XMM-Newton Cluster Survey (XCS)

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on behalf of the **XCS** collaboration:

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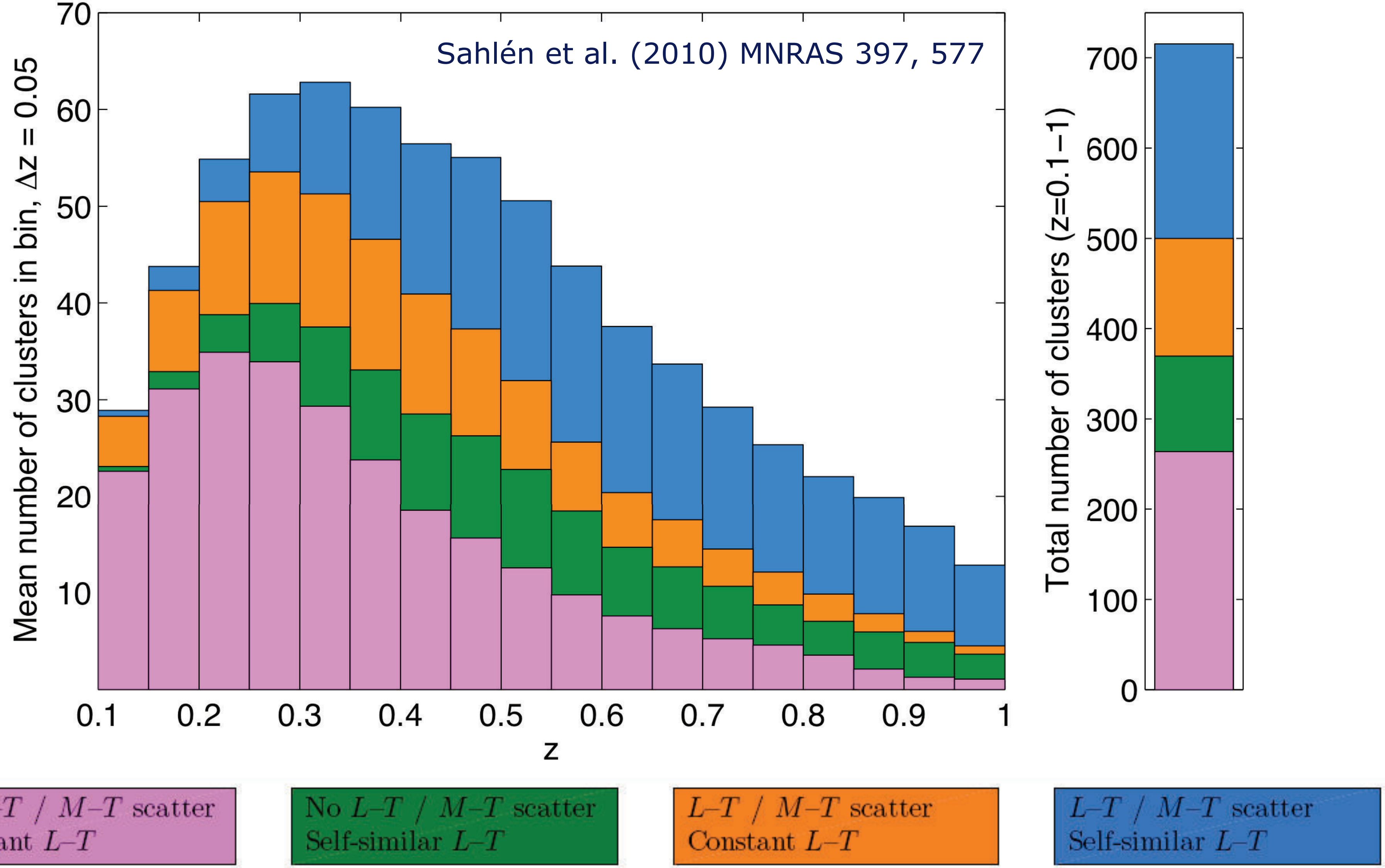
http://xcs-home.org

Assuming that Ω_m=0.3, Ω_Λ=0.7 and σ_8=0.8, then between 1500 to 3300 clusters of galaxies with 2 < T < 8 keV are expected to be detected in the redshift range 0.1 to 1, about 20% of which, or 260 to 710, with more than 500 counts, thus enabling their X-ray temperatures to be estimated with less than 20% error (1σ) from the serendipitous data alone.



Current Status

Almost 8000 *XMM-Newton* observations have been performed as of March of 2010, with nearly 5000 of these searched for serendipitous galaxy clusters by the XCS collaboration. In excess of one thousand clusters have been optically confirmed and had their redshift estimated among many more candidates. We expect the final XCS catalogue to have an effective sky area of ≈500 deg^2 and an associated effective bolometric flux limit of the order of 5×10^{-14} $ergs^{-1}$ cm^{-2}.

XCS objective

Construction of a large catalogue of galaxy clusters with redshifts extending beyond unity and a well-defined selection function

XCS science goals

Galaxy clusters as cosmological probes - σ_8, Ω_m, Ω_Λ [Ω_w, w] (number density evolution, baryon fraction, H(z) from the Sunyaev-Zel'dovich effect - X-ray/sub-mm joint analysis)

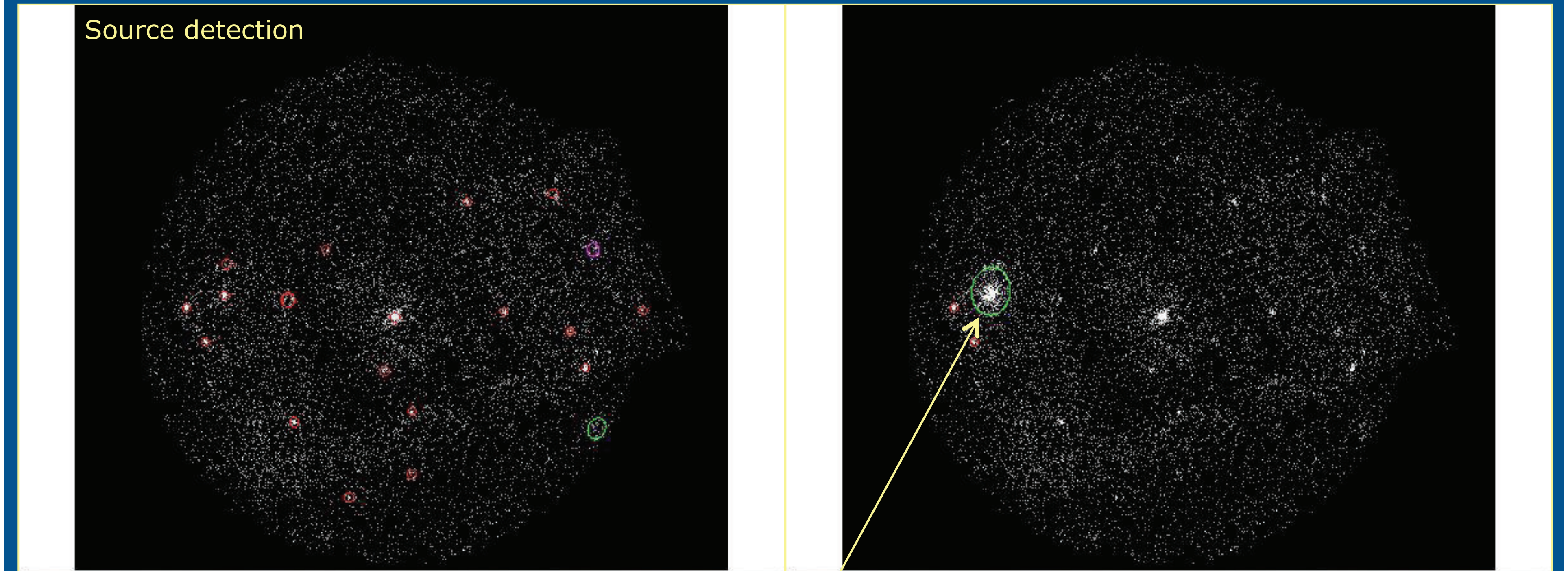
Evolution of intracluster gas properties as a probe to the physics of cluster formation and evolution

Evolution of the properties of cluster galaxies as a window on the processes responsible for galaxy formation and evolution

Current Status

XMM Cluster Survey

An automated download and data analysis pipeline is in place, generating a continuously updated source list from data that falls on the public domain. Wavelet based software for the identification and characterization of extended sources has been developed to cleanly separate the cluster population, and enable point sources within extended sources to be identified and excised. Extensive Monte Carlo simulations have been done to determine the XCS selection function.

