An Excess of Dusty Starbursts at z=2.2
Helmut Dannerbauer (Vienna)

Kurk, De Breuck, Altieri, Coia, Emonts, Galametz, Hatch, Kodama, Koyama, Miley, Röttgering, Seymour, Tanaka, Sanchez-Portal, Santos, Valtchanov, Venemans, Ziegler

➡ *Dannerbauer, Kurk, De Breuck et al., 2014, A&A, 2014, 570, 55*
➡ *Dannerbauer, Emonts et al., 2015, to be submitted*

institut für
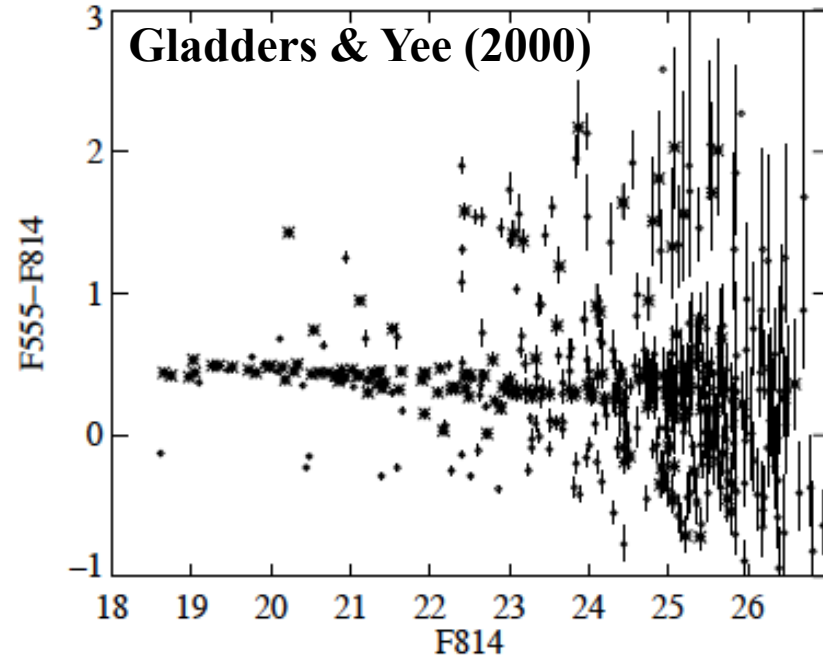astrophysik
UNIVERSITÄTSSTERNWARTE WIEN

universität
wien

Motivation

formation red sequence

complete census (pop., SFR) of overdensities

Gladders & Yee (2000)

SFR

Motivation

formation red sequence

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Gladders & Yee (2000)

SFR

?
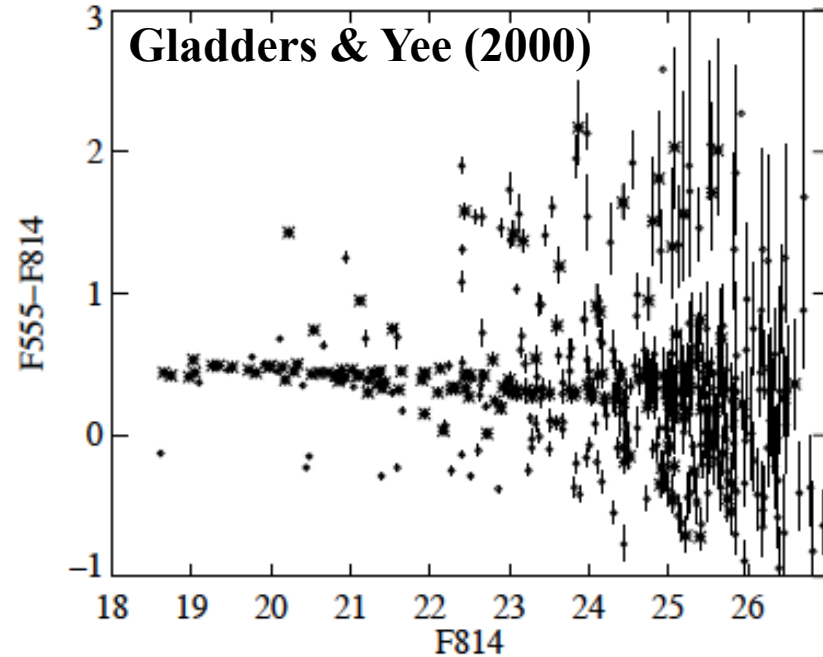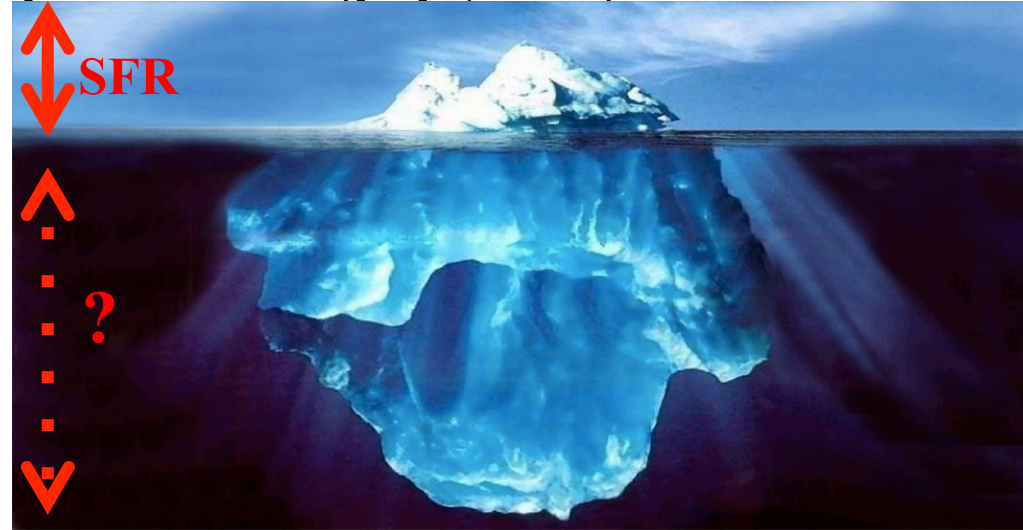
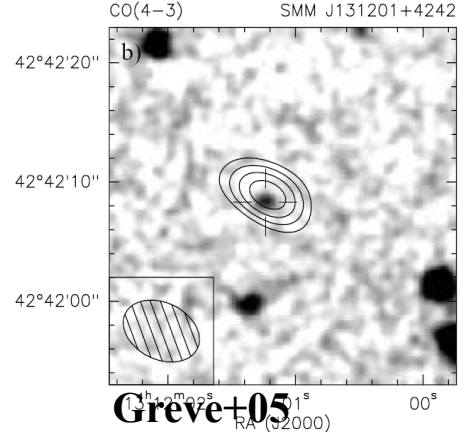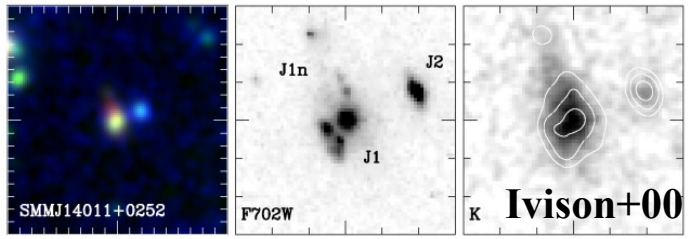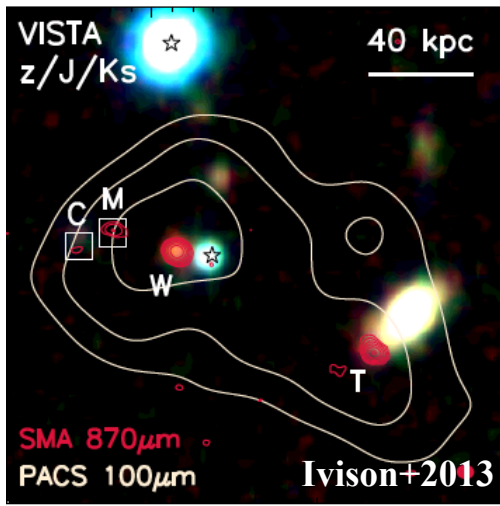➡️ *search for massive galaxies in formation*

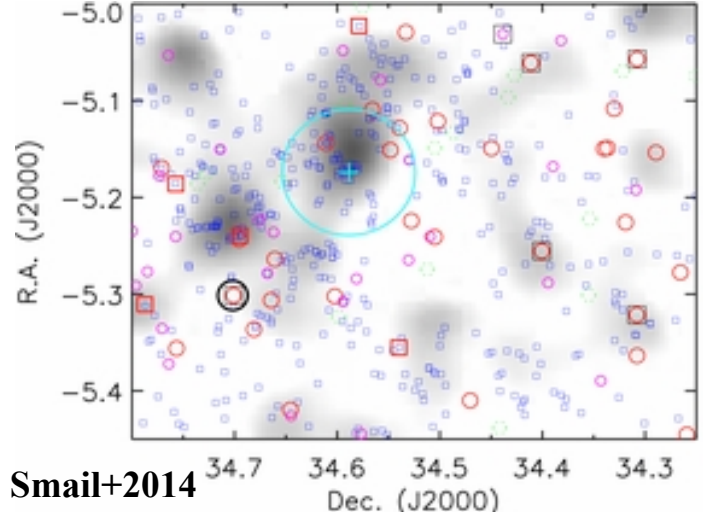# Detecting Large Scale Structure in the (Sub)mm

Submm-selected galaxies (SMGs):

- very massive up to $10^{11} M_\odot$
- gas-rich
- high SFR: several 100 $M_\odot$/yr
- merger-like morphology
- ellipticals in formation

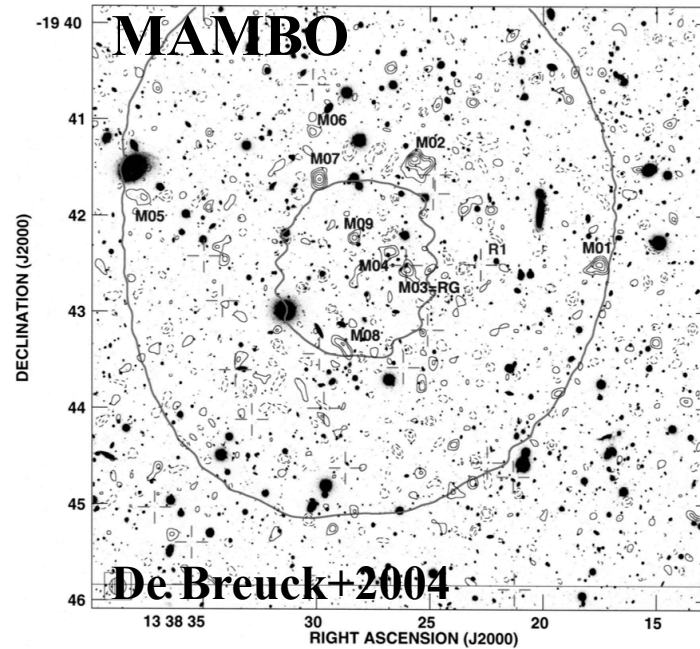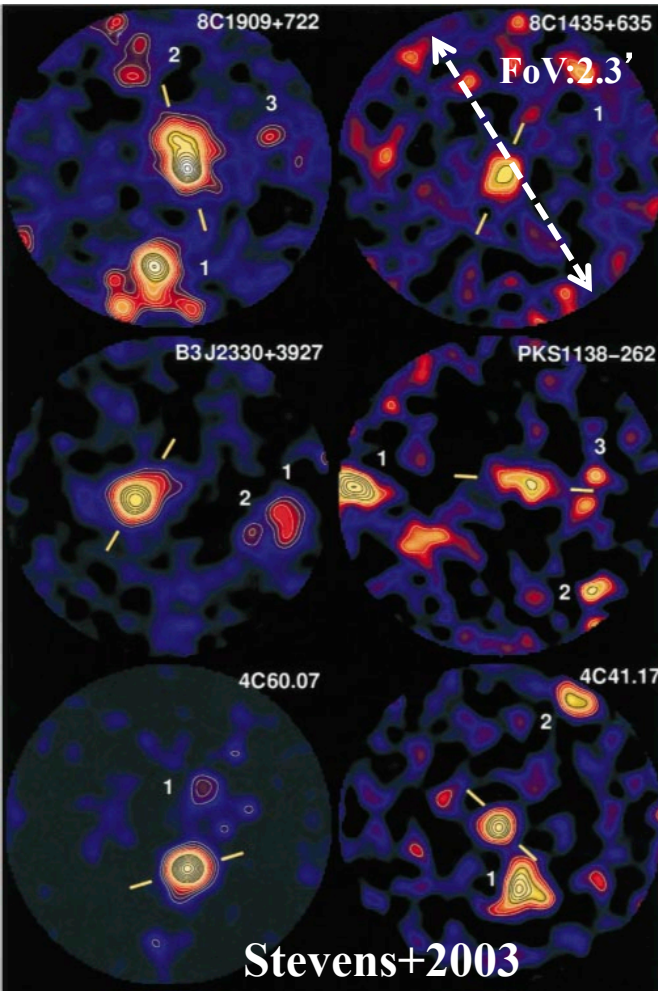➔ *excellent tracers of mass-density peaks*

