How to make bursty star-formation in the high-z universe
— clues of vigorous feedback —

very rapid

driven by AGN or SNe?

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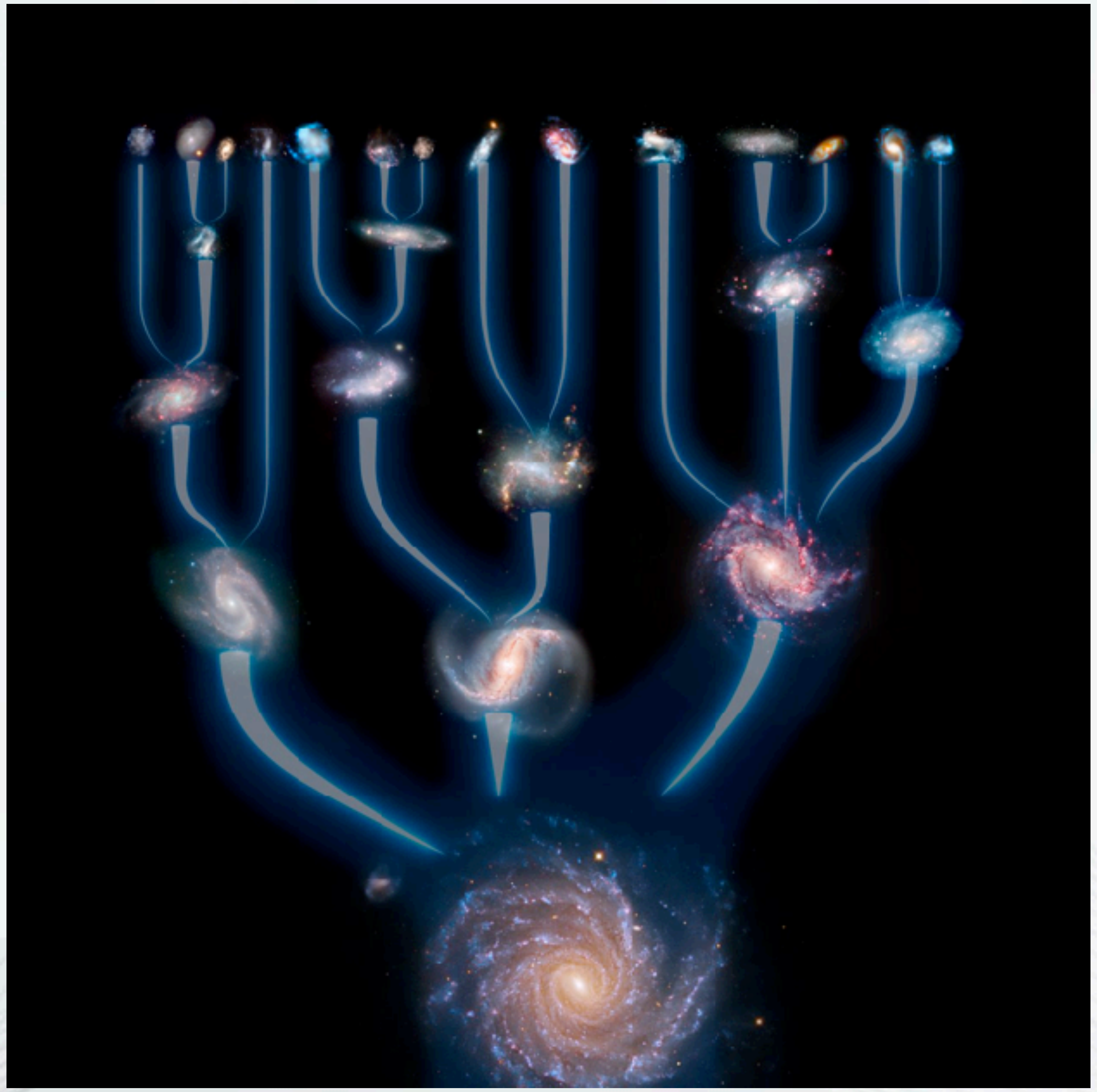
EET2025 at YITP

Aug 8, 2025

Low-mass high-z galaxies as progenitors of the MW

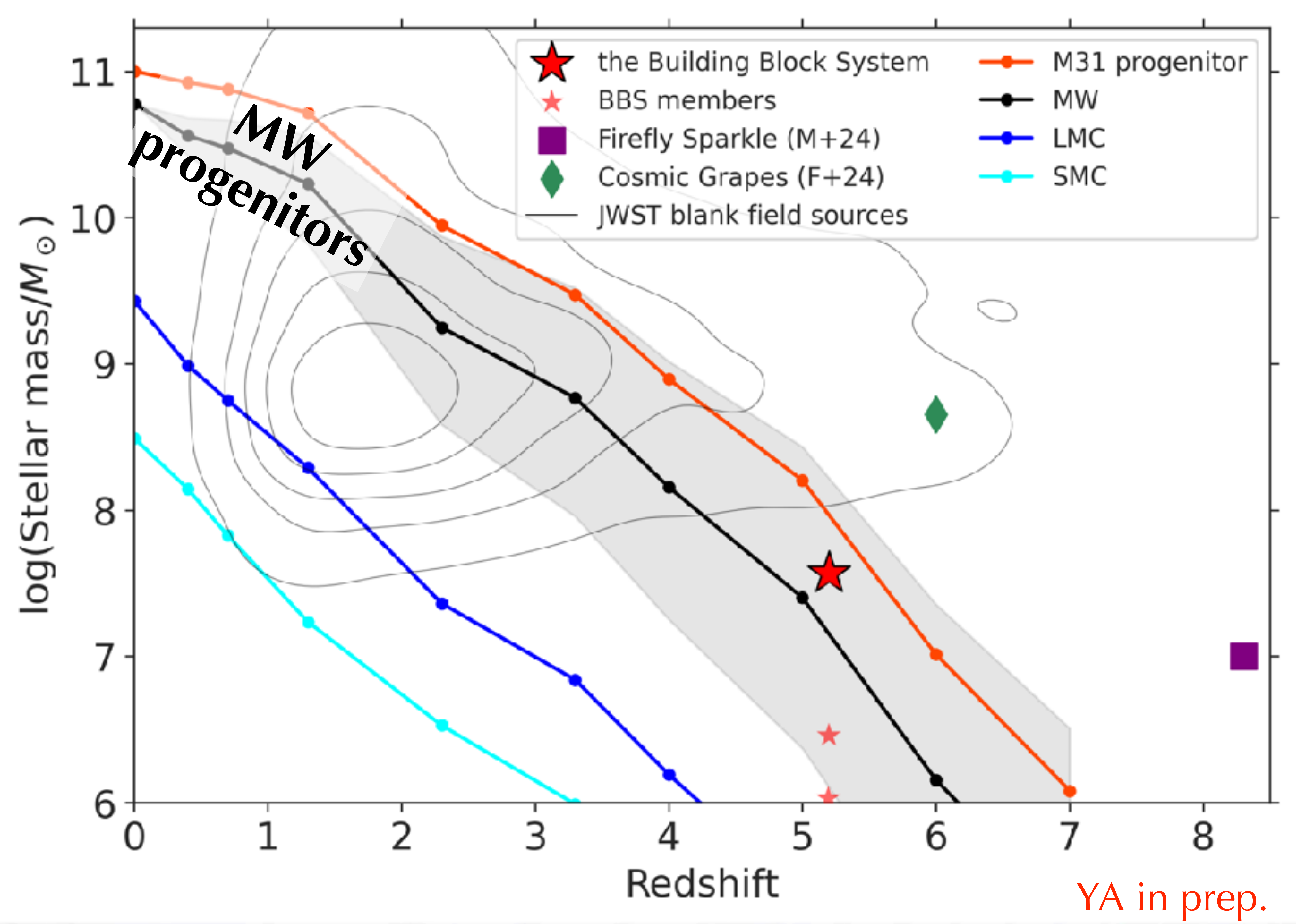
- Low-mass ($M^*<10^{8\text{-}9}$ Msun) high-z (z>4) galaxies would evolve into MW-like galaxies at z=0
  - JWST opened the window to glimpse this parameter space



