

The « cool-core bias » in X-ray cluster samples

Context



Context

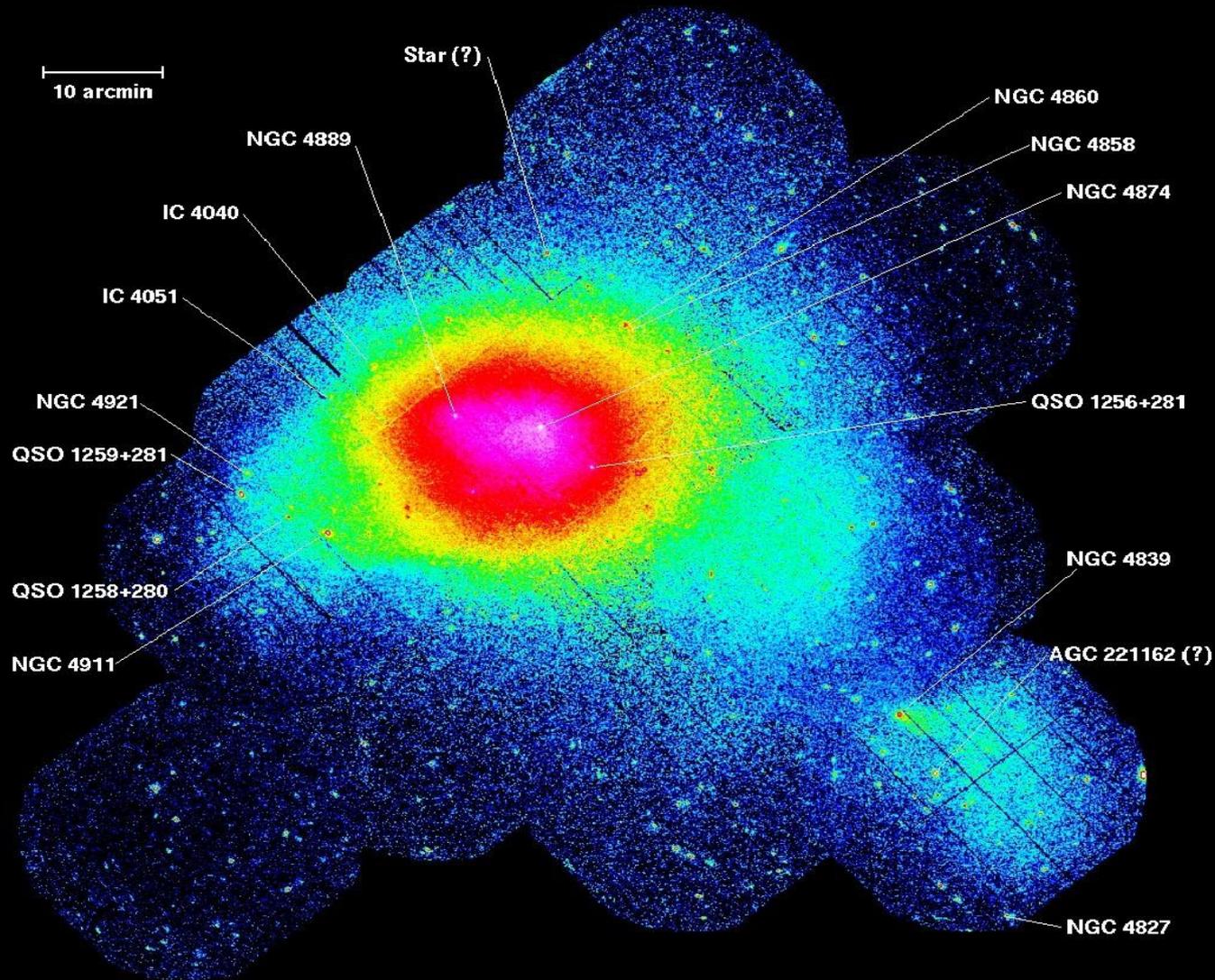
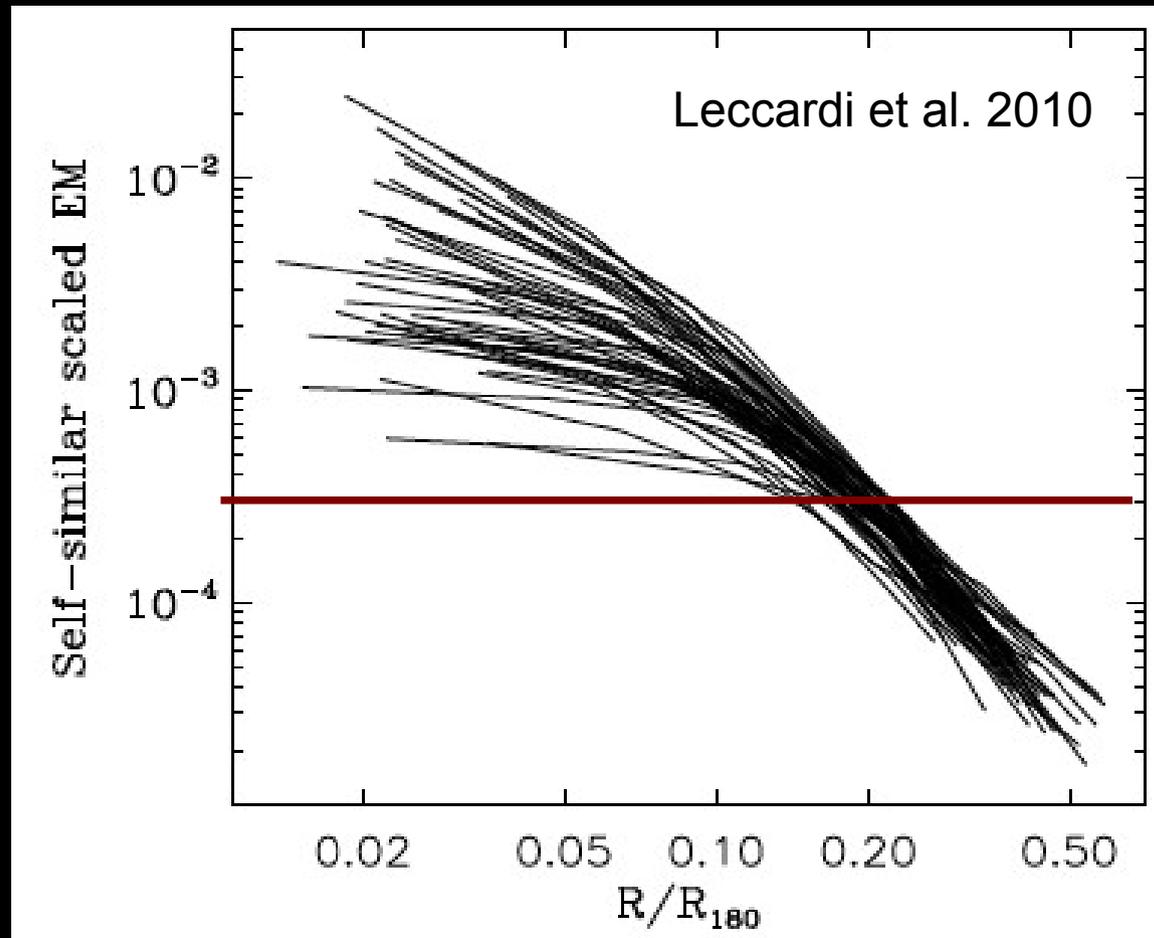


