XXL

The ultimate XMM extragalactic survey

die Kunst über in der Wissenschaft

X-ray AGN in galaxy clusters

The role of cluster mass in AGN activity

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DE LA RECHERCHE À L'INDUSTRIE
cea
SACLAY

cnes
CENTRE NATIONAL D'ÉTUDES SPATIALES

cnrs
dépasser les frontières

Perseus in Sicily, Noto, May 2018

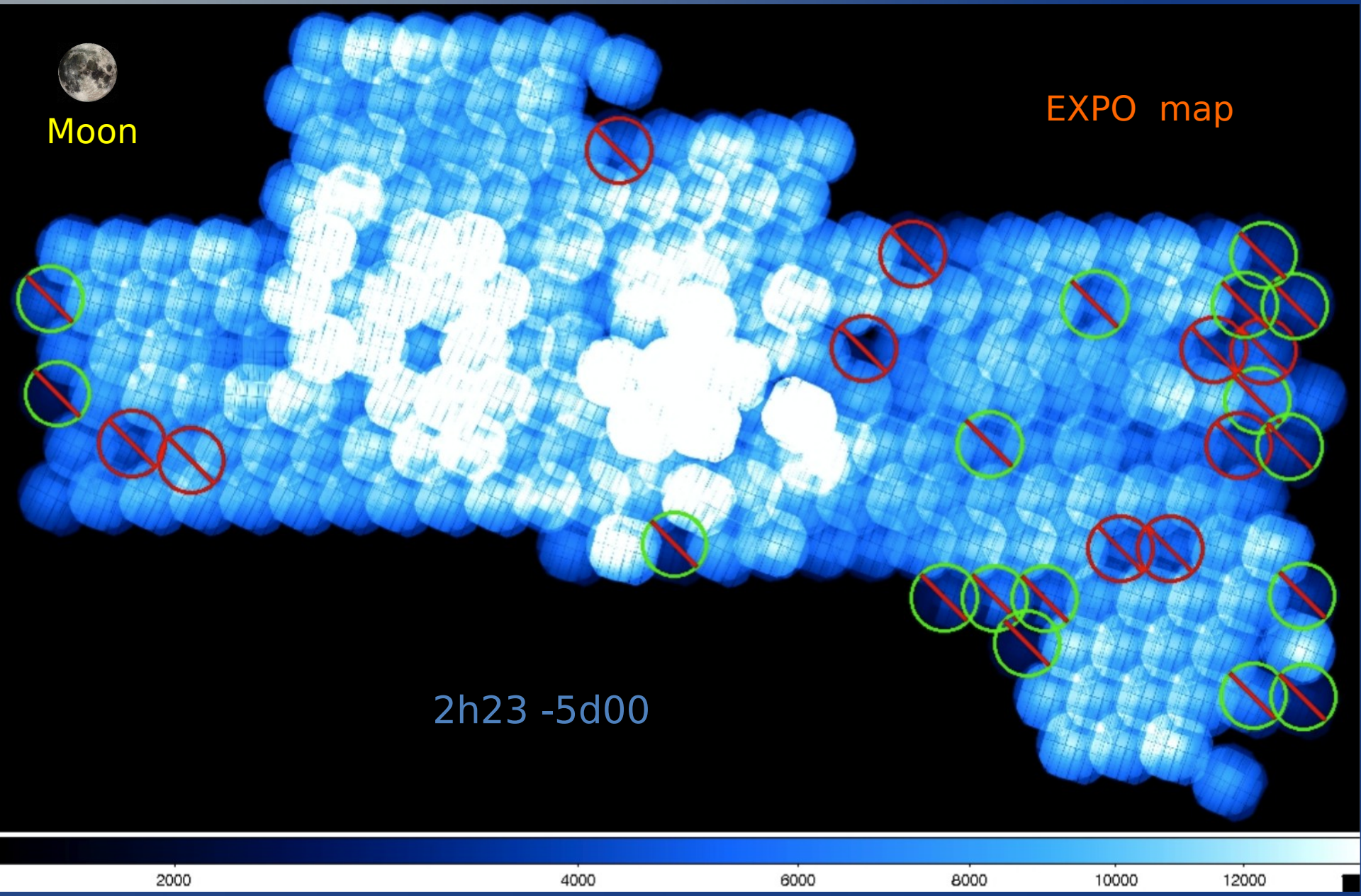
The XXL survey
XMM VLP (AO-10, PI: M.Pierre)

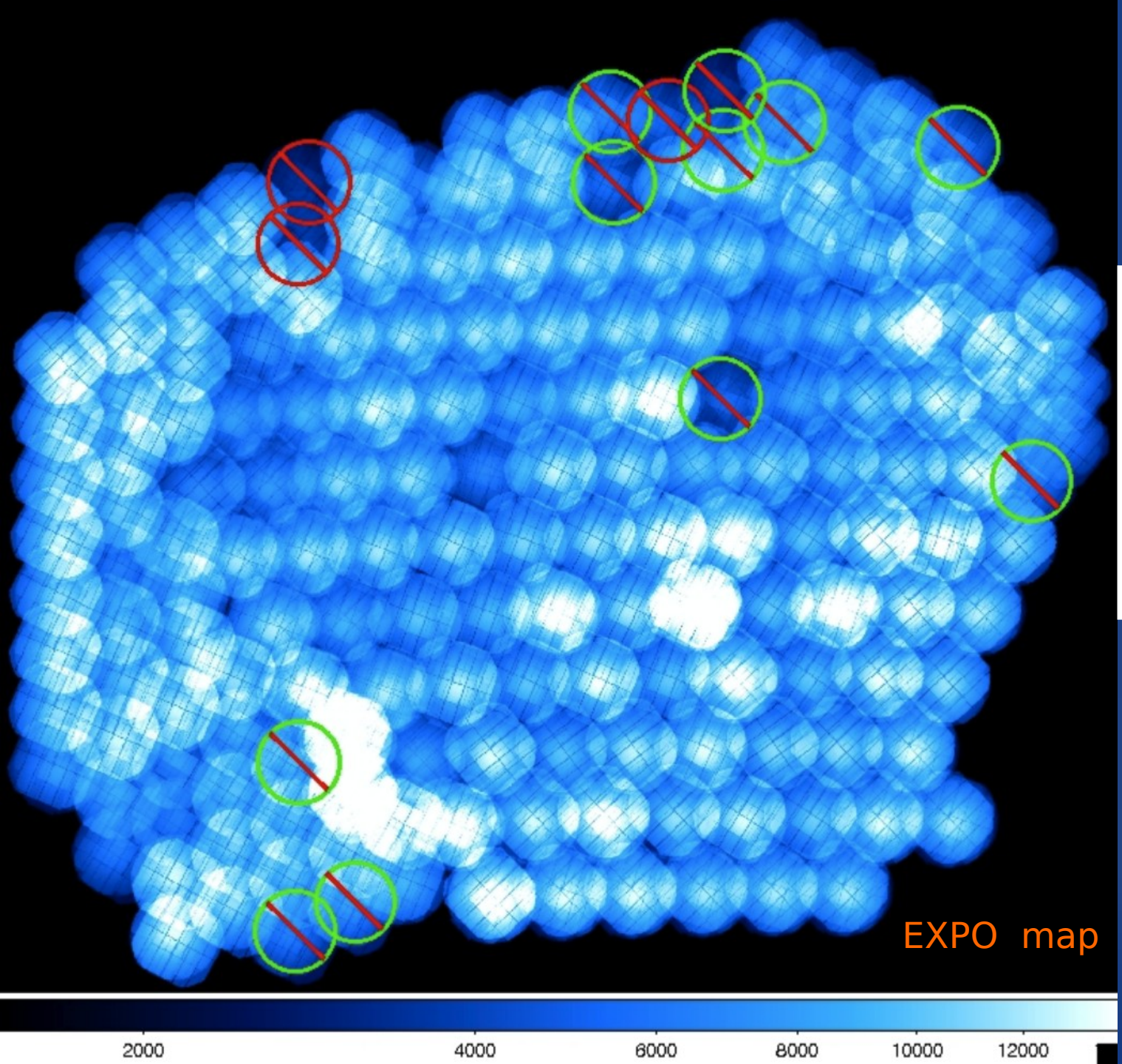
- 2 x 25 sq. deg.
- 6.9 Ms – 452 XMM observations (2011-2013)
- Nominal XMM exposure time : 10 ks

