Deep X-ray view of the bare nucleus Seyfert Ark120: unveiling the core of AGN

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G. Matt, A. Marinucci, A. Tortosa and the Nustar AGN team

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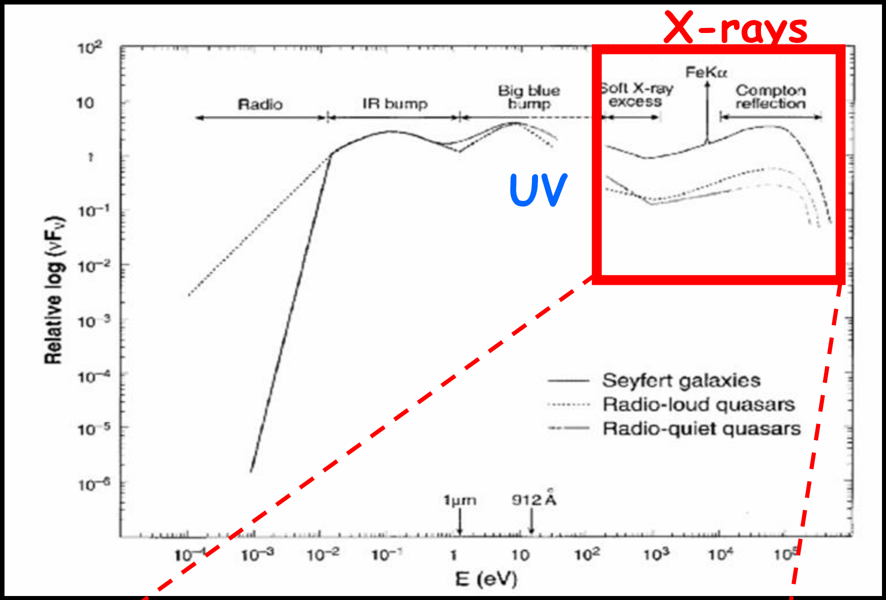
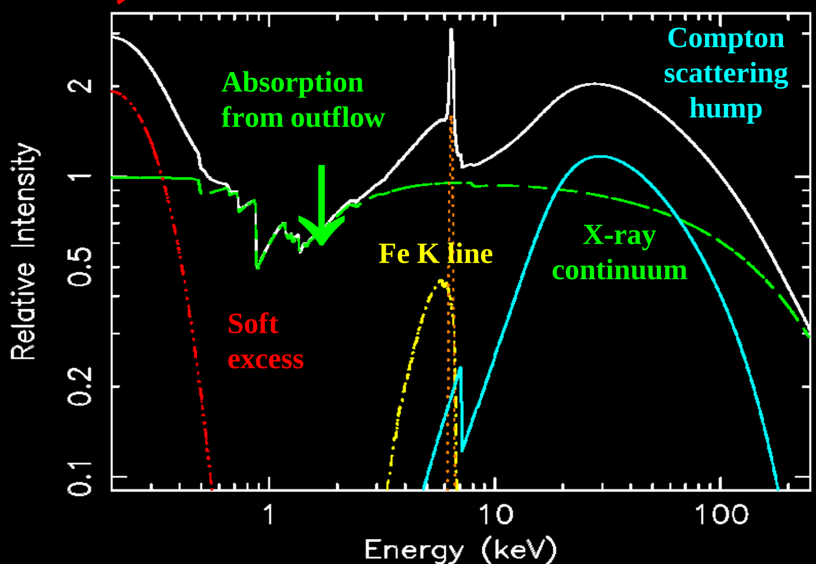
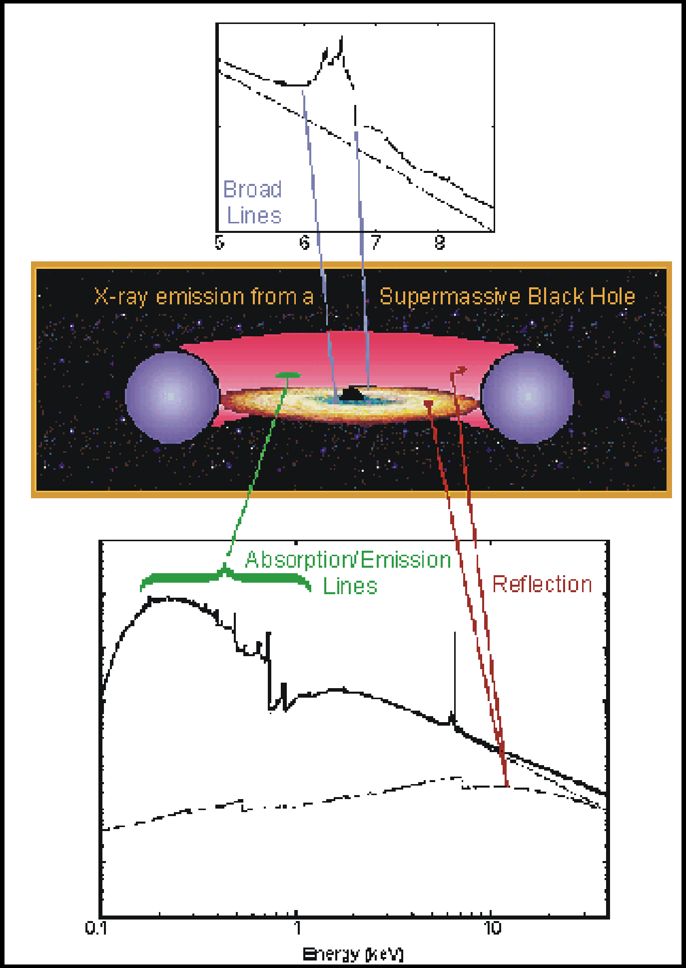
Spectral Energy Distribution of AGN







