銀河
40a

SXDF の z = 5.7 原始銀河団 および銀河の性質

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Abstract

■ Subaru/XMM-Newton Deep Survey

✔ NB816 imaging with Subaru/Sprime-Cam

・discovery of z = 5.7 LSS including two protoclusters

・Ouchi et al. 2005

↓

■ Our works

✔ follow-up spectroscopy with Keck/DEIMOS (PI: Ouchi)

✔ estimate of the masses of two protoclusters

↓

■ Future works

✔ investigation of the properties of these galaxies

✔ understanding the high-redshift universe

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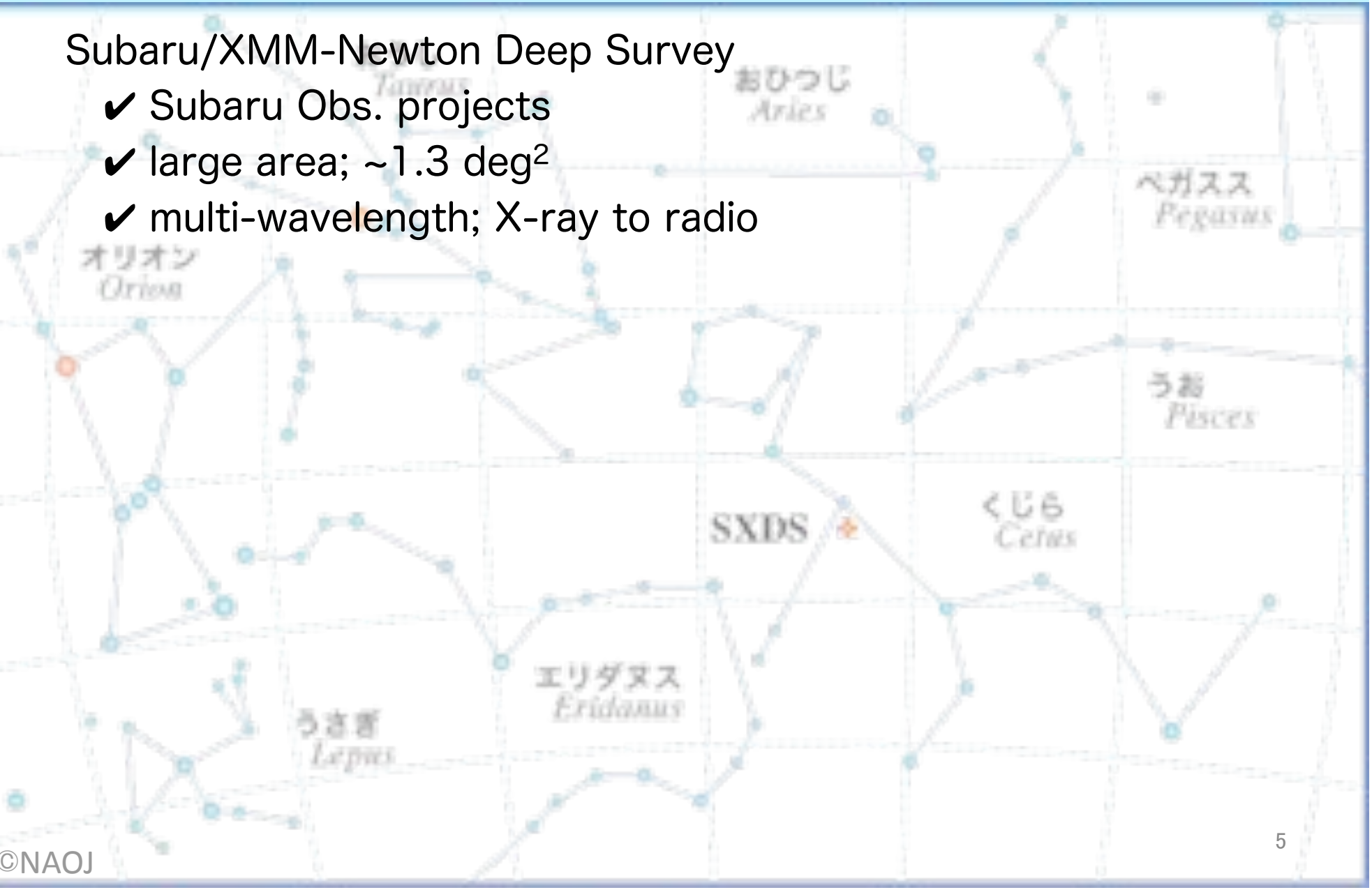
SXDS

