SPICA workshop (16, Dec, 2010 @ NAOJ)

SPICAで究める 遠方銀河団・銀河群・大規模構造

"Ultimate study for distant clusters, groups, and large-scale structures"

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SPICA MIR extragalactic survey team

Powerfulness of SPICA

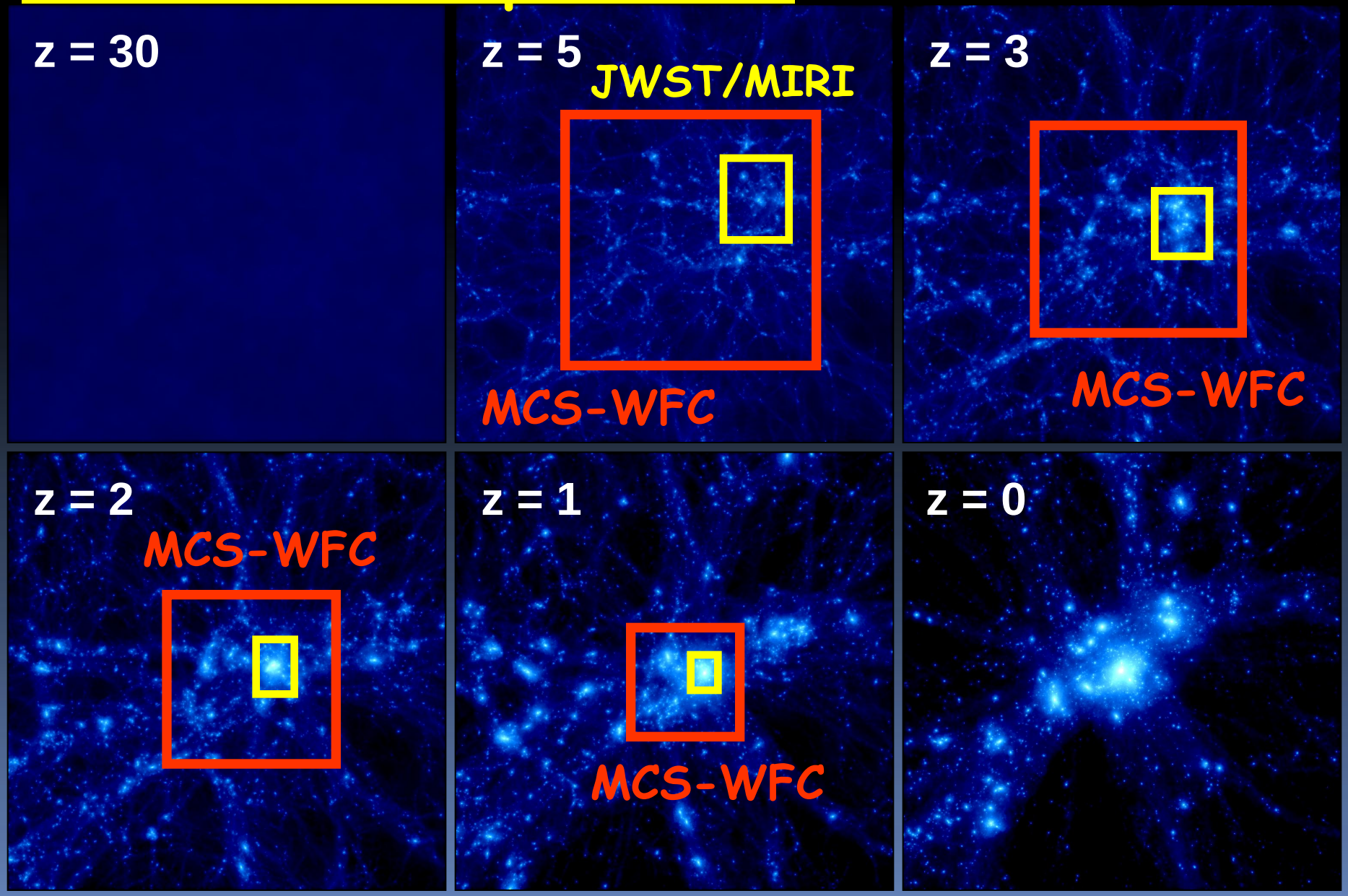
(1) Wide-field coverage in all wavelength

- 5′ x 5′ FoV in 5μm< λ <40μm (MCS-WFC)

(2) High sensitivity at λ > 20μm

- 20μm<λ<40μm (MCS-WFC), λ>40μm (SAFARI)

"Wide-field" is powerful !

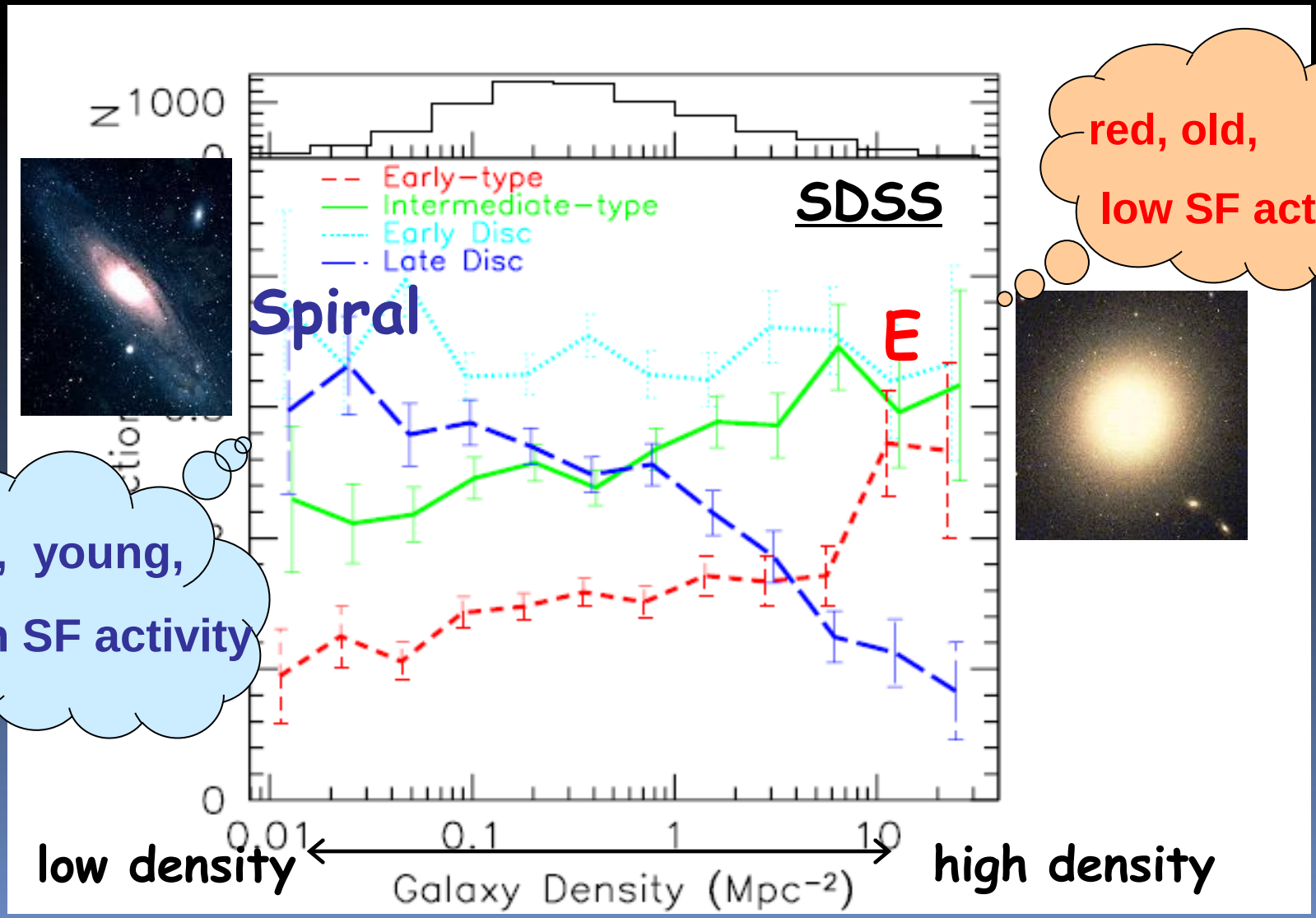


M=6×10^14 Msun, 20Mpc×20Mpc (co-moving)

Yahagi et al. (2005)

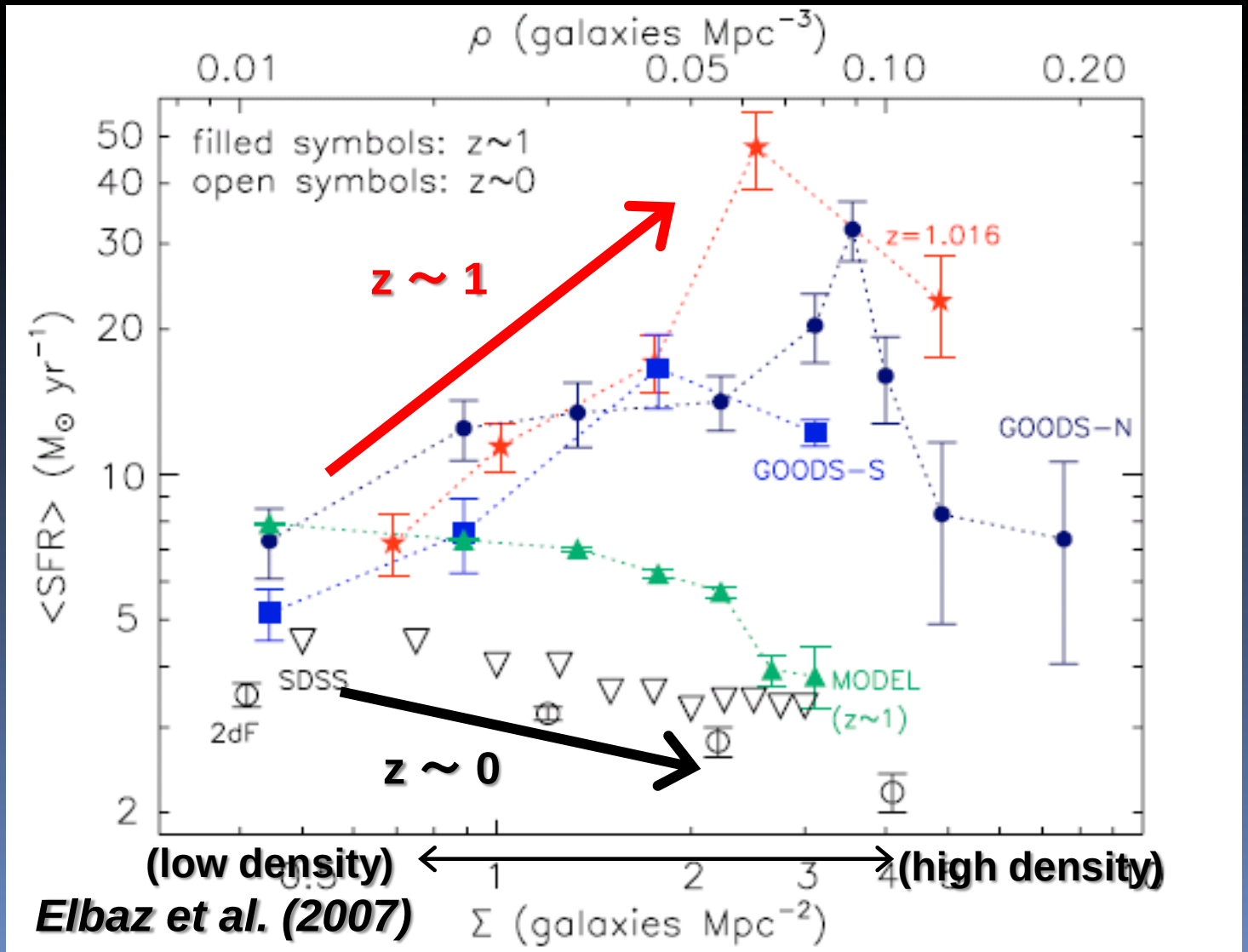
Galaxy properties are dependent on environment

Morphology-Density relation (Goto et al. 2003)



Reversal of the relation at z∼1 ?

Dramatic change of SF-density relation between z=1 and 0



Elbaz et al. (2007)

Questions to be answered with SPICA

(1) What happened since z~1 ?

- Complete understanding of galaxy evolution in clusters/groups (role of environment) between z=1 and z=0.

