A broad-line region origin for the iron Ka line in NGC 7213

Bianchi et al., 2008, MNRAS, 289, 52L

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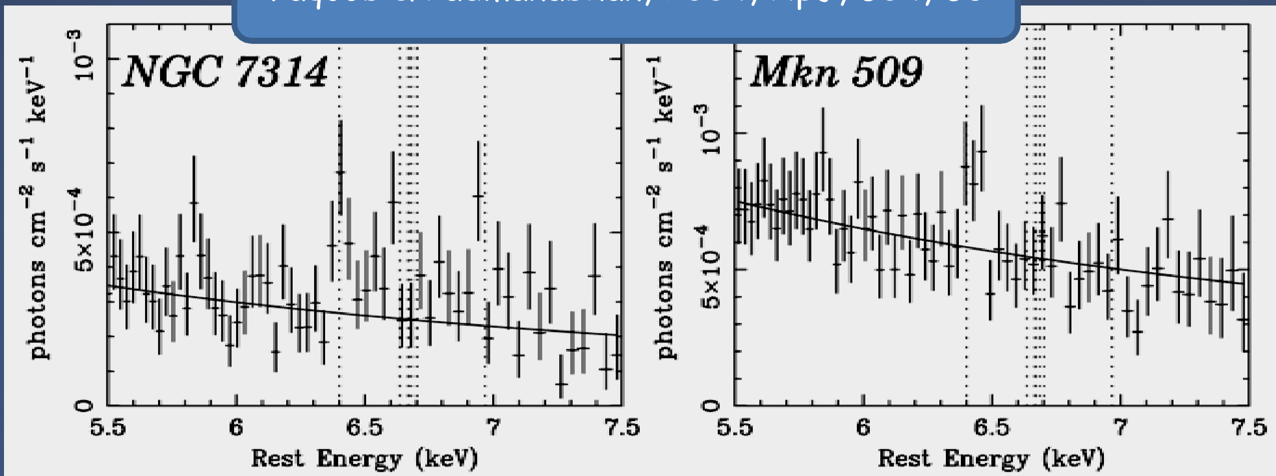
"High resolution X-ray spectroscopy: towards IXO"

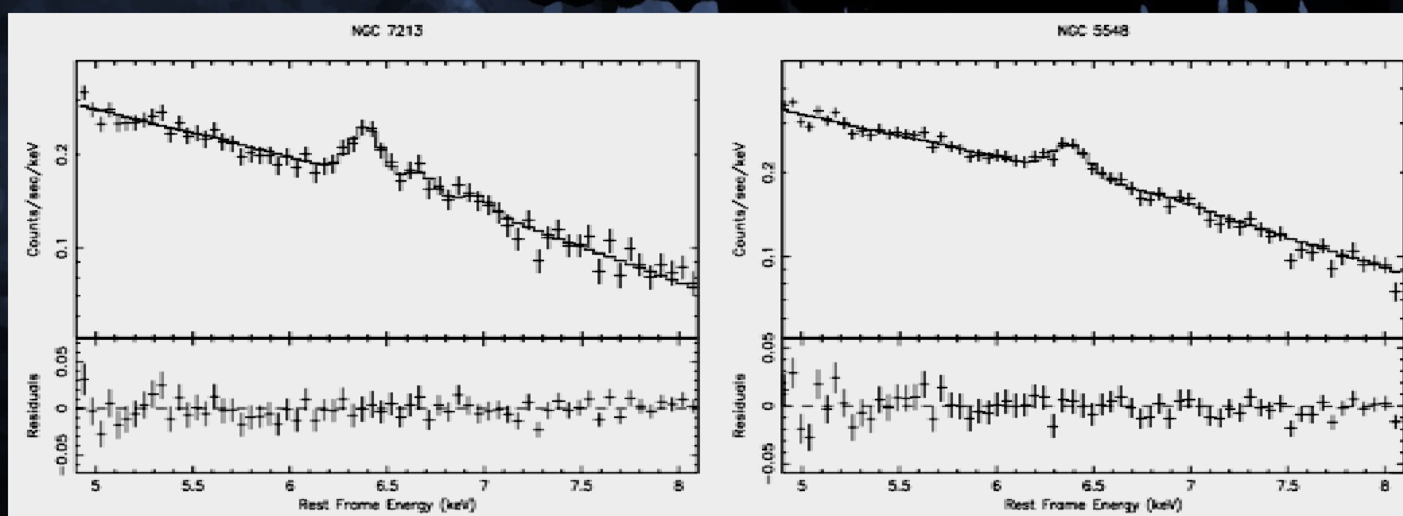
Thursday 19th March 2009 - UCL Mullard Space Science Laboratory (MSSL)

