Detecting First Stars and First Galaxies with IR astronomy

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2022.4.1

@Student Seminar

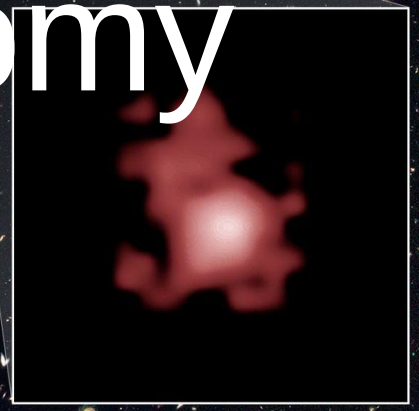
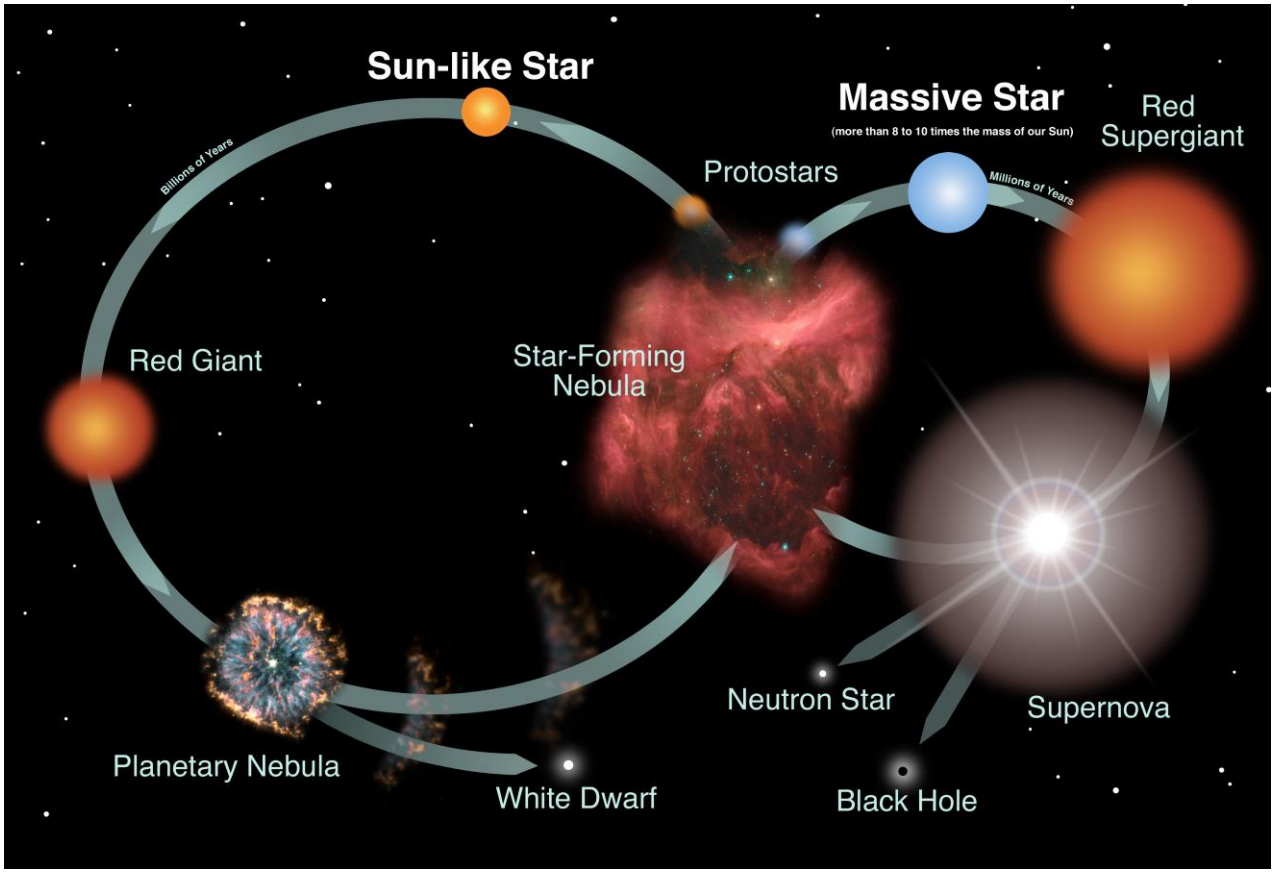


Image: NASA, ESA, and P. Oesch

How stars form and cycle?

Beyond cycle:
SN feedback
Metal enrichment



Credit: NASA and the Night Sky Network

How galaxies form and evolve?

