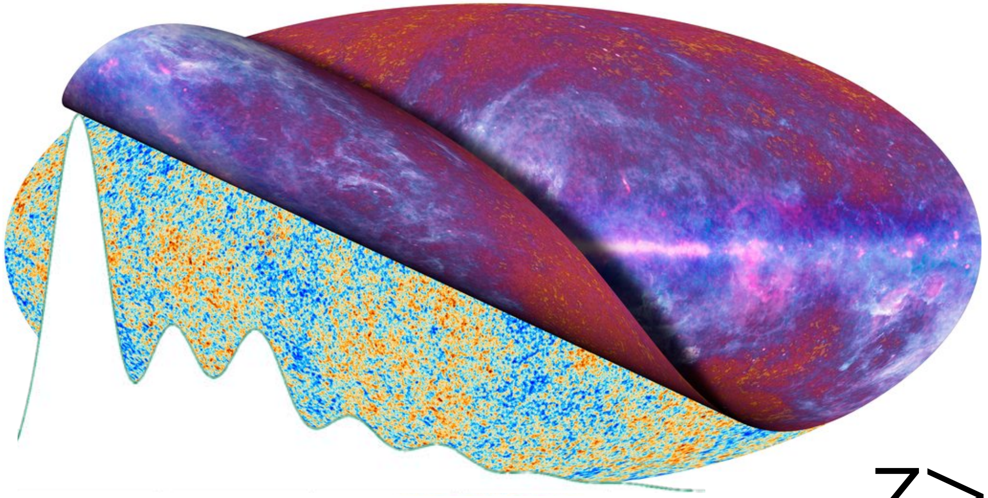


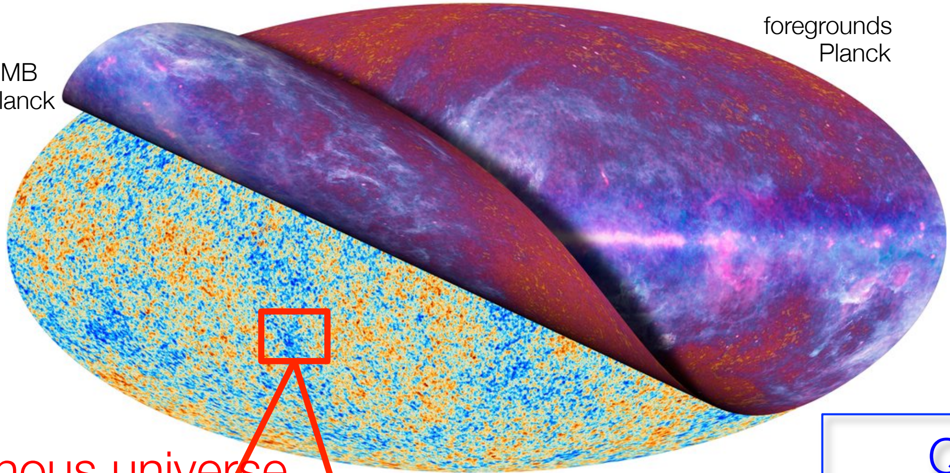
Planck, Herschel & Spitzer unveil z>2 cluster candidates. Prospects for next space missions.

planck
herschel
jwst
euclid

Hervé Dole on behalf of Planck Collaboration

Institut d'Astrophysique Spatiale, Orsay, France
Université Paris Sud & CNRS & univ. Paris-Saclay
Institut Universitaire de France
http://www.ias.u-psud.fr/dole/

1. some of the challenges in cosmology



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

homegenous universe

z=1090

?

cosmological
model
ΛCDM

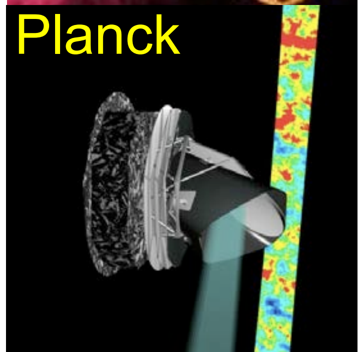
Q: processes of structure formation, esp. first clusters, mass assembly, gas cooling, star formation, galaxies ?

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

inhomogeneous
structured,
universe

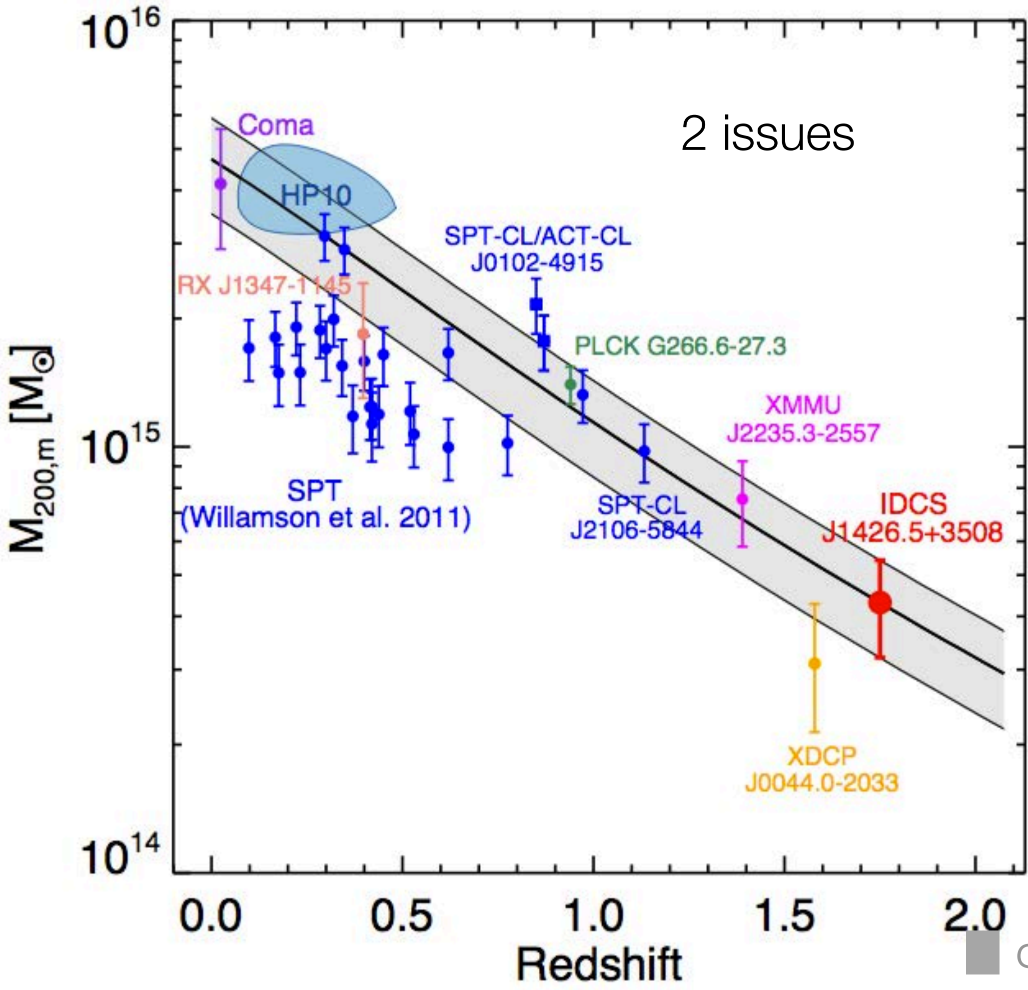
z=0

processes implying :
- fundamental forces
- dark components
- baryon physics
- cosmological parameters



searching for high-z massive structures: link DM-baryons

Predictions / mesurements: massive clusters vs redshift



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 JWST, CI J0227

Euclid, JWST

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

Gobat Cl.

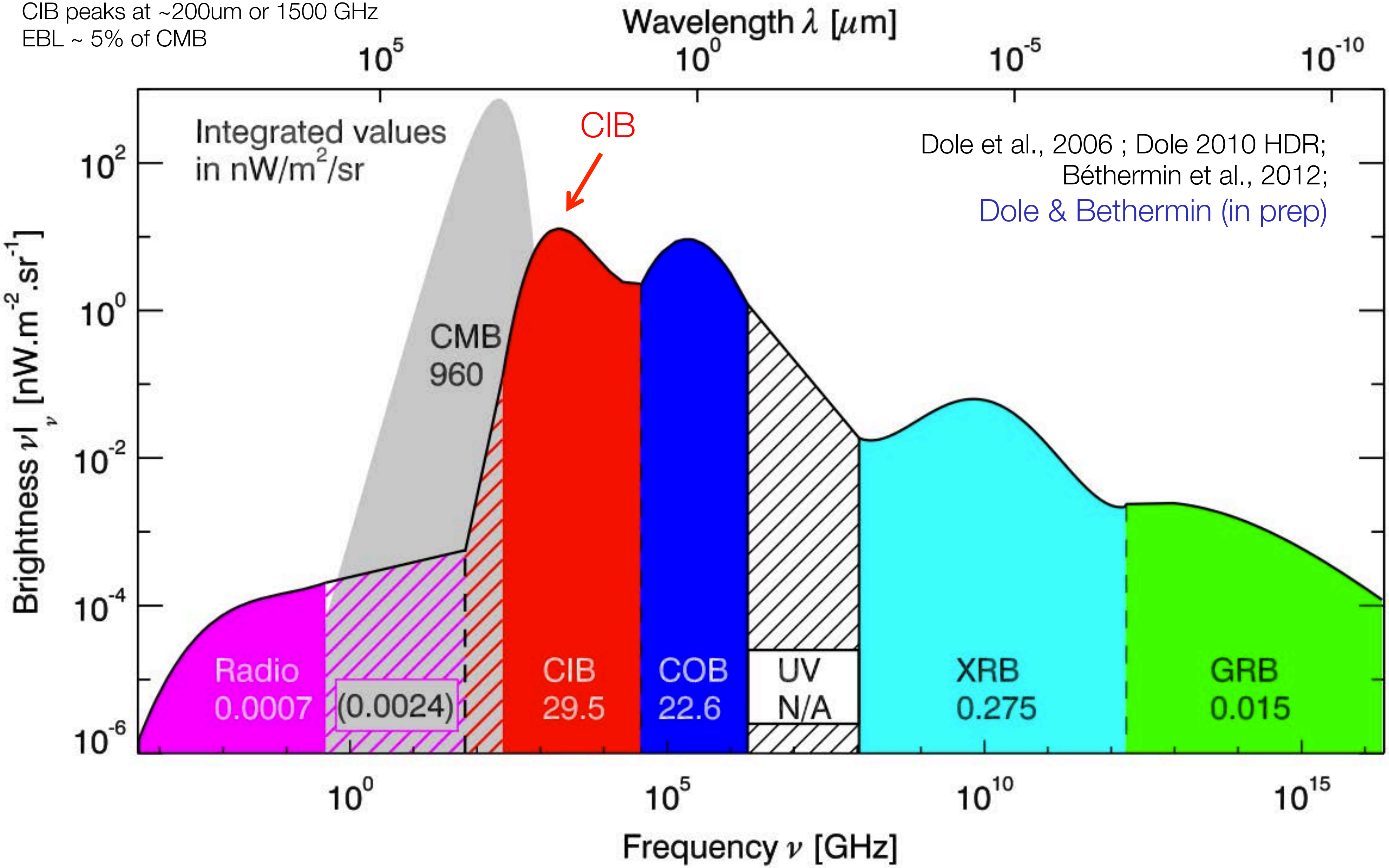
how to find z>2 clusters ?

