Subaru GLAO workshop @ Hokkaido Univ., 14/6/2013

Environmental Effects on Galaxy Dynamics and Star Formation in the Distant Universe

MAHALO-Subaru collaboration

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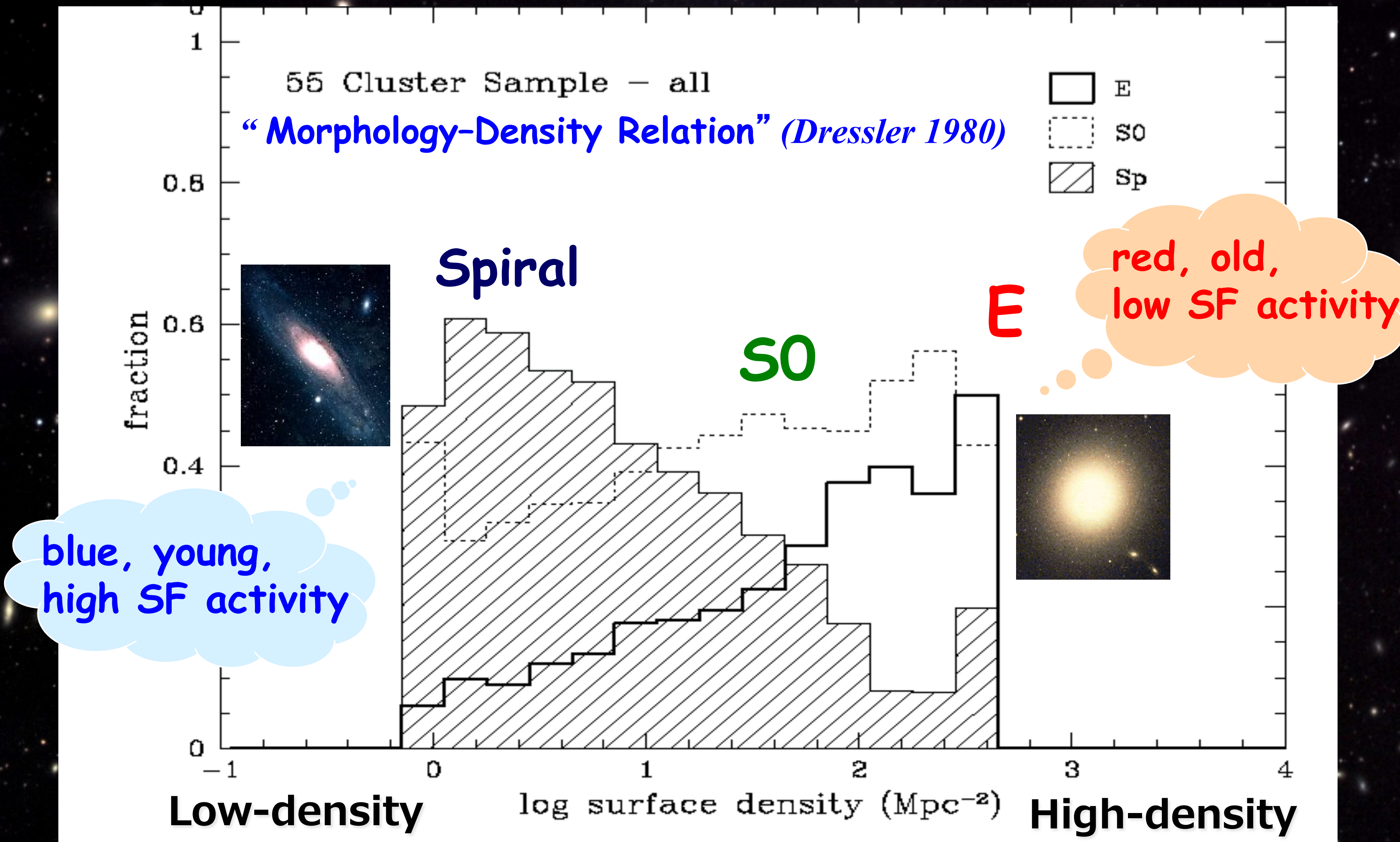
Outline

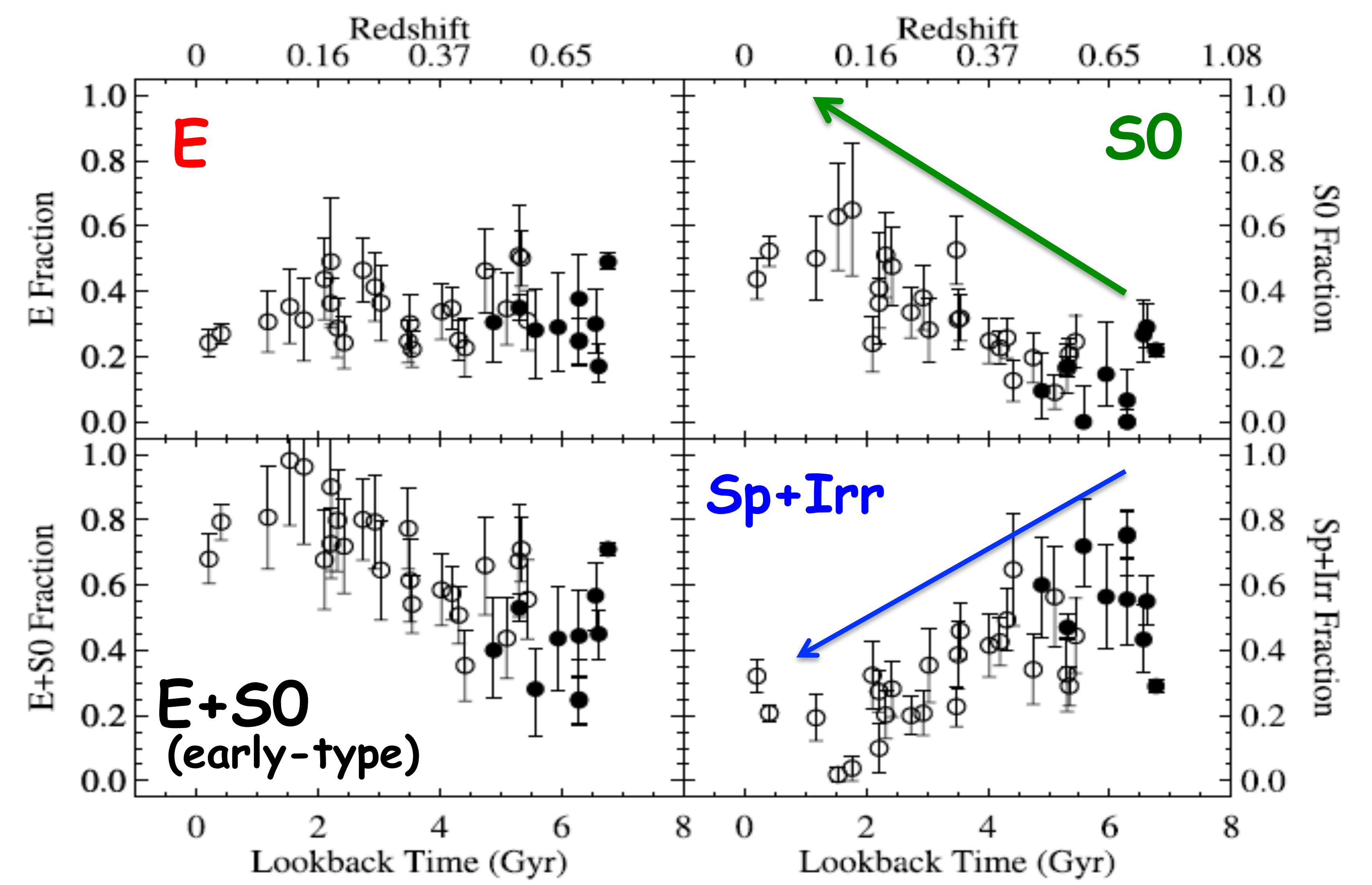
1. Background
2. Our approach: *MAHALO-Subaru*
3. Key Results from MAHALO
4. Future with Subaru+GLAO

