CHORUS. III. Photometric and Spectroscopic Properties of Lyα Blobs at z=4.9-7.0

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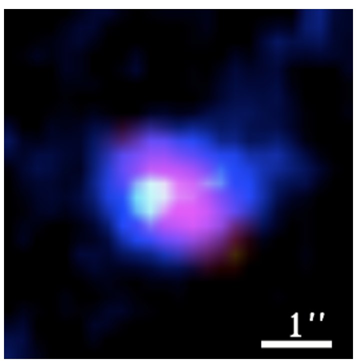
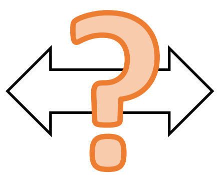
(Zhang et al. 2019; Submitted to ApJ)

Introduction

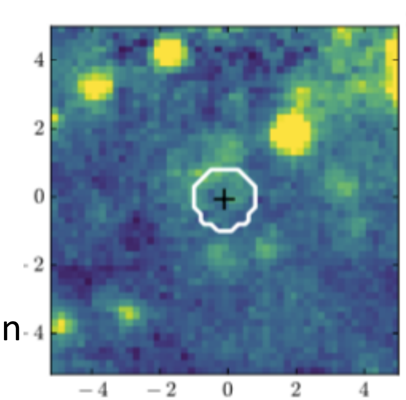
- **Lyα blobs (LABs)**: luminous ($\log(L_{Ly\alpha}) \gtrsim 43.4$) erg s^{-1}) and spatially extended LAEs found at $z \leq 6.6$.
- **Lyα halos (LAHs)**: around faint ($\log(L_{Ly\alpha}) \sim 42 - 43$ erg s^{-1}) LAEs found at $z \sim 3 - 6$ by VLT/MUSE (Leclercq+17).
- Connections between LABs and LAHs are unknown.



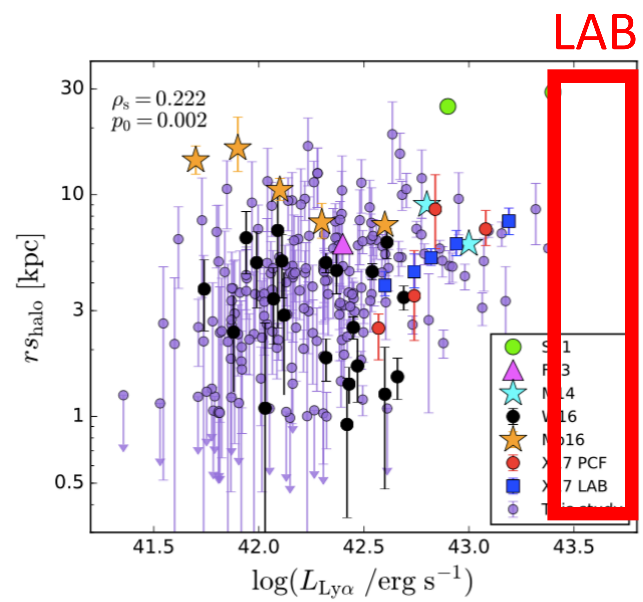
LAB Himiko at z = 6.6
(Ouchi+09)



Same population



LAH #547 at z =5.98
(Leclercq+17)

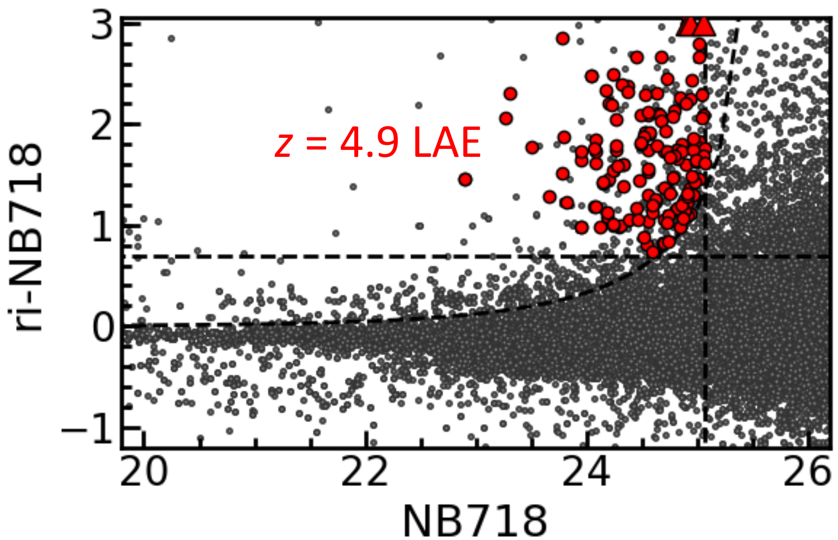


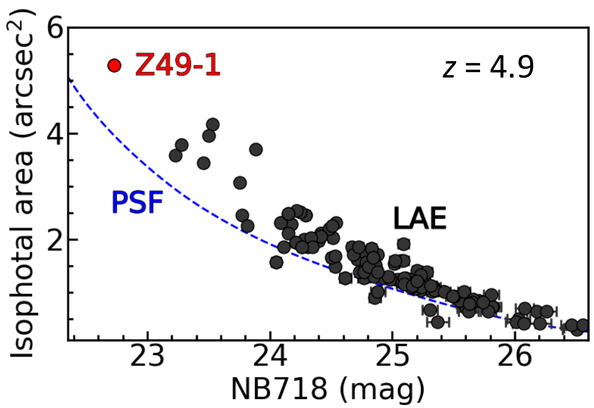
(Leclercq+17)