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

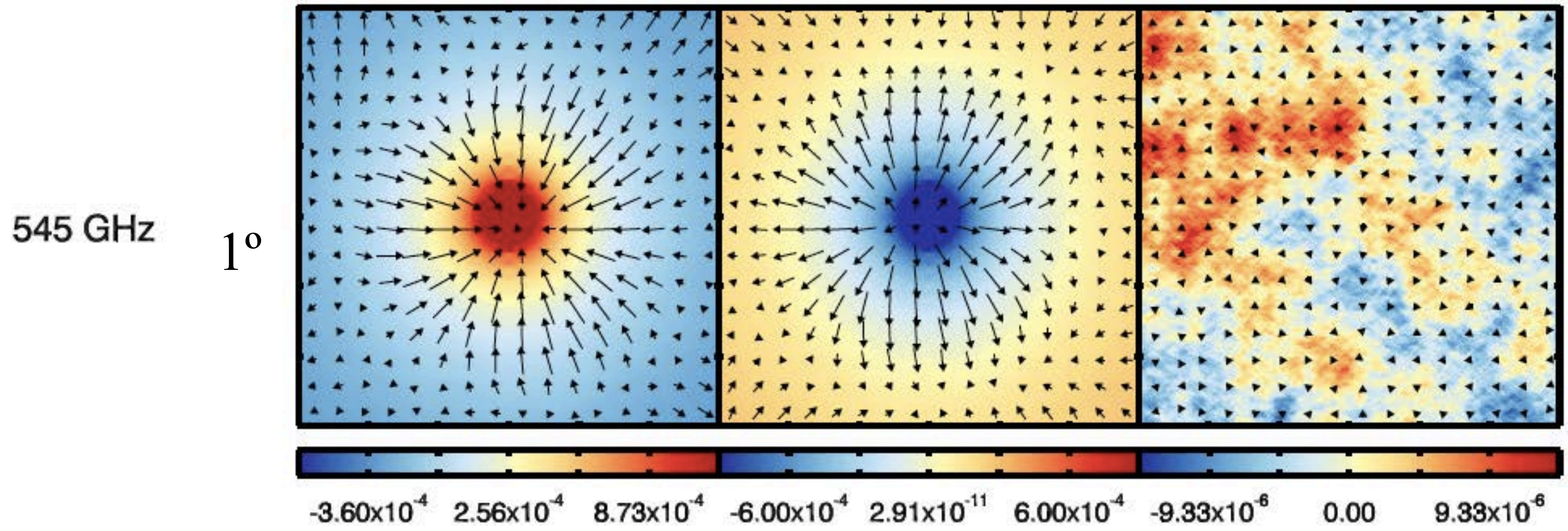
Galaxy clusters are proxies for massive DM halos

2. Extragalactic Background Light SED

CIB > COB
CIB peaks at ~200um or 1500 GHz
EBL ~ 5% of CMB



CIB peaks correspond to mass peaks…

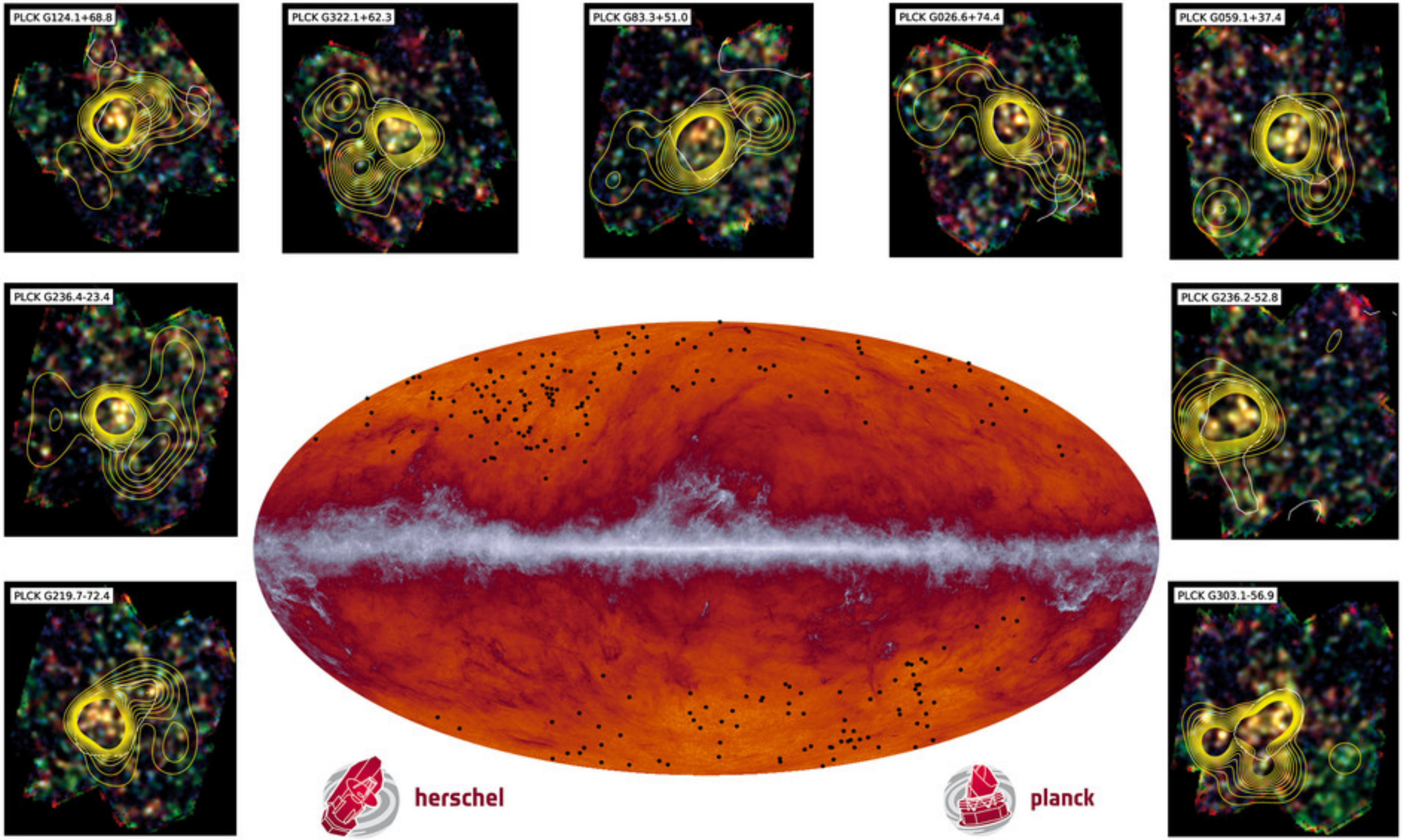


... and the CIB probes also high-z SFR

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

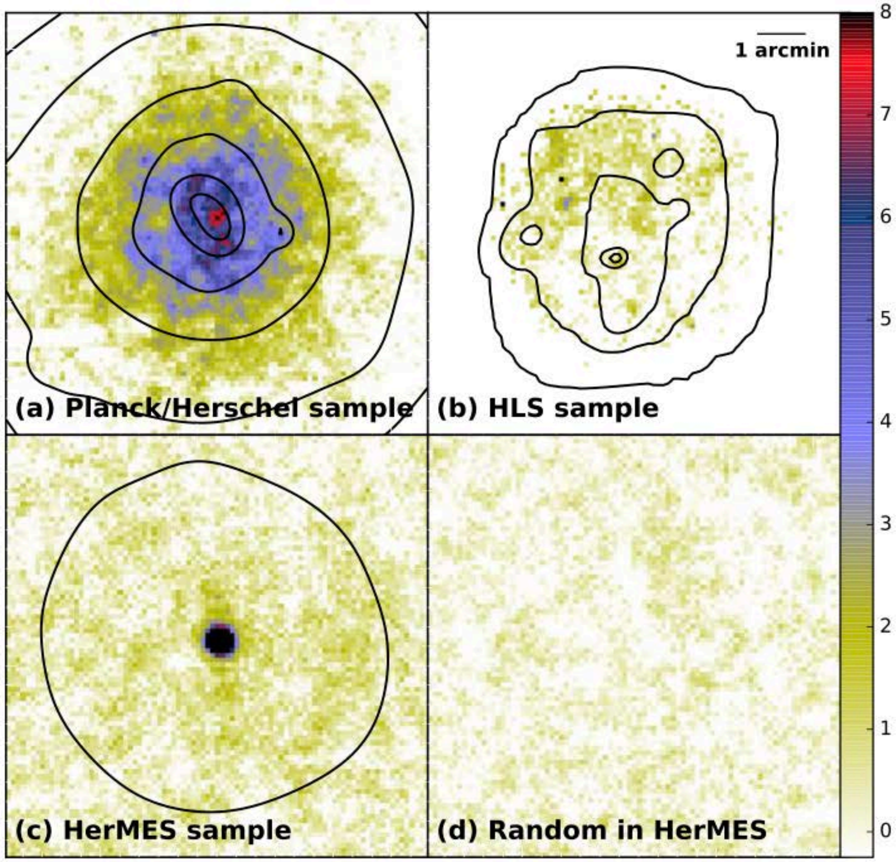
Planck 15 months
Planck Collaboration, 2013, 18

3 Herschel and Planck proto-cluster candidates

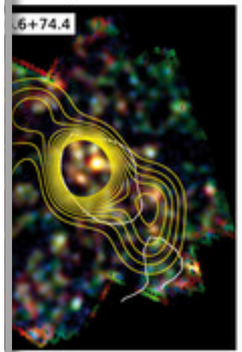


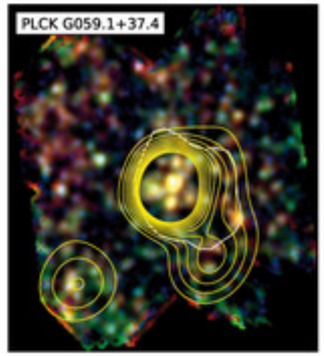
Planck Collab., 2015, Int XXVII and ArXiV:1503.08773
Press Releases (March 31st, 2015): ESA, NASA, CNRS, A&A

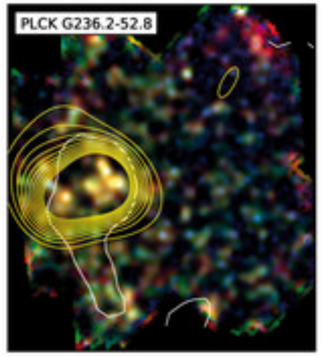
3 Herschel and Planck proto-cluster candidates

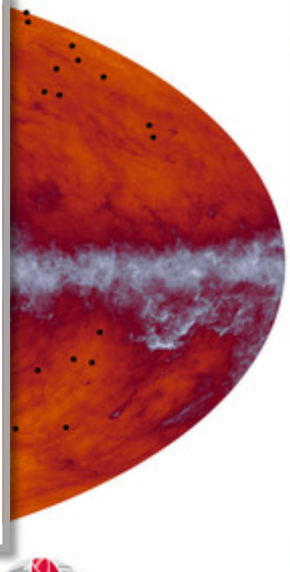


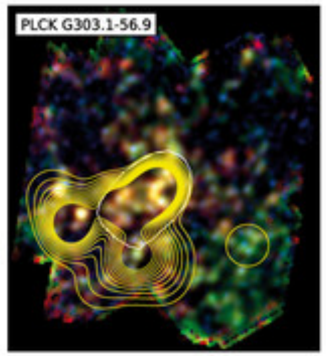
re 12. Stacks of SPIRE 350 μm data (8.7′ × 8.7′): (a) 220 *Planck Herschel* fields; (b) 278 HLS clusters; (c) 500 sources in the MES Lockman field, peaking at 350 μm; and (d) 500 random positions in the HerMES Lockman field. Black contours show the ity of red sources (using AKDE). Our *Planck* fields clearly exhibit a high significance of extended (a few arcminutes) submm sion, due to the presence of many red point sources, not seen in the HLS or HerMES sources. See Sect. 6.2 for details.