→ Make full use of the "wide-field" availability

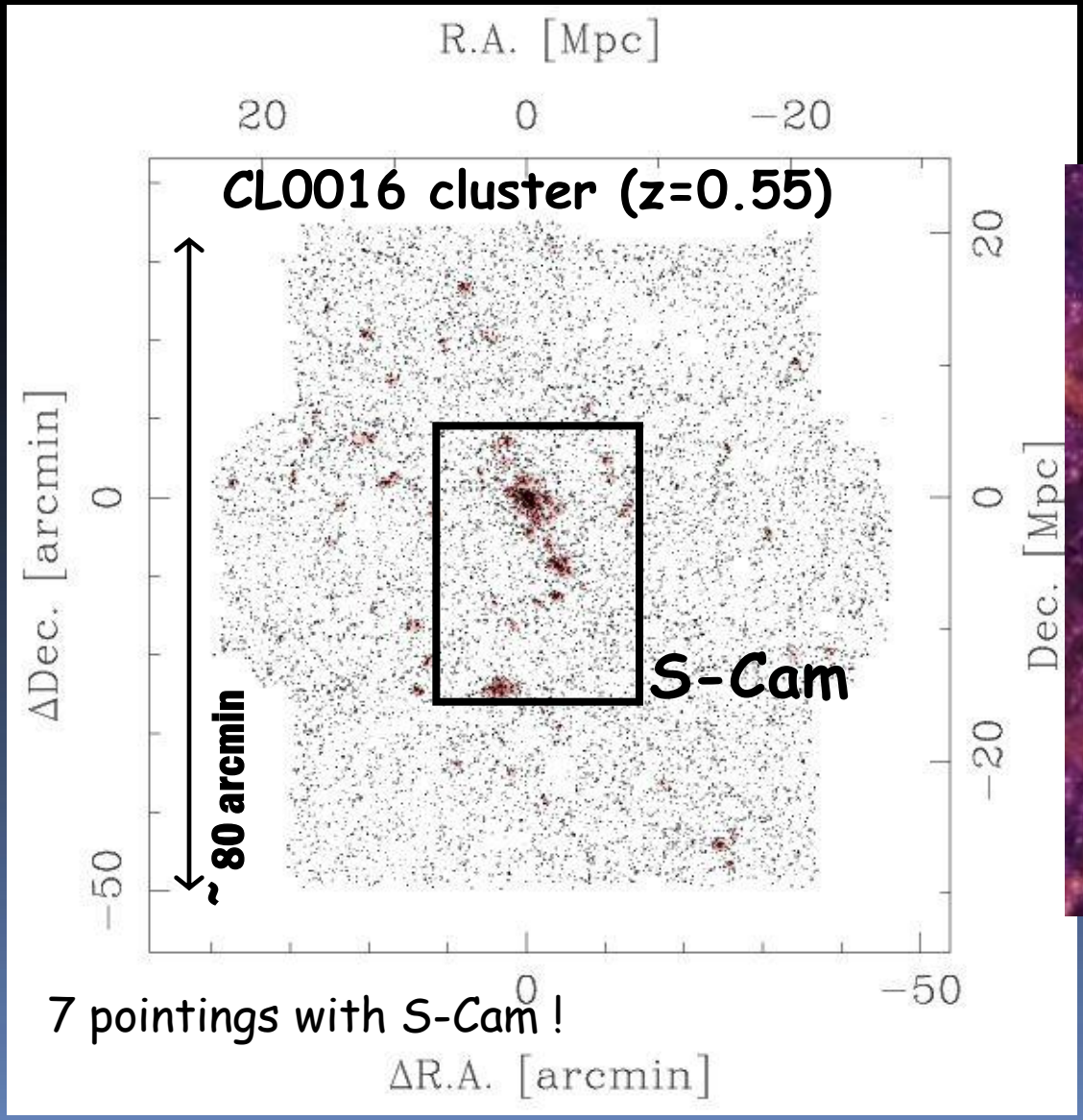
(2) How about in the more distant Universe ?

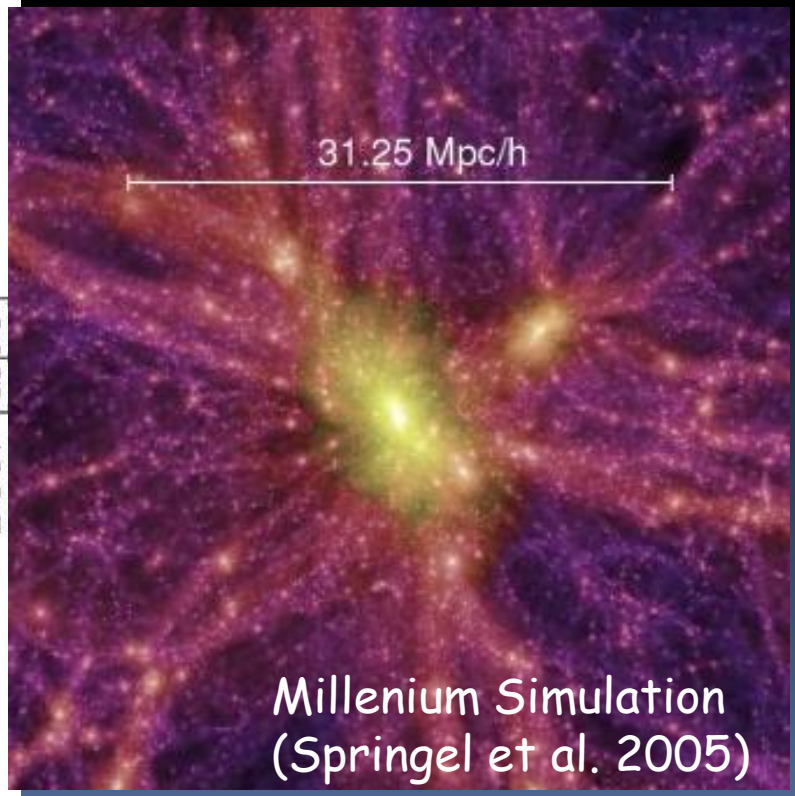
- Explore the (IR-based) SF activity and its relation to environment up to z~3-4.

→ Great advantage in the high sensitivity at λ>20μm

A Huge Cosmic Web at z=0.5 over 50 Mpc

(Tanaka et al. 2009)

