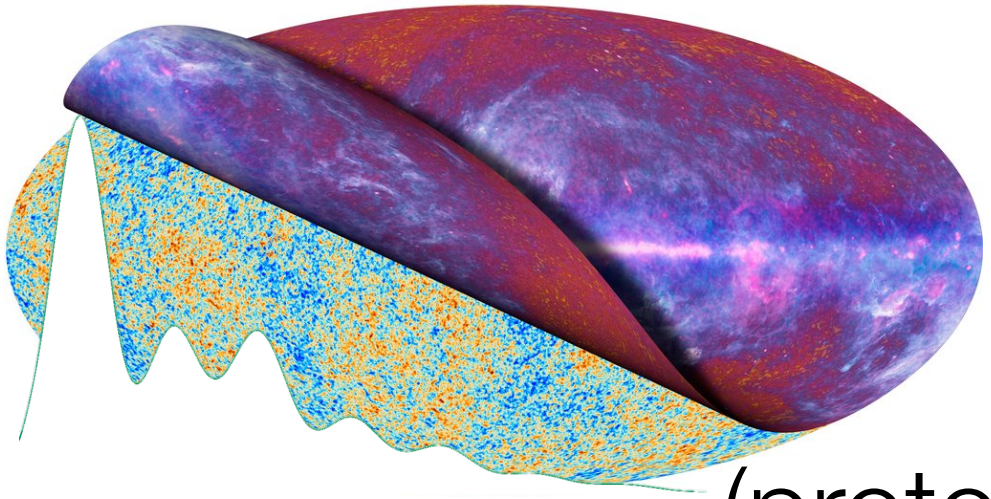


Planck, Herschel & Spitzer unveil z>2 (proto-)cluster candidates. Prospects for JWST & Euclid

planck

herschel

jwst

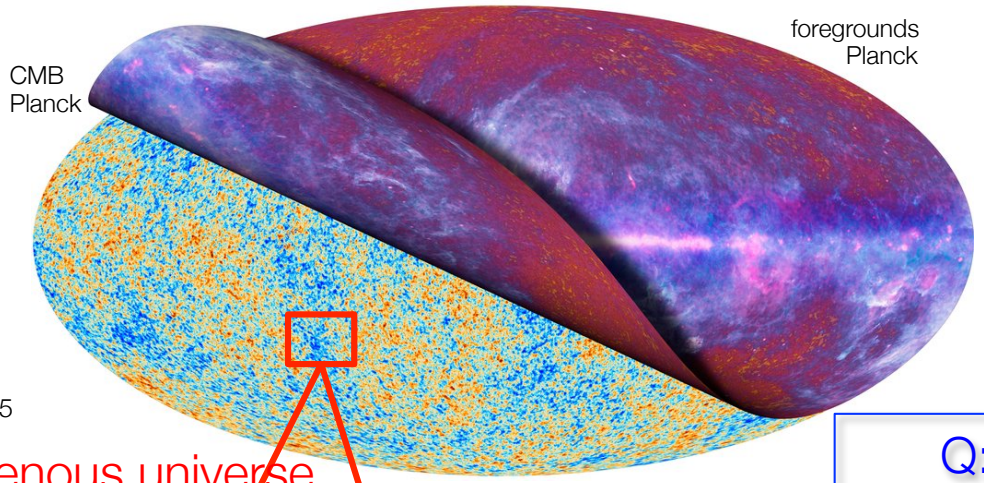
euclid

Introduction: high-z (proto-)clusters 1.
digging into the Planck CIB 2.
Planck & Herschel & Spitzer outcome 3.
High-z clusters: towards JWST, Euclid, Athena 4.
conclusions 5.

Hervé Dole et al.

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

1. some of the challenges in cosmology



$\Delta\rho/\rho \sim 10^{-5}$
homegenous universe
z=1090

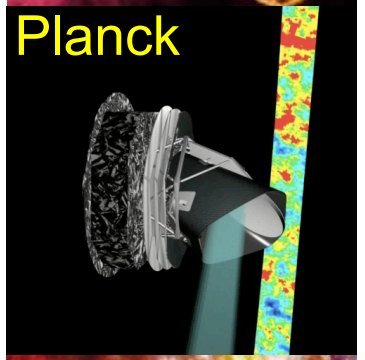
?

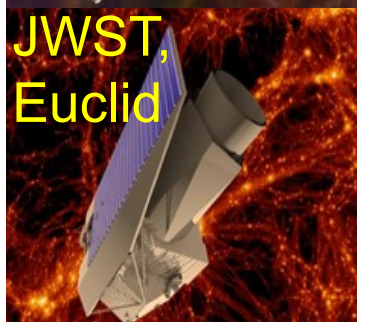
cosmological model ΛCDM

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

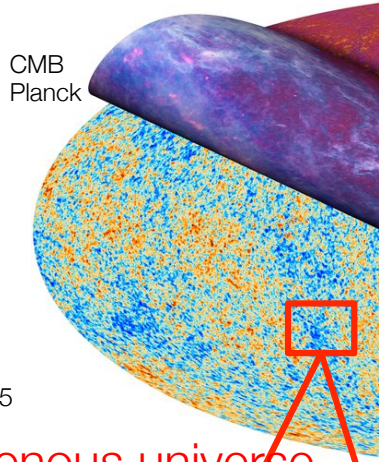
$\Delta\rho/\rho > 10^{20}$
inhomogeneous structured, universe
z=0

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





1. some of the challenges in cosmology



$\Delta\rho/\rho \sim 10^{-5}$
homegenous universe
z=1090

$\Delta\rho/\rho > 10^{20}$
inhomogeneous structured, universe
z=0

Table 9. Parameter 68 % confidence levels for the base ΛCDM cosmology computed from the *Planck* CMB power spectra, in combination with the CMB lensing likelihood ("lensing").

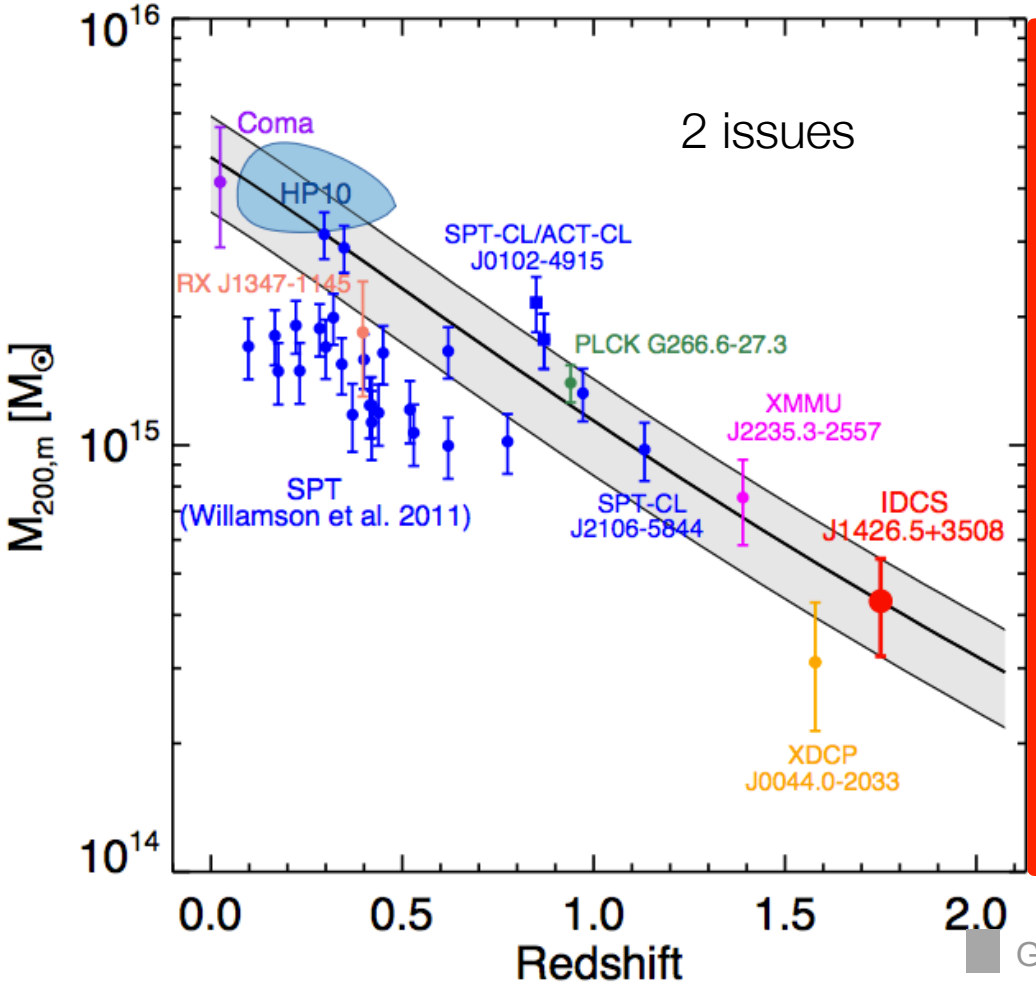
Parameter	*Planck* TT+lowP+lensing
$\Omega_b h^2$	0.02226 ± 0.00023
$\Omega_c h^2$	0.1186 ± 0.0020
$100\theta_{MC}$	1.04103 ± 0.00046
τ	0.066 ± 0.016
$\ln(10^{10} A_s)$	3.062 ± 0.029
n_s	0.9677 ± 0.0060
H_0	67.8 ± 0.9
Ω_m	0.308 ± 0.012
$\Omega_m h^2$	0.1415 ± 0.0019
$\Omega_m h^3$	0.09591 ± 0.00045
σ_8	0.815 ± 0.009
$\sigma_8 \Omega_m^{0.5}$	0.4521 ± 0.0088
Age/Gyr	13.799 ± 0.038
r_{drag}	147.60 ± 0.43
k_{eq}	0.01027 ± 0.00014

Planck Collab, 2015, 1

0.3% uncertainty !

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, WFIRST

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

Gobat CI.

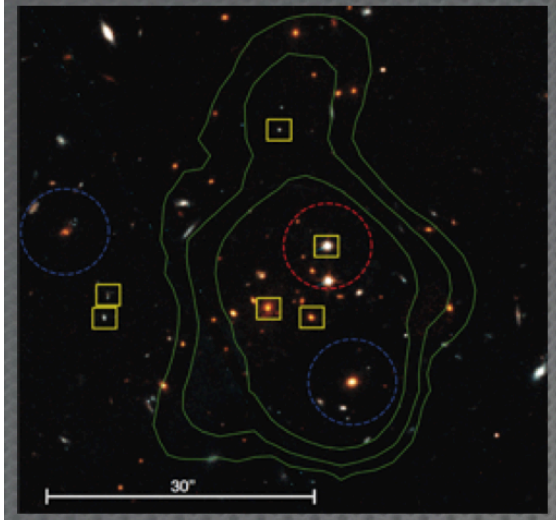
how to find z>2 clusters ?

