Redshift Evolution of the Electron Density and Extremely Low C/N Galaxies with supersolar N/O at z ~ 4–10 Uncovered with JWST/NIRSpec

Isobe+23a, arXiv: 2301.06811
Isobe+23b, arXiv: 2307.00710

Released yesterday!

Yuki Isobe (3rd-year PhD; U. Tokyo)

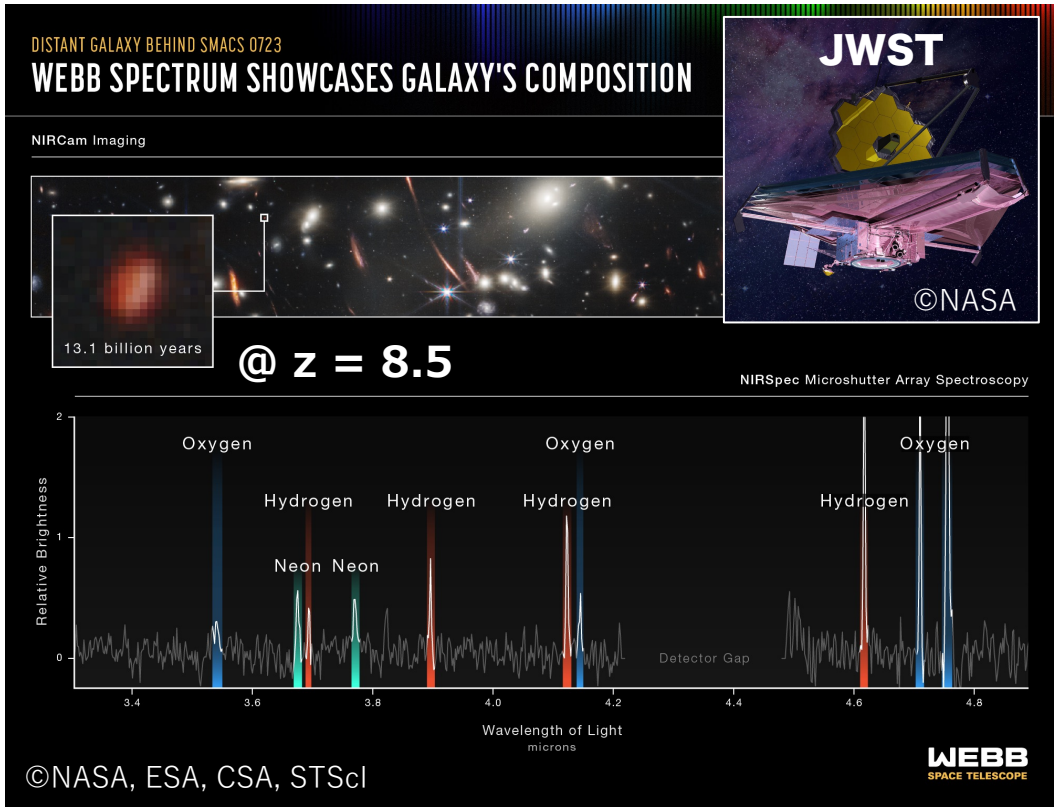
Collaborator: M. Ouchi, N. Tominaga, K. Watanabe, K. Nakajima, H. Umeda, H. Yajima, Y. Harikane, H. Fukushima, Y. Xu, Y. Ono, and Y. Zhang

東京大学
THE UNIVERSITY OF TOKYO

ICRR
Institute for Cosmic Ray Research
University of Tokyo

Introduction

Amazing JWST/NIRSpec spectra



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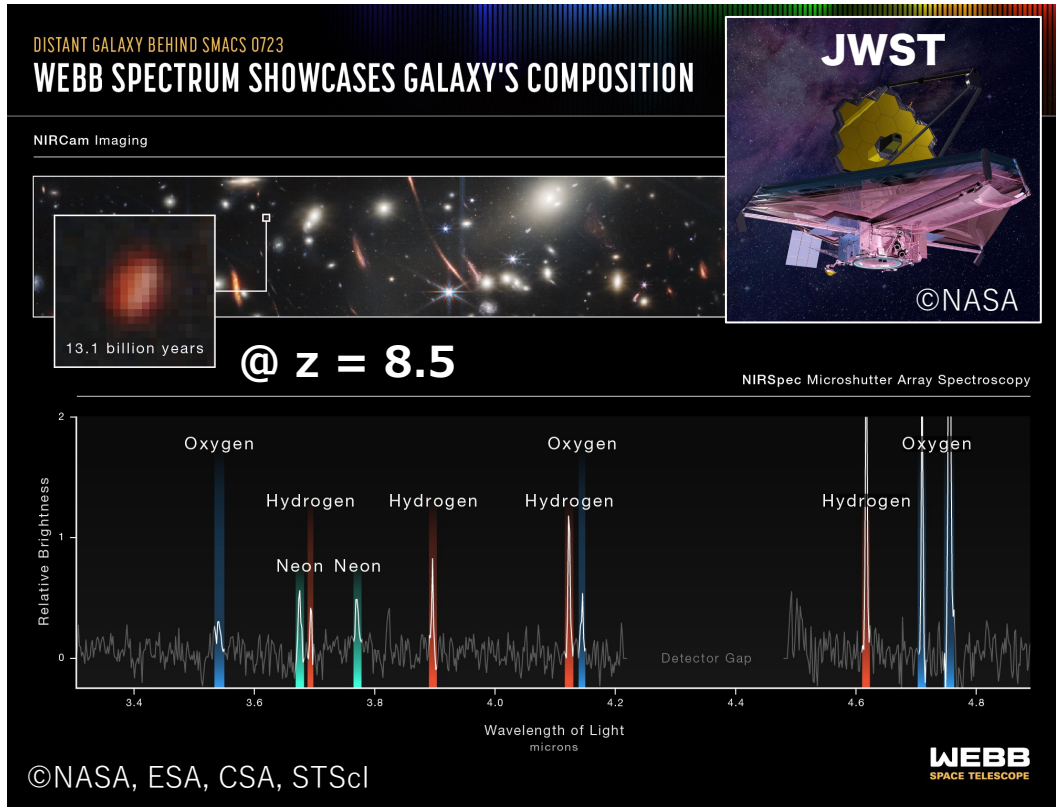
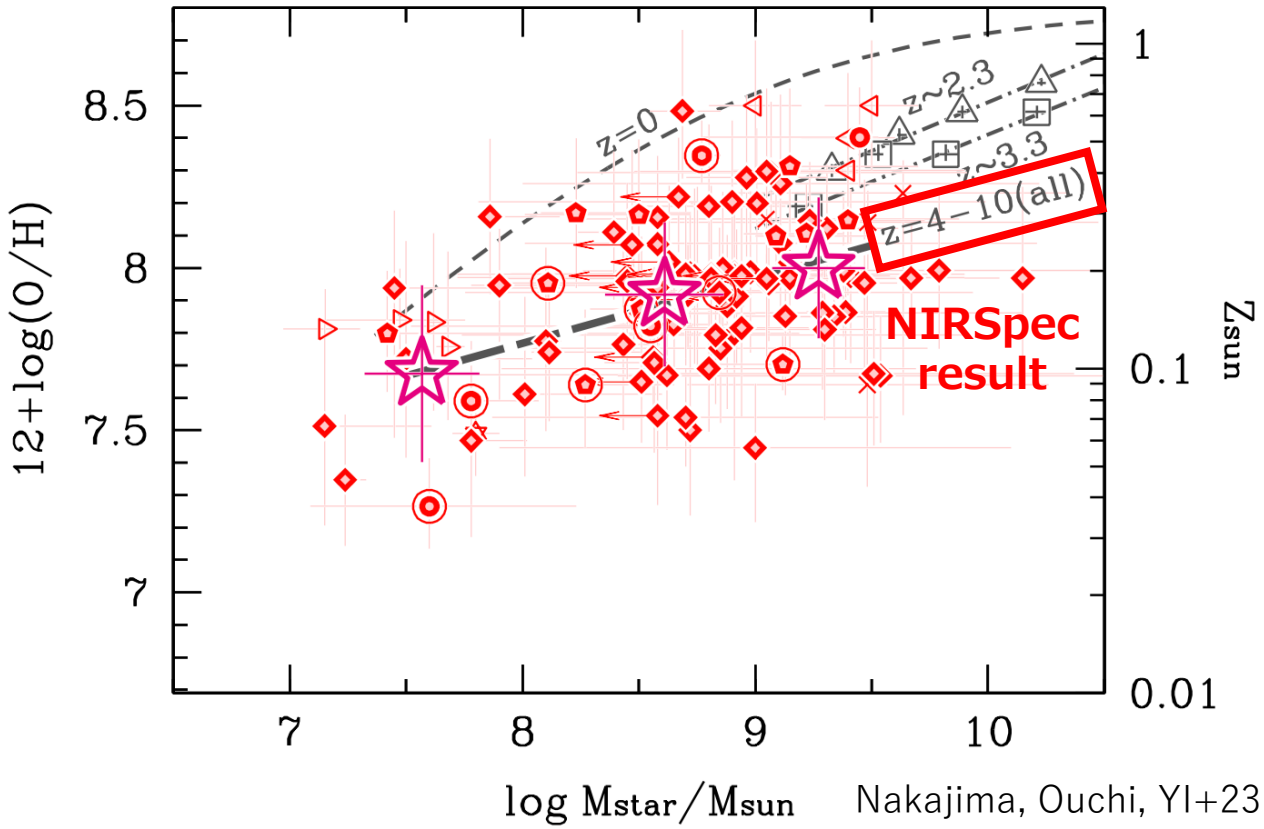


E.g., Metallicity measurement at z ~ 4–10 (Nakajima+23; Curti+23; …)



Nakajima, Ouchi, YI+23

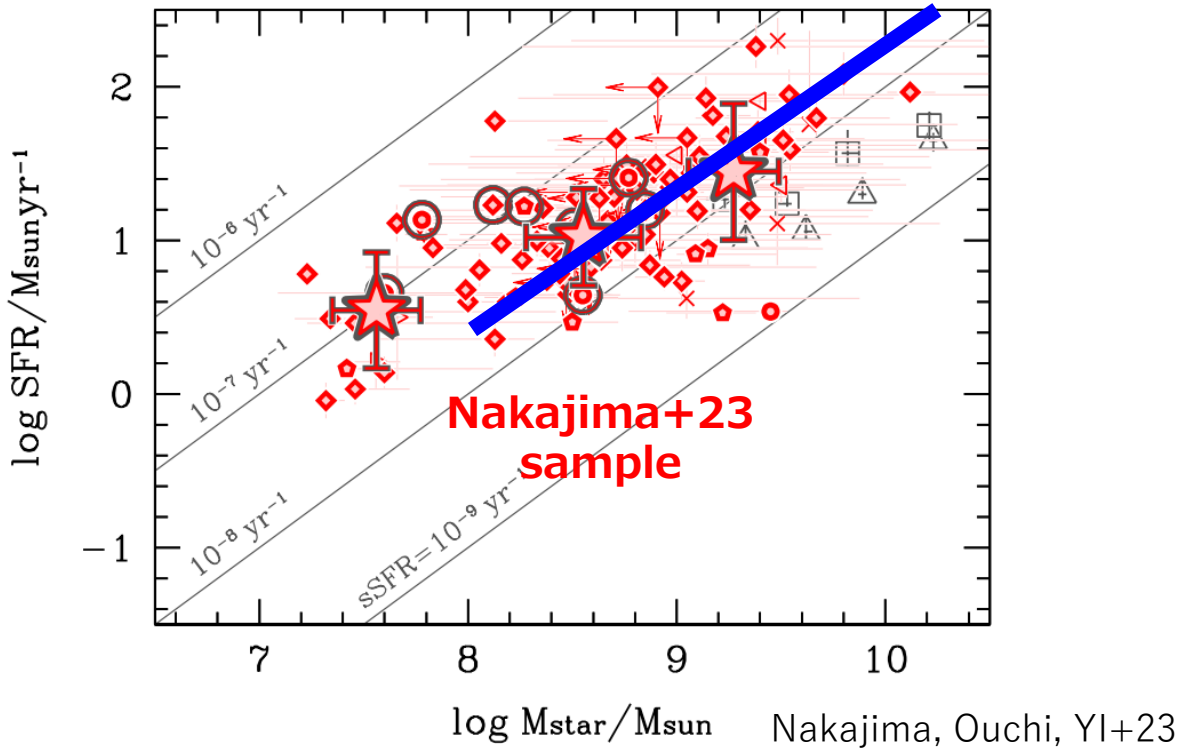
Data and Sample

Thanks to the NIRSpec public surveys

ERO (Pontoppidan+22)
GLASS (Treu+22)
CEERS (Finkelstein+22)

Data reduction by Nakajima+23
→ 111 galaxies at z = 4–10

z = 5-6 main sequence
(Santini+17)