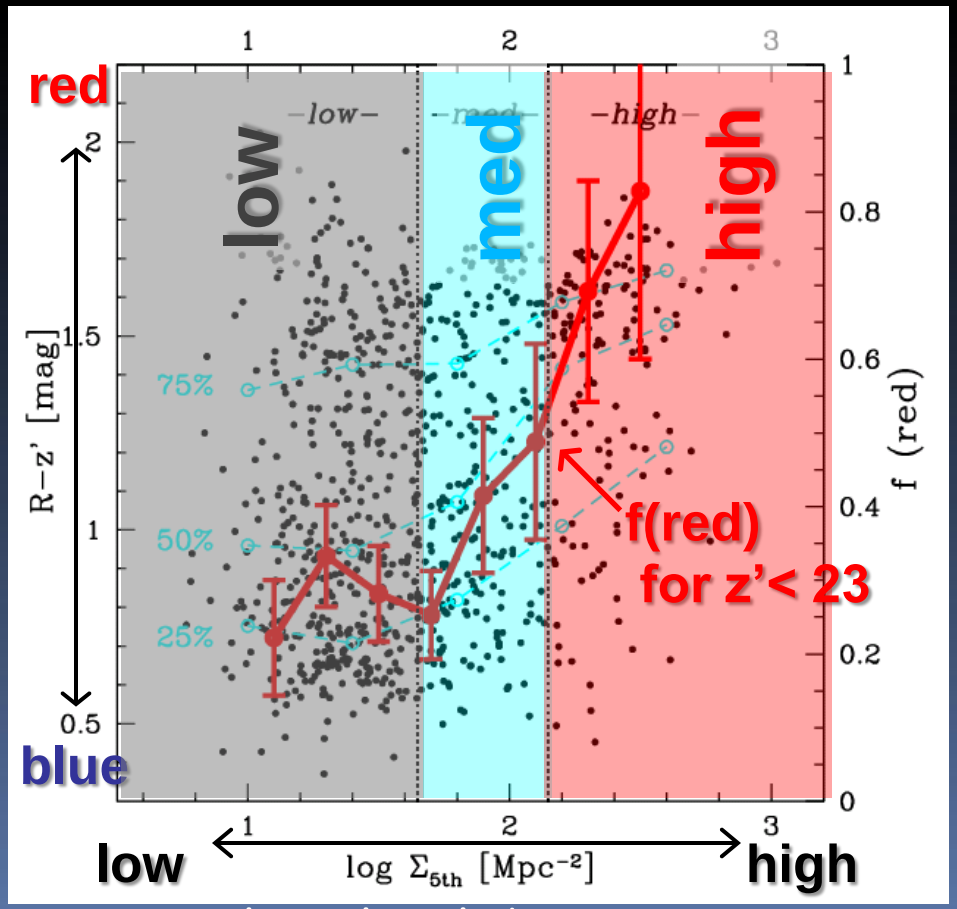




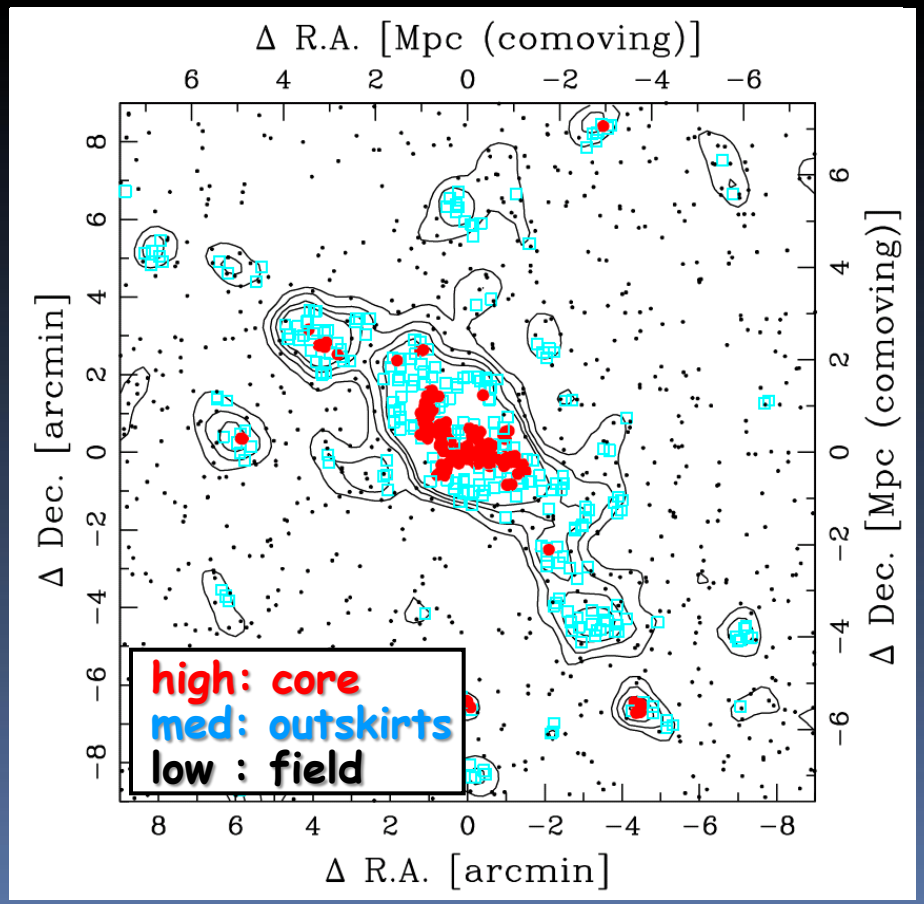
Important role of cluster outskirts

Sharp colour transition in "medium-density" regions

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



galaxy local density

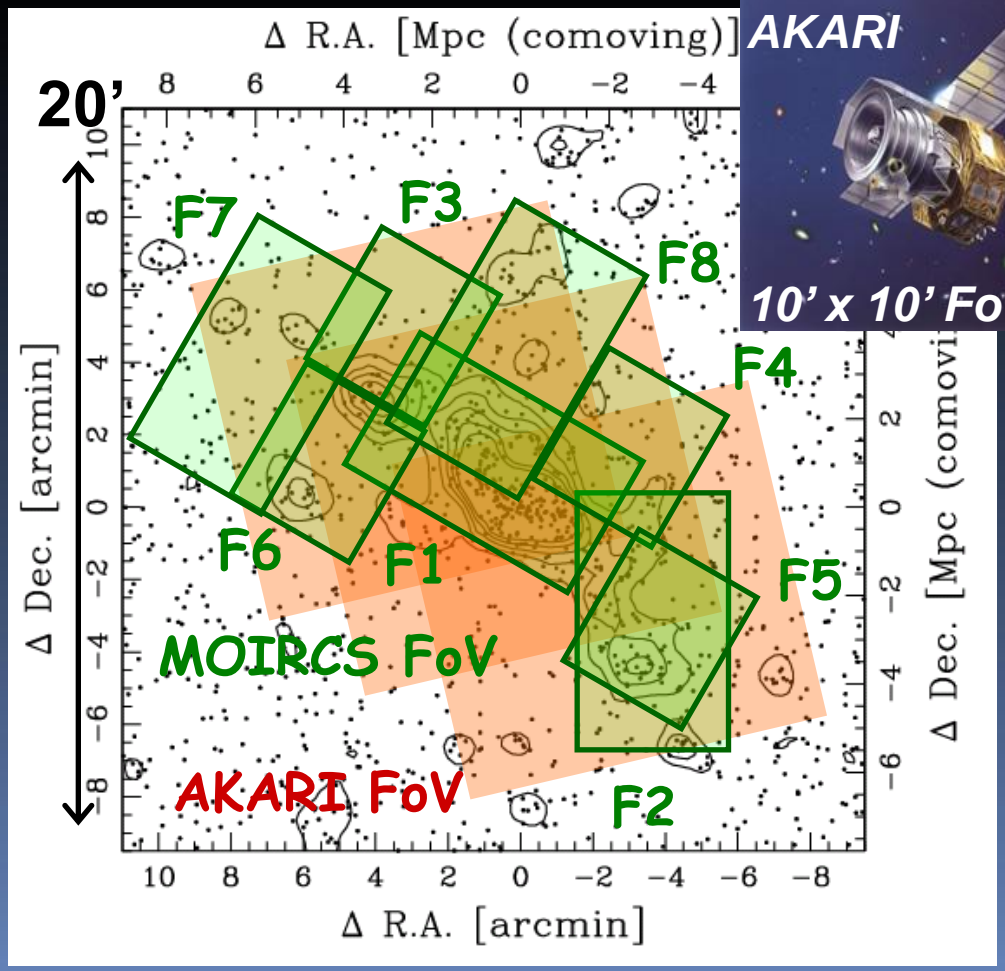


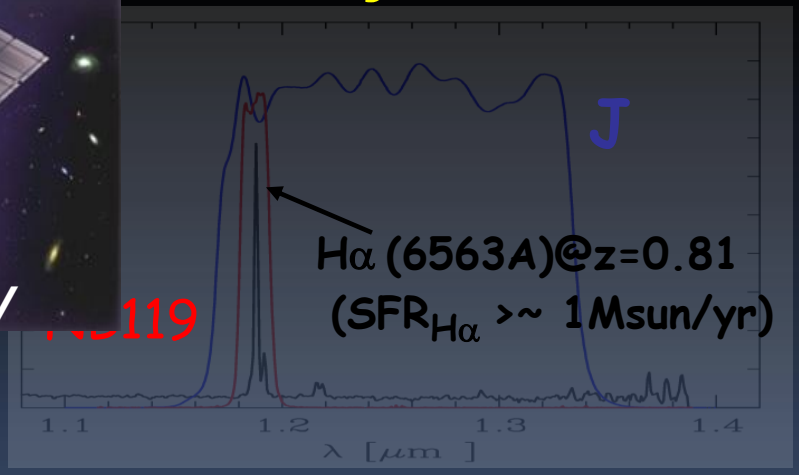
Koyama et al. (2008)

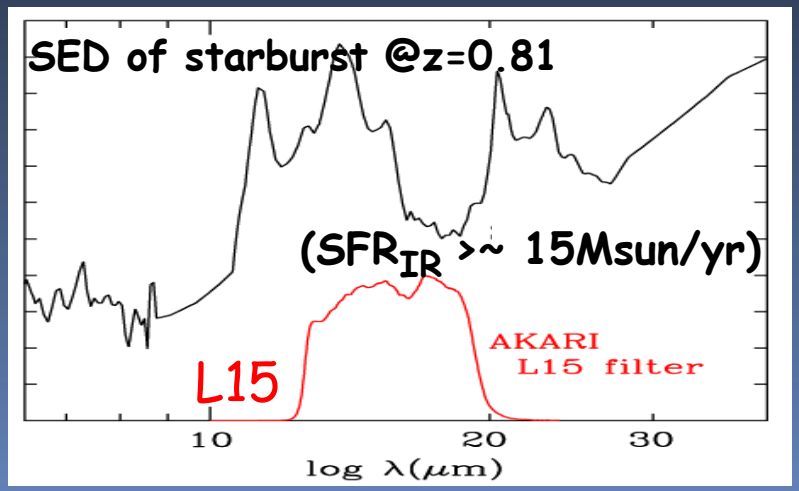
Mapping star formation around the RXJ1716 cluster at z=0.81 with Hα and MIR

Subaru/S-Cam (*VRi'z'*) MOIRCS (*J, NB119*) AKARI/IRC (*N3,S7,L15*)

Subaru / AKARI Joint Survey

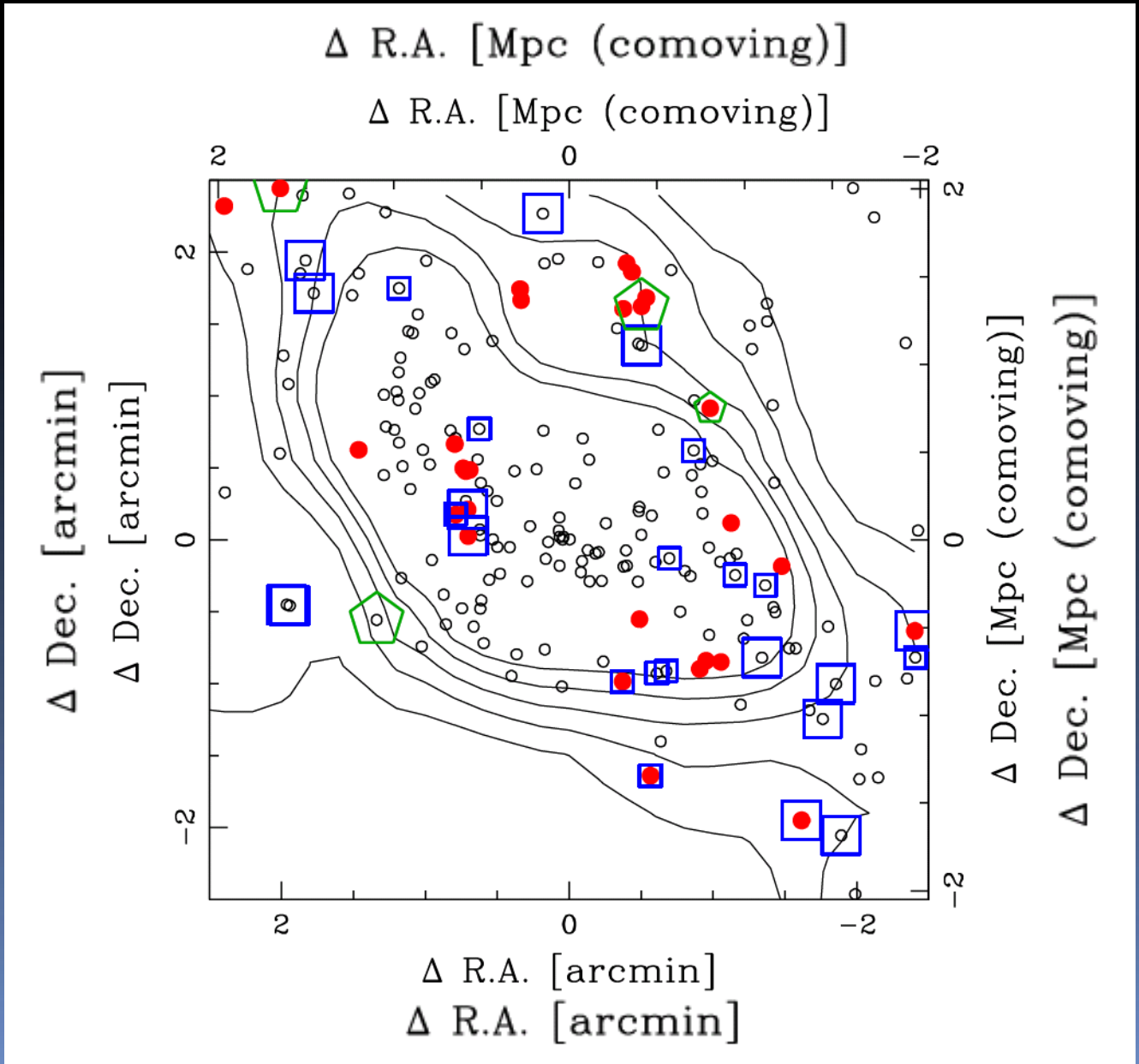






(Koyama et al. 2010, MNRAS, 403, 1611)

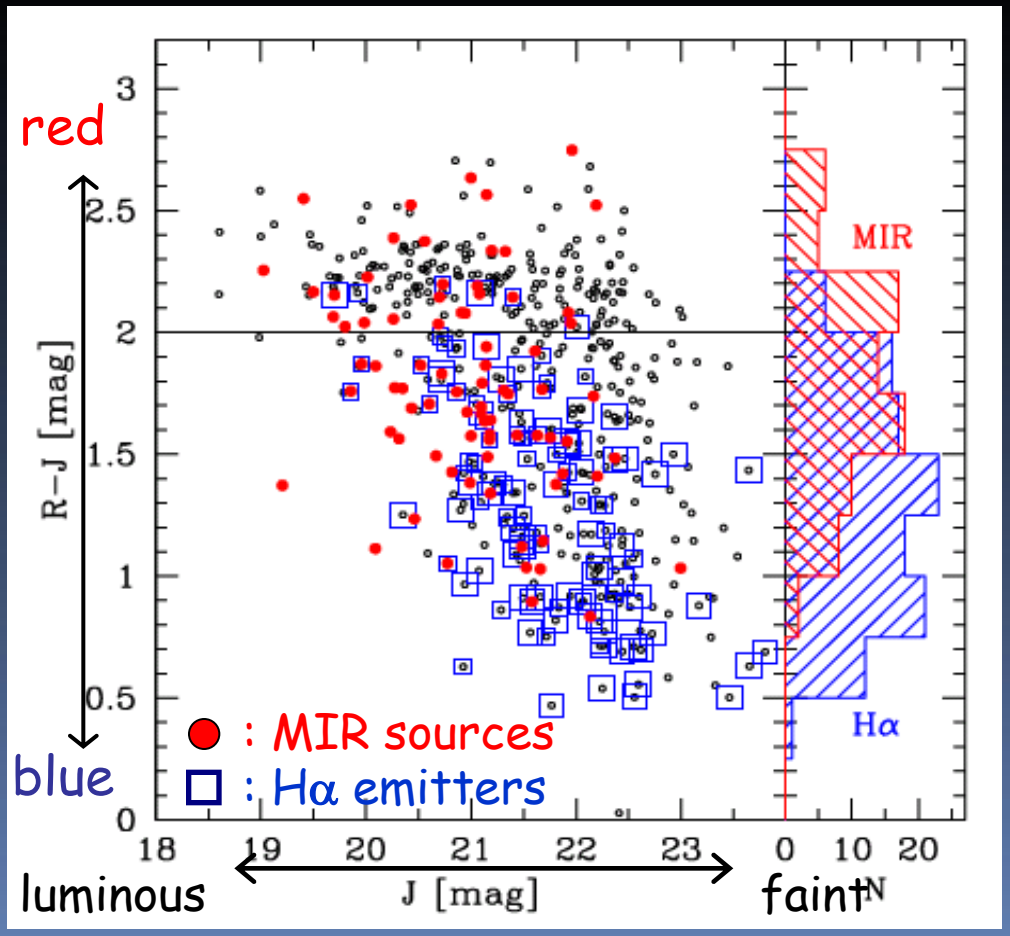
Spatial distribution of Hα emitter/MIR source

