

Growing-up at high redshift: from proto-clusters to clusters, 11/9/2012 @ESAC

Red Star Forming Galaxies in Distant Clusters: a key population under environmental effect?

MAHALO-Subaru collaboration

Yusei Koyama (Durham/NAOJ, JSPS fellow)

Tadayuki Kodama (NAOJ), Ken-ichi Tadaki (Univ. of Tokyo),
Masao Hayashi (NAOJ), Masayuki Tanaka (IPMU/Tokyo),
Ichi Tanaka (NAOJ), Ian Smail (Durham), Jaron Kurk (MPE)

MAHALO-Subaru

(PI: T. Kodama; see talk by K. Tadaki, M. Hayashi)

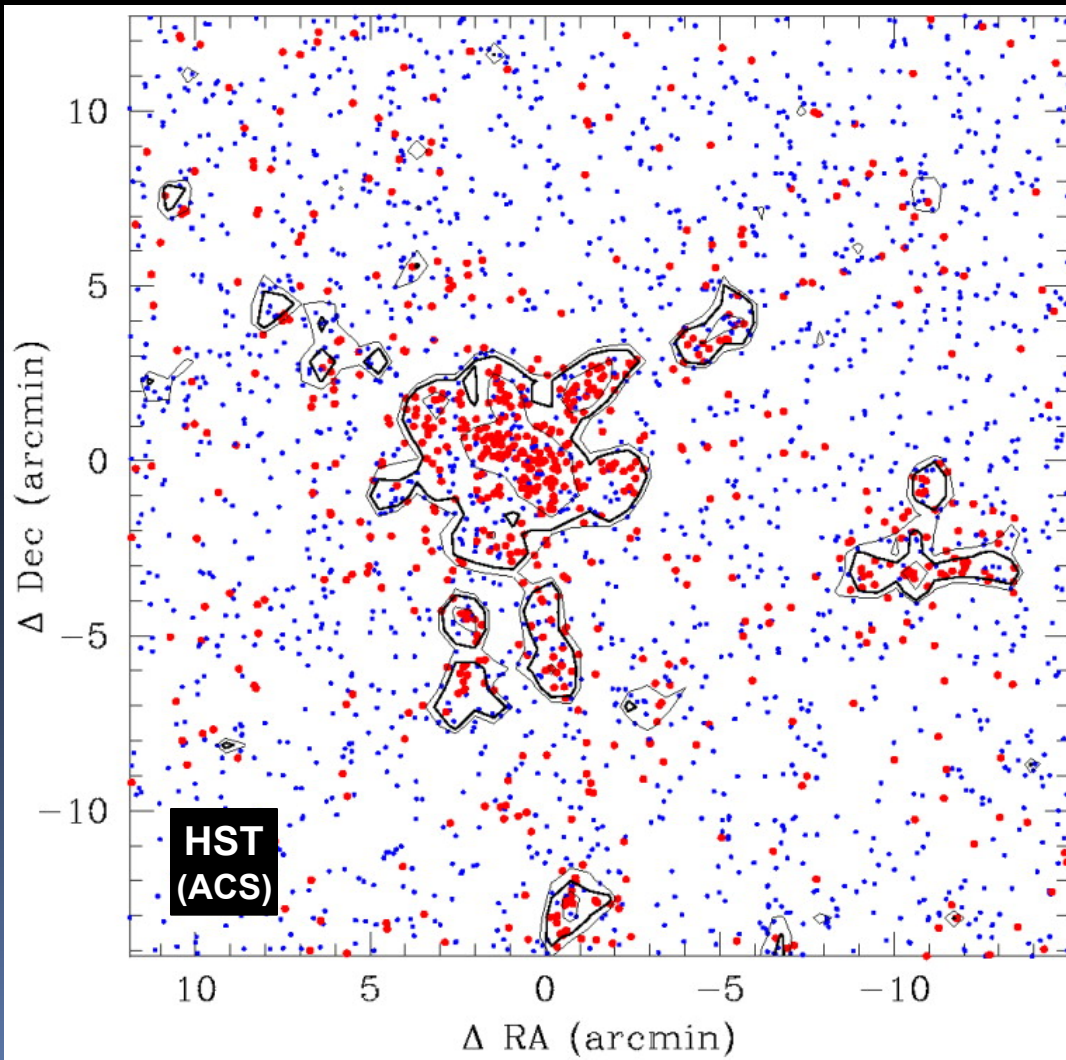
“Panoramic + H α + MIR” approach

a subsample of our MAHALO targets

| Target | z | Subaru H α NB | MIR | Reference |
|--------------|------|----------------------|--------------|---------------------------|
| CL0939+4713 | 0.41 | NB921/S-Cam | MIPS/Spitzer | Koyama et al. 2011 |
| RXJ1716+6708 | 0.81 | NB119/MOIRCS | IRC/AKARI | Koyama et al. 2010 |
| 4C65.22 | 1.52 | NB1657/MOIRCS | IRC/AKARI | Koyama et al. in prep. |
| Q0835+580 | 1.53 | NB1657/MOIRCS | MIPS/Spitzer | Shimakawa et al. in prep. |
| PKS1138-262 | 2.16 | NB2071/MOIRCS | MIPS/Spitzer | Koyama et al. 2012 |
| 4C23.56 | 2.48 | NB2288/MOIRCS | MIPS/Spitzer | Tanaka et al. 2011 |

- ✓ Panoramic: cover wide range in environment
- ✓ H α study: locally well-calibrated SF indicator
- ✓ IR study: sensitive to dust-obscured SF

Panoramic view of A851 ($z=0.4$) with Subaru



A prominent large-scale structure is discovered by panoramic imaging with **Suprime-Cam**.

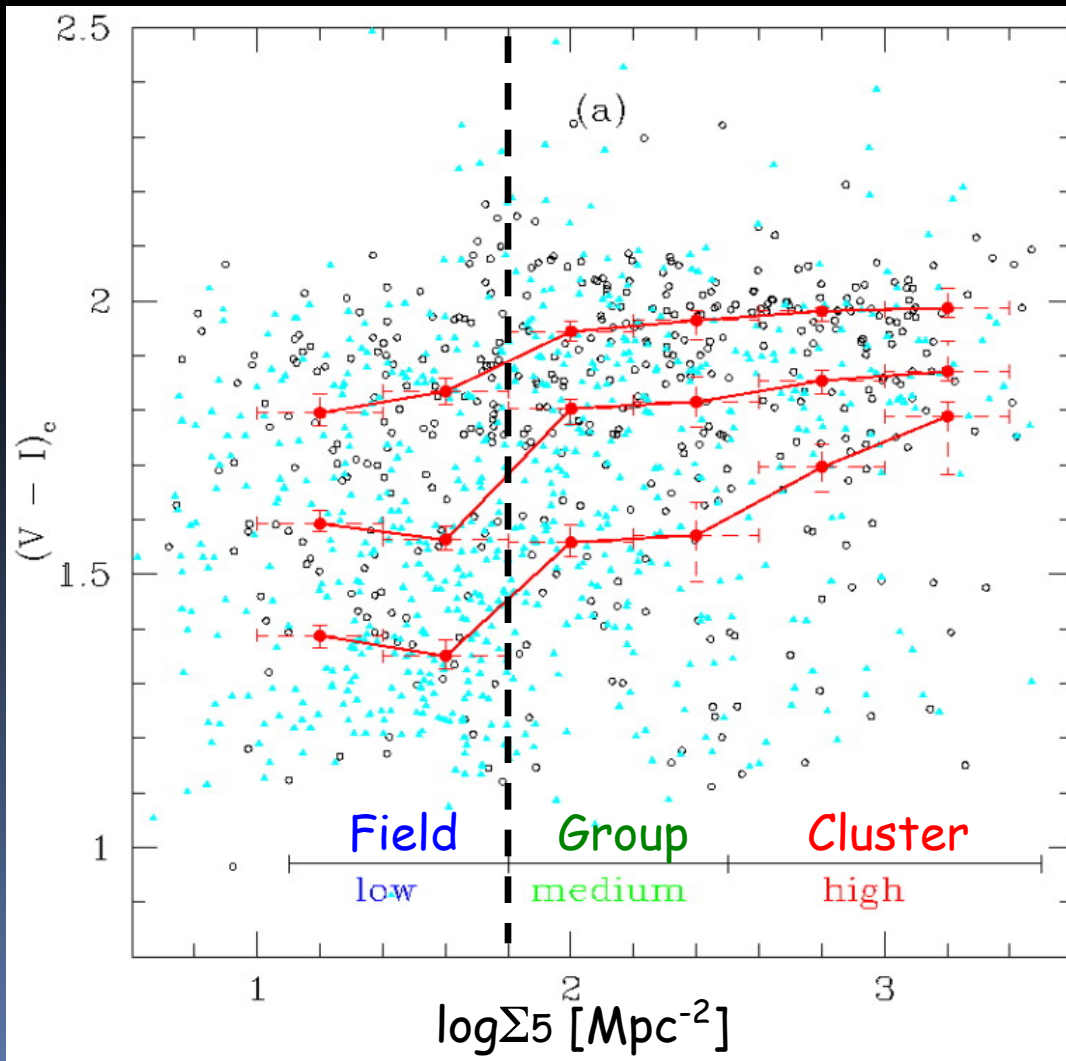
Kodama et al. (2001)

Galaxy transition takes place in "medium-density" groups/filaments.

