INAF
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OAR

1st RECAP Collaboration Workshop

Exploring the Lyα damping wing effect in early ionized regions: overdensity or field?

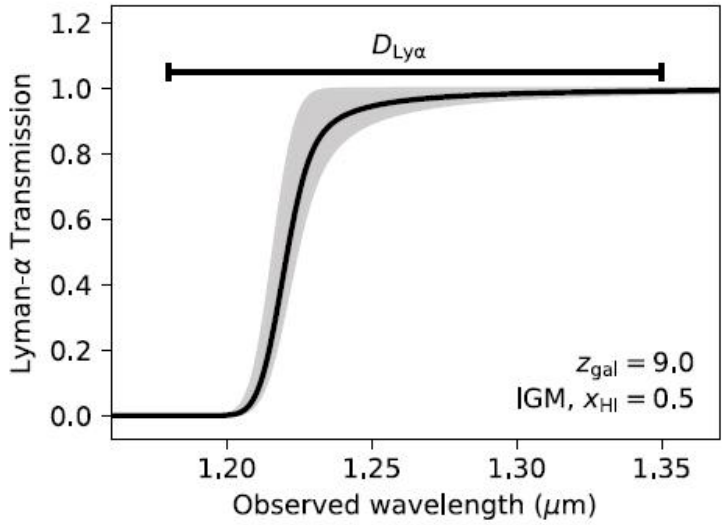
Dario Dottorini – PhD @ INAF-OAR

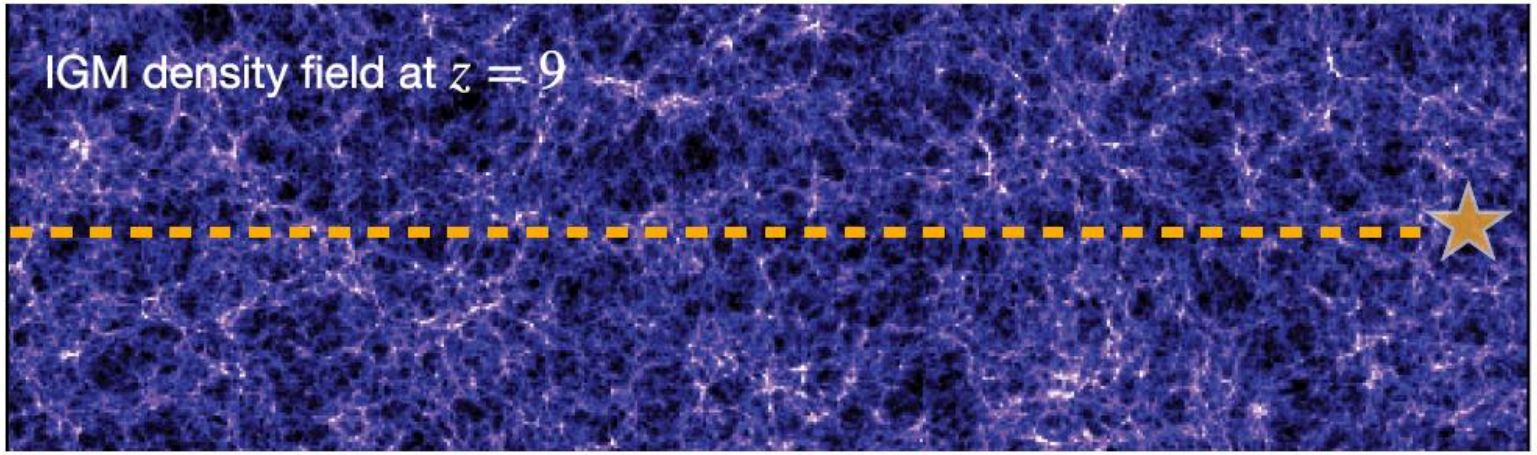
RECAP
erc synergy grant

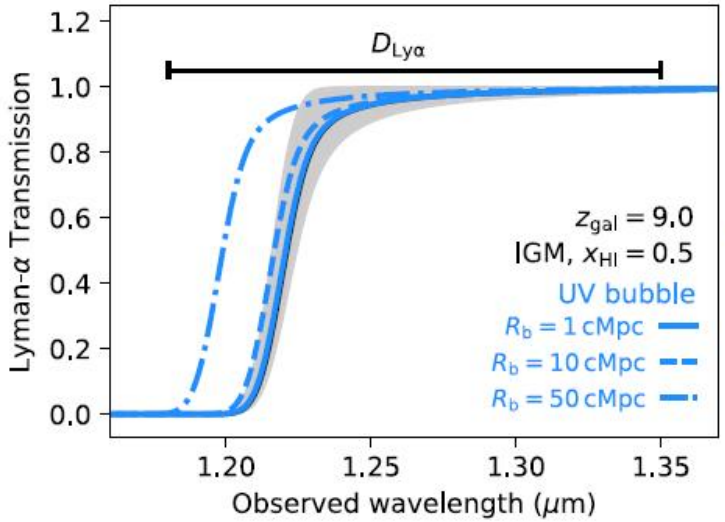
This work is supported by the ERC grant RECAP
under grant agreement No 101166930

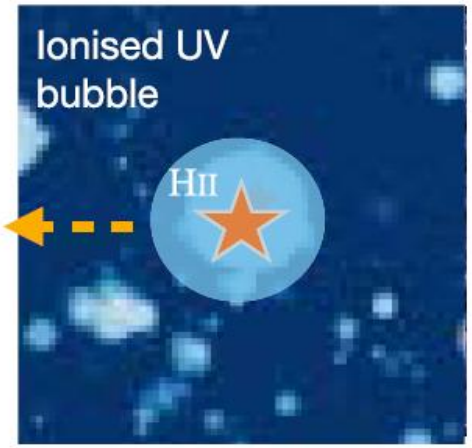
Funded by
the European Union

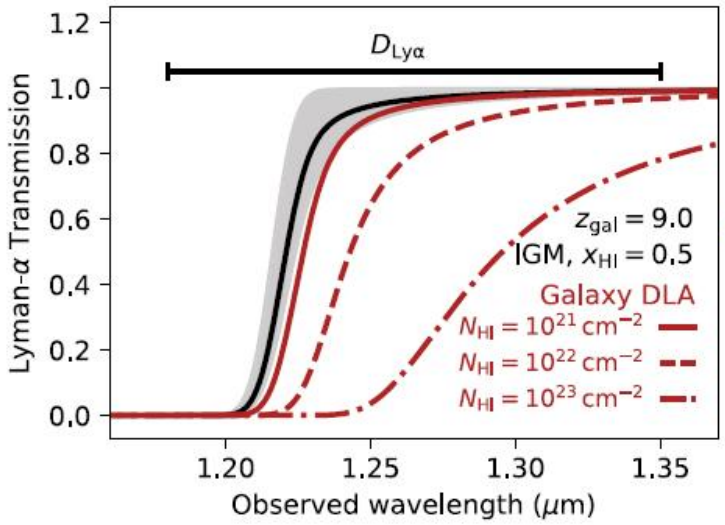
erc
European Research Council
Established by the European Commission

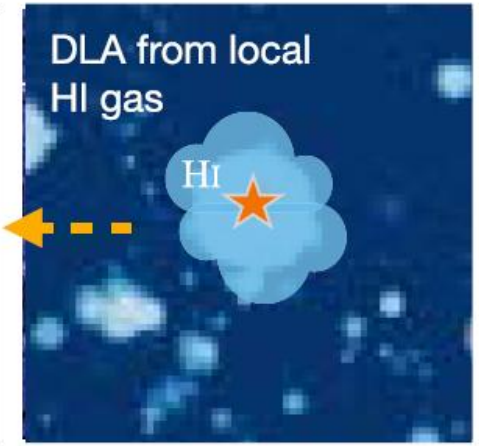












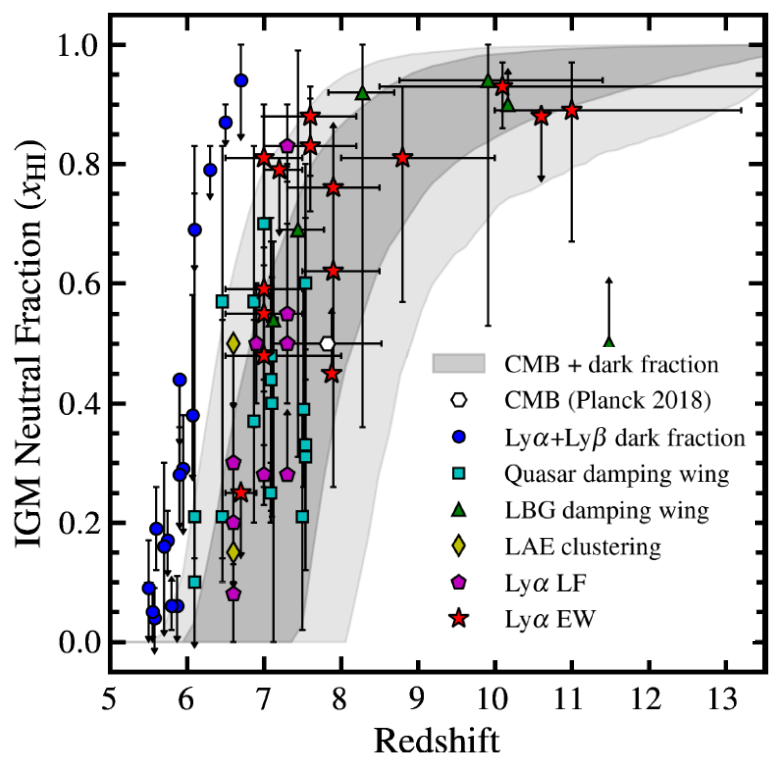
Heintz et al. (2025)

