Radio galaxies and their environment at 1<z<2 (and beyond...)

Joël Vernet (ESO)
Carlos De Breuck, Audrey Galametz, Jack Mayo, Dan Stern,
Nick Seymour, and the SHizRaG team

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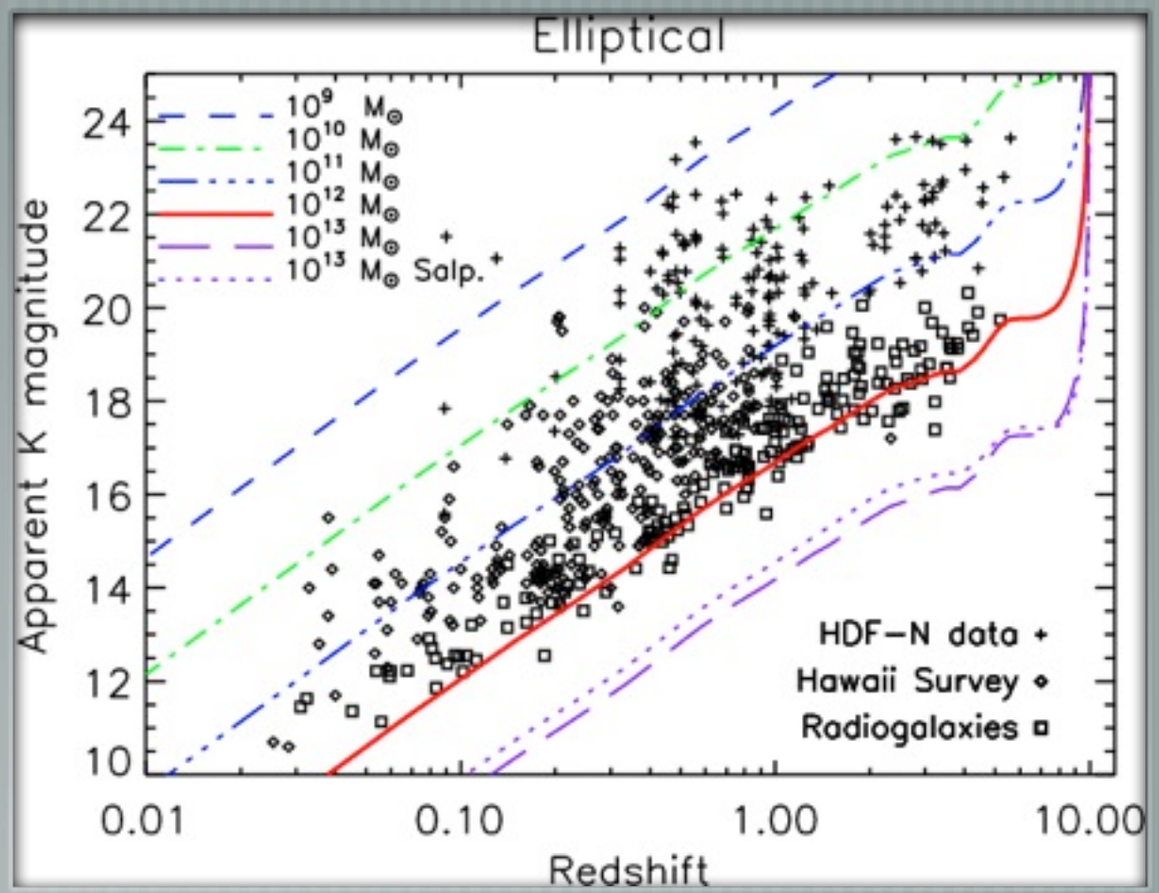
Why around RG?

- Among the largest, most luminous, most massive galaxies at every epoch
  - Progenitors of gE and cD
  - Exist from z=0 to z>5



Environment of High Redshift Radio Galaxies

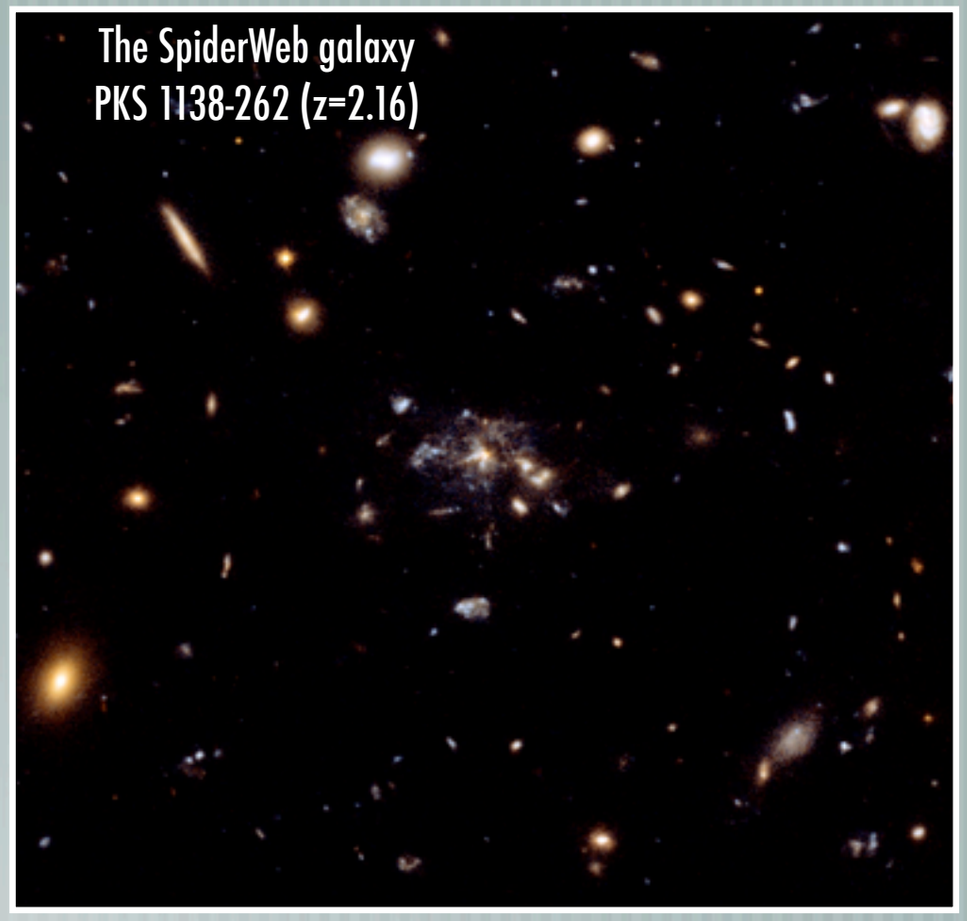
Narrow line emitters searches

(narrow band imaging+spectroscopic confirmation, led by G. Miley and coll.)

Pros: redshifts is known, little contamination form interlopers

Cons: samples only a small fraction of the total mass of the proto-cluster

Much less done on search for evolved (red sequence) galaxies around RGs



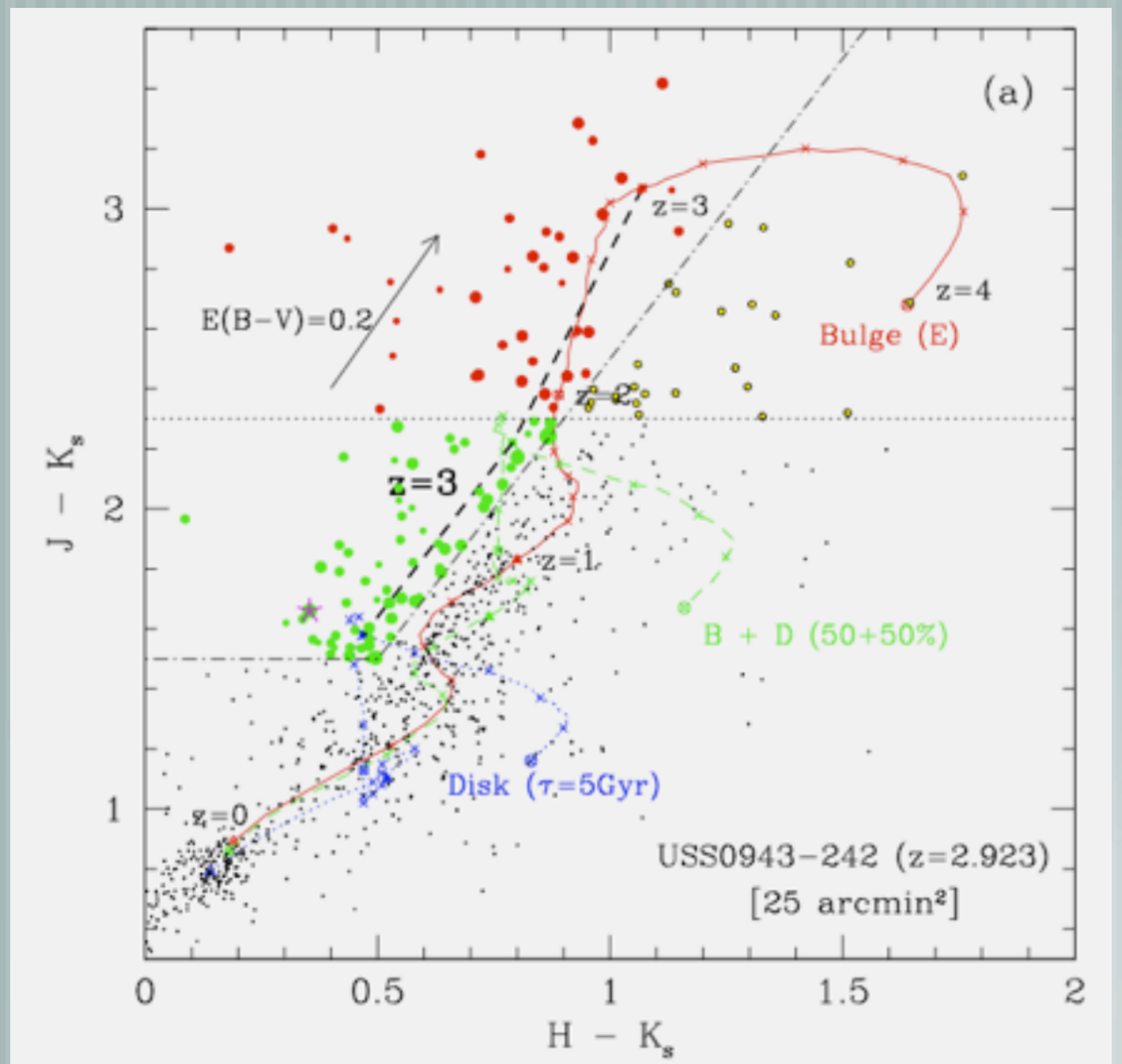
Ex: The SpiderWeb galaxy
The most studied protocluster at z>2

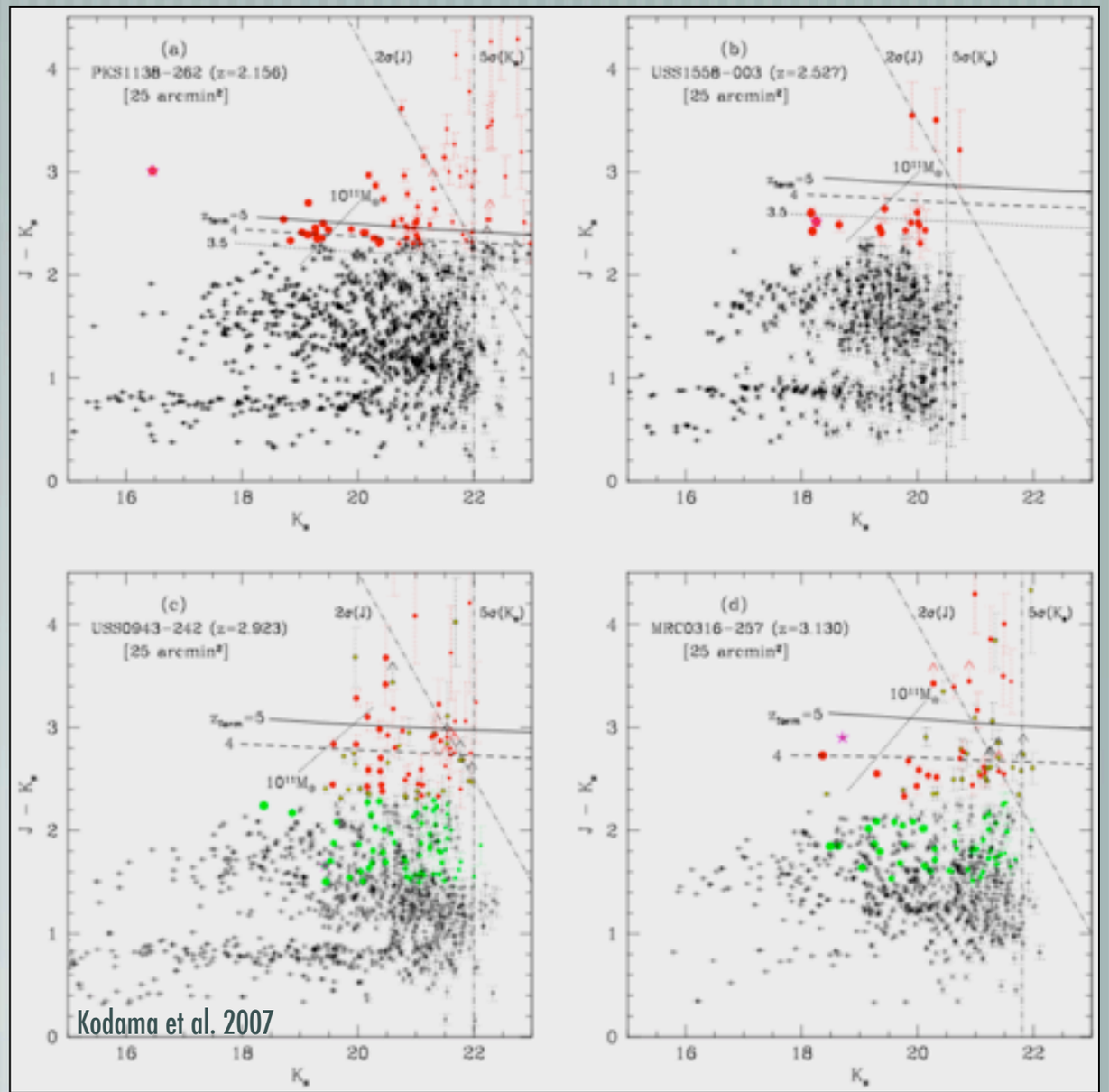
Lyα and Hα emitters, EROs, Lyman break galaxies
... And now massive red cluster members

Environment of High Redshift Radio Galaxies

Near infrared imaging + colour criteria (eg. J-K>2.3) to select more massive components tat would populated the red sequence