See also Tanaka et al. (2005)

Koyama et al. (2008)

Panoramic view of A851 ($z=0.4$) with Subaru



A prominent large-scale structure is discovered by panoramic imaging with **Suprime-Cam**.

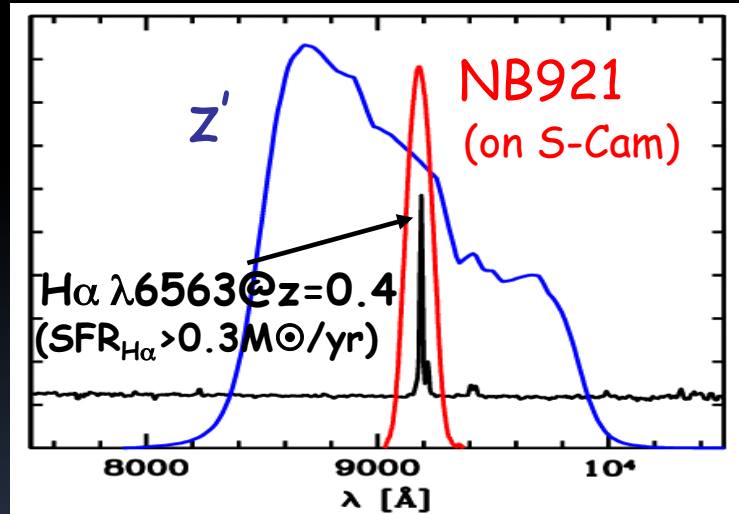
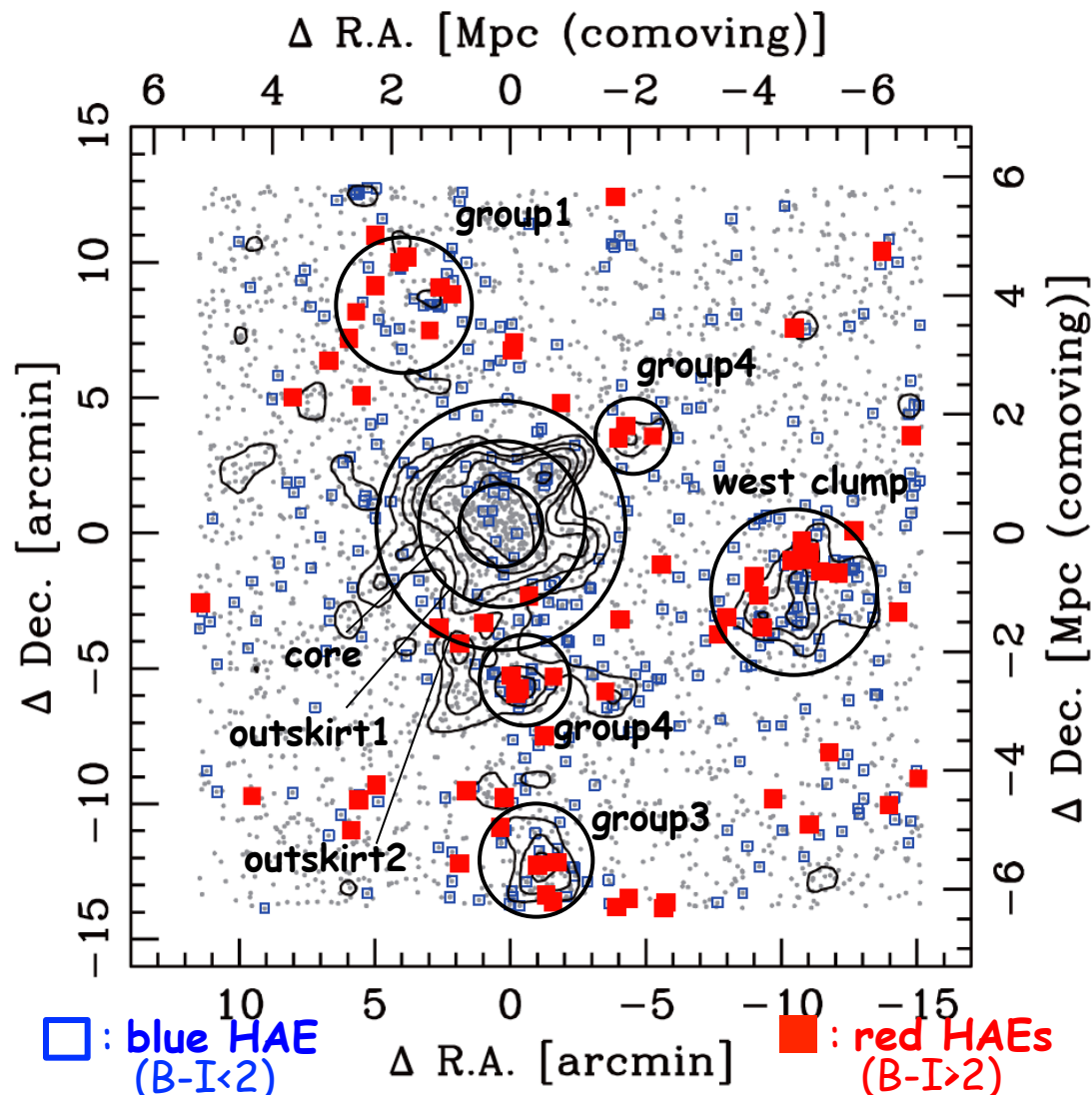
Kodama et al. (2001)

Galaxy transition takes place in "medium-density" groups/filaments.

See also Tanaka et al. (2005)

Koyama et al. (2008)

