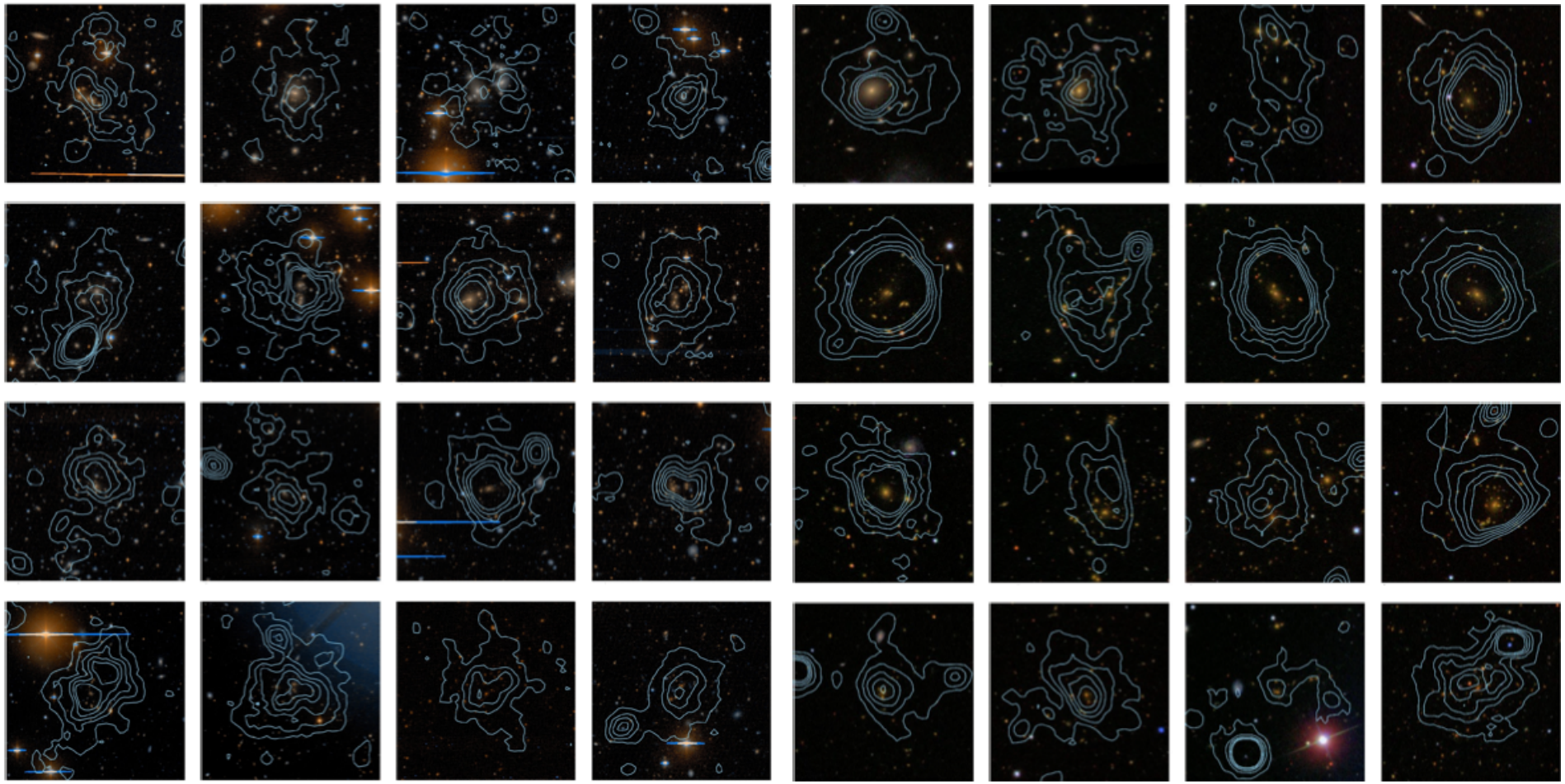
Evolution of the X-ray luminosity – temperature relation from XCS-DR1

XCS
XMM Cluster Survey



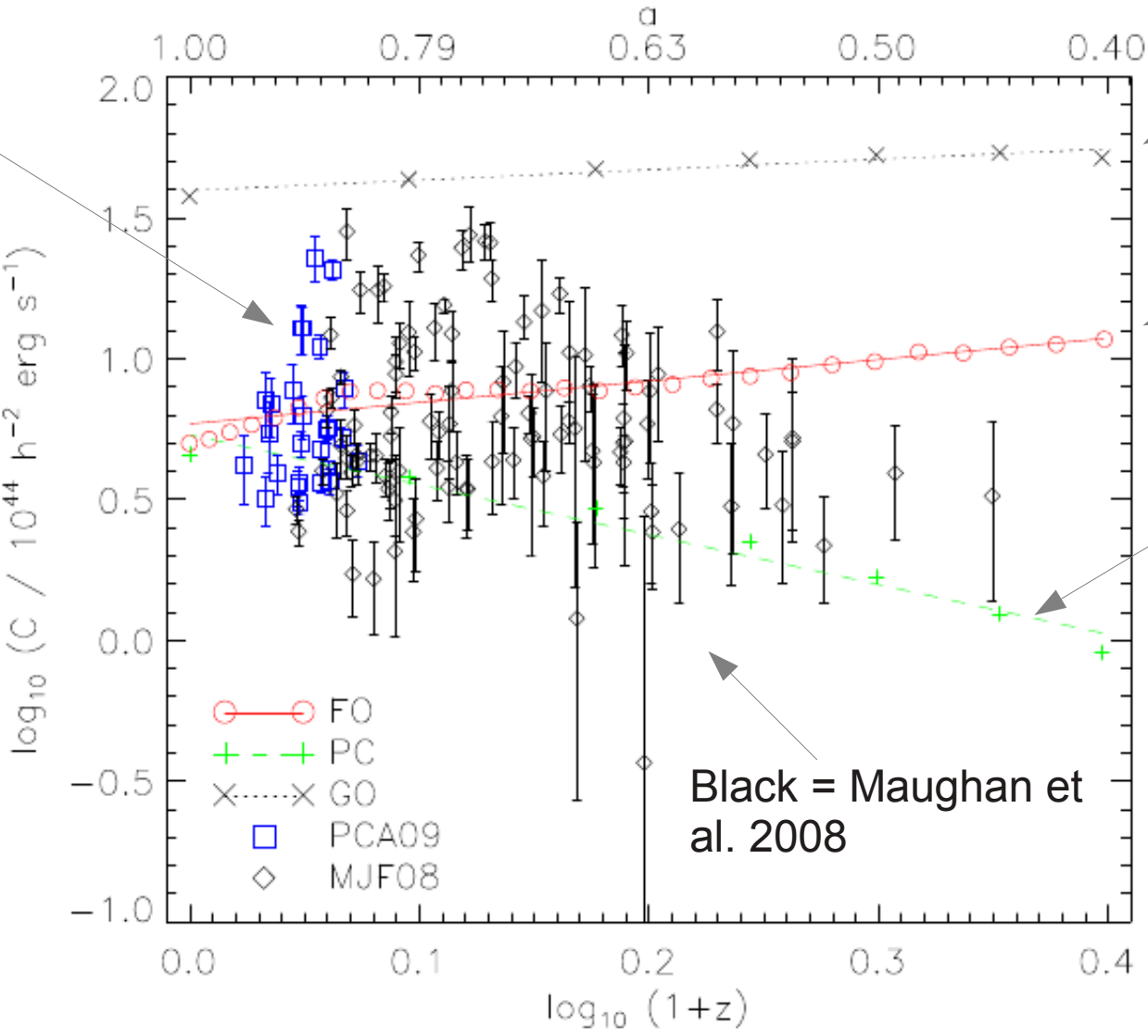
Matt Hilton, on behalf of the XCS collaboration