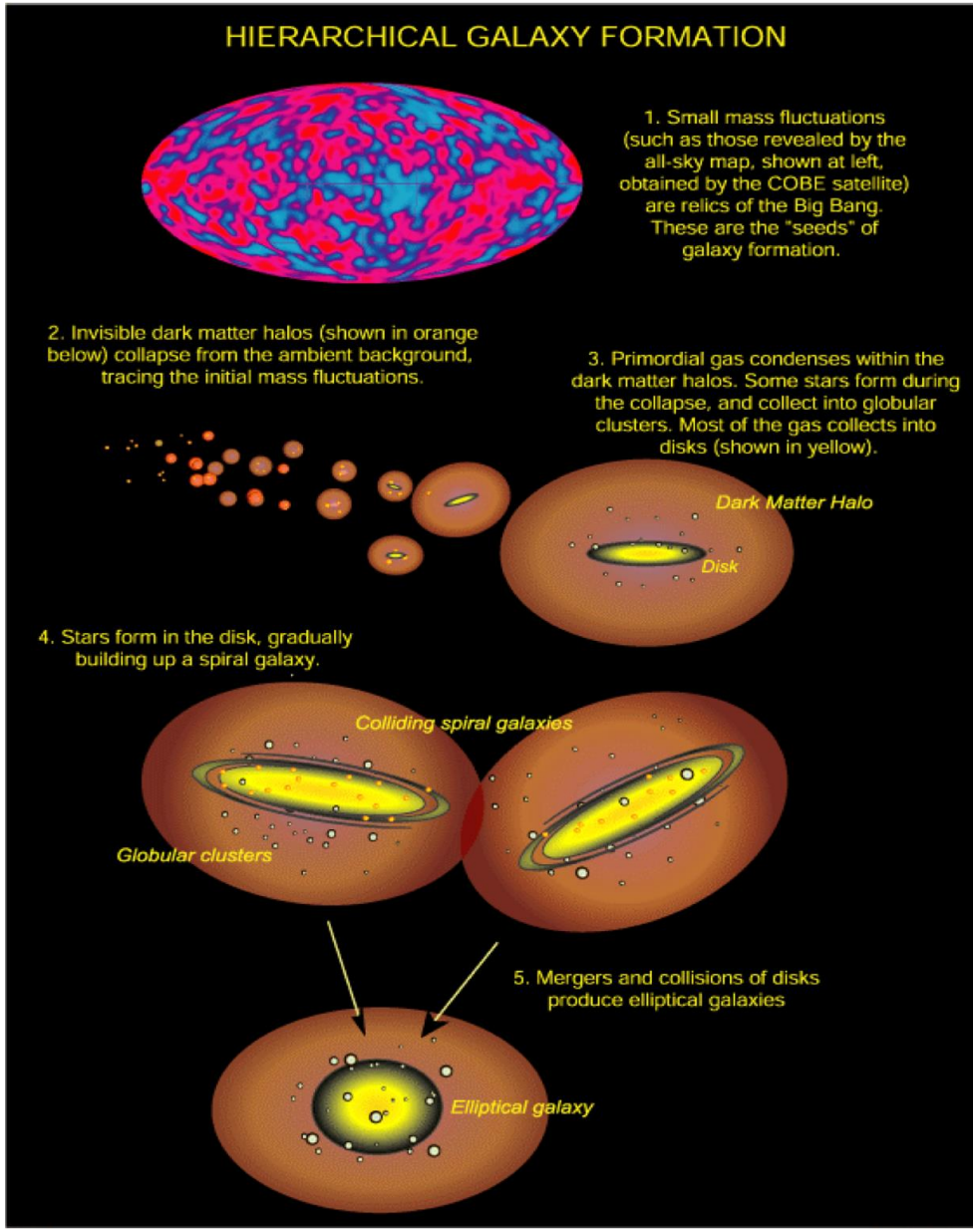
Seeds

DM halos

Gas clouds collapse

Stars and Galaxies

Merge and Collision



Abraham et al 2000

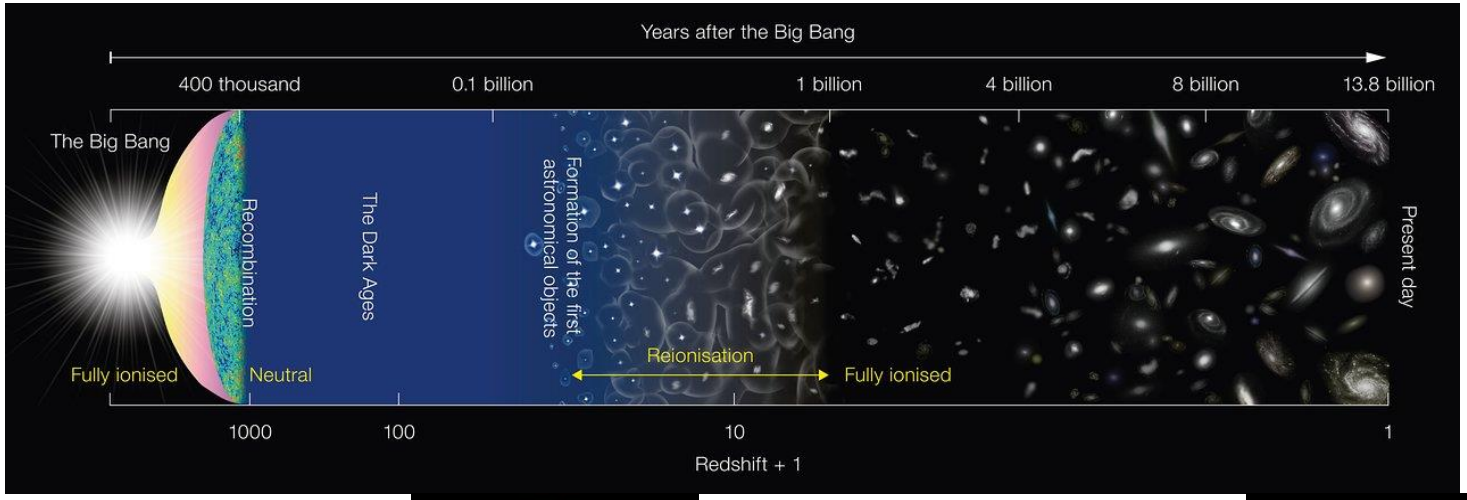
Open questions

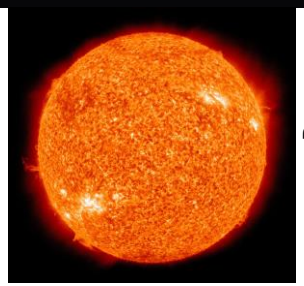
- When were first stars/galaxies form?
- Stars first, galaxies later? Or coincide?
- Mass function of host DM halos? DM models?
- Environment for first galaxies? Gas rich/poor? Metal rich/poor? SN? Dust? AGNs?

Only Observations can answer!

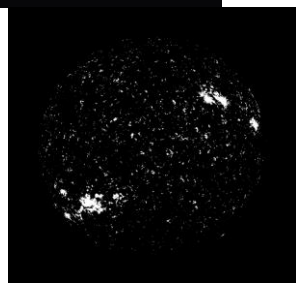
Lyman α emitter
Lyman break
GRB
Hα
…

Let's do some calculation first.





