High Redshift 3CR Sources: Chandra Observations - a status report

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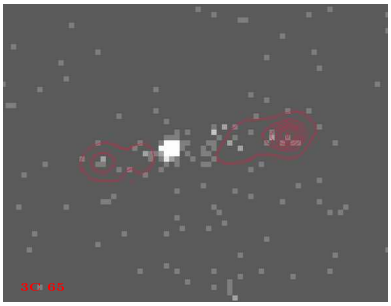
Abstract

We report preliminary results from new Chandra, snap–shot observations of 25 sources from a complete subset of 38 radio–lobe–selected, 3CRR massive radio galaxies with $1 < z < 2$. These data will allow us to measure the strength of the nuclear activity and study the relation of X–ray flux and spectral hardness to orientation, estimated from the radio core–dominance. In combination with the rich, multi–wavelength dataset for this inclination unbiased sample (to include Spitzer 3.6–70μm photometry - see [1], [2]), we will test AGN Unification at these redshifts. SED fitting will further constrain models for the obscuring material, the relative numbers of obscured and unobscured quasars and X–ray selection effects.



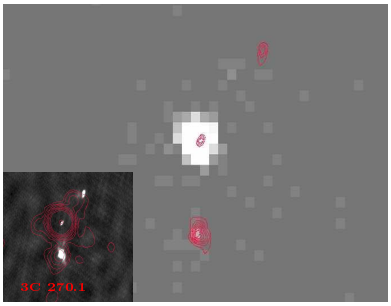
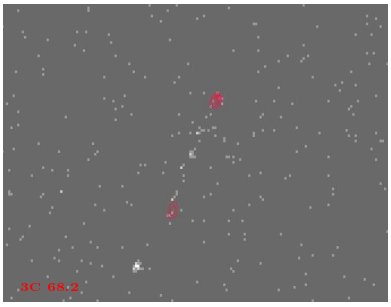


Table 1. Sample

Name	Redshift	Type[1]	Date of Obsv.	Extended X-rays?
3CRR13	1.351	NLRG	06/01/2008	...
3CRR14	1.469	QSR/L	05/29/2008	yes
3CRR43	1.459	QSR/CSS	02/17/2008	...
3CRR65	1.176	NLRG	06/30/2008	yes
3CRR68.1	1.238	QSR/L	02/10/2008	...
3CRR68.2	1.575	LERG	03/06/2008	yes
3CRR181	1.382	QSR/L	...	...
3CRR190	1.195	QSR/CSS	12/31/2007	...
3CRR204	1.112	QSR/L	01/13/2008	...
3CRR205	1.534	QSR/L	01/26/2008	...
3CRR208	1.110	QSR/L	01/08/2008	...
3CRR241	1.617	NLRG	03/13/2008	...
3CRR252	1.100	NLRG	03/11/2008	yes
3CRR266	1.275	NLRG	02/17/2008	...
3CRR267	1.140	NLRG	...	...
3CRR268.4	1.398	QSR/L	...	...
3CRR270.1	1.532	QSR/L	02/16/2008	yes
3CRR318	1.574	QSR/CSS	04/05/2008	...
3CRR356	1.079	NLRG	01/20/2008	yes
3CRR368	1.131	NLRG	06/01/2008	...
3CRR437	1.480	NLRG	01/07/2008	yes
3CRR469.1	1.336	LERG	...	...
3CRR470	1.653	NLRG	03/03/2008	...
4C16.49	1.880	QSR/L	01/21/2008	...
4C13.66	1.450	NLRG	02/05/2008	...

[1]QSR/L: lobe dominated quasar, NLRG: Narrow Line Radio Galaxy, QSR/CSS: Compact Steep Spectrum quasar, thought to be young FRII radio source, LERG: Low Excitation Radio Galaxy.



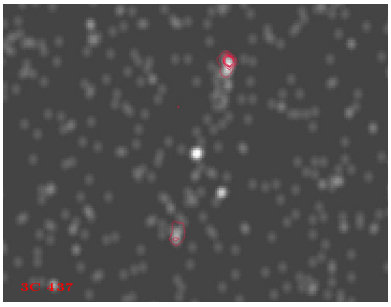


Fig.3 – 3CR sources with extended X-ray emission associated with radio lobes. Red contours show radio emission. Insert to 3C 270.1 figure shows X-ray emission as red contours plotted over radio emission. Angular separation between radio lobes: 3C 270.1: 9", 3C 437: 37". Bright X-ray source SW of 3C437 has no optical or radio identification.

