Giornate RSN1 9-11 febbraio 2026

The early Universe: first galaxies and quasars, and cosmic reionization

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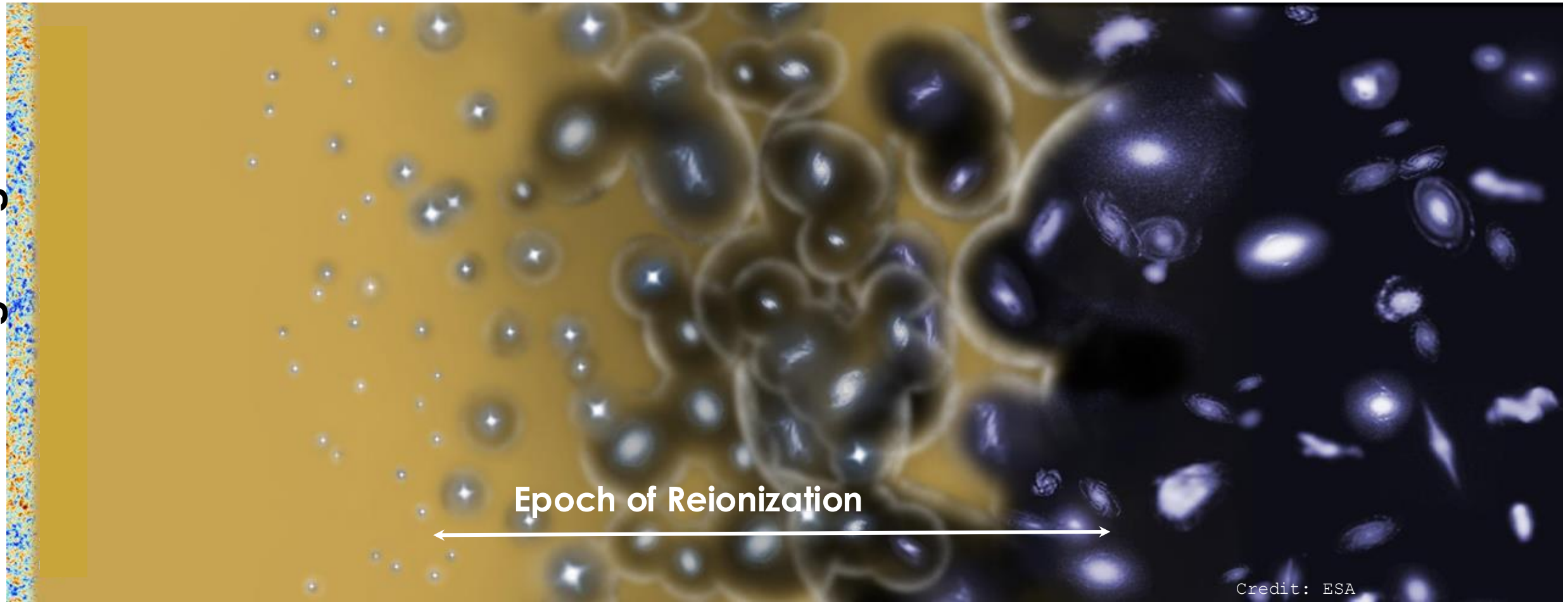
European Research Council
Established by the European Commission

A condensed history of the Universe

Time:

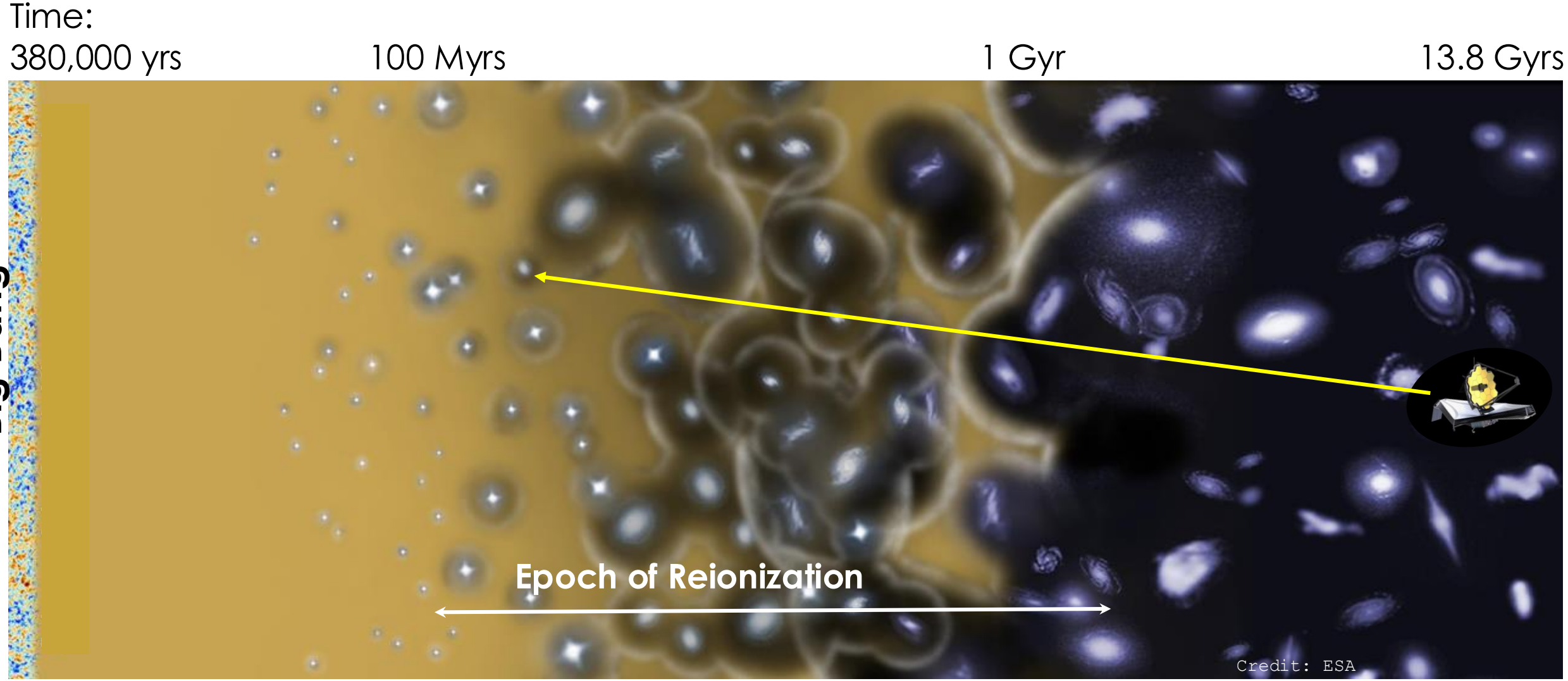
380,000 yrs | 100 Myrs | 1 Gyr | 13.8 Gyrs



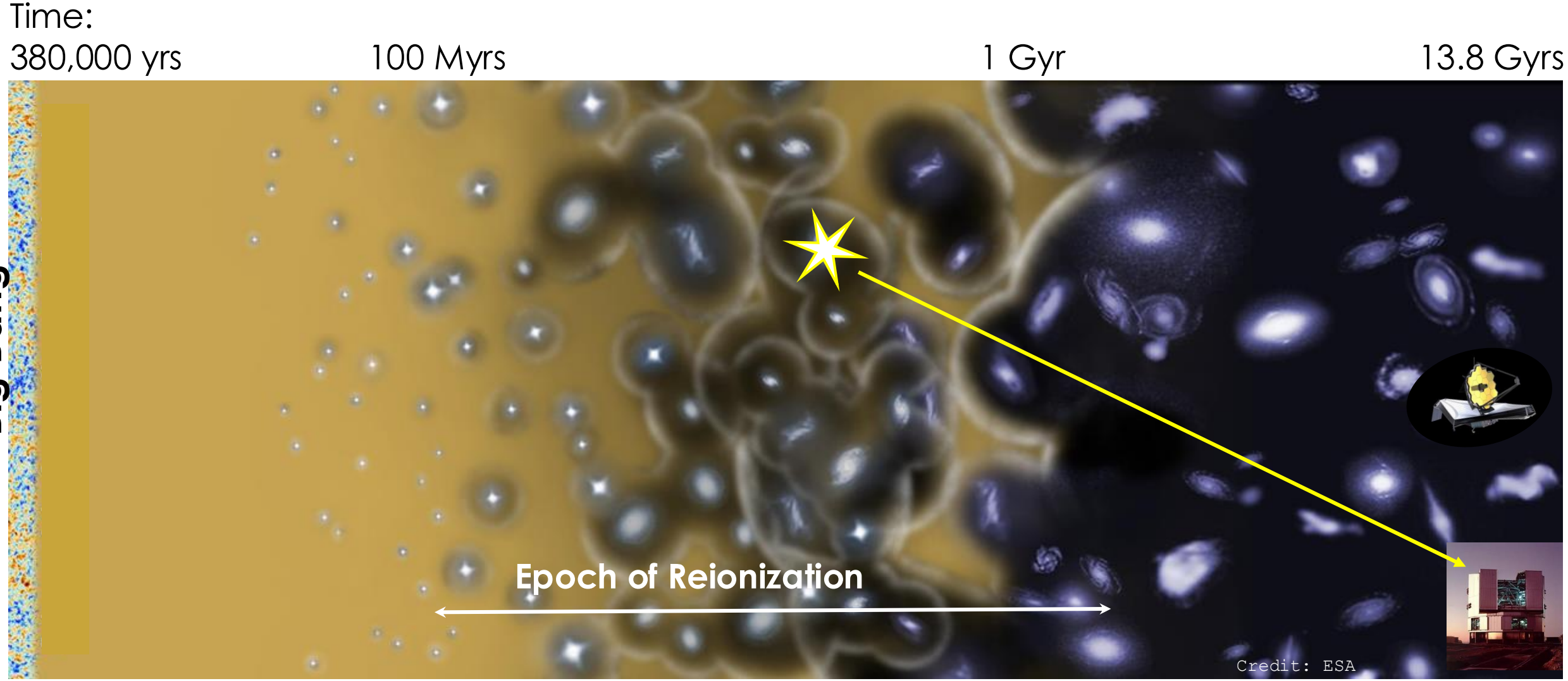
Redshift:

1100 | 30 | 6 | 0

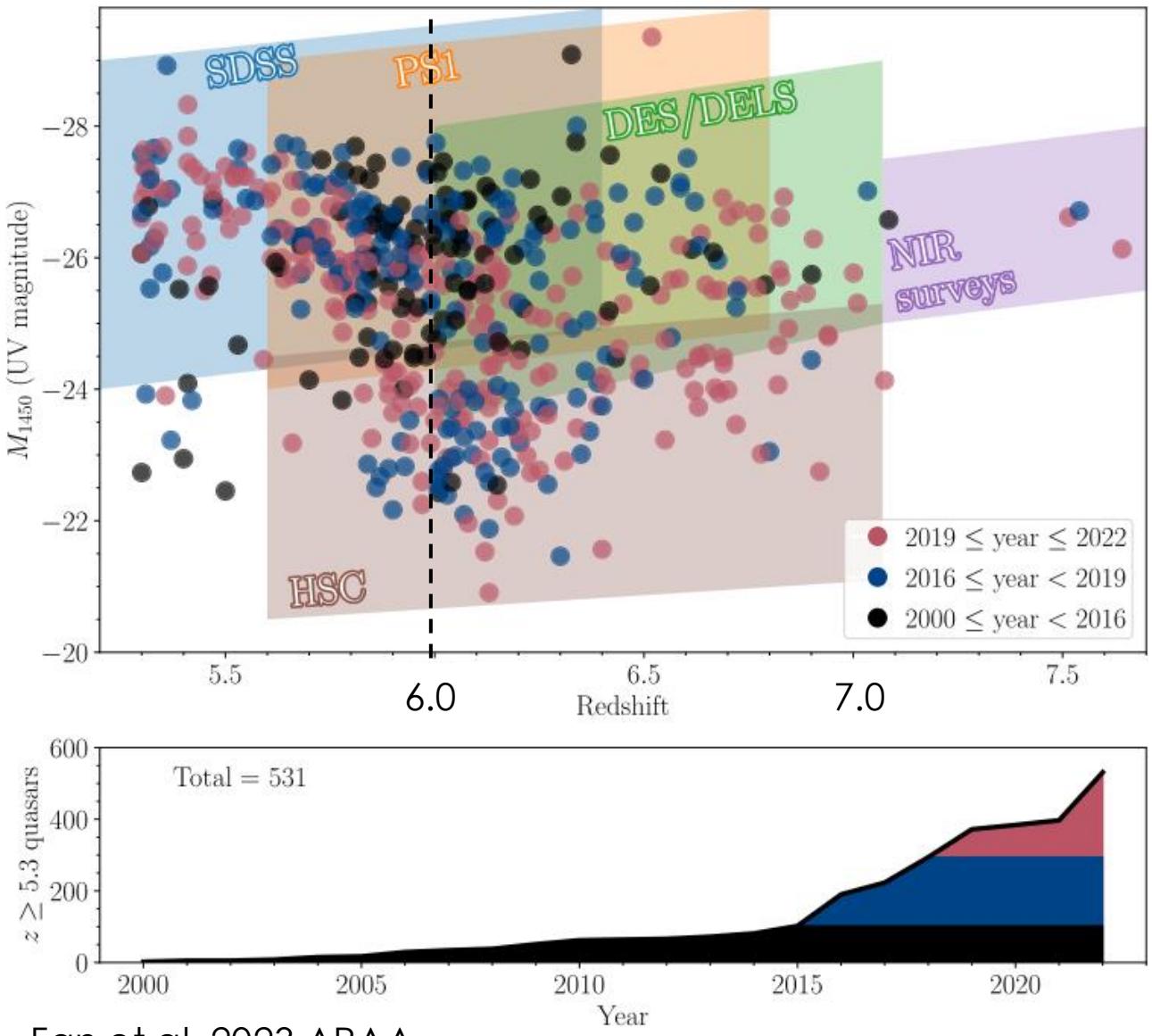
A condensed history of the Universe



A condensed history of the Universe

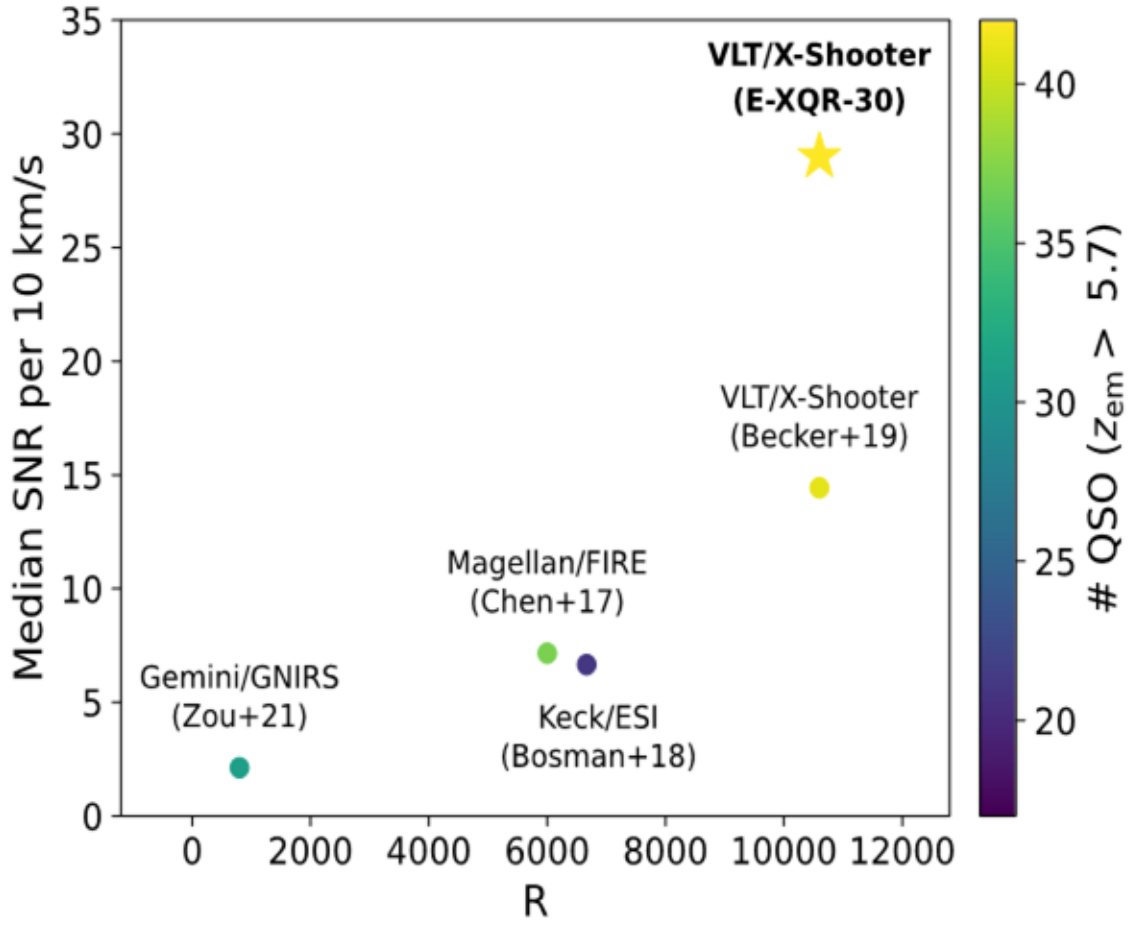


Quasars as probes of Reionization



Fan et al. 2023 ARAA

XQR-30



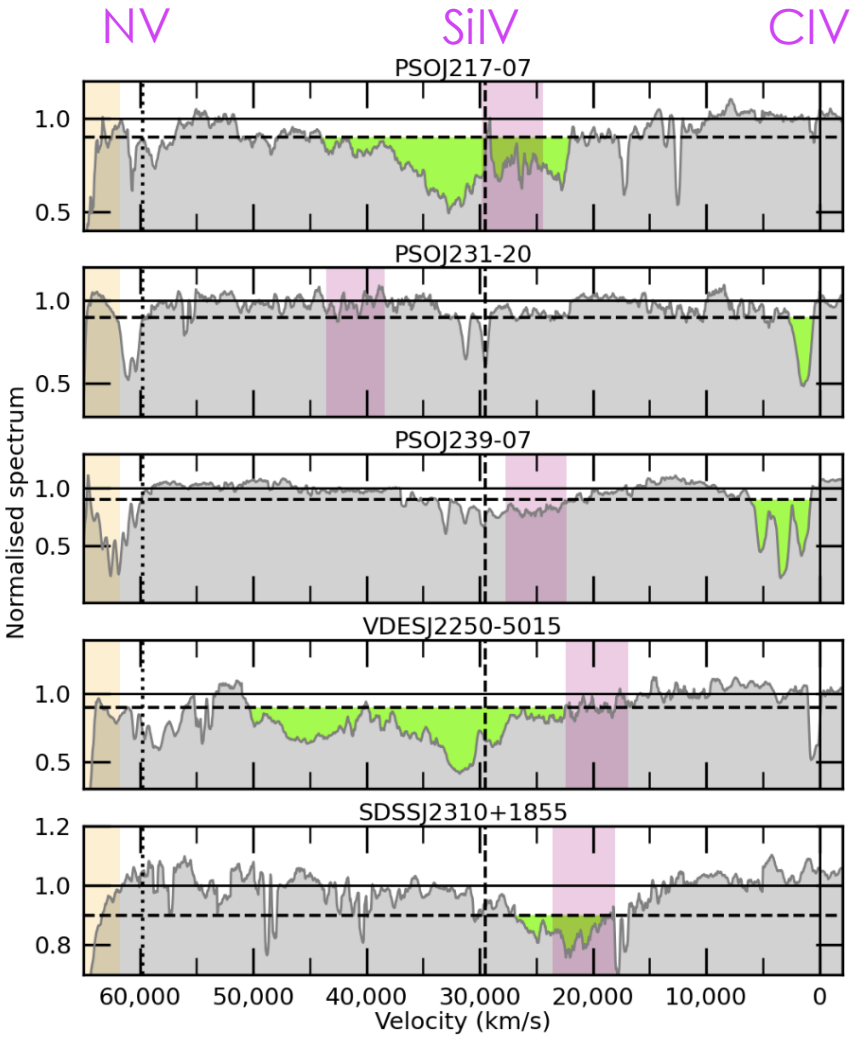
International effort with large INAF participation

