An evolving proto-cluster with two prominent clumps at z=2.53

Wide-field Hα emission survey around a radio galaxy at z=2.53 with MOIRCS/Subaru

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Collaborators

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Subaru UM 2011

MAHALO-Subaru

"MAHALO-Subaru"

MApping HAlpha and Lines of Oxygen with Subaru

A narrow-band mapping of star forming galaxies at the peak epoch of galaxy formation at 0.4<z<2.5 (primarily at 1.5<z<2.5).

Pilot obs (5 nights) + Intensive (10 nights @S10B-11A) + Normal (3 nights @S11B)

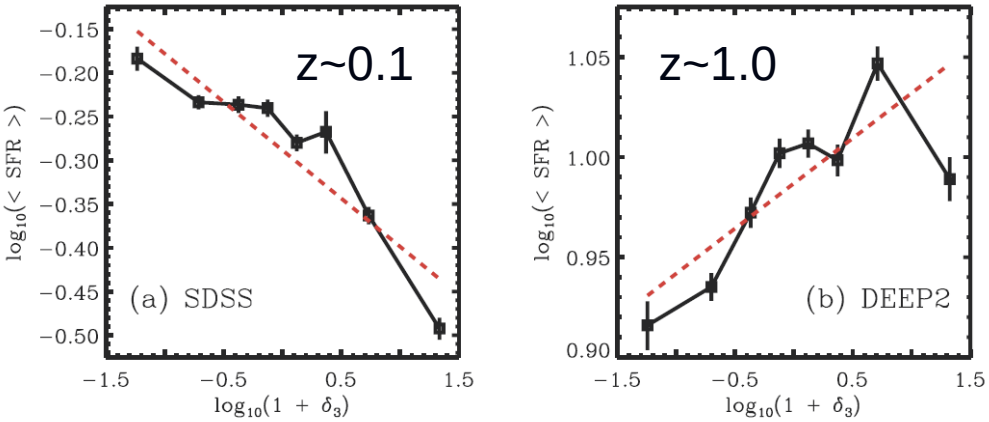
environment	target	z	line	λ (μm)	camera	NB-filter	continuum	status (as of Nov 2011)
Low-z cluster	CL0024+1652	0.395	Hα	0.916	Suprime-Cam	NB912	z'	Kodama+'04
	CL0939+4713	0.407	Hα	0.923	Suprime-Cam	NB921	z'	Koyama+'11
	RXJ1716+6708	0.813	Hα	1.190	MOIRCS	NB1190	J	Koyama+'10
			[O II]	0.676	Suprime-Cam	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+'11b
Proto-cluster	PKS1138–262	2.156	Hα	2.071	MOIRCS	NB2071	K_s	Koyama+ in prep.
	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+ in prep.
General field	GOODS-N (62 arcmin^2)	2.19	Hα	2.094	MOIRCS	NB2095	K_s	Tadaki+'11a
			[O II]	1.189	MOIRCS	NB1190	J	observed
	SXDF (110 arcmin^2)	2.19	Hα	2.094	MOIRCS	NB2095	K	Tadaki+ in prep.
			Hβ	1.551	MOIRCS	NB1550	H	not yet
			[O II]	1.189	MOIRCS	NB1190	J	not yet

Tadayuki Kodama (Subaru; PI), Masao Hayashi (NAOJ), Yusei Koyama (Durham), Ken-ichi Tadaki (Univ. of Tokyo), Ichi Tanaka (Subaru), et al.

(from Kodama-san's slide)

Star formation activity in high-z clusters

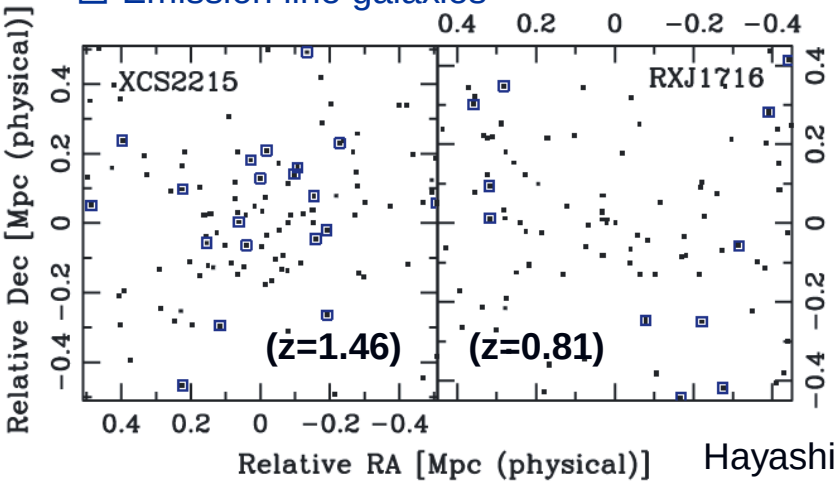
Reversal of SFR-density relation?