- Some 100 scientists
- ESO LP and numerous associated surveys from UV to 74 MHz

- The survey's main goals are to provide constraints on the dark energy equation of state from the space-time distribution of clusters of galaxies and to serve as a pathfinder for future, wide-area X-ray missions.

XXL-N 25 deg2

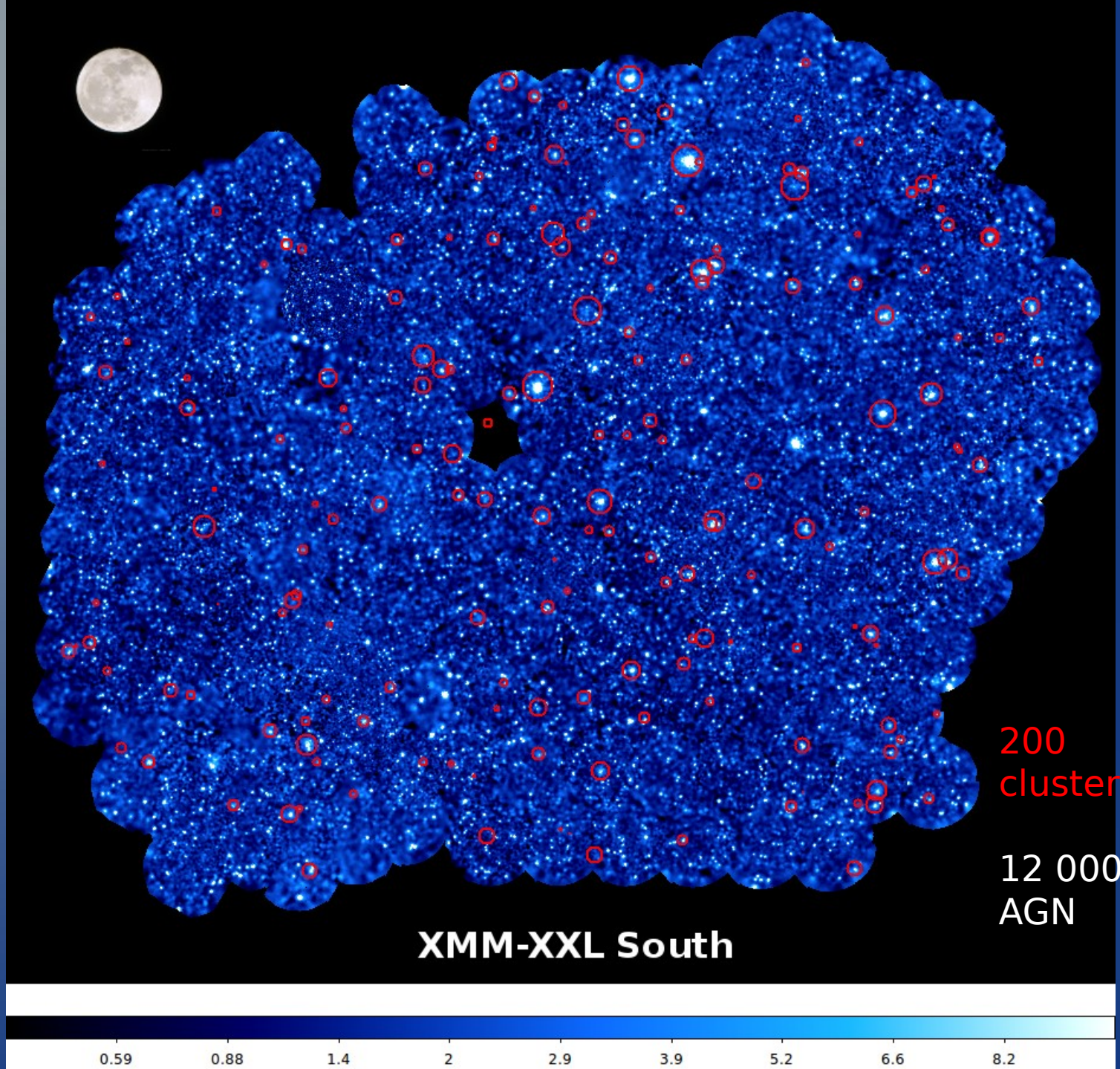




XXL-S
25
deg2

23h30 -55d00

within the SPT
100 deg2
Deep Field


200
clusters
12 000
AGN
XMM-XXL South
0.59
0.88
1.4
2
2.9
3.9
5.2
6.6
8.2

The XXL survey

2016: first series of papers out

Officially published today in an A&A special issue

- **14 articles**
- **brightest 100 clusters released (spectro z, L , T)**
- **brightest 1000 AGN released (z, multi-λ)**
- **XMM images released**

