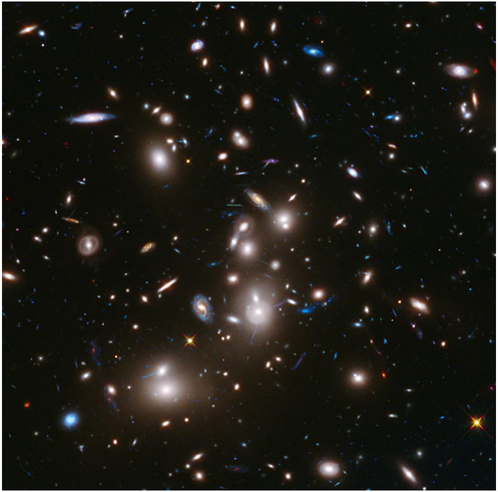
Spitzer analysis of z>2 proto-clusters candidates found by Planck and Herschel.

Clément Martinache

Under the supervision of Pr. Hervé Dole

Why study galaxy clusters ?

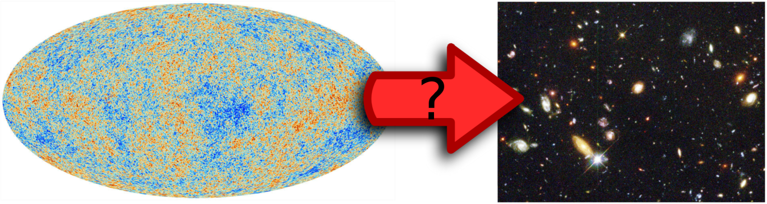


The galaxy cluster Abell 2744

The large scale structure of the Universe

Question :

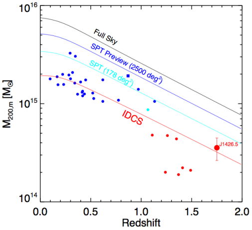
How did structures form in the Universe ?



What galaxy clusters can tell us : The cosmological perspective.

Clusters as cosmics informants.

- Probe of the cosmic matter distribution at the largest scales.
- Constraints on cosmic parameters (e.g. Ω_m, σ_8) through their statistics.



Most massive object allowed by theory. Mortonson (2010) One case could disprove ΛCDM.

Clusters of galaxies : laboratories for galaxy evolution

- Galaxies in clusters evolve differently from field galaxies.
- According to hierachical model, they assemble their mass at $z \sim 2$: Galaxies inside the clusters are supposed to experience quick and intense phase of star formation as they fall inside the potential. During this phase, we refer to the system as a proto-cluster.
- But never seen yet (Almost... e.g [Clements 2013], [Rigby 2013]). Rare objects difficult to find (10^{-2}deg^{-2})

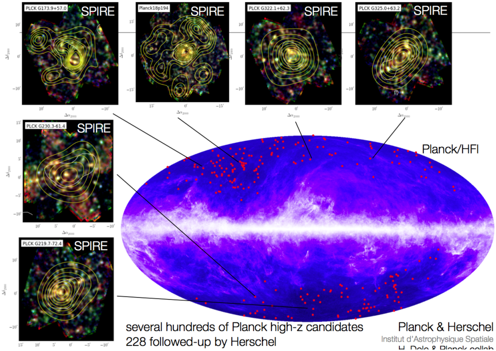
Previous studies

- Previous studies have often targeted components associated with mature clusters (AGN [Wylezalek 2013], X-Ray emission). Although some are found at $z > 1.5$ [Gobat 2011], mass assembly is over.
- Some studies [Papovich 2008] [Rettura 2014] used a color selection to search for proto-clusters (More on this later...) Large surveys but not all-sky.
- Our approach : target star formation !

Planck and Herschel : A new window on clusters

A Unique dataset

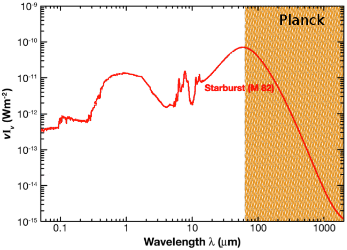
- All sky survey : target excess emission at 545 GHz (CIB Fluctuations)
- Overdensities ? Lensed sources ?
- A few 100s Planck high-z candidates → 228 Herschel fields → 40 Spitzer fields.



Planck and Herschel : A new window on clusters

But...

