

Planck,
Herschel &
Spitzer unveil

$z > 2$ cluster candidates.

Prospects for Euclid, JWST, WFIRST

Hervé Dole

on behalf of the Planck collaboration

- introduction 1.
- digging into the Planck CIB 2.
- Herschel outcome 3.
- few cases 4.
- conclusions 5.

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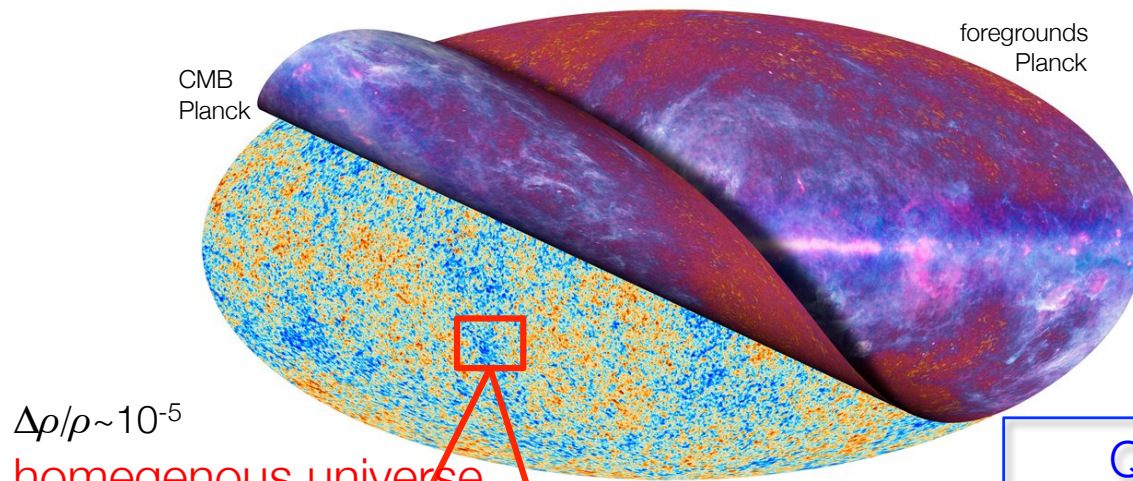


planck



euclid

1. some of the challenges in cosmology



$\Delta\rho/\rho \sim 10^{-5}$

homogenous universe

$z=1090$



?

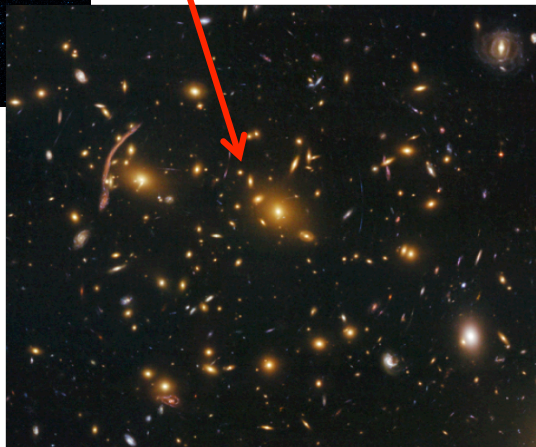
cosmological model Λ CDM

Q: processes of structure formation, esp. galaxies, first clusters, clusters, mass assembly, gas cooling, star formation ?

$\Delta\rho/\rho > 10^{20}$

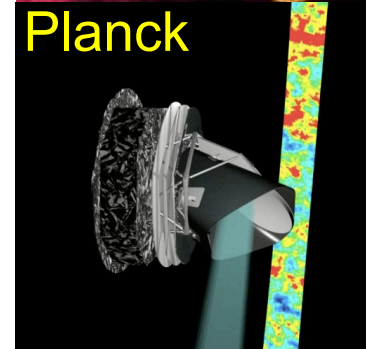
inhomogeneous structured, universe

$z=0$

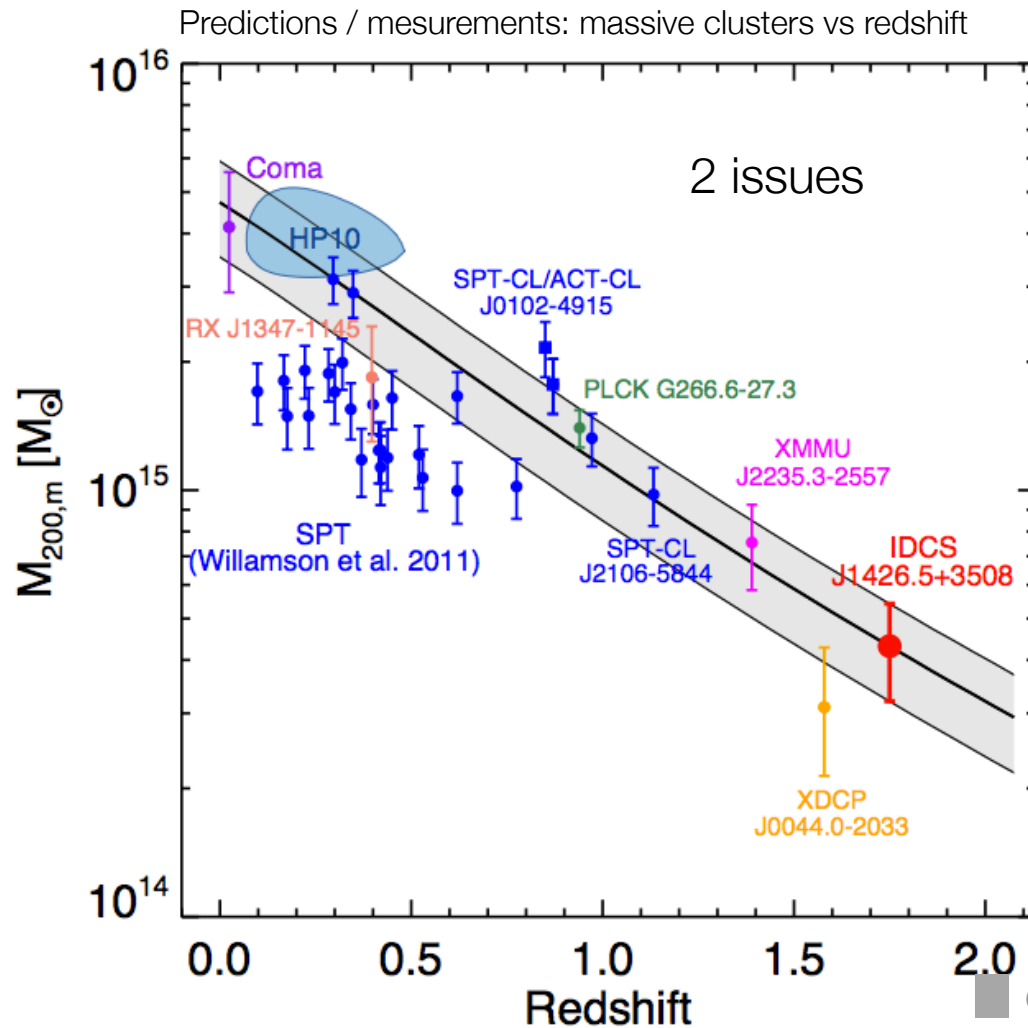


processes implying :

- fundamental forces
- dark components
- baryon physics
- cosmological parameters



searching for high-z massive structures: probe of DE ?



