Exploring the outskirts of Abell 133 with Suzaku and Chandra observations

INTRODUCTION

The properties of the intracluster medium (ICM) in the galaxy cluster outskirts have been actively explored with a combination of multi-wavelength observations and state-of-art numerical simulations. Simulations indicate that the gas density distribution in the outskirts becomes increasing inhomogenous (i.e. 'clumpy'). Ignoring the gas clumping will lead to significant systematic bias in the X-ray measurements of ICM properties, in particular for the outskirts. To precisely correct gas clumping effect for the thermodynamic profiles, we attempted to identify significant clumps based on Chandra images and mask them from Suzaku spectral analysis.

WHY Abell 133?

In the past decades, Chandra have accumulated **2.4 Ms** ultra-deep exposure on Abell 133 , out to extremely large radii, providing a special coverage in the outskirts even beyond R200. More importantly, Suzaku observations offer a similar coverage out to R200, enabling us to directly measure the thermodynamic properties . As an increasing trend of clumping from the core towards the outskirts is predicted (Nagai & Lau 2011), Abell 133 is a unique laboratory to study the clumping of ICM.

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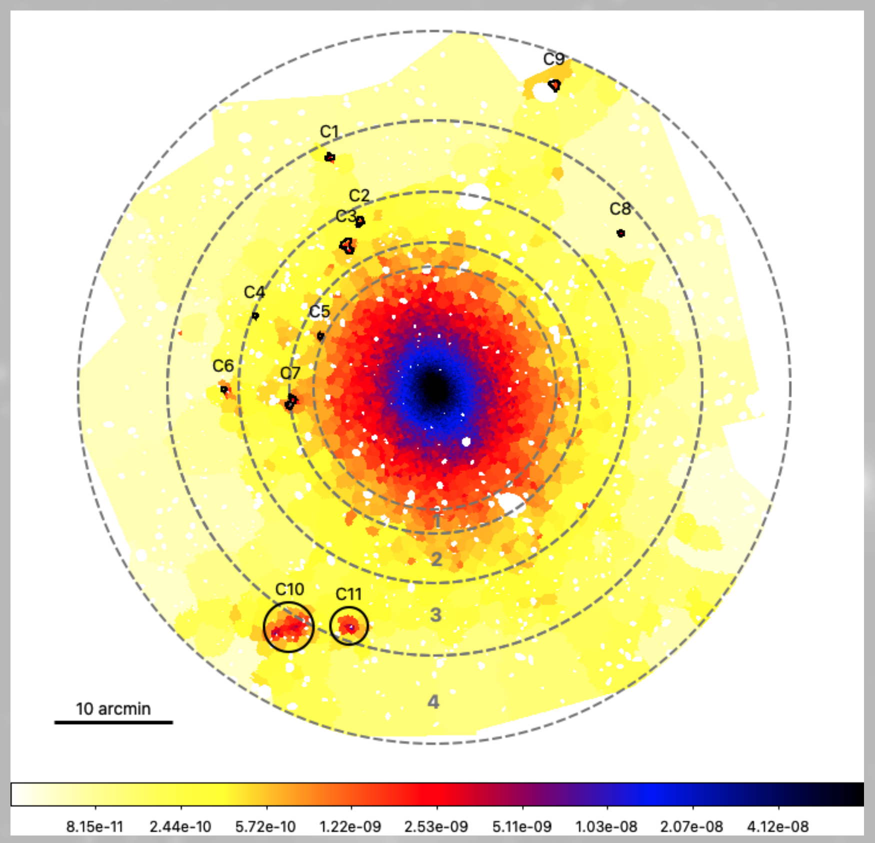
CLUMPS

We identified 11 clumps with beyond 2 sigma significance. With comparison to the cluster catalog from the DESI Legacy Imaging Surveys (Zou et al. 2021) and the r-band image taken with CFHT, **most of our clump candidates are background clusters or galaxies (C2, C3, C6, C7, C9, C10, C11), some are weak point sources missing from the wavedetection (C4, C8), and the rest need further exploration (C1, C5).**