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

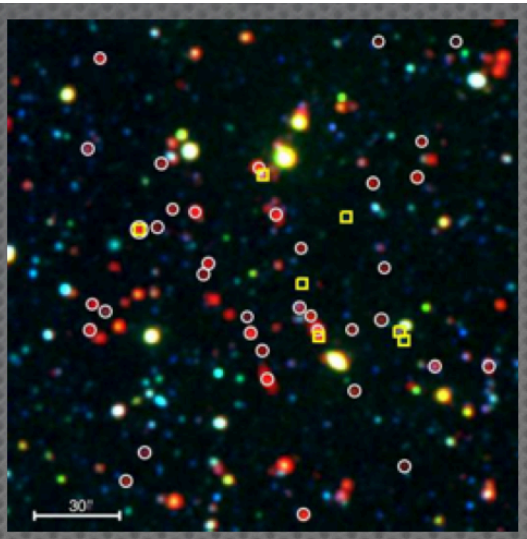
Galaxy clusters are proxies for massive DM halos

high-z proto-clusters: status

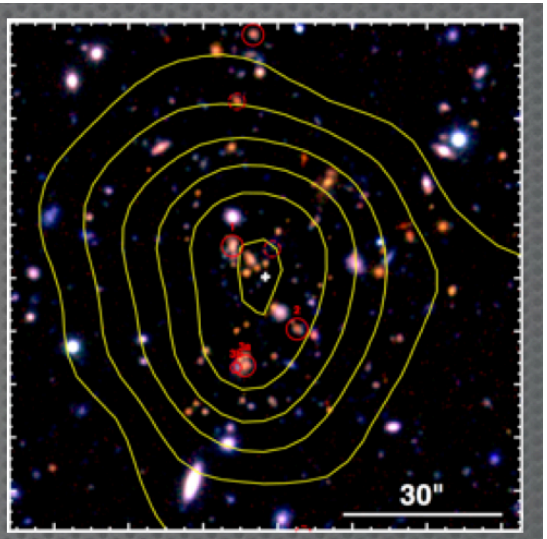
From Nina Hatch, 2015



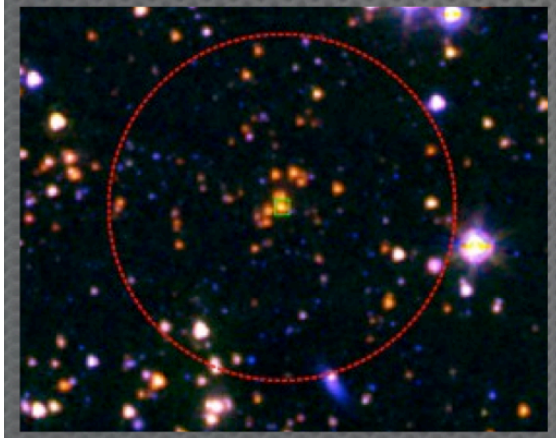
z=1.75; Stanford+ 2012



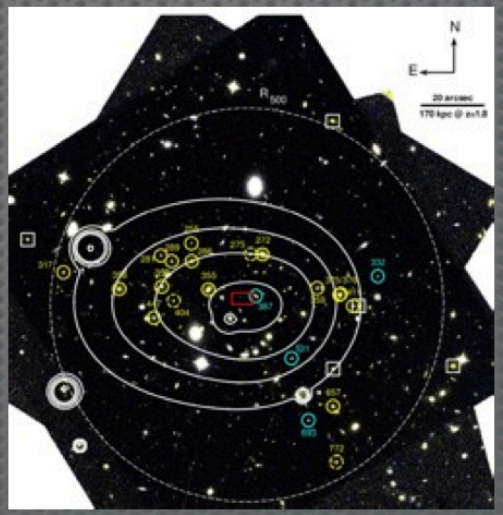
z=1.89; Zeimann+ 2012



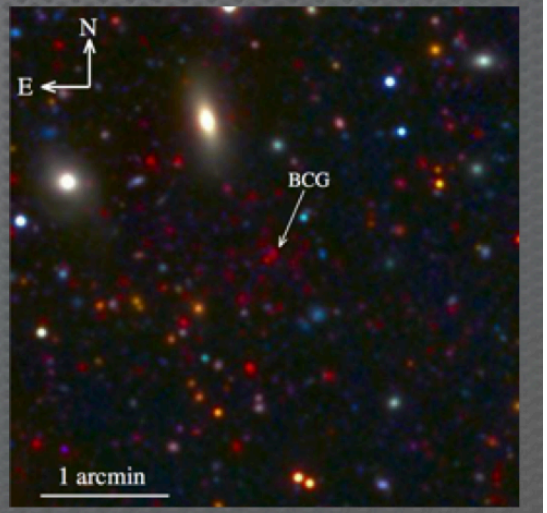
z=1.58; Fassbender+ 201



z=1.58; Cooke+ 2015



z=1.80; Newman+ 2014



z=1.7; Webb+ 2015

high-z proto-[illegible] status

Yuan et al., 2014 z=2.095

Strazzullo et al., 2015 z~2

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

Brodwin et al., 2014 z=1.75

Chiang et al., 2014 z=1.6-3.1

Cucciati et al., 2014 z=2.9

Muzzin et al., 2013 z=1.63

Cooke et al., 2014 z=2.5

Galametz et al., 2013 z=2.02

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

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

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

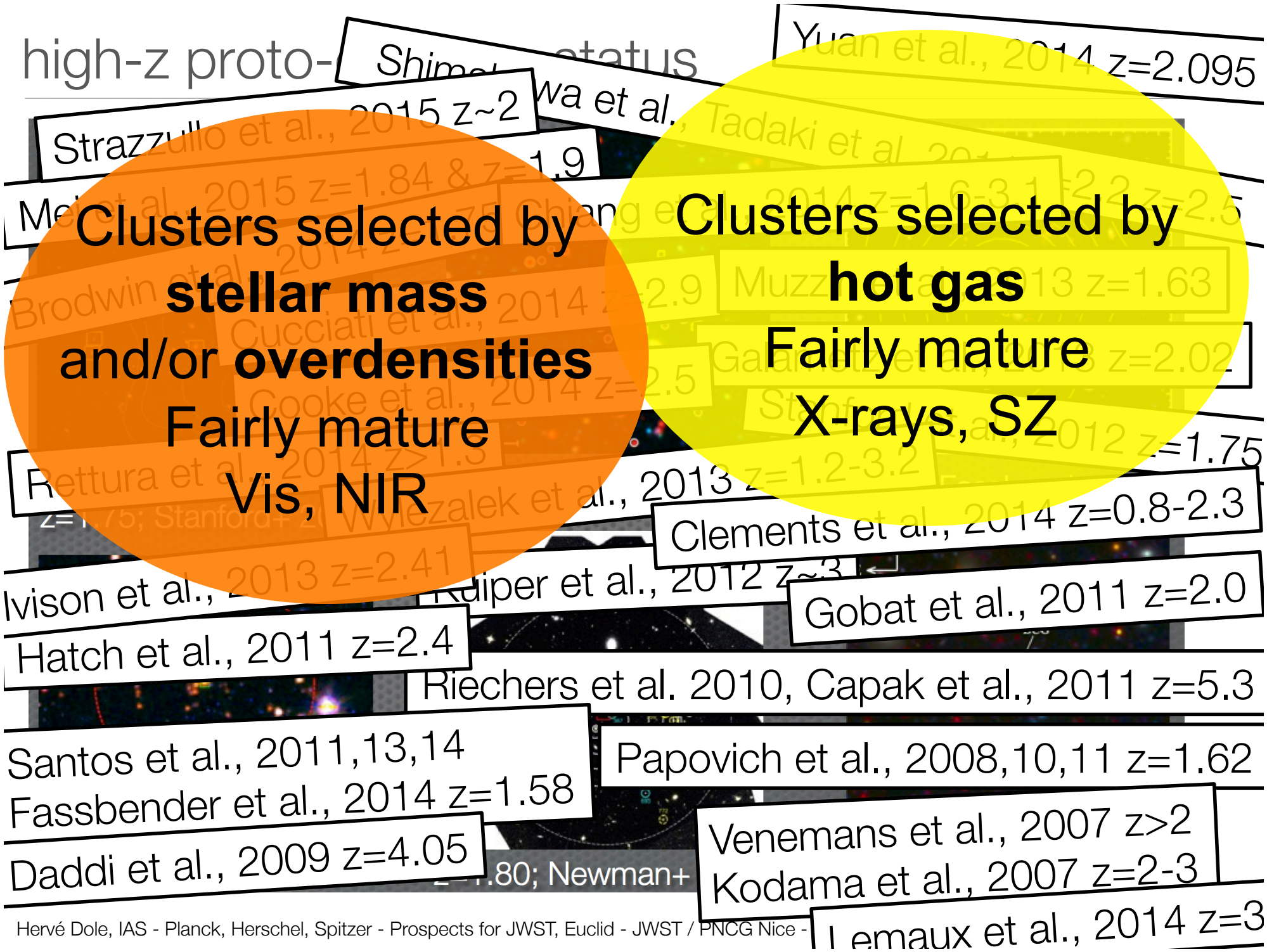
Fassbender et al., 2014 z=1.58

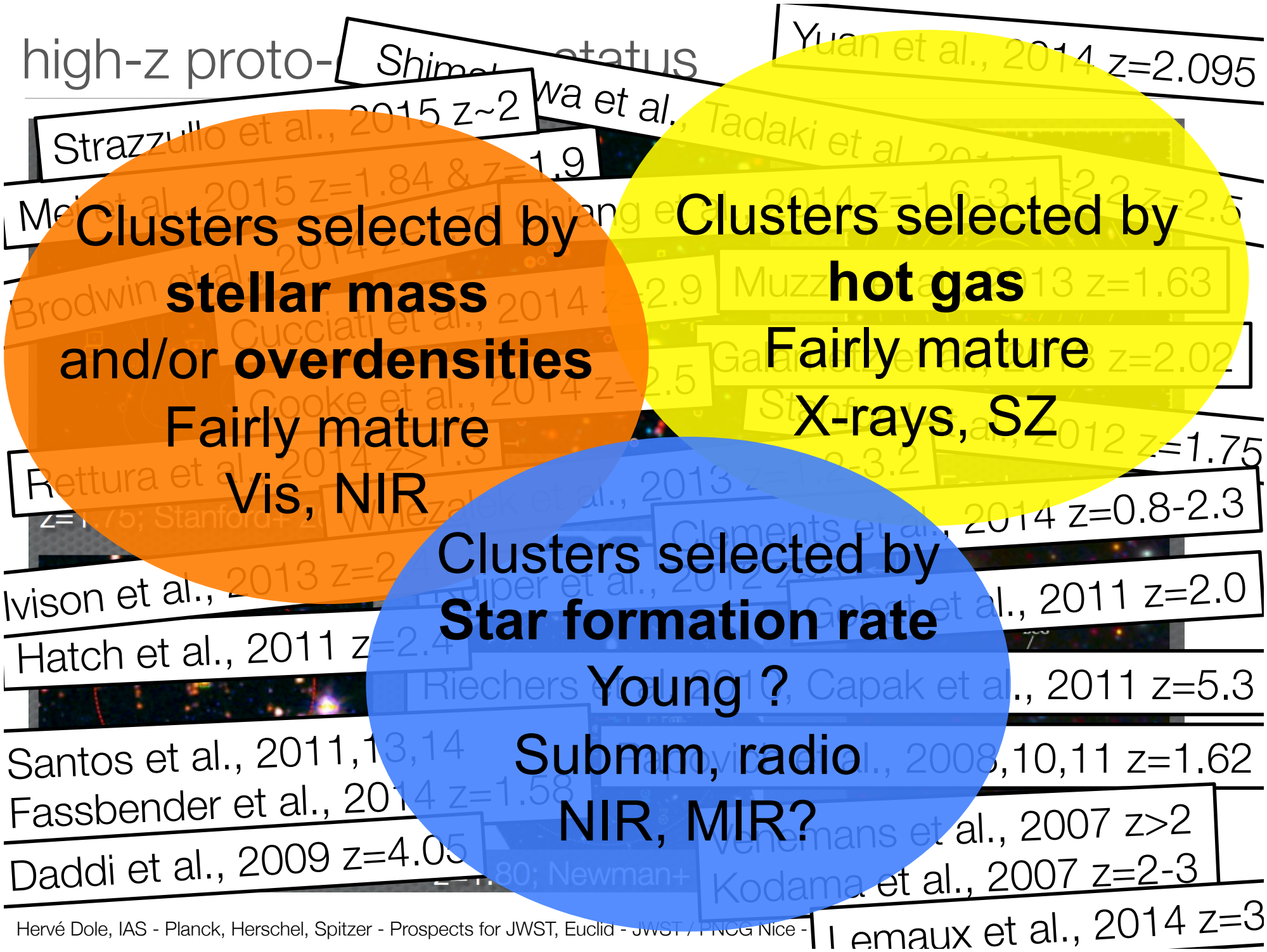
Daddi et al., 2009 z=4.05

Venemans et al., 2007 z>2

Kodama et al., 2007 z=2-3

Lemaux et al., 2014 z=3


high-z proto-
status
Clusters selected by
stellar mass
and/or overdensities
Fairly mature
Vis, NIR
Clusters selected by
hot gas
Fairly mature
X-rays, SZ
Yuan et al., 2014 z=2.095