Cooper et al. (2008)

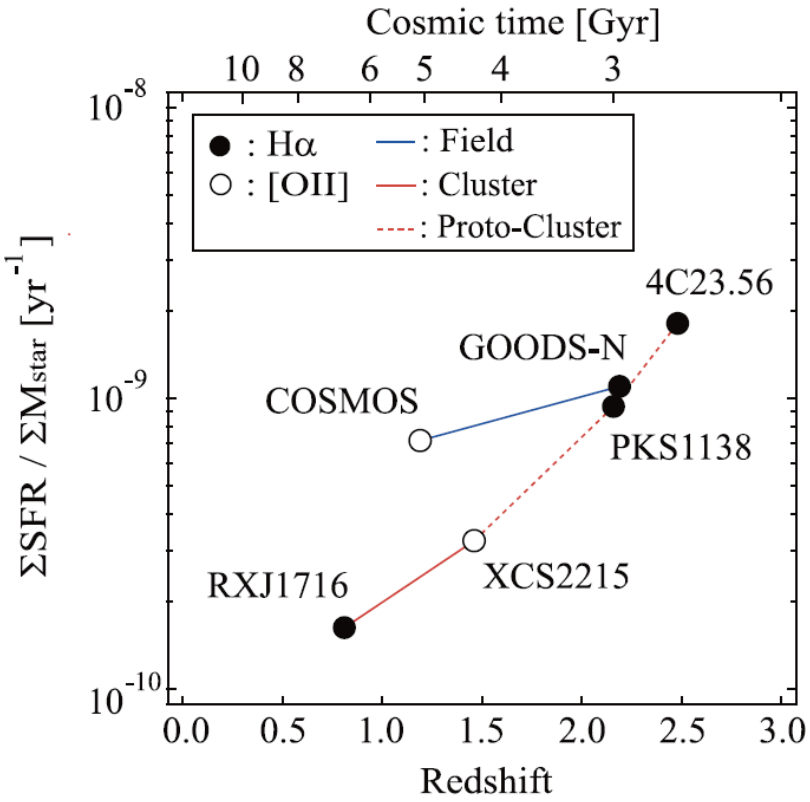
Active star formation in the cluster core

☐ Emission line galaxies



Hayashi et al. (2010)

Redshift evolution of star formation activity in fields and clusters



Tadaki et al. (2011)

It is interesting to investigate the galaxy activity in a high density region at z>2.