Kodama et al. 2007, see also Zirm et al 2007

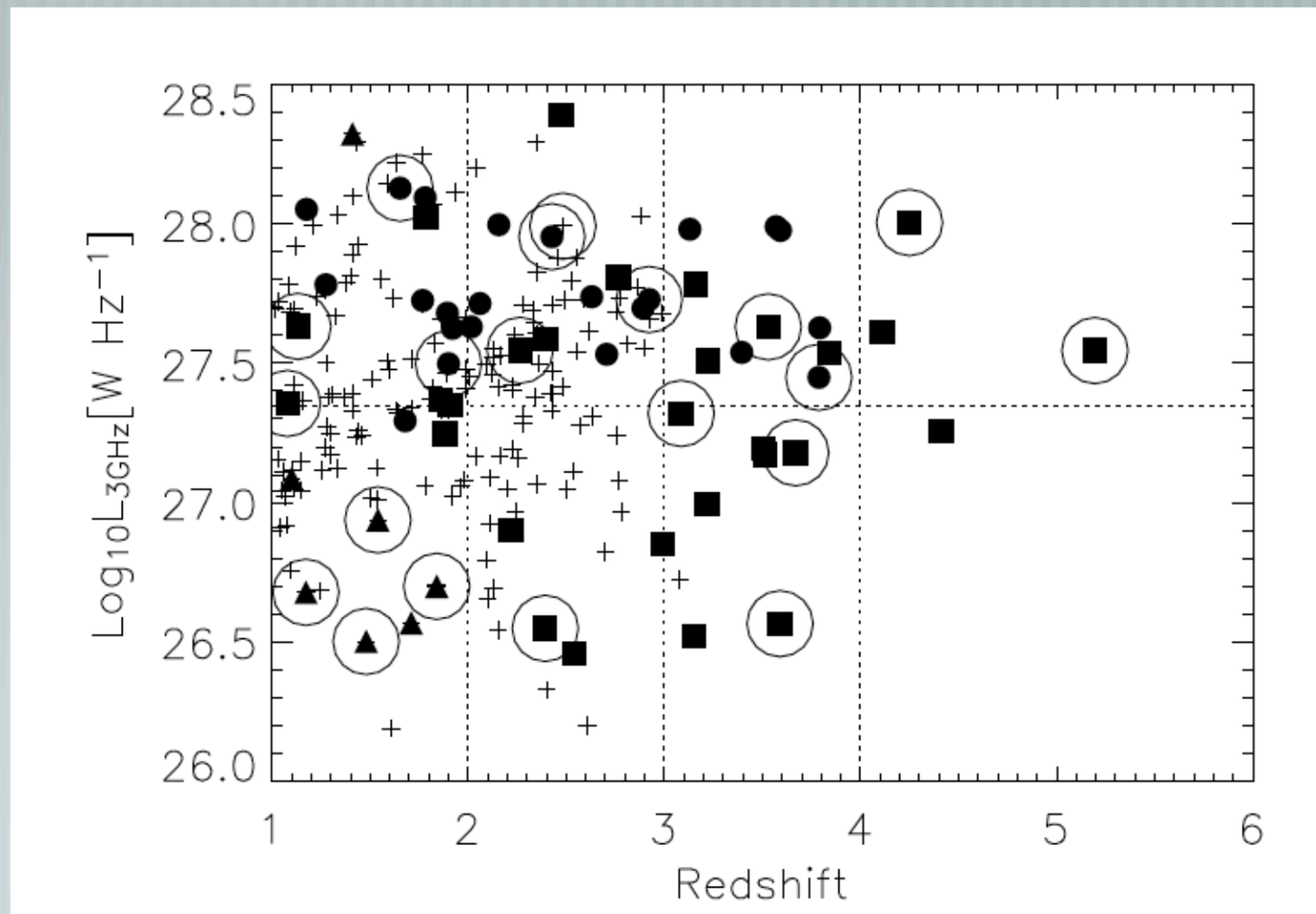




The sample

- Cover the radio luminosity - redshift plane as uniformly as possible in the range $1 < z < 4$, covering two orders of magnitude in radio luminosity
- Sample chosen to maximize number of supporting observations without biasing
- Optical/near-IR imaging and spectroscopy+polarimetry
- Spitzer (3.6, 4.5, 5.8, 8.0, 16 and 24 μm)
- Hershel (70/100, 160, 250, 350 and 500 μm)

Solid symbols - HzRGs in our Spitzer sample with IRAC/IRS imaging
Large circles - MIPS observations as well
Filled circles - HzRGs with HST data
Filled squares - HzRGs with SCUBA data
Plusses - parent sample of 225 HzRGs from which our sample of 70 was drawn

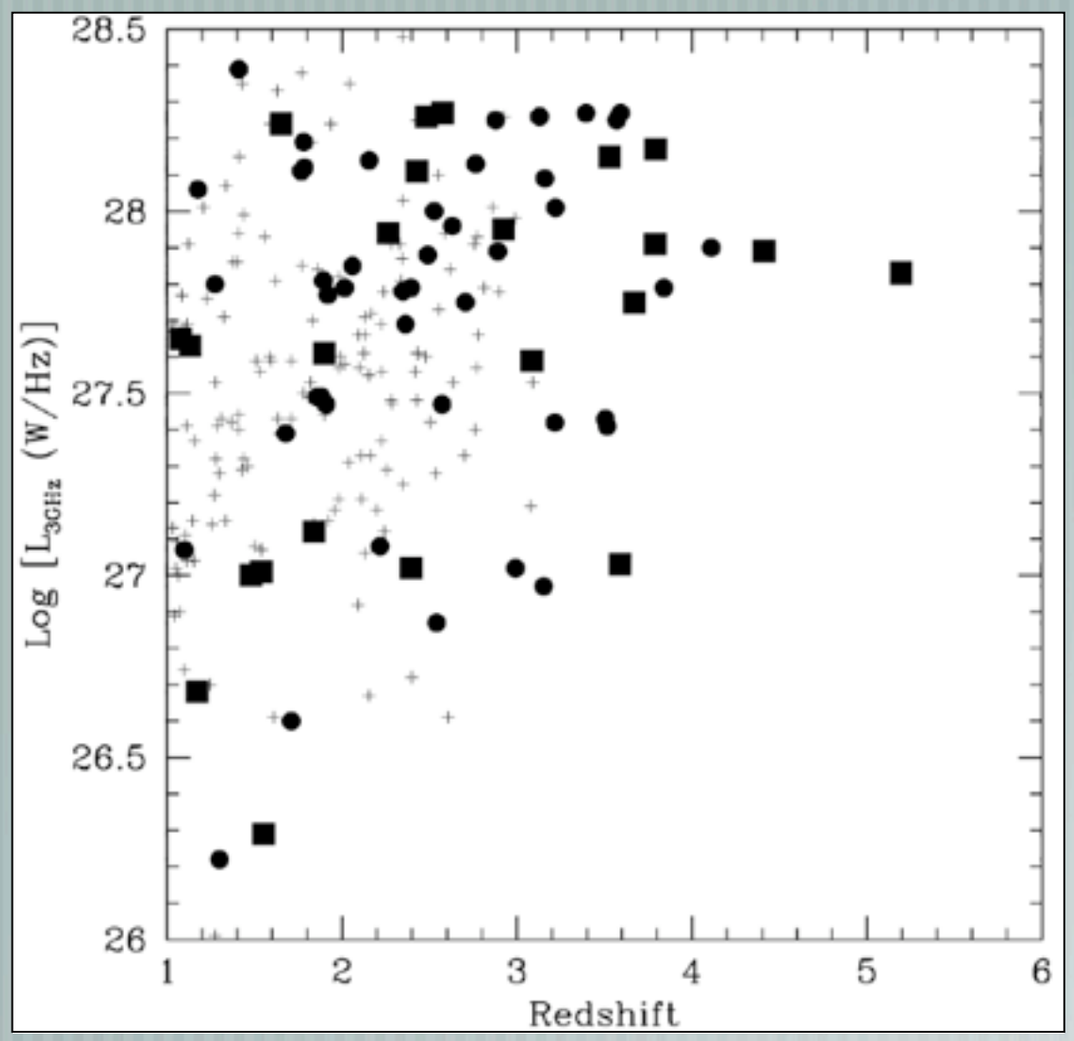


Galametz, De Breuck, Vernet, et al. 2010

Two Projects

Galametz, Vernet, De Breuck et al. 2011

CFHT / WIRCAM

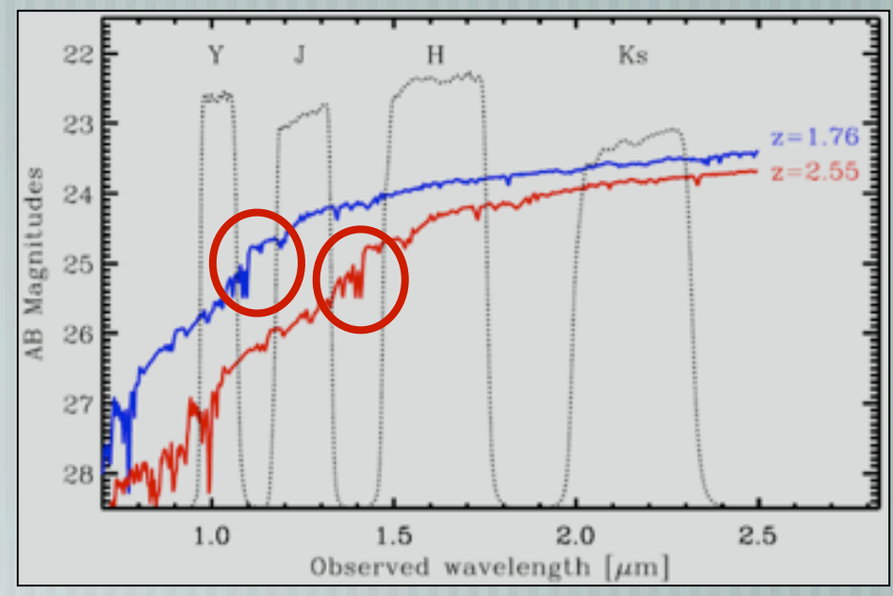


VLT / Hawk-I

Sample of 10 HzRGs with 1.7<z<2.5

MRC 1017-220 (z=1.77) MRC 0156-252 (z=2.02)
MRC 1324-262 (z=2.28) USS 1425-148 (z=2.35)
MRC 0406-244 (z=2.43) MG 2308+0336 (z=2.46)
MRC 2104-242 (z=2.49) MRC 2139-292 (z=2.55)
MRC 0324-228 (z=1.89) MRC 0350-279 (1.90)

Observed in YHK or JHK with HAWK-I to bracket the 4000Å break



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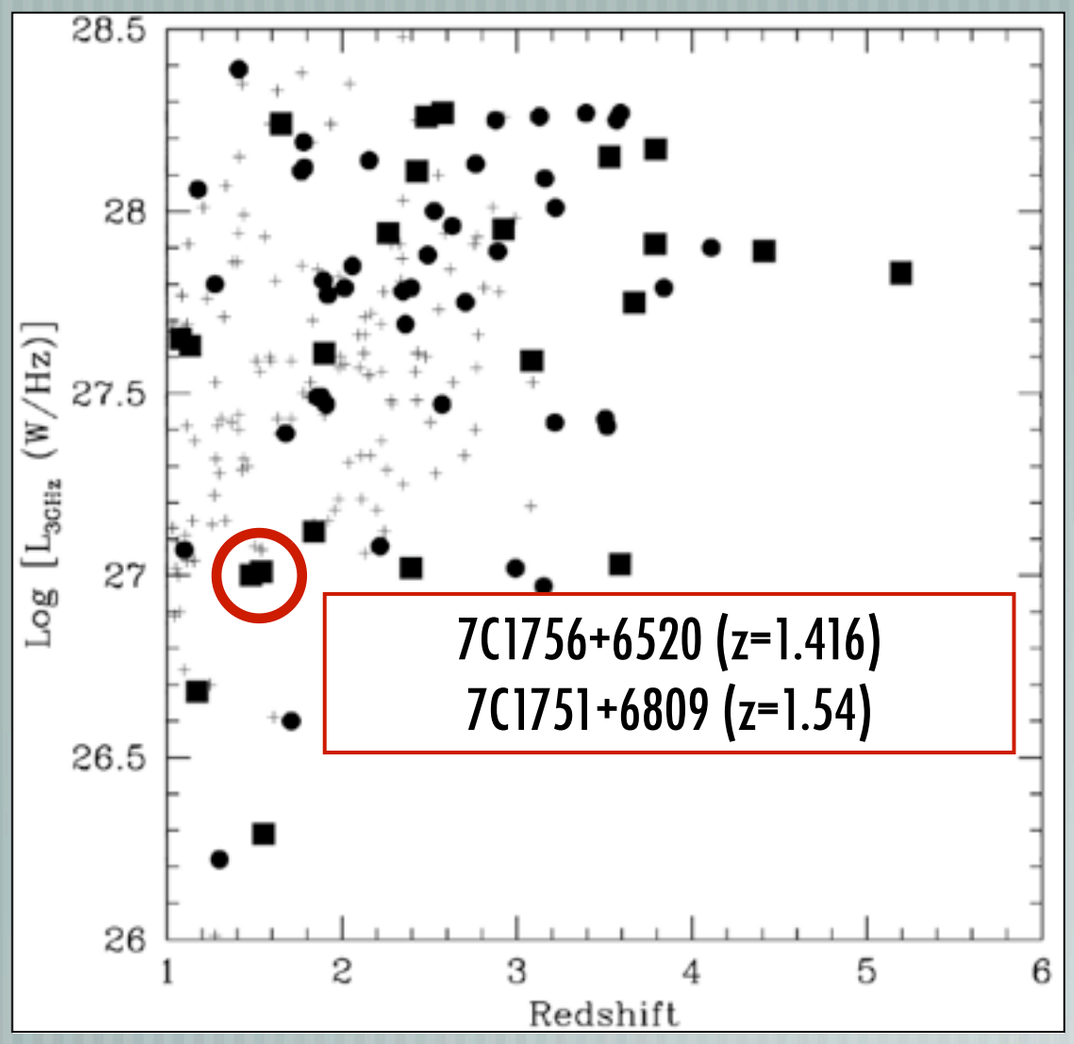

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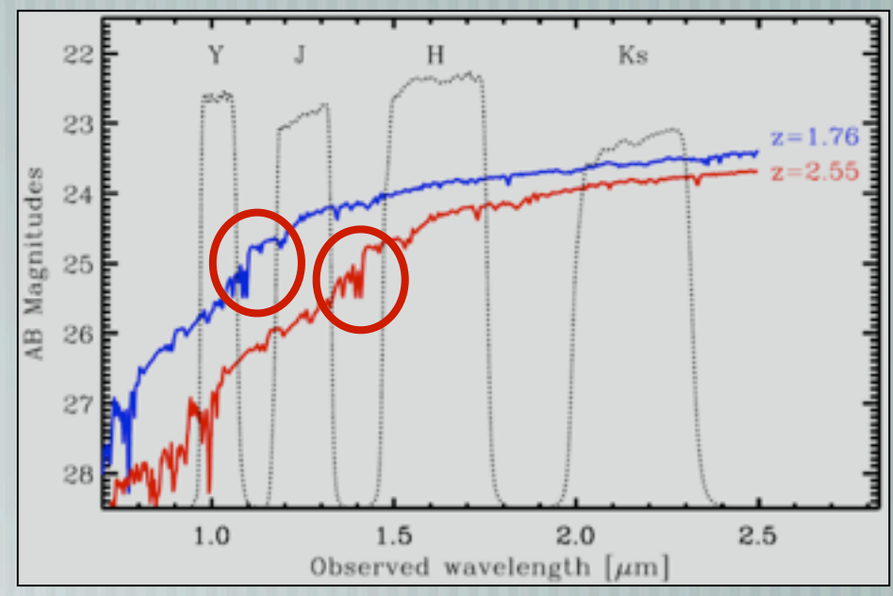