The University of Nottingham

The XMM Cluster Survey

- The XMM Cluster Survey (XCS) is a serendipitous galaxy cluster survey being conducted using data from the XMM Science Archive
- XCS has three main science goals:
  - To constrain cosmological parameters through the evolution of the cluster mass function with redshift
  - To study galaxy evolution in clusters
  - To study the evolution of the cluster gas with redshift, as traced by the X-ray scaling relations → Hilton et al. (2012, MNRAS submitted)

- Measuring the evolution of the L-T relation is one way to distinguish between different AGN feedback models



Blue = REXCESS (Pratt et al. 2009)

Gravity only

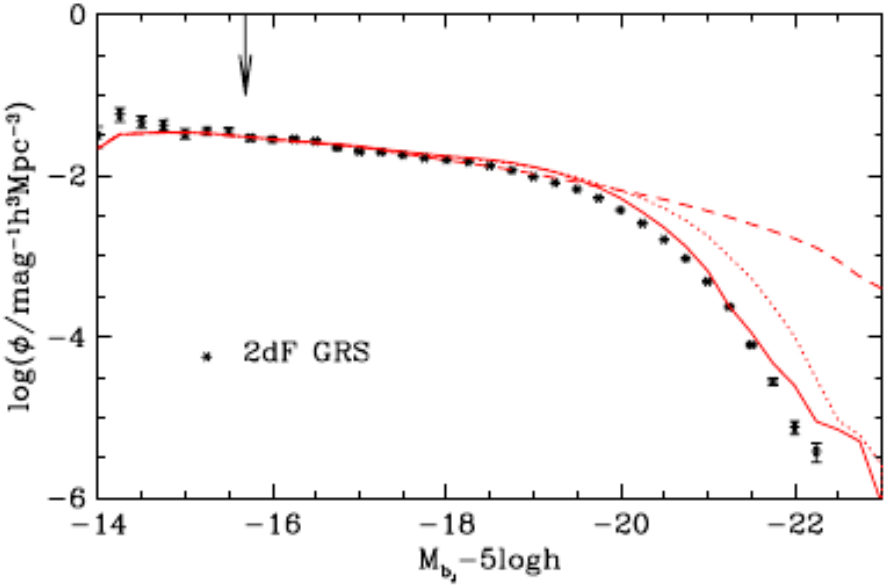
AGN feedback

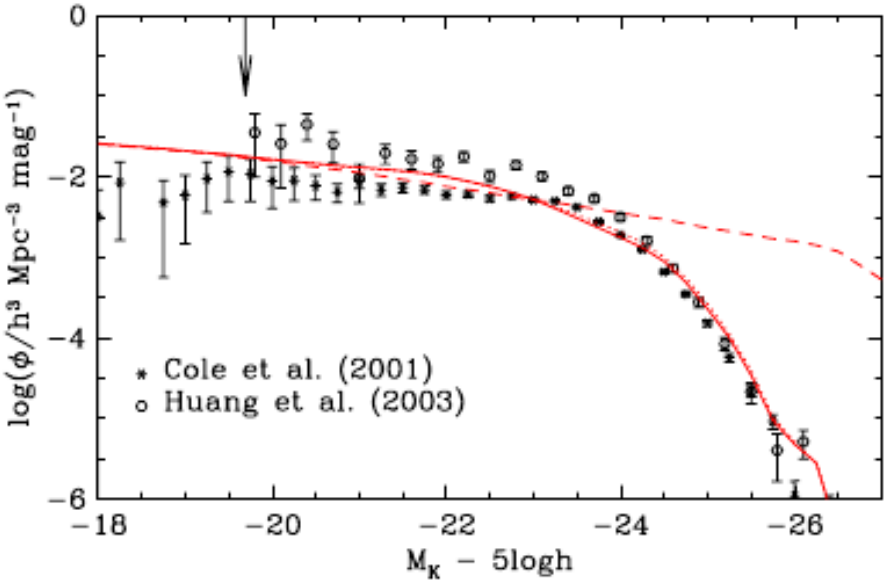
Preheating and radiative cooling

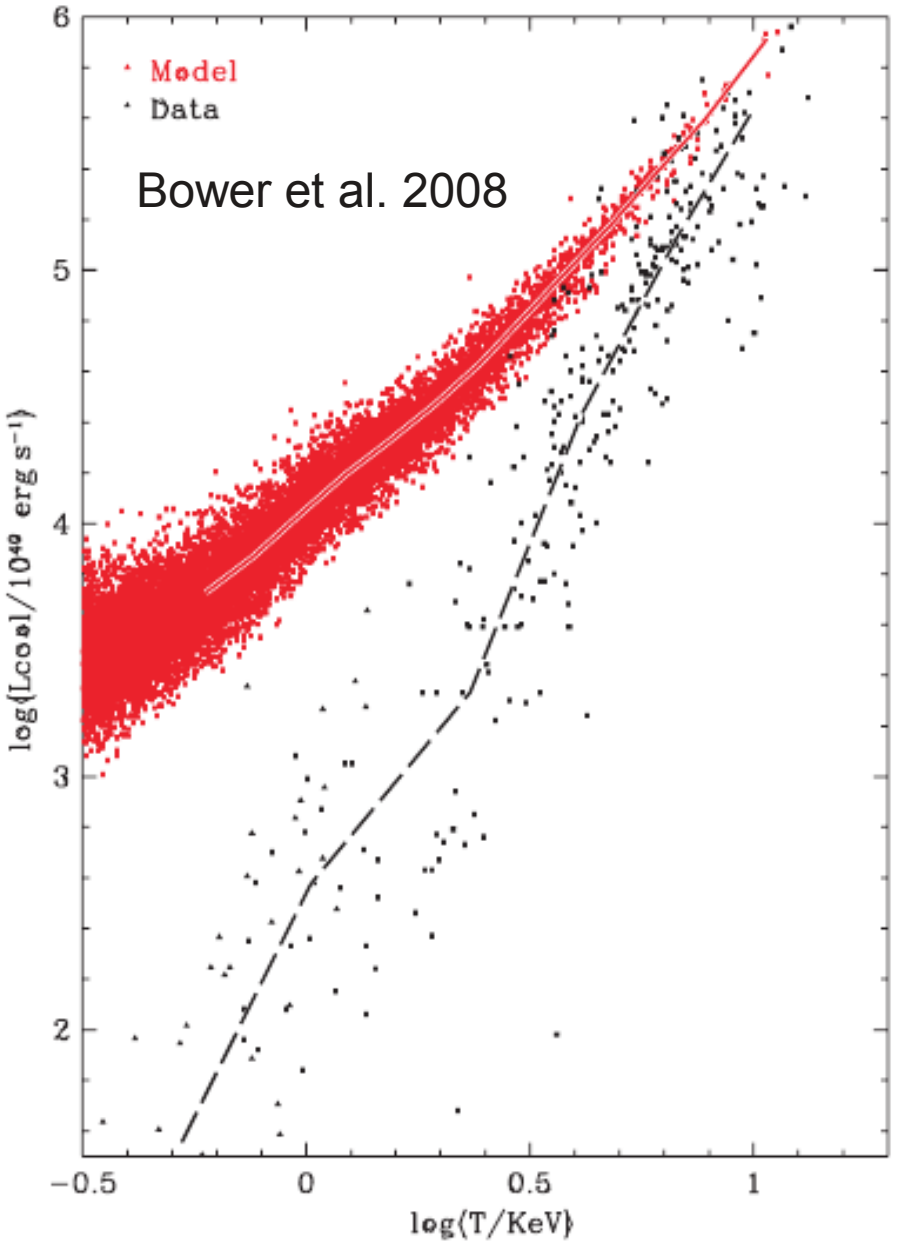
Black = Maughan et al. 2008

Short et al. (2010) – Millennium Gas project

- AGN feedback is a key ingredient of semi-analytic galaxy formation models – a good model should be able to reproduce cluster scaling relations in addition to the galaxy luminosity function







