



**X
X
L**

**The ultimate
XMM extragalactic survey**

*die Kunst
über
in der Wissenschaft*

The XXL survey an overview (of the cluster catalogue)

C. Adami, L. Faccioli, E. Koulouridis, F. Pacaud,
M. Pierre

And the XXL consortium

X-ray treasures – Toulouse- May 2018

Plan of the talk

- Presentation of XXL
- The cluster catalogue : recent results
- Next and final steps

An overview of the XXL survey

The largest XMM programme to date:

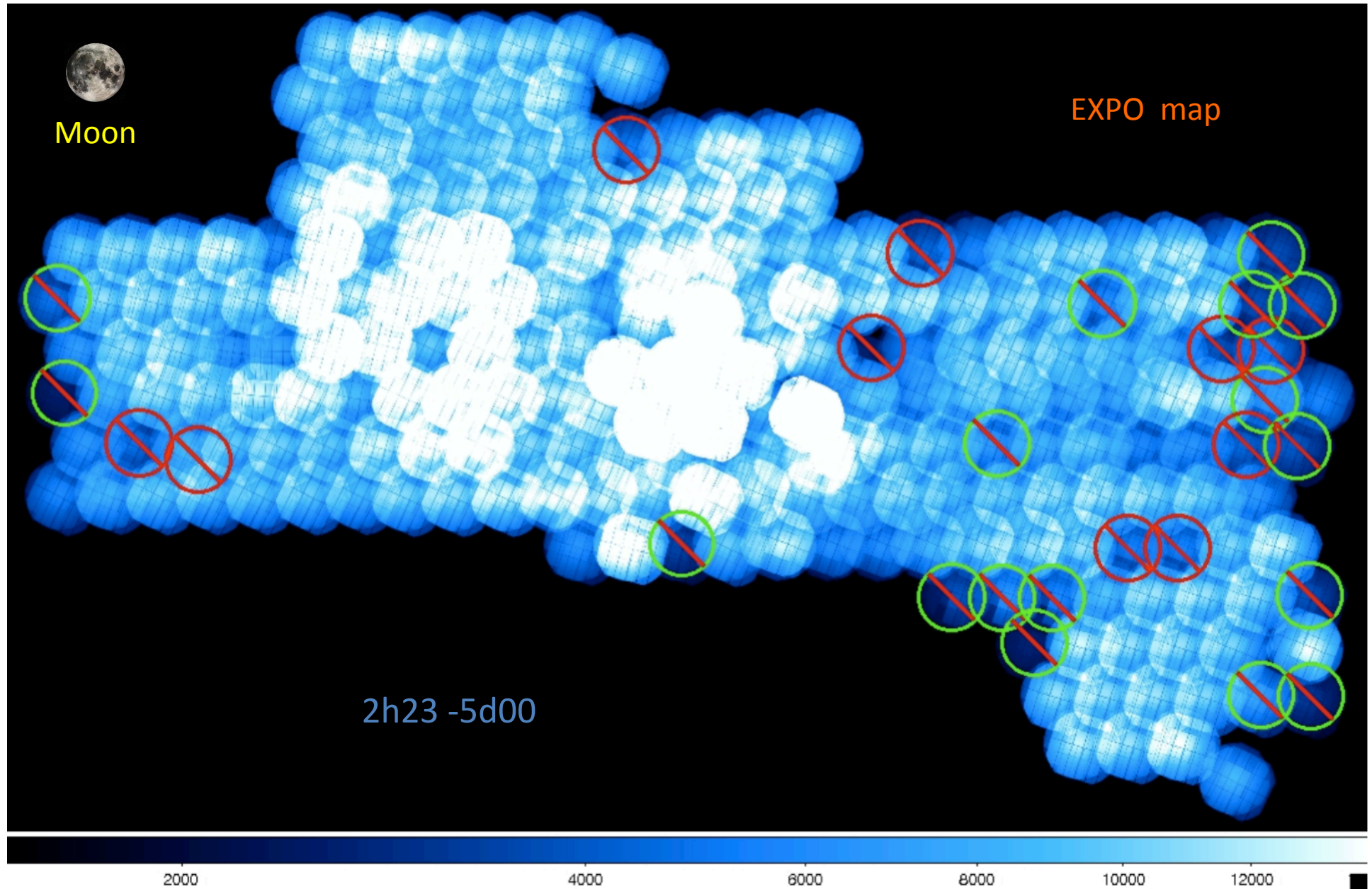
- 6.9 Ms of XMM time over two 25 deg² areas
- ~ 100 collaborators
- 1st series of 14 papers published in 2016
- 2nd series of 15 papers will be out by mid-2018

Primary goal : cosmology with the $0 < z < 1$ clusters

Self-consistent derivation of the scaling relations with the XXL sample clusters

Other goals : cluster physics and AGN environmental studies with very large samples and extended multi- λ data sets.

XXL-N 25 deg²



XXL north

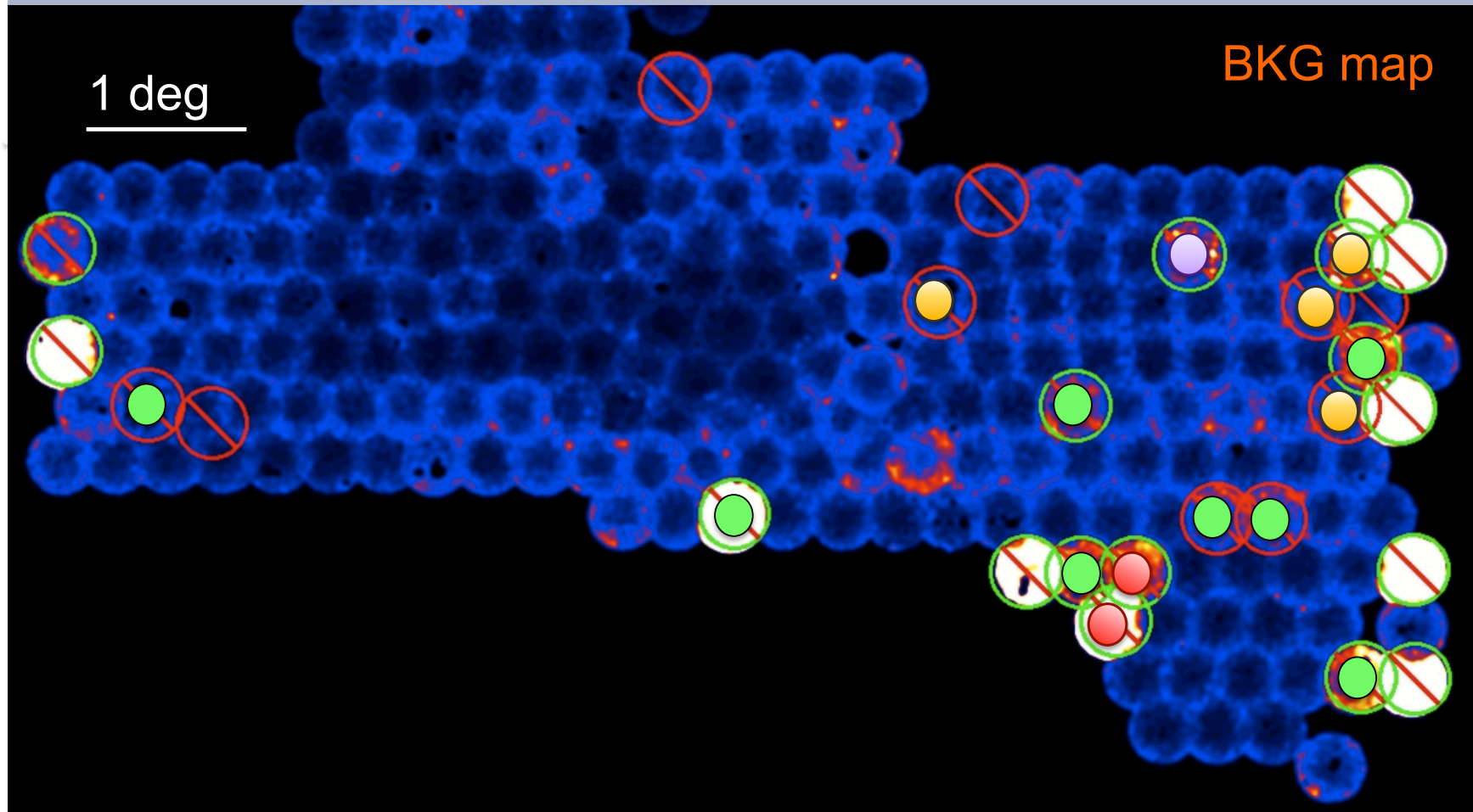
13 pointings (+2 thanks to mosaic mode)