Image courtesy of U. Briel, MPE Garching, Germany

Coma Cluster of galaxies

European Space Agency 

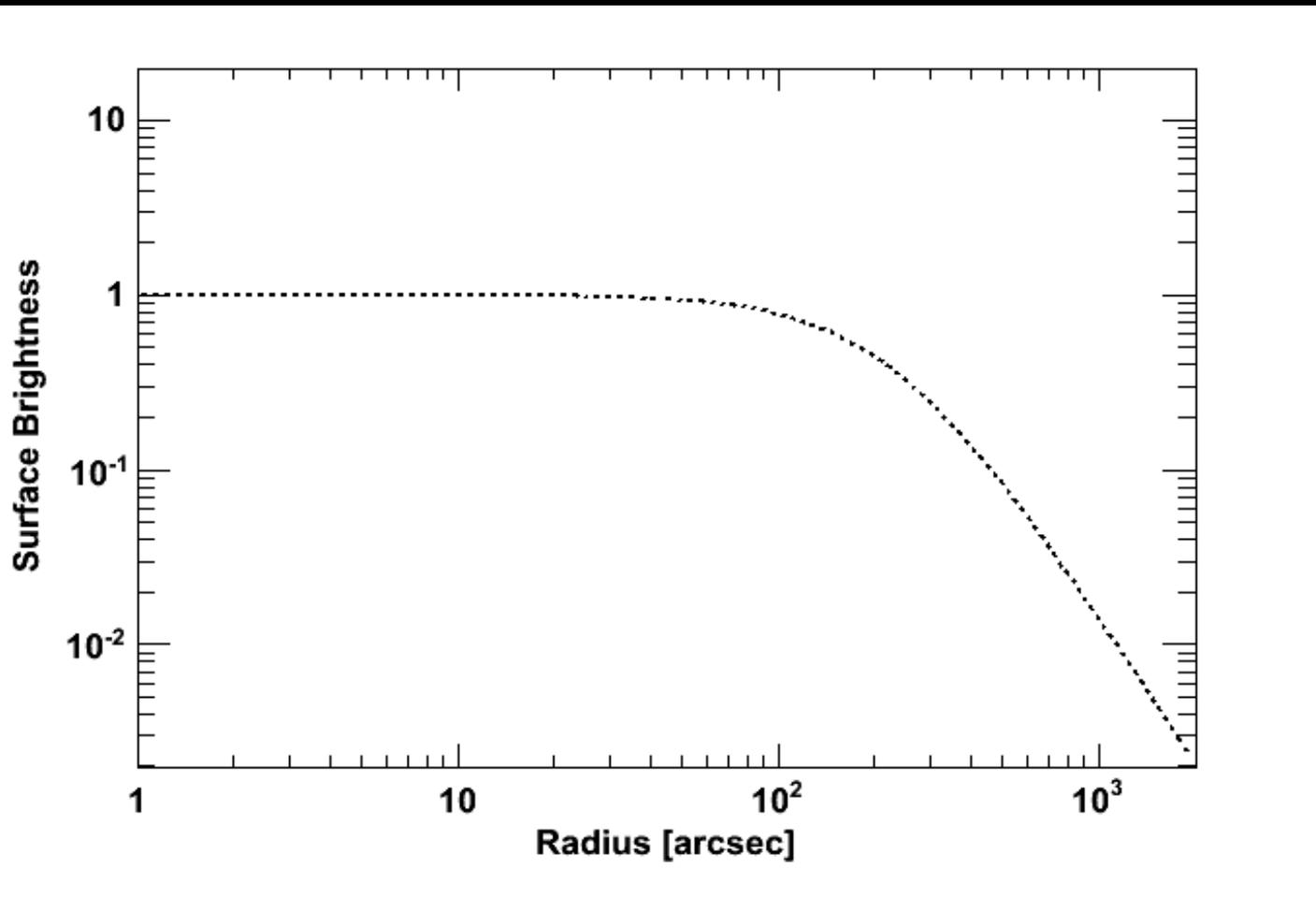
Context



- CC: relaxed, peaked profile, central T drop
