Active Galaxies

Giorgio Matt

(Dipartimento di Fisica, Università Roma Tre, Italy)

Plan of the talk

A (incomplete and biased) review of:

- ***the main XMM-Newton contributions to the field***
- ***the major open issues***
- ***what XMM-Newton can potentially do but has not done yet***

XMM-Newton's main results

The combination of large collecting area, broad band coverage and moderate (CCD) to high (Gratings) spectral resolution provided fundamental results on:

- ***Relativistic lines***

  (see talks by Fabian and de la Calle)

- ***Warm/hot absorbers and warm/hot reflectors***

  (see talks by Kaastra, Arav and Guainazzi)

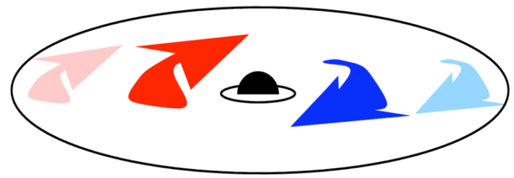
- ***The soft X-ray excess***

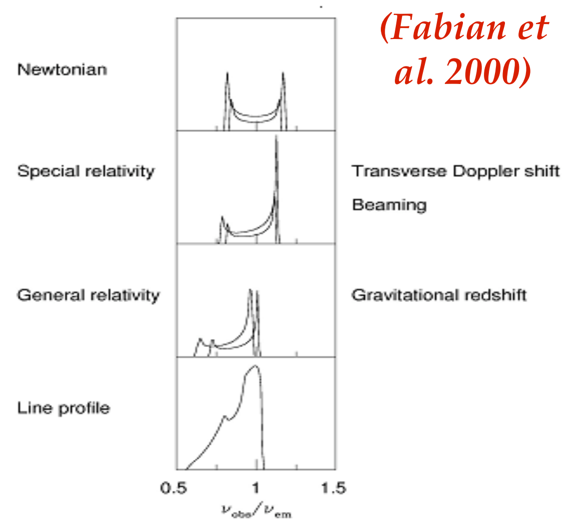
- ***The (many) circumnuclear cold regions***

Relativistic lines

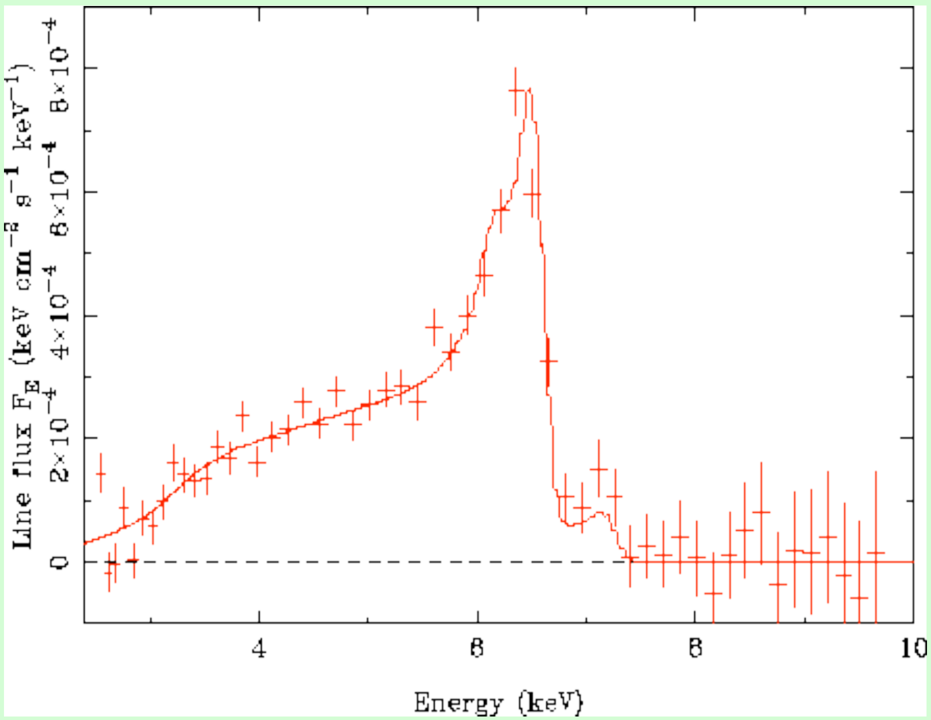
Relativistic lines are often observed, but not always

Why? **(Ionization, truncated disc, …)**

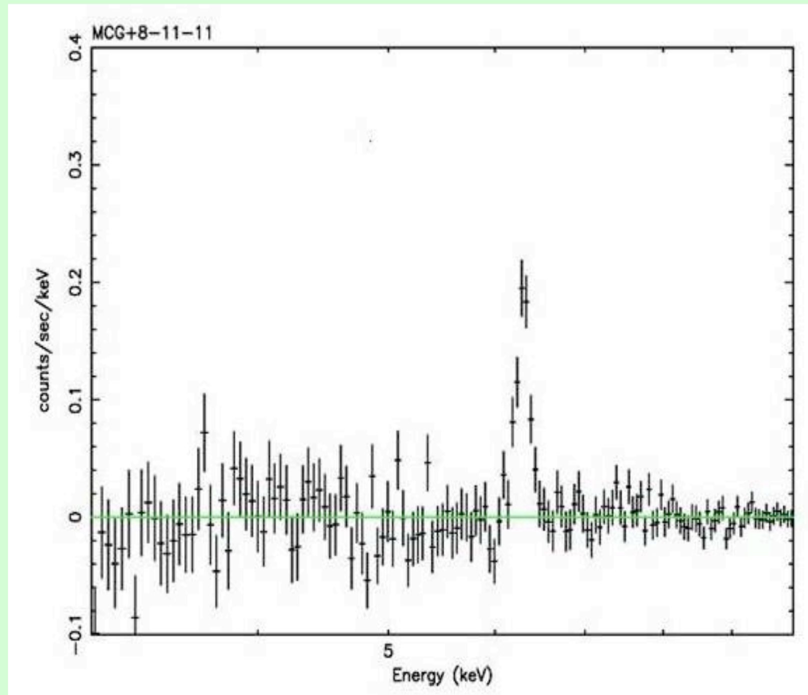




(Fabian et al. 2000)



MCG-6-30-15
(Fabian et al. 2002)



