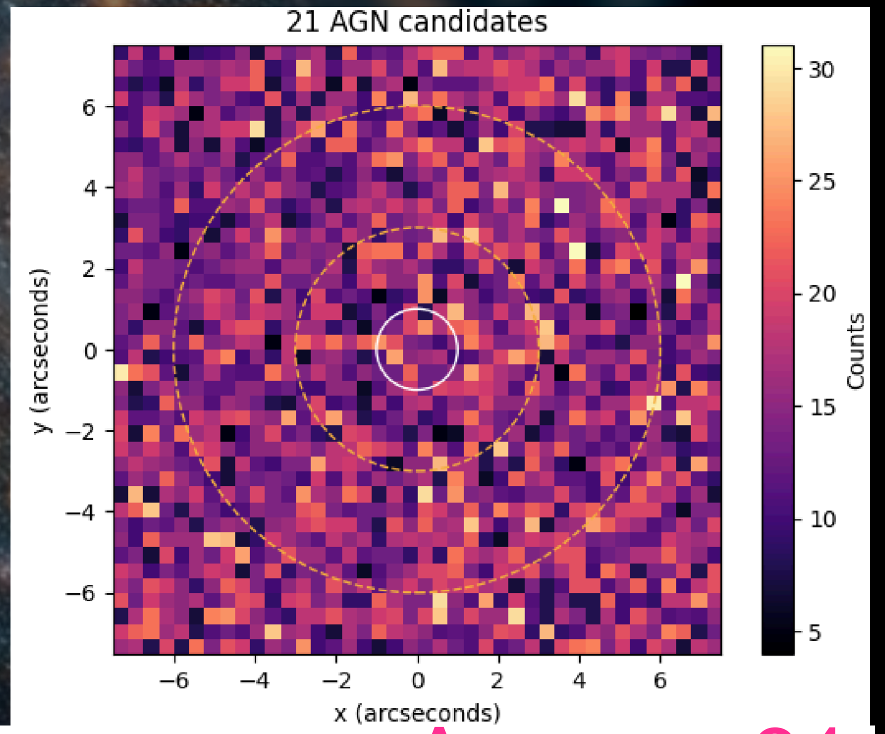


Wang+24

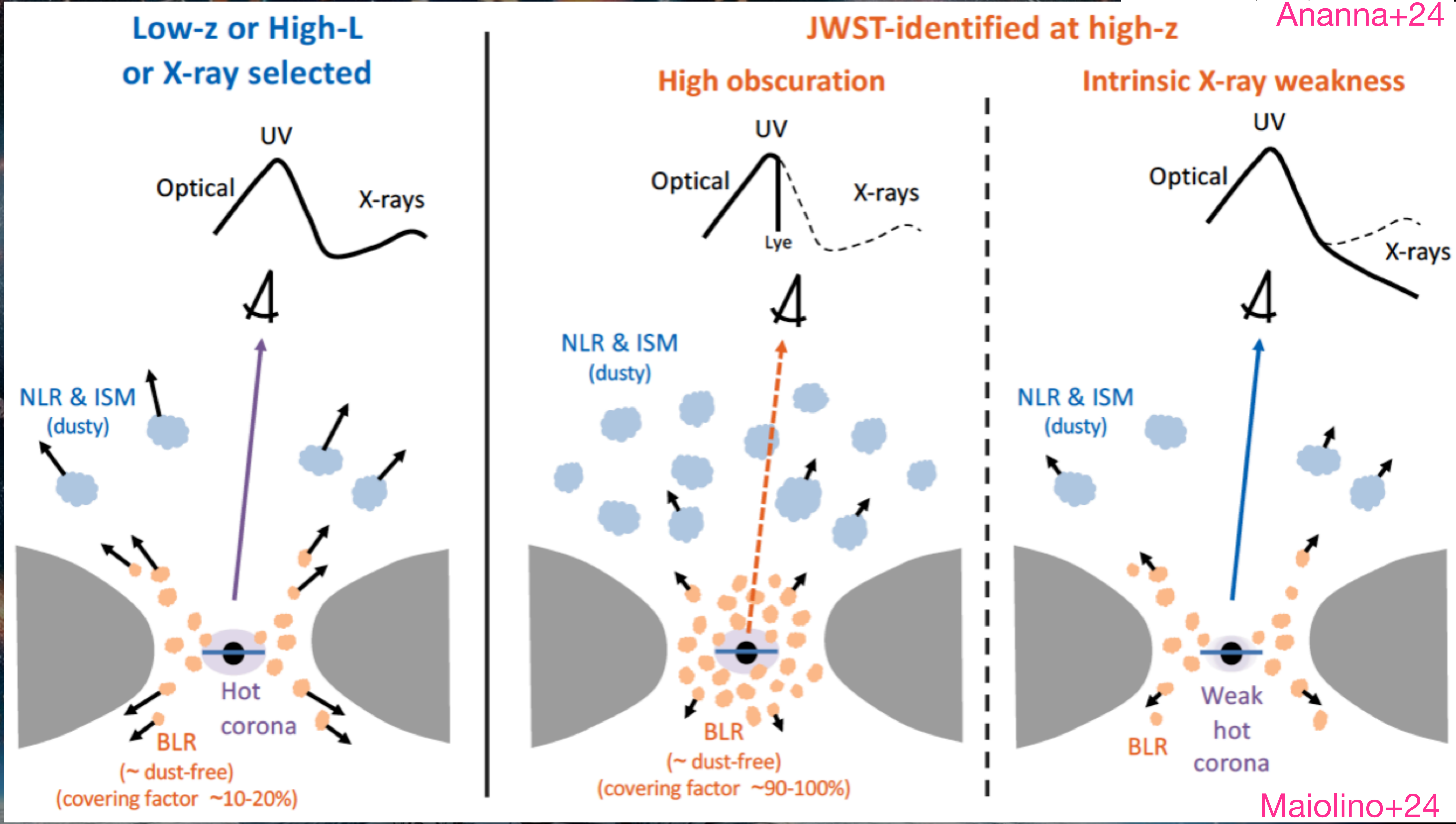


Little Red Dots: A previously unseen population of AGN?

- Points towards very dusty AGN at z>6 and/or formation of the quiescent cores of first massive quiescent galaxies.
- Can they be AGN? Complications from x-ray non-detections.
- Non-AGN models need to explain the observed broad emission lines.
- Completely unseen (and unexpected?) population. What is their contribution to re-ionization?
- What are the current day properties of these high-z objects?



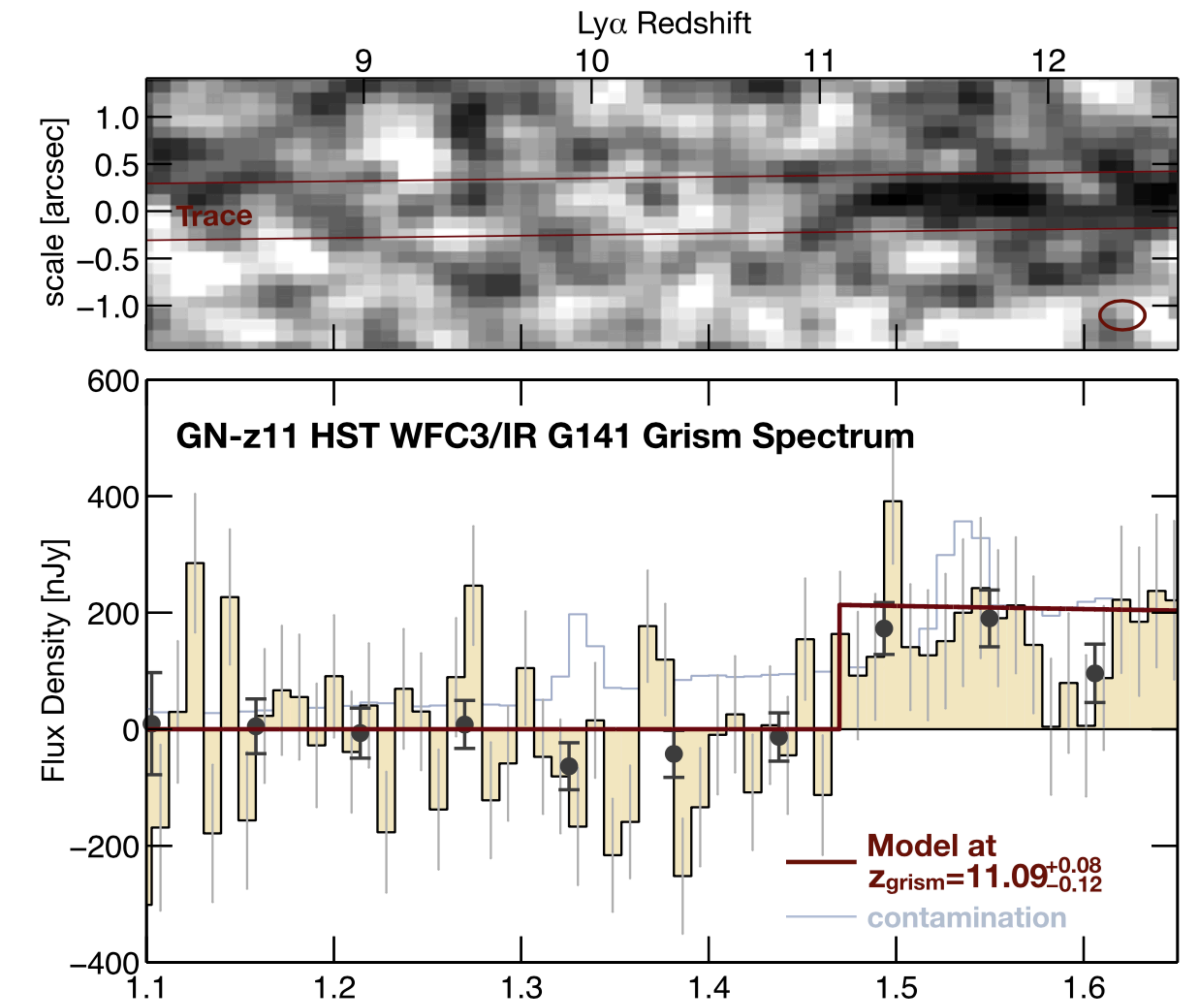
Ananna+24



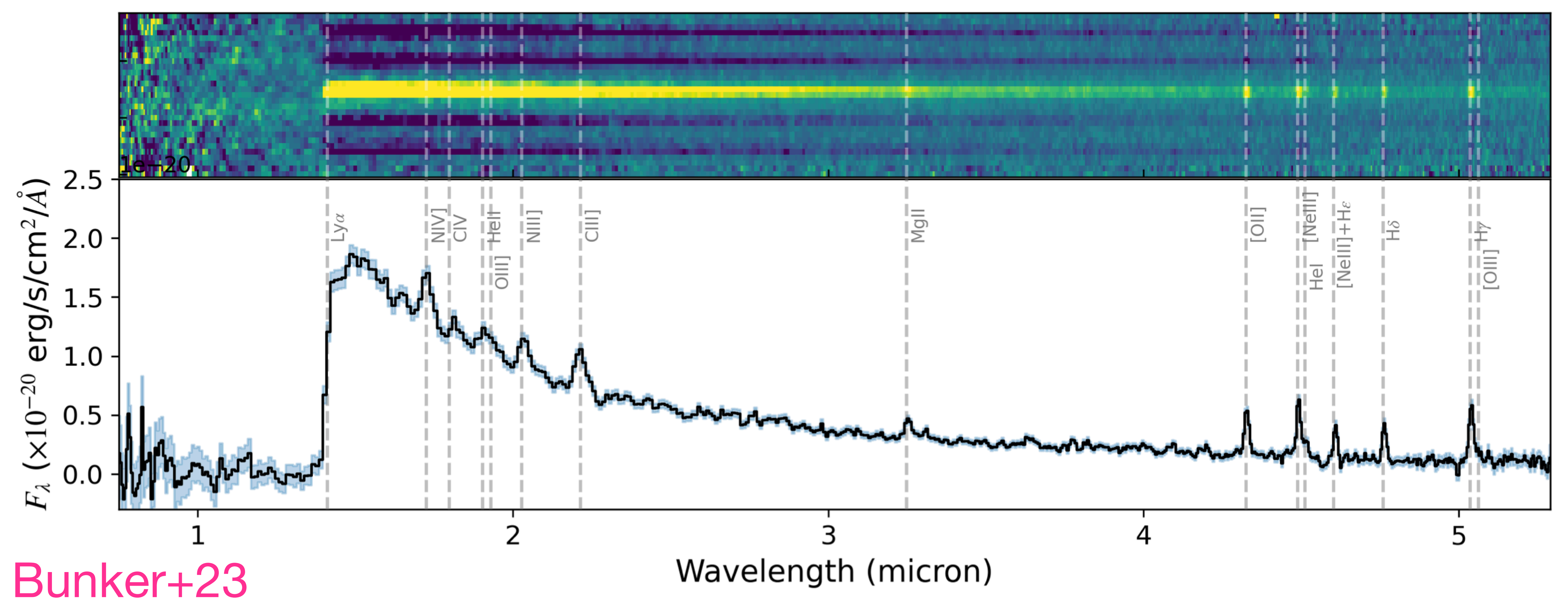
Maiolino+24

The luminous z>10 population. How are they powered?

AGN even at much earlier times?