"Suns" z=20



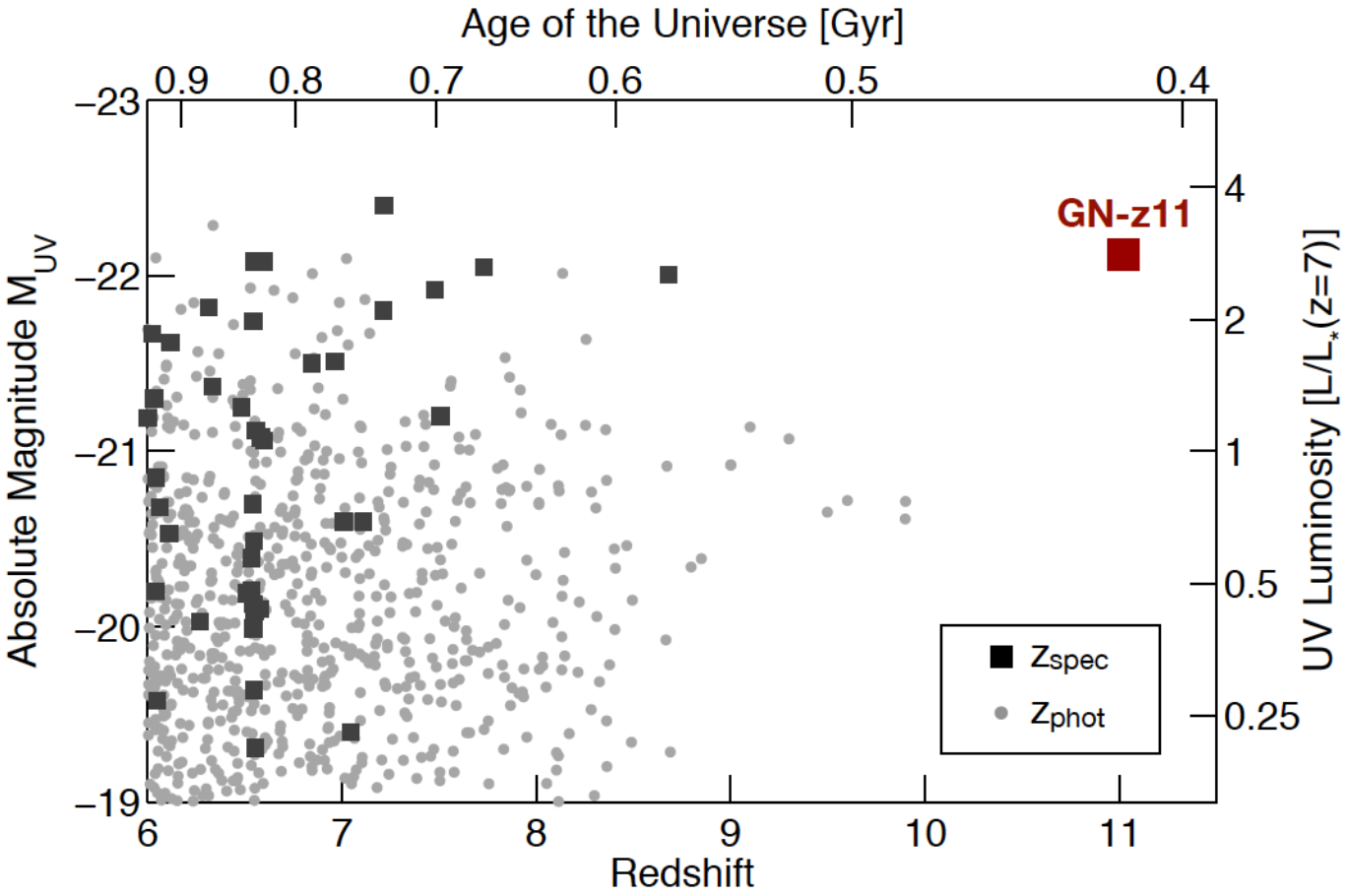
"Suns" z=0

$$\lambda_{obs} = \lambda_{rest} \frac{1 + z_{emit}}{1 + z_{obs}}$$

$$\lambda_{rest} = 580\text{nm} \qquad \lambda_{obs} = 12.18\mu\text{m}$$

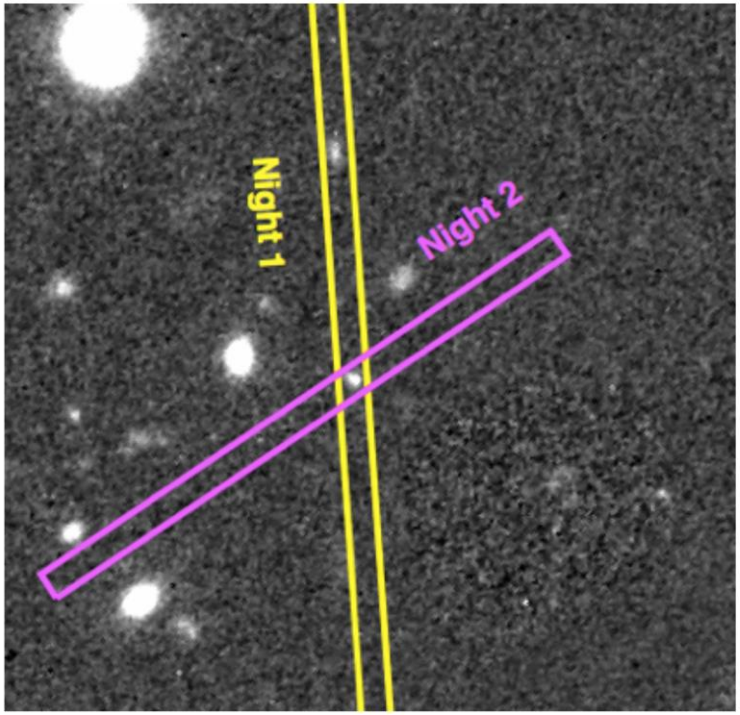
We need Infrared observations!

