Quasar Environment and Feedback at z~2 Probed with Lyα Emitters and Continuum Selected Galaxies

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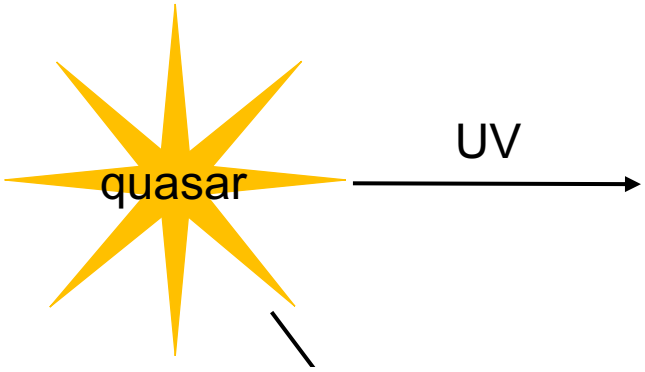
初代星・初代銀河研究会

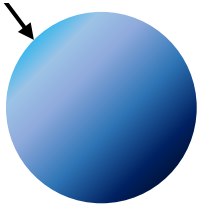
RCSCE EHIME U. RESEARCH CENTER FOR SPACE AND COSMIC EVOLUTION

Introduction

photoevaporation effect

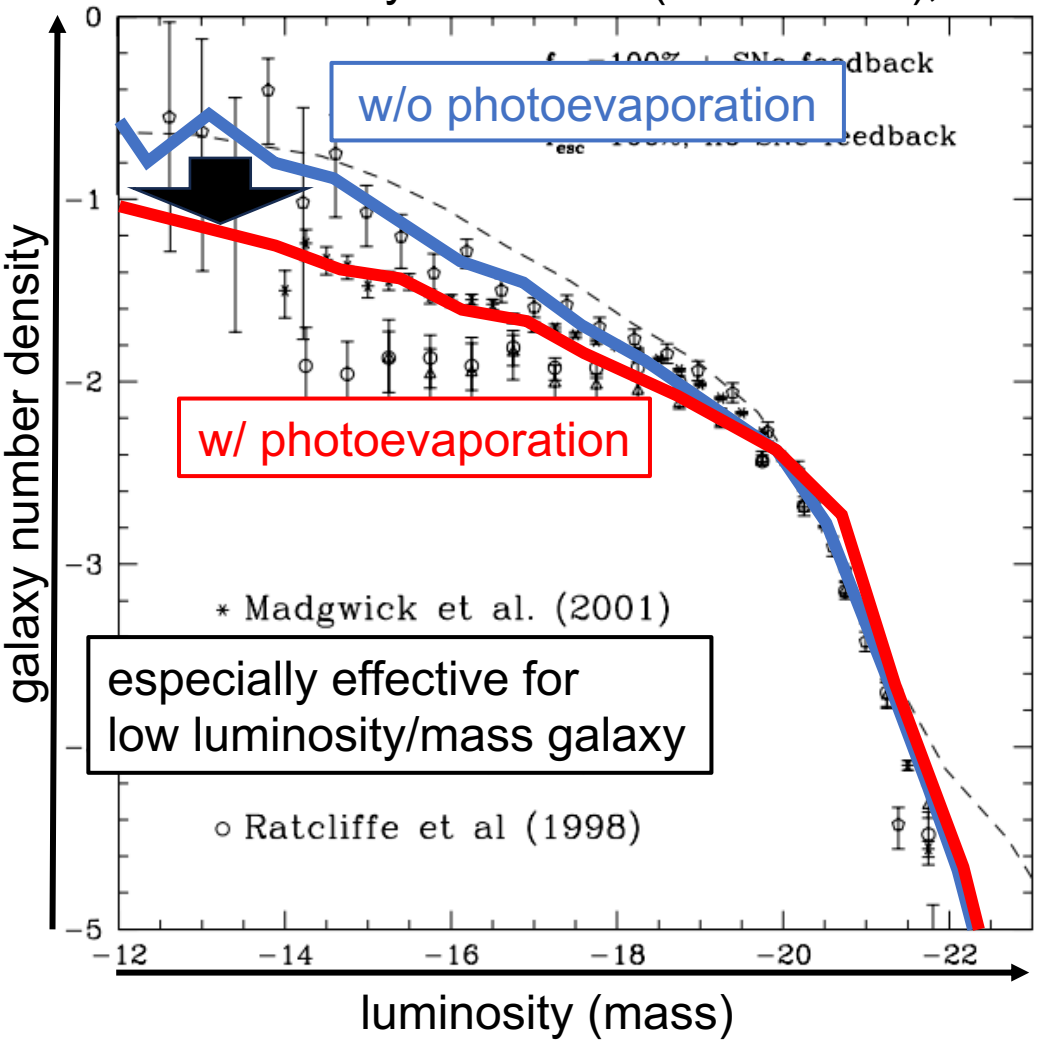


gas heating/ionization
→ suppression of star/galaxy formation

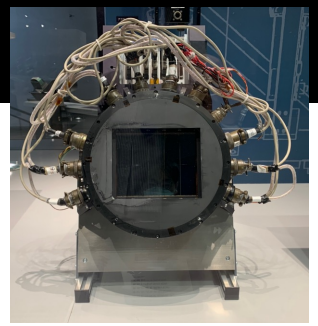


dark matter halo

In semi-analytical model (Benson+02),



Introduction



observational study with Subaru/Suprime-Cam

LAEs = lower-mass galaxies, LBGs = higher-mass galaxies