SMGs within overdensities

VISTA z/J/Ks — 40 kpc — SMA 870μm — PACS 100μm — **Ivison+2013**

SMMJ14011+0252 — F702W — J1n — J2 — J1 — K — **Ivison+00**

CO(4–3) — SMM J131201+4242 — **Greve+05**

search for overdensities in the (sub)mm

Smail+2014

Previous Work

SCUBA
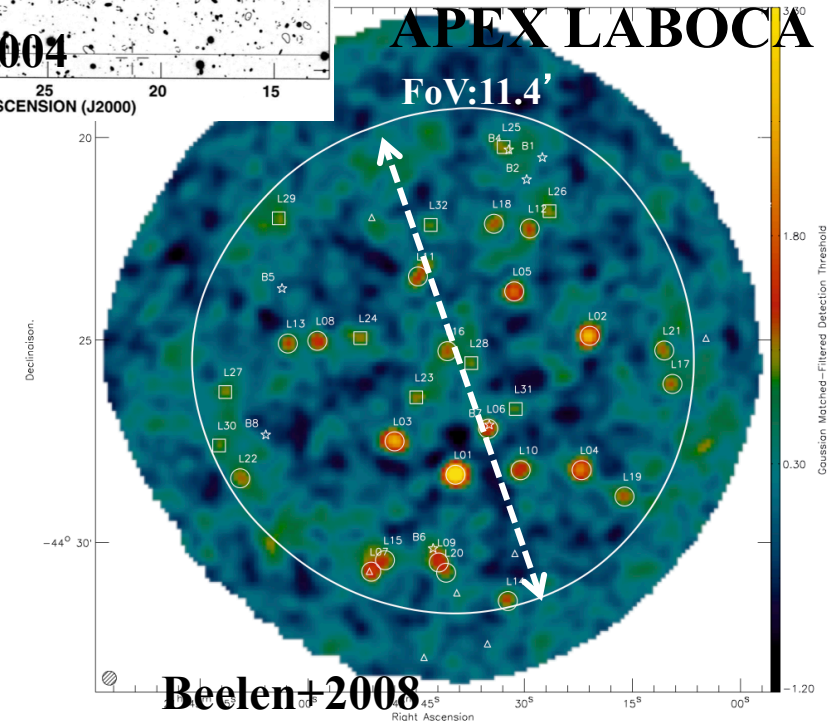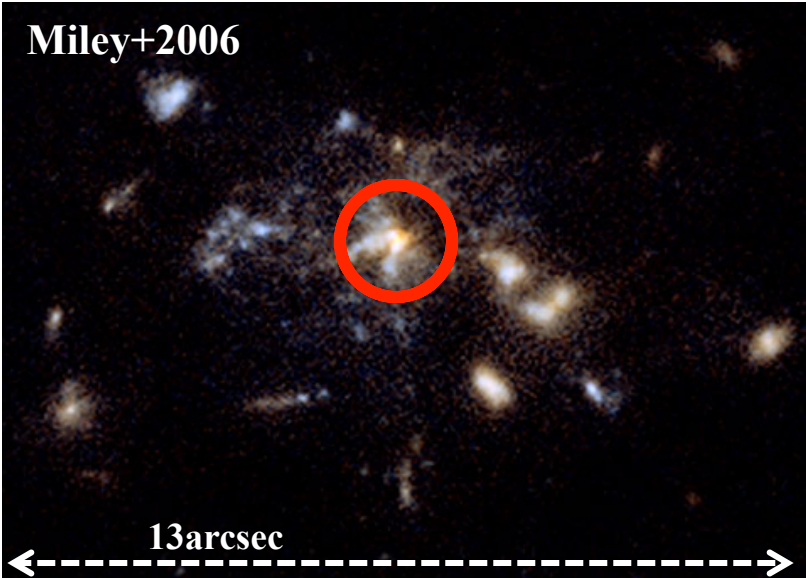
Stevens+2003

MAMBO

De Breuck+2004

APEX LABOCA

FoV:11.4'

Beelen+2008

FoV:2.3'
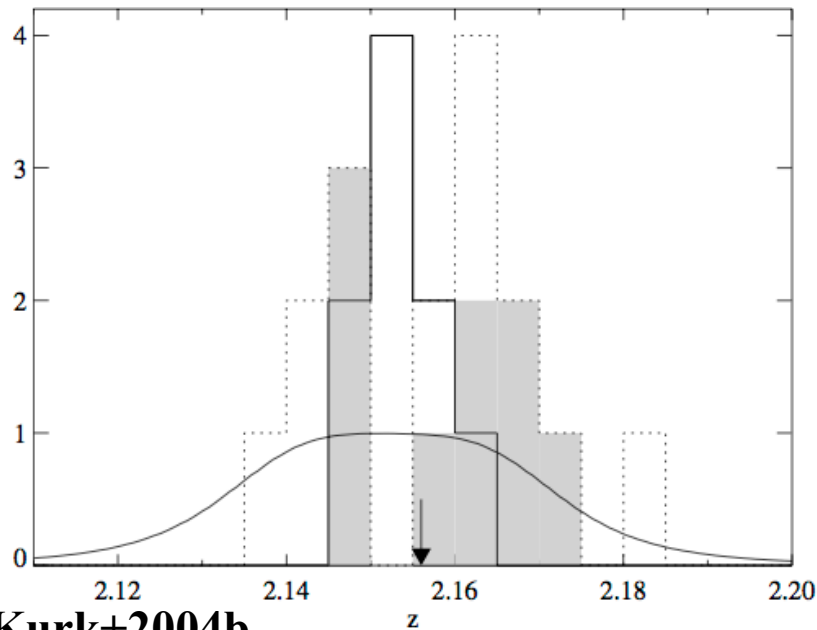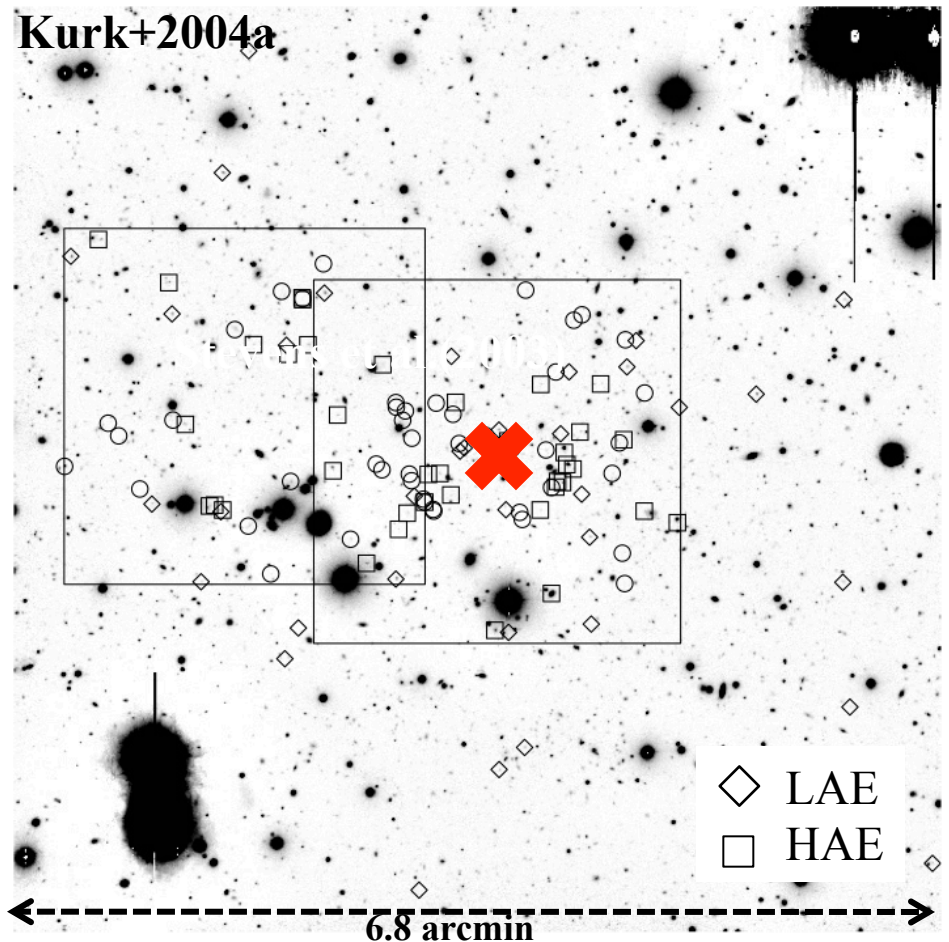
Protocluster MRC1138 @ z=2.16

Miley+2006
13arcsec

Kurk+2004b

Protocluster:

structure/collection of galaxies - not virialized -, which will evolve into a galaxy cluster @z=0

Kurk+2004a

◇ LAE
☐ HAE

6.8 arcmin

Protocluster MRC1138 @ z=2.16

Miley+2006

13arcsec

Protocluster:

structure/collection of galaxies - not virialized -, which will evolve into a galaxy cluster @z=0
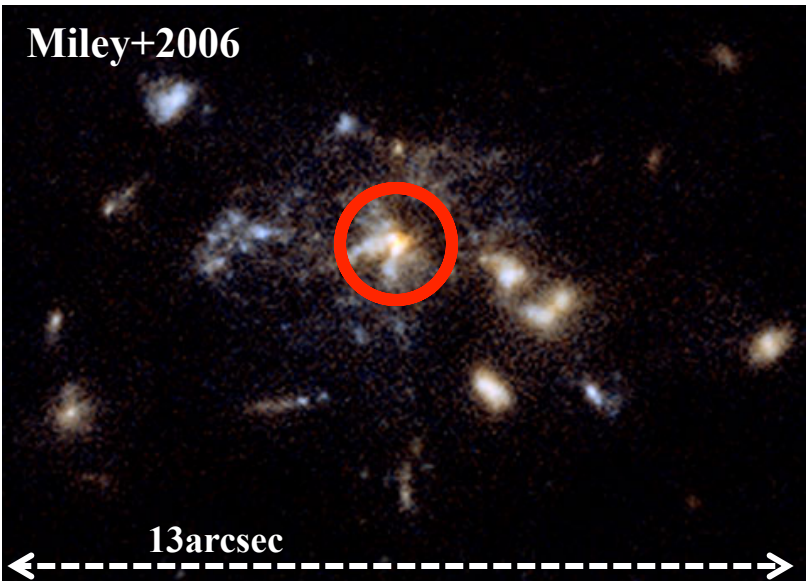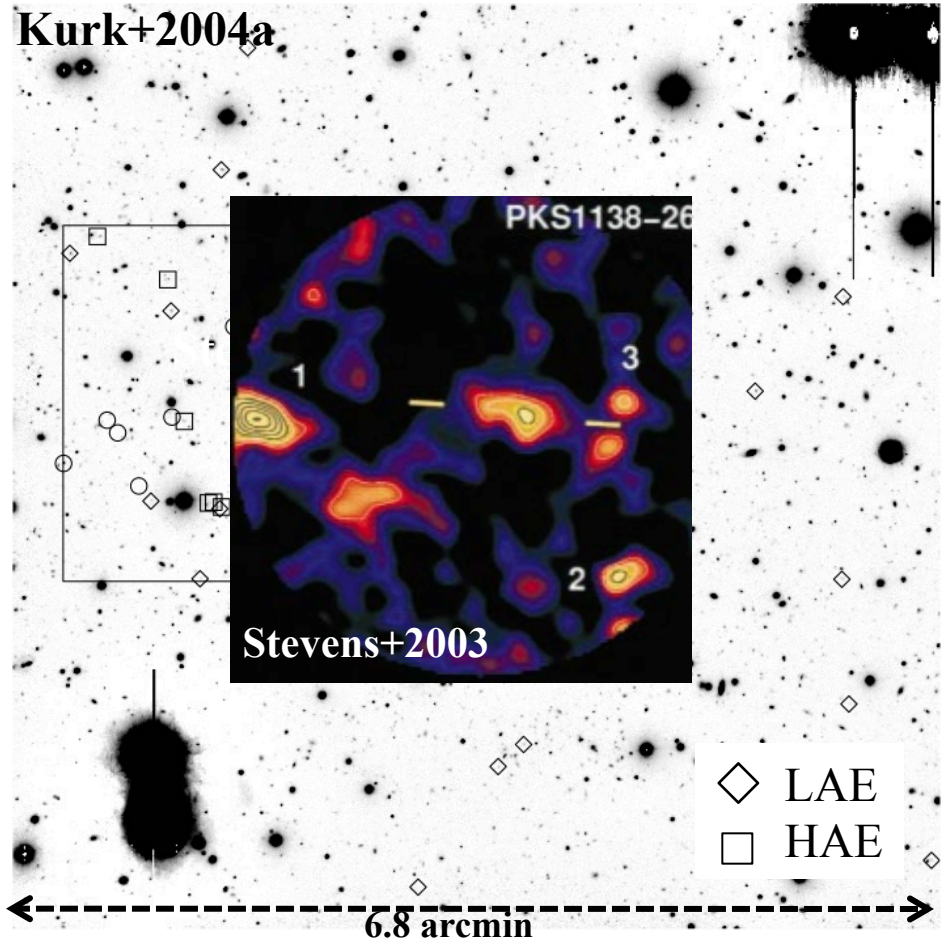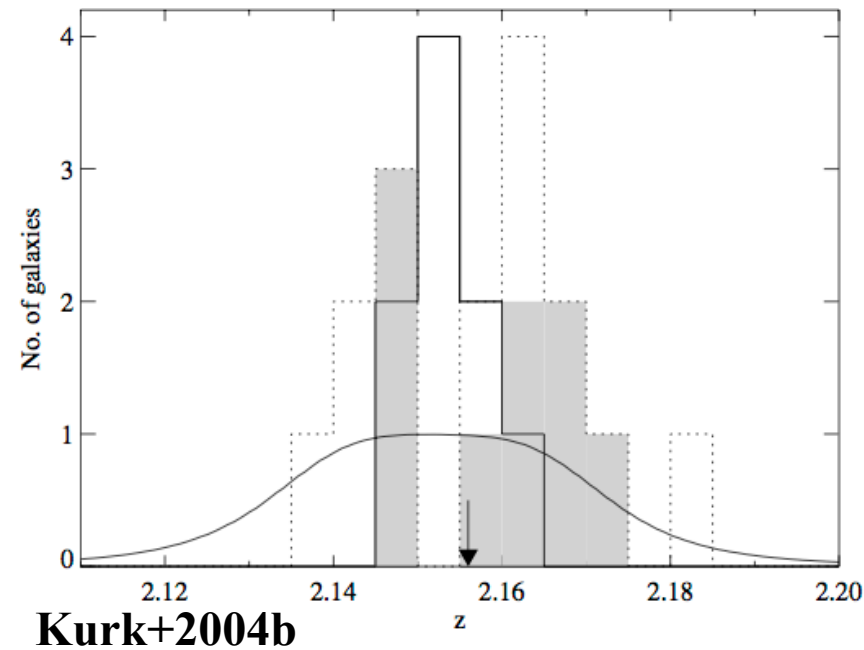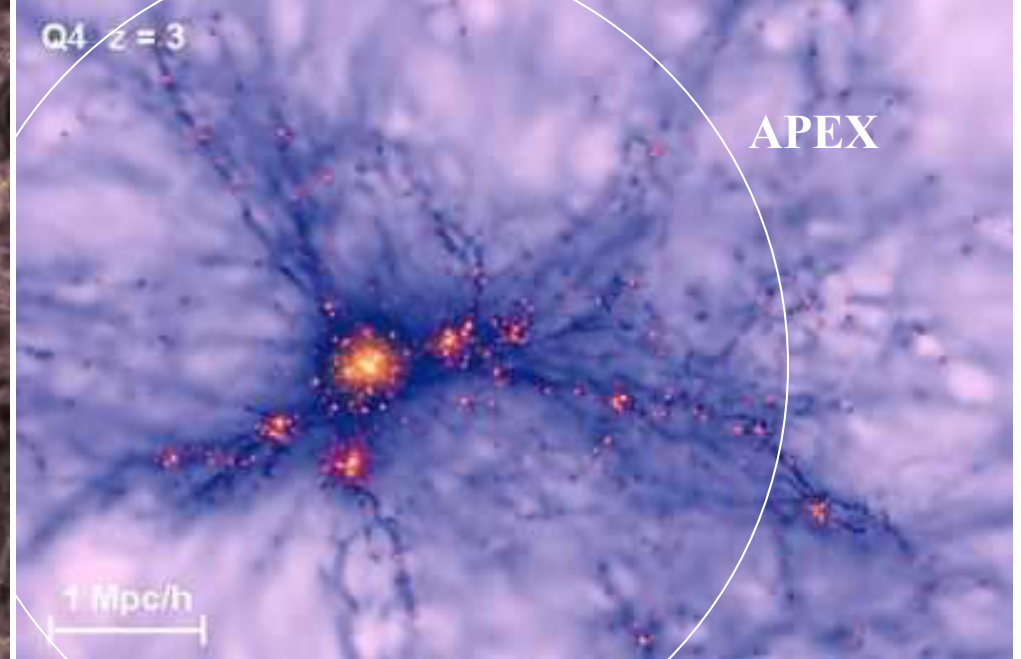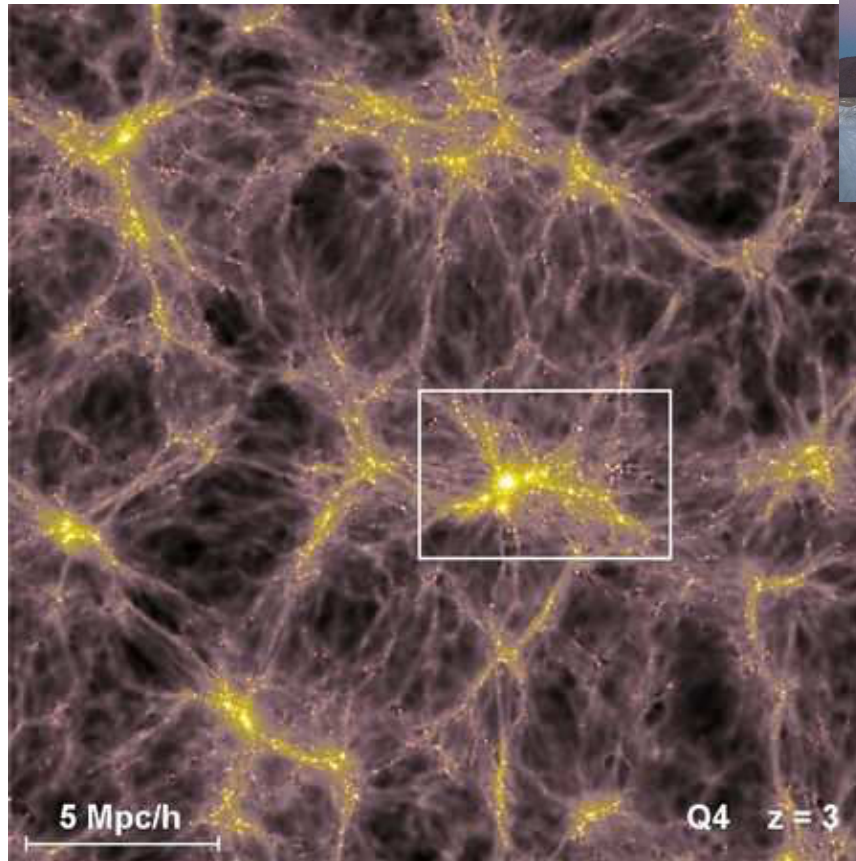

Kurk+2004a

PKS1138−26

Stevens+2003

◇ LAE
□ HAE

6.8 arcmin

Kurk+2004b

APEX LABOCA Observations

5 Mpc/h   Q4   z = 3
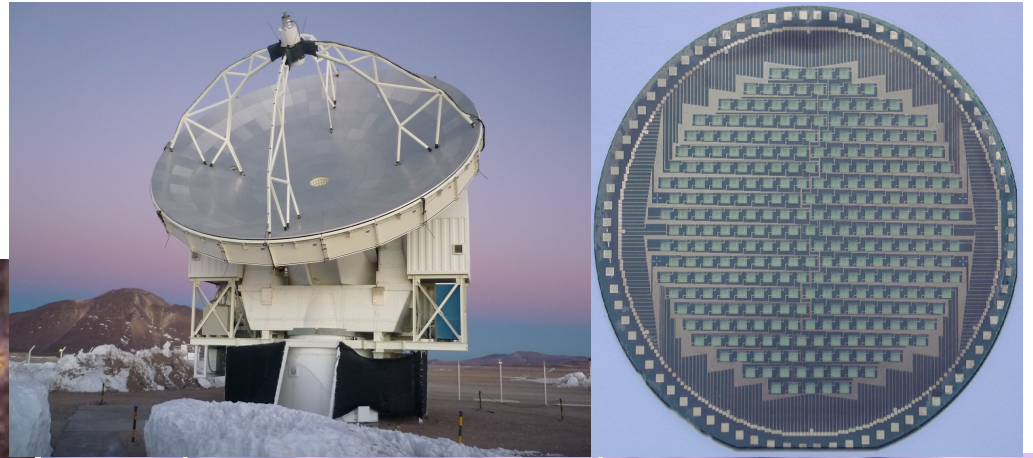
Springel & Hernquist (2003)

Q4   z = 3   APEX

1 Mpc/h

APEX LABOCA Observations

- **16 sources down to 4mJy (3σ)**
- **one of deepest LABOCA map**
- **overdensity at least factor 4 compared to blank fields**
- **consistent with SPIRE 500μm overdensity (Rigby+14)**

eso1431 — Science Release

Construction Secrets of a Galactic Metropolis

APEX reveals hidden star formation in protocluster

15 October 2014

SPACE SCOOP

Dannerbauer et al. (2014)

rms: 1.5mJy to 3.0mJy
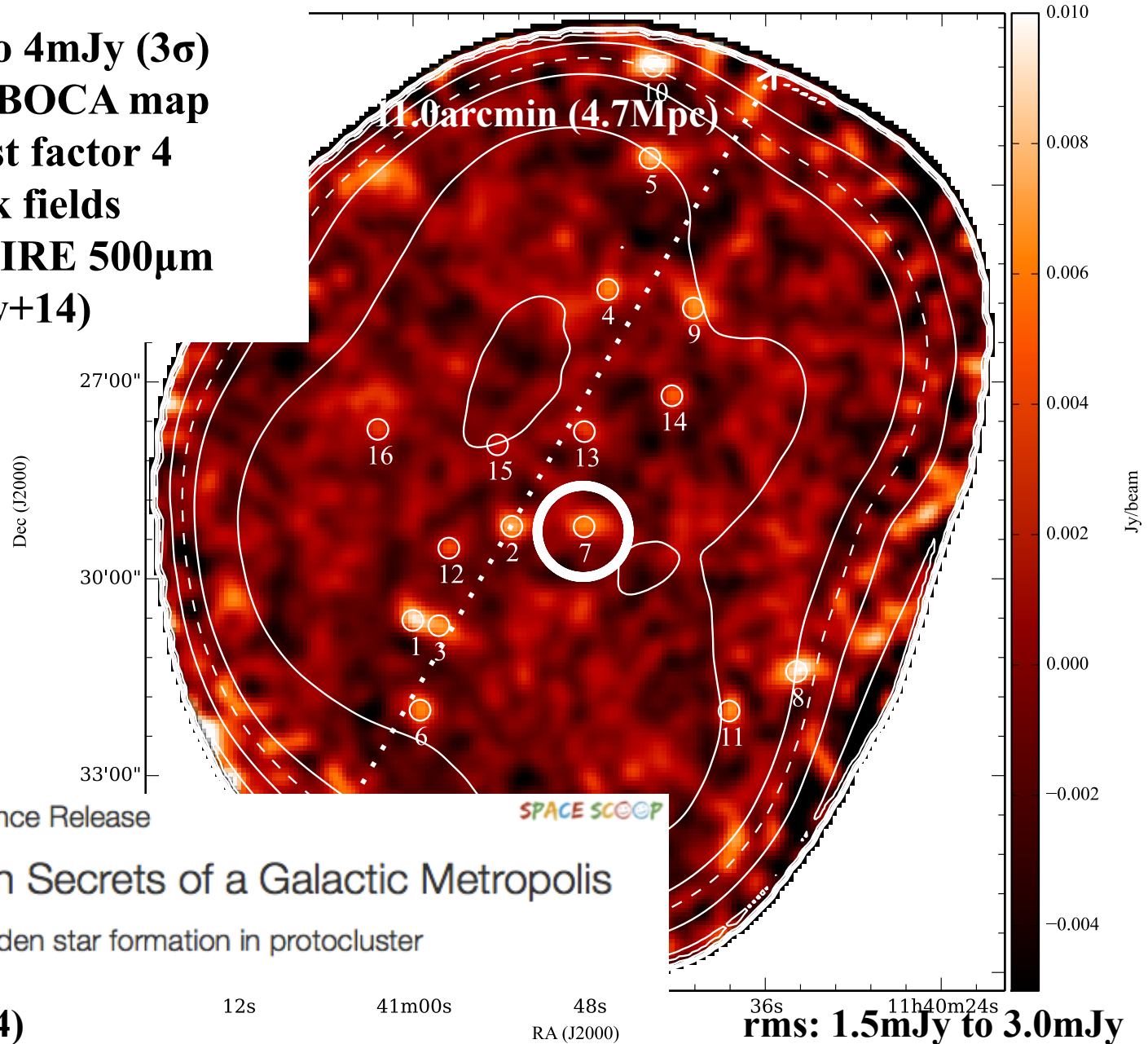
Source Reliability - Herschel Counterparts
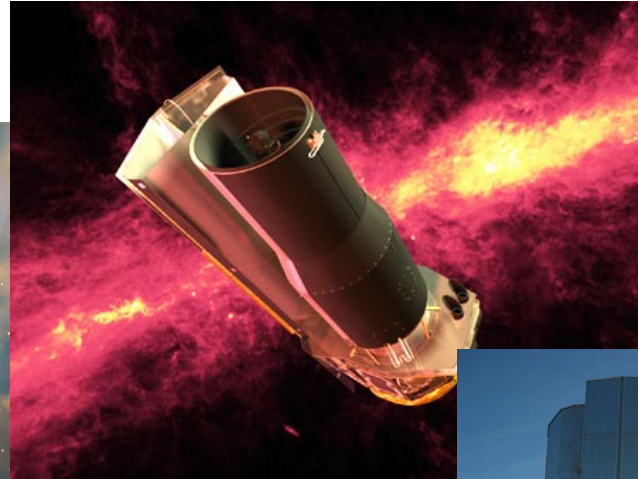

