



# The *Planck* catalogue of high- $z$ source candidates PHz

L. Montier

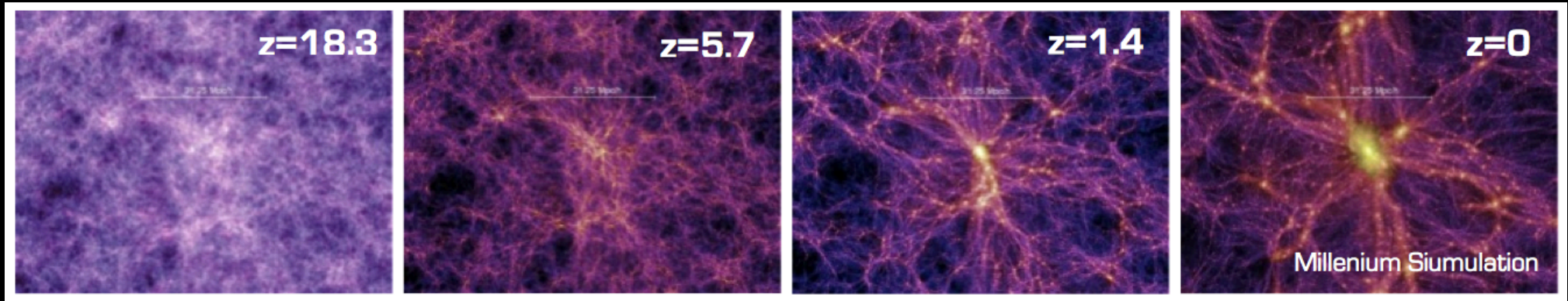


*on behalf on the Planck Collaboration*



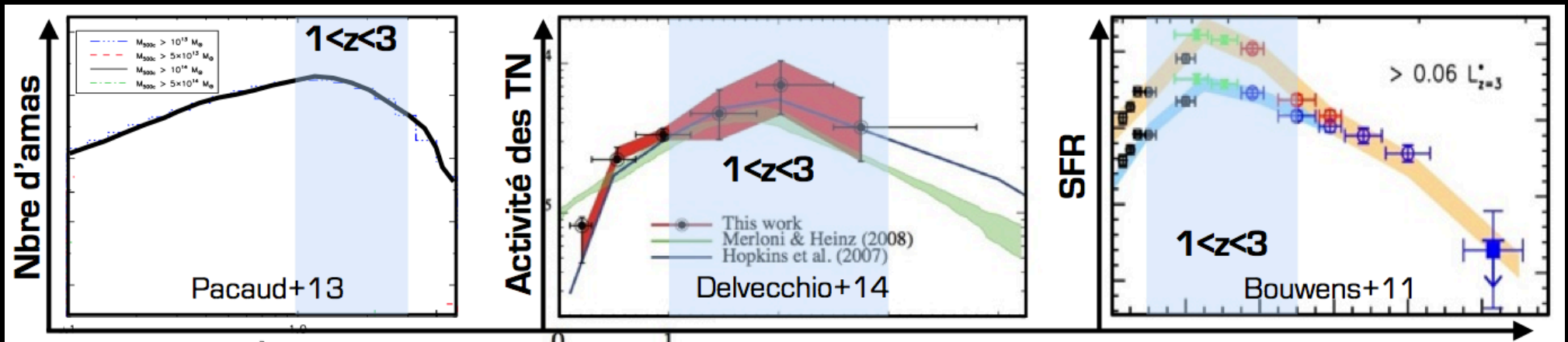
# Context

## The formation of large scale structures



Structures form from initial fluctuations of the density field via a hierarchical process

The formation of the largest halo(groups and clusters of galaxies) is concomitant to the maximum of SFR in galaxies and peak of BH activity





# Context

## Detections of galaxy clusters

### Via the hot gas:

- X-ray emission
- SZ signature



Tracing virialised structures  
 $z < 1.5$

Planck Collab. 2013, 2014

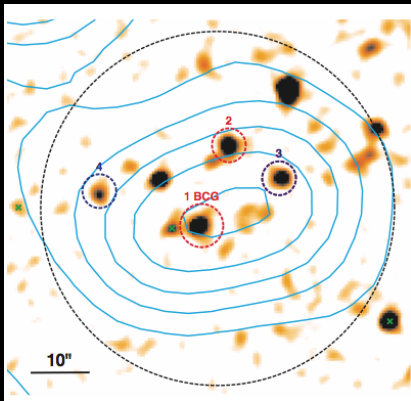
### Via the emission from galaxies:

- Optical+nIR
- IR (SPITZER, Herschel)
- mm/sub-mm
- CO emission

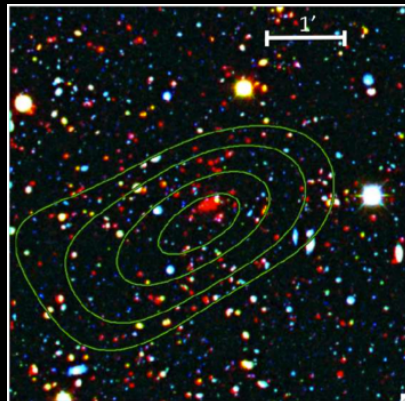


Biased towards radio / AGN  
target sources

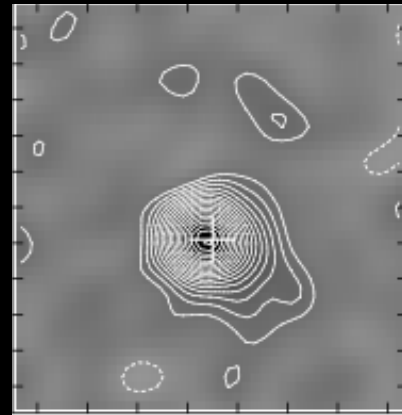
Small deep fields



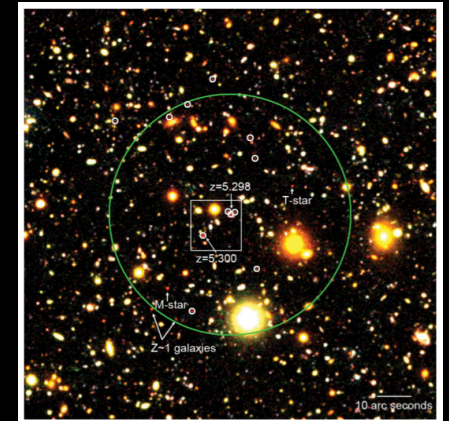
Fassbender et al. (2010)  
 $z=1.56$



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



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



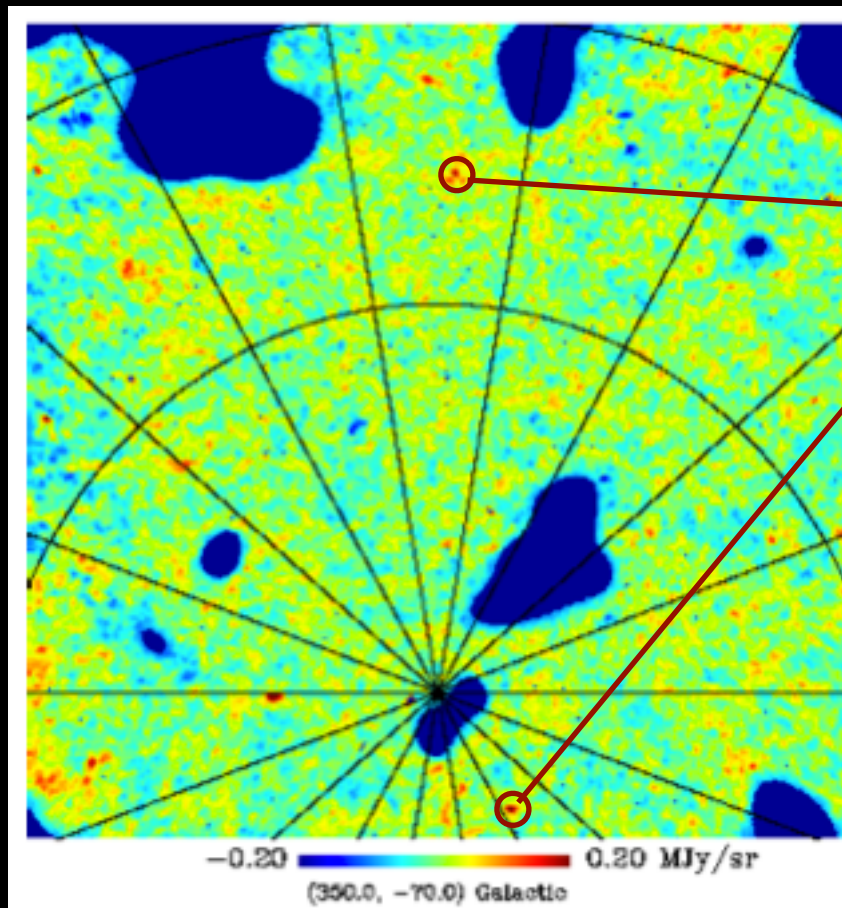
Çapak et al. (2011)  
 $z=5.3$



# Context

## Planck's uniqueness

Detection of the submm dust emission from high- $z$  galaxies embedded in the CIB emission to track proto-cluster candidates



'Red'  
clumps  
 $\sim z > 1.5$

Large Structures  
Alignment ?

Lensed  
ULIRGS ?

Proto  
Clusters ?