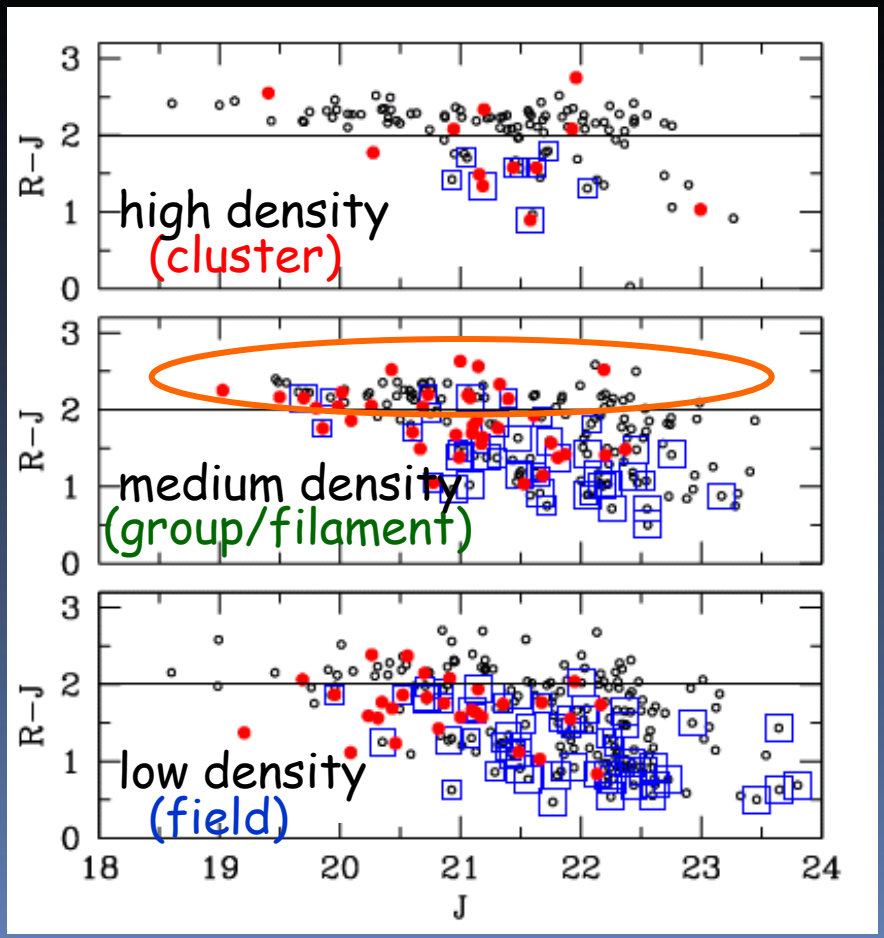


Optical colours of Hα emitters/MIR sources

MIR galaxies are dusty and tend to be redder than Hα emitters.

Red SF galaxies are preferentially found in groups/filaments.

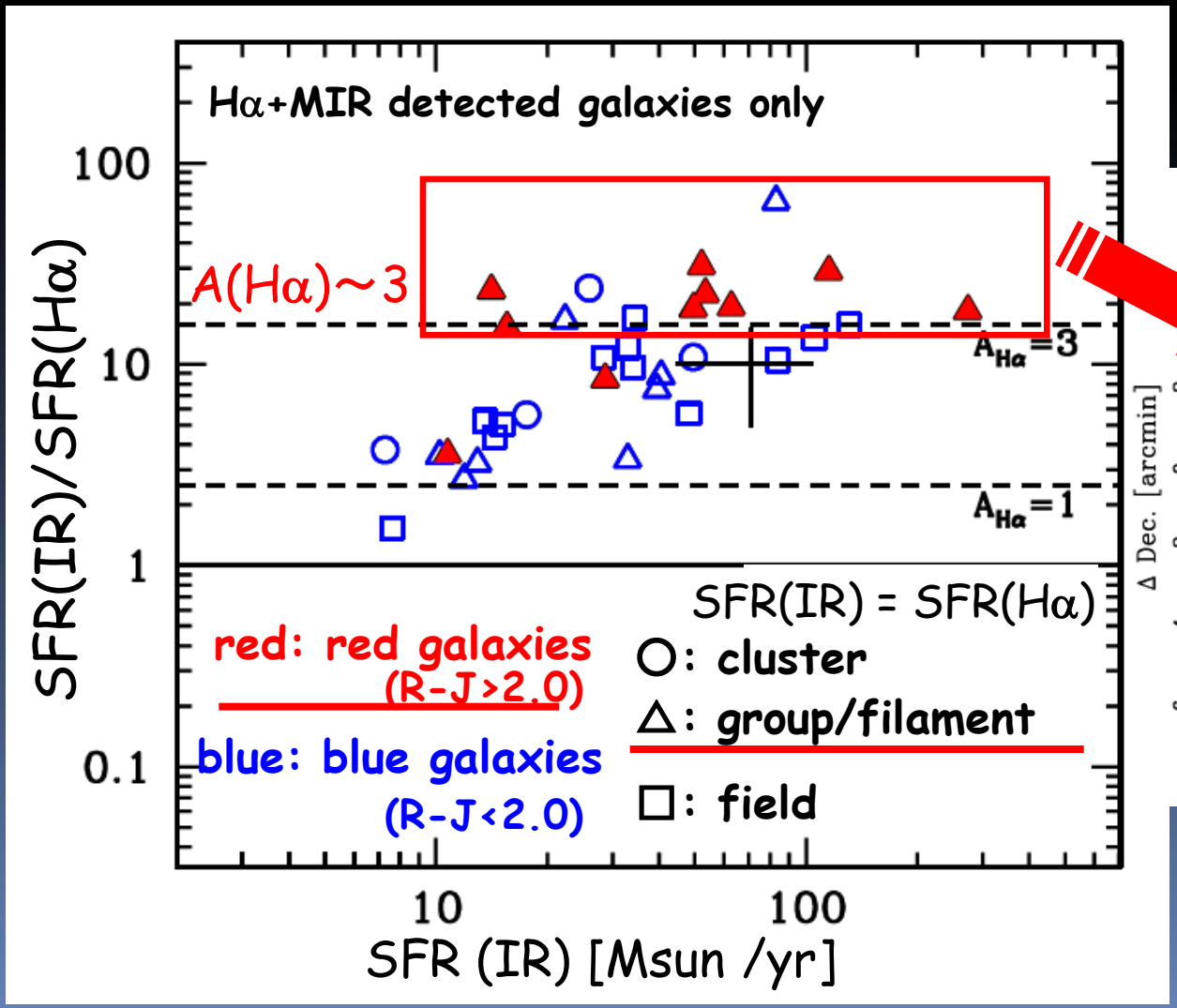


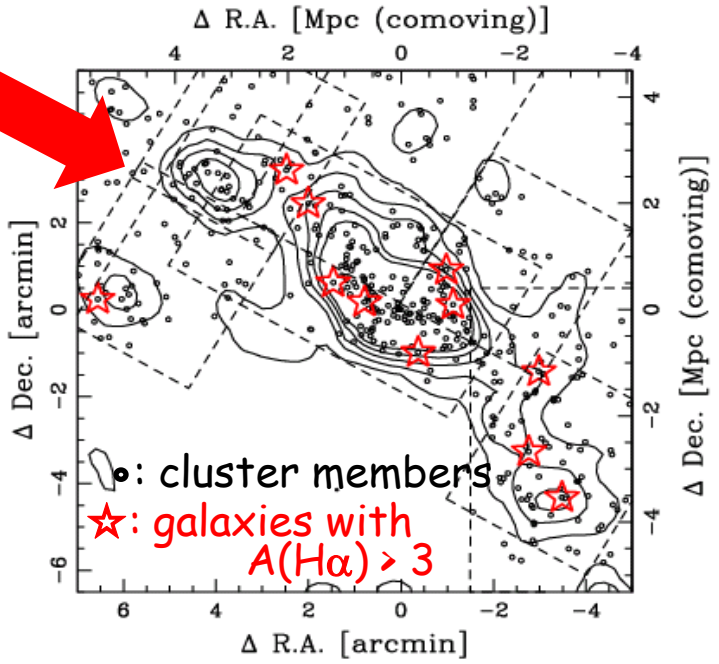


(Koyama et al. 2010)

SFR(Hα) vs SFR(IR)

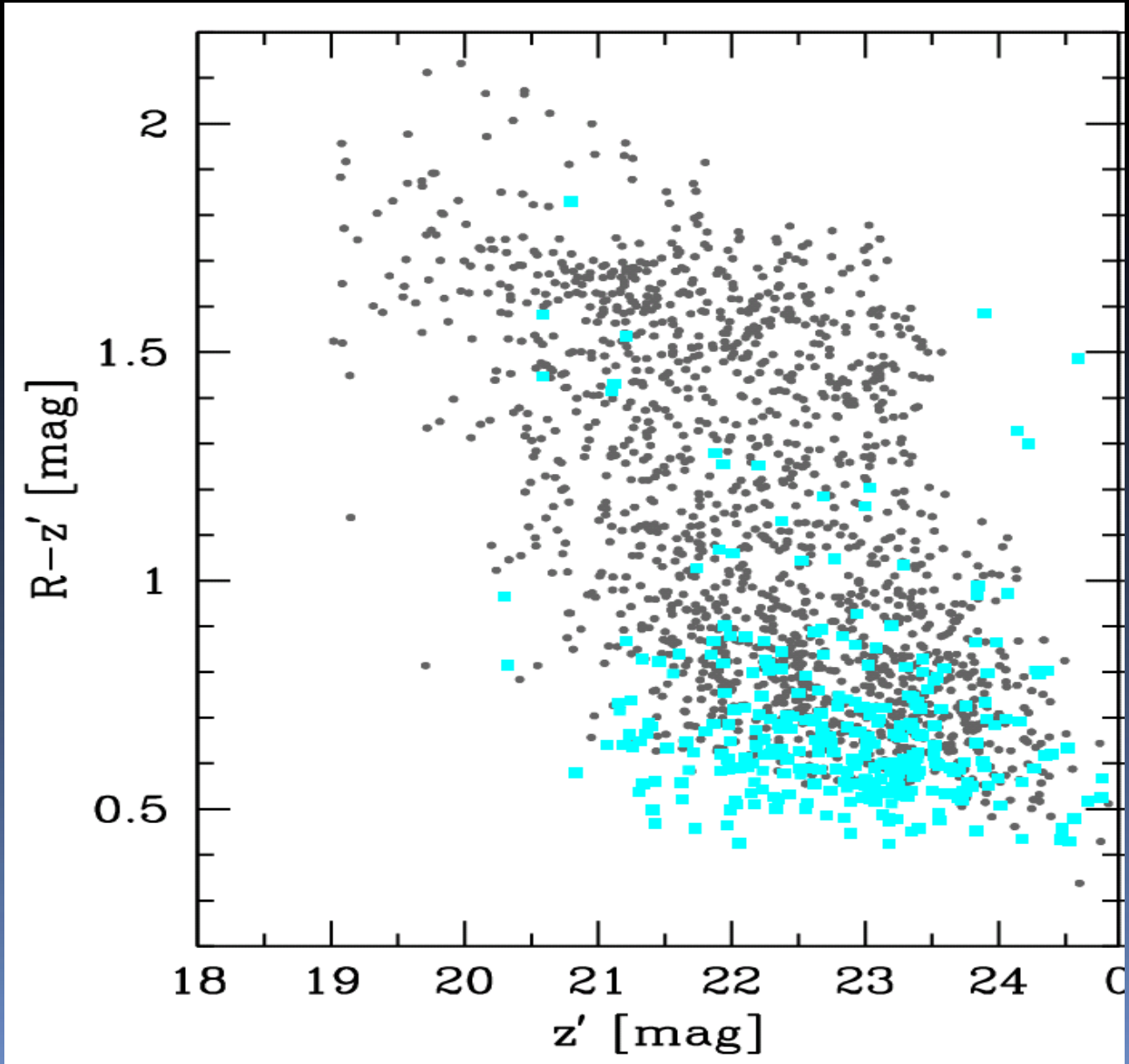
Underestimate SFR(Hα) especially for galaxies in group/filament



