Detection and characterisation of the first Planck high-z candidates

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on behalf of the Planck Collaboration
Acknowledgements

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Millenium Simulation
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

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) $z=4.05$
- Čapak et al. (2011) $z=5.3$

Fassbender et al. (2010) $z=1.56$
Planck’s unique capabilities

Full-sky coverage
Wavelength range 0.35-3 cm
The Planck Multi-Wavelength Detection

The Planck signal:

\[ S_\nu = S_{\text{gal-dust}} + S_{\text{CMB}} + S_{\text{CIB}} + S_{\text{dust-gal-cl}} + N \]

Local correlation and template removal:

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

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

Source Detection:

- Two excess maps: at 353GHz & 545 GHz  
  \( (\text{Excess Map})_{353} = (\text{Clean Map})_{353} - (\text{Power Law Interpolation})_{217->857} \)

  
- 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

Galactic dust emission cleaning → CMB cleaning

Detection over excess maps

Planck List of High-z candidates

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XMM-Newton Science Workshop on Galaxy Clusters

Madrid, 23/05/2012
First confirmed candidates

- 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-wavelength validation
A new distant cluster candidate

High-z Candidate

P.I.: L. Montier

250 μm

350 μm

500 μm

FWHM~18"  FWHM~25"  FWHM~36"

Planck

857GHz  545GHz  353GHz  217GHz

FWHM~5'

Herschel/SPIRE

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A new distant cluster candidate

Five resolved sources in Herschel/SPIRE coincident with Planck detection
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

Herschel / SPIRE blobs coincident with Planck detection

Over-density of sources in J-K > 1.5
A new distant cluster candidate

Photometric Redshift Estimate
Hyper-z (Bolzonella et al. 2000)

Cross correlation between SPIRE / CFHT sources

- Individual Galaxies
**Photometric Redshift Estimate**

Hyper-z (Bolzonella et al. 2000)

Cross correlation between SPIRE / CFHT sources

- Individual Galaxies

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A new distant cluster candidate

Photometric Redshift Estimate
Hyper-z (Bolzonella et al. 2000)

Cross correlation between SPIRE / CFHT sources

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

2D Spectra

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

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Madrid, 23/05/2012
A new distant cluster candidate

Zeroth order physical characterisation:

- Velocity dispersion
  --> Virialised DM halo mass $\sim 1.3 \times 10^{13} \, M_\odot$

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

  --> $L_X \sim 10^{43} \, \text{erg/s}$

- $L_X$-$T_X$ scaling relation (Maughan et al. 2011)
  --> $T_X \sim 1.2 \, \text{keV}$
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)
  $z=1.46$, $T_X=4.3\text{keV}$, $L_{500}=6.8\times10^{44}\text{erg/s}$

3C322: (Belsole et al. 2004)
  $z=1.7$, $T_X=4\text{keV}$, $L_X=5\times10^{44}\text{erg/s}$

XMMU J1007.4+1237: (Fassbender et al. 2011)
  $z=1.56$, $T_X=4.2\text{keV}$, $L_{500}=2.1\times10^{44}\text{erg/s}$
Prospectives with X-rays

XMM XCS sample (Mehrtens et al. 2012)
Simulated spectrum (400ks) as seen by ATHENA of a galaxy group at $z=2$ with $T_X=2$ keV

From ATHENA Yellowbook
Summary

**Planck allows us to build a unique sample of distant candidates**

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 objects
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