Credit: ESO/L. Calaçada

High-z

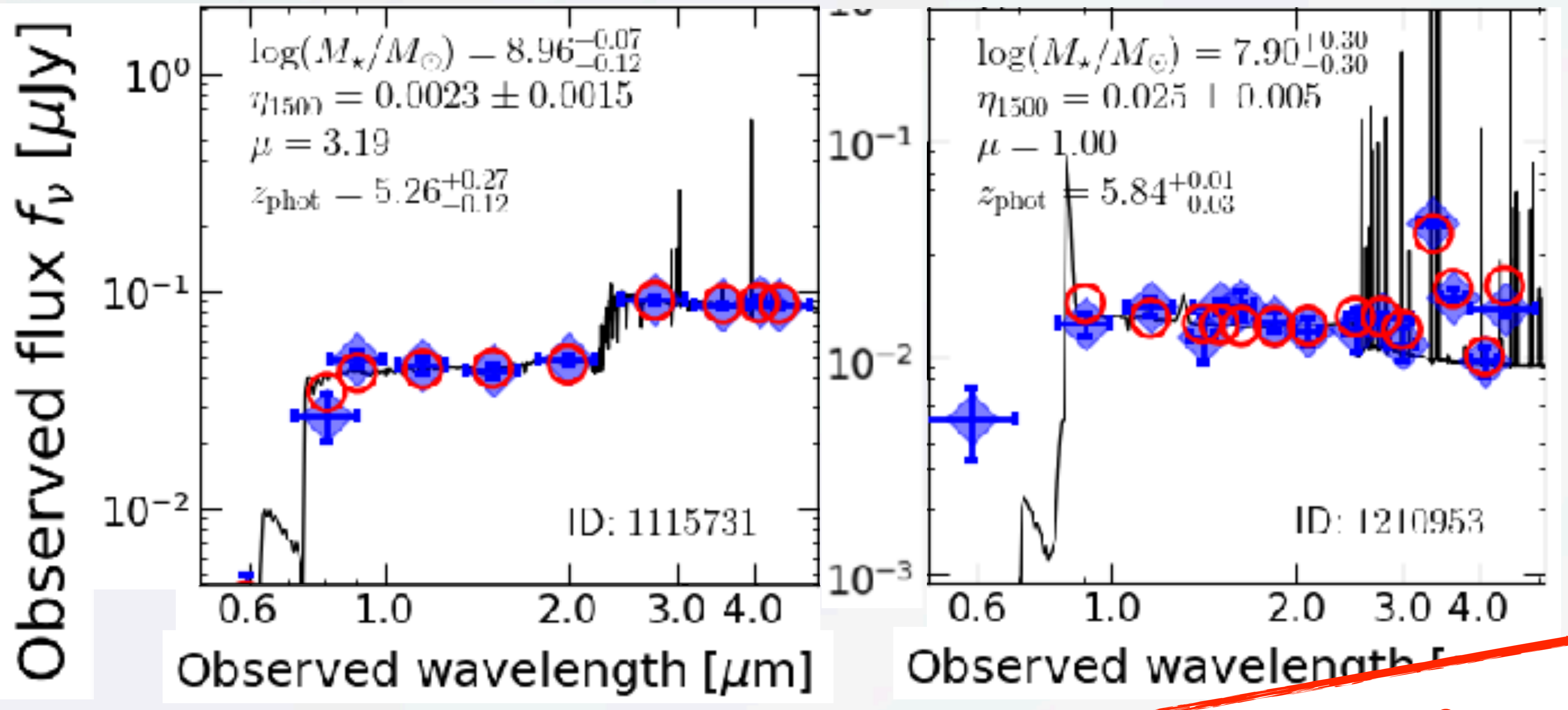
z=0

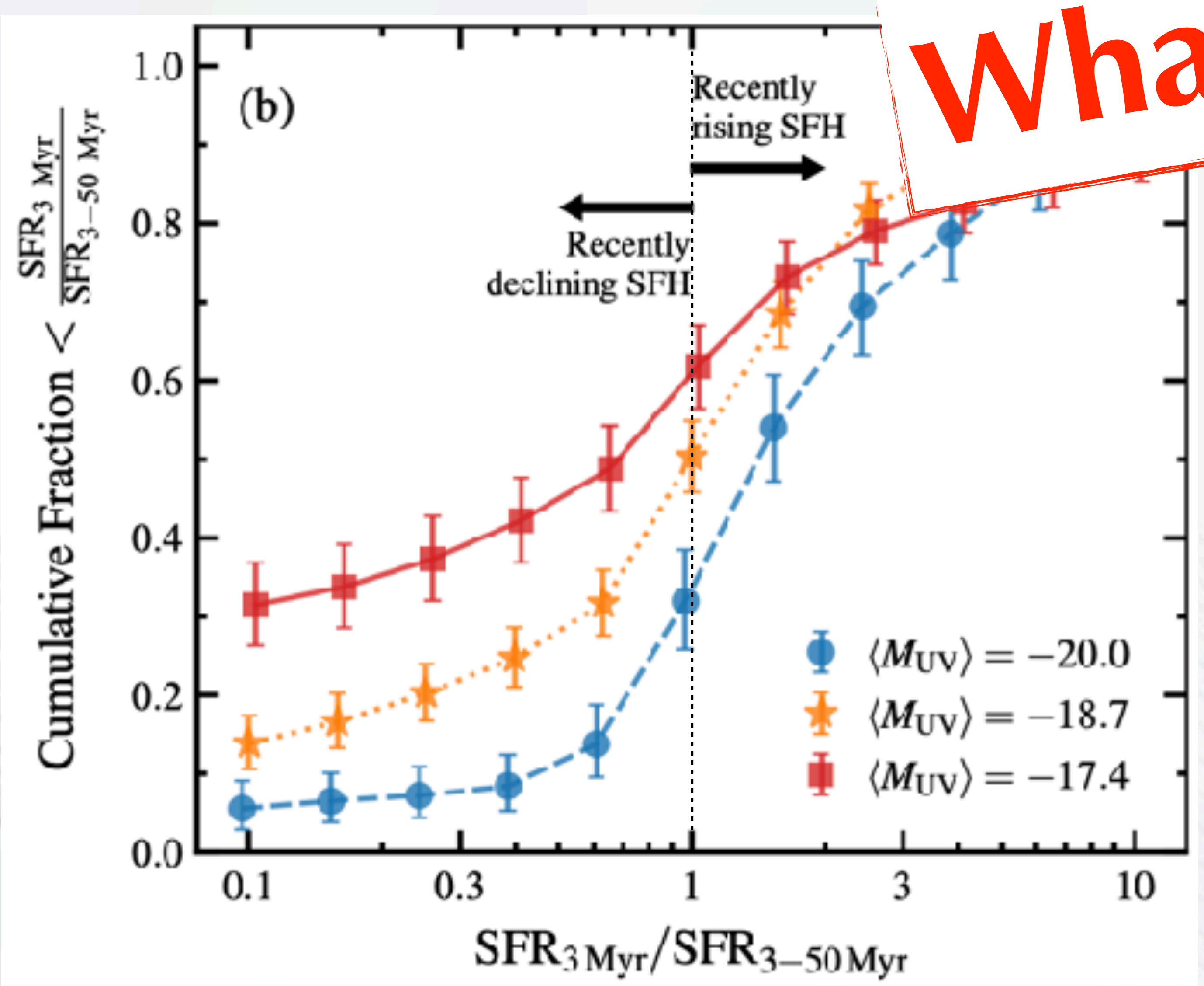


YA in prep.

Short time-scale SFH variations

- Findings with JWST: very rapid fluctuation in their star-formation histories (SFHs)

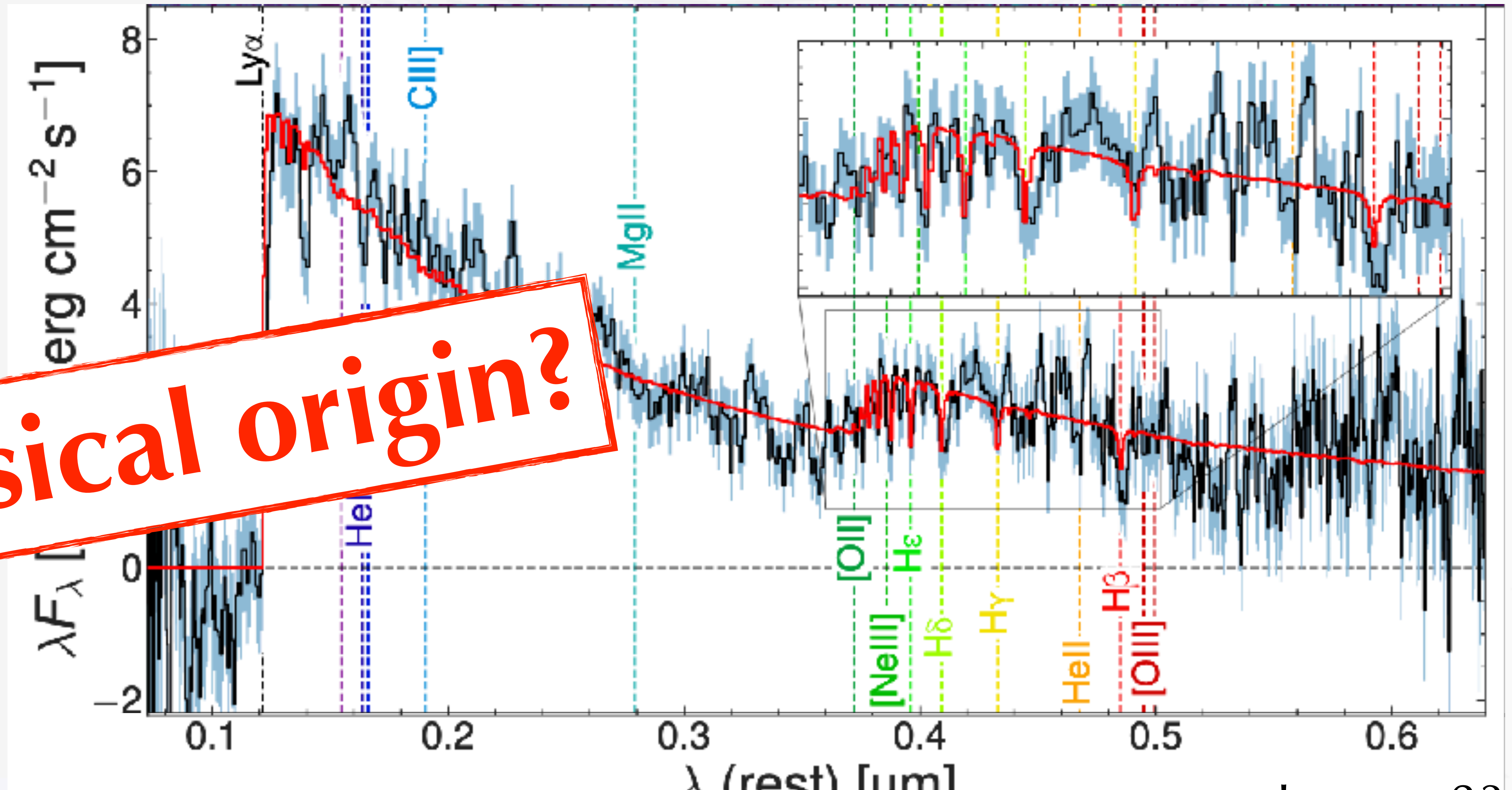




Endsley+25

What is the physical origin?

Spec confirmation of a recently quenched galaxy at $z_{\rm spec}$=7.3



Looser+23

Blue in UV   Strong Balmer break

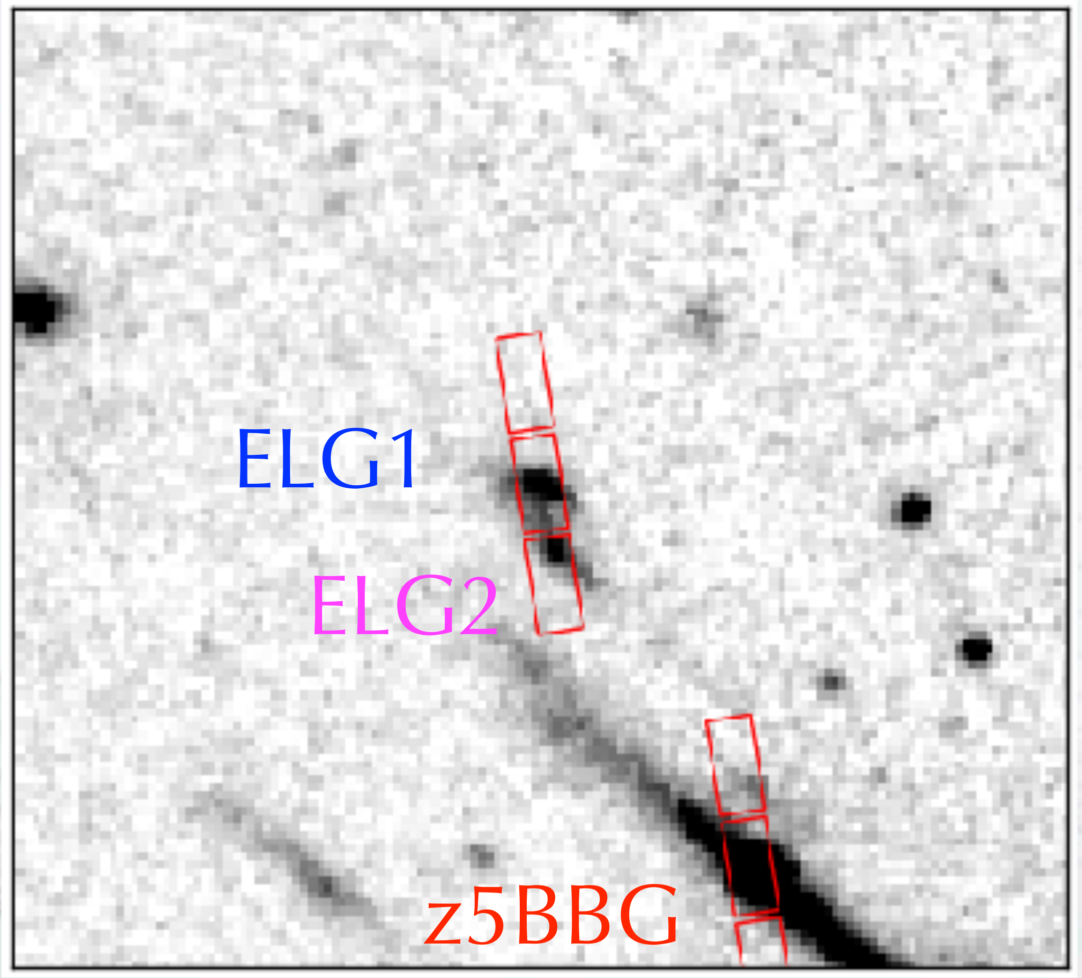
—> **Very rapid** fluctuation in low-mass high-z galaxy SFHs

~ a few 10 Myr (e.g., YA+24, McClymont+24, Endsley+25)
could be < 10 Myr in some cases (Gelli+23)

