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

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

Ark 120: brightest and cleanest bare AGN (z~0.033)

- No intrinsic reddening in its IR/optical continuum.
- No absorption signature in X-rays and UV:
  no warm absorber at least on the line of sight

⇒ *direct view of the inner part of the accretion disc*

- A prominent soft X-ray excess and a possible relativistic FeK line…

An extensive simultaneous observation campaign in March 2014:

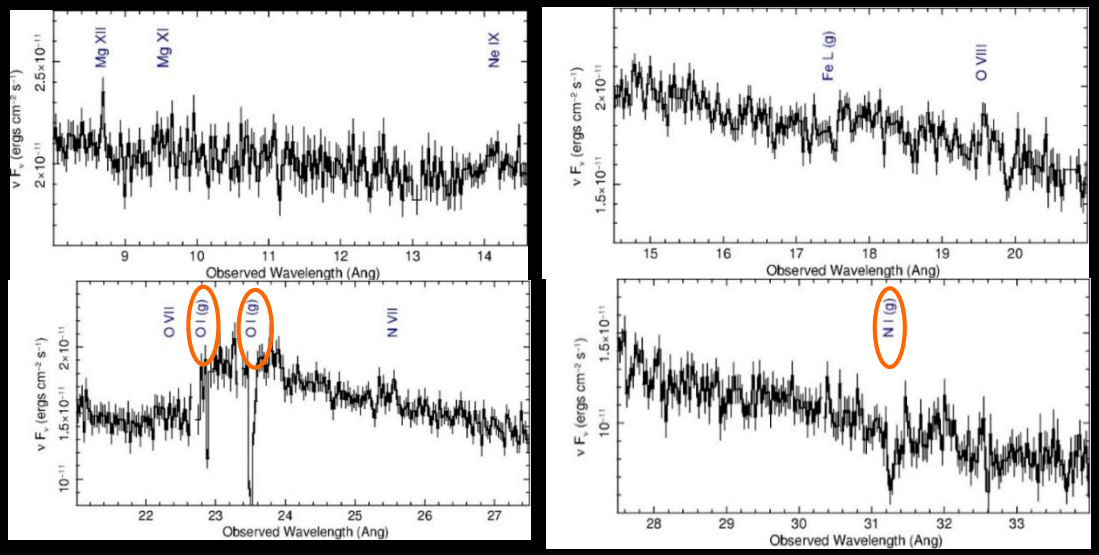
Large XMM-Newton Program of 480 ks (OM, RGS, EPIC)
(PI: D. Porquet; ~5.5 days) over 4 consecutive orbits March 18-24.
Highest S/N data and longest elapsed time observation for a bare AGN.

+ 120ks Chandra/HETG observation (PI: D. Porquet)
First Chandra observation of Ark 120.

+ 65ks Nustar observation performed during the 3rd XMM-Newton observation (PI: Nustar AGN team; 65ks)

A very deep RGS observation Ark 120

(Reeves et al. 2016, Paper I)



480 ks of RGS data
($\geq$ 6.5 x 10^5 counts,
S/N > 25 per bin)

- ✓ No ionized absorption line from Ark 120
  - → no warm absorber on the l.o.s.
  - → Confirmation of the "bare" characteristic of Ark 120
- ✓ Only neutral absorption lines from the Galactic ISM

BUT several ionized emission lines from H-like and He-like ions (N, O, Ne, Mg) from Ark 120

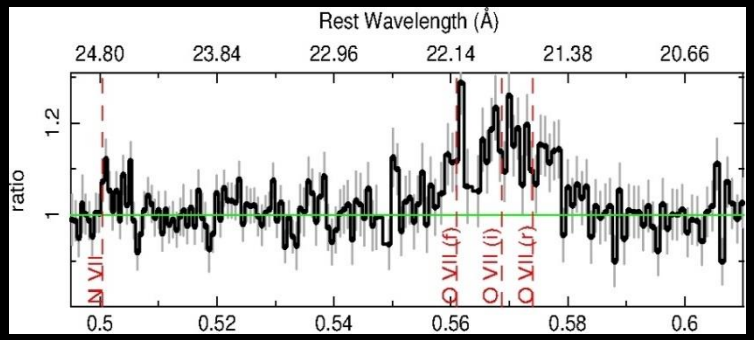
Observed for the first time for a bare AGN !