Oesch+16

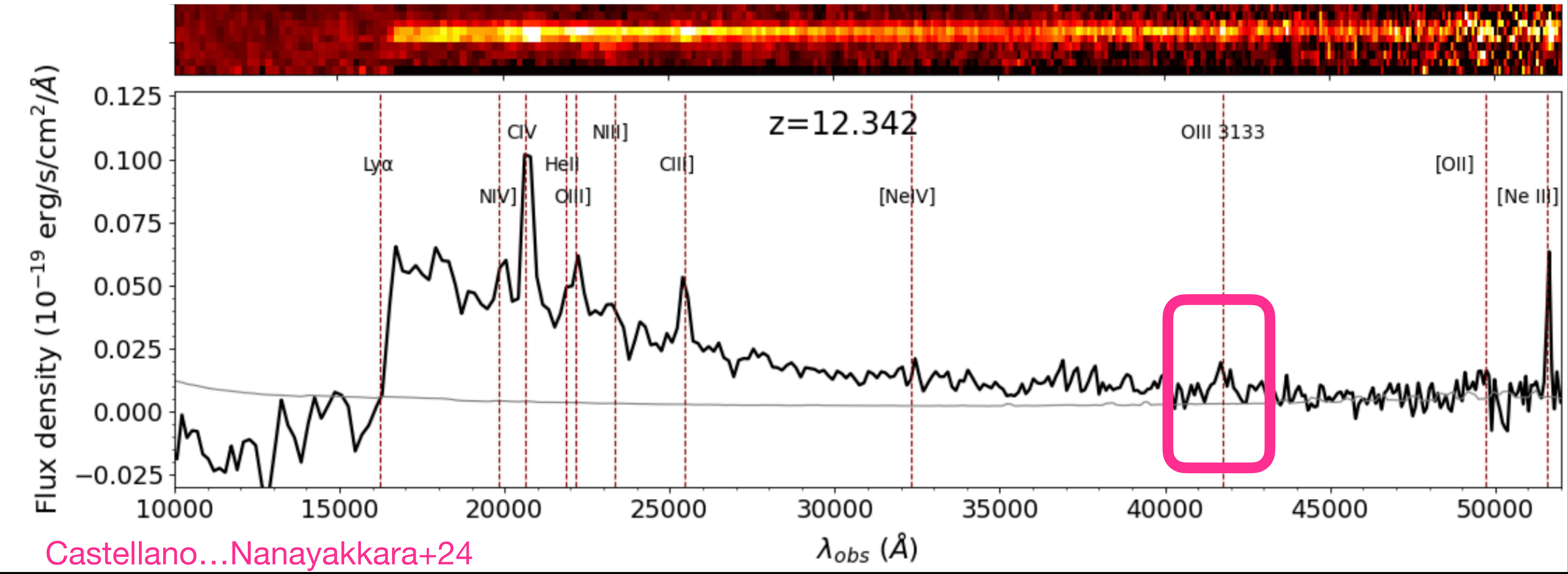


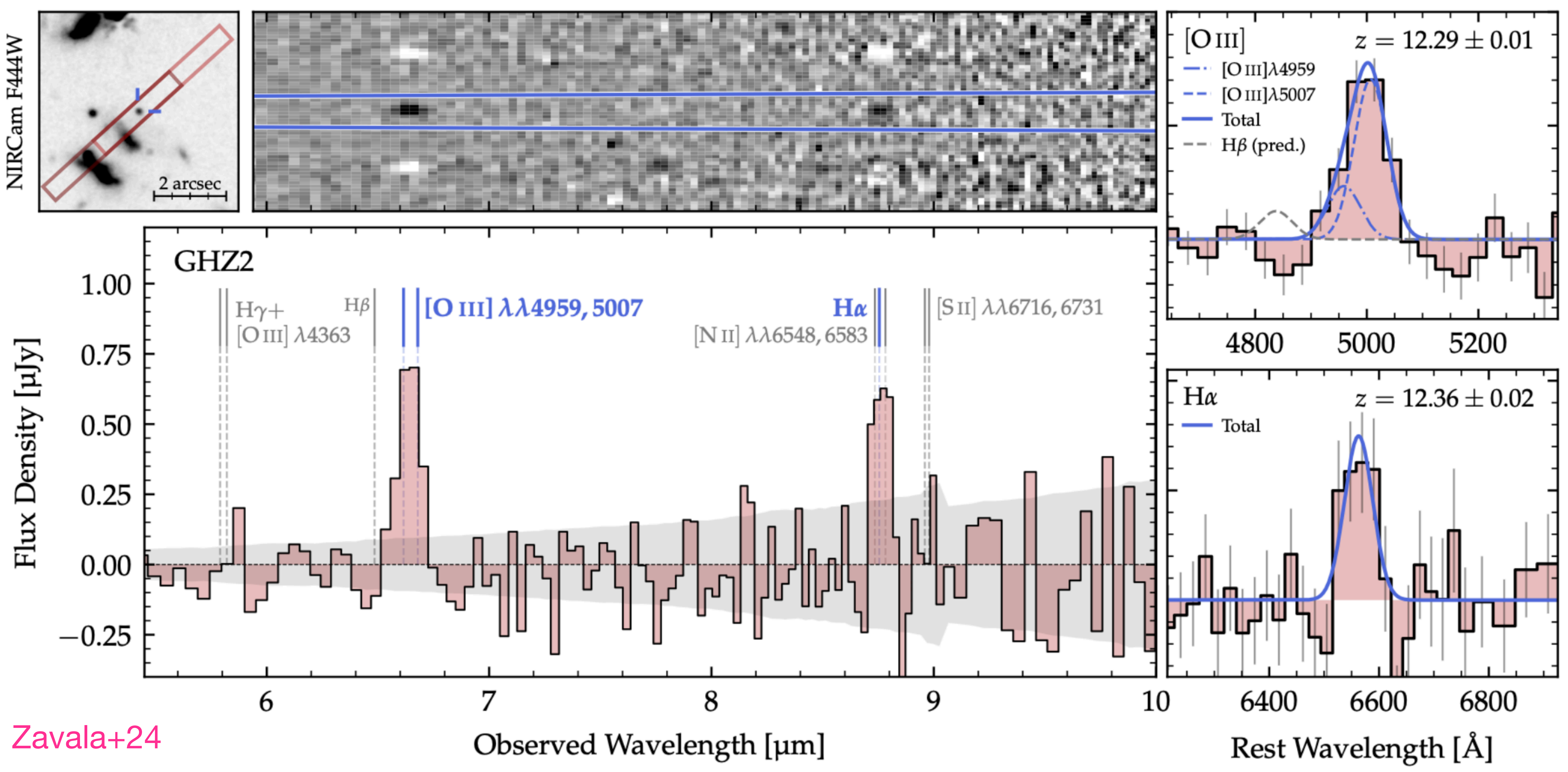
Bunker+23

The luminous z>10 population. How are they powered?

Early N enrichment

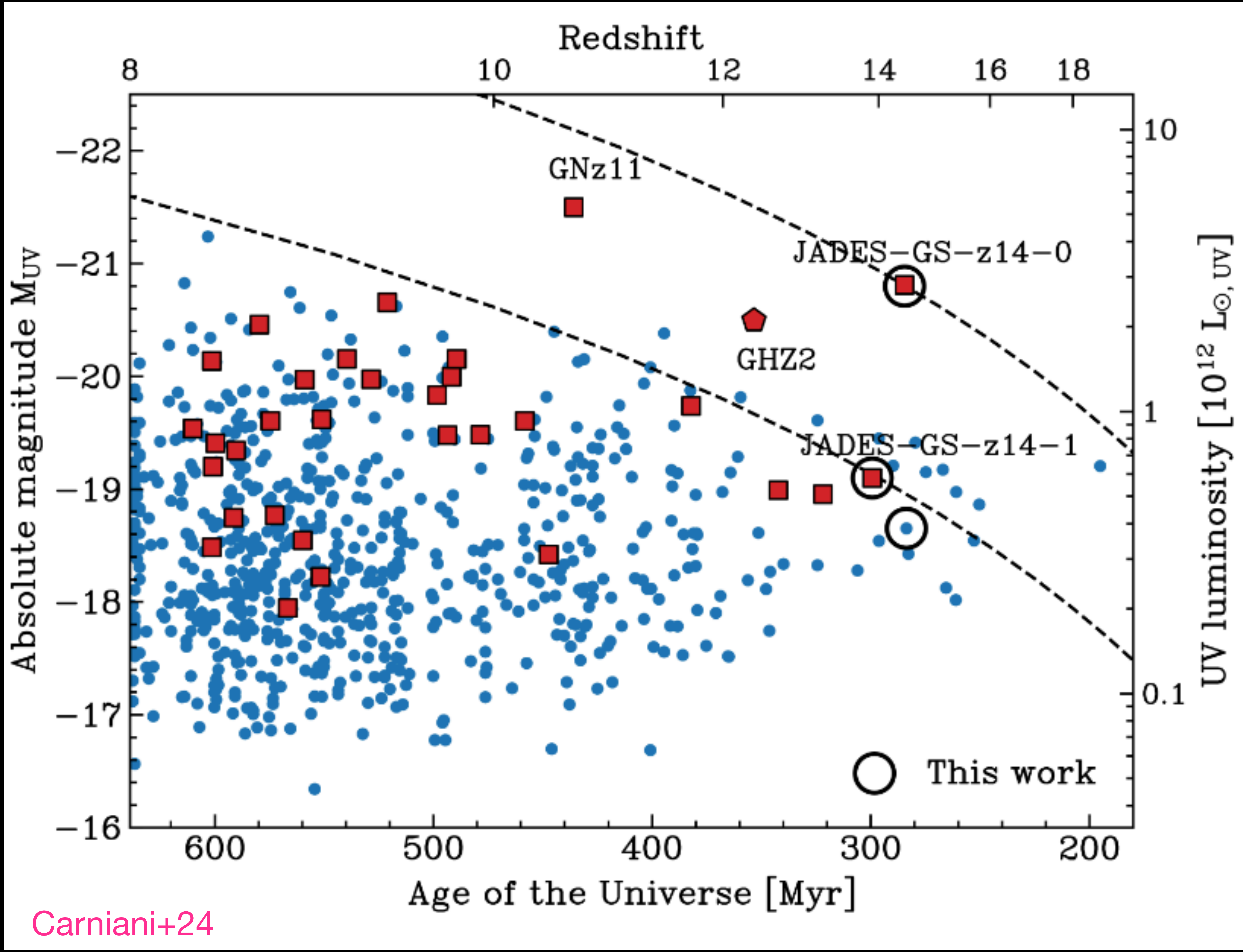
- Sources show high ionisation parameters, high electron densities, and high star formation rate surface densities.
- Why are some sources heavily enriched in N?
- Clues from FMR and compact nature of SF
- Newer supernova enrichment and/or WR atmosphere models?
- High density linked to proto-globular cluster formations?
- Why haven't we seen similar sources at z<10?





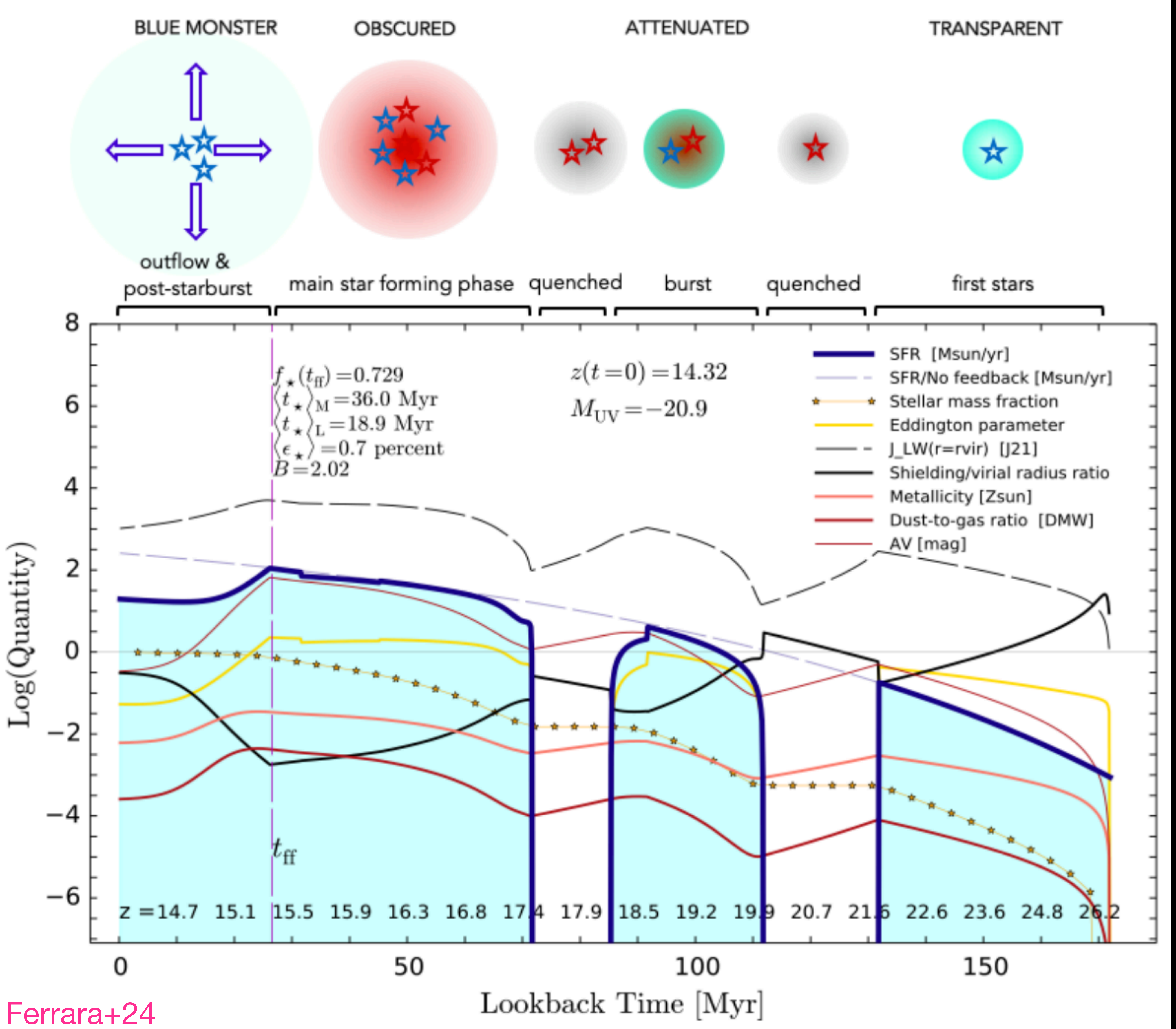
The luminous z>10 population. The origin of the "blue monsters"

- Many mechanisms proposed to address the abundance of UV bright sources at z>10.
  - Feedback Free SF
  - Variable SF
  - Top Heavy IMF
  - Photo-z issues?



The luminous z>10 population. The origin of the "blue monsters"

- Several theories exist to explain the formation and evolution of such sources within the λCDM.
- Imperative to obtain observational evidence to constrain these mechanisms and/or look for alternative theories.
- Entering a regime: new frontiers need to open up with sub-mm facilities?