Ionized UV bubble effect

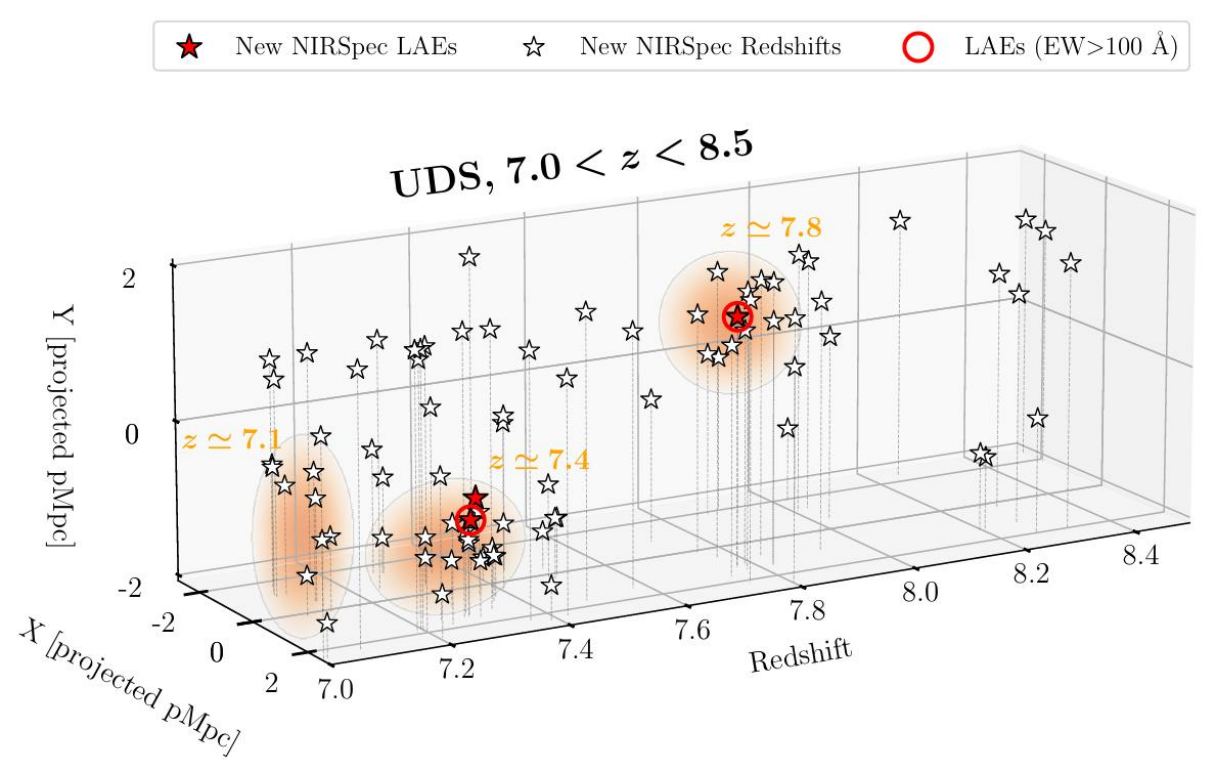
DLA from local HI gas effect

Our Work

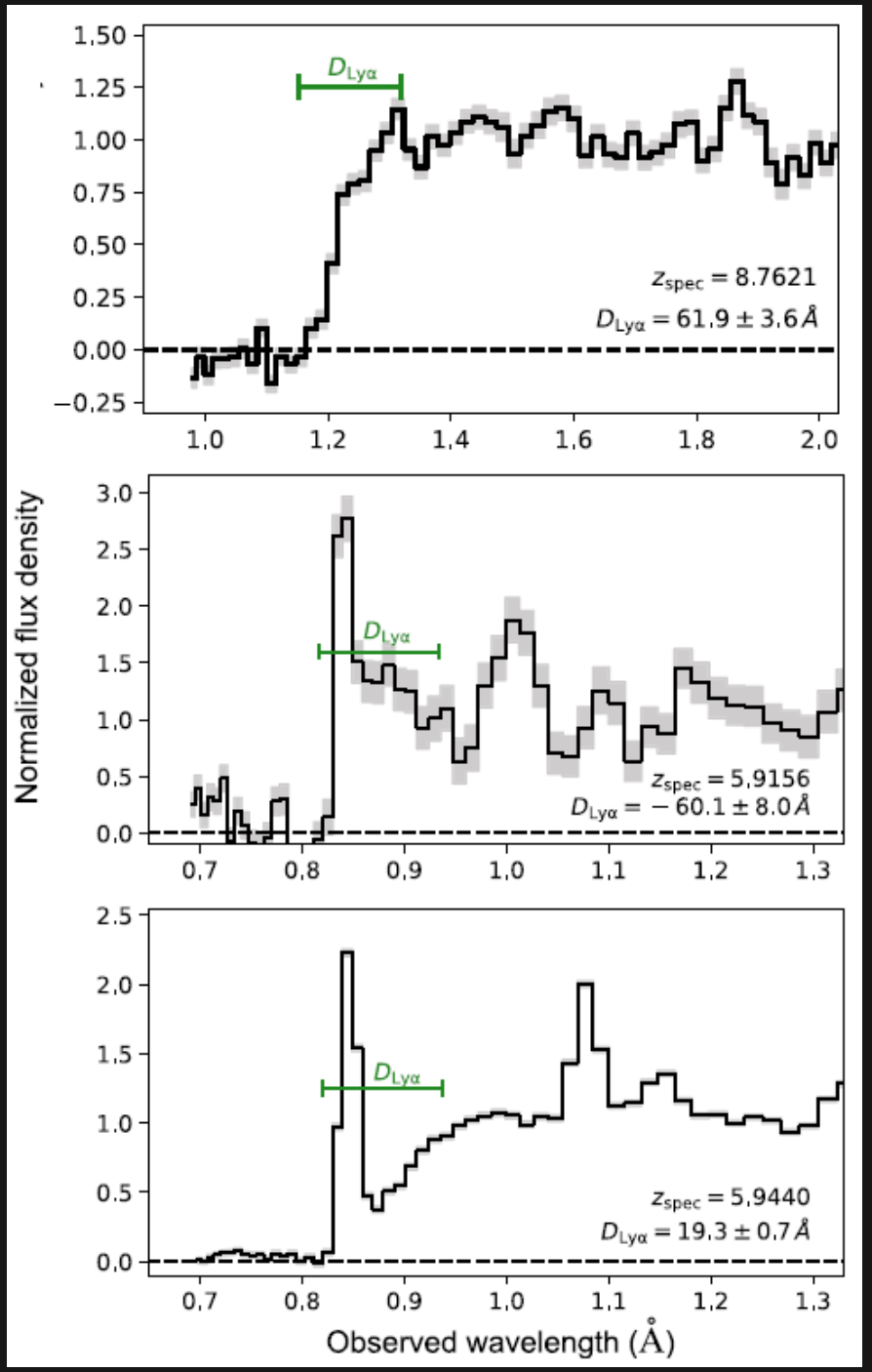
$7.4 < z < 8.2$



Stark et al. (2025)



Chen et al. (2025)