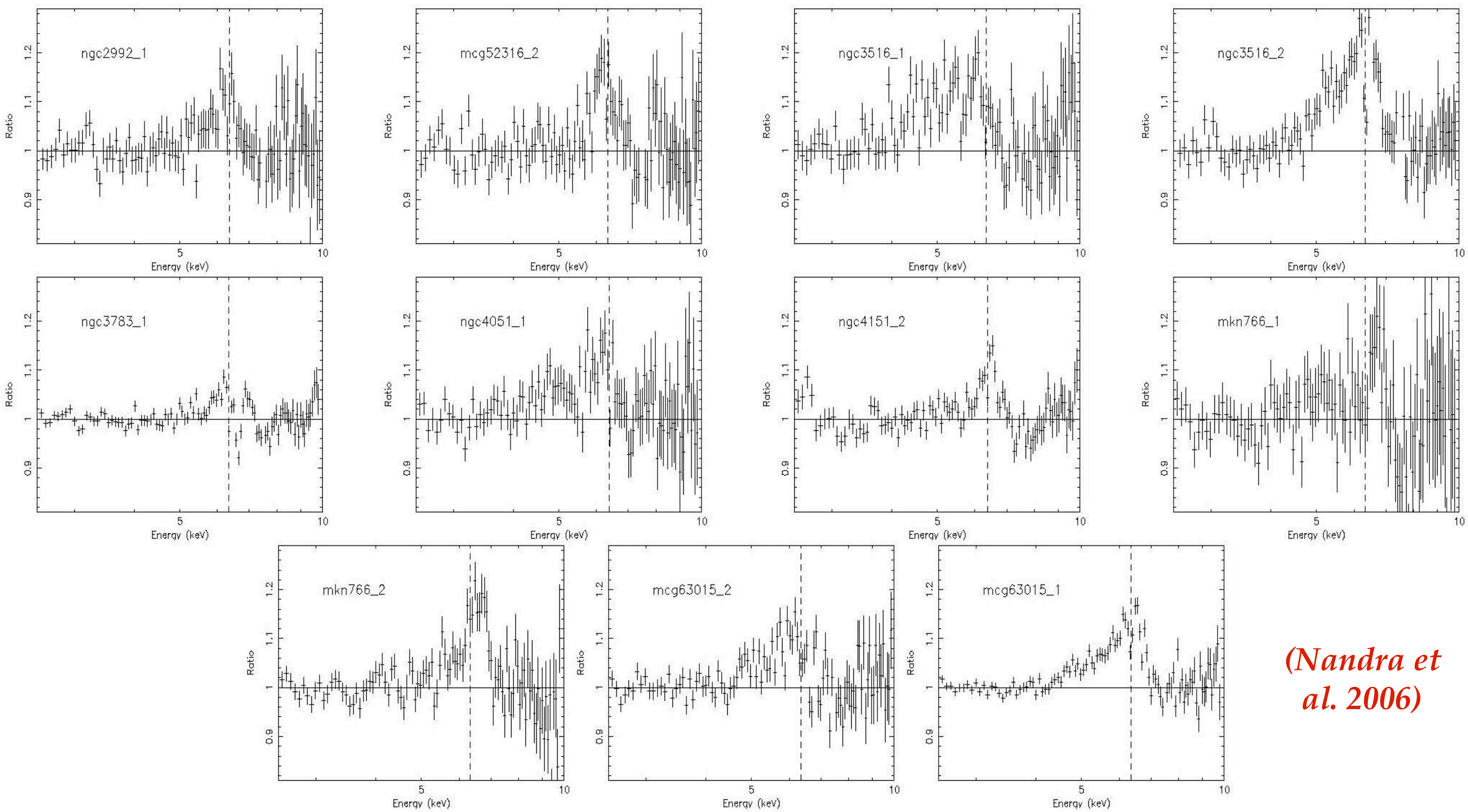
MCG-8-11-11
(Matt et al. 2006)

How common are relativistic lines in AGN ?

Even with XMM-Newton, the number of sources *with enough counts (>10000) to search for relativistic lines* is small, because of insufficient exposure times.

About 30% of `well exposed' objects (2 dozens or so) show clear evidence for relativistic lines (Guainazzi et al. 2006, Nandra et al. 2006).

How common are relativistic lines in AGN ?



(Nandra et al. 2006)

Paul Nandra's relativistic `dream team'

How common are relativistic lines in AGN ?

Even with XMM-Newton, the number of sources *with enough counts (>10000) to search for relativistic lines* is small, because of insufficient exposure times.

About 30% of `well exposed' objects (2 dozens or so) show clear evidence for relativistic lines (Guainazzi et al. 2006, Nandra et al. 2006).

***Is the presence of a relativistic iron line related to some parameter*? (e.g. the accretion rate) (see de la Calle's talk and A.L. Longinotti's poster).**

Not enough sources with long enough exposures !!!

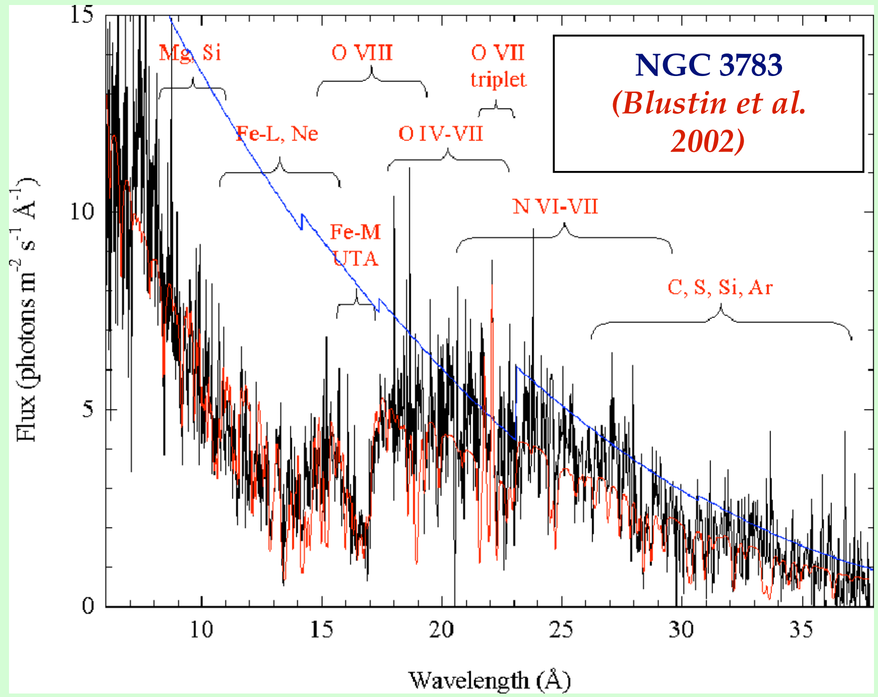
Warm/hot circumnuclear matter. I. Warm Absorbers

Warm Absorbers are outflowing matter (velocities of a few hundred km/s) with typical hydrogen column densities of 10^{21}-10^{22} cm^{-2} (e.g. Blustin et al. 2005)

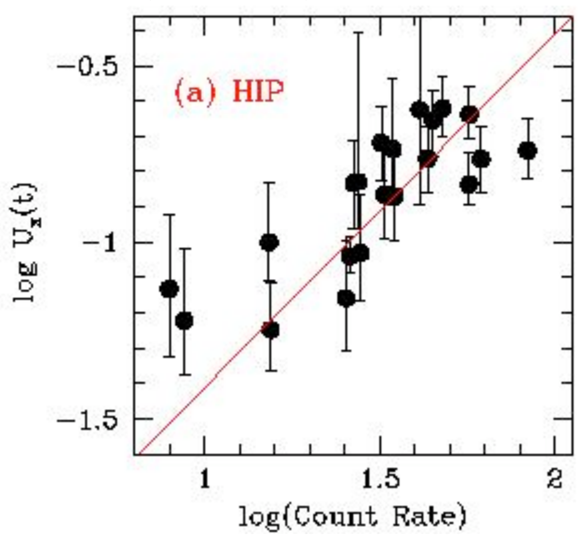
The major unknown is the location - and therefore the mass and kinetic energy - involved (is matter leaving the system and feeding the ISM?).

