

XMM-NEWTON DISCOVERY OF A STRONG RELATIVISTIC FE $K\alpha$ EMISSION LINE IN 4U 1344-60

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Outline

Introducing 4U 1344-60

Optical data

XMM-Newton data

The broad Fe $K\alpha$ line

Future Work / Conclusions

The (poor) history of 4U 1344-60

- Discovered by the UHURU X-ray satellite Observatory when scanning the Galactic Plane (Forman et al. 78)
- Detected in the HEAO-1 Large Area Sky Survey with $F_x \sim 2 \times 10^{-11}$ cgs
- First position with good accuracy with EXOSAT (Warwick et al. 88)
- 4U lies $\sim 14'$ from the radiogalaxy Cen B \rightarrow serendipitously obs. with ASCA, XMM

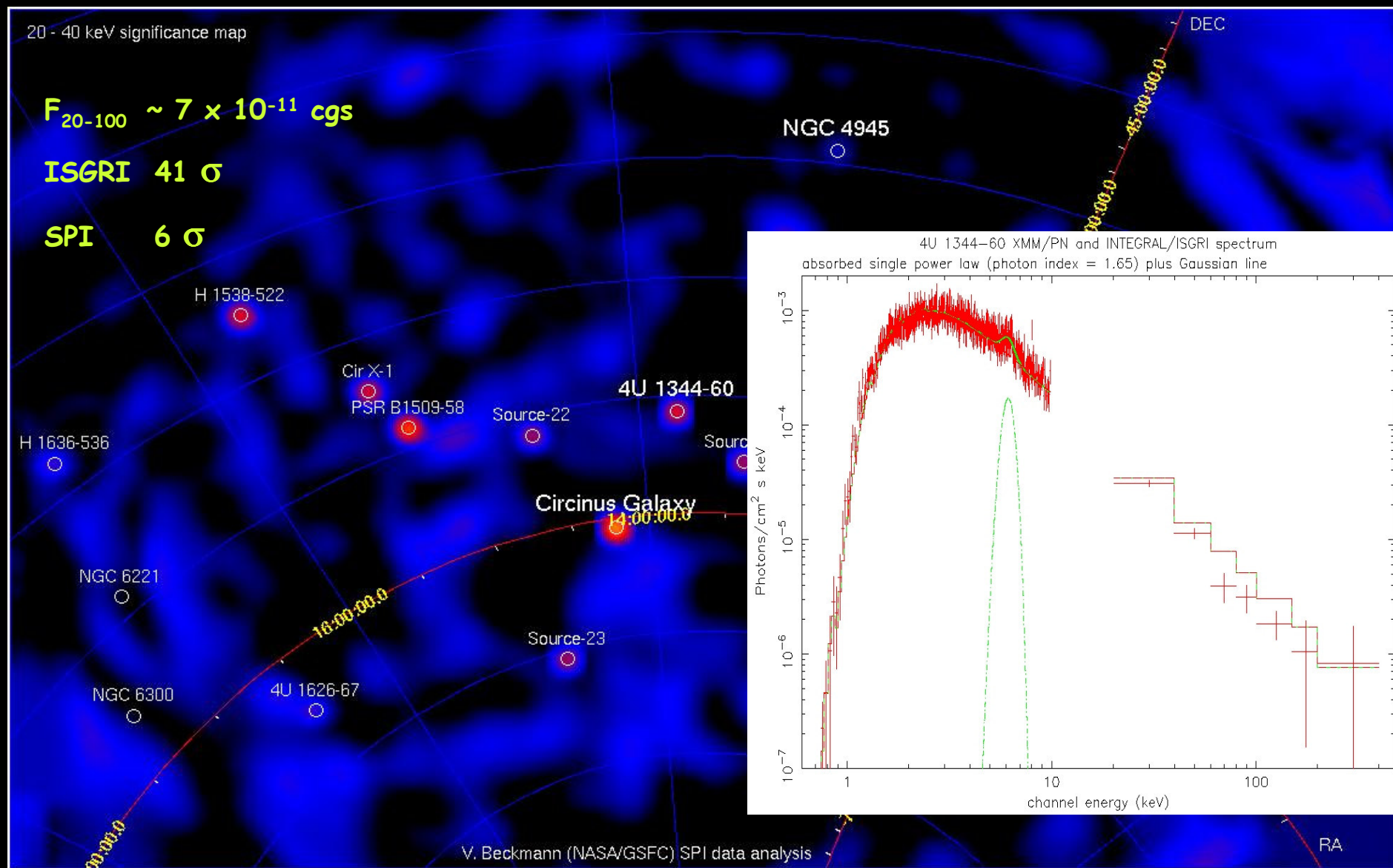
4U 1344-60 lies deeply in the Galactic Plane ($b = 1^\circ.51$)