- 4.5 arcmin beam .
-



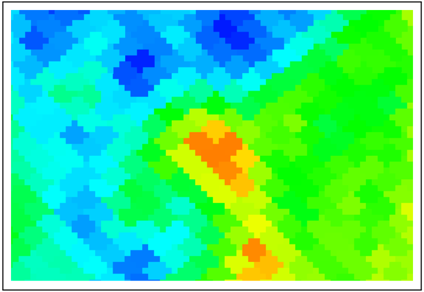
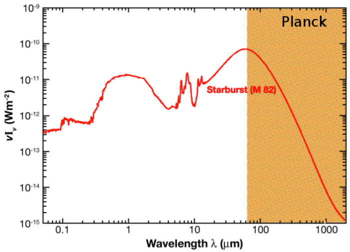


Image Planck HFI (350μm).
30 arcmin $\times$ 30 arcmin.

Planck and Herschel : A new window on clusters

But...

- 4.5 arcmin beam $\Rightarrow$ Herschel follow up($\times$11)
-



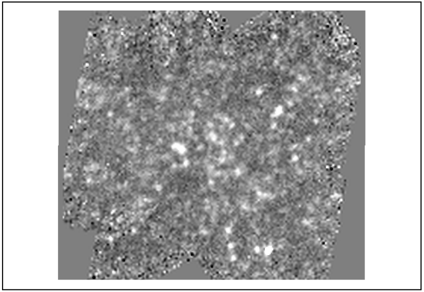
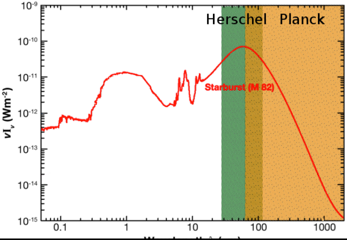


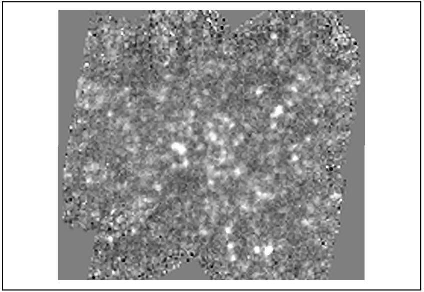
Image SPIRE (350μm).
30 arcmin $\times$ 30 arcmin.

Planck and Herschel : A new window on clusters

But...

- 25 arcseconds beam.
- SPIRE gives access to the peak of FIR emission → SFR. (Kennicut 1998)





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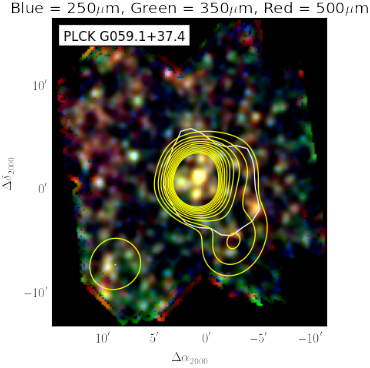
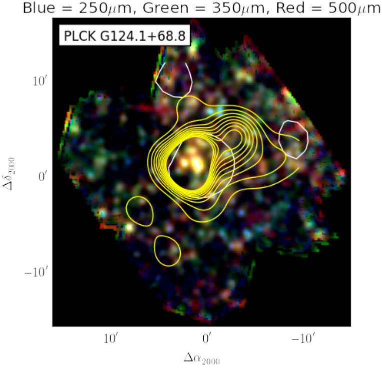
SPIRE Results

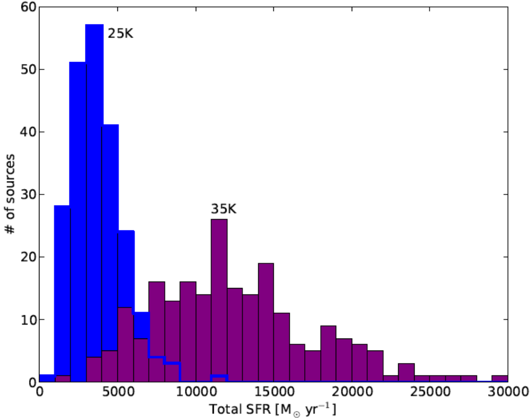
Overdensities of red sources.





SPIRE Results

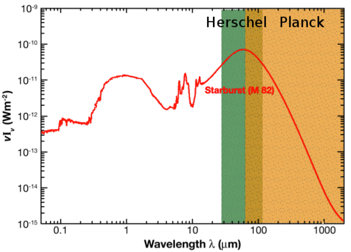
High SFR in Planck Source. Planck Collaboration XXVII, 2014, PIP, submitted to A&A,

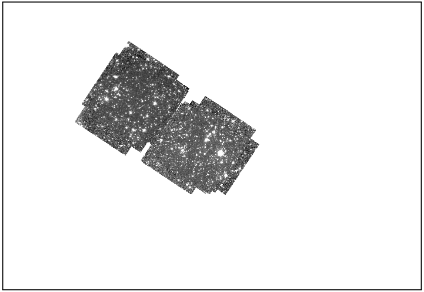


The need for a Spitzer analysis

Spitzer/IRAC (3.6μm, 4.5μm)

- Resolution improved again ($\times$ 14).
- Sensitive to the 1.6μm peak $\rightarrow$ stellar masses.
- Color is a good indicator of redshift.