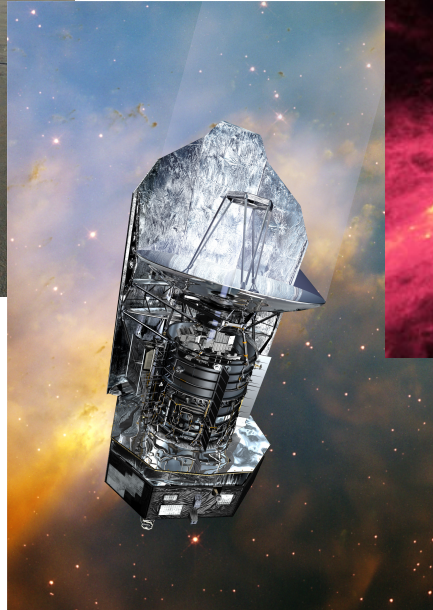SPIRE 350μm
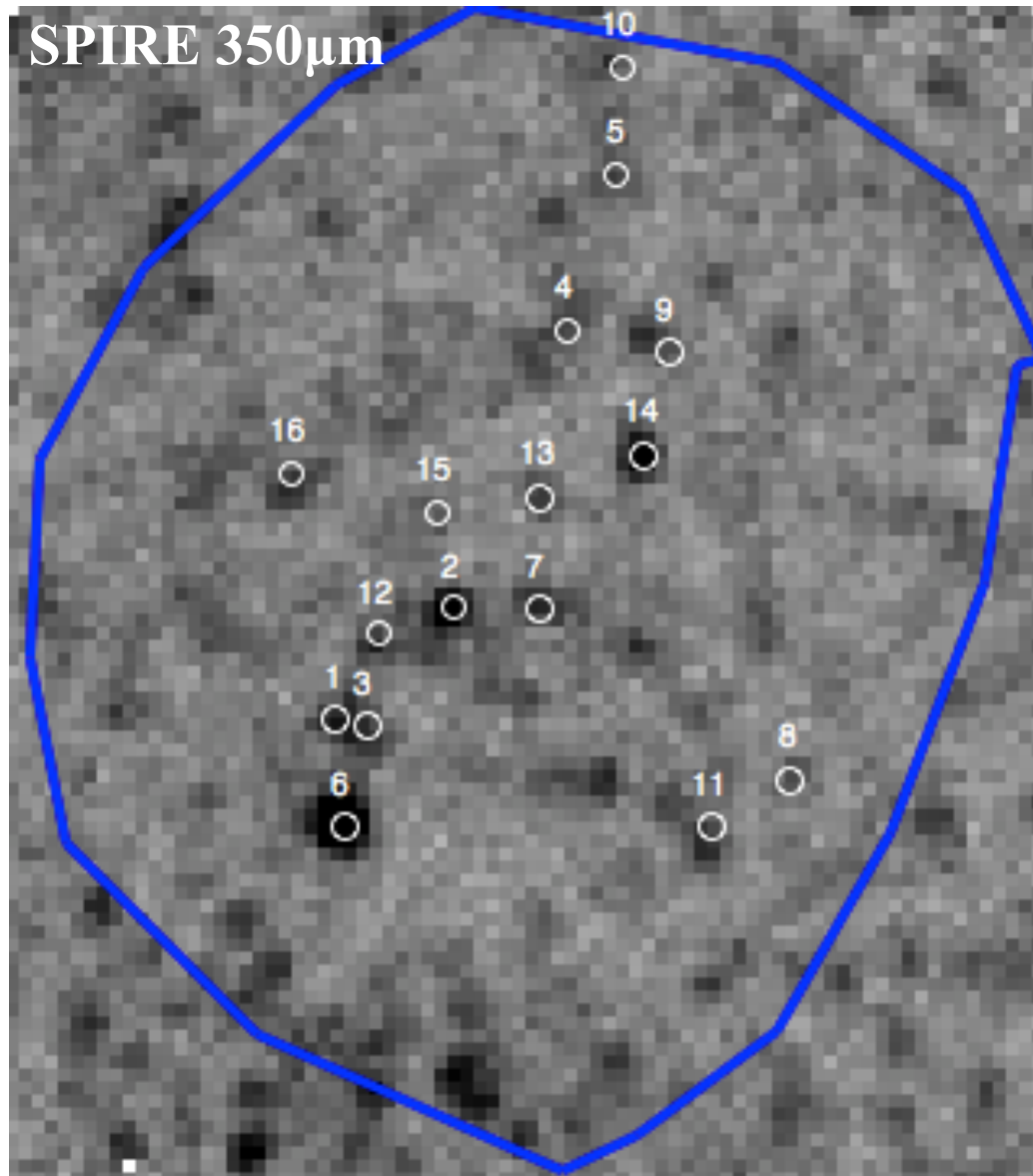
Vatlchanov+2013; Rigby+2014
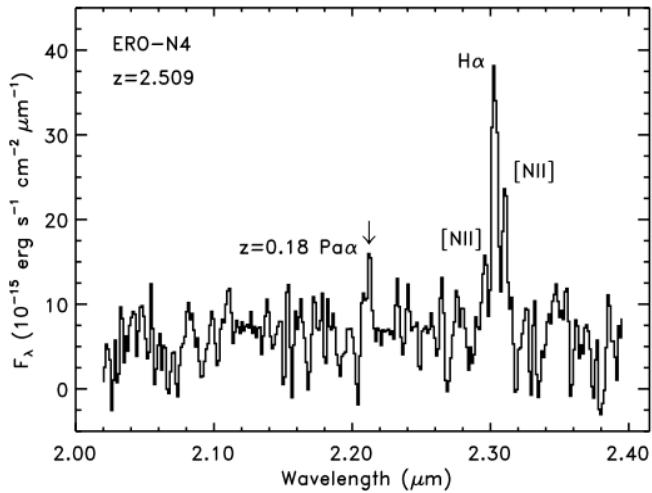
Identification Work
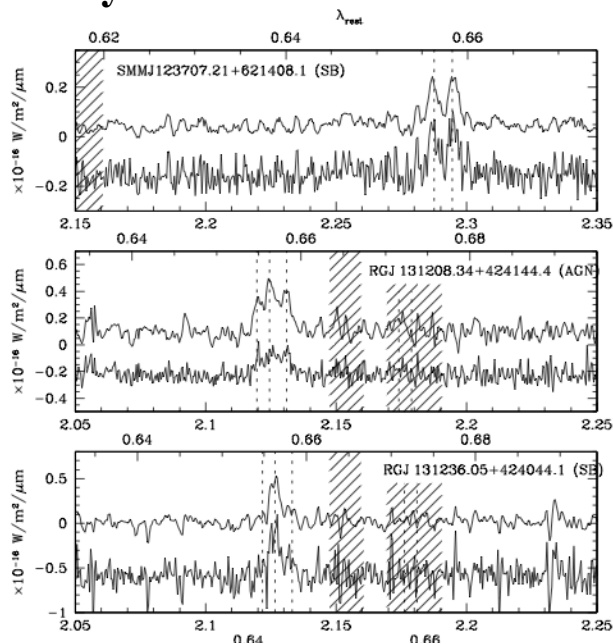
• best approach would be mm-interferometry

• counterpart identification could be done based on probabilistic statistic
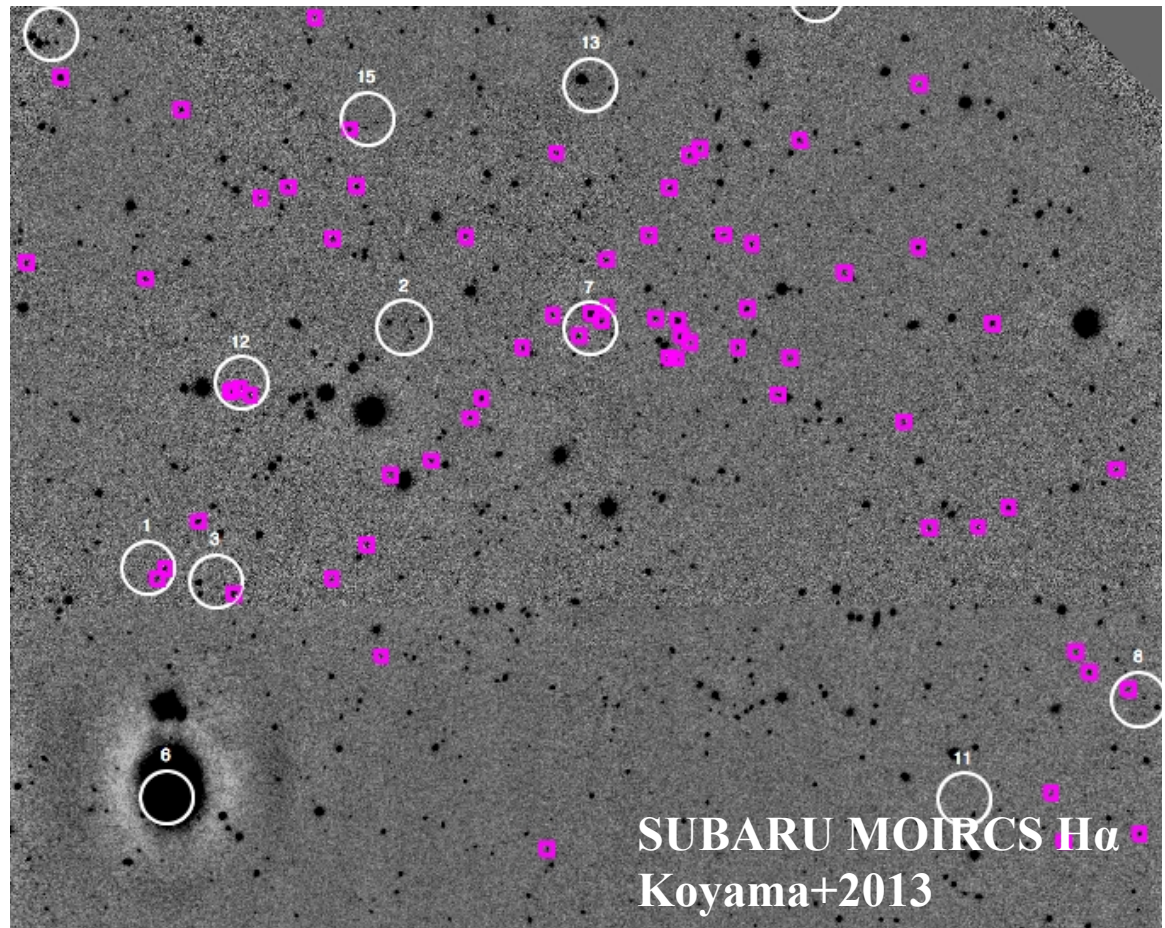➔ corrected Poissonian Probability (p-statistics; Downes+86)
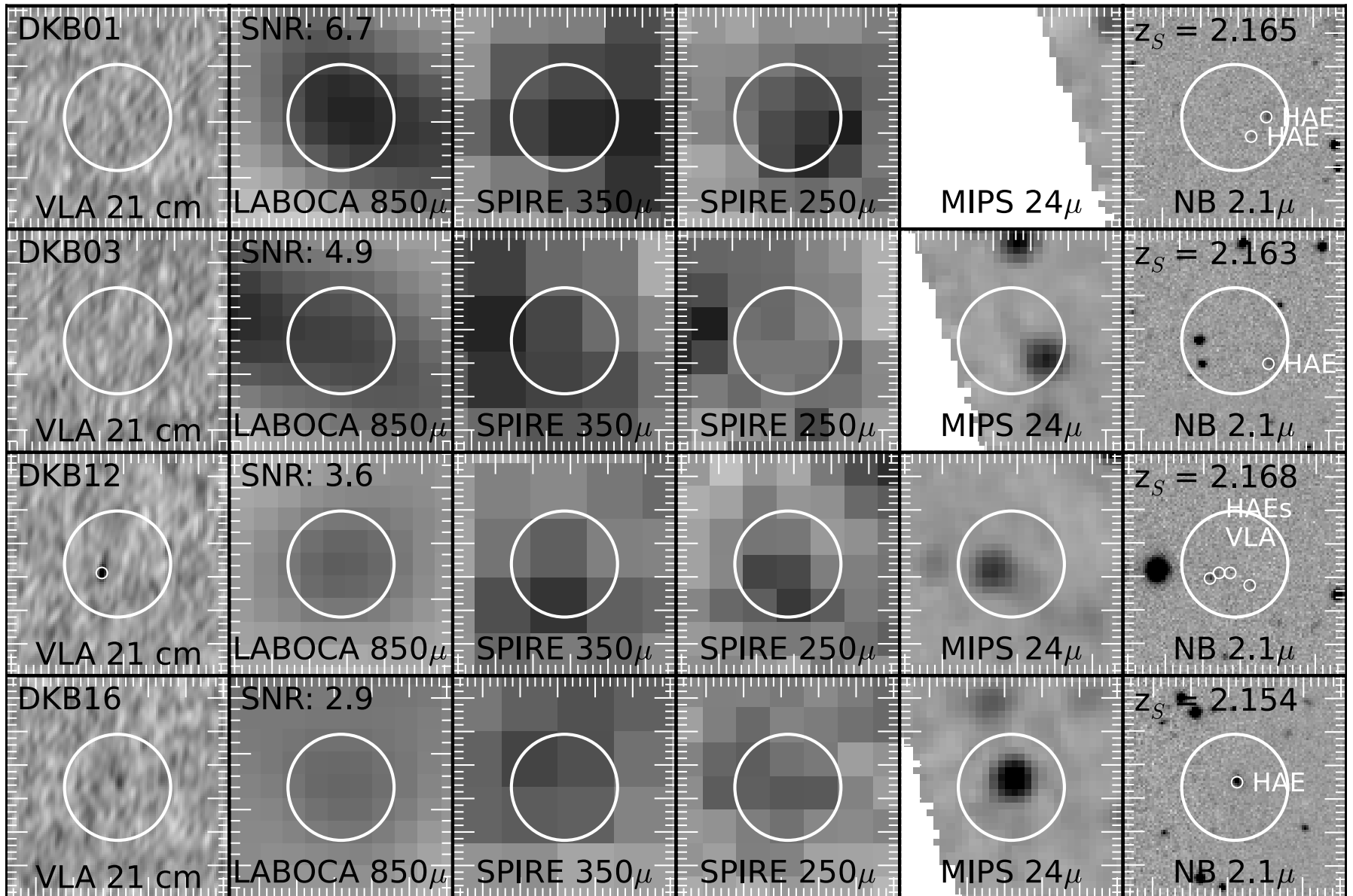
HAEs associated with SMGs