Yaqoob & Padmanabhan, 2004, ApJ, 604, 63



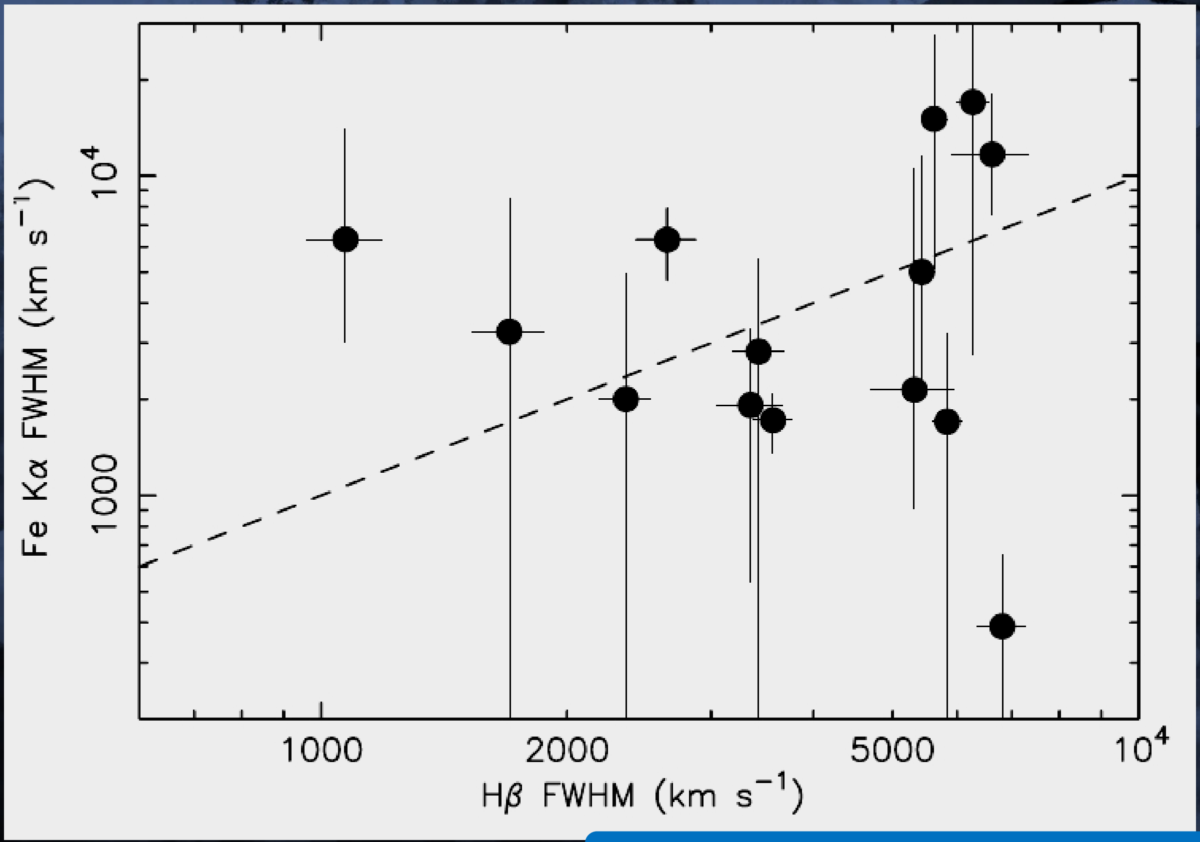
A narrow component of the iron Ka emission line is almost invariably present in *Chandra* high-energy gratings (HEG) and *XMM-Newton* CCD spectra of active galactic nuclei (AGN) (e.g. Yaqoob & Padmanabhan 2004; Bianchi et al. 2007, and references therein).

The line, typically unresolved with upper limits of several thousands km s^{-1} for the FWHM, must be produced far from the nucleus, either in the torus envisaged in the Unification Model (Antonucci 1993) or in the broad-line region (BLR).



Bianchi et al., 2004, A&A, 422, 65

If it is produced in the BLR, the intrinsic width of the iron line should be the same as that of the optical broad lines