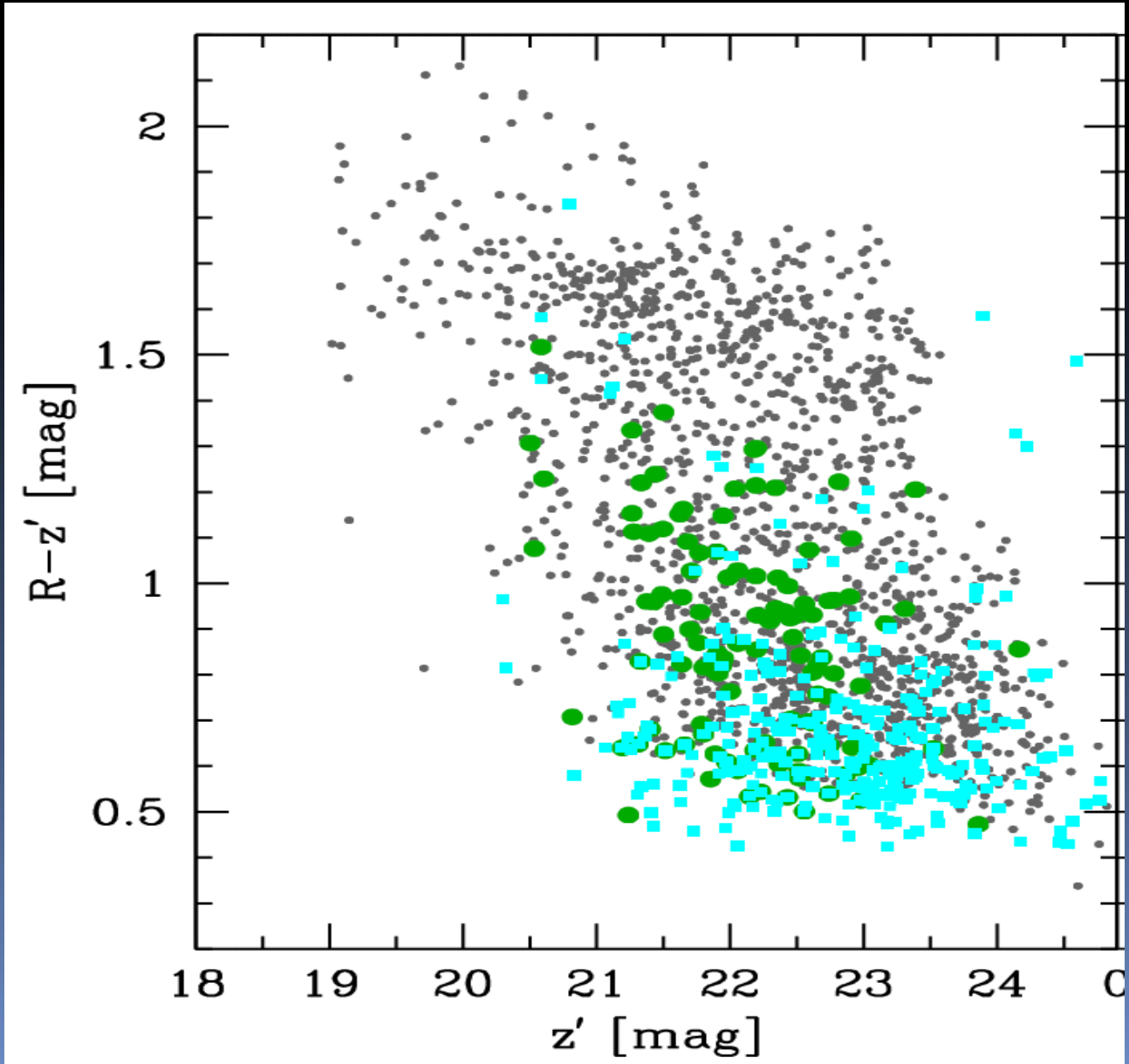


(Koyama et al. 2010)

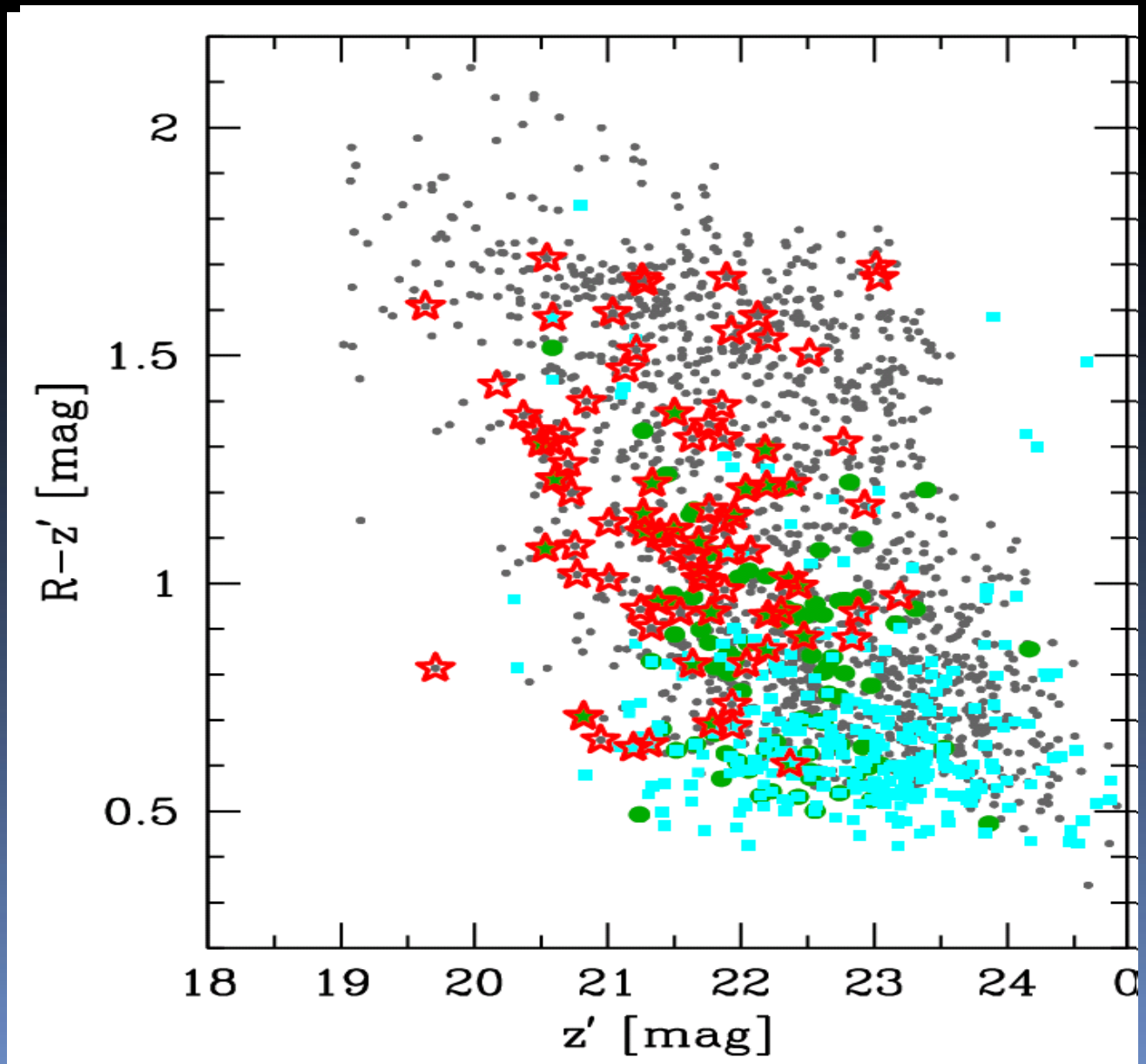
Colour-magnitude diagram (with [oii])



Colour-magnitude diagram (with [oii]+Hα)

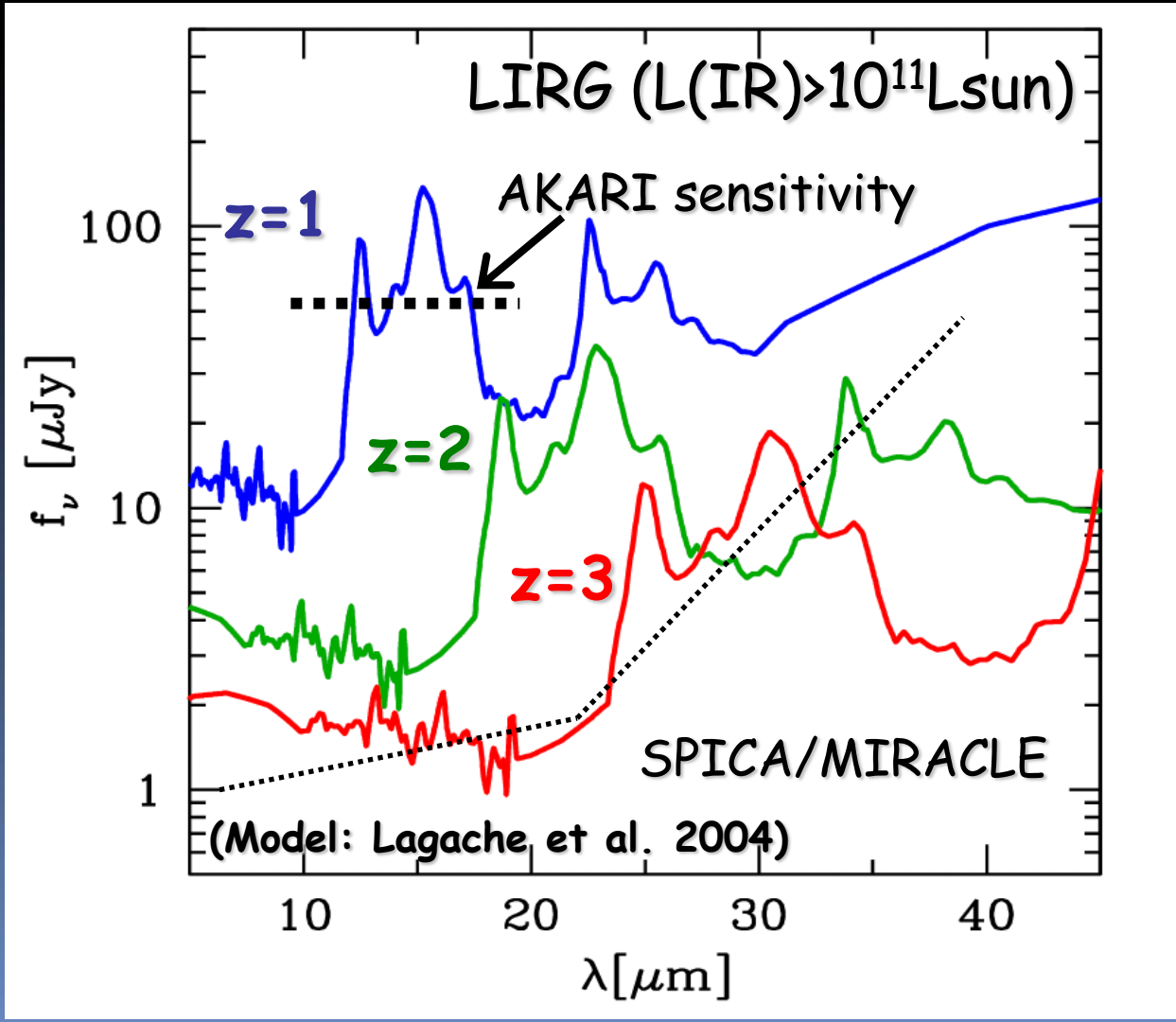


Colour-magnitude diagram (with [oii]+Hα+MIR)



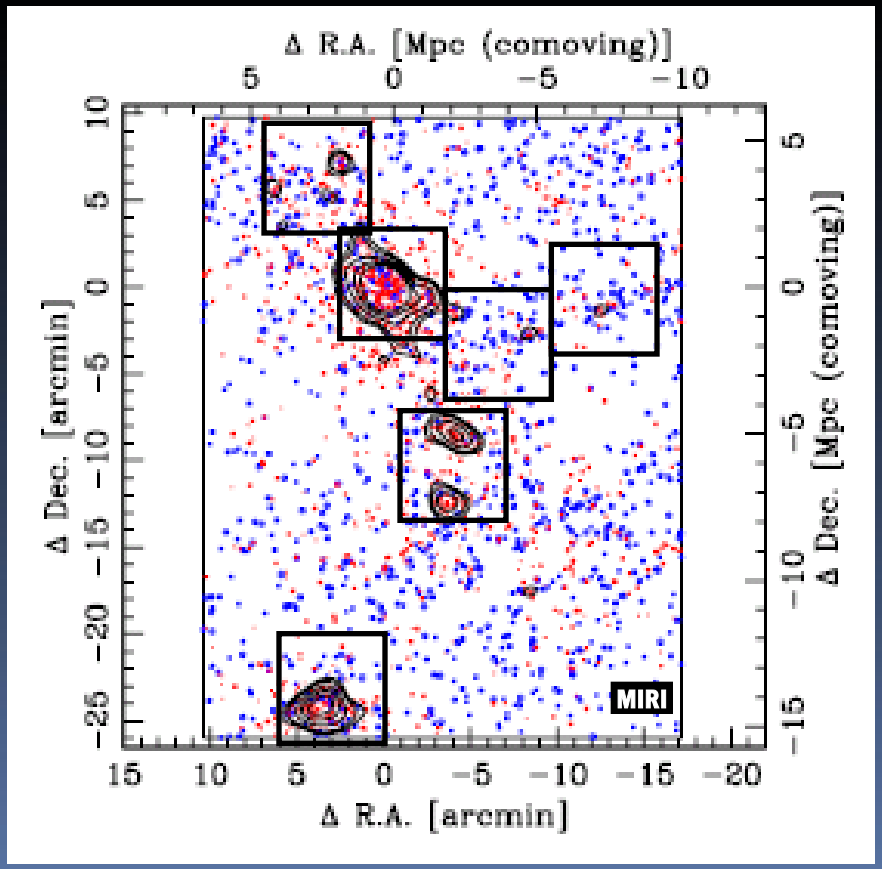
SPICA can go deep !