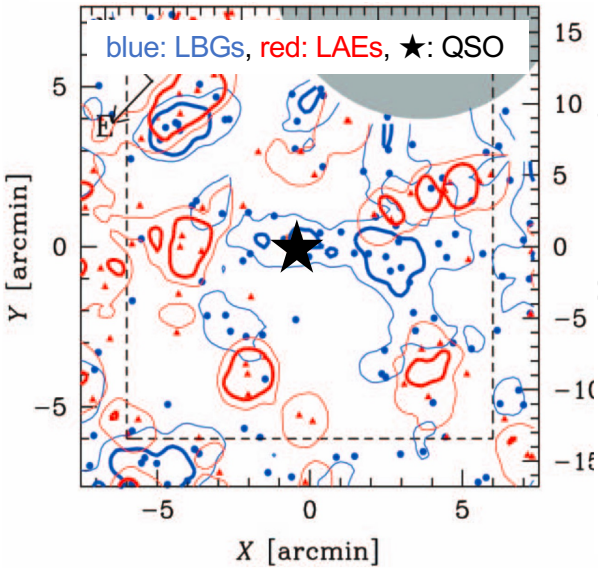
Kashikawa+07 (LAEs & LBGs)
Utsumi+10 (LBGs) & Goto+17 (LAEs)
Ota+18 (LAEs & LBGs)
Uchiyama+19 (LAEs)

galaxy density is low around quasars
→ suggestion of photoevaporation effect

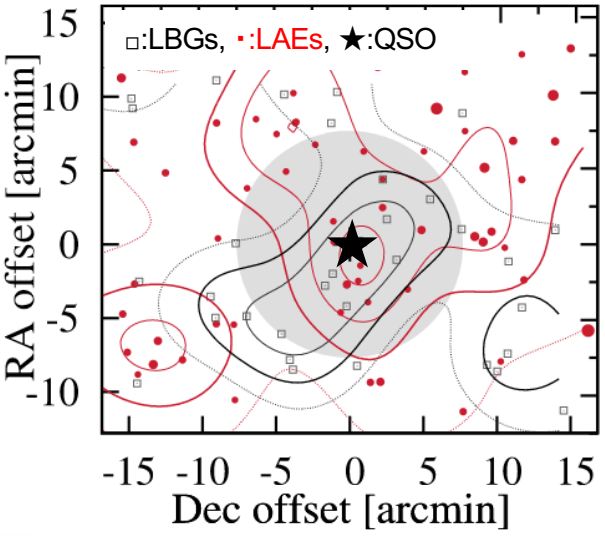
Kikuta+17 (LAEs & LBGs)
Bosman+20 (LAEs; spectroscopic follow-up)

galaxy density is **not** low around quasars
→ no evidence of photoevaporation effect

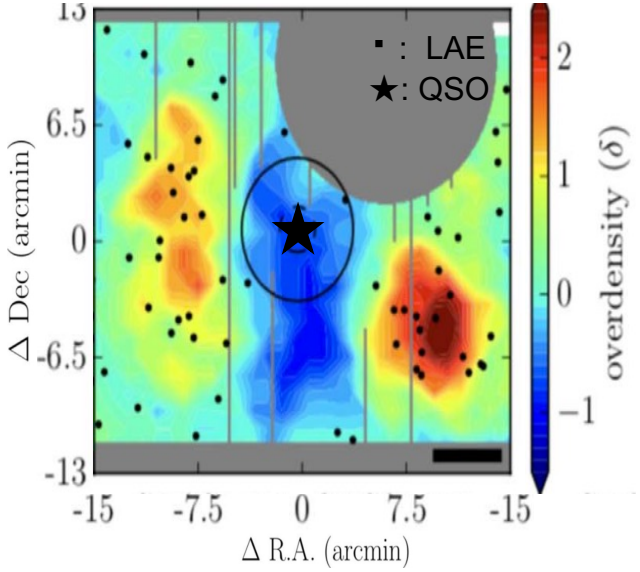
Kashikawa+07: 1 field @ z ~ 4.9



Kikuta+17: 2 fields @ z ~ 4.9



Uchiyama+19: 11 fields @ z ~ 2.2-3.2

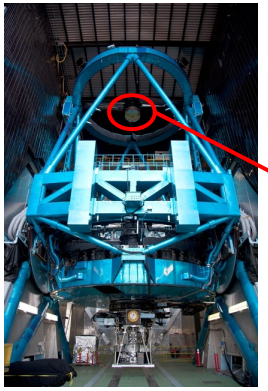


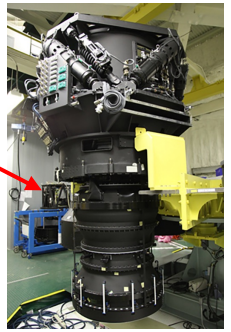
Photoevaporation effect is still controversial