The JWST-PRIMAL archival survey

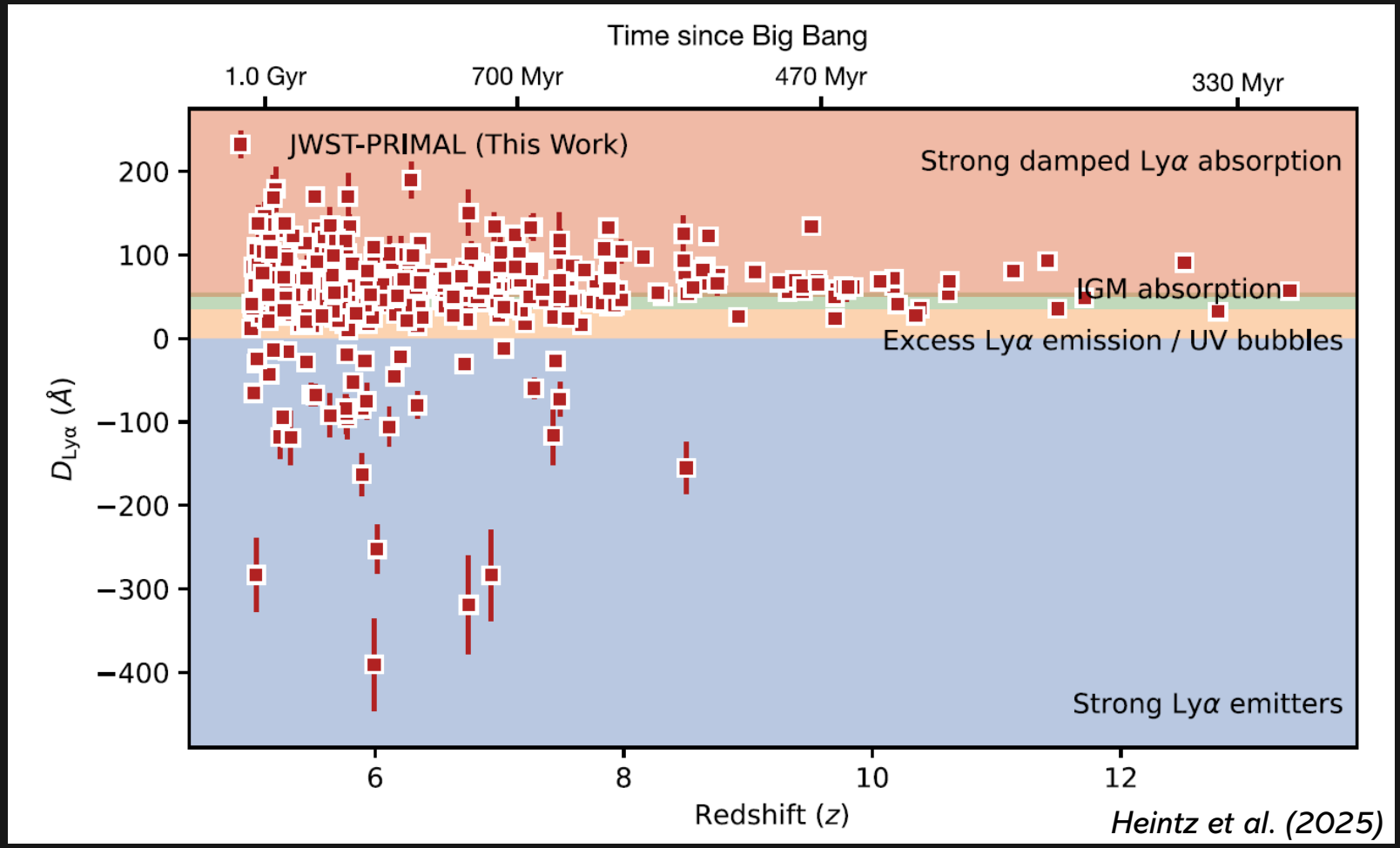
A JWST/NIRSpec reference sample for the physical properties and Lyman-absorption and emission of 600 galaxies at z = 5.0 – 13.4

K. E. Heintz, G. B. Brammer, D. Watson et al. 2025

$$D_{Ly\alpha} \equiv \int_{\lambda_{Ly\alpha,low}=1350\text{Å}}^{\lambda_{Ly\alpha,up}=1180\text{Å}} (1 - F_\lambda / F_{cont}) d\lambda / (1 + z_{spec})$$

A&A, 693, A60 (2025)
https://doi.org/10.1051/0004-6361/202450243

$D_{Ly\alpha} > 55$Å → Excess damped Lyα absorption from local HI (with $N_{HI} > 10^{21} cm^{-2}$)



Heintz et al. (2025)

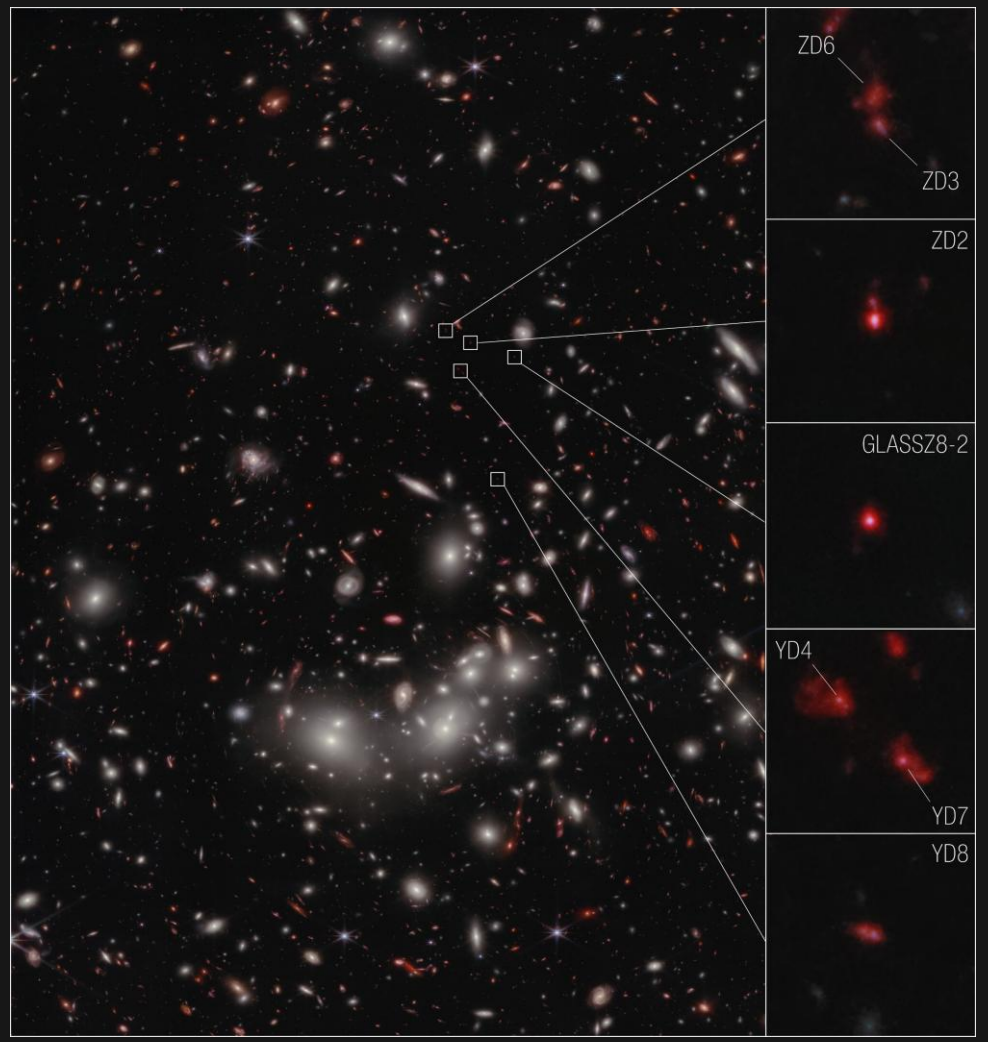
35Å $< D_{Ly\alpha} < 55$Å
Prevalence of the effect on the Lyα damping wings of an increasing neutral IGM

0Å $< D_{Ly\alpha} < 35$Å
Cases with excess continuum flux suggesting contributions from ionized bubbles or weak LAEs

