Galaxy growth and physical properties at the frontier of our Universe

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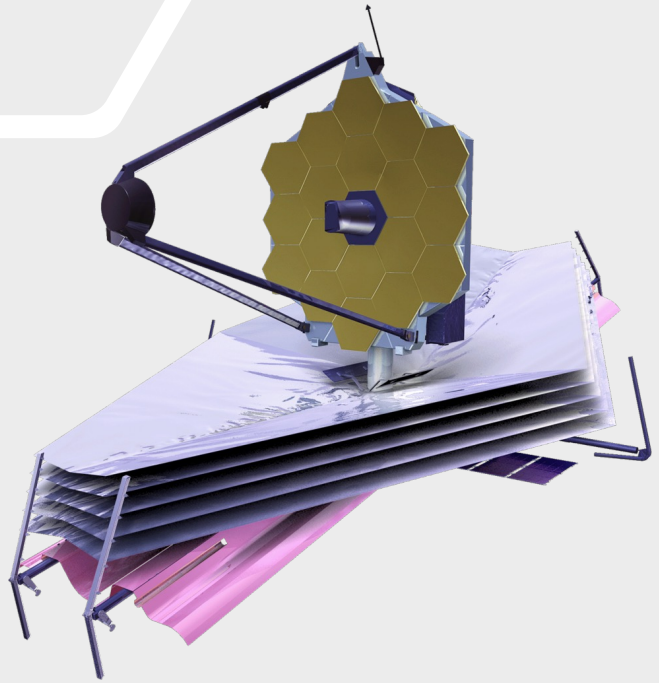
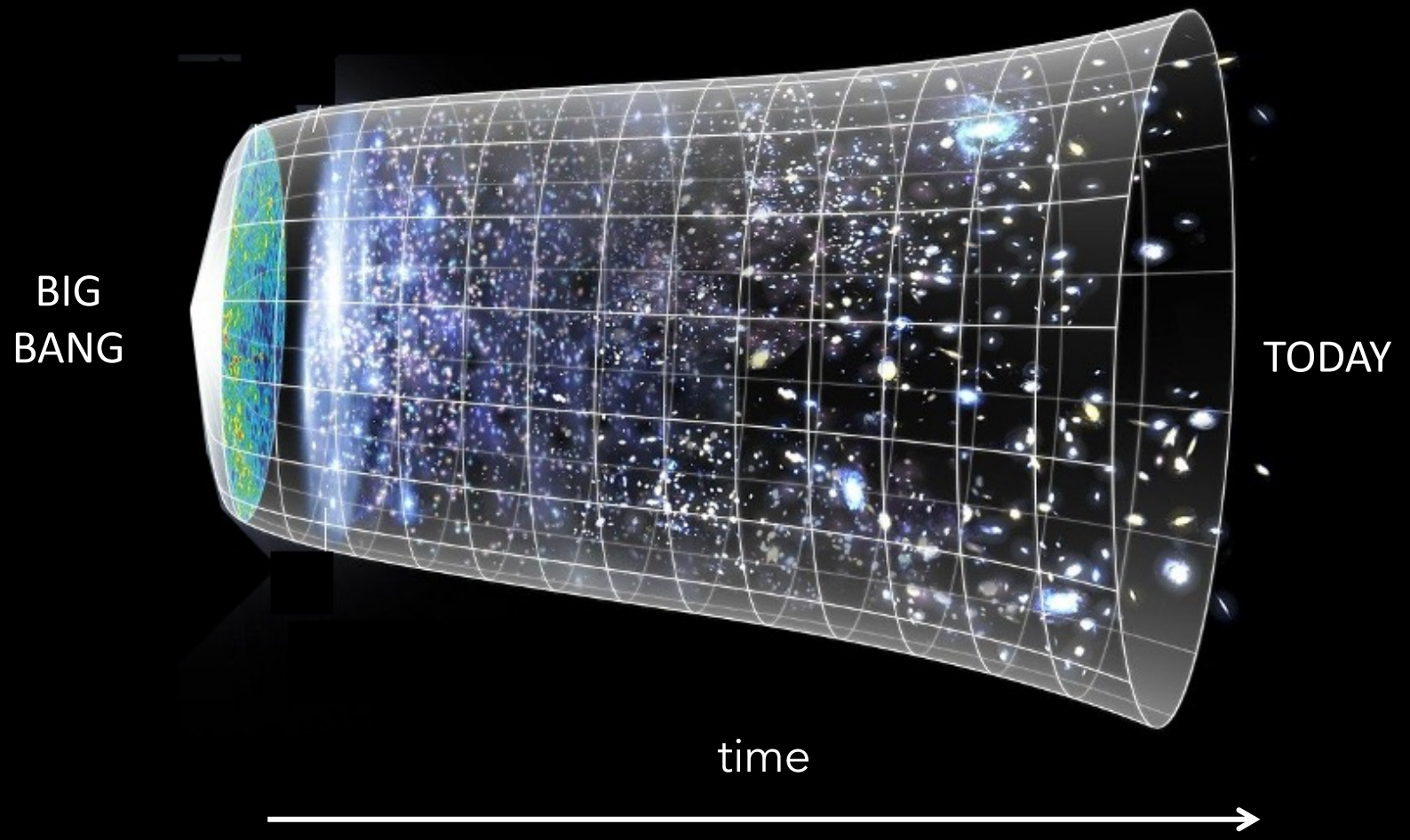


Vulcano Workshop 2024 “Frontier Objects in Astrophysics and Particle Physics”, Ischia, 26 May – 1 Jun 2024

