The dynamical and cool core state of Planck SZ-selected clusters

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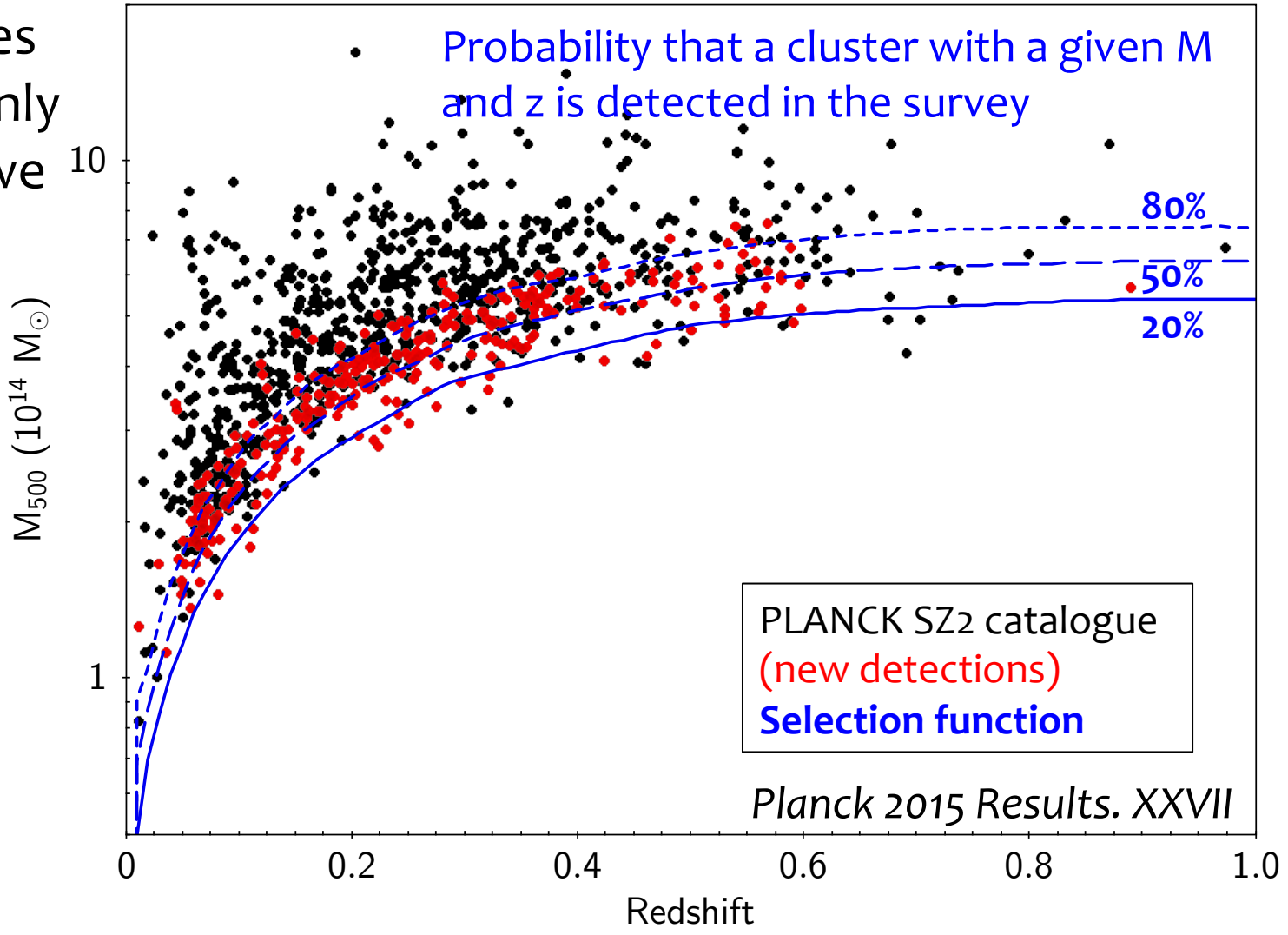
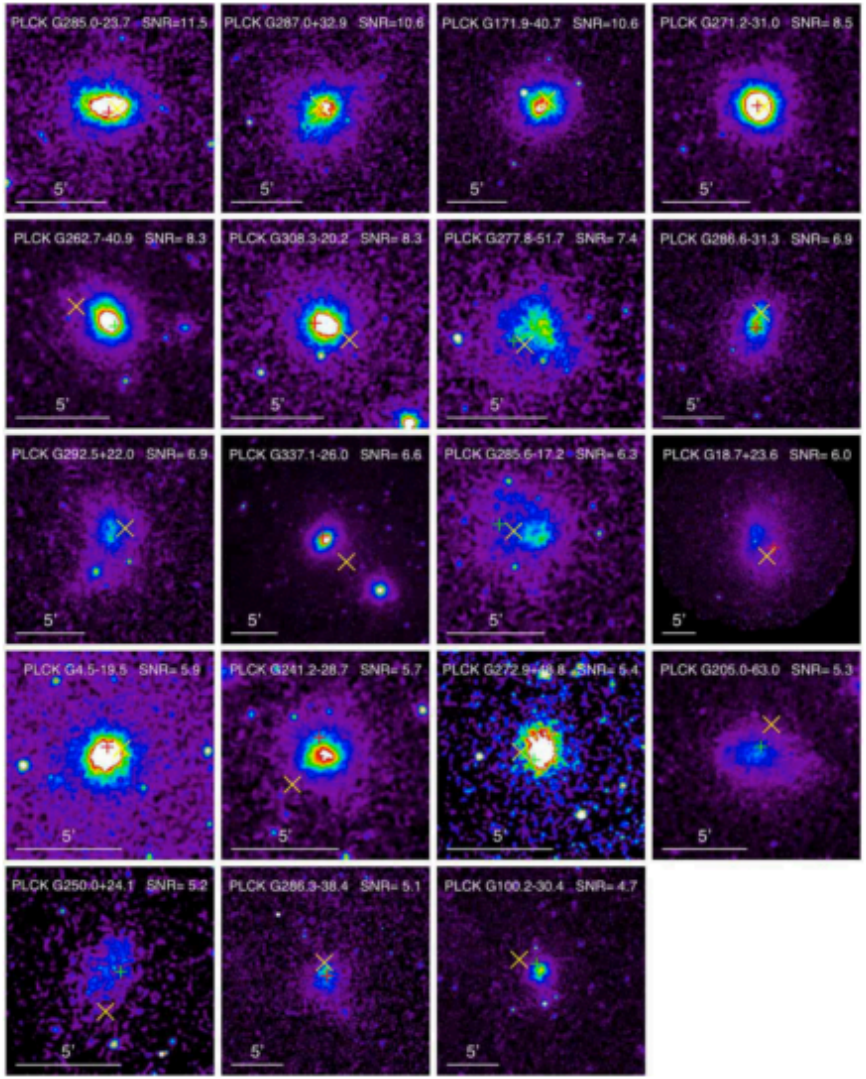
INAF

Selection function

If the object selection does not depend only on M and z, we need to be careful



A selection bias?



"The majority of newly discovered Planck clusters show evidence for significant morphological disturbances"

(Planck Collaboration 2011, Planck Early results IX)

* **Do we expect the Planck selection to be biased towards disturbed objects?**

A selection bias?

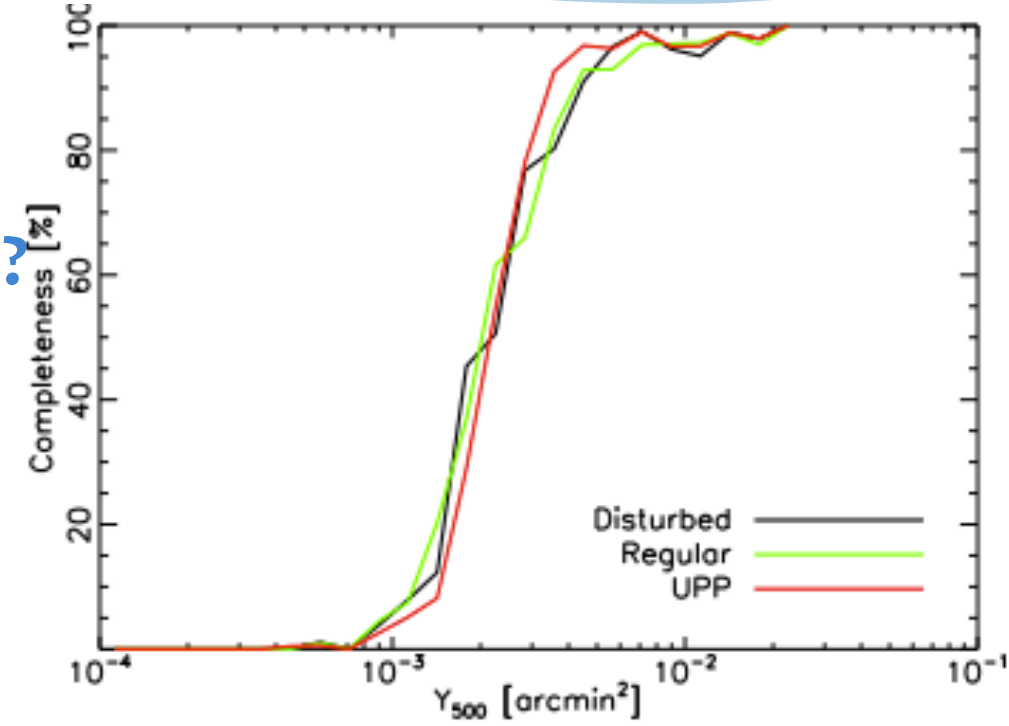
* **Do we expect the Planck selection to be biased towards disturbed objects?**

Test with MC simulations:

Injection of SZ maps of disturbed/relaxed clusters in simulated sky.

