

First results from the XMM-XXL survey

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Theoretical and Observational Progress on the Large-Scale Structure of the Universe
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**X
X
L**

**The ultimate
XMM extragalactic survey**

*die Kunst
über
in der Wissenschaft*

LSS Surveys Roadmap

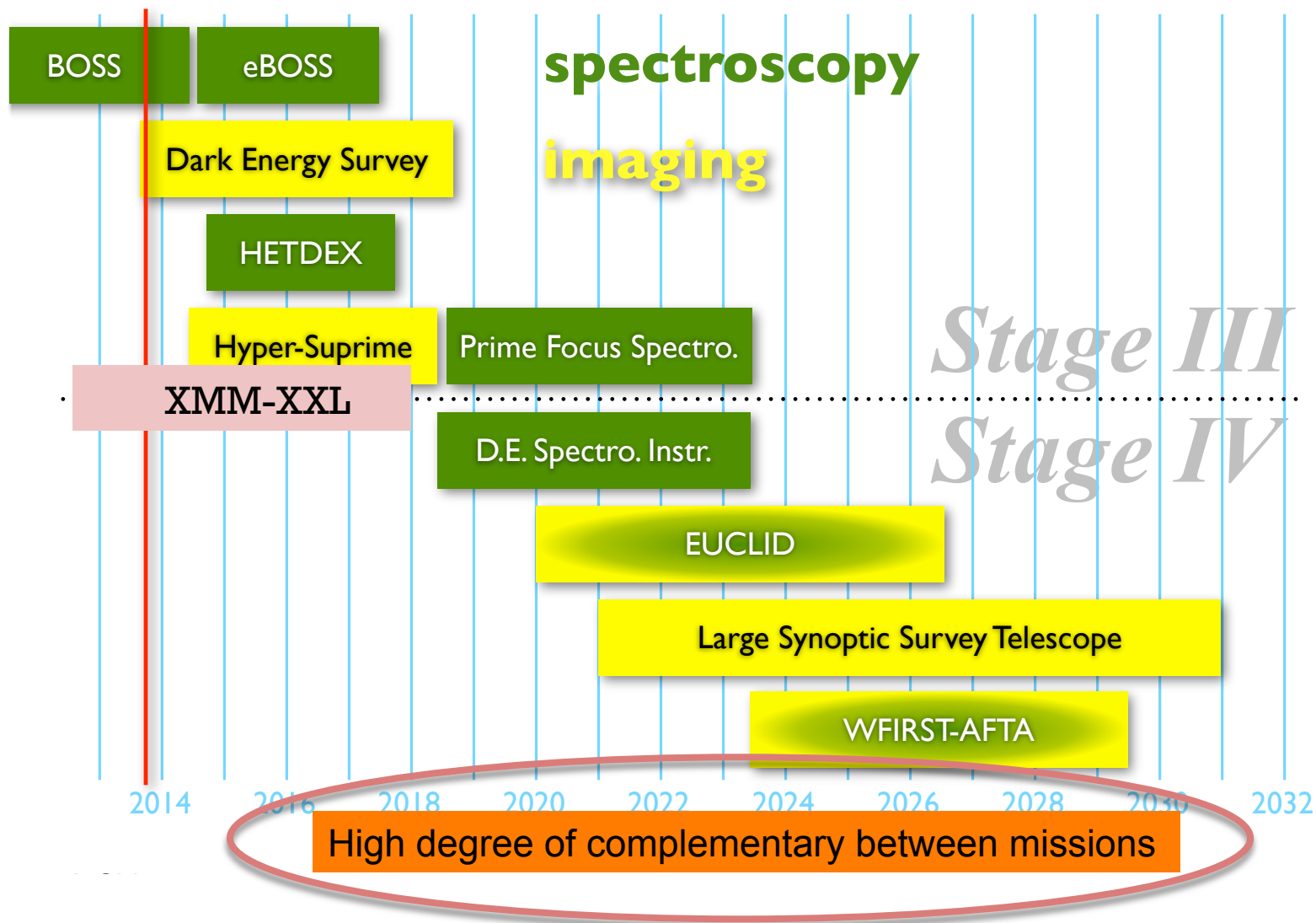
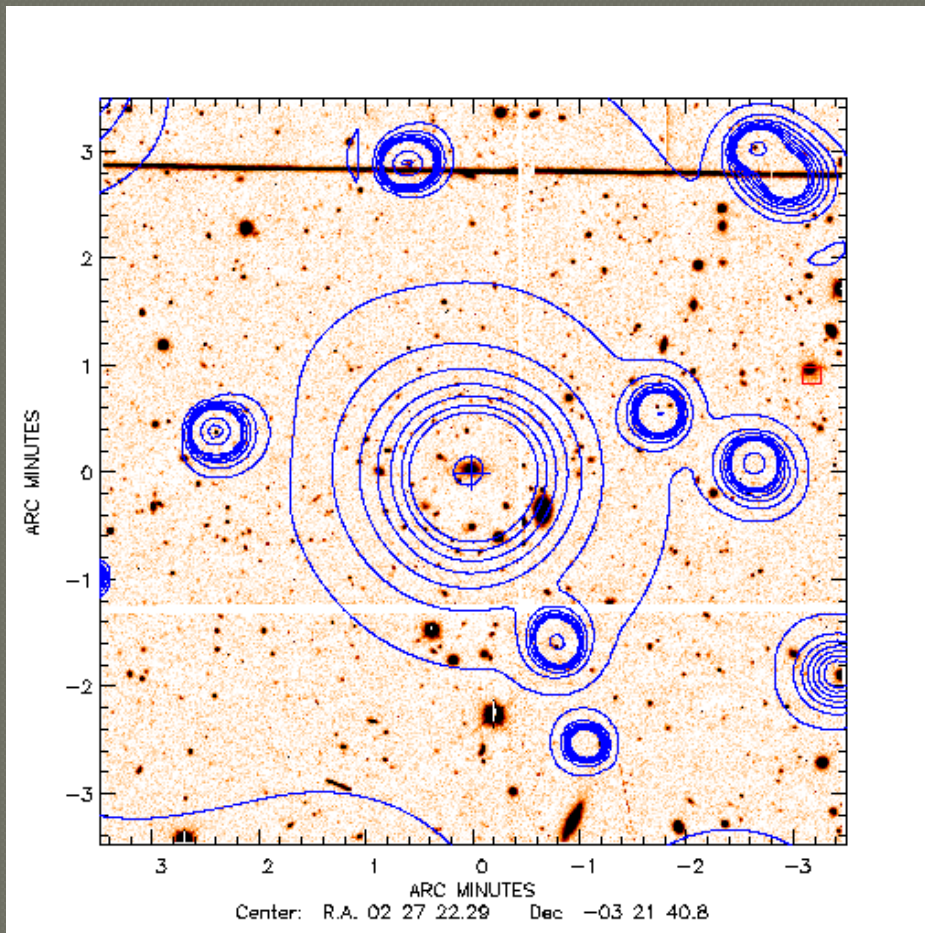


Image: Ian Shipsey

X-ray emission from clusters



Background image : CFHT i
Blue contours : XMM

XXL in short:

1) FIND

~ 500 X-ray clusters
in 50 deg²

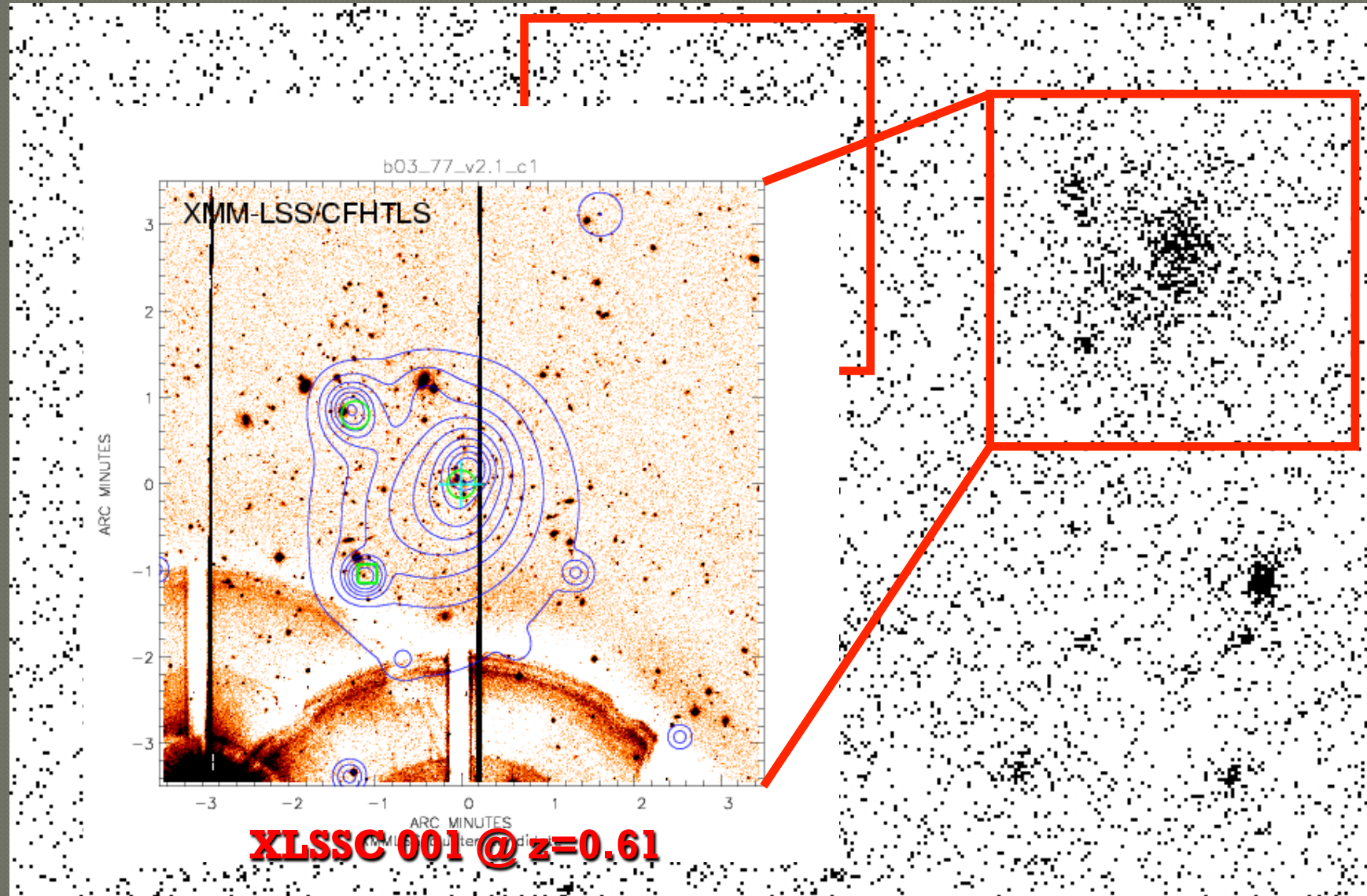
2) DO COSMOLOGY

X-ray clusters ~ 5%

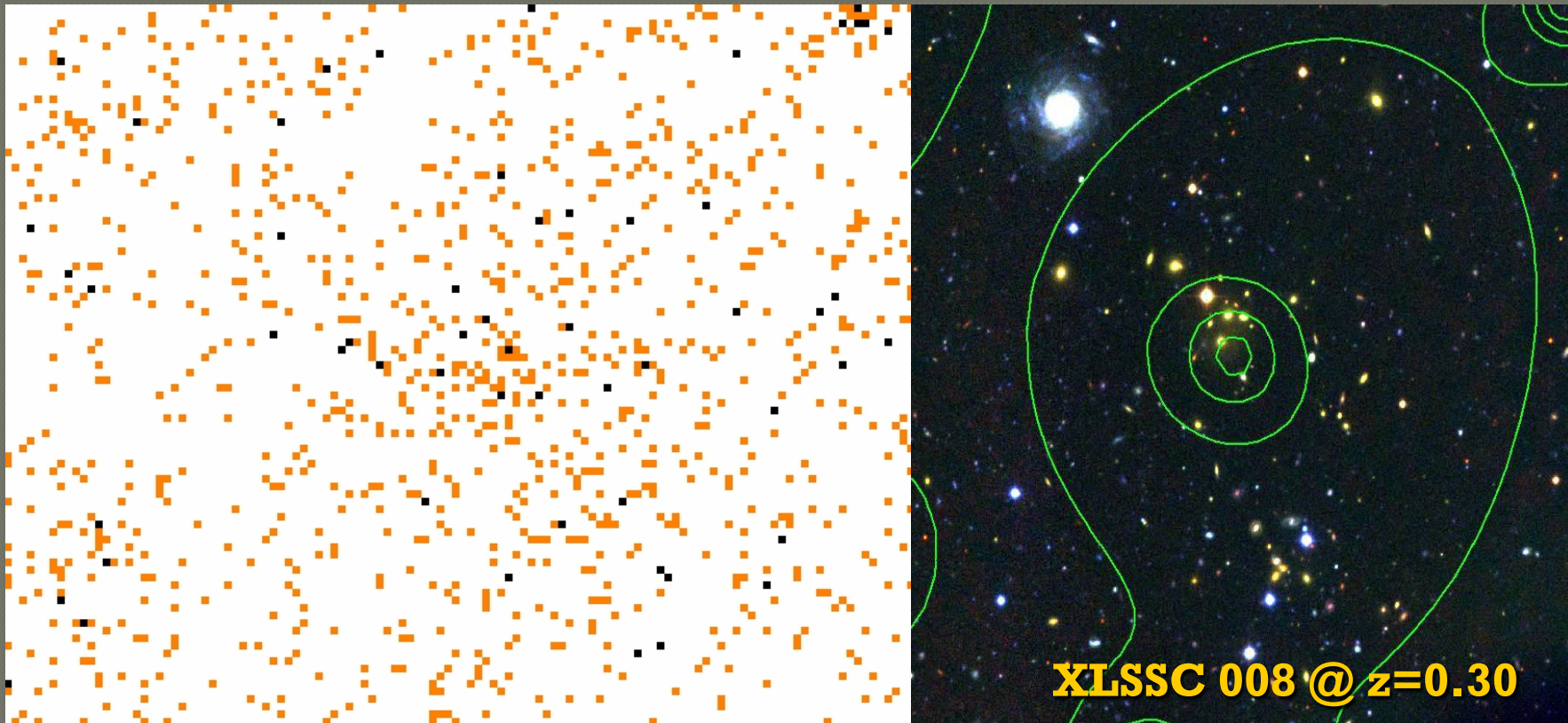
To make things clear... and exciting!