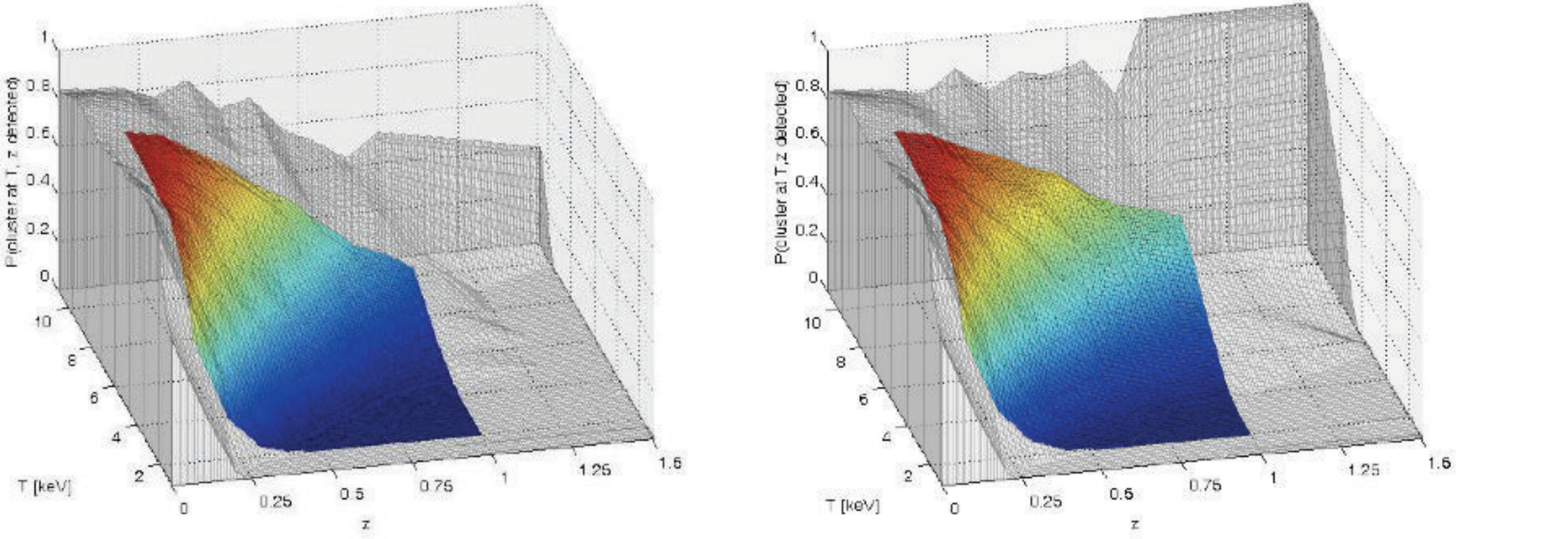


Mock galaxy cluster

Hosmer 2009, PhD thesis

Current Status

XCS selection function



(a) Constant L–T relation

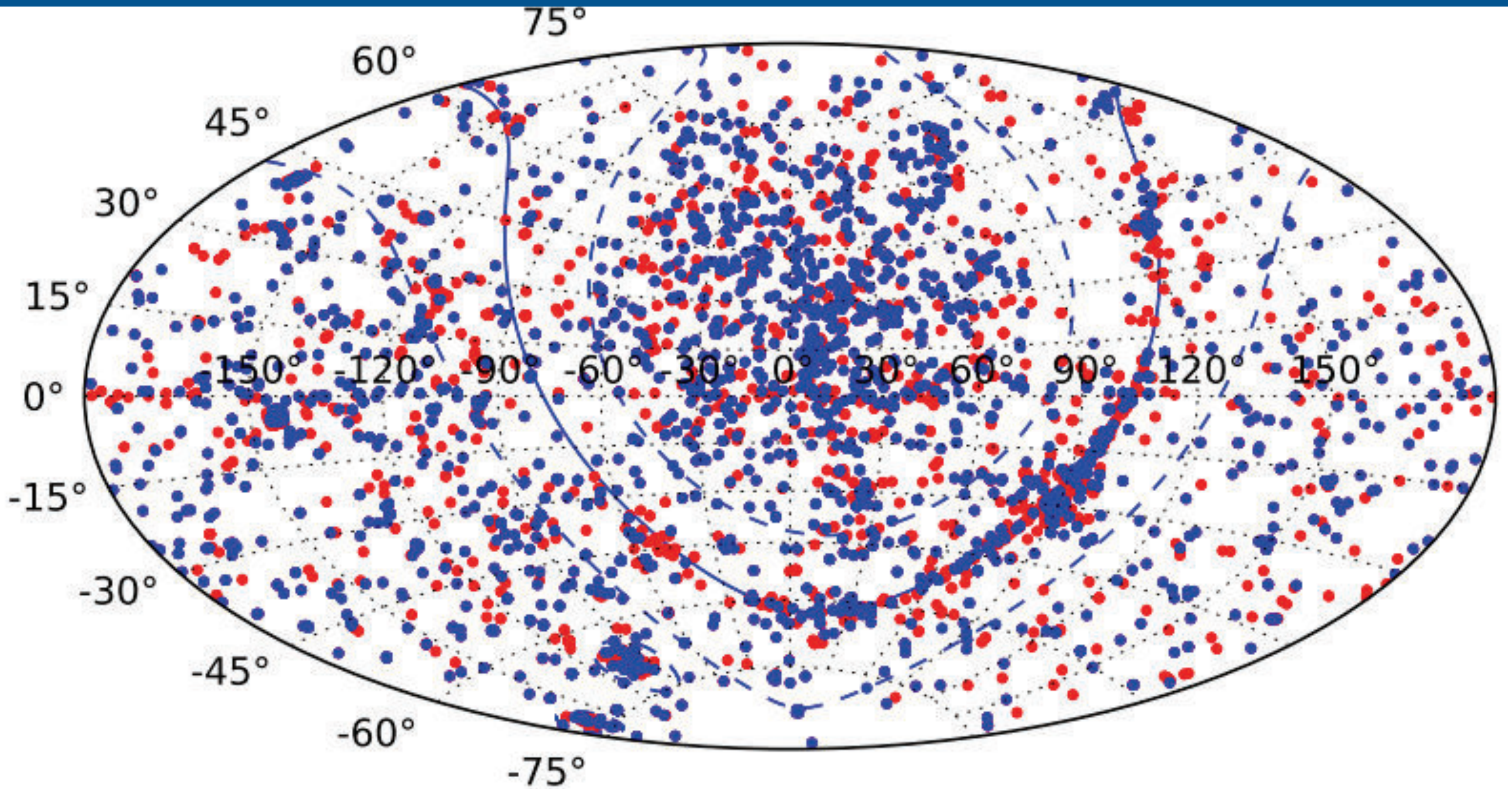
(b) Self-similar L–T relation

Selection function for our fiducial cosmology and different L–T evolution. Values in the shaded region are extrapolated from those in the coloured region ($0.1 \leq z \leq 1.0$, $2\,\mathrm{keV} \leq T \leq 8\,\mathrm{keV}$), for which the selection function has been calculated explicitly.

