



The broad band view of AGN

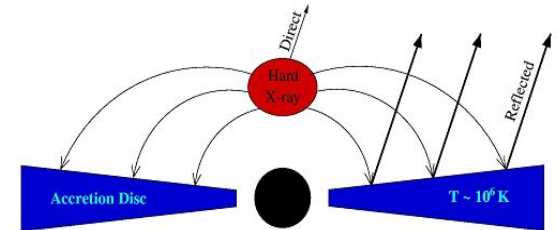
Giorgio Matt

(Universita' Roma Tre, Italy)

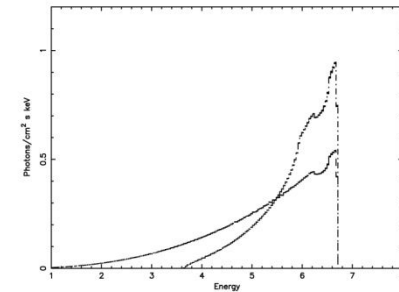
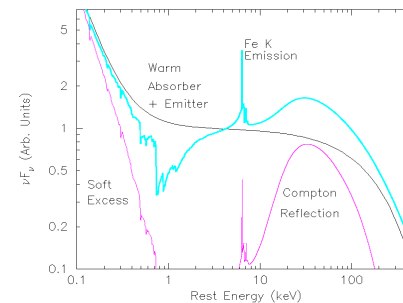
***On behalf of the NuSTAR AGN Physics WG
(see <http://www.nustar.caltech.edu/for-astronomers/science-working-groups>)***

Scientific rationale

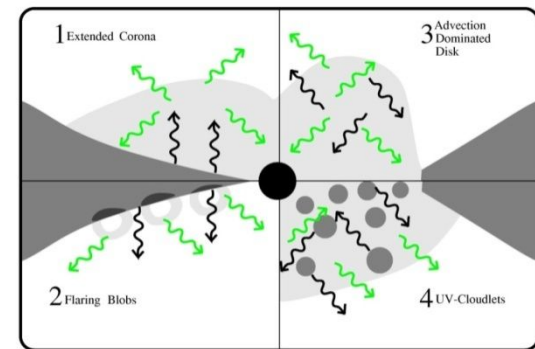
❖ Determine the physical parameters of the hot corona (temperature, optical depth)



❖ Measure the spin of the Black Hole



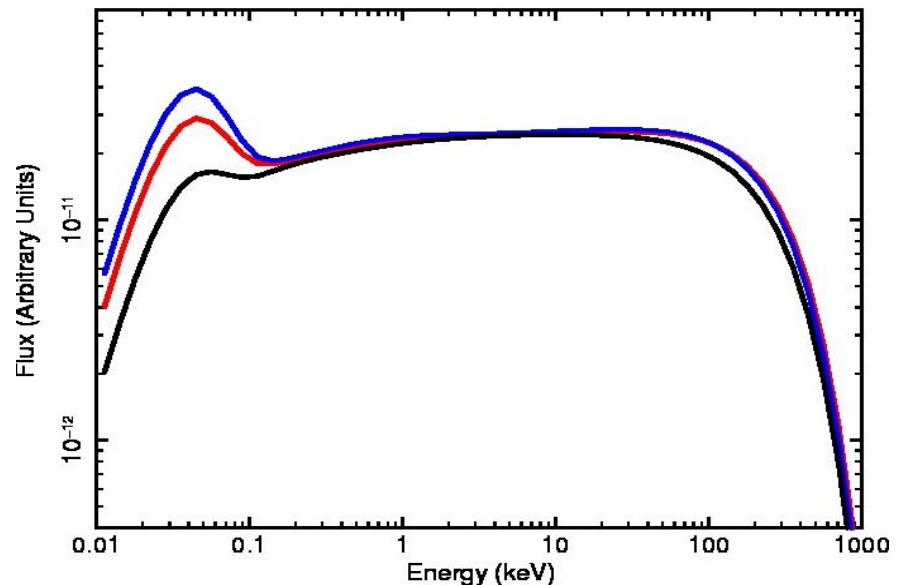
❖ Search for similarities and differences between radio quiet and radio loud AGN



