1.5 Ms *XMM-Newton* and *NuSTAR* Observing Campaign

An X-ray view of highly variable AGN

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IRAS 13224-3809 Collaboration

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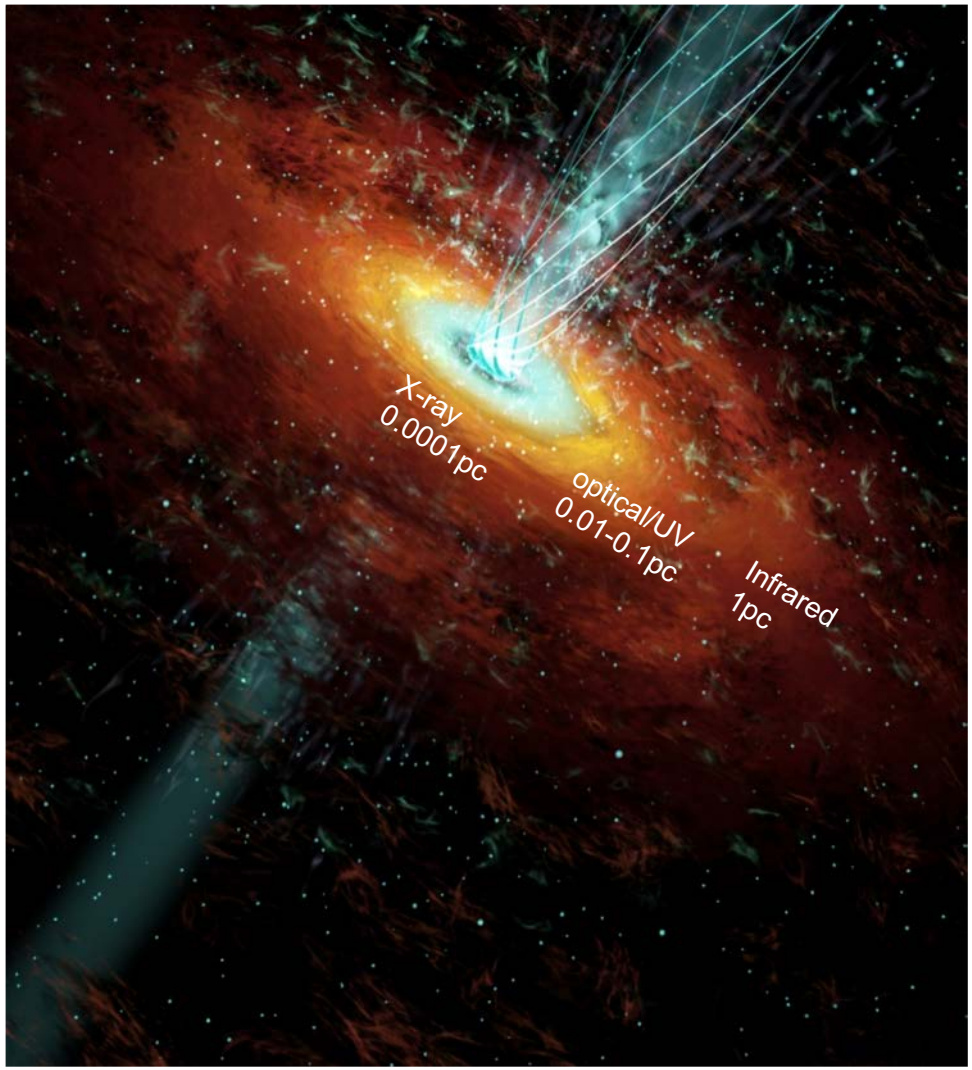
Outline

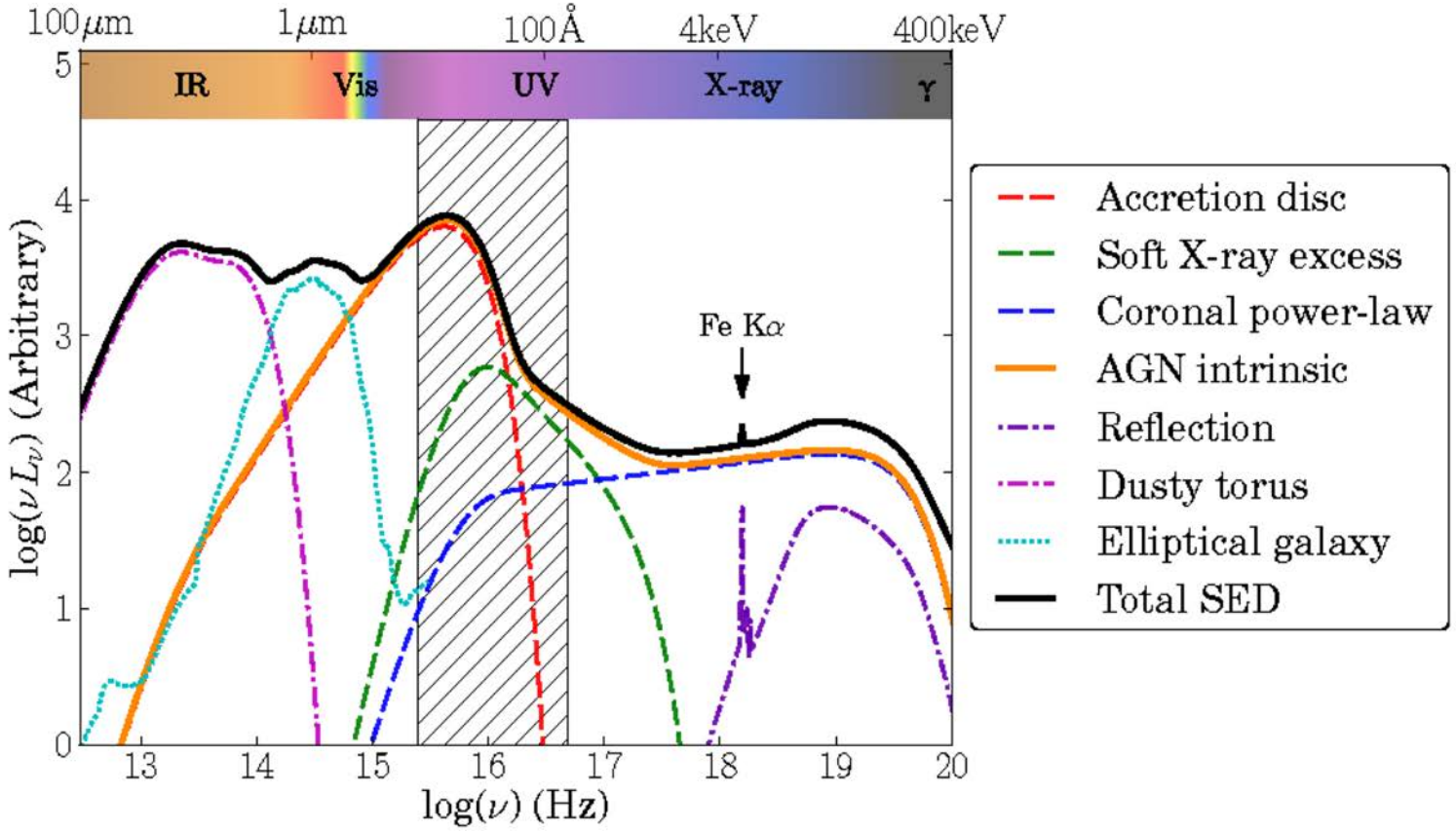
1. Active galactic nuclei (AGN) in X-ray band
2. Black hole disk-corona system
3. Variable X-ray spectrum from AGN
4. IRAS 13224-3809

