Chemical abundances inform LyC escape conditions at z ~5

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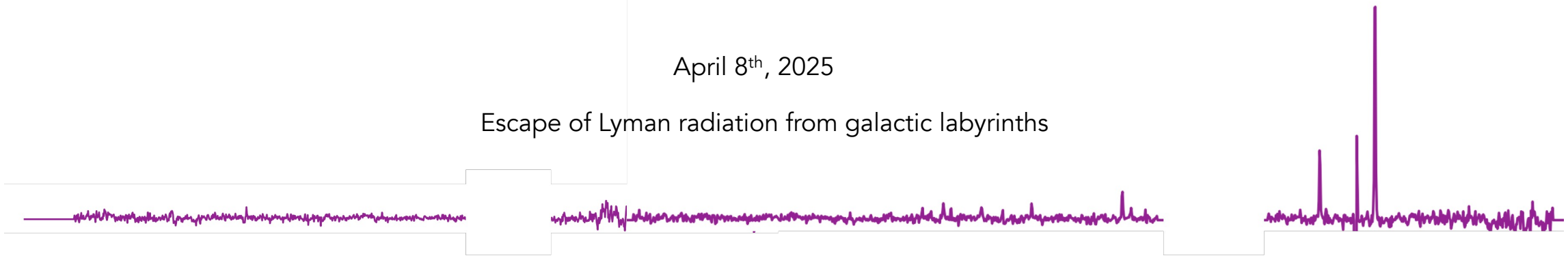
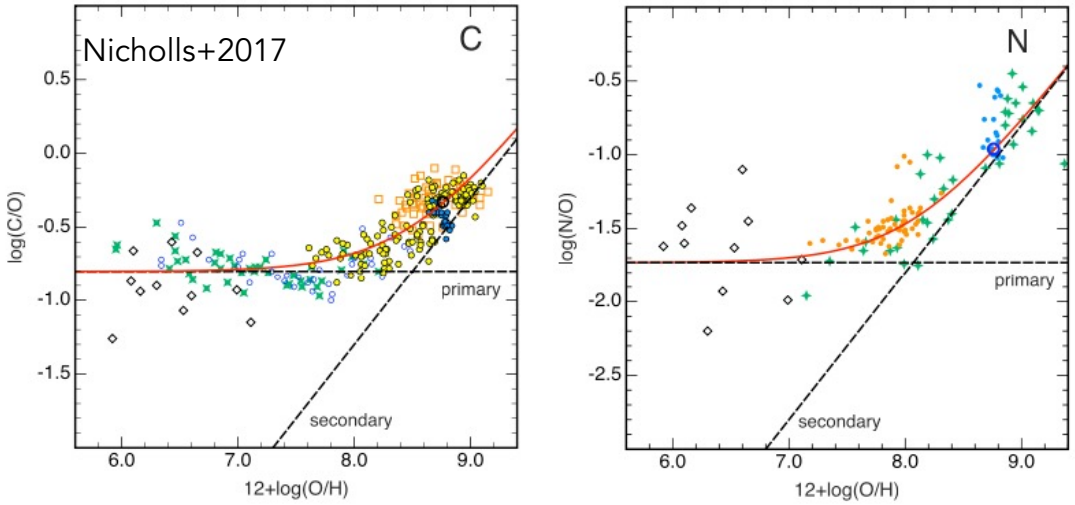
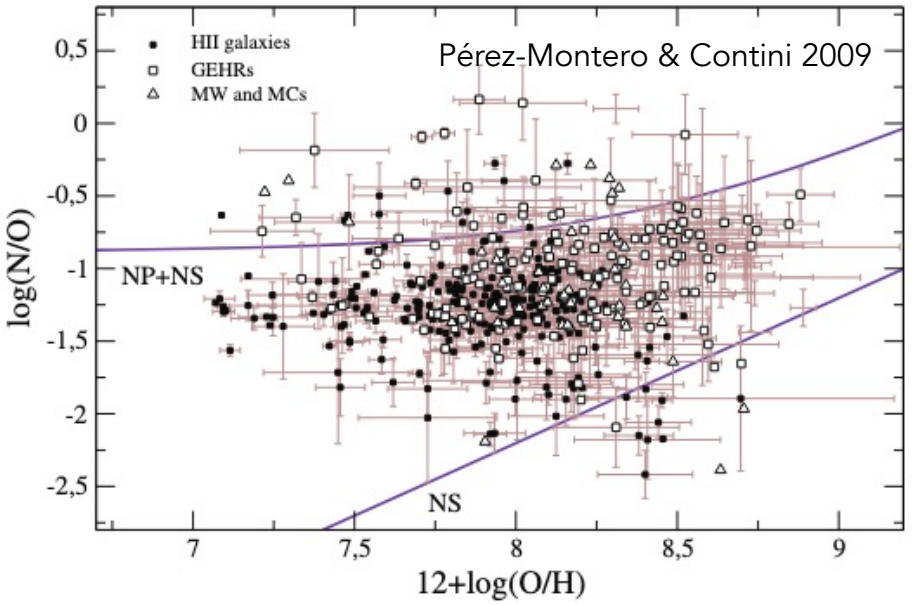
Escape of Lyman radiation from galactic labyrinths



