# Environment of a supermassive black hole at z=6.4

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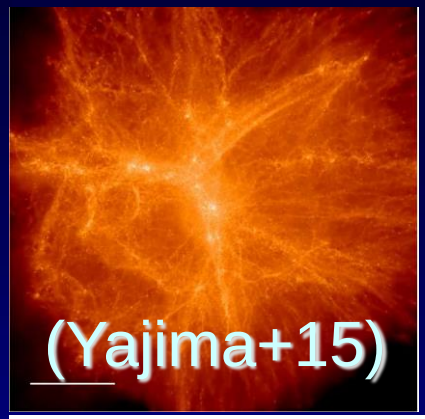
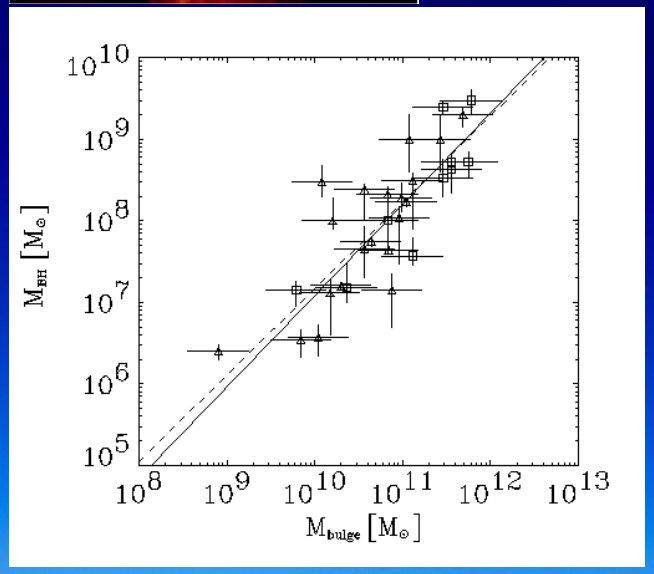
Utsumi, Goto et al. 2010, ApJ, 721,1680
Goto, Utsumi, Kikuta et al. MNRAS accepted

# Do QSOs trace overdensity at z>5.8?




- Massive galaxies form in overdense regions.
- Massive galaxies harbor massive QSOs(Magorrian)




Magorrian et al.(1998)

Portinari et al. (2012)

**Massive QSOs expected in dense regions.**

*Tomo GOTO*

# However, observationally… results very.

- Overdensity detected
  - Djorgovski +2003; Swinbank +2012; Husband+ 2015; Stiavelli+2005; Zheng+2006
- Not detected
  - Francis & Bland-Hawthorn 2004; Kashikawa +2007, Kim+2009; Banados+2013; Mazzucchelli +2017, Kikuta+17, Uchiyama+17.

Why?

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- One physical reason: QSO UV radiation may suppress galaxy formation (K07).
- One practical reason: HST/ACS FoV was too small to see this
- (esp z~6).