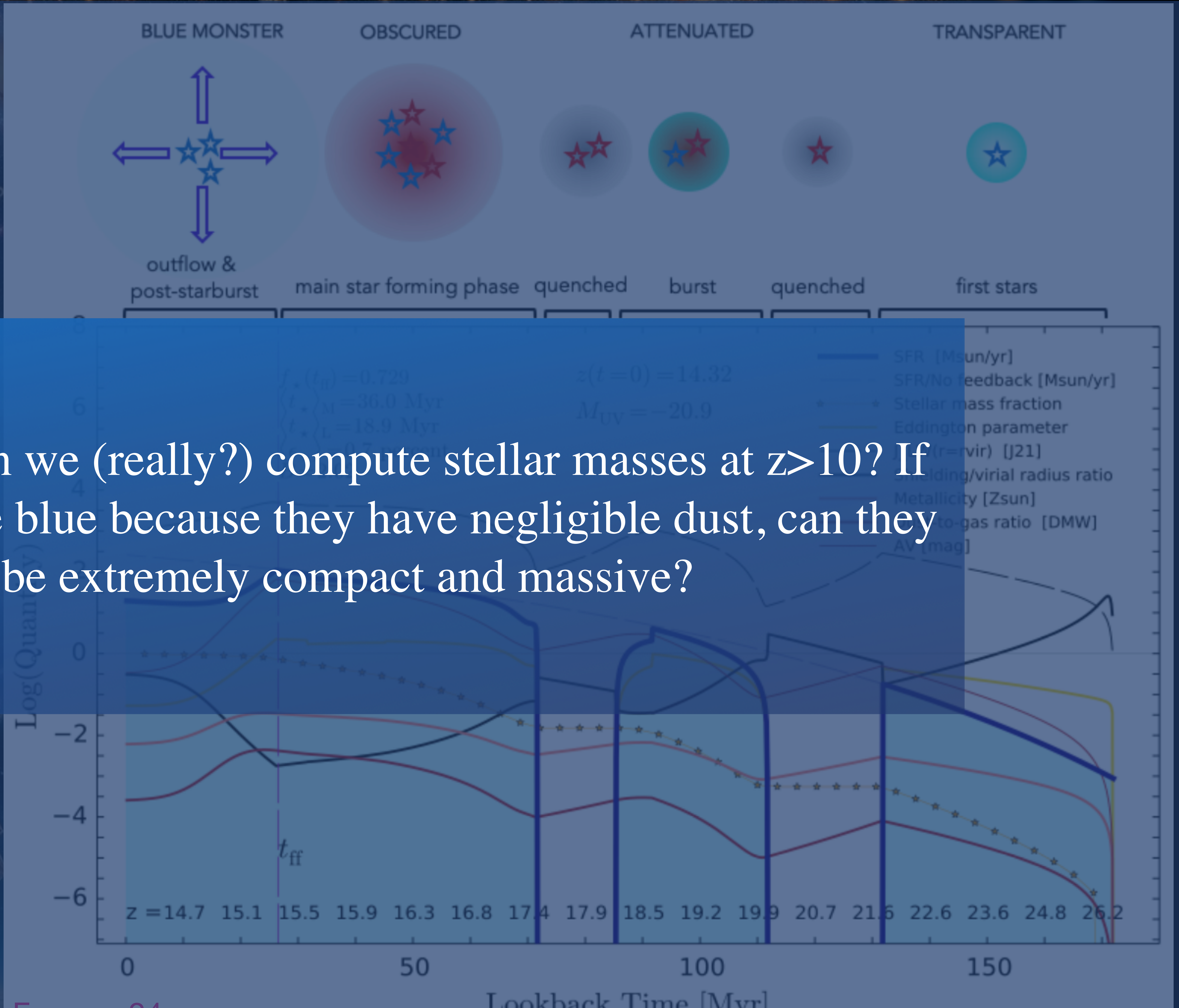


Ferrara+24

The luminous z>10 population. The origin of the "blue monsters"

- Several theories exist to explain the formation and evolution of such sources within the λC
- Imperative to obtain observational evidence to constrain these mechanisms and/or look for alternative theories.
- Entering a regime: new frontiers need to open up with sub-mm facilities?

(4) How well can we (really?) compute stellar masses at z>10? If z>10 galaxies are blue because they have negligible dust, can they also be extremely compact and massive?



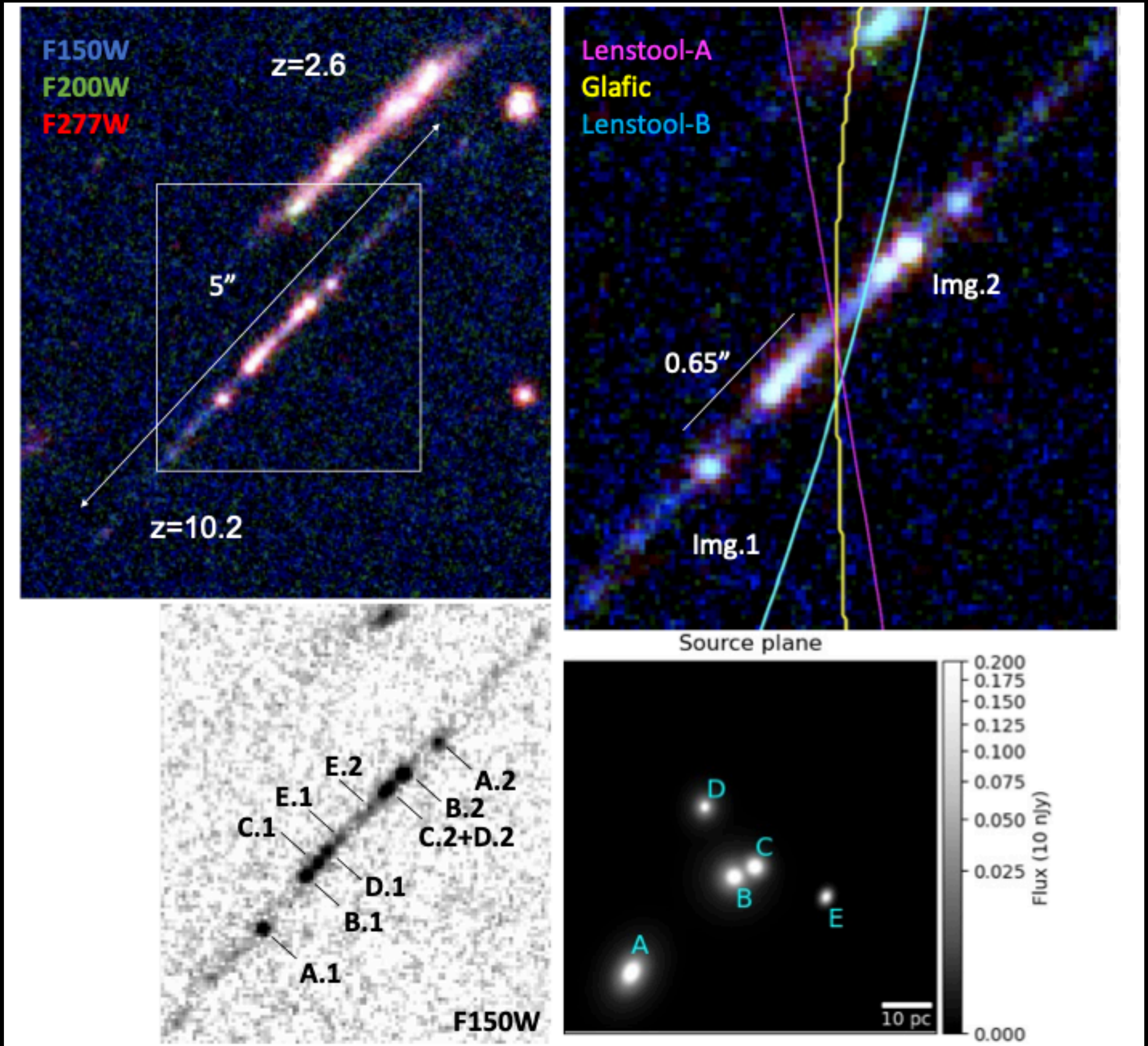
Ferrara+24


Cosmic MYSTERIES
III Ionizing Photons

Aided by gravitational lensing, we can reach the faint end of the UV LF

Star cluster complexes at z~10

- High density linked to proto-globular cluster formations?
- These complexes show:
  - Low metallicity
  - Low dust attenuation
  - Young ages
  - Very high stellar density (>3 mag higher than local star clusters)

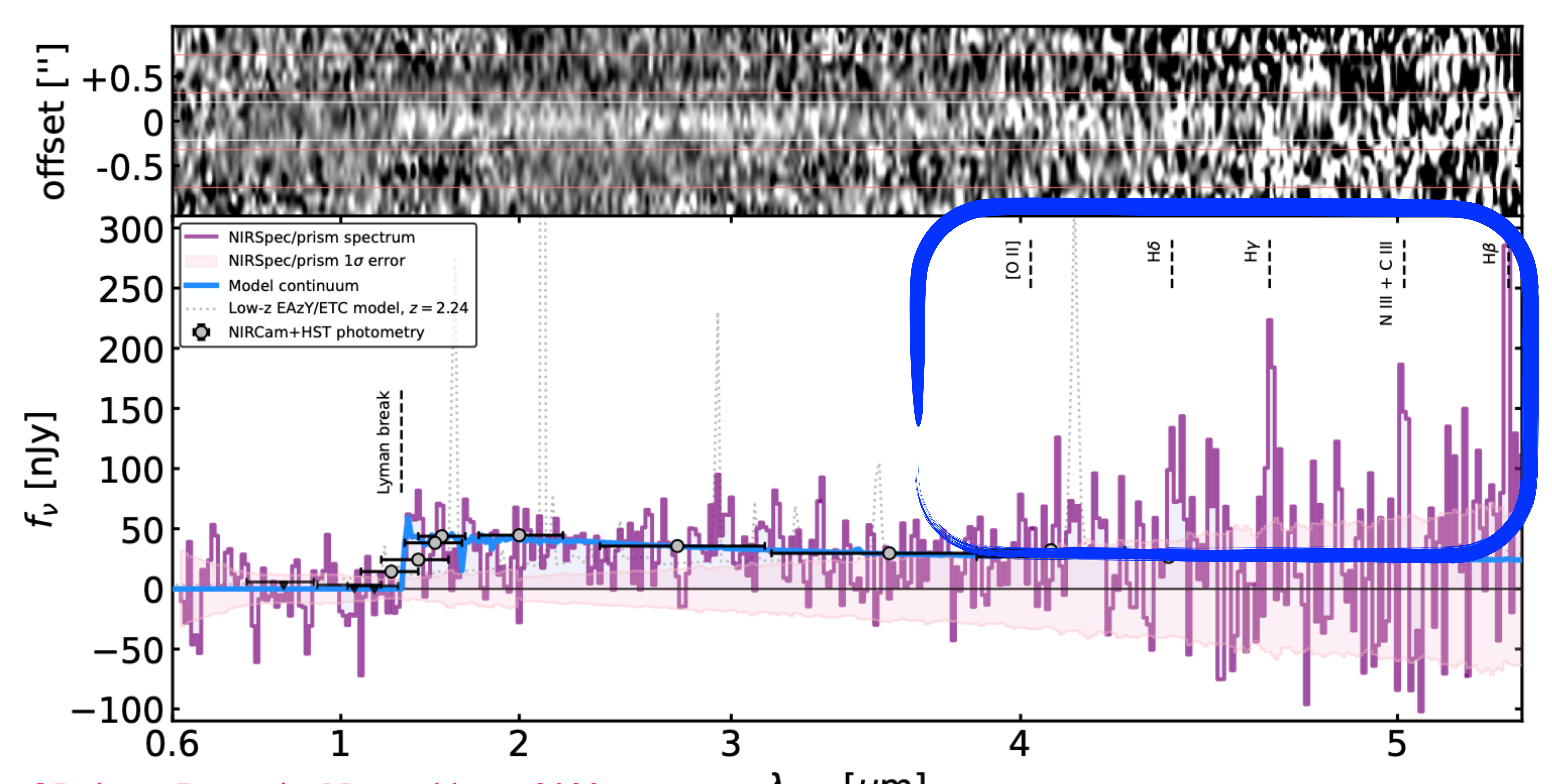


Adamo+24

JWST spectroscopy is opening up a new window into probing the faint low mass galaxies at z~10. Constraining the luminosity density of such sources is crucial to determine the reionization of the Universe.

$0.05L_{*}$ galaxy with $\sim 0.5Z_{\odot}$

$\log M_{*}/M_{\odot} = 7.48$



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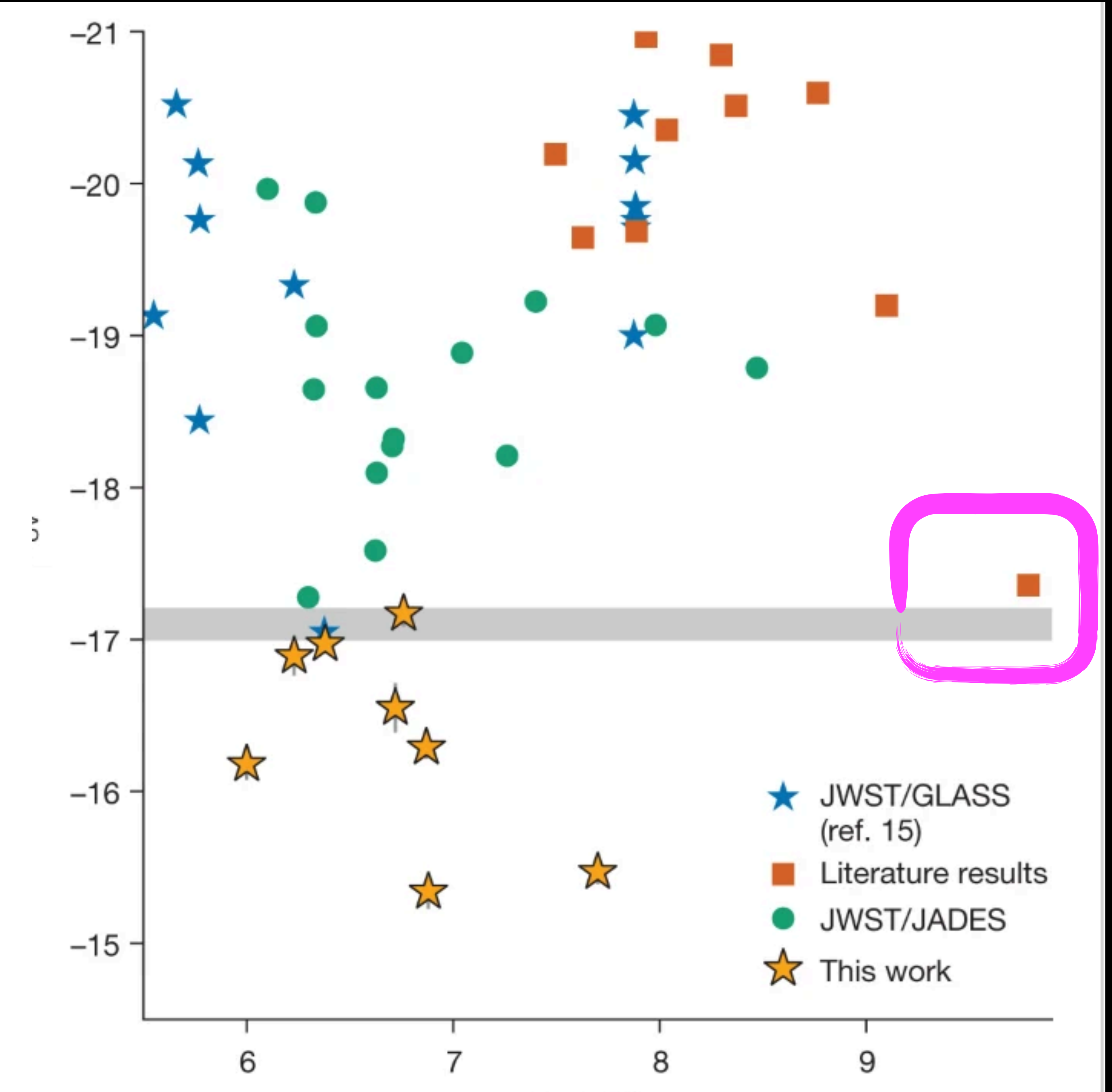

