# Detection and characterisation of the first *Planck* high-z candidates

**Inés Flores-Cacho**
(IRAP - CNRS/Université de Toulouse)

on behalf of the *Planck* **Collaboration**

# Acknowledgements

The scientific results that we present today are the product of the *Planck* Collaboration, including individuals from more than 50 scientific institutes in Europe, the USA and Canada

*Planck* is a project of the European Space Agency, with instruments provided by two scientific Consortia funded by ESA member states (in particular the lead countries: France and Italy) with contributions from NASA (USA) and telescope reflectors provided in a collaboration between ESA and a scientific Consortium led and funded by Denmark.
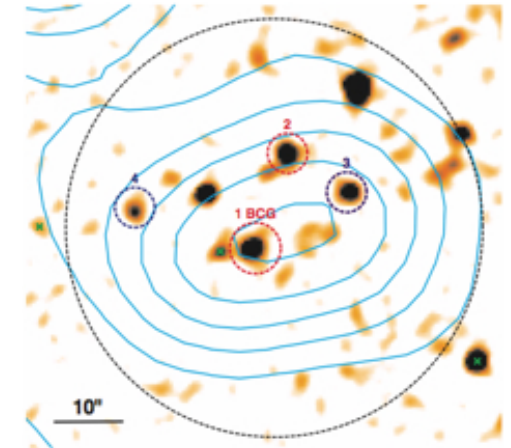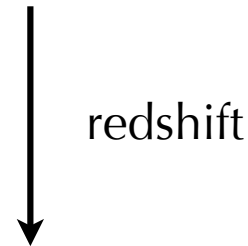
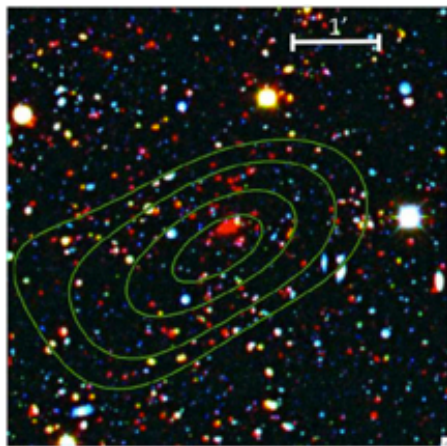# Context
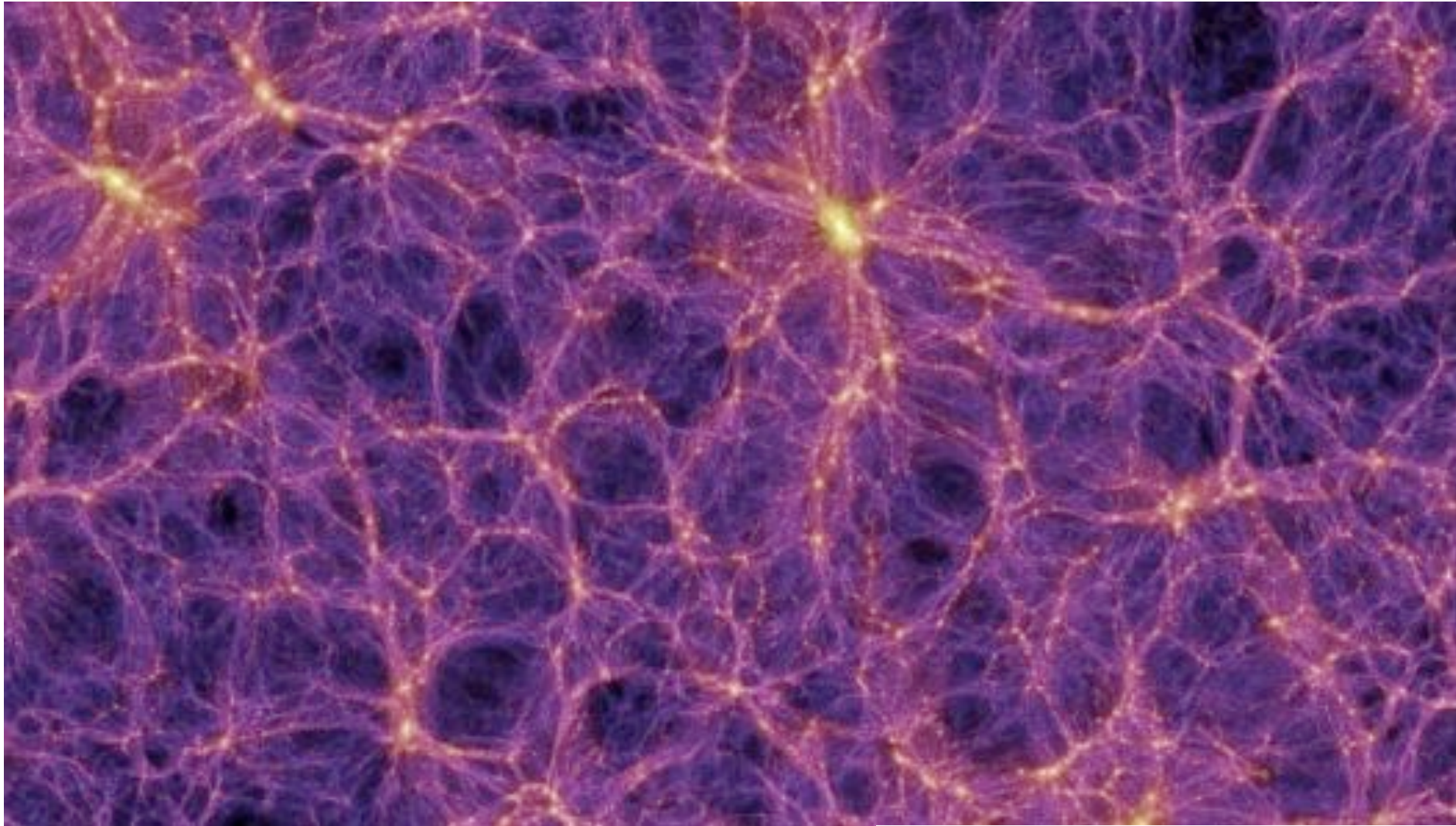


**Millenium Simulation**

# Context



**Detection of high-*z* clusters/groups/proto-clusters**
- Via their X-ray emission (heated gas - enough in virialising objects?)
- Via their SZ signature
- Via their galaxy emission
  - Optical+nIR
  - IR (SPITZER, Herschel)
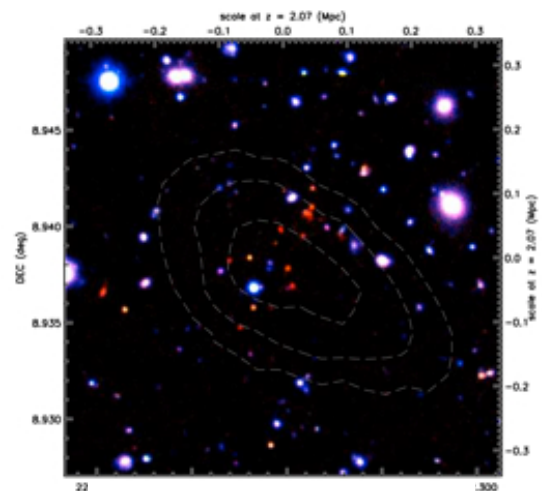  - mm/sub-mm
  - CO emission