Beam of  
8' at  $z=2$



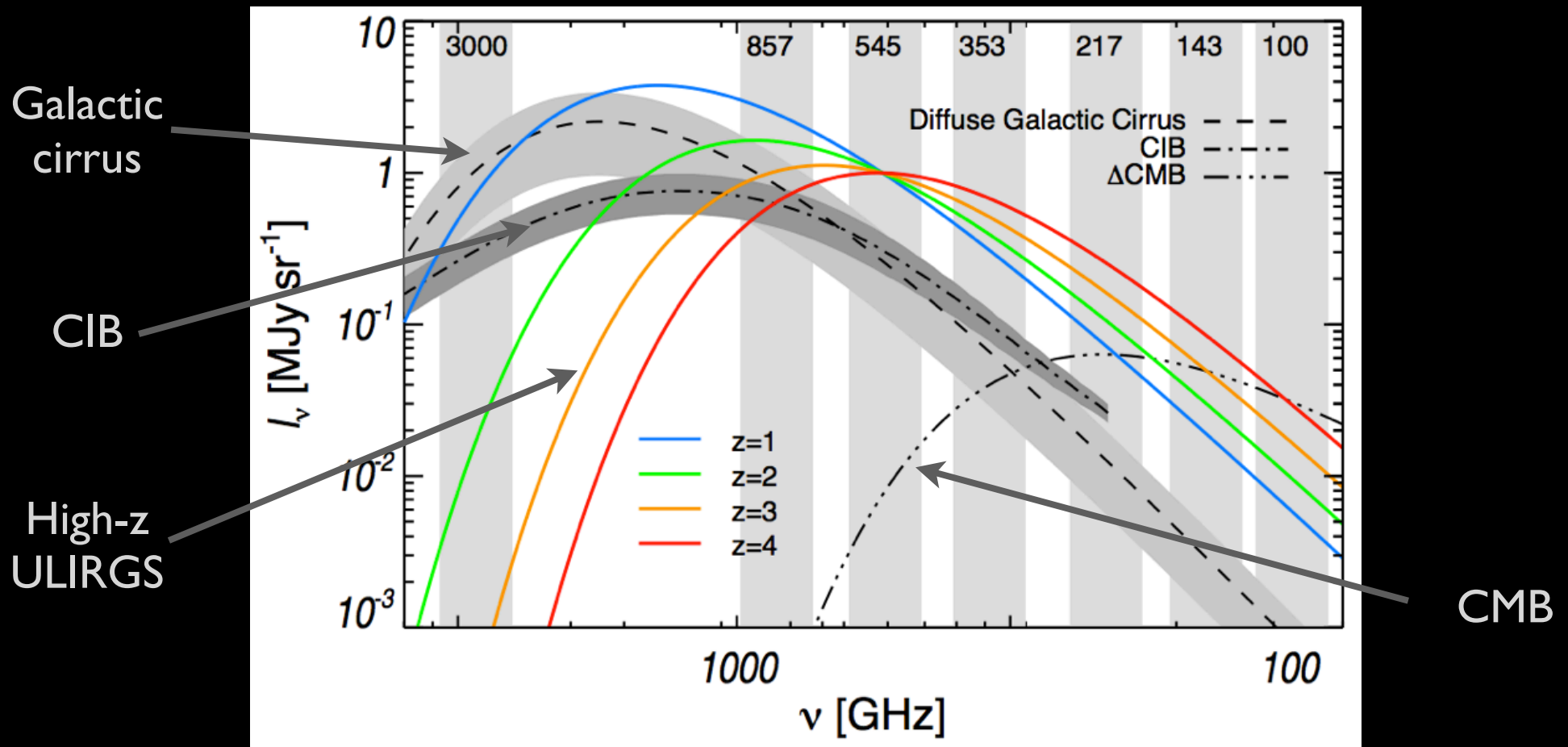
Comoving  
Size of  
 $\sim 4$  Mpc



# The *Planck* submm detection method

## Component separation

Combine the *Planck*/HFI highest bands with the IRAS 3THz band

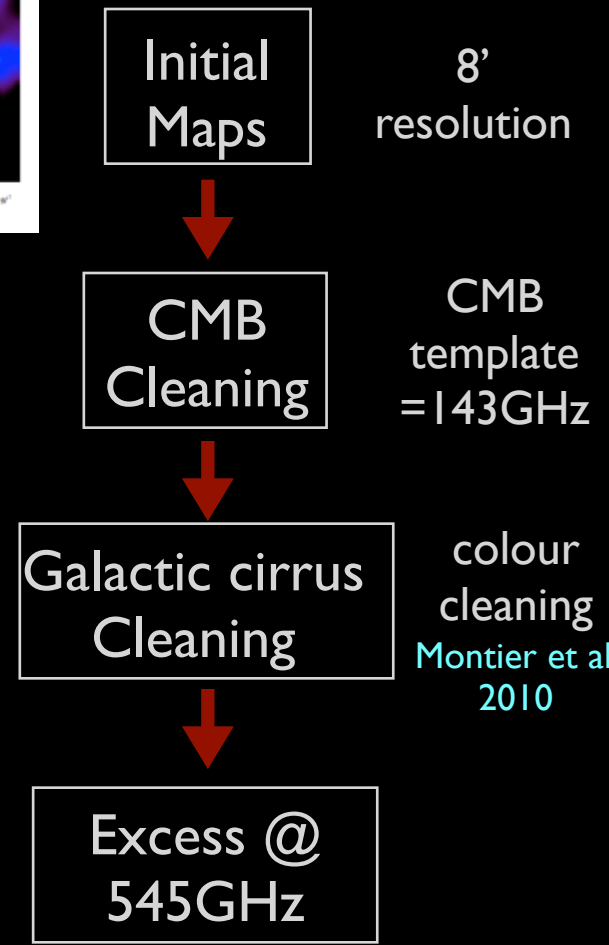
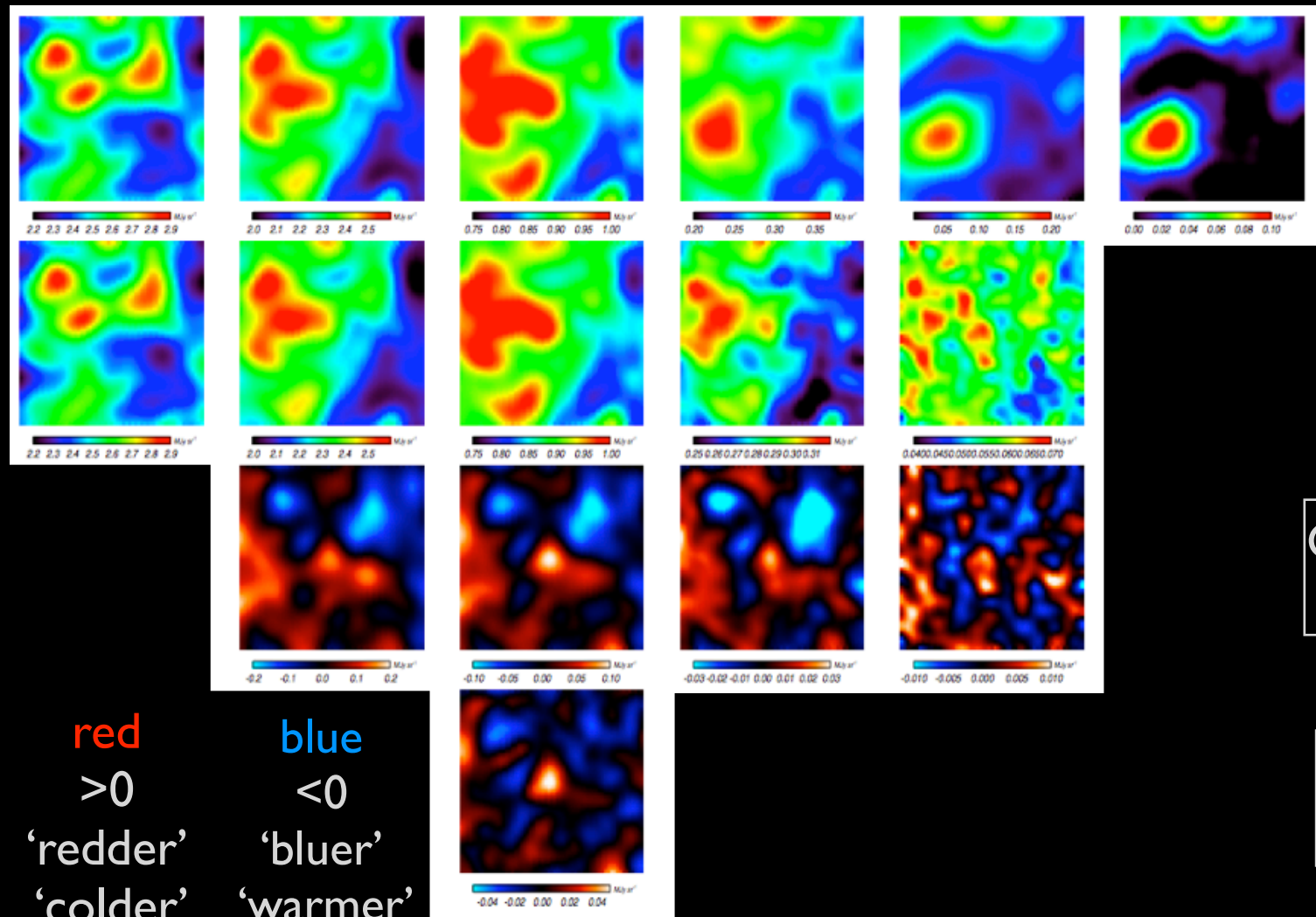




# The *Planck* submm detection method

## Component separation

3THz    857GHz    545GHz    353GHz    217GHz    143GHz





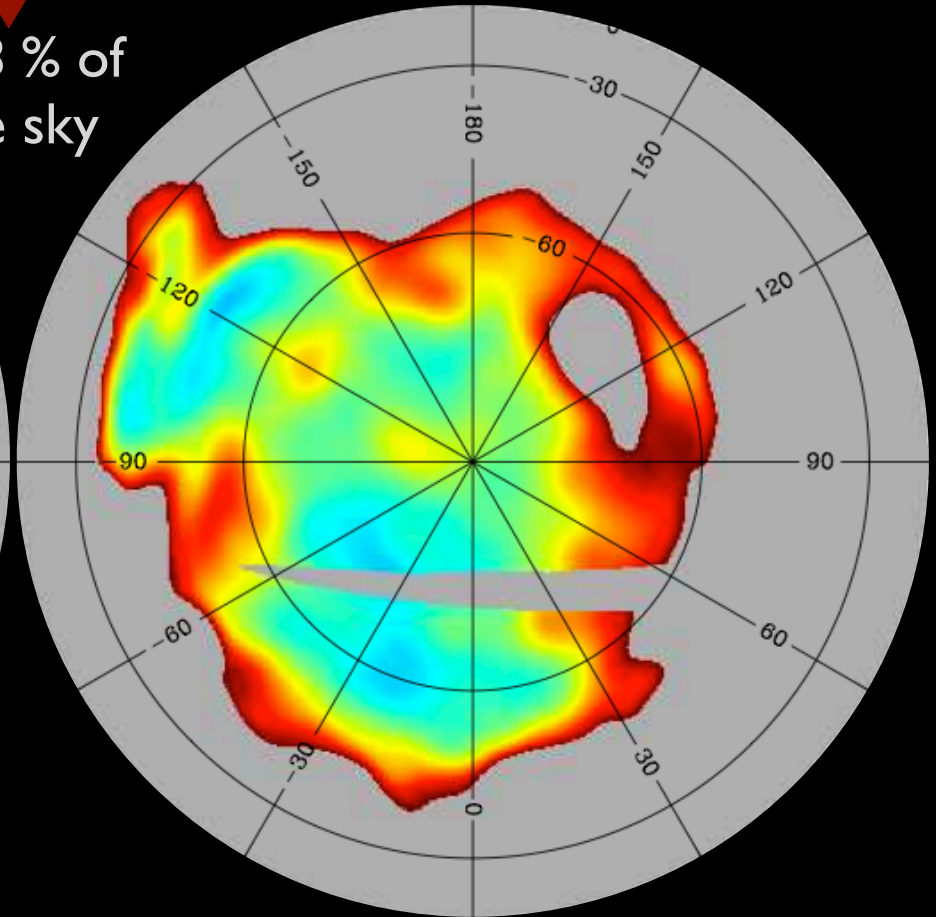
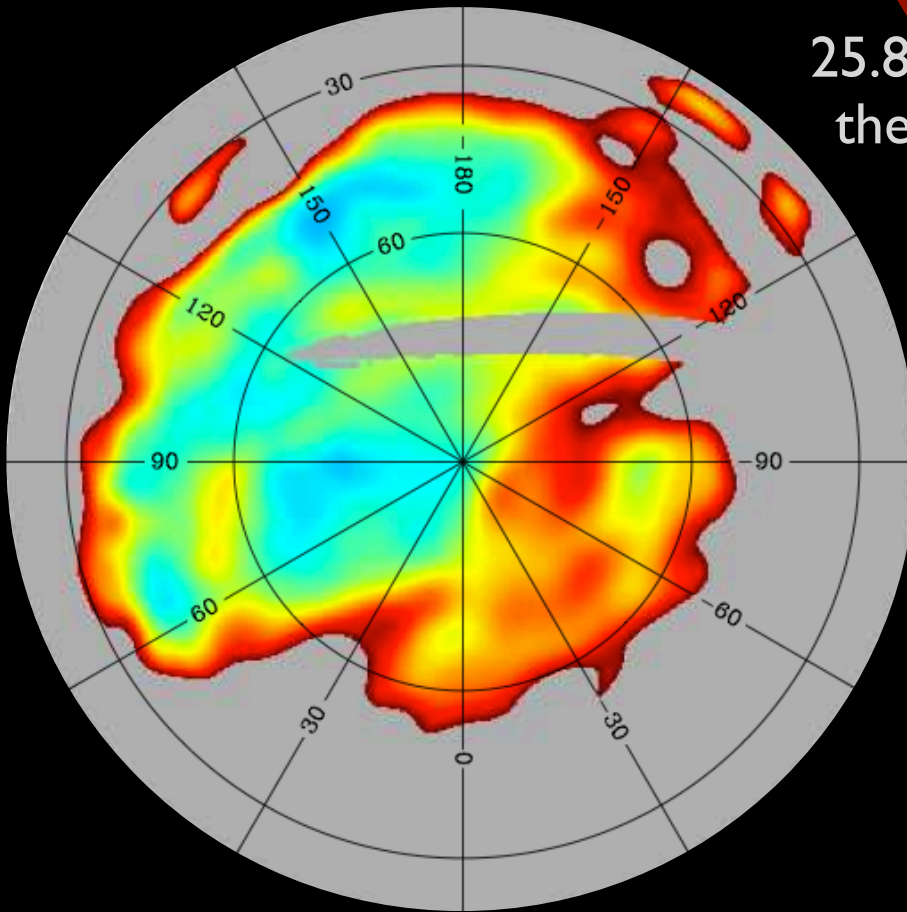
# The *Planck* High-*z* Candidate Catalogue

