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ROMA TRE UNIVERSITÀ DEGLI STUDI

with invaluable help from

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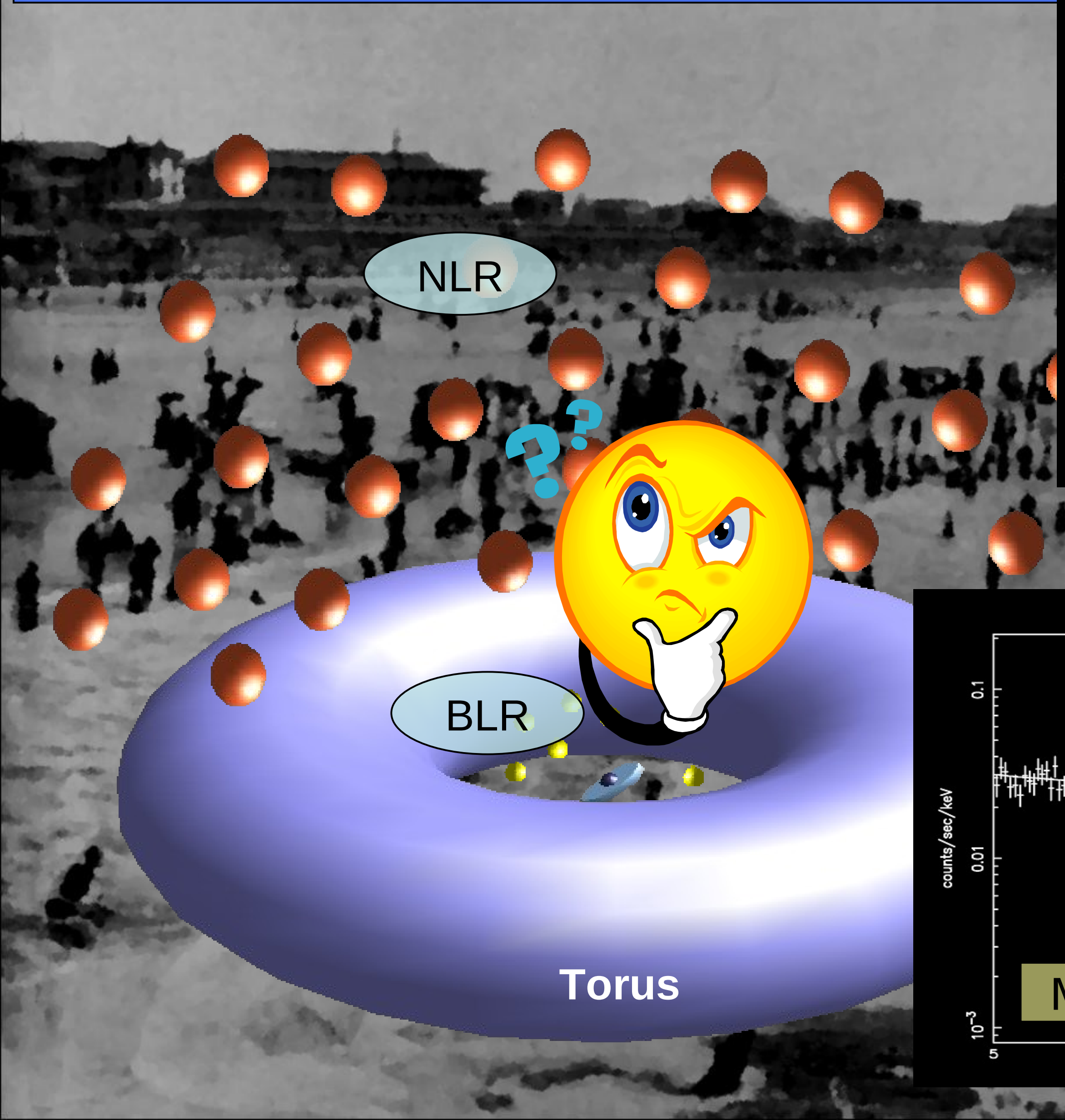
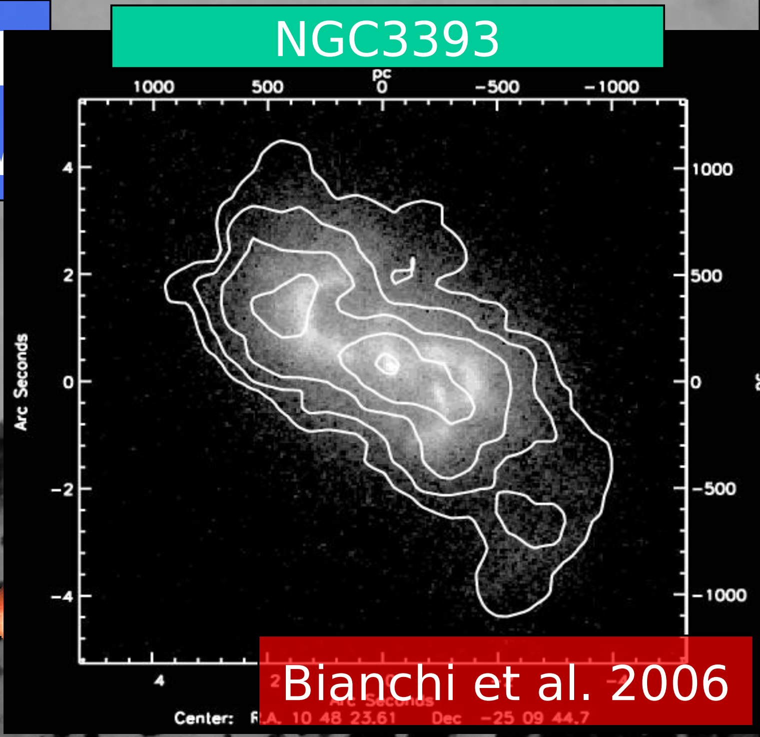
Beyond the Unification Models in AGN

