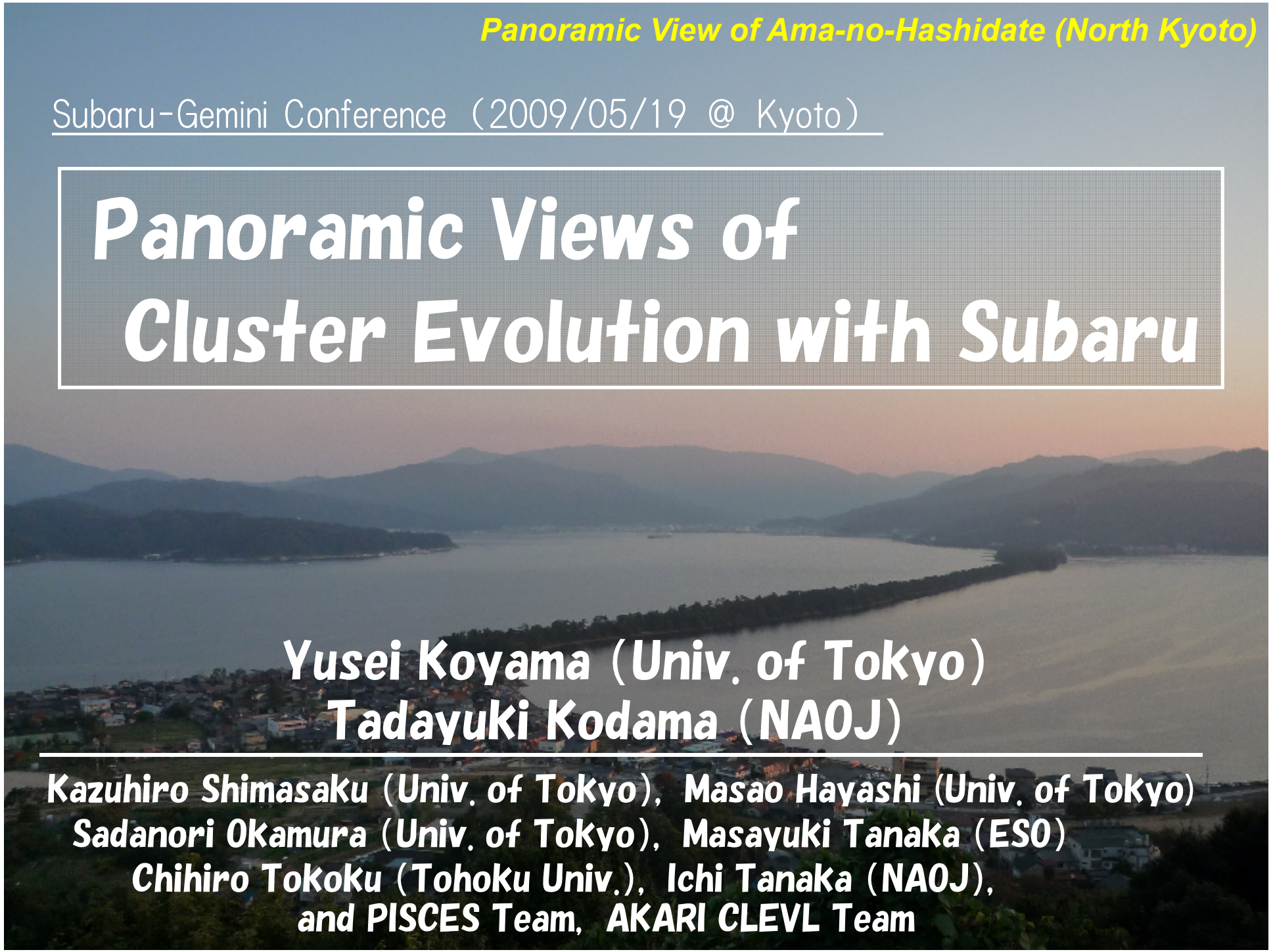


Panoramic View of Ama-no-Hashidate (North Kyoto)

Subaru-Gemini Conference (2009/05/19 @ Kyoto)

Panoramic Views of Cluster Evolution with Subaru

Yusei Koyama (Univ. of Tokyo)
Tadayuki Kodama (NAOJ)

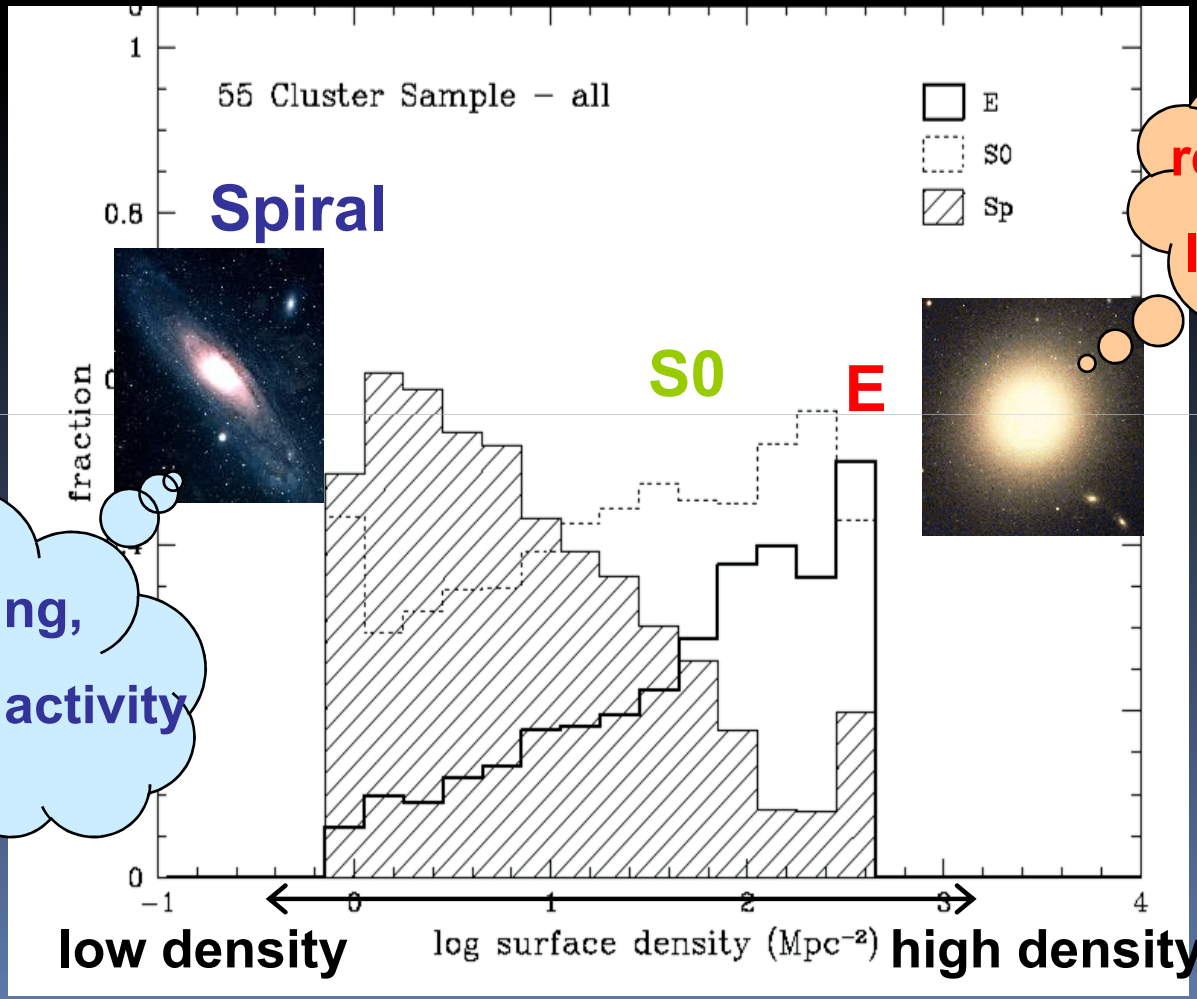
Kazuhiro Shimasaku (Univ. of Tokyo), Masao Hayashi (Univ. of Tokyo)
Sadanori Okamura (Univ. of Tokyo), Masayuki Tanaka (ESO)
Chihiro Tokoku (Tohoku Univ.), Ichi Tanaka (NAOJ),
and PISCES Team, AKARI CLEVL Team

Outline

- Introduction to the PISCES project
- Large-scale structures at all redshifts (0.4<z<1.4)
  (e.g. Tanaka et al. 2009, in prep)
- Starbursts and truncation of star formation in groups / filaments at z~0.8
  (Koyama et al. 2008, 2009 in prep)
- High star-formation activity in z~1.5 cluster
  (Hayashi et al. 2009, in prep: see Hayashi-san's poster A11)

Galaxy properties are dependent on environment

Morphology-Density relation (*Dressler 1980*)