We can detect SF activity down to z~3 LIRGs.

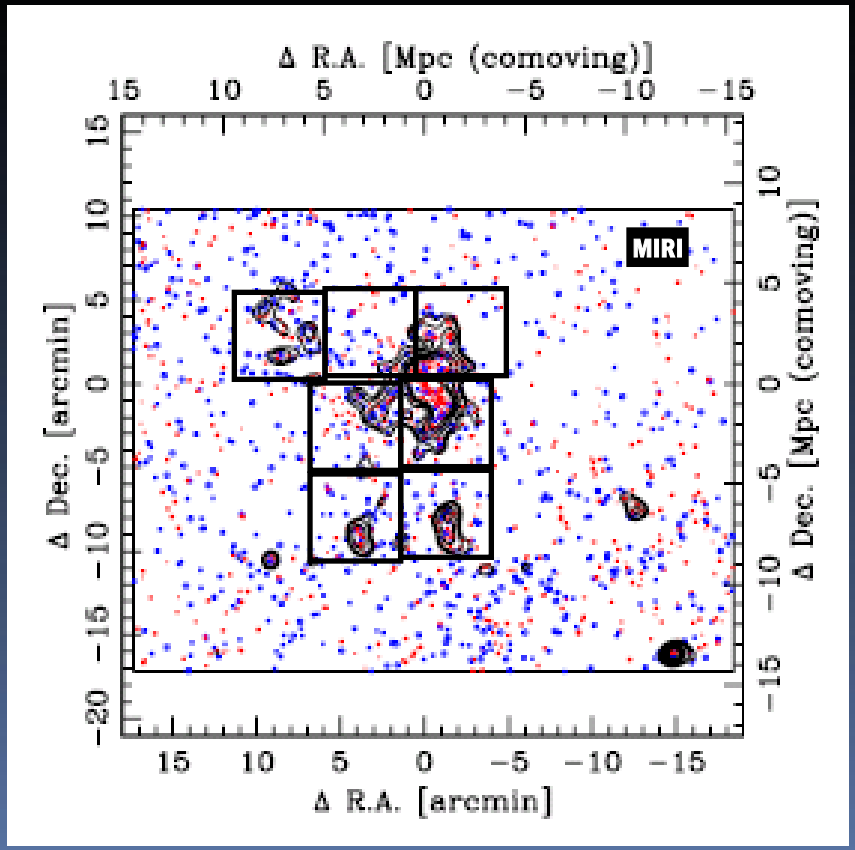


Possible SPICA targets at z~1

Large-scale structures at z~1 discovered by Subaru.
SPICA can go deep and detect low-mass galaxies.



CL0016 @ z=0.55 → 12um



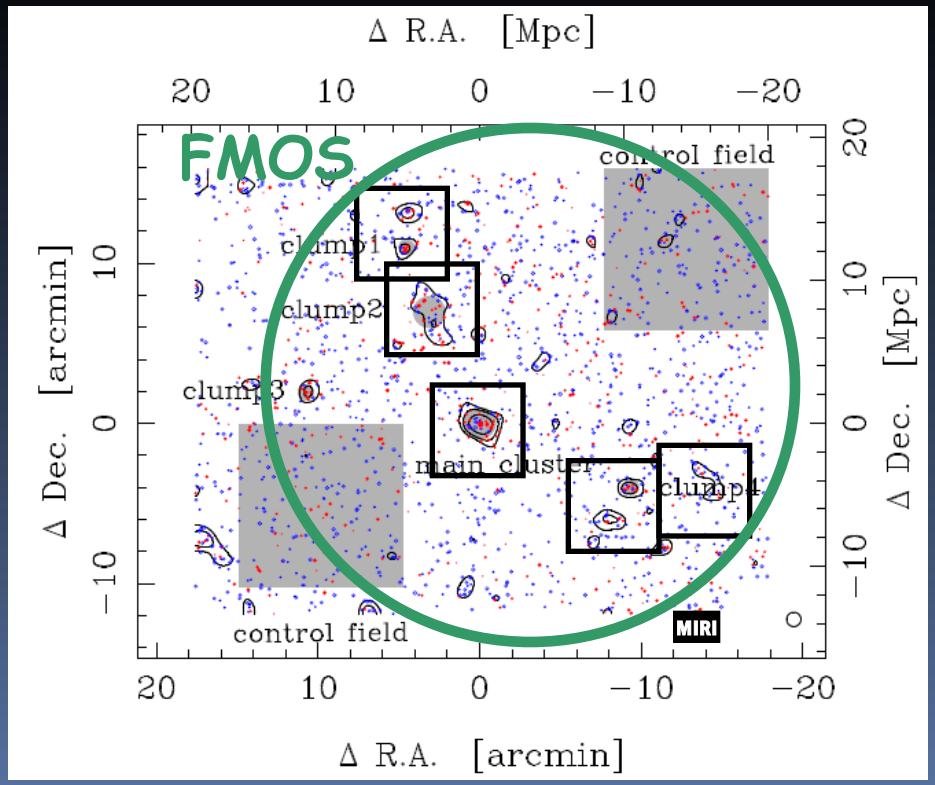
RXJ0152 @ z=0.83 → 15um

by PISCES project (Kodama et al. 2005)

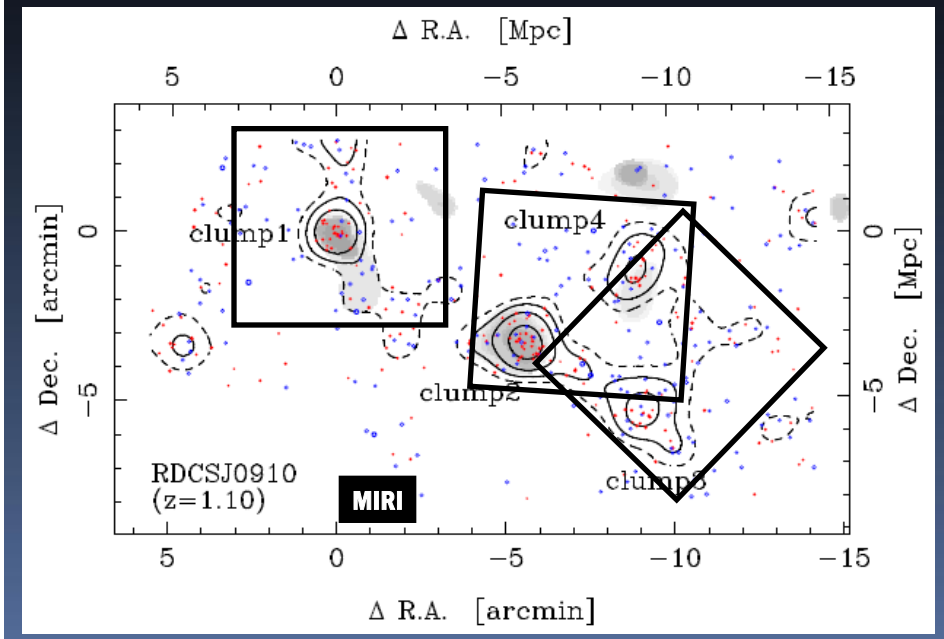
Clusters at "cluster desert" (1<z<2)

The number of 1<z<2 known clusters is now increasing

SPICA + FMOS collaboration will be powerful



RDCS1252 @z=1.24 → 17um

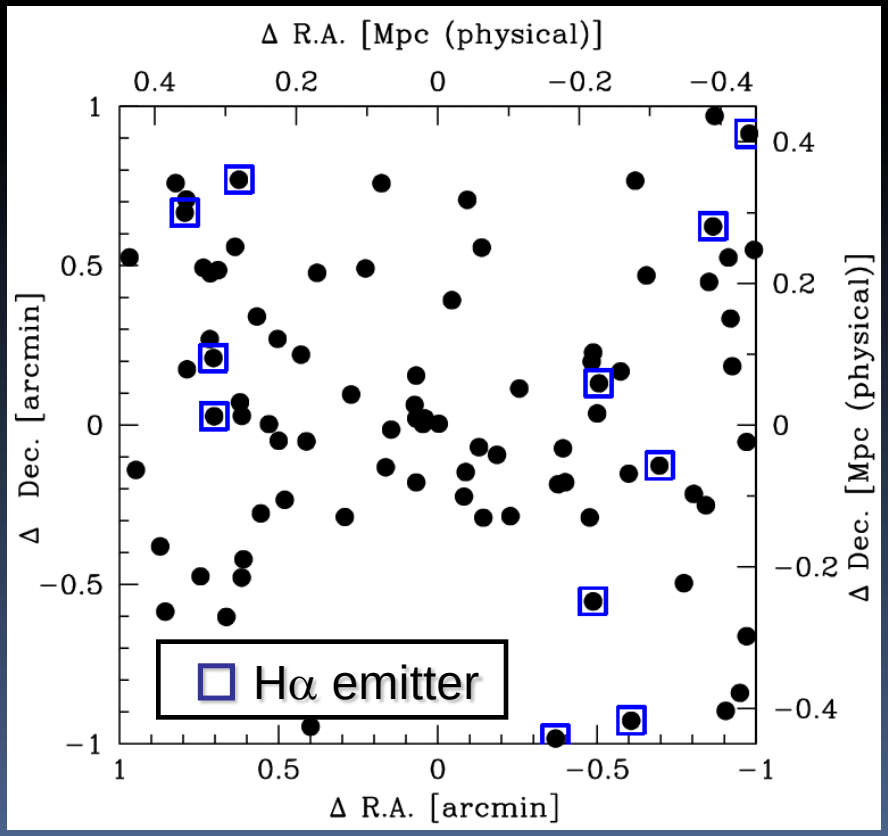


RDCS0910 @z=1.1 → 16um

(Tanaka et al. 2007, 2008)

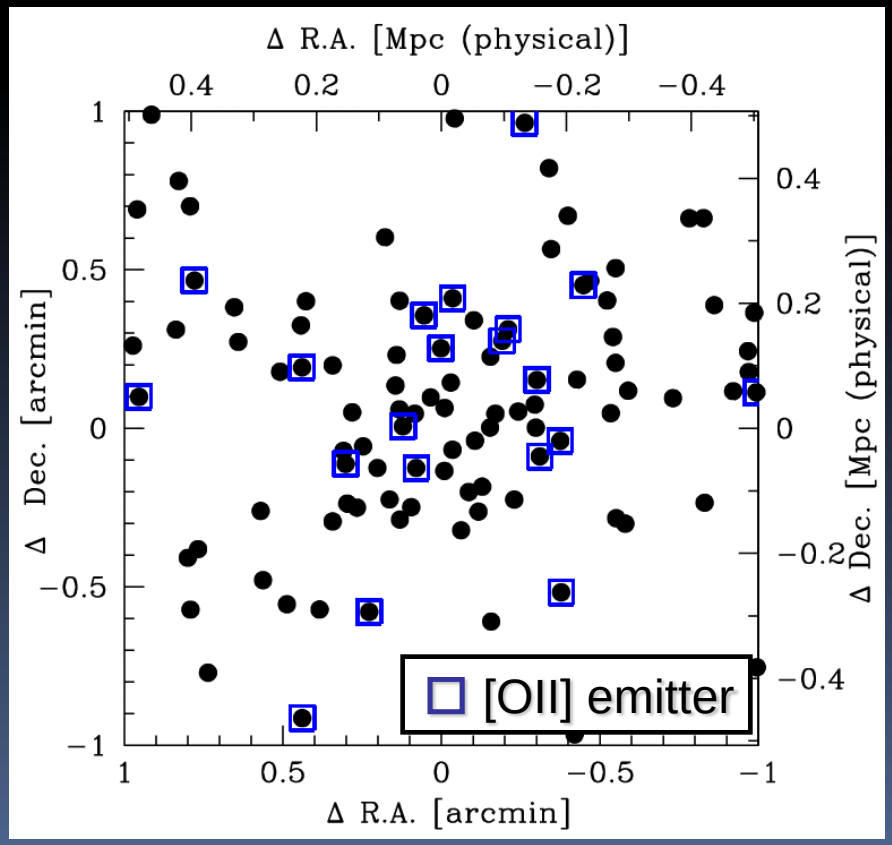
Looking back to more distant clusters

Hα emitters at z=0.81 (RXJ1716)