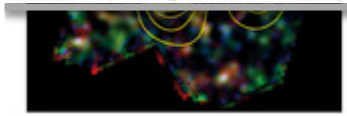












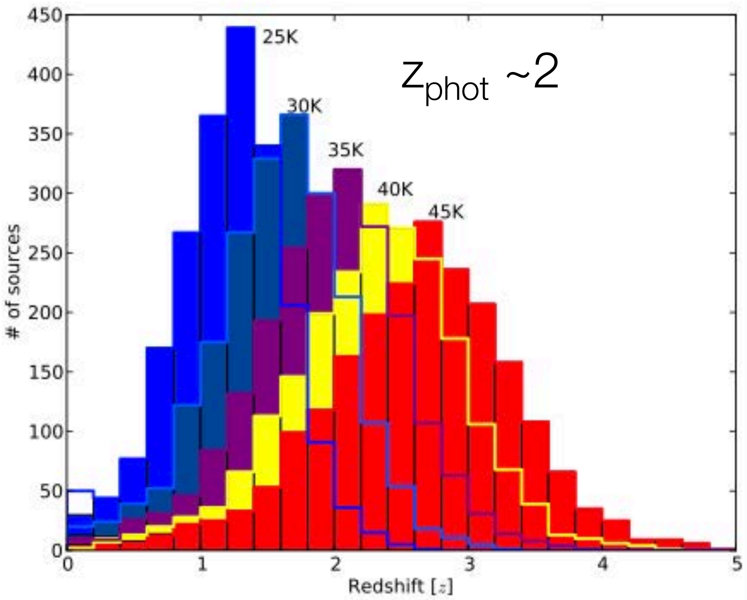
herschel

planck

Planck Collab., 2015, Int XXVII and ArXiV:1503.08773
Press Releases (March 31st, 2015): ESA, NASA, CNRS, A&A

3 Herschel and Planck proto-cluster candidates

esa



igure 13. SPIRE photometric redshift distribution of th
ughly 2200 SPIRE sources in the IN regions, as a functio
f the fixed assumption for dust temperature: T_d = 25, 30, 35
), and 45 K (from left to right). See Sect. 6.3 for details.

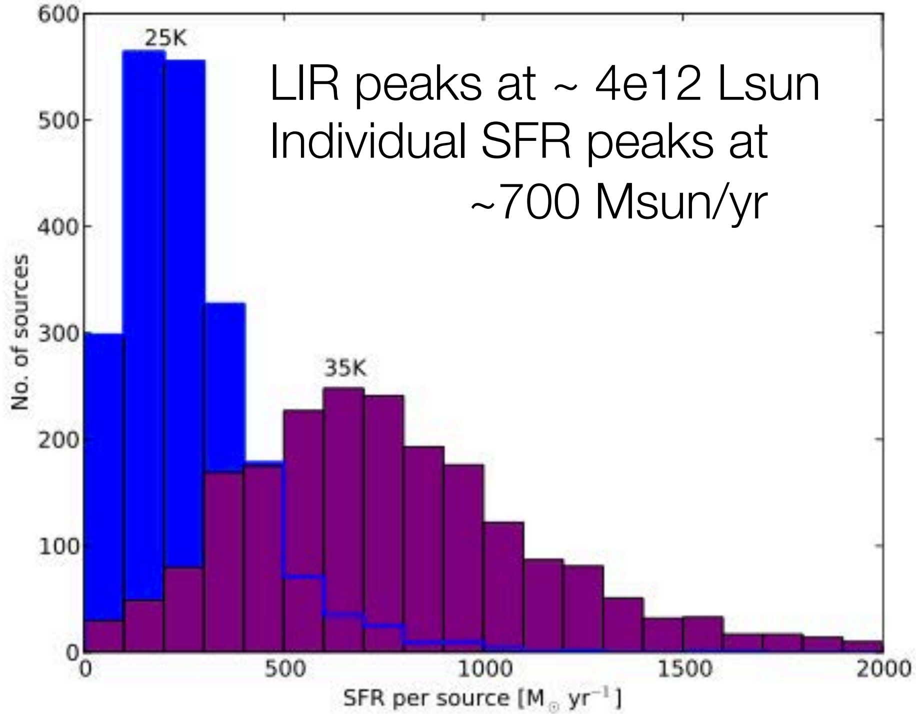
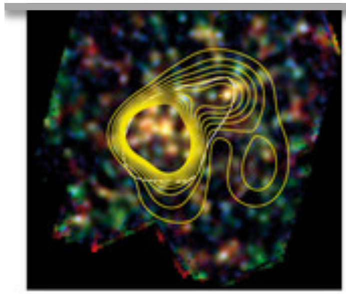


Figure 15. Star formation rate (SFR) for individual SPIRE sources in the overdensity sample (i.e., in the *Planck* IN region). For T_d = 35 K, a dust temperature favoured by the literature, (purple, right histogram) the distribution peaks at 700 $M_\odot\,yr^{-1}$. We also show for illustration T_d = 25 K (blue left histogram peaking at 200 $M_\odot\,yr^{-1}$). See Sect. 6.3 for details.

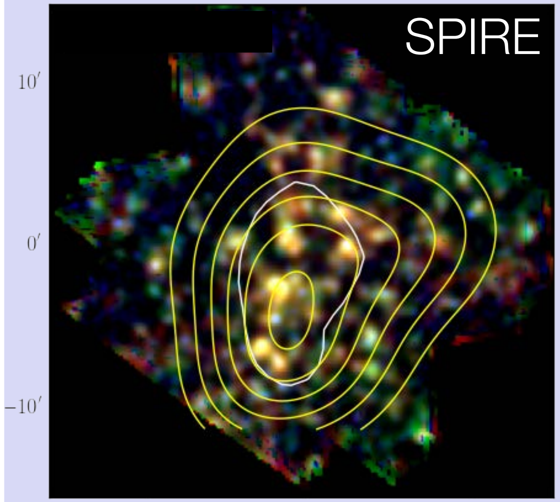


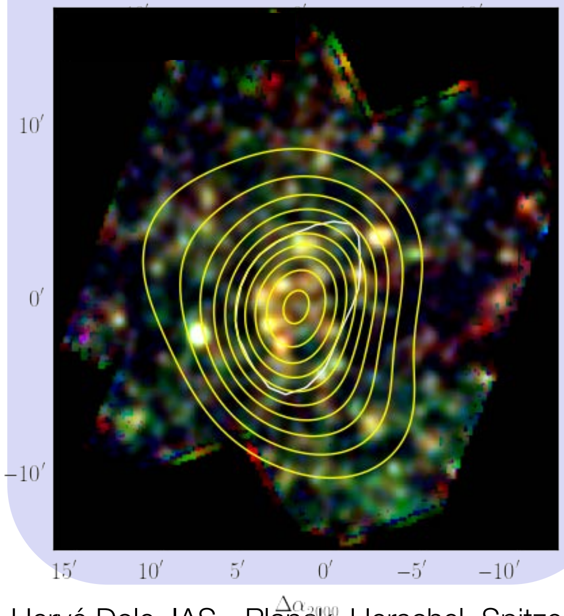
herschel

Planck Collab., 2015, Int XXVII and ArXiV:1503.08773
Press Releases (March 31st, 2015): ESA, NASA, CNRS, A&A

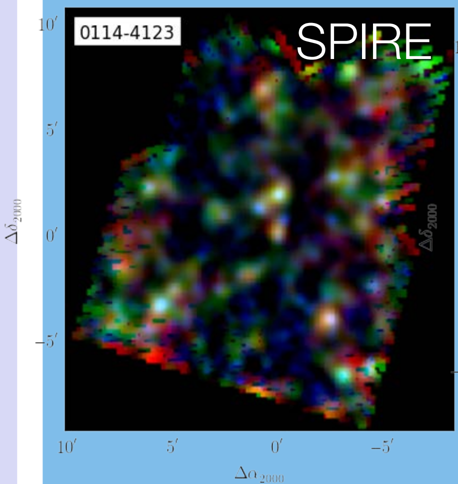
a remarkable Planck+Herschel dataset among others

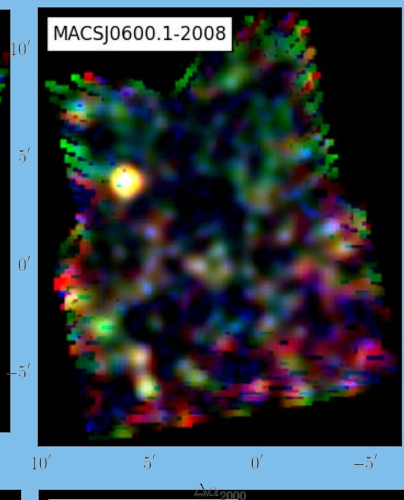
Planck/Herschel HPASSS 30' x 30' (Planck subm)

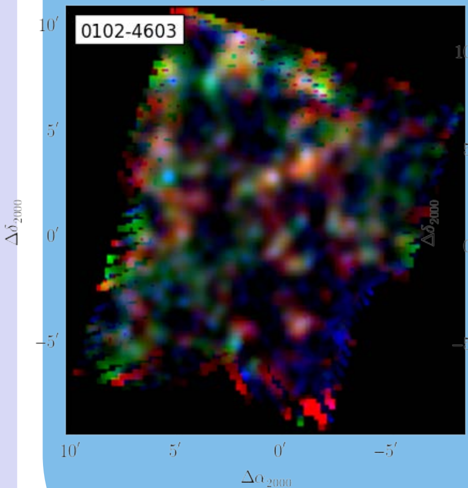


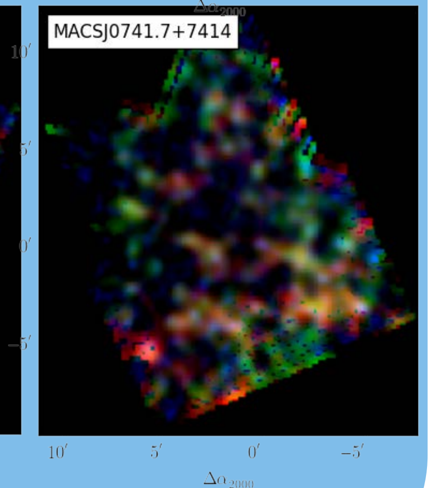


HLS 20' x 20' (Egami+2010)

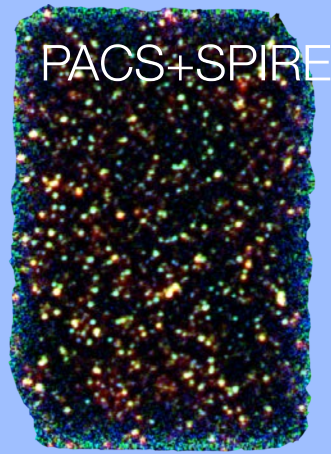


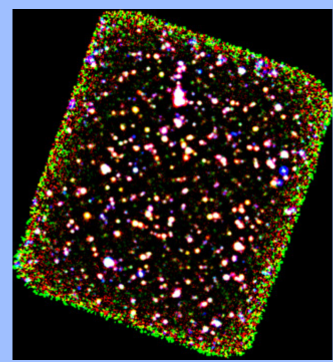






GOODS 16' x 10' (Elbaz+2011)