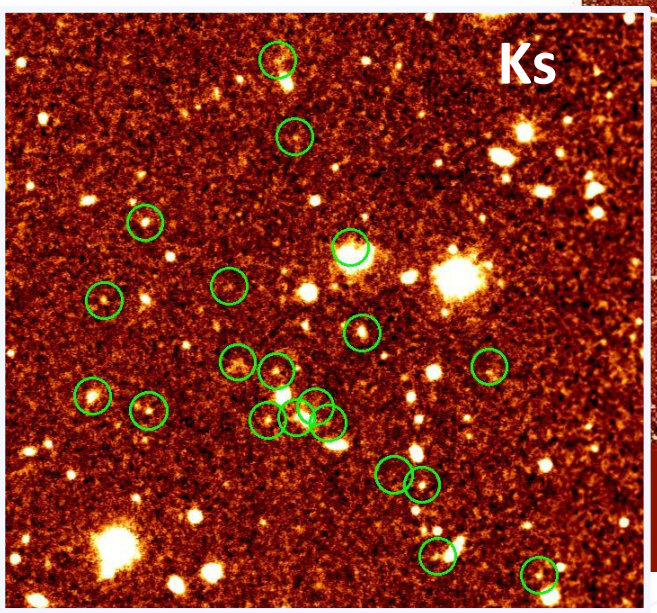
USS1558-003 proto-cluster at z=2.53

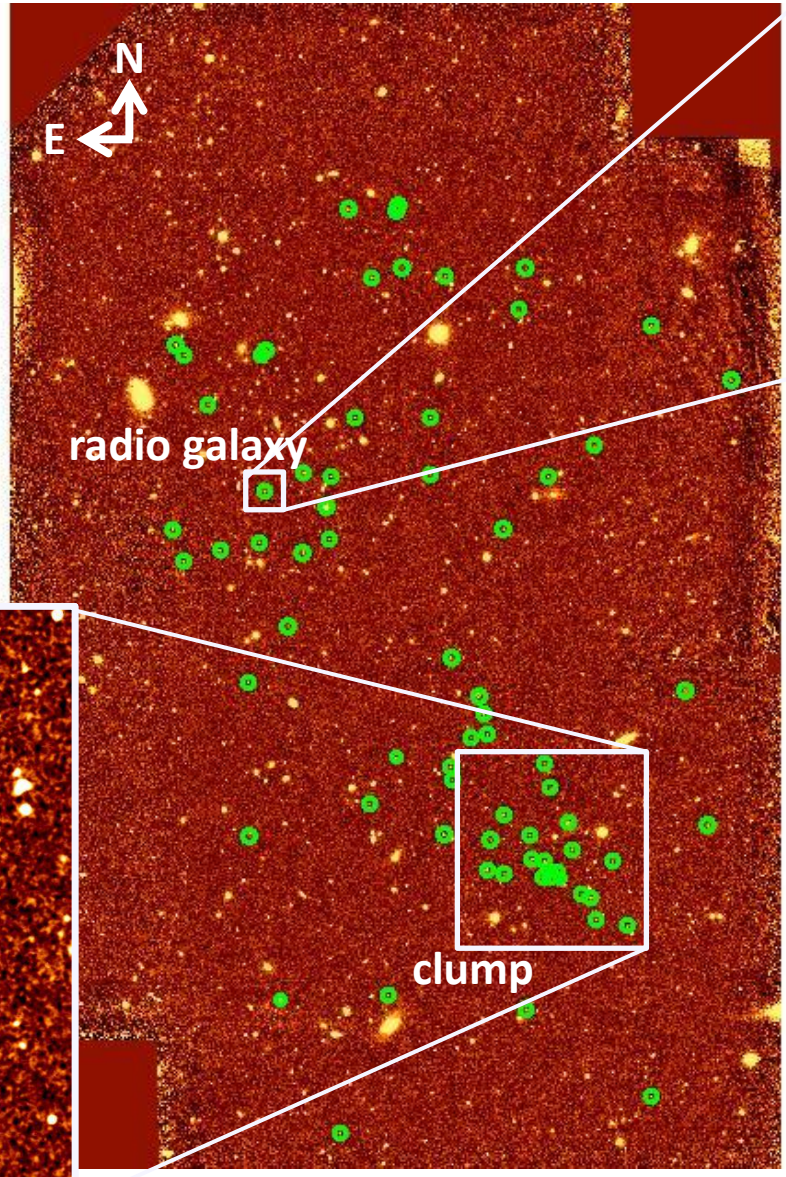
Ha emitters = HAEs

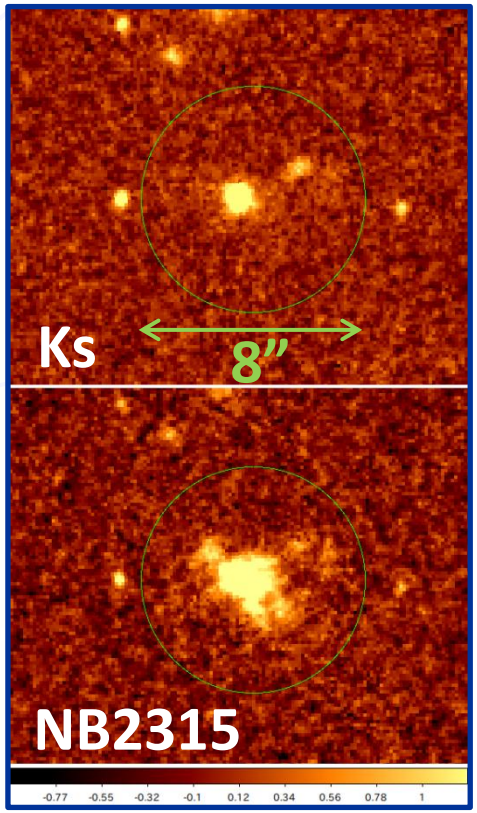
~ 4 x 7 arcmin^2

~ 6.8 x 11.9 Mpc^2 (comoving)

~ 1.93 x 3.38 Mpc^2 (physical)







This region is known as an over-density region of Distant Red Galaxies (DRGs). (Kodama+2007)

Hα survey in proto-cluster at z=2.53

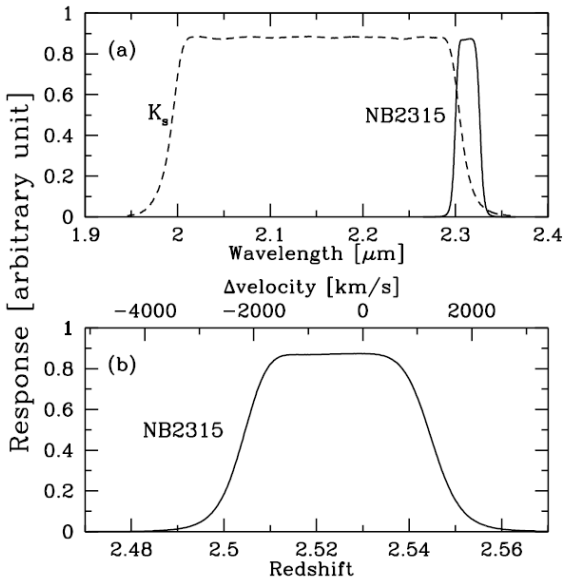
☐ Target

- ✓ USS 1558-003 proto-cluster @ z=2.53
  (overdensity region around a radio galaxy)

☐ Data

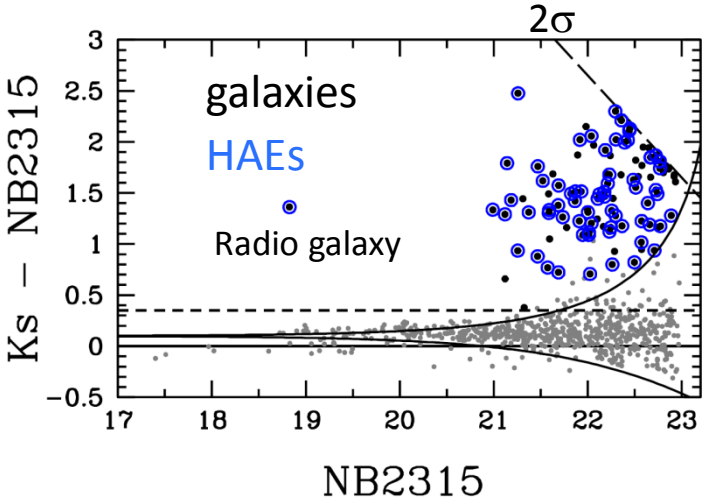
- ✓ B, r', z' (Subaru/Suprime-Cam)
- ✓ J, H, Ks, NB2315 (Subaru/MOIRCS)
  => aim to detect **Hα emissions from galaxies at z~2.53**
- ✓ 5 σ limiting mag. in AB system:
  23.65 (Ks), 23.01 (NB2315)