Sahlén et al. (2010) MNRAS 397, 577

Current Data

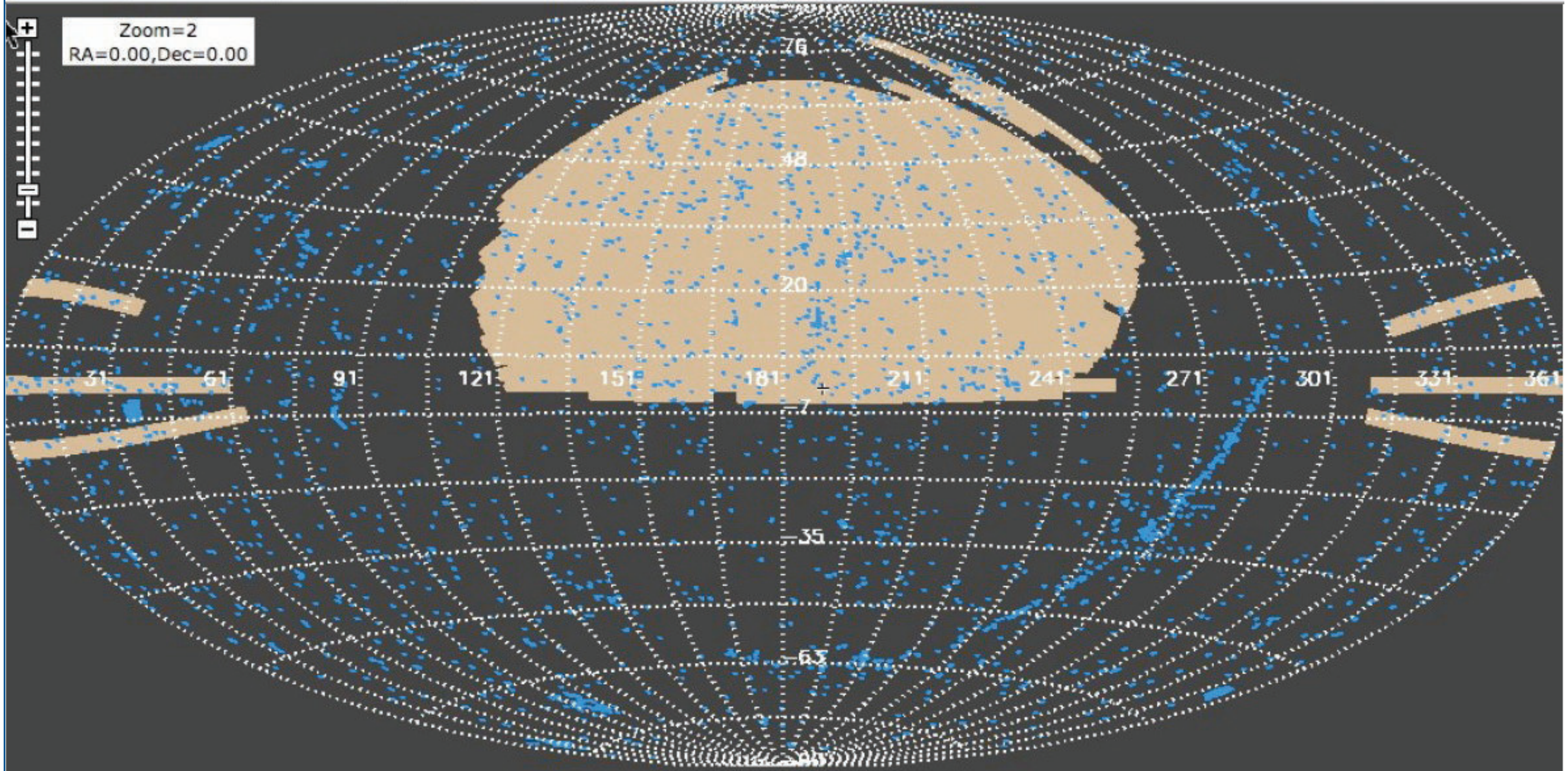
XCS
XMM Cluster Survey



Red: spatial & spectral analysis completed
Blue: analysis ongoing
Dashed: Galactic cut

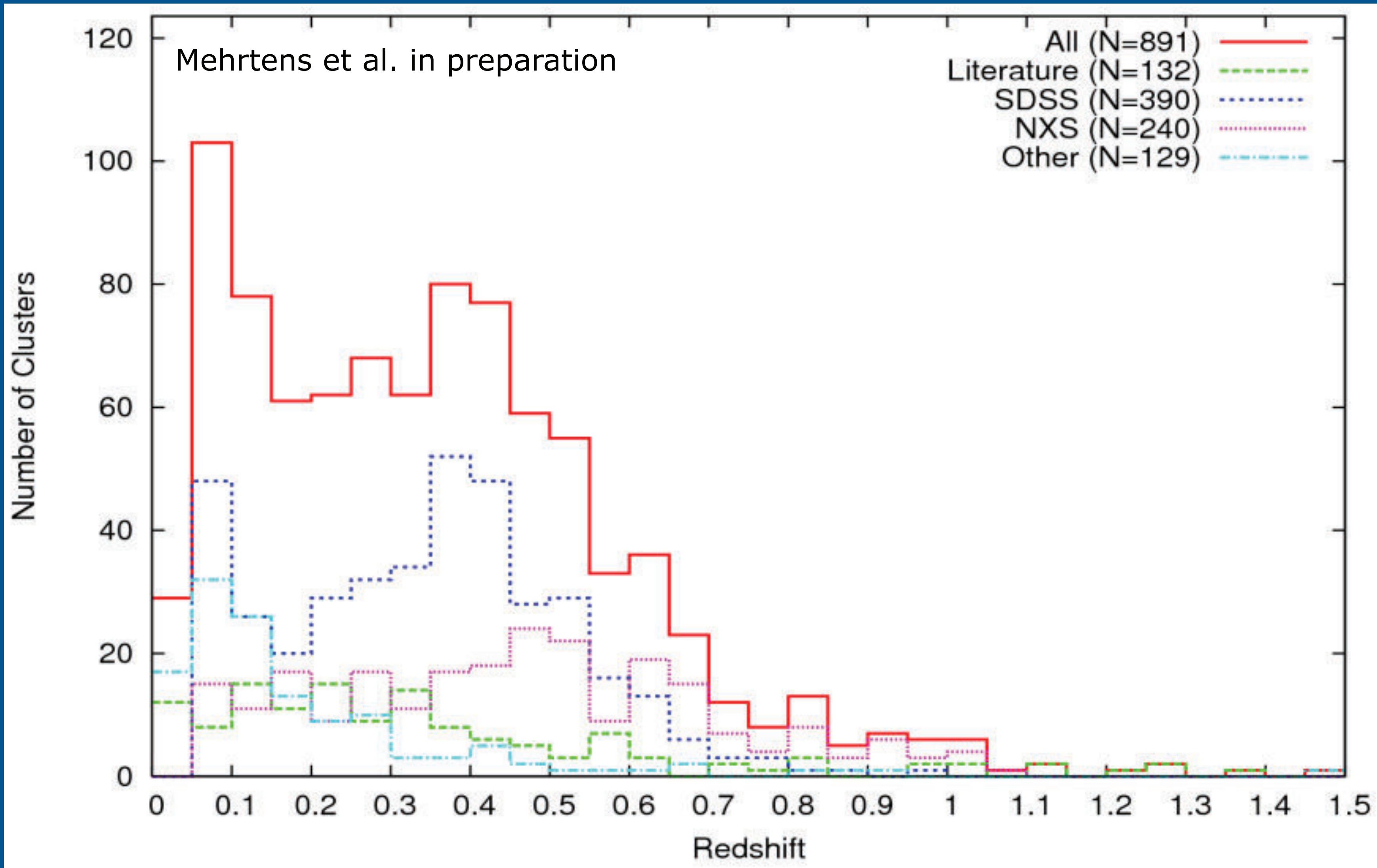
First XCS catalogue released in 2010

Current Data



Overlap with SDSS: allows confirmation and redshift estimation – Mehrtens et al. in preparation