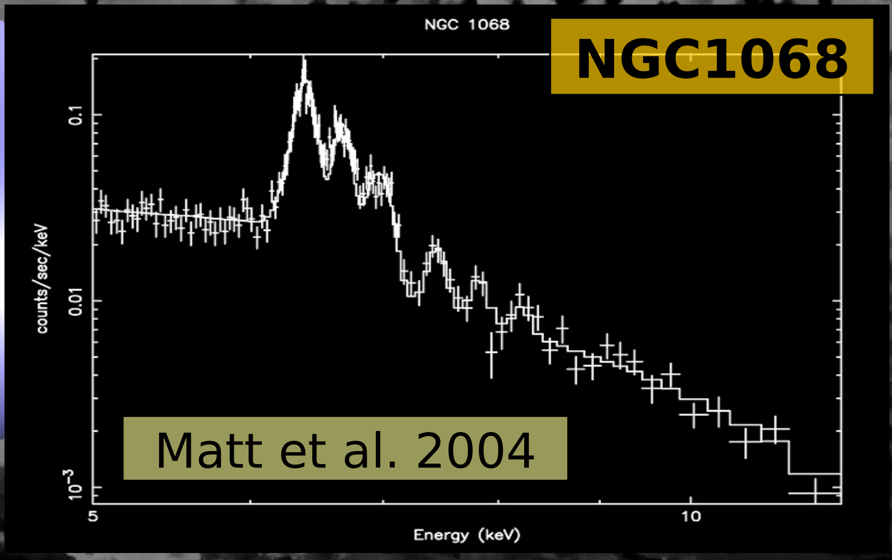
The BLR in the X-rays

Chandra's First Decade of Discovery

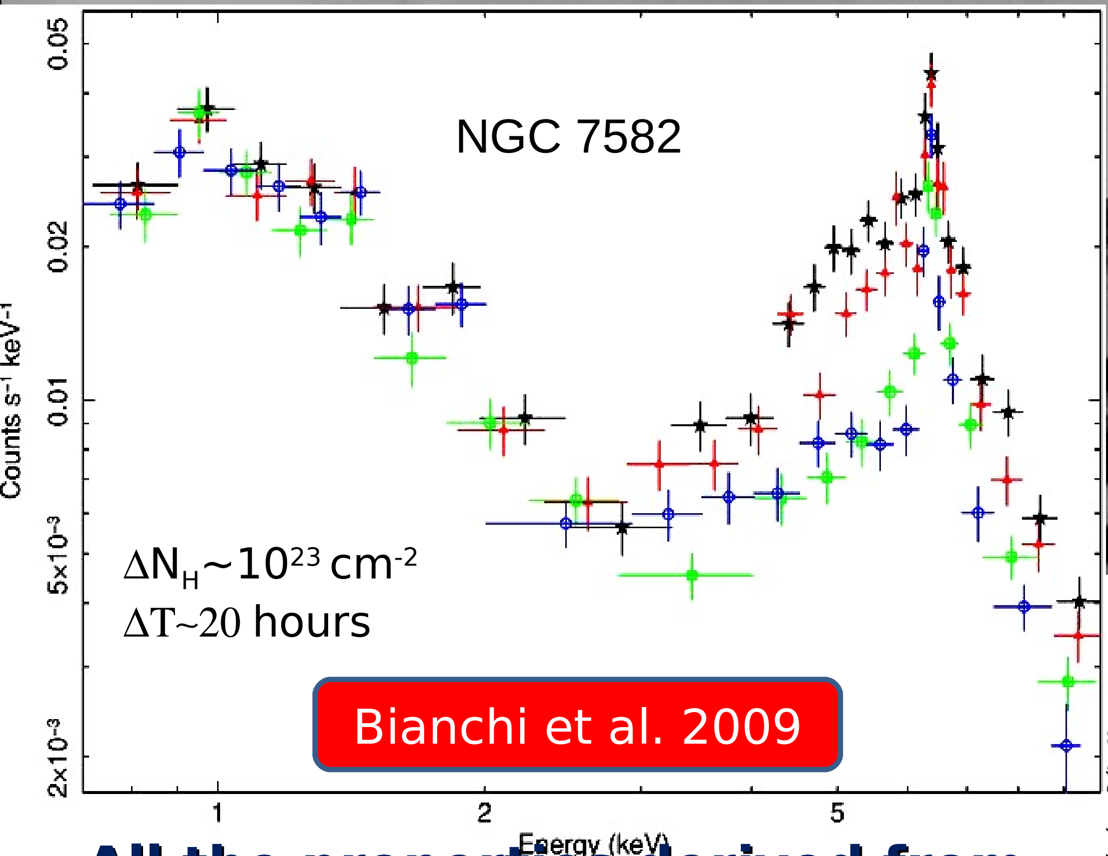
Circumnuclear matter in AGN
The Unification Model view



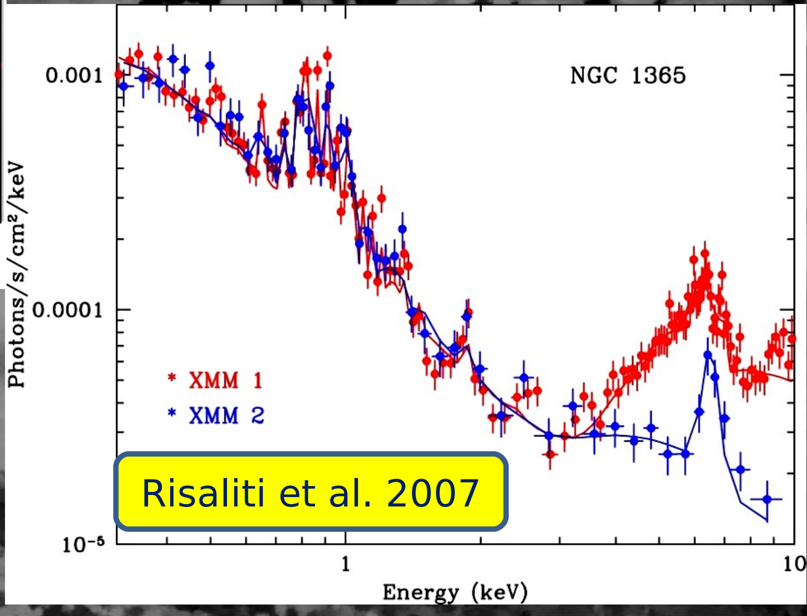




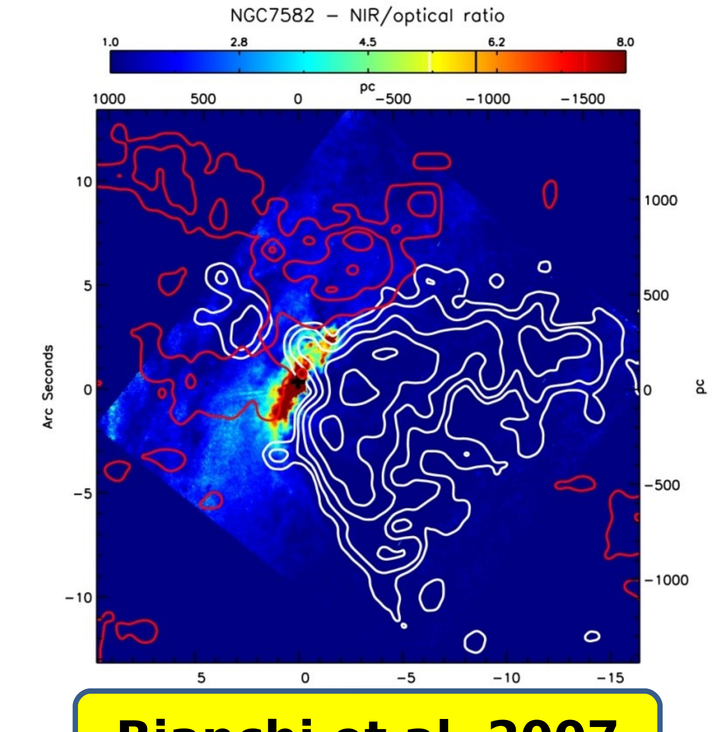
The BLR as an X-ray absorber



In the last years, we observed a number of sources which experience very fast column density variations along the line of sight.
This is at odds with the standard view of most of the obscuration occurring at a pc-scale torus