\rightarrow it isn't easily accessible at all wavelengths, in particular the optical to soft X-rays

\rightarrow No optical counterpart!!

The inclusion in the First INTEGRAL AGN catalog (Beckmann et al. 05) has re-awoken interest in this source...

INTEGRAL observations of 4U 1344-60



Optical ID. of 4U 1344-60

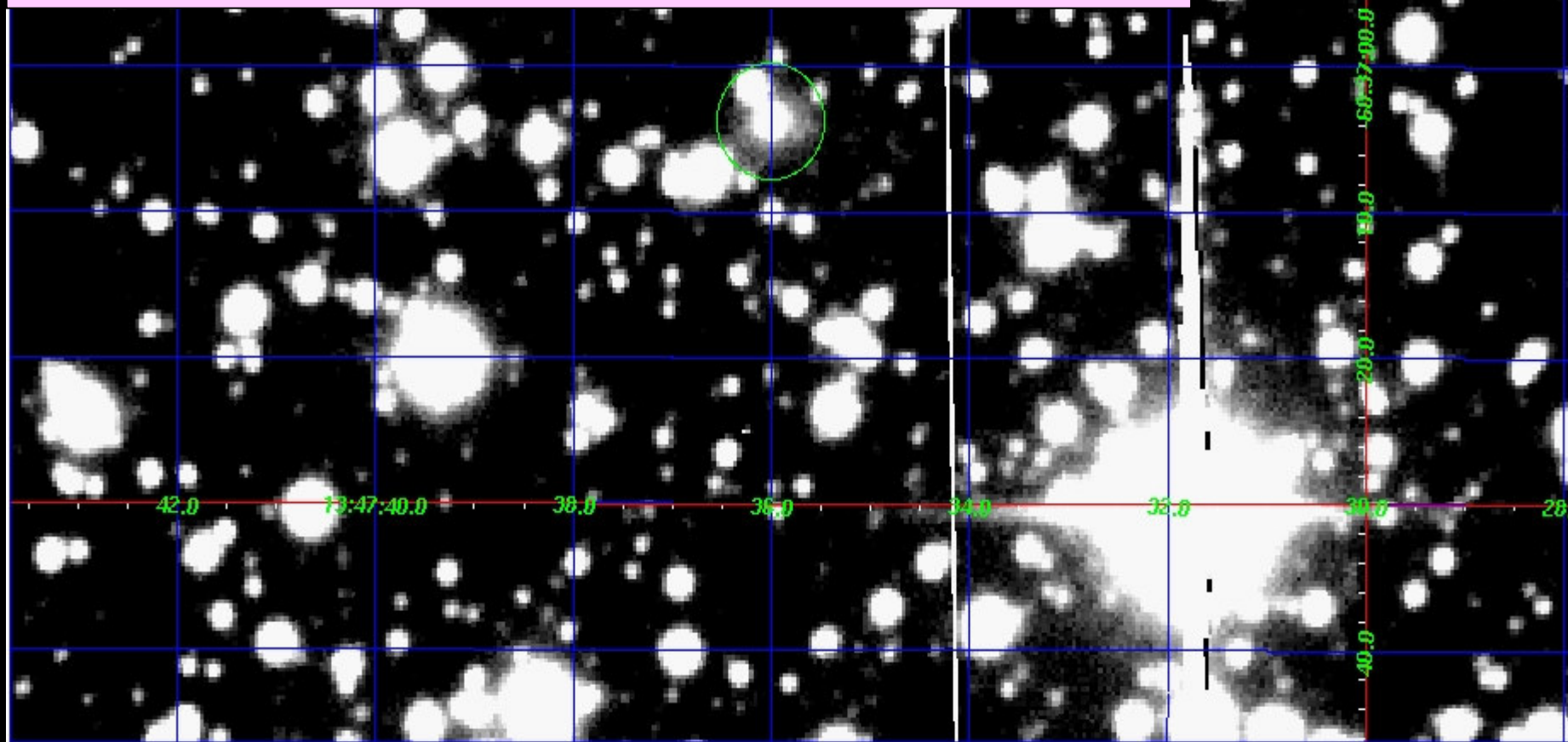
ESO observation: 3.6 EFOSC I-band 300s (PI C. Motch)

