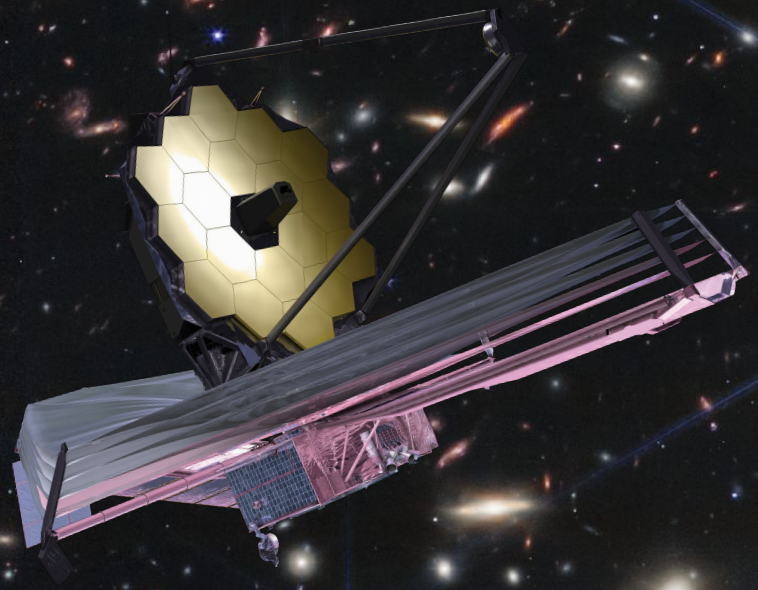
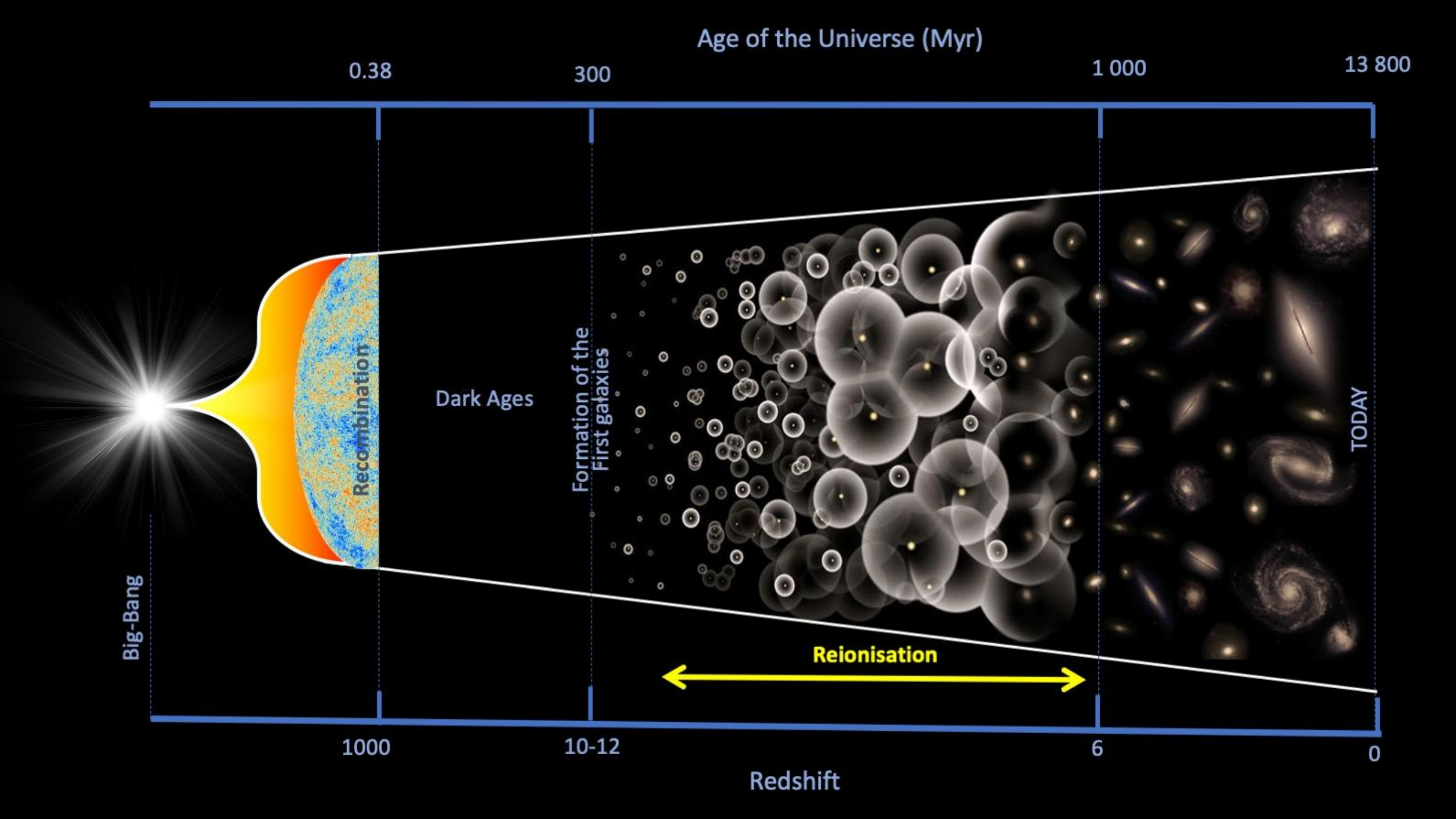
Early galaxy with JWST : a challenge for λCDM ?

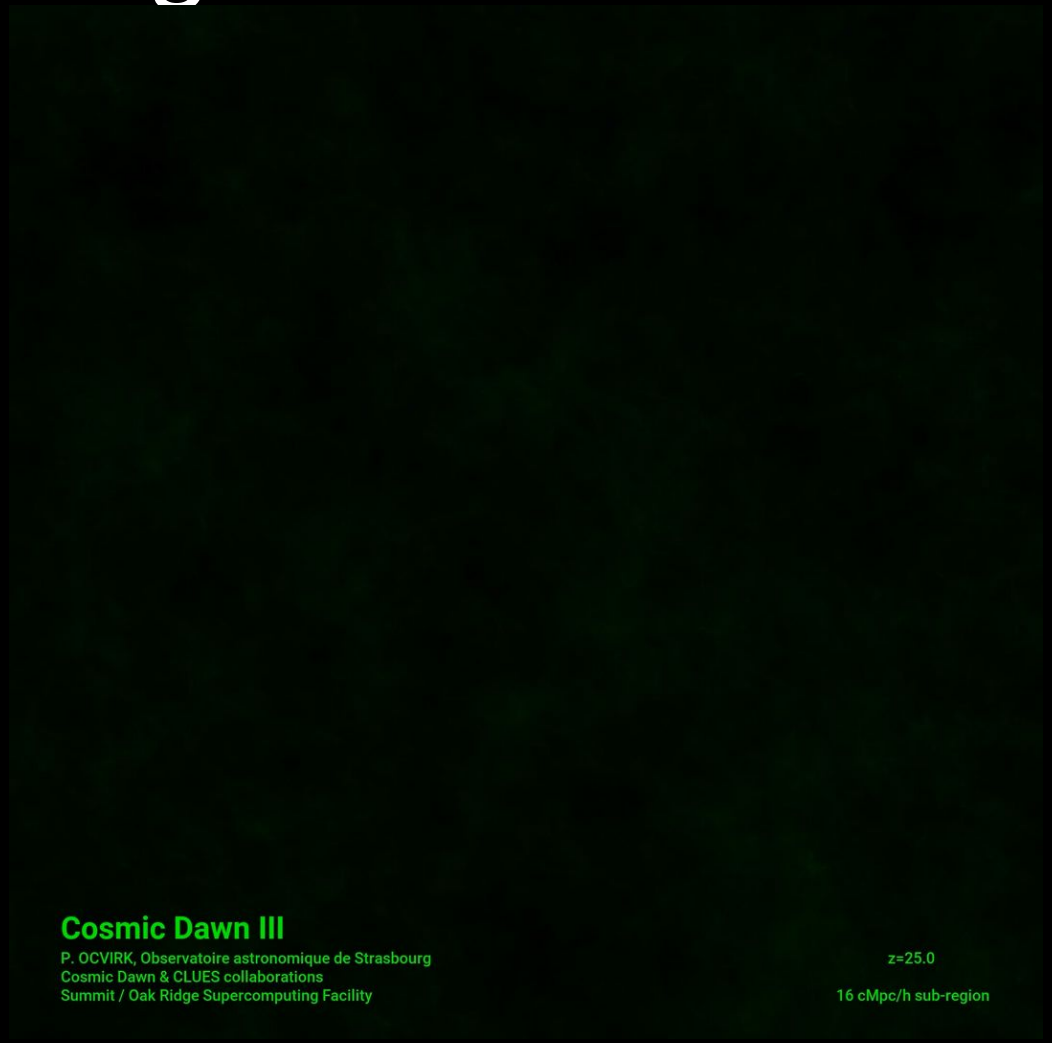


Nicolas Laporte

14 november 2024 – News From The Dark

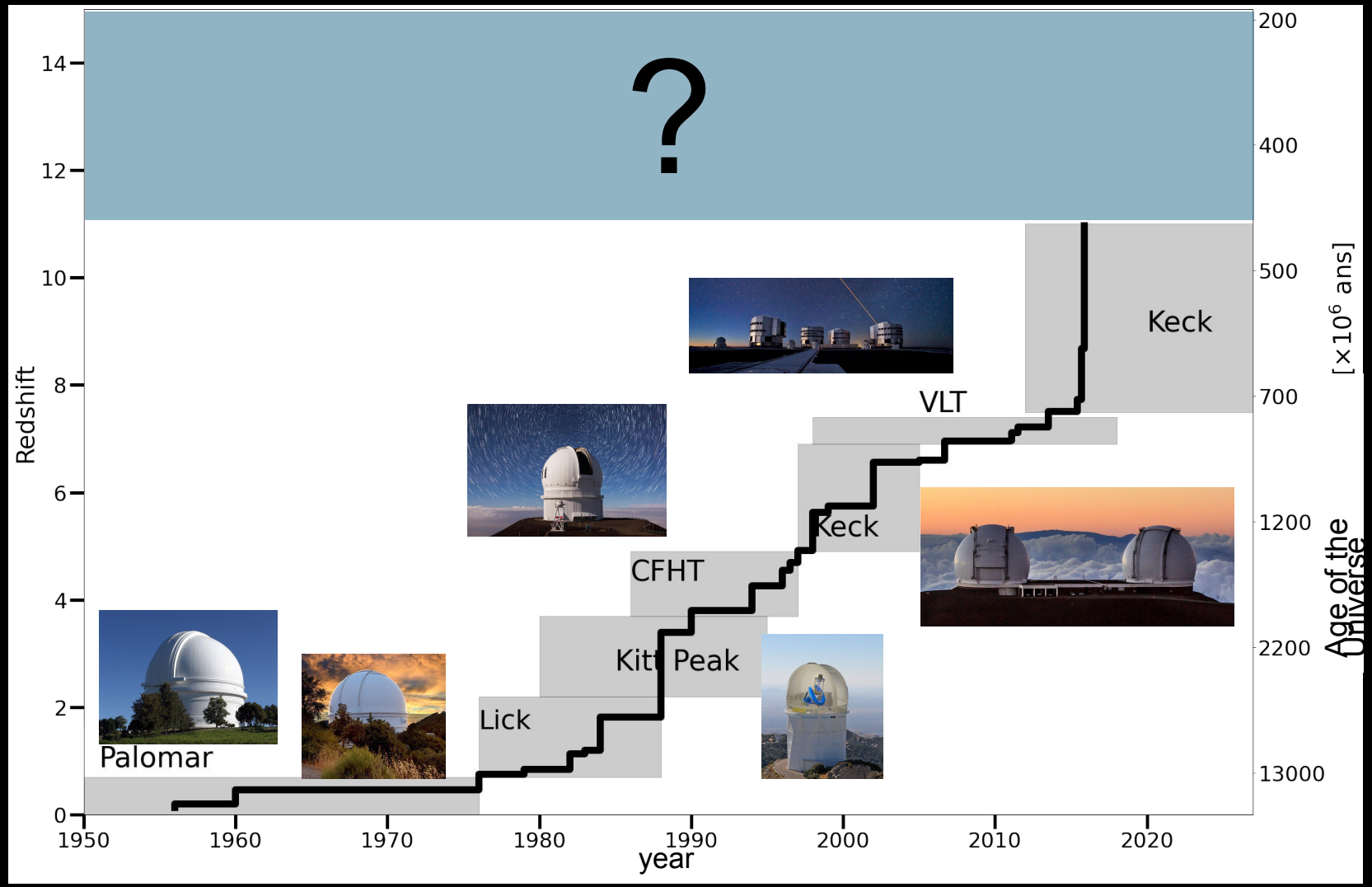

Age of the Universe (Myr)
0.38
300
1 000
13 800
Big-Bang
Recombination
Dark Ages
Formation of the First galaxies
TODAY
Reionisation
1000
10-12
6
0
Redshift

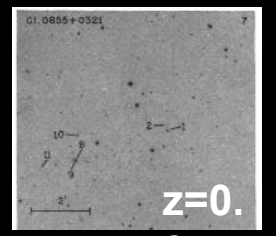
The main questions on the primeval galaxies

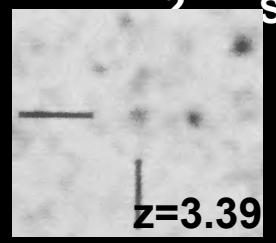


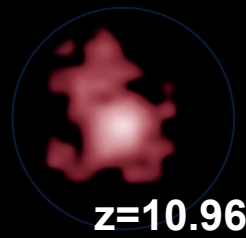
- When did the first stars and galaxies form in the early Universe ?
- What are the physical properties of the first galaxies ?
- What are the sources responsible for reionisation ?
- How did the first structures form in the early Universe ?