Scientific rationale

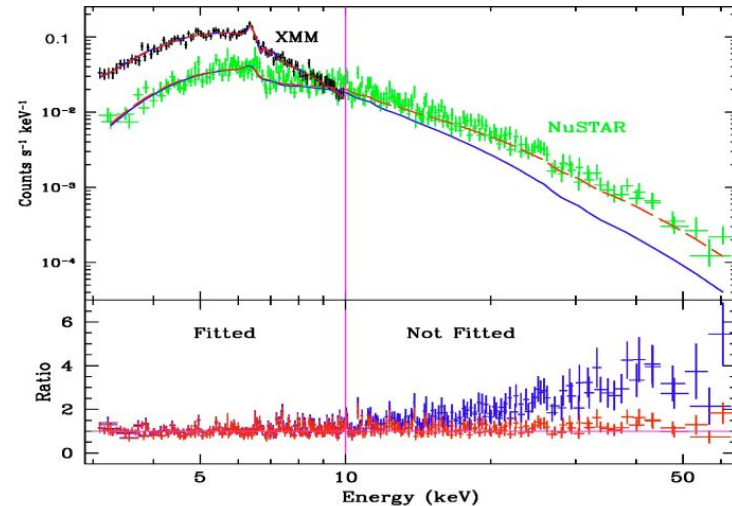
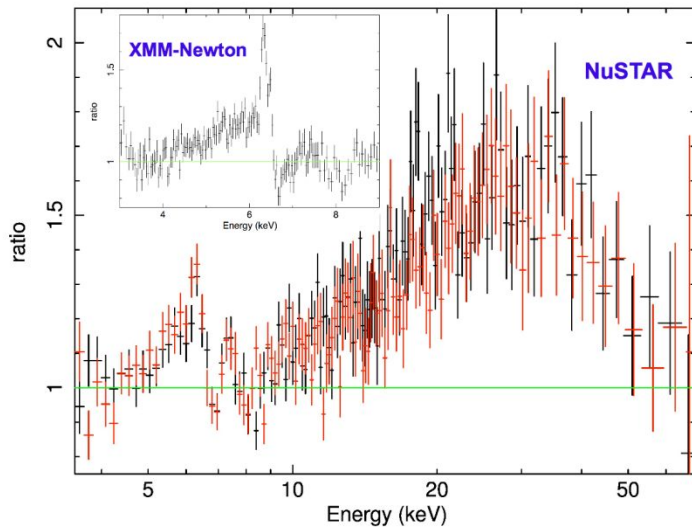
One of the main open problem for AGN (and the most important which requires observations in hard X-rays) is the origin of the primary X-ray emission. It is almost certainly Comptonization, but the geometry, optical depth and temperature of the emitting corona are largely unknown (we are not even sure that the electron population is in thermal equilibrium).

Most popular models assume thermal Comptonization with temperatures in between tens and hundreds keV, which imply a quasi-exponential cut-off with $E_c \sim 2-3kT$. So far, we have only a handful of results based on non focusing, and therefore strongly bkg-dominated, satellites (BeppoSAX-PDS, Suzaku-PIN, INTEGRAL, Swift-BAT).



Scientific rationale

- Precise and reliable measurements of the BH spin require a good understanding of the continuum emission (see the case of NGC1365, Risaliti et al. 2013)



- Is the emission of (non-blazar) Radio Galaxies similar to that of Seyferts? Is the reflection really less important? Is emission really due to ADAF? What is the contribution of jet emission?

List of observations in the AGN Physics NUSTAR Program

- 4 sources observed simultaneously with XMM [**Swift J2127.4+5654**, **MCG-6-30-15**, **3C120**, **Ark 120**] for BH spin and corona T
- 2 sources observed simultaneously with Suzaku [**IC4329A**, **NGC4151**] for BH spin and corona T
- **MCG-5-23-16** observed twice, the second time simultaneously with Suzaku
- **Mrk 335** observed twice, in coordination with Suzaku, during an extended low state
- A monitoring campaign on **NGC4051**
- NuSTAR is joining the XMM-led monitoring campaign on **NGC5548**
- A few Radiogalaxies [**Cygnus A**, **Centaurus A**, **3C390.3**] (+3C120) observed or planned
- Two more RQ sources, **NGC3783** and **Fairall 9**, to be observed, hopefully in coordination with XMM

Content of the talk

- **IC4329A** (Brenneman et al., in preparation)
- **MCG-5-23-16** (Baloković et al., in preparation)
- **SwiftJ2127.4+5654** (Marinucci, Matt, work in progress)
- **Ark 120** (Matt, very preliminary)

- **MCG-6-30-15** → *see talks by M. Parker and A. Marinucci*
- **NGC 4051** → *see talk by G. Risaliti*

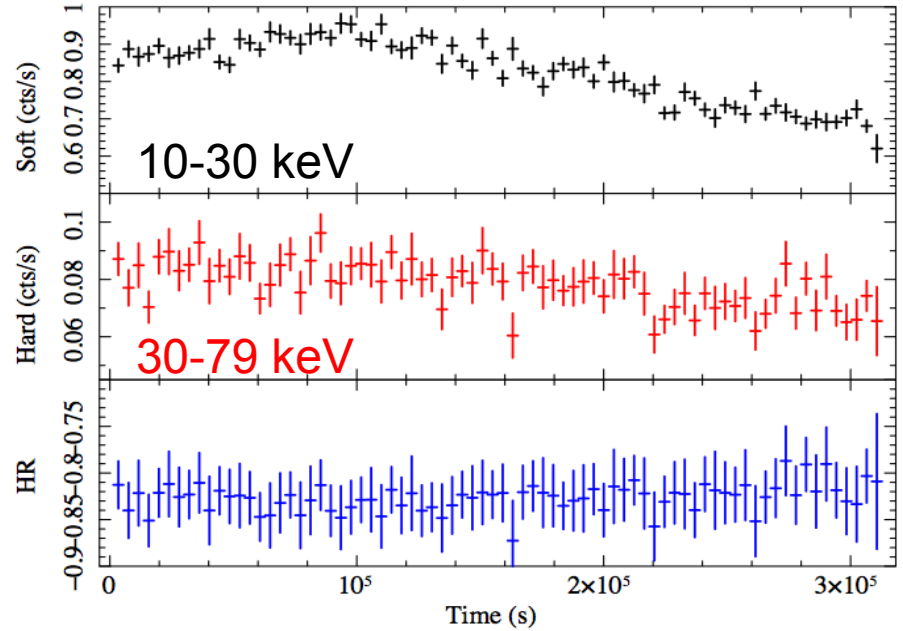
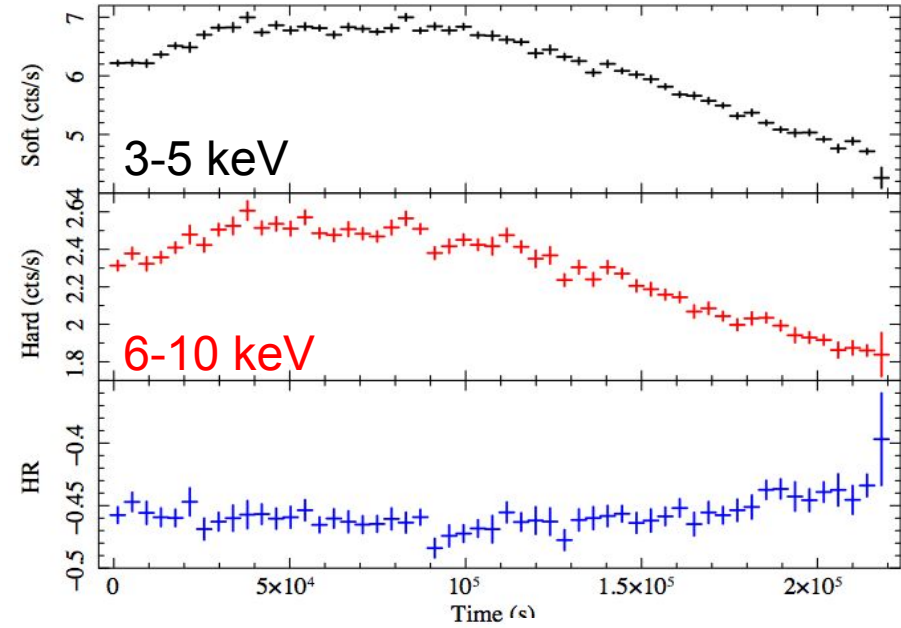
IC4329A (*Brenneman et al., in prep.*)