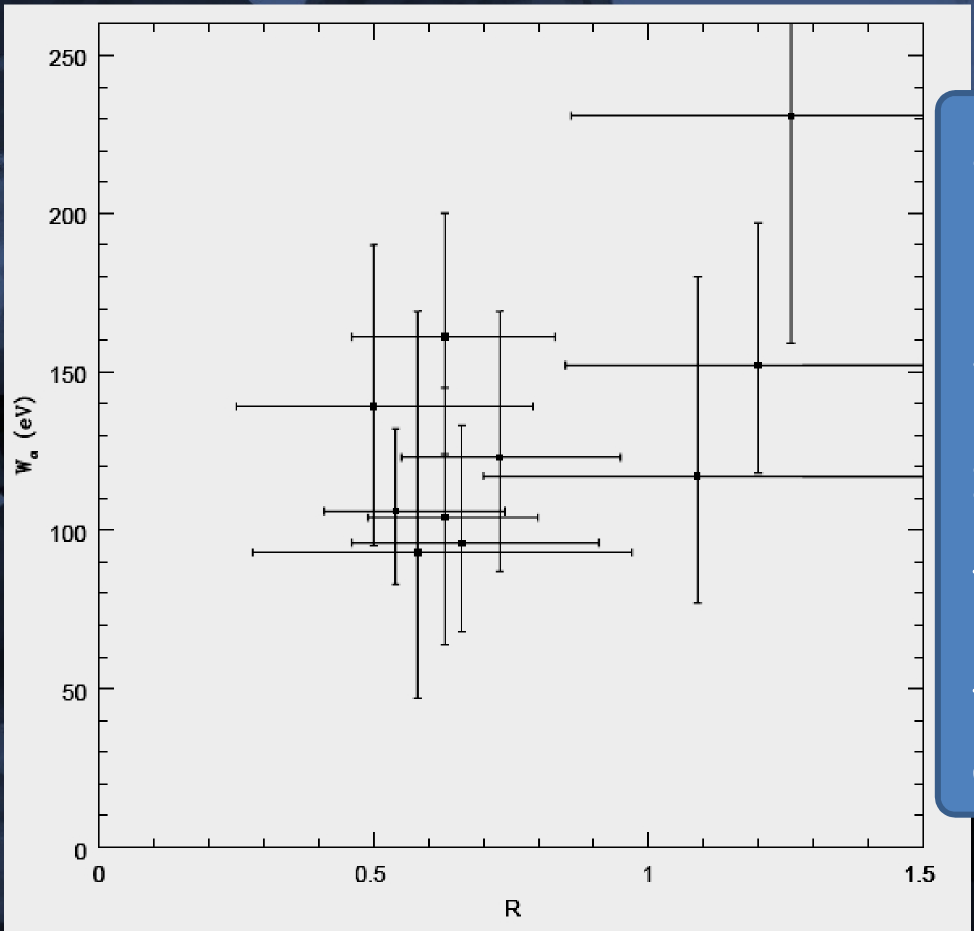


Nandra, 2006, MNRAS, 368, 62L

However, <u>there is no correlation between the X-ray and optical line widths.</u>
Moreover, it appears that the Hβ widths are, on average, much larger than those of the Fe Kα lines. This suggests that the iron line core comes from outside the BLR, likely the torus (Nandra 2006)

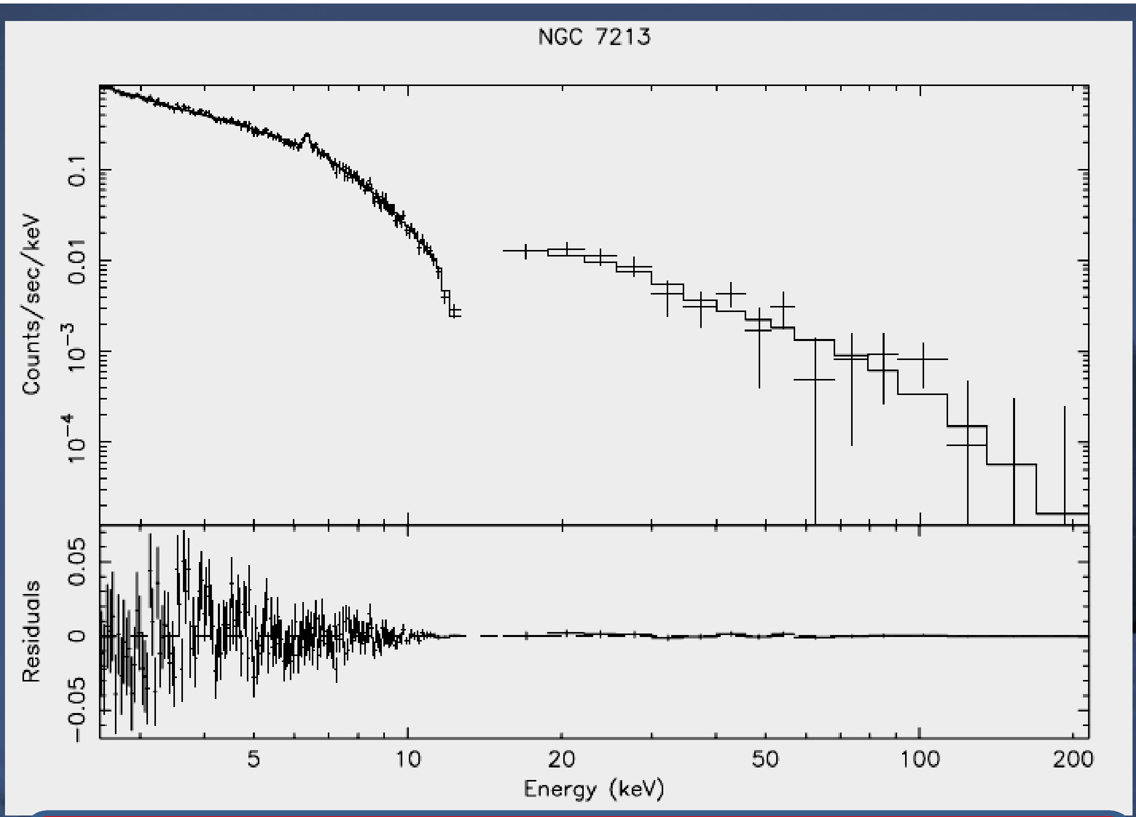
If the iron line is produced in the torus and if the torus is Compton thick, a Compton reflection component should also be present.

The presence of a Compton Reflection component is ubiquitous in Seyfert galaxies (e.g. Perola et al. 2002, Bianchi et al. 2004). On average, the observed EW of the iron line is of the right amount expected from the simultaneously measured strength of the Compton Reflection component