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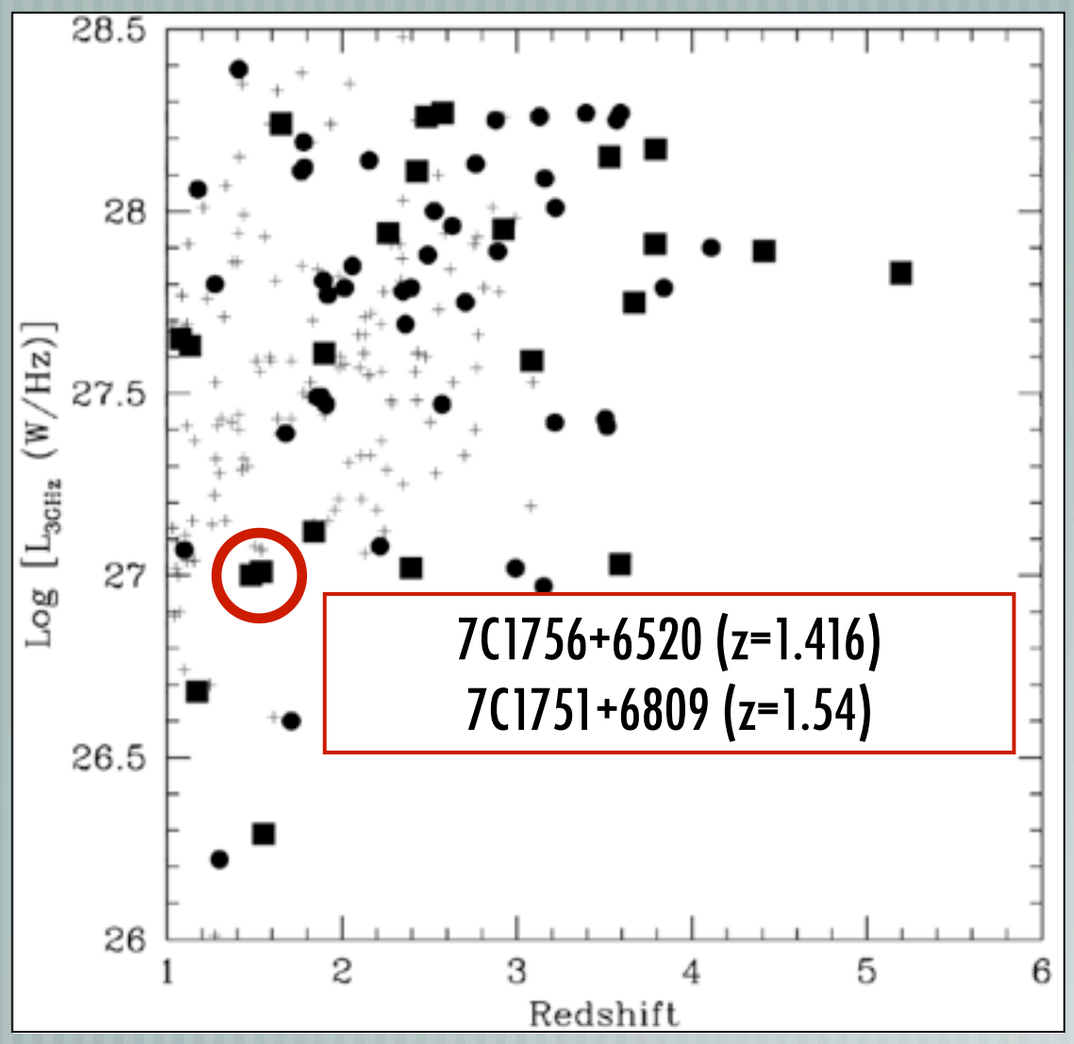

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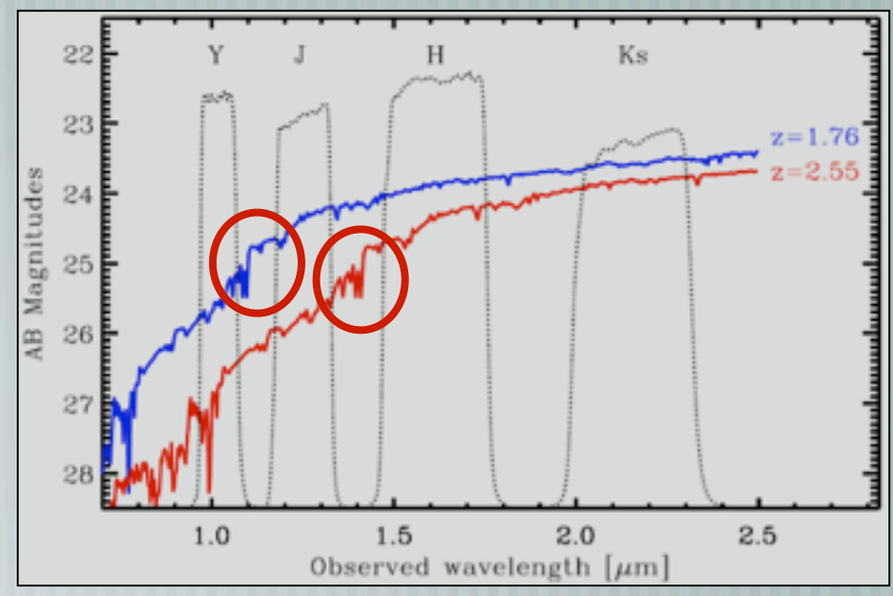


Two Projects

redshift 1.5

7C1756+6520 (z=1.416)
7C1751+6809 (z=1.54)

- Bb & z band – Palomar/LFC
- J & Ks bands – CFHT/WIRCam

Large scale (15'x15')

redshift 2

MRC1017-220 (z=1.77)
MRC0156-252 (z=2.02)

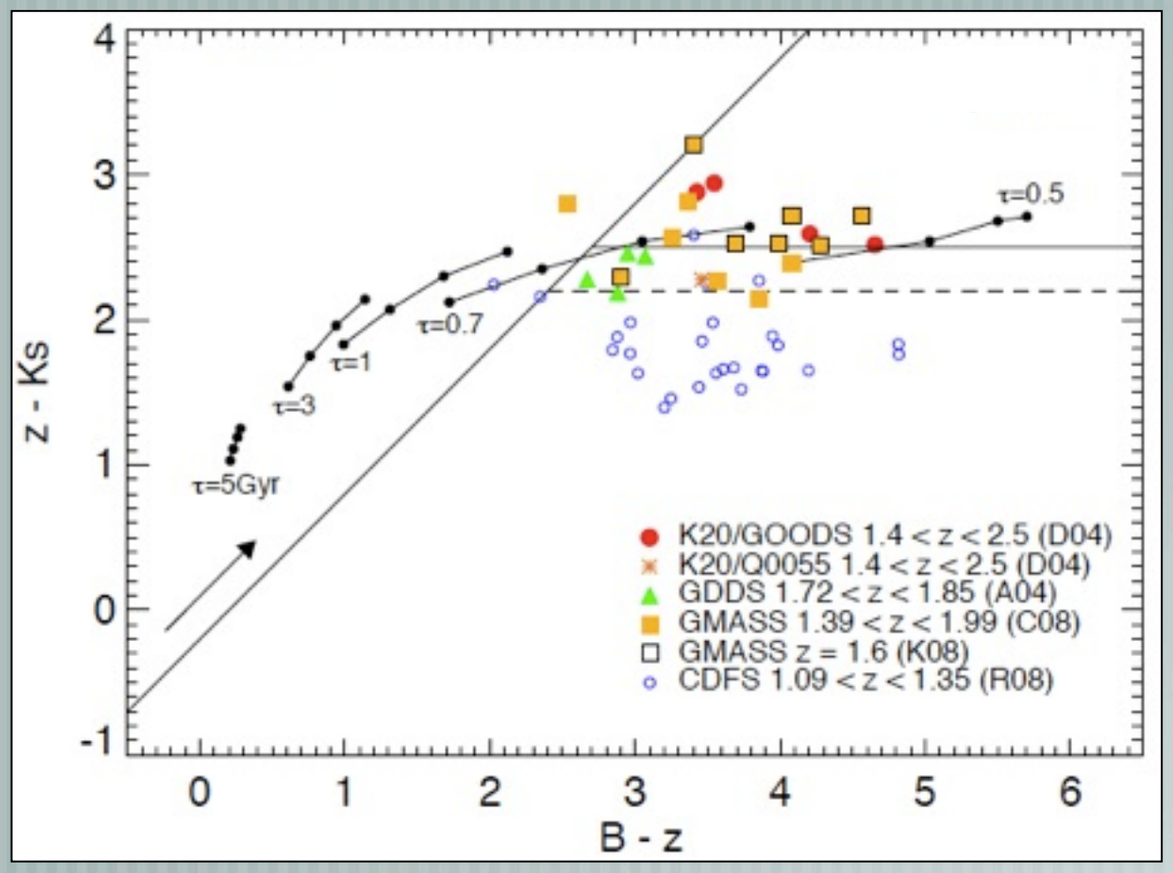
- YHK bands – VLT/HAWK-I

Large scale (7.5'x7.5')

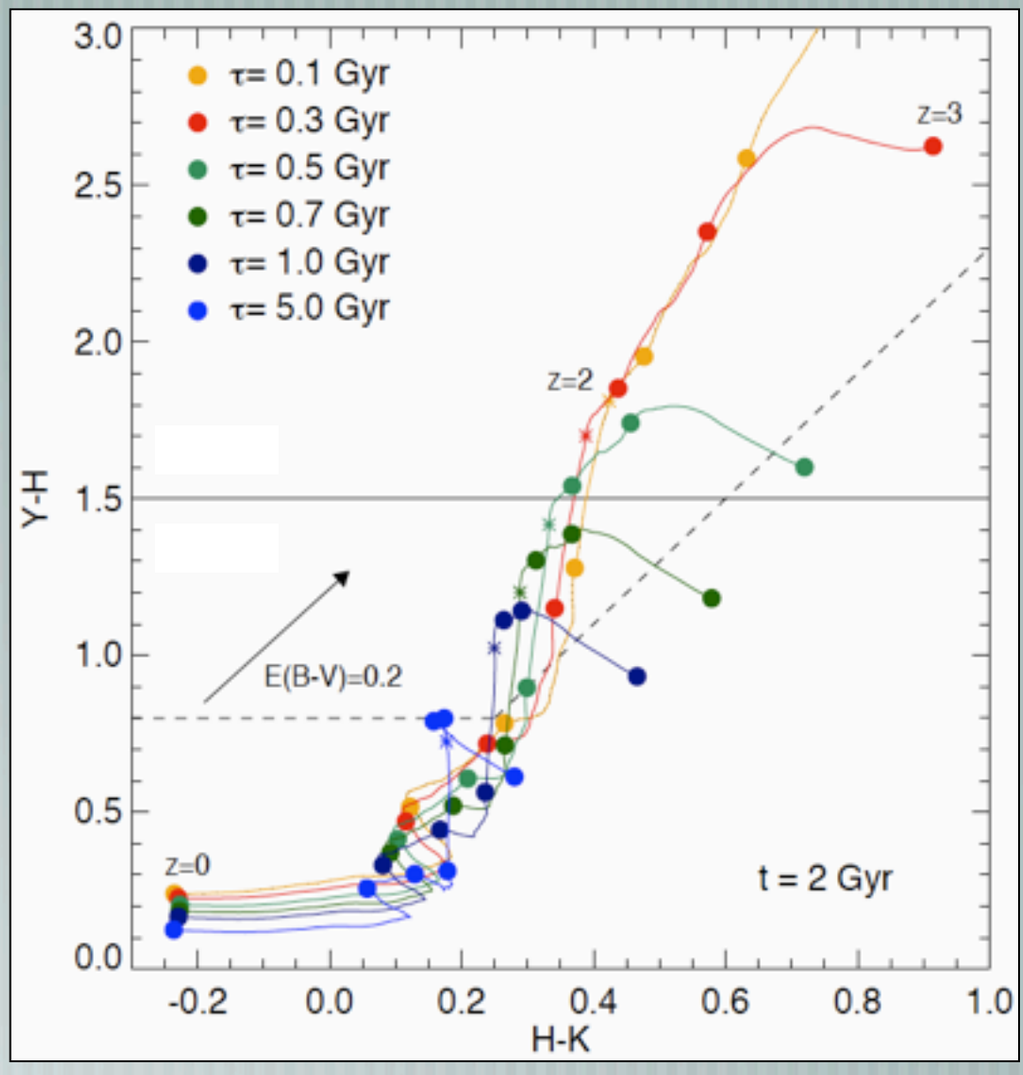
- Extraction of source catalogues
- Design of modified/new colour criteria
- Tests on colour criteria
- Selection of cluster member candidates
- Detection of overdensities / compare to large field surveys
- Color magnitude diagrams

Color criteria

redshift 1.5



redshift 2



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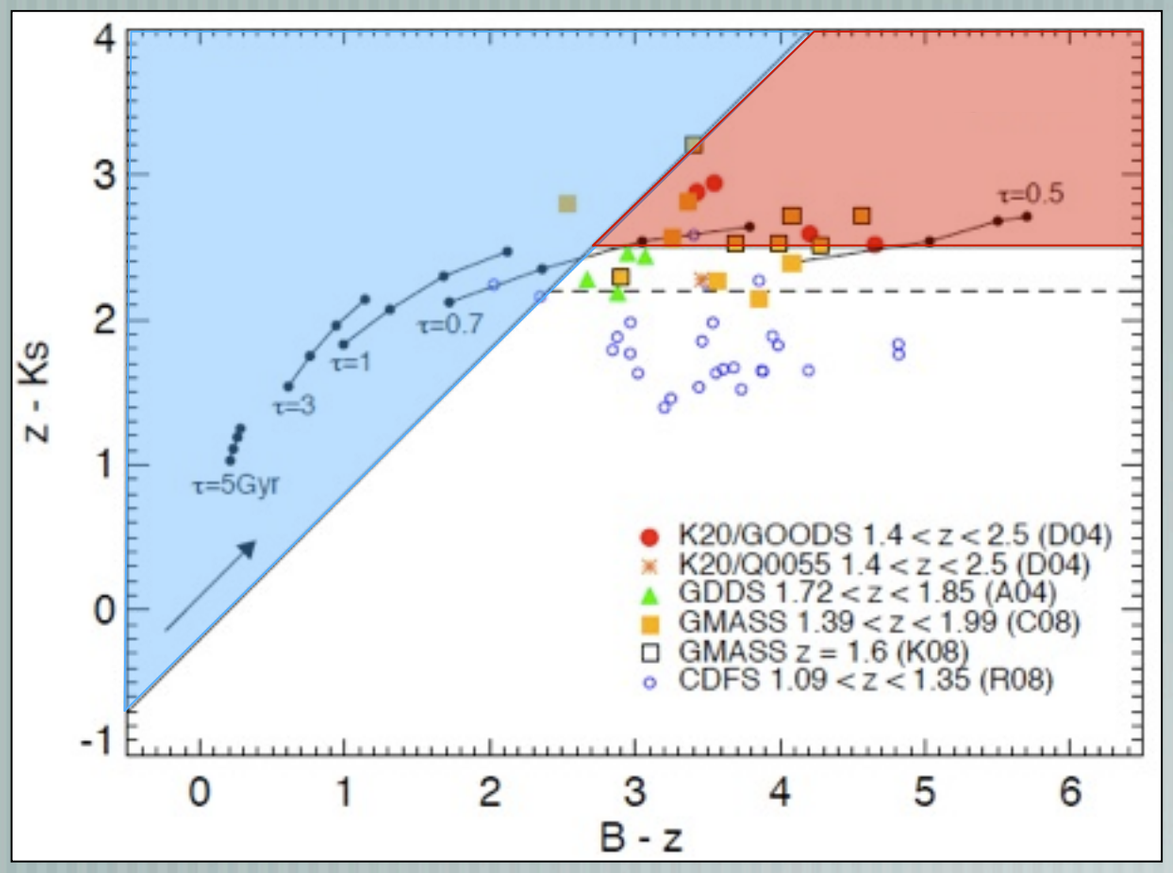
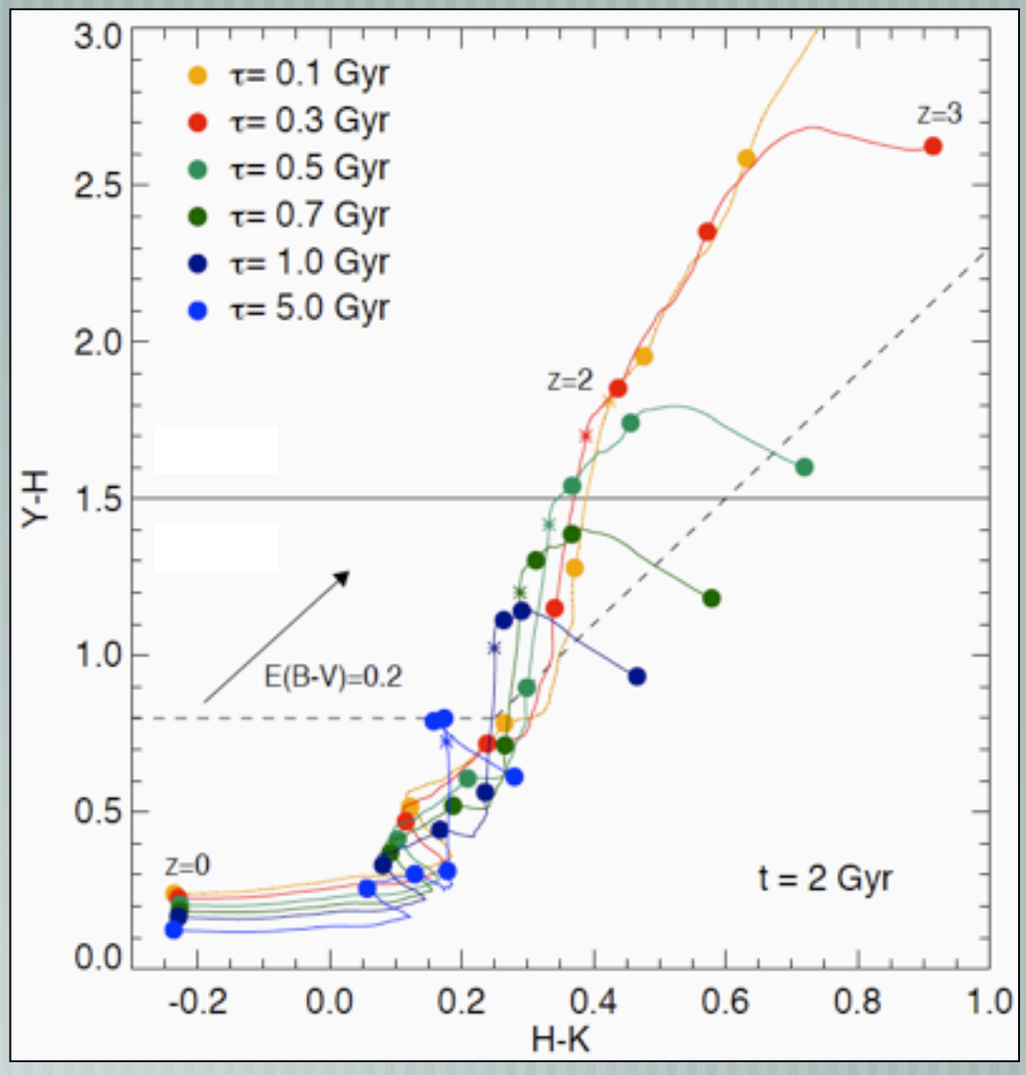