ERO-N4
z=2.509

Hα

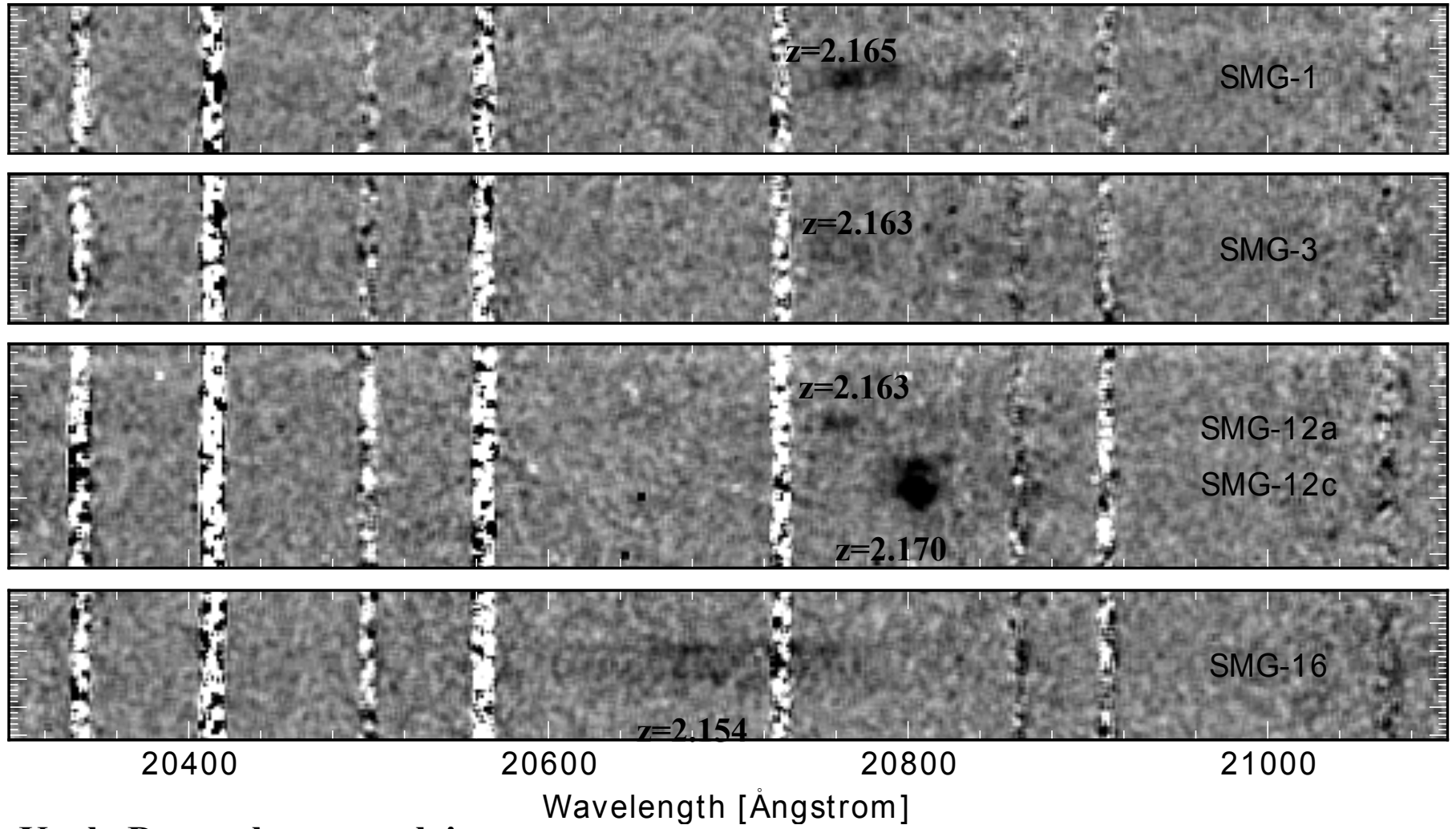[NII]

z=0.18 Paα

[NII]

Frayer+2004

SMMJ123707.21+621408.1 (SB)

RGJ 131208.34+424144.4 (AGN)

RGJ 131236.05+424044.1 (SB)

Swinbank+2003

SUBARU MOIRCS Hα
Koyama+2013

applying p-statistics on HAEs

Counterparts

Dannerbauer et al. (2014)

ISAAC Spectroscopy

z=2.165 SMG-1

z=2.163 SMG-3

z=2.163 SMG-12a SMG-12c

z=2.170

SMG-16

z=2.154

Wavelength [Ångstrom]

Kurk, Dannerbauer et al. in prep

FIR-photo-z

FIR-photo-z

DKB01a

λ_{rest} (μm)

F_ν (mJy)

z_spec = ———
z_FIR = 2.3 ± 0.7, #13

λ (μm)

DKB01b

λ_{rest} (μm)

F_ν (mJy)

z_spec = 2.165
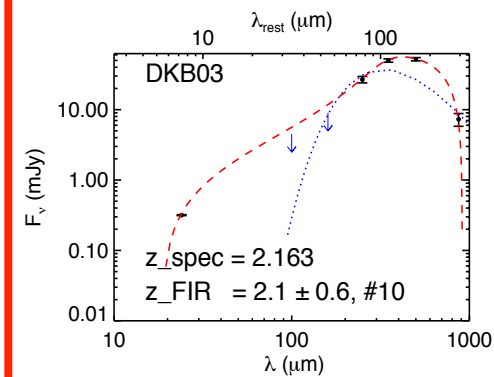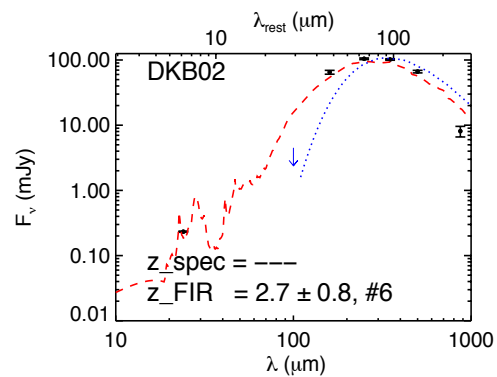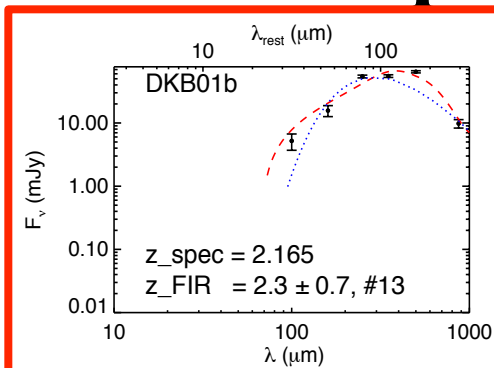z_FIR = 2.3 ± 0.7, #13

λ (μm)

DKB02

λ_{rest} (μm)

F_ν (mJy)

z_spec = ———
z_FIR = 2.7 ± 0.8, #6

λ (μm)

DKB03

λ_{rest} (μm)

F_ν (mJy)

z_spec = 2.163
z_FIR = 2.1 ± 0.6, #10

λ (μm)

DKB14

λ_{rest} (μm)

F_ν (mJy)

z_opt/NIR = 1.37
z_FIR = 1.3 ± 0.4, #14

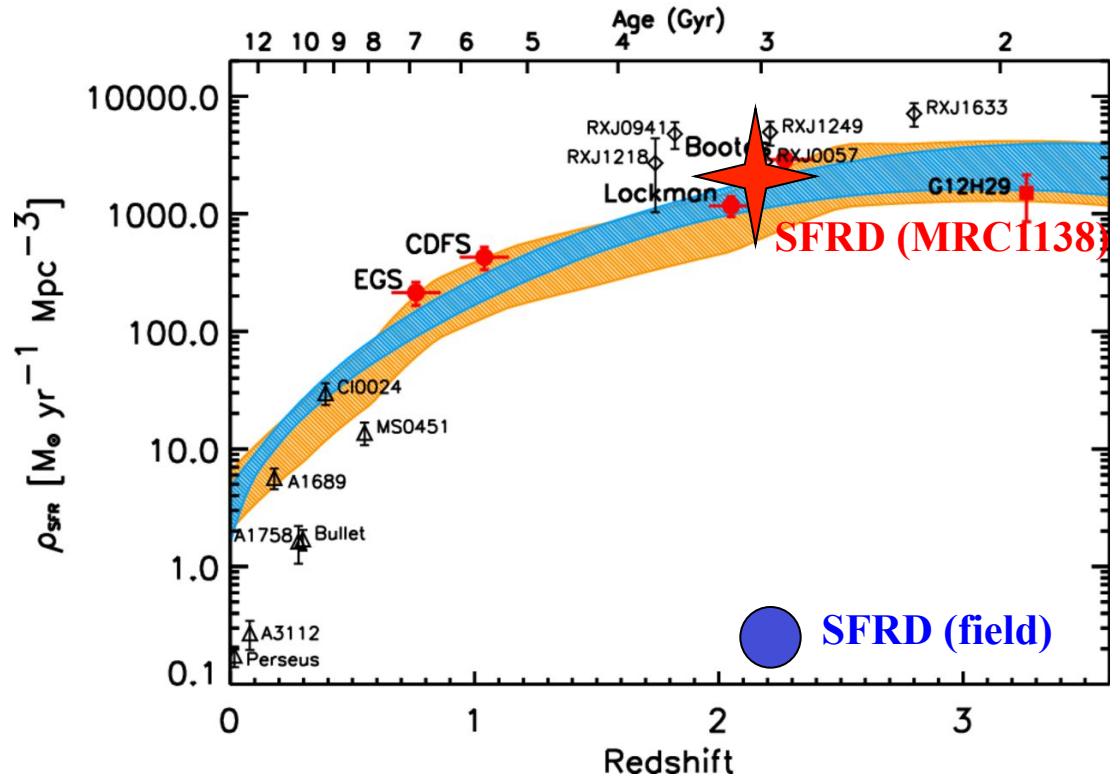λ (μm)

DKB15

λ_{rest} (μm)

