

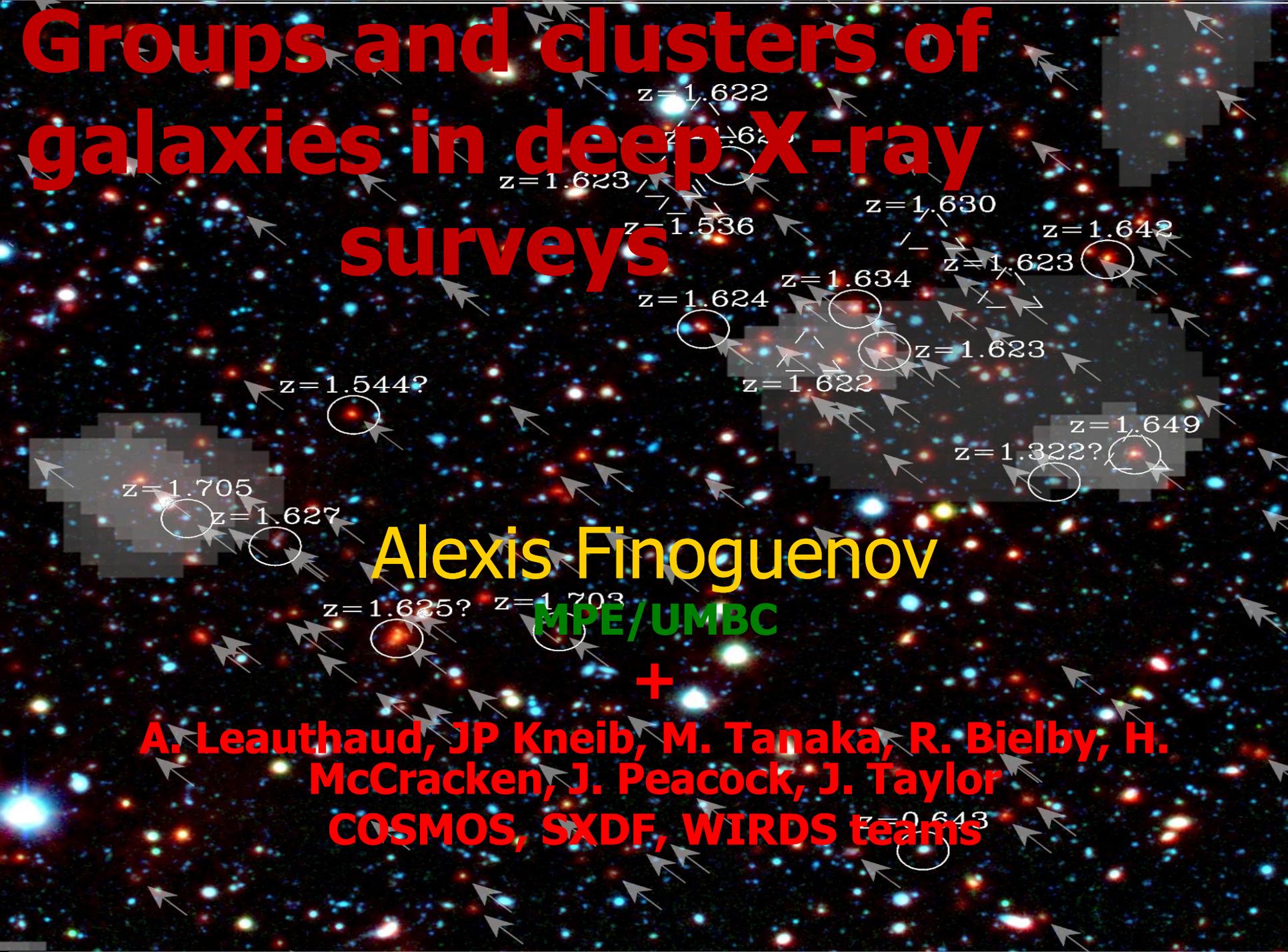
Groups and clusters of galaxies in deep X-ray surveys

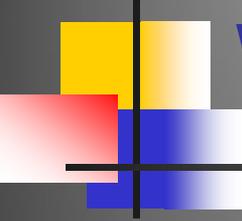
Alexis Finoguenov

MPE/UMBC

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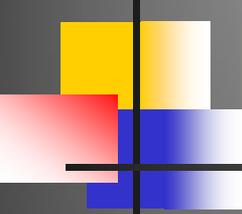
A. Leauthaud, JP Kneib, M. Tanaka, R. Bielby, H. McCracken, J. Peacock, J. Taylor
COSMOS, SXDF, WIRDS teams





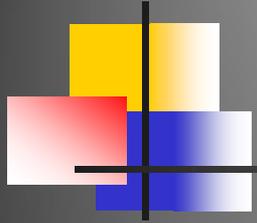
Why study galaxy clusters?

- Sensitive cosmological probes
- Well-defined environment
- Simplest examples of halos



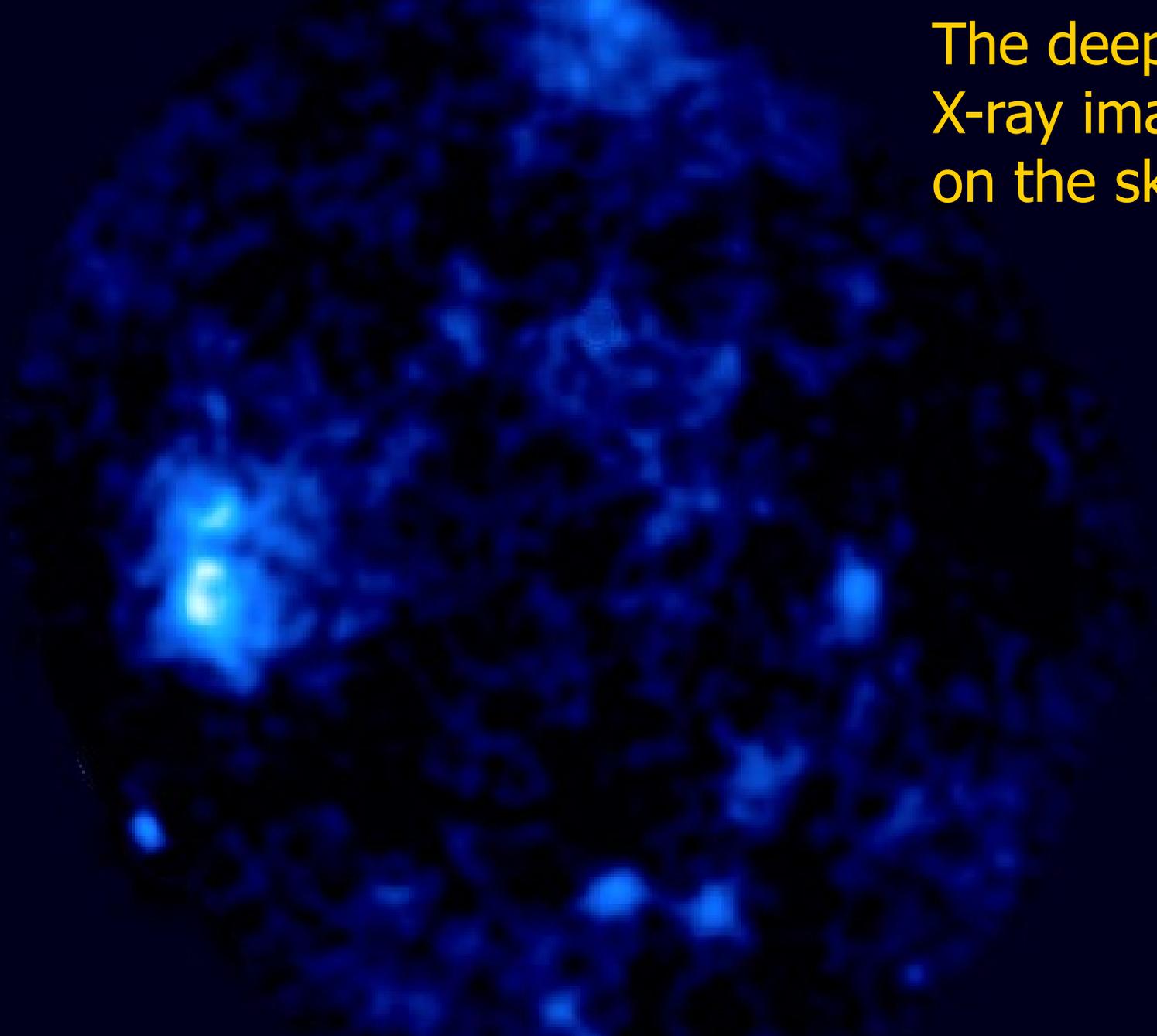
How to study galaxy clusters?

- Galaxy concentration 0.1/sq.degs.
- Red sequence 100/sq.degs.
- Galaxy redshift surveys 1000/sq.degs.
- Gravitational lensing 3/sq.degs.
- X-ray emission 300/sq.degs.
- tSZ 0.1/sq.degs.

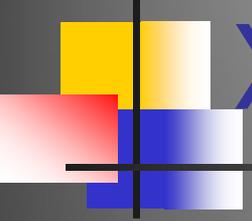


How does the deepest X-ray image of the sky look like?