redshift 2



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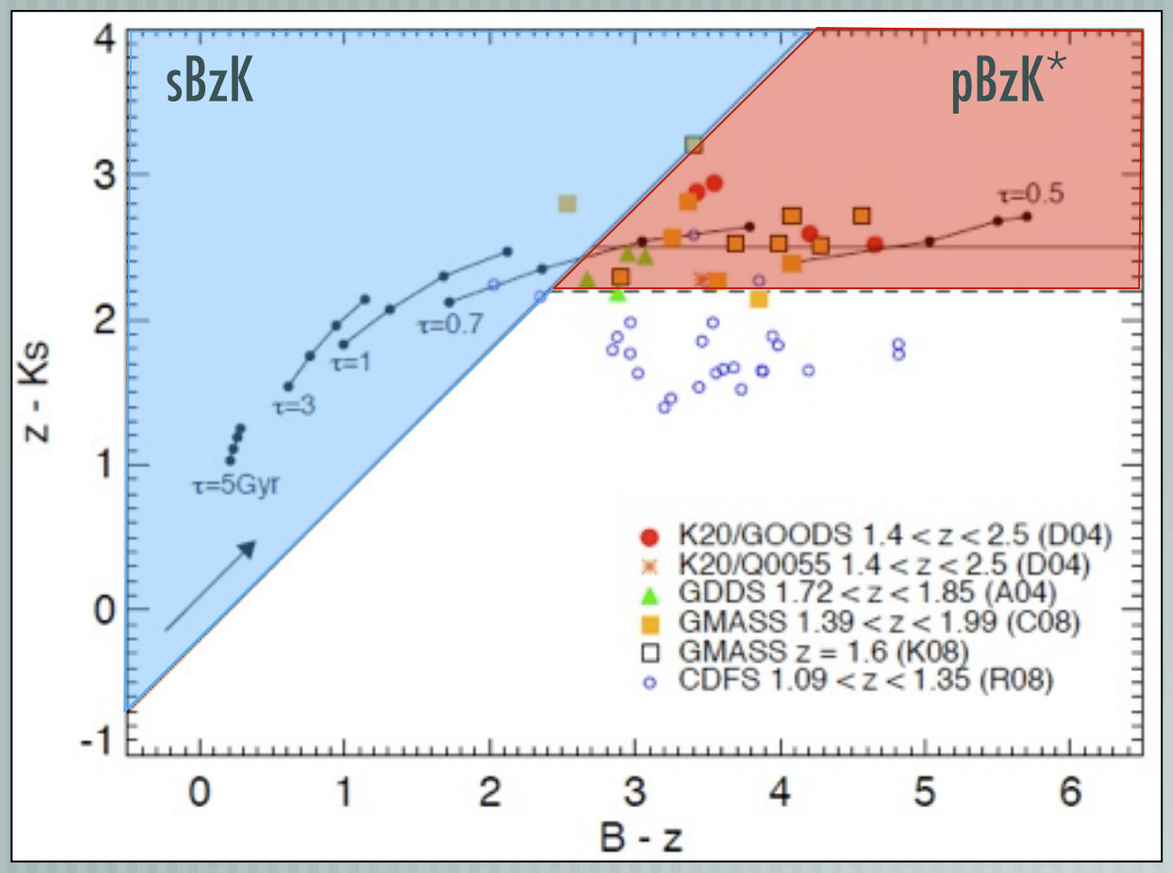

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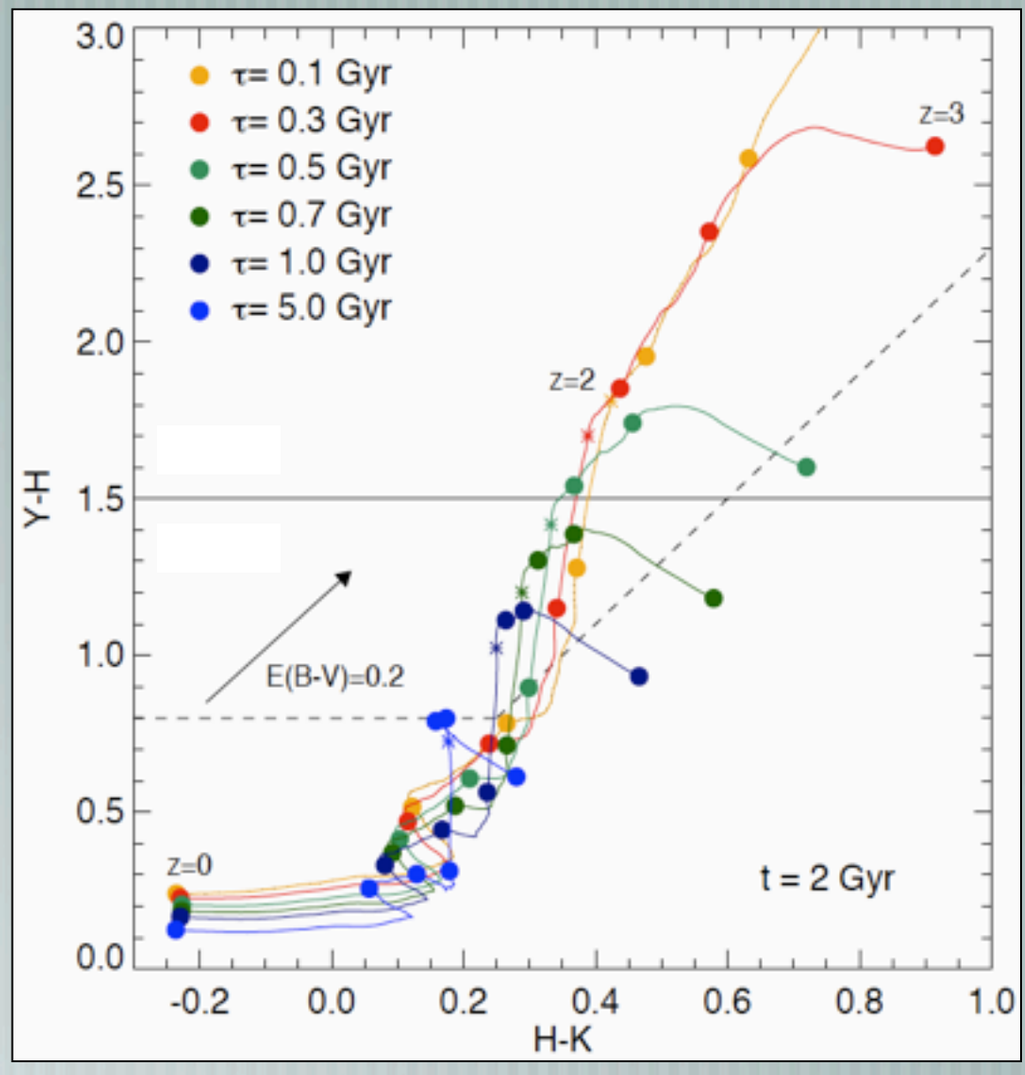

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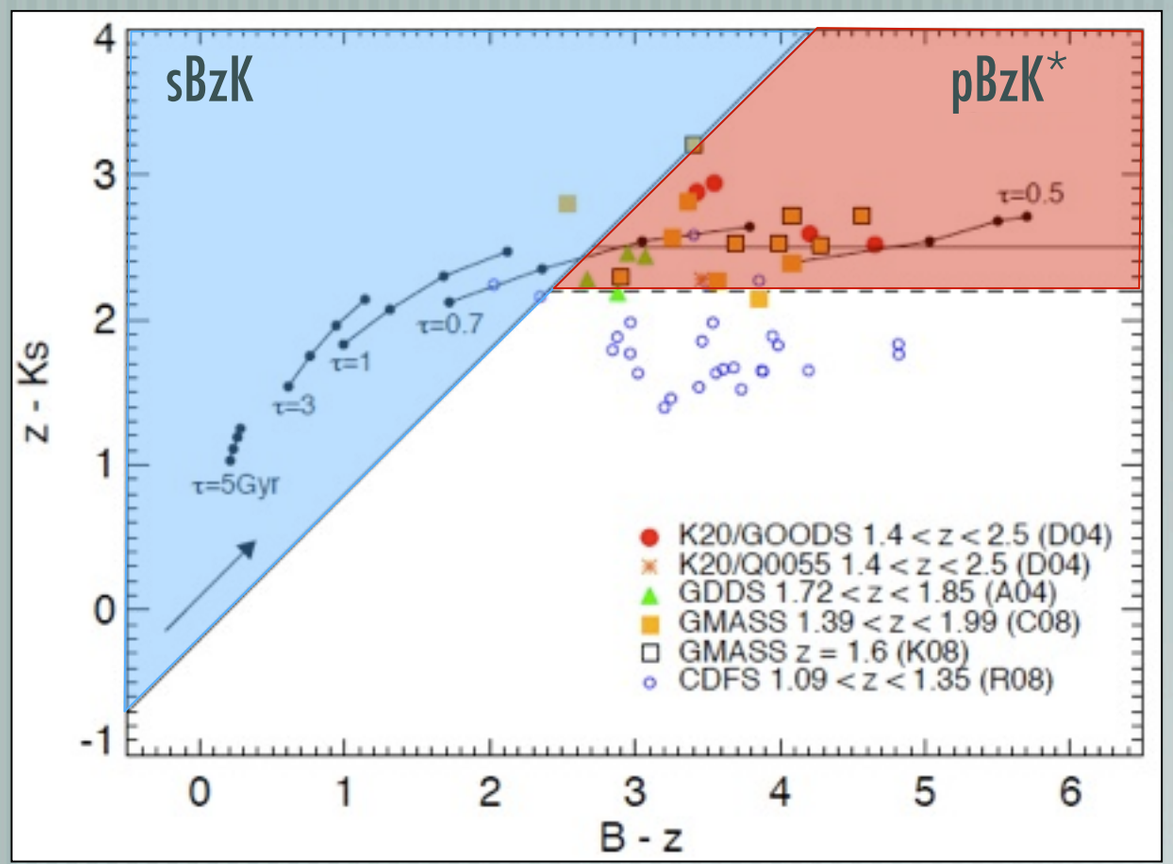

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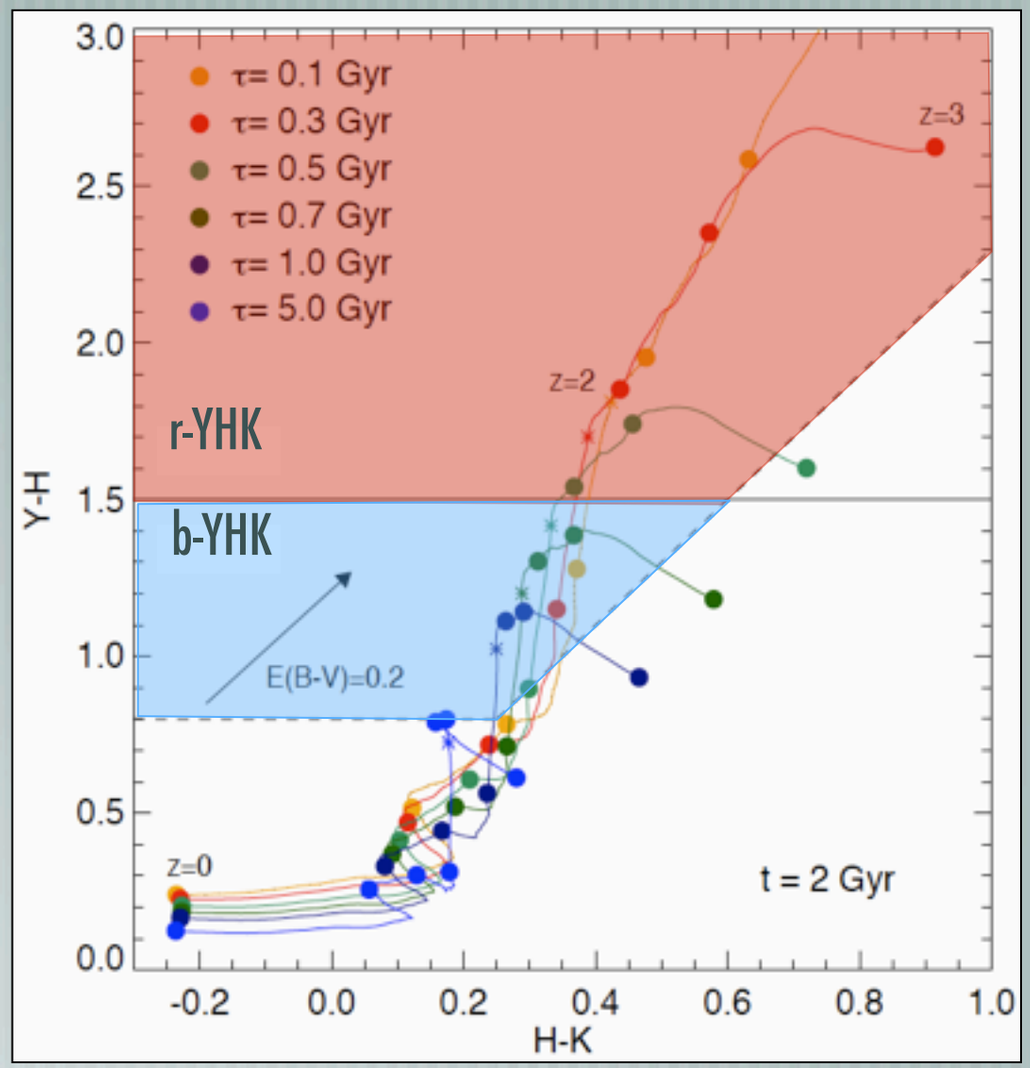