- One of the brightest Seyfert galaxies $F(2-10 \text{ keV}) \sim 10^{-10} \text{ erg/cm}^2/\text{s}$
 - Modest variability (20-30%)
 - Large Galactic absorption - $N_{\text{H}} \sim 3 \times 10^{21} \text{ cm}^{-2}$
 - $E_{\text{cut}} > 180$ (*BeppoSAX, Perola et al. 2002*);
 $= 100^{+200}_{-40}$ (*INTEGRAL/BAT, Molina et al. 2013*)

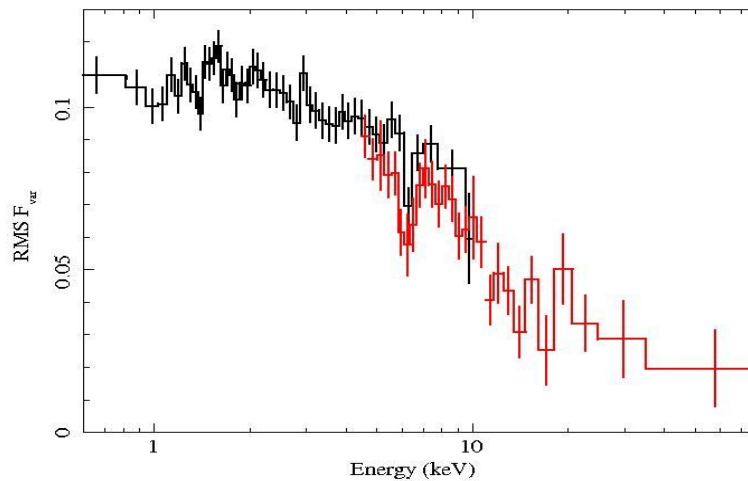
*****_*****

- Observed simultaneously by Suzaku and NuSTAR
on August 2012
 - Exposure times: 118 ks (Suzaku)
160 ks (NuSTAR)

IC4329A (Brenneman et al., in prep.)

