Giant Radio Lobes of Centaurus A Studied with the *Chandra* X-ray Observatory

UNIWERSYTET JAGIELLOŃSKI W KRAKOWIE

K. Balasubramaniam[1] (karthik@oa.uj.edu.pl), Ł. Stawarz[1], V. Marchenko[1]

[1]Astronomical Observatory of the Jagiellonian University, ul. Orla 171, 30-244 Krakow, Poland

Abstract

We present a *preliminary* analysis of the *Chandra* data for the giant lobes in the radio galaxy Centaurus A. Five distinct regions within the lobes have been observed with the ACIS instrument, each region for about 20 ks. Here we focus on investigating the point sources detected in these pointing and perform the count statistics from soft and hard bands using the BEHR code [2].

Introduction

Two distinct regions within the southern giant lobes of Centaurus A, $\simeq 1/3 \times 1/3$ deg each, have previously been mapped in X-rays with the *Suzaku*'s X-ray Imaging Spectrometer [1]. These studies have been followed up with the *Chandra* observations, targeting the two *Suzaku*'s fields in the southern lobe, plus three analogous regions selected within the northern lobe. Here we present a preliminary results of the analysis of these Chandra data, totaling to 97 ks exposure.

- First, we identify all the point sources detected with the ACIS instrument, and search for their infrared counterparts in WISE All sky data release.
- Next, due to the limited photon statistics for each detected point source, instead of a spectral modelling we perform a simple analysis of counts of the cross-matched sources using the Bayesian Estimation of Hardness Ratio [2].