- Mean density of the ICM is ~ 1 atom/liter
 - 5 times emptier than the best vacuum obtained on Earth
 - But the total gas mass of a cluster is $\sim 10^{14}$ Mo!
- We collect ~ 1 cluster photon per minute
 - Typically 100-500 photons per cluster in 10 ks
 - Less than the number of galaxies in clusters!

Typical 10ks XMM image of an 'empty field'



Typical 10ks XMM image of an 'empty field'



Working with these data : difficult !
: misleading (Poisson)
: ambitious

... but feasible and exciting !

Outlook 1

- XMM VLP (2010) following XMM-LSS (2000-2010) :
 - 2 x 25 deg² area
 - Total time > 6Ms
- An international consortium gathering ~ 100 scientists.
- The ~ 540 XMM observations were completed in 2013
- First series of papers submitted to A&A in July 2015

Outlook 2

1. Scientific motivations
2. The XMM observations
3. The follow-up programme
4. The cluster catalogue
5. Overview of the first results 9 papers submitted
6. A comprehensive associated simulation programme. Future

1 Scientific motivations

Cosmology

- Obtain a sample of ~ 500 clusters of galaxies out to $z \sim 1$
- Well-defined selection effects
- Self-consistent cluster mass measurements
- Cluster counts AND cluster LSS
→ Standalone cosmological constraints

Predictions for XXL

= 50 deg²

Table 7. Cosmological constraints. Survey configuration A2 - 50 deg² 1/4 depth (10 ks XMM exposures) 1- σ errors on w_0 / w_a

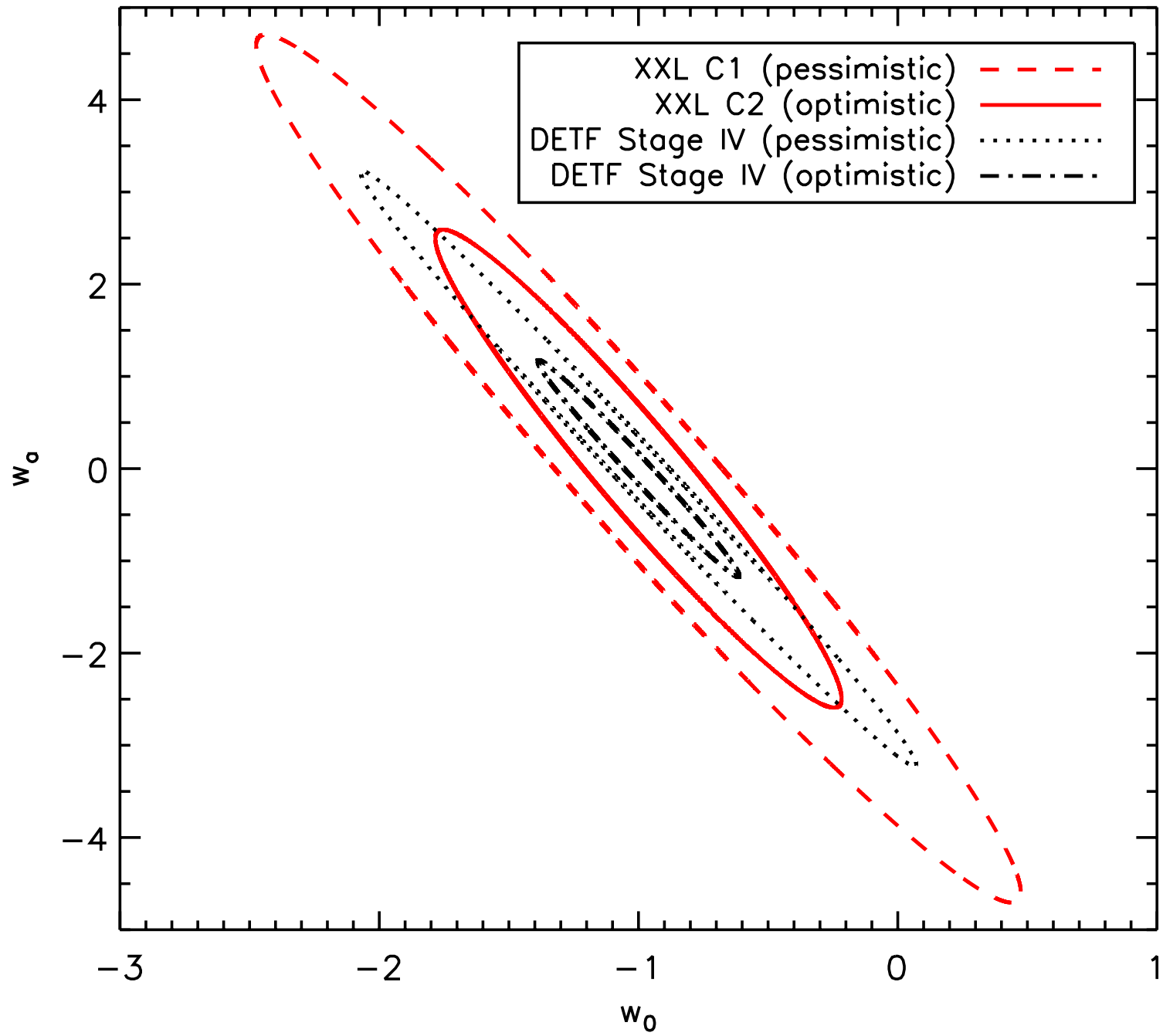
XXL

Selection	Redshift range	dn/dz + Planck	dn/dz + ξ + Planck
C1 (pessimistic)	$0 < z < 1$	2.77 / 5.98	0.97 / 3.08
C2 (optimistic)	$0 < z < 2$	1.14 / 2.44	0.55 / 1.70

Table 8. Cosmological constraints from clusters following the DETF survey designs 1- σ errors on w_0 / w_a

Ref.
Dark Energy Task
Force
clusters

Stage	Pessimistic	Optimistic
III	0.70 / 2.11	0.26 / 0.77
IV	0.73 / 2.18	0.24 / 0.73



Cluster and AGN science

- Cluster physics ~ 500 clusters
 - Scaling relations
 - Baryon budget
 - Galaxies in clusters
- AGN physics ~ 25,000 AGNs
 - AGN evolution
 - AGNs in LSS
 - Search for exotic and very distant objects

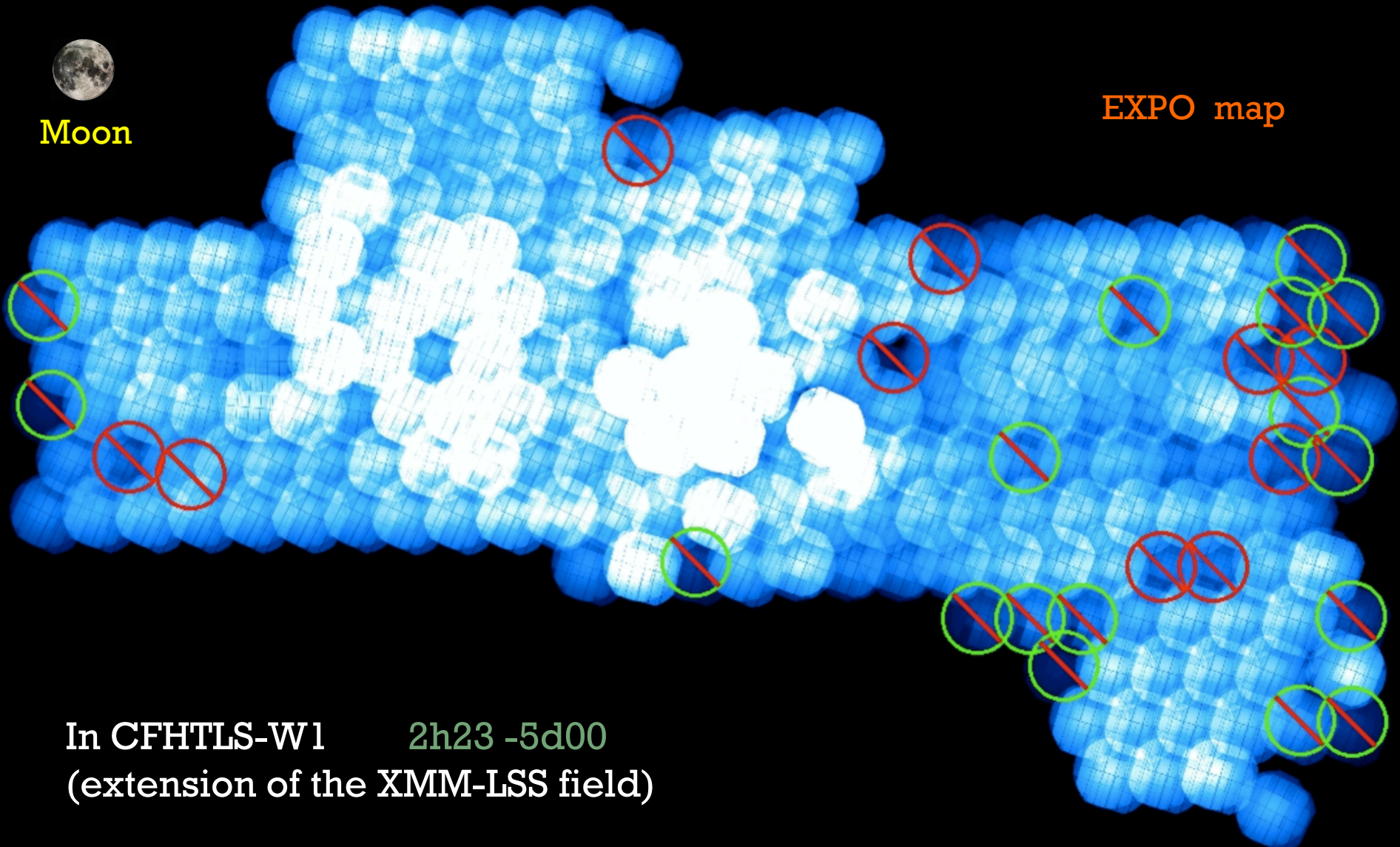
2 The XMM observations

XXL-N 25 deg²



Moon

EXPO map



In CFHTLS-W1 2h23 -5d100
(extension of the XMM-LSS field)