Current observations cannot provide enough samples!

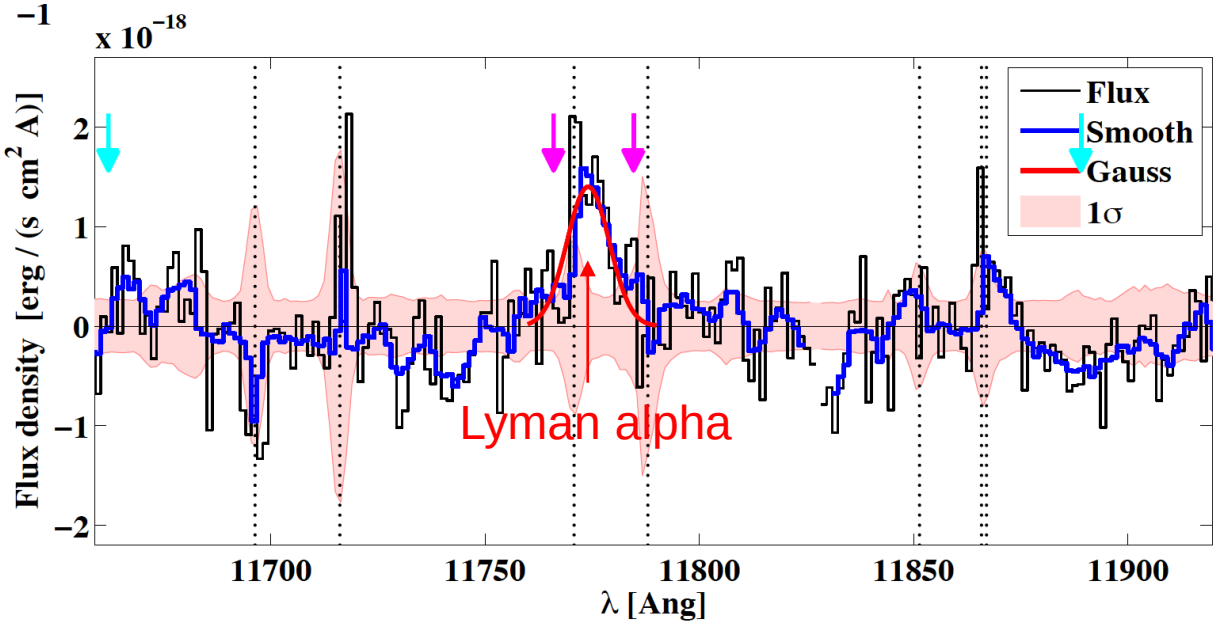


Oesch et al 2016

EGSY8p7

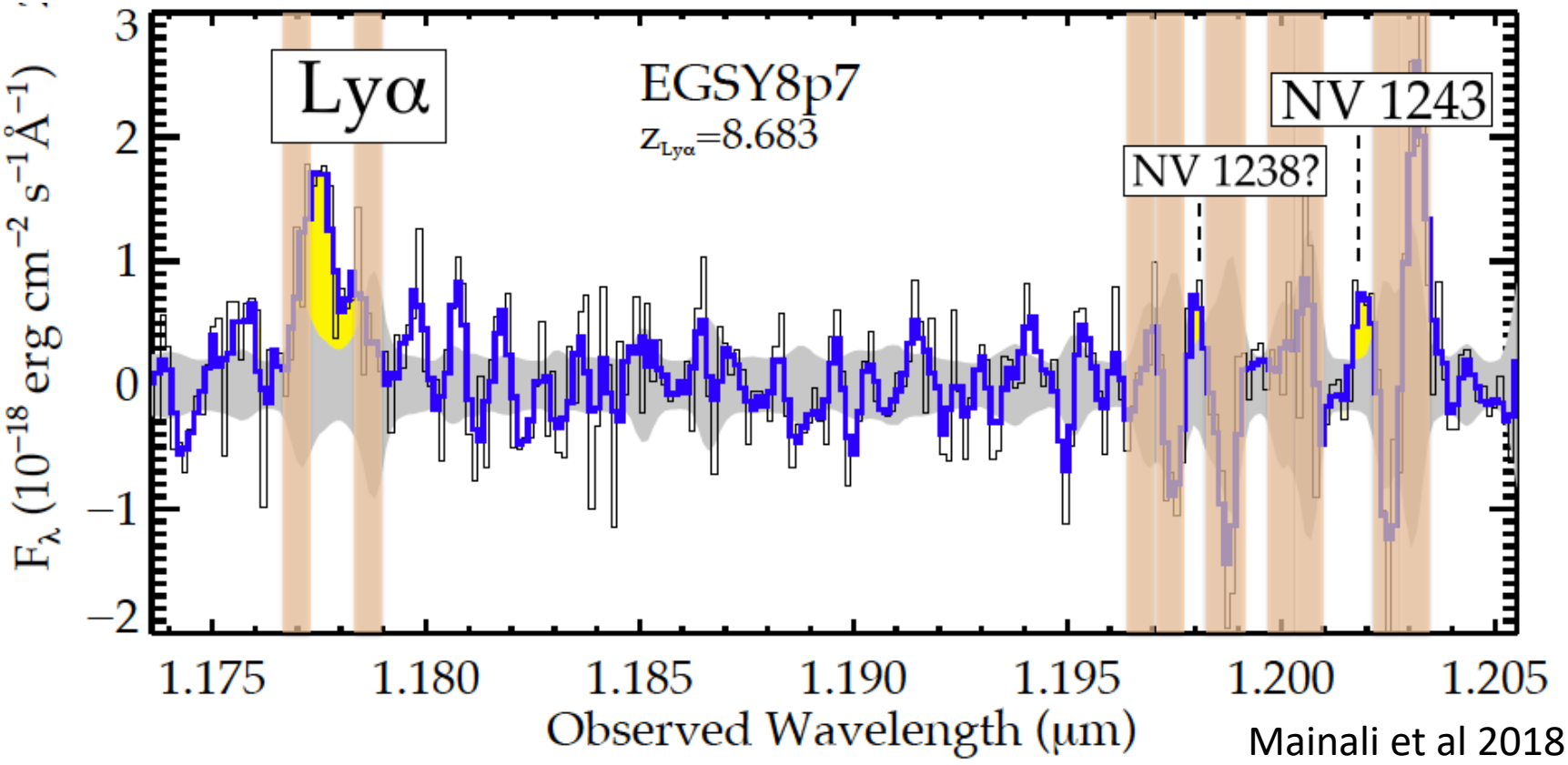


- Keck/MOSFIRE, July 2015
- z=8.68
- m_{AB} = 25.26, M ~ 10^{10} $M_{\odot}$



