The *Planck* list of high-z source candidates PHZ

Ludovic Montier

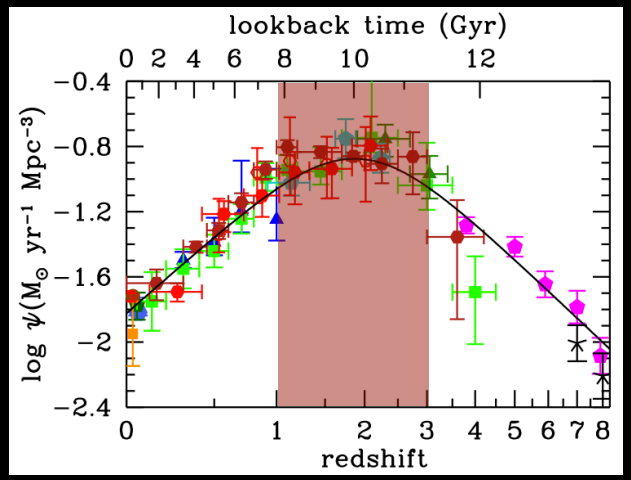
irap

on behalf on the Planck Collaboration

Context

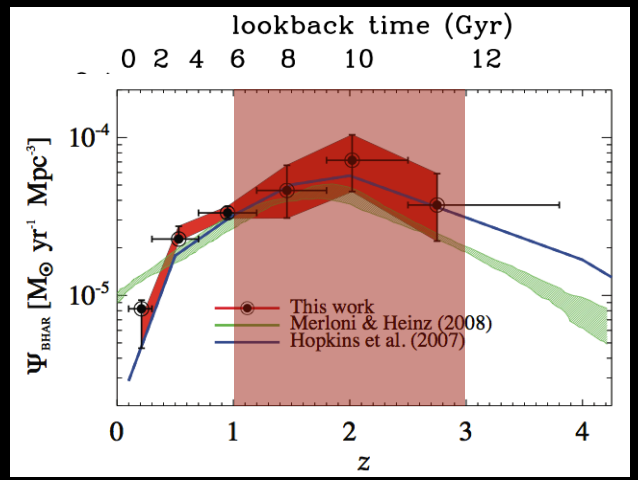
Tracking the formation of large scale structures

Star Formation Rate



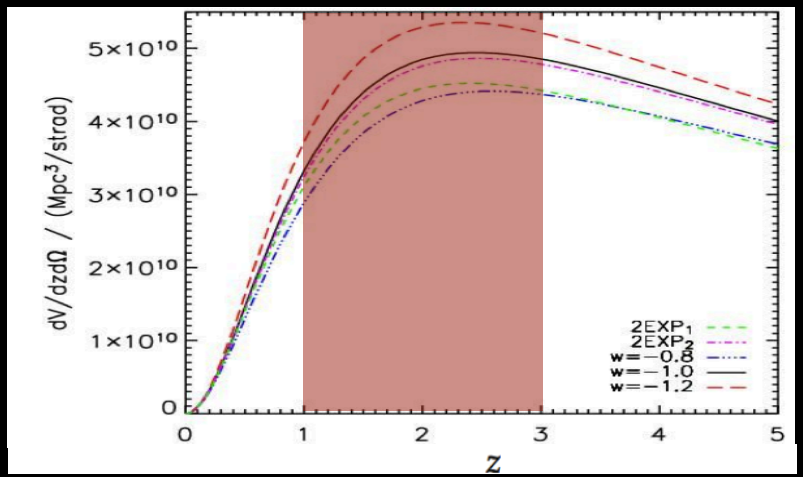
Madau & Dickinson (2014)

Black Hole Activity



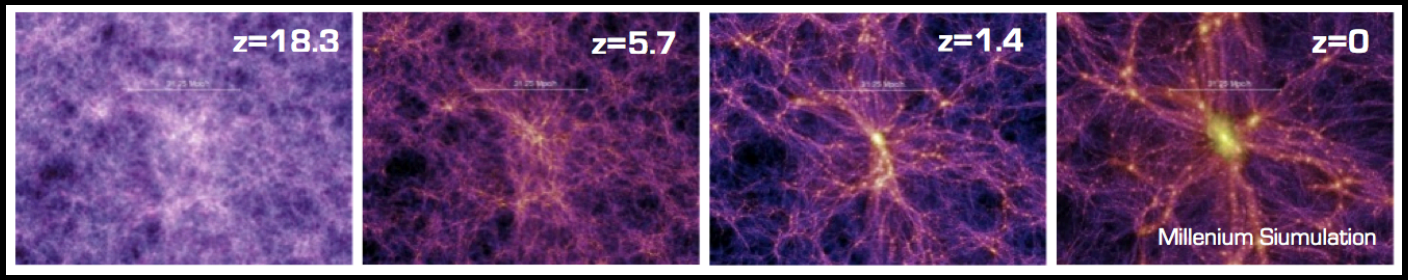
Delvecchio et al. (2014)

Formation of largest Halos



Nunes et al. (2009)

Tracing the Large Scale Structures taking advantage of the peak of SFR around z=2 by looking at the FIR dusty star-forming galaxies emission



Context

How to detect galaxy clusters at high z ?

Via the hot gas:

- X-ray emission
- SZ signature

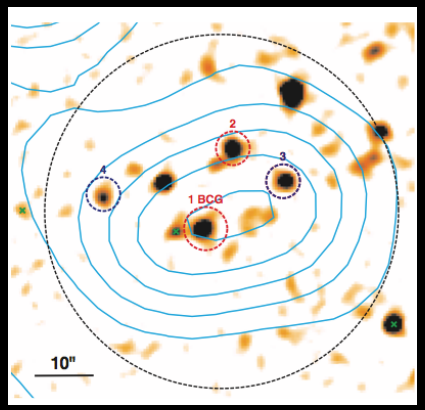
→ Tracing virialised structures
z < 1.5
Planck Collab. 2013, 2014

Via the emission from galaxies:

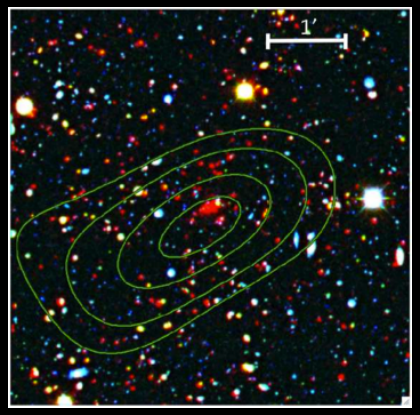
- Optical+nIR
- IR (SPITZER, Herschel)
- mm/sub-mm
- CO emission