- NCC: unrelaxed, flat profile, constant T

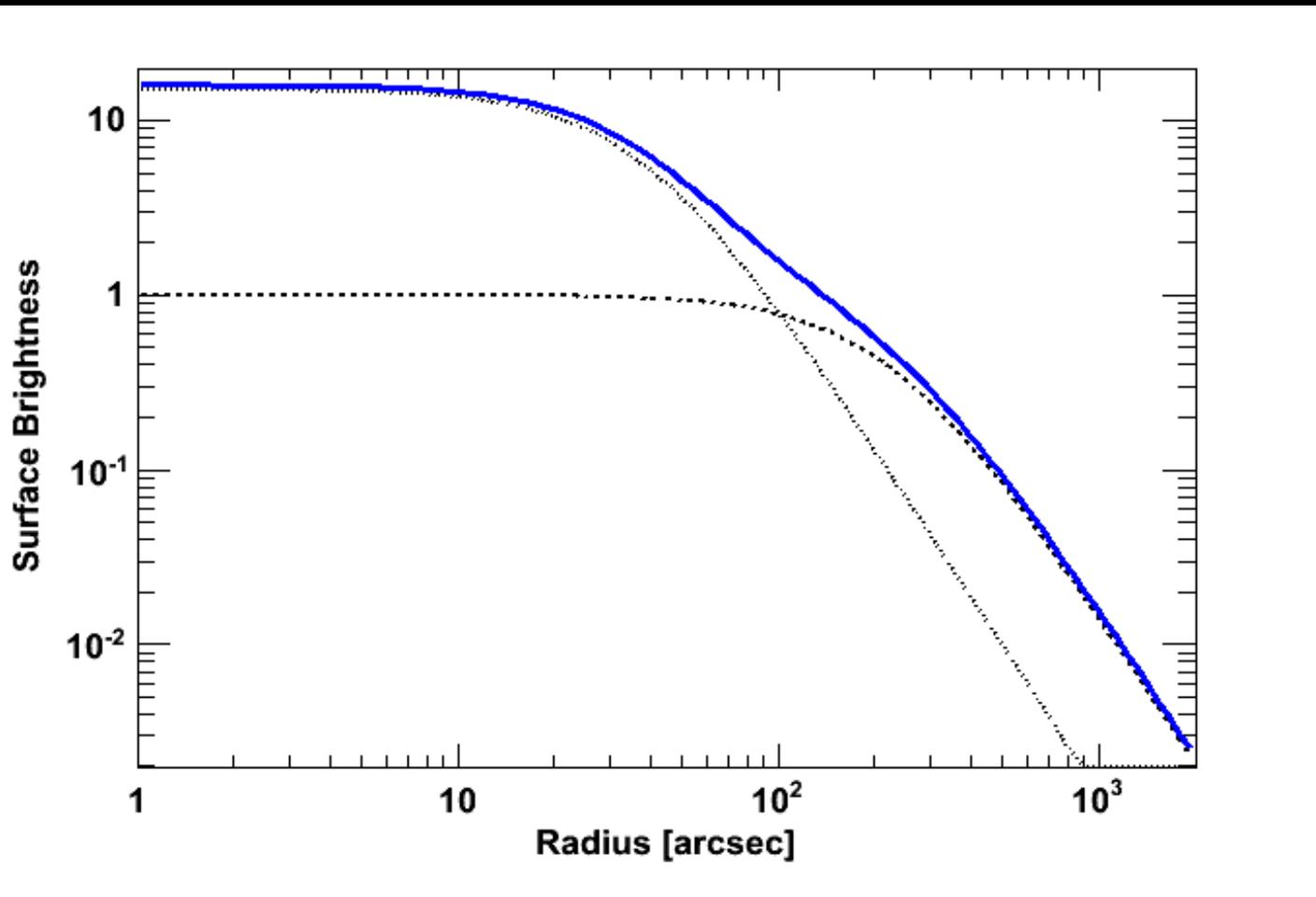
Beta model

$$I(r) \sim \left[1 + \left(\frac{r}{r_c} \right)^2 \right]^{-3\beta/2}, \quad \beta = \frac{\mu m_p \sigma_r^2}{k T_g}$$