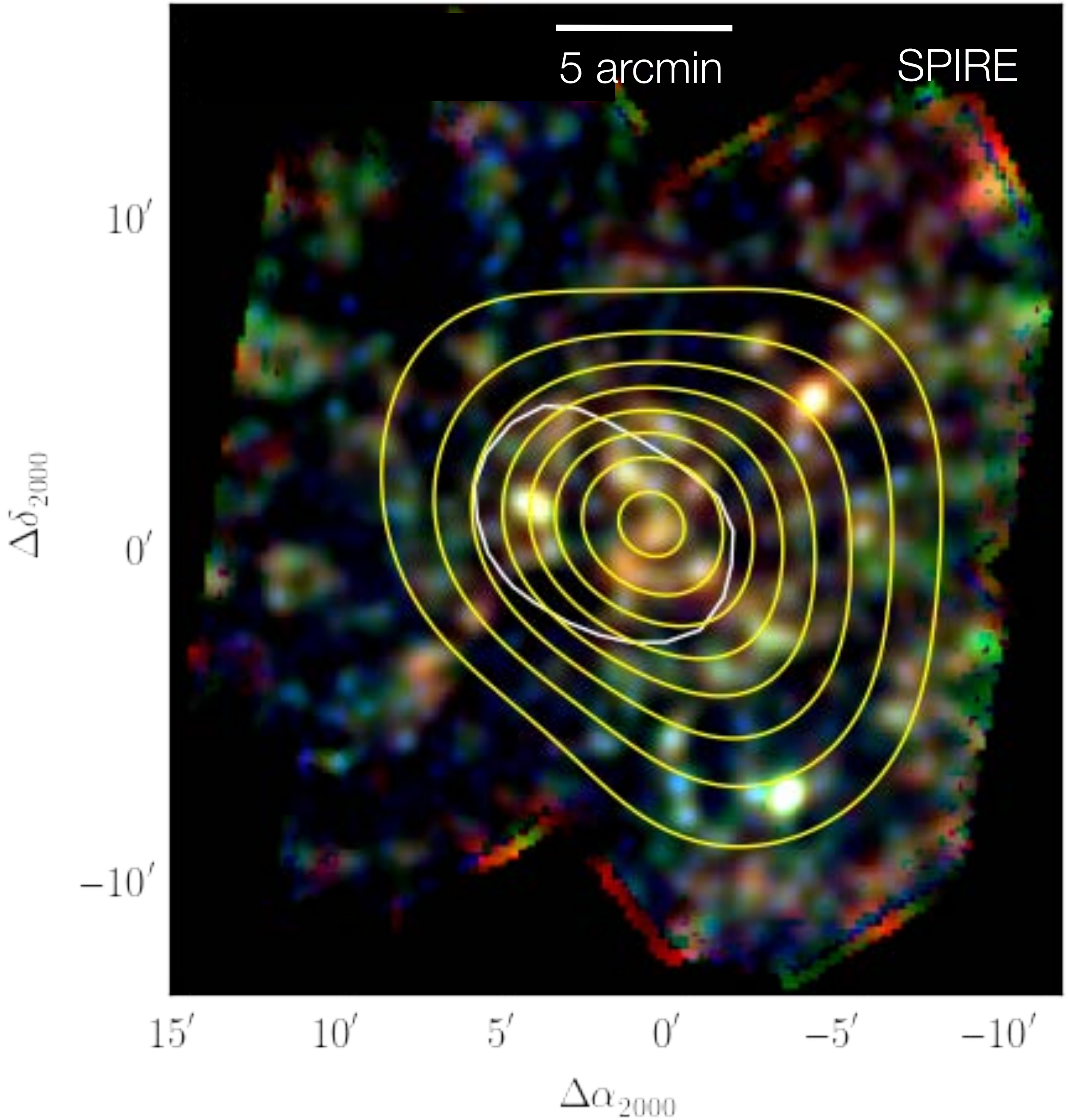




H. Dole & Planck collab

the case of one field: Spitzer and VLT

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

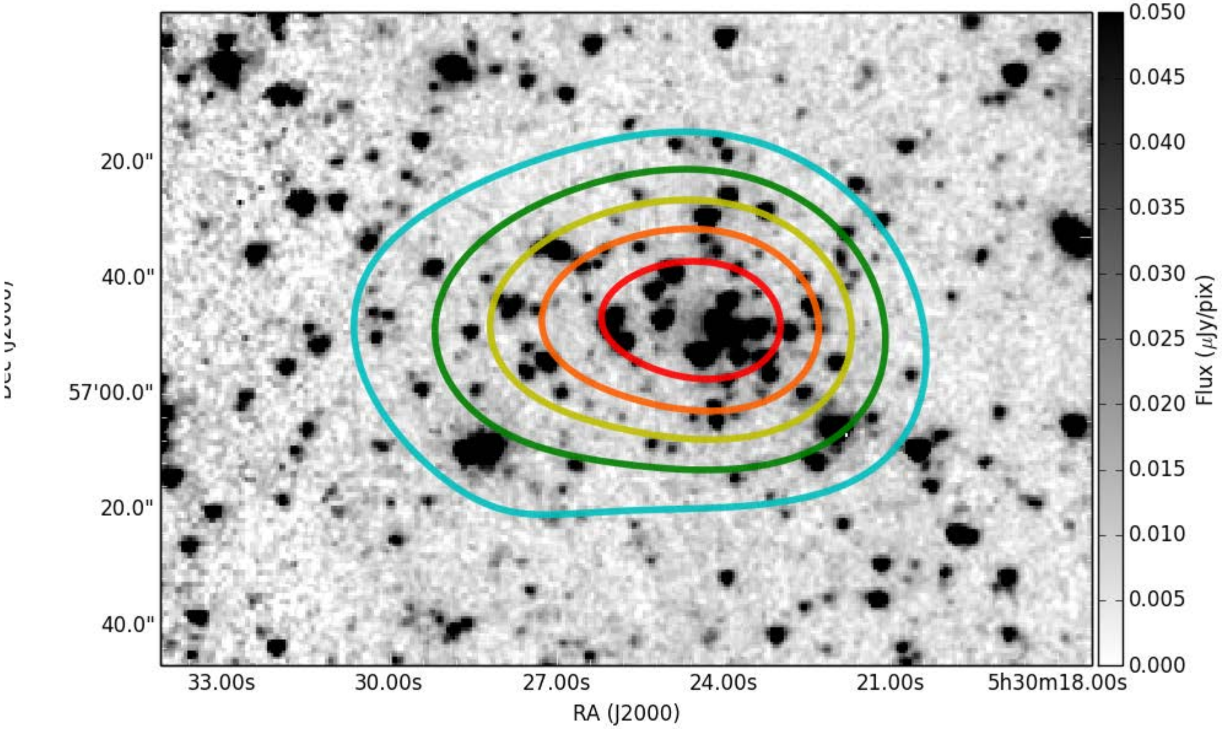


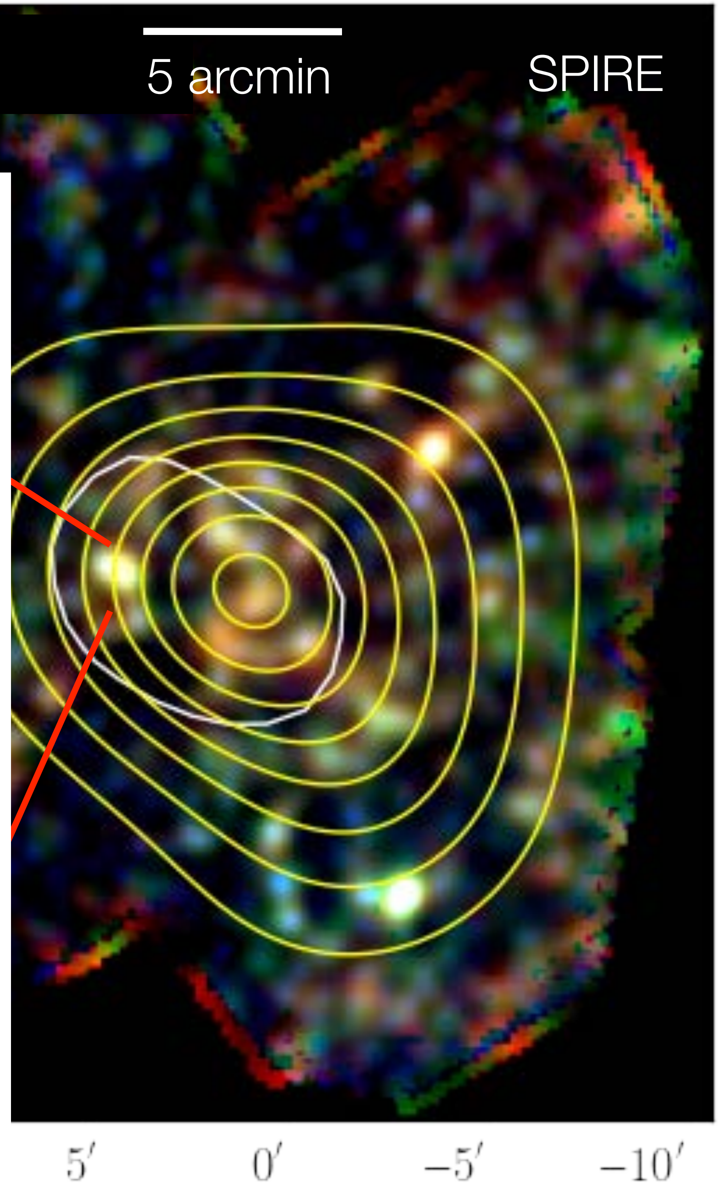
the case of one field: Spitzer

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

Euclid will provide this kind of sensitivity over the whole sky !
JWST and WFIRST much better, on smaller sky areas !

IRAC   30 arcsec

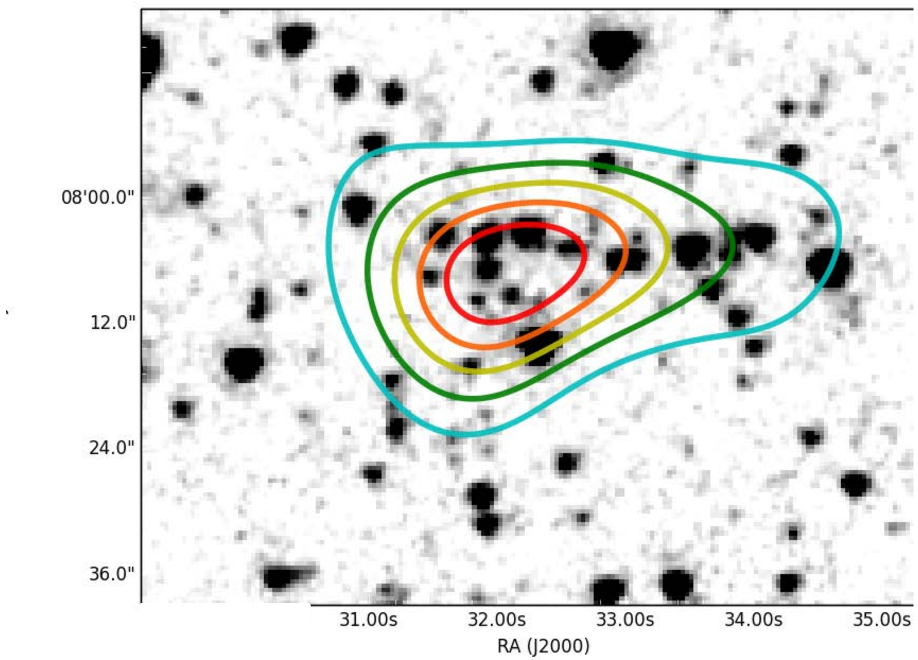


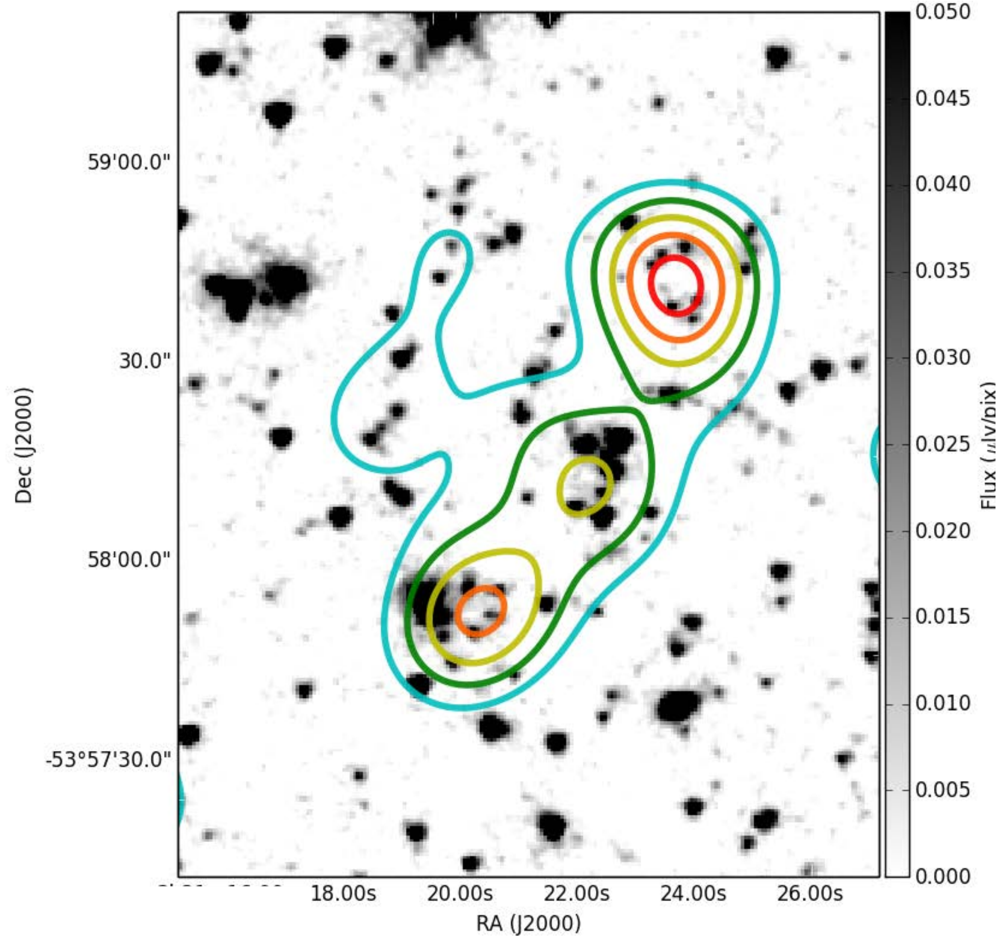


Martinache et al., in prep

4. Spitzer helps before JWST, Euclid, WFIRST: examples

PRELIMINARY
estimated photo-z: z> 1.4
estimated stellar mass: ~3e11 Msun per galaxy





Martinache et al., in prep

4. high-z clusters: status; Spitzer towards JWST, Euclid, WFIRST

4. high-z clusters: status; Spitzer towards

Yuan et al., 2014 z=2.095

Tadaki et al., 2014 z=2.5

Strazzullo et al., 2015 z~2

Shimakawa et al.