Zitrin et al 2015

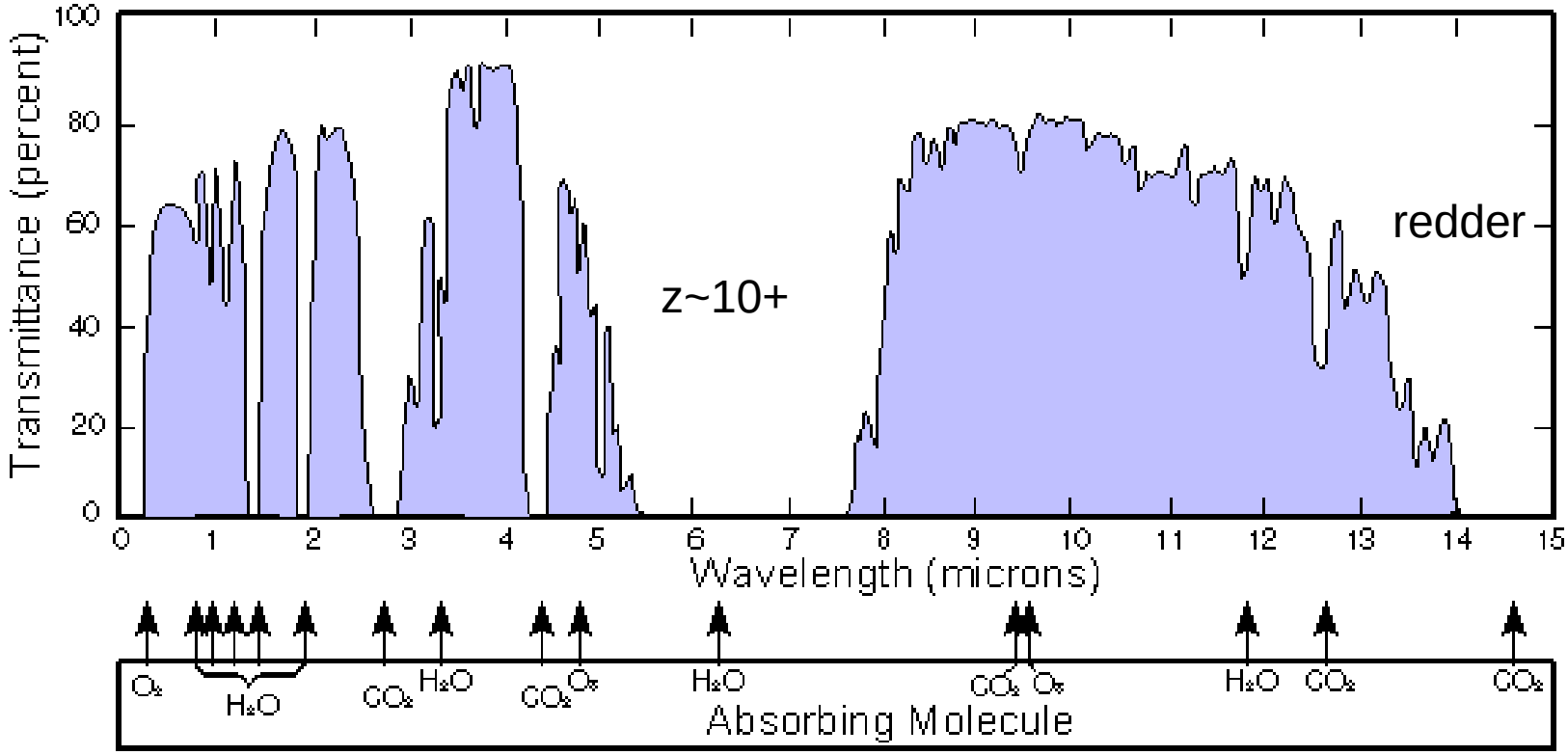
EGSY8p7



Mainali et al 2018

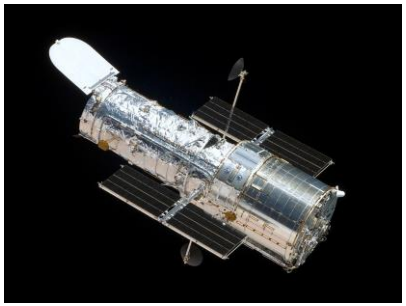
The detection of NV emission indicated AGN activities or fast radiative shocks.