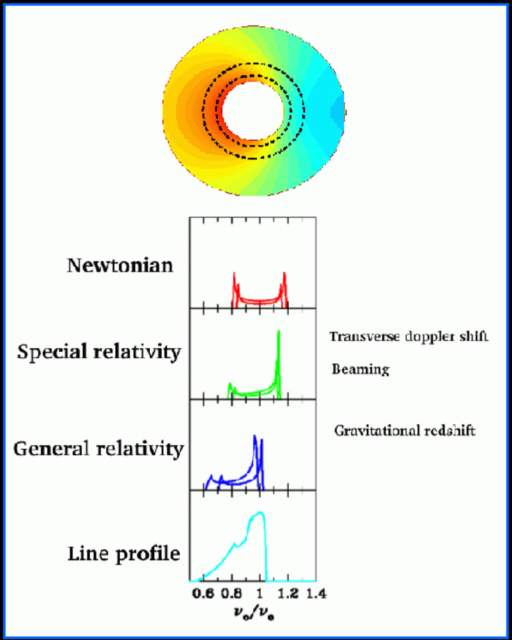
The study of X-ray spectral features:

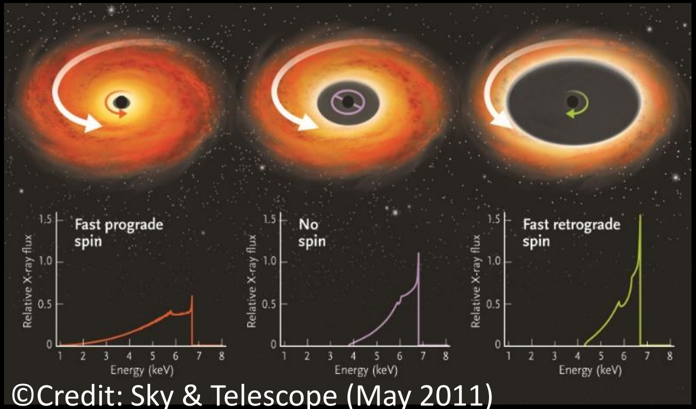
⇨ probe AGN from the inner part of the accretion disc to much larger scales :

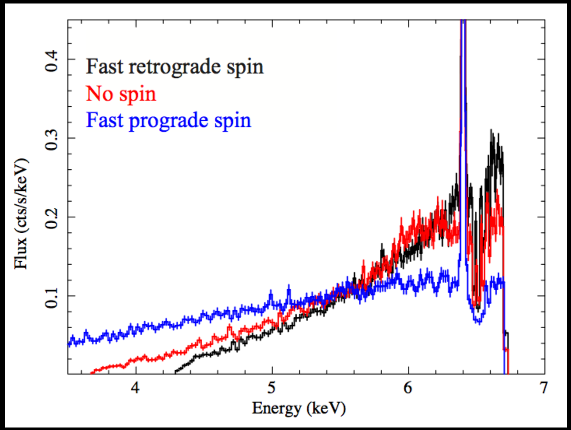
BLR, NLR, torus, Warm absorber, outflows, …