The quest for *Cosmic Dawn* before 2022



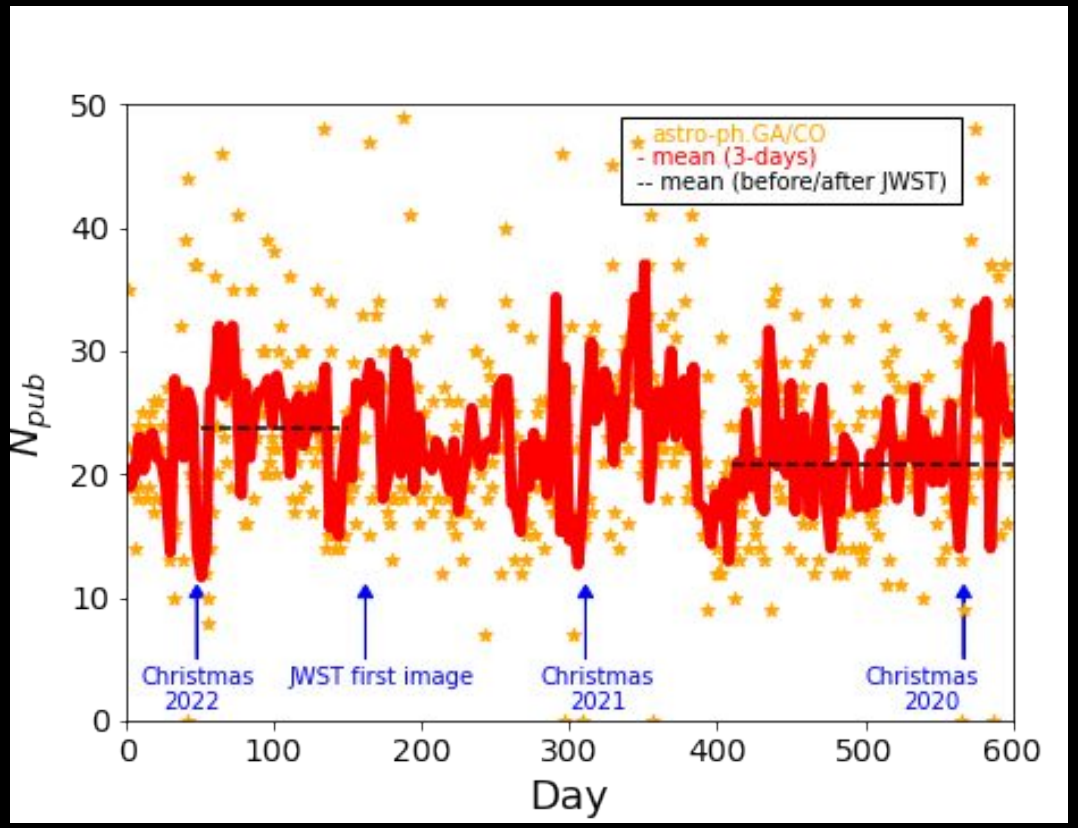






Humason et al. 1956
Minkowski 1960
Spinrad et al. 1975
Spinrad & Smith 1976
Smith et al. 1979
Spinrad 1982
Spinrad & Djorgovsky 1984
Lilly 1988
Chambers et al. 1990
Lacy et al. 1994
Petitjean et al. 1996
Franz et al. 1997
Day et al. 1998
Hu et al. 1999, 2002
Pelló et al. 2004
Iye et al. 2006
Fontana et al. 2010
Vanzella et al. 2011
Ono et al. 2012
Shibuya et al. 2012
Finkelstein et al. 2013
Oesch et al 2014
Zitrin et al. 2015
Oesch et al. 2016

The first results from the *Webb*



TIMELINE OF THE FIRST PUBLICATIONS

- **15 July** : Pascale et al. (2022) ; Mahler et al. (2022)
- **18 July** : Caminha et al. (2022)
- **19 July** : Carnall et al. (2022) ; Cheng et al. (2022)
- **20 July** : Castellano et al. (2022) ; Naidu et al. (2022) ; Ferreira et al. (2022)
- **21 July** : Schaerer et al. (2022)
- **22 July** : Suess et al. (2022)
- **25 July** : Adams et al. (2022) ; Leethochawalit et al. (2022)
- **26 July** : Atek et al. (2022) ; Roberts-Borsani et al. (2022) ; Trump et al. (2022) ; Curti et al. (2022) ; Sun et al. (2022) ; Donnan et al. (2022) ; Chen et al. (2022) ; Yan et al. (2022) ; Morishita et al. (2022) ; Santini et al. (2022), Merlin et al. (2022)

ERO
SMACS0723
ERS GLASS

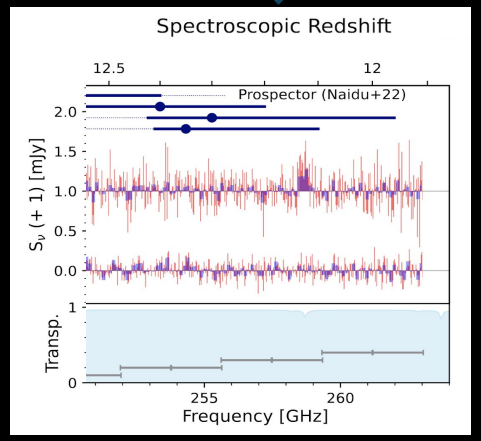
ERS CEERS
Lensing

Calibration data

Some surprising results since July 2022

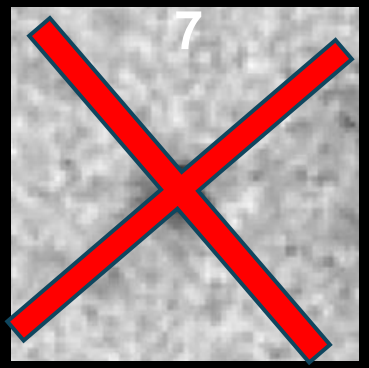
z=13

GLASS-z13 (Naidu et al. 2022)

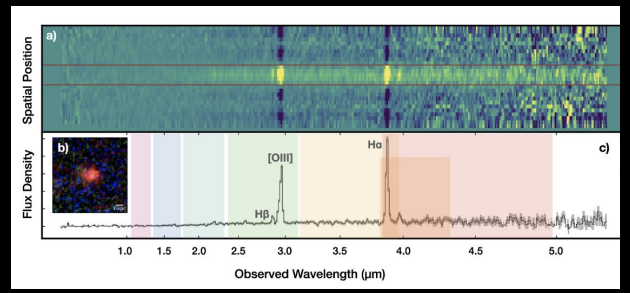


Bakx et al.

z=16.39±0.2

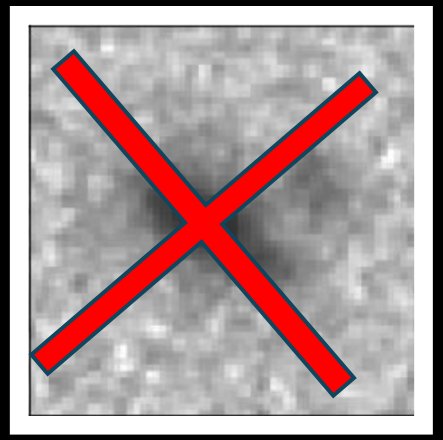


Donnan et al. (2022)

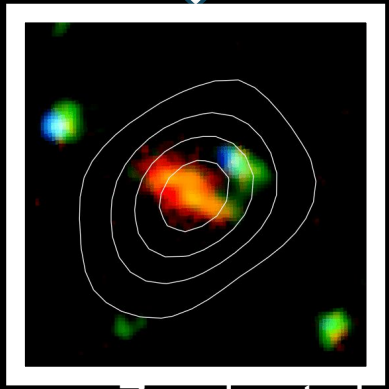


Arrabal-Haro et al. (2023)

z=17

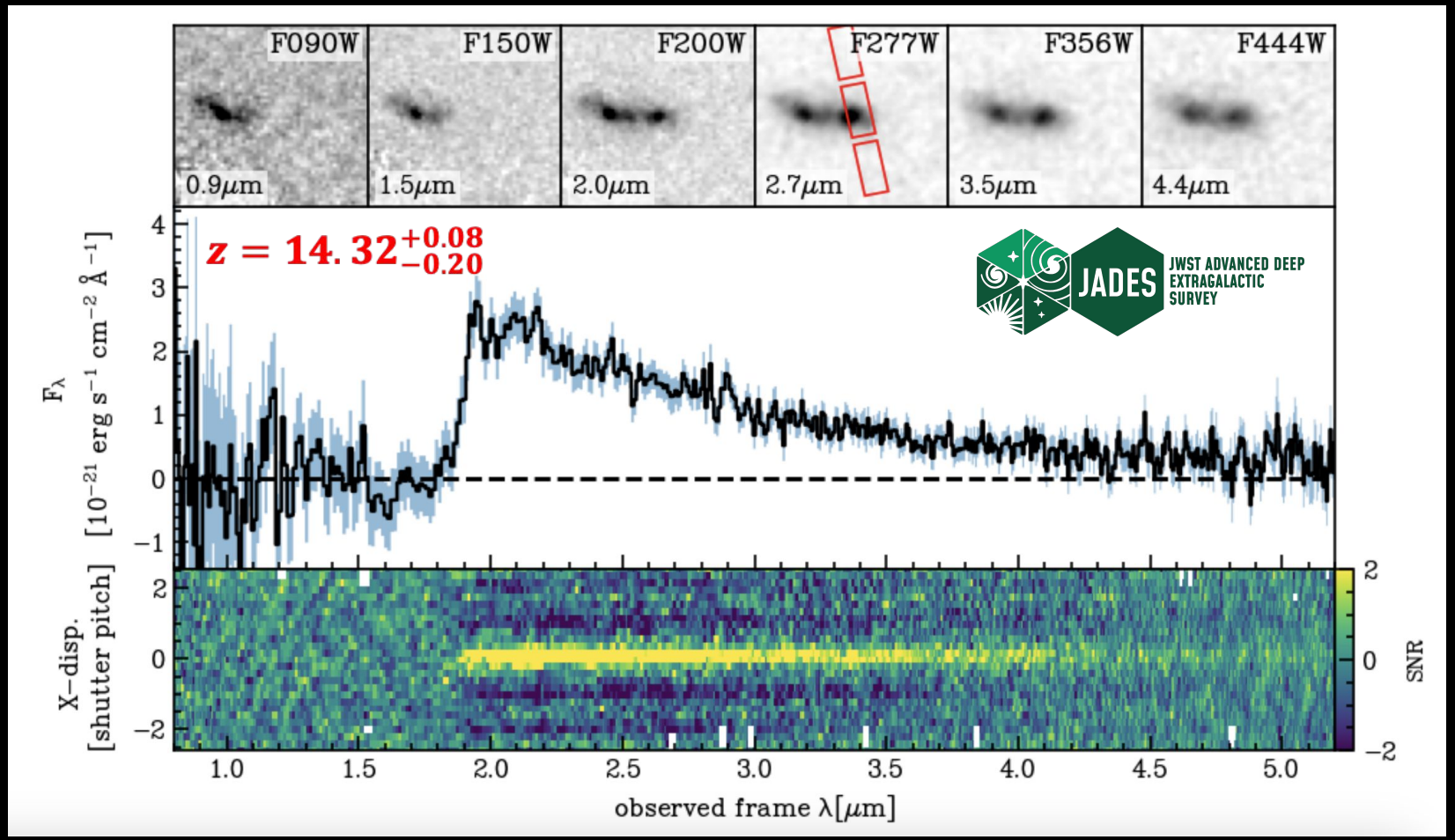


CEERS-DSFG-1 (Finkelstein et al. 2022)