Strazzullo et al., 2015 z~2
Tadaki et al.
Brodwin et al., 2014 z=2.9
Cucciati et al., 2014 z=2.5
Muzzin et al., 2013 z=1.63
Cooke et al., 2014 z=2.5
Rettura et al., 2014 z>1.3
Wylezalek et al., 2013 z=2.41
Stanford+ 2012 z=1.75
Clements et al., 2014 z=0.8-2.3
Ivison et al.,
Kuiper et al., 2012 z~3
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
Daddi et al., 2009 z=4.05
Newman+
Venemans et al., 2007 z>2
Kodama et al., 2007 z=2-3
Lemaux et al., 2014 z=3


high-z proto-
status
Clusters selected by
stellar mass
and/or **overdensities**
Fairly mature
Vis, NIR
Clusters selected by
hot gas
Fairly mature
X-rays, SZ
Clusters selected by
Star formation rate
Young ?
Submm, radio
NIR, MIR?
Yuan et al., 2014 z=2.095
Strazzullo et al., 2015 z~2
Brodwin et al., 2014 z=1.84 & z=1.9
Tadaki et al., 2014 z=1.6-3.1
Muzzin et al., 2013 z=1.63
Cucciati et al., 2014 z=2.5
Gabasch et al., 2004 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=2.3
Clements et al., 2014 z=0.8-2.3
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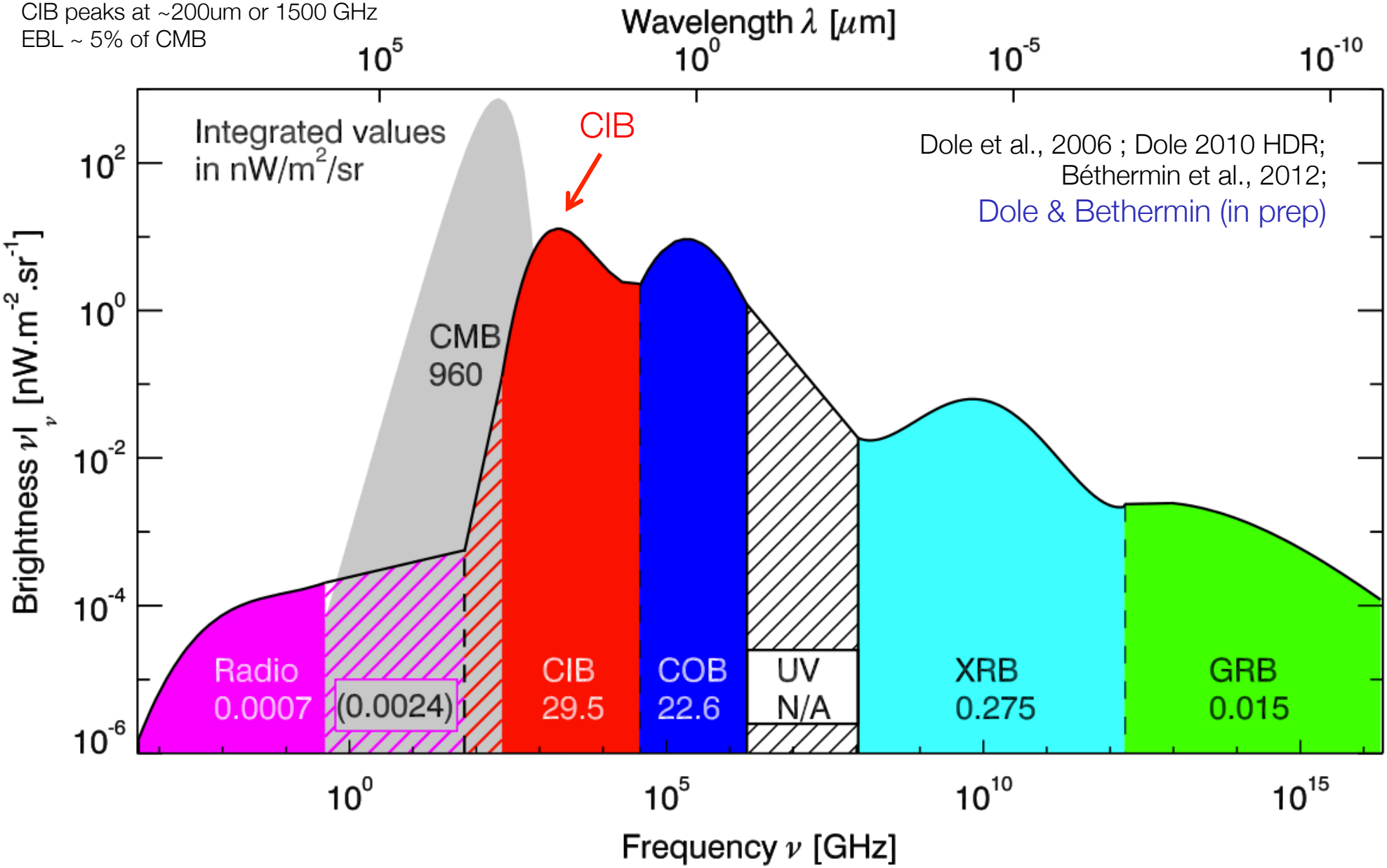
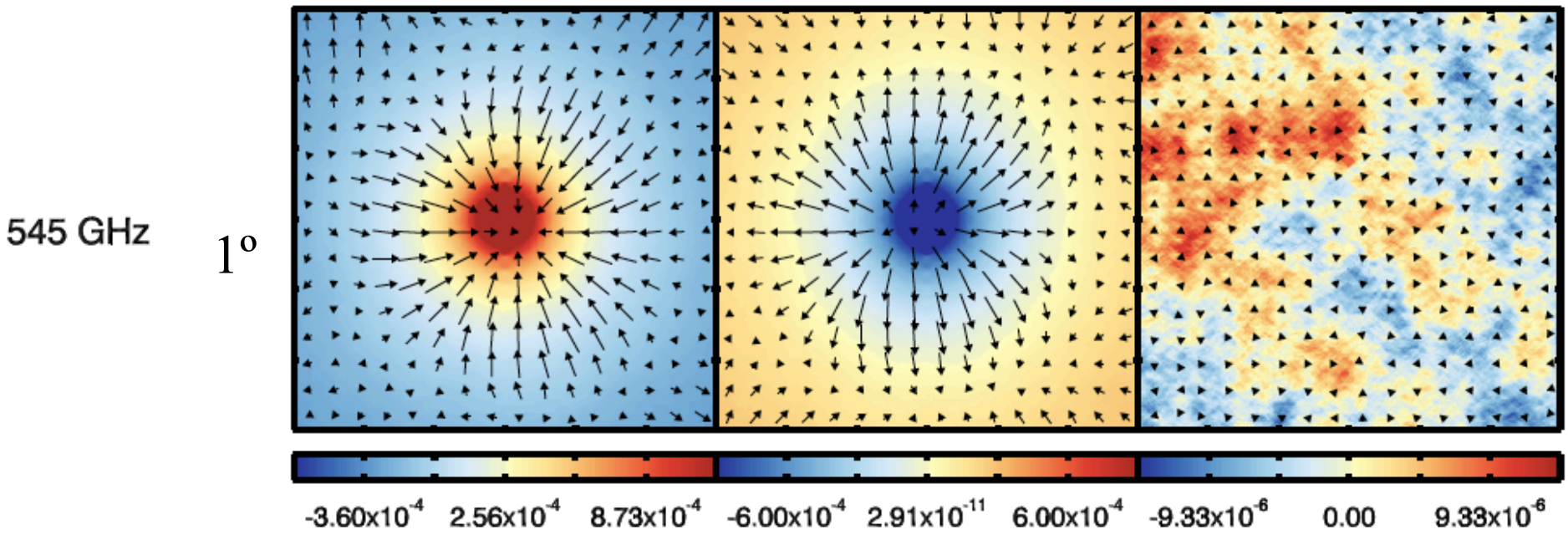
Gobat et al., 2011 z=2.0
Hatch et al., 2011 z=2.4
Riechers et al., 2010; Capak et al., 2011 z=5.3
Santos et al., 2011,13,14
Fassbender et al., 2014 z=1.58
Daddi et al., 2009 z=4.05
Papovich et al., 2008,10,11 z=1.62
Venemans et al., 2007 z>2
Kodama et al., 2007 z=2-3
Lemaux et al., 2014 z=3