→ Biased towards radio / AGN target sources

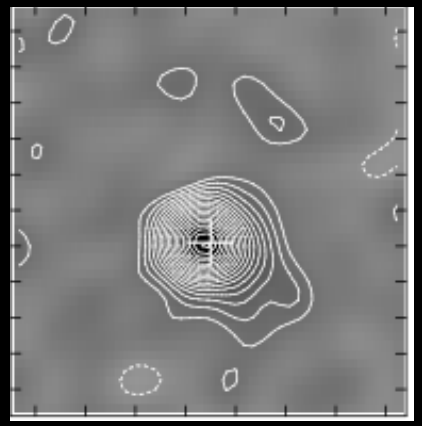
Small deep fields



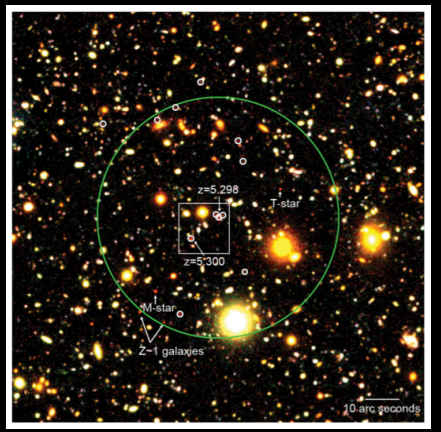
Fassbender et al. (2010)
z=1.56



Brodwin et al. (2012)
z=1.75



Carilli et al. (2011)
z=4.05



Çapak et al. (2011)
z=5.3

The *Planck* submm detection method

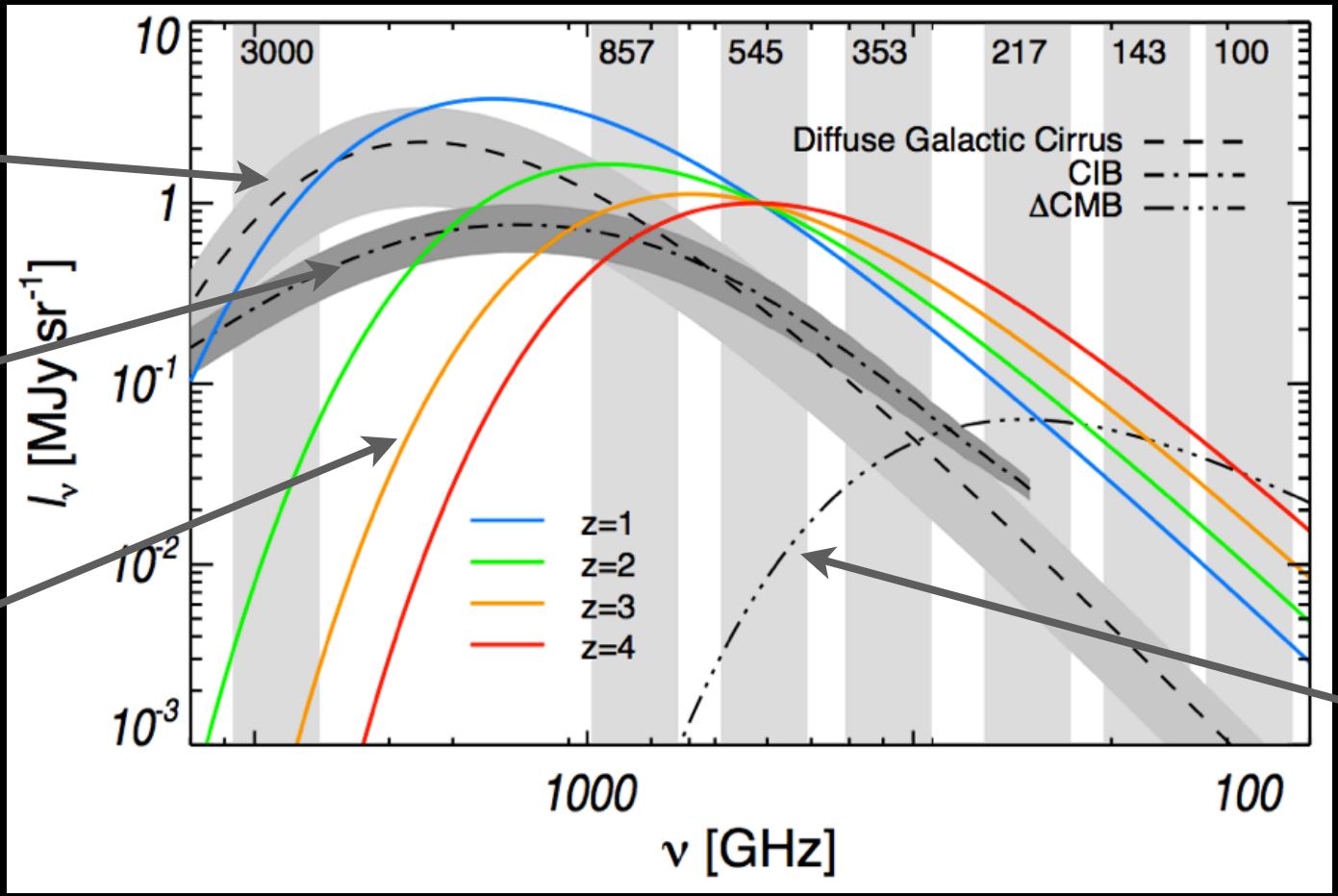
The *Planck* frequency coverage

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

Galactic cirrus

CIB