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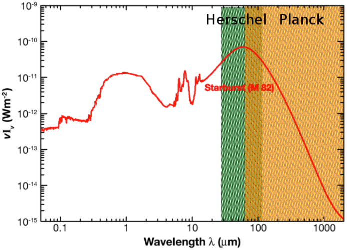

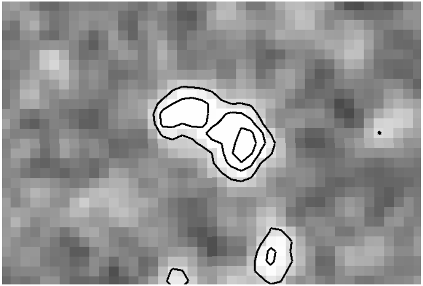

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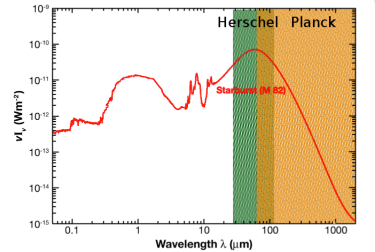

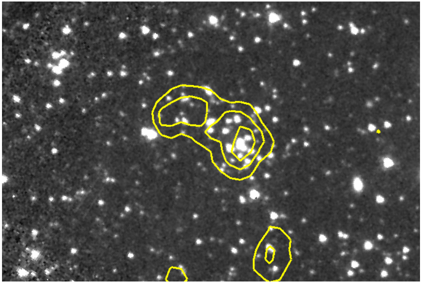

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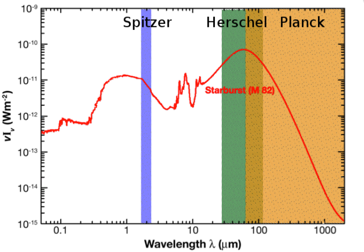

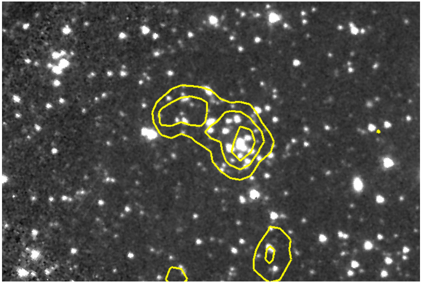

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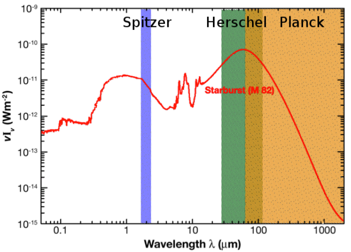
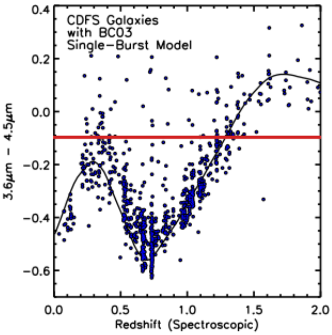
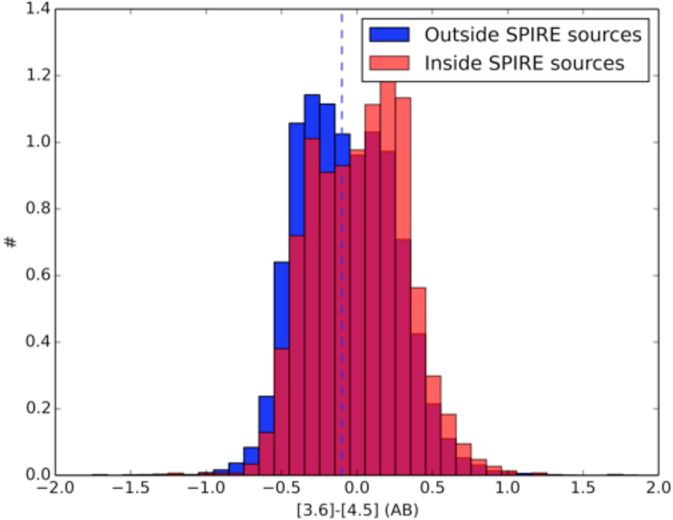




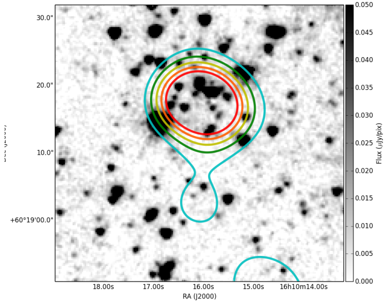
Muzzin+14.
$[3.6] - [4.5] > -0.1$ selects $z > 1.3$ galaxies.

