The changing X-ray corona in Ark 120

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Outline

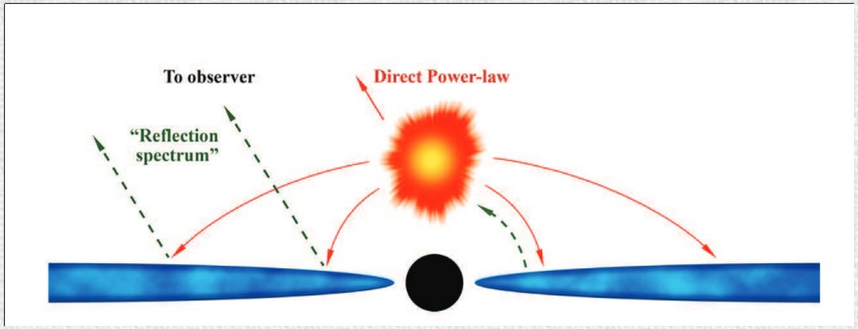
Introduction

The source – Ark 120

The Model – MoCA

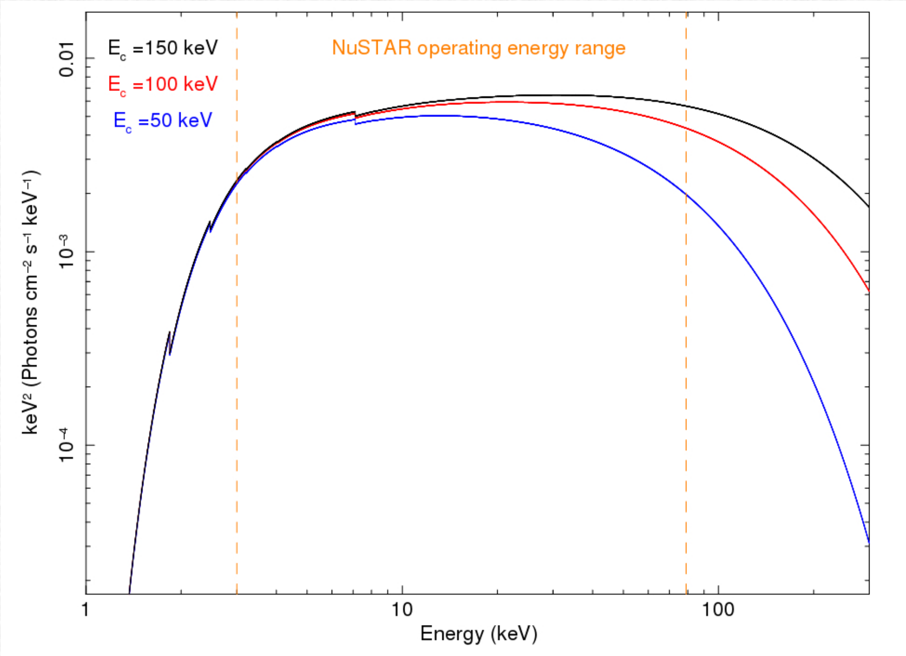
The results

Coronal parameters in local Seyfert galaxies



One of the main open problem for AGN is the nature of the primary X-ray emission.

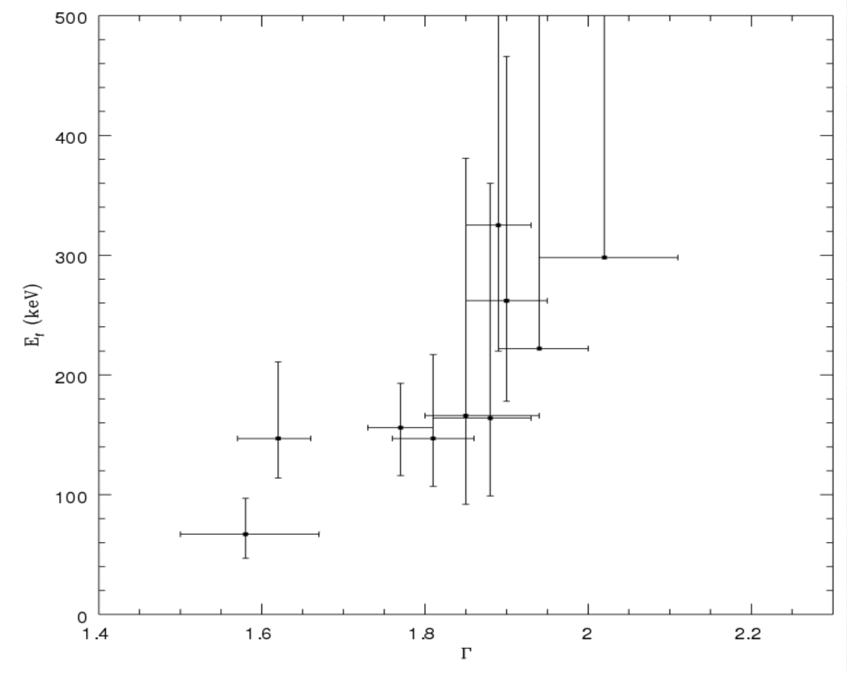
It is due to Comptonization of soft photons, but the geometry, optical depth and temperature of the emitting corona are largely unknown.