The deepest
X-ray image
on the sky

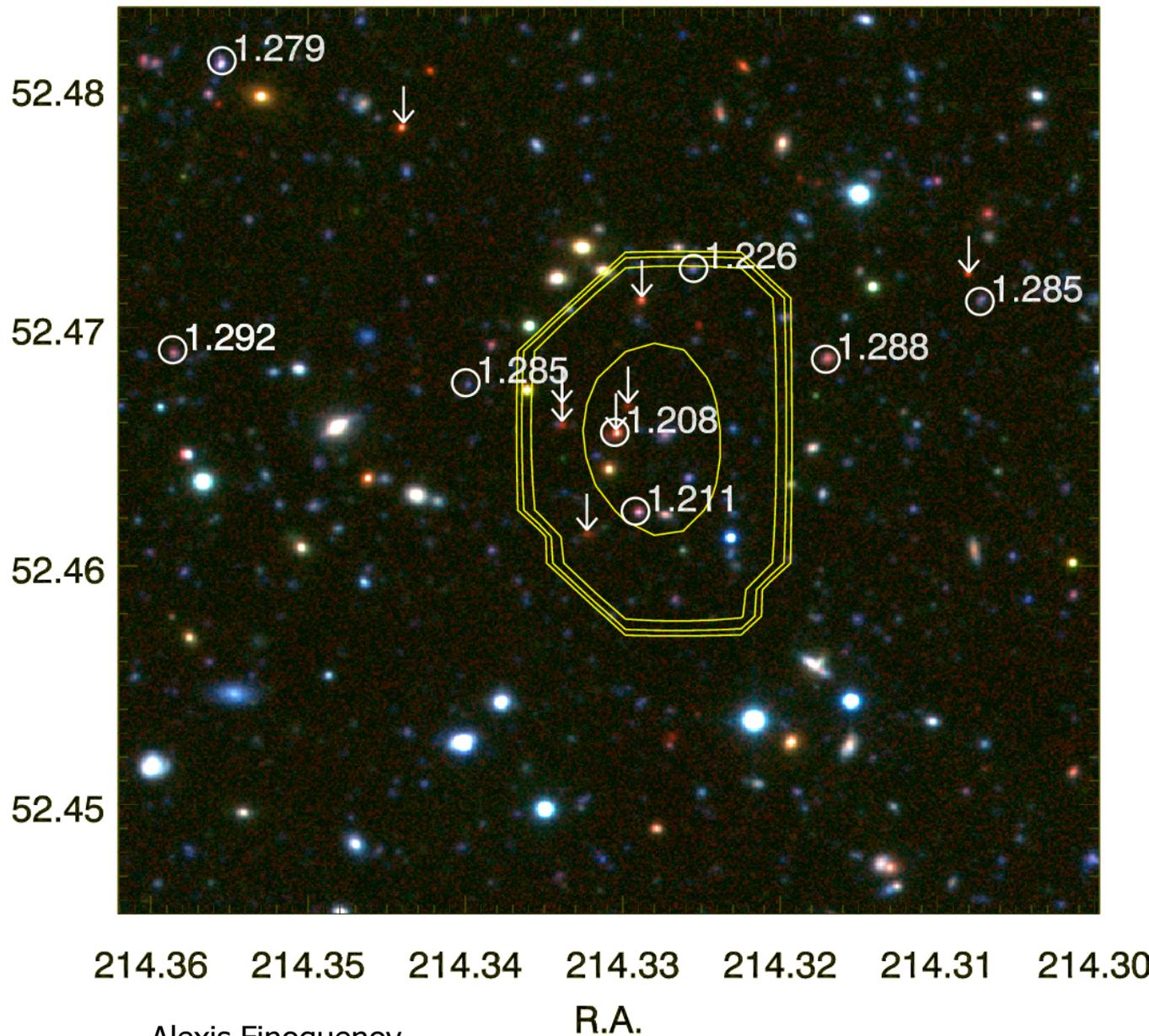


What is so specific regarding X-ray studies?



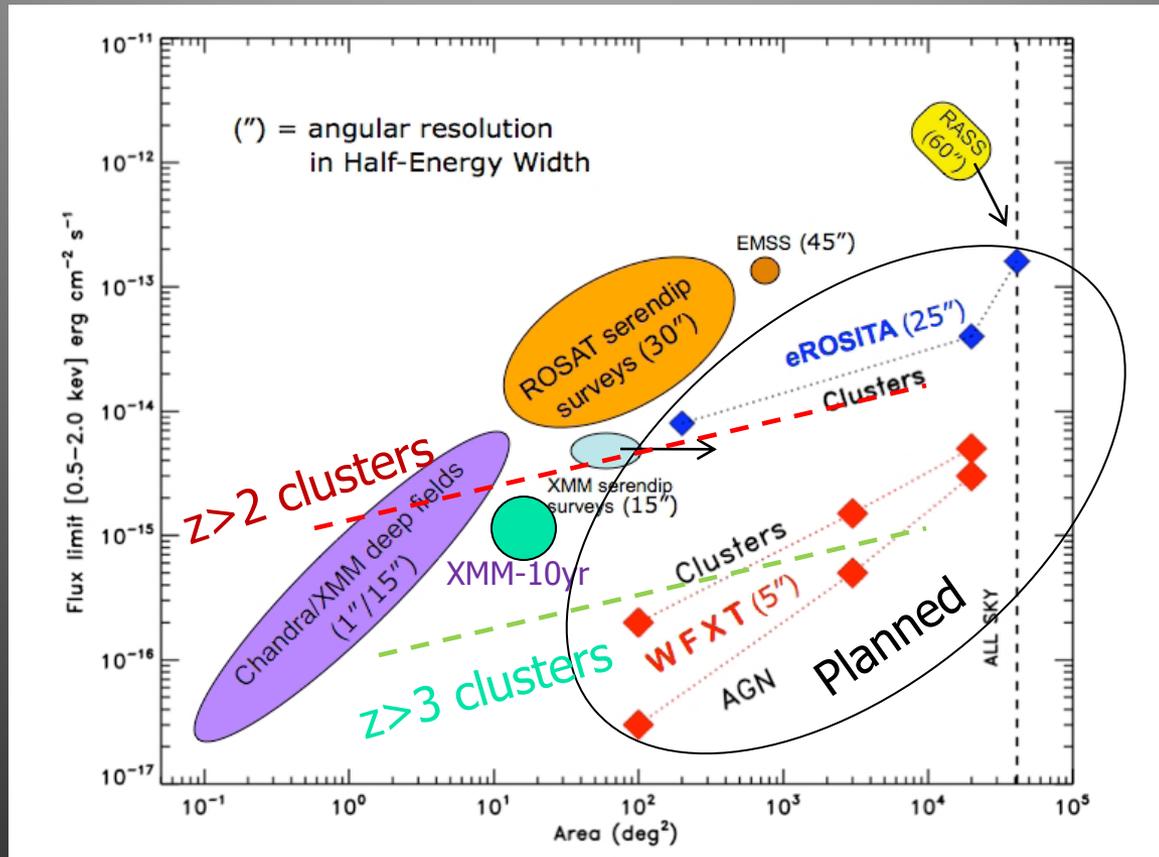
- Started relatively recently – 40yr ago – young field
- Increase in sensitivity by 7 orders of magnitude
- Reached the final depths, but over the small area
- 2-dimentional – need auxiliary data to identify clusters.

