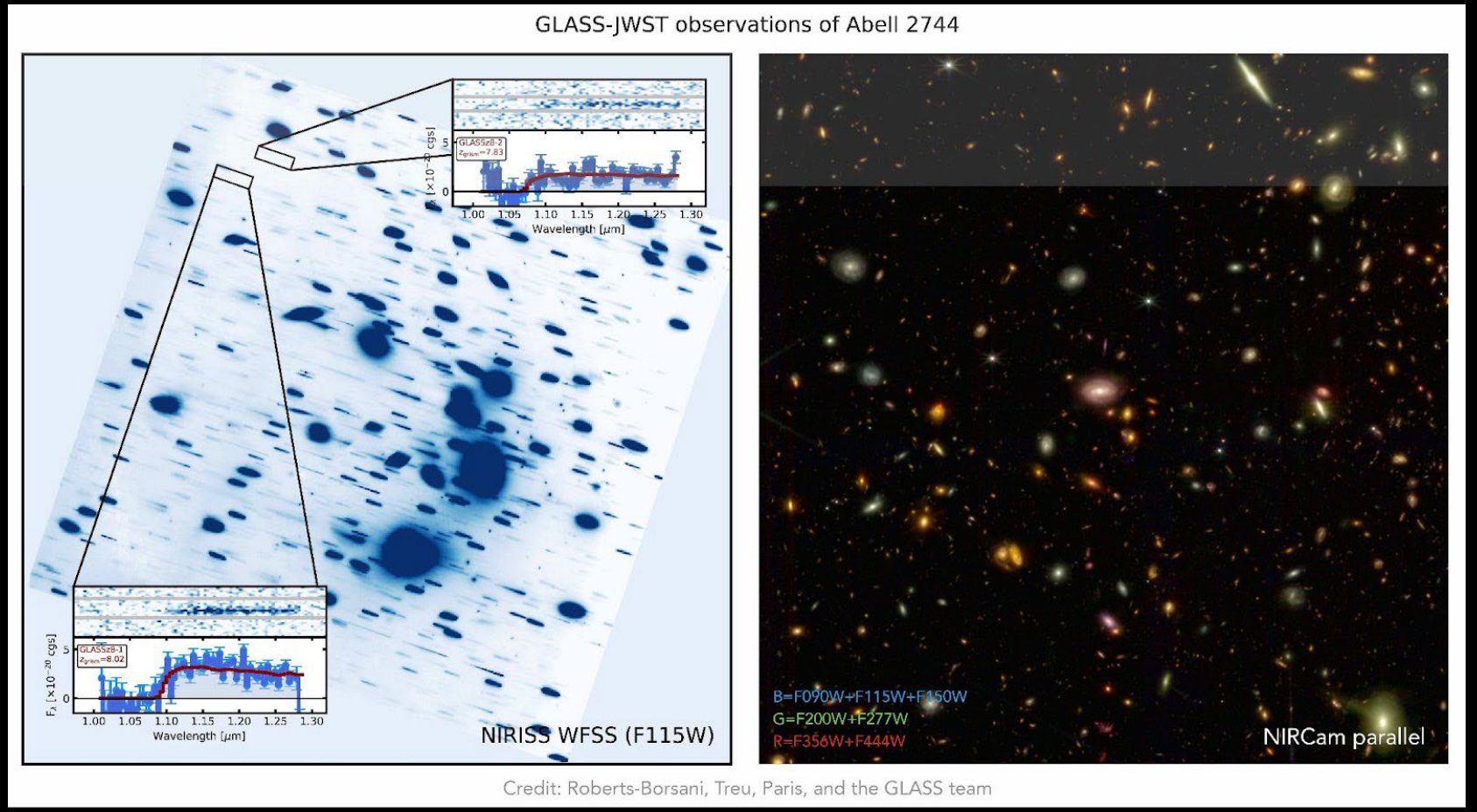
Cosmic Dawn. Results from the GLASS-JWST Early Release Science Program



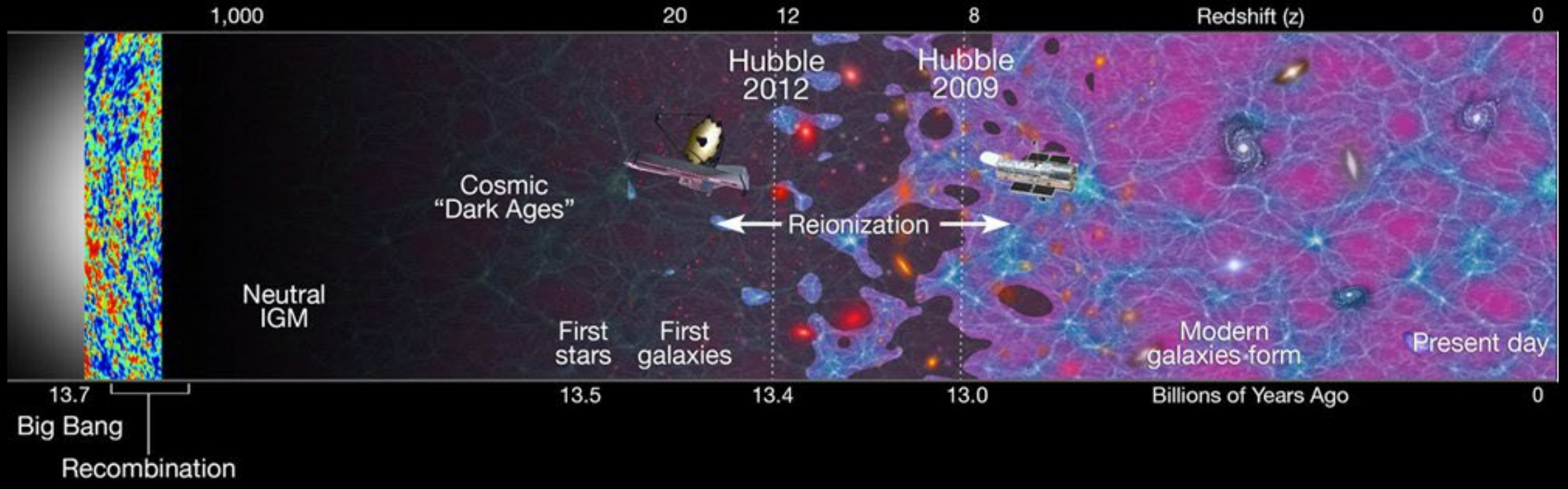
Tommaso Treu (UCLA) and the GLASS-JWST-ERS Team

Outline

- Introduction on Cosmic Dawn.
  - The big questions
  - Why is JWST a Cosmic Dawn Machine?
- Results from Early Release Science Program GLASS-JWST

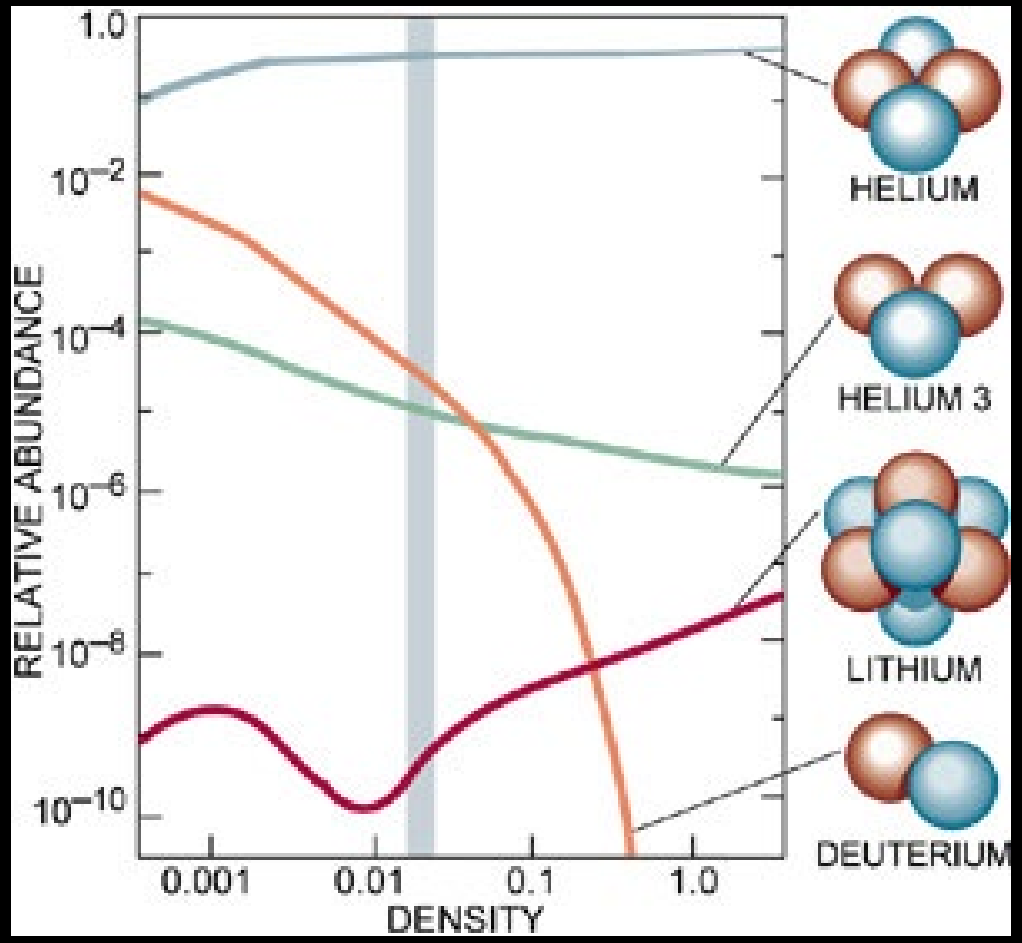
Cosmic Dawn. the Big Questions

- When did the first stars and galaxies form?
- What sources re-ionize the universe? Galaxies seen by Hubble not enough