$$U = \frac{n_{ph}}{n_{gas}} = \frac{Q}{4\pi R^2 n_e c}$$

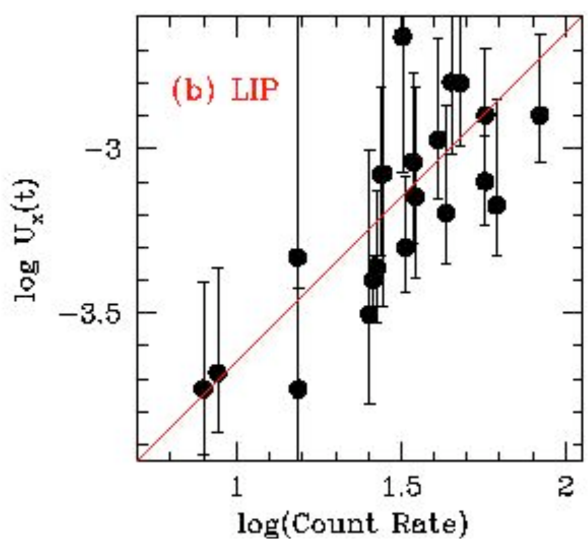
n and R cannot be measured separately



R=(1.3-2.6)x10^{15} cm



R< 8.9x10^{15} cm



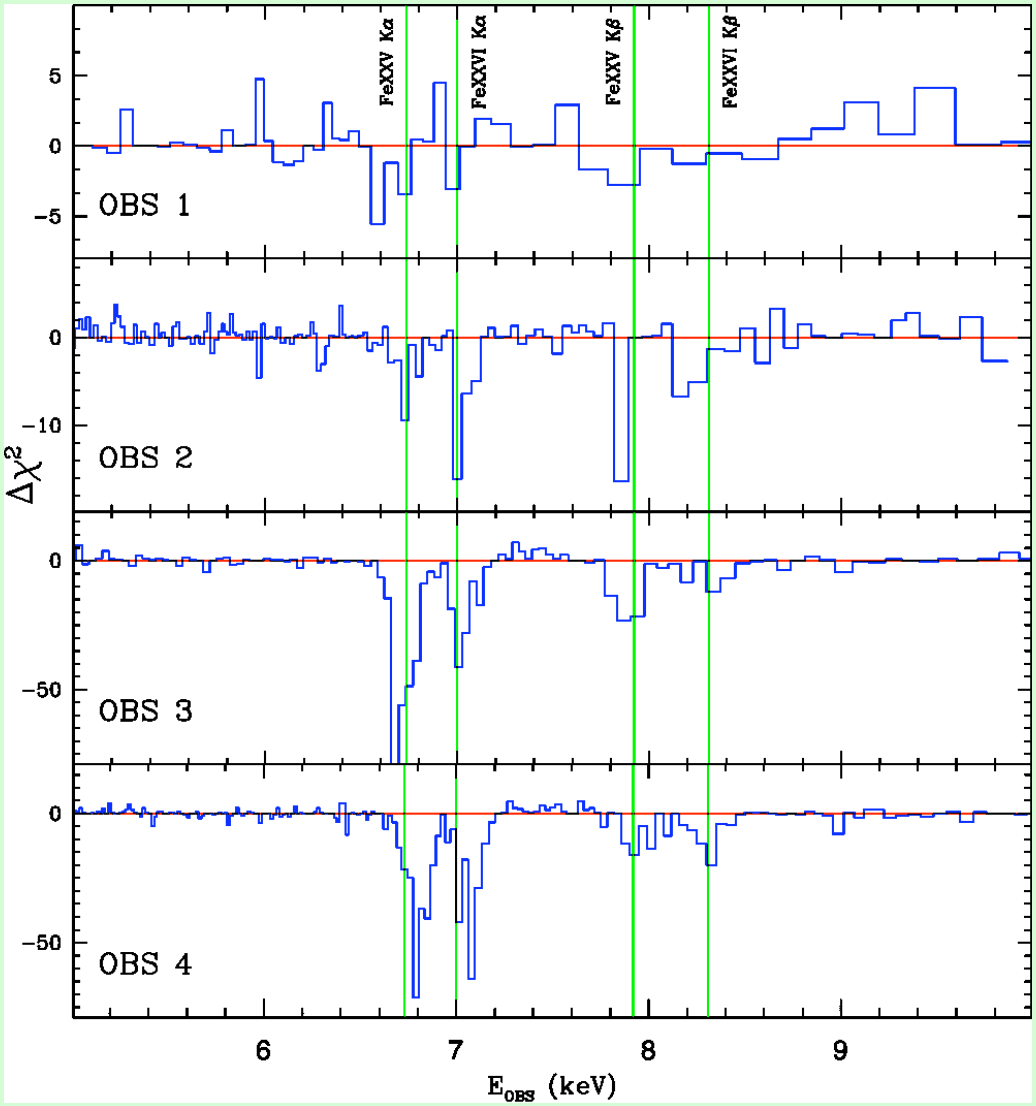
An estimate of n (and thence R) may be provided by time resolved spectroscopy.

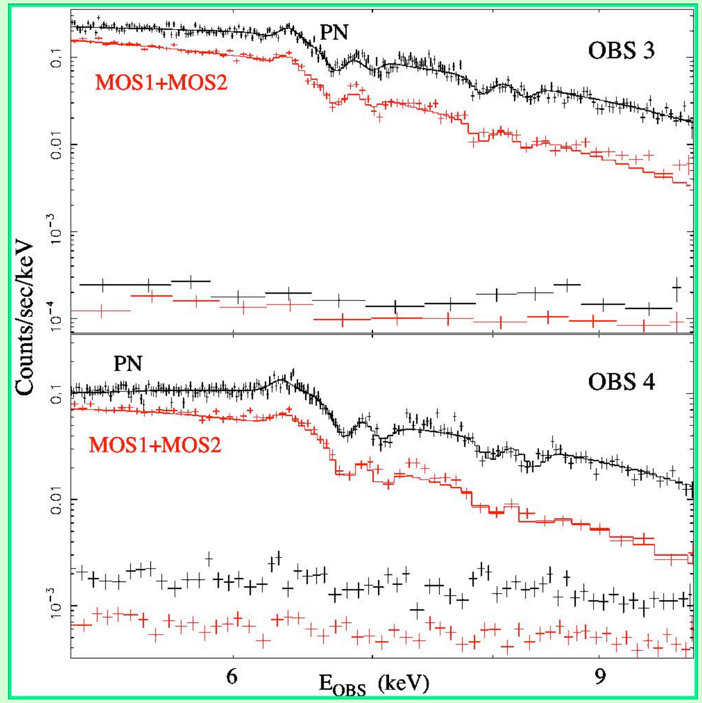
NGC 4051
(Krongold et al. 2007)