Galaxy Clusters: filled with red & dead early-types



Coma cluster @ z=0.02

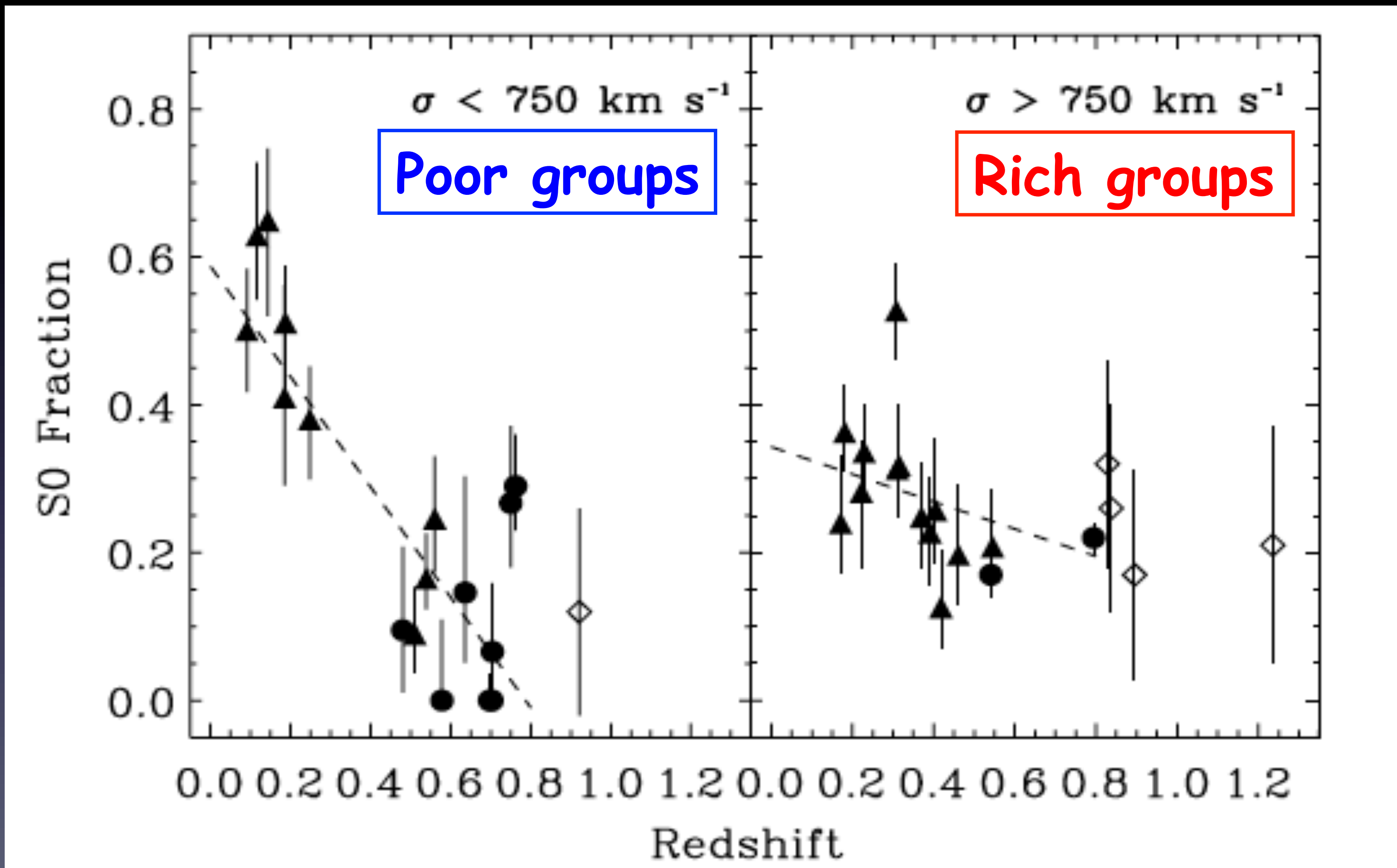
Morphology evolution in clusters



(Desai et al. 2007)

Group environment is the key ?

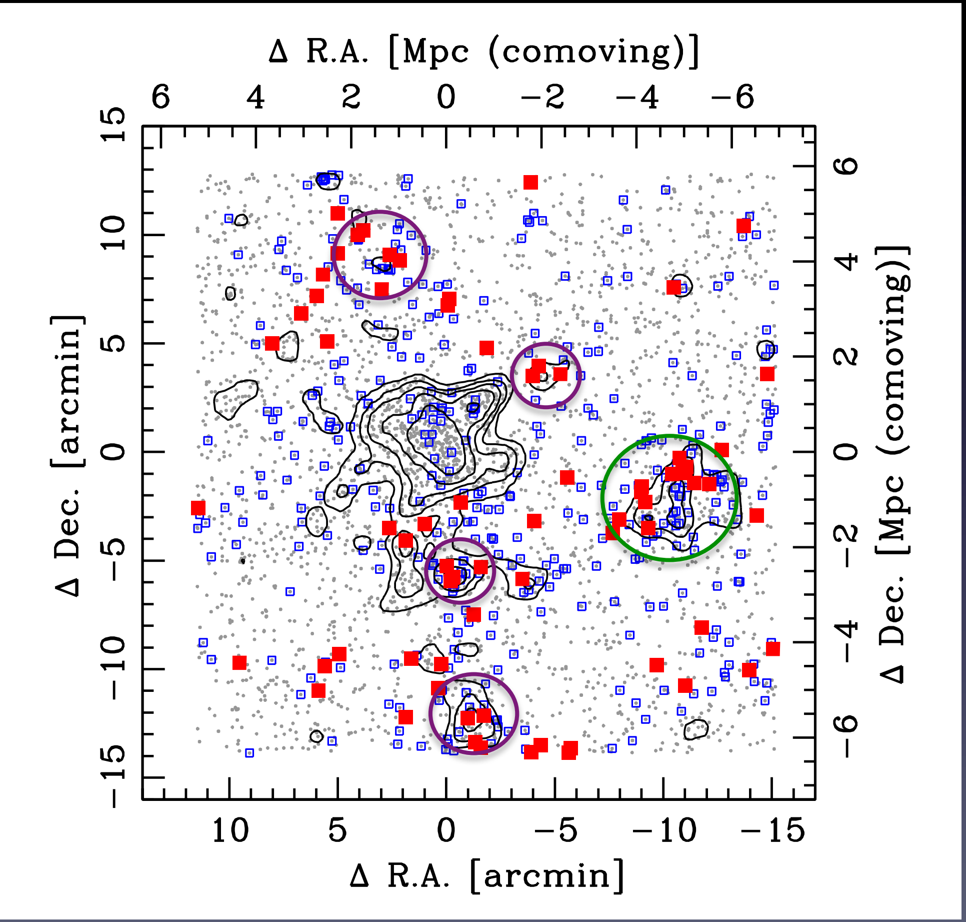
"Poor groups" are likely the major sites of S0 galaxy formation.

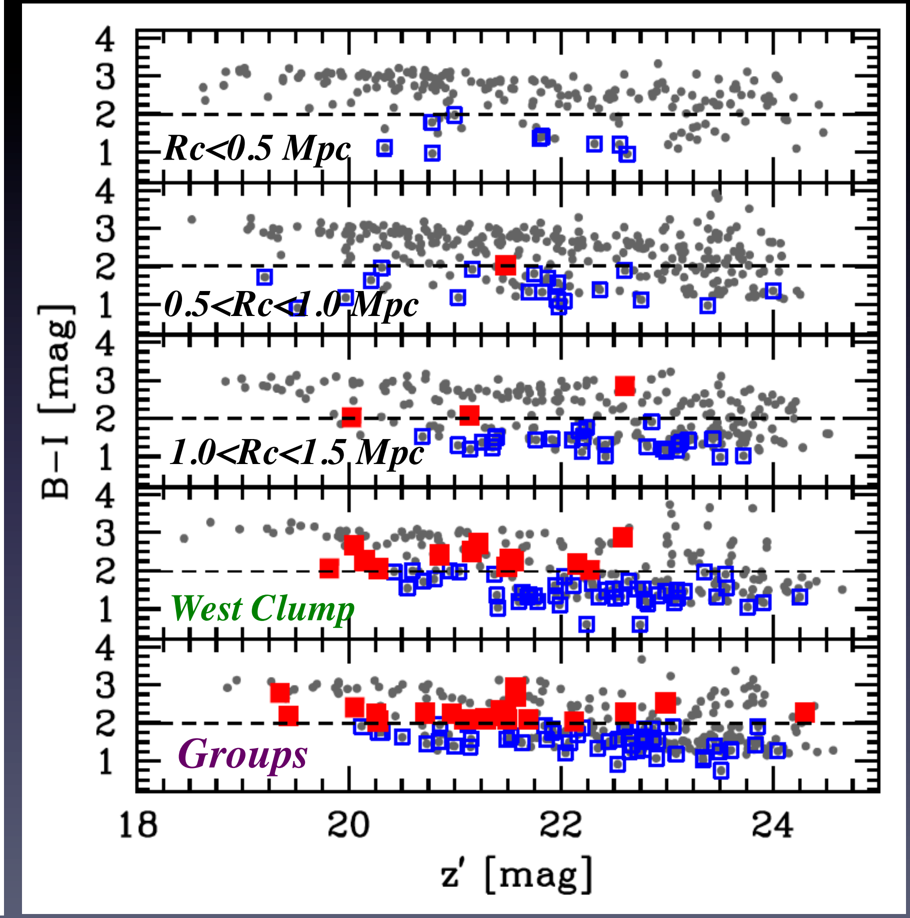


(Just et al. 2010)

Dusty galaxies in groups: S0 progenitors?

Our panoramic Hα survey with S-Cam (NB921) of Abell851 cluster at z=0.4 revealed a large number of red SF galaxies in cluster surrounding groups.