The cycle of Baryons

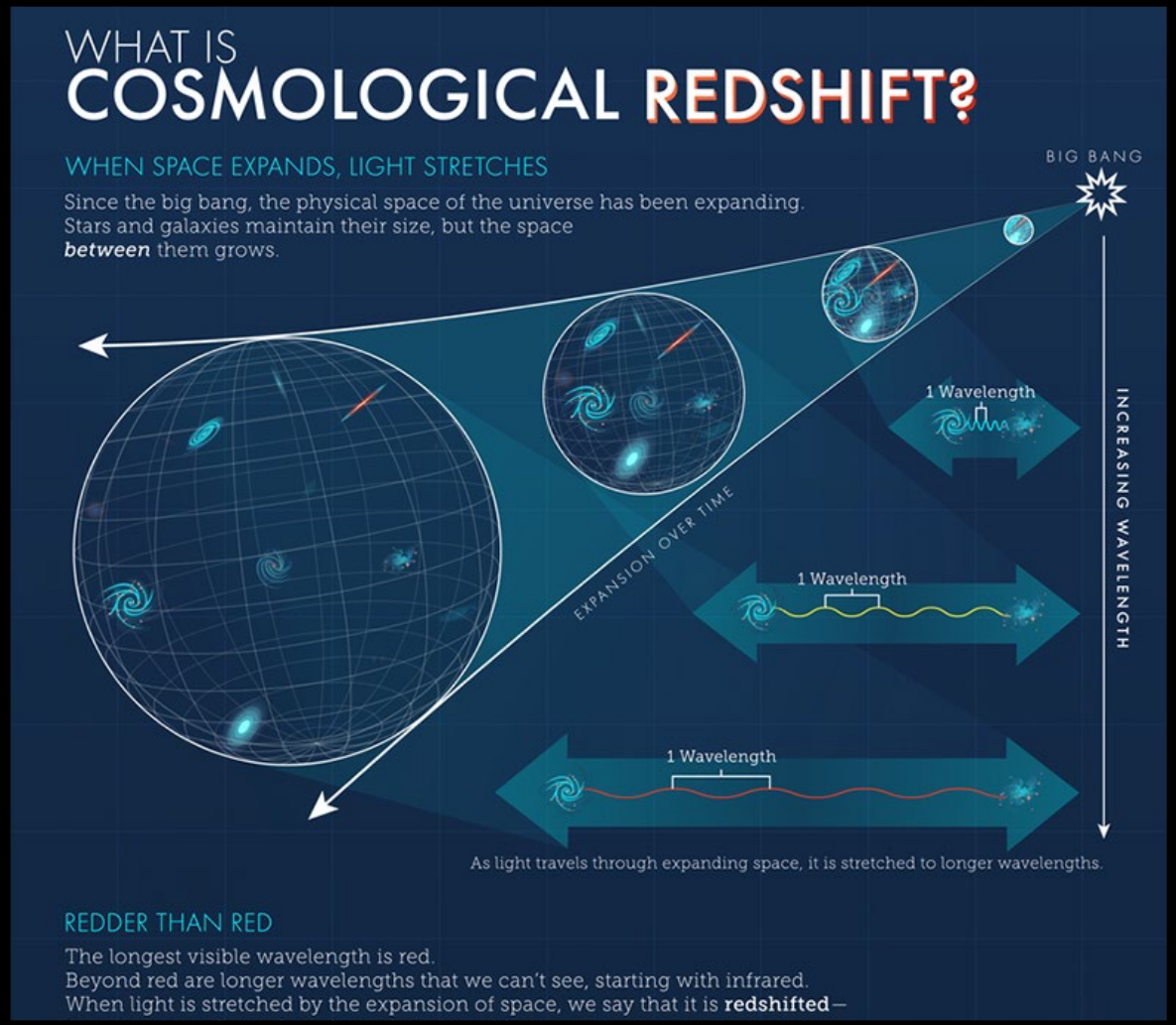
How and when did galaxies transform H/He/Li/Be formed in the three minutes after the Big Bang into all the elements of the periodic table?

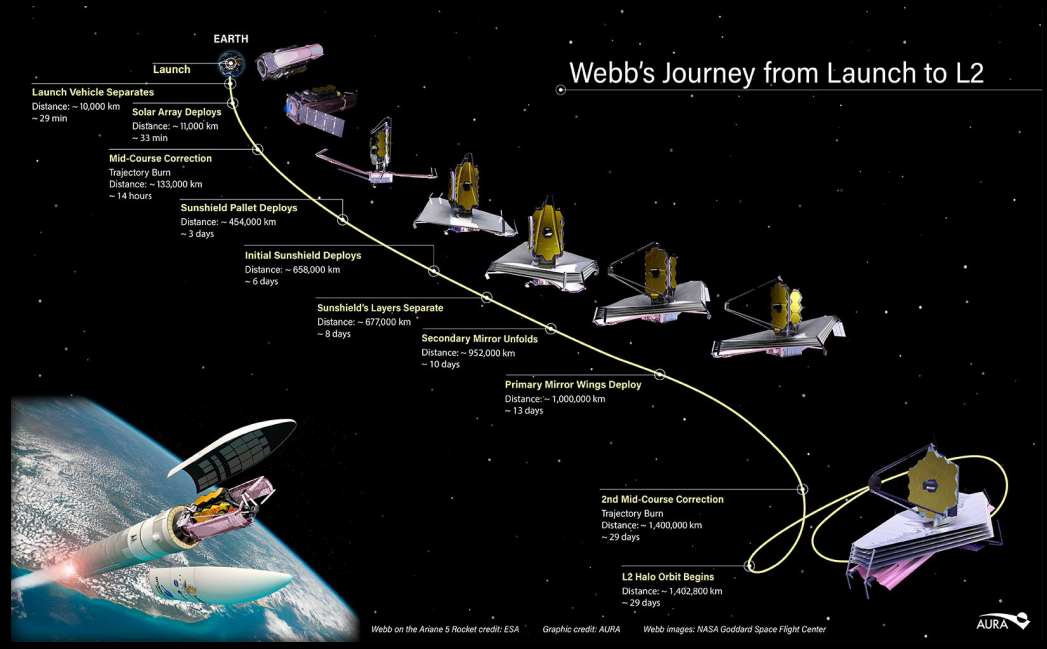


Big Bang Nucleosynthesis: H, He, Li

Stars and Galaxies: Everything else

Cosmological redshift means cosmic dawn needs to be observed in the infrared





JWST is LARGE and COLD

JWST is a time machine!

JWST is a new telescope with the most complex instruments ever flown into space!

- How do you quickly get the community up to speed with JWST?
- One way is to have “beta-testers” or the JWST Early Release Science programs
  - Taken within the first 5 months
  - Data public immediately
  - Teams release high level data products
- 13 ERS programs selected in 2017

A personal note

The Fundamental Plane of Elliptical Galaxies at Low and High Redshift

Hide affiliations

Treu, T. (-)

No abstract

Publication: The Next Generation Space Telescope: Science Drivers and Technological Challenges, 34th Liège Astrophysics Colloquium, June, 98, Edited by B. Kaldeich, p. 255.

Pub Date: July 1998

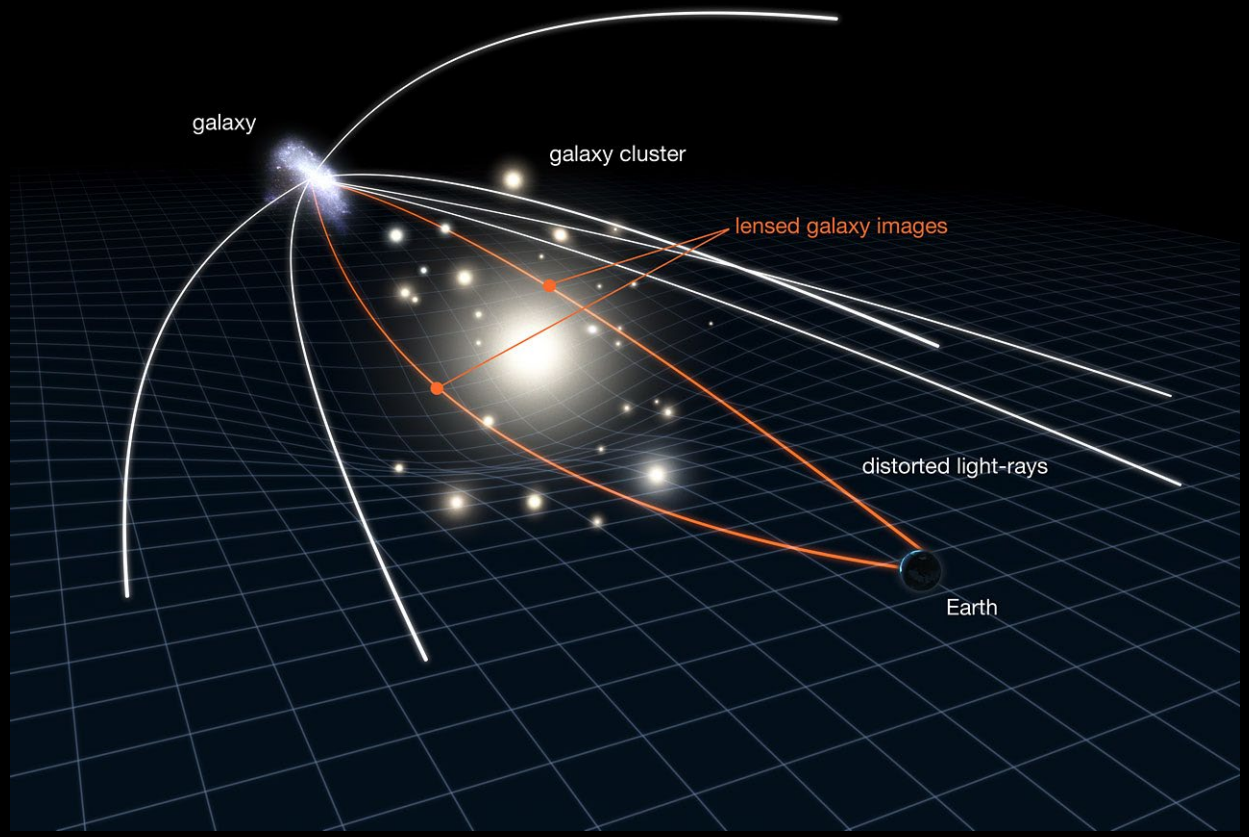
Bibcode: 1998ESASP.429..255T

24 years later

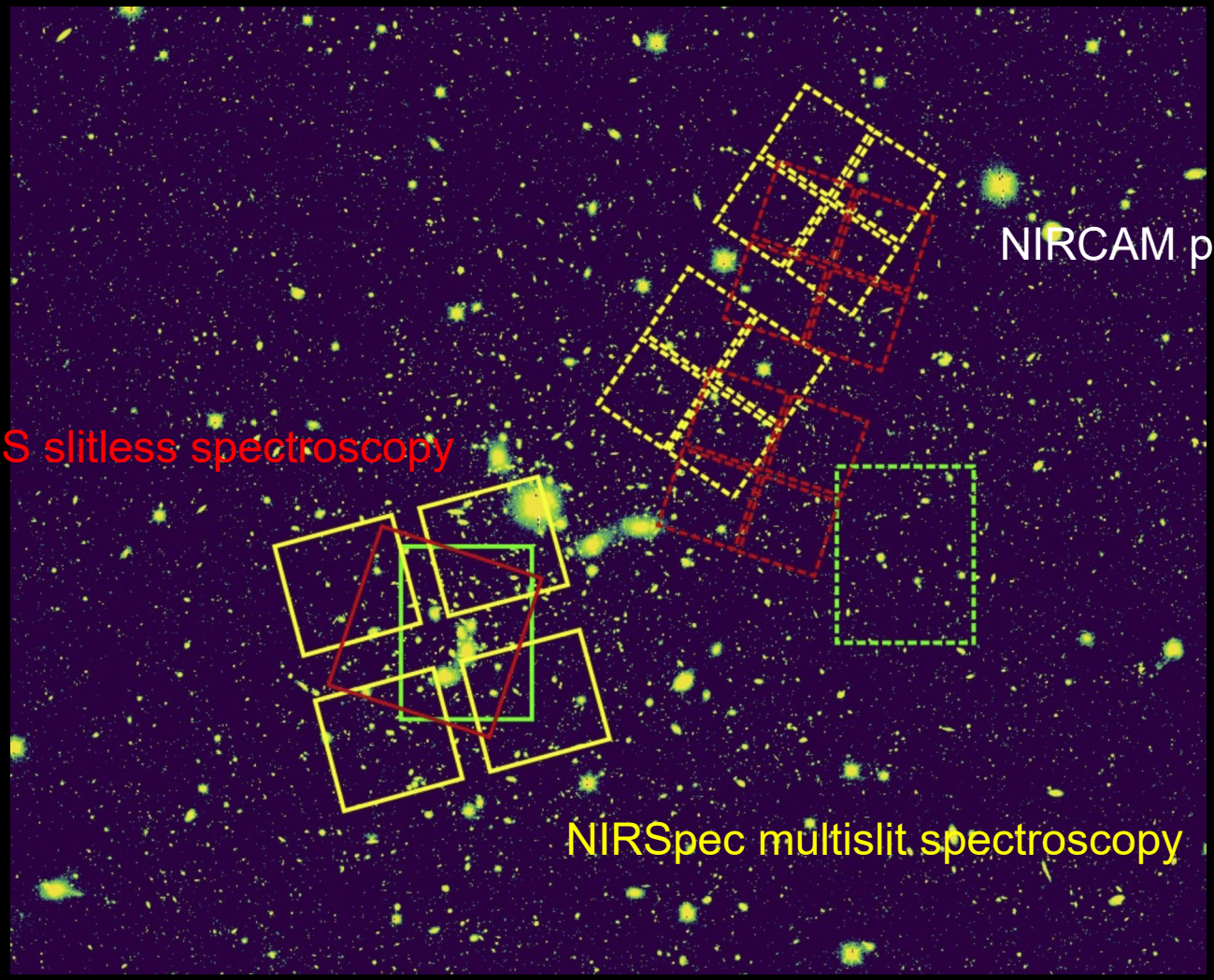
http://glass.astro.ucla.edu/ers/

GLASS-JWST is the deepest ERS program

- Long exposure times (15-20 hours/instrument)
- mag limit~30AB in imaging
- Magnification up to factors 10-20 enables spectroscopy of sources down to mAB~29-30

