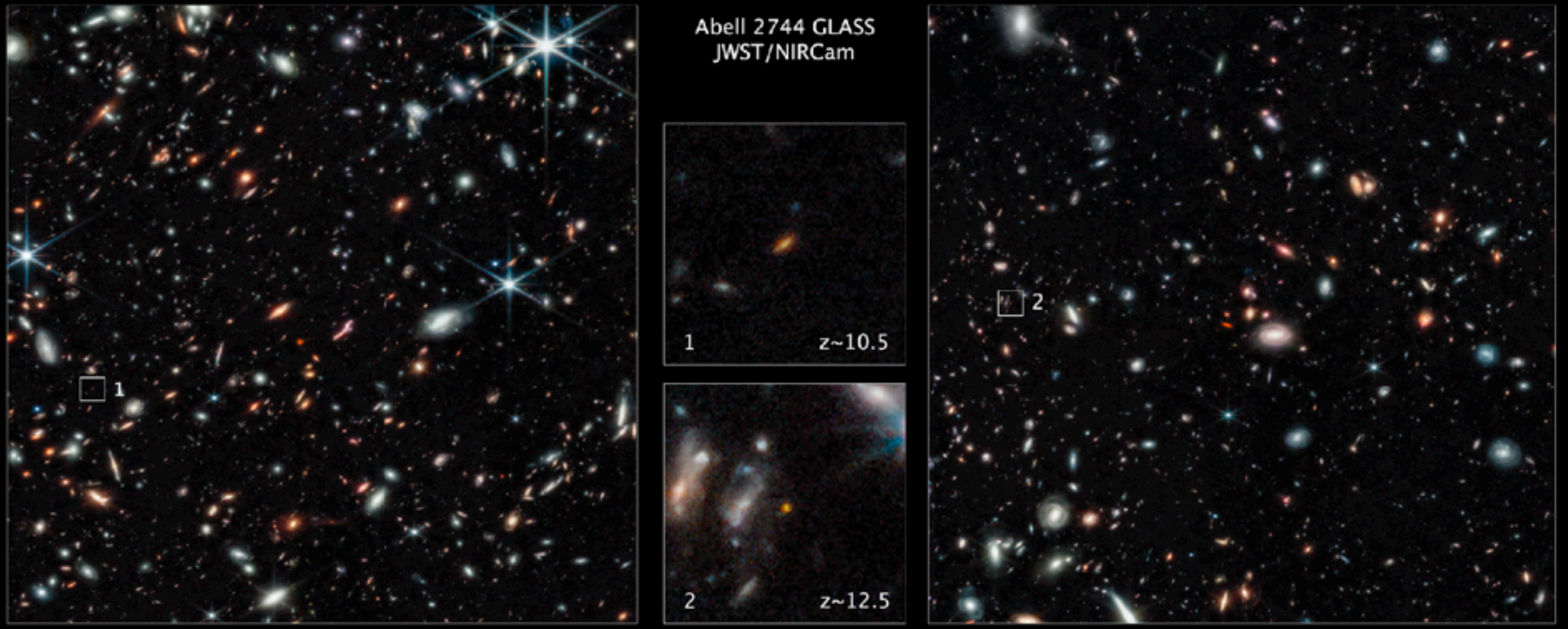
First Galaxies with JWST

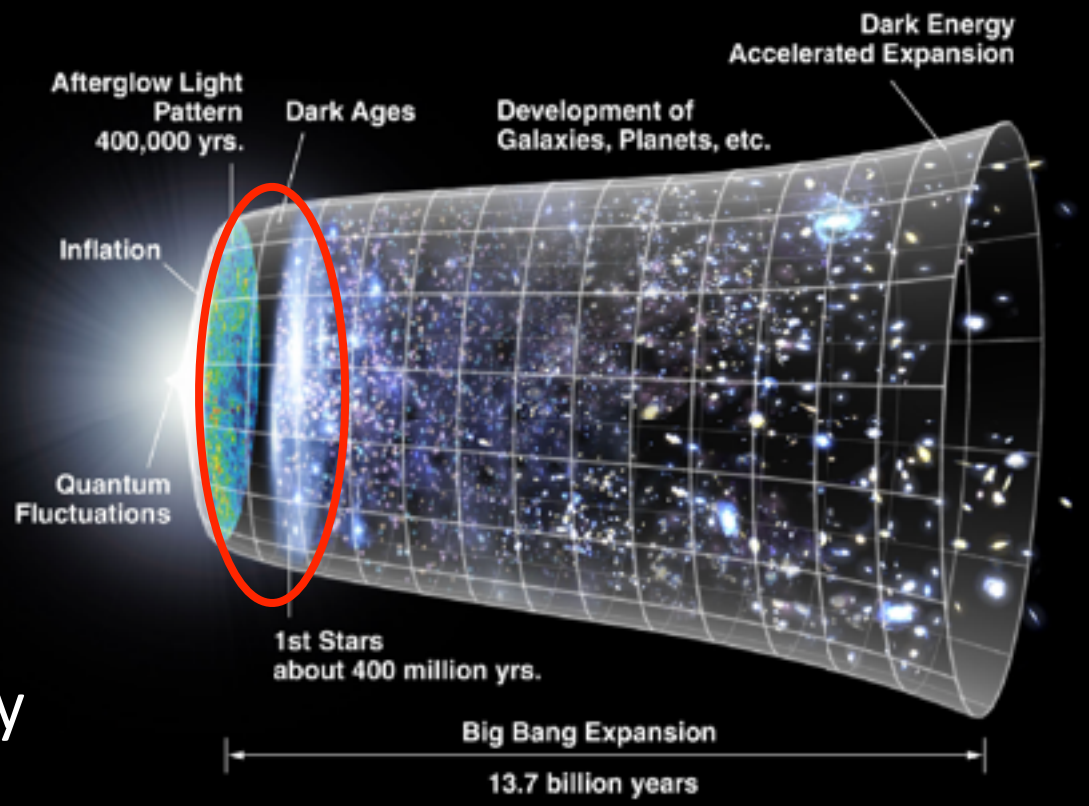


Adriano Fontana
Istituto Nazionale di Astro Fisica

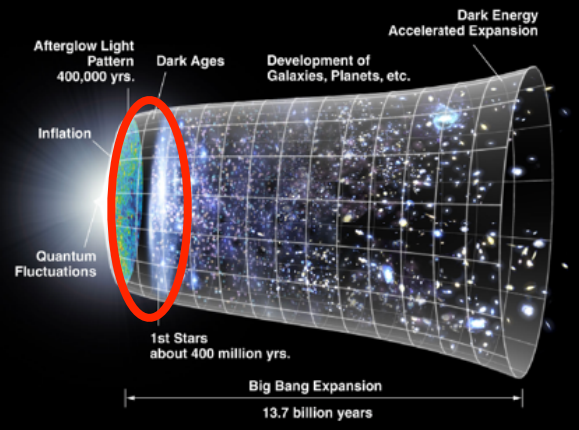
Why is it so interesting to study the high-z Universe?

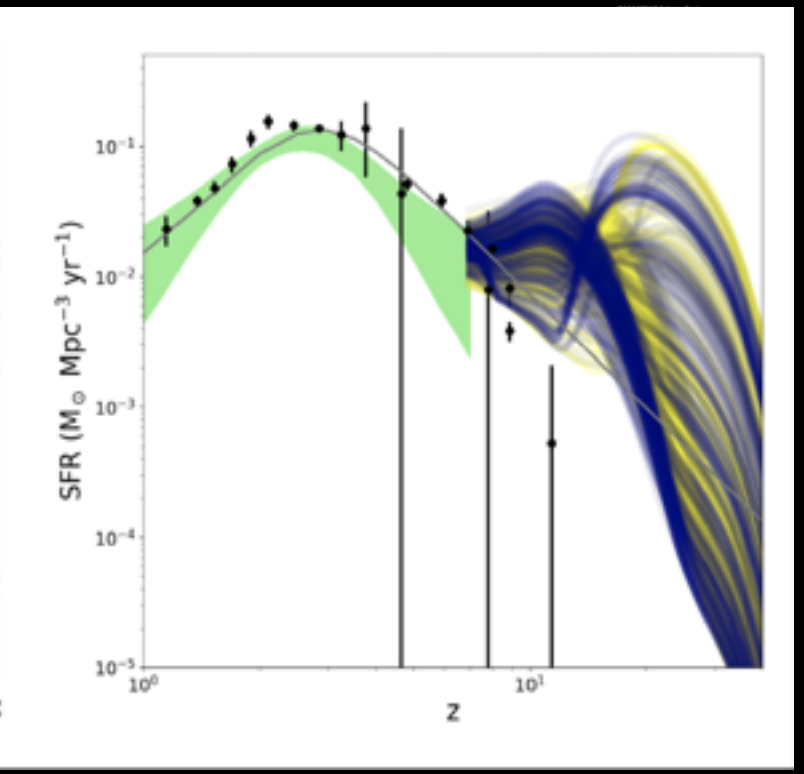
Physical conditions were completely different:

- Universe much denser
- Primordial/Very low metallicity
- “Warmer” CMB
- No UVB
- Density fluctuations much smaller than today



Why is it so interesting to study the high-z Universe?





Cappelluti et al 2021

There is room to show evidence of *"New Physics"*

e.g.:

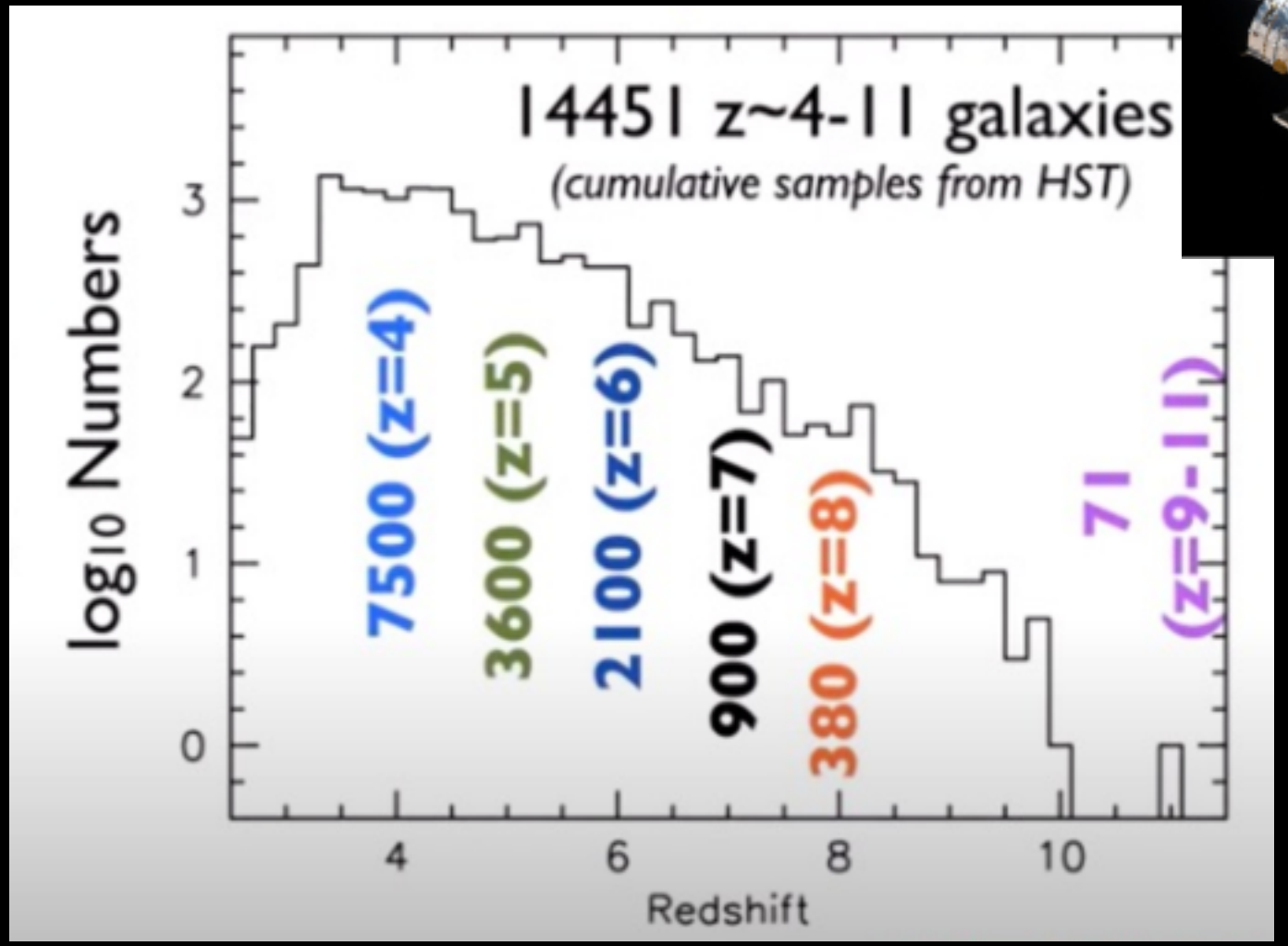
Non-standard Λ-CDM:

- redshift-time relation different? (more time to build structures?)
- WDM? Lower abundance of small structures

New constituents?

