Statistics of broad lines in XMM-Newton AGN

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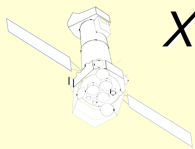
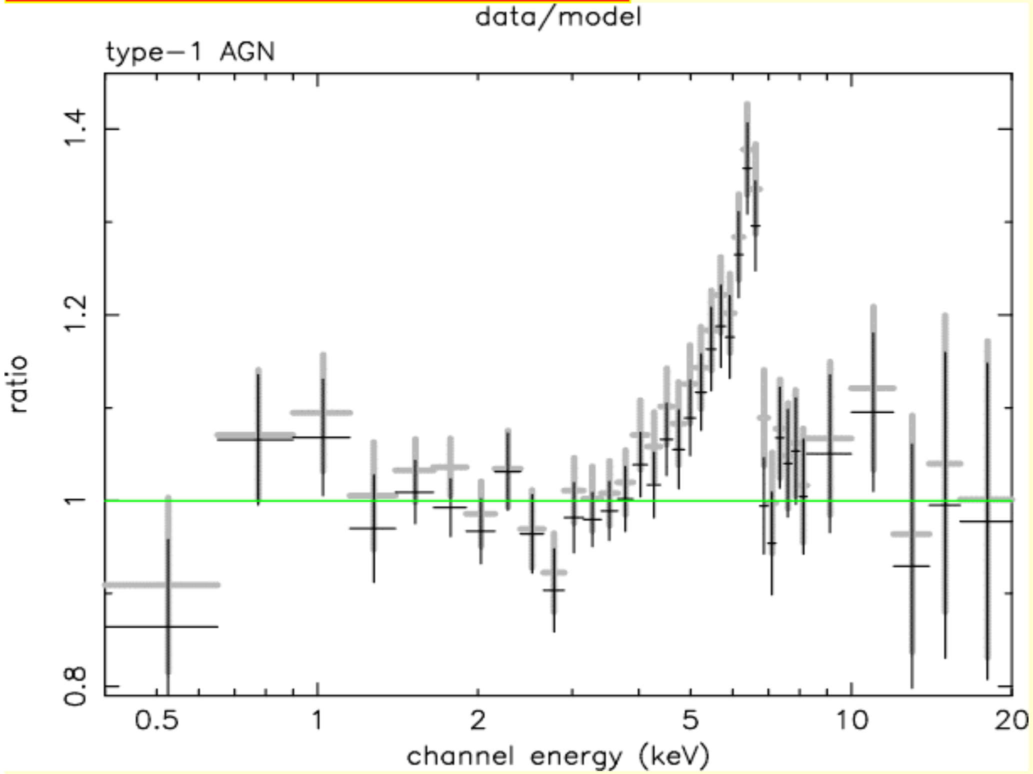
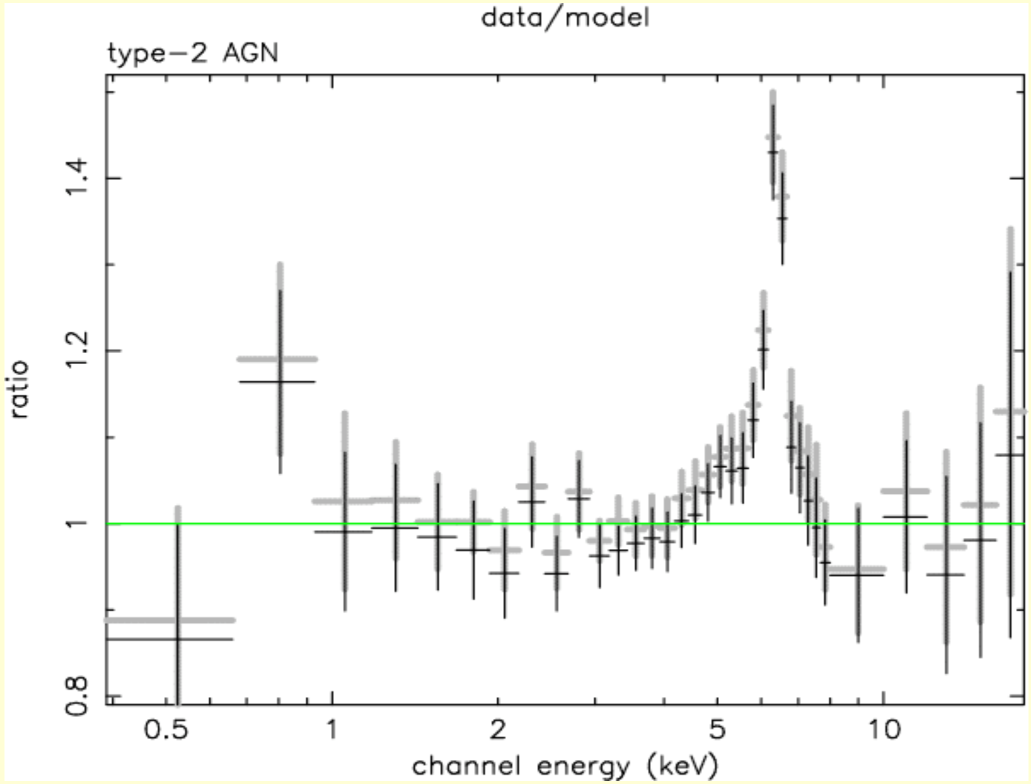


Ubiquity of broad lines?

Lockman Hole AGN



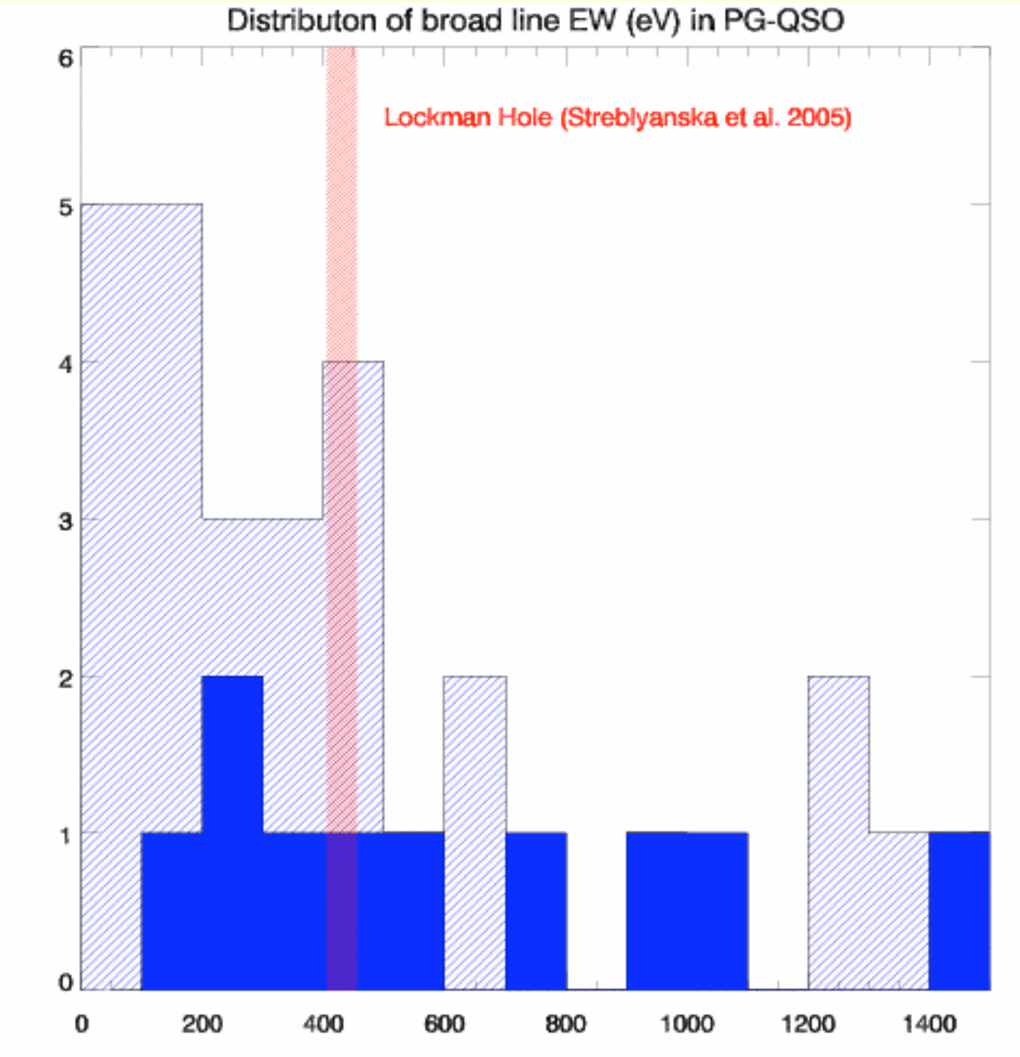


(Streblianska et al. 2005)