Chemical evolution of N (and C)





The N/O (C/O) vs. O/H relation is a key diagnostic tool for understanding:

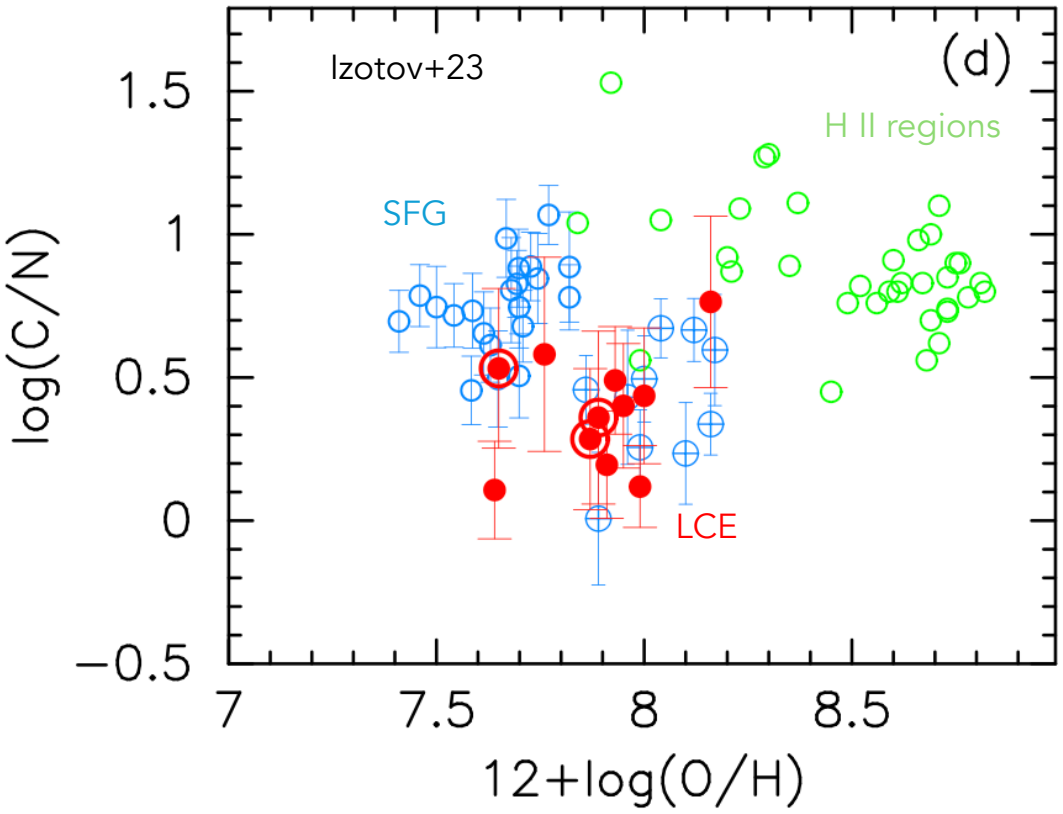
- The production of elements in stars
- Star-formation history of galaxies
- Constraints on chemical evolution models (timescales of chemical enrichment)

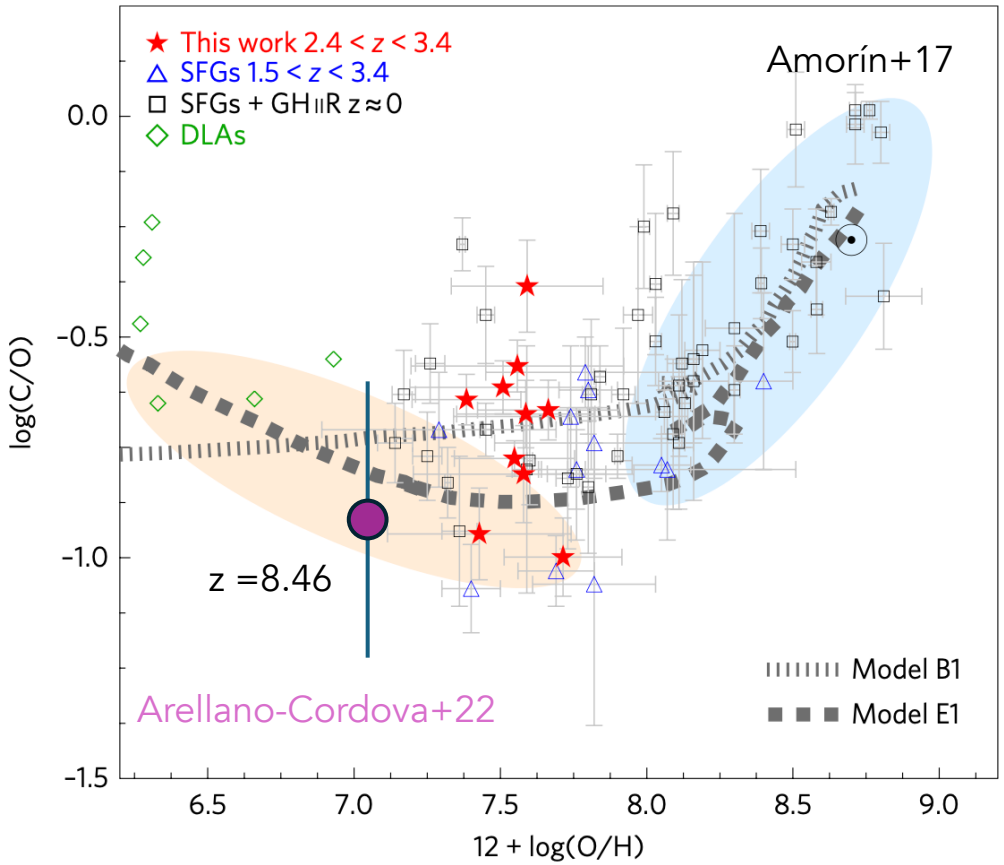
Source of enrichment:

Massive star: Core-collapse supernovae
Low and intermediate stars: Asymptotic Giant Branch (AGB) stars

Other studies: Garnett+90, Henry+00, Andrews & Martini 2013, Vincenzo+16, Esteban & García-Rojas+19, Skillman+13, Croxall+16, Berg+19, 20, Arellano-Córdova+21, Johnson+2021, Vincenzo+21, Stephenson+23, Hayden-Pawson+22, Strom+2016, Kobayashi+20

Chemical evolution of N and C in LyC emitters





- LyC leaker tend to show elevated N/O ratios, while their C/O ratios is consistent with those typical dwarf SFGs (se also, Amorín+2010, Izotov+17, 18, 21, Ravindrananth+2020, Guseva+2020).

Building a sample to study chemical enrichment across cosmic time

Early e**X**tragalactic **C**ontinuum and **E**mission **L**ine **S**urvey

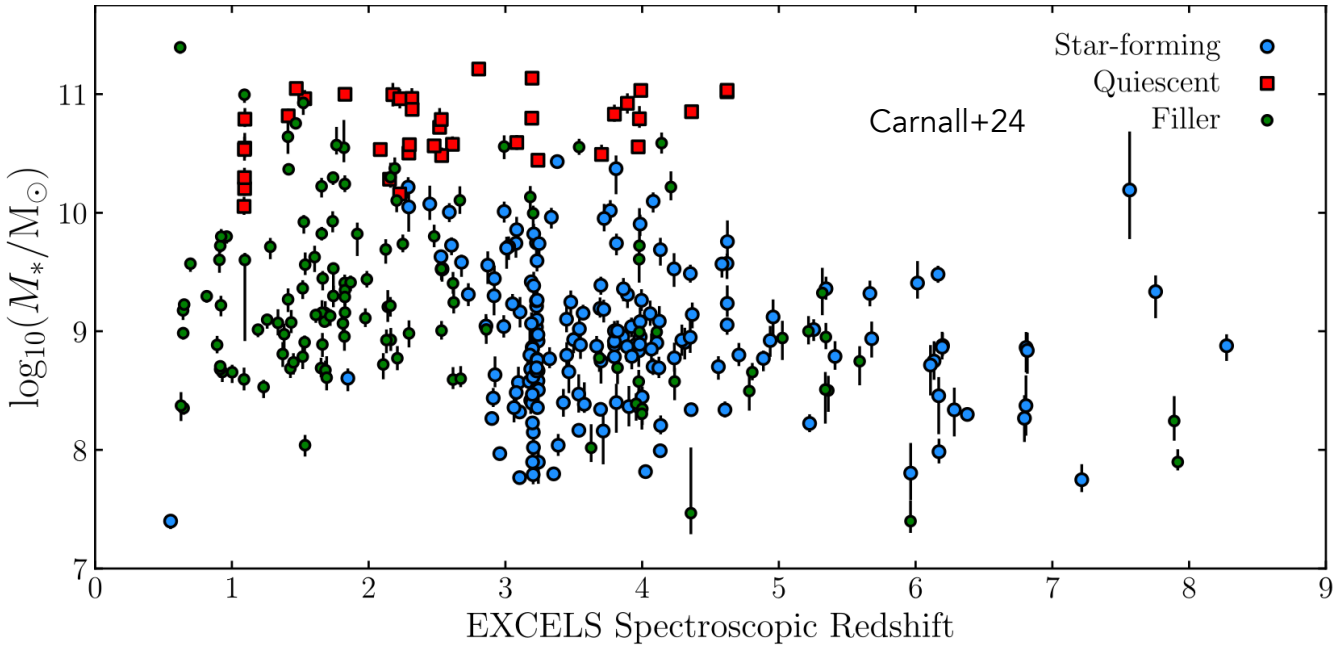
PI: Adam Carnall, Co-PI: Fergus Cullen

- NIRSpec/MSA observations of SFGs at z = 2-8
- Covering UV+optical data
- Direct chemical abundance determinations (Ne, Ar, N, C)