Perola et al., 2002, A&A, 389, 802

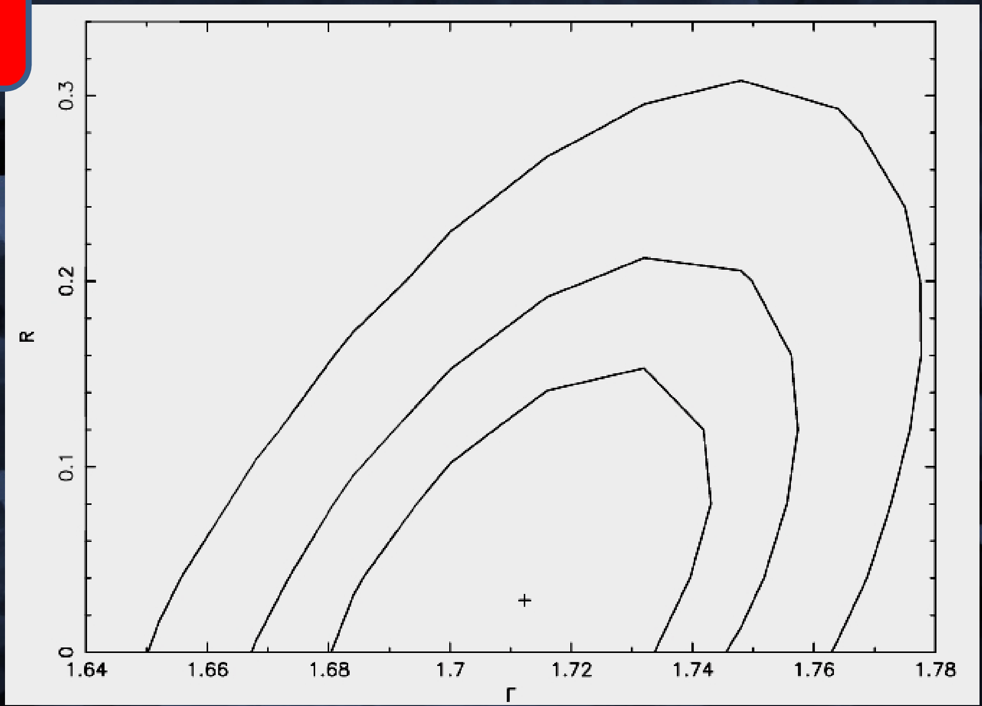
<u>The torus hypothesis seems to be preferred for the majority of sources</u>