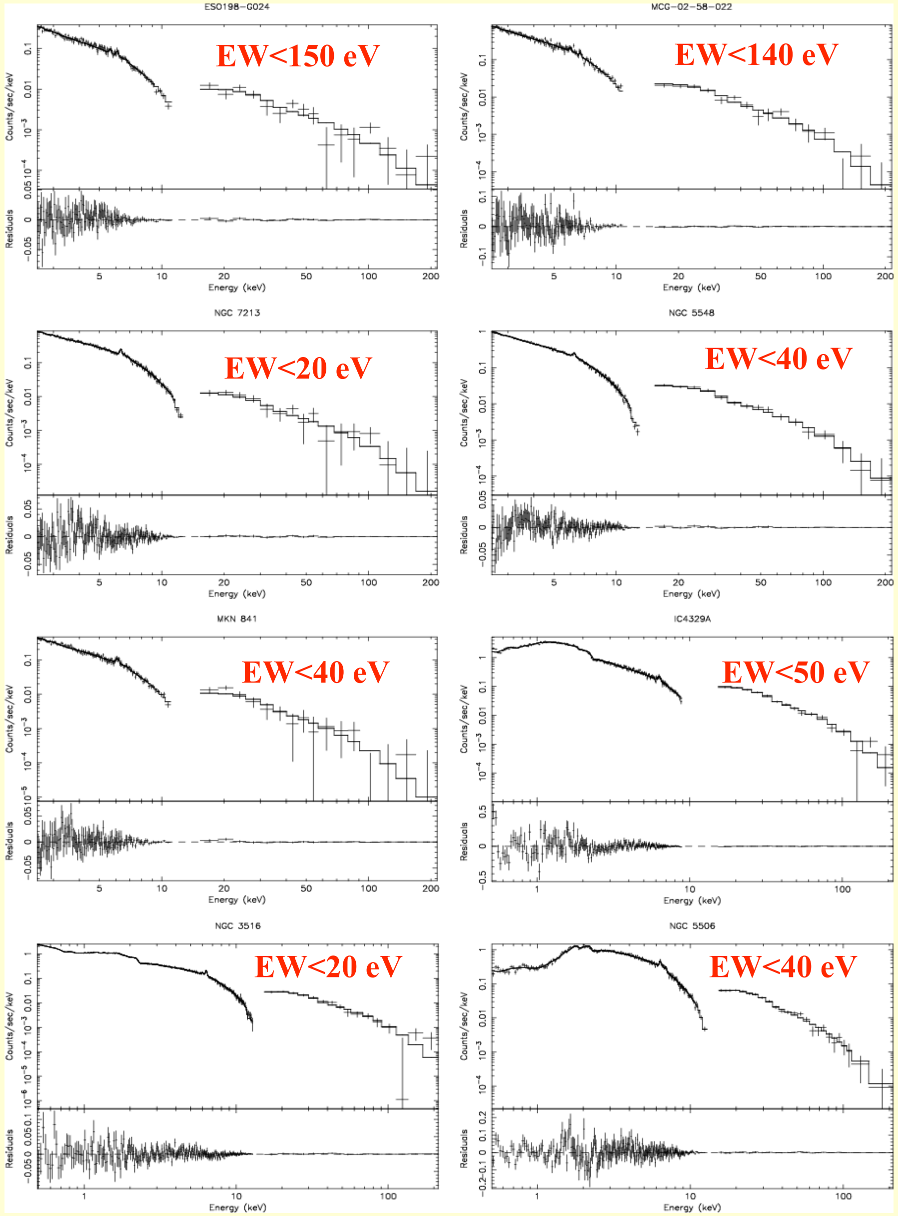
$F_X \approx 2\times10^{-15}\text{-}10^{-13}$ erg s^{-1} cm^{-2}
EW≈ 420-560eV

$F_X \approx 3\times10^{-15}\text{-}3\times10^{-14}$ erg s^{-1}
EW≈ 280-460 eV

... or not?



(after Jiménez-Bailón et al. 2005)



(Bianchi et al. 2005)

Question to be answered

- How often does relativistic broadening appear in AGN spectra?
- Are there any dependencies/correlation from/with other observables?
- Which properties of the accretion flow/black hole can we extrapolate to the parent population from the existing observations?

$\Downarrow$

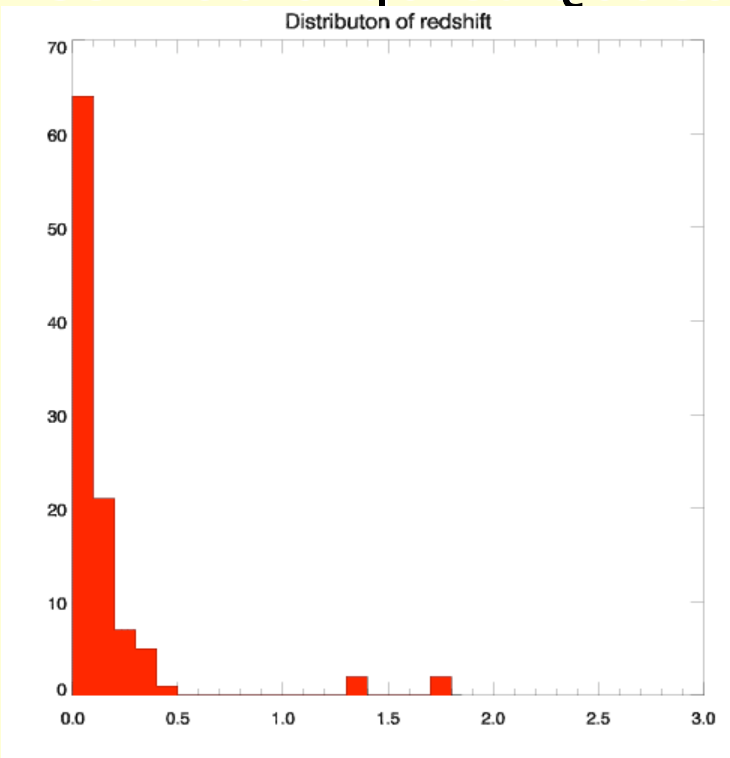
Study of the largest sample of high-quality X-ray spectra currently available

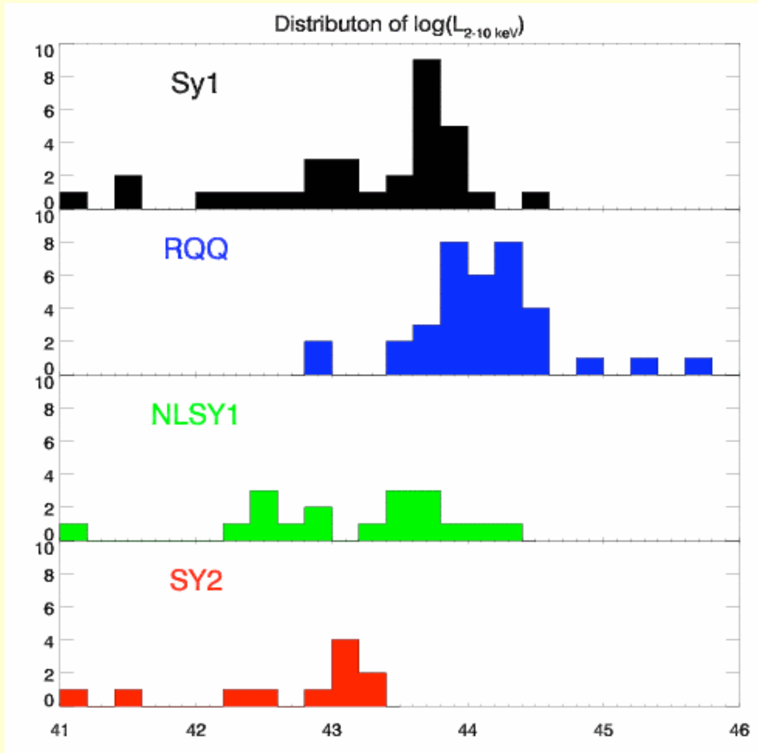
$\Downarrow$

XMM-NEWTON SCIENCE ARCHIVE

The "sample"

- 102 AGN in pointed XMM-Newton observations
  - 32 Seyfert 1 (Sy1)
  - 13 Compton-thin ($N_H < 10^{22.5}$ cm^{-2}) Seyfert 2 (Sy2)
  - 18 Narrow Line Seyfert 1 Galaxies (NLSy1)
  - 39 Radio-quiet Quasars (RQQ)



