Dusty Star Formation in Clusters and in the Field at z < 0.5

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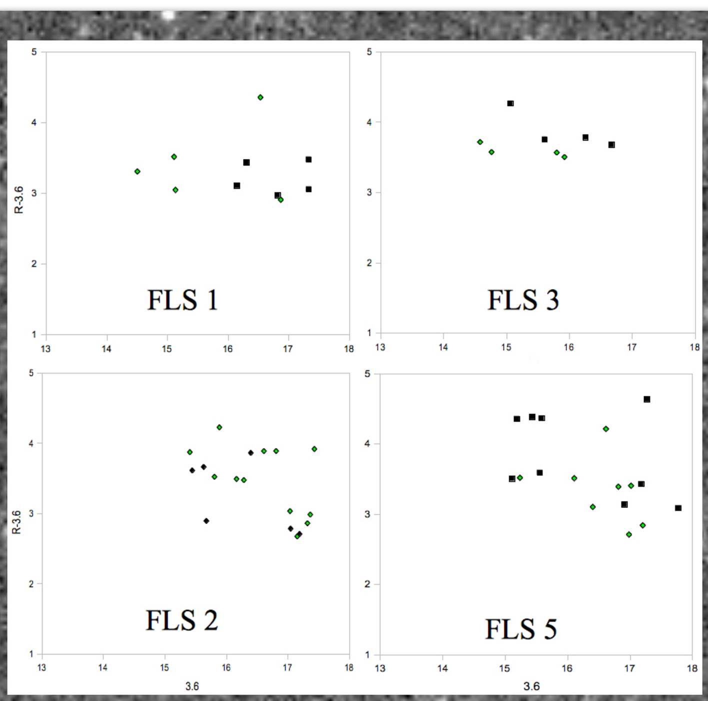
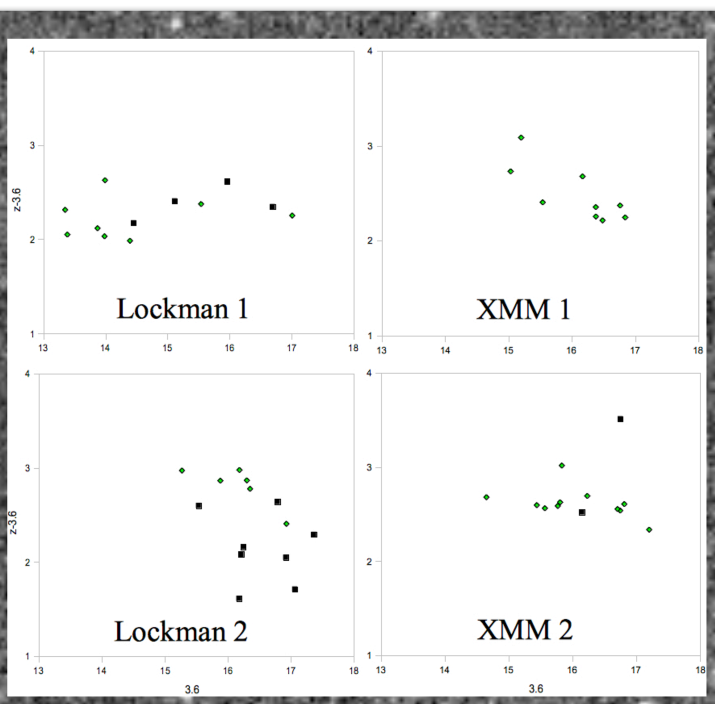
Abstract

We present a spectroscopic and photometric study of 104 , ***Spitzer*/MIPS** 24μm selected galaxies in the fields of ***Spitzer* First Look survey (FLS)** , **XMM LSS** and **Lockman** of **SpARCS**. We spectroscopically confirm 8 clusters of galaxies at $0.07 < z < 0.49$ and investigate the nature of the cluster members (44 galaxies) and field galaxies (60 galaxies) and compare their dusty star formation activities. Spectroscopic classification of the galaxies shows different populations in clusters (54 / 22 / 6 / 12 % Star forming / Passive / Post-Starburst / AGN) and in the field (66 / 5 / 2 / 28 %). In our sample, star forming galaxies in clusters have relatively high IR SFRs compared with star forming galaxies in the field, which have a larger range of IR SFRs. This is due to a selection bias. The SFR inferred from Hα is lower for cluster galaxies than for field galaxies of the same IR-inferred SFR, suggesting that cluster galaxies may be dustier.