● Observed

● Good

● Usable

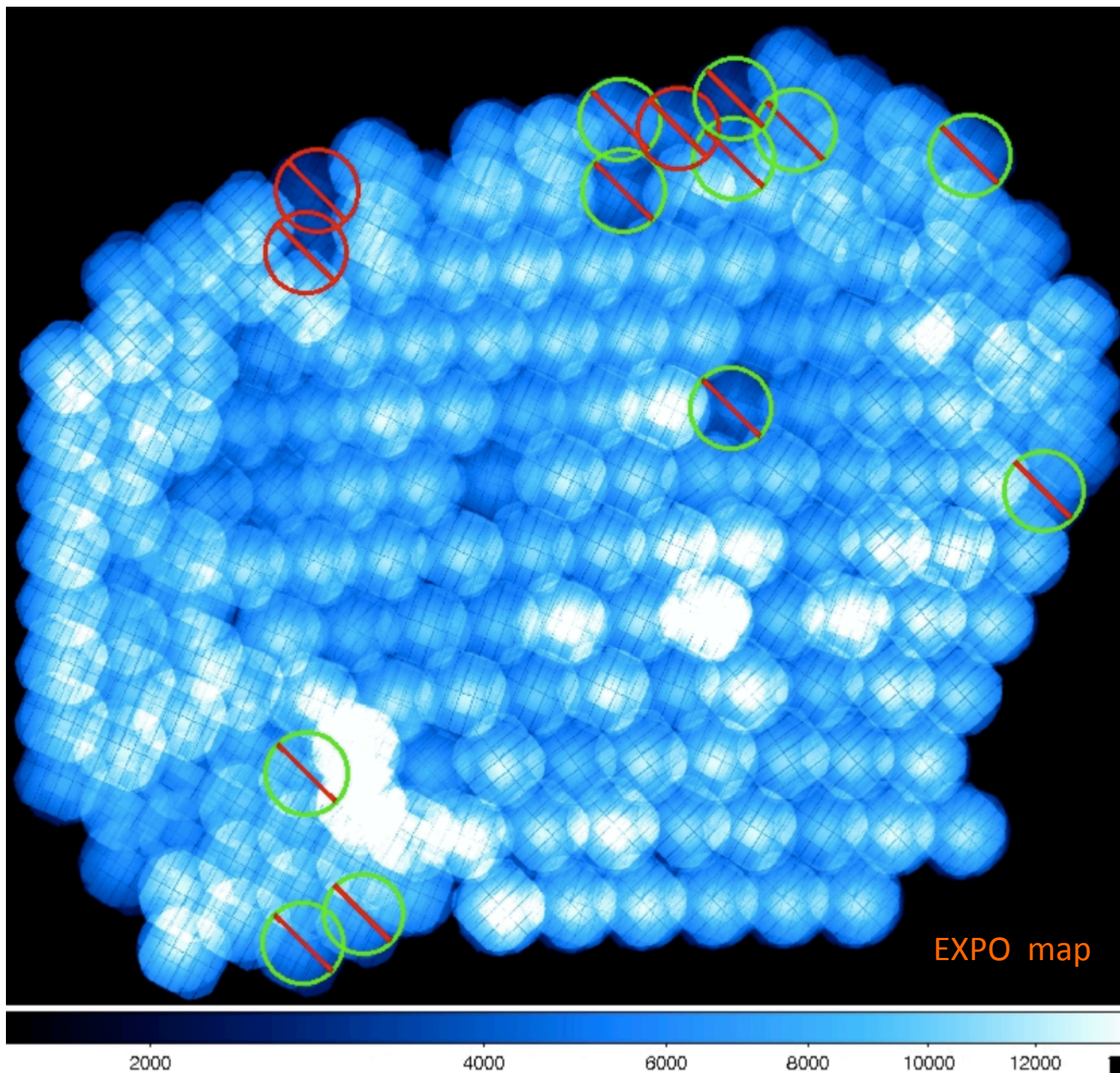
● Lost



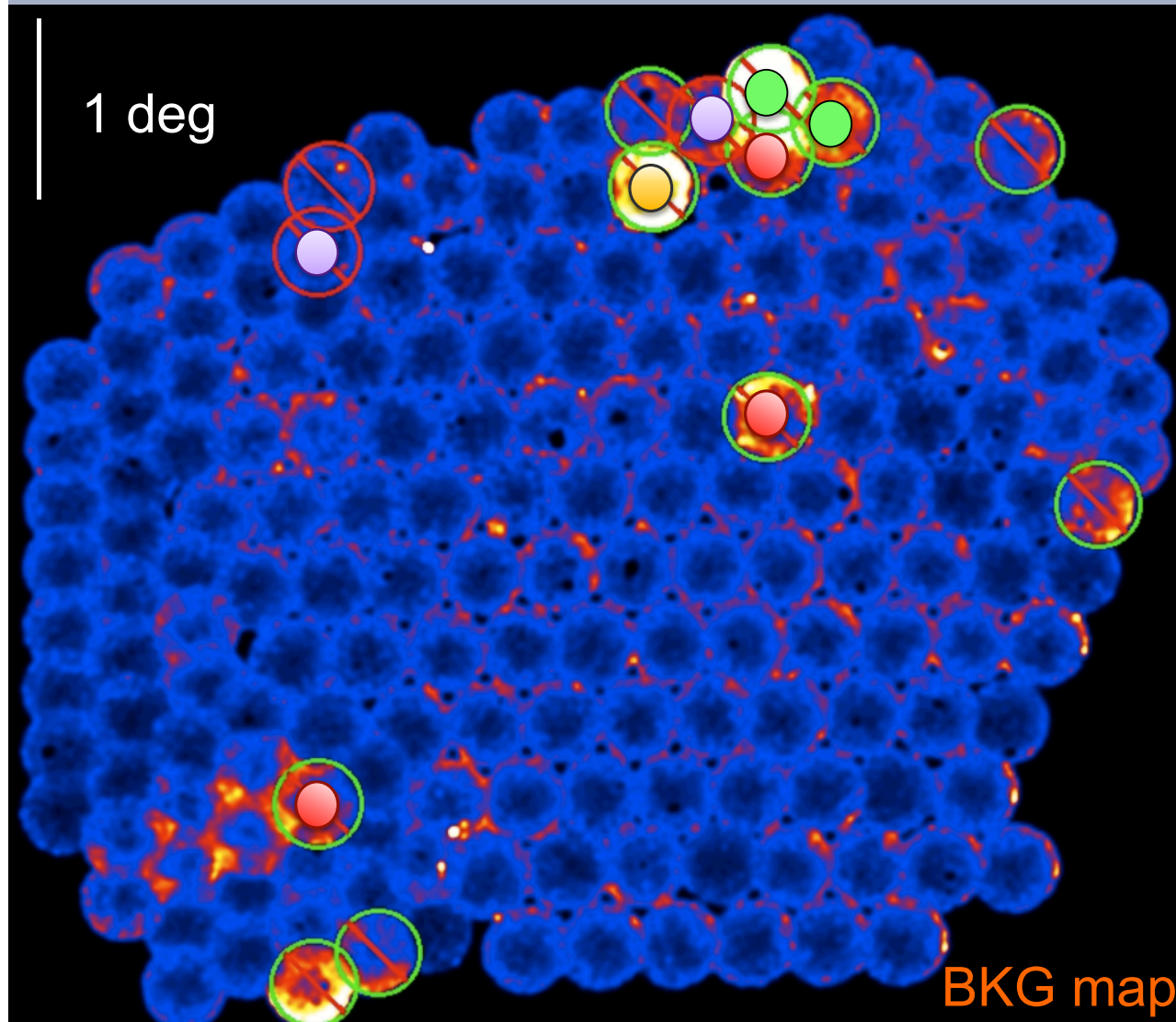
XXL-S
25 deg²

23h30 -55d00

within the SPT
100 deg²
Deep Field

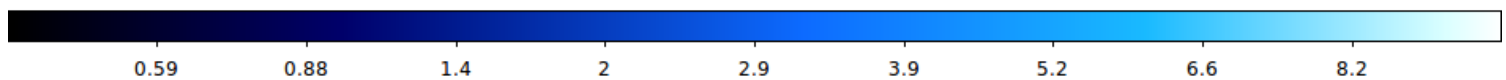
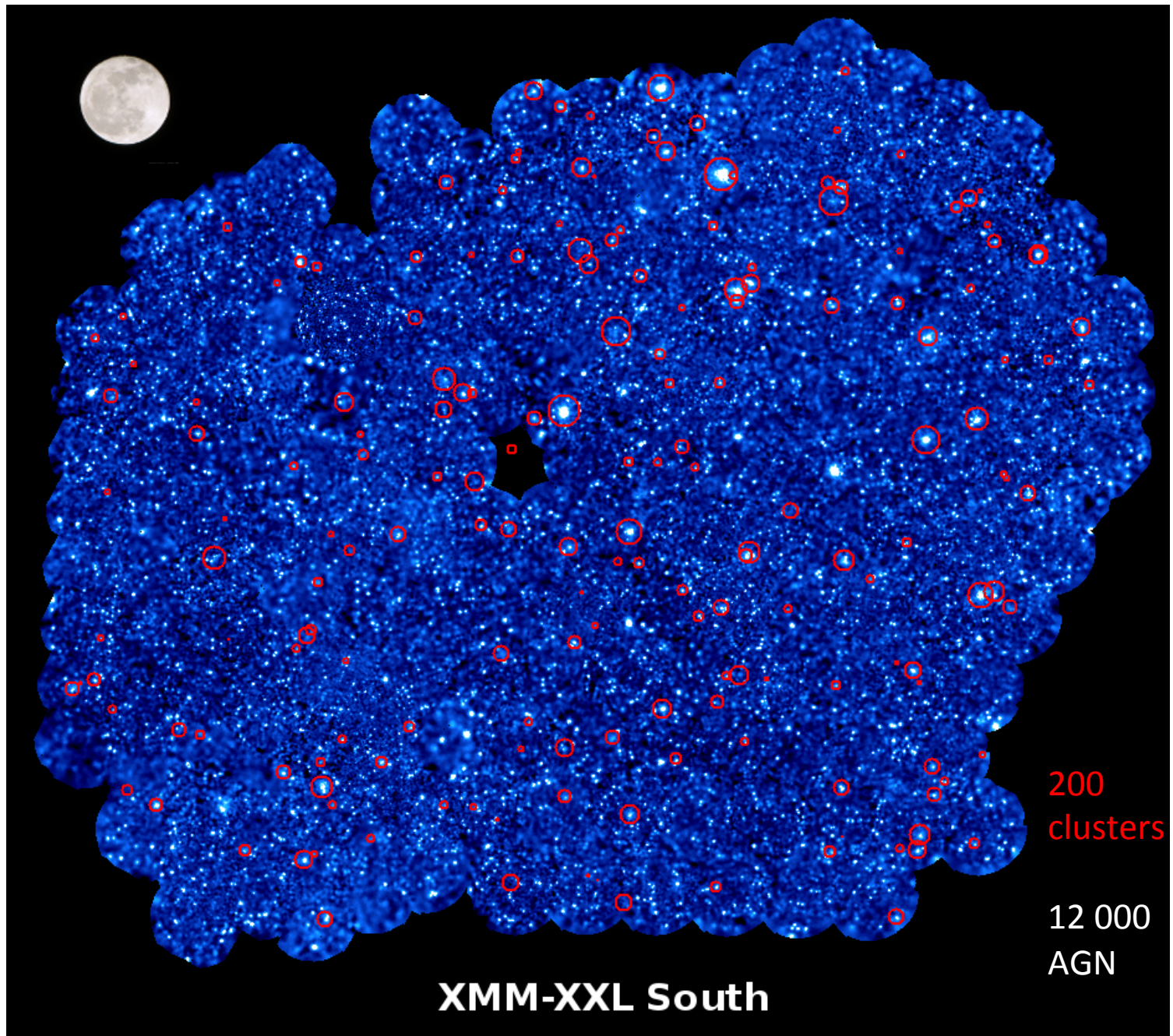


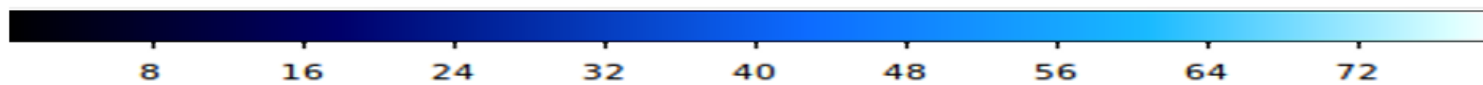
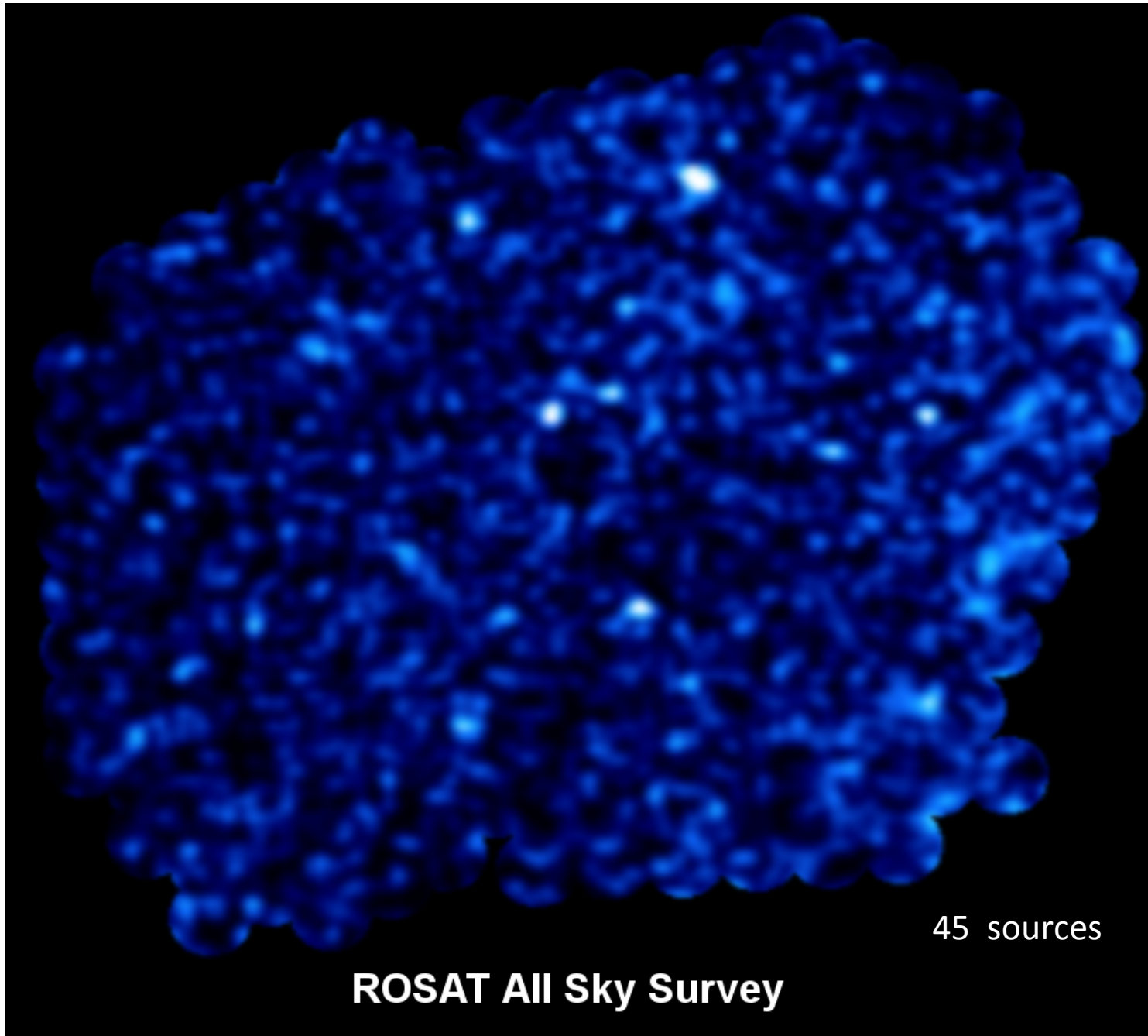
XXL south



7 pointings
(+1 with mosaic)

