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

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

Ark 120: brightest and cleanest bare AGN ( $z \sim 0.033$ )

- 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.

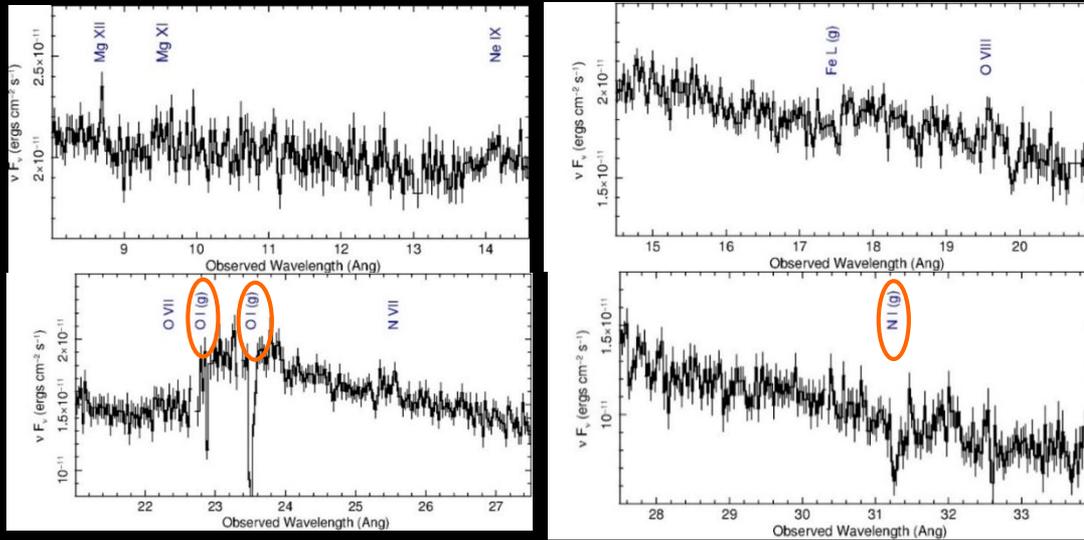
+ 120ks Chandra/HETG observation (PI: D. Porquet)

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  
( $\geq 6.5 \times 10^5$  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

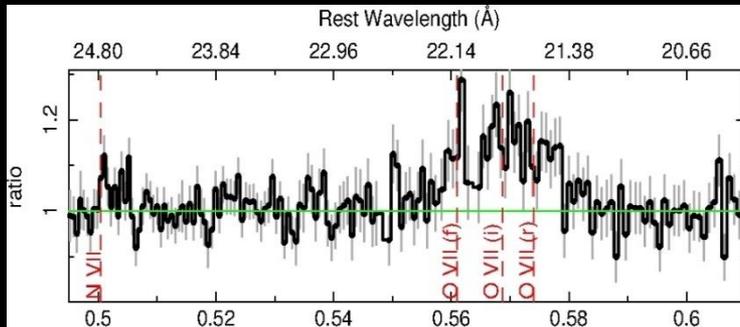
Observed for the first time for a bare AGN !

# 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



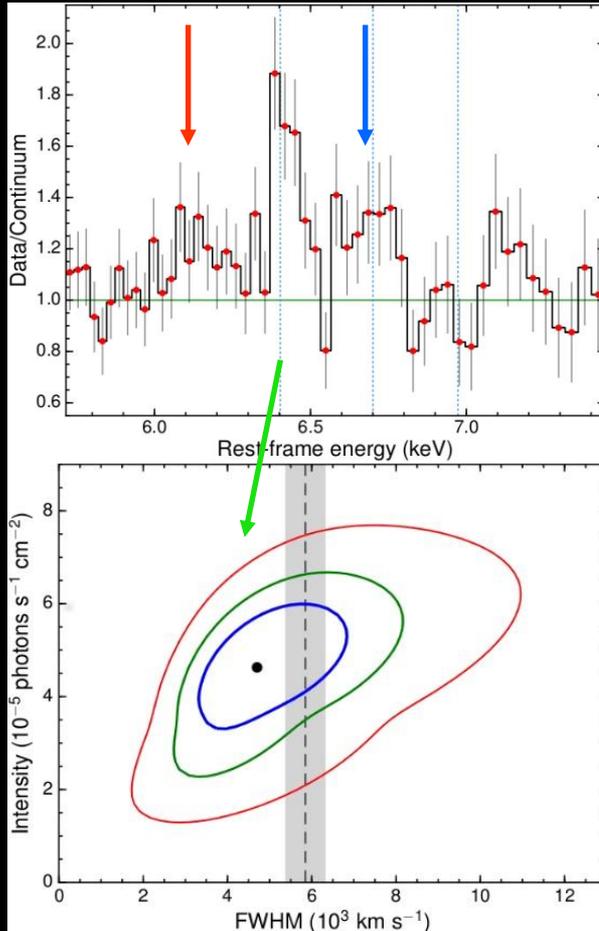
- ✓ A blend of narrow lines can be ruled out
- ✓ Can be fitted by a blend of velocity broadened lines with a common velocity of  $\sim 4600$  km/s (BLR= 5800 km/s),  
→ sub-pc scale