2nd paper release this summer in an A&A special issue

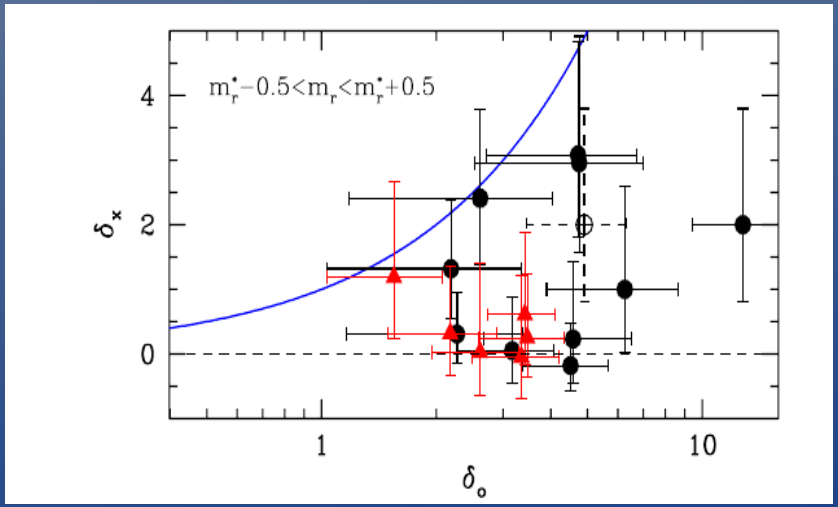
- **All spectroscopically confirmed clusters (365)**
- **~26000 point-like sources + info**

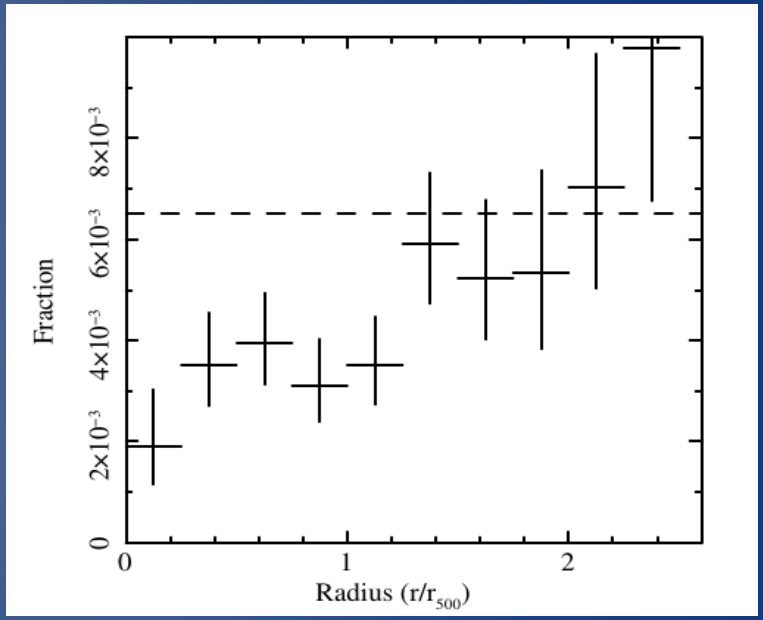
AGN in massive galaxy clusters

Koulouridis & Plionis (2010)

- **Sample of 16 Abell clusters in the SDSS area (XMM-Newton>10 Ks)**
- **Higher optical galaxy density than X-ray AGN density**

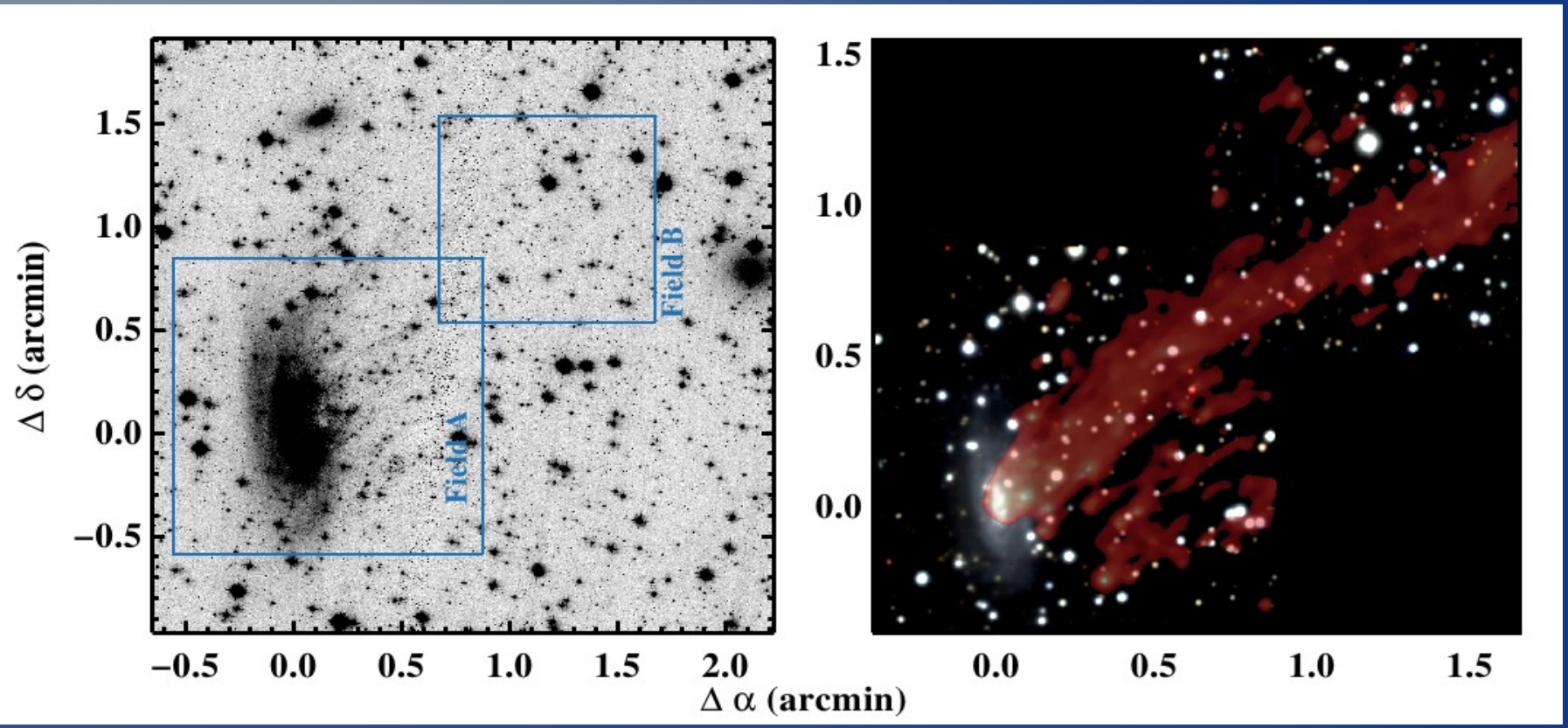
AGN phenomenon is suppressed in the dense environment of rich clusters.





