

Extended Ly α Halos around z~2-7 LAEs Investigated by Intensity Mapping Technique

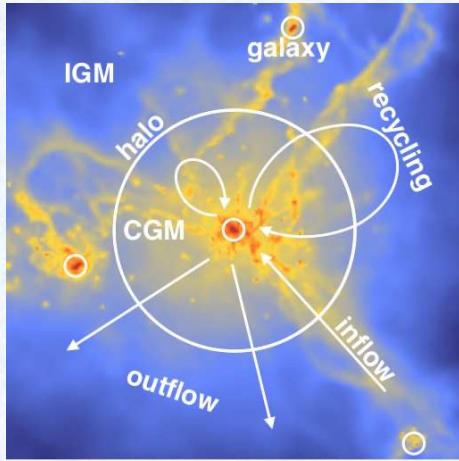
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Lya Halos

※See also Momose-san's review



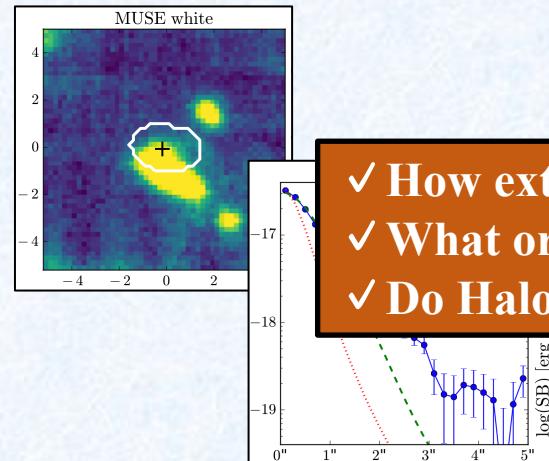
Van de Voort+16

- Emitted Lya photons are scattered by circumgalactic medium (CGM)
= **Lya halos (LAHs)**

- Hard to be detected at high-z due to sensitivity

- Individual detection

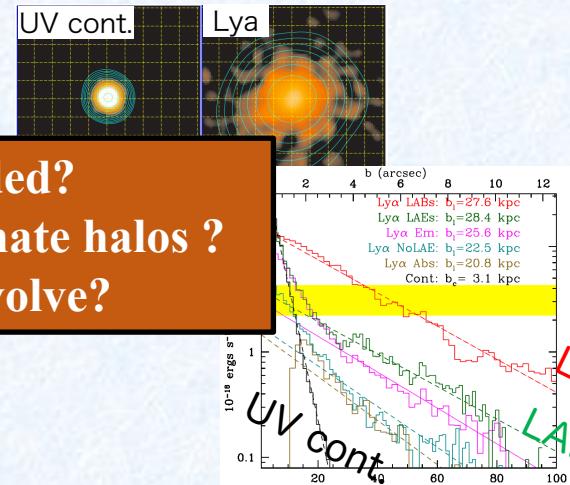
e.g., z=3-6 LAEs (Leclercq+20,+17)



See also Leclercq+20, +17, Wisotzki+18, +16, Patricio+16, Rauch+08, Swinbank+07, etc.

- Stacking

e.g., z=2.65 LBGs (Steidel+11)



See also Erb+18, Xue+17, Momose+16, +14, Matsuda+11, +04, Ono+10, Hayashino+04, Steidel+00, etc.

✓ How extended?
✓ What originate halos ?
✓ Do Halos evolve?

How to detect LAHs?



① Intensity mapping technique

e.g., Croft+18, +16 (SDSS/BOSS)

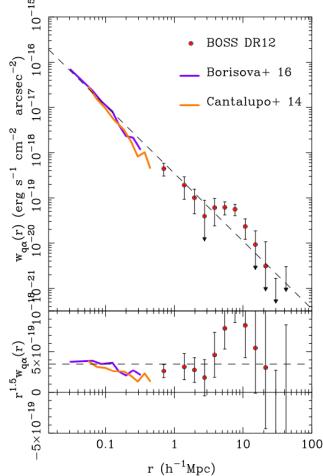
Positions of
 $z=2\text{--}3.5$ QSOs

X

Lya emission
(fiber spectra)

Cross
correlation

Systematics from
fore/background
sources are removed



$\sim 10^{-21}$ erg/s/cm²/arcsec²

See also Battaia+18, etc.