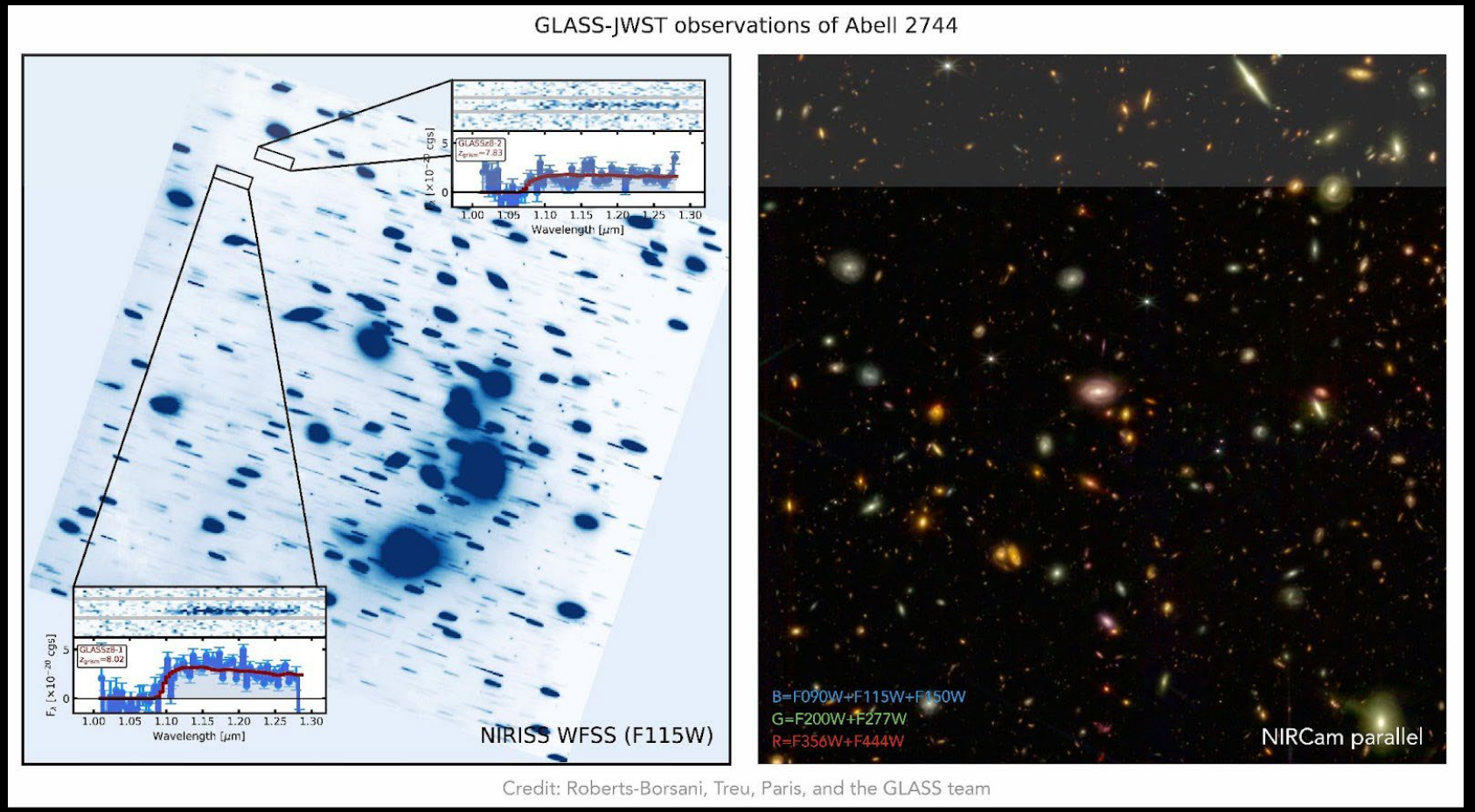


Experimental Setup



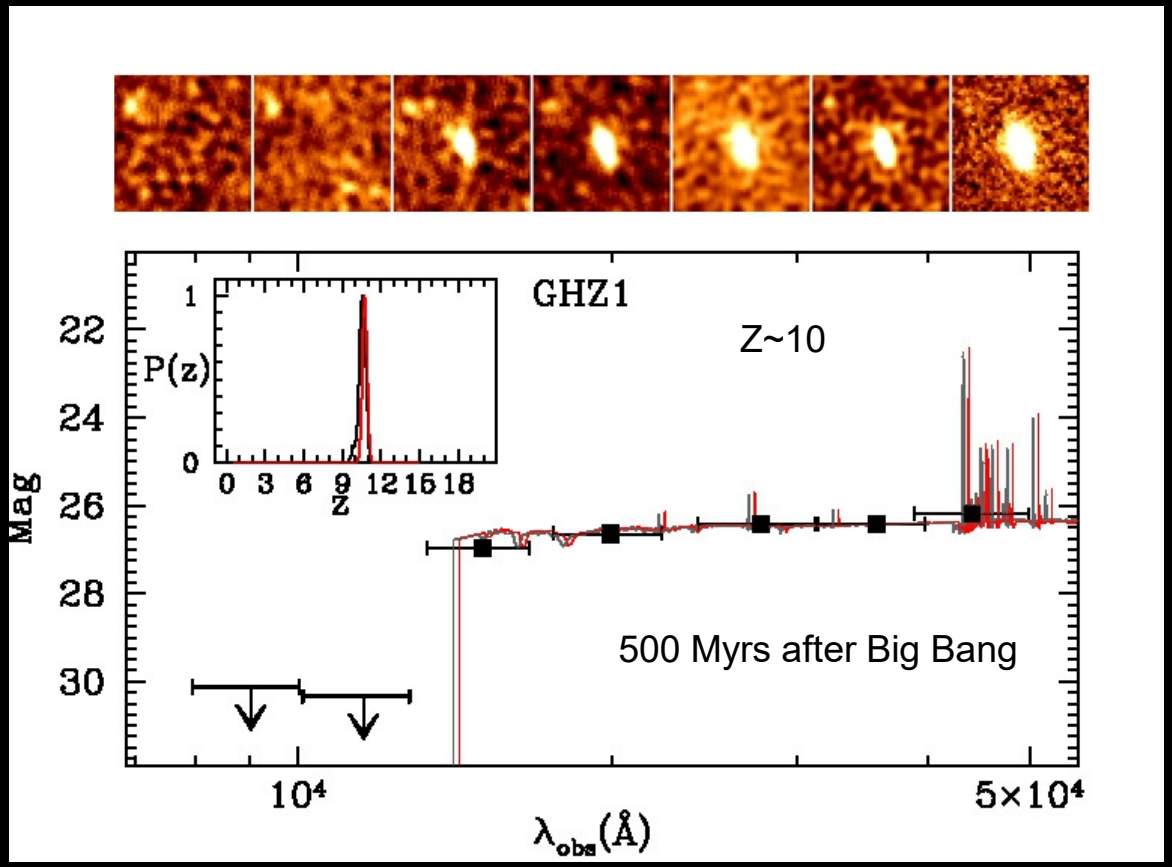
Treu et al. 2022

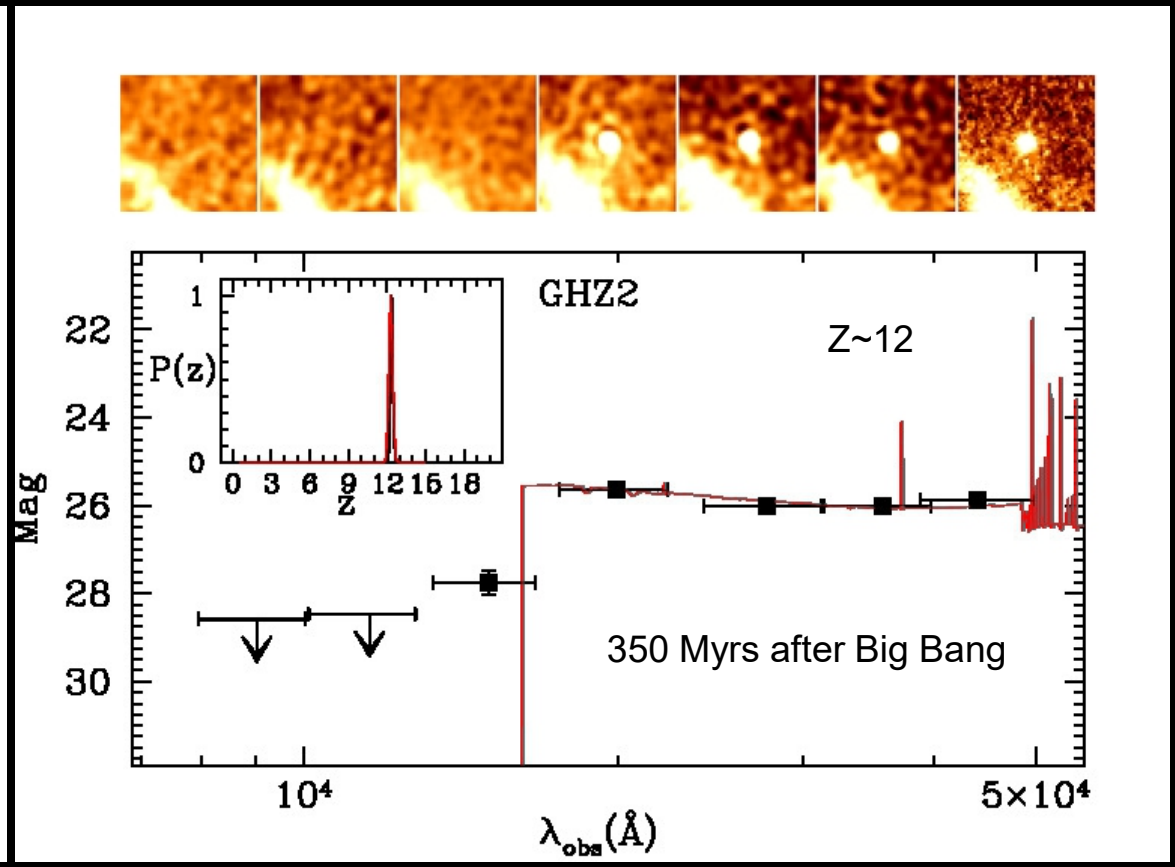
July 14: the GLASS-JWST data arrive!