Galactic Plane part of the ID program of the XMM-Newton Survey
Science Center (Motch et al. 03)

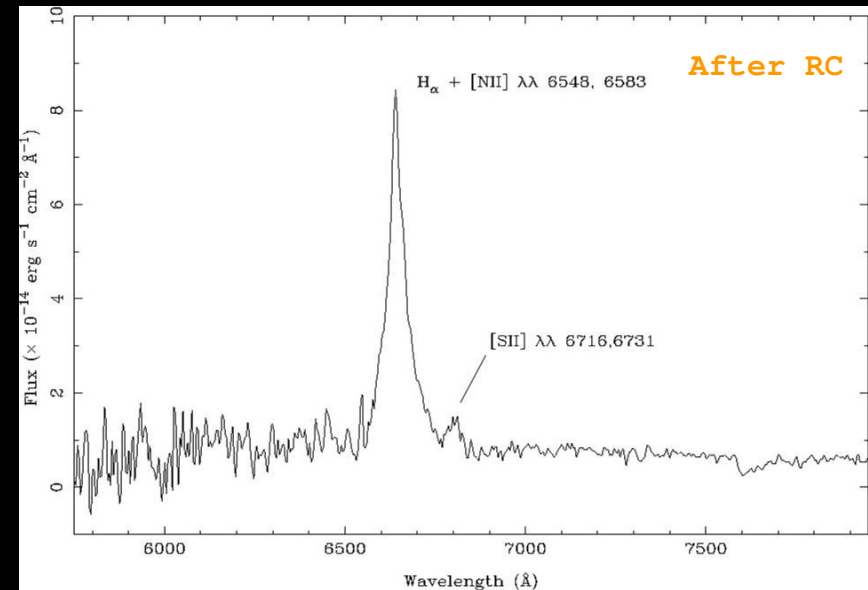
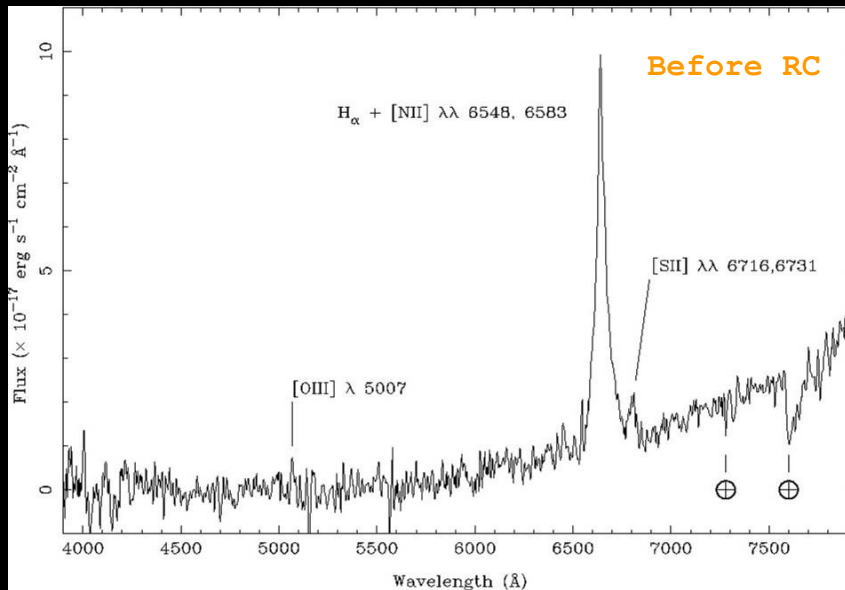
Early type spiral galaxy; AGN (Michel et al. 04) **XMM**