ID = 23, z = 1.21, flag: 1

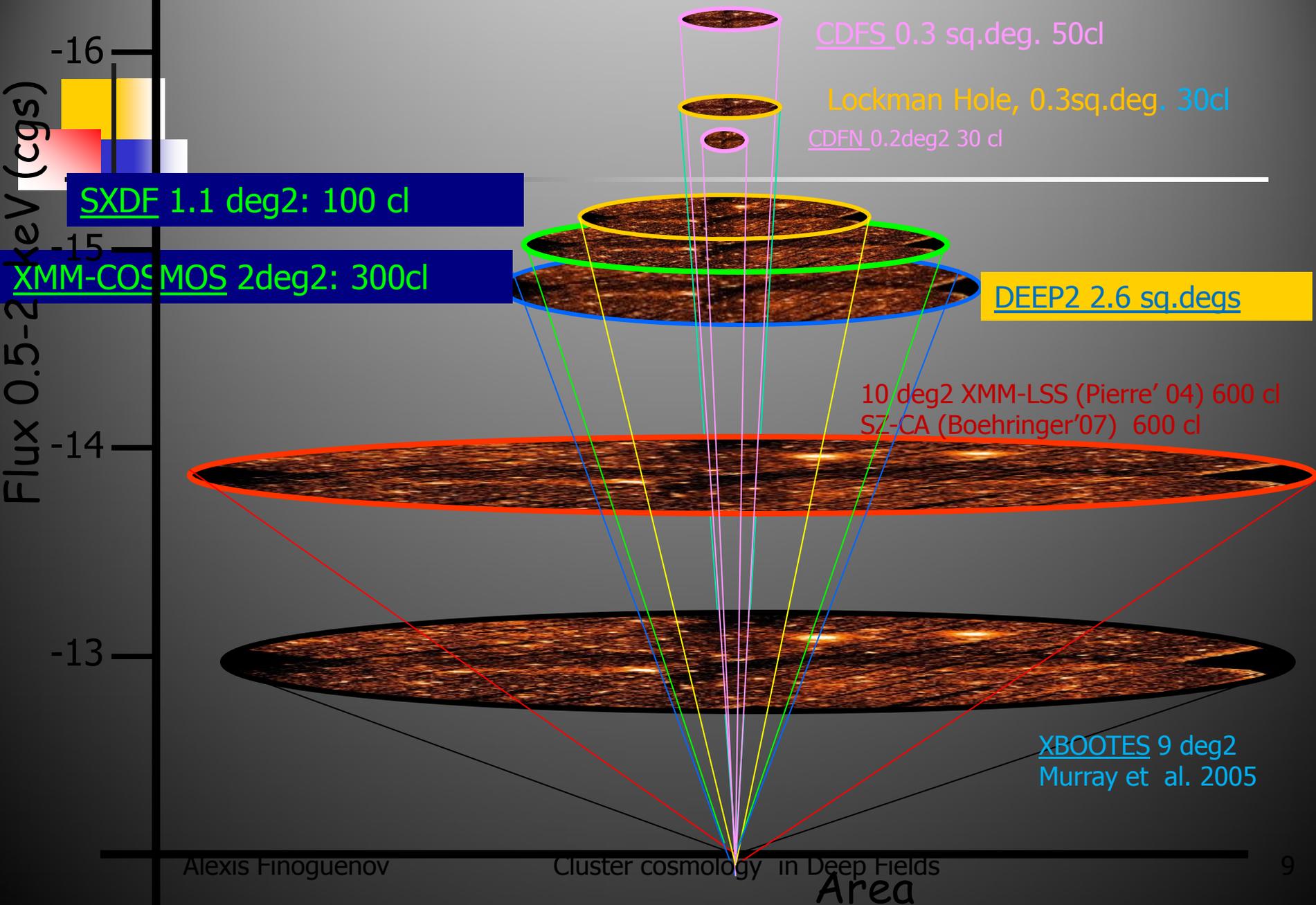


High-z
groups

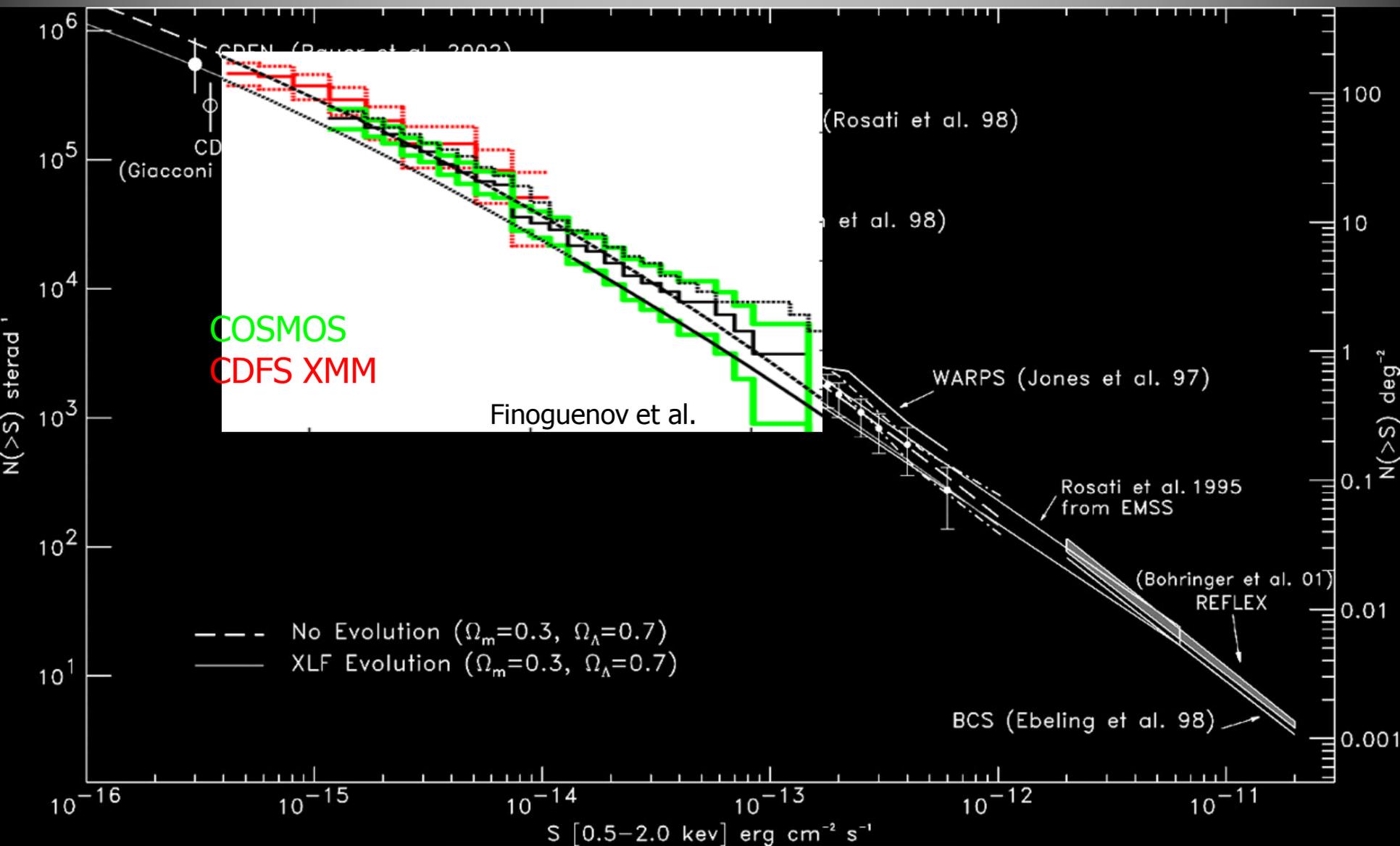
X-ray surveys in comparison

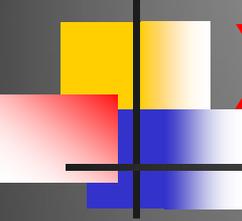


Contiguous X-ray cluster surveys in context



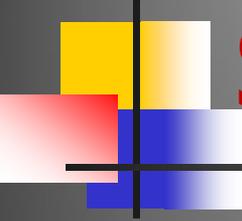
Cluster X-ray number counts





X-ray clusters: deep and wide

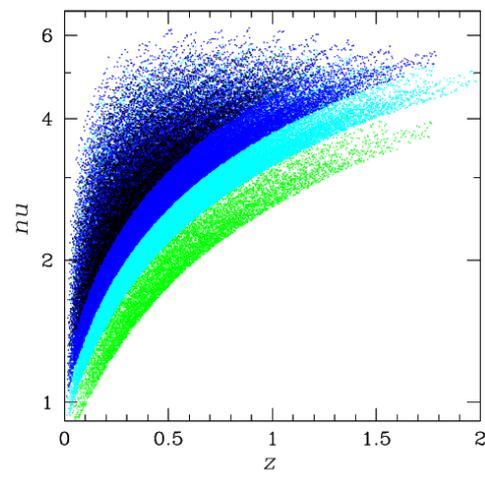
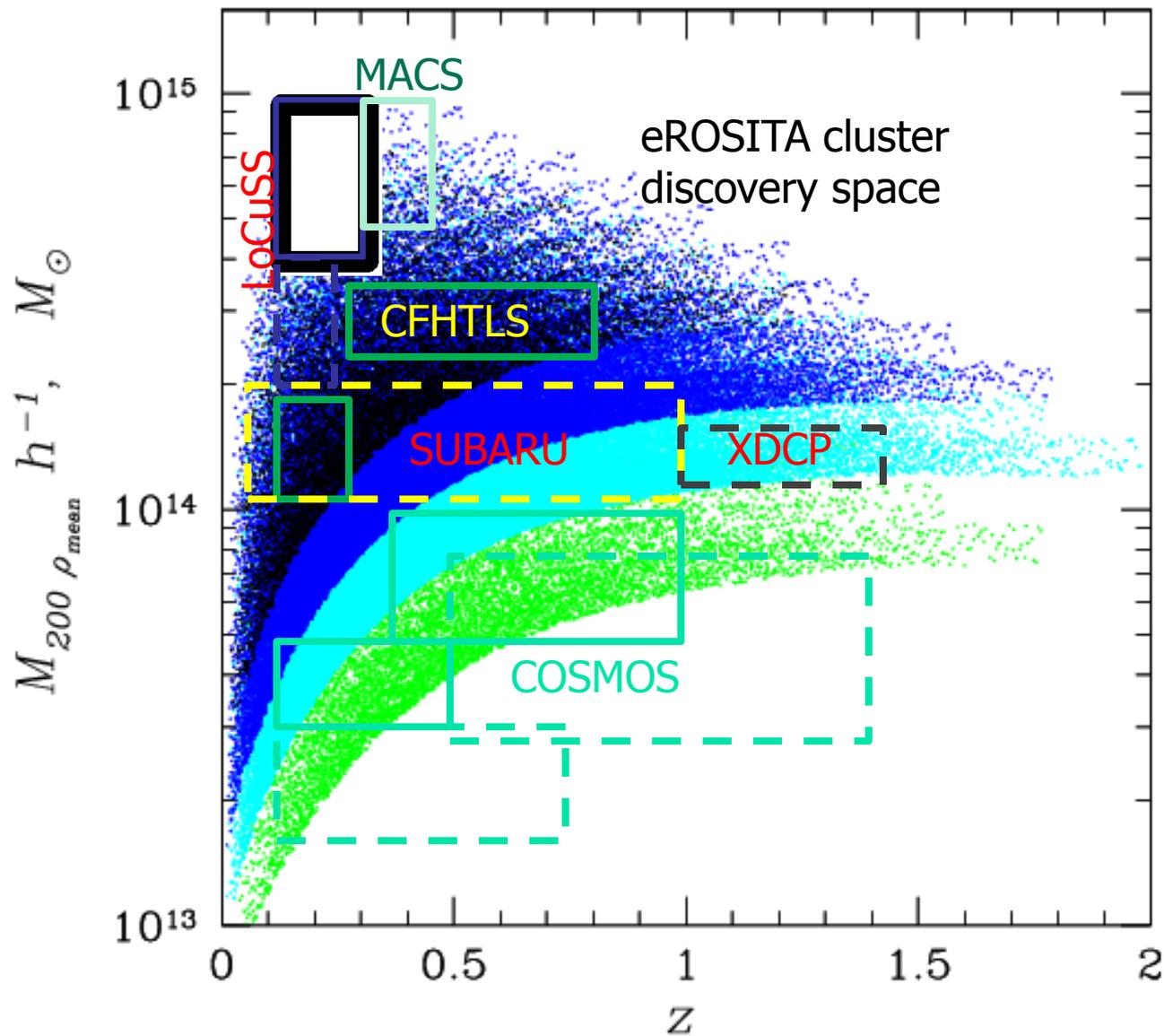
- Deep: total of 10 sq.degs. At 100-300 groups per sq.degs.: a total of 1000 groups
- Wide: 20 sq.degs. at 20-50 groups per sq.degs.: a total of 1000 groups
- Guided XMM-CFHTLS: 100 sq.degs at 1 cluster per sq.degs.: total of 100 clusters