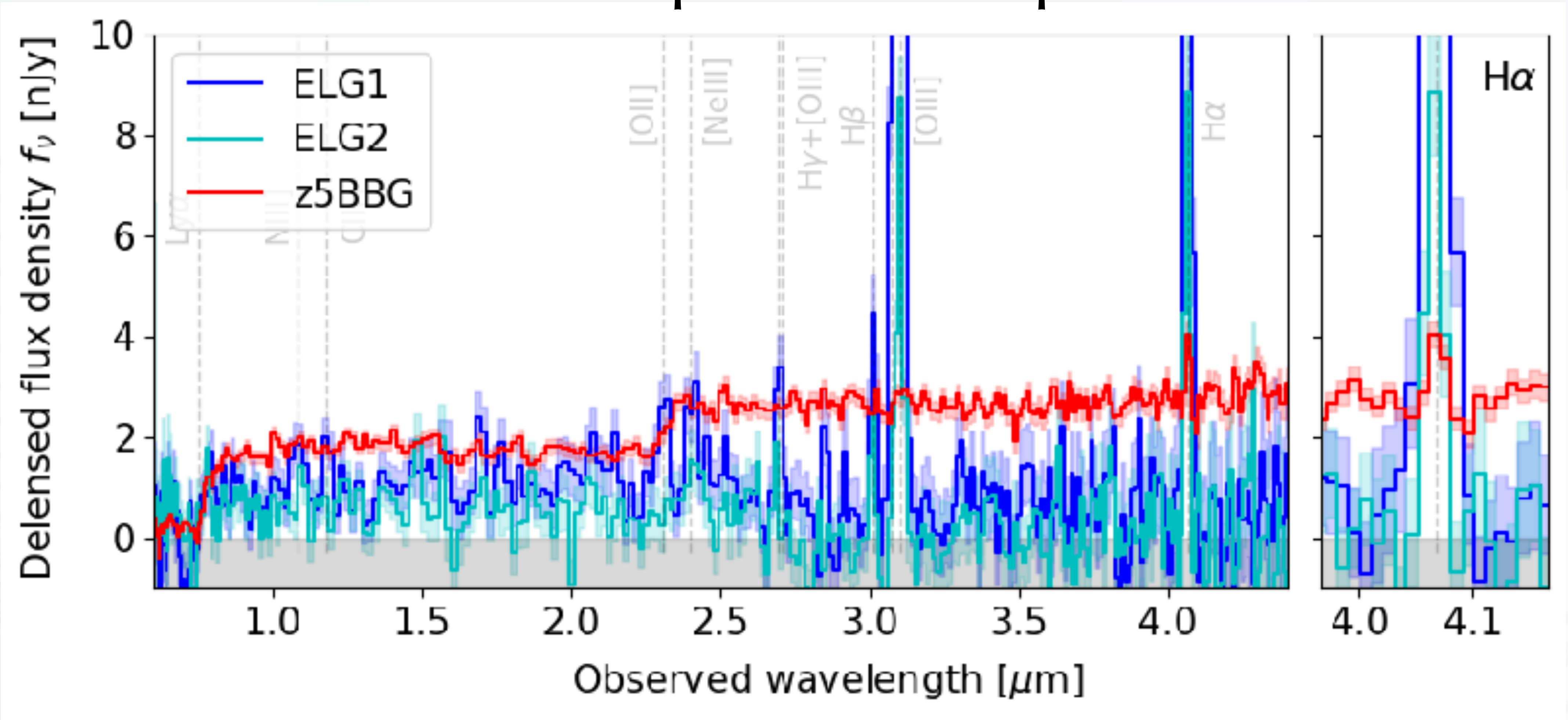
JWST × gravitational lensing: an ideal labolatory

- A group of very low-mass galaxies at $z_{\rm spec} = 5.2$ (YA+23, Strait+23, YA+ in prep.)
  - All gravitationally lensed by x>20 + JWST NIRCam + NIRSpec observation found:
    - ELG1 & ELG2 are now seeing the starburst phase
    - z5BBG shows a prominent Balmer break, suggesting recent rapid quenching
    - They are all low-mass of M*~10$^{6.4\text{-}7.5}$ Msun

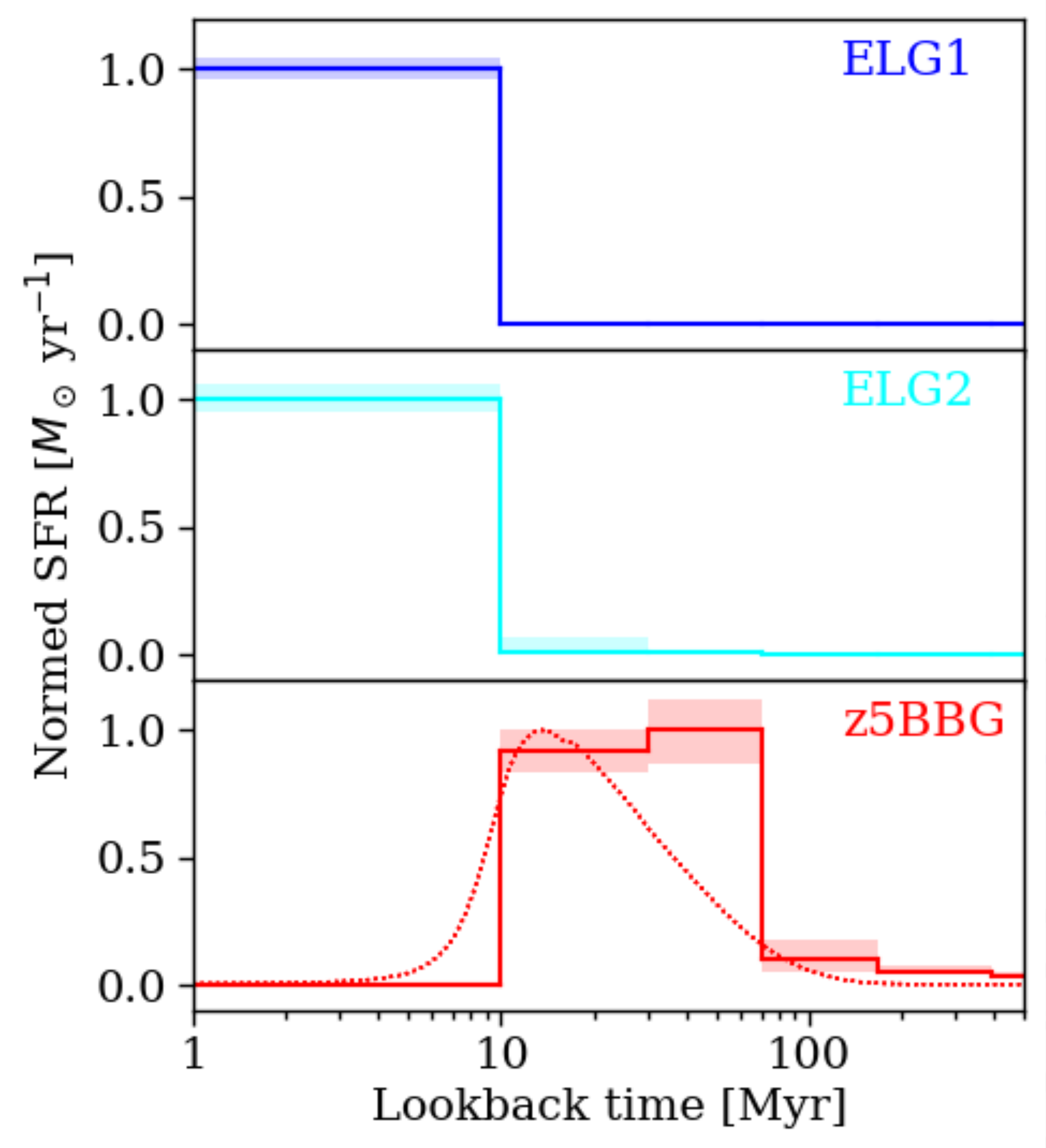
NIRCam F277W



NIRSpec/Prism spectra



SFHs

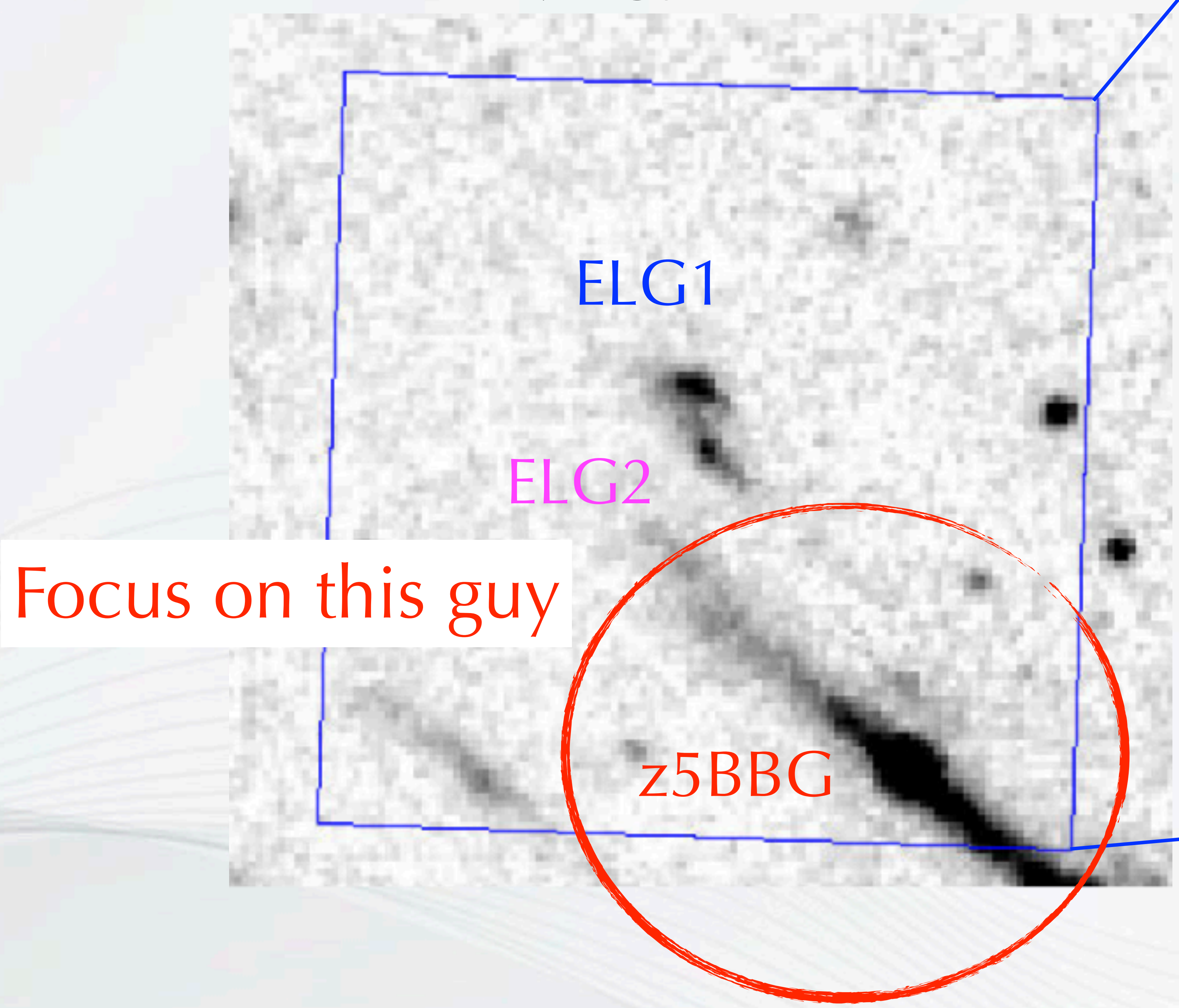


YA in prep.