D'Odorico et al. 2023

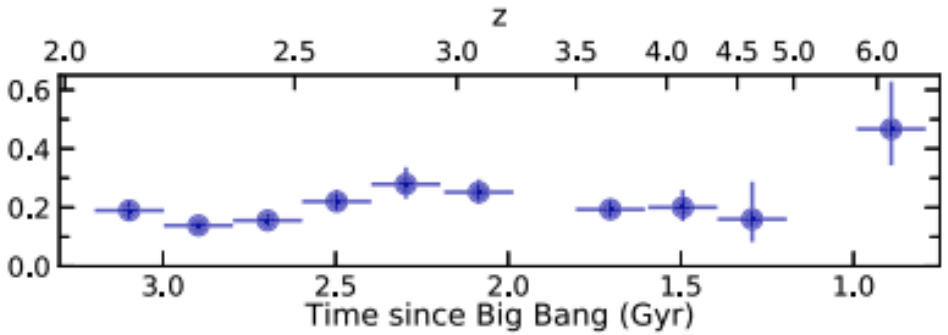
Strong outflows in high-z quasars

XQR-30

Bischetti et al. 2022, 2023

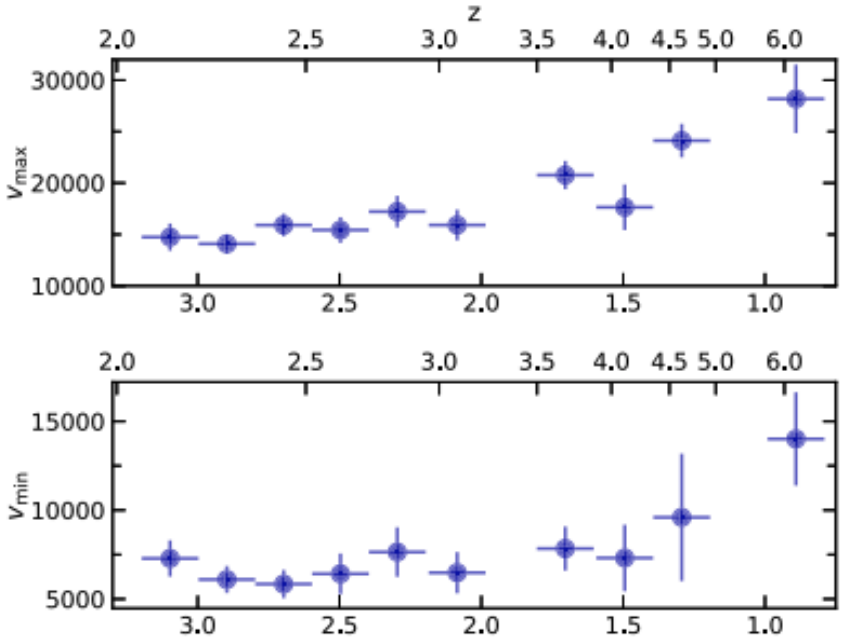


Significant BH feedback in the 1st Gyr



BAL fraction

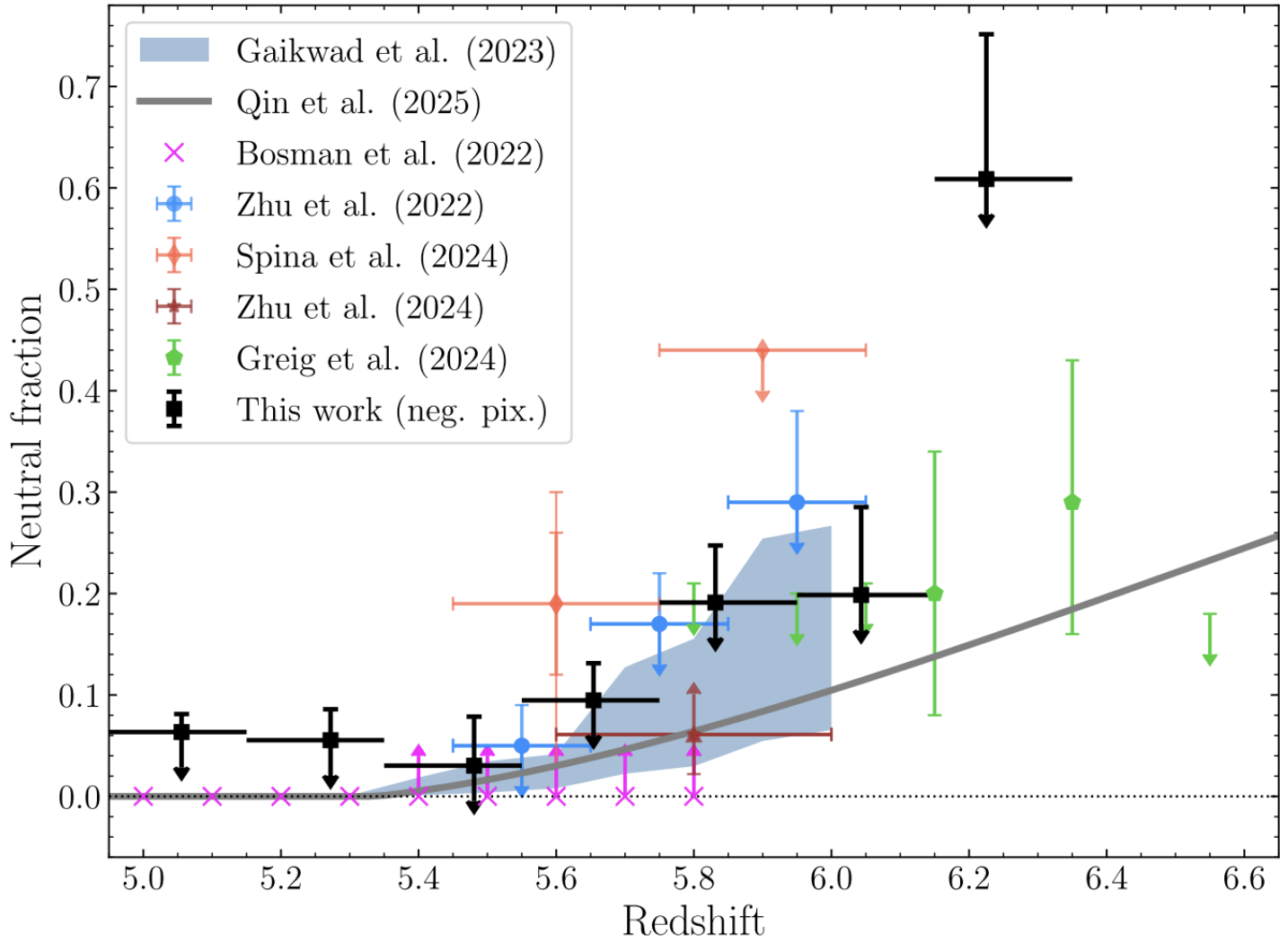
Velocity of the CIV BAL outflows



Constraints on the neutral hydrogen fraction

Reionization ends gently below z~6, reaching probably z~5.3

XQR-30



Combination of:

- transmission evolution
- size of the dark troughs
- troughs' damping wings
- dark pixels' statistics
- damping wings

F. Davies et al. 2025

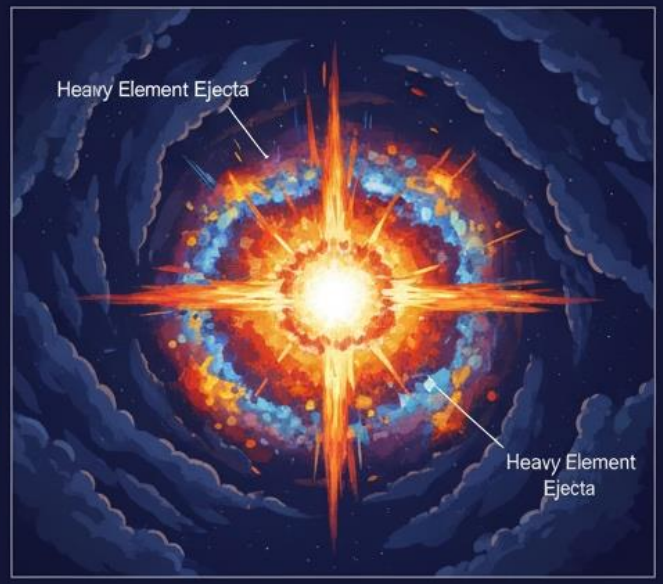
Metal enrichment in the early Universe

Pristine Universe
(H, He only)

First Stars
(Pop III)

Stellar Death
(Supernovae)

Metal-enriched Universe
(Heavy Elements)