Current Data



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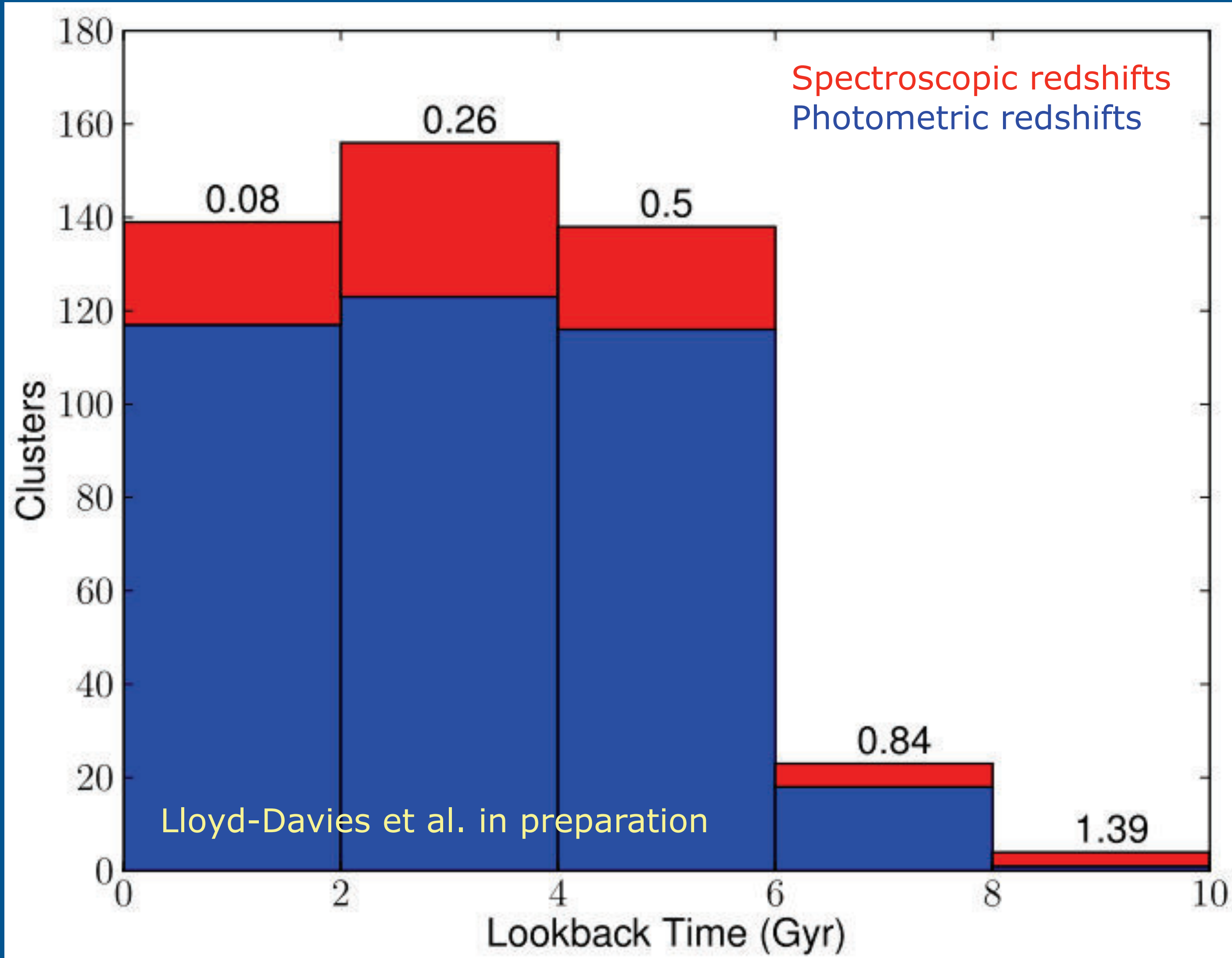
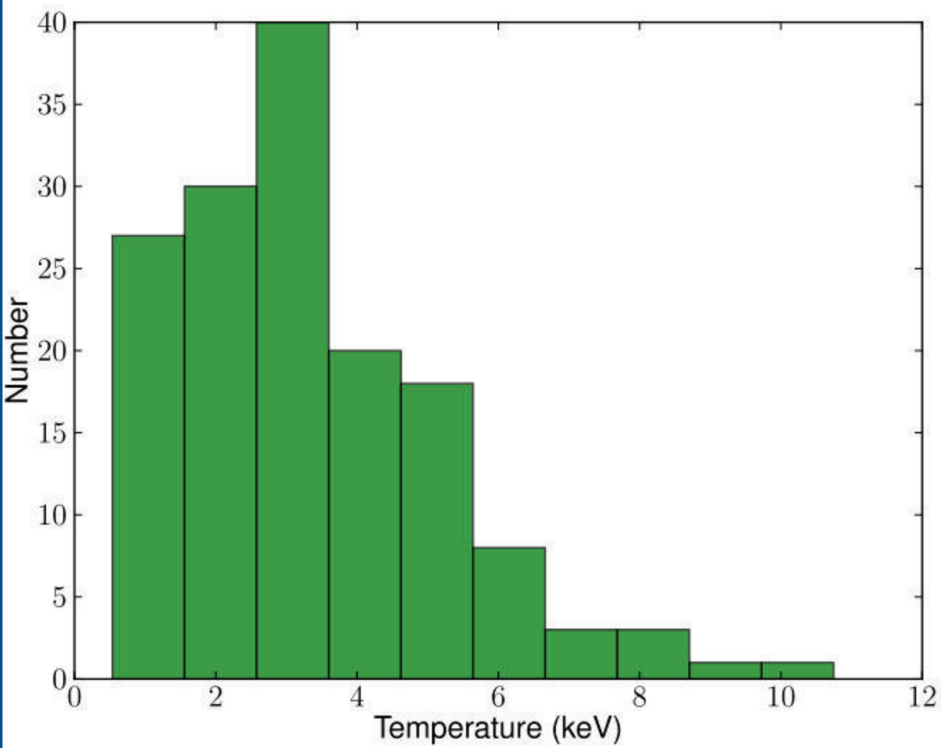
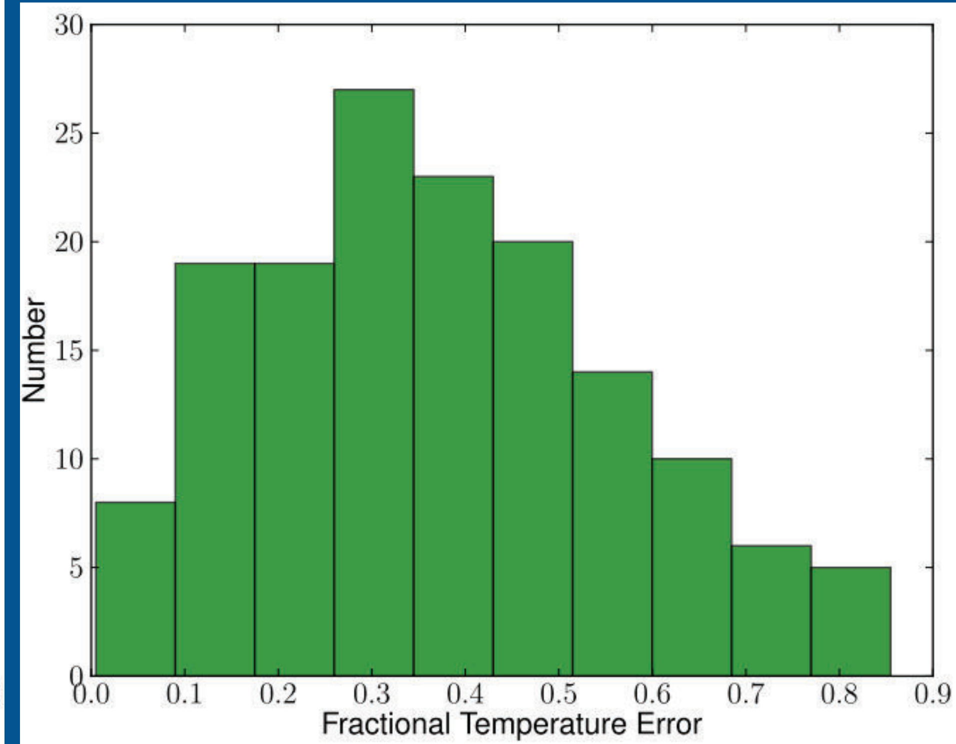