The « relativistic » FeKα line

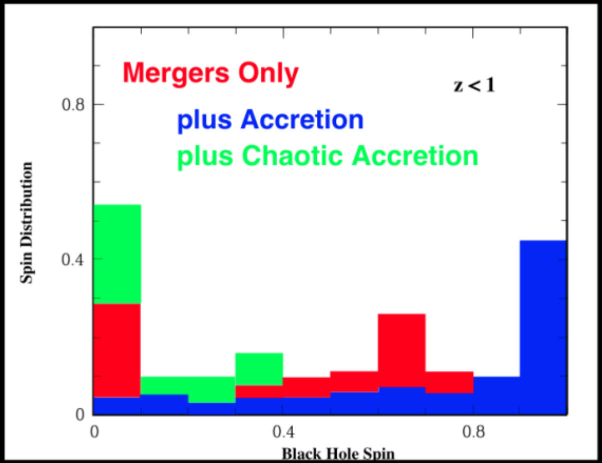
See also Andy's talk







The shape of the Fe Kα line ⇨ BH spin



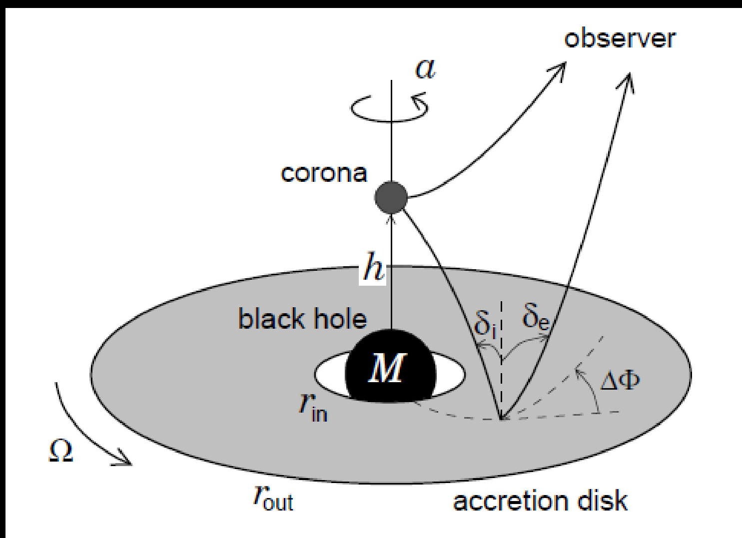
SMBH Spin
⇨ accretion mode : chaotic versus prolonged, plus mergers ?

⇨ galaxy evolution.

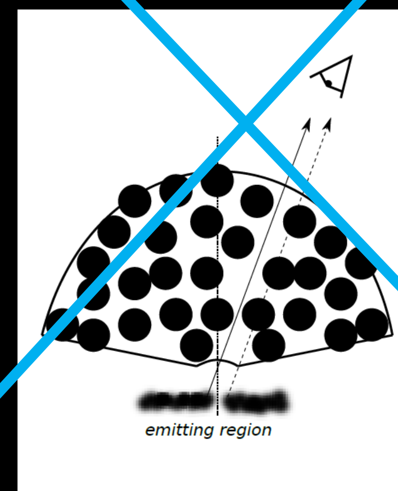
However, two interpretations/contributions for the apparent broadening of some FeK line have been proposed ….

Relativistic reflection on the disc

-> FeK broadening directly related to the BH spin



Warm absorber(s) which distorts the underlying continuum and mimicks an apparent broadening of the FeK line line or at least make the analysis rather complex

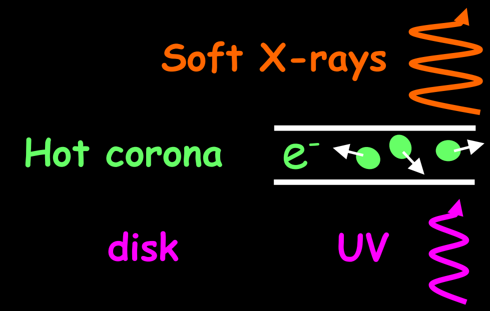


- ⇨ Observation of **bare AGN** (i.e. without Warm absorber)
- ⇨ Direct view of the inner part of the accretion disc
- ⇨ Test for relativistic reflection contribution without any contamination on the line-of-sight

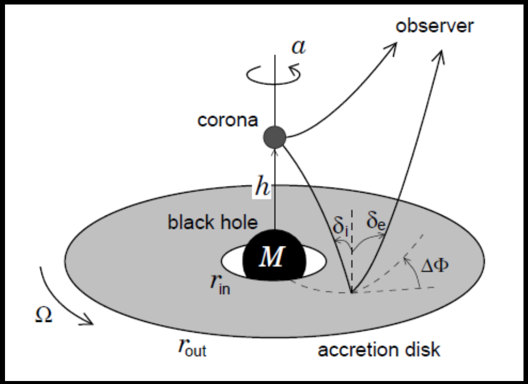
⇨ Study of the broad-band continuum (XMM-Newton + Suzaku + Swift) of a sample of bare AGN (Patrick et al. 2011)

Spin determination is strongly model-dependent, i.e. how the soft X-ray excess is modeled :

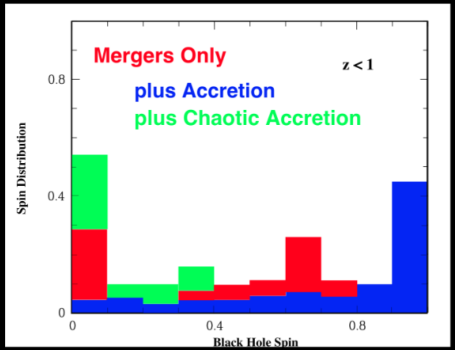
- If due to Comptonisation of the UV disc photons by the hot e- of a corona :
  low spin values
  ⇨ chaotic accretion



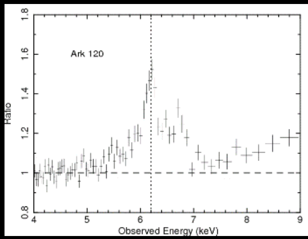
- If due to relativistic reflection :
  high spin values
  ⇨ prolonged accretion



See also Walton et al. 2013: relativistic reflection
-> high spin values



Deepest X-ray observations of a « bare » AGN: Ark 120



Ark 120: brightest and cleanest bare AGN (z~0.06398)
- No absorption signature in X-rays and UV.
- A prominent soft excess and a possible relativistic line…

PI: D. Porquet (XMM-Newton)

1) A very deep XMM-Newton Large Program observation of 480 ks (~5.5 j): OM + RGS +EPIC

- ✓ RGS: Confirm/infirm the bare AGN property, soft X-ray emission features ?
- ✓ X-ray (+ UV, optical) spectral and timing analysis.
- Soft excess origin : relativistic reflection versus Comptonization.
- The properties of the accretion disc and the black hole spin

Highest S/N data for a bare AGN ⇒ will serve as a template for AGN in general ?

