Perseus in Sicily: From Black Hole to Cluster Outskirts
Proceedings IAU Symposium No. 342, 2018
K. Asada, E. de Gouveia Dal Pino, M. Giroletti,
H. Nagai & R. Nemmen, eds.

doi:10.1017/S1743921318005148

Preliminary analysis of the X-ray emission from the central regions of the Pictor A

R. Thimmappa, Ł. Stawarz, K. Balasubramaniam and V. Marchenko

Astronomical Observatory, Jagiellonian University, 30-244 Krakow, Poland
email: rameshan@oa.uj.edu.pl

Abstract. Here we present some preliminary results of our analysis of the combined *Chandra* observations of the Pictor A radio galaxy. All the available *Chandra* data for the target, consisting of multiple pointings spanning over 15 years and amounting to the total exposure time of 464 ks, have been included in the analysis. We studied in detail the PSFs of the core region in the individual pointings, as well as the radial profile of the X-ray surface brightness of the source in the combined dataset, in order to discriminate between the radiative output of the unresolved core and the host galaxy. Based on these, we have performed spectral modeling of the active nucleus, constraining its variability.

Keywords. galaxies: active — X-rays: galaxies — X-rays: Individual (Pictor A)

1. Introduction

The radio galaxy Pictor A is one of the most prominent radio source in the Southern sky. It is an excellent candidate for a comprehensive study of the physics of relativistic jets, due to its large size and high luminosity of the extended lobes. Pictor A is also a natural laboratory for investigating the physics of Active Galactic Nuclei (AGN), for its strong emission-line spectrum, including broad forbidden and permitted lines.

2. The Analysis

Chandra has observed Pictor A on 14 separate occasions over the past 15 years, for a total of 464 ks of the observing time. The pointings of the observations differ, and this affects the quality of the available data for various regions of the source, because the effective point spread function of the combined dataset is a complicated function of the position. The other complication is that, due to a high flux of the Pictor A nucleus, the Chandra spectra for the central parts of the source suffer from a significant pile-up problem. Due to this fact, in their analysis of the AGN variability in Pictor A, Hardcastle *et al.* (2016) has considered only the wings of the central PSF (from 6.3 px up to 29 px), excluding in this way the pixels piled up at more than the 1% level at any epoch. Still, due to the dependence of the PSF shape on the photon energy, the core spectra extracted in this way had to be corrected further via simulations.

We have anayzed all the Chandra data for the target using software CIAO 4.9 and CALDB 4.6.7. The readout streaks were removed for each observation and the events files were then reprojected to a single physical coordinate system. The merge_obs script was used to produce merged events files, exposure maps and exposure-corrected ("fluxed") images after masking out point sources detected with wavdetect with minimum psf. The resulting X-ray surface brightness profile of the central parts of Pictor A (up to

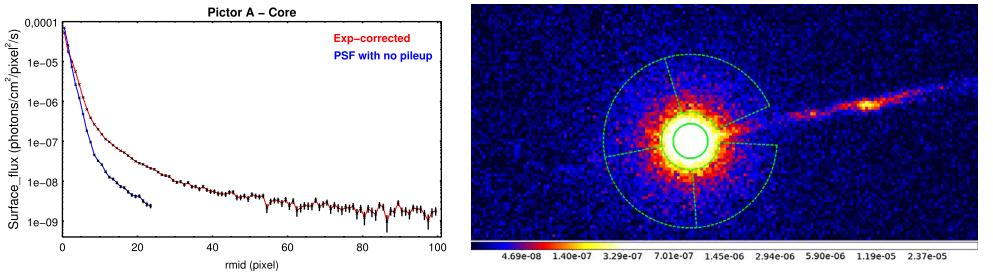

Figure 1. Left: The surface brightness profile of the Pictor A central region, obtained for the merged event file (red); the profile of the corresponding central PSF (not corrected for the pile-up) is shown for a comparison (blue). Right: ACIS-S image of the central parts of Pictor A, within the energy range 0.5–7 keV. AGN source extraction region (< 6 px) and the background region (10 px–30 px, omitting the jet), are denoted by green contours.

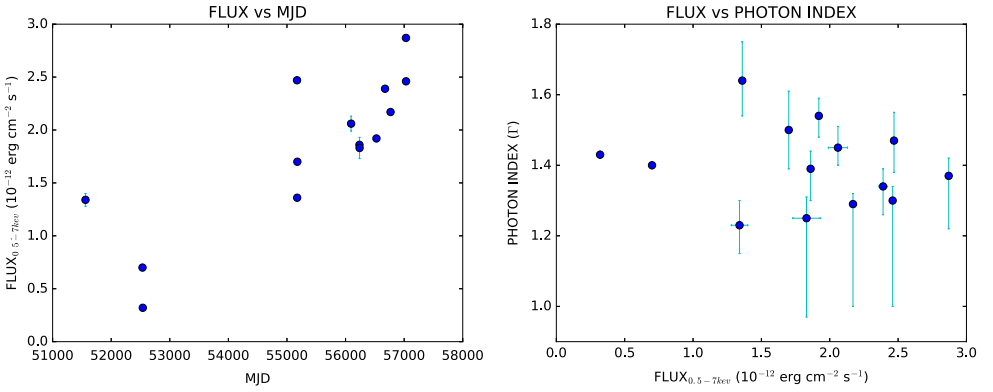

Figure 2. Left: Fluxes calculated for individual observations with 0.5–7.0 kev energy range, vs. observation time. Right: Relation between the 0.5–7.0 keV flux of the core and the photon index of the X-ray continuum.

100 px $\simeq 50''$ from the core, i.e. ~ 35 kpc at the source distance), is shown in Figure 1, left panel. There we also present the profile of the central PSF, obtained by merging the exposure-corrected MARX-simulated PSFs (50 simulated images for each pointings, totaling to 700 PSFs). As the simulated PSFs have not been corrected for the pile-up, a discrepancy can be seen in the figure between the observed surface brightness profile and the PSF profile, within the innermost parts of the source.

For the AGN spectral analysis, we have extracted the source spectra from the circular region with radius 6 px for each pointing; the backgrounds were taken from the annual region (omitting the jet) with radii 10 px and 30 px, as shown in Figure 1, right panel. Spectral fitting was done in SHERPA, assuming the simplest model consisting of the absorbed power-law. In all of the cases, the intrinsic absorption was consistent with hydrogen column densities much below the Galactic value in the direction of the source. The results of the fitting are shown in Figure 2.

3. Conclusions & Future work

The next step of the analysis will include updated PSF simulations including the pileup effect. With the properly characterized PSF shape, we will update also the source

https://doi.org/10.1017/S1743921318005148 Published online by Cambridge University Press

(AGN) and the background (host galaxy, plus extended lobes) regions, and perform a more detailed spectral modeling, constraining also the presence of the iron line in the source spectrum. The image deconvolution and the spectral modeling for the large-scale jet and the extended lobes will also be performed.

Reference

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https://doi.org/10.1017/S1743921318005148 Published online by Cambridge University Press