FERO (Finding Extreme Relativistic Objects): Statistics of Relativistic Fe K_α Lines in Type1 AGN

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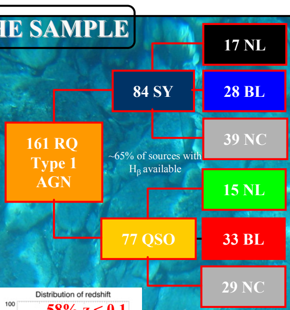
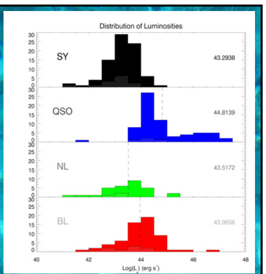
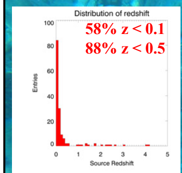
The detection of a broadened and skewed Fe K_α line in AGN spectra is generally interpreted as an effect on X-ray photons due to the gravitational field of the black hole. Measuring the parameters of broad Fe lines provides therefore a diagnostic of the accretion disc structure. The presence of this feature has been debated among the AGN community for a long time. Most studies of bright individual sources have shown that the detection of a broad line can be very dependent on the assumed spectral model. Recent works on large samples of AGNs converged to say that the broad line is more common in low luminosity AGN (Nandra et al. 1997, 2006, Streblyanska et al. 2005, Guainazzi et al. 2006) but there is no agreement on the fraction of detected Fe lines and on the average line intensity. We present the results of the analysis of a large sample composed by 161 XMM-Newton archival observations of AGN, expanding the work presented in Guainazzi et al. 2006. The main results may be summarised as follows: a) Strong broad Fe lines are found only in AGN with spectra of extremely good statistical quality (Longinotti's talk) b) Stacking of the upper limits shows that the "red wing" is far less common than expected and that any broad line emission is nearly absent in sources at higher 2-10 keV luminosity.

THE SAMPLE





$<L_x>_{SAMPLE} = 1.0\ 10^{44}$ erg s^{-1}



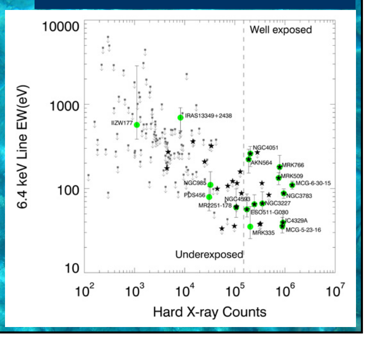
- The Full Sample: 161 Type 1 AGN corresponding to 221 XMM-Newton observations public up to March 07.
- Only sources with $N_H < 2\ 10^{22}$ cm^{-2} are included.
- Only EPIC-pn data used, in different observing modes.
- Exposure times between 1 ksec and 400 ksec, with 90% of observations < 100 ksec.

Spectral Analysis
- *Pre-analysis cut*: only source spectra with good statistics are fitted (>17 d.o.f).
- Spectra rebinned with 25 background subtracted cts/channel, and > 3 bins.
- Fit done in the 2 – 10 keV rest frame.
- The same model has been uniformly applied to the whole sample.

RESULTS: Fe Broad Line Detections

Within our Full Sample there is a
Flux Limited Sample:
- 31 Sources RXTE all-sky Slew Survey fulfilling: CR (3-8 keV) > 1 cts/sec, $N_H < 2\ 10^{22}$ cm^{-2}

149 Sources (fulfill the *pre-analysis* cut)
- 5σ Broad Fe K_α Line Detections
- 90% C.L. Upper Limits
- Flux Limited Sample Sources



Detection Fraction[(1)]

SAMPLE	
FULL	FLUX LIMITED
8 ± 2 %	32 ± 11 %

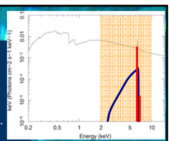
(1) Spurious detections not taken into account (IZW177, IRAS13349+2438, NGC985, PDS456 and MR2251-178)

SUMMARY and CONCLUSIONS

Broad lines in Stacked Spectra are WEAK: Intensity never higher than 80 eV

- Possible trends with physical drivers (BH mass, accretion rate, L_x): inconclusive
- With hard X-ray luminosity: very tentative evidence
- Possible trends with source type: to be investigated
  - Seyfert and Quasars show similar EW but hard residuals are prominent in QSO: effect of different intrinsic continuum or simply poor statistics ?
  - BL type significantly differ from NL type apparent contradiction with lack of trend with accretion rate

THE MODEL



Starting model: Power law + Pexrav + 5 zero-width Fe K lines+ Kyrline

Model Components:
- Two *pexrav* components to test for the presence of torus and accretion disc reflection.