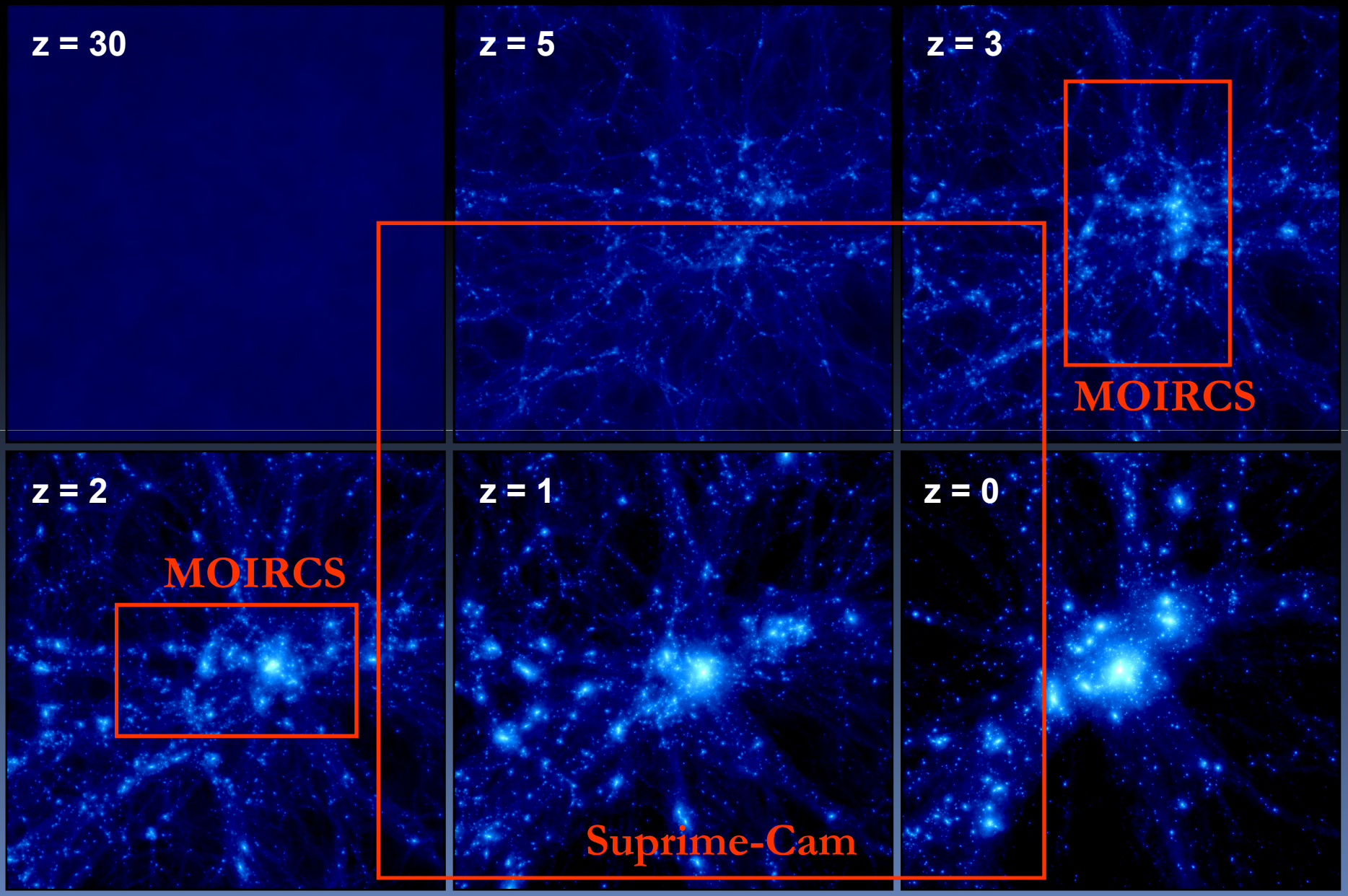


blue, young, active SF activity

red, old, low SF activity

How this relation was built-up ? What happened in the past clusters ?

Why Subaru ?



M=6×10^14 Msun, 20Mpc×20Mpc (co-moving)

Yahagi et al. (2005)

Panoramic Imaging and Spectroscopy of Cluster Evolution with Subaru (PI : T. Kodama)

~10 X-ray detected clusters at 0.4 < z < 1.45

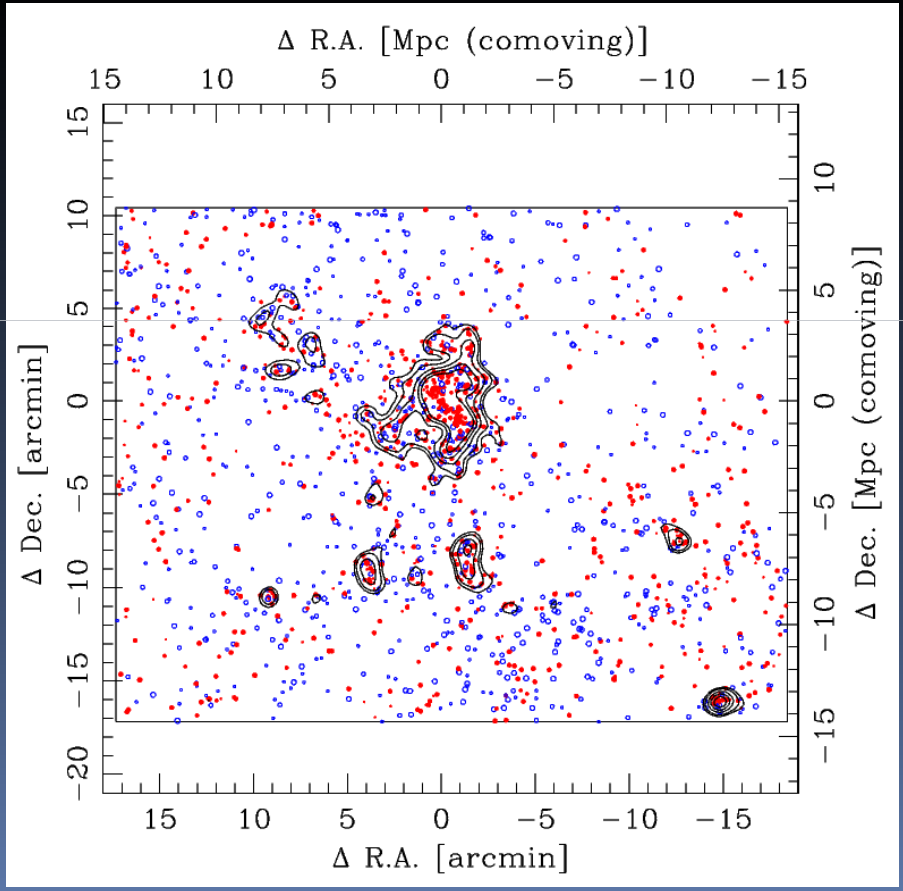
Class	Cluster	RA (J2000)	Dec (J2000)	z	L_X 10^{44}	Bands	Coordination
z~0.4	CL 0024+1654	00 26 35.7	+17 09 43.1	0.39	3.2	BRz',NB	ACS, XMM, Chandra
	CL 0939+4713	09 42 56.2	+46 59 12	0.41	9.2	$BVRI$,NB	XMM
	(RX J2228+2037)	22 28 36	+20 37 12	0.42	16.5	$BVRi'$	Chandra, S-Z
z~0.55	MS 0451.6−0305	04 54 10.9	−02 58 07	0.54	12.0	$BVRI$	ACS (3.5′), Chandra, S-Z
	CL 0016+1609	00 18 33.5	+16 26 13.4	0.546	26.0†	$BVRi'z'$	ACS (3.5′), XMM, Chandra, S-Z
	(MS 2053.7−0449)	20 56 21.8	−04 37 51.4	0.583	5.0	$BVRi'z'$	ACS (3.5′), XMM, Chandra, S-Z
z~0.85	RX J1716.4+6708	17 16 49.6	+67 08 30	0.813	2.7‡	$VRi'z'$,NB	Chandra, Astro-F target
	(MS 1054.4−0321)	10 56 59.5	−03 37 28.4	0.83	20.0	$VRi'z'$	ACS (6′), XMM, Chandra, S-Z
	RX J0152.7−1357	01 52 42.0	−13 57 52.9	0.831	16.0	$VRi'z'$	ACS (6′), XMM, Chandra, S-Z
	(RX J1226.9+3332)	12 26 58.2	+33 32 49	0.9	53.0	$VRi'z'$	XMM, Chandra, S-Z
	(CL 1604+43)	16 04 28.3	+43 16 24.0	0.9	2.0	$VRi'z'$	ACS (6′), XMM
z~1.2	RDCS J0910+5422	09 10 44.9	+54 22 08.9	1.11	2.1	$VRi'z'$	Chandra ACS(3.5')
	CL 1252−2927	12 52 54.4	−29 27 17.0	1.23	6.6	$VRi'z'$	ACS (6′), XMM, Chandra
	(RX J1053.7+5735)	10 53 43.4	+57 35 21	1.14	2.0‡	$VRi'z'$	ACS (6′) XMM
	RX J0848.9+4452	08 48 46.9	+44 56 22	1.26	2.8	$BVRi'z'$	ACS (6′), XMM, Chandra
z~1.4	(XMMU2235.3-2557)	22 35 20.6	-25 57 42.0	1.393	3.0	*VRi'z'*	XMM
	XMMJ2215.9-1738	22 15 58.5	-17 38 02.5	1.45	4.4	*VRi'z'*,NB	XMM

Kodama et al. (2005)

Panoramic Views of Cluster Assembly

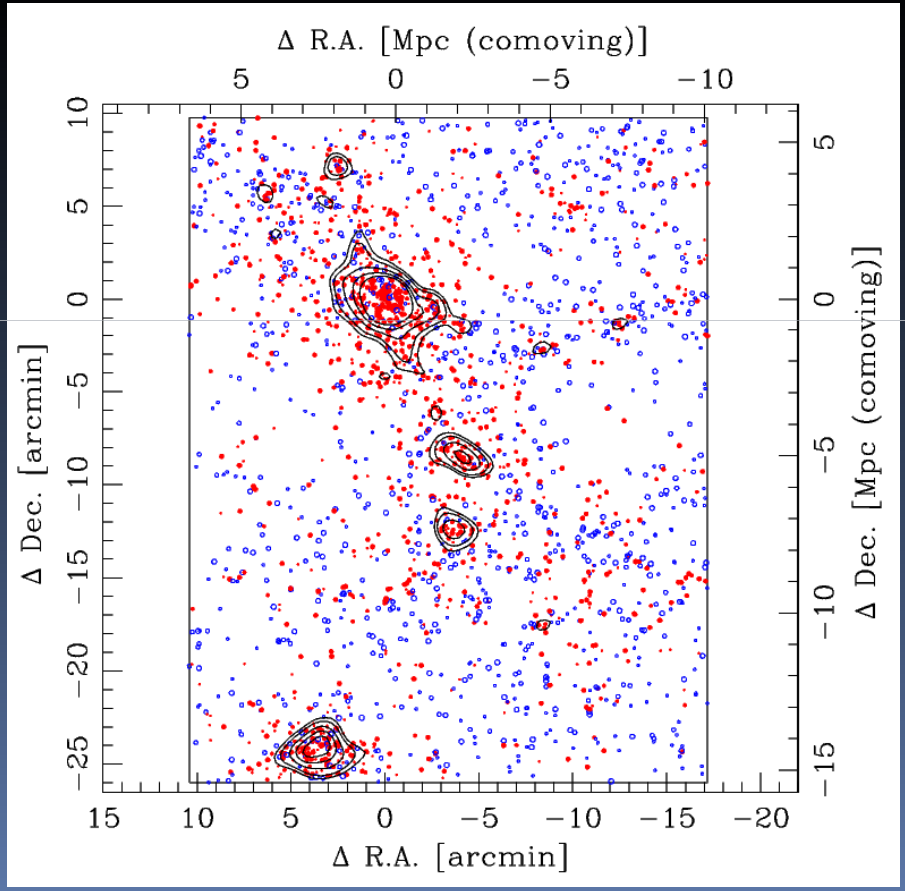
Spatial distribution of phot-z members ($\Delta z = -0.05 \sim +0.03$)

RXJ 0152.7-1357 (VRIz')



z=0.83 (7Gyr ago)

CL 0016+16 (BVRi'z')