2000

4000

6000

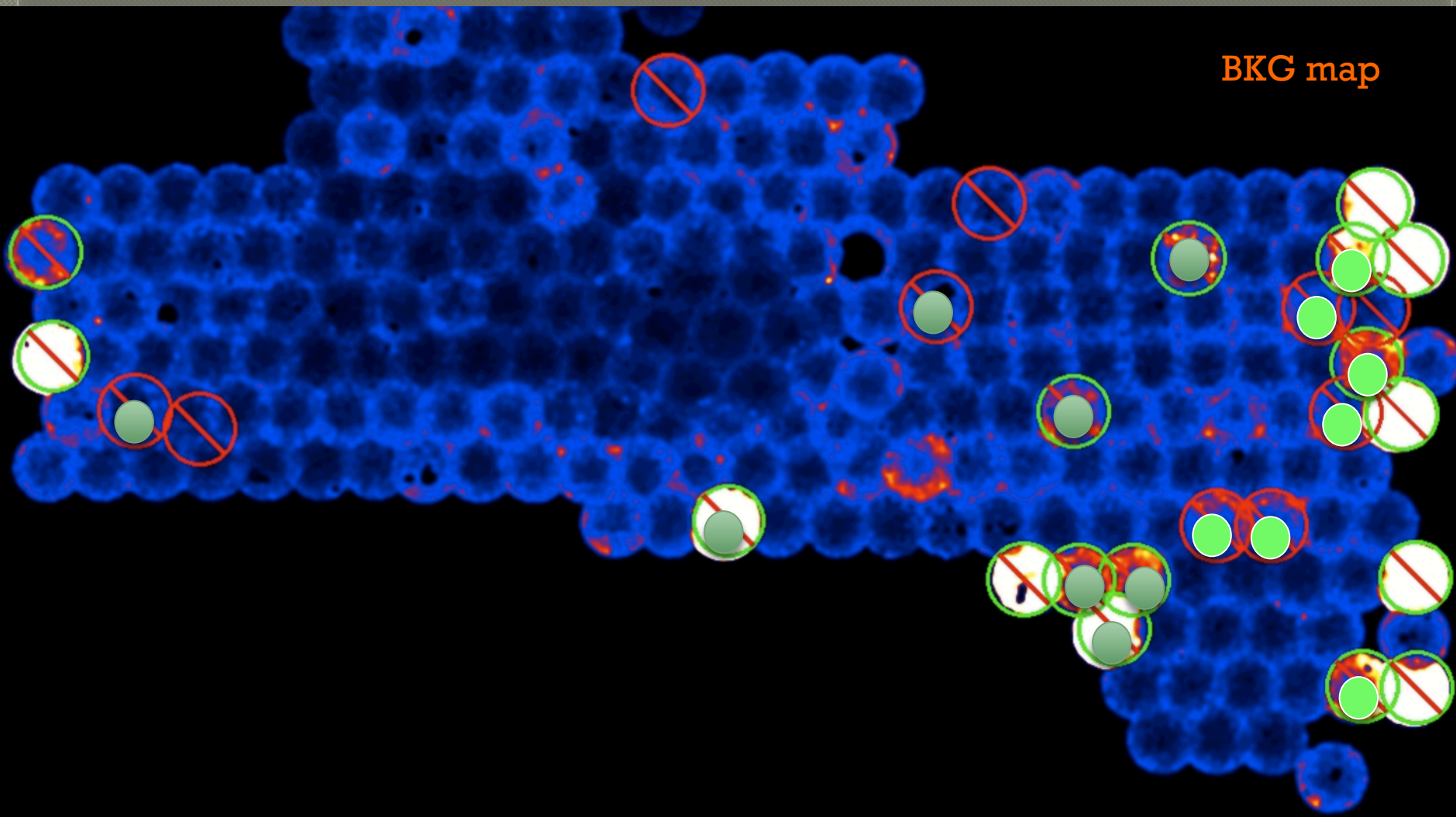
8000

10000

12000

XXL-N

BKG map



XXL-S
25 deg²

23h30 -55d00

within the SPT
100 deg²
Deep Field

EXPO map

2000

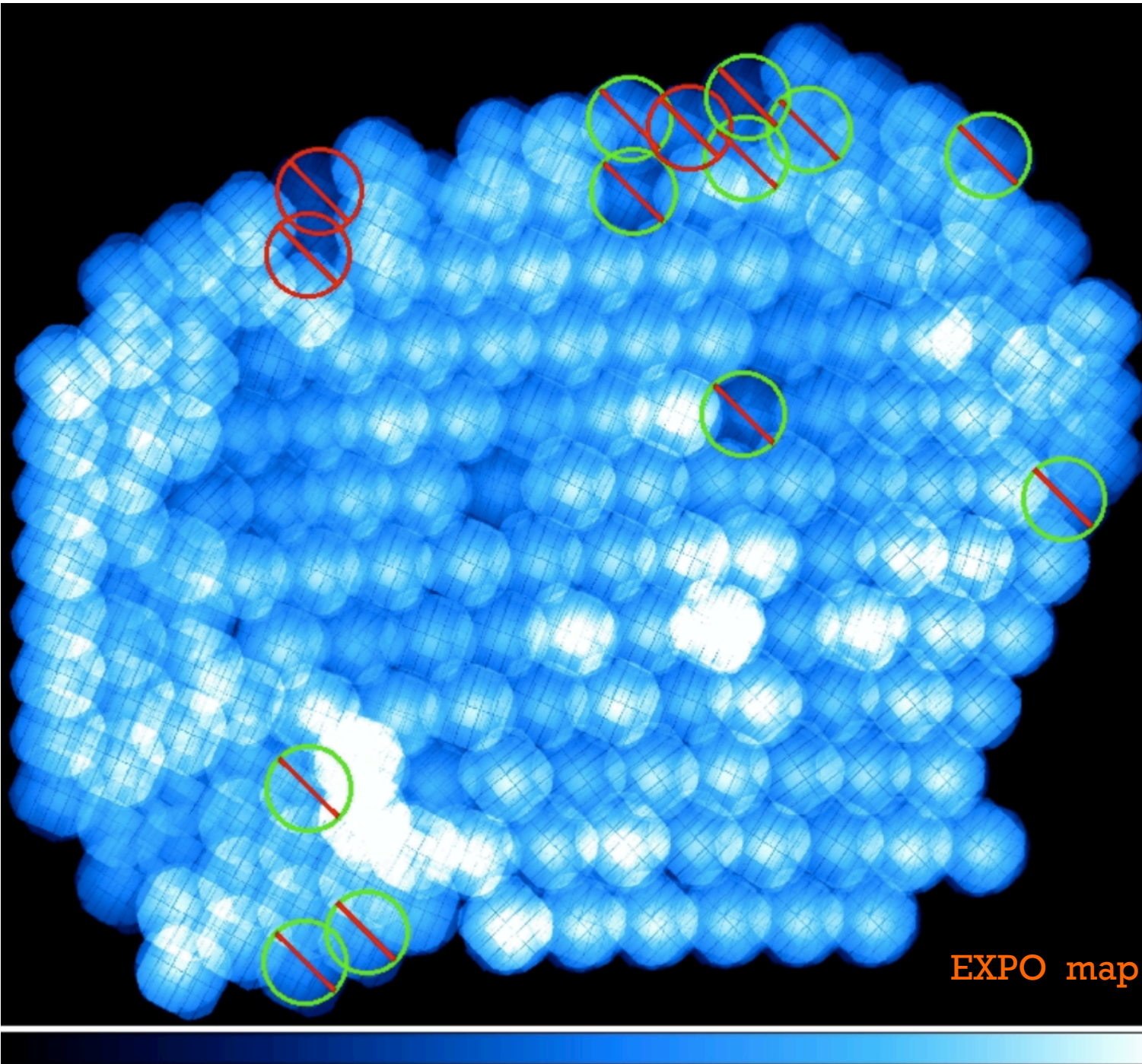
4000

6000

8000

10000

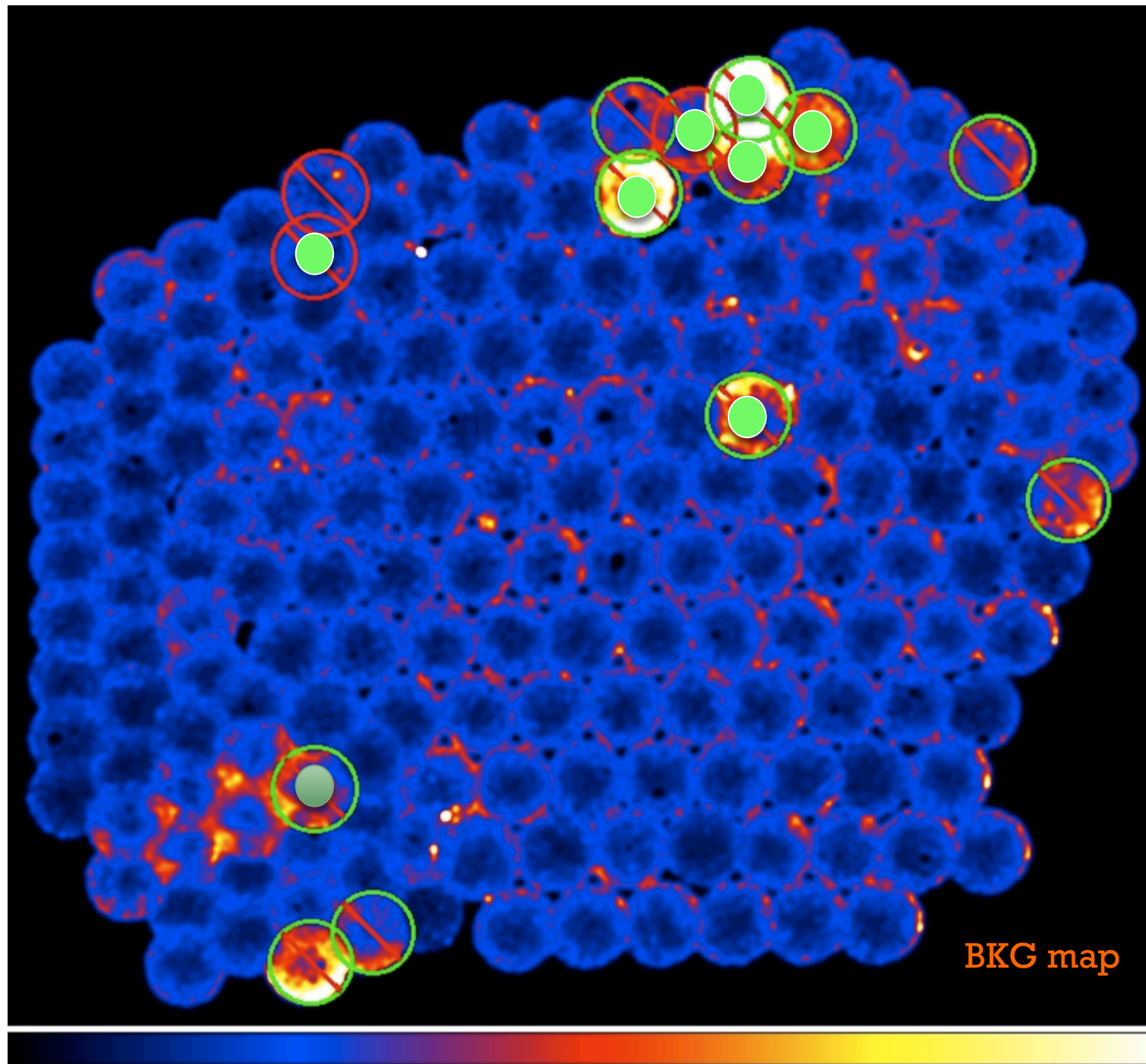
12000



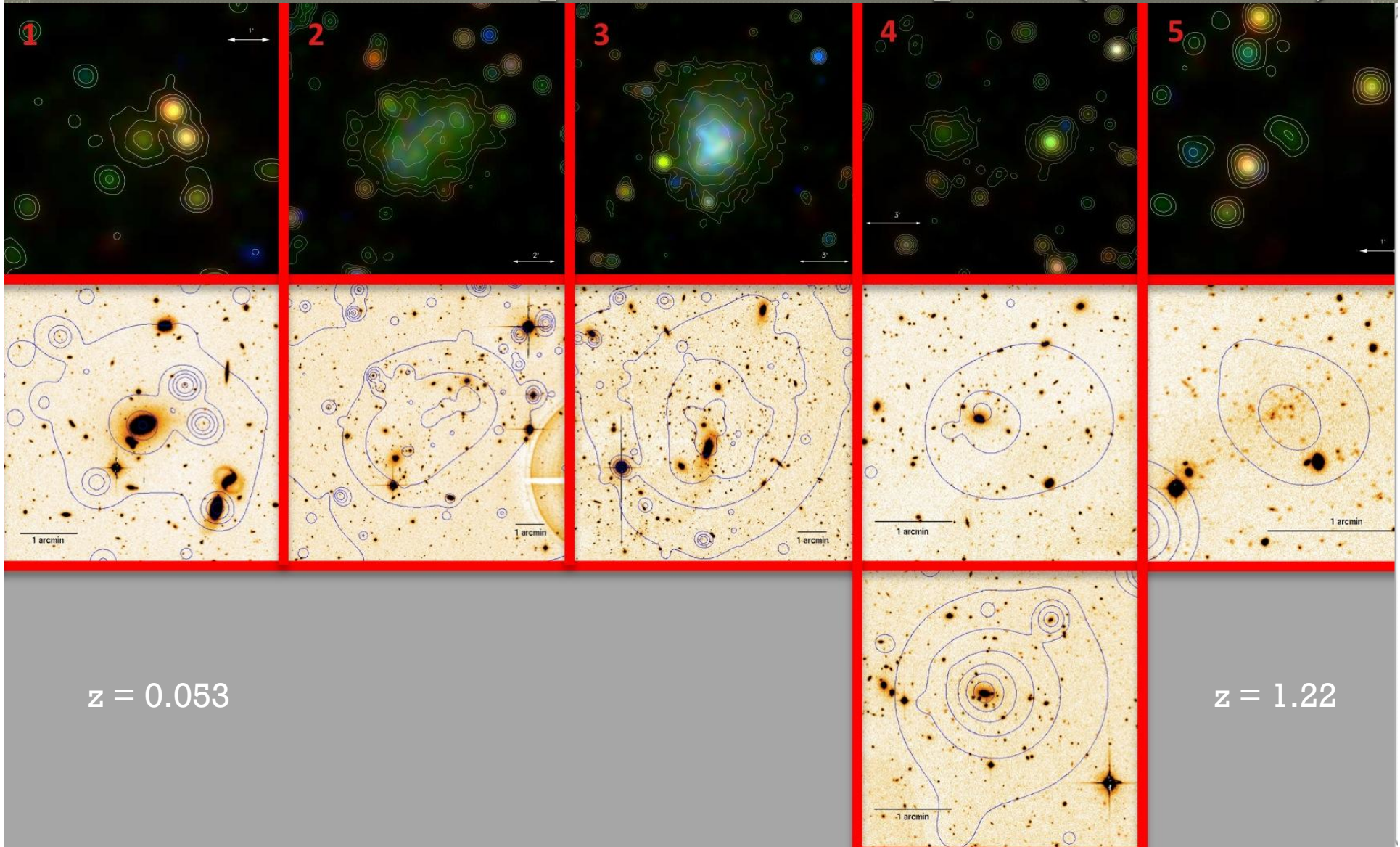
XXL-S

BKG map

0 1E-05 2E-05 3E-05 4E-05 5E-05

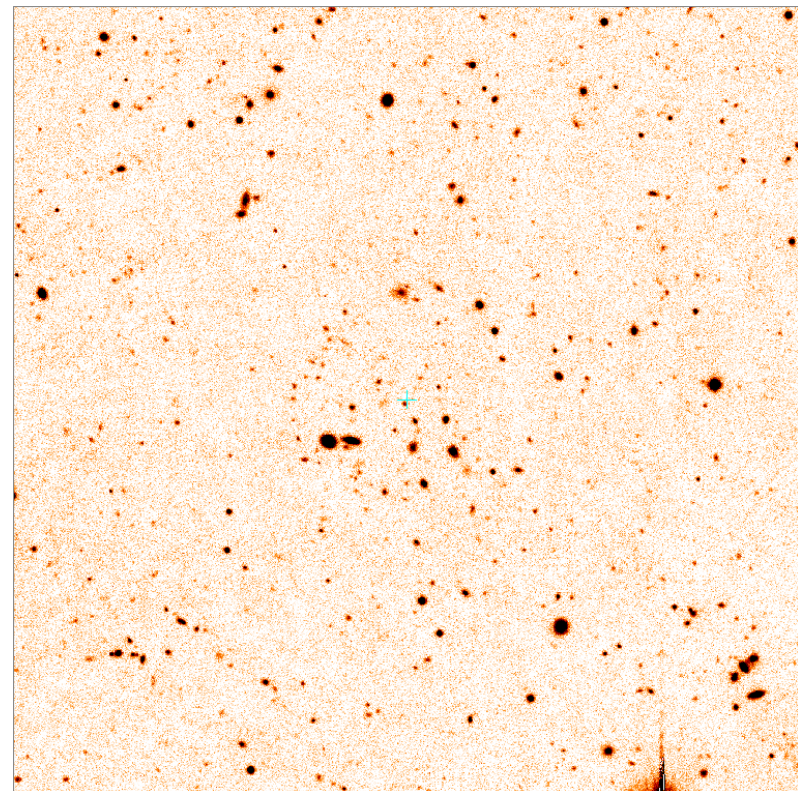
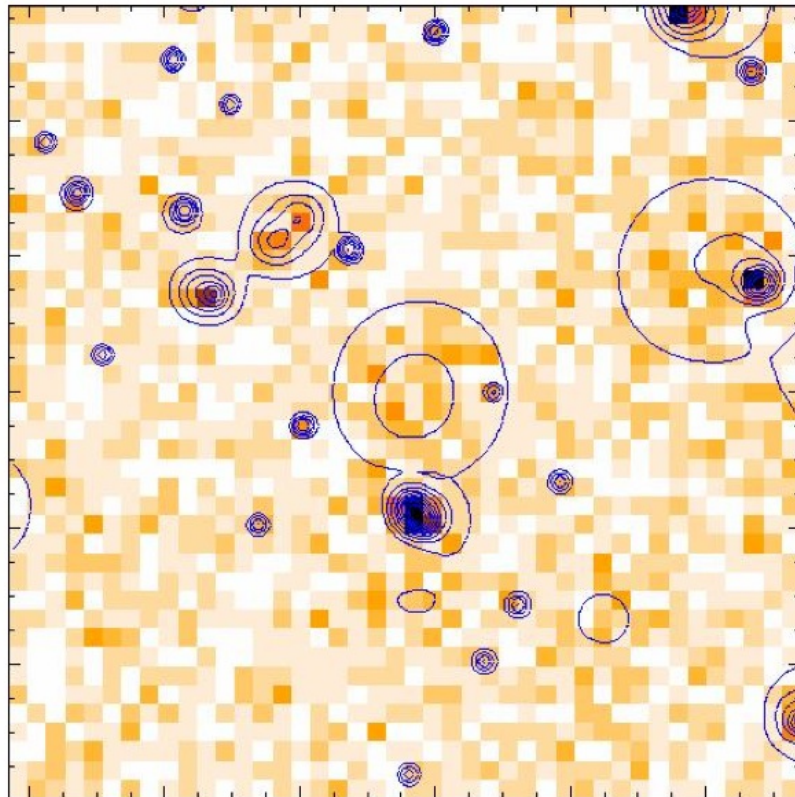


XXL clusters of galaxies and their optical counterpart (CFHTLS)



A distant candidate at $z \sim 1.5$

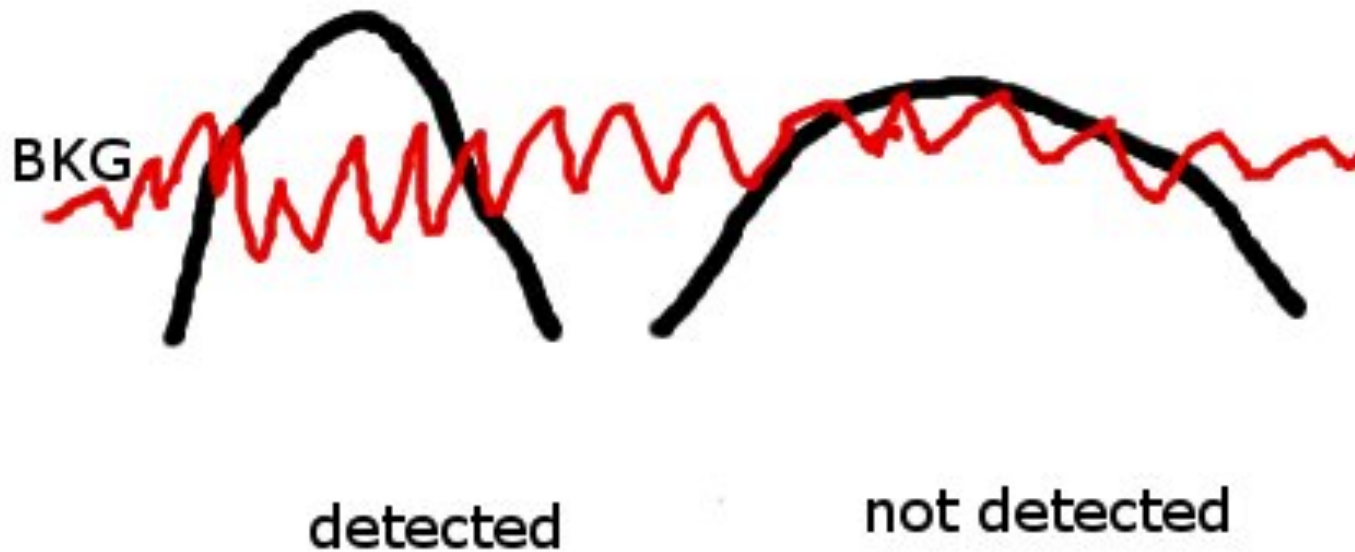
ID_1762



I 3.6 μm 4.5 μm

Not a flux limit !

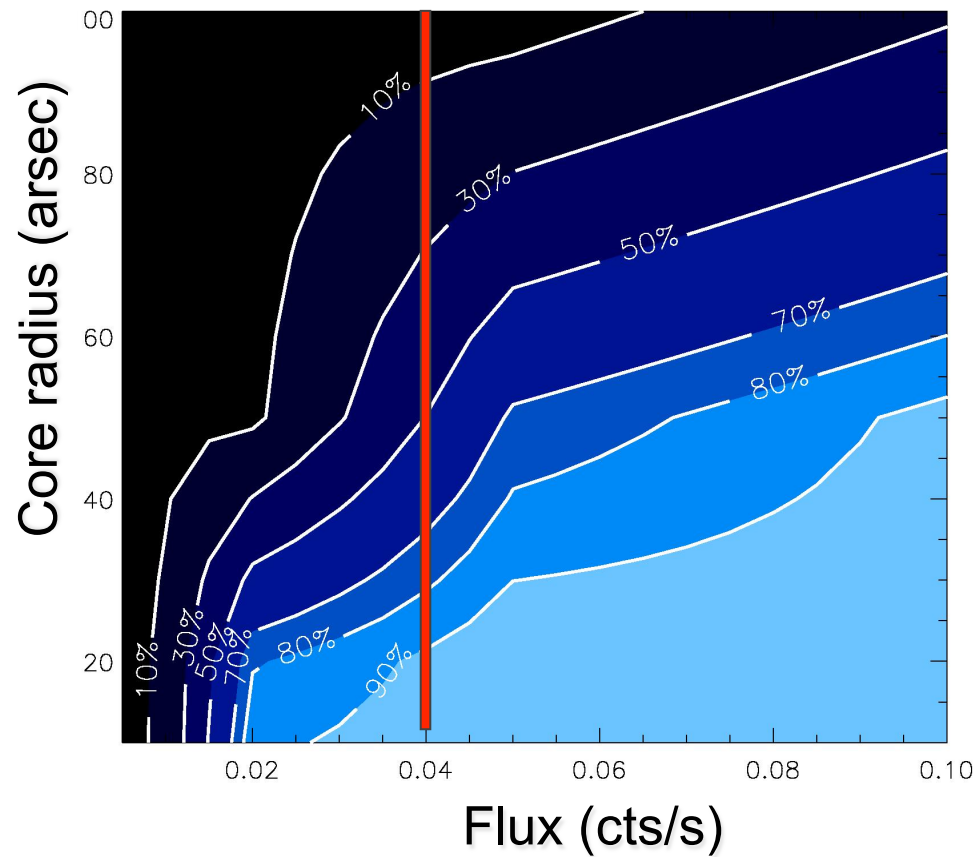
2 clusters with same flux