2. Extragalactic Background Light SED

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



CIB peaks correspond to mass peaks…

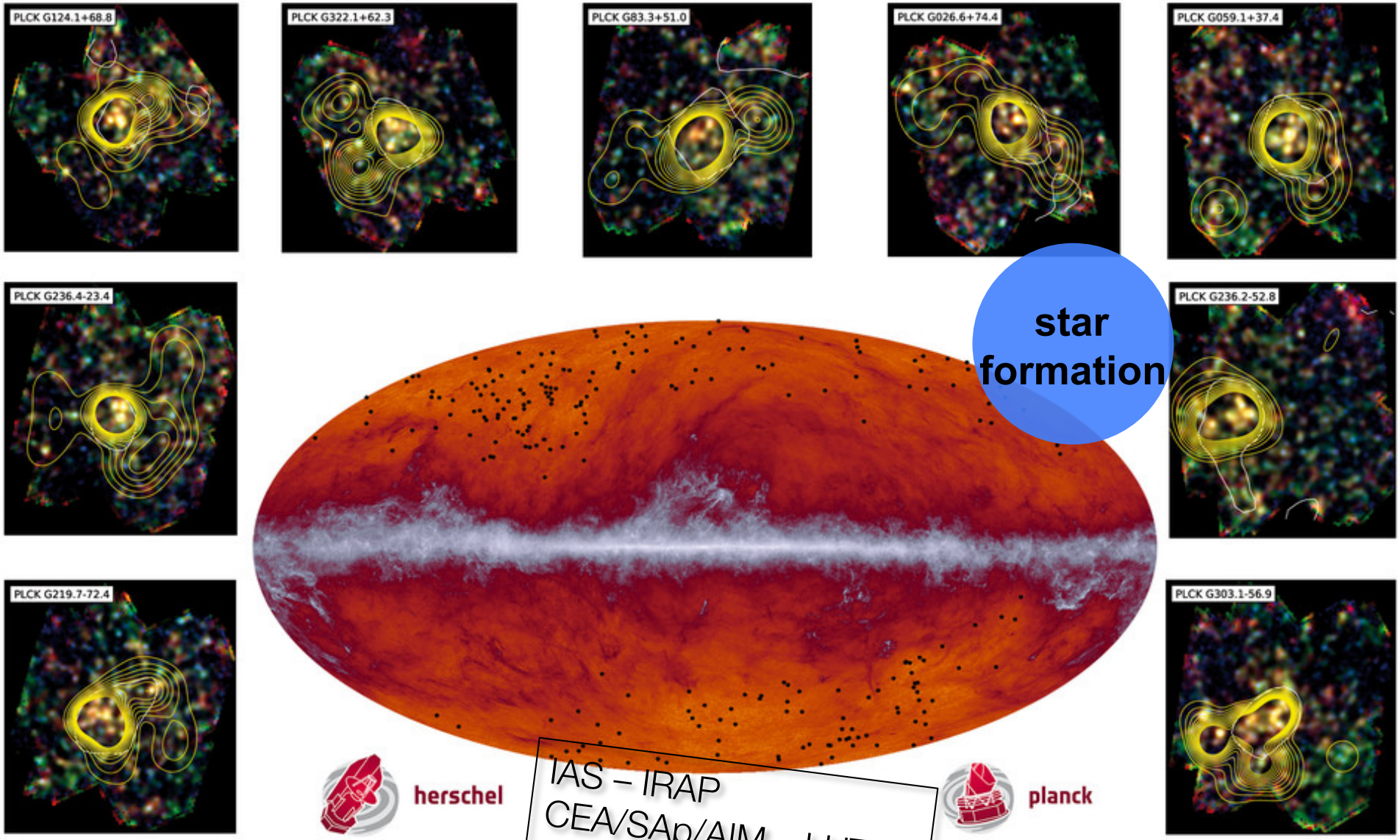


… and the CIB probes also high-z SFR

-> 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



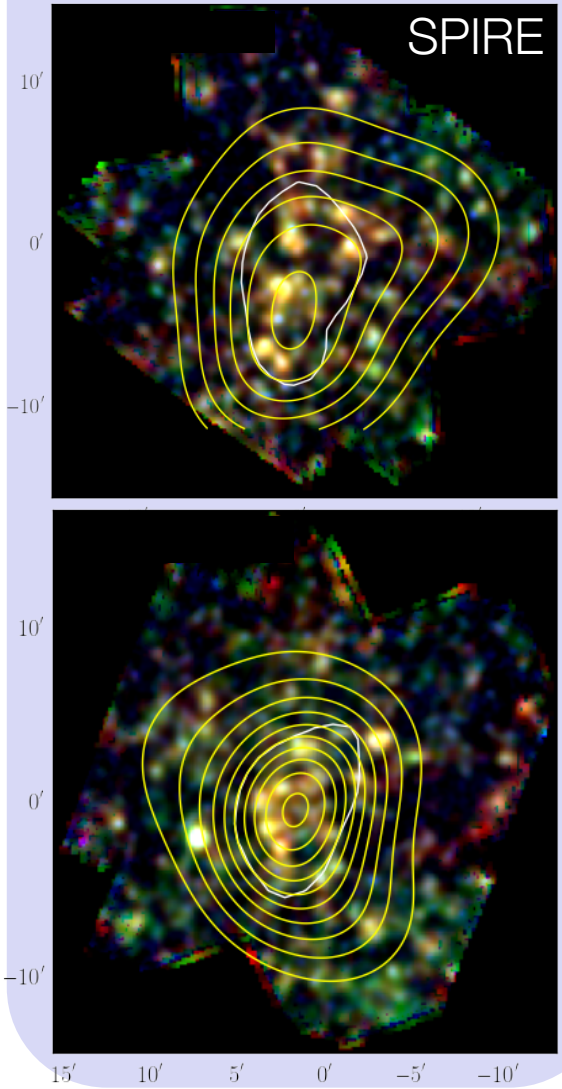
IAS – IRAP
CEA/SAp/AIM – LUTh
LAM – IPAG – LPSC
Caltech – UofA – ESAC

Thèse: David Guéry

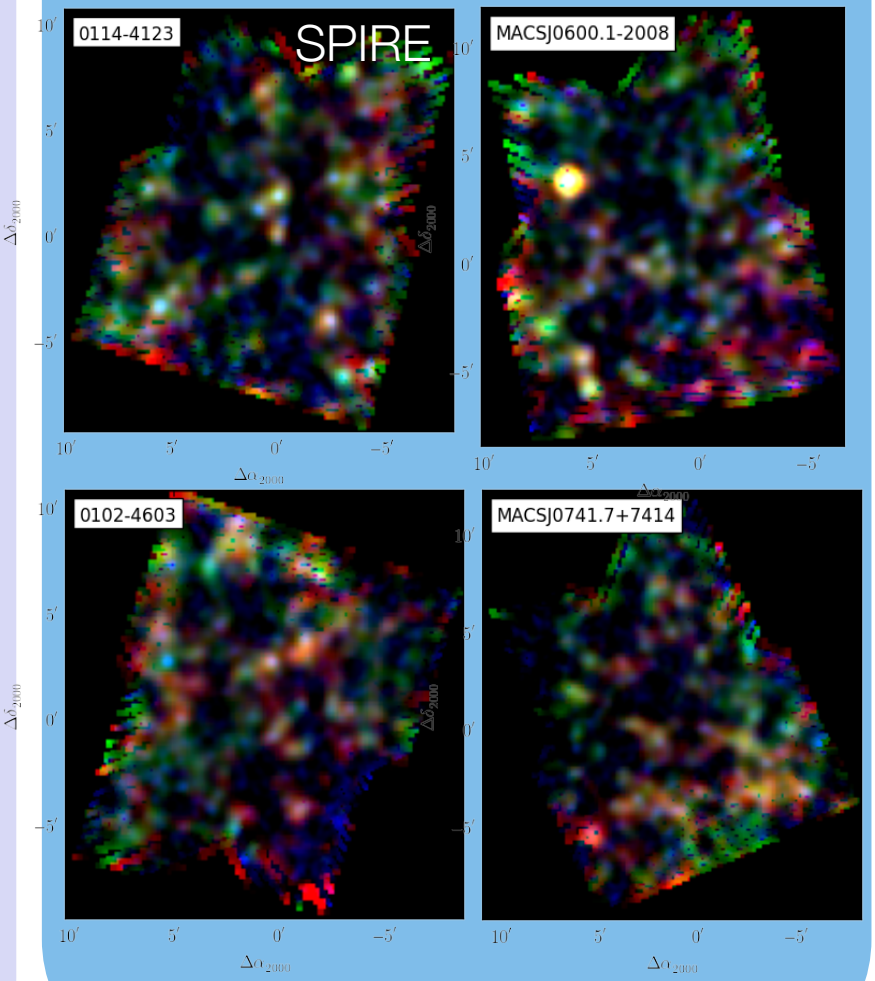
Planck Collab., 2015, Int XXVII, arXiv:1506.01962
Planck Collab., 2015, Int XXXIX, arXiv:1508.04171
Press Releases: ESA, NASA, INSU, A&A

3. a remarkable Planck+Herschel dataset

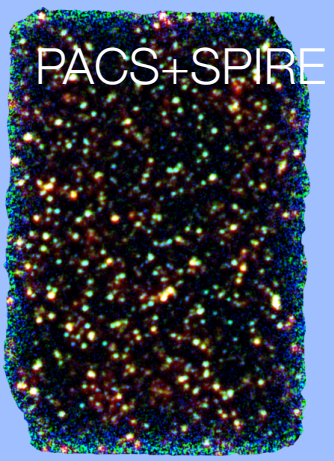
Planck/Herschel HPASSS
30’ x 30’ (Planck subm)

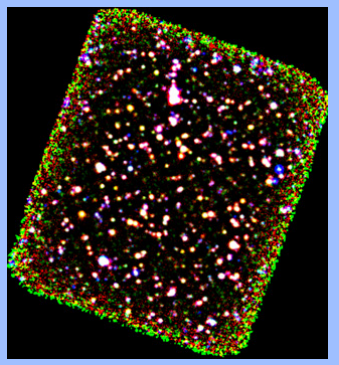


HLS 20’ x 20’
(Egami+2010)



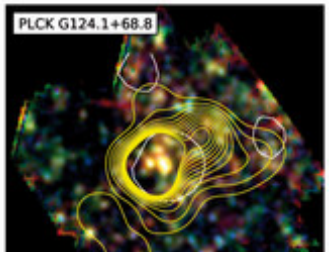
GOODS 16’ x 10’
(Elbaz+2011)

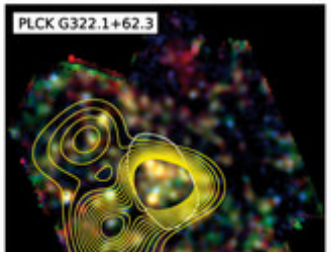


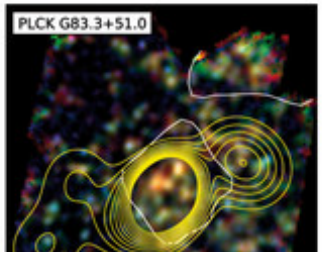


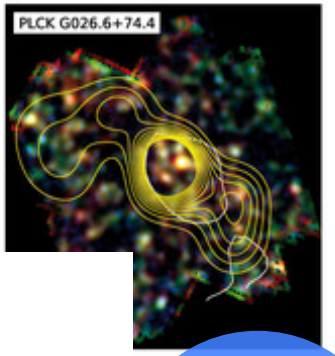
Planck Collab., 2015, Int XXVII, arXiv:1506.01962
Planck Collab., 2015, Int XXXIX, arXiv:1508.04171
Press Releases: ESA, NASA, INSU, A&A

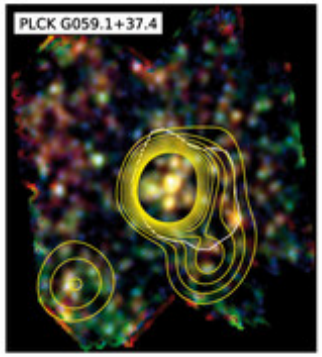
3 Herschel and Planck proto-cluster candidates