$\dot{M}$out = (0.02-0.05) $\dot{M}$accr

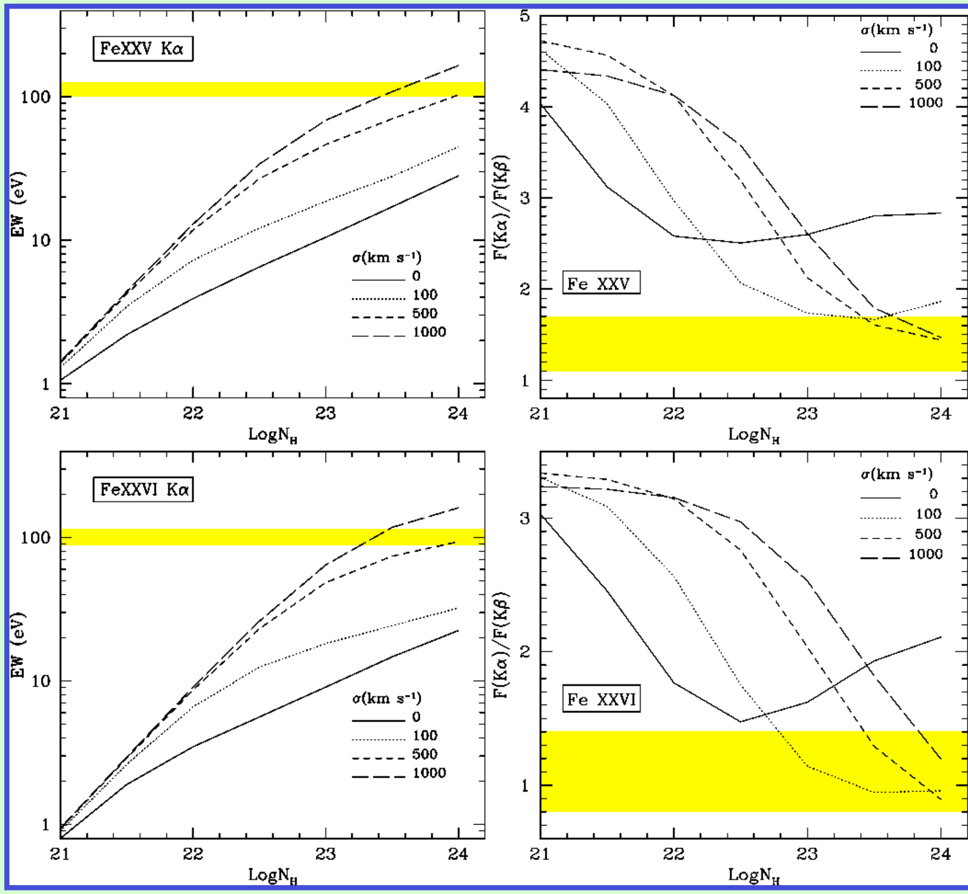
Warm/hot circumnuclear matter. II. Hot Absorbers

NGC 1365 (Risaliti et al. 2005)





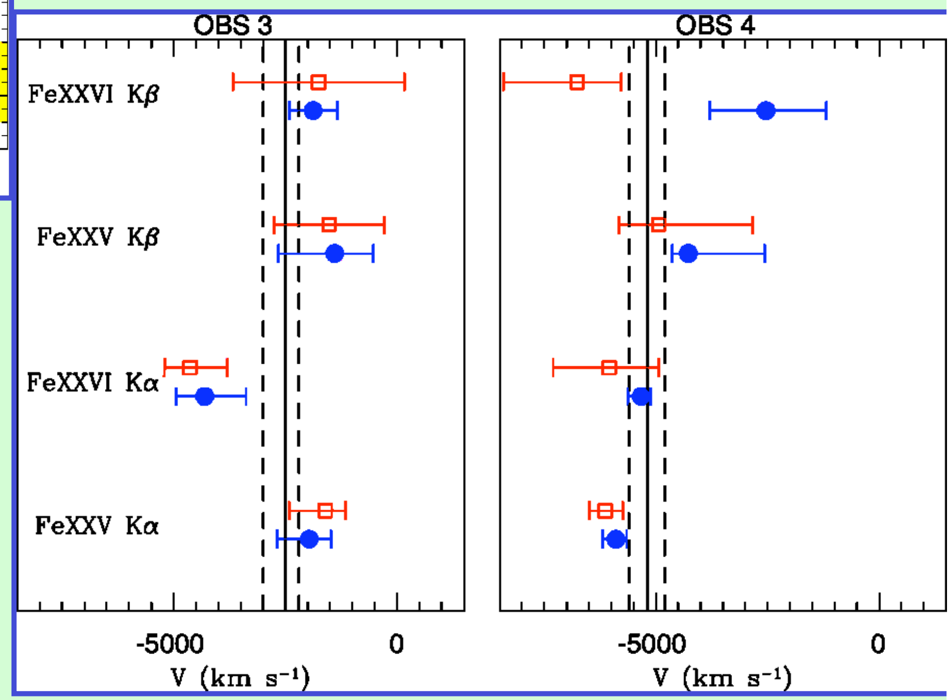
Fe XXV Kα @ 6.70 keV	**Fe XXV Kβ @ 7.88 keV**
Fe XXVI Kα @ 6.97 keV	**Fe XXVI Kβ @ 8.27 keV**



Risaliti et al. (2005), see also Bianchi et al. (2005)

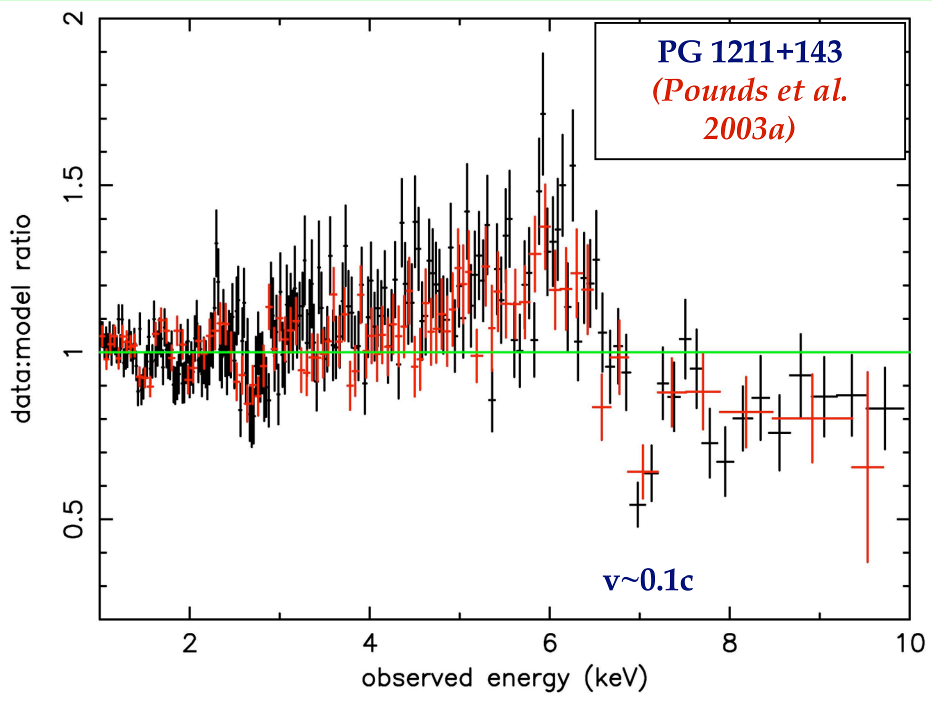
The large Kβ/Kα ratio implies that the Kα line is saturated, the Kβ is not.
→NH ~ 5x10^{23} cm^{-2} and turbulence ~ 500-1000 km/s