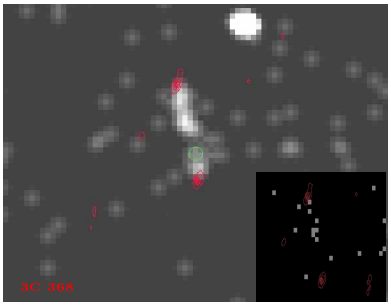
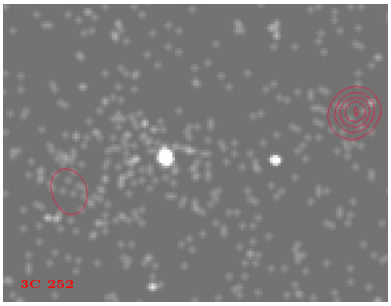


Fig. 1 – 3CR sources with extended X-ray emission in between radio lobes. Red contours show radio emission. Angular separation between radio lobes is: 3C 65: 17.5", 3C 68.2: 23.5", 3C 368: 9". The bright X-ray source lying SE of 3C 68.2 southern jet is NVSSJ023452+331326. **3C368**: Most of the extended emission in between the lobes comes from the soft (0.3–2keV) X-ray band, Insert to figure shows lack of emission in the hard (2–8keV) X-ray band; Green circle shows the position of quasar.

QSO Nuclear X-ray Spectra

Initial results show harder X-ray spectra in the galaxies than in quasars, as expected for edge-on viewing angle:

- 3C65 (NLRG): $HR = +0.3$, $N_H \sim$ few$\times 10^{22}$ cm^{-2}, (hard (2–8 keV) counts: 126.59±11.27, soft (0.3–2 keV) counts: 78.63±8.89)
- 3C270.1 (QSO, lobe-dominated): $HR = -0.5$, $N_H \sim$ few$\times 10^{21}$ cm^{-2} (hard counts: 168.77±13.00 , soft counts: 563.87±23.75)



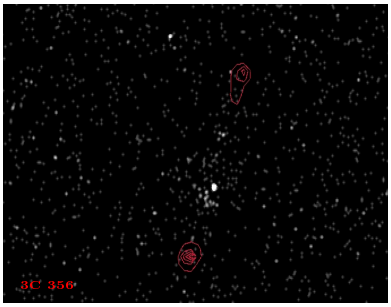


Fig. 2 – 3CR sources with diffuse X-ray emission not correlated with radio emission. Red contours show radio emission. Angular separation between radio lobes: 3C 252: 52", 3C 356: 72.5". Bright X-ray source W of 3C252 has no optical or radio identification.

3C 270.1

Extended X-ray emission includes 45 counts (35 soft, 10 hard) where:

- the southern radio lobe includes 15.60 ± 4.0 counts, most 14.88 ± 3.87 are soft (0.3-2 keV)
- the northern X-ray emission (close to the radio lobe) includes 9.6 ± 3.2 also mostly soft counts: 8.8 ± 3.0 , hard counts: 0.8 ± 1.0
- cluster of galaxies detected in deep optical data out to a radius of ∼1' (see [3]). Reminder of diffuse X-rays (∼ 20 counts, HR∼ 0) may be associated with the cluster.

The steep (soft) spectrum in the lobes is consistent with an aging electron population.

Summary

Preliminary results include detection of extended X–ray emission which:

- is associated with radio lobes as in: 3C 270.1, 3C 437
- has structure in between radio lobes as in: 3C 65, 3C 68.2, 3C 368
- is diffuse and not correlated with radio emission: 3C 252, 3C 356, 3C 14.

Related posters/talks:
[1] F. Heymann "Cluster assembly around z=1.53 quasar 3C270.1"
[2 C. Leipski "High redshift 3CR sources: Spitzer mid-IR spectra"
[3] S. Willner "High redshift 3CR sources: Mid-IR spectral energy distributions"