All the properties derived from the observations ($N_H = 10^{23}$-10^{24} cm^{-2}; $n_e = 10^{10}$-10^{11} cm^{-3}; $D \sim 100$-1000 r_g) point to BLR clouds as the obscuring gas in



Bianchi et al. 2007

Is the BLR the only obscuring gas in AGN?

In some cases, moderate X-ray column densities (~10^{22} cm^{-2}) are in agreement with an origin in **large-scale dust-lanes** (see e.g. Matt, 2000)

Many Compton-thick (>10^{24} cm^{-2}) sources do not show any variability even on long timescales, suggesting that the obscuration occurs on (at least) pc-scale, like **the standard torus**

It seems that the line of sight is still playing a primary role in the classification of obscured sources, but three different scales (BLR, torus, dust-lane) must be considered for the obscuration

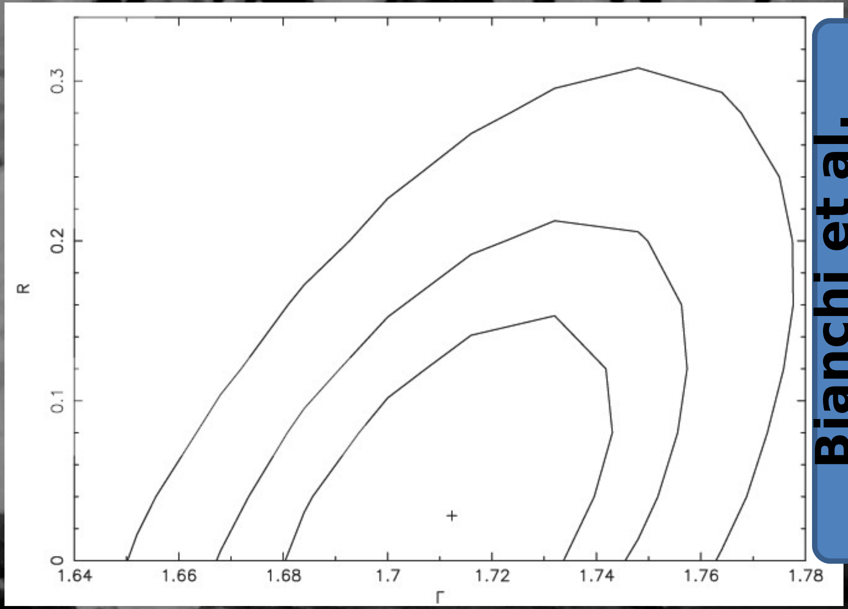
The BLR as an X-ray emitter

While there are sources whose highly ionized X-ray emission lines are thought to originate in the BLR (e.g. Costantini et al. 2007, Longinotti et al. 2008, see also poster 9.6), the observed obscuring clouds are mostly neutral, so **we would expect fluorescent emission from neutral iron**