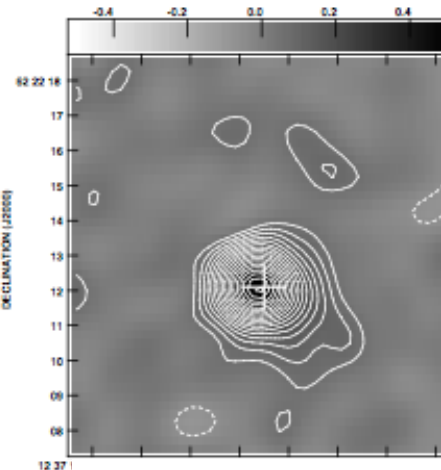redshift

Fassbender et al. (2010)
*z*=1.56

**Few tens of confirmed clusters at *z*>1.0**



Brodwin et al. (2012)
*z*=1.75



Gobat et al. (2010)
*z*=2.07



Carilli et al. (2011)
*z*=4.05



Çapak et al. (2011)
*z*=5.3

# Context



L* Galaxy at z~2

Reddy et al. (2012)
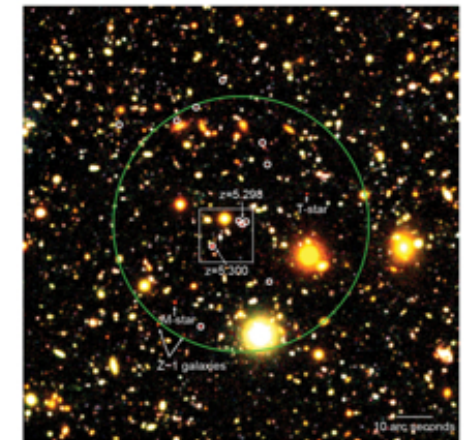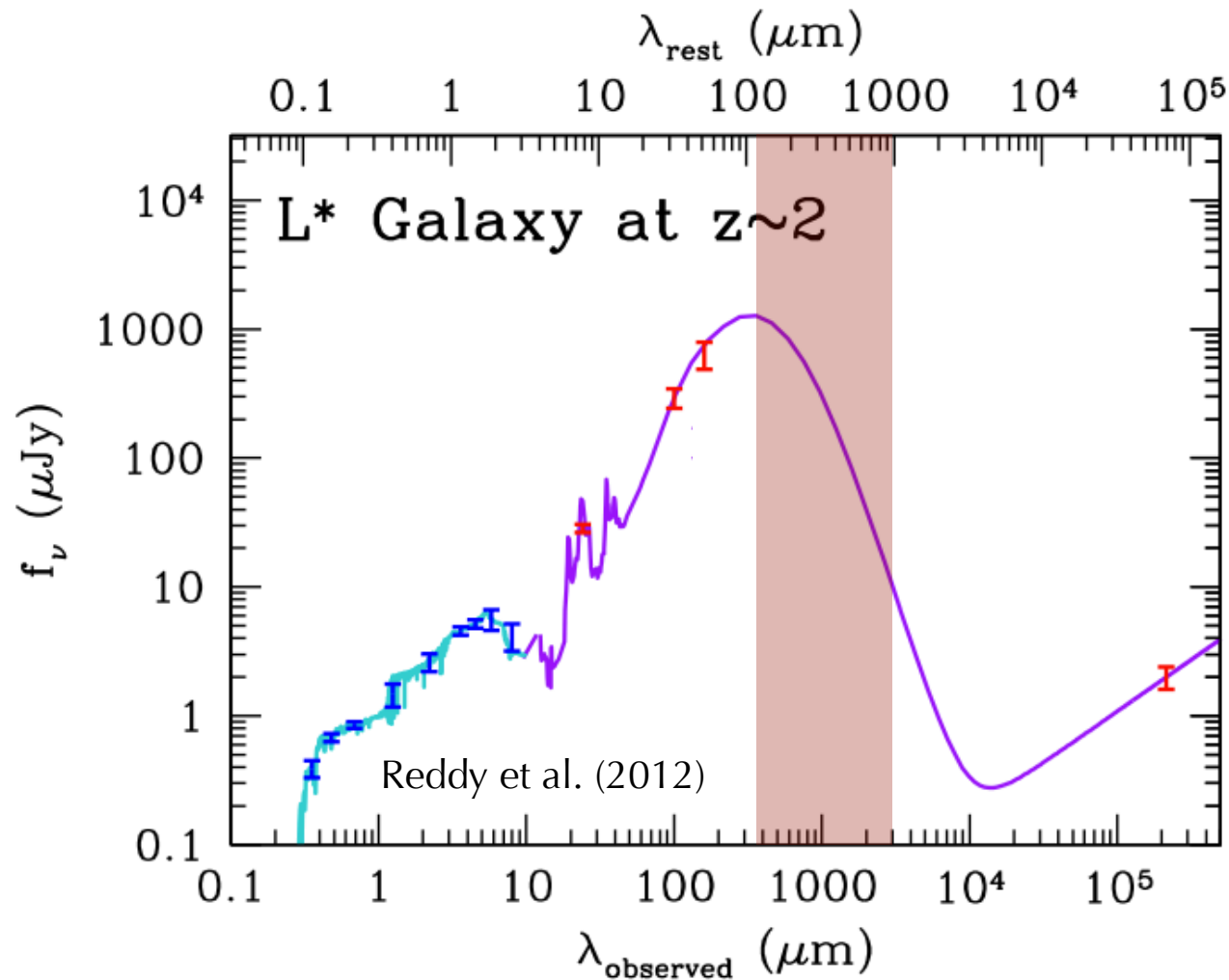
***Planck's* unique capabilities**

Full-sky coverage

Wavelength range 0.35-3 cm
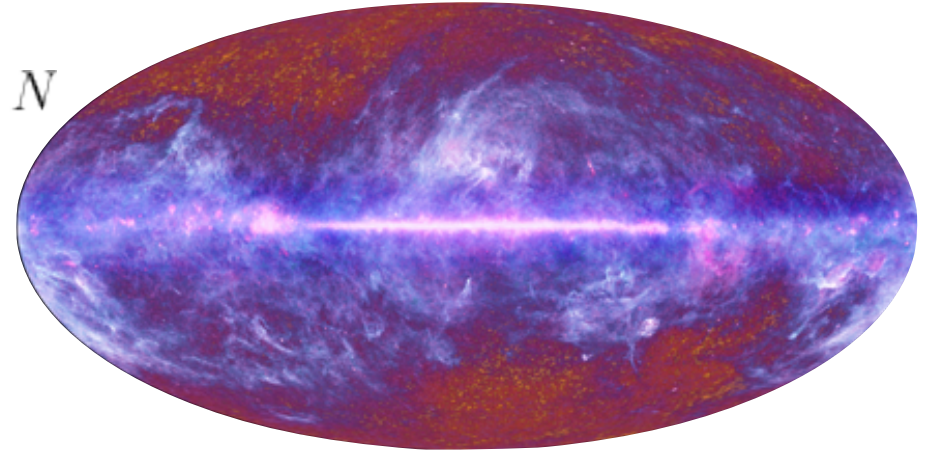
# The *Planck* Multi-Wavelength Detection

The *Planck* signal:

$$S_\nu = S_{gal-dust} + S_{CMB} + S_{CIB} + S_{dust-gal-cl} + N$$

Local correlation and template removal:

- Use only HFI: 857-100 GHz
- Cleanest 30% of the sky
- $S_{gal-dust}$ --> IRAS 100 μm
  (Galactic Cirrus Color Cleaning - CoCoCoDeT - Montier et al. 2010)
- $S_{CMB}$ --> HFI 143 GHz