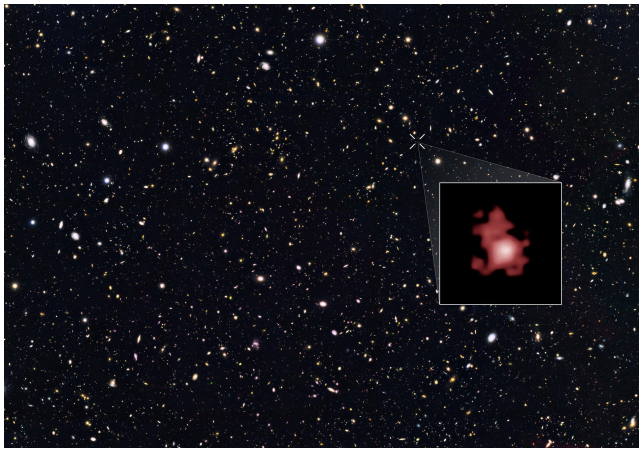
IR window



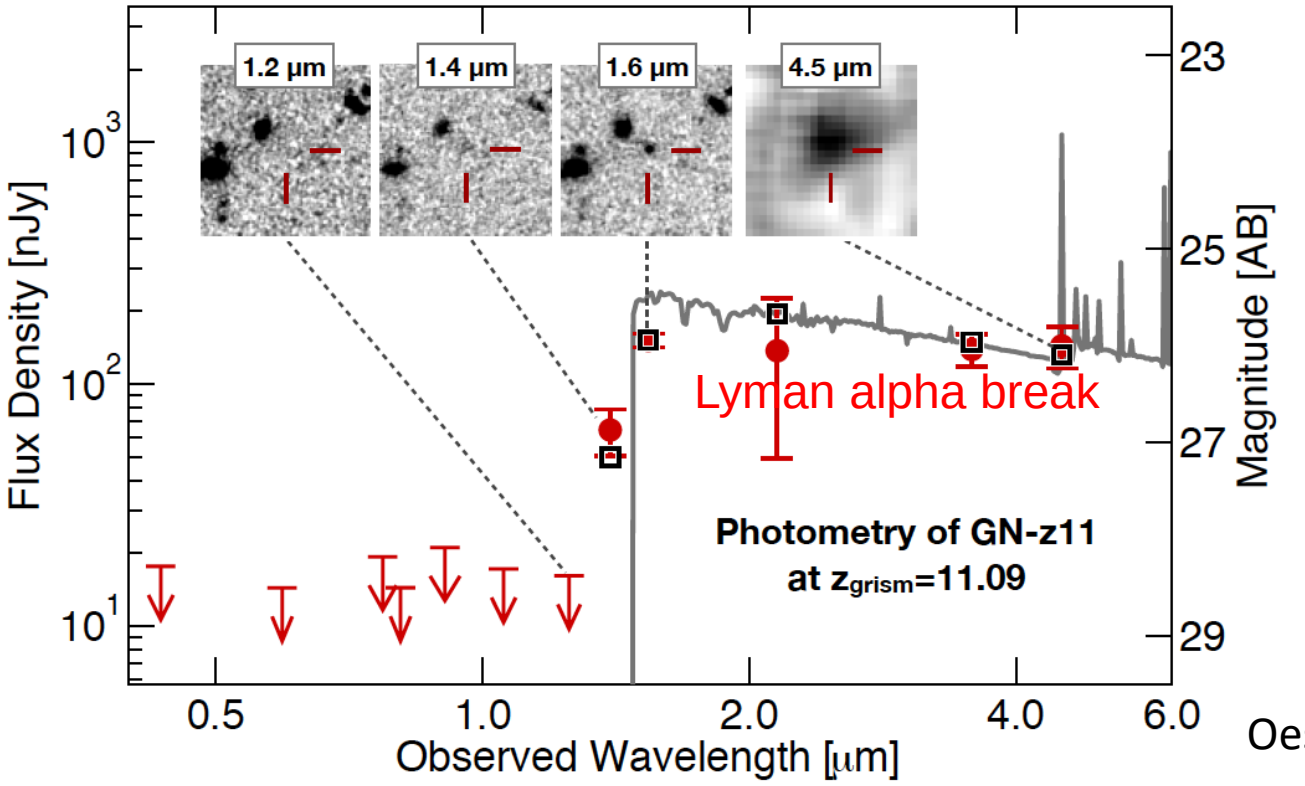
If we want to see some “old” first galaxies, we need space telescopes!