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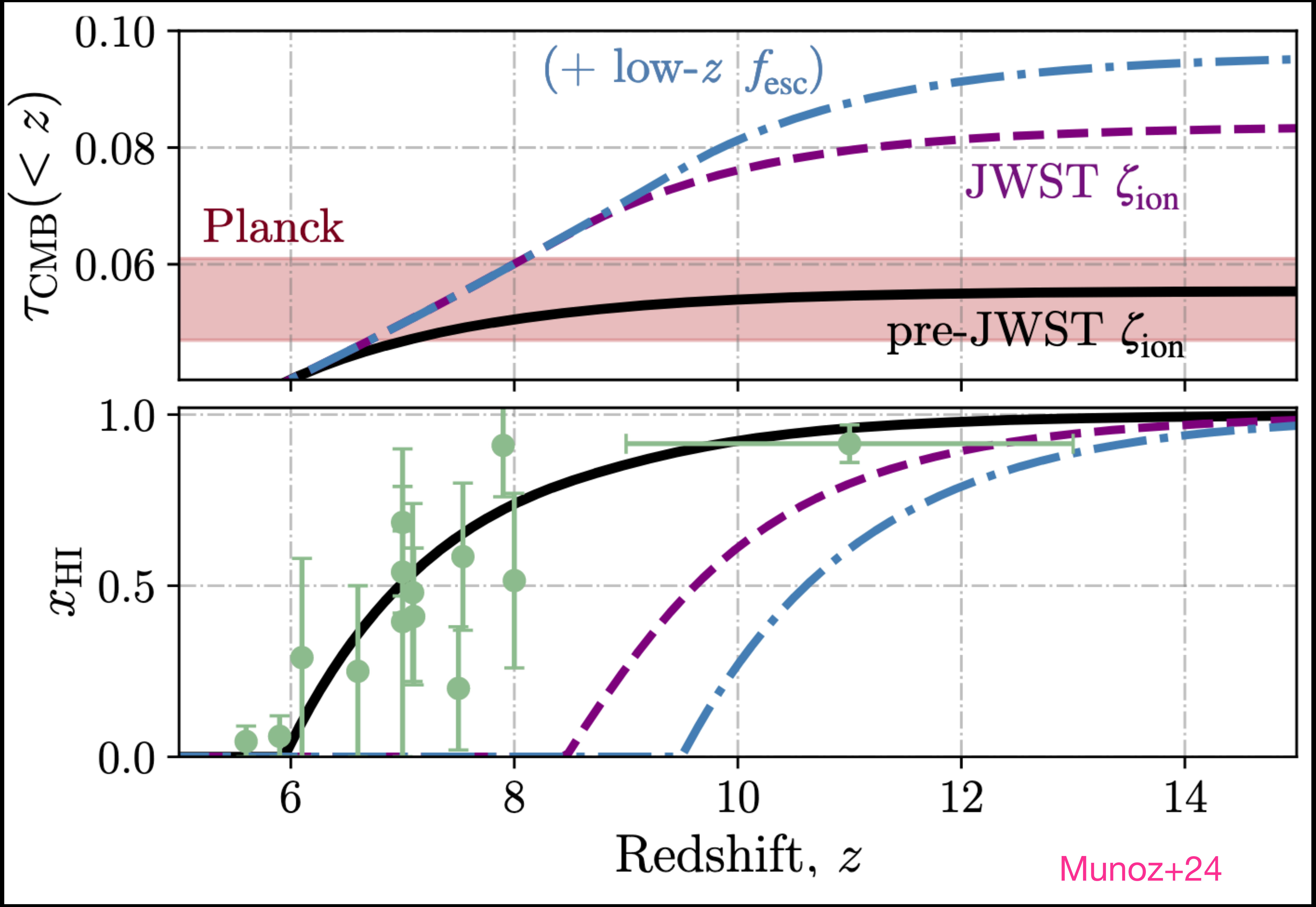
New evidence from UV faint galaxies suggest there maybe too many ionizing photons at z>6

- Manifested through multiple methods from UV LF to high production of ionising photons in fainter galaxies etc(~4X more).
- Links to local analogues become tricky
- Dust and sightline related issues. What can we really learn?



New evidence from UV faint galaxies suggest there maybe too many ionising photons at z>6

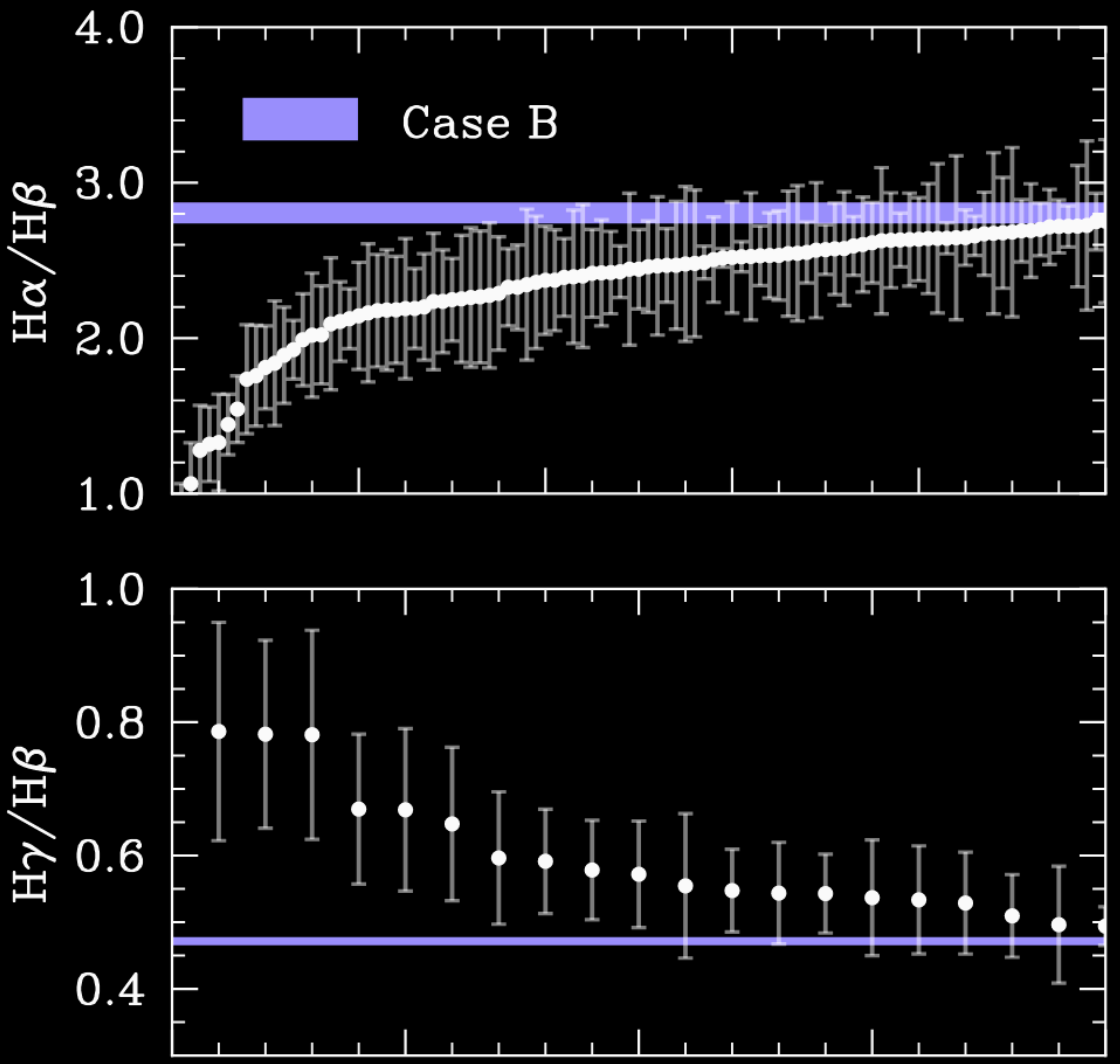
Munoz+24

New evidence from UV faint galaxies suggest there maybe too many ionising photons at z>6

Munoz+24

(5) How well can we really constrain the ionising photon production efficiencies, LyC escape fractions, and N of recombinations/photons?

Departures from Case B: density bounded nebulae tied to SFH is invoked to explain a significant fraction of z>2 sources that show anomalous Balmer line ratios



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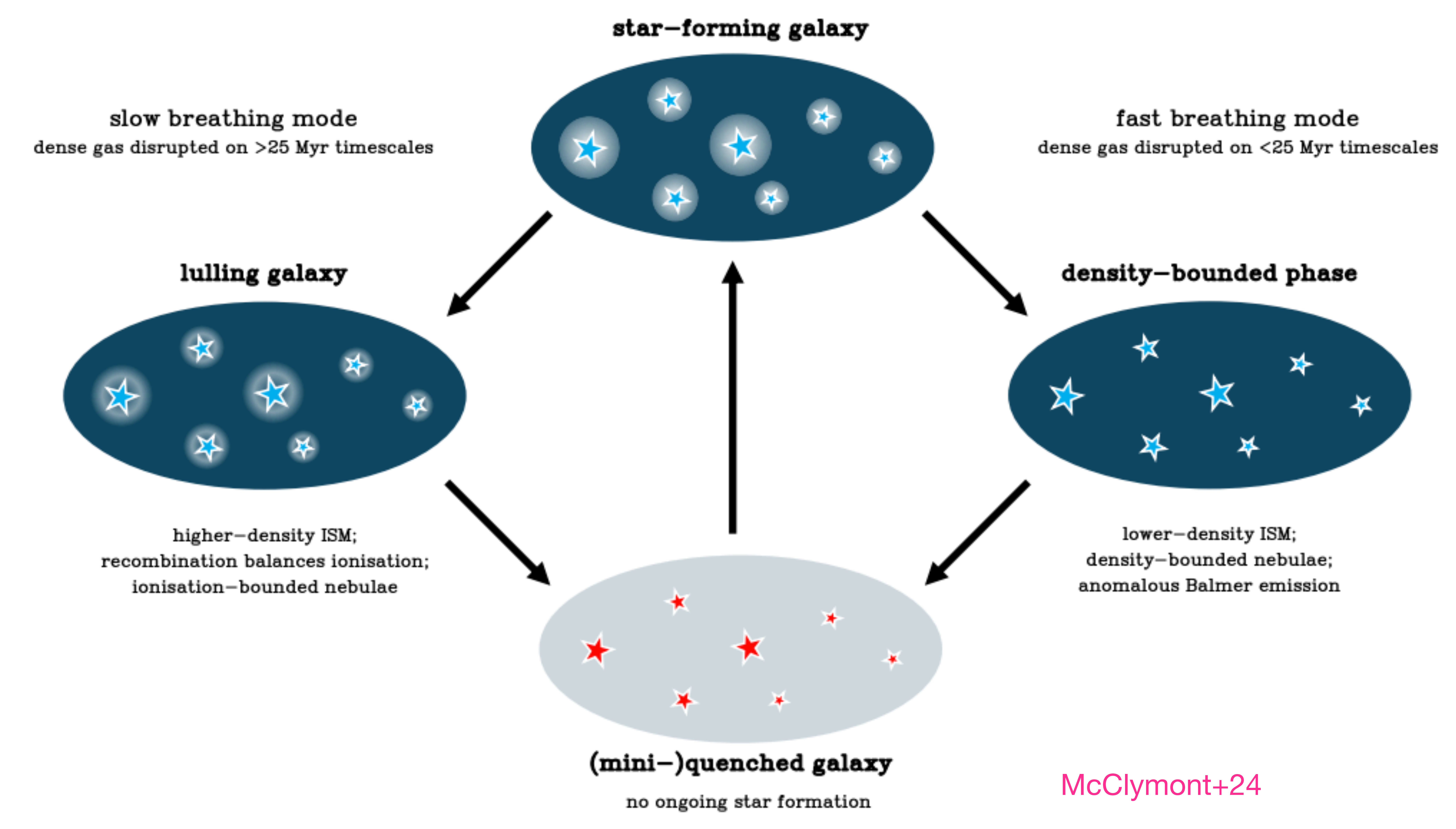
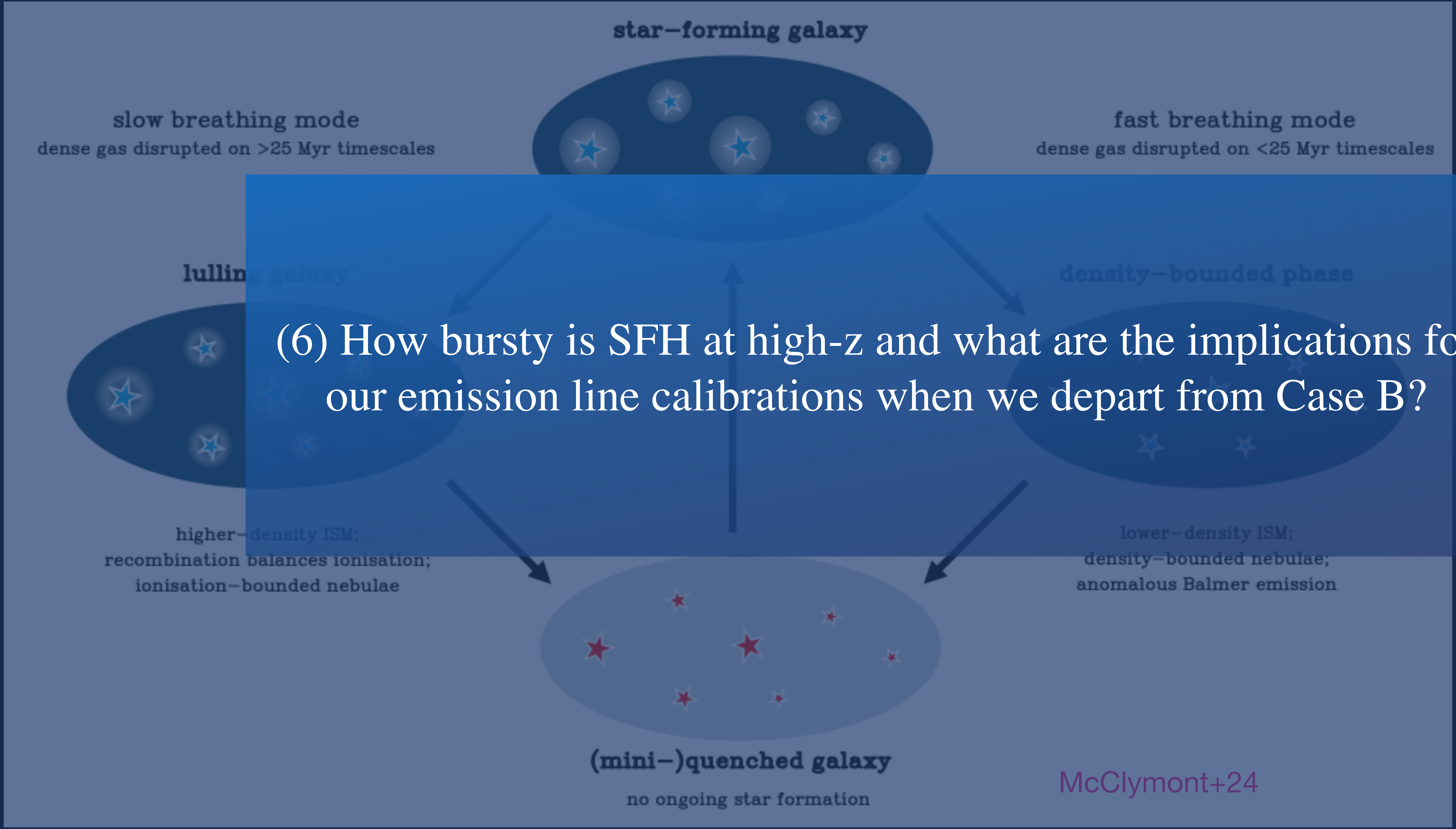