Chandra data

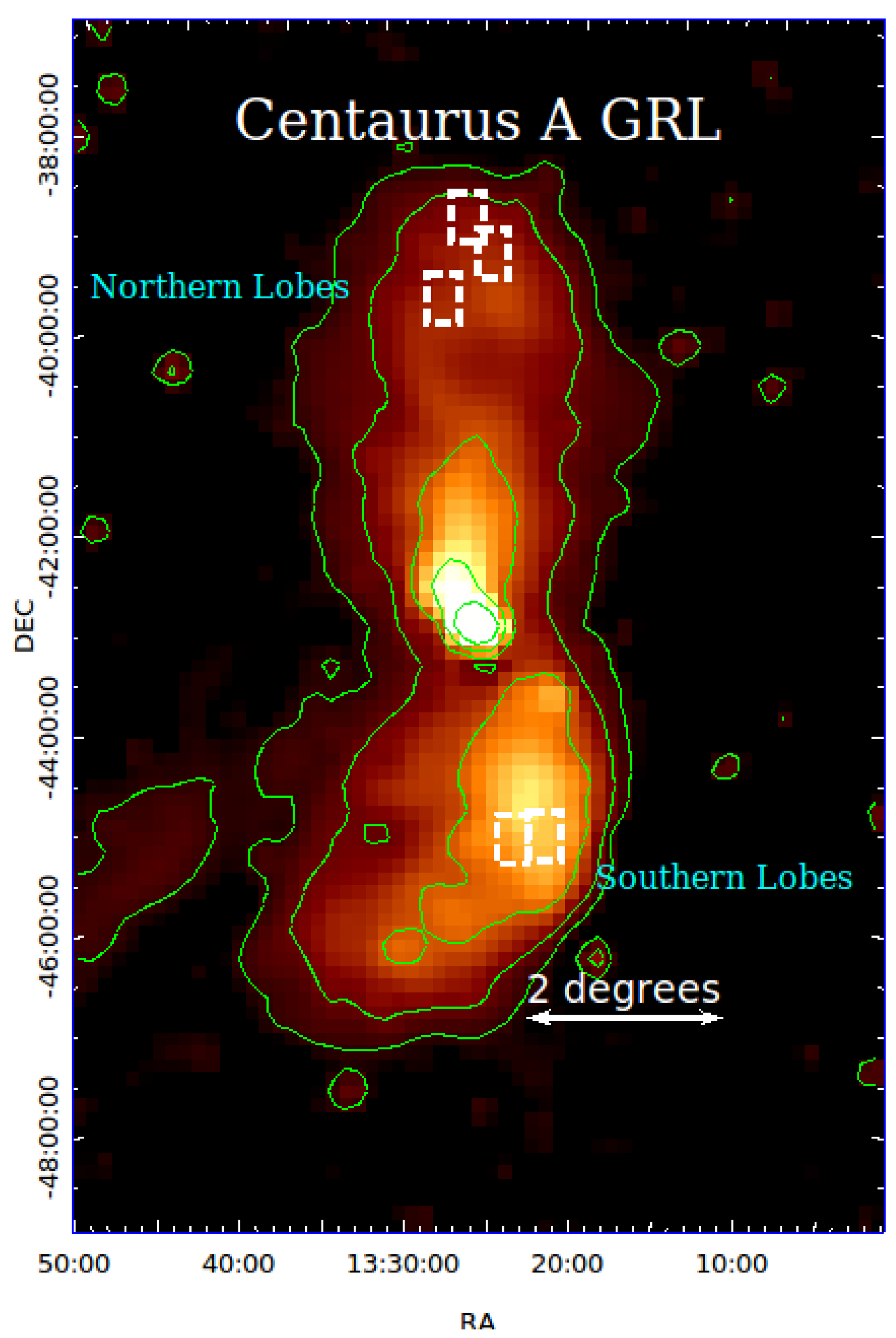

Figure 1: 1.4 GHz low-resolution map of the giant radio lobes in Centaurus A. Five *Chandra* pointings analyzed here are denoted in the image as thick white squares.

Data analysis

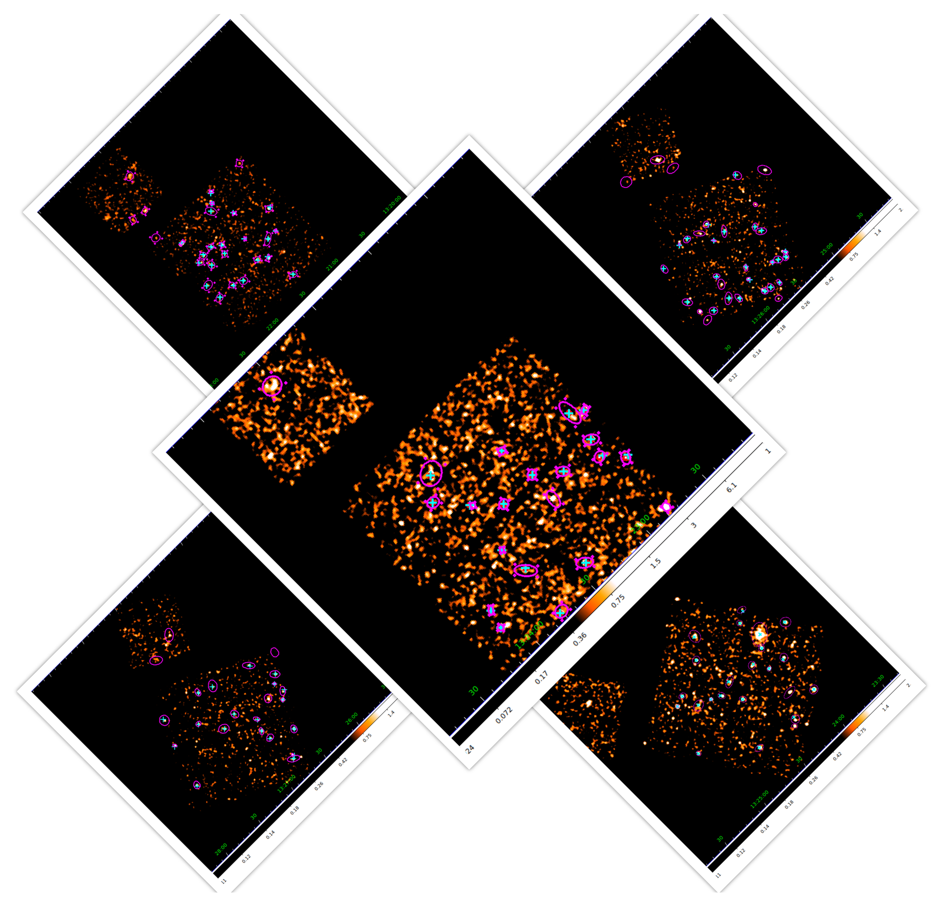

Figure 2: ACIS images corresponding to the five pointings analyzed here, with the point sources detected with *wavdetect* denoted by magenta ellipses, and WISE counterparts denoted by cyan crosses.

Table 1: Point sources detected in Obs ID 15199, along with the MIR colors of their WISE counterparts

RAJ(2000)	DE(J2000)	(W1-W2)	(W3-W4)
200.94	-45.29	0.33	3.14
201.02	-45.25	-0.019	1.02
200.68	-45.22	-0.34	3.69
200.71	-45.20	-0.12	2.98
200.85	-45.27	0.086	3.56
201.01	-45.23	-0.047	-0.17
200.92	-45.23	-0.33	3.22
200.93	-45.19	-0.02	1.01
200.88	-45.16	1.08	1.45
200.77	-45.18	1.53	2.55
200.81	-45.16	0.13	3.23
200.82	-45.11	0.34	2.96
200.92	-45.13	-0.048	3.69
200.95	-45.10	0.17	2.66
200.93	-45.08	-0.14	0.12
200.68	-45.15	0.86	2.37
200.70	-45.18	0.92	2.54
200.70	-45.14	-0.29	3.60

As an example, here we list all the 18 point sources detected in one of the analyzed observations (Obs ID 15199), for which we have found WISE counterparts