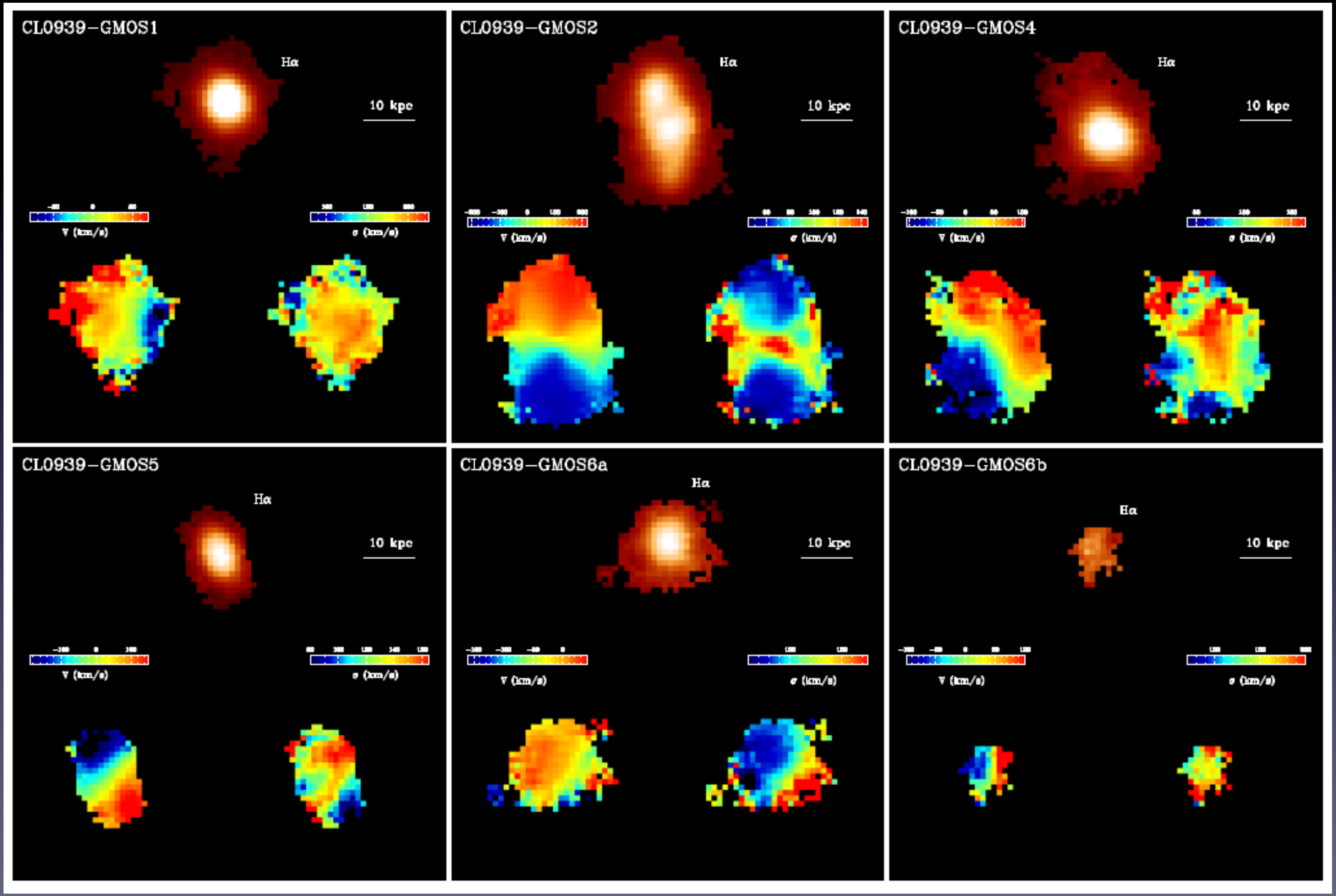


■:red Hα emitter (B-I>2)
□:blue Hα emitter (B-I<2)

(Koyama et al. 2011)

Dusty galaxies show "disk" kinematics

Further supporting our idea that red Hα emitters are S0 progenitors.



Dusty galaxies show “disk” kinematics

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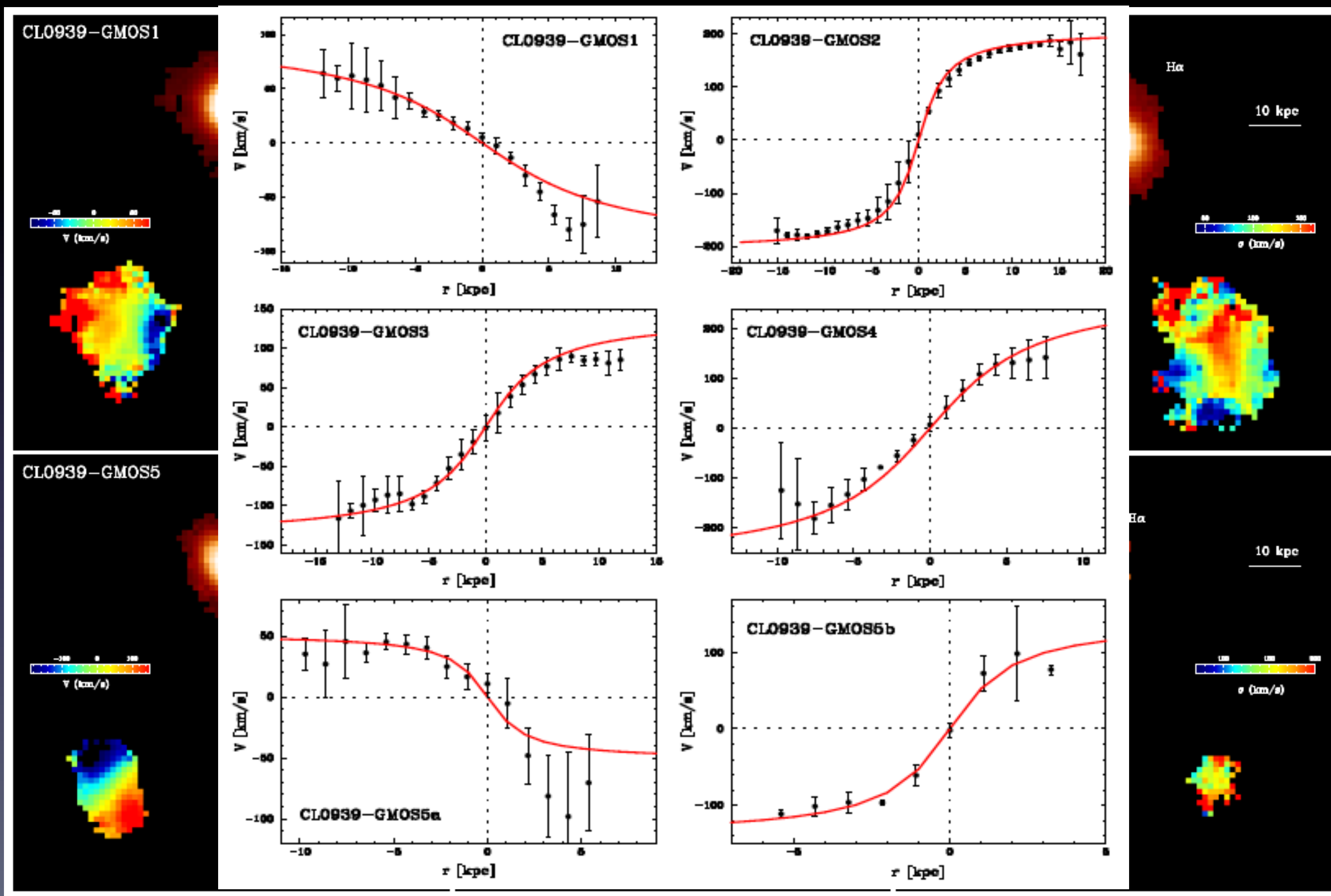


MAHALO-Subaru project

MApping H-Alpha and Lines of Oxygen with Subaru

Narrow-band Ha/[OII] emission-line survey for 0.4<z<2.5

environ-ment	target	z	line	λ (μm)	camera	NB-filter	conti-nuum	status (as of Nov 2011)
Low-z cluster	CL0024+1652	0.395	Hα	0.916	Suprime-Cam	NB912	z'	Kodama+'04
	CL0939+4713	0.407	Hα	0.923	Suprime-Cam	NB921	z'	Koyama+'11
	RXJ1716+6708	0.813	Hα	1.190	MOIRCS	NB1190	J	Koyama+'10
			[O II]	0.676	Suprime-Cam	NA671	R	observed
High-z cluster	XCSJ2215–1738	1.457	[O II]	0.916	Suprime-Cam	NB912, NB921	z'	Hayashi+'10,11
	4C65.22	1.516	Hα	1.651	MOIRCS	NB1657	H	observed
	Q0835+580	1.534	Hα	1.664	MOIRCS	NB1657	H	observed
	CL0332–2742	1.61	[O II]	0.973	Suprime-Cam	NB973	y	observed
	ClGJ0218.3–0510	1.62	[O II]	0.977	Suprime-Cam	NB973	y	Tadaki+'12
Proto-cluster	PKS1138–262	2.156	Hα	2.071	MOIRCS	NB2071	K_s	Koyama+'13a
	4C23.56	2.483	Hα	2.286	MOIRCS	NB2288	K_s	Tanaka+'11
	USS1558–003	2.527	Hα	2.315	MOIRCS	NB2315	K_s	Hayashi+'12
General field	GOODS-N	2.19	Hα	2.094	MOIRCS	NB2095	K_s	Tadaki+'11a
	(62 arcmin^2)		[O II]	1.189	MOIRCS	NB1190	J	observed
	SXDF	2.19	Hα	2.094	MOIRCS	NB2095	K	Tadaki+ in prep.
	(110 arcmin^2)		Hβ	1.551	MOIRCS	NB1550	H	not yet
			[O II]	1.189	MOIRCS	NB1190	J	not yet