Q: processes of cluster
 - stellar mass assembly
 - star formation ?
 --> can we find a new way to select highly star-forming clusters ?

$z > 2$
 Planck
 Herschel, ALMA
 then Euclid,
 WFIRST, JWST

Brodwin et al, 2012 – Mortonson et al., 2011

how to find $z > 2$ clusters ?

(observationally) rare objects can be unveiled using all-sky surveys: Planck, Euclid, and further studied with JWST, WFIRST

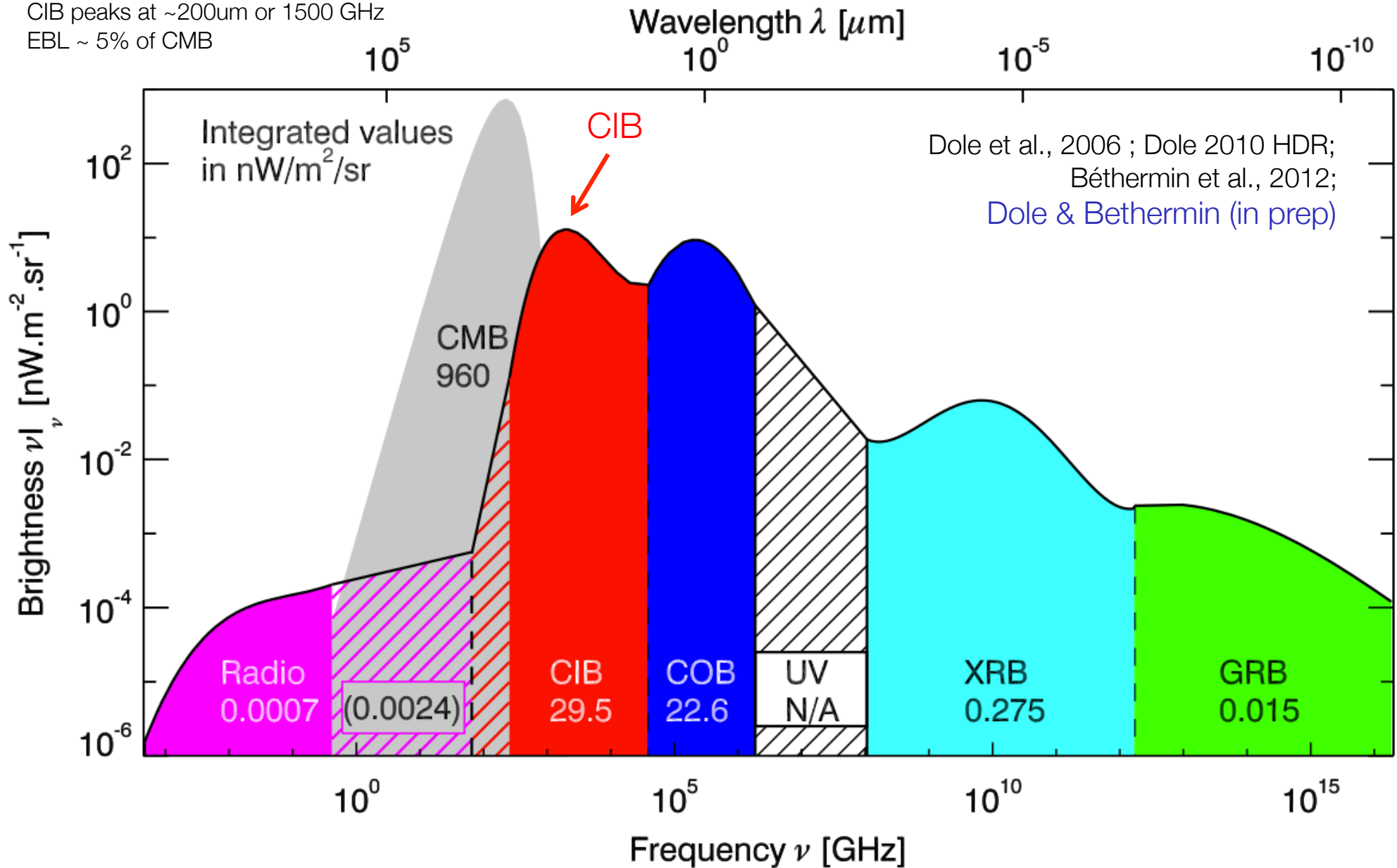
Galaxy clusters are proxies for massive DM halos

Extragalactic Bkg Light SED

CIB > COB

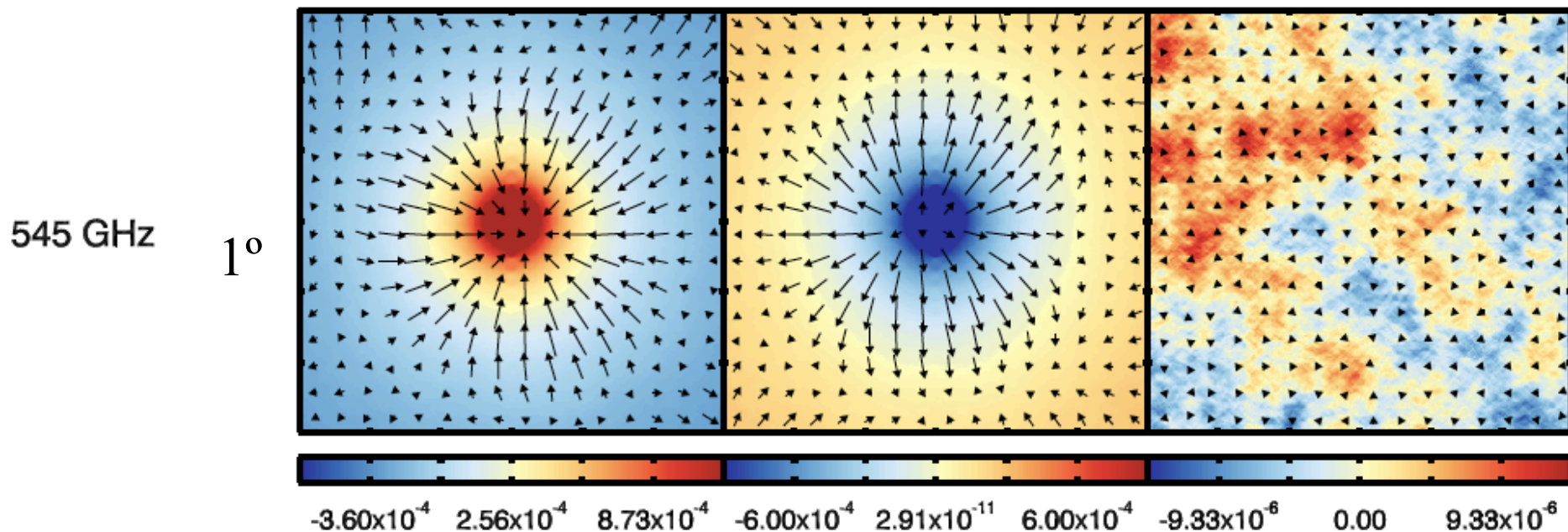
CIB peaks at ~200μm or 1500 GHz

EBL ~ 5% of CMB



CIB peaks correspond to mass peaks

Stacking the Planck mass maps at the positions of peaks and troughs of Cosmic Infrared Background leads to a strong detection of the mass (obtained by CMB lensing) associated with these distant star forming galaxies. This is mostly Dark Matter.



