Combining X-ray and SZ observations to characterize cluster outskirts: current work and future prospects

Silvano Molendi

IASF-Milano/INAF

In collaboration with:

D.Eckert, S.Ettori, F.Gastaldello, M.Rossetti, M.Roncarelli, F.Vazza

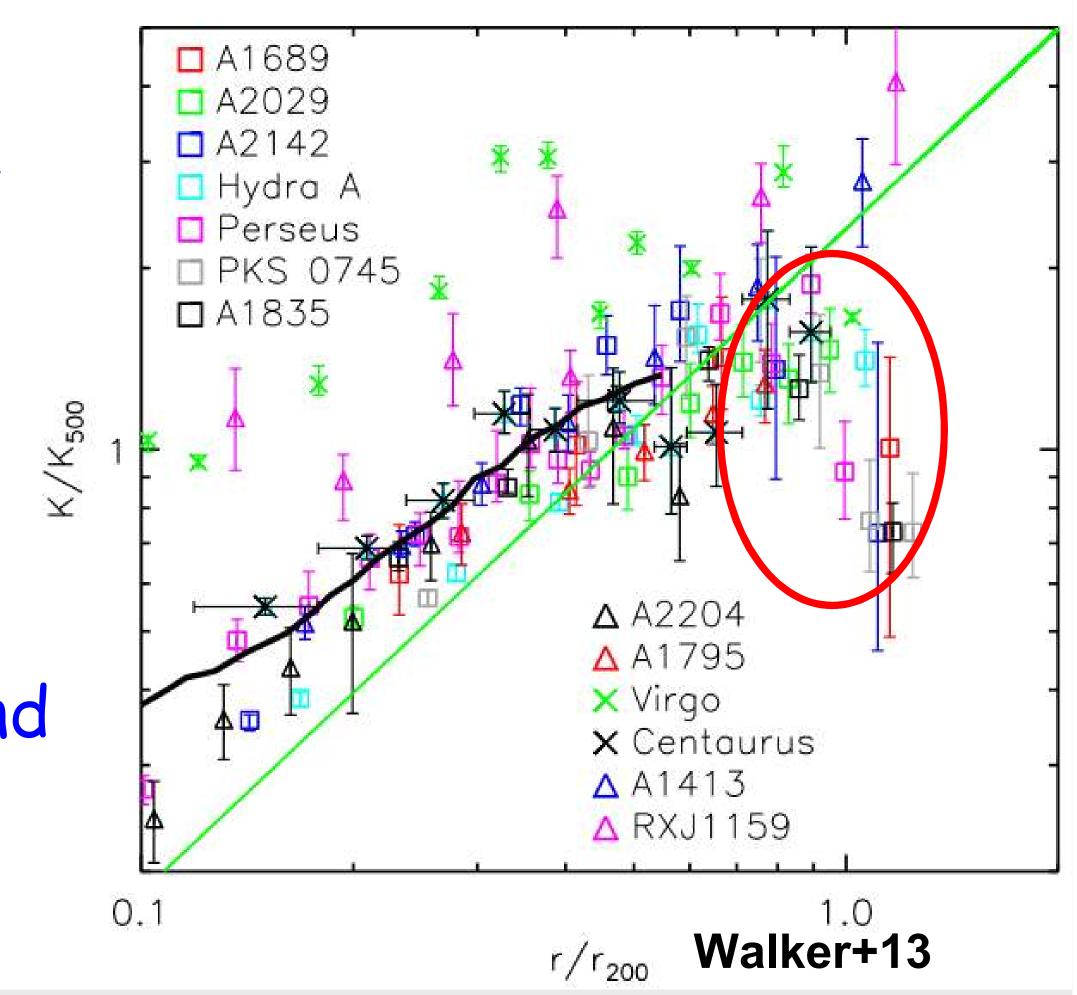
Entropy profiles

Over the last 4 years Suzaku observations have extended measurements to larger radii

One way of presenting results is through entropy profiles.

