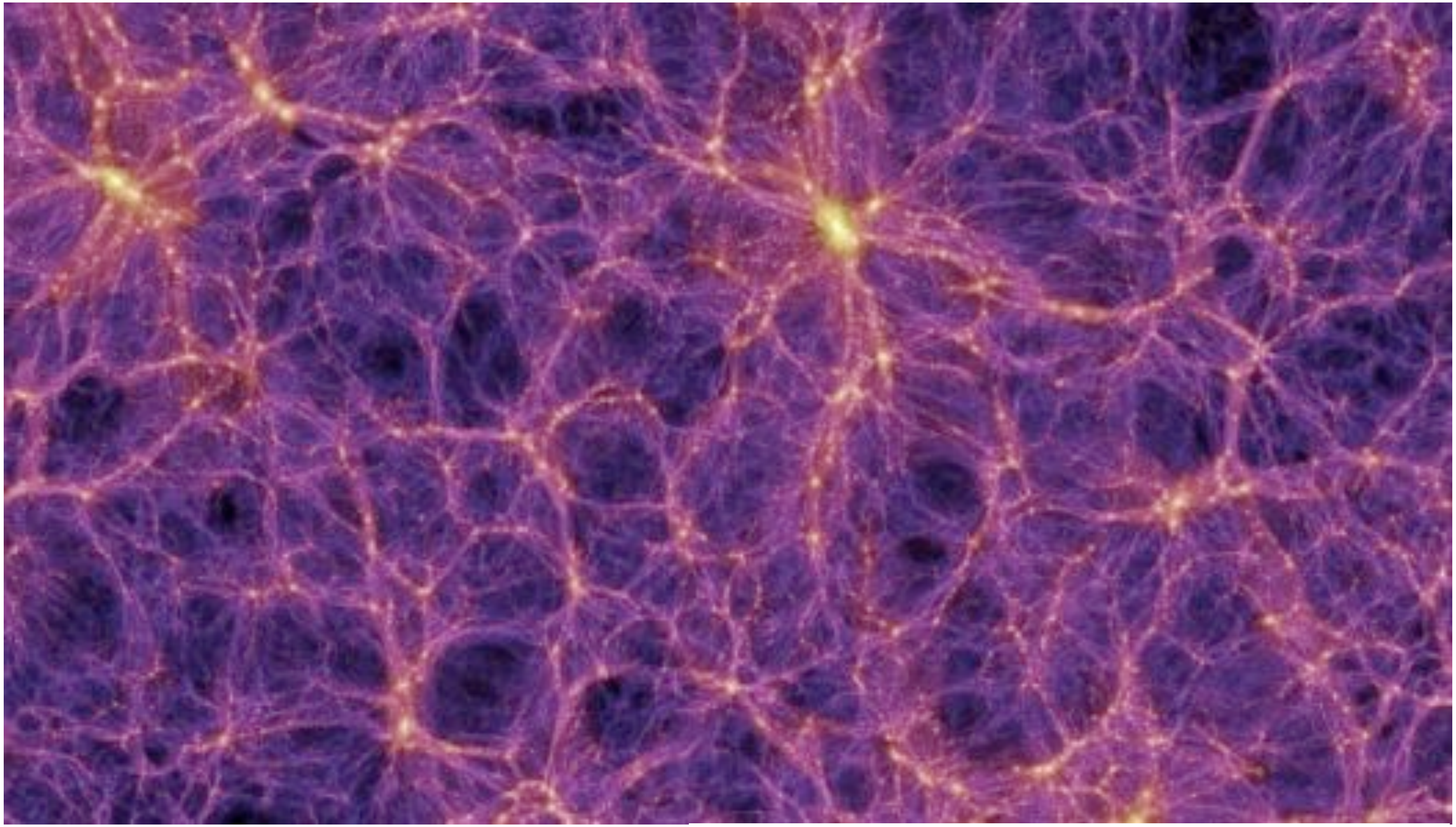
Characterization of the first *Planck* high-z candidates

Ludovic Montier

on behalf of the
Planck Collaboration

‘Looking back at the dawn of time..’



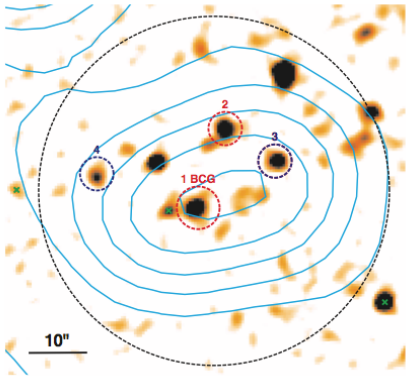
Millenium Simulation

Searching for distant galaxy-clusters

Detection of high-z clusters/groups/proto-clusters

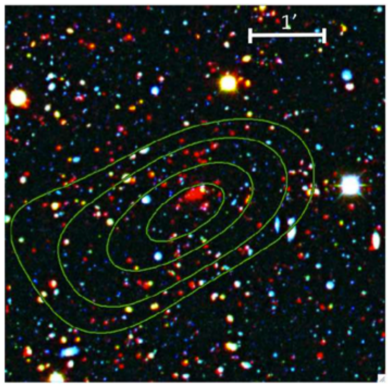
- Via their X-ray emission
- Via their SZ signature
- Via their galaxy emission
    - Optical+nIR
    - IR (SPITZER, Herschel)
    - mm/sub-mm
    - CO emission

(heated gas - enough in virialising objects?)

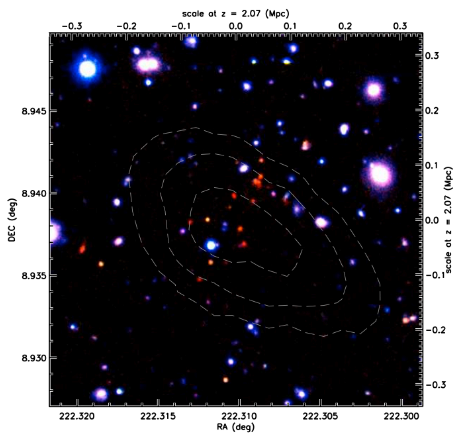


Fassbender et al. (2010)
z=1.56

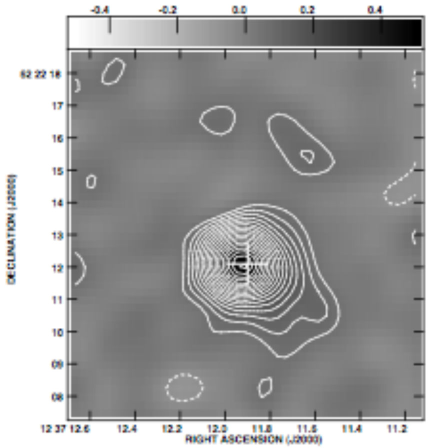
→ Few tens of confirmed clusters at z>1.0