Introduction

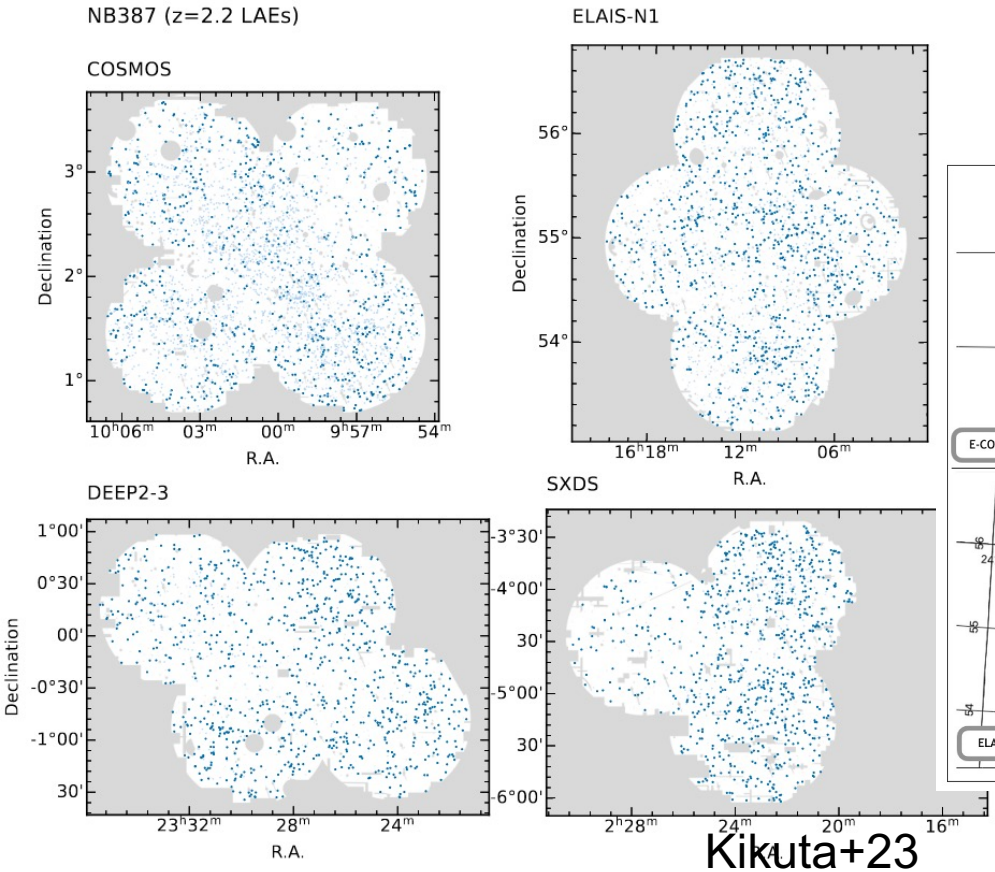
To get the average picture of photoevaporation effect

- Larger quasar field sample for statistical study
- Simultaneous sampling for both lower- and higher-mass galaxies

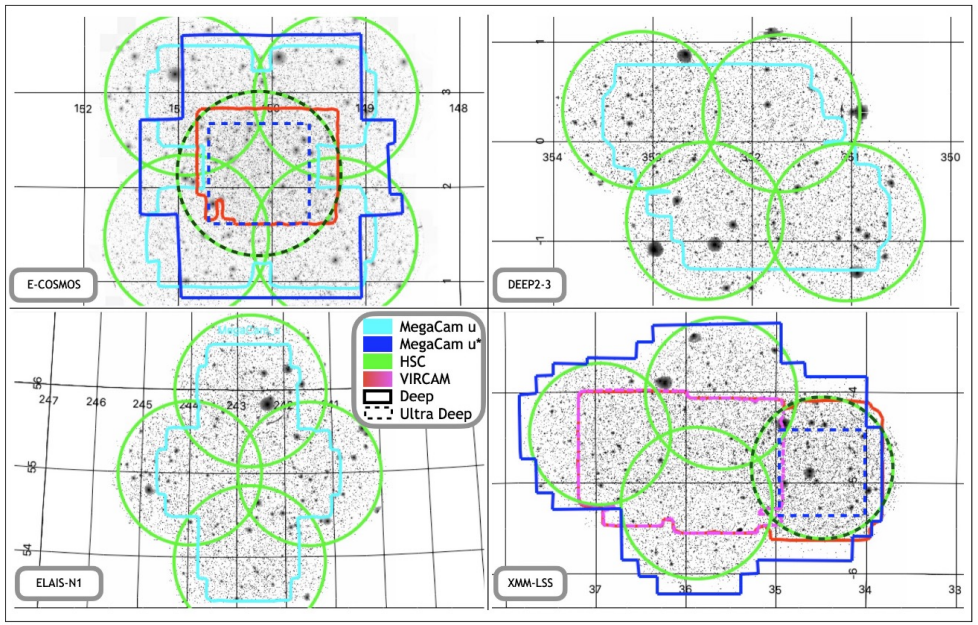




→ HSC-SSP Deep/UltraDeep layer,
- covers an area > 20 deg^2
- contains multiple broad/narrow band filters data set



Kikuta+23



Desprez+23

Data and Sample

- **LAEs: SILVERRUSH catalog (Kikuta+23)**
  lower-mass galaxy
  $z_{\mathrm{Ly}\alpha} = 2.178 \pm 0.023$ which is corresponded to NB387 coverage

- **galaxies: HSC-SSP＋CLAUDS photo-*z* galaxy catalog (Desprez+23)**
  higher-mass galaxy
  photo-*z* is taken by six broad band photometry (u, g, r, i, z, and y)

- **quasars: SDSS DR16 quasar catalog (Wu+22; Lyke+20)**
  redshifts are obtained by spectroscopy

photo-*z* galaxies selection

$i < 25.0$

$\left|z_{\mathrm{Ly}\alpha} - z_{\mathrm{photo}}\right| \leq 0.15\left(1 + z_{\mathrm{Ly}\alpha}\right)$