- Primordial BH trigger (additional) star-formation

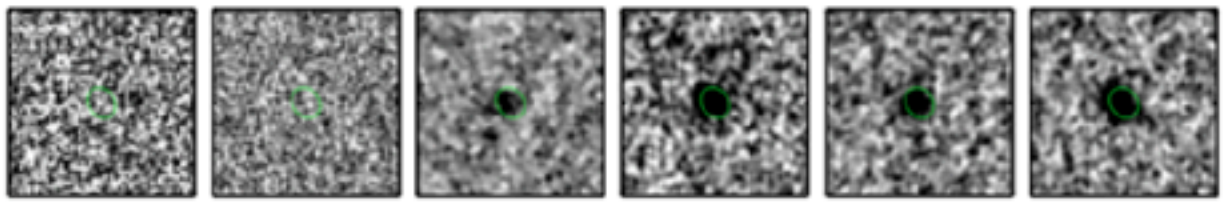
The picture at the end of the HST era…

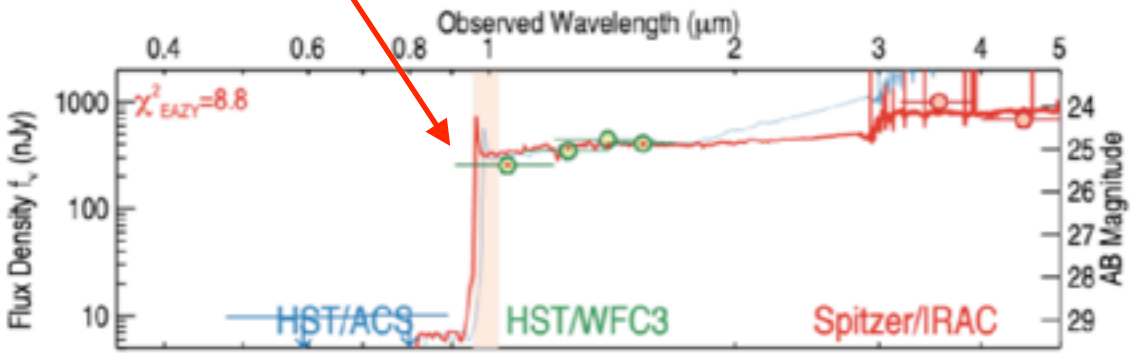


Courtesy of R. Bouwens, R. Ellis

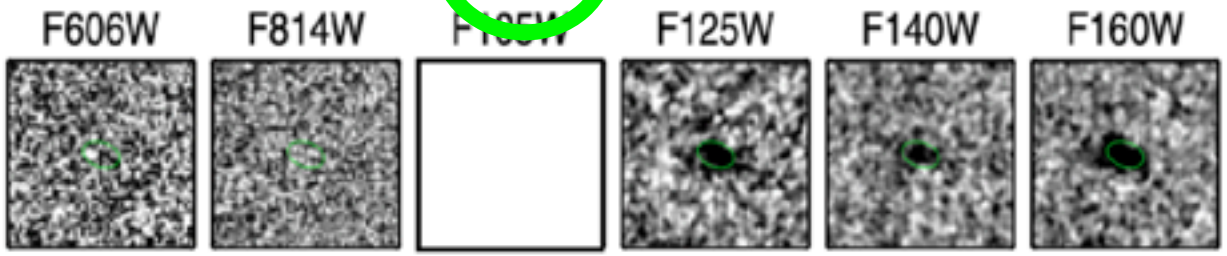
Lyman α (121.567nm) —> 1.2μm @z=9

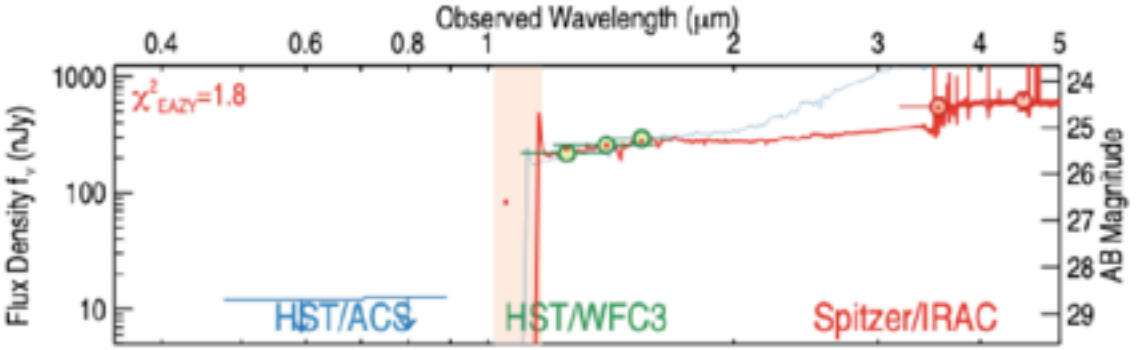
ID=13433, m=25, z=6.9



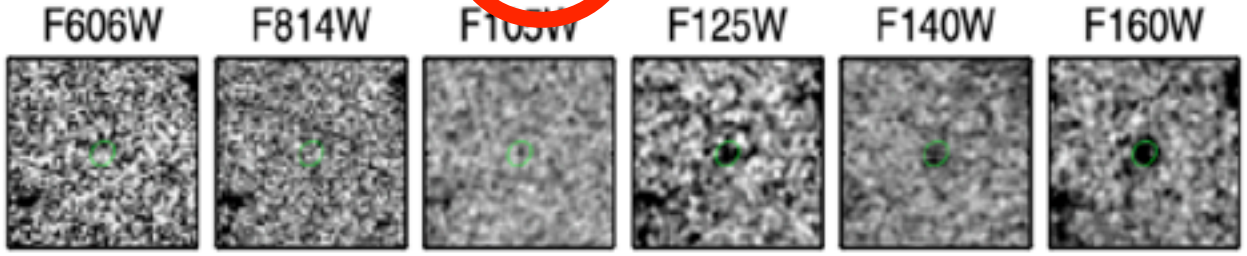


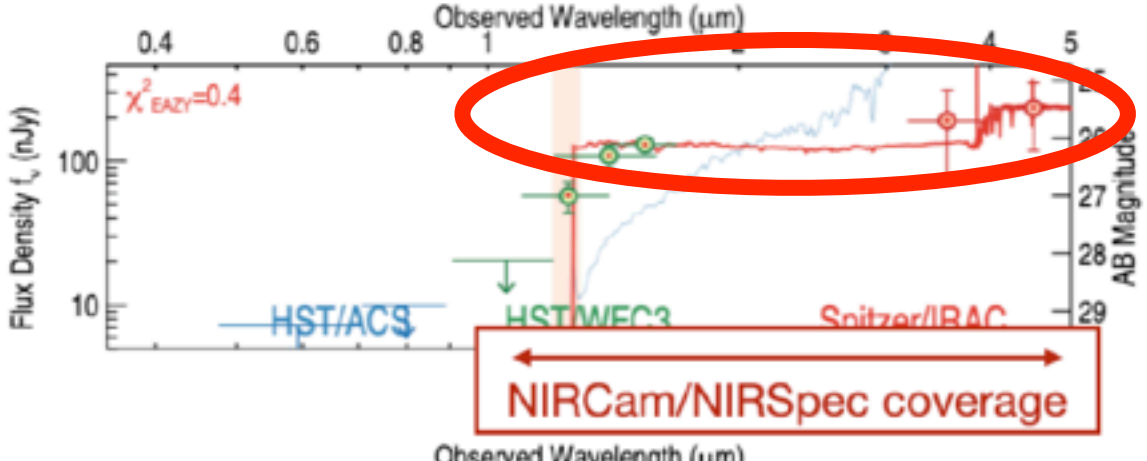
ID=7364, m=25.2, z=8.4





ID=26816, m=26.1, z=9.4

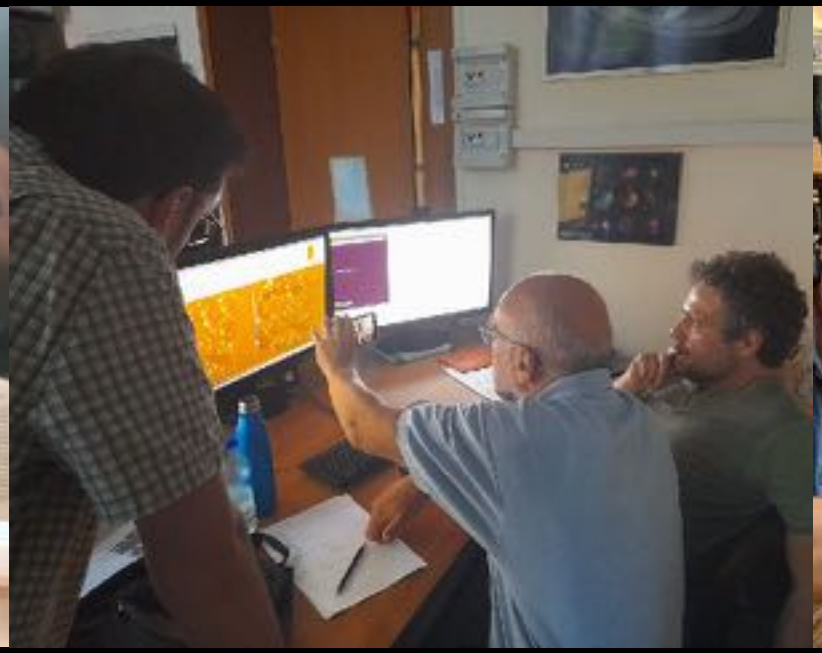




ID=26890, m=26.1, z=9.0

On July 14, the first JWST *raw* data were made public…!

A number of *public* programs were made available.
Including the data from the *GLASS* program, a US/Italian collaboration.
PI: Tommaso Treu (UCLA)


Marco Castellano, Emiliano Merlin, Diego Paris, Paola Santini,
Antonello Calabrò, Sara Mascia, Laura Pentericci, Eros Vanzella (INAF)
Andrea Correnti, Matteo Correnti, Gianluca Polenta (ASI SSDC)

[Submitted on 19 Jul 2022 (v1), last revised 26 Sep 2022 (this version, v2)]

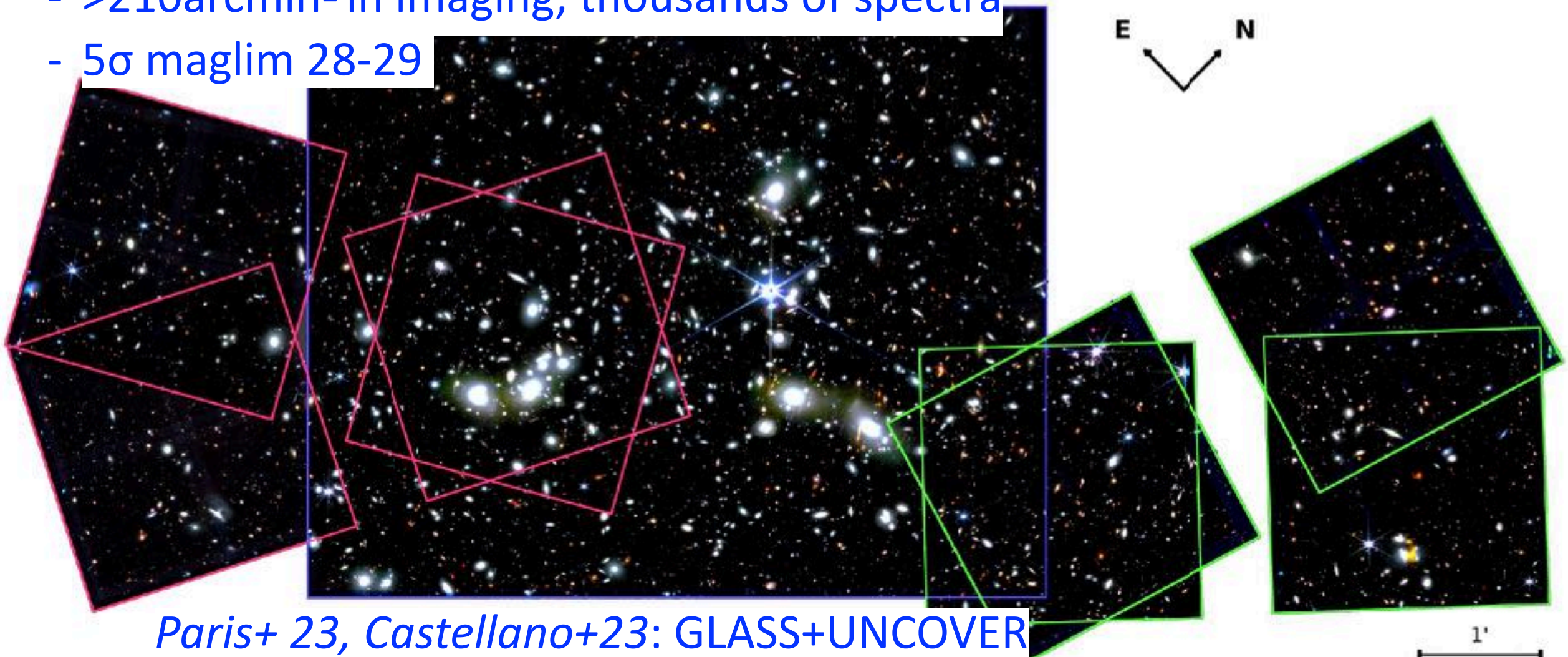
Early results from GLASS-JWST. III: Galaxy candidates at z~9-15

Marco Castellano, Adriano Fontana, Tommaso Treu, Paola Santini, Emiliano Merlin, Nicha Leethochawalit, Michele Trenti, Uros Mestric, Eros Vanzella,

GLASS Deep Field: the *deepest* field obtained so far with JWST

In only 10 months, a spectacular data set has already been collected:

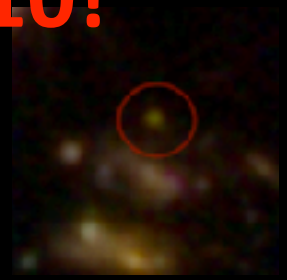
- 12 public deep fields (images and spectra)
- each with at least 7-8 bands + HST data
- >210arcmin^2 in imaging, thousands of spectra
- 5σ maglim 28-29



Paris+ 23, Castellano+23: GLASS+UNCOVER

What did we get?
A lot of surprises!

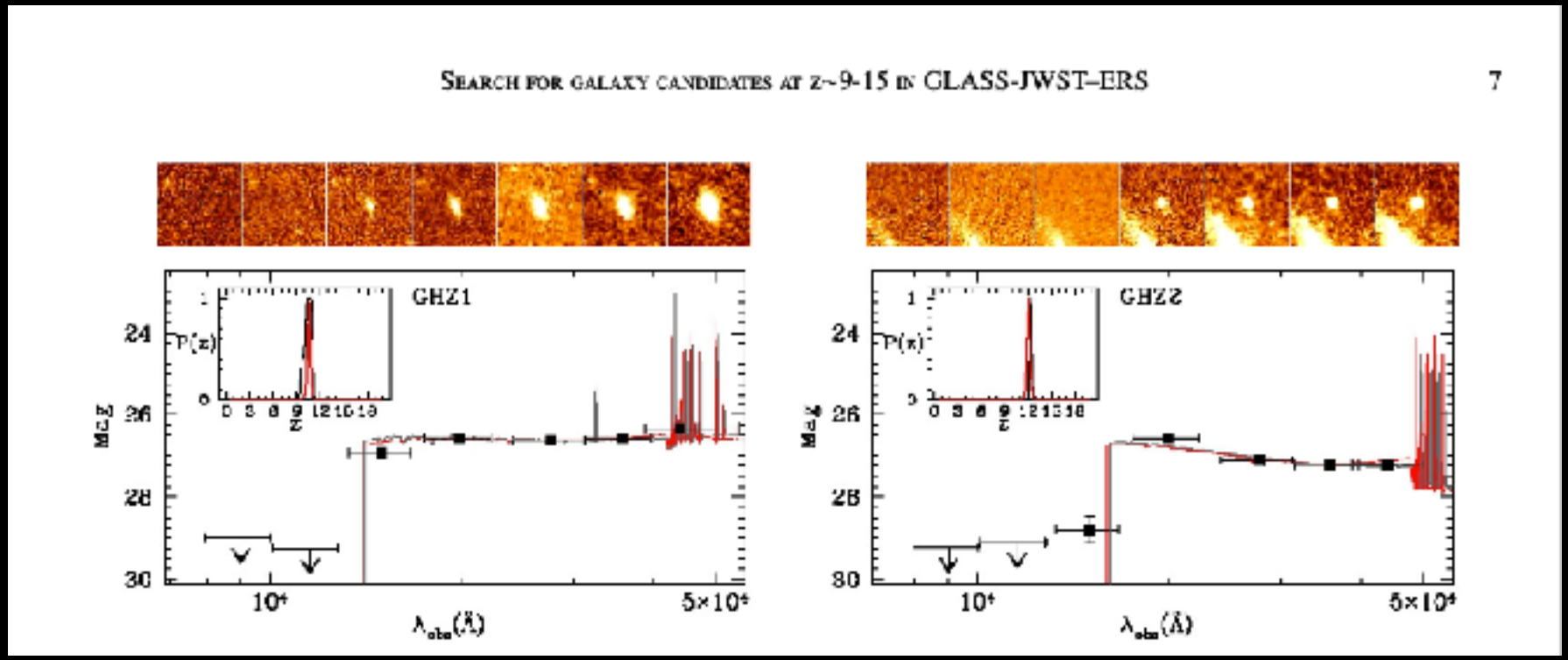
Surprise#1: Too many UV bright galaxies at z>10!