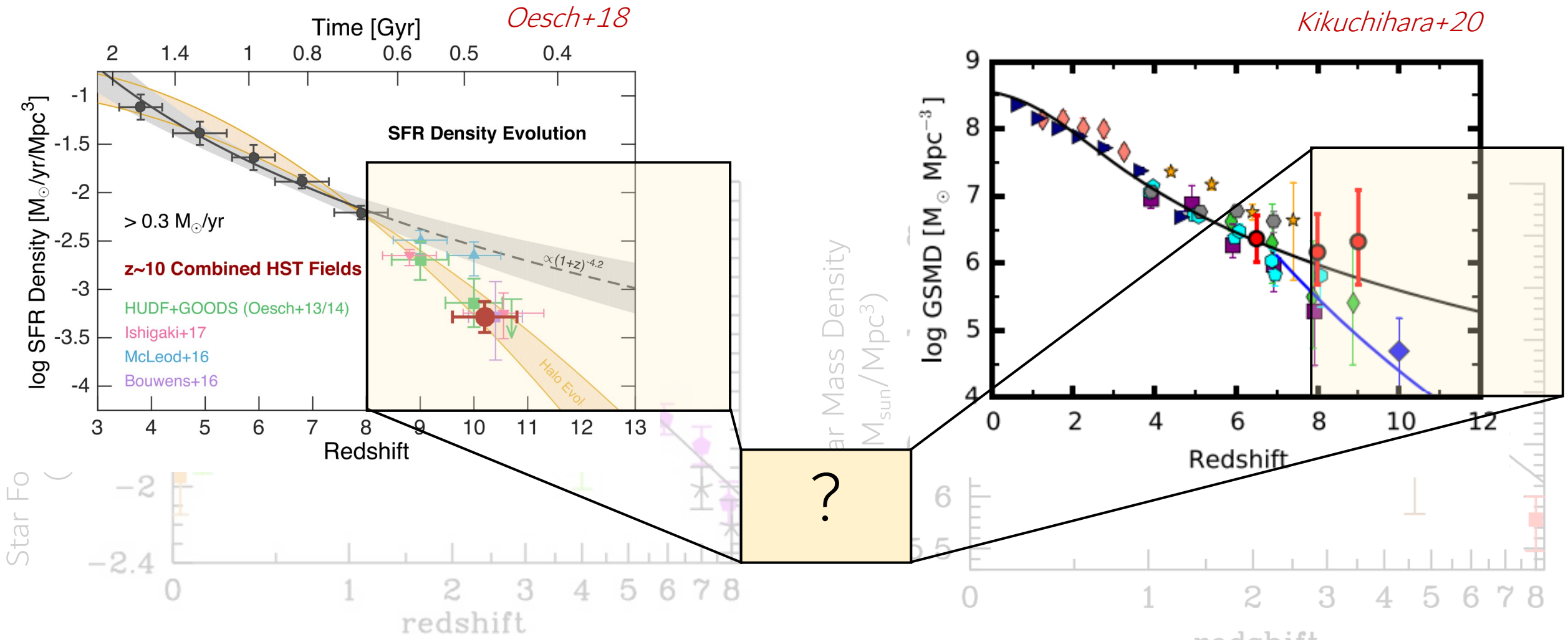
The primordial Universe was

- denser
- warmer
- no stars
- no ”heavy” elements

Open question
When and how did the first galaxies form?

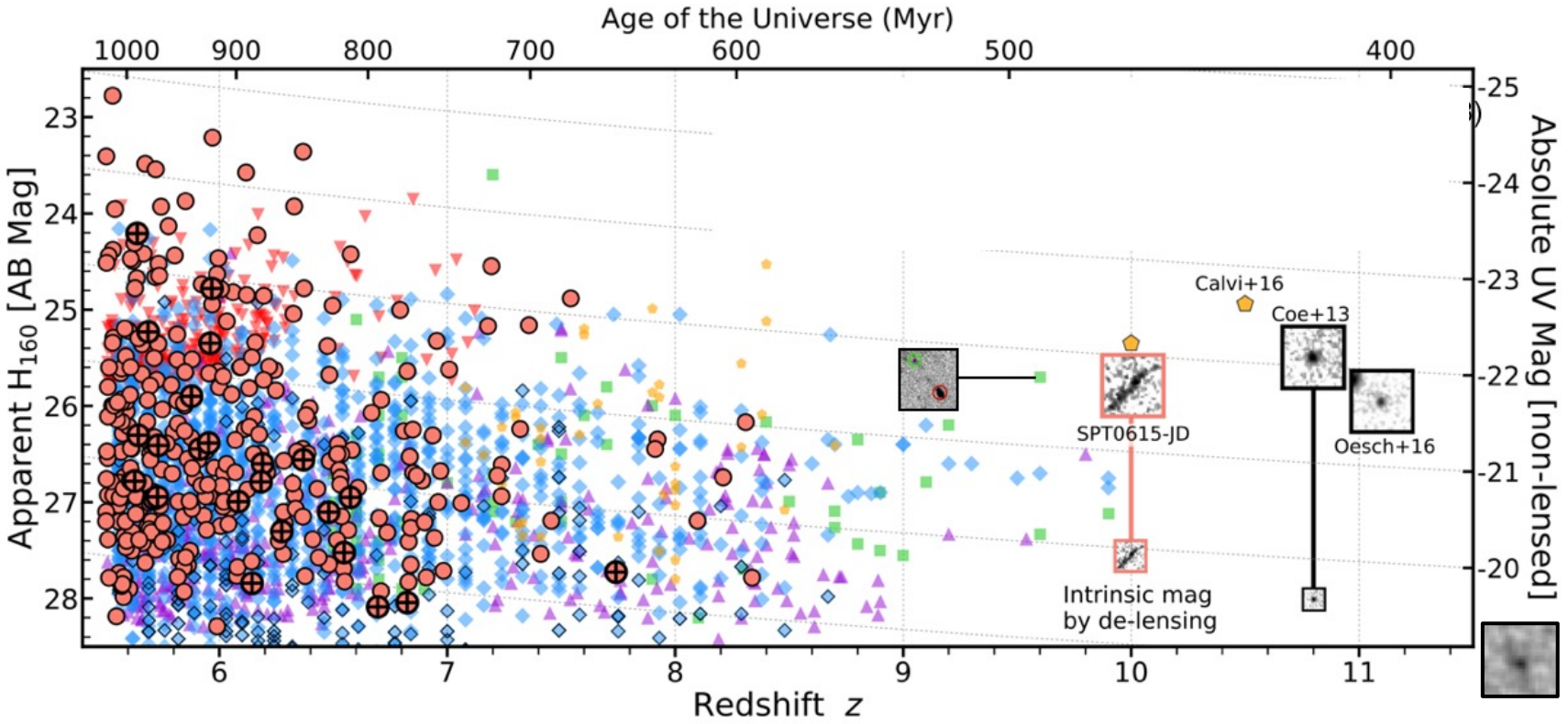


Galaxy growth through cosmic time



- pretty well established at z<~6
- affected by huge uncertainties at earlier epochs

The Hubble legacy

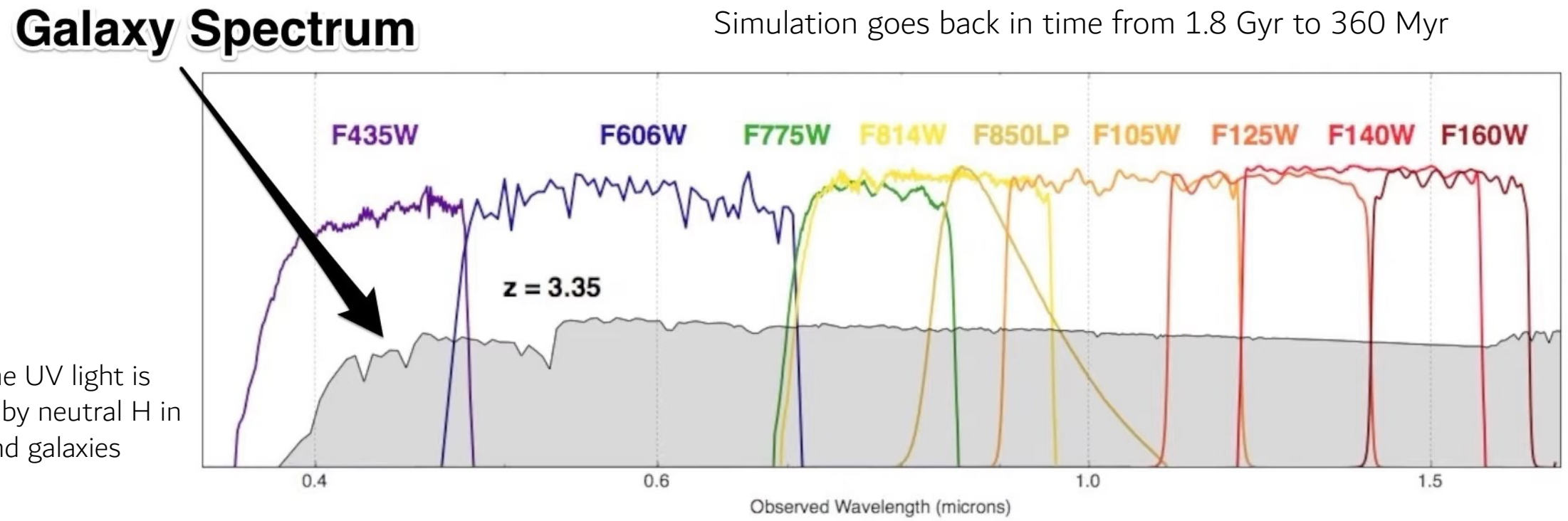


(adapted from) Salmon+18

Why an IR telescope?