**4 clean maps: 217GHz, 353GHz, 545GHz, 817GHz**

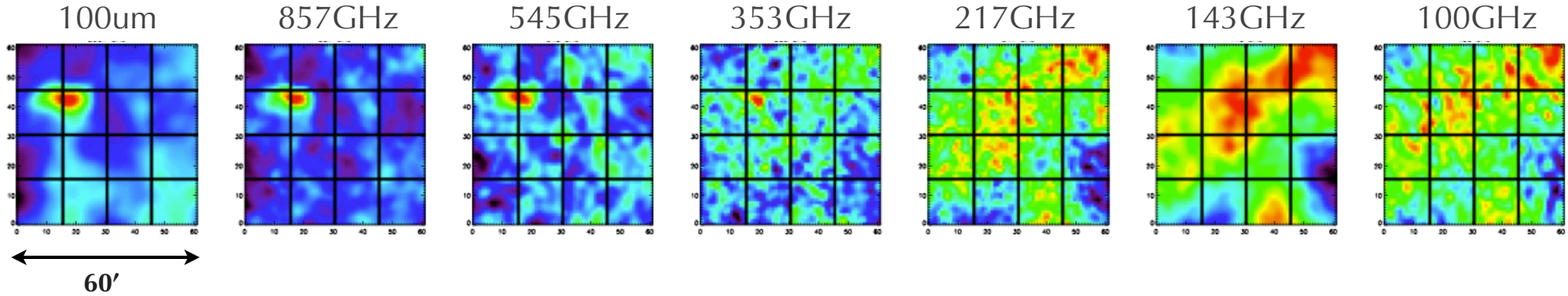Source Detection:

- Two excess maps: at 353GHz & 545 GHz
  (Excess Map)$_{353}$ = (Clean Map)$_{353}$ - (Power Law Interpolation)$_{217\to857}$

- Joint detection using Mexican Hat Wavelet filter

**Blind Multi-Frequency + Multi-Scale Detection**

# The *Planck* Multi-Wavelength Detection

| 100um | 857GHz | 545GHz | 353GHz | 217GHz | 143GHz | 100GHz |
|---|---|---|---|---|---|---|

60'

**Galactic dust emission cleaning**     **CMB cleaning**

| 857GHz | 545GHz | 353GHz | 217GHz |
|---|---|---|---|

60'
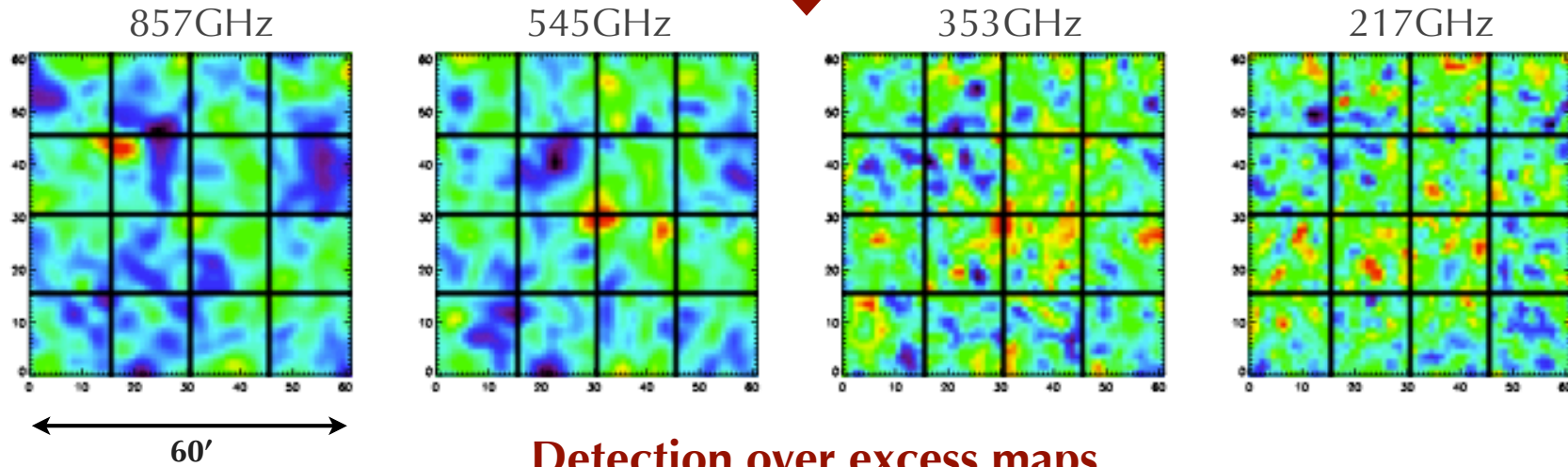
**Detection over excess maps**

*Planck* **List of High-*z* candidates**

# First confirmed candidates



857GHz  545GHz  353GHz  217GHz

z=2.783

z=3.26

z=2.738

z=5.2

z=1.48
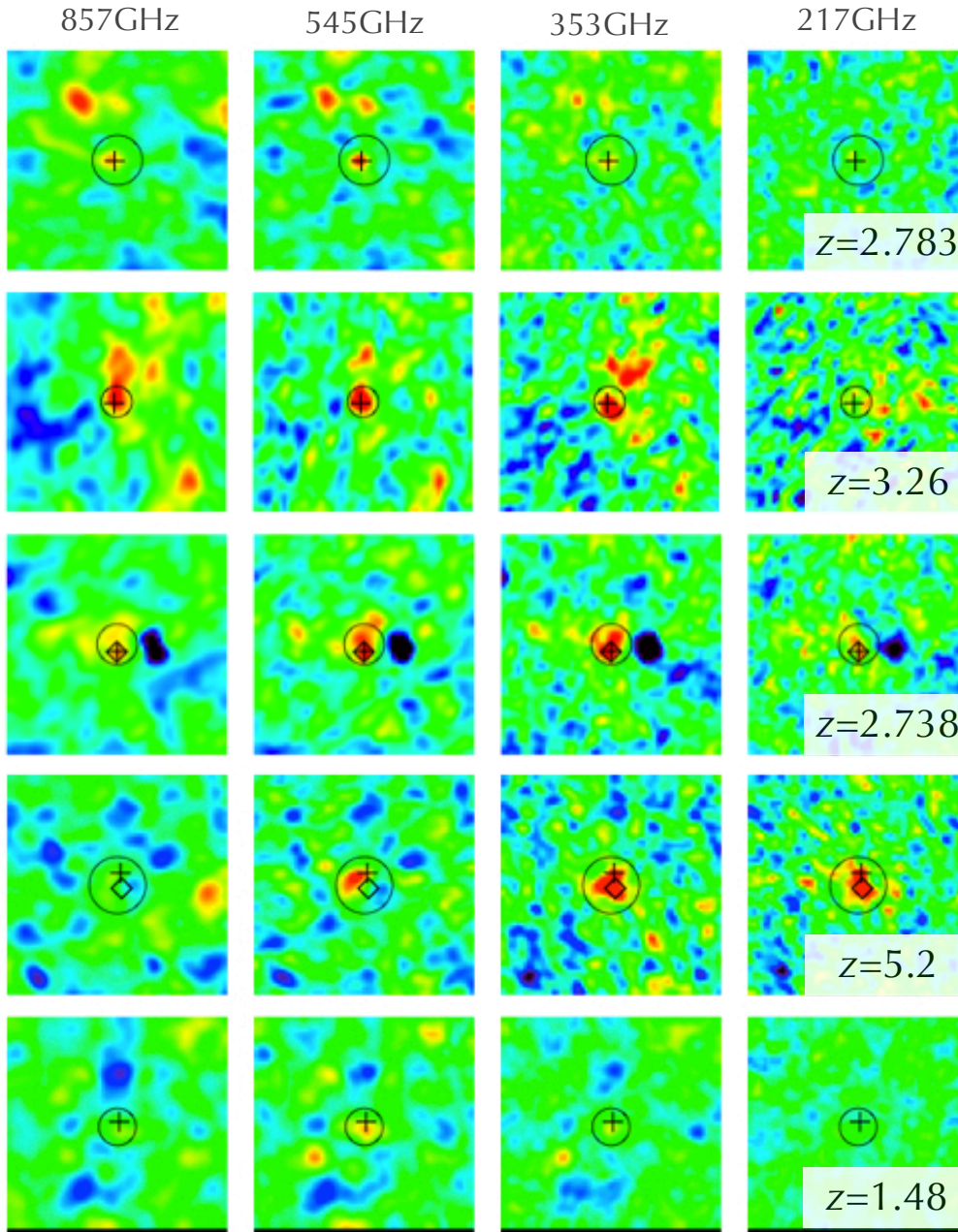
- Spatial cross-correlation with:
  - SPT sources  (Vieira et al. 2010, Greve et al. 2012)
  - Herschel ATLAS  (Herranz et al.2012, Fu et al. 2012)
  - HLS  (Egami et al. 2010, Combes et al. 2012)
  - (Proto)clusters in the literature
    (Galametz et al.2009)