F_ν (mJy)

z_spec = ———
z_FIR = 3.4 ± 1.0, #11

λ (μm)

N
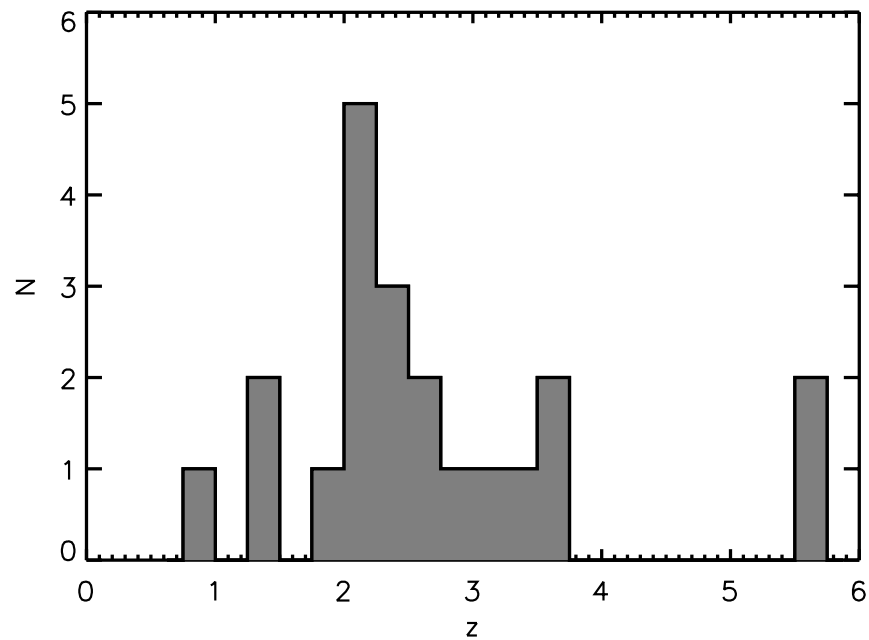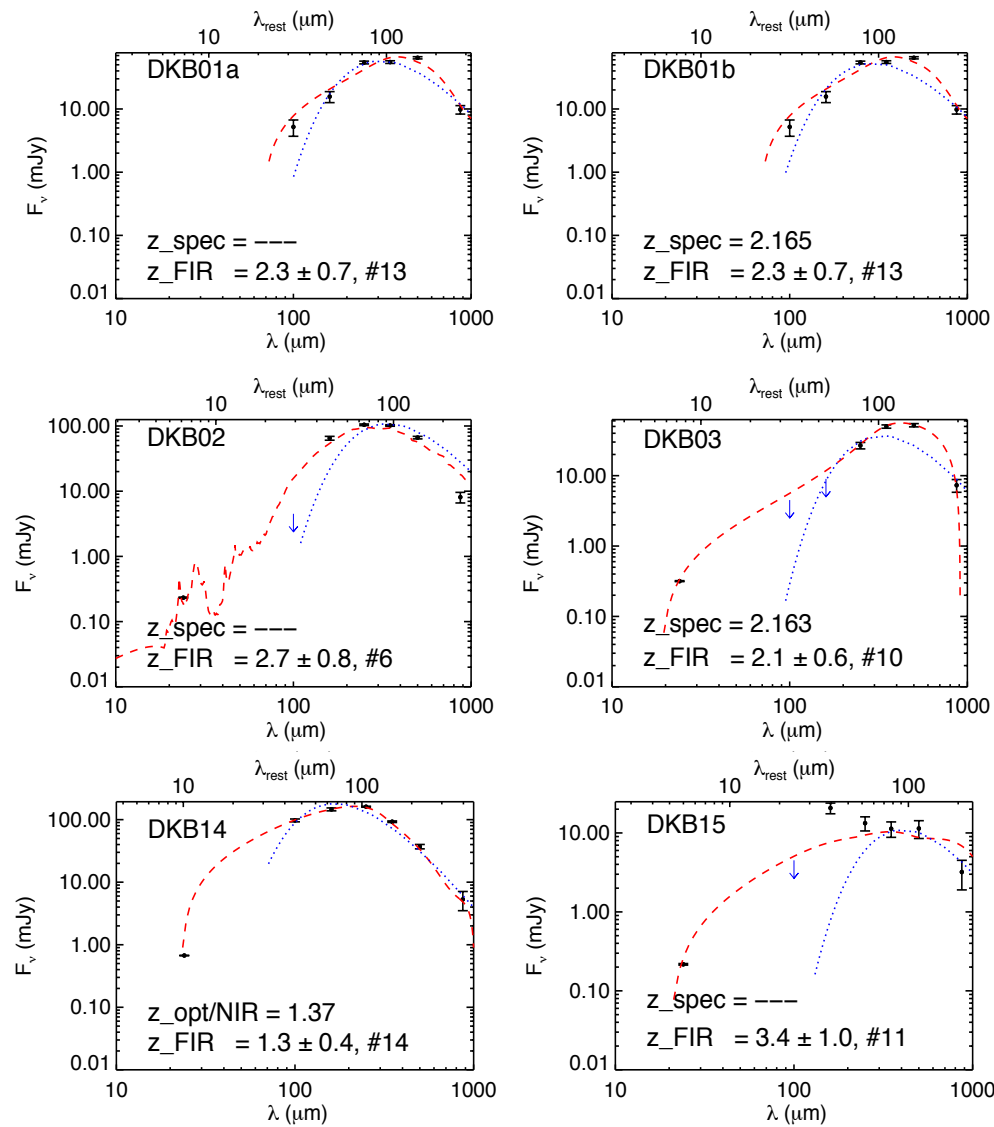
z
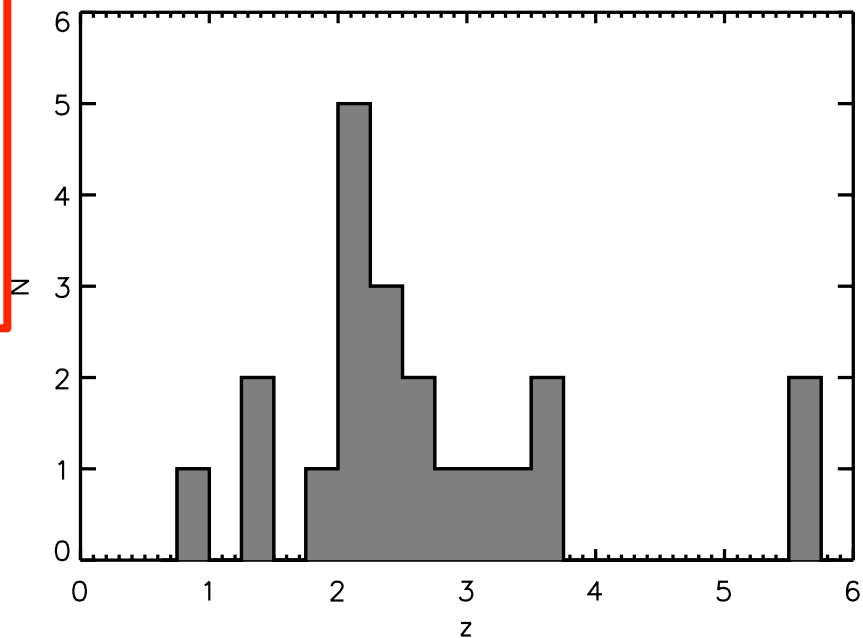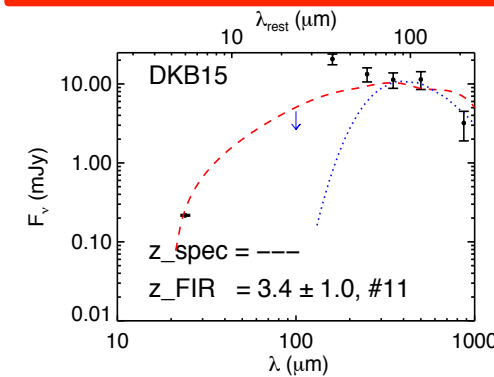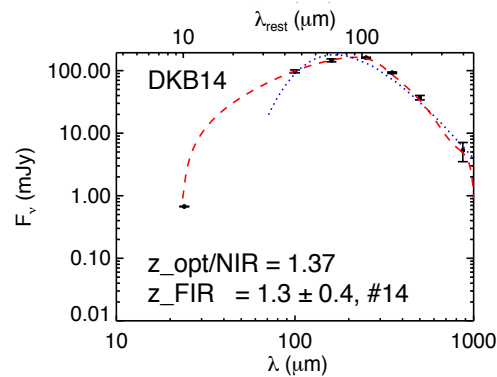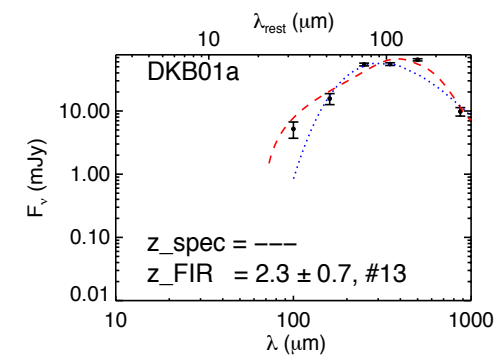
ISAAC sources @z=2.16:
z_phot_IR consistent with z_spec_Hα

Dust Obscuration and Star Formation
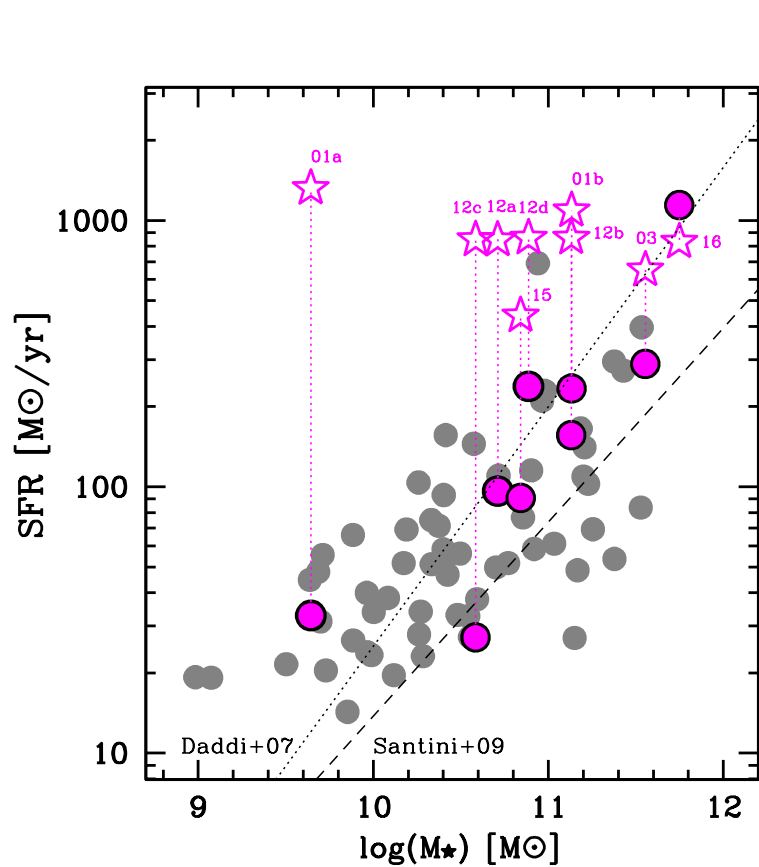
Clements+2014