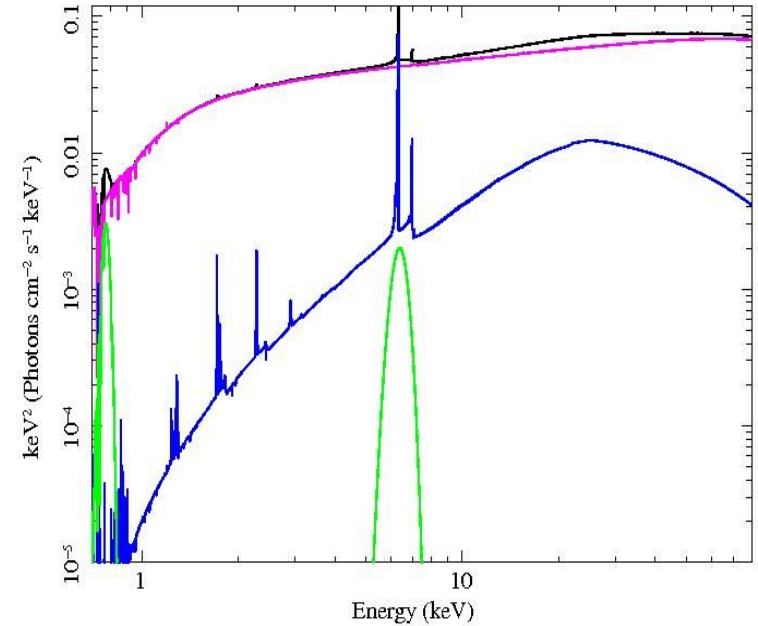
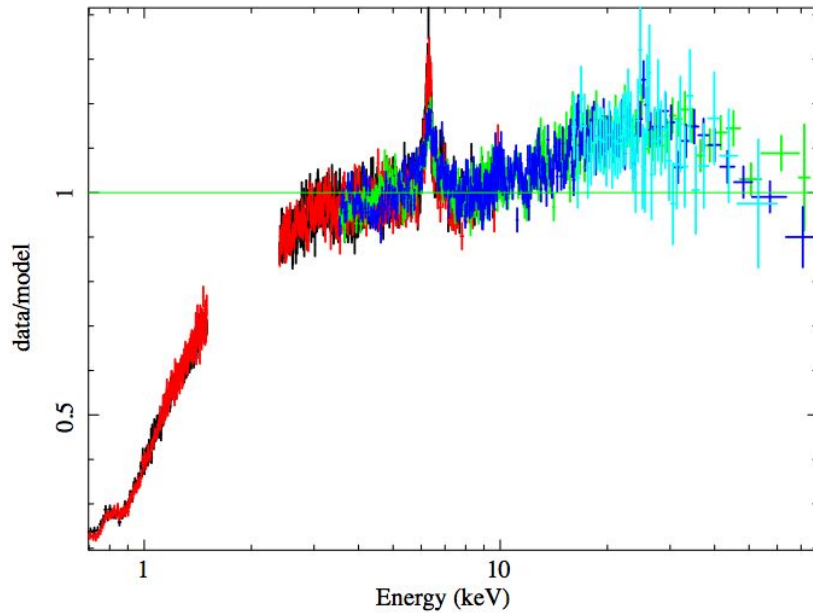


Suzaku XIS



NuSTAR FPMA

IC4329A (*Brenneman et al., in prep.*)



$E_c = 145 \pm 9 \text{ keV}$

$KT \sim 50 \text{ keV}, \tau \sim 1.5 \text{ (compPS)}$