Two bright & robust candidates in GLASS at z=10 and 12…

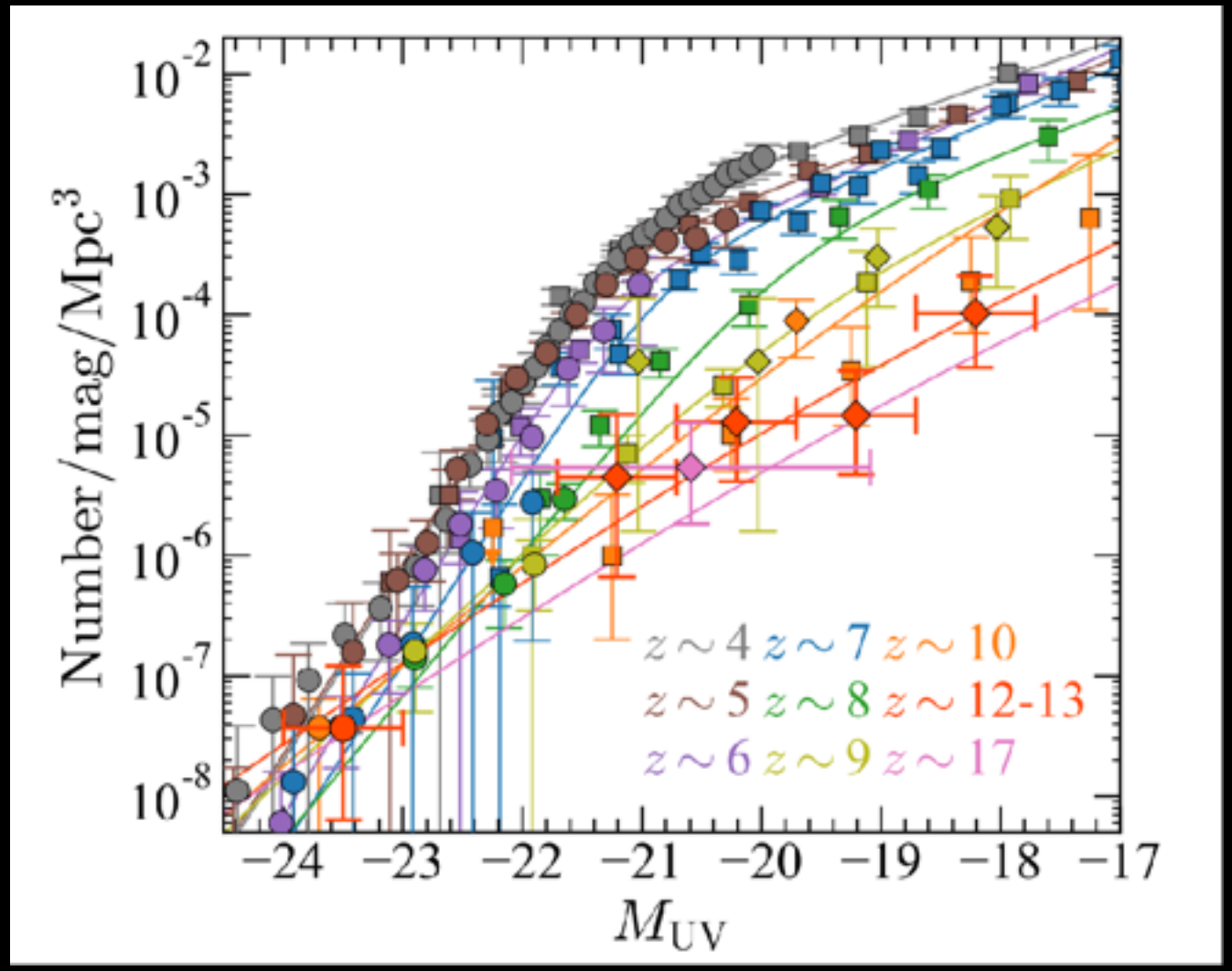
…We were expecting 0.1!

Castellano, AF+22

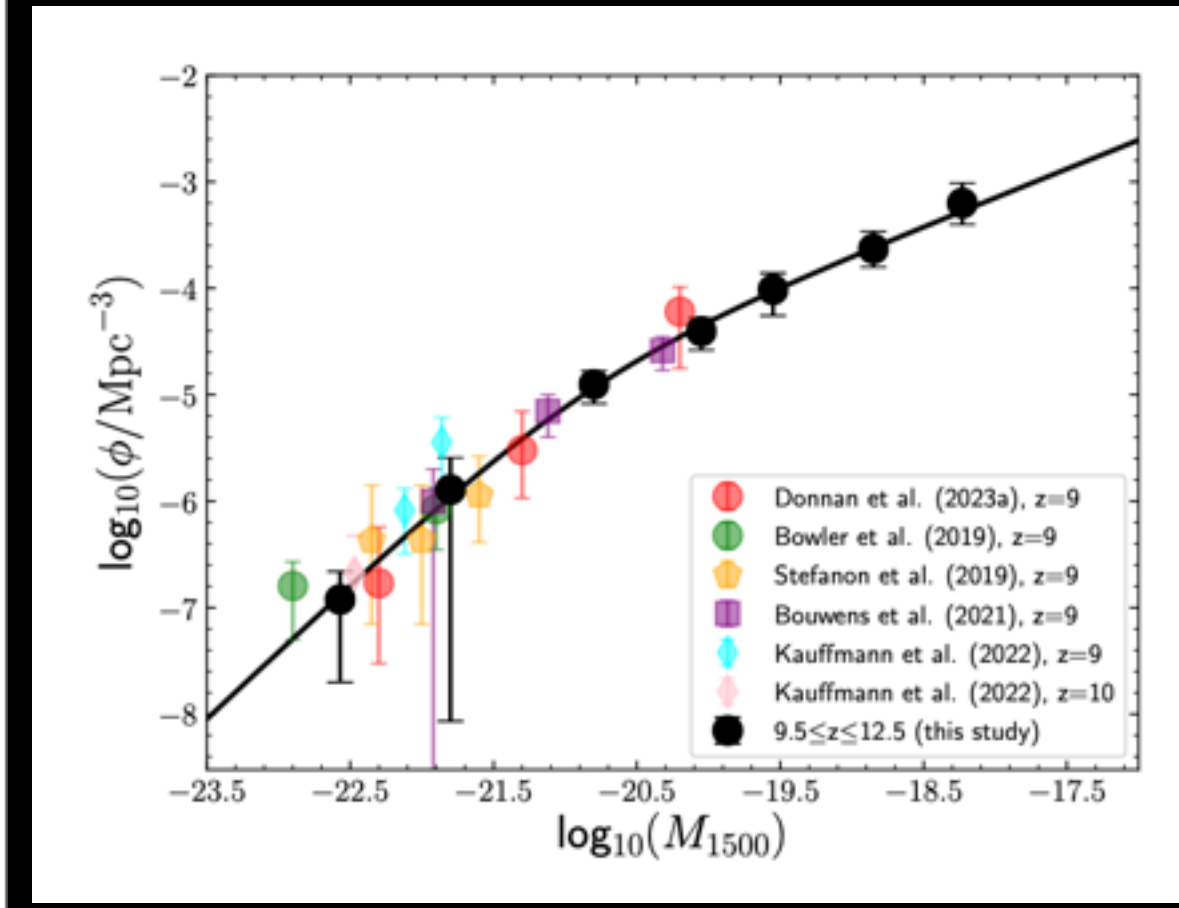


Later on discovered that GLASS is overdense (Castellano+23)

The observed evolution from z~8 to z~12 is marginal, especially for bright galaxies

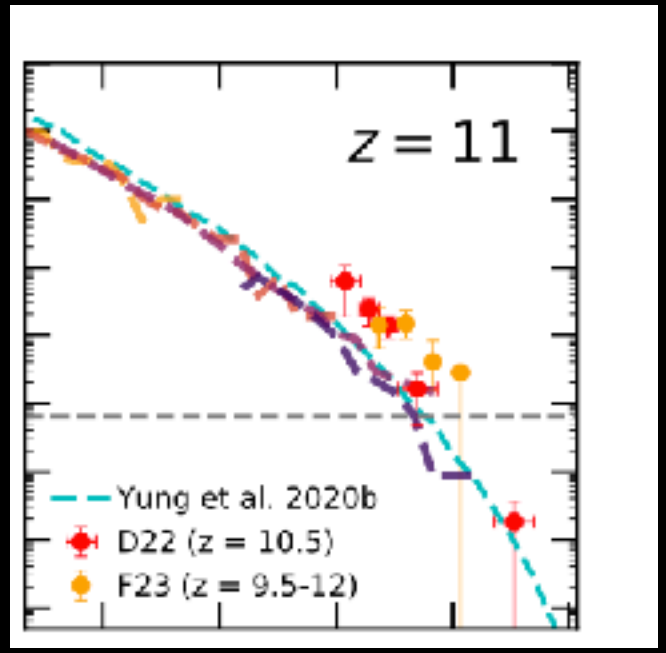


Harikane+22

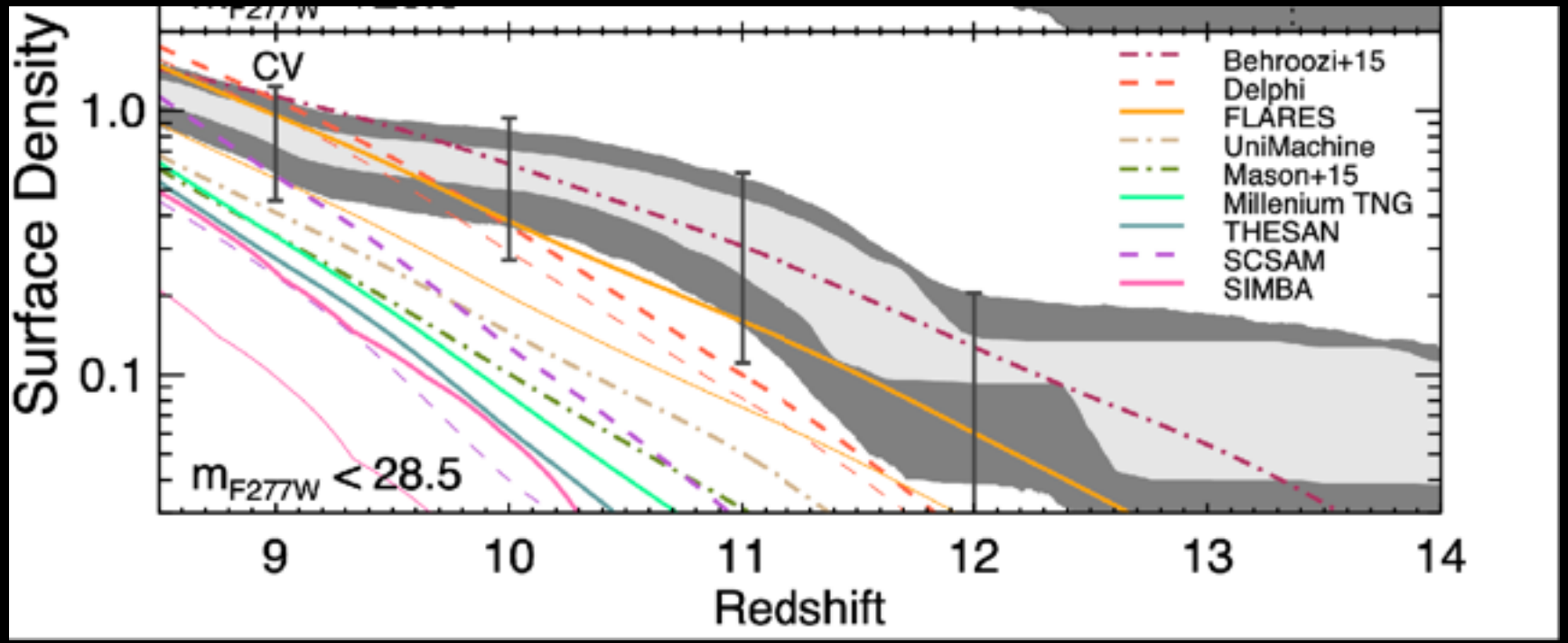


McLeod+23

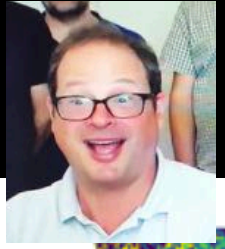
The number of bright galaxies is way larger than predicted by *any* theoretical model