~ surface brightness limited

Detection rates from analytical simulations

Class 1 sample



Not a flux
limit !

3 Associated follow-up programmes

A comprehensive multi- λ data set

1

- ◉ Deep multi-band imaging
 - CFHTLS
 - DECam (Lidman et al)
 - HSC
- ◉ Extensive spectroscopic follow-up
 - ESO LP – NTT & VLT (Adami et al)
 - WHT (Poggianti et al)
 - AAOmega (Lidman et al)
 - Associated with GAMA and VIPERS

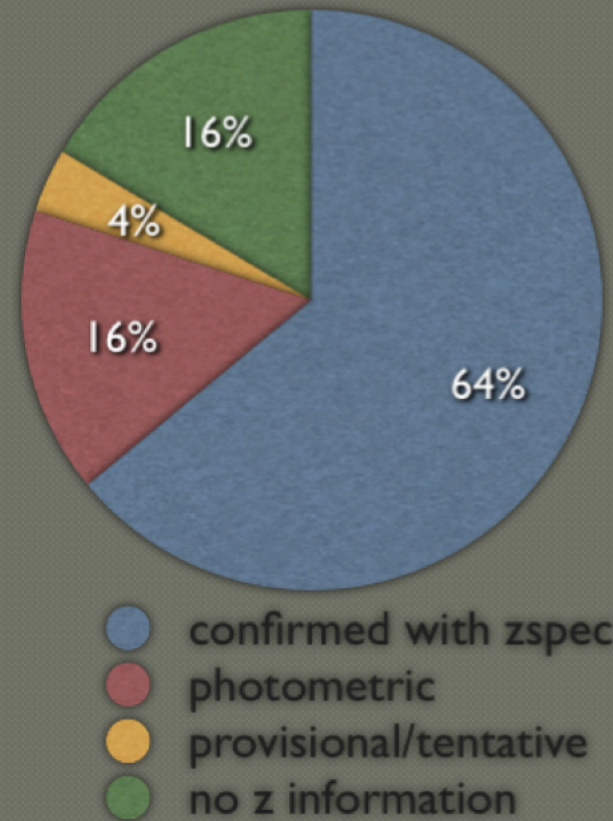
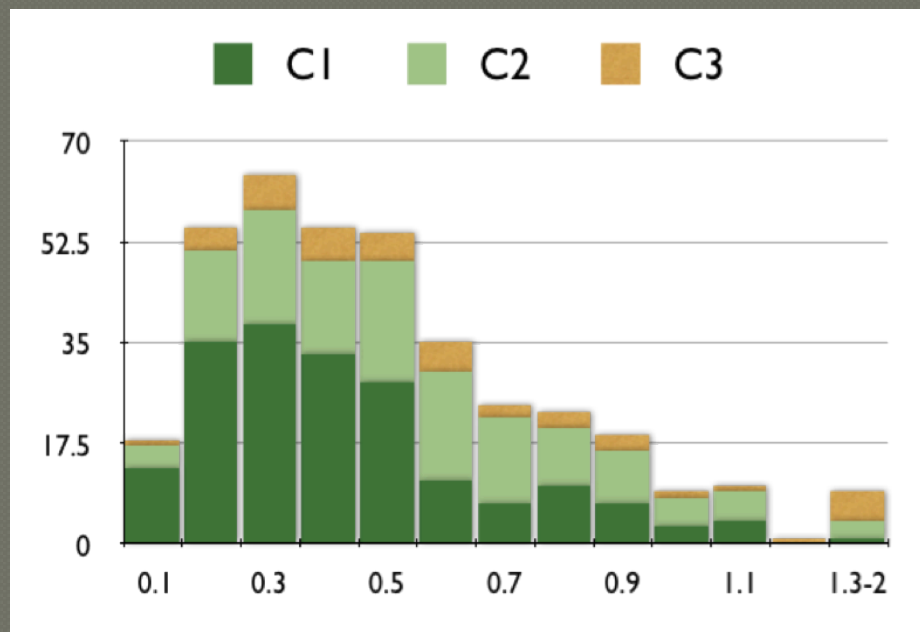
A comprehensive multi- λ data set

2

- Full IR coverage
 - Spitzer
 - WIRCAM @ CFHT
 - VISTA
- On-going radio surveys
 - GMRT (Raychaudury et al)
 - VLA, ATCA (Smolcic et al)
 - SPT, ACT
- Existing public surveys
 - SDSS, Galax, . . .