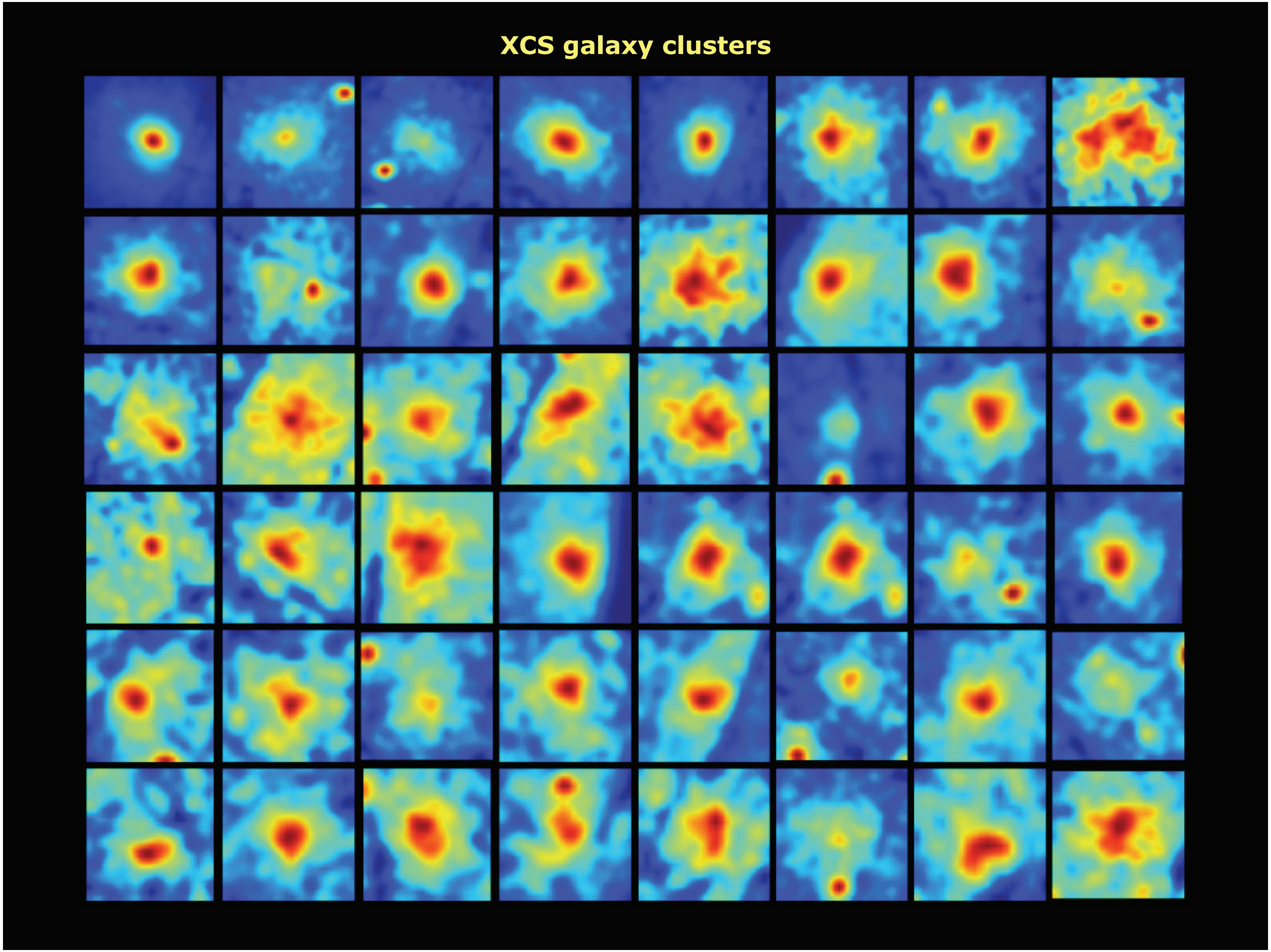
Current Data

XCS
XMM Cluster Survey

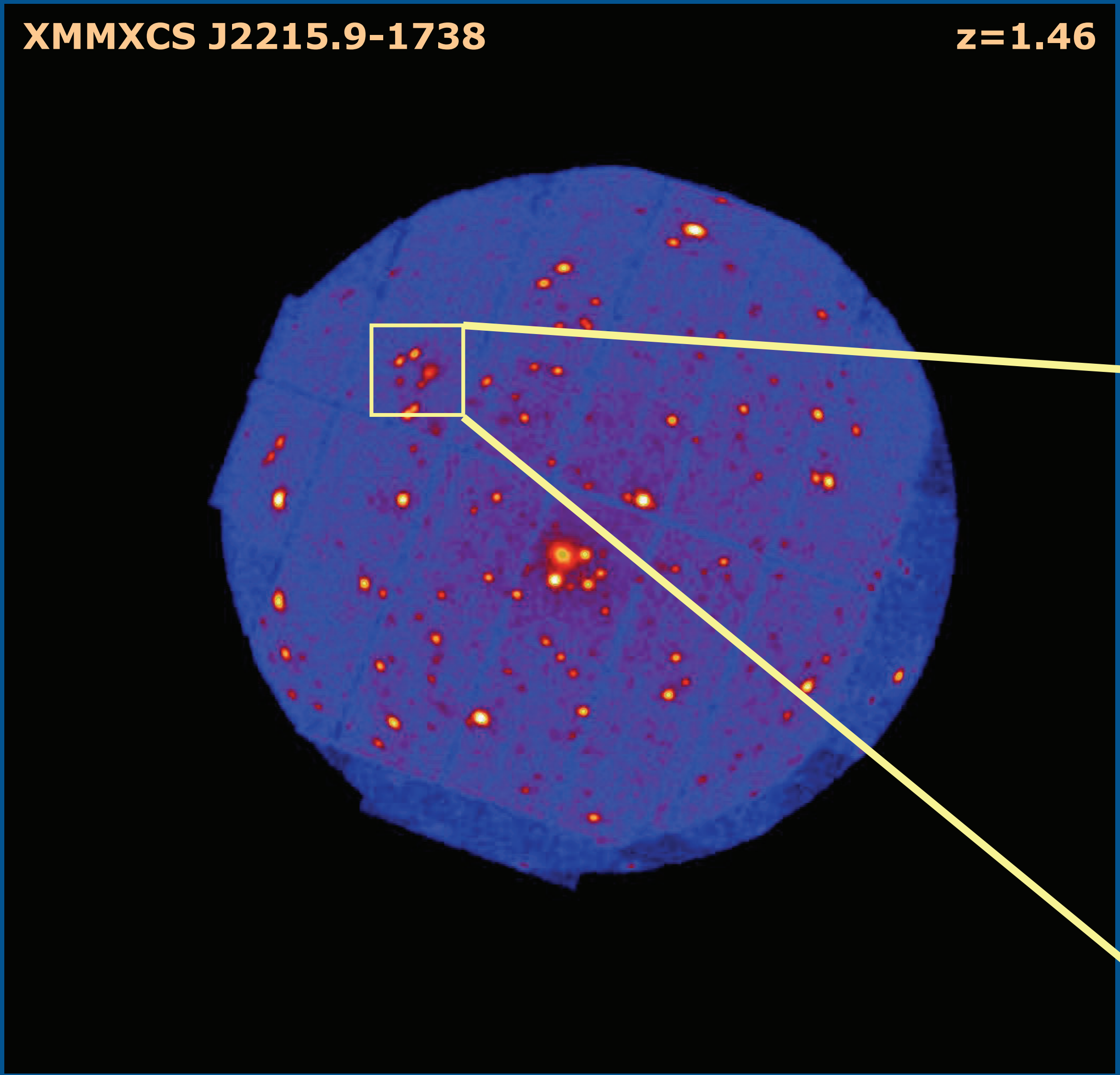




Lloyd-Davies et al. in preparation


XCS galaxy clusters

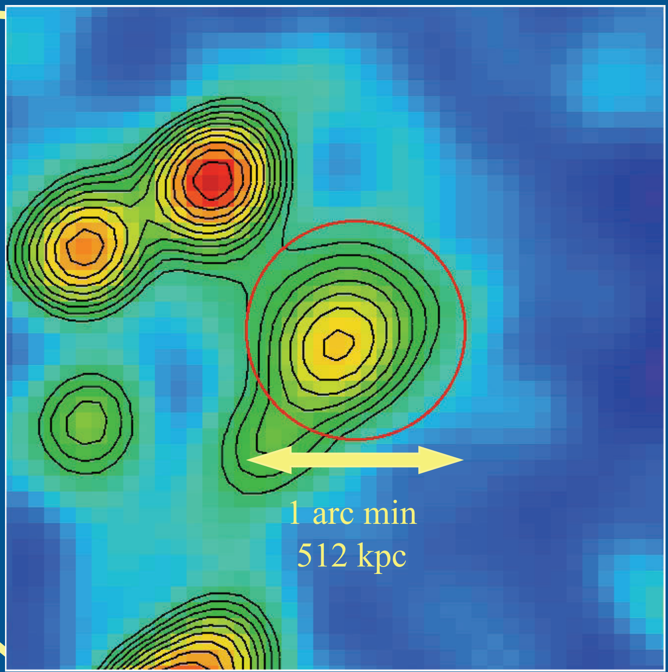
Many tens of clusters are expected with redshift above 1!



T_x = 4.12 [3.21, 4.67] keV

L_{bol} = 2.92 [2.57, 3.16] x10^{44} erg/s

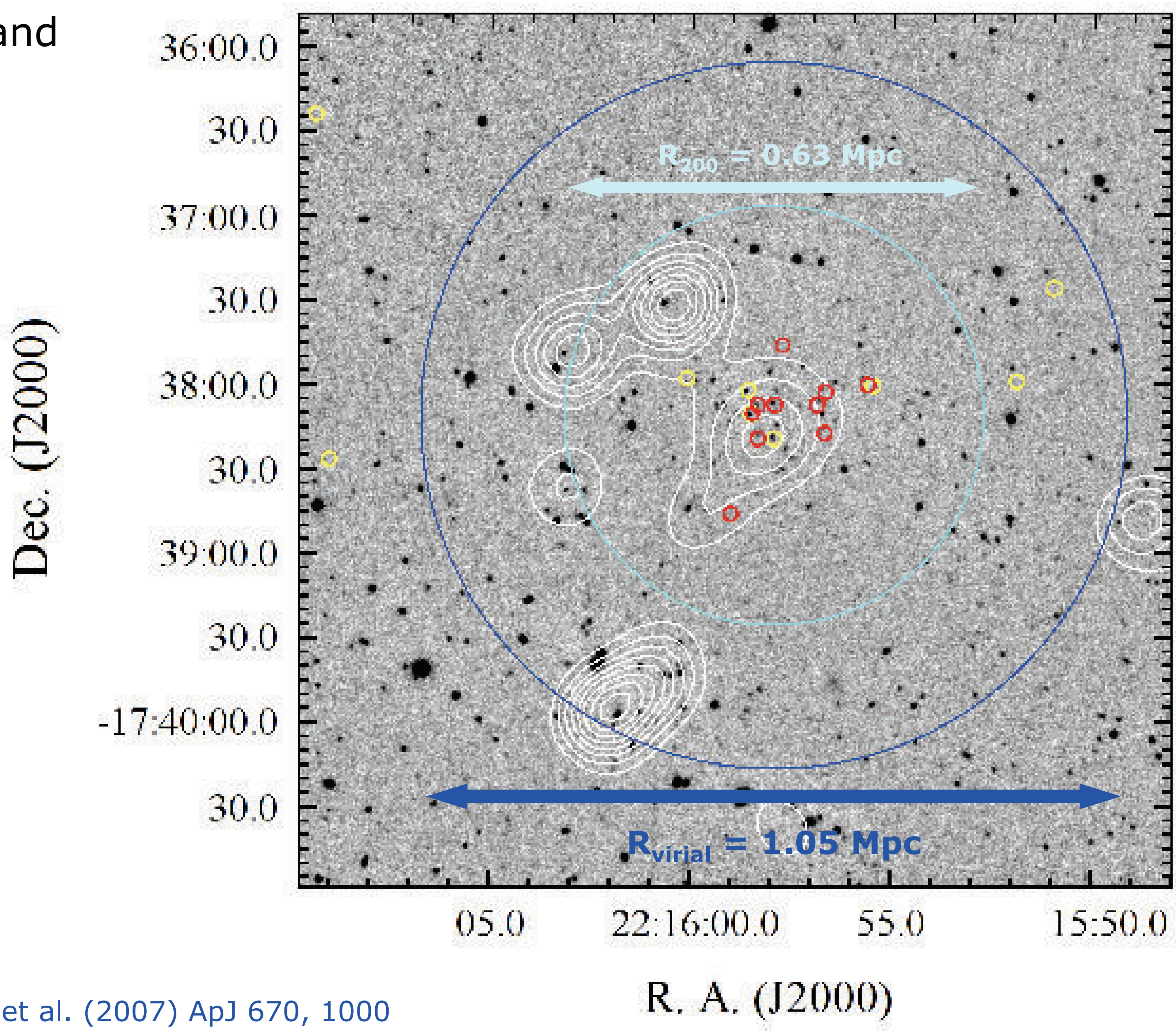