A very deep RGS observation Ark 120

Reeves et al. (2016, Paper I)

The emission ionized lines from Ark 120 :

- H-like line profiles are narrow and unresolved → pc scale (NLR)
- He-like line profiles are velocity broadened



- ✓ A blend of narrow lines can be ruled out
- ✓ Can be fitted by a blend of velocity broadened lines with a common velocity of ~4600 km/s (BLR= 5800 km/s),

→ sub-pc scale

⇒ Warm gas (~ BLR and NLR) as found generally in AGN
but here observed out of the line-of-sight (so only observed in emission)

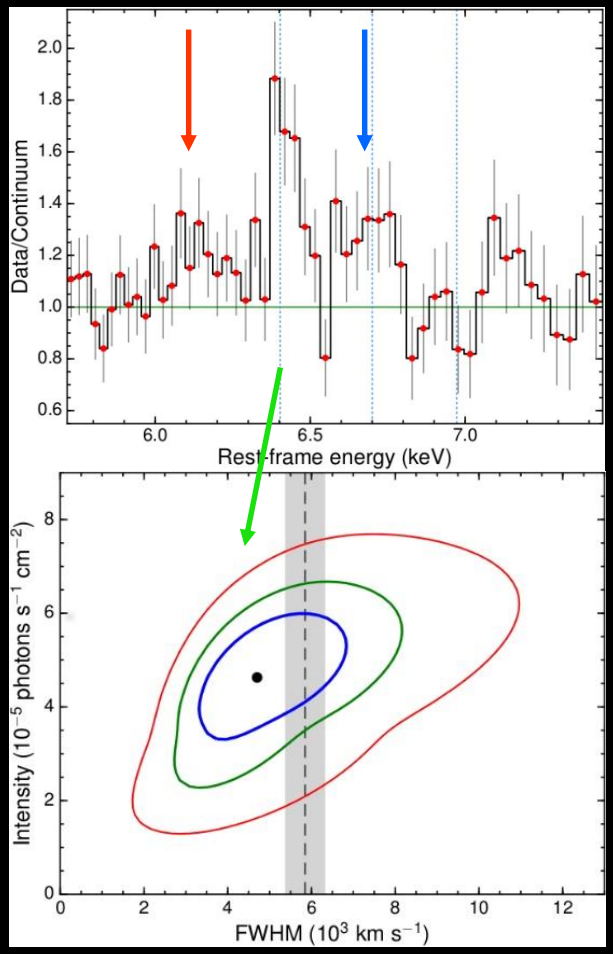
→ Ark 120 is not intrinsically bare !

⇒ Ark 120 is not a peculiar AGN type but an AGN for which the l.os. does not intercept the warm absorber.

The deep view of the FeK complex: HETG + pn

Nardini et al. (2016, Paper II)

Chandra/HETG



FeK narrow core component resolved thanks to Chandra /HETG:

E = 6.42 ± 0.02 keV

Width = 43 (+22,-15) eV
FWHM =4700 (+2700, -1500) km/s
≈ BLR (FWHM ~5800-6100 km/s)

Red and blue emission features :