Credits: Gemini

Redshift
1100

30

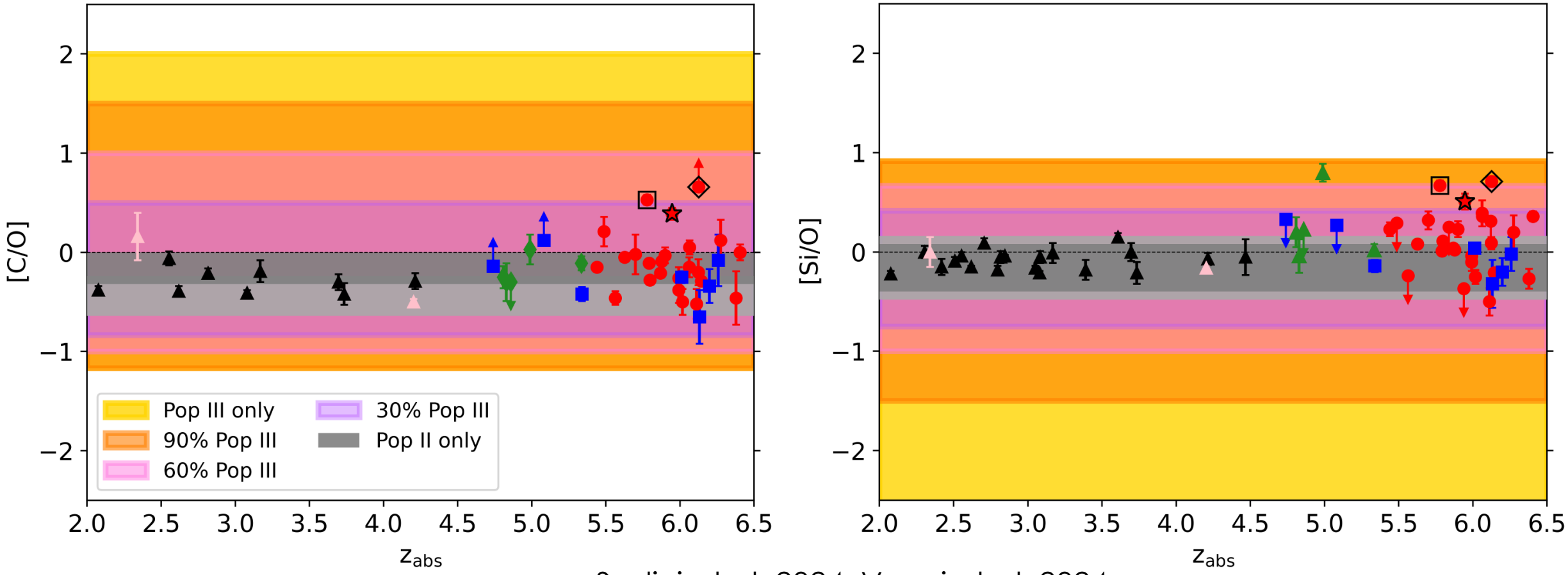
20

6

PopIII signatures in the high-z Universe

Chemical abundances in metal poor neutral absorbers as a function of redshift

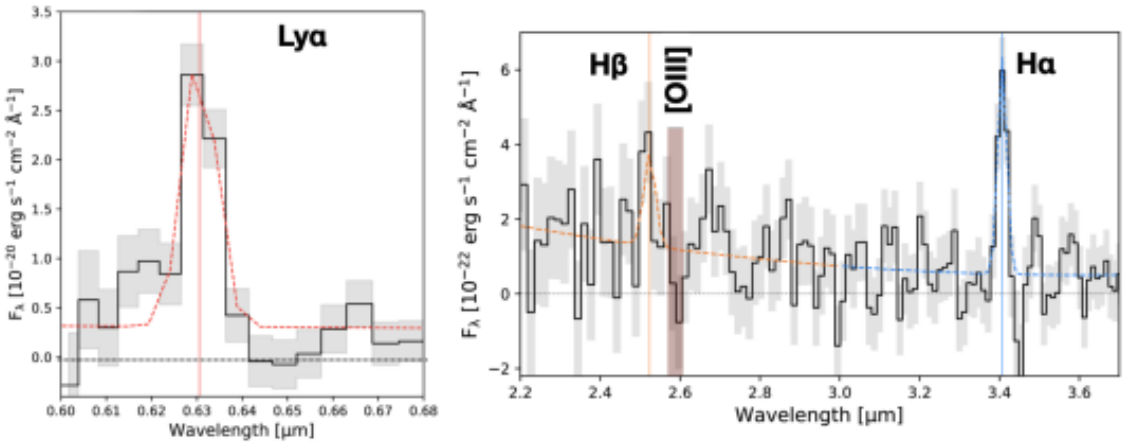
Increased scatter is a signature of PopIII enrichment



Sodini et al. 2024; Vanni et al. 2024

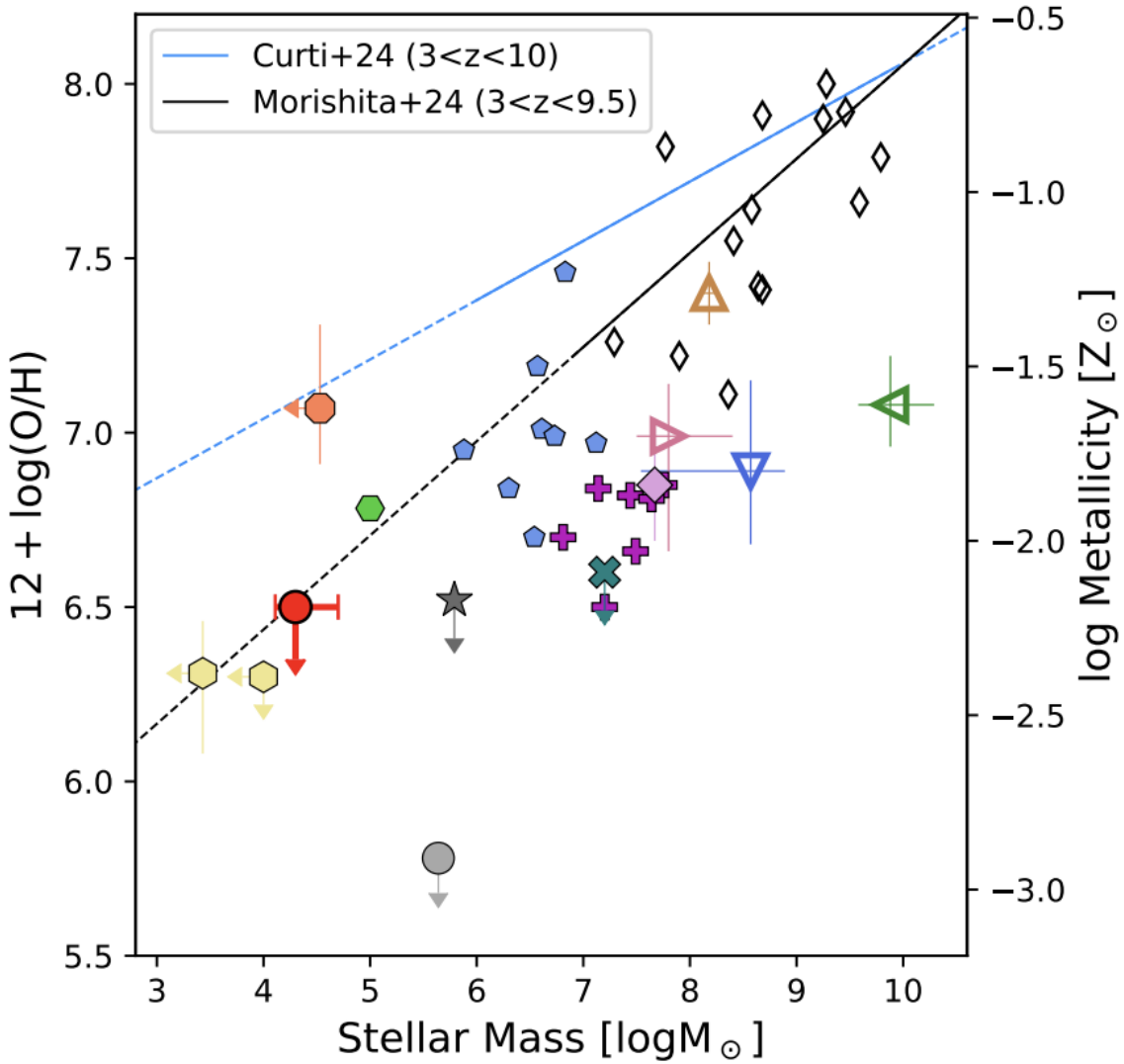
PopIII signatures in the high-z Universe

Vanzella et al. 2023, 2026



Are these metallicity sufficient to say that we are seeing PopIII galaxies?

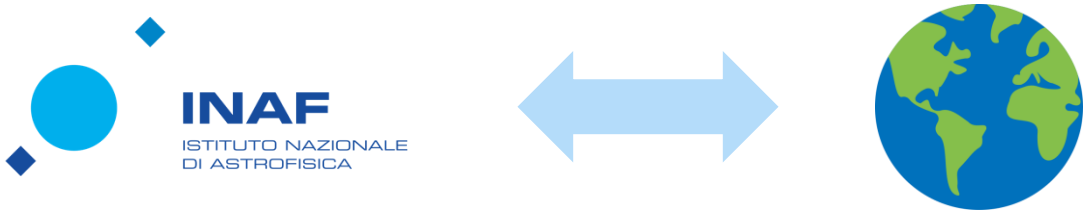
Very metal poor galaxies or stellar clumps



Open questions

- How did Reionization proceed?
- Which are the sources of Reionization?
- How does feedback work?
- What was the nature of the first stars?

INAF impact

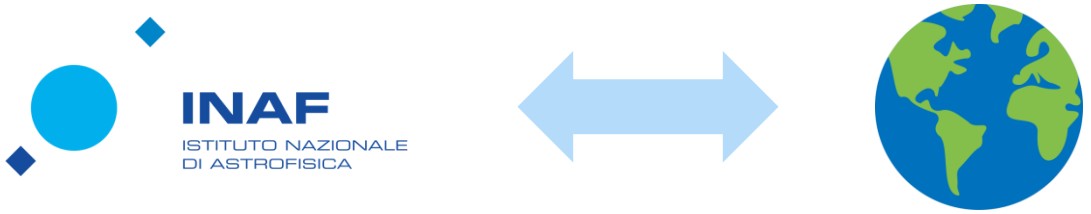


Studies of the IGM/CGM – identification and characterization of bright, high-z quasars:

- Small group but internationally recognized;
- Strong intersection and complementarity with high-z AGN community;
- Synergy with high-z galaxy studies for the characterization of the Reionization epoch (RECAP ERC Synergy project)
- Synergy with stellar studies for the characterization of the first stars

Credits: IconsNova

INAF impact



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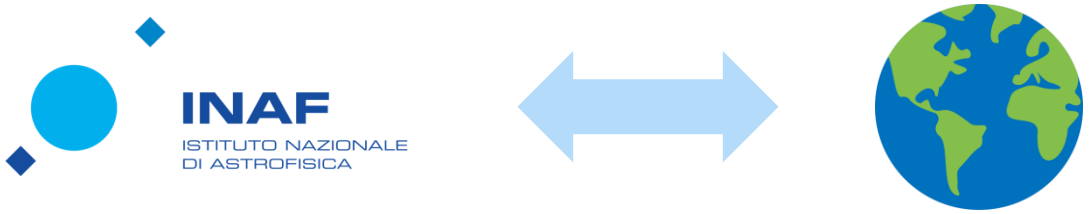