Project : In Spitzer FLS survey and SpARCS survey fields we found a statistically significant excess of 24μm counts in the neighborhood of candidate galaxy clusters. The 24μm excess is not caused by chance foreground/background interlopers and it is related to the dust-obscured starburst galaxies in the clusters. We acquired observing time to do multi-object spectroscopy of both red-sequence galaxies and MIPS 24μm selected galaxies in the field of 6 candidate clusters from FLS and 6 candidate clusters from SpARCS at $0.1 < z_{ph} < 0.6$. Spectroscopy was performed using the COSMIC Spectrograph on the 200 inch Hale Telescope at Palomar Mountain. In total we have observed 28 masks and each mask has ~ 23 slits (~ 650 targets).



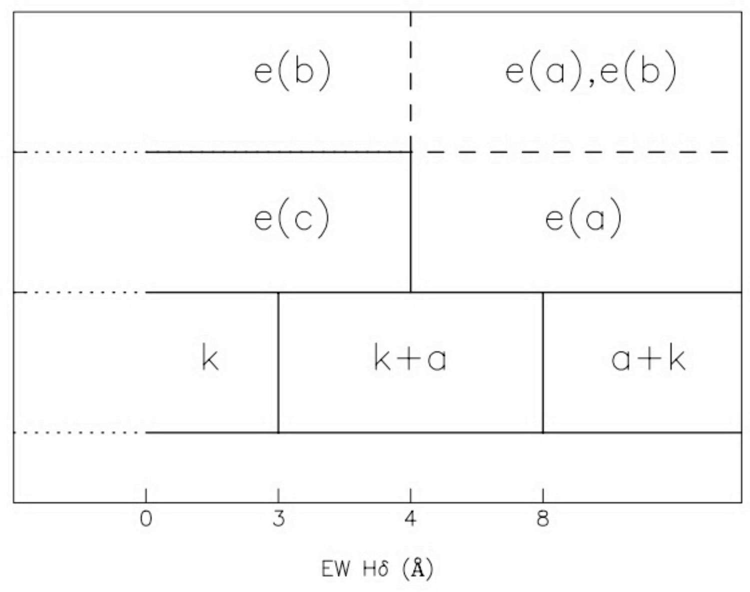
Cluster	R.A.	Dec.	z_{cl}	N_{tot}	N_{24}	σ_v (km/s)	R_{200} (Mpc)	M_{200} ($10^{14} M_{sun}$)
FLS 1	17:10:59.80	59:34:16.40	0.125 ± 0.001	7	3	696 ± 284	1.6 ± 0.7	$5.4^{+9.7}_{-4.3}$
FLS 2	17:24:49.00	59:21:22.90	0.251 ± 0.001	13	11	984 ± 284	2.1 ± 0.6	14^{+16}_{-9}
FLS 3	17:15:05.20	58:59:41.40	0.253 ± 0.001	5	2	364 ± 182	0.8 ± 0.4	$0.73^{+2.44}_{-0.64}$
FLS 5	17:14:31.10	59:57:52.20	0.222 ± 0.002	8	8	1238 ± 468	2.7 ± 1.0	29^{+47}_{-22}
Lockman 1	10:41:01.03	58:17:41.90	0.072 ± 0.001	9	8	538 ± 220	1.3 ± 0.5	$2.6^{+4.6}_{-2.0}$
Lockman 2	10:42:09.60	57:53:50.86	0.487 ± 0.002	6	2	1107 ± 495	2.1 ± 0.9	18^{+36}_{-15}
XMM 1	02:22:58.58	-04:07:15.10	0.288 ± 0.001	9	5	396 ± 140	0.8 ± 0.3	$0.92^{+1.36}_{-0.67}$
XMM 2	02:15:37.74	-04:01:23.32	0.353 ± 0.001	11	5	847 ± 268	1.7 ± 0.6	$8.7^{+11.1}_{-5.9}$