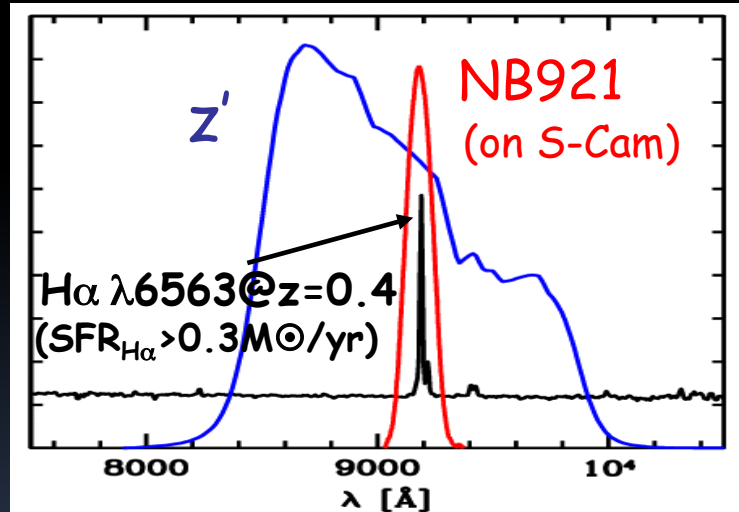
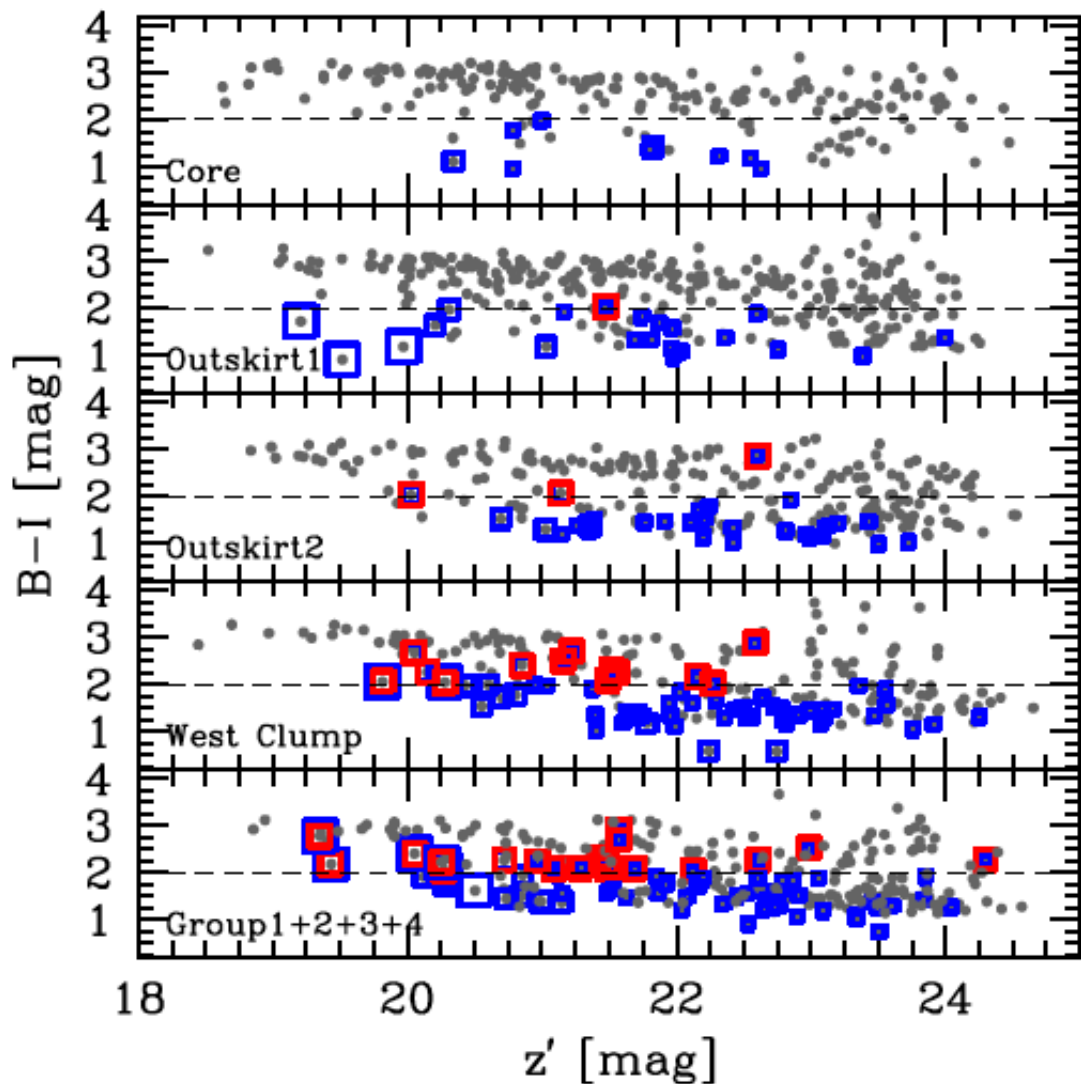
Panoramic "H α view" of A851 with Subaru



>400 HAEs along the large-scale structure

"Red SF galaxies" are preferentially found in the group-scale environment

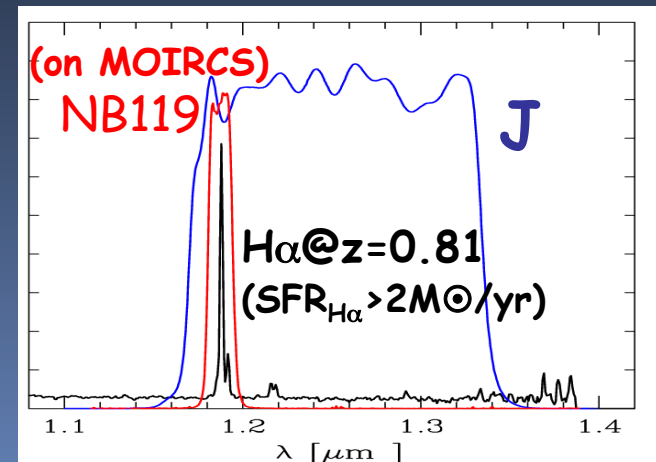
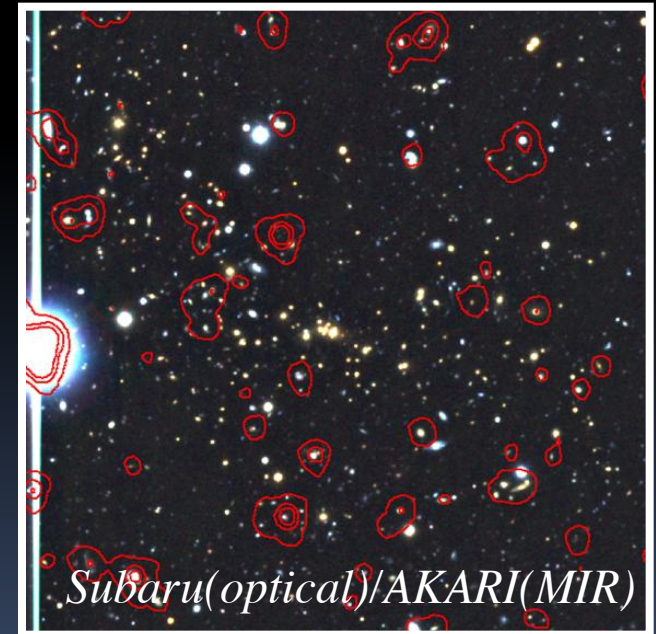
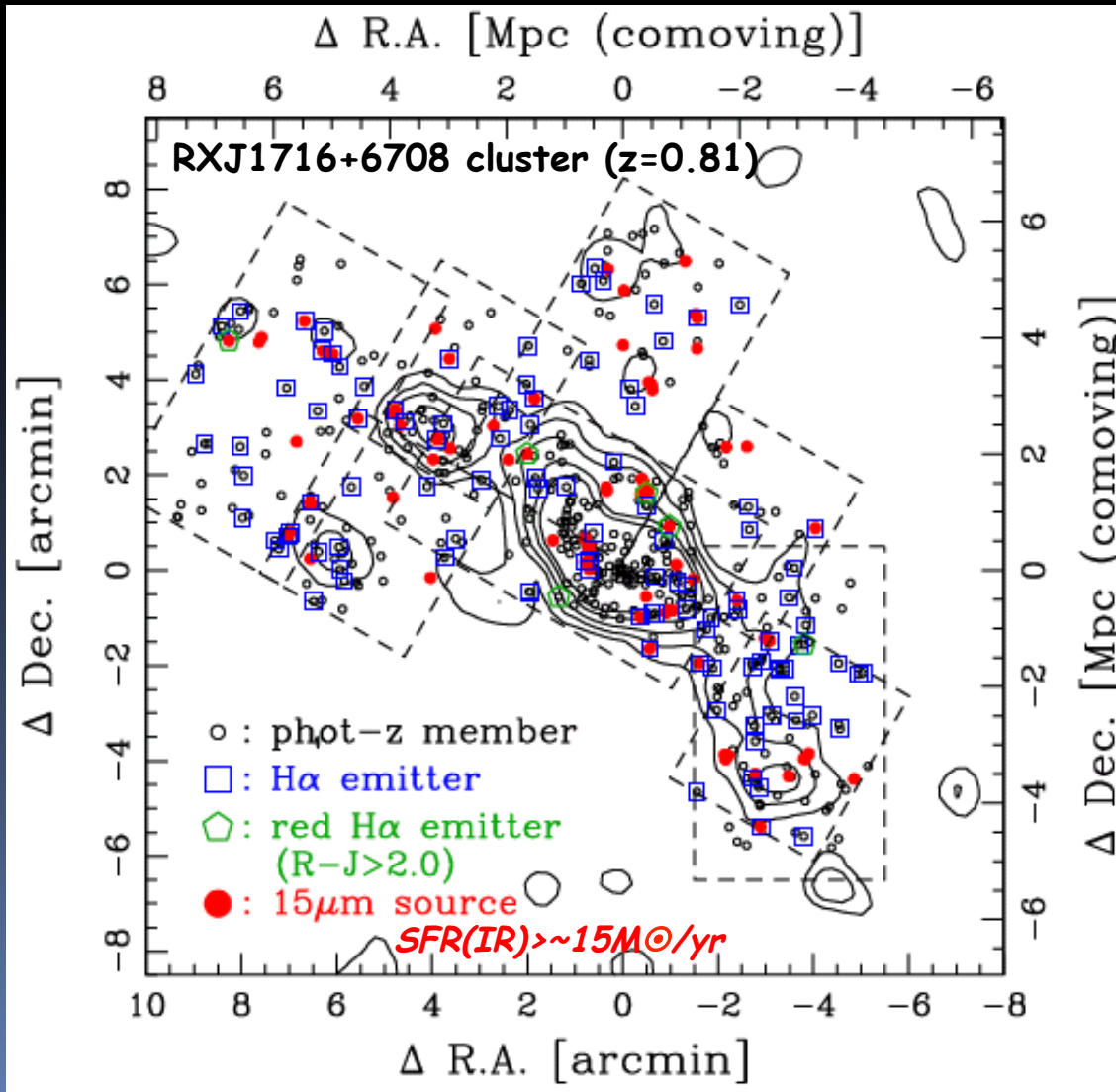
Panoramic "H α view" of A851 with Subaru



