RevMexAA (Serie de Conferencias), **32**, 62–64 (2008)

FERO (FINDING EXTREME RELATIVISTIC OBJECTS): STATISTICS OF RELATIVISTIC BROAD FE Kα LINES IN AGN

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RESUMEN

Las propiedades de las líneas de emisión Fe Kα ensanchadas relativísticamente en núcleos activos de galaxias (AGN) son aún materia de debate en la comunidad. Los trabajos recientes parecen excluir que la línea ancha de Fe es un rasgo común en los AGN. Se presenta el análisis de una gran muestra de 157 observaciones de archivo del *XMM-Newton* de AGN radio callados. Este trabajo en curso es lo desarrollado desde lo reportado en Guainazzi et al. (2006).

ABSTRACT

The properties of the relativistically broadened Fe Kα line emitted in Active Galactic Nuclei (AGN) are still debated among the AGN community. Recent works seem to exclude that the broad Fe line is a common feature of AGN. The analysis of a large sample composed by 157 *XMM-Newton* archival observations of radio quiet AGN is presented here. This ongoing project is a development of the work reported in Guainazzi et al. (2006).

Key Words: galaxies: active — line: profiles — X-rays: galaxies

1. INTRODUCTION

The detection of a broadened and skewed Fe Kα line in AGN spectra is generally interpreted as an effect on X-ray photons due to the gravitational field of the black hole. Measuring the parameters of broad Fe lines provides therefore a diagnostic of the accretion disc structure and of the central object (see Fabian & Miniutti 2005 for a review). Many publications on individual sources observed by the high throughput X-ray satellite *XMM-Newton* invoke the presence of a relativistic disc Fe line (e.g. Wilms et al. 2001; Fabian et al. 2002; Longinotti et al. 2003). Recent works on large samples of AGN converged to say that the broad line is more common in low luminosity AGN (Nandra et al. 1997, 2007; Streblyanska et al. 2005; Jimenez-Bailón et al. 2005; Guainazzi et al. 2006). Nonetheless, there is no agreement on the line parameters such as its intensity and equivalent width (EW). Using a collection of 107 AGN from the *XMM-Newton* archive, Guainazzi et al. (2006) found a detection fraction of relativistic Fe line of 25%. The mean EW was inferred to be $\sim$200 eV and the strongest lines were found in the sources with low 2–10 keV luminosity.

2. THIS WORK: PRELIMINARY RESULTS

We have expanded the work by Guainazzi et al. (2006) by refining the baseline model and including more sources. The final sample is made by 157 type 1 radio-quiet AGN with $N_H < 10^{22.5}$ cm^{-2} (see Bianchi et al. 2007 for more details on the sample). The assumed baseline model is made by the following spectral components: primary X-ray power law, Compton reflection originated in the torus, 4 narrow emission lines with fixed energies corresponding to Kα transitions from Fe I, XXV, XXVI and Kβ from Fe I. A Gaussian line of 50 eV width is included to fit the Compton Shoulder. The intensities of the Fe Kβ and of the Compton Shoulder are tied to the Fe Kα flux. Absorption from ionized gas is also included to take into account any spectral curvature at 6–7 keV which may be induced by warm absorbing gas along the line of sight as for NGC 3783 (Reeves et al. 2004). The *kyrline* model (Dovčiak et al. 2004) was adopted for fitting the relativistic disc line. The presence of an (additional) reflection component arising from the disc and thus gravitationally blurred, was extensively tested but it could not be distinguished from the torus reflection due to the limited *XMM-Newton* bandpass. A single reflection component is included in the final baseline model. When considering the whole sample, the broad line detection fraction is found to be of the order of 10% for a significance threshold of 5σ (Figure 1). However, a flux-limited ($F_{2-10} > 1.8 \times 10^{-11}$ ergs cm^{-2} s^{-1}) sub-sample of 22 sources has been defined with the

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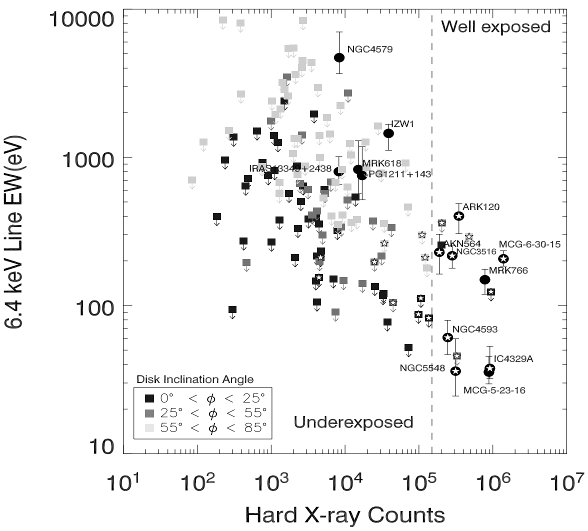