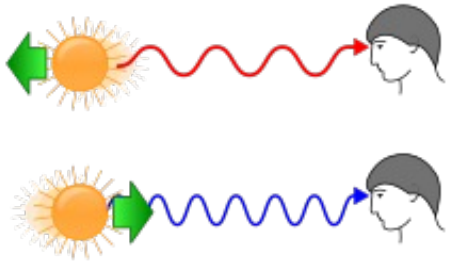
a) detection of z>12 galaxies

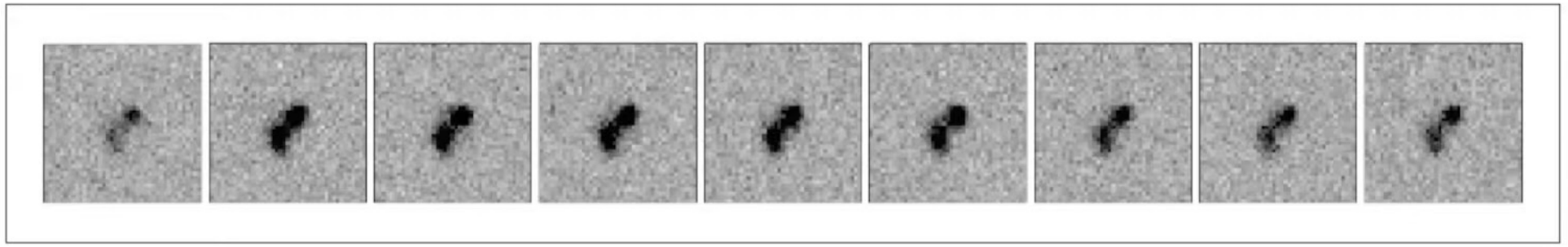
Simulation goes back in time from 1.8 Gyr to 360 Myr



Rest-frame UV light is absorbed by neutral H in and around galaxies

COSMOLOGICAL REDSHIFT: due to space expanding while light travels

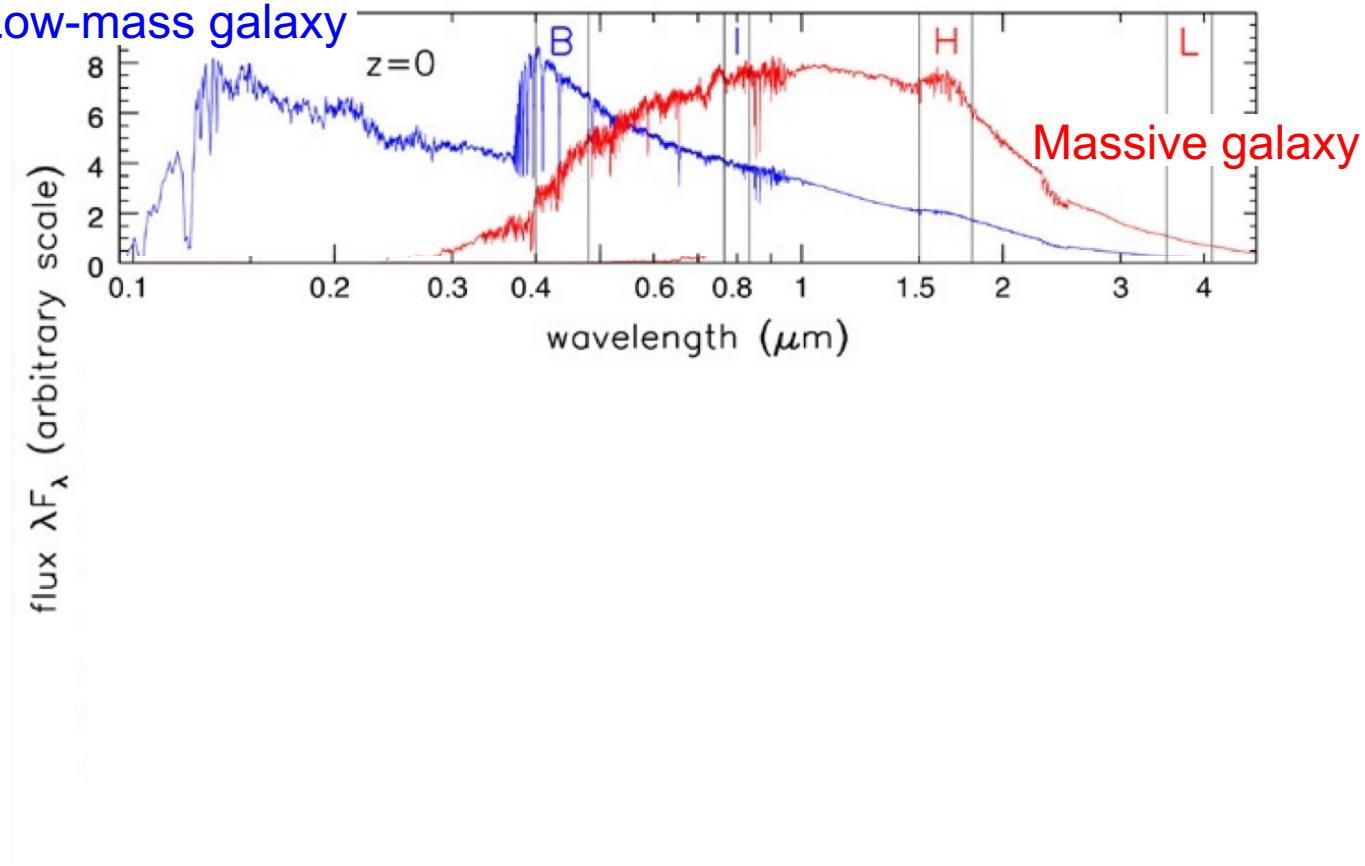




Credit: D. Magee, R. Bouwens, P. Oesch, & G. Illingworth

Why an IR telescope?