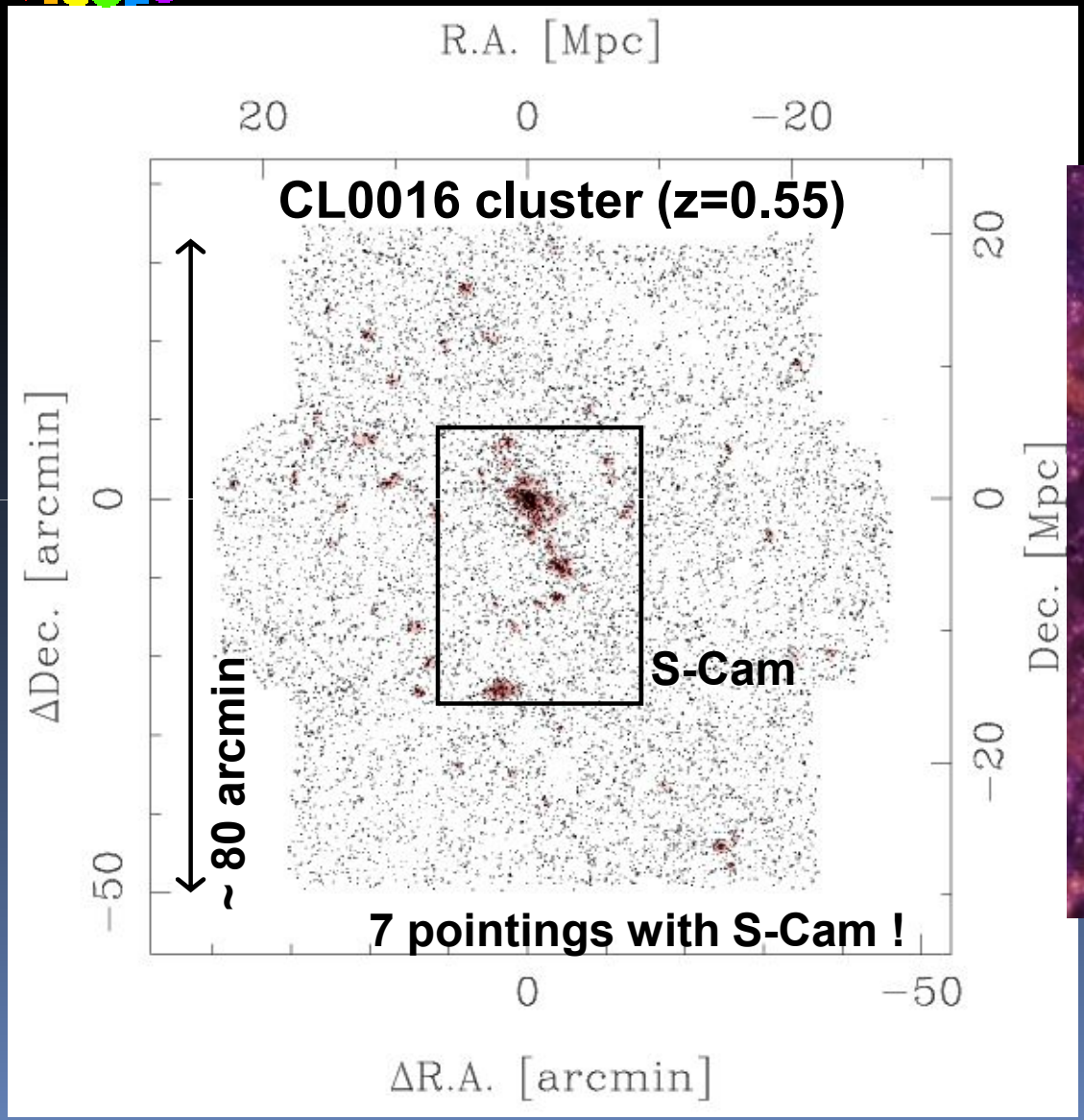


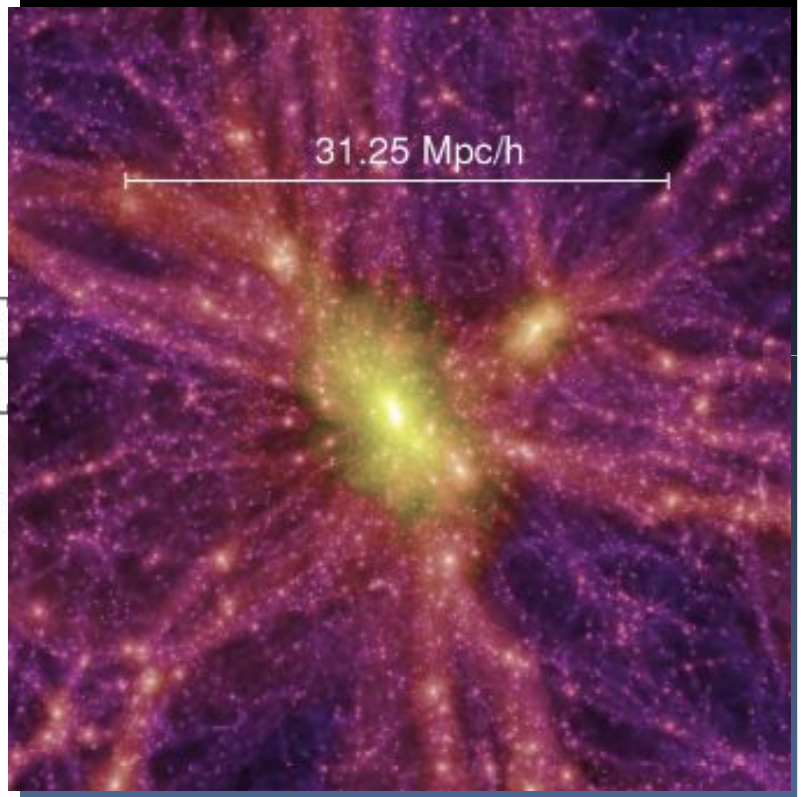
z=0.55 (5.4Gyr ago)

Kodama et al. (2005)

A Huge Cosmic Web at z=0.5 over 50 Mpc

(Tanaka, et al., in prep.)





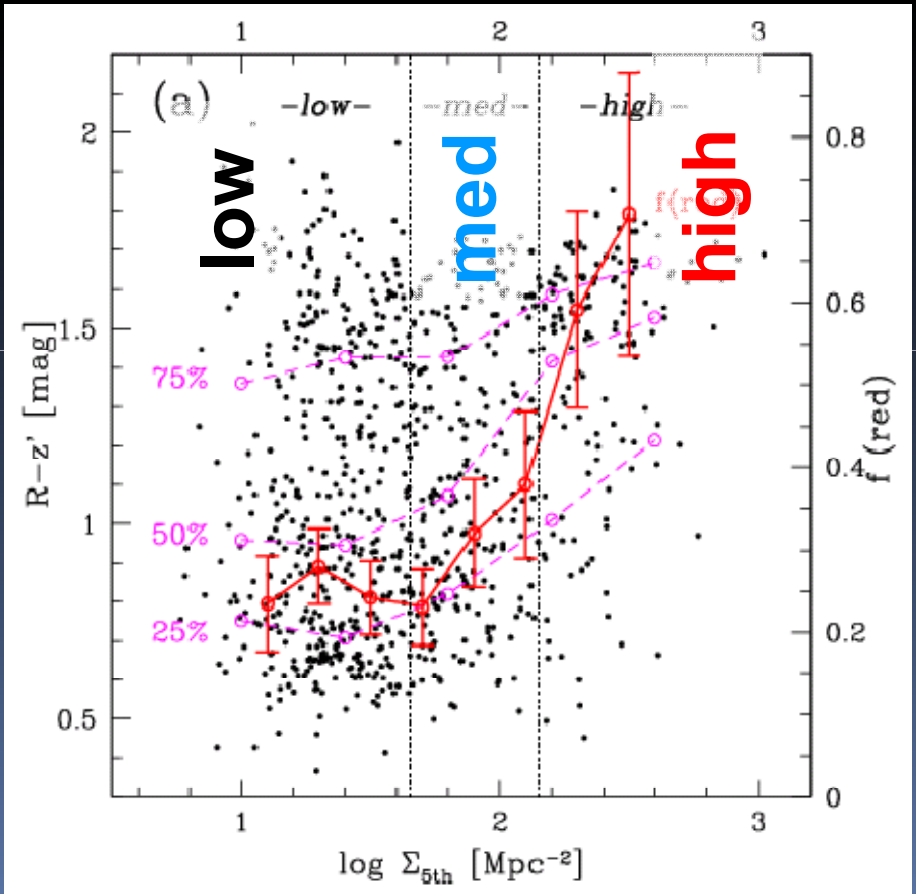
Millenium Simulation
(Springel et al. 2005)

Initially traced by red-sequence galaxies in V-I colours / now spec-z confirmed

Important role of cluster outskirts

Sharp colour transition in medium-density regions

(i.e. cluster outskirts / groups / filaments)

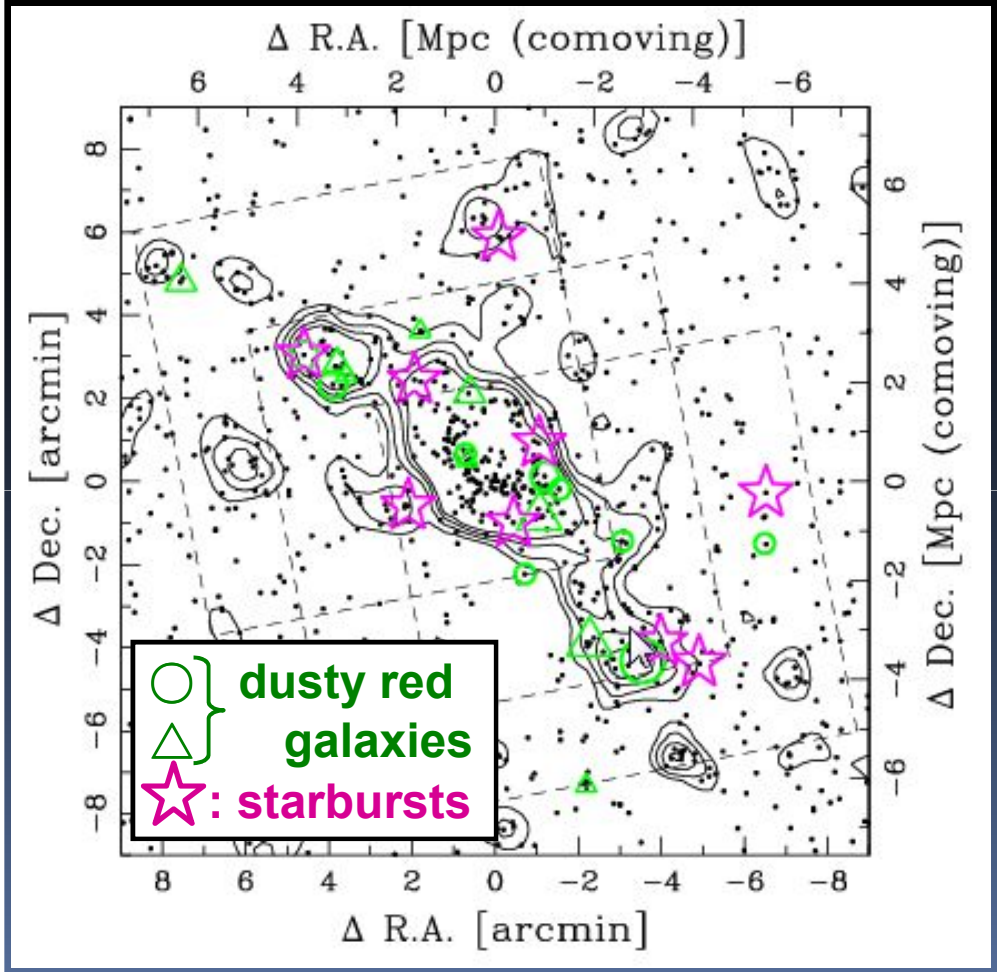


RXJ1716 cluster (z=0.81)