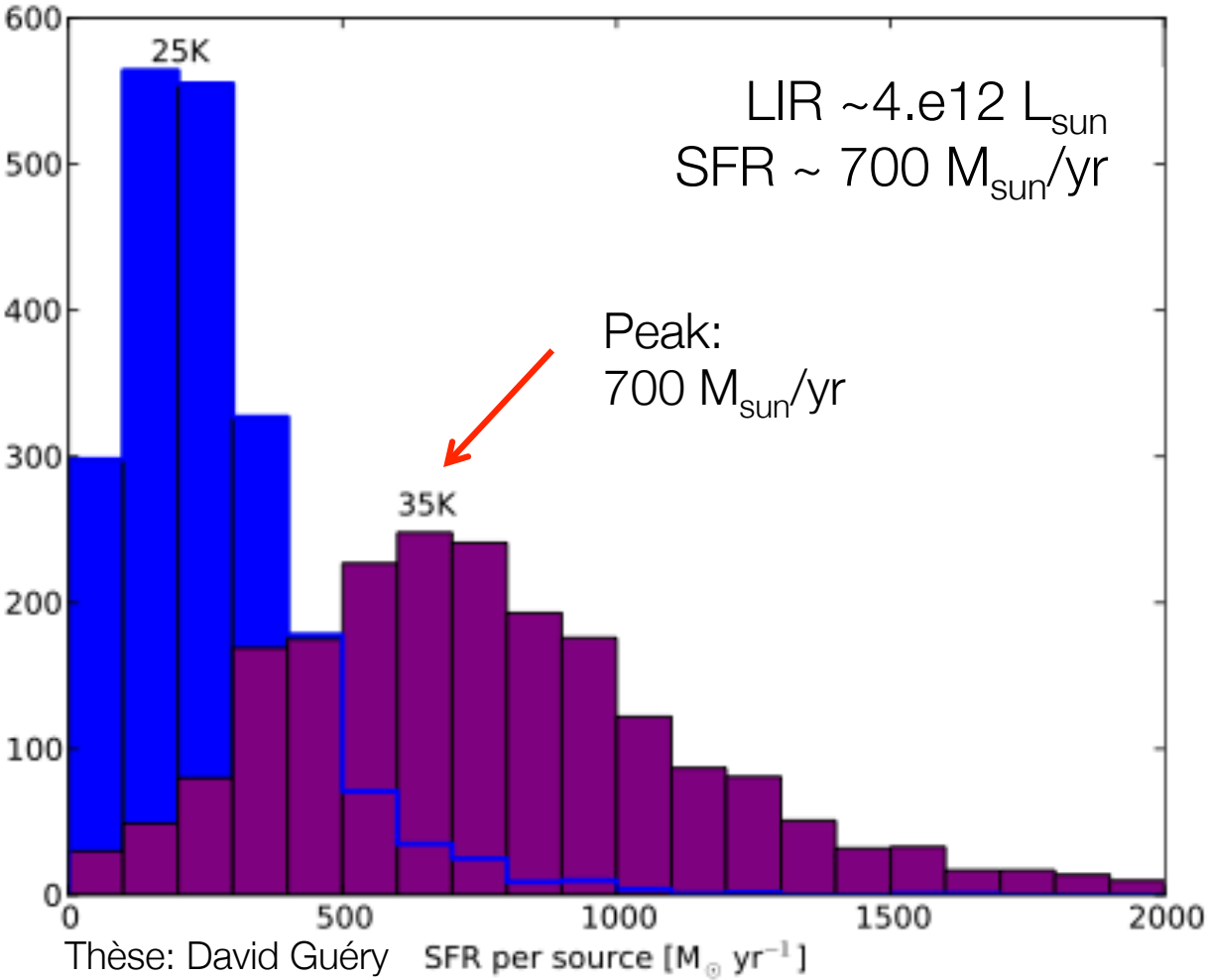




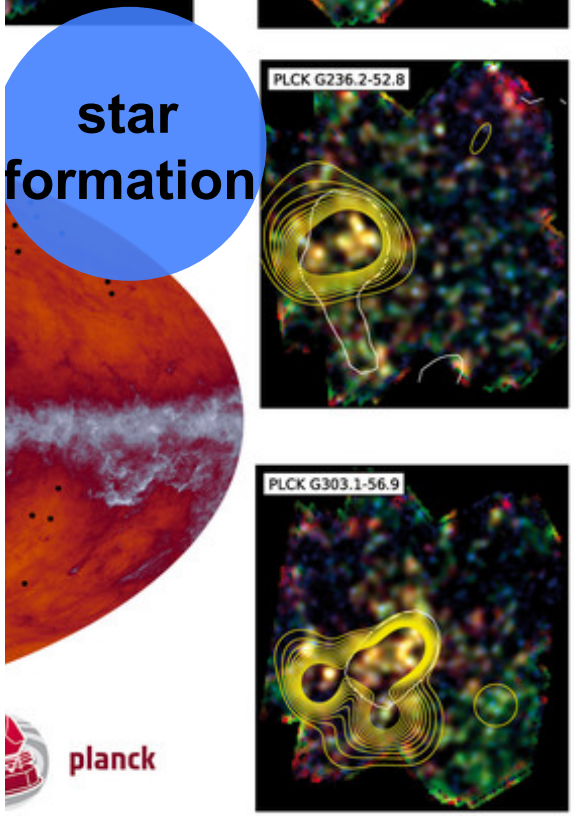








Thèse: David Guéry

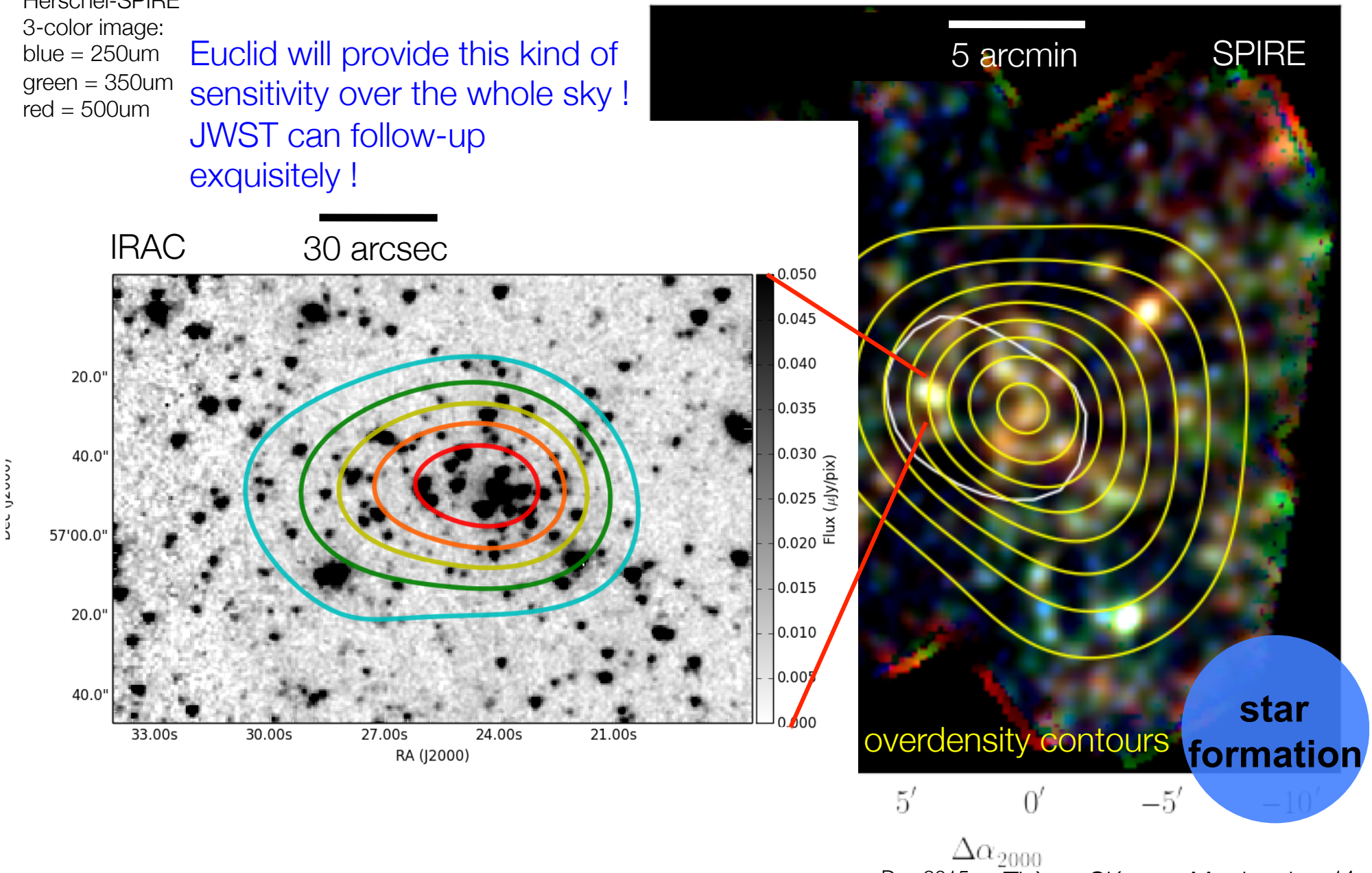


Collab., 2015, Int XXVII, arXiv:1506.01962
Collab., 2015, Int XXXIX, arXiv:1508.04171
Press Releases: ESA, NASA, INSU, A&A

the case of one field: Herschel & Spitzer

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

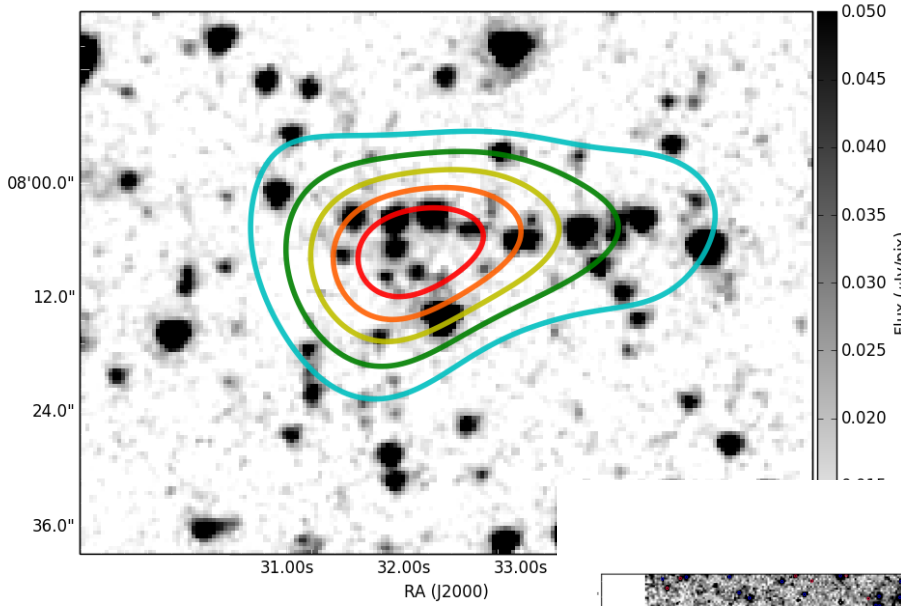
Euclid will provide this kind of sensitivity over the whole sky !
JWST can follow-up exquisitely !



