

The broad band view of Seyfert galaxies

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On behalf of the NuSTAR AGN Physics WG (see http://www.nustar.caltech.edu/forastronomers/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 quasiexponential cut-off with Ec~2-3x*kT*. 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 to study the spectral variability of NGC4051
- NuSTAR joined 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.

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 et al., in prep)

• MCG-6-30-15 \rightarrow see next talk by Andrea Marinucci

IC4329A (Brenneman et al., in prep.)

- One of the brightest Seyfert galaxies F(2-10 keV) ~ 10⁻¹⁰ erg/cm²/s
 - Modest variability (20-30%)
 - Large Galactic absorption NH ~ 3x10²¹ cm⁻²
 - E_{cut} > 180 (BeppoSAX, *Perola et al. 2002*);

= 100⁺²⁰⁰ (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.)



IC4329A (Brenneman et al., in prep.)





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

----> Ec = 145±9 keV <----KT ~ 50 keV, τ~1.5 (compPS)

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

- A bright Seyfert 1.9 F(2-10 keV) ~ (7-10)x10⁻¹¹ erg/cm²/s
 - Compton-thin absorption NH ~ $1.6x10^{22}$ cm⁻²
 - E_{cut}=150⁺⁷⁰ (BeppoSAX, *Perola et al. 2002*);

= 72⁺²¹₋₁₄ (INTEGRAL/Swift, Beckmann et al. 2008)

• Both a narrow and a broad line (e.g. Balestra et al. 2004; Reeves et al. 2007; Braito 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 keV) ~ 3.3x10⁻¹¹ erg/cm²/s
 - Very variable
 - Large Galactic absorption NH ~ 8x10²¹ 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



Start Time 16235 17:44:50:917 Stop Time 16240 13:18:10:917





NuSTAR

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



Preliminary results:

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

Ec ~ 120-140 keV



- A 'bare' Seyfert 1 F(2-10 keV) ~ (2-4)x10⁻¹¹ erg/cm²/s
 - Prominent soft excess (XMM, Vaughan et al. 2004)
 - Relativistic iron line (Suzaku, Nardini et al. 2011)

Observed simultaneously by XMM and NuSTAR on February 2013
Exposure times: 90 ks (XMM)

80 ks (NuSTAR)





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

No High Energy Cutoff detected

Extrapolation to XMM shows strong excess







Indeed, the broad-band best fit is with a Comptonization model for the soft excess. A *cutoff p.l.*, *compTT, nthcomp* or **optxagnf** provide fits of comparable quality.

Optxagnf (Done et al. 2012) is a disk/corona emission model which assumes a thermal disk emission outside the coronal radius, and soft and hard Comptonization inside.

Best fit parameters:

BH Mass: 1.86x10⁸ (fixed) - Distance: 133 Mpc (fixed) Eddington ratio: 0.17 - Spin: unconstrained Coronal radius: 11 Rg - KTe: 0.34 keV Tau: 12.6 - Γ: 1.72 Ec: >120 keV



- 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 probably 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