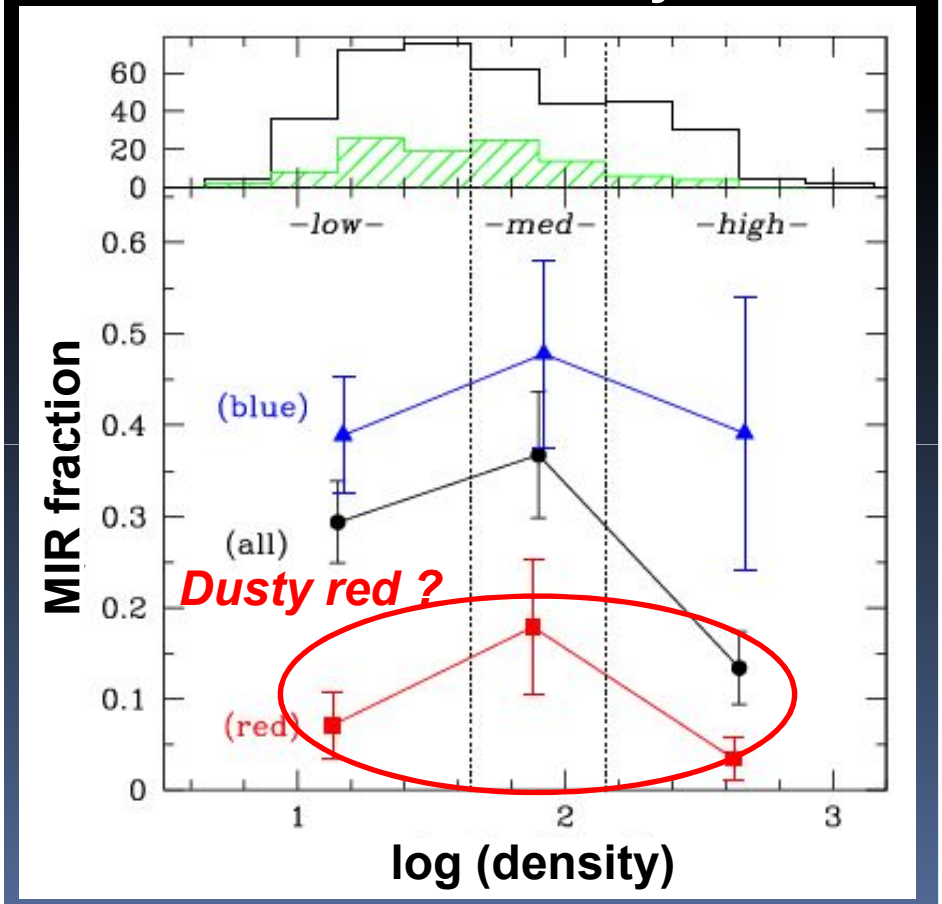
Koyama et al. (2008)

(see also Kodama+01, Tanaka+05)

Spatial distribution of 15μm galaxies



SFR > 20 Msun/yr



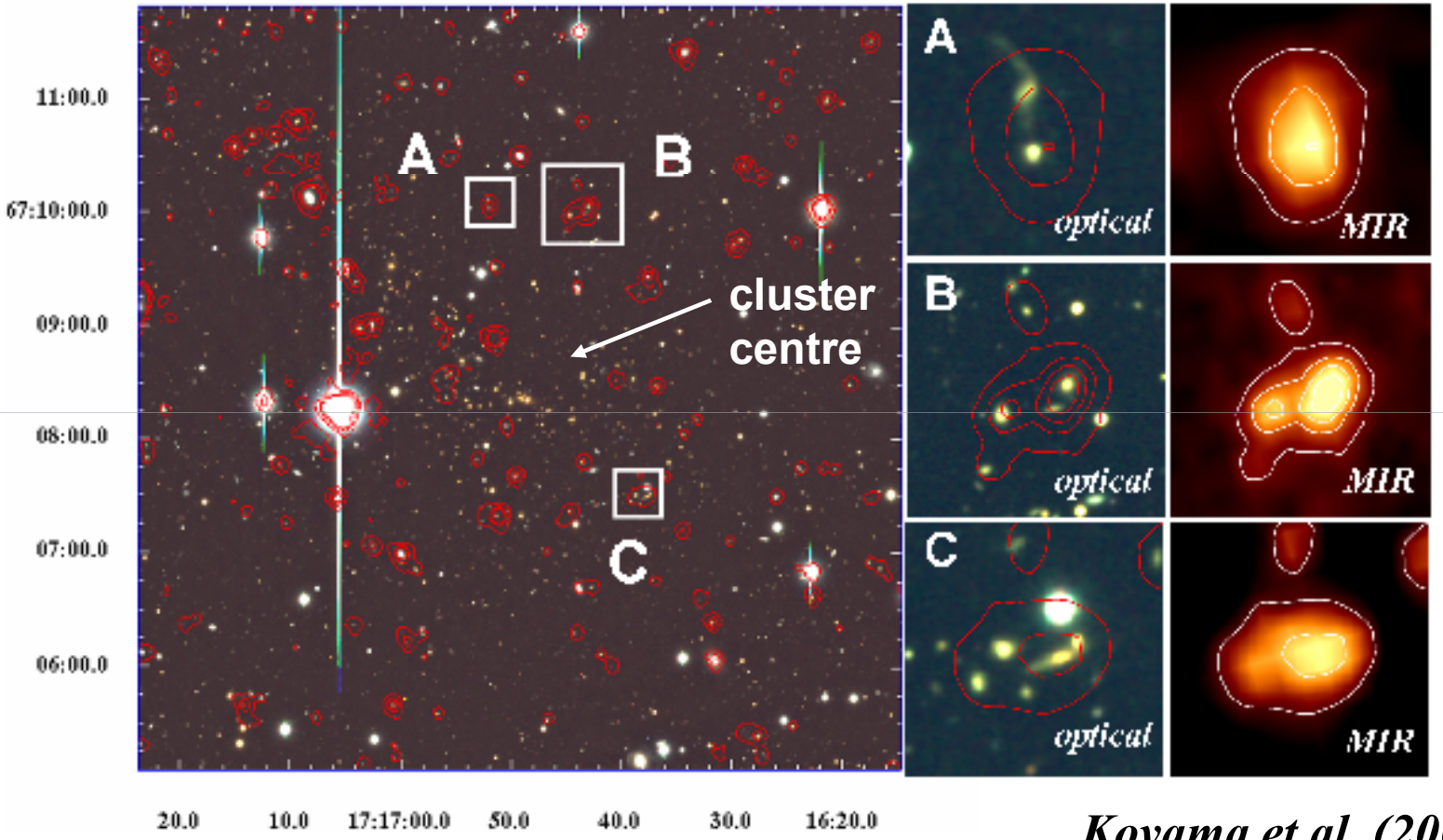
15um galaxies are preferentially found in outskirts / groups / filaments

Starbursts look induced along the filaments

Koyama et al. (2008)

What is the trigger of starbursts ?

Image: Subaru optical / Contour: AKARI MIR



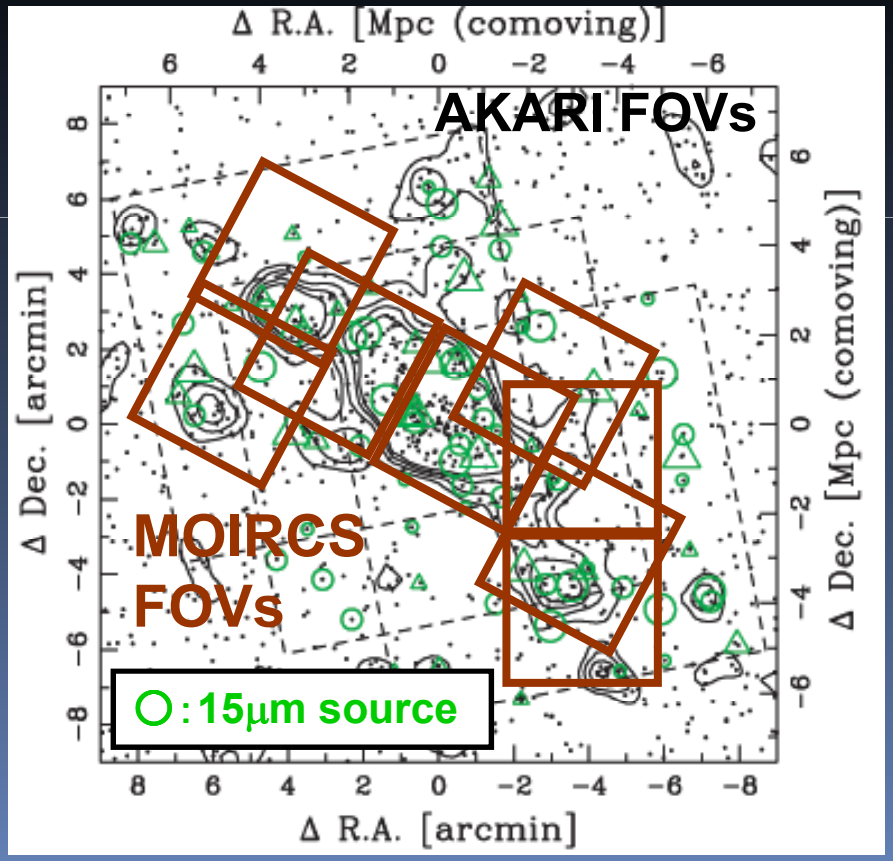
Koyama et al. (2008)

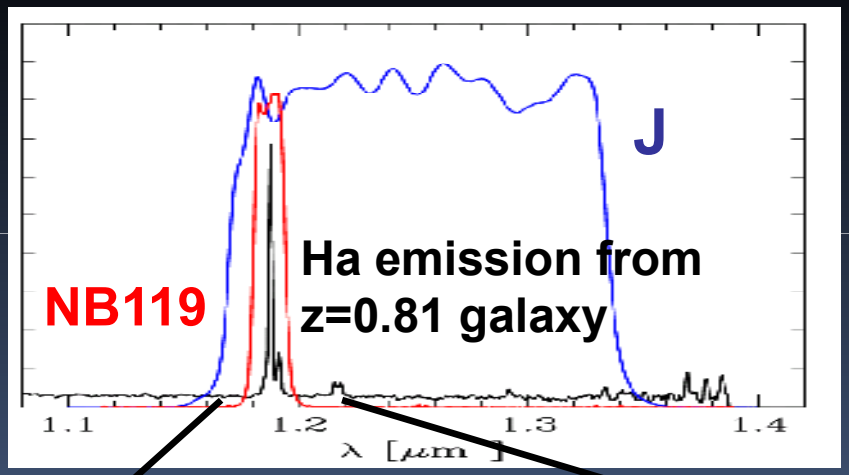
galaxy-galaxy interactions in small in-falling groups should contribute to gas consumption and SF quenching (at least partly)