Fig. 1. Equivalent width of the broad 6.4 Fe Kα line versus the 2–10 keV counts. Filled circle: line detection at 5σ; filled squares: line upper limit at 97% c.l. Stars mark sources in the flux-limited sample.

aim of performing a more thorough statistical analysis. The detection fraction in this subset rises up to 33%. As pointed out by Guainazzi (2006), broad lines are mostly detected in well-exposed sources, i.e. in spectra with a number of 2–10 keV X-ray counts greater than 1.5×10^5 counts (Figure 1). These (still preliminary) results will be reported in de la Calle et al. in prep.

For 65% of the objects, measurements of Hβ FWHM are available, allowing us to investigate if any relation holds between the presence of broad Fe line and the properties of the system such as black hole mass and accretion rate. No apparent correlation seems to exist in any of the cases (Figure 2). However, any circumstantiated conclusion should be made after performing the proper statistical tests for which the results are not yet available. Figure 2 contains also the correlation of the broad line EW versus the X-ray luminosity (third panel): unlike the tight correlation found for the *narrow* Fe line EW and the X-ray luminosity (Bianchi et al. 2007), no particular trend can be derived for the broad component. This issue is examined in the following section.

3. STACKED SPECTRA

To gather information on the spectra of underexposed sources, the spectral ratios of sources with no detection of broad line have been stacked together The ratio plots employed in the stacking were obtained assuming the continuum (with no emission features) as a baseline model. Figure 3a shows the stacked plots for *all* the sources with upper limits. The prominent peak at 6.4 keV is produced by the narrow Fe Kα and the residuals at 6.5–7.2 keV are likely to be due to the contribution of ionized Fe lines and possibly of Fe Kβ. There is no significant evidence for a broad line profile in the stacked spectra ratio, the data points below 6.4 keV are statistically consistent with the fitted continuum model. Nonetheless, this ratio was obtained by "mixing" sources with different X-ray luminosities. To disentangle this effect the sources have been splitted in 3 luminosity groups (almost) equally populated. By comparing the profile of the stacked ratios to the theoretical broad line profile (blue curve in the plots), it can be concluded as a qualitative estimate that the line intensity never gets higher than 50 eV and it seems to faint with increasing luminosity. More details will be presented in a forthcoming paper (Longinotti et al. in prep.).

Ignacio de la Calle would like to acknowledge support by the Torres Quevedo fellowship from the Ministerio de Educación y Ciencia Español and INSA.

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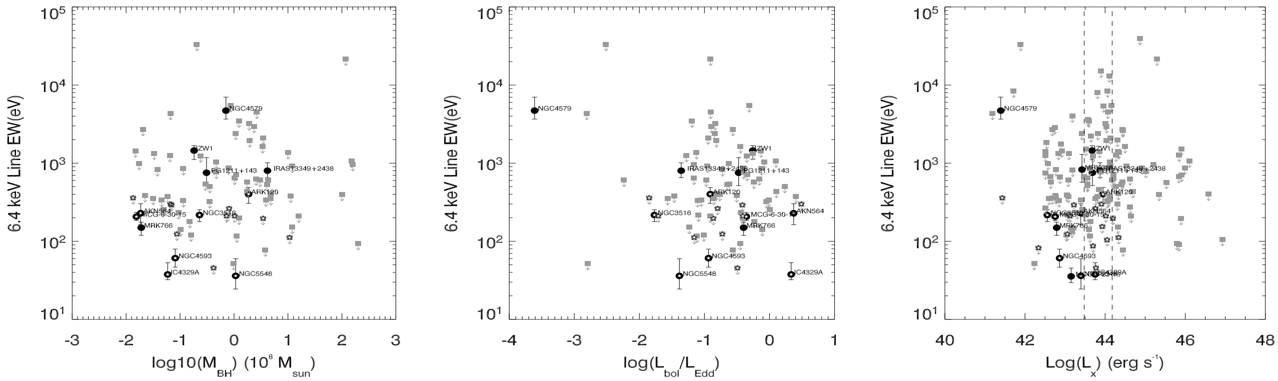

Fig. 2. Trend of the Fe Kα EW versus physical properties of the sources. Black circles mark the detections, grey squares mark the upper limits, stars mark sources in the flux limited sample. From left to right:EW versus black hole mass and EW versus accretion rate (for a subset of the sample); EW versus 2–10 keV luminosity (all sources in the sample, the dashed lines mark the same luminosity bins as Figure 3). No correlation is evident in any of the figures.