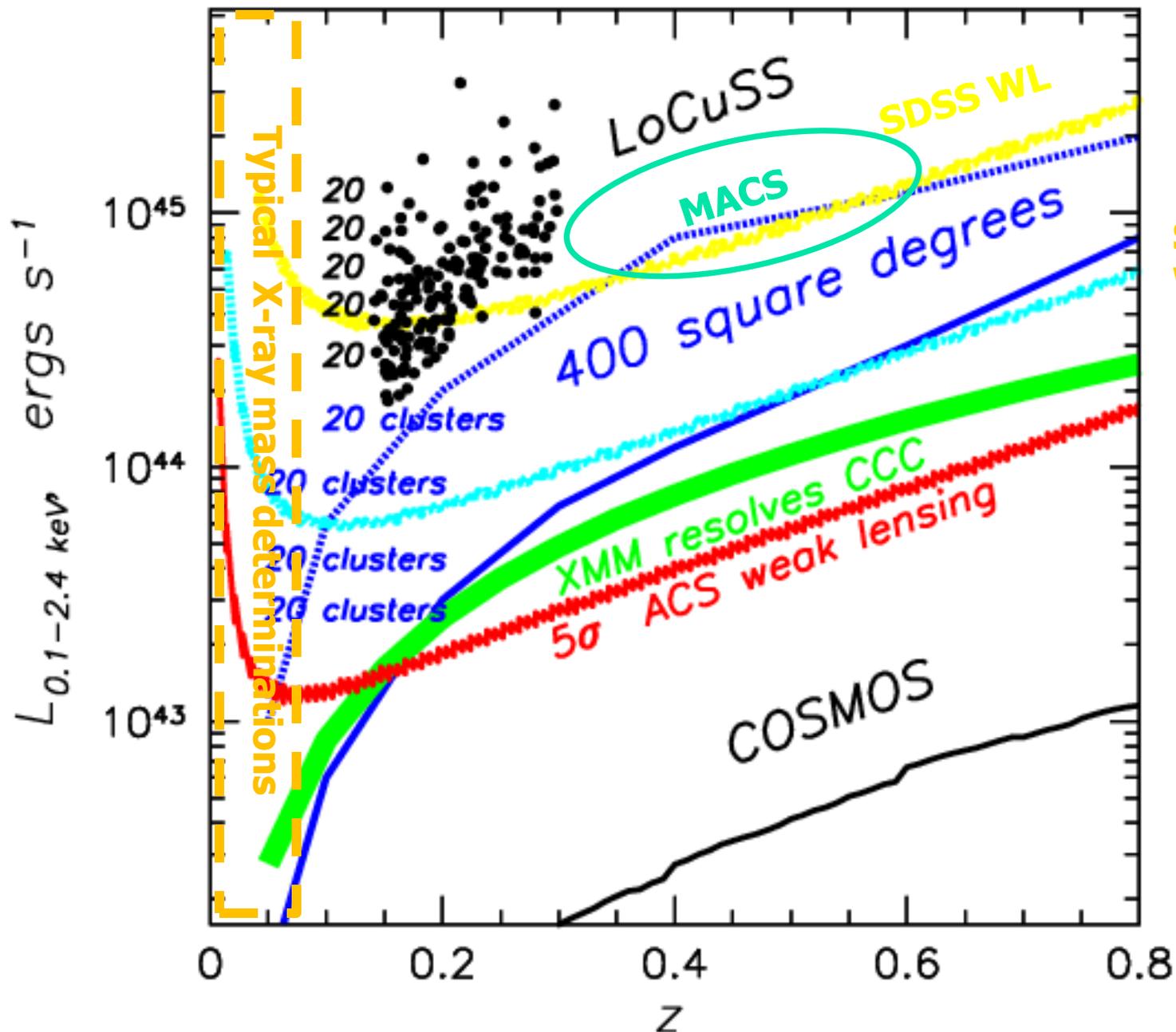


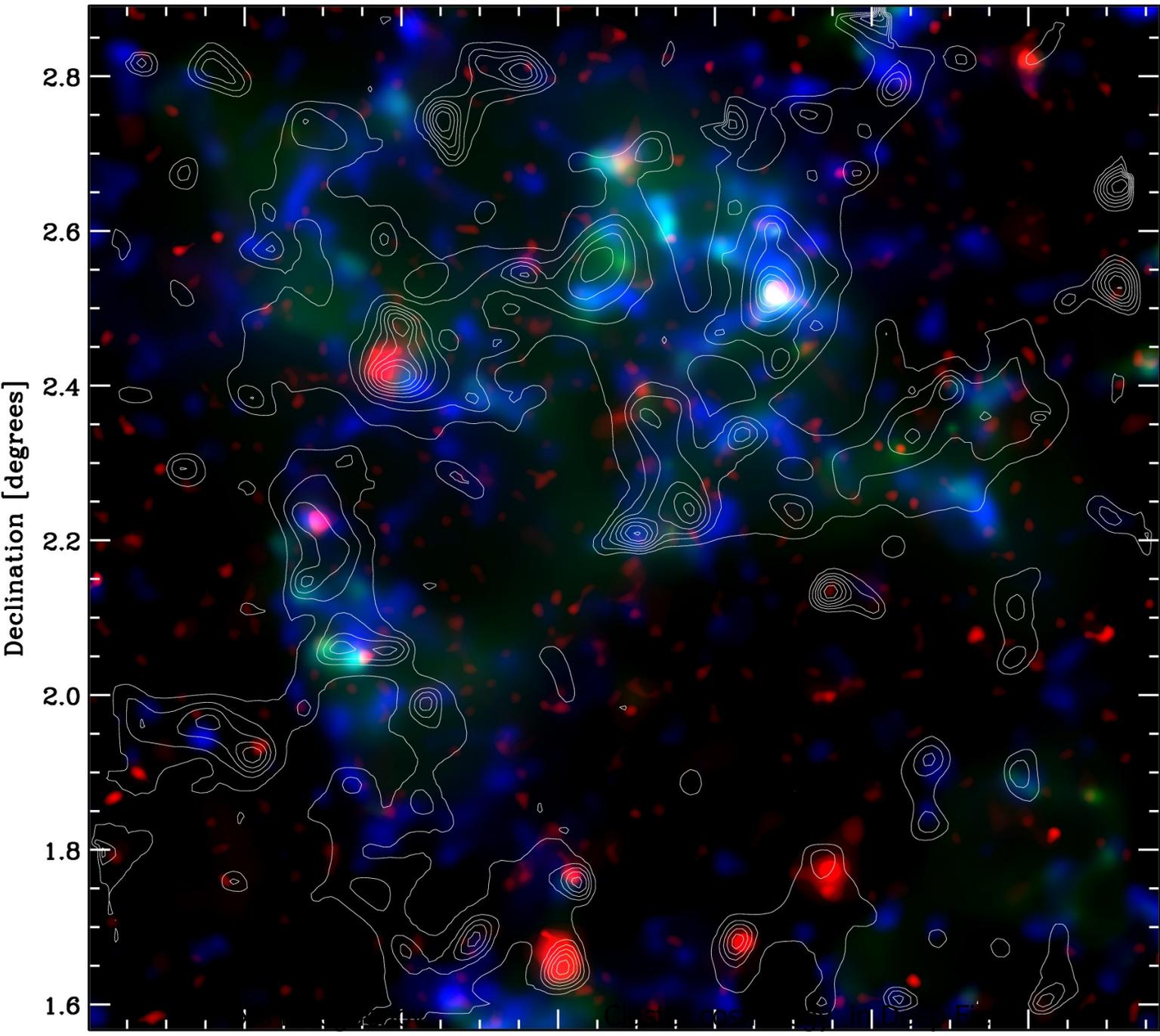
Specifics of mass calibration

- In most cases X-ray masses are not feasible due to both faint and compact origin of sources
- Weak lensing data is best of its class (Leauthaud, AF, et al. 2010)
 - ACS imaging
 - Best photo-z
- Clustering analysis using conditional on density mass function (Faltenbacher, AF, Drory 2010)

All clusters, all surveys



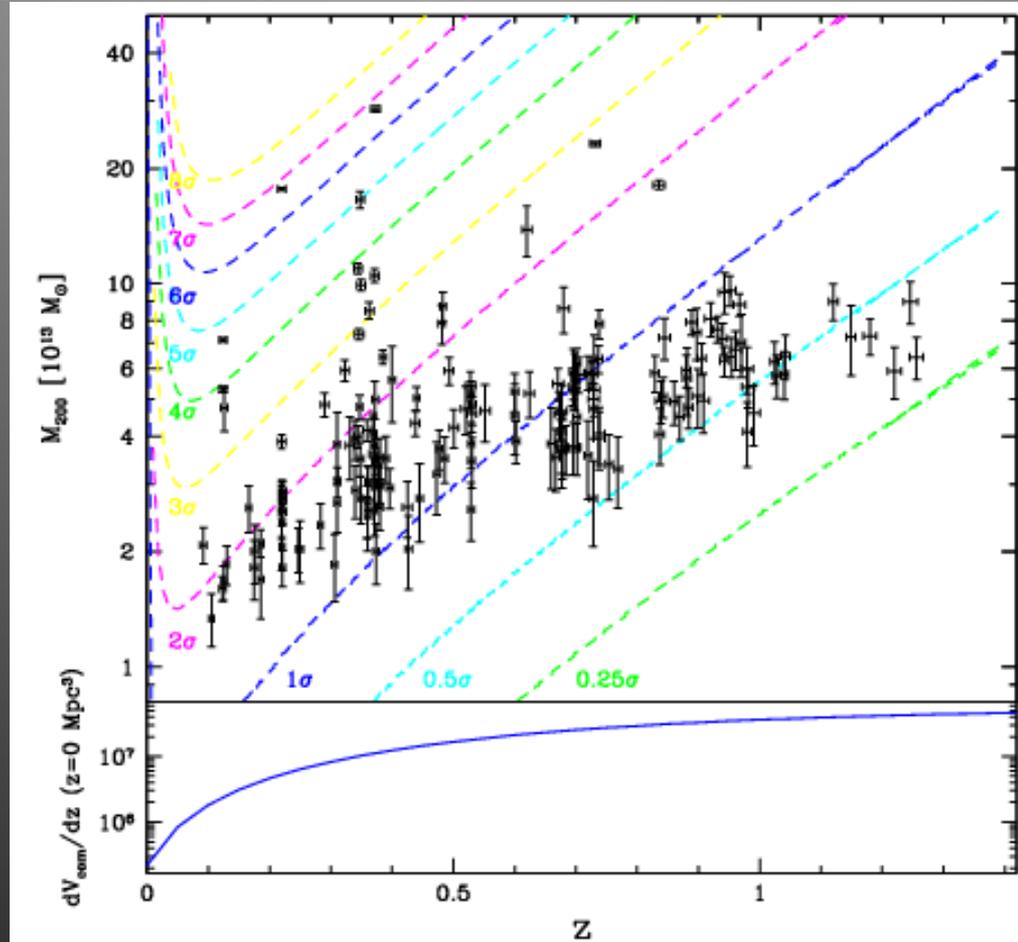




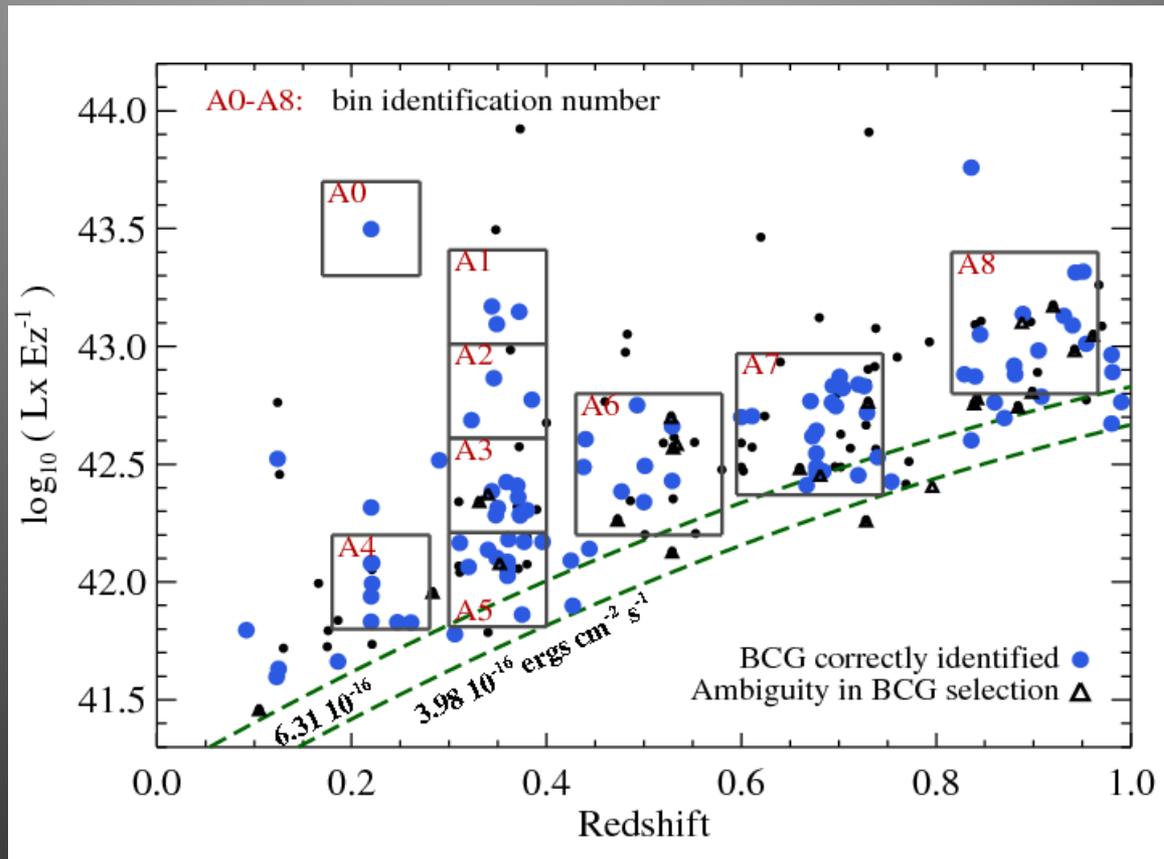
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Massey
et al.
2007