High-z ULIRGS

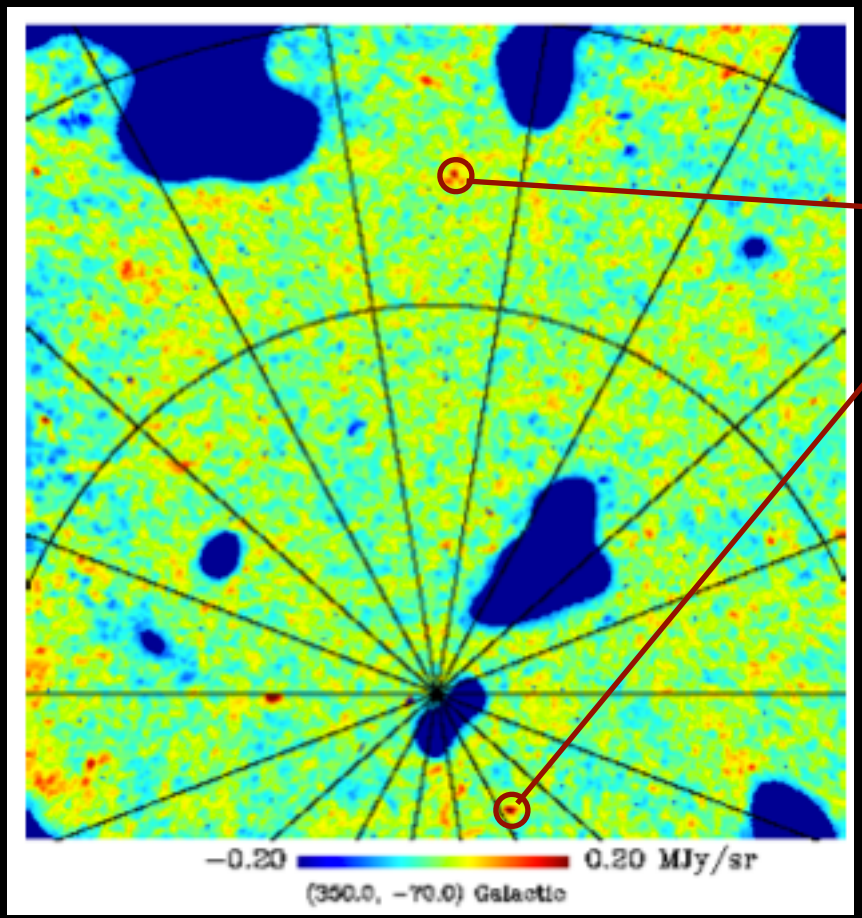


CMB

The *Planck* submm detection method

Principle

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



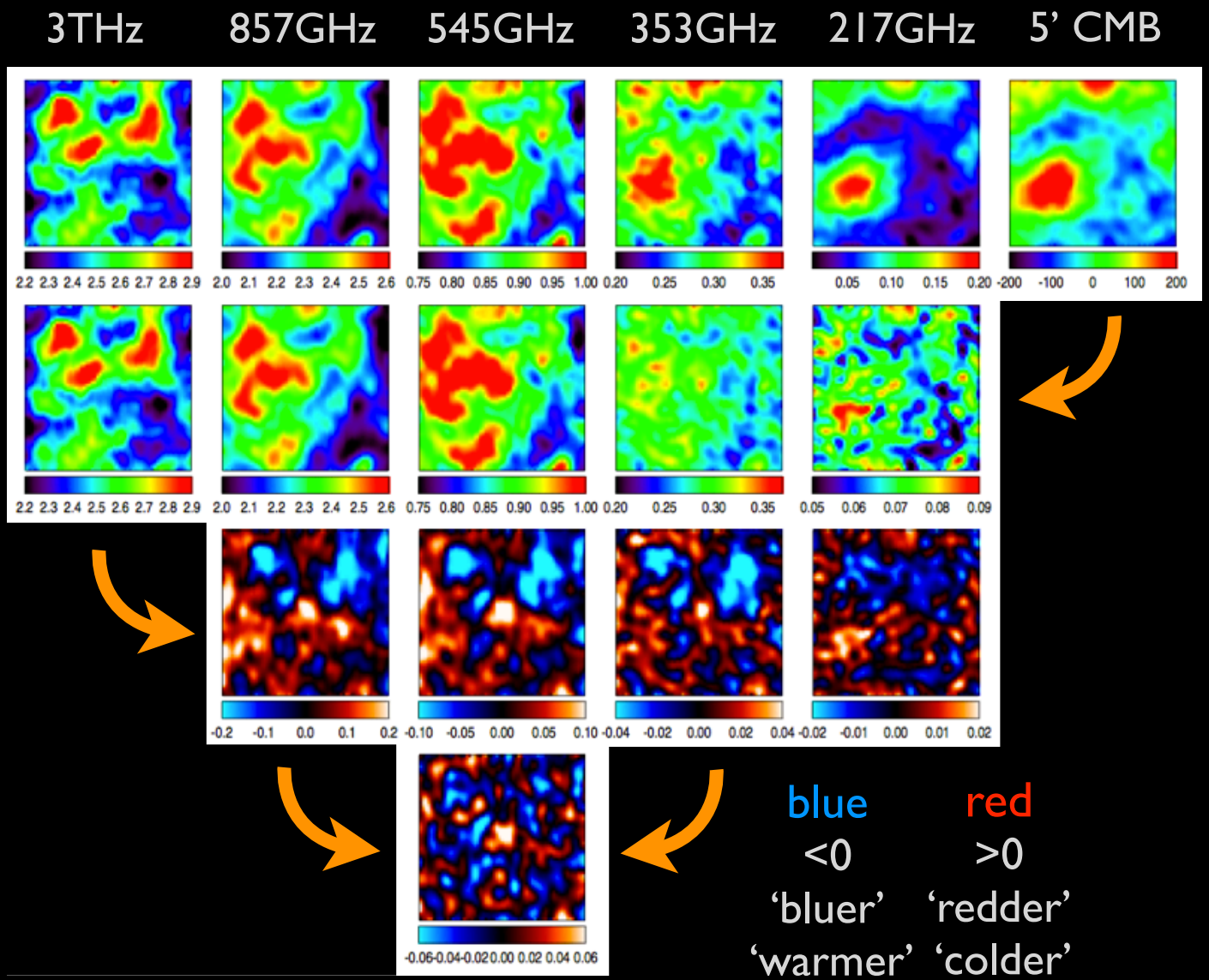
'Red' clumps
~ z>1.5

- Large Structures Alignment ?
- Lensed ULIRGS ?
- Proto Clusters ?

Beam of 5' at z=2 → Comoving Size of ~ 2.5 Mpc

The *Planck* submm detection method

Component separation



blue <0 'bluer' 'warmer'

red >0 'redder' 'colder'