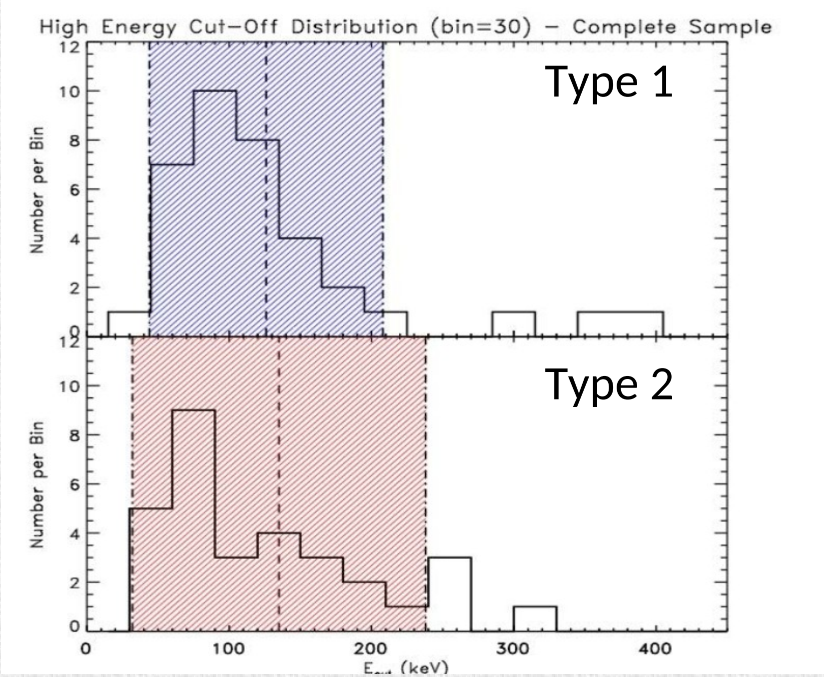
Most popular models imply E_{cut}=2-3x kT_e (Petrucci+00,+01), so measuring E_{cut} helps constraining Comptonization models.

Coronal parameters in local Seyfert galaxies

Before the launch of NuSTAR, we only had a handful of results based on non-focusing, and therefore strongly background-dominated, satellites (BeppoSAX-PDS, Suzaku HXD-PIN, INTEGRAL, Swift-BAT)