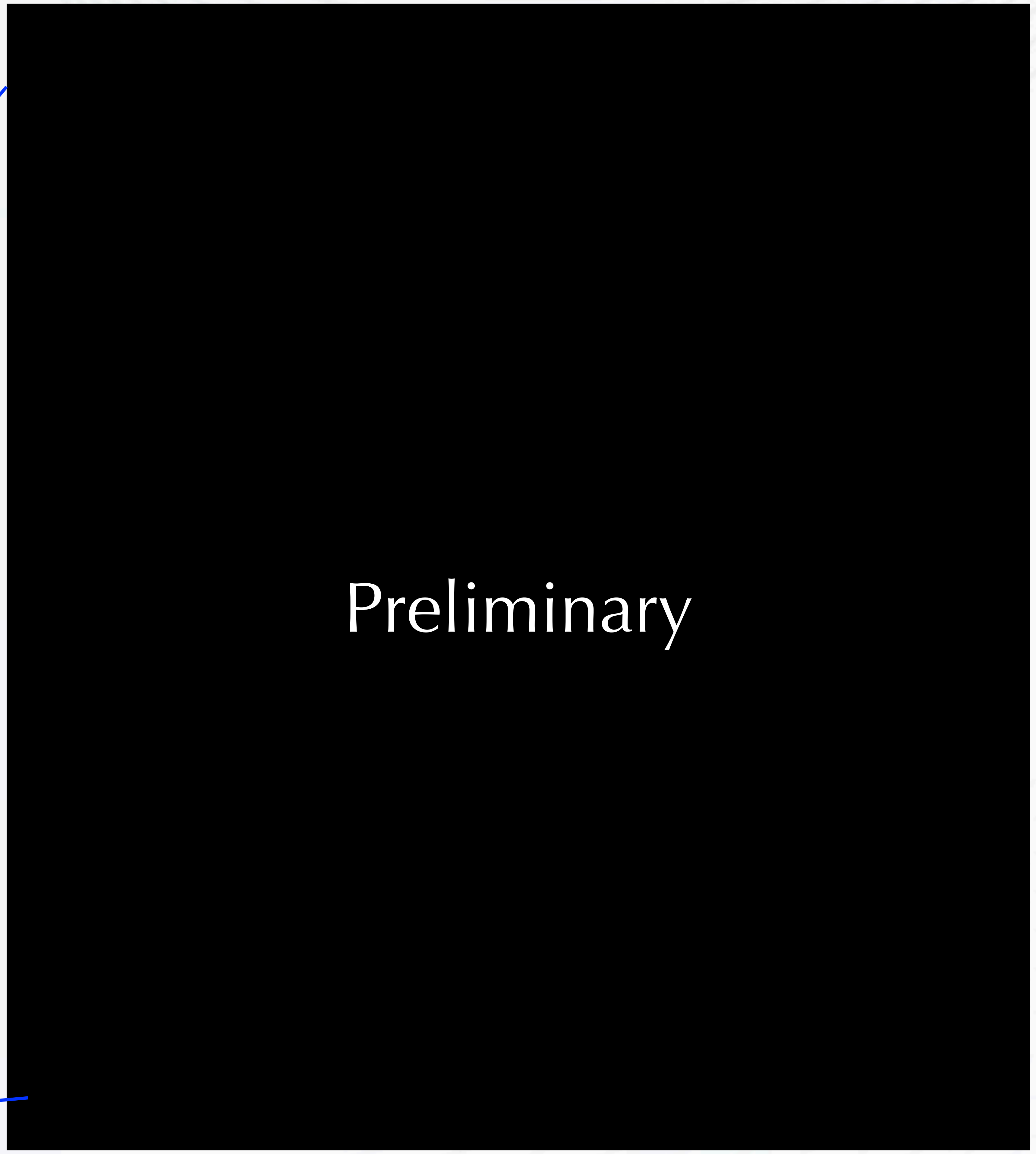
Deep NIRSpec IFU observation

- NIRSpec IFU in Cycle 3 (GO-5119, PI: Asada)
  - G235M/F170LP, R~1000
  - Data analysis with the aid of Sugahara-san at Waseda U.

NIRCam F277W



Channel map around [OIII]5007



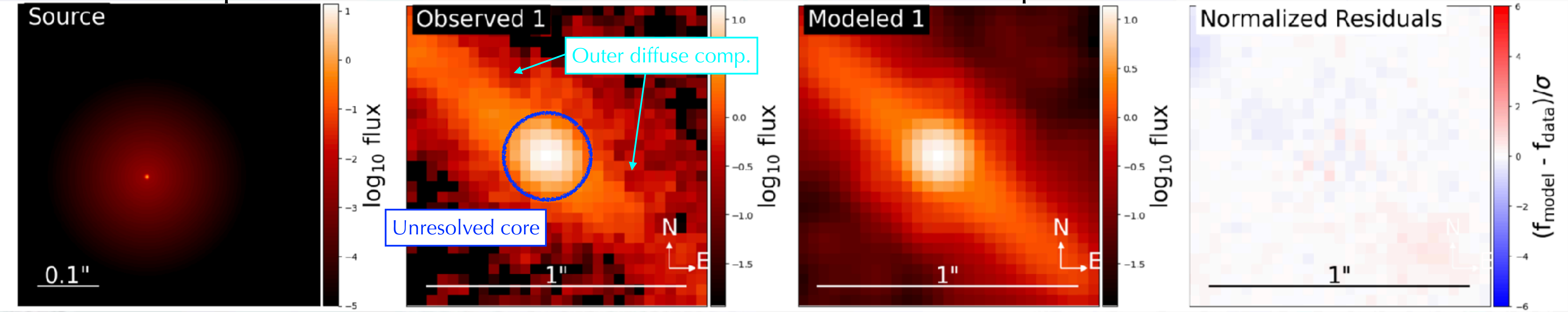
YA in prep.

Ultra-compact morphology of z5BBG

- NIRCam resolution (~0.1 arcsec) & ~x100 gravtional lens boosting
  - z5BBG is composed of two components
    1. Unresolved, bright compact core: half-light radius < 12 pc
    2. Diffuse, faint component: half-light radius = 300 ± 150 pc

Work by Jon Judež
at Ljubljana Univ.

Light profile model in the source plane | NIRCam F444W image | Light profile model in the observed plane | Residual

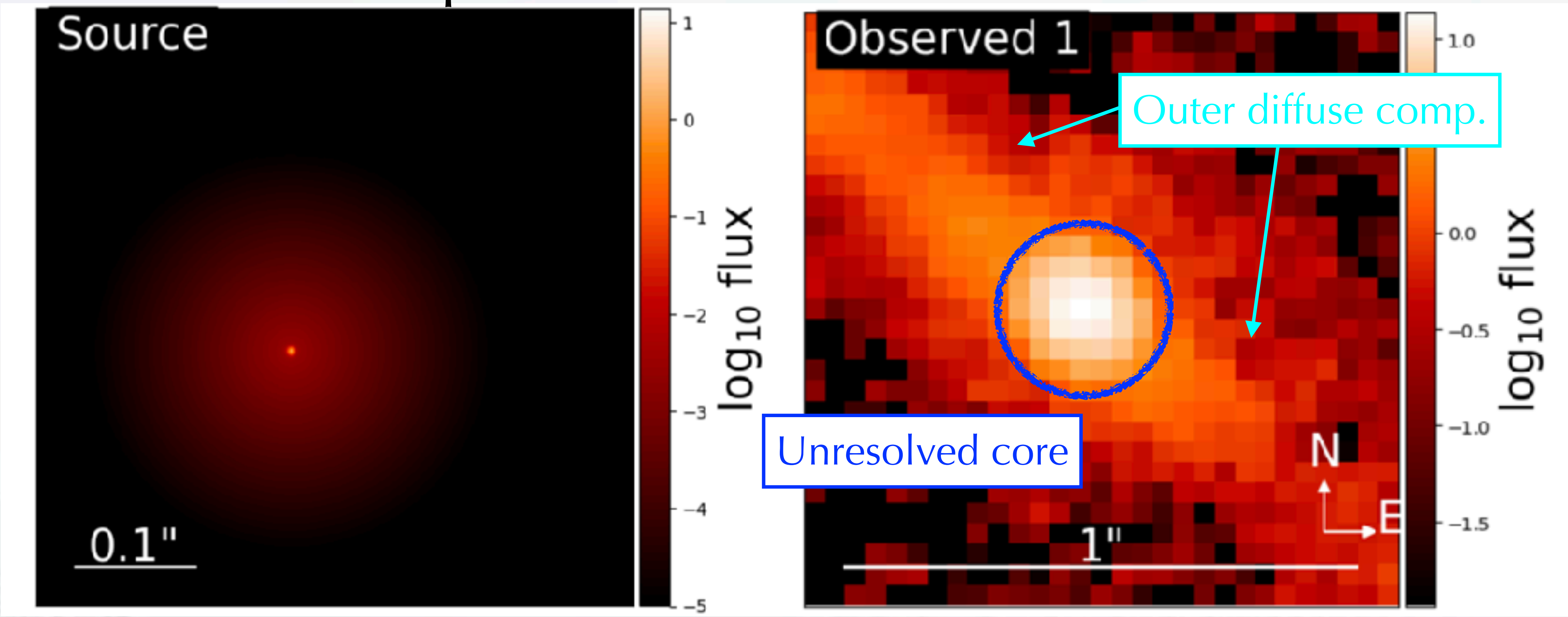


Ultra-dense morphology of z5BBG

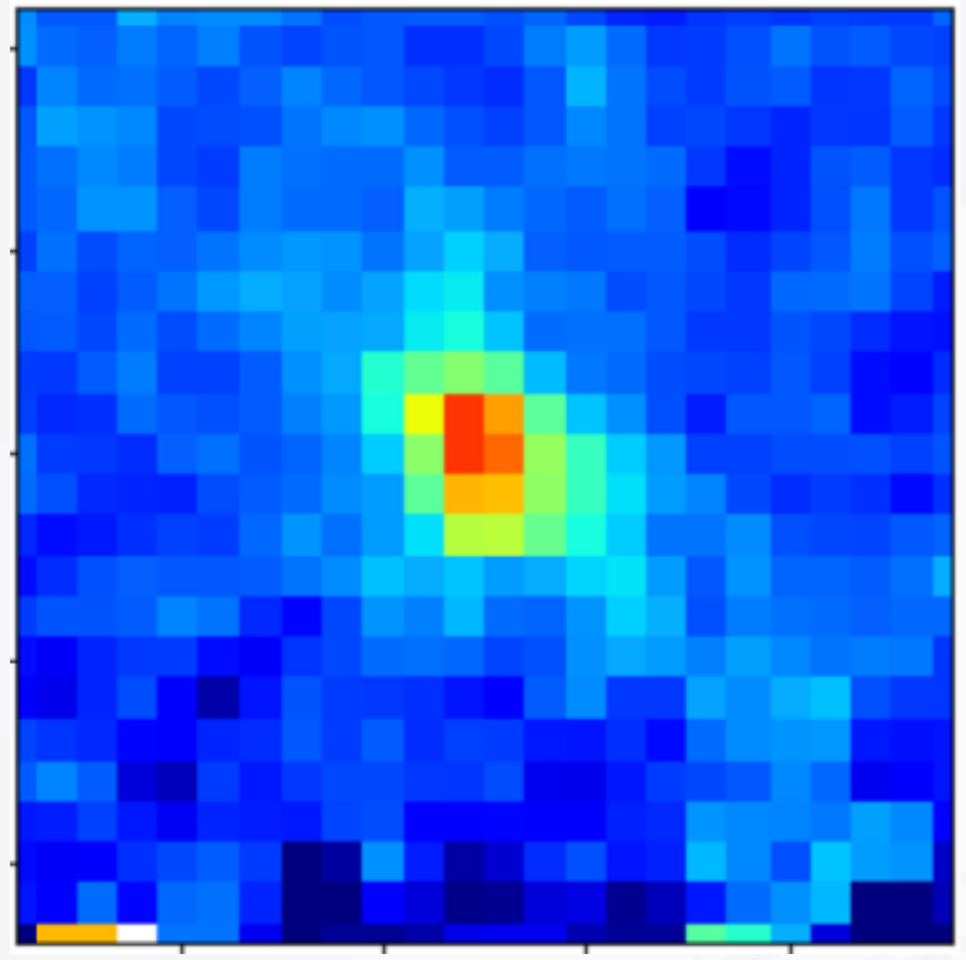
- NIRCam resolution (~0.1 arcsec) & ~x100 gravtional lens boosting
  - z5BBG is composed of two components
    1. Unresolved, bright compact core: half-light radius < 12 pc
    2. Diffuse, faint component: half-light radius = 300 ± 150 pc
  - The stellar component is in the unresolved compact core —> $\Sigma_\star > 2.0 \times 10^4\ M_\odot/\mathrm{pc}^2$