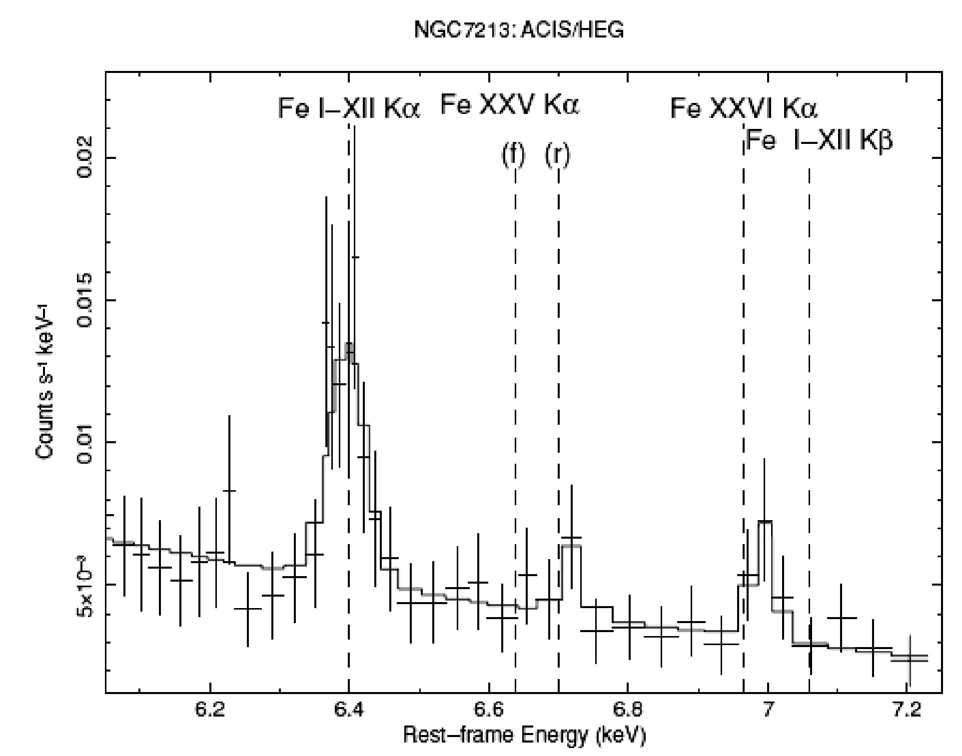
Therefore, the observed neutral iron line cannot be associated to a Compton-thick material, like the torus, but it must be due to Compton-thin gas, like the BLR.

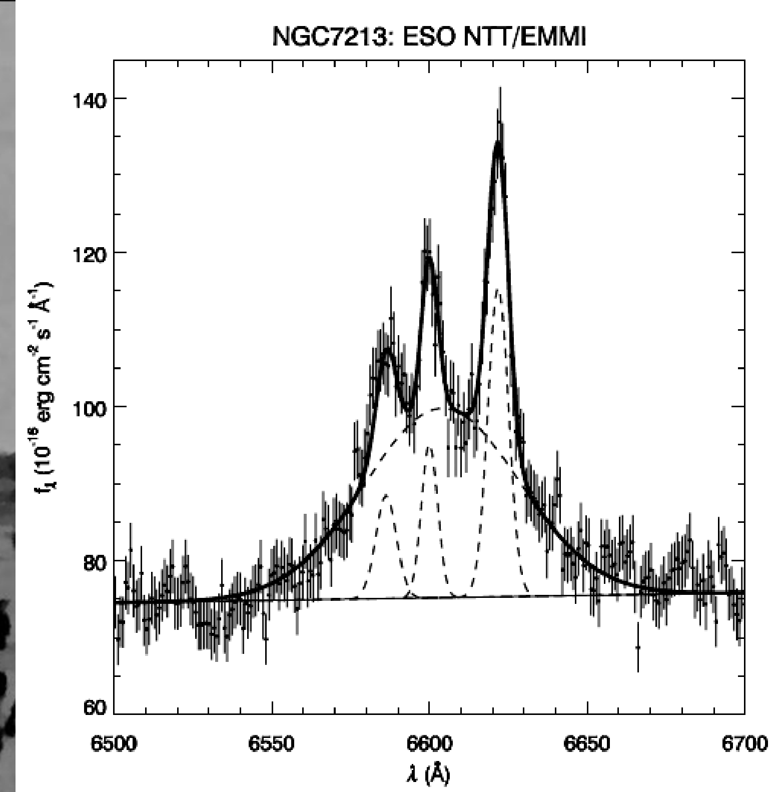
NGC 7213

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



Bianchi et al. (2003)