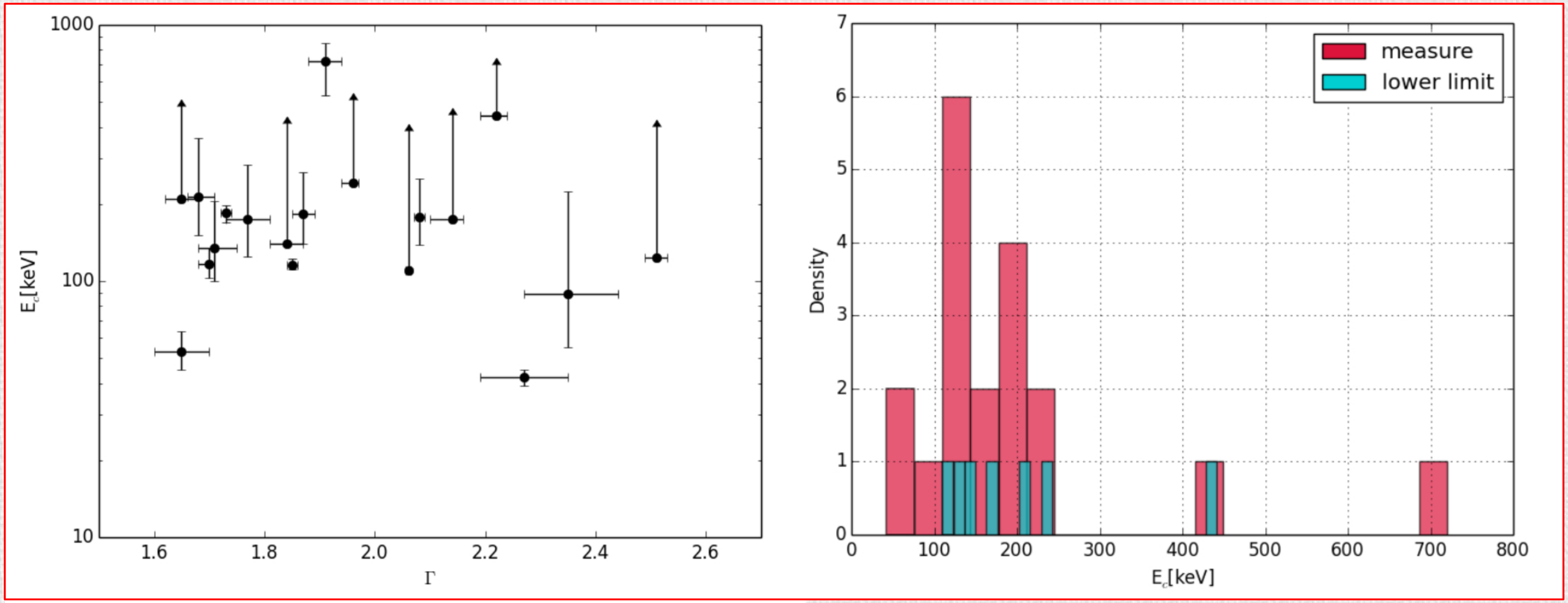


Perola+02



De Rosa+12; Molina+13

Coronal parameters in local Seyfert galaxies



Tortosa+, in prep.

So far, about twenty sources have been observed and their primary continua investigated.

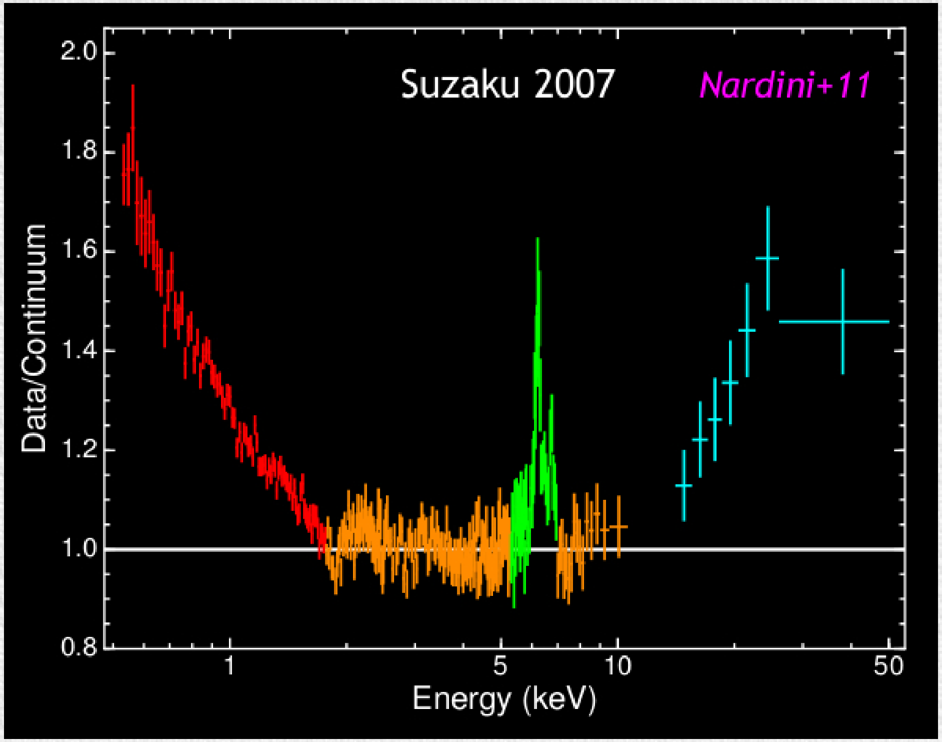
No statistically significant correlations are found with accretion rate/BH mass.