- Observed
- Good
- Usable
- Lost

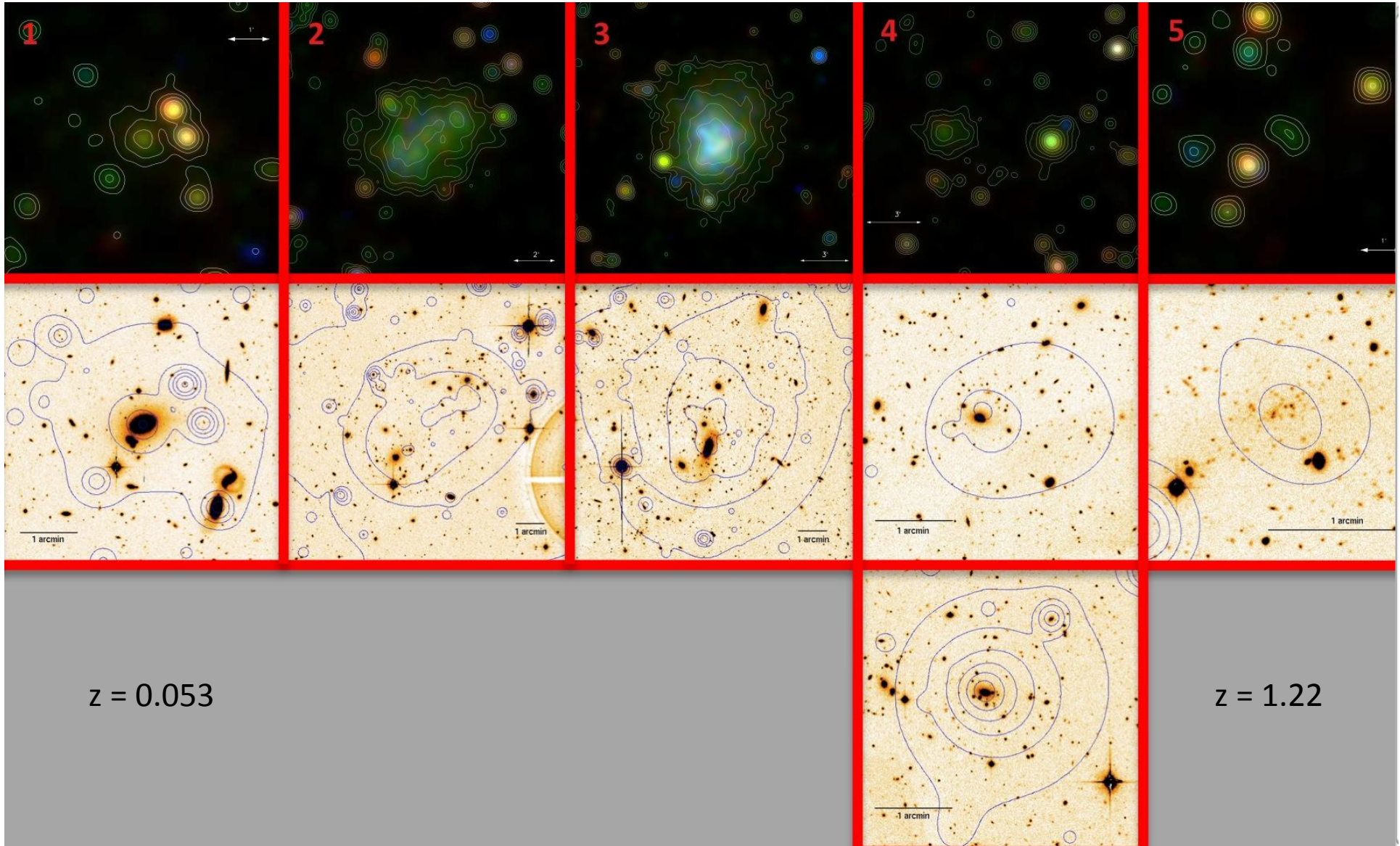




Advantages of a LSS survey

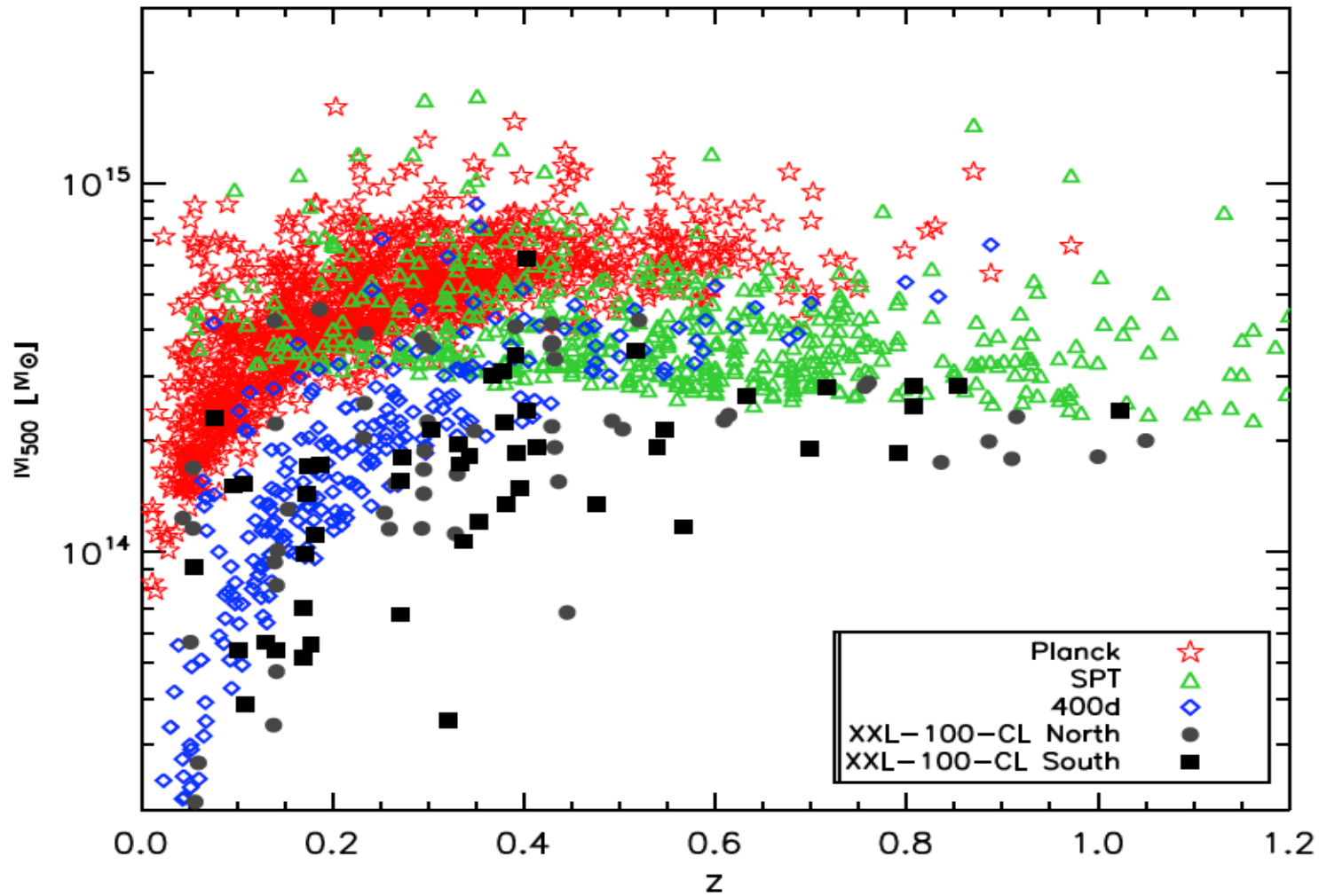
- Spatial information (topology) => more constraints on the cosmology
- Uniform multi- λ coverage => considerably eases the source identification procedure and the production of photo-z
- XRB LSS studies (impossible with Chandra and eRosita)

XXL clusters of galaxies and their optical counterpart (CFHTLS)



Cluster mass range

XXL paper II : 100 brightest clusters *Pacaud et al, A&A 2106*



XLSSC-122

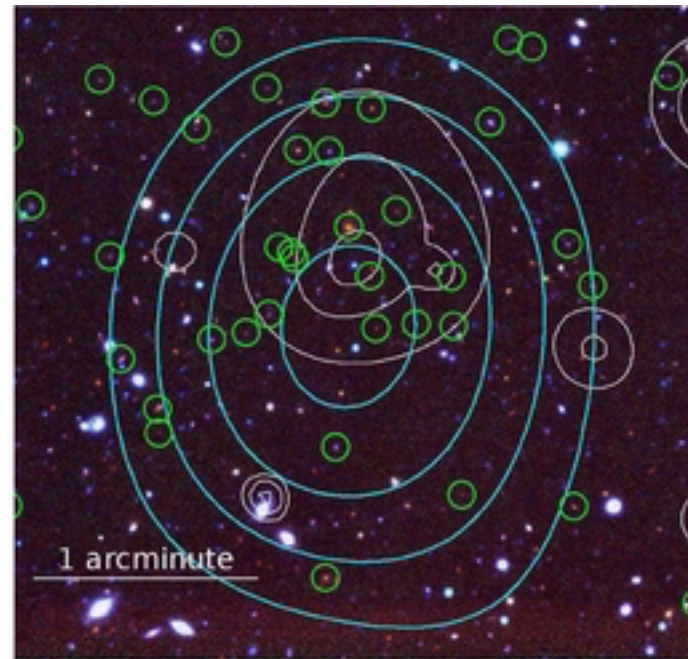
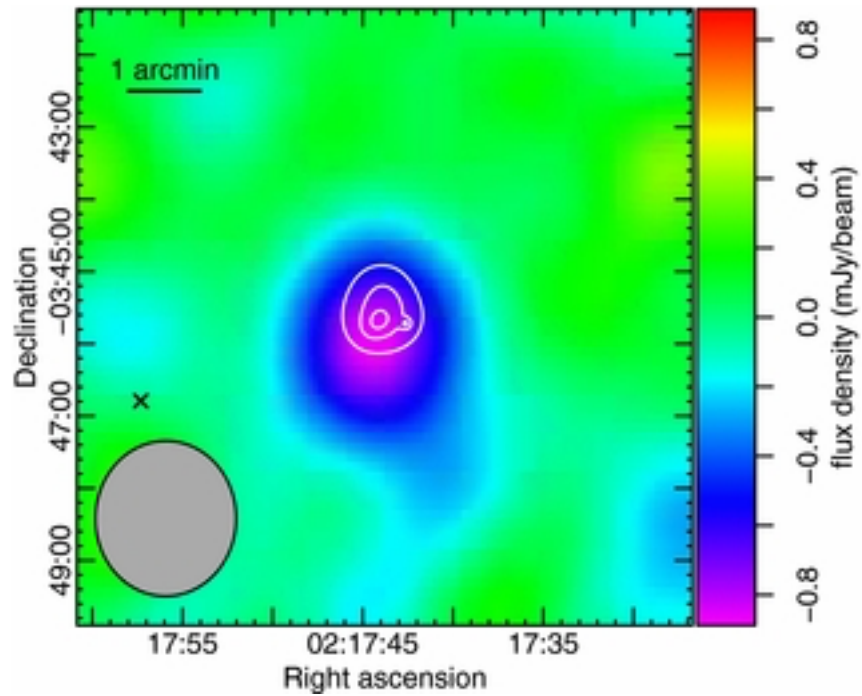
Mantz et al 2014
XXL paper V

z-phot~1.9

CARMA

XMM

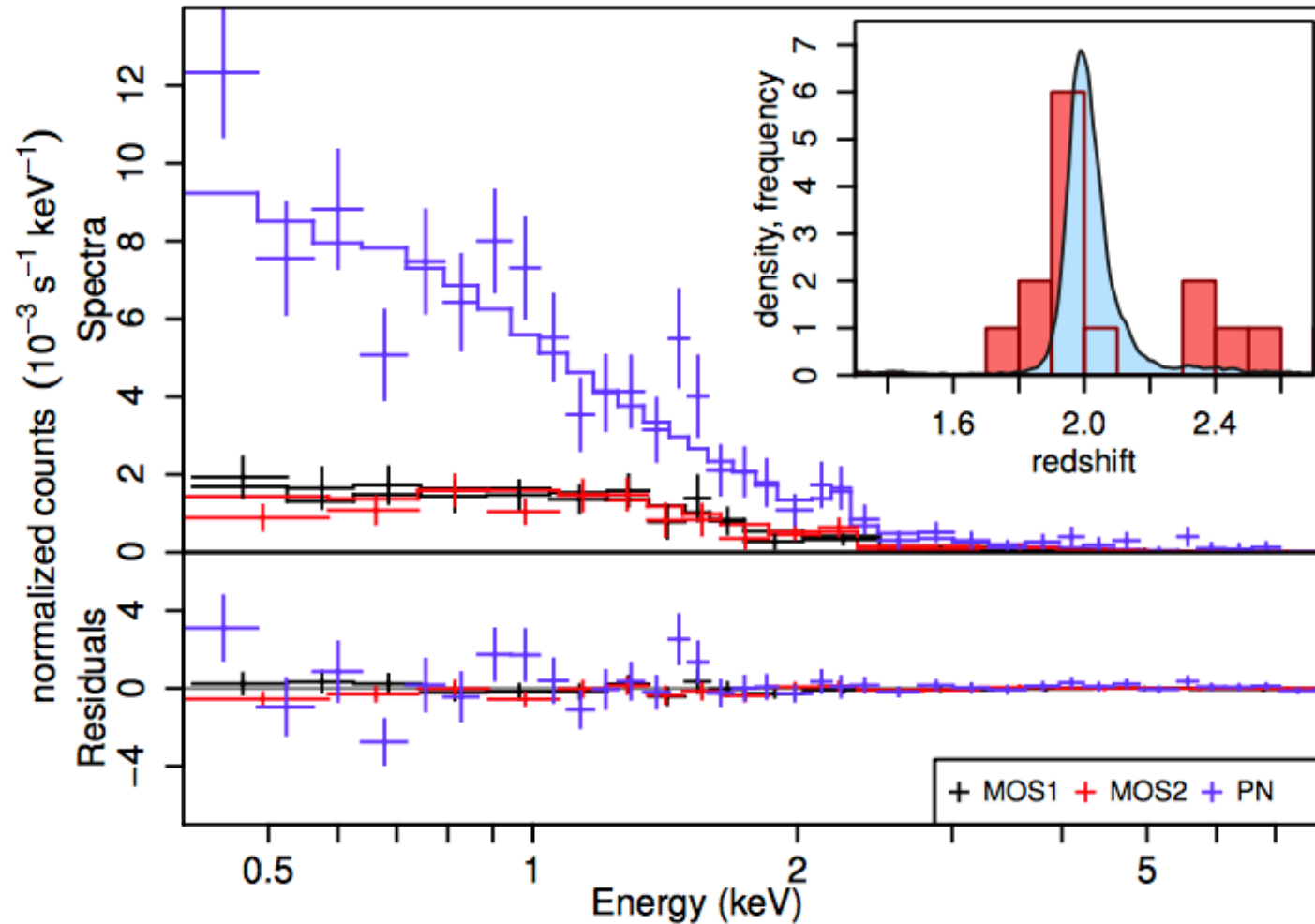
CFHT



Redshift confirmation by deep XMM obs.