- ⇒ Warm gas ( $\sim$  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:

$$E = 6.42 \pm 0.02 \text{ keV}$$

$$\text{Width} = 43 (+22, -15) \text{ eV}$$

$$\text{FWHM} = 4700 (+2700, -1500) \text{ km/s}$$

$\approx$  BLR (FWHM  $\sim$  5800-6100 km/s)

**Red** and **blue** emission features :

$$\sim 6.13 \text{ keV}, \sigma \sim 83 \text{ eV}$$

$$\sim 6.68 \text{ keV}, \sigma \sim 64 \text{ eV}$$

$\rightarrow$  broad

+ variable on short time-scale (pn energy-time map);

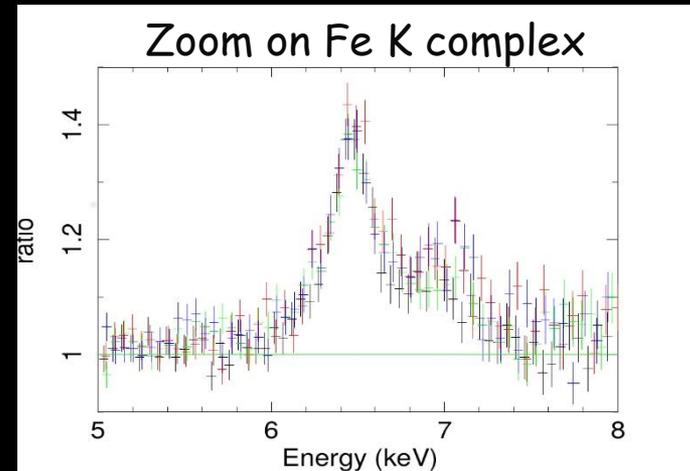
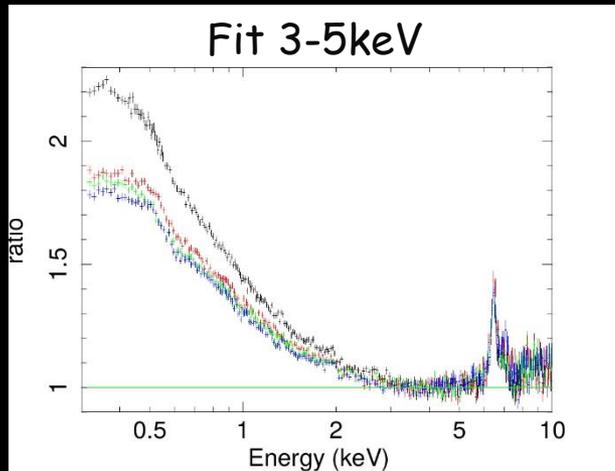
$\sim$  30-50ks ( $\sim$  10-15 hours)

$\rightarrow$  Located at 10s  $R_g$  from BH

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

# The four consecutive pn observations Ark 120

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



$\langle \Gamma \rangle = 1.87 \pm 0.02$  : 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)

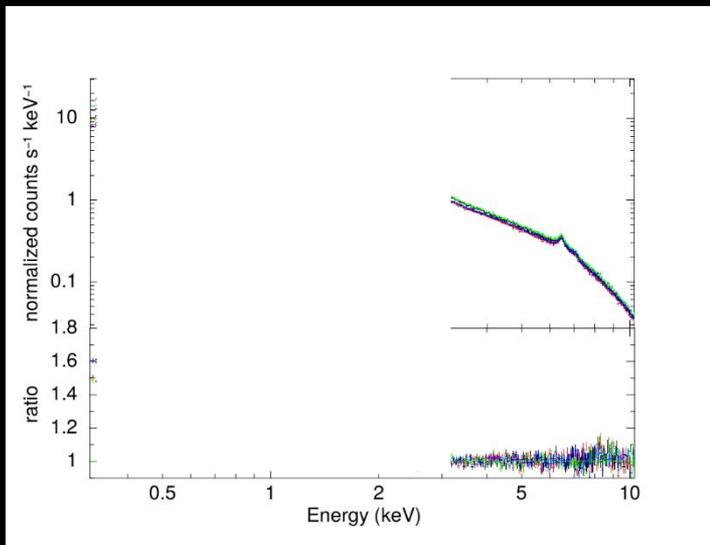
- Fit of the four pn spectra above 3 keV with a relativistic reflection model (relxill: Dauser et al. , Garcia et al.) (+ BLR FeK emissions)