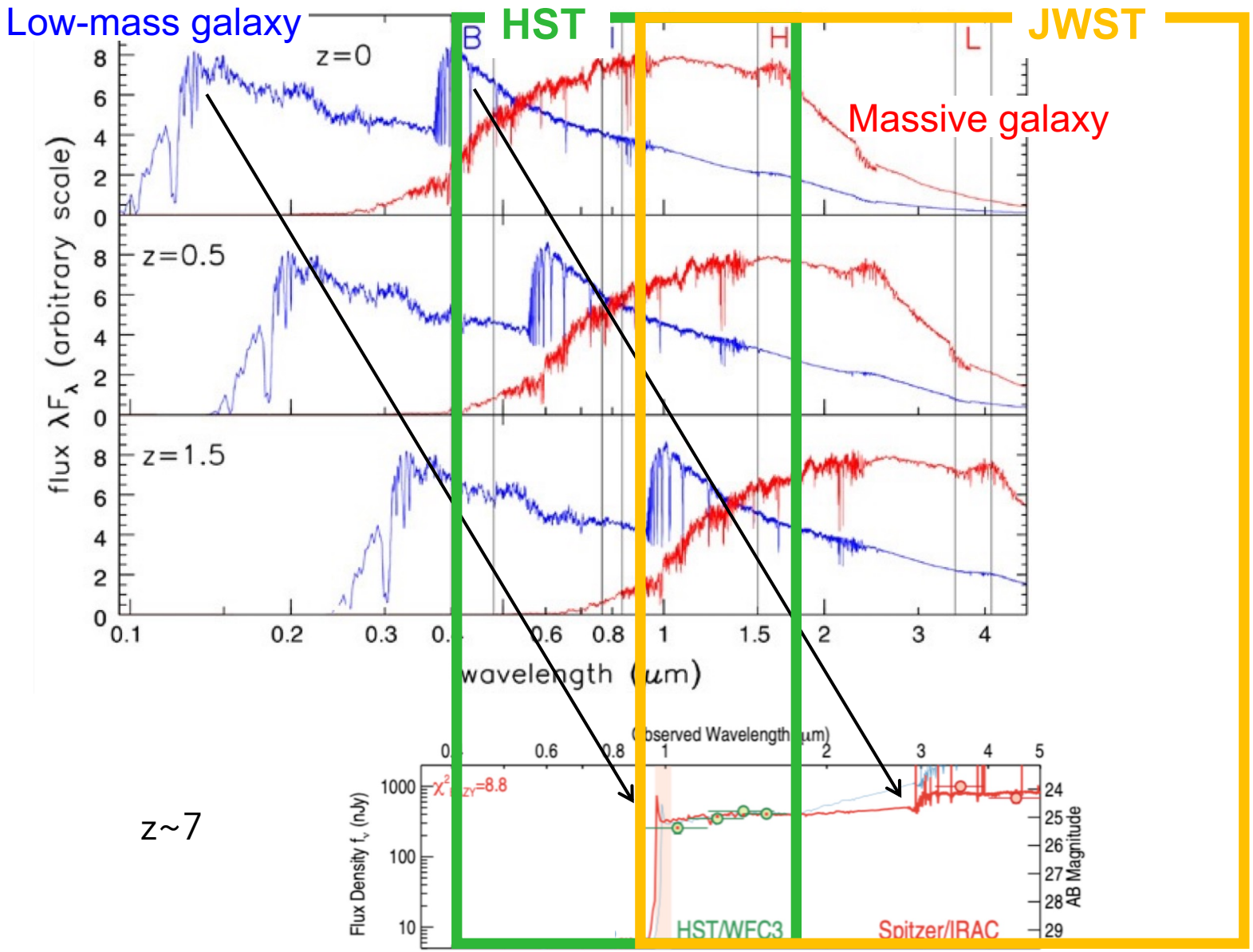
Low-mass galaxy



Massive galaxy

Why an IR telescope?