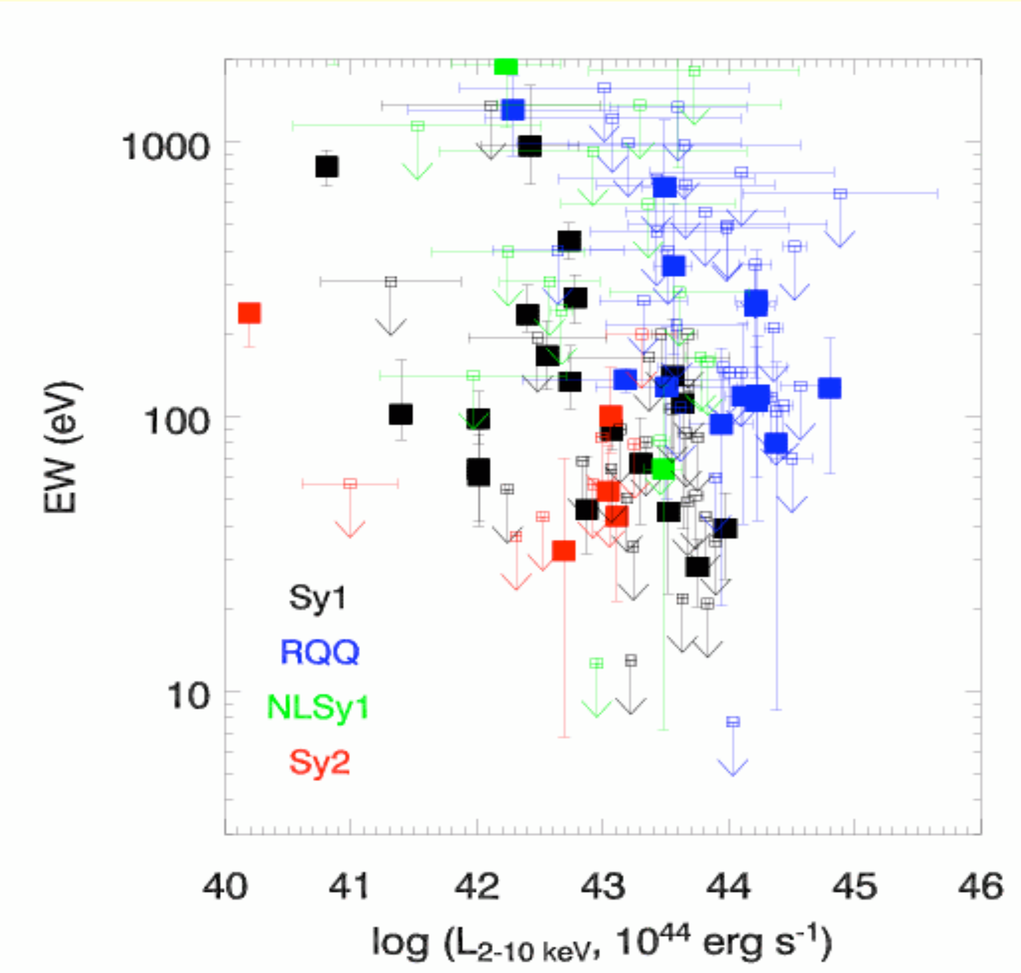


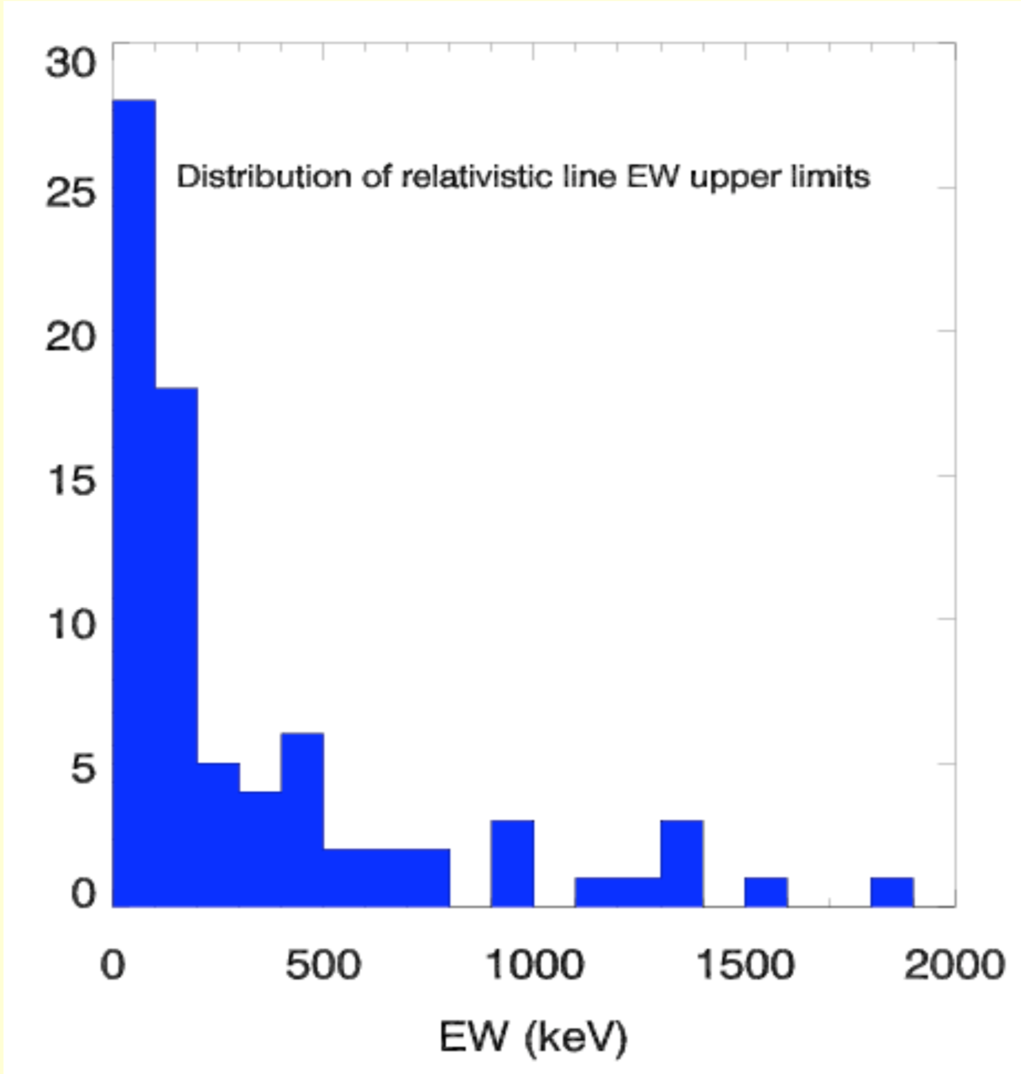
Rules of the game

- Fit of pn spectra in the 2.5-12 keV band
- Baseline model: $exp(-\sigma_{ph}N_H)\times A[E^{-\Gamma}+C(R,i,E)]+\Sigma_i G_i+B(i,\beta,a)$
  - C → Compton reflection
    - i → inclination
    - R → reflection component normalization (partly degenerate with i)
    - Solar metallicity
  - G → Unresolved Gaussian profiles with E_{rest}=6.4, 6.7, 6.96 keV
  - B → Broad line component (`diskline`, `laor`, `ky`)
    - β → radial dependence of emissivity
    - a → black hole spin
    - $E_{rest}=6.4\div6.7$ keV
    - $R_{in}=R_{ISCO}$ and $R_{out}=400r_g$ (*i.e.* using β as an indicator of "relativiteness")

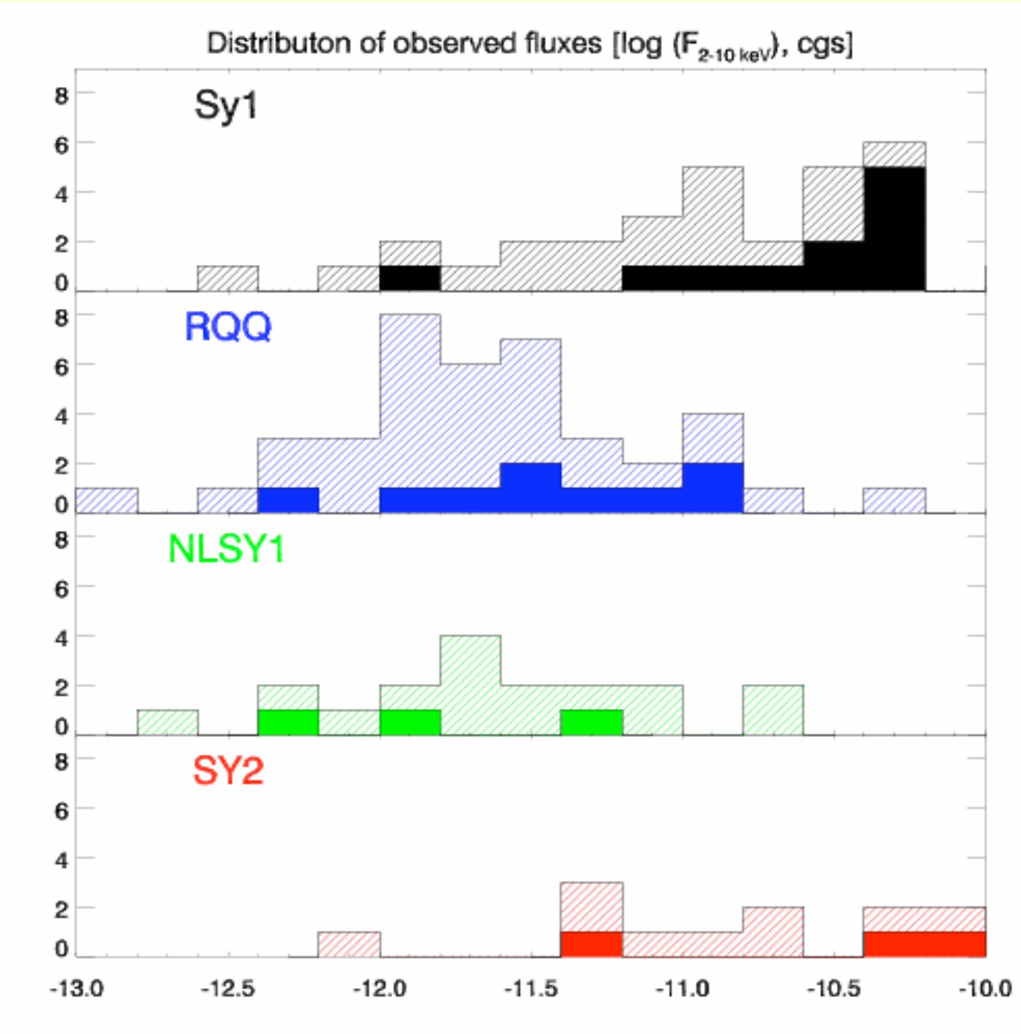
(Dovčiak et al. 2005)