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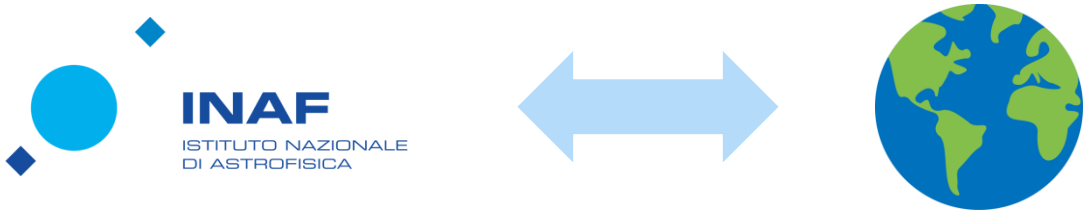

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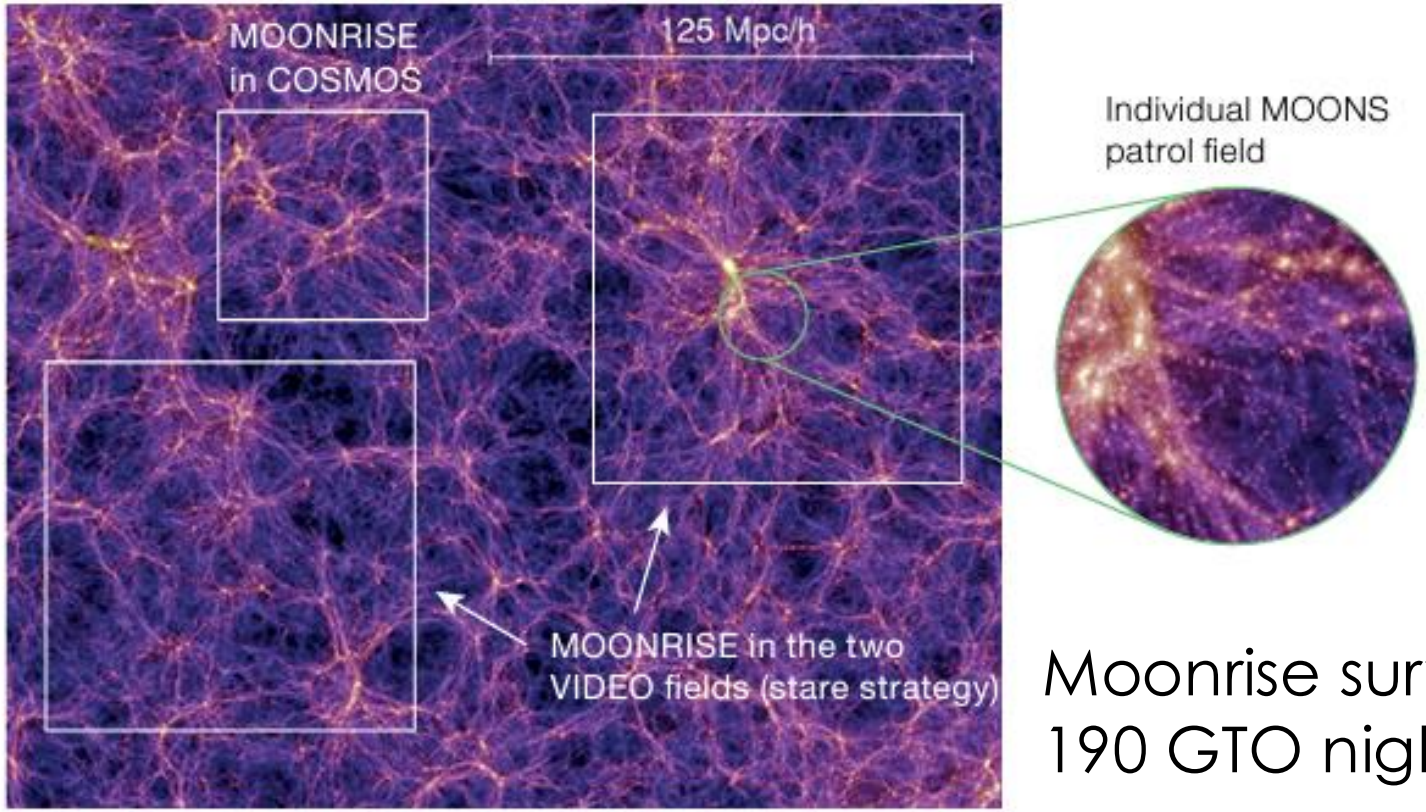
Credits: IconsNova

Future perspectives (INAF-centric)

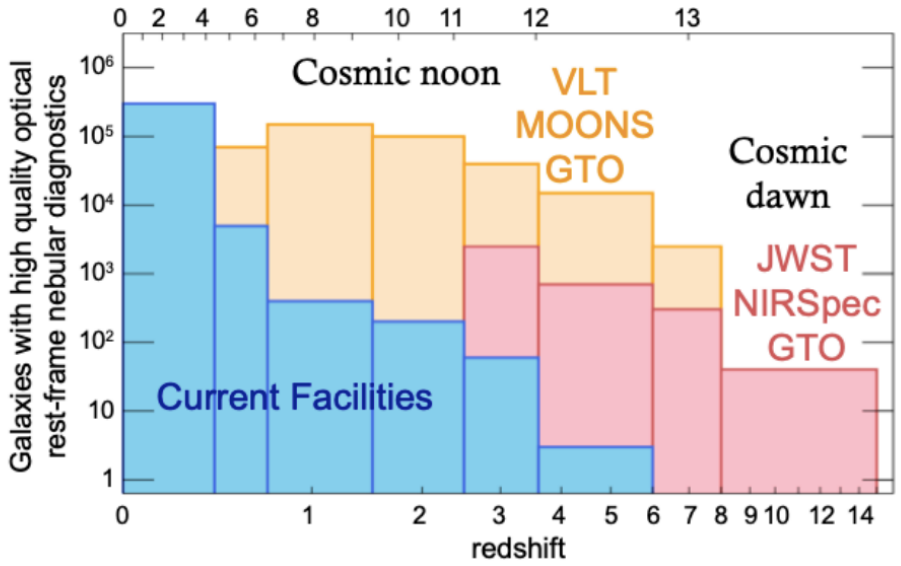
Multi Object Optical and Near-infrared Spectrograph for the VLT

INAF PI-ship of many scientific WGs

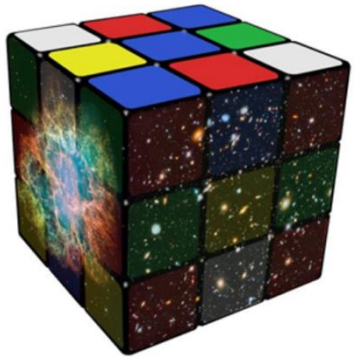
INAF PI-ship of development of control SW



Moonrise survey
190 GTO nights

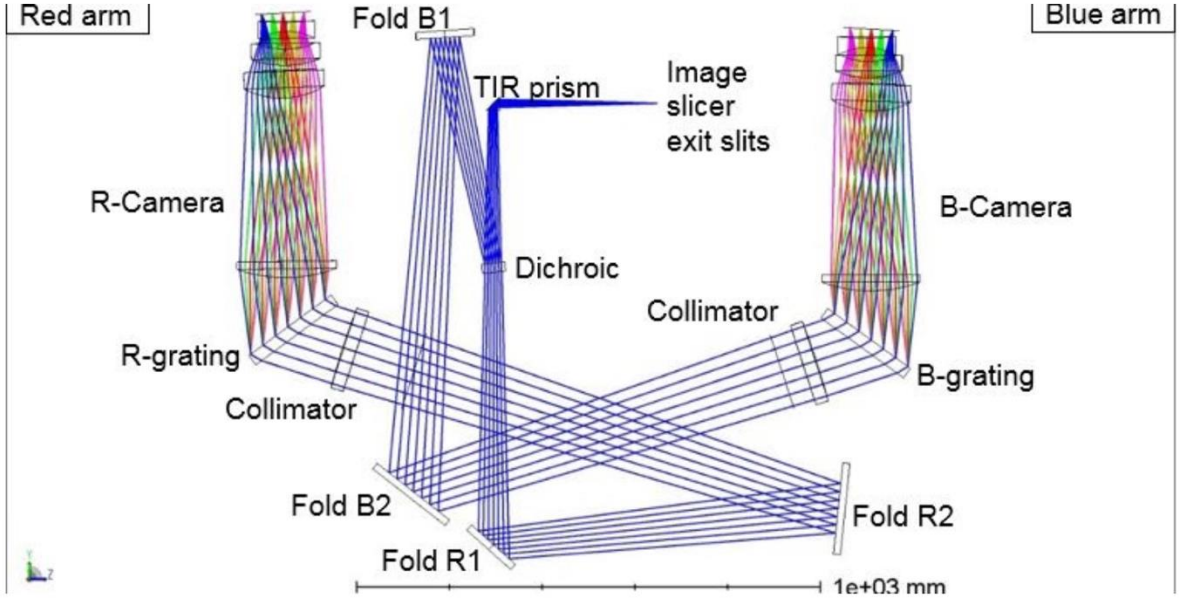


Future perspectives (INAF-centric)