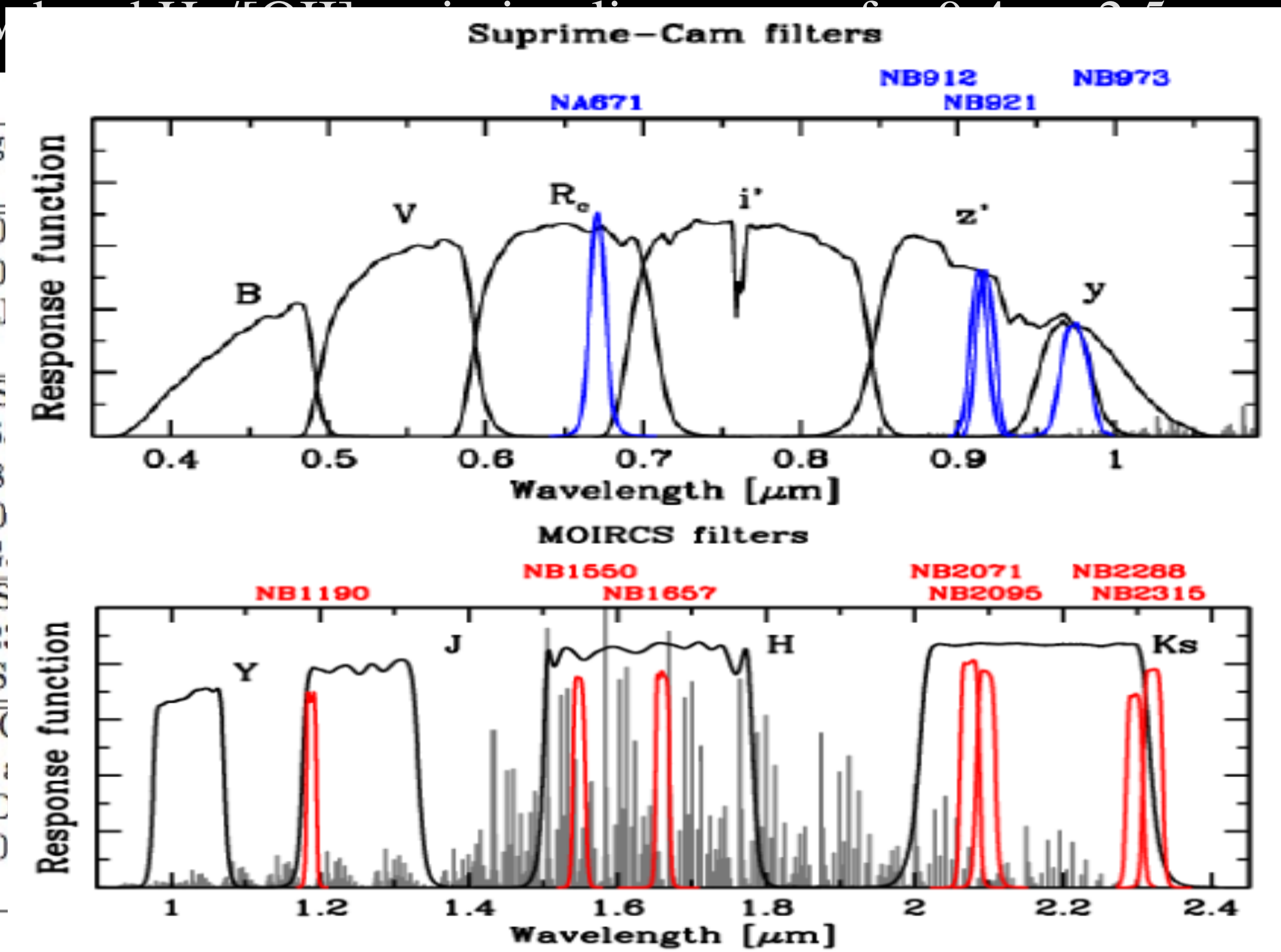
Collaborators: T.Kodama (PI), M.Hayashi, K.Tadaki, I.Tanaka, R.Shimakawa

MAHALO-Subaru project

MApping H-Alpha and Lines of Oxygen with Subaru

Narrow

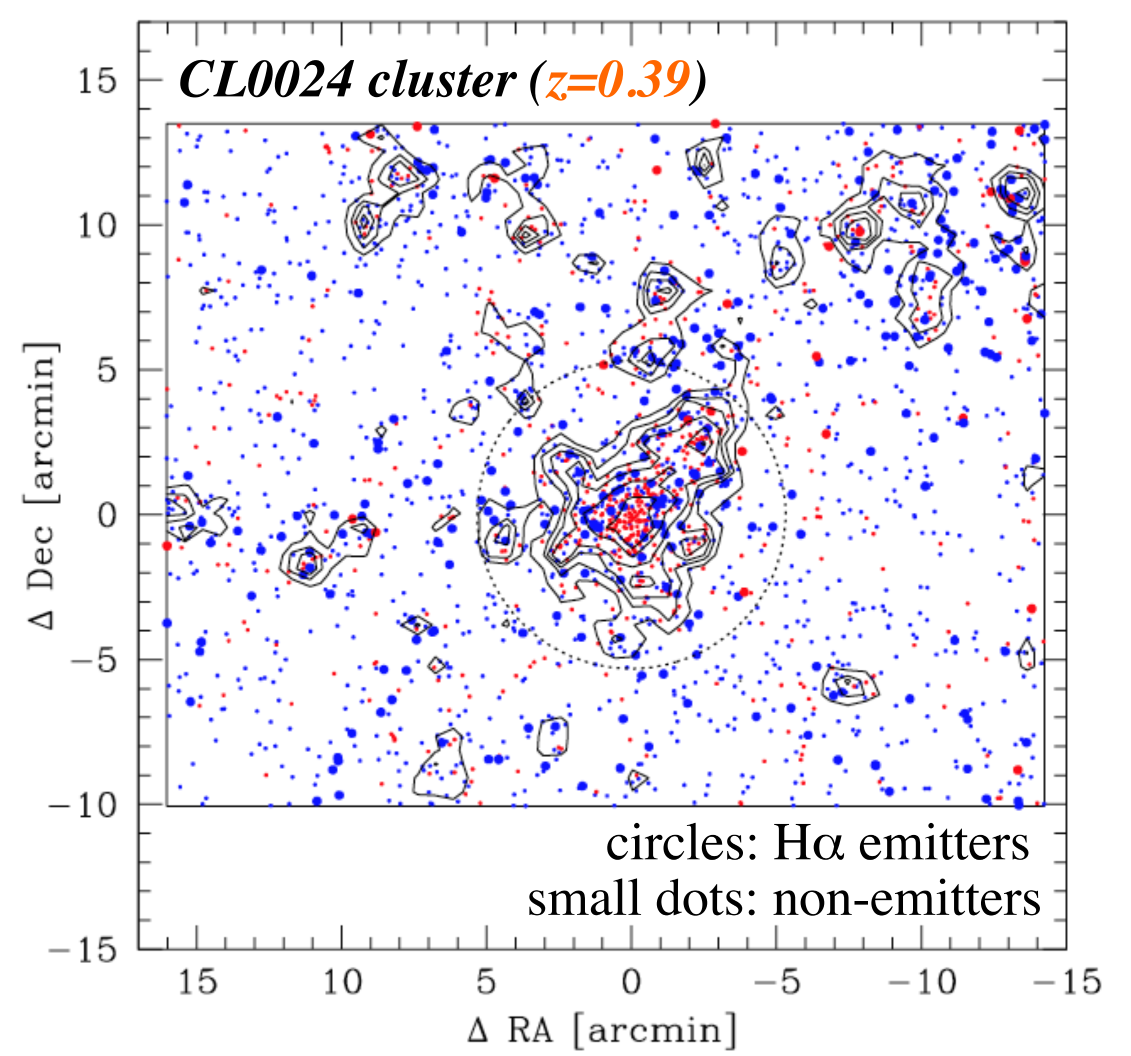
environ-ment	targ	atus (as of Nov 2011)
Low-z cluster	CL0 CL0 RXJ	odama+'04 oyama+'11 oyama+'10 bserved
High-z cluster	XCS 4C6 Q08 CL0 ClG	ayashi+'10,11 bserved bserved bserved adaki+'12
Proto-cluster	PKS 4C2 USS	oyama+'13a anaka+'11 ayashi+'12
General field	GOO (62 SXD (110	adaki+'11a bserved adaki+ in prep. ot yet ot yet

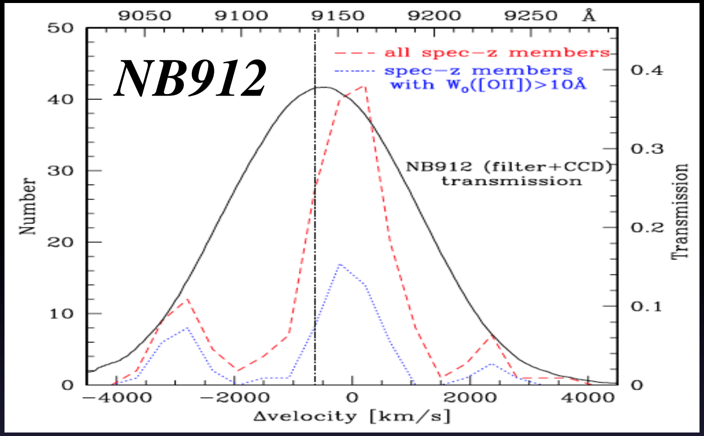


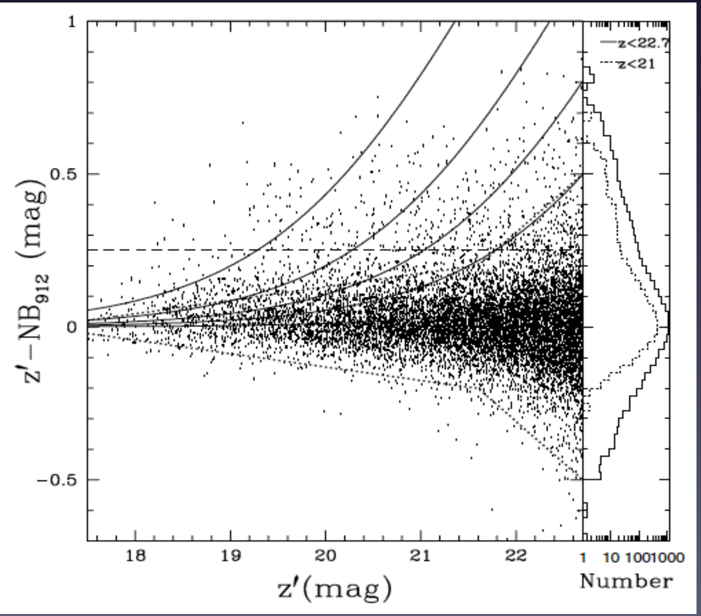
Collaborators: T.Kodama (PI), M.Hayashi, K.Tadaki, I.Tanaka, R.Shimakawa

Wide-field + NB imaging approach

A very effective way to construct a big SF galaxy sample across environments.