b) estimate of accurate physical properties at z>~7

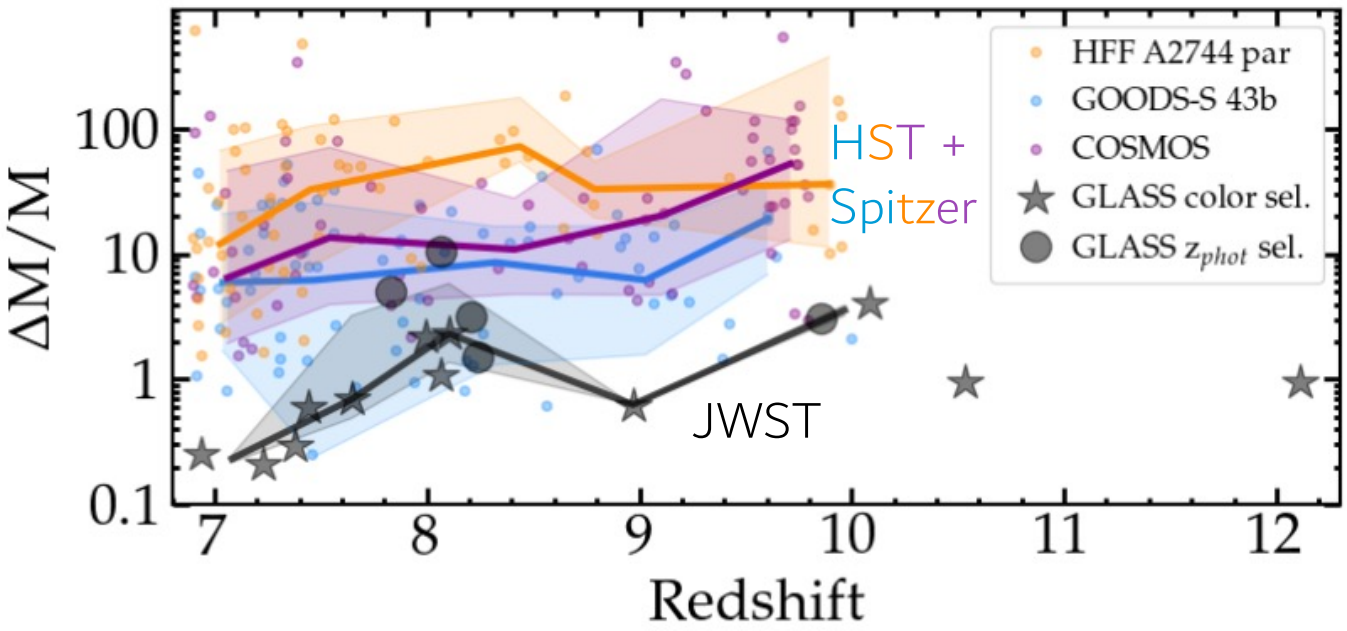


z~7

JWST: improvement in the stellar mass estimates

PS+23

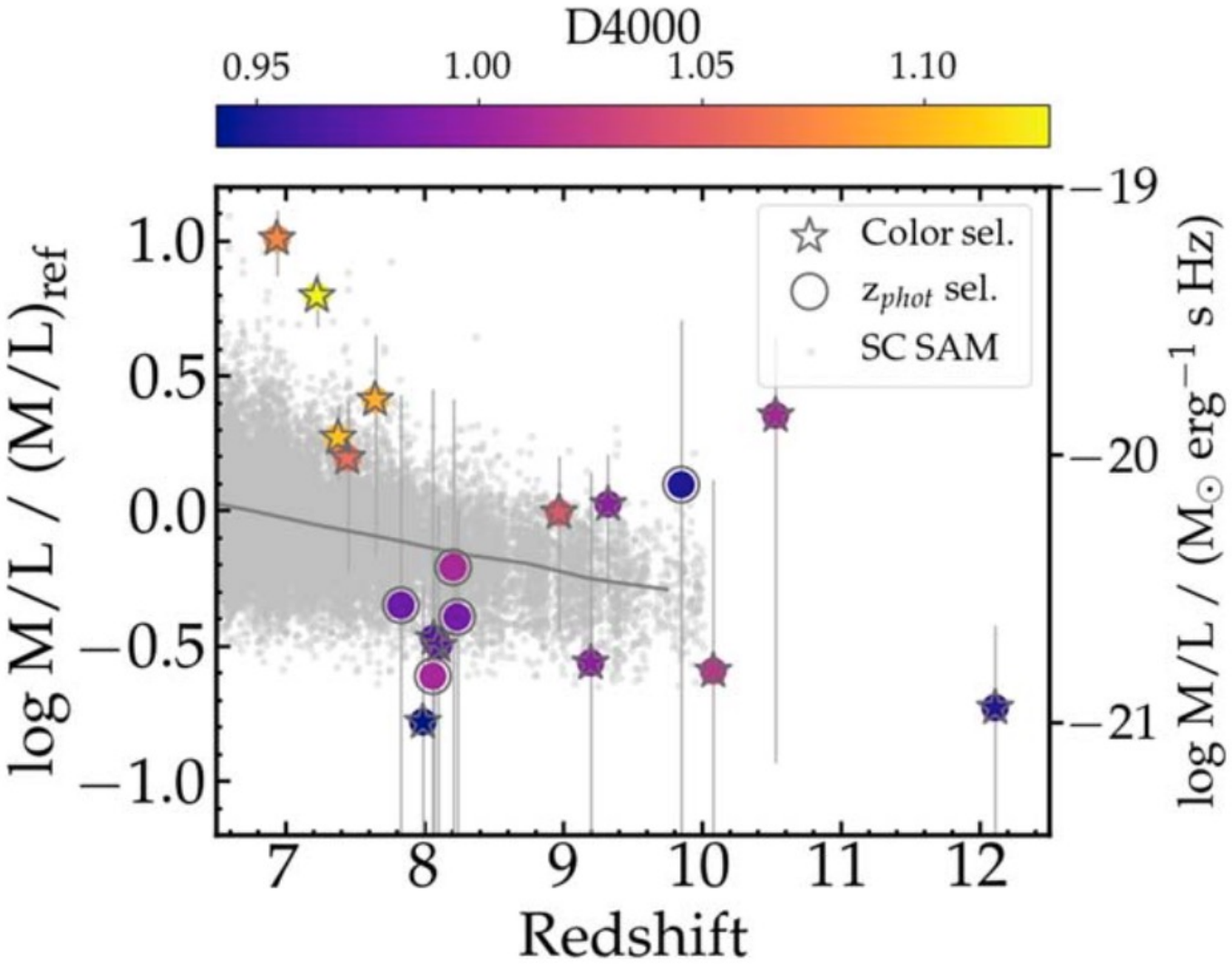
Stellar mass accuracies improved by ~10x (at least)



and better control of systematics

see also Papovich, … PS+23

A variety of physical conditions at high-z



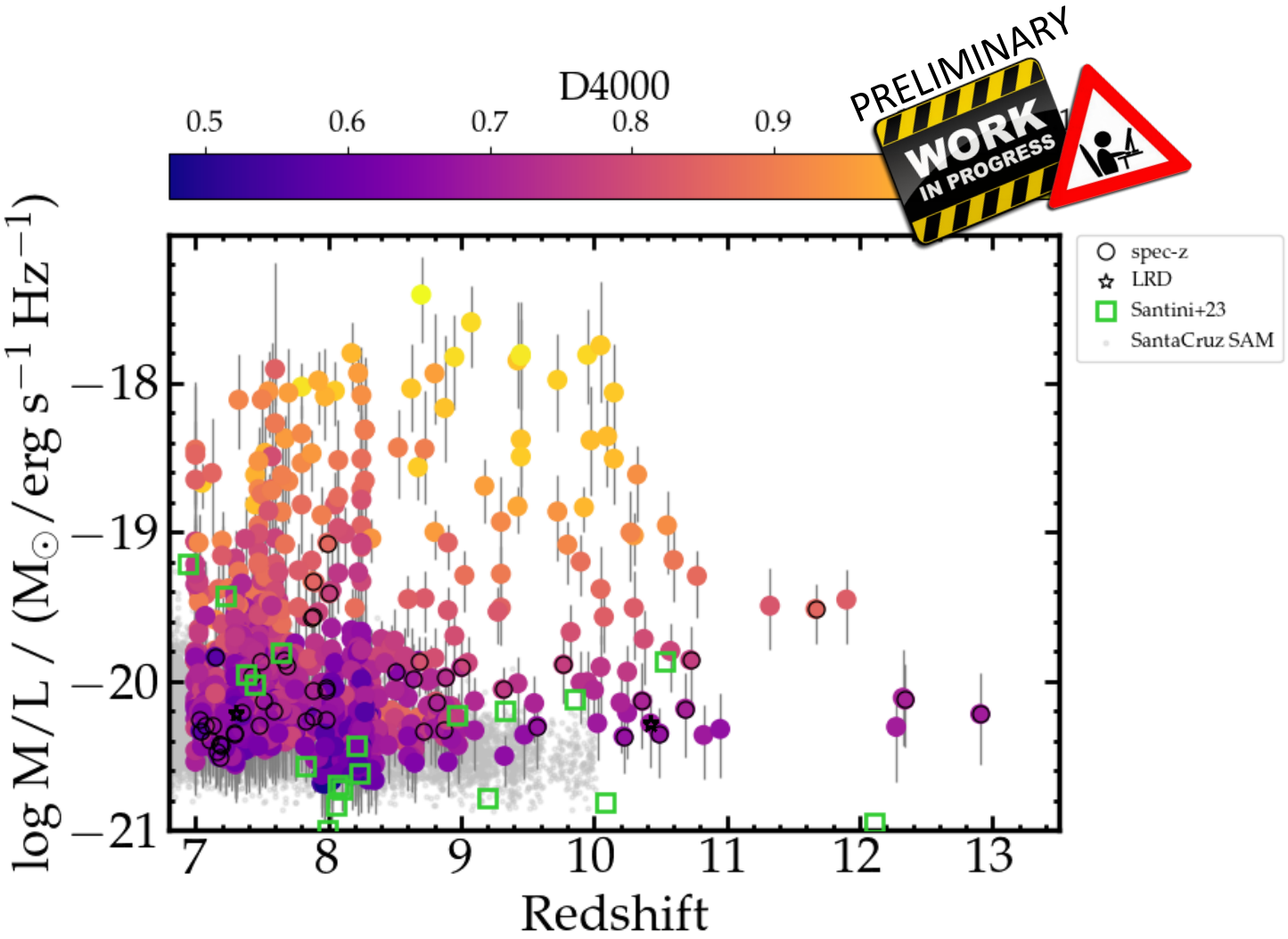
PS+23

Wide range in Mass / Luminosity:

- heterogeneous high-z galaxy population (not reproduced by models)

Wide diversity also found in the ISM conditions
(*Schaerer+22, Sanders+23, Cameron+23, Curti+23, Tang+23, D'Eugenio+23, Nakajima+23, …*)