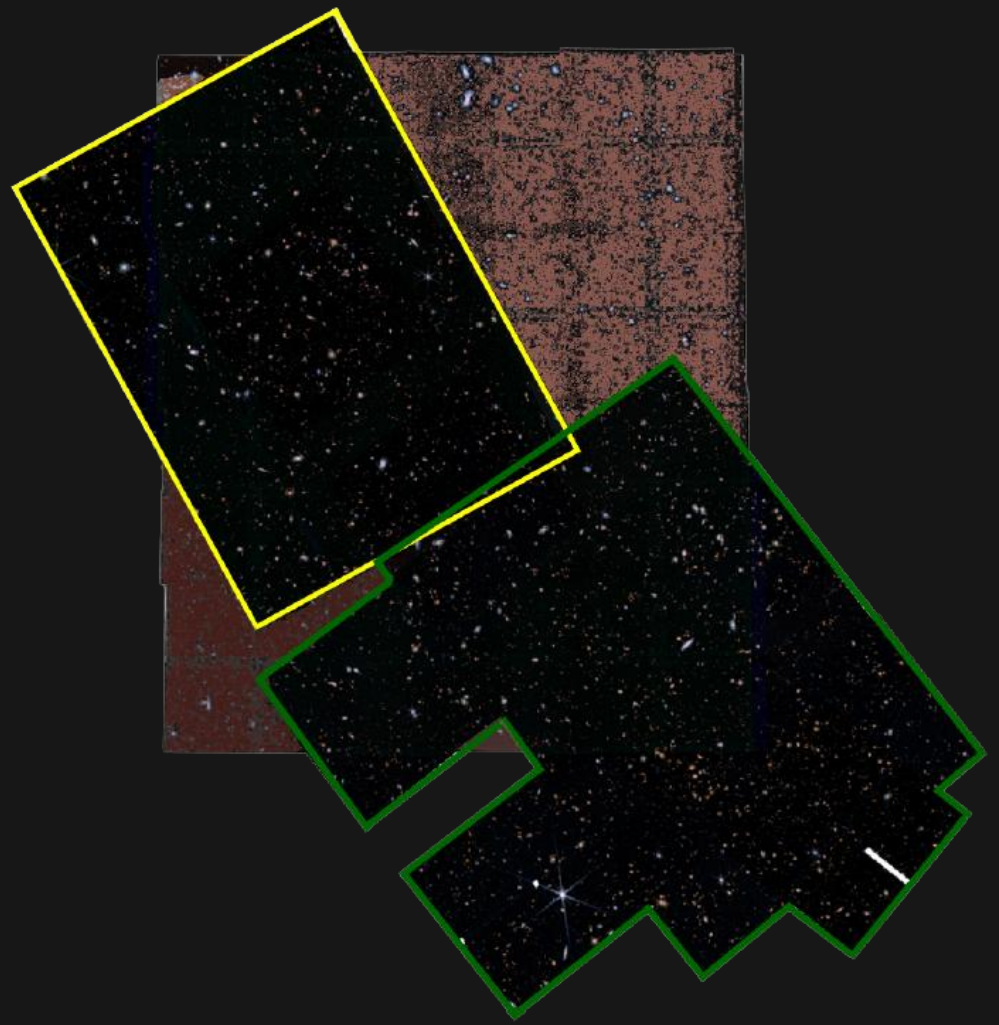
$D_{Ly\alpha} < 0$Å → Strong LAEs

Our Work

Overdensity ← $D_{Ly\alpha}$ → Field



ABELL2744 Protocluster @ z ~ 7.88

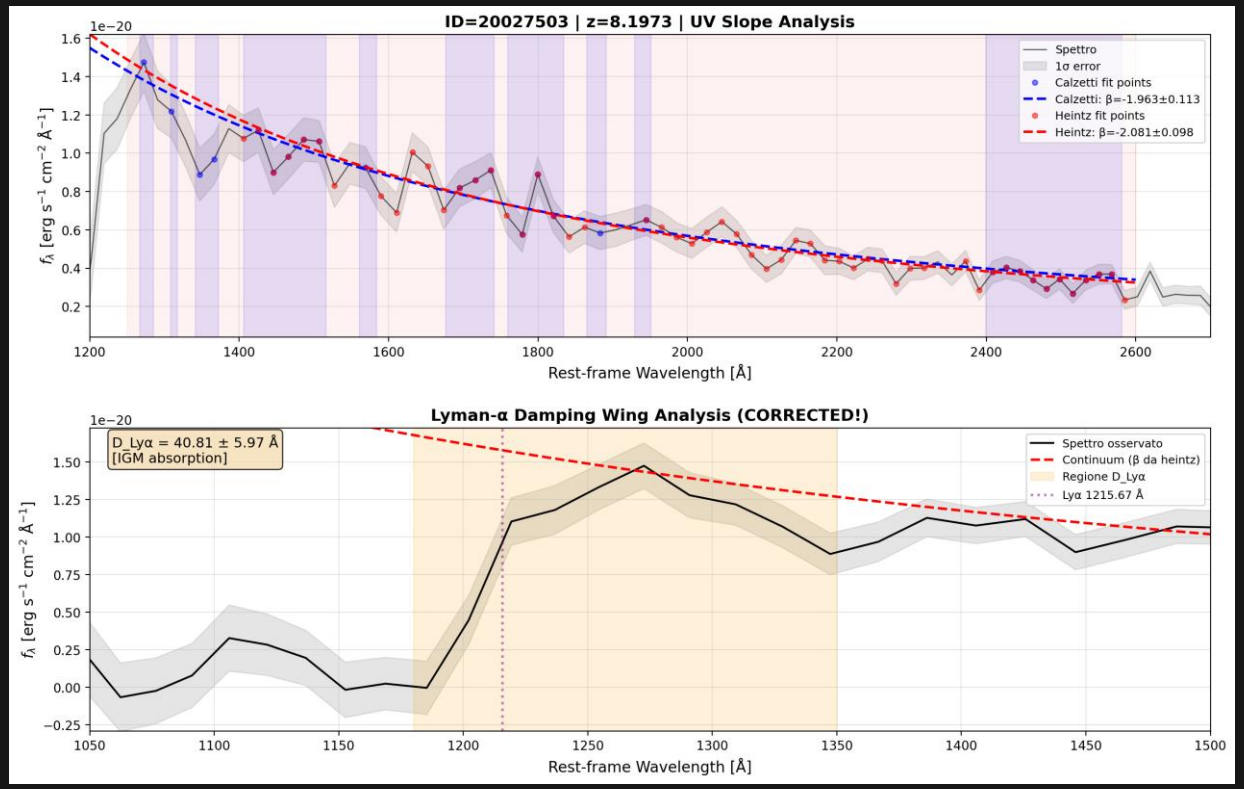


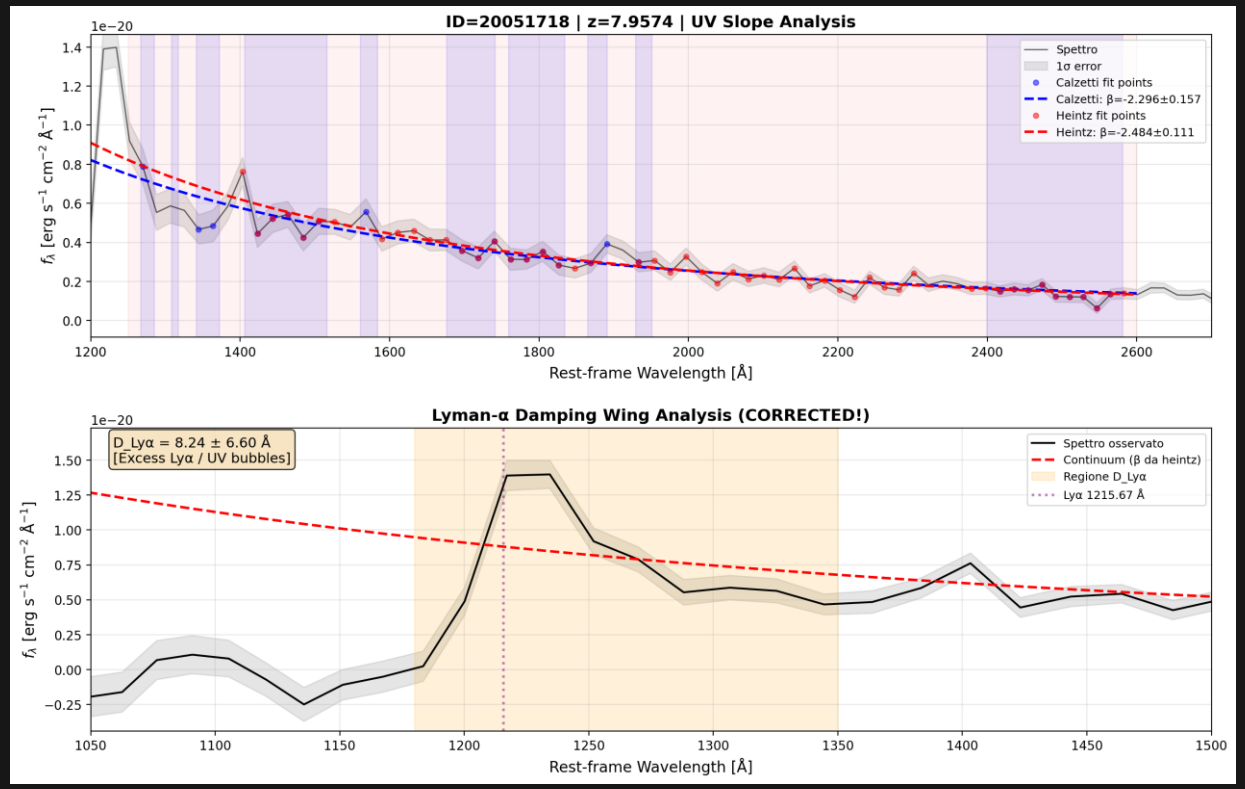
JADES GOODS-S Field

Spectroscopic Data

Latest spectroscopic catalogues versions from the same fields:
ABELL2744, CEERS, JADES-GS, JADES-GN, PRIMER-COSMOS, PRIMER-UDS