Mantz et al, 2017, A&A in press

XXL paper XVII



$z = 2.0$

$kT =$
 $5.0 \pm 0.7 \text{ keV}$

The SZ-X offset
remains

An outlook on XXL paper series II
(in press)

The 365 cluster catalogue

XXL paper XX, Adami et al

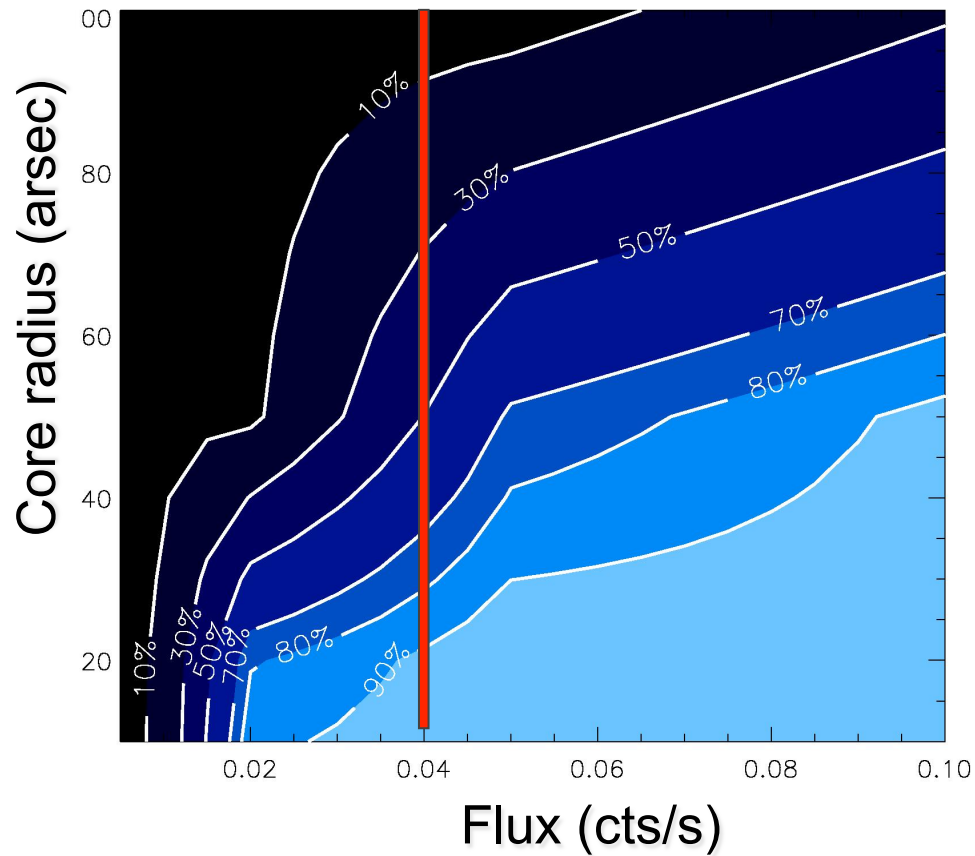
- All clusters (but 24) are spectroscopically confirmed
 - 207 C1 (pure & complete),
 - 119 C2 (pure but uncomplete yet)
 - 39 C3 (undefined selection function)
- Temperature measurements for 176 clusters
- R_{500} , M_{500} estimates from $L_{300\text{kpc}}$ using an internally self-consistent system of scaling relations

Detection rates

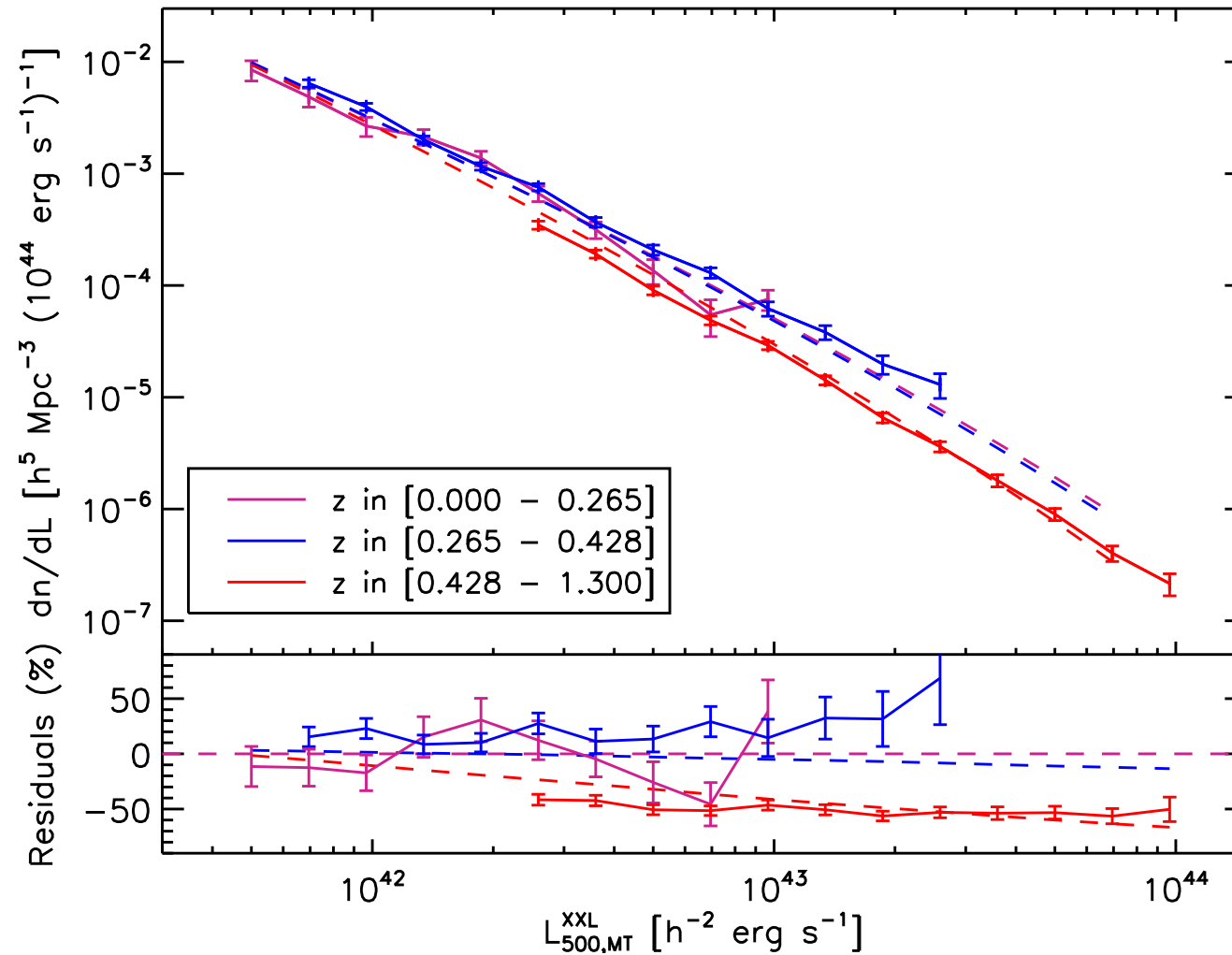
from analytical simulations

Class 1 sample : < 5% contamination

**Not a flux
limit !**

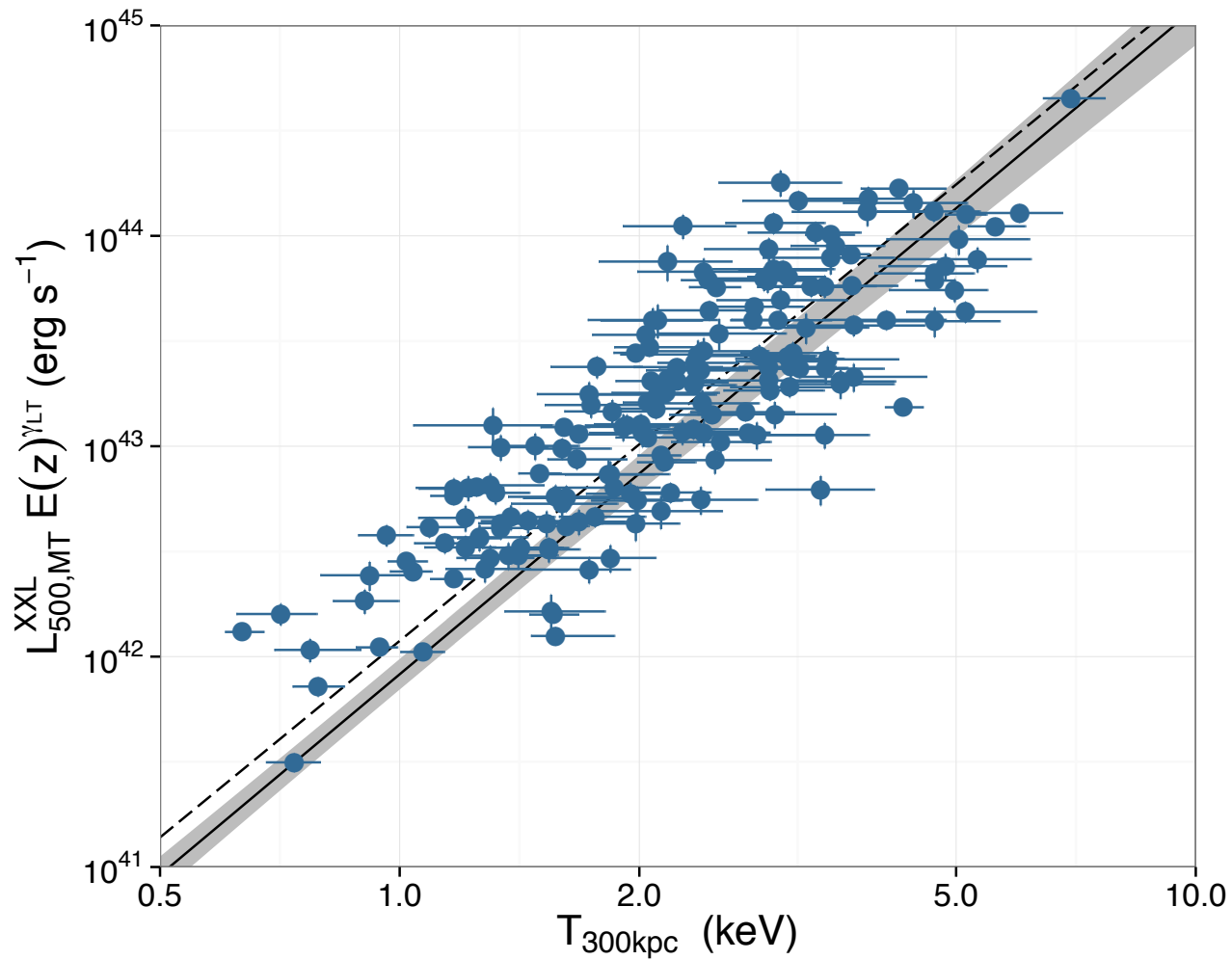


The cluster luminosity function



Almost no evolution of the LF . . . Which does not mean that the clusters do not evolve

The L-T relation



Cosmological fit with full account of the selection biases:
totally compatible with self-similar evolution.