→Subaru

z=6 structures, 10s of Mpc scale

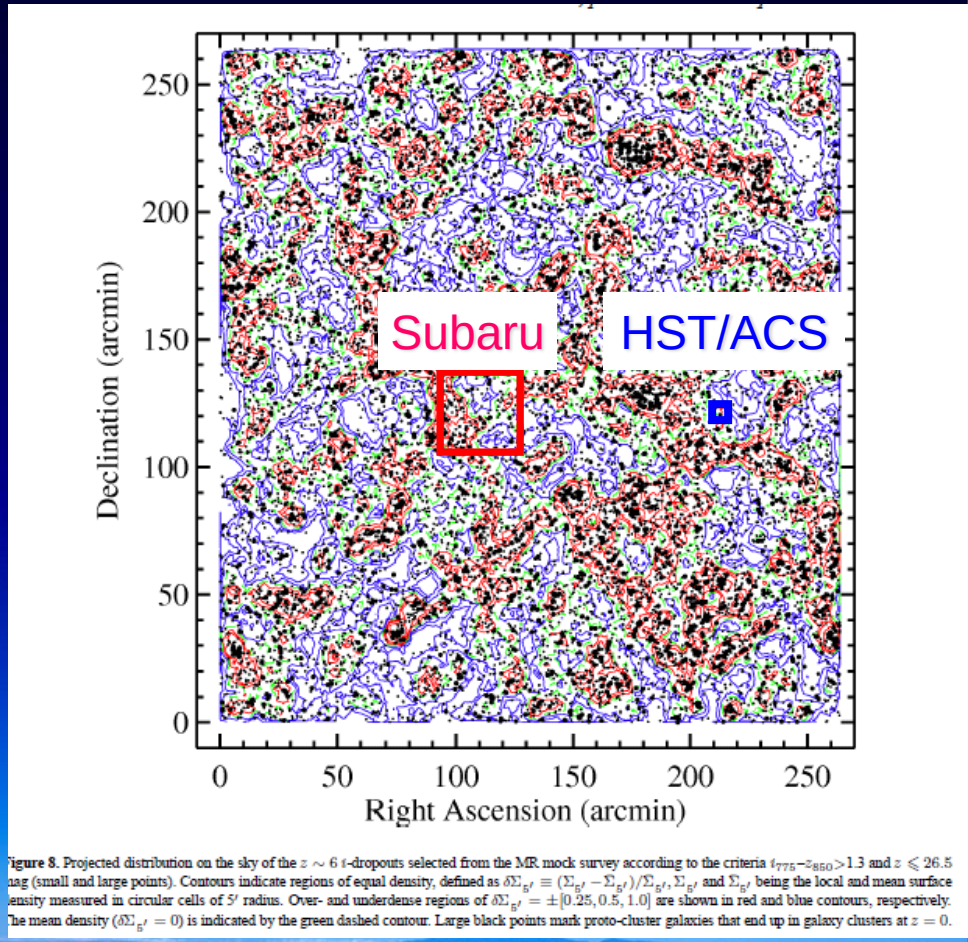



Figure 8. Projected distribution on the sky of the $z \sim 6$ i-dropouts selected from the MR mock survey according to the criteria $i_{775}-z_{850}>1.3$ and $z \leqslant 26.5$ mag (small and large points). Contours indicate regions of equal density, defined as $\delta\Sigma_{5'} \equiv (\Sigma_{5'} - \Sigma_{5'})/\Sigma_{5'}$, $\Sigma_{5'}$ and $\Sigma_{5'}$ being the local and mean surface density measured in circular cells of 5′ radius. Over- and underdense regions of $\delta\Sigma_{5'} = \pm[0.25, 0.5, 1.0]$ are shown in red and blue contours, respectively. The mean density ($\delta\Sigma_{5'} = 0$) is indicated by the green dashed contour. Large black points mark proto-cluster galaxies that end up in galaxy clusters at $z = 0$.

Overzier et al. 2009

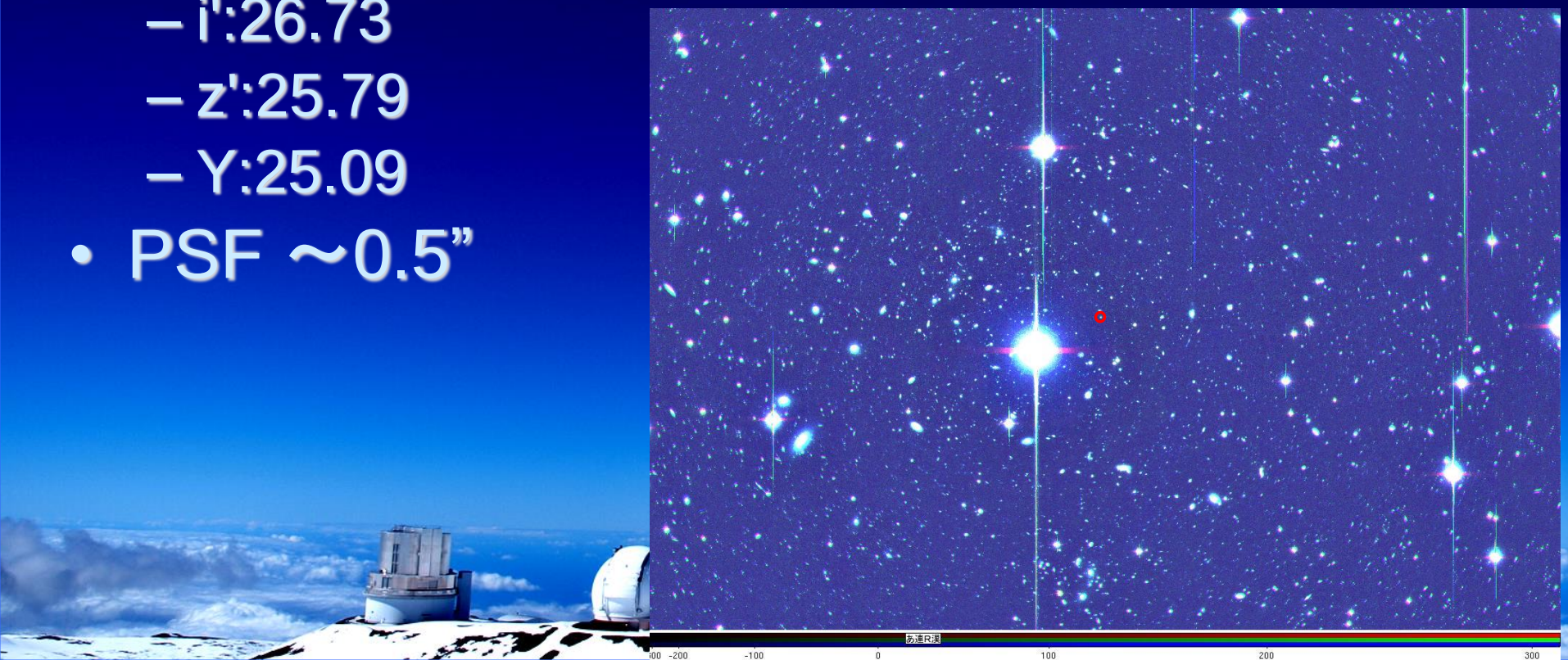
*Tomo GOTO*


Waldo cannot be found if out of FoV.
Hubble Space Telescope/ ACS camera
Subaru/Suprime camera