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

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

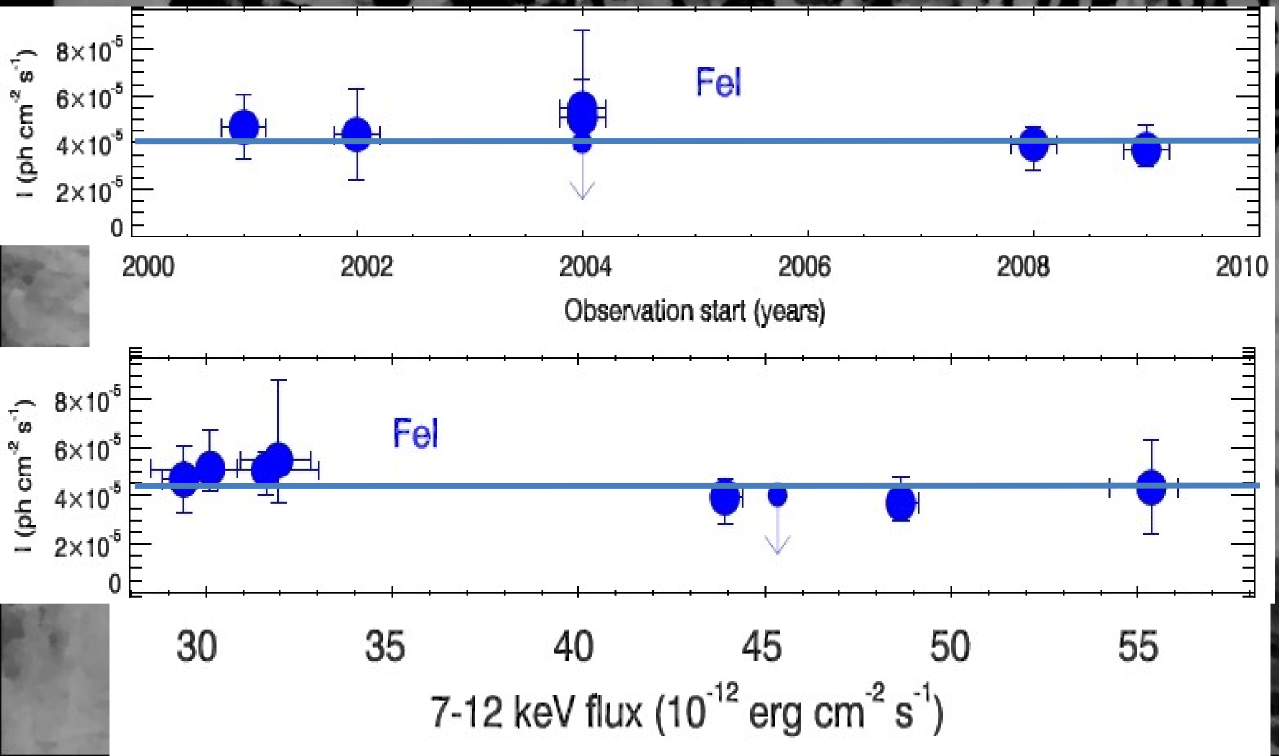
from Yaqoob et al. (2001), derived from Krolik & Kallman (1987)

Assuming a covering factor $f_c = 0.35$, a column density $N_H \sim 3 \times 10^{23}\ \mathrm{cm}^{-2}$, 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).

Is the Fe Kα line always produced in the BLR?

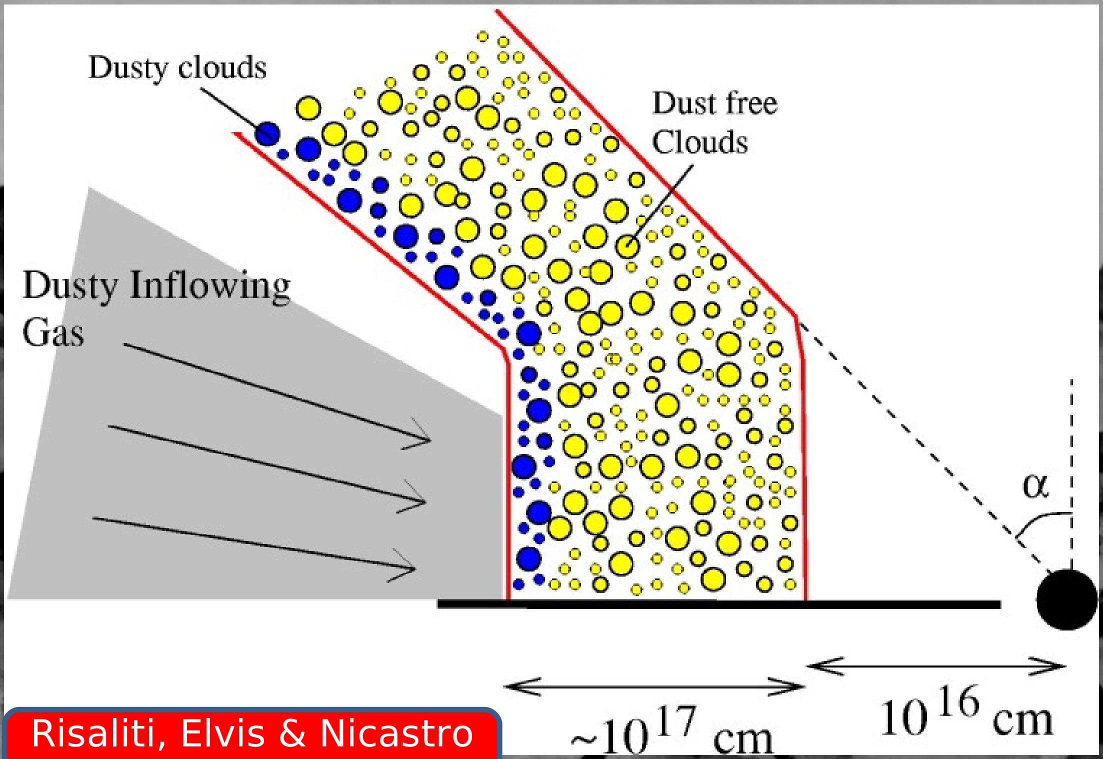
In most cases, the width of the iron Kα line is completely uncorrelated with that of the BLR lines (e.g. Nandra et al. 2006)
Moreover, the iron line and the Compton reflection component are ubiquitous in Seyfert galaxies (e.g. Bianchi et al. 2004) and are almost **never observed to vary**