both revised after point-source extraction based on Chadra data



Stanford et al. (2006) ApJ 646, L13

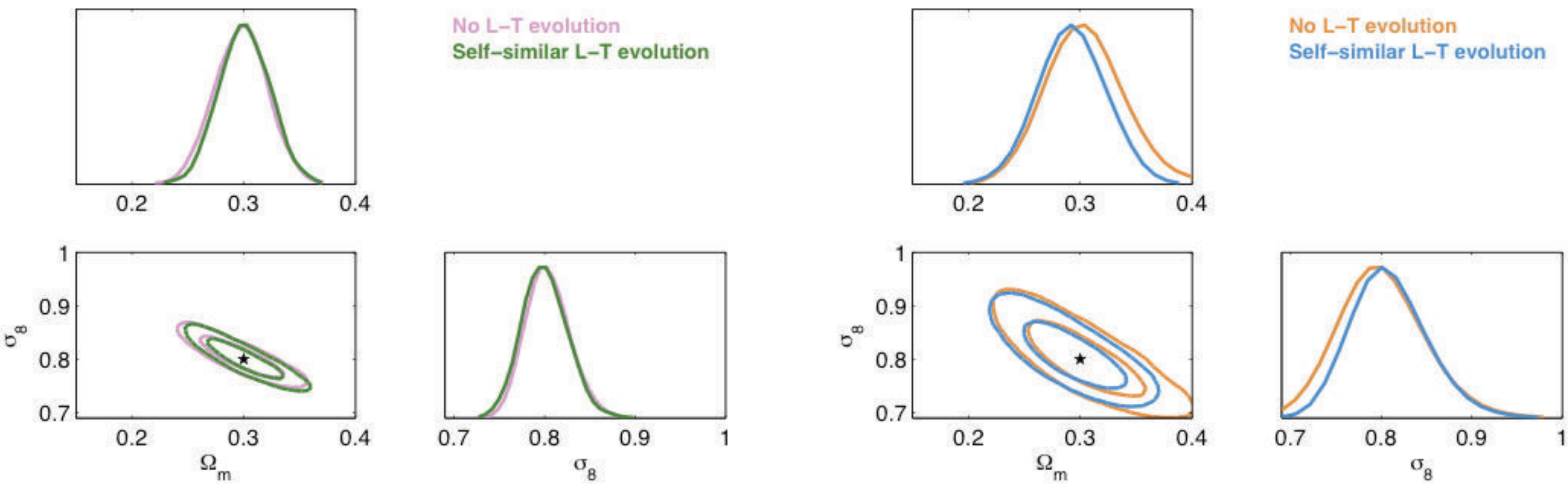
Evidence of earlier galaxy assembly than predicted by standard structure formation models, with brightest cluster galaxies experiencing an early period of rapid growth rather than prolonged hierarchical assembly - Collins et al. (2009) Nature 458, 603.