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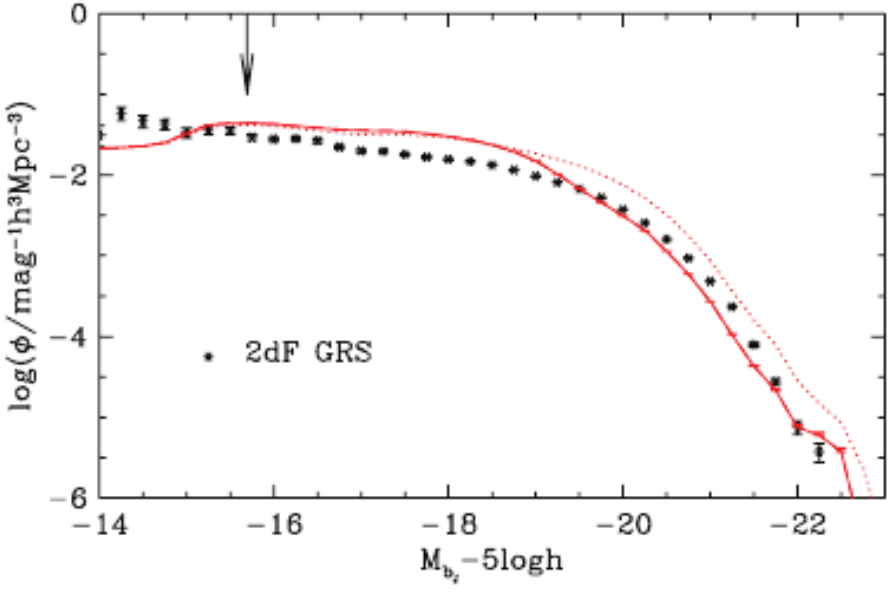
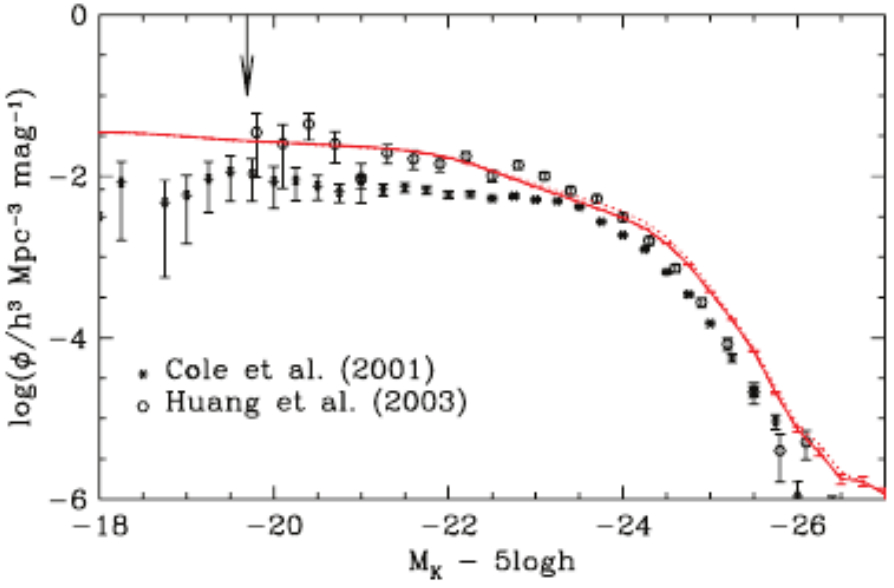