Overdensities?

redshift 1.5

Comparison with control fields

- GOODS-S field
  GOODS-MUSIC catalogue
  (Santini et al. 2009)

- MUSYC fields (Gawiser et al. 2006)
  4 fields
  ~1400 sq. arcmin

No overdensity around 7C1751+6809

7C1756 - overdense in red galaxies (factor 2)
- consistent in blue galaxies
- within 2′, overdense in red (factor 5)
and blue galaxies (factor 2)

Also an overdensity of mid-IR selected AGN

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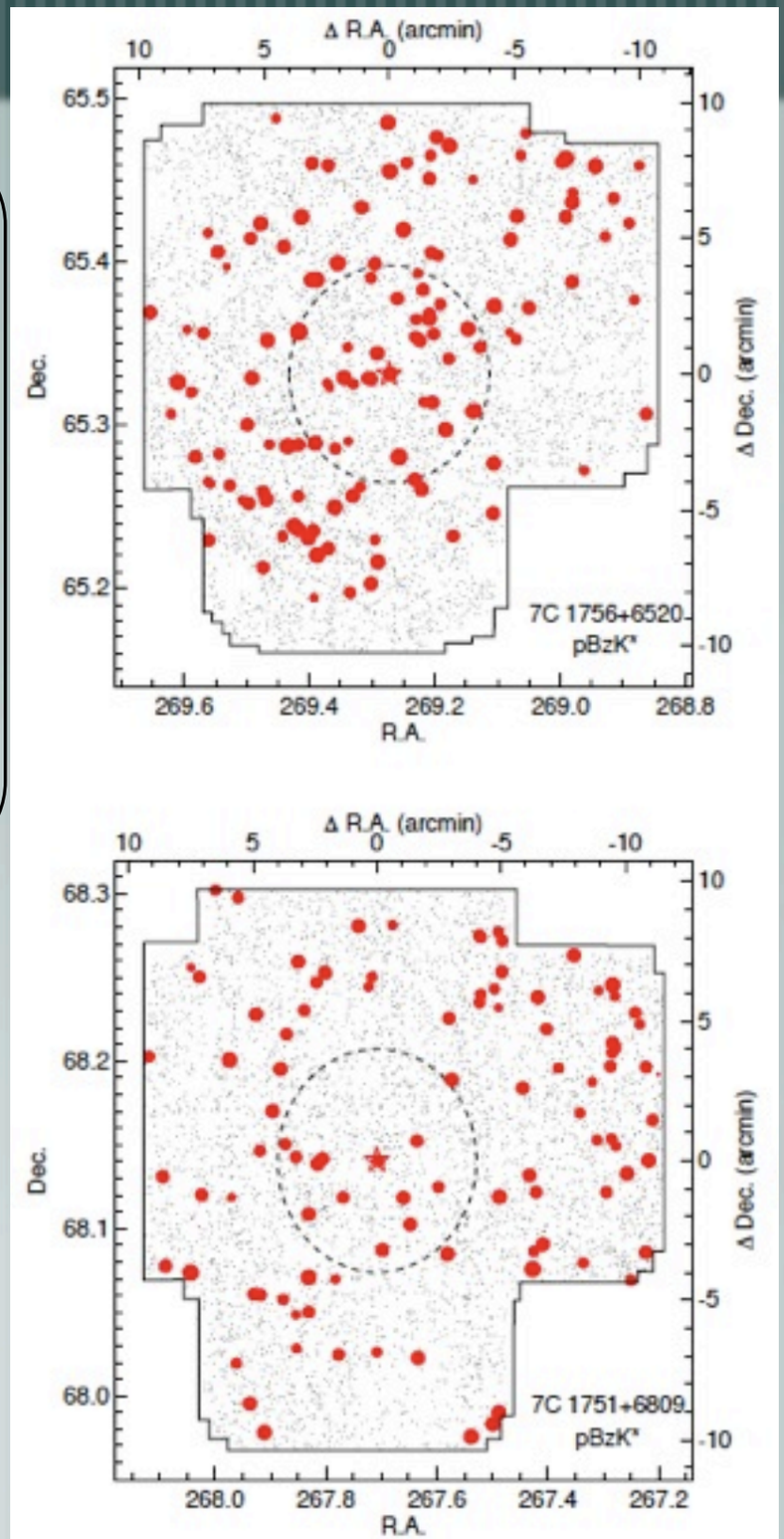

7C 1756

7C 1751

Overdensities?

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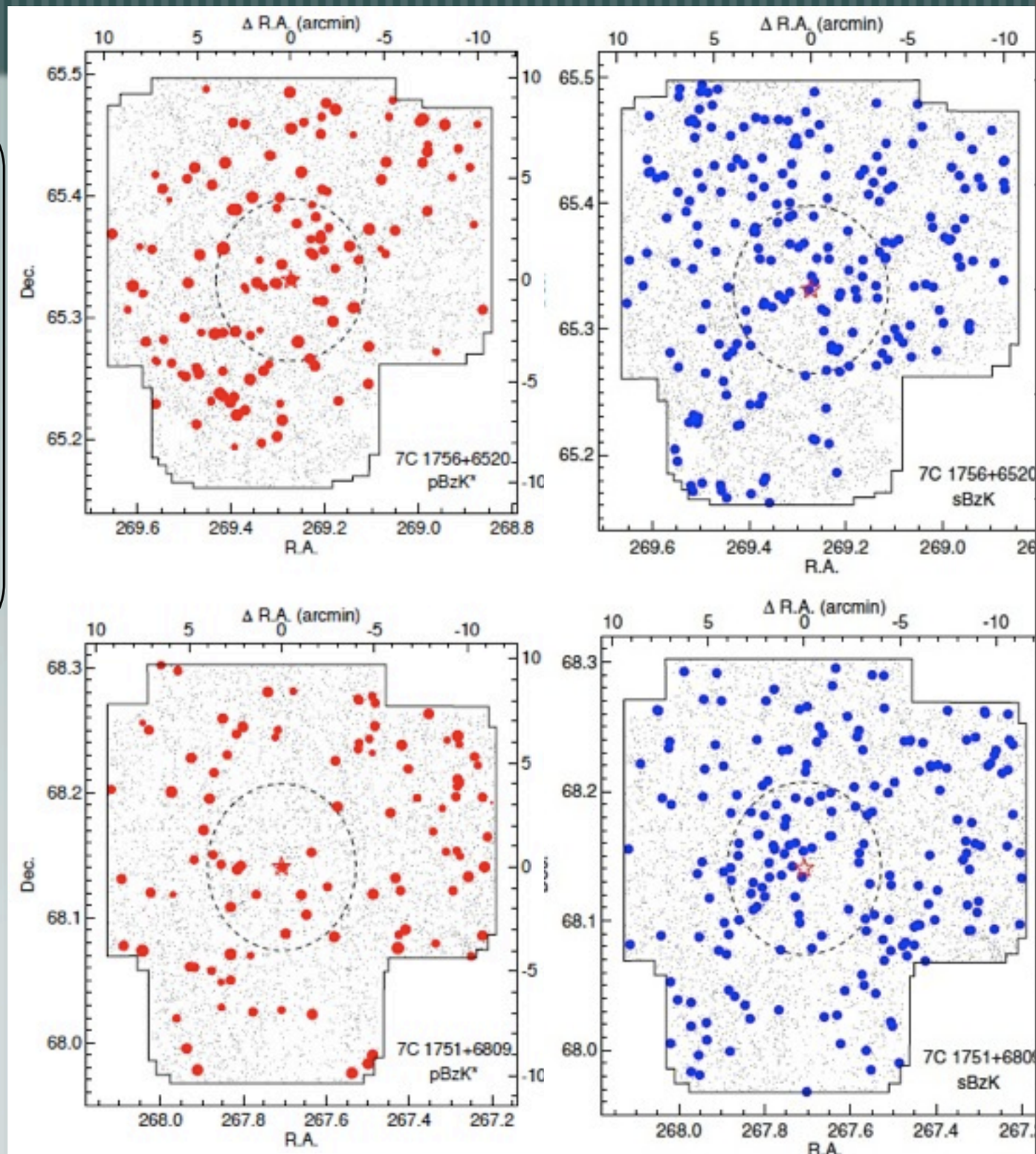


Overdensities?

redshift 2

Comparison with control fields

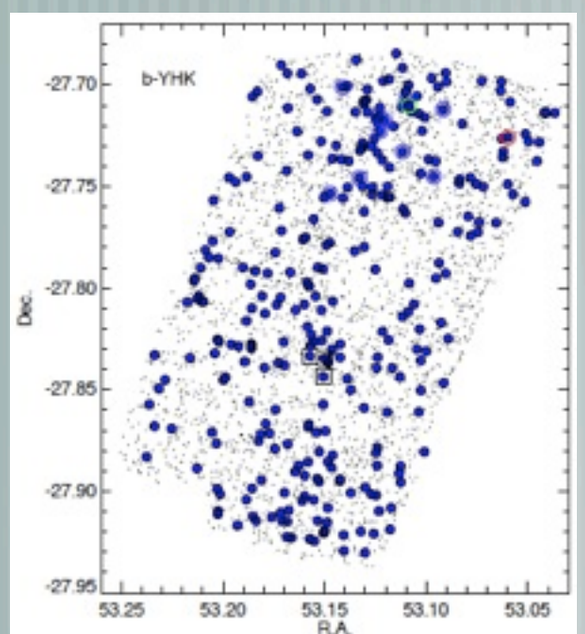
GOODS-S:

- 2 HAWK-I pointings

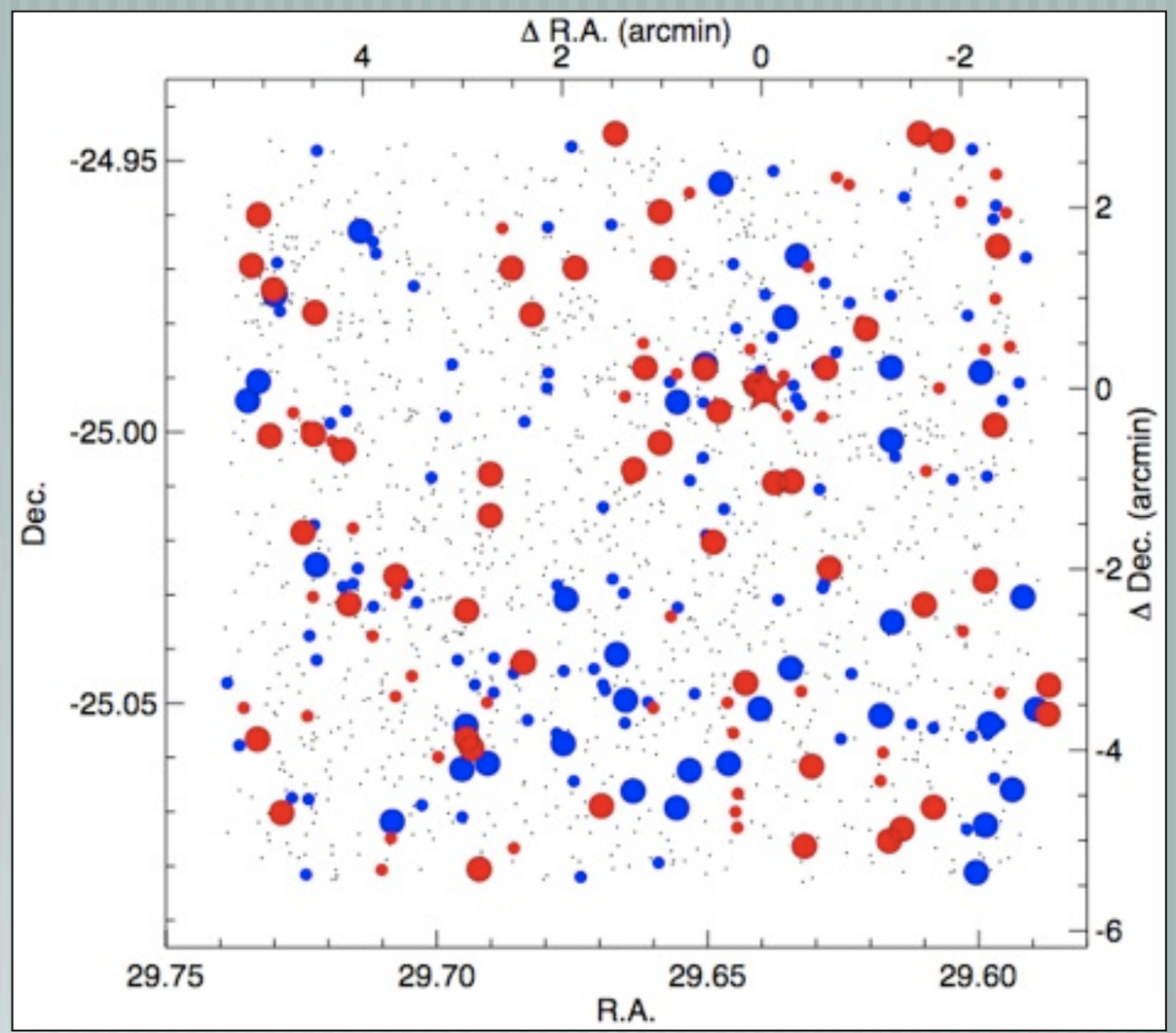
1 Control field:

- 1 HAWK-I pointing (CF)

A galaxy sheet at z=1.6 in GOODS-S



Cl 0332-2742
(z=1.61)
Kurk et al. 2009



Compact concentration of
both red and blue sources
within 1Mpc of MRC0156-252

Overdensities?

redshift 2

Comparison with control fields

GOODS-S:

- 2 HAWK-I pointings

1 Control field:

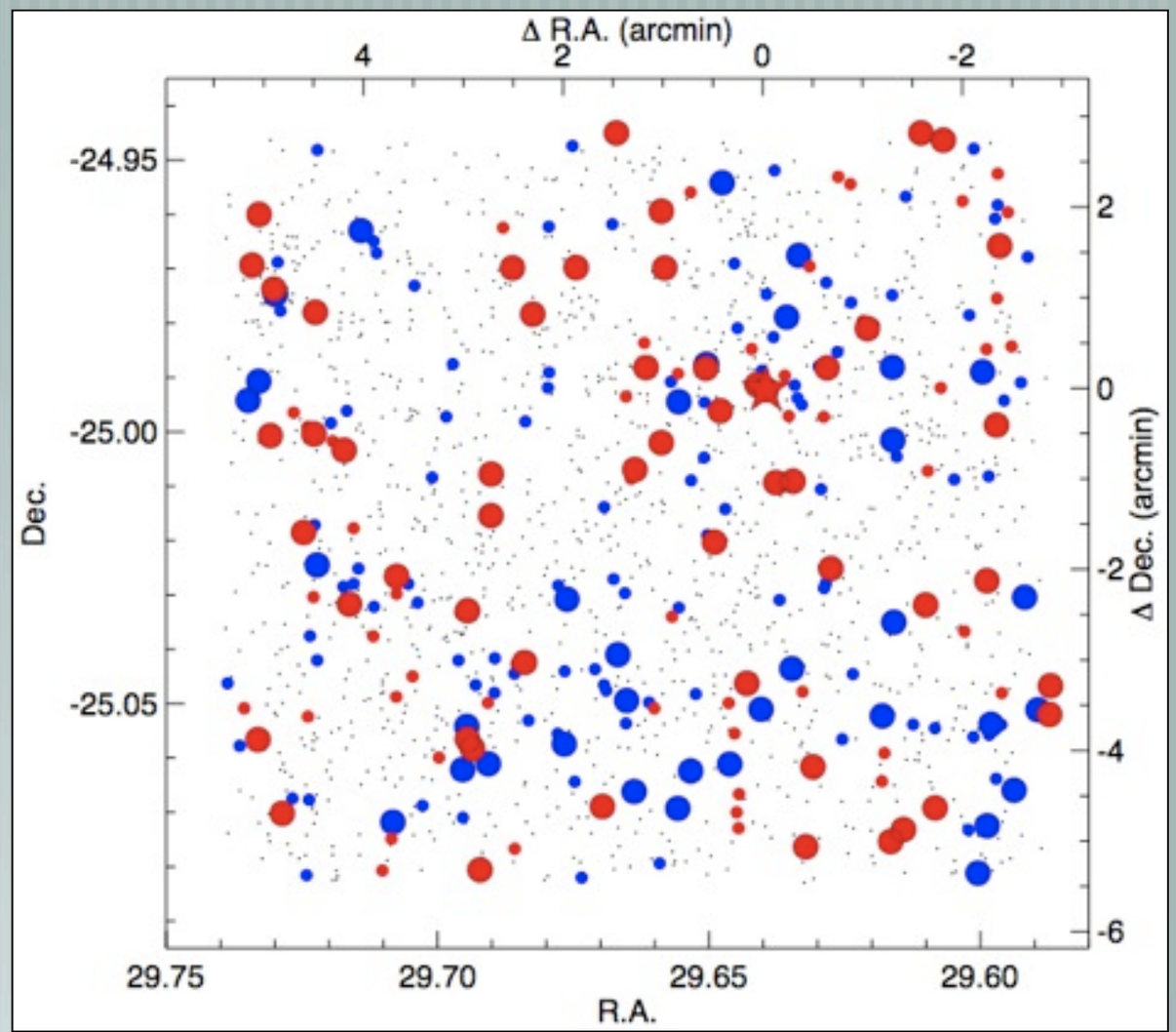
- 1 HAWK-I pointing (CF)

No overdensity around MRC1017-220

MRC0156-252 - densest field in red galaxies (x3.2 1017 and x1.6 GOODS-S)

- Even denser at z<2′ (x3.9 with 1017)

- slightly denser in blue galaxies (x1.5-2)



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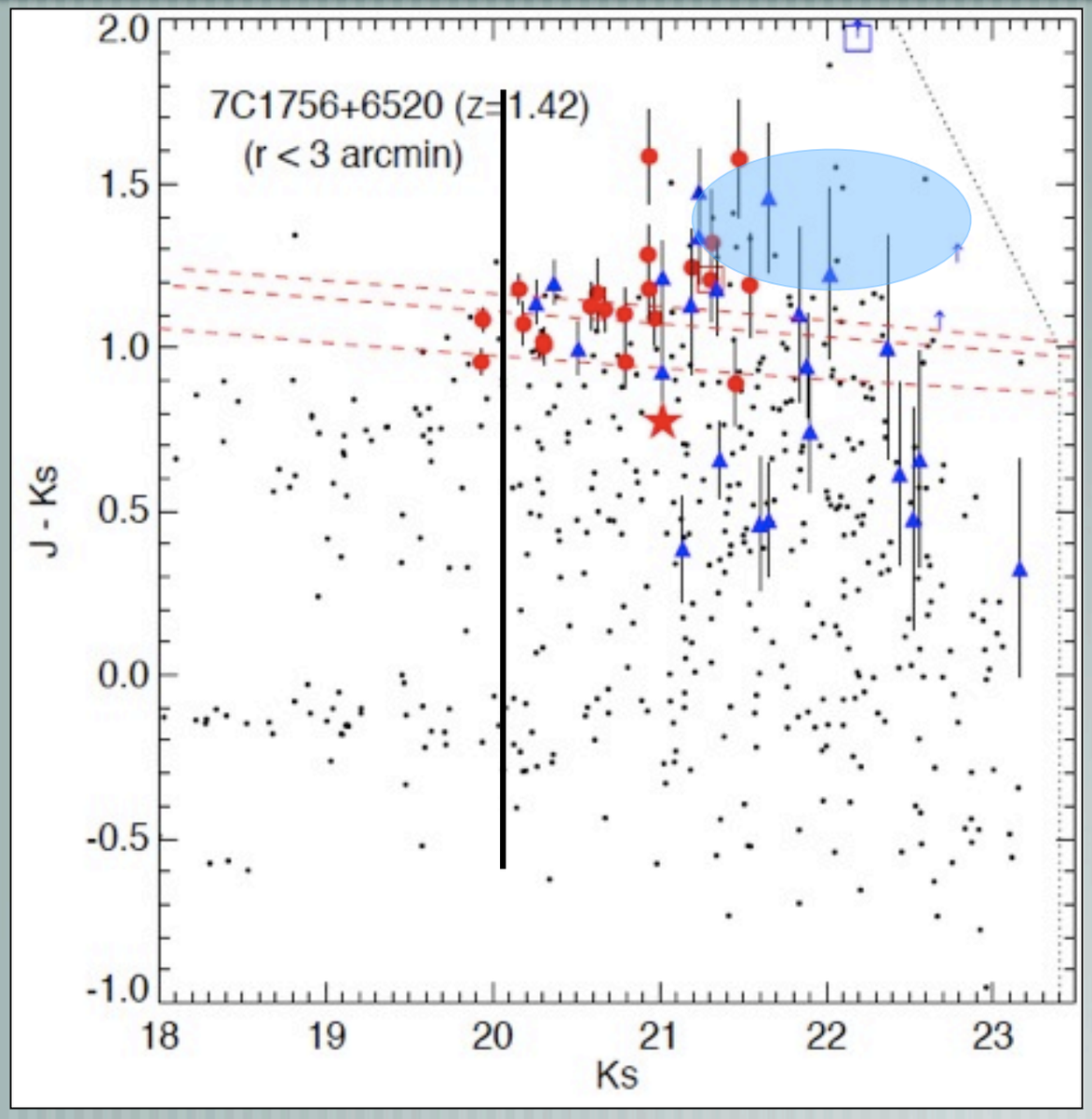
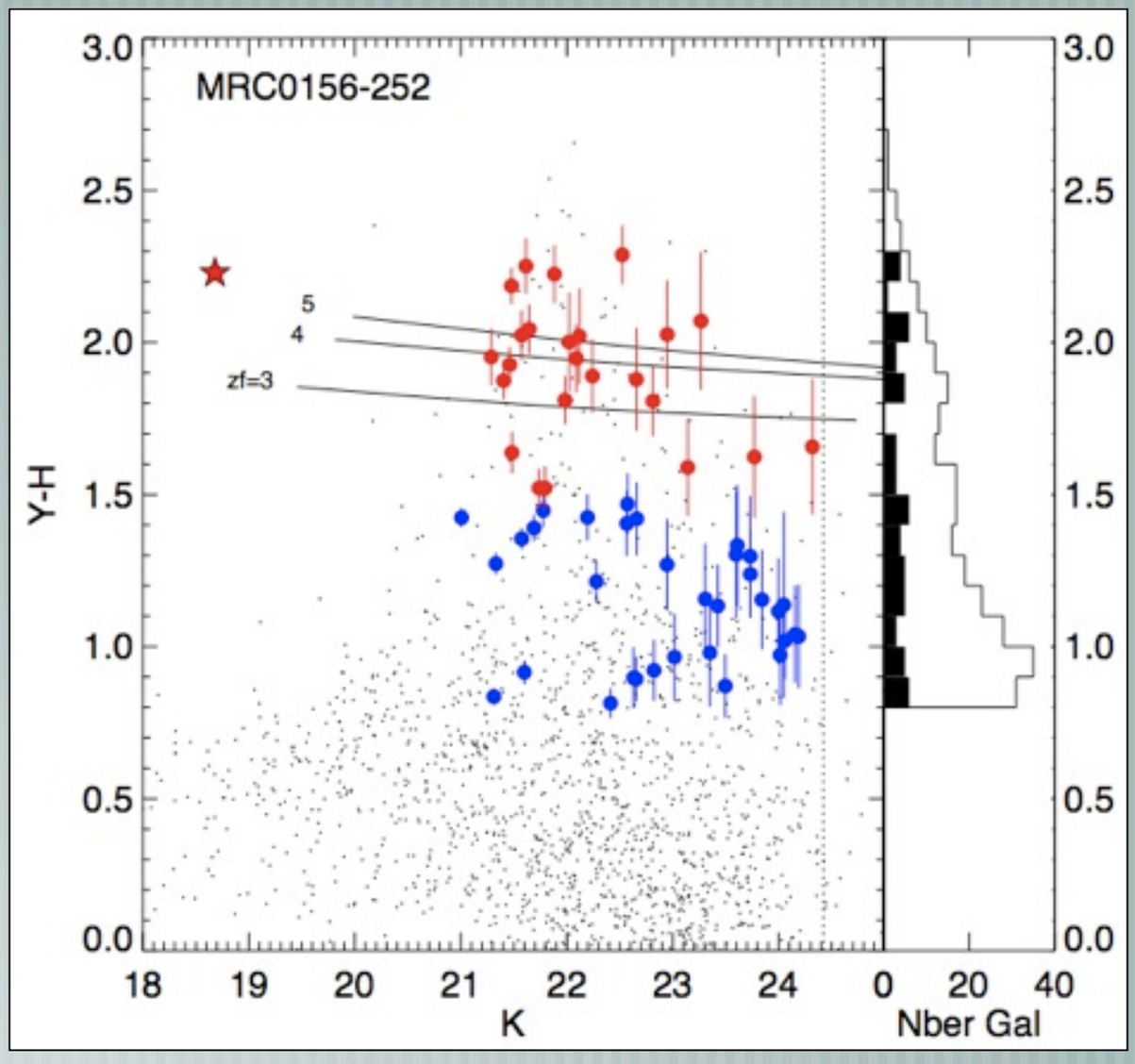
Color-magnitude diagrams

redshift 1.5



- Red galaxies colours consistent with red sequence models at zf>2
- Truncation at K_{AB}>21

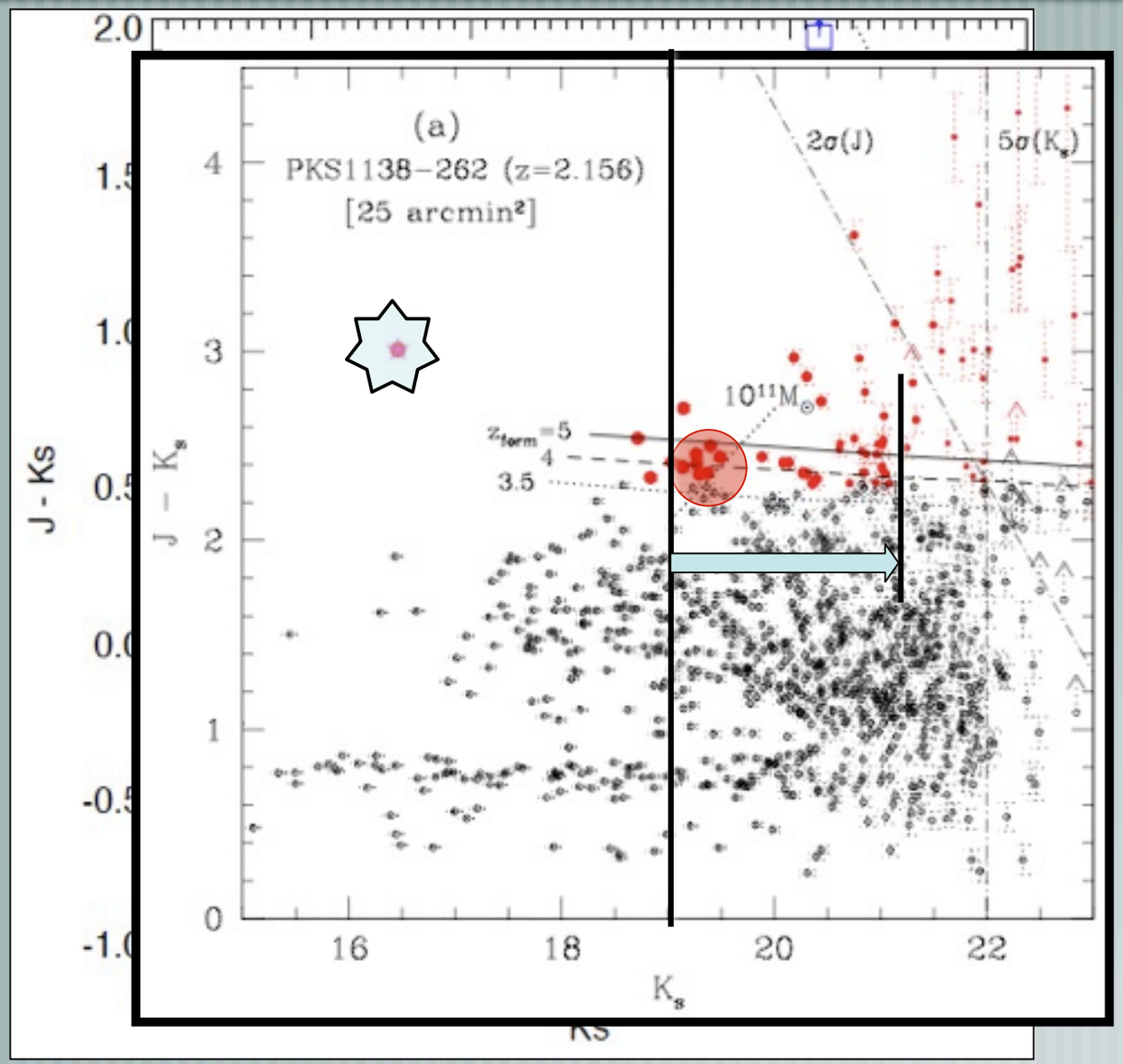
redshift 2



- Red galaxies colours consistent with red sequence models at zf>3
- Structure similar to PKS1138-262

Color-magnitude diagrams

redshift 1.5



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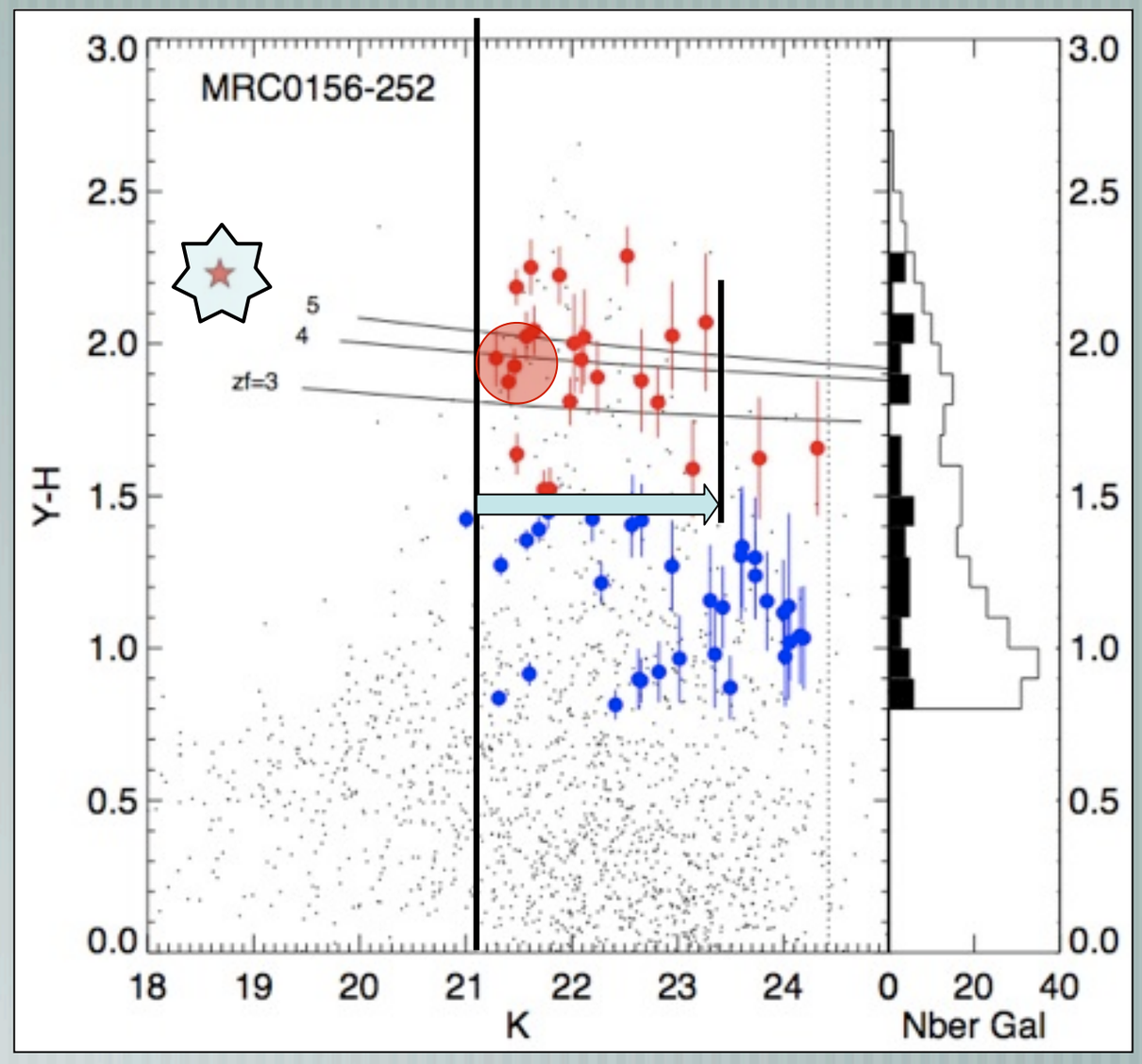

