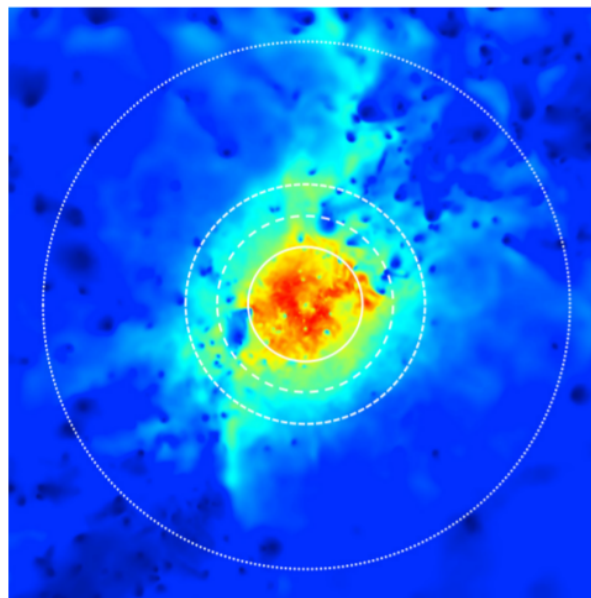
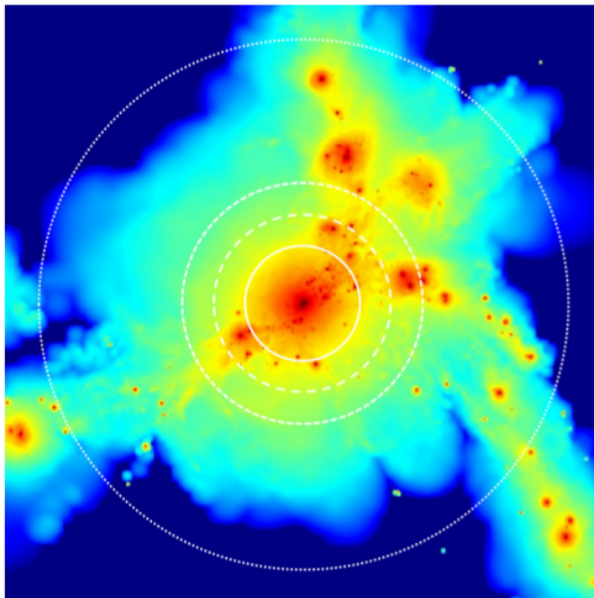


# X-RAY STUDY OF A FOSSIL GROUP OUT TO THE VIRIAL RADIUS

Azores Summer School 2014  
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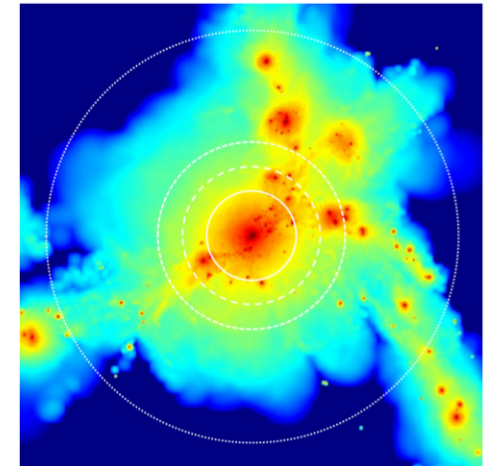


- Main X-Ray emission mechanism of the intracluster gas is bremsstrahlung
- Gas density drops fast towards large radii
- Most X-Ray studies are limited to  $\sim r_{500}$ 
  - $r_{500}$ : radius where the density is 500 x critical density
- Crude approximation:  $r_{200} \approx r_{vir}$