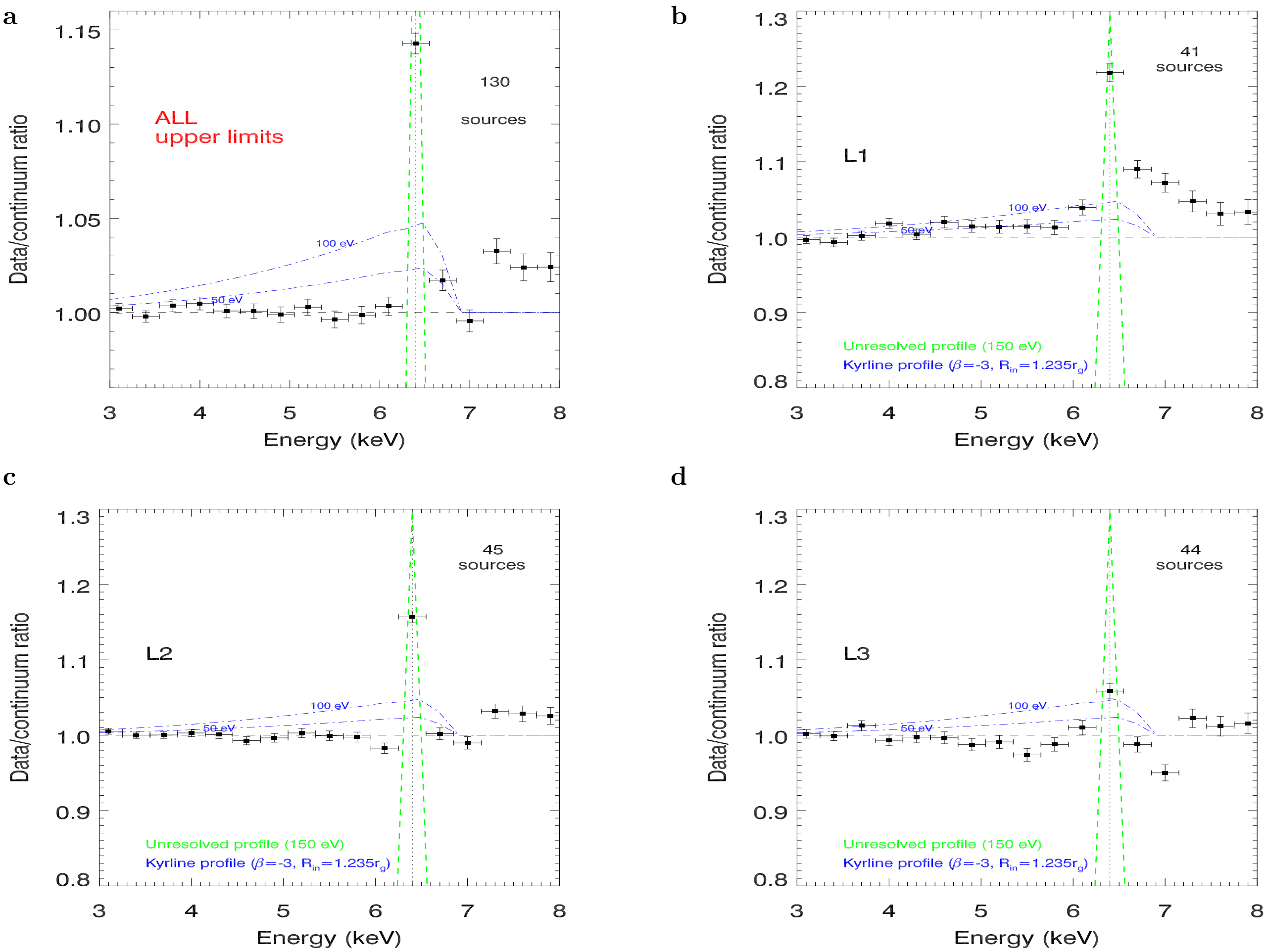

Fig. 3. (a) Stacking of all upper limits; (b,c,d,) Iron line stacked residuals in the following hard X-ray luminosity groups (in ergs/s): (b) Lx$< 3\times10^{43}$; (c) $3\times10^{43} <$ Lx $< 1.5\times10^{44}$; (d) Lx $> 1.5\times10^{44}$. The green and the blue profile represent the theoretical models for the narrow and the broad Fe line.