Initial Maps — 5' resolution

↓

CMB Cleaning — *Planck* CMB template

↓

Galactic cirrus Cleaning — colour cleaning Montier et al. 2010

↓

Excess @ 545GHz

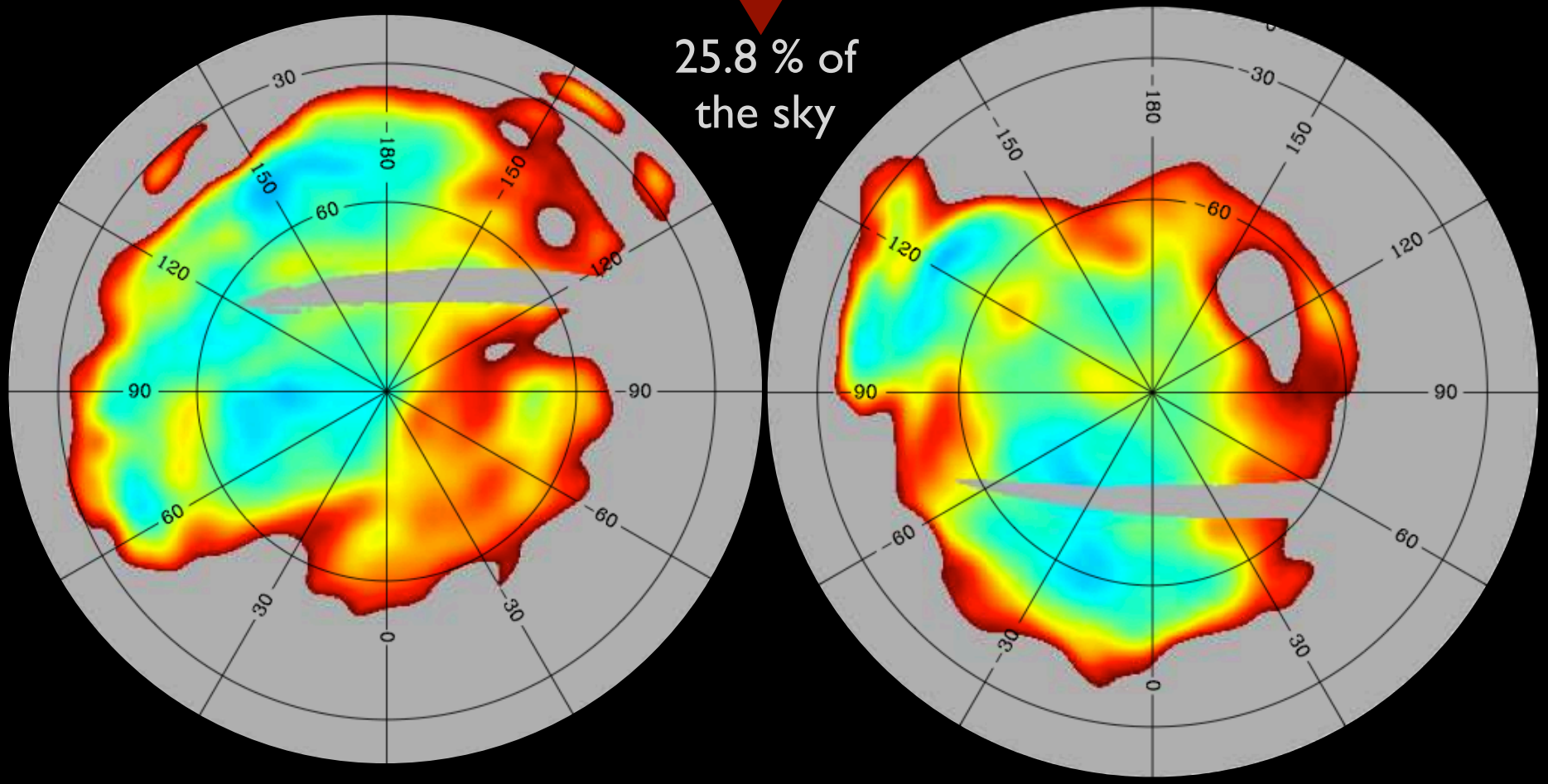
The *Planck* High-z Source Candidate List