    XMM-Newton and *NuSTAR* observations

Active galactic nuclei

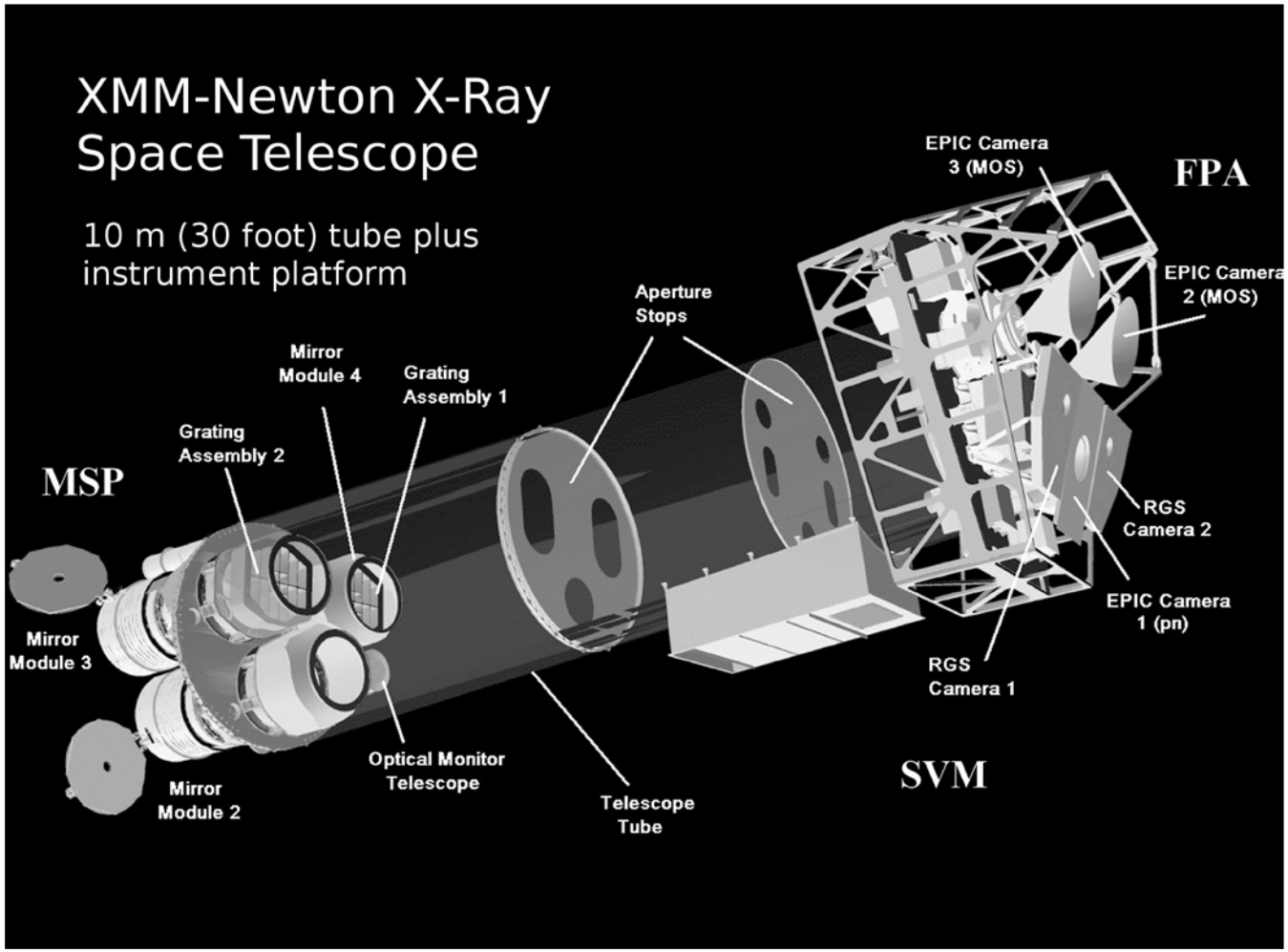


Active Galactic Nuclei



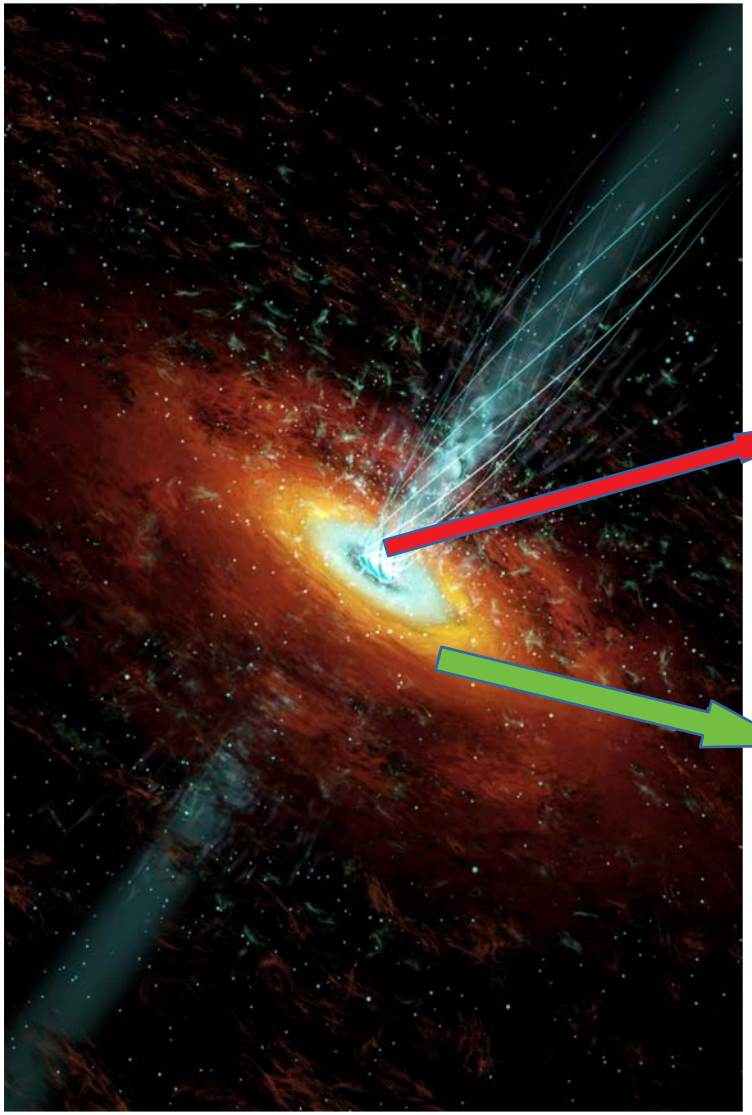
Collinson+17

XMM-Newton

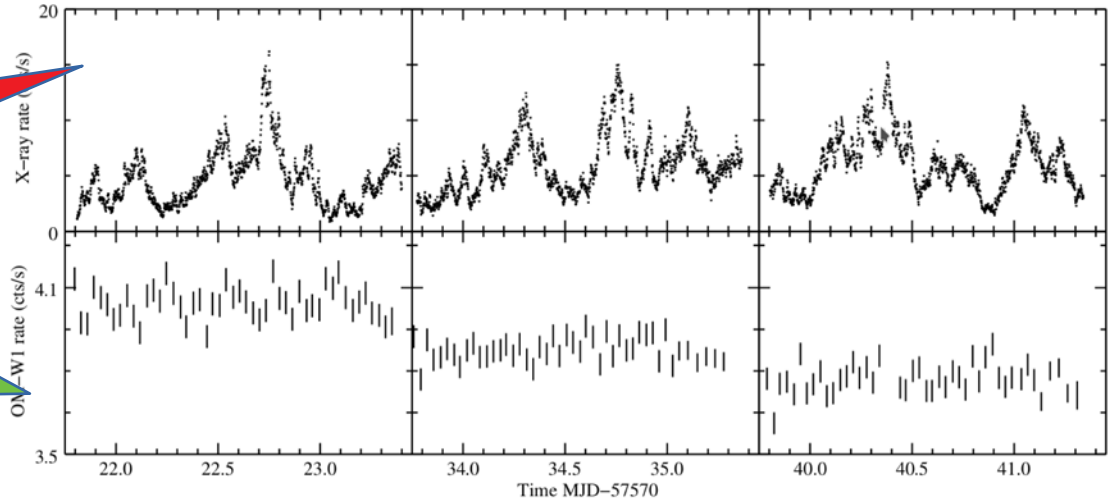


Credit: ESA/XMM-Newton

XMM-Newton view of AGN



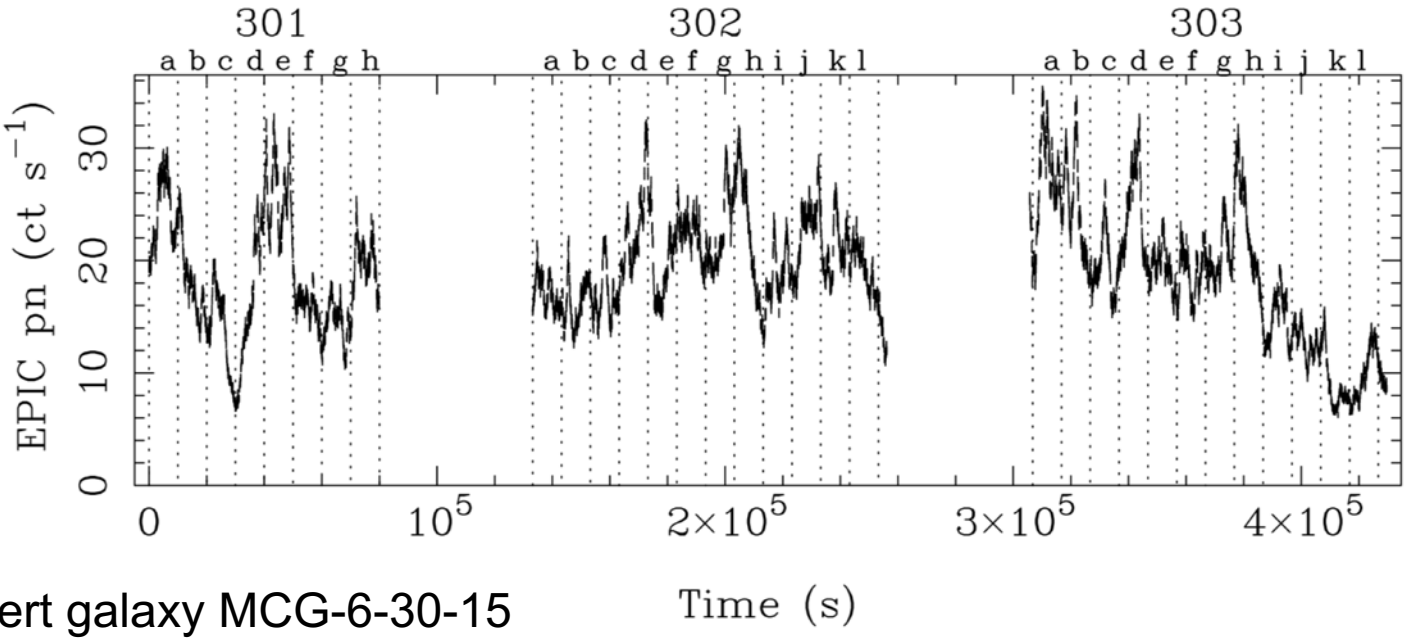
X-ray (XMM-Newton EPIC pn)



Optical (XMM-Newton OM W1)