$z_{\mathrm{photo\_err}} < 0.1$

quasars selection

$z_{\mathrm{quasar}} = z_{\mathrm{Ly}\alpha} (= 2.178 \pm 0.023)$

We extracted the **21 quasar fields!**

Analysis

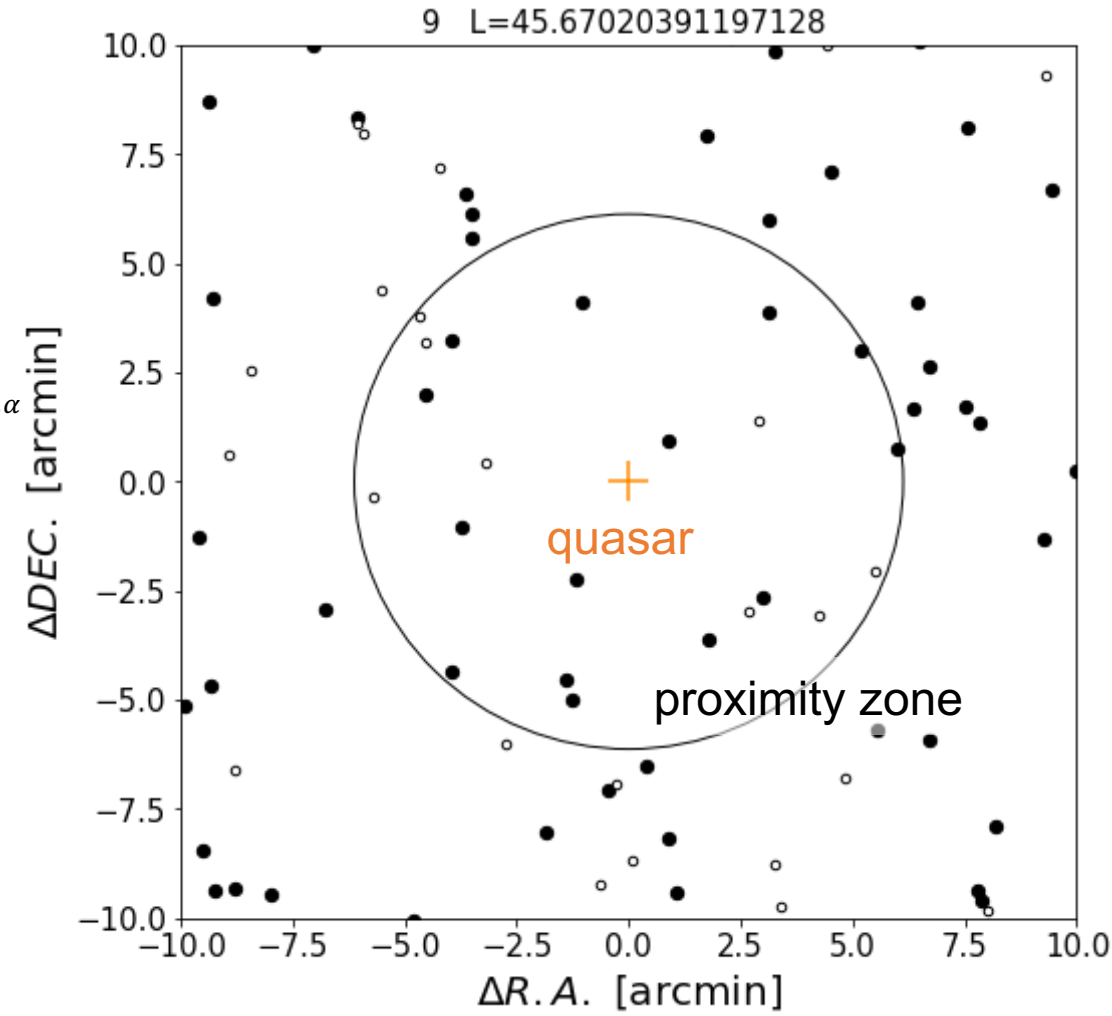
measure proximity zone of the quasars

the region quasar UV radiation > UV background radiation

$$r_{\rm prox} = \frac{1}{4\pi}\sqrt{\frac{L_{\nu_{\rm L}}}{J_{21}(\frac{\nu}{\nu_{\rm L}})^{\alpha} \times 10^{-21}}}$$

$L_{\nu_{\rm L}}$: quasar luminosity at Lyman limit
α: slope of the flux density of the quasar, $F_\nu \propto \nu^\alpha$
J_{21}: UVB isotropic UV intensity at Lyman limit