A variety of physical conditions at high-z



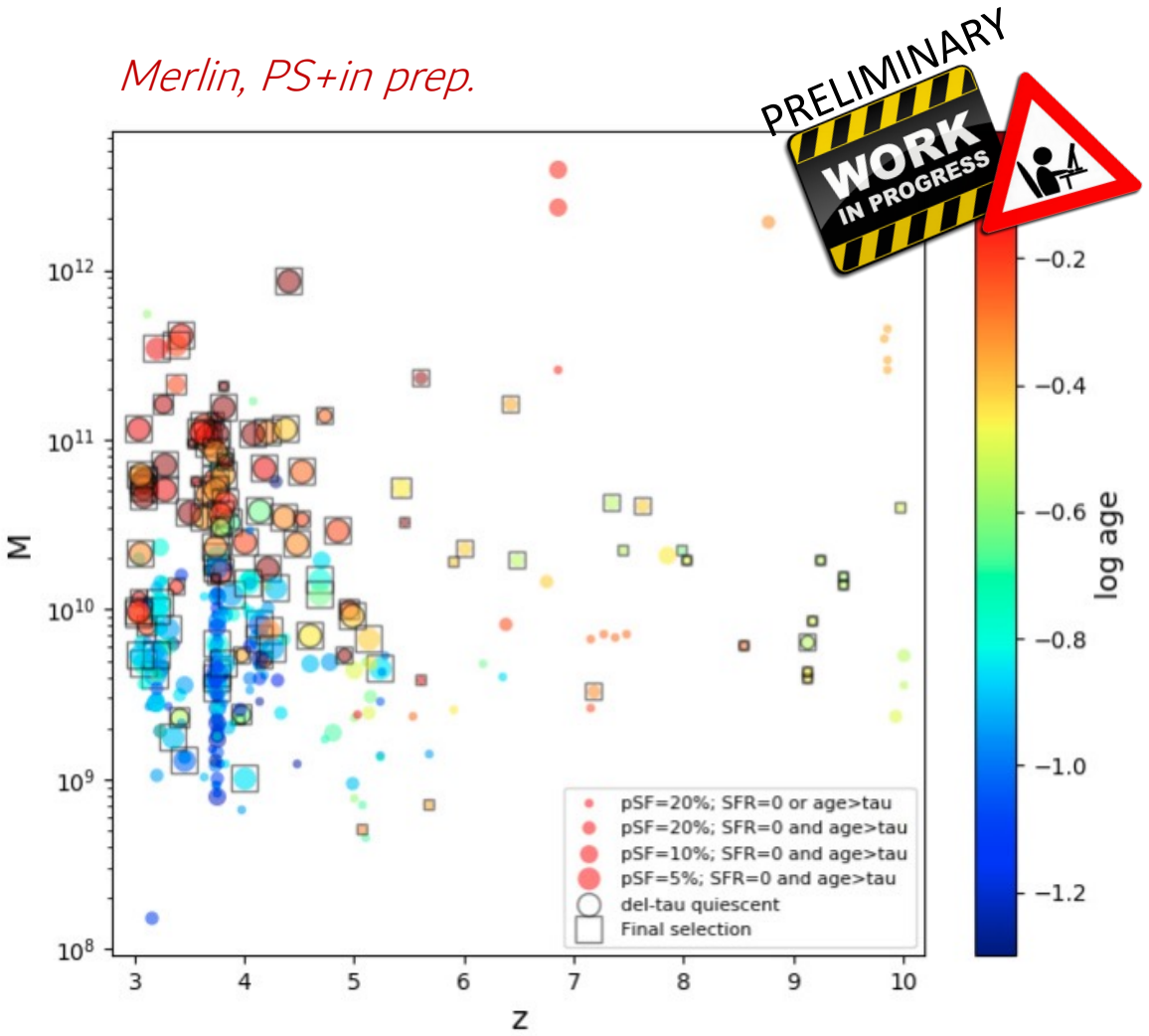
PS+in prep.

Wide range in Mass / Luminosity:

- heterogeneous high-z galaxy population (not reproduced by models)
- high M/L → evolved stellar populations (galaxy formation faster than thought?)

...including passive galaxies at very early epochs

Merlin, PS+in prep.



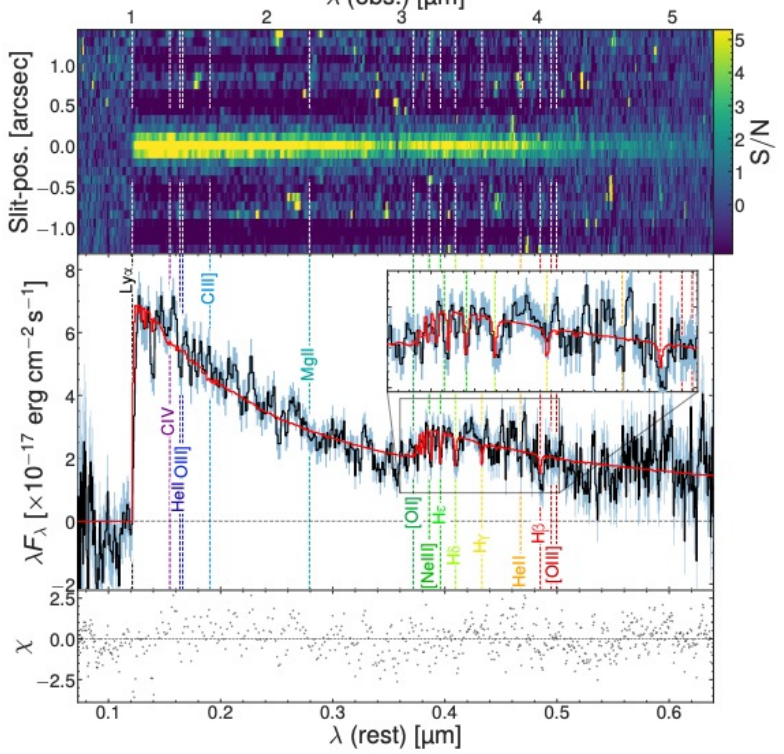
see also *Valentino+23, Carnall+23a, Nanayakkara+24, Kakimoto+24, ...*