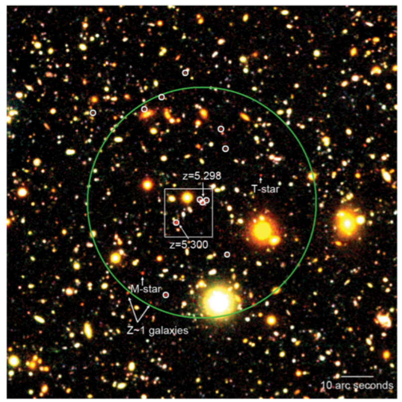
Brodwin et al. (2012)
z=1.75



Gobat et al. (2010)
z=2.07



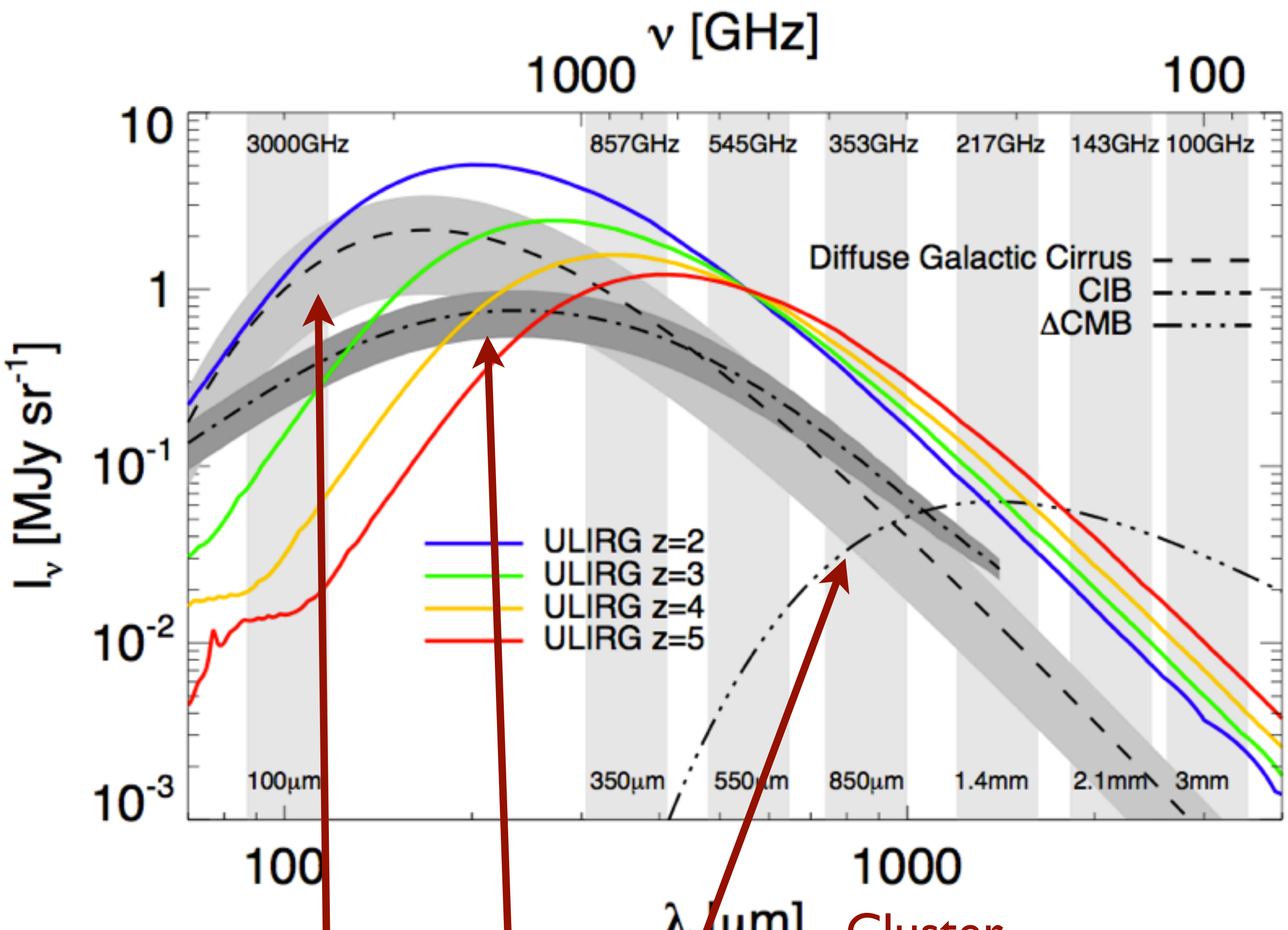
Carilli et al. (2011)
z=4.05



Çapak et al. (2011)
z=5.3

Planck High-z sources Extraction

The submm Context



$S_\nu =$ Cirrus + CIB + CMB + Cluster Galaxies Dust + Noise

Planck-HFI :

- All sky
- 6 bands : 0.3 mm to 3mm
- 5' resolution (~2.5 Mpc at z=2)

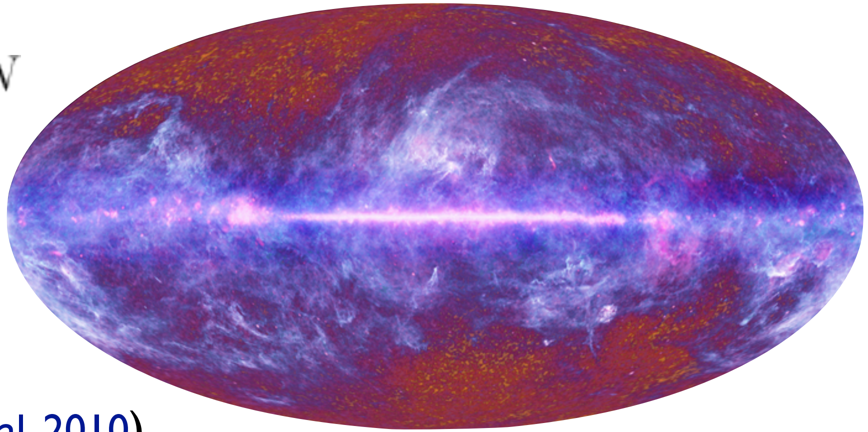
If detected, likely to be at z>1.5

Planck High-z sources Extraction

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: 0.35mm --> 3mm
- Cleanest 30% of the sky
- Galactic Cirrus --> IRAS 100 µm
  (Color Cleaning - CoCoCoDeT - Montier et al. 2010)
- CMB --> HFI 2.1mm

4 clean maps: 350µm, 550µm, 850µm and 1.4mm

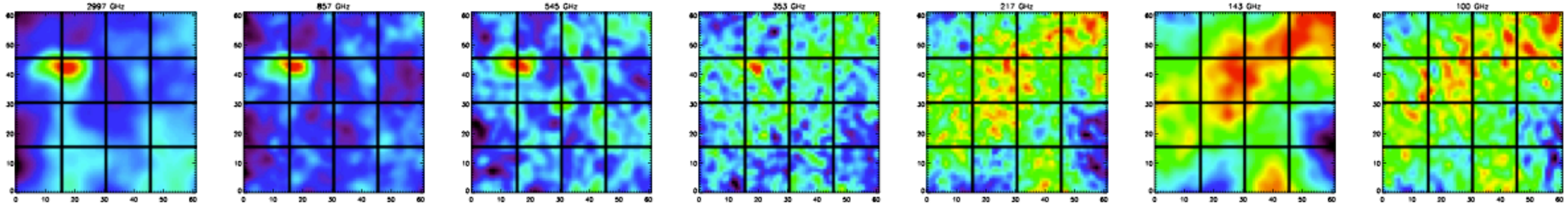
Source Detection:

- Two excess maps: at 550 µm & 350 µm
  $(\text{Excess Map})_{550} = (\text{Clean Map})_{550} - (\text{Power Law Interpolation})_{350\text{->}850}$
- Joint detection using Mexican Hat Wavelet filter

Blind Multi-Wavelength + Multi-Scale Detection

Planck High-z sources Extraction

100µm 350µm 550µm 850µm 1.4mm 2.1mm 3mm

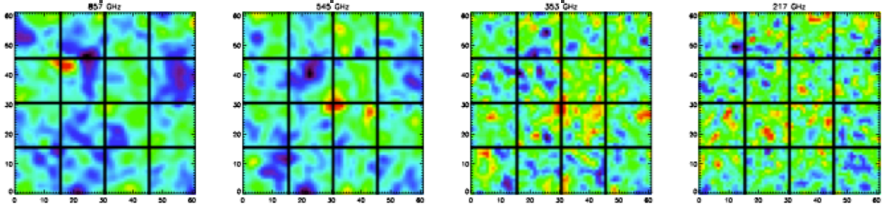


60'

Galactic dust emission cleaning

CMB cleaning

350µm 550µm 850µm 1.4mm

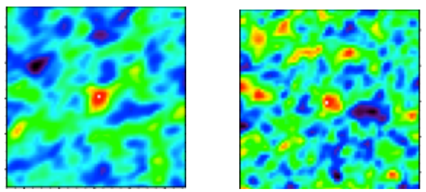


Colour-Colour selection
Flux density threshold
Size Selection

550µm Excess

850µm Excess

Source Detection



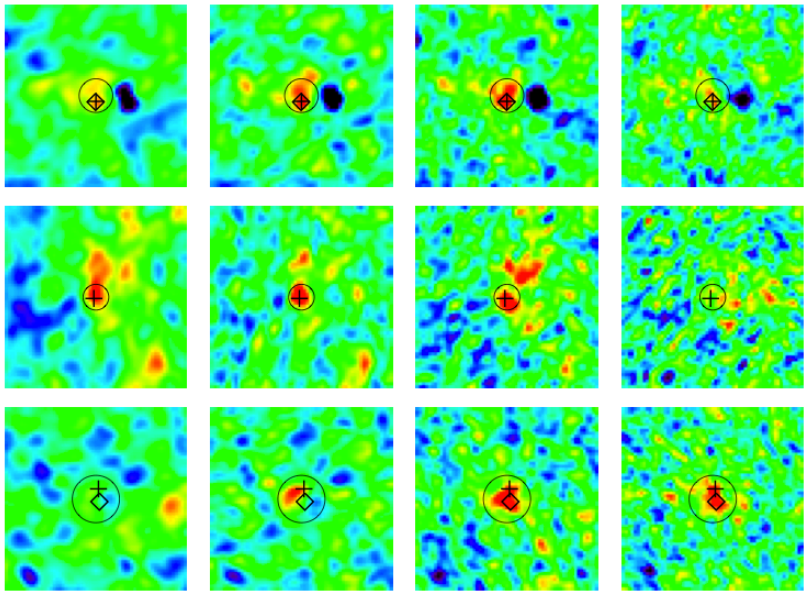
Original List of 100s
of *Planck* high-z Point Source
Candidates
over 30% of the sky

.. nature of these candidates ?

First confirmed *Planck* High-z sources

Planck cutouts after cleaning

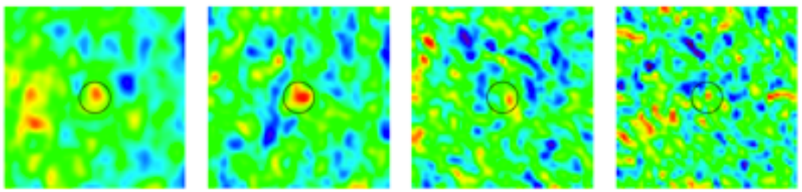
350µm 550µm 850µm 1.4mm



Confirmation	Redshift	Nature
SPT	2.783	Lensed Dusty Galaxy (Greve et al. 2012) (Marrone et al. in prep)
Herschel ATLAS	3.26	Lensed Dusty Galaxy (Herranz et al.2012) (Fu et al. 2012)
Herschel Lensing Survey	5.2	Lensed Dusty Galaxy behind a Galaxy Cluster (Combes et al. 2012)

Lensed Dusty Galaxies versus Proto-Clusters ?

- z>~2
- Are all *Planck* high-z candidates lensed dusty galaxies ? **NO !**
- More details to come on the Proto-Cluster candidates:



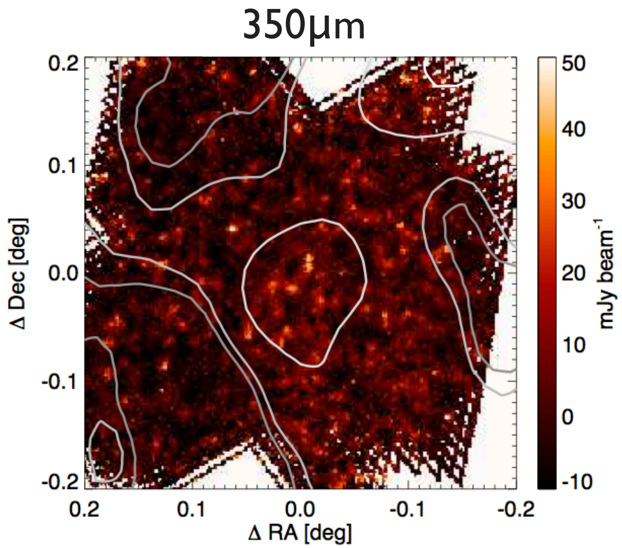
Planck	1.67	Proto-Cluster Candidate (Planck Collaboration in prep.)