# Observation: Subaru S-Cam(30x30‘)

## CFHQSOJ2329 z=6.4 (most distant at the date)

- Limiting magnitude
  - i':26.73
  - z':25.79
  - Y:25.09
- PSF ～0.5”



# Merit at high-z
# z=6.4
# (most distant QSO environment)

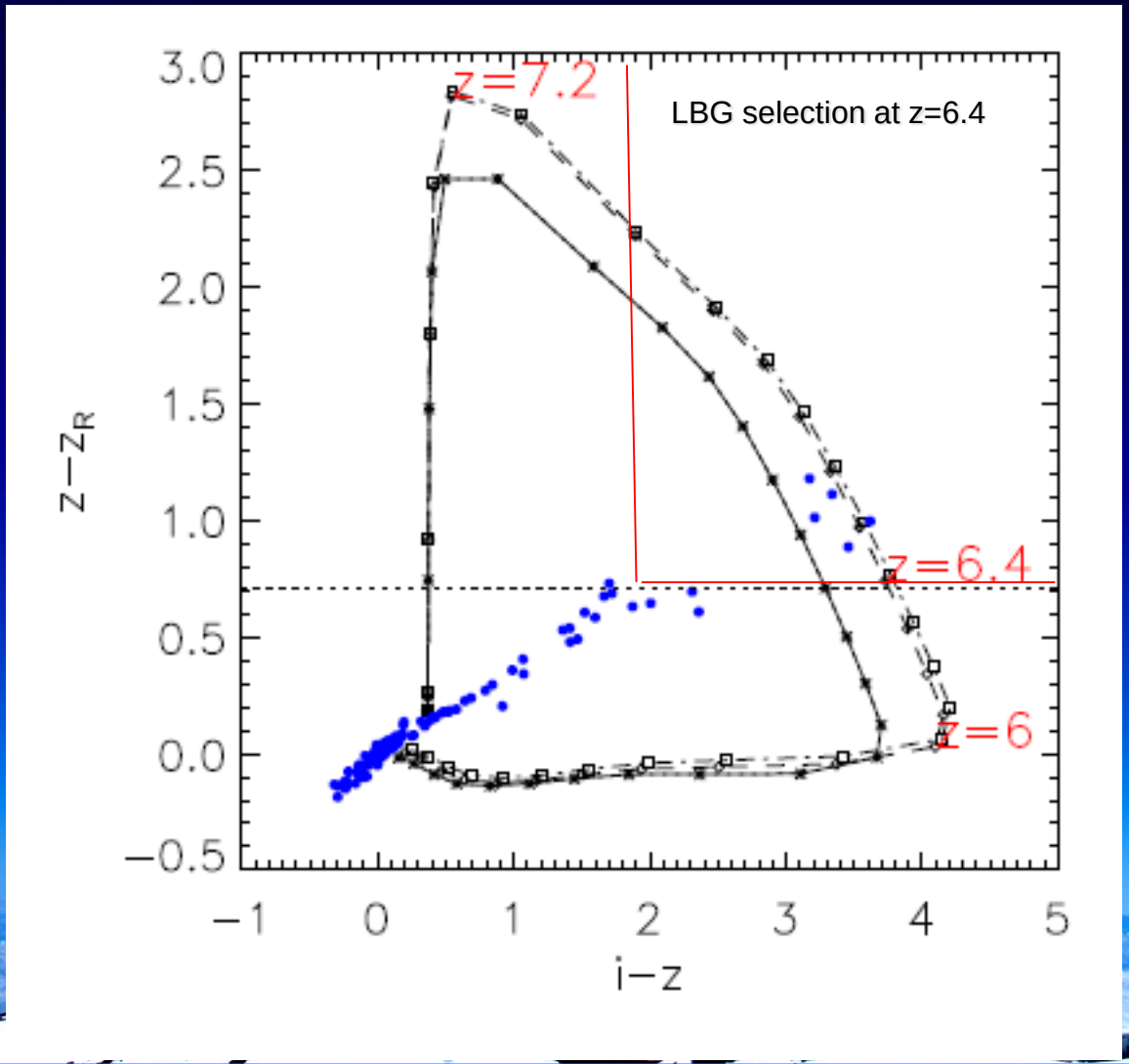
Both galaxy and QSO are young.