Light profile model in the source plane

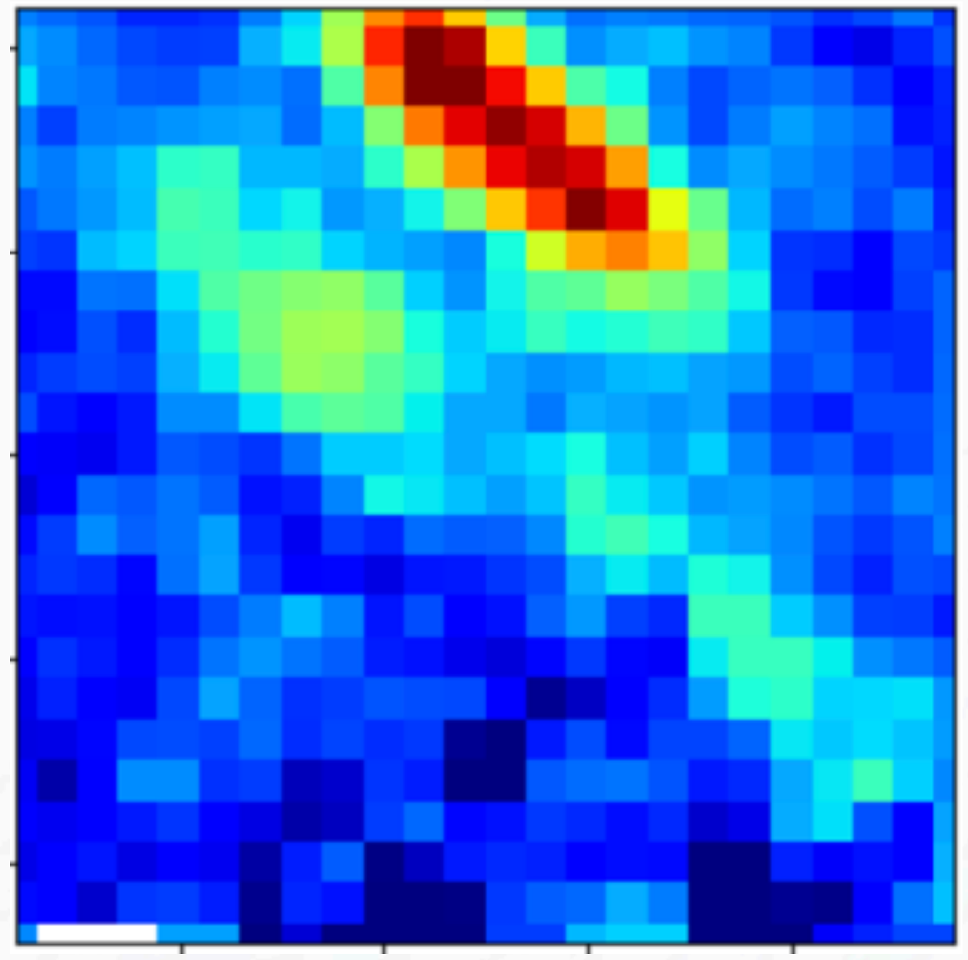
NIRCam F444W image



Stellar continuum



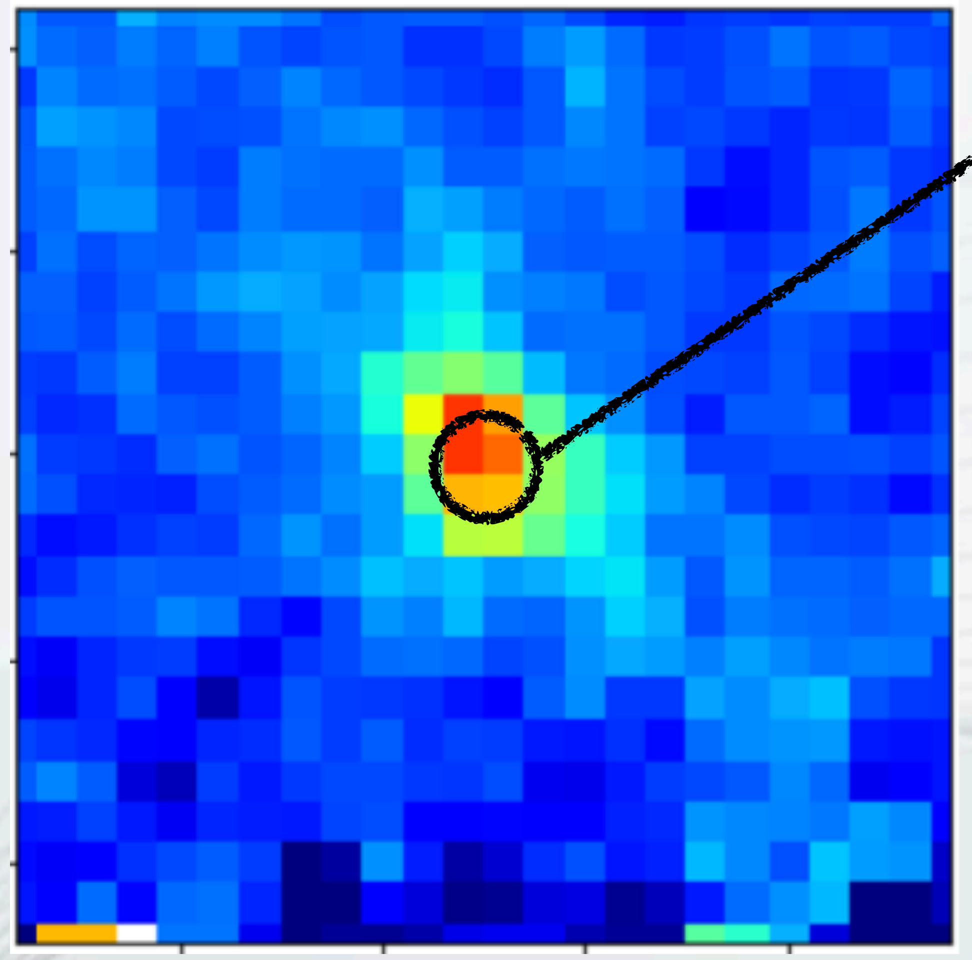
[OIII]5007 moment 0

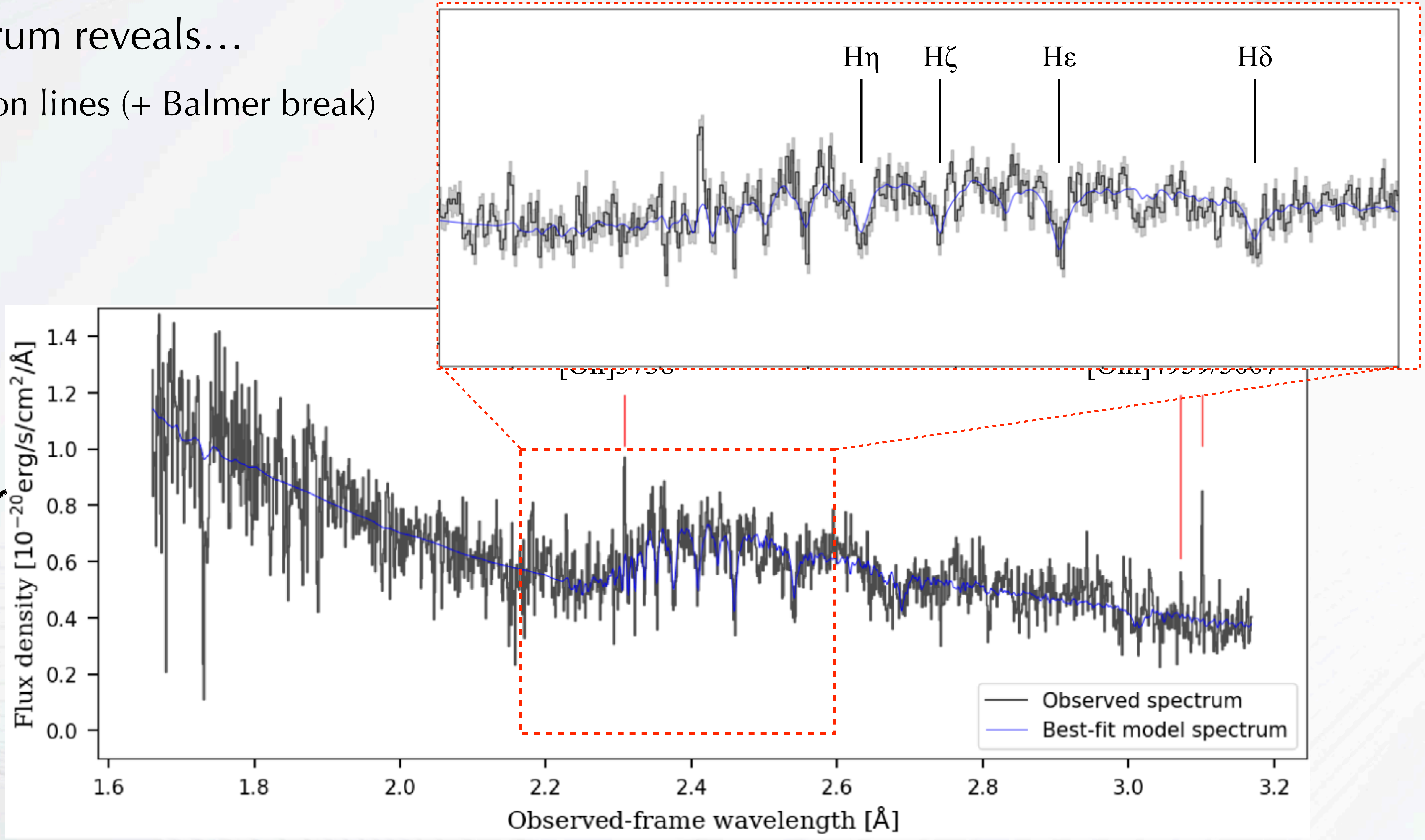


NIRSpec spectrum of z5BBG

- Deep G235M spectrum reveals…
  - Clear Balmer absorption lines (+ Balmer break)