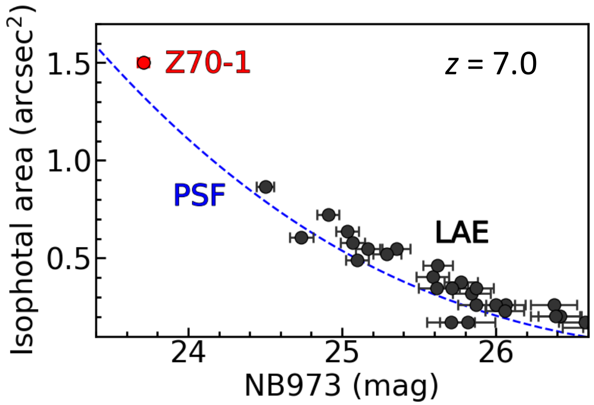
Data and Method

- **Imaging data**: Subaru/HSC NB718 and NB973 from CHORUS survey + NB and BB from SSP survey in COSMOS and SXDS fields.
- In total, 141 LAE candidates at $z = 4.9$ selected by us + 34 LAE candidates at $z = 7.0$ from Itoh+18.

➡ **Two new LABs** (z49-1 and z70-1) + five previously known LABs at $z = 5.7$ and 6.6.

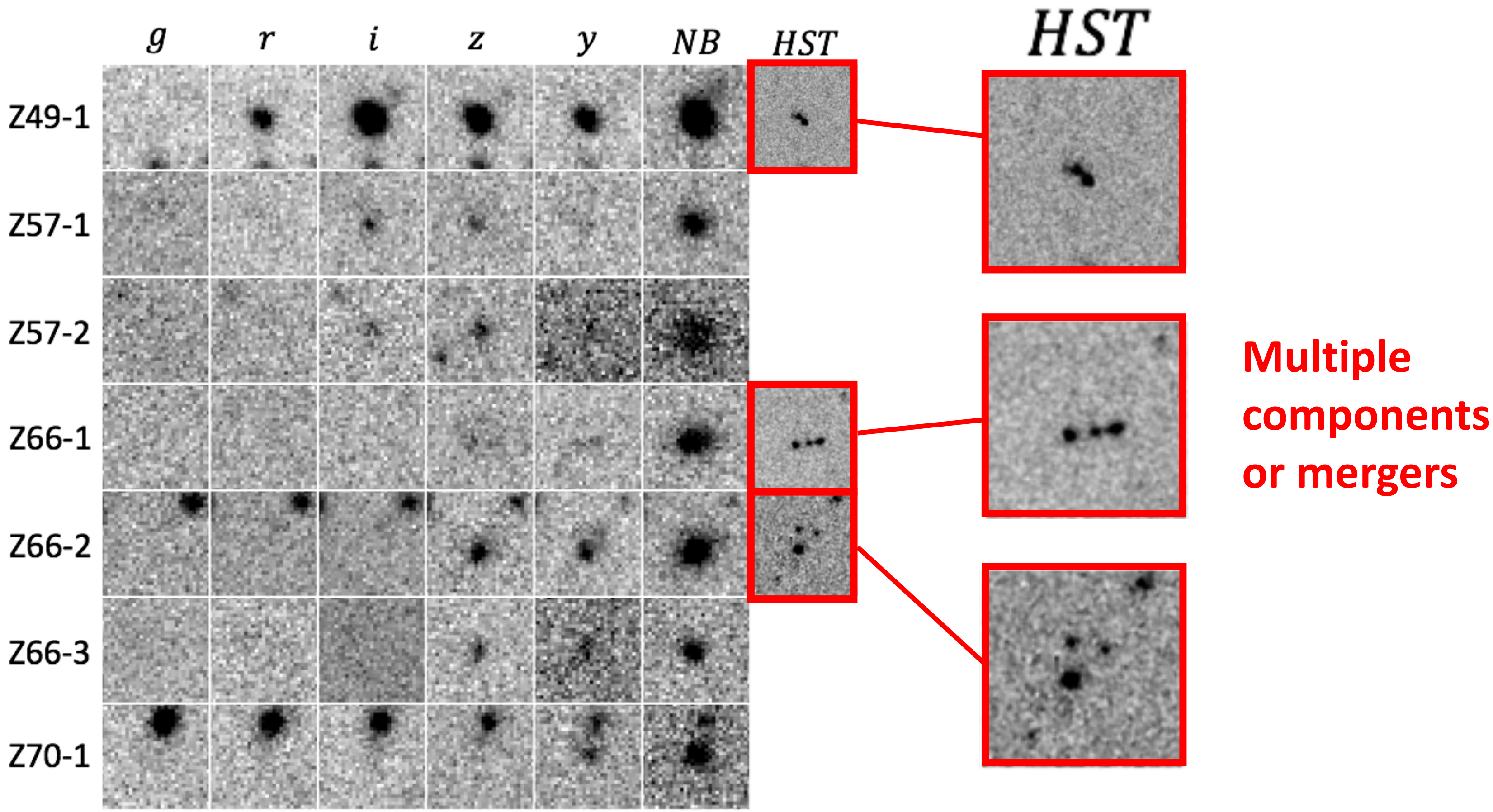






Data and Method

- Snapshots of the 7 LABs:



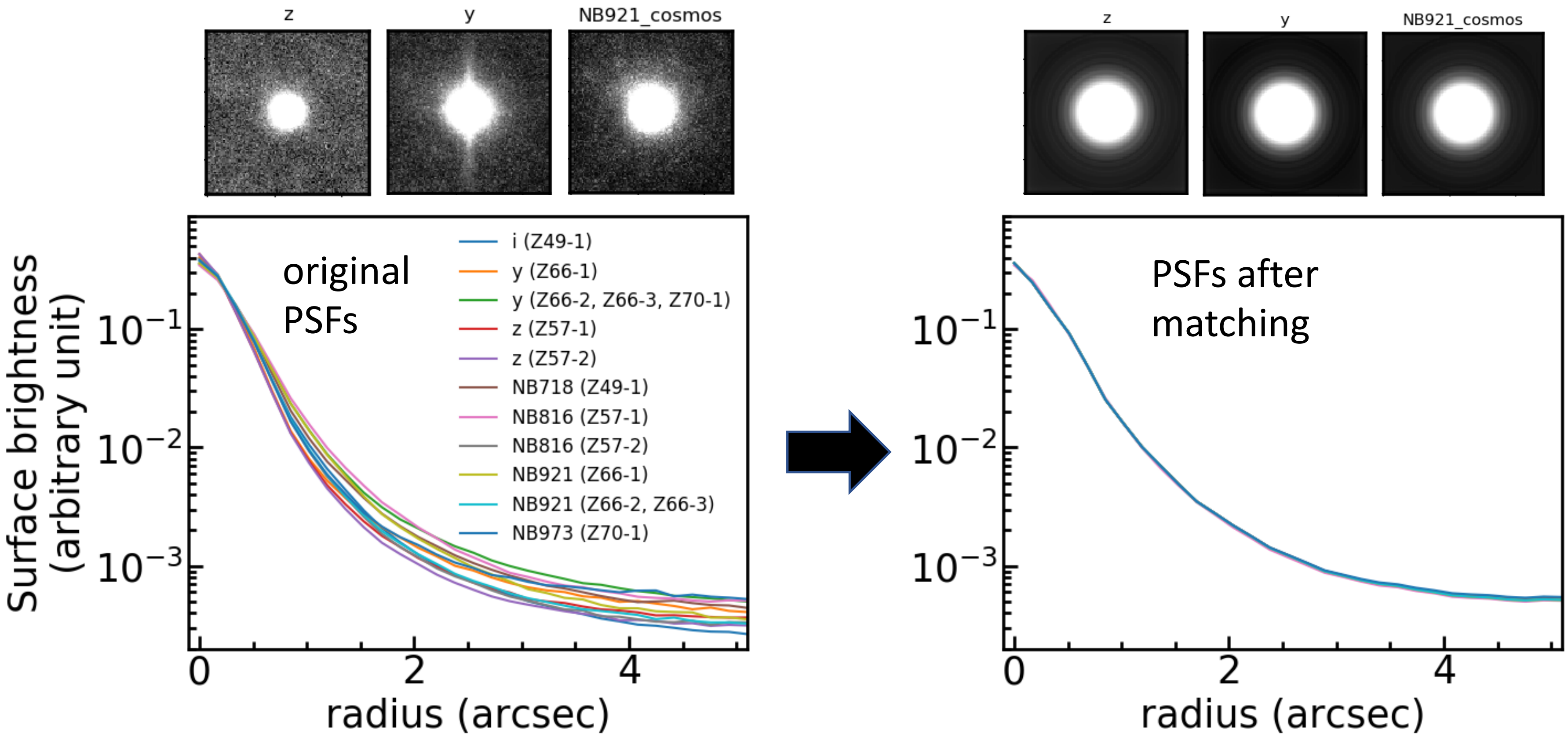
- NB (Lyα) images are more extended than continuum images.
- Multiple components may be common among high-z LABs.

Data and Method

- We <u>unify</u> the point spread functions (PSFs) to accurately extract Ly**α** (NB − continuum) images, following

$$K = \mathrm{FT}^{-1}\left(\mathrm{FT}(\mathrm{PSF_t}) \times \frac{1}{\mathrm{FT}(\mathrm{PSF_i})}\right),$$

where FT means Fourier transform.