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Spectroscopic confirmation of a z=1.42 cluster

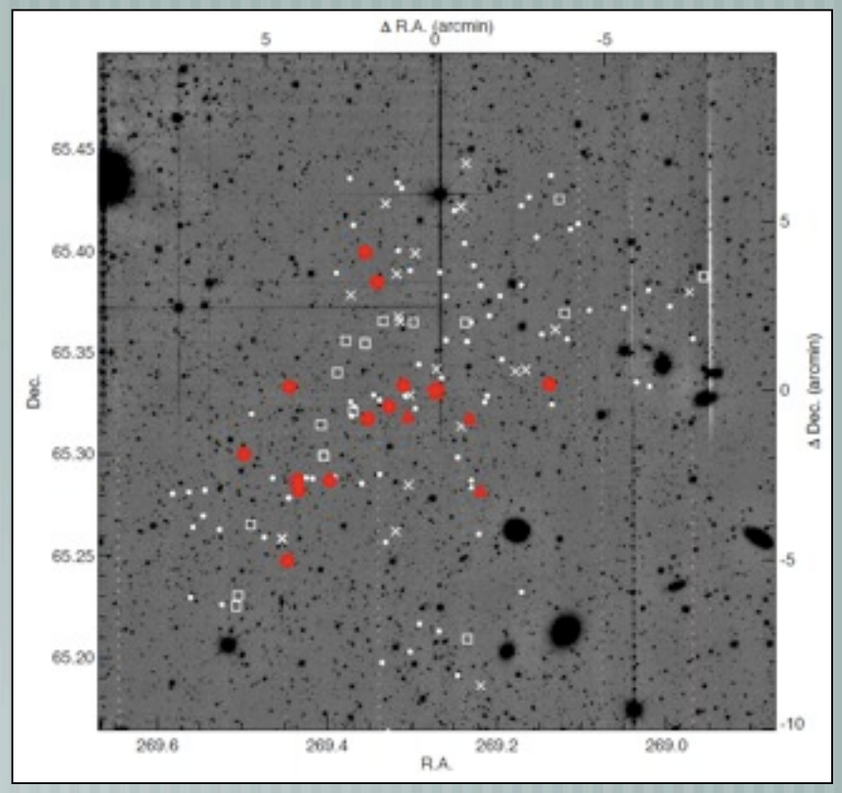
Galametz et al. 2010b

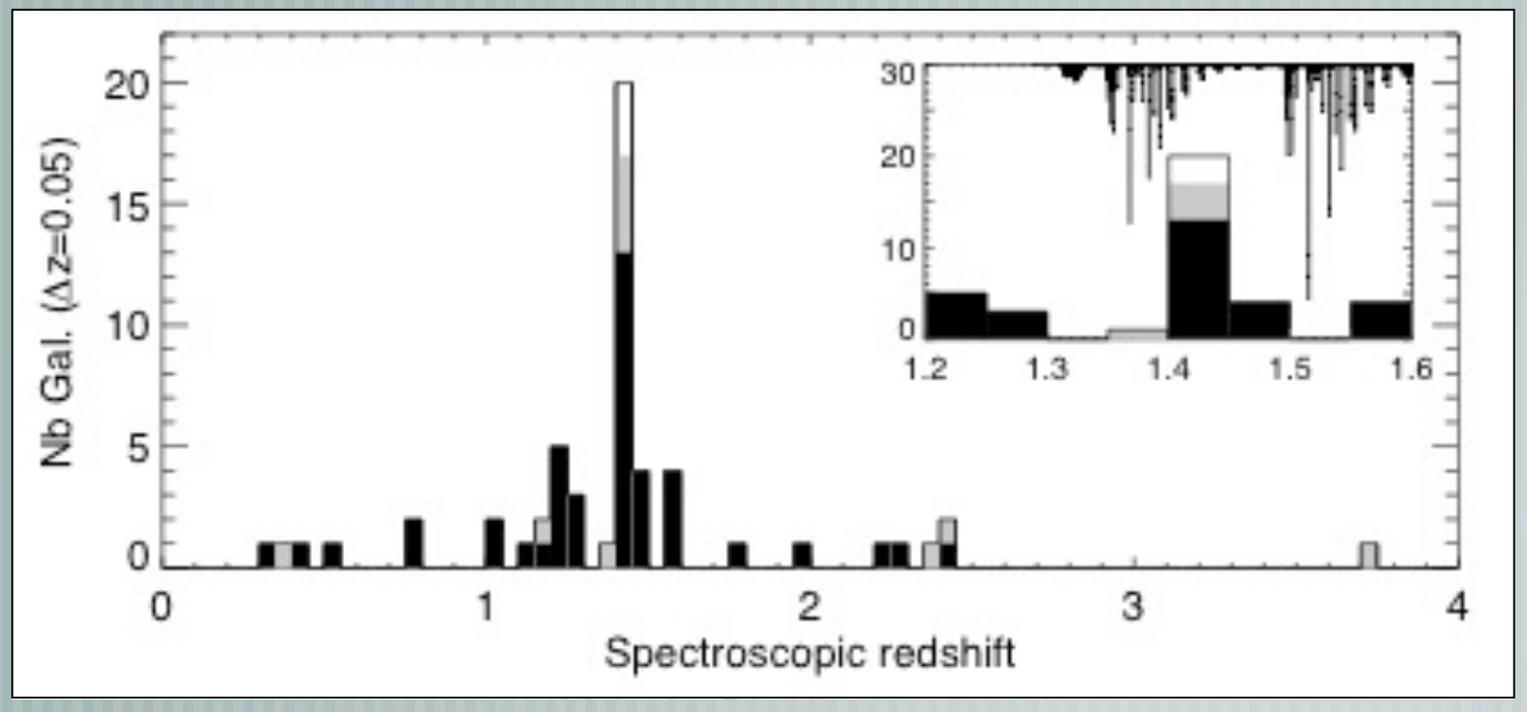
Follow-up of the overdensity around 7C1756+6520 with Keck/Deimos

- 129 BzK galaxies: 82 sBzK & 47 pBzK*
- 11 AGN candidates + 7C 1756+6520

Redshifts obtained for

- 36 sBzK
- 7 pBzK*
- 9 AGN + 7C 1756+6520 (z=1.4156)





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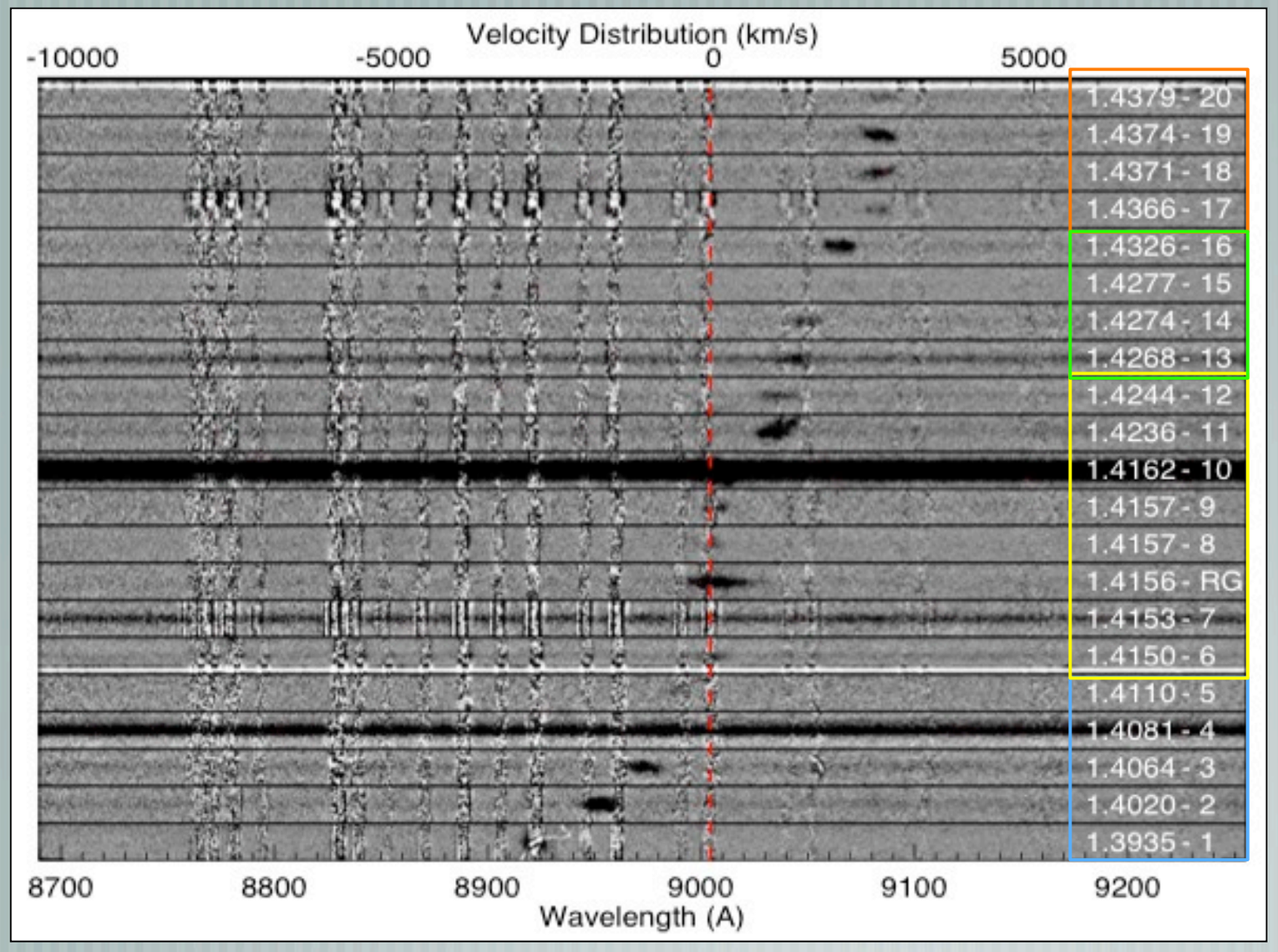
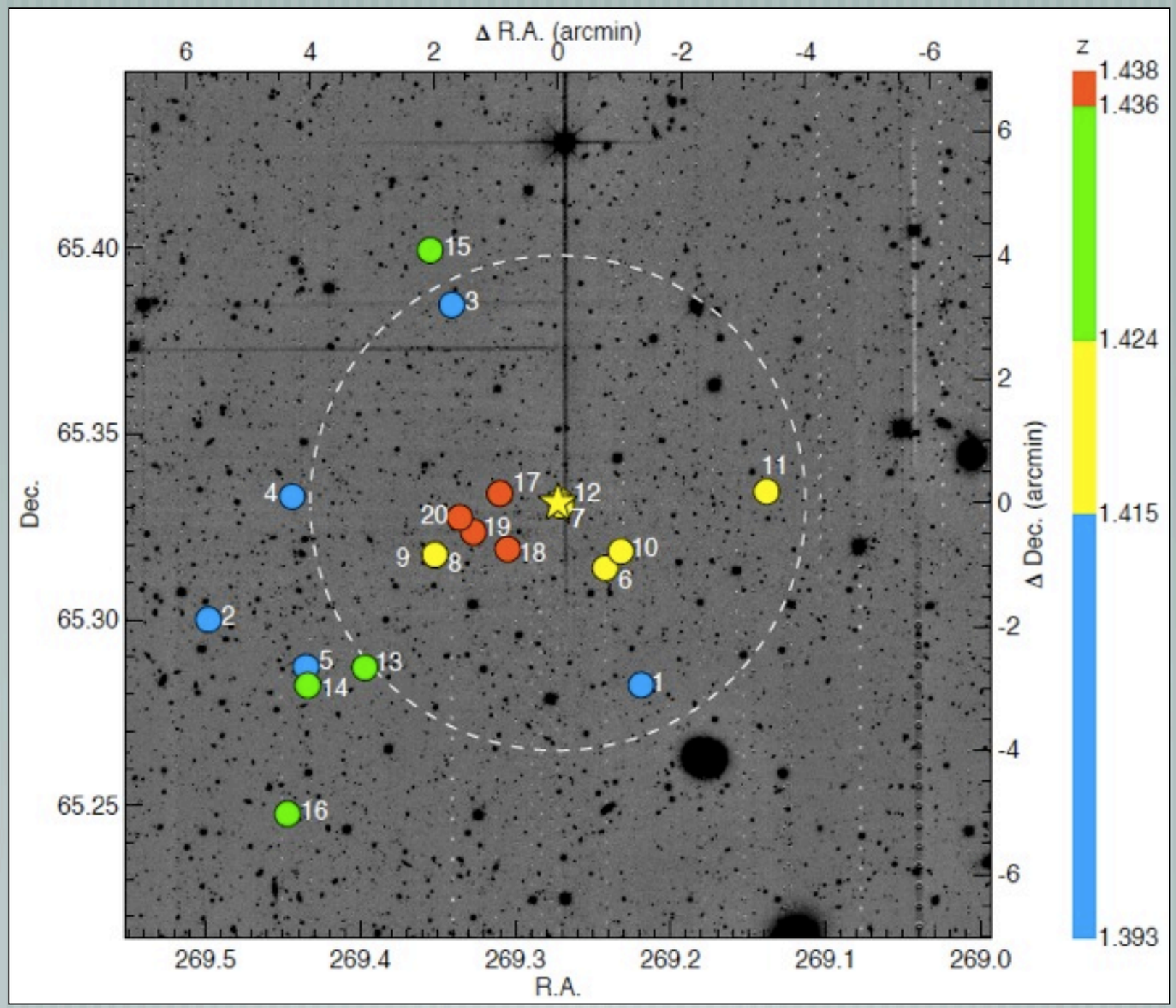


20 galaxies within $\Delta v < 3000$ km/s:

- 10 sBzK galaxies
- 3 pBzK galaxies
- 4 AGN
- 3 serendipitous

Spectroscopic confirmation of a z=1.42 cluster



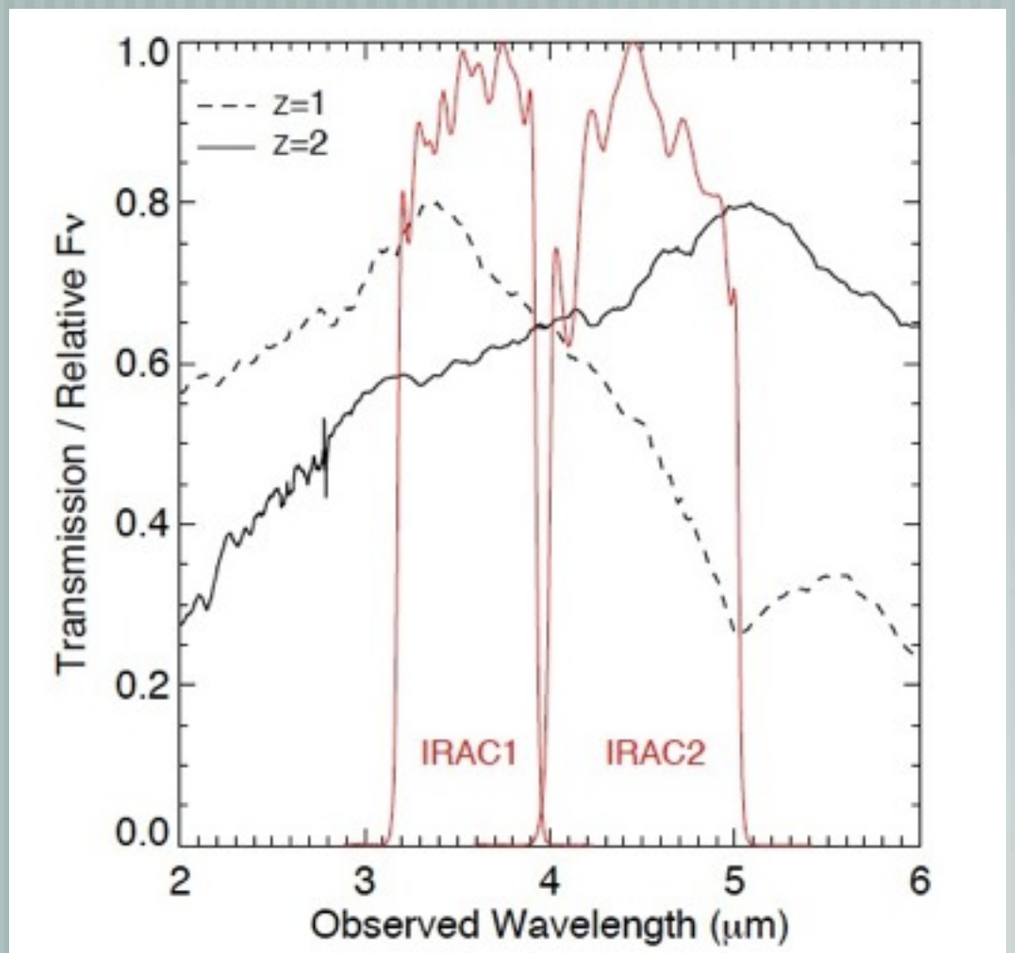
Now on the whole sample...

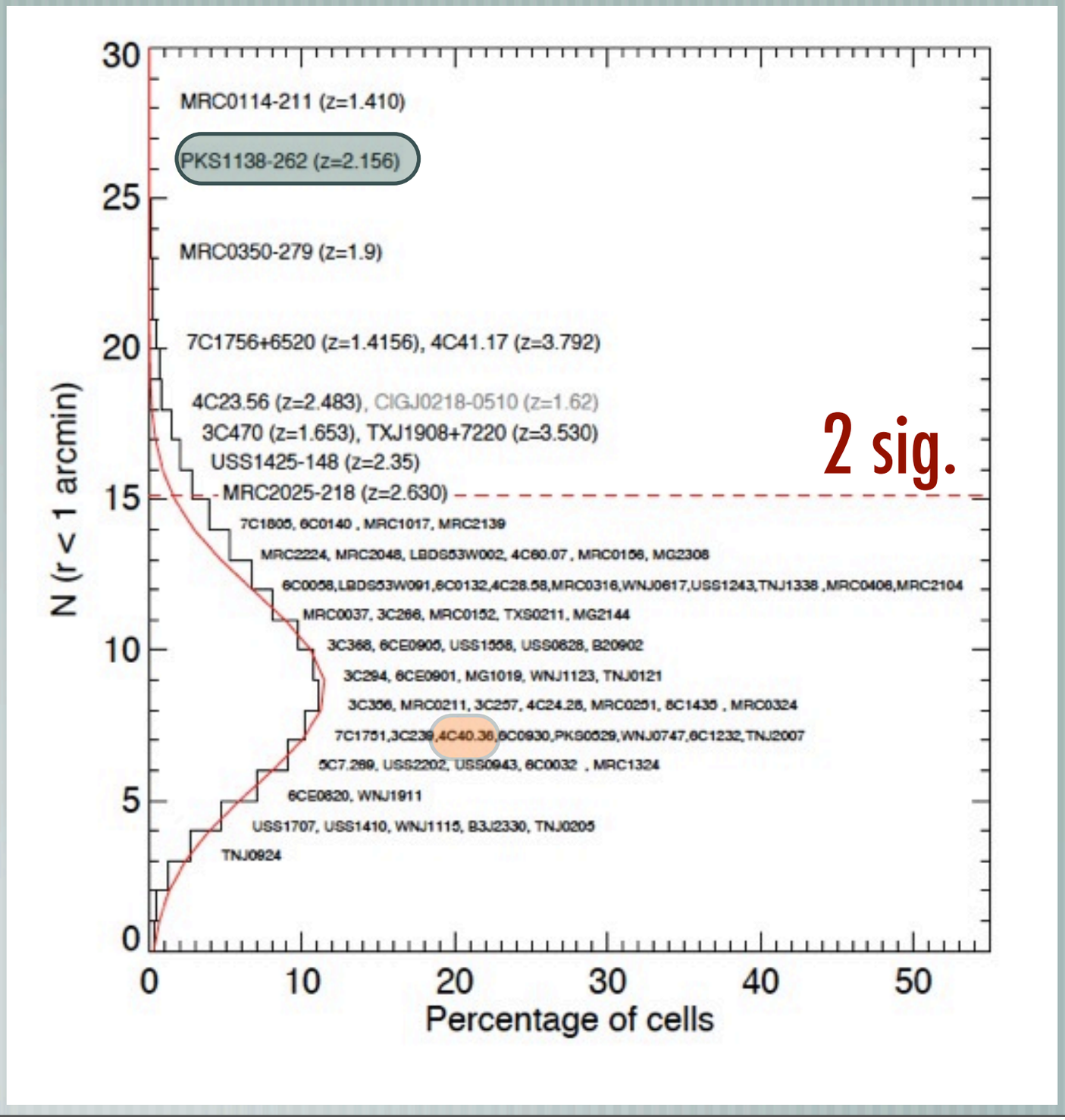
- Clear diversity. Some fields are overdense, others not...
- 2 studies on the whole sample:
  - IRAC Ch. 1 & 2
  - MIPS 24μm
- Comparison with SWIRE, shallow but a good match to our data
- Have a statistical measurement + identify good candidates

The passive neighborhood

Galametz et al., submitted to ApJ

3.6μm-4.5μm > -0.1
isolates galaxies at z>1



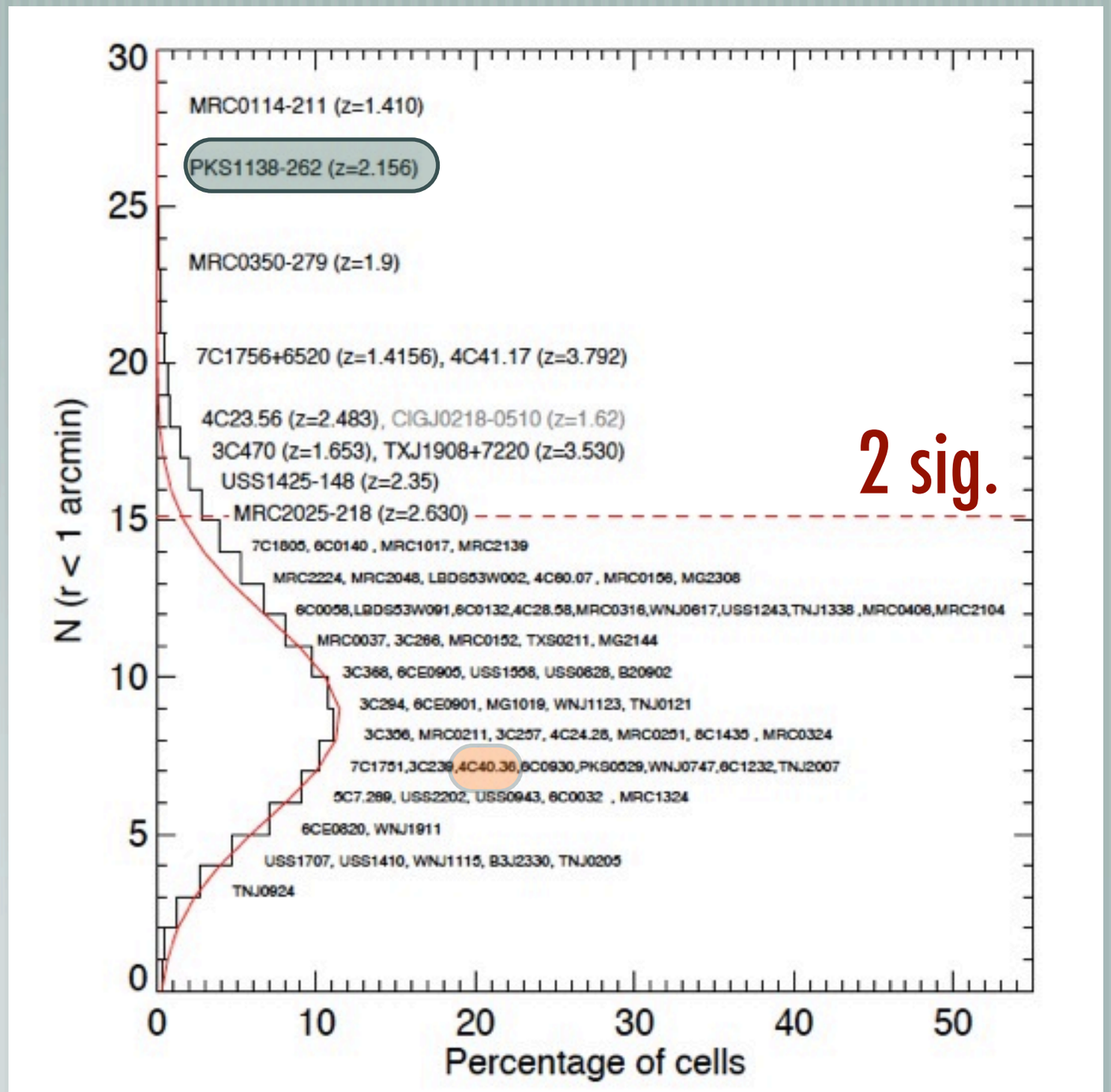


The passive neighborhood

Galametz et al., submitted to ApJ

3.6μm-4.5μm > -0.1
isolates galaxies at z>1

- Counts in cells
- Compare to wide area blank fields from SWIRE
- 11 fields > 2sig overdensity
- 6 of these were known overdensties, 5 new
- some targets with known overdensity of line emitters do not stand out here but...

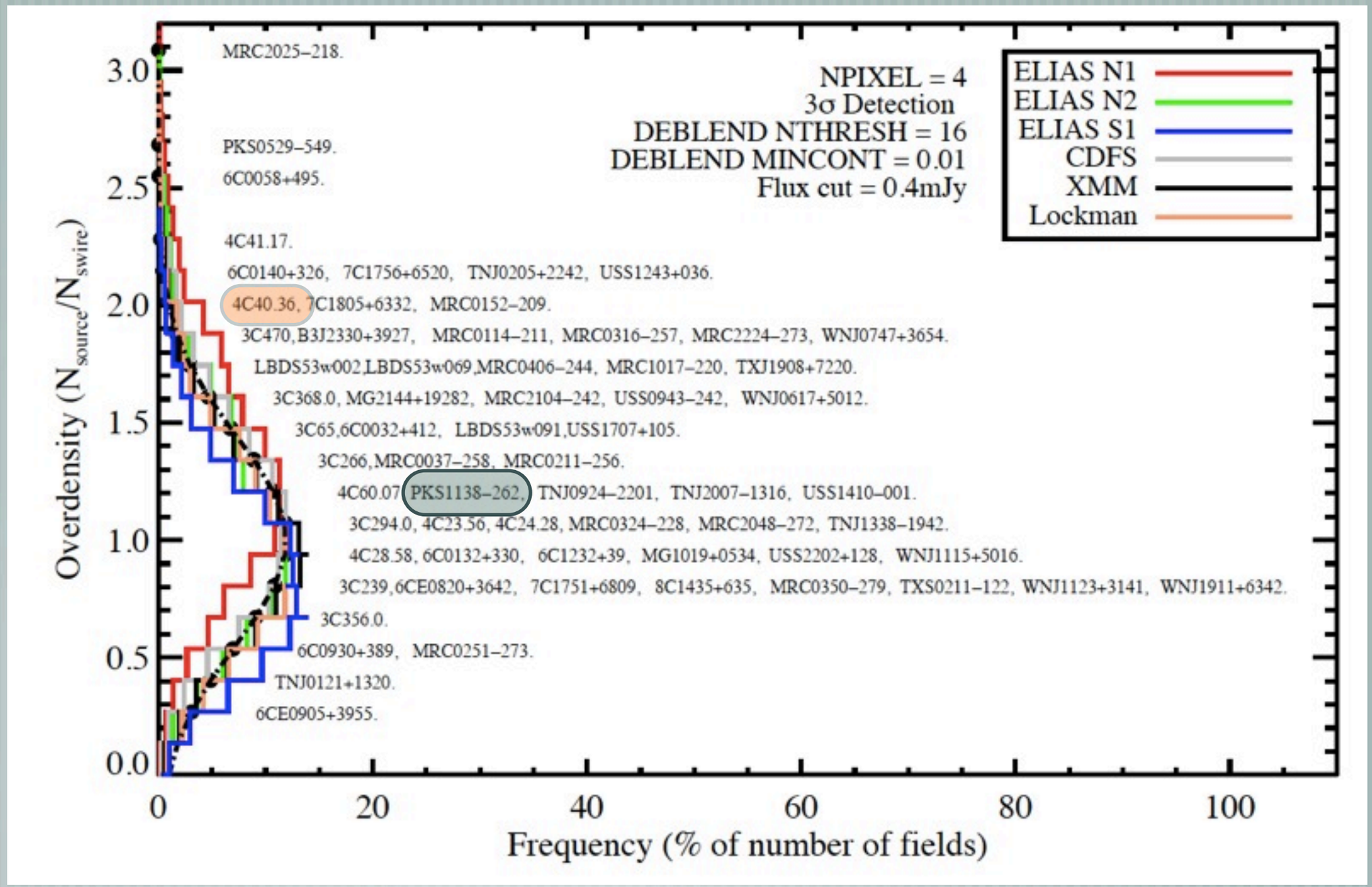


The active neighborhood

Mayo et al., in prep

At 24 μm
Active galaxies
SF with PAHs &
AGN thermal

- Cut to the same depth
- Count in 3′x3′cells
- Reference wide area blank fields from SWIRE



Conclusions

- RG in general live in denser than average environment
- But this environment is very diverse:
  - Example, 4c40.36 and PKS1138-262, about the same redshift (same selection effects), one is overdense in active objects, the other in passive ones
  - An indication for some weak correlation with radio power (higher density of passive galaxies around more powerful galaxies)
- Any difference between Radio loud and radio quiet AGN neighborhood (CARLA project)?