Entropy is built as combination of n and T
$K=T/n^{2/3}$

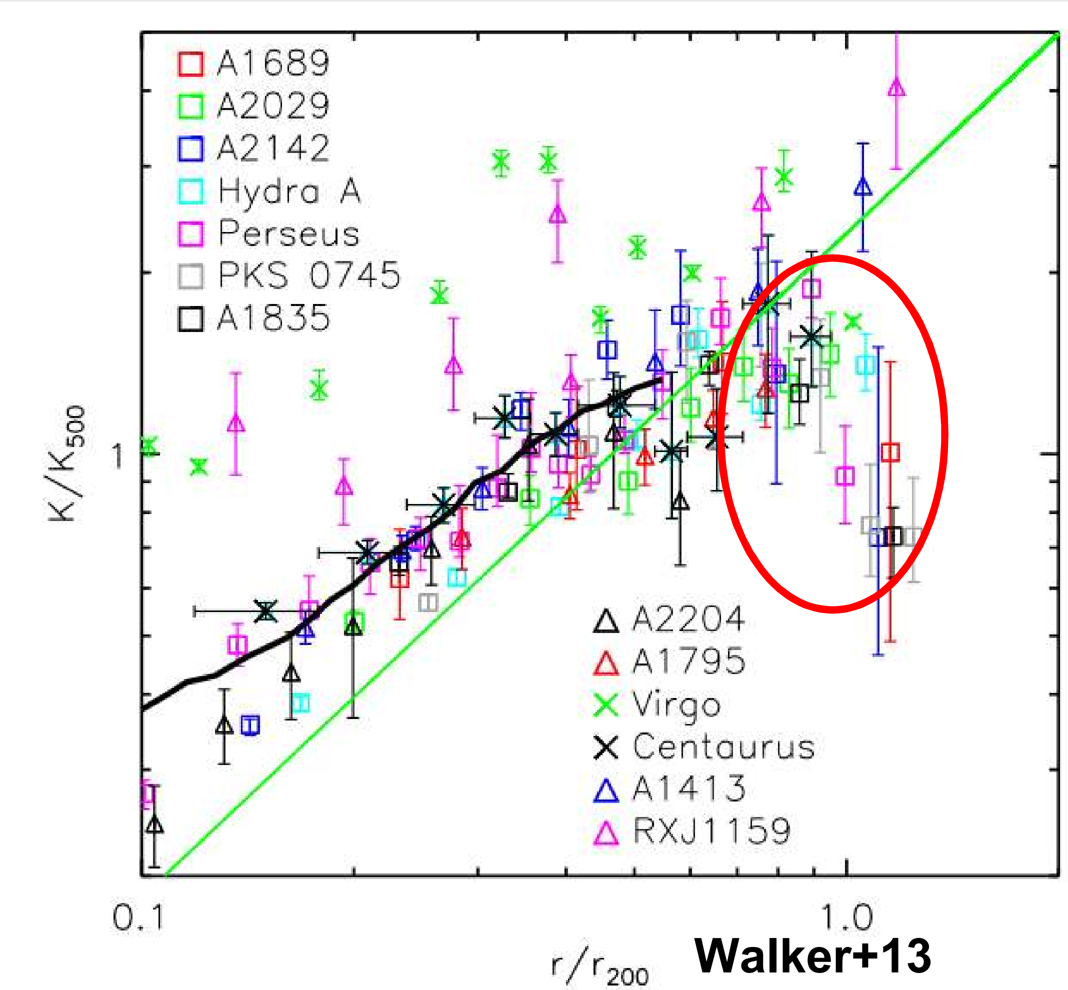
Suzaku profiles appear to flatten significantly beyond 0.7 r200.



Entropy profiles

This is potentially a very interesting result

However we should try to understand how robust it is.



Alternative approach

- SB measures are the easiest to make
- SZ measurements are intrinsically more sensitive to outskirts:

  X-ray SB scales like n^2

  SZ signal scales like n
- Combine ROSAT SB (Eckert…SM,+12) with Planck Pressure measures to derive:

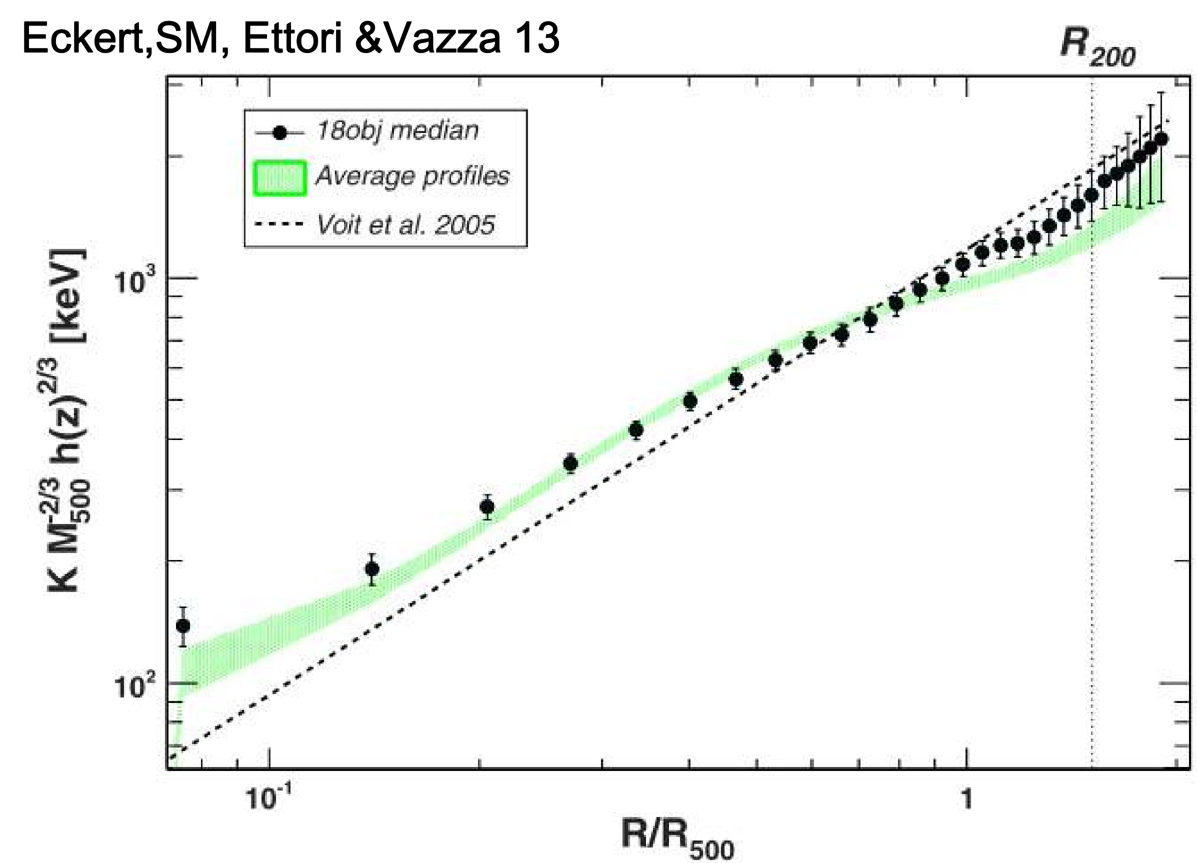
  n,T and K

Entropy profiles

1. Mean profiles for samples
2. 18 objects in common between 2 samples

Results from 18 objects somewhat different from those derived by combining averages of ROSAT and Planck samples

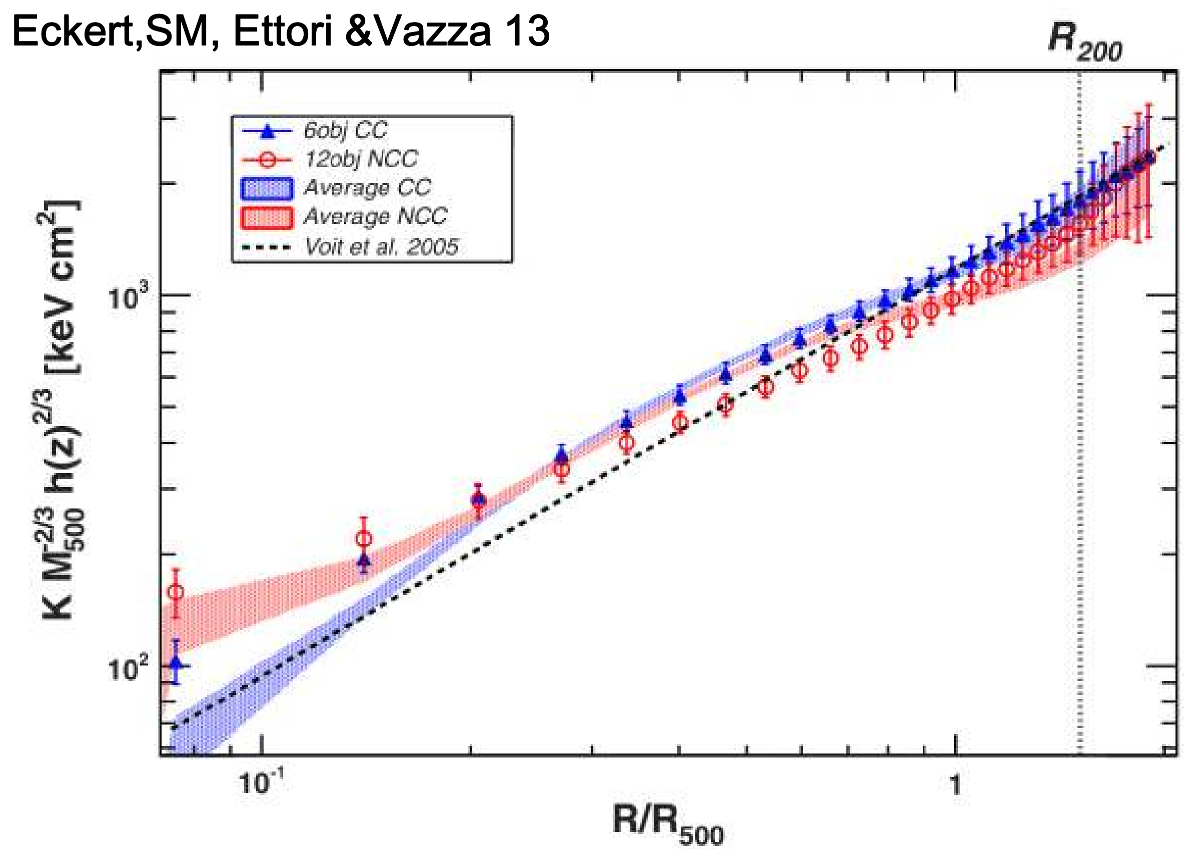
Mild deviations from self similar expectations