2) A 120 ks simultaneous Chandra/HETG observation.

- ✓ Measurement of the narrow component of the FeK complex: origin: disc, BLR or torus ?
- ✓ Remove possible degeneracy between the narrow core the broad component FeK contribution.
- ✓ Ionized iron lines : FeXXV, FeXXVI ?

+ ☺ After the acceptance of this proposal :
A simultaneous Nustar observation was planned (PI: G. Matt + Nustar AGN team)

Deep X-ray observations of a « bare » AGN: Ark 120

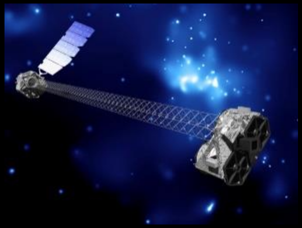
Observation log:

- 4 x 120ks consecutive XMM-Newton observations:

Note : source flux was about twice than in 2013

- 3 (splitted) observations with Chandra/HETG (total :120 ks) :

It was the first Chandra observation of Ark 120 !



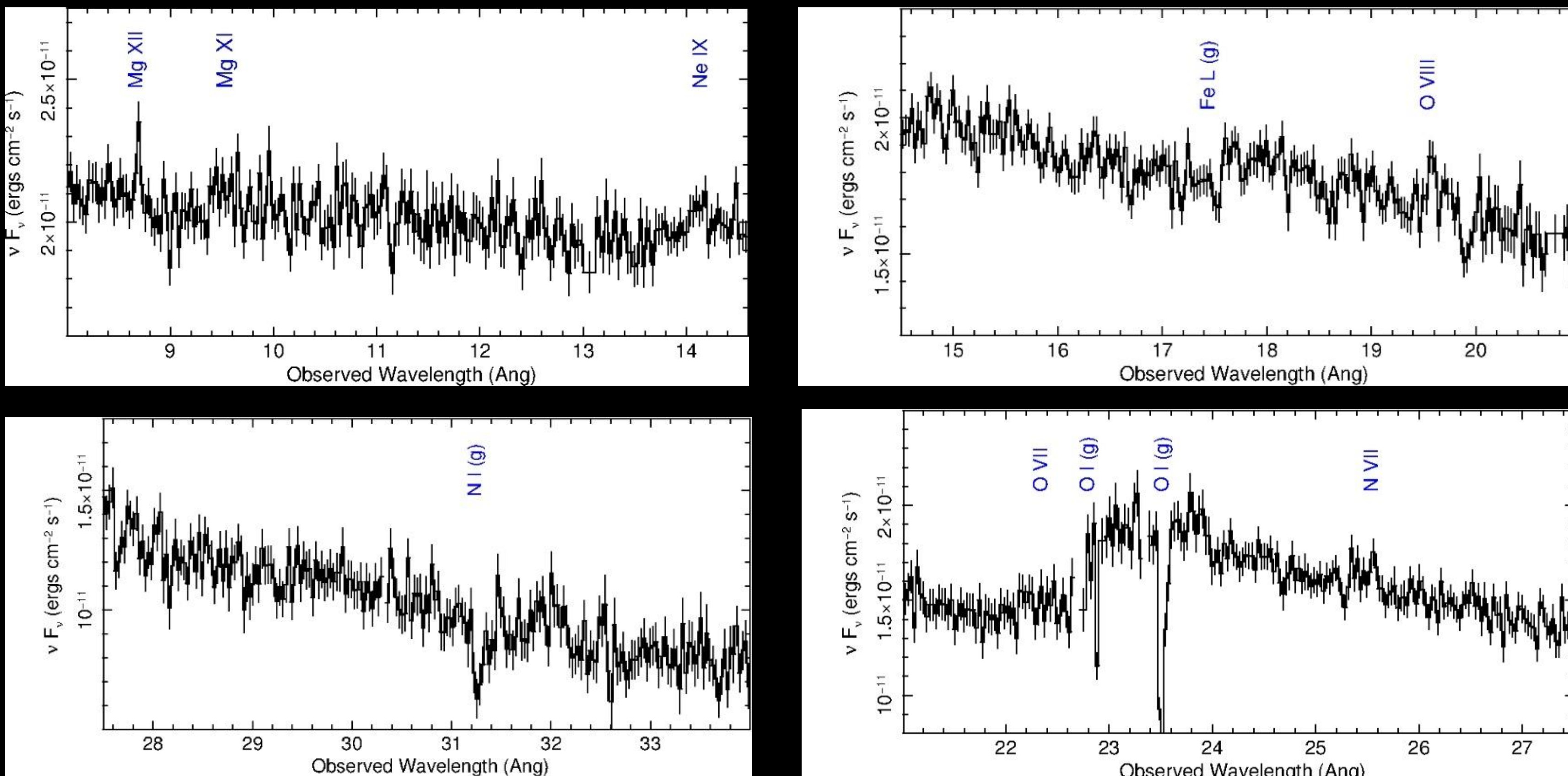
- One Nustar observation of 55 ks,

simultaneous with the third XMM-Newton observation.