Buisson+18

AGN X-ray Spectroscopy

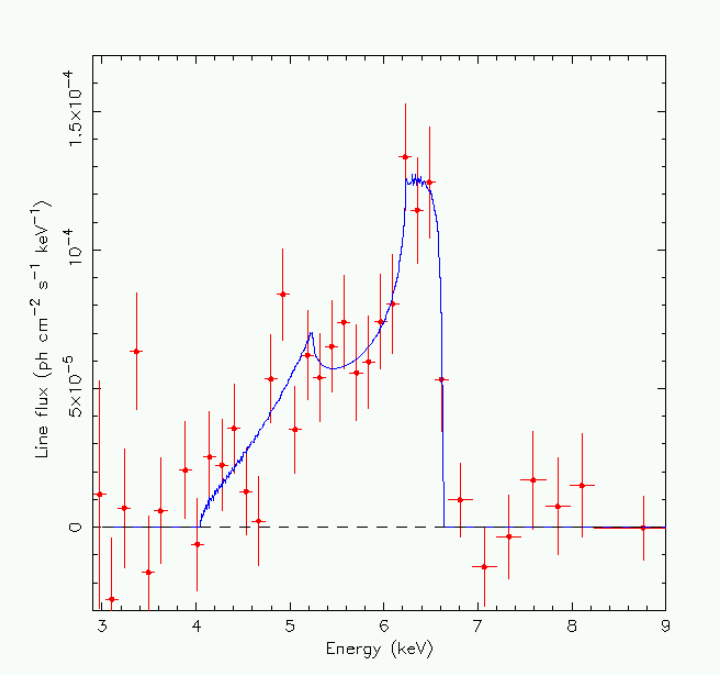


Seyfert galaxy MCG-6-30-15
XMM-Newton

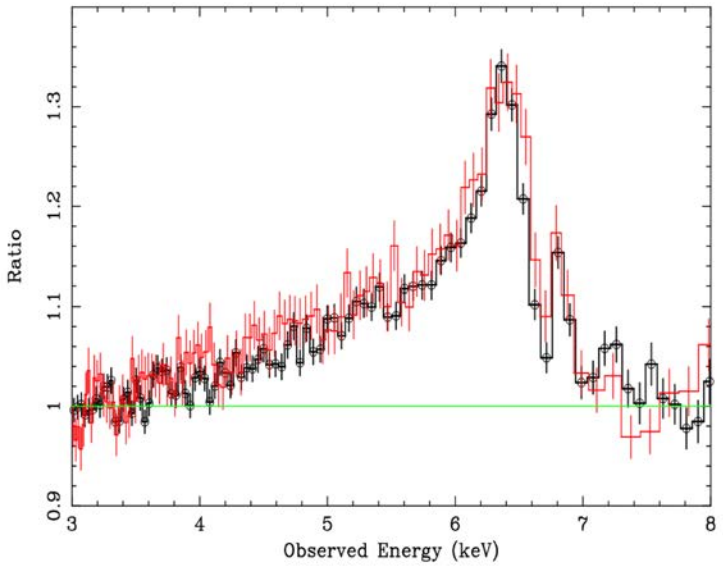
Fabian+03

AGN X-ray Spectroscopy

Seyfert galaxy MCG-6-30-15



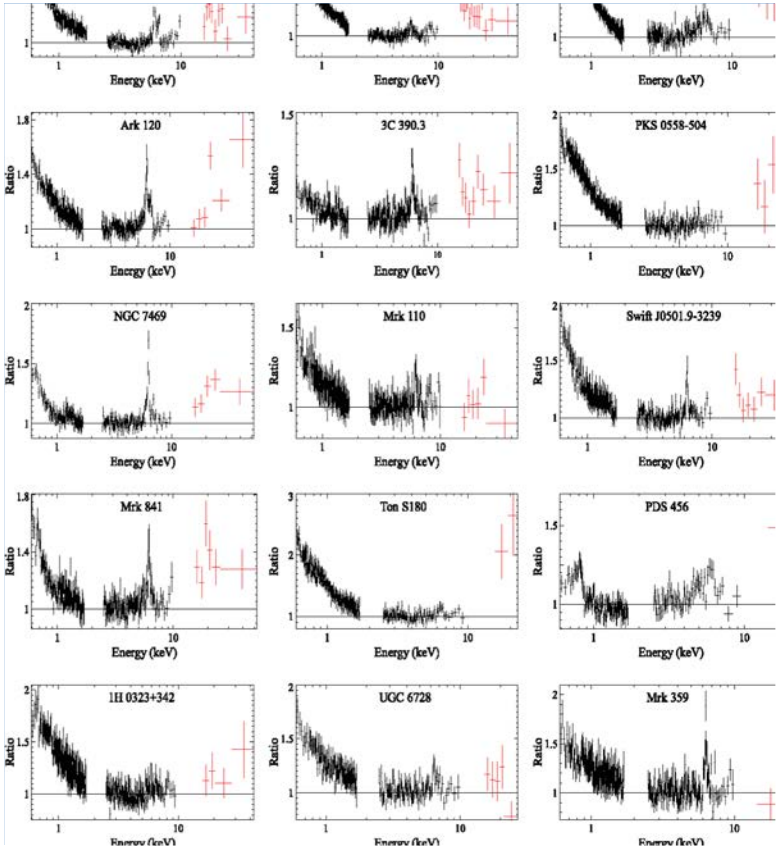
ASCA



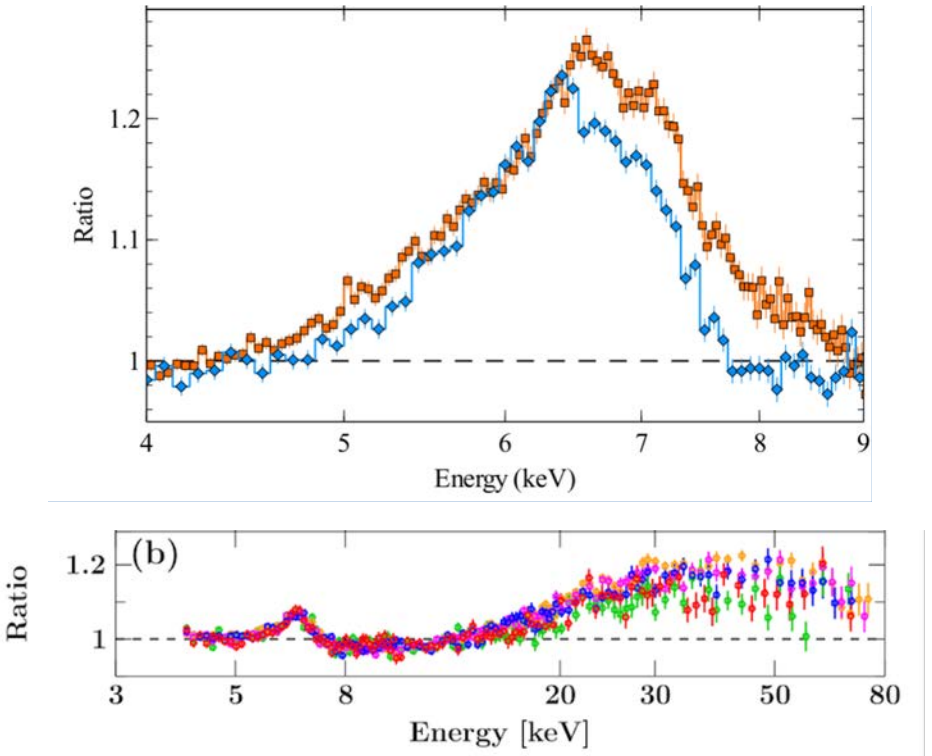
XMM-Newton, Suzaku