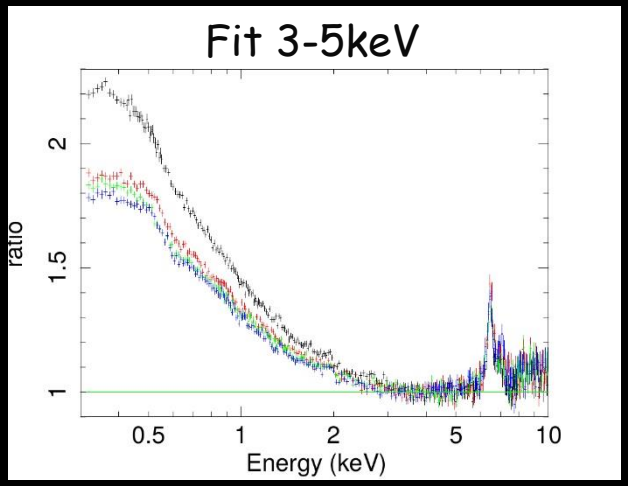
~ 6.13 keV, σ ~ 83 eV
~ 6.68 keV, σ ~ 64 eV
→ broad

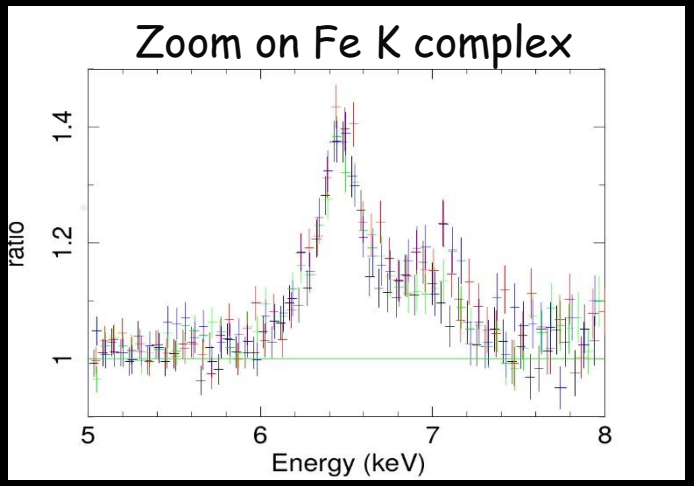
+ variable on short time-scale (pn energy-time map);
~ 30-50ks (~ 10-15 hours)
→ Located at 10s Rg from BH

+ much more results : see Emanuele's talk (Thursday)

The four consecutive pn observations Ark 120

(Porquet et al. 2017, subm. Paper IV)





$\langle\Gamma\rangle$ =1.87 ± 0.02 : typical for a radio-quiet quasar.

A prominent variable smooth soft excess, and a significant FeK complex

→ Confirmation of previous XMM-Newton and Suzaku observations (e.g., Vaughan et al. 2004, Patrick et al. 2011, Nardini et al. 2011, Walton et al. 2013, *Matt et al. 2014*)

The four consecutive pn observations Ark 120

(Porquet et al. 2017, subm. Paper IV)

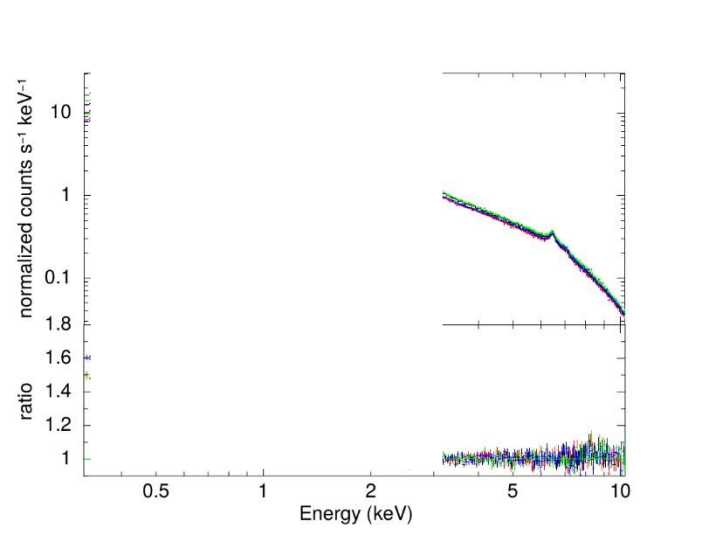
- Fit of the four pn spectra above 3 keV with a relativistic reflection model (relxill: Dauser et al. , Garcia et al.) (+ BLR FeK emissions)