At most massive end. Effect of UV radiation


Hubble Space Telescope/ ACS camera

# LBG selection

Utsumi, Goto et al. 2010, ApJ, 721,1680

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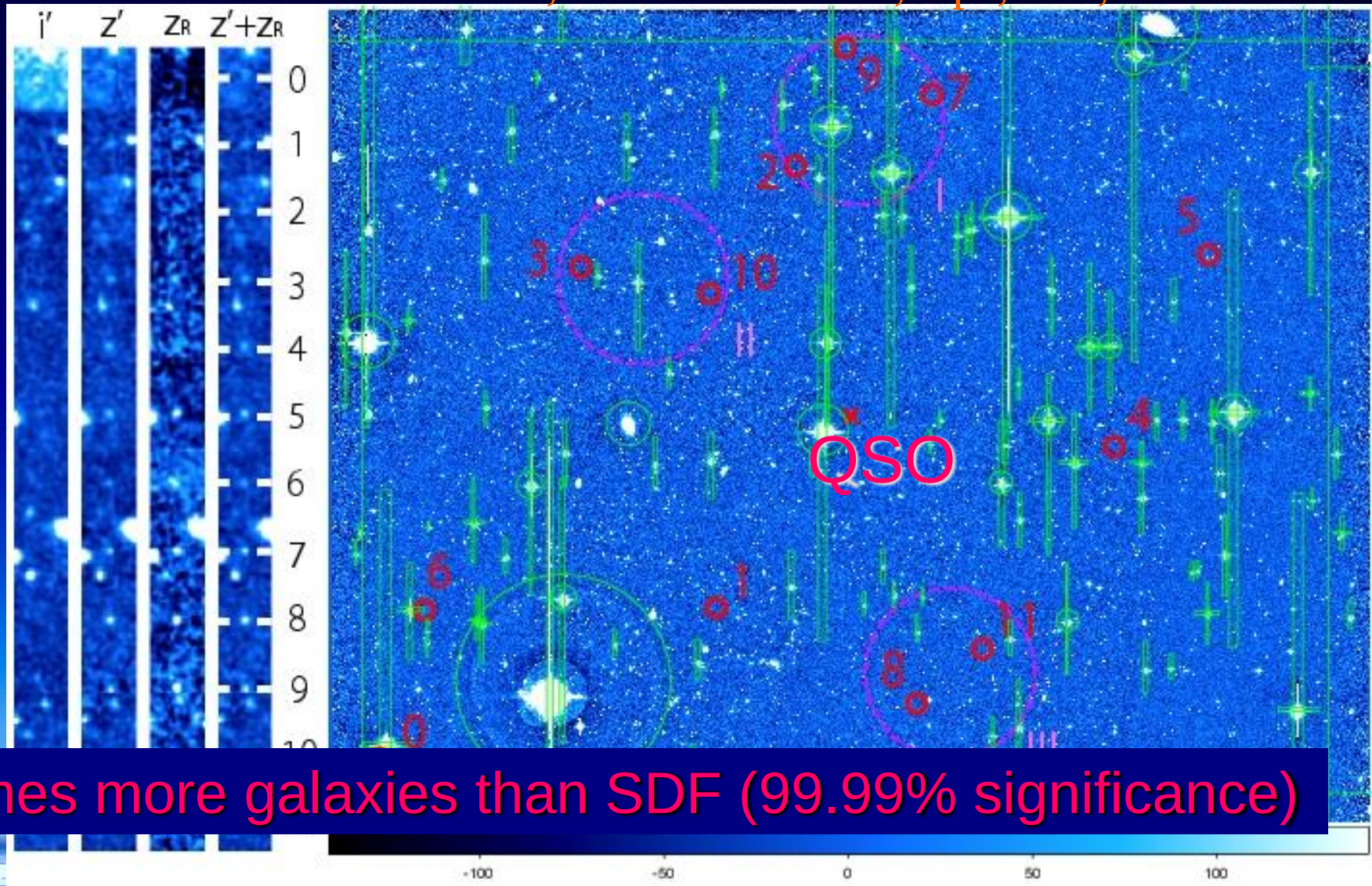
# Subaru i,z,y image of z=6.4 QSO