Tanaka+95, Miniutti+06

Black Hole X-ray Spectroscopy



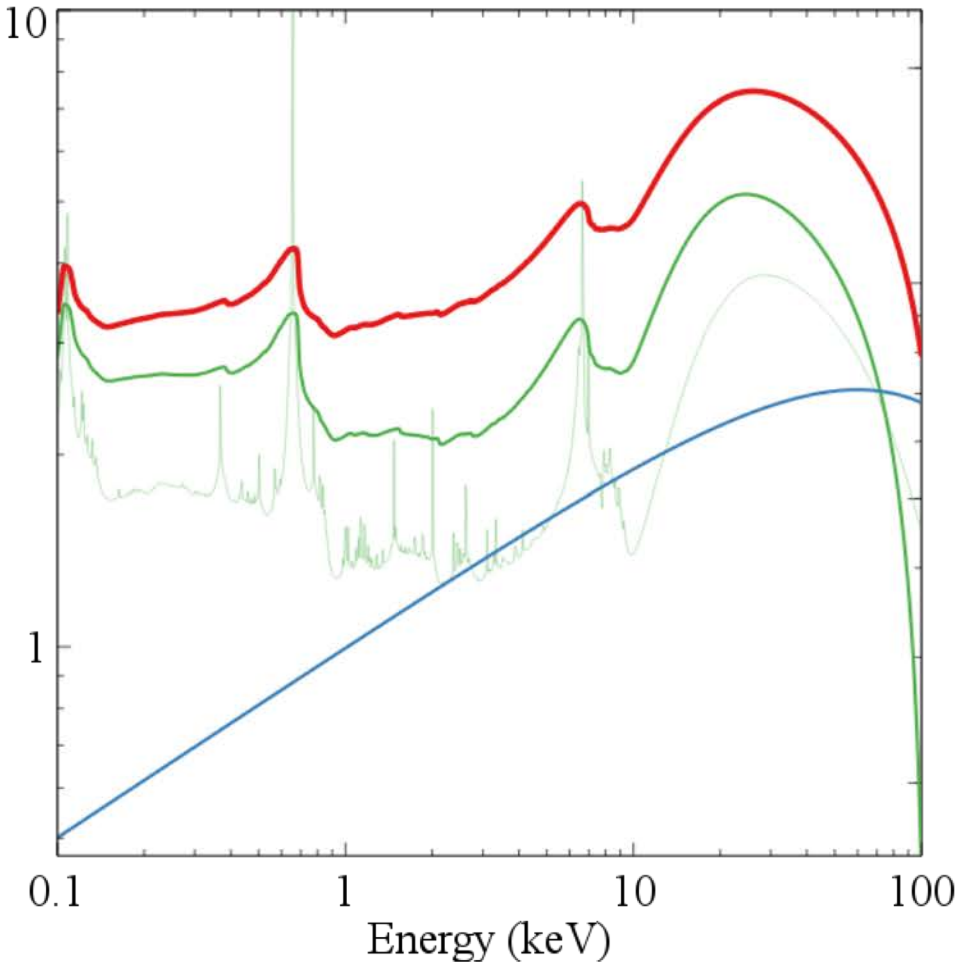
Unobscured AGN
Suzaku

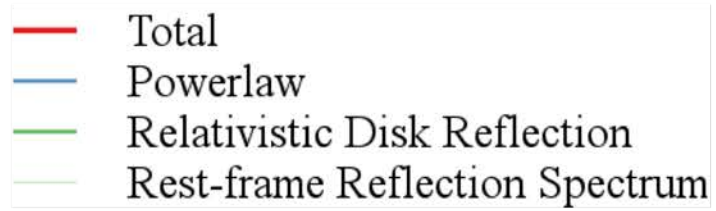


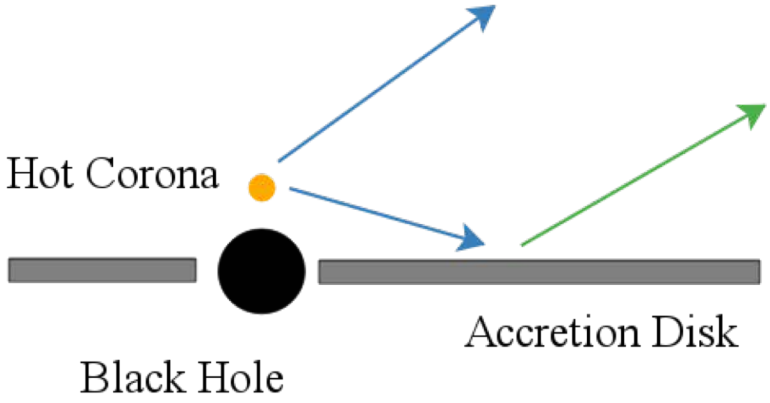
Galactic Black Holes
Suzaku, NuSTAR

Walton+14, Parker+15, Fürst+15

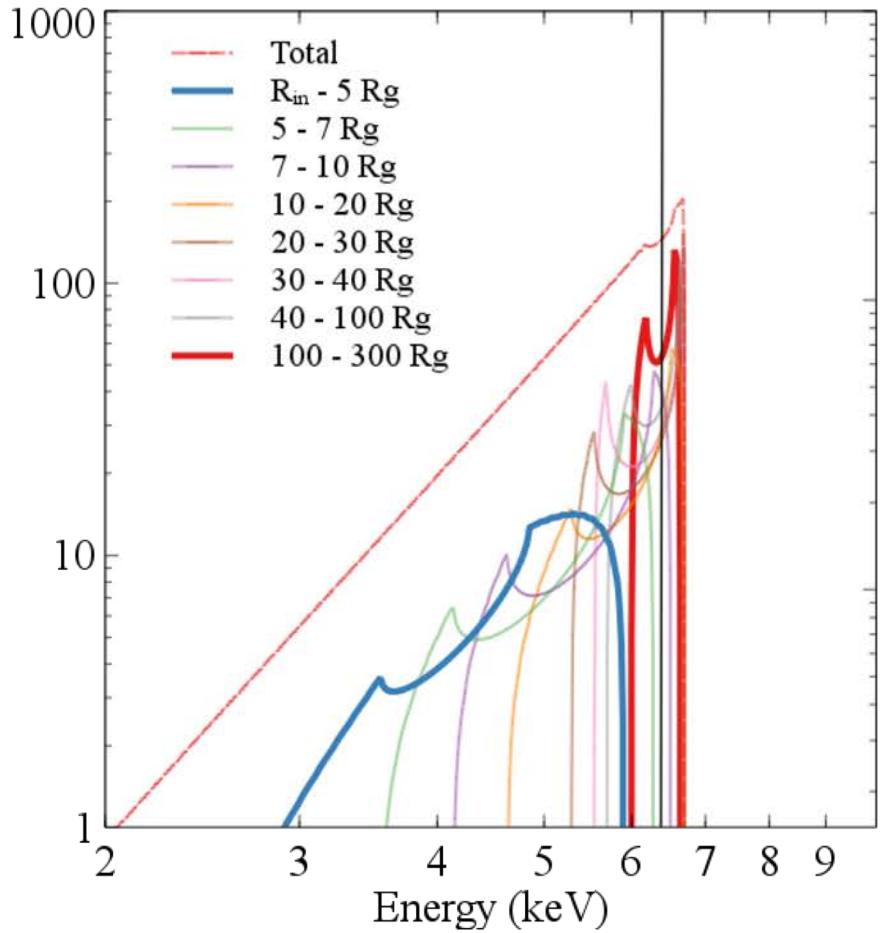
Disk-Corona System