ΔT ~ 6 months

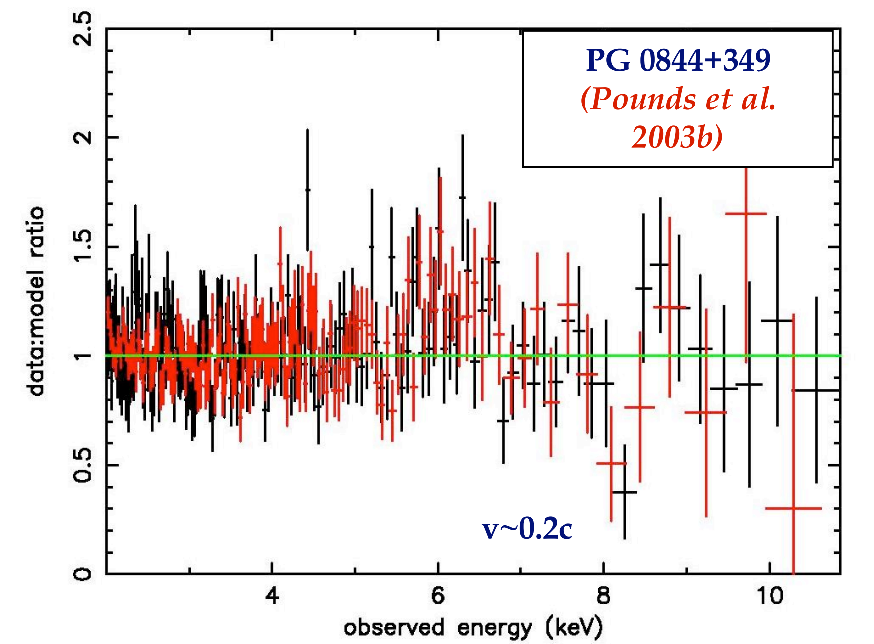


***Lines are blueshifted*, with variable velocities.**
Is matter accelerating? Or two independent clouds? What is the kinetic energy associated?

Warm/hot circumnuclear matter. II. Hot Absorbers



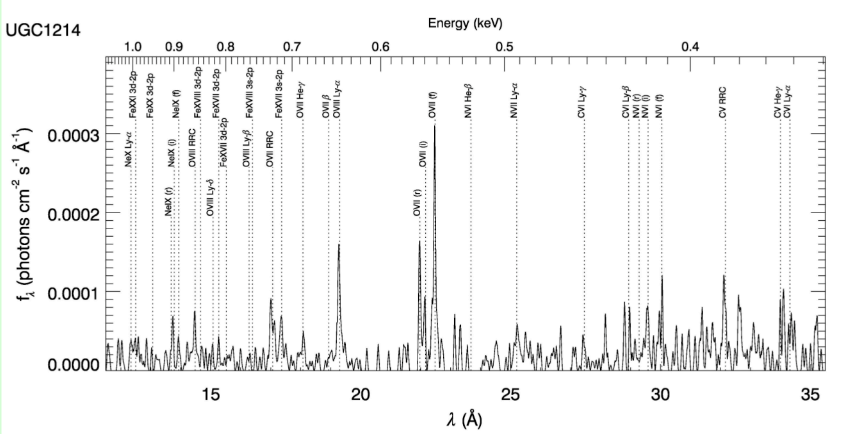
Highly ionized, high velocity (v~0.1-0.2 c) iron lines were also discovered (e.g. Pounds et al. 2003a,b). The column density is large (almost C-thick).



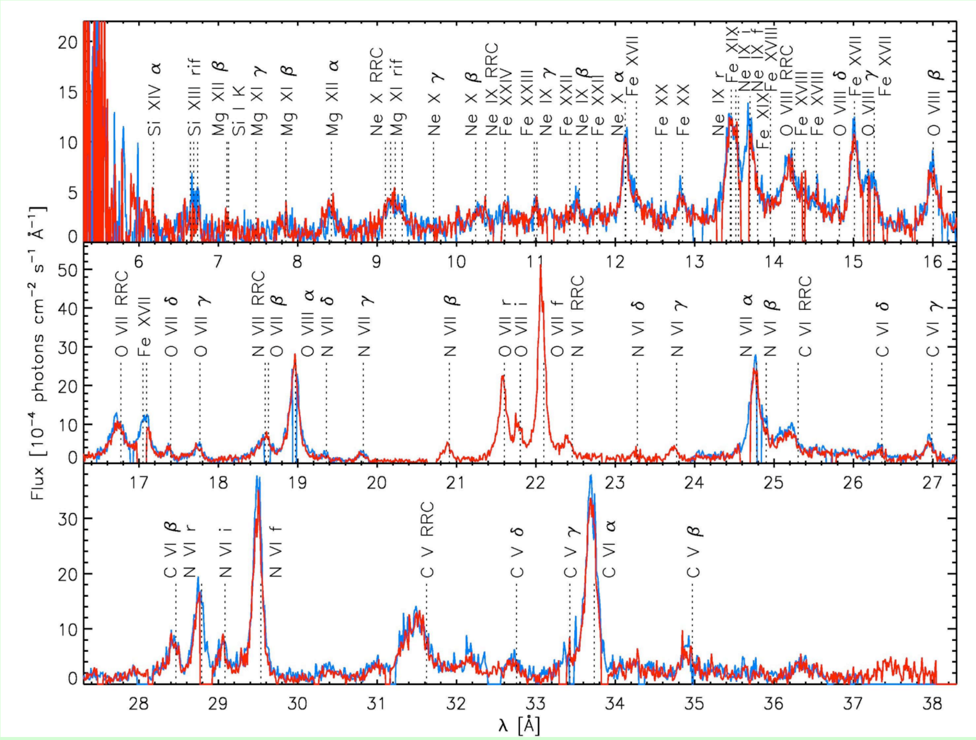
The missing link between the BH and the host galaxy? (feedback)

Warm/hot circumnuclear matter. III Warm/hot reflectors

Soft X-ray emission in Seyfert 2s is due to ***photoionized `warm' material, emission being largely dominated by lines***
(e.g. Guainazzi & Bianchi 2007, see also Guainazzi's talk)