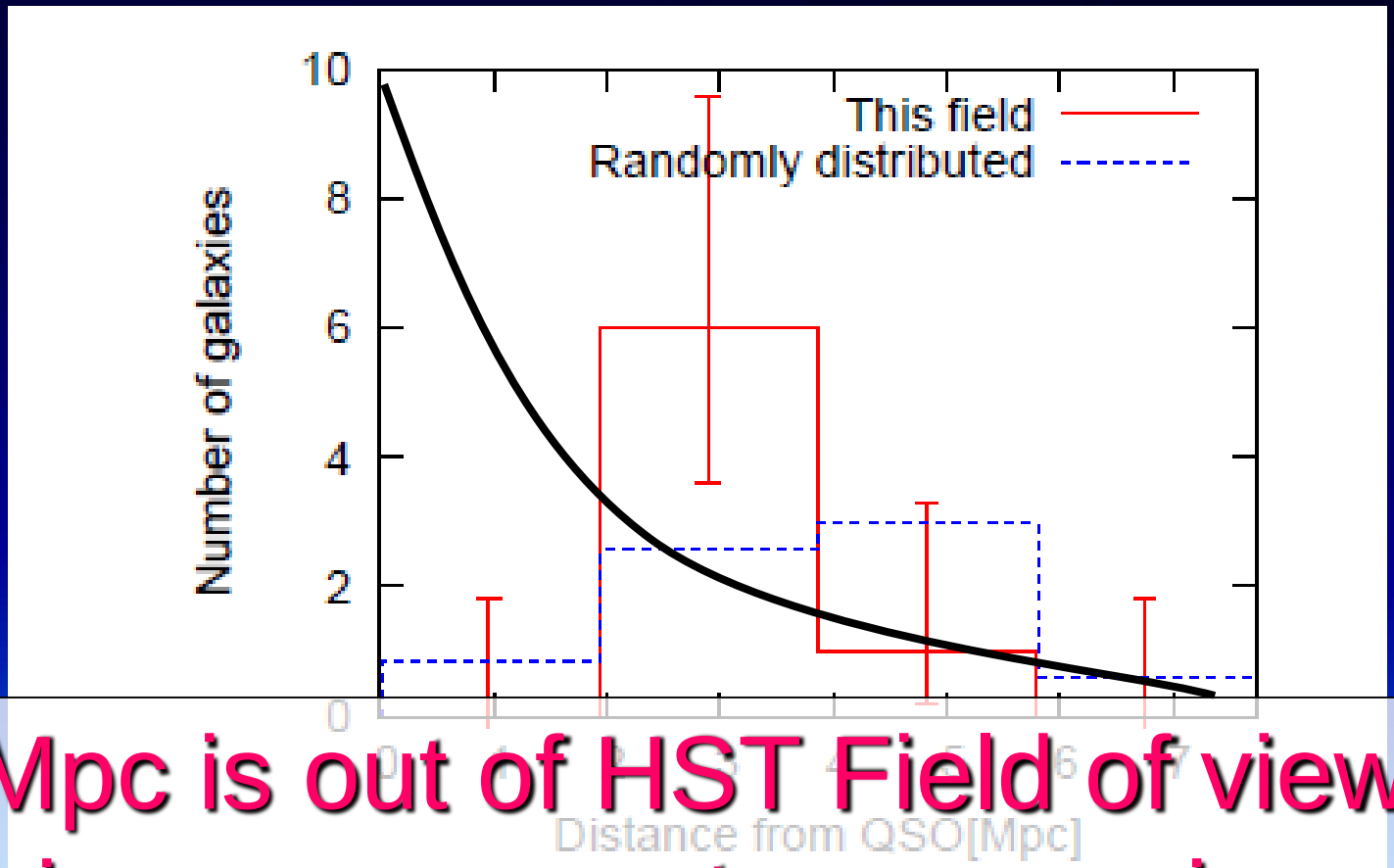
## *the first images with red CCDs*

Utsumi, Goto et al. 2010, ApJ, 721,1680




7 times more galaxies than SDF (99.99% significance)

# Radial distribution peaks at 3Mpc
## (87% different from random)




- 3Mpc is out of HST Field of view.
- This may suggest suppression of galaxy formation by QSO UV light

# Distribution of LBGs at z=6.4


- 7 times more galaxies than SDF (99.99% significance)
  ⇒Discovery of the most distant (z=6.4) proto-cluster candidate (overdensity) around QSO.
- Radial distribution peaks at 3Mpc (87% different from random)
  ⇒Suggests suppression of galaxy formation by QSO UV light

# LBG's redshifts are uncertain.

They are too faint for spectroscopic observation. (~25mag).