GN-z11



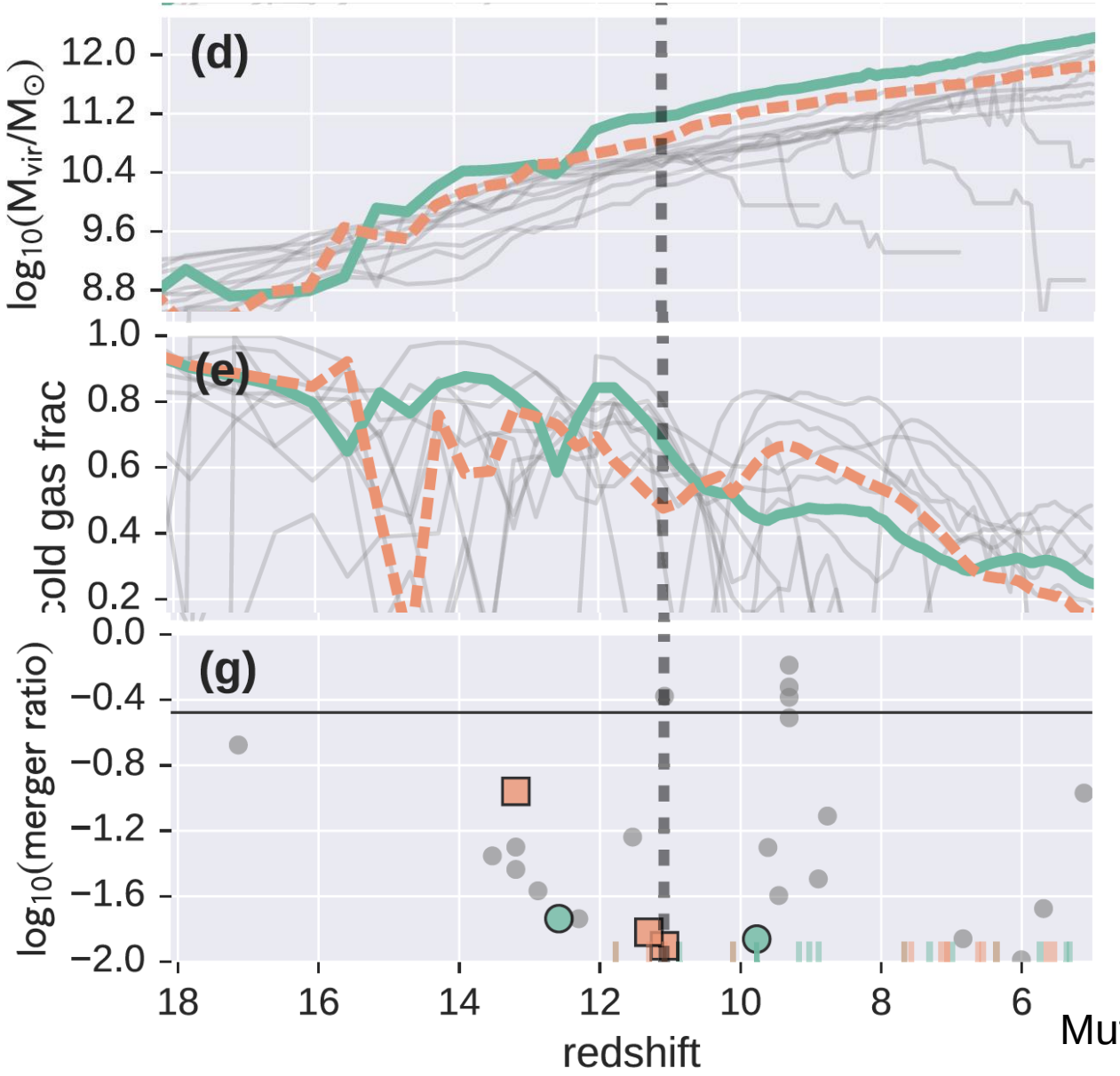


- Hubble WFC3/IR, March 2016
- z =11.1
- m_{AB} = 26.0, M ~ 10^9 $M_\odot$



Oesch et al 2016

GN-z11 might be formed in a growing, gas-rich and isolated DM halo.



Mutch et al 2016

Debate about GN-z11 flash

Original paper suggests a UV flash associated with GRB

A possible bright ultraviolet flash from a galaxy at redshift $z \approx 11$

Linhua Jiang[1,2]✉, Shu Wang[1,2], Bing Zhang[3]✉, Nobunari Kashikawa[4,5], Luis C. Ho[1,2], Zheng Cai[6], Eiichi Egami[7], Gregory Walth[8], Yi-Si Yang[9,10], Bin-Bin Zhang[9,10] and Hai-Bin Zhao[11,12]

Supporters

GN-z11-flash in the context of Gamma-Ray Burst Afterglows

D. A. Kann,[1] M. Blazek,[1] A. de Ugarte Postigo,[1,2] and C. C. Thöne[1]

A solar system object?

A more probable explanation for a continuum flash towards a redshift ≈ 11 galaxy

Charles Louis Steinhardt[1,2]✉, Michael I. Andersen[1,2], Gabriel B. Brammer[1,2], Lise Christensen[1,2], Johan P. U. Fynbo[1,2], Peter Laursen[1,2], Bo Milvang-Jensen[1,2], Pascal A. Oesch[1,2,3] and Sune Toft[1,2]

a Russian Proton rocket?

GN-z11-flash from a man-made satellite not a gamma-ray burst at redshift 11

Michał Jerzy Michałowski✉, Krzysztof Kamiński✉, Monika Katarzyna Kamińska and Edwin Wnuk

A Satellite Glint?

The GN-z11-Flash Event can be a Satellite Glint

Guy Nir[1], Eran O. Ofek[1], and Avishay Gal-Yam[1]

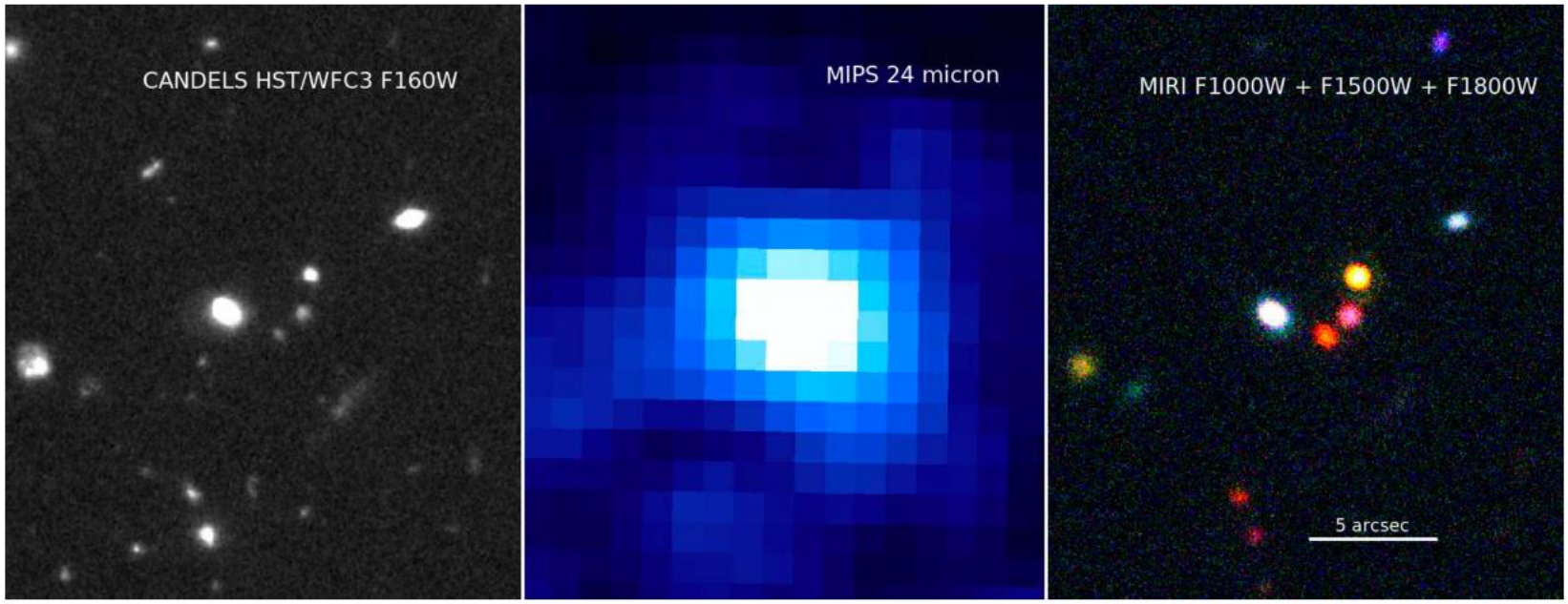
SNe?