4 The XXL cluster catalogue

The current sample ~ 450 objects

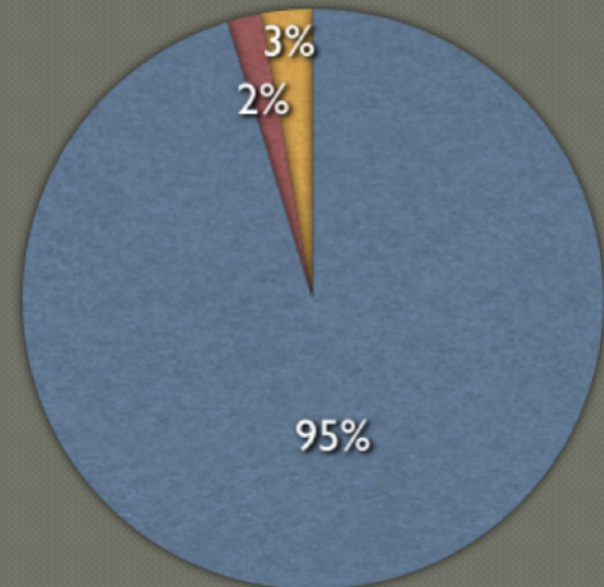
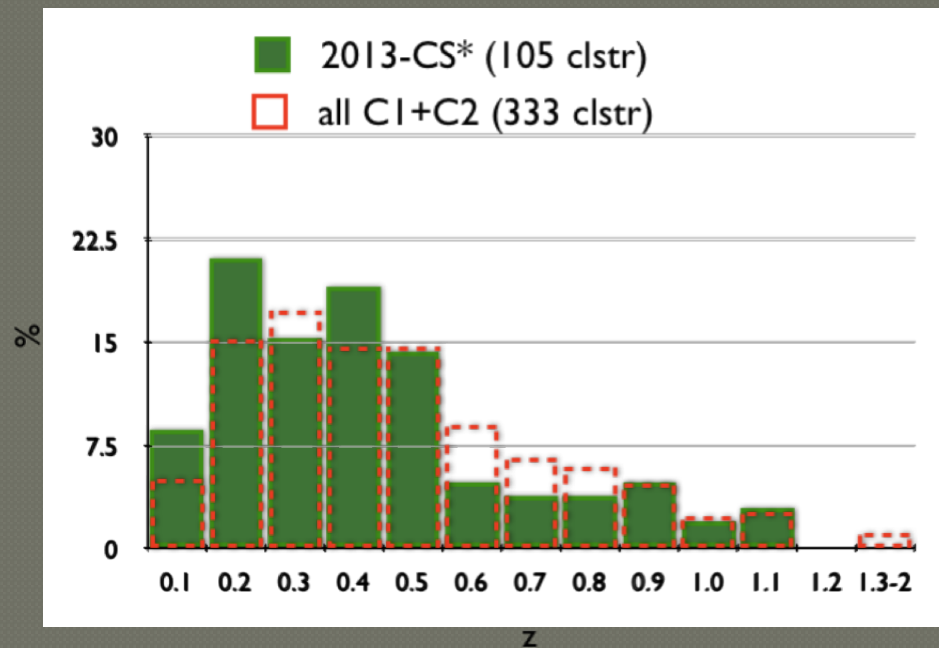


The brightest 100-cluster sample

XXL paper II Pacaud, Clerc et al, submitted

Selection: C1+C2

flux in $r=1'$ ($>3 \cdot 10^{-14}$)