Roberts-Borsani et al. 2022; Merlin et al. 2022

July 19: The first high redshift galaxy candidates





We expected 0.1!

Castellano et al. 2022; see also Naidu et al. 2022, Donnan et al. 2022

Galaxies form earlier and faster than we thought!

On the stunning abundance of super-early, massive galaxies revealed by JWST

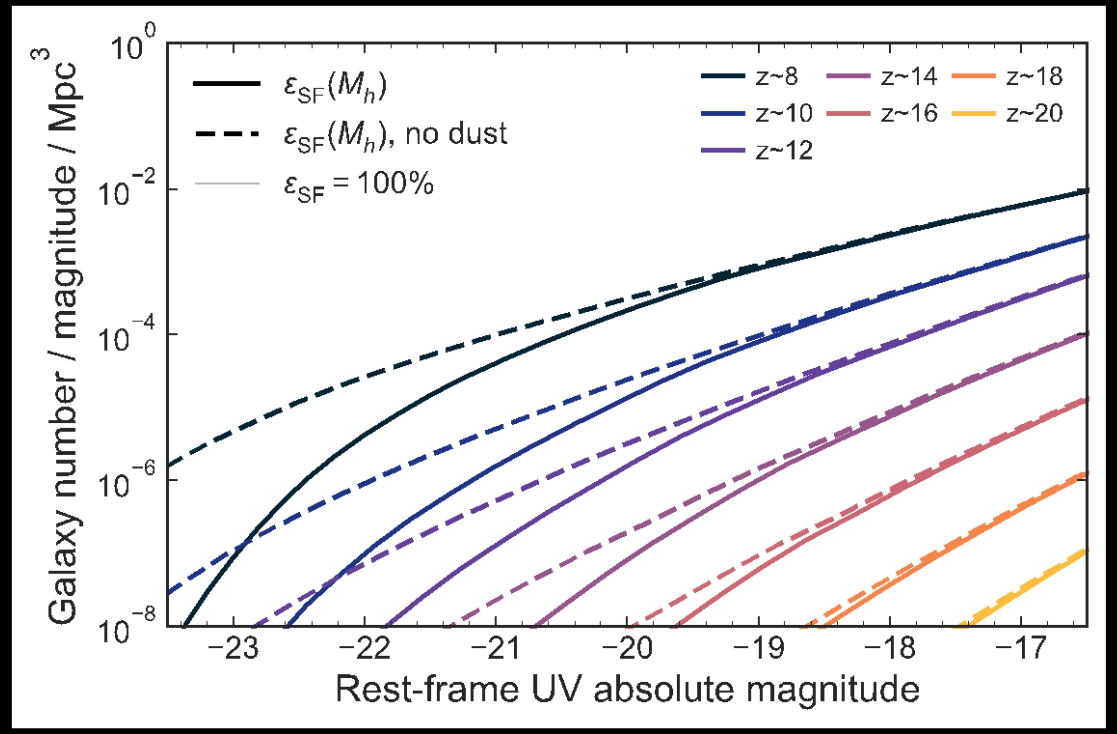
Andrea Ferrara [1], Andrea Pallottini [1], and Pratika Dayal [2]

[1] Scuola Normale Superiore, Piazza dei Cavalieri 7, 50126 Pisa, Italy
[2] Kapteyn Astronomical Institute, University of Groningen, 9700 AV Groningen, The Netherlands

The brightest galaxies at Cosmic Dawn

Charlotte A. Mason[1,2]*, Michele Trenti[3,4] and Tommaso Treu[5]
[1] Cosmic Dawn Center (DAWN)
[2] Niels Bohr Institute, University of Copenhagen, Jagtvej 128, 2200 København N, Denmark
[3] School of Physics, University of Melbourne, Parkville 3010, VIC, Australia
[4] ARC Centre of Excellence for All Sky Astrophysics in 3 Dimensions (ASTRO 3D), Australia
[5] Department of Physics and Astronomy, University of California, Los Angeles, 430 Portola Plaza, Los Angeles, CA 90095, USA

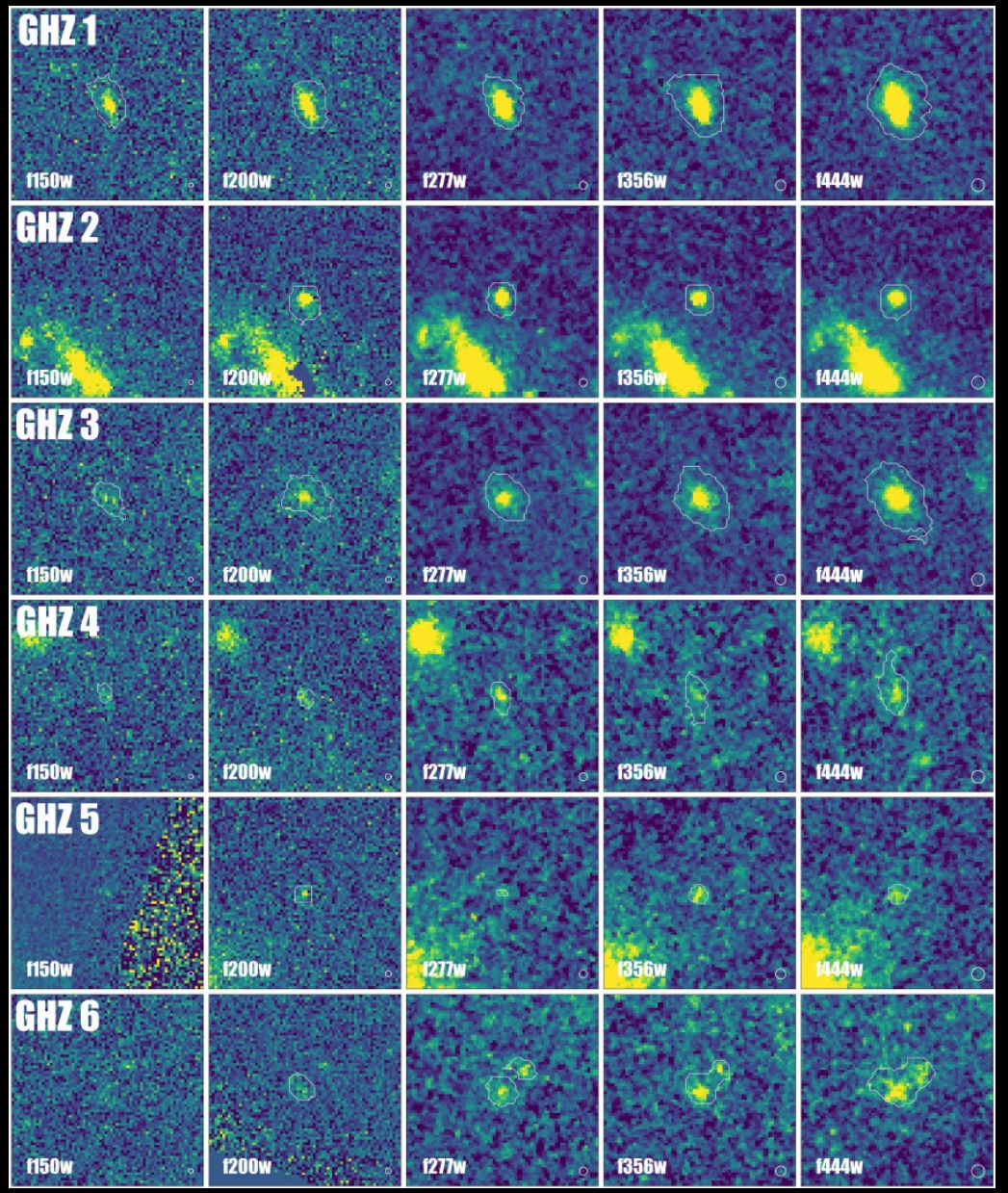
- Galaxies appear to form earlier and more rapidly then previously thought. Do we understand star formation?
- Less dust than previously thought. Do we understand dust formation?