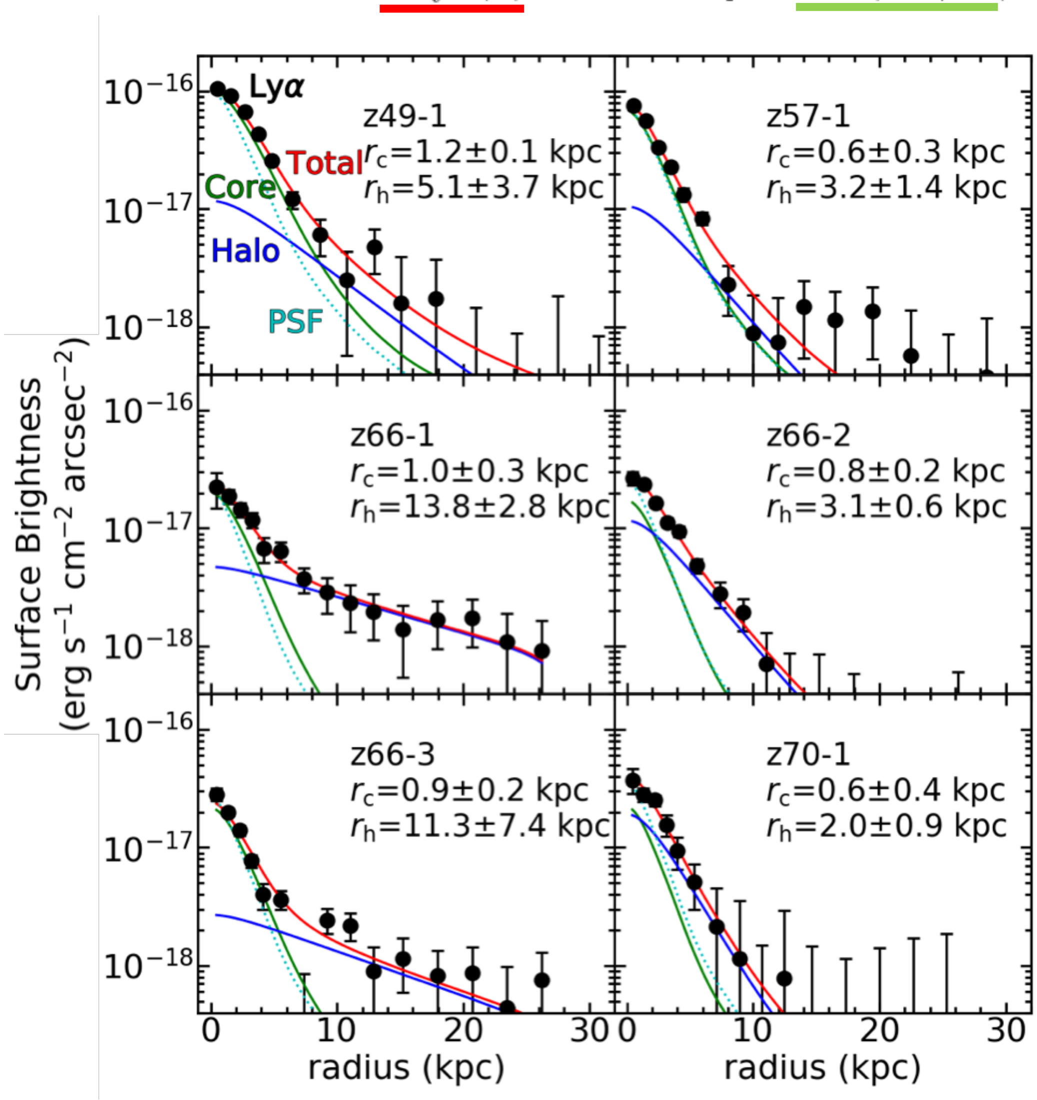


Data and Method

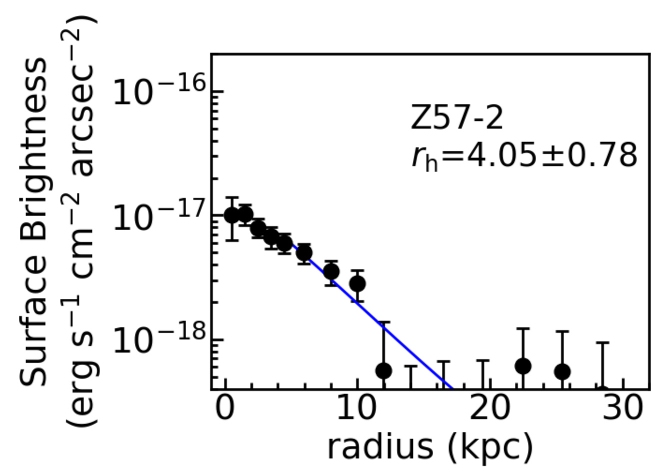
- Two-component exponential function fitting:

$$S_{\rm cont}(r) = {\rm PSF} * A_1 \exp(-r/r_{\rm c}) \text{ and}$$

$$S_{\rm Ly\alpha}(r) = {\rm PSF} * [A_2 \exp(-r/r_{\rm c}) + A_3 \exp(-r/r_{\rm h})]$$

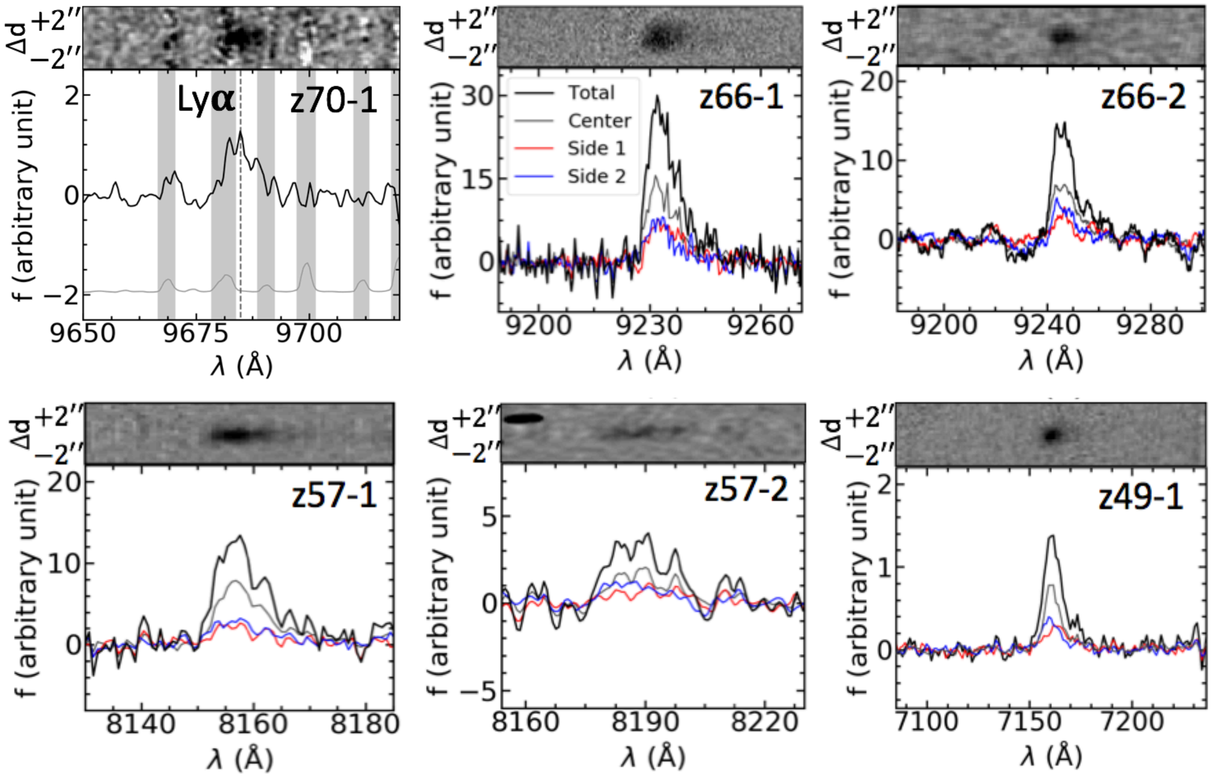


z57-2: offset between Lyα and continuum centers → one-component fitting.