- confirmed
- photometric
- provisional/tentative

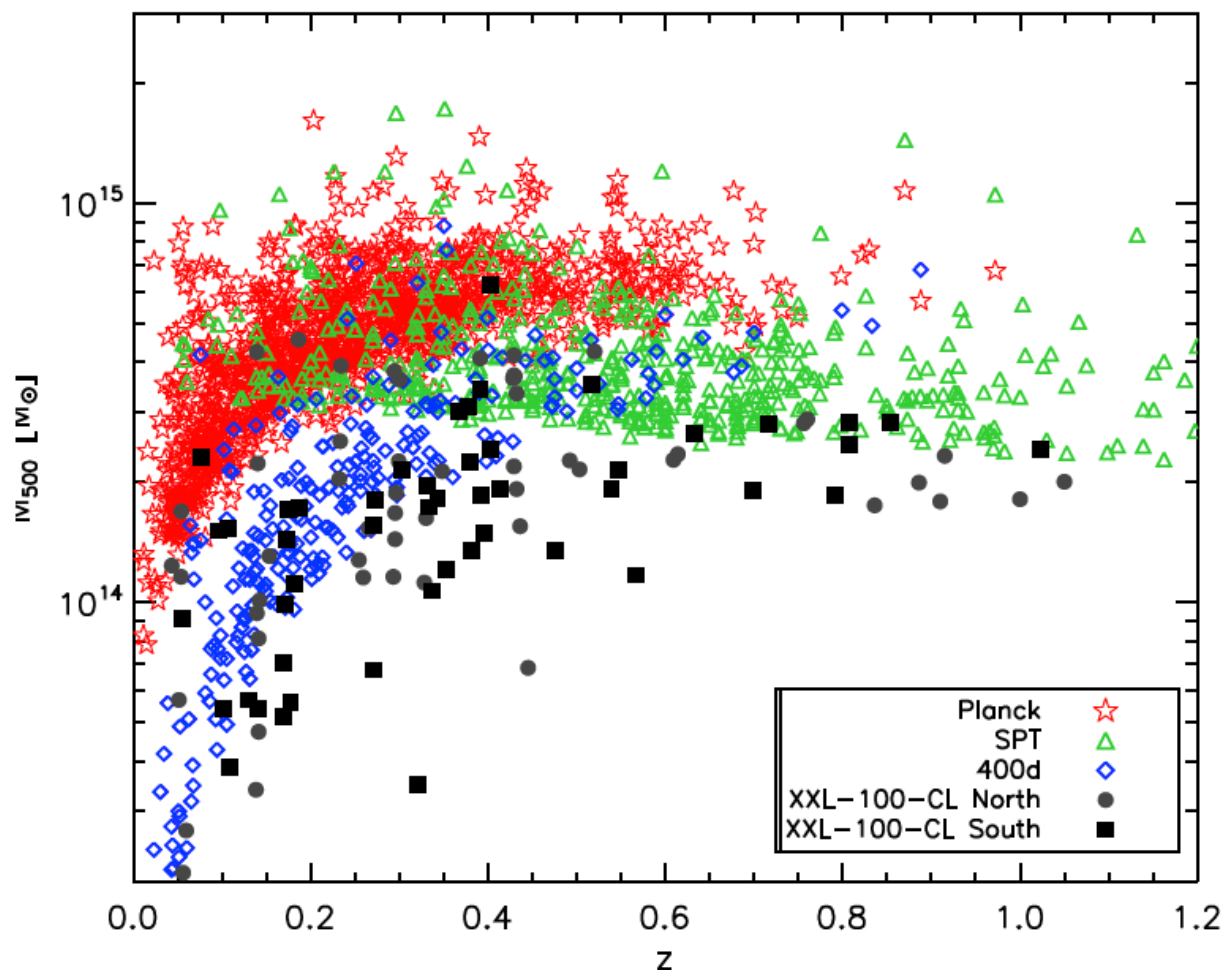
5 First results – an overview

Brightest 100 cluster sample

Self-consistent analyses
WMAP9 cosmology assumed

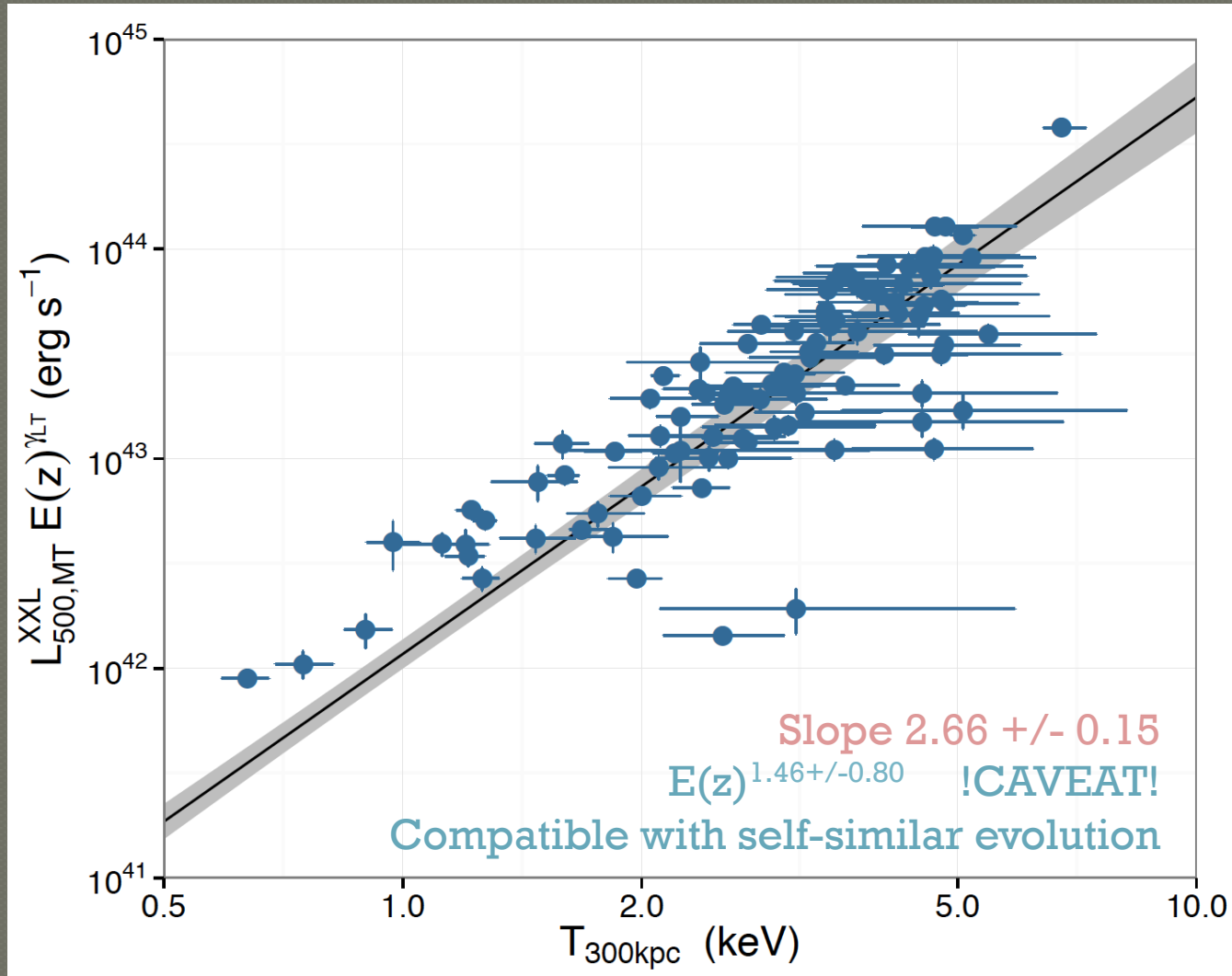
Cluster mass range

XXL paper II Pacaud, Clerc et al, submitted



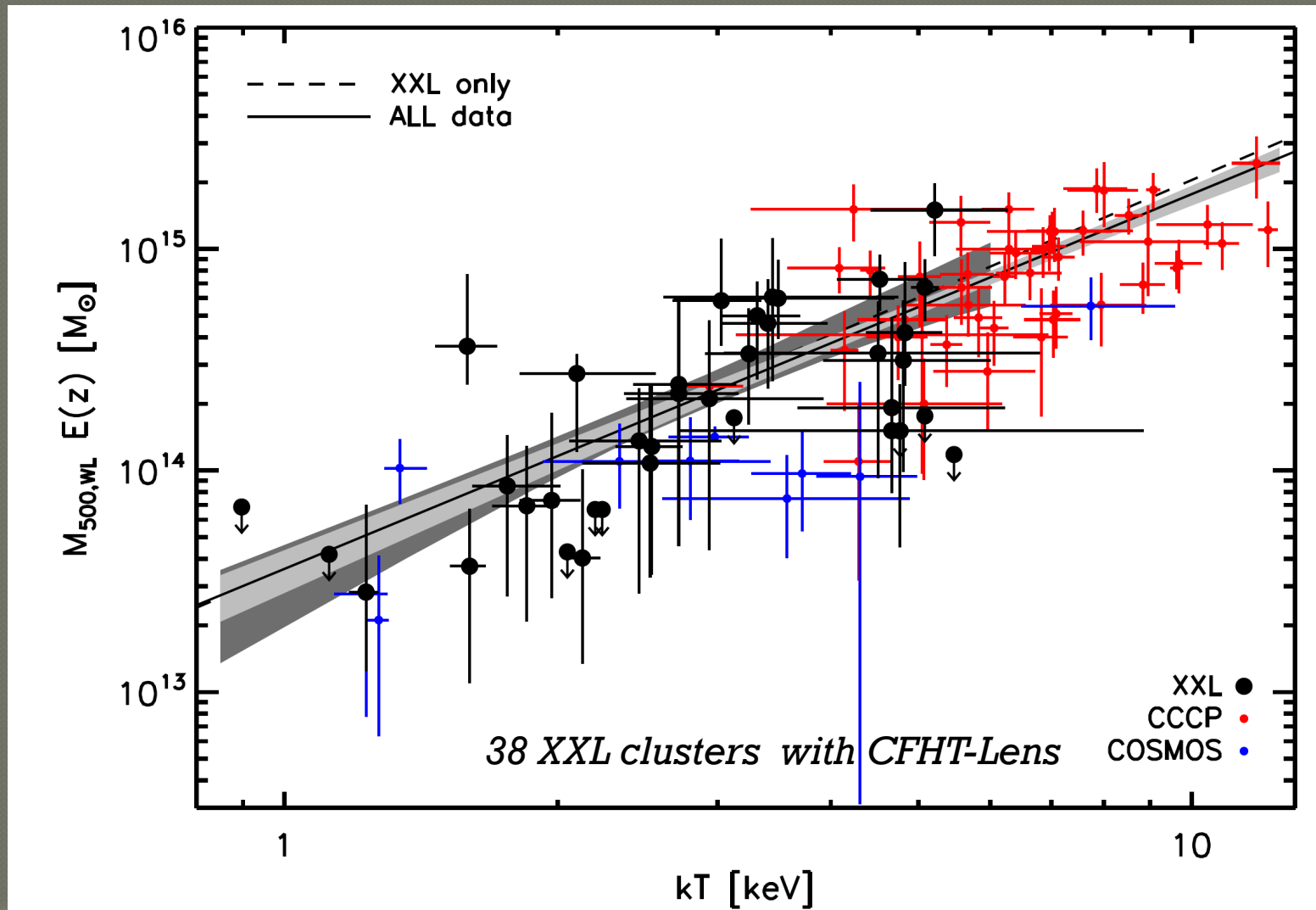
Cluster L-T relation

XXL paper III Giles, Maughan et al, submitted



Cluster M-T relation

XXL paper IV Lieu, Smith et al, submitted



Cluster M-T relation

XXL paper IV Lieu, Smith et al, submitted

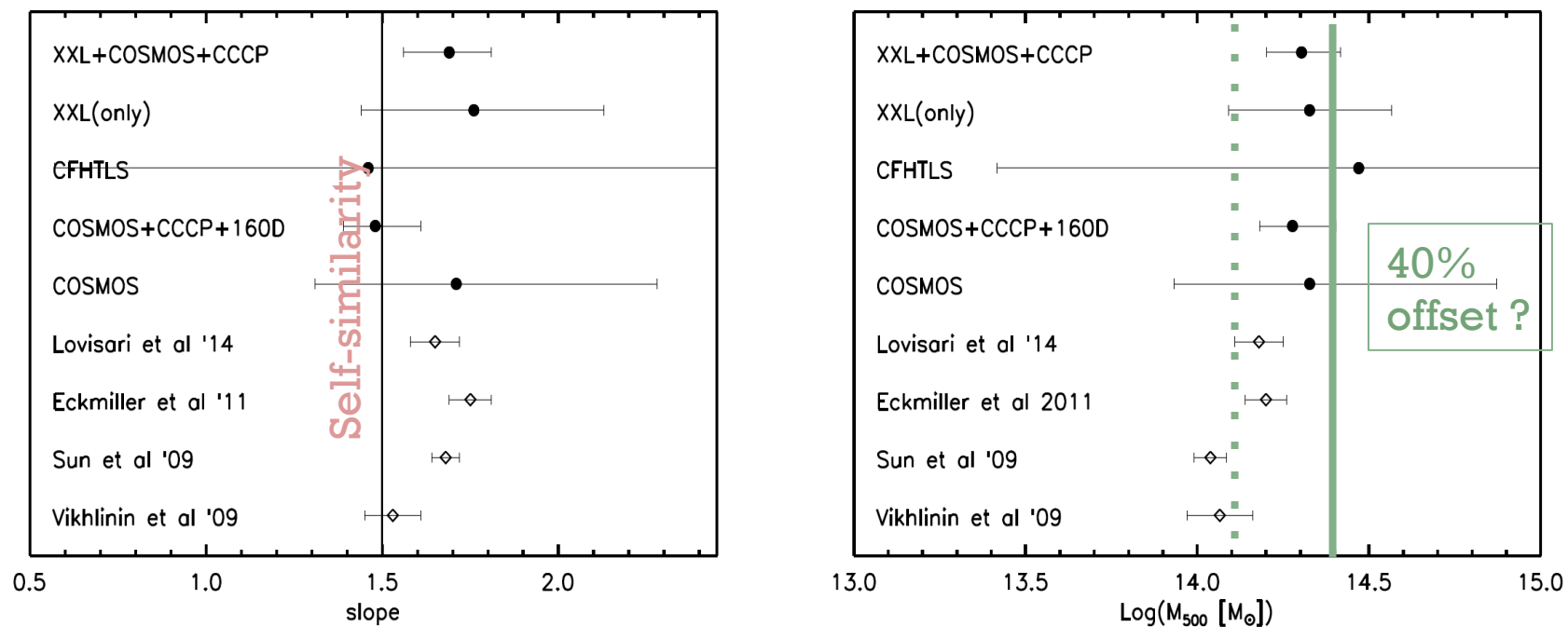
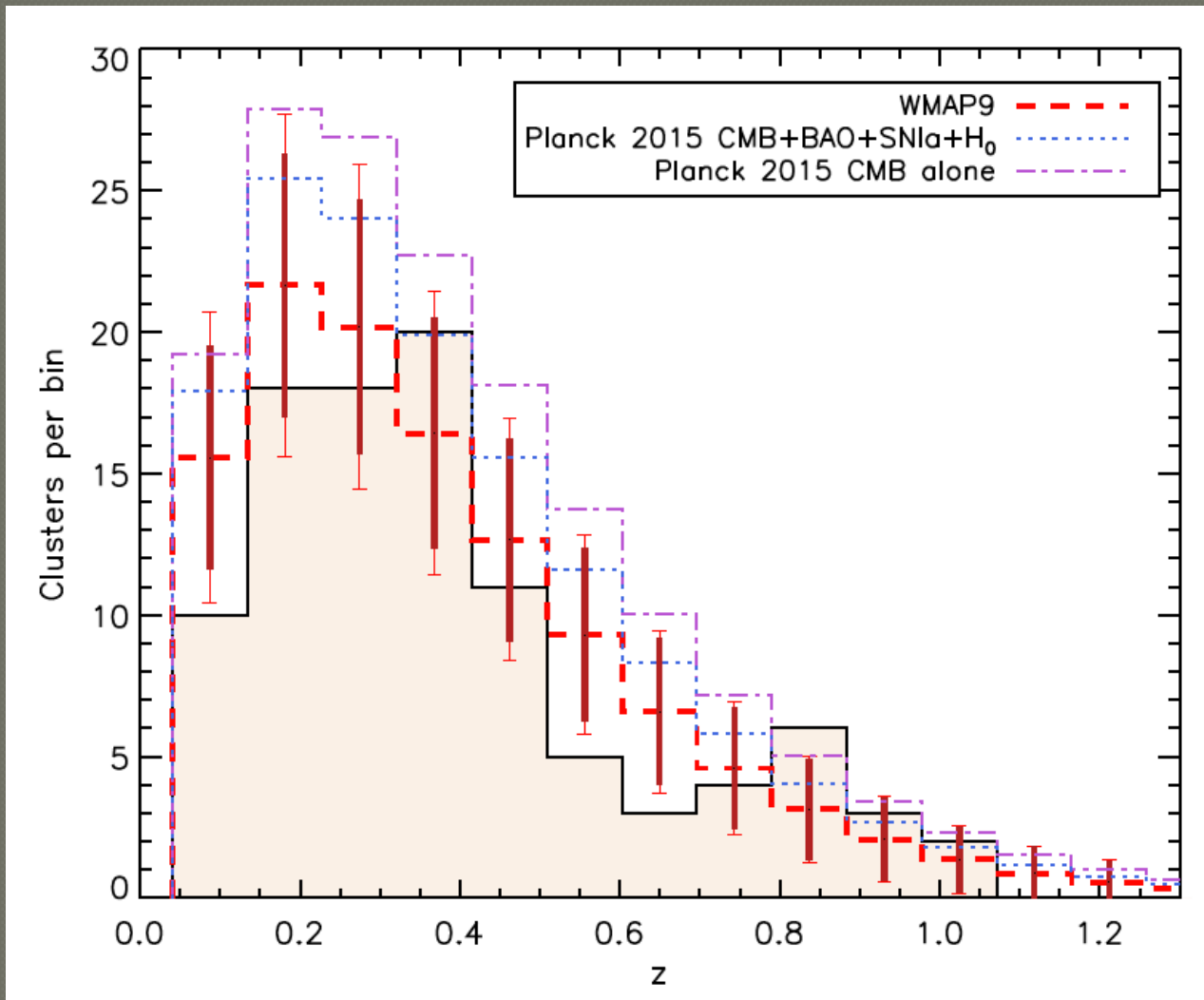


Fig. 8. LEFT: Comparison of our results on the slope of the mass-temperature relation with those in the literature. RIGHT: Comparison of the mass of a cluster of temperature $T = 3$ keV at $z = 0.3$ based on mass-temperature relations and those in the literature. In both panels, filled circles are samples that use weak lensing masses, open diamonds are samples that use hydrostatic masses. The COSMOS+CCCP+160D and COSMOS -only relations are from [Kettula et al. \(2013\)](#) and the CFHTLS relation from [Kettula et al. \(2014\)](#).