Subaru/XMM-Newton Deep Survey

- ✔ Subaru Obs. projects
- ✔ large area; ~1.3 deg^2
- ✔ multi-wavelength; X-ray to radio



high-z galaxies

最も遠い銀河ベストテン (2012 年 6 月 4 日) ©NAOJ

順位	名前	座標	赤方偏移	億光年	論文	出版年月
1	SXDF-NB1006-2	J021856.5-051958.9	7.215	129.1	澁谷他	2012.6
2	GN-108036	in GOODS NORTH field	7.213	129.1	小野他	2012.1
3	BDF-3299	J222812.3-0350959.4	7.109	129.0	Vanzella 他	2010.12
4	A1703_zD6	J131501.0+515004	7.045	128.9	Schenker 他	2012.1
5	BDF-521	J222703.1-350707.7	7.008	128.9	Vanzella 他	2010.12
6	G2-1408	J132357.1+272448	6.972	128.8	Fontana 他	2010.12
7	IOK-1	J132359.8+272456	6.964	128.8	家他	2006.9
8	HUDF09_1596	J033303.8-275120	6.905	128.7	Schenker 他	2012.1
9	SDF46975	in Subaru Deep field	6.844	128.6	小野他	2012.1
10	NTTDF-6345	J120536.9-074522.3	6.701	128.4	Pentericci 他	2011.12

high-z clusters

- protoclusters

	redshift	overdensity	region	paper
1	6.01	~6σ	SDF	Toshikawa et al. 2012
2	5.7	4.8σ	SXDF	Ouchi et al. 2005

- mature clusters (present-day-like clusters)

	redshift	overdensity	region	paper
1	2.07	~20σ	Daddi Field	Gobat et al. 2011

clusters

■ mature clusters (present-day clusters)

✔ ~10^{14} $M_\odot$, ~5Mpc

✔ crossing time ~ 10^{10} yr (~ age of the universe)

✔ Gobat+2011: z=2.07 "the most distant, mature cluster"

✔ X-ray emission from high-temperature plasma (intergalactic medium)

・"The unambiguous signature of an evolved cluster is the X-ray emission from the ICM, as it implies a deep and established potential well."