## Mask

Based on Galactic Extinction:  
 $N_{\text{H}2} < 3 \times 10^{20} \text{ cm}^{-2}$

Planck Collab  
2013

25.8 % of  
the sky



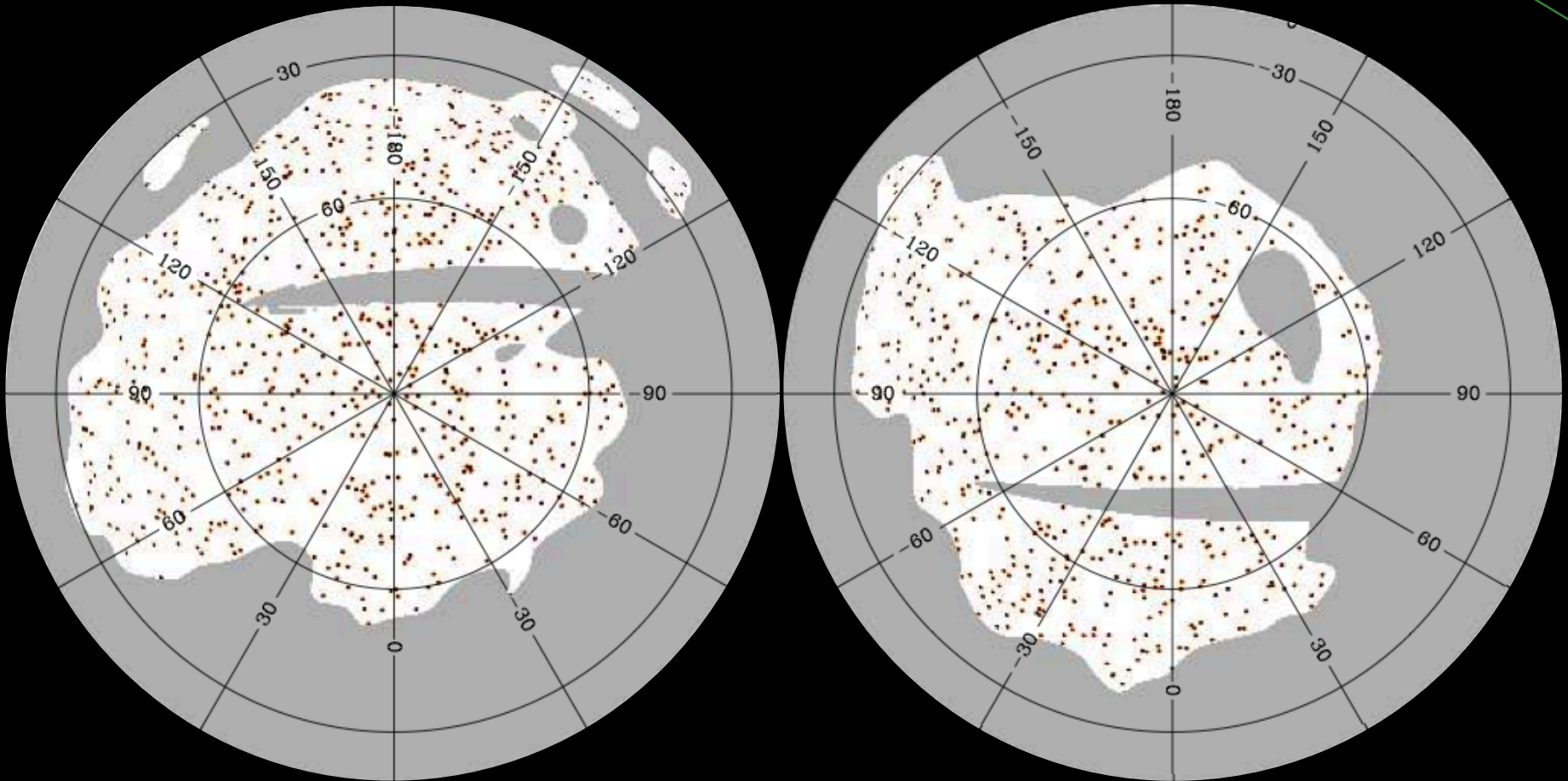


# The *Planck* High-*z* Candidate Catalogue

The *Planck* high-*z* candidates

1261 sources

Preliminary





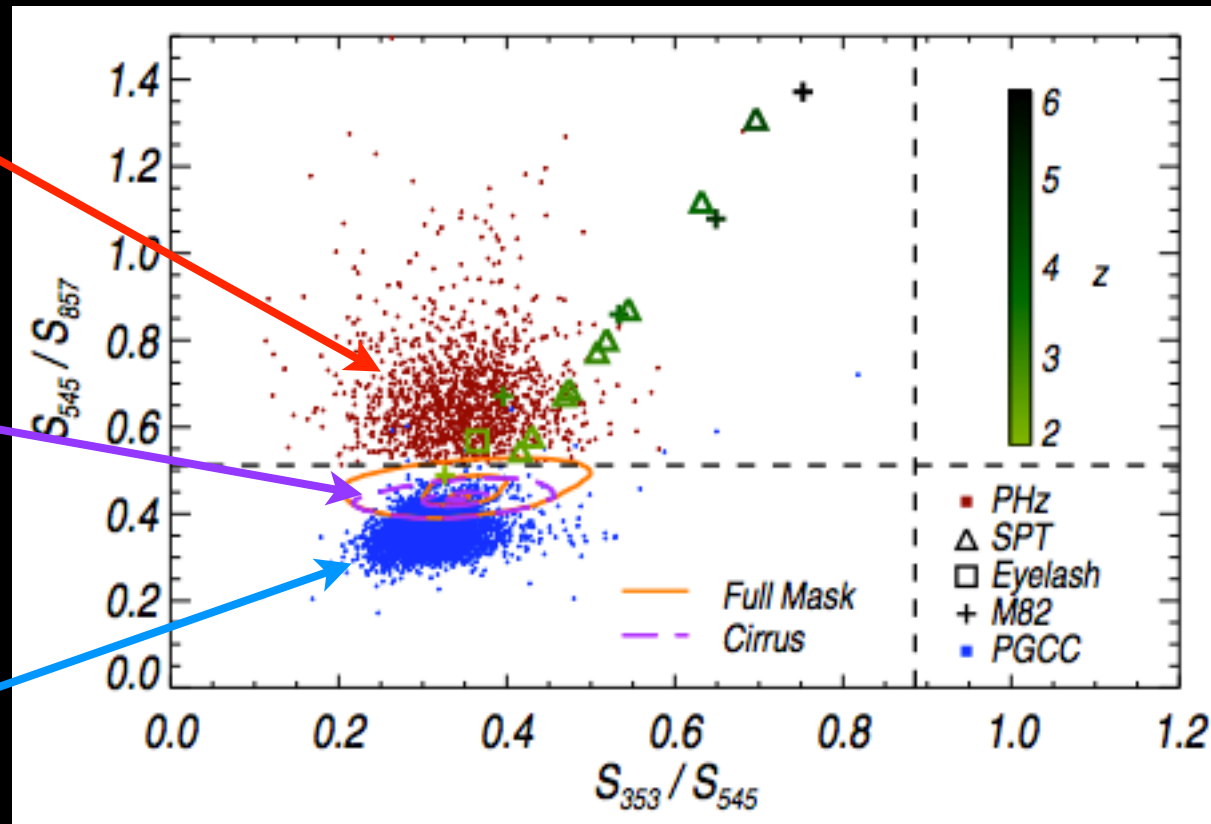
# The *Planck* High-*z* Candidate Catalogue