Type 1 Seyfert at $z=0.013\pm 0.001$ (Masetti et al. 06) **INTEGRAL**

Member of a small cluster around Cen B (Schroeder et al. 06) **DENIS**



Optical spectroscopy of 4U 1344-60



Before Reddening correction

The $H\alpha$ line complex is very intense; affected by large noise; continuum disappears $\leq 5750\text{\AA}$

After Reddening correction

~ symmetric $H\alpha + [\text{NII}] \lambda\lambda 6548, 6583\text{\AA}$ line complex

Peak at $H\alpha$ narrow component $\rightarrow z=0.012\pm 0.001$

Deblend the 4 components by a simultaneous fit of 4 Gaussian profiles $\rightarrow I(H\alpha)$ broad and narrow

$H\alpha / [\text{SII}] \sim 3$ (AGN-like); Broad $H\alpha$ component width ~ 4400 km/s (Seyfert 1.x galaxy)

Seyfert Type $\sim 1 + [I(\text{Narrow } H\alpha) / I(\text{Broad } H\alpha)]^{0.4}$ (Netzer 90) \rightarrow Seyfert 1.5 (-1.8)

XMM-Newton results: X-ray continuum

Despite its X-ray "Piccinotti-like" brightness, no X-ray satellite directly pointed 4U with an adequate exposure time, so its X-ray spectral properties were almost unknown up to XMM-Newton...

"Serendipitous" EPIC observation of 25 ks: extreme off-axis position!! (~14' from CenB)

Very complex spectrum:

highly obscured + emission line-like features

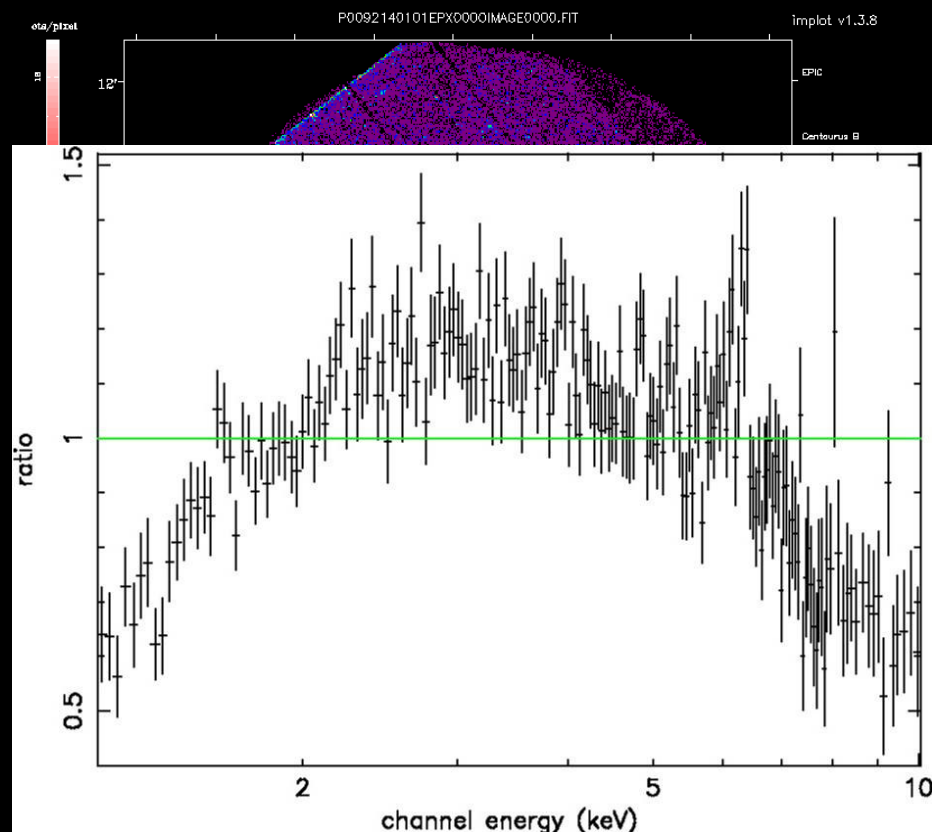
Different continuum models applied (5-7 keV excluded): wabs; pcf; pexrav