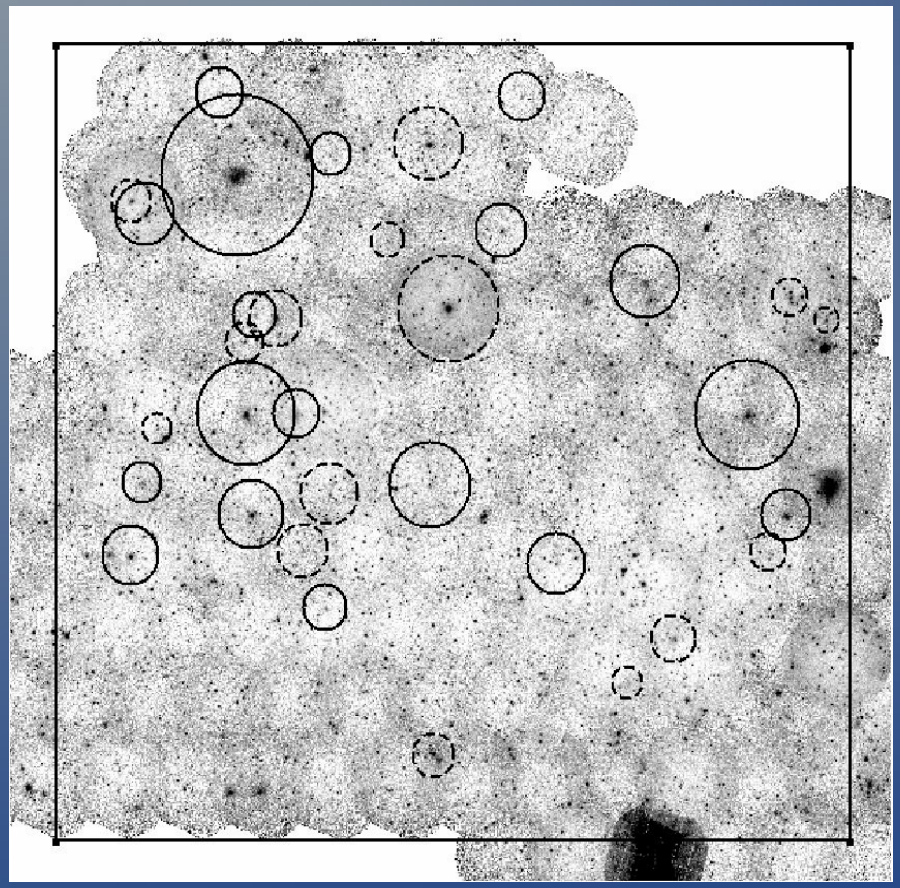
- **Ehlert et al. (2013; 2014;) argue that the X-ray AGN fraction in the central regions of 42 of the most massive clusters known to date is about three times lower than the field value**

Ram pressure stripping by the hot ICM.



Fumagalli+14 (MUSE spectroscopy)

AGN in the XMM-LSS clusters
Koulouridis et al. 2014



- 19 poor clusters $z<0.33$
- 14 high-z ($0.43<z<1.05$) moderately rich clusters

→ AGN with $L_X>10^{42}$ erg/s.

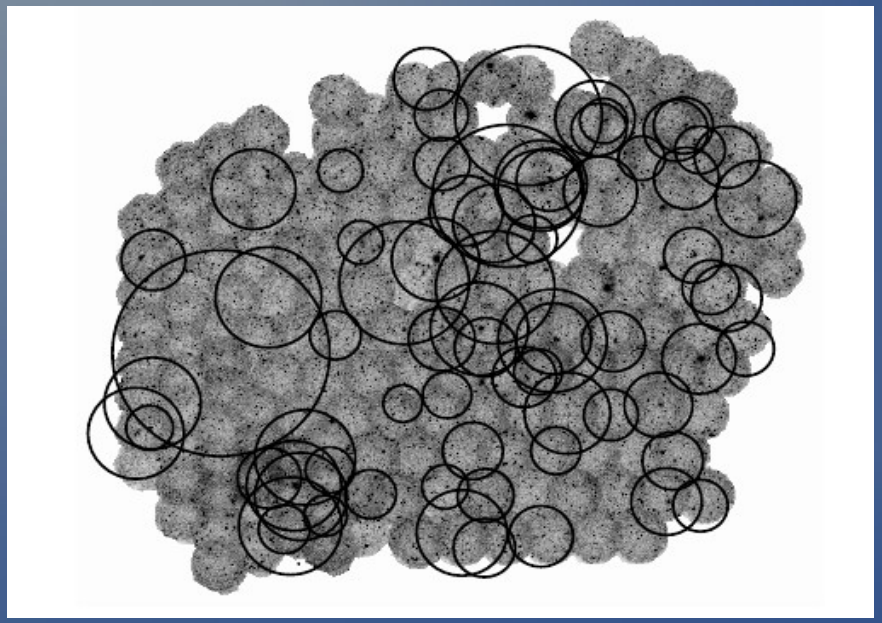
Results:

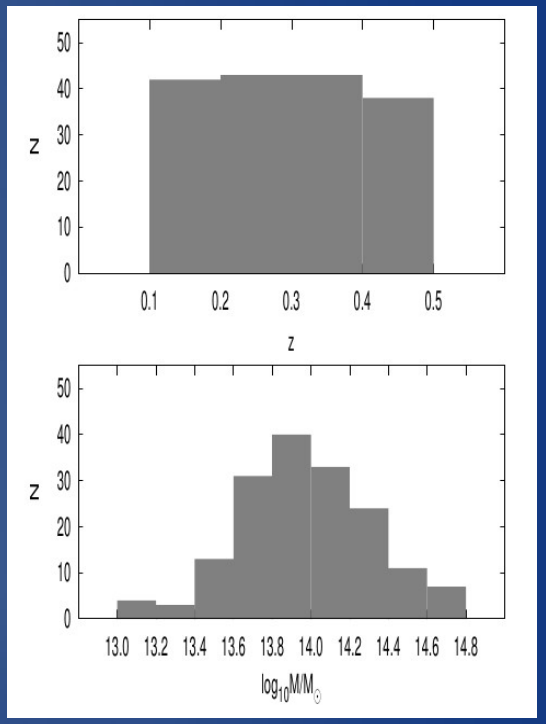
- AGN density consistent with the field density
- Evidence for AGN triggering in the cluster outskirts