Mason, Trenti & Treu 2023; see also Ferrara et al. 2023

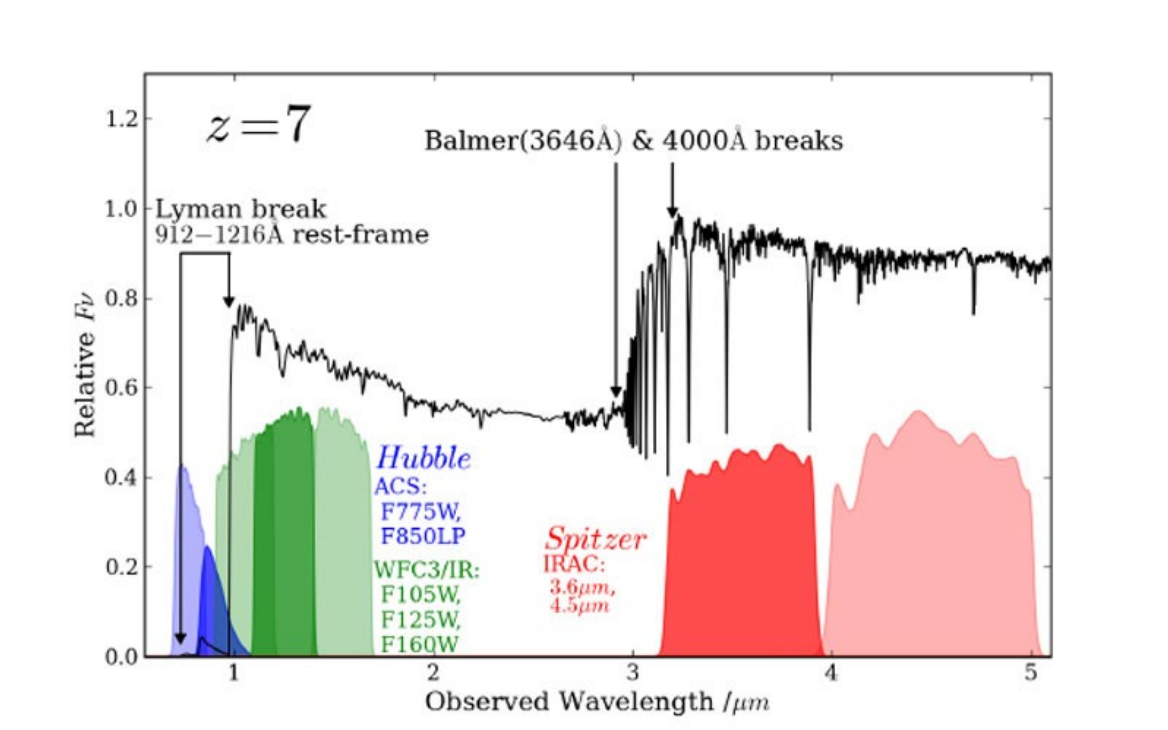
Clues from morphology and size

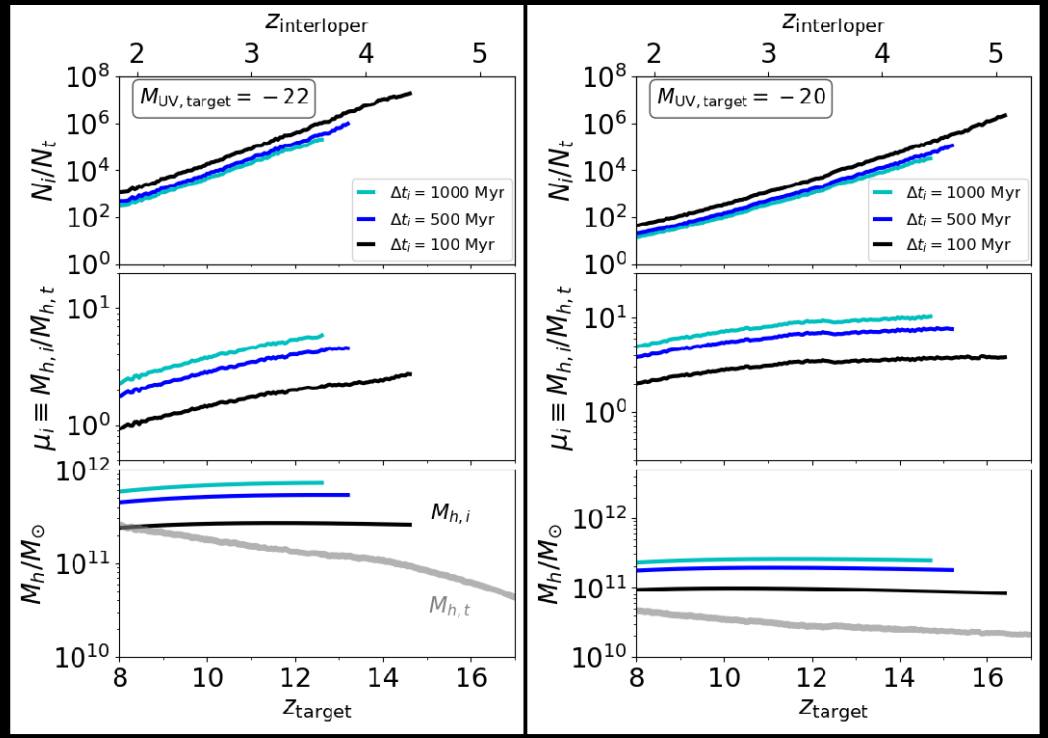
- Galaxies at z>7 are very compact: 100-200pc!
- They are practically galaxy scale starbursts
- Run Run Run as Fast as you Can!



Treu et al. 2023; Yang et al. 2022b

Are these galaxies really at z>10? Potential contaminants

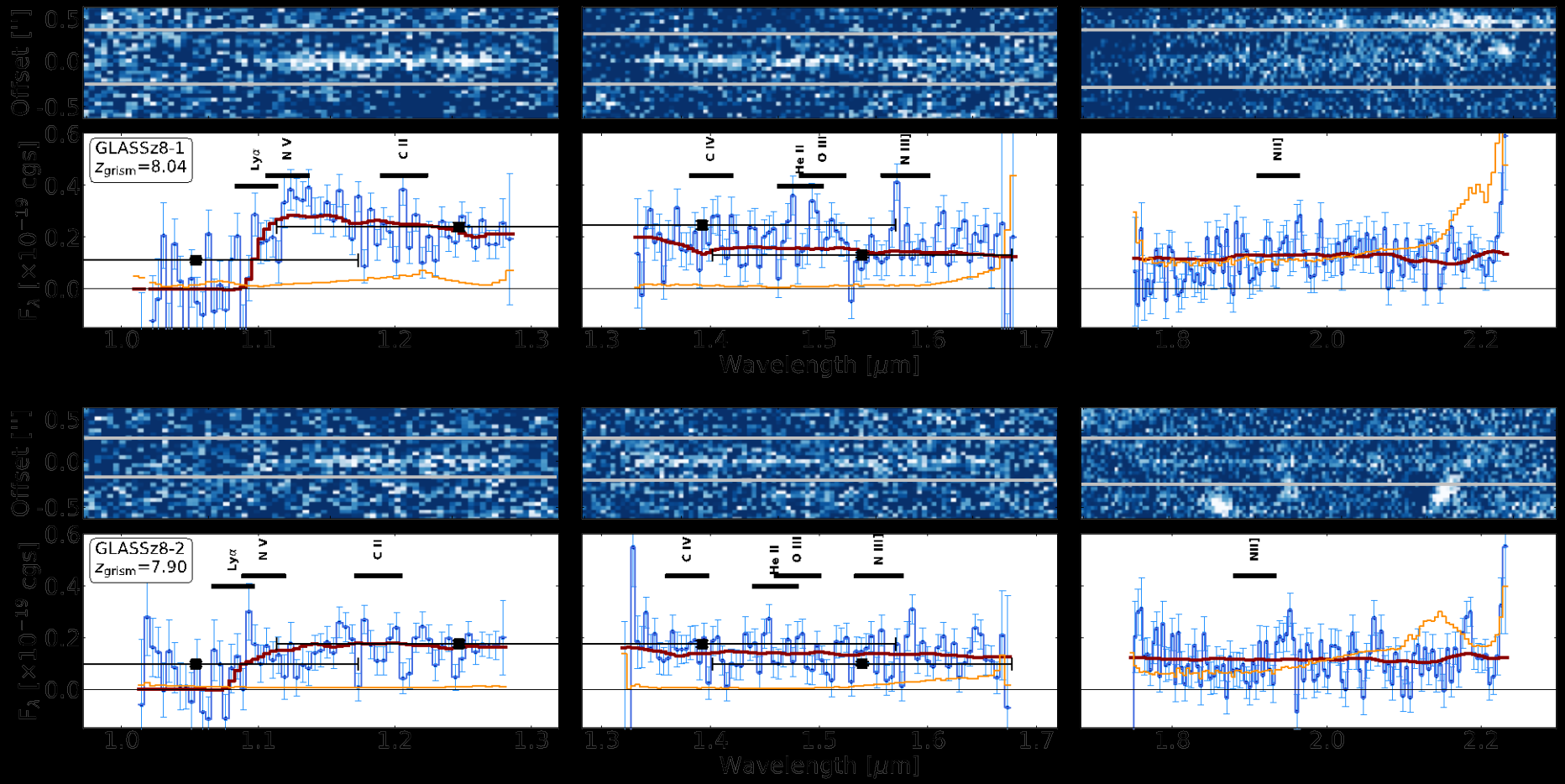




Balmer Break Instead of Lyman Break
Unlikely because many “detection bands” and galaxies are very blue