*ICM = intergalactic medium of clusters

■ protoclusters: overdense regions in the early universe

✔ ≦10^{14} $M_\odot$, ~5Mpc

✔ no X-ray emission

✔ physically immature system

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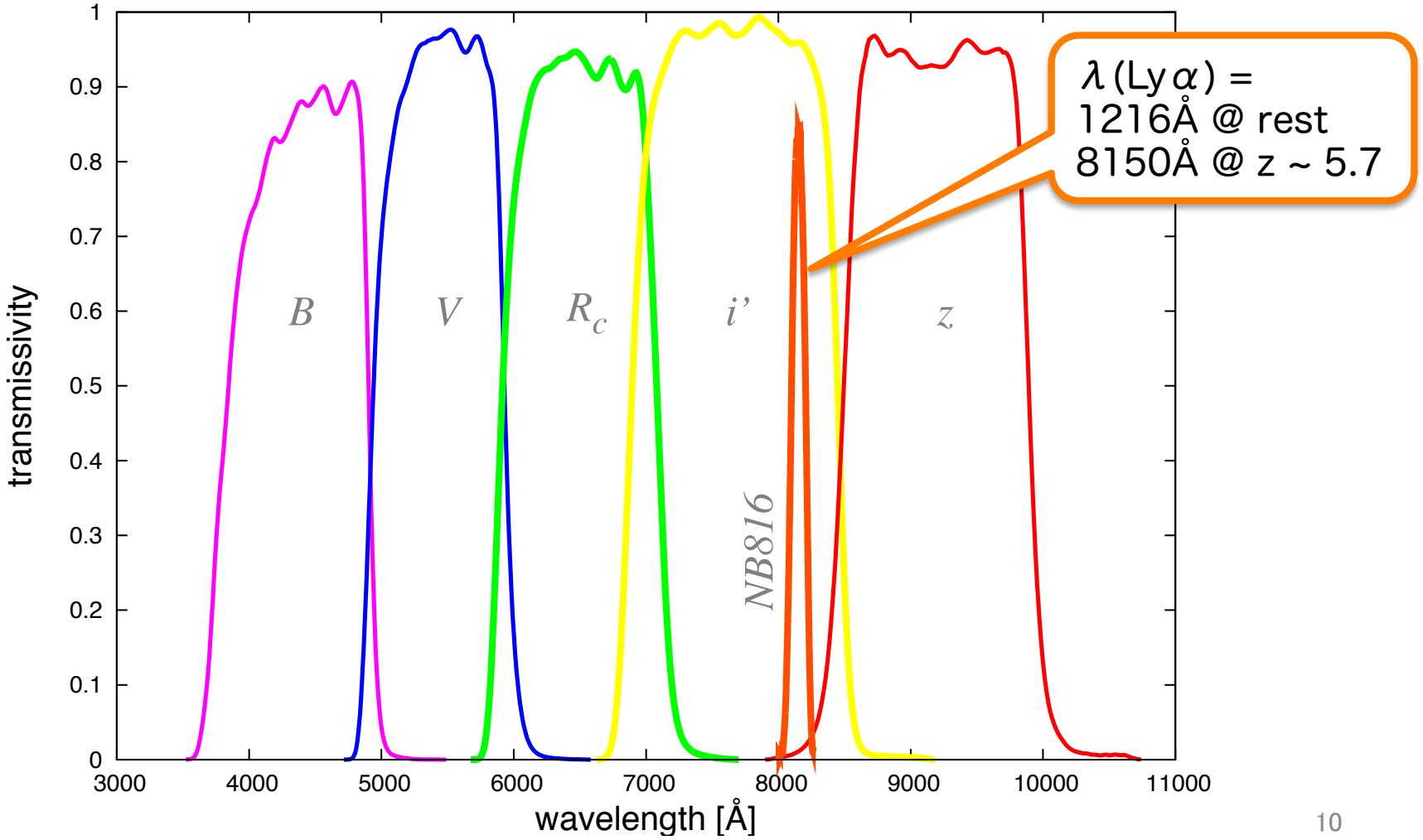
selection of LAEs