Ark 120 – A 'bare Seyfert' galaxy

- Nearest and brightest
  D = 144 Mpc
  $F_X = 7\times10^{-11}$ erg/cm^2/s

- Bare line of sight (Reeves+16)
  $N_H <$ a few 10^{19} cm^{-2}

- BH mass known from reverberation mapping
  $M_{BH} = 1.5\times10^8 M_{sun}$



2013 X-ray campaign (PI: G. Matt)
- One XMM-Newton orbit (net exposure 80 ks)
- Simultaneous NuSTAR observation (80 ks)

2014 X-ray campaign (PI: D. Porquet)
- Four consecutive XMM-Newton orbits (7.5 days, net exposure 330 ks)
- Chandra HETG spectrum overlapping with XMM#2 + XMM#3 (120 ks)
- NuSTAR observation simultaneous with XMM#3 (65 ks)

Ark 120 – A 'bare Seyfert' galaxy

Matt+2013
- Soft X-ray excess due to Comptonization
- No relativistic Iron Kα detected

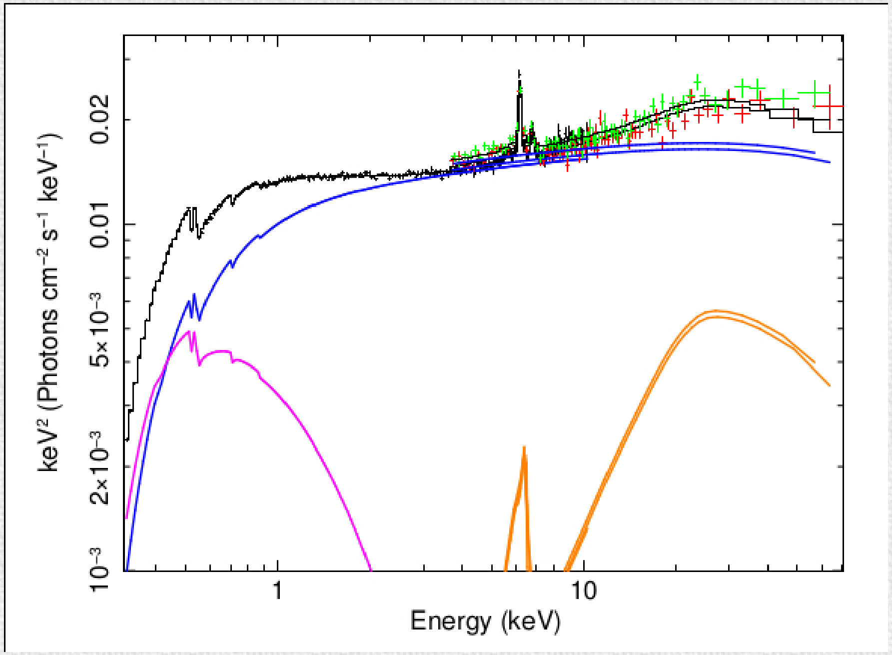
Reeves+2016 (Paper I)
- XMM RGS data analyzed and N_H inferred
- Several emission lines associated with the AGN detected

Nardini+2016 (Paper II)
- Chandra HETGS analyzed and more complex Iron Kα structure revealed
- Accretion disk hotspots originating at 60-120 r_g

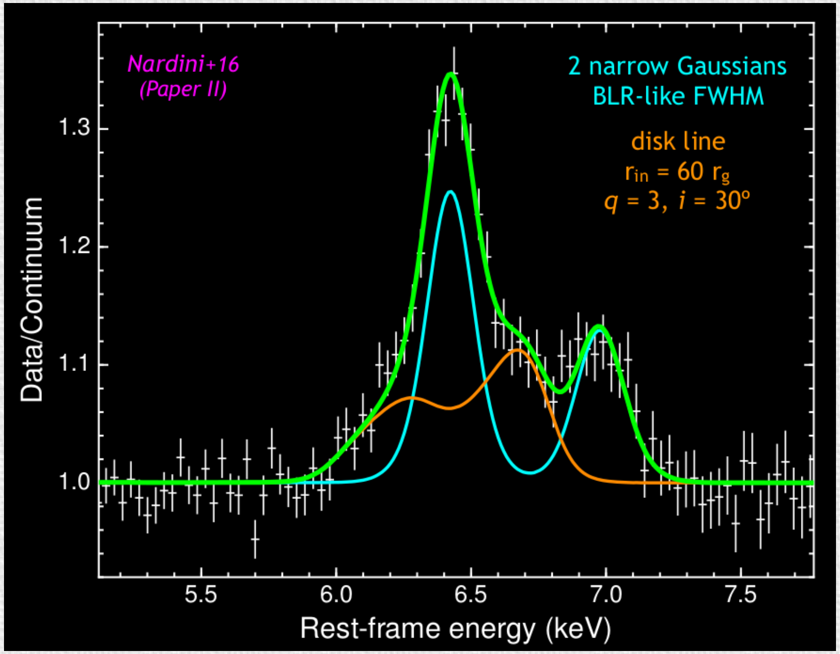
Lobban+2017 (Paper III)
- Timing analysis of the XMM EPIC-pn data
- Previous findings are confirmed