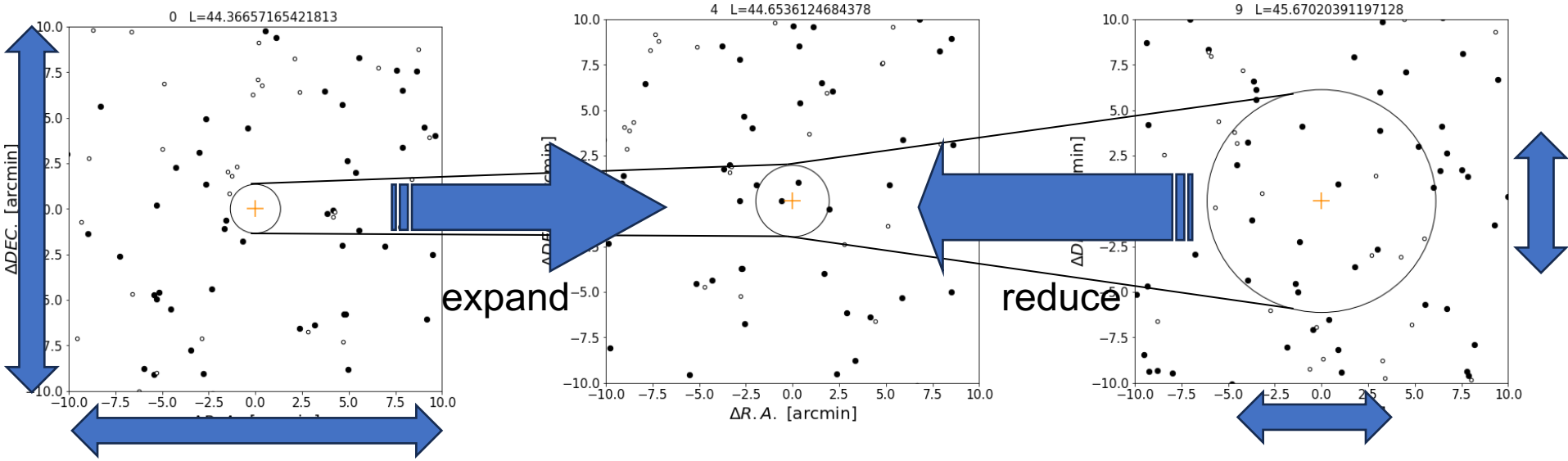
$J_{21} = 1.0^{+0.5}_{-0.3}$ (Cooke+97; Uchiyama+19)



Analysis

measure the galaxy density with stacked to examine average picture of photoevaporation
→ rescaling fields to match a median proximity zone

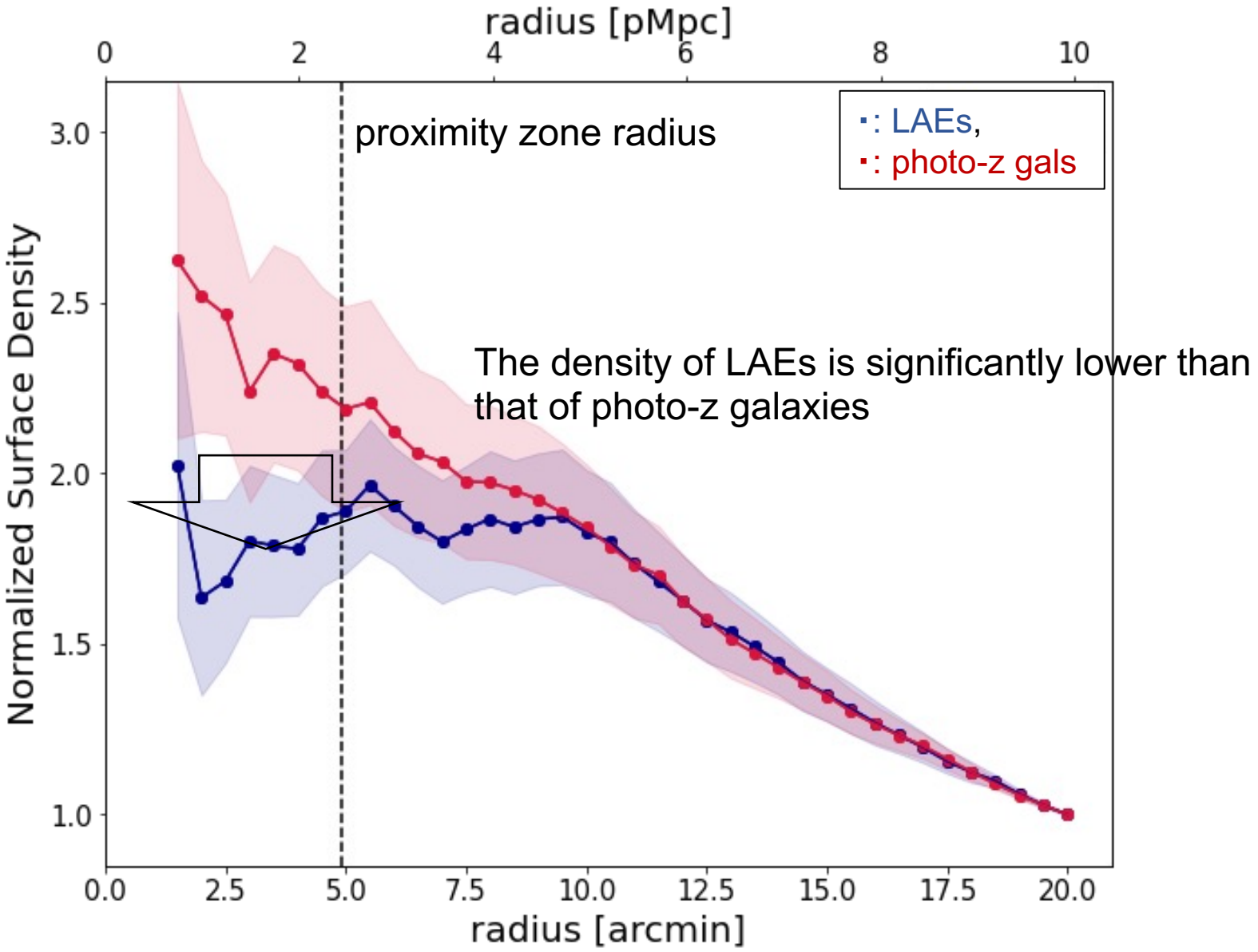
e.g.,



The fields are normalized to the median proximity zone size, and stacked
→ cumulative number count (density radial profile)