... and the CIB probes also high-z SFR

-> a novel method to search for high-z clusters in formation
(CIB > high SFR > massive high-z clusters)

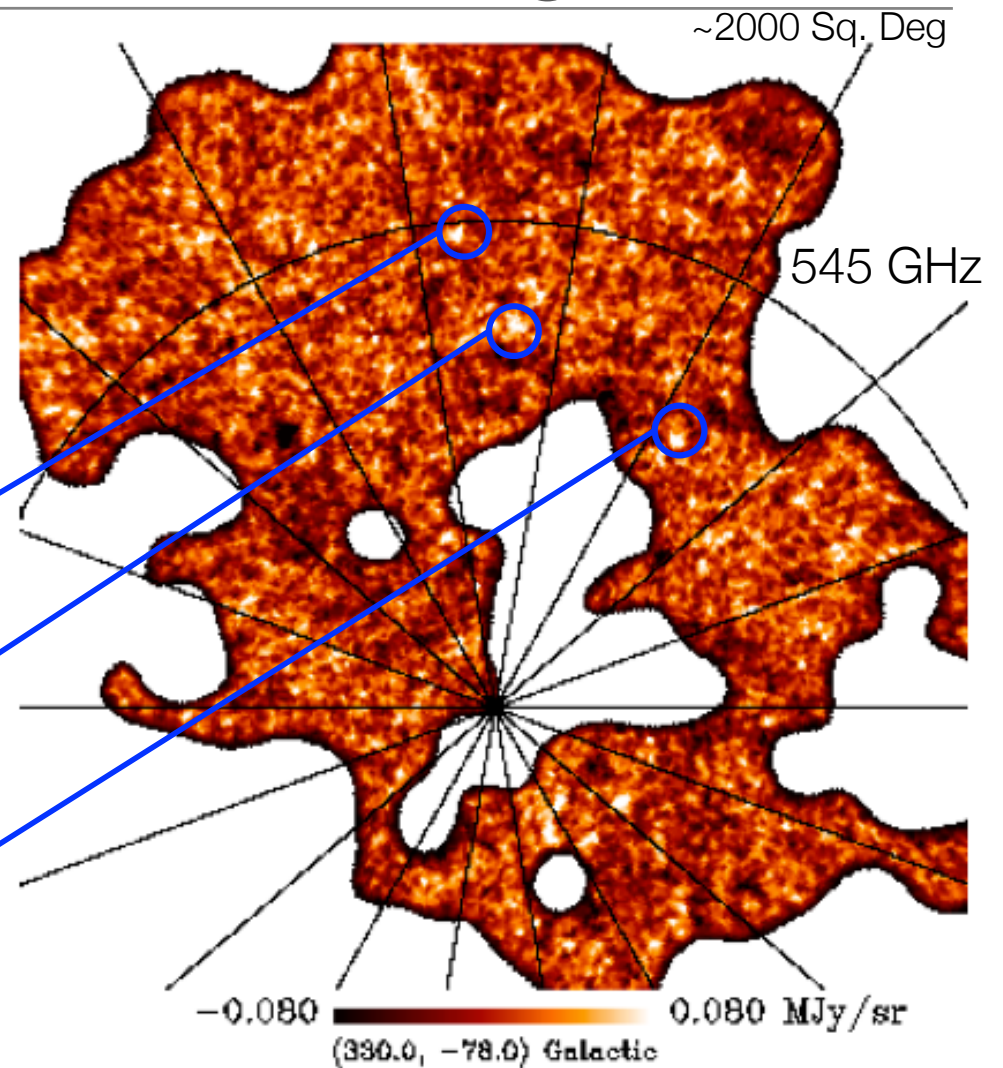
Planck 15 months
Planck Collaboration, 2013, 18

2. digging into the Cosmic IR Background

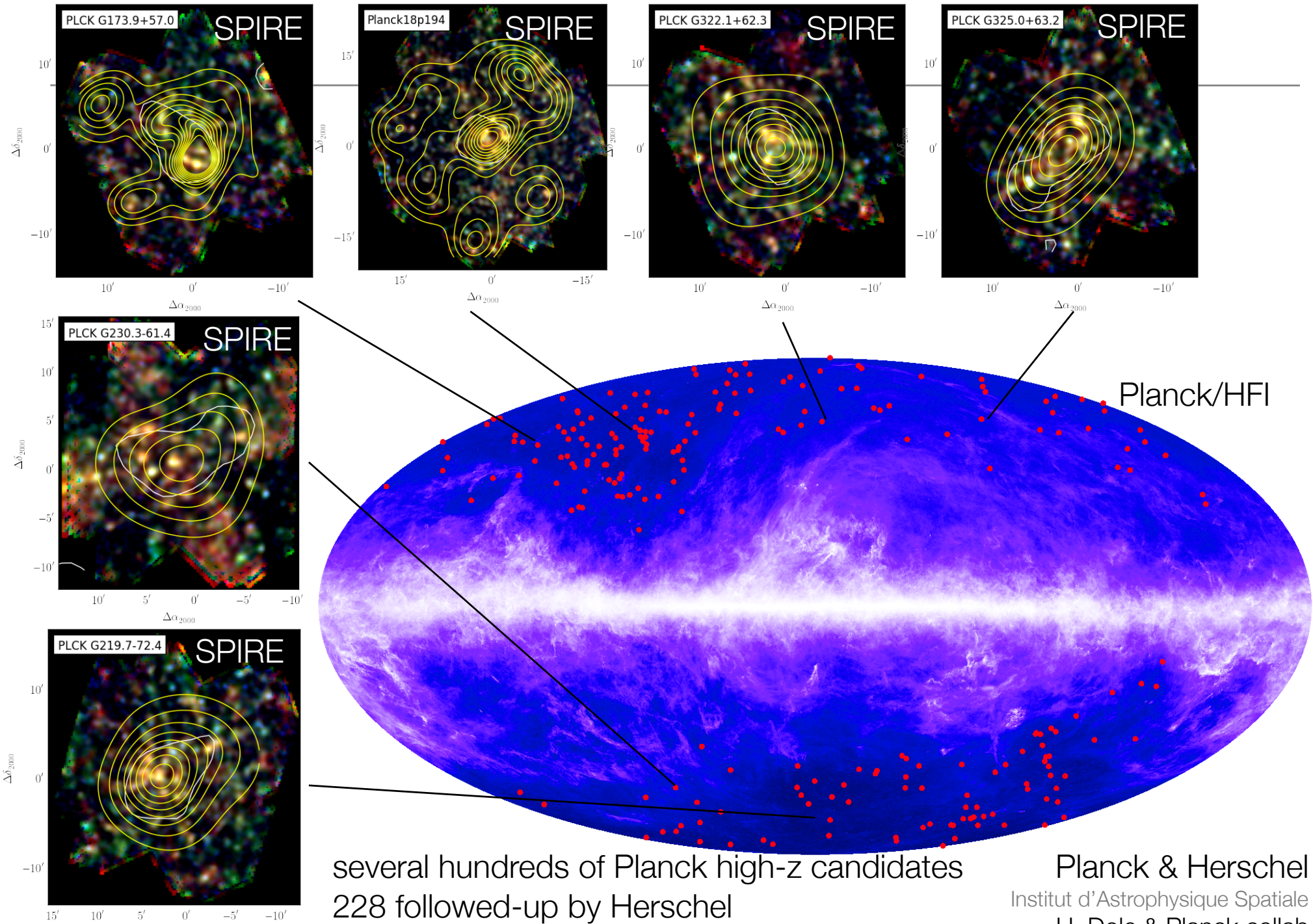
our approach: preferentially select systems w/ *high SFR*.