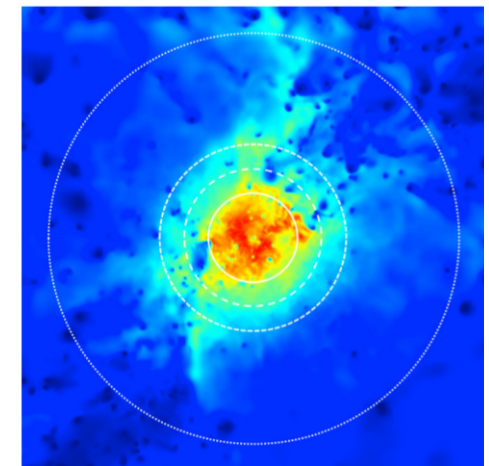
Outskirts:

$$r_{500} < r < 3r_{200}$$

Only 10% in terms of volume  
have been studied in detail!



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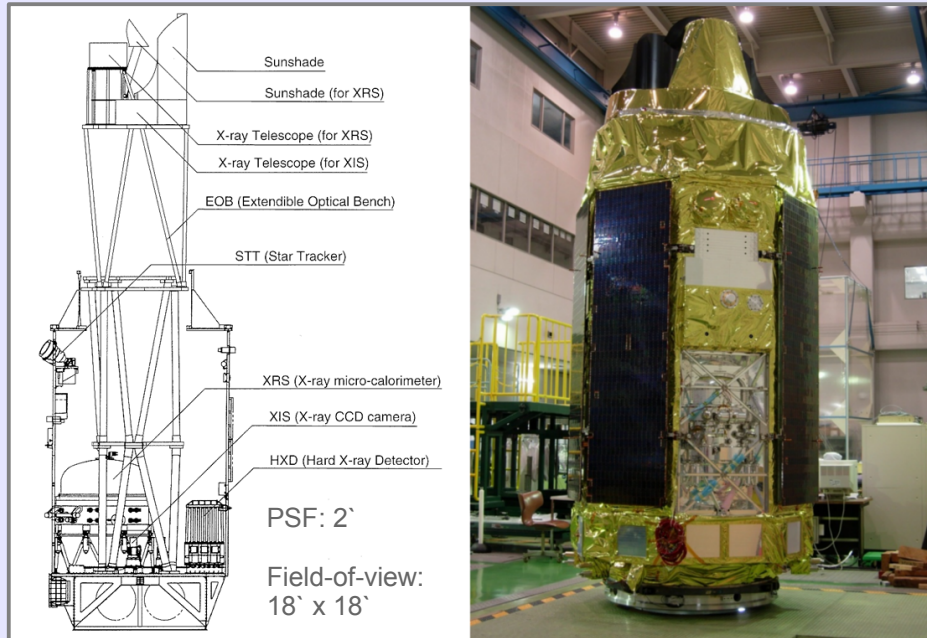
Intracluster gas in a simulated cluster  
Outwards:  $r_{500}$ ,  $r_{200}$ ,  $r_{vir}$ , and  $3r_{200}$   
Top: Surface Brightness 0.5-2.0keV  
Bottom: Temperature map 0-11keV  
(linear scale)

- Very important property for obs. cosmology is **cluster mass**
- Temperature and density profiles extrapolated to large radii  
 → **Systematic errors** in mass estimate

- Interesting physical effects dominated by structure formation, e.g.:
  - Breakdown of equilibrium states
  - Accretion shocks

- Up to now: Mostly galaxy clusters are being studied
- **Deficit on low mass end** (→ scaling relations )