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

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

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

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



# The four consecutive pn observations Ark 120

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

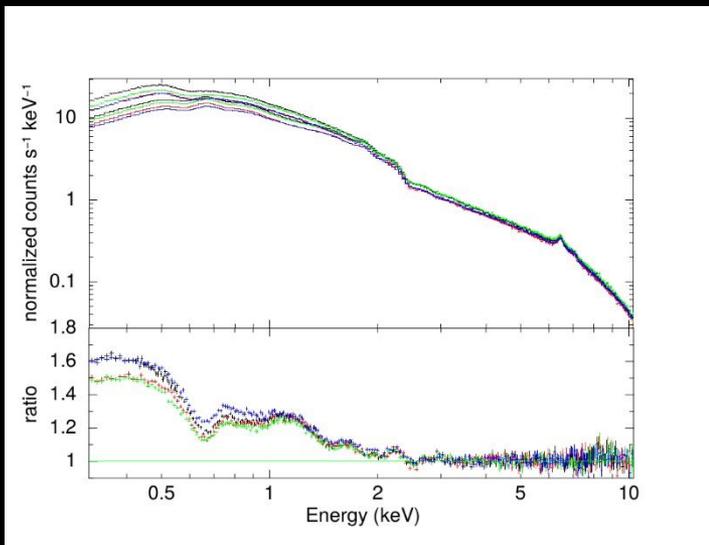
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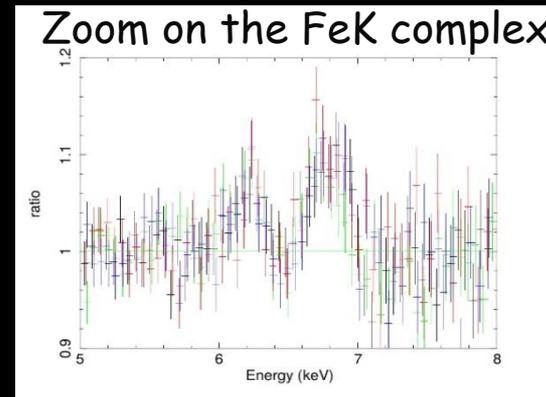
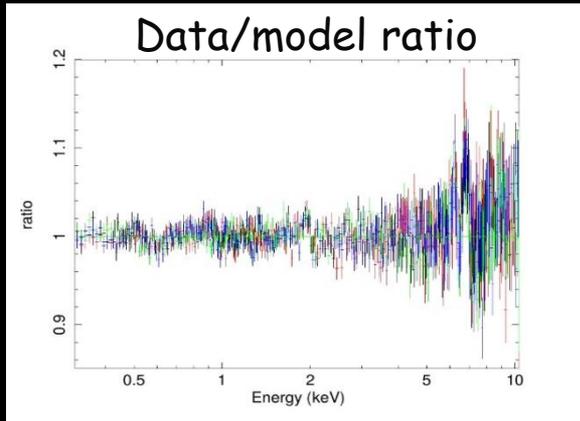


When extrapolated down to 0.3keV  
the soft X-ray excess is not accounted for

# 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  $\sim 0.97$  reflection fraction  $\sim 10$ ,  $q_1 \sim 7-8$ ,  $\Gamma \sim 2.4-2.5$  !  
 $\neq$  From fit above 3keV reflection ( $R \sim 0.4-0.5$ ,  $q \leq 1.1$ ,  $\Gamma \sim 1.9$ )

→ red and blue emission disk features still present !

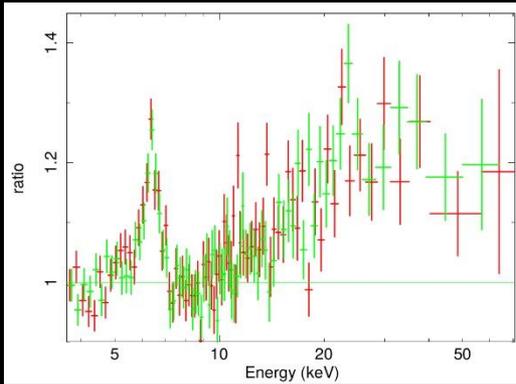
Due to a more complex disk emissivity shape (twice broken powerlaw shape), or ionization gradient, or lamppost geometry, ... ? NO