X-ray AGN in XXL galaxy clusters

0.1<z<0.5

Koulouridis et al. 2018, XXL paper XXXV





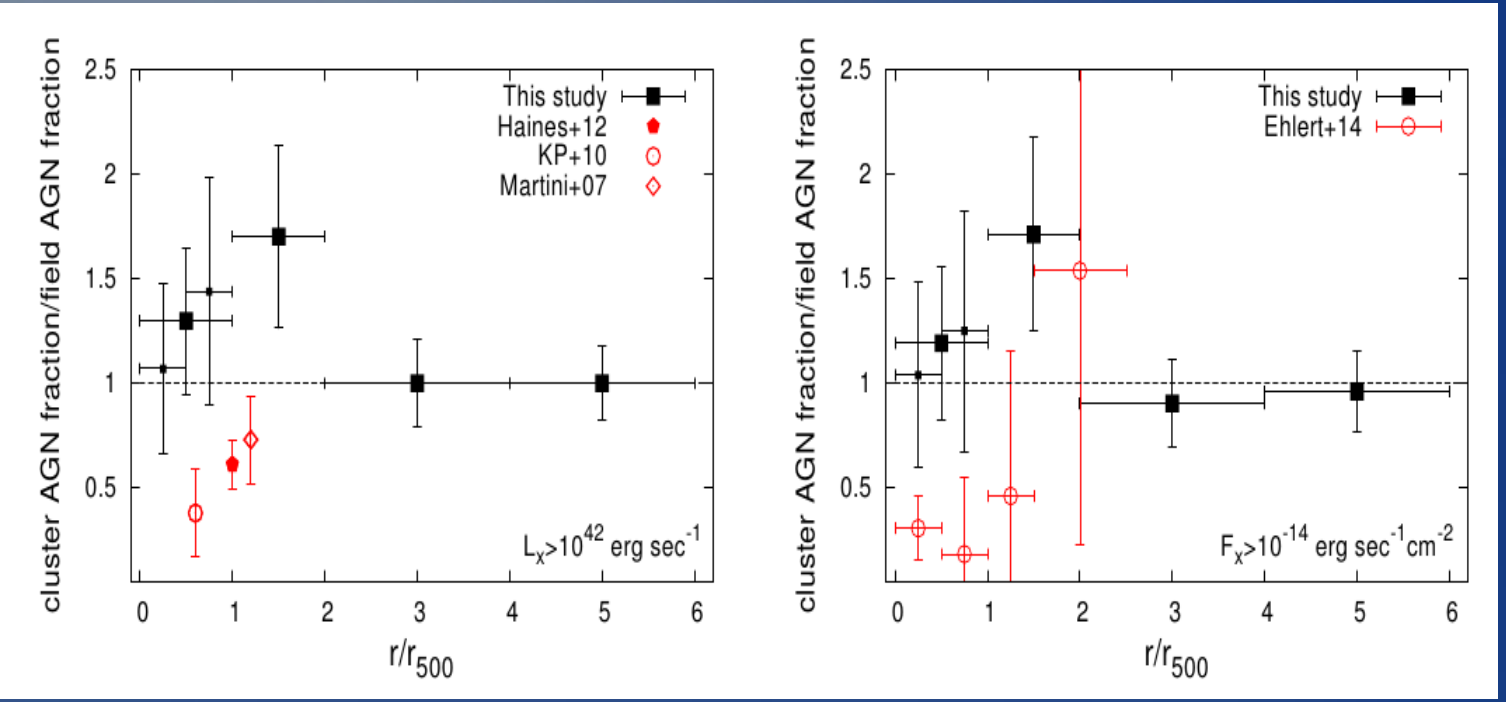
167 clusters with measured Tx –> mass – r500 radius

- **X-ray AGNs with spectroscopically confirmed optical counterparts and Lx>10^{42} erg/s.**
- **High spectroscopic completeness. ~70% in the north, ~90% in the southern field.**