Signatures of population III supernovae at Cosmic Dawn: the case of GN-z11-flash

Hamsa Padmanabhan[1] · Abraham Loeb[2]

Future: JWST

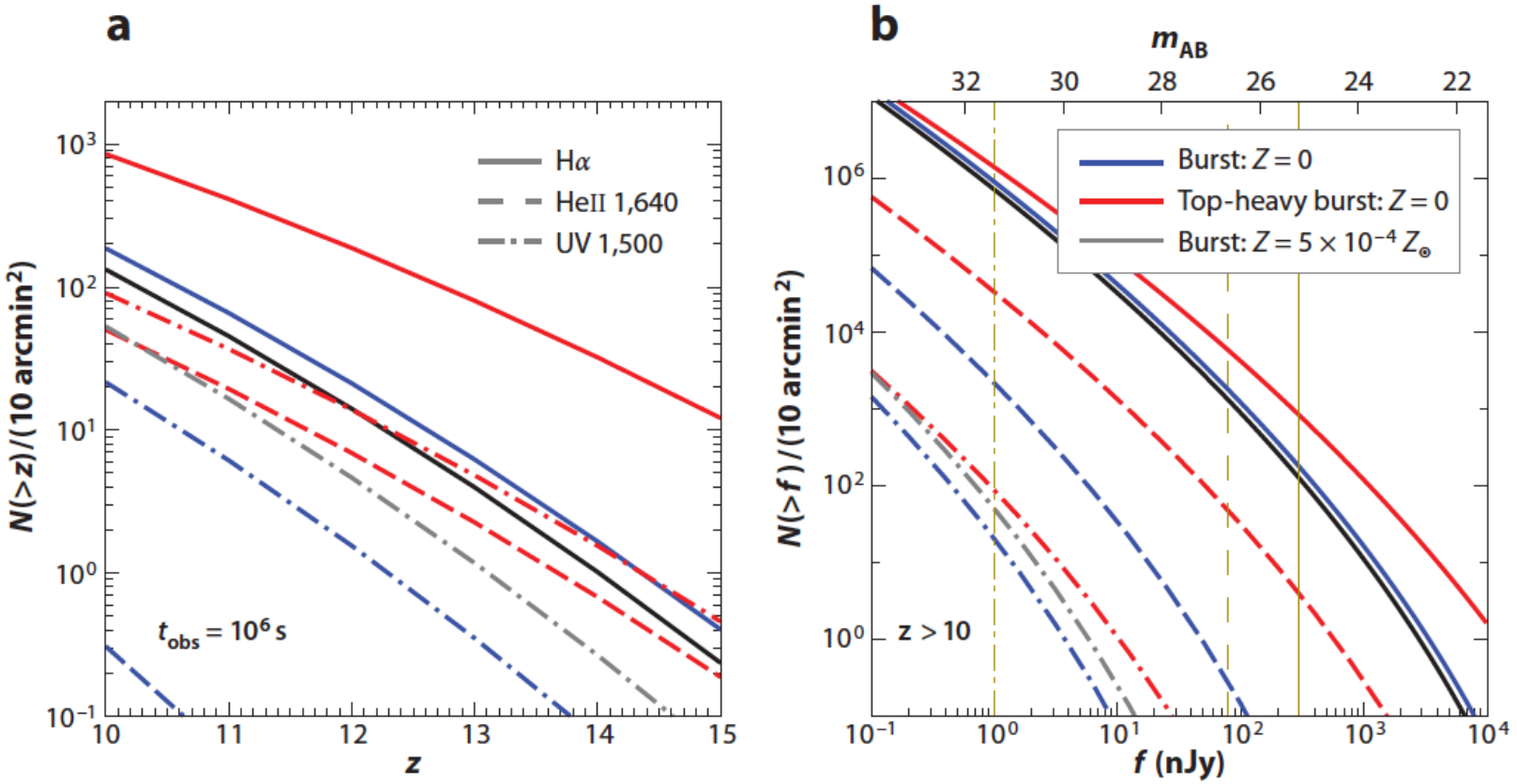
@Chen & Zhang's talk



HST/WFC3 Spitzer/MIPS JWST/MIRI (simulated)

Jason 2018

JWST can detect 10~1000 star-forming galaxies with z>10.



Pawlik et al 2011

We need other detections as IR cannot provide complete samples by itself.

- 21cm intensity mapping
- Thomson scattering optical depth/Global 21cm signal
- Early BHs
- Local ultrafaint dwarf galaxies
- …

Take home messages

- First stars and galaxies are missing from current formation history.
- IR astronomy has made numerous efforts to study their formations and environments, and will make more in the future.
- We needs other detections.