Mei et al., 2015 z=1.84 & z=1.9

Chiang et al., 2014 z=1.6-3.1

z=2.2 z=2.5

Brodwin et al., 2014 z=1.75

Cucciati et al., 2014 z=2.9

Muzzin et al., 2013 z=1.63

Galametz et al., 2013 z=2.02

Cooke et al., 2014 z=2.5

Stanford et al., 2012 z=1.75

Rettura et al., 2014 z>1.3

Wylezalek et al., 2013 z=1.2-3.2

Clements et al., 2014 z=0.8-2.3

Ivison et al., 2013 z=2.41

Kuiper et al., 201

Gobat et al., 2011 z=2.0

Hatch et al., 2011 z=2.4

Riechers et al. 2010, Capak et al., 2011 z=5.3

Santos et al., 2011,13,14

Fassbender et al., 2014 z=1.58

Papovich et al., 2008,10,11 z=1.62

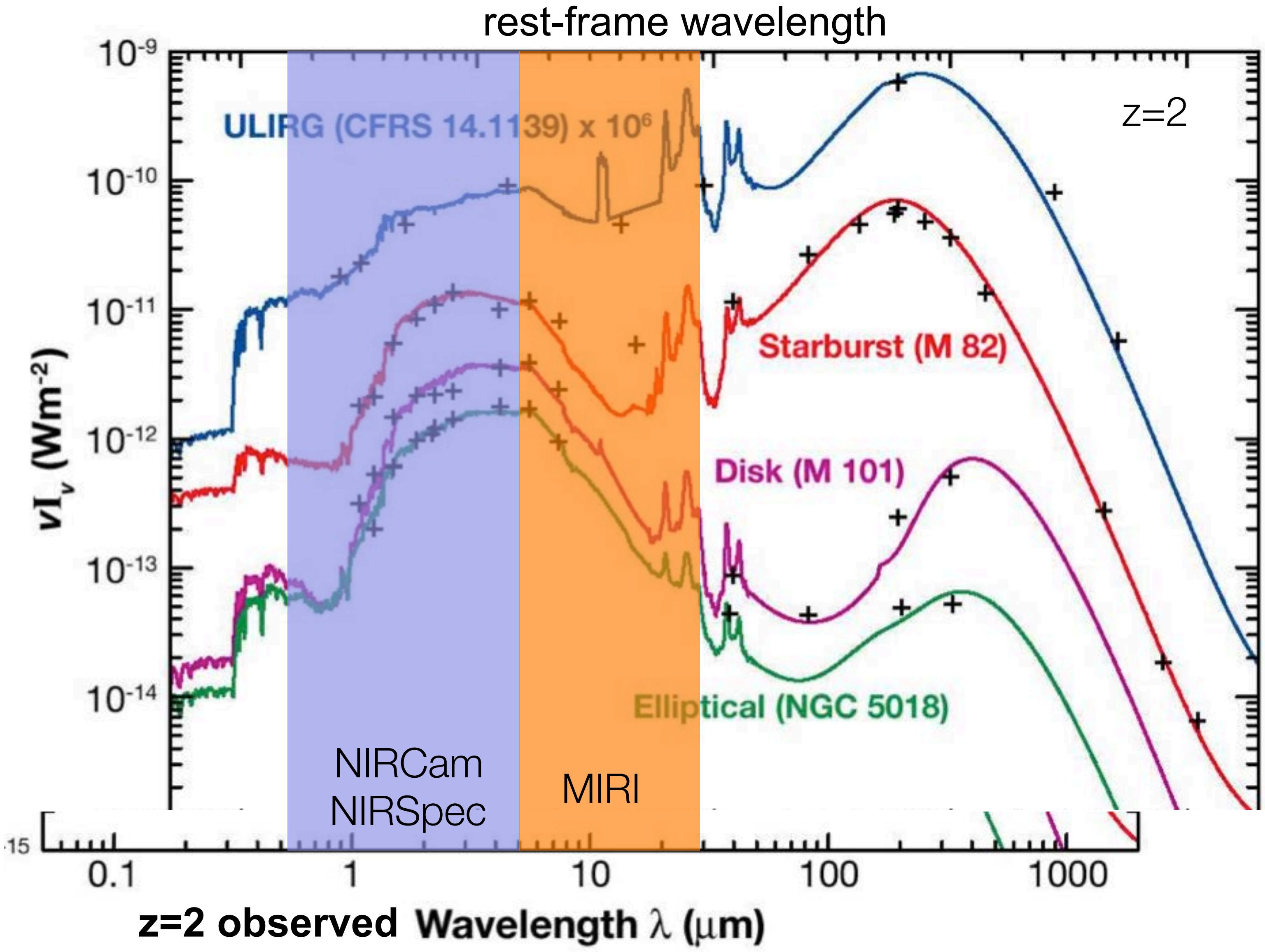
Venemans et al., 2007 z>2

Kodama et al., 2007 z=2-3

Daddi et al., 2009 z=4.05

Lemaux et al., 2014 z=3

NIR and MIR: a key range for z~2-4 structures

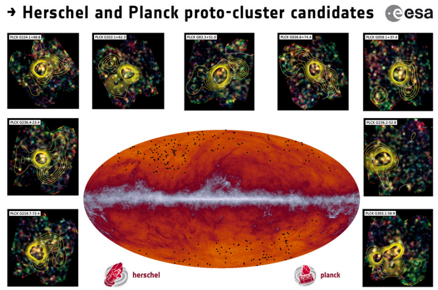


In the redshift range ~1 < z < ~3:

- NIR probes stellar component
- MIR probes unique spectral features, even at low spectral resolution

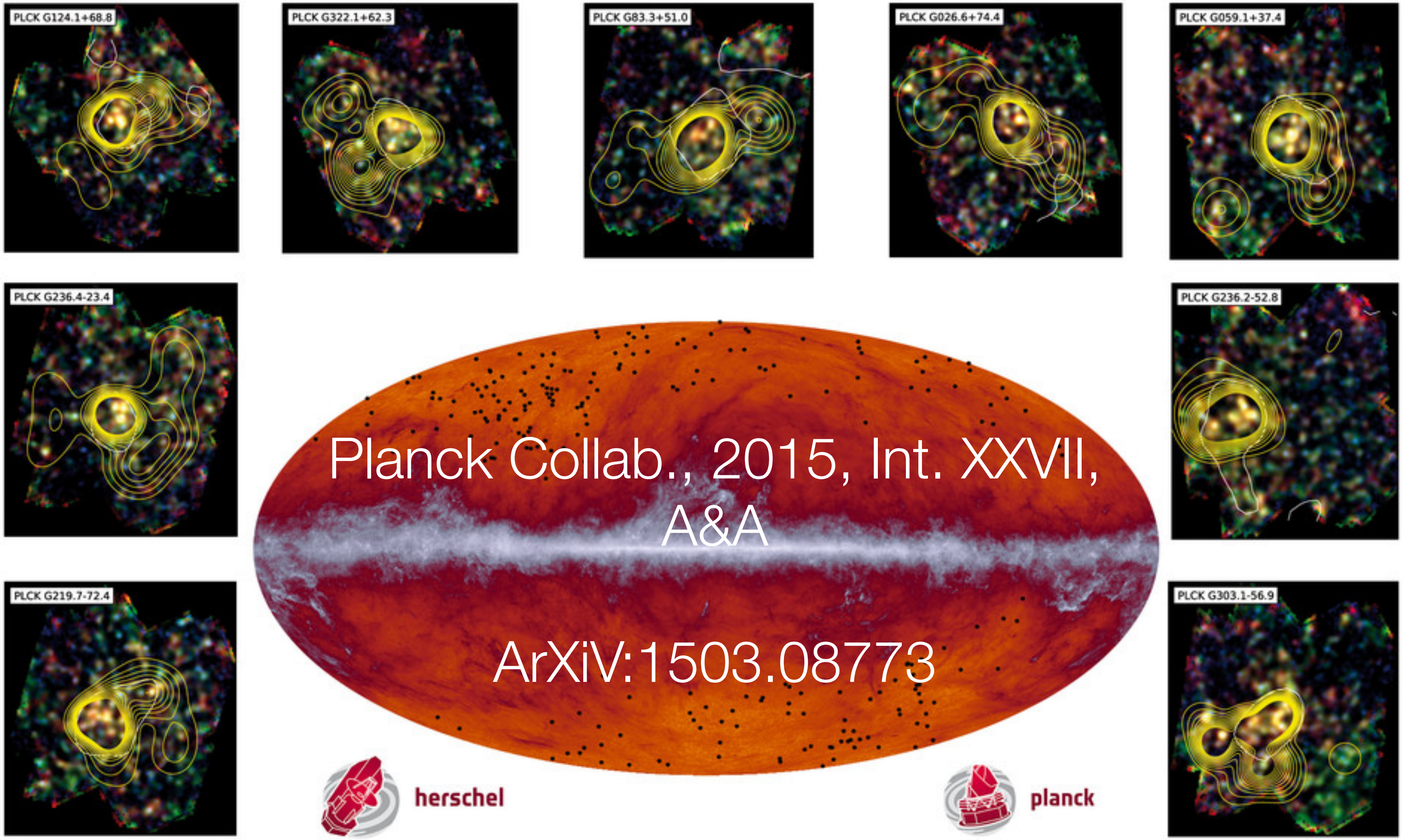
Lagache, Dole, Puget, 2005, ARAA
from Galliano 2004

5. summary & conclusions: high-z clusters



- High-z clusters are exciting
  - Cosmology, LSS
  - Galaxy evolution
  - e.g. Planck/Herschel; Spitzer; Lya
- Many samples of z>2 cluster (confirmed or candidates) exist: many targets are already identified
- Different selections, nicely complementing each-other
- Planck / Herschel / Spitzer high-z cluster candidates
- Prospects: NIR+MIR let's benefit from
  - Euclid all-sky (new candidates)
  - JWST depth and instrumentation capabilities (e.g. IFU)
  - WFIRST depth (new and existing candidates)
  - Census of galaxies, their gas and IGM in densest environments and halos
  - Also prospects in the mm

➔ Herschel and Planck proto-cluster candidates



Planck Collab., 2015, Int. XXVII, A&A

ArXiV:1503.08773

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.

extra slides

Planck Collab. paper

Planck intermediate results. XXVII. High-redshift infrared galaxy overdensity candidates and lensed sources discovered by *Planck* and confirmed by *Herschel*-SPIRE★