A very deep RGS observations Ark 120

- Bare or not bare AGN ? 480 ks of RGS data (Reeves et al. to be subm.):

$\geq 6.5 \times 10^5$ counts (S/N > 25 per bin)



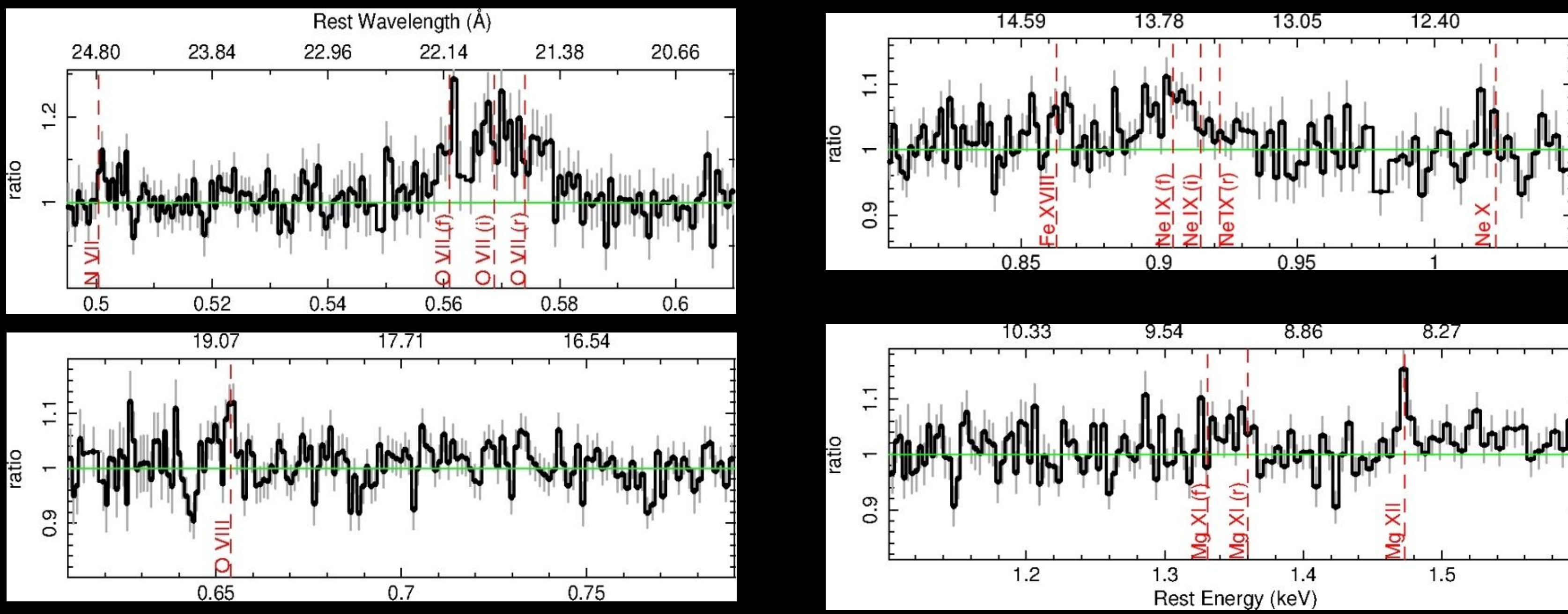
$\Rightarrow$ No absorption lines from Ark 120.

Only absorption lines from the ISM (Gal)

A very deep RGS observations Ark 120

Reeves et al.

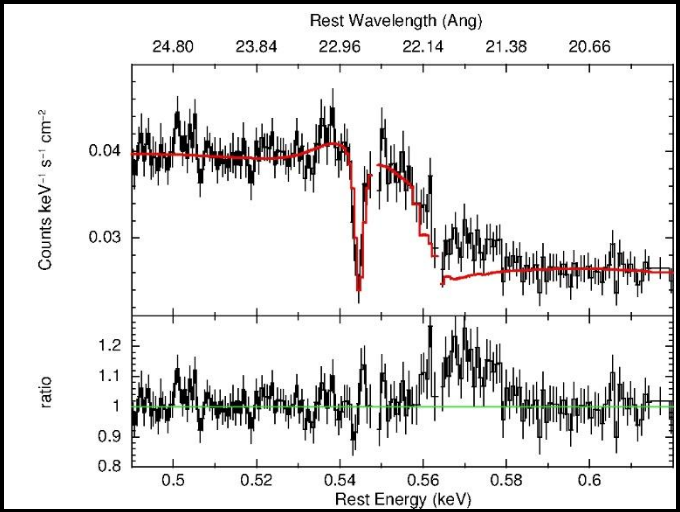
- No absorption line from Ark 120 but several broadened emission lines

