Hunting for the First Galaxies with JWST

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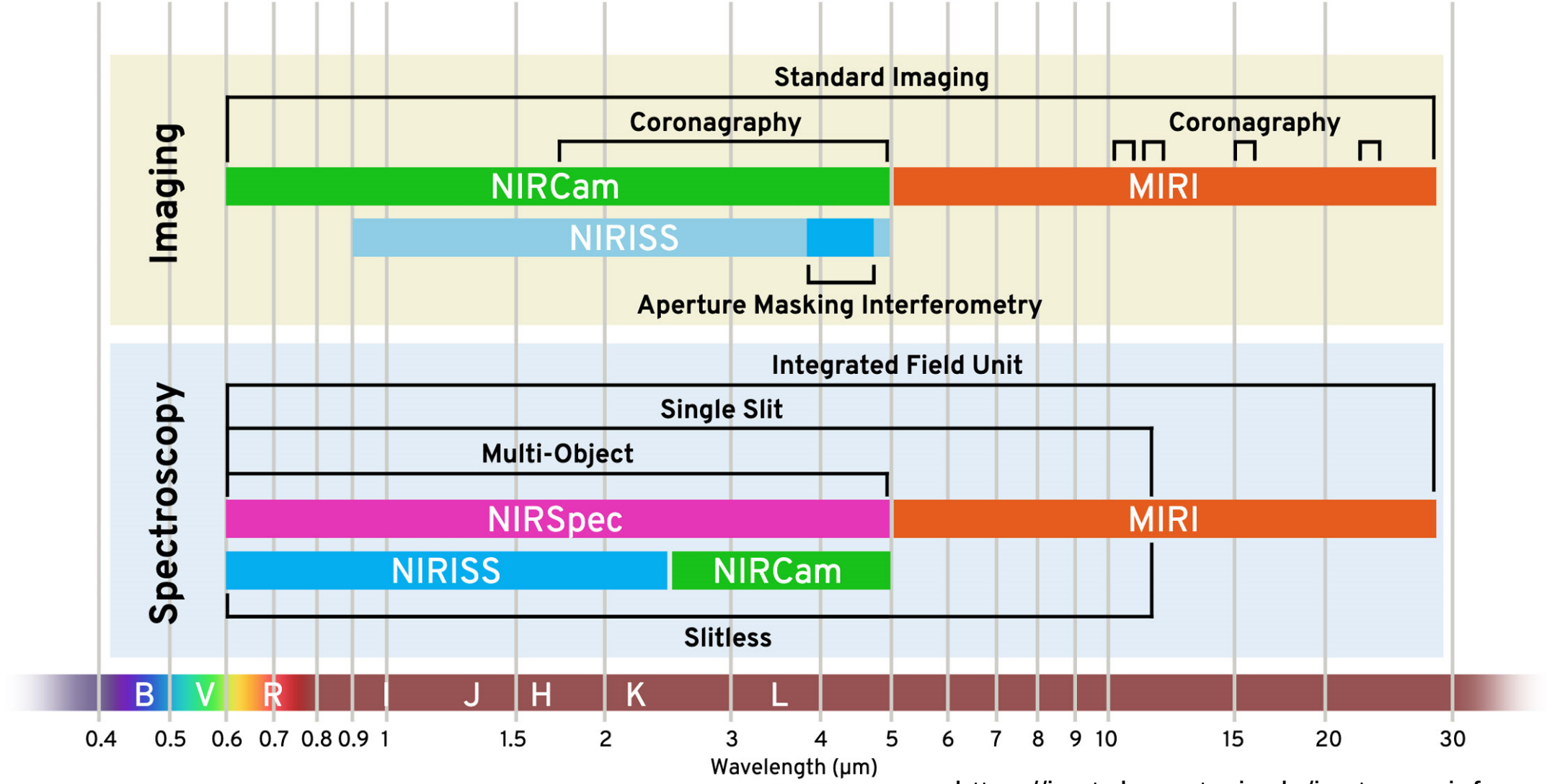
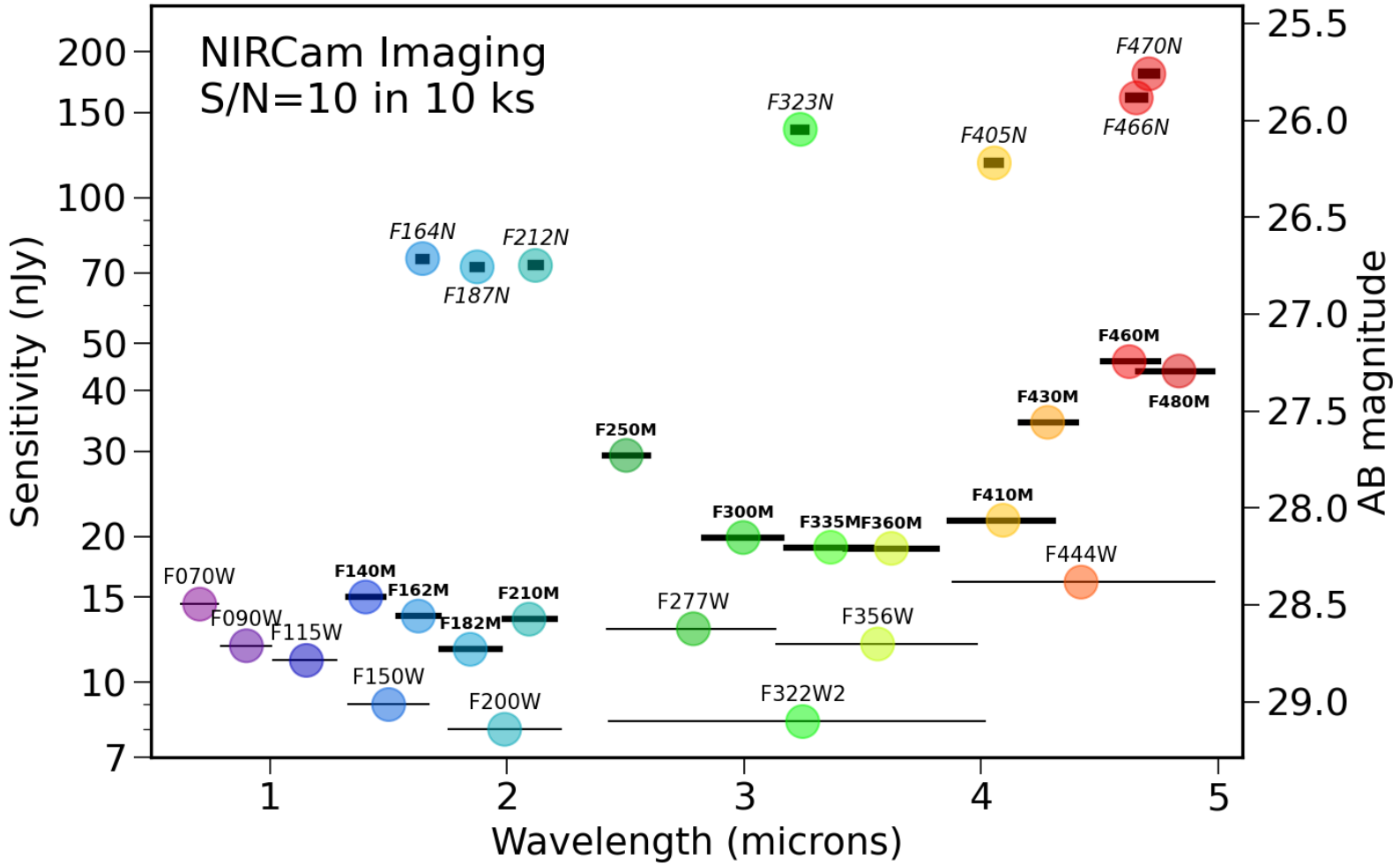
2023.03.10