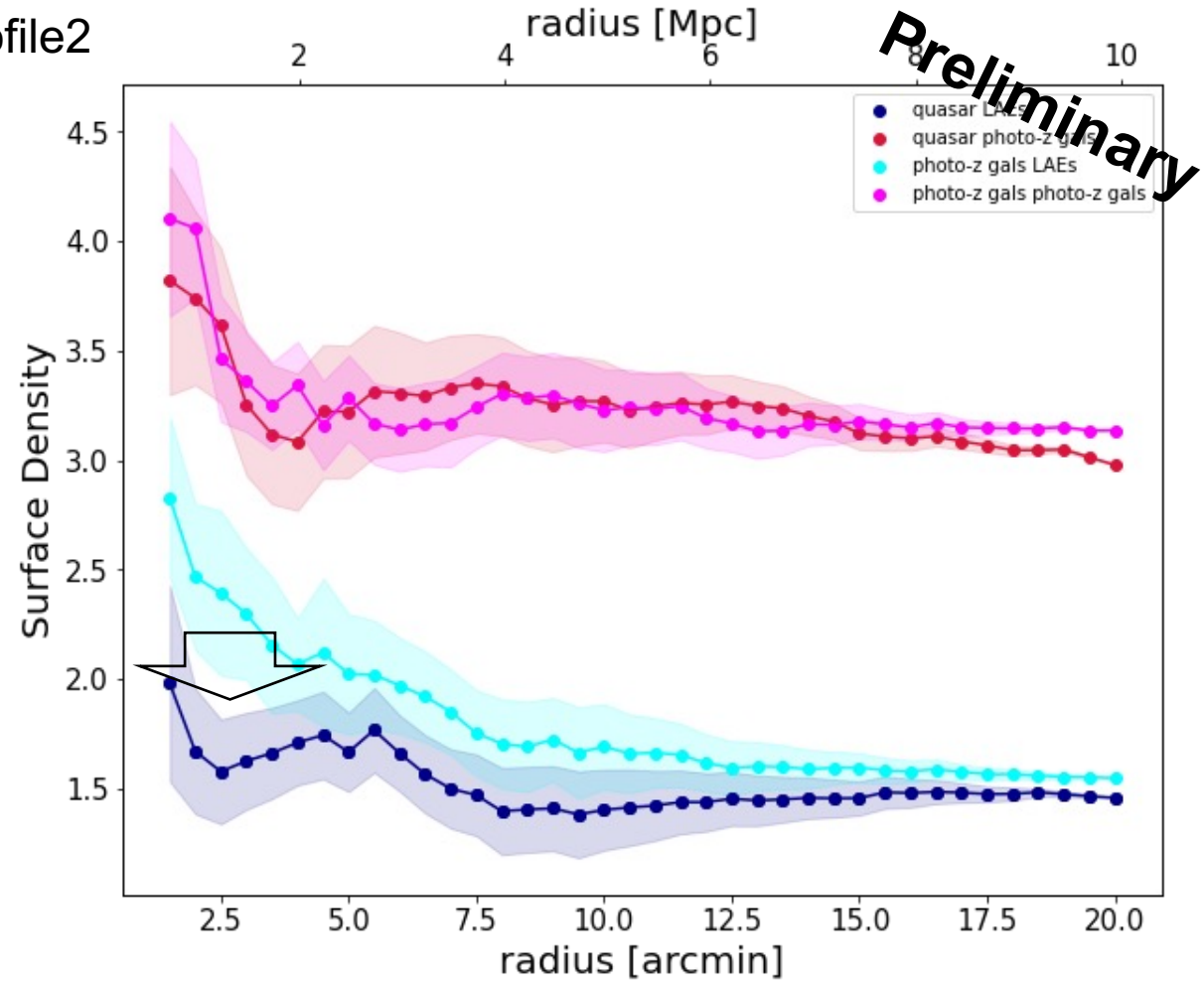
Results & Discussion

density radial profile



Results & Discussion

density radial profile2



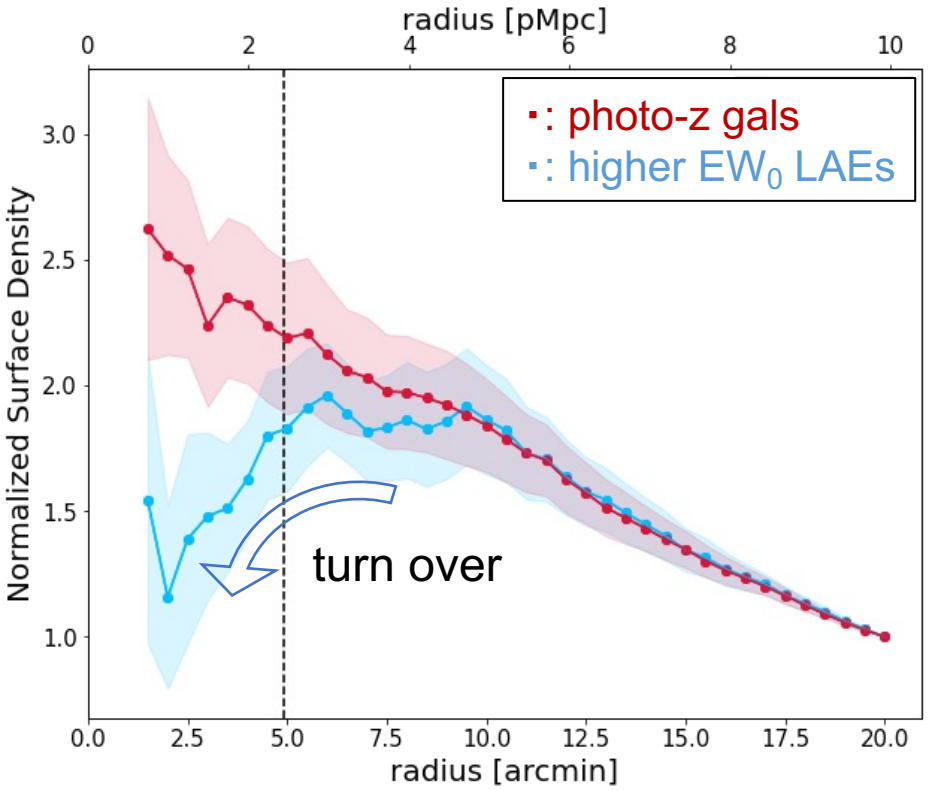
▪: LAEs around quasars, ▪: photo-z gals around quasars
▪: LAEs around photo-z gals, ▪: photo-z gals around photo-z gals