## The Suzaku satellite



Left: © NASA  
Right: © ISAS

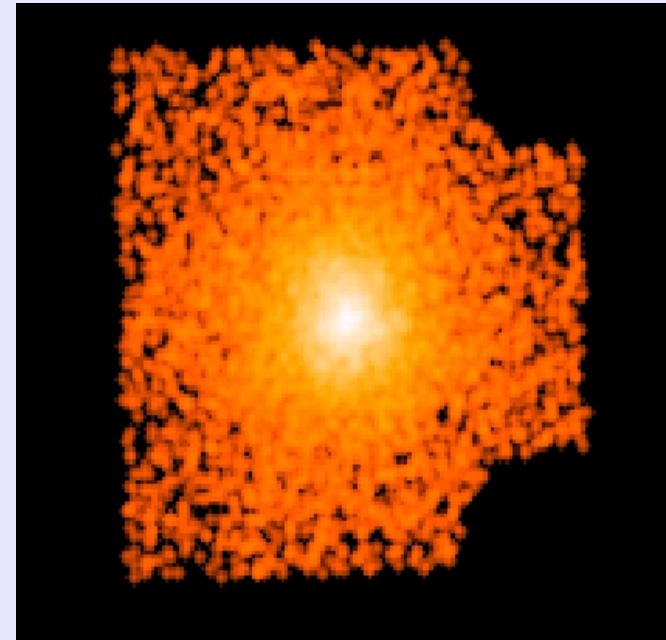
Launched in July 2005

Low-Earth-Orbit

- ➔ Low instrumental background
- ➔ Well suited for studying outskirts

Loss of liquid helium shortly after launch, but **X-Ray Imaging Spectrometer (XIS)** still usable