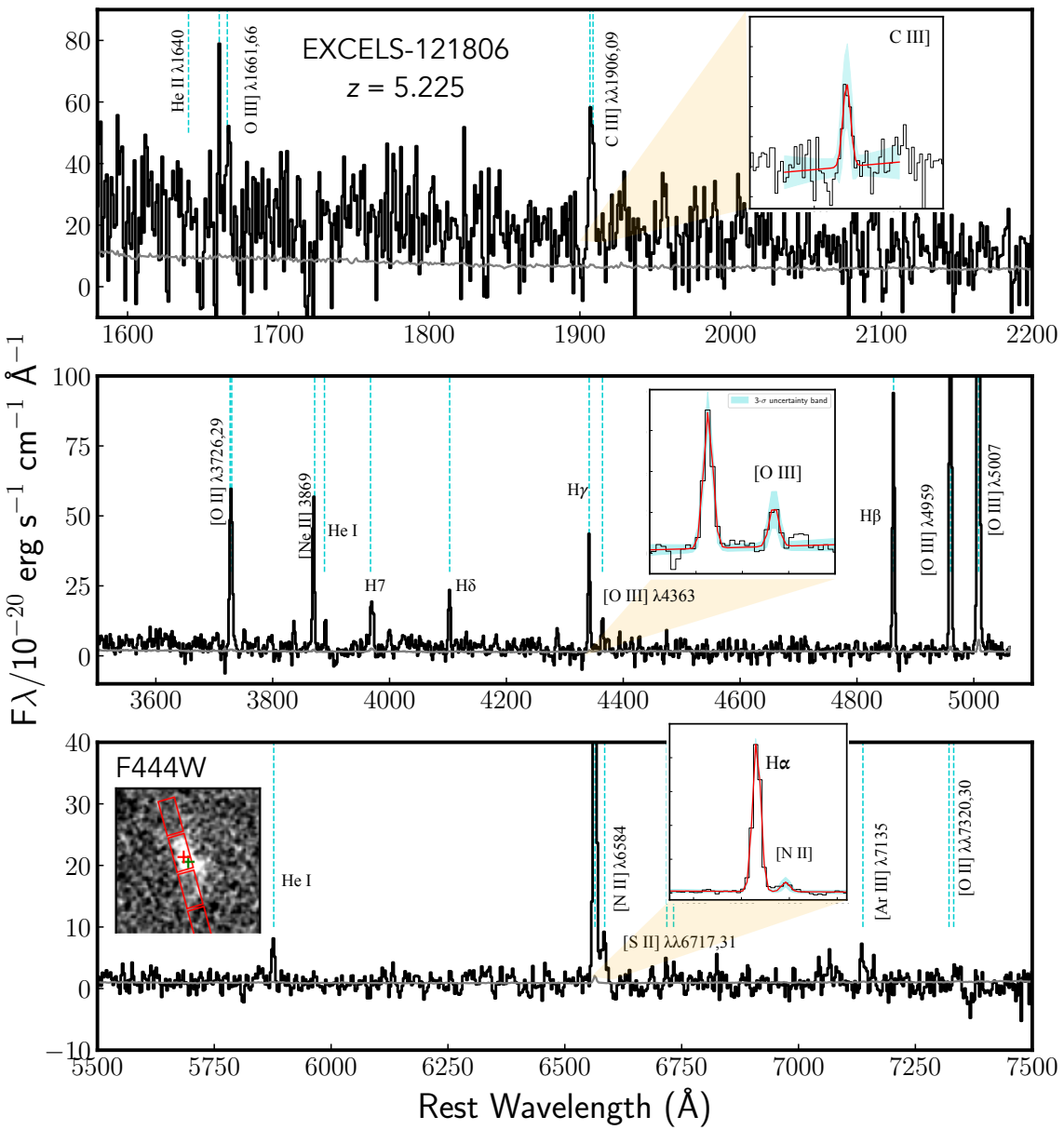
Carnall+24, Cullen+24, Stanton+24, Arellano-Cordova+24b, Scholte+25

Berg+2022, James+2022, Mingozzi+22,24, Arellano-Córdova+24, Xu+22, Parker+24

- 45 star-forming galaxies (0.002 < z < 0.182, UV+optical)
- Broad galaxy properties (Stellar mass, SFR, ionization parameter)