LAEs = high-redshift galaxies selected with 2 broadband and 1 narrowband filters



NB816 imaging

■ NB816

✔ λ_c = 8150 Å

✔ FWHM = 120 Å

■ z = 5.7 LAEs selection

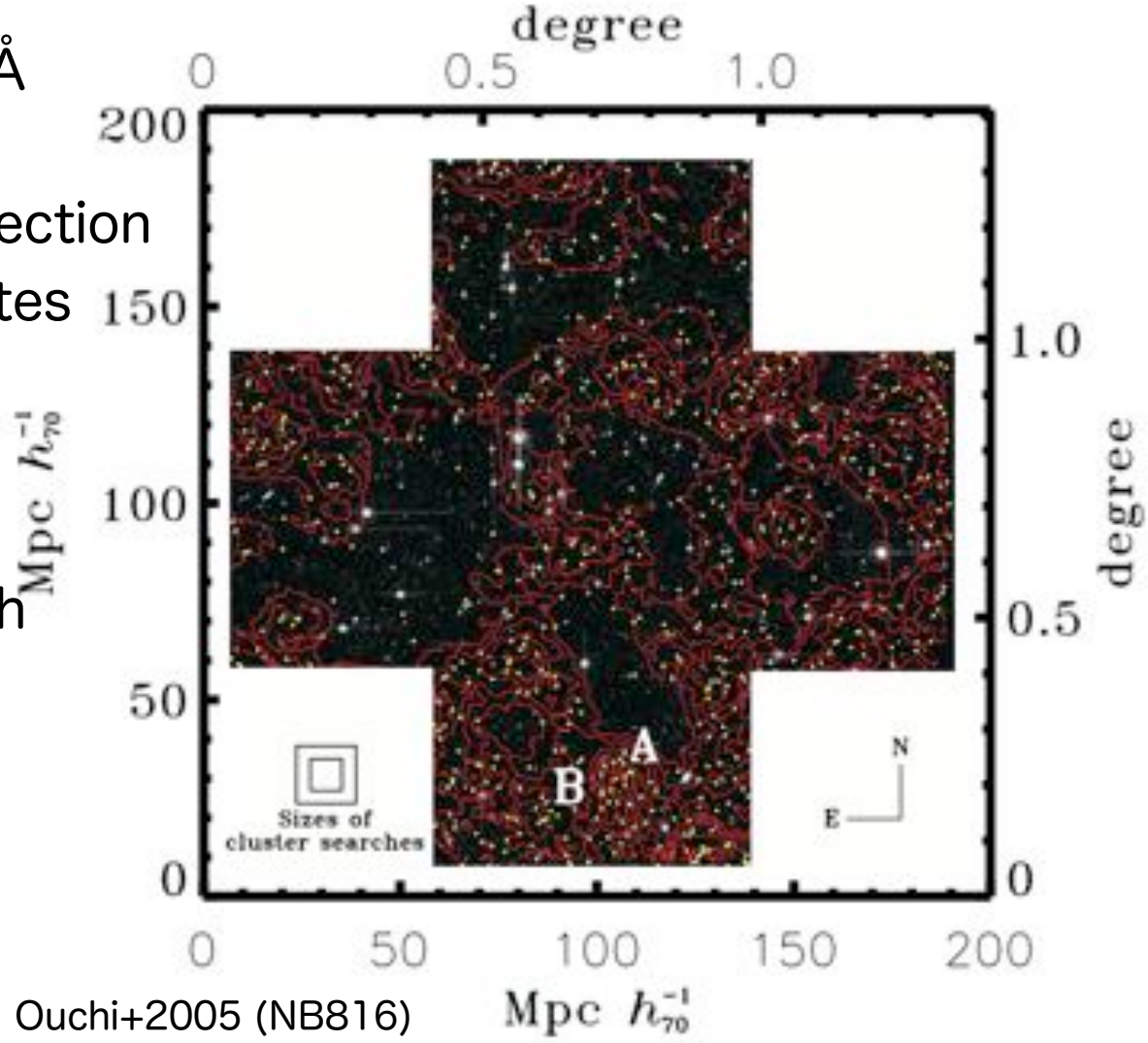
278,458 candidates

↓

z = 5.7 LAEs

404@SXDF

174@SXDF-South



Ouchi+2005 (NB816)

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spectroscopy observations

	December 2003	February 2010
telescope/instrument	Subar/FOCAS	Keck/DEIMOS
mirror diameter (area)	8.2m (1)	9.96m(1.48)
instrument FoV	6'(circular) ~ 28 arcmin^2	16.7*5.0 ~ 81.5 arcmin^2
spectral range	4900 – 9100 Å	5980 – 9820 Å
grating	300 lines/mm	830 lines/mm
resolution	λ/Δλ ~ 1000	λ/Δλ ~ 2500
distinct [OII] doublet from Lyα	cannot	can