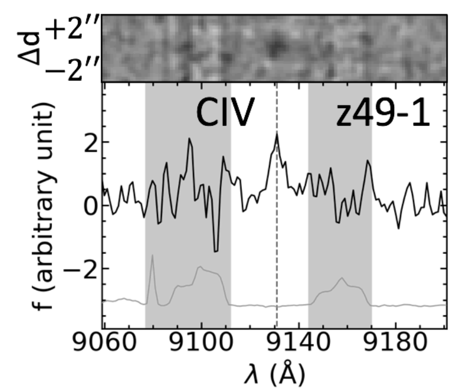


Data and Method

- Spectra of the 7 LABs showing Ly**α** lines:

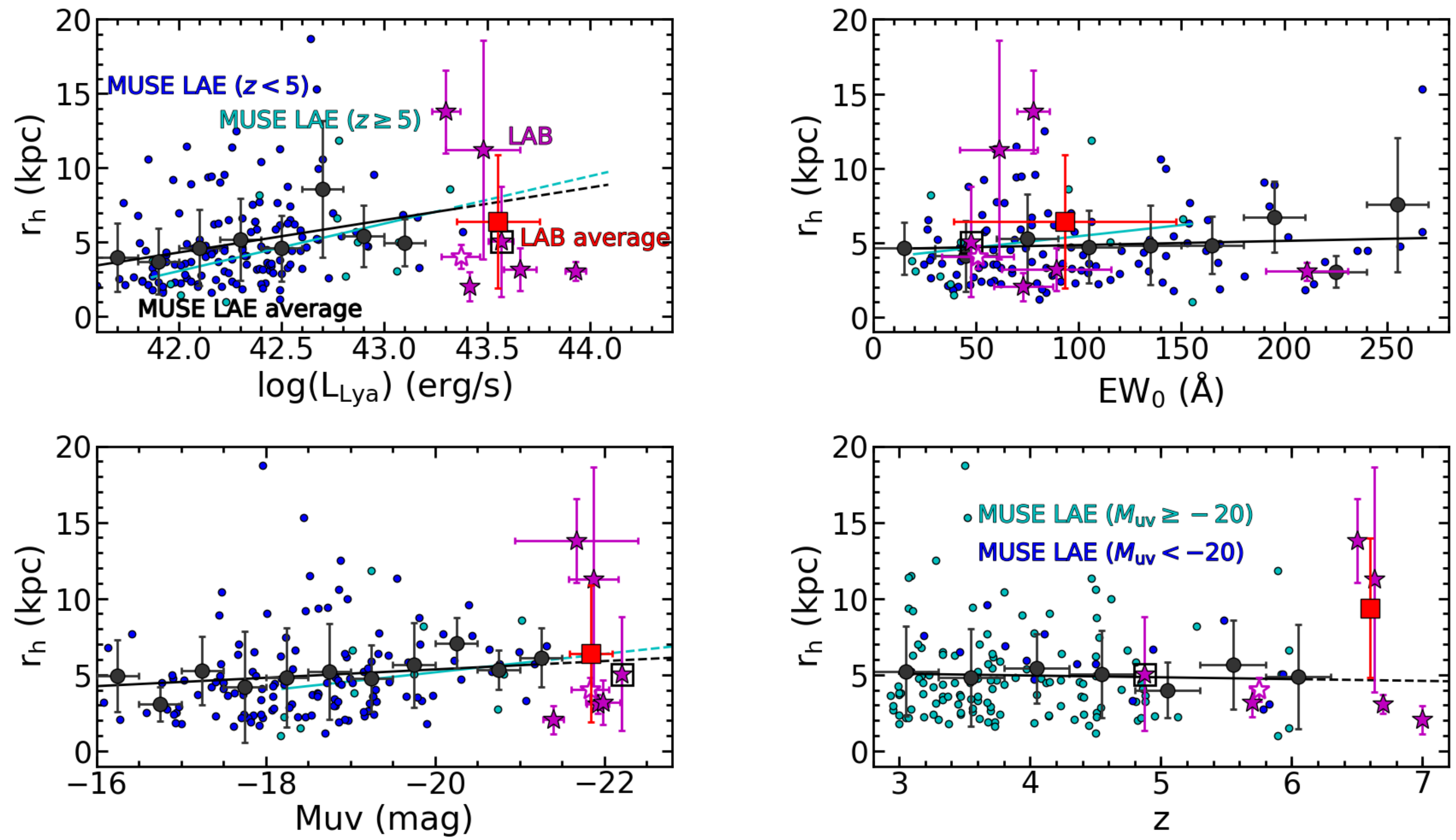


- Redshifts of the 7 LABs are **all confirmed**.
- No other emission lines except CIV of z49-1.