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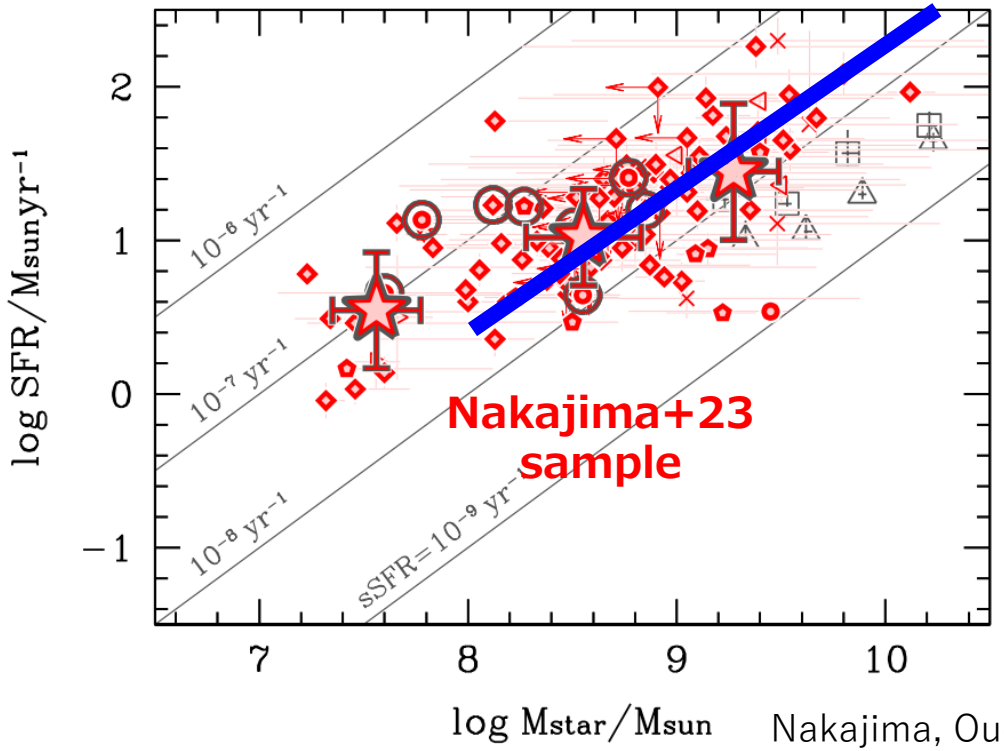
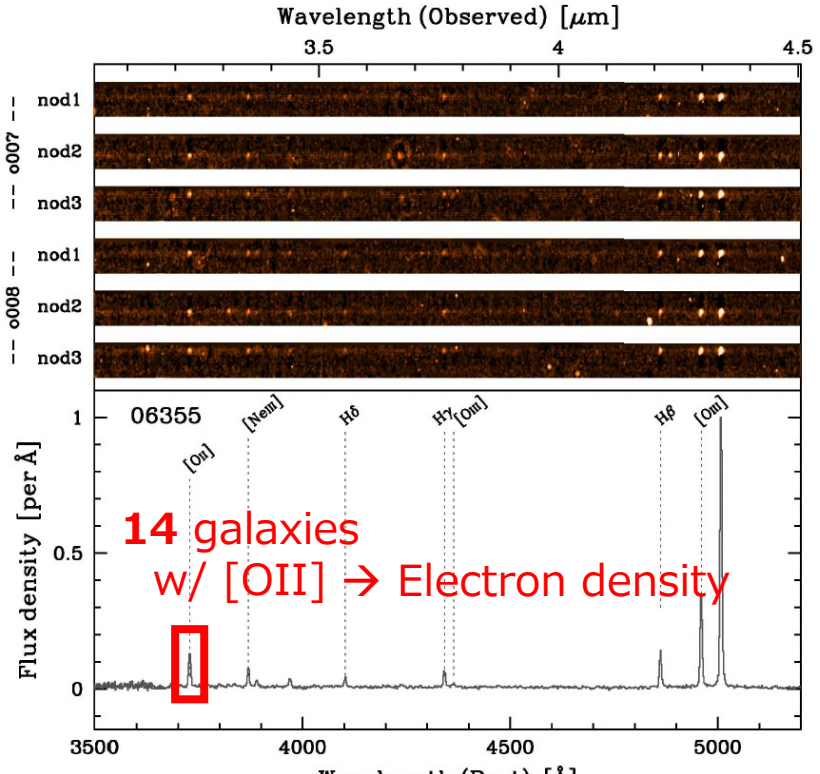


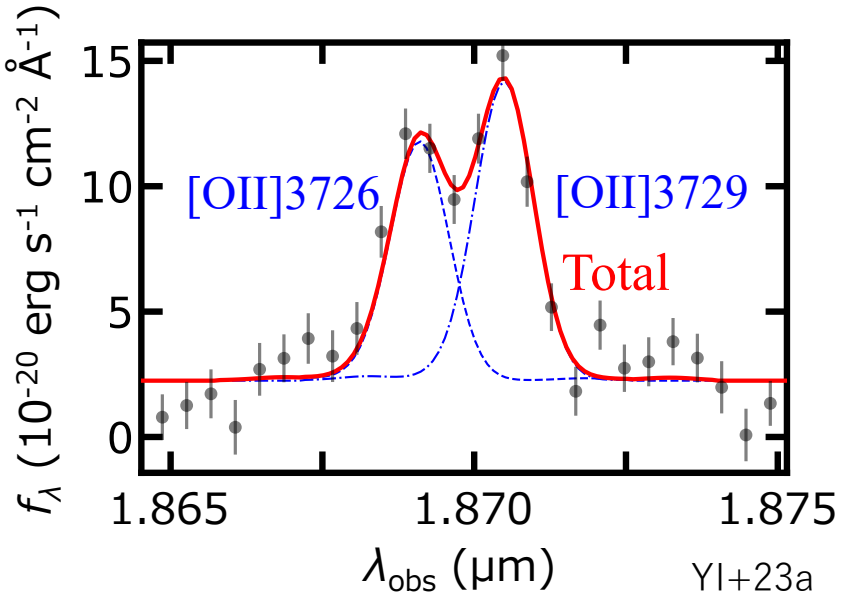
Nakajima, Ouchi, YI+23

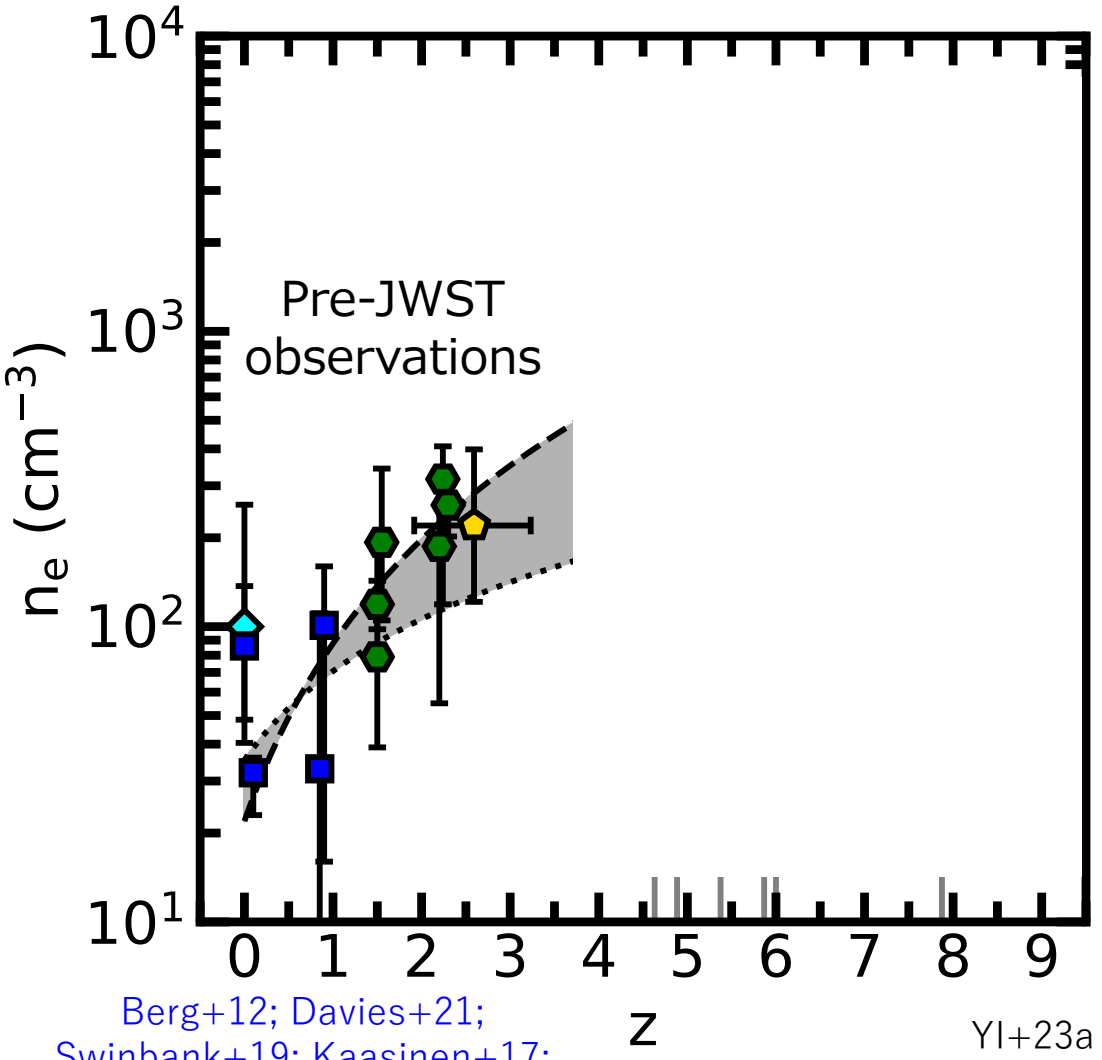


Nakajima, Ouchi, YI+23

Redshift Evolution of Election Density

Deriving LSFs for
careful [OII] separation





Berg+12; Davies+21;
Swinbank+19; Kaasinen+17;
Davies+21; Kashino+17;
Sanders+16; Steidel+14

Redshift Evolution of Election Density

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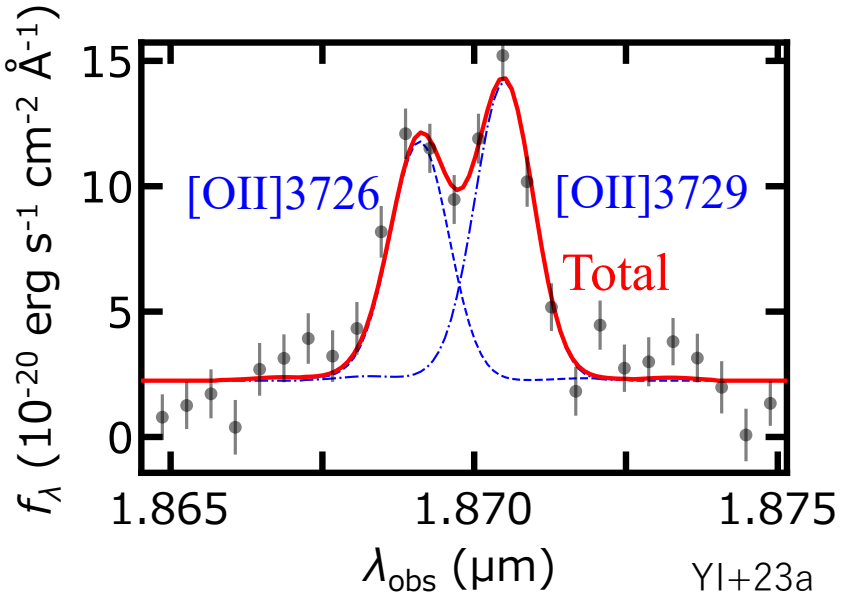