→narrow band technique

# Custom made filter NB906 for z=6.4 Lyα emission

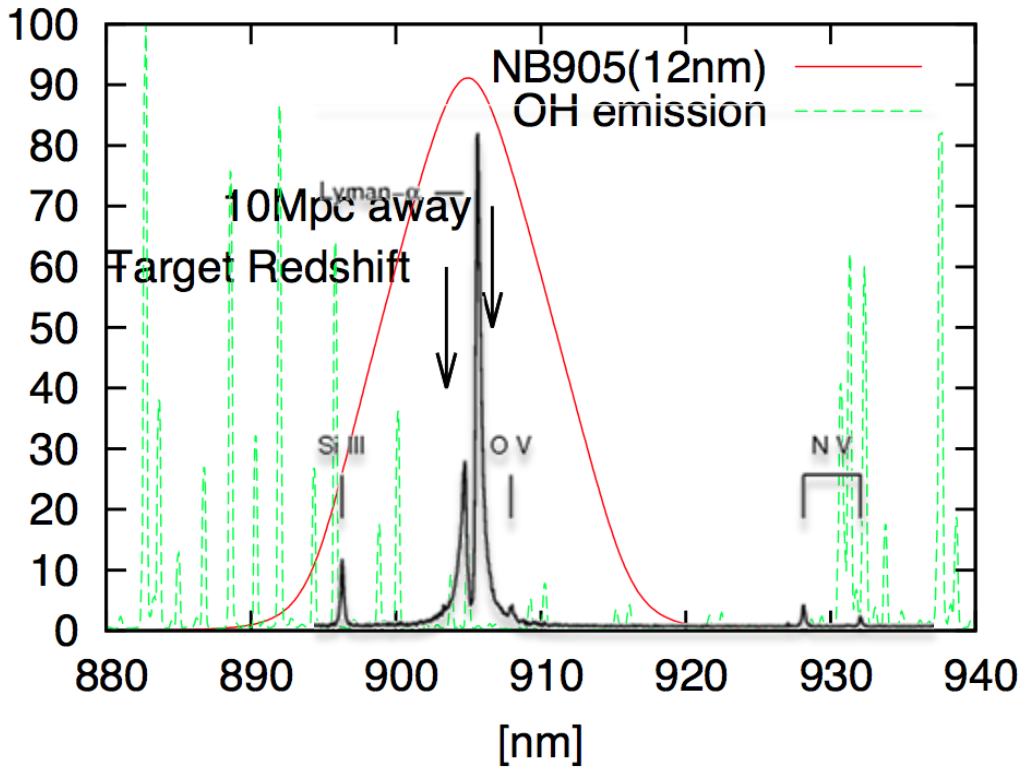
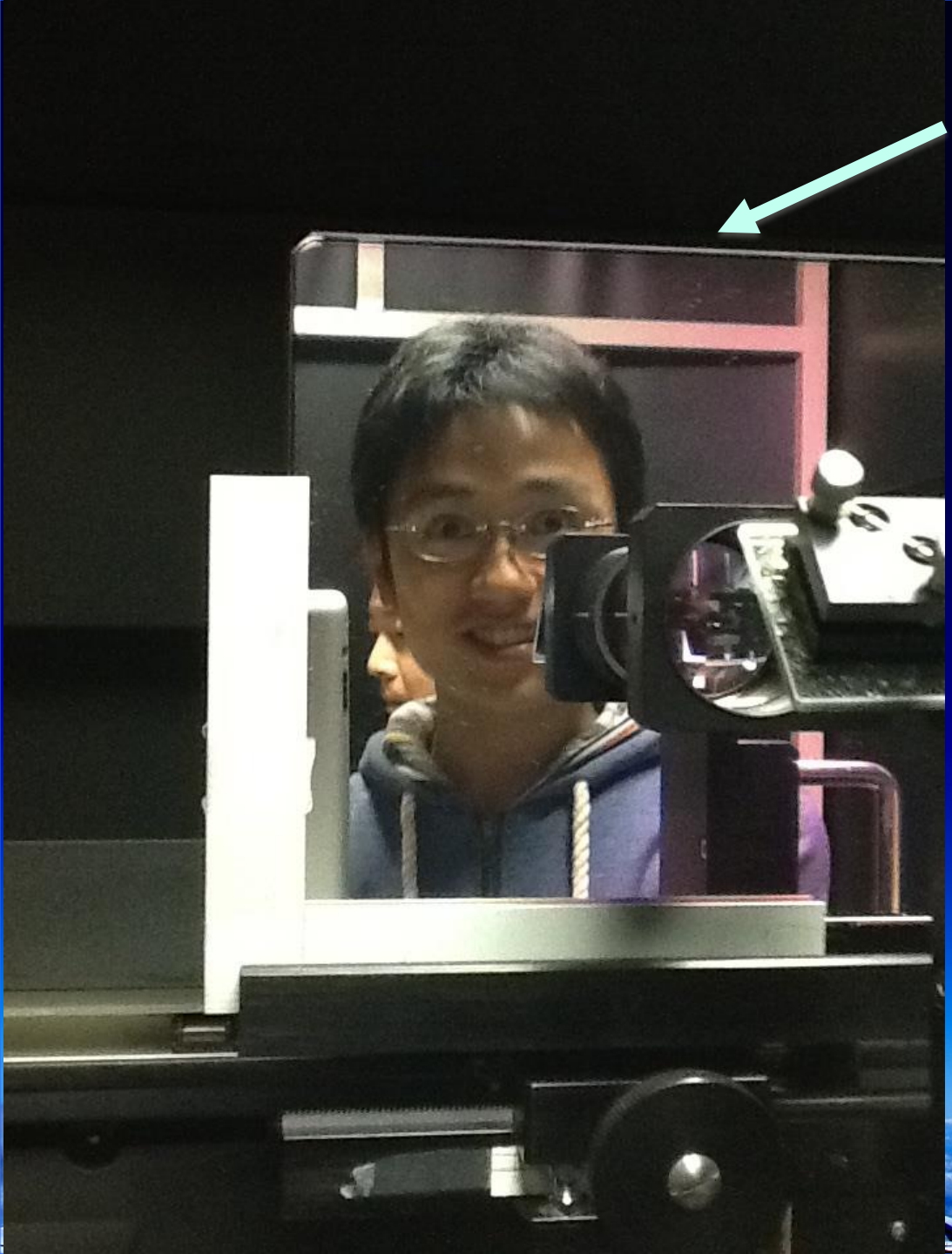



Figure 3: A filter NB905 we designed to capture Ly$\alpha$ emission from $z = 6.4$.