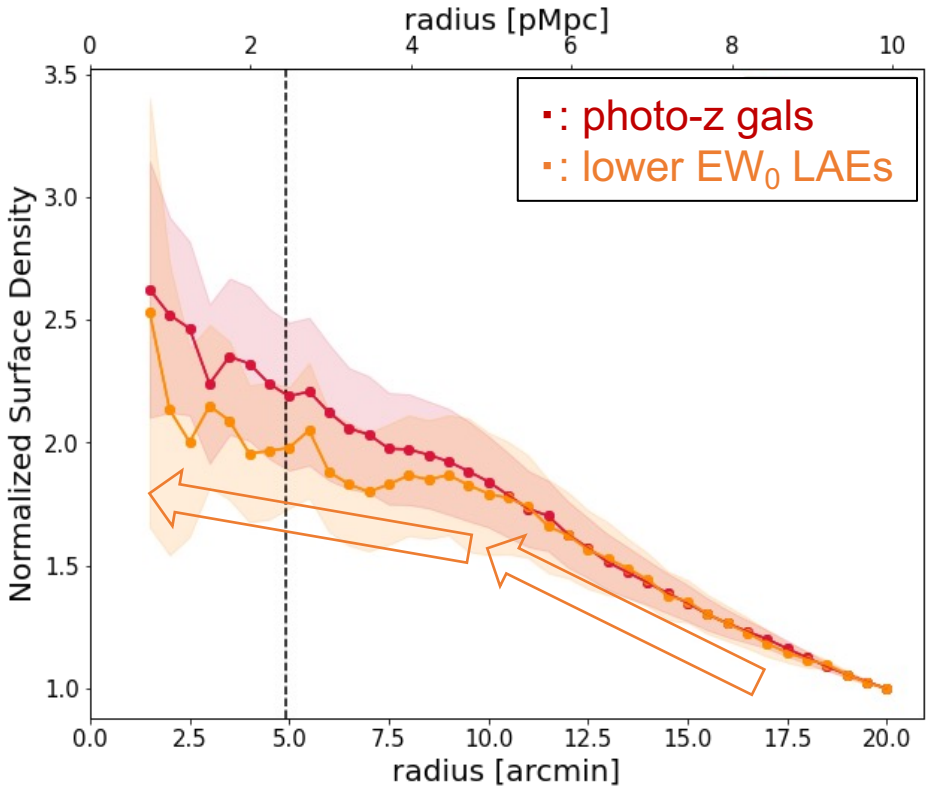
- photo-z galaxies comparably cluster around quasars and photo-z galaxies
- while density of LAEs around quasars are less than that around photo-z galaxies

→ LAE formation is suppressed by quasar UV radiation.

Results & Discussion

density radial profile3





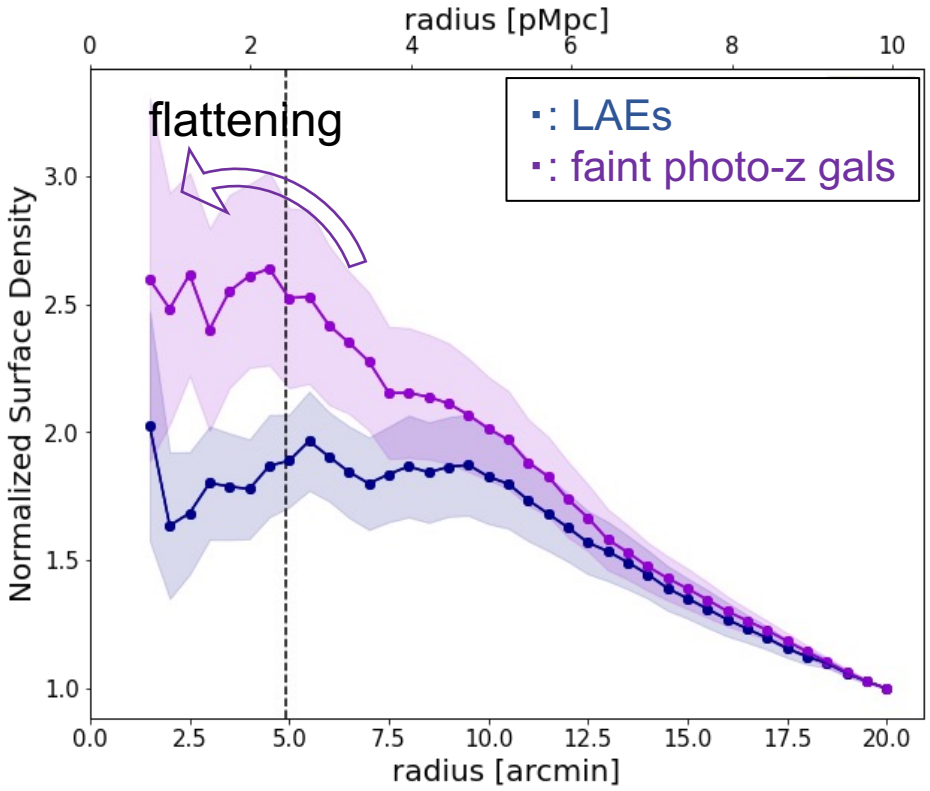
- density of higher EW$_0$ LAEs turns over within proximity zone
- density of lower EW$_0$ LAEs increases like that of photo-z galaxies