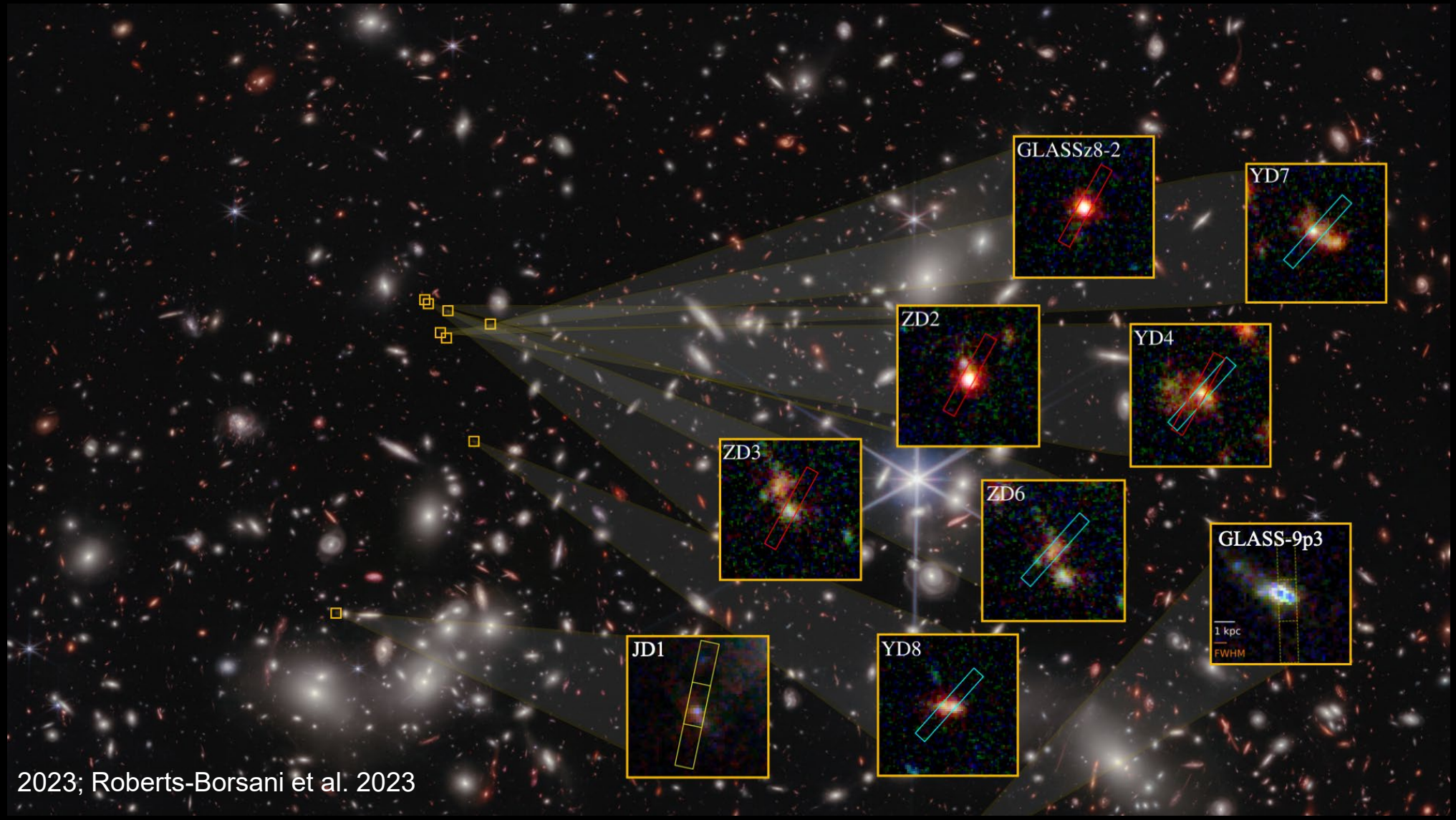
Furlanetto & Mirocha 2022

JWST confirmations: NIRISS continuum z~8



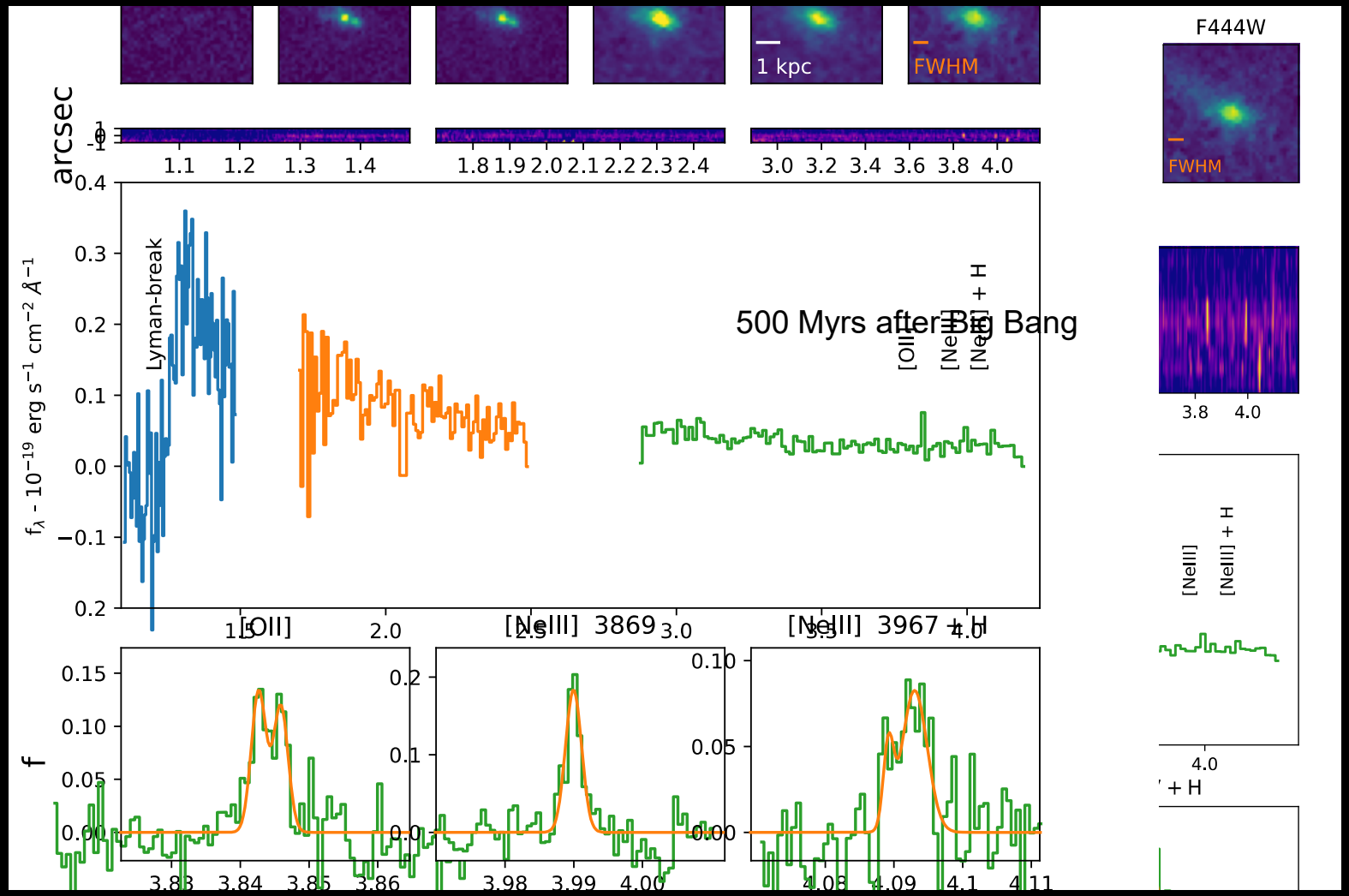
Roberts-Borsani et al. 2022a

November 2022: NIRSpec data arrive!



Morishita et al. 2023; Roberts-Borsani et al. 2023

A massive galaxy at z=9.3 (10^9 M_{sun})



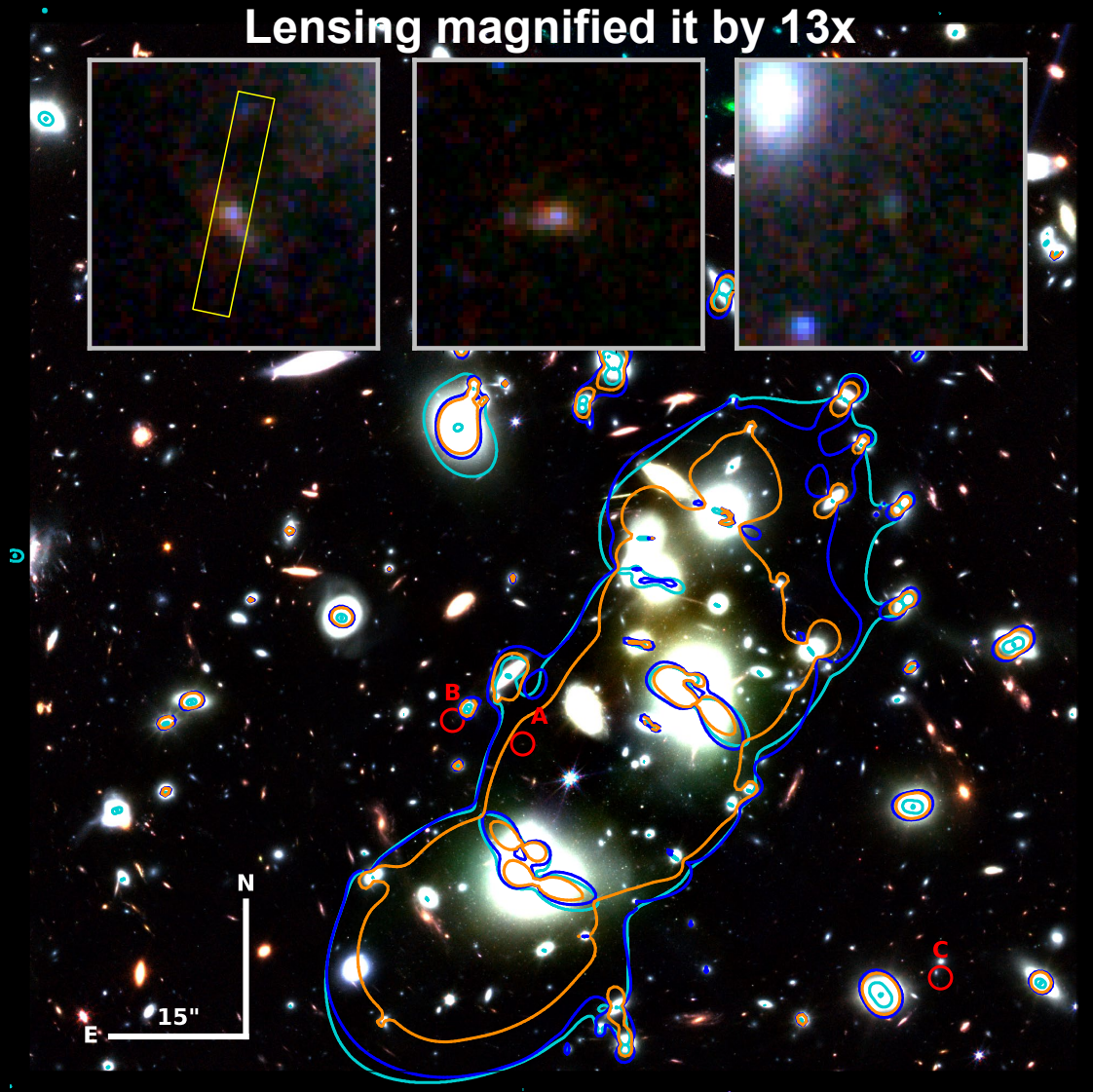
Boyett et al. 2023

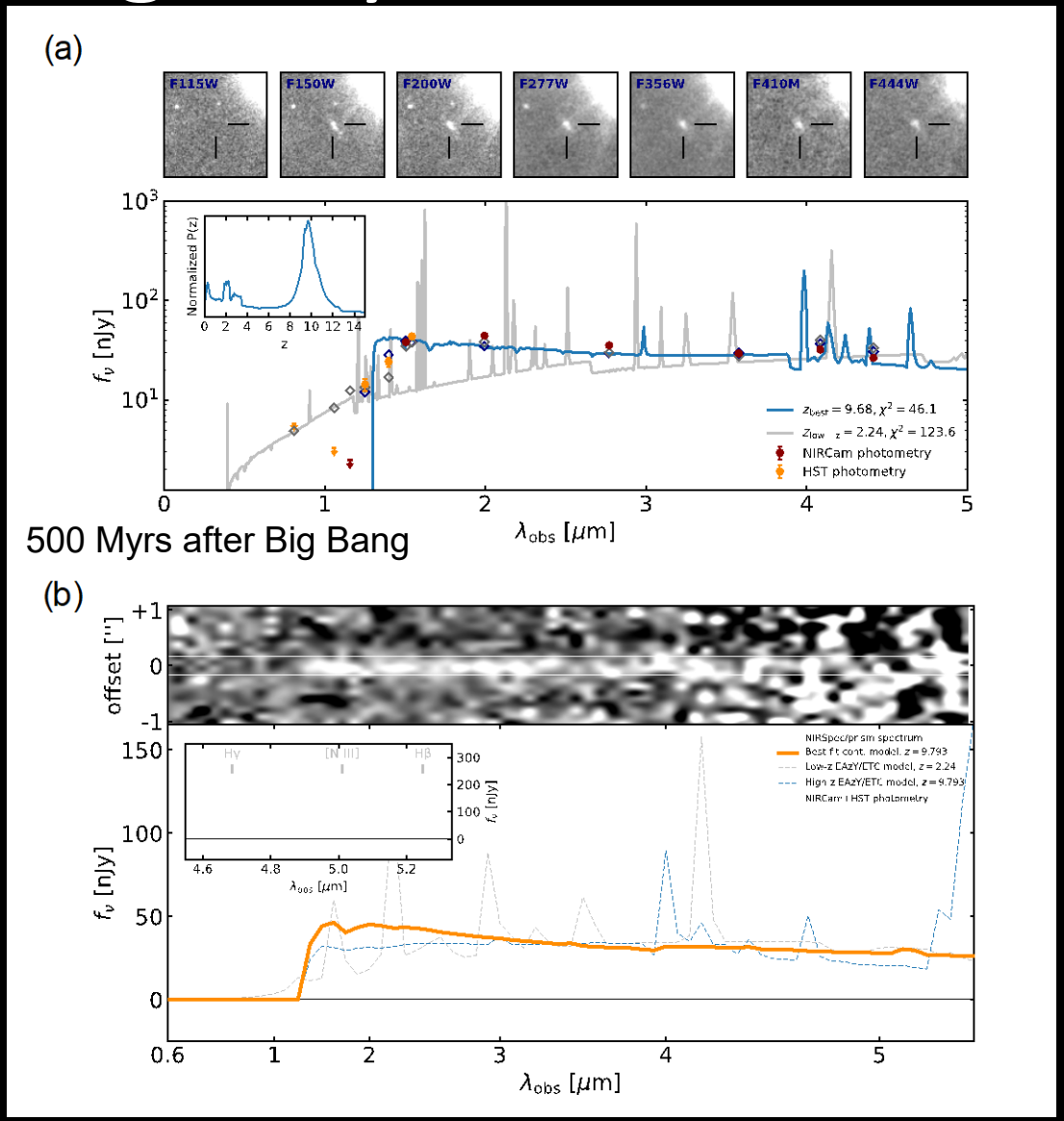
Identifying the (faint) sources of reonization