black: 174 z=5.7 LAE cadidates

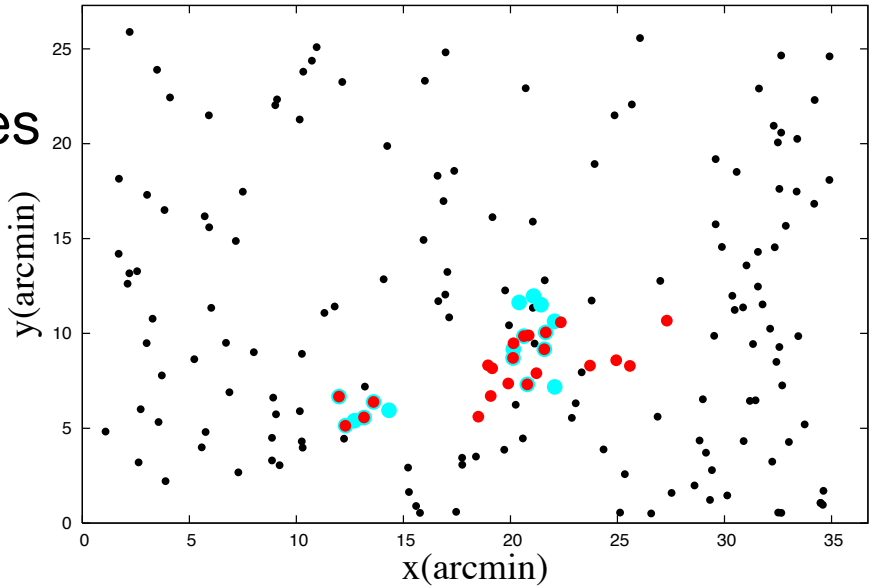
cyan: 17 FOCAS objects

red: 22 DEIMOS objects

(sum = 30 objects)

↓

20 z = 5.7 LAEs



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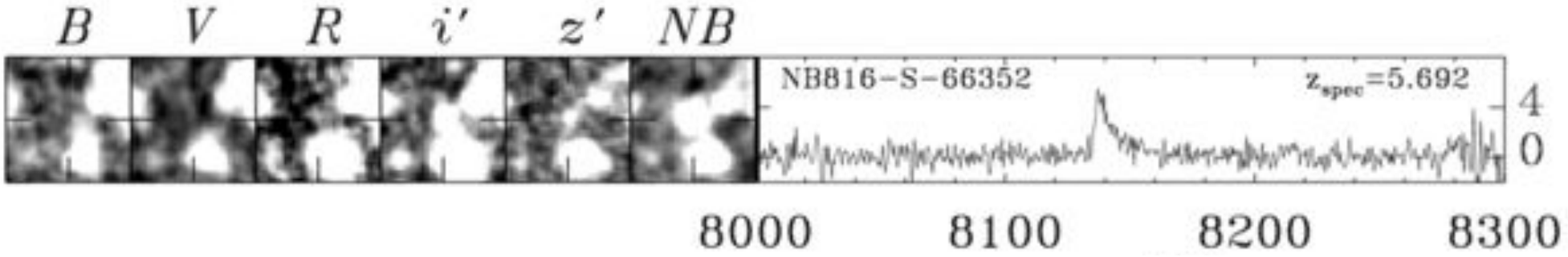
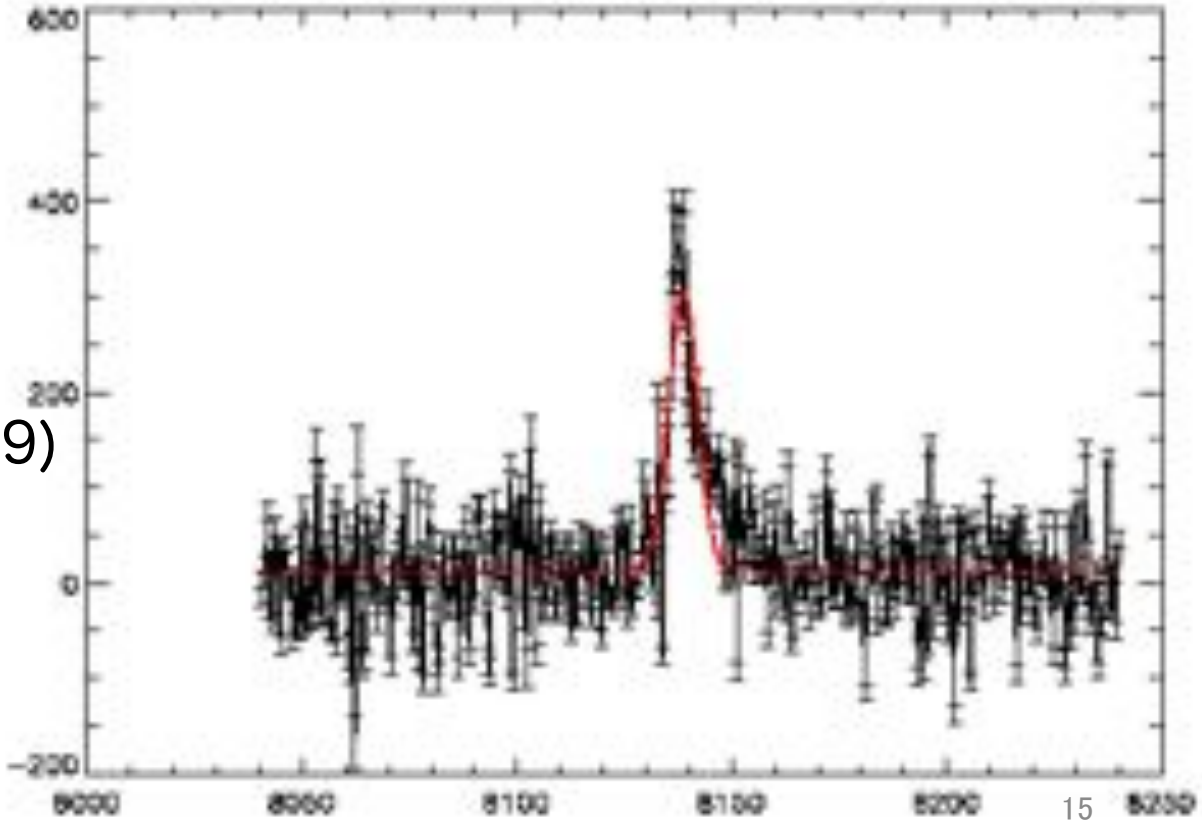
spectrum