In NGC5506, the iron line flux varies less than 25% during 8 years, while the hard X-ray flux varies by 100% (Guainazzi et al., in prep.)



Most of the iron line flux must be produced farther away from the BLR, in the torus

BLR/Torus continuum?



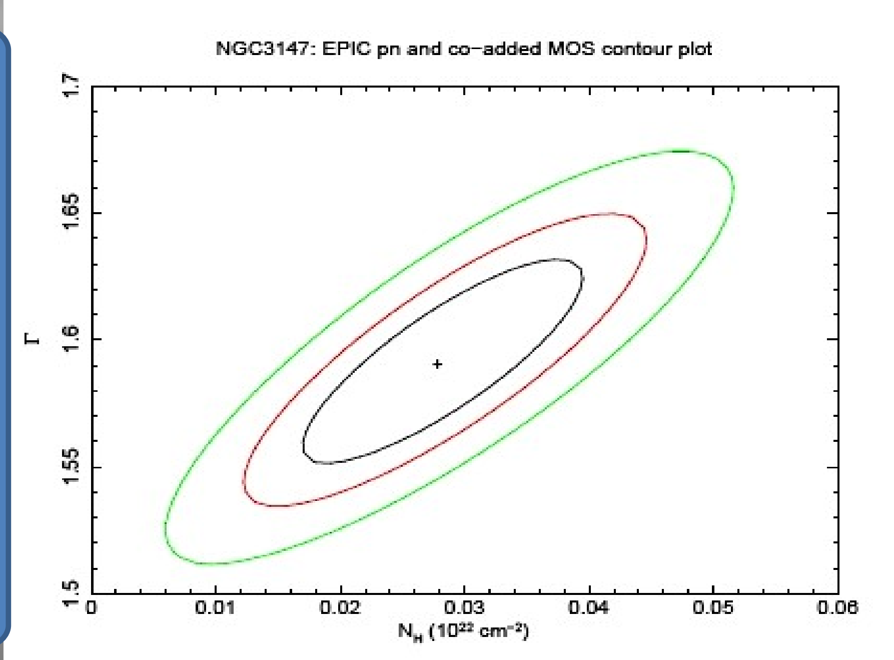
Risaliti, Elvis & Nicastro (2002)

Most of the models for the formation of the BLR predict that it should disappear at low luminosities (Elitzur & Shlosman, 2006) and/or Eddington ratios (Nicastro, 2000)
Where are these sources?

The BLR and the torus likely form a smooth "continuum" (e.g. Risaliti et al., 2002; Elitzur & Shlosman, 2006)
However, the sublimation radius clearly separates two regions:
-**<u>The inner dust-free BLR</u>**
-**<u>The outer dusty torus</u>**

The presence of dust-free gas along the line of sight explains the anomalous gas-to-dust ratio observed in many sources (e.g. Maiolino et al. 2001)

Bianchi et al. (2008)



NGC3147 is an optically-classified Seyfert 2, whose XMM-Newton spectrum is absorbed by a very low local column density: $N_H < 5\times10^{20}$ cm^{-2}