Preliminary cosmological analysis

! Results to appear soon!

- 178 C1 clusters
- dn/dz : *Pacaud et al , XXL paper XXV*
- ξ : *Marulli et al, XXL paper XXXVII*

Reminder :

Planck CMB and S-Z clusters (2014)

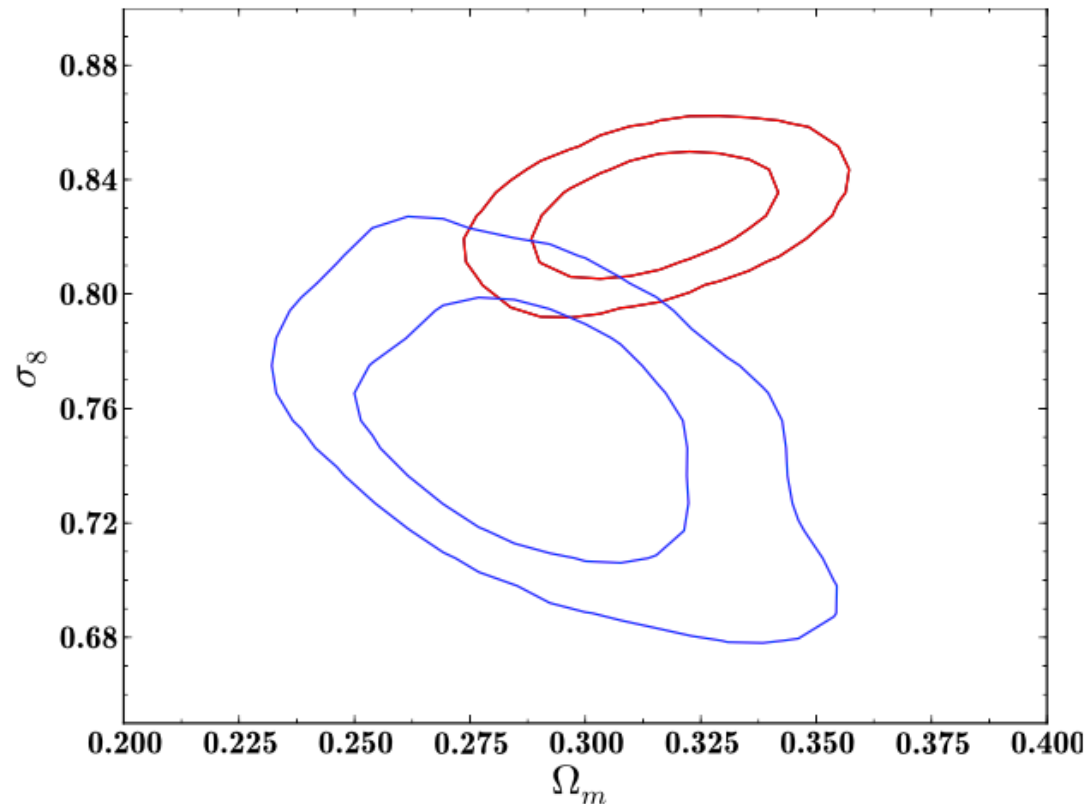
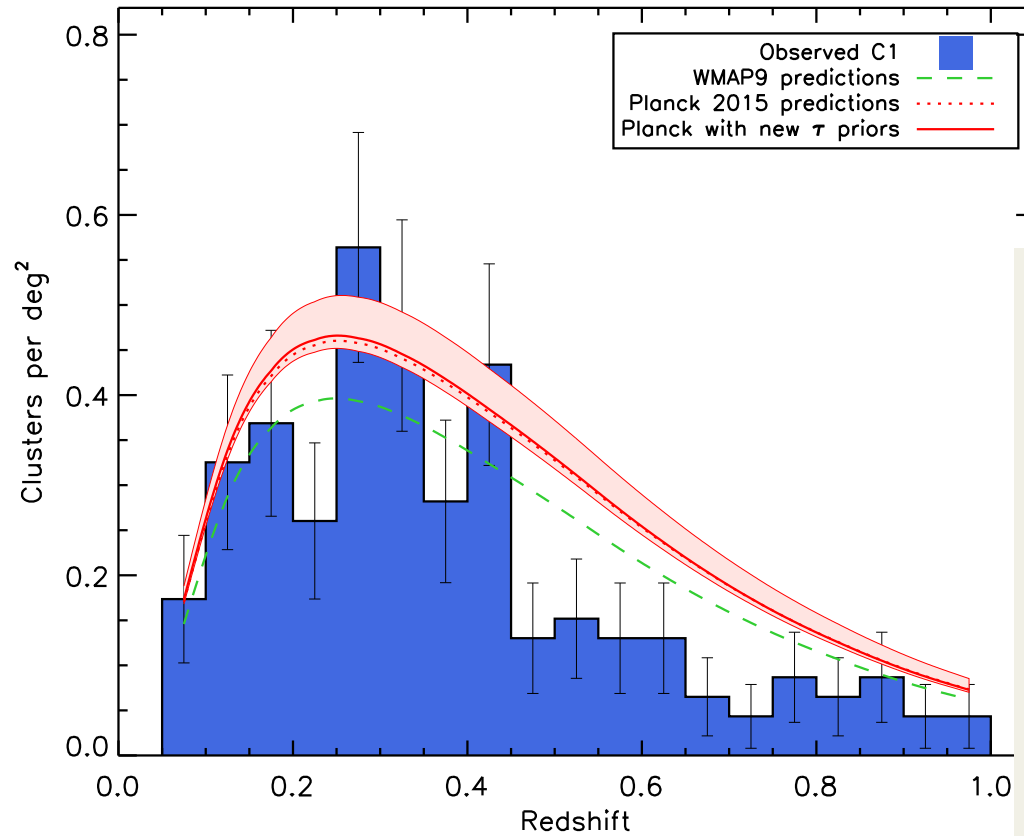


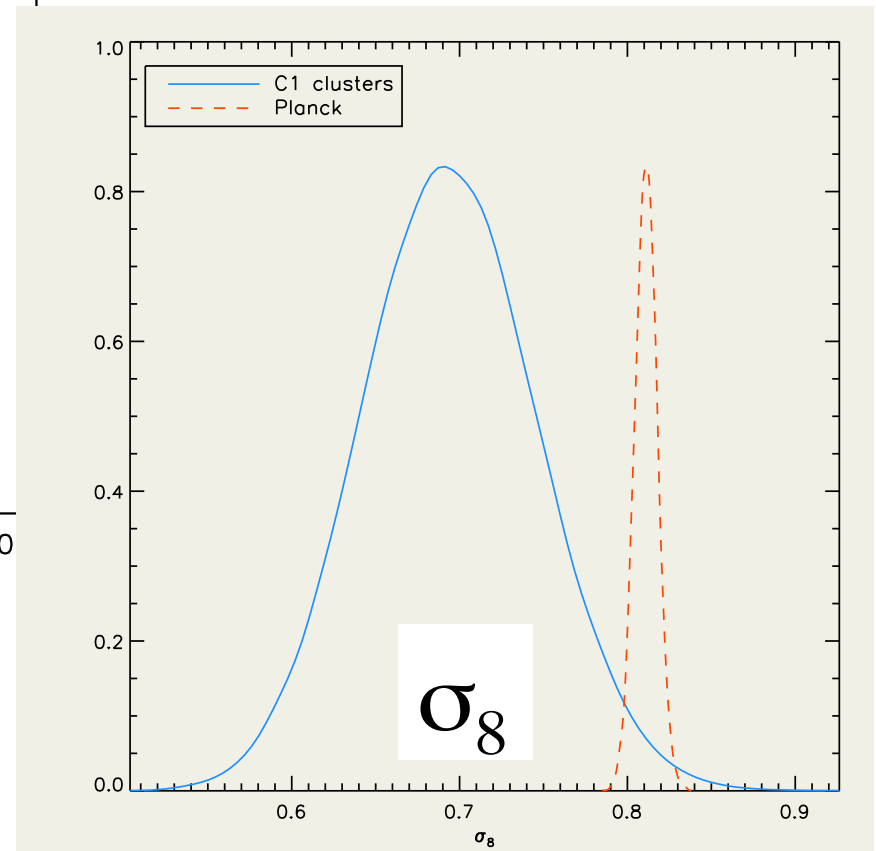
Fig. 11. 2D Ω_m - σ_8 likelihood contours for the analysis with *Planck* CMB only (red); *Planck* SZ and BAO and BBN (blue) with $(1 - b)$ in $[0.7, 1]$.

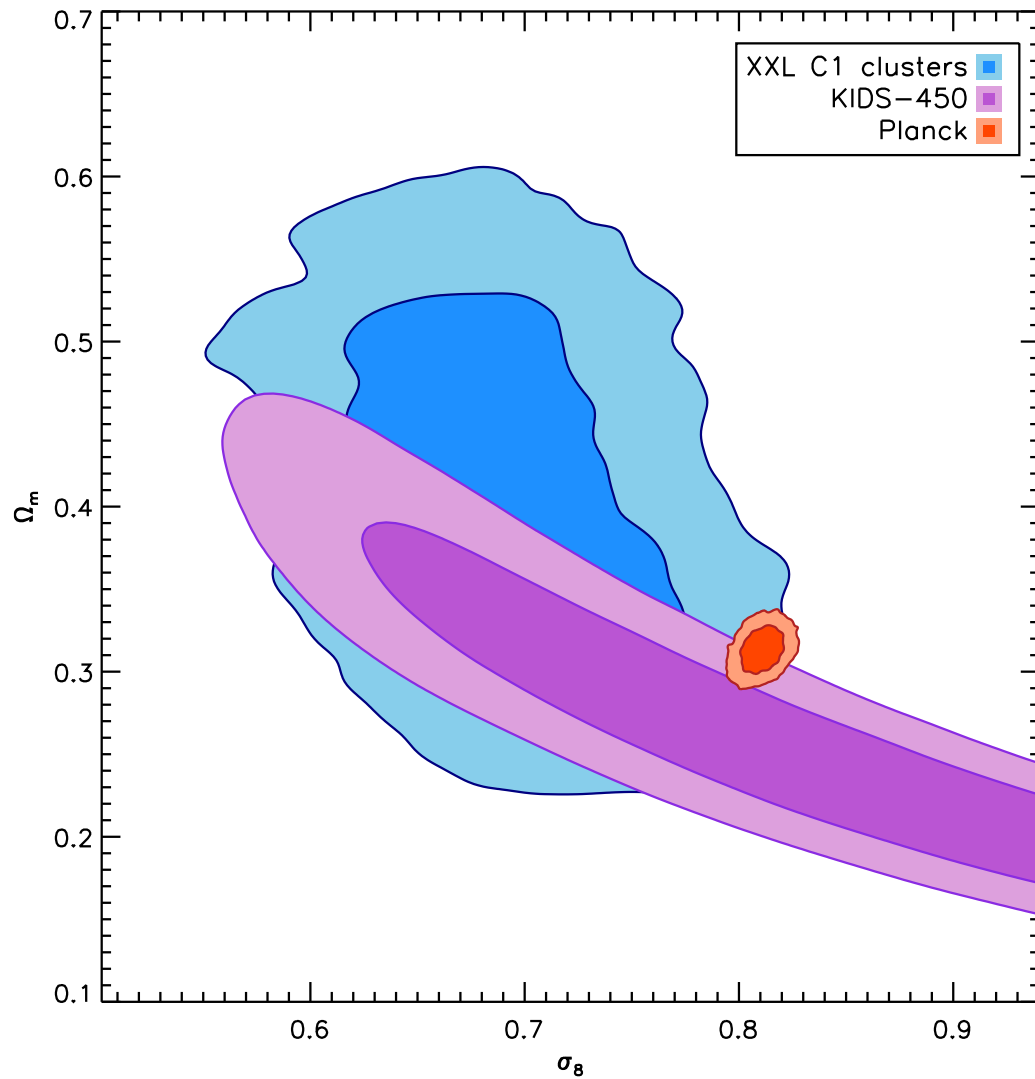
Analysis of the cluster dn/dz

(preliminary results)