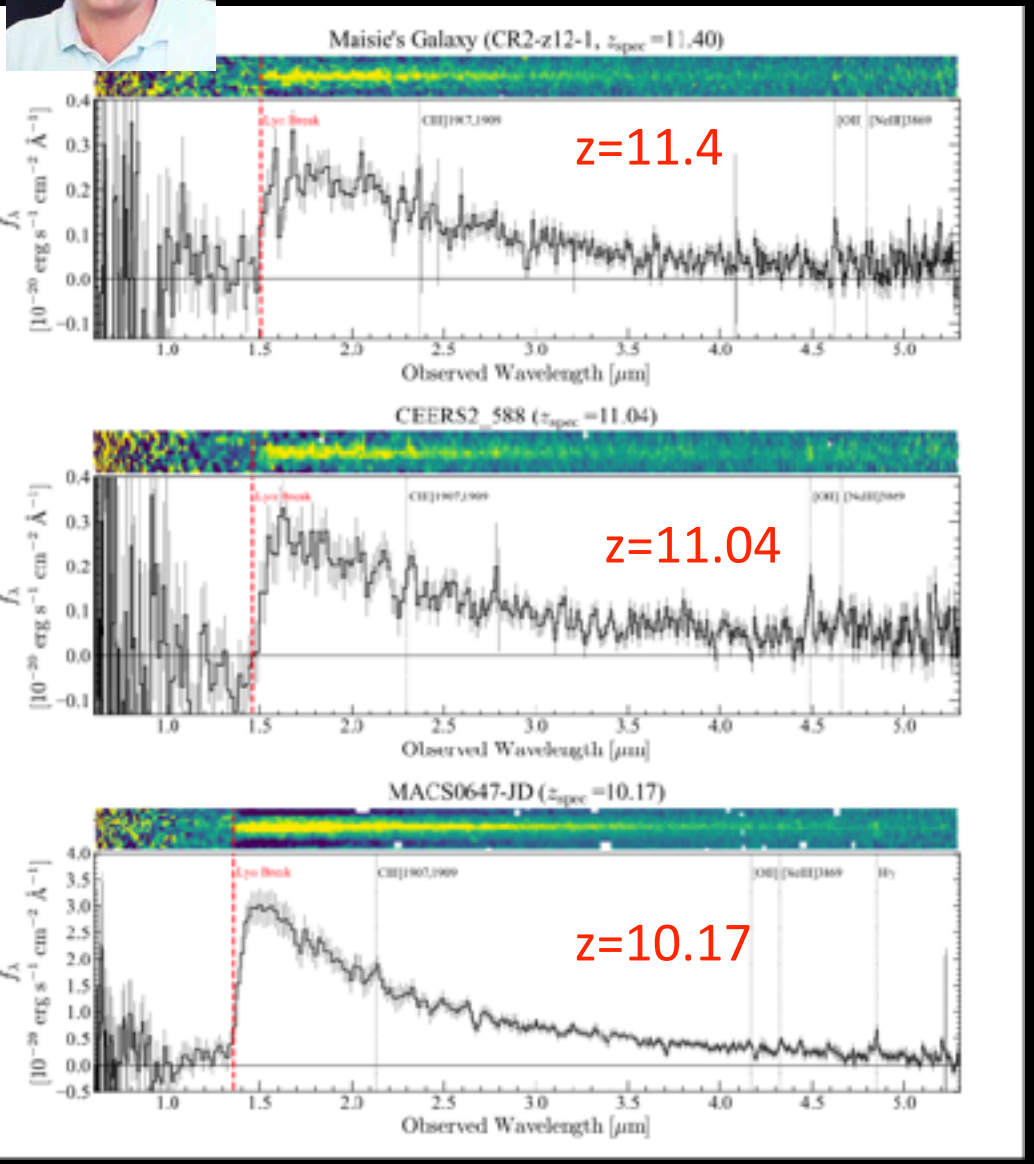
Yung+23, 2304.04348



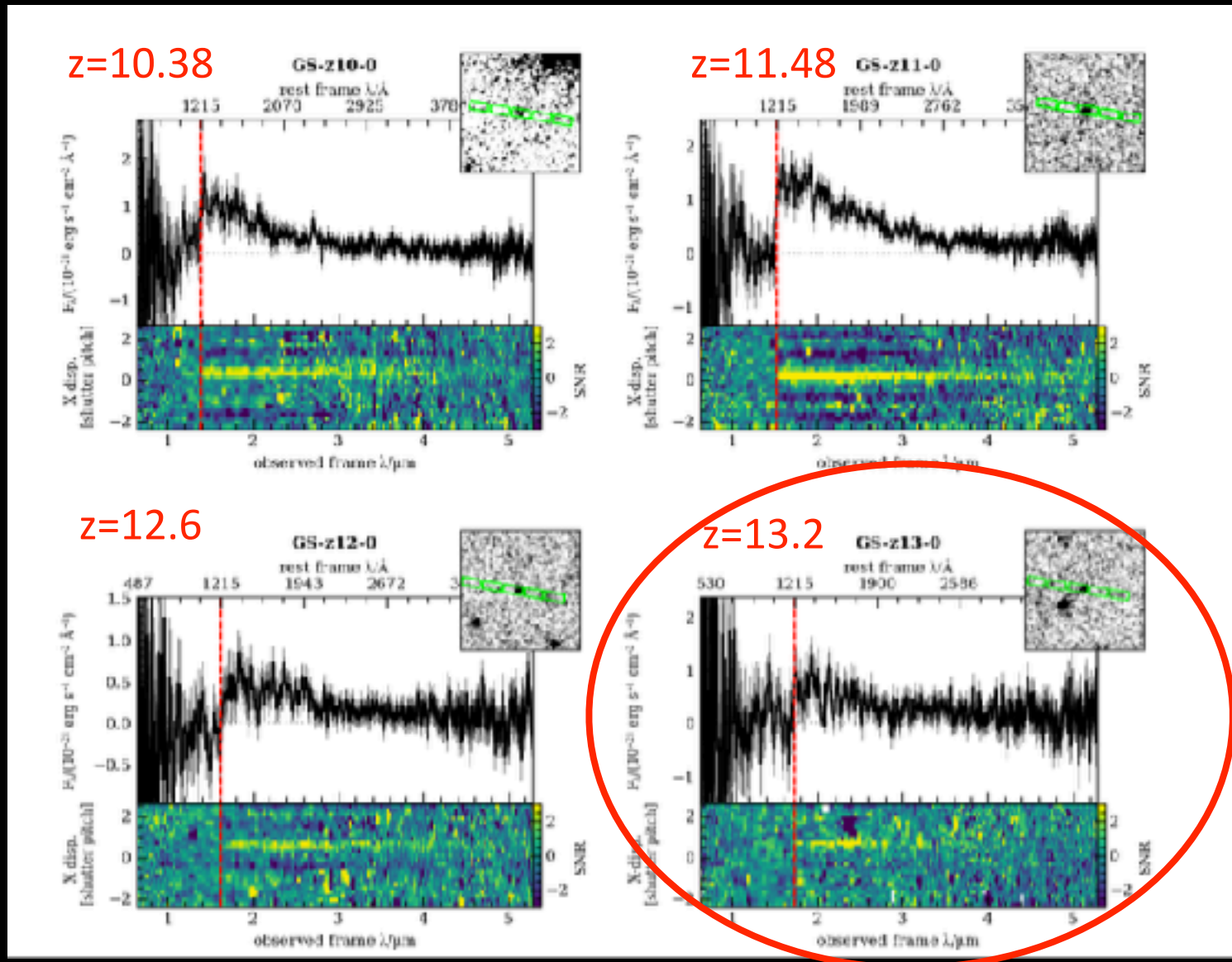
Finkelstein+23
also Mason+23



Surprise#2: We can get spectra up to z~13!