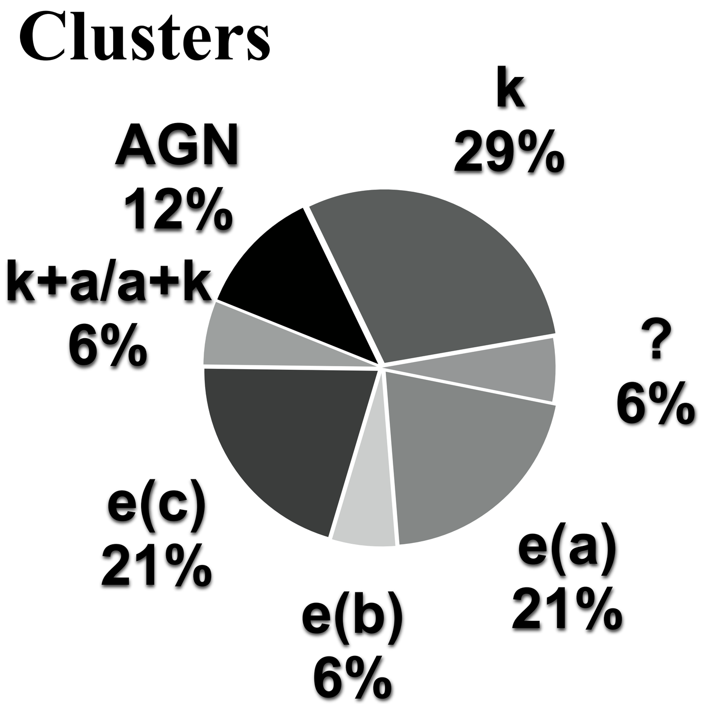
Spectral Types (Dressler et al. 1999)

Spectral Classification Scheme

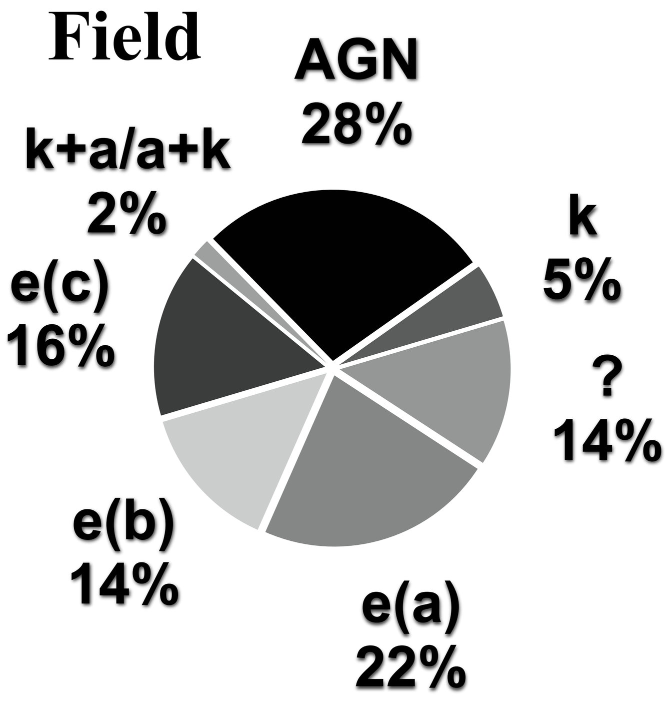
Class	EW [O II] 3727 (Å)	EW Hδ (Å)	Color	Comments
k	Absent	<3	...	Passive
k+a......	Absent	3–8	...	Moderate Balmer absorption without emission
a+k......	Absent	≥8	...	Strong Balmer absorption without emission
e(c)	Yes, <40	<4	...	Moderate Balmer absorption plus emission, spiral-like
e(a)	Yes	≥4	...	Strong Balmer absorption plus emission
e(b)	≥40	...	...	Starburst
e(n)	...	...	...	AGN from broad lines or [O III] 5007/Hβ ratio
e	Yes	?	...	With at least one emission line but S/N too low to classify
?..........	?	?	...	Unclassifiable
CSB	...	...	Very blue	Photometrically defined starburst