- For each point source, we split the data into the hard band $\mathcal{H}$, 3.0–7.0 keV, and the soft band $\mathcal{S}$, 0.5–2.0 keV.
- We calculated the number of counts and areas in the $\mathcal{H}$ & $\mathcal{S}$ bands within the *wavdetect* ellipses (see Figure 2), along with the neighbouring background regions.
- Next, with the BEHR code [2] we calculated the Simple Hardness Ratios $\mathcal{R} = \frac{\mathcal{S}}{\mathcal{H}}$, the Colors $\mathcal{C} = log_{10}\frac{\mathcal{S}}{\mathcal{H}}$, and the Fractional Differences $\mathcal{HR} = \frac{\mathcal{H}-\mathcal{S}}{\mathcal{H}+\mathcal{S}}$, all as plotted in Figure 3.

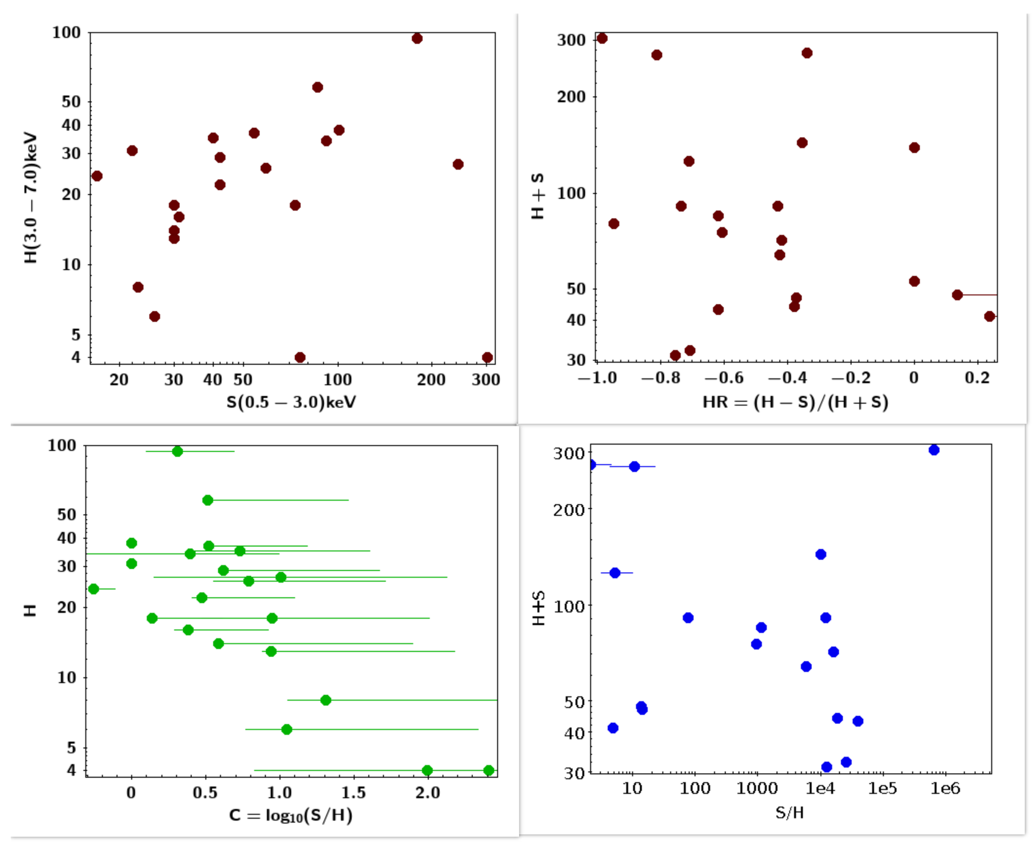

Figure 3: X-ray hardness analysis for the point sources in Obs Id 15199

Discussion & future plan

- The observed X-ray emission of the giant radio lobes in Centaurus A, includes a weak diffuse emission component (contributed by a non-thermal emission of relativistic electrons filling the lobes, a thermal emission of the hot gas from the Centaurus group of galaxies, as well as the extragalactic background and Galactic foreground emission), plus point sources (background galaxies and AGN, foreground stars and XRBs, possibly also compact emission regions associated with radio filaments within the giant lobes, see the discussion in [1]).
- Our analysis of the point sources detected in the five *Chandra* observations of the giant radio lobes in Centaurus A, consisting of the hardness analysis using the BEHR code, and the analysis of the MIR colors of the WISE counterparts, will enable us to classify the sources, and to perform a basic population study of the background AGN.
- With the point sources removed, we will study in detail the diffuse emission component present in the analyzed ACIS images.

Ref. & Acknowledgments

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[1] Stawarz, Ł., et., al 2013, ApJ, 766, 48

[2] Park, T., & et., al 2006, ApJ, 652, 610