Chemical evolution of C/N at z ~ 5

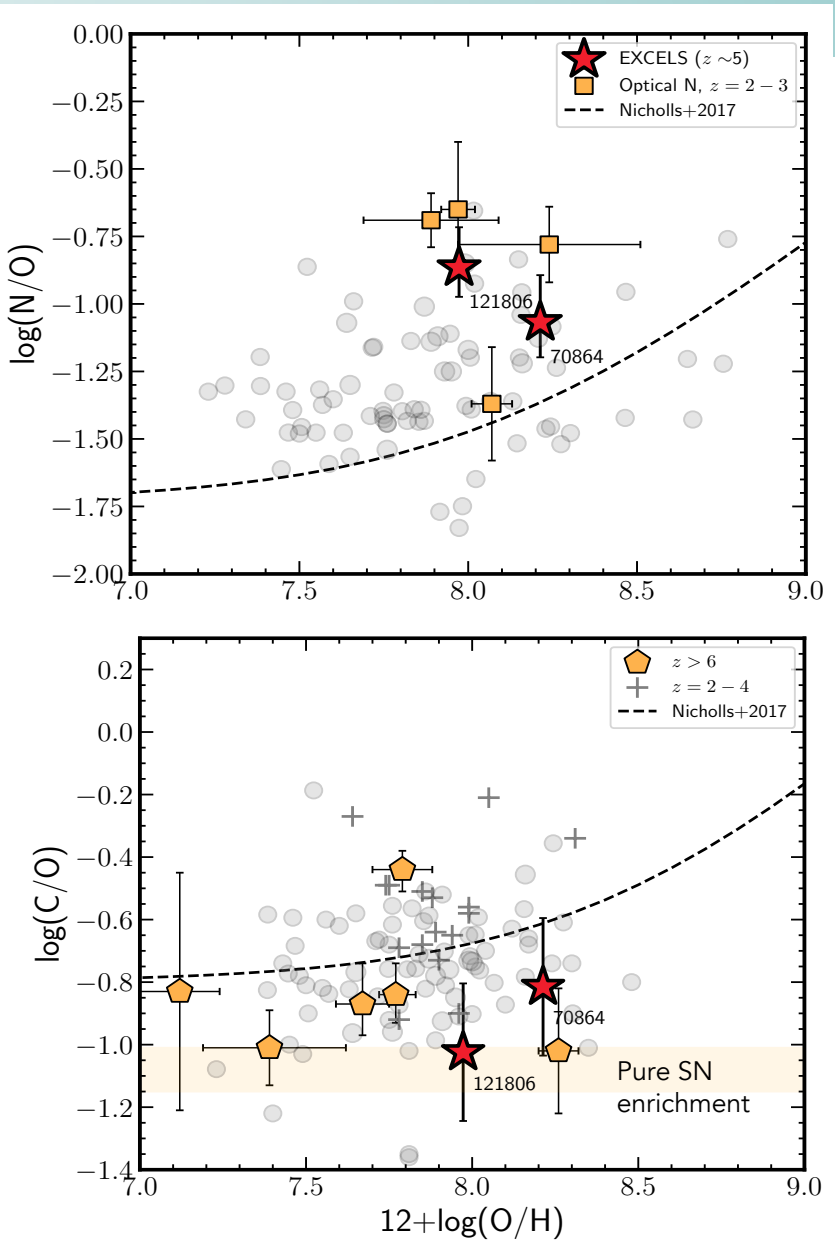


Arellano-Córdova et al. (2024b: arXiv:2412.10557)

- Two EXCELS galaxies at z ~ 5 with C III] and [N II]
- Several emission lines to analyze: the ionization stare of the gas, physical conditions and chemical abundances of C, O and N (and Ne and Ar).

- ✓ Investigate the chemical evolution of C/O and N/O
- ✓ Chemical evolution models with different IMF to understand the abundance patterns at z~5
- ✓ Comparison with other local and high-z galaxies

The N/O (C/O) – O/H relation at z ~ 5



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Physical conditions and chemical abundances