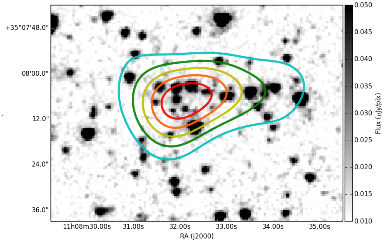
SPIRE sources are redder in IRAC



Overdensities of red sources

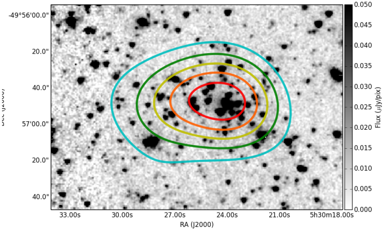
Adaptative Kernel Density Estimator (AKDE). (Pisani 1996)



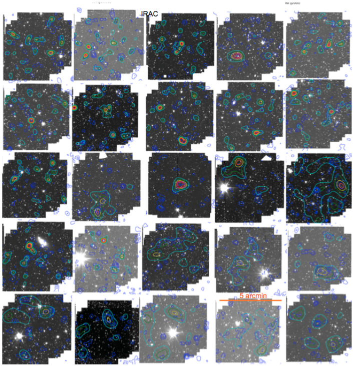


$\delta = 7.0$
Associated with SPIRE emission.

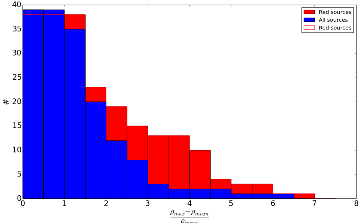
$\delta = 4.3$


-49°56'00.0"
20.0"
40.0"
57'00.0"
20.0"
40.0"
33.00s
30.00s
27.00s
24.00s
21.00s
5h30m18.00s
RA (J2000)
0.050
0.045
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
Flux (μJy/pix)

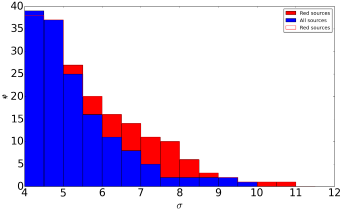
$\delta = 3.8$


IRAC
5 arcmin

Overdensities of red sources : Statistics



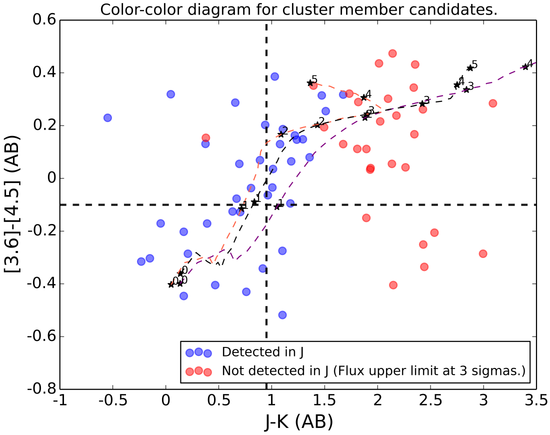
Overdensities



Significance

Near Infrared follow-up of one candidate

J (1.2 μm) and K (2.2 μm) on one candidate. Look for "J-dropouts."



5

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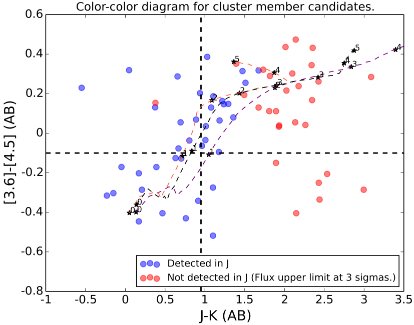

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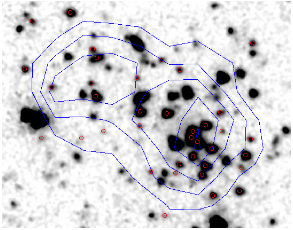

Summary

Conclusions

- Unique dataset ready to give answers to some outstanding questions in galaxy formation and evolution.
- Multi-wavelength analysis on one source (J,K), obtained data on some other fields. Ongoing analysis.
- 3 SPIRE sources spectroscopically observed ! Gives $z = 1.7, 2, 2.36$. Our enemy : chance alignment.
- How to derive relevant quantities (redshift, mass) with galaxy modeling.