McClymont+24

Departures from Case B: density bounded nebulae tied to SFH is invoked to explain a significant fraction of z>2 sources that show anomalous Balmer line ratios

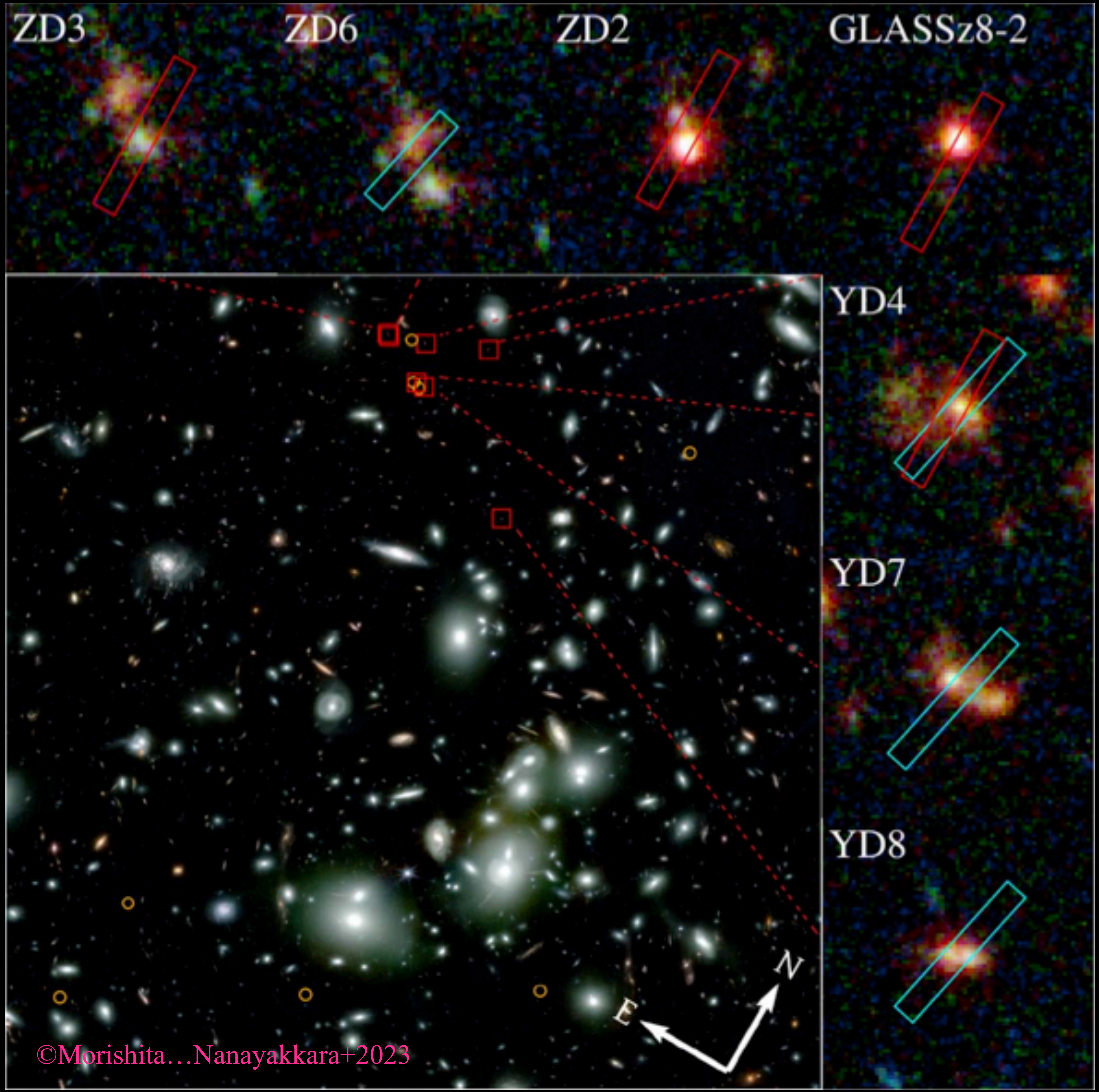


McClymont+24

(6) How bursty is SFH at high-z and what are the implications for our emission line calibrations when we depart from Case B?

Cosmic MYSTERIES

IV Challenges to the larger picture of galaxy evolution at cosmic dawn



Deep imaging combined with spectroscopy has started to probe the environment of the early Universe

Proto-cluster at z~7.8

- 6 spec-z + 8 photo-z candidates
- 130 X the field average
- $>4\text{x}10^{11}$ $M_{\odot}$ halo mass with σ=1200km/s
- Lack of strong Ly-α suggesting highly neutral IGM (>45%) with small ionised bubbles (R~0.78Mpc)
- Coma like cluster at z~0?

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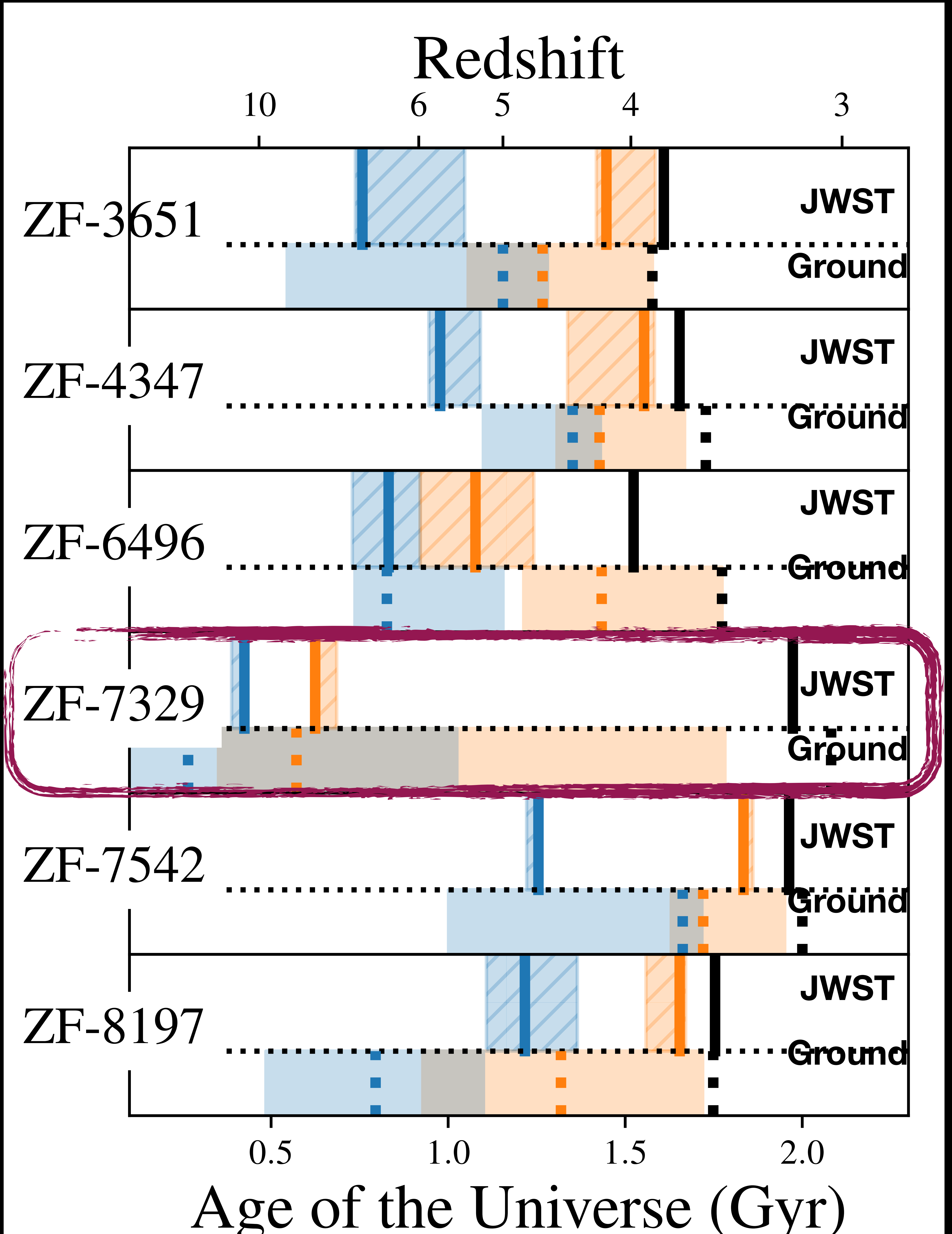
- Lack of strong Ly-α suggesting highly neutral IGM (>45%) with small ionised bubbles (R~0.78Mpc)
- Coma like cluster at z~0?

(7) When does the local environment start to influence galaxy formation?

There is strong evidence for z~11 formation for some of the massive quiescent sources



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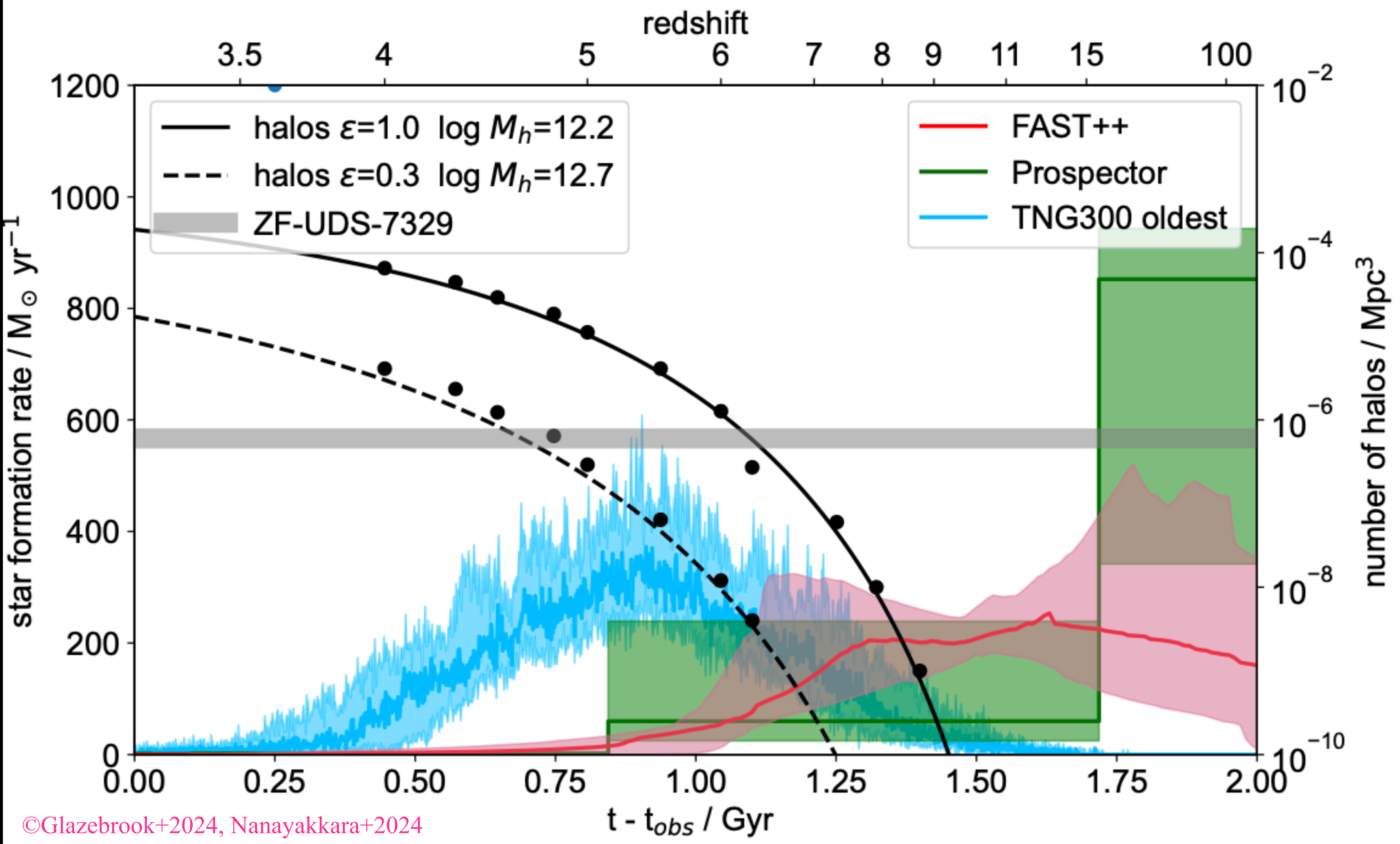
There is strong evidence for z~11 formation for some of the massive