# NB906 filter (1 Million NTD)

Y.Utusmi (Hiroshima U)

# 9.6 hour exposure with Subaru (3 million NTD x2 nights)

# In 34x28' area ~100 Lyα emitting galaxies are expected. Results?

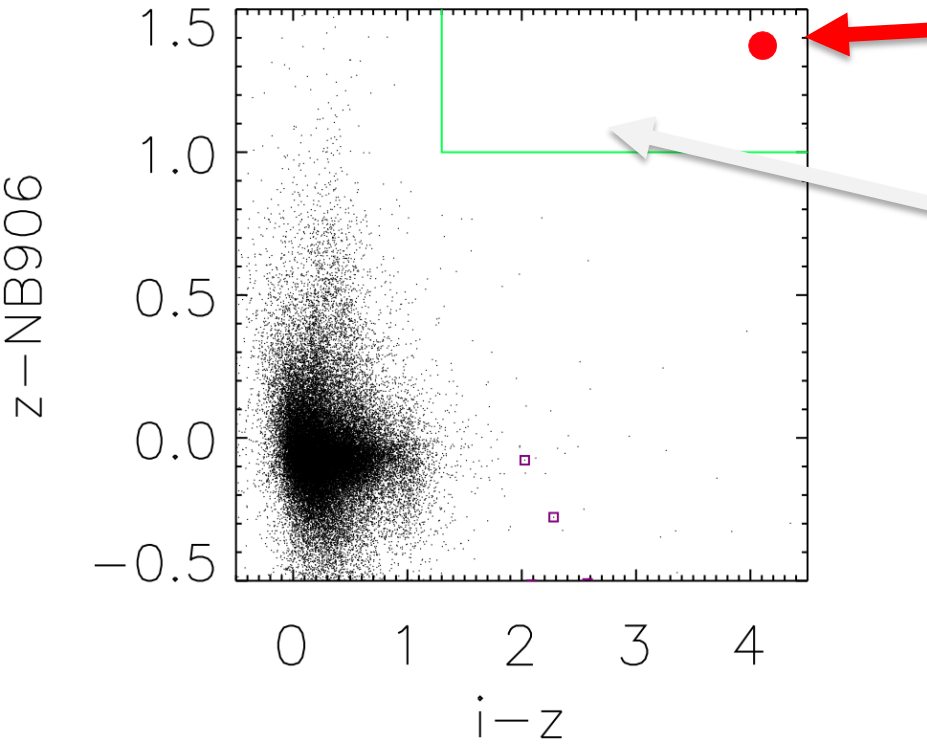
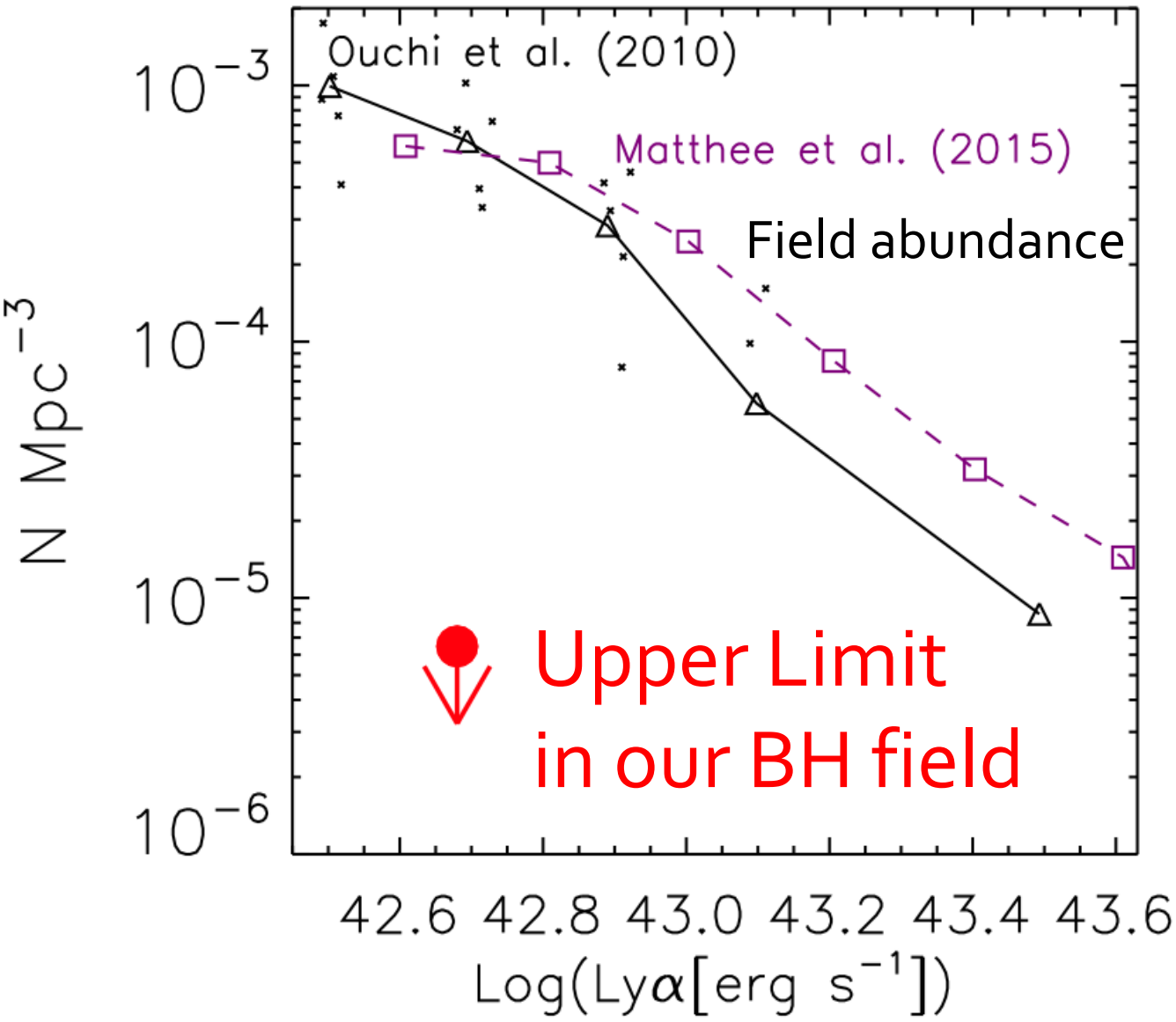