Result and Discussion

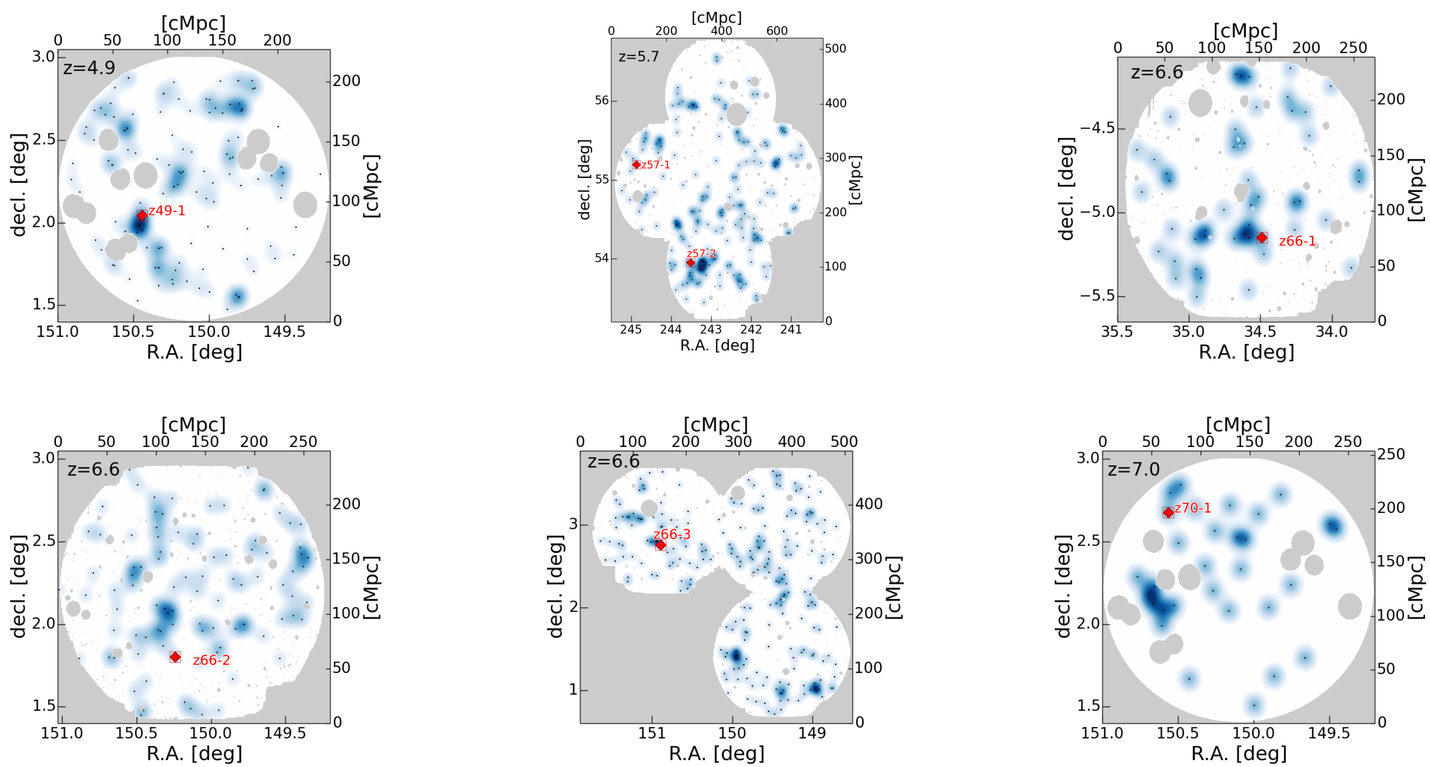
1. Comparison of r_h between LABs and LAHs:



- **Typical high-z LABs are star-forming galaxies at the bright end.**
- Our LABs do not have a significant redshift evolution of r_h.

2. Large scale structure around LABs

- LAE overdensity $\delta = \frac{n - \bar{n}}{\bar{n}}$, where n is the number of LAEs in a cylinder (l=40 cMpc, r=10 cMpc).



- LABs in overdensed regions: 6/7.