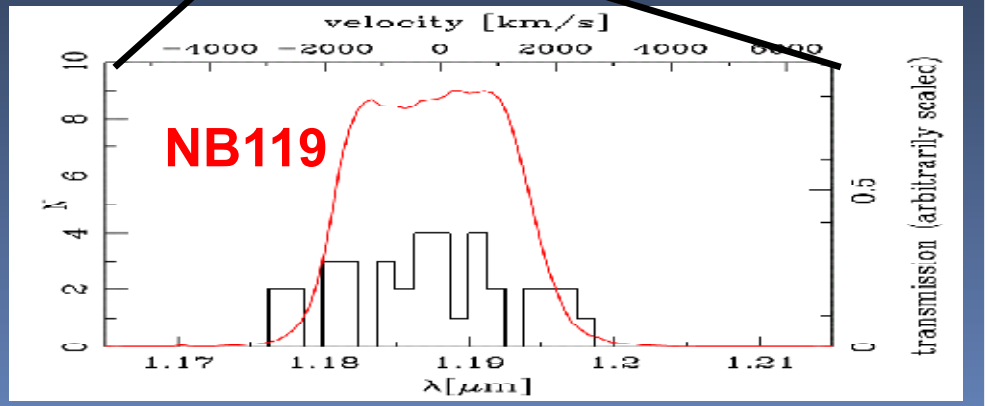
How about normal (moderate) SF ?

Hα line at z=0.81 ⟶ **NB119 filter (MOIRCS)**
(λc=11885A, Δλ=141A)

Deep and wide-field Hα imaging of RXJ1716 (down to ~ 1 Msun/yr)





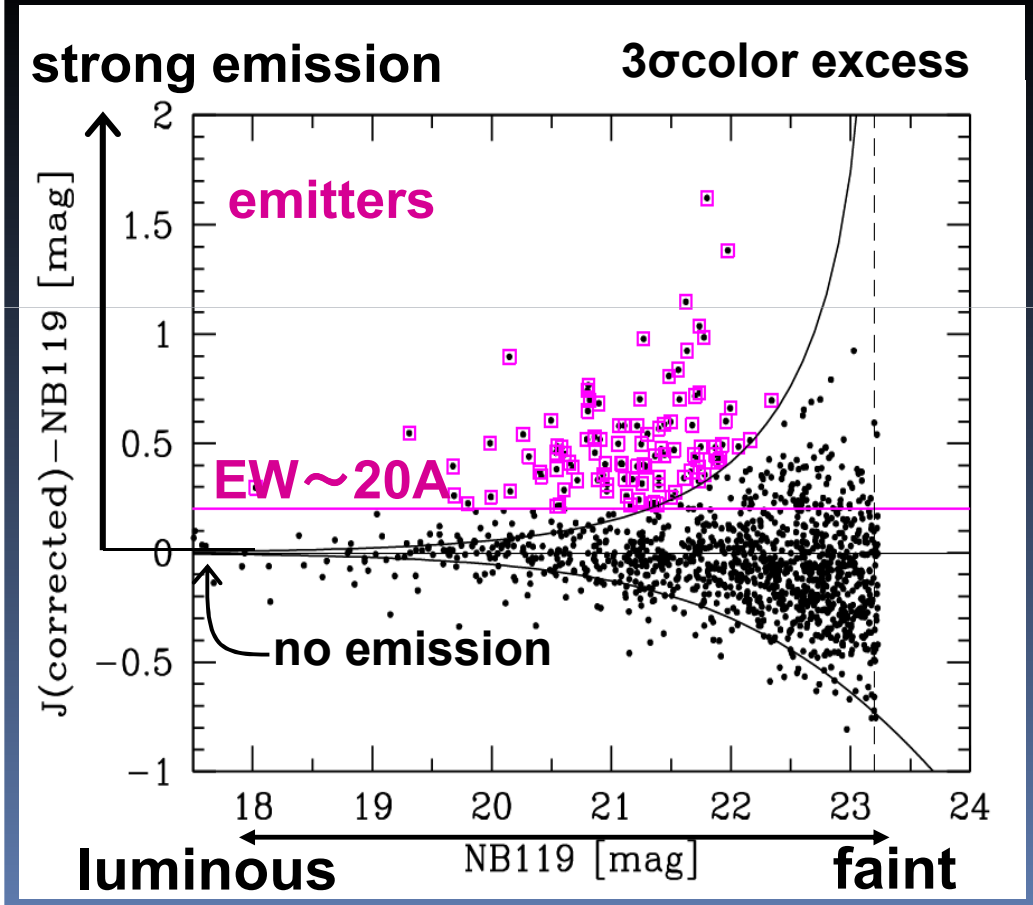


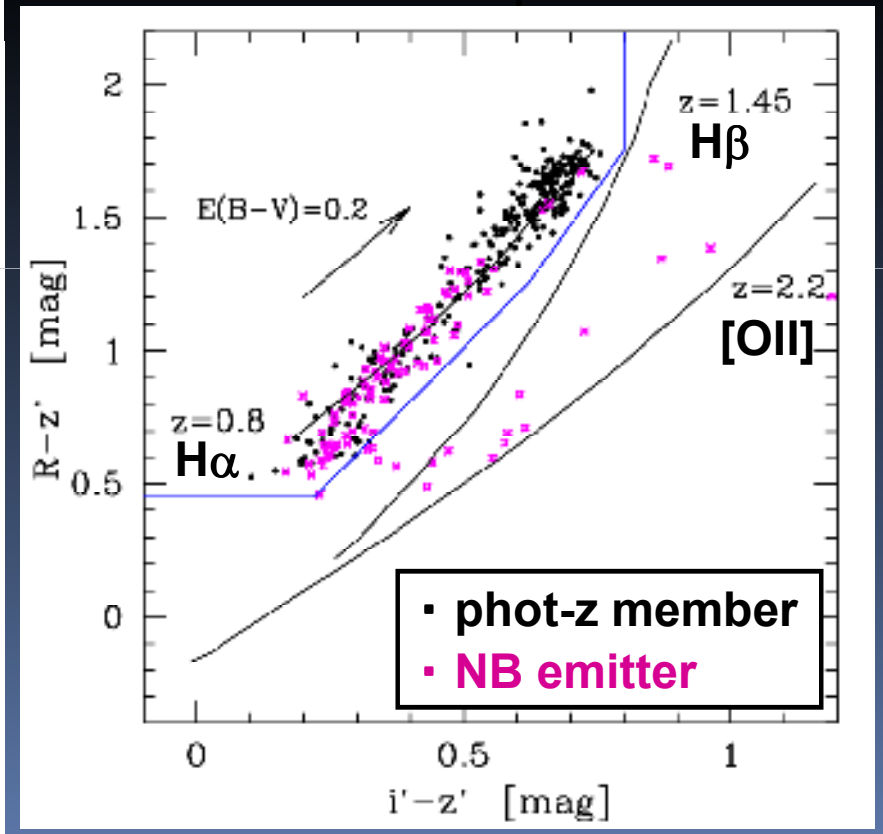
(Koyama et al. 2009, in prep)

Selecting Hα emitters at z=0.81

Hα emitters are selected in a normal way:

J-NB colour excess + appropriate broad-band colour

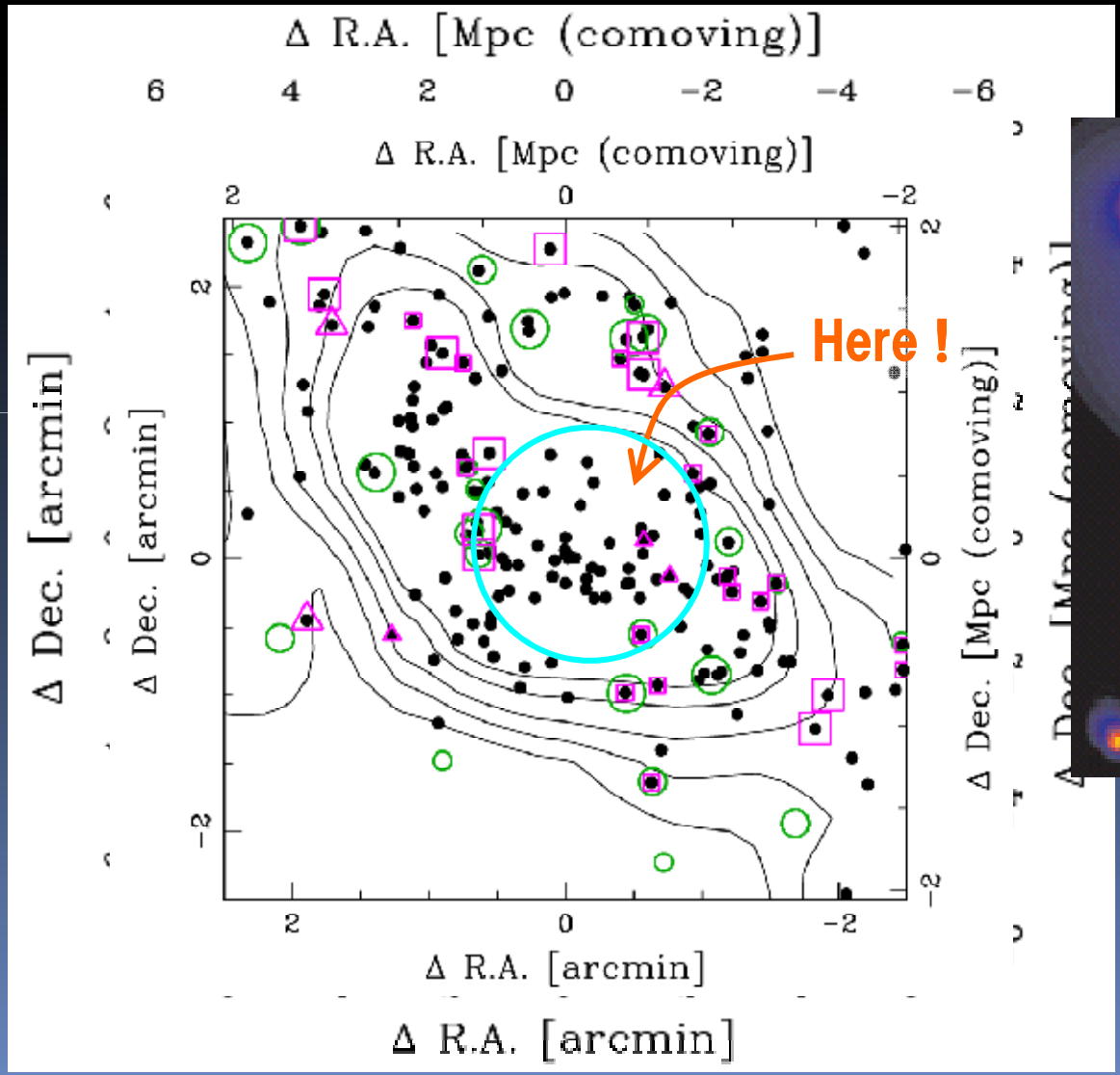


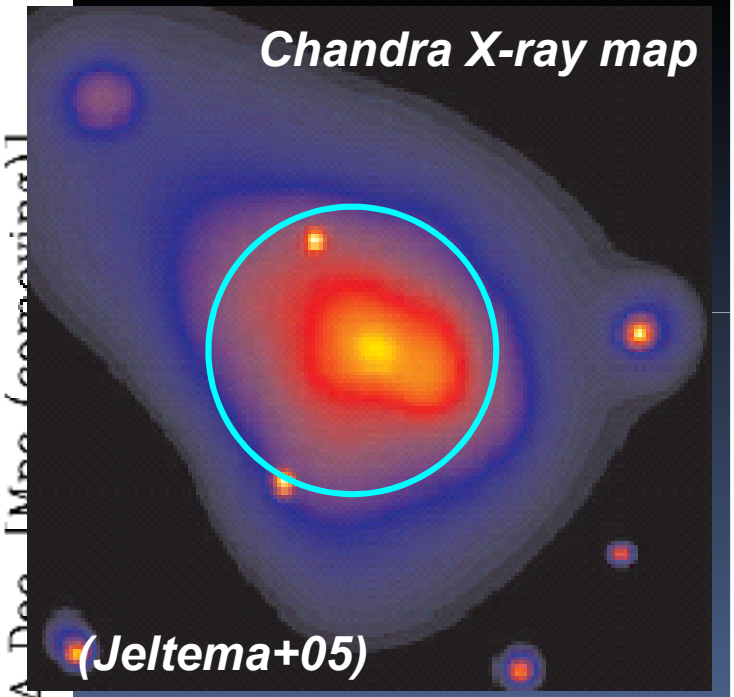


(Koyama et al. 2009, in prep)

Spatial distribution of the Ha emitters

Very similar to AKARI 15μm source (but direct overlap is not so many)

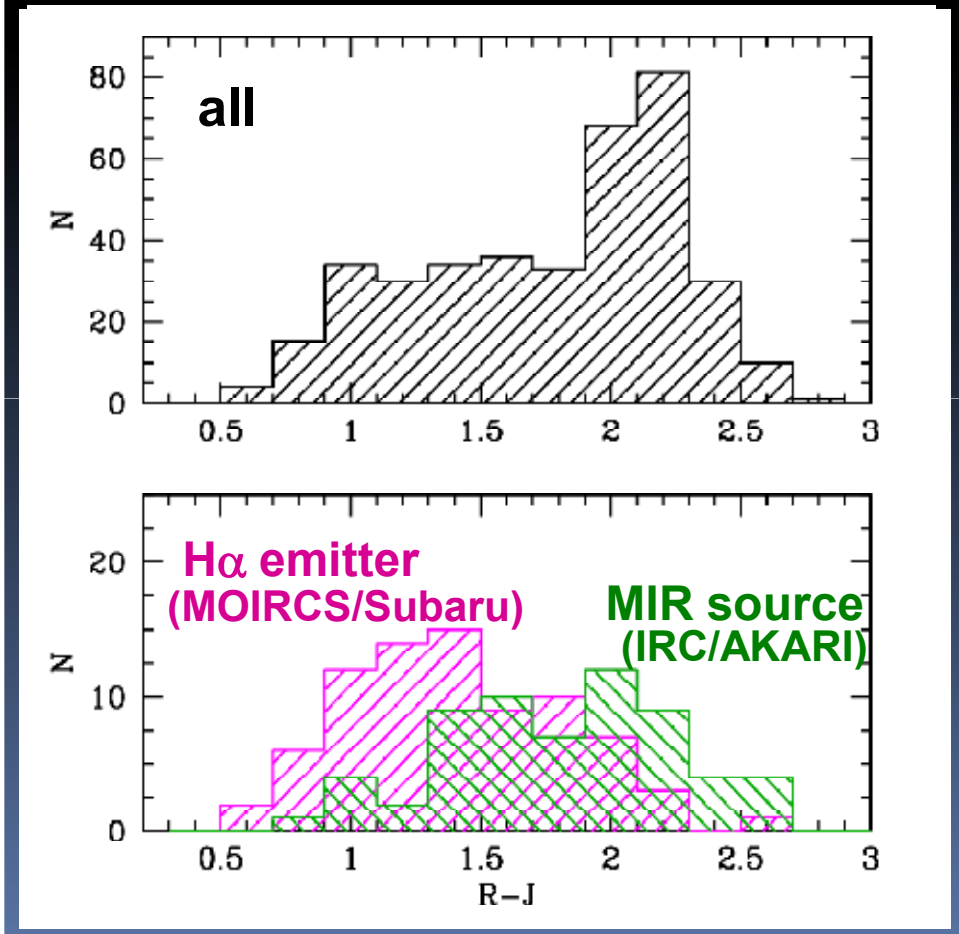


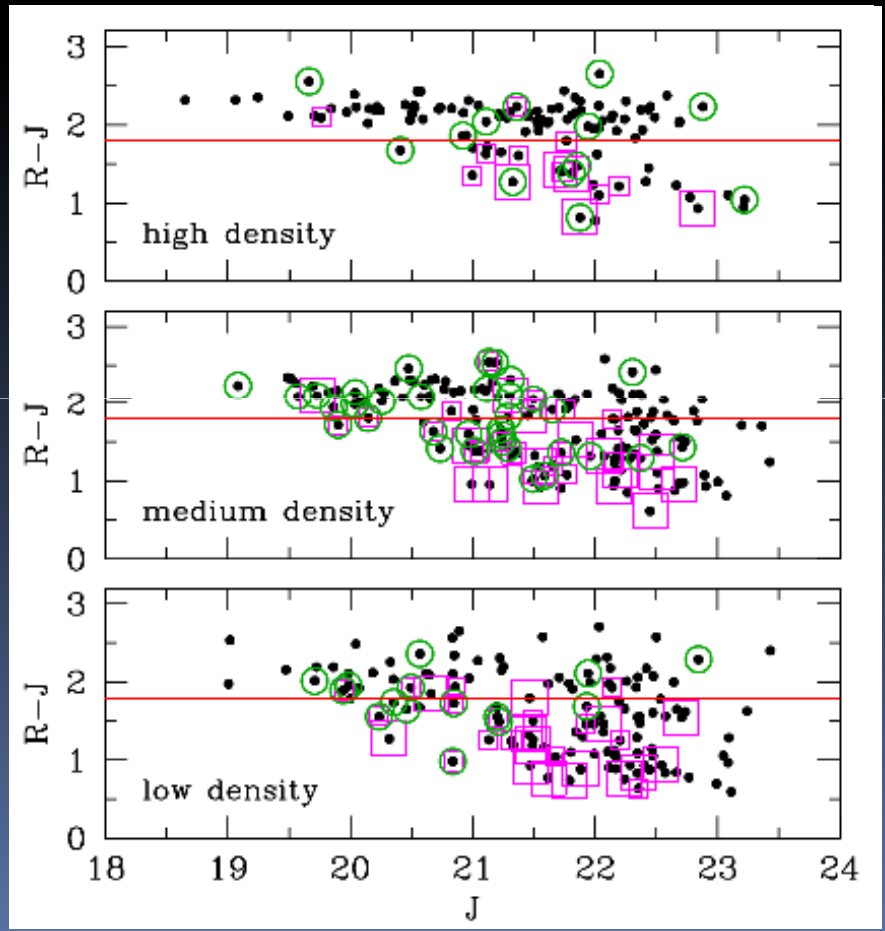


(Koyama et al. 2009)

Colours of Hα emitters

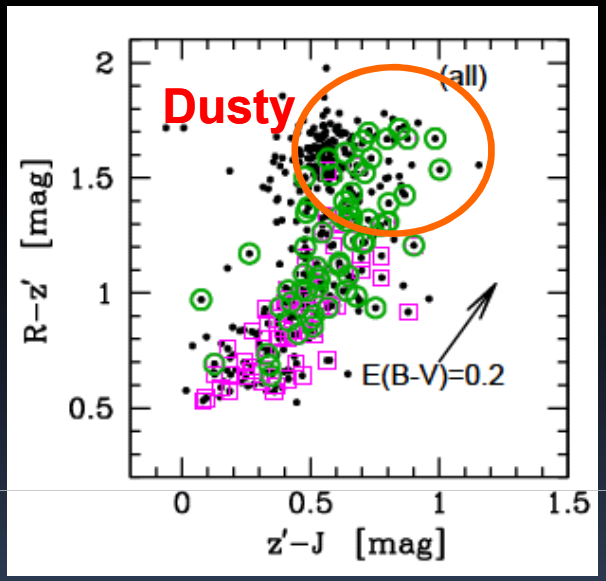
Hα emitters are mainly from blue galaxies. Red emitters are rare.