- Grade > 2 for z_spec

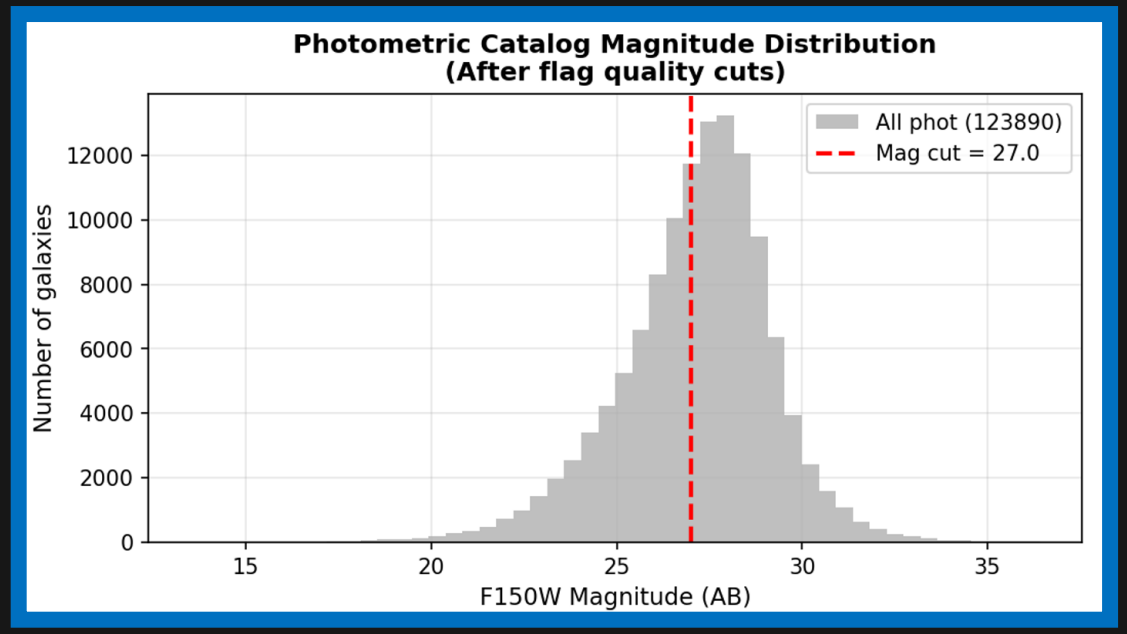




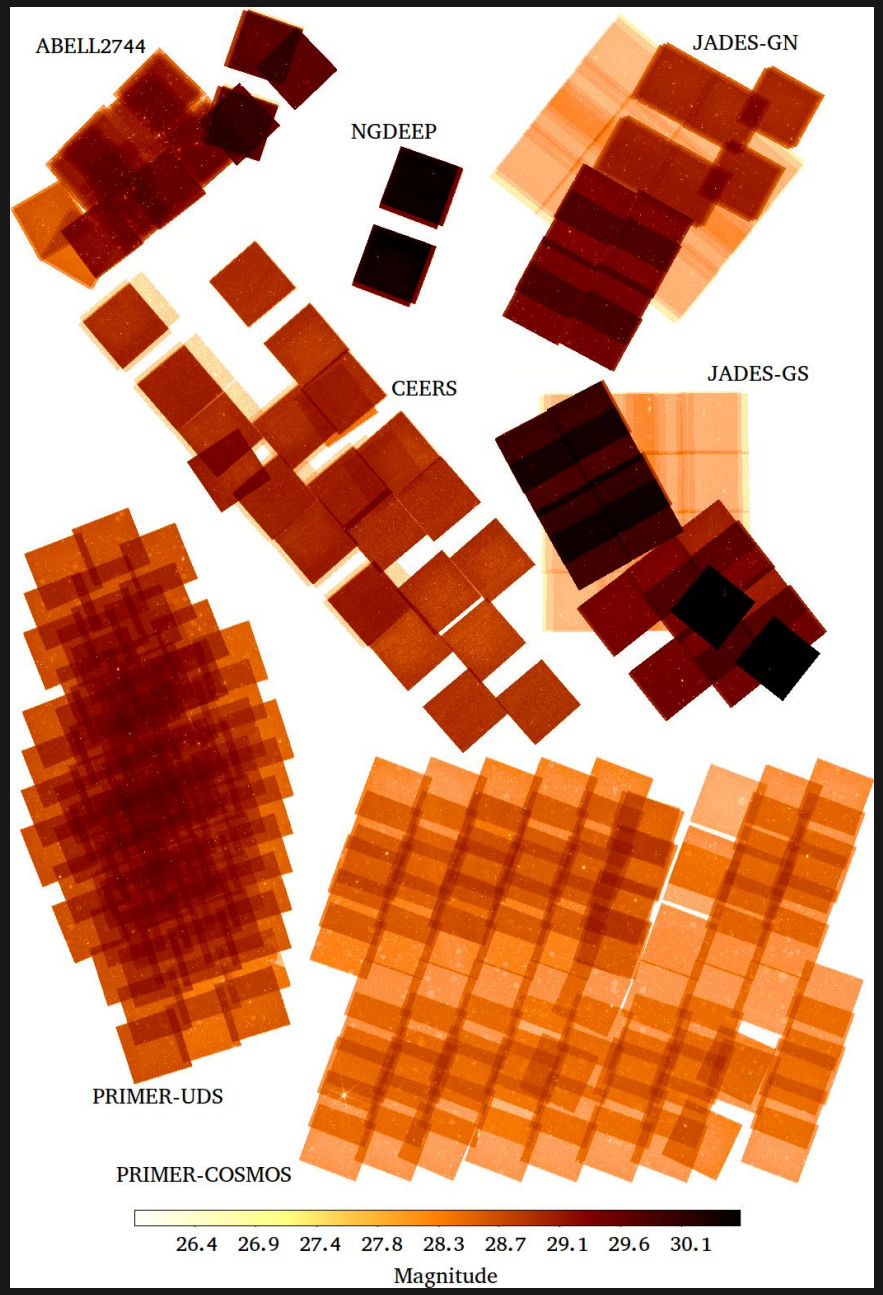
Photometric Data

Latest photometric catalogues versions from the fields:
ABELL2744, CEERS, JADES-GS, JADES-GN, PRIMER-COSMOS, PRIMER-UDS

- **Magnitude < 27.0**
- **Quality Flag < 10**
- **Redshifts Scatter < 0.3**
- **S/N > 3-10**