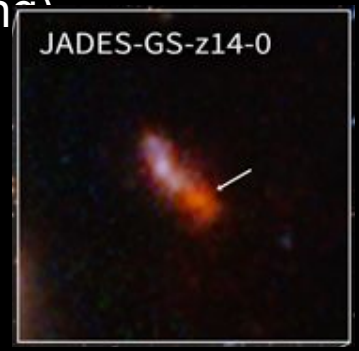
Zavala et al. (2022)

The *current frontiers* of the observable Universe

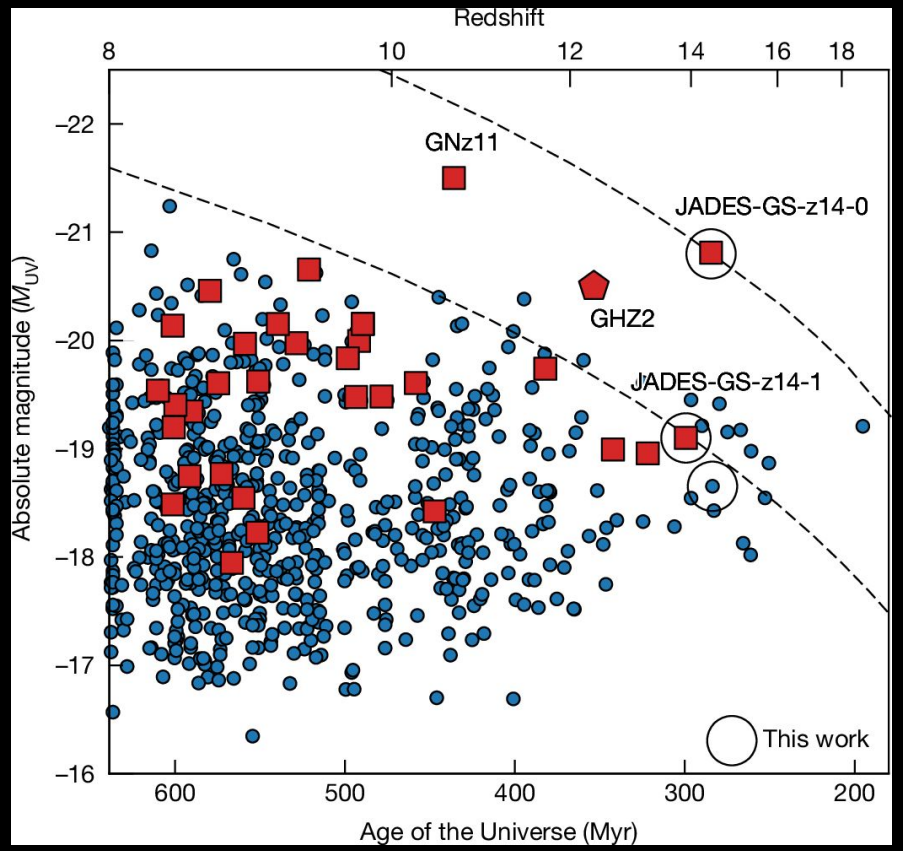


Carniani et al. (2024)

- Two modes if spectroscopic observations :
  - Low resolution (R~100) for the stellar continuum
  - High résolution (R~2900) for emission/absorption lines
- To date, the most distant galaxy has been detected in GOODS-South at z~14.3 (300 million years after the Big-Ban~)



The *current frontiers* of the observable Universe

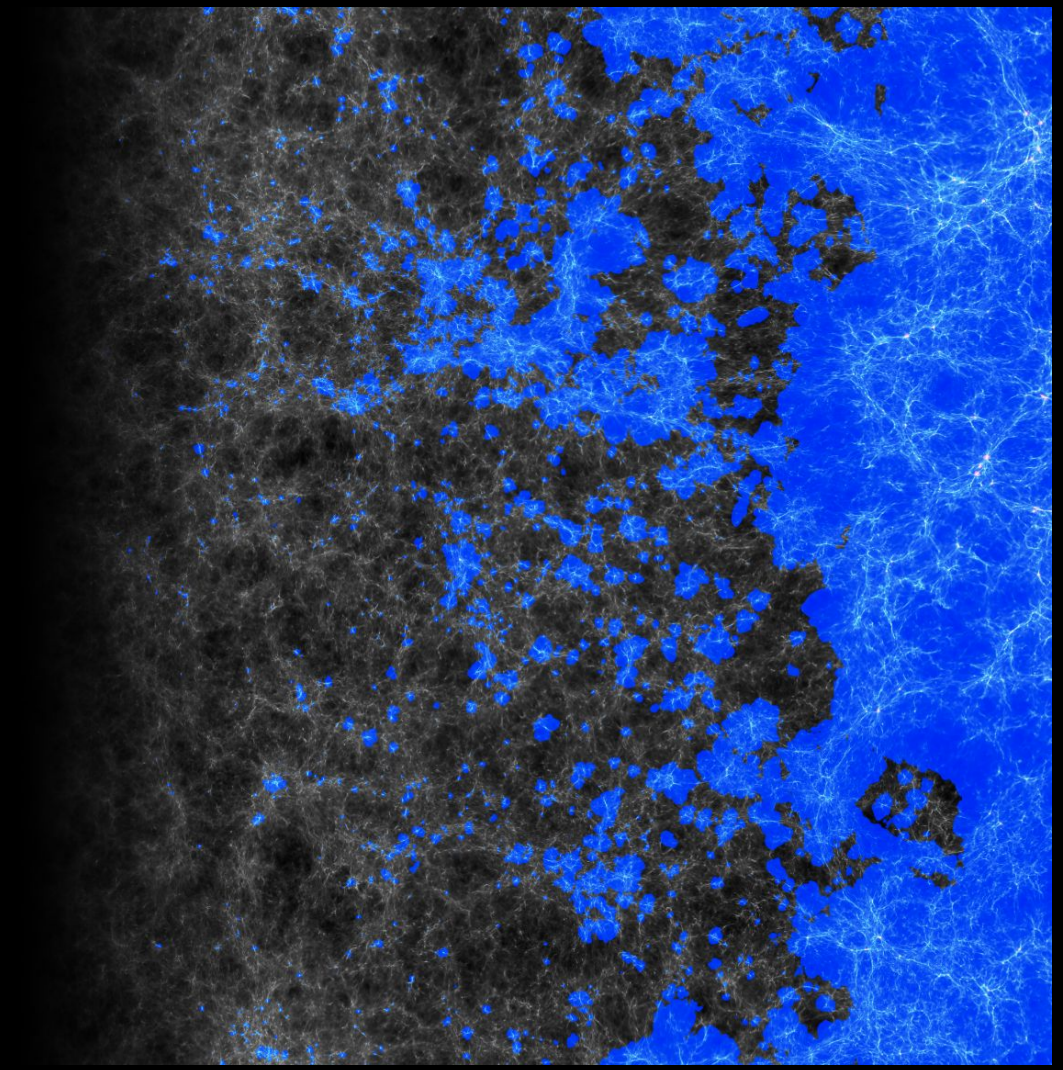


Carniani et al. (2024)

- **This galaxy is one of the most luminous galaxies detected at z>7 in the GOODS-N and GOODS-S field.**
- **Its stellar mass is not in contradiction with what can be obtained with λCDM**

ID	JADES-GS-z14-0
Redshift	$14.32^{+0.08}_{-0.20}$
UV slope β	-2.20 ± 0.07
M_{UV}	-20.81 ± 0.16[b]
UV radius (r_{UV}) (pc)	260 ± 20
$\log_{10}(M_{star}/M_{\odot})$[a]	$8.6^{+0.7}_{-0.2}$[b]
SFR_{100} $(M_{\odot}\ \mathrm{yr}^{-1})$	4^{+9}_{-3}[b]
SFR_{10} $(M_{\odot}\ \mathrm{yr}^{-1})$	19 ± 6[b]
sSFR_{10} (Gyr^{-1})	45^{+56}_{-35}
A_V (mag)	$0.31^{+0.14}_{-0.07}$
$\log_{10}(Z/Z_{\odot})$	$-1.5^{+0.7}_{-0.4}$
f_{esc}^{LyC}	$0.84^{+0.09}_{-0.16}$

The main questions on primeval galaxies



Ocvirk et al. (2018) - ObsAS

- When did the first stars and galaxies form in the early Universe ?
- What are the physical properties of the first galaxies ?
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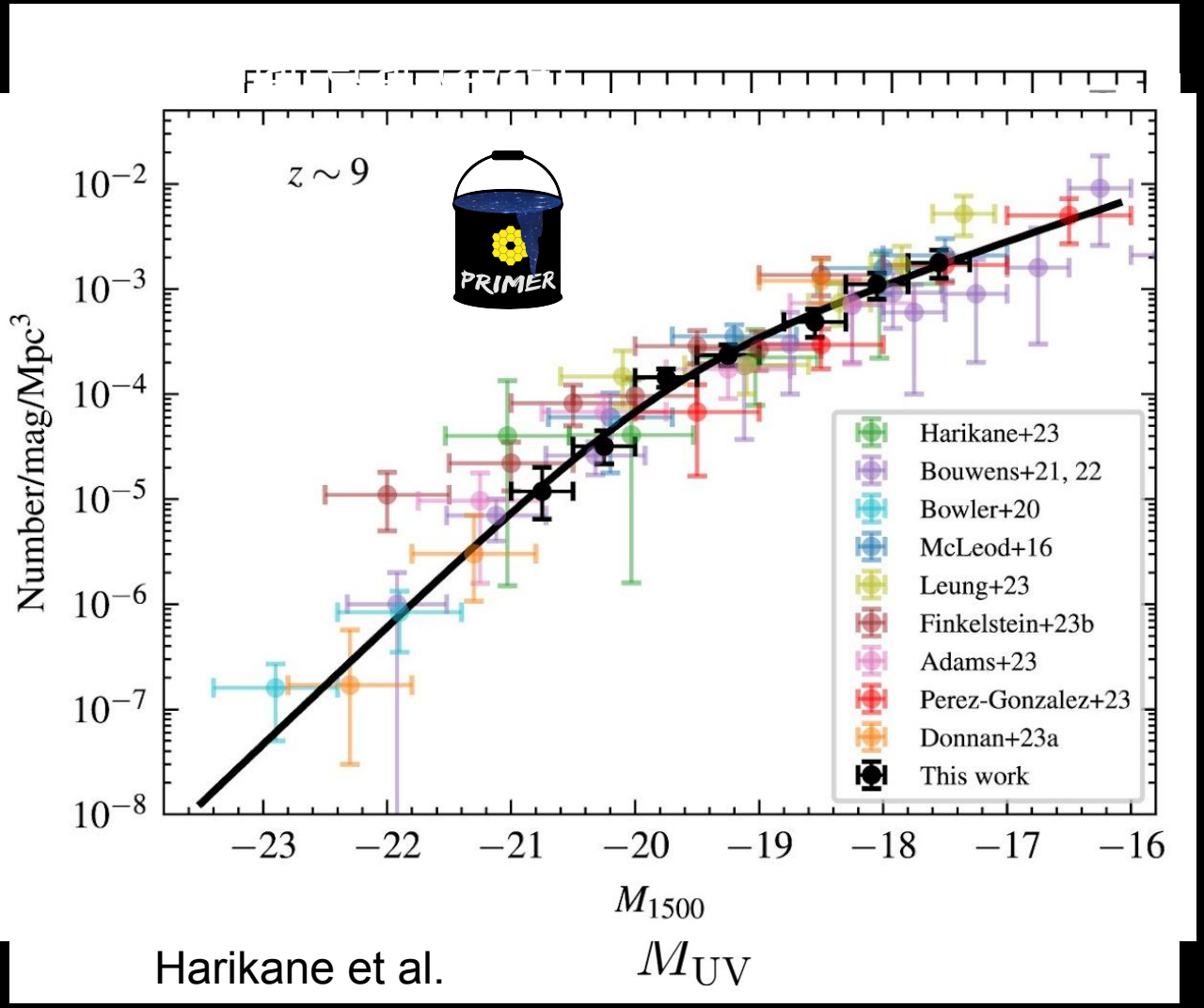
- How did the first structures form in the early Universe ?

The distribution in Luminosity of galaxies



Harikane et al.

- The distribution in luminosity of the number densities of galaxies allows to constrain :
  - AGN activity (bright part)
  - The minimum mass of the dark matter halo
- The shape of the bright part
  - The density of AGN at high-redshift seems small
- The shape of the faint part
  - Not deep enough to constrain the mass of the dark matter halo.