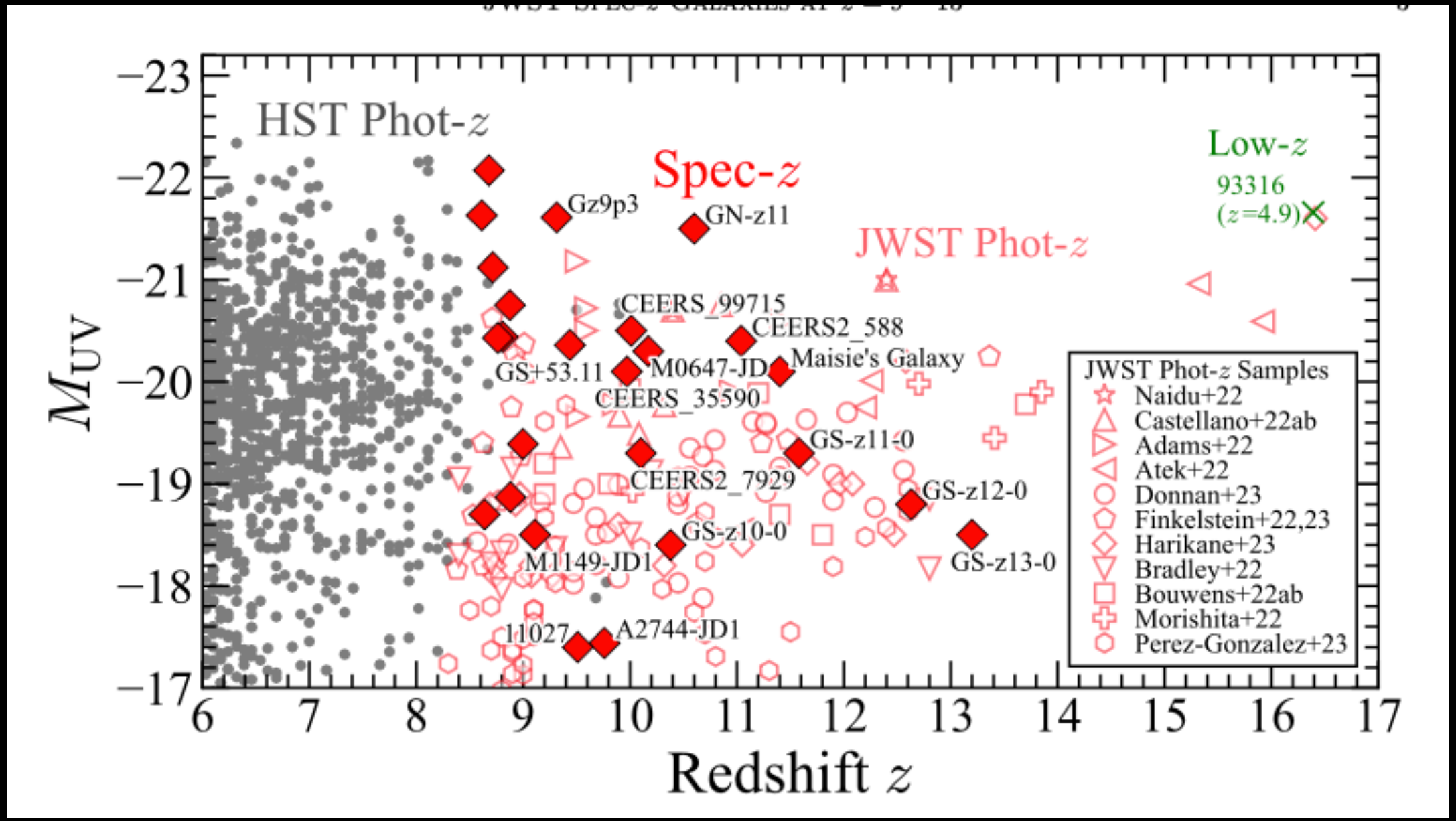


Harikane+23, 2304.06658



Curtis-Lake+23, Nature

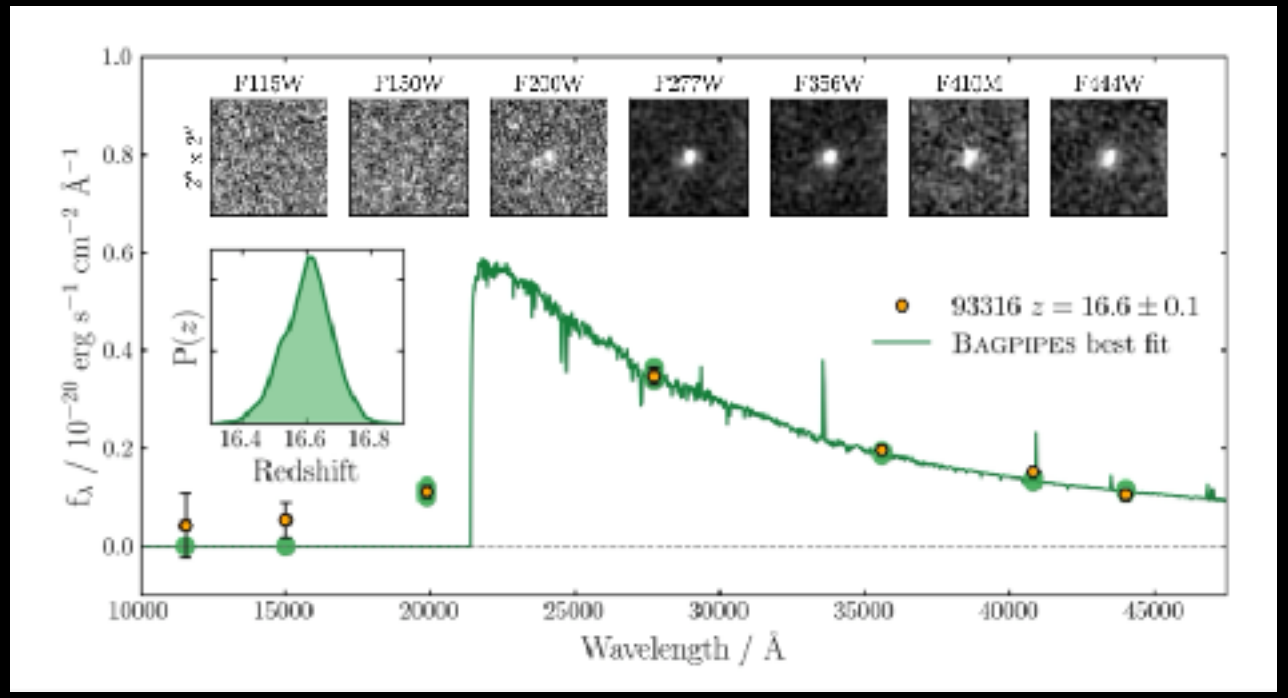
Age of the Universe=0.32Gyr

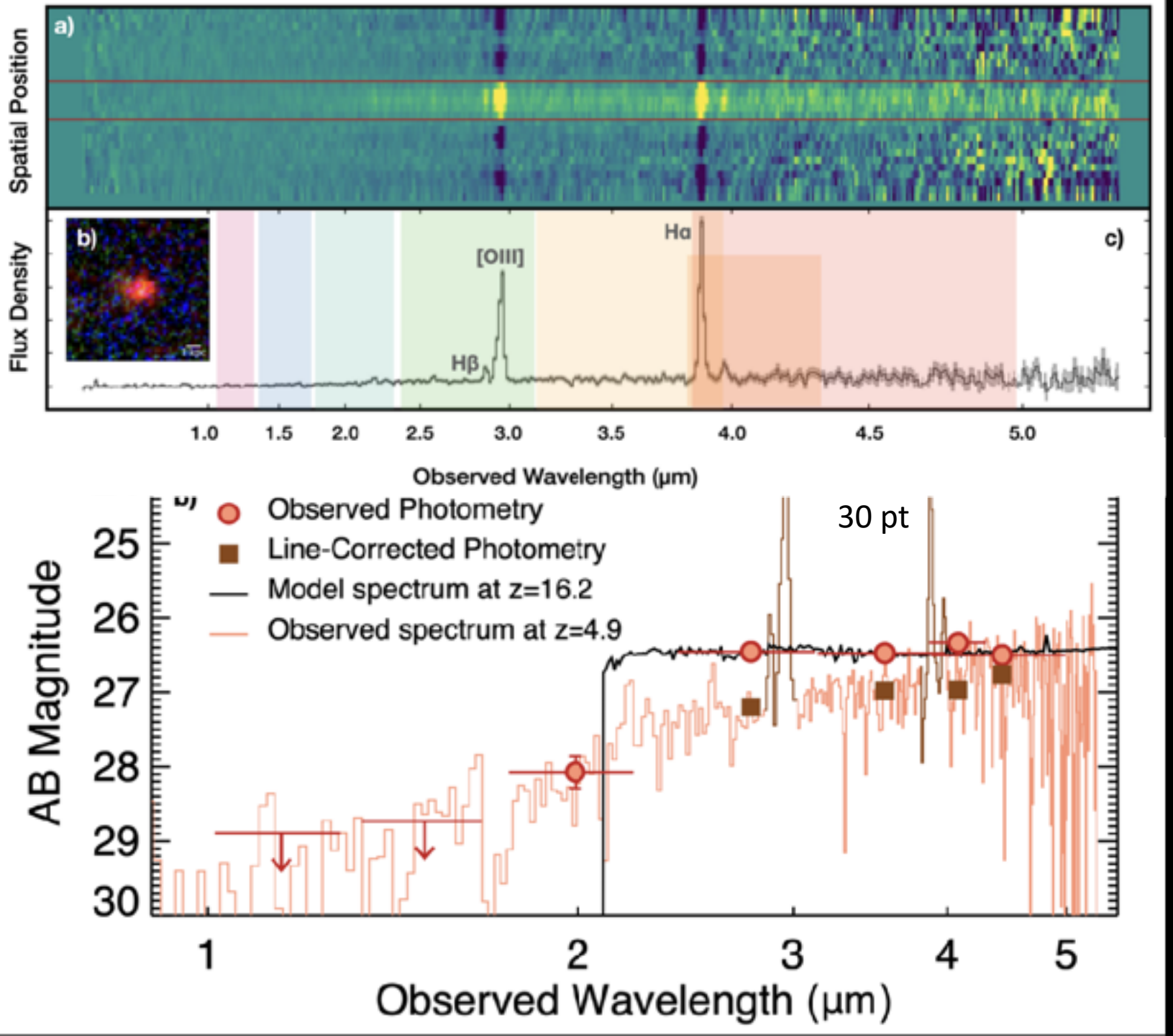


Harikane+23, 2304.06658

Surprise#2b: You can't win them all…

The best z~16 candidate so far…



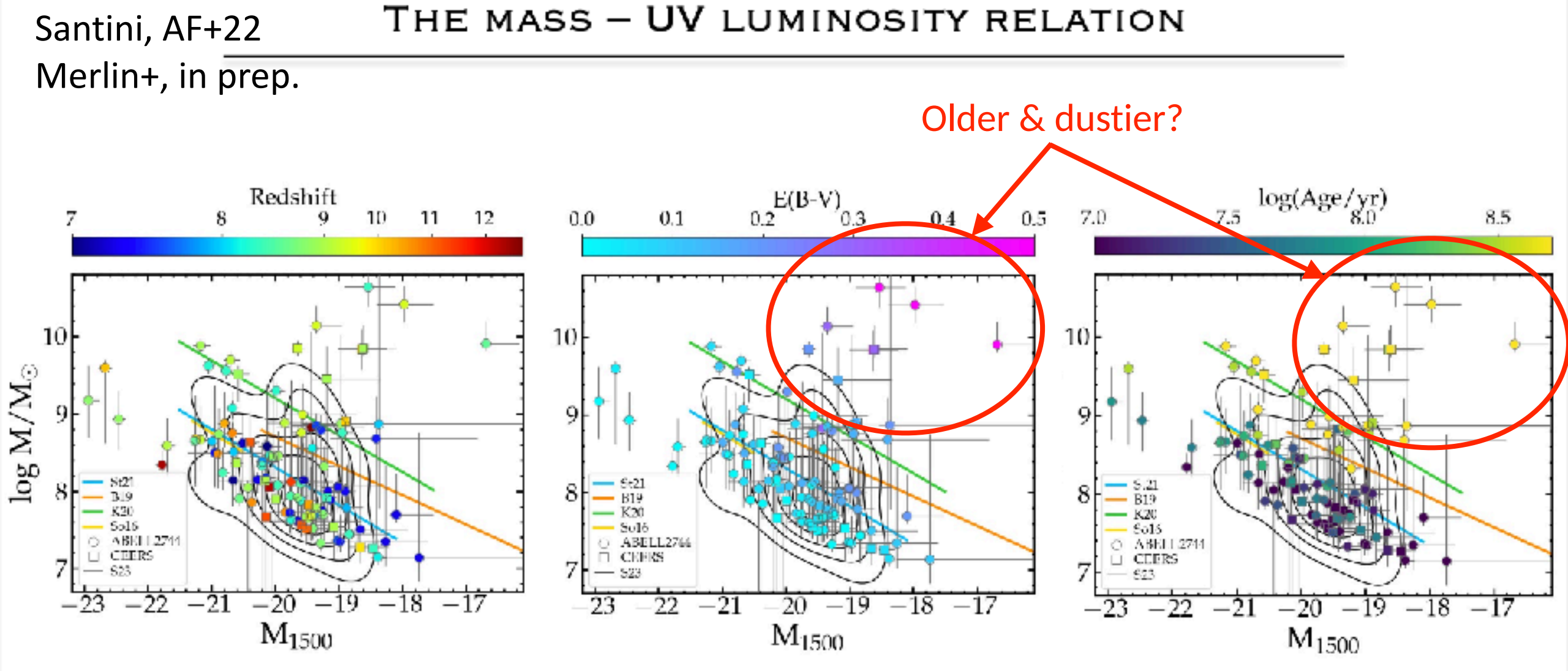


Is actually at z~5.5…

Arrabal-Haro+, 2303.15431

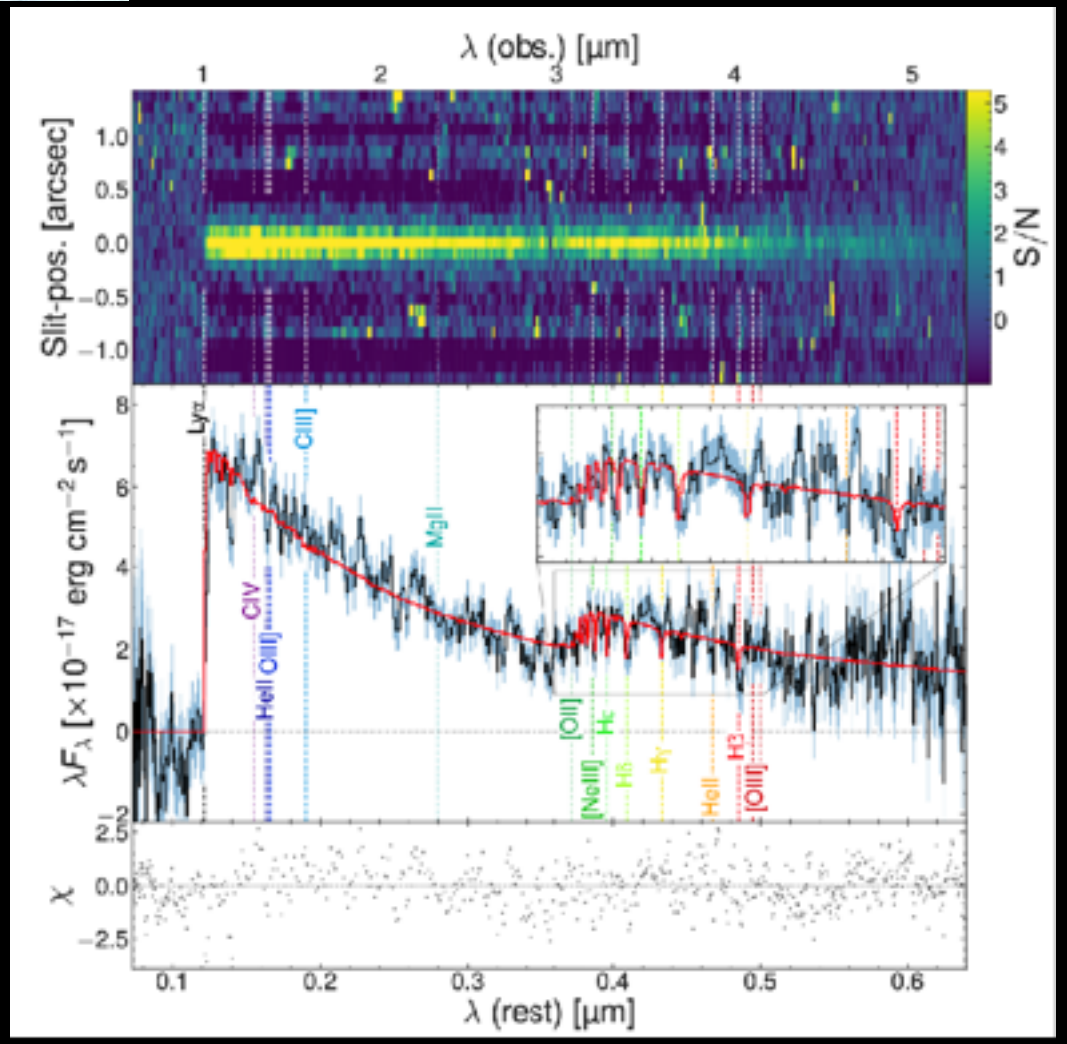
Surprise#3: Galaxies at z>8 come in a variety of flavours.. …indicative of different evolutionary status

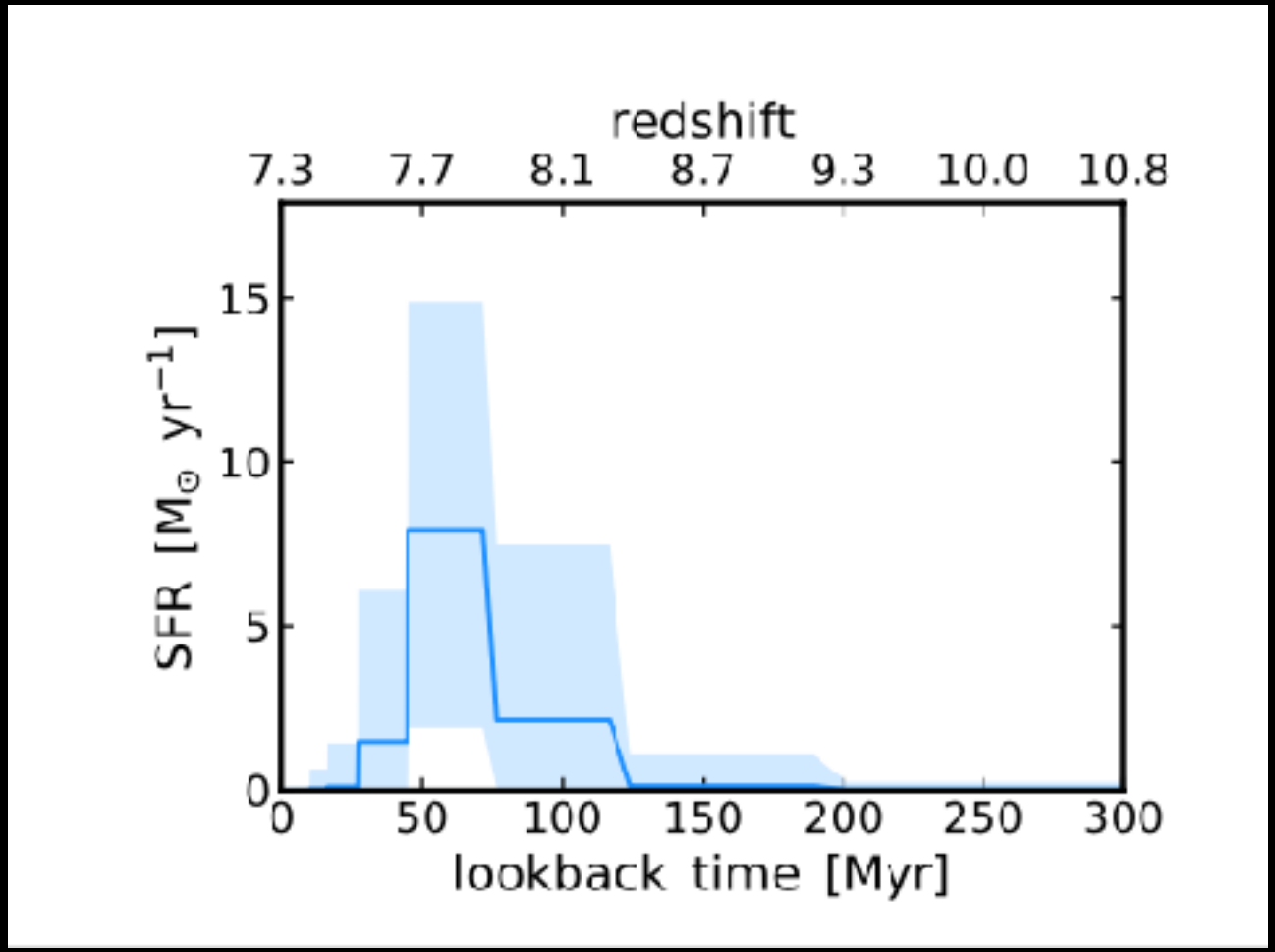
Santini, AF+22
Merlin+, in prep.