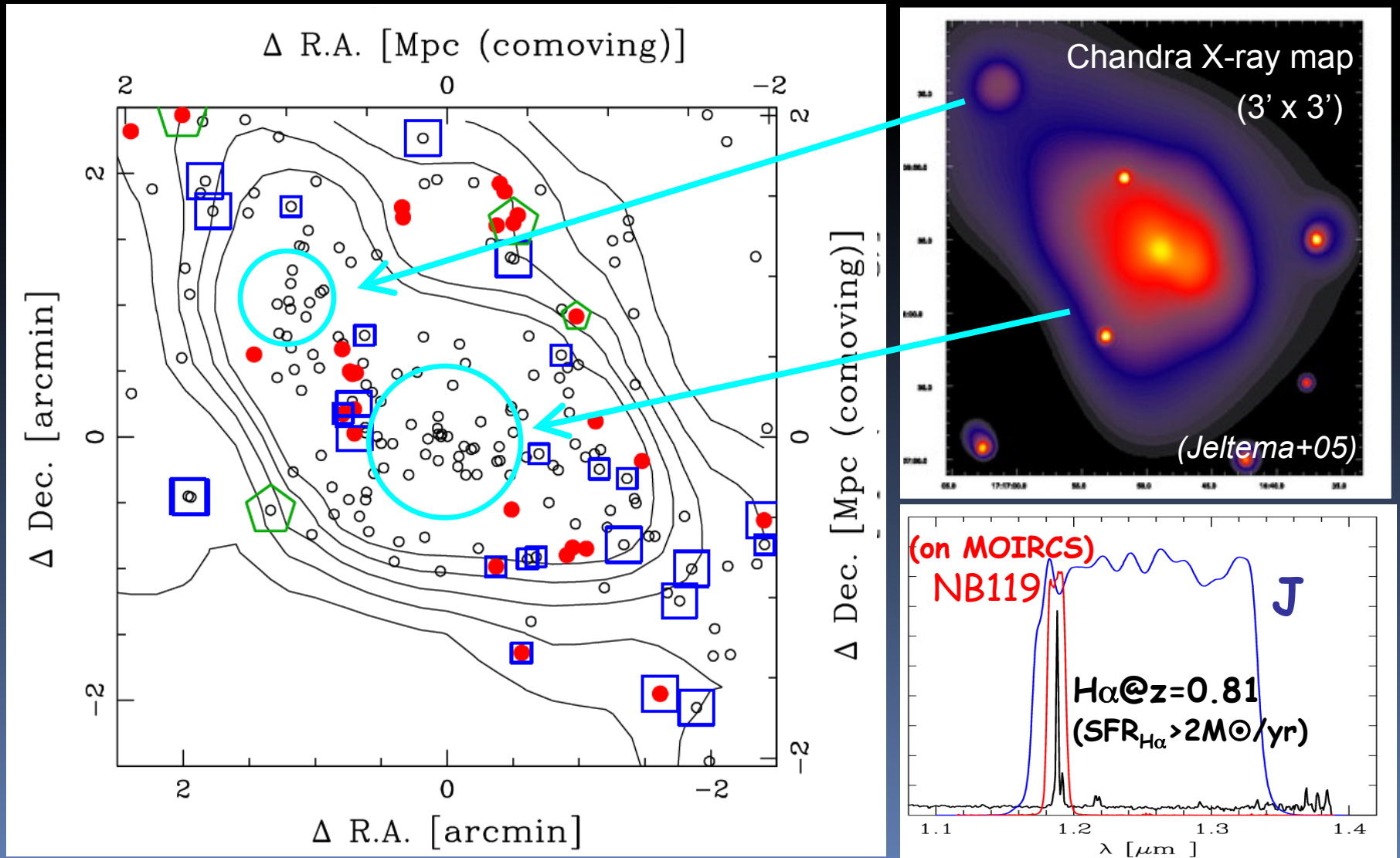
>400 HAEs along the large-scale structure

"Red SF galaxies" are preferentially found in the group-scale environment

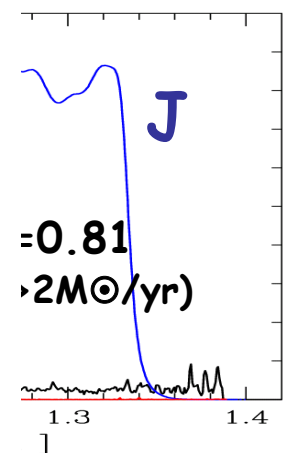
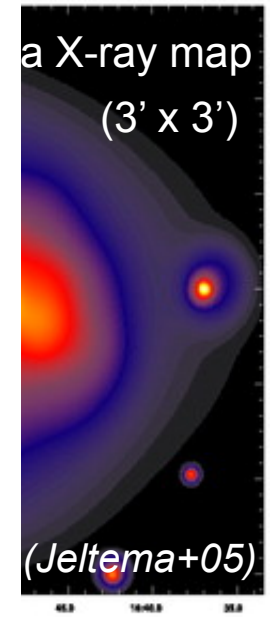
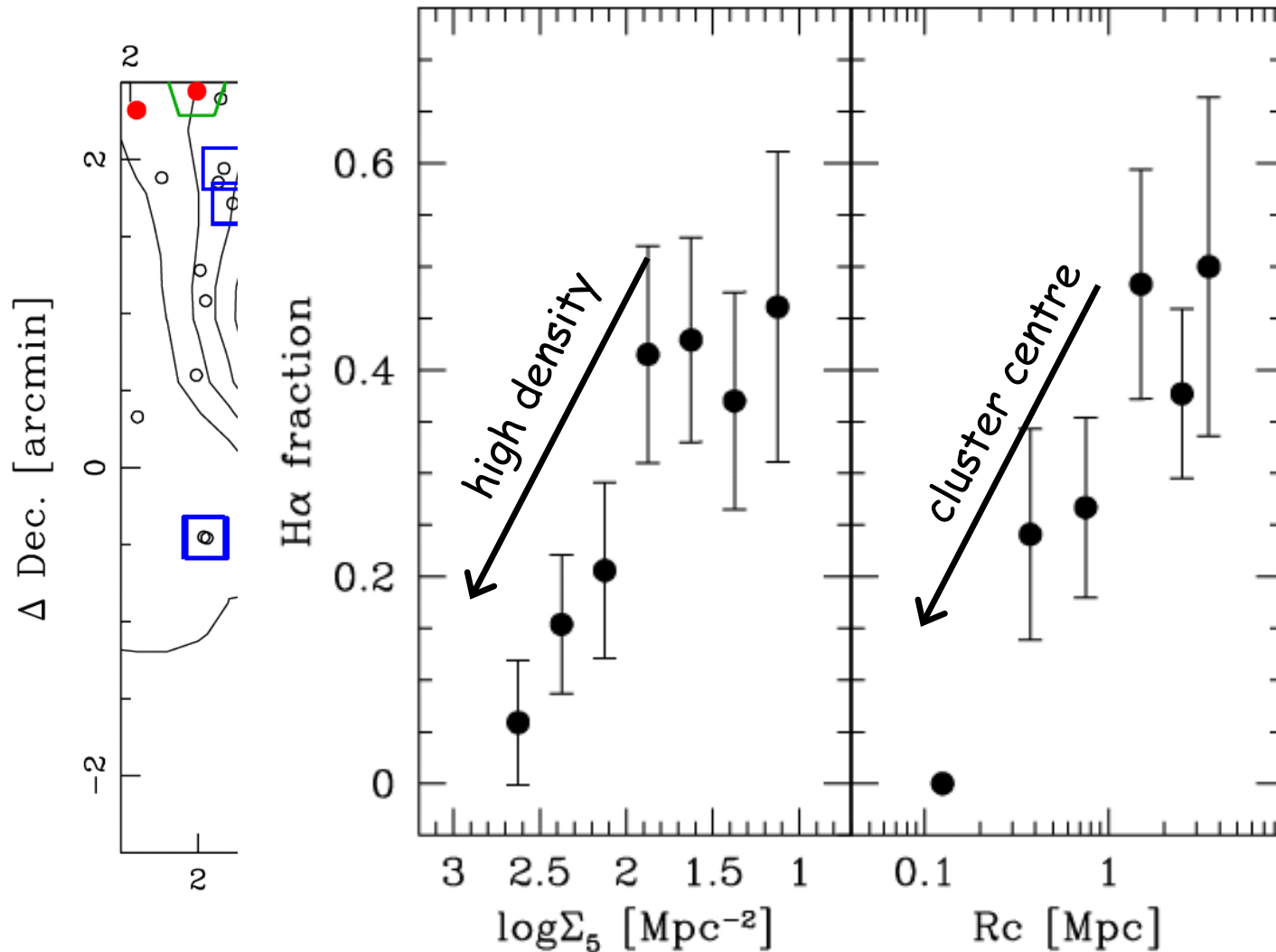
Panoramic H α +MIR view of a $z=0.8$ cluster