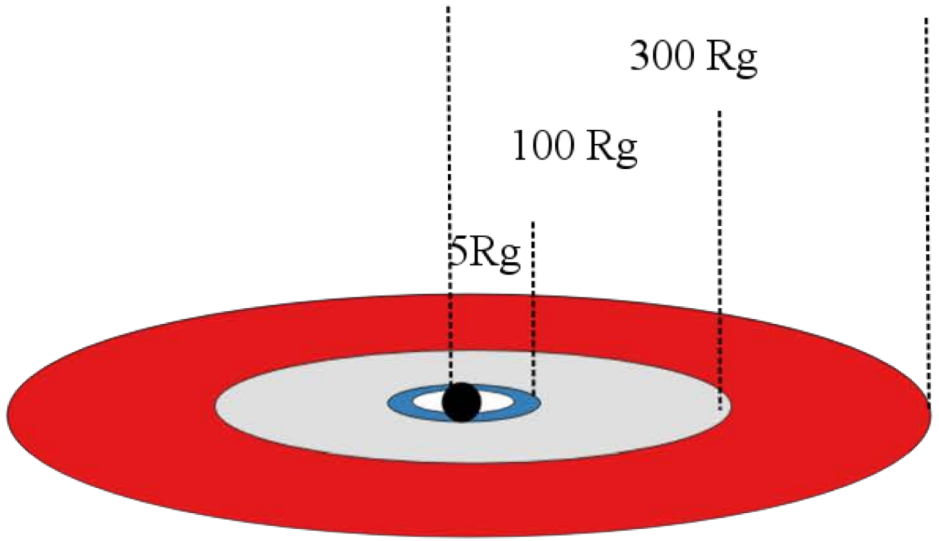




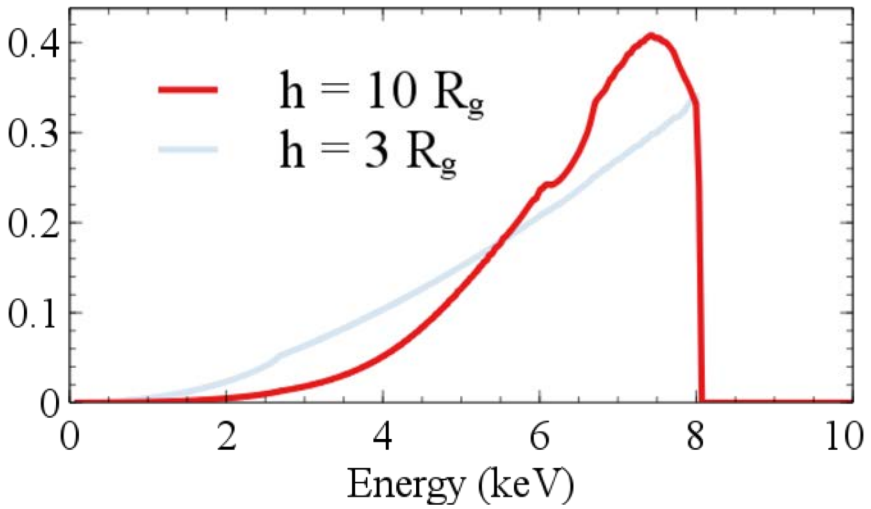


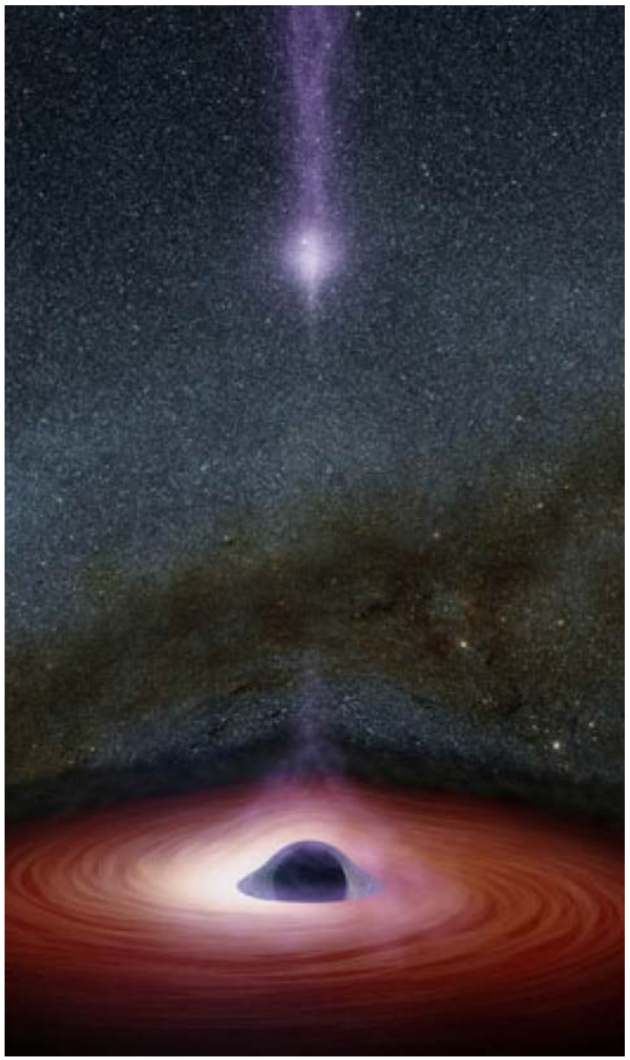
Disk-Corona System



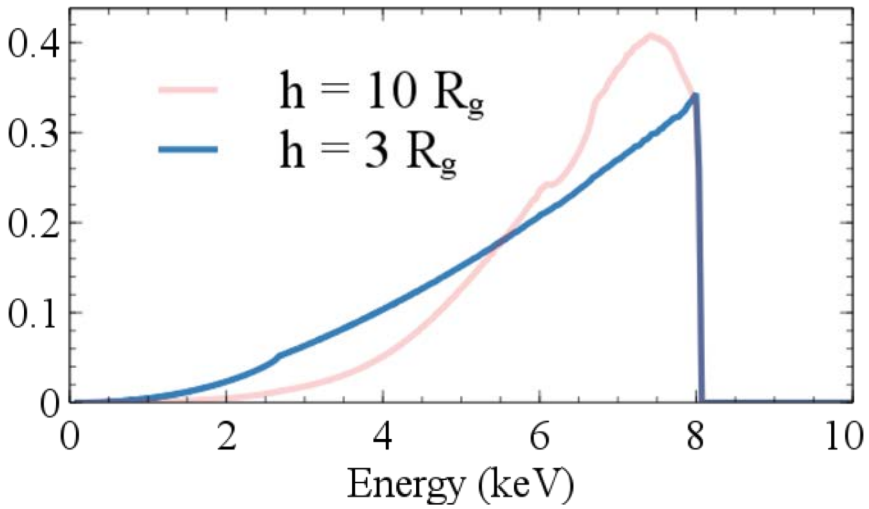


Disk-Corona System





Disk-Corona System



IRAS 13224-3809

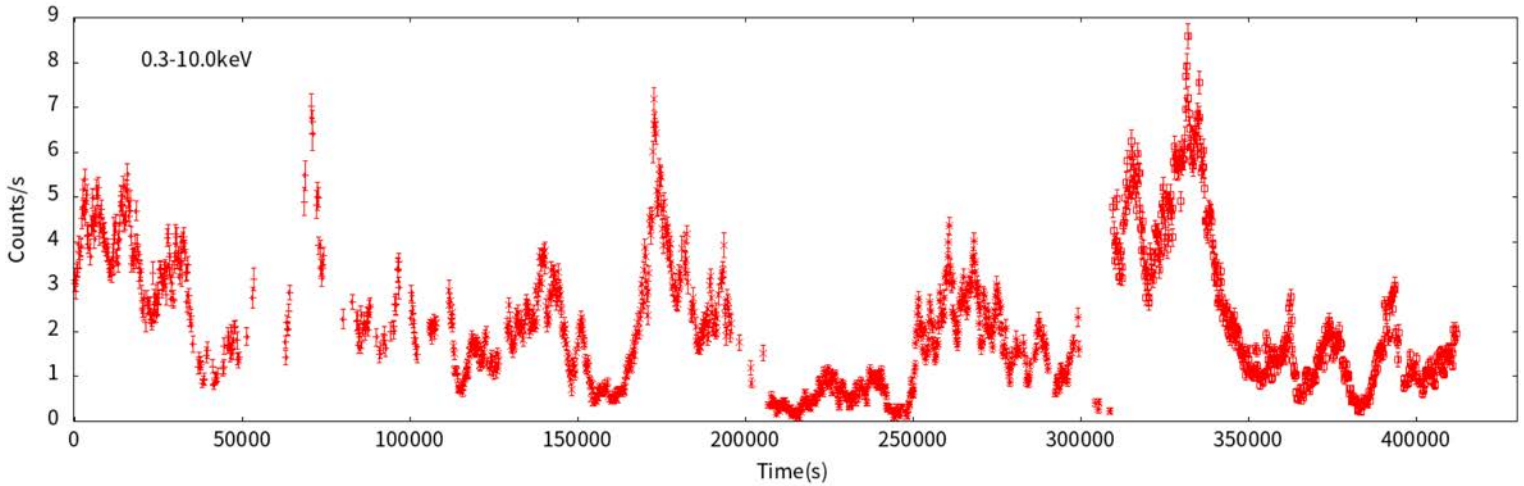
1. Narrow Line Seyfert 1 Galaxy

(z=0.066, radio-quiet)