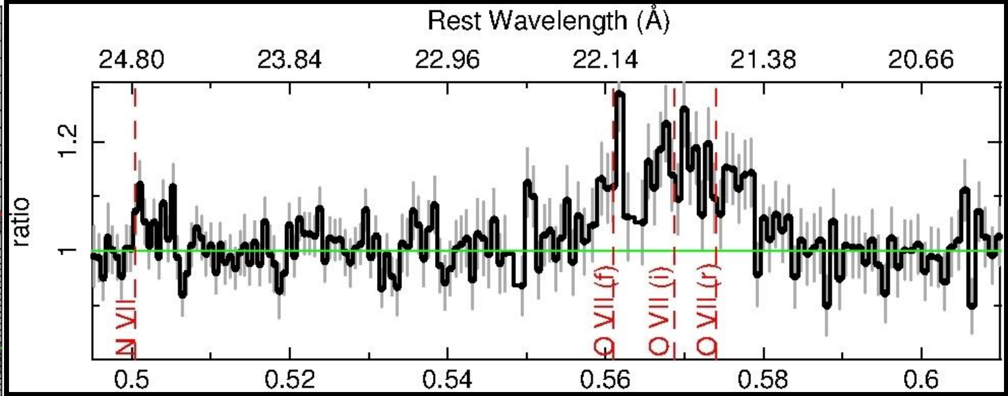


Best-fit ISM absorption model (tbnew, Wilms et al. 2000)

A very deep RGS observations Ark 120

Reeves et al.

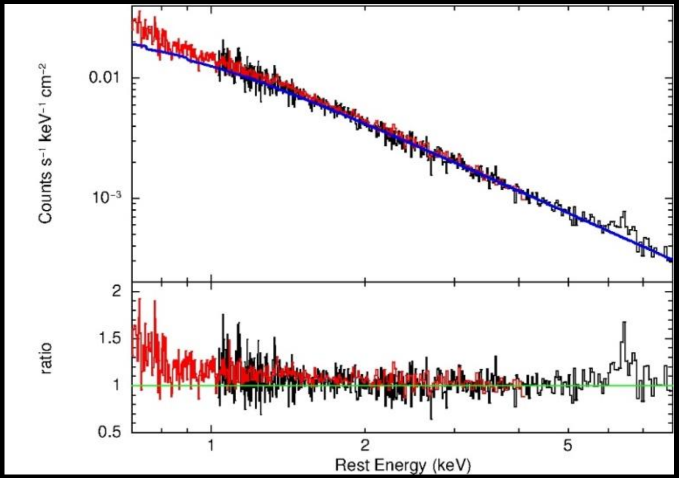


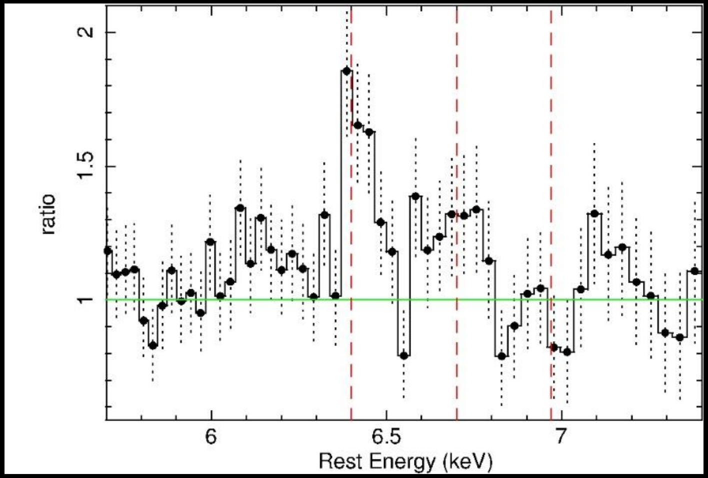


- ✓ A blend of narrow lines can be ruled out (χ^2/dof= 3135/3565), the majority of the OVII flux is not accounted for
- ✓ Can be fitted by a blend of velocity broadened lines with a common velocity of 8500 (+1700,-1500) km/s (BLR= 5800 km/s)
- ✓ Similar to the one found for MR 2251-178 (Reeves et al. 2013) !

Chandra/HETG observation of Ark 120: First Chandra observation !

Reeves et al.,



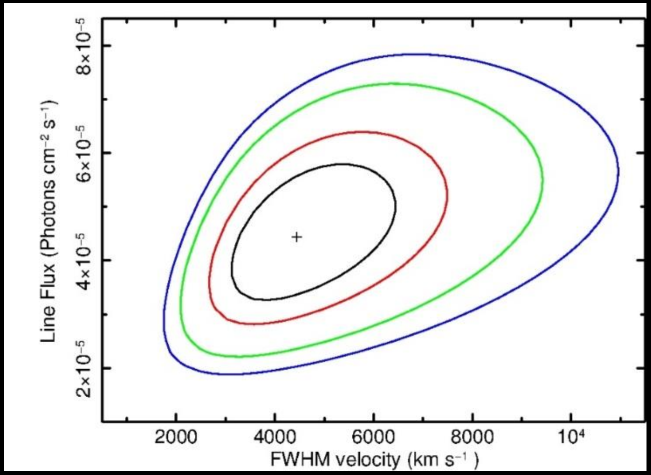


FeK narrow component resolved:

E = 6.41 ± 0.02 keV

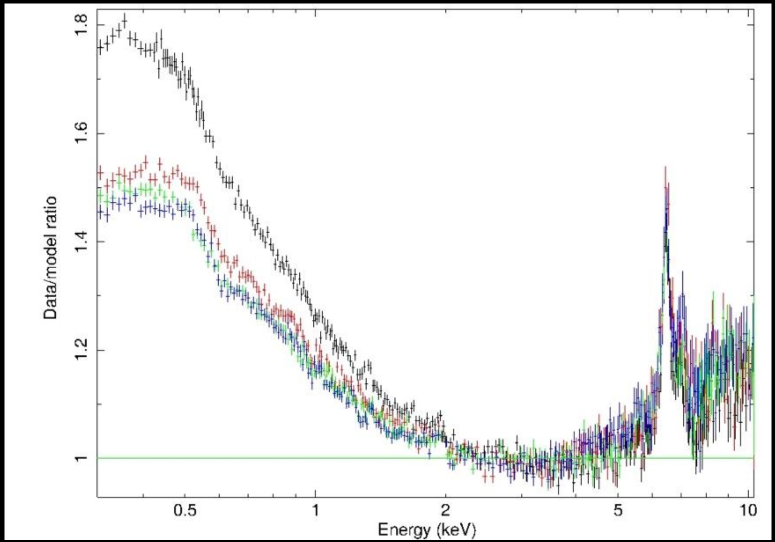
EW= 81 (+26,-23) eV

Width = 42 (+20,-12) eV
FWHM =4620 (+2200, -1650) km/s
≈ BLR (FWHM ~5800 km/s)

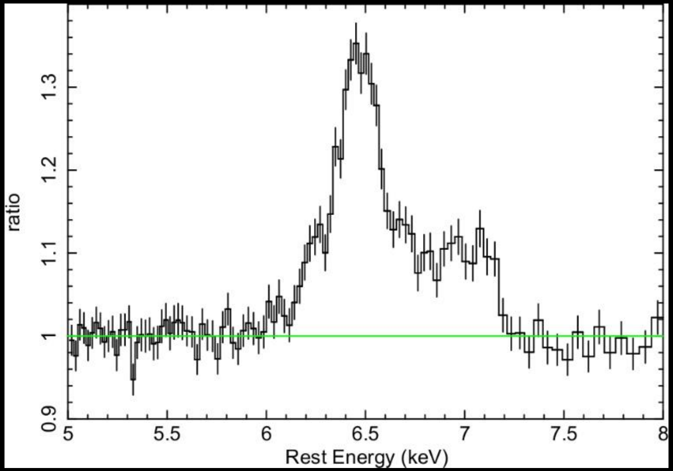


A very deep XMM-Newton pn observations Ark 120

(Porquet et al., in progress)



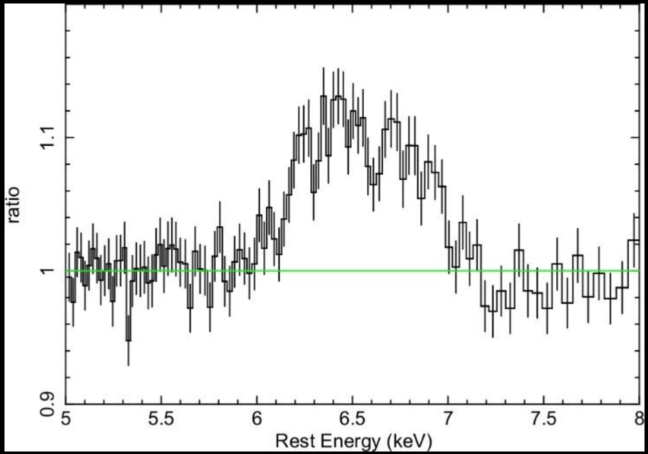
Zoom on Fe K complex



A prominent soft excess, and a significant FeK complex :

→ Confirmation of previous XMM-Newton and Suzaku observations
(e.g., Vaughan et al. 2002, Nardini et al. 2011, Walton et al. 2013, Matt et al. 2014)
See also A. Marinucci's talk

Fit without broad line



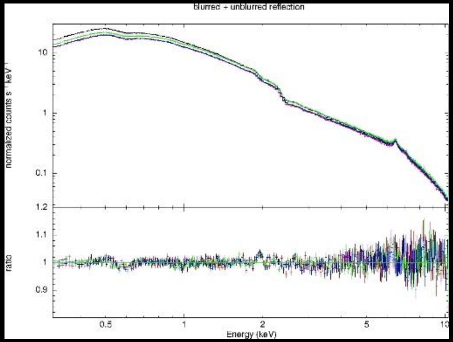
A very deep XMM-Newton pn observations Ark 120

(Porquet et al., in progress)

- « Pure reflection » model (blurred + unblurred) to explain both the soft excess and the FeK complex

The very smooth soft excess → need for highly blurred relativistic reflection to explain it.