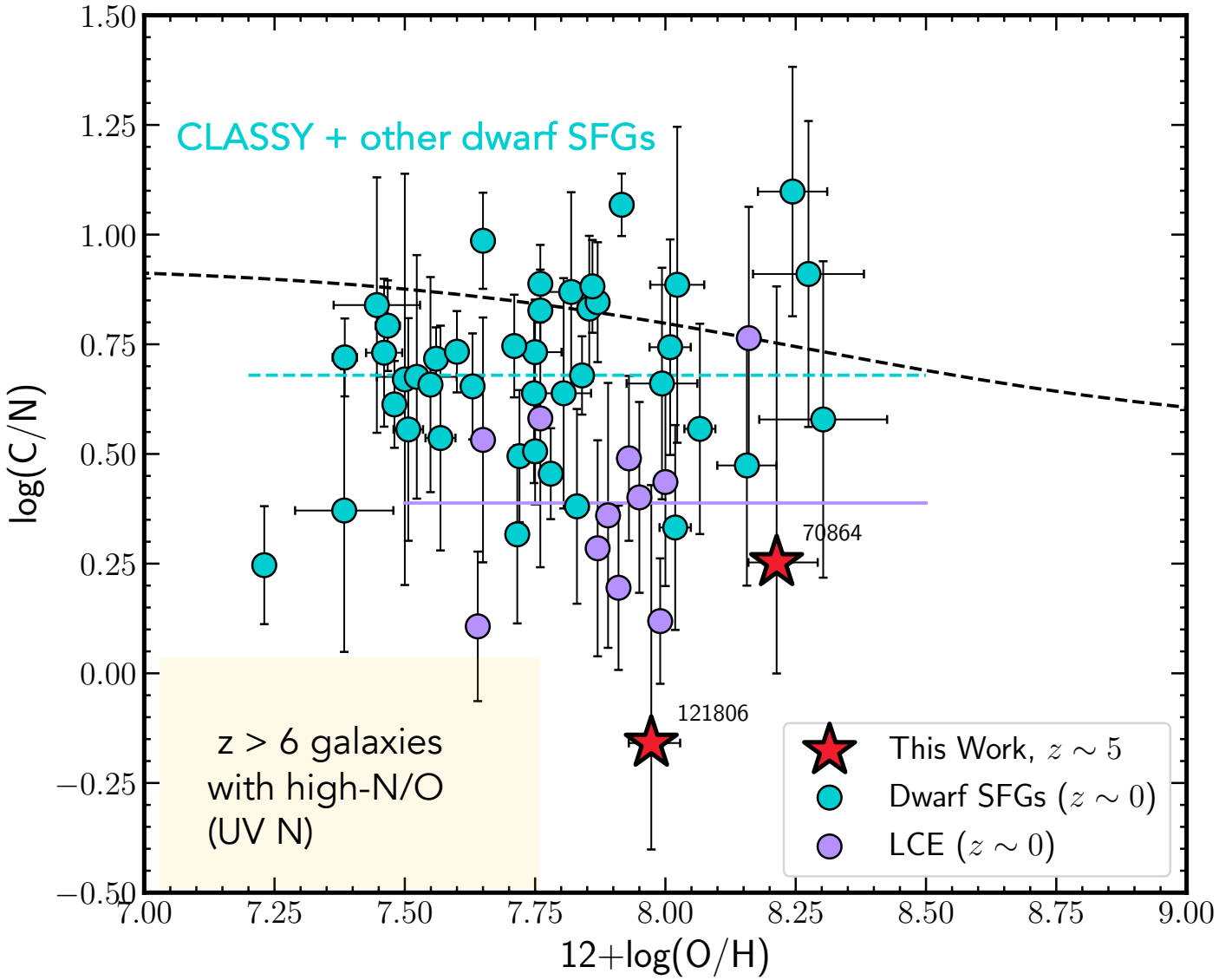
- Metallicity: 12+log(O/H) = 7.97-8.21
- High-density: ne[S II] ~ 600 cm^-3

- High N/O enrichment, comparable to galaxies at z = 2-3
- Low C/O ratios consistent with predict yields from CCSNe
- Galaxy properties (SFR and stellar mass) align with z~0 SFGs

Sanders+23, Rogers+24, Welch+24 , Llerena+23, Arellano-Cordova+22, Hasio+2024, Calistro+23, Isobe+23, Marques-chaves+24.
CLASSY sample: Stephenson et al. 2023, Arellano-Cordova et al. in prep, and Martinez in prep.

The C/N-O/H relation

Arellano-Córdova et al. (2024b: arXiv:2412.10557)



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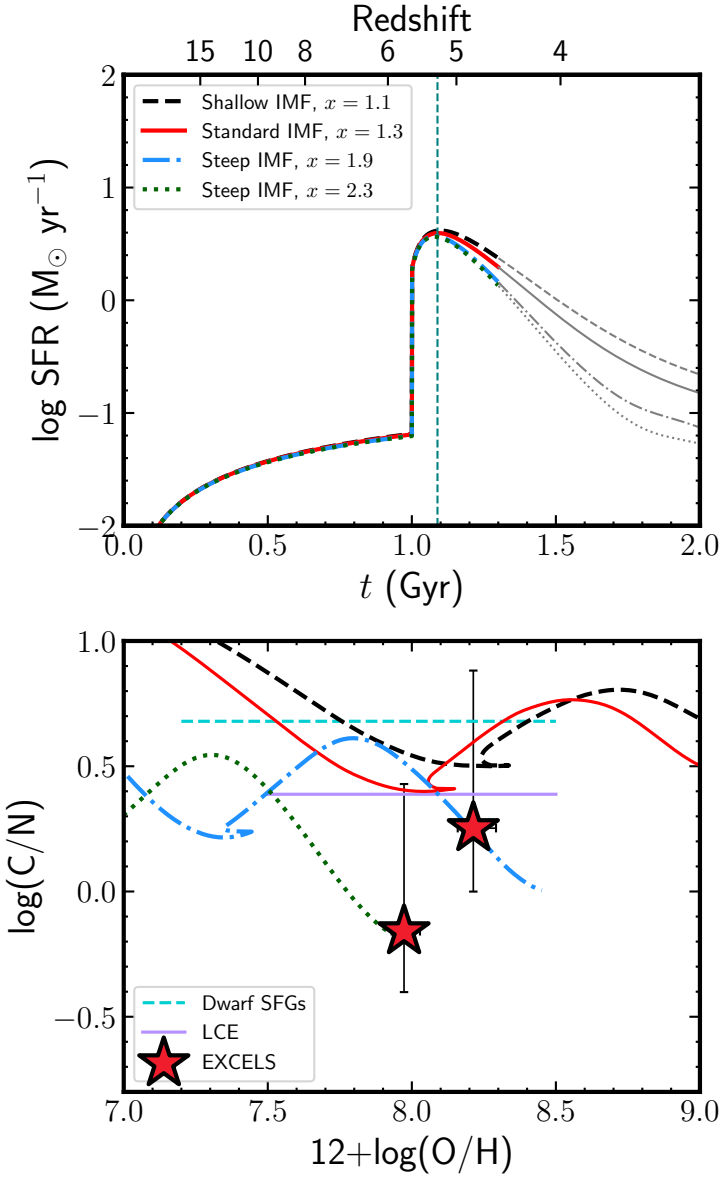
Understanding the C/N – O/H relation at z ~ 5