Planck Collaboration: N. Aghanim[54], B. Altieri[35], M. Arnaud[66], M. Ashdown[63,6], J. Aumont[54], C. Baccigalupi[79], A. J. Banday[88,10], R. B. Barreiro[59], N. Bartolo[27,60], E. Battaner[90,91], A. Beelen[54], K. Benabed[55,87], A. Benoit-Lévy[21,55,87], J.-P. Bernard[88,10], M. Bersanelli[30,47], M. Bethermin[66], P. Bielewicz[88,10,79], L. Bonavera[59], J. R. Bond[9], J. Borrill[13,83], F. R. Bouchet[55,81], F. Boulanger[54,78], C. Burigana[46,28,48], E. Calabrese[86], R. Canameras[54], J.-F. Cardoso[67,1,55], A. Catalano[68,65], A. Chamballu[66,14,54], R.-R. Chary[52], H. C. Chiang[24,7], P. R. Christensen[75,33], D. L. Clements[51], S. Colombi[55,87], F. Couchot[64], B. P. Crill[61,76], A. Curto[6,59], L. Danese[79], K. Dassas[54], R. D. Davies[62], R. J. Davis[62], P. de Bernardis[29], A. de Rosa[46], G. de Zotti[43,79], J. Delabrouille[1], J. M. Diego[59], H. Dole[54,53], S. Donzelli[47], O. Doré[61,11], M. Douspis[54], A. Ducout[55,51], X. Dupac[36], G. Efstathiou[57], F. Elsner[21,55,87], T. A. Enßlin[72], E. Falgarone[65], I. Flores-Cacho[10,88], O. Forni[88,10], M. Frailis[45], A. A. Fraisse[24], E. Franceschi[46], A. Frejsel[75], B. Frye[85], S. Galeotta[45], S. Galli[55], K. Ganga[1], M. Giard[88,10], E. Gjerløw[58], J. González-Nuevo[59,79], K. M. Górski[61,92], A. Gregorio[31,45,50], A. Gruppuso[46], D. Guéry[54], F. K. Hansen[58], D. Hanson[73,61,9], D. L. Harrison[57,63], G. Helou[11], C. Hernández-Monteagudo[12,72], S. R. Hildebrandt[61,11], E. Hivon[55,87], M. Hobson[6], W. A. Holmes[61], W. Hovest[72], K. M. Huffenberger[22], G. Hurier[54], A. H. Jaffe[51], T. R. Jaffe[88,10], E. Keihänen[23], R. Keskitalo[13], T. S. Kisner[70], R. Kneissl[34,8], J. Knoche[72], M. Kunz[16,54,2], H. Kurki-Suonio[23,41], G. Lagache[5,54], J.-M. Lamarre[65], A. Lasenby[6,63], M. Lattanzi[28], C. R. Lawrence[61], E. Le Floc'h[66], R. Leonardi[36], F. Levrier[65], M. Liguori[27,60], P. B. Lilje[58], M. Linden-Vørnle[15], M. López-Caniego[36,59], P. M. Lubin[25], J. F. Macías-Pérez[68], T. MacKenzie[20], B. Maffei[62], N. Mandolesi[46,4,28], M. Maris[45], P. G. Martin[9], C. Martinache[54], E. Martínez-González[59], S. Masi[29], S. Matarrese[27,60,39], P. Mazzotta[32], A. Melchiorri[29,49], A. Mennella[30,47], M. Migliaccio[57,63], A. Moneti[55], L. Montier[88,10], G. Morgante[46], D. Mortlock[51], D. Munshi[80], J. A. Murphy[74], P. Natoli[28,3,46], M. Negrello[43], N. P. H. Nesvadba[54], D. Novikov[71], I. Novikov[75,71], A. Omont[55], L. Pagano[29,49], F. Pajot[54], F. Pasian[45], O. Perdereau[64], L. Perotto[68], F. Perrotta[79], V. Pettorino[40], F. Piacentini[29], M. Piat[1], S. Plaszczynski[64], E. Pointecouteau[88,10], G. Polenta[3,44], L. Popa[56], G. W. Pratt[66], S. Prunet[55,87], J.-L. Puget[54], J. P. Rachen[19,72], W. T. Reach[89], M. Reinecke[72], M. Remazeilles[62,54,1], C. Renault[68], I. Ristorcelli[88,10], G. Rocha[61,11], G. Roudier[1,65,61], B. Rusholme[52], M. Sandri[46], D. Santos[68], G. Savini[77], D. Scott[20], L. D. Spencer[80], V. Stolyarov[6,63,84], R. Sunyaev[72,82], D. Sutton[57,63], J.-F. Sygnet[55], J. A. Tauber[37], L. Terenzi[38,46], L. Toffolatti[17,59,46], M. Tomasi[30,47], M. Tristram[64], M. Tucci[16], G. Umana[42], L. Valenziano[46], J. Valiviita[23,41], I. Valtchanov[35], B. Van Tent[69], J. D. Vieira[11,18], P. Vielva[59], L. A. Wade[61], B. D. Wandelt[55,87,26], I. K. Wehus[61], N. Welikala[86], A. Zacchei[45], and A. Zonca[25]

(Affiliations can be found after the references)

Submitted 11 Aug 2014 / Accepted 13 March 2015

Planck Collab., 2015, Int XXVII and ArXiV:1503.08773
Press Releases (March 31st, 2015): ESA, NASA, CNRS, A&A

Planck & Herschel overdensities

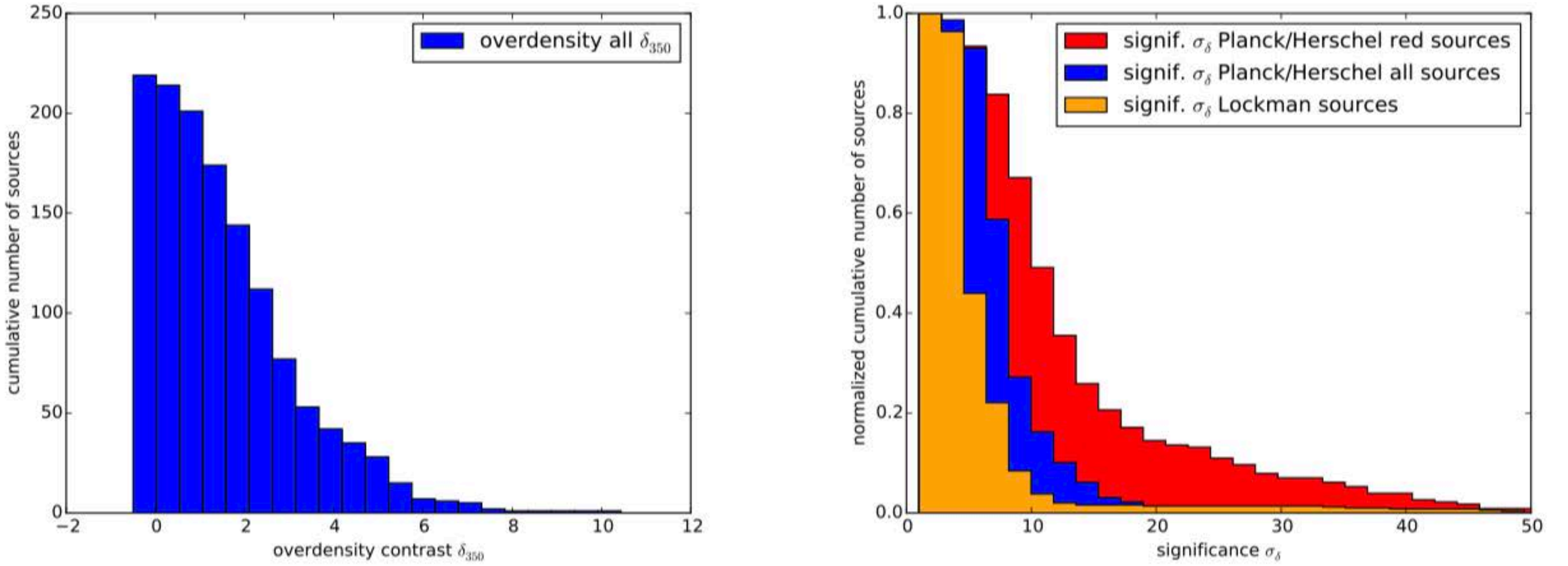
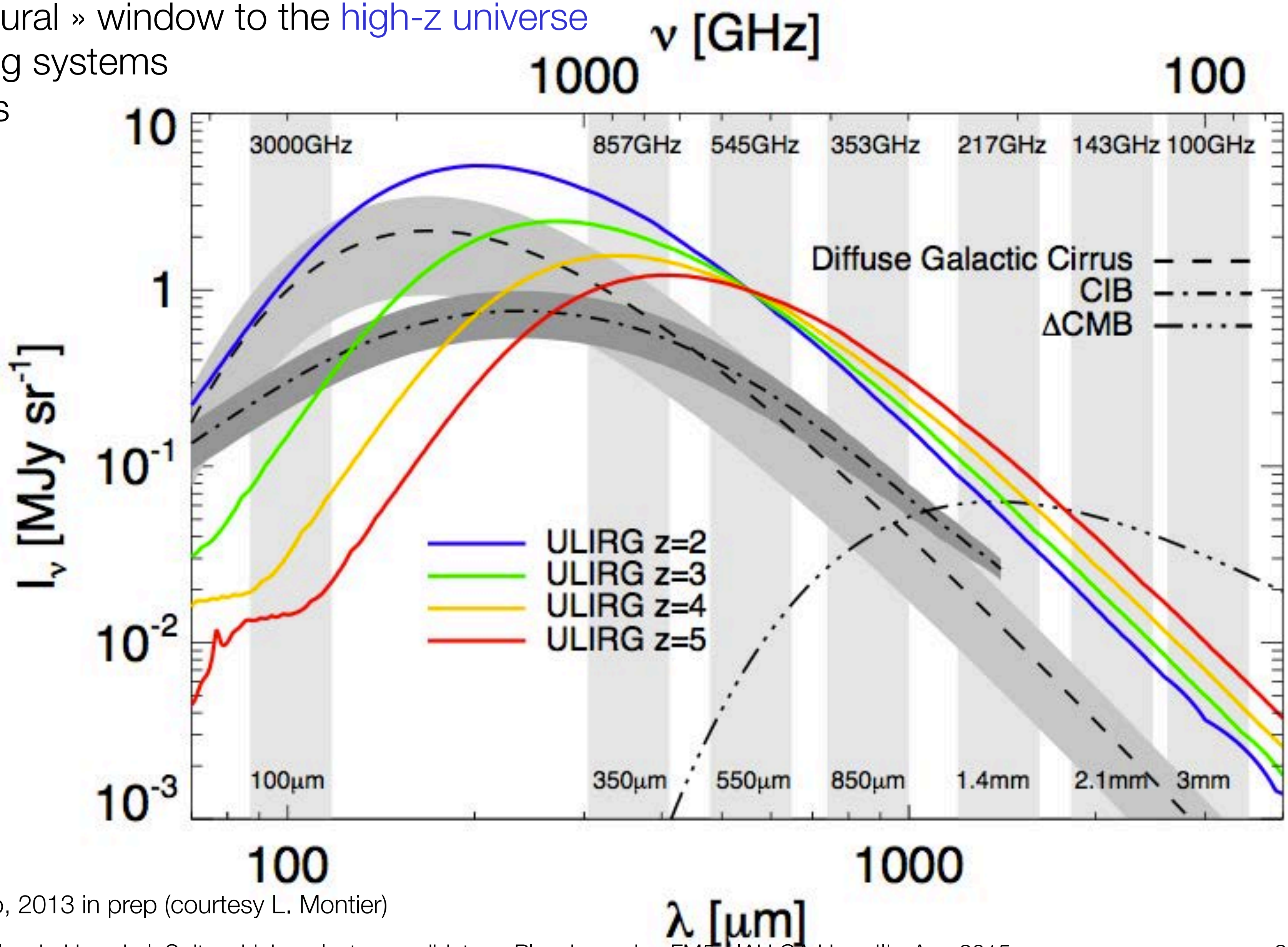


Figure 6. *Left*: Cumulative histogram of the overdensity contrast δ_{350} (blue) of each *Planck* field (based on 350 μm SPIRE sources). Overdensities are fairly large, with 59 fields having $\delta_{350} > 3$. *Right*: Cumulative (normalized) statistical significance in σ derived from the density maps. Blue represents all our SPIRE sources, red represents only redder SPIRE sources, defined by $S_{350}/S_{250} > 0.7$ and $S_{500}/S_{350} > 0.6$, and orange 500 random fields in Lockman. Most of our fields have a significance greater than $4\,\sigma$, and the significance is higher still for the redder sources. See Sect. 4.2 for details.