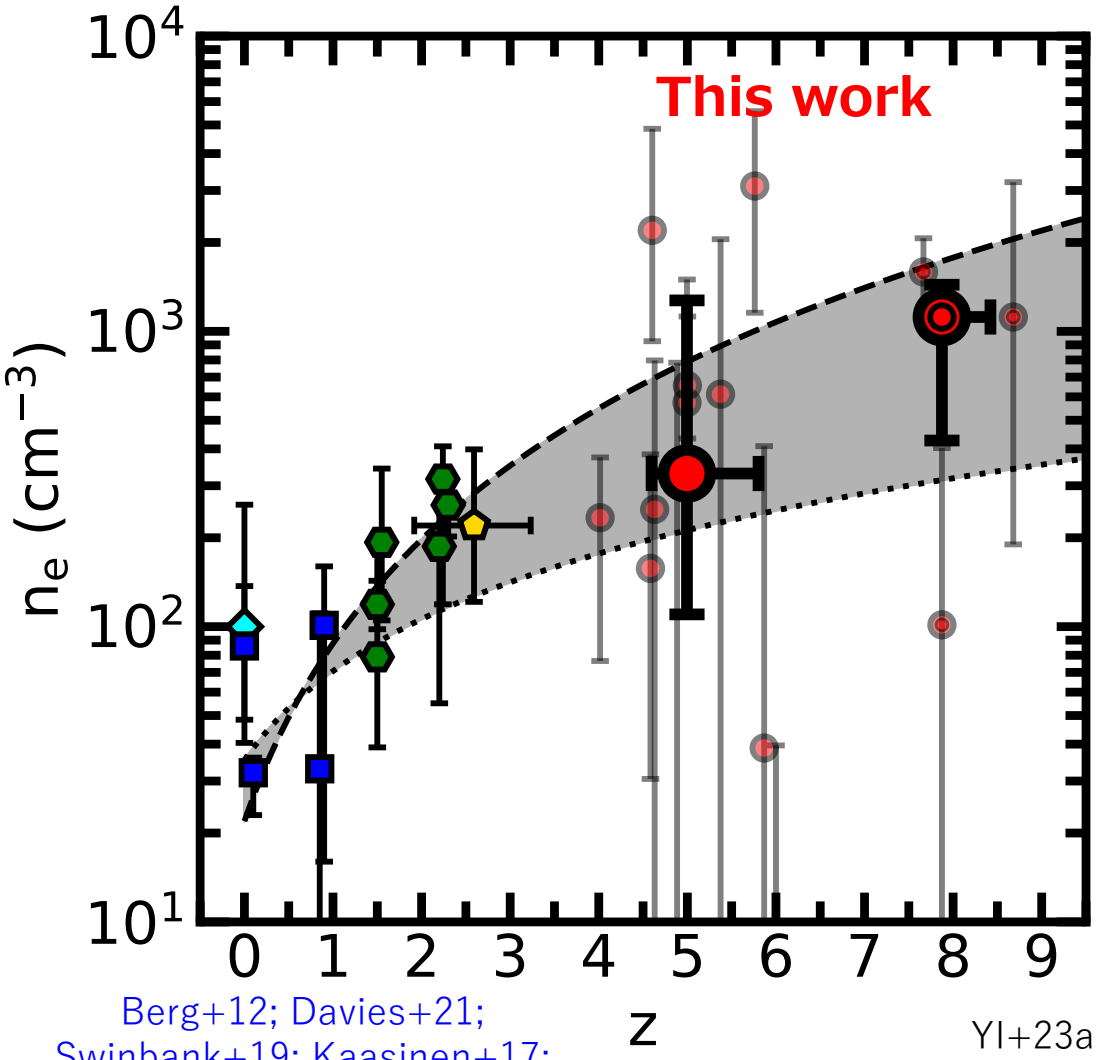

Berg+12; Davies+21;
Swinbank+19; Kaasinen+17;
Davies+21; Kashino+17;
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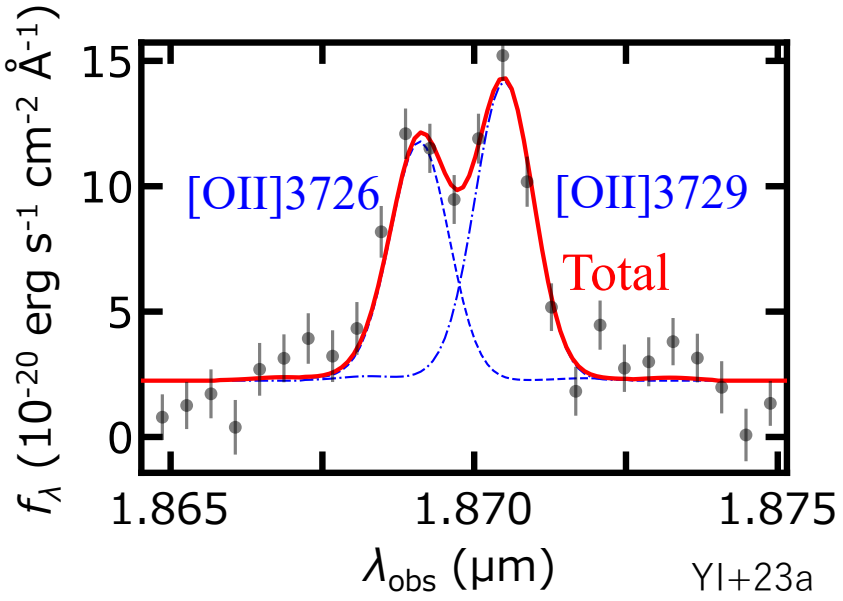
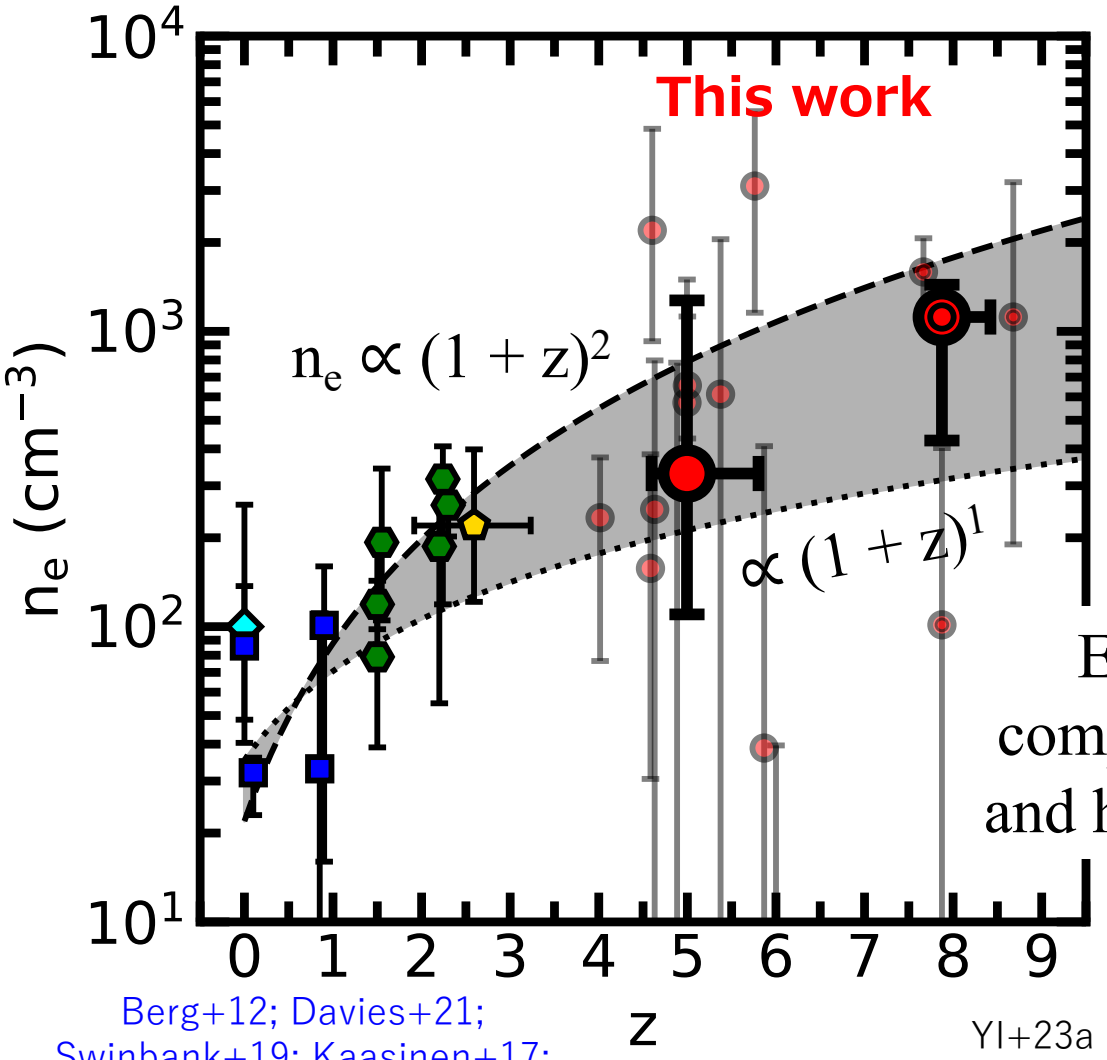
Increase!

Redshift Evolution of Election Density

Deriving LSFs for careful [OII] separation



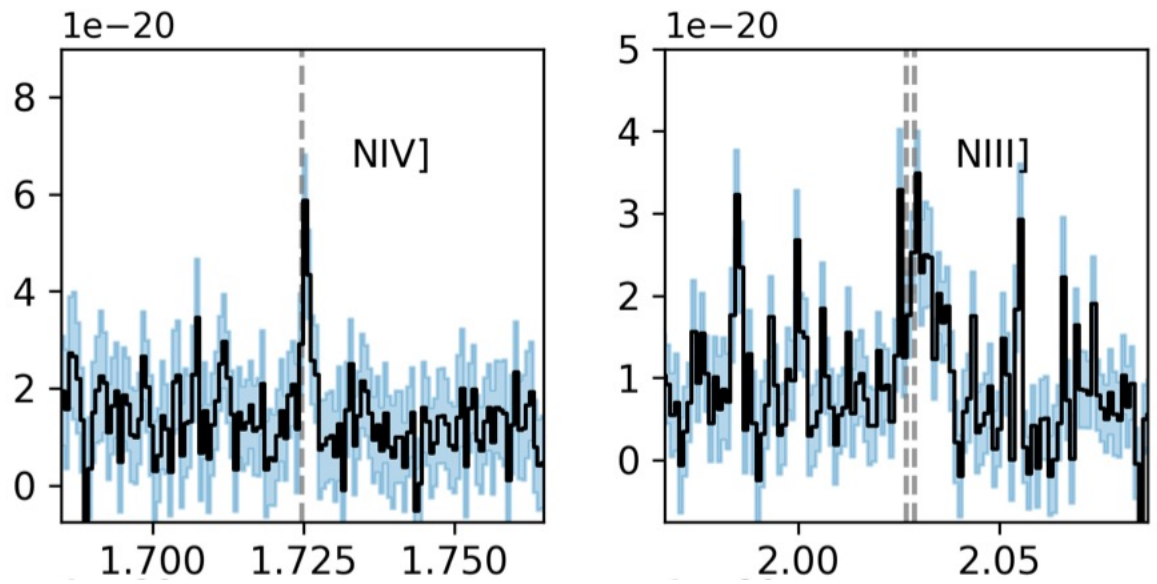


Explainable by compact morphology and high temperature?

Berg+12; Davies+21; Swinbank+19; Kaasinen+17; Davies+21; Kashino+17; Sanders+16; Steidel+14

Supersolar N/O in GN-z11 @ z = 10.6

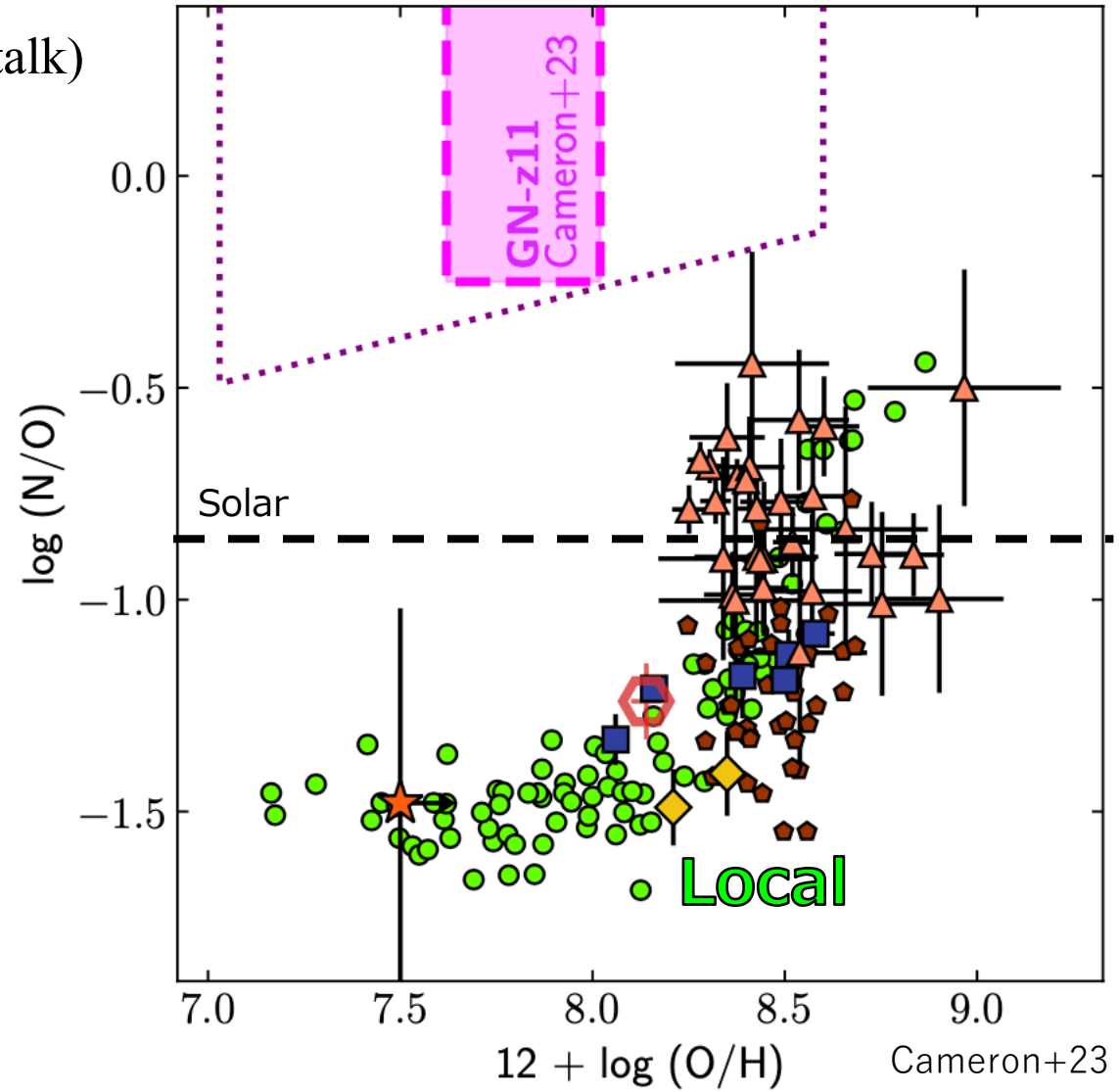
Unexpectedly strong NIII] and NIV] lines from GN-z11 (JADES; Bunker+23; see Jan Scholtz's talk)



Bunker+23

Supersolar N/O (Cameron+23; Senchyna+23)