CONTINUUM BEST-FIT:

Power-law continuum ($\Gamma \sim 1.55$) obscured by two cold absorbers ($N_{\text{Hf}} \sim 10^{22}$ & $N_{\text{Hp}} \sim 4 \times 10^{22} \text{ cm}^{-2}$), the latter covering only the 50% of the primary X-ray source ($\chi^2/\text{dof} = 138/145$)

..SUPPORTS THE OPTICAL CLASSIFICATION AS INTERMEDIATE TYPE SEYFERT GALAXY

!! CONSISTENT WITH INTEGRAL RESULTS !!



The Role of Broad Fe K Lines in Astrophysics

Asymmetric double-horned/skewed Fe K lines are interpreted as the result of the emission from dense matter in the innermost region of the accretion disk where effects such as Doppler and gravitational broadening operate.

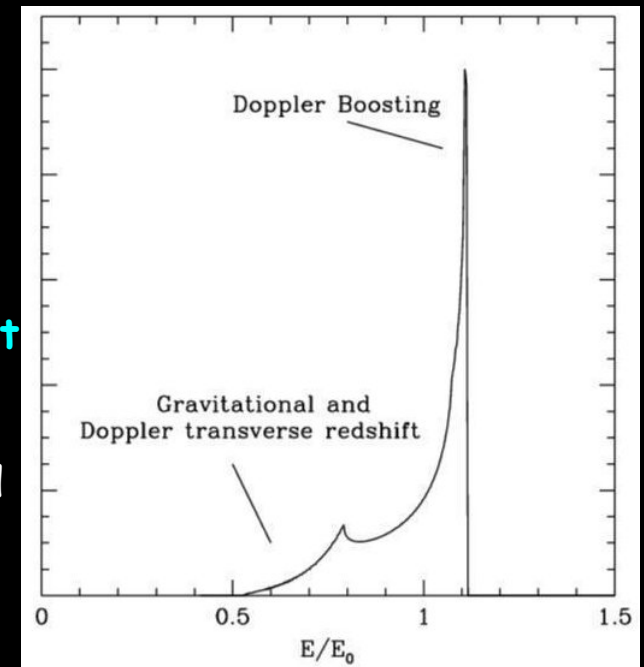
They provide a tool to:

*Investigate the nature of the spacetime in the immediate vicinity of the Black Hole

*Trace the matter distribution down to the last stable orbit

OBSERVATIONAL DATA:

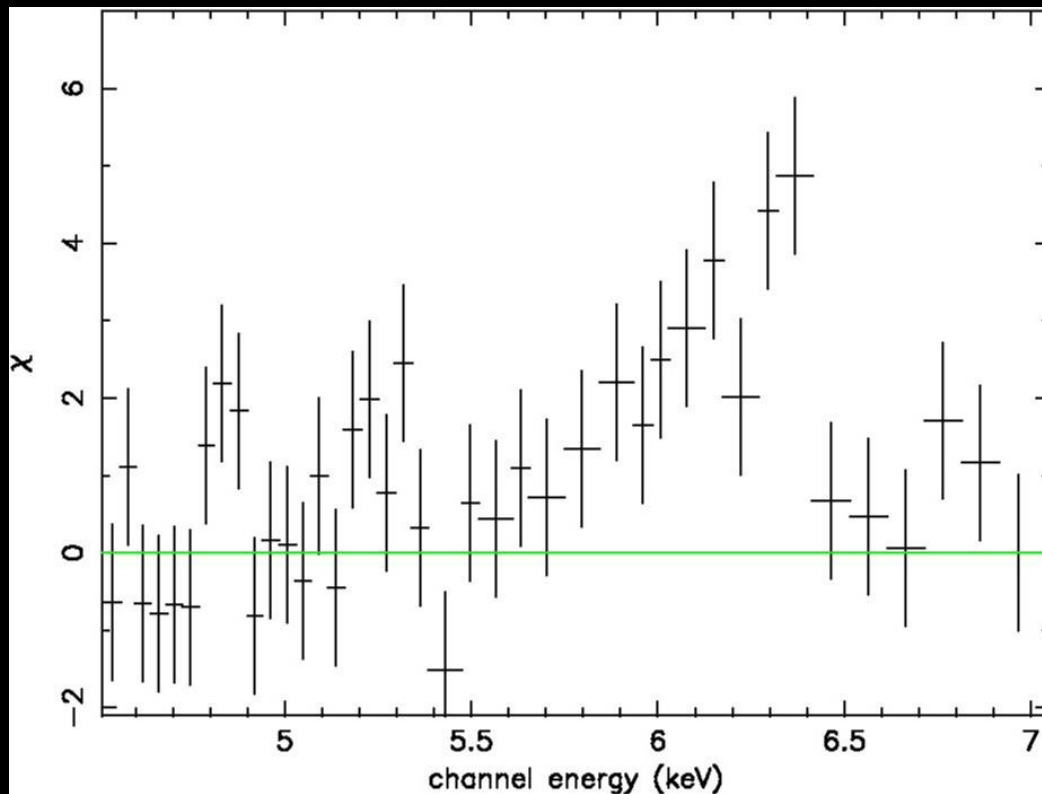
ASCA reported the common occurrence of Fe line with broad profiles in the spectrum of most bright Seyferts



In the *XMM-Newton* & *Chandra* spectra of AGNs the broad part of the line is absent while an ubiquitous core at 6.4 keV has been observed (Bianchi et al. 04; Jimenez-Bailon et al. 05; Yaqoob 04) → **EXCEPTION RATHER THAN THE RULE!!**

Apart from the prototypical examples MGC-6-30-15 and NGC 3516, only a small number (~10) of sources show a Fe line with a (mildly) broadened profile (e.g. Braitó's talk)

The relativistic iron line in 4U 1344-60



XMM data suggest that the fluorescence takes place at few gravitational radii from the BH with the inner radius of the Fe emitting region located at $R \geq 10 R_G$

...Why not down to the MSO?

*No disk?

*Ionized disk \rightarrow Fe stripped?

*No X-ray emitting active region at $< 10 R_G$?