No significant differences in the selection function.

(Planck 2015 Results, XXVII)



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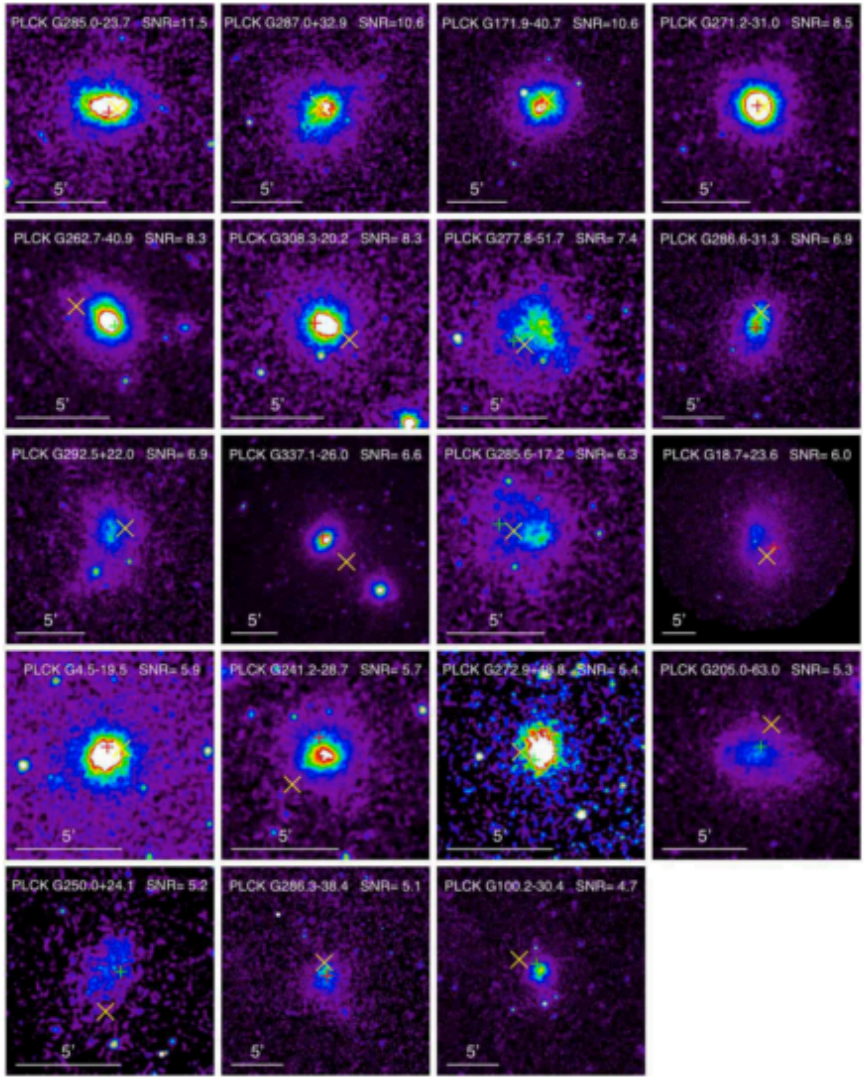


"The majority of newly discovered Planck clusters show evidence for significant morphological disturbances"

(Planck Collaboration 2011, Planck Early results IX)

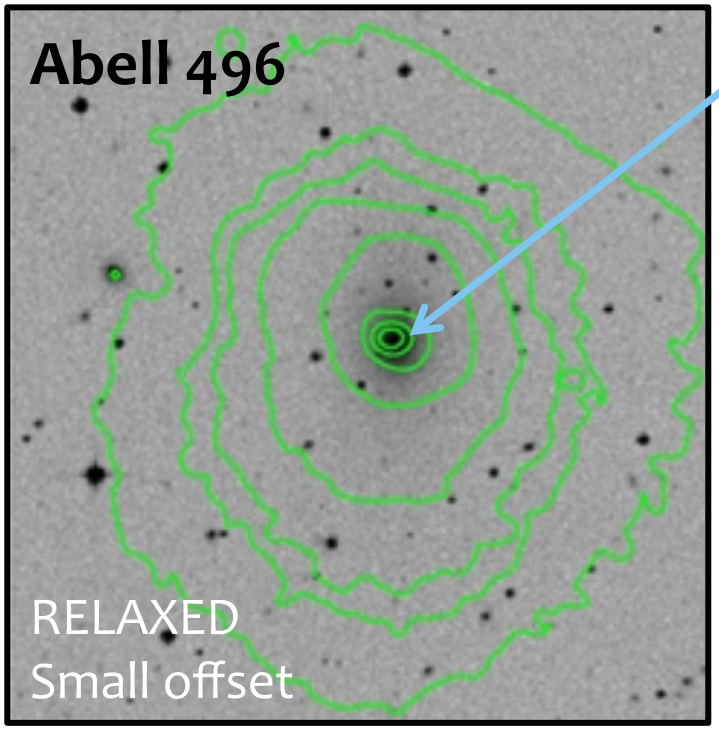
* **Do we expect the Planck selection to be biased towards dist. objects?** **NO**
* **Are Planck SZ-selected clusters really more dynamically disturbed than expected?** **Compare with X-ray selected samples**

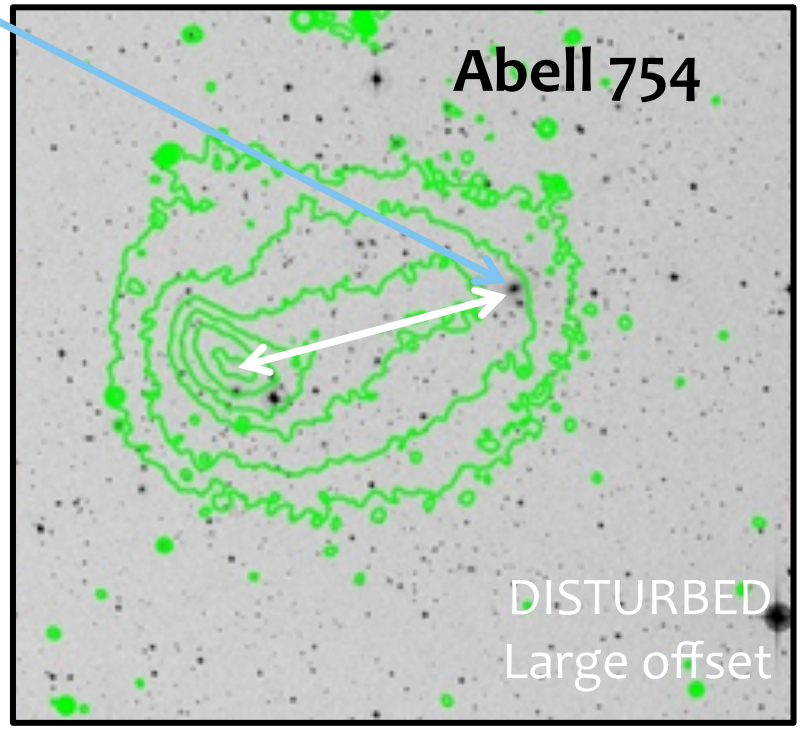
The method (I)

Offset between X-ray peak and BCG* position as a dynamical indicator

(Hudson et al 2010, Sanderson et al 2009, Mann & Ebeling 12)

*BCG= Brightest Cluster Galaxy





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The sample (I)

Starting point:

PSZ1 cosmological sample

189 clusters with S/N > 7, at high galactic latitude

(Planck 2013 results XX)

Further cut in S/N: S/N>8

Mimics Planck Selection

Allows a more complete X-ray + optical information

132 clusters

128 with public X-ray (Chandra or XMM) observations and BCG identification (literature + archival analysis)