Surprise#4: Quiescent galaxies exist even in the first Gyr…

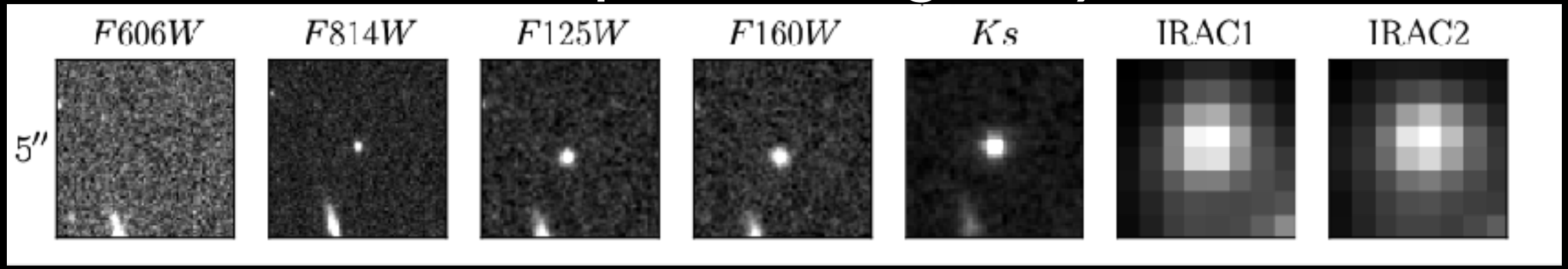
A recently quenched galaxy at z~7.3

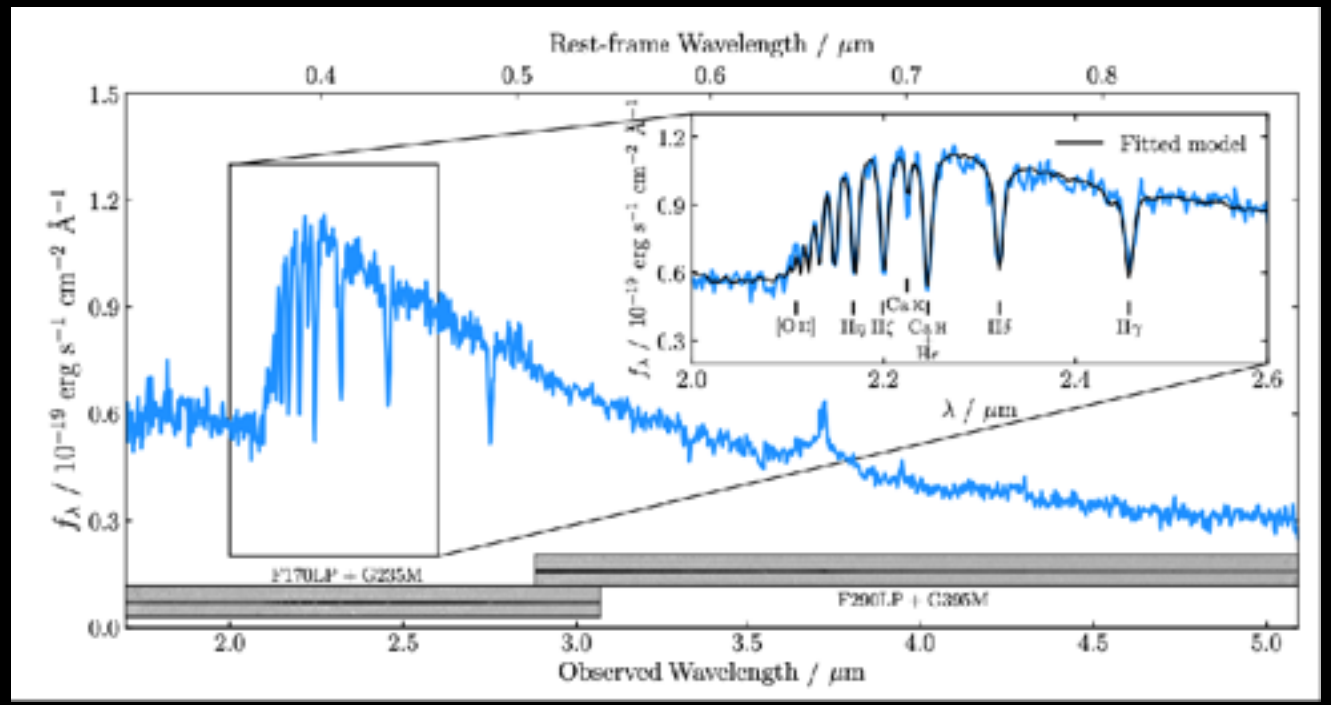


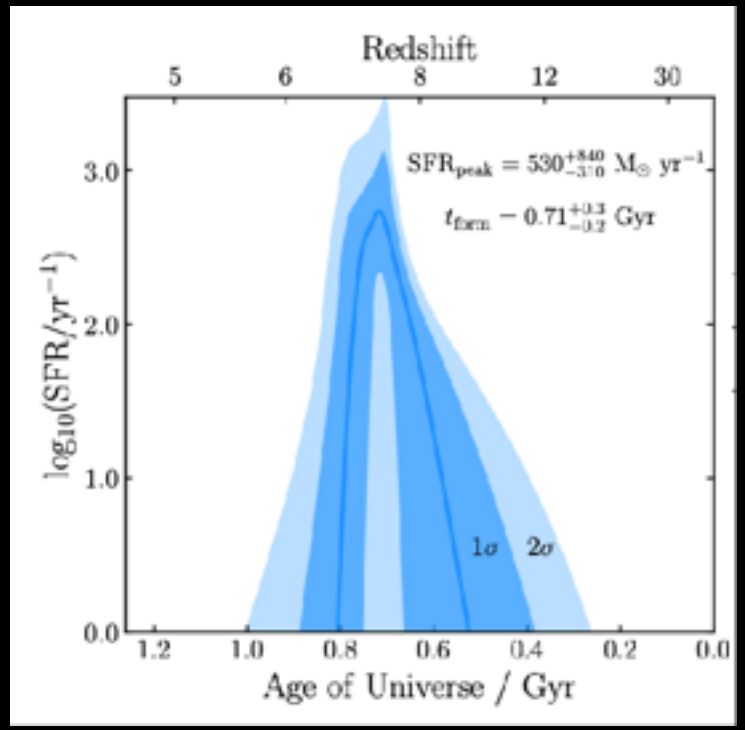


Looser+23, 2302.14155

A massive quiescent galaxy at z=4.7



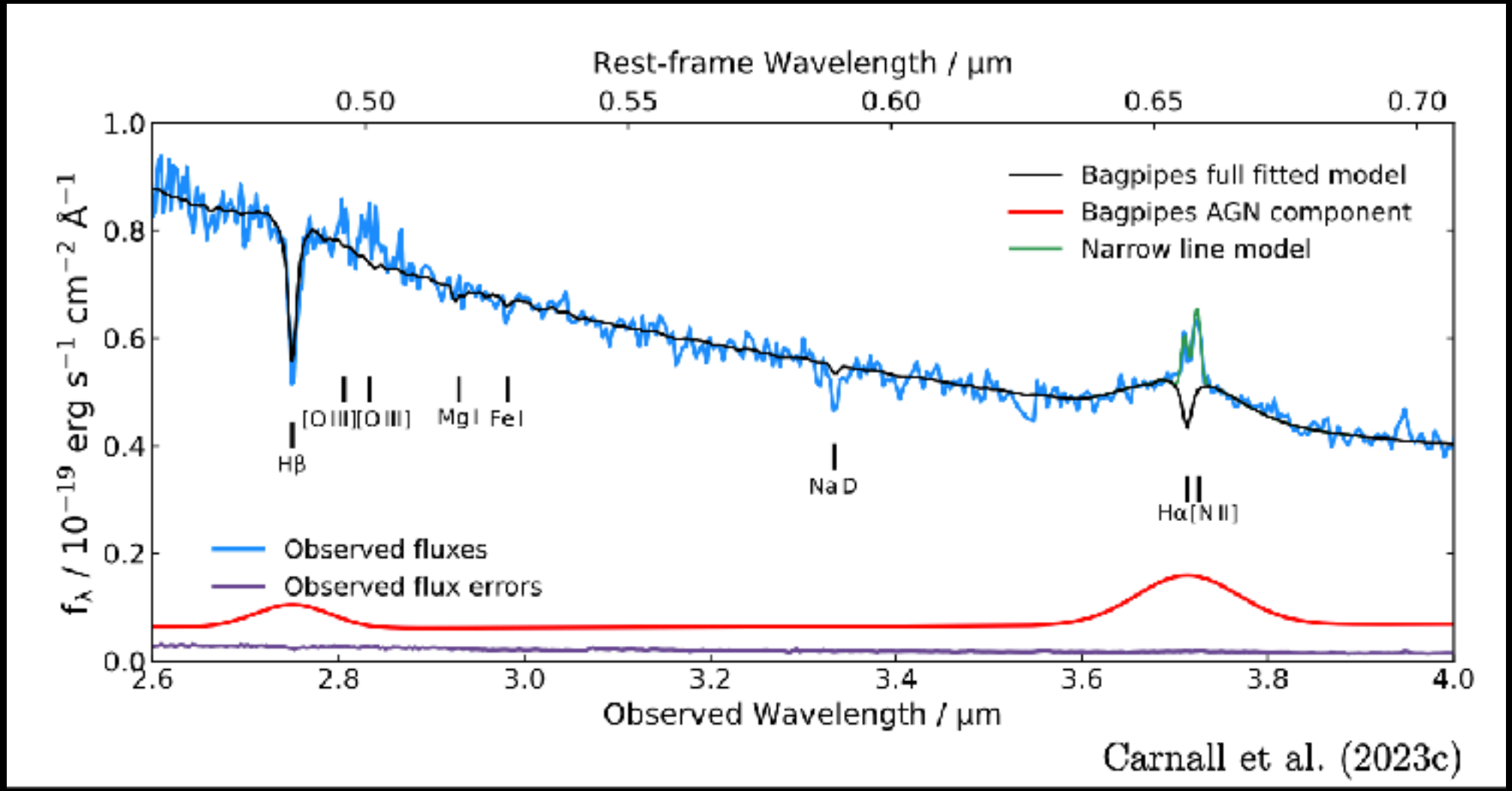




Carnall+2301.11413

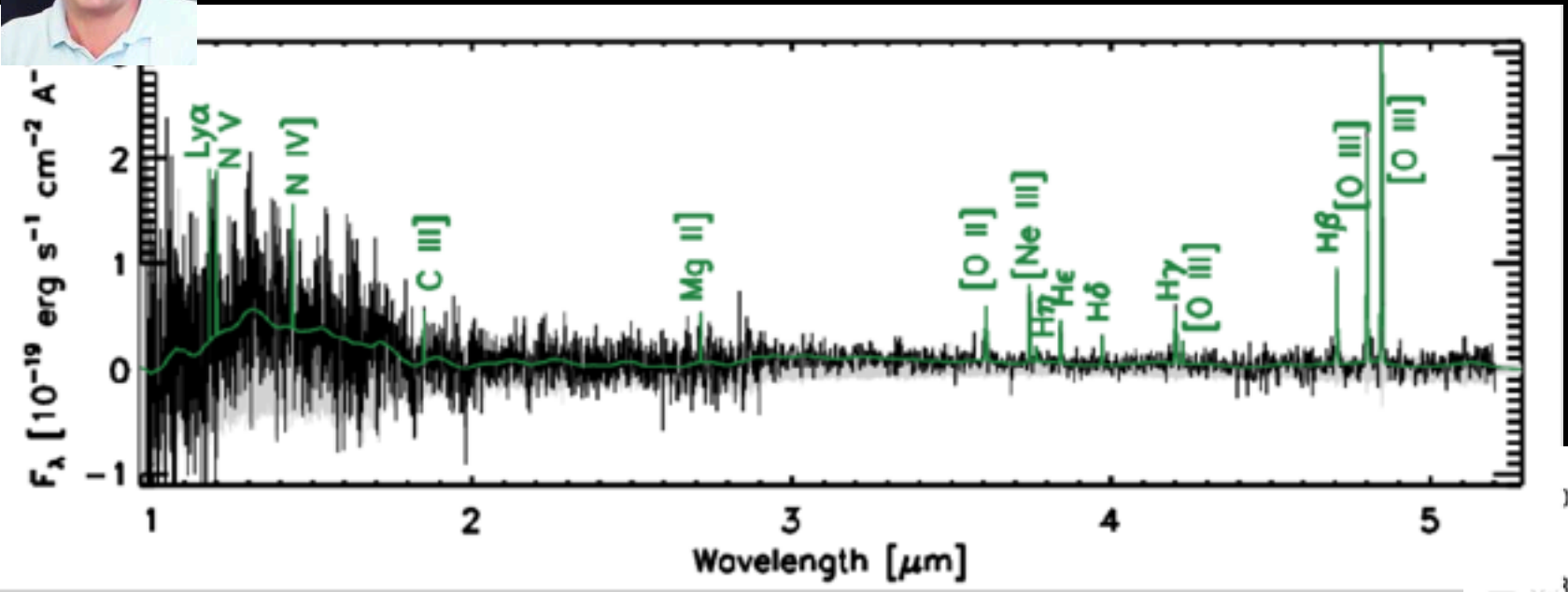
Age of the Universe=1.3Gyr

A massive quiescent galaxy with AGN at z=4.7

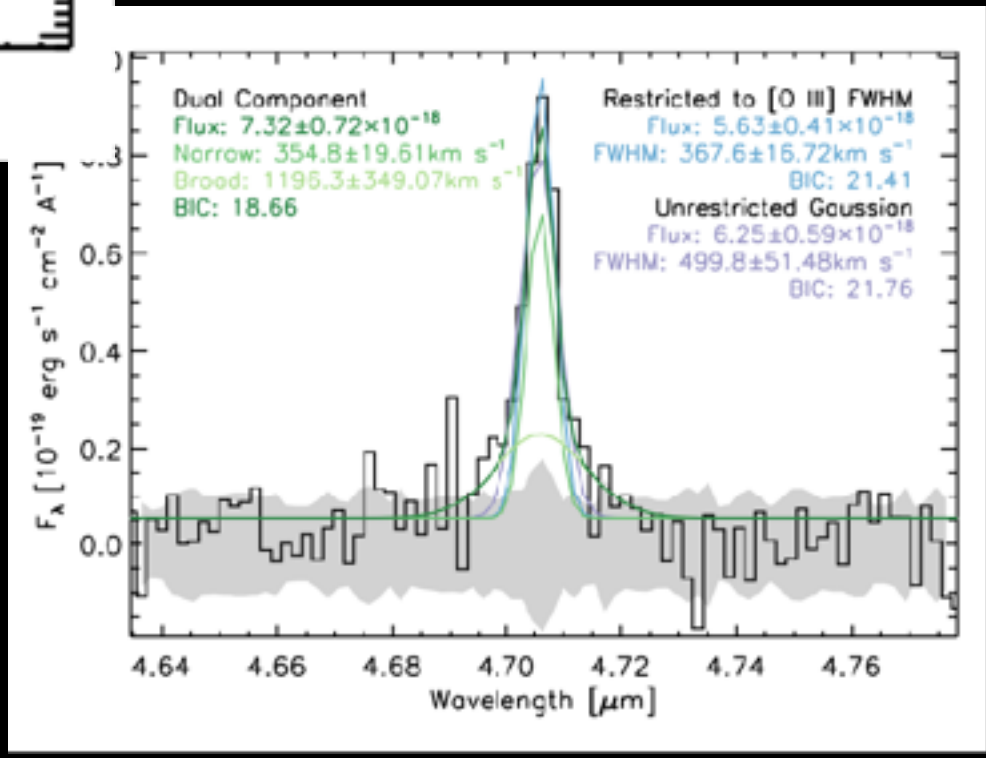


Carnall+2301.11413

Surprise#5: A lot of AGNs….