K band



Hilton et al. (2007) ApJ 670, 1000

XCS expected constraints on cosmological parameters



(a) Known scaling relations, no scatter

(b) Self-calibration of L–T relation, with scatter

Expected 68 and 95 per cent parameter constraints for ^{500}XCS, without measurement errors. Stars denote the fiducial model assumed.

The Markov Chain Monte Carlo analysis does not include explicitly the X-ray flux measurements of XCS galaxy clusters, though taking them into account would bring the analysis close to case (a).

Sahlén et al. (2010) MNRAS 397, 577

XCS expected constraints on cosmological parameters

L–T evolution		Known scaling relations, no scatter	Self-calibration of L–T, with scatter
Constant	Ω_m	0.30 ± 0.02	0.30 ± 0.03
	σ_8	0.80 ± 0.02	0.80 ± 0.05
	$\sigma_{\log L_X}$	–	$[0.2, 0.4]$
	α	–	-1.91 ± 0.12
	β	–	2.50 ± 0.33
	γ_z	–	$[-1, 1.5]$
Self-similar	Ω_m	0.30 ± 0.02	0.30 ± 0.03
	σ_8	0.80 ± 0.02	0.80 ± 0.04
	$\sigma_{\log L_X}$	–	$[0.2, 0.4]$
	α	–	-1.92 ± 0.12
	β	–	2.55 ± 0.31
	γ_z	–	$[-1, 1.5]$

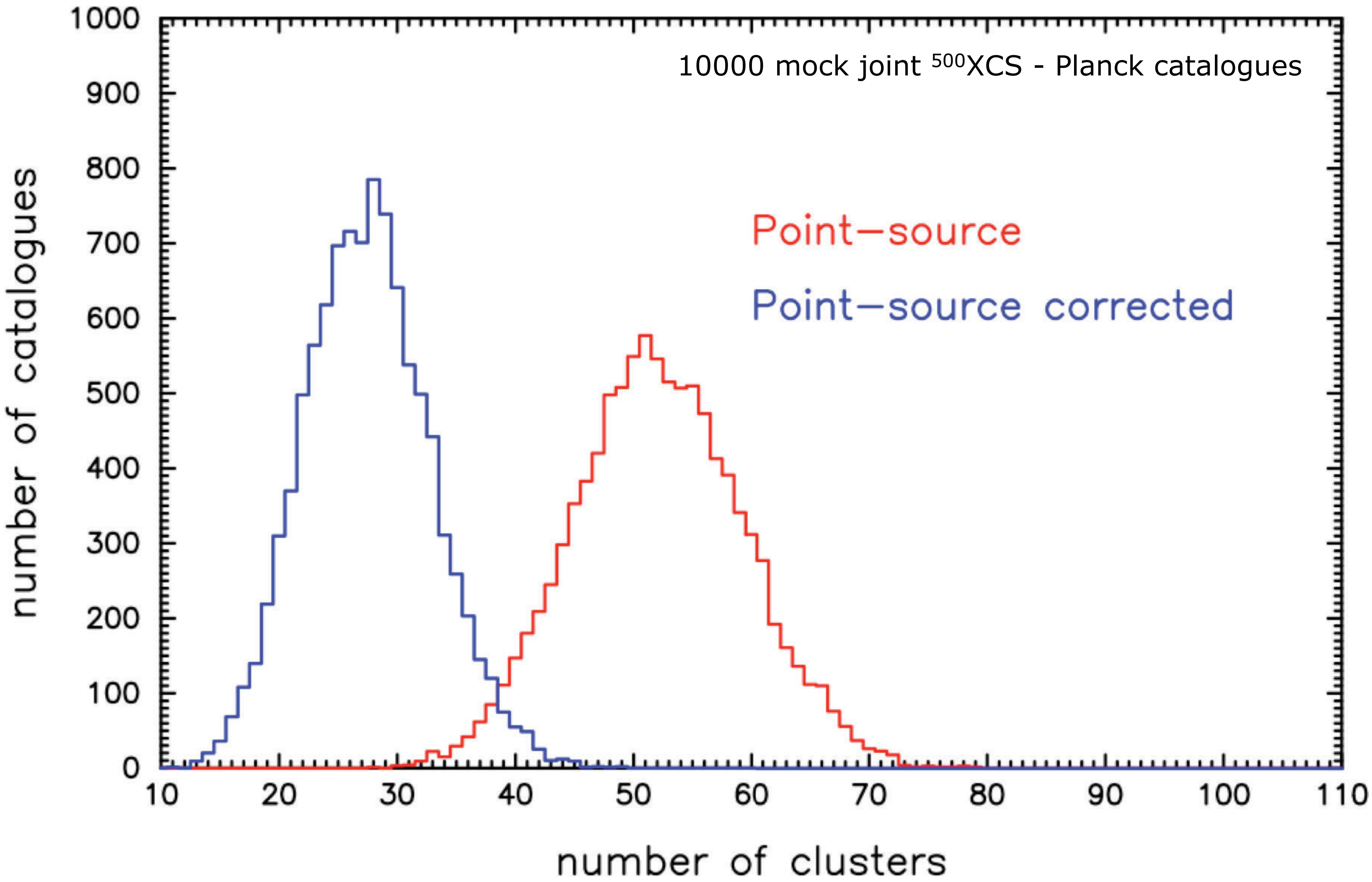
Expected 1σ parameter constraints for ^{500}XCS when marginalized over all other parameters, without measurement errors.

$$\log_{10}\left(\frac{L_X}{10^{44}\,h^{-2} erg\, s^{-1}}\right) = \alpha + \beta \log_{10}\left(\frac{kT}{1keV}\right) + \gamma_s \log_{10}\left[\Delta_V(z) E^2(z)\right] + \gamma_s \log_{10}(1+z) + N(0, \sigma_{\log L_X})$$