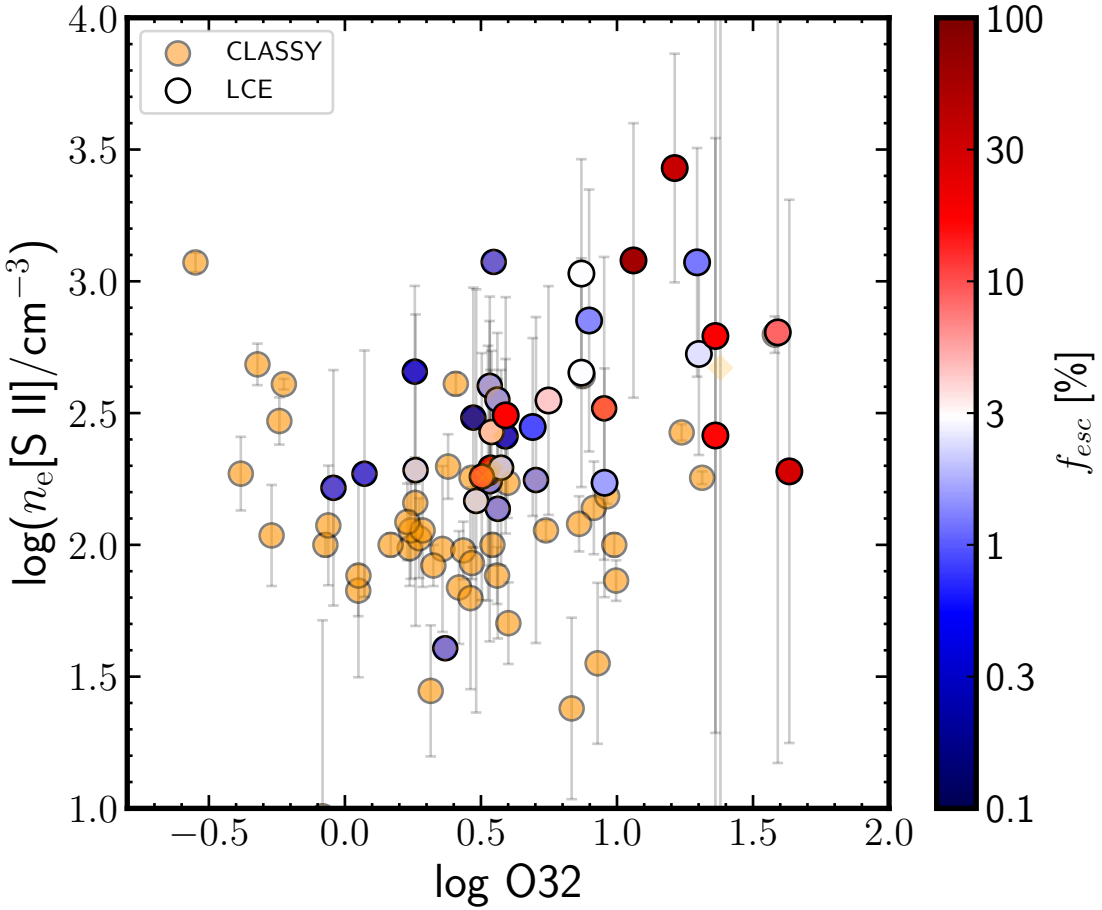


- Toy Chemical evolution model (Kobayashi+20, Kobayashi & Ferrara 2024) including WR stars:
  - IMF:
    - Standard: x =1.3, mass range: 0.01-120 $M_\odot$ (Kroupa+01)
    - Top-heavy (x = 1.1)
    - Bottom-heavy (x = 1.9 and 2.3)

- Standard- or Botton-heavy IMF better explain the C/N abundance patterns.
- N-enrichment is likely to intermediate mass stars (~ 4-7 $M_\odot$).

How can N and C inform the escape of ionizing photons?