Stellar continuum

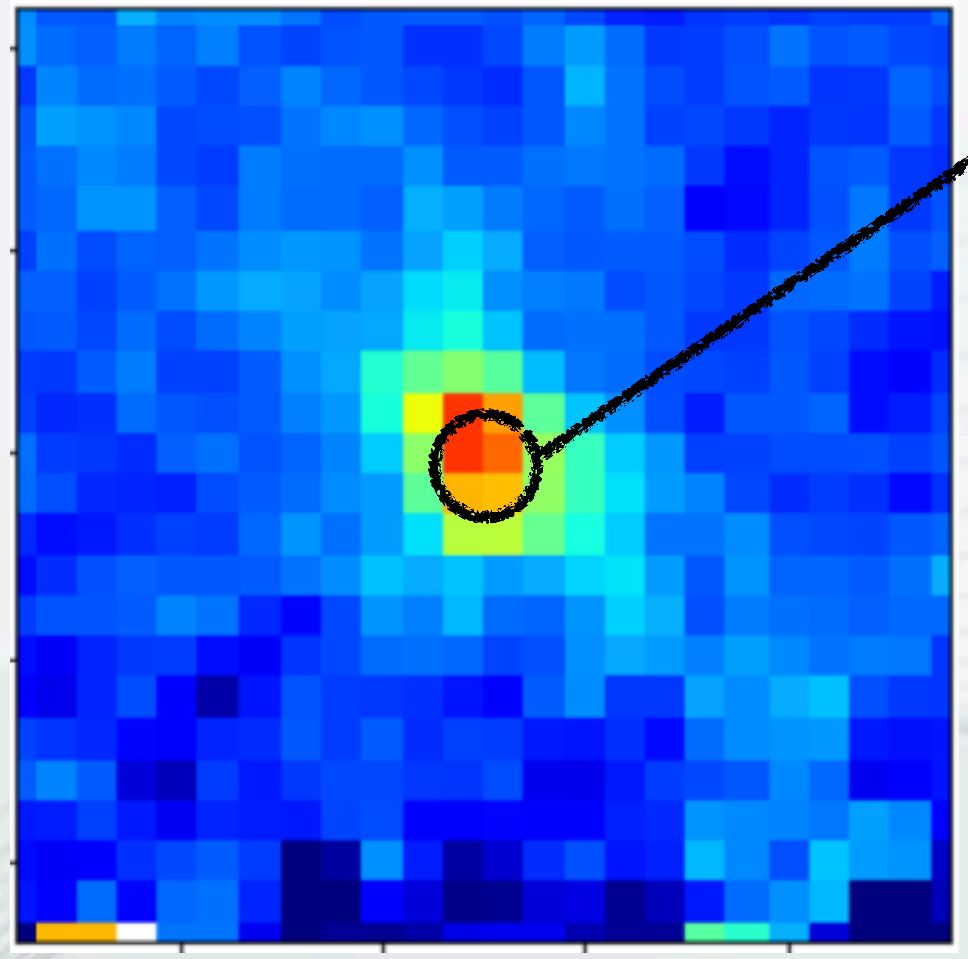


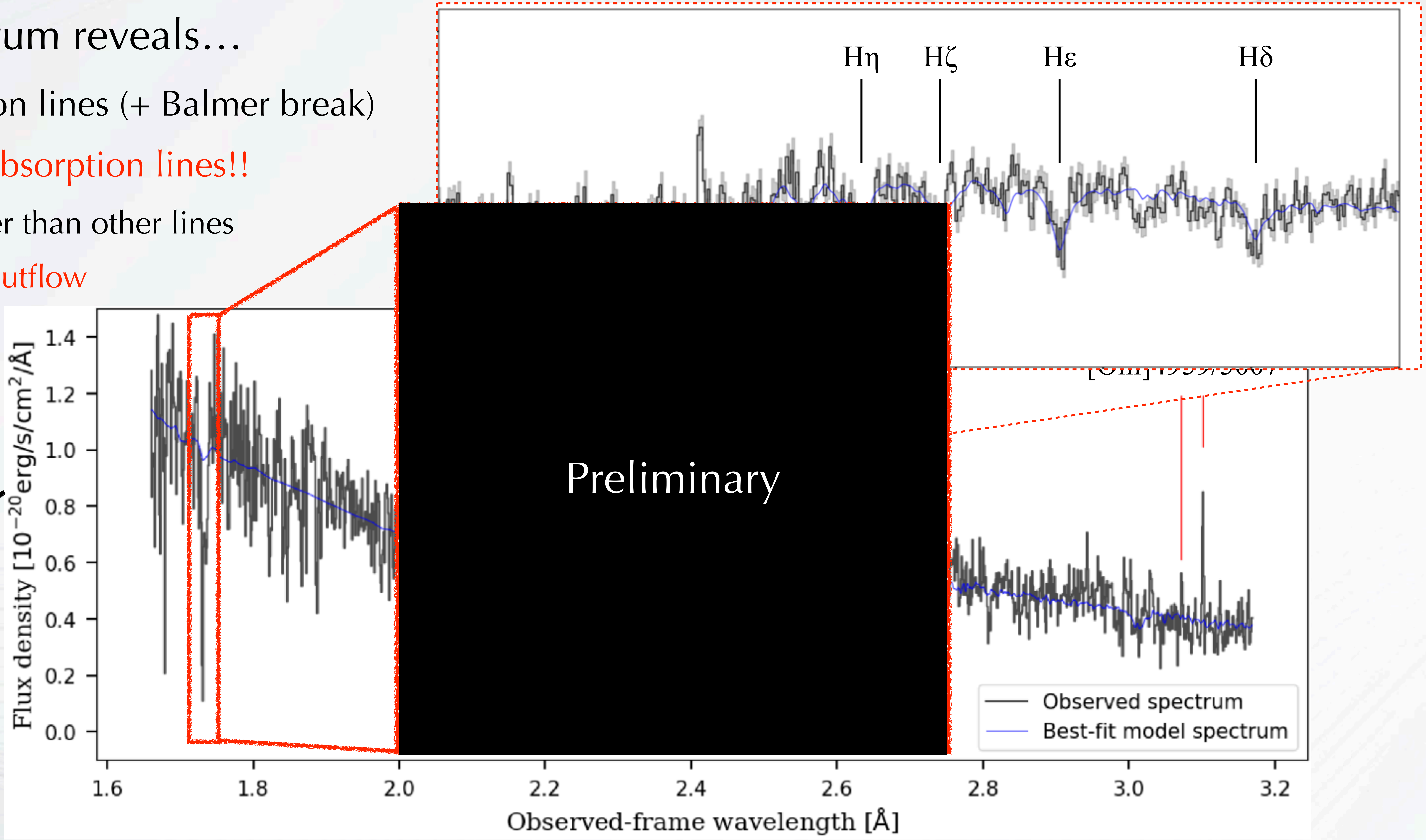


NIRSpec spectrum of z5BBG

- Deep G235M spectrum reveals…
  - Clear Balmer absorption lines (+ Balmer break)
  - And MgII 2796,2803 absorption lines!!
    - Blue-shifted and broader than other lines
    - —> Neutral hydrogen outflow

Stellar continuum



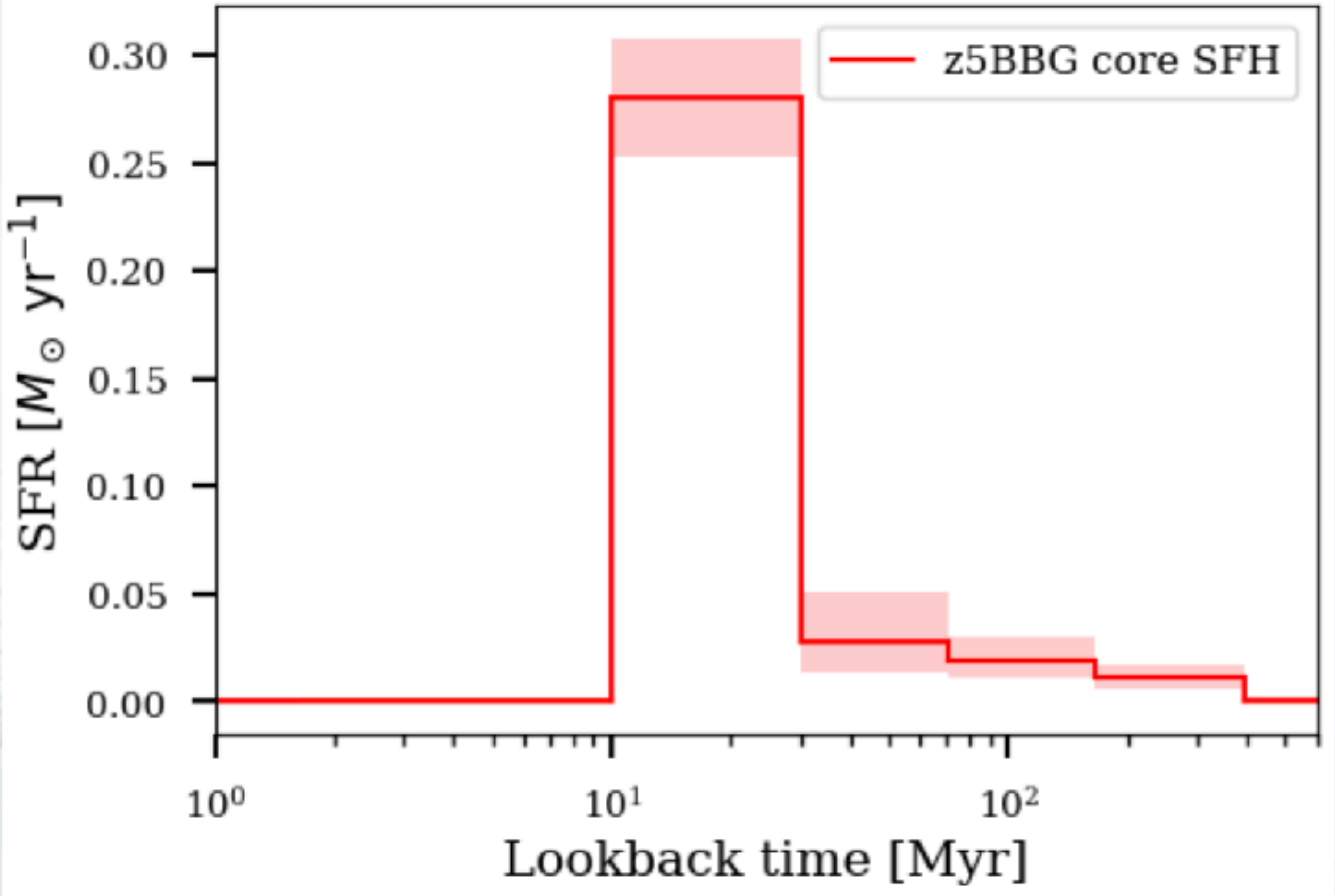


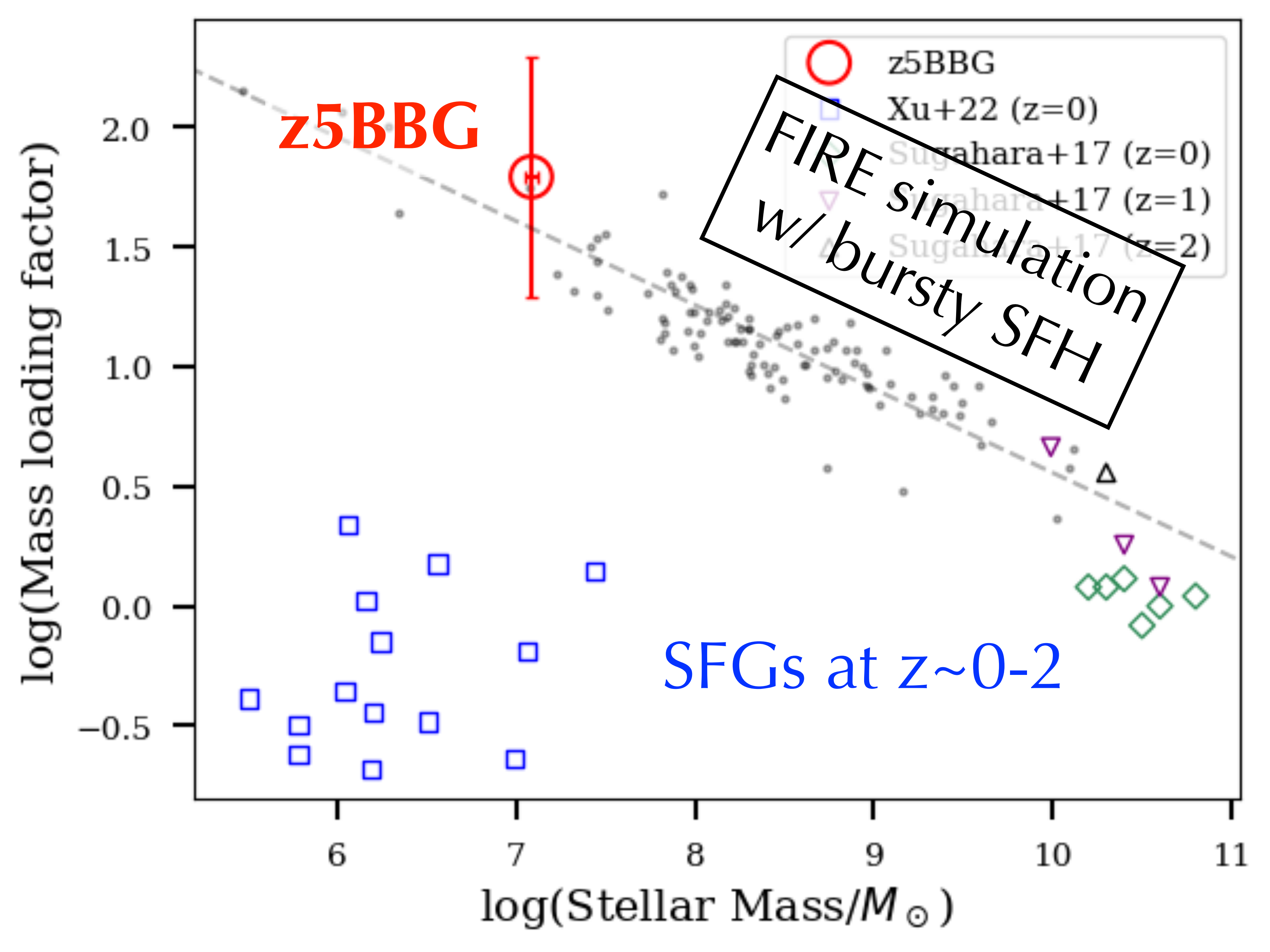
Very raid quenching due to intense feedback and outflow?