→ Very good statistical fit ($\chi^2_{(reduced)} \sim 1$) :

$\Gamma \sim 1.85$-1.92, small reflection fraction ~0.4-0.5

BUT either very flat disk emissivity index $q \leq 1.1$ for R_{in} = ISCO

or $R_{in} \geq 56\ R_g$ ($R_g = GM/c^2$) assuming a standard $q = 3$



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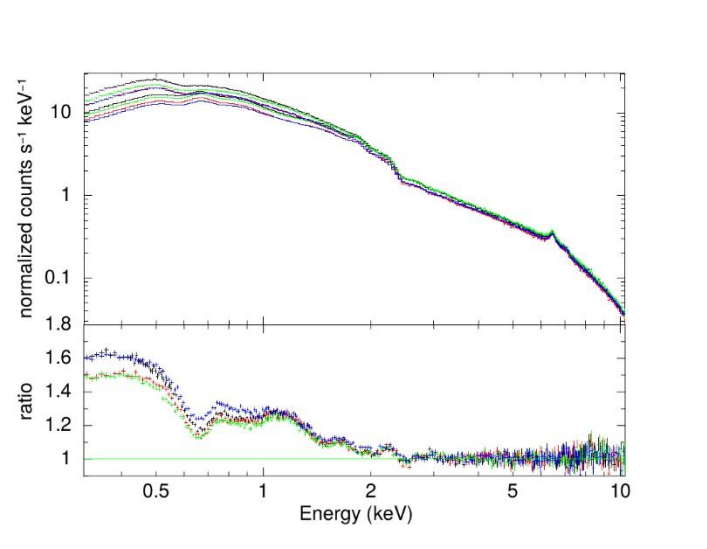
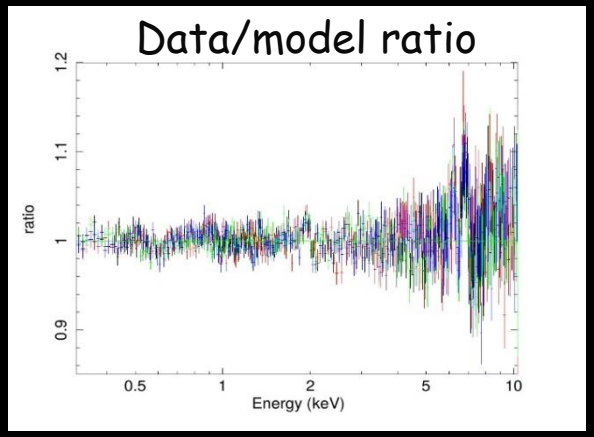


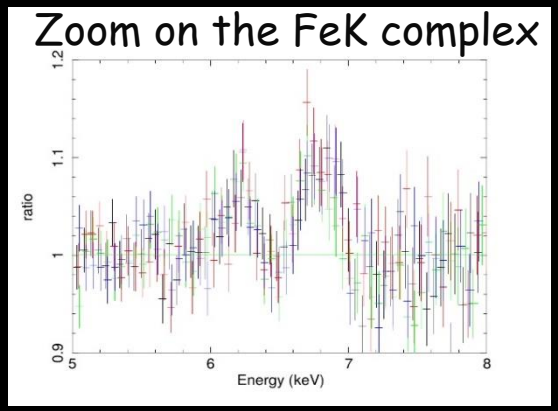
When extrapolated down to 0.3keV
the soft X-ray excess is not accounted for

The four consecutive pn observations Ark 120

(Porquet et al. 2017, subm., Paper IV)

Fit with relxill over the 0.3-10keV energy range:





To fit the featureless soft excess: extrem and fine-tuned values are found: Spin ~ 0.97 reflection fraction ~ 10, q_1 ~ 7—8, Γ ~ 2.4-2.5 !
$\neq$ From fit above 3keV reflection (R ~ 0.4-0.5, $q \leq 1.1$, Γ ~ 1.9)

$\rightarrow$ red and blue emission disk features still present !