Mask

Based on Galactic Extinction:
$N_{H2} < 3 \times 10^{20}$ cm^{-2}

Planck Collab
2013

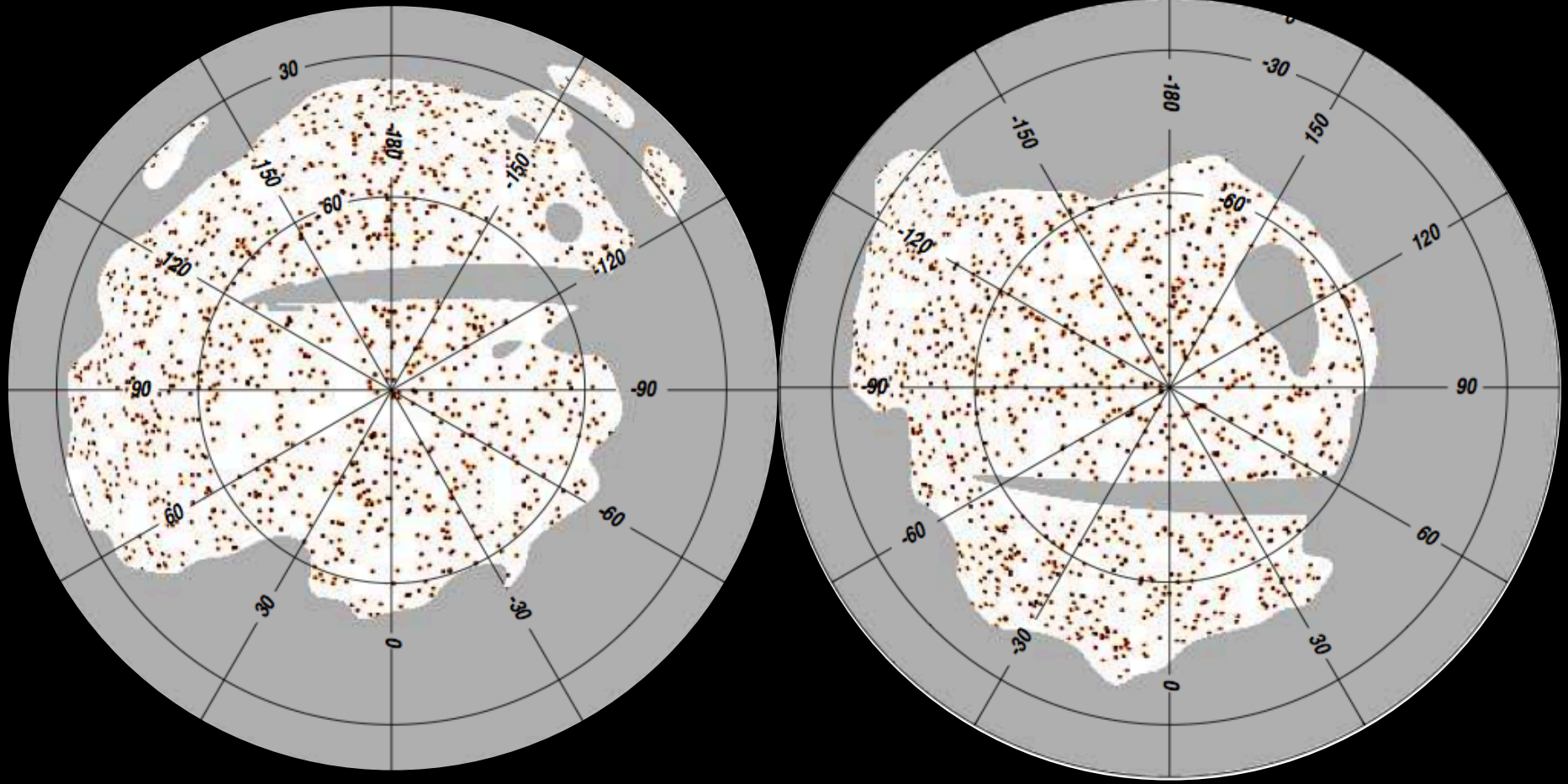
25.8 % of
the sky



The *Planck* High-z Source Candidate List

The *Planck* high-z candidates

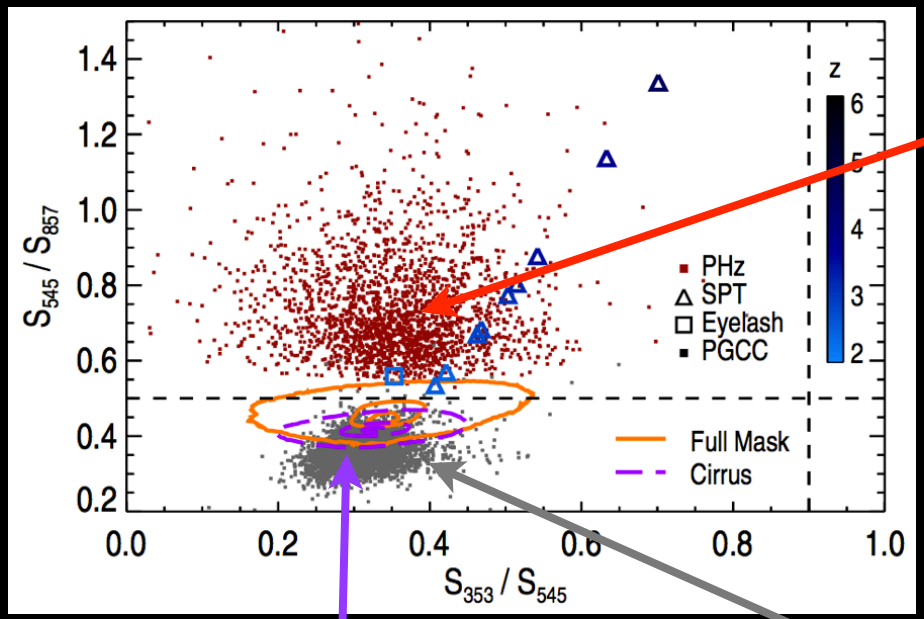
2151 sources



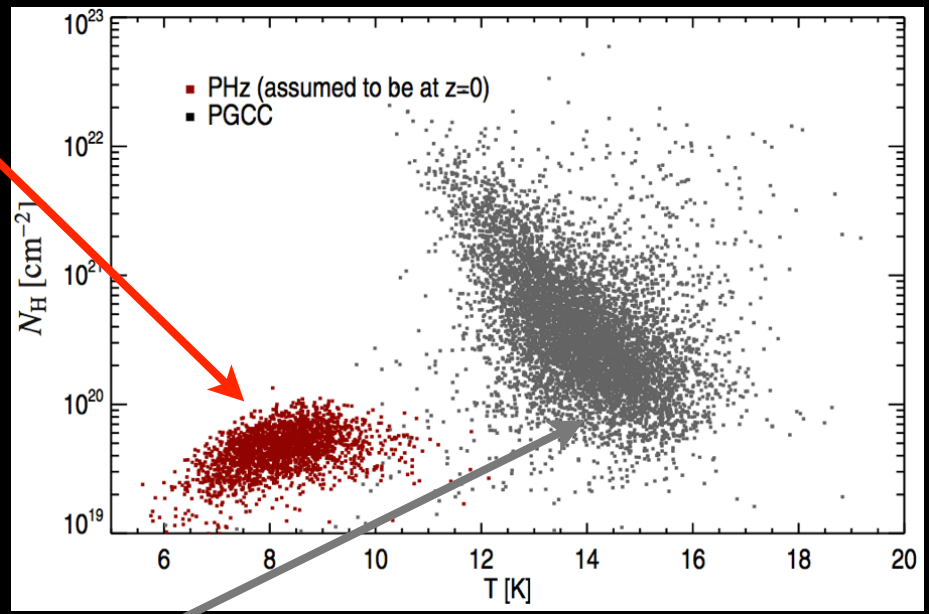
The *Planck* High-z Source Candidate List

Galactic cirrus Contamination ?