Filter response function



Selection of Hα emitters at z~2.53

NB excess galaxies



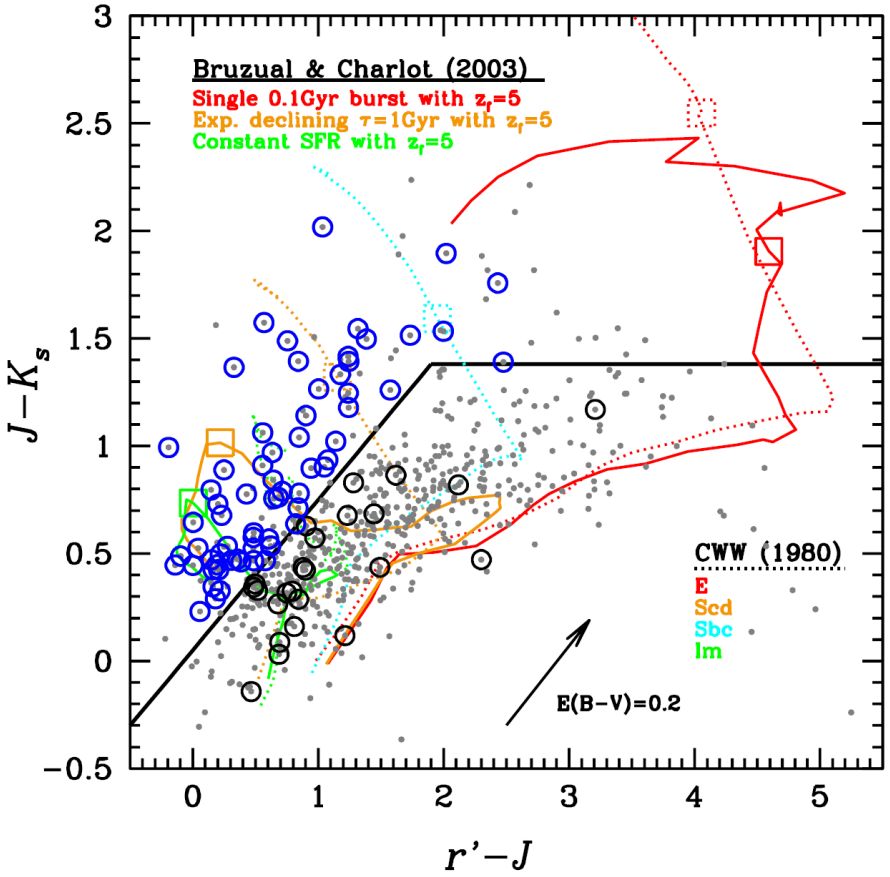
[selection criteria]

color term = 0.1

more than 3sigma color excess in Ks-NB

Ks-NB>0.35

Identification of galaxies at z~2.5



How to select Hα emitters

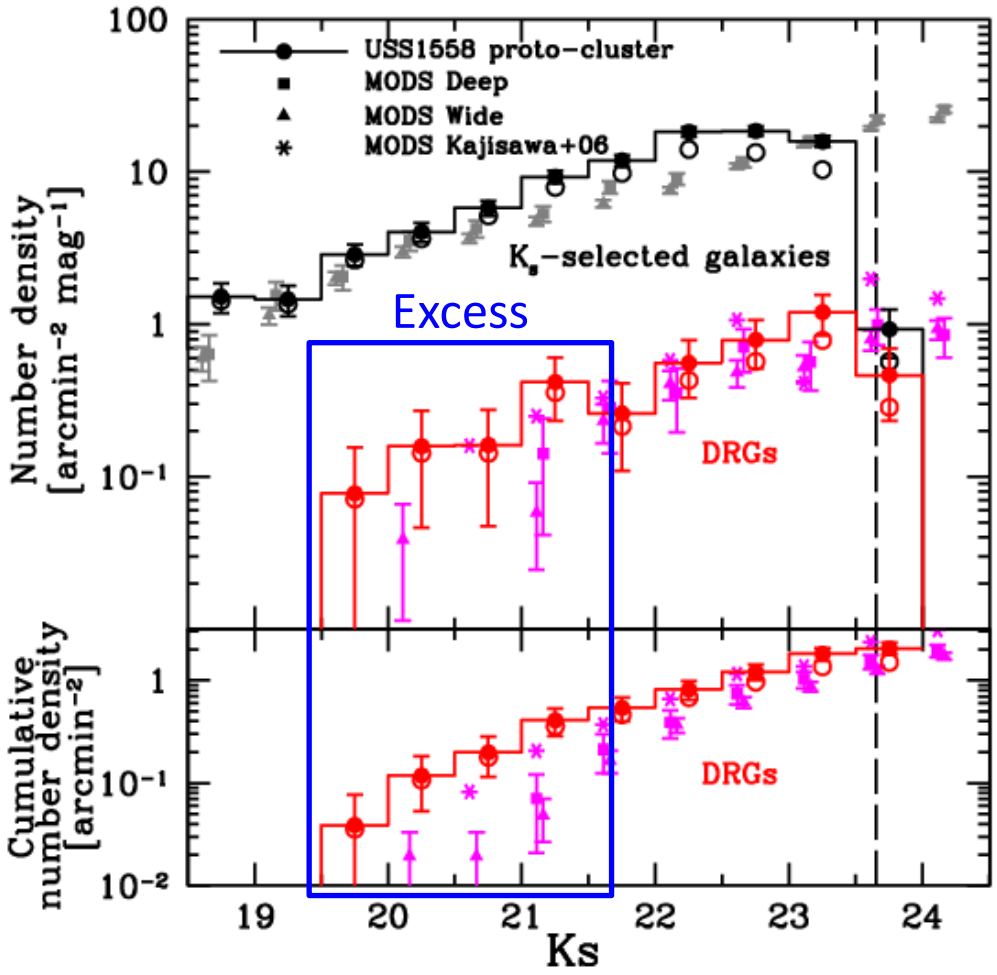
- r'-J < 1.9 J-Ks > 0.7(r'-J)+0.05
- r'-J > 1.9 J-Ks > 1.38