CUBES
Cassegrain U-Band Efficient Spectrograph

INAF PI-ship, PM, SE, SSE



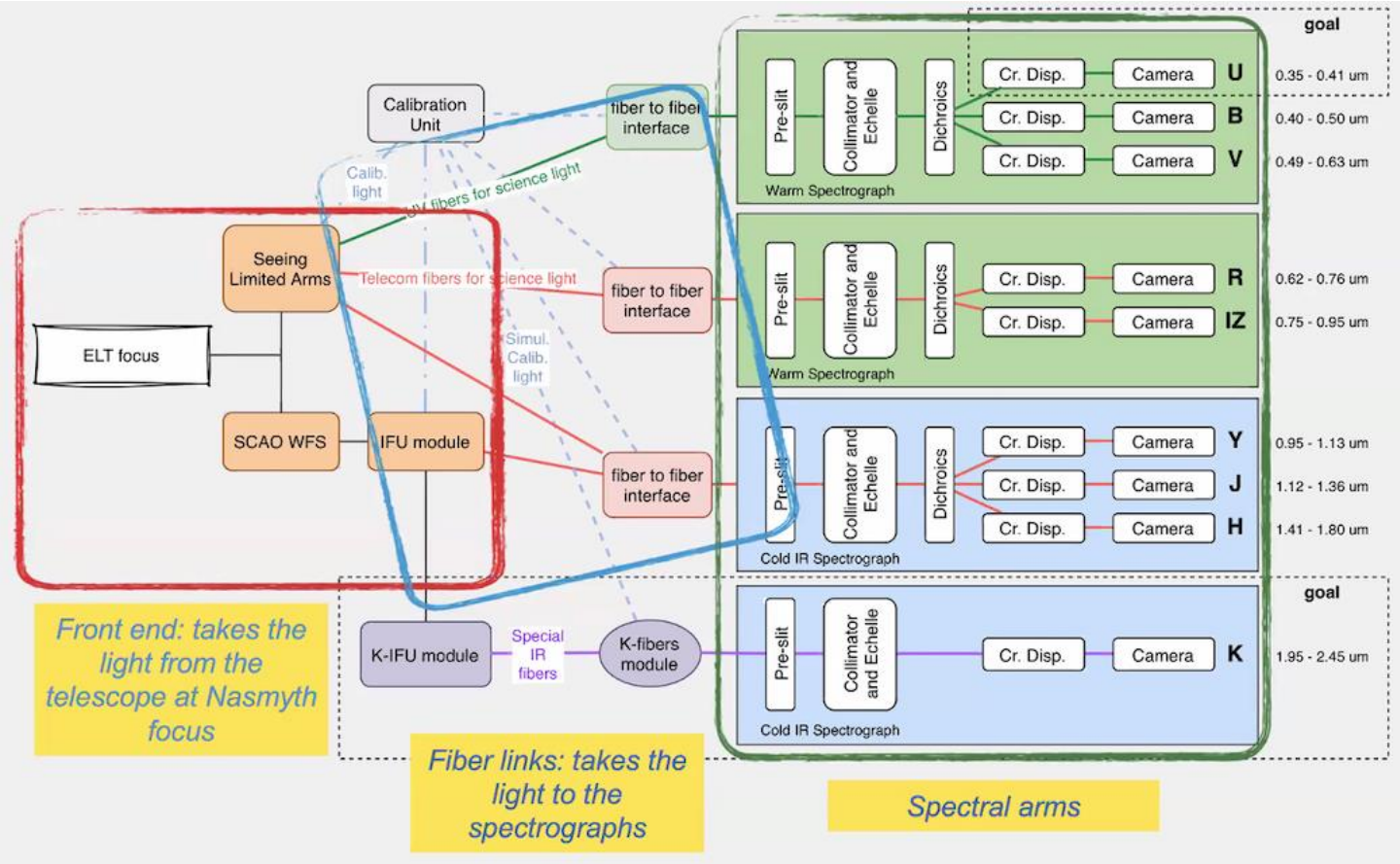
Spectral coverage 305-400nm

Resolution 20,000

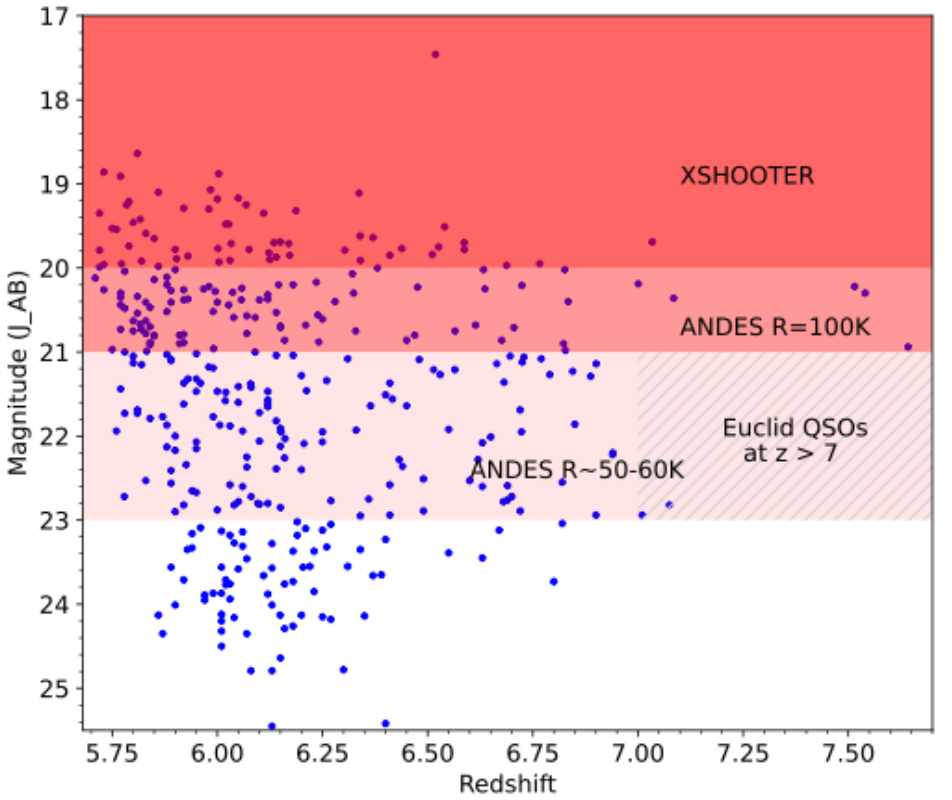
Future perspectives (INAF-centric)

ANDES - ArmazoNes high Dispersion Echelle Spectrograph

PI-ship + most of the project office + significant participation in the ST



High-z quasars in the South (Fan+ 2023)

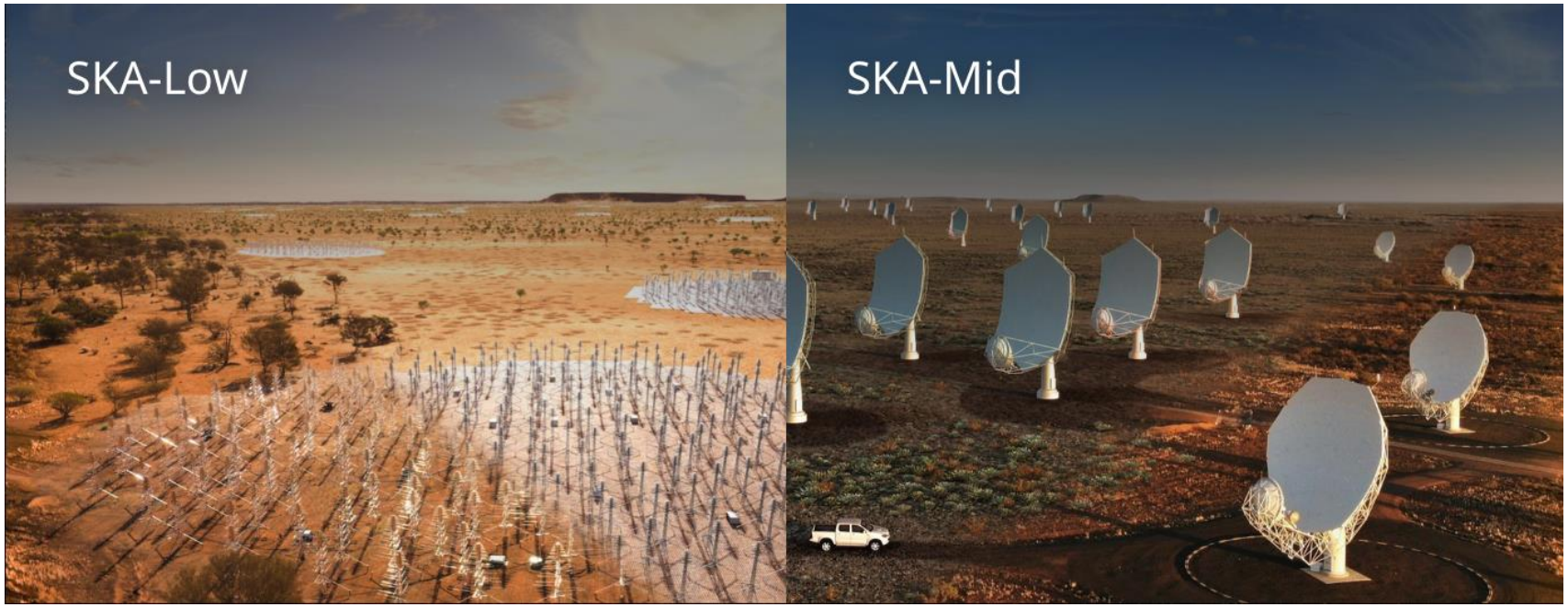


Future perspectives (INAF-centric)