Color-Color selection



A posteriori Check: N_H-T



PHZ

Galactic Cirrus

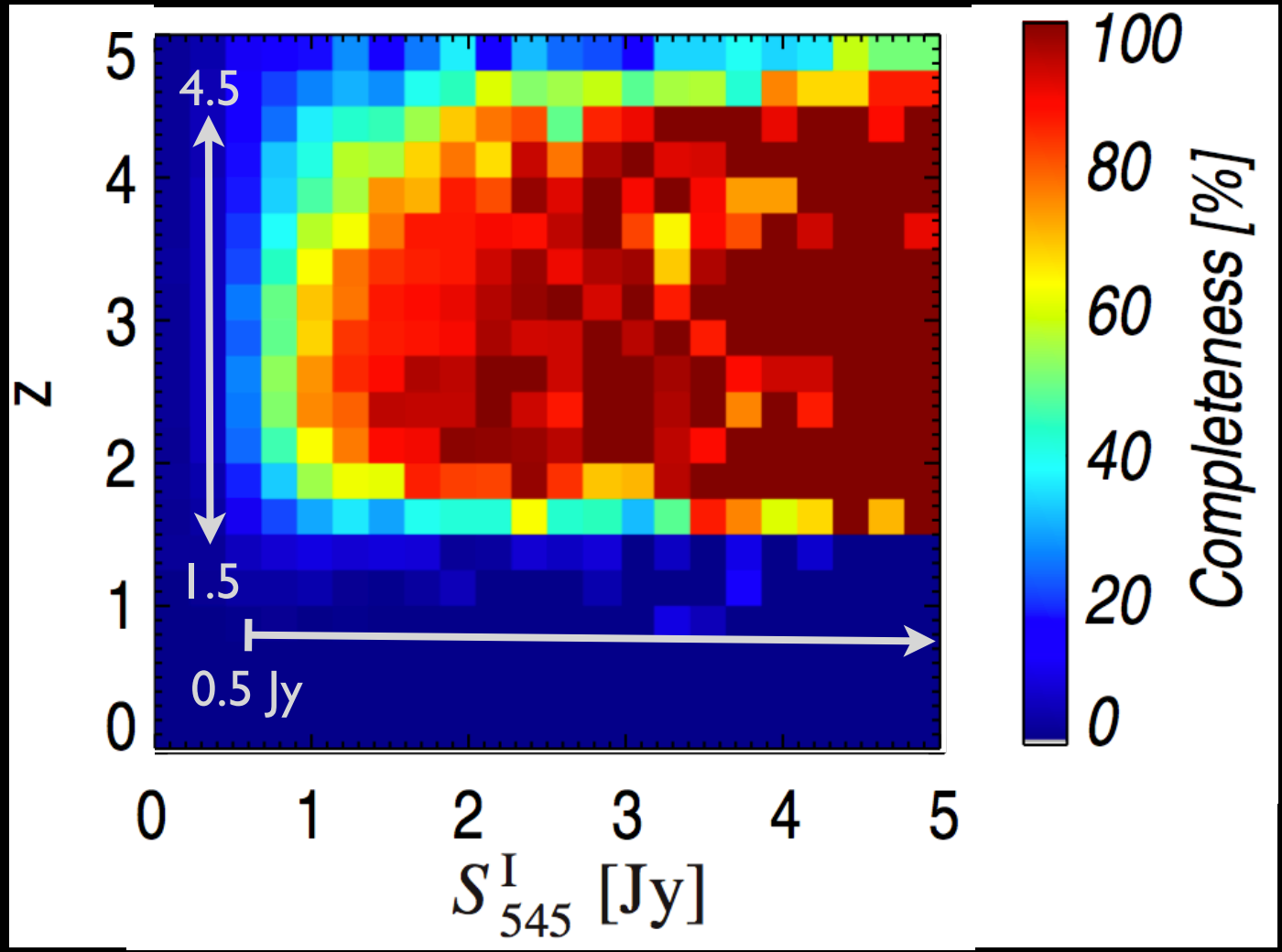
Galactic Cold Clump Sources

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

The *Planck* High-z Source Candidate List

z - flux density completeness

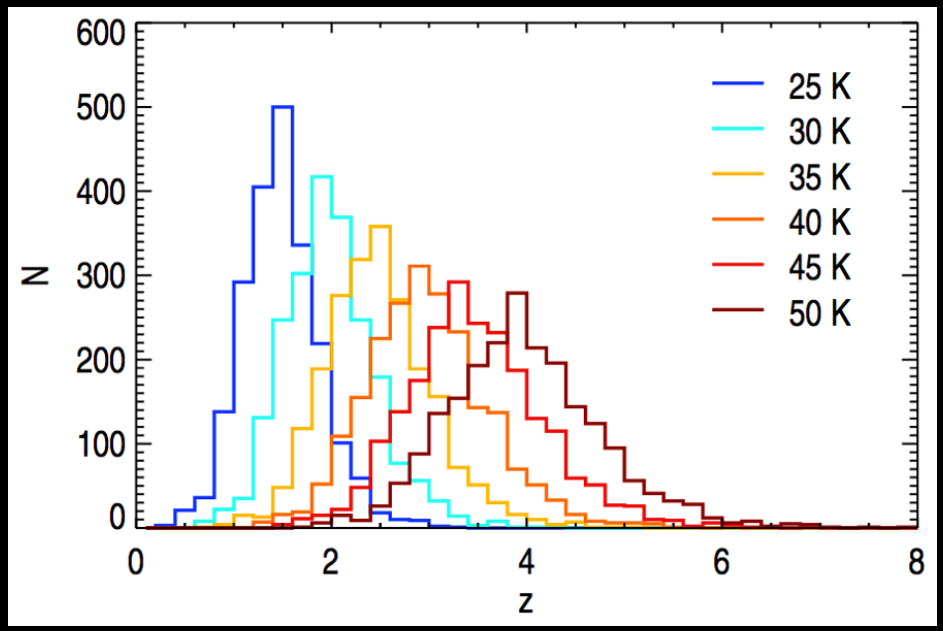
Based on Monte-Carlo Simulations

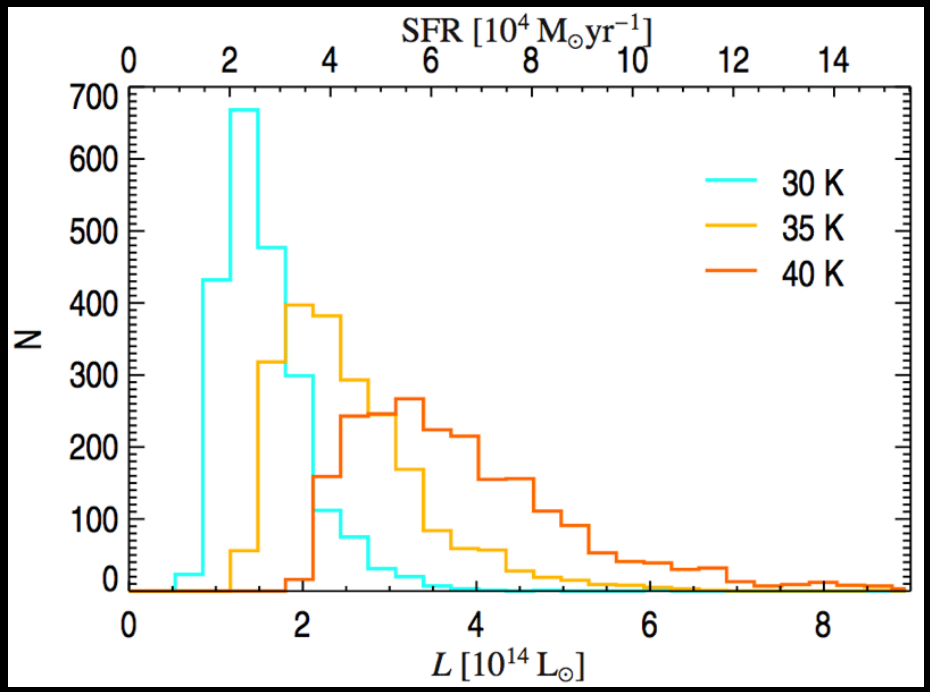


The *Planck* High-z Source Candidate List

Physical Properties

Photometric z in *Planck* bands





(using Kennicutt 1998)

For a typical temperature T = 35K :

z : 1.5 - 3.5

LFIR : 1 - 4 x10^{14} $L_\odot$

SFR : 2 - 7 x10^4 $M_\odot$ /yr

Extremely luminous objects at z= ~2-3 with strong SFR !

What are the *Planck* High-z candidates ?

Follow-up observations

Herschel / SPIRE

Dedicated Surveys

(Planck Int. XXVII 2014)

OT-1
OT-2
HPASSS

Calls →

204
targets selected from previous versions of the Planck High-z Candidates list

+

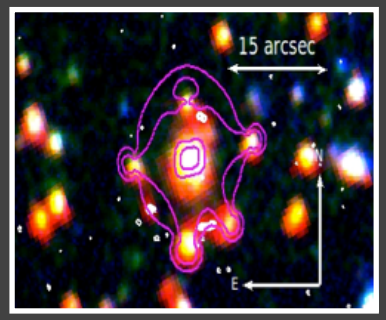
24
targets from the PCCS 2013

Public Data from large surveys

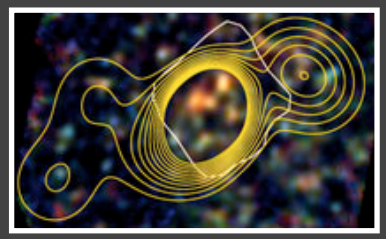
(to be subm)

HerMES
H-ATLAS

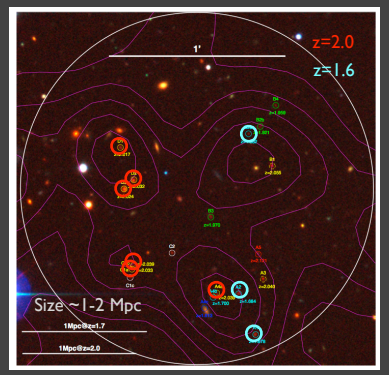
→ **21** sources in PHZ



Lensed galaxies

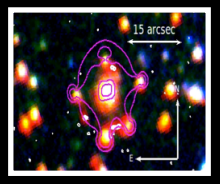


Overdensities of red galaxies



Proto-cluster of galaxies

What are the *Planck* High-z candidates ?