Koyama et al. (2010)

[OII] emitters at z=1.46 (XCS2215)



Hayashi et al. (2010)

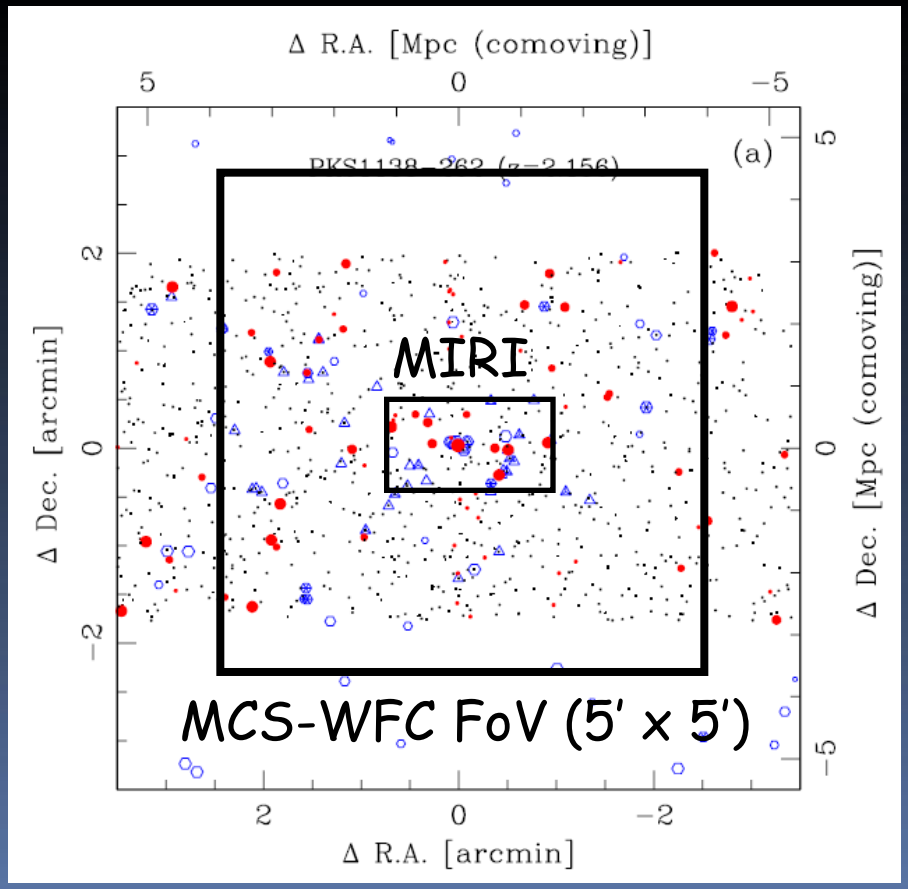
Propagation of SF site?
(cluster core at z=1.5 → outskirts at z=0.8)

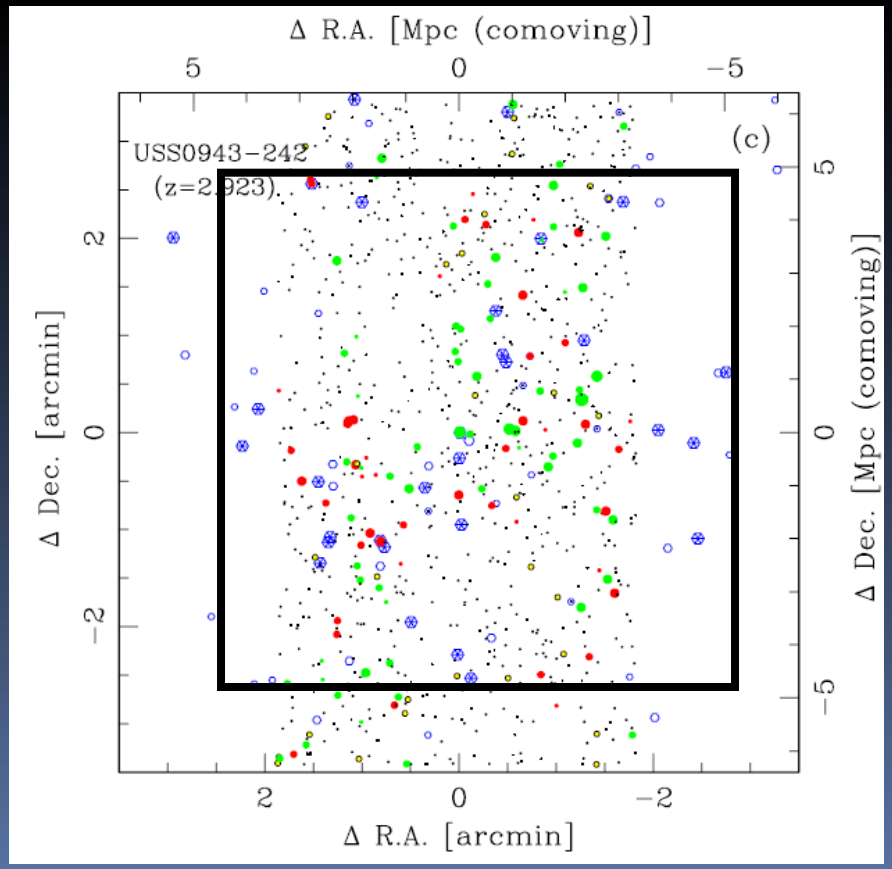
Proto-clusters at z>2

How large amount of SF is hidden in forming clusters ?

z ~ 2 proto-cluster → 23um

z ~ 3 proto-cluster → 30um





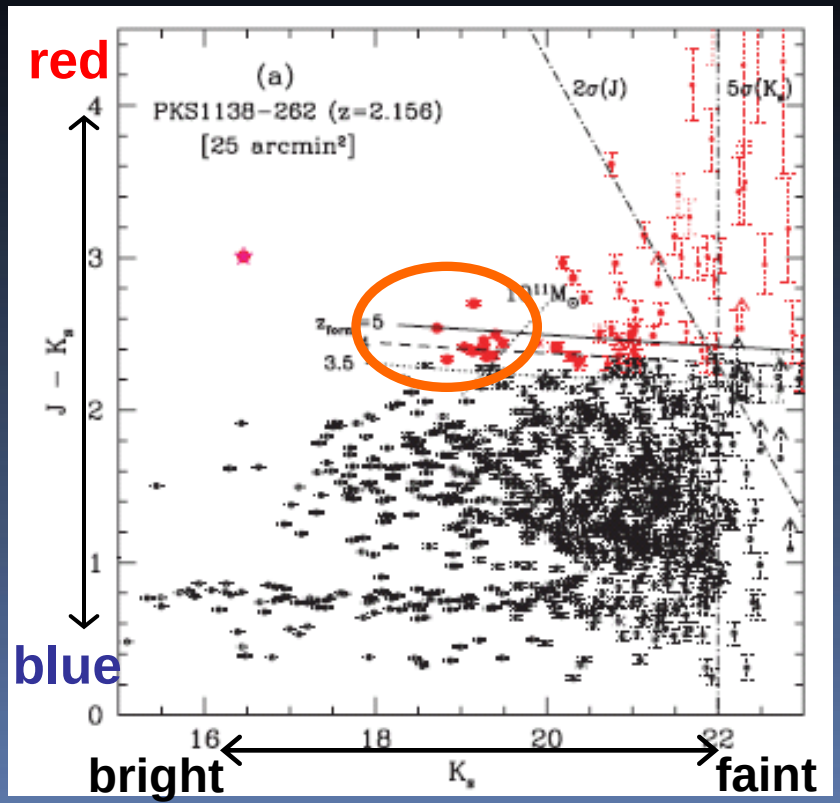
NIR-selected members around radio galaxy by Kodama et al. (2007)

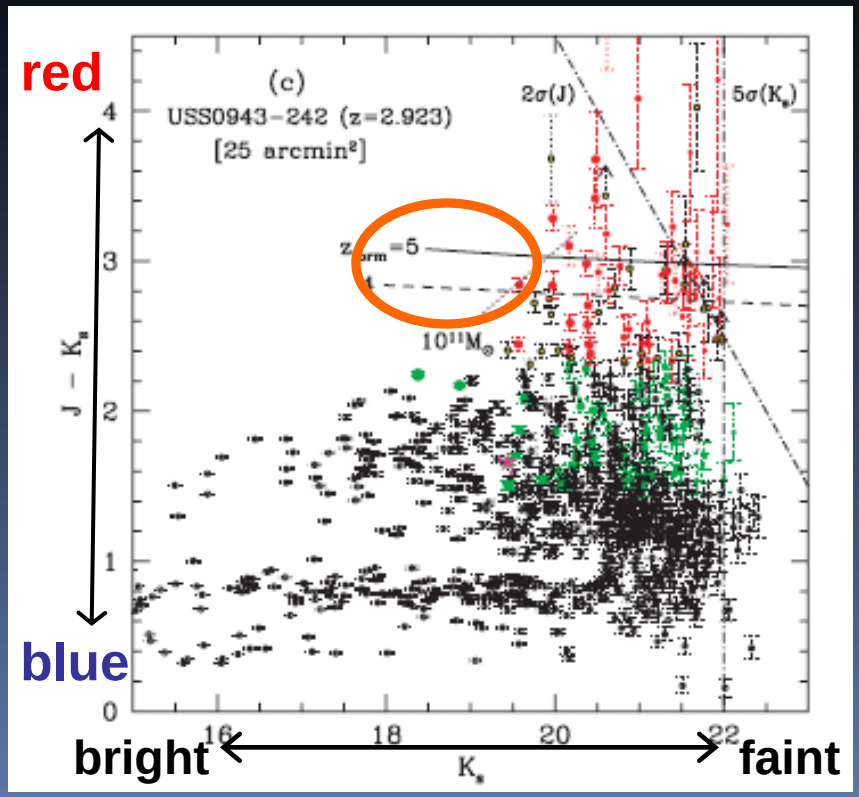
Proto-clusters at z>2

Massive end of red sequence ($M^*>10^{11}$ Msun) disappear at z~3

Cluster massive galaxy is formed at z~2-3 ?

How are they formed ?