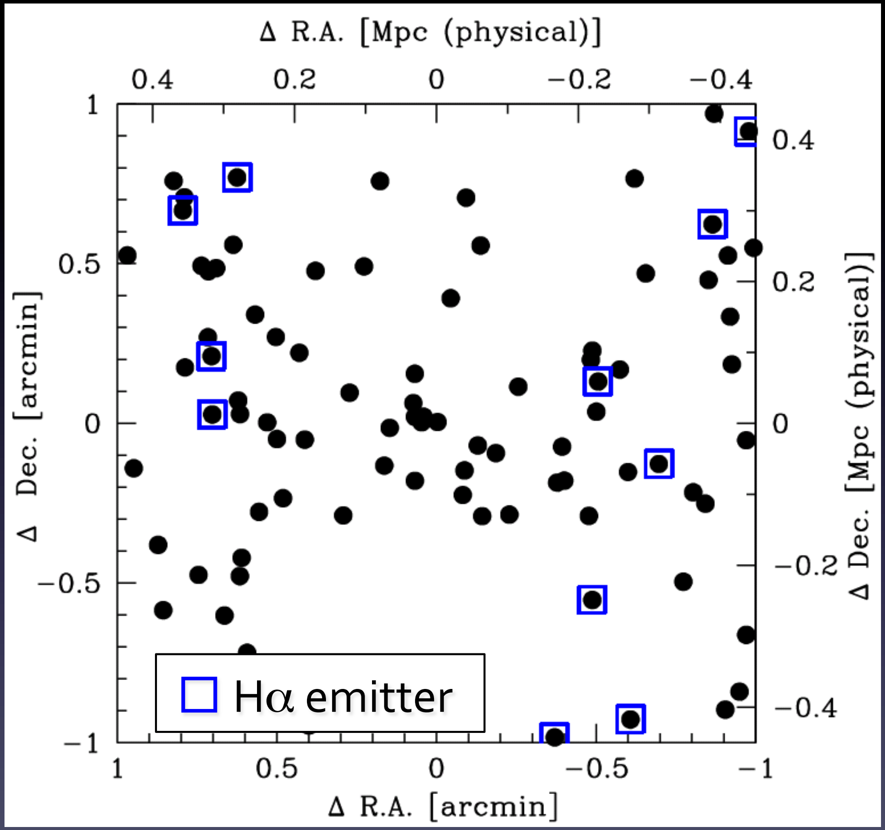




(Kodama, Balogh, et al. 2004)

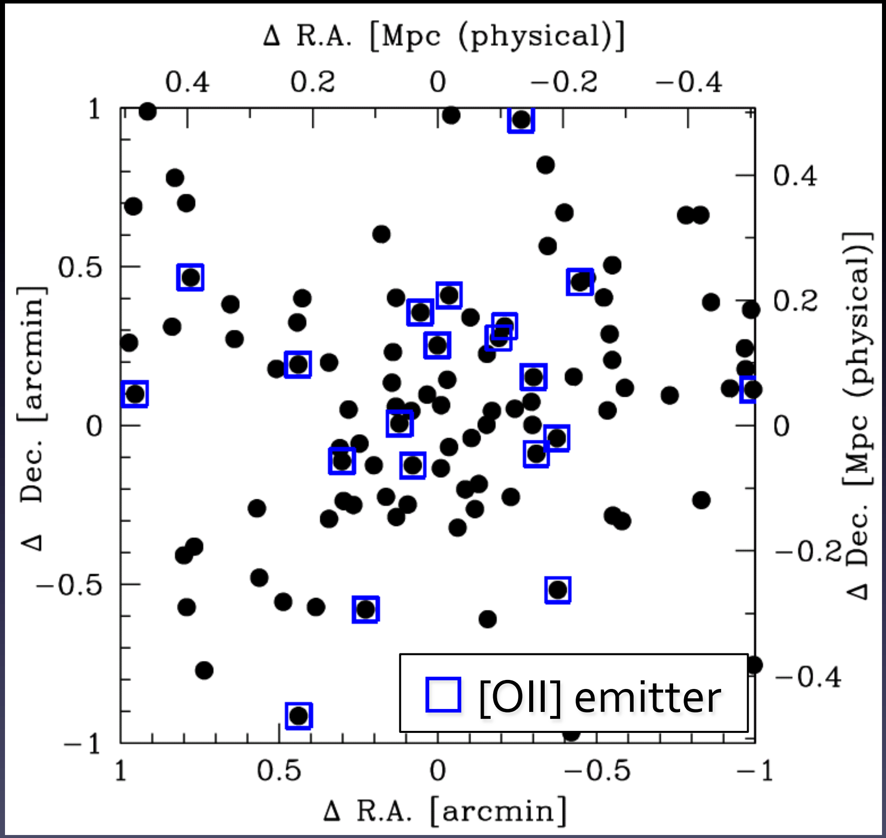
Big change at z~1.5 ?

Hα emitters at z=0.81 (RXJ1716)



Koyama et al. (2010)

[OII] emitters at z=1.46 (XCS2215)



Hayashi et al. (2010)

Active SF site changes from cluster core (z=1.5) to outskirts (z=0.8) ?

Galaxy clusters at z>1.5

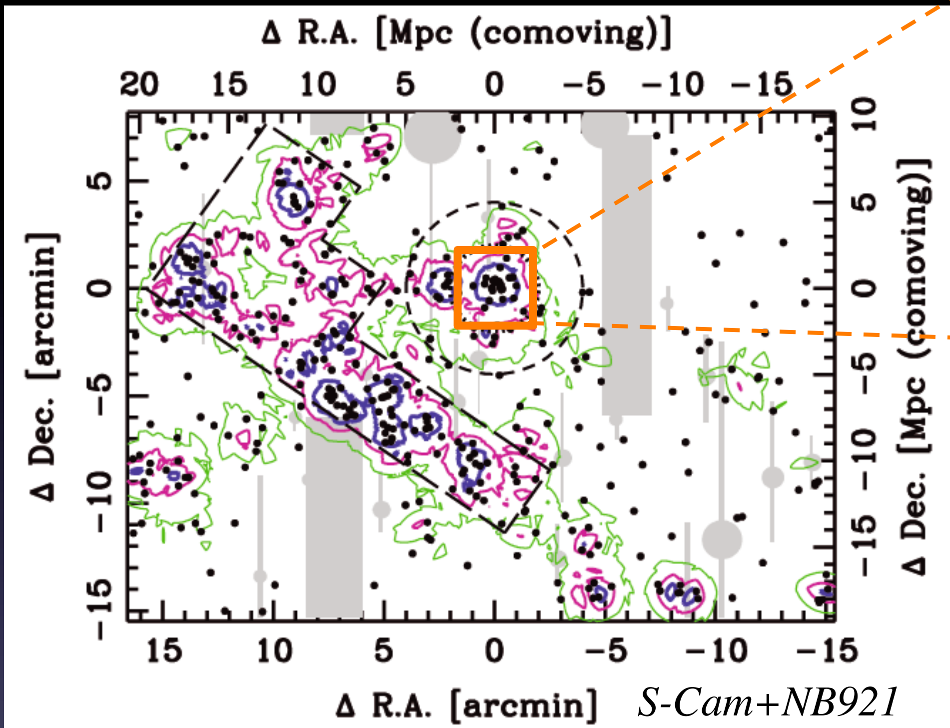
Spec-z confirmed & X-ray detected clusters only

(candidates are much more – apologize if I miss some recent discoveries…)

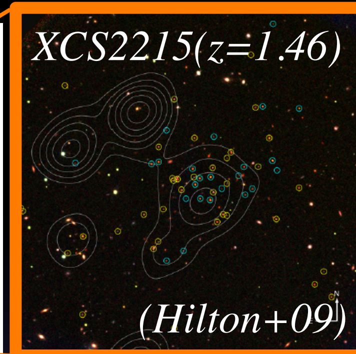
CL J1449+0856	z=2.00	Gobat et al. (2011; 2013)
IDCS J1426.5+3508	z=1.75	Stanford et al. (2012)
XMMU J105324+572348	z=1.75	Henry et al. (2010)
ClG J0218.3-0510	z=1.62	Papovich et al. (2010), Tanaka et al. (2010)
XMMU J0044.0-2033	z=1.58	Santos et al. (2011)
XMM J1007+1237	z=1.56	Fassbender et al. (2011)
XMMU J0338.8+0021	z=1.49	Nastasi et al. (2011)
XMMXCS J2215.9-1738	z=1.46	discovery by Stanford et al. (2006)

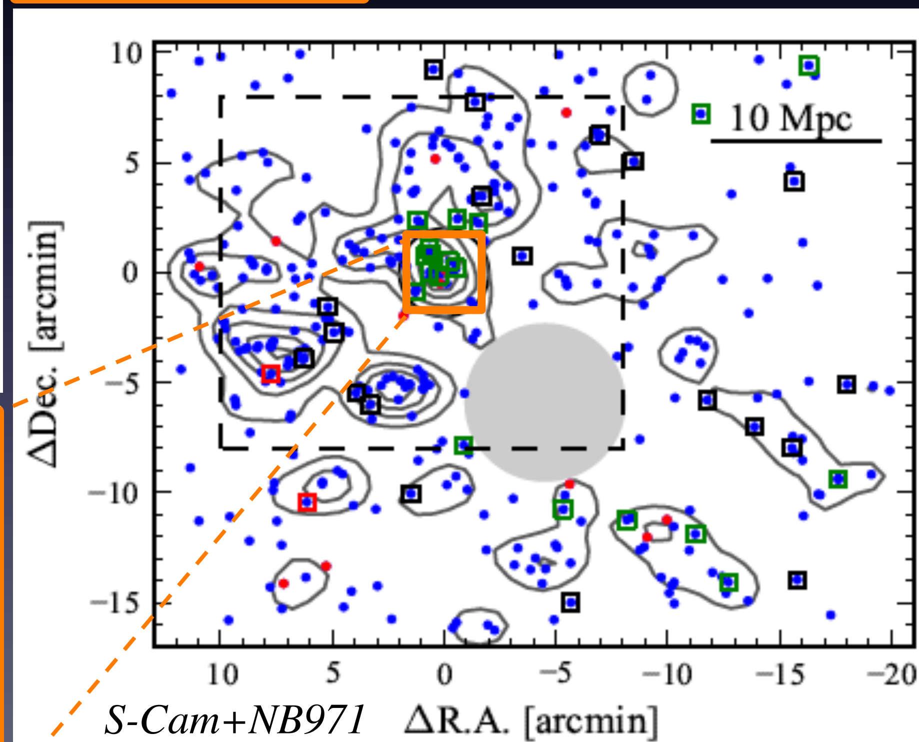
Large-scale structures at z~1.5

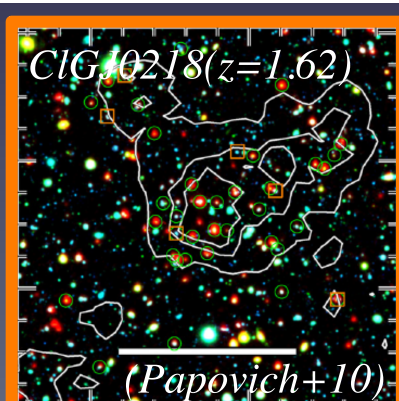
S-Cam [OII] emitter survey revealed ~20Mpc-scale filament at z~1.5