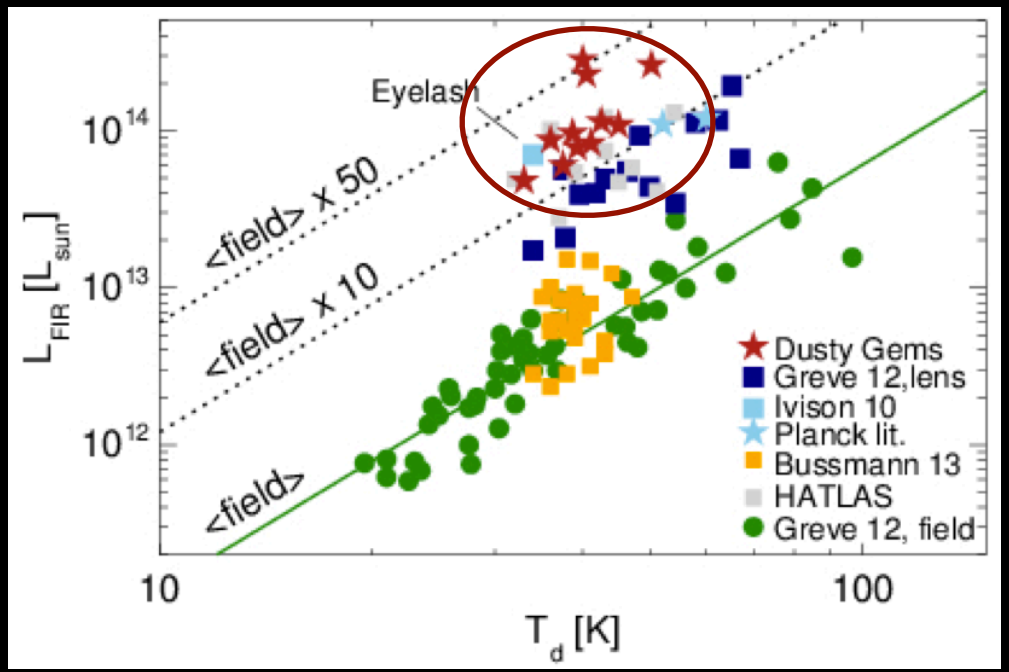


Follow-up observations

Lensed sources

Dedicated surveys:
11 *Planck*-discovered strongly lensed galaxies spectroscopically confirmed to be at high redshift (2.2<z<3.6)

(Canameras et al. 2015)

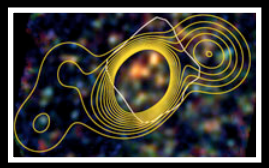


X-Match with *Herschel* catalogues of Dusty Star-Forming Galaxies
(HerMES / H-ATLAS / HLS / SPT)
Selection bias: (to be subm)
$2 < z < 4$
$S_{500um} > 150mJy$

PHZ may contain the brightest high-z lensed candidates over 26% of the sky

More than 100 lensed sources expected in PHZ
(~6% of the full sample)

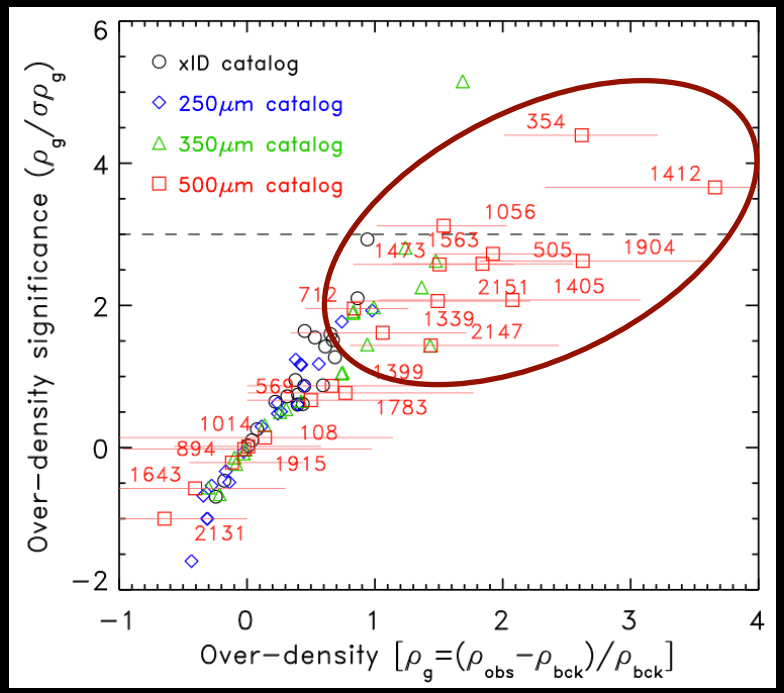
What are the *Planck* High-z candidates ?



Follow-up observations

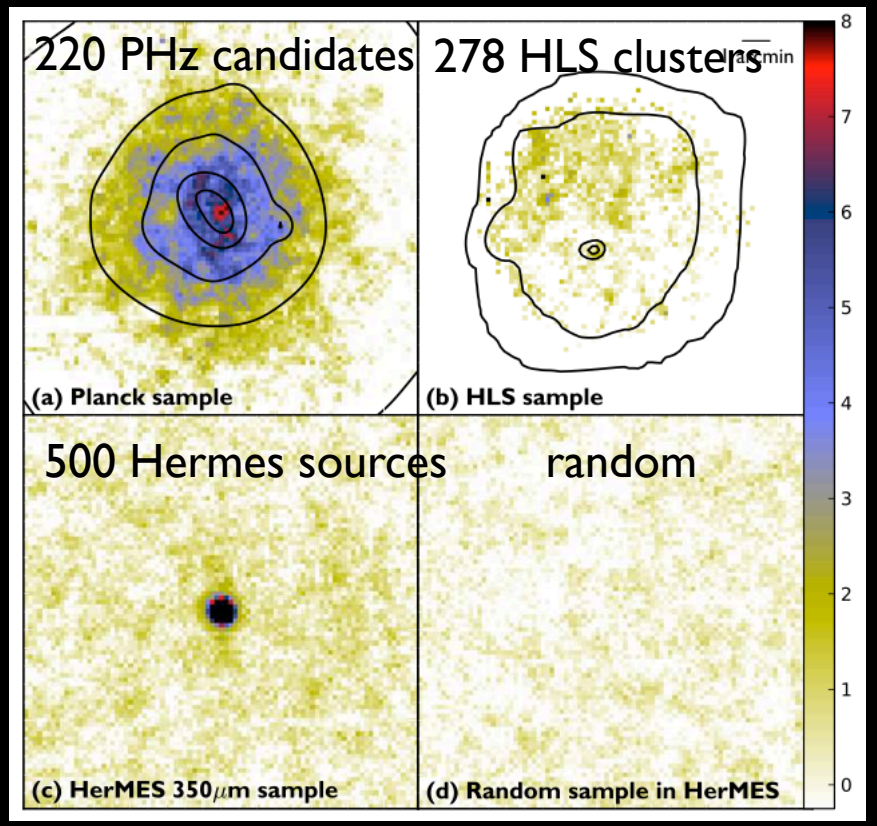
Herschel red over-densities

Evidence of overdensities of red *Herschel* sources



(to be subm.)