② Deep & wide images of Subaru/HSC

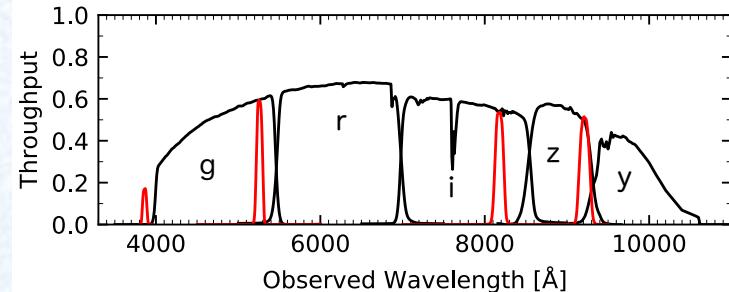
CHORUS (Cosmic HydRogen Reionization Unveiled with Subaru)



Hyper Suprime-Cam Subaru Strategic Program

Inoue+ submitted

DR2; Aihara+19



LAEs : $z=2.2$

$z=3.3$

$z=5.7$

$z=6.6$

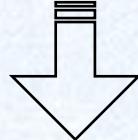
▫ Field = UD COSMOS (~2 deg² wide; >10x)



LAE Selection (Ono+ in prep.)

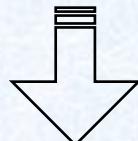
Color Selection

- Use SExtractor to detect sources
- Apply color selection to detected sources to find LAEs

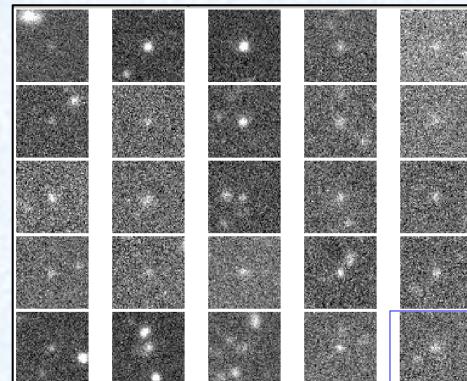


Machine learning
&
Visual inspection

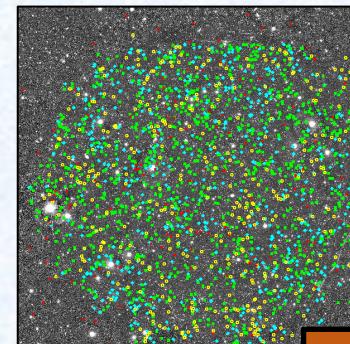
- Use Convolutional Neural Network (CNN)
- Remove spurious sources



Final catalog



(10''x10'')



◆ N($z=2.2$ LAEs) = 567
■ N($z=3.3$ LAEs) = 959
○ N($z=5.7$ LAEs) = 486
● N($z=6.6$ LAEs) = 179

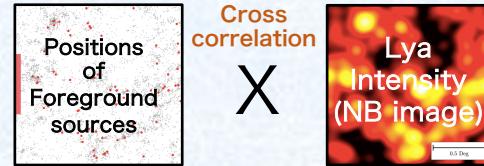
Total ~2,000 LAEs

Intensity Mapping

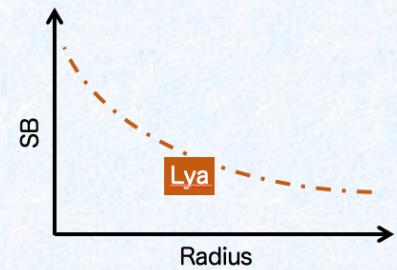
SB(total)



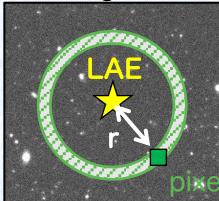
SB(sys.)