⇒ 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

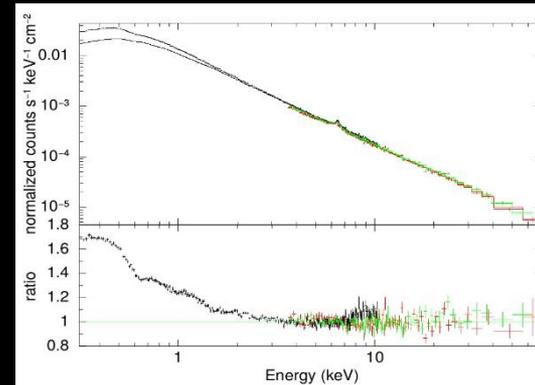
(Porquet et al. 2017, subm. Paper IV)

NuSTAR **FPMA** and **FPMB**



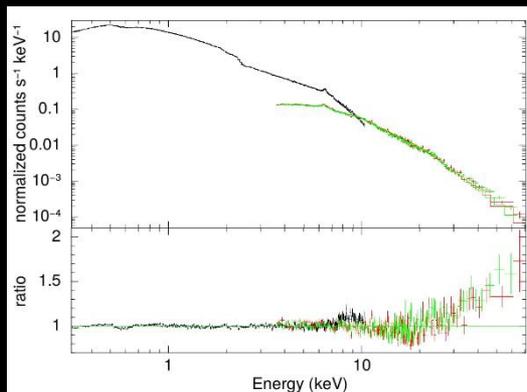
⇒ Prominent FeK complex  
+ hard X-ray « hump »

Fit above 3keV and extrapolation



→ Soft excess is not accounted for

Fit over 0.3-79keV



⇒ X-ray excess above 30keV

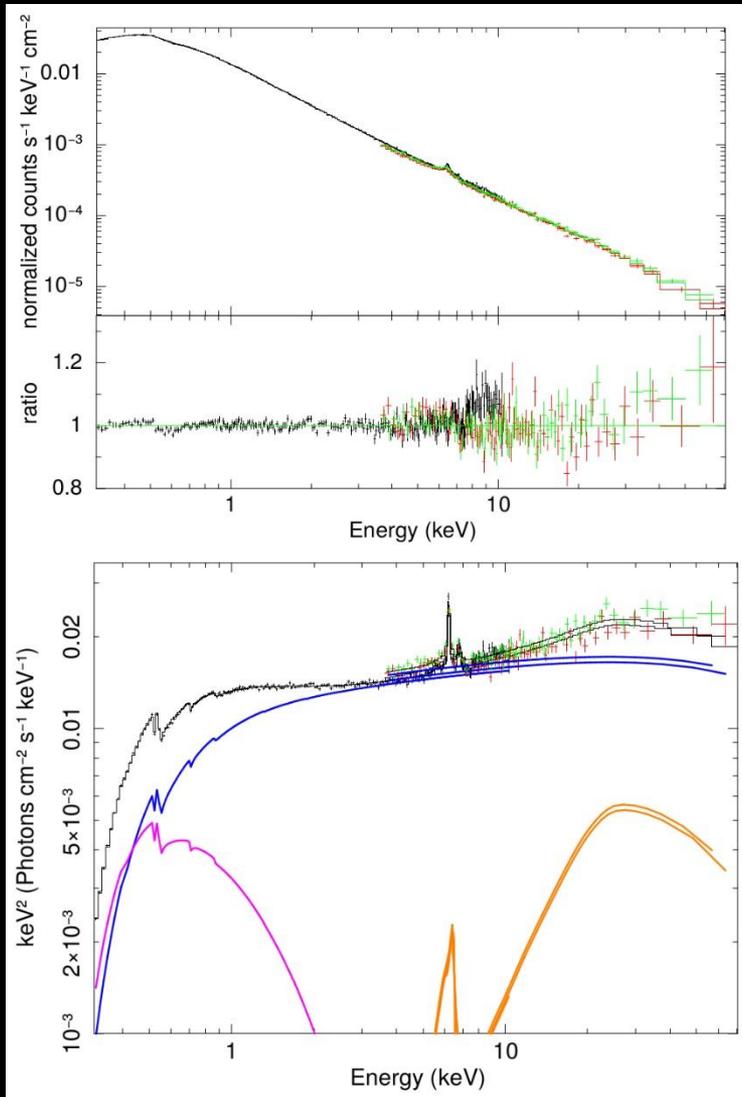
Relativistic reflection emission not able to account for both the soft and hard X-ray excesses

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)**  
 $kT_e \sim 0.5 \text{ keV}$     optical depth  $\sim 9$   
→ Warm optically thick corona
  - **Hard comptonization (cutoff PL)**  
Hot optically thin corona  
 $\Gamma \sim 1.9$
  - **Relativistic reflection (relxill)**  
 $R_{\text{in}} \sim 26 R_g$
- ⇒ 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.o.s.): 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 ( $kT \sim 0.5 \text{ keV}$ ) optically thick corona ( $\tau \sim 8$ ) + from hot optically thin corona + mildly relativistic reflection at  $10s R_g$