JWST Wavelength Coverage



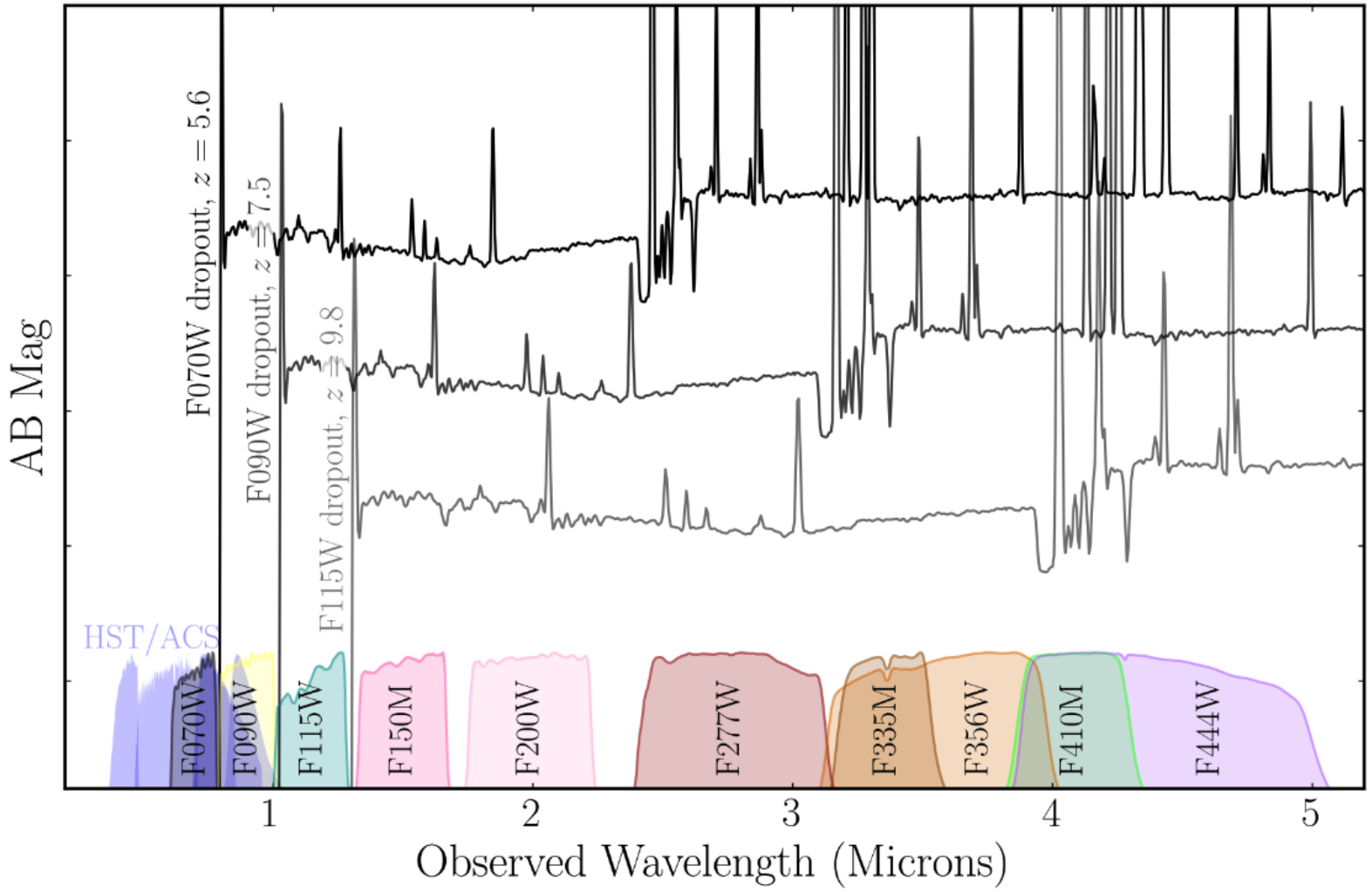
https://jwst-docs.stsci.edu/jwst-near-infrared-camera