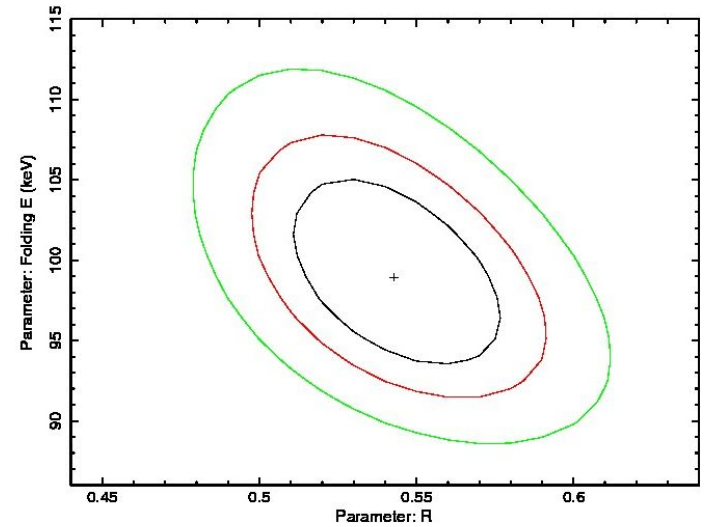
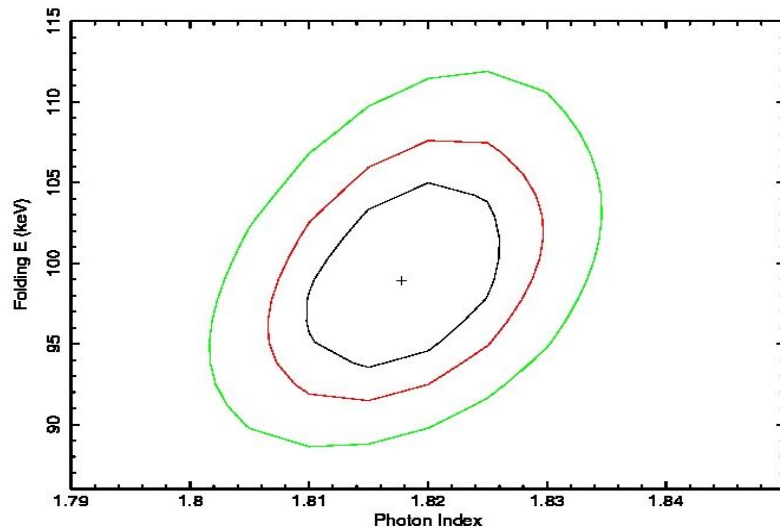
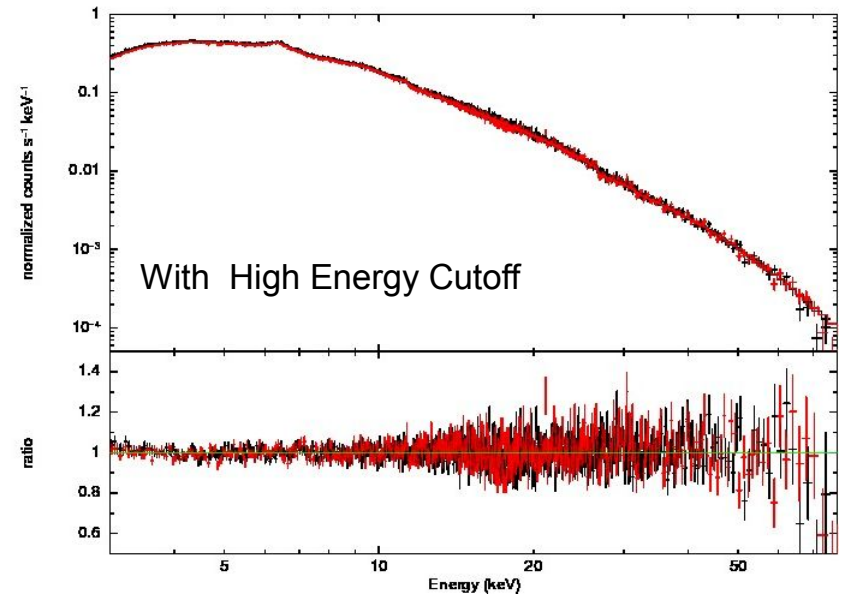
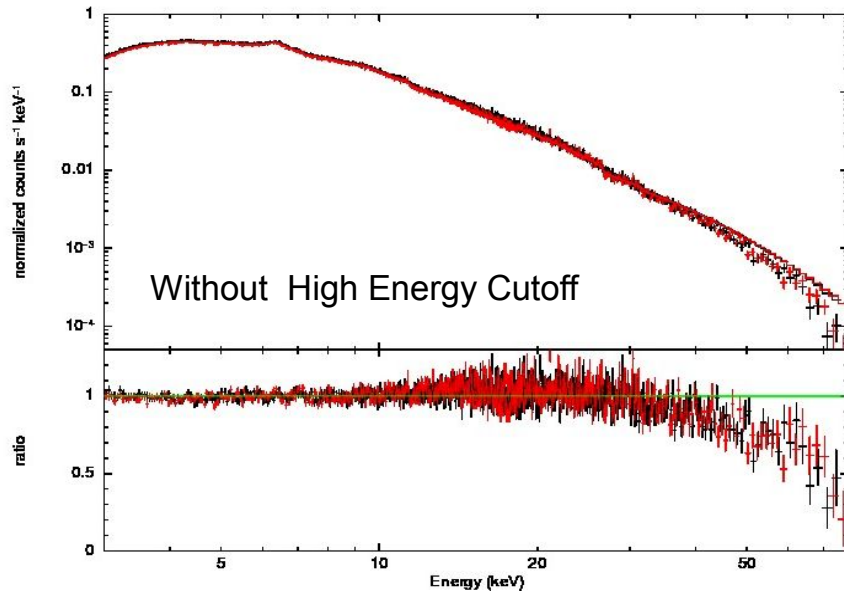
No evidence for relativistic lines.
Iron line and CR from distant matter