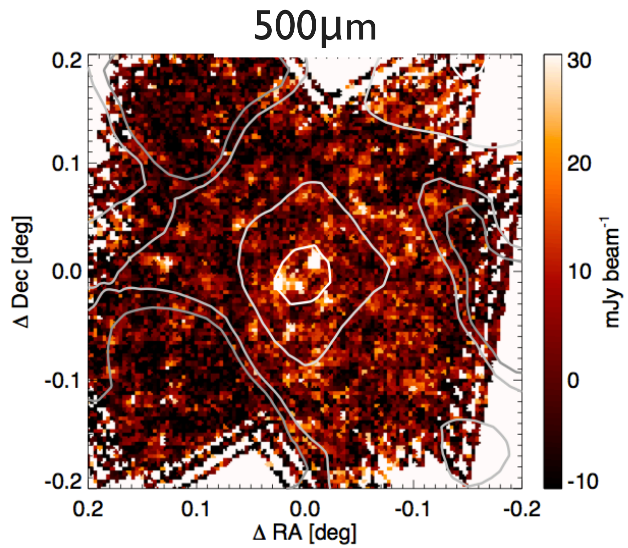
Herschel Follow-up

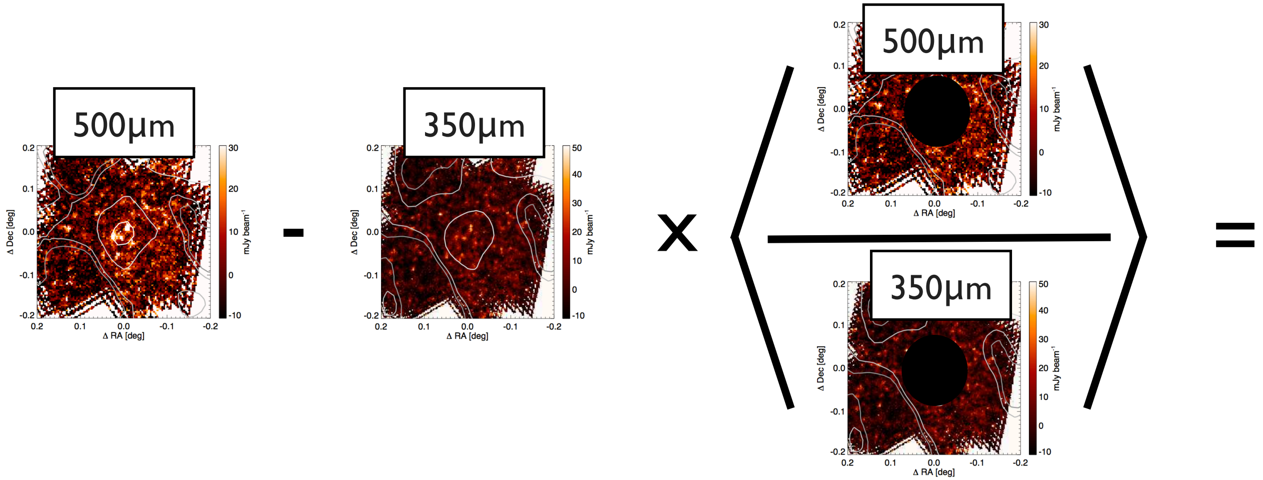
71 *Planck* high-z new targets followed-up with Herschel/SPIRE OT1 & OT2 calls
(PI Montier) (PI Dole)

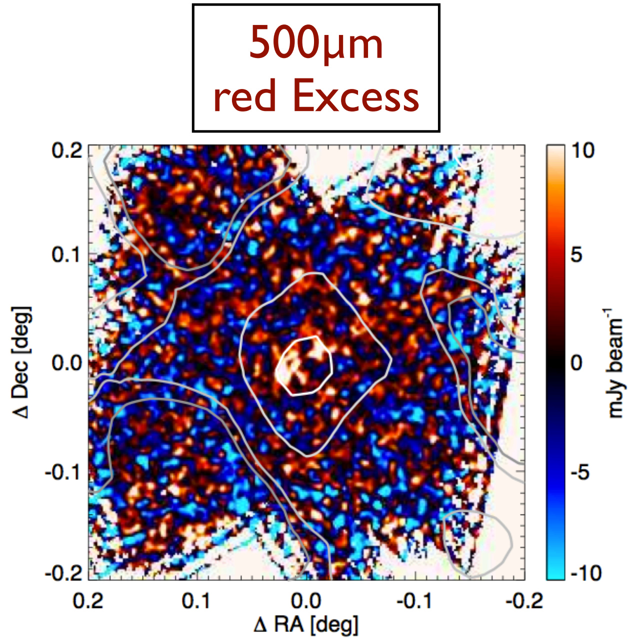
29 already observed

Evidence of groups of sources showing red excess at 500µm

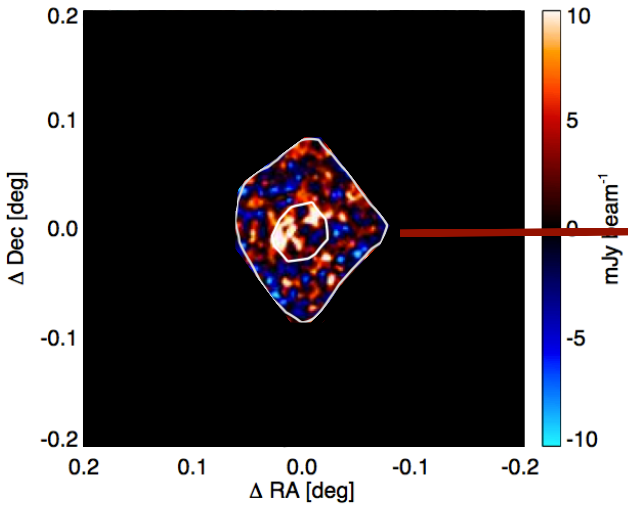






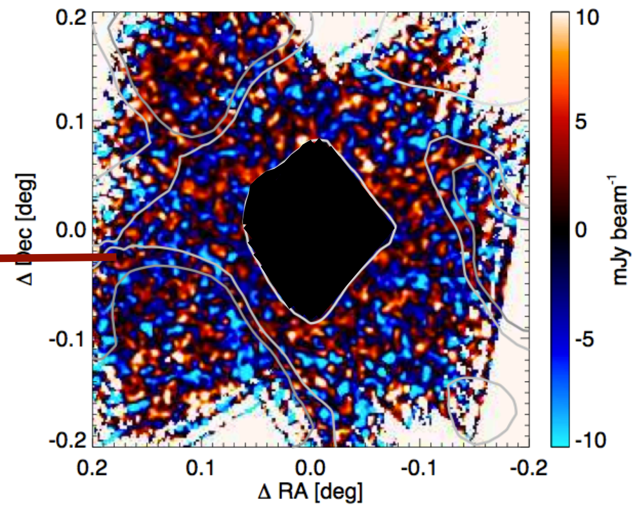


Herschel Follow-up



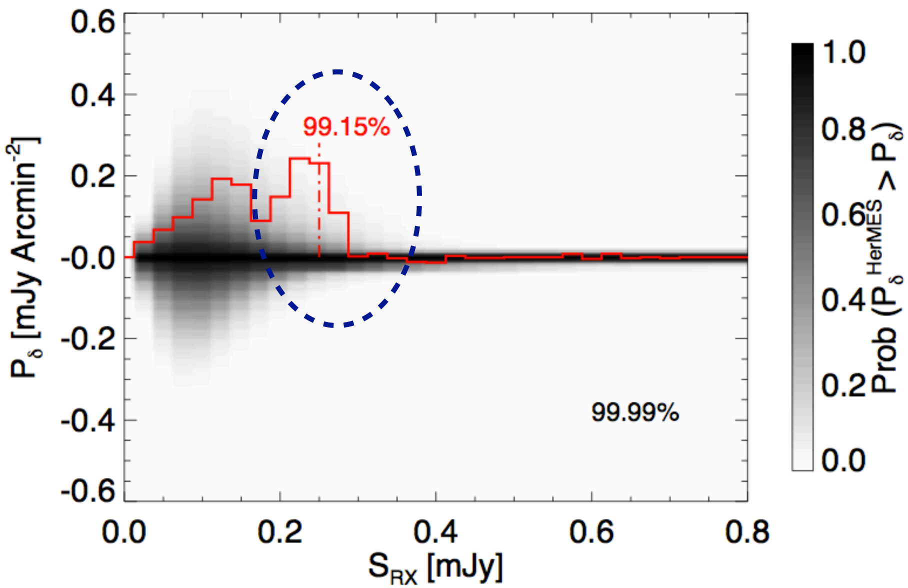
Differential pixel histogram analysis

$$\underbrace{P_{peak}(D) \; - \; P_{bkg}(D)}_{P_{\delta}(D)}$$



Comparison with the same kind of statistics randomly taken inside Hermes Fields ($74 deg^2$)