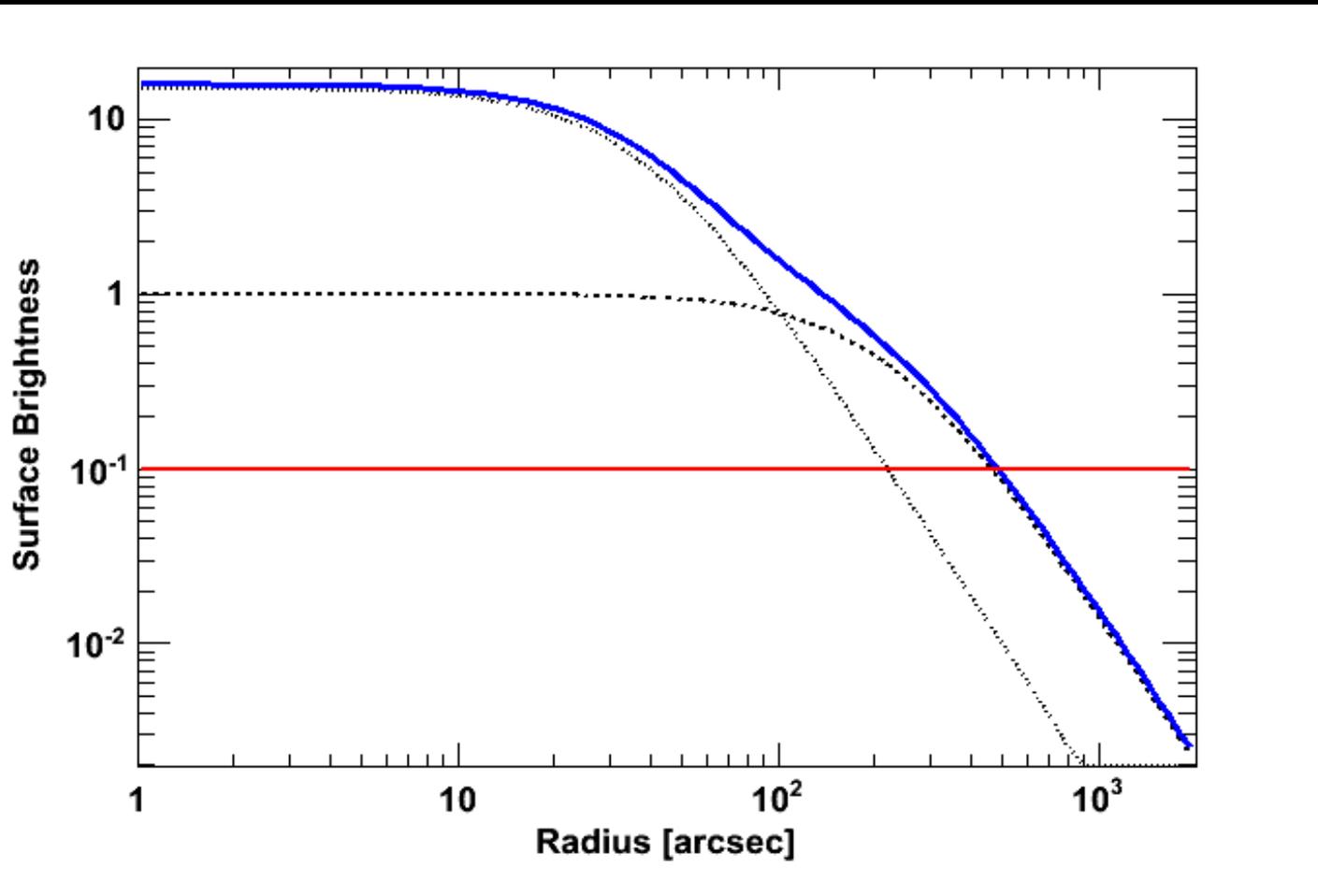
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Method

- Recent works: CC/NCC are about 50% (e.g. Chen et al. 2007)
- We would like to quantify the bias on the fraction of CC vs NCC clusters measured in cluster samples
 - Numerically: predict the importance of the bias in well-known samples
 - Observationally: give a measurement of the fraction of CC vs NCC clusters not affected by this bias