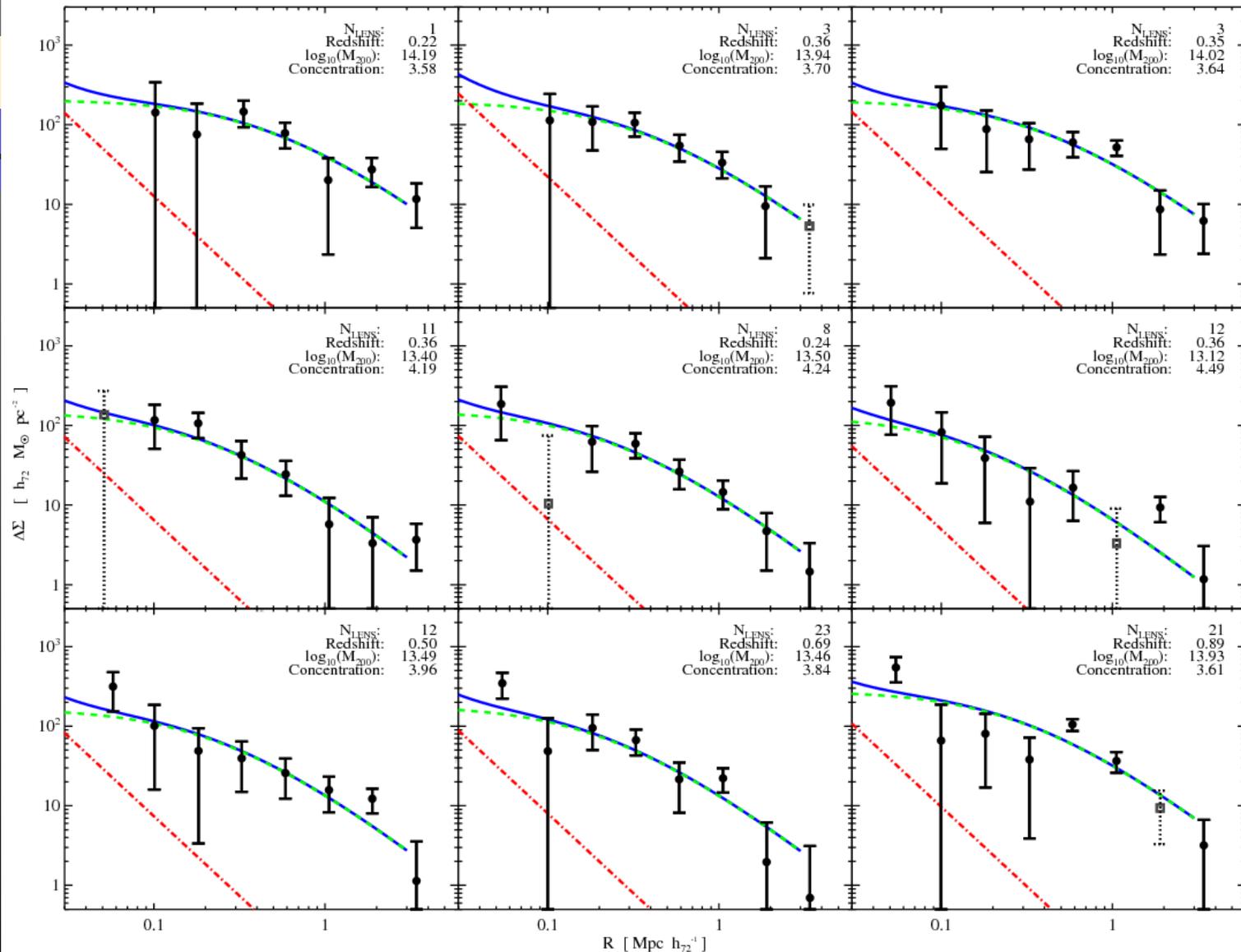
How to stack groups: significance



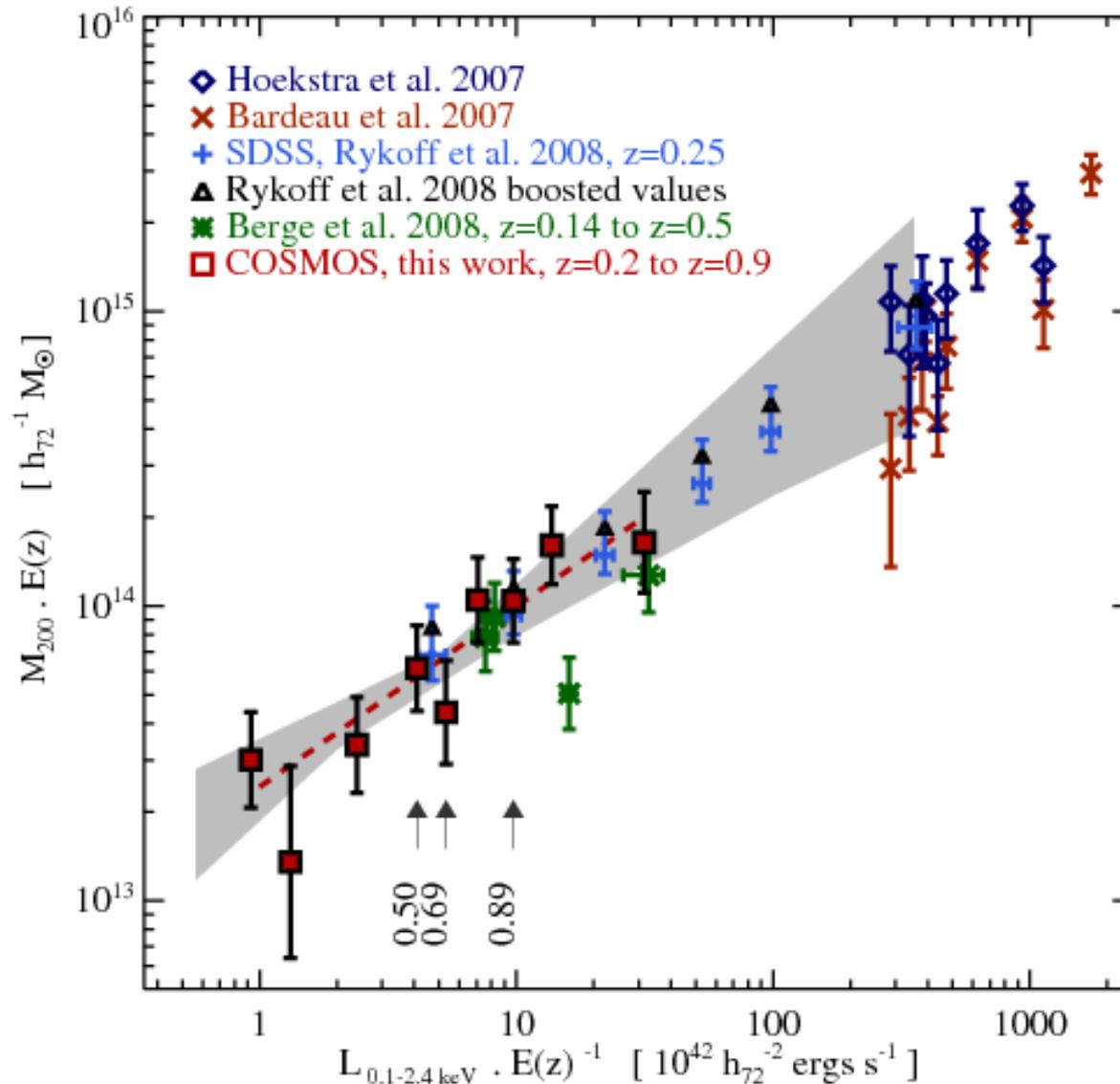
Weak lensing binning scheme



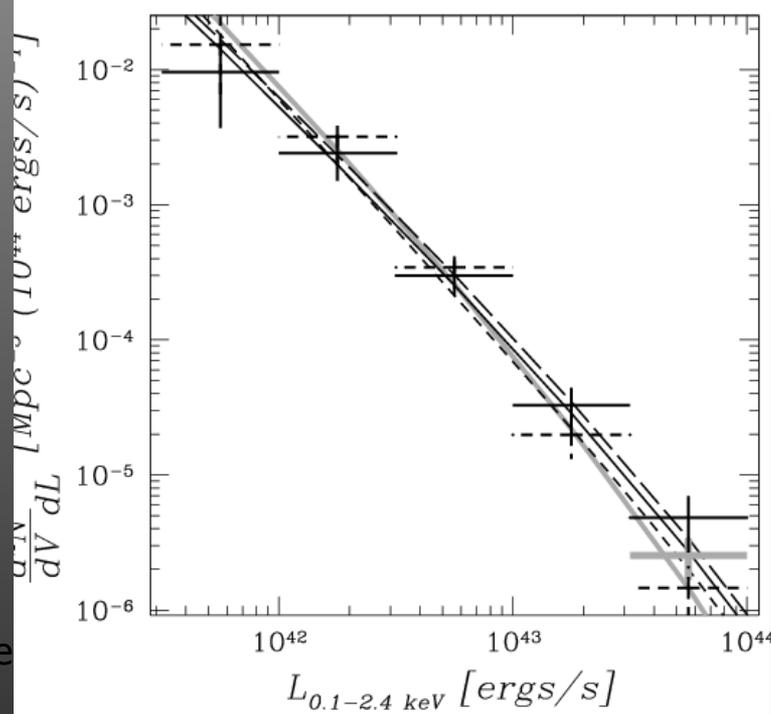
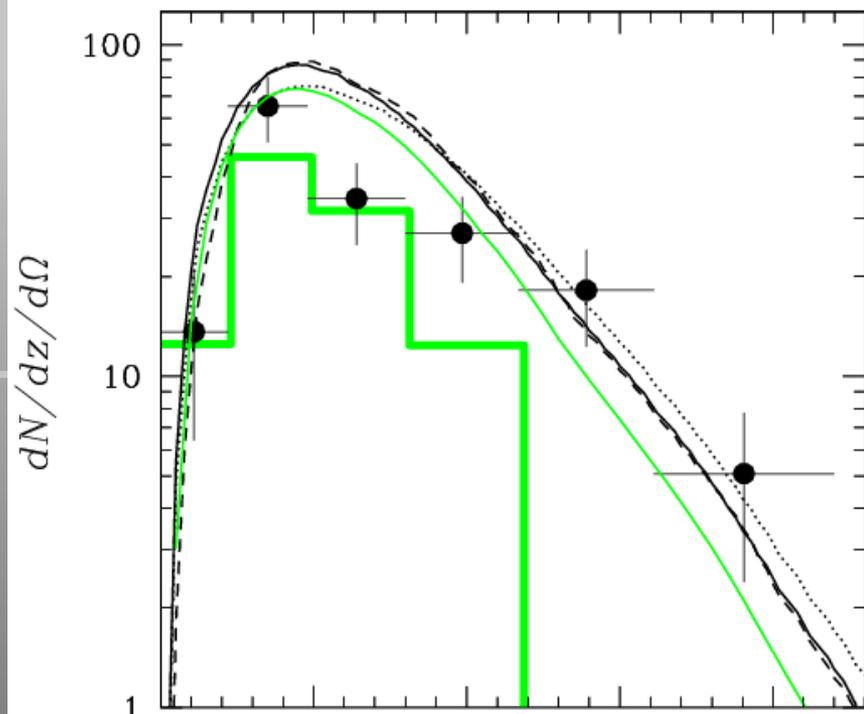
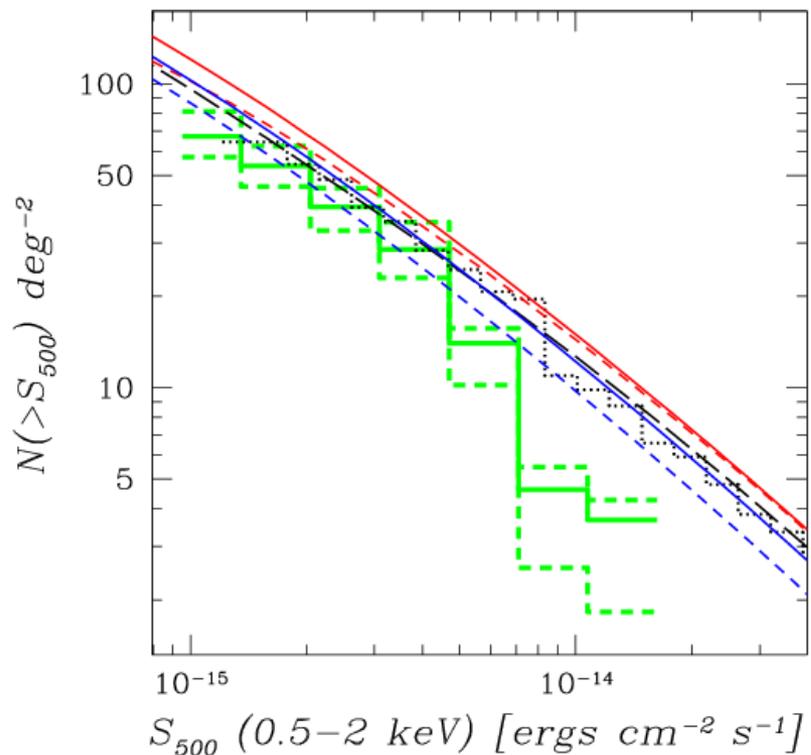
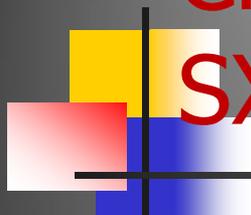
Mass surface density profiles