## The fossil group UGC03957



One of the most luminous local groups

Redshift: 0.034

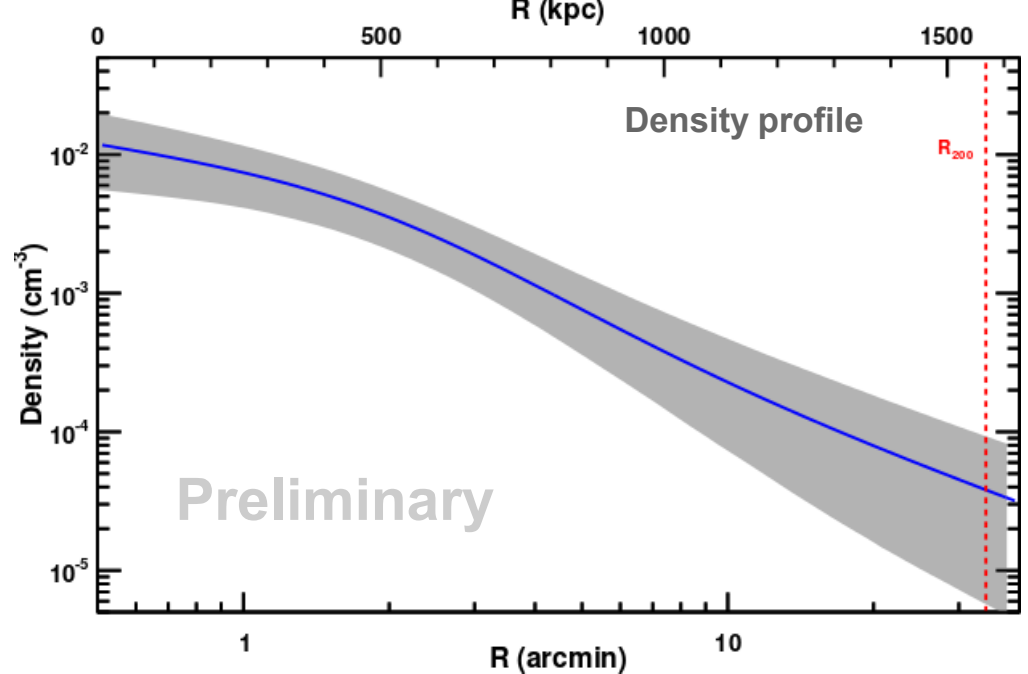
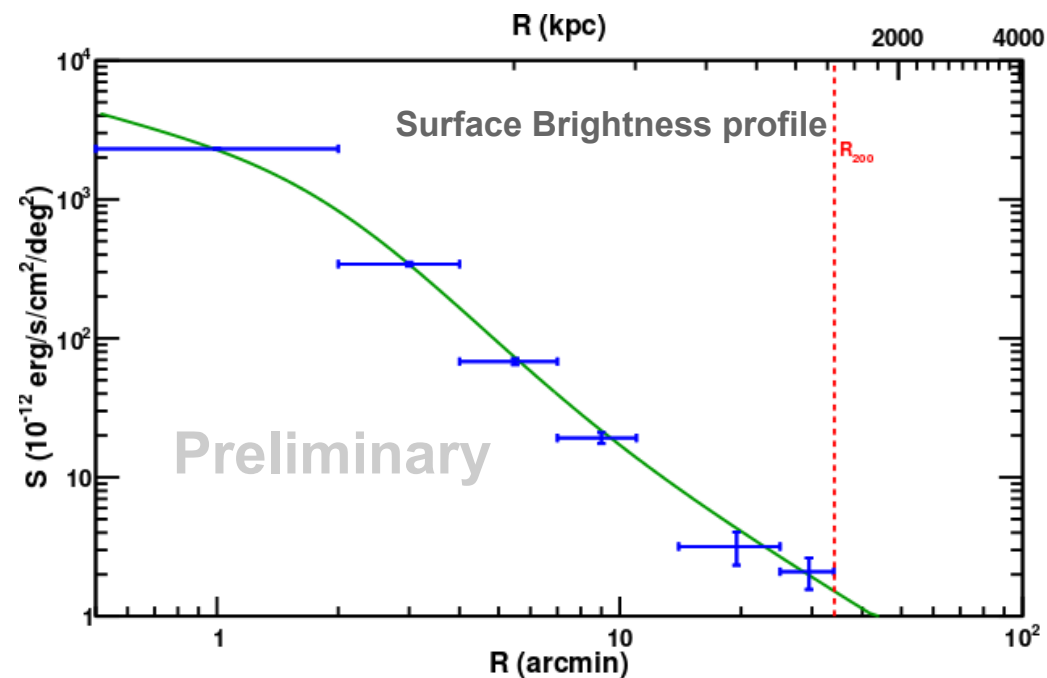
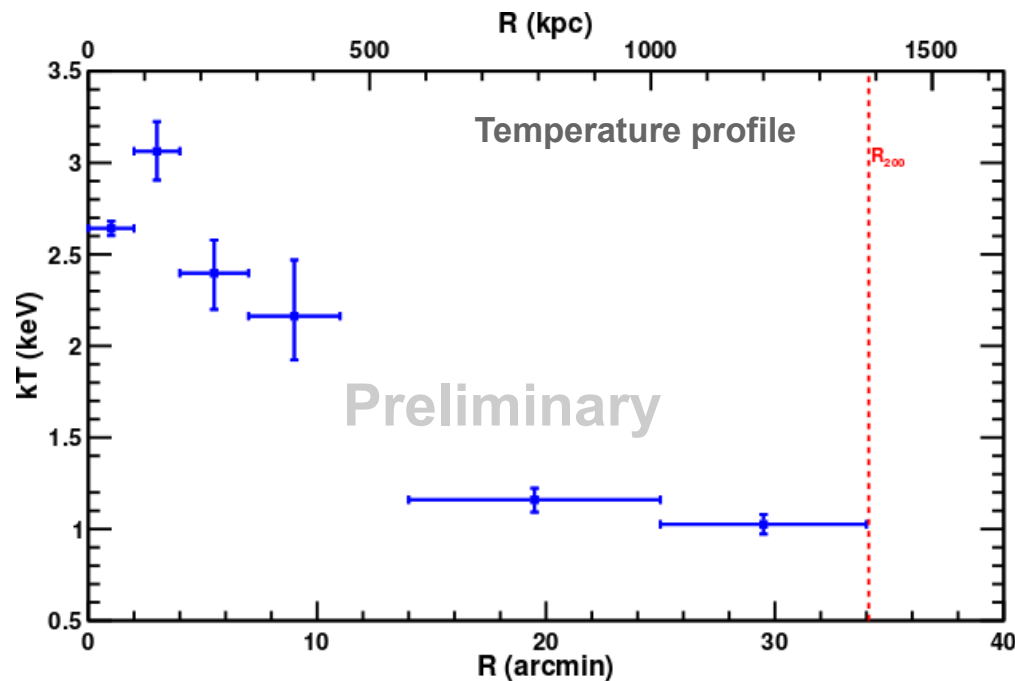
$R_{200} \sim 34'$  (1.4Mpc)