Hayashi et al. (2011)

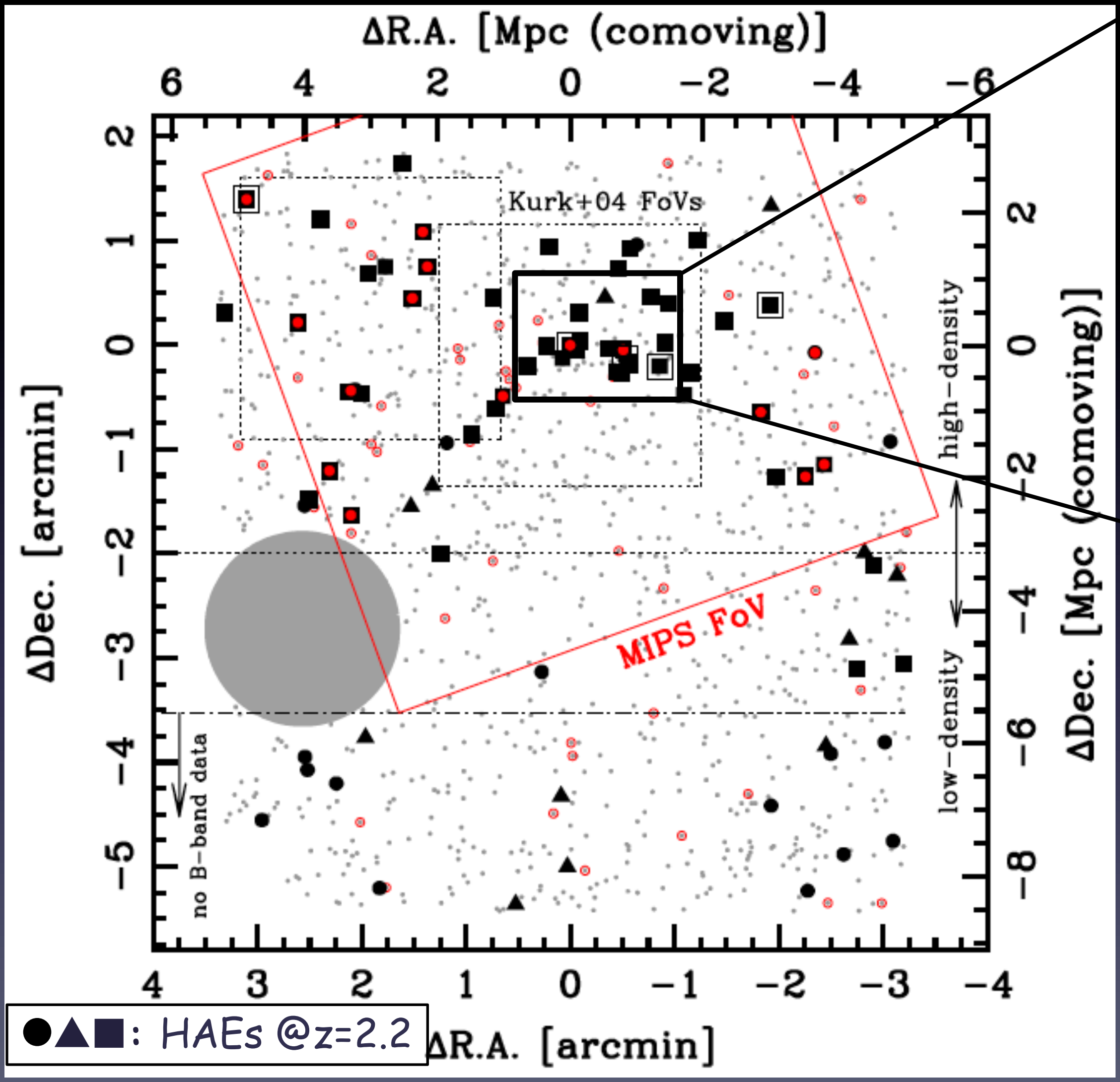


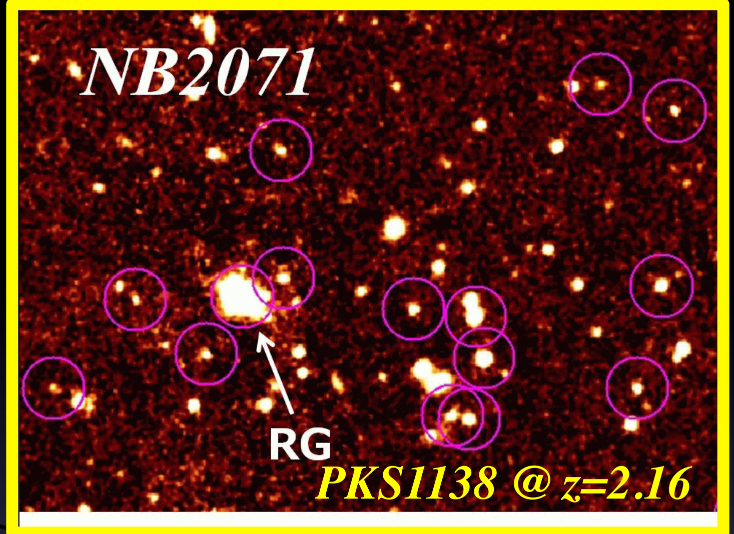


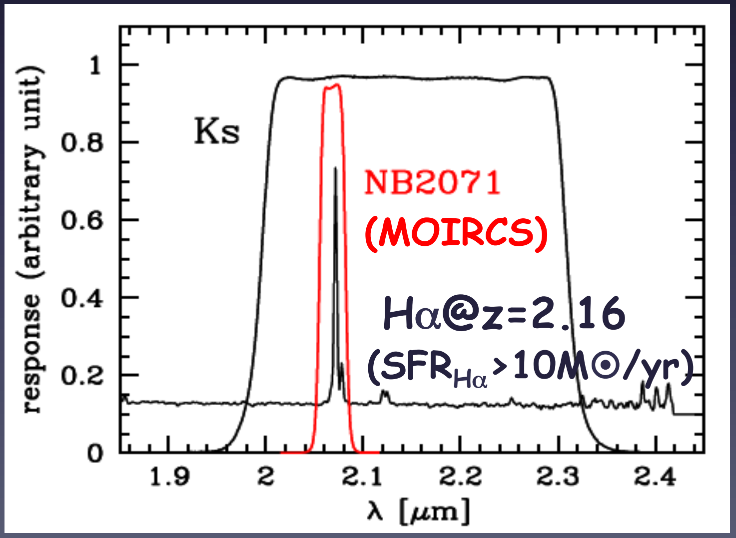


Tadaki et al. (2012)