- Previous burst of star-formation (~10 Myrs ago) should be related with the outflow
  - Mass loading factor ~62 — more than 1dex higher than SFGs at z ~ 0-2

    —> Powerful enough to abruptly quench the low-mass galaxy
  - Kinetic energy rate of the outflow $\dot{E}_{\rm out} \sim 7 \times 10^{41}$ erg s^{-1} $\sim 0.7 \times \dot{E}_{\rm SNe}$

    —> Cannot be explained by SNe?? AGN-powered outflow, very top-heavy IMF, (or efficient conversion of SNe energy…)

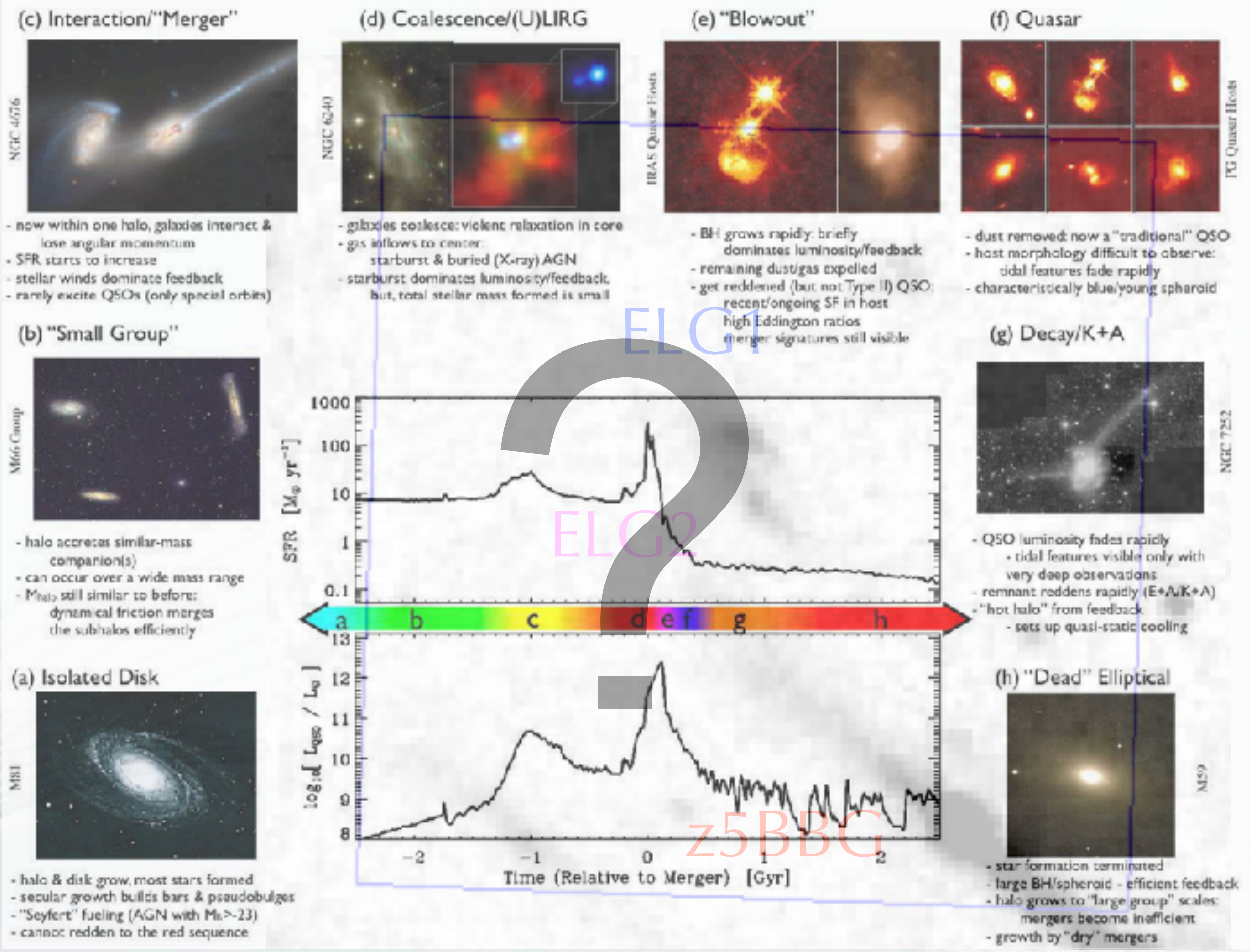


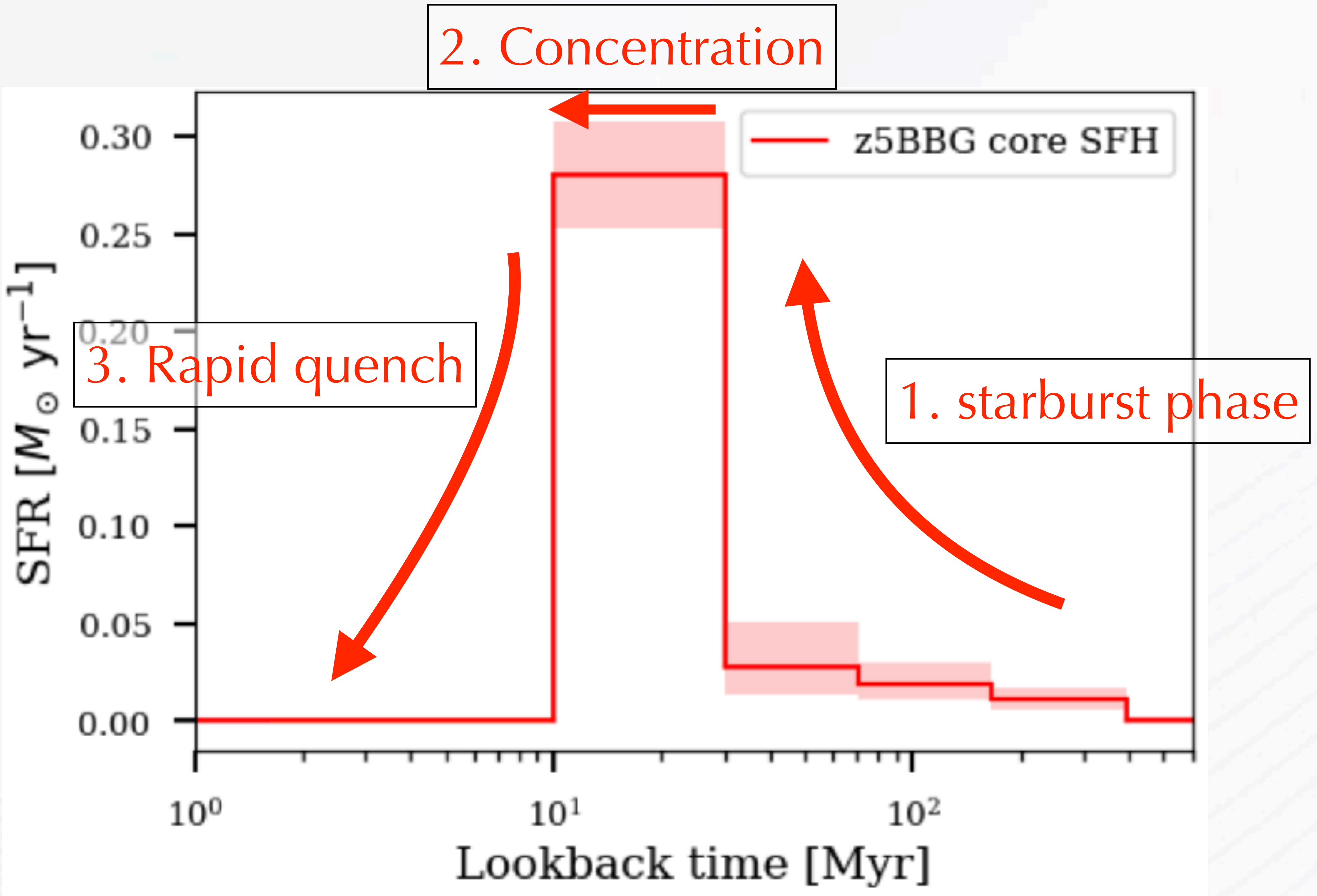


How is z5BBG made bursty?

- Hypothesis: Interaction-triggered gas inflow, concentrated starburst, and vigorous feedback
  1. Interaction with ELG1+ELG2 ~ a few 10 Myrs ago triggers gas inflow into z5BBG center
  2. Centrally concentrated starburst —> compact morphology, may also activate the central AGN
  3. Intensive feedback blows out the neutral hydrogen gas reservoir, shutting down the star formation