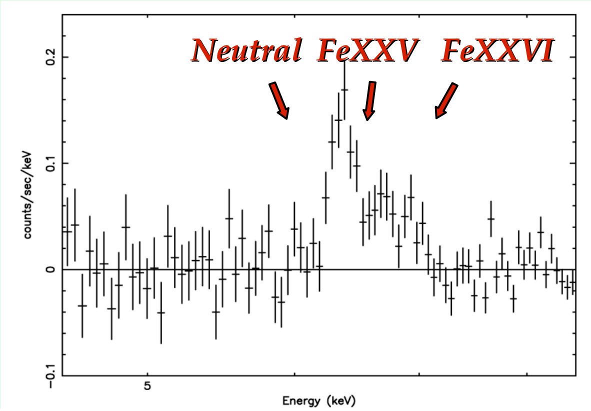


UGC 1214 *(Guainazzi & Bianchi 2007)*



NGC 1068 *(Kinkhabwala et al. 2002)*

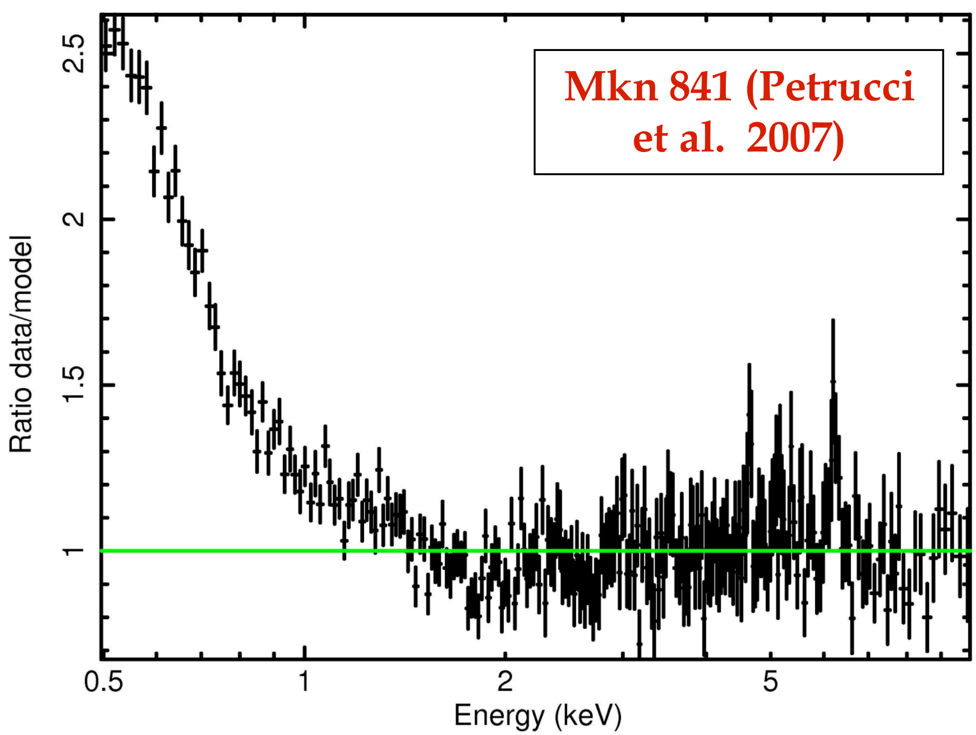
NGC 5506
(Matt et al. 2001)



Ionized iron emission lines from `hot' matter are also often present (Bianchi et al. 2005). Column densities are quite substantial (~10^{23} cm^{-2}). ***Where is this matter?*** Is the same as in NGC 1365? ***How common is it?***

Soft X-ray excesses

The **soft X-ray excess** was first discovered in the EXOSAT spectrum of Mkn 841 *(Arnaud et al. 1985).* XMM-Newton found it quite common in unobscured Seyfert and QSOs *(e.g. Porquet et al. 2004, Piconcelli et al. 2005).*

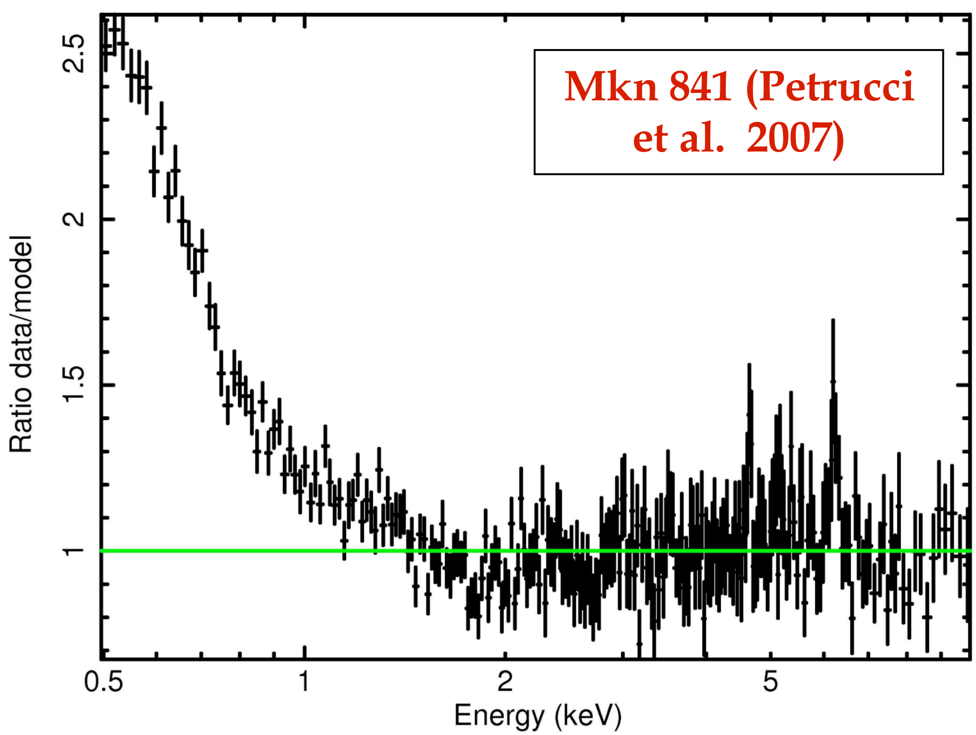


It was originally believed to be related to the thermal disc emission. However, there are two problems for this interpretation: *the derived temperatures are too high and almost constant* ($T \propto M^{-1/4}$).

Is the soft excess related to atomic physics? Two models: *relativistically smeared absorption* (Gierlinski & Done 2004) and *ionized disc reflection* (Crummy et al. 2006)

Soft X-ray excesses

The *soft X-ray excess* was first discovered in the EXOSAT spectrum of Mkn 841 (Arnaud et al. 1985). XMM-Newton found it quite common in unobscured Seyfert and QSOs *(e.g. Porquet et al. 2004, Piconcelli et al. 2005).*



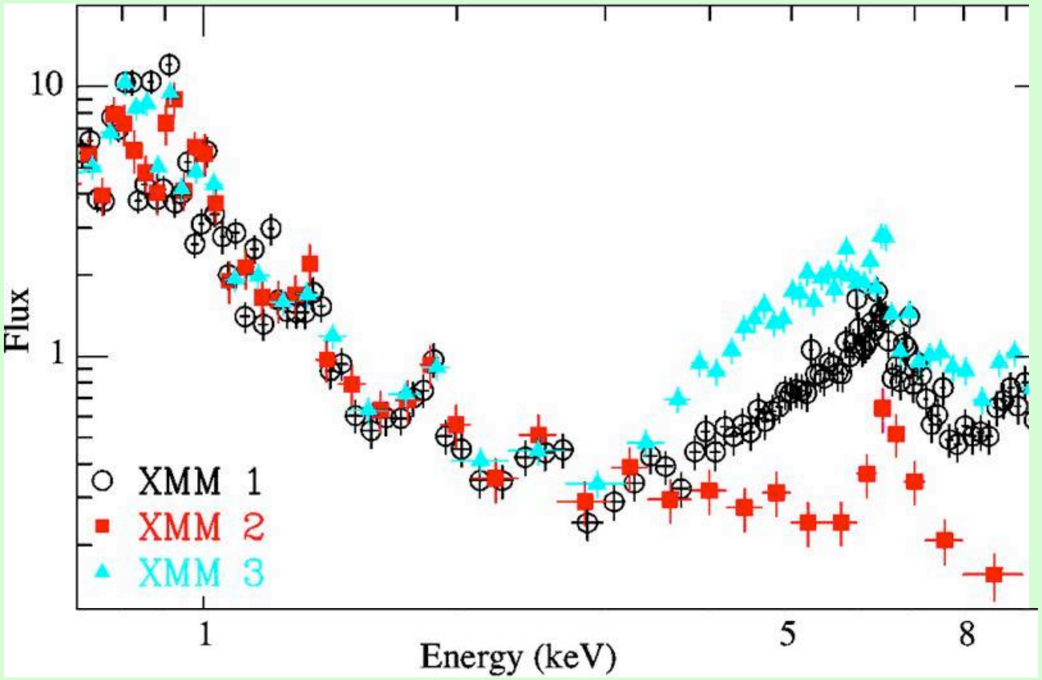
Spectroscopy alone has been so far unable to solve this issue. A broader band is required