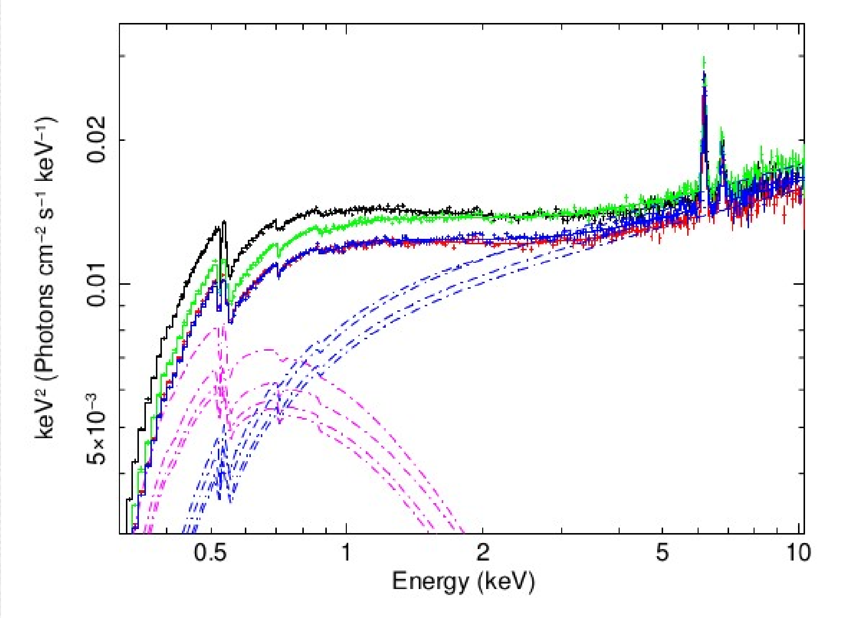
Porquet+2017 (Paper IV)
- Comprehensive study of the XMM/NuSTAR 2014 campaign
- Warm+Hot Comptonization, relativistic reflection from ~25 r_g