- Five identified objects
  - Lensed galaxies or (proto)clusters
  - Redshift range: 1.5-5.2

- High-$z$ sources are blindly detected with *Planck*

- The *Planck* properties of these confirmed candidates are not different from others in the sample
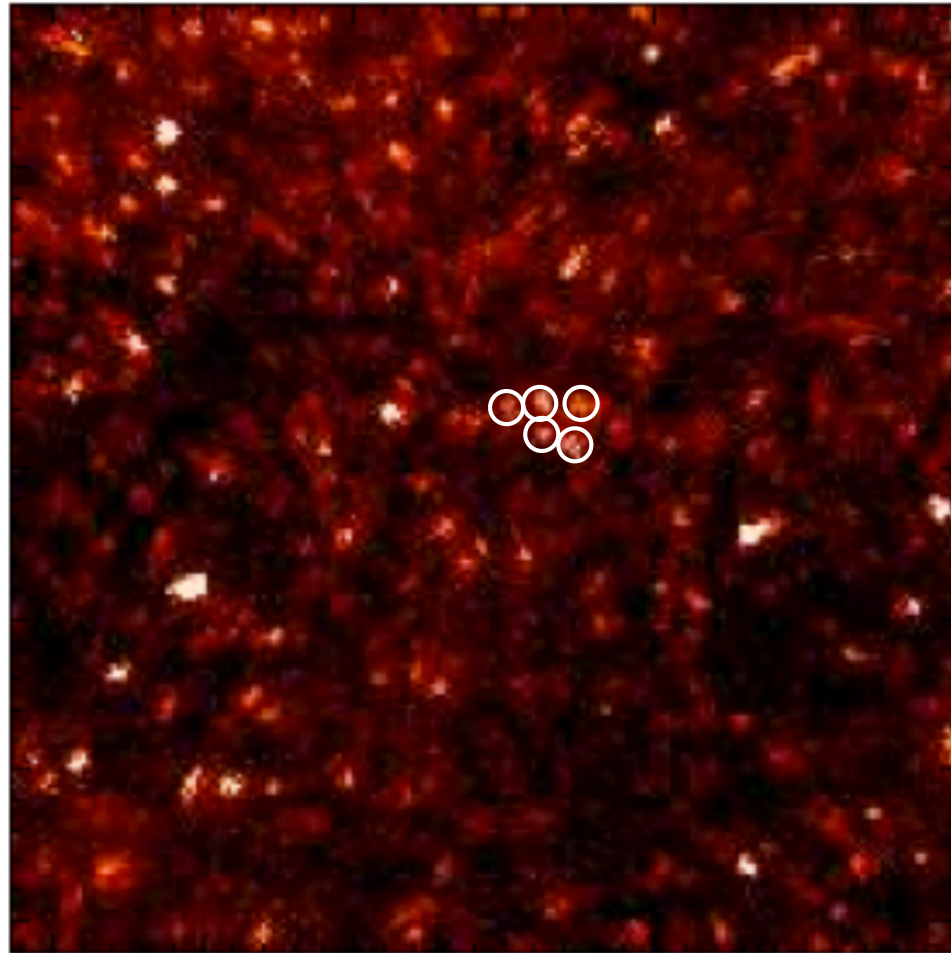
### Multi-wavelentgh validation

# A new distant cluster candidate



*Planck*

857GHz     545GHz     353GHz     217GHz

60'

FWHM~5'

**Herschel/SPIRE**

250 μm     350 μm     500 μm

19'    FWHM~18"     FWHM~25"     FWHM~36"
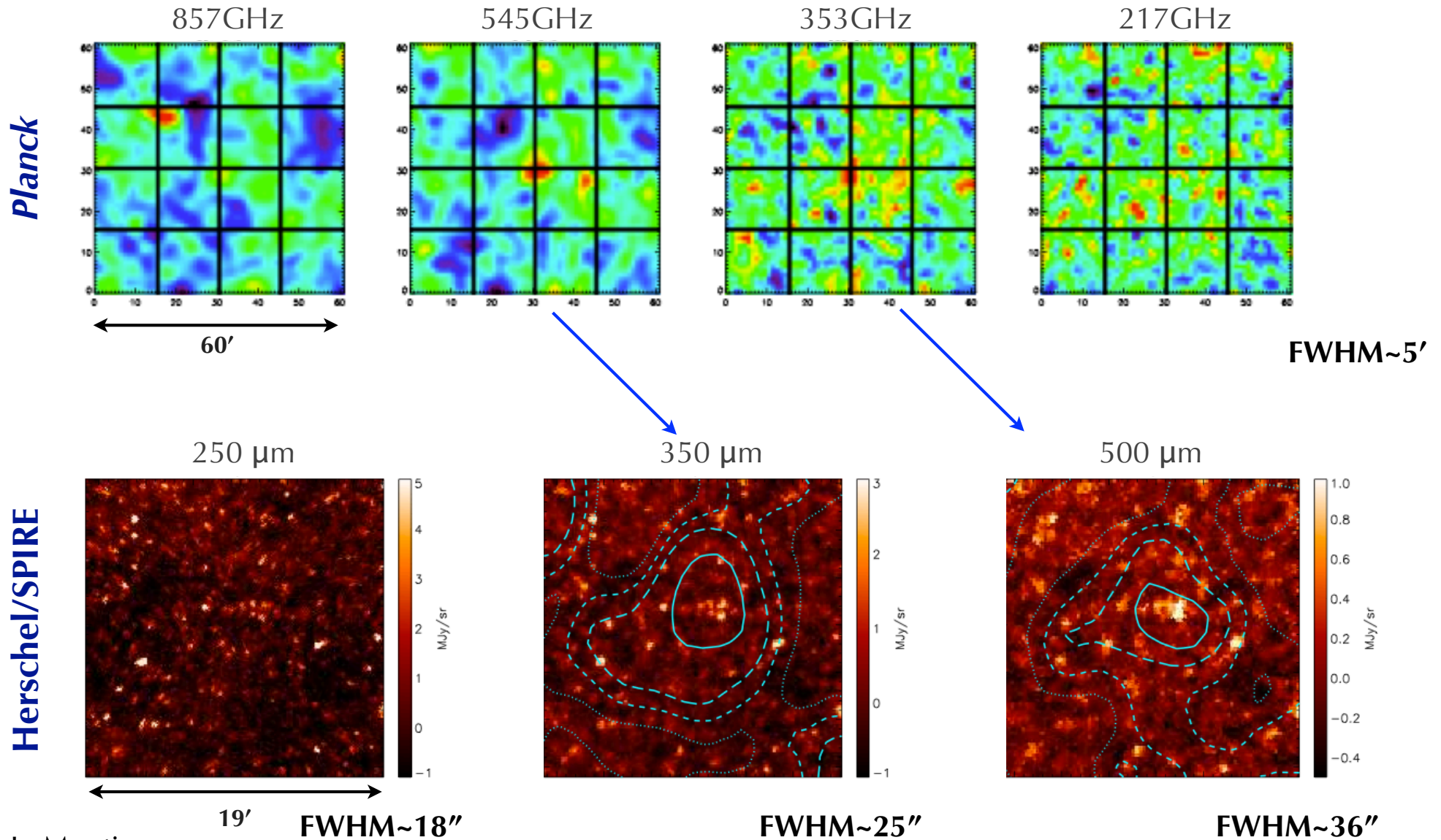
P.I.: L. Montier