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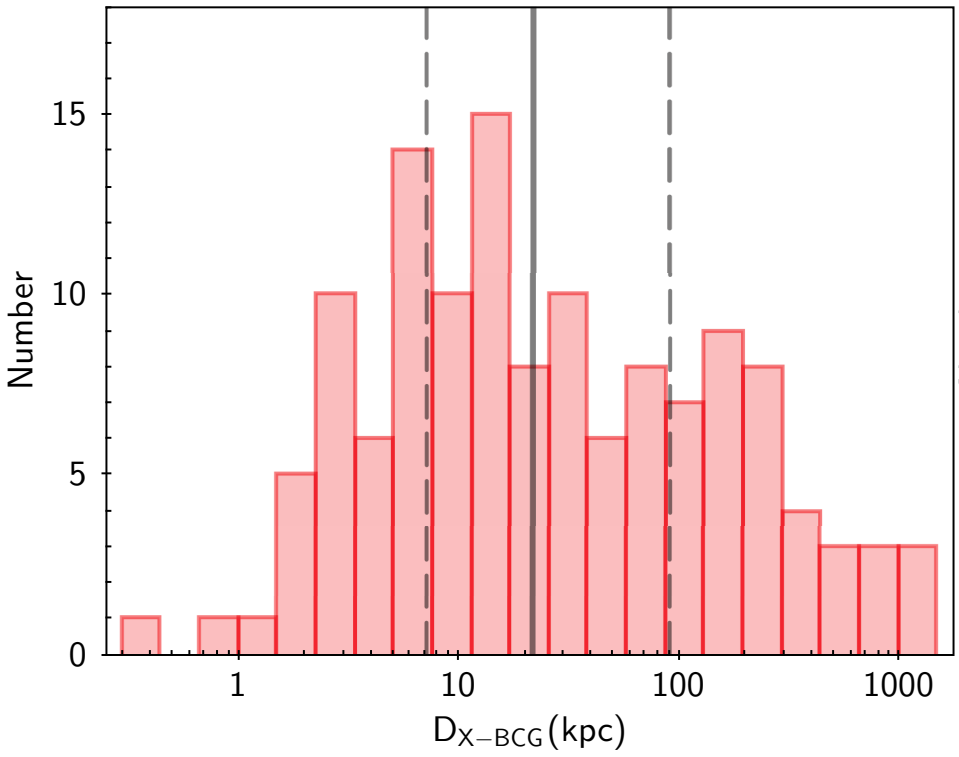
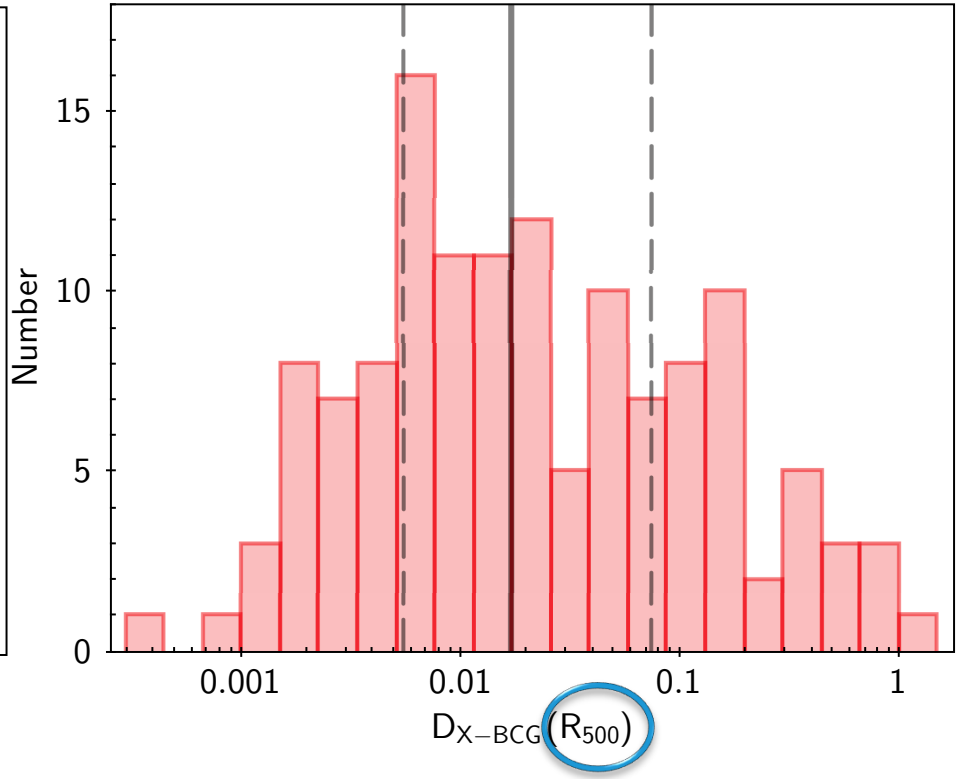
Results (I)





Radius containing a mean density 500 times $\rho_c(z)$

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SZ vs X-ray samples (I)

Literature information on the BCG – Xray peak offset available for many samples, often with heterogeneous selection.

We compared only with purely X-ray selected samples

eMACS *(Mann & Ebeling 2012)*:

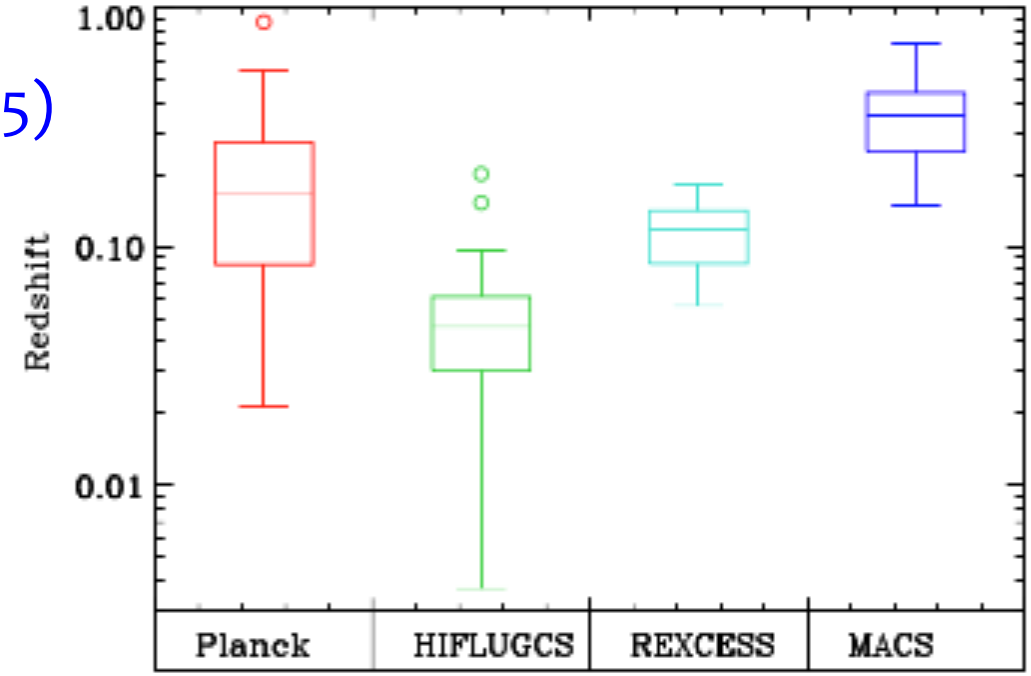
108, most massive high-z (>0.15) objects in RASS data

HIFLUGCS *(Zhang+, 2011)*:

62, Brightest X-ray clusters, local, low mass objects

REXCESS *(Haarsma+2010)*:

30, intermediate luminosity and z



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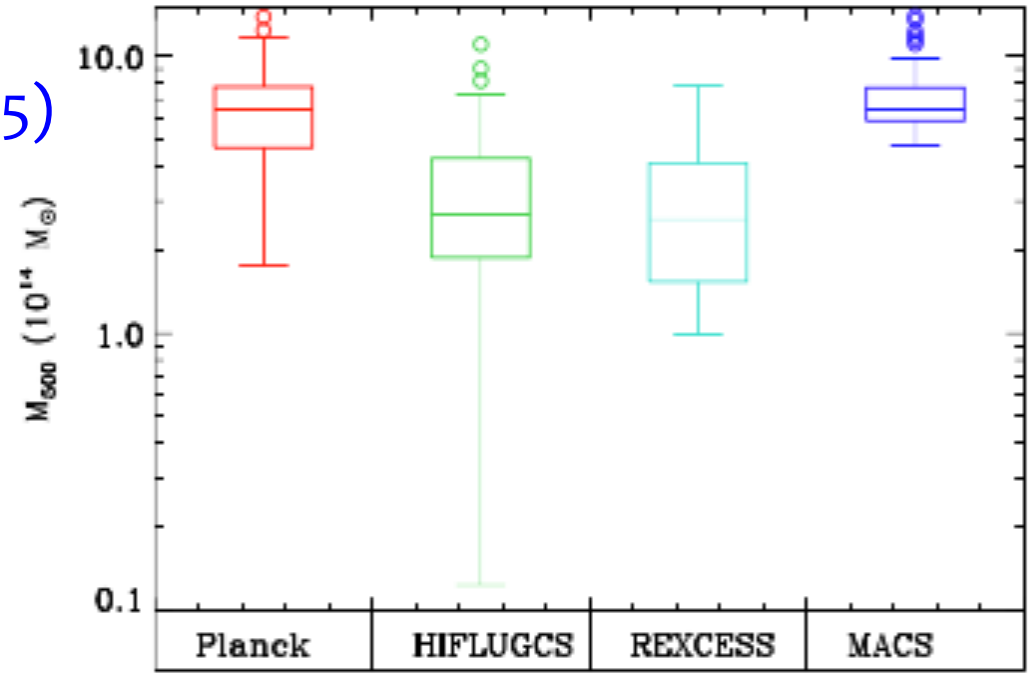