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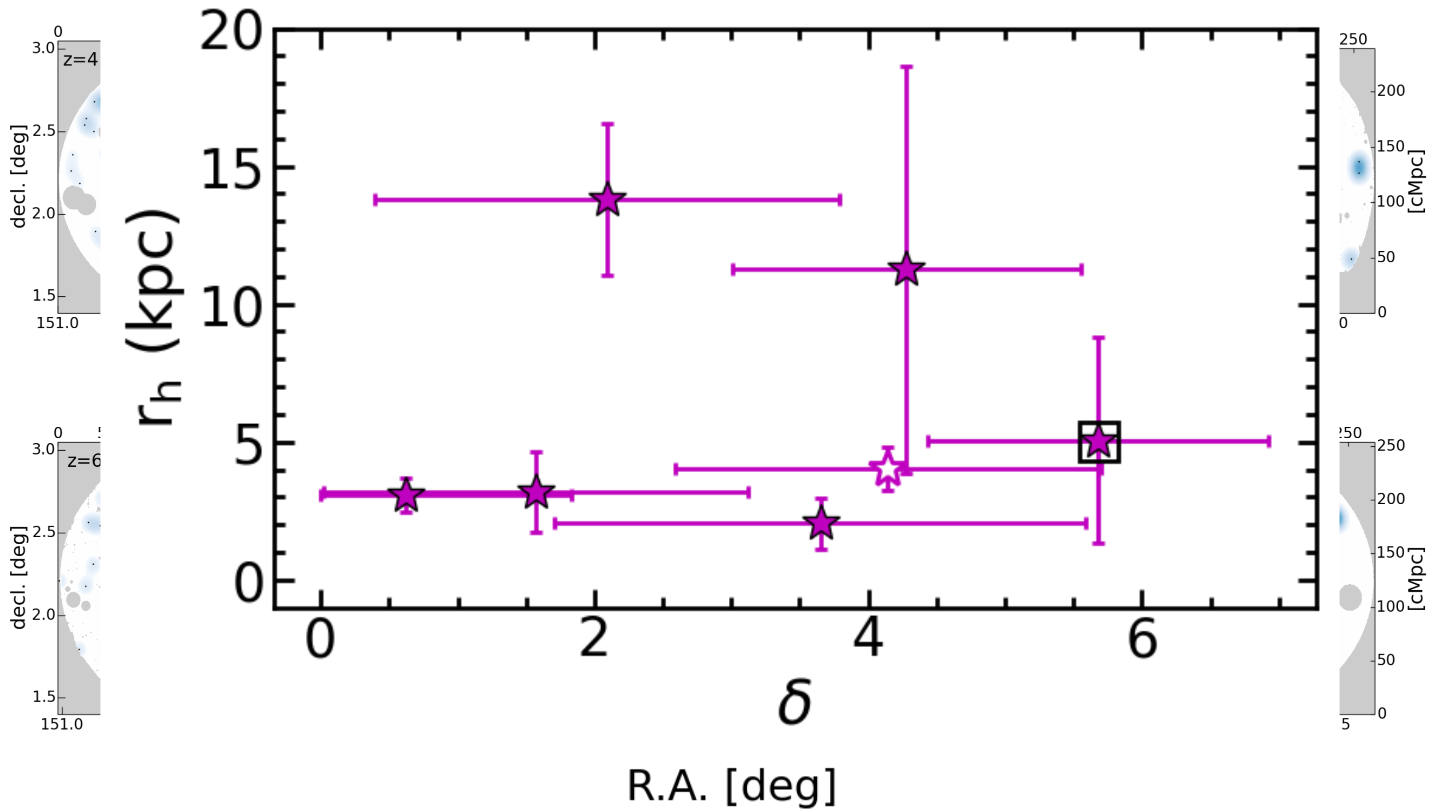
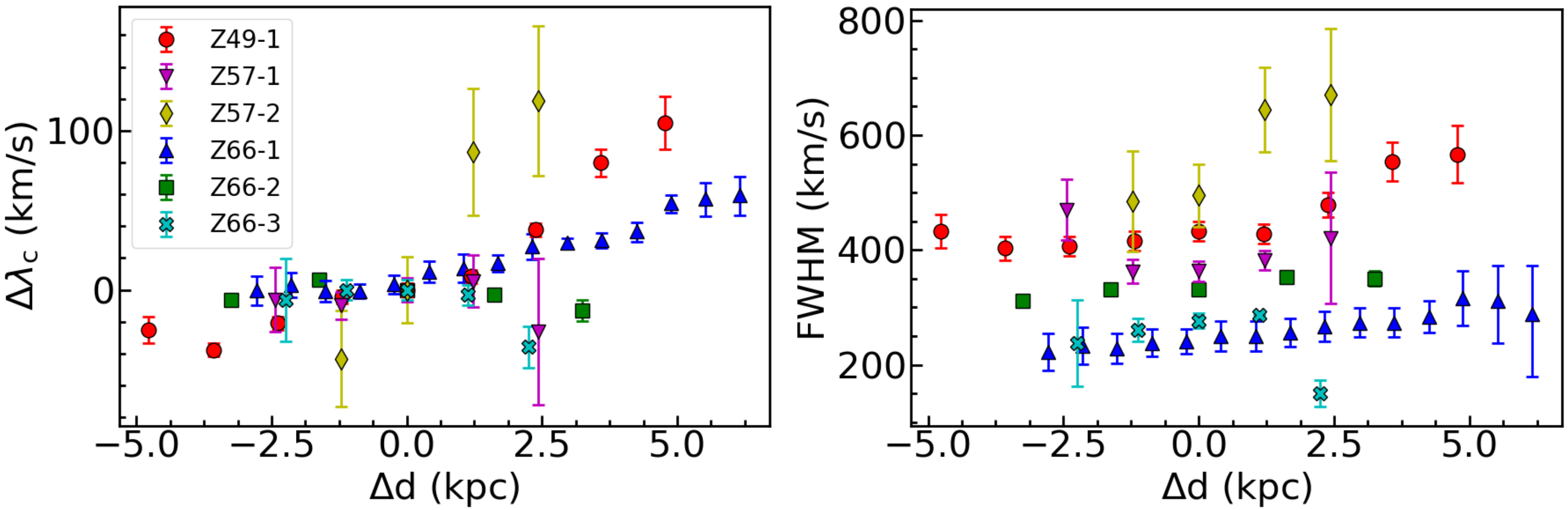


- LABs in overdensed regions: 6/7.
- No significant correlation between r_h and δ.

Result and Discussion

3. Velocity gradients and FWHMs of the Ly**α** lines:

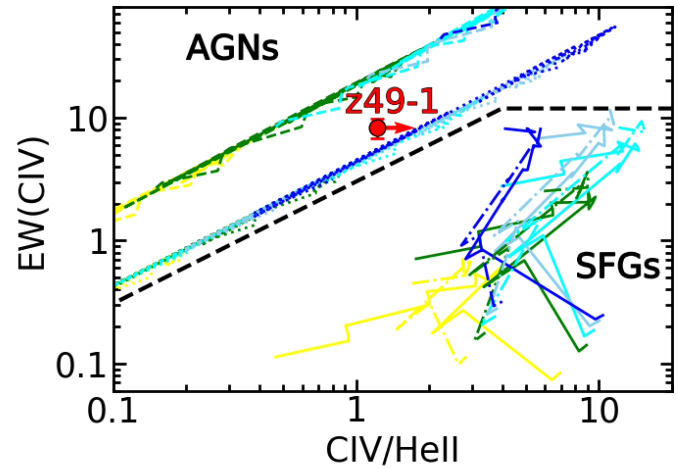


- LAEs at $z = 5.7$ and 6.6 have FWHMs of <u>100 – 400</u> km/s (Ouchi+10, Shibuya+18b).
- Clearly **z49-1 and z57-2** have relatively **large velocity gradients and FWHMs**.