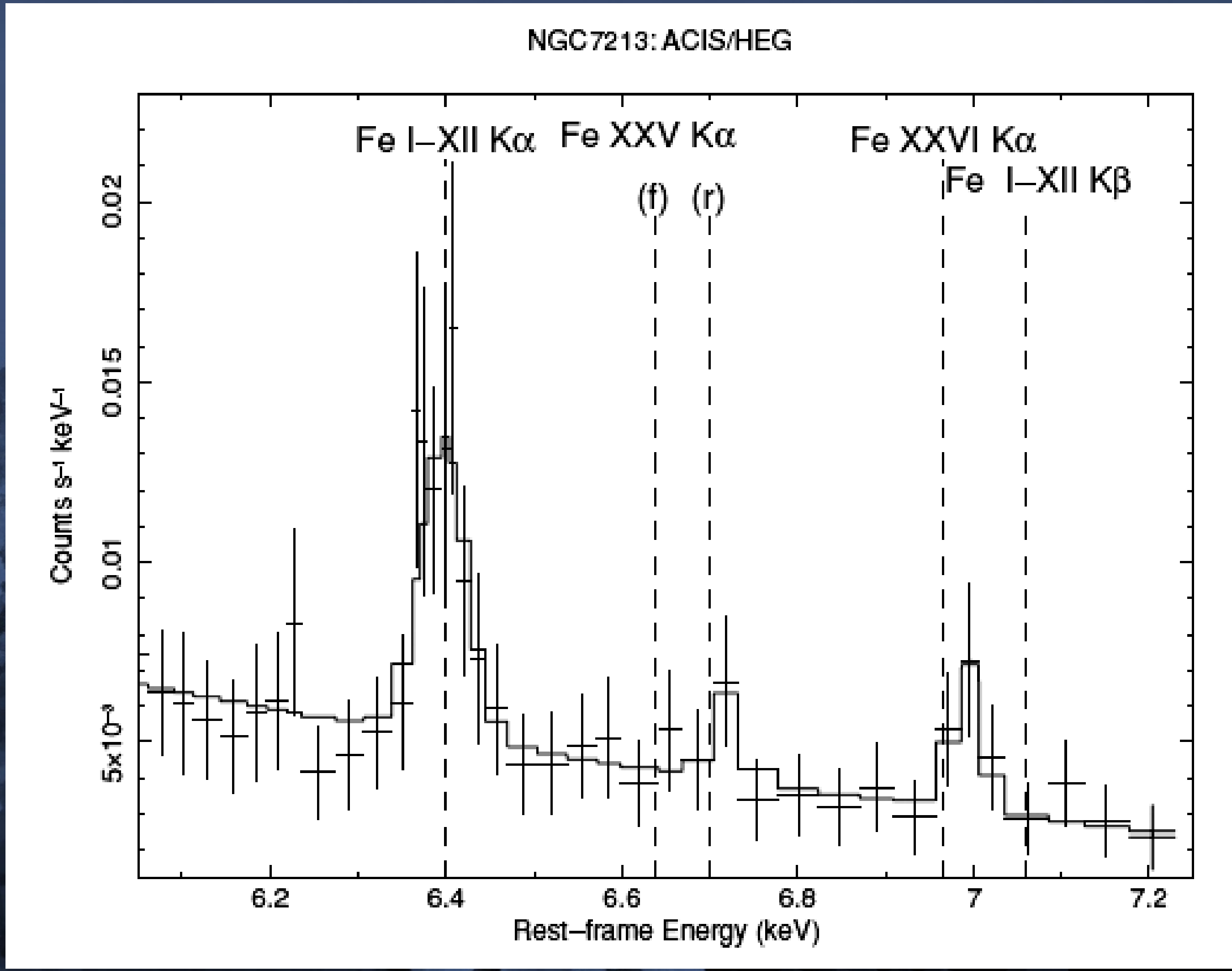


Simultaneous XMM-*Newton*/BeppoSAX data: Bianchi et al., 2003, A&A, 407, 21L

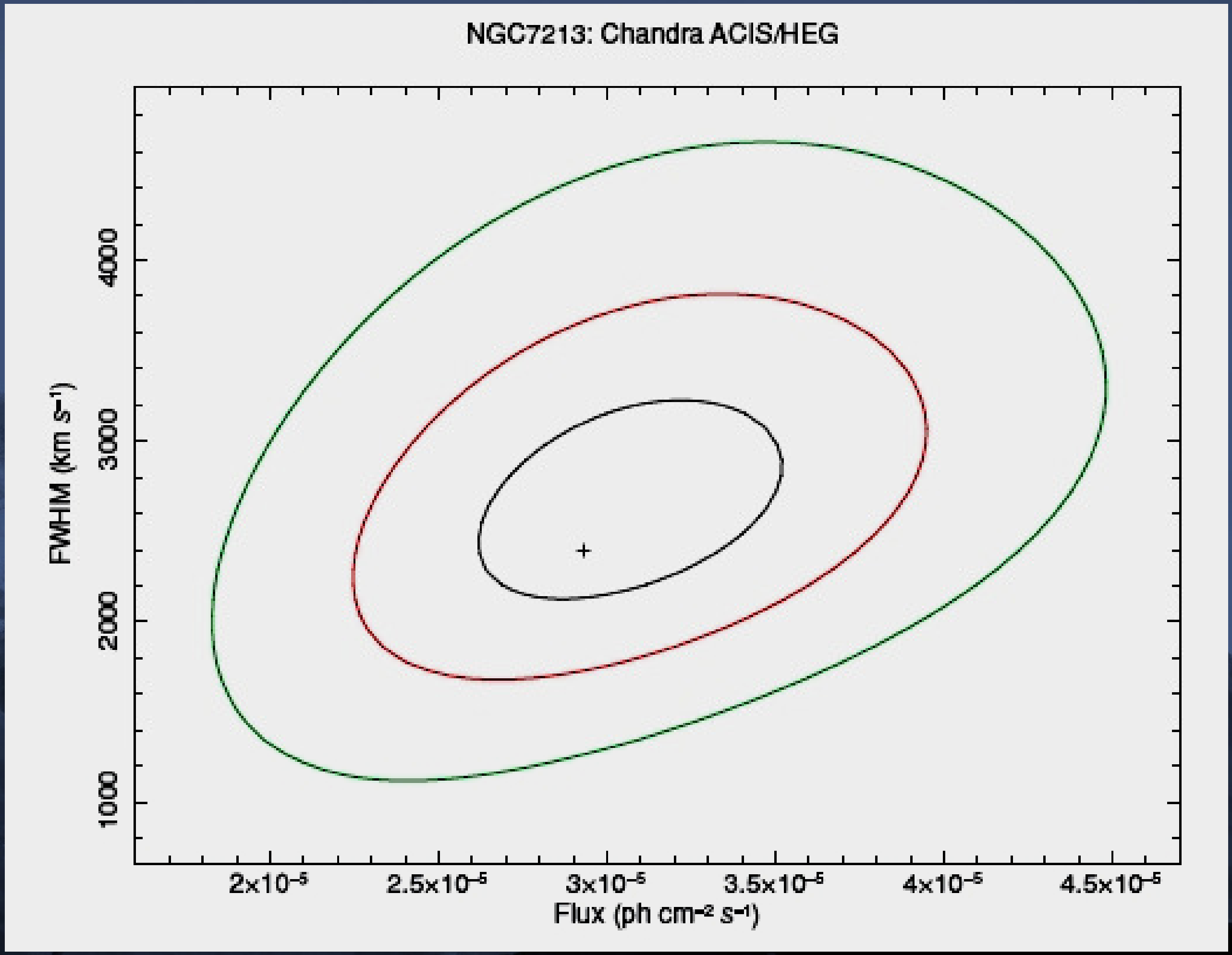
The Seyfert 1/LINER NGC 7213 presents a negligible amount of Compton reflection ($R = \Delta\Omega/2\pi < 0.19$: Bianchi et al. 2003, 2004). <u>This result is unique among bright Seyfert 1s observed by BeppoSAX</u> (Perola et al. 2002; Risaliti 2002; Dadina 2008).

Therefore, the observed neutral iron line cannot be associated to a Compton-thick material, like the torus, but is due to Compton-thin gas, like the BLR.