SB(Lya)



NB image



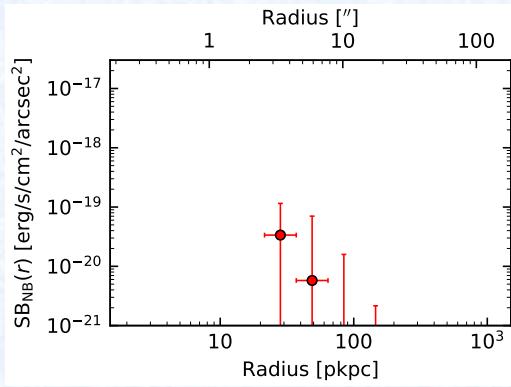
$$SB = \sum_i \mu_{r,i} / \sum_i i$$

pixel i (pixel value = $\mu_{r,i}$)

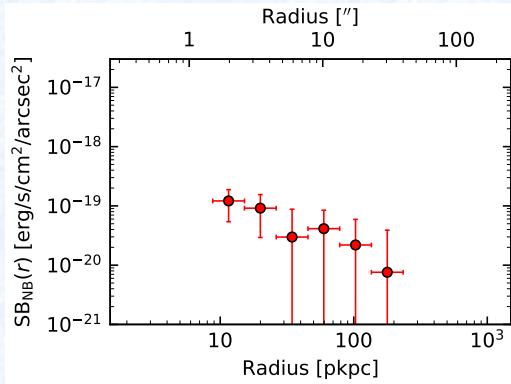
- Select foreground sources s.t. m_{NB} & $FWHM_{NB}$ distribution match to that of LAEs

Result: LAH SB Profiles around z~2-7 LAEs

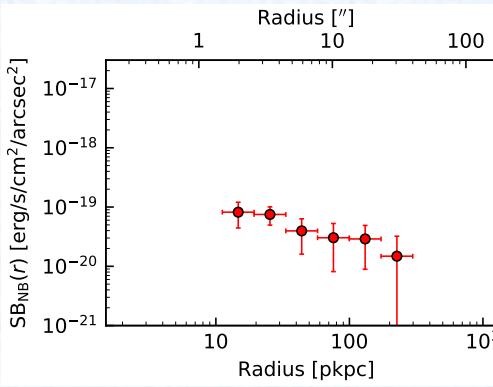
NB387
(z=2.2 LAEs)



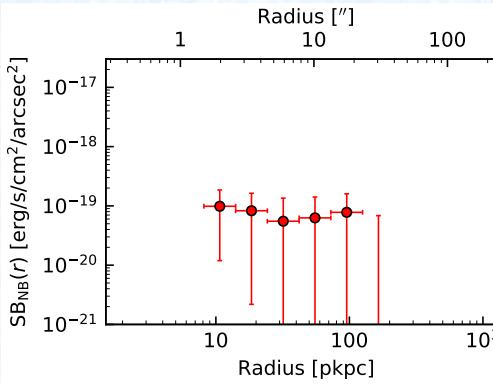
NB816
(z=5.7 LAEs)



NB527
(z=3.3 LAEs)



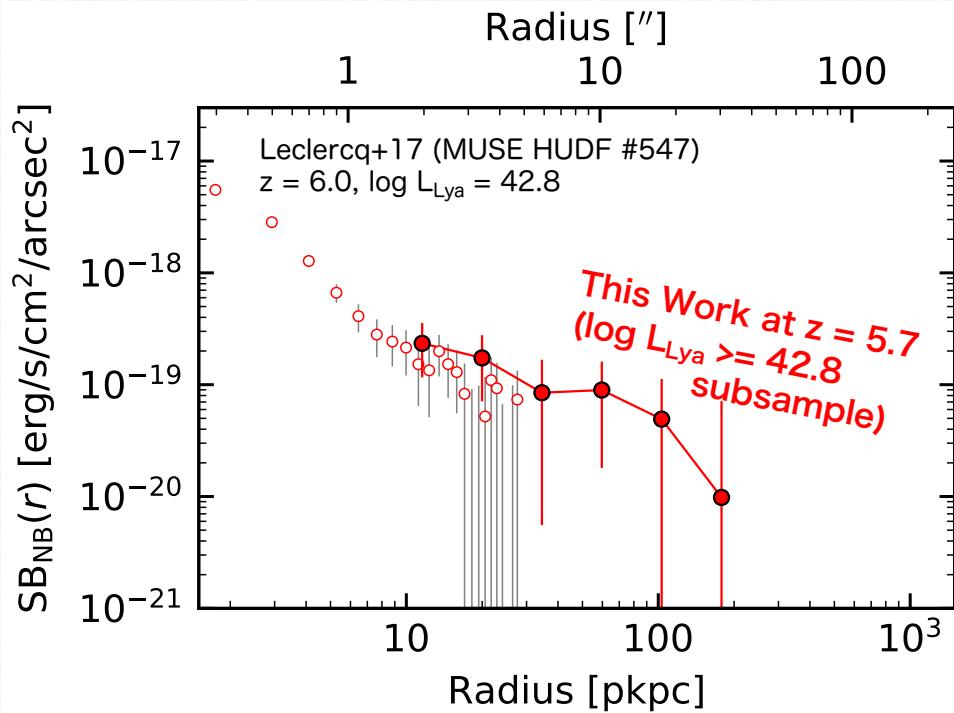
NB921
(z=6.6 LAEs)