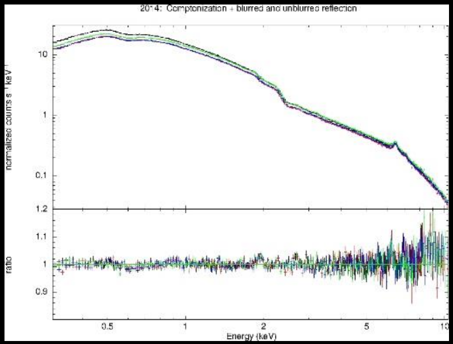
Good fit ($\chi 2 \sim 1.06$) with high spin value : a ~ 0.97



- Comptonization model to explain the soft excess

and blurred reflection for E>2keV:

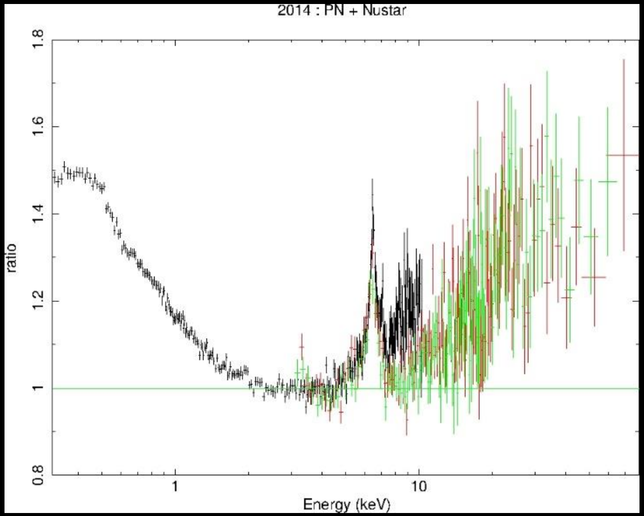
Good fit ($\chi 2 \sim 1.07$) with spin a >-0.5 (TBC)

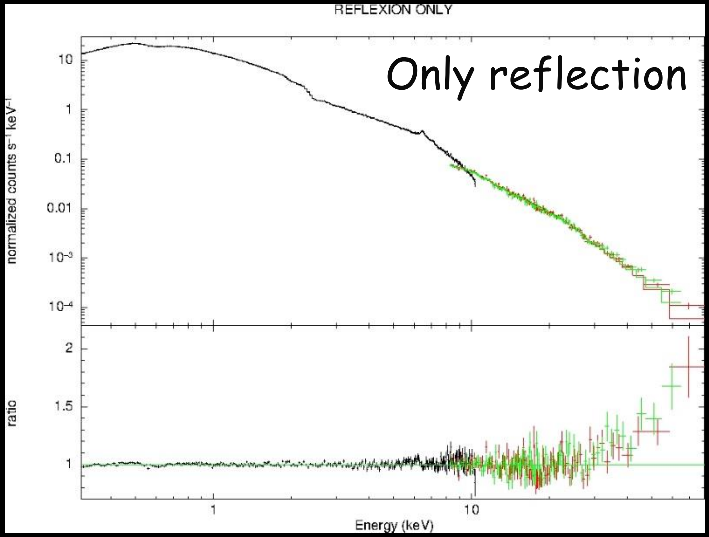


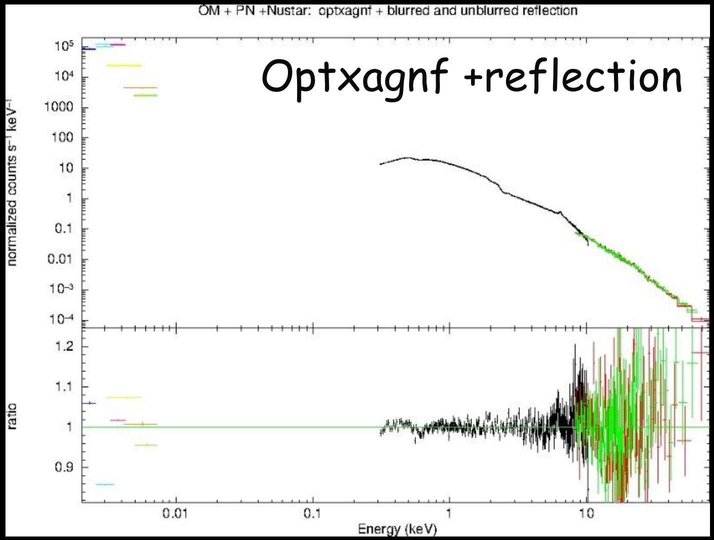
→ No discrimination between both scenario with pn only.

2014 broad-band X-ray view: (OM+) pn + Nustar

(Porquet et al.)







Summary:

2014 XMM-Newton LP + Chandra + Nustar:

- First Chandra observation of Ark 120: The FeK narrow core resolved and its width consistent with BLR

- XMM-Newton: deepest observation for a bare AGN

RGS: definitively confirmed the bare property + detection of broadened emission lines (OVII)

PN: Highest S/N of the Fe K complex
Confirmation of the significant soft excess : Both SE scenario possible

- (OM+) PN + Nustar :

For pure reflection modeling: hard X-ray excess above 30 keV
While a good fit with Comptonization + blurred reflection

Several papers to be submitted or in preparation :
RGS/HETG (Reeves et al.), FeK Complex (Nardini et al.), timing (Lobban et al.), broad-band analysis (Porquet et al.), detailed comptonization modeling (Tortosa et al.), Comptonization ⊗ reflection (Wilkins et al.), long-term spectral analysis (Matzeu et al.), …