SFR(IR)=5-10xSFR(Hα)
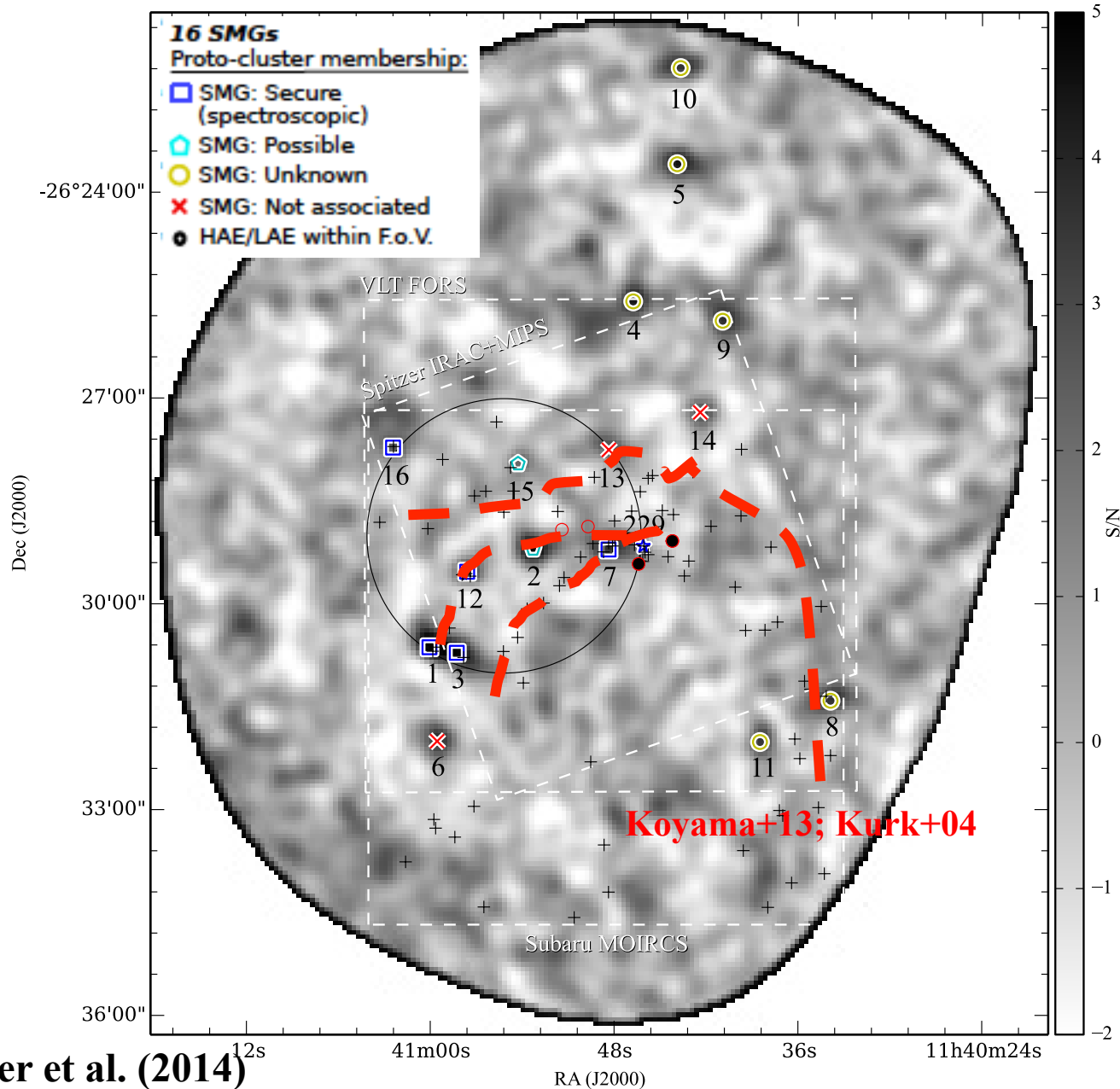
simulations by Granato+15

≠ **underpredict by a factor 5 to 10 the SFRD➜revise feedback/SF models**

Proto-Cluster Membership

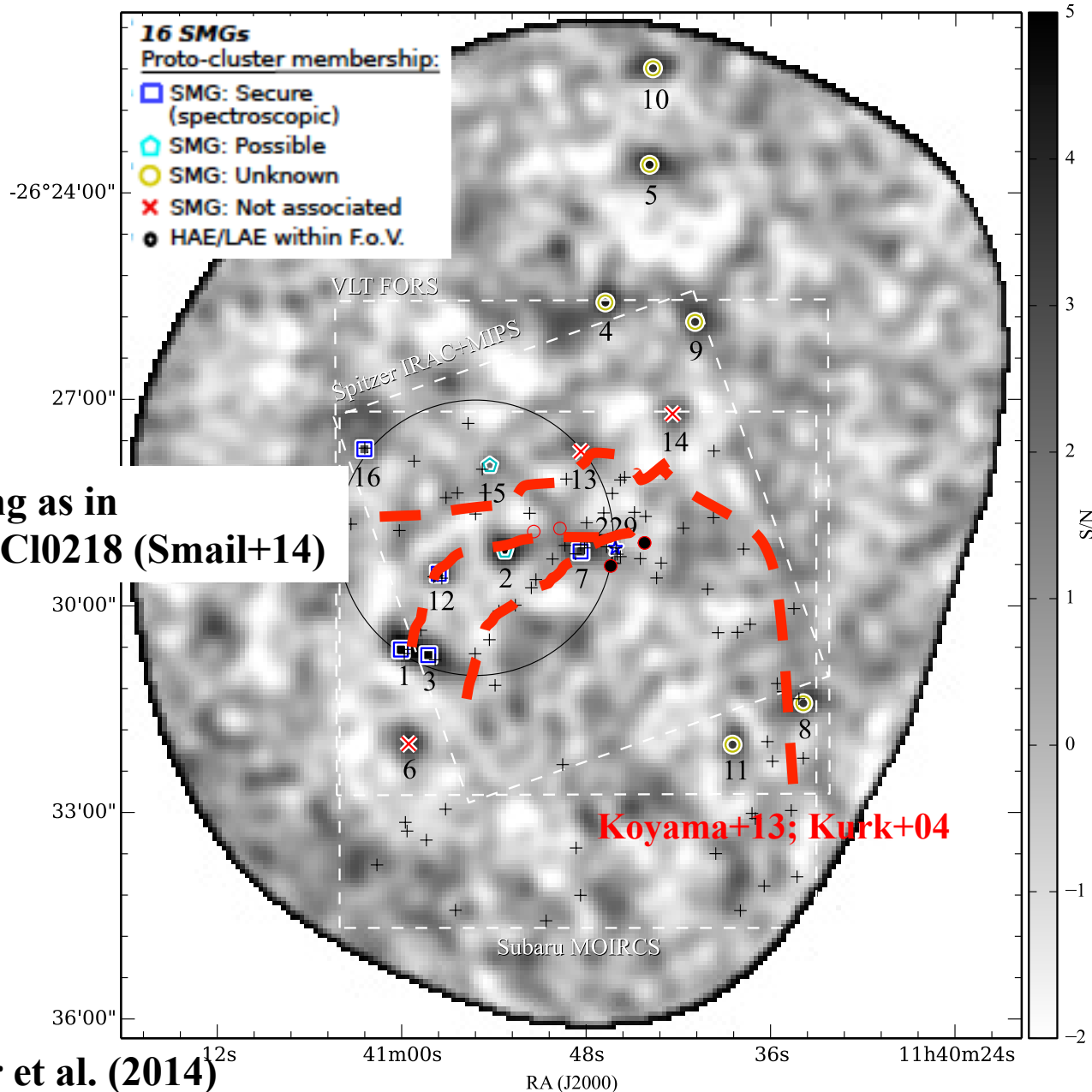Dannerbauer et al. (2014)
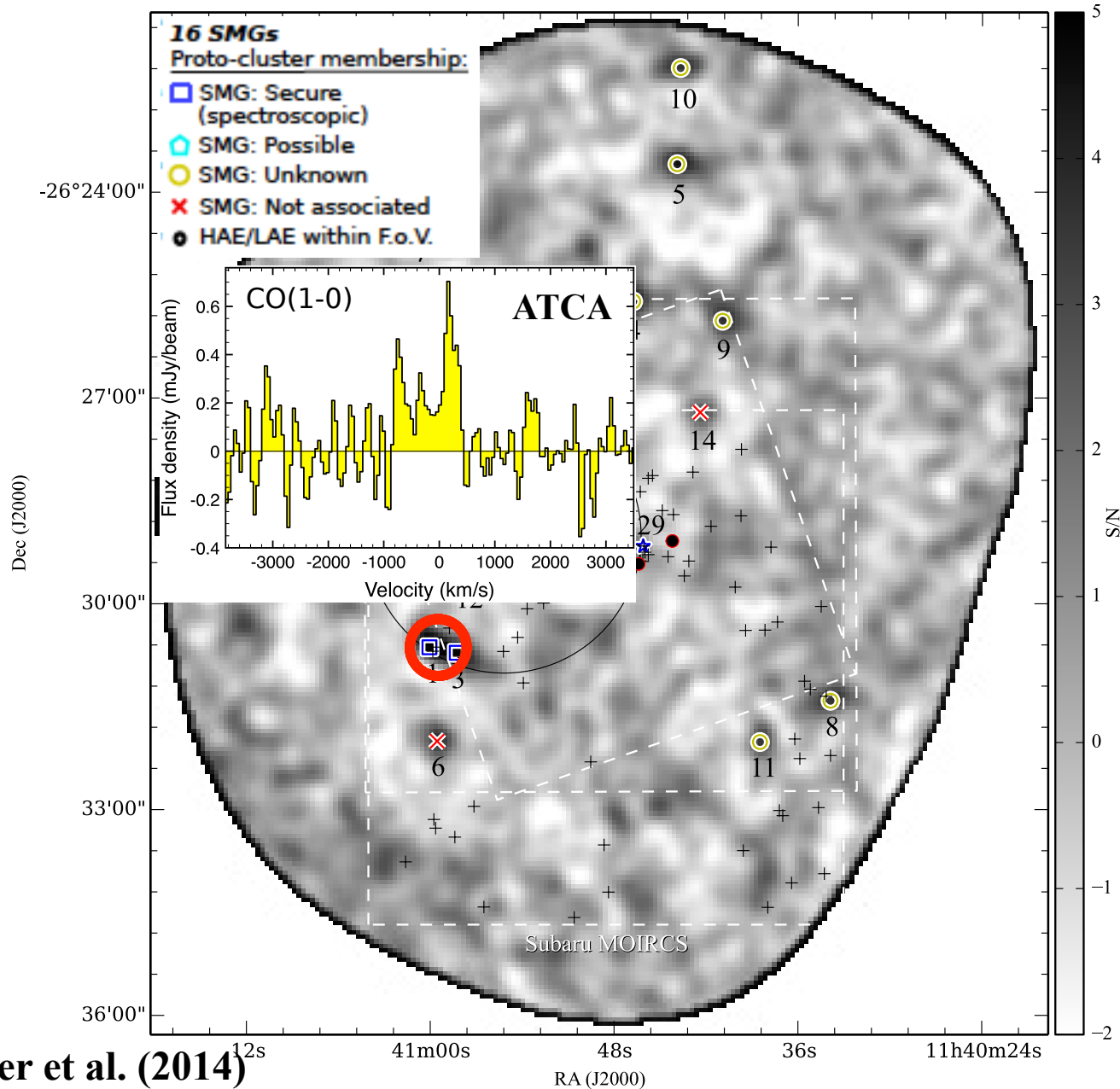
Proto-Cluster Membership

Dannerbauer et al. (2014)

Proto-Cluster Membership

16 SMGs
Proto-cluster membership:
- □ SMG: Secure (spectroscopic)
- ⬠ SMG: Possible
- ○ SMG: Unknown
- ✕ SMG: Not associated
- ⦿ HAE/LAE within F.o.V.

VLT FORS

Spitzer IRAC+MIPS

similar finding as in
z=1.5 cluster Cl0218 (Smail+14)

Koyama+13; Kurk+04

Subaru MOIRCS

Dannerbauer et al. (2014)

RA (J2000)

S/N

Proto-Cluster Membership

16 SMGs
Proto-cluster membership:
- □ SMG: Secure (spectroscopic)
- ⬠ SMG: Possible
- ○ SMG: Unknown
- ✕ SMG: Not associated
- ⊙ HAE/LAE within F.o.V.

Dannerbauer et al. (2014)

HAE229 ..... alias SCUBA SMG#3

ATCA

50 kpc

FWHM_PB

Spiderweb Galaxy
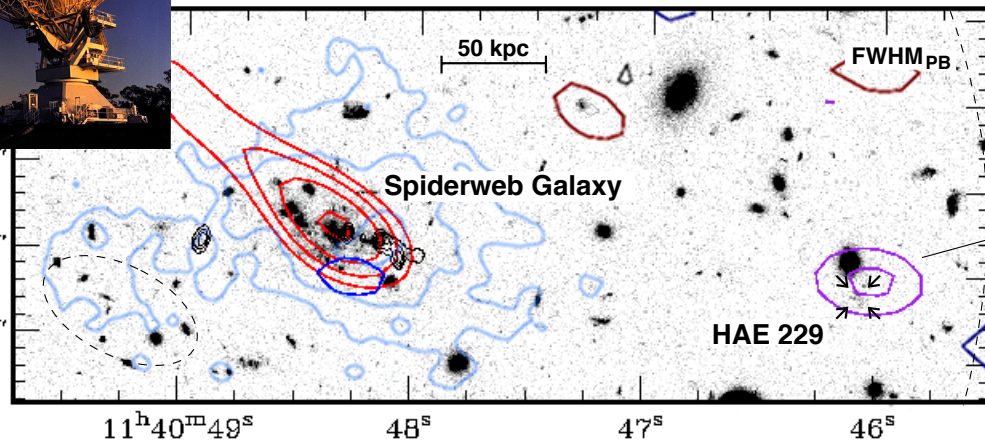
HAE 229

Emonts et al. (2013)