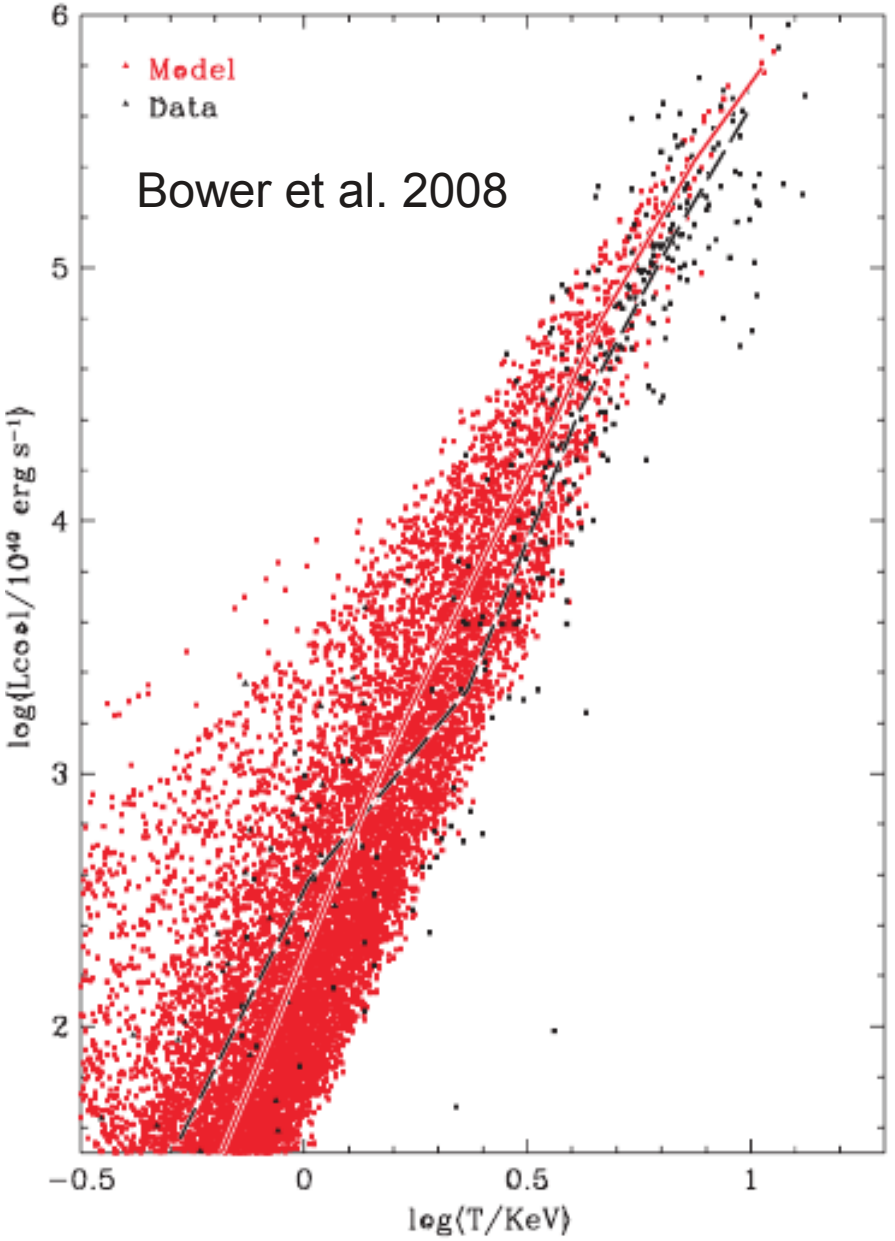
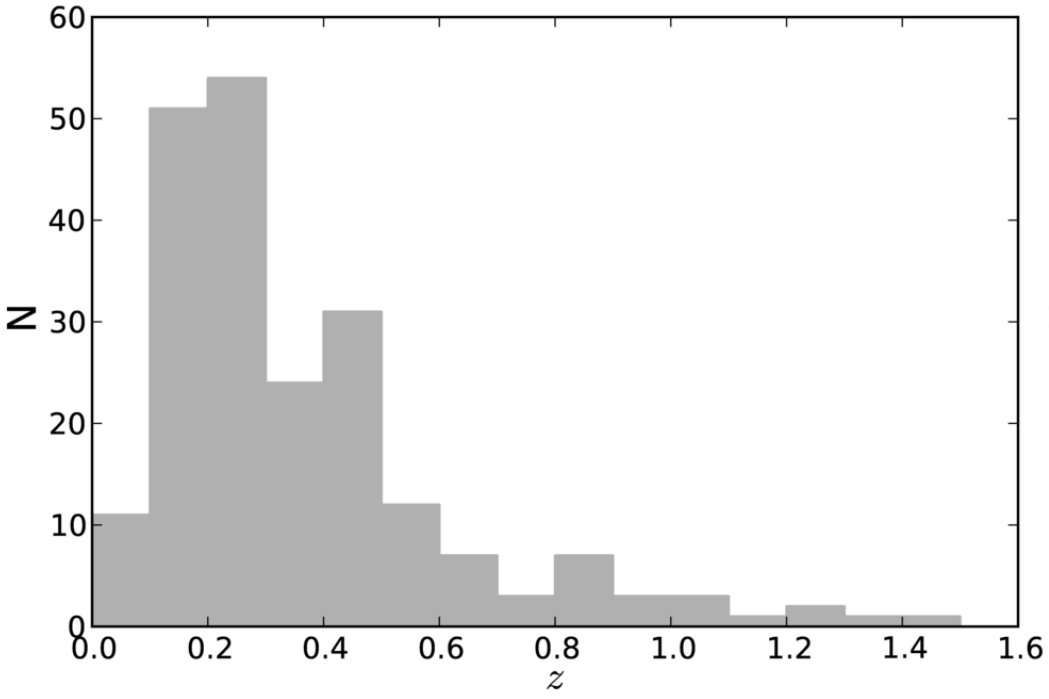
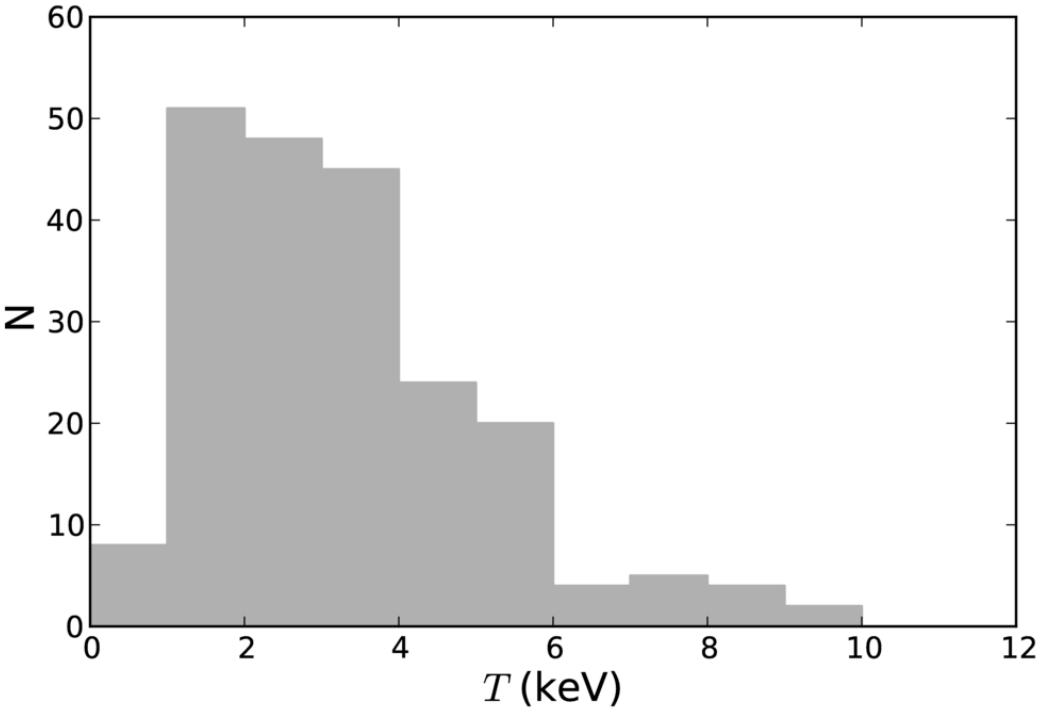