Ark 120 – The overall scenario



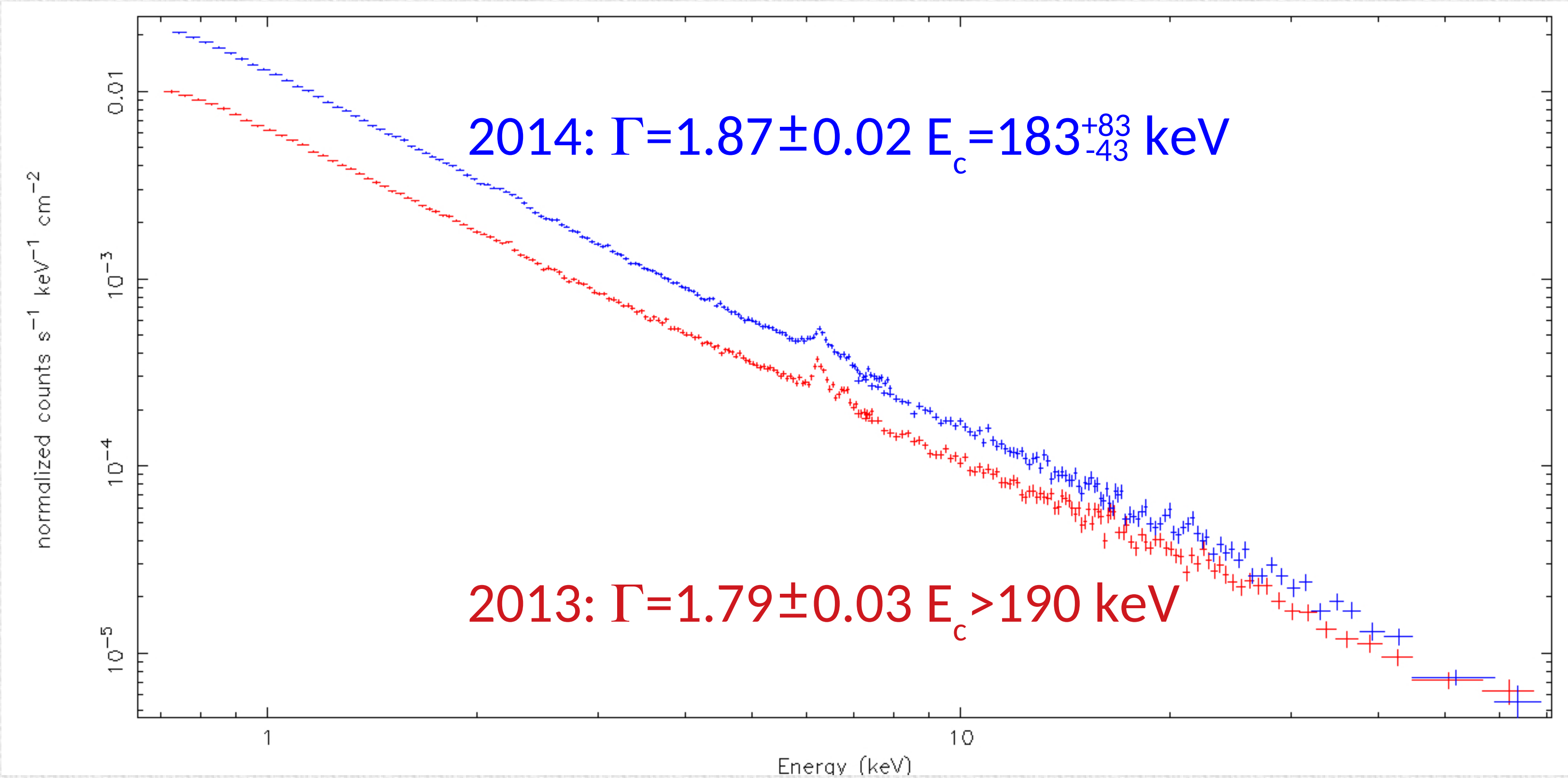
Porquet+2017





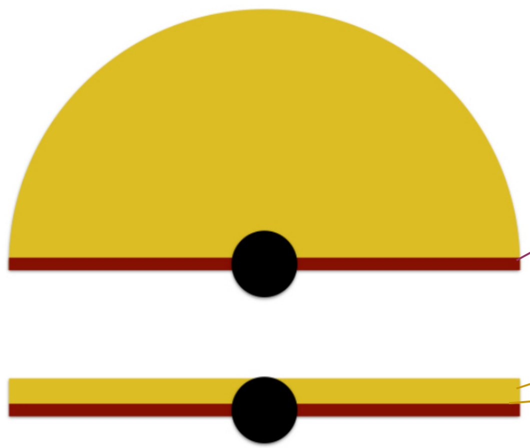
In the four XMM observations taken in 2014, both the hot and warm Comptonization components are found to be variable in amplitude.

Ark 120 – The overall scenario



A significant steepening has been observed in the 2014 XMM/NuSTAR spectra: our aim is to investigate the hot coronal component.
The warm Comptonization is found to be variable only in terms of relative normalizations, while kT and τ are compatible (kT=0.5 keV, τ=10).