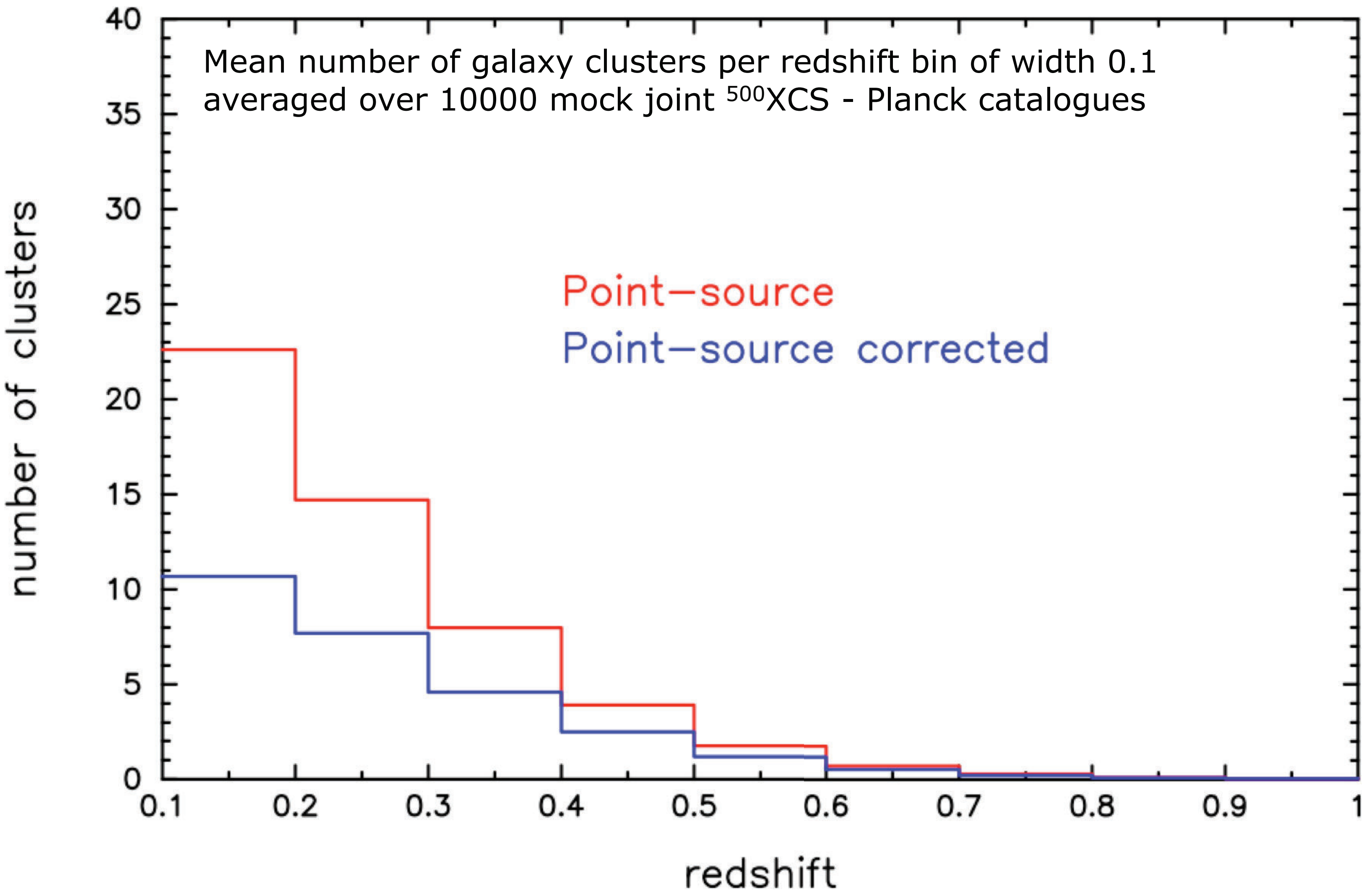
Sahlén et al. (2010) MNRAS 397, 577

XCS-Planck overlap

with António da Silva (CAUP) and Elsa Ramos (CAUP PhD student)

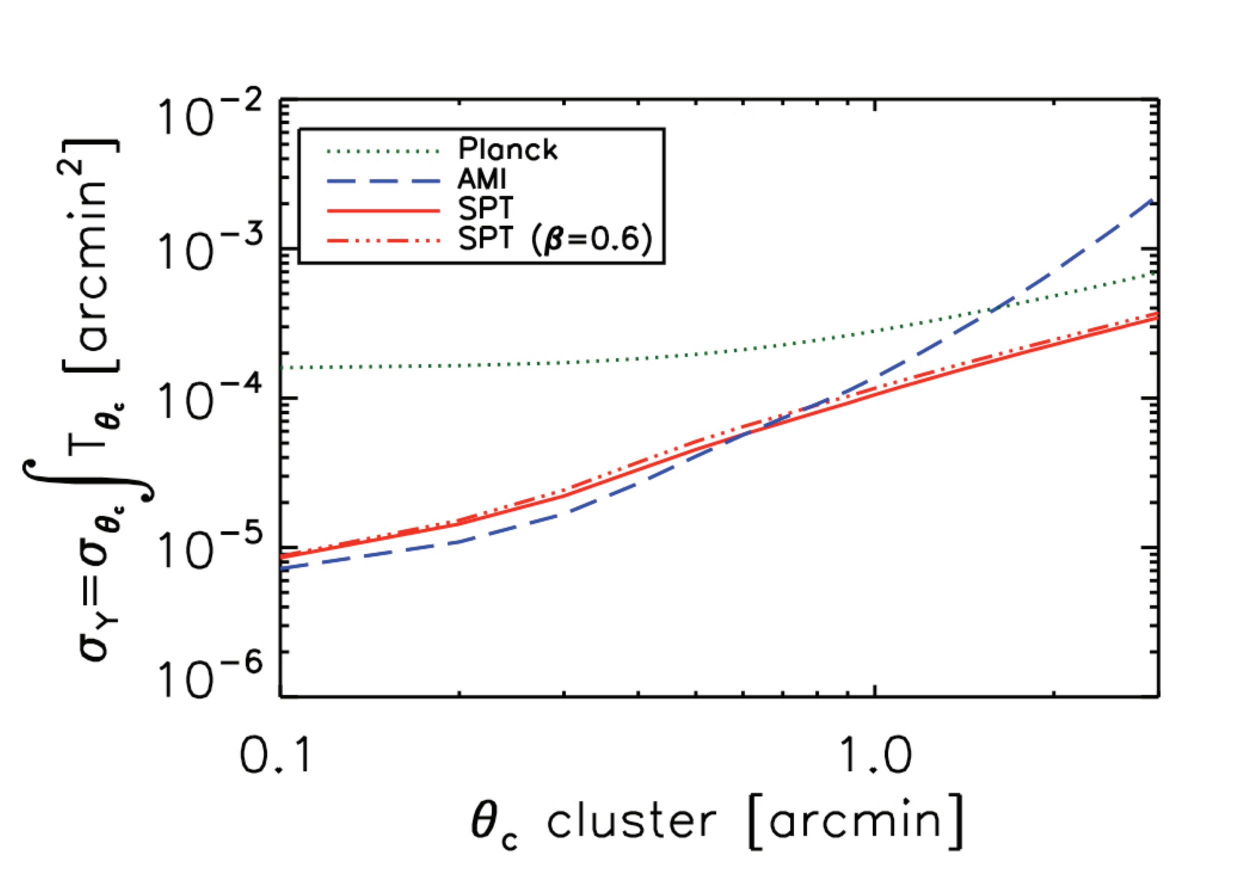


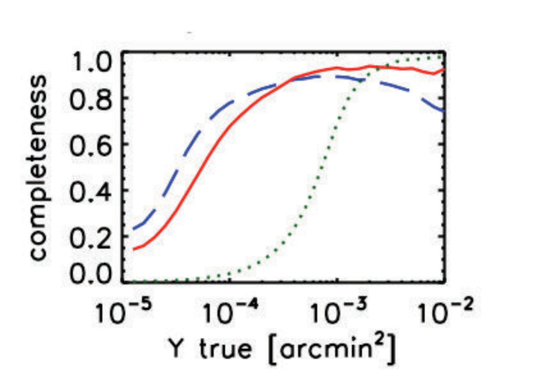
Number of catalogues as a function of the number of galaxy clusters, with $0.1 < z < 1.0$ and $2 < T < 8$ keV, expected to be part of both the ^{500}XCS and Planck cluster catalogues. A flat cosmological constant dominated universe with $\Omega_m=0.3$, $\sigma_8=0.8$ and $h=0.7$ was assumed, and the pre-heating Millennium Gas Simulation results were used to model the galaxy cluster population.



Unfortunately, not only the number of galaxy clusters expected to be part of both the ^{500}XCS and Planck cluster catalogues is quite low, but the redshift distribution is also very shallow. Nevertheless, more than 2/3 of the clusters detected by Planck in XMM-Newton fields should be in the ^{500}XCS sample. Most probably all the Planck clusters in the XMM-Newton fields will be detected by the XCS, with the possible exception of those with very low X-ray surface brightness, i.e. both with low redshift and low X-ray luminosity. This makes the XCS a very interesting tool to help characterize the selection function of the Planck cluster catalogue.

The assumption of galaxy clusters as point sources in Planck maps breaks down for $z < 0.5$, and thus the effective detection limit for probably most of the expected ^{500}XCS - Planck clusters is higher than the assumed Y=0.0008 arcmin^2 point-source limit.





A cluster with $Y = \sigma_Y(\theta_c)$, where θ_c is the template core radius, is detected at a signal–to–noise ratio q=1. At a fixed detection threshold q (e.g. 3 or 5), the completeness of a survey rapidly increases from zero to unity in the region above its corresponding curve $q\sigma_Y$ [Melin et al. (2006) A&A 459, 341].