**Figure 2.** $i - z - NB906$ color-color diagram. The red point is the color of CFHQS J2329−0301. The black dots are all objects with `flag=0`. The purple squares are LBGs identified in Utsumi et al. (2010). The green lines show our selection criteria.

Black hole

Zero found!


Ouchi et al. (2010)
Matthee et al. (2015)
Field abundance
Upper Limit
in our BH field
N Mpc$^{-3}$
$10^{-3}$
$10^{-4}$
$10^{-5}$
$10^{-6}$
42.6 42.8 43.0 43.2 43.4 43.6
Log(Ly$\alpha$[erg s$^{-1}$])

# Can Black hole's UV light suppress galaxy formation?

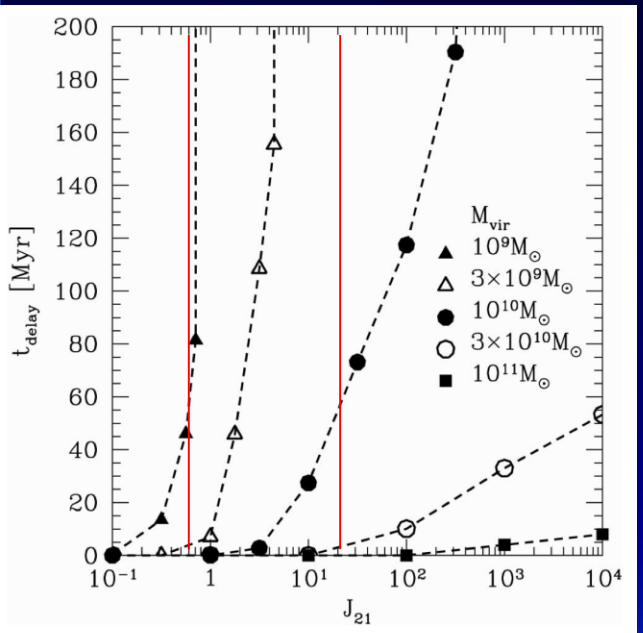



FIG. 8.—Delay time of star formation, $t_{delay}$, as a function of the radiation intensity, $J_{21}$, for a given virial mass, $M_{vir}$, according to the hydrodynamical model of Kitayama et al. (2000, 2001). The delay time is counted from the time when 1/10 of the baryon mass of each halo was cooled without UV radiation. The local radiation density in the region where LAEs are deficit around the QSO corresponds to $J_{21} \gtrsim 72$. [*See the electronic edition of the Journal for a color version of this figure.*]

Kashikawa+07

- Within 1 Mpc→ galaxy can form.
- 5Mpc (edge of the field) →not enough UV photon.
- Why no galaxy? Interesting question.
  - not a single collapse?
  - Not spherical, but disk formation?

Goto et al. accepted for MNRAS

# Summary

- Using a custom made NB filter N906
- LAE search at highest z around a z=6.4 QSO
  - highest z around a QSO
- No LAE found. LAE density x100 below field.
- QSO UV can suppress LAE <1Mpc,
  - but why no LAE at ~5Mpc?