The role of cluster mass in AGN activity

0.1<z<0.5

Koulouridis et al. 2018, XXL paper XXXV

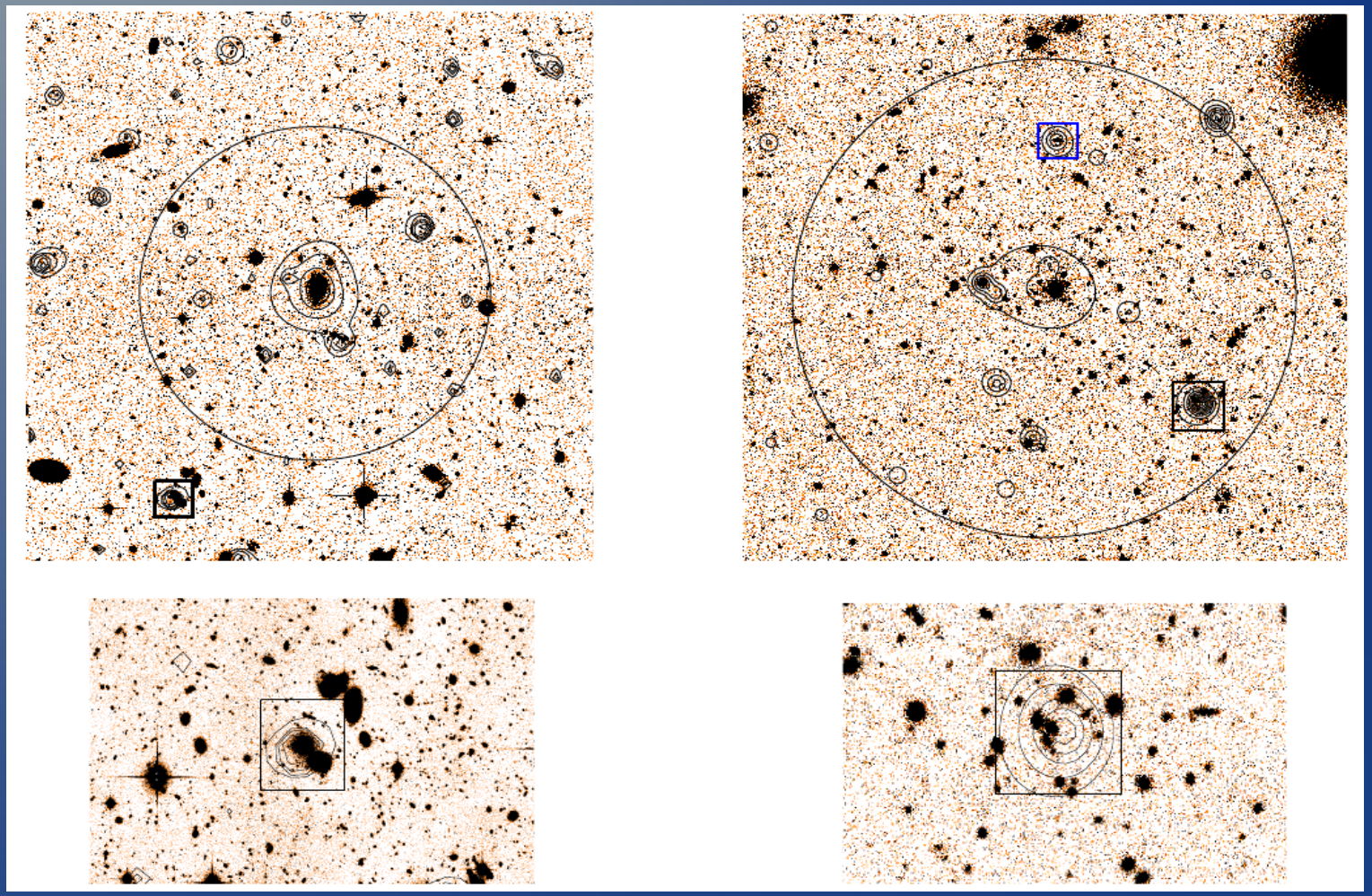


- Evidence for AGN triggering in the cluster outskirts (1-2 r500)
- Ram pressure stripping towards the cluster centre but less efficient than in massive clusters