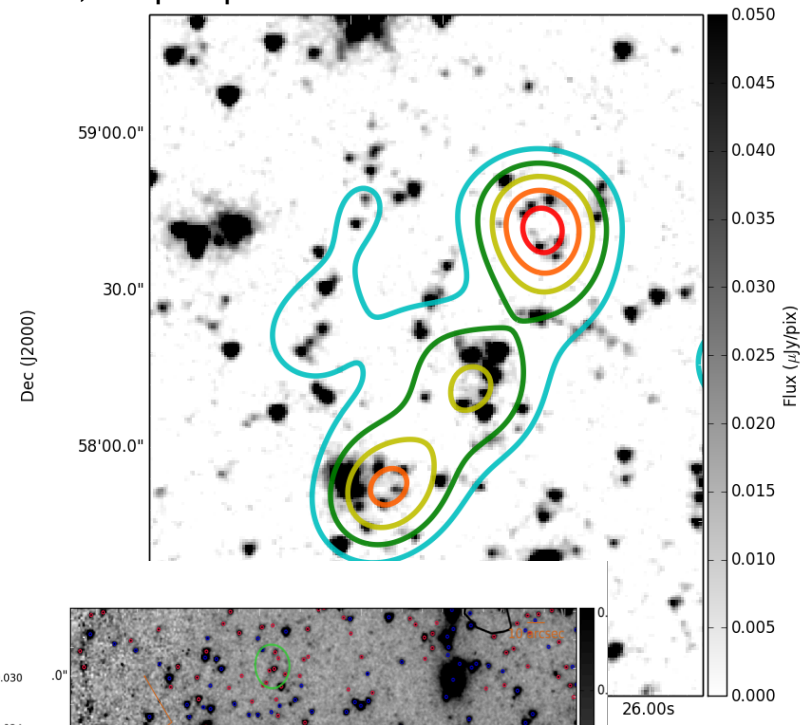
many more Spitzer examples of Planck src

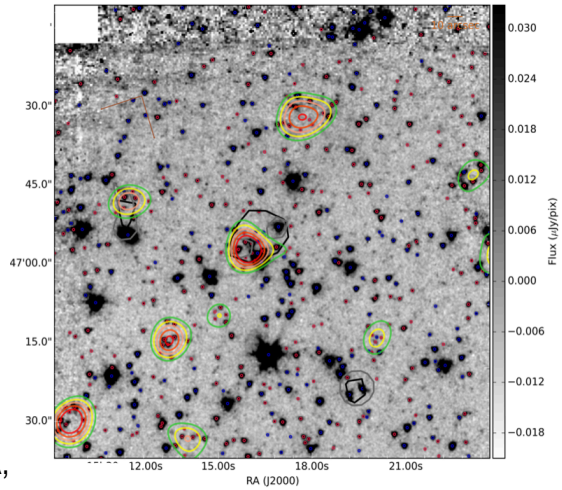
Martinache et al., in prep

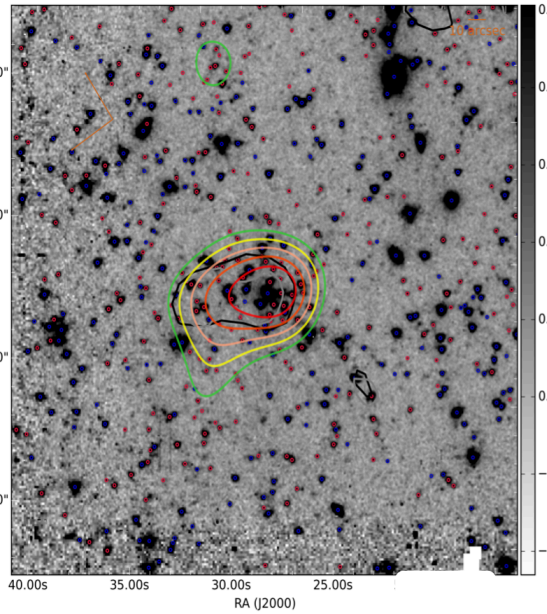
IRAC



IRAC







star formation

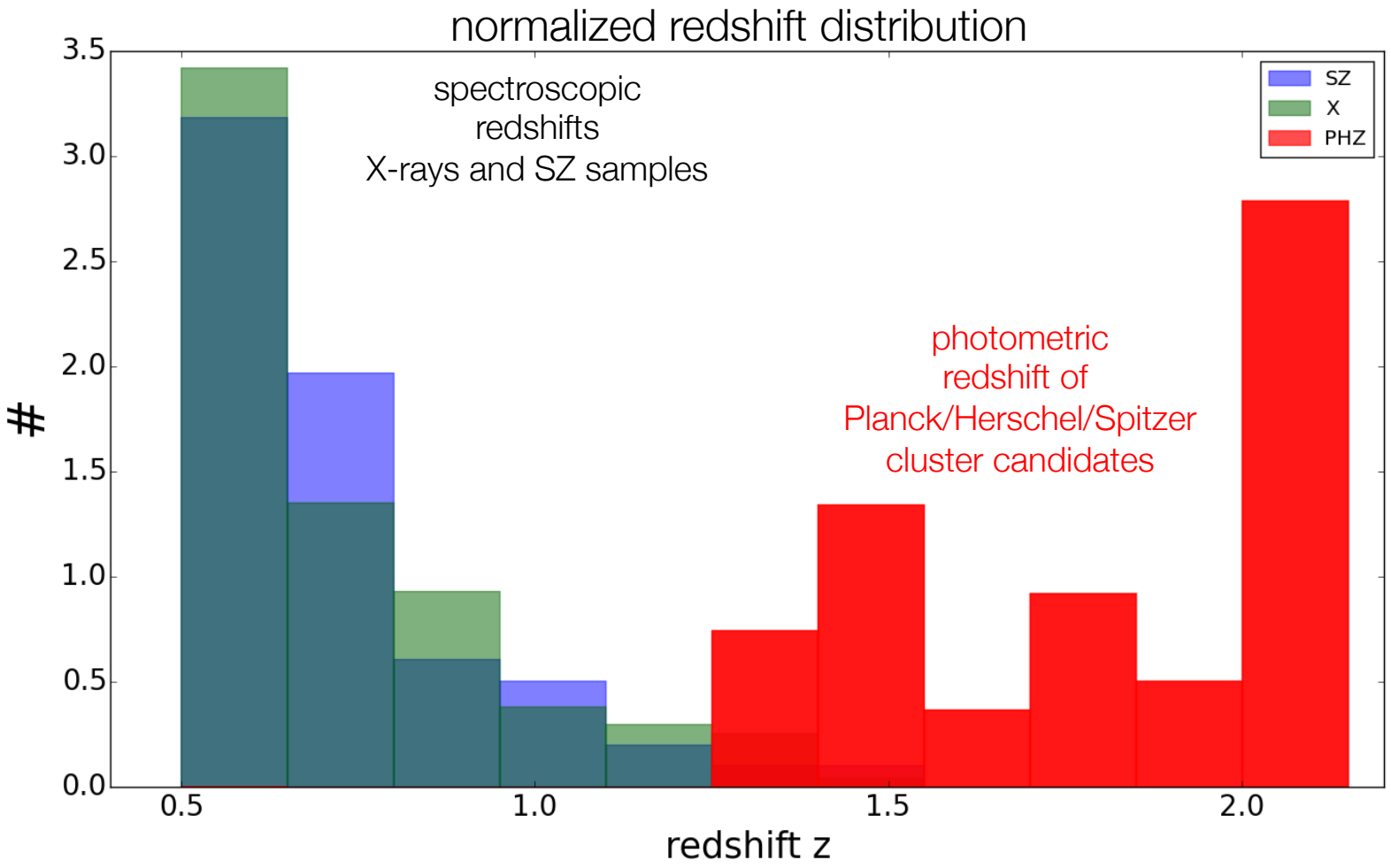
See also Flores-Cacho et al., 2015, A&A,

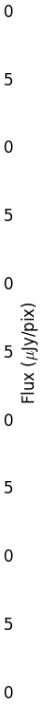
many more Spitzer examples of Planck src