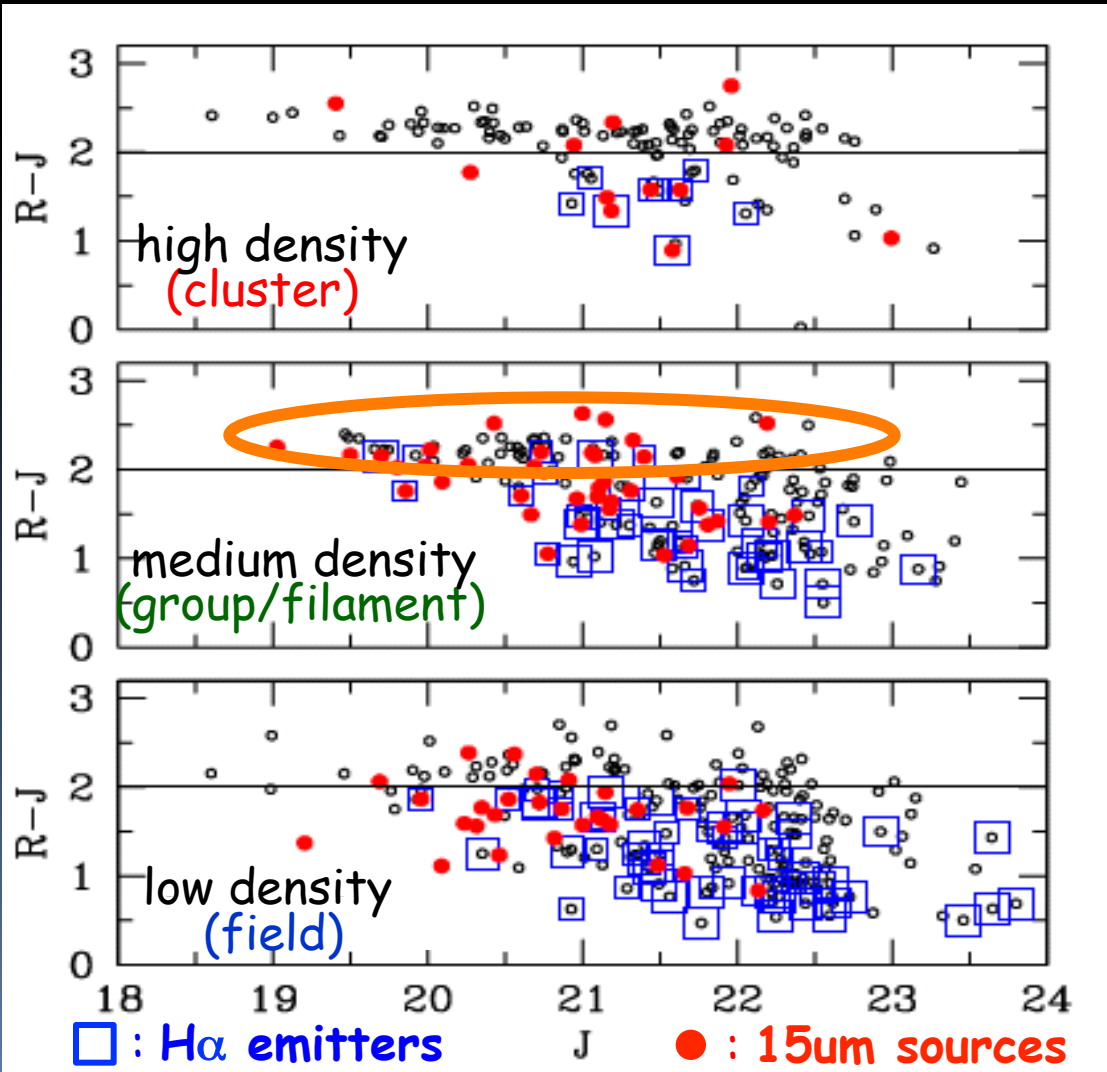
Panoramic $H\alpha$ +MIR view of a $z=0.8$ cluster



Panoramic H α +MIR view of a $z=0.8$ cluster

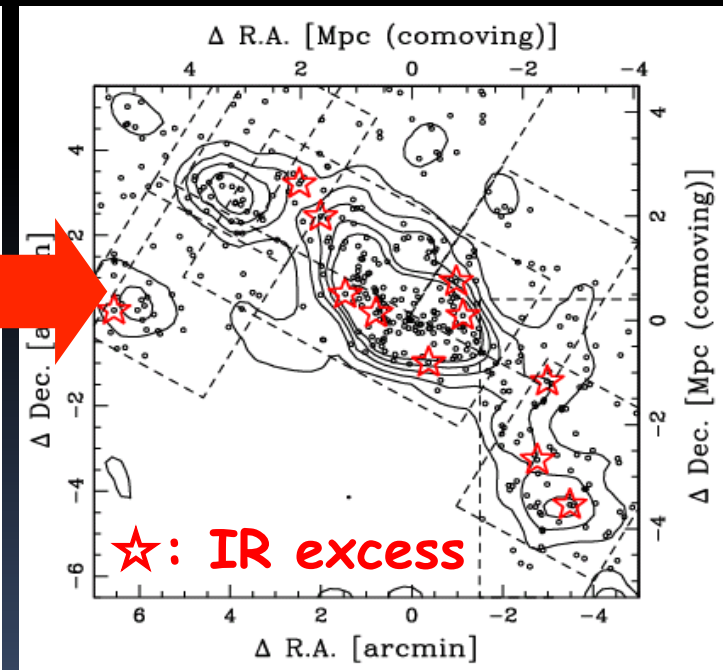
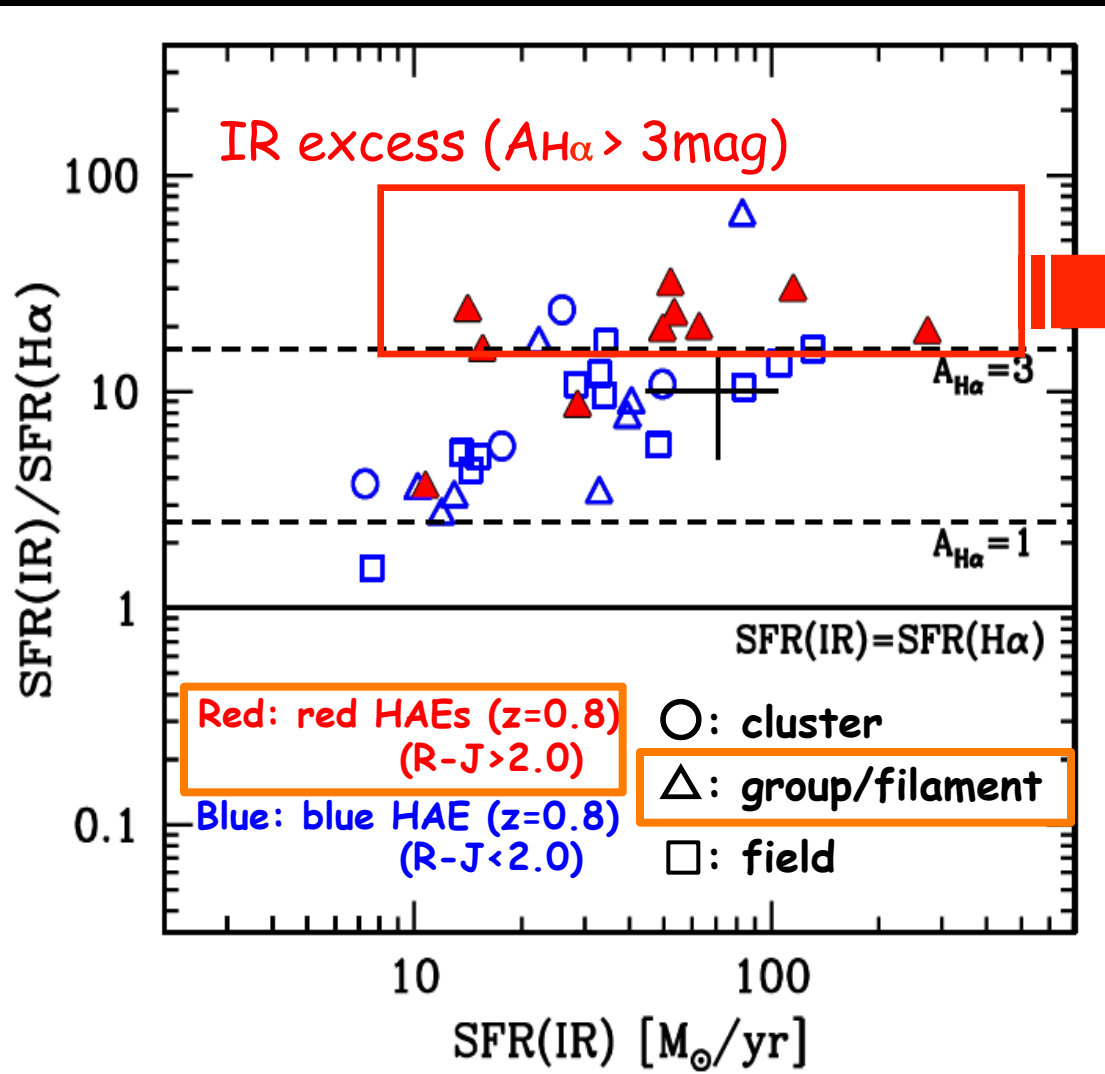