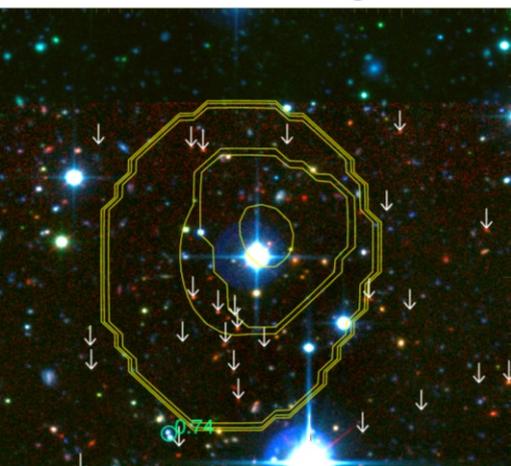
Lx-Mass from weak lensing



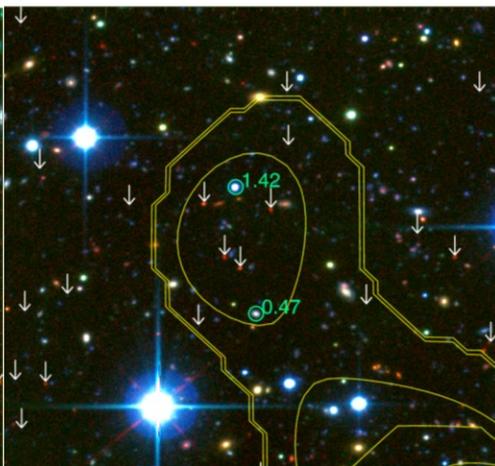
Cluster cosmology: SXDF



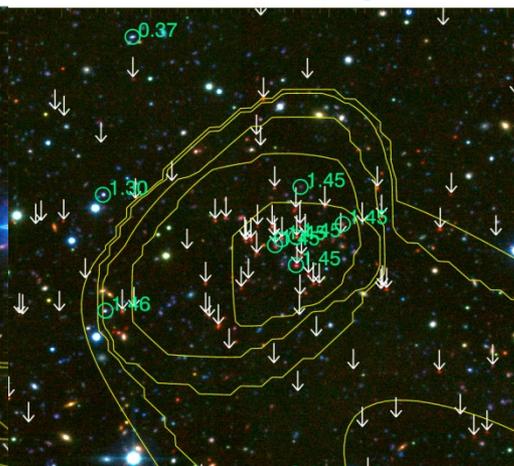
ID = 37, z = 1.16, flag: 5



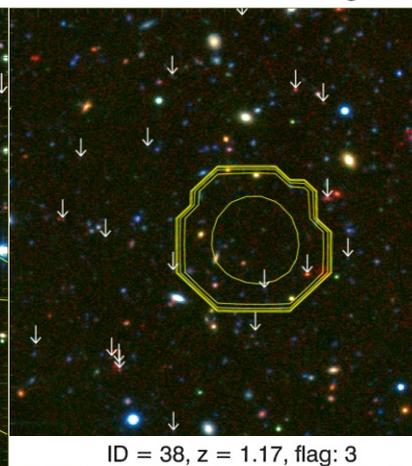
ID = 32, z = 1.40, flag: 3



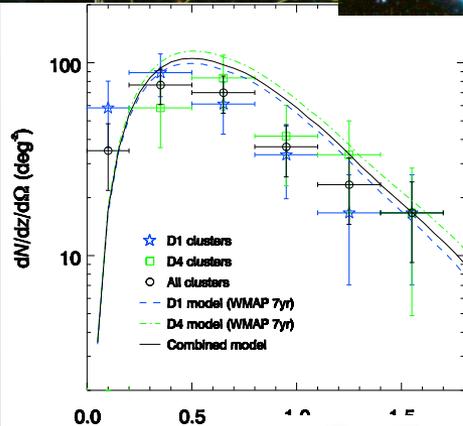
ID = 25, z = 1.45, flag: 3



ID = 15, z = 1.73, flag: 3

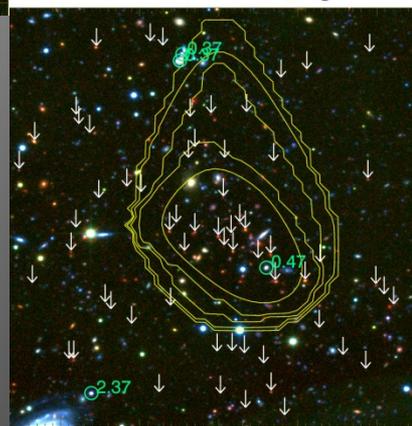


WIRDS

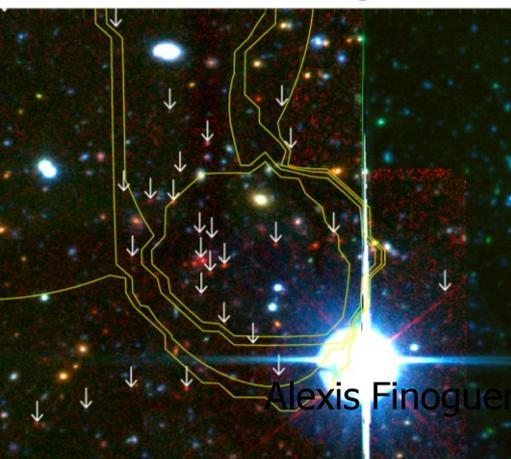


Bielby, AF, et al. subm.