PRIMER-UDS Example



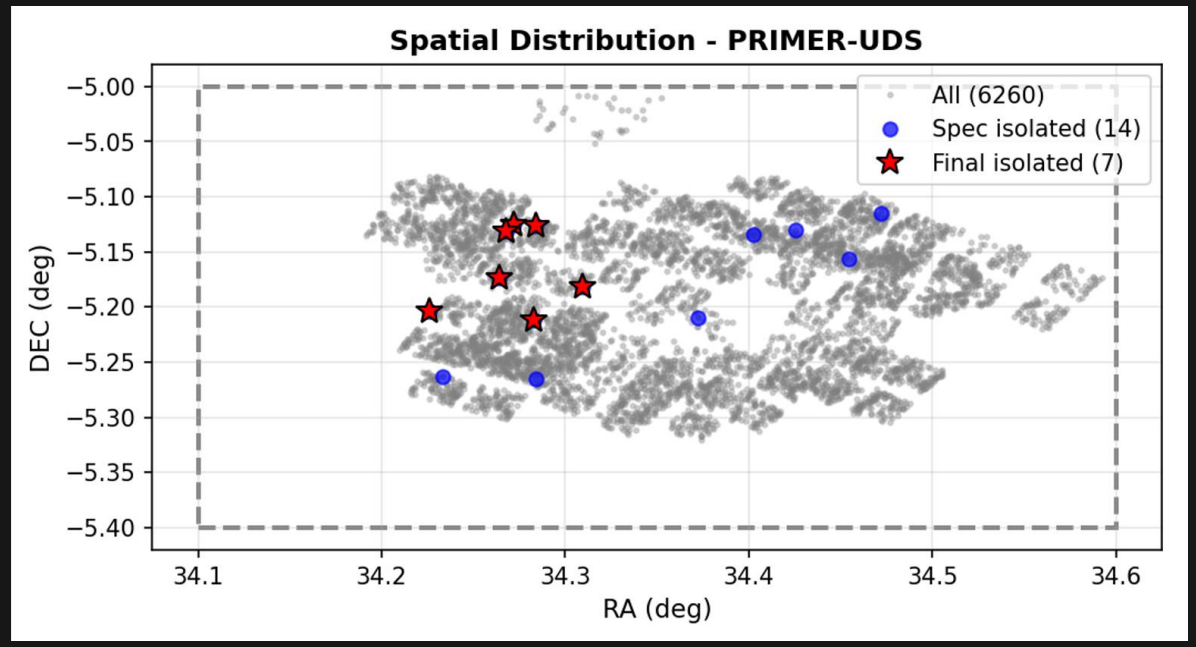
Merlin et al. 2024

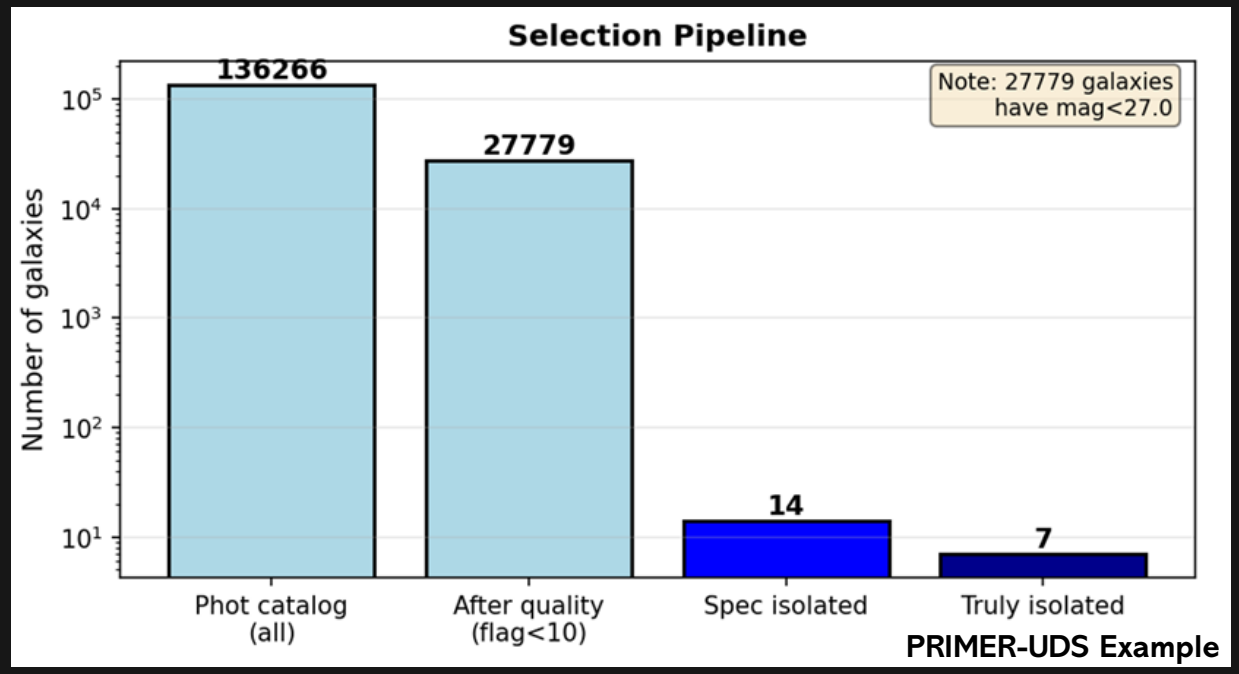
Field Galaxies: Selection

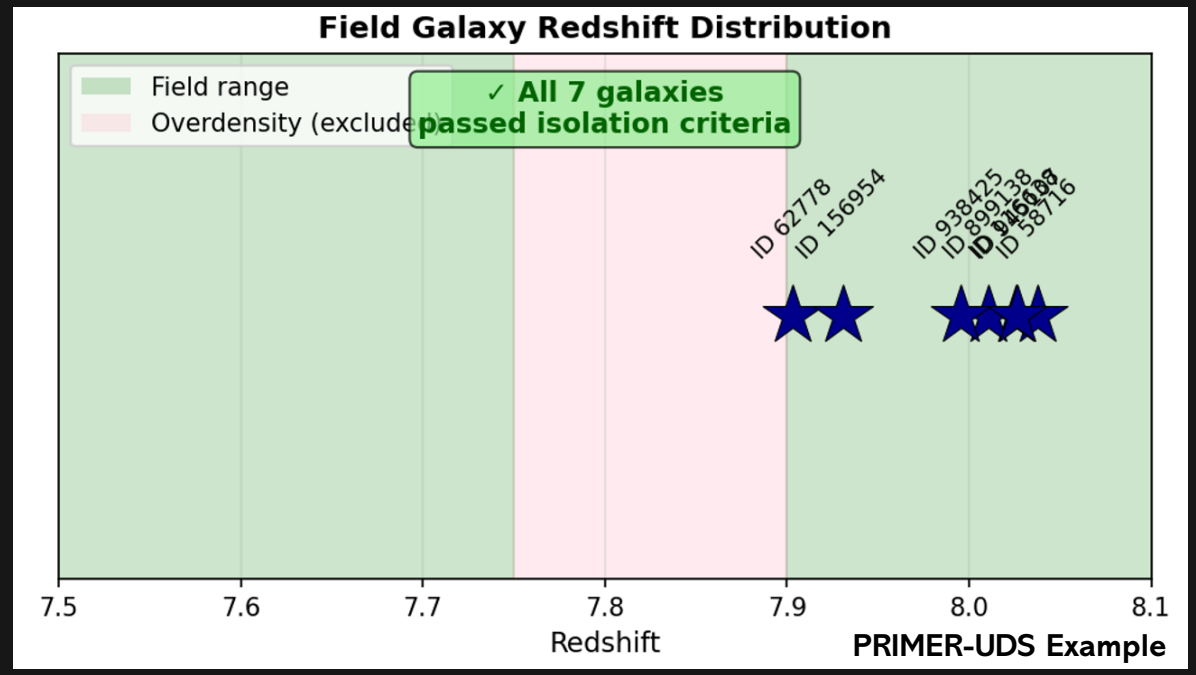
Isolation Criteria
- ang_sep = 4.0 arcmin
- dz_spec = 0.1
- dz_phot = 0.6

Maximum Neighbors
- max_spec = 5
- max_phot = 2

Total Galaxies: 57
Z_Range = 7.40 – 8.20
Mean_MUV = 27.42 ± 0.90
Mean S/N = 1.0 ± 0.7



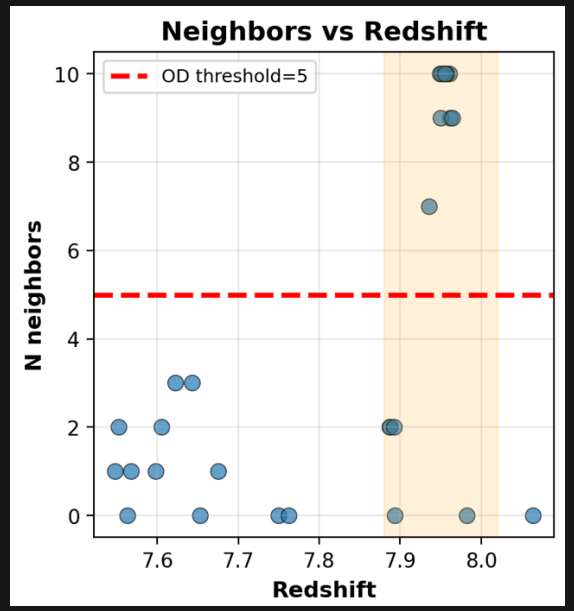




Overdensity Galaxies: Selection

PHASE 1 → Systematic Search

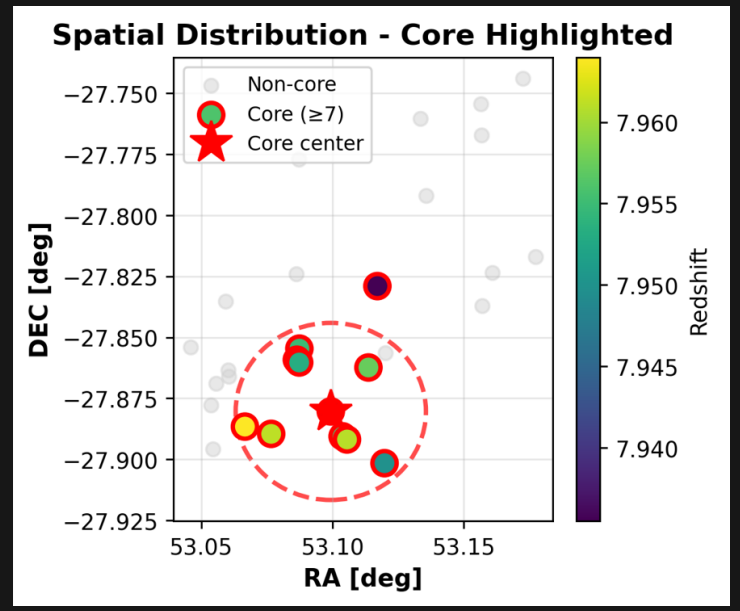
3D clustering with fixed threshold (≥5 neighbors)



JADES-GS Example

PHASE 2 → Detailed Core Analysis

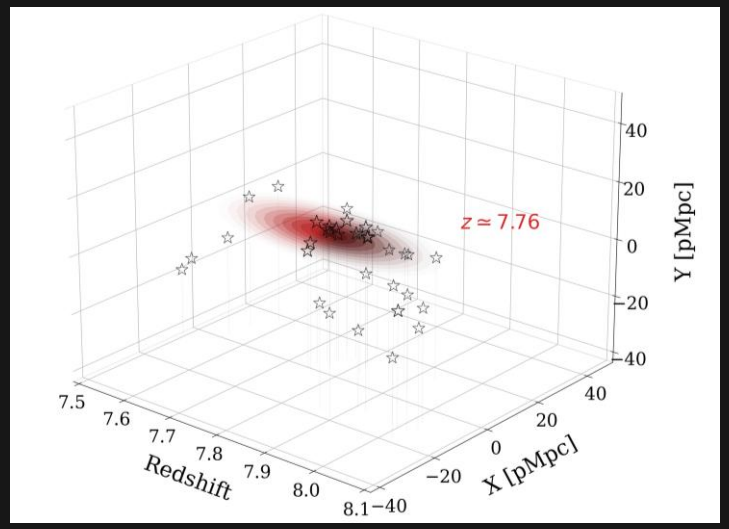
Once the overdensity is confirmed, I characterize it in detail and identify the physical core