only h ; Ω_m ; Ω_b ; σ_8 ; n_s are let free

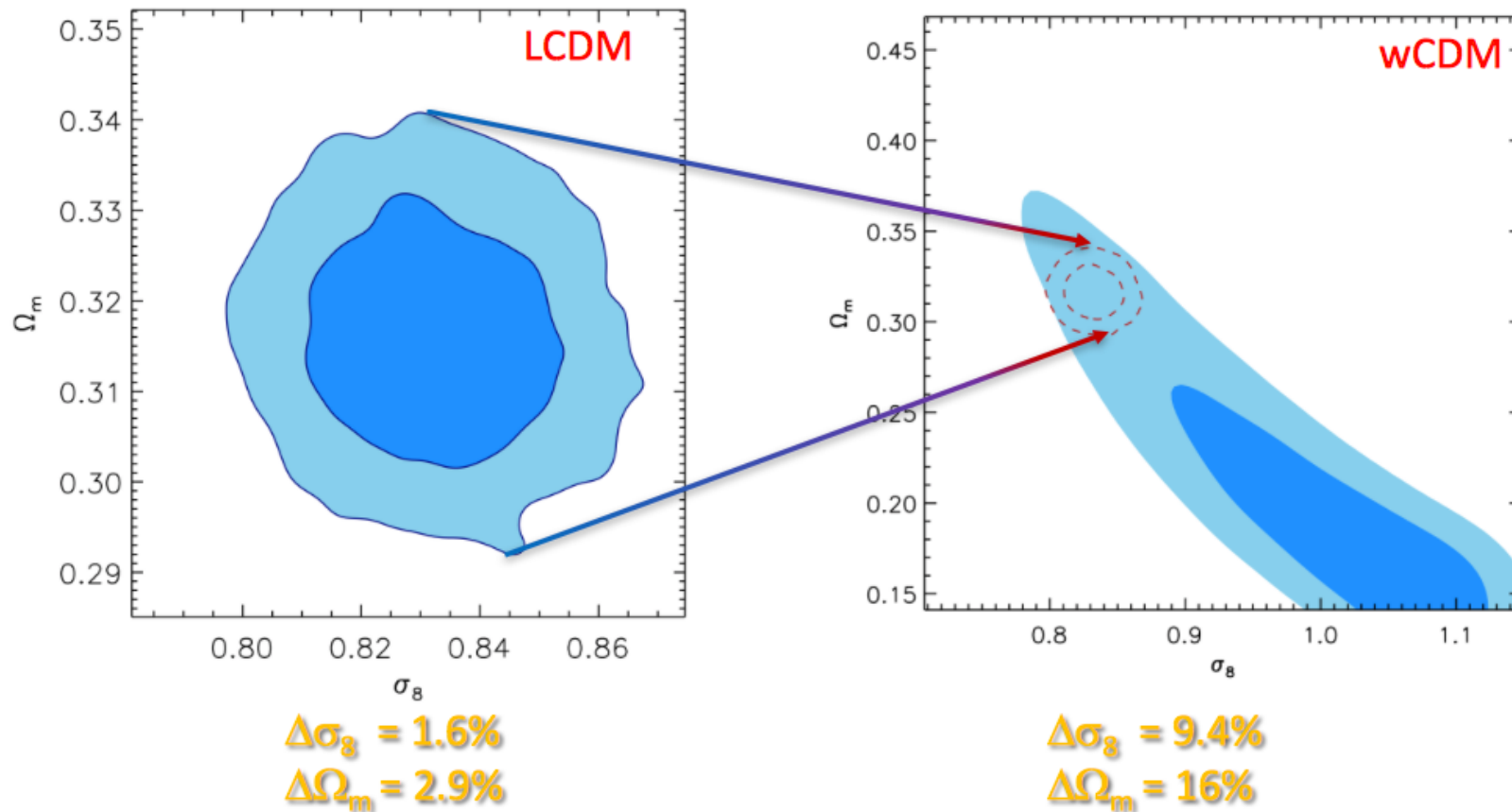




A similar dissension
is observed with KIDS
(lensing)

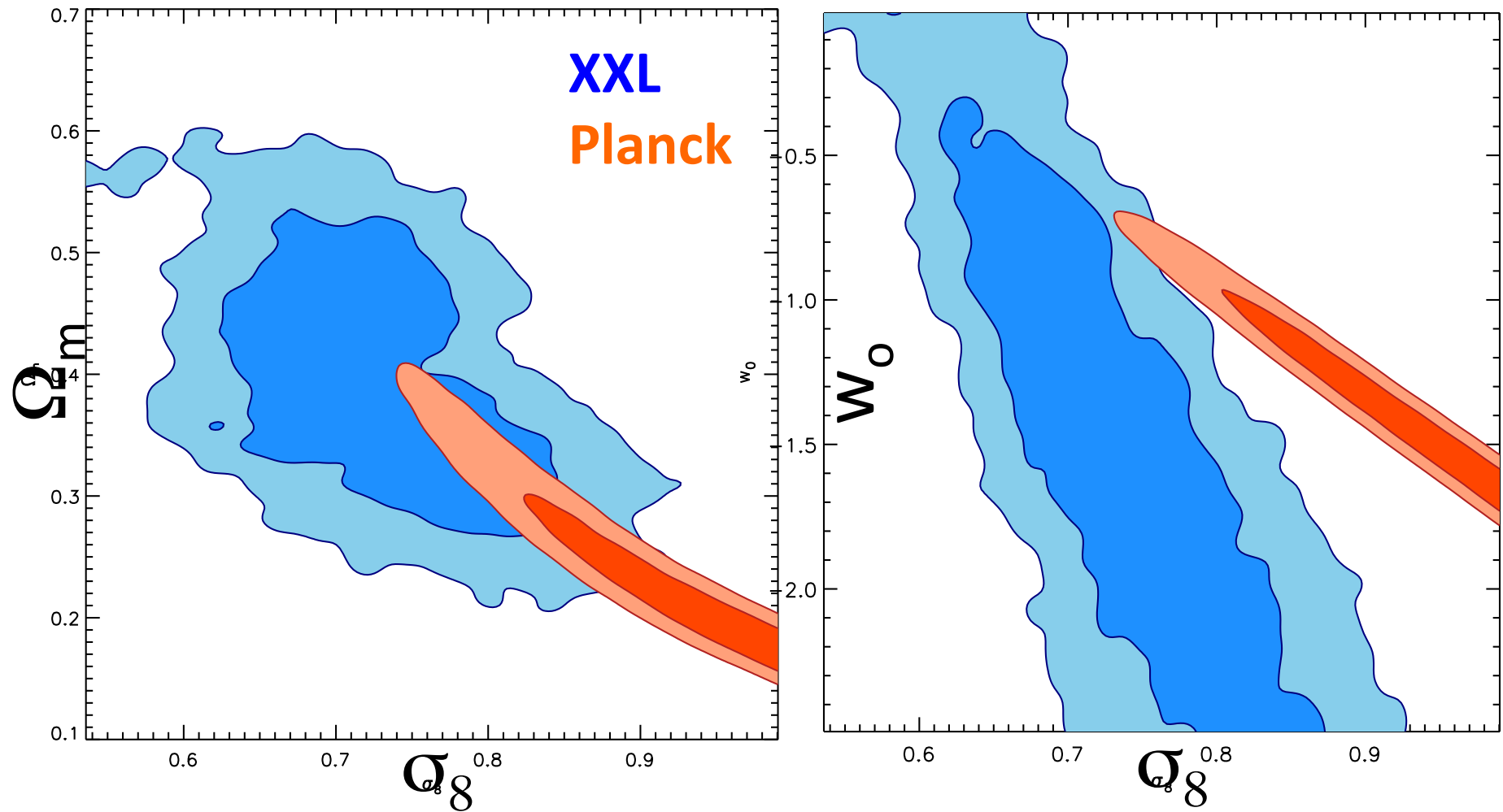
The DE equation of state ?

- Planck only provides tight constraints for the default 5 parameter LCDM model
- Errors blow up as soon as any parameter is added :

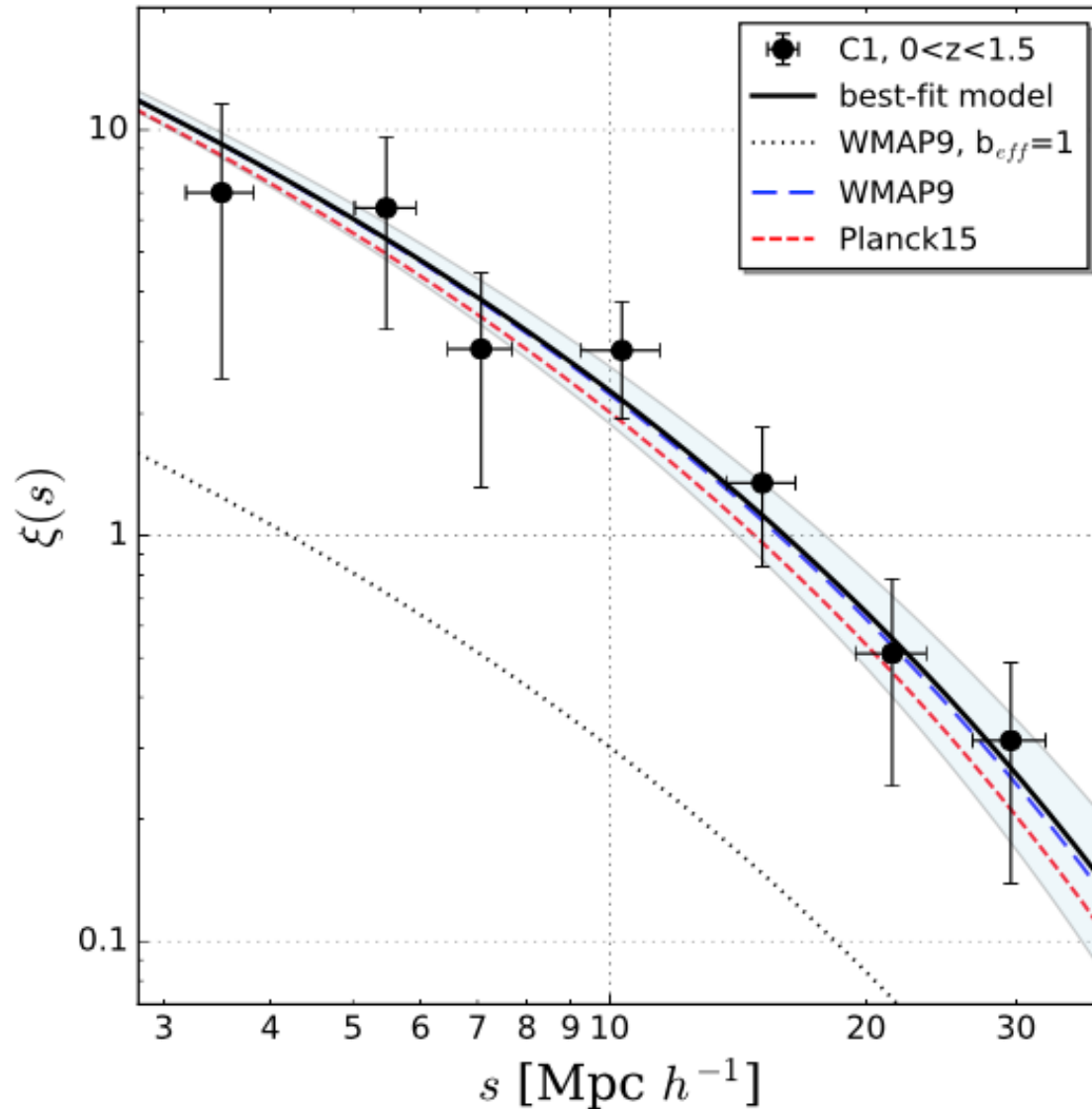


- There is – in principle – freedom to reconcile clusters and CMB

Now, if we let w free



The C1 correlation function



First time that the cluster correlation function is computed at these masses and redshifts !

When w is let free, Combining ξ with dn/dz improves the cosmological constraints by a factor of 2

Next and final steps

- Reprocessing of the entire area with pointing overlap
- Final catalogues
 - ~ 500 clusters out to $z \sim 2$
 - $> 30\,000$ AGN out to $z \sim 4-6$
- Paper series III (2021)
 - Comprehensive cosmological analysis
 - Cluster and AGN (environmental) science

THE END

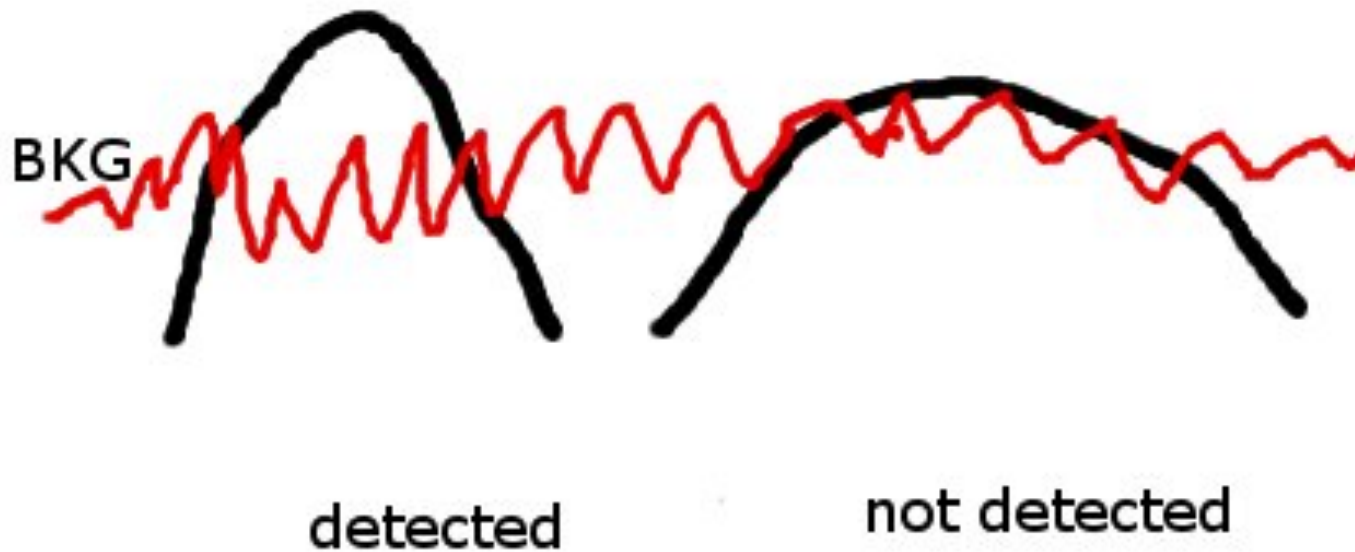
This project is supported in France by:



**Commissariat à l'Énergie Atomique
Laboratoire d'Astrophysique de Marseille
Observatoire de la Côte d'Azur.**

Not a flux limit !