  Discarded: The limited XMM bandwidth does not allow to distinguish two continua.
- Test relativistically blurred *pexrav* (*kdblur* blurring code, Fabian et al. 2002) to account for reflection off inner accretion disc.

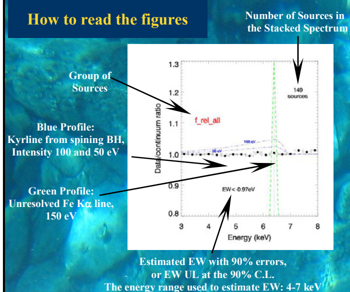
  Discarded in favour of torus reflection given the presence of ubiquitous narrow Fe K line (Bianchi+07, Yaqoob+04).
- Addition of *absori to* account for ionised absorption although no significant dependence has been found for line EW and intrinsic N_H.

Model Parameters:
- *Kyrline* disc inclination limited to < 60° after considering that the sources are all type 1 and edge-on discs should not be seen according to unification models.
- *R* and *Γ* limited to ±3σ errors after Dadina (2008) (Γ=1.89±0.48, R=1.23±0.7)
- *Kyrline* spin values fixed to 0 and 1, and free; no significant difference found between spin 0 and 1, so spin free assumed.
- Width of the 6.4 Fe K line left free with upper limit fixed to optical FWHM H_β line (only for sources where this is available, other case width fix to 1 eV)

Final model: Power law*absori + Pexrav + 5 Fe K lines+ Kyrline

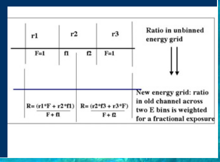
RESULTS: Stacked Spectra

How to read the figures

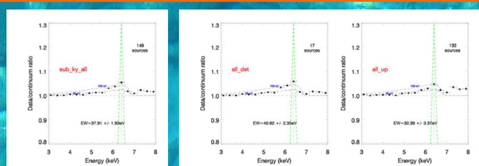


Methodology

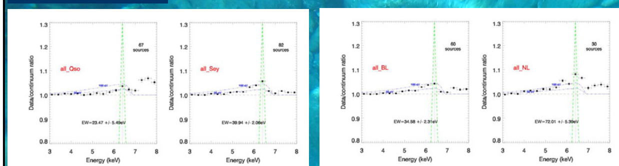
Take unbinned ratios for every source:
- Calculate redshift correction.
- Perform rebinning (150 or 300 eV).
- If new energy bins contain fractions of channels in the old grid, an exposure fraction F is assigned to the ratio:
- Once all ratios are on the same energy grid, the stacked ratio is calculated as the weighted mean and re-plotted *(see left figure)*



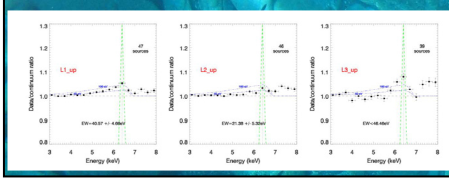
Stacked Spectra of the ratios of the data to the full relativistic model minus the *Kyrline* component for different groups of sources.



Det: Detection
Up: Upper Limits



QSO: Quasars
SY: Seyfert1
BL: Broad Line
NL: Narrow Line



Detections not included in these stacked plots to avoid bias of bright sources

Luminosity Bin:
- L1: $L_x < 3\ 10^{43}$ erg s^{-1}
- L2: $3\ 10^{43}$ erg s^{-1} < L_x < $1.5\ 10^{44}$ erg s^{-1}
- L3: $L_x > 1.5\ 10^{44}$ erg s^{-1}

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