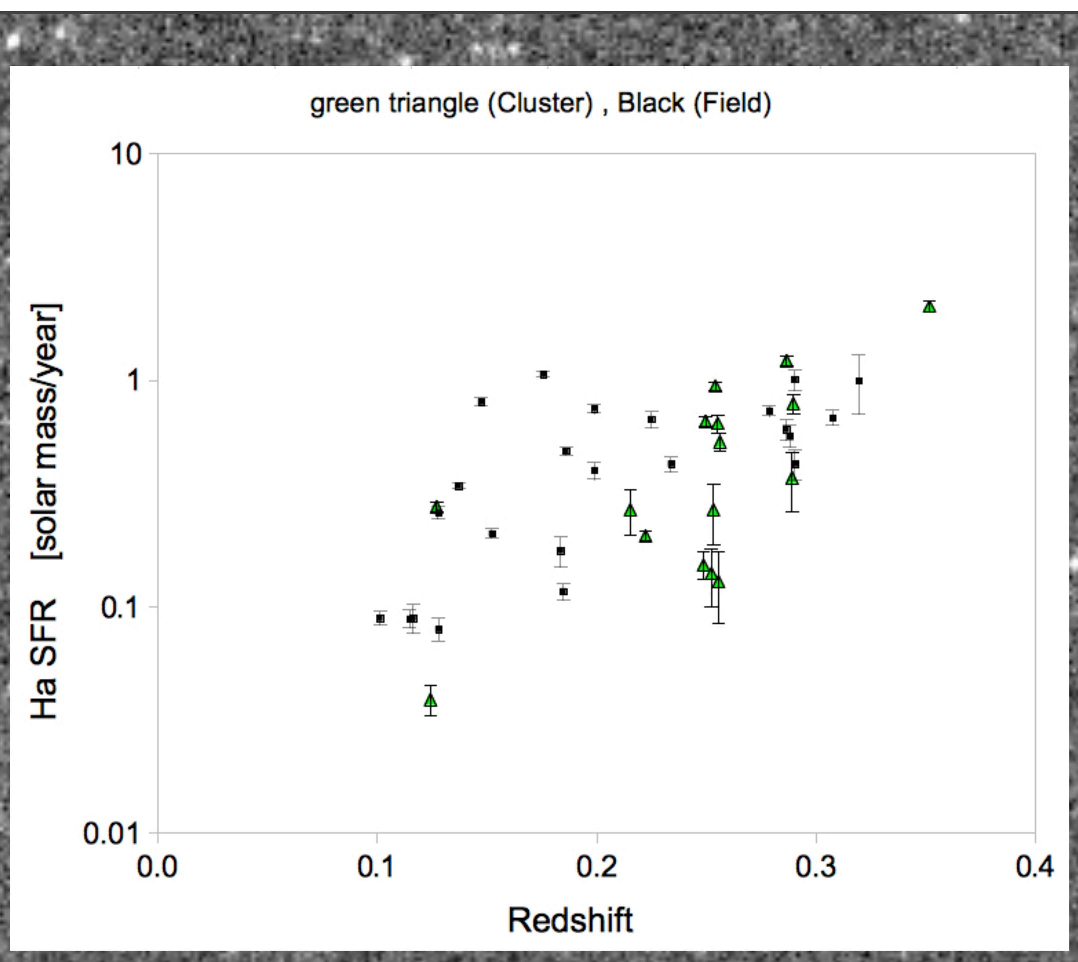


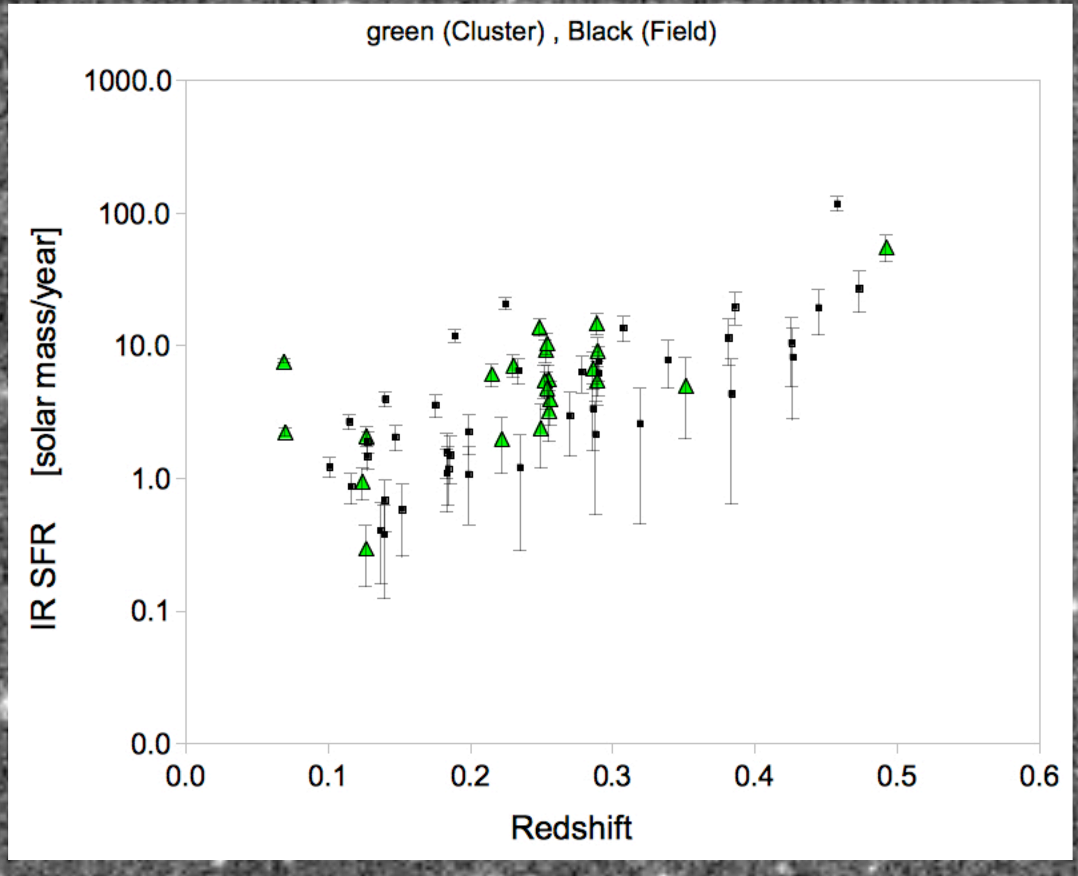
Clusters

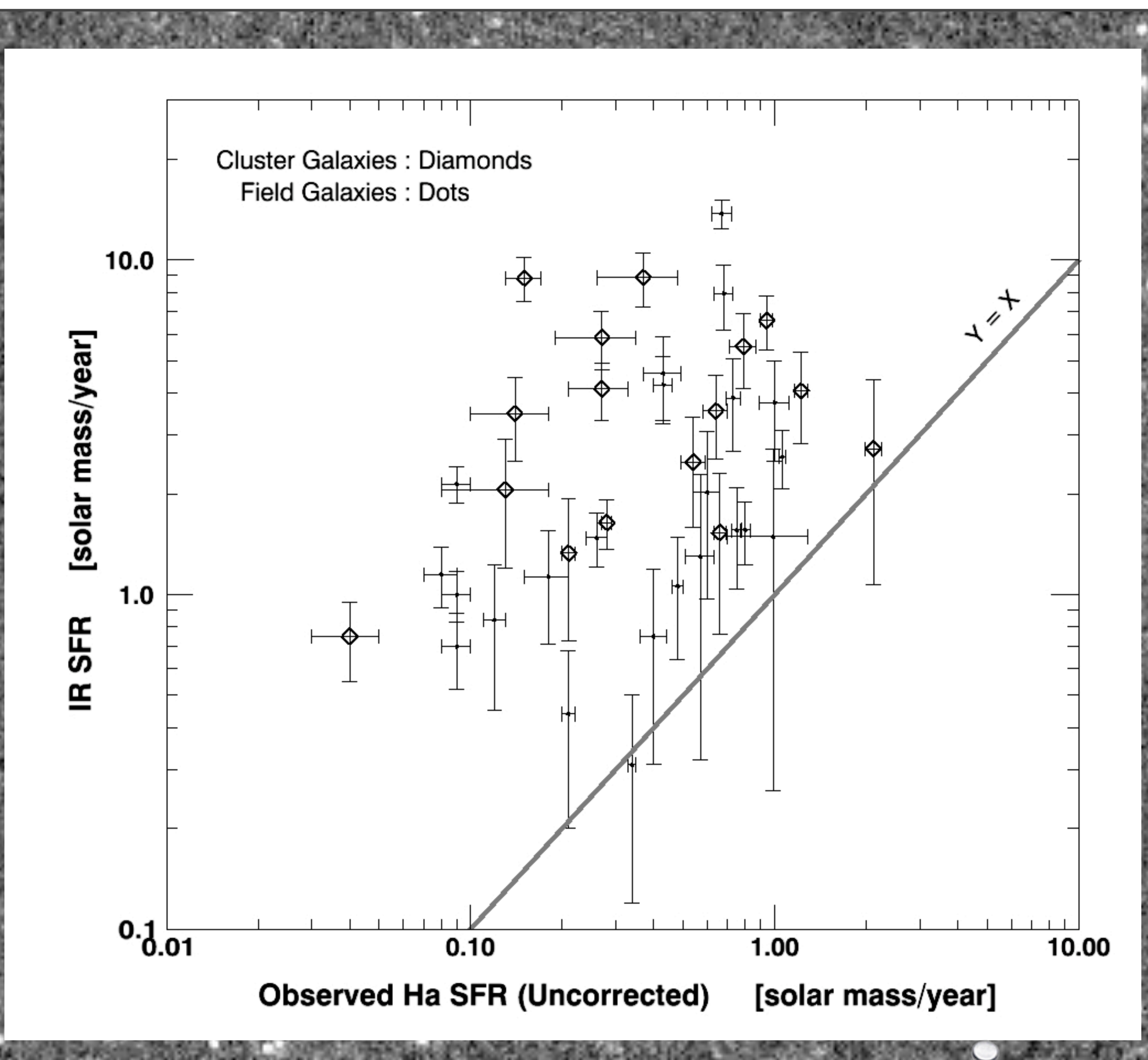


Field









IR SFR vs. Hα SFR at 0.10 < z < 0.35

In our sample, star forming galaxies in clusters have relatively high IR SFRs compared with star forming galaxies in the field, which have a larger range of IR SFRs. This is due to a selection bias.

The SFR inferred from Hα is lower for cluster galaxies than for field galaxies of the same IR-inferred SFR, suggesting that cluster galaxies may be dustier.

SFR estimation

The Hydrogen Balmer line Hα λ6563 is currently the most reliable tracer of star formation and for the redshift range of our data set is the best choice. We take the relation of Kennicutt 1992 ($SFR(H\alpha) = 7.9 \times 10^{42} L(H\alpha) \times E(H\alpha)$) with $E(H\alpha) = 1$ mag where luminosity of Hα feature in the spectrum is $L(H\alpha) = Flux(H\alpha) \times 4\pi D_L^2$. Also $Flux(H\alpha) = FC \times EW(H\alpha)$ where FC is the continuum flux at the position of the Hα feature. We measured observed Hα SFRs not corrected for dust extinction. We estimated total IR luminosity (3-1000μm) of star forming galaxies from 24μm fluxes using Dale & Helou (2002) normal galaxy infrared spectral energy distribution models. We converted the total IR luminosity to IR SFR using the relation from Kennicut (1998).