Hα mapping of z~2 proto-clusters

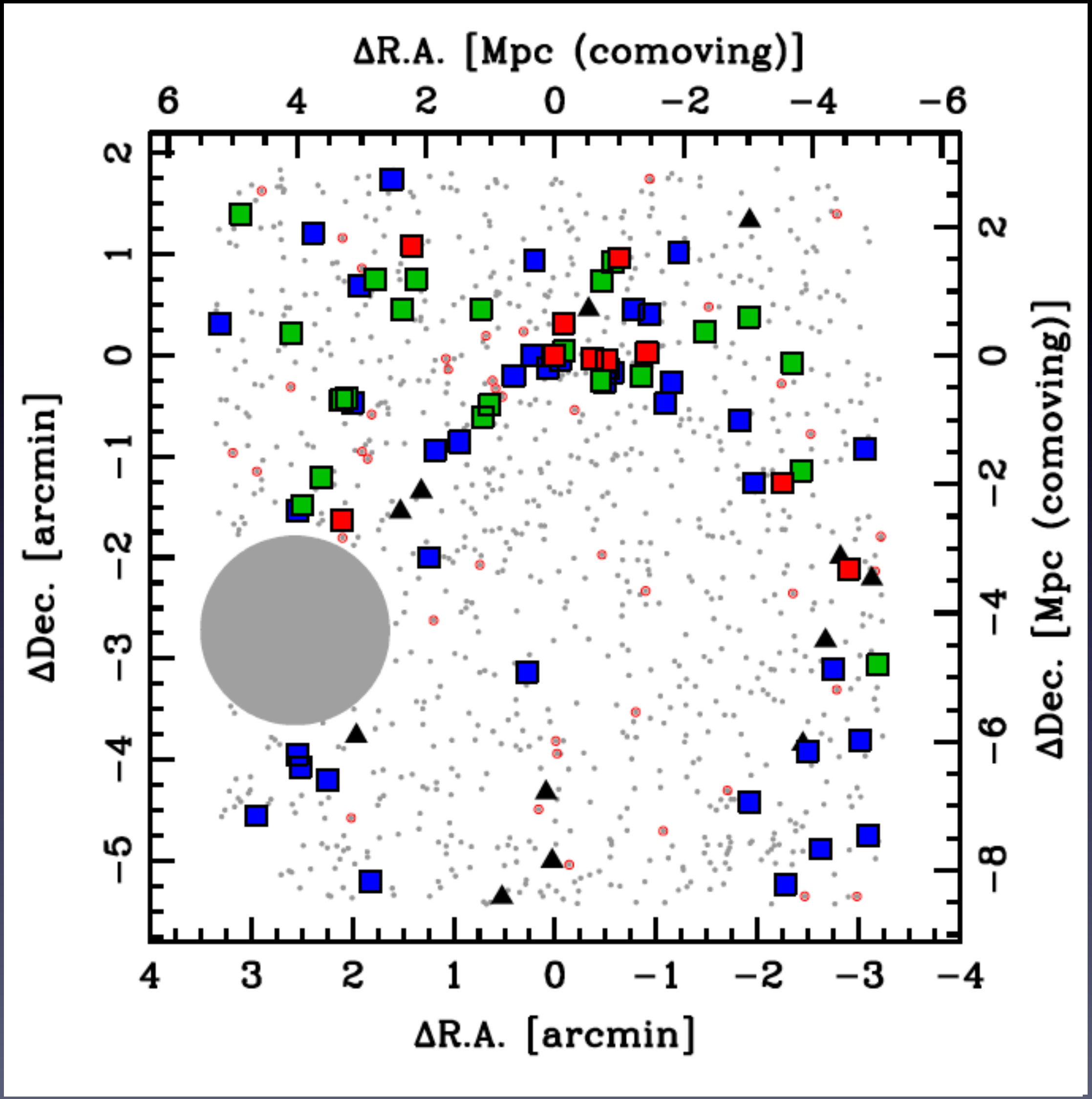






(Koyama et al. 2013a)

"Massive starbursts" in proto-cluster

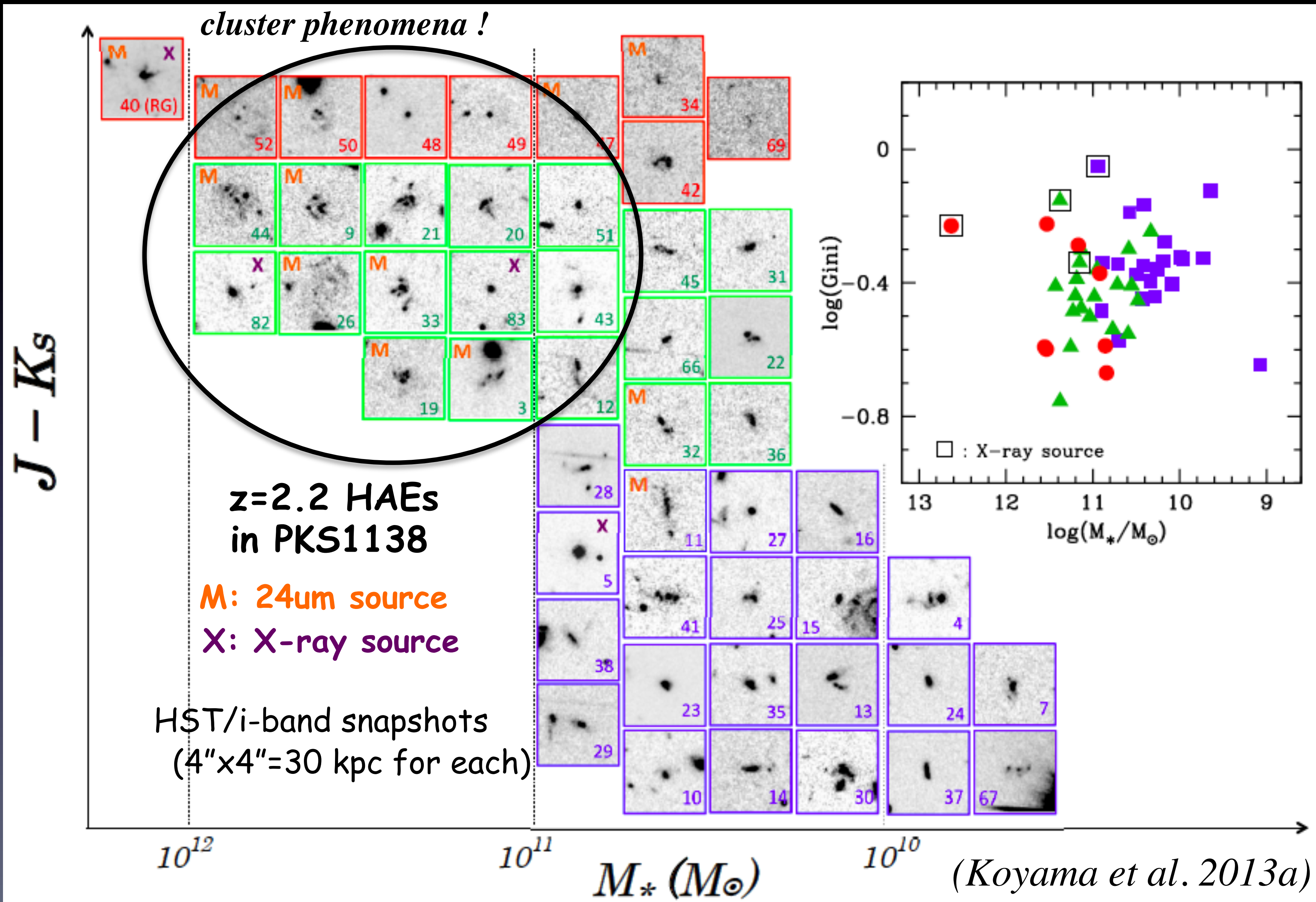


SF galaxies in the proto-cluster show redder colours and higher M* (>10^{11}M⊙) compared to general field galaxies.

■ : red HAE (J-KAB>1.38, DRG)
■ : green HAE (0.8<J-KAB<1.38)
■ : blue HAE (J-KAB<0.8)

(Koyama et al. 2013a)

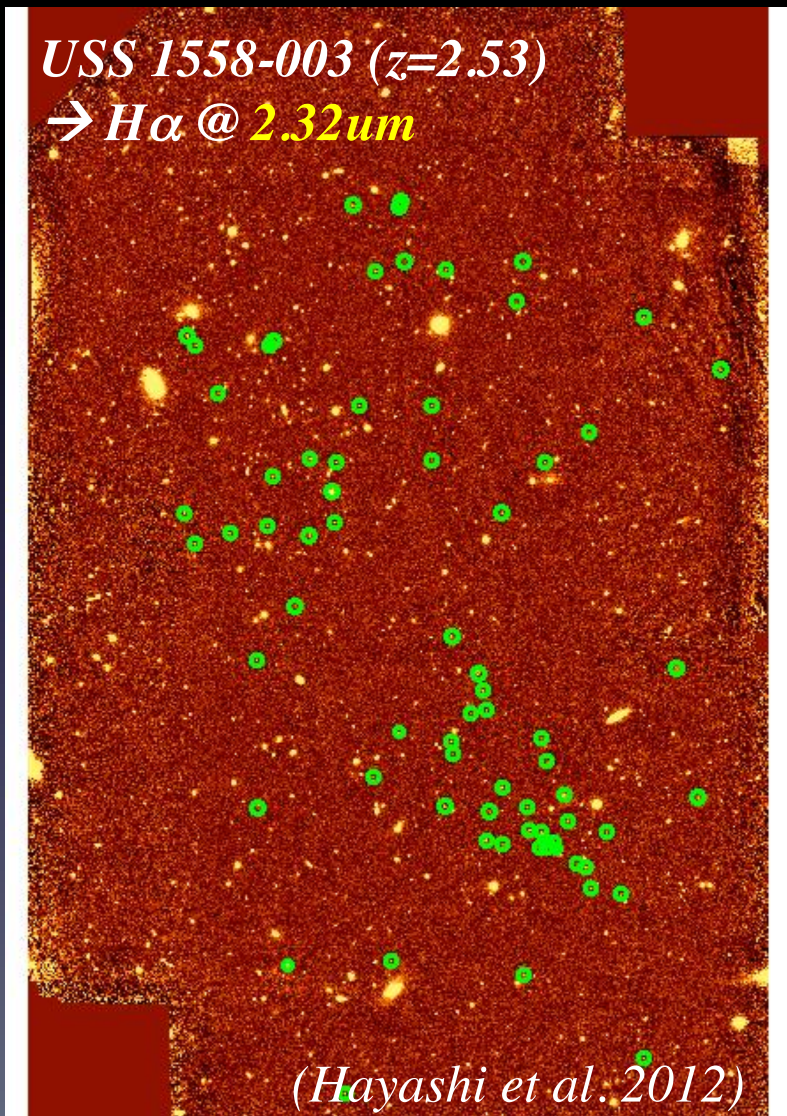
Rest-UV morphologies of proto-cluster galaxies