2. Supermassive Black Hole

($10^{6\text{-}7}M_{sun}$, spin a>0.988M, viewing angle i~65 deg)

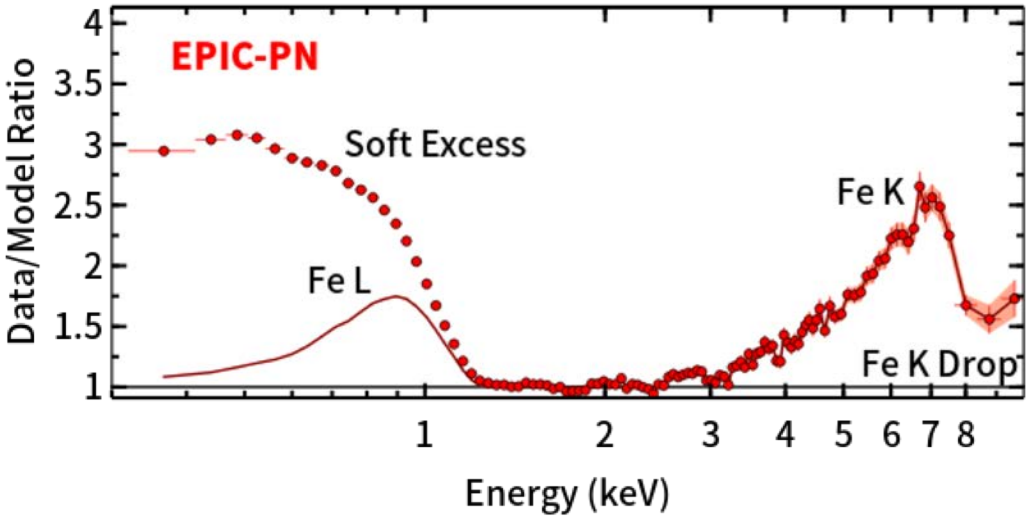
3. Extreme and fast X-ray variability



Previously on X-ray

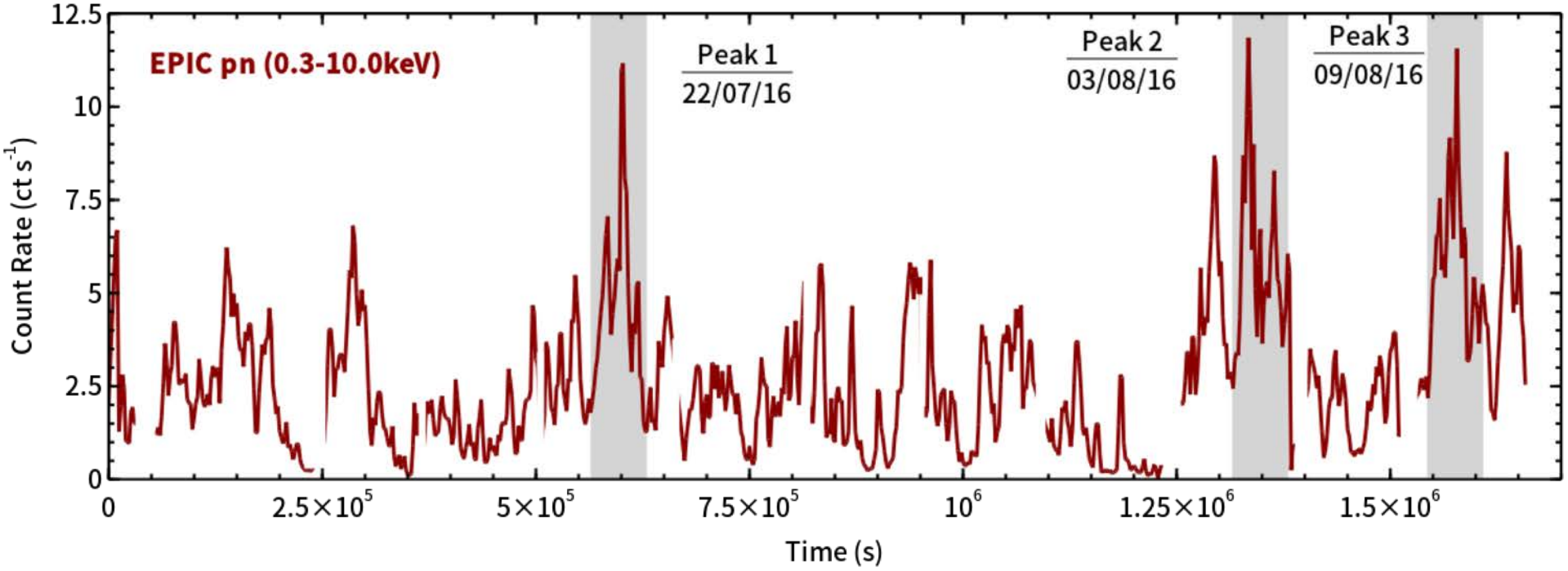
Spectral Analysis

1. **Strong relativistic**
   Fe K and L emission lines
2. **A quasi-blackbody soft excess**
3. **Very soft continuum**
   photon index 2.5~2.7
4. **Very steep emissivity index**
   h~2 R_g
5. **No warm absorbers**
6. **Flux dependent ultra-fast outflow absorption**



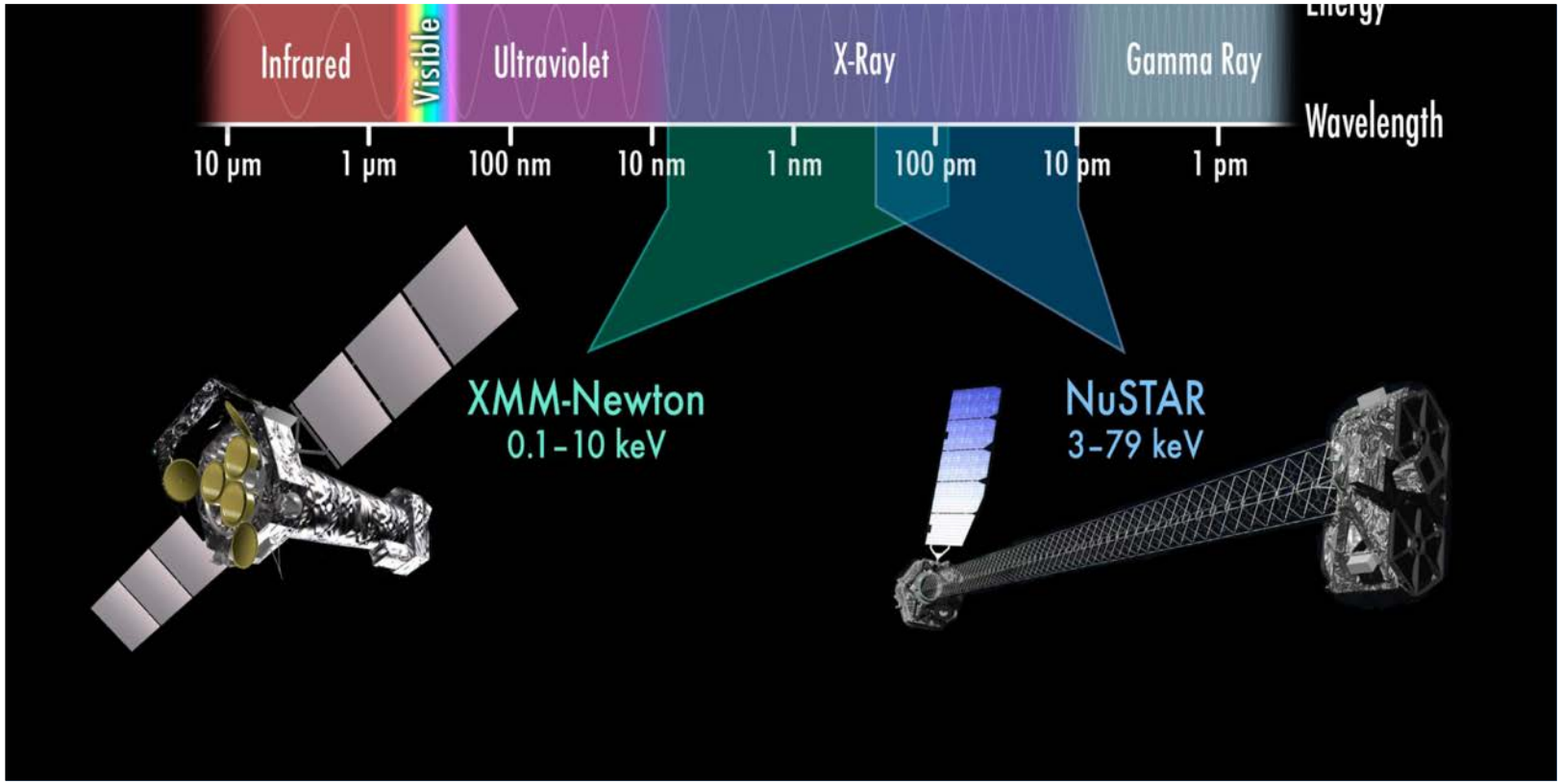
Boller 03, Ponti 10, Fabian 13,
Chiang 15, Parker 17, Pinto 17, Jiang18