JADES-GS Example

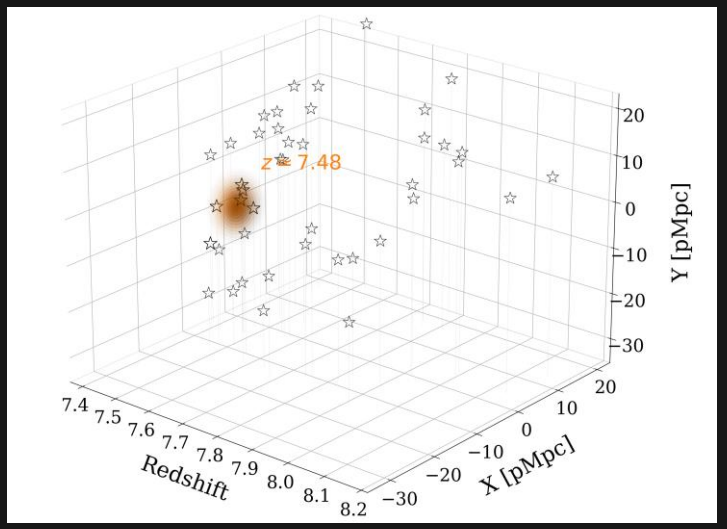
PRIMER-UDS Example

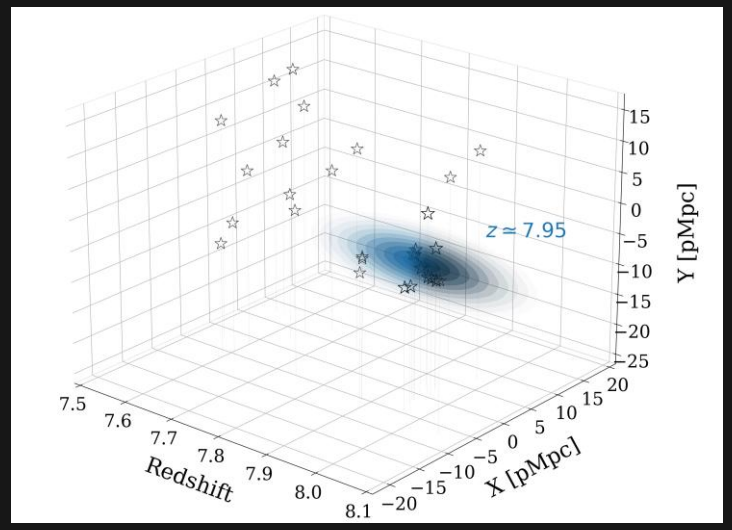
Overdensity Galaxies: Selection



PRIMER-UDS
7 Galaxies

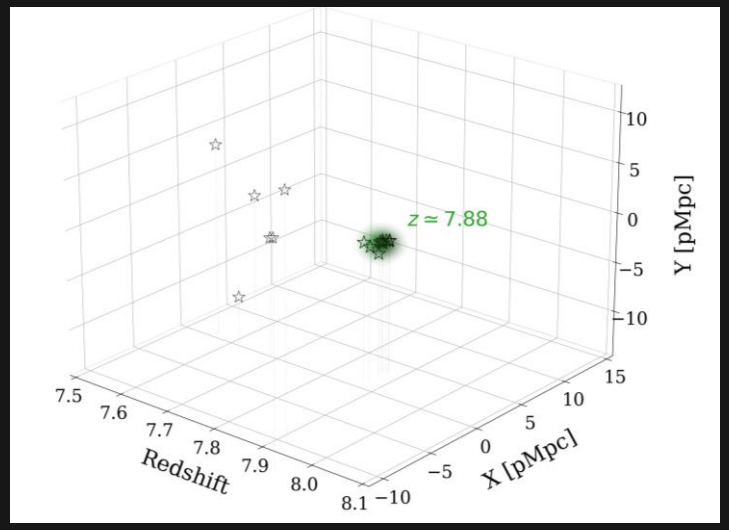
CEERS
7 Galaxies

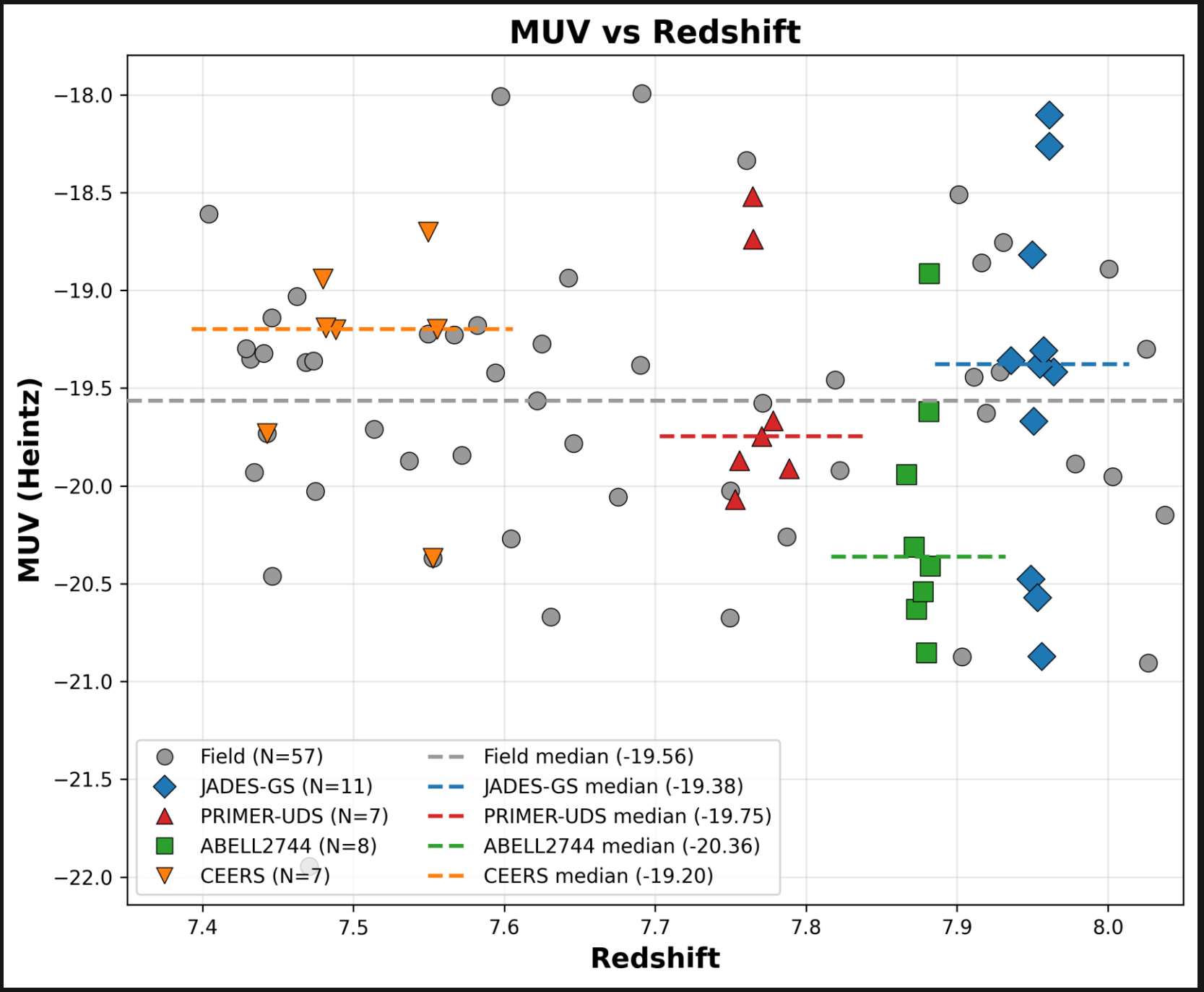




JADES-GS
11 Galaxies

ABELL2744
8 Galaxies



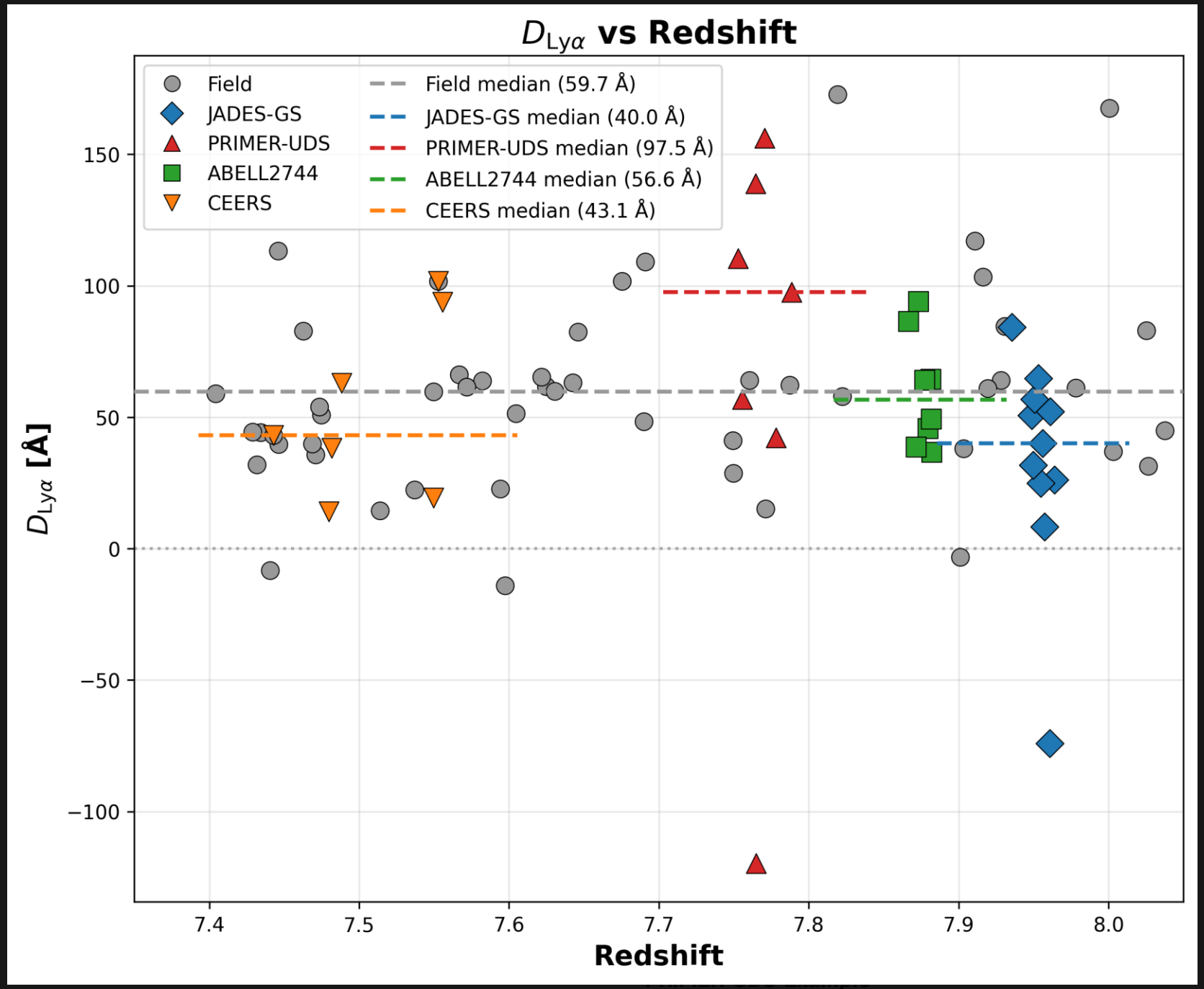


MUV Distribution

→ **Matching Between Fields**
The MUV distributions are almost identical between CEERS, JADES-GS, Field and PRIMER-UDS

ABELL2744
Needs to get corrected for lensing magnification!

No Correlations (Spearman):
D_Lyα vs MUV: ρ=-0.004, p=0.973
D_Lyα vs β: ρ=0.160, p=0.132
D_Lyα vs z: ρ=0.106, p=0.319



D_Lya Estimate

PRIMER-UDS