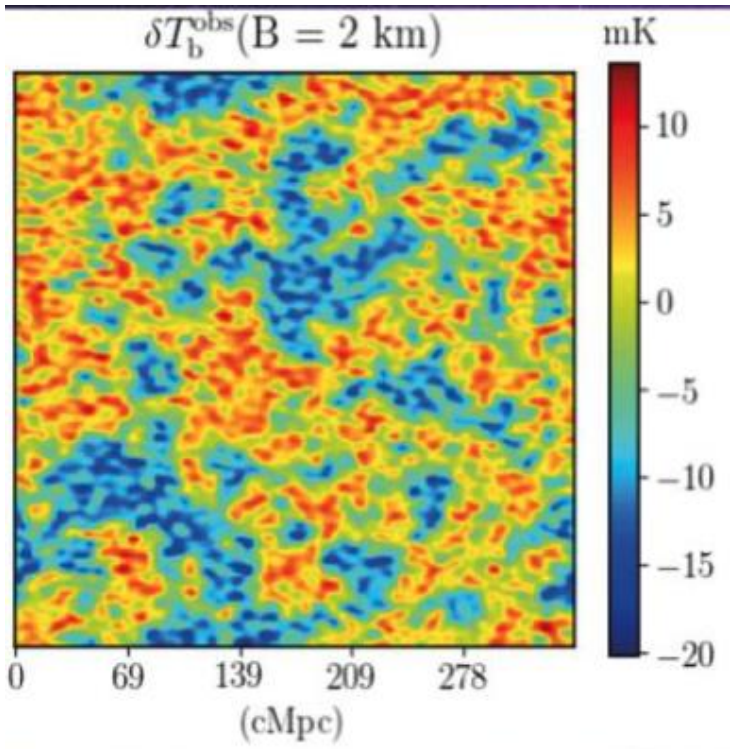
Square Kilometer Array Observatory

see the talk by Isabella on Tuesday

Topology of reionization and reionization history through the detection of the 21 cm emission/absorption from the neutral HI



simulated 21 cm signal at z=8



Future perspectives (INAF-centric)

Critical points:

- Formation of young researchers
- Recruitment aimed at the exploitation of the future projects (will it work?)
- Appeal for ERC winners (chiamata diretta, overheads)

RECAP
erc synergy grant

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Council Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

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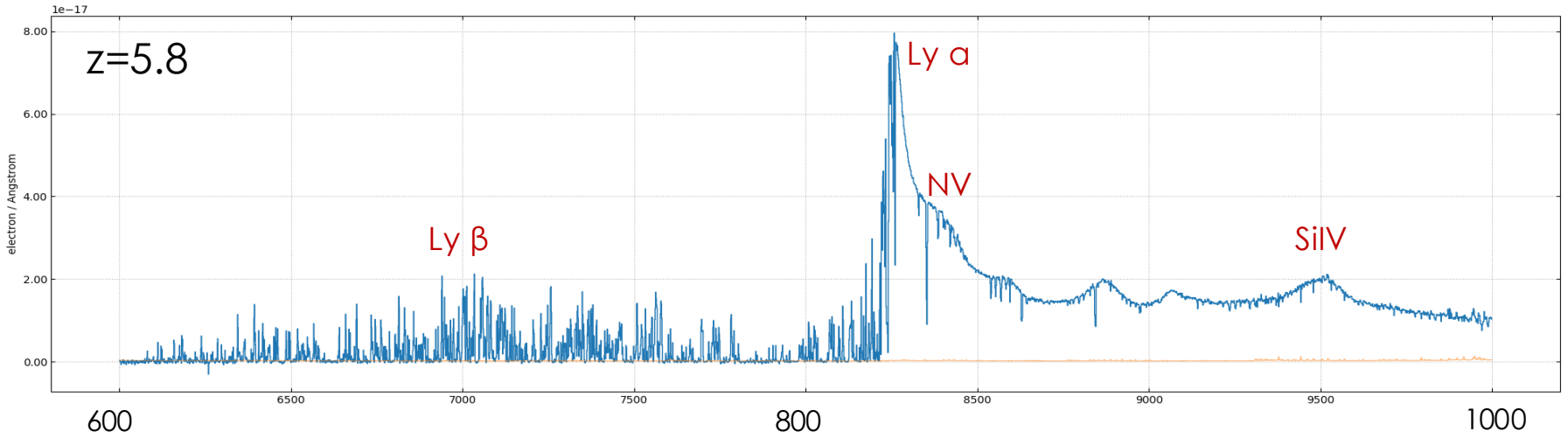
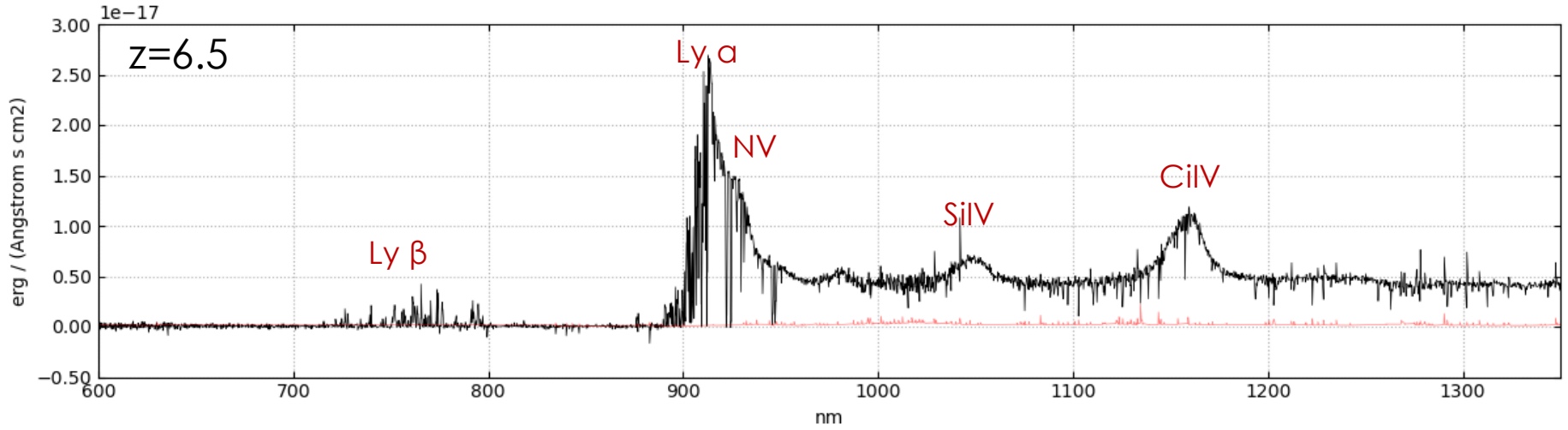
Established by the European Commission

Thanks!

The E-XQR-30 sample





The E-XQR-30 sample

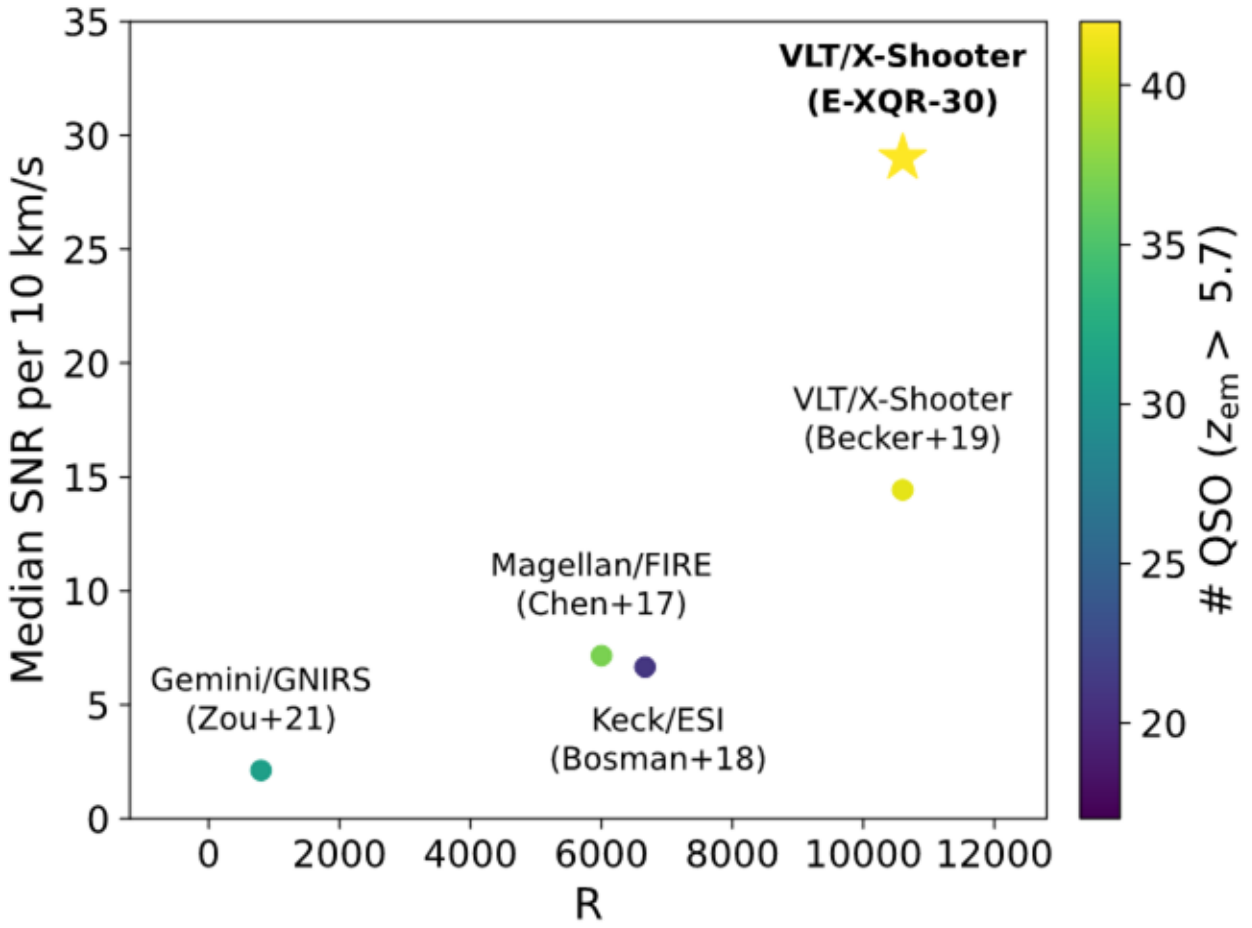
XQR-30 survey (P.I. D'Odorico) +
12 XSHOOTER archive spectra

Average 8.3h per source

Emission redshift $5.8 < z < 6.6$
$R_{VIS} \sim 11400$ $R_{NIR} \sim 9800$
Median S/N~29 per 10km/s pixel