## High-*z* Candidate

# A new distant cluster candidate

250μm



Five resolved sources in Herschel/SPIRE coincident with Planck detection

19'

# A new distant cluster candidate

**Summer 2011 - Optical & nIR broad band follow-up at CFHT**

MEGACAM: g, i  (Depth: 25.0, 23.5 mag)
WIRCAM: J, H, Ks (Depth: 22.5, 22.0, 21.5 mag)

## Evidence of an over-density of red galaxies



J-K<1          1 < J-K< 1.5          1.5 < J-K< 4

7'
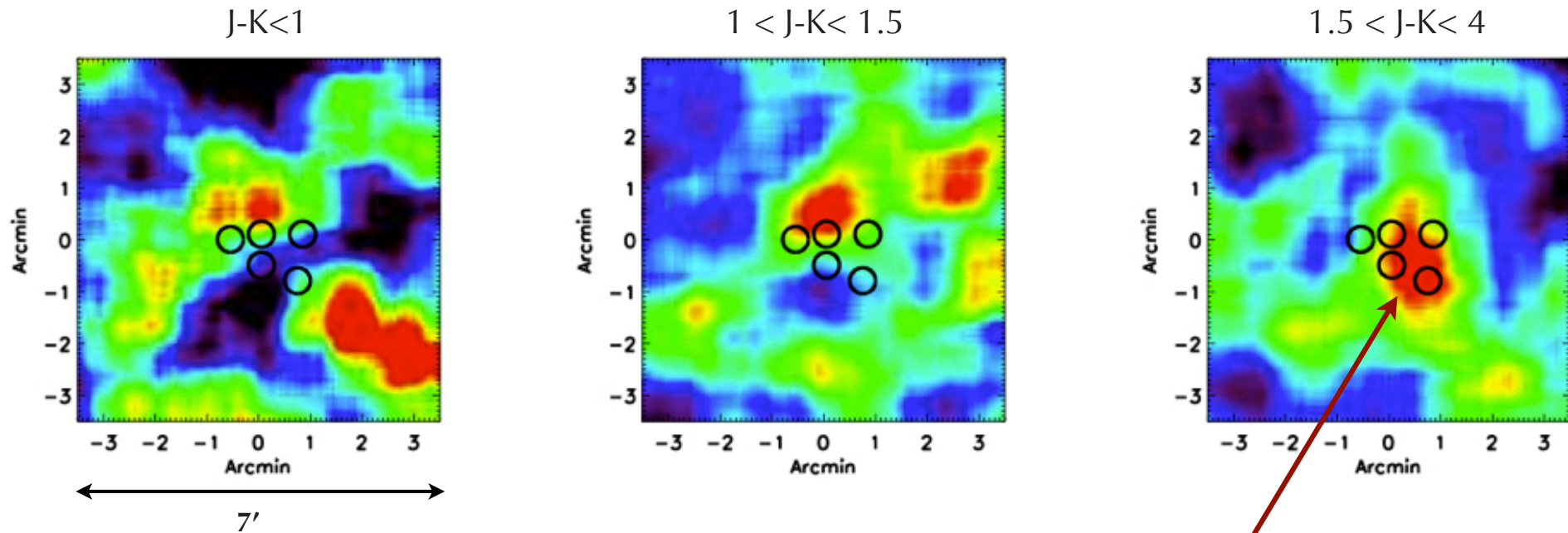
**Over-density** of sources in J-K > 1.5

○  *Herschel* / SPIRE blobs coincident with *Planck* detection

# A new distant cluster candidate

**Photometric Redshift Estimate**

Hyper-z (Bolzonella et al. 2000)

Cross correlation between SPIRE / CFHT sources

0    1    1.4    2    $Z$

250 μm          350 μm          500 μm

8'

■ Individual Galaxies

# A new distant cluster candidate

**Photometric Redshift Estimate**

Hyper-z (Bolzonella et al. 2000)

Cross correlation between SPIRE / CFHT sources



250 μm    350 μm    500 μm
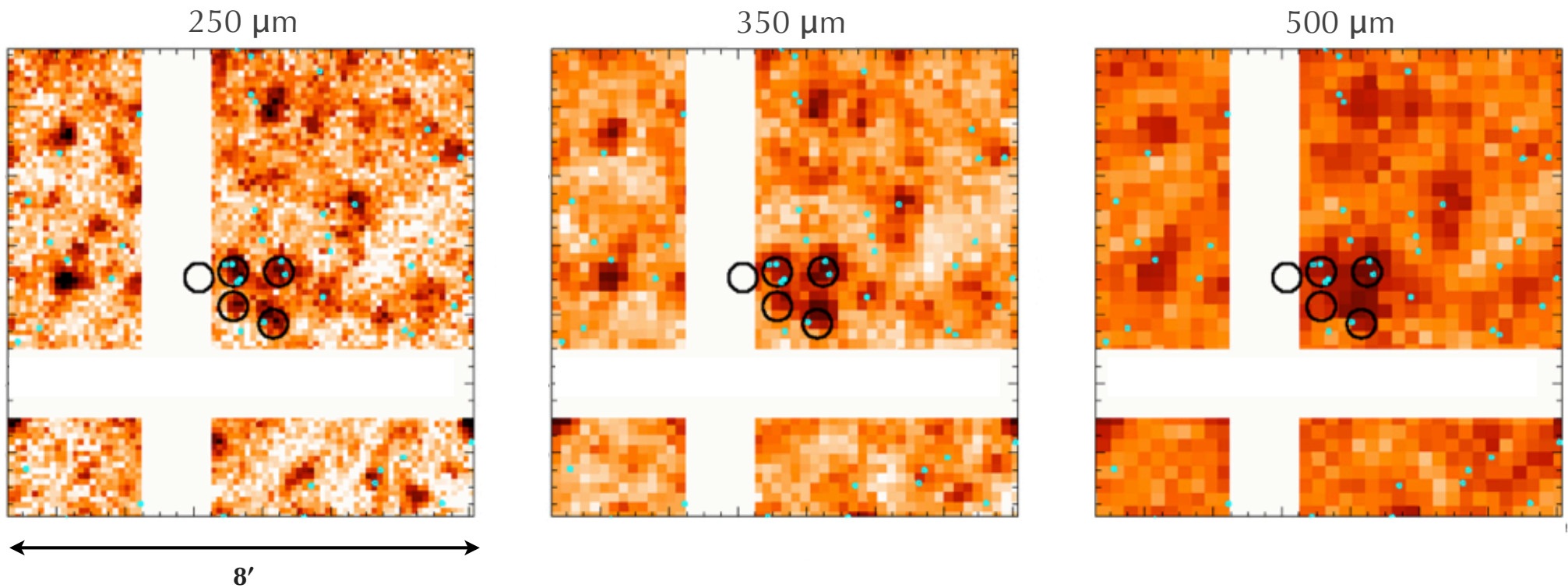
8′

■ Individual Galaxies

# A new distant cluster candidate
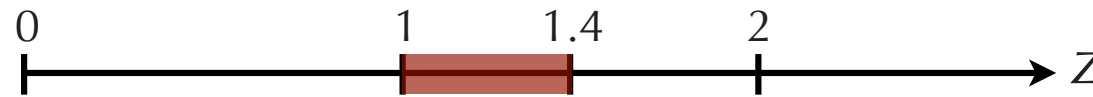
**Photometric Redshift Estimate**

Hyper-z (Bolzonella et al. 2000)