※Errors estimated by bootstrap method

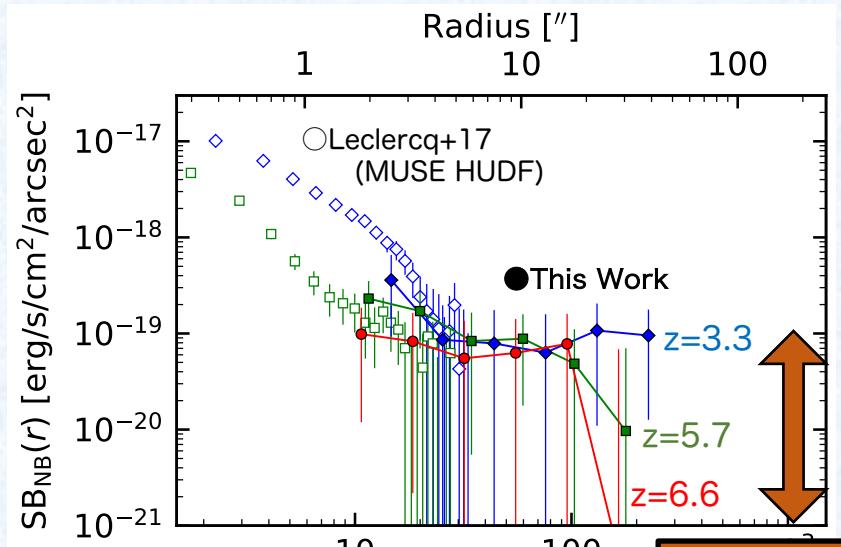
Result: LAH SB Profiles around z~2-7 LAEs

NB816

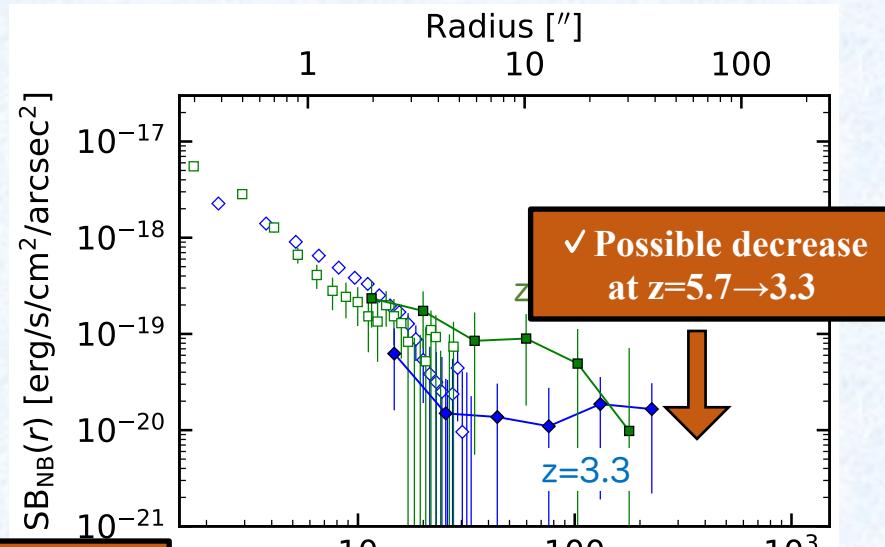


- ✓ We find LAHs extended up to ~ 100 pkpc at $z \sim 2-7$
- ✓ Outer profiles \sim extrapolation of inner profiles (if $L_{\text{Ly}\alpha}$ matched)

Profile Evolution?