Merging and AGN triggering in the outskirts

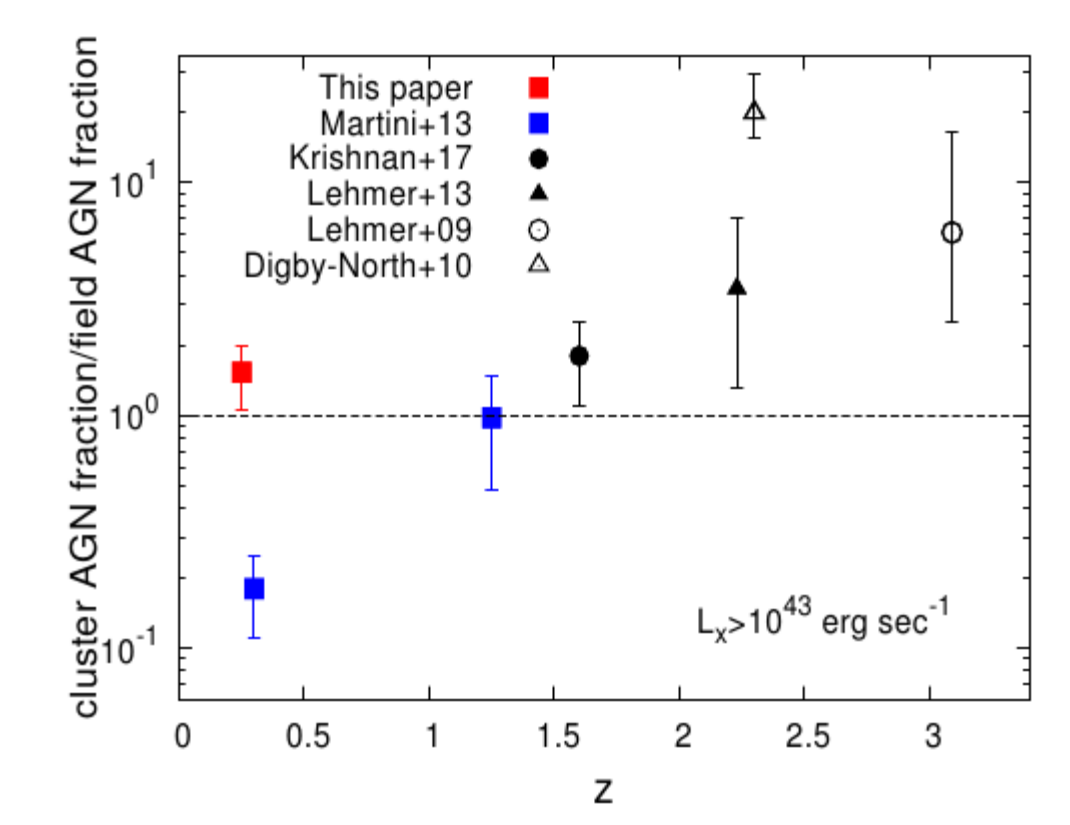
0.1<z<0.5

Koulouridis et al. 2018, XXL paper XXXV



The role of cluster mass in AGN activity

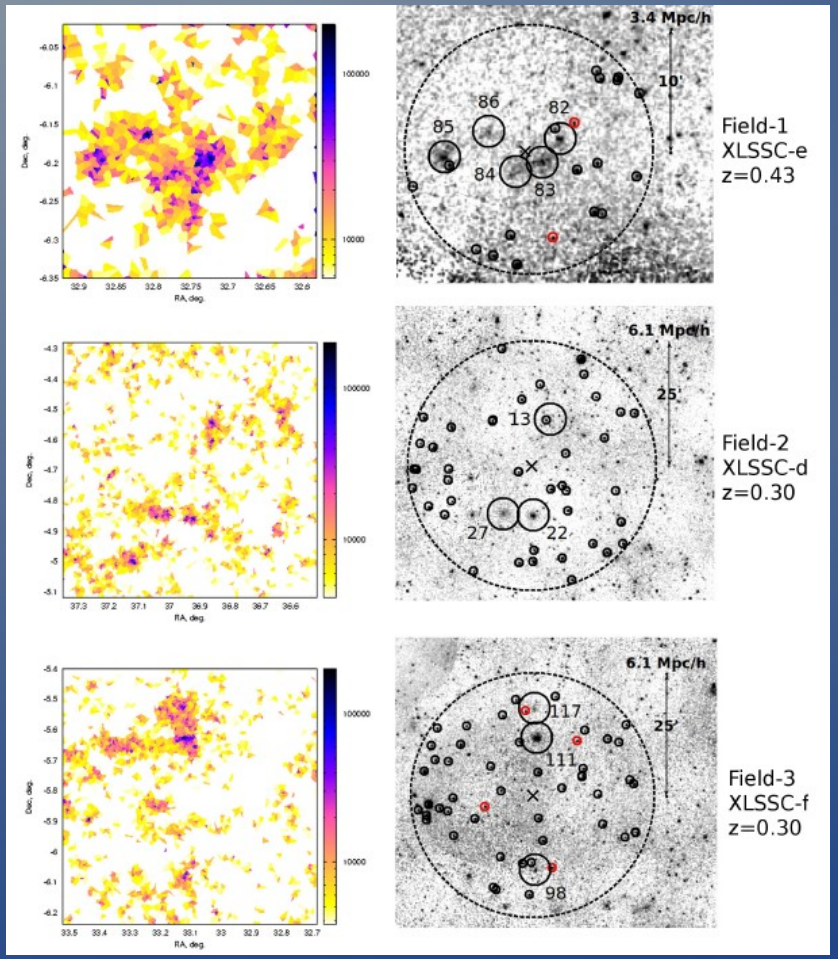
Koulouridis et al. 2018, XXL paper XXXV



- AGN density consistent with clusters and proto-clusters above z=1.

XXL XII. X-ray AGN in three super-clusters

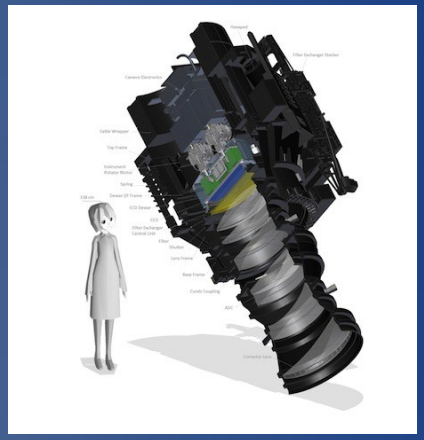
Koulouridis+16a

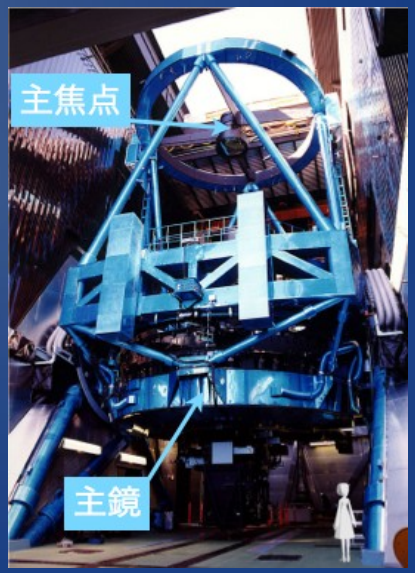


- **Redshifts for 455 galaxies in total, 56 of which are counterparts of X-ray point-like sources.**
- **Determination of the redshift of the merging supercluster XLSSC-e, which consists of six individual clusters at z∼0.43, and confirmation of the redshift of XLSSC-d at z∼0.3.**
- **Discovery of a new supercluster, XLSSC-f, that comprises three galaxy clusters at z∼0.3. We find a significant overdensity of X-ray point-like sources only in XLSSC-e.**
- **Comparing our findings with the optical galaxy overdensity we conclude that the total number of AGN in the area of the three superclusters significantly exceeds the field expectations.**

Future work in z>0.5 clusters: XXL - Hyper Suprime Cam (HSC) joint project

- National Astronomical Observatory of Japan, University of Tokyo, Nagoya University, Tohoku University, KEK, ASIAA, Princeton University, Ehime University, Kyoto University, ISAS, Kona University, National Central University (Taiwan), Nagasaki University, Kagoshima University, Shinshu University, Tokyo Gakugei University





COSMO-OWLS simulations

- SPH - Gadget-3
- Cosmologies: WMAP7, Planck.
- Number of particles: $2x1024^3$
- A certain fraction of rest mass energy of accreted gas is assumed to heat local gas thermally.

  3 AGN models: 8.0 – 8.5 – 8.7
- Current results using model 8.0

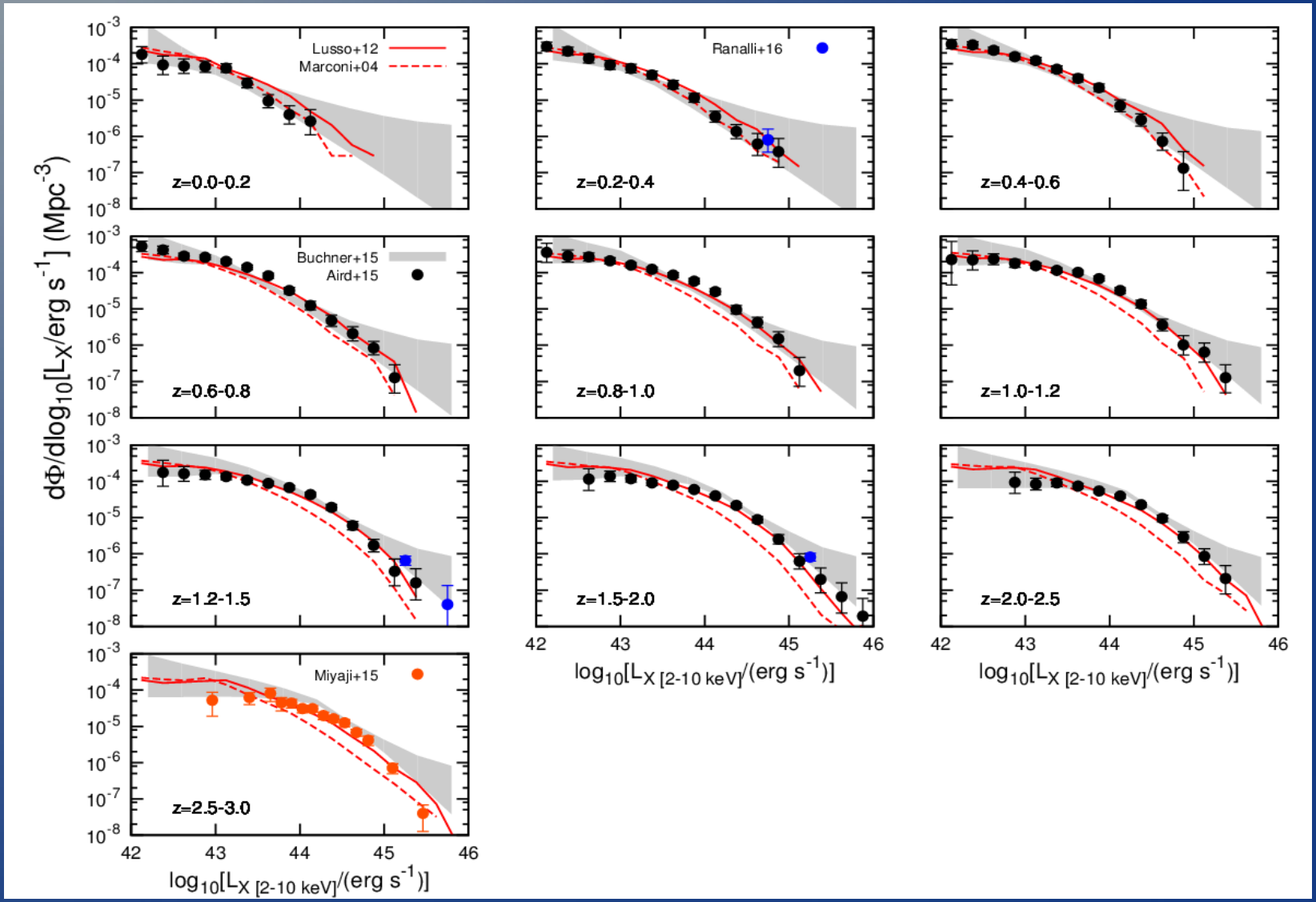
- Black hole (BH) seeds placed at the centre of haloes that exceed some threshold mass, i.e., 100 particles ~ logM(FoF)=11.6 (on the fly).
- Given some seed mass: mseed<<mg (subgrid BH – 0.001 x the gas particle mass)
- BHs grow by mergers with other BHs and by Bondi-Hoyle accretion of neighbouring gas (no disruption and capture of stars)