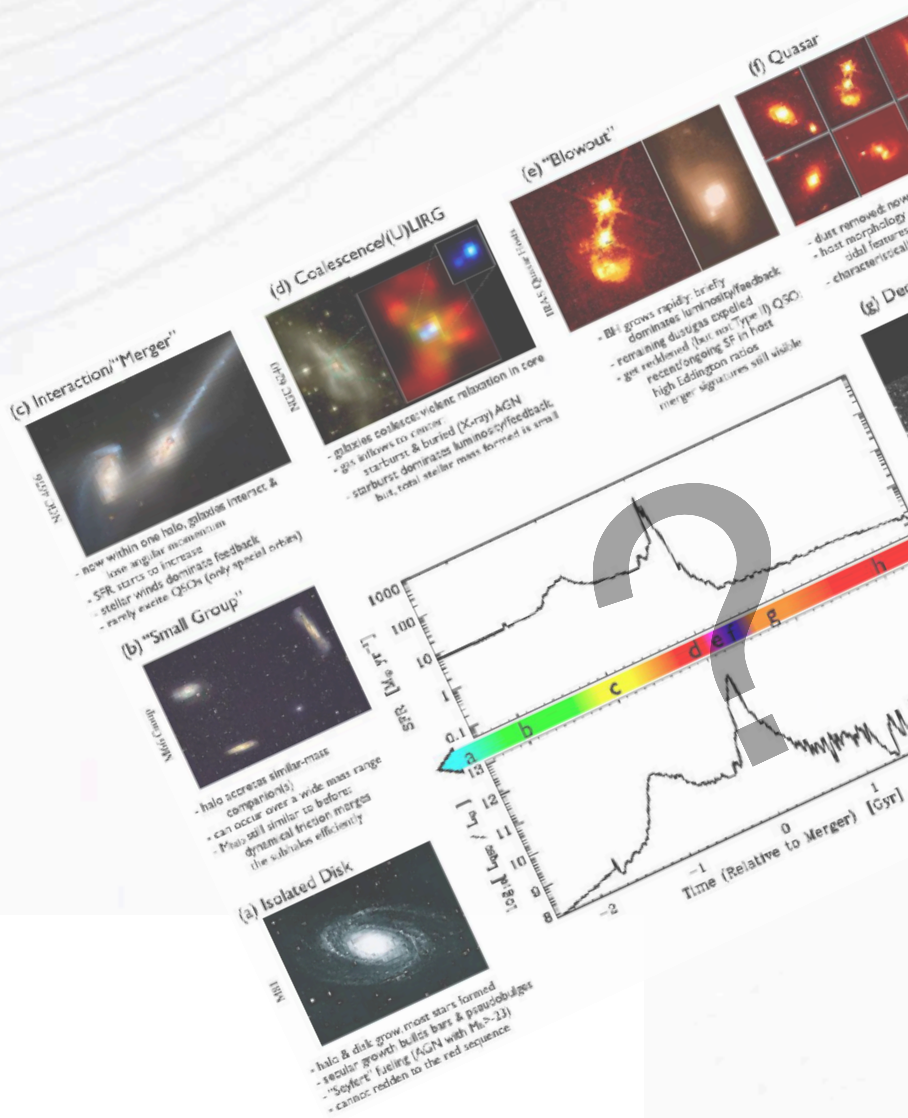
  —> Similar to low-z cQGs, but much faster, less massive, and smaller scale by >2 dex





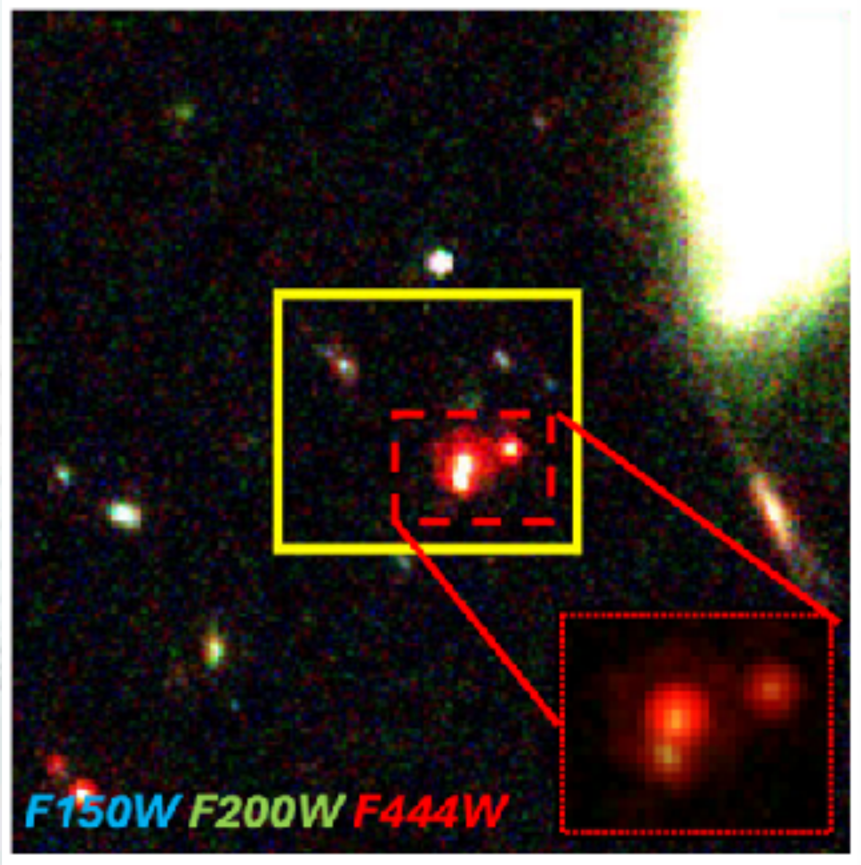
Discussion: possible connection with LRDs?

- Typical physical scales:
  - Size: <10 pc, Stellar mass: ~10^7 Msun, Time scale: ~10 Myr, Gas mass: ~10^8 Msun
  - —> stellar surface density: $> 2.0 \times 10^4\ M_\odot/\mathrm{pc}^2$, (previous) gas density: > 10^6 cm^{-3}

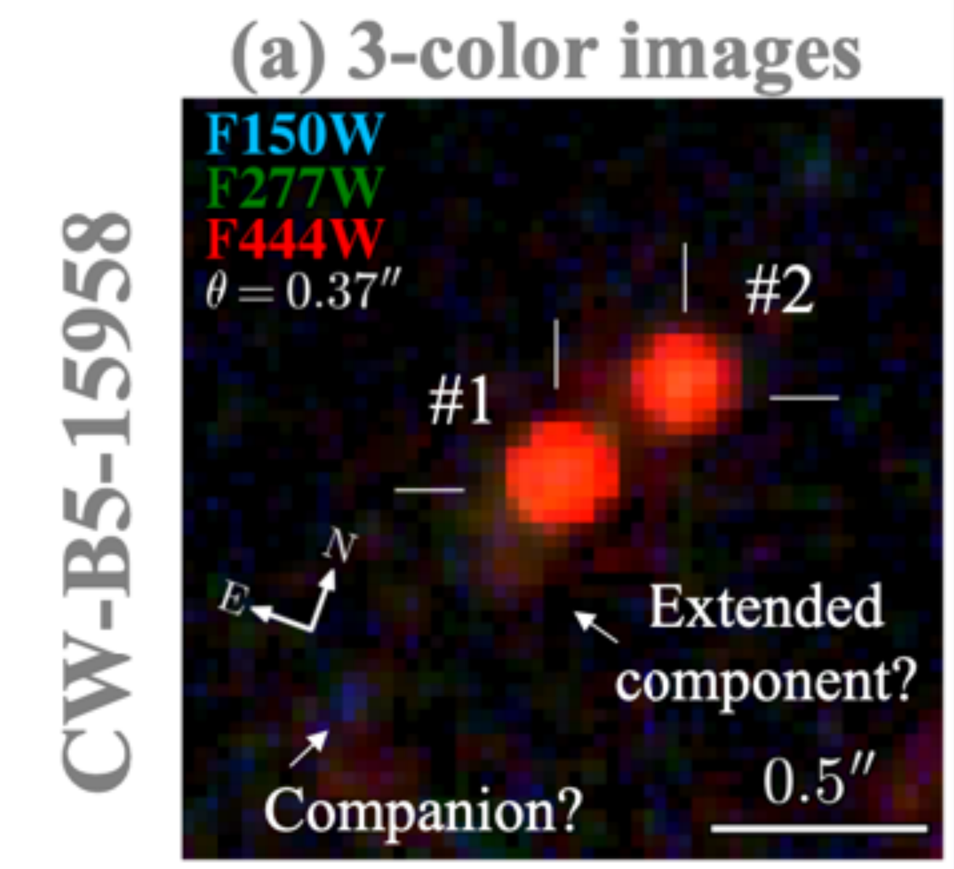


- Are we seeing the post-LRD phase as a "recently quenched galaxy" at high-z?
- Could a low-mass merger/interaction be a channel of LRD emergence?

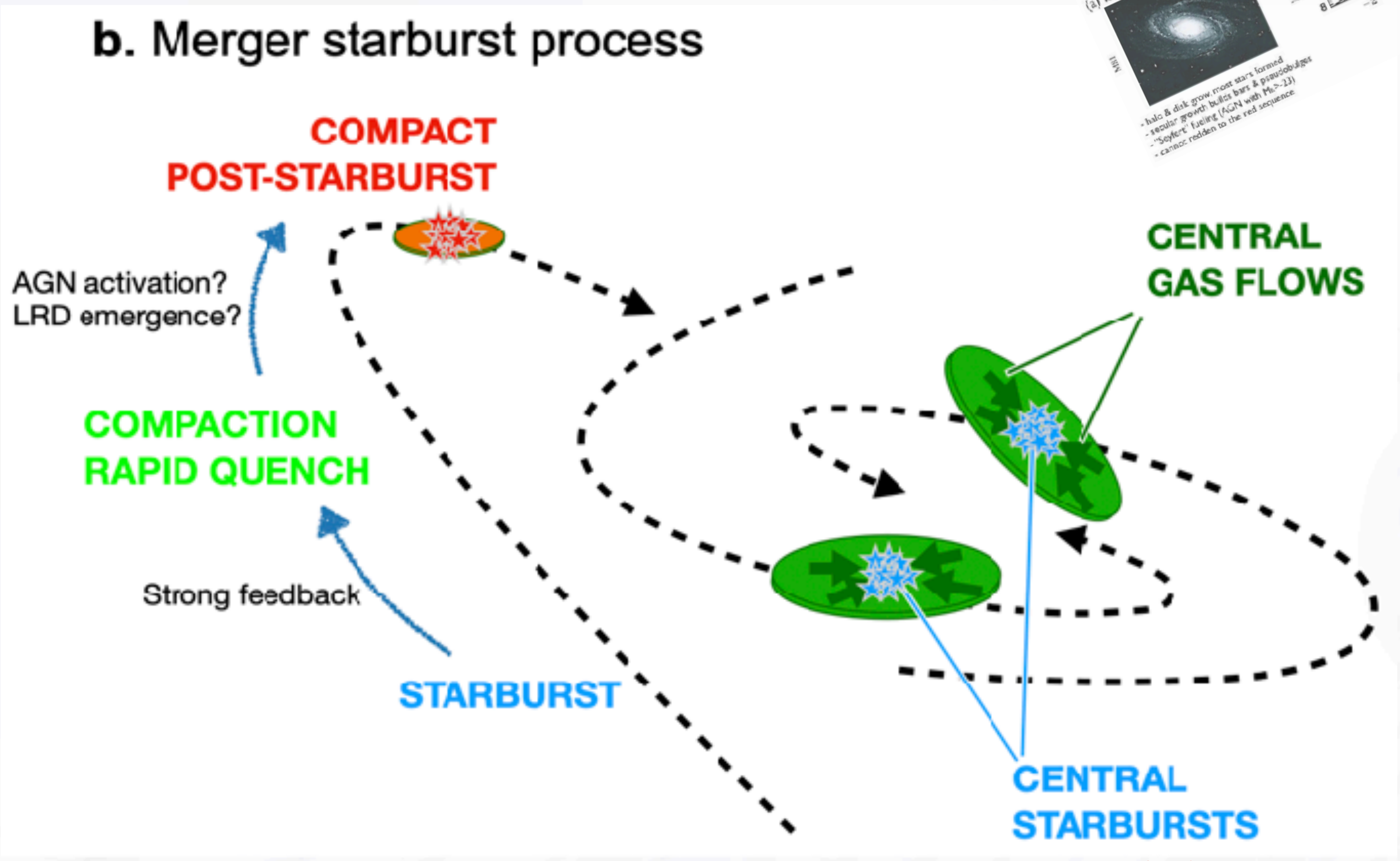
Several examples of LRDs in pair



Rosa et al. (incl. YA) 2025



Tanaka+25



YA in prep.

Summary

- NIRSpec IFU observation of an ultra-low-mass merger system at z=5.2
  - The primary galaxy z5BBG shows clear Balmer absorptions + [MgII] absorption
    - Abrupt quenching due to strong feedback blowing out the neutral gas reservoir
    - "Bursty SFH" can be connected with interaction-induced gas inflow and feedback
    - AGN (or exotic SNe) could be the origin of the intensive feedback
    - Low-mass mergers might be a channel of LRD emergence?

Robust

Speculative