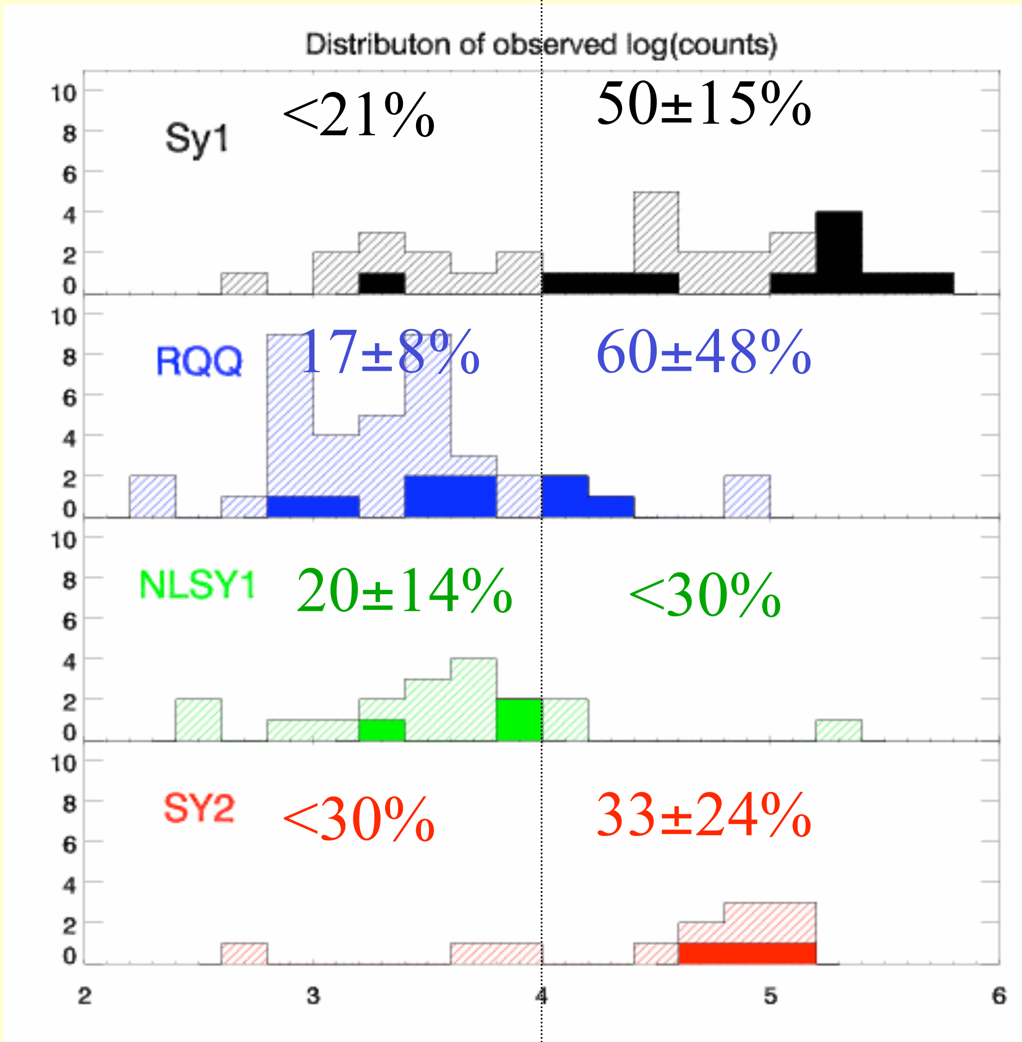
Detection results





Detection statistics

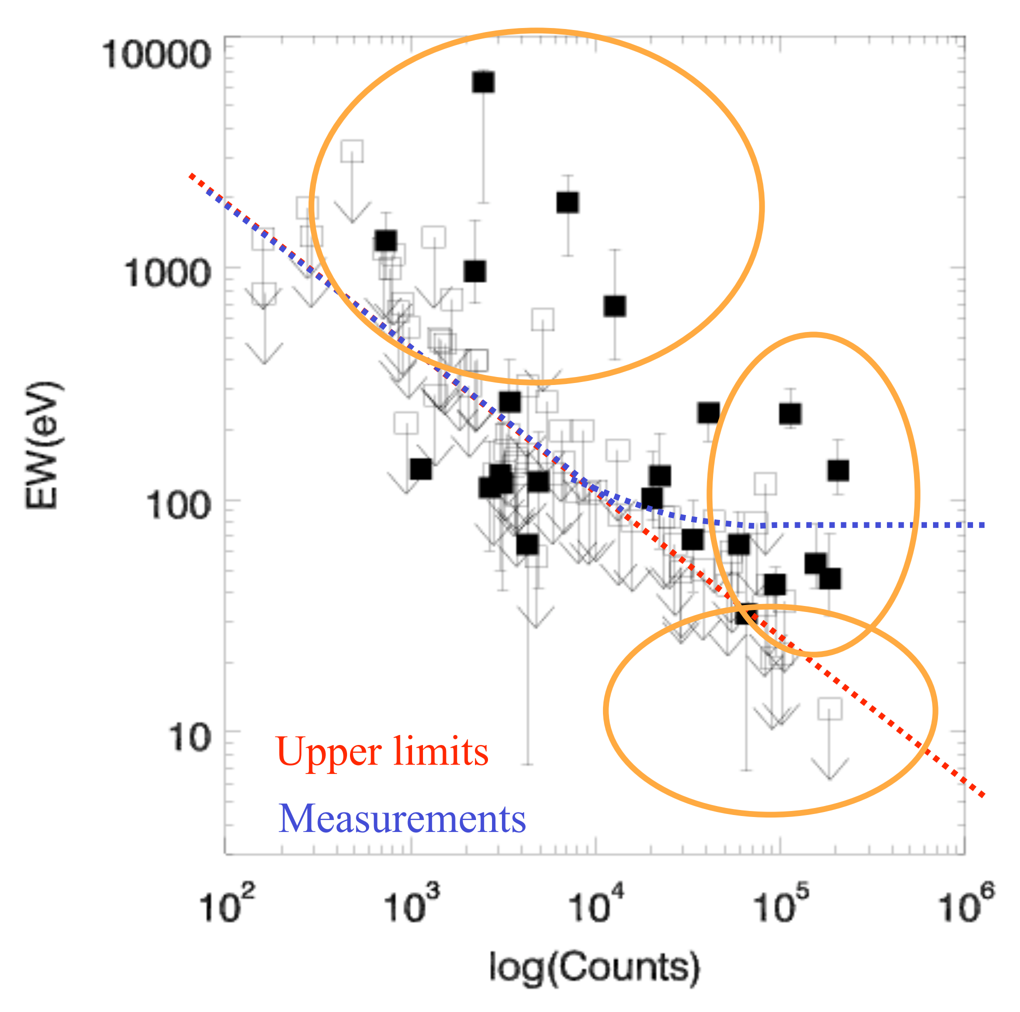


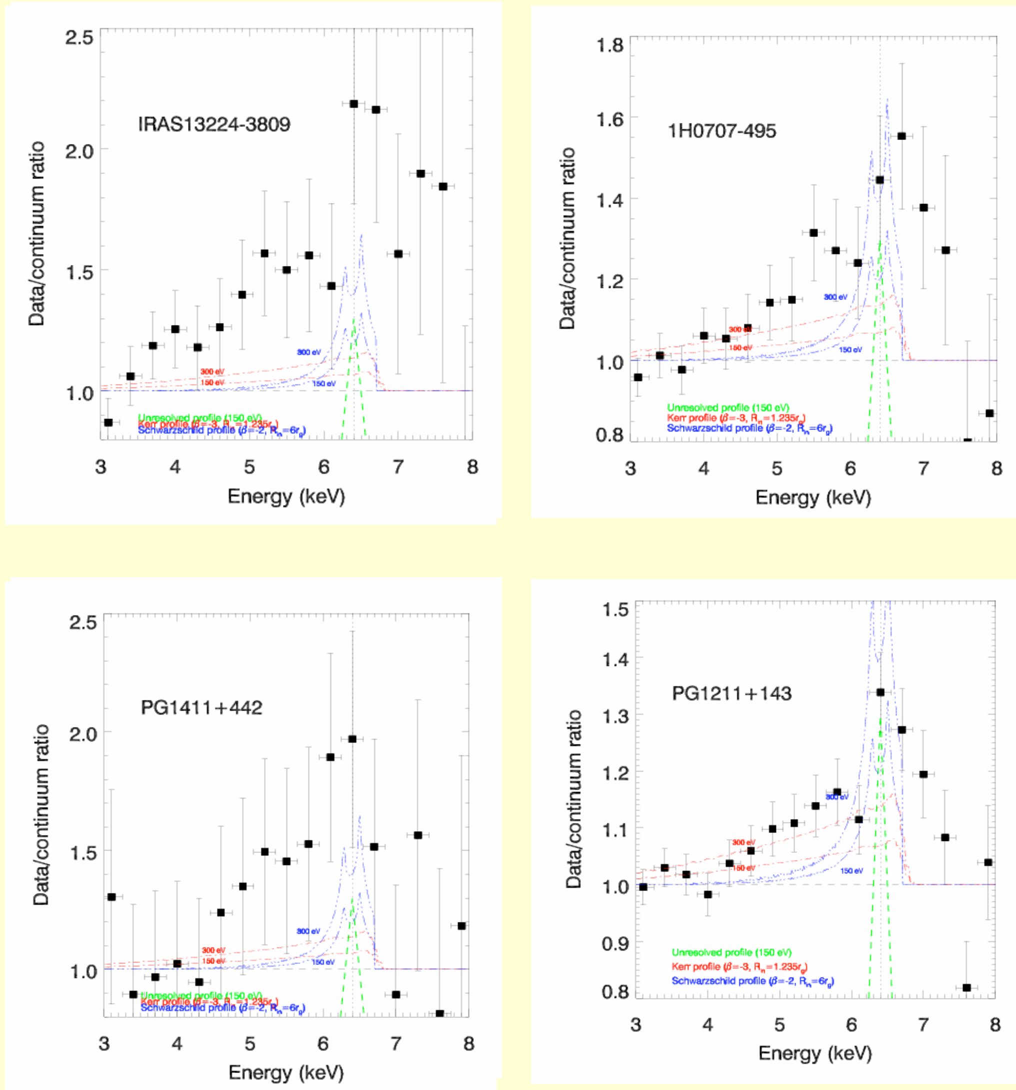


16±6%

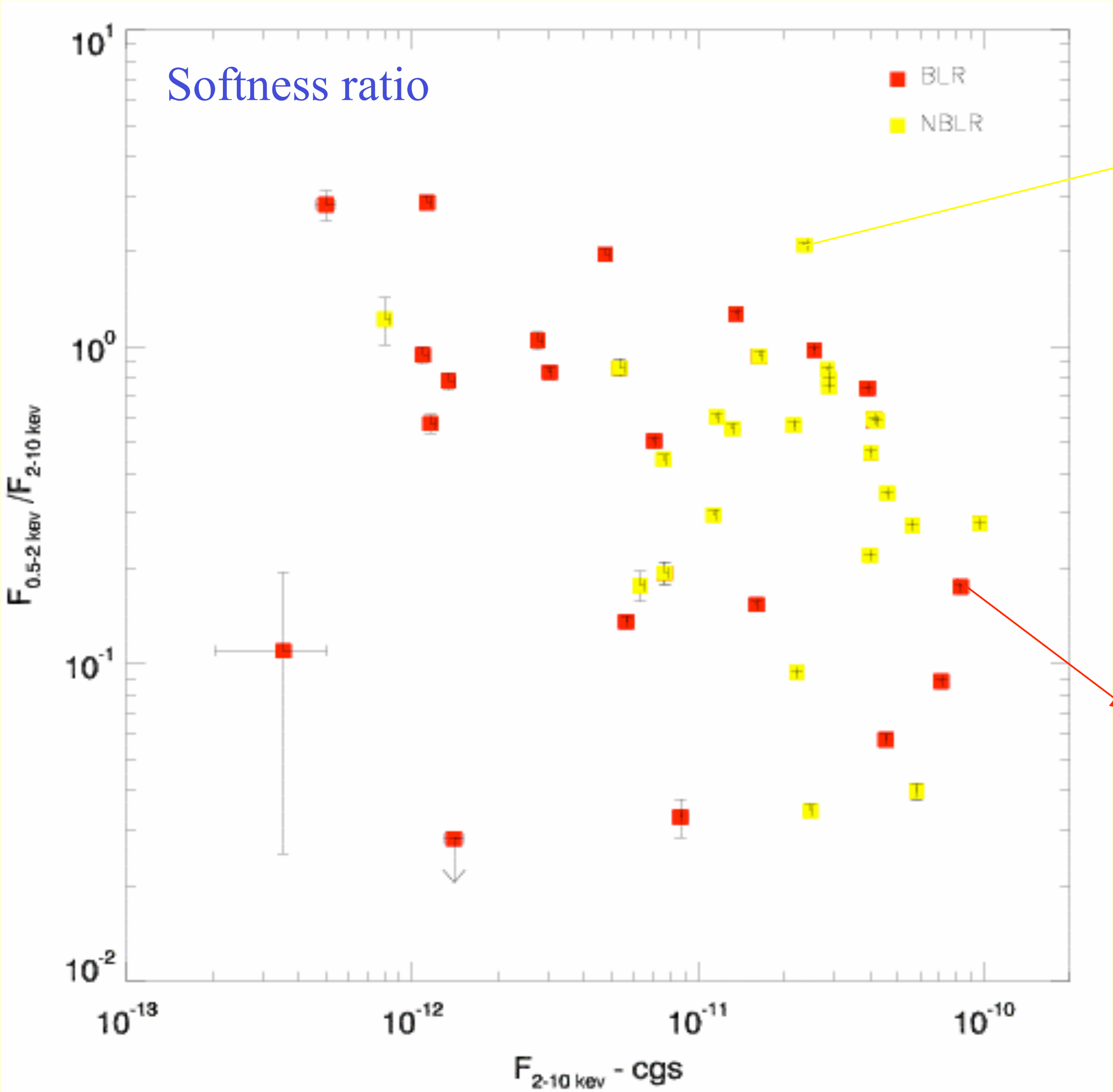
42±13%

What have we indeed detected?