Entropy profiles: CC vs NCC

Beyond R500 CC systems consistent with self-similar predictions, NCC slightly below.

This is NOT in agreement with Suzaku findings



CC vs NCC

Entropy computed from density and pressure

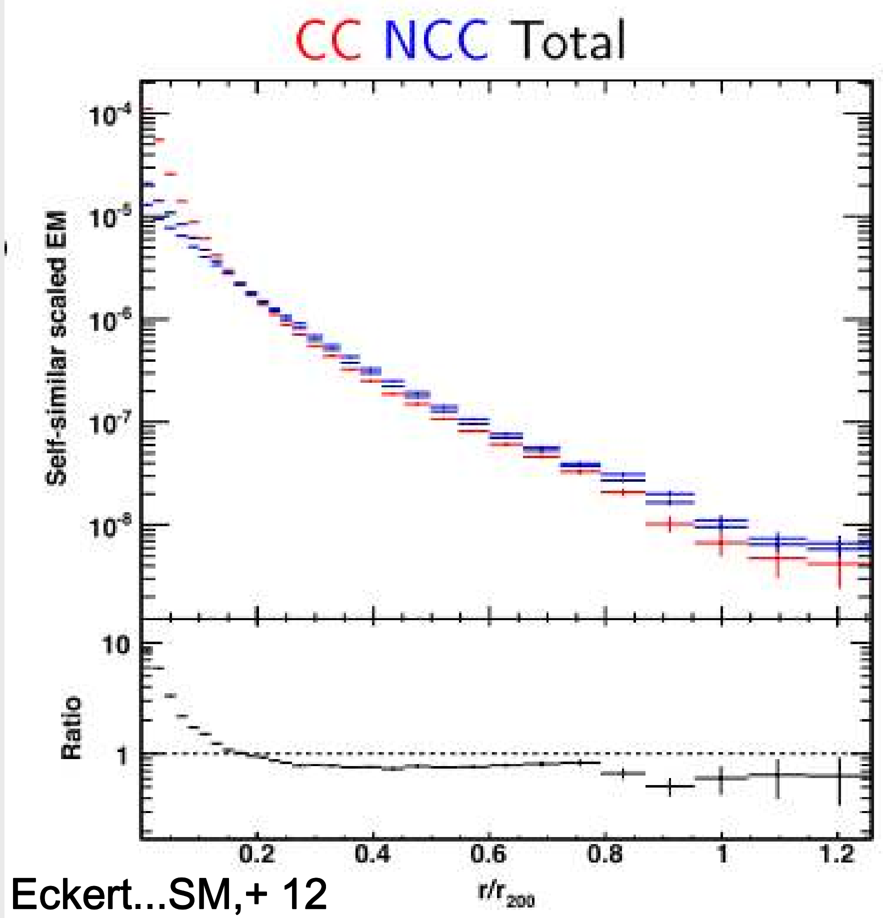
Pressure profiles for CC and NCC very similar

Some modest differences in density

What is the origin of the residual density difference:

Is it a genuine astrophysical difference?

Related to some measurement bias?