## Colour-Colour Selection

PHz  
Candidates

Galactic  
Cirrus

Galactic  
Cold Clumps  
Sources



Preliminary

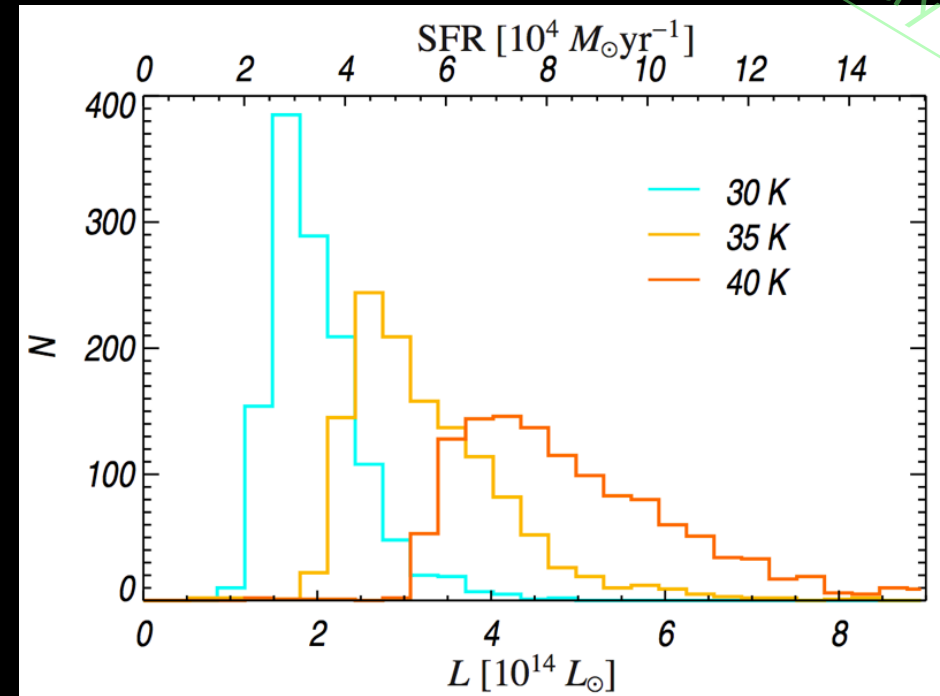
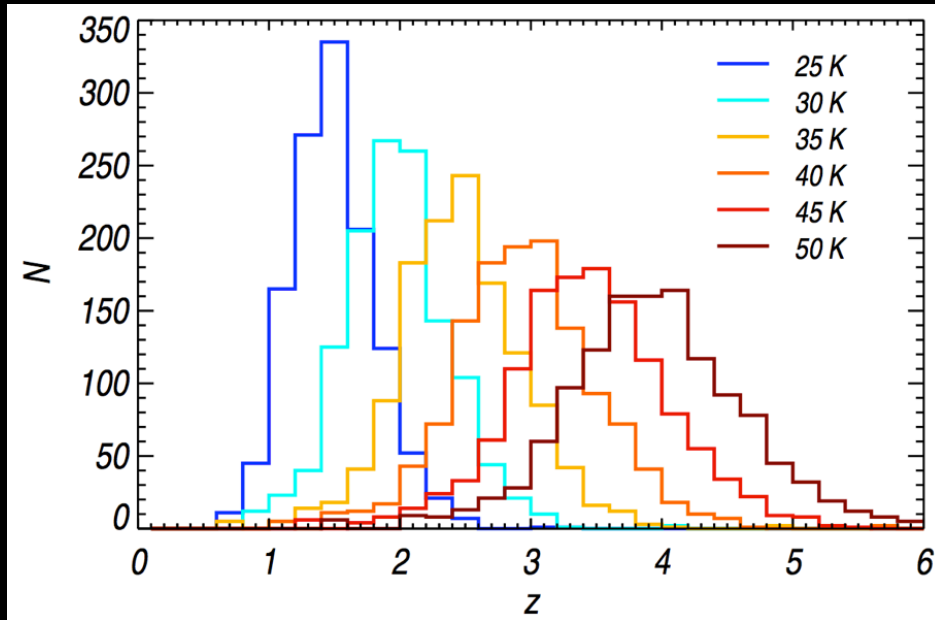
PHz candidates are well distinguished from Galactic cirrus and Galactic cold clumps and mostly compatible with high-*z* sources



# The *Planck* High-*z* Candidate Catalogue

## Physical Properties

Preliminary



For a typical temperature  $T = 35\text{K}$  :

*z* : 1.5 - 3.5

LFIR :  $2 - 4.5 \times 10^{14} L_{\odot}$

SFR :  $4 - 8 \times 10^4 M_{\odot} \text{yr}^{-1}$

Extremely luminous objects at  $z \sim 2-3$   
with strong star-formation rate !