 Needs of gravitational lensing

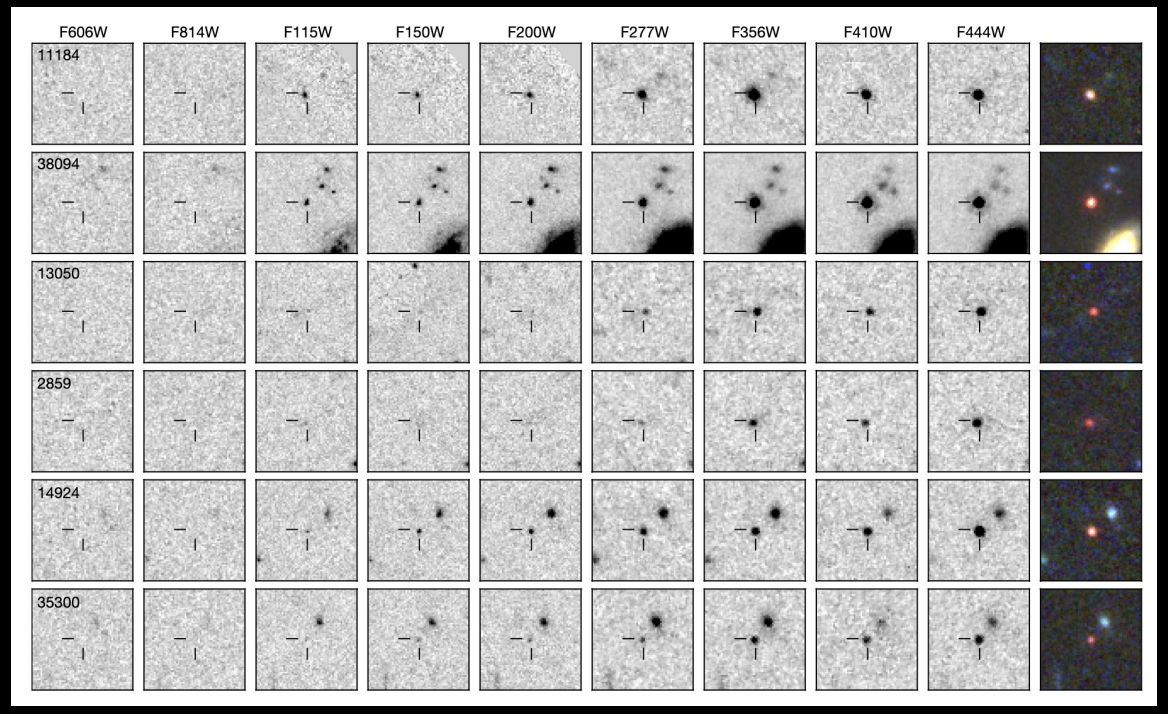
Too many and too massive high-z galaxies ?

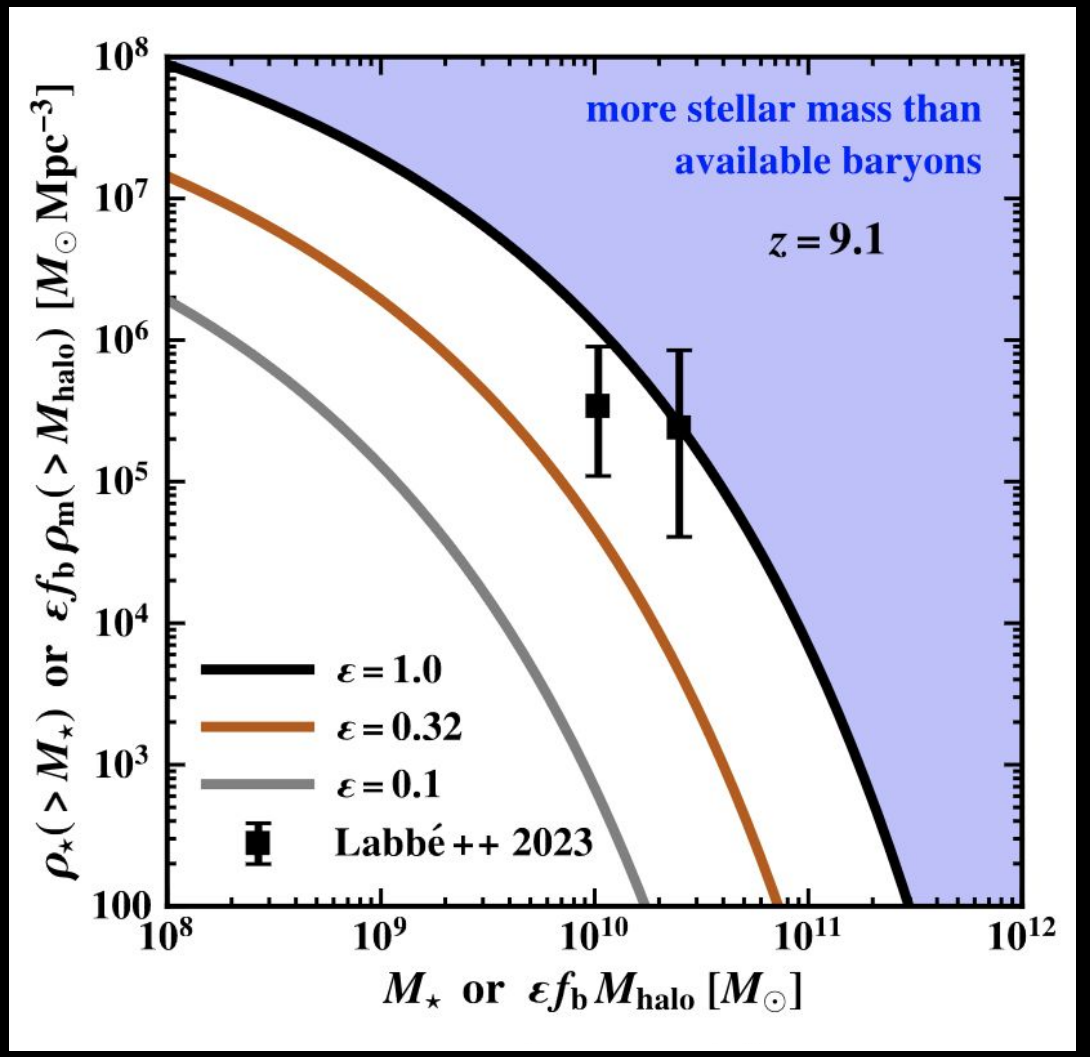
Article

A population of red candidate massive galaxies ~600 Myr after the Big Bang

https://doi.org/10.1038/s41586-023-05786-2
Received: 25 July 2022
Accepted: 2 February 2023

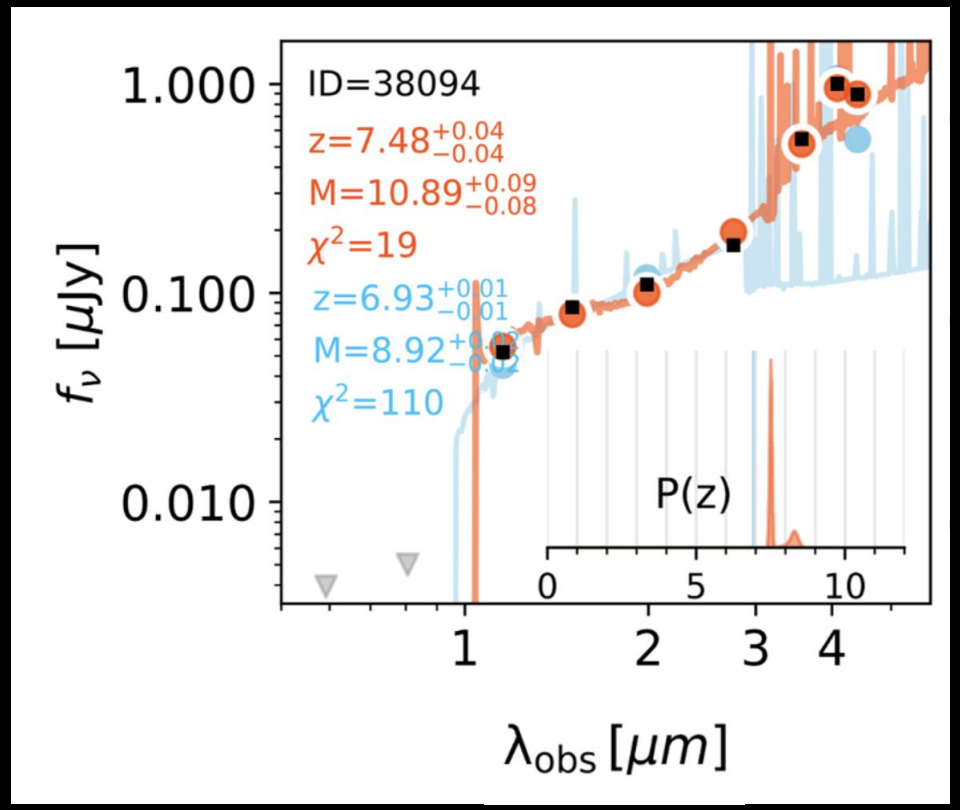
Ivo Labbé[1]✉, Pieter van Dokkum[2], Erica Nelson[3], Rachel Bezanson[4], Katherine A. Suess[5,6], Joel Leja[7,8,9], Gabriel Brammer[10], Katherine Whitaker[10,11], Elijah Mathews[7,8,9], Mauro Stefanon[12,13] & Bingjie Wang[7,8,9]





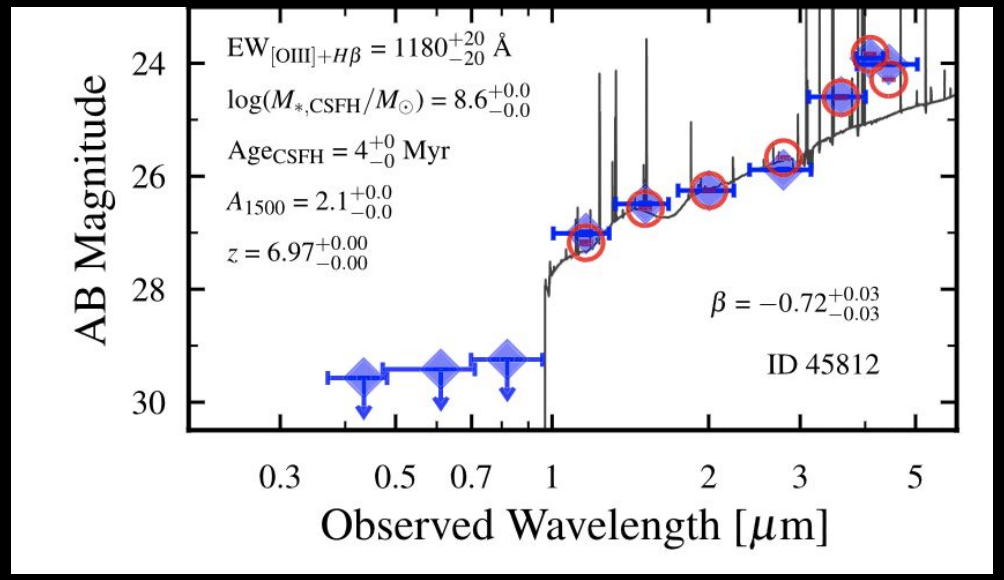
Labbe et al. (2023)

Too many and too massive high-z galaxies ?



Labbe et al. (2023)

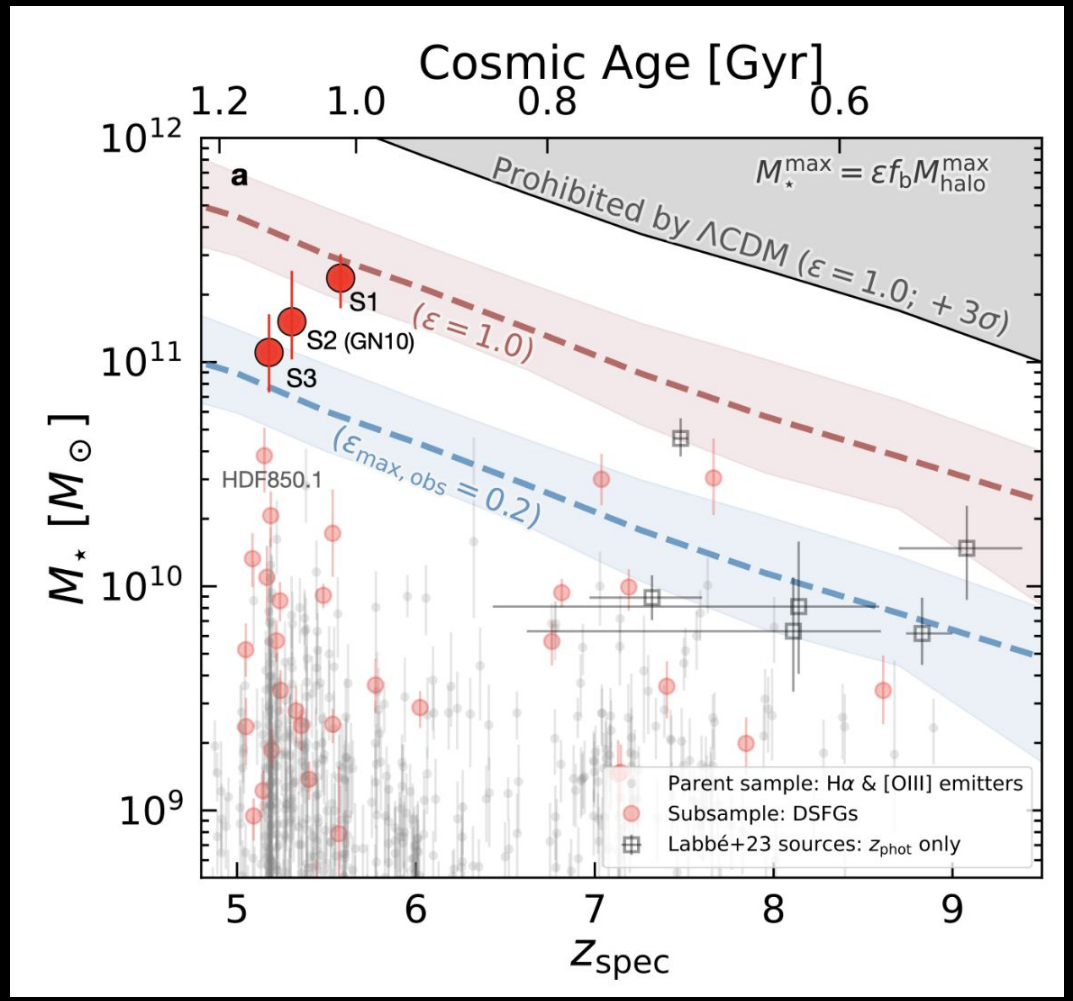
It is now well-known that at high-z stars have a higher ionising efficiency, leading to the emission of stronger emission lines