(→ Simbol-X)

However, at least for the brightest sources, spectral variability may provide an answer.

Cold circumnuclear matter

XMM-Newton has shown that usually there are ***more than one circumnuclear cold regions***. The `torus' is likely Compton-thick and on parsec-scale, but there are Compton-thin regions on larger (dust lanes, galactic discs, …) and smaller (BLR?) scales.



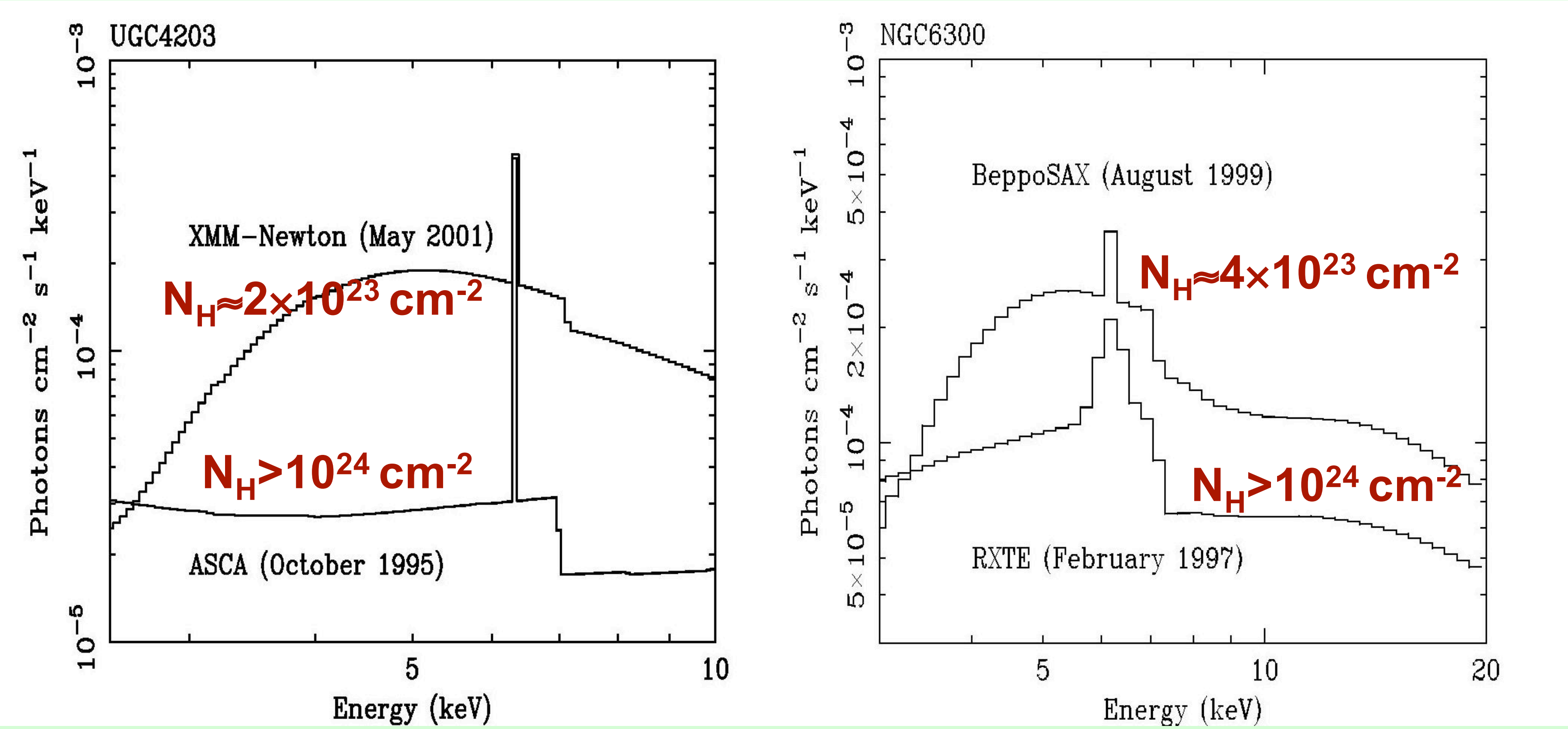
The cold absorber of NGC 1365 changes from Compton-thin to Compton-thick and back in 2 days
(Risaliti et al. 2005, 2007).

Dense clouds very close to the BH !!!

Is NGC 1365 unique? Maybe not (there are other sources switching from C-thin to C-thick)

Cold circumnuclear matter

Guainazzi et al. (2001, 2002), Matt et al. (2003)



NH variations (NGC 1365) or switching off of the nuclear light (NGC 2992)?

Is NGC 1365 unique? Maybe not (there are other sources switching from C-thin to C-thick)

What's next for XMM-Newton?

There is still much to do for XMM-Newton, without the need to wait for next generation X-ray satellites (Con-X and XEUS).

So far, mostly relatively short (<100 ks) observations of bright individual sources (or relatively small samples), with specific scientific goals.

In the second part of its life, it is conceivable to use XMM-Newton also (mainly?) for long observations of individual objects or for observing large samples of sources (legacy programs).

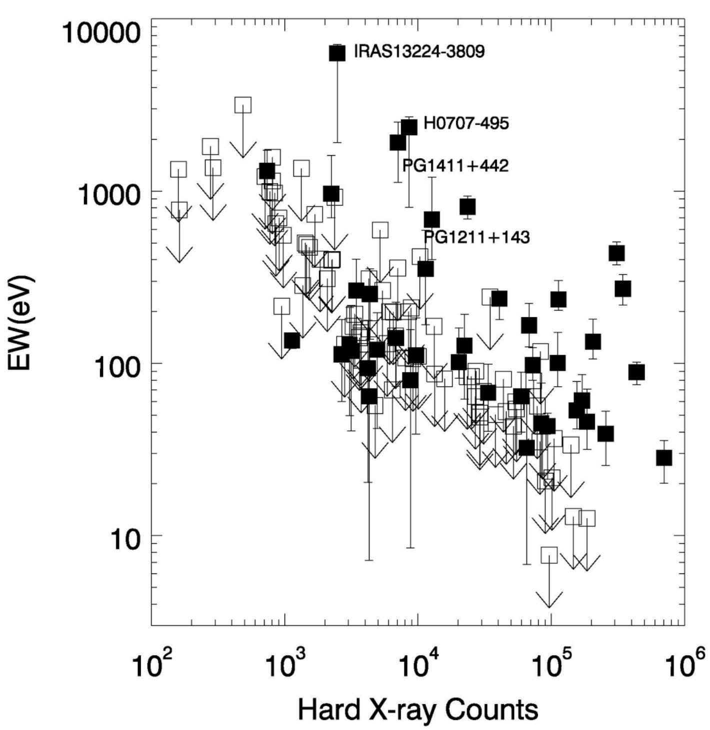
What's next for XMM-Newton?