2 clusters with same flux



~ surface brightness limited

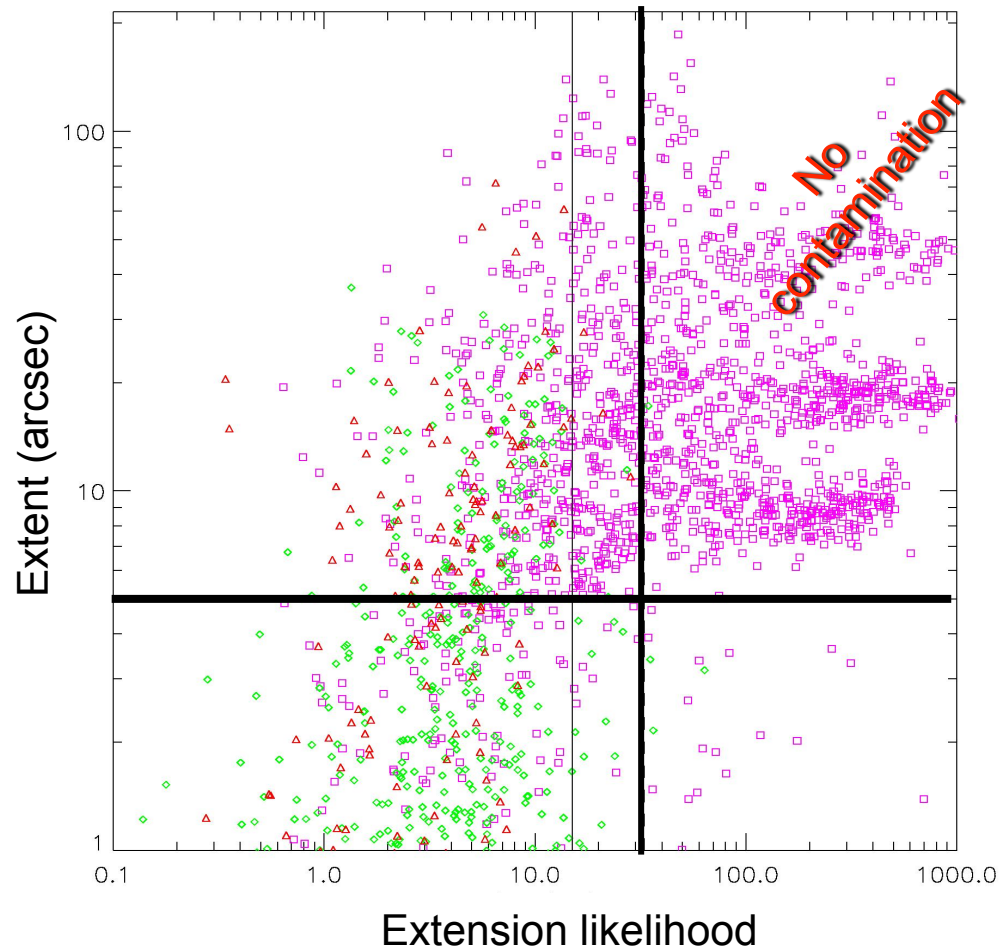
The cluster selection process

2 classes of extended X-ray sources

Green = AGNs

Magenta = clusters

Red = Spurious



Class 1 (C1):

$\sim 4/\text{deg}^2$

no contamination

Class 2 (C2) – fainter objects:

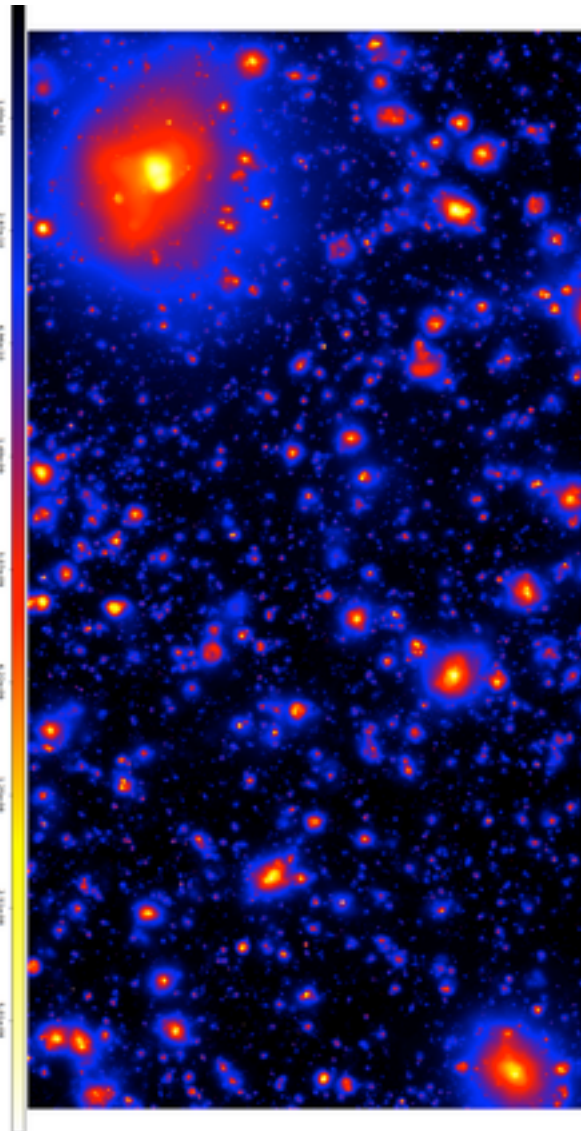
$\sim 5 \text{ more} / \text{deg}^2$

+ 5 false det.

50% contamination

Cosmo-OWLS simulation

Le Brun, McCarthy et al 2014



1x2 deg² FIELD

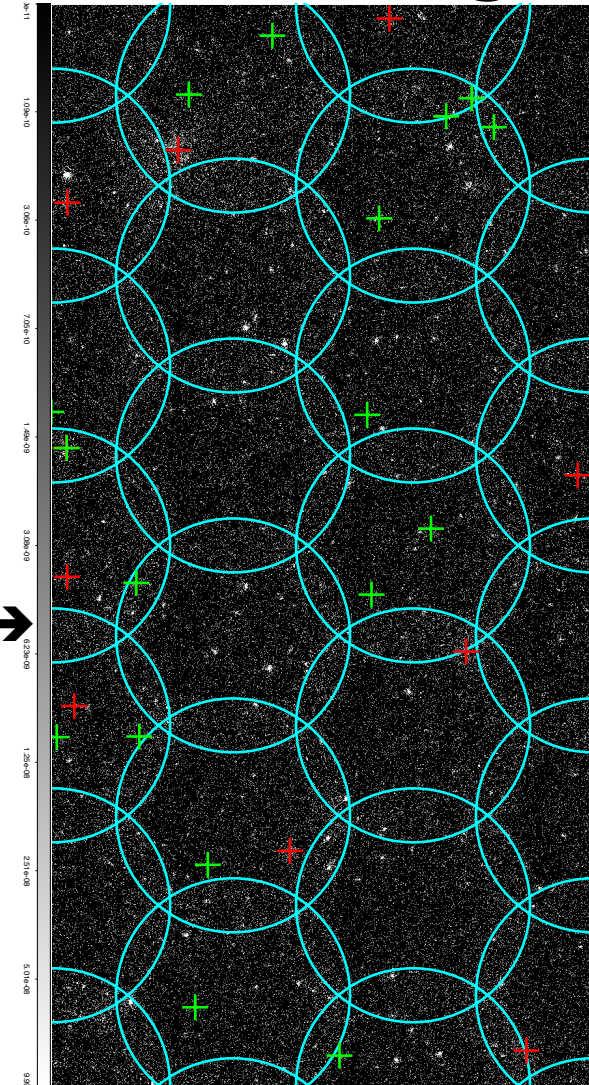
← Input = hot gas

Output = XMM photon image →

All instrumental effects and background components are taken into account

AGN are added

XMM image

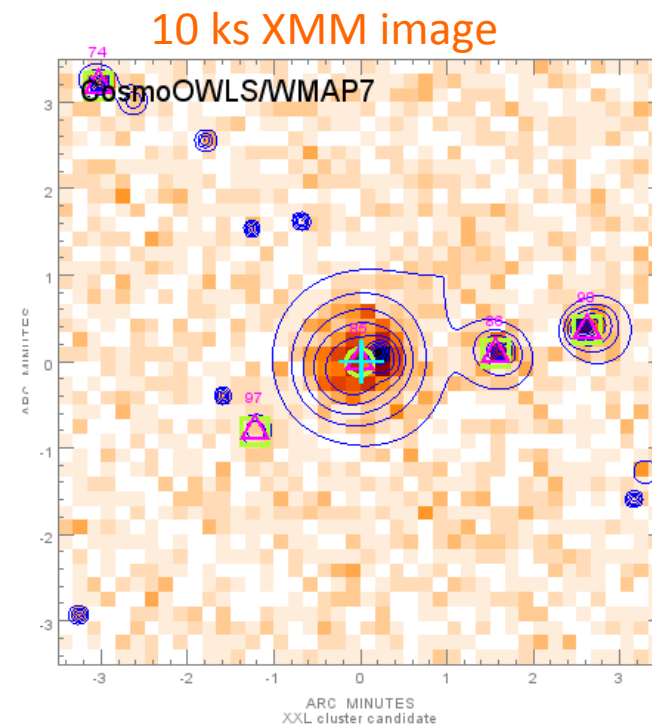
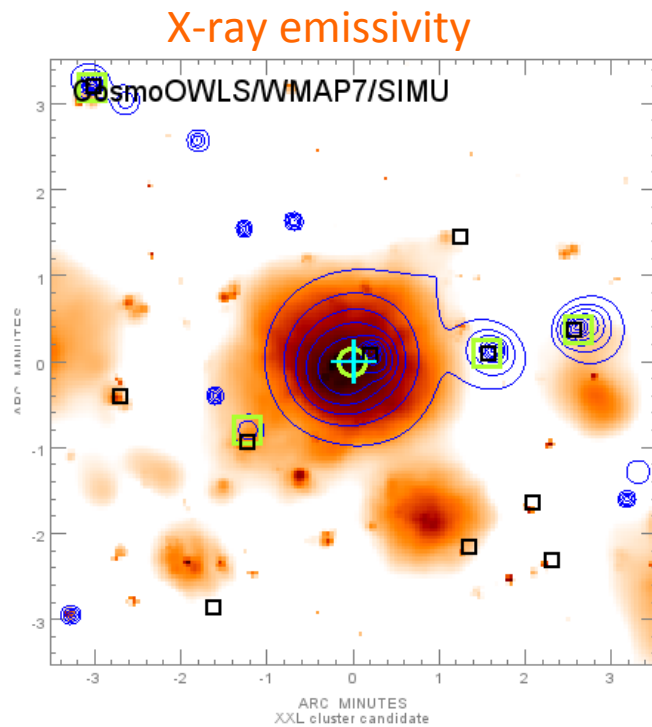


Hydrodynamical simulations used to:

- Compute more accurate selection functions
 - Irregular cluster shape
 - AGN simulated in situ (not randomly). See Elias' talk
 - Effect of cool cores
 - Study the dependence of ICM physics (via AGN activity) and cosmology
- Quantify the detectability of clusters within $1 < z < 2$

X-ray pipeline output

Cosmo-OWLS simulations, *Le Brun et al 2014*
AGN X-ray contribution, *Koulouridis et al, accepted*