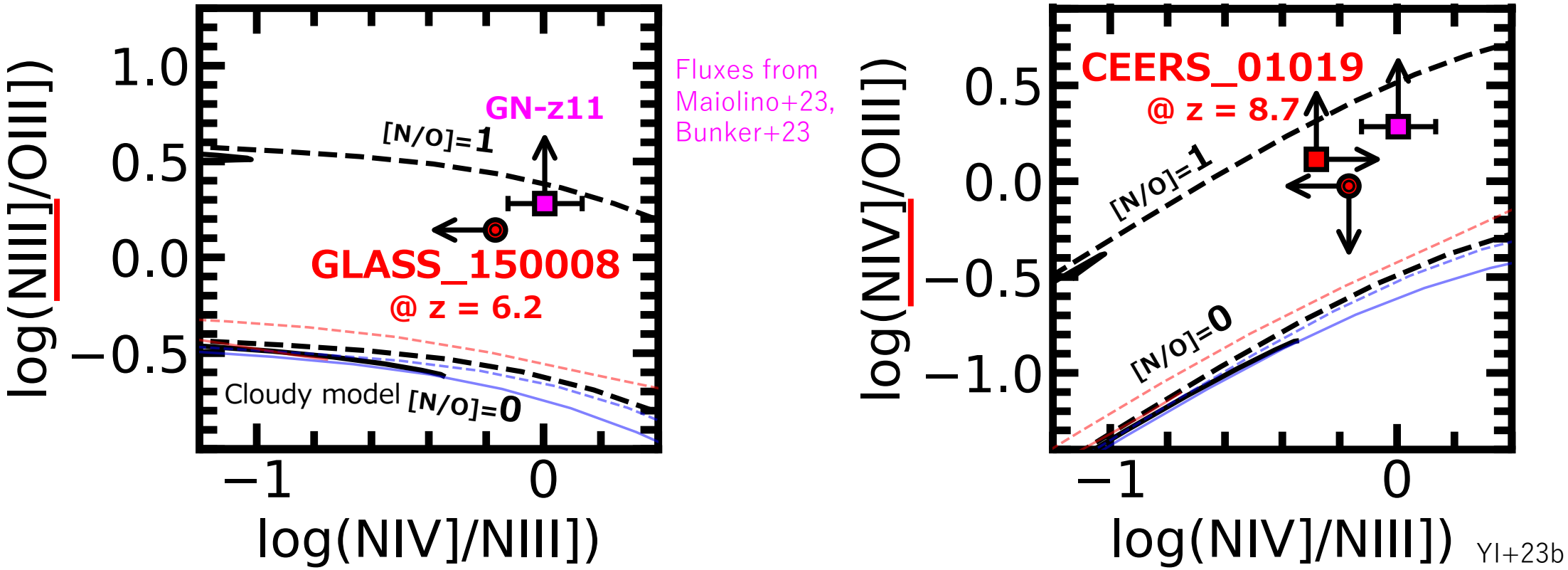
→ Any other high-z galaxy w/ [N/O] > 0?



Cameron+23

NIII] or NIV] Detection Other Than GN-z11

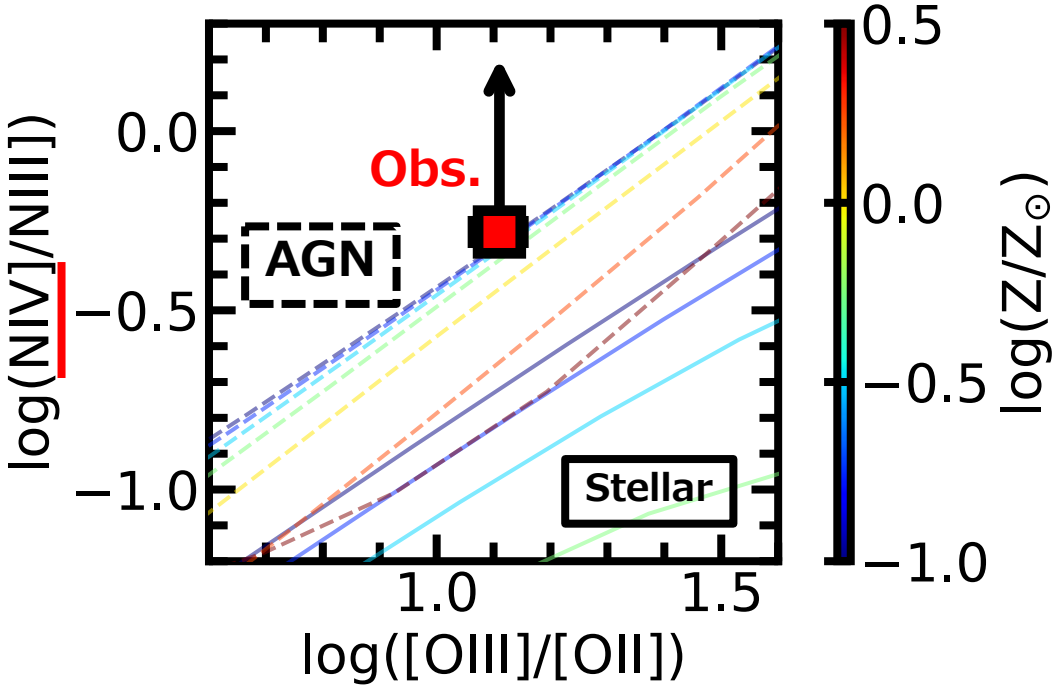
From 70 of Nakajima+23 sample galaxies (w/ grating obs.)



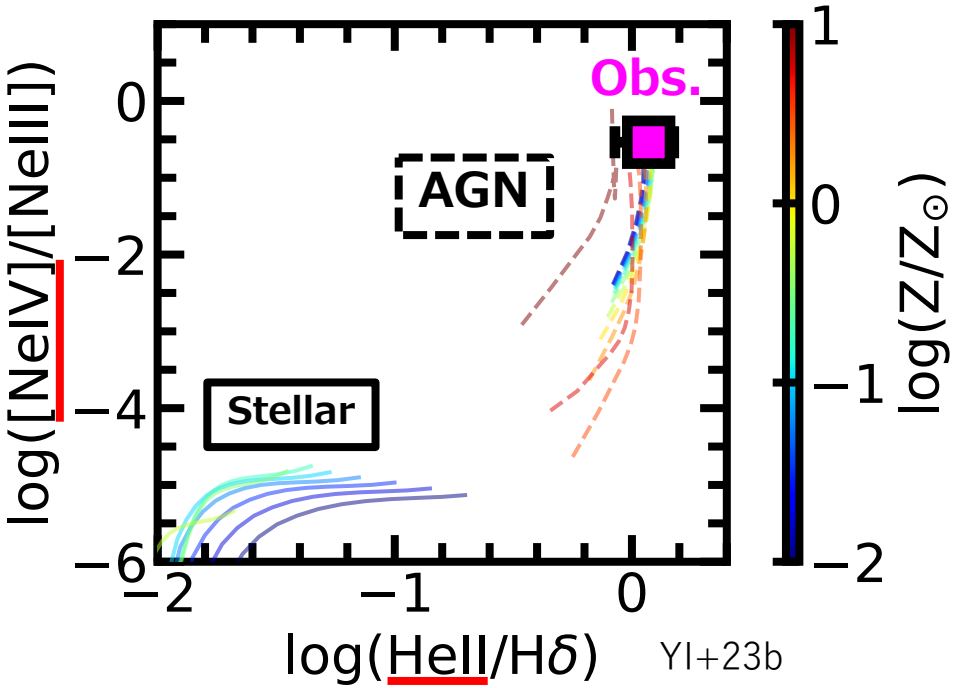
→ **Promising to have supersolar N/O**

Star-forming galaxy? AGN?

CEERS_01019



GN-z11 Fluxes from Maiolino+23

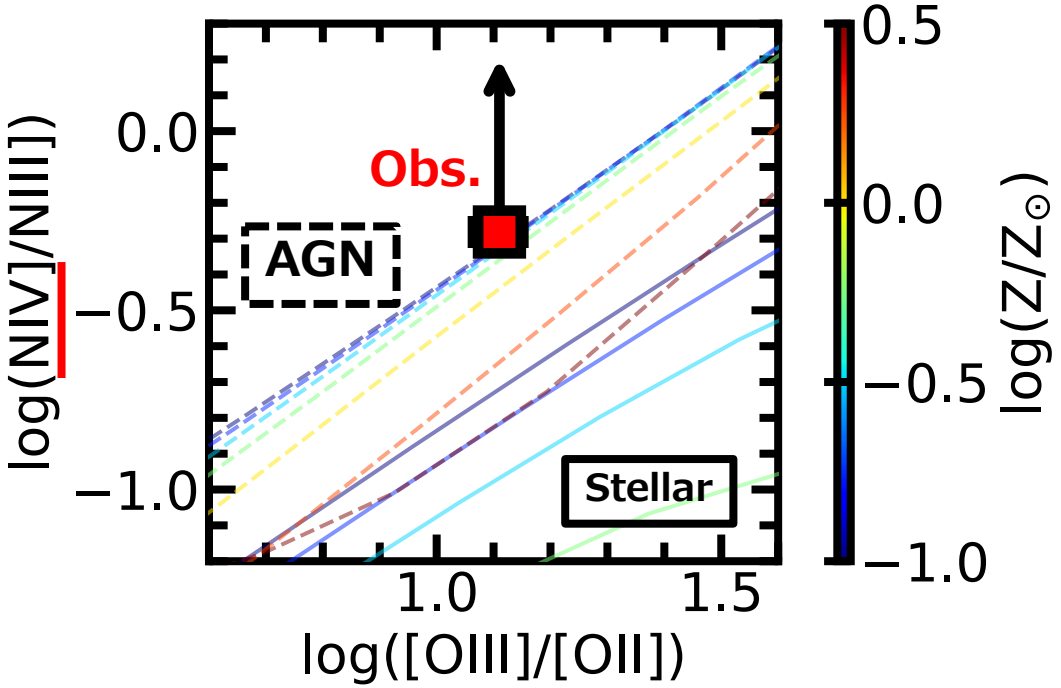


YI+23b

cf. Jan Scholtz's talk

Star-forming galaxy? AGN?

CEERS_01019



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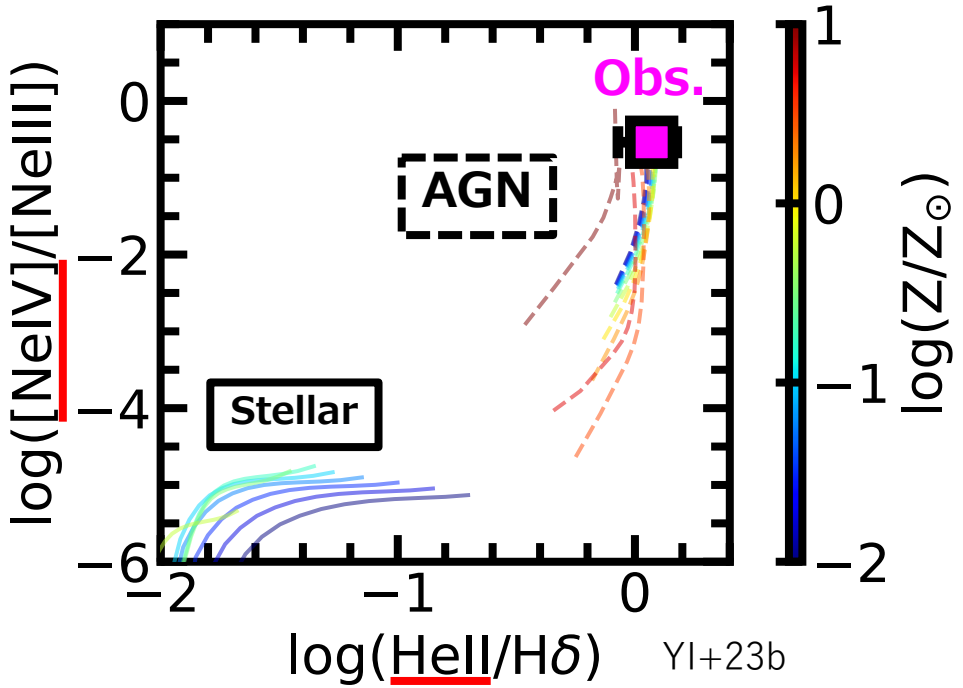