There is still much to do for XMM-Newton, without the need to wait for next generation X-ray satellites (Con-X and XEUS).

- **Science requiring many counts**
  (but not necessarily high countrates)
- **Science requiring long-looks or monitoring campaigns (variability studies)**
- **Multiwavelength observations**
- **Large samples of objects (legacy programs)**

Science requiring many counts
(but not necessarily high countrates)

For relatively bright sources, enough counts may be simply obtained by long (but still reasonable) exposures.



Guainazzi et al. 2006

Example: search for (stationary) relativistic lines.

A large number of counts (>10000) is required.

The sample of sources with a detection or a tight u.l. may be significantly enlarged.

*(Better determination of disc parameters → **BH spin**)*

Science requiring long-looks or monitoring campaigns (variability studies)

Examples:

- ❖ Reflection from the inner disc *(light bending effects, orbiting spots)*
- ❖ Time-evolving photoionization *(location of WA)*
- ❖ Dynamics of flows *(nature of winds)*
- ❖ Search for QPO's *(are AGN like GBH, just bigger?)*
- ❖ NH variability *(where is the absorbing material?)*
- ❖ Spectral variability *(what is the nature of the soft excess?)*

\+ ……….

Multi-λ (time-coordinated) observations

❖ Radio *(Blazars, …)*

❖ IR (Spitzer, AKARI, Herschel, JWST) *(Blazars, ….)*

❖ Optical (ground based) *(Blazars, tests of U.M., …)*

❖ UV (WSO-UV) *(Blazars, disc-corona models, …)*

❖ Hard X-rays (INTEGRAL) *(Blazars, Comptonization, …)*

❖ γ-rays (Agile, GLAST) *(Blazars)*

❖ TeV (HESS, Magic, CTA) *(Blazars)*

❖ Non e.m. (GW, …) *(????)*

Large samples (legacy programs)

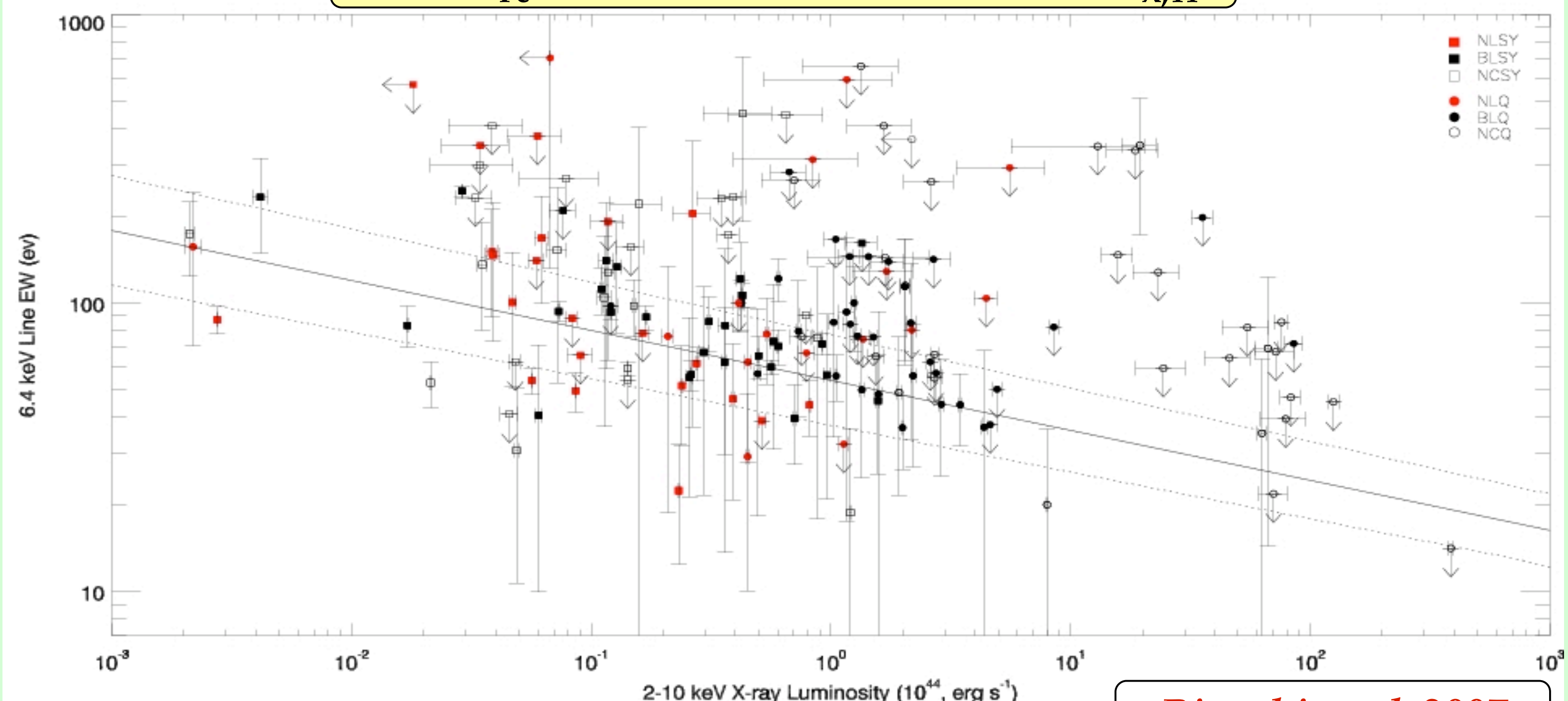
Many interesting results may be obtained using large samples from the public archive.

An example: the IT effect *(see S. Bianchi's poster)*

The *Iwasawa-Taniguchi (a.k.a. X-ray Baldwin)* effect is the anticorrelation between the EW of the (narrow core) of the iron line and the X-ray luminosity. It may be due to a *decrease with L of the covering factor of the reflecting matter* (a similar effect has been found by Maiolino et al. 2007 using infrared data).

Possible dependence on mdot (Bianchi et al. 2007), but more data are needed.

$$\log(EW_{Fe})=(1.73\pm0.03) + (-0.17\pm0.03)\,\log(L_{X,44})$$



Bianchi et al. 2007

Large samples (legacy programs)

Many interesting results may be obtained using large samples from the public archive.

These samples, however, suffer from incompleteness, biases and large differences in number of counts.

A *legacy program* consisting of observations of a flux limited, unbiased sample of AGN may turn out to be extremely useful.

(e.g. the *XMM-Newton Slew Survey* provides such a sample. Several hundreds AGN with 0.2-12 keV flux > 10^{-12} cgs are already there.)

300 sources x 50 ks = 15 Ms

Still a lot of work for *XMM-Newton !*