With Planck: selection of **extremely high SFR $z > 2$** systems using CIB « cold spots ».

- $z > 1.5$ overdensities of intensely star forming galaxies ?
- $z > 1.5$ extremely bright lensed sources ?
- large scale structure alignments ?
- residual Galactic cirrus ?



Planck Collab., 2013, 30

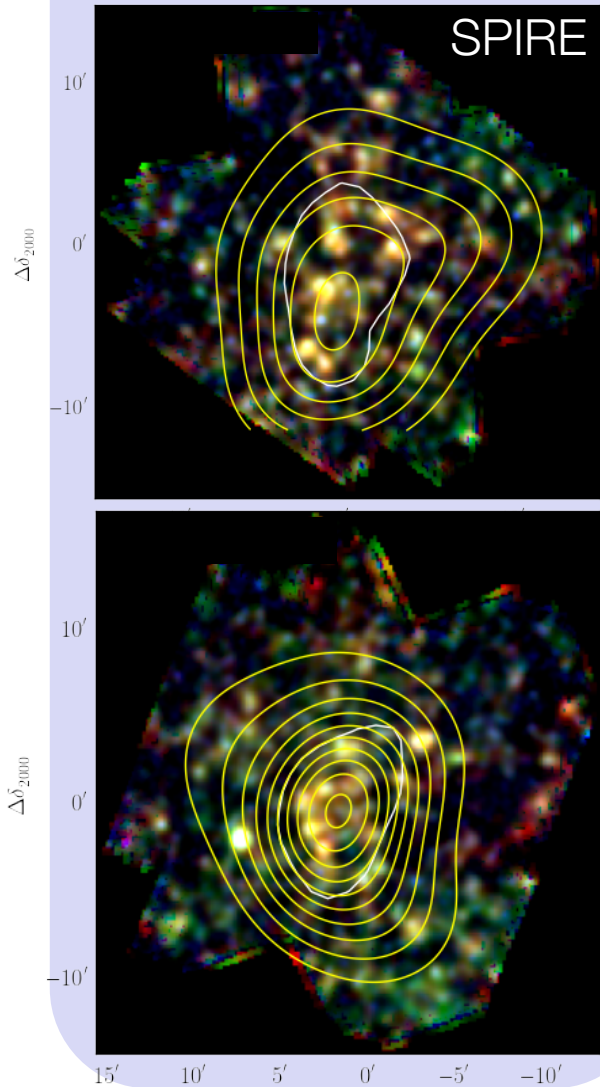


several hundreds of Planck high-z candidates
 228 followed-up by Herschel

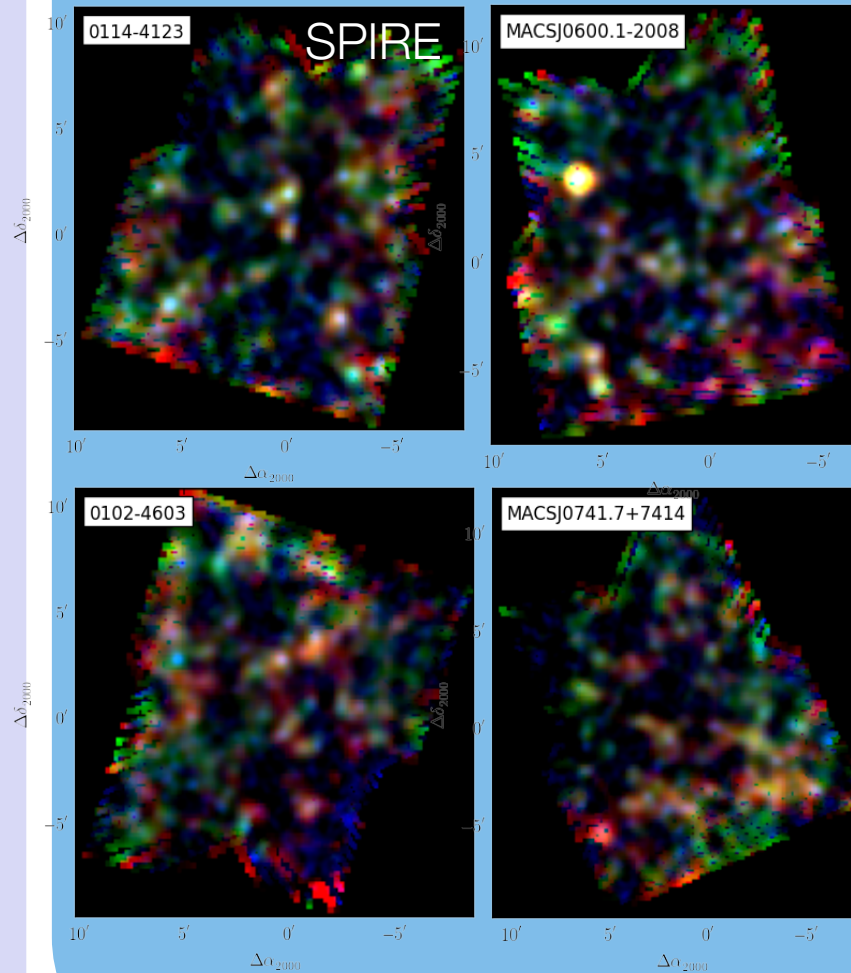
Planck & Herschel
 Institut d'Astrophysique Spatiale
 H. Dole & Planck collab

3. a remarkable Planck+Herschel dataset among others

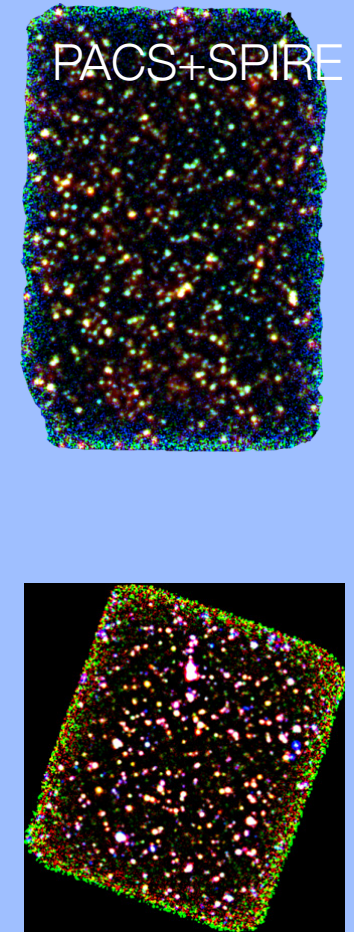
Planck/Herschel HPASSS
30'x 30' (Planck subm)