Detection Limit of NIRCam



https://jwst-docs.stsci.edu/jwst-near-infrared-camera

Filters of NIRCam

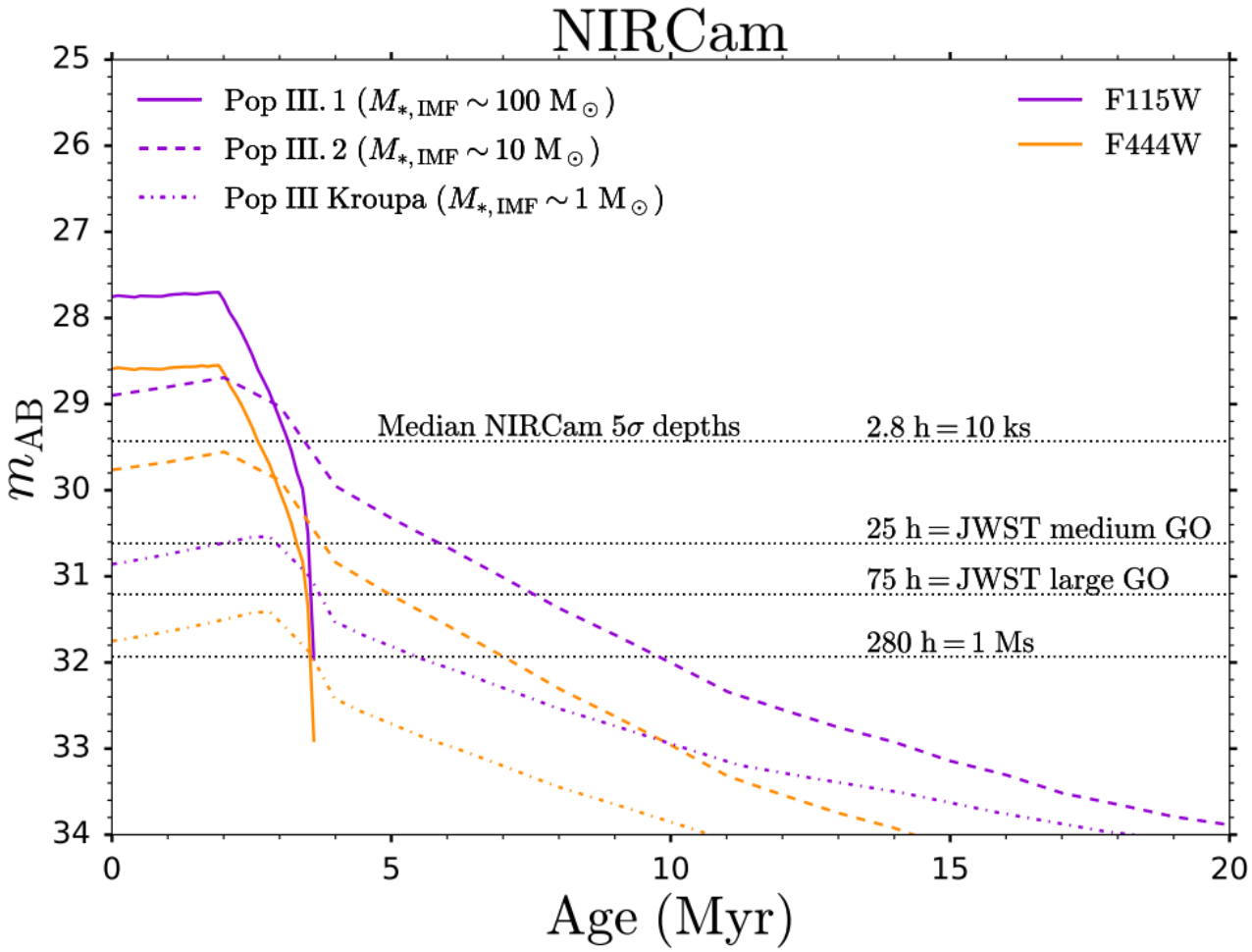


Hainline et al. 2023

Observability of Pop III Galaxies

$z = 8, \qquad M_{\rm gal} = 10^6 M_\odot$

	NIRCam		MIRI	
IMF	F410M	F444W	F560W	F770W
Pop III.1 ($M_{*,\rm IMF} \sim 100\ M_\odot$)	28.69 2.34	28.59 1.25	27.69 12.53	29.23 660.97
Pop III.2 ($M_{*,\rm IMF} \sim 10\ M_\odot$)	29.88 21.32	29.76 10.98	28.84 106.19	30.41 5704.01
Pop III Kroupa ($M_{*,\rm IMF} \sim 1\ M_\odot$)	31.87 818.12	31.75 421.43	30.84 4150.45	32.40 227080.67



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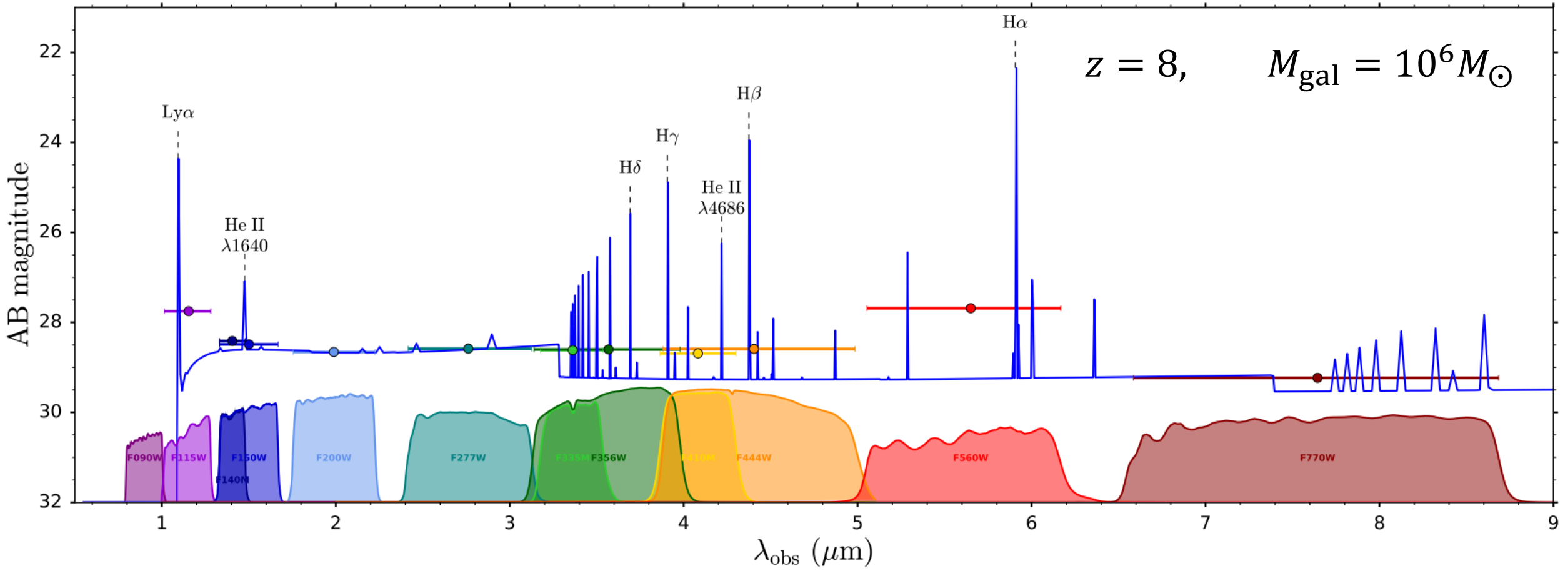
Spectral Features of Pop III Galaxies



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Identification of Pop III Galaxies

$$\mathrm{F444W} - \mathrm{F560W} > 0.85$$
$$\mathrm{F560W} - \mathrm{F770W} < -1.5$$