# What are the *Planck* High-*z* candidates ?

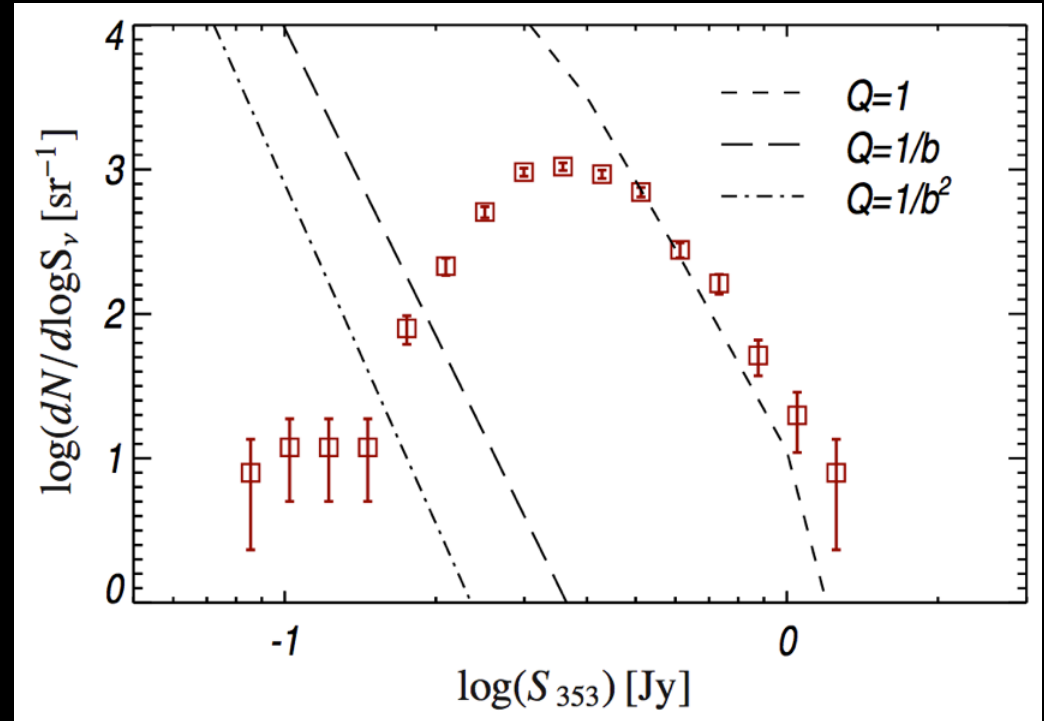
## Chance alignments

Preliminary

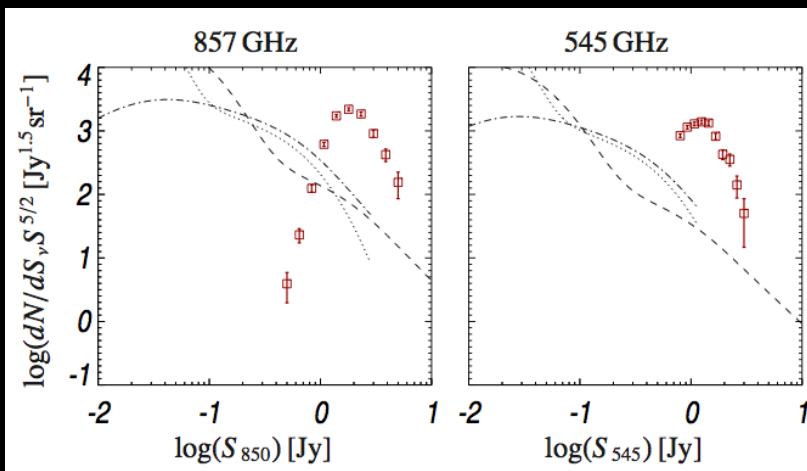
1261 sources over  
26% of the sky

0.12 sources deg<sup>-2</sup>  
at  $S_{545} > 800$  mJy

Too large to be explained by  
point sources  
continuous distribution



Number counts at 353GHz  
compatible with predictions of  
proto-cluster counts



(Negrello et al. 2005)



# What are the *Planck* High-*z* candidates ?

## Follow-up observations

*Herschel* / SPIRE

(Planck Int. XXVII 2014)

OT-1

OT-2    Calls

HPASS



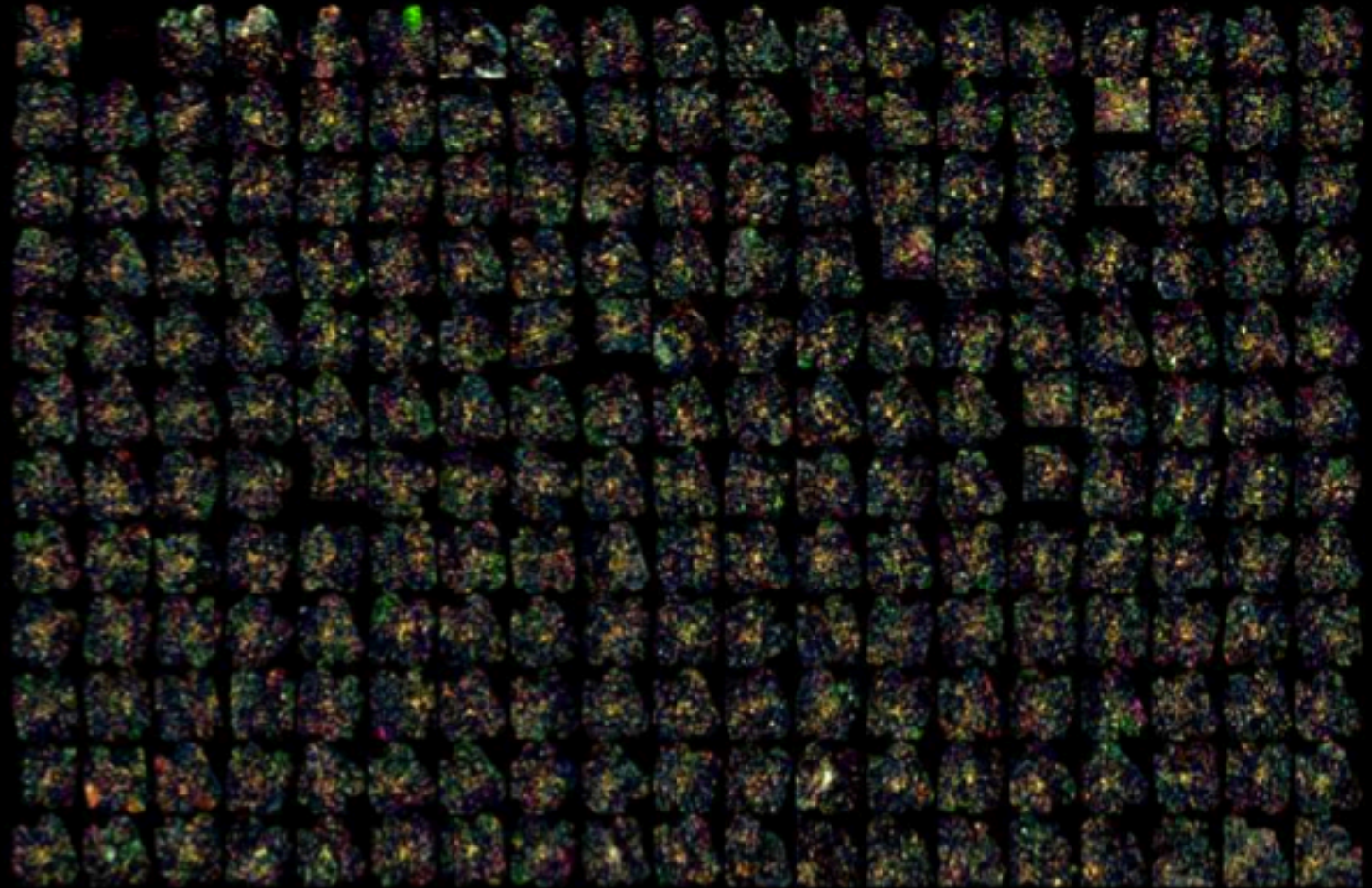
**204**

targets selected  
from previous  
versions of the  
*Planck* High-*z*  
Candidates  
Catalogue