Dust-obscured SF in/around $z=0.8$ cluster



Red HAEs and 15 μm sources are most numerous in group-scale environment.

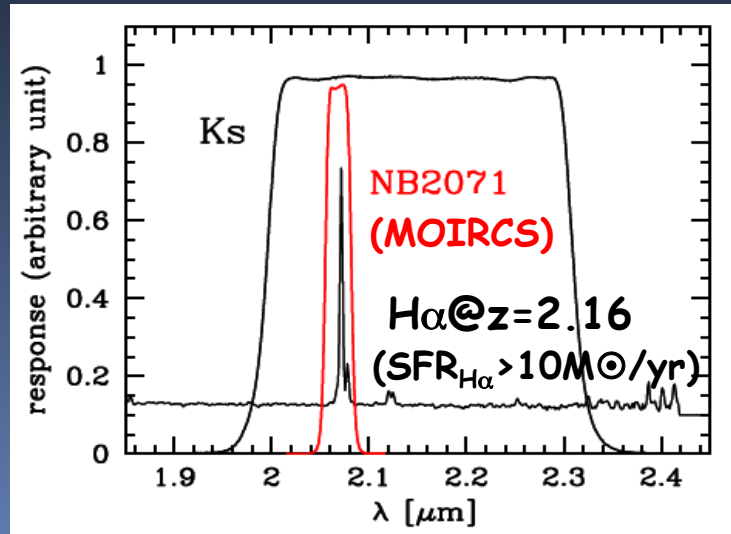
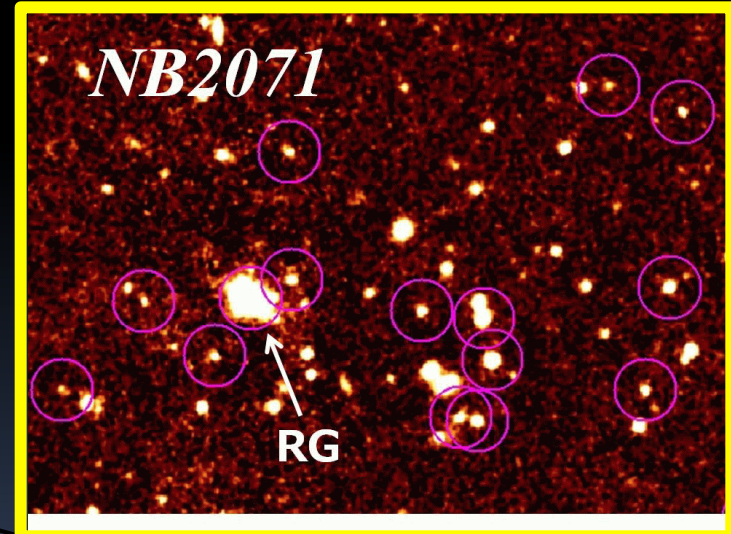
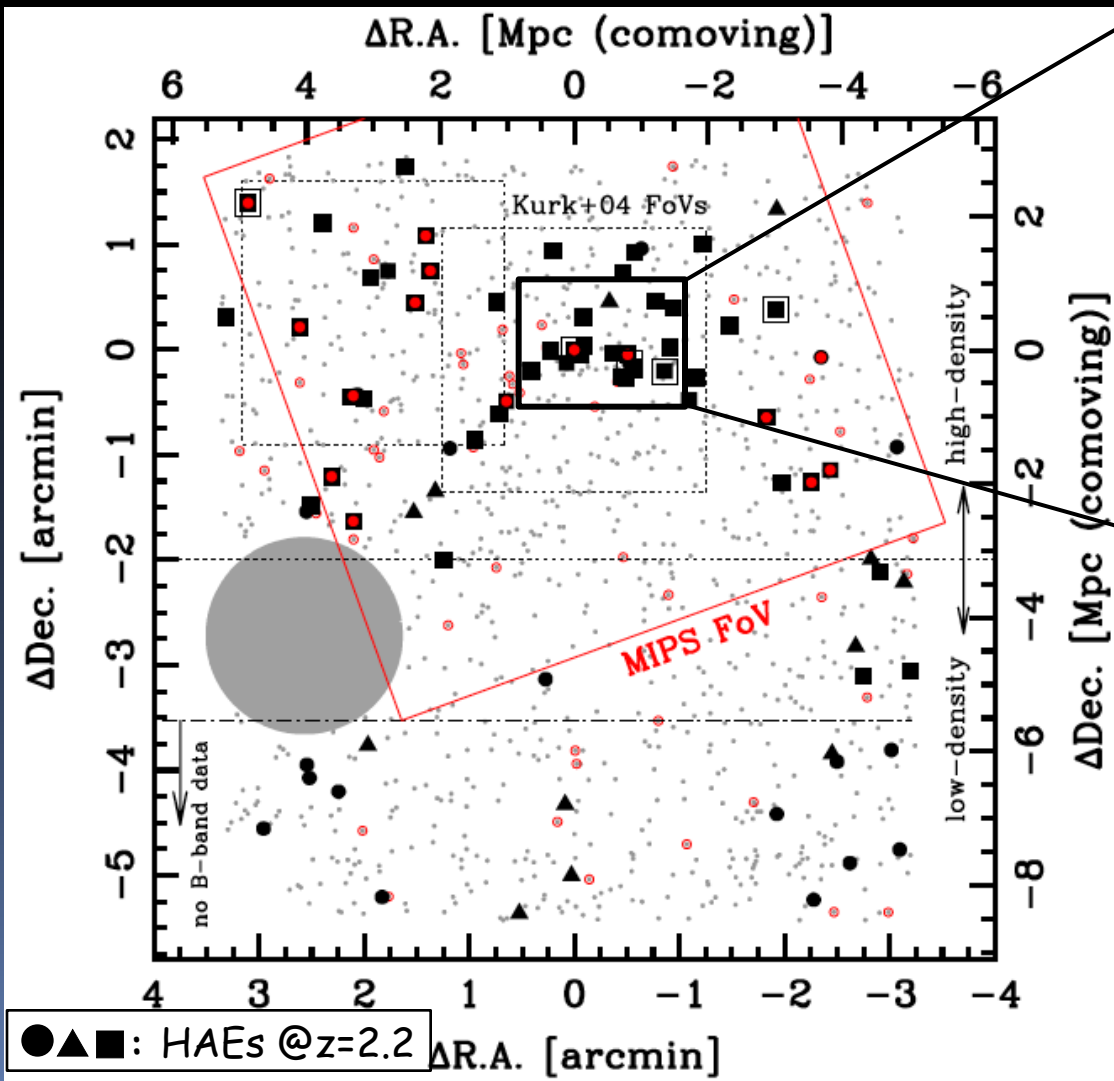
Dust-obscured SF in/around $z=0.8$ cluster



= accelerated galaxy evolution in the cluster in-falling regions?