with several candidates already spectroscopically confirmed

z~7.3

t_{Univ}~700Myr

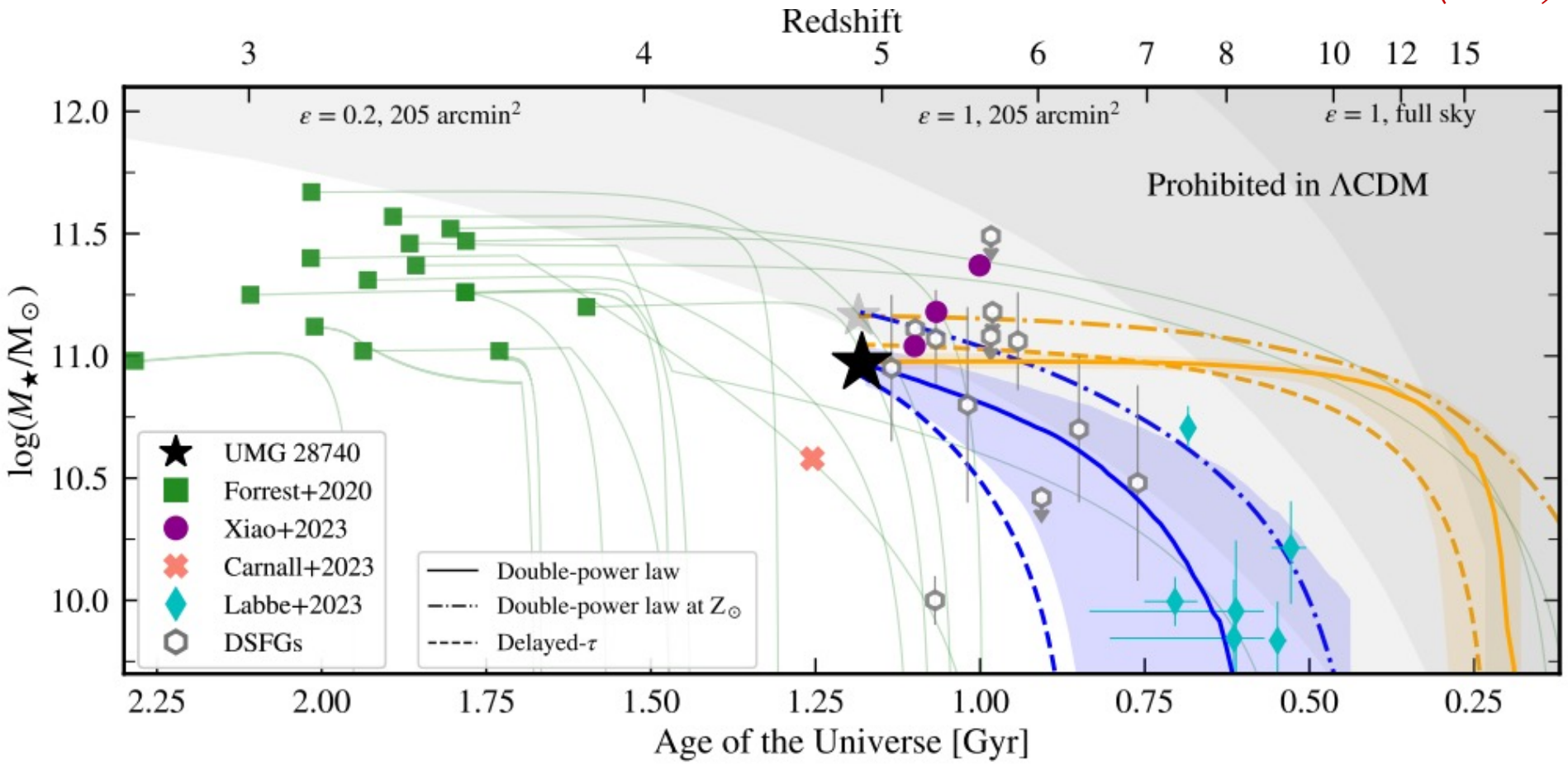
Looser+24



see also *Strait+23, Carnall+23b,24 Nanayakkara+24, Kakimoto+24, Urbano Stawinski+24 (subm.)...*

Too rapid mass build-up in contrast with ΛCDM?

Urbano Stawinski+24 (subm.)

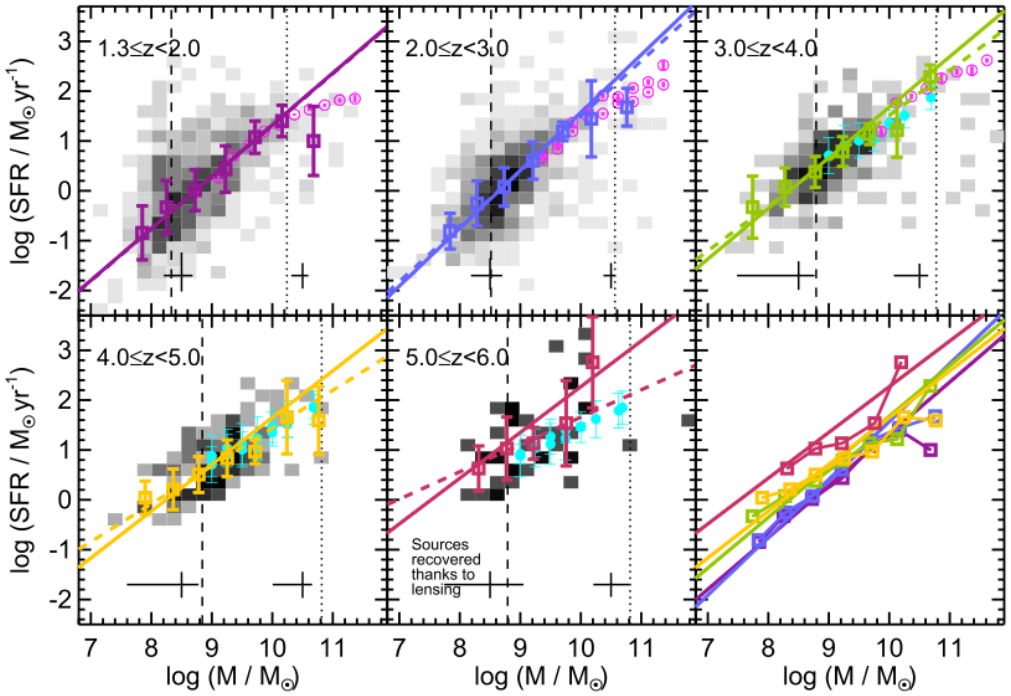


See also *Menci+20,22, Boylan-Kolchin23, Lovell+23, Lin+23, Gong+23, Parashari&Laha23, Xiao+23, Glazebrook+24, …*

Galaxy growth through cosmic time: the relation between M_{star} and SFR

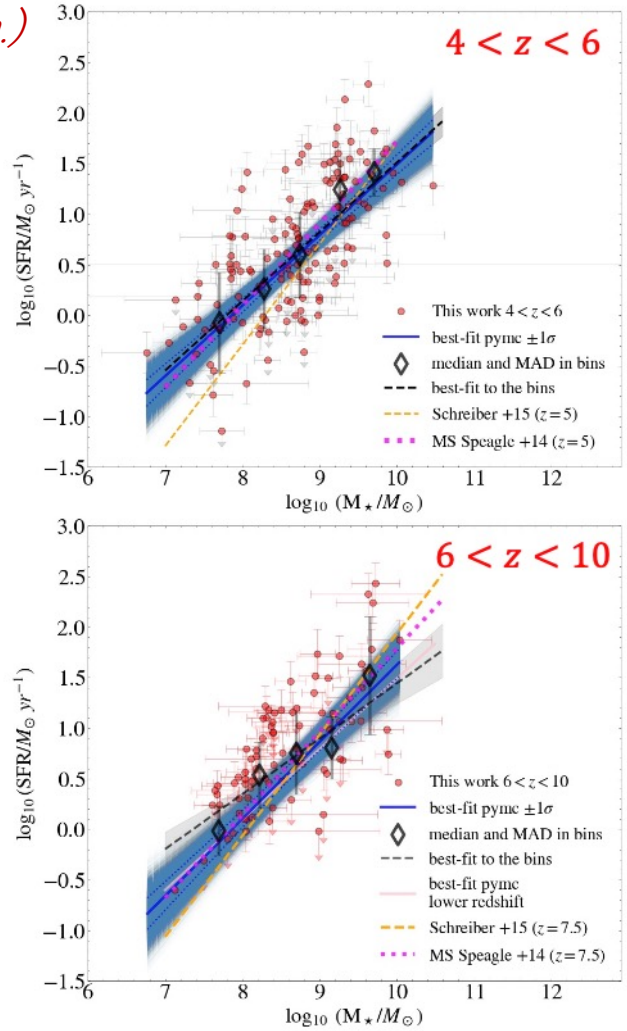
Slope ~ constant, normalization increases from low to high z

PS+17

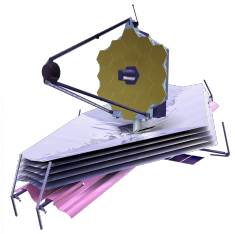


Brinchmann+04, Daddi+07, Noeske+07, Santini+09,17, Rodighiero+11, Lamastra+13, Whitaker+14, Speagle+14, Schreiber+15, Popesso+22, and many many others …

Calabrò, Pentericci, PS+23 (subm.)