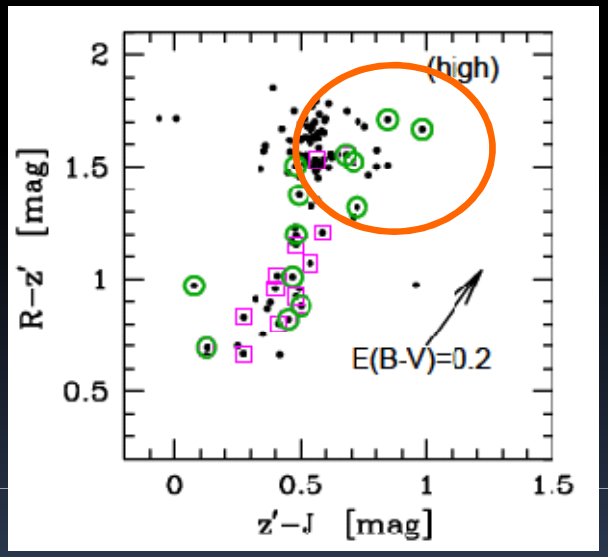


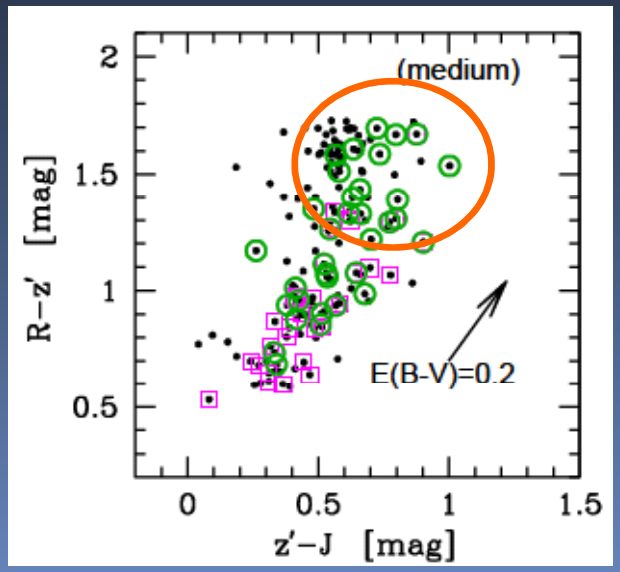


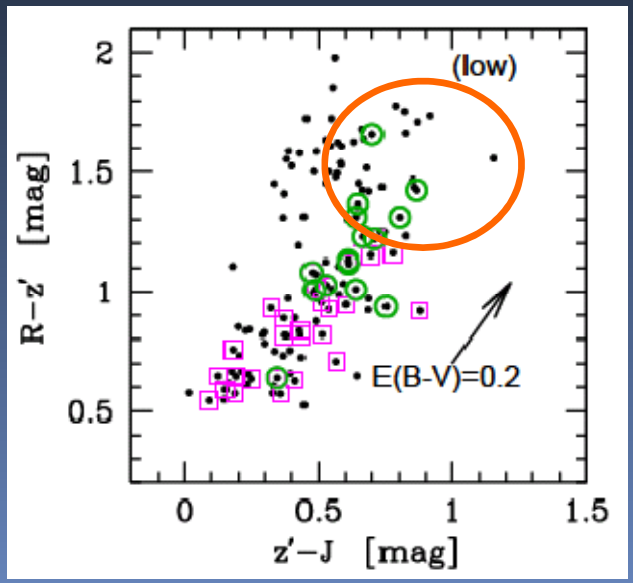
MIR galaxies are dusty and 'not' detected as strong Hα emitters

Colours of Hα emitters





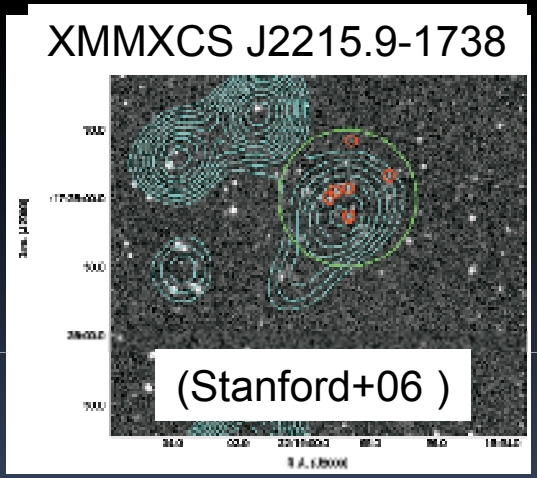


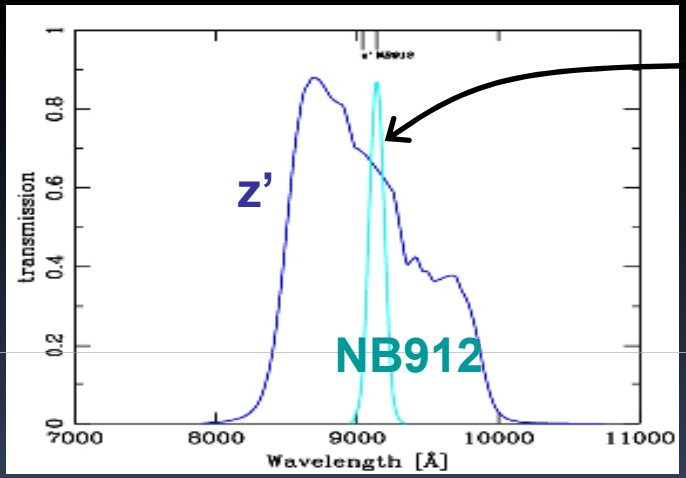


Going back to more distant Universe

A narrow-band [OII] imaging of XCS2215 cluster (@z=1.457) with Suprime-Cam

Most distant X-ray detected cluster ever known !





[OII] @ z=1.46

↓

NB912 filter on S-Cam
(λc=9139A, Δλ=134A)

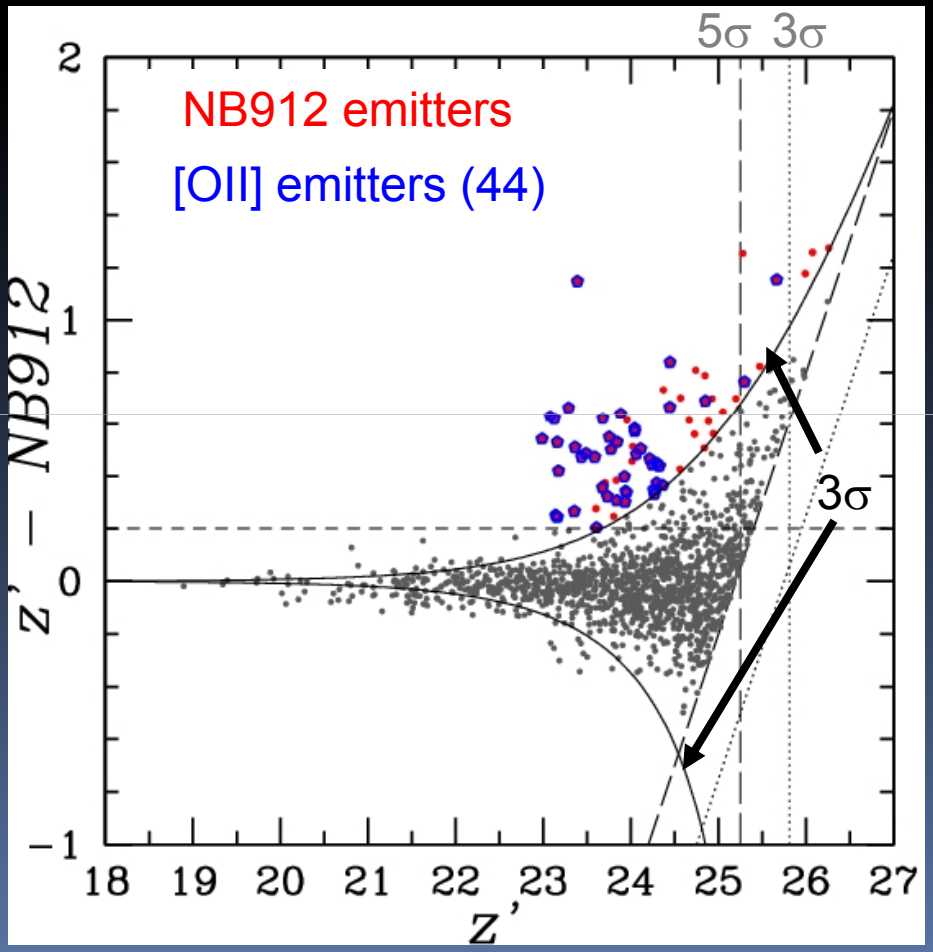
Hayashi et al. (2009), in prep.

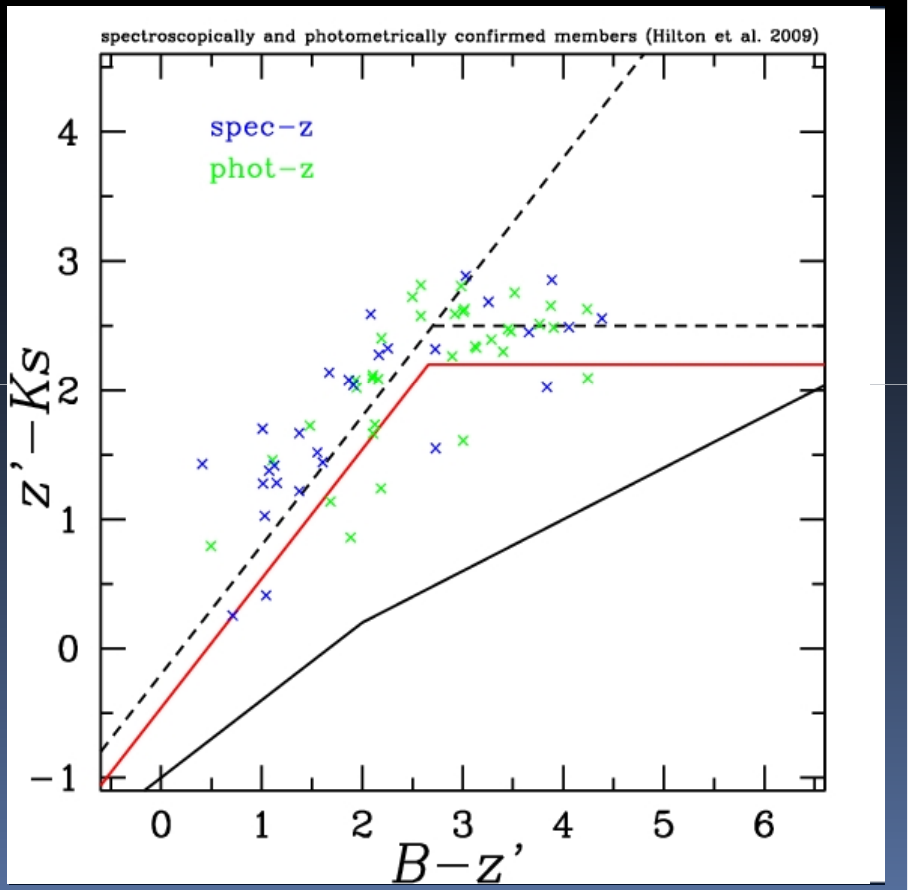
Poster A11

instruments	Suprime-Cam			MOIRCS	
passbands	B	z′	NB912	J	Ks
dates	2008. 07.30-31			2008. 06.30-07.01	
pointings	1			4	
FoV	32' x 23'			6.1' x 5.8'	
3σ mags	27.59	25.81	25.75	23.84-24.57	23.07-23.65
seeing	1.09"			1.09"	

Selection of [OII] emitters at z=1.46

z'-NB912 colour excess + broad-band colour (modified BzK this time)