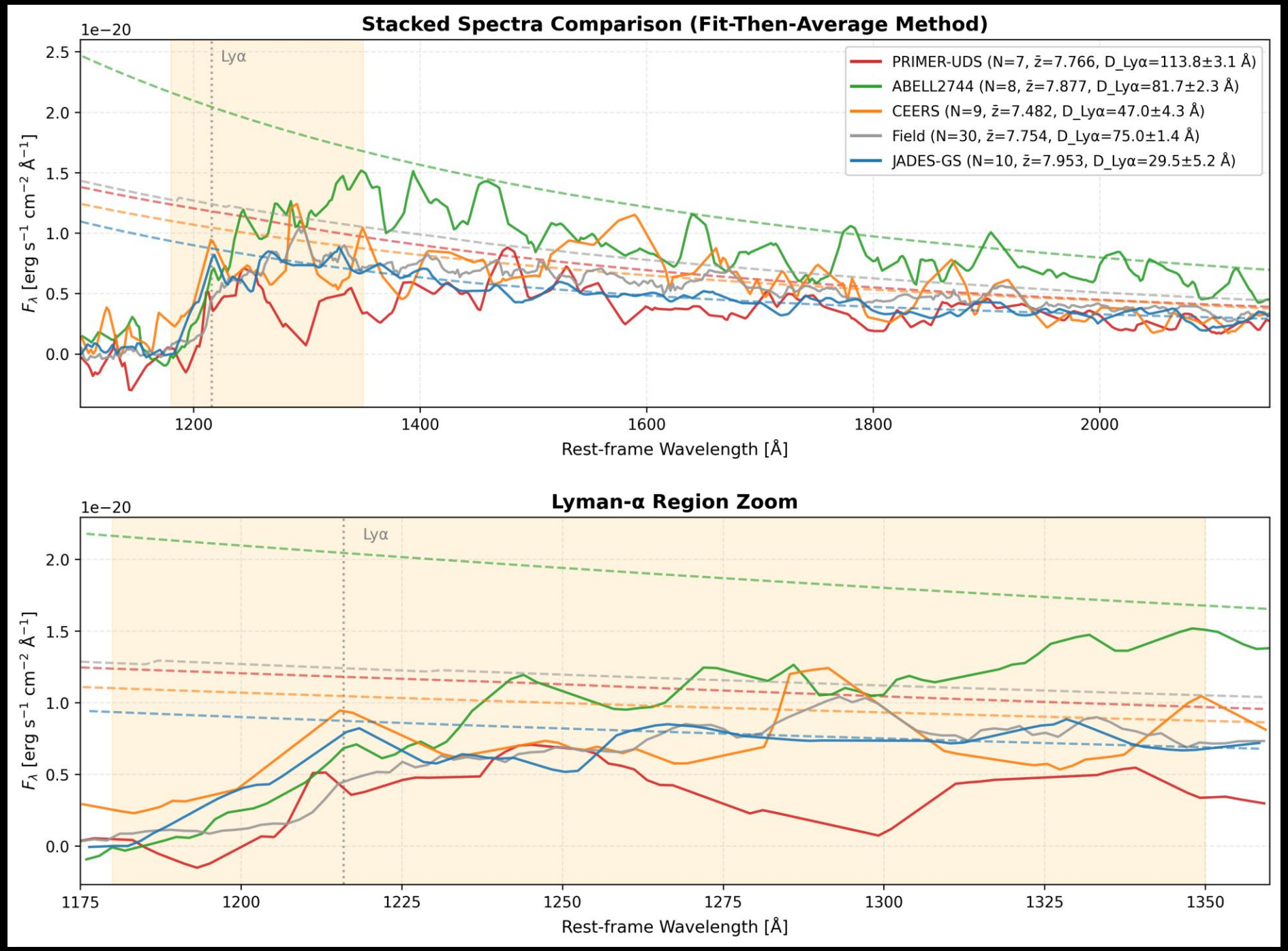
- D_Lyα = 97.5 Å
  → Strongest IGM Absorption
- Range: -119.7 to 156.2 Å
  → Very High Dispertion

Field and ABELL2744

- D_Lyα = 59.7 Å e 56.6 Å
  → Moderate IGM Absorption

CEERS and JADES-GS

- D_Lyα = 43.1 Å e 40.0 Å
  → Most Ionized IGM


Stacked Spectra Comparison (Fit-Then-Average Method)
1e−20
Lyα
PRIMER-UDS (N=7, z̄=7.766, D_Lyα=113.8±3.1 Å)
ABELL2744 (N=8, z̄=7.877, D_Lyα=81.7±2.3 Å)
CEERS (N=9, z̄=7.482, D_Lyα=47.0±4.3 Å)
Field (N=30, z̄=7.754, D_Lyα=75.0±1.4 Å)
JADES-GS (N=10, z̄=7.953, D_Lyα=29.5±5.2 Å)
F_λ [erg s^{-1} cm^{-2} Å^{-1}]
Rest-frame Wavelength [Å]
Lyman-α Region Zoom
1e−20
Lyα
F_λ [erg s^{-1} cm^{-2} Å^{-1}]
Rest-frame Wavelength [Å]