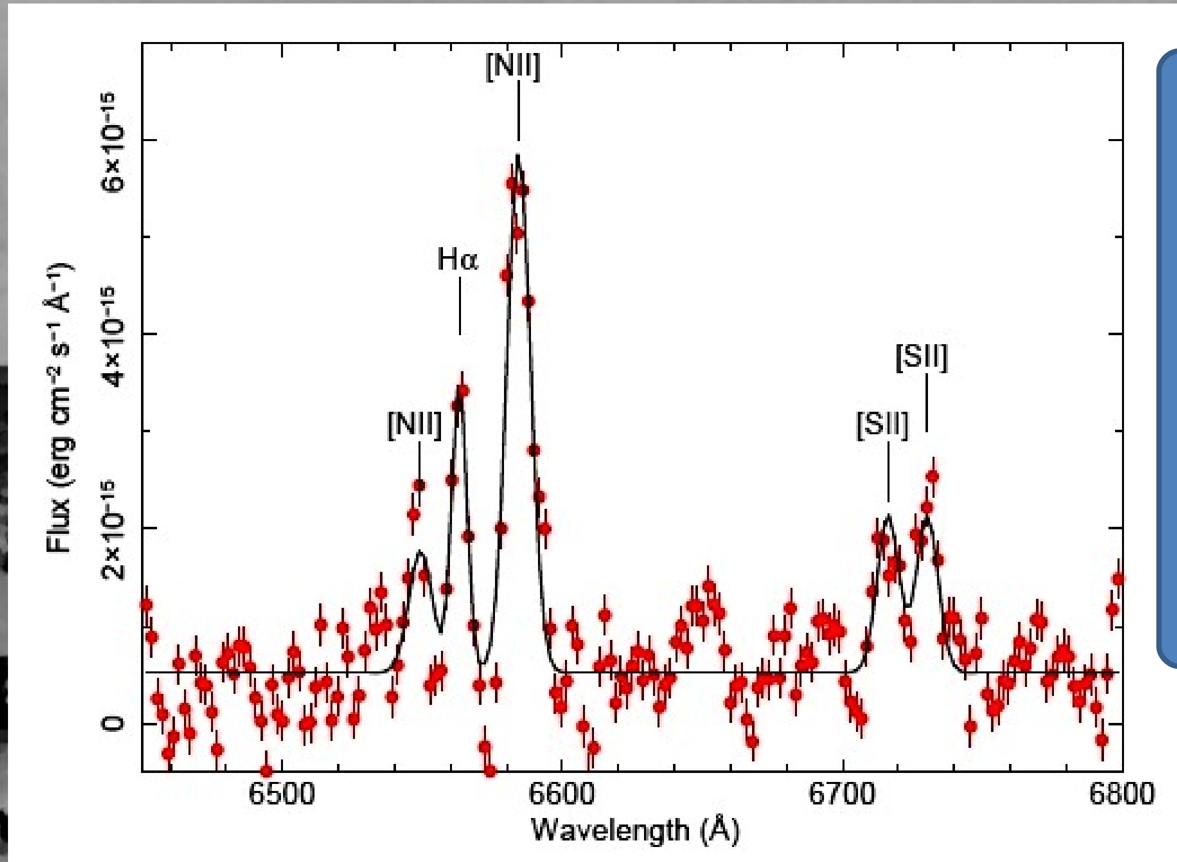
NGC3147 is NOT Compton-thick:

- Neutral iron Kα EW: ~130 eV

-X-ray/IR/[OIII] flux diagrams

-$\Gamma \sim 1.6$

-$a_{ox} \sim 1.33$



Bianchi et al. (2008)

In the <u>simultaneous optical spectrum</u> there is

NO BROAD Hα or Hβ!

The flux of any broad component of the Hα would be at most 5% of the total Hα flux

The lack of broad optical lines in NGC3147 is an intrinsic property of the source and not an artefact of low S/N

The SIMULTANEOUS optical spectrum confirms the lack of broad permitted lines!

The very low column density measured in the X-rays ($N_H < 5x10^{20}$ cm^{-2}) corresponds to A_V<0.3, at odds with the large amount of dust required to obscure the BLR

NGC3147 intrinsically lacks the BLR!

Low luminosity

The BLR may disappear at very low bolometric luminosities (Elitzur & Shlosman 2006)
The bolometric luminosity of NGC3147 is about 5x10^{42} erg s^{-1}, larger than the 'threshold' calculated in this scenario

Low accretion rate

Below a minimum accretion rate, the BLR cannot form (Nicastro 2000)
The Eddington ratio of NGC3147 ranges between 8x10^{-5} and 2x10^{-4}, well below the 'threshold' proposed in this scenario

Conclusions

There is now mounting evidence that the BLR is 'active' in the X-rays

ABSORPTION

Rapid variability of moderately high column densities (10^{23}-10^{24} cm^{-2}) must occur at the distance of the BLR

However, the presence of obscuration at larger scales (torus, dust-lane) is required by the data in many sources

EMISSION

The BLR is expected to produce some iron K emission. In at least one case (NGC7213) it seems to be the only contribution to the total flux, but in most cases the bulk of the line appears to be produced at larger scales, the torus

The BLR and the torus are likely part of a smooth 'continuum', but the sublimation radius separates a dust-free from a dusty region

At low Eddington ratios, the BLR may disappear (see NGC3147)