$$\dot{m}_{acc} = \alpha \frac{4\pi G^2 m_{BH}^2 \rho}{(c_s^2 + u^2)^{3/2}}$$

Booth & Schaye 2009

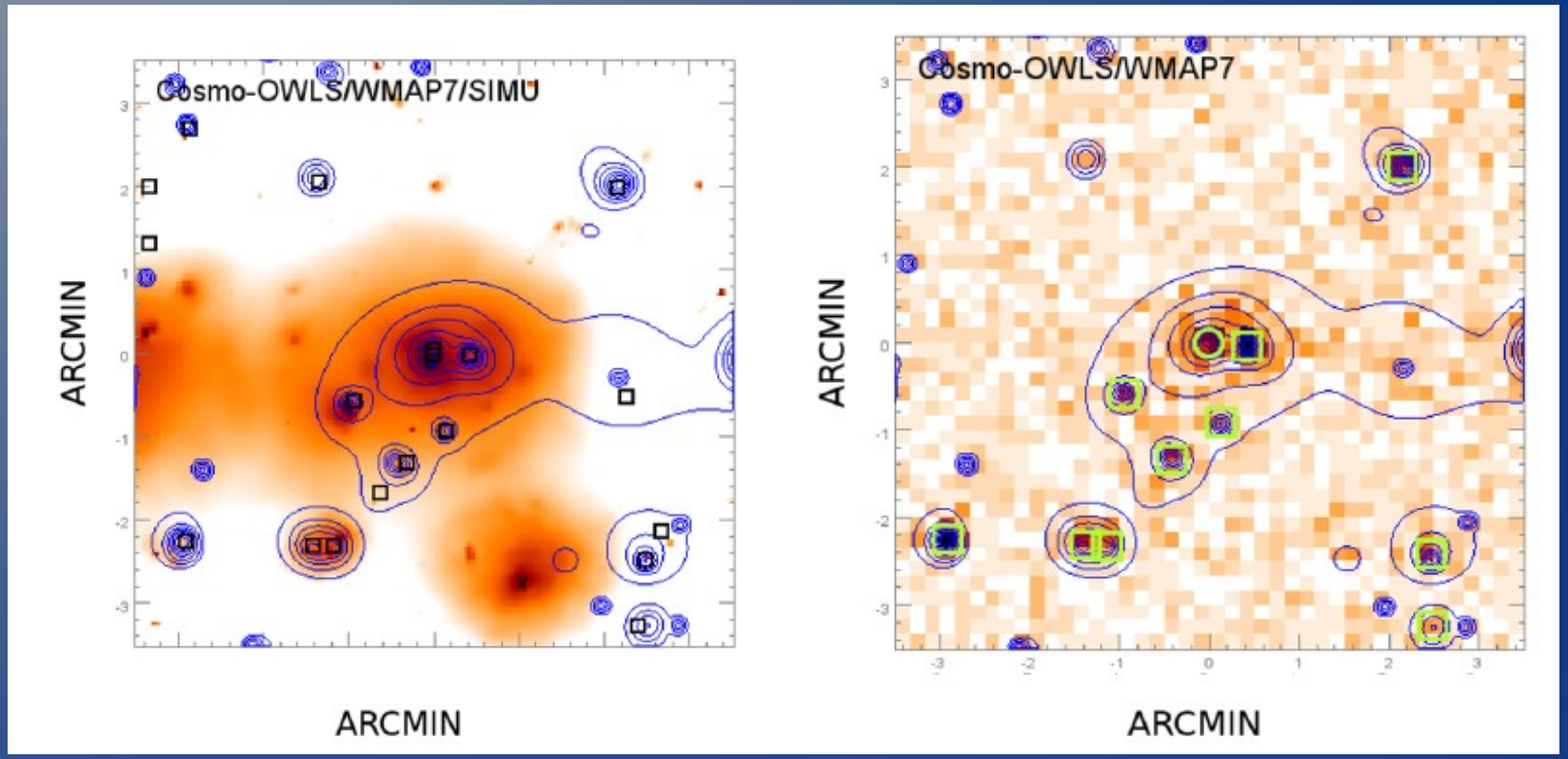
The hard X-ray [2.0-10 keV] unabsorbed Luminosity Function

Koulouridis et al. (XXL paper XIX)



XMM-Newton simulated images with realistic X-ray AGN catalogues

Koulouridis et al. (XXL paper XIX)



Summary

- Evidence for AGN triggering in the cluster outskirts (1-2 r500)
- Ram pressure stripping towards the cluster centre but less efficient than in massive clusters
- AGN density consistent with clusters and proto-clusters above z=1.

Future Work

- Thorough classification of the X-ray AGNs of our clusters
- AGNs in high-redshift clusters
- AGN density in super-clusters
- Testing with cosmological simulation