THE NUCLEAR ENVIRONMENT OF 3C 33 AS OBSERVED BY CHANDRA AND XMM-NEWTON

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ABSTRACT

We report the results obtained from a complete X-ray analysis of the FRII Narrow Line Radio Galaxy (NLRG) 3C 33 using all the observations available in the XMM-Newton and Chandra public archives (for more details see Torresi et al. 09).

FRII NLRG optically classified as High Excitation Galaxies, HEG (Jackson & Rawlings 97), share with their radio-quiet counterparts, Seyfert 2 galaxies, several spectral properties. Their continuum is heavily obscured ($N_H \approx 10^{23-24}$ cm^{-2}) by an oriented thick torus that hides the bright accretion disk and the Broad Line Region. Reprocessed features like a prominent Fekα line and the Compton Reflection component are signs of this obscuration. Moreover at lower energies (0.5-2 keV), a soft unabsorbed tail is detected. While high resolution spectroscopy proved that in Seyfert 2s this excess is due to gas photoionized by the central engine (Kinkhabwala et al. 02; Guainazzi & Bianchi 07), the origin of the soft X-ray emission in NLRGs is still matter of debate. The most popular interpretation related this component to the jet emerging from the edge of the torus. On the other hand the recent discoveries of photoionized emission-lines in radio-loud sources such as 3C 445 (Grandi et al. 07; Sambruna et al. 07) and 3C 234 (Piconcelli et al. 08), has opened an alternative way to interpret the soft-excess. The 3C 33 results reported here represent another piece of evidence in support of the photoionized picture.

SPECTRAL ANALYSIS

3C 33 is a genuine type II radio galaxy, it is one of the nearest HEG of the 3CRR catalogue (z=0.0597), and it exhibits the highest [OIII]λ5007 flux among the nearby NLRGs of the sample.
Our Chandra and XMM-Newton accurate analysis revealed for the first time the real nature of the soft emission in this NLRG.
There are two observational results pointing to the photoionized scenario:

1) Both Chandra and XMM spectra need a scattered power-law and emission-lines to model the soft-excess. Note that ACIS and PN data required soft emission-lines at the same centroid energies, that are expected in case of circumnuclear photoionized gas (Figure 1).

DETECTED LINES

OVII RRC; FeXVII 3s-2p E= $0.76^{+0.02}_{-0.13}$ keV Int= $\left(2.93^{+1.16}_{-1.02}\right)\times 10^{-6}$ ph cm^{-2} s^{-1}

NeIX rif E= $0.93^{+0.04}_{-0.02}$ keV Int= $\left(2.51^{+0.85}_{-1.20}\right)\times 10^{-6}$ ph cm^{-2} s^{-1}

MgXI Heα E= $1.30^{+0.04}_{-0.02}$ keV Int=$(1.41 \pm 0.46)\times 10^{-6}$ ph cm^{-2} s^{-1}

2) The perfect overlapping between soft X-ray and the [OIII]λ5007 images indicates the Narrow Line Region as the location of such gas, in impressive agreement with Seyfert 2s (Figure 2).

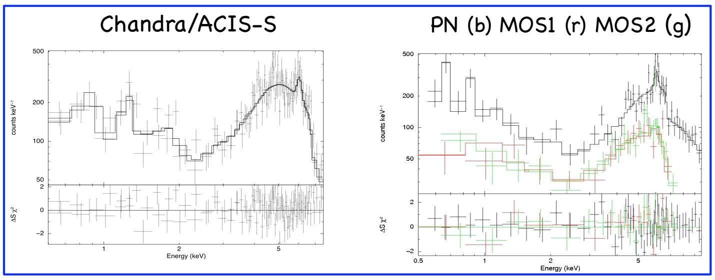

FIGURE 1. Chandra spectrum (left panel) and XMM spectra (right panel) of 3C 33.

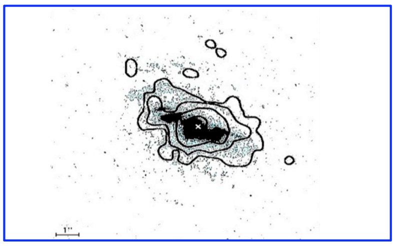

FIGURE 2. Chandra soft-X contours superimposed on a HST [OIII] λ5007 image.

CONCLUSIONS

Our results show that photoionized circumnuclear gas (i.e. warm gas) is present also in radio galaxies. This important result, if definetively confirmed, would imply that the feedback between AGN and surroundings is mainly driven by radiative processes, at least on pc scales, also in AGNs with strong jets.
Although the studies performed with the CCDs have been important in distinguish between thermal and non-thermal processes at soft energies, they are not sufficient to define the properties of the gaseous environment. High resolution spectroscopy is the unique tool able to explore in detail the real physical and geometrical conditions of the emitting-line gas, confirming its non-collisional nature.

REFERENCES Grandi, P., et al. 2007 MNRAS, 381, L21; Guainazzi, M., & Bianchi, S. 2007, MNRAS, 374, 1290; Jackson, N., & Rawlings, S. 1997, MNRAS, 286, 241; Kinkhabwala, A., et al. 2002, ApJ, 575, 732; Piconcelli, E.,et al. 2008 A&A, 480, 671; Sambruna, R.M., et al. 2007 ApJ, 665, 1030; Torresi, E., et al. 2009, ArXiv Astrophysics e-prints, arXiv:0901.3351