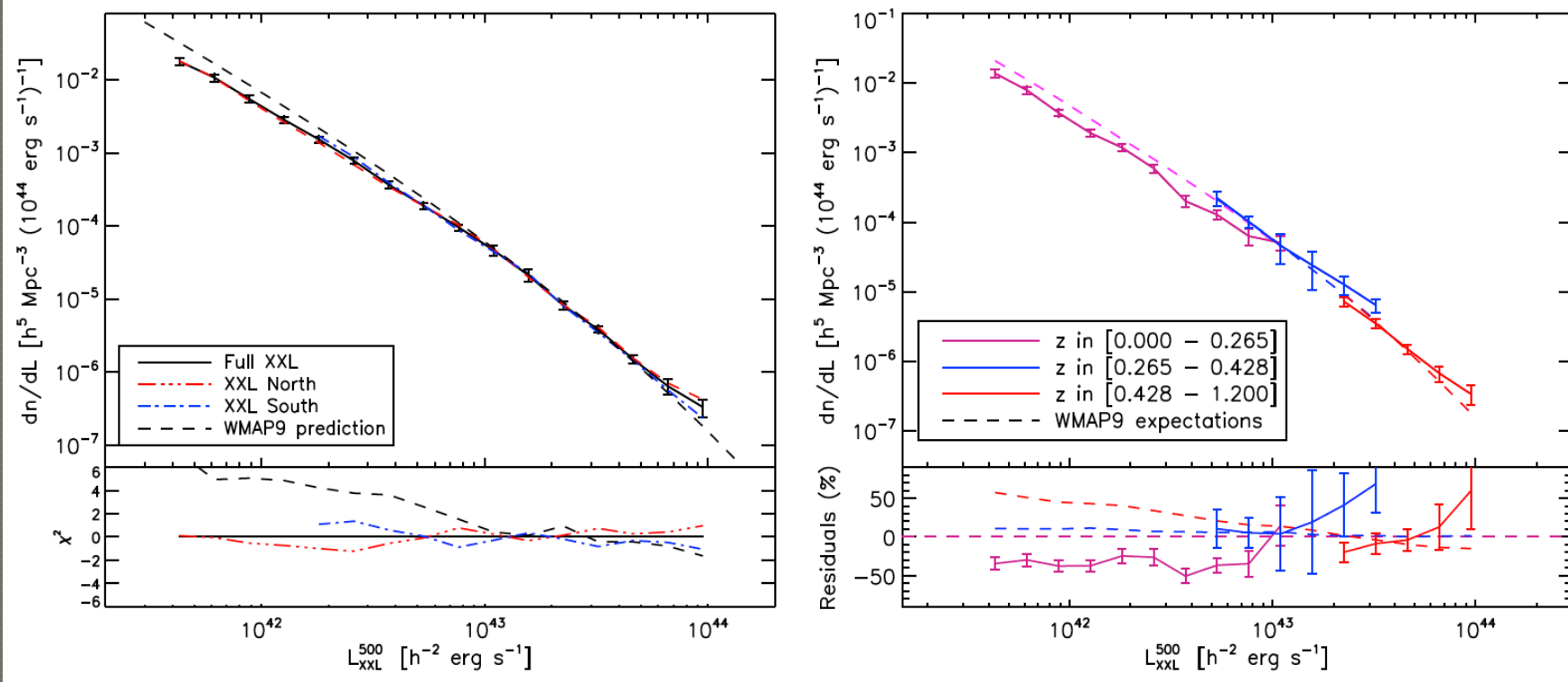
Cluster redshift distribution

XXL paper II Pacaud Clerc et al, submitted



Cluster luminosity function

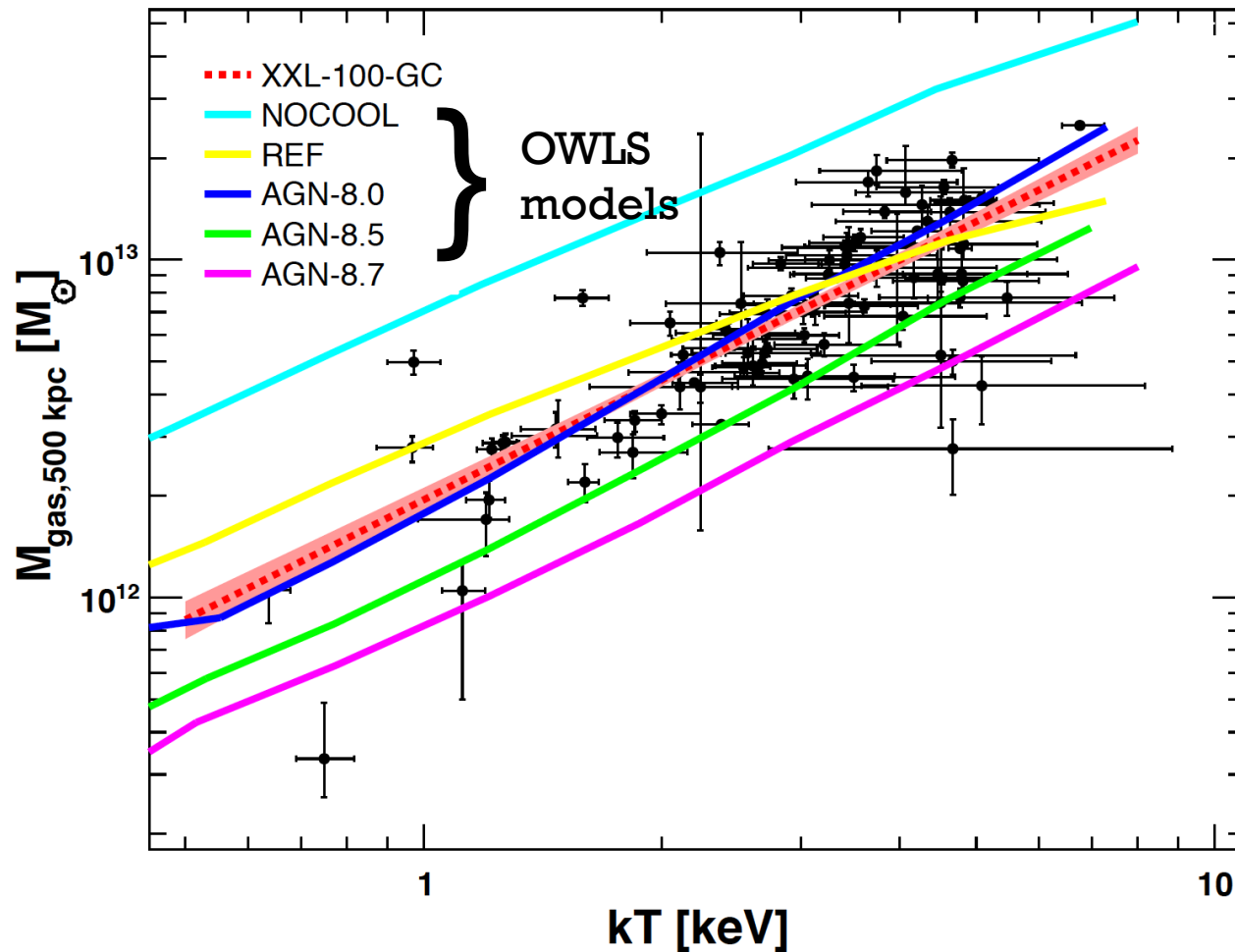
XXL paper II Pacaud, Clerc et al, submitted



No evolution for $F(L_x)$!

Gas mass and temperature

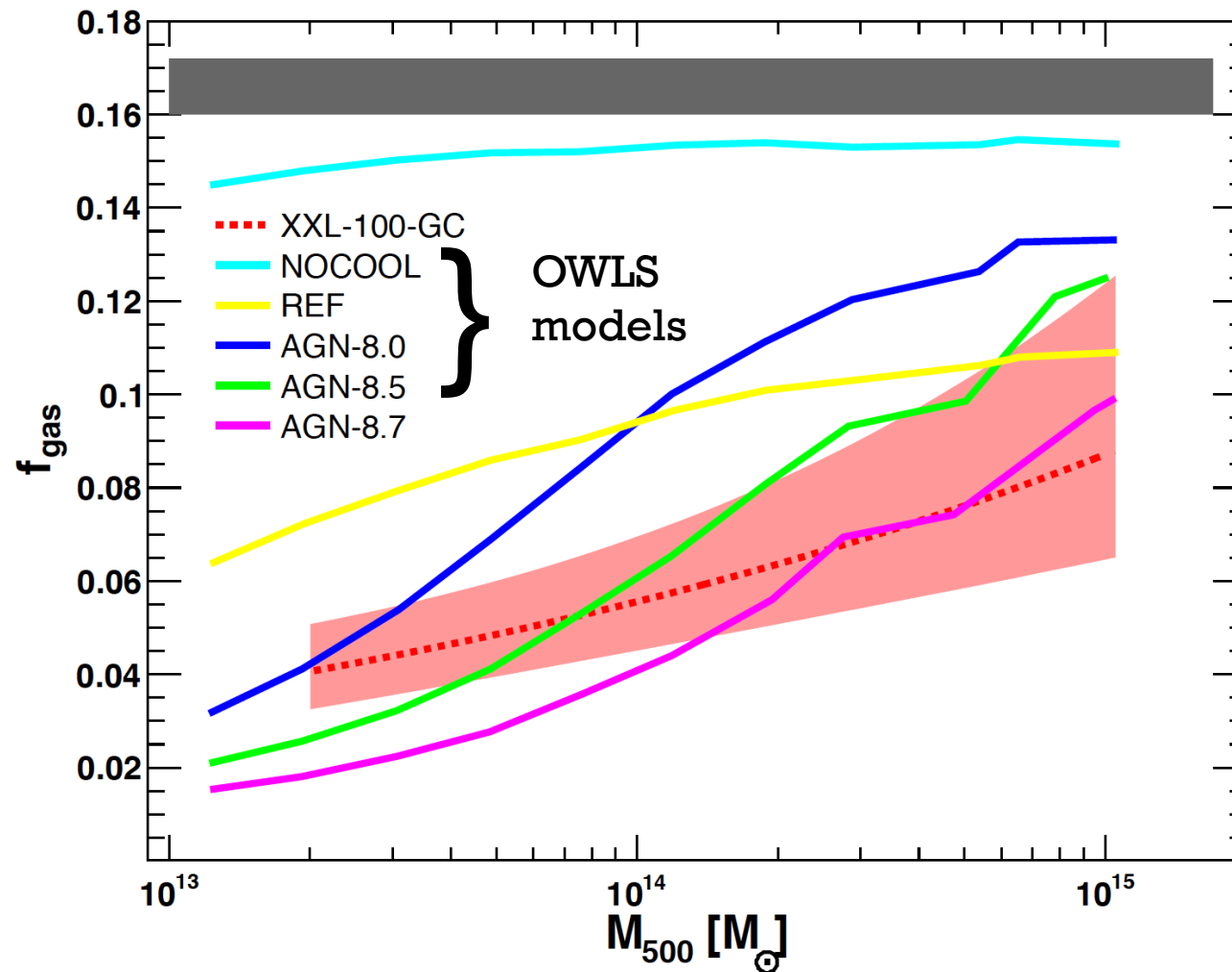
XXL paper XIII Eckert, Ettori et al, in prep