1.5 Ms XMM-Newton VLP

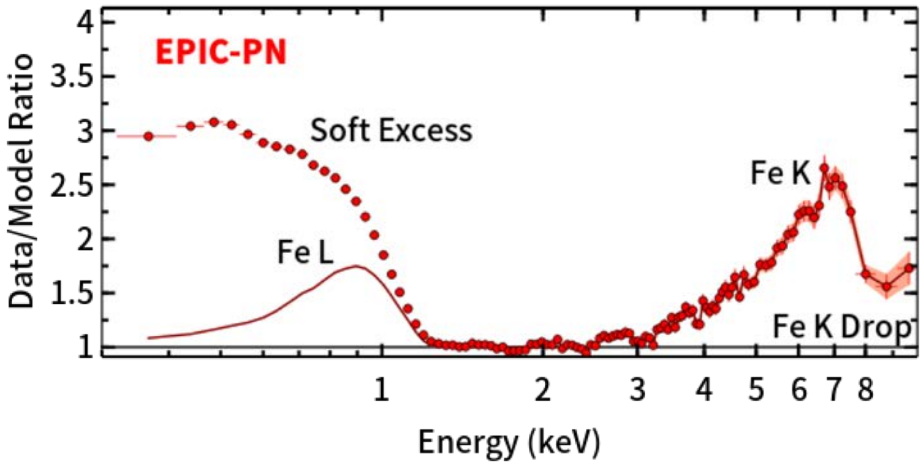


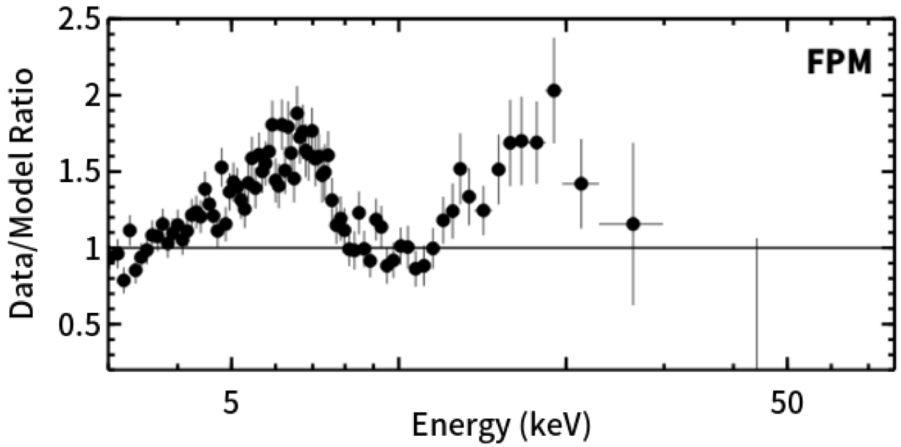
Jiang+18

1.5 Ms XMM-Newton VLP



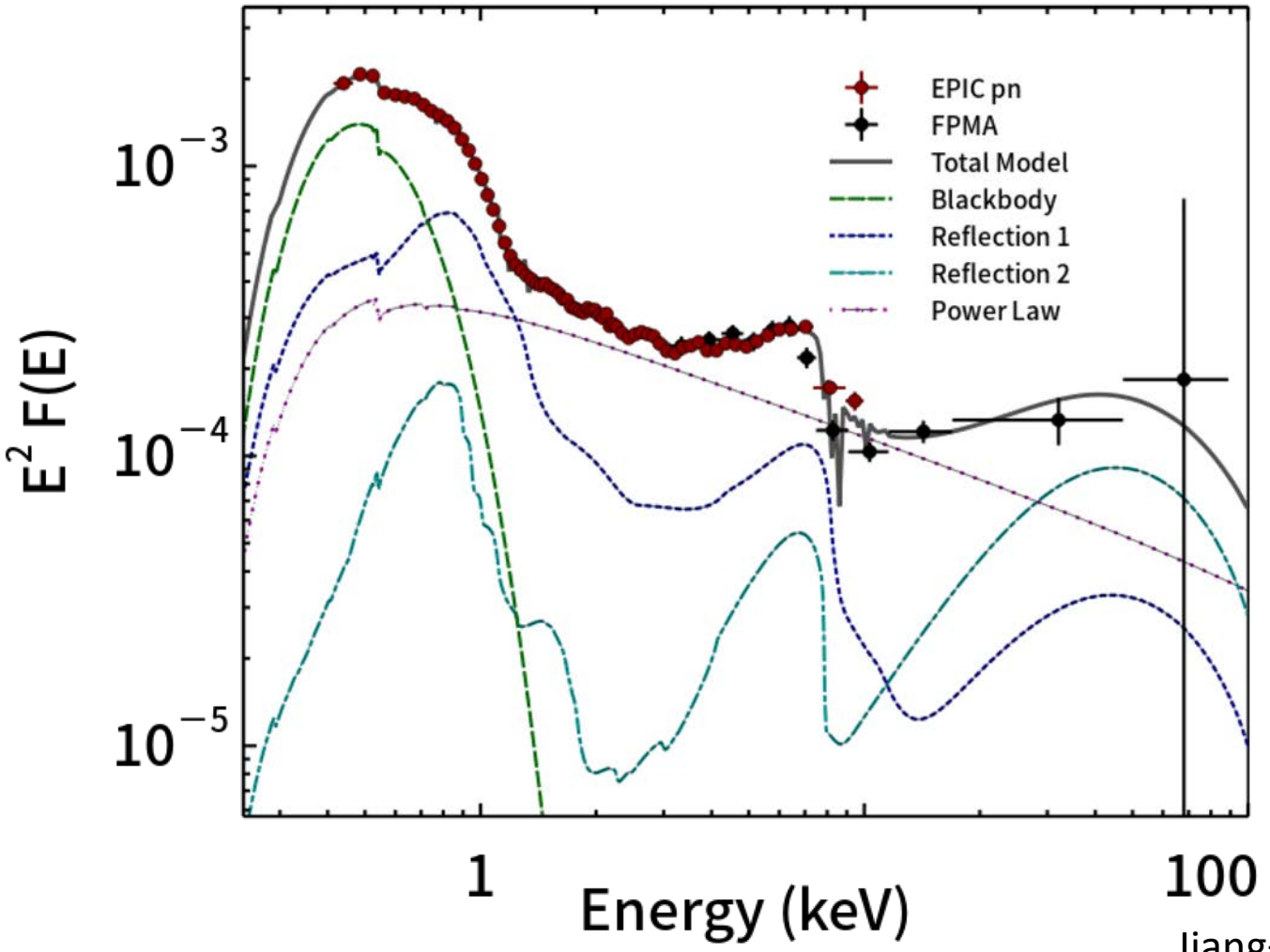
XMM-Newton & NuSTAR Spectra





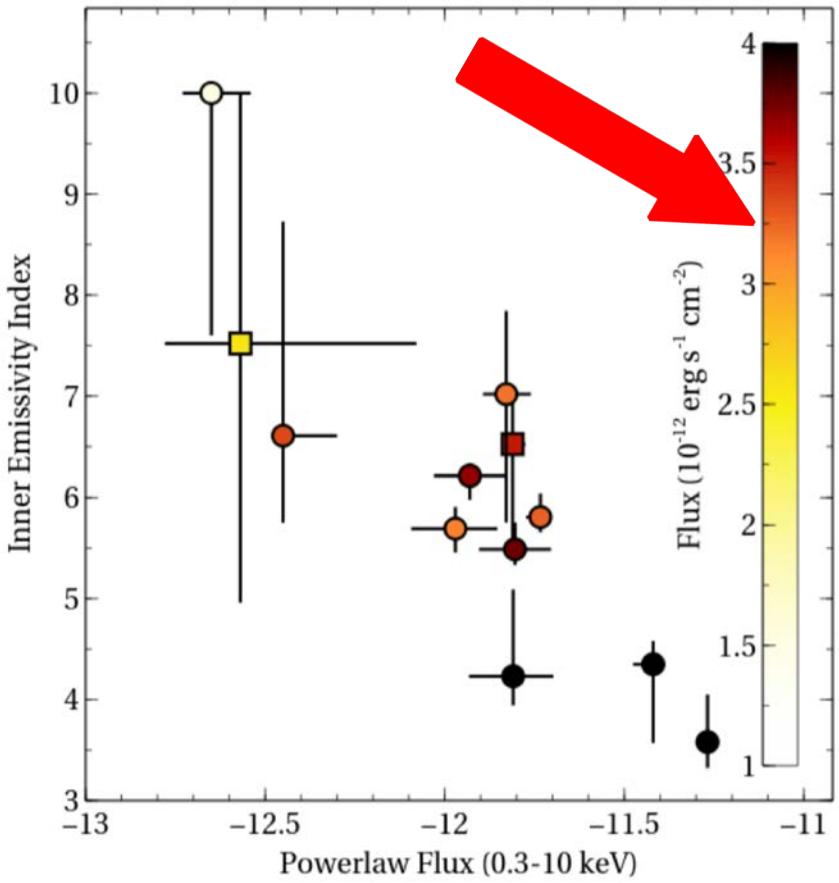