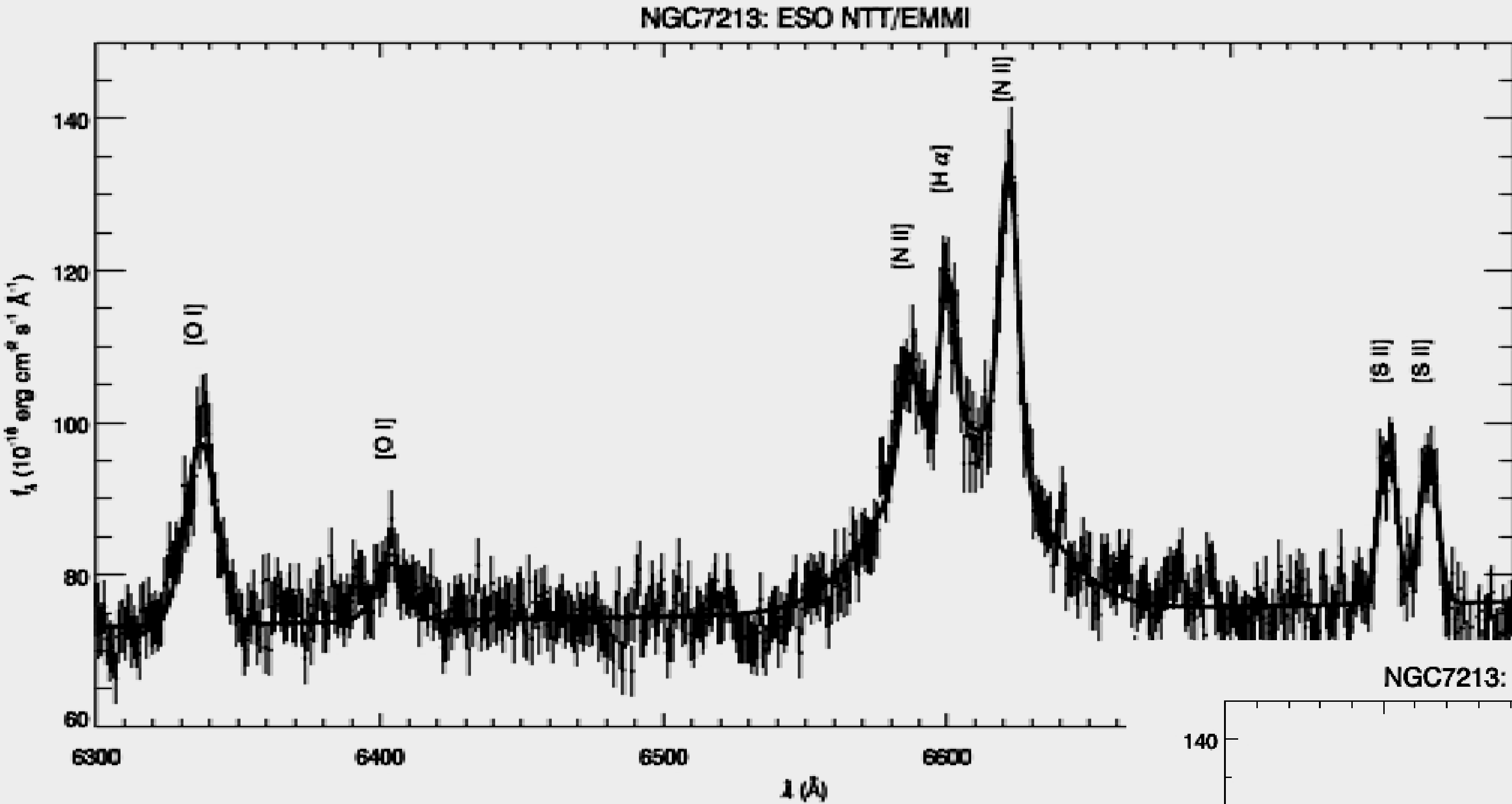


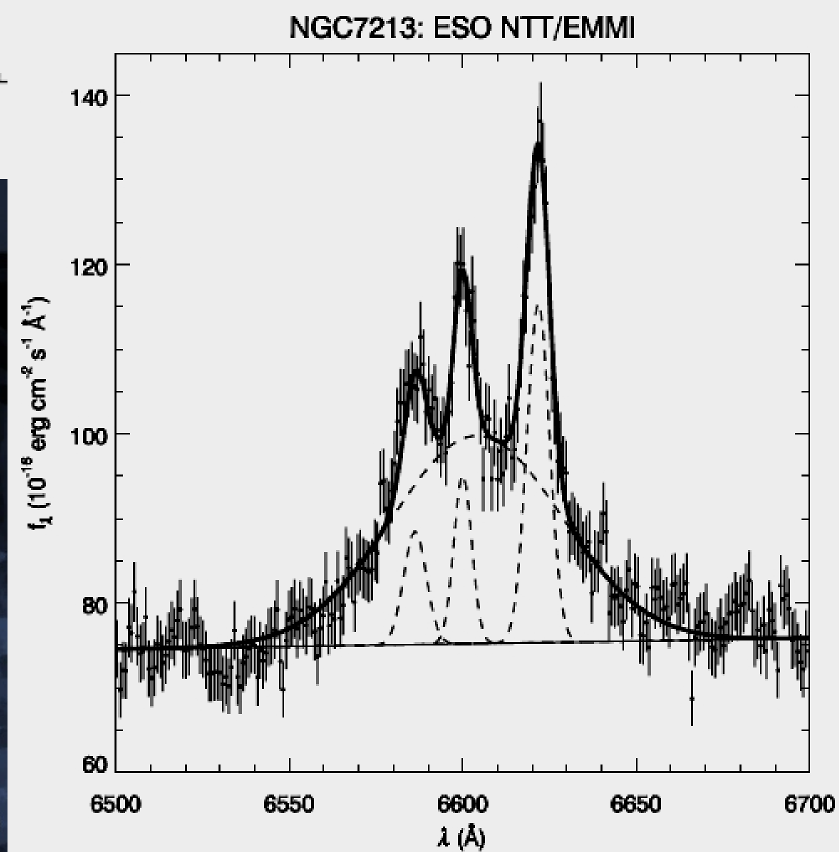
In order to test this scenario, we asked for a 150 ks *Chandra* HEG observation. The observed flux ($2.9^{+0.9}_{-0.7} \times 10^{-5}$ ph cm^{-2} s^{-1}) and the EW (120^{+40}_{-30} eV) are in agreement, within errors, with those found by XMM-*Newton* (Bianchi et al. 2003).



<u>The iron line is resolved by the Chandra HEG</u>.

The presence of a Compton Shoulder or blending with iron lines from higher ionisation states cannot account for the measured width. Doppler broadening is left as the most likely explanation for the width of the iron line, which would correspond to a FWHM= 2400^{+1100}_{-600} km s^{-1}.