+

**24**

sources from the  
PCCS 2013





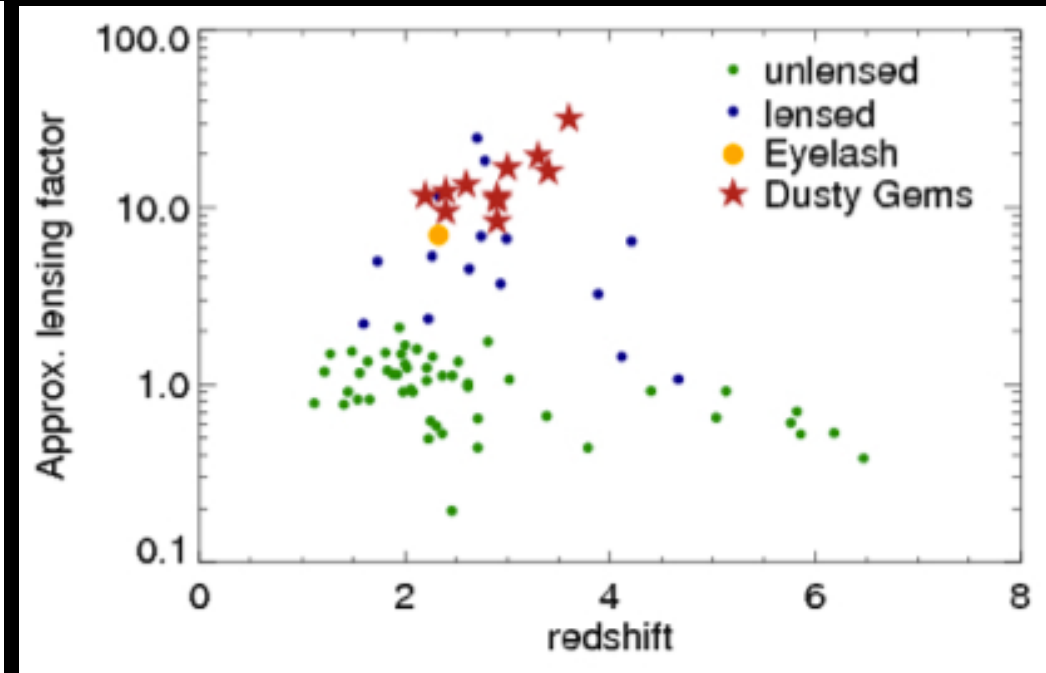
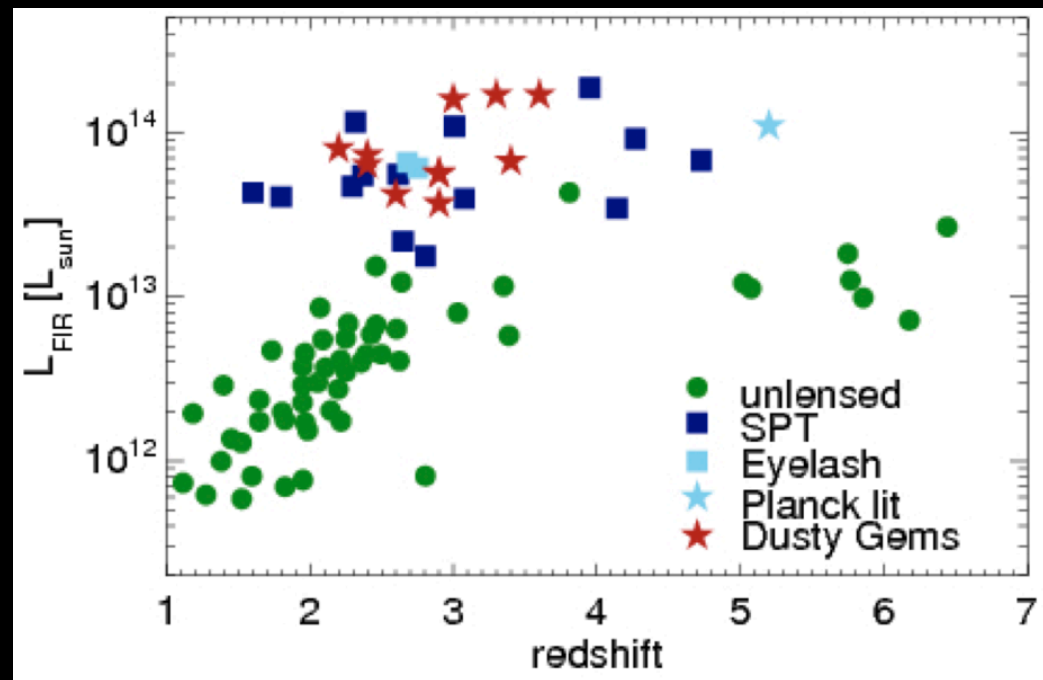
# What are the *Planck* High- $z$ candidates ?

## Follow-up observations

### *Lensed sources*

(Canameras et al. 2014, subm)

|| *Planck* discovered lensed at high redshift, spectroscopically confirmed ( $2.2 < z < 3.6$ )



*Planck* is able to detect the brightest ( $300 \text{ mJy} < S_{350 \mu\text{m}} < 1 \text{ Jy}$ ) high- $z$  lensed candidates over 26% of the sky



# What are the *Planck* High- $z$ candidates ?

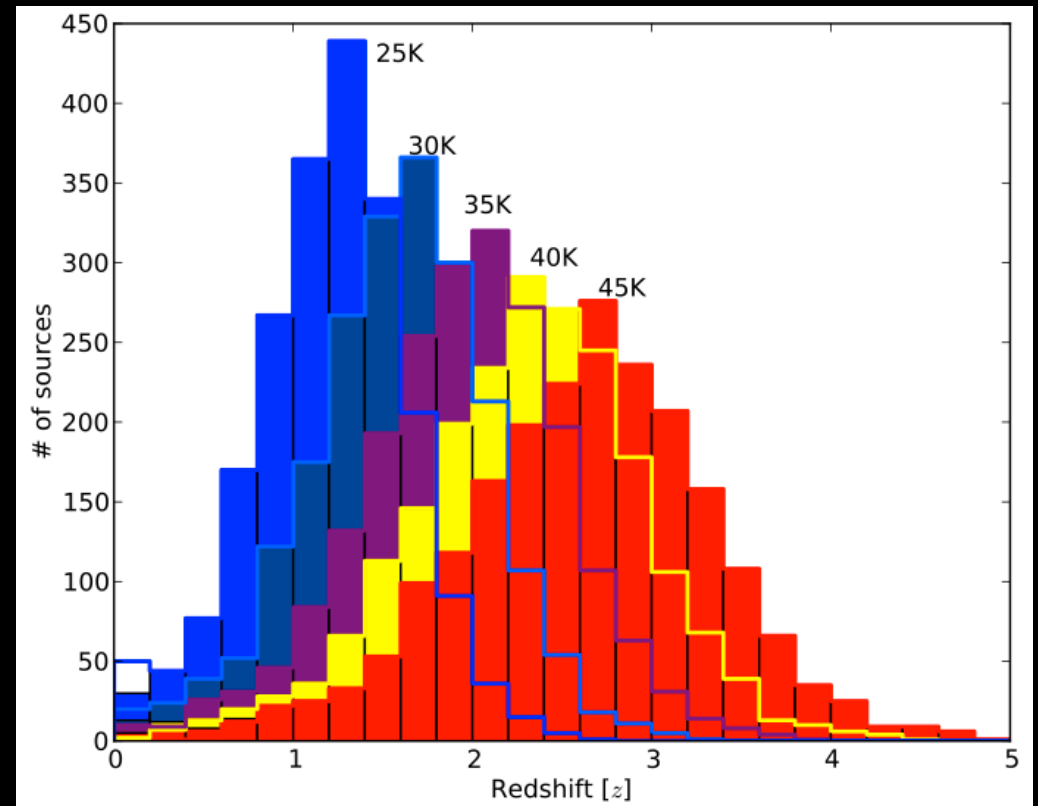
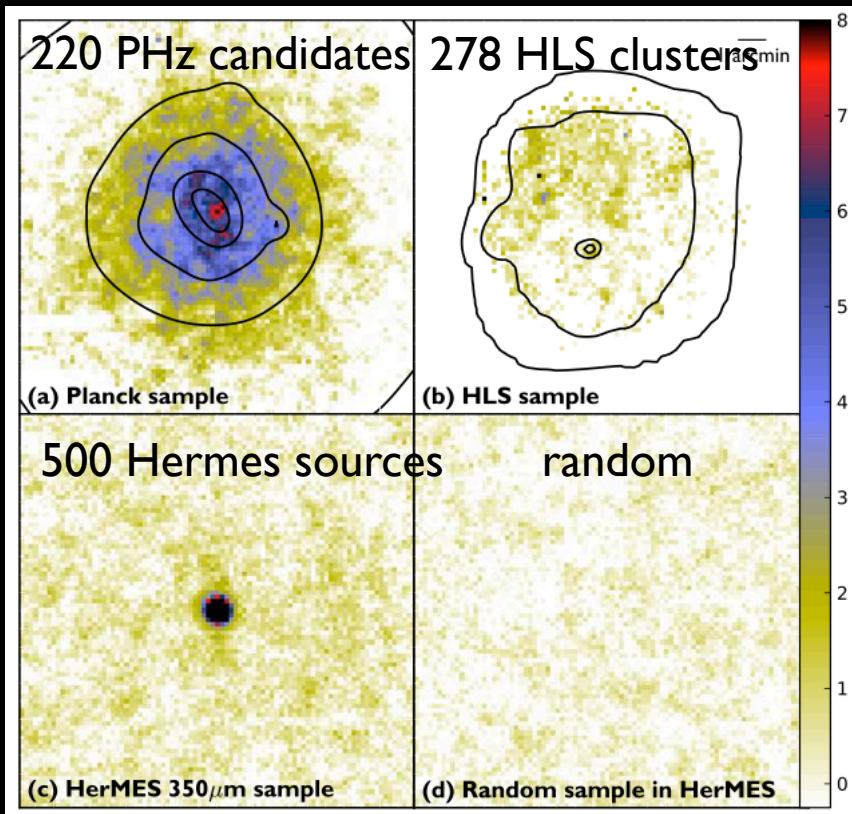
## Follow-up observations