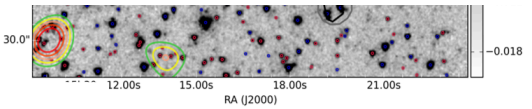
PRELIMINARY

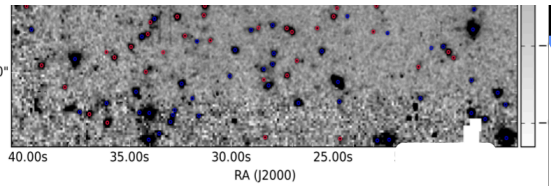
Martinache et al., in prep

IRAC





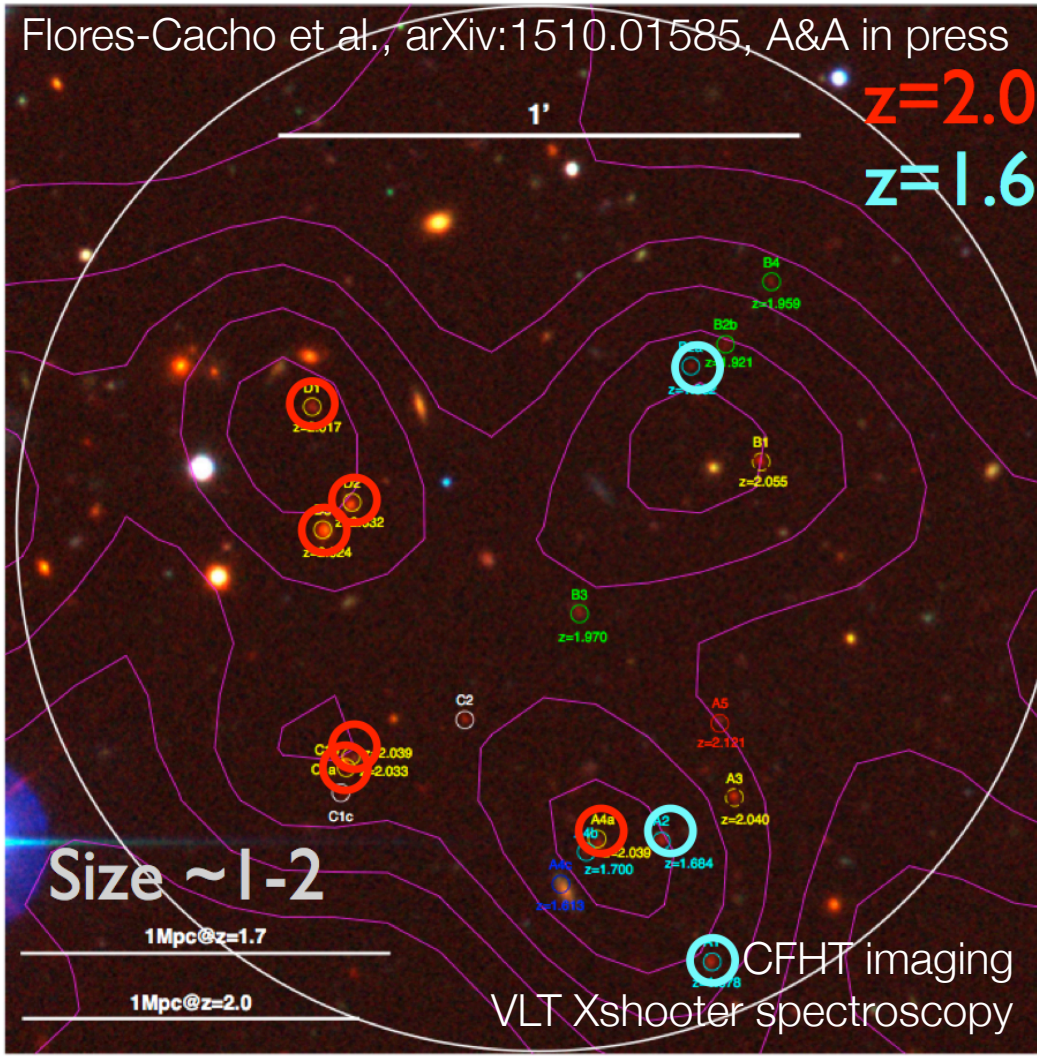




rormation

See also Flores-Cacho et al., 2015, A&A,

spectroscopic confirmations: 2 cases



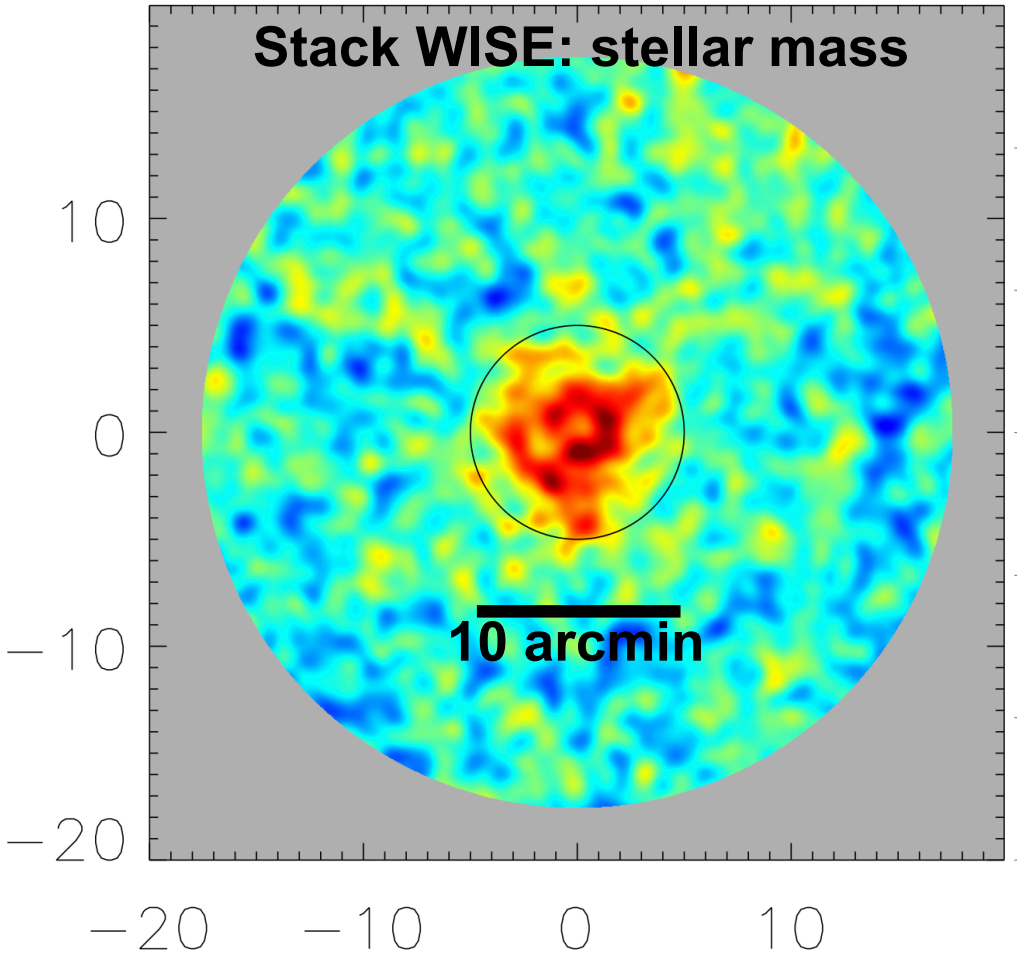
+ IRAM source,
Cf Clément Martinache thesis

stacking of Planck proto-cluster candidates

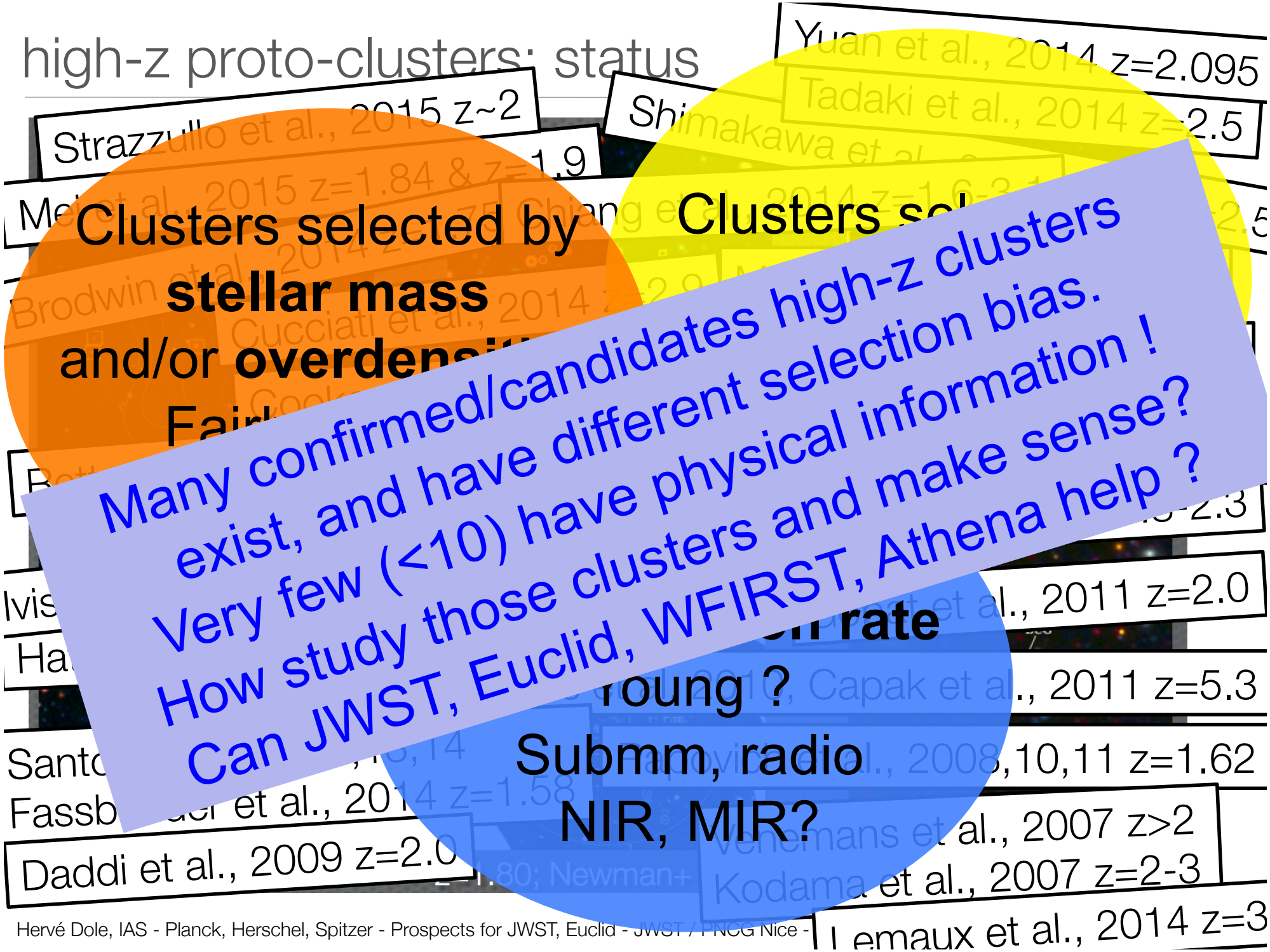
PRELIMINARY Hurier et al., in prep

Stack CMB lensing: total mass -> likely massive haloes

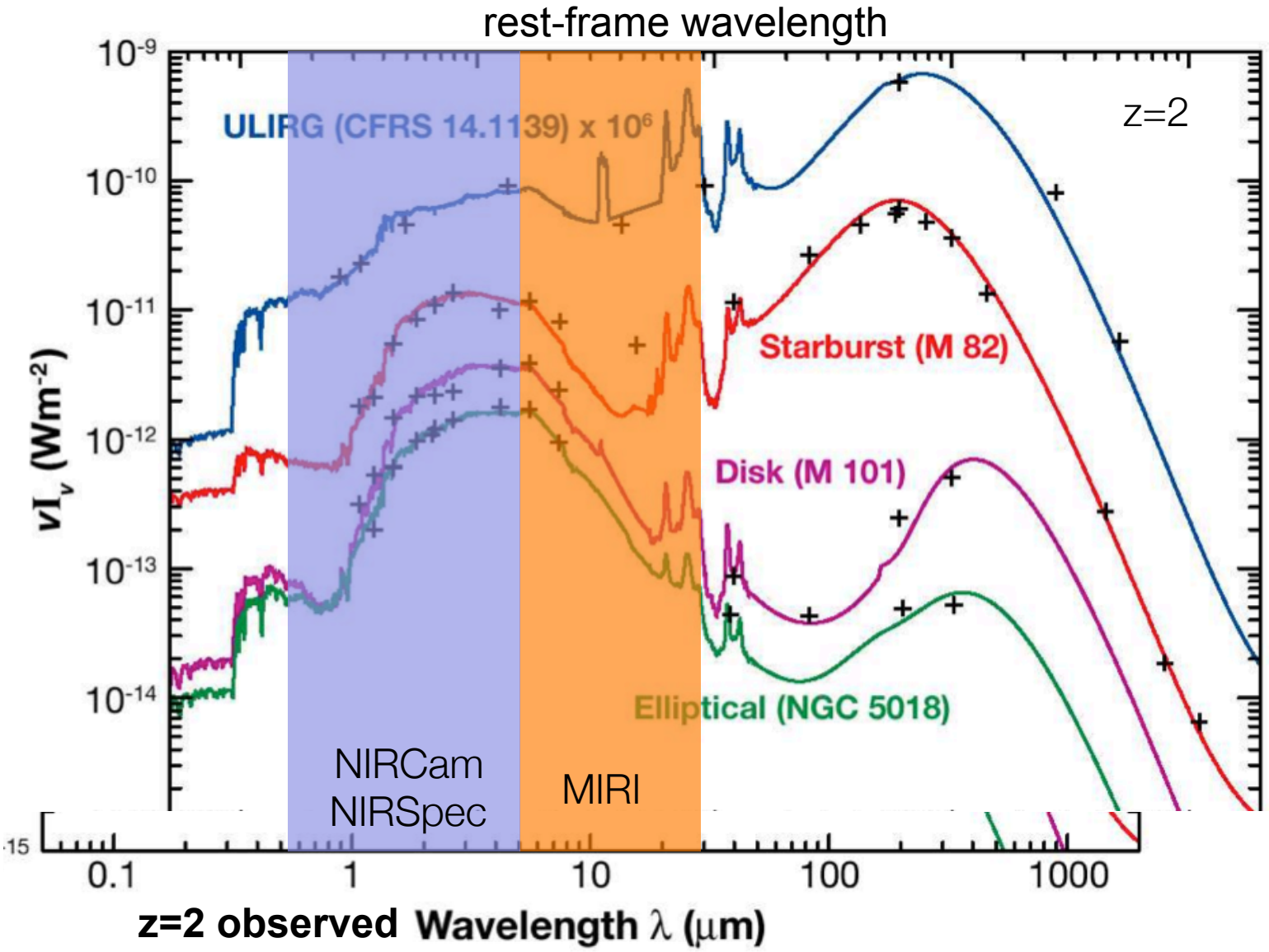
+ Stack Herschel: SFR



high-z proto-clusters: status



4. NIR+MIR: a key range for z>1 structures



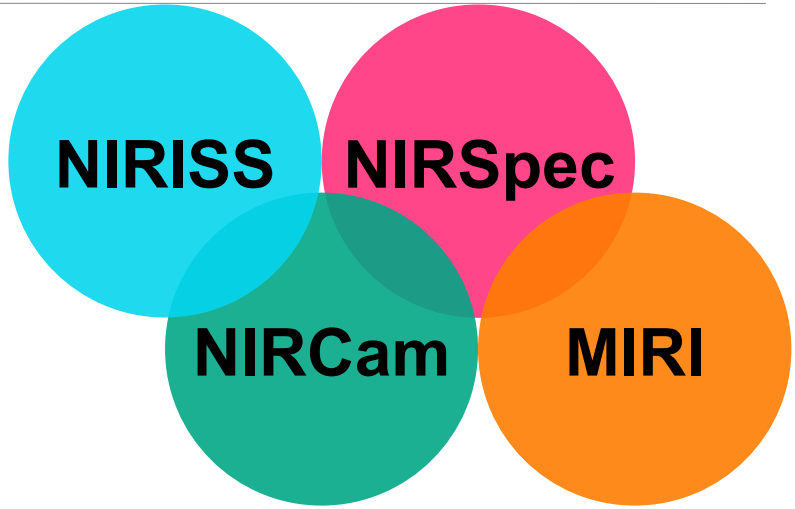
In the redshift range
~1 < z < ~4
MIRI probes
unique spectral
features,
even at low spectral
Resolution

AGN vs SF
H2

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

a coherent JWST GO on high-z clusters ?