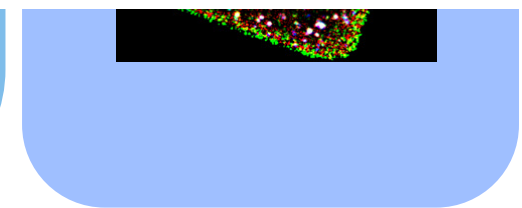
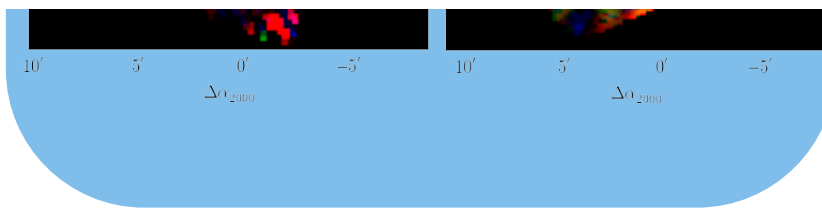
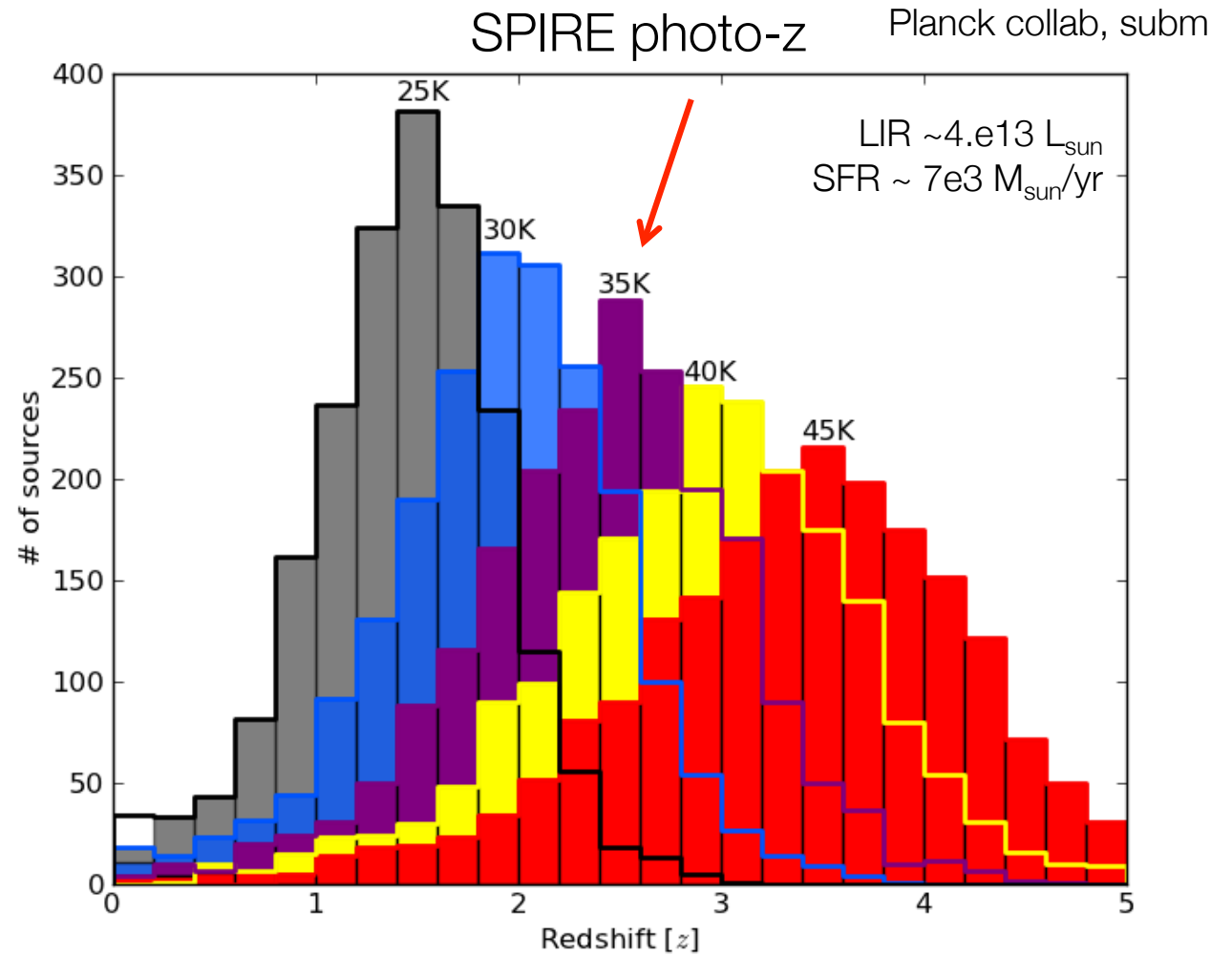
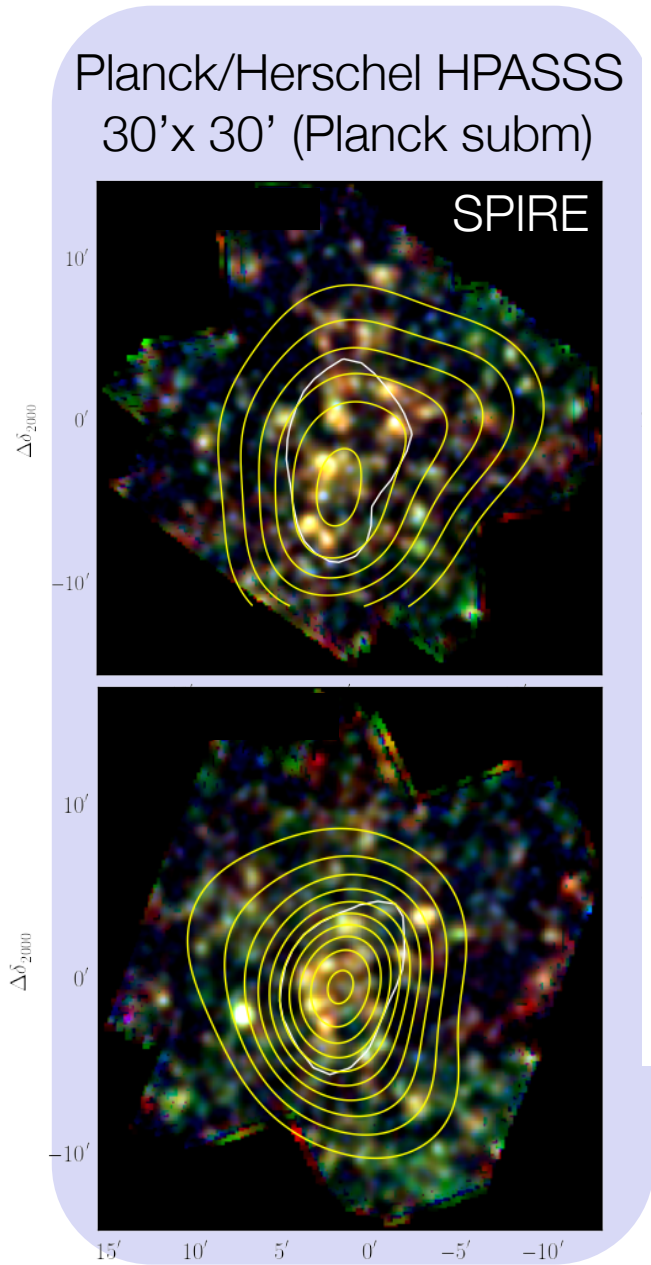
HLS 20'x 20'
(Egami+2010)



GOODS 16'x 10'
(Elbaz+2011)