$CO(1-0)$
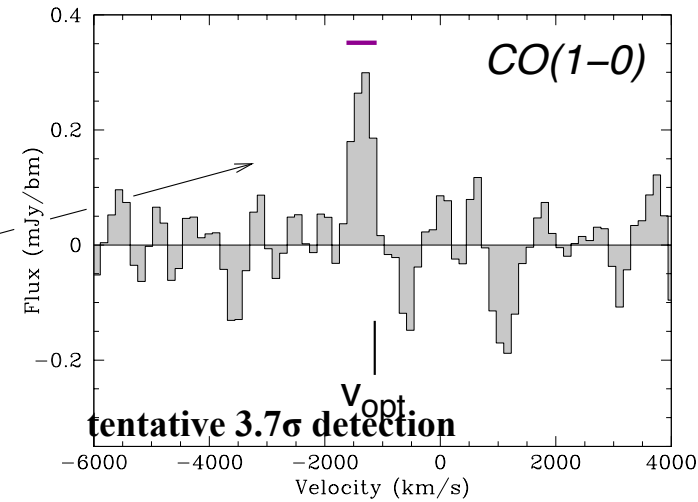
tentative 3.7σ detection

$V_{opt.}$

now 9σ detection
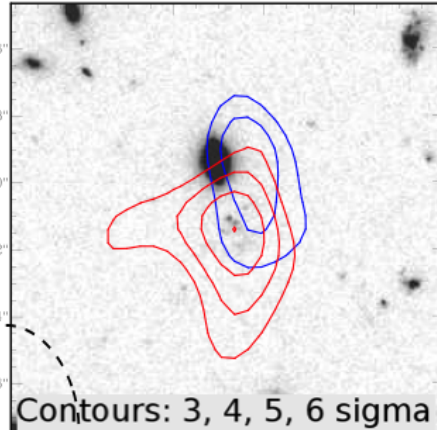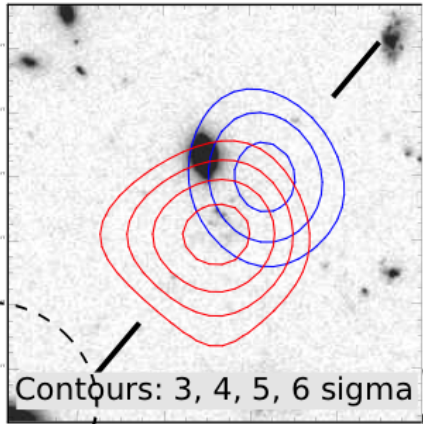
Dannerbauer, Emonts et al. to be subm.

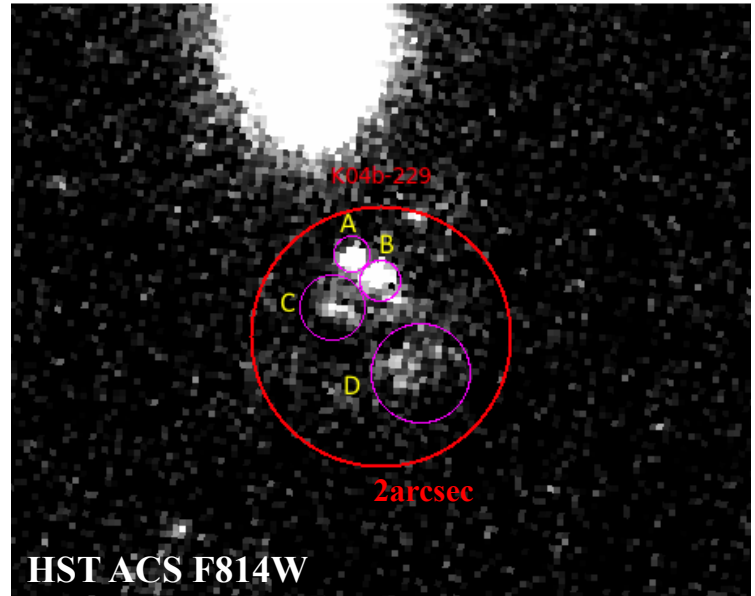PKS1138-26

HAE229

Main sequence galaxy

uvrange = 0 - 31 k-lambda
uvrange = 0 - 60 k-lambda
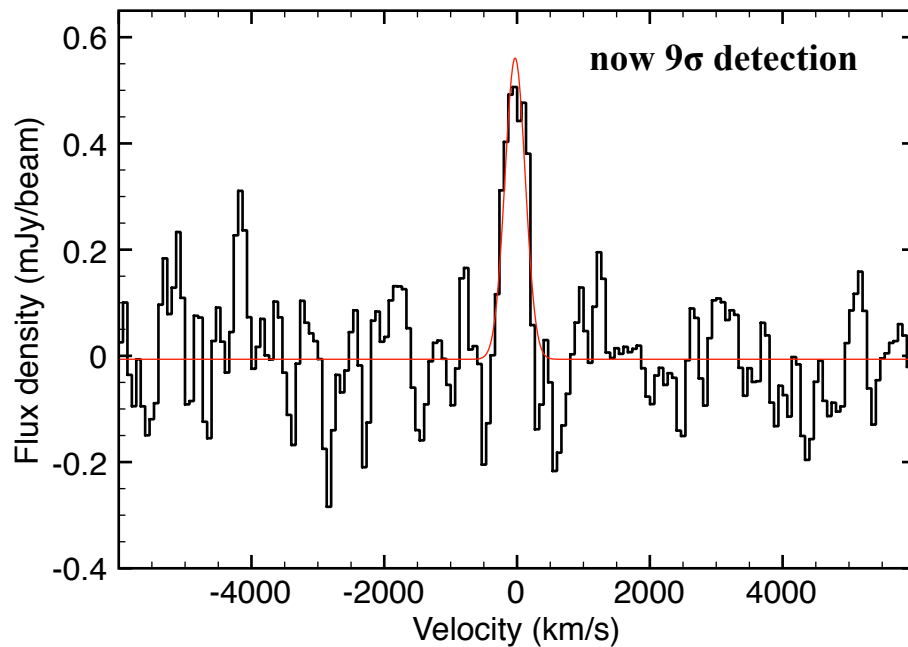
Contours: 3, 4, 5, 6 sigma

HST ACS F814W

Contours: 3, 4, 5, 6 sigma

HAE229

Dannerbauer, Emonts et al. to be subm.
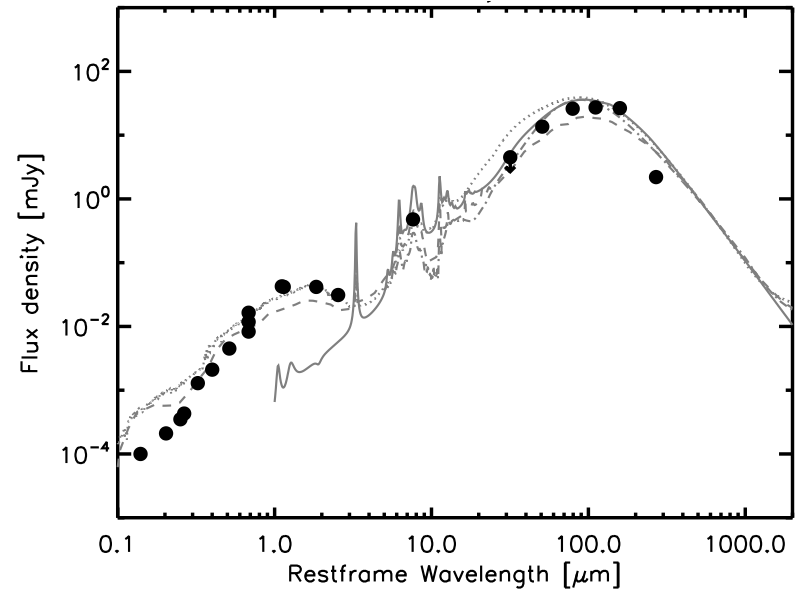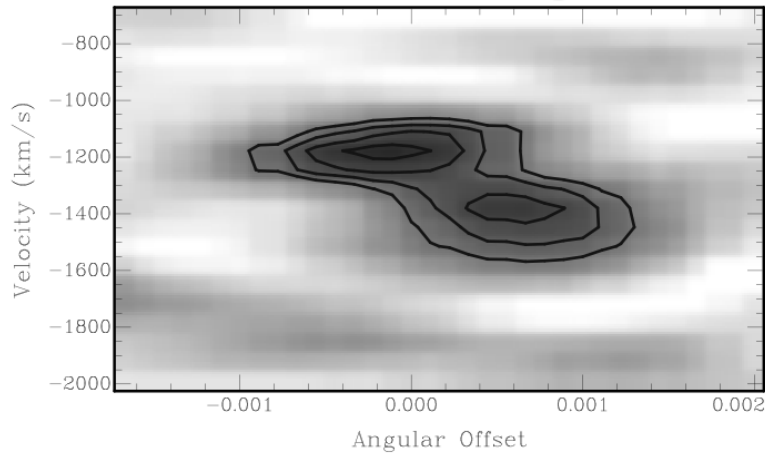
HAE229
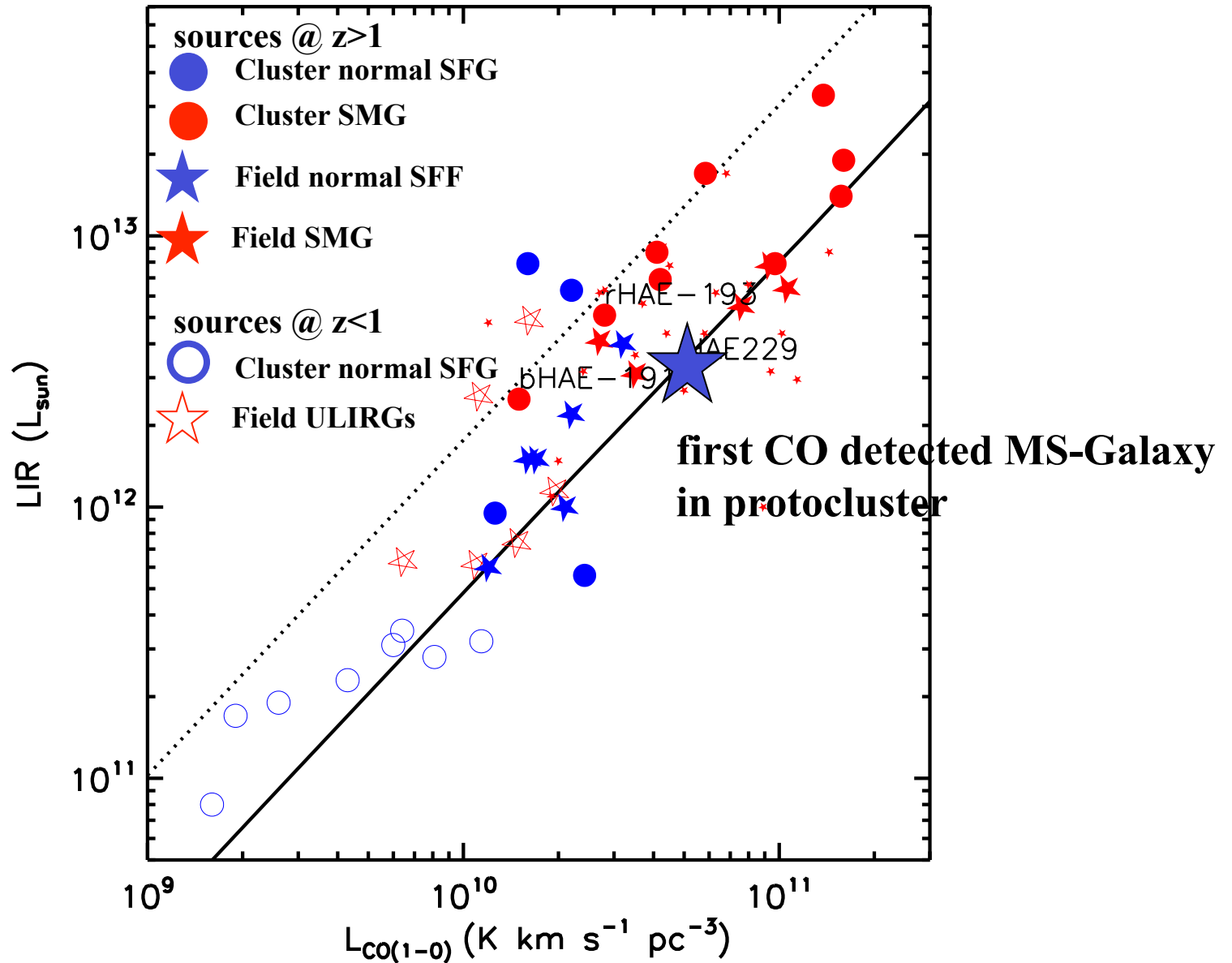
Conclusion

- **overdensity of dusty starbursts associated to MRC1138**

- **at least 8 SMGs are members of the proto-cluster**

- **HAEs promising approach to trace (part of) the SMG (system)**

- **LABOCA (submm) imaging seems to be a good way to search for overdensities/large scale structures➔Poster #28 Umehata see also for z>1 clusters: #27 Noble, #46 Webb and #48 Santos**

- **first CO of main-sequence galaxy in protocluster**
  - ➔*Dannerbauer, Kurk, De Breuck et al., 2014, A&A, 2014, 570, 55*
  - ➔*Dannerbauer, Emonts et al. , 2015, to be submitted*