Oliver et al. (2012)

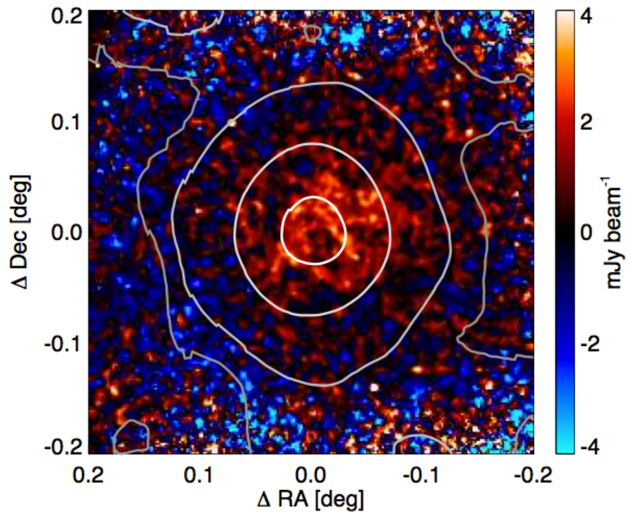


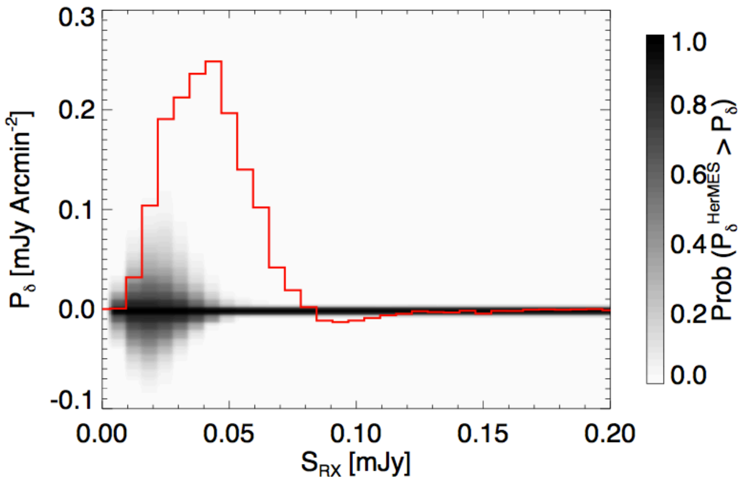
Overdensity of Red Excess at largest fluxes

Probability to find such an overdensity is lower than 10^{-4}

Herschel Follow-up

Stacking of the
29 available
red excess maps





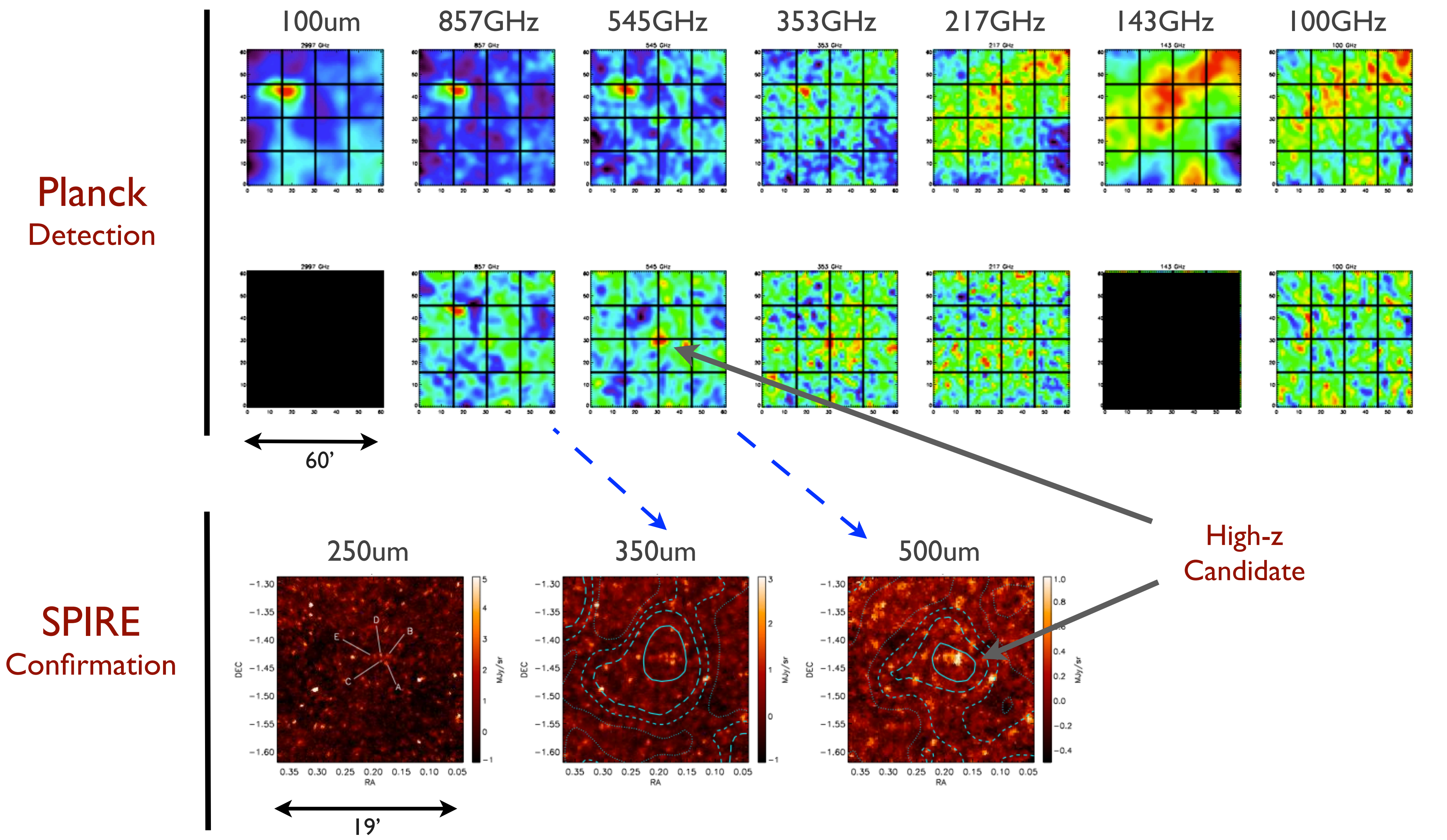
What do we learn from Herschel ?

- ~80% of the *Planck* candidates detected at 5' are confirmed at 30' resolution
- Presence of significative red excess at 500μm compared to Hermes fields.

- A few show single sources.
- The others are overdensities of red sources => proto-cluster candidates ?

- But should it be chance alignment ?
- Are those structures linked ?
- What is the redshift of such structures ?