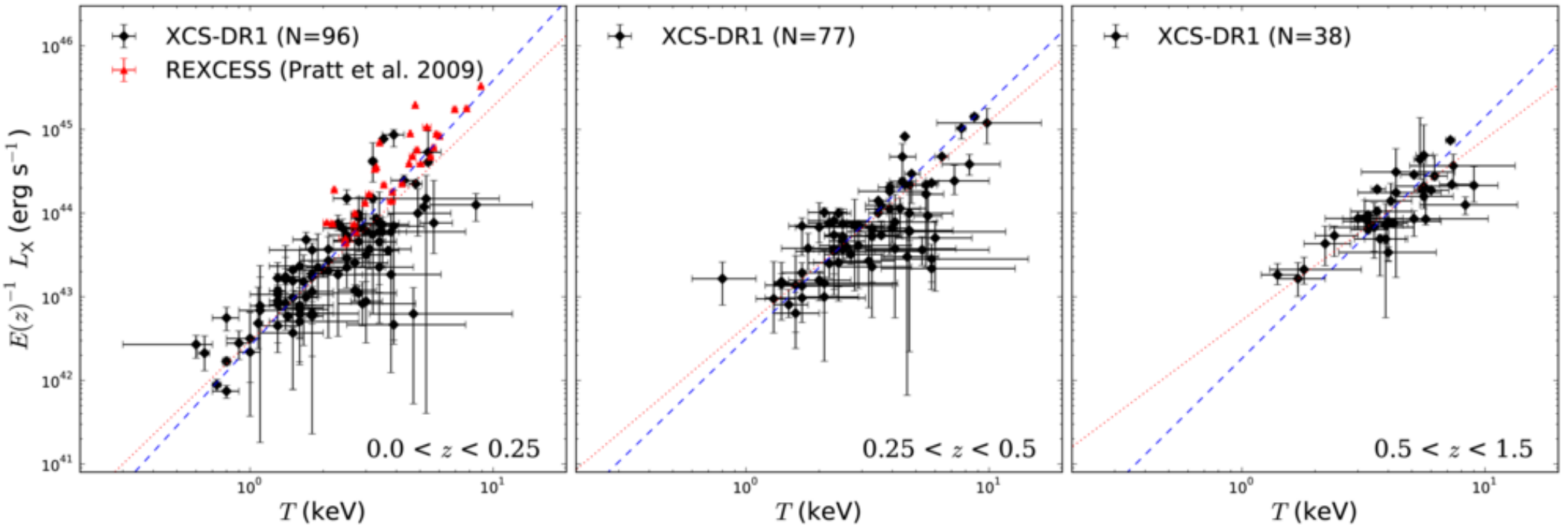
XCS Sample for L-T evolution work

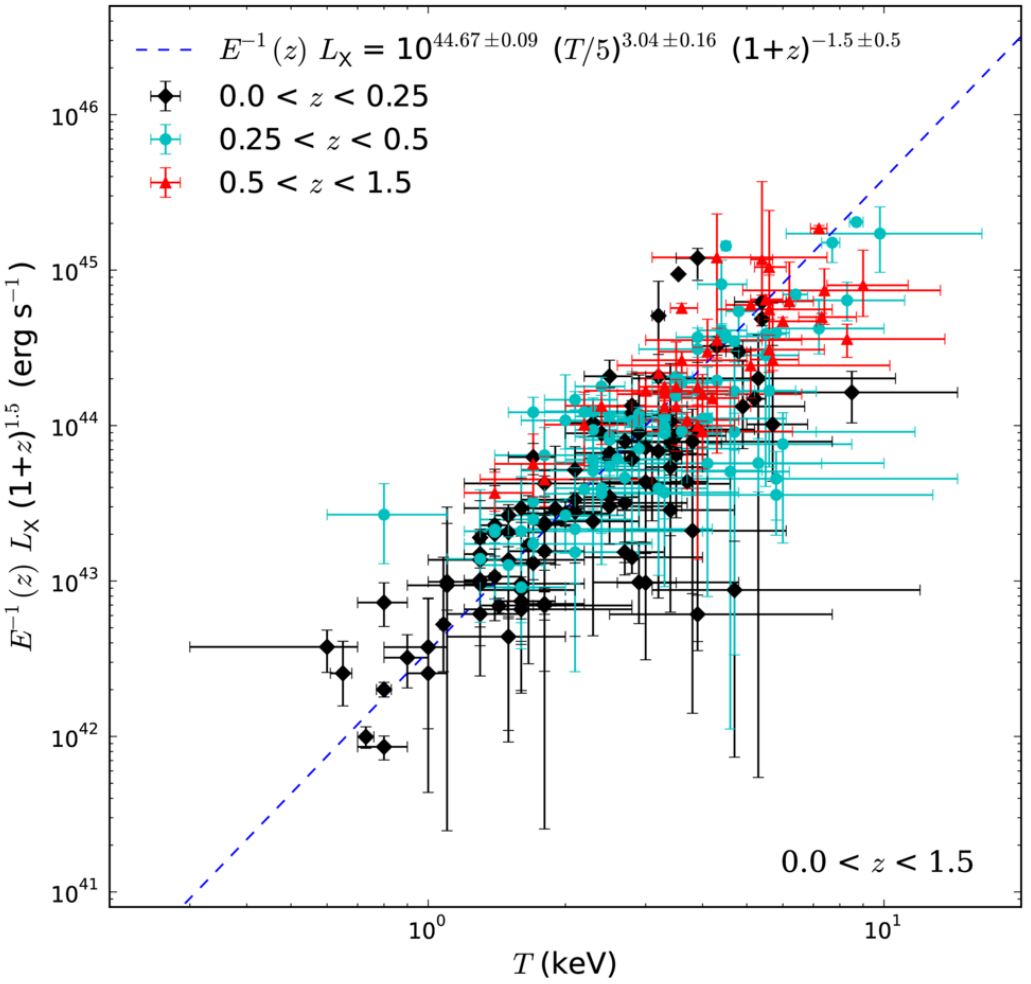


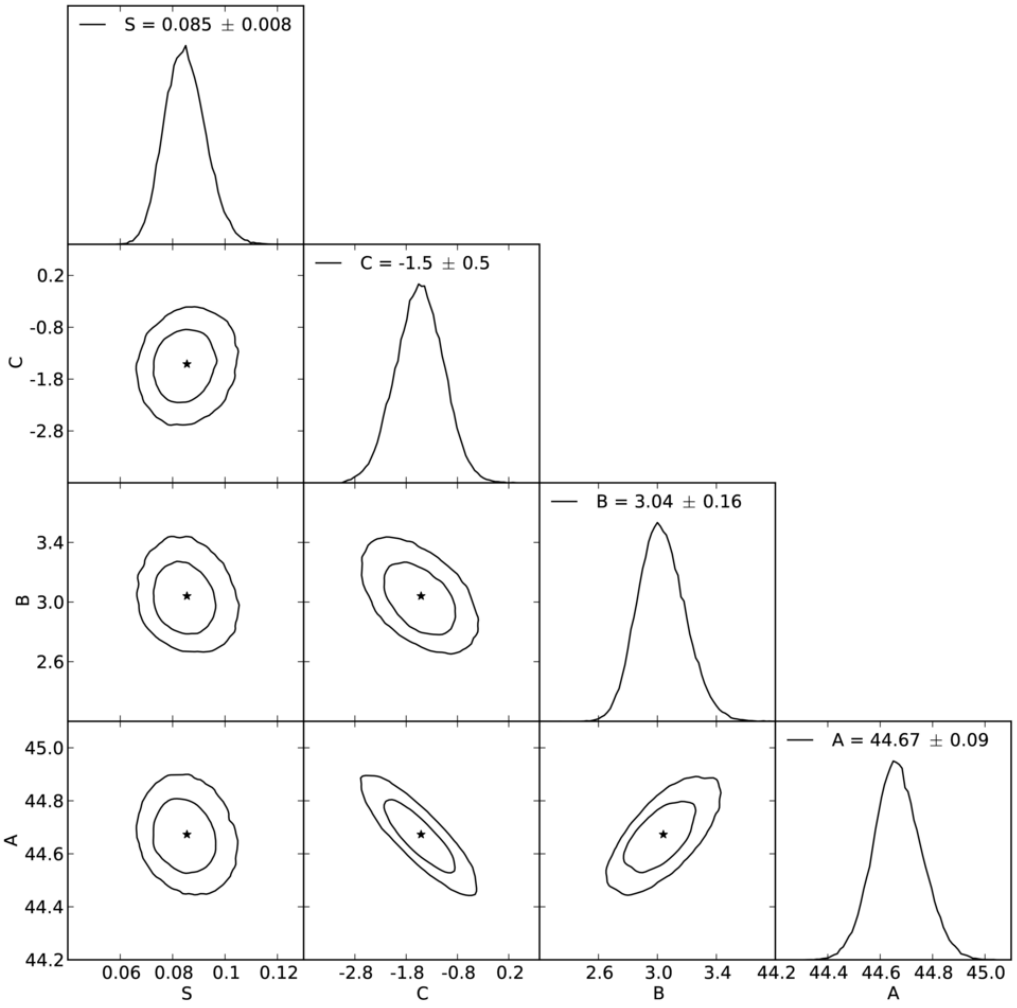


- 211 spectroscopically confirmed clusters with luminosities and temperatures, from the XCS-DR1 catalogue (Mehrtens et al. 2012)
- Redshift range 0.06 – 1.46 (median z = 0.28)
- Temperature range 0.6 – 9.8 keV (median T = 2.9 keV)
- X-ray data analysis described in Lloyd-Davies et al. (2011)