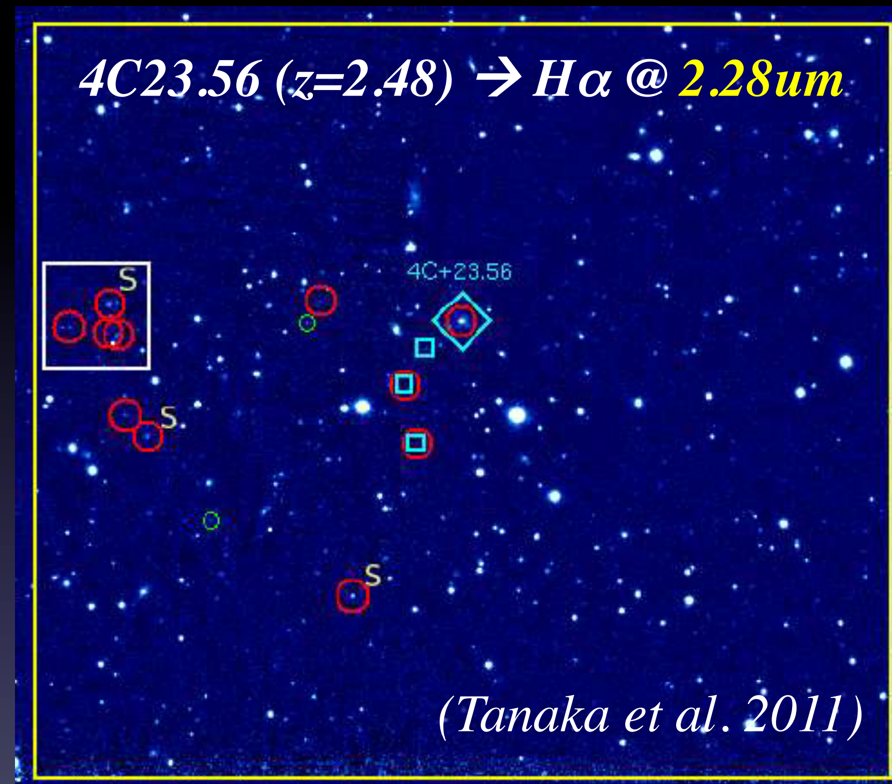


(Koyama et al. 2013a)

"Star-bursting" proto-clusters at z~2.5

Unveiled by the Hα search (most distant case from ground-based telescope)



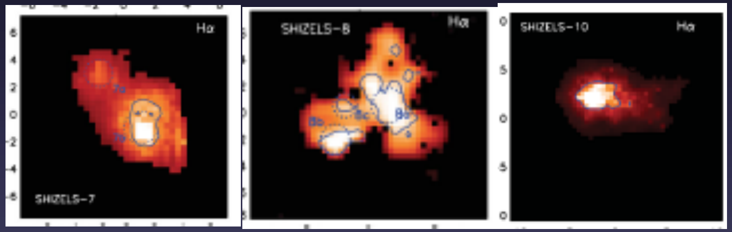


We observed these highest-density regions at z=2.5 with IRCS+AO188 in May 2013. Hope I can show the results in the next GLAO workshop…

What's next (with GLAO)?

(1) GLAO+NB imaging: "Ultimate-MAHALO"

- "Hα geometry" survey across environments
- measure Hα size (profile) for "all" galaxies in FoV
- statistical sample of spatially resolved Hα map
- provide "best sample" for TMT



Hα map of z>1 Hα emitters with SINFONI (Swinbank et al. 2012)

(2) GLAO+BB imaging

- needed for technical reason (continuum subtraction)
- but BB imaging can reveal stellar profile for "all" galaxies

What's next (with GLAO)?

(1) GLA ... ALO"

- "Hα g

- meas ... n FoV

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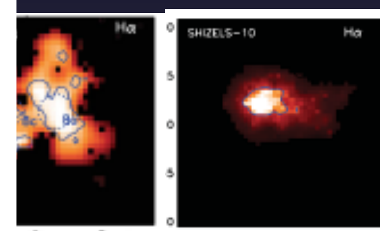
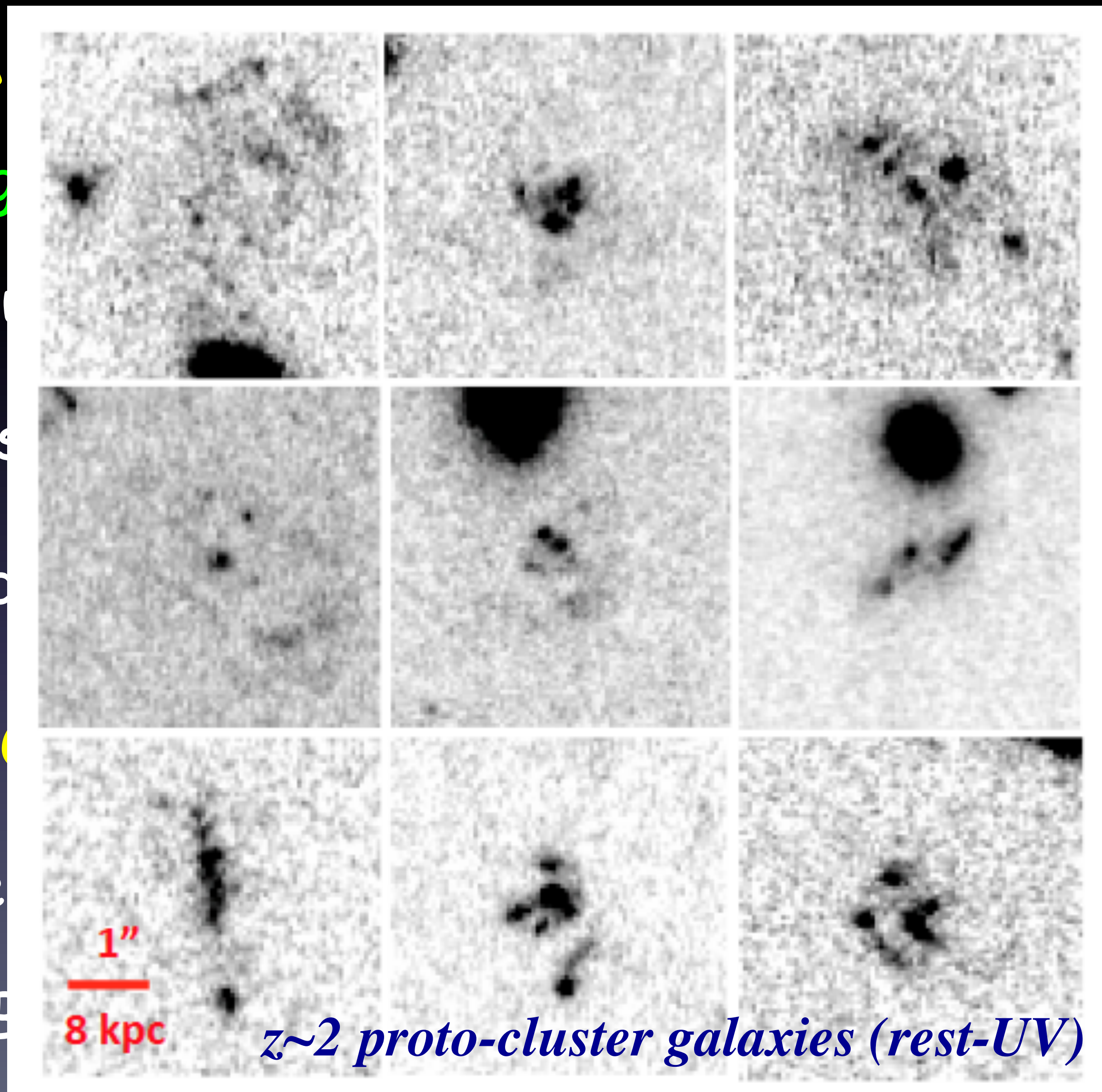


emitters with SINFONI
winbank et al. 2012)

(2) GLA

- neede ... raction)

- but BE ... "all" galaxies



Survey strategy (very rough idea)

Target: ~20 clusters at $0.4<z<2.5$ and their surroundings

- we need to develop ~15 NB filters (throughout z/Y/J/H/K)

- ~30′x30′ for z<1.5 clusters (4 pointings; 1.5hour for BB; 3hour for NB)

18 hours x 10 clusters = 180 hours ~ 20 nights

~100-200 emitters in 30′ x 30′ → Hα geometry of ~1500 galaxies

- ~15′x15′ for z>1.5 clusters (1 pointing; 3 hour for BB, 5 hour for NB)

8 hours x 10 clusters = 80 hours ~ 9 nights

~30-50 emitters in 15′ x 15′ → Hα geometry of ~400 galaxies

- Our goal is to construct ~2000 galaxies from various z and environments.

- MOS spectroscopy follow-up needed to confirm cluster membership

- multi-IFU can reveal kinematics of individual galaxies

Answers to the questions

Q1. Which instrument is essentially important for your science cases?

→ *Wide-field NIR imager is essential. Multi-IFU is also attractive, but KMOS will do a lot of things before start of GLAO operation…*

Q2. What is the optimal plate scale / FoV for your science cases?

→ *The default 0.1”pix scale (and 14’x14’ FoV) is fine for imager. For multi-IFU instrument, default 1.8”x1.8” FoV (per IFU) may be too small in some extreme cases (massive starbursts in proto-cluster).*

Q3. Can you highlight synergies between this instrument and the TMT?

→ *The proposed wide-field NB imaging survey (in clusters/fields) can provide the “best sample” for TMT (e.g. target finer structure, other lines, etc).*

Answer to the questions

Q4. Does this instrument have competitive (or complementary) capabilities with planned Near-IR space missions such as JWST, Euclid and WISH?

→ *Probably yes -- at least in the sense that we can install as many NB filters as we want even after the GLAO mission started?*

Q5. A brief observation plan for your science cases which can be (a part of) Legacy Science Survey with Subaru GLAO

- Survey Area / Fields: *~20 clusters at $0.4<z<2.5$ and their outskirts*
- Observing modes: *BB + NB imaging*
- Number of nights: *30 nights ?*
- Uniqueness: *Sample provided by (seeing-limited) Subaru. Take full advantage of large FoV. Strong impacts only with imager?*

Q6. How could these observations be used to leverage TMT capabilities?

→ *Again we can provide the best, feasibly bright galaxy sample for TMT, and I am sure that we can maximize the efficiency of the science output of TMT.*

Summary

✓ (seeing-limited) MAHALO-project made a great success

- Revealed large-scale structure out to z~2.5
- Red/massive starbursts in proto-cluster environments

✓ Our next step is "GLAO-assisted MAHALO"

- NB imaging is not only for "selecting" emitters
- AO+NB imaging enables "SF geometry" survey
- keen to test environmental effects on internal SF geometry !