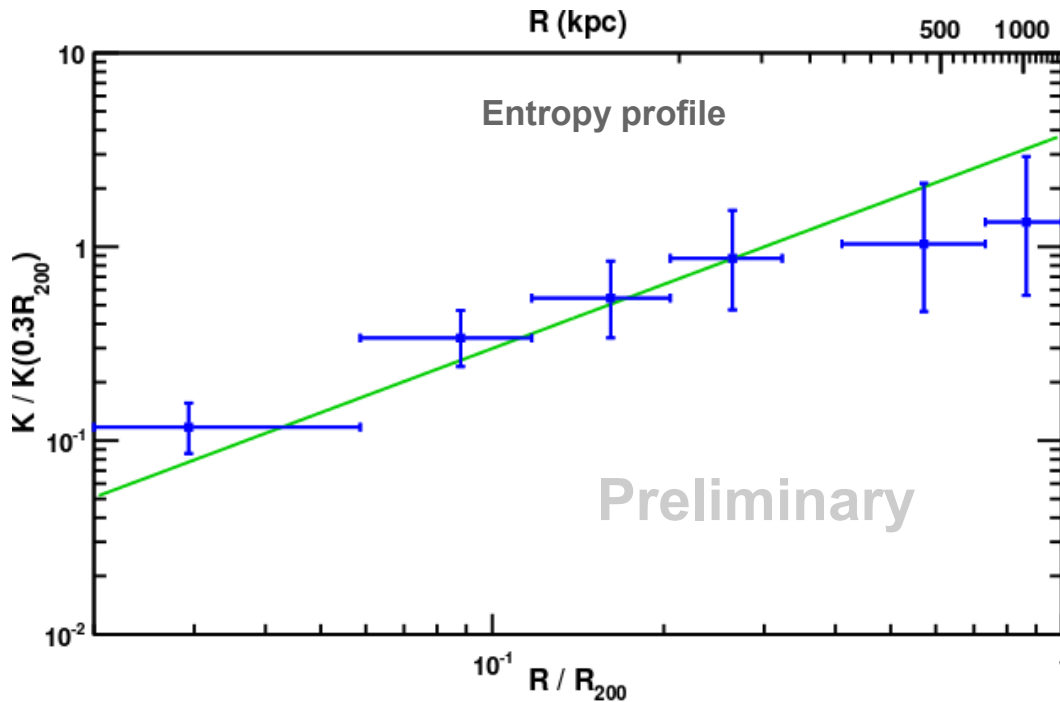
5 Suzaku observations:  
1 center + 4 outskirts in each azimuthal direction

No azimuthal deviations found in spectral analyses

↓

Simultaneous spectral analysis of the 4 outskirts-observations is performed





Entropy:  
 $K = k_B T n^{-2/3}$

From simulations:

Tozzi & Norman (2001)  $K \propto r^{1.1}$

Flattening of entropy profile observed

Possible explanations:

- Clumping of gas → overestimation of density e.g. Simionescu et al. (2011), Nagai (2011)
- Thermal equilibrium not fulfilled →  $T_e \neq T_{\text{gas}}$  e.g. Hoshino et al. (2010), Akamatsu et al. (2011)
- Collisional ionization equilibrium not fully established  
 → Underestimation of electron temperature Reiprich et al. (2013)