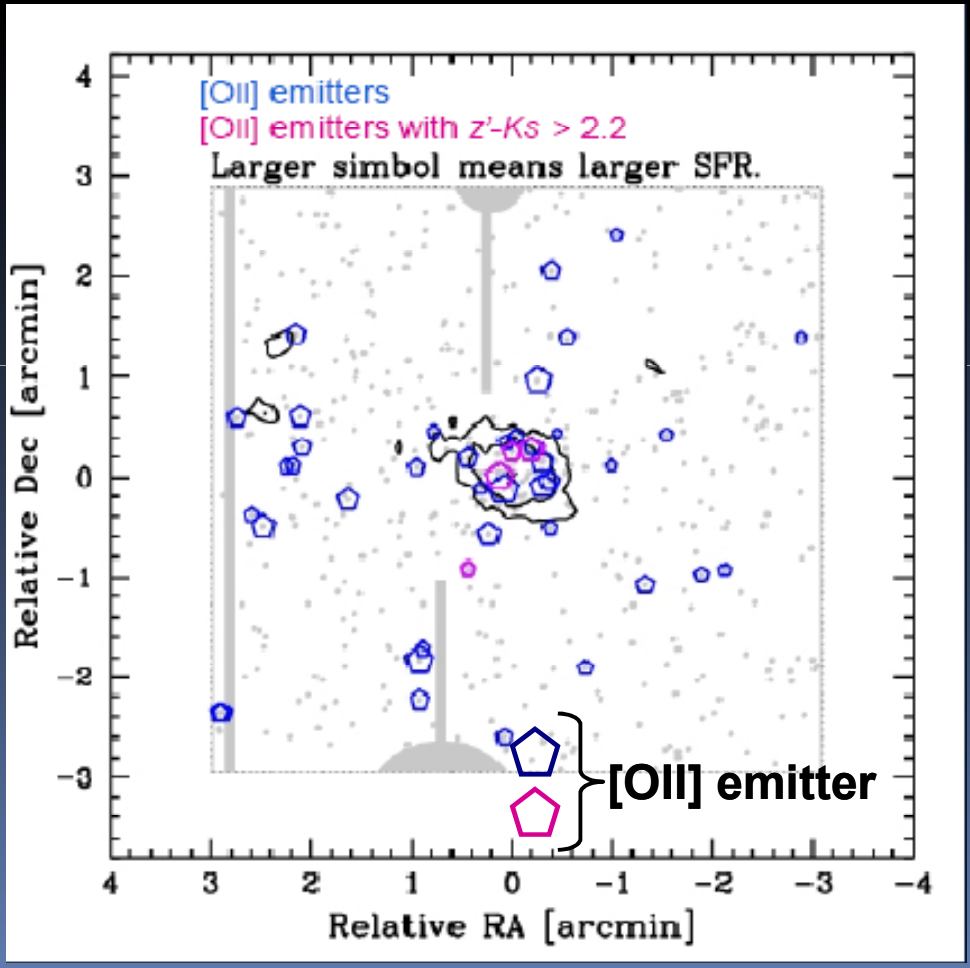
SFR ([OII]) > 2.6 M⊙/yr

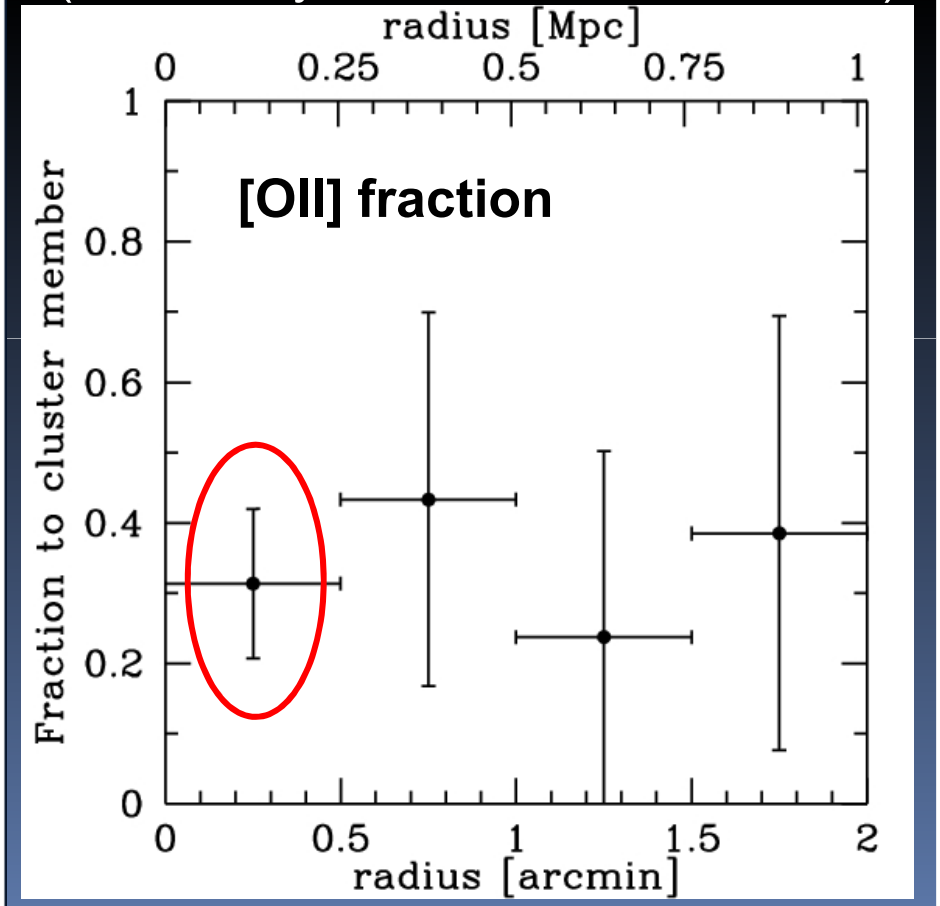
Hayashi et al. (2009), in prep.

Spatial distribution of the [OII] emitters

High star formation activity even in the very centre of the cluster !

(some may be AGN contamination)

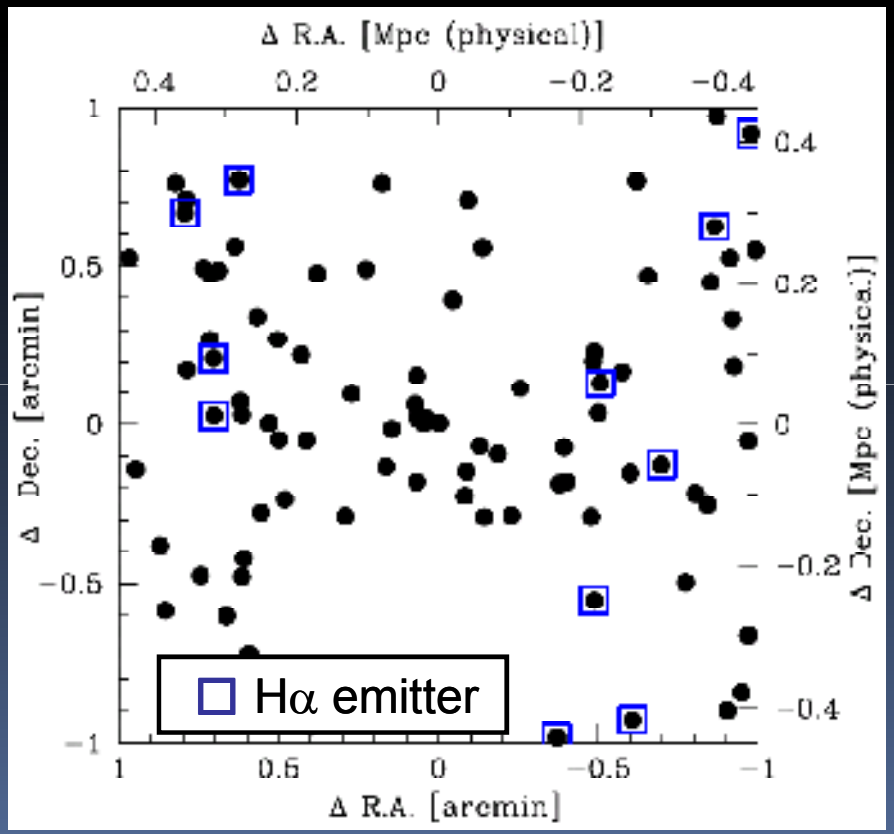




Hayashi et al. (2009), in prep.

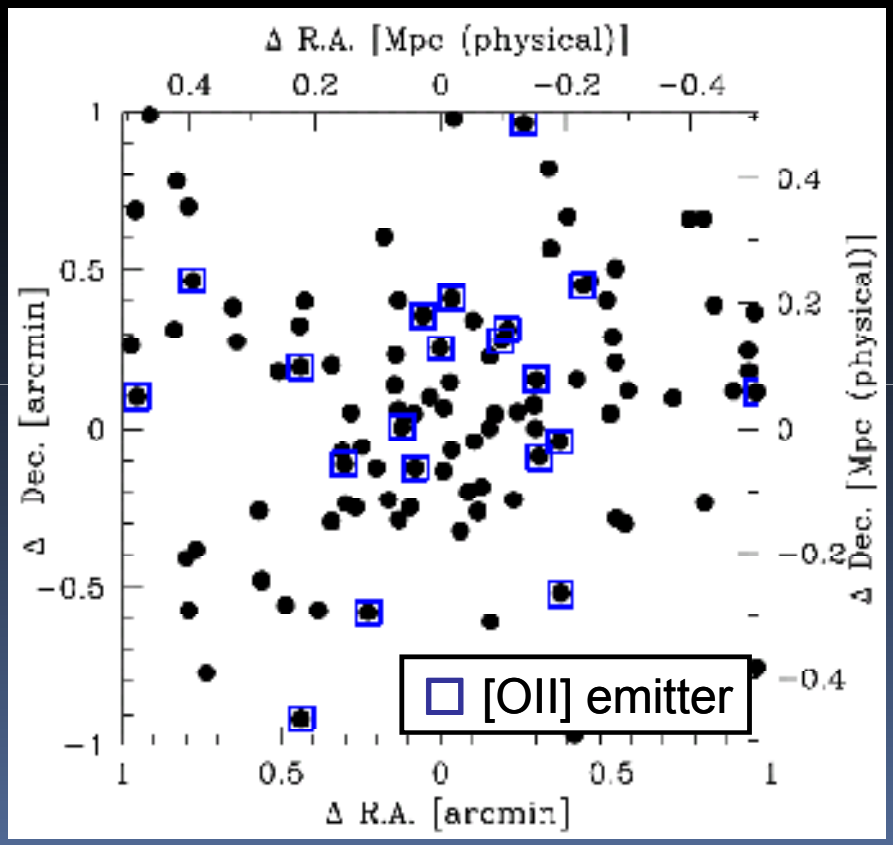
Cluster evolution from z=1.5 → z=0.8?

Hα emitters at z=0.81 (RXJ1716)



Koyama et al. (2009)

[OII] emitters at z=1.46 (XCS2215)



Hayashi et al. (2009)

Propagation of SF site? (cluster core at z=1.5 → outskirts at z=0.8)

(Need more sample to arrive at firm conclusion)

Summary

We are now approaching the cluster formation epoch .
Recent progresses of PISCES project are …

■ **Large-scale structures in the distant Universe**

- Prominent large-scale structure at all redshifts
- Discovery of a gigantic structure at z=0.5

■ **Starbursts in cluster outskirts/groups/filaments at z~0.8**

- galaxy transition in cluster outskirts accompanying starbursts
- Large amount of SF is hidden in optical light (even Ha ?)

■ **SF activity is high even in the cluster core at z~1.5**

- Galaxies are still active in cluster core (many [OII] emitters)
- Evidence for dramatic cluster evolution from z~1.5 → z~0.8 ?

Panoramic View of Ama-no-Hashidate (North Kyoto)