We also asked for DDT to obtain a quasi simultaneous observation of NGC 7213 at the ESO NTT telescope
The analysis confirmed the presence of a broad component of the Ha line, for which we measured a FWHM= 2640^{+110}_{-90} km s^{-1}.

The widths of the two lines are in very good agreement, which suggests that they are likely to be produced in the same material, the BLR

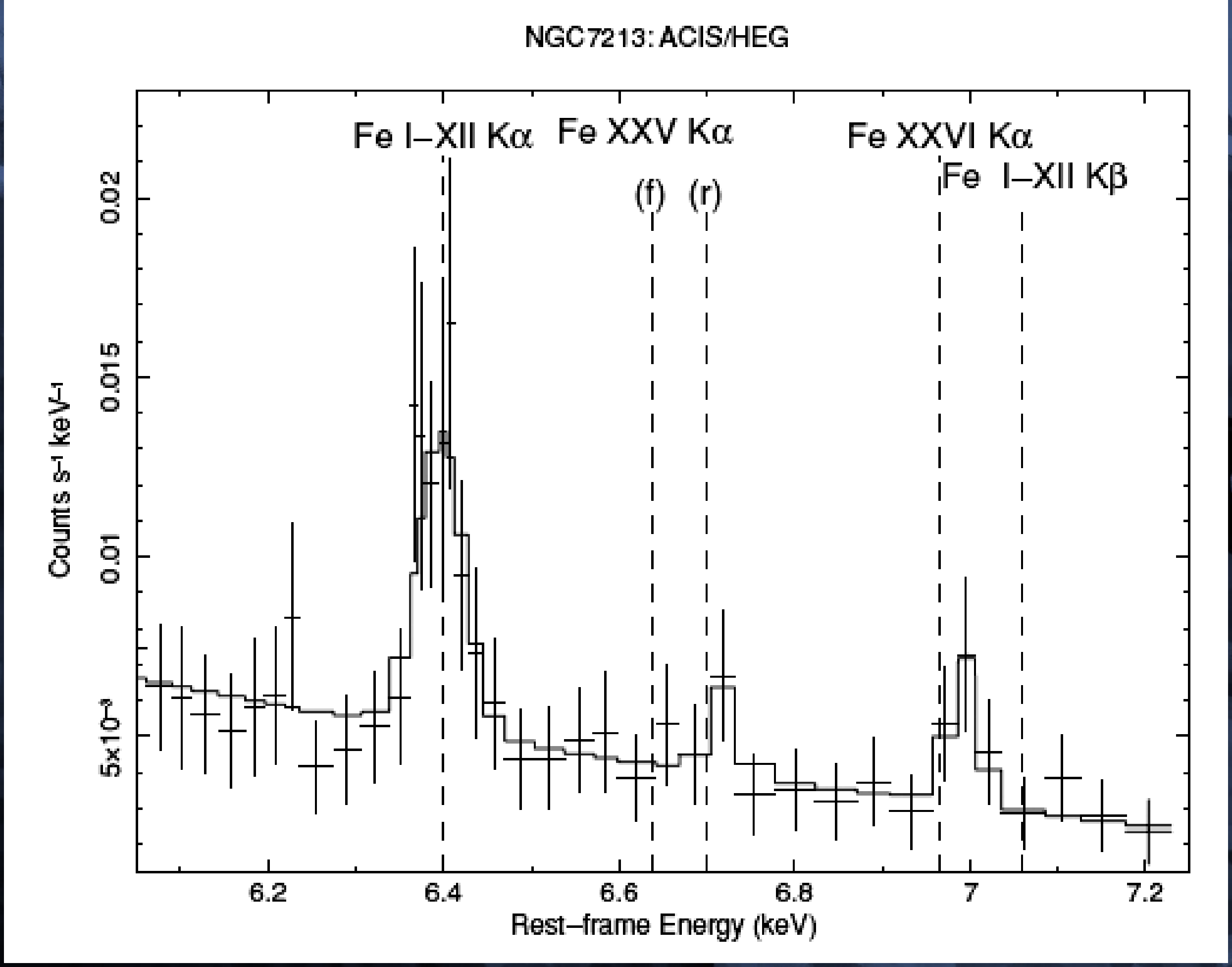
$$\mathrm{EW_{FeI}} \simeq 34 \left(\frac{f_c}{0.35}\right) \left(\frac{N_\mathrm{H}}{10^{23}\,\mathrm{cm^{-2}}}\right)\ \mathrm{eV}$$

from Yaqoob et al. (2001), derived from Krolik & Kallman (1987)