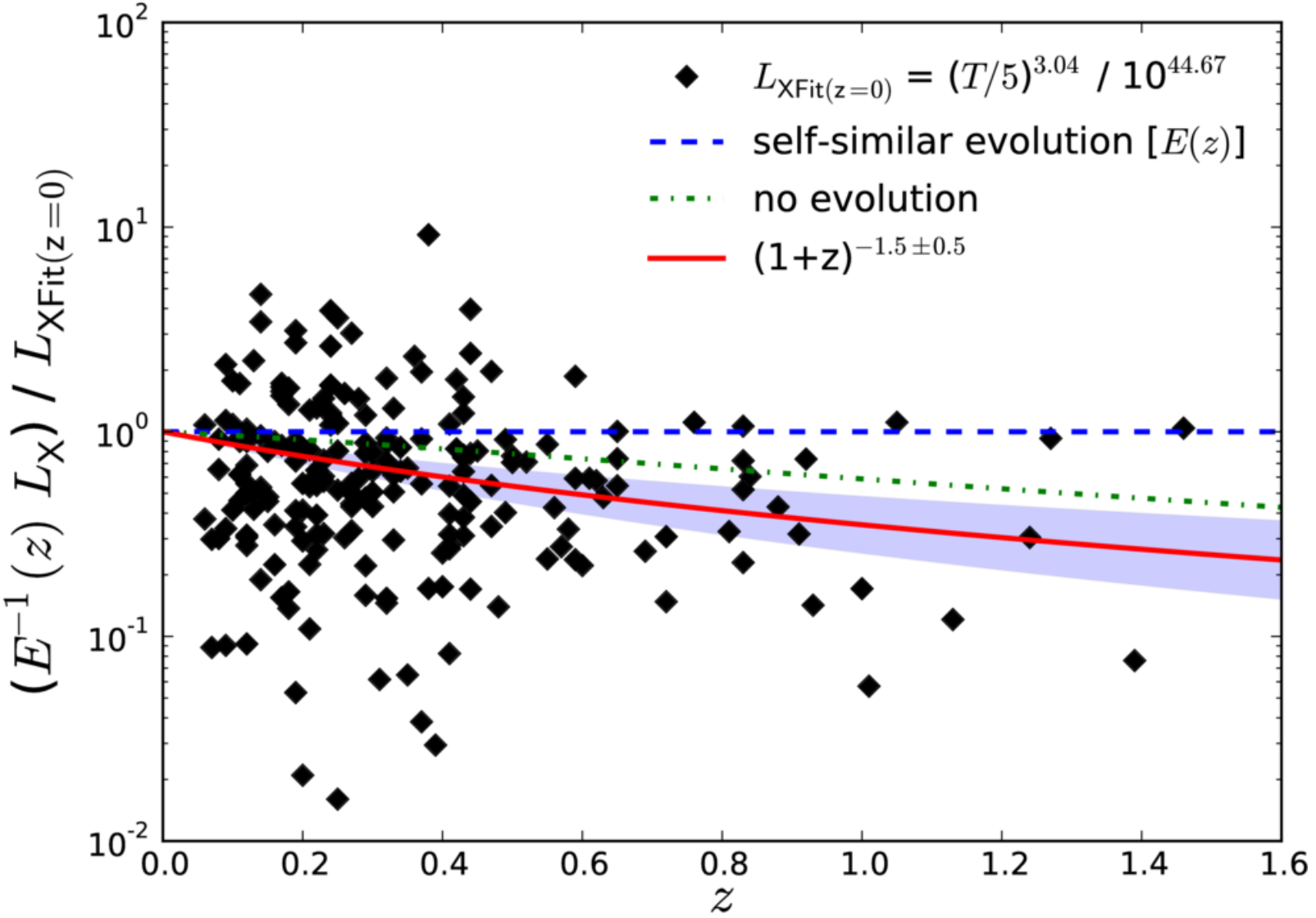
- Model fitted: $\log(E^{-1}(z)\,L_{\rm X}) = A + B\log(T/5) + C\log(1+z)$
- Two MCMC regression methods, orthogonal and bisector
- First check for evolution in slope and scatter by fitting in z bins (C = 0):
  - Slope gets shallower with increasing z using bisector (2.8 → 2.2), no significant change for orthogonal method (3.2 → 2.8)
  - Slight decrease in intrinsic scatter with increasing z ($\sigma_{\rm logLX}$ ~ 0.33 → 0.24), but not significant



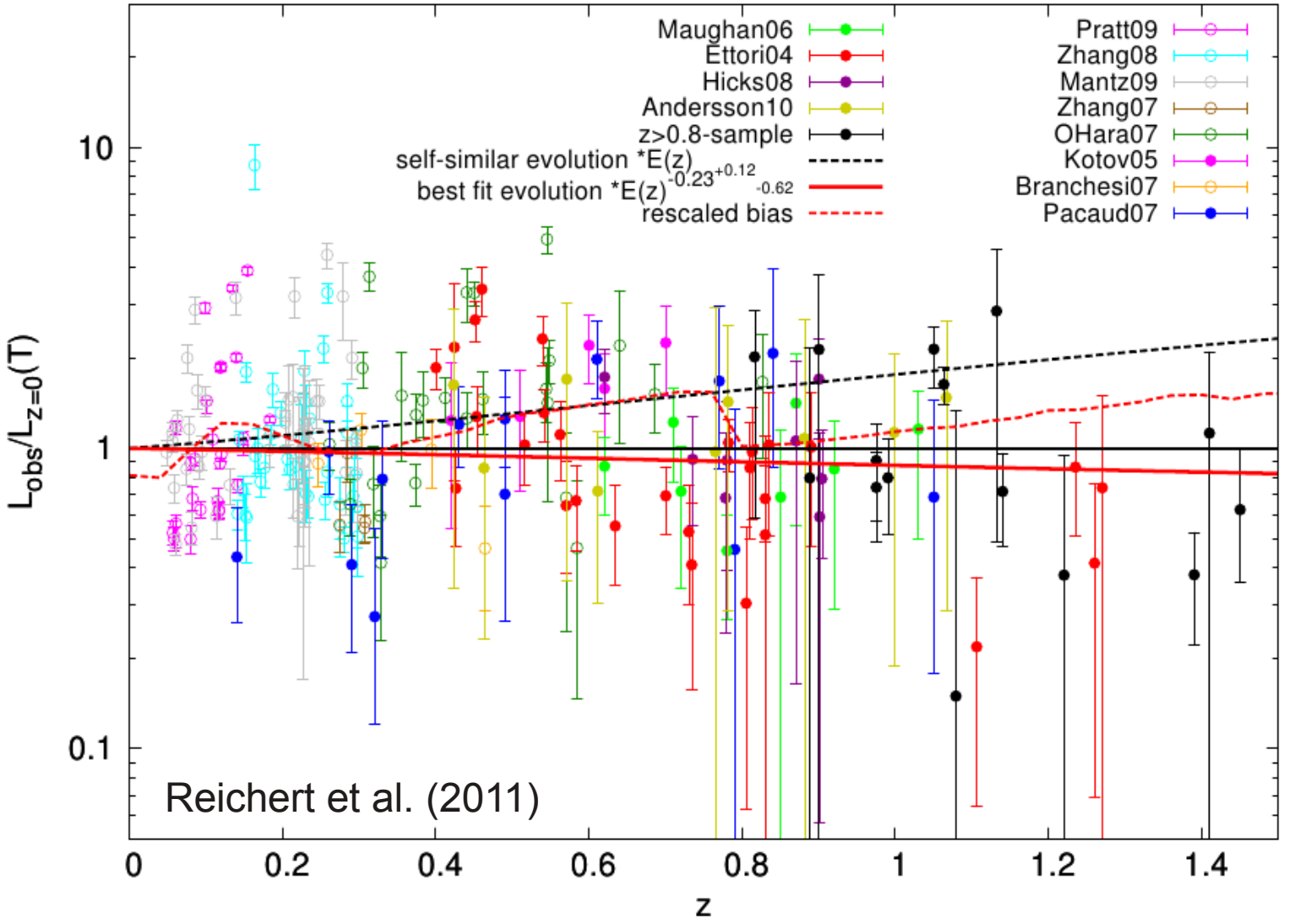




- Orthogonal fit results with redshift evolution (C) as a free parameter
- Slope consistent with z = 0 sample, normalisation slightly lower than REXCESS



- We see negative evolution with respect to self-similar
- Similar behaviour is seen in a study of 14 heterogeneous datasets (including the XDCP z > 0.8 sample) by Reichert et al. (2011) – also Ettori et al. (2004)