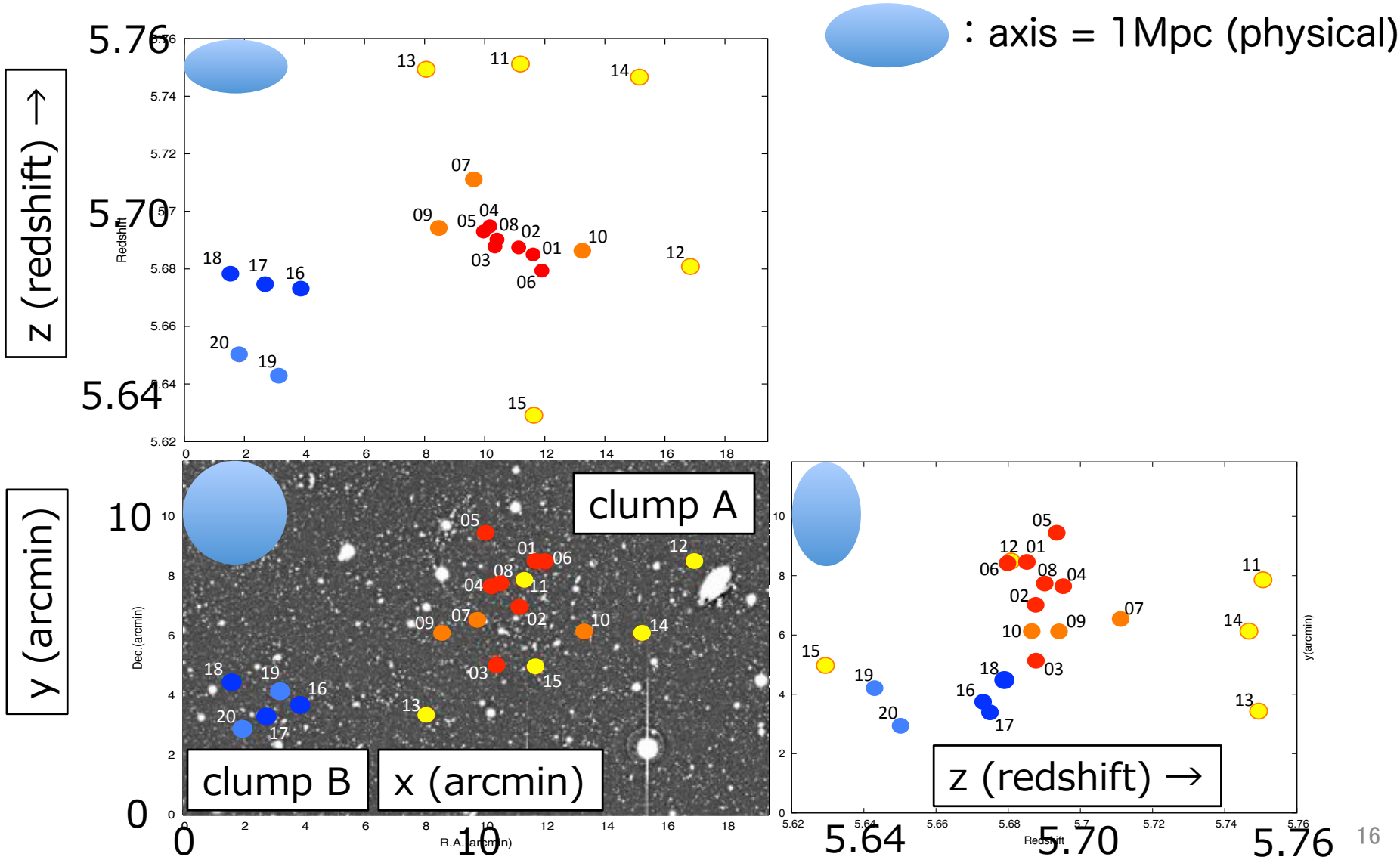


■ Lyα emission
  ✔ asymmetry (red tail)

■ central wavelength λ_c
  ✔ MPFIT (Markwkrdt 2009)
    ・1-d gaussian fit for Keck/DEIMSO data
    ↓
    ・λ_c, FWHM



3d map


: axis = 1Mpc (physical)
z (redshift) →
y (arcmin)
clump A
clump B
x (arcmin)
z (redshift) →
Redshift
Dec.(arcmin)
R.A.(arcmin)
y(arcmin)
5.76
5.70
5.64
0
10

overdensity

■ number density

✔ SXDF: (2.9~4.0)*10^{-4} Mpc^{-3}

✔ region A: (5.3~7.1)*10^{-3} Mpc^{-3}

✔ region B: 1.4*10^{-2} Mpc^{-3}

↓

■ overdensity = region A(or B)/SXDF – 1

✔ region A: 12~20

✔ region B: 34~47

✔ assume size = 1Mpc (physical units)

→ overdensity = 47~85(clump A), 47~65(clump B)

■ compare virialized systems (present-day clusters)

✔ present-day cluster: 100~200

mass

■ assumption

✔ the protoclusters are virialized: $M = \frac{3\sigma^2 r}{G}$

■ estimate masses

✔ $M_A = 3.8*10^{13}\ M_\odot$

✔ $M_B = 6.2*10^{12}\ M_\odot$

■ expectation of the virialied systems with the masses