Planck Collab., 2015, Int XXVII and ArXiV:1503.08773
Press Releases (March 31st, 2015): ESA, NASA, CNRS, A&A

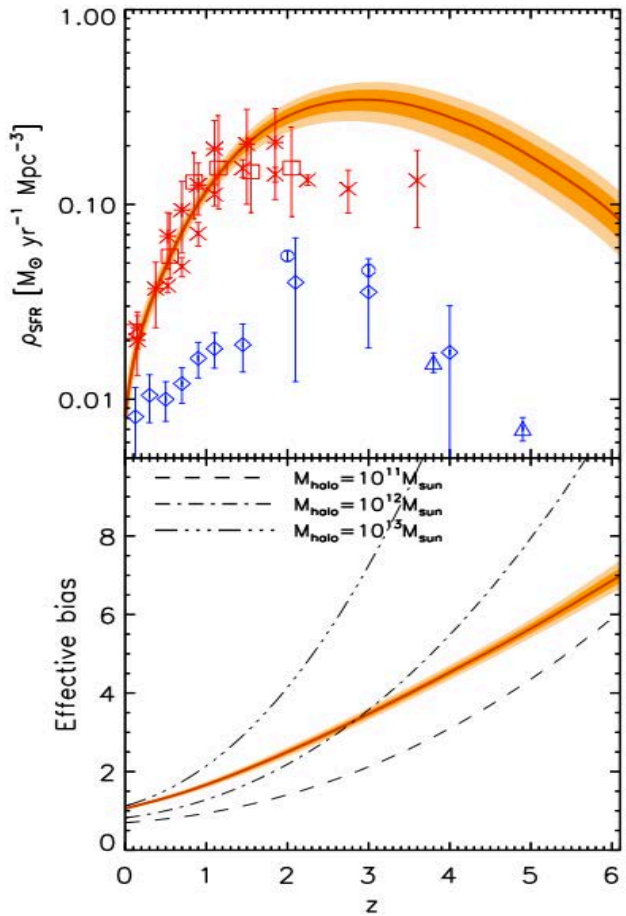
What's so special about submm/mm ?

- it is a « natural » window to the high-z universe
- star forming systems
- SZ clusters

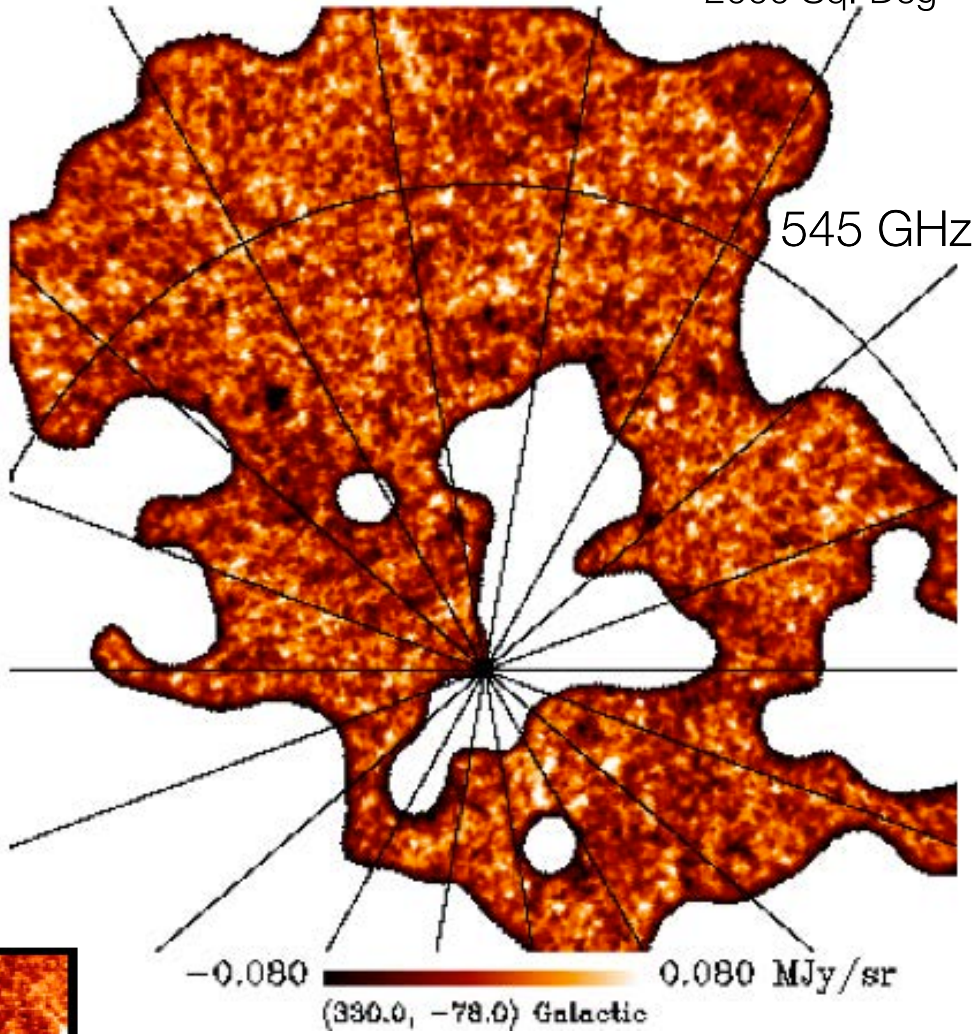


Planck Collab, 2013 in prep (courtesy L. Montier)

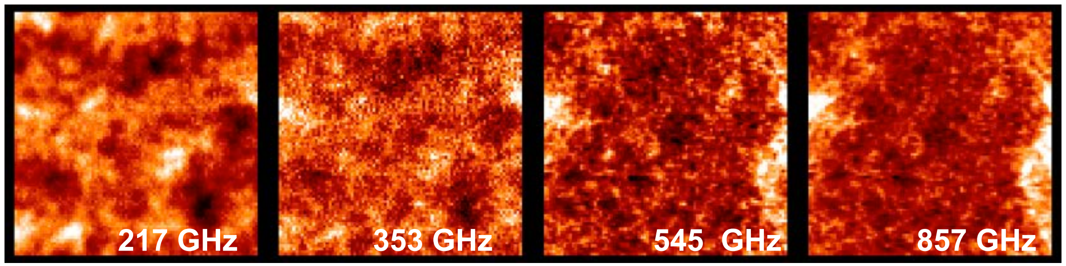
Cosmic IR Background maps probe high-z SFR