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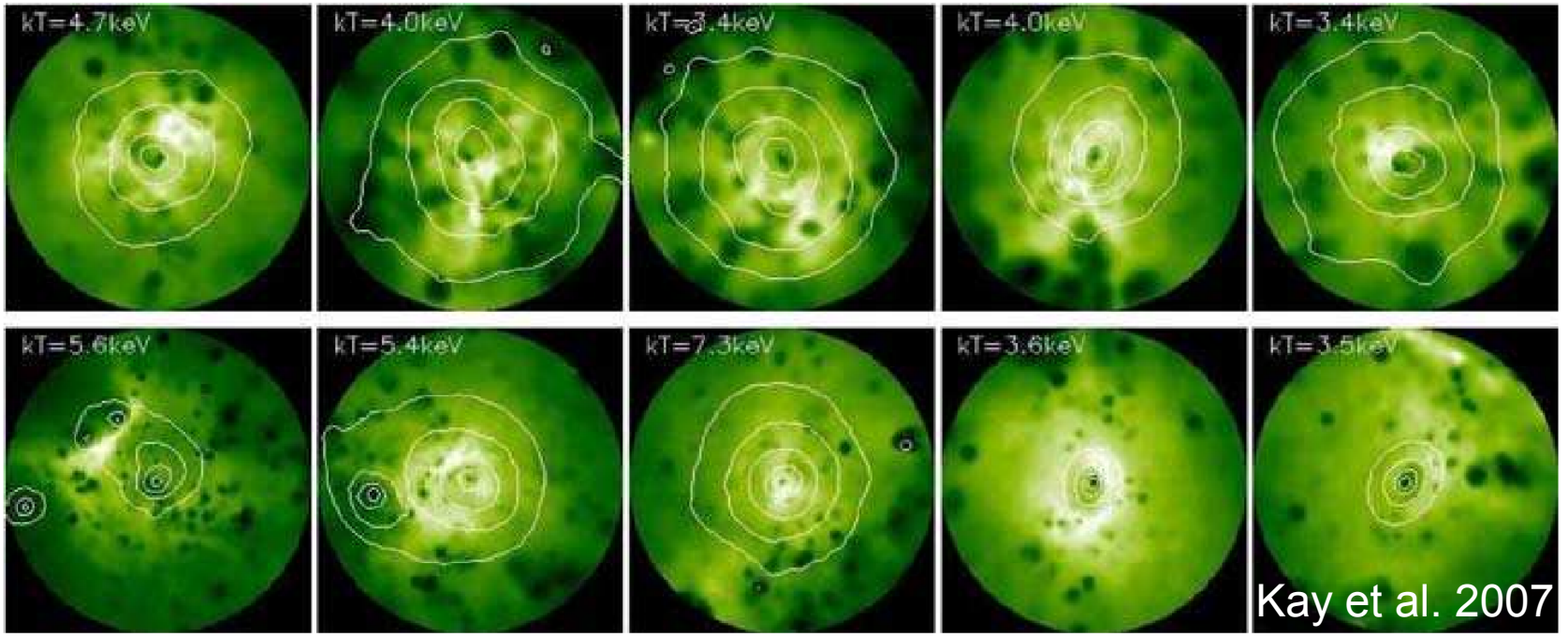
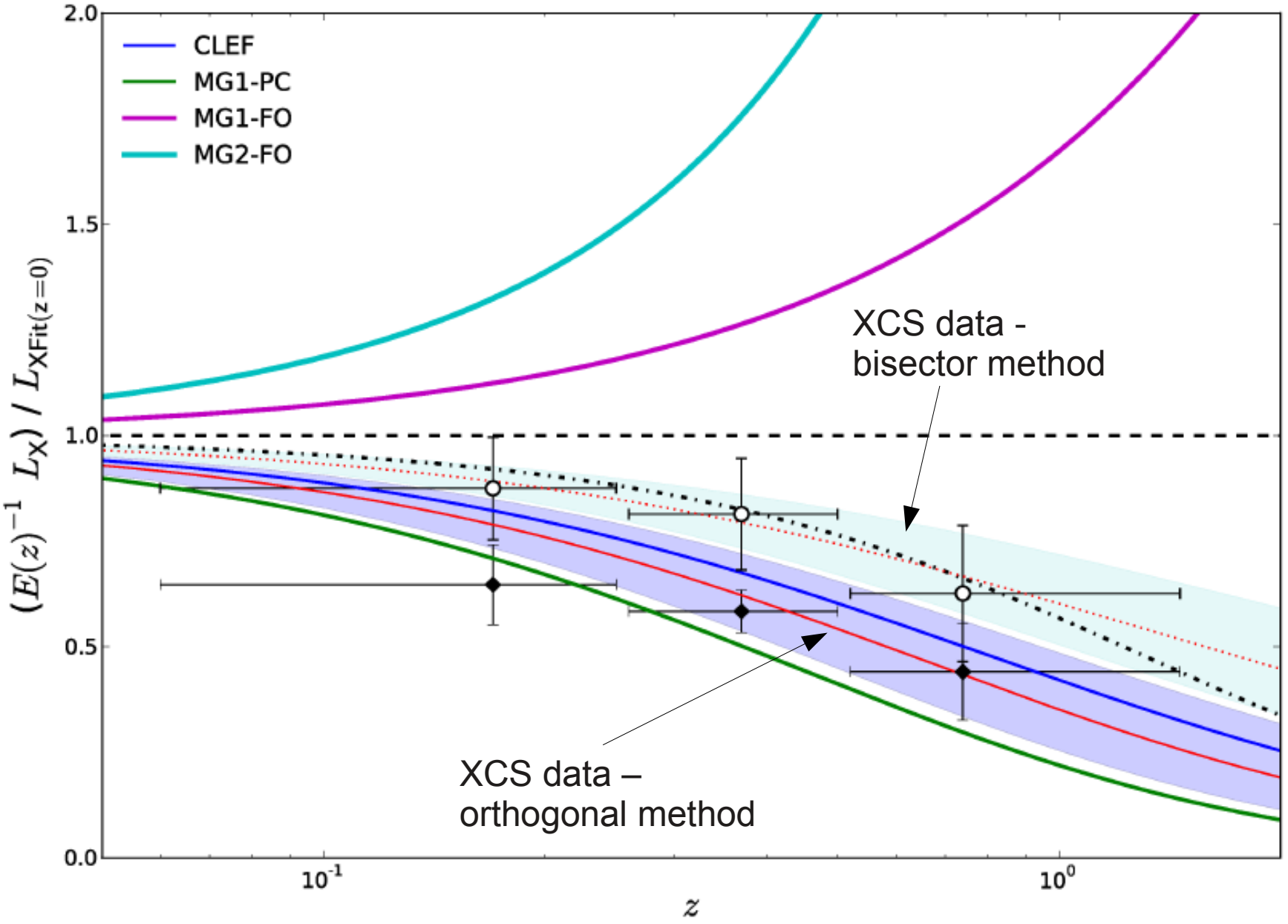
What does this mean?

- Comparison with numerical simulations:
  - CLEF (Kay et al. 2007), uses `strong feedback' model from Kay (2004)
  - Millennium Gas models (Short et al. 2010):
    - Pre-cooling (MG1-PC), AGN feedback only (based on De Lucia & Blaizot al. 2007 semi-analytic prescription)
    - New version of AGN feedback model (Short, Thomas & Young 2012), based on feedback prescription in Guo et al. (2011)