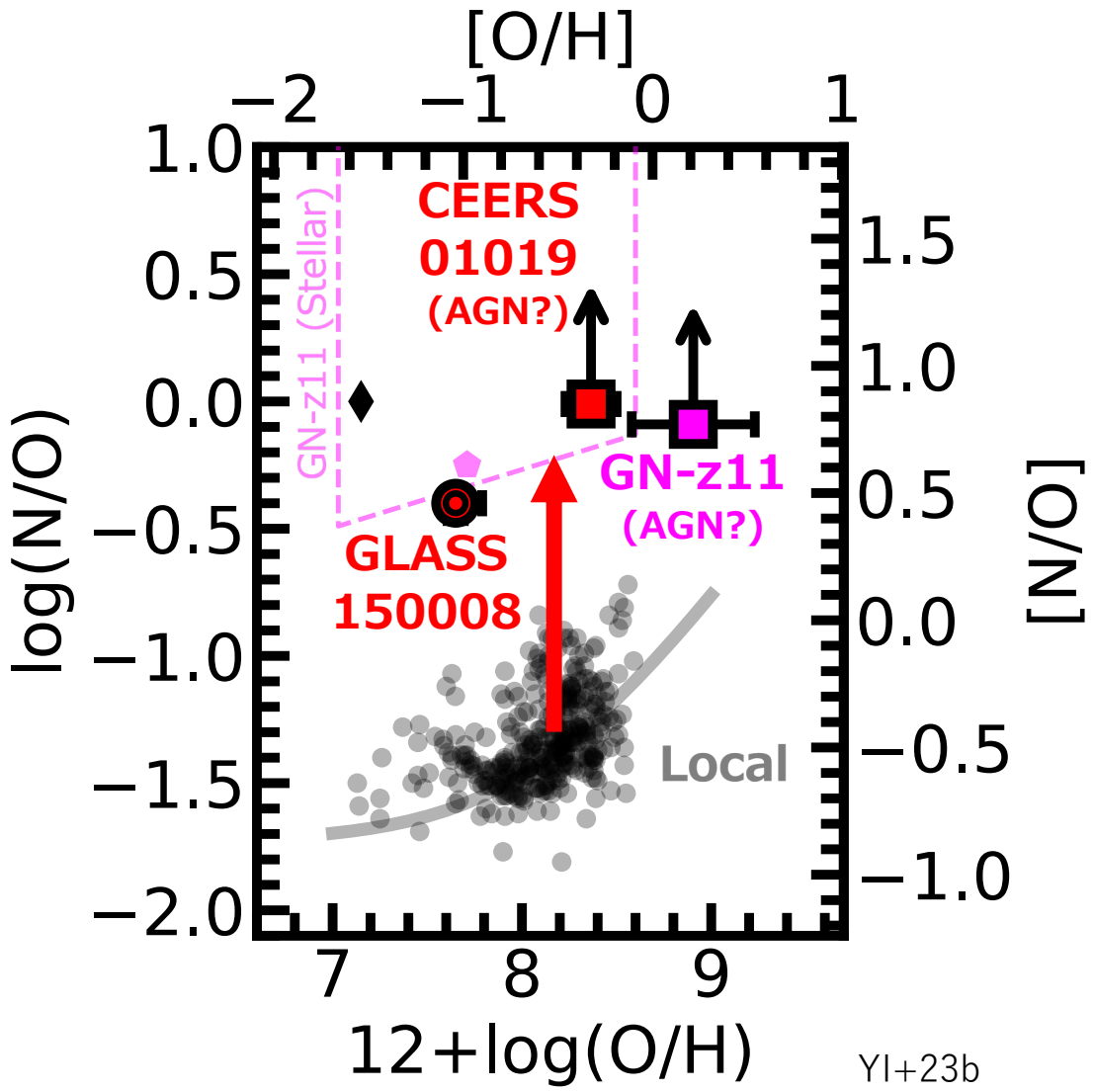
YI+23b

cf. Jan Scholtz's talk

GLASS_150008 does NOT have high-ionization line

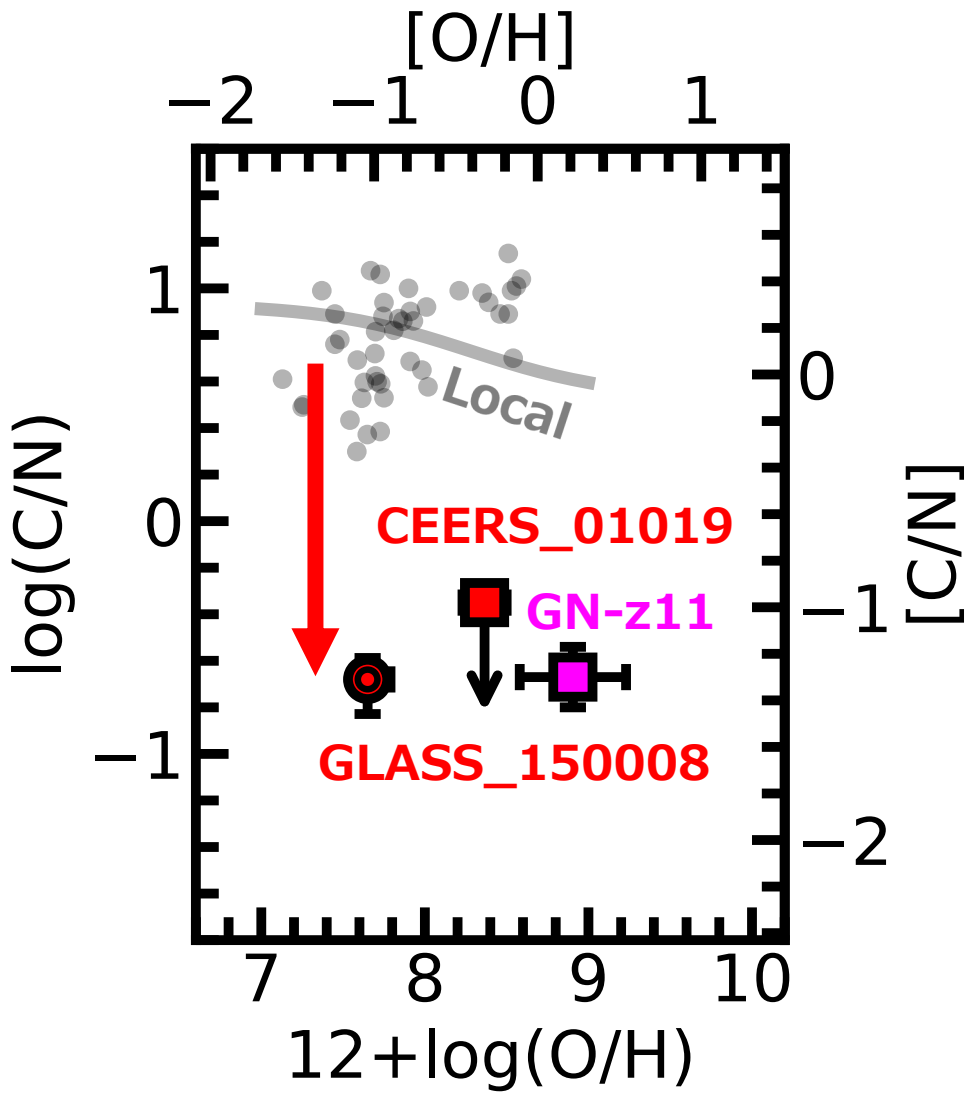
→ Star-forming galaxy?

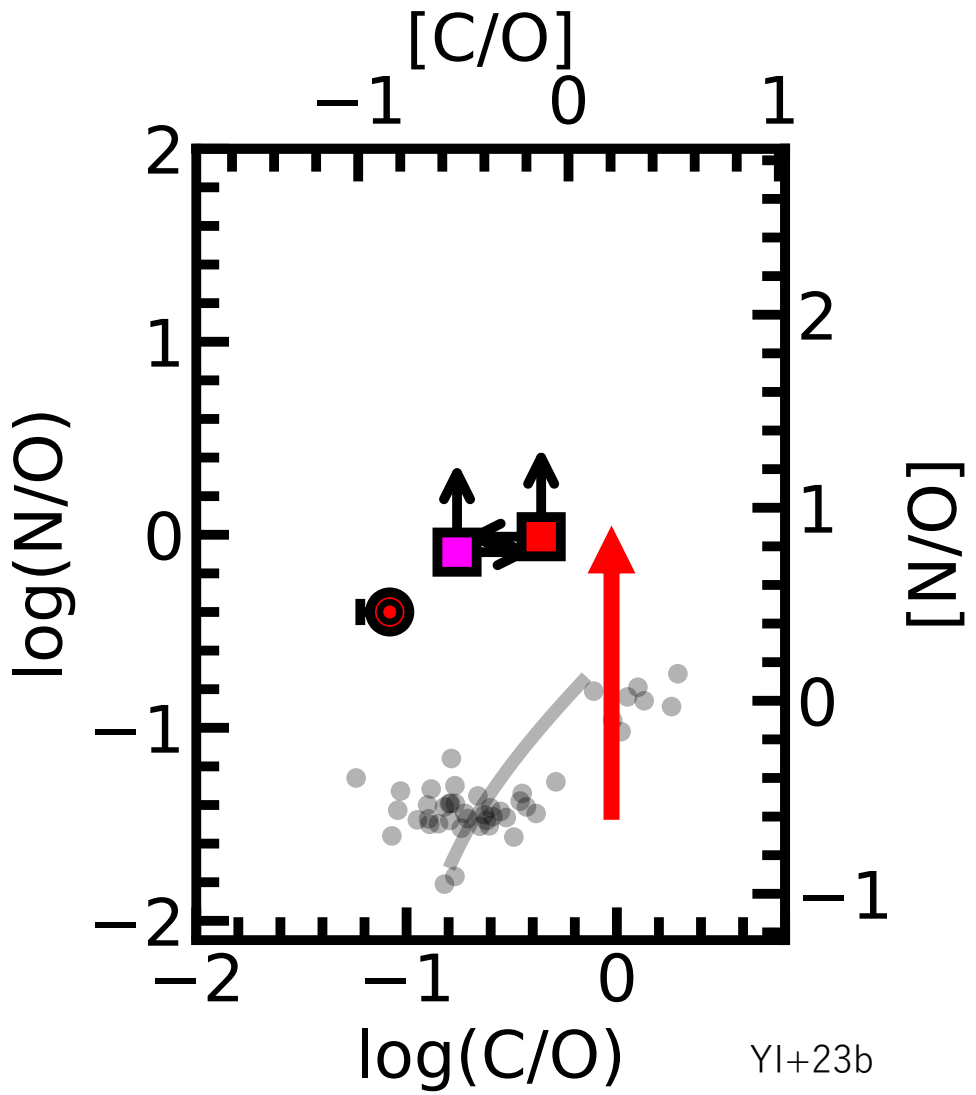
N/O vs. 12+log(O/H)



[N/O] ≳ 0.5
→ Supersolar N/O galaxies exist other than GN-z11!