Correlation between broad lines and warm absorbers?



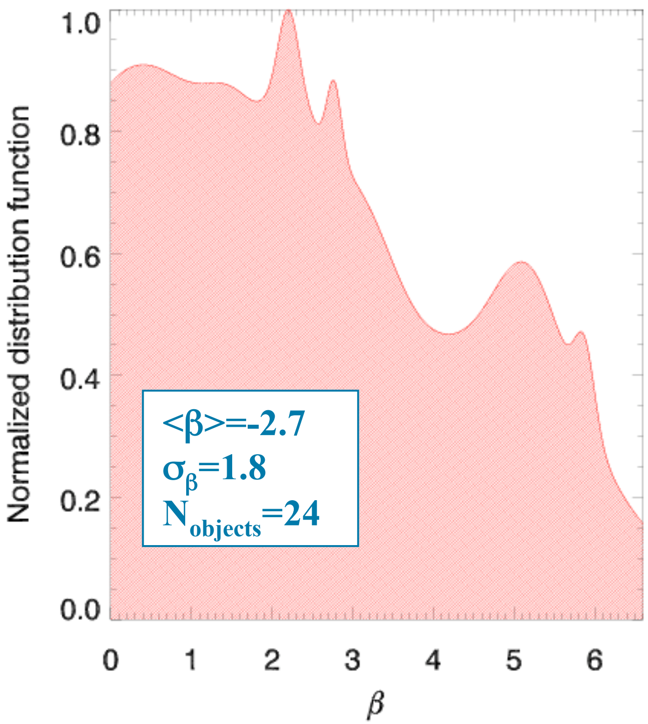
Objects with an upper limit on the broad line EW <100 eV

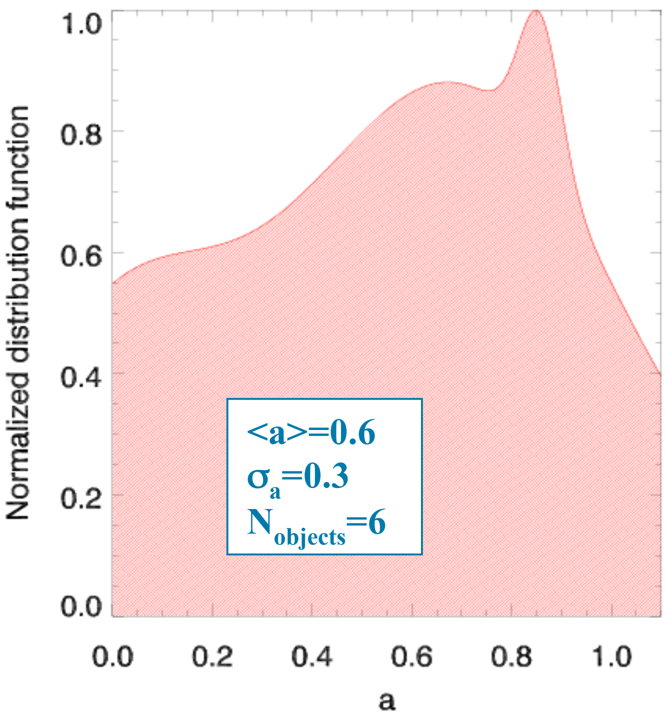
Objects with a detected broad line

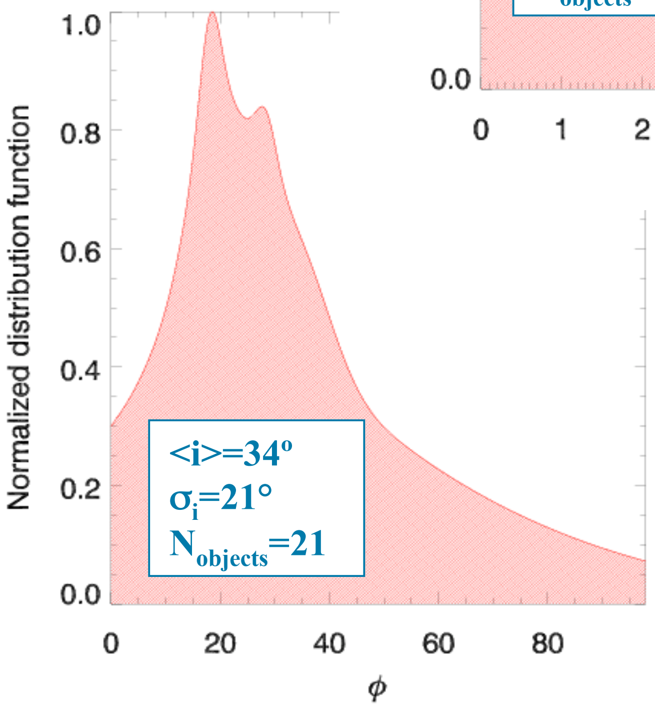
Properties derived from detected lines – II.

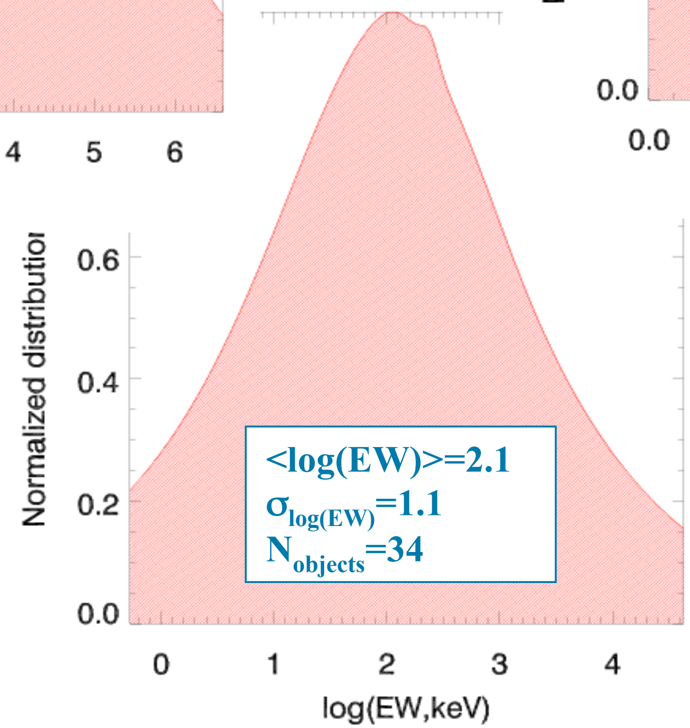
ky

(Dovčiak et al. 2004)