Applicable redshift range: 7.55 – 8.10

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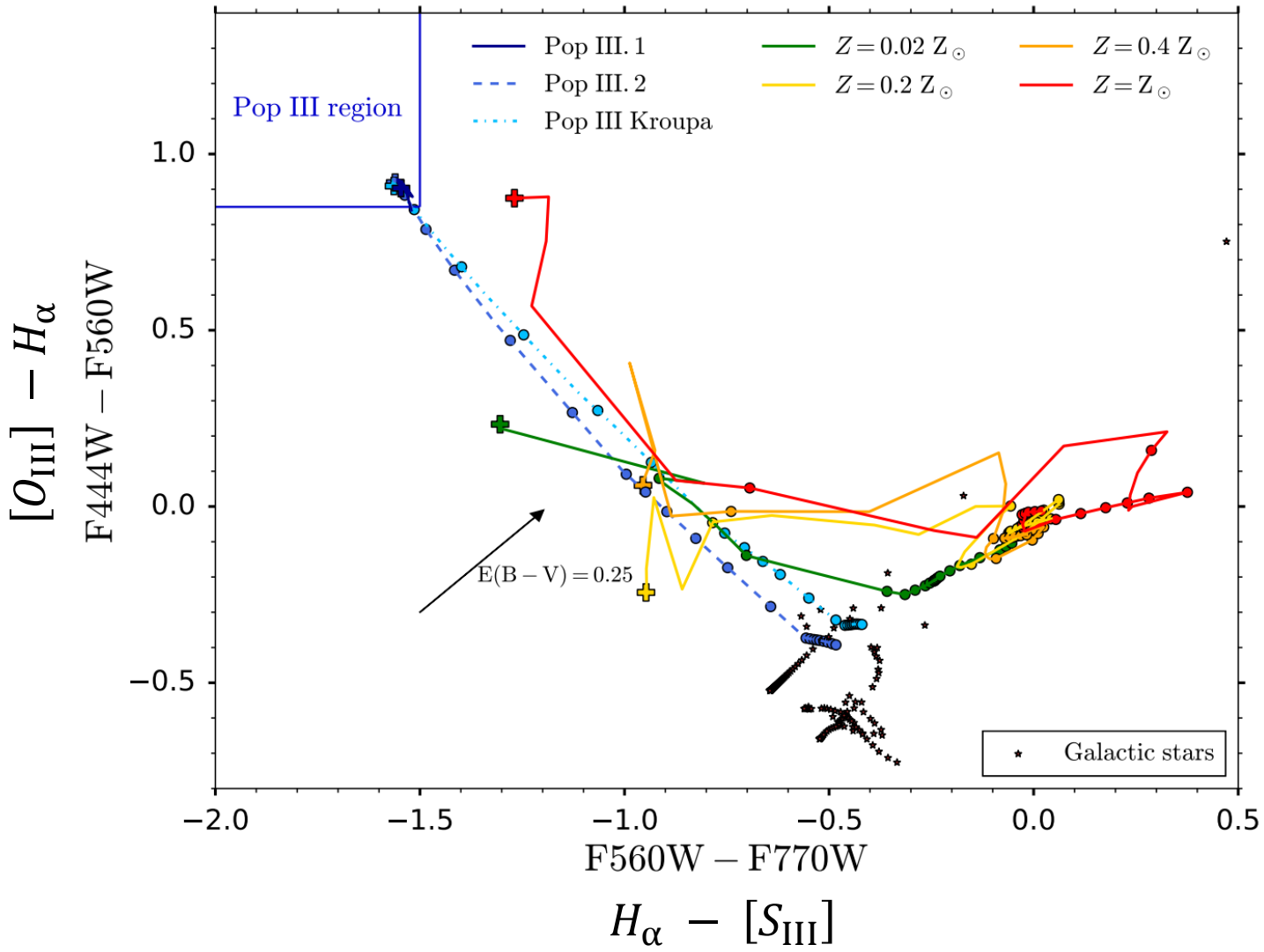
ignore $Z = Z_{\odot}$ galaxies:

$$\mathrm{F444W} - \mathrm{F560W} > 0.75$$
$$\mathrm{F560W} - \mathrm{F770W} < -1.25$$

Applicable redshift range: 7.00 – 8.35



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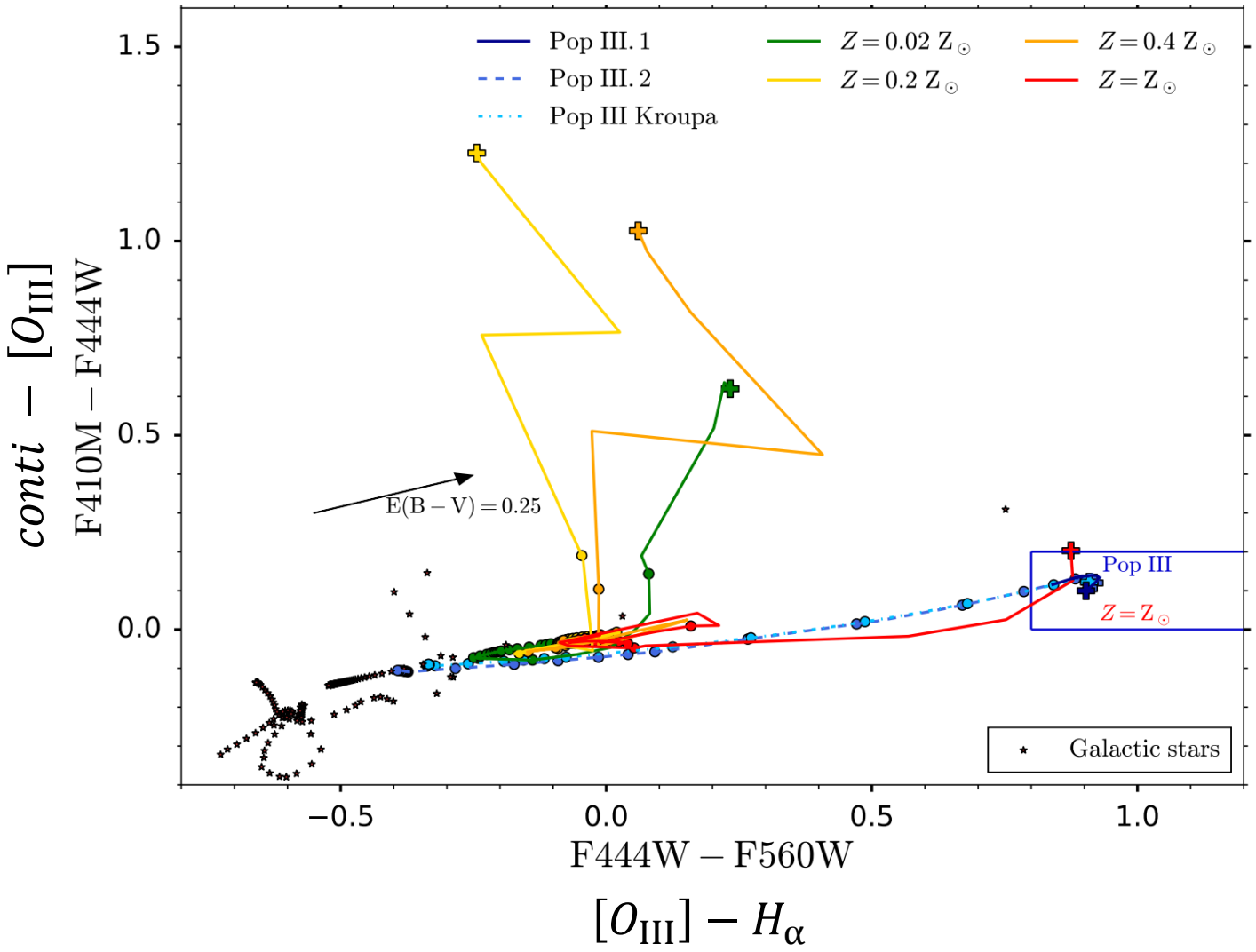
Identification of Pop III Galaxies