➡ Possibly caused by <u>AGNs (not likely for z57-2), mergers, and/or dense HI clouds</u>.

4. AGN activity

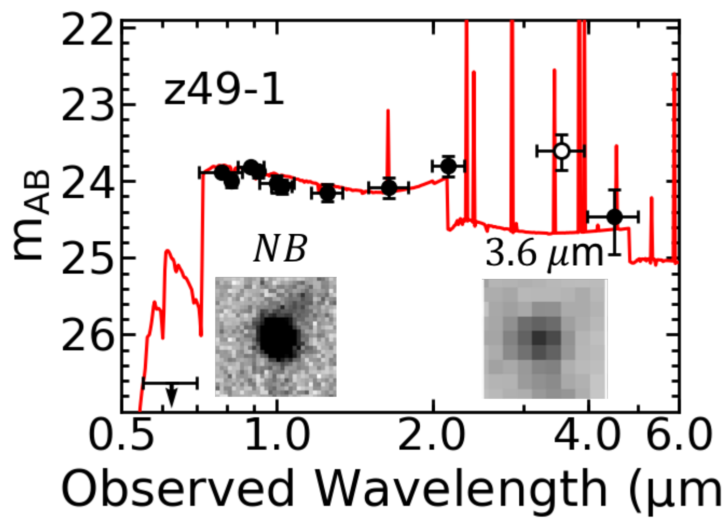
- No LAB shows X-ray and NV detections.
- CIV of z49-1: **likely an AGN** but can be explained by a low-metallicity SFG.



(AGN and SFG Models from Nakajima+18)

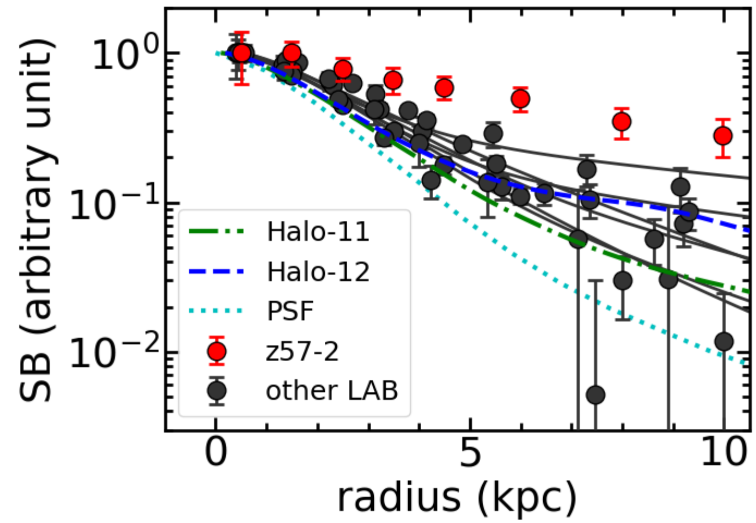
5. Hα Emission of z49-1

- The 3.6 μm band is not included in the SED fitting.
- Hα luminosity: $3.6 \pm 1.2 \times 10^{43}$ erg s^{-1}.
- Lyα escape fraction: 0.11 ± 0.04.



6. An Extremely Diffuse LAB at z=5.7

- LAB z57-2 is more diffuse than the other LABs. Models cannot explain.
- Possibly caused by multiple clumps, mergers, or dense HI clouds.



(Halo-11 and Halo-12 from Yajima+17)

7. Physical origin of the extended Lyα emission around LABs

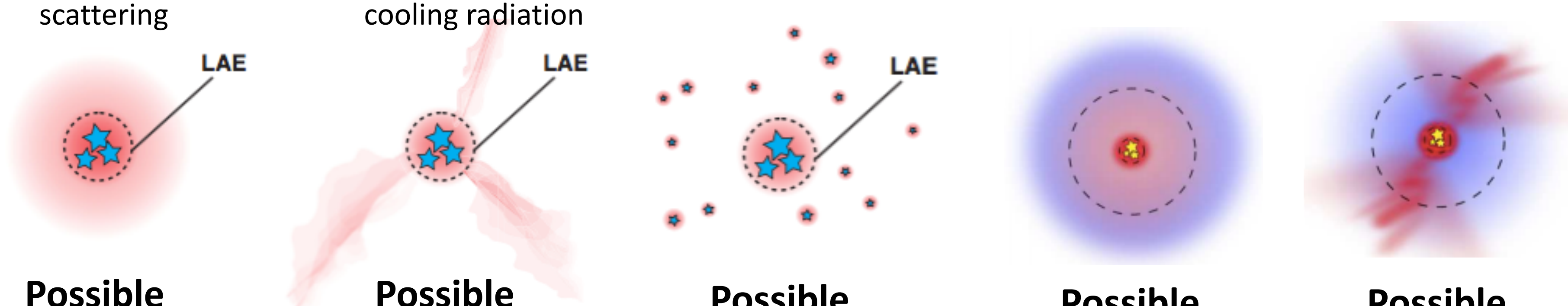
(a) Resonant scattering

(b) Gravitational cooling radiation

(c) Satellite galaxies

(d) Fluorescence

(e) Outflows



Possible **Possible** **Possible** **Possible** **Possible**

(Figures from Momose+16 and Fujimoto+19)

Summary

- We have identified 2 new LABs of z49-1 and z70-1, and **z70-1** is the **most distant LAB** found to date.
- Typical high-z LABs are not special objects, but **star-forming galaxies at the bright end**.
- We find that z49-1 and z57-2 have **large Lyα velocity gradients and FWHMs**, and that z57-2 is more diffuse than the other LABs.
- We find no evidence of AGNs in the 7 LABs **except z49-1**.
- The extended Lyα emission could be caused by resonant scattering, gravitational cooling radiation, satellite galaxies, fluorescence, and outflows.