68 Hα emitters at z=2.5

Selection of Distant Red Galaxies

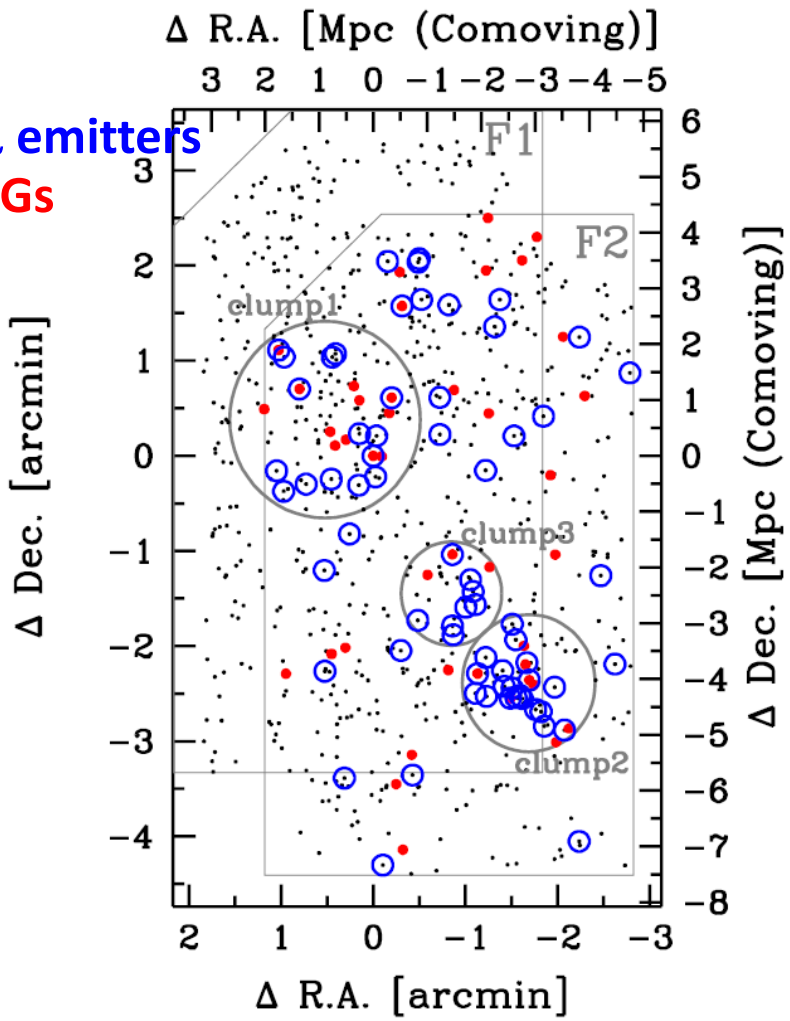
Distant Red Galaxies (DRGs): galaxies with red color of **(J-Ks)vega>2.3**

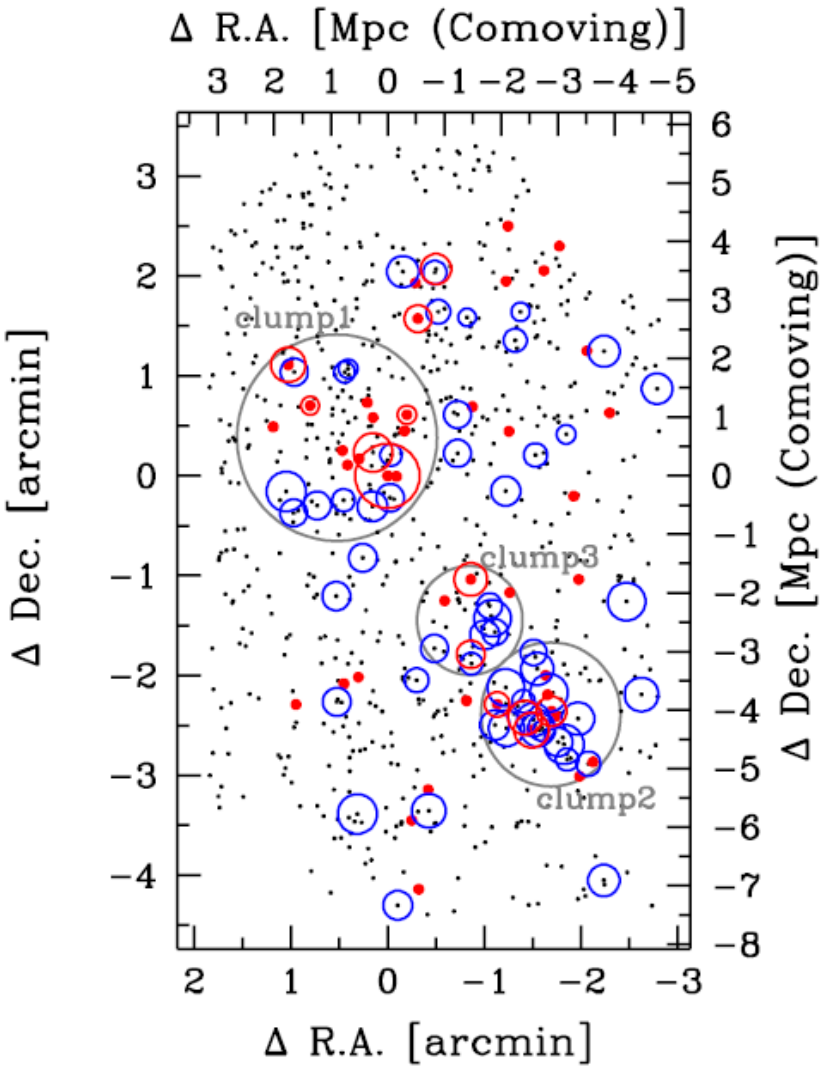
- Passively evolving galaxies or dusty starburst galaxies