$$0.0 < \mathrm{F410M} - \mathrm{F444W} < 0.2$$

$$\mathrm{F444W} - \mathrm{F560W} > 0.8$$

Applicable redshift range: 7.90 – 8.30

Cannot deal with $Z = Z_{\odot}$ galaxies



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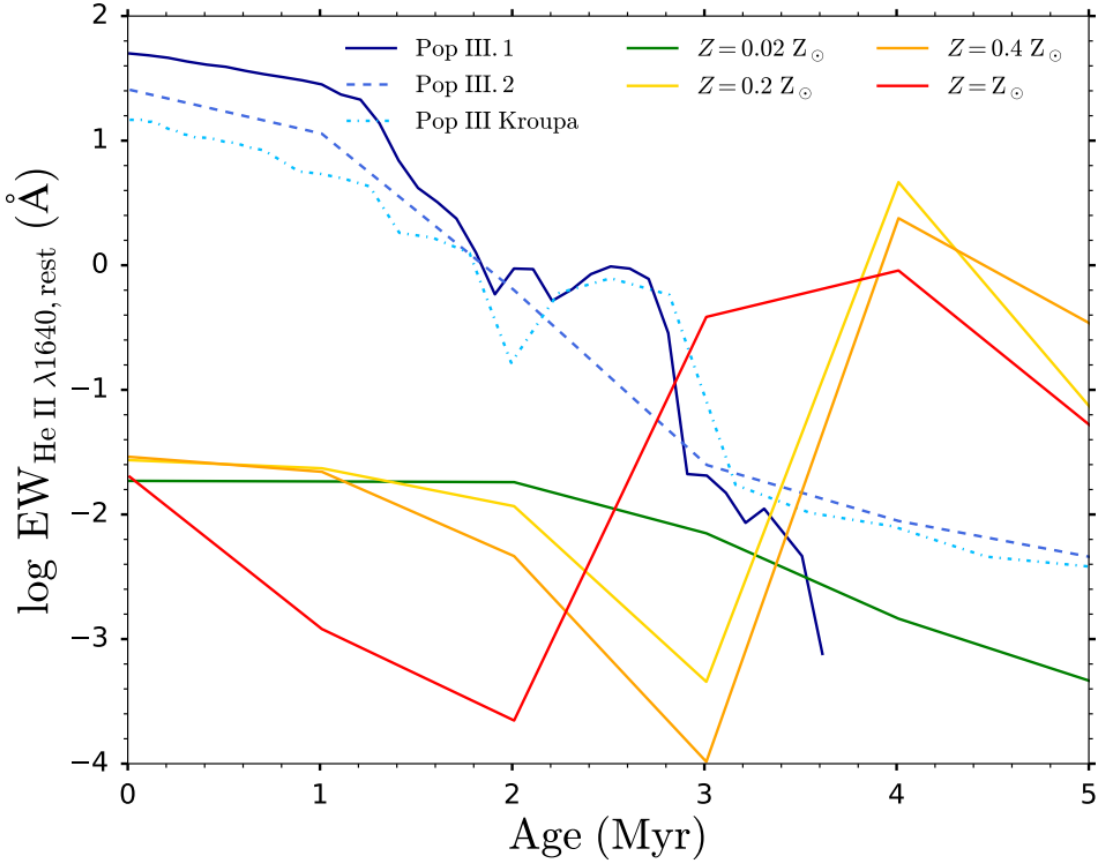
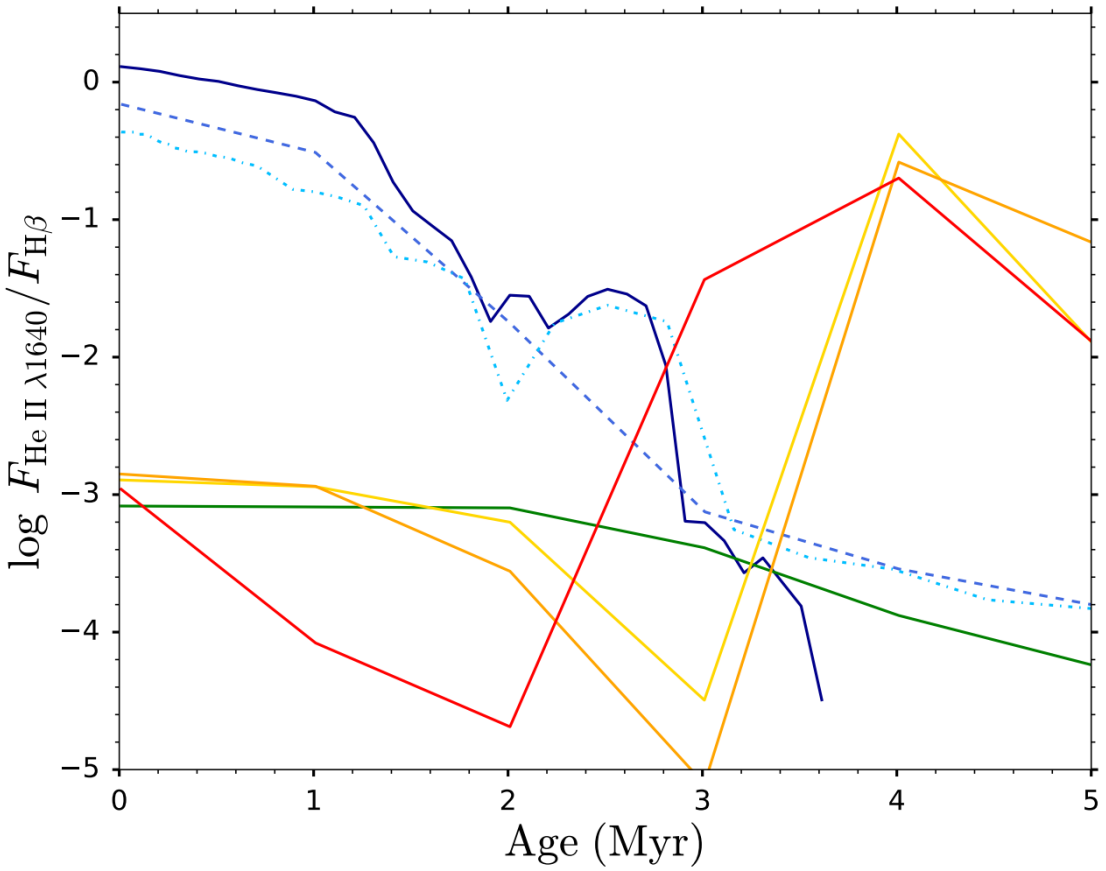
Identification of Pop III Galaxies