Eckert...SM,+ 12

CC vs NCC/2

The answer to this question has profound implications for our understanding of the ICM and use of clusters for cosmology

- If difference is not real then once the bias is removed mass proxies calibrated on hydrostatic mass estimates of CC systems can be applied to NCC
- If real then mass proxies derived for CC systems may well provide biased estimate of NCC masses

The Emissivity Bias

$$\sqrt{\frac{< n^2 >}{< n >^2}} > 1$$

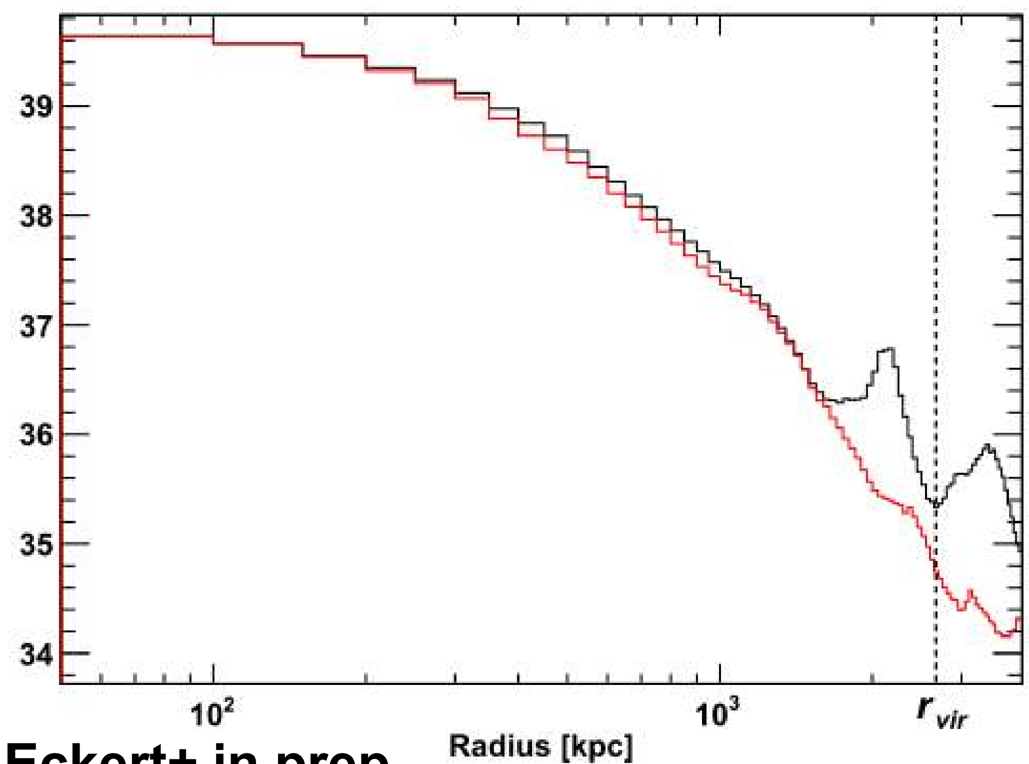
- This is an emissivity bias. It will be present every time the density in the region under inspection is not homogenous.
- The term clumping is missleading as it is associated to one of many astrophysical scenarios resulting in the bias
- Another case is that of morphologically irregular systems, where inhomogeneities occur on large scales
- NCC systems will on average suffer from a larger emissivity bias

The Emissivity Bias/2

Recently various attempts to correct for E-bias:

Roncarelli+13, Zhuraleva+13,Morandi+13

Extracting unbiased estimate of "mean" surface brightness from azimuthal distribution.



Eckert+ in prep.

- Use of median is promising
- In the process of validating a median based technique on simulations

Going beyond ROSAT+Planck

In the near future we will have many new SZ experiments (CCAT, SPT3G etc..; B.Benson's talk)

1. Experiments will provide mostly unbiased census of clusters out to z=1.
2. Pressure measurements for large number of systems
3. Full thermo-dynamical characterization only for a few hot systems, little or no measures for typical outskirts.

Going beyond ROSAT+Planck

Design X-ray mission to perform SB measures to complement SZ measures and derive other thermo-dynamic quantities

SB is the easiest quantity to measure, we can improve on ROSAT with small inexpensive telescope

Summary

- Some Suzaku results in the r500-r200 range deviate dramatically from self-similar predictions.
- Serious concerns about Suzaku measurements
- Combining ROSAT SB with Planck P measures we find much milder deviations from prediction, CC systems do not deviate
- A cheap soft X-ray mission would provide the necessary complement to the next generation SZ experiments.