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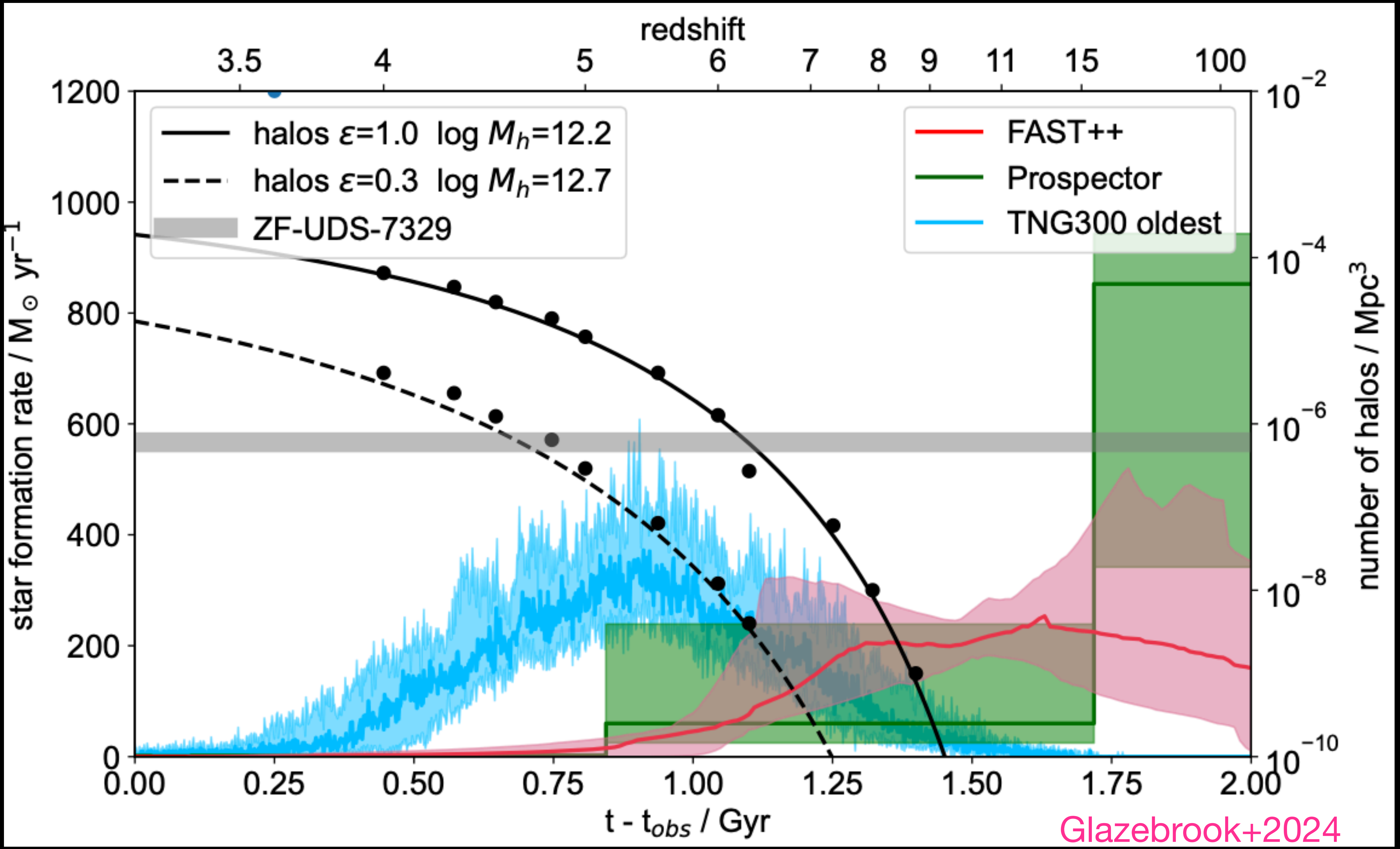
More evidence for early ultra-massive sources

More evidence for early ultra-massive sources

- SFHs suggest very early formation for some of the z~3-5 massive quiescent galaxies.
- Degeneracies with SED fitting techniques and systemic uncertainties in standard assumptions need to be explored.
- Some sources require 100% baryon to star conversion rates within λCDM cosmology.
- Evolutionary picture for the most massive high-z sources maybe starting to form.



Glazebrook+2024

More evidence for early ultra-massive sources

- SFHs suggest ver
for some of the z~
quiescent galaxie
- Degeneracies wit
techniques and sy
uncertainties in st
assumptions need
- Some sources req
baryon to star co
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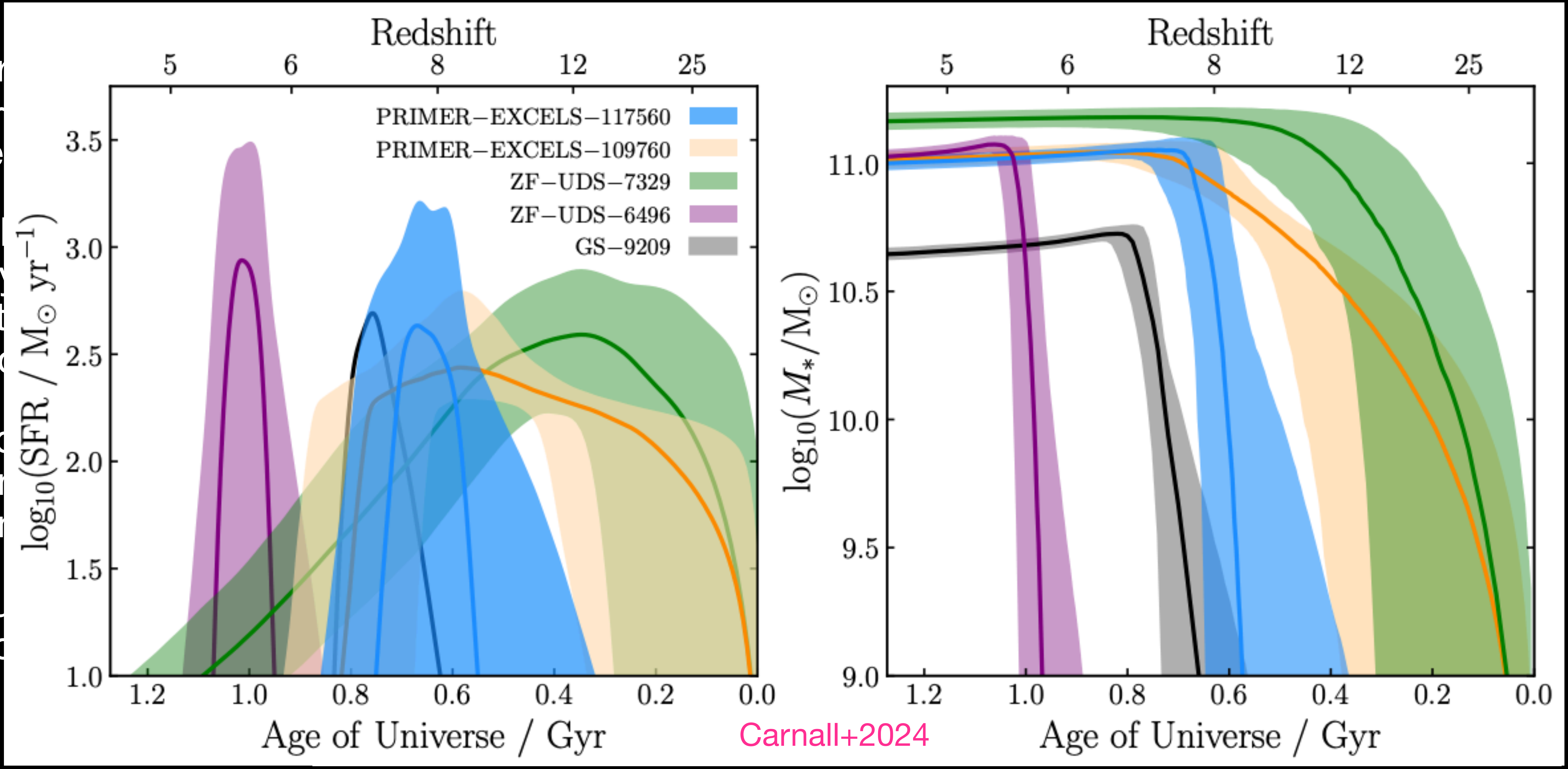
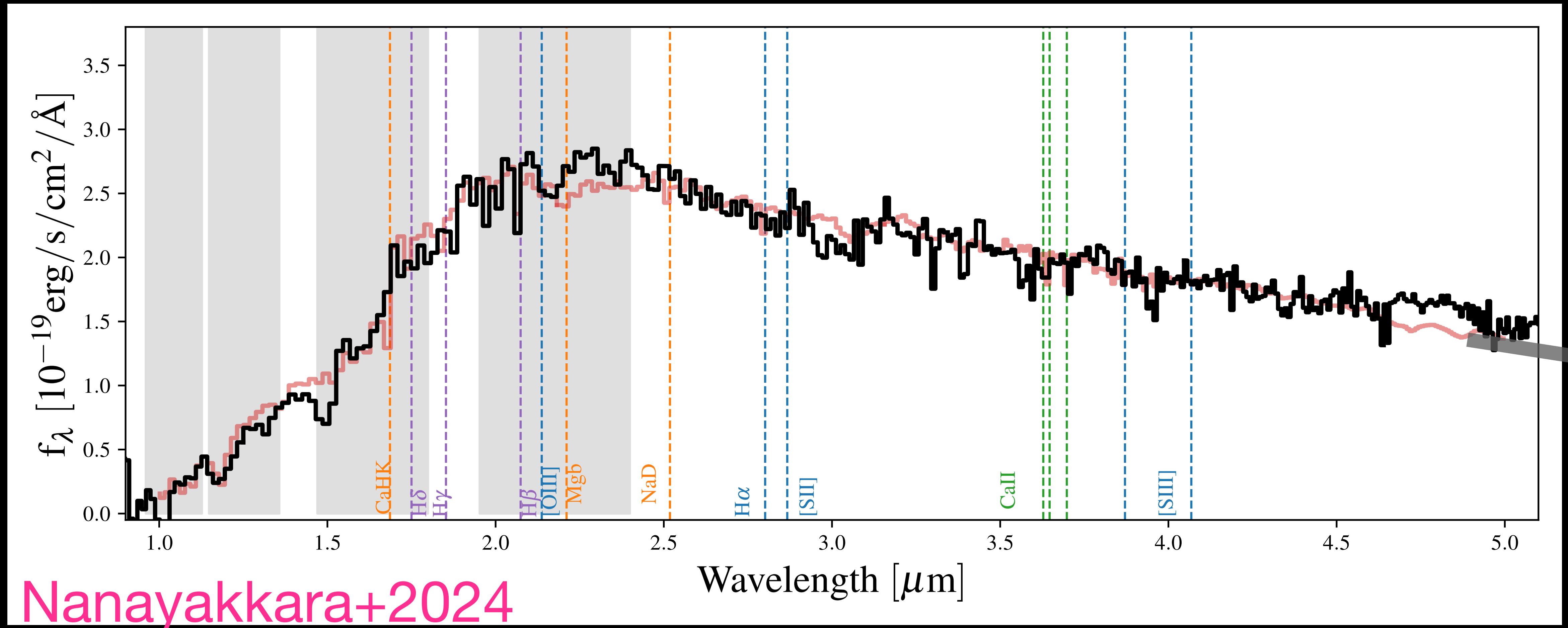
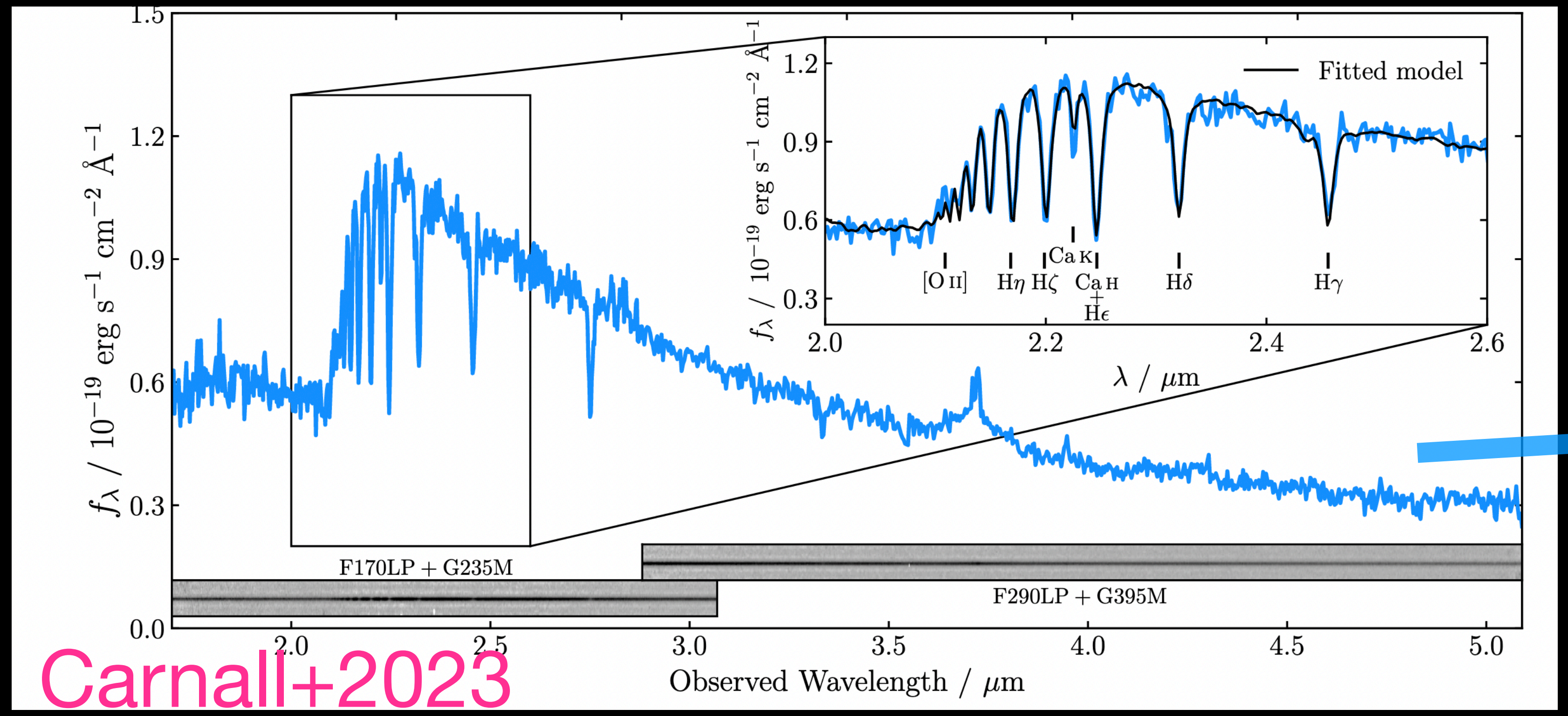
- Evolutionary pictu
massive high-z so
starting to form.