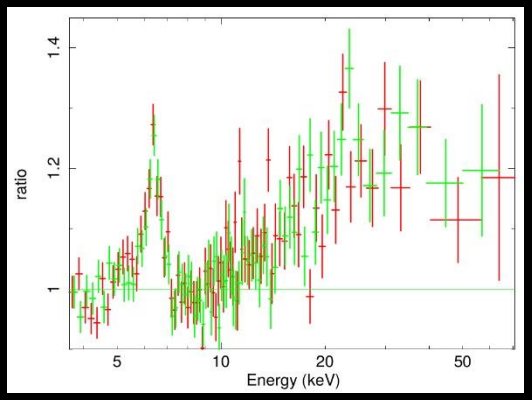
Due to a more complex disk emissivity shape (twice broken powerlaw shape), or ionization gradient, or lamppost geometry, … ? NO

$\Rightarrow$ Relativistic reflection models cannot simultaneously account for both the soft X-ray excess and the FeK red and blue disk features.

Broad-band X-ray view on 2014 March 22: pn + Nustar

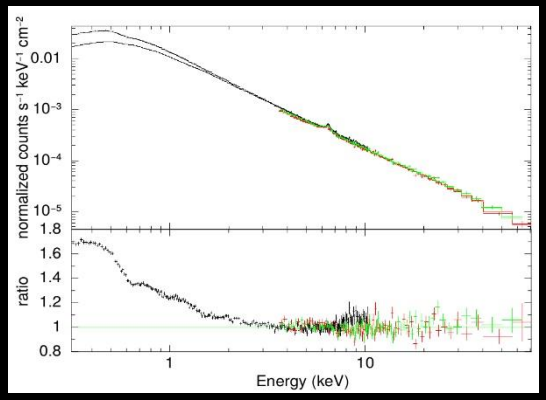
(Porquet et al. 2017, subm. Paper IV)

NuSTAR FPMA and FPMB



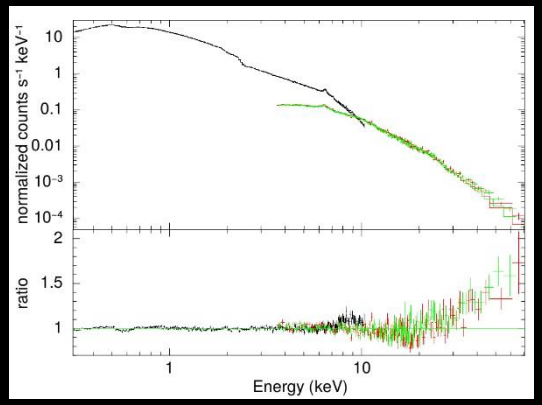
⇒ Prominent FeK complex
+ hard X-ray « hump »