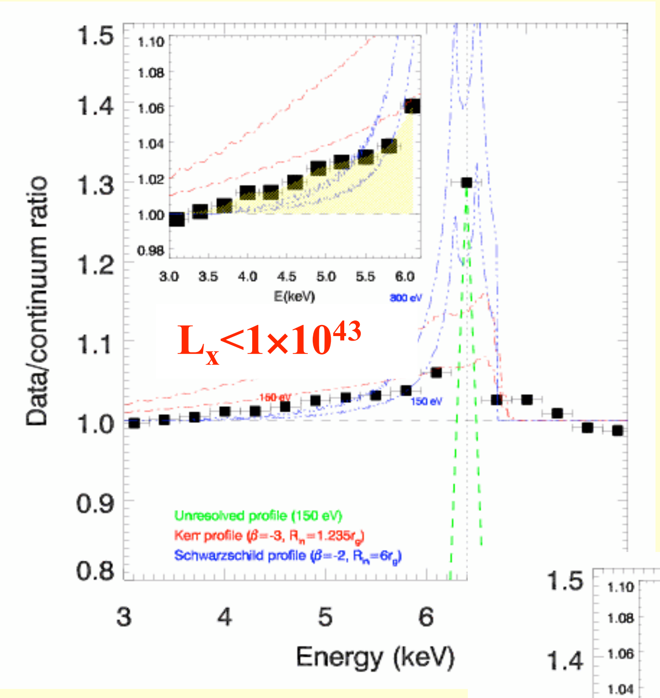


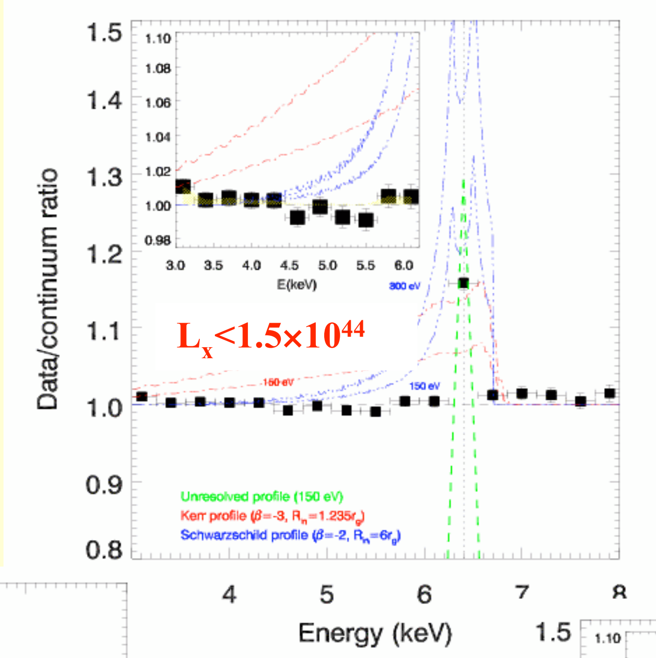


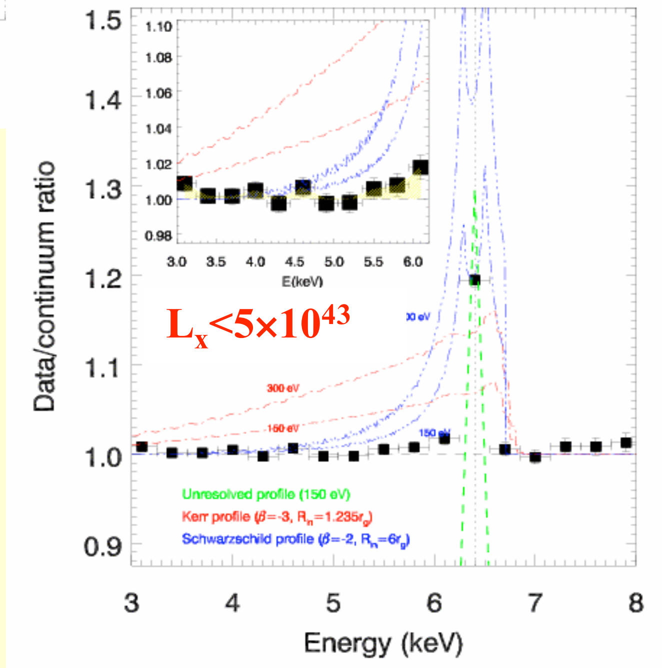


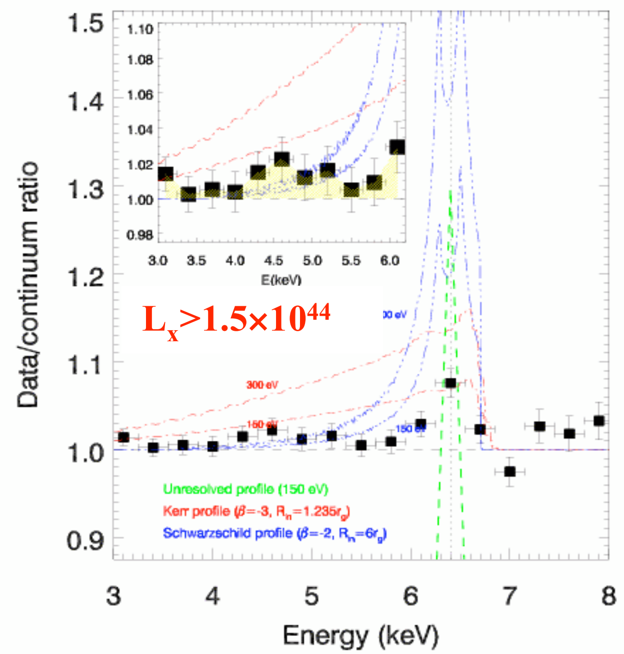


Stacked spectra – I.