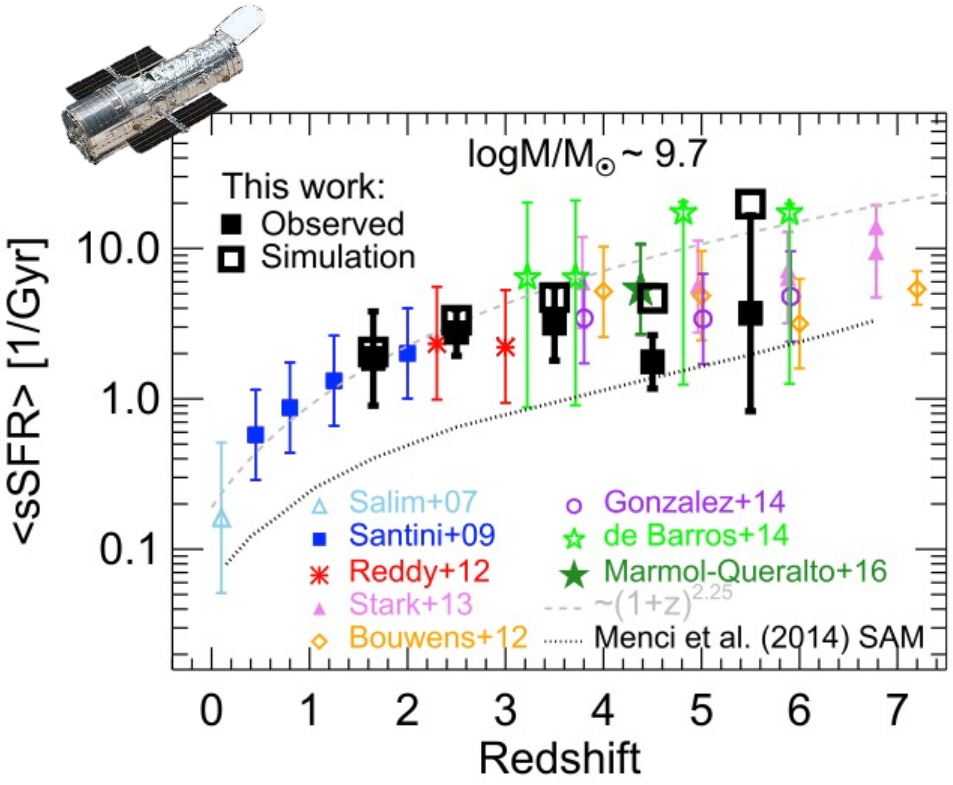


see also *Leethochawalit+23, Rodighiero+23, Cole+23 (subm.), …*



Galaxy growth through cosmic time: the relation between M_{star} and SFR

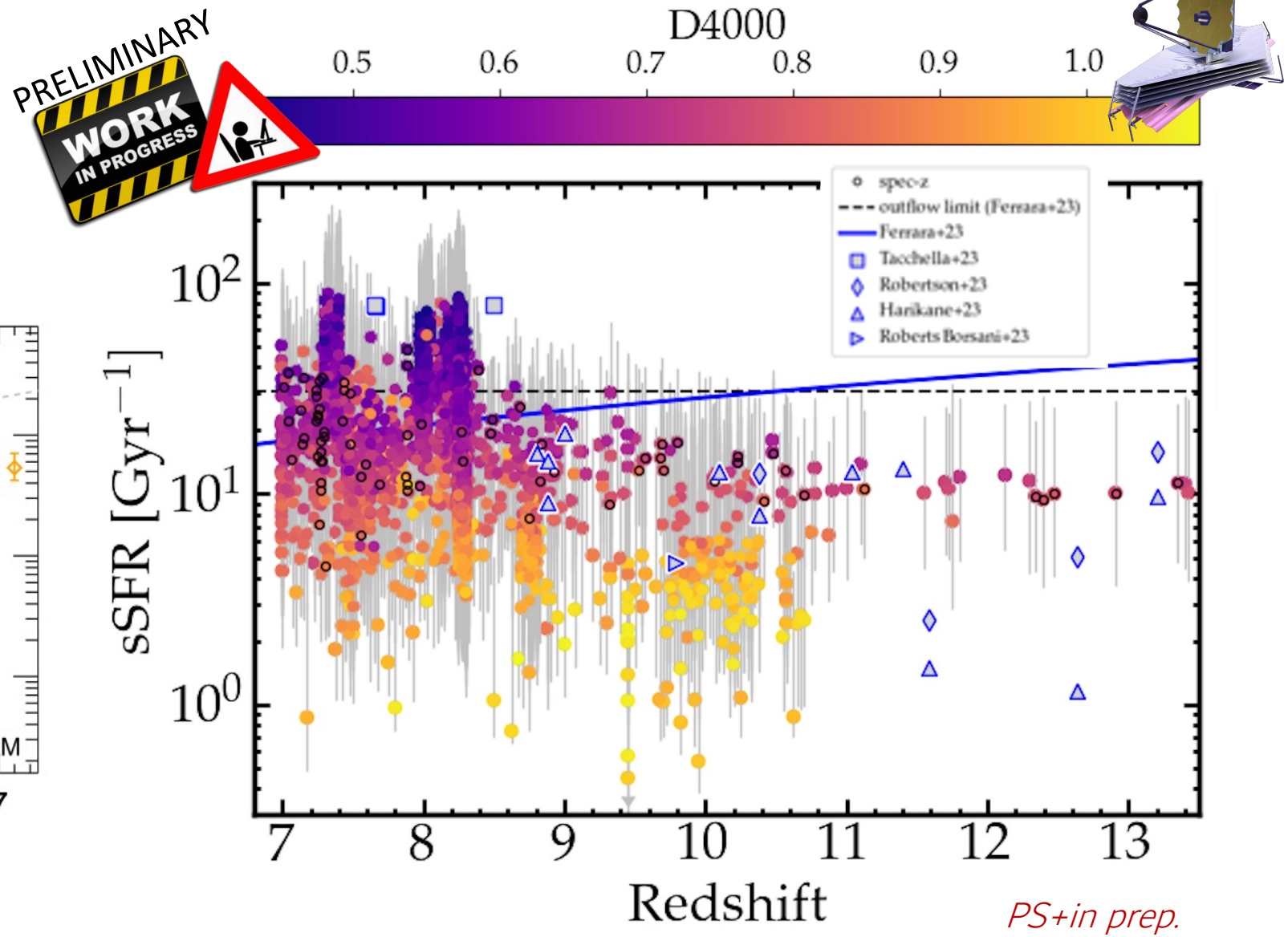
sSFR=SFR/M_{star}



PS+17

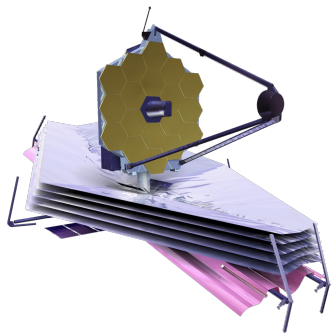
PRELIMINARY

WORK IN PROGRESS



PS+in prep.

Take-home messages



- JWST allows for the first time to investigate the first phases of galaxy growth and reveal their physical properties
- A lot of early and bright galaxies see next talk by Marco Castellano
- Distant galaxies (z>7) come in a variety of physical conditions,
- including passive galaxies already in place in the first Gyr
- This apparent very rapid mass build-up is impacting our understanding of galaxy formation (higher SF efficiencies? revised cosmological model?)

Thank you for your attention