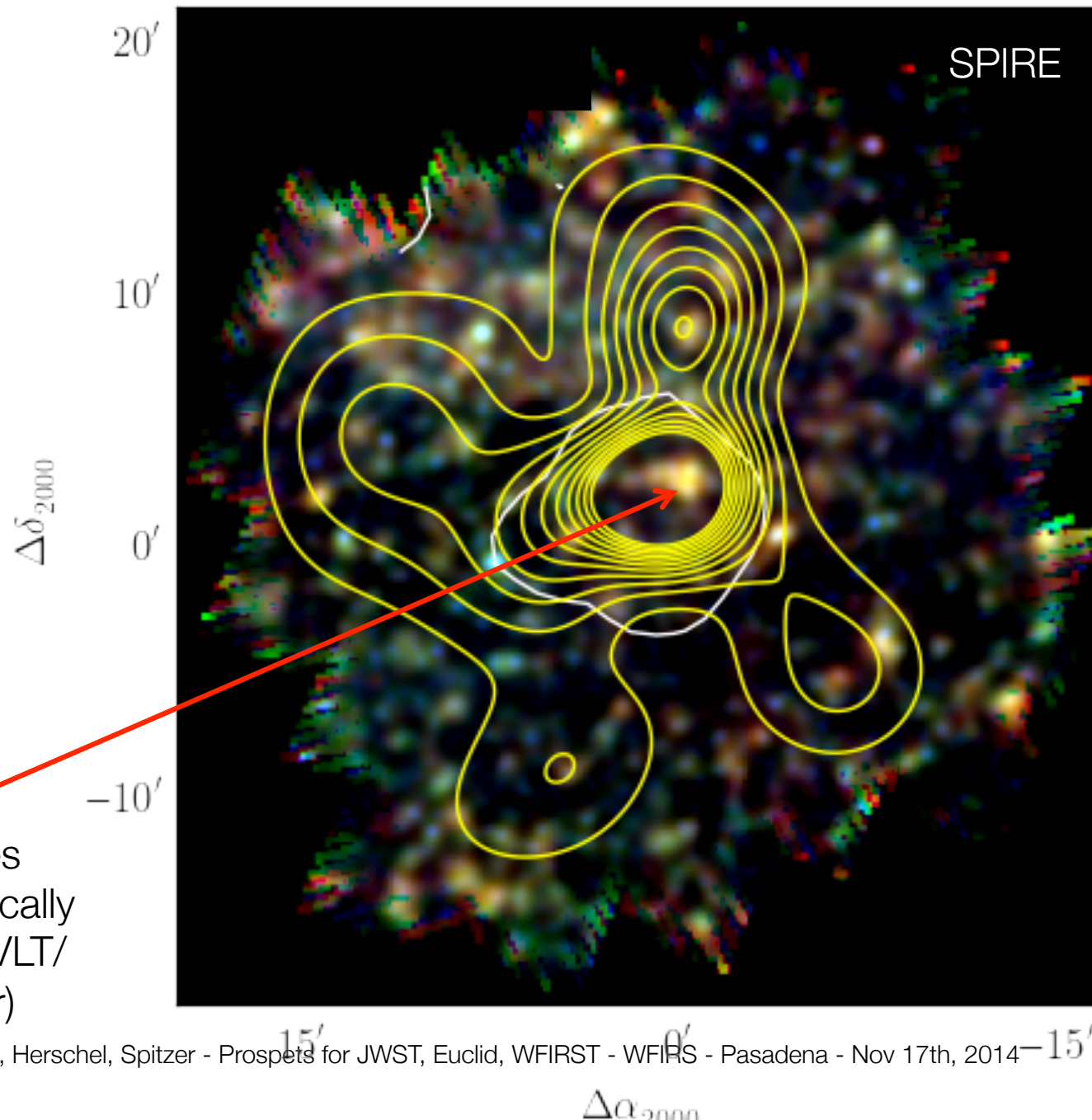


3. a remarkable Planck+Herschel dataset among others



4. a double structure at $z=1.7$ and 2.0

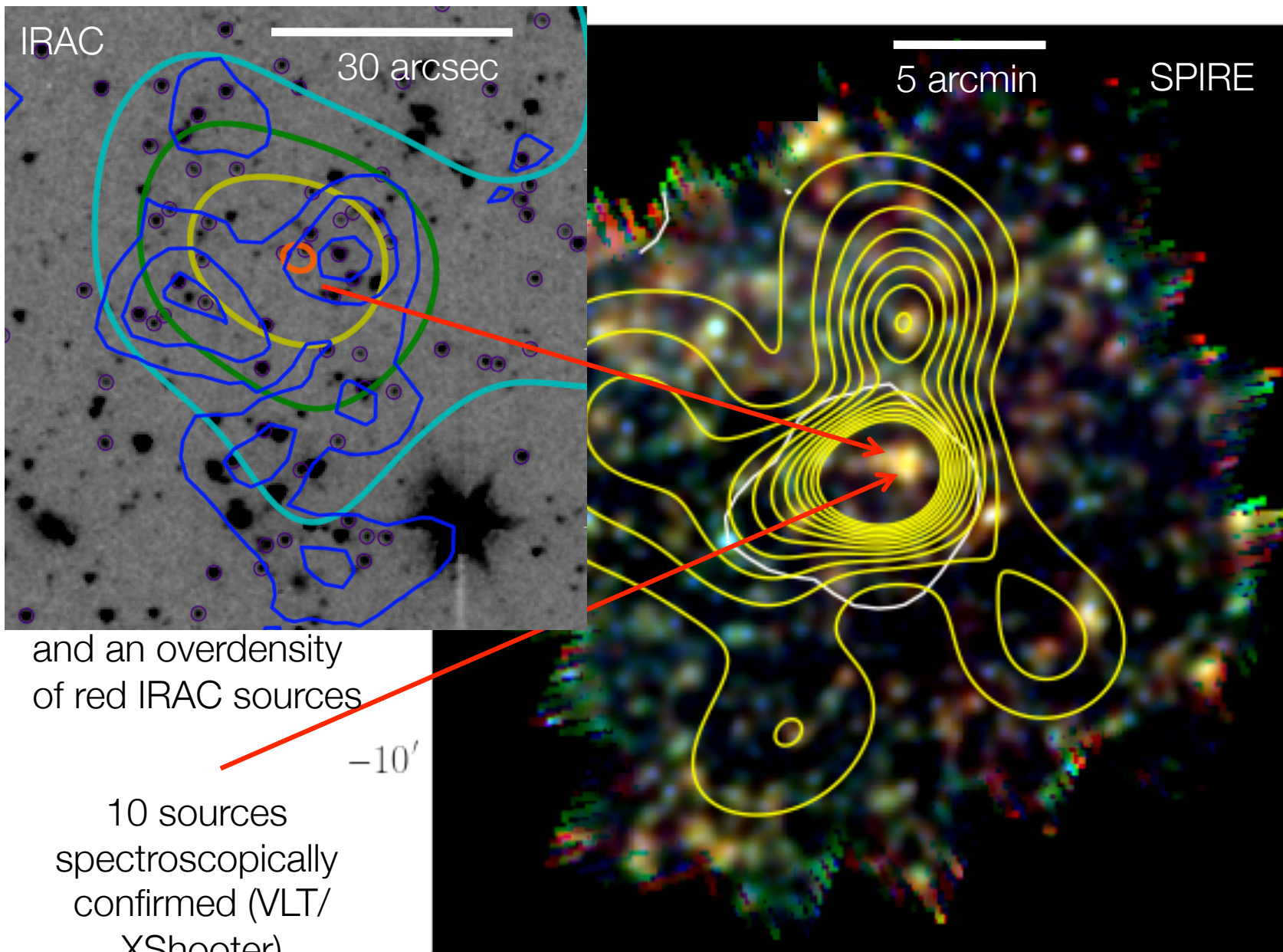
Herschel-SPIRE
3-color image:
blue = 250um
green = 350um
red = 500um