~2000 Sq. Deg

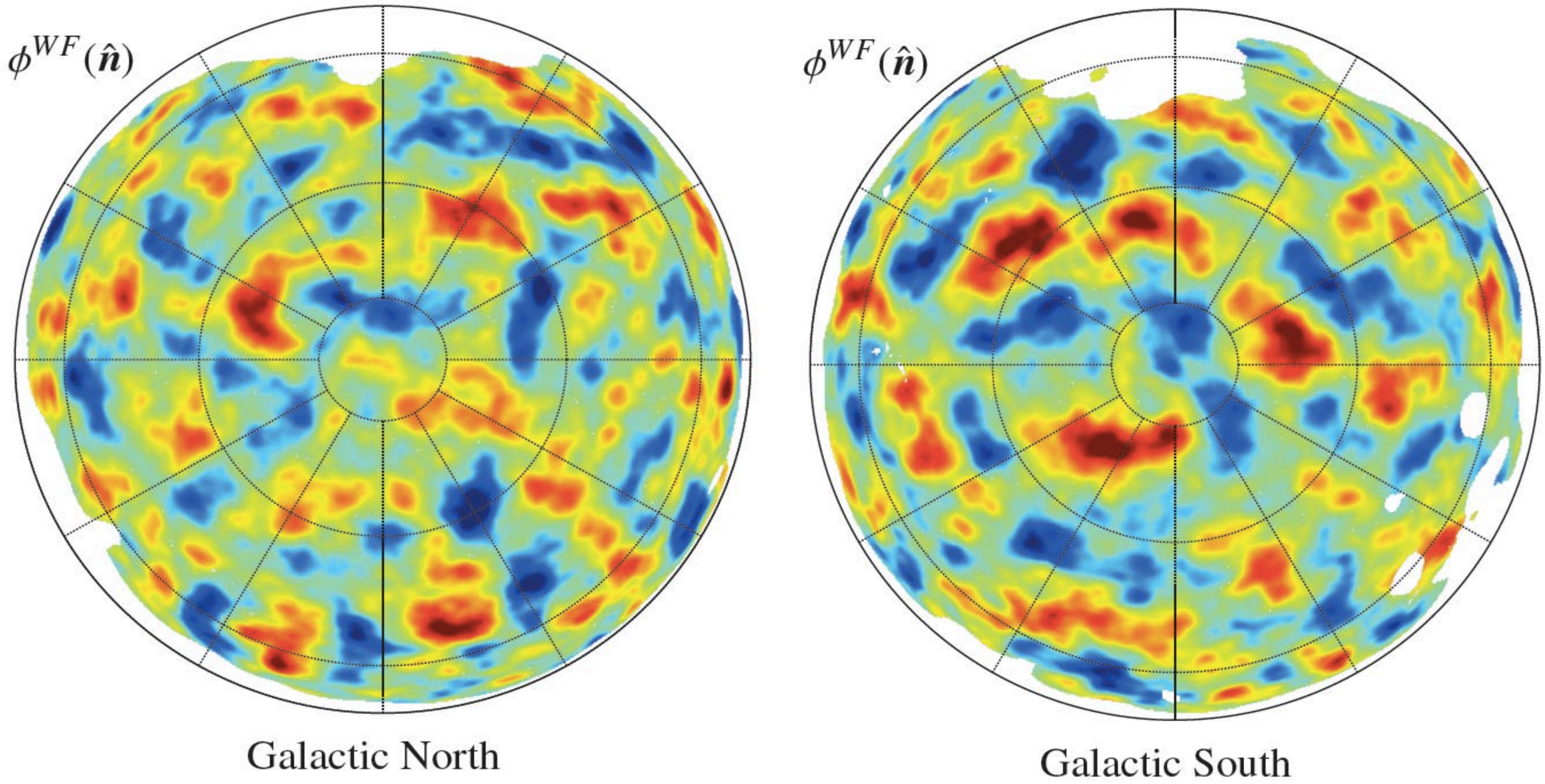


Planck Collab., 2013, 30



few 10 Sq Deg fields in 2011

Planck all-sky map of the dark matter



Planck 15 months
Planck Collaboration, 2013, 17

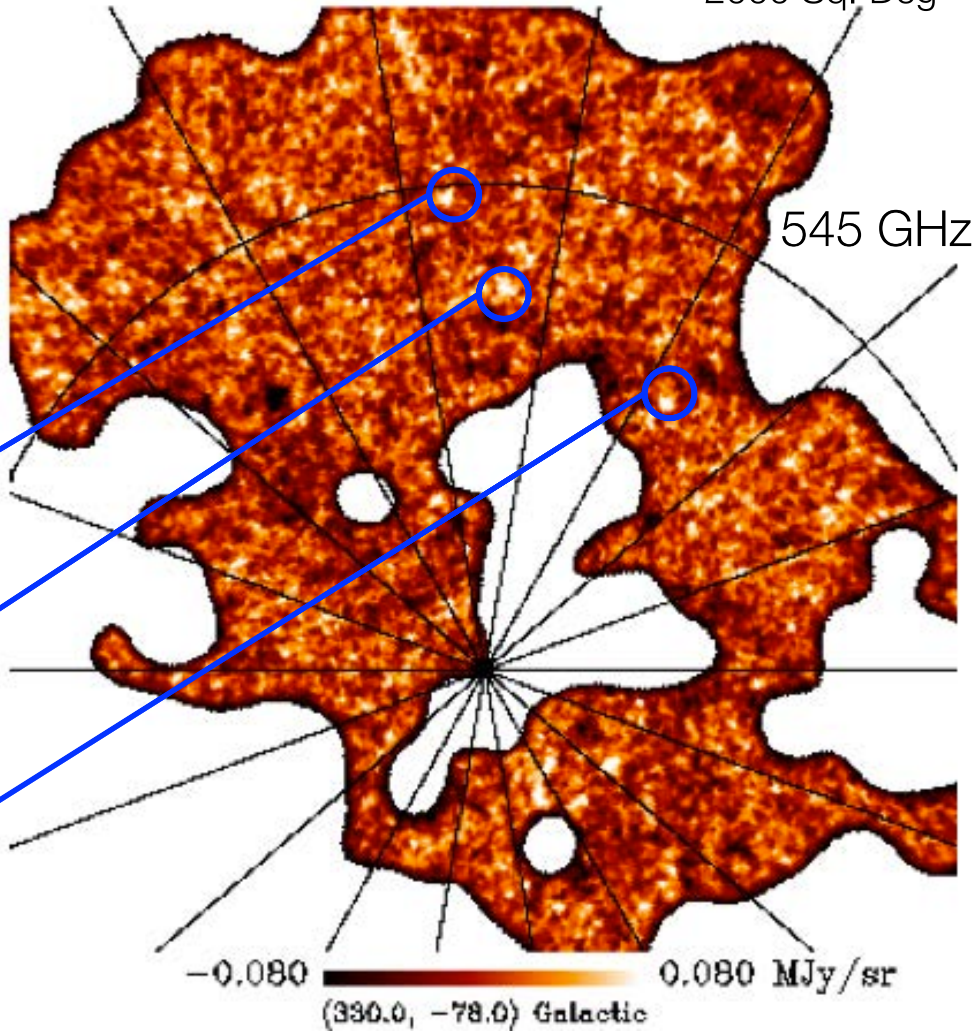
digging into the Cosmic IR Background

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 ?

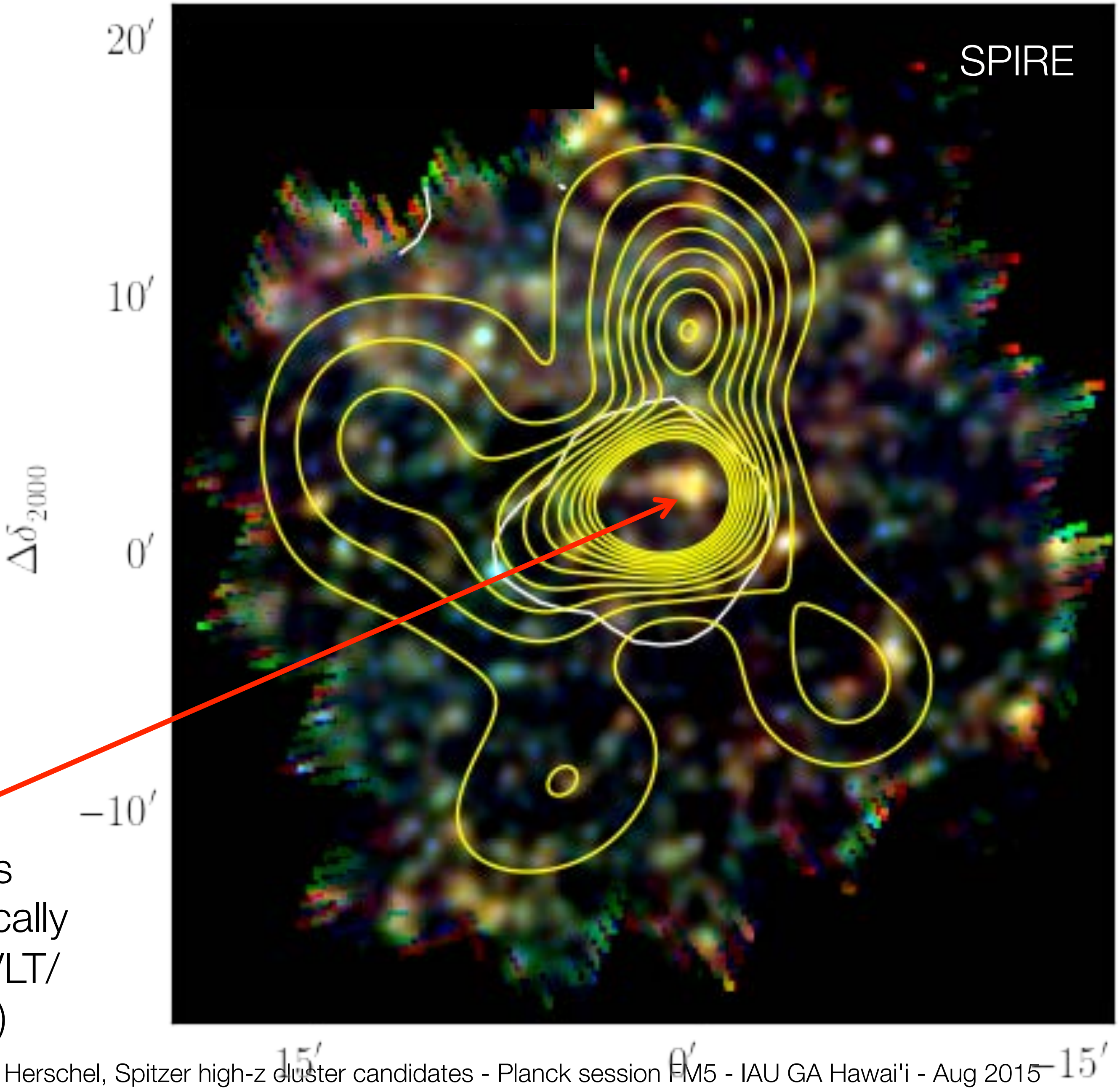
~2000 Sq. Deg



Planck Collab., 2013, 30

a double structure at z=1.7 and 2.0

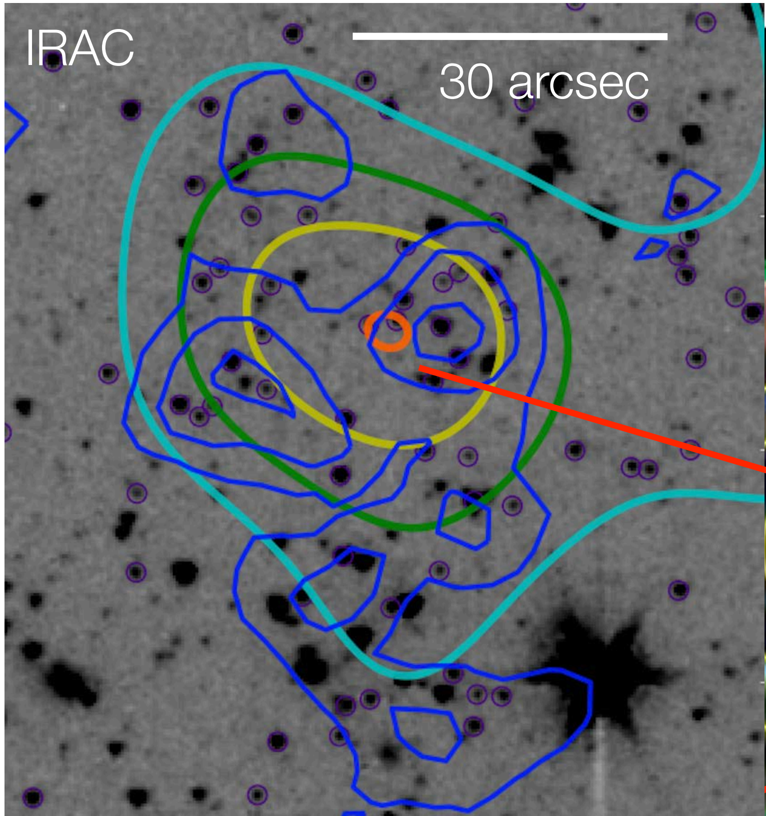
Herschel-SPIRE
3-color image:
blue = 250um
green = 350um
red = 500um

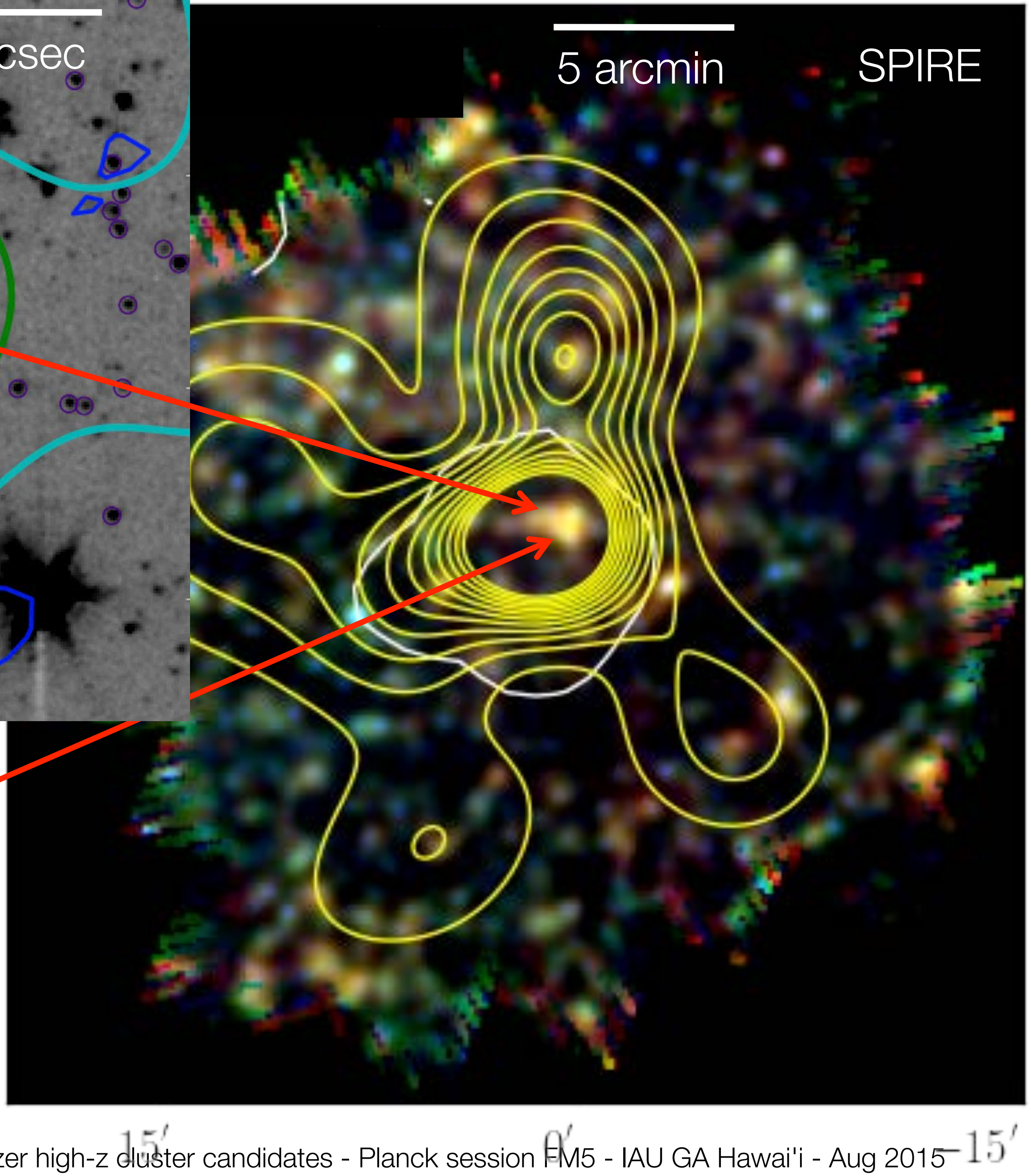


10 sources spectroscopically confirmed (VLT/XShooter)

Flores-Cacho et al., subm

a double structure at z=1.7 and 2.0





and an overdensity of red IRAC sources

10 sources spectroscopically confirmed (VLT/ XShooter)

Flores-Cacho et al., subm