A new *Planck* High-z candidate

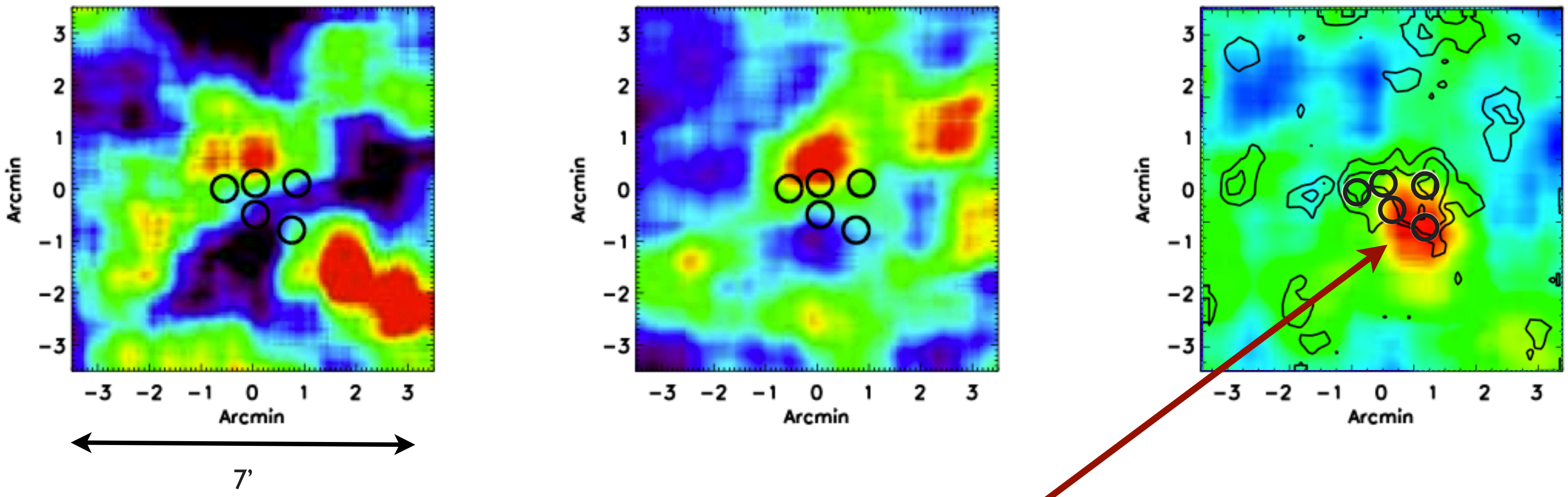


A new *Planck* High-z candidate

Evidence of an overdensity at high-z

CFHT Follow-up in i,g,J,H.,K bands (PI Nesvadba)