✔ based on Λ CDM model (Mo & White 2002)

・< 3 clusters with M(≧ $6.2*10^{12}\ M_\odot$)

・< 0.001 clusters with M(≧ $3.8*10^{13}\ M_\odot$)

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properties of high-z galaxies

■ background

✔ redshift vs properties

- luminosity function (LF), EW
- surface density, galaxy-dark matter bias, DMH masses
  z = 3.1, 3.7, 5.7, 6.6 (Ouchi+2008, 2010)
- cosmic varinace
  z = 4.79, 4.86 (Shimasaku+2004)

✔ environment vs properties

- age, SF time scale, SFR, dust extinction
  z = 2.15 (Tanaka+2010)
- EW(Lyα)
  z = 3.1 (Kuiper+2012)
- L(UV), L(Lyα), EW(Lyα)$_{rest}$, FWHM(Lyα)
  z = 6.01 (Toshikawa+2012)

Future Works

- properties of z = 5.7 LAEs in/around protoclusters
  - ✔ environment vs properties @ z = 5.7
- evolution of environmental dependence of galaxies
  - ✔ redshift vs environment vs properties
  - ✔ z = 0 ~ 5.7 ~ 6.01, 7, 8, ...
- general properties of high-redshift galaxies
  - ✔ formation of protoclusters
  - ✔ evolution of LSS