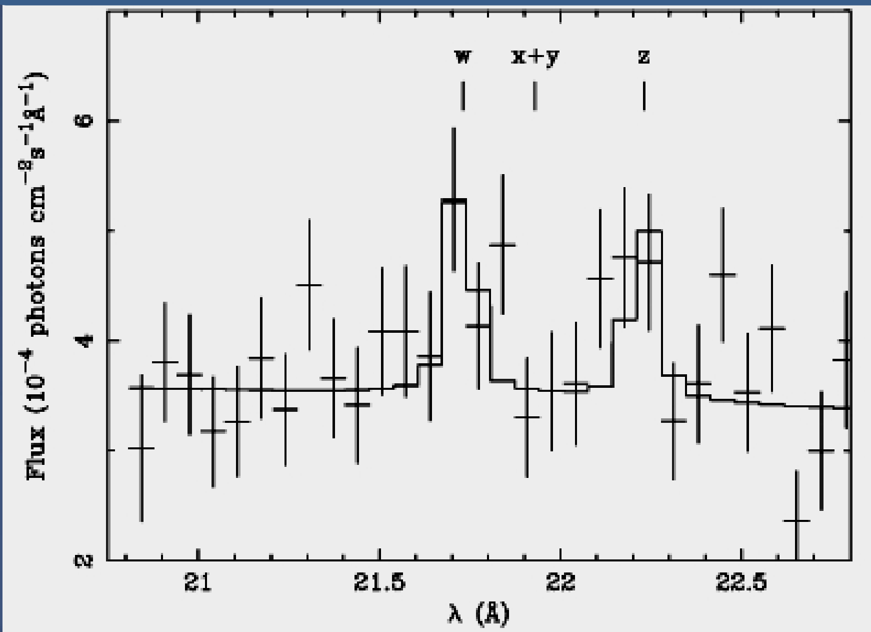
Assuming a covering factor $f_c = 0.35$, a column density $N_H \sim 3 \times 10^{23}$ cm^{-2}, we can reproduce an EW~100 eV, which is of the order of magnitude found by *Chandra* and XMM–*Newton*. These values for f_c and N_H are within the ranges usually assumed in photoionization models of BLRs (Netzer 1990), even if more 'canonical' values around 0.1 and 0.25 are generally found.
In any case, f_c and N_H can be lower, provided that iron abundance is larger than solar and/or the X-ray illumination of the BLR is anisotropic (see e.g. Yaqoob et al. 2001, and references therein).

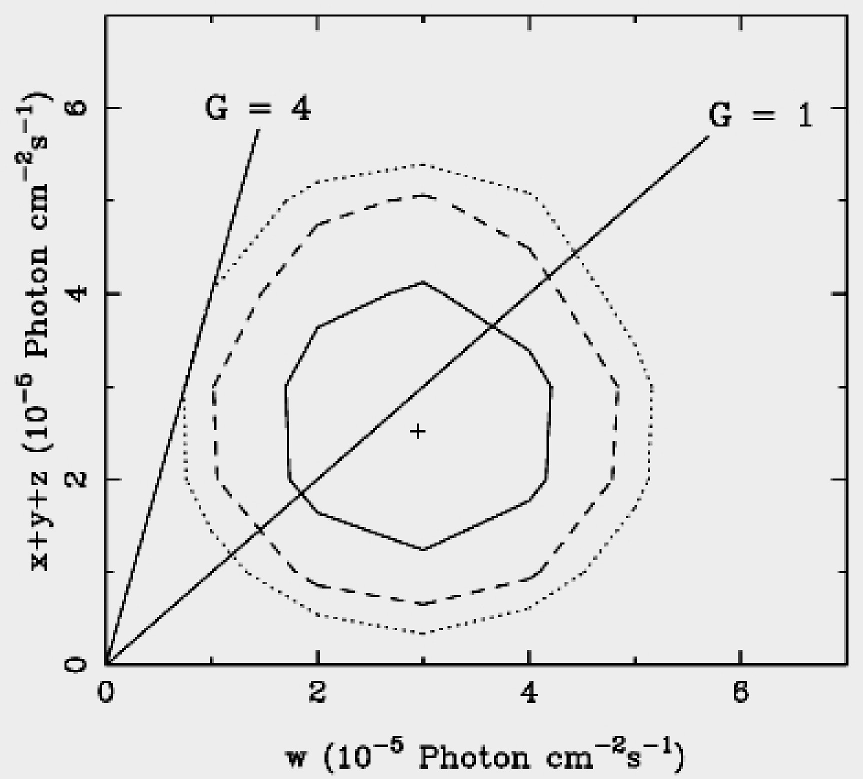
On the other hand, we cannot exclude a further contribution to the iron line EW from a Compton-thin torus, located on a pc-scale, but we stress here that we do not have any other piece of evidence to support its presence.

Along with the neutral iron line, two other significant emission lines are observed in the HEG spectrum of NGC 7213, at $6.721^{+0.010}_{-0.016}$ and $6.987^{+0.090}_{-0.006}$ keV. The fluxes and EWs of the two lines are consistent with those found by XMM-*Newton* (Bianchi et al. 2003).
A common blueshift (~900 km s^{-1}) is recovered if they are identified with the resonant component (6.700 keV) of the Fe XXV triplet and the Fe XXVI line



Starling et al., 2005, MNRAS, 356, 727





Their origin may be in gas photoionised by the AGN, as found in many Seyfert 1s and 2s (e.g. Bianchi & Matt 2002; Bianchi et al. 2005). However, the gratings data presented here revealed that the resonant line is the dominant component in the Fe XXV triplet, which is suggestive of an origin in gas in collisional equilibrium. This is in agreement with the results found by Starling et al. (2005) using diagnostic tools based on the O VII triplet observed in the XMM-*Newton* RGS spectrum of NGC 7213.

The hot, line emitting, gas can be in the form of a starburst driven wind (see e.g. Heckman 2003).
If this is the case, this could be the first measure of the velocity of a starburst wind from its X-ray emission.

Conclusions

NGC7213 is the only bright Seyfert 1 without a Compton reflection component. This implies that the observed iron Ka emission line must be produced in a Compton-thin material, like the BLR

We tested this scenario with a Chandra HEG X-ray observation and a quasi-simultaneous optical observation at ESO. The iron line width is resolved and its FWHM is in agreement with that of the Ha

NGC7213 is therefore the only Seyfert galaxy whose iron line emission is unambiguously produced in the BLR

The detection of the resonant component of the Fe XXV triplet suggests the presence of a gas in collisional equilibrium and outflowing with velocities around 900 km/s, possibly due to a starburst wind