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

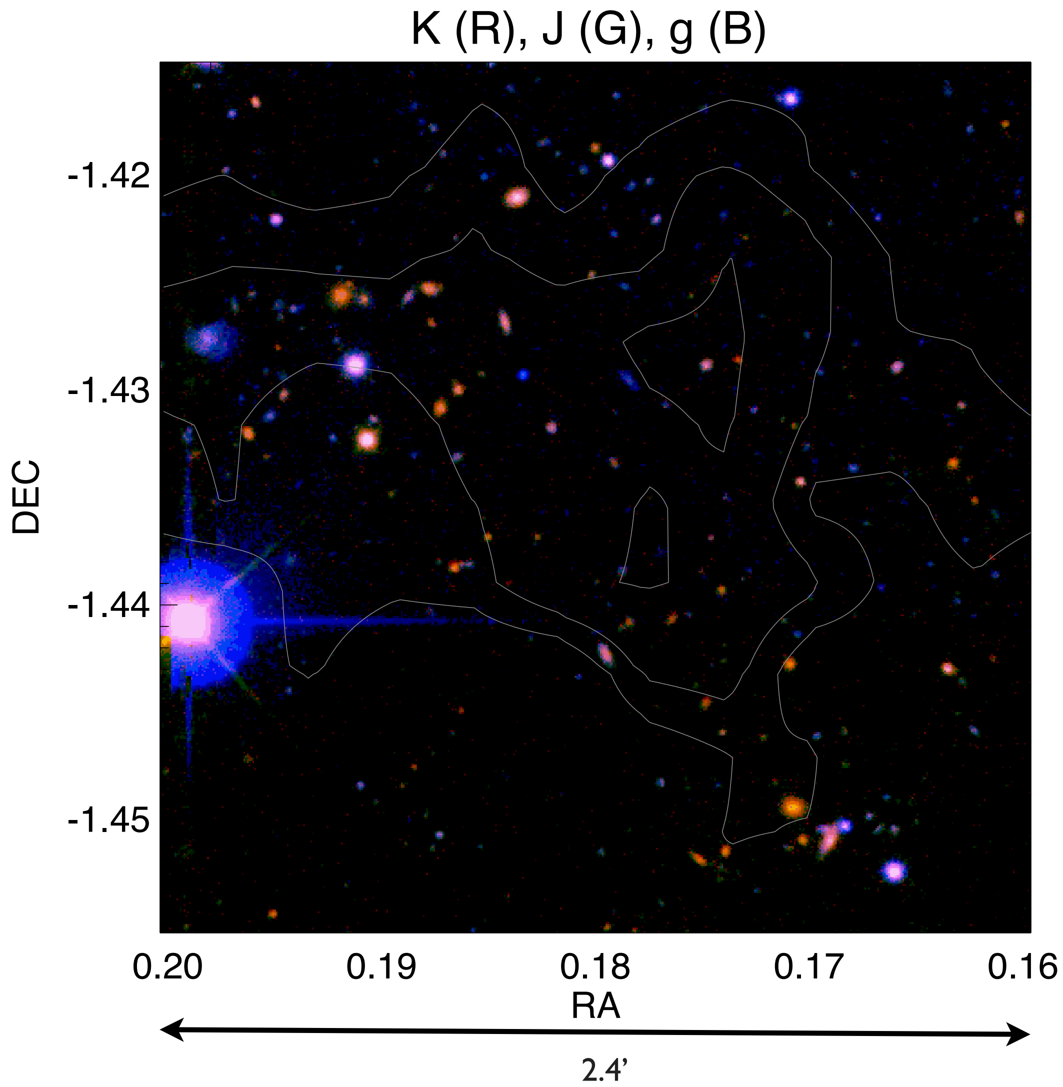


Overdensity
of sources in J-K > 1.5

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

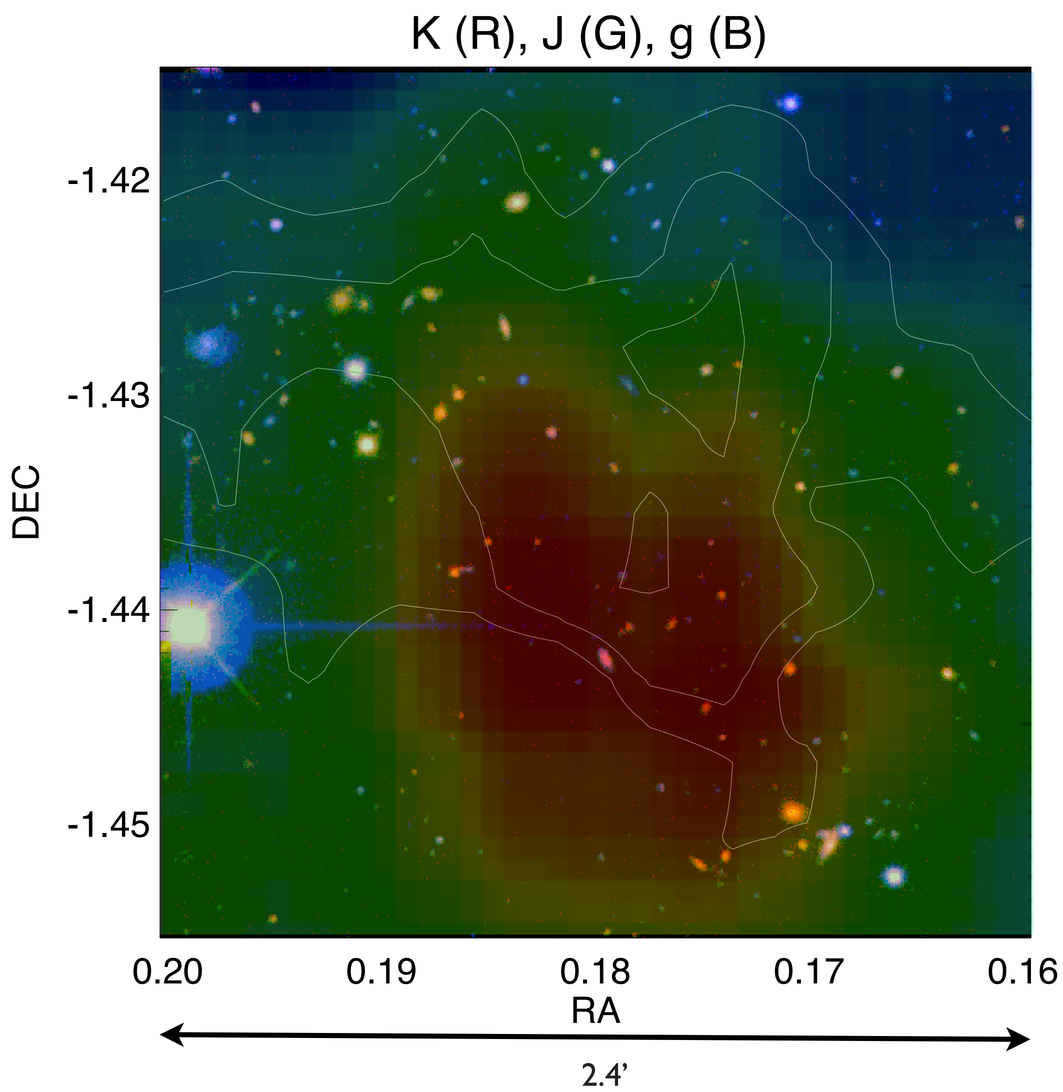
A new *Planck* High-z candidate

Optical / NIR image



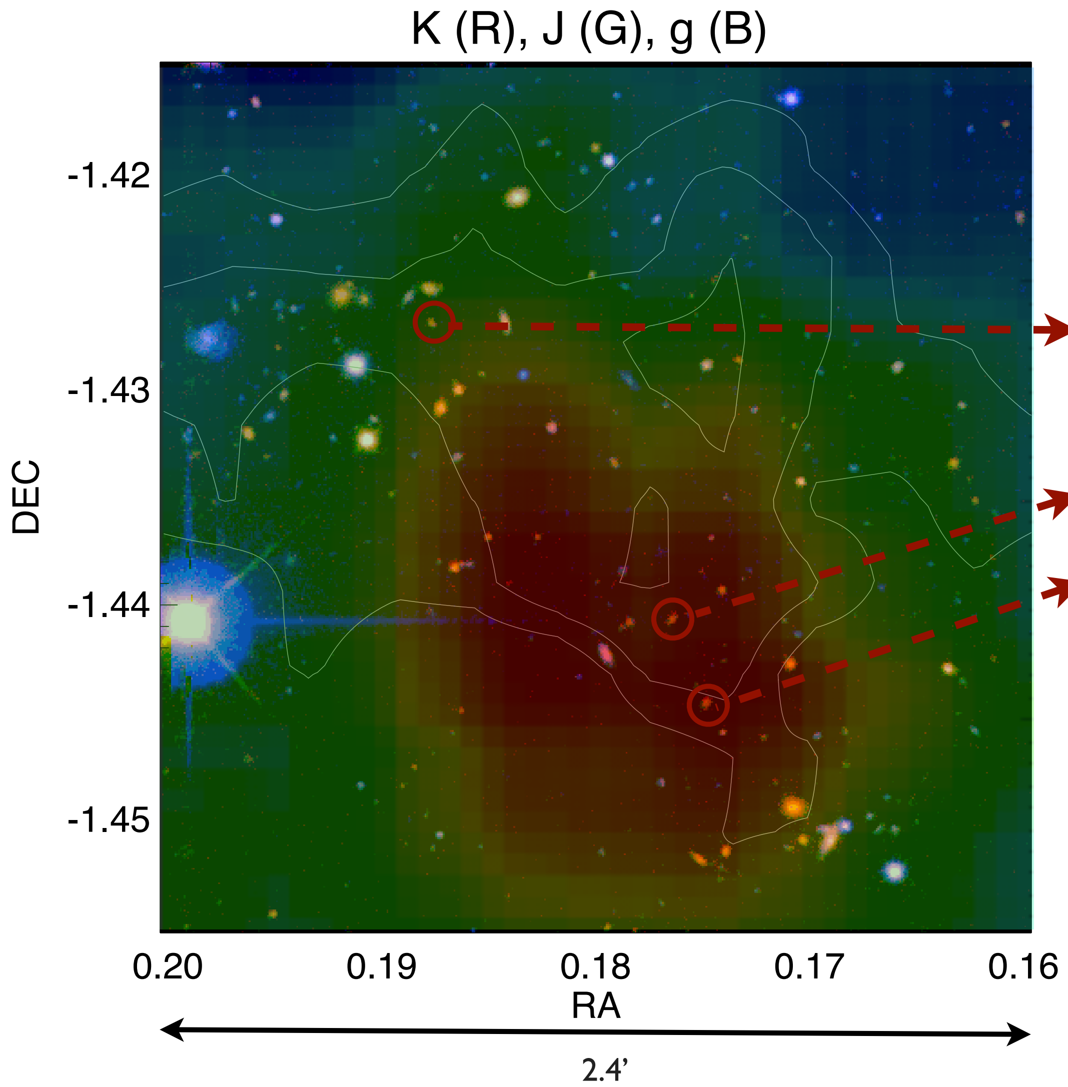
A new *Planck* High-z candidate

Optical / NIR image



A new *Planck* High-z candidate

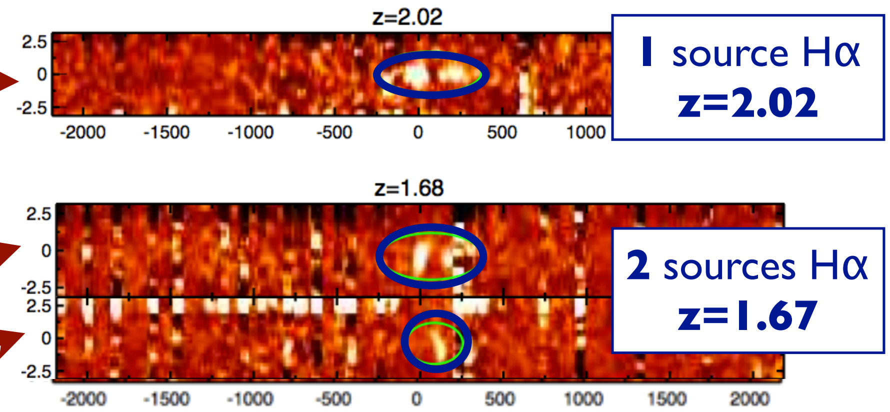
Spectroscopic Redshift Estimate



VLT XSHOOTER Follow-up: (PI Nesvadba)