Endsley et al. (2023)

If we update the models used to estimate the stellar masses of the candidates, all the galaxies have more reasonable masses

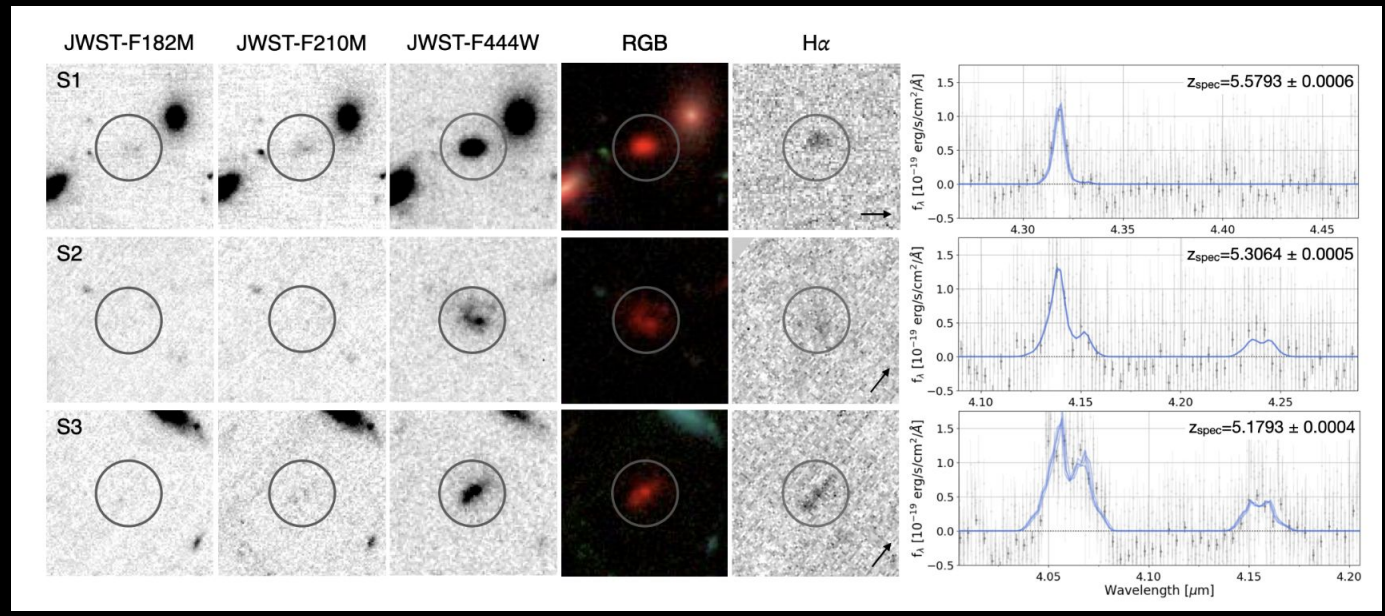
Too many and too massive high-z galaxies ?



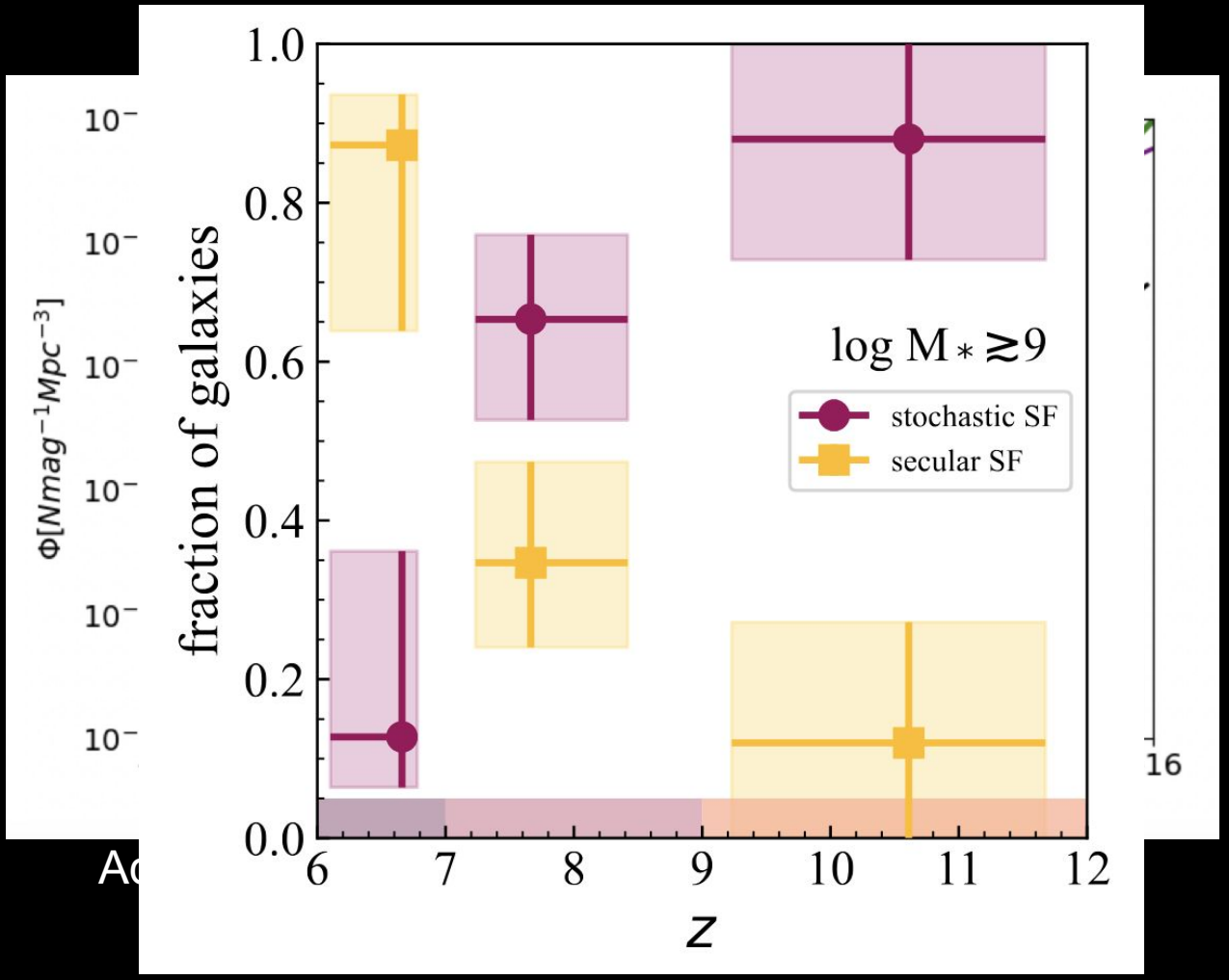
Xiao et al. (2024)

Using JWST data, the SFE of a sample of 36 star-forming galaxies has been estimated. The most massive galaxies shows an average SFE of ~50%.

This is much higher than what is observed in the local Universe (~3 x) but not in conflict with λCDM



An abundance of "*Little Red Dots*"



Ciesla et al. (2024)
LAM

- Too many galaxies are found at z>11 compared to predictions
- Several hypotheses:
  - Higher star formation efficiency
  - Non-negligible contamination by low-redshift interlopers
  - Stochastic star formation history

Evidence for a dynamical Dark Energy equation ?

DRAFT VERSION OCTOBER 31, 2024
Typeset using LaTeX **twocolumn** style in AASTeX631

The Excess of JWST Bright Galaxies: a Possible Origin in the Ground State of Dynamical Dark Energy in the light of DESI 2024 Data

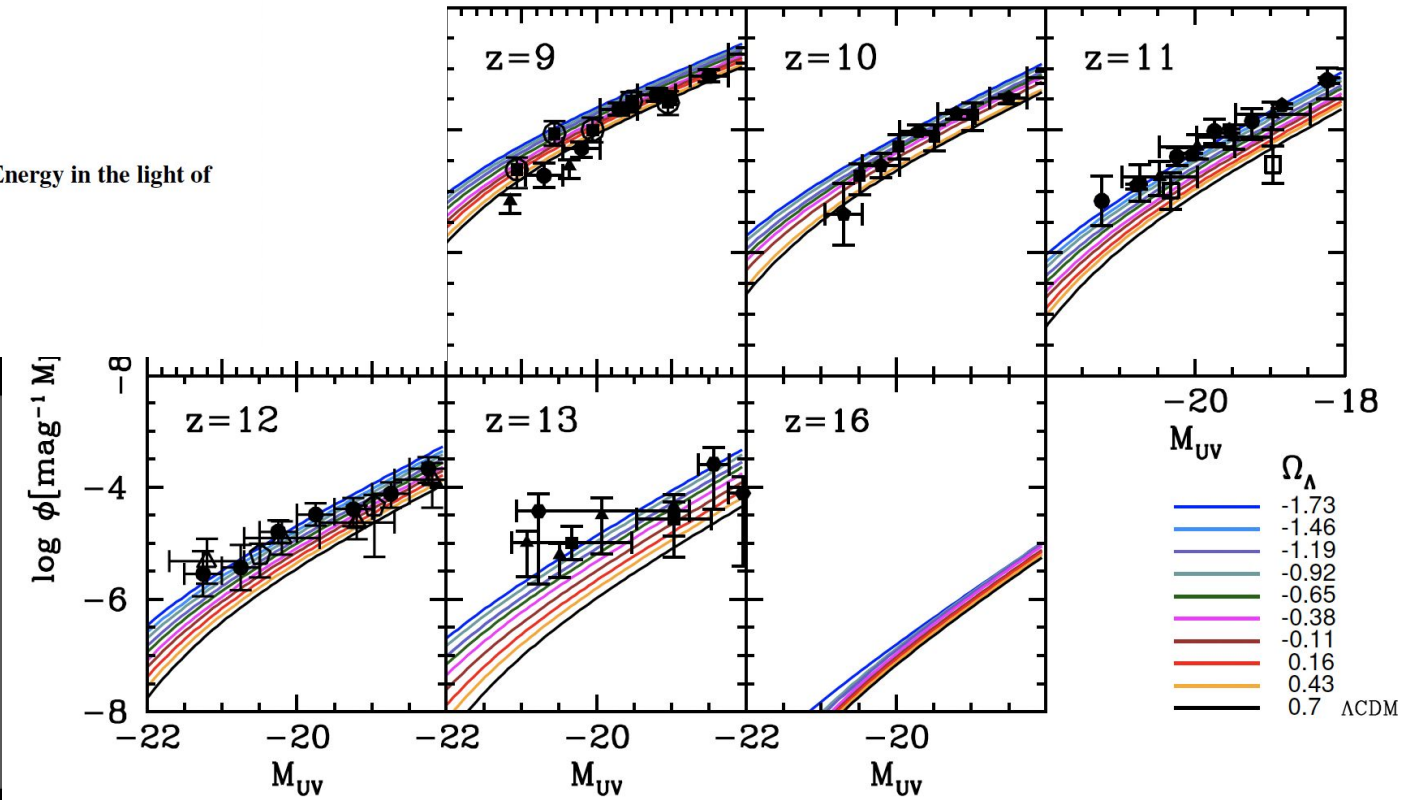
N. MENCI[1], A. A. SEN[2], M. CASTELLANO[11,2]

[11] *INAF - Osservatorio Astronomico di Roma, via Frascati 33, I-00078 Monte Porzio, Italy*
[22] *Centre For Theoretical Physics, Jamia Millia Islamia, New Delhi, 110025, India.*