Cross correlation between SPIRE / CFHT sources



250 μm     350 μm     500 μm
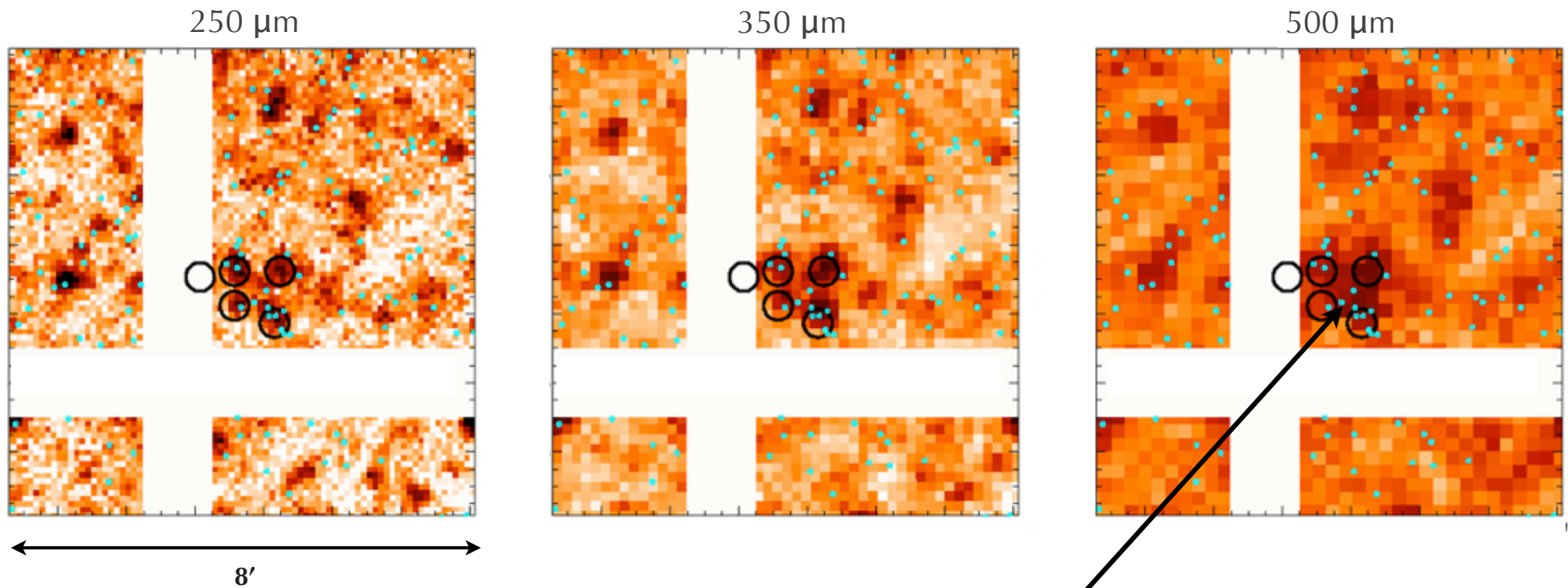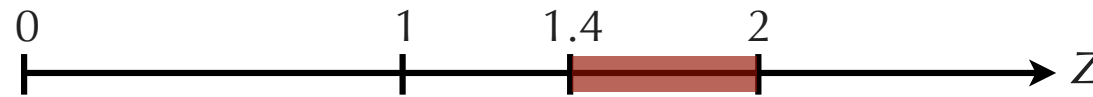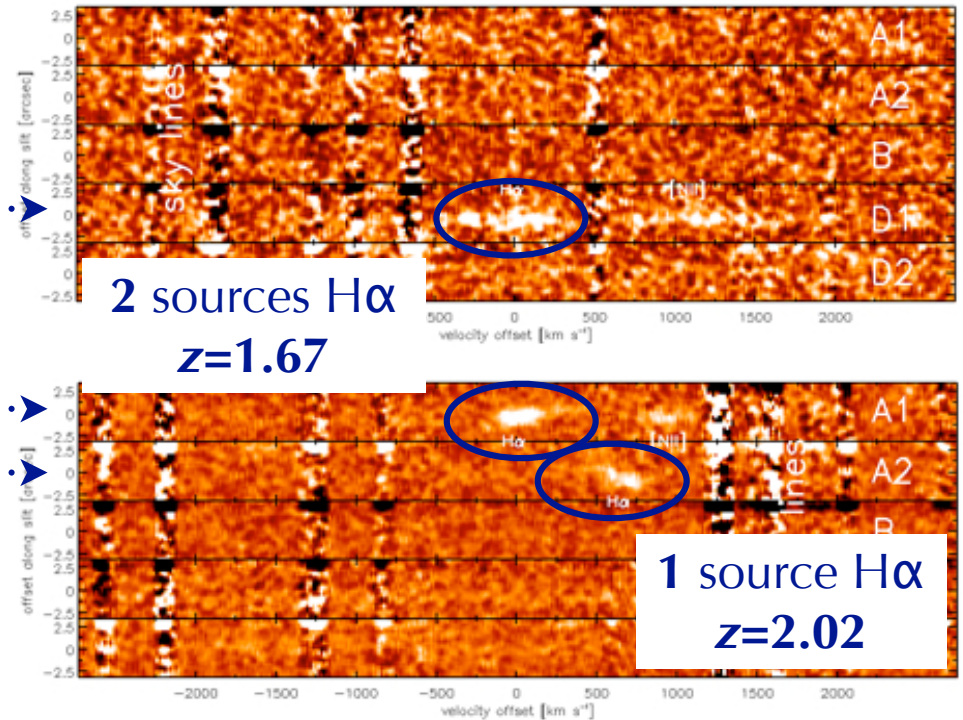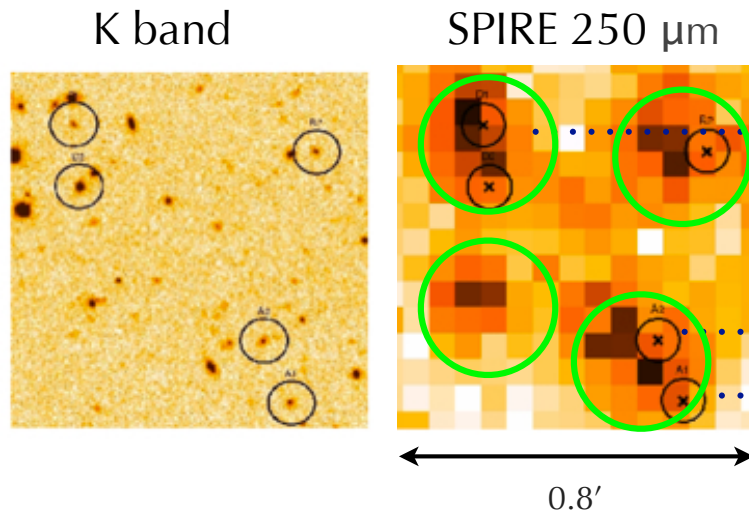
8'
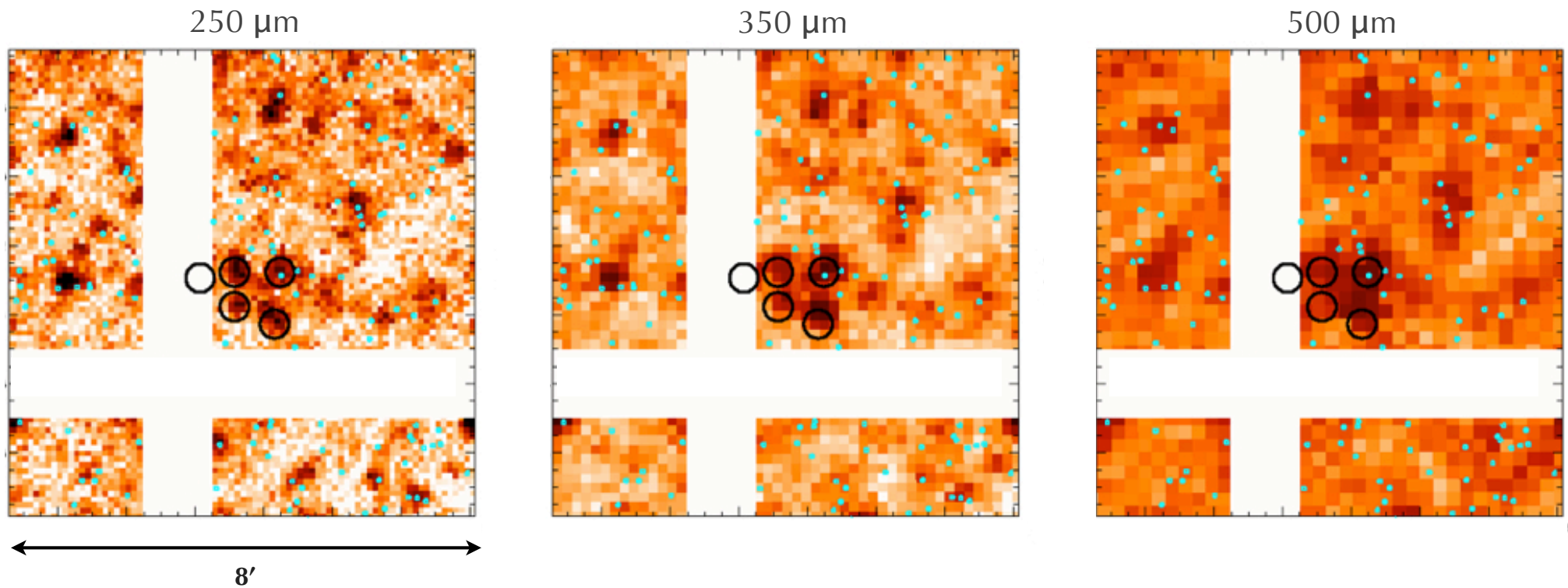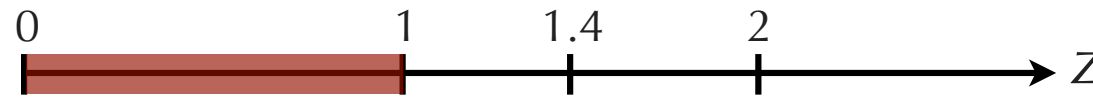
■ Individual Galaxies