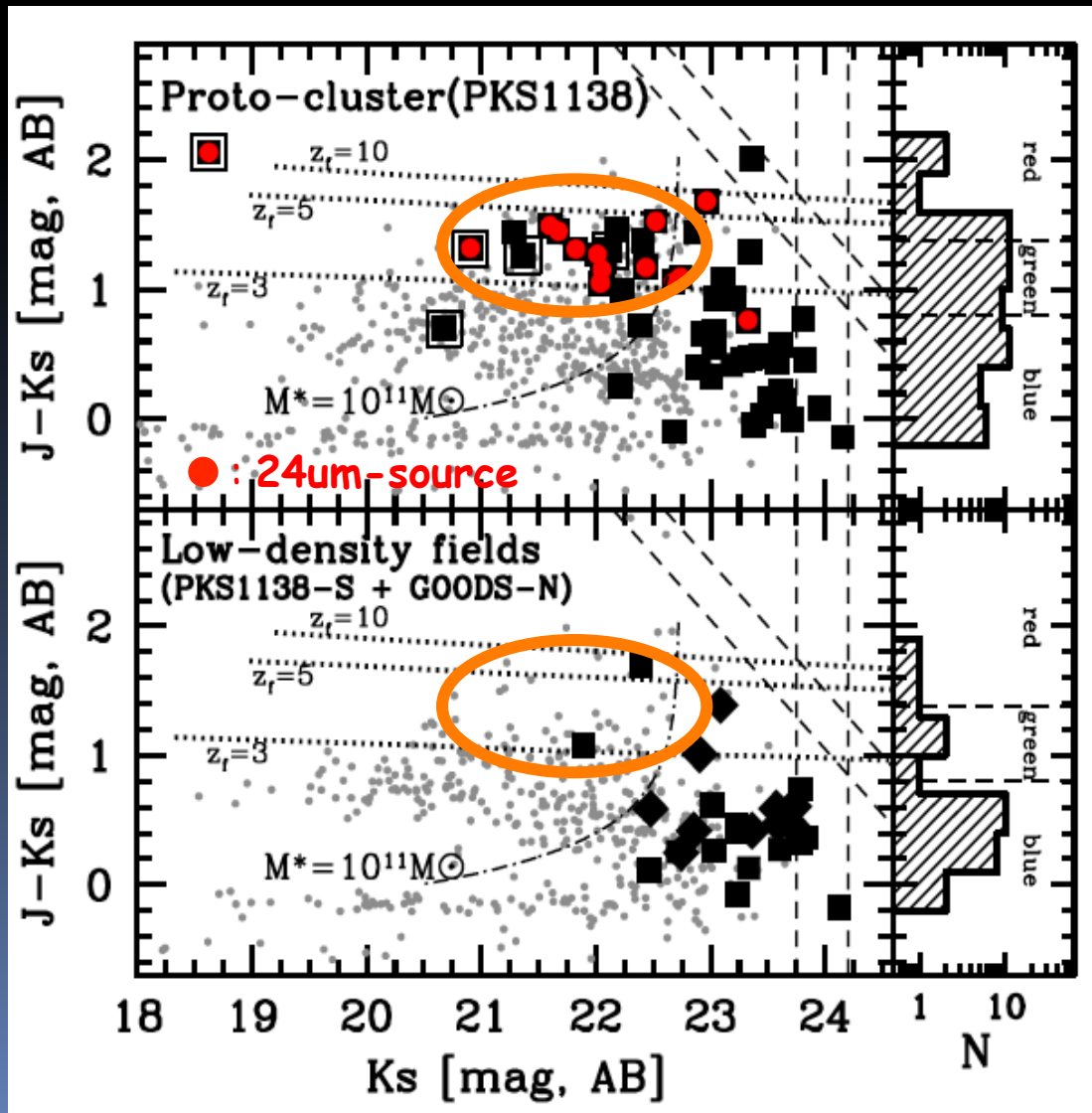
Panoramic H α mapping of a $z=2.16$ proto-cluster

(Koyama et al. 2012, MNRAS, submitted)



PKS1138-262: talk by e.g. M.Tanaka, N.Hatch, H.Dannerbauer, M.Sanches-Portal

"Massive starbursts" in the z=2 proto-cluster

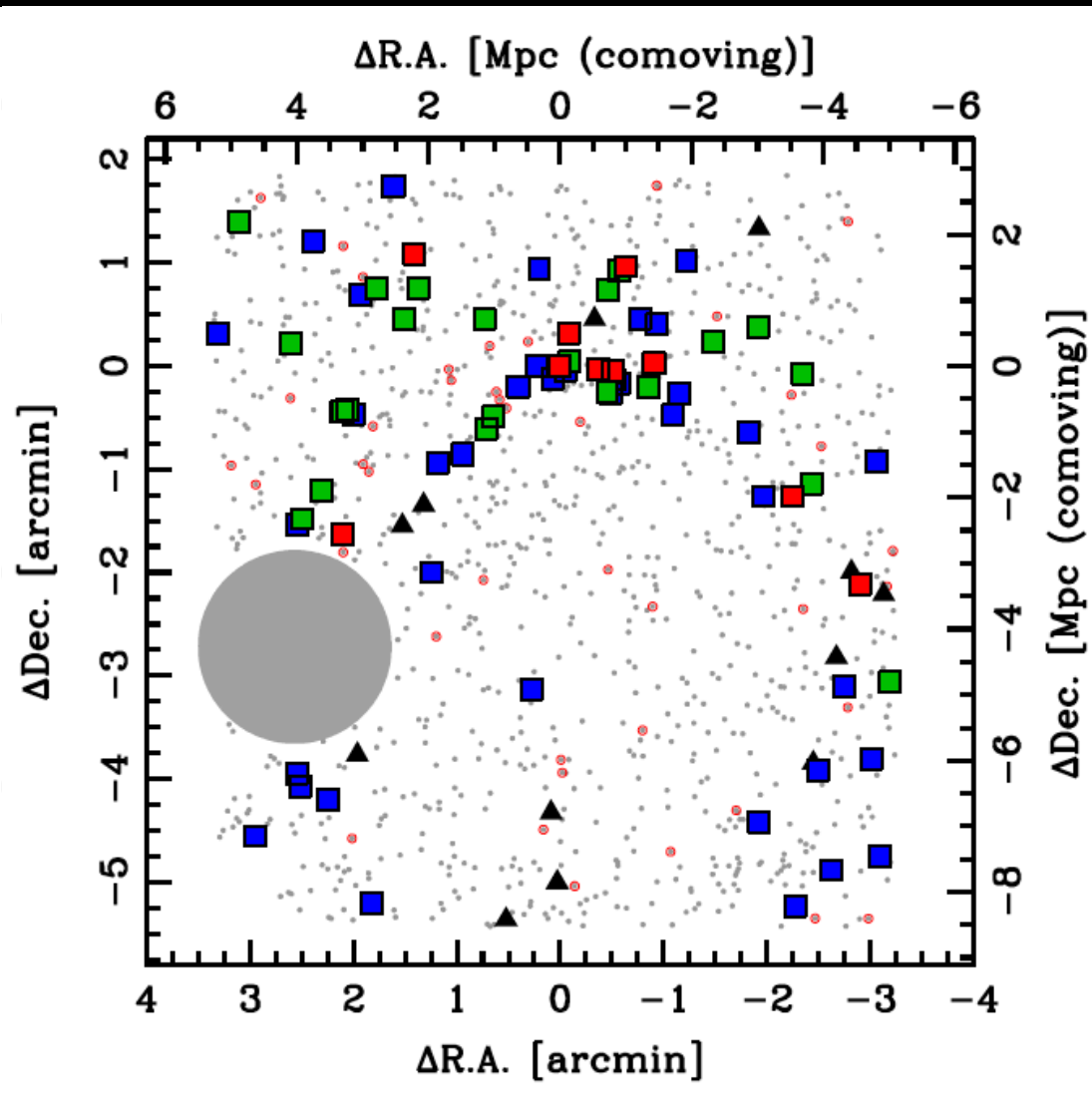


SF galaxies in the proto-cluster show redder colours and higher M^* ($>10^{11} M_\odot$) compared to general field galaxies.