MCG-5-23-16 (Baloković et al., in prep)

- A bright Seyfert 1.9 - $F(2-10 \text{ keV}) \sim (7-10) \times 10^{-11} \text{ erg/cm}^2/\text{s}$
 - Compton-thin absorption - $NH \sim 1.6 \times 10^{22} \text{ cm}^{-2}$
 - $E_{\text{cut}} = 150^{+70}_{-40}$ (*BeppoSAX, Perola et al. 2002*);
 $= 72^{+21}_{-14}$ (*INTEGRAL/Swift, Beckmann et al. 2008*)
- Both a narrow and a broad line (*eg Balestra et al. 2004; Reeves et al. 2007; Braitto et al. 2007*)

- Observed for about 30 ks on July 2012 and for 160 ks (coordinated with Suzaku) on June 2013
 - *Only NuSTAR data presented here*

MCG-5-23-16 (Baloković et al., in prep)



SwiftJ2127 (Marinucci, Matt, et al., work in progress)

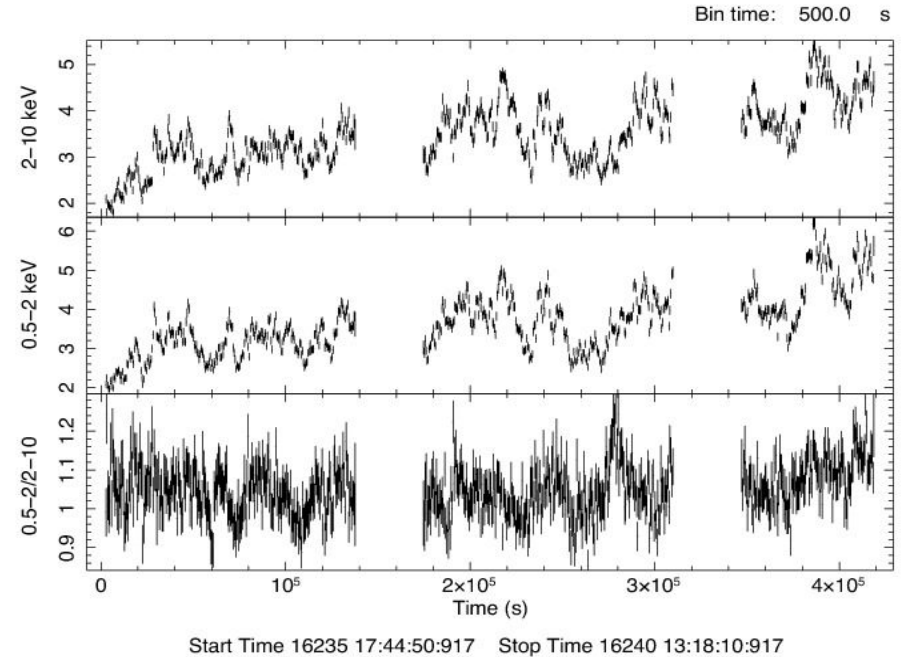
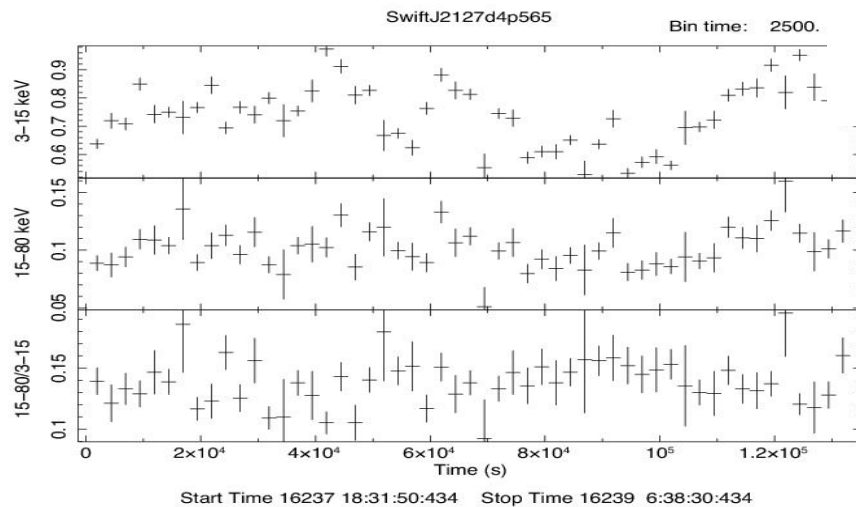
- A bright NLSy1 galaxy, $F(2-10 \text{ keV}) \sim 3.3 \times 10^{-11} \text{ erg/cm}^2/\text{s}$
 - Very variable
 - Large Galactic absorption - $N_H \sim 8 \times 10^{21} \text{ cm}^{-2}$
- Broad iron line with intermediate BH spin (Miniutti et al. 2009)

- Observed simultaneously by XMM and NuSTAR
on November 2012
 - Exposure times: 240 ks (XMM)
195 ks (NuSTAR)

SwiftJ2127 (Marinucci, Matt, et al., work in progress)

Extremely variable (factor 2.5) but with only modest - and largely erratic - spectral variability.

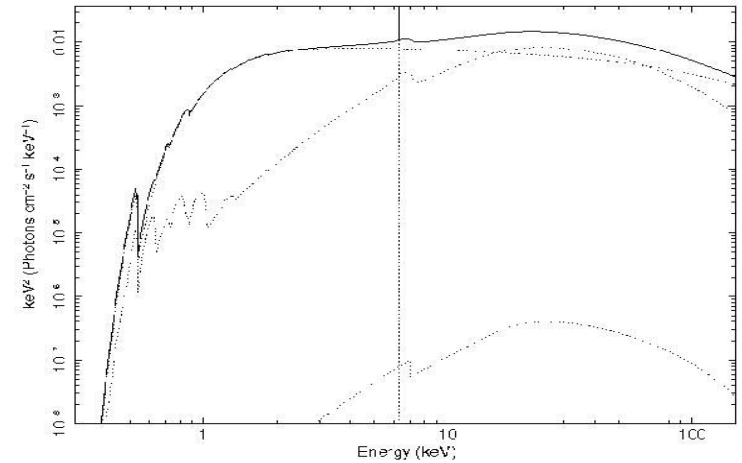
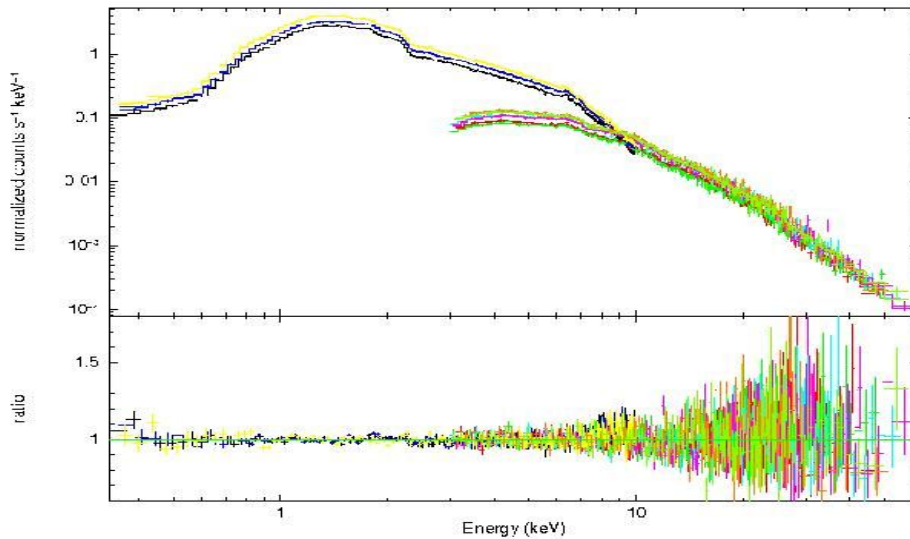
→ global analysis



XMM

NuSTAR

SwiftJ2127 (Marinucci, Matt, et al., work in progress)