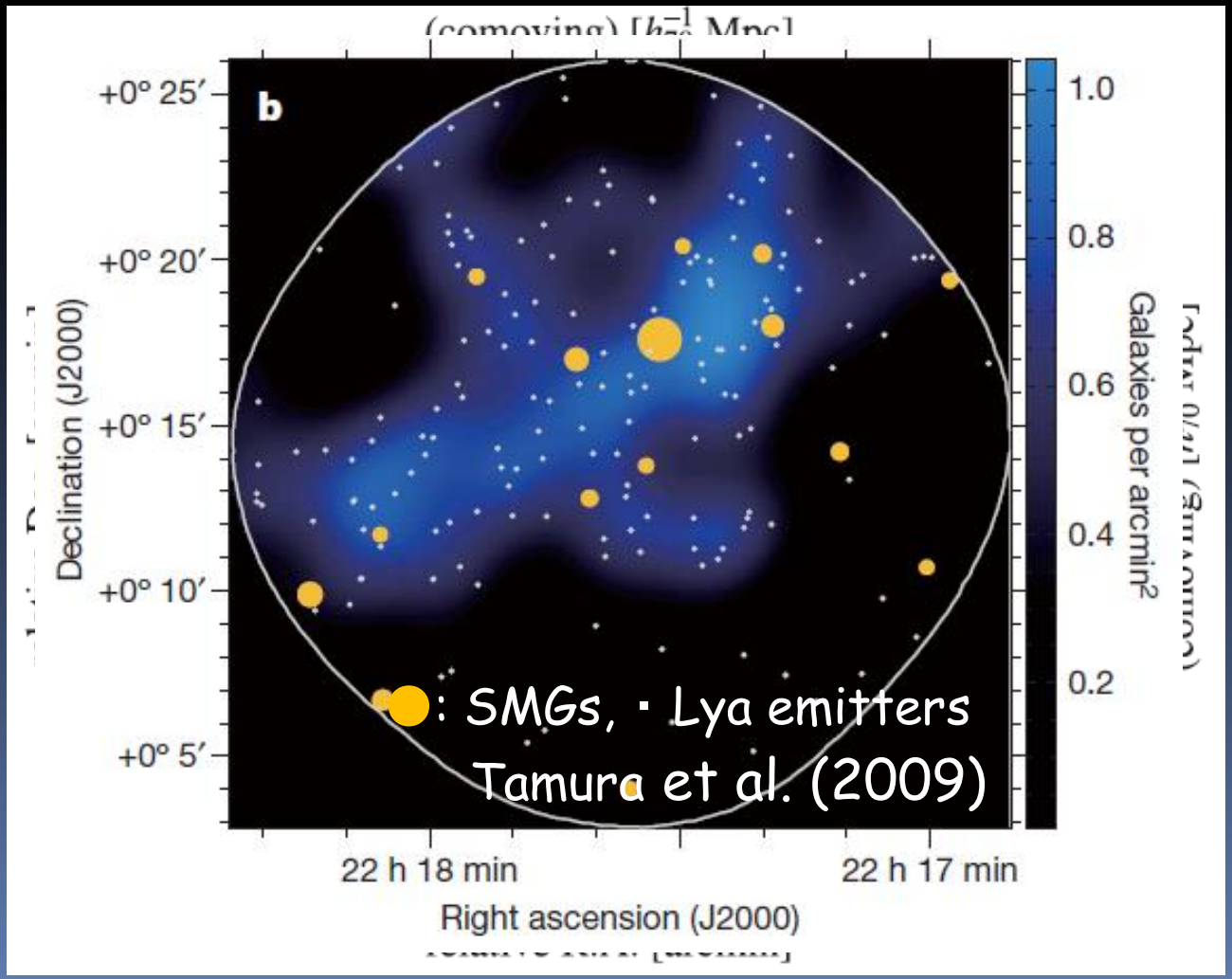




Kodama et al. (2007)

LAE/LBG clusters at z~3

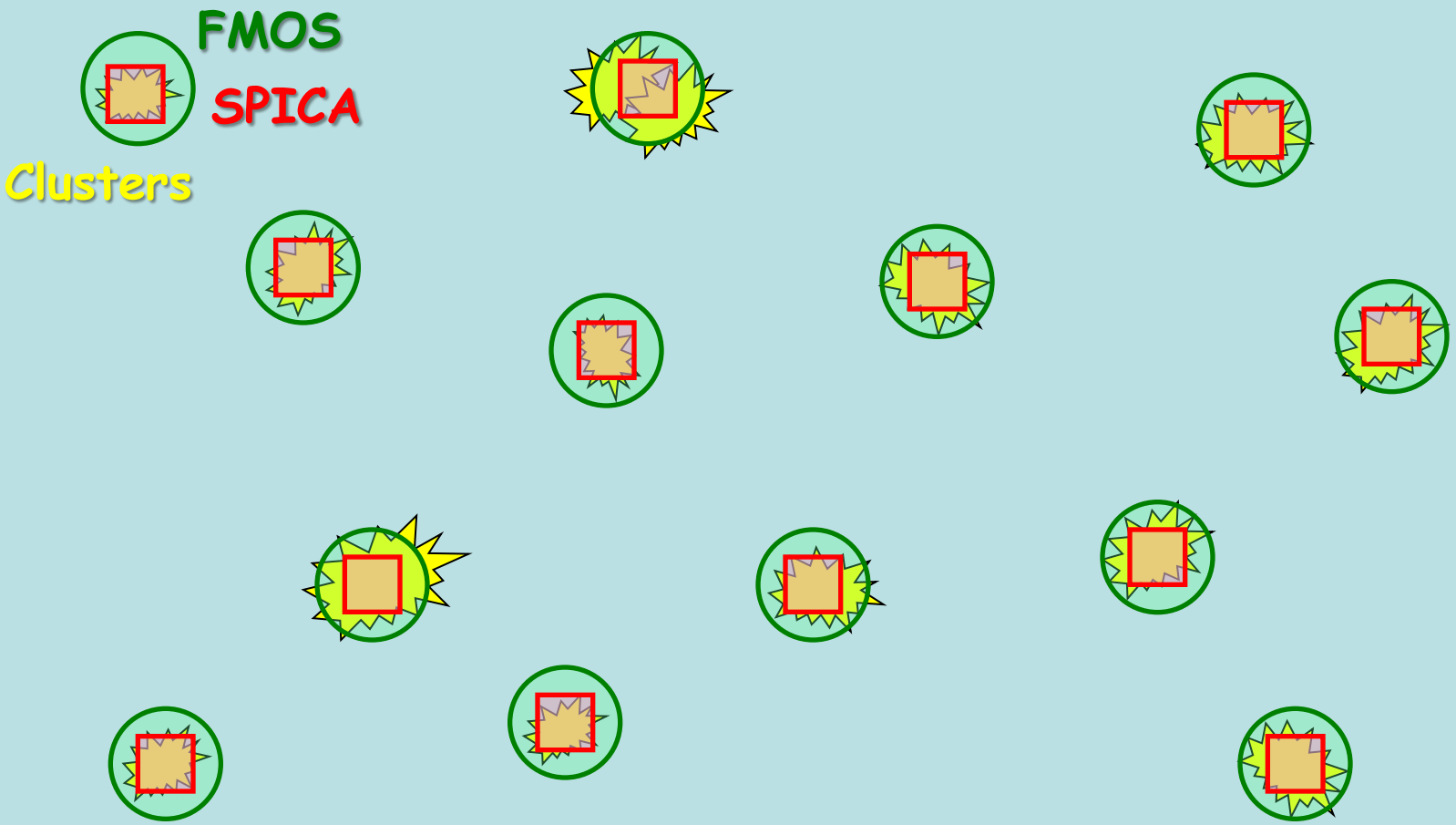
e.g. SSA22 @z=3.1 → 32um , Hayashino et al. (2004)



Many LAE/LBG clusters will be found by **HSC** ultra wide-field survey

Synergy with Subaru new instruments

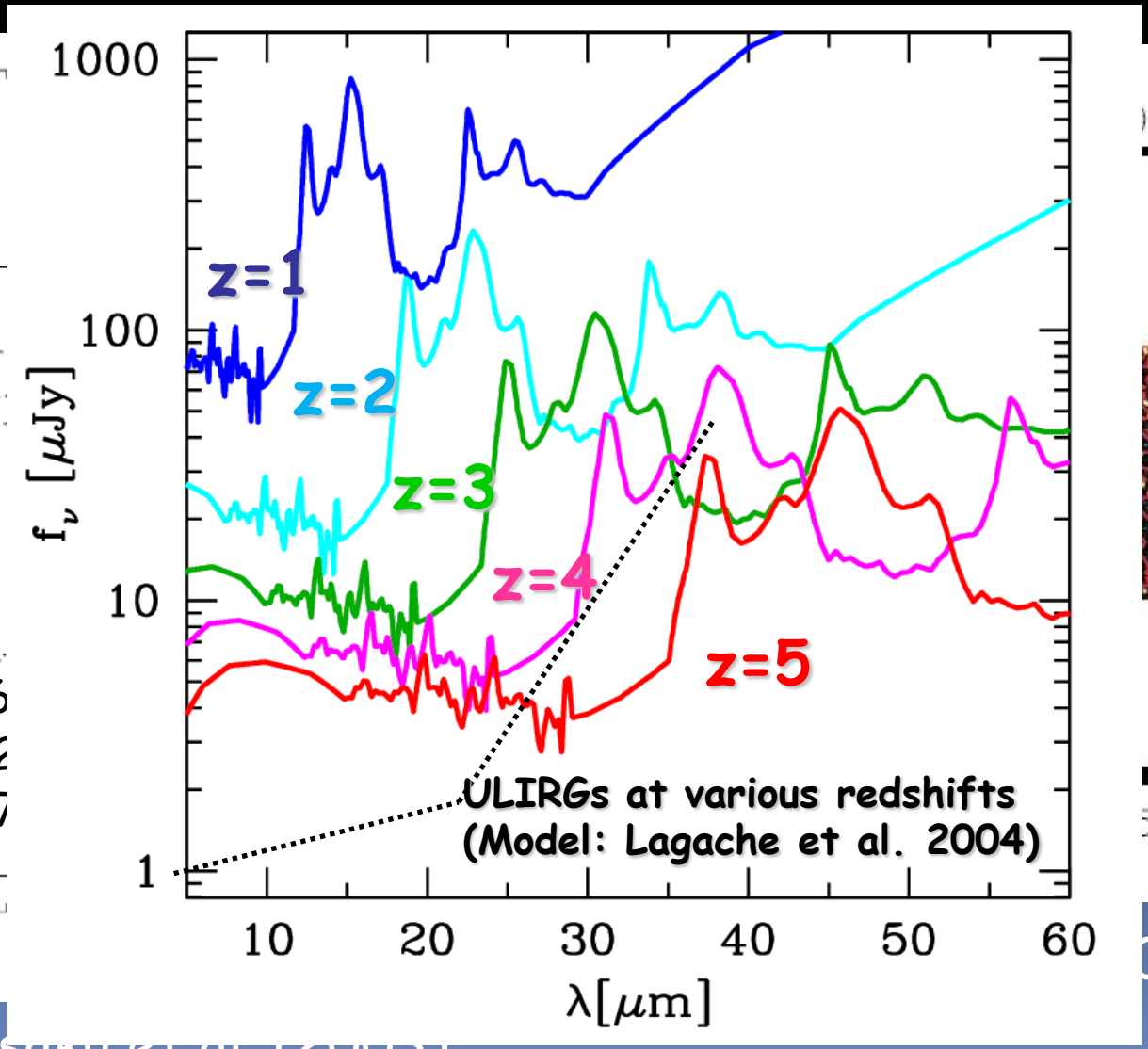
HSC survey field (e.g. LAE survey for z~3, Oii survey for z~1.5)

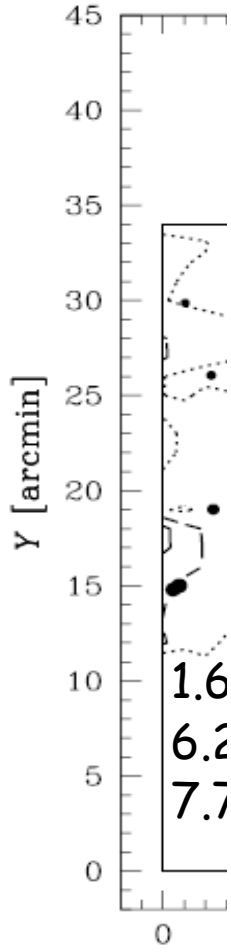


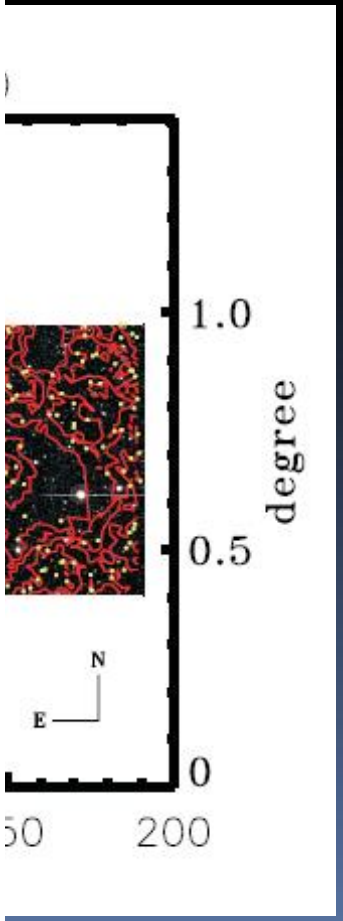
ULIRG mapping at z>>3 ?

LAE cluster at z=4.86 in SDF

LAE cluster at z=5.7 in SXDF







Shimasaku et al. (2005)

Summary

Optical study miss a huge amount of SF at all redshifts.

We propose intensive study of clusters at 0.5<z<4 with SPICA.

(mainly based on rest-frame 7.7um PAH)

z ~ 1 clusters

- Ultimate understanding of environmental effect
- Hidden star formation in low-mass galaxies

1 < z < 2 clusters

- Formation of the cluster core
- Rapid evolution of clusters and its link to dusty SF activity

z > 2 proto-clusters

- How large amount of SF hidden in high-z clusters ?
- When and where massive cluster galaxies are formed ?
- Large sample will be available soon …