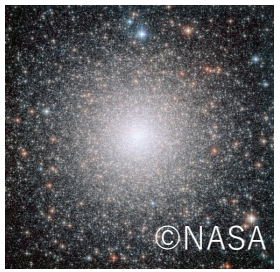
C/N vs. 12+log(O/H) & N/O vs. C/O



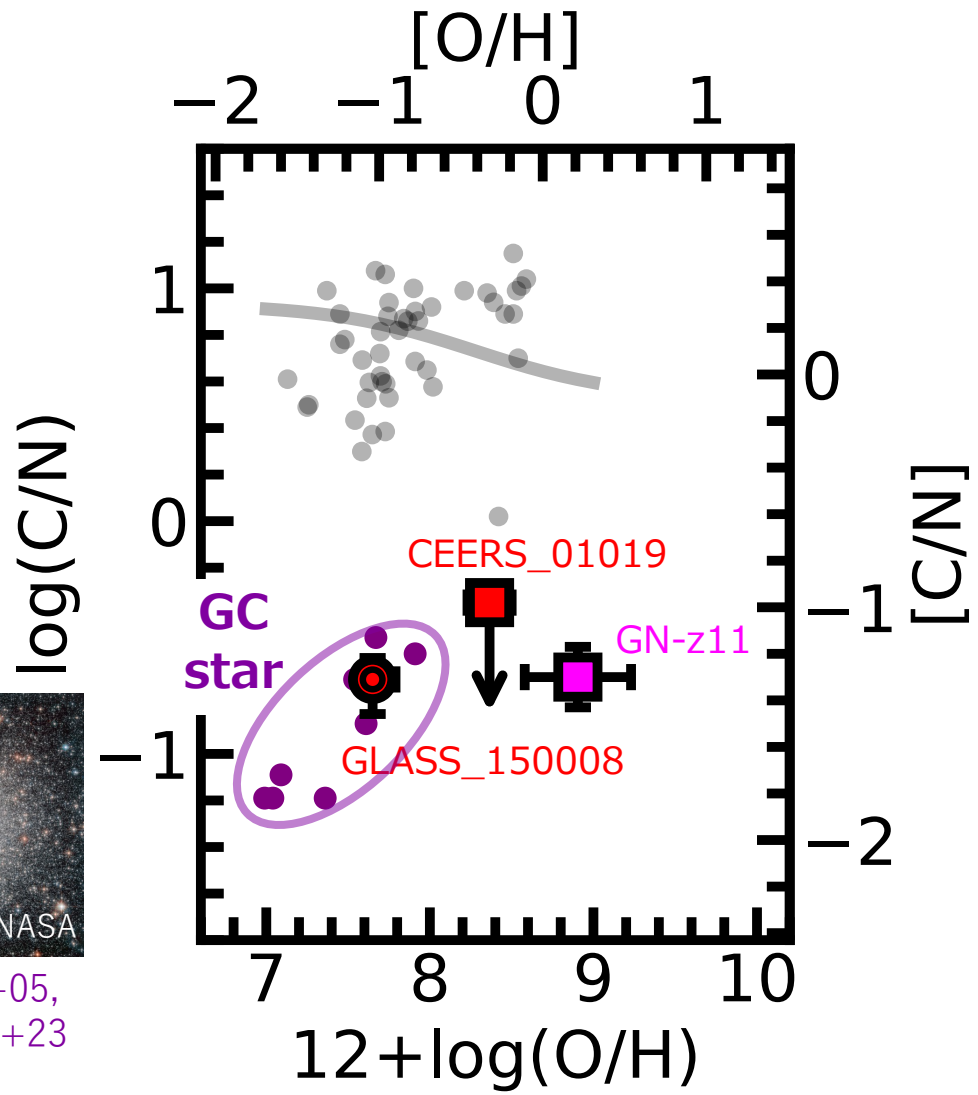


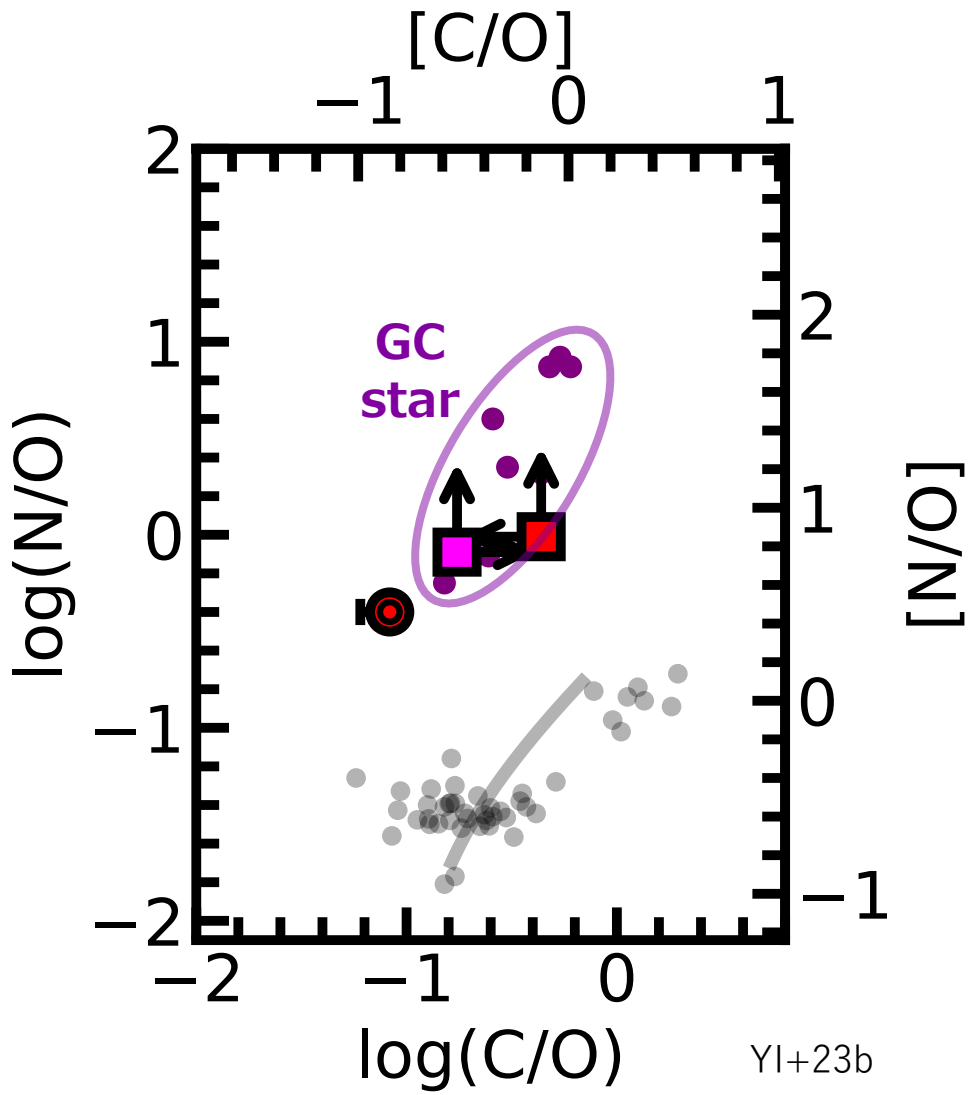
→ N selectively enriched

Similarity to Globular Cluster (GC) Star



Carretta+05,
Senchyna+23



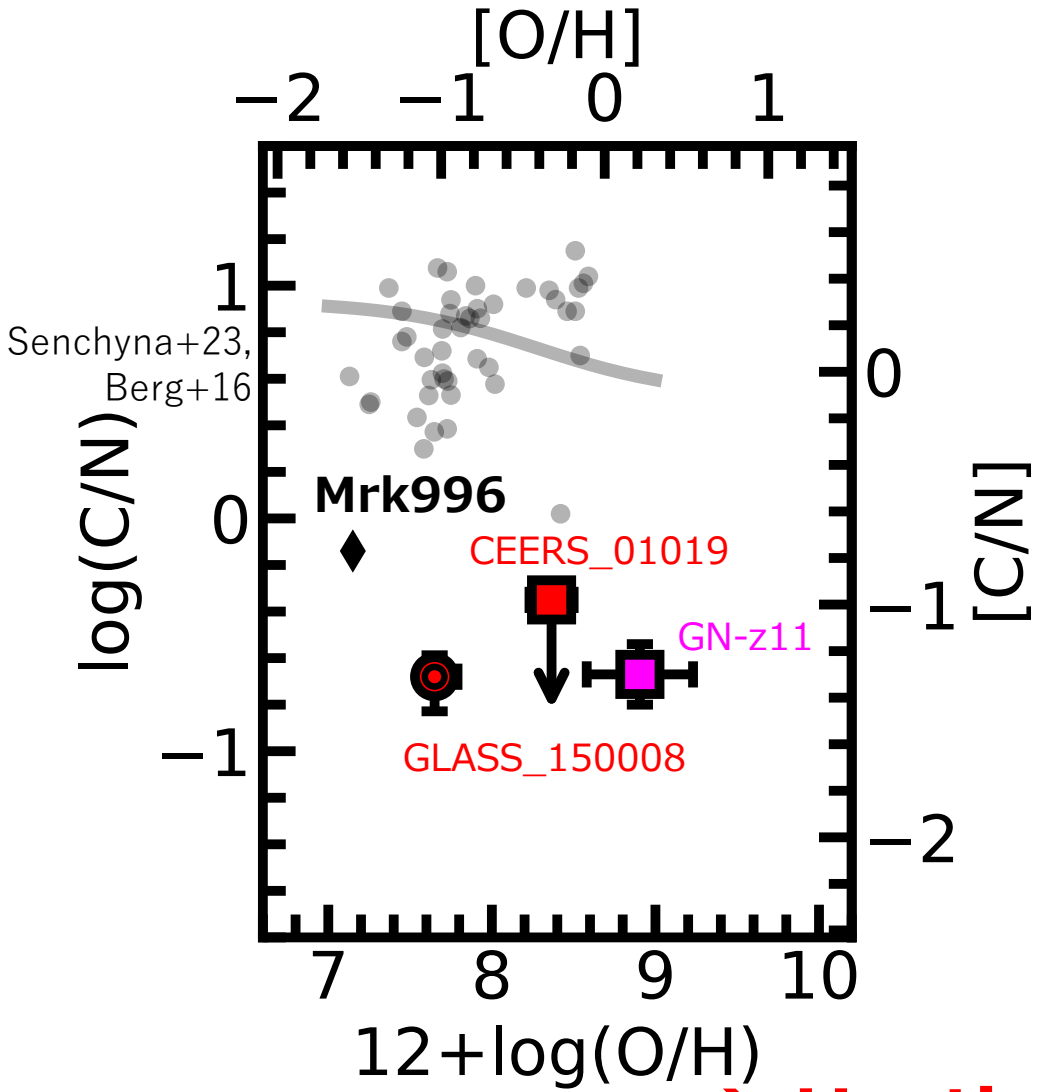


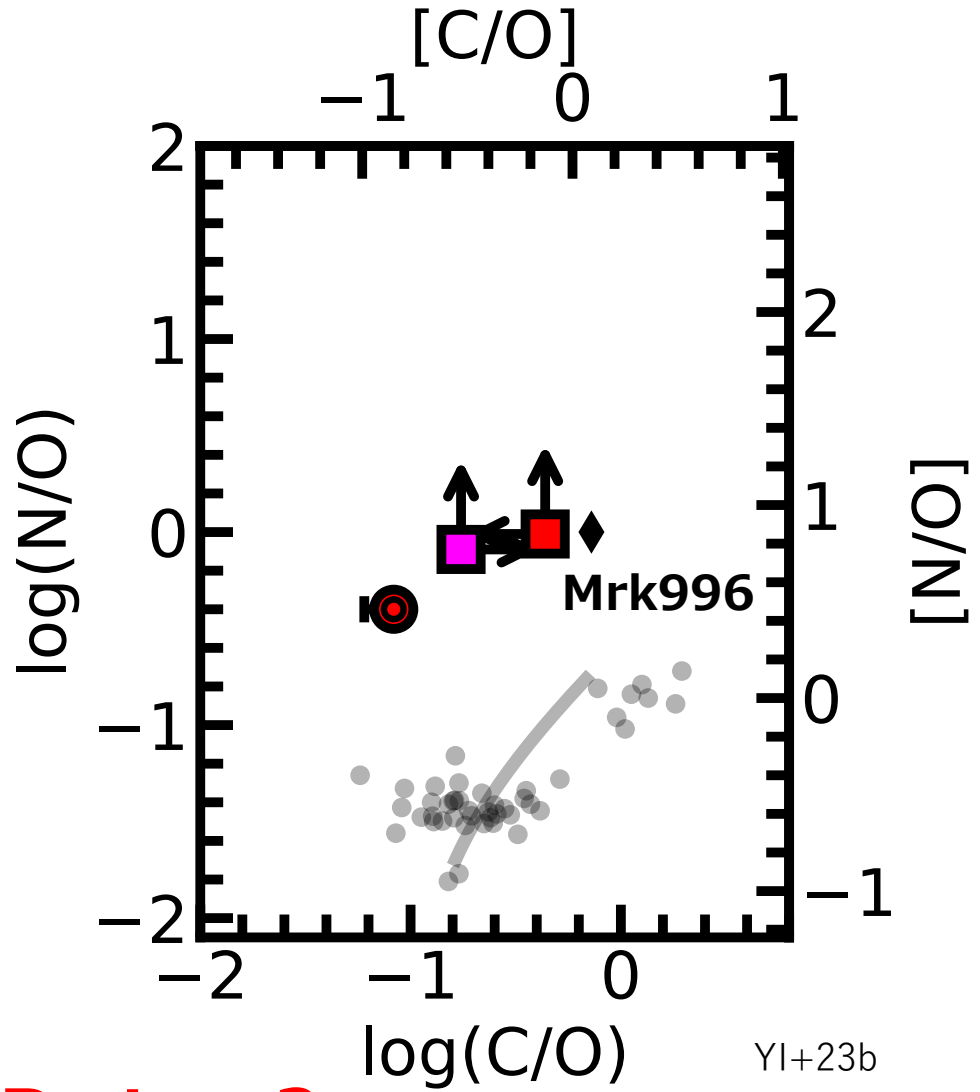
YI+23b

→ GC progenitor?

Similarity to Wolf-Rayet (WR) Galaxy

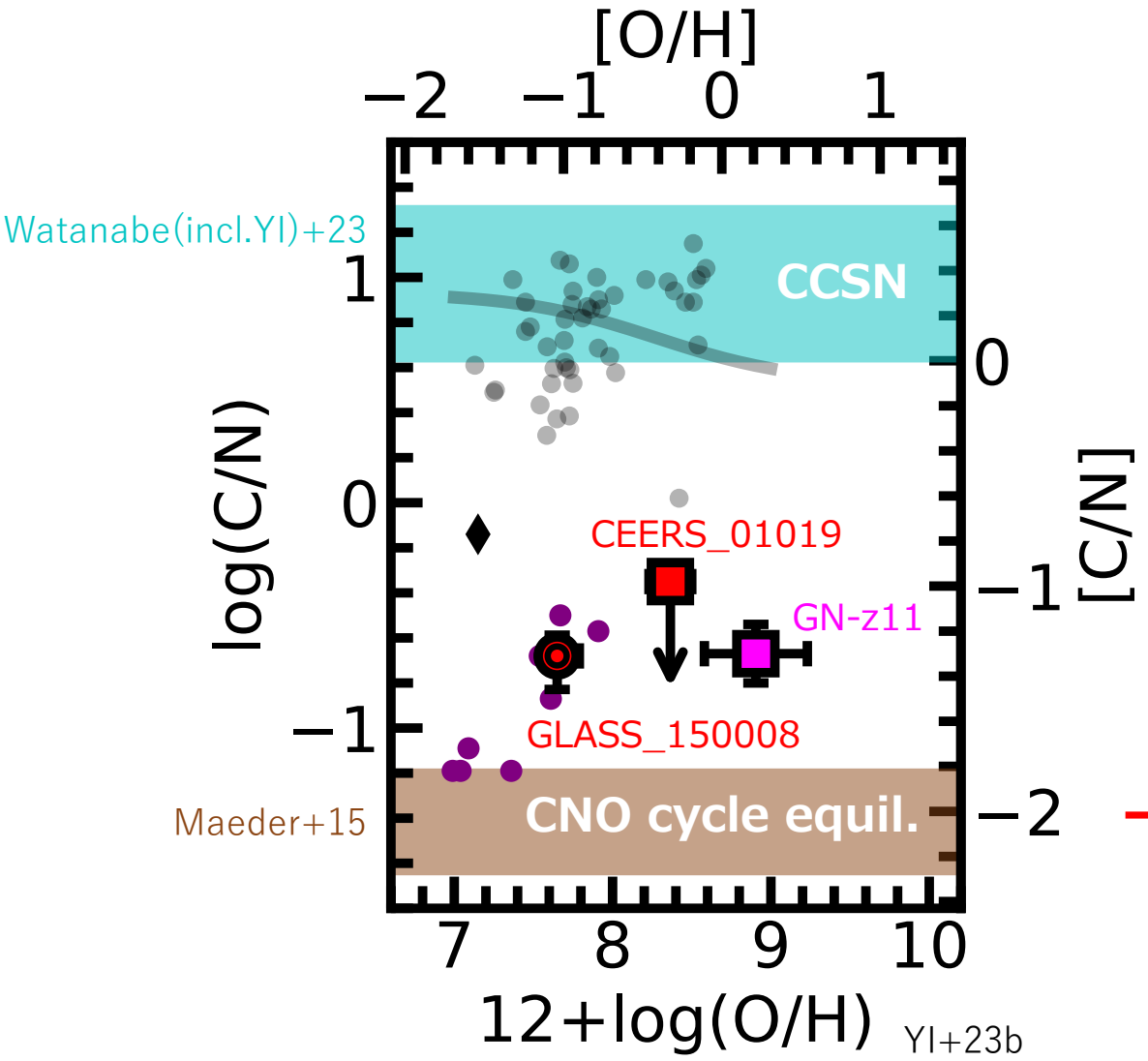
Mrk996 at z ~ 0: Hosting WR stars (Telles+14)