Preliminary



- 54 LCEs z ~ 0.3 :
  - Te[O III], ne[S II] → O/H, N/O, C/O, and fesc.
  - (Izotov+16- 23, Ravindranath+20, Fernandez+22, Jung+24)
  - Ionization parameter, and galaxy properties
  - LzLCS (Flury+22)

- LCEs tend to show higher electron densities compared to typical dwarf galaxies (see also Guseva+2020, Sanders+2016, Topping+25).
- Other density diagnostics in play: [Ar IV], CIII]?

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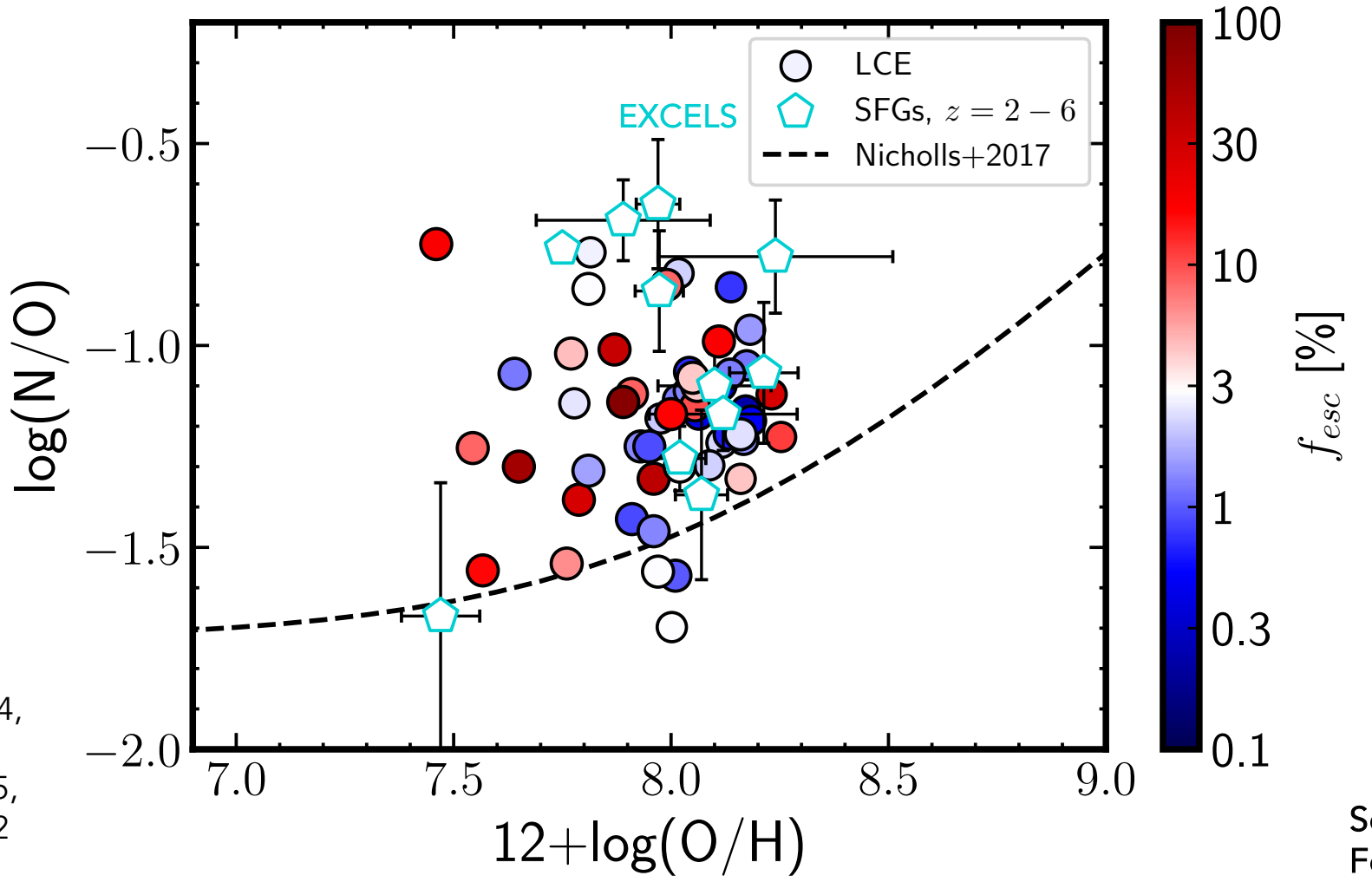

Izotov+16- 23, Ravindranath+20, Fernandez+22, Jung+24, Arellano-Cordova+24b, Scholte+25, Stanton+25, Welchs+24, Sanders+22

See Kaelee's Talk For CLASSY

Summary & Takeaways

- EXCELS: CNO at z~5

  - ✓ High-metallicity (O/H = 7.97-8.21)
  - ✓ N-enrichment, log(N/O) =-0.86, -1.07
  - ✓ C/N ratios show similar abundance patterns that LCE (z~0)

- Preliminary analysis of the properties of LCE

  - High ne[S II] compared to typical dwarf galaxies and high-z galaxies.
  - High-N/O with some scatter. No clear correlation with the escape fraction.