Assuming a negative Cosmological Constant, a new equation governing the expansion of the Universe can be derived :

$$\left[\frac{H(a)}{H_0}\right]^2 = \Omega_m a^{-3} + \Omega_\Lambda + \Omega_x f(a)$$

where $f(a) = a^{-3(1+\omega_0+\omega_a)}\exp[-3\omega_a(1-a)]$

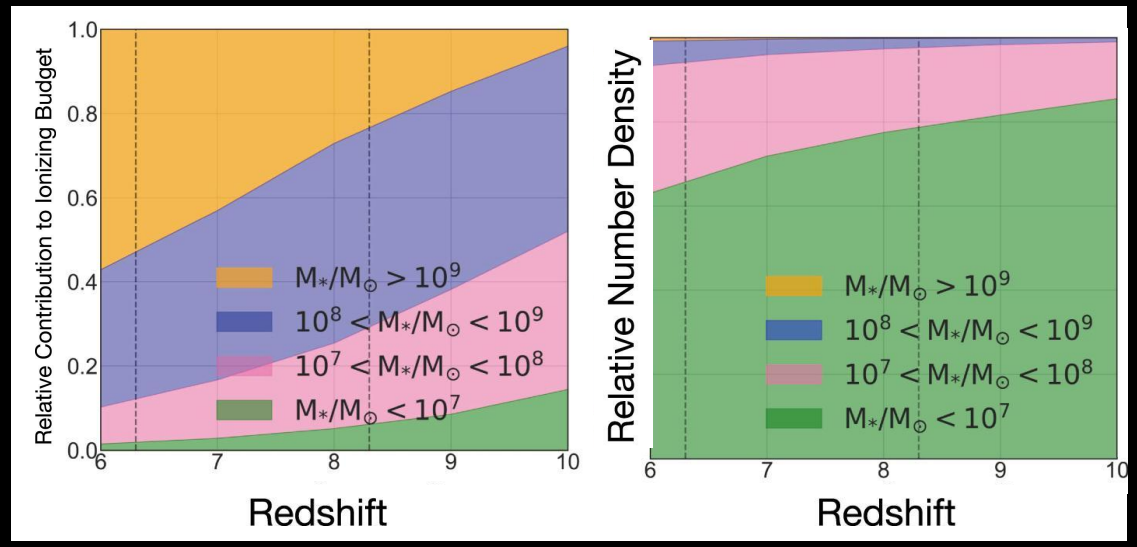


If the overdensity of galaxies at z>10 is confirmed, this new model with a negative Cosmological Constant could explain it.

Menci et al. (2024)

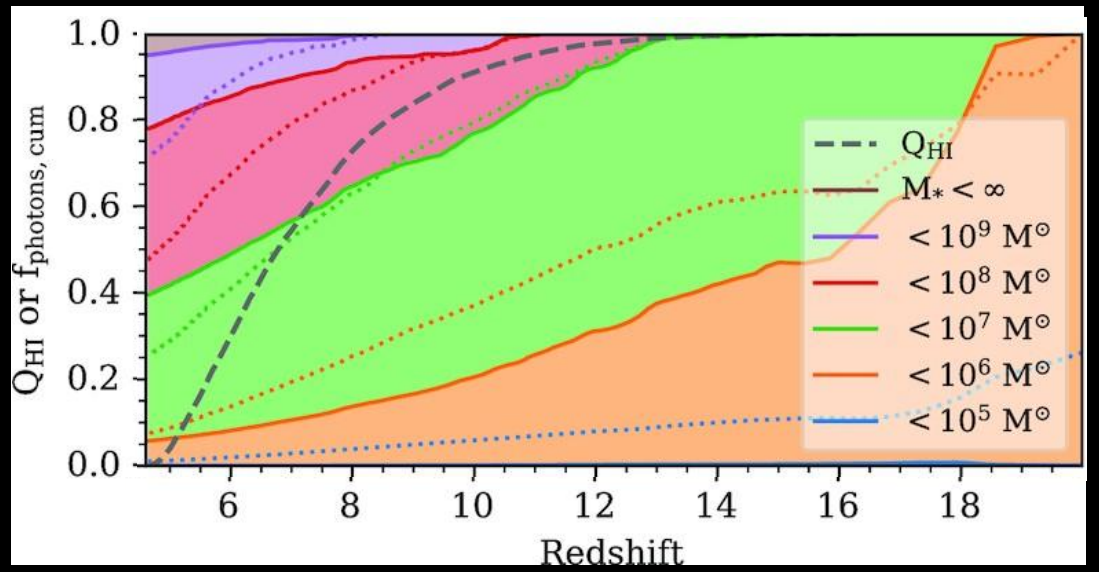
The sources responsible for reionisation

The Active Galactic Nuclei (*AGN*)



Naidu et al. (2021)

The star-forming galaxies

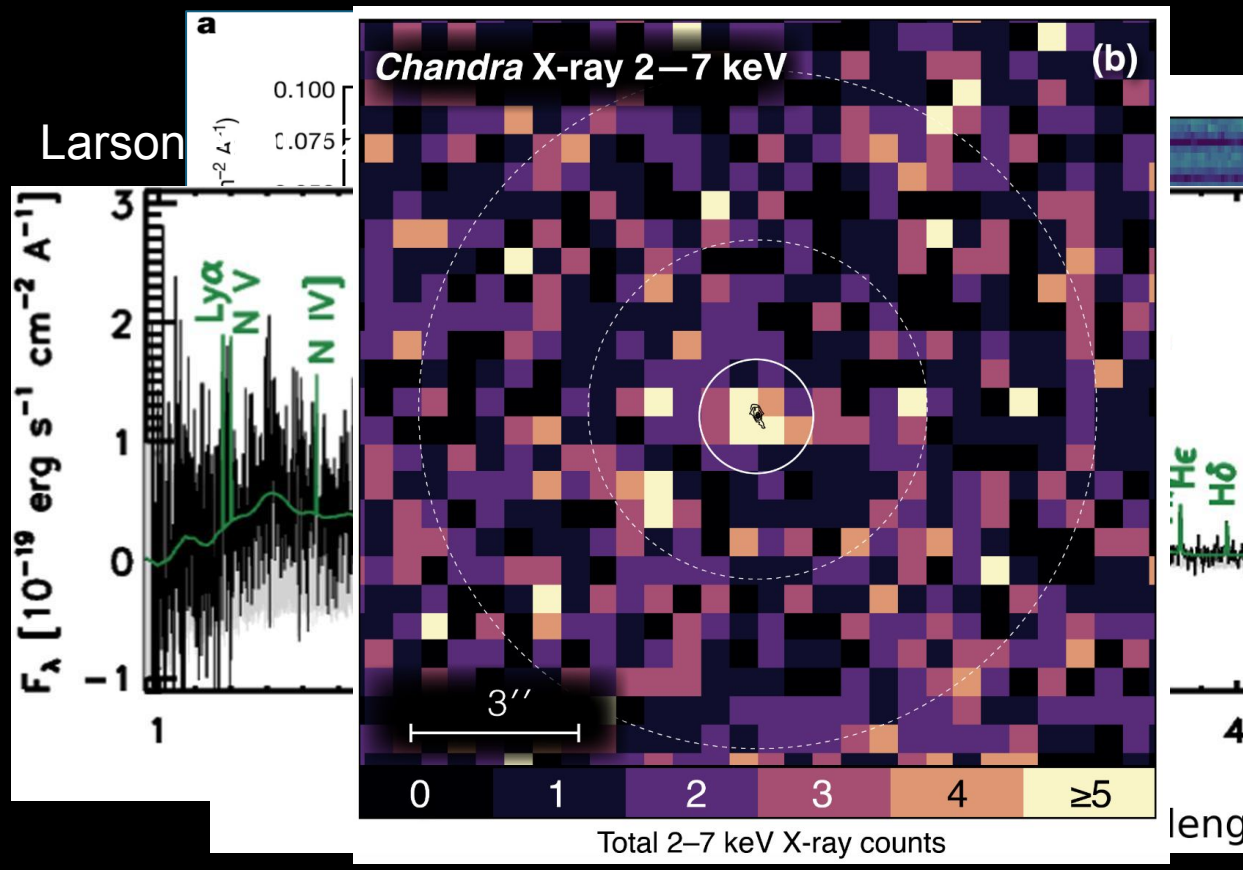


Rosdahl et al. (2022)
CRAL

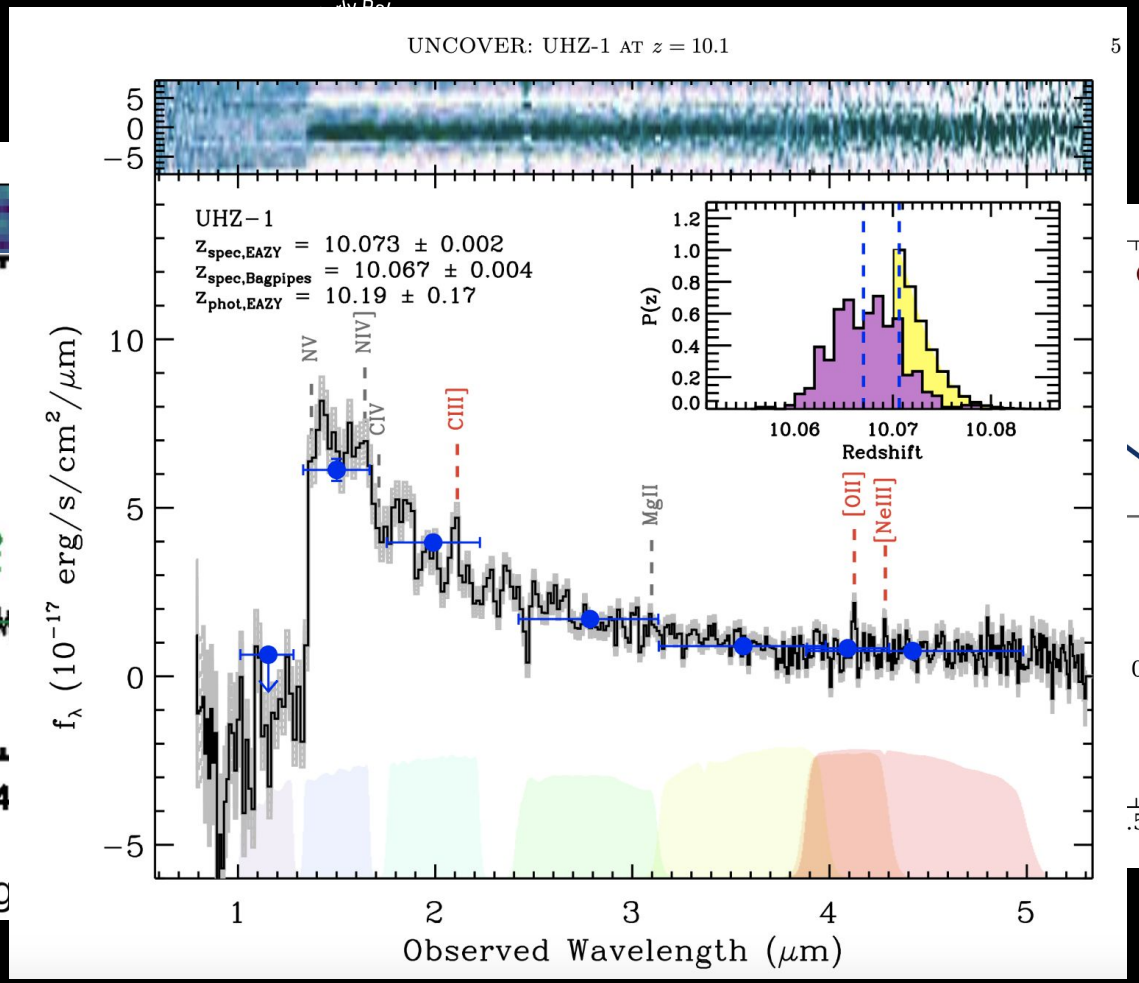
A result that restart the debate: *many AGNs in the epoch of reionisation ?*

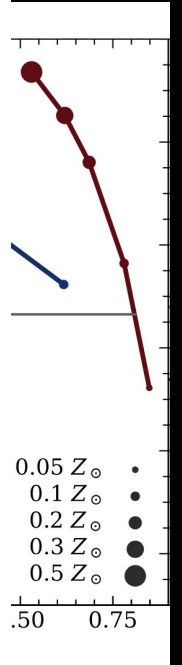
Maiolino et al. (2024)

Larson et al. (2024)