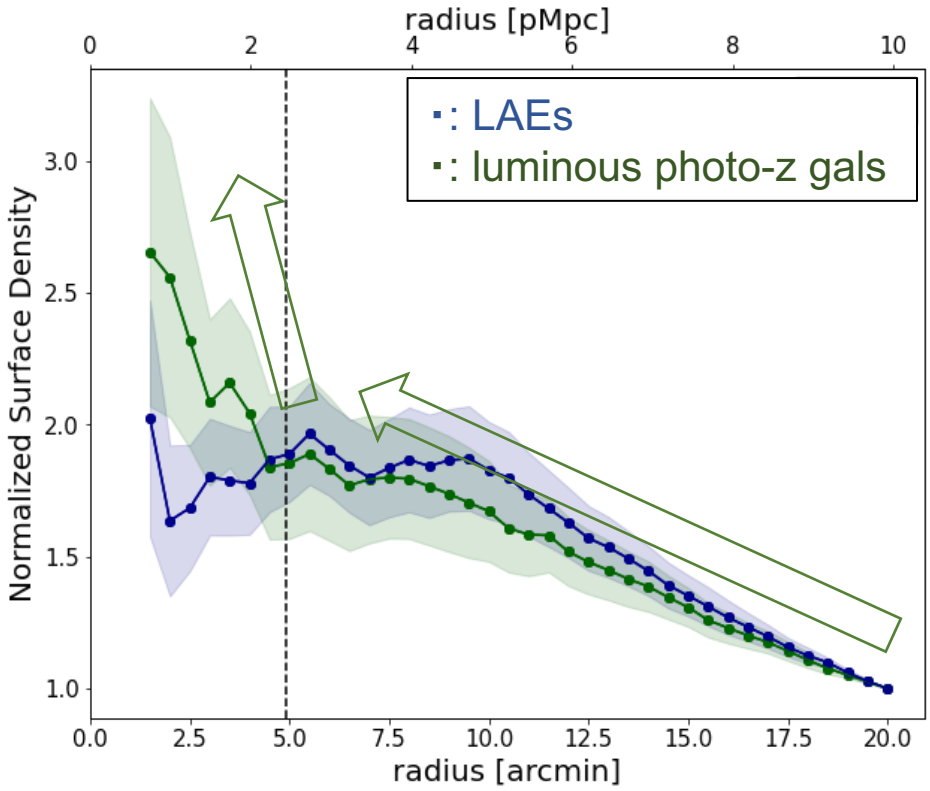
→ Photoevaporation is effective for LAEs, especially higher EW$_0$ ones

cf.) Uchiyama+19 found that the density of higher EW$_0$ LAEs is lower around quasars

Results & Discussion

density radial profile4





- density of faint photo-z galaxies are flattening within proximity zone
- density of luminous photo-z galaxies steeply increase within proximity zone

→ Photoevaporation effect could affect faint photo-z galaxies?

Results & Discussion

How effective is the photoevaporation effect?

DM halo mass

LAEs at z ~ 2.17 (Kusakabe+18):
$\langle M_{\rm h} \rangle = 4.0^{+5.1}_{-2.9} \times 10^{10}\ {\rm M_{sun}}$

galaxies at z ~ 2.2 (Harikane+22):
$\langle M_{\rm h} \rangle = 2.57^{+0.06}_{-0.05} \times 10^{12}\ {\rm M_{sun}}$

In the simulations, UV radiation can suppress galaxy formation in DM halos with

Kashikawa+07:
$M_{\rm vir} \leq 3.0 \times 10^{10}\ {\rm M_{sun}}$
→ can suppress **only** low mass LAEs

Bruns+12:
$M_{\rm vir} \leq 2.5 \times 10^{12}\ {\rm M_{sun}}$
→ can suppress photo-z galaxies

Ota+18:
- LAEs with $M_{\rm h} \leq 1 - 3 \times 10^{10}\ {\rm M_{sun}}$ are suppressed

Uchiyama+19:
- LAEs with $M_{\rm h} = 3.6^{+12.7}_{-2.3} \times 10^{9}\ {\rm M_{sun}}$ are suppressed
- LAEs with $M_{\rm h} = 2.9^{+14.0}_{-1.8} \times 10^{10}\ {\rm M_{sun}}$ are **not** suppressed

Our results support this one?

Summary

- ✓ **Examined quasar local environments at z ~ 2.17, using LAEs and photo-z galaxies based on HSC-SSP**
- ✓ **Stacking the 21 quasar fields and measuring radial density profile**
- ✓ **The density of LAEs is significantly lower than that of photo-z galaxies within the quasar proximity zone**
- ✓ **Especially, the density of lower EW_0 LAEs remarkably down within the quasar proximity zone**
- ✓ **Photoevaporation could affect more massive halos mass?**