Observed

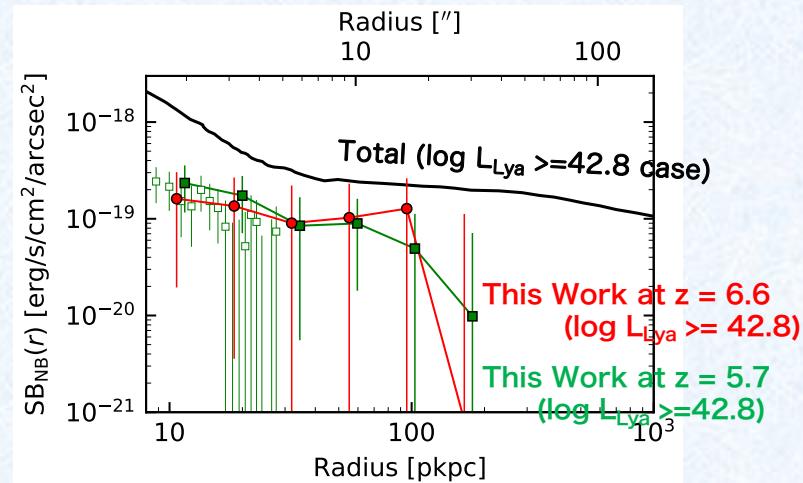
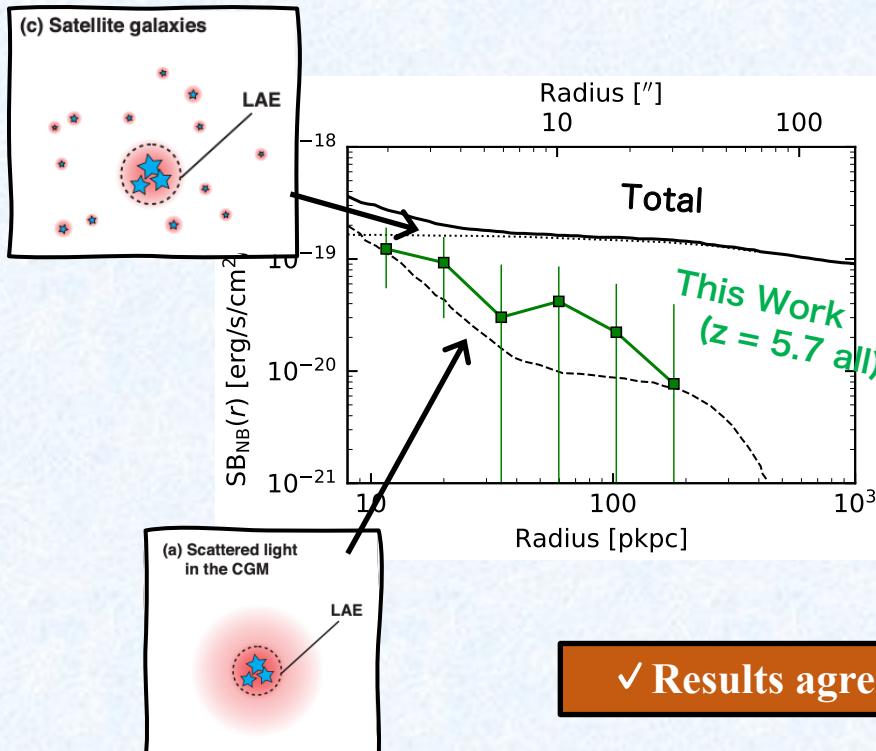


SB scaled to $z=5.7$ by $\propto(1+z)^{-4}$

- ※ Comparing $\log L_{\text{Ly}\alpha} >= 42.8$ subsamples
- ※ NB387 not plotted due to insufficient N_{LAE}

Comparison to Simulation near Reionization Epoch

- Simulation (Zheng+11)
 - Ly α radiative transfer + HD cosmological sim. at $z \sim 5.7$



✓ Results agree with resonant scattering in CGM

Summary

First attempt to investigate extended LAHs at z~2-7
with HSC x intensity mapping technique

- ~2,000 LAEs at z~2-7 using Subaru/HSC CHORUS+SSP NB images
- LAHs are extended up to ~100 pkpc at z~2-7
- LAH profiles may decrease at z~7→3 (if cosmological dimming effect is corrected for)
- Comparison to simulation suggests resonant scattering in CGM
- What to do next:
 - Profile dependence on LAE profiles (e.g., $L_{\text{Ly}\alpha}$, M_{UV} , EW, overdensity, etc.)
 - Intensity mapping using, e.g., Ha and [OIII]