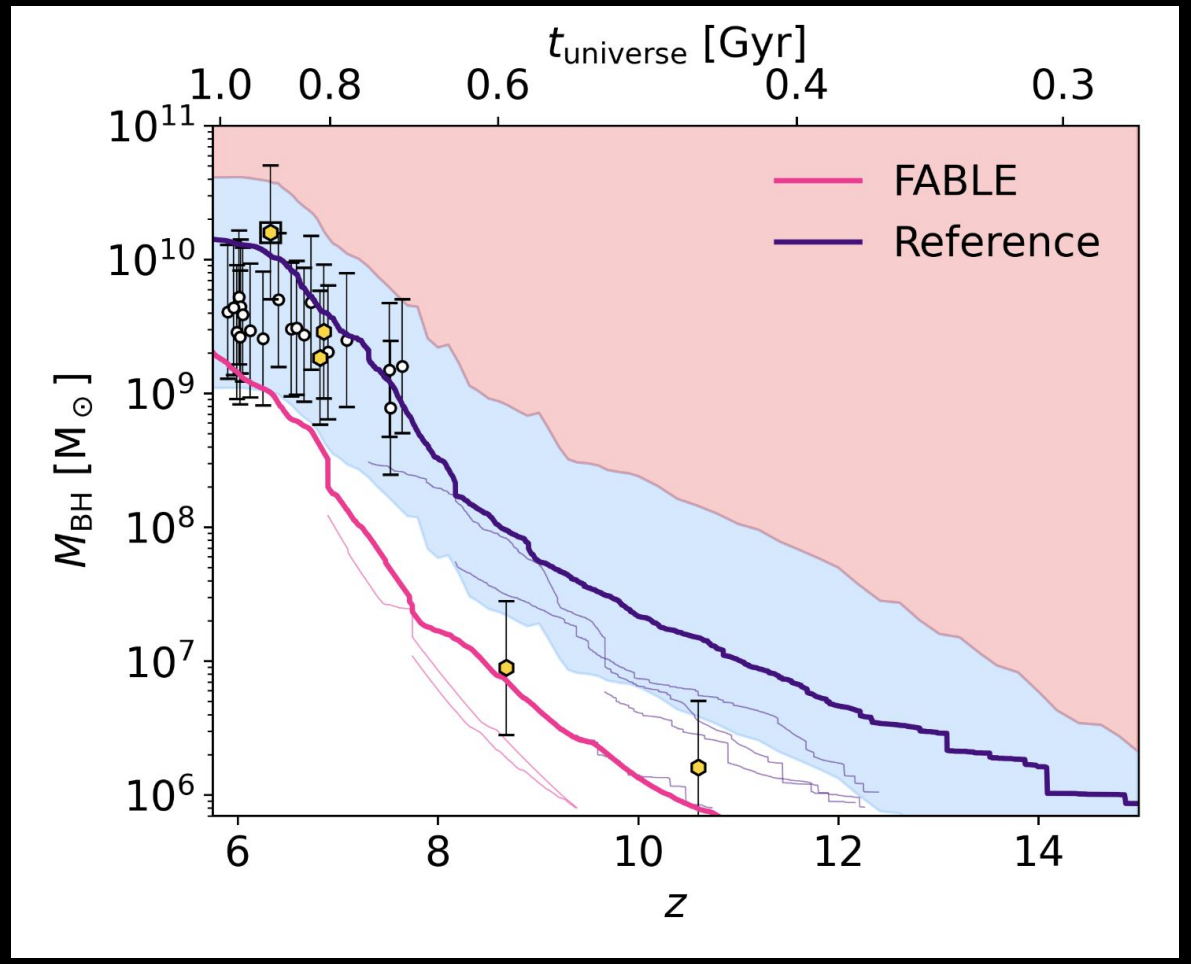


Goulding et al. (2024)





A result that restart the debate: *many AGNs in the epoch of reionisation ?*



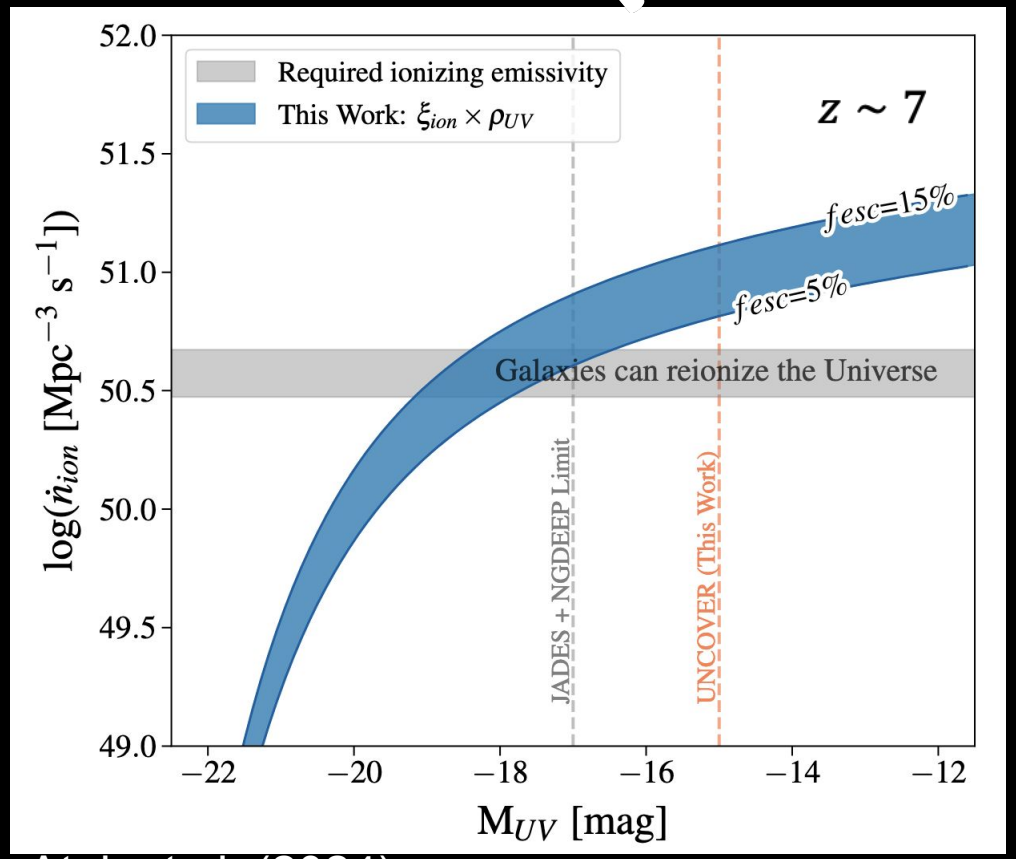
Bennett et al. (2024)

- Every week *Webb* identifies AGNs at z>6. This ask several questions :
  - What are the origin of this supermassive black holes in the early Universe ?
  - What is the fraction of AGN within the first billion years of the Universe ?
  - What are their contribution to the reionisation process ?

 Need for a large spectroscopic follow-up campaign with MOS.

The key role of the faintest galaxies at high-z

UNCOVER



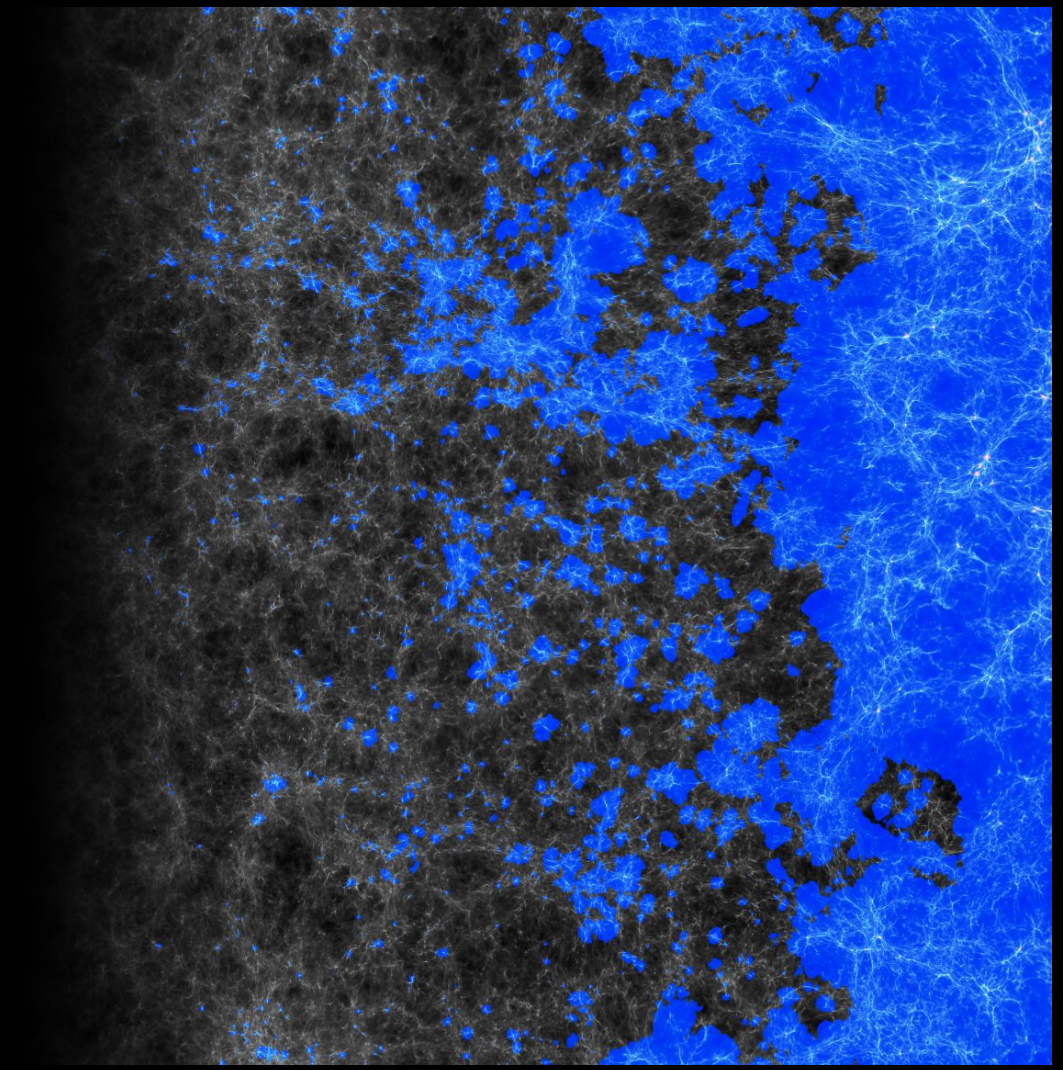
Atek et al. (2024)

IAP

- Despite the huge sensitivity of *Webb*, the use of gravitational telescopes is clearly needed to probe the faintest galaxies
- Preliminary results using galaxy clusters show that the faintest galaxies are sufficient to explain the reionisation process, and that they have a major role in this process.

There is a need for a huge spectroscopic follow-up campaign for the faintest galaxies.