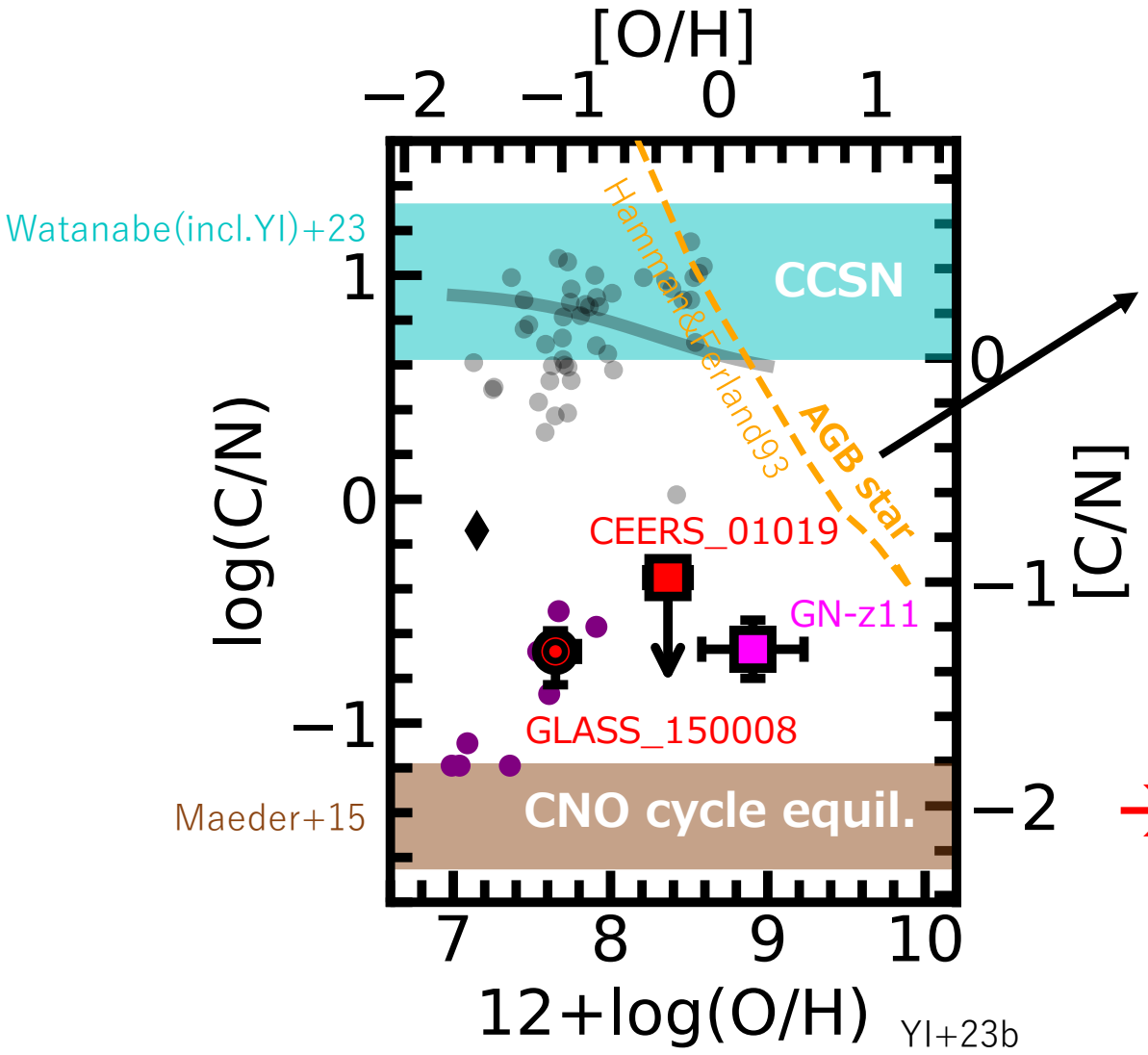
→ Hosting WR stars?

Origin of Low C/N



→ **Dominated by CNO-cycle processed gas**

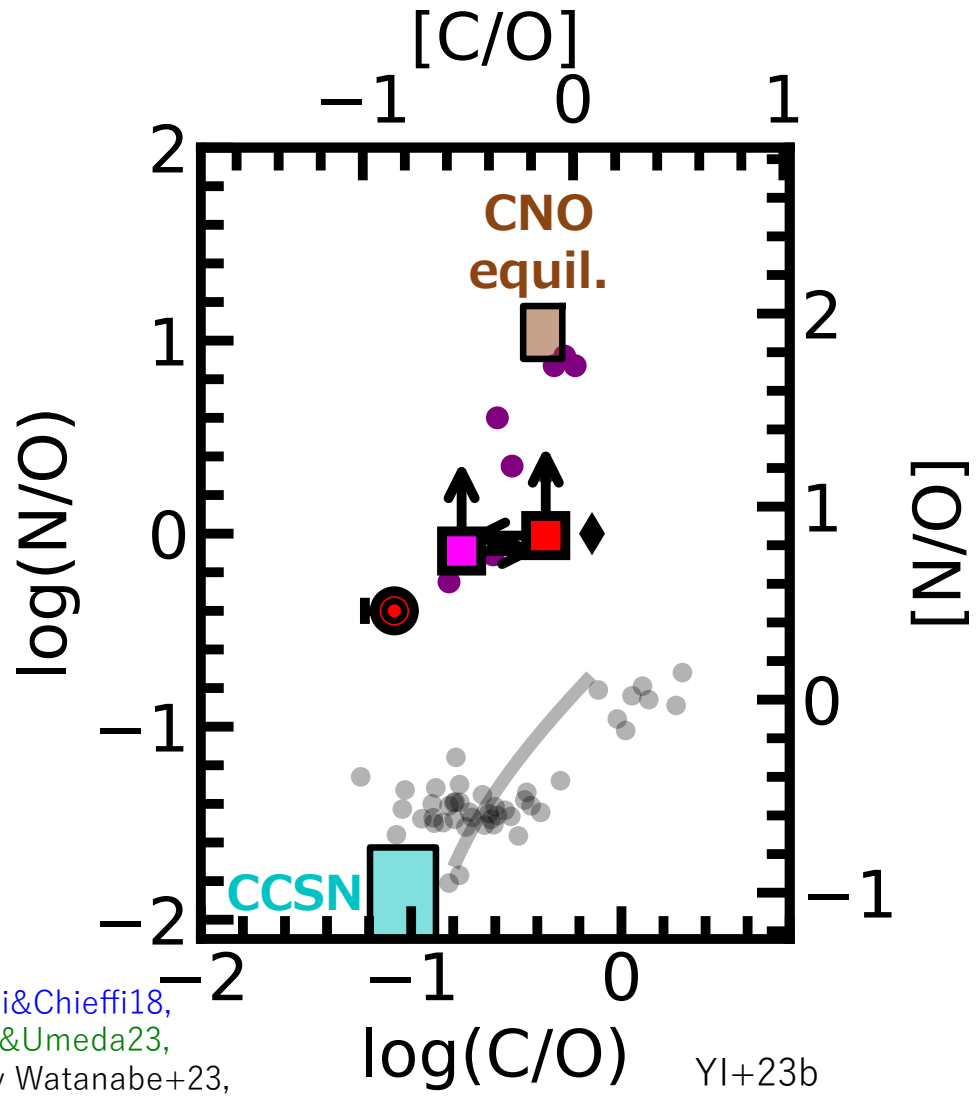
Origin of Low C/N



(Nitrogen-loud) quasar model incl. **AGB** star
Too much O/H at [C/N] ~ −1
→ Not likely?

→ Dominated by CNO-cycle processed gas

CNO-cycle-based Scenarios



Limongi&Chieffi18,
Nagele&Umeda23,
Modeled by Watanabe+23,
Watanabe+in prep

YI+23b

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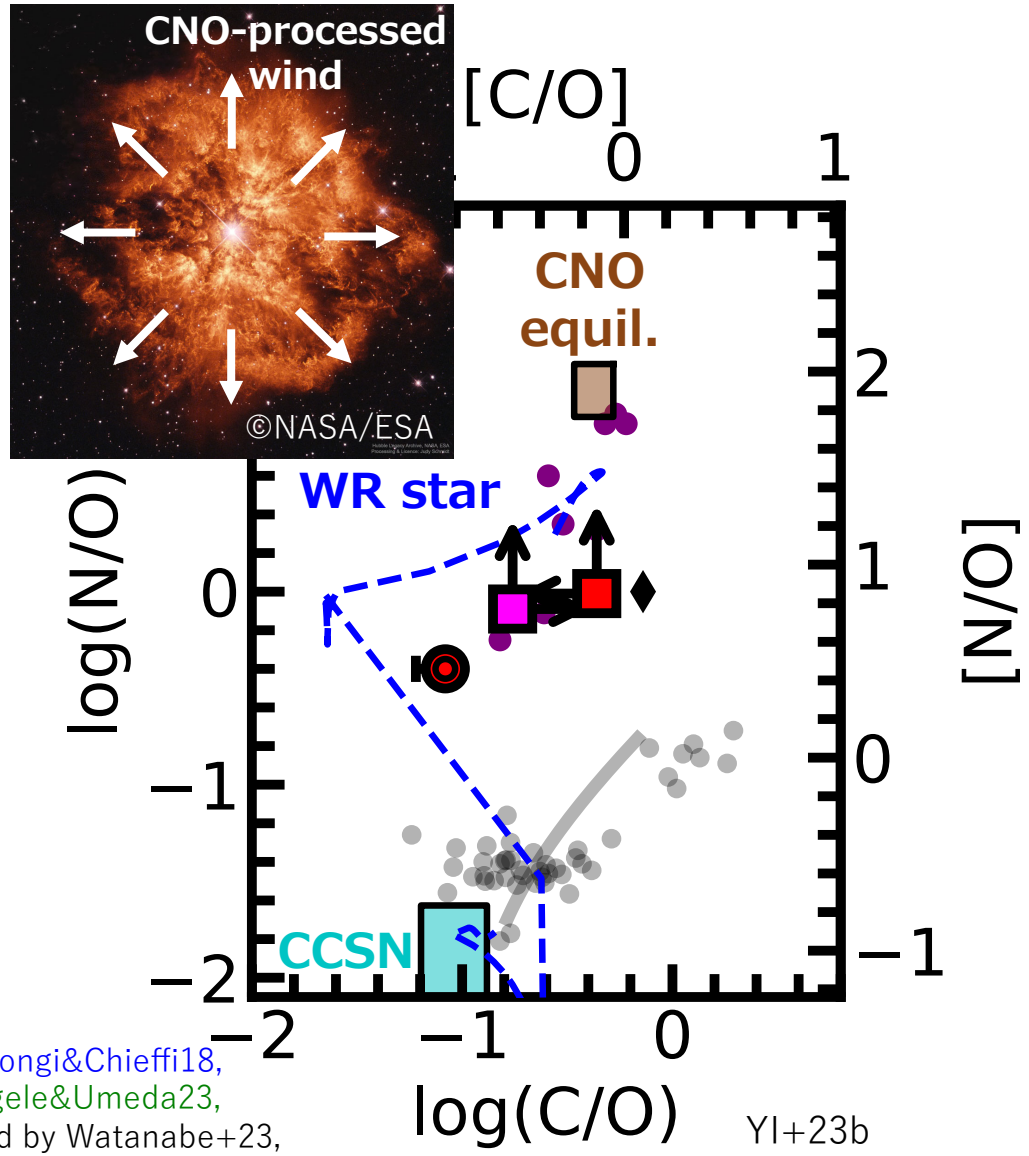