10 sources
spectroscopically
confirmed (VLT/
XShooter)

Flores-Cacho et al., subm

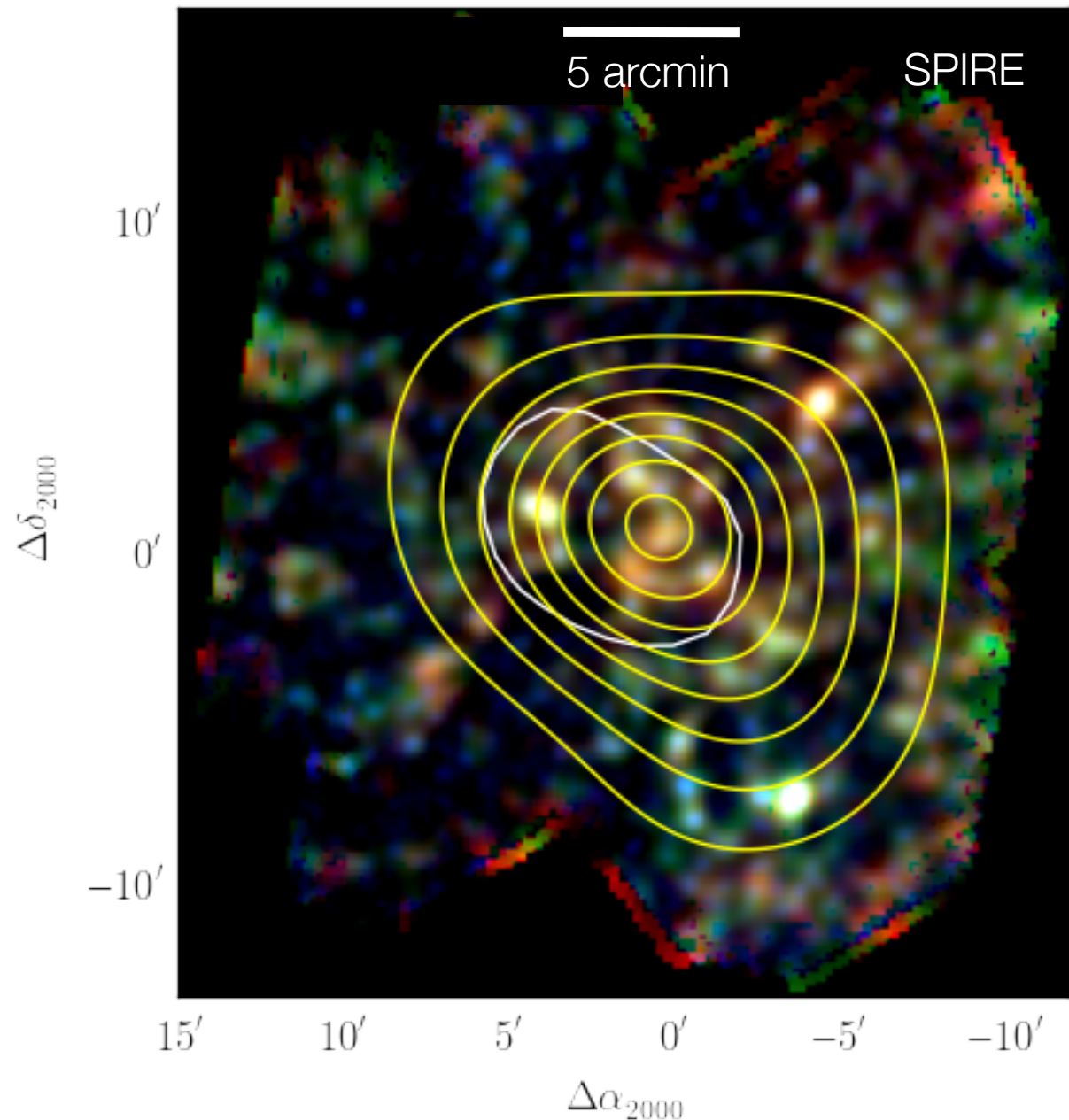
4. a double structure at $z=1.7$ and 2.0



Flores-Cacho et al., subm

the case of one field: Spitzer and VLT

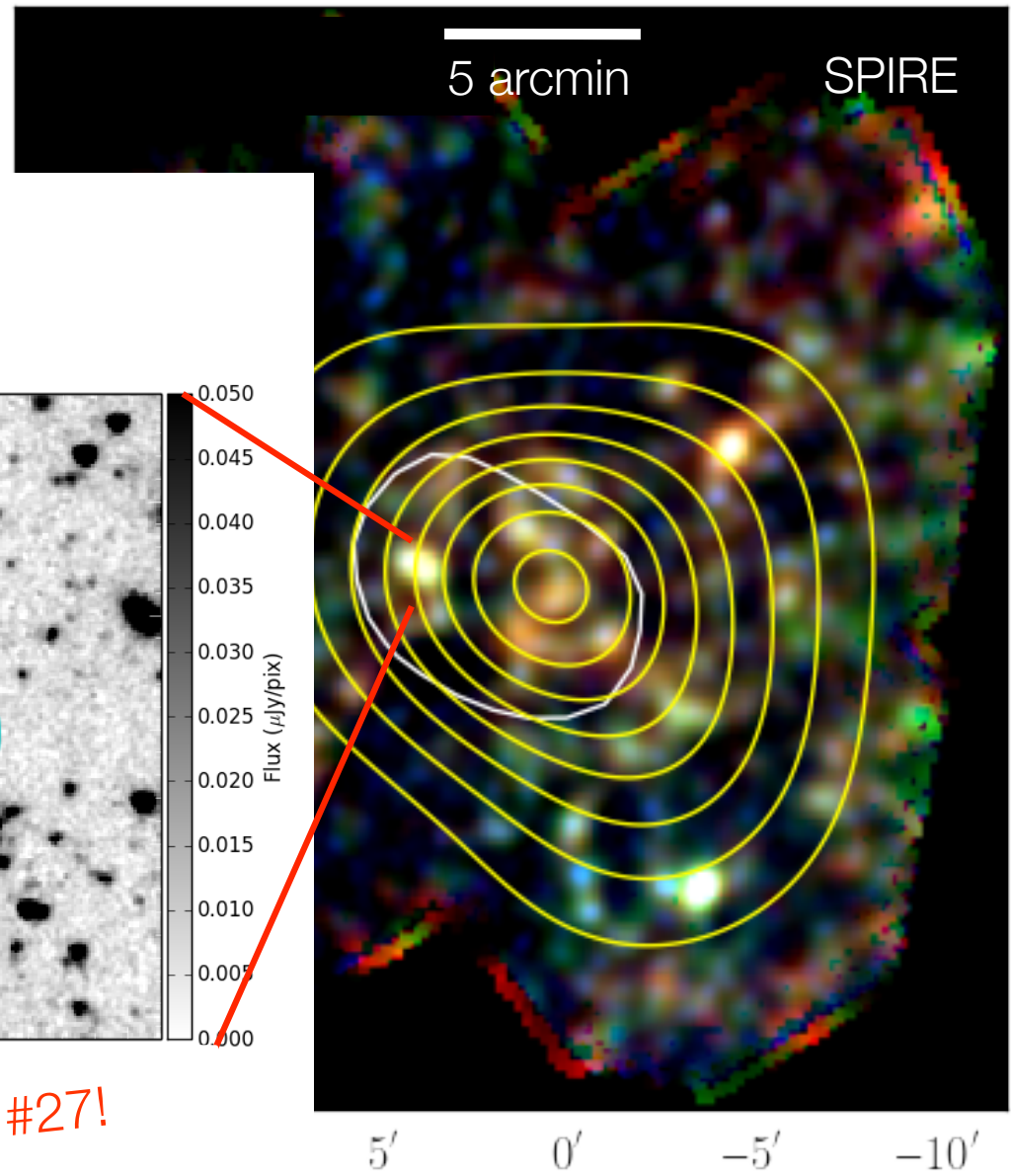
Herschel-SPIRE
3-color image:
blue = 250um
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red = 500um