Line width of [He_{II}]



[He_{II}] / [H_β] ratio



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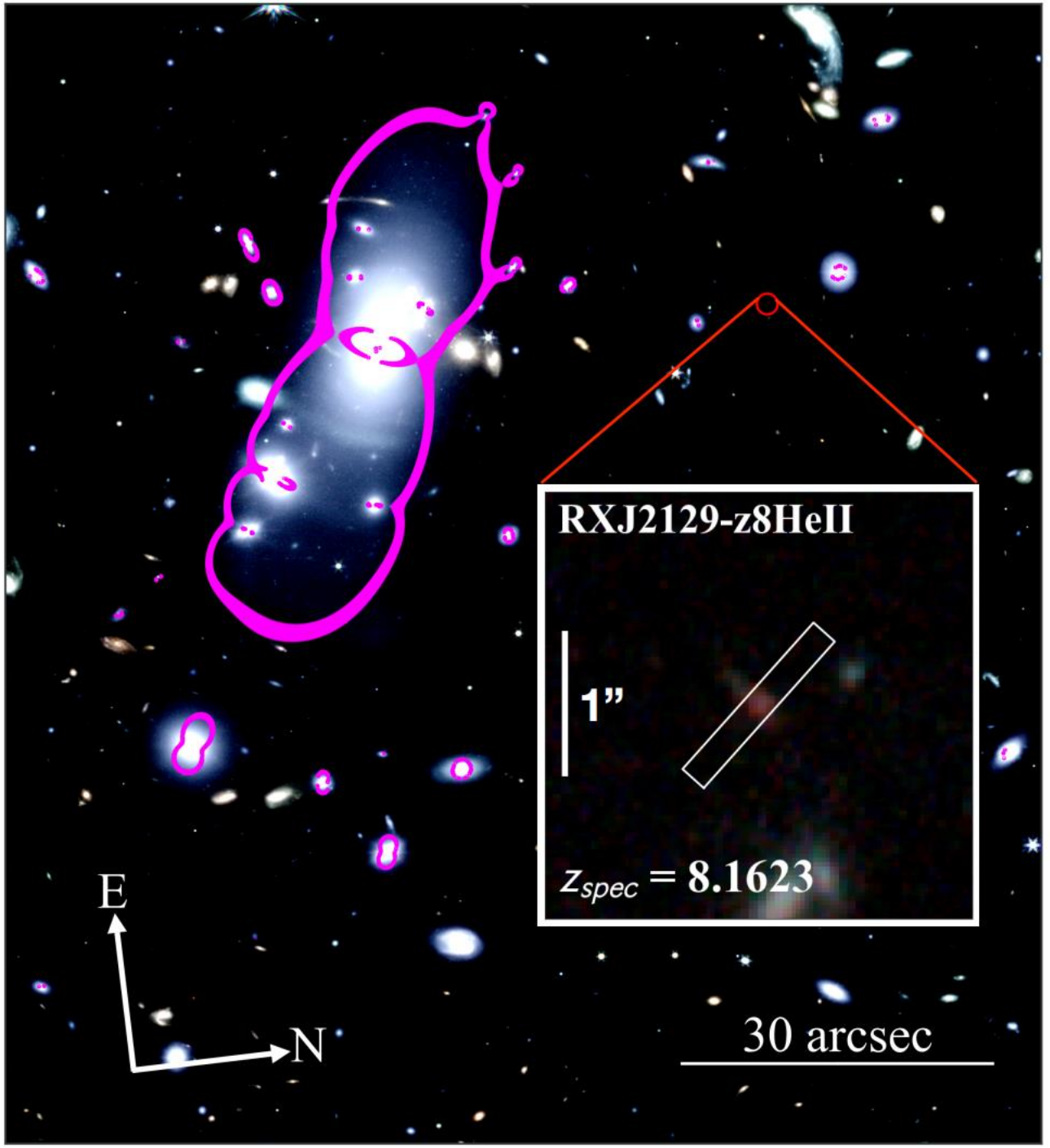
Observed Signals from Pop III Stars by JWST

- $z_{\mathrm{spec}} \approx 8.16$
- $M_* \approx 10^{7.65} M_\odot$
- $Z_* \approx 10^{-0.86} Z_\odot$
- $SFR \approx 2\, M_\odot/yr$