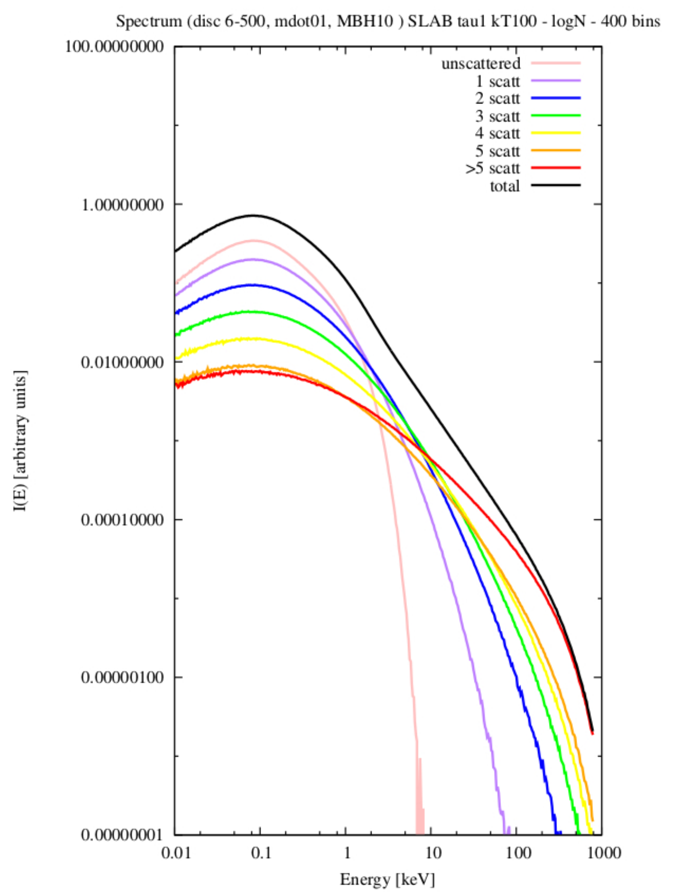
A MC code for Comptonization in Astrophysics (MoCA)



$$T(R) = \left[\frac{3GM\dot{m}}{8\pi R^3\sigma_{SB}}\left(1-\sqrt{\frac{R_{in}}{R}}\right)\right]^{\frac{1}{4}}$$

kT_e

$d\tau = n_e \sigma_{kn}\, dx$



Assumptions and advantages:

1. Shakura-Sunyaev neutral accretion disc
2. Extended coronae
3. Single photon approach
4. Polarization signal

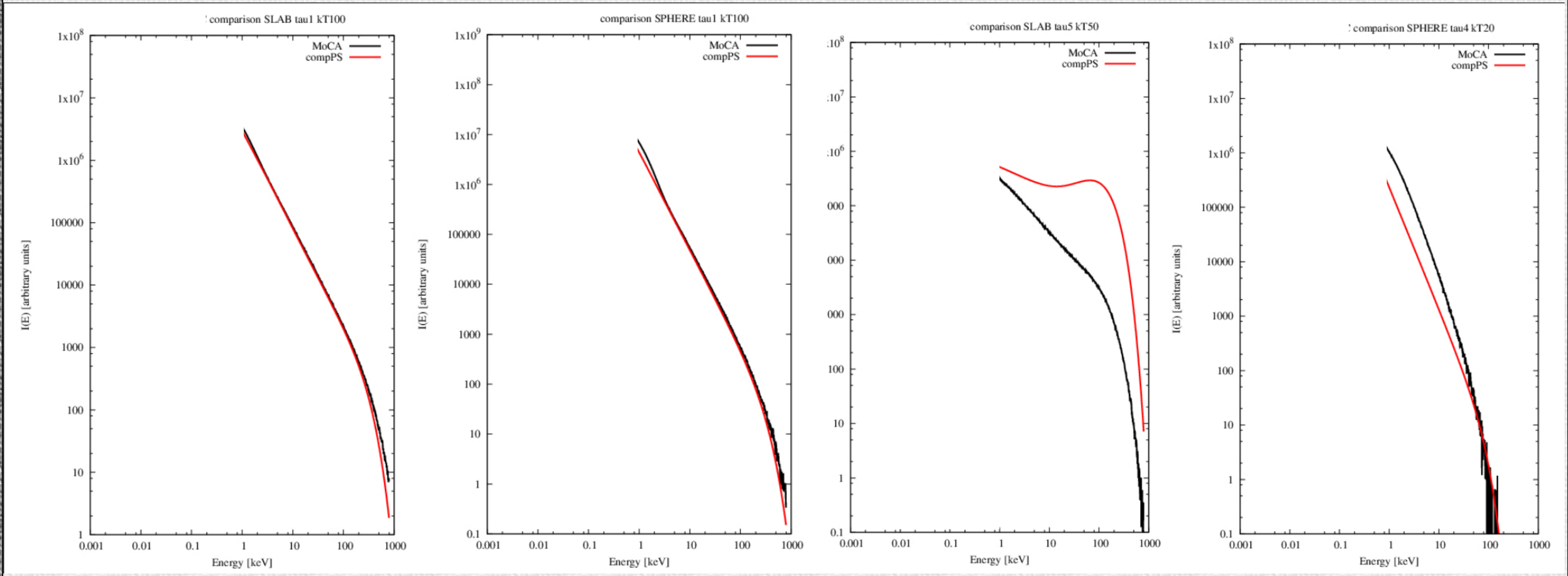
We generated two table models (slab, sphere) in the ranges:

kT: 40-120 keV

τ:0.5-2.5

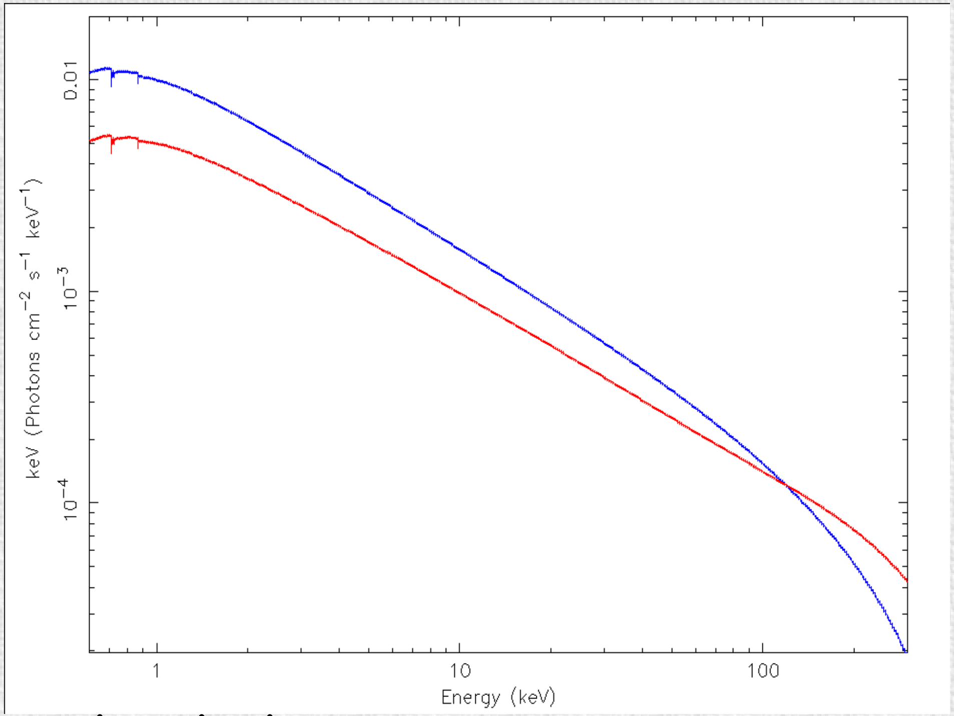
Tamborra+, submitted

A MC code for Comptonization in Astrophysics (MoCA)



Different Comptonization codes (comptt, compPS) give similar predicted spectra but cannot be applied to particular ranges of kT and optical depth.

Results



Marinucci +, in prep.

Once we apply the two models to the XMM/NuSTAR data set we are not able to statistically discriminate between a spherical or slab geometry.
(Reduced χ^2=1.05 for 750 d.o.f.)

SLAB		SPHERE	
kT=65±10 keV	kT=110±10 keV	kT=105±10 keV	kT>95 keV
τ=1.2±0.2	τ=1.2±0.2	τ=1.1±0.2	τ=1.5±0.3

A clear evolution in the hot coronal configuration is observed.
This could be due to geometrical effects (changes in the height/truncation radius?) or to the heating/cooling mechanism.

Conclusions

Two different Comptonization systems (warm/hot coronae) are necessary to explain the spectral behavior of Ark 120

Detailed studies (Paper I-V) of the long 2014 observing campaign have provided a unique insight on the disk-corona environment in this bare AGN

Perfect example of the synergy between the major X-ray observatories (NuSTAR-XMM-Chandra).

References:

- Paper I: Reeves et al. 2016, ApJ 828, 98
- Paper II: Nardini et al. 2016, ApJ 832, 45
- Paper III: Lobban et al. 2017 arXiv.1707.05536
- Paper IV: Porquet et al. 2017 arXiv.1707.08907
- Paper V: Marinucci et al., in prep.