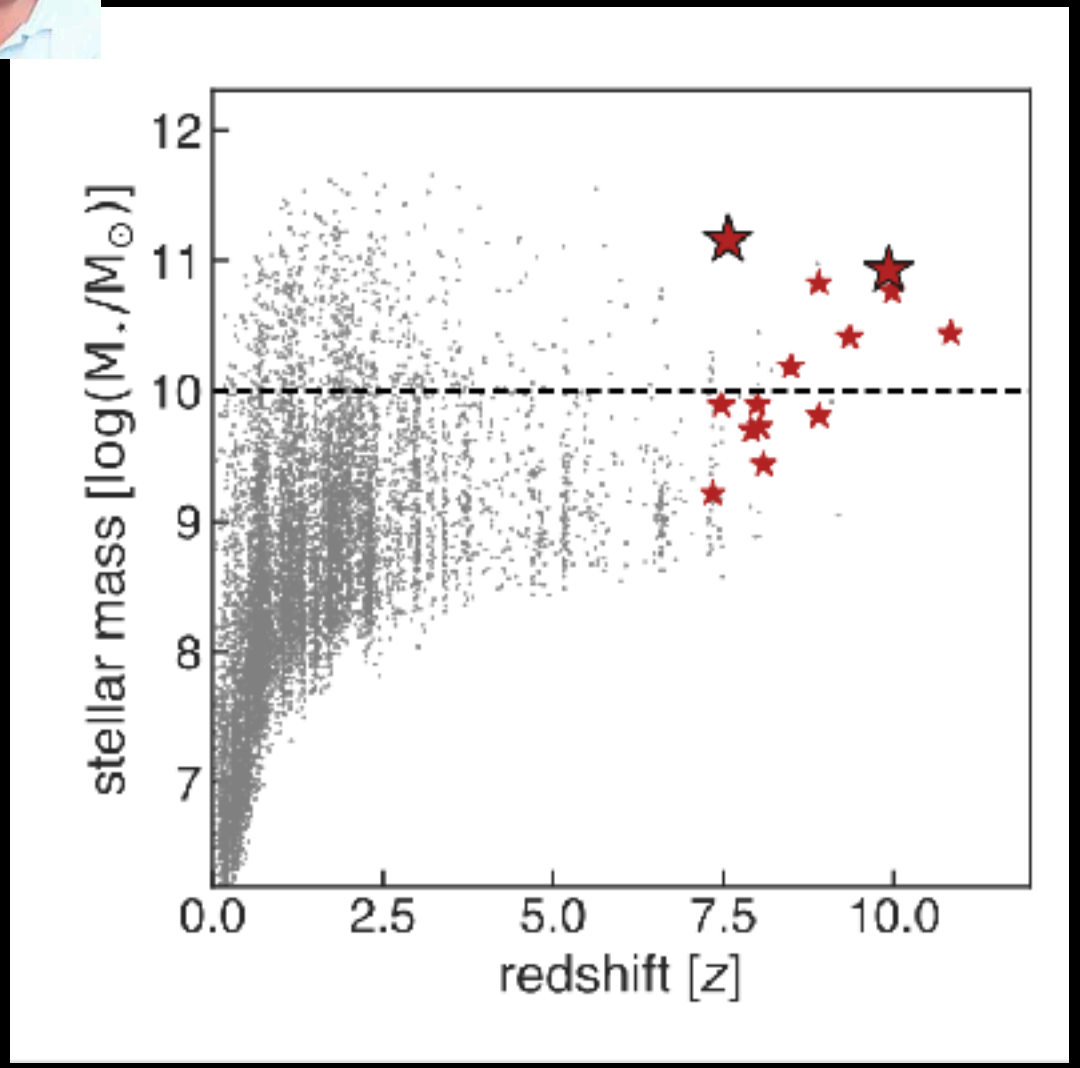


An AGN at z~8.67

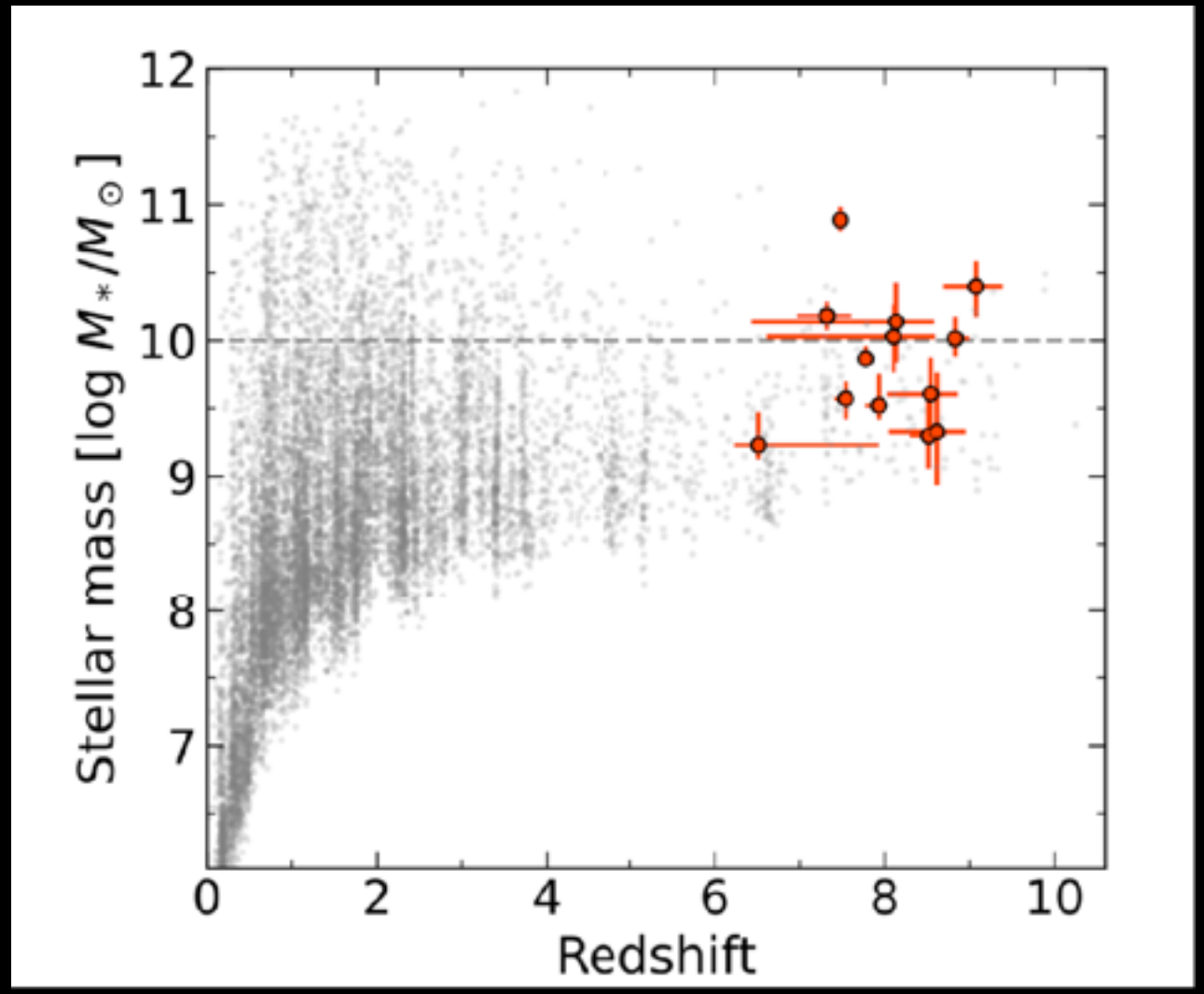


Larson+23,2303.08918

Surprise#6: Massive Galaxies in the 1Gyr…

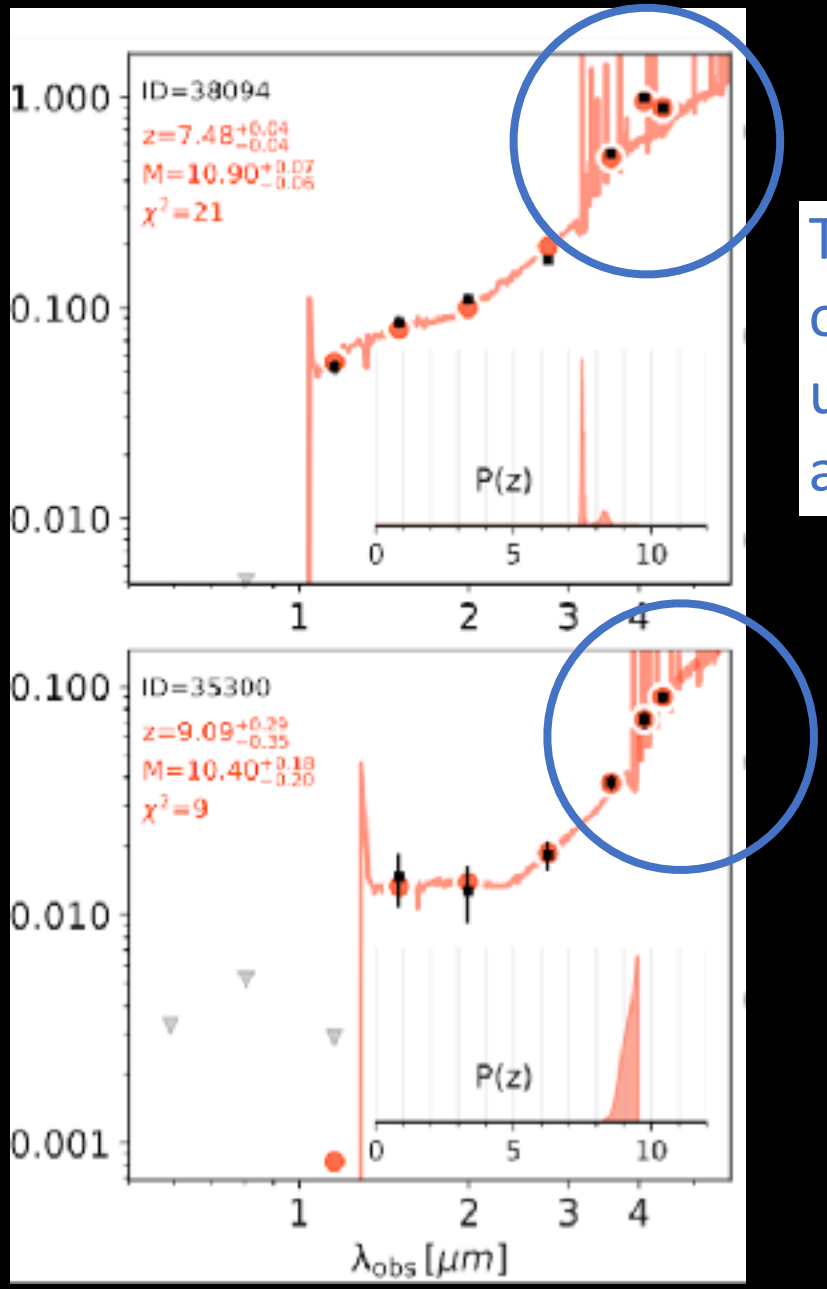


Labbe+23,2207.12446 Version 1



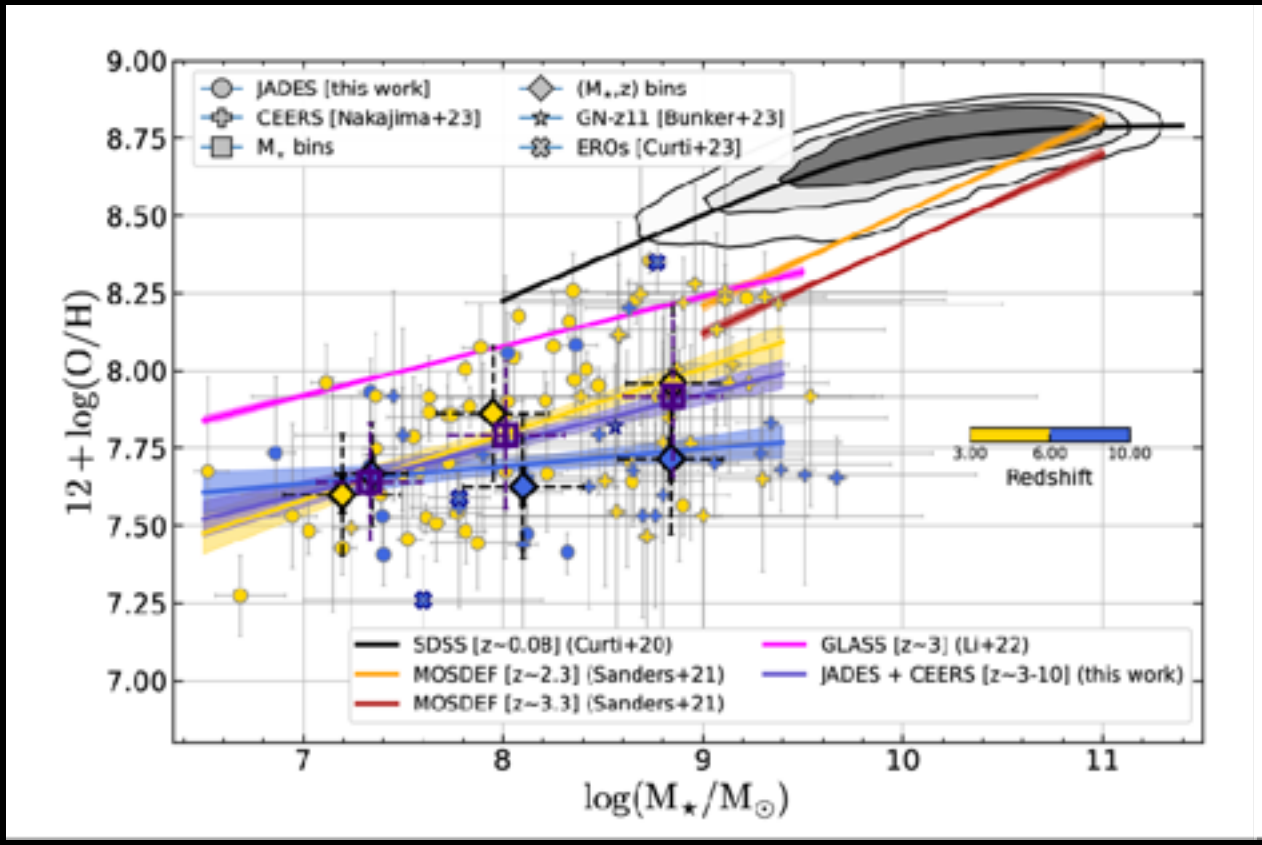
Labbe+23 Version 2 (Nature)

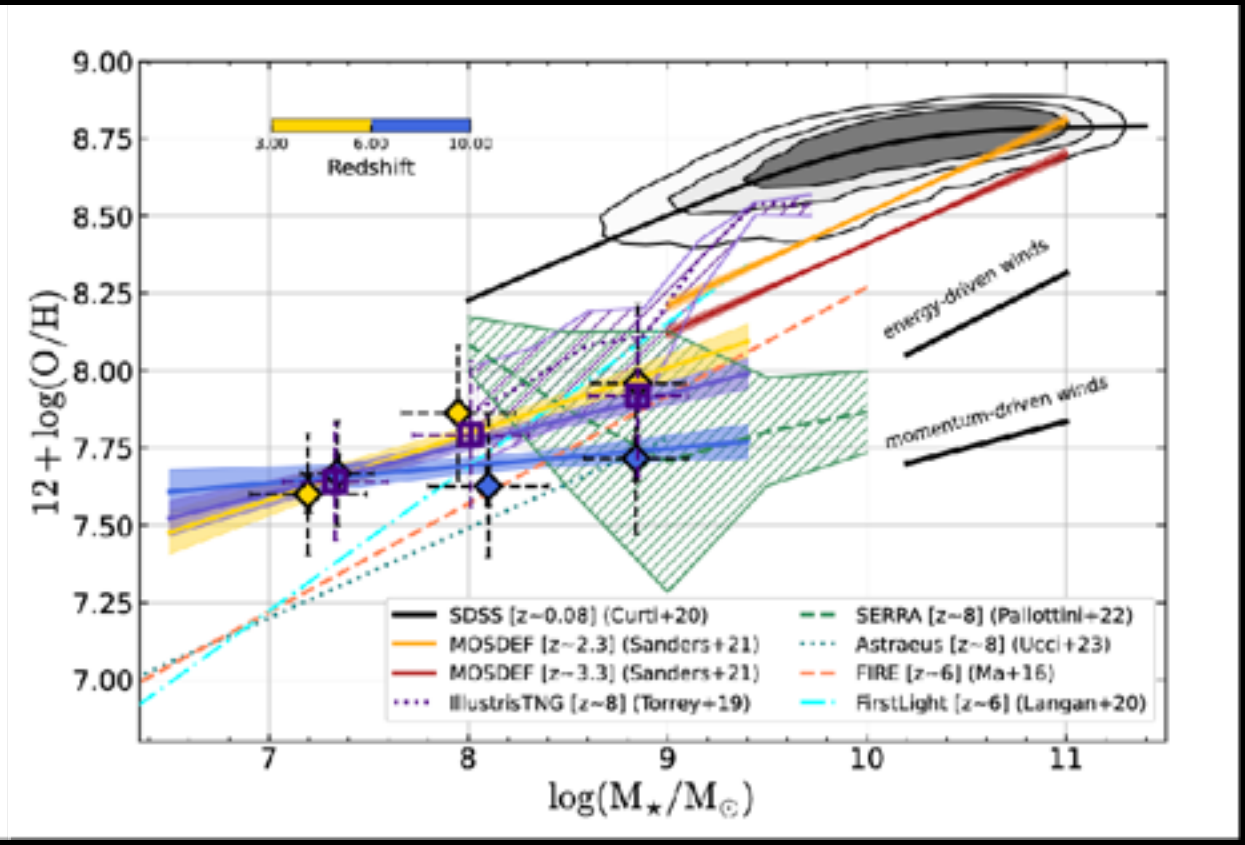
Surprisingly Massive Galaxies and AGN in the 1Gyr...



The SED suggests the presence of a hidden AGN which biases upward both the stellar mass and the redshift

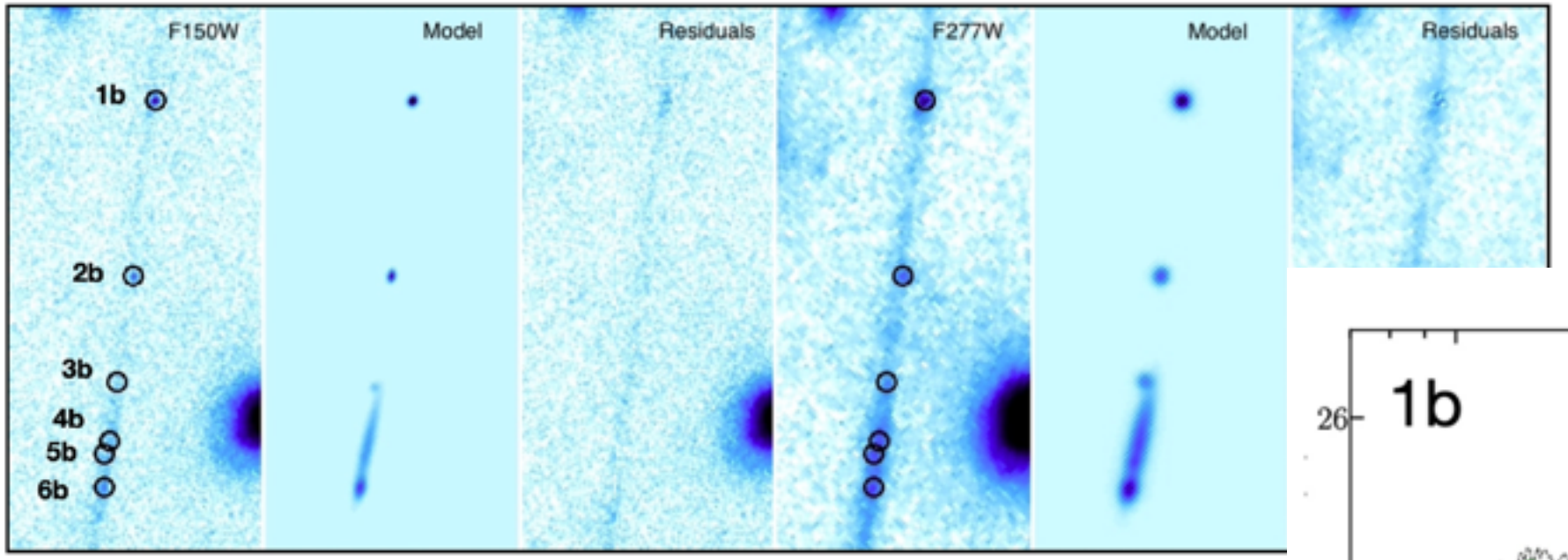
Surprise#7: Metallicity evolution is lower than expected

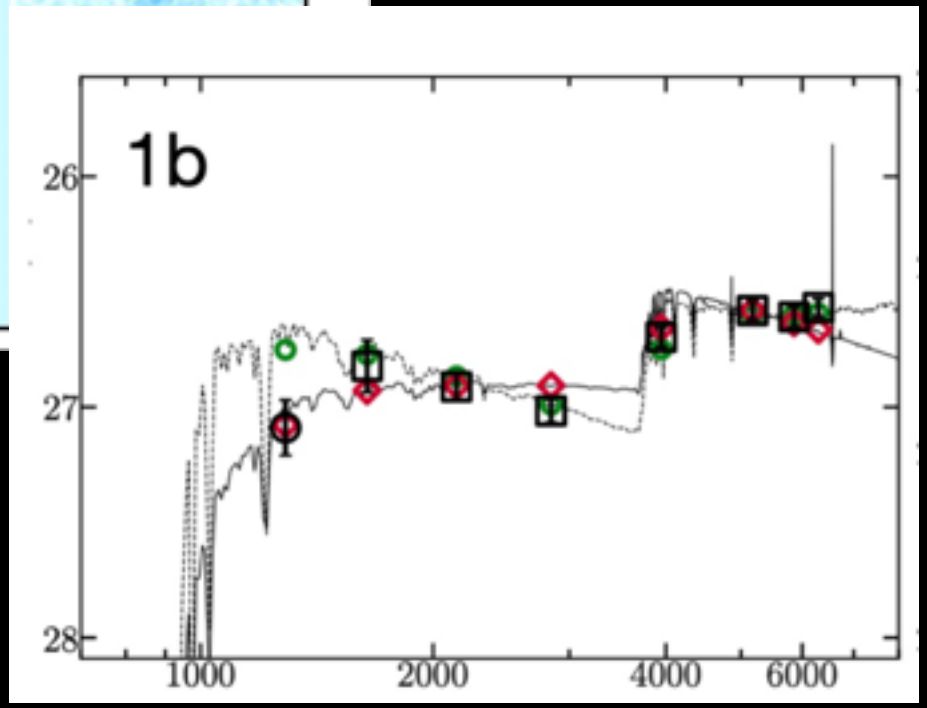




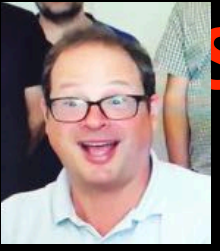
Curti, Maiolino+23,2304.08516

Surprise#8: We detect proto-globular clusters at z~6!