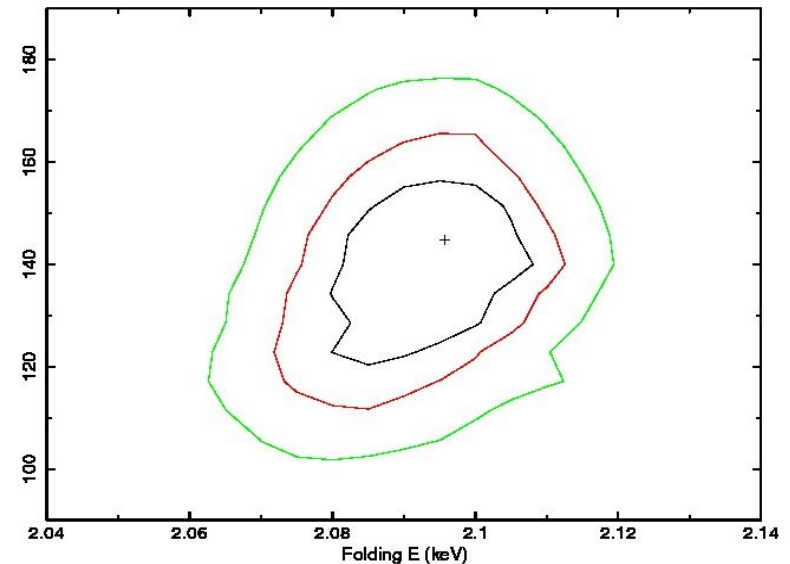


Preliminary results:

Fit with cutoff PL, distant and relativistic reflection, narrow iron line (from BLR?).

$E_{\text{cut}} \sim 120\text{-}140$ keV

Intermediate BH spin ?



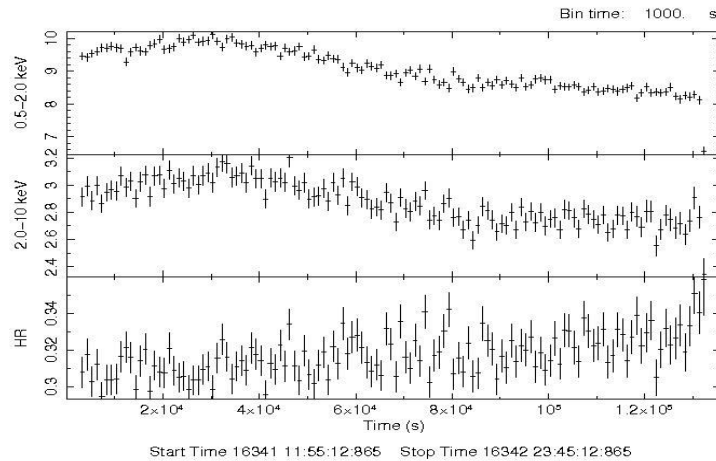
Ark 120 (Matt et al., very preliminary)

- A 'bare' Seyfert 1 - $F(2-10 \text{ keV}) \sim (2-4) \times 10^{-11} \text{ erg/cm}^2/\text{s}$
 - Prominent soft excess (Vaughan et al. 2004)
 - Relativistic iron line (Nardini et al. 2011)

- Observed simultaneously by XMM and NuSTAR
on November 2012
 - Exposure times: 90 ks (XMM)
80 ks (NuSTAR)

Ark 120 (Matt et al., very preliminary)

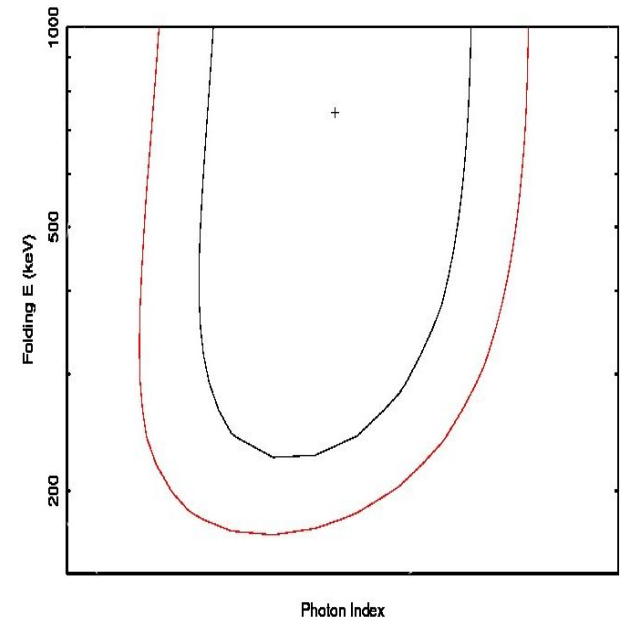
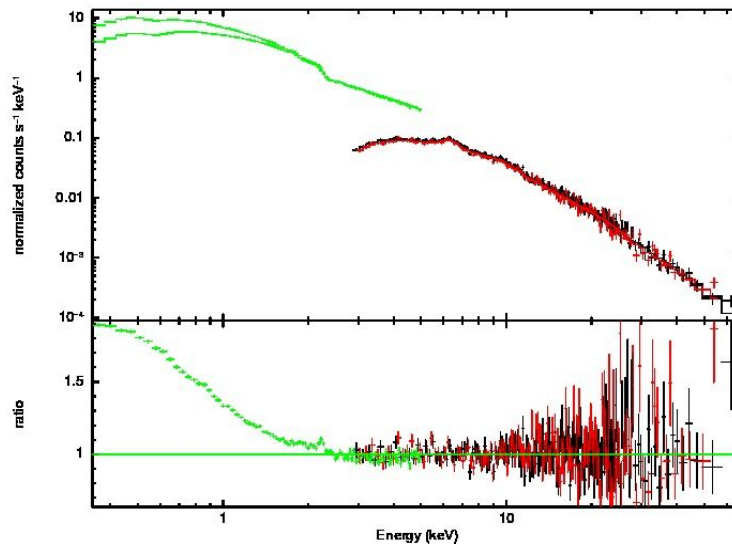
XMM