Map of HAEs at z~2.53

Hα emitters
DRGs

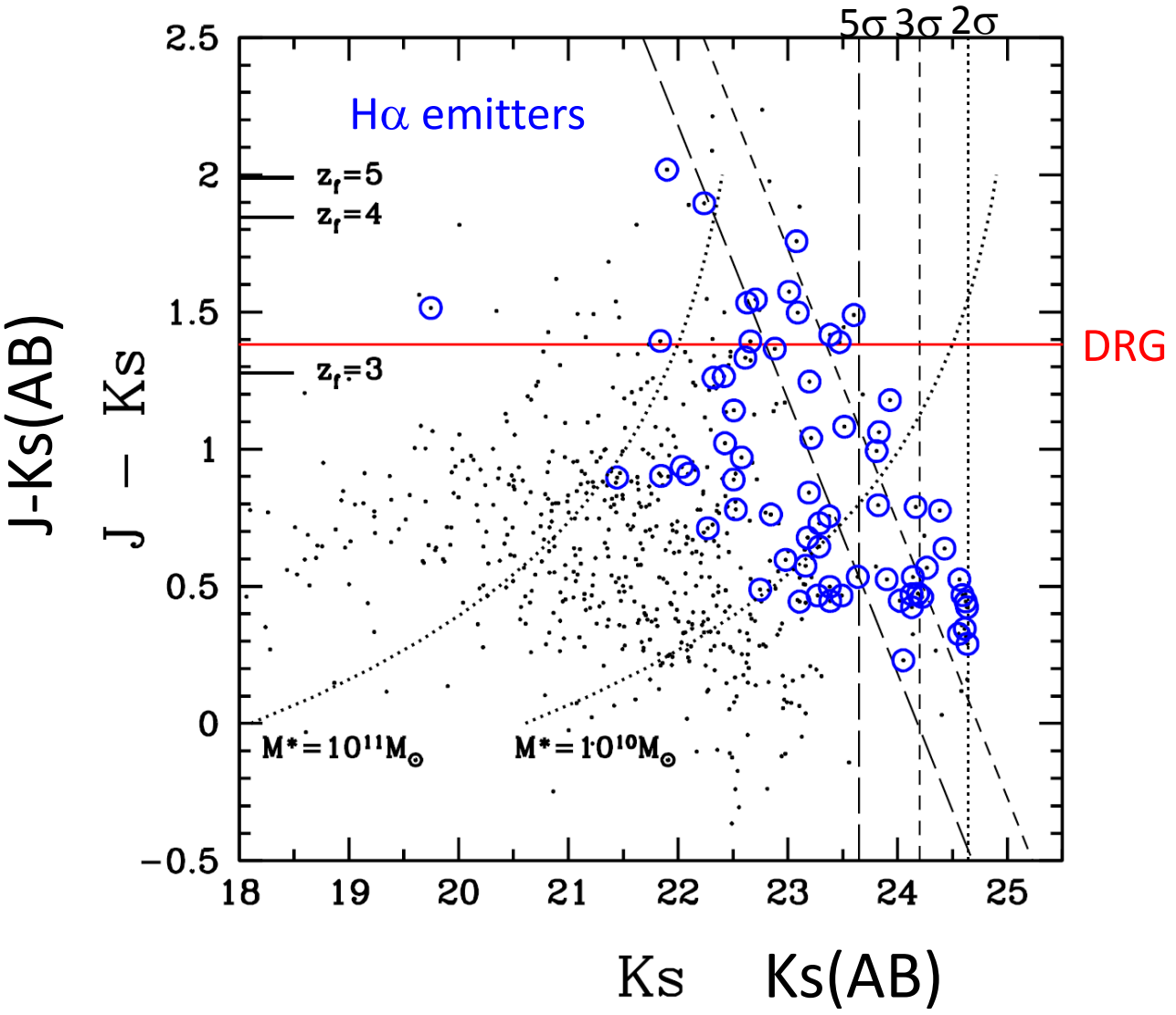




Red emitters tend to be located in clumps, which is different situation to that in lower-z clusters