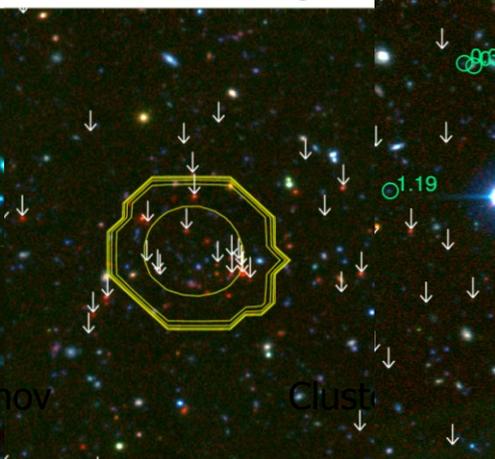
ID = 38, z = 1.17, flag: 3



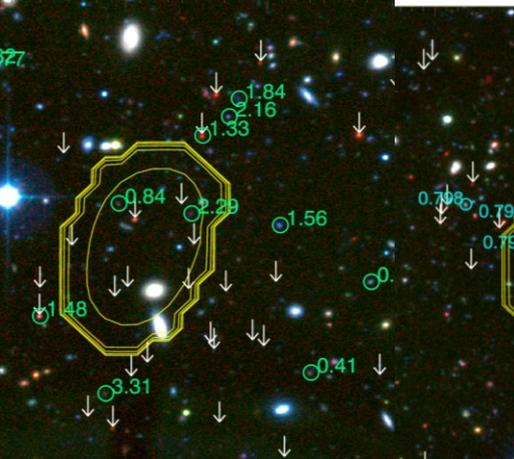
ID = 23, z = 1.45, flag: 2



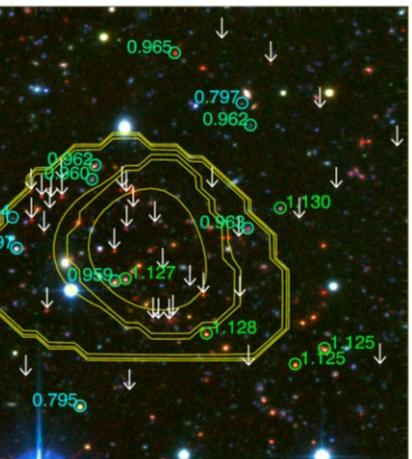
ID = 44, z = 1.39, flag: 3



ID = 48, z = 1.32, flag: 3



ID = 76, z = 1.49, flag: 3



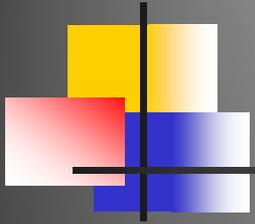
Alexis Finoguenov

Clust

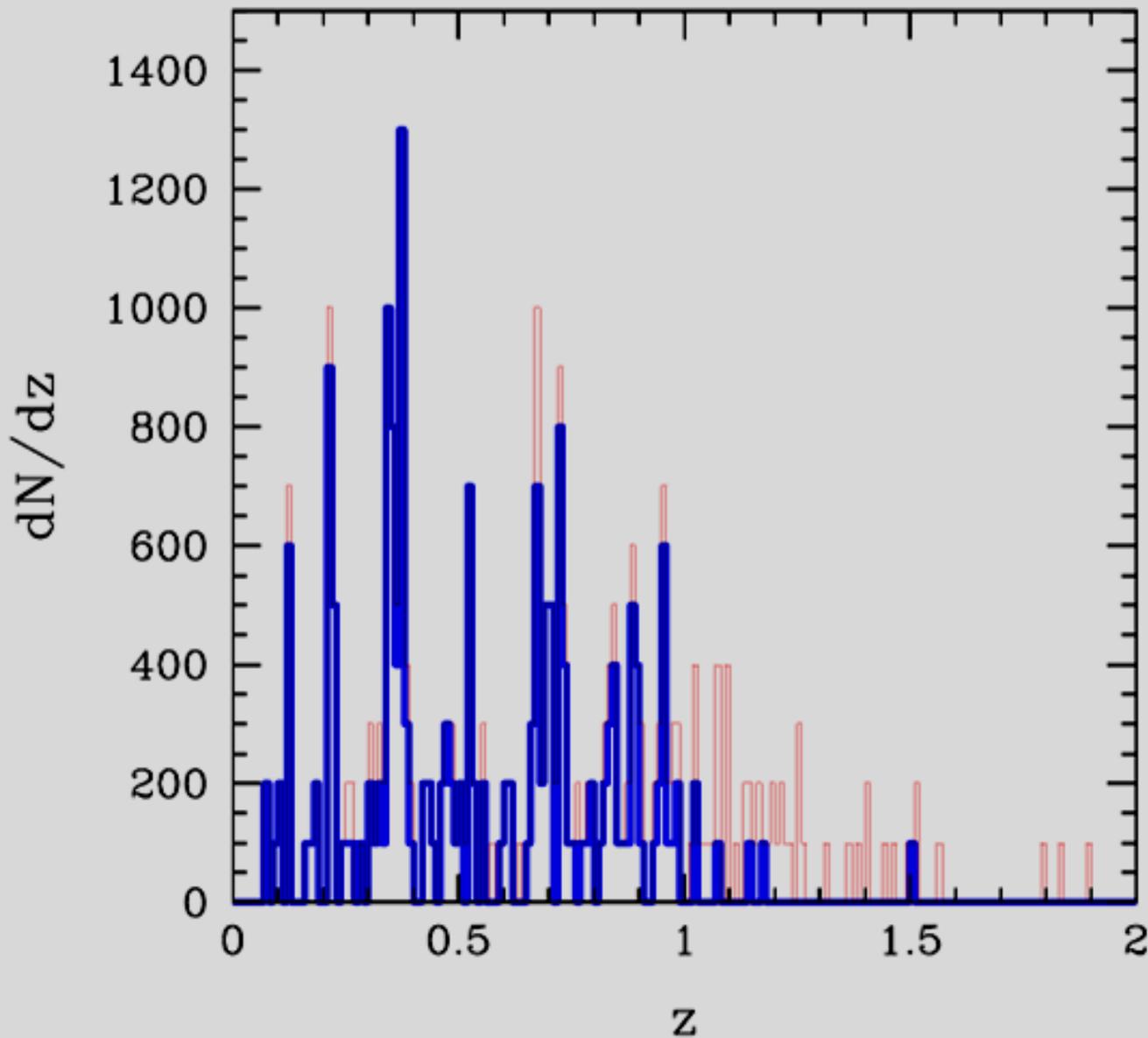


Mdyn=0.6-1.1e14 Msun
Mx=6.e13Msun
Tanaka, AF, Ueda 2010

Breaking
the
record
on the
highest
redshift
X-ray
selected
cluster



X-ray vs spectroscopic groups



X-ray+red sequence:
278

Xray+spectroscopy:
195

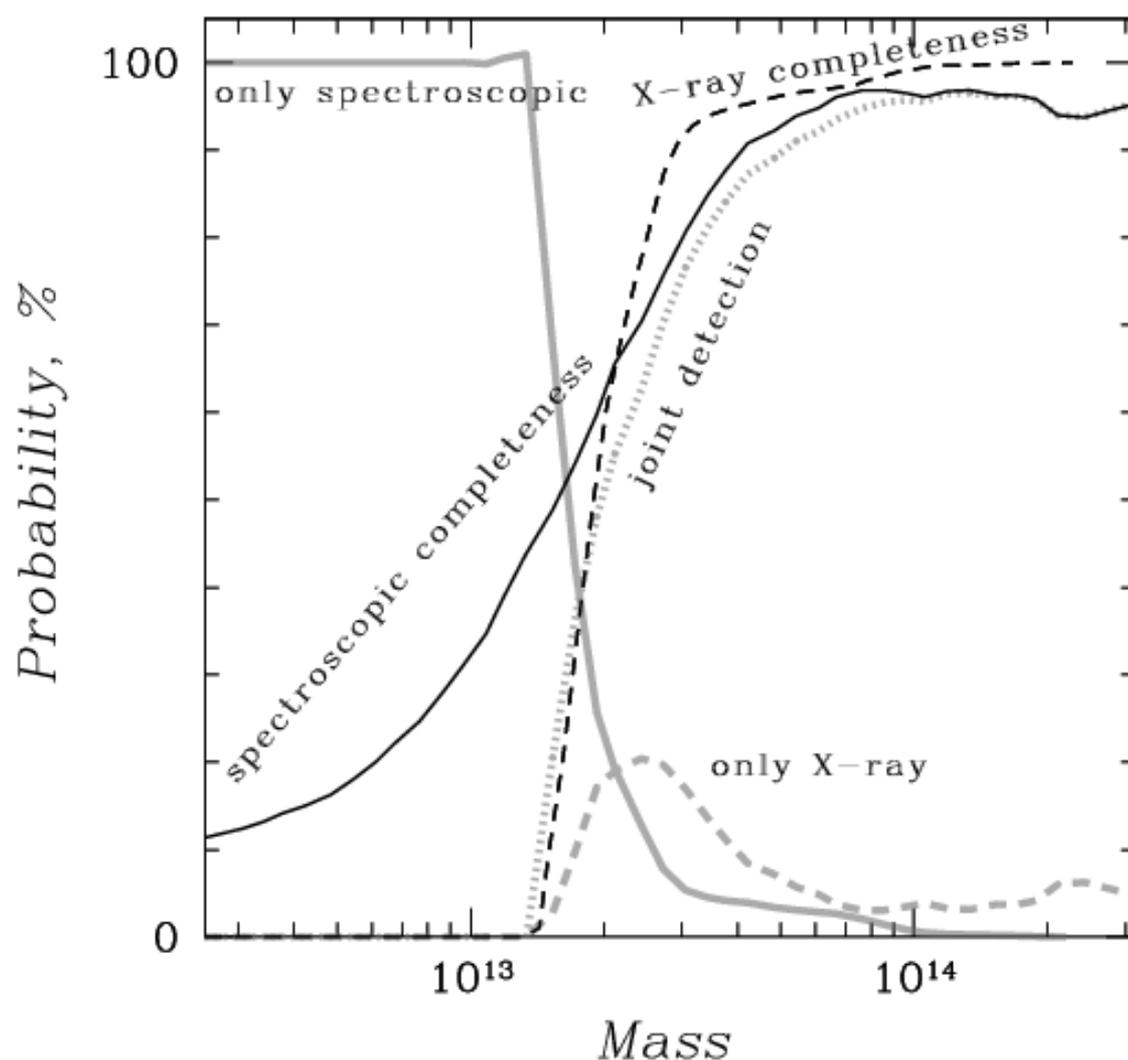
$z < 0.8$ 152/175 91%

$0.8 < z < 1$ 37/50 74%

$z > 1$ 6/53 11%

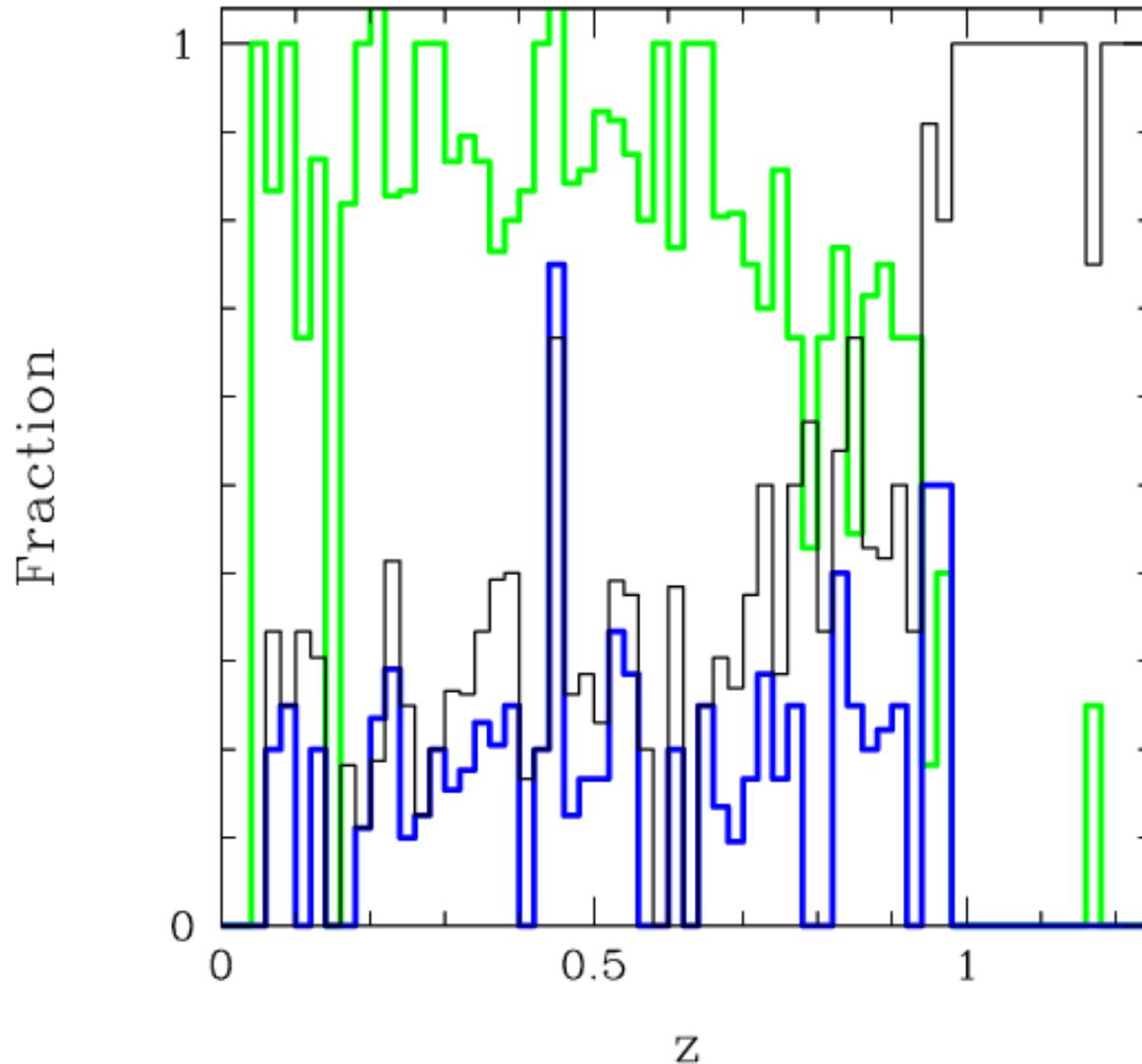
$N(z) \Rightarrow 2$

How X-ray groups are different from spectroscopic groups?