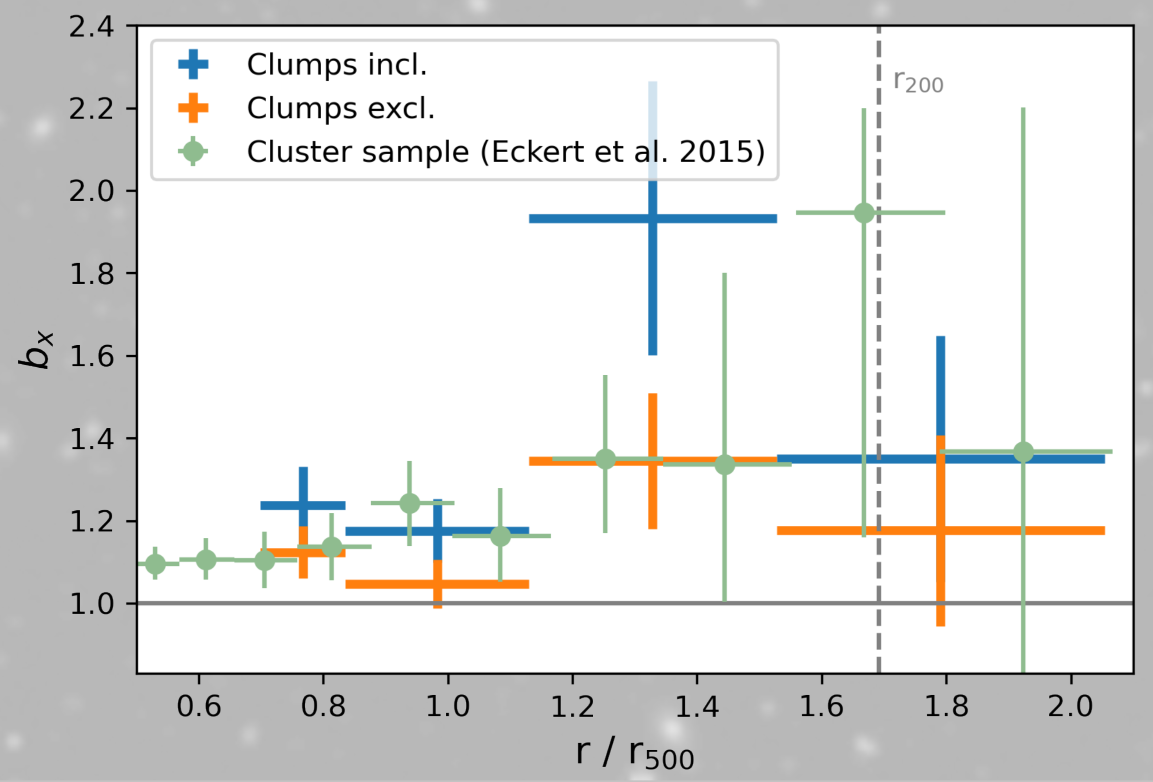


CLUMPING

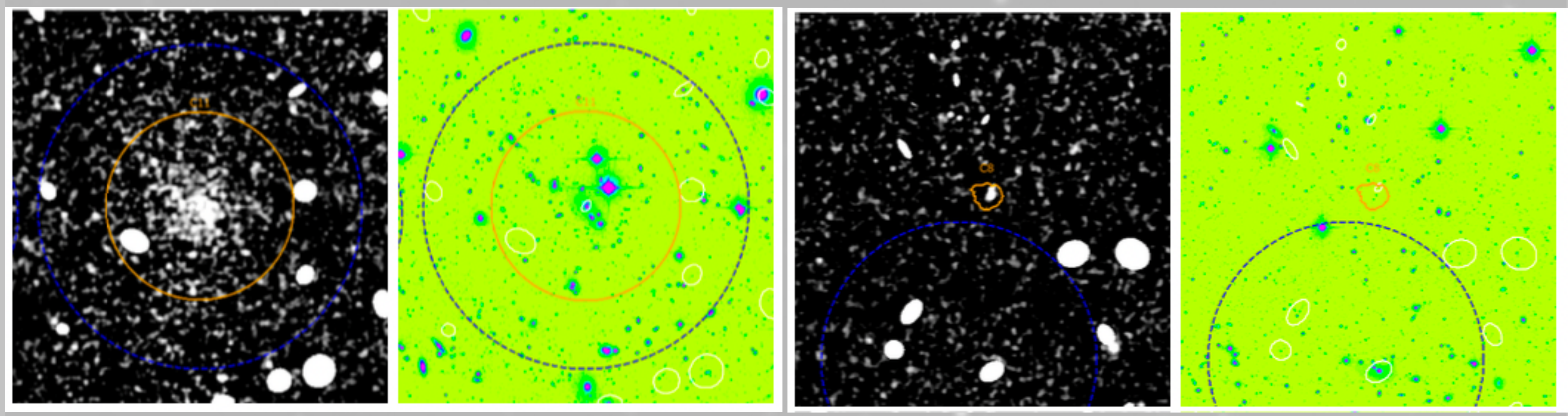
To quantitatively trace the clumping effect, we have utilized the emissivity bias bx, which is defined as

bx = Fmean / Fmedian (Eckert et al. 2015),

to check the difference after removal of our identified clumps. For each annulus, we use the mean and median flux of bins within this annulus for Fmean and Fmedian. Here we overplot the average emissivity bias profile measured by Eckert et al. (2015) from 31 selected clusters. **No significant increasing clumping is seen beyond R200.**