mAB~29-30

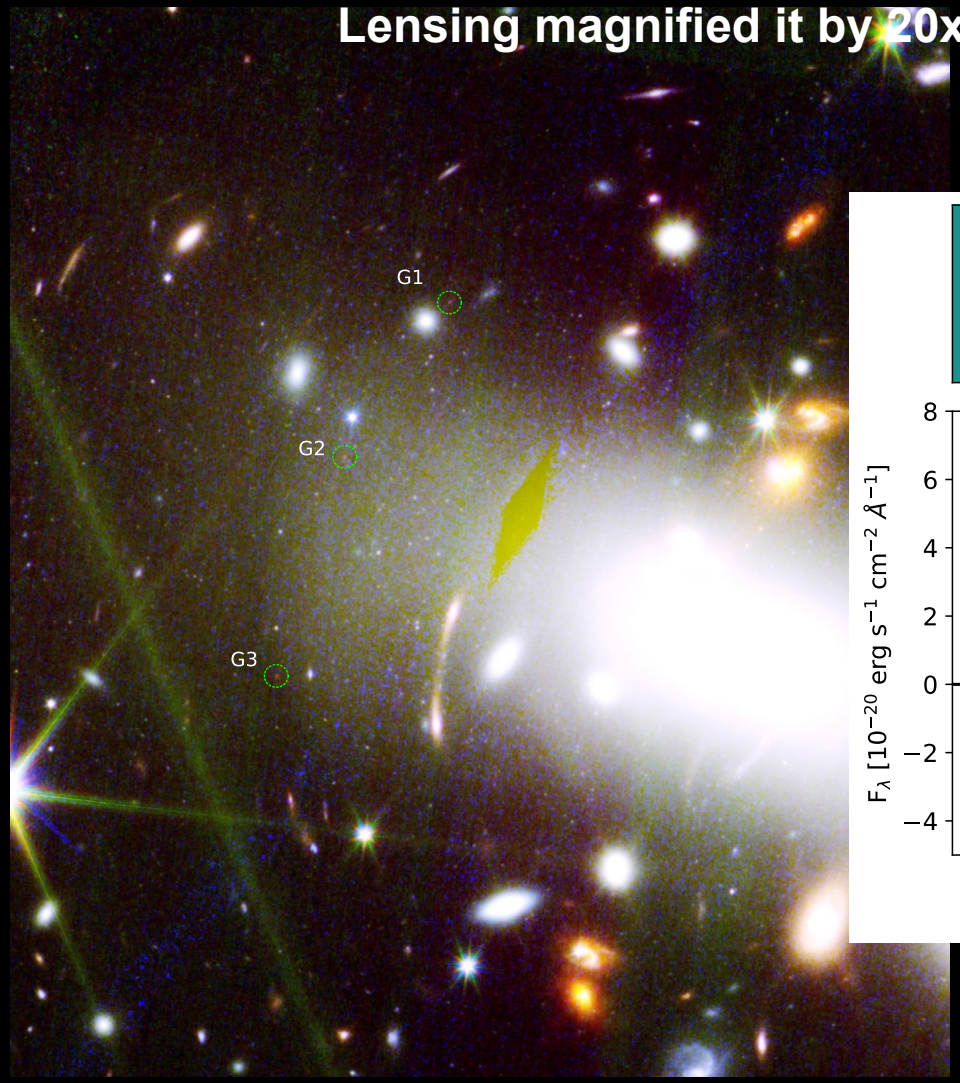
Roberts-Borsani et al. 2023, Nature, in press

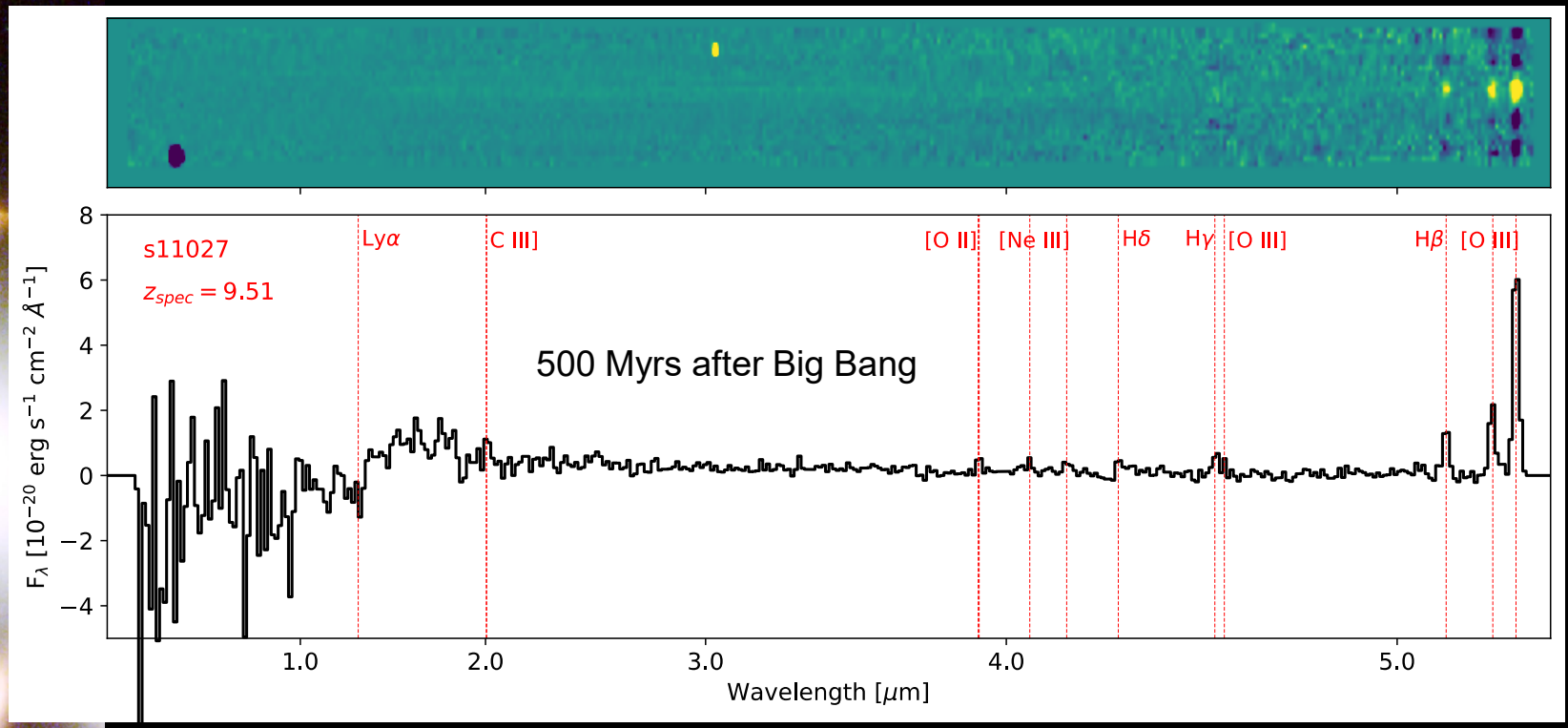
JWST confirmation: faint galaxy at Z=9.79





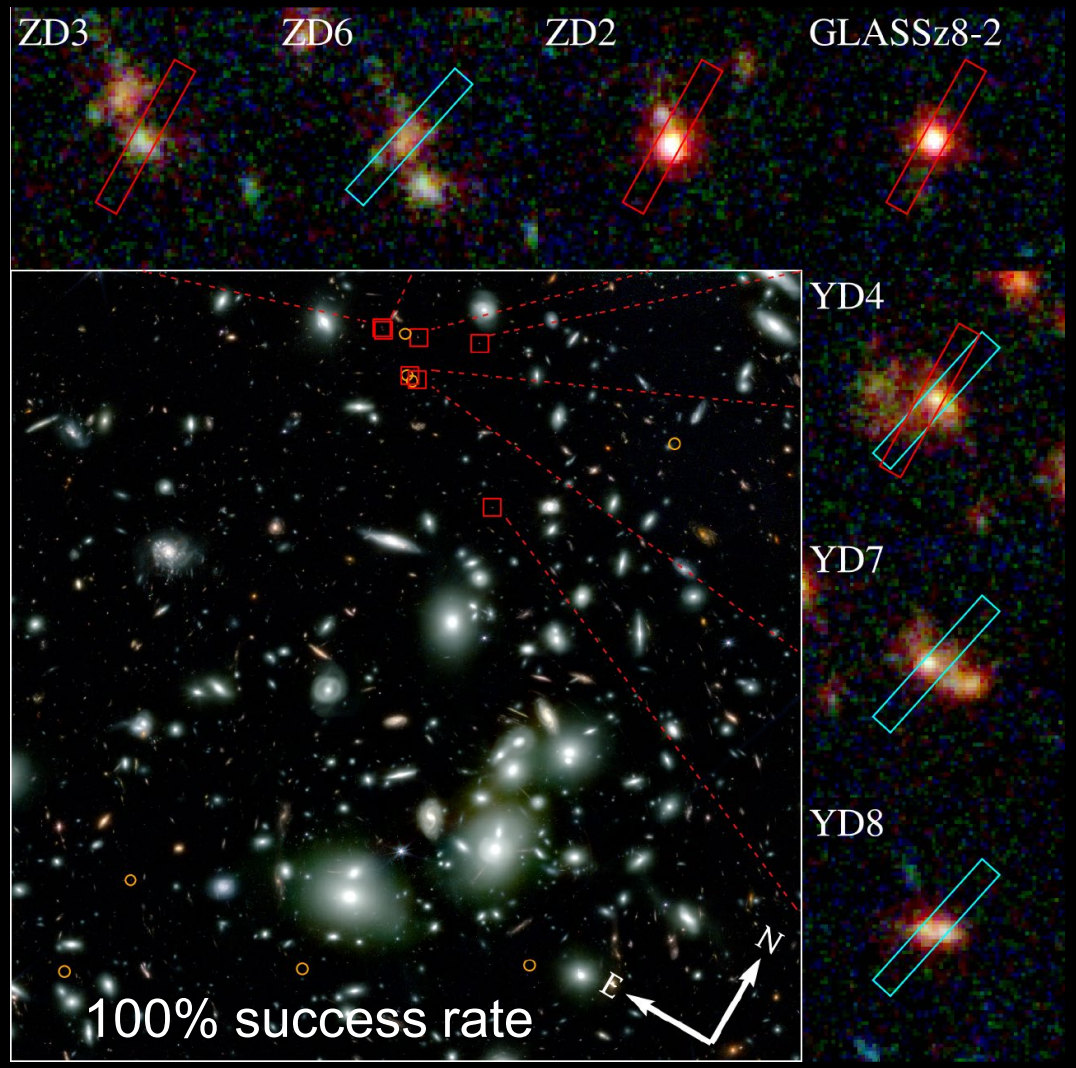
JWST confirmation: faint galaxy at Z=9.51