A comprehensive picture may start to be forming…?



Nanayakkara+2024



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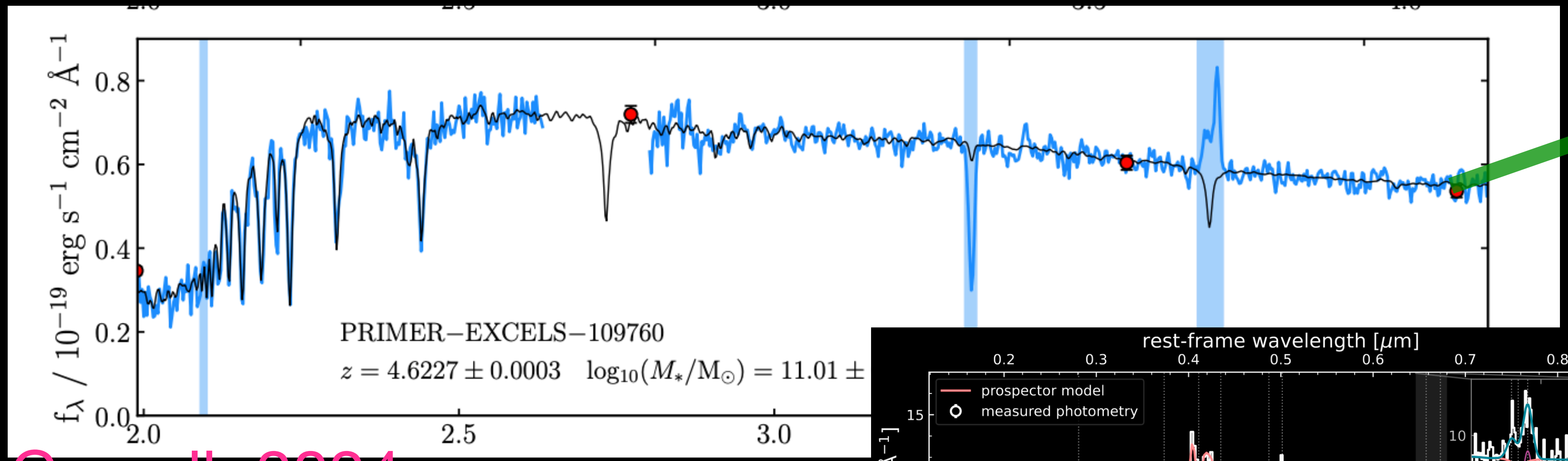

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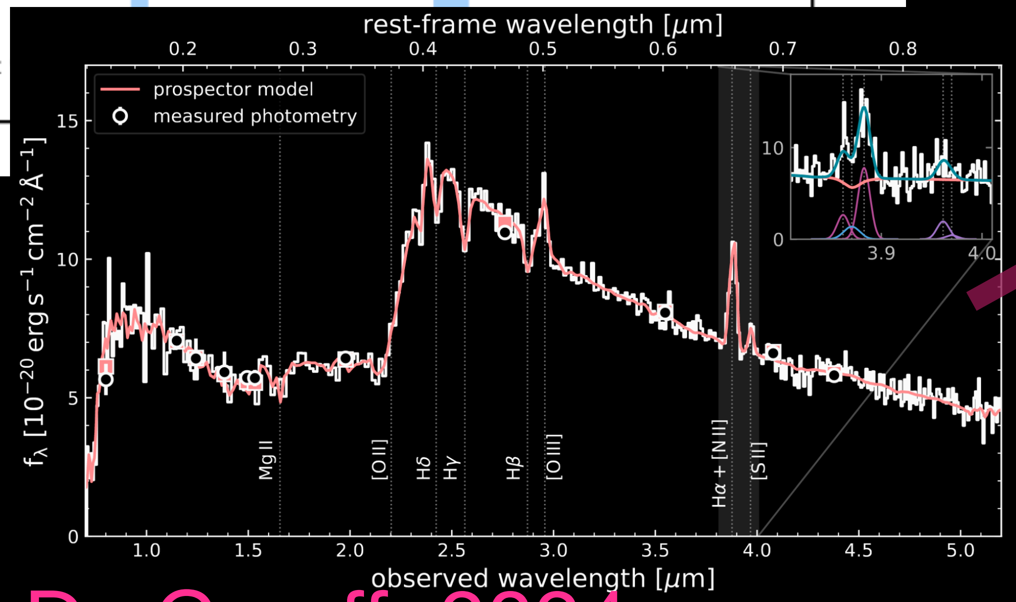

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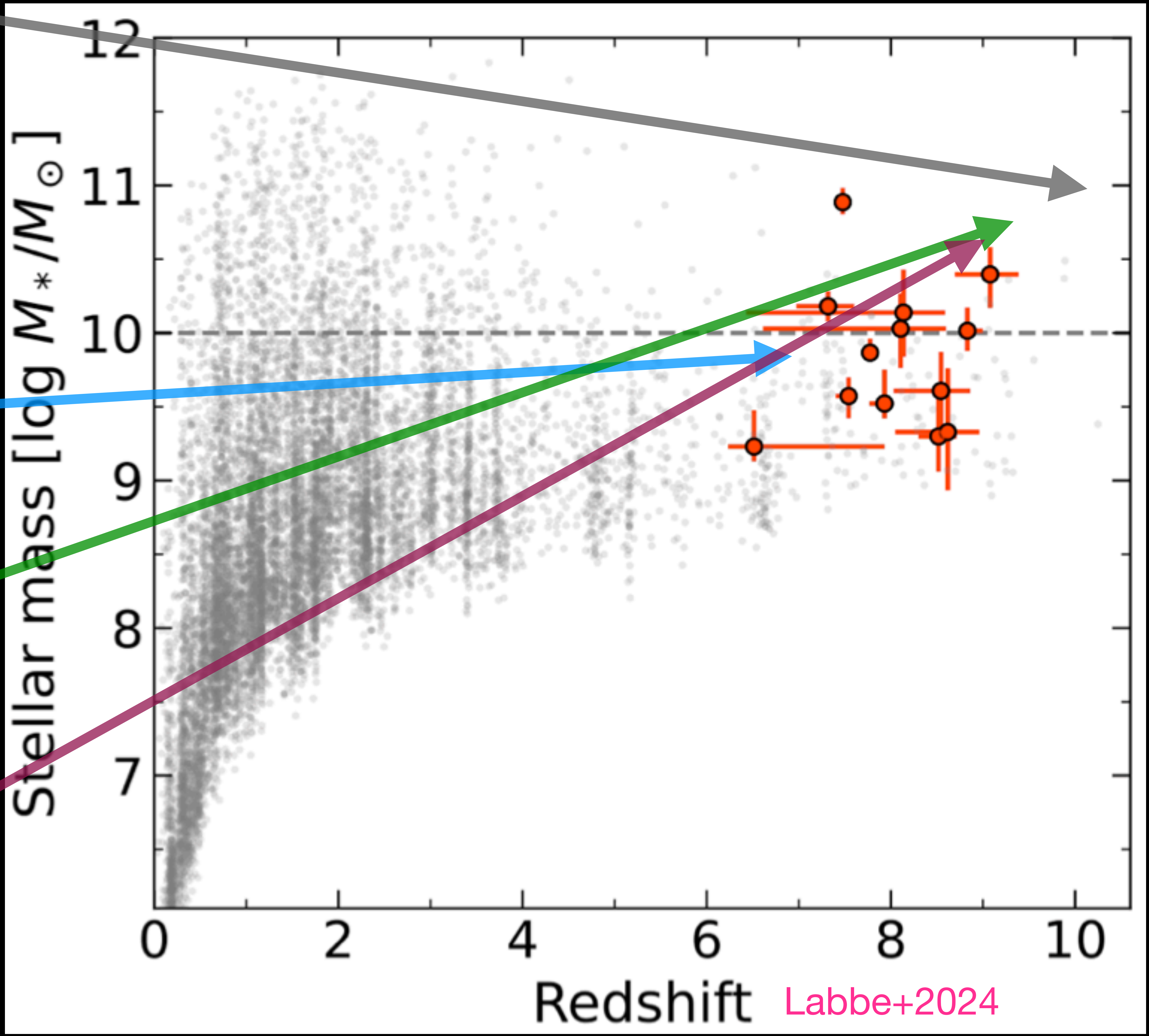
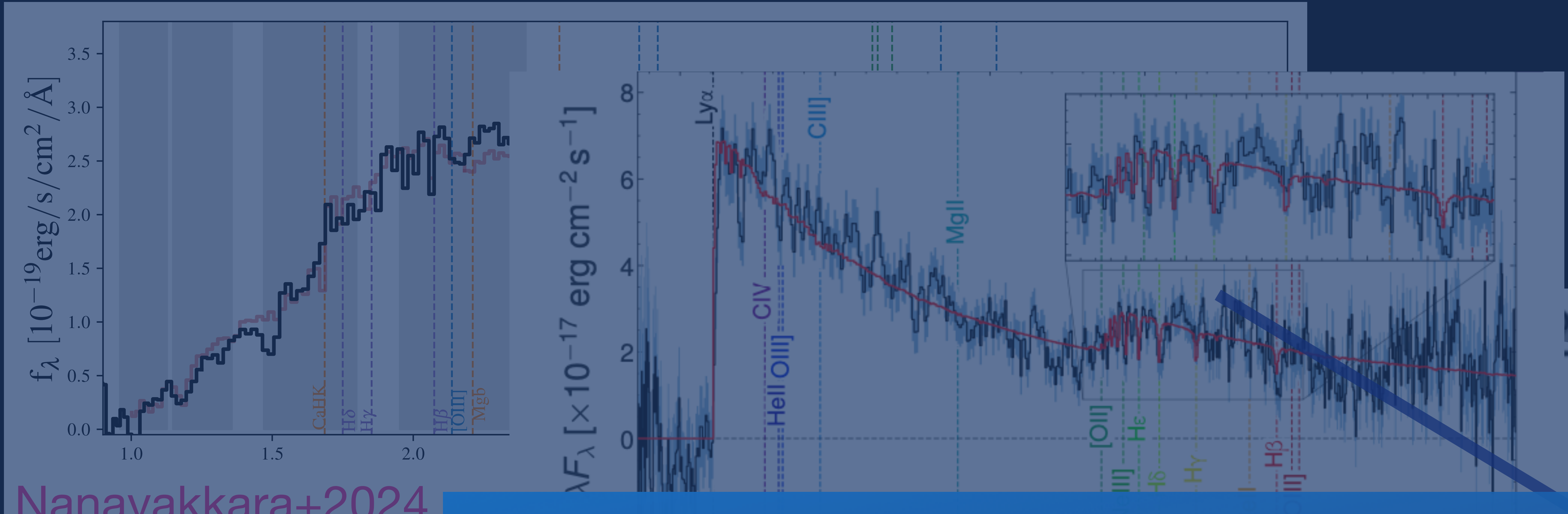


Labbe+2024

A comprehensive picture may start to be forming…?

A comprehensive picture may start to be forming…?



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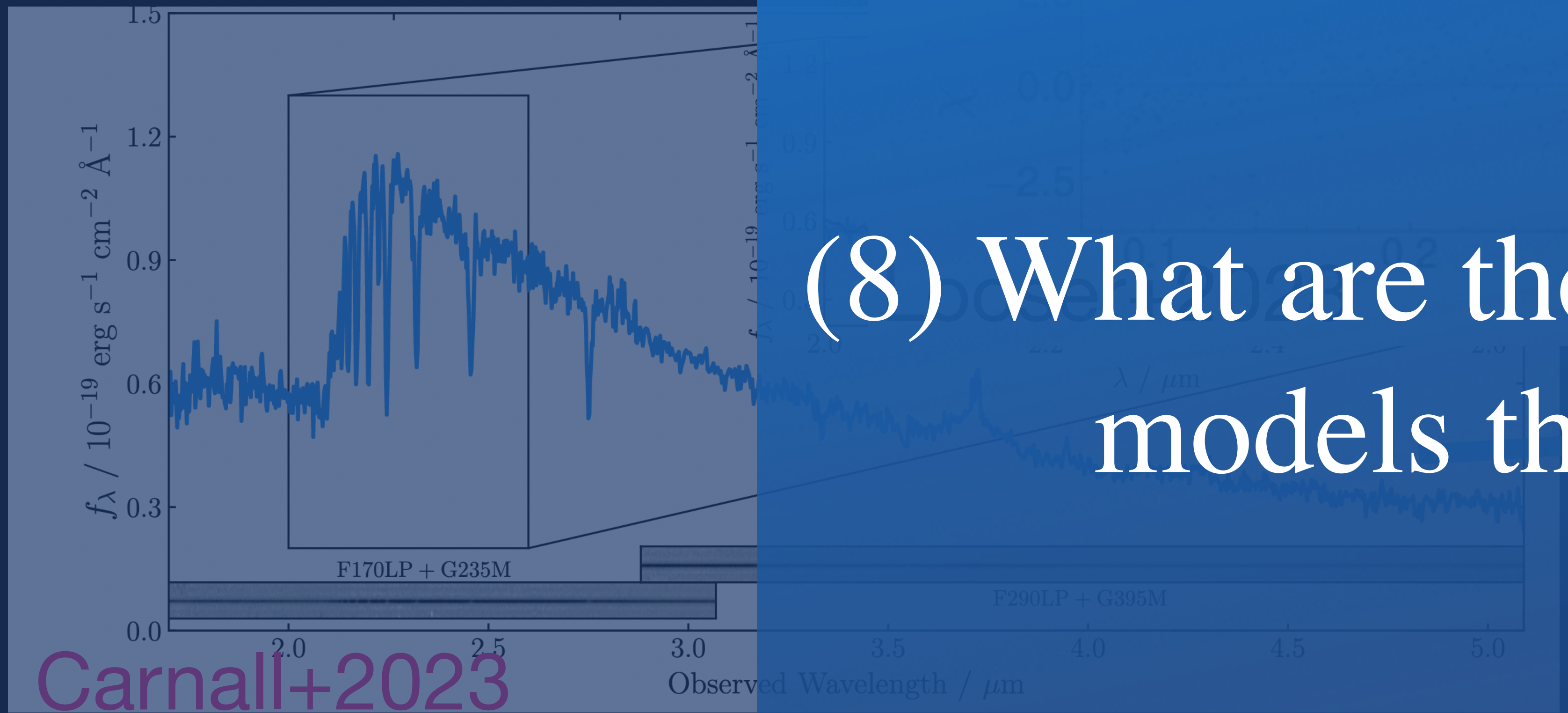