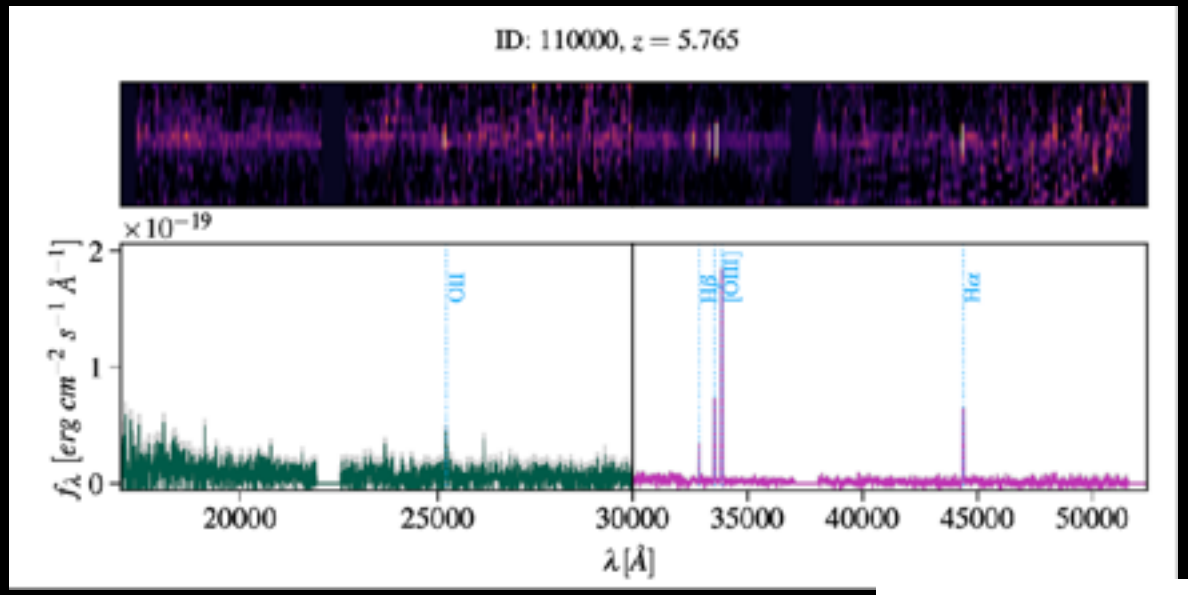




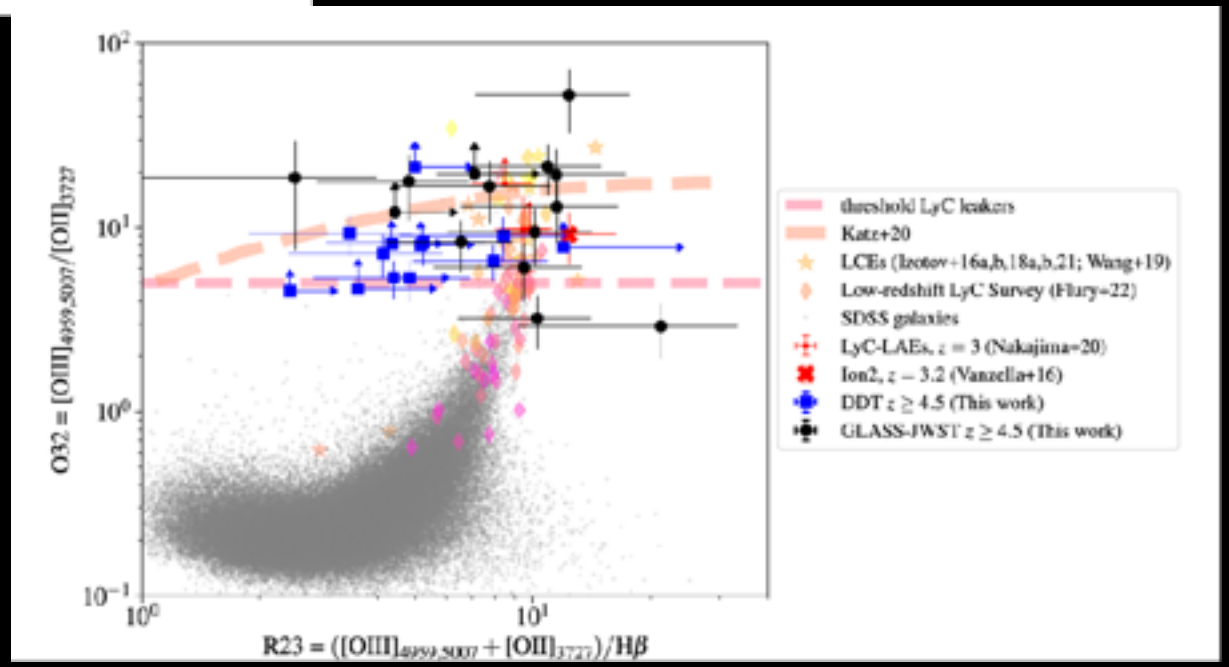
Vanzella, Castellano+23



Surprise#9: Closing in on the sources of cosmic reionization

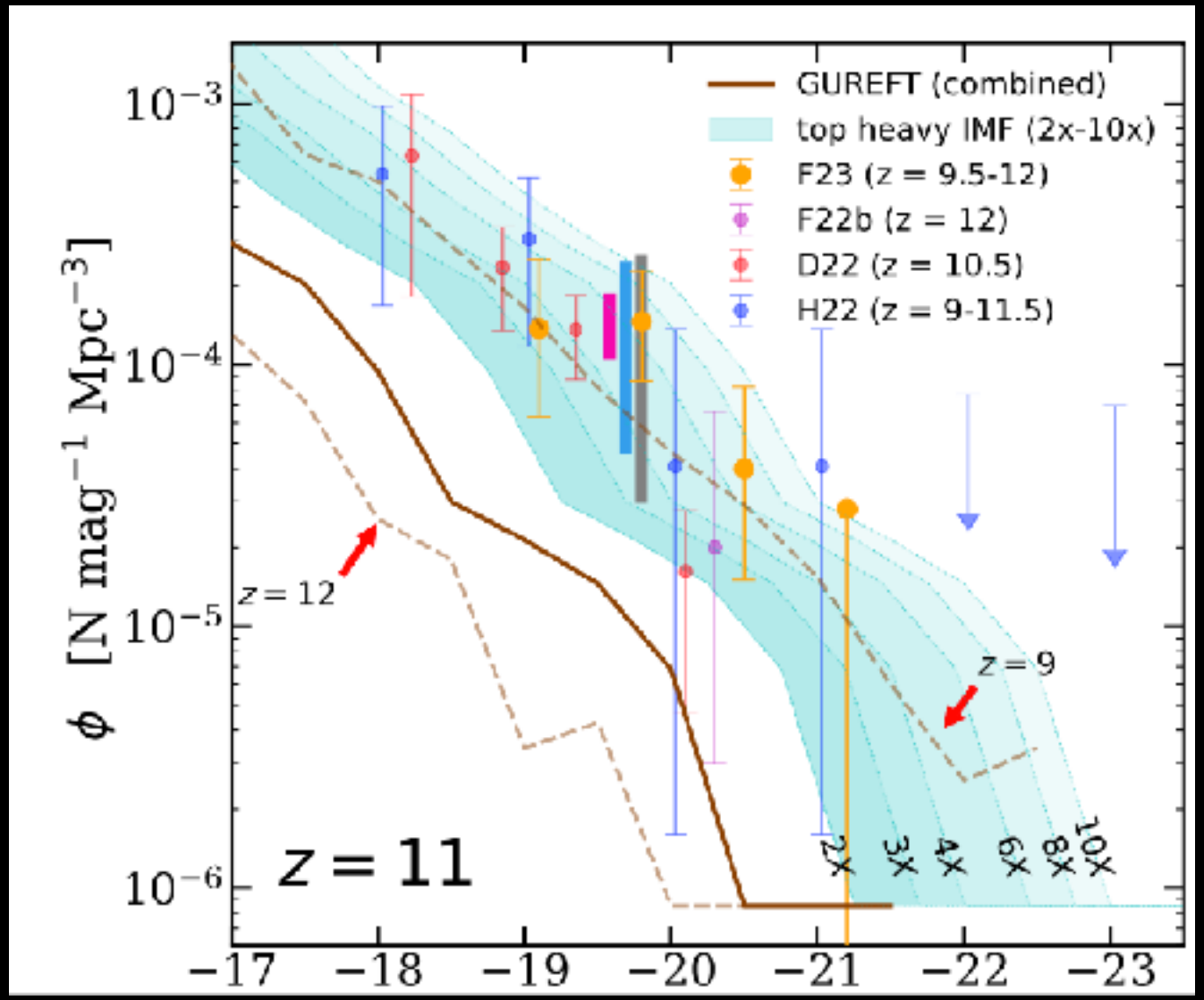


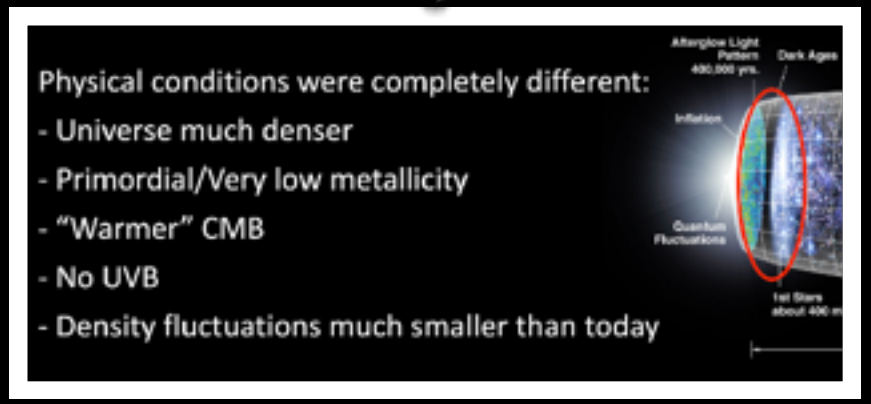
Spectroscopic evidence that low-mass galaxies are LyC leakers and contribute to reionisation



Mascia, Pentericci+23

These early surprises are challenging our theoretical models.





- Top Heavy IMF?
- Very low Z / PopIII?
- Stronger feedback from SN/ AGN?

Yung+23, 2304.04348

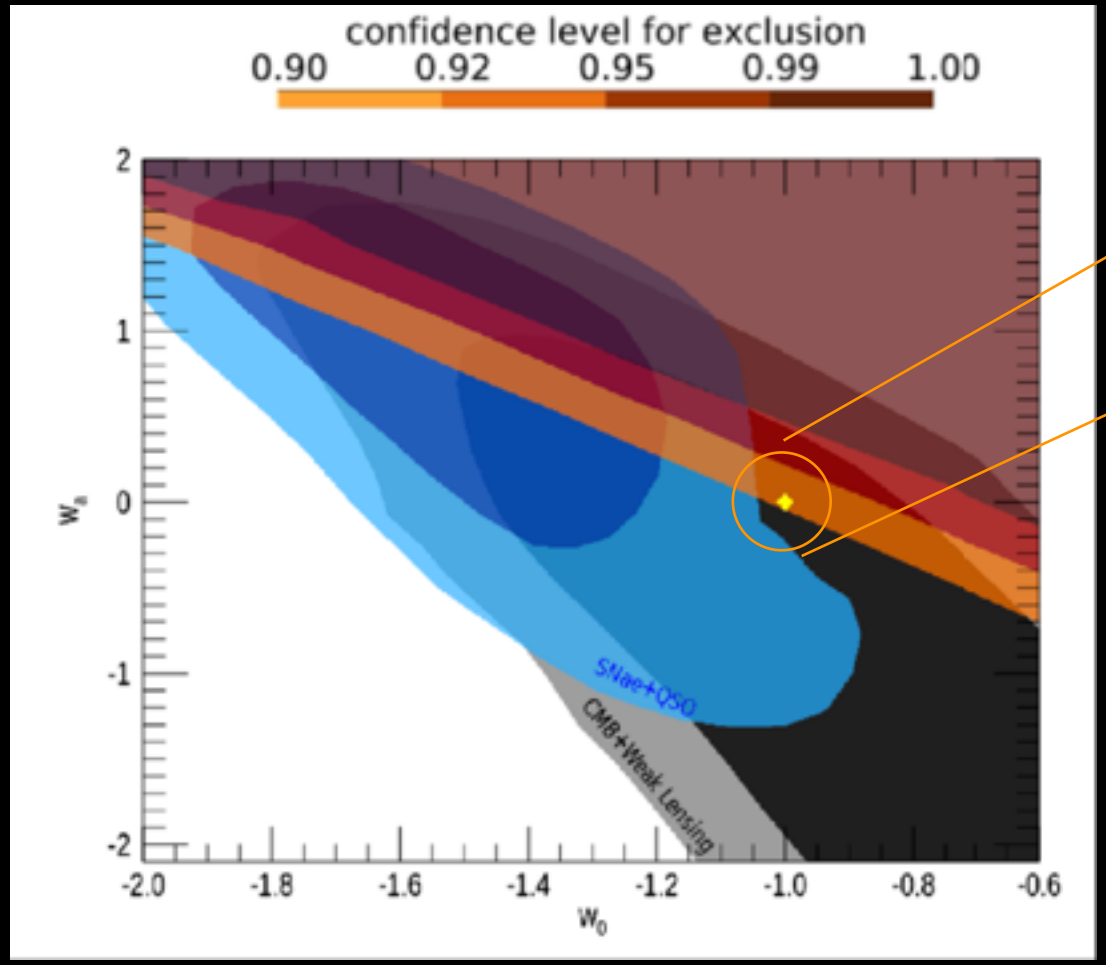
Is there space for “new physics”?

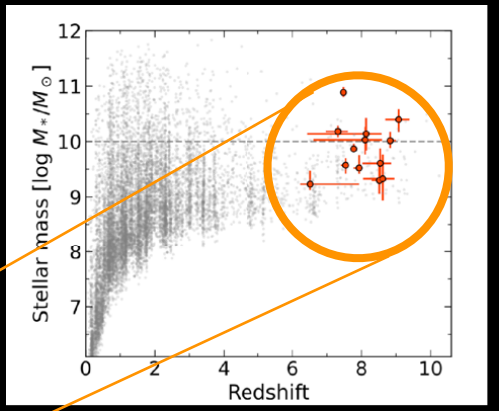
High-redshift Galaxies from Early JWST Observations: Constraints on Dark Energy Models

N. Menci[1], M. Castellano[1], P. Santini[1], E. Merlin[1], A. Fontana[1], and F. Shankar[2]
[1] INAF—Osservatorio Astronomico di Roma, via Frascati 33, I-00078 Monte Porzio, Italy; nicola.menci@inaf.it
[2] School of Physics & Astronomy, University of Southampton, Highfield, Southampton SO17 1BJ, UK
Received 2022 August 24; revised 2022 September 16; accepted 2022 September 27; published 2022 October 12

We need more statistics and bulletproof results.

The jury is still out…





Labbe+23