Fit with NuSTAR data only (power law + reflection + iron line)

No High Energy Cutoff detected

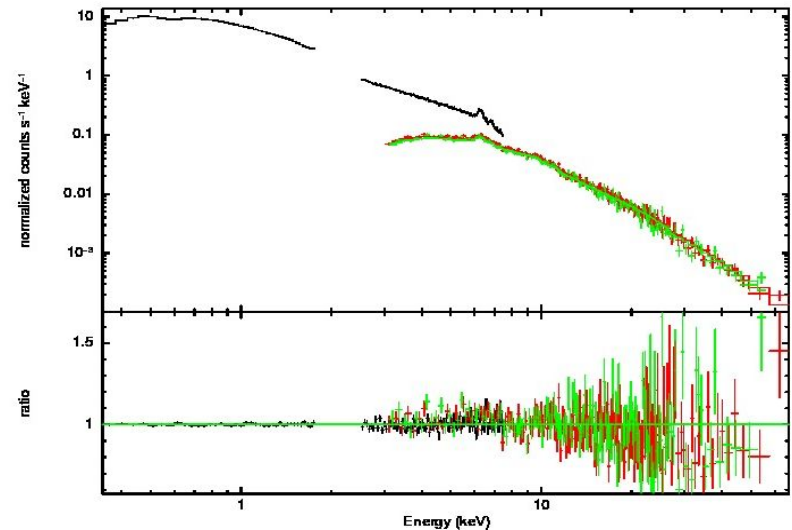
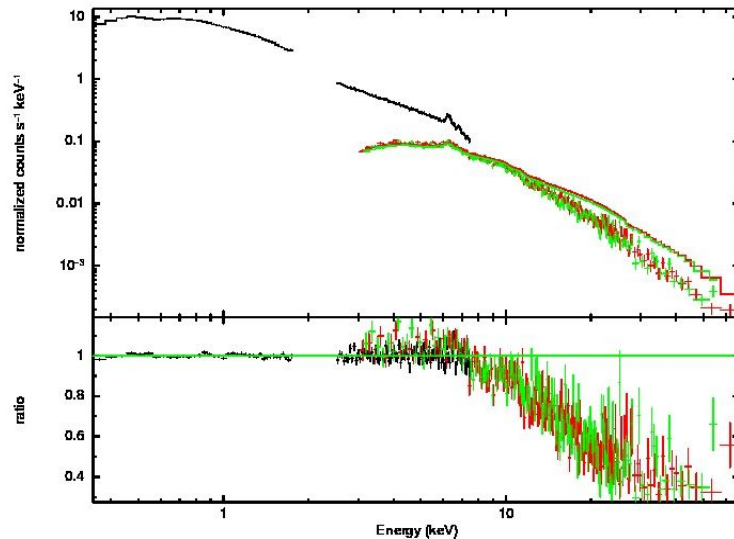
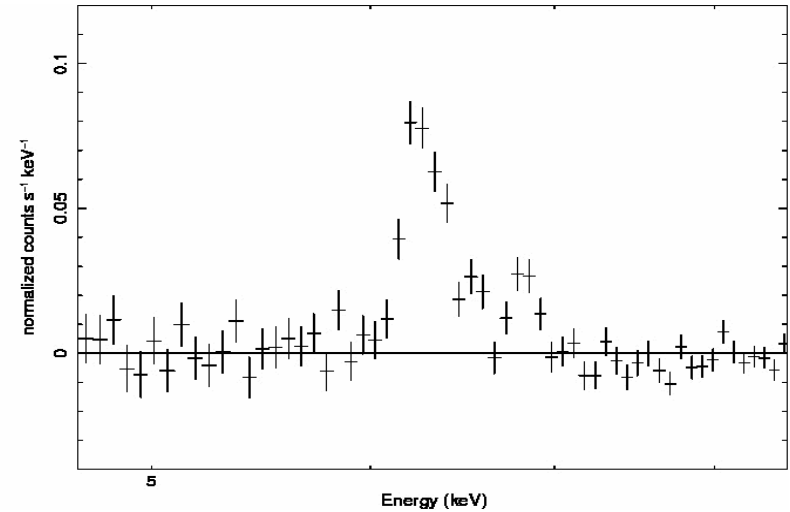
Extrapolation to XMM shows strong excess



Ark 120 (Matt et al., very preliminary)

XMM: no obvious evidence for rel. line

Soft excess with a simple power law or with a cutoff PL (Comptonization) give comparable fits to the XMM spectrum, but very different extrapolation to NuSTAR (ionized reflection included in the fit)



Summary

- **NuSTAR** is providing AGN spectra of unprecedented quality above 10 keV
- First results show that a high energy cutoff in the 100-150 keV range is common but not ubiquitous
- The very broad band spectra from observations coordinated with XMM or Suzaku allow to disentangle the various spectral components and shed light to poorly known components like eg the soft excess

MORE TO COME SOON!