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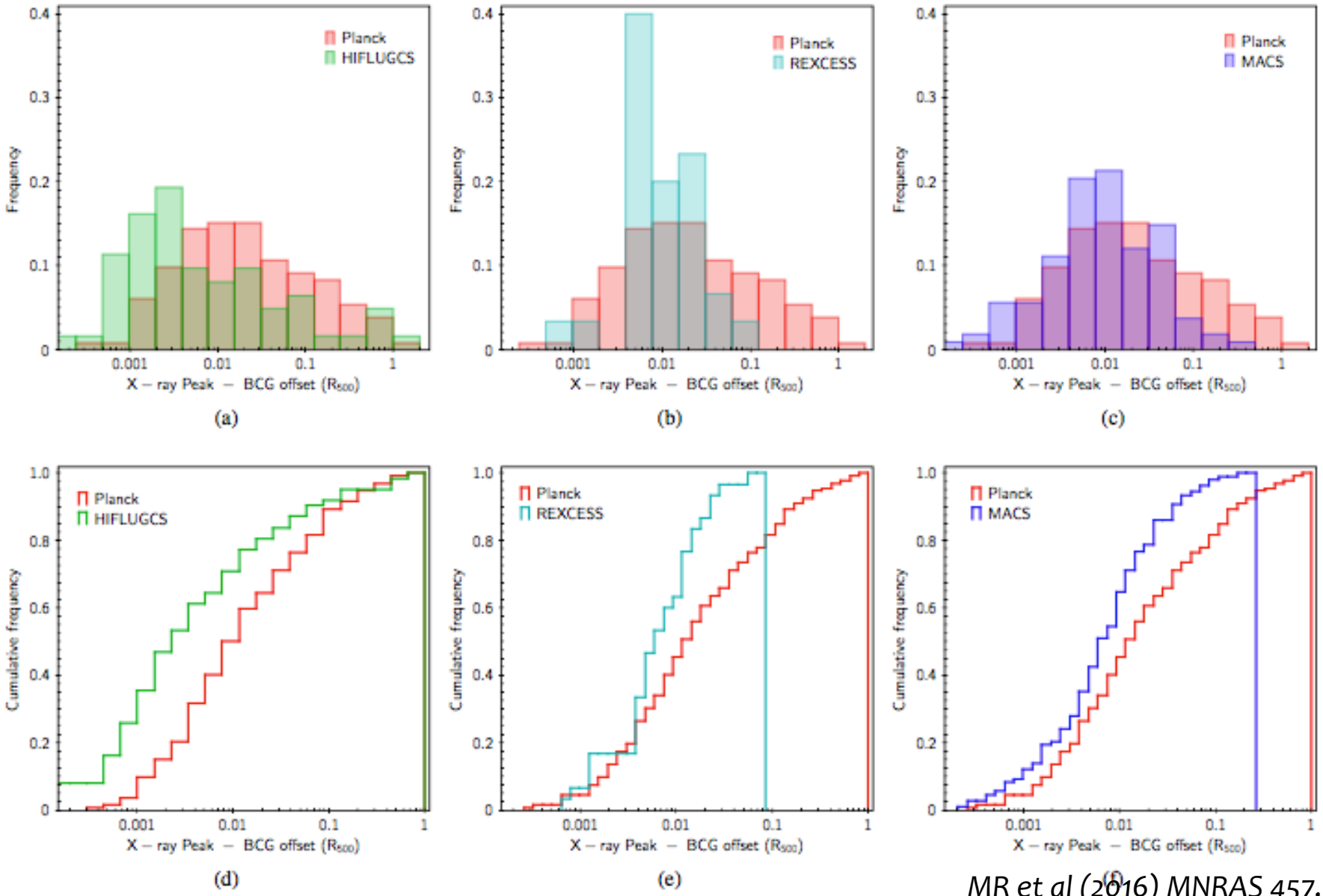

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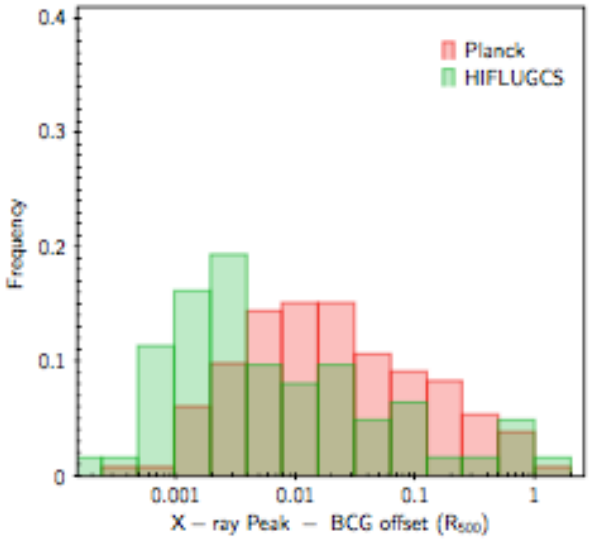
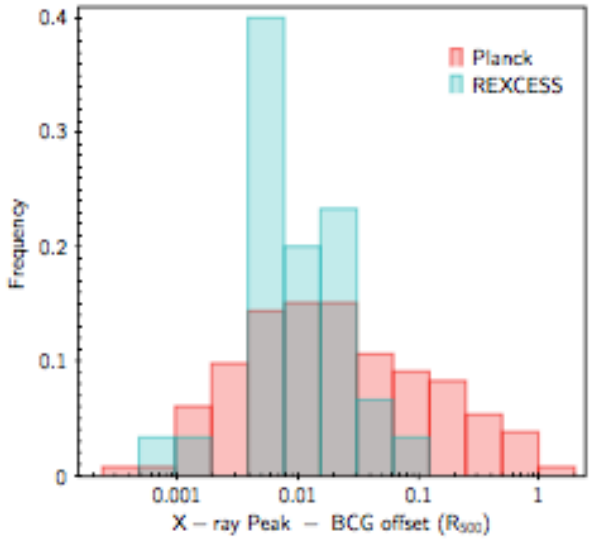


Kolmogorov-Smirnov test

KS Statistic=0.336

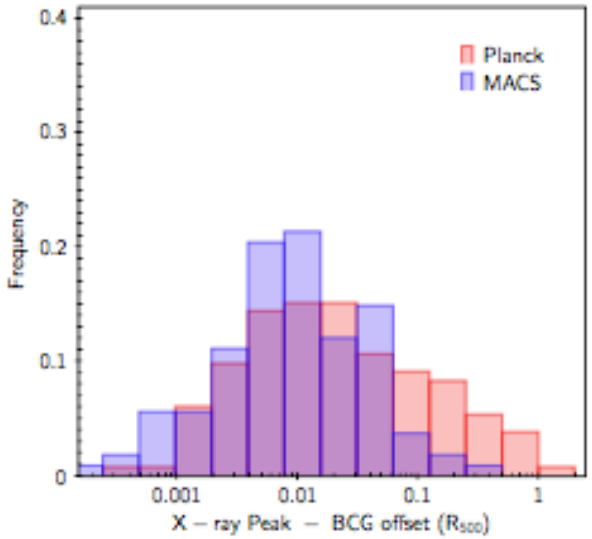
Null hypothesis prob=**0.01%**



Kolmogorov-Smirnov test

KS Statistic=0.297

Null hypothesis prob=**2%**



Kolmogorov-Smirnov test

KS Statistic=0.228

Null hypothesis prob=**0.4%**

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Results (I)

"Relaxed" Clusters: Offset < 0.02 R_{500} *(Sanderson et al 2009)*

According to X ray peak – BCG offset:

Fewer "relaxed" objects in our sample than in X-ray selected samples

Indication of differences in SZ vs X-ray sample

	Relaxed fraction	Rel. Frac null hyp prob
Planck	68/132 (52±4%)	
HIFLUGCS	46/62 (74±5%)	**0.05%**
eMACS	79/108 (73±4%)	**<0.001%**
REXCESS	23/30 (77± 7%)	**0.2%**