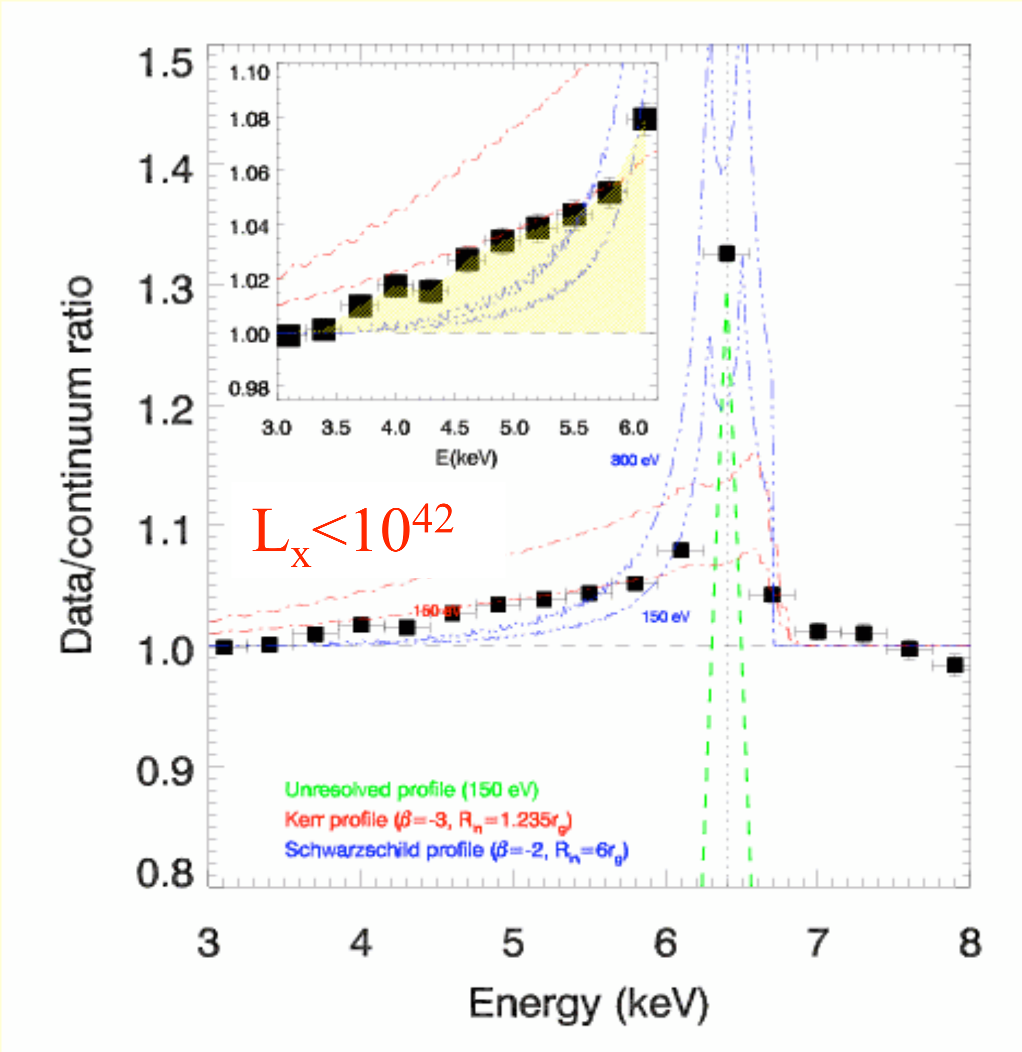


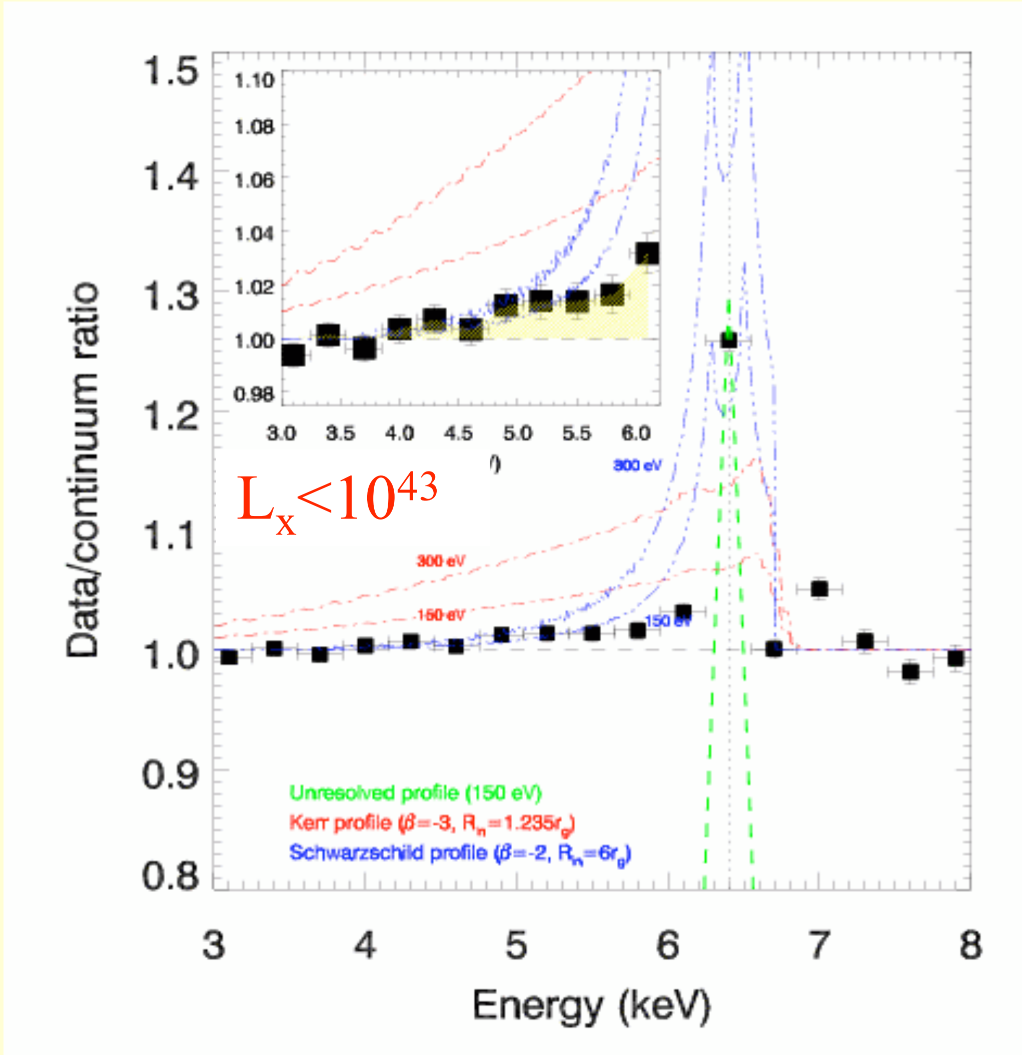




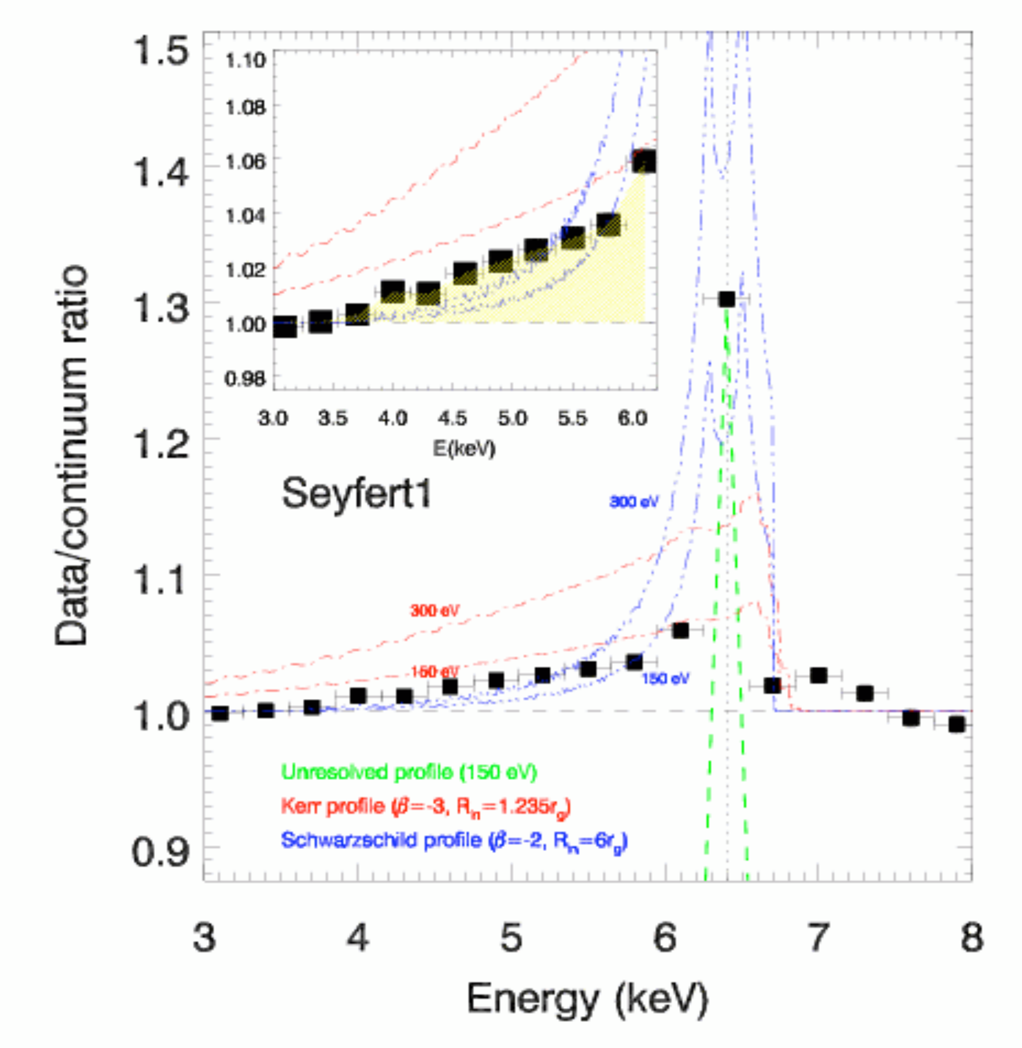


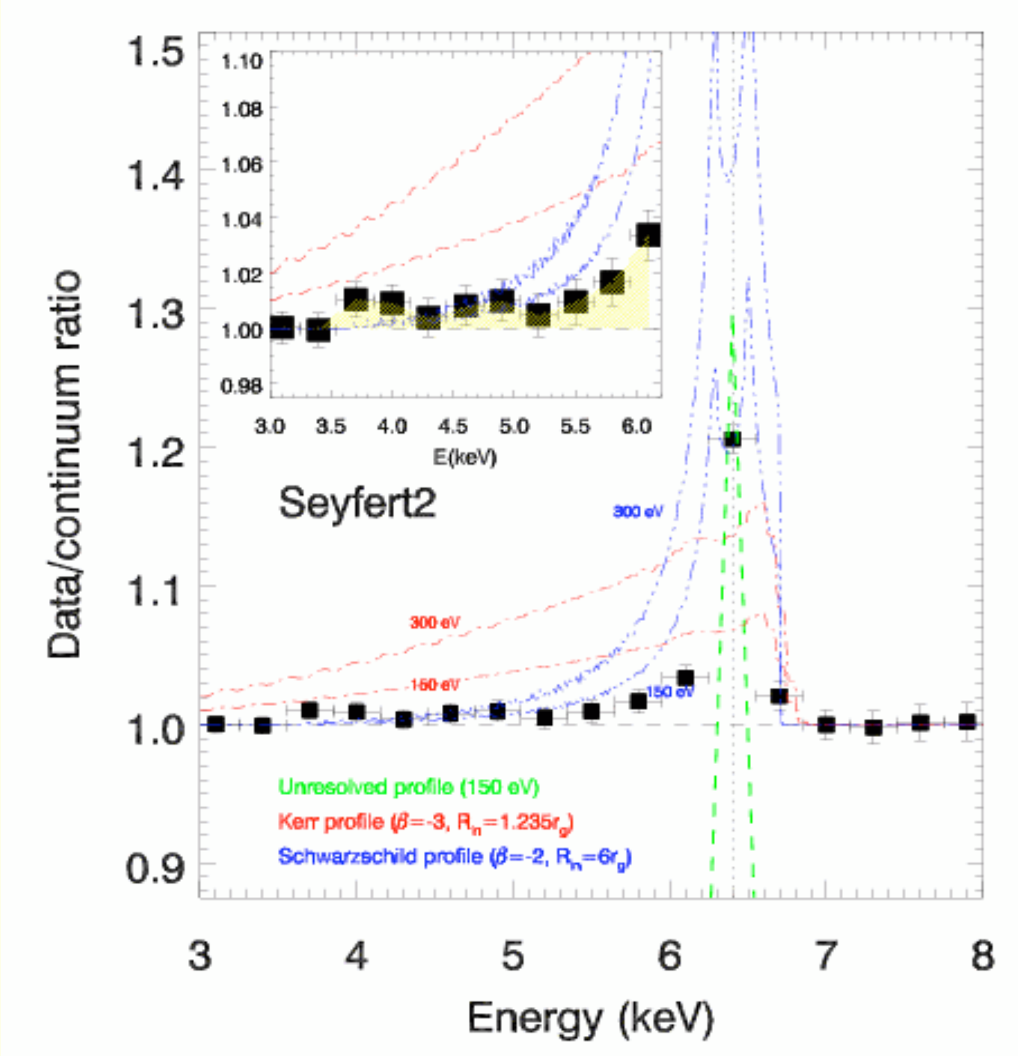
Stacked spectra – low L_X



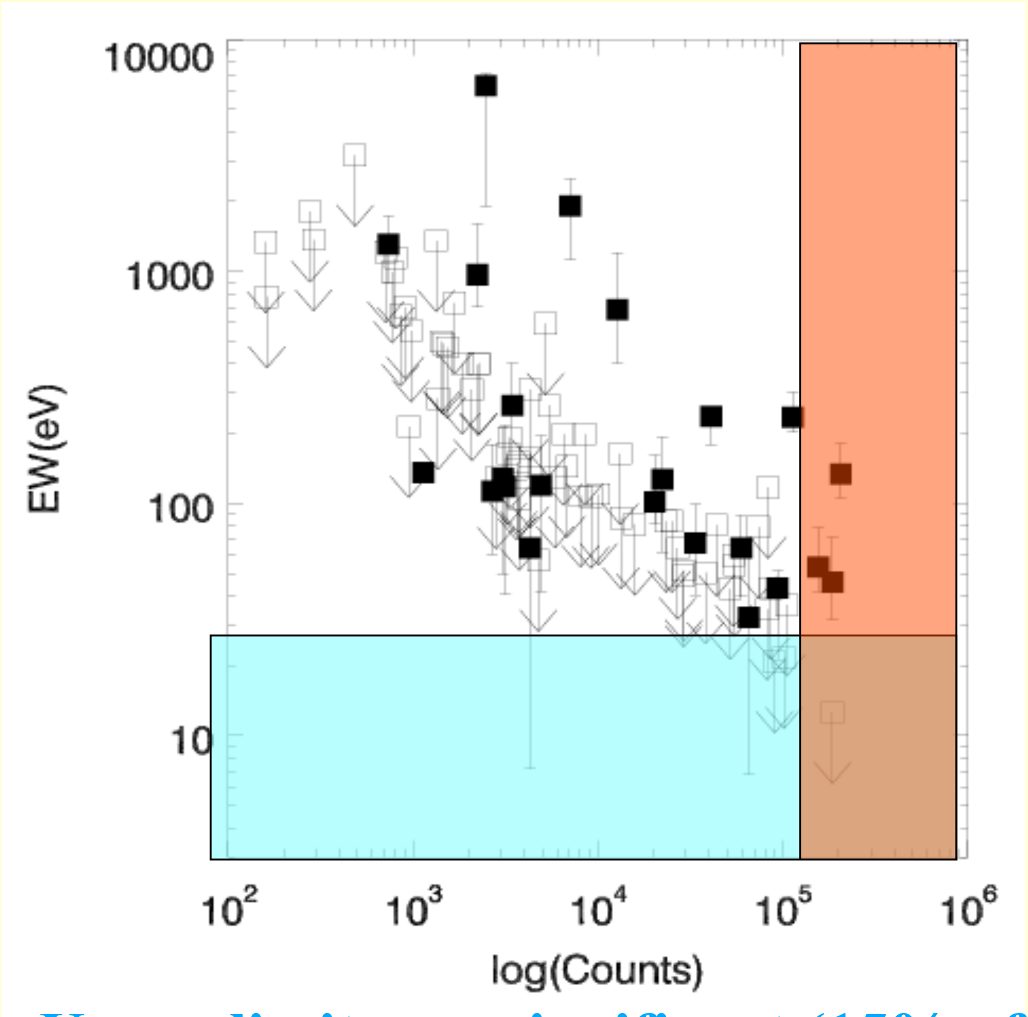


Accretion in type 1/type 2 AGN





What do we need to get the true fraction of relativistic AGN?



- Two ingredients are required
  1. A complete sample
  2. Enough statistics
- *Complete sample*: Piccinotti
- *Enough statistics*: $\geq 2\times10^5$ counts in the 2-10 keV band

$\Downarrow$

We need 2735 XMM-N ks more

Upper limits are significant (15% of well exposure sources)

Measurements and u.l. are inconsistent

2750 ks? Are you kiddin’?