CHANDRA & CFHT images of the clump candidates



C11: example of background clusters

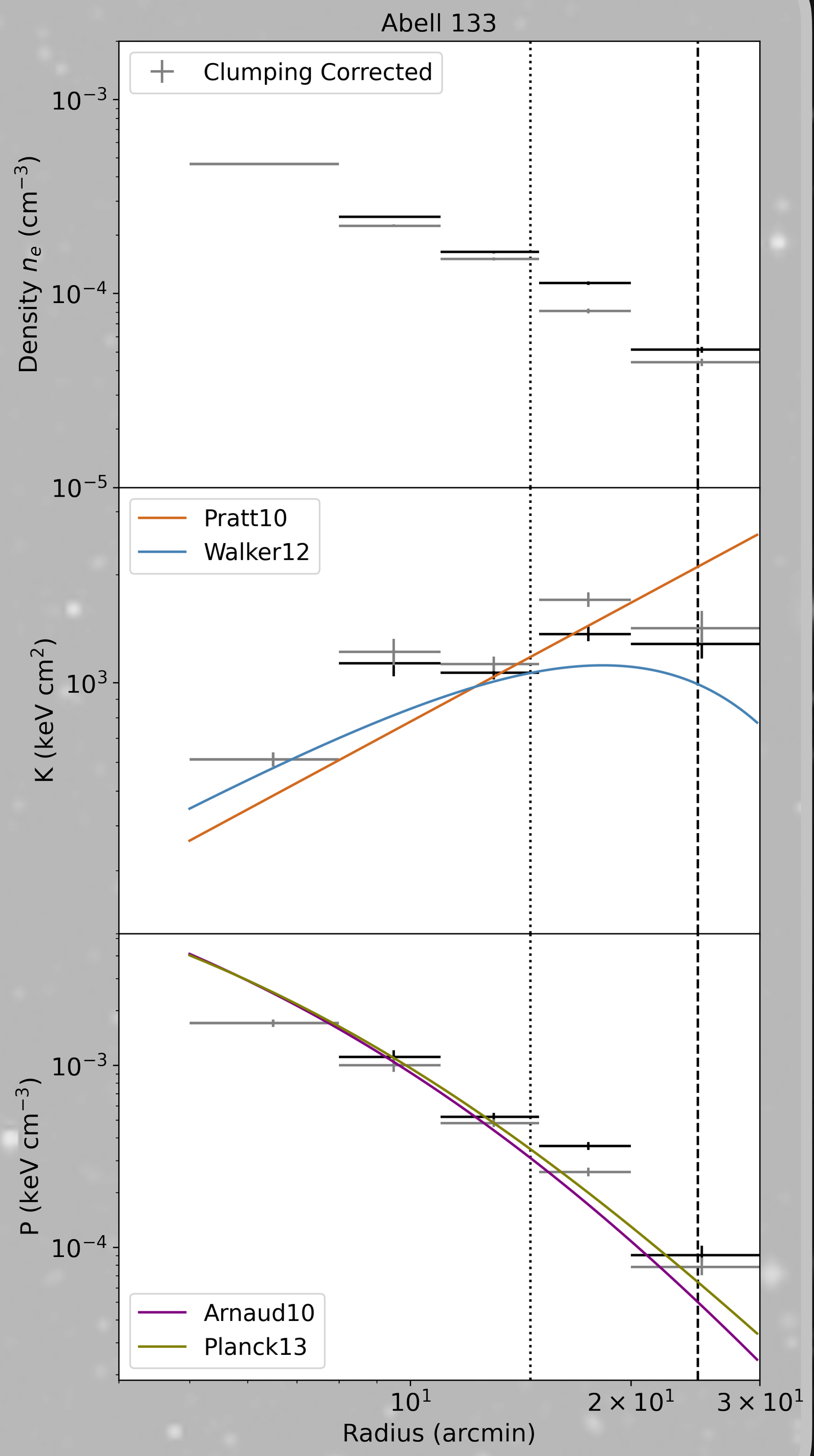
C8: example of weak point sources

ENTROPY & PRESSURE Profiles

To obtain the deprojected properties, we have applied the XSPEC model ***projct*** assuming spherical symmetry.

Based on the resulting measurements of deprojected temperatures and electron density, we further derived the deprojected pressure (P = ne kT) and entropy (K = kT/ne^(2/3)).

In this Figure, we compared the azimuthally averaged density, entropy and pressure profiles with their reference models. The grey data points show the results after clumping correction.



CONCLUSIONS

1) The clumps we identified from Chandra are mainly background clusters or galaxies, instead of genuine inhomogeneity.
2) Even after the correction of the clumping effect, the entropy profile approaching the outskirts still flattens, deviating from the power law model.