Color-magnitude diagram

J(Vega)=J(AB)-0.941, H(Vega)=H(AB)-1.38, Ks(Vega)=Ks(AB)-1.86

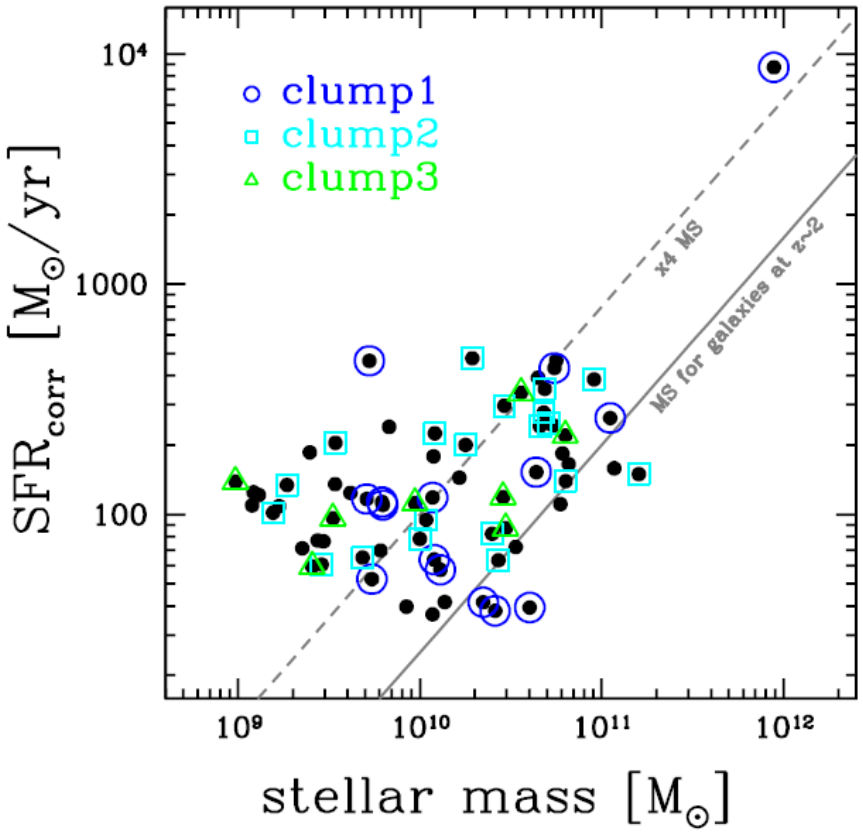


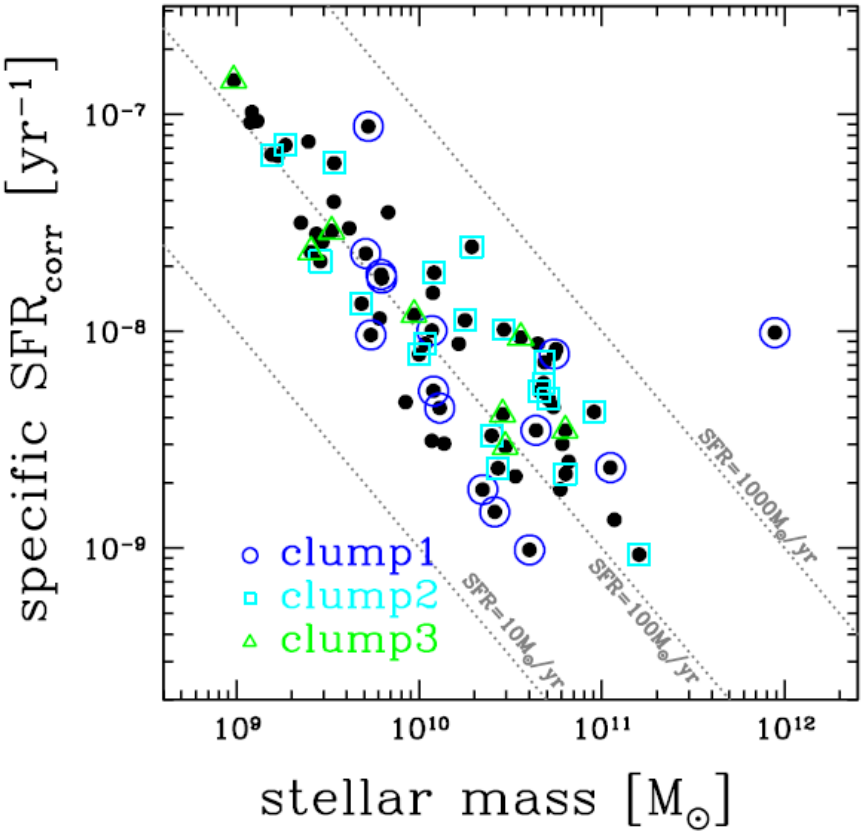
Star formation rate for HAEs

SFR is derived from Ha luminosity using the relation given in Kennicutt (1998)

Dust extinction, A(Ha): Garn et al. (2010), Contribution of [NII], NII/Ha: Sobral et al. (2011)