**Cluster candidate?**

# A new distant cluster candidate

## October 2011 - Spectroscopic follow-up with XSHOOTER@VLT

Wavelength range: 300-2500 nm
5 targets

K band

SPIRE 250 μm

0.8'

**2D Spectra**



**2** sources Hα
***z*=1.67**

**1** source Hα
***z*=2.02**

3 detections in Hα and NII
Robust!

No NIR line detection of 2 others sources
Due to extinction?

No UV/Optical line detection for all sources
Consistent with high extinction

# A new distant cluster candidate

**Zeroth order physical characterisation:**

- Velocity dispersion
  - --> Virialised DM halo mass ~ $1.3 \times 10^{13}$ M$_\odot$

- Width of H$\alpha$ line
  - --> SFR > 60 M$_\odot$/yr per galaxy

- $L_X$-Mass scaling relation (Pratt et al. 2009, Reichert et al. 2011)
  - --> $L_X \sim 10^{43}$ erg/s

- $L_X$-$T_X$ scaling relation (Maughan et al. 2011)
  - --> $T_X \sim 1.2$ keV

# Prospectives with X-rays

### New distant cluster candidate?

No evidence for counterparts in ROSAT →

Given its SFR, $L_X$ and $T_X$:

**--> Probably young object, not yet virialised**
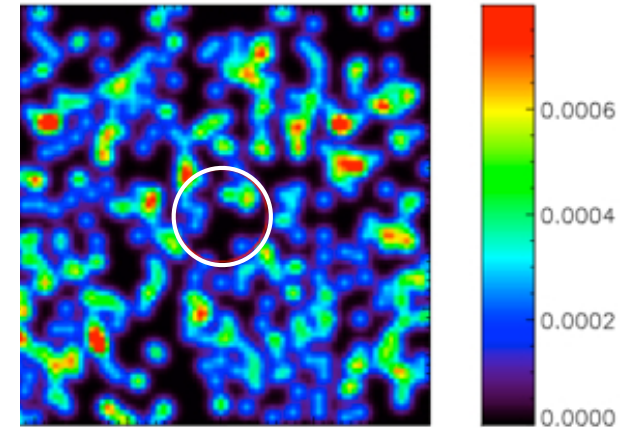


### Known groups/clusters at similar redshifts:

XMMXCS J221559.6-173816.2:     (Stanford et al. 2006, Mehrtens et al. 2012)

$z$=1.46, $T_X$=4.3keV, $L_{500}$=6.8x10$^{44}$erg/s

3C322:     (Belsole et al. 2004)

$z$=1.7, $T_X$=4keV, $L_X$=5x10$^{44}$erg/s

XMMU J1007.4+1237:     (Fassbender et al. 2011)

$z$=1.56, $T_X$=4.2keV, $L_{500}$=2.1x10$^{44}$erg/s

# Prospectives with X-rays

XMM XCS sample (Mehrtens et al. 2012)