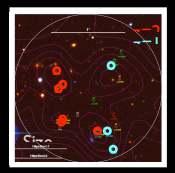
Clustering observed by stacking



(Planck Int. XXVII 2014)

~90 % of the *Planck* high-z candidates are red over-densities

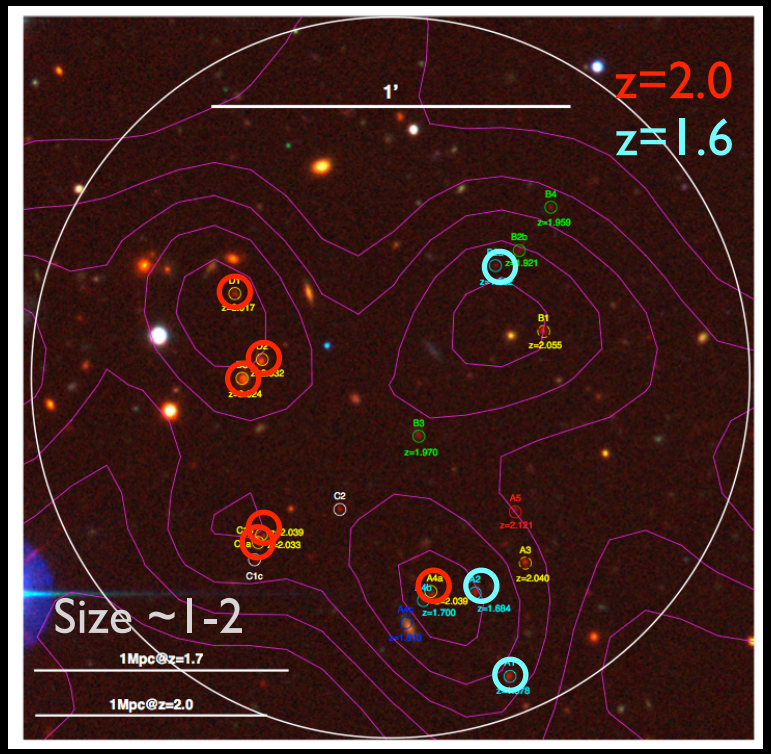
What are the *Planck* High-z candidates ?



Follow-up observations

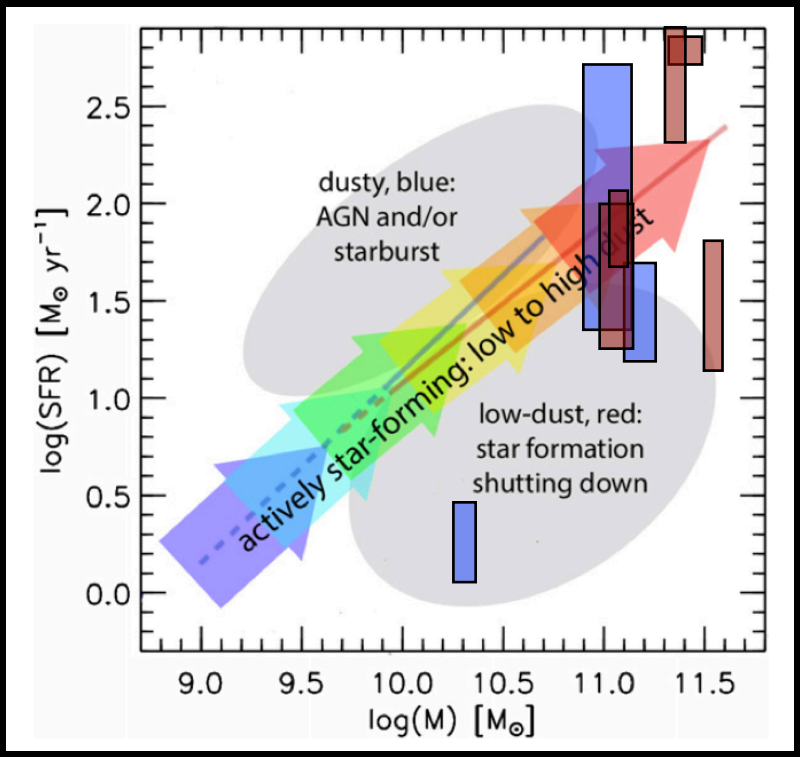
Proto-cluster

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



(Flores-Cacho et al. 2014, subm)

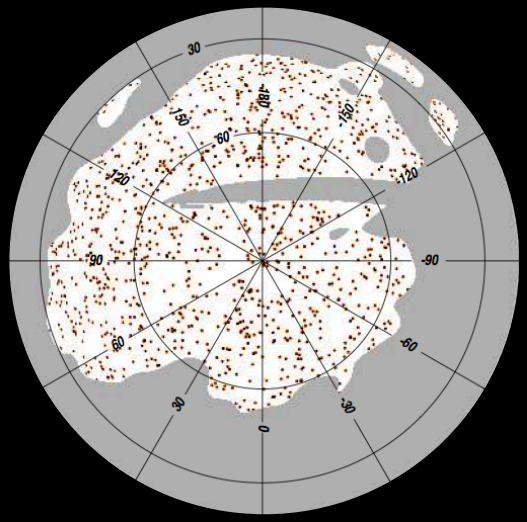
Planck + Herschel + CFHT + Spitzer + VLT/XSHOOTER



Integrated SFR $2\text{-}3\times10^3$ $M_\odot$/yr

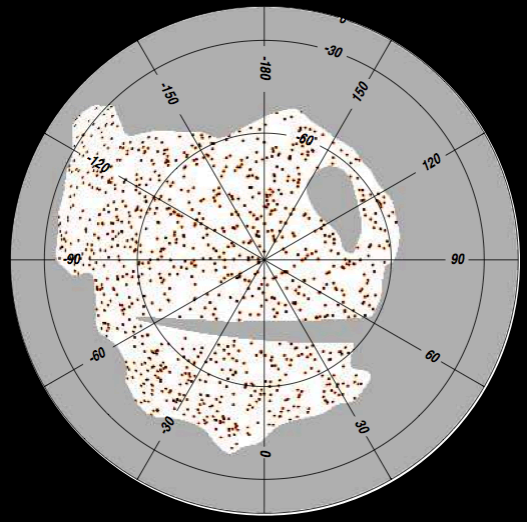
Consistent with SFR of 4929 $M_\odot$/yr computed for another proto-cluster observed with *Planck* at z=2.05 (Clements et al. 2014)

Take-Home Messages



PHZ

- Blind catalogue over 26% of the sky
- 2151 high-z candidates
- Likely 1.5 < z < 4
- ~90% overdensities of red sources
- ~6% bright lensed galaxies
- Strong Luminosities and SFR



Galaxy Evolution

- Star Formation
- Morphology
- Extreme objects
- Environment Impact

Large Scale Structures

- From Proto-Clusters...
  ... to virialized Clusters
- Filamentary structures
- Building blocks of the cosmic web

Cosmology

- Constraints on Mass content at large scale

Planck intermediate results. XXXIX + Planck Legacy Acrchive

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.