Specific SFR = SFR / stellar mass

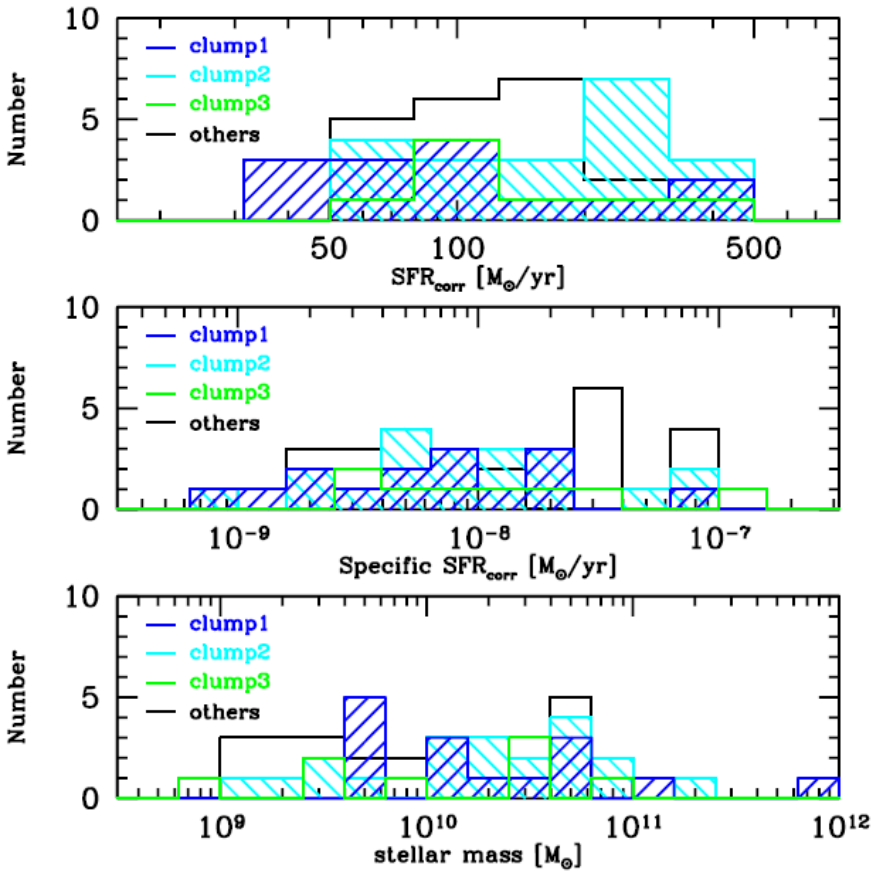




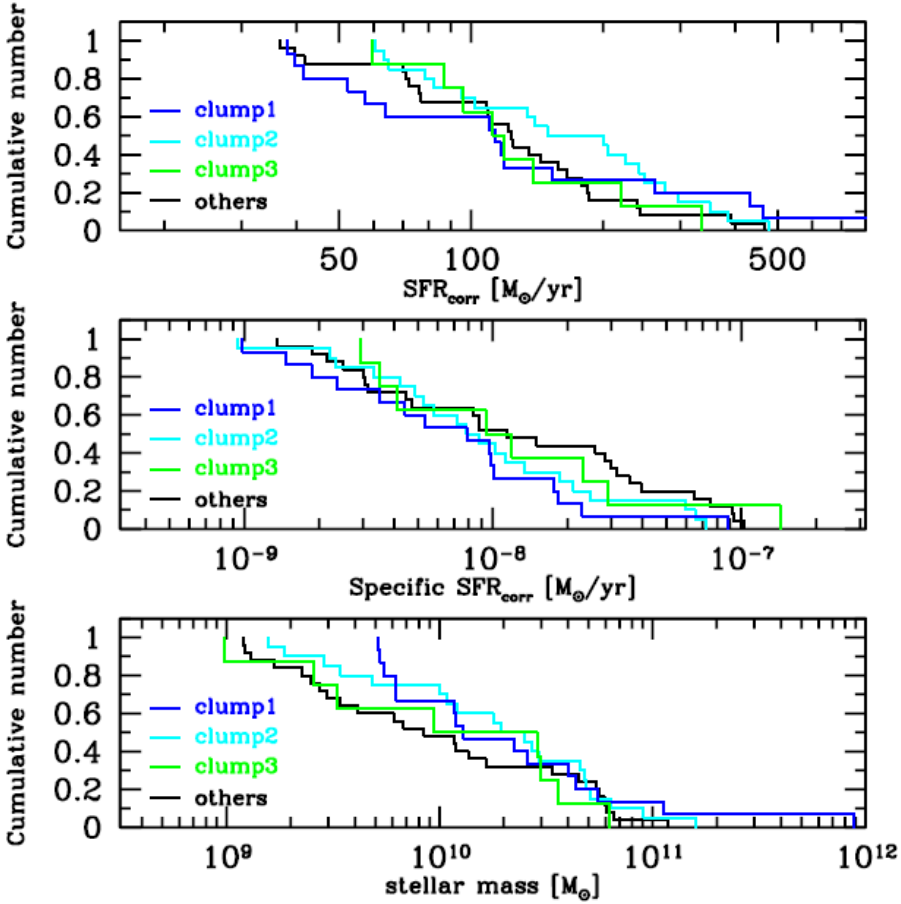
There is no strong correlation between SFR and stellar mass, but specific SFR is decreasing with larger stellar mass.

Environment dependence

Histogram of SFR, sSFR, Mstar



Cumulative number of SFR, sSFR, Mstar



There is no strong dependence of SFR, sSFR and stellar mass on environment.

Summary

Hα emission survey in the proto-cluster around USS1558-003 radio galaxy at z=2.53 with MOIRCS/Subaru

- Clumps of HAEs and DRGs, which are thought to marge later and to evolve into a massive galaxy cluster
- Red HAEs, which tend to be located in clumps rather than outskirts
- Faint end of red sequence occupied by red HAEs
- No significant dependence of SF activity on environment

Future works

- Follow-up NIR spectroscopy of Hα emitters
  - ✓ Determination of accurate redshift
  - ✓ Metal abundance and AGN activity
- Follow-up observation with ALMA
  - ✓ Gas mass and dusty SFR