Spec. completeness is better at low z
But drops faster with redshift

Comparison of a group definition



X-ray only

Spec-z groups with X-rays

Spec-z 3 member groups,
no X-rays: stacked X-ray
signal @ $<2.e-16$

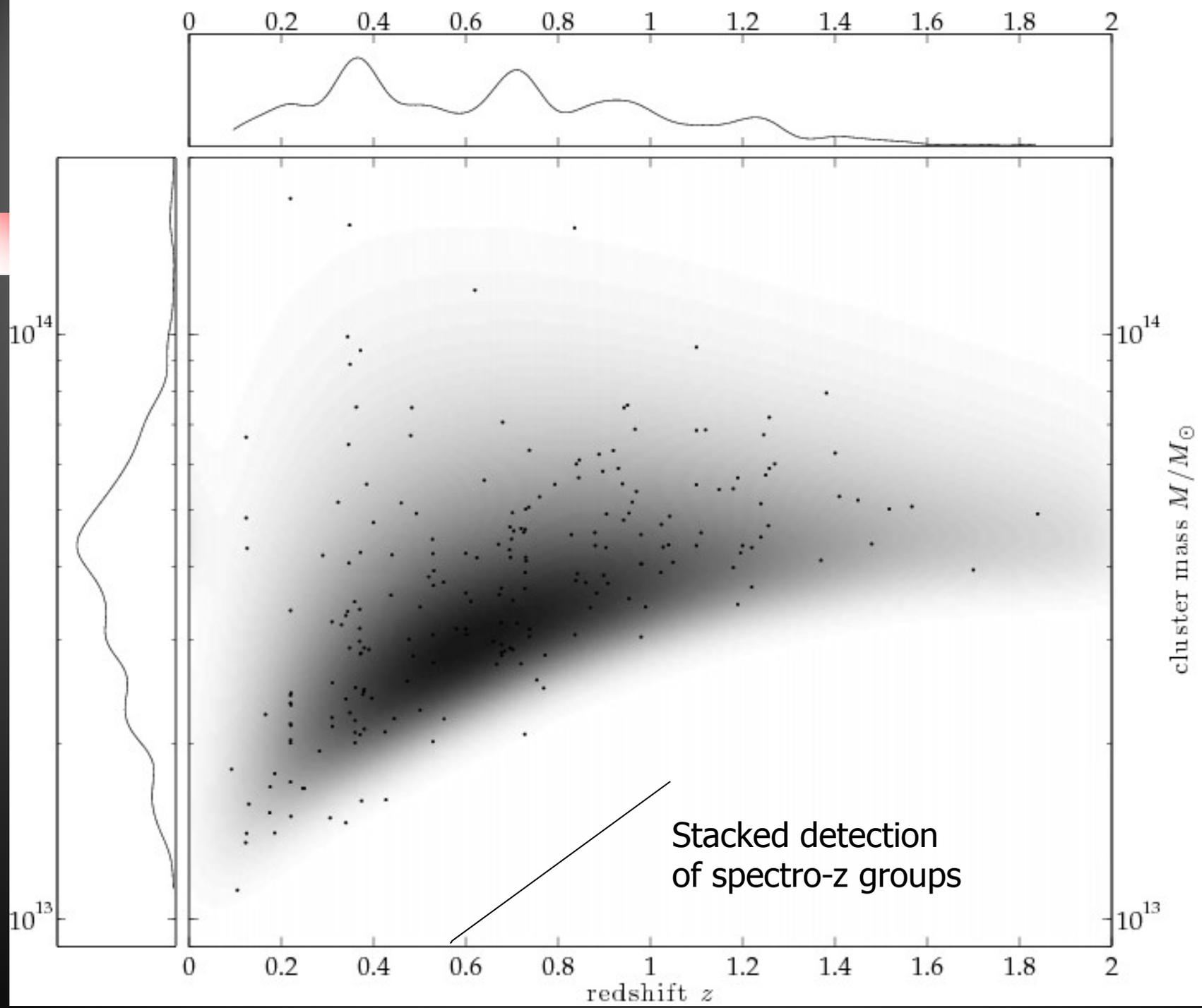
@ $z > 0.8$ X-rays ($\sim 6.e-16$
cgs) are more

sensitive group tracer
compared to $I_{AB} < 22.5$
galaxies

6 groups follow-up
returning 25 members

Inside dense LSS

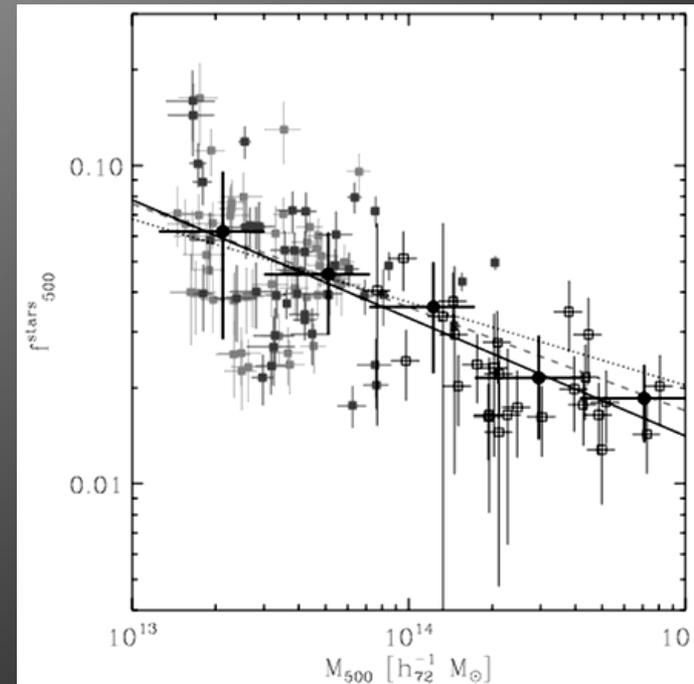
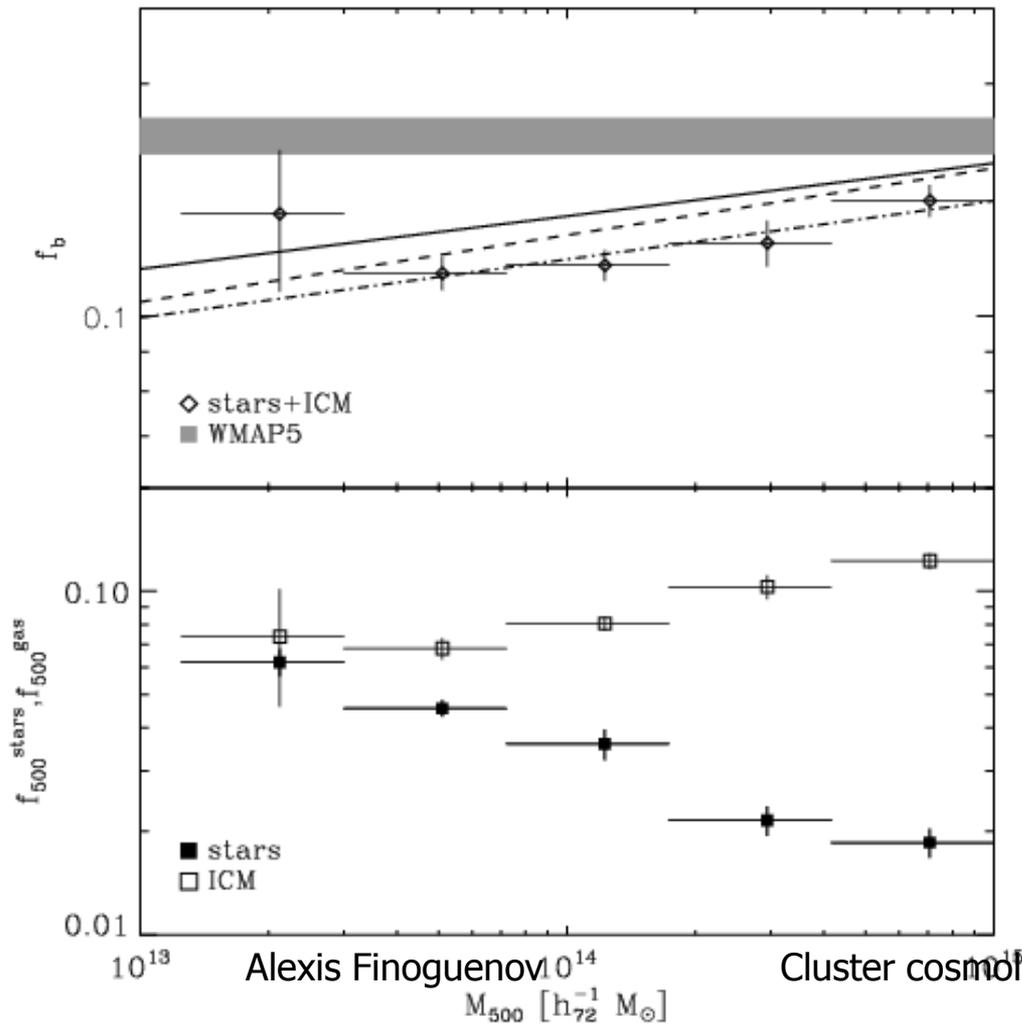
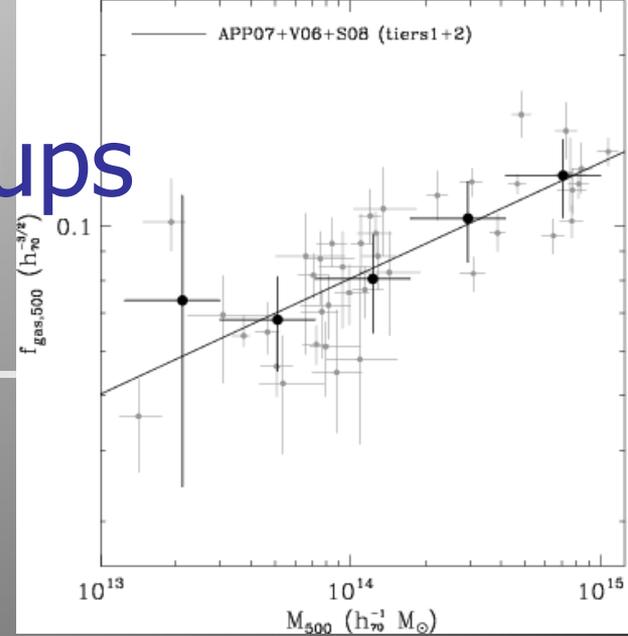
Fraction of X-ray groups
increases by a factor of 2



Stellar content of galaxy groups

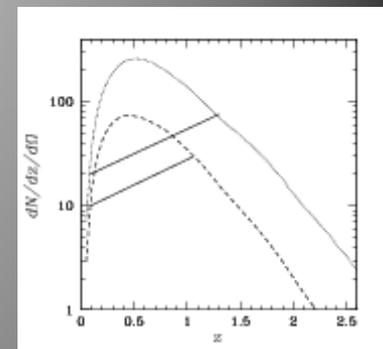
Giodini, et al. arXiv0904.0448

Less gas



More stars

Conclusions



I presented how modern X-ray surveys identify dark matter halos through their X-ray emission

- **We used the stacked weak lensing to calibrate the mass-observable relation**
- **An application to cosmology is shown with 5% constraint on σ_8**
- **Need a better precision on σ_8 from CMB in order to constrain the non-Gaussianity**
- **The record breaking X-ray cluster is found at $z=1.623$**
- **Deeper observations of COSMOS are needed to extend the weak lensing calibration to $z \sim 1.5$**