Monte-Carlo simulation pipeline

Typical SB parameters

β, r_{c1}, r_{c2}, R

21cm maps

NH

X-ray LF

z, L_x

apparent r_{c1}, r_{c2}

CC/NCC

Count rate

Total Flux

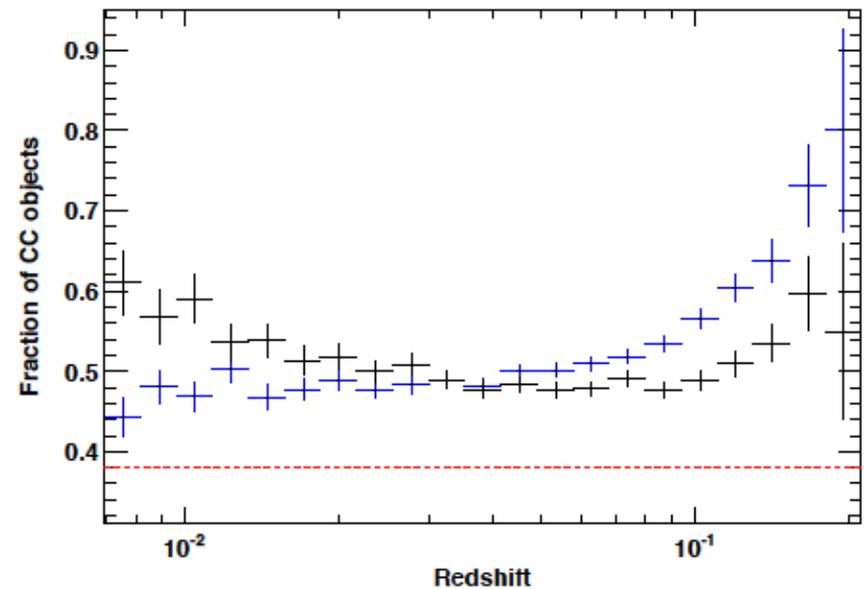
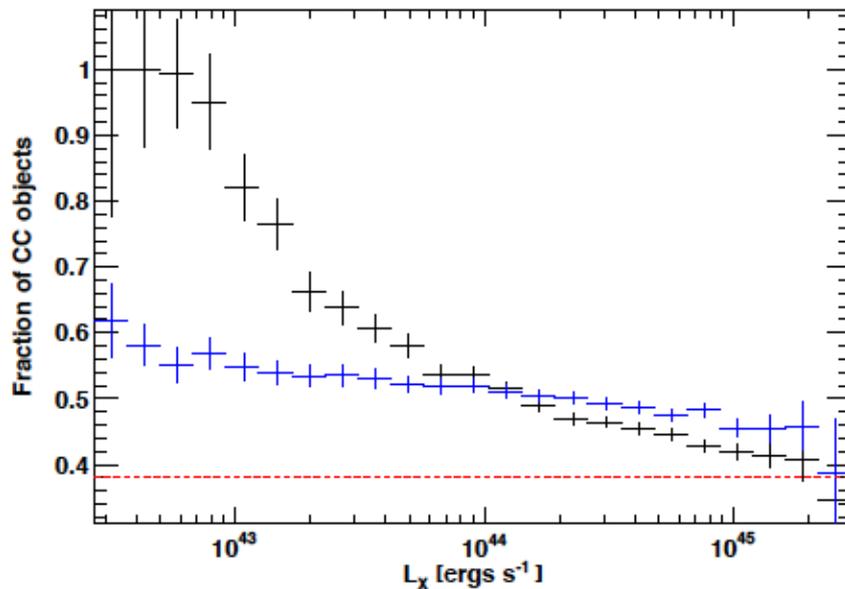
Apparent count profile
Comparison with bkg profile

Observed Flux F_{obs}

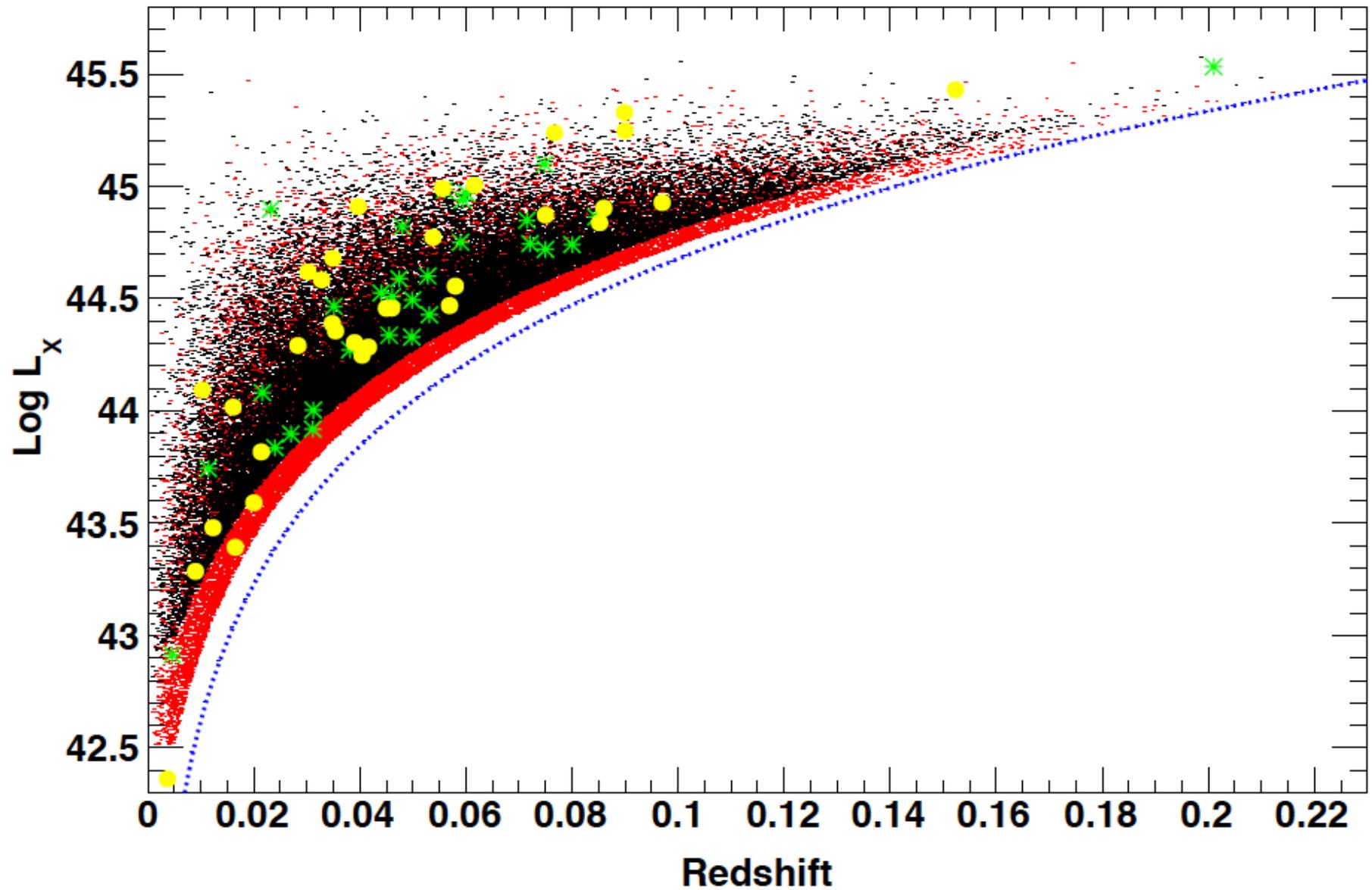
If $F_{obs} > F_{lim}$, selection in sample