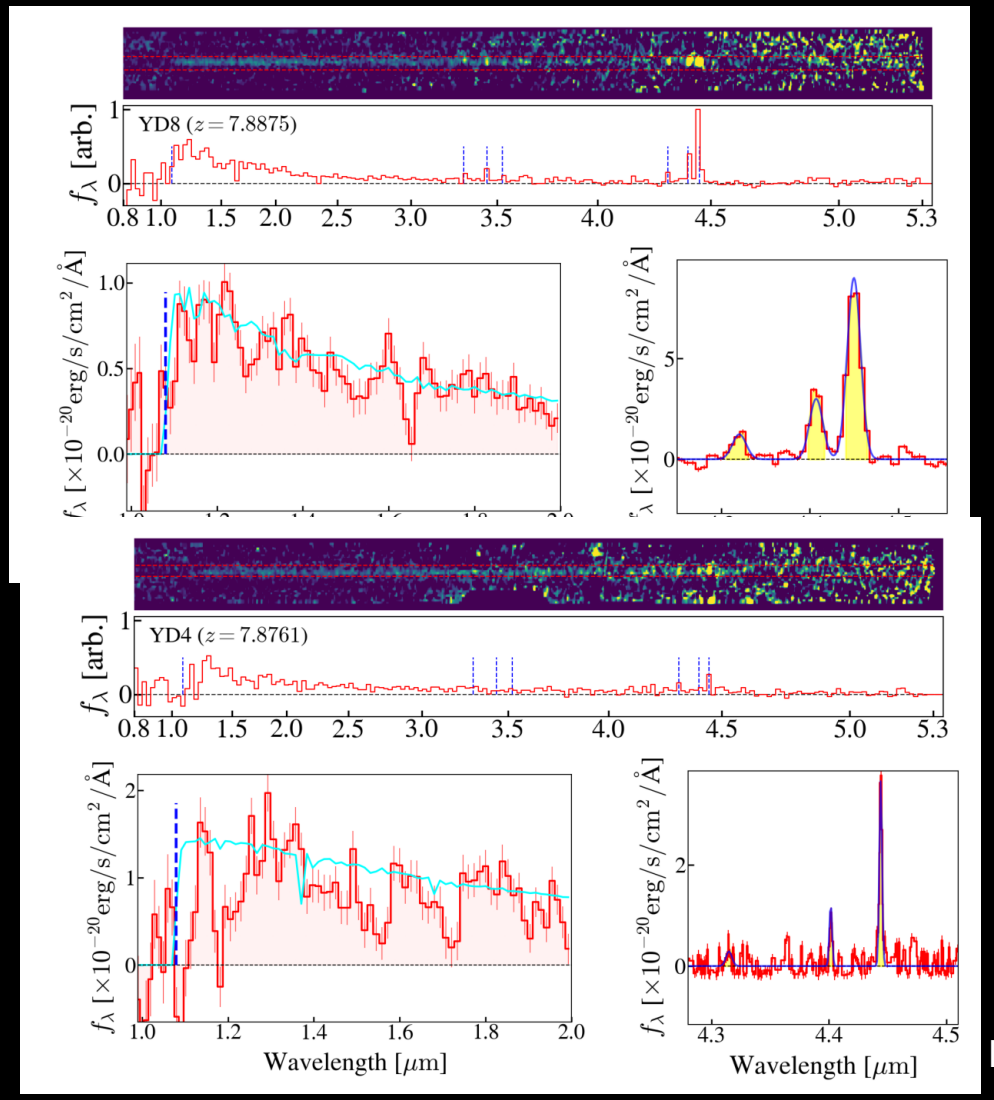




Williams et al. 2023, Science, in press

JWST confirmation: protocluster at z=7.9

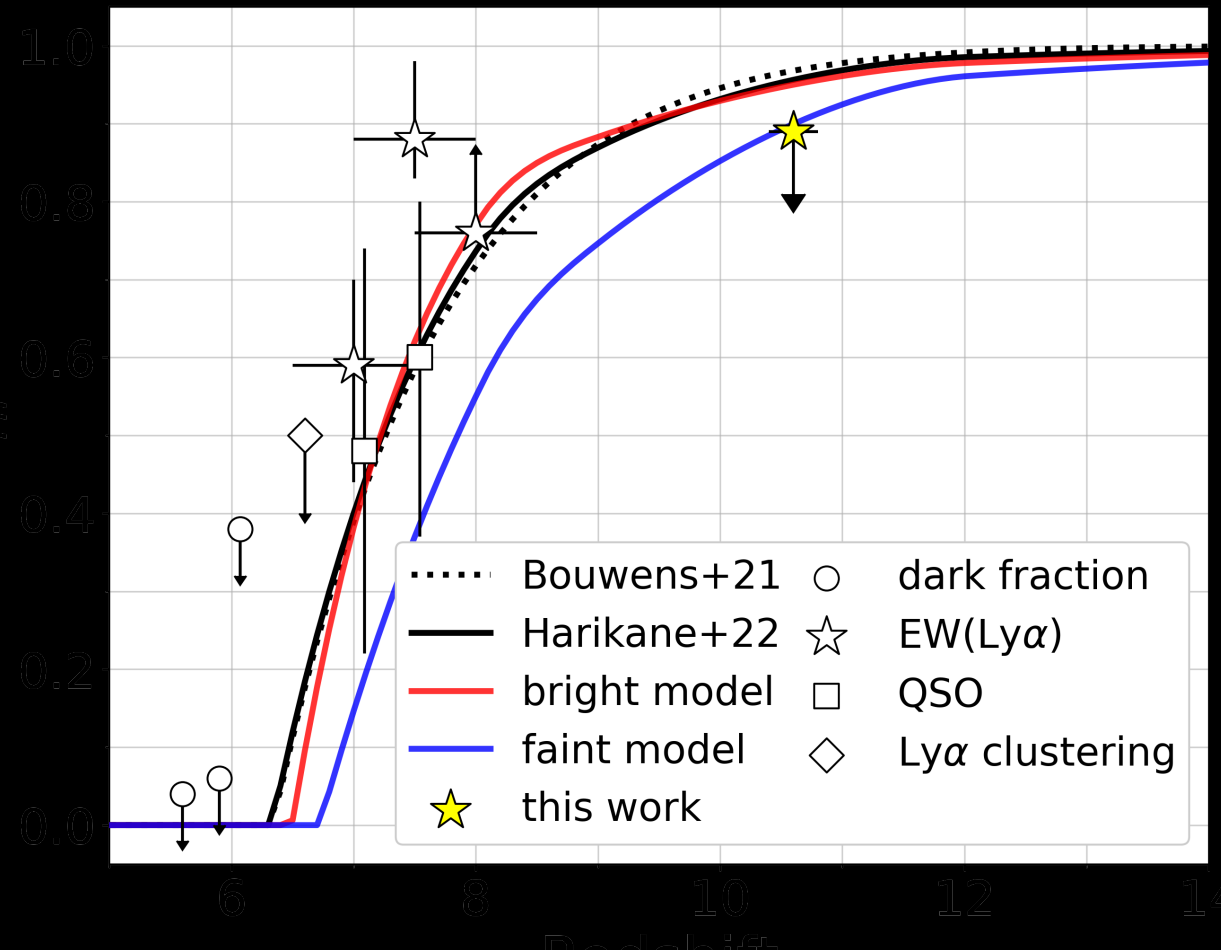




Morishita et al. 2023

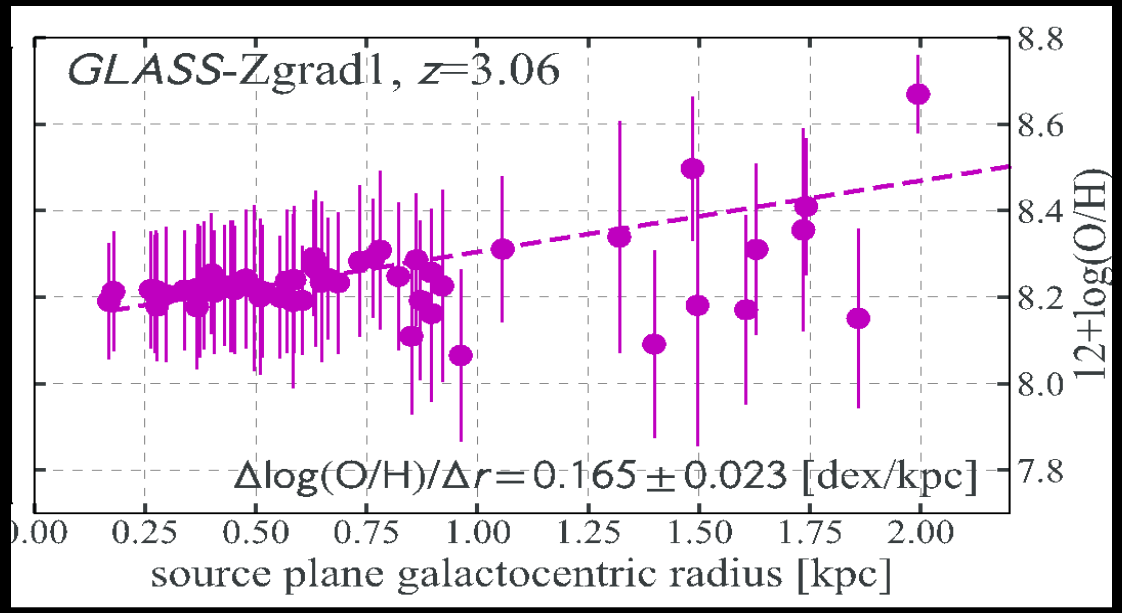
A Bubbly Universe?

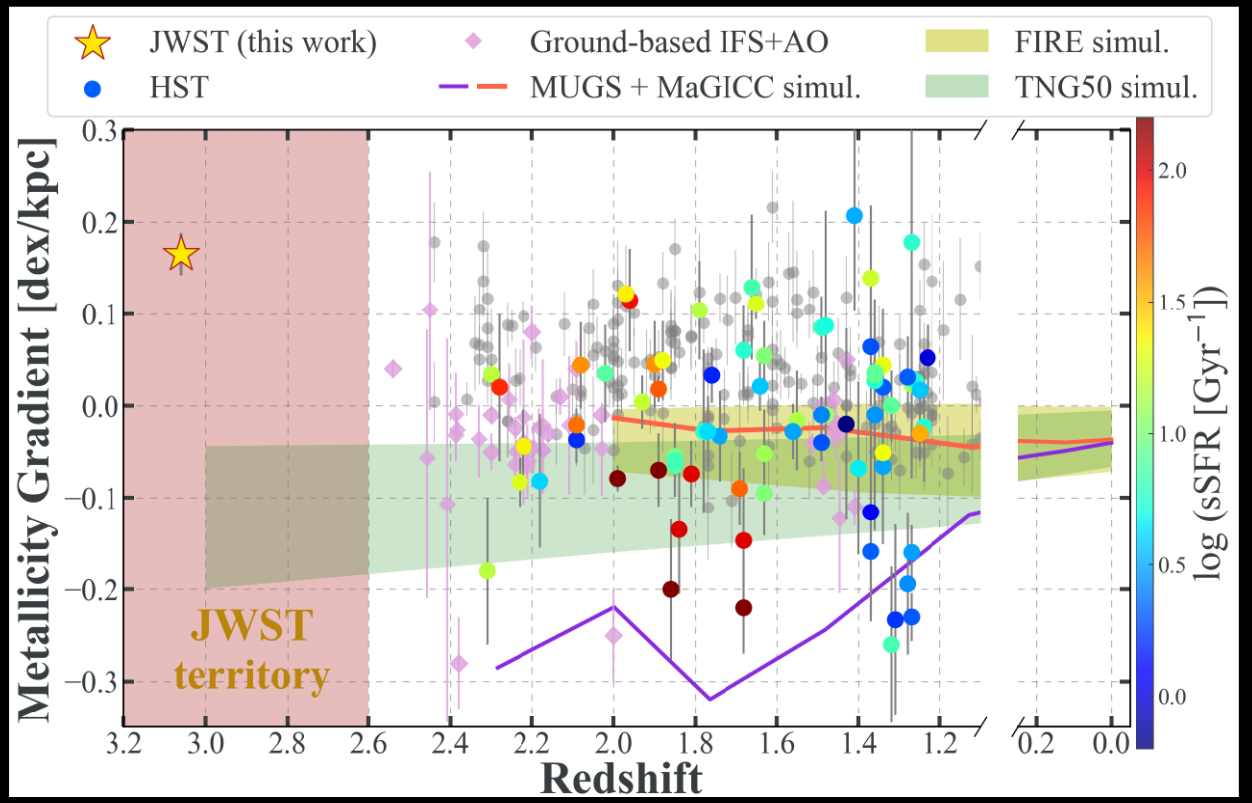
- No Lya detected in protocluster at z=8 (Morisihita et al. 2023)
- Lya detected in very bright galaxy at z=10.6 (Bunker et al. 2023)
- What determines where bubbles arise?



Bruton et al. 2023; based on Bunker et al. 2023

The cycle of baryons: turbocharged winds





This is just the first galaxy. Tens more are being analyzed

Wang et al. 2022

Summary

- **We have discovered a new population of galaxies at z>10, when the universe was less than 500Myrs old.**
  - **Galaxies form earlier and faster than we thought**
  - **These bright early galaxies grow through a fast galaxy-scale starburst, converting gas into stars as fast as they can, with very little dust**
- **We have started to identify spectroscopically the sources of reionization**
- **Work is under way to study how they ionize the universe and how they produce and disperse into the universe elements heavier than the ones formed during the Big Bang.**