- : red HAE ($J-K_{AB} > 1.38$, DRG)
- : green HAE ($0.8 < J-K_{AB} < 1.38$)
- : blue HAE ($J-K_{AB} < 0.8$)

(Koyama et al. 2012, submitted)

"Massive starbursts" in the $z=2$ proto-cluster

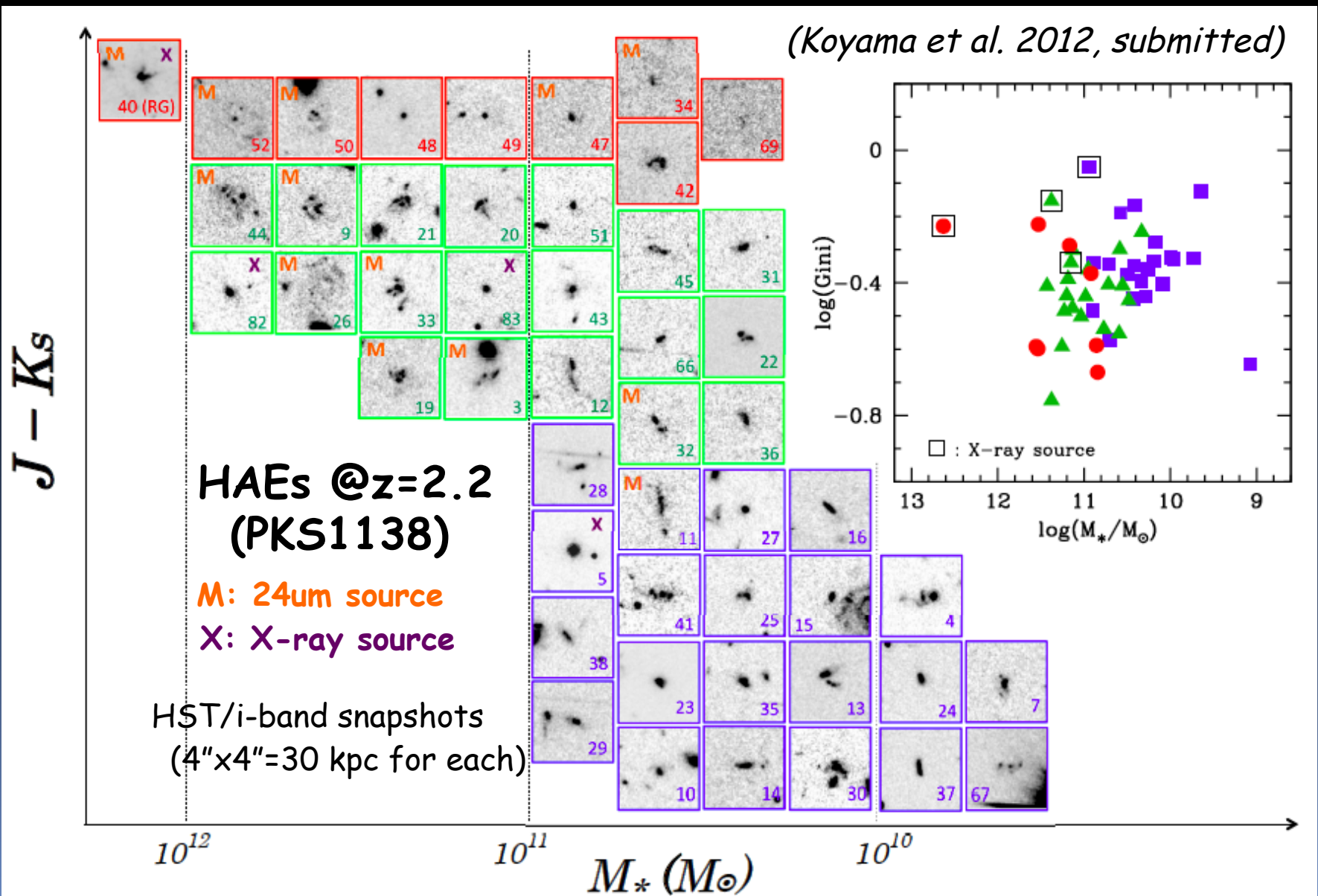


SF galaxies in the proto-cluster show redder colours and higher M^* ($>10^{11} M_{\odot}$) compared to general field galaxies.

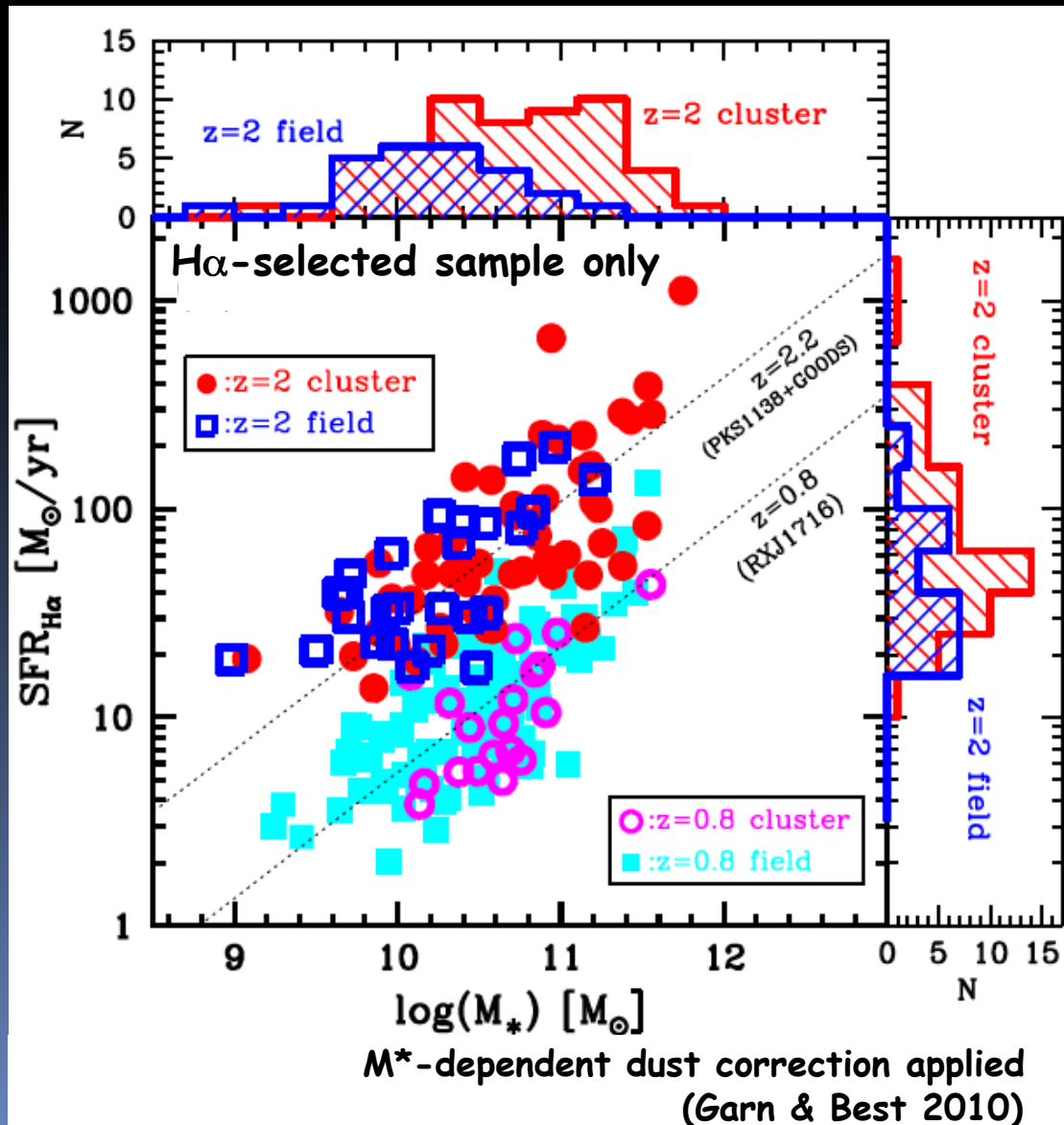
- : red HAE
($J-K_{AB} > 1.38$, DRG)
- : green HAE
($0.8 < J-K_{AB} < 1.38$)
- : blue HAE
($J-K_{AB} < 0.8$)

(Koyama et al. 2012, submitted)

Rest-UV morphologies on colour- M_* plane



The "Main Sequence" in cluster environment



Proto-cluster galaxies follow the same "main sequence" as for field galaxies at $z=2$ (but with excess in its massive end)

Very massive SF galaxies "disappeared" in the $z=0.8$ cluster (i.e. massive galaxies are already passive)

(Koyama et al. 2012, submitted)

Summary

✓ From $z < 1$ cluster study:

- SF galaxies 'avoid' cluster core regions.
- Red SF galaxies (+ MIR bright sources) are numerous in group-scale environment.

✓ From $z \sim 2$ proto-cluster study:

- red, massive starbursts are likely to be more common in cluster (PKS1138).
- Proto-cluster HAEs follow the same SFR vs M^* relation as field SF galaxies with some excess in the massive end.