Jiang+18

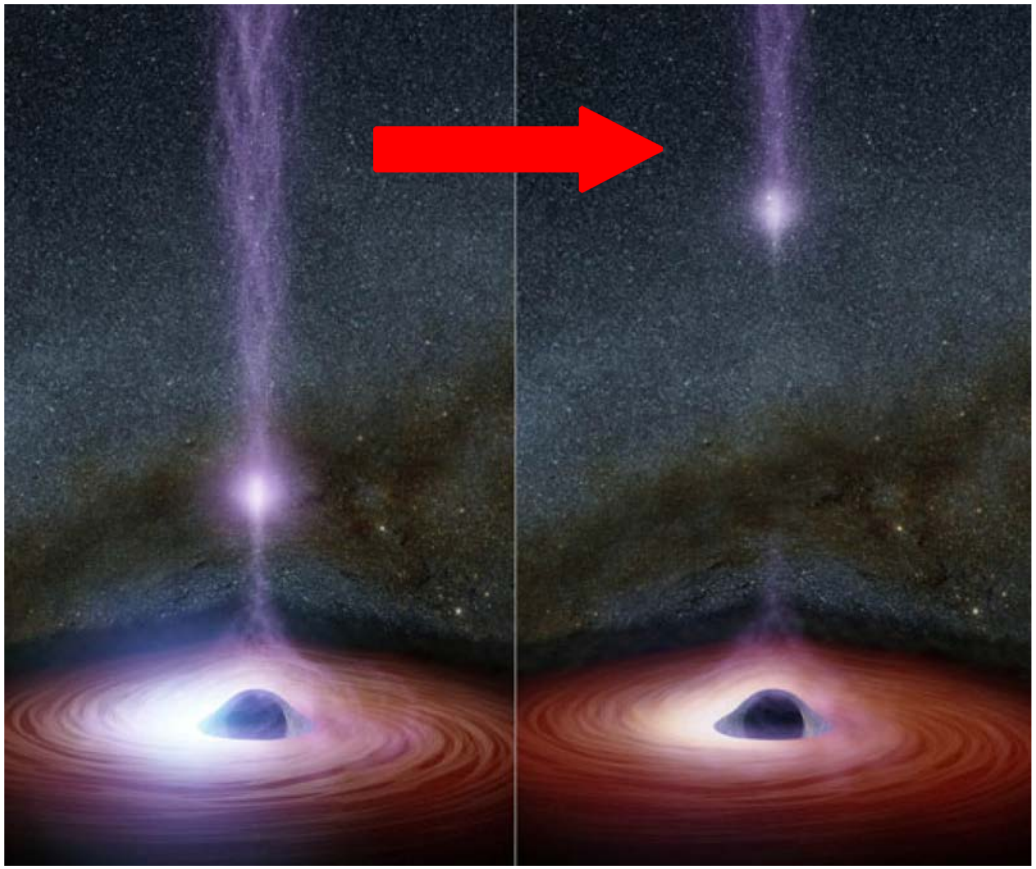
XMM-Newton & NuSTAR Spectra



Jiang+18

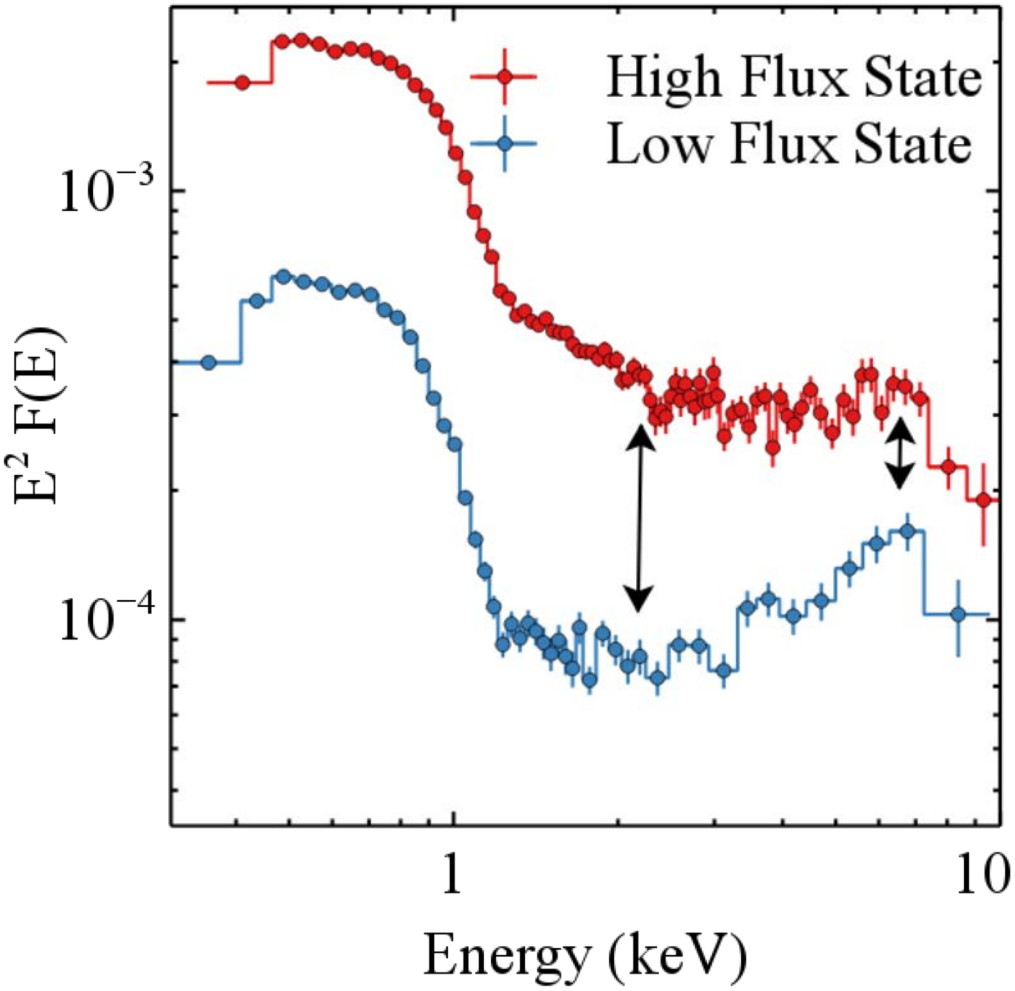
Disk Reflection





Jiang+18

Disk Reflection



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