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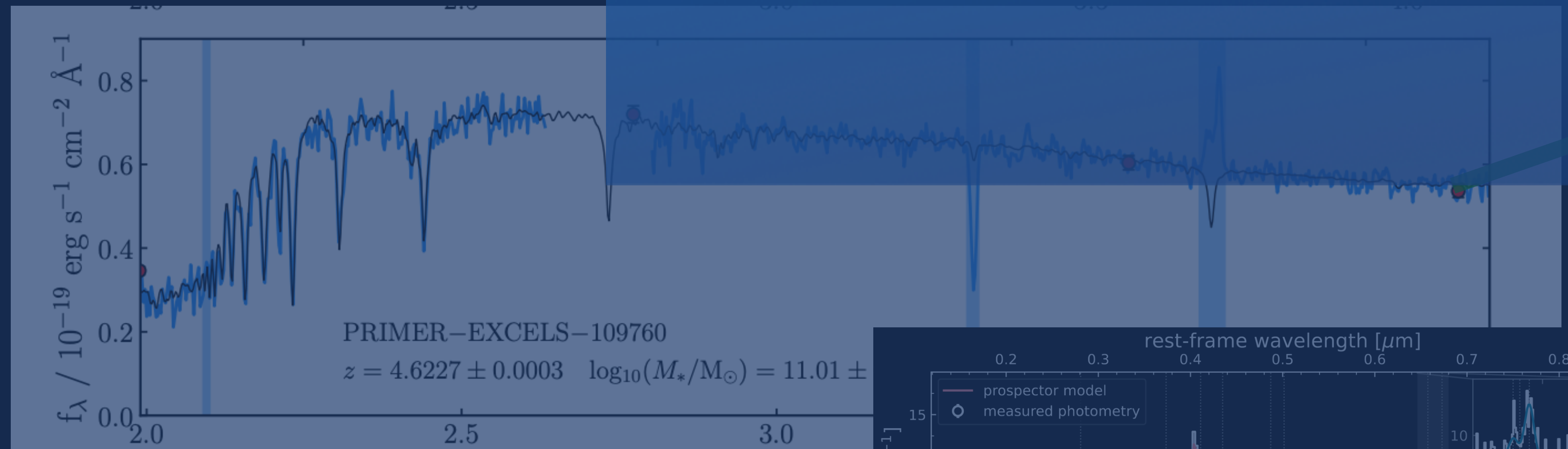

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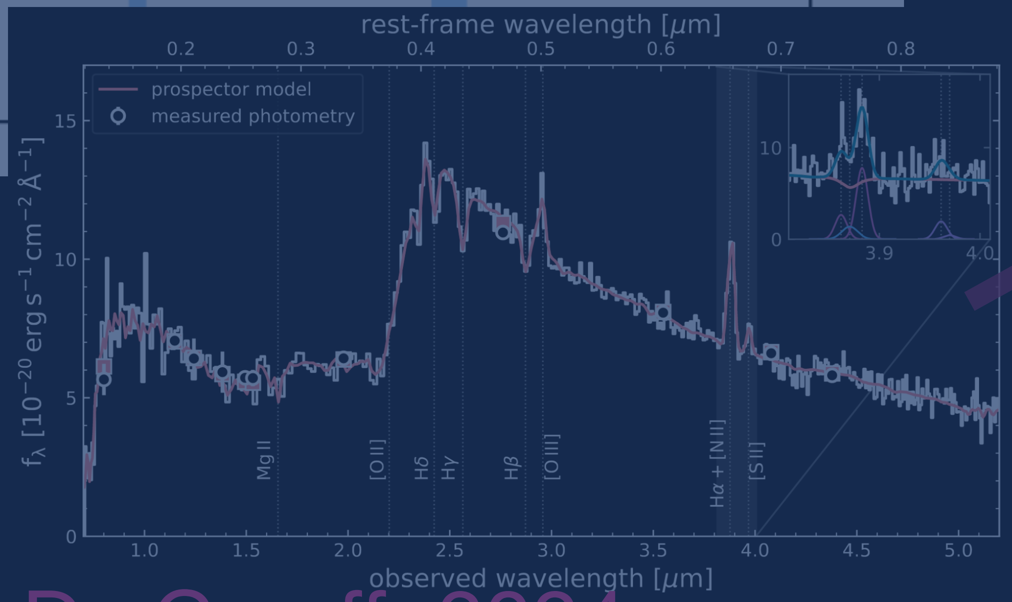

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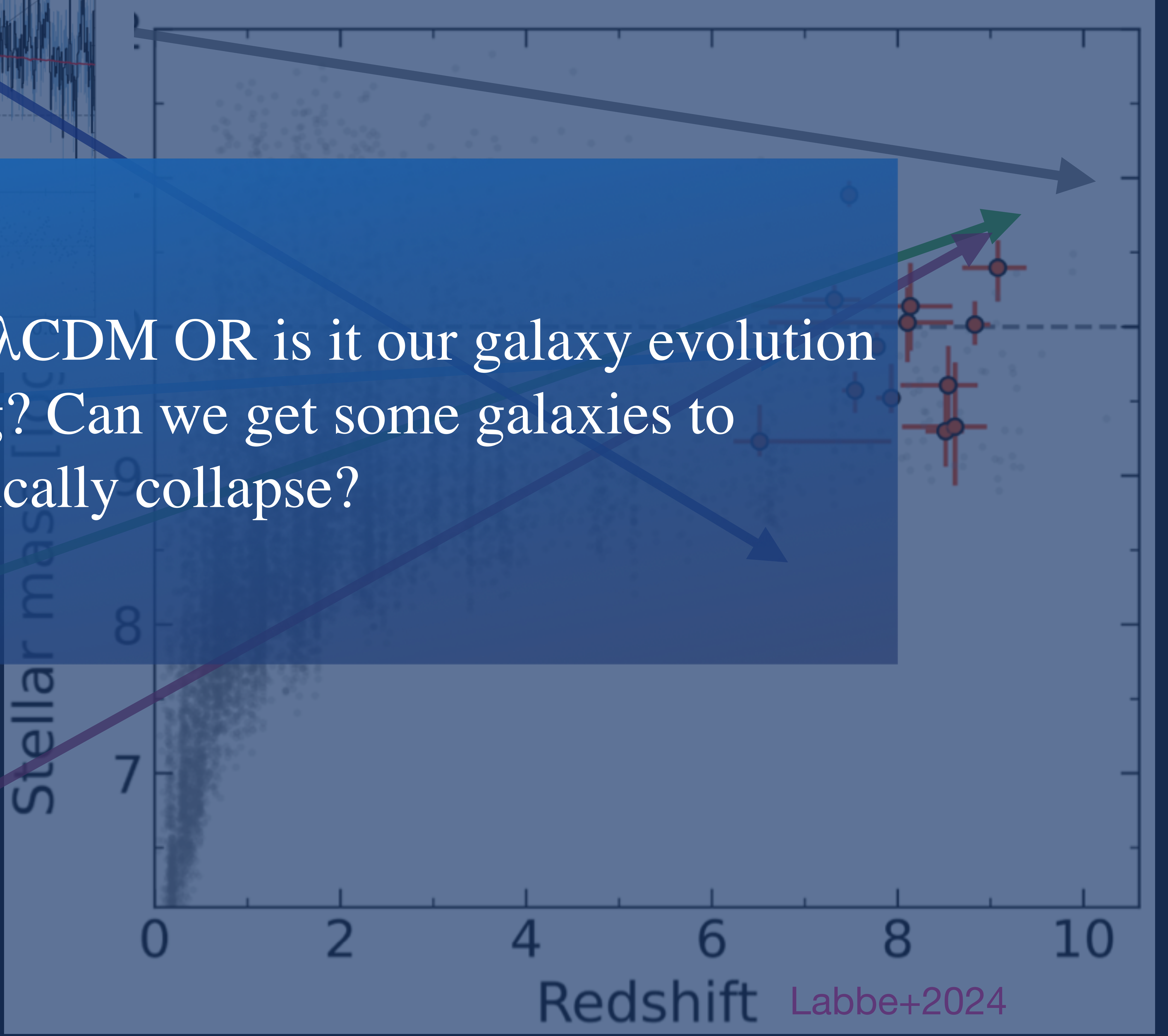
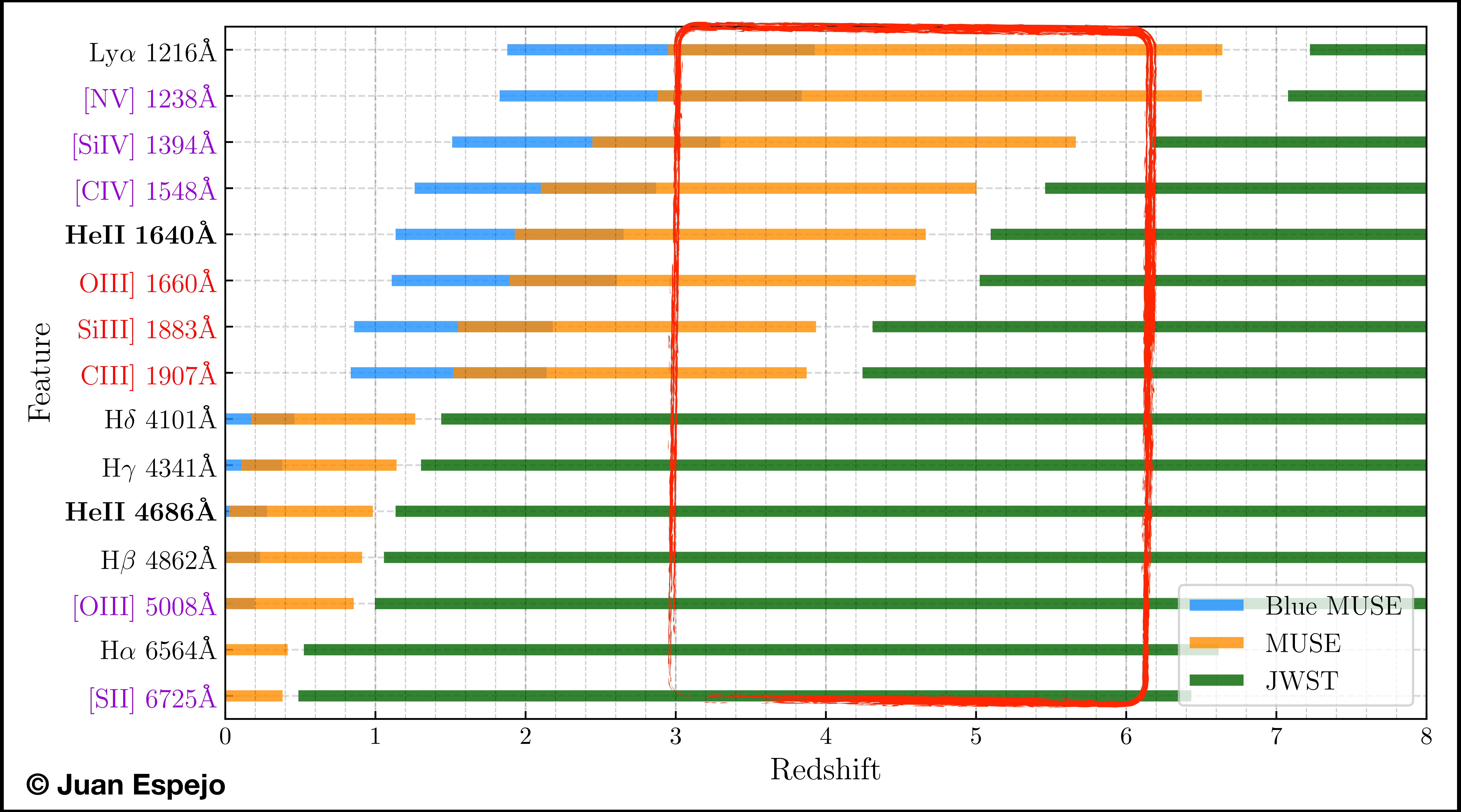


Labbe+2024

(8) What are the challenges to λCDM OR is it our galaxy evolution models that need refining? Can we get some galaxies to monolithically collapse?

Future Ground + JWST spectroscopic studies



IAUS391

The first chapters of our cosmic history with JWST

IAU General Assembly Symposium

6-9th August 2024 Cape Town, South Africa

VISION

To foster a dynamic exchange of innovative scientific ideas of the early cosmos through the lens of JWST and ignite a passion for space among the Africa's next generation of scientists.

XXXII IAU GENERAL ASSEMBLY

CAPE TOWN, SOUTH AFRICA, 2024

science & innovation
Department: Science and Innovation
REPUBLIC OF SOUTH AFRICA

NRF National Research Foundation | SAAO South African Astronomical Observatory

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KEY SCIENTIFIC THEMES
- Uncovering the physical and chemical properties of first galaxies in the Universe with JWST.
- Determining the role of first stars, galaxies, AGN, and quasars in reshaping the first billion years of the Universe.
- Revealing the rapid mass and dust build up pathways of the first massive galaxies in the early Universe with JWST.
- The abundance and quenching mechanisms of the first massive quiescent galaxies in the Universe.
- The large scale structures of the early Universe uncovered by JWST.
- Simulating the first chapters of our cosmic history with new observational constraints from JWST.
- JWST observatory updates: what have we learnt about the facility in the first 2 years.
- Utilizing JWST effectively with strengths of Hubble and other ground based facilities.
- Addressing critical science that has not been covered with JWST by Cycle 3.

Registration: https://astronomy2024.org/registration/

Invited Speakers
Rebecca Bowler
Pratika Dayal
Karl Glazebrook
Masafusa Onoue
Naveen Reddy
Adam Carnall
Ken Duncan
Joel Leja
Laura Sommovigo
Laure Ciesla
Richard Ellis
Nancy Levenson
Laura Pentericci
Jorge Zavala
Fergus Cullen
Jeyhan Kartaltepe
Paola Santini

SOC
Denis Burgarella
Valentino Gonzalez
Kathryn Grasha
Hanae Inami
Taysun Kimm
Michael Maseda
Themiya Nanayakkara
Irene Shivaei
Laurence Tresse

https://jadc.swin.edu.au/#IAUS391