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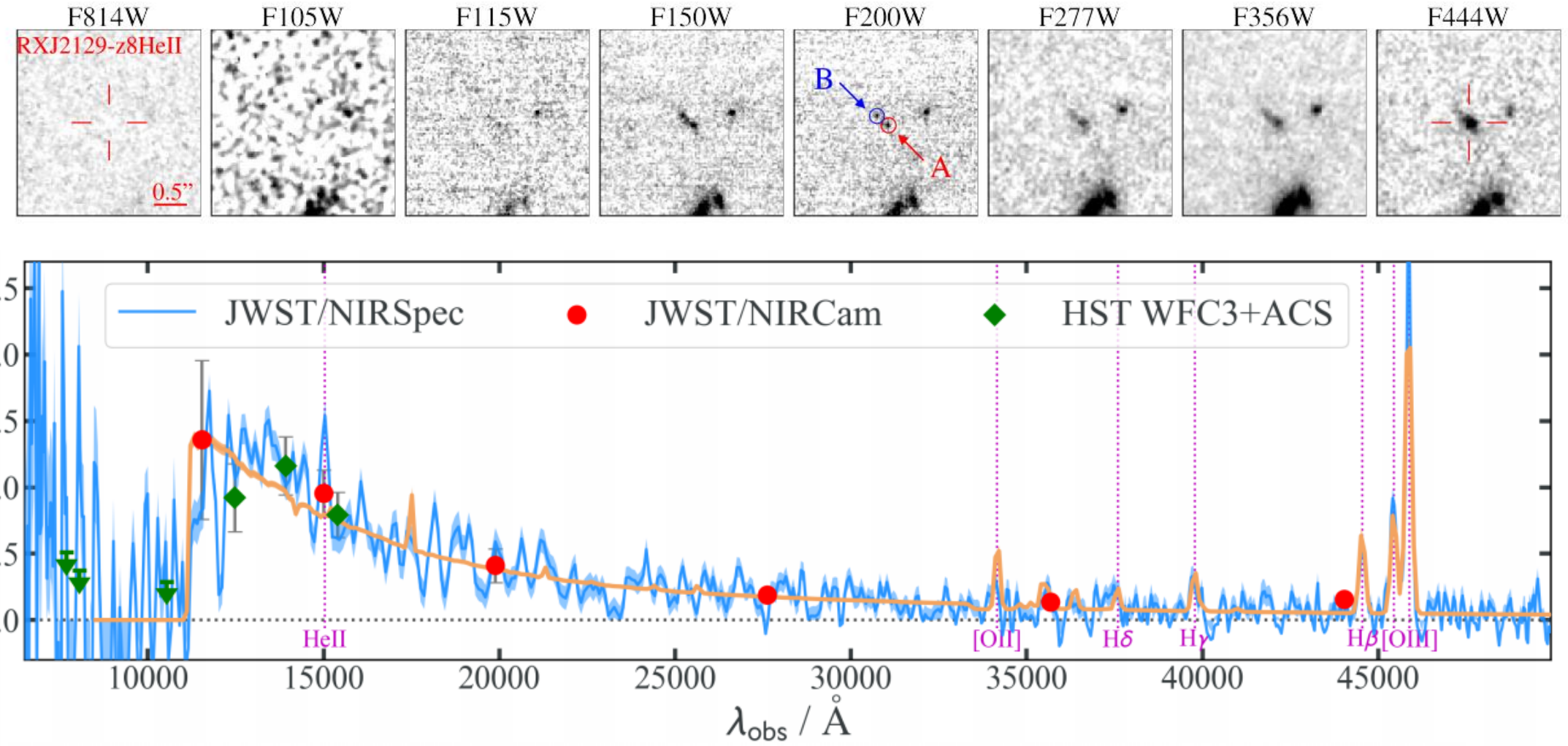
Observed Signals from Pop III Stars by JWST



- $EW[\mathrm{He_{II}}] \approx 19$ Å
- $F[\mathrm{He_{II}}] \,/\, F[\mathrm{H_\beta}] \approx 2.1$

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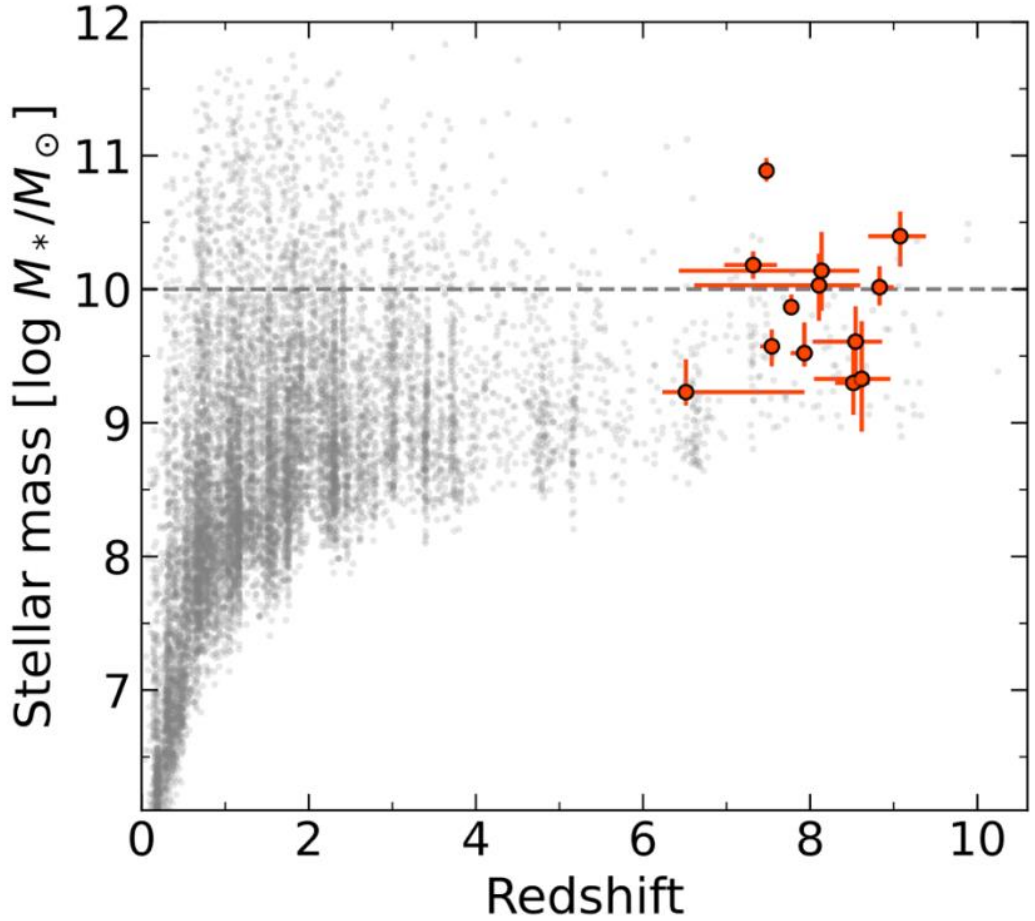
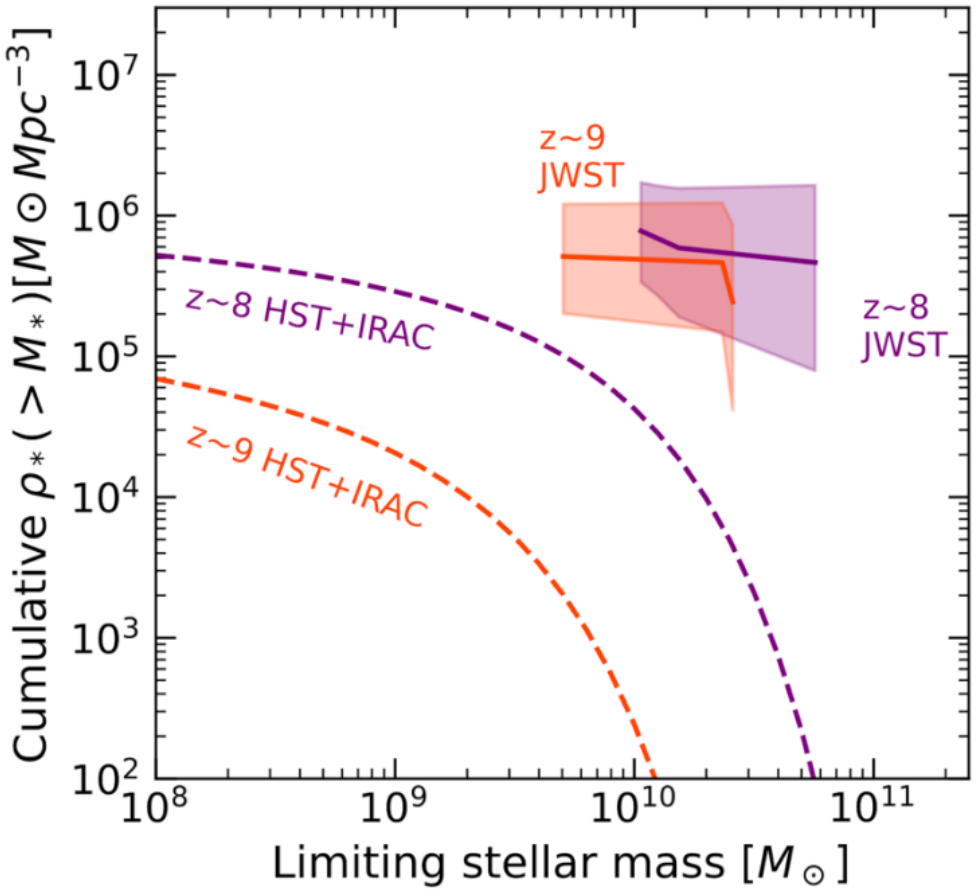
Possible Revolution from JWST Very Early Galaxies