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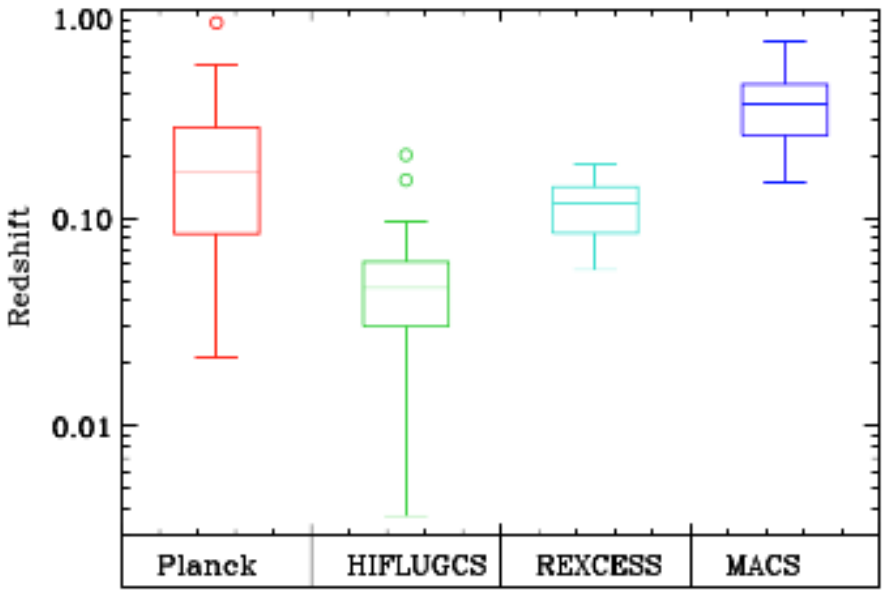
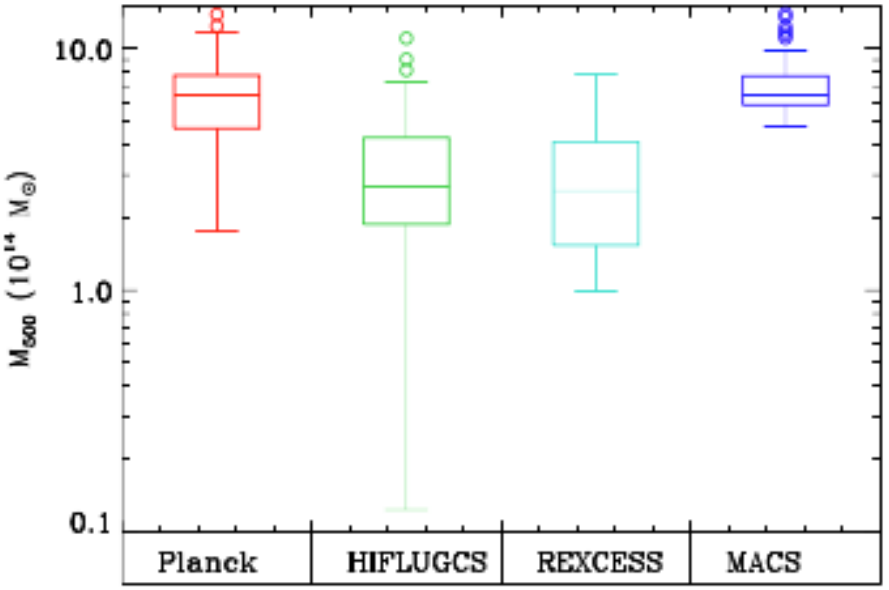
Evolution vs selection effects





Differences between Planck and SZ samples due to different mass and redshift distribution?

* $D_{X\text{-}BCG}$ distribution in Planck sample different from ALL X-ray samples

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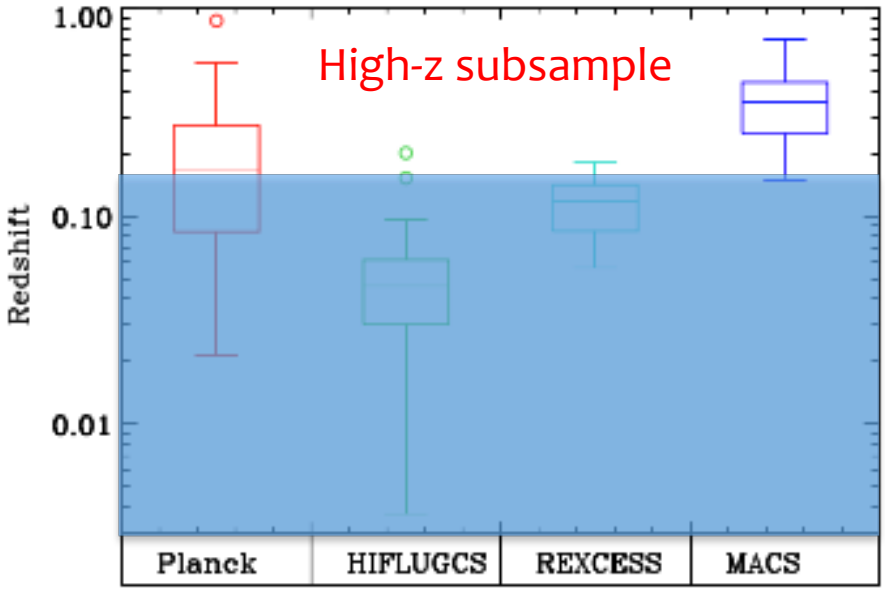

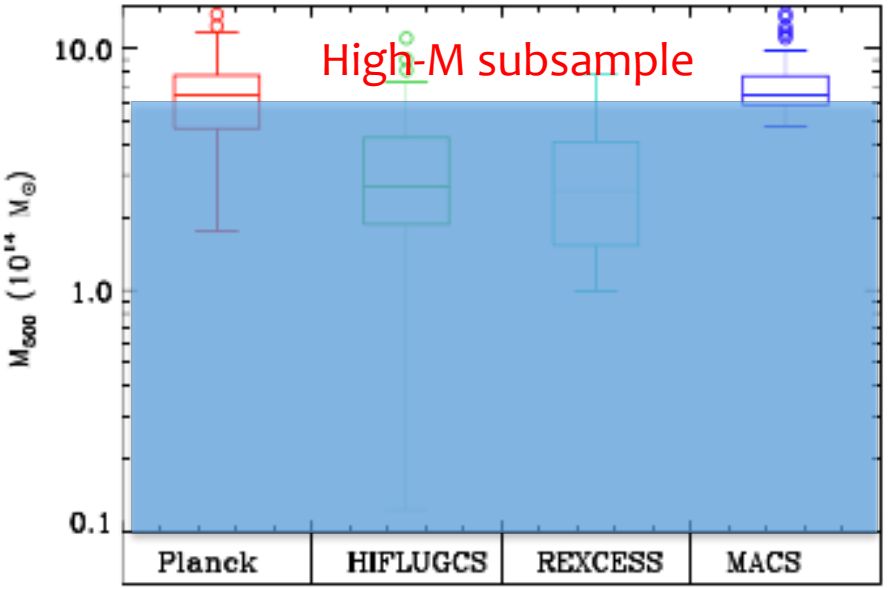

Differences between Planck and SZ samples due to different mass and redshift distribution?

* $D_{X\text{-}BCG}$ distribution in Planck sample different from ALL X-ray samples
* Compare high-z and high-M subsample from Planck and eMACS: differences still remain

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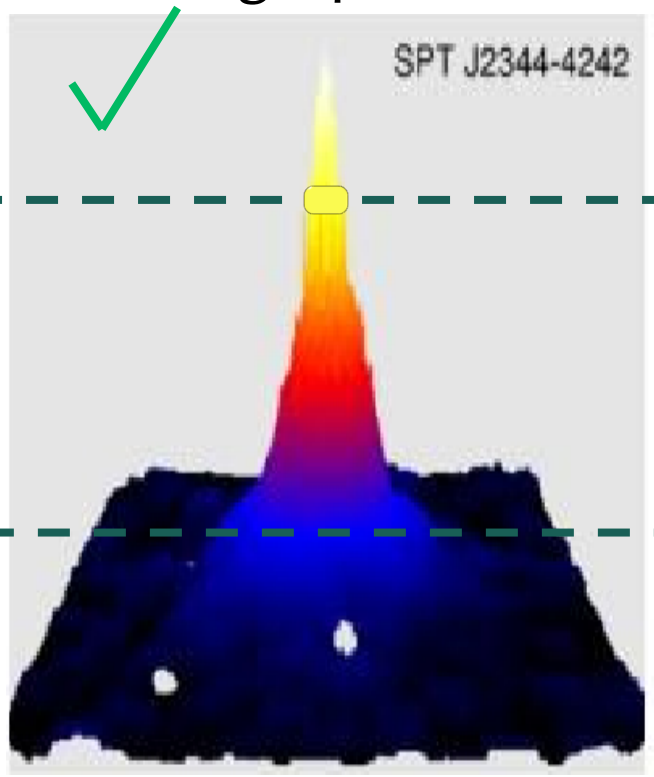
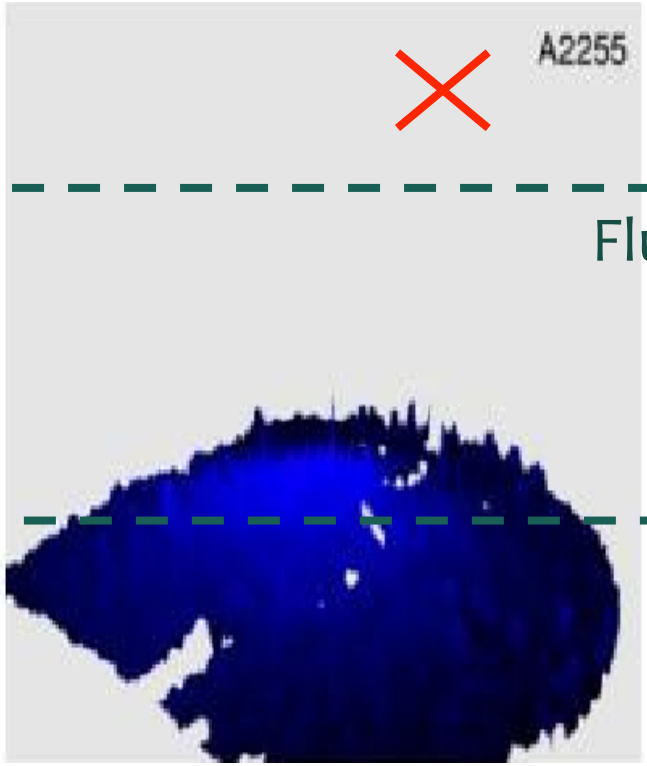
Cool core bias

Relaxed clusters usually feature a centrally peaked density profile, causing a prominent surface brightness peak