Gas fraction in the XXL clusters

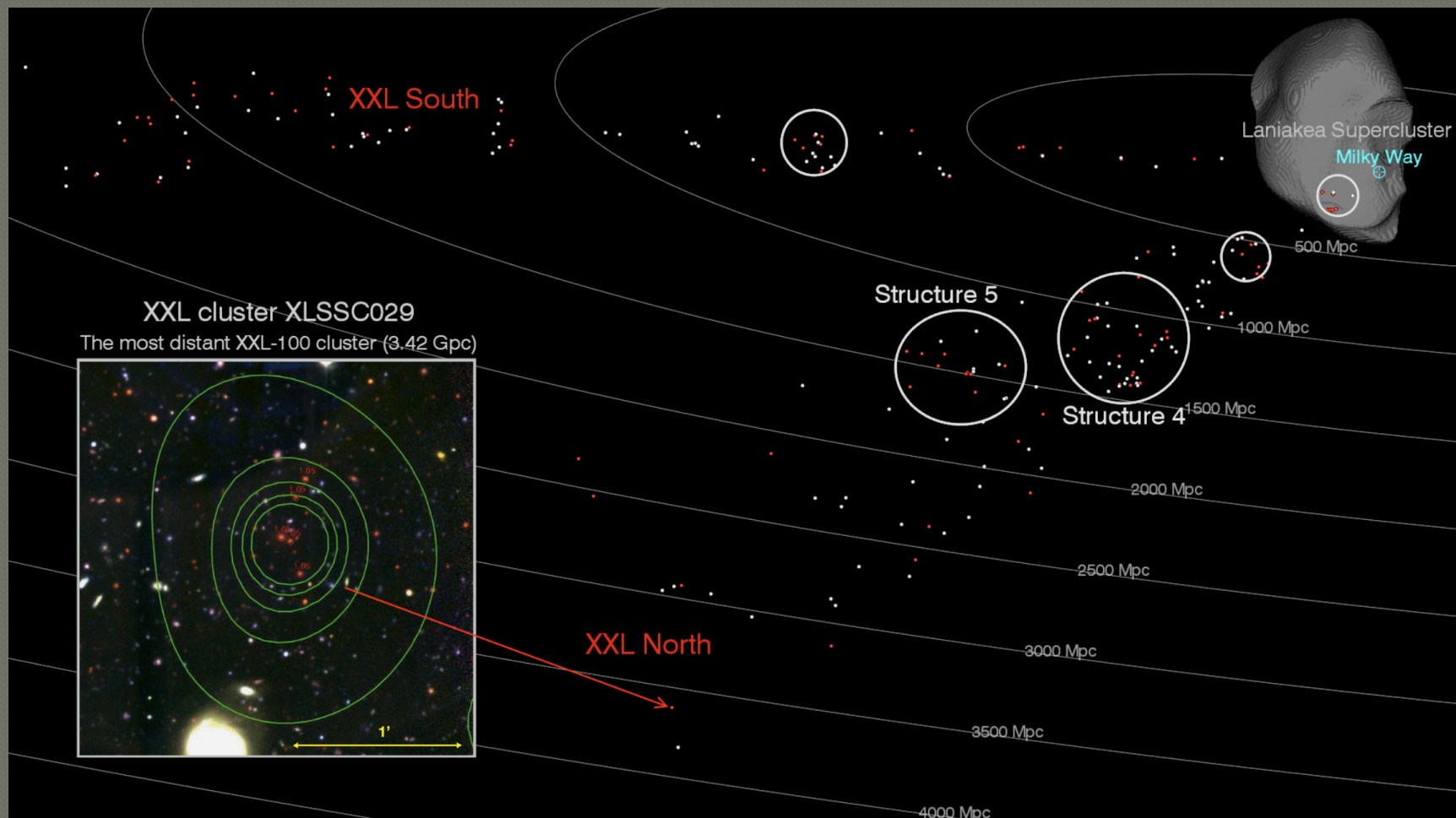
XXL paper XIII

Eckert, Ettori et al, in prep



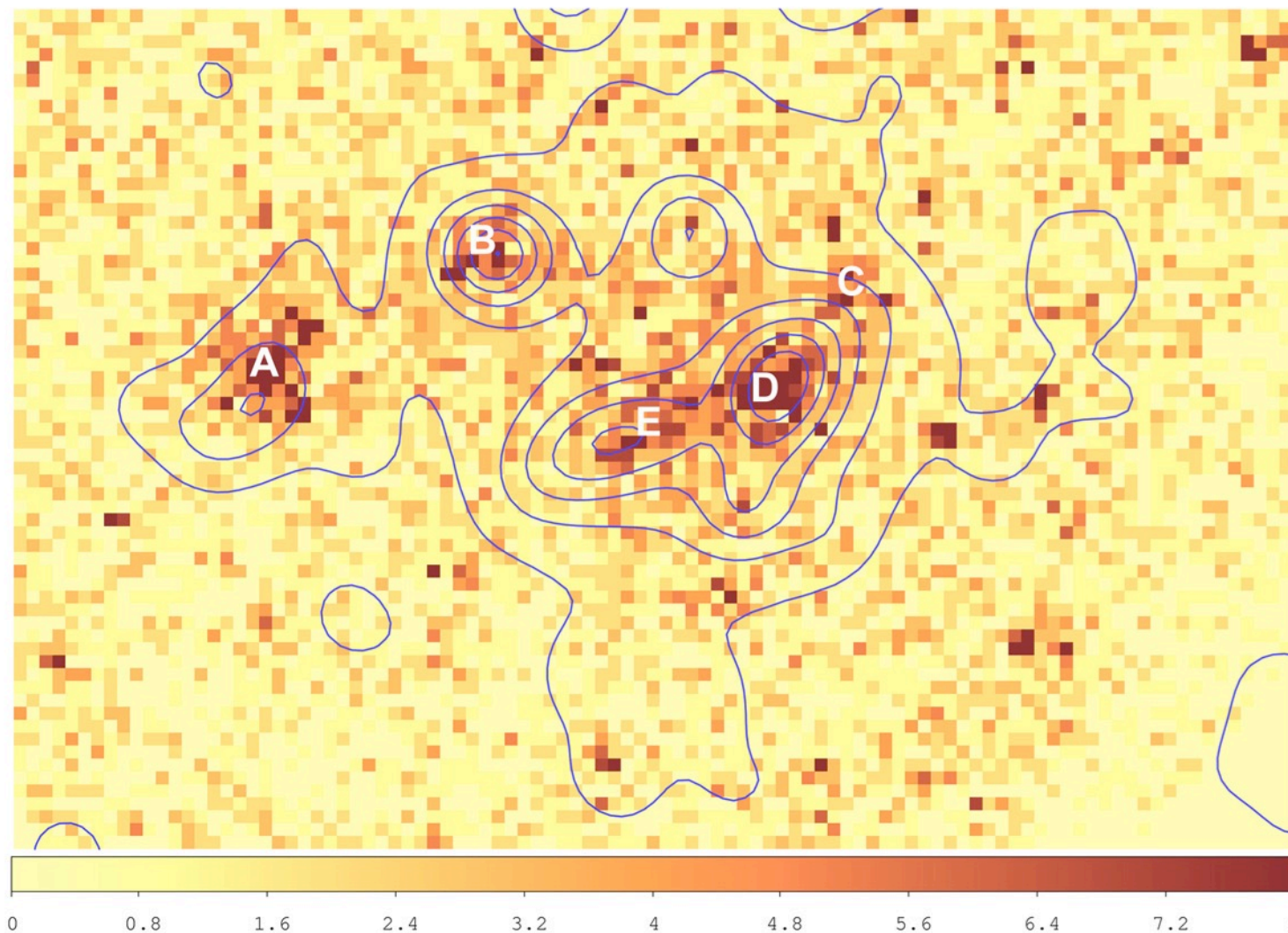
Using
lensing
masses

Five new superclusters



. XXL 100 sample

A supercluster at $z \sim 0.45$

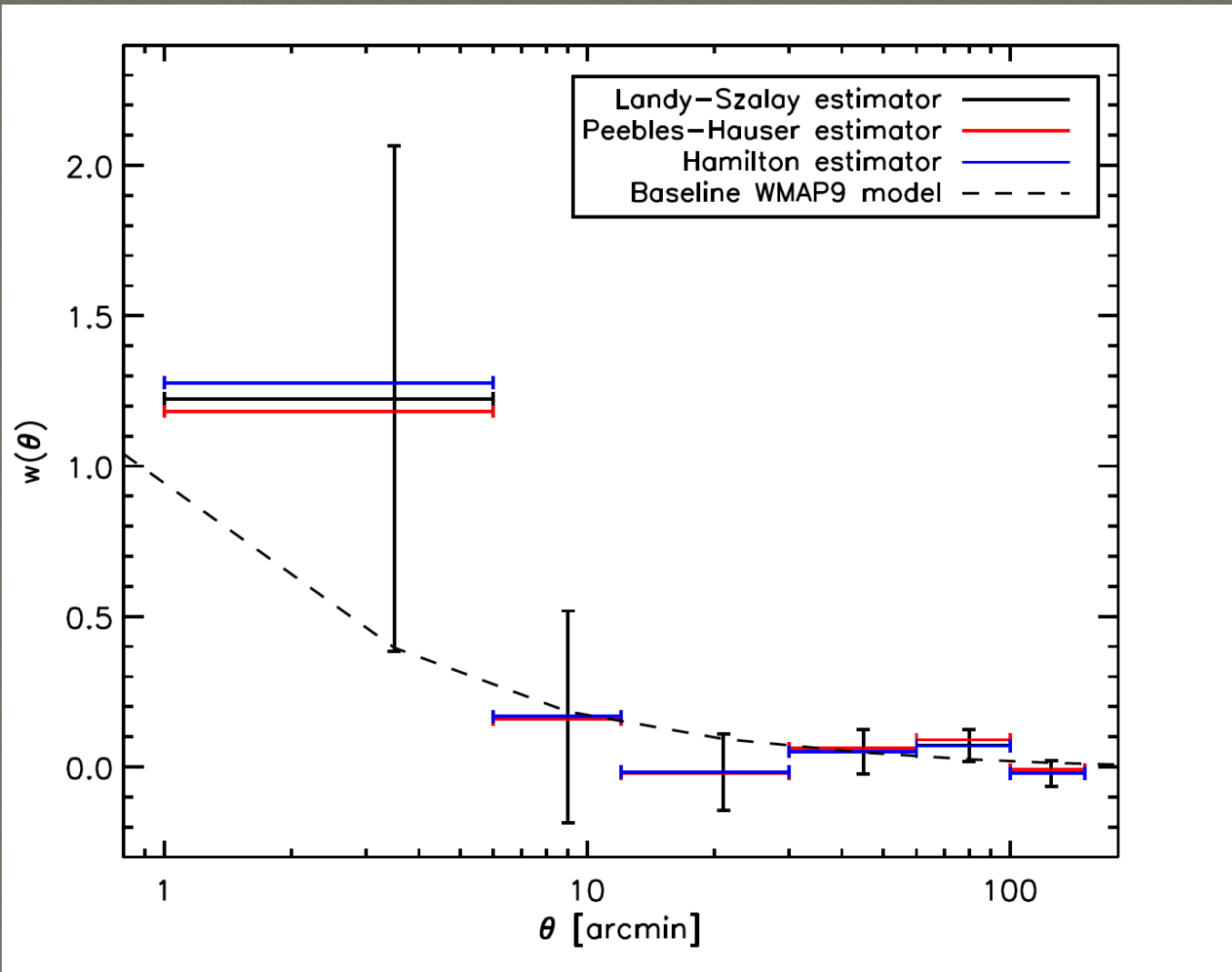


XMM
photon map

Optical
galaxy
density
contours

Image size
20'x13'

The cluster-cluster ξ



6 FUTURE

~ 500 clusters

~ 10 000 AGNs ($5 \cdot 10^{-15}$ erg/s/cm², completeness limit)
> 25 000 AGNs in total

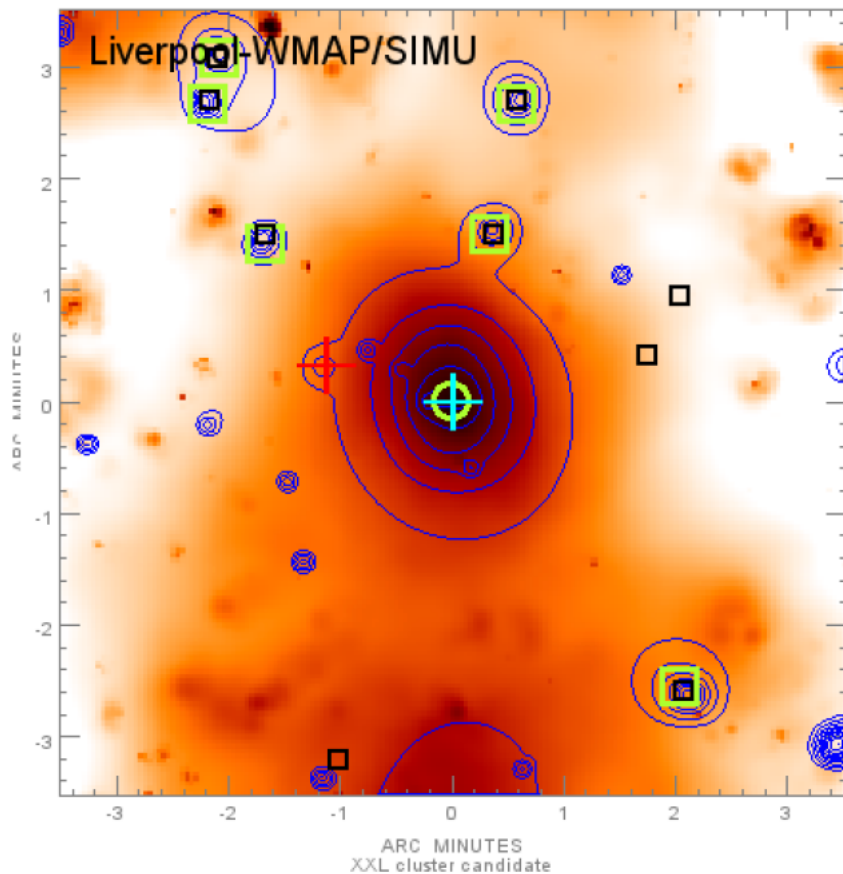
Next steps

- Cosmology with the full cluster sample (2016)
Simultaneous fit of:
 - Cosmology
 - Selection effects
 - Cluster physics evolution (scaling relations – baryon fraction)
- Use numerical simulations to refine the selection function:
 - OWLS (McCarthy et al)
 - Aardvark (Evrard et al)
 - Horizon (Devriendt et al)
 - DEUS (Alimi et al)
- And, of course, AGN LSS and AGN science

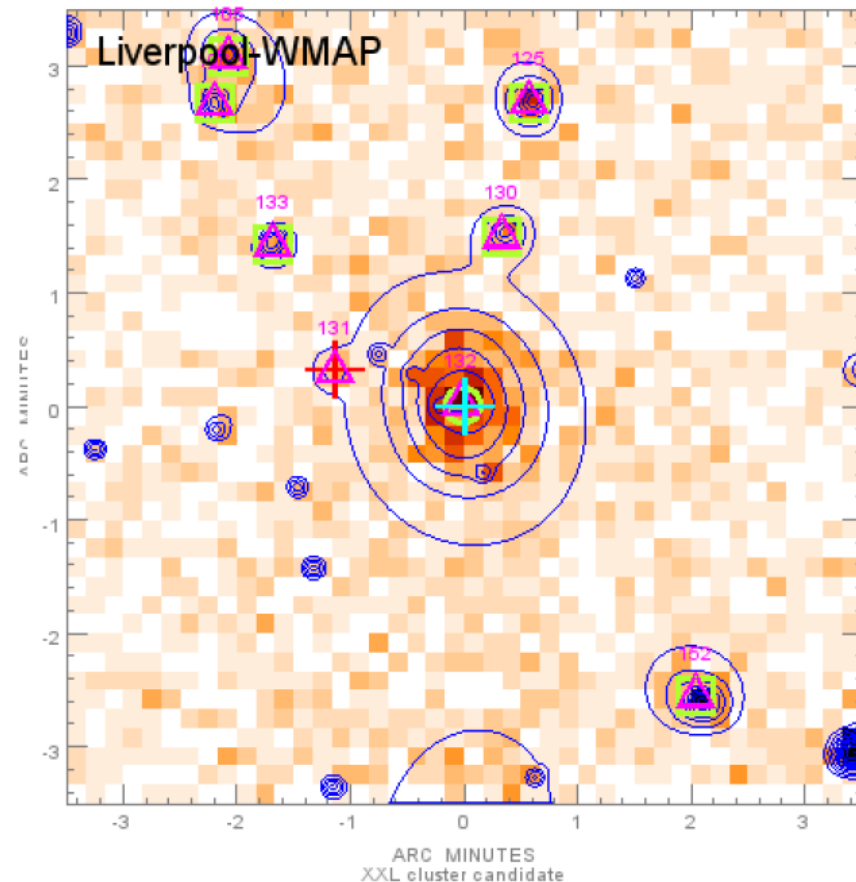
An outlook onto simulated XXL

OWLS simulations (X-ray flux)
McCarthy, Le Brun, 2014

10ks XMM photon image



Photon band image + X-ray Wavelet Contours.
 $\log_{10}(\text{photons/cm}^2/\text{sec}): -9.500, -6.500$



Raw X-ray photon image + X-ray Wavelet Contours.

FIN

First 10 XXL papers
to appear on arXiv
early September

Stay tuned!