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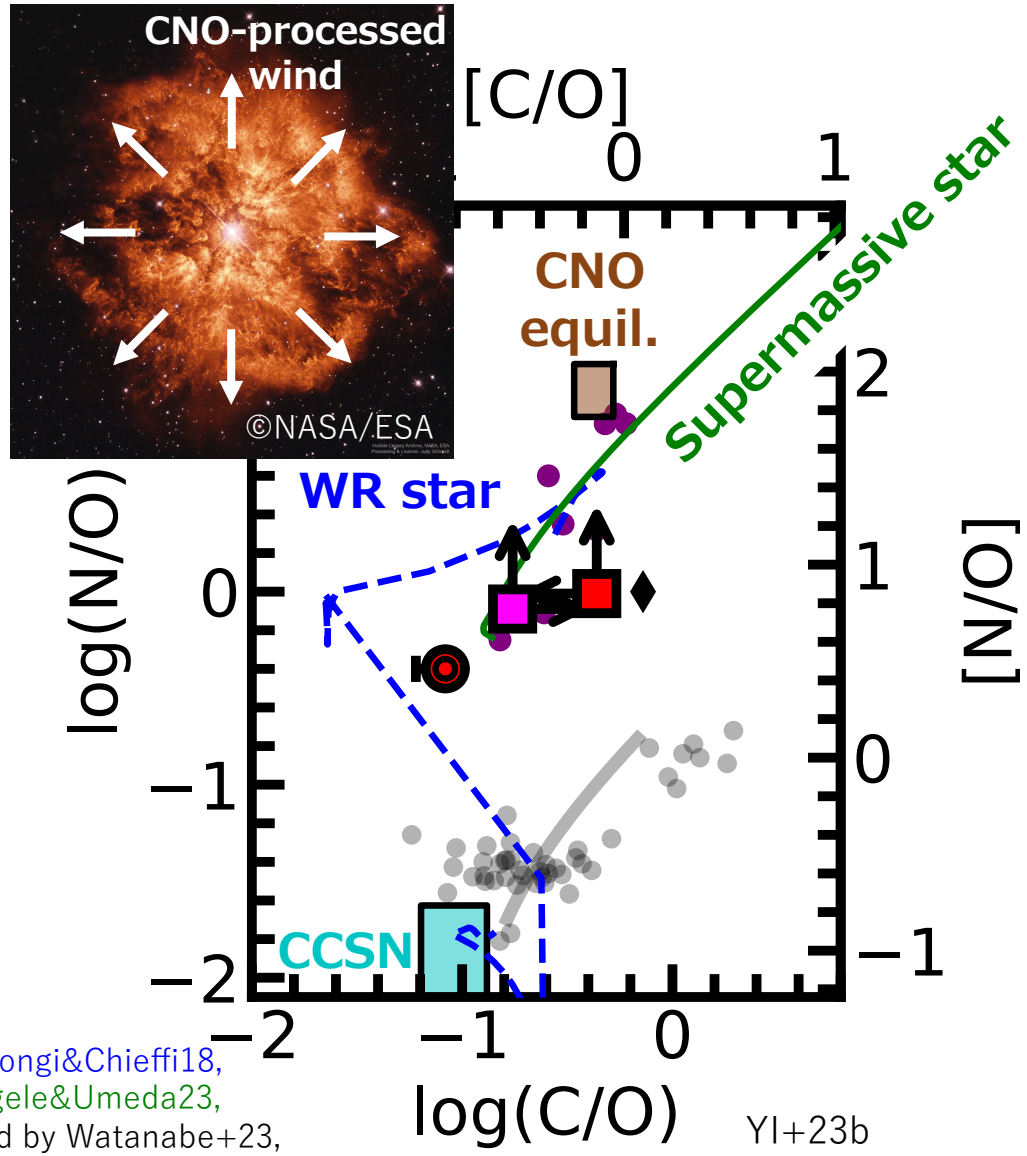

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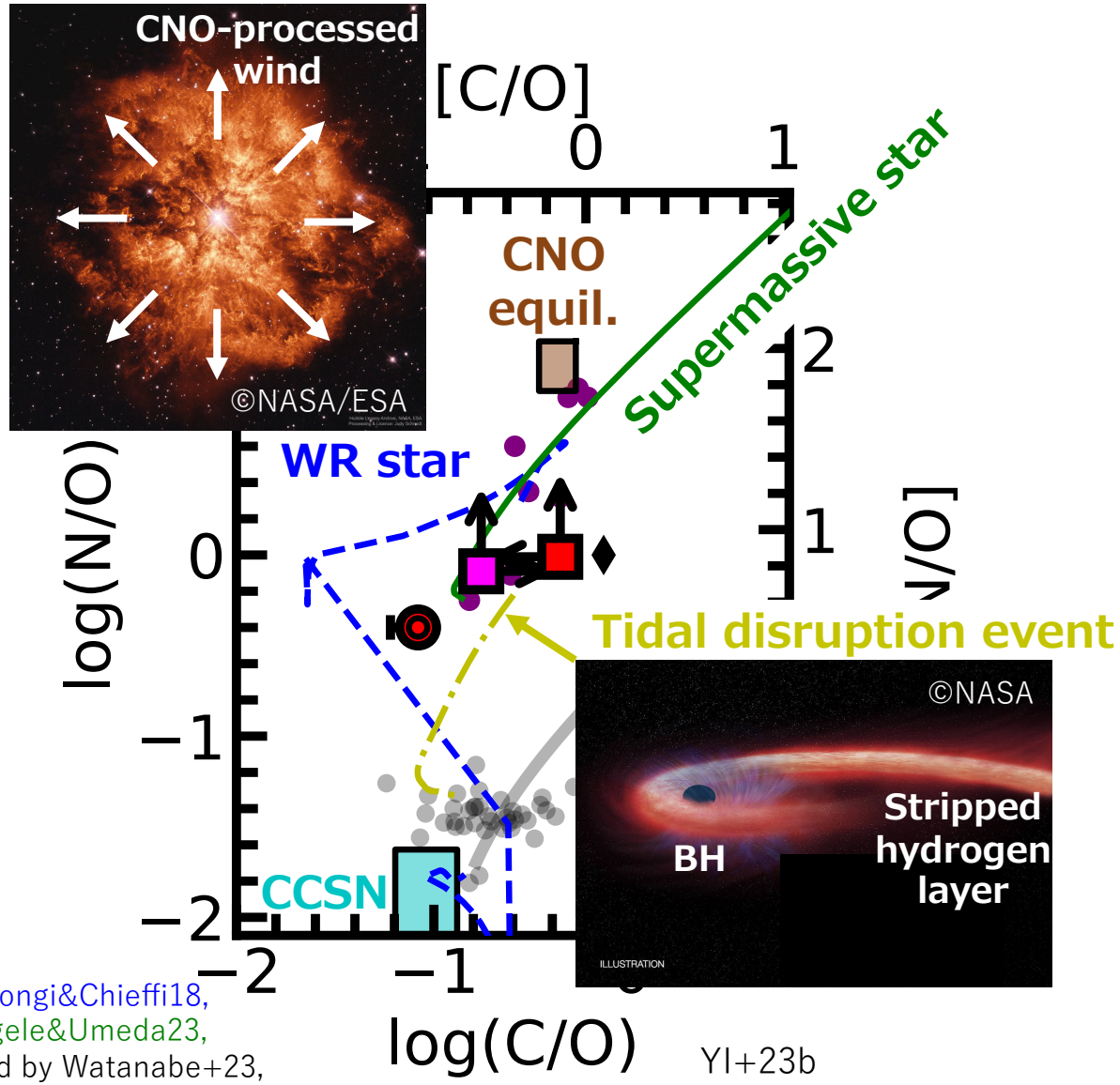

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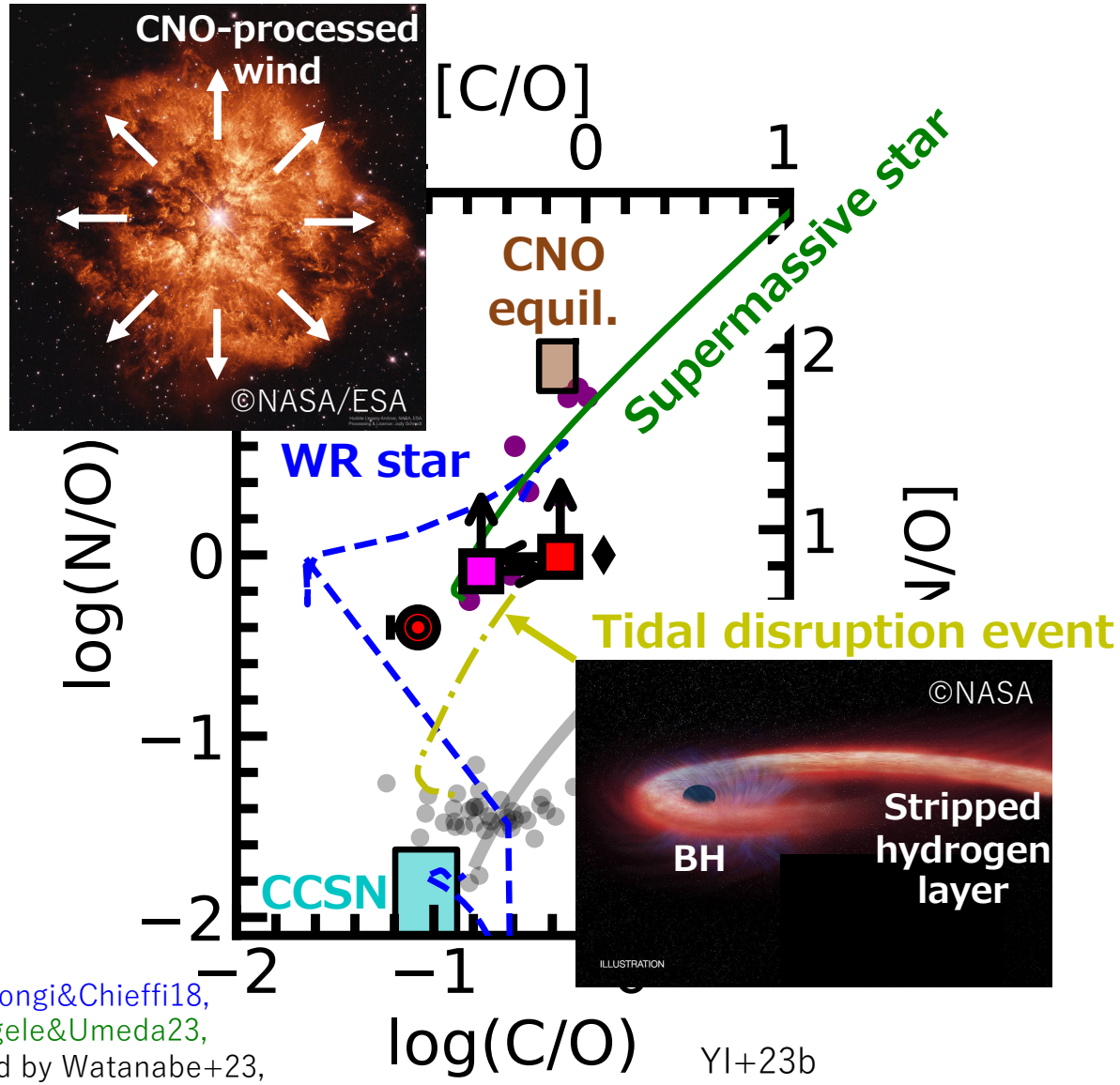

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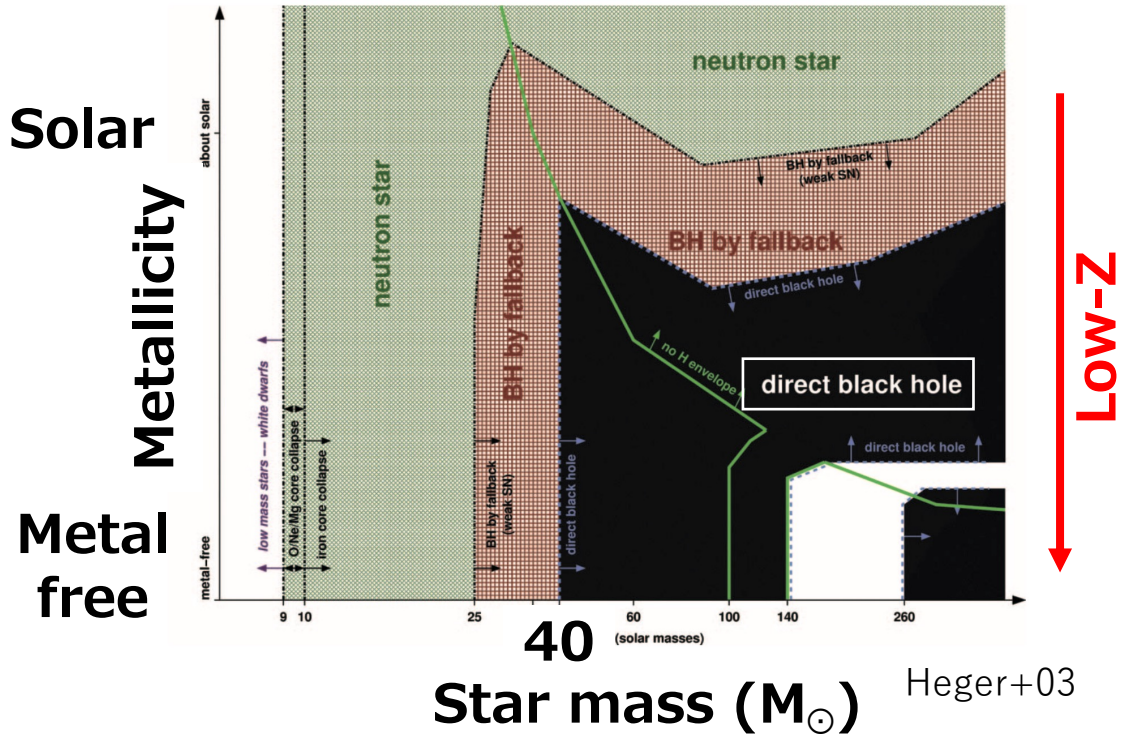
YI+23b

× Direct collapse



Heger+03

→ **Low-Z** seems crucial but something more?

Summary

Electron density increases from z ~ 0–1 to 1–3 and 4–9
Explainable by a combination of compact morphology
and high temperature at high redshifts

Identifying **2** galaxies at z > 6
CEERS_01019 and GLASS_150008
with **supersolar N/O** ratios similar to GN-z11

The 3 galaxies have **[C/N] < –1**
→ Dominated by **CNO-cycle** processed gas
Favoring CNO-cycle-based scenarios
e.g., WR star, SMS, TDE w/ direct collapse