Observed between 300-2500 nm

XSHOOTER 2D Spectra



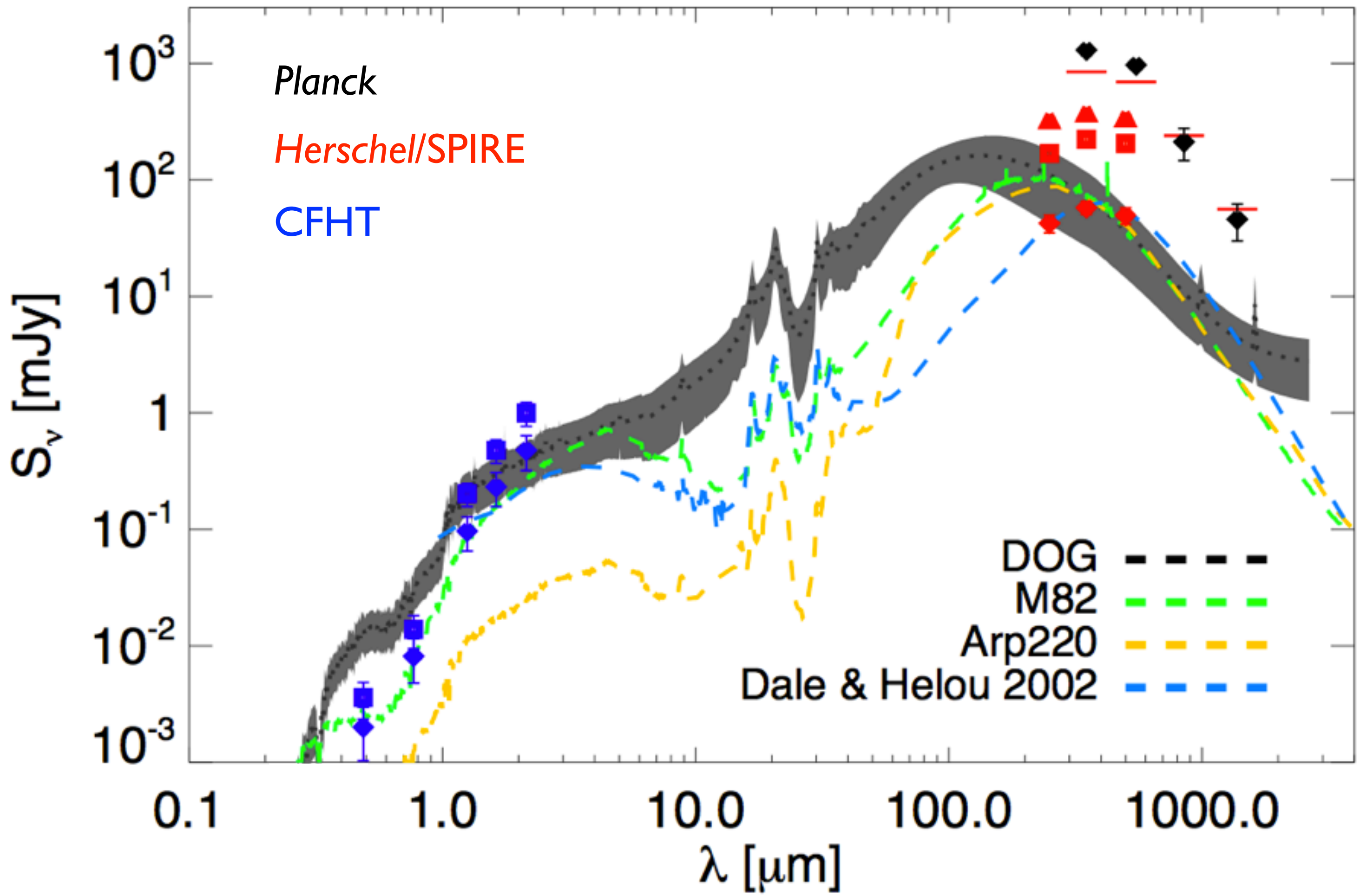
zeroth order properties:

Virialized DM halo Mass ~ $1.3 \times 10^{13}\ M_\odot$

SFR > 60 $M_\odot$/yr per galaxy

A new *Planck* High-z candidate

Towards a Synthetic SED



Issue with beam dilution
Planck : 5'
Herschel : 36''
CFHT : 1''

Further spectroscopic observations in progress

A new *Planck* High-z candidate

Prospectives with X-ray

zeroth order predictions:

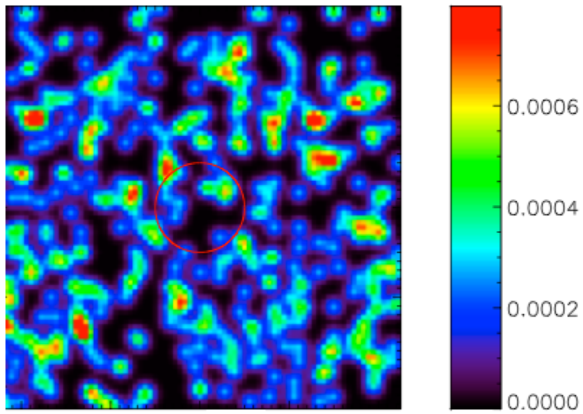
L_X-Mass scaling relation => $L_X \sim 10^{43}$erg/s

(Pratt et al. 2009
Reichert et al. 2011)

L_X-T_X scaling relation => $T_X \sim 1.2$keV

(Maughan et al. 2011)

No evidence for counterparts in ROSAT →



Given its SFR, L_X and T_X:

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

Take away points

Planck is unique:

- All-sky Blind, Multi-Wavelength, Multi-Scale detection algorithm.
- Provides list of a few 100s of high-z candidates at z>1.5
- < 5% already included in the *Planck* Legacy Catalogues (ERCSC)

- A few candidates already confirmed on pilot programs:
  - 80 % of 29 *Herschel*/SPIRE follow-ups are red overdensities
  - 1 proto-group/cluster candidate at z =1.67

.. and Follow-up are crucial:

- Optical + Submm Follow-ups are required to confirm/identify sources:
- Redshift estimates are the key issue for science analysis
- Large Follow-Up Programs are planned / on-going:

  (*Herschel* / SCUBA2 / CFHT / Hawk-I / Spitzer / IRAM / XSHOOTER)

More to come:

- *Planck* collaboration paper on those first candidates very soon.
- *Planck* high-z candidates catalogue delivered by mid 2013.

Acknowledgements

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