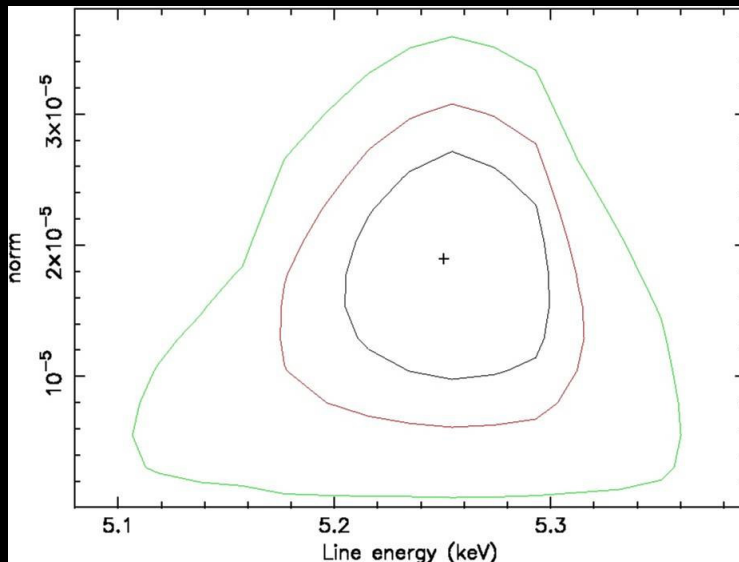
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One of the clearest examples of relativistic lines found so far!!

- ◆ Independent from the model applied to the underlying continuum.
- ◆ Both Schwarzschild and Kerr models provide an excellent description of the skewed line profile.
- ◆ Disk inclination $< 45^\circ$
- ◆ Disk inner radius $>$ marginally stable orbit (MSO)
- ◆ EW ~ 350 eV
- ◆ Velocity FWHM $\sim 70,000$ km/s
(most extreme MCG-6-30-15: $\sim 100,000$ km/s)
- ◆ No narrow core is required

The emission features around 5 keV: further relativistic lines?

Our analysis has revealed the presence of two narrow line-like emission features at 4.9 and 5.3 keV, significant at 95.5% and 98.5% confidence level, respectively.



Similar features were also observed in the X-ray spectra of a handful of bright Seyfert galaxies (e.g. Turner et al. 02; Guinazzi et al. 03; Della Ceca et al. 05).

Their origin remains puzzling...

Dovčiak et al. 04 proposed a possible explanation:

X-ray corona concentrated in a number of small active regions ("flares") that illuminate the underlying disk close to the BH → Fe emission lines can emerge from "hot-spots" on the accretion disk surface → The centroid of the line is redshifted due to relativistic effects.

Centroids at 5-6 keV suggest that the irradiation lasts only for a portion of the orbit

4U 1344-60: an excellent opportunity

A short off-axis XMM observation has revealed the presence of a strong relativistic Fe line in this poorly-studied source.

High flux in X-rays + lack of short-term flux variability + lack of warm absorber features →

4U is an ideal source to study the innermost region of the accretion disk in AGN

Deep observations carried out with XMM-Newton, HETG Chandra and Suzaku will shed light on the emission line-like features detected in its spectrum

Unambiguous confirmation of the broad line

Accurate determination of the diskline parameters

Accurate estimate of the contribution of any possible narrow emission line originating from distant matter (i.e. torus, BLR)

Temporal behaviour of narrow emission features present in the 4.5-6 keV band

Observations from IR to Gamma-rays to reveal basic physical properties of the source

"4U 1344-60: a bright intermediate Seyfert galaxy at $z=0.012$ with a relativistic Fe $K\alpha$ emission line" A&A in press
[astro-ph/0603713]

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SUMMARY

4U 1344-60 is a very bright (10^{-11} cgs) X-ray source in the Zone of Avoidance. On the basis of optical data we propose to classify 4U as an intermediate type Seyfert galaxy (Sey1.5) at $z=0.012$. X-ray data lend support to our classification

4U exhibits a broad (FWHM $\sim 70,000$ km/s) and skewed Fe K line...possibly the best case for such a feature after MGC-6-30-15.

Fluorescence at $>10 R_g$, no narrow core observed (**NB** the determination of the line/disk parameters hampered by "low-quality" XMM data)

Marginal presence of two emission lines at ~ 5 keV. Highly-redshifted Fe line from orbiting spots? (the simultaneous presence of the broad line reinforces this hypothesis)

Thanks to its brightness 4U is an ideal source for deeply investigating such spectral features, rarely detected in AGN.

Future XMM, HETG Chandra, Suzaku observations of 4U 1344-60 are needed!!