Results

- HIFLUGCS (flux limit 2×10^{-11} ergs s^{-1} cm^{-2} , 0.1-2.4 keV): observed fraction of CC = 0.49 (Chen et al. 07)
- To reproduce this fraction in the simulation we need 38% CC clusters, bias 27%

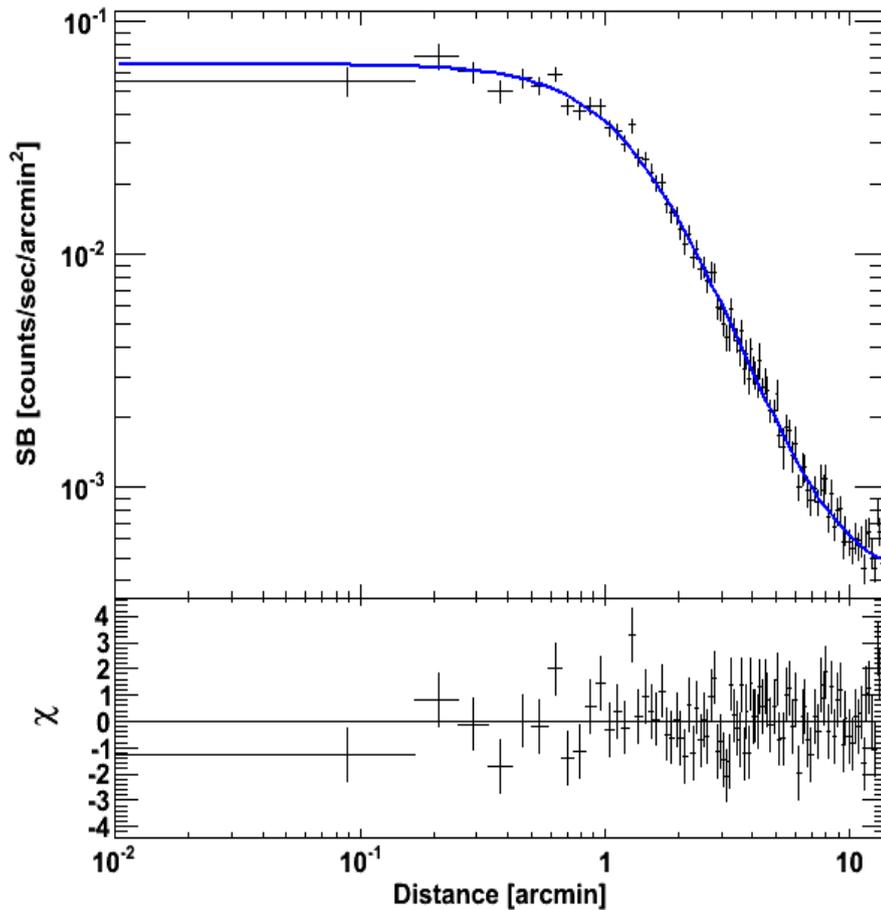


Log L_x vs z plane

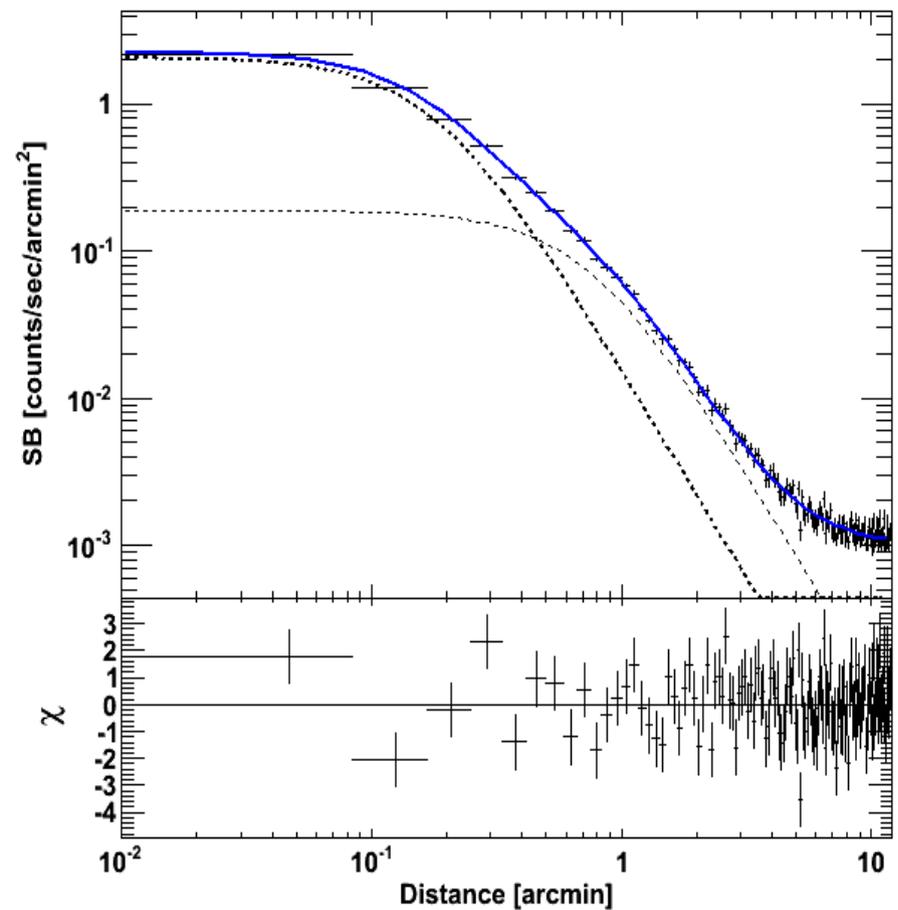


Observational approach

- SB profiles from XMM and ROSAT for all HIFLUGCS clusters

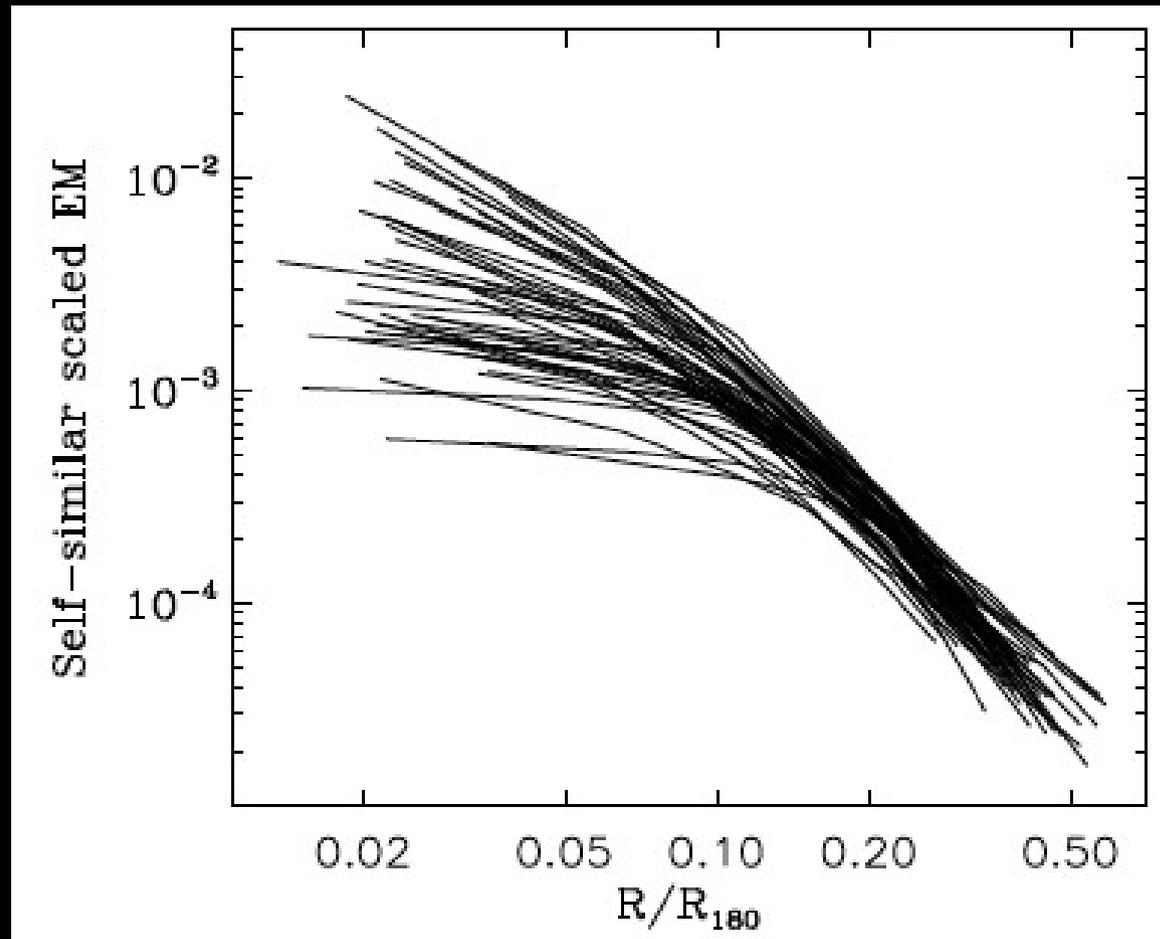


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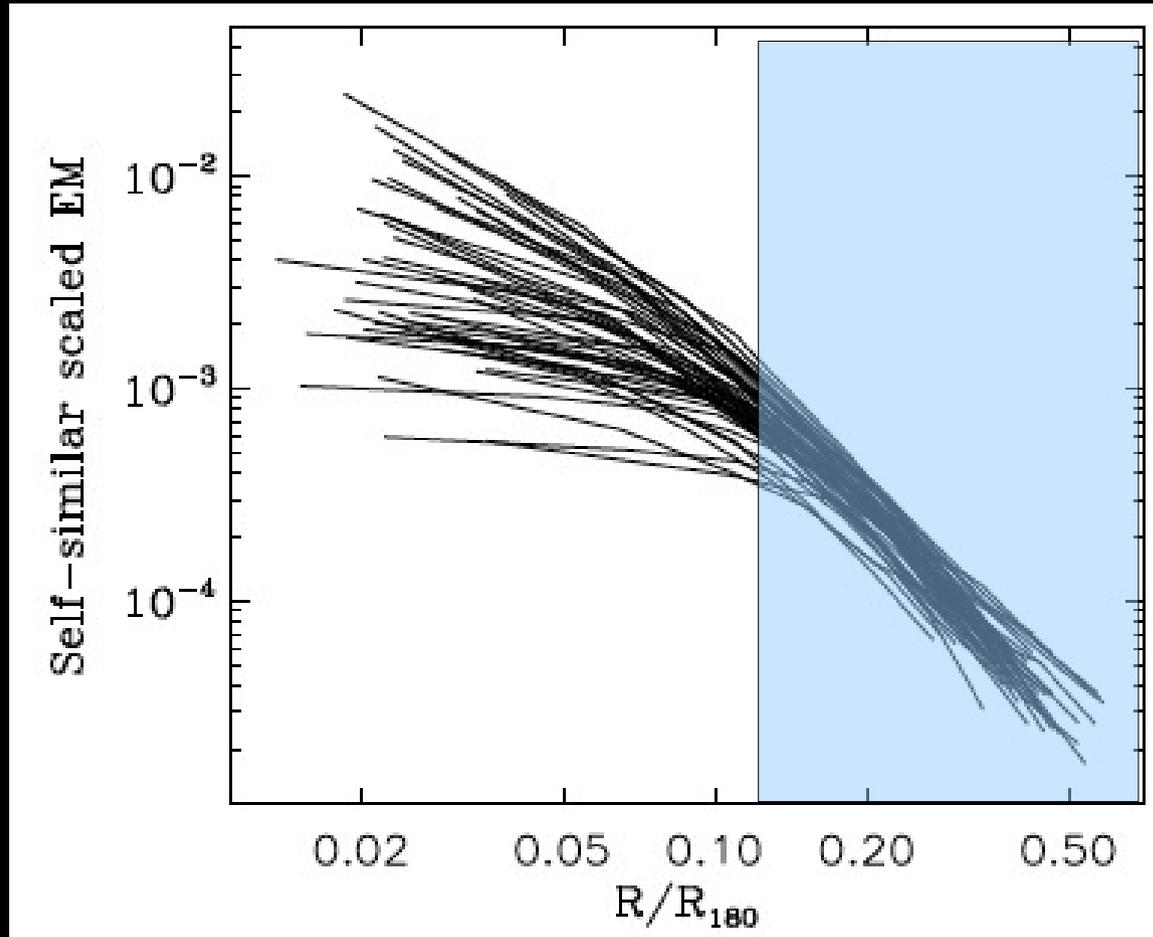