the case of one field: Spitzer and VLT

Herschel-SPIRE
 3-color image:
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Euclid will provide this kind of sensitivity over the whole sky !
 JWST and WFIRST much better, on smaller sky areas !



See Clément Martinache's poster #27!

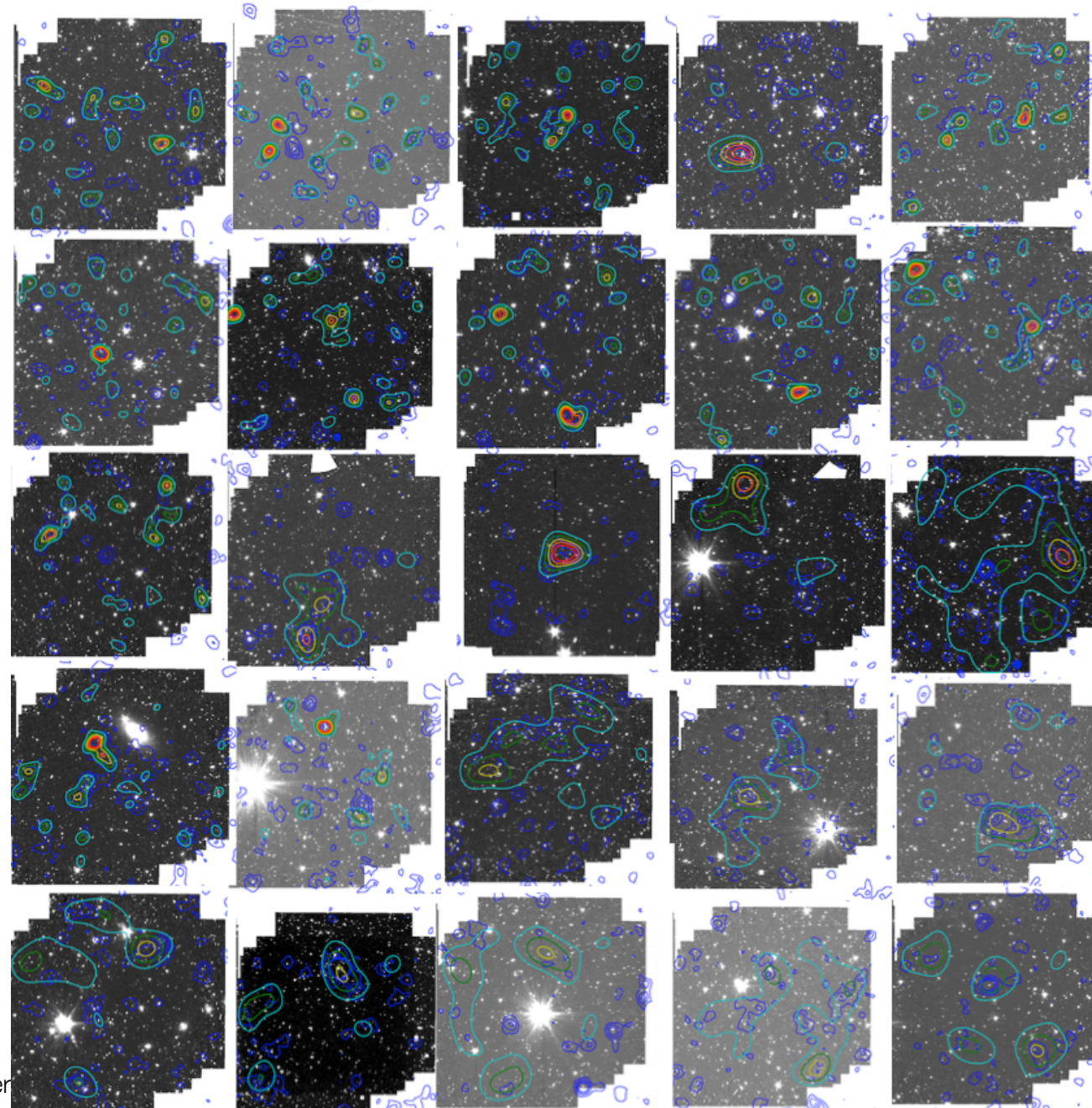
Δo Martinache et al., in prep

25 Spitzer fields having $>5\sigma$ overdensities

IRAC fields,
about 5'x 5' each

color contours:
significance of red
IRAC source
overdensity

deep blue contours:
SPIRE 350um



See
Clément Martinache's
poster #27!

5. summary & conclusions: high-z clusters

- Planck color selection of **cold sources of the CIB (all sky)**:
 - **few hundreds** of $z > \sim 2$ candidates
 - redshifted dusty FIR signature: selection by **extreme SFR**; not SZ
- **200+** Herschel-SPIRE counterparts:
 - red and **SED $z > \sim 2$** ; 94% are **overdensities**
 - a few bright lensed sources (all at redshift confirmed $z > 2.2-3.5$)
- **main results of the Planck, Herschel, Spitzer sample**
 - indications that many overdensities are at $z > 2$
 - **Spitzer and NIR follow-up mandatory ! Proof of concept for planned missions**
 - Spitzer data: compatible with $z > 2$ hypothesis; work in progress
 - **extreme SFR** (1000's M_{sun}/yr) -> consistent w/ selection
 - 2 confirmed redshifts z : 1.7-2.0; 2.36 (CO)
 - might be proto-clusters in their **intense starbursting** phase
 - are promising samples for high- z ($z > 2$) studies:
 - cosmology; astrophysics
- **synergy Planck – Herschel – Spitzer in action**
- **Euclid, WFIRST & JWST (GO) will see more – work in progress**

See Clément
Martinache's
poster #27

Planck Coll, PIP XXVII, subm
Flores-Cacho et al., subm
Canameras et al., subm
Planck Collab., in prep
Martinache et al., in prep

The scientific results that we present today are a product of the Planck Collaboration, including individuals from more than 100 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.



HPASSS

Herschel & Planck
All Sky Snapshot legacy Survey

each image ~30'x30' – Planck Collab PIP-XXVII subm – D. Guéry thes