ALMA ([C II]) and MUSE parallel programmes

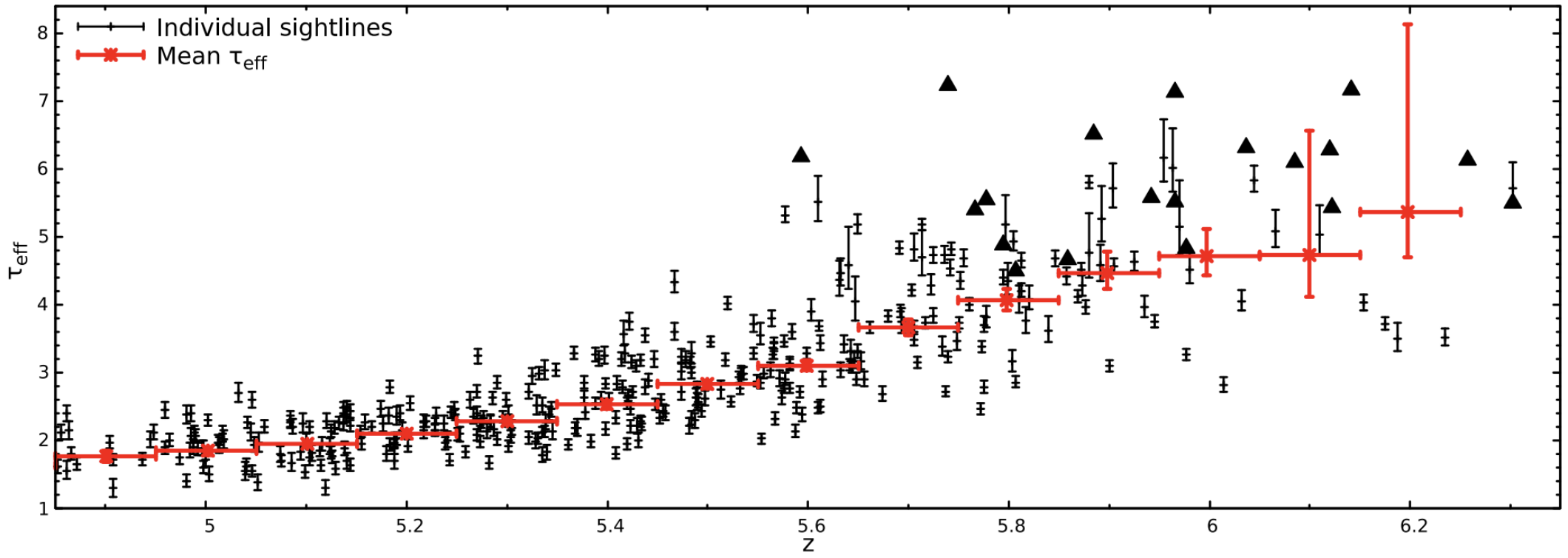
Presentation paper
D'Odorico et al. 2023



Evolution of the Lya optical depth

XQR-30

Bosman+ 2022, 67 quasar sigthlines at 4.9 < z < 6.2

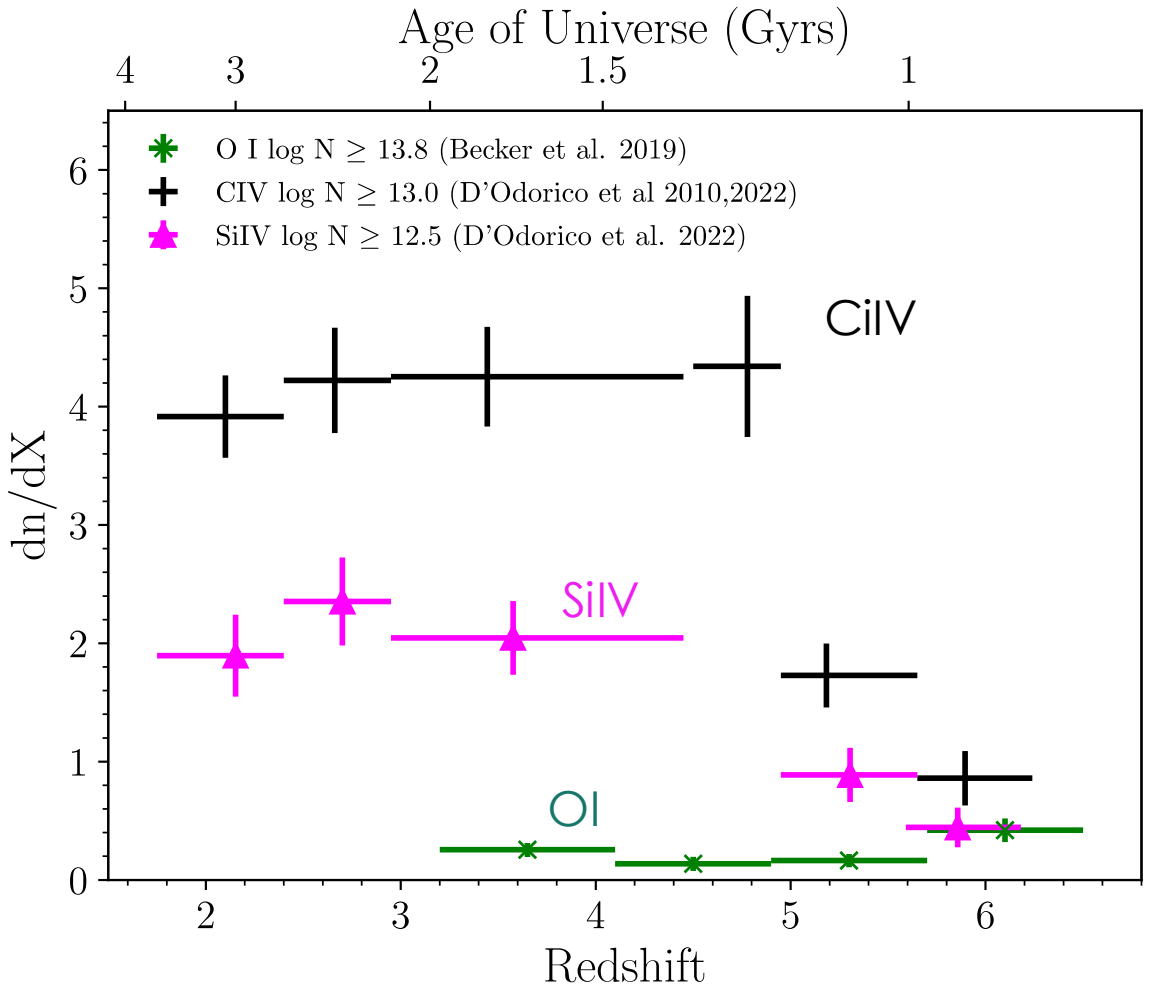


Fan+2006; Becker+2015; Bosman+2018; Eilers+2018,2019; Yang+2020

Multi-ions' approach

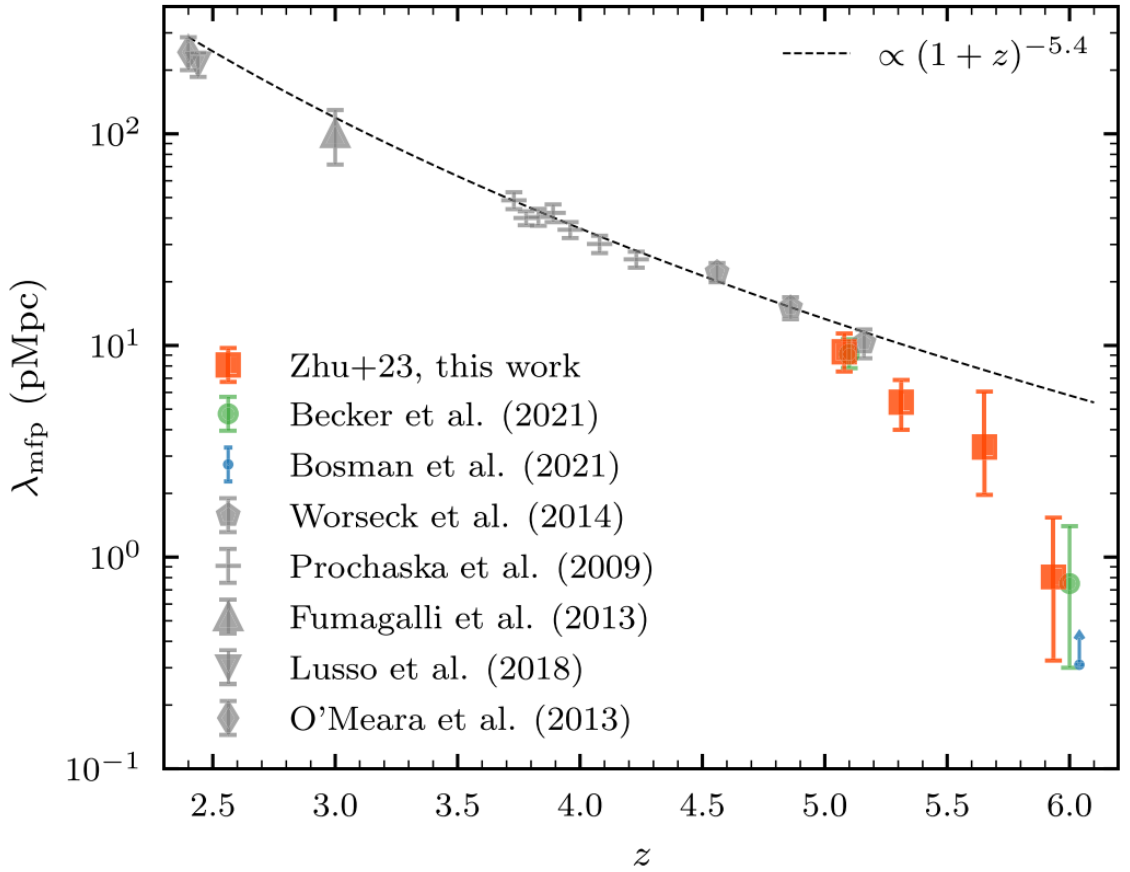
Comparison of the number density of different ions as a function of z

XQR-30



Becker+2019; D'Odorico+ 2022

Fast evolution of the mean free path of ionizing photons (Zhu+ 2023)



See also P. Gaikwad+ 2023 ; F. Davies+ 2024