*Herschel* red over-densities

(Planck Int. XXVII 2014)

Clustering observed by stacking

$z \sim 1 - 3$



95 % of the *Planck* high- $z$  candidates are red over-densities



# What are the *Planck* High-*z* candidates ?

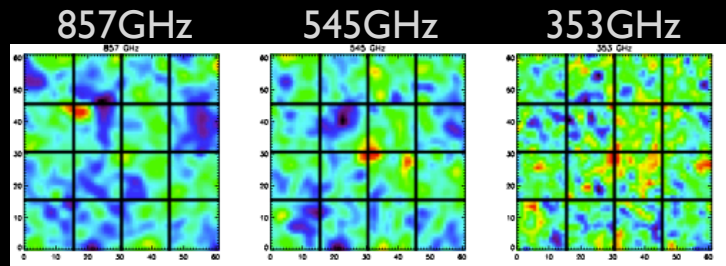
## Follow-up observations

### Proto-cluster

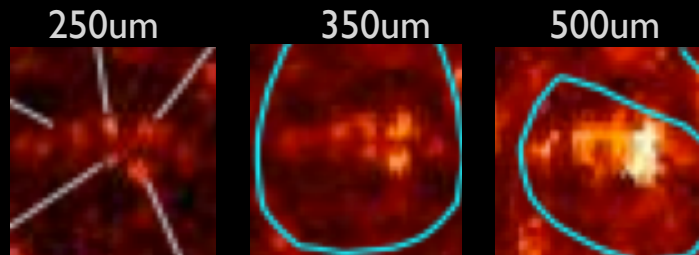
(Flores-Cacho et al. 2014, subm)

I *Planck* candidate confirmed to be a double structure at  $z=1.7$  and  $z=2.03$

*Planck*  
Detection



*Herschel*  
SPIRE



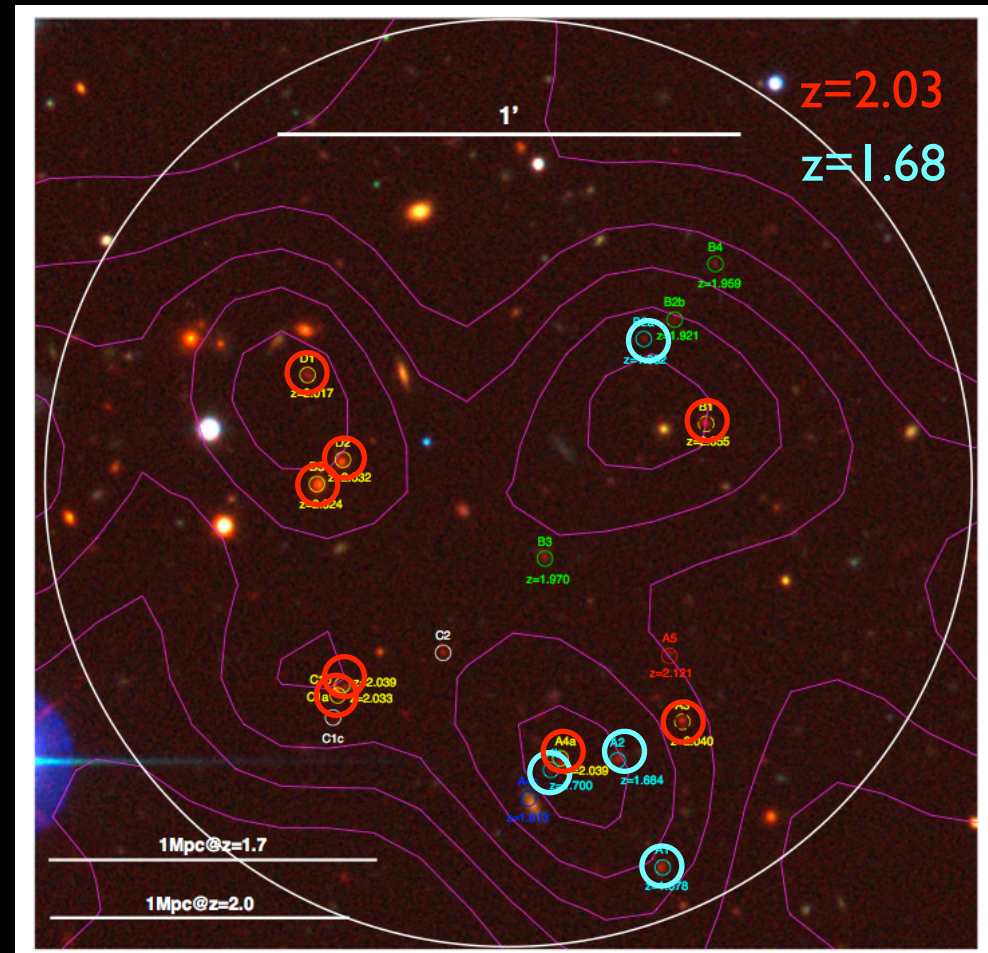
CFHT + Spitzer + VLT/XSHOOTER

Size  $\sim 1-2$  Mpc

SFR  $\sim 2 - 3 \times 10^3 M_{\odot} \text{yr}^{-1}$

$M \sim 4-5 \times 10^{14} M_{\odot}$

Consistent with  
previous estimates  
of proto-clusters





# Take-Home Messages

Preliminary

## *The PHz candidate catalogue is unique:*

- Blind, Multi-Wavelength detection algorithm over 26% of the sky
- 1261 candidates of high- $z$  sources at  $z > 1.5$
- Fully original catalogue (<1% included in the PCCS)
- Likely multi-objects structures
- Strong Luminosities and SFR
- A few candidates already confirmed on pilot programs:
  - 11 strongly lensed dusty star-forming galaxies at  $z = 2.2 - 3.6$
  - 95 % of 228 *Herschel*/SPIRE follow-ups are red overdensities
  - 1 proto-group/cluster candidate: two structures at  $z = 1.68$  &  $2.03$

## *.. and Follow-ups 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)



# Thank you

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.