2-10 keV Luminosity bin ($erg\ s^{-1}$)	“Source completeness” (for how many sources we already have 2×10^5 counts)	XMM-N time (ks) to achieve “completeness”
$L_X \leq 10^{43}$	4 out of 10	905
$10^{44} \geq L_X > 10^{43}$	2 out of 7	490
$10^{45} < L_X$	0 out of 10	1340

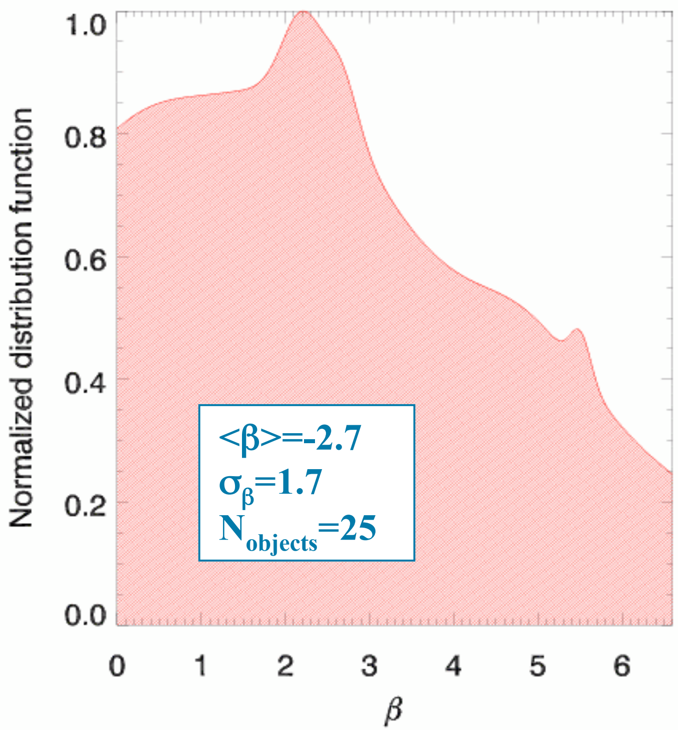
In the current “optimally exposed” sample (6 objects), the fraction of AGN where relativistic lines are found is: **50±32%**

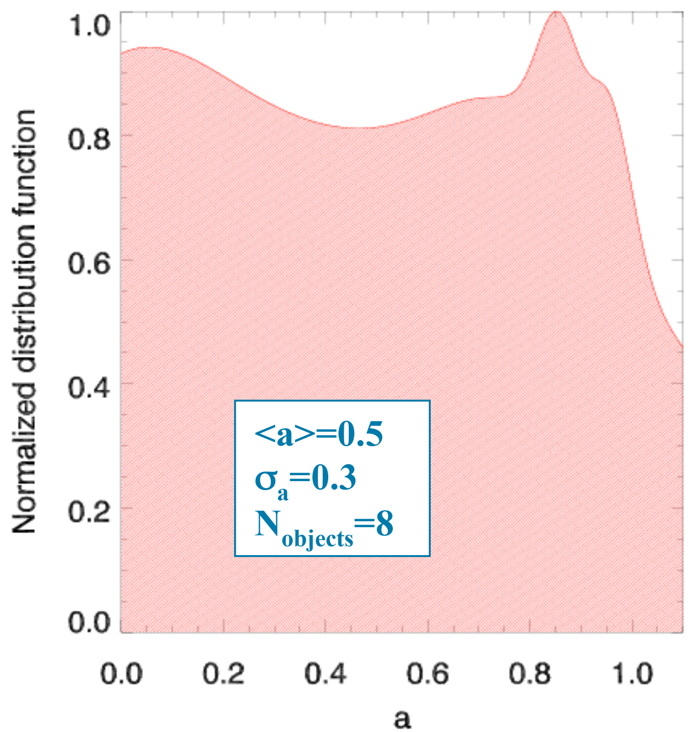
Conclusions

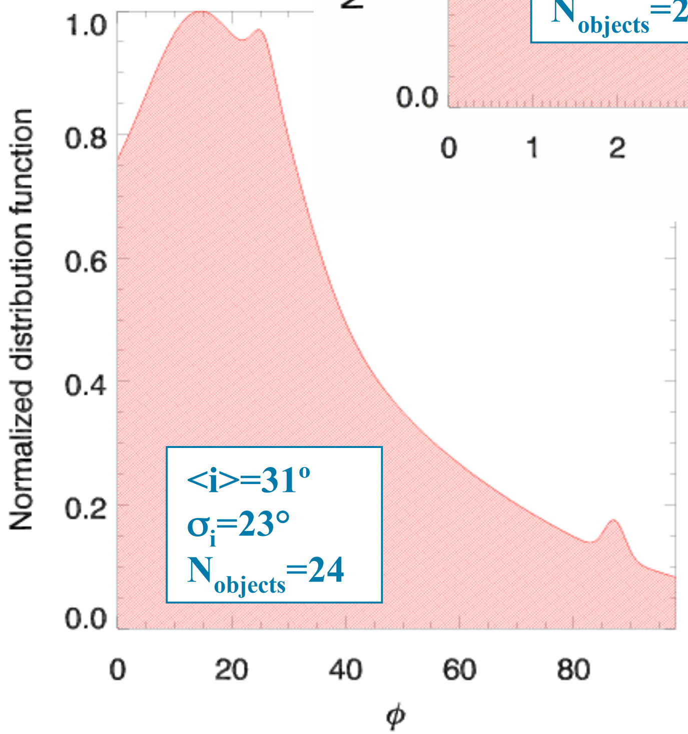
- Broad lines:
  - are present in about 50% of sufficiently well exposed spectra
  - are no significantly different between type 1 and type 2 AGN (factor <2 difference at face value)
  - cover a large range of EW:
    - <log(EW)>=2.0
    - $\sigma_{\log(EW)}$=1.1
  - are significantly more common in low luminosity AGN
- They tell us about:
  - Disk inclination (<i>=34º)
  - Accretion flow radial properties (<β>=-2.7)
  - Black Hole spin (more Kerr than Schwarzschild)
- Results still to be refined to improve:
  - Study dependency on continuum models
  - Complete coverage of line parameter space

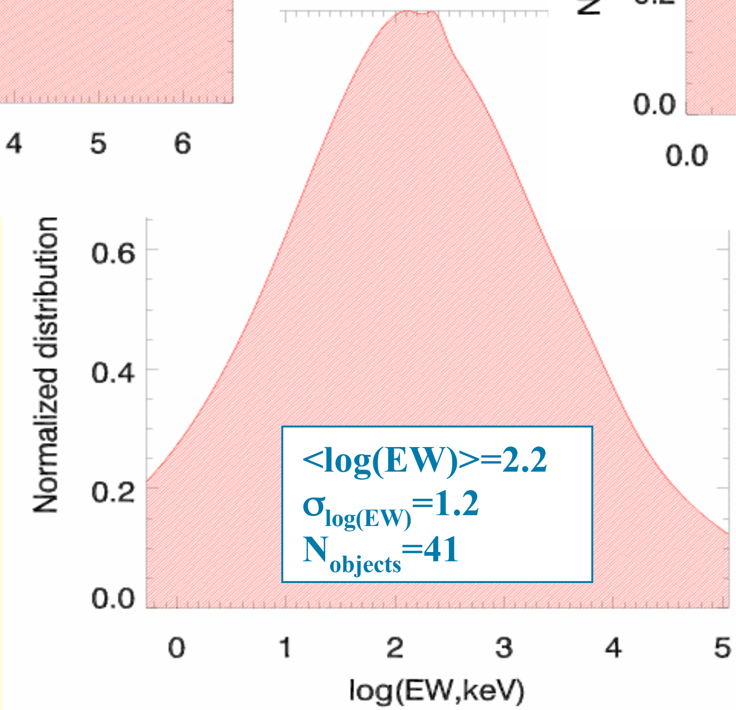
Do you want more?
Give us more data!

Properties derived from detected lines

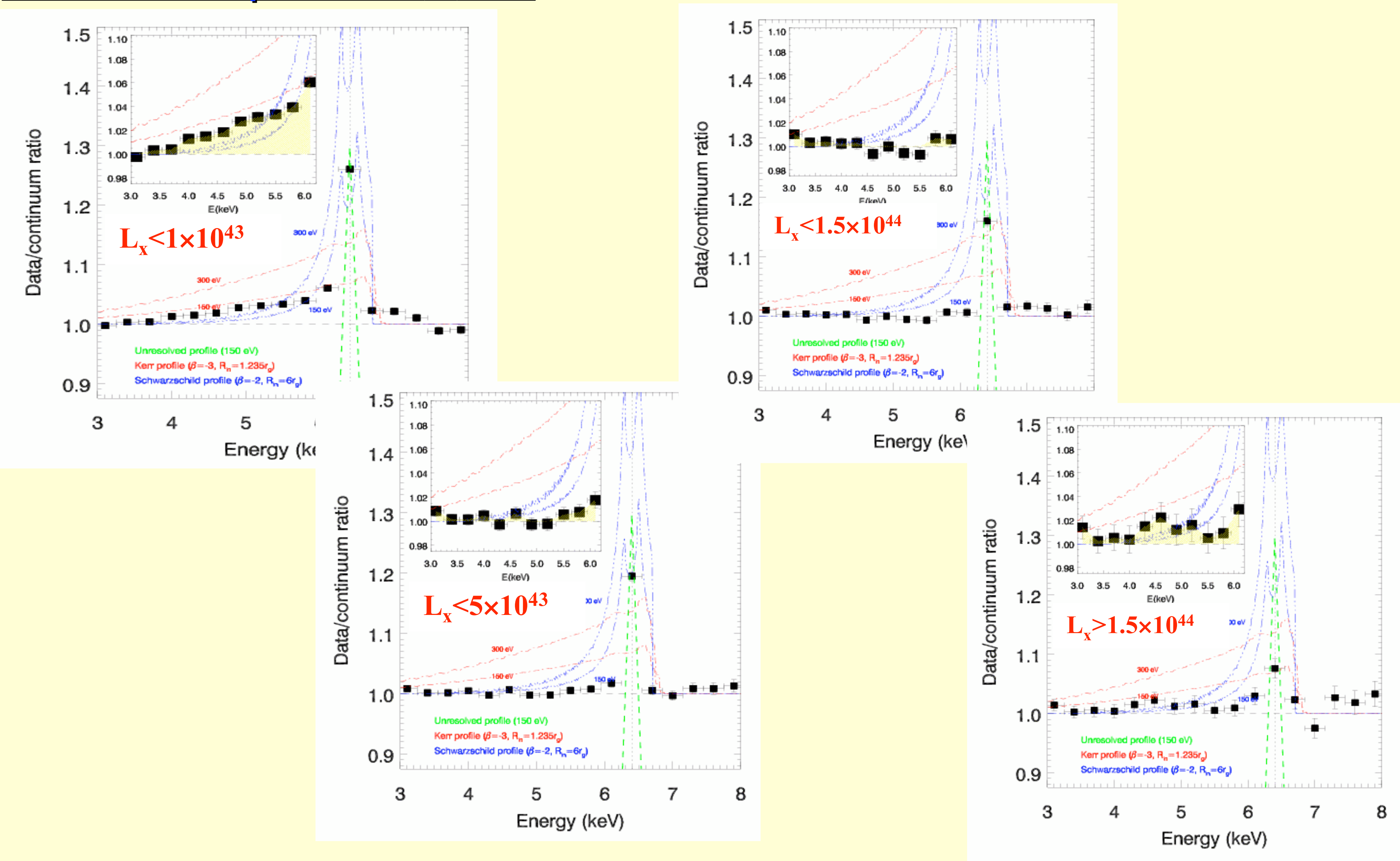








Stacked spectra – II.



Caveats

Limitations of the current approach:

- Decoupling of the "broad line" from the "soft excess" problem
  - No ionized reflection
  - No ionized absorption

- Intrinsic curvature of Comptonized spectra neglected

- No explicit inclusion of absorption features in the model

However:

- It includes explicitly narrow emission line contributions from cold reflection and warm scattering

  - $\Rightarrow$ EW of the relativistic iron line could be underestimated