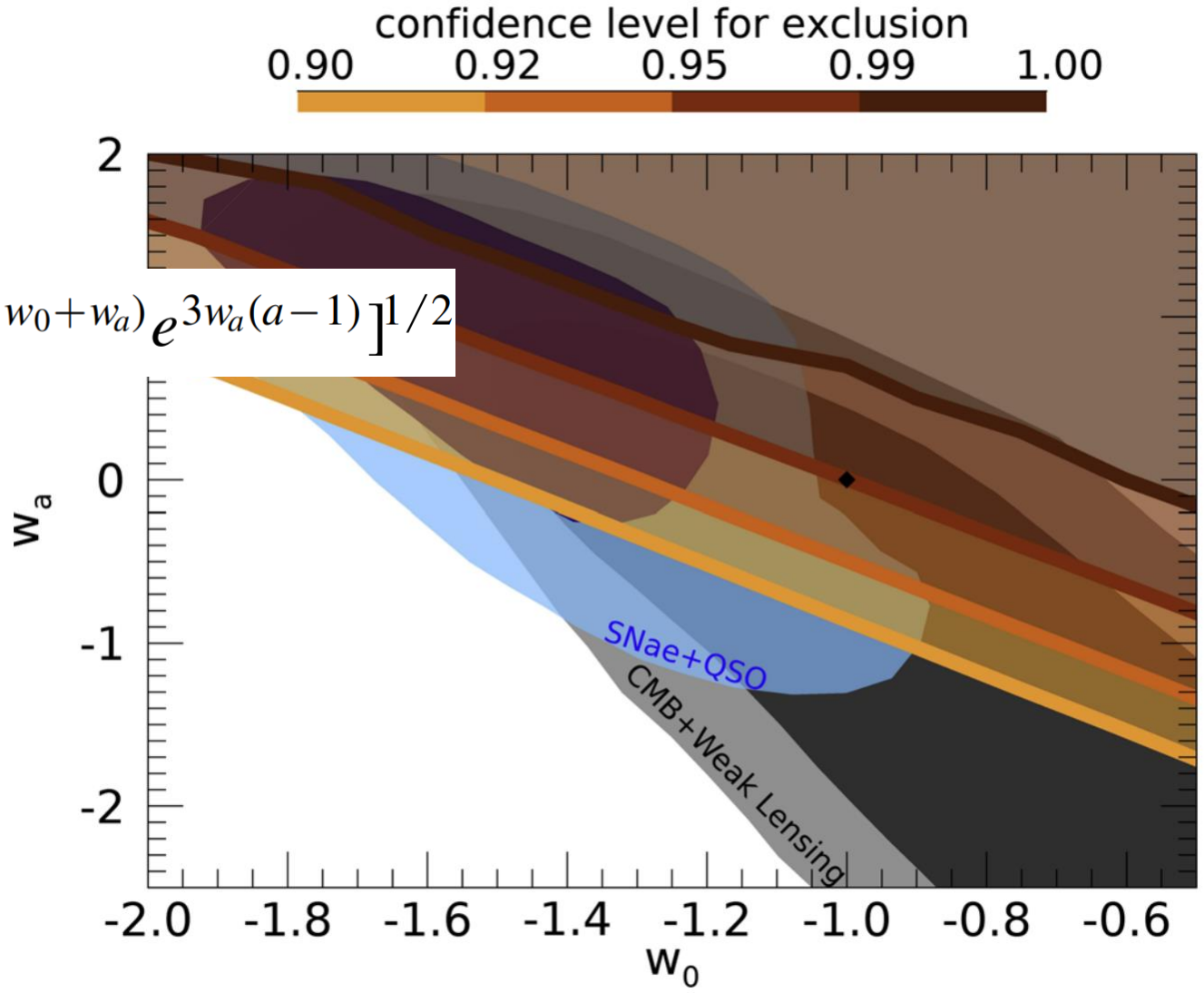




Labbe et al. 2022

Possible Revolution from JWST Very Early Galaxies

$$E(z) \equiv H/H_0$$
$$= [\Omega_M\, a^{-3} + \Omega_\Lambda a^{-3(1+w_0+w_a)} e^{3w_a(a-1)}]^{1/2}$$



Labbe et al. 2022

Thanks for listening