# Prospectives with X-rays
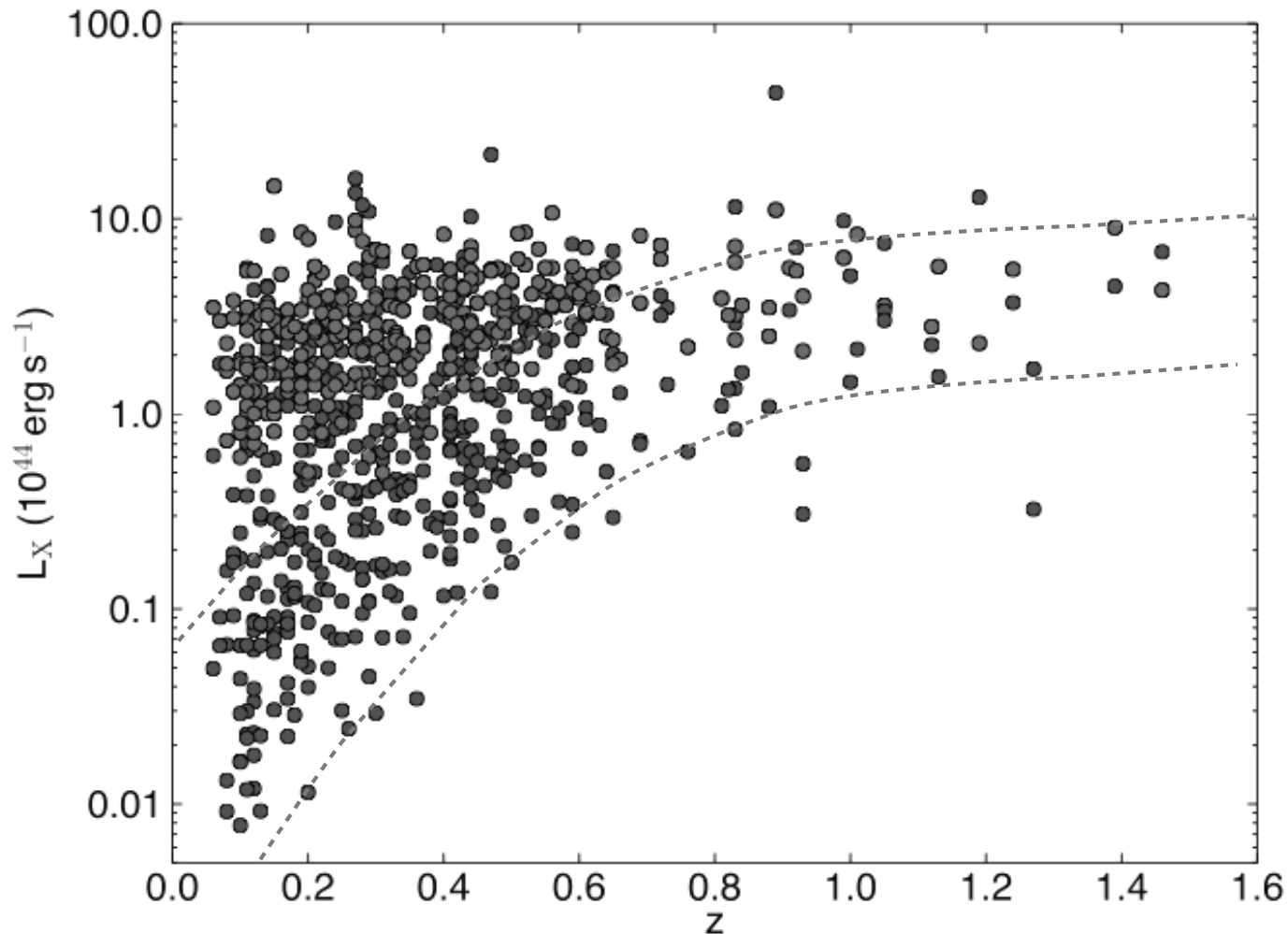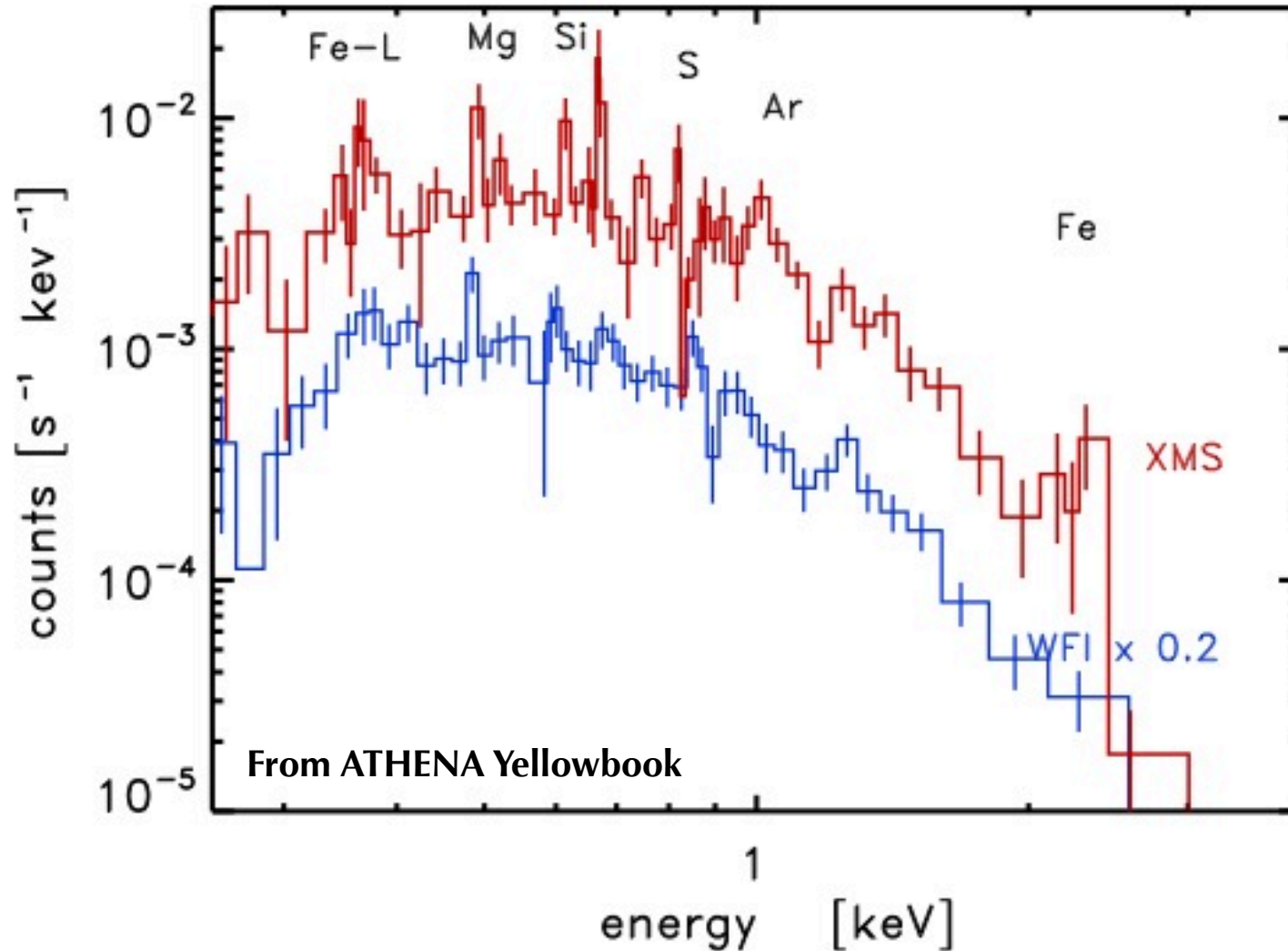


**Simulated spectrum (400ks) as seen by ATHENA of a galaxy group at z=2 with $T_X$=2keV**

# **Summary**

**PLANCK ALLOWS US TO BUILD A <u>UNIQUE SAMPLE OF DISTANT CANDIDATES</u>**
**POTENTIALLY LOOKING THE FIRST FORMING CLUSTERS/GROUPS**

Blind all-sky multi-wavelength & multi-scale detection

First list of a few 100s candidates for high-$z$ objets

Five confirmed as high-$z$ lensed galaxies or (proto)clusters

Multi-wavelength characterisation follow-up on-going

   Confirm/provide redshift estimate

   Constrain the nature of the *Planck* detected objects

   Synergy with X-ray studies