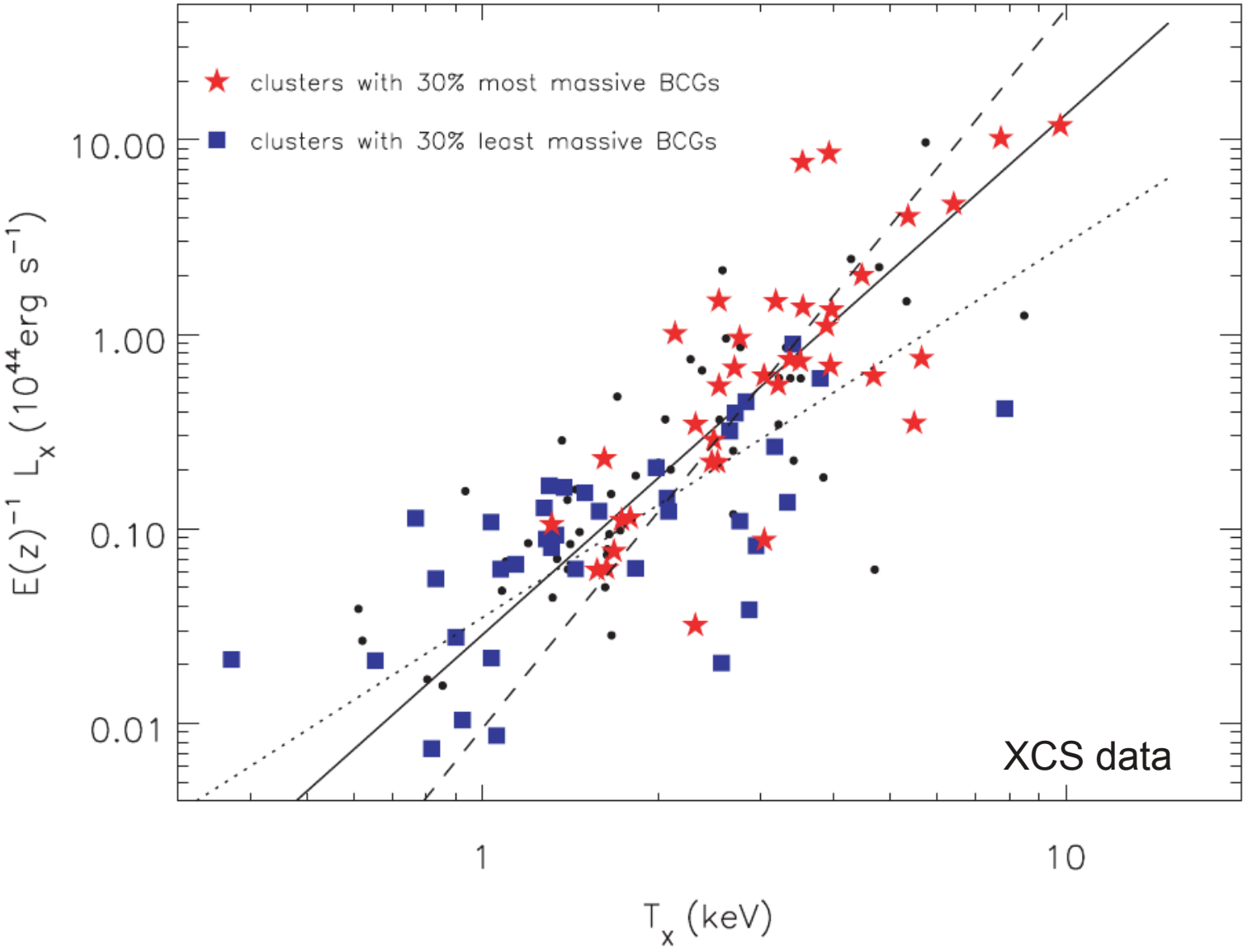




- XCS data looks more like CLEF or MG1-PC (precooling model), i.e. models in which energy is injected into the ICM preferentially at high redshift

More XCS-DR1 L-T work...

- Stott et al. (2012) – XCS-DR1 z < 0.3 cluster sample cross matched with SDSS and FIRST



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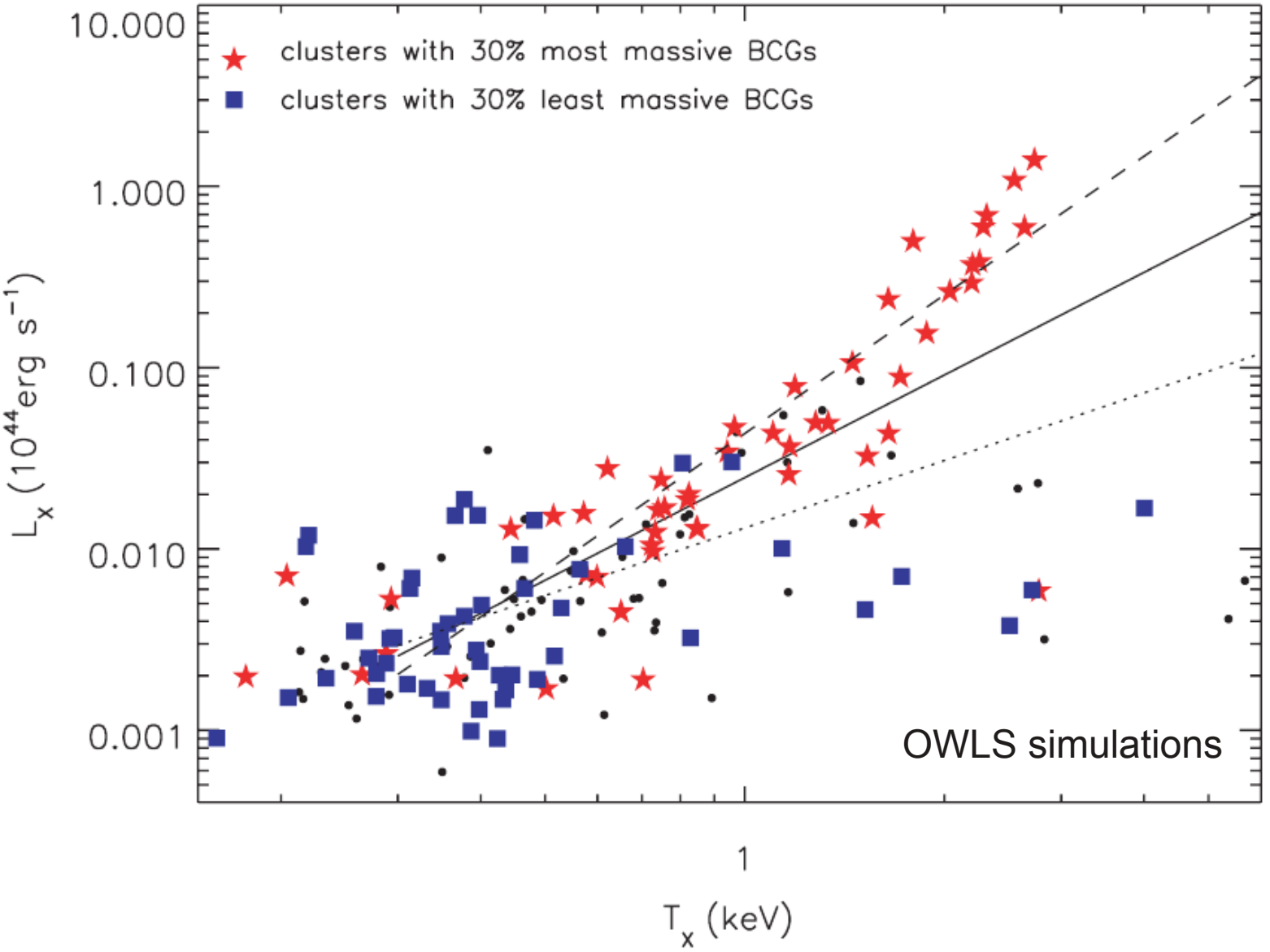

Summary

- We have measured the evolution of the X-ray luminosity – temperature relation using 211 clusters with spectroscopic redshifts drawn from XCS-DR1
- We find the evolution of the normalisation is negative with respect to self-similar, but within 2σ of zero evolution, when using an MCMC orthogonal regression technique (in good agreement with the findings of Reichert et al. 2011)
- From comparison with numerical simulations, the XCS data favour models in which energy is injected into the ICM preferentially at high redshift, as in the CLEF simulations or the Millennium Gas pre-cooling model – some AGN feedback models based on semi-analytic prescriptions are disfavoured at more than 5σ
- Caveats: the effect of the selection function and cluster mass function are not taken into account as yet