Fit above 3keV and extrapolation



→ Soft excess is not accounted for

Fit over 0.3-79keV



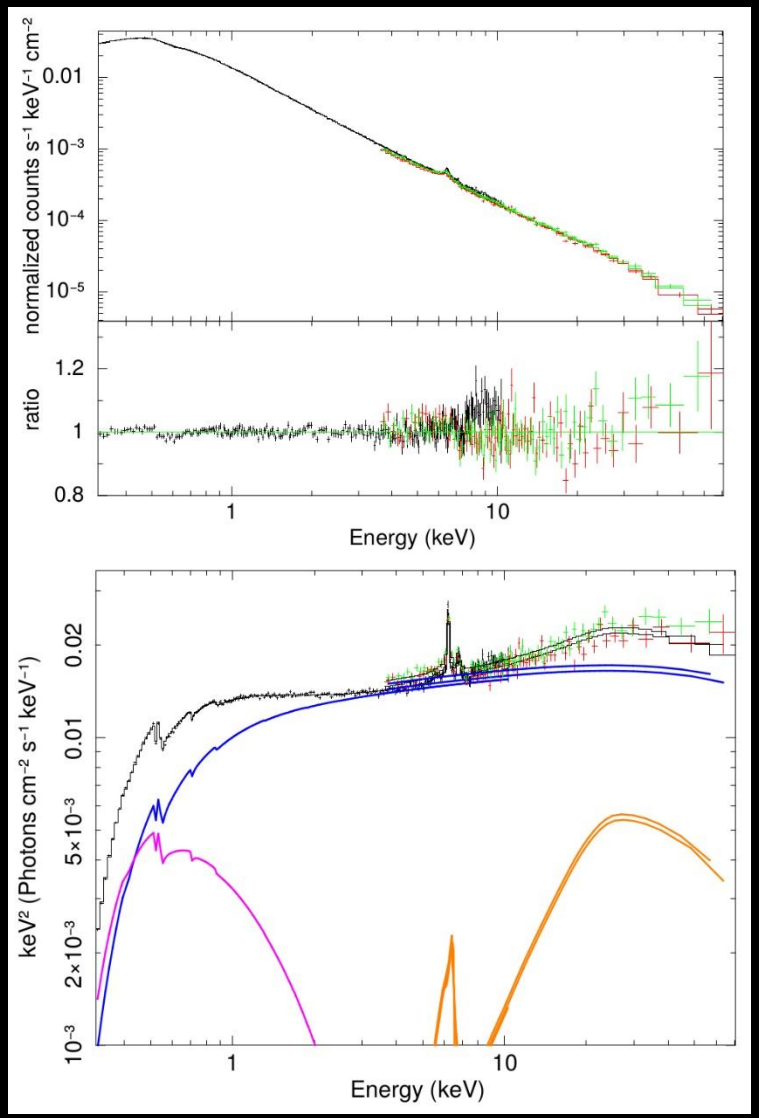
⇒ X-ray excess above 30keV

Relativistic reflection emission not able to account for both the soft and hard X-ray excesses

whatever models used (emissivity shape, ionization gradient, geometry, density, ….) .

Broad-band X-ray view on 2014 March 22: pn + Nustar

(Porquet et al. 2017, subm. Paper IV)



Best fit model:

- Soft Comptonization (comptt)

kTe ~0.5 keV optical depth ~ 9

→ Warm optically thick corona

- Hard comptonization (cutoff PL)

Hot optically thin corona
Γ~1.9

- Relativistic reflection (relxill)

R_{in} ~26 R_g

⇒ 2014 X-ray spectra dominated by warm and hot Comptonization
+ relativistic reflection at 10s R_g

Summary of this 2014 campaign on Ark120:

Deep RGS spectrum (Reeves et al. 2016)

✓ No X-ray absorption lines (i.e no warm absorber along the l.os.): bare !

✓ Detection for the first time of soft X-ray emission lines
→ warm gas out of the l.o.s (~ BLR and NLR)
→ Not intrinsically bare ! Match the Unified scheme
→ Not a peculiar type of AGN.

Chandra/HETG + deep pn (Nardini et a. 2016)

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

+ discovery of red and blue transient features from the accretion disk

The broad-band X-ray spectrum: pn + NuSTAR (Porquet et al. 2017)

Soft variable and smooth X-ray excess + FeK complex + hard X-ray excess

- Relativistic reflection models unable to account simultaneously for the soft X-ray excess, the red and blue disk features and the hard X-ray excess

- X-ray broad-band spectra dominated by Comptonization with Comptonization from warm (kT~0.5keV) optically thick corona (τ~8) + from hot optically thin corona + mildly relativistic reflection at 10s R_g