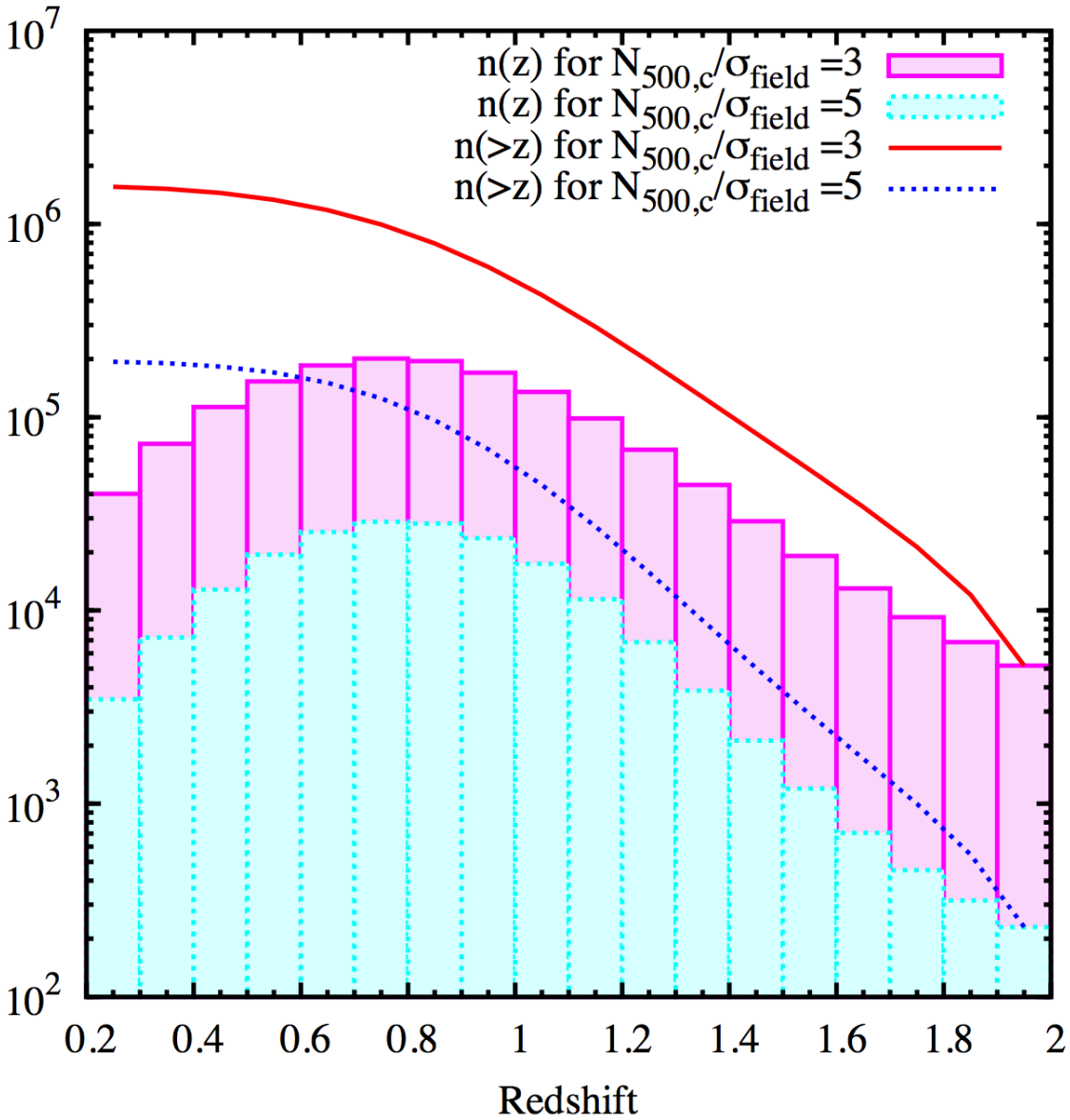
- 450 high-z (proto-)clusters: about 150 clusters of each class at z>~2



- Science goals: cluster formation / bias baryons vs DM / star formation/ AGN in dense environements w/ z
- census of cluster formation
- DM-baryons links, and gas dynamics
- NIR+MIR lines
  - Galaxies and cluster dynamics w/ galaxies and gas
  - Mass, (z), SF vs AGN, energetics

- NIR and MIR spectroscopy
  - Slitless NIRISS+NIRCam
  - or NIRSpec MOS
  - and MIRI IFU
  - + preimaging

how Euclid can help: stellar component



Sartoris et al., 2015, arXiv:1505.02165

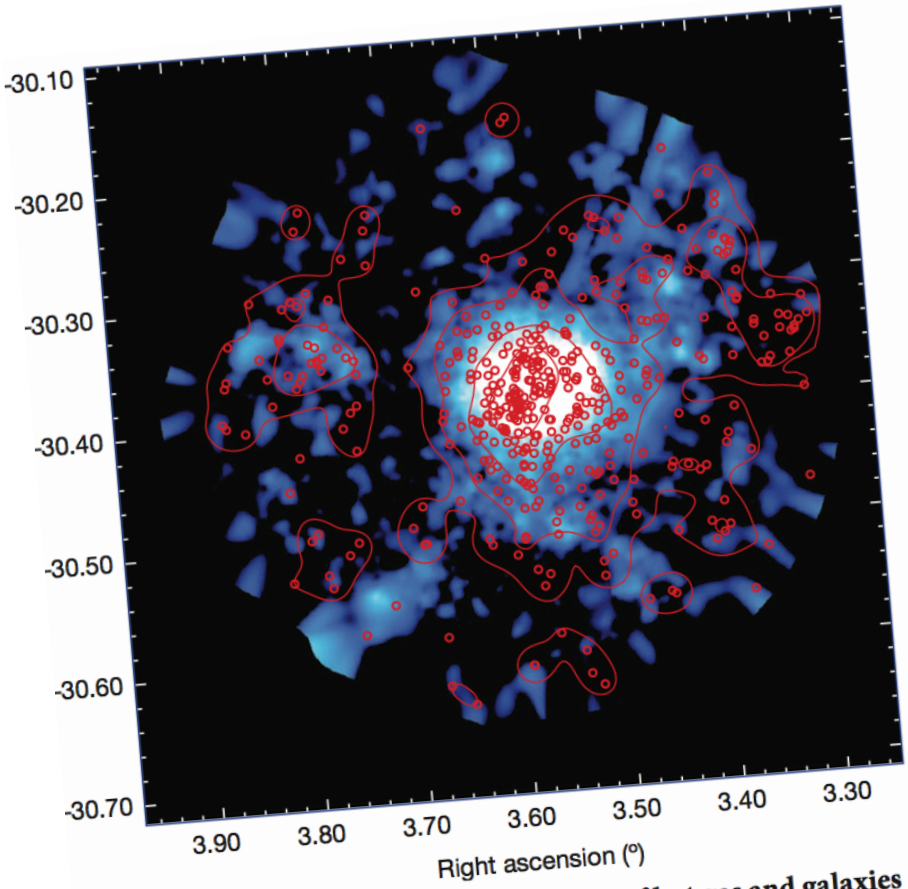
Euclid will detect thousands of z~2 clusters

Euclid might also detect many z>2 clusters and proto-clusters

Today, Spitzer detects some alreday, with similar sensitivity as Euclid

-> good prospects for Euclid to detect many z> 2 clusters and proto-clusters

how Athena could help as well: hot baryons



re 2 | Comparison between the distribution of hot gas and galaxies
e region surrounding Abell 2744. Shown is the XMM-Newton image
bell 2744 (same data as Fig. 1); also shown are the positions of member
cies with spectroscopic redshift within $\pm 5{,}000\,\mathrm{km\,s^{-1}}$ of the cluster
n^{18} (red dots); red curves show galaxy number density contours.

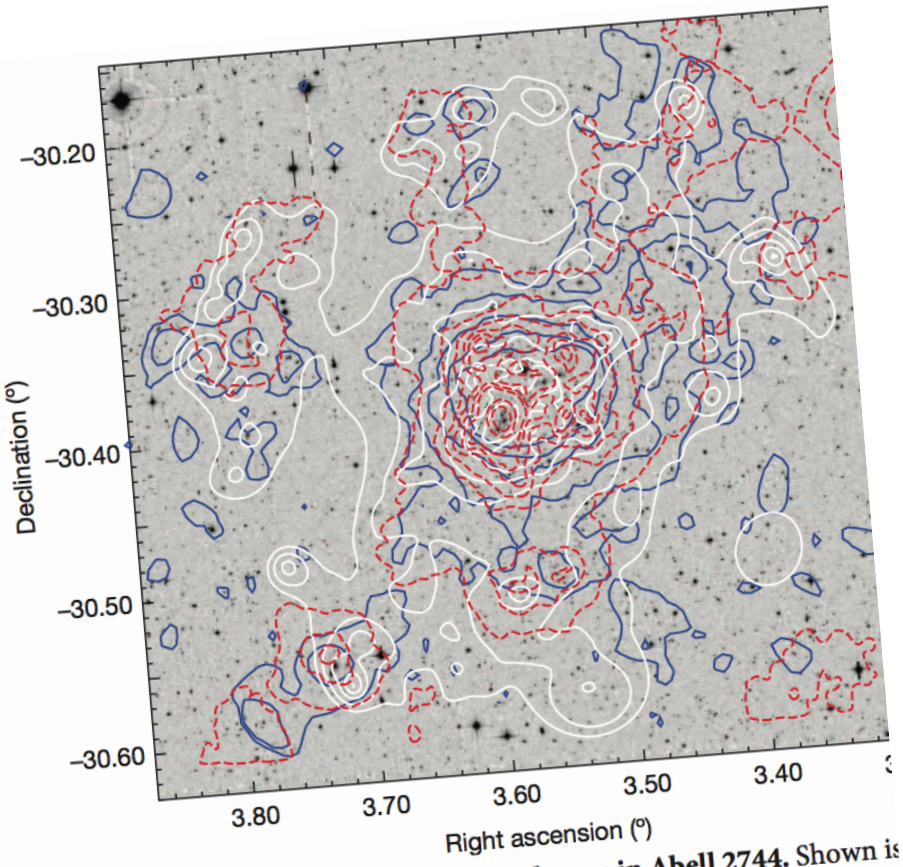


Figure 3 | Hot gas, visible light and total mass in Abell 2744. Shown is
the CFHT image of Abell 2744 and the surrounding large-scale structur
The contours show X-ray isophotes (blue), mass distribution reconstruc
from combined strong and weak lensing (white), and optical light
(dashed red).

Eckert, Jauzac et al., 2015, Nature

5. summary & concl.: high-z (proto-)clusters

- High-z (proto-)clusters are exciting
  - Cosmology, LSS / Galaxy evolution
- Many samples of z>2 cluster exist
  - confirmed or candidates
  - targets are already identified
  - or to be identified: open discovery space
- Different & complementary selections
- French community plays an important role
- Planck / Herschel / Spitzer high-z cluster candidates
- Coordination for a high-z cluster JWST proposal
- Euclid will likely help
- Athena as well in the longer run
- Science goals
  - cluster formation / bias baryons vs DM / star formation/AGN in dense environements w/ z