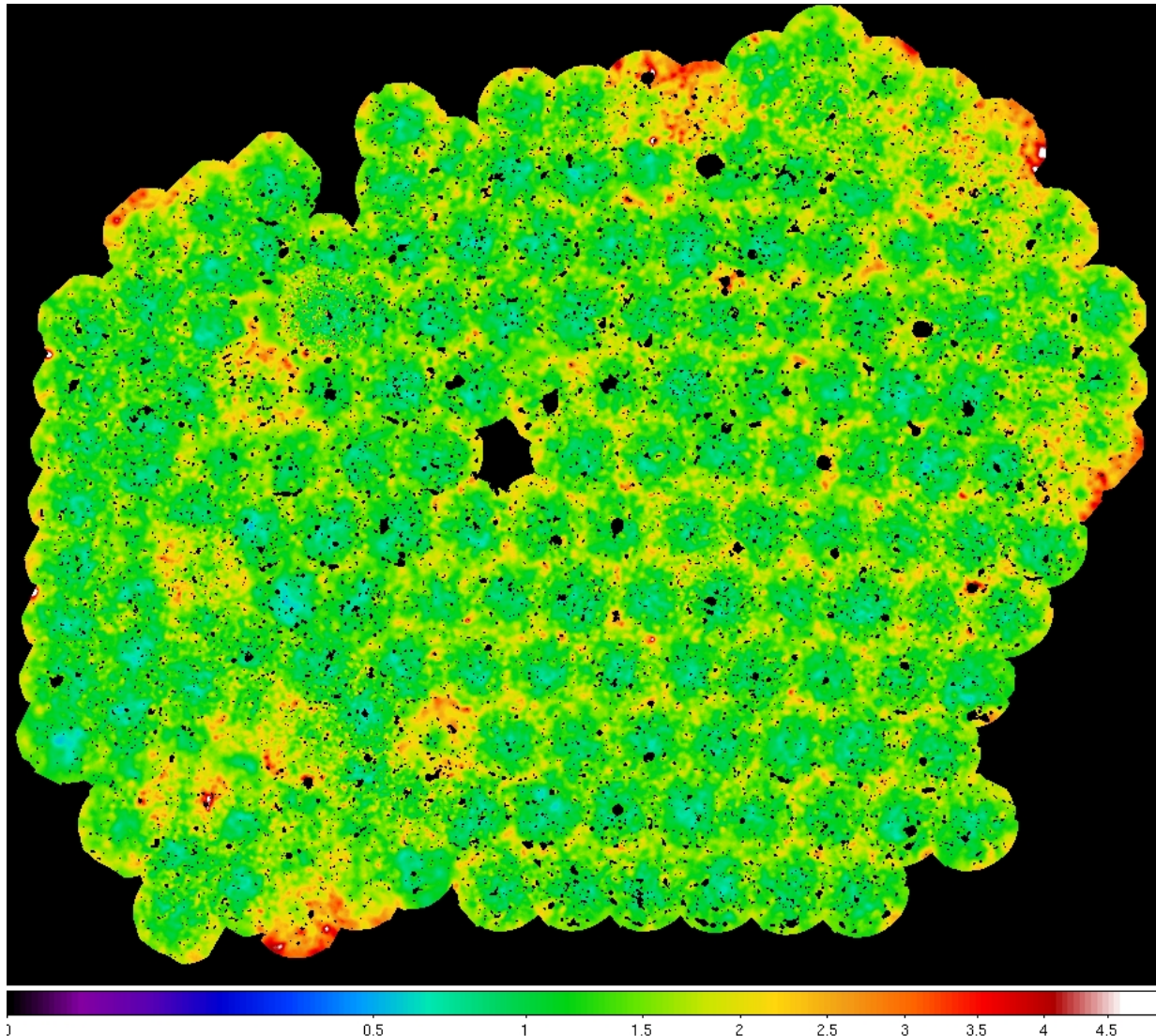


7'x7' image centered on a $z = 0.95$ cluster ; $M_{500} = 3.5 \cdot 10^{14} M_{\odot}$
– the black squares are the in-situ simulated AGN

SUMMARY AND CONCLUSION

- By mid-June we shall release several catalogues:
 - 365 clusters, all with spectroscopic z
 - 26 000 pointlike sources + UV \rightarrow IR IDs; 1000s of spectro- z
 - ATCA and GMRT radio sources
- A first cosmological analysis of the C1 clusters
- Next an final steps (~ 2020)
 - Reprocessing of the whole 50 deg² area with pointing overlaps
 - More than 500 clusters expected; and $\sim 35\,000$ AGN
 - Final deep catalogues
 - Estimate of the number density of the $1 < z < 2$ clusters
 - Final cosmological analyses for w -cosmologies
 - $dn/dM/dz$ + correlation function
 - ASpiX

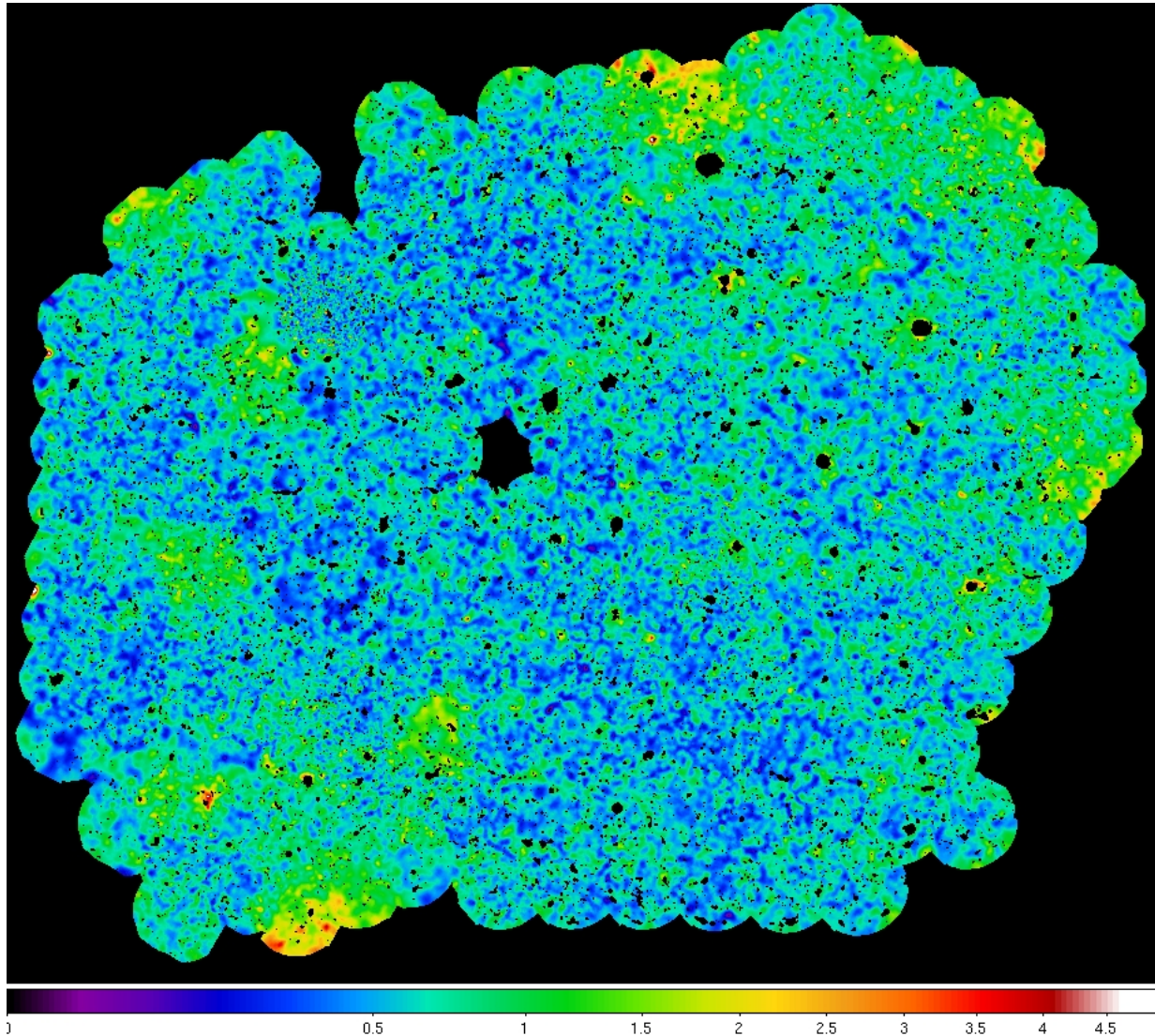
Exposure Correction of the Count Image



XXL-South

- Smoothed count rate (exposure corrected count image) image with no background subtraction
- Honeycomb structure due to the particle background being exposure corrected using the vignetted exposure map
- Brightest regions likely due to soft proton contamination

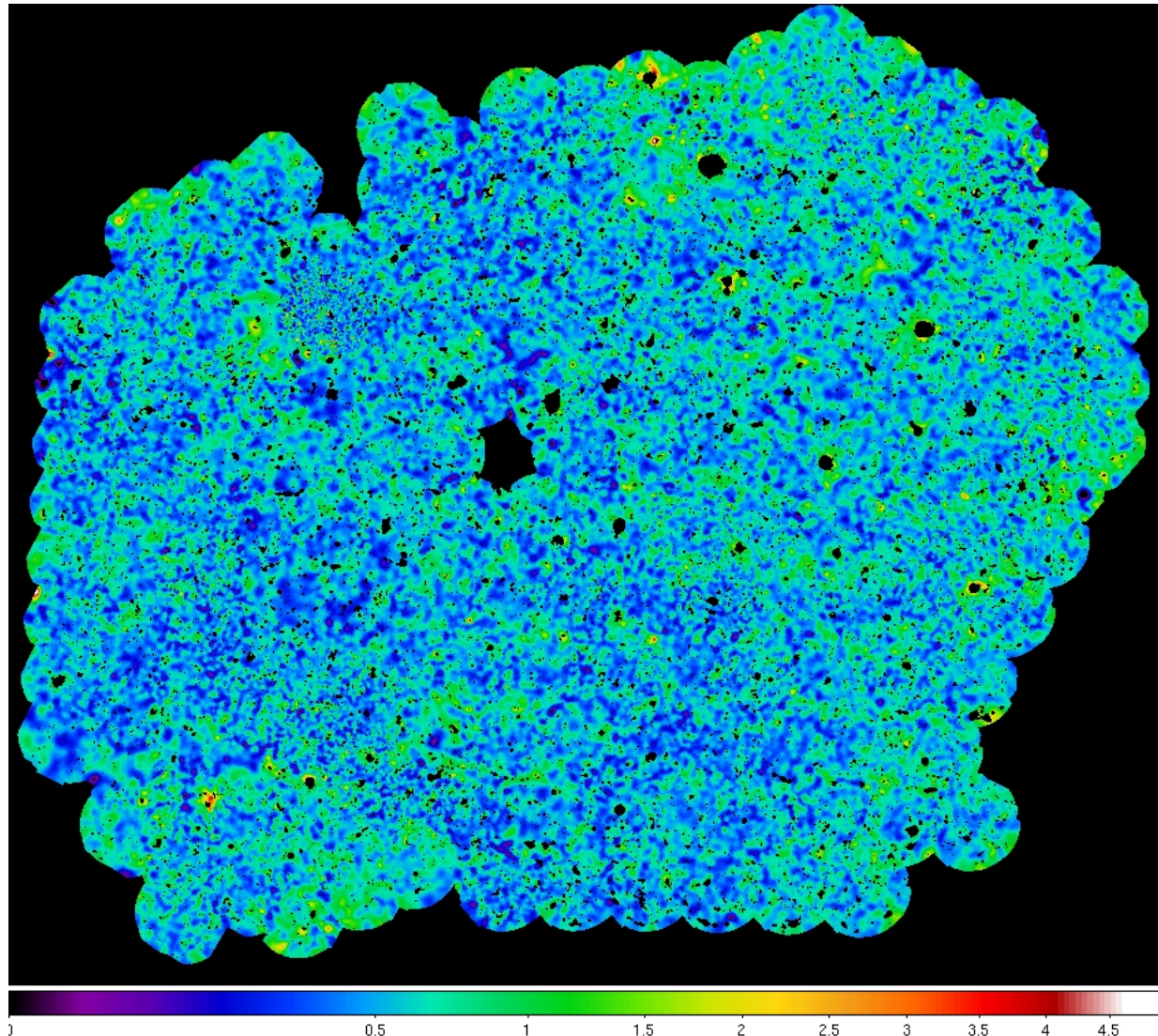
Exposure Correction of the Count Minus Particle Background Image



XXL-South

- Smoothed count rate (particle background subtracted and exposure corrected count image) image
- The honeycomb structure has been removed

Exposure Correction of the Count Minus Particle and Soft Proton Backgrounds Image



XXL-South

- Smoothed count rate (particle and soft proton background subtracted and exposure corrected count image) image
- Some structure remains, could some of it be the cosmic web?
- Still need one last correction – examine and model any residual offsets between adjacent pointings

Courtesy: S. Snowden