The main questions on primeval galaxies



Ocvirk et al. (2018) - ObsAS

- When did the first stars and galaxies form in the early Universe ?
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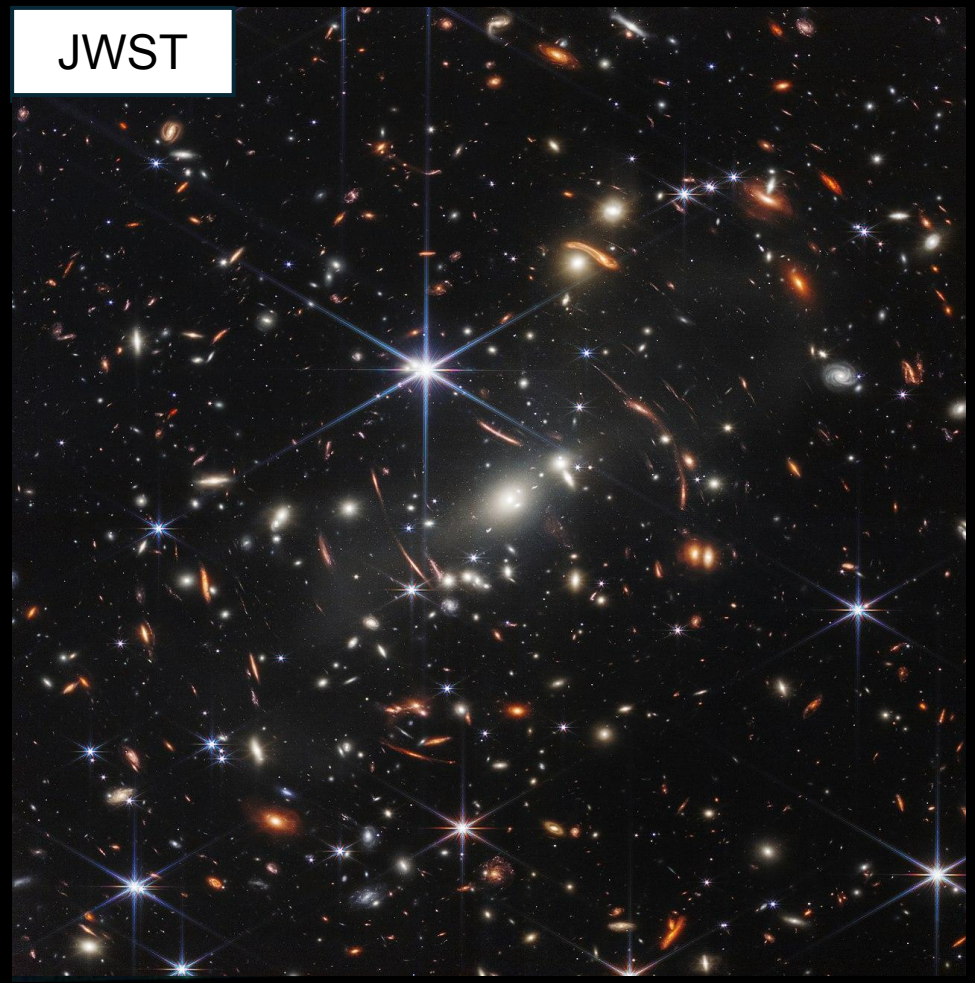
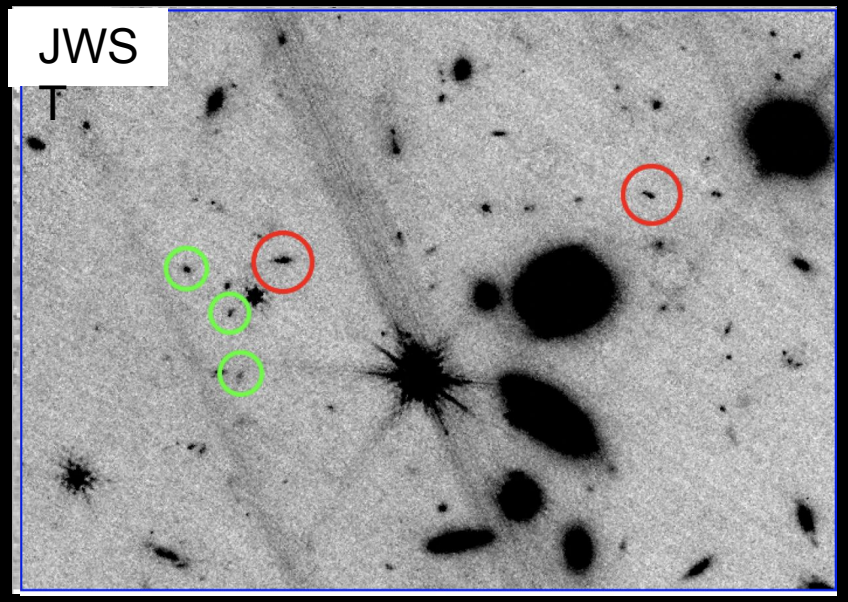
- How did the first structures form in the early Universe ?

The environment of primeval galaxies

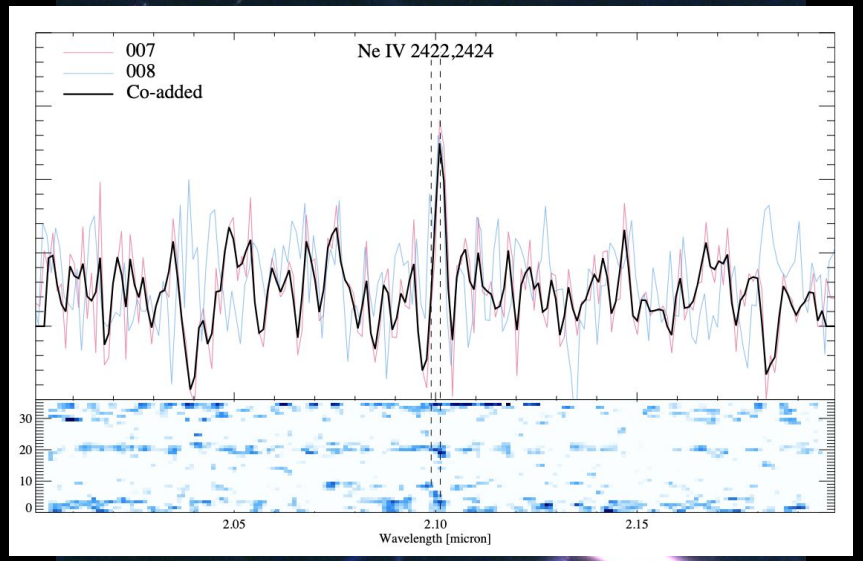


Laporte et al. (2022)
LAM



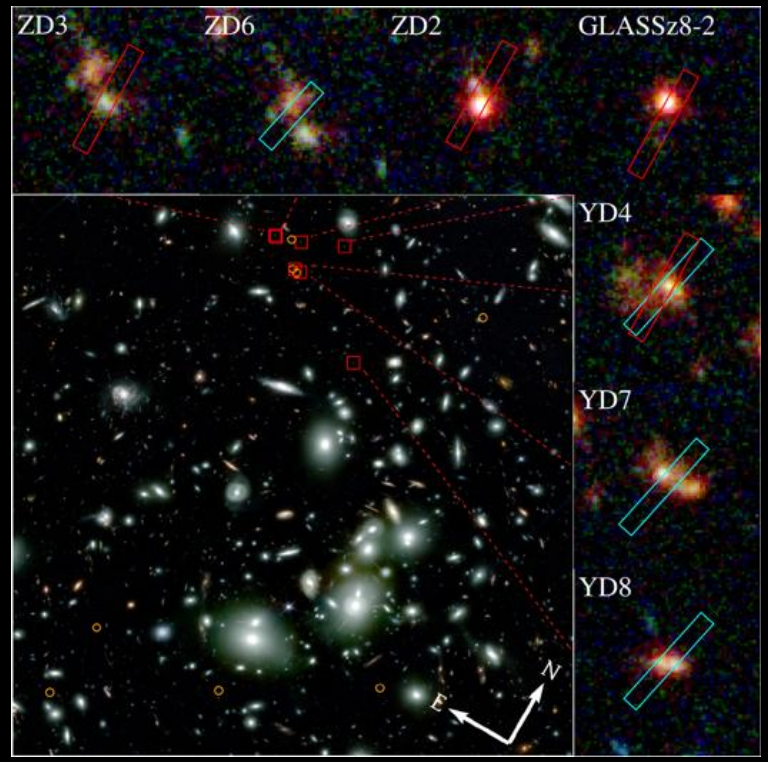
- *Webb* can detect galaxies well beyond *Hubble's limits*
- We can for the first time detect and study the first structure in the early Universe

The three most distant proto-clusters with AGN in their cente

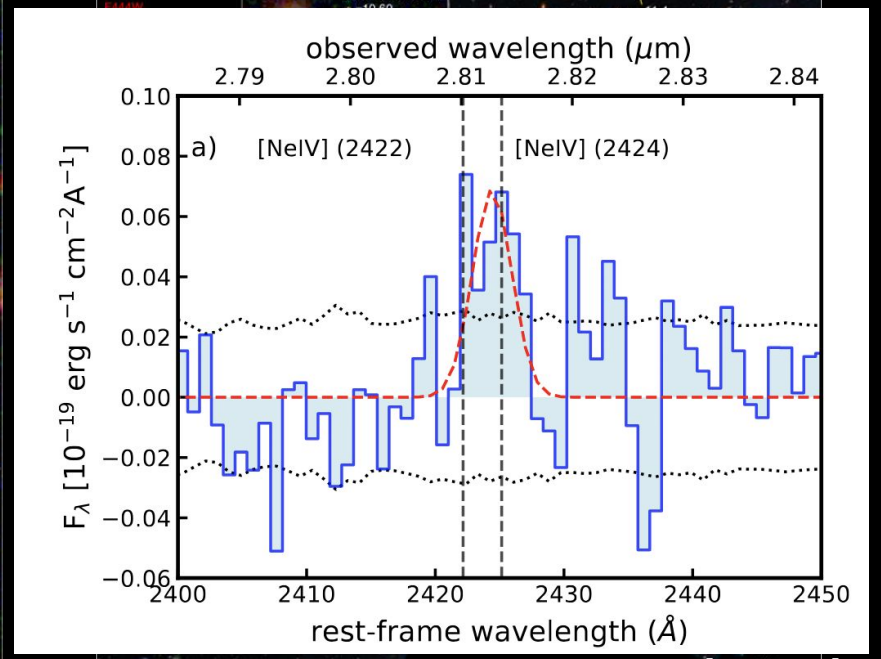


Brinchmann et al. (2023)

Laporte et al. (2022)
LAM

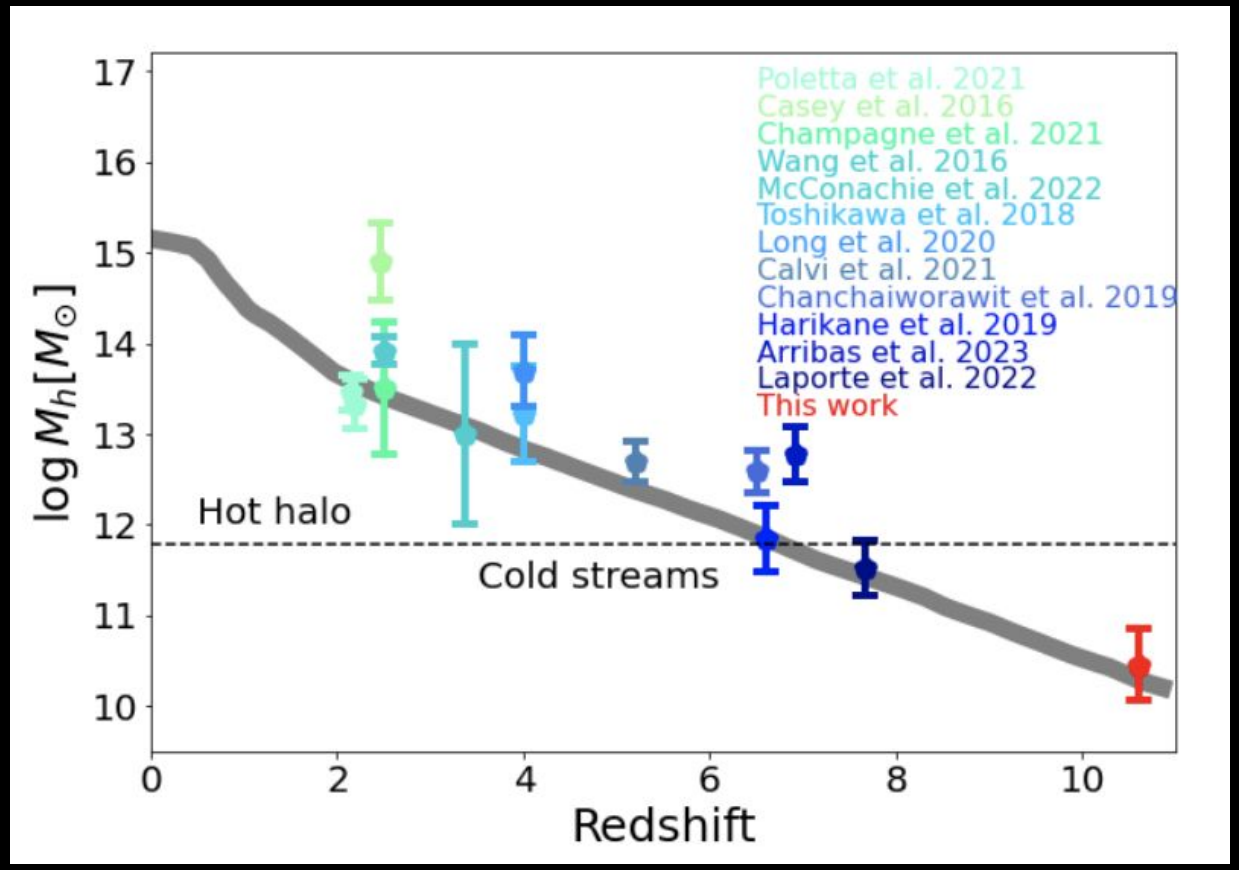


Morishita et al. (2023)



Maiolino et al. (2024)
Tacchella et al. (2023)

The formation of the first structures



Scholtz & Witten et al. (2023)

- To date , at least 3 proto-clusters have been identified in *Webb* ‘s images
- They allow to trace the evolution of the large scale structures known today (eg. Amas de Coma)

 There is a need for identifying other proto-clusters

 There is a need for a large spectroscopic follow-up campaign with MOS.

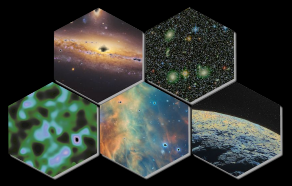

Conclusions

New facilities within the next decade

Huge spectroscopic follow-up campaign on the brightest targets

Huge spectroscopic follow-up campaign with multi-object spectrographs

Huge spectroscopic campaign on the faintest targets at high-z



MOSAIC

SuMIRe Prime Focus Spectrograph

The need for identifying proto-clusters in Webb data in preparation for the first SKAO observation

SKAO

The first billion years of the Universe seen by the *James Webb* Space Telescope

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LE FIGARO

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Vers une révolution cosmologique majeure ?

Par Tristan Vey

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