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Unbiased subsample



Unbiased subsample



- We select objects according to the flux in an annulus excluding the core
⇒ 13 (of 64) objects excluded because of too small F_{annulus}

Merger rate in the local Universe

- Evolution of the CC fraction:

$$\frac{df_{NCC}}{dt} = r_{he} f_{CC} - r_{cool} f_{NCC}$$

- Assumption of equilibrium: $\frac{df_{NCC}}{dt} \approx 0$

$$r_{he} \approx \frac{f_{NCC}}{\tau_{cool} f_{CC}}$$

- Numerical simulations find: $\tau_{cool} \approx 5 \text{ Gyr}$
- Our work: $f_{CC} = 0.35$, $f_{NCC} = 0.65$
- Result: $r_{he} \approx 0.3 \text{ Gyr}^{-1}$

Conclusions

- Simulations: CC bias in HIFLUGCS is $\sim 27\%$
- Low-L objects (groups) are more biased than high-L (clusters)
- Bias increases with redshift
- Among our selected objects: 35% instead of 44% are CC
Excellent agreement with simulations
- We provide a subsample of HIFLUGCS free of the CC bias
- Merger rate in the local Universe: $r_{\text{he}} \sim 0.3 \text{ Gyr}^{-1}$
- On-going:
 - computation of the bias in other ROSAT samples
 - predictions for future X-ray survey missions (eROSITA, WFXT)