Flux limit

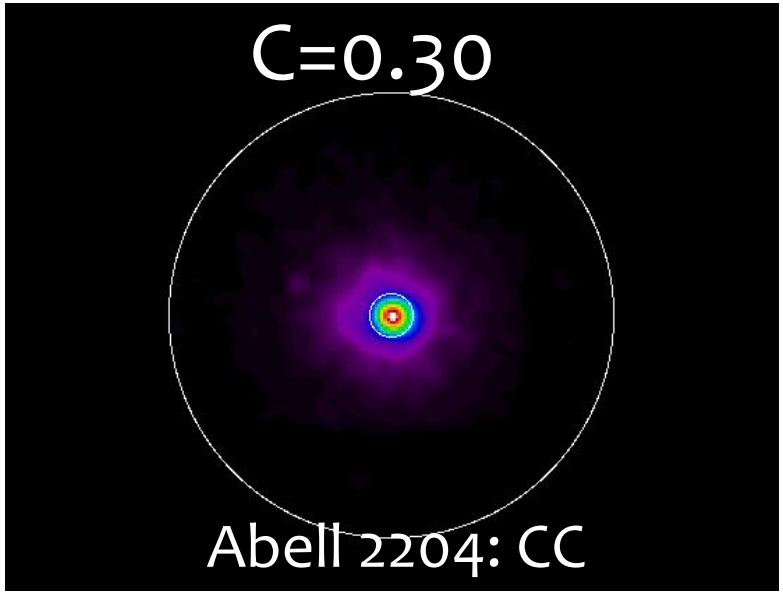
It affects X-rays surveys ($I_x \approx n_e^2$,Eckert et al 2010) and is predicted to be small in SZ-surveys ($I_{SZ} \approx n_e$, Lin et al 2015, Pipino & Pierpaoli 2010), especially with Planck (beam size much larger than core size)

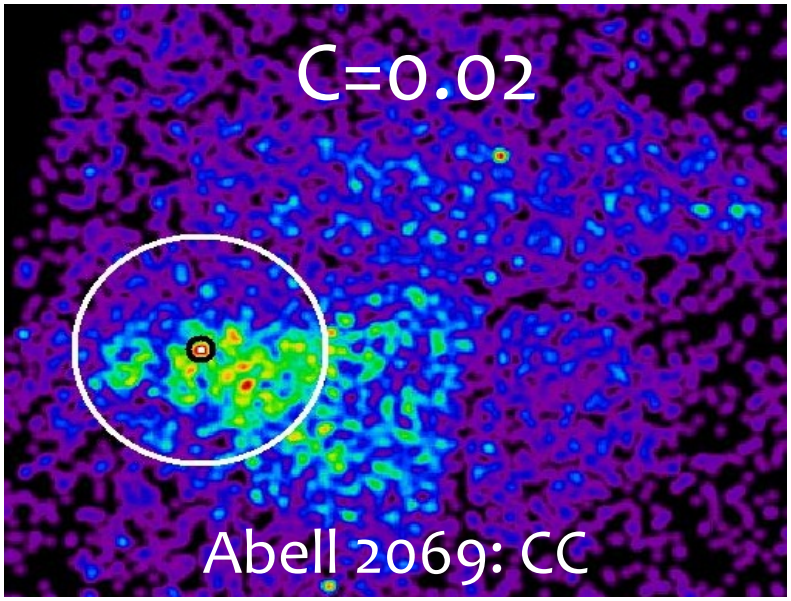
Method (II)

$D_{X\text{-}BCG}$ is not a direct indicator of the presence of a prominent density peak

Redo the analysis with the concentration parameter (Santos et al 2008)

$$c = \frac{I(R < 40\ \mathrm{kpc})}{I(R < 400\ \mathrm{kpc})}$$





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Sample:

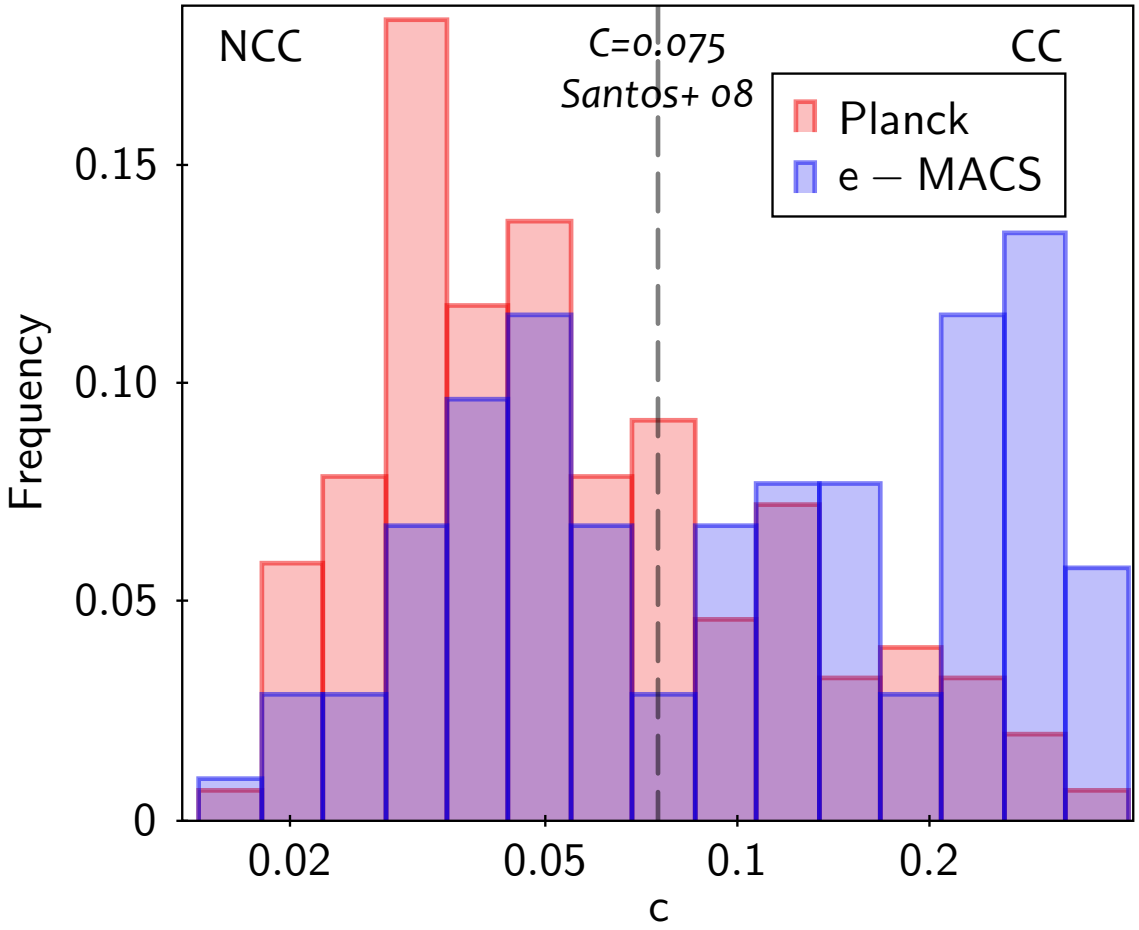
* Based on the PSZ1 cosmo catalogue (189 high S/N objects)
  * 153 clusters with Chandra observations

Work in progress:

including also XMM data for the missing clusters

Results (II)

Comparison with 104 eMACS clusters (Mann & Ebeling 2012) on which we performed the same Chandra analysis



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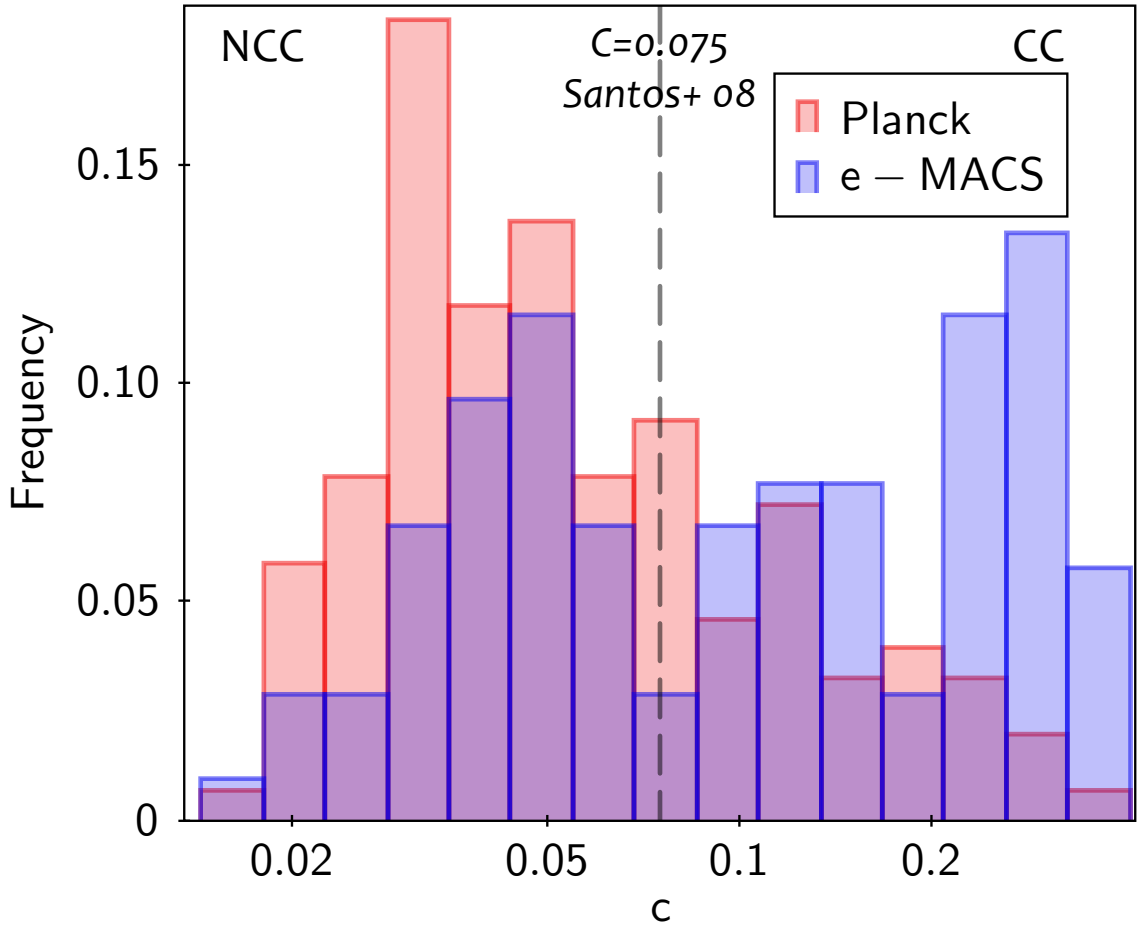


Cool core fraction

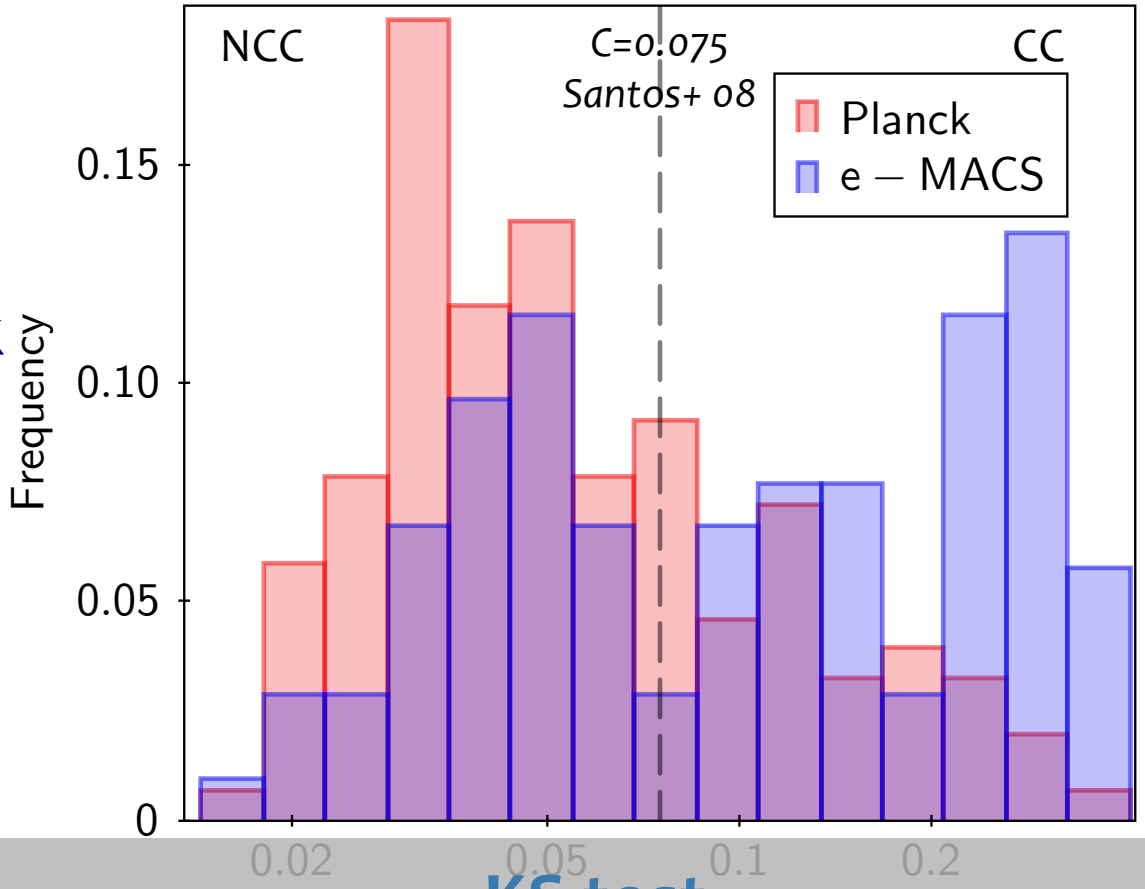
Planck: (31 +/- 4)%

eMACS: (59 +/-5)%

Results (II)

Comparison with 104 eMACS clusters (Mann & Ebeling 2012) on which we performed the same Chandra analysis

Even more significant difference btw Planck and MACS than with $D_{X\text{-}BCG}$



Cool core fraction

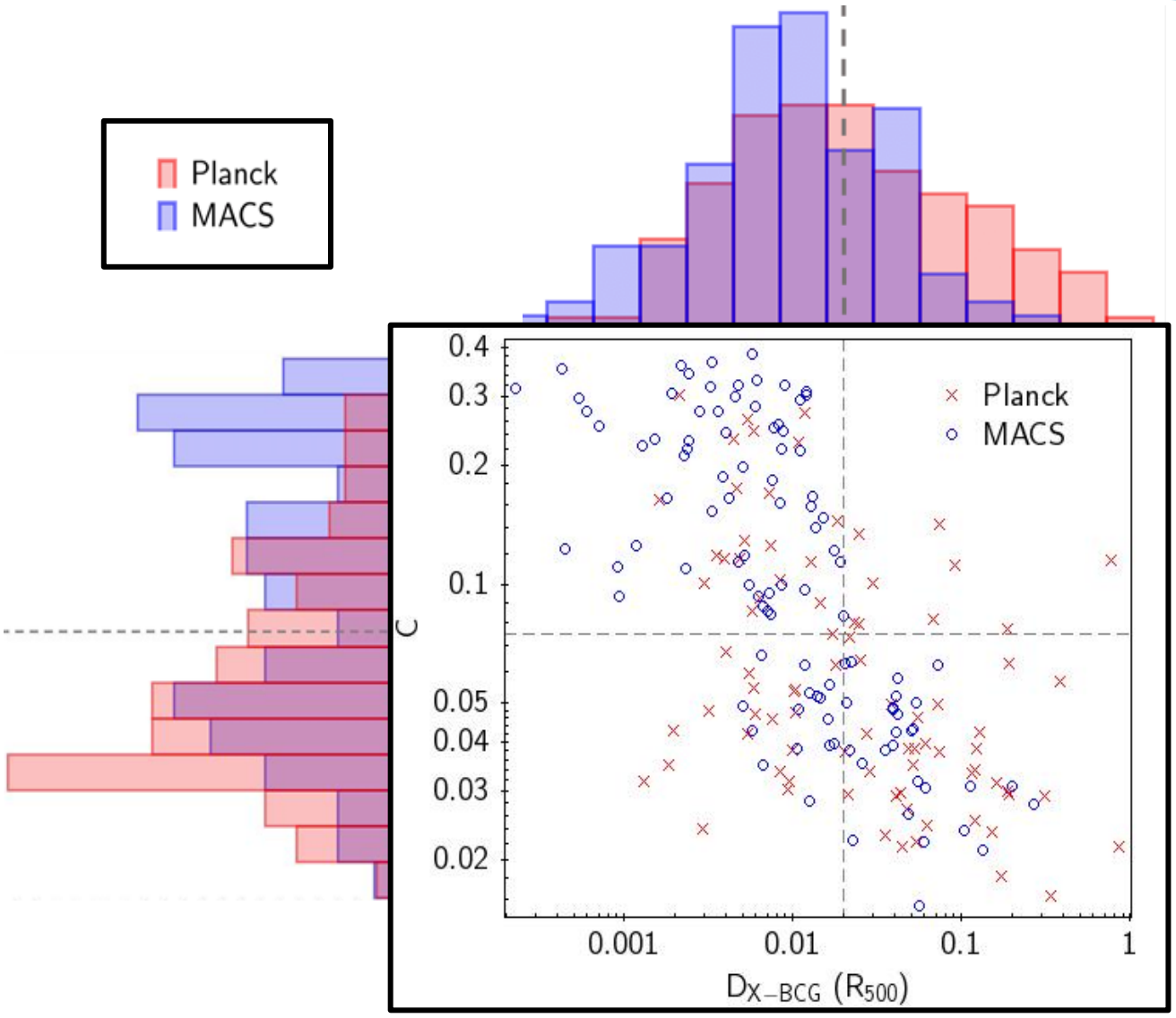
Planck: (31 +/- 4)%

eMACS: (59 +/-5)%

KS test

KS statistic D=0.33, Null hyp. Prob. $p_0=1.5\ 10^{-6}$

Results (III)



More cool core and relaxed objects in eMACS than in Planck

2D KS test

$P_o = 3.7\ 10^{-4}$

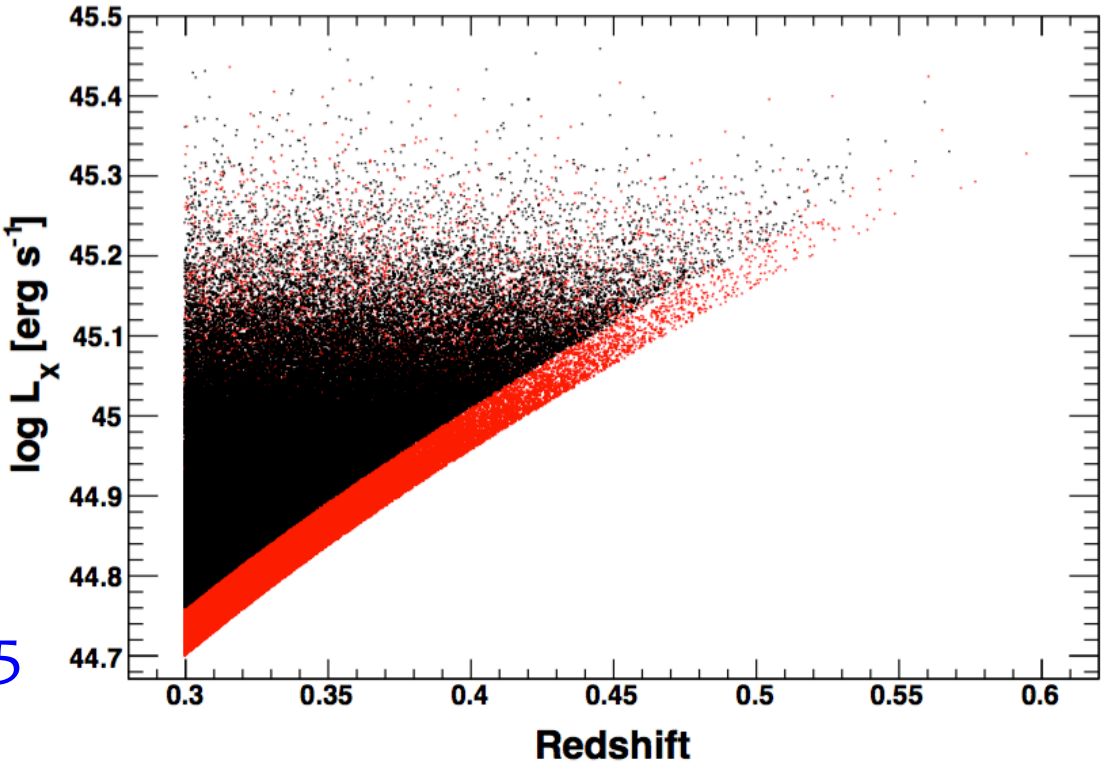
Simulations

We can simulate the CC-bias in flux-limited X-ray surveys (Eckert et al 2010).

Assuming the real CC fraction is 0.3, what is the CC fraction in a eMACS-like survey?

0.47-0.54

Observed eMACS 0.59+/-0.05



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Summary

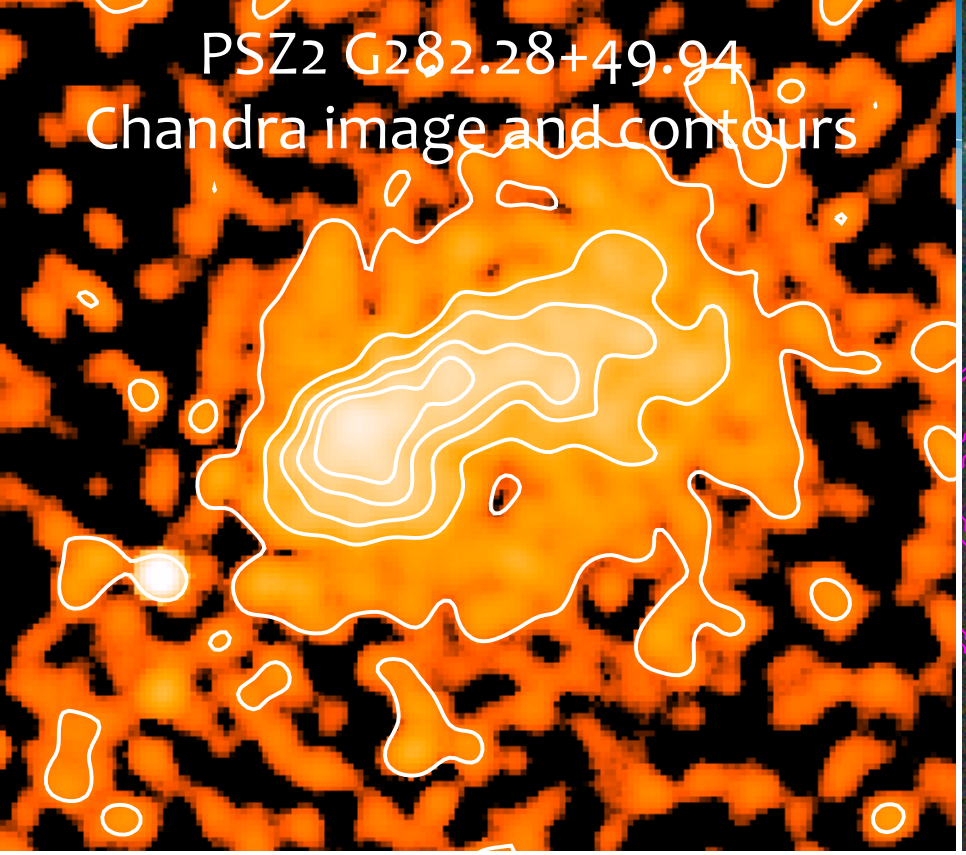
* We measured the dynamical and CC state of Planck Clusters
* Different distribution in Planck sample and X-ray selected samples
* Smaller fraction of relaxed and CC objects in Planck
* Not an evolution effect: selection effect (CC bias) affecting X-ray surveys
* Can we reproduce it with simulations? Work in progress

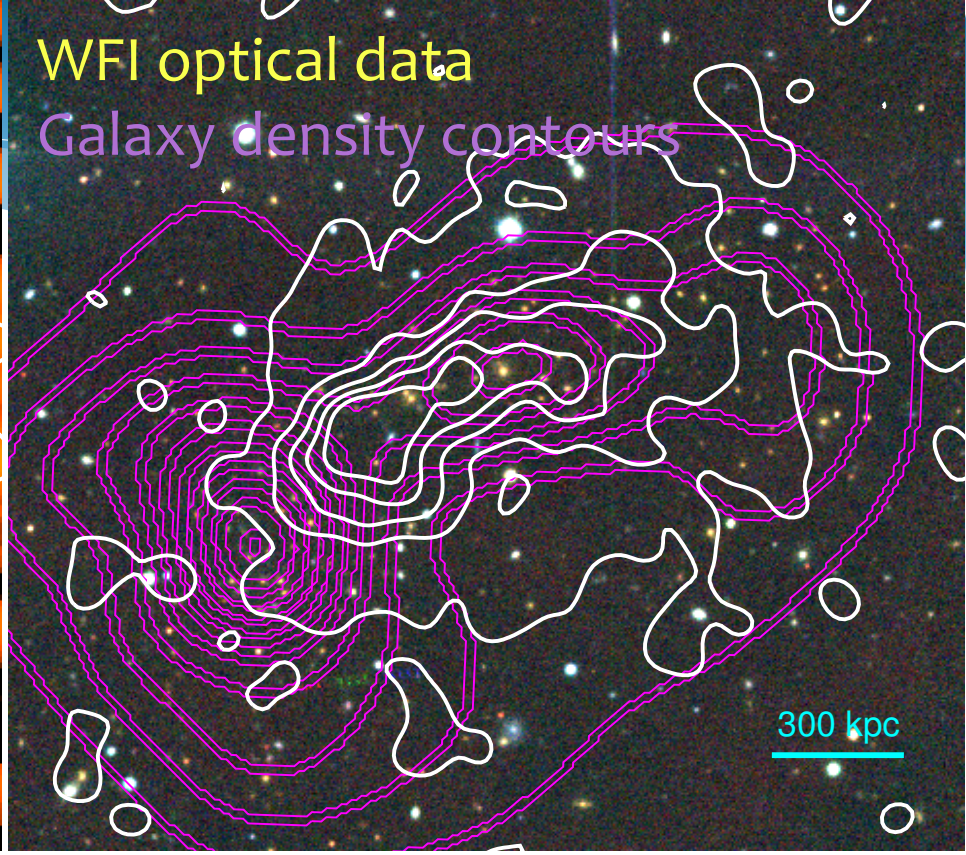
MR et al. (2016) MNRAS 457,4515

MR et al. in preparation

Electronic tables at:

http://cosmo.fisica.unimi.it/persone/mariachiara-rossetti/measuring-the-dynamical-state-of-planck-sz-selected-clusters/





Chandra program to follow-up the most massive and high redshift (z>0.5) clusters in the Planck survey (AO15 PI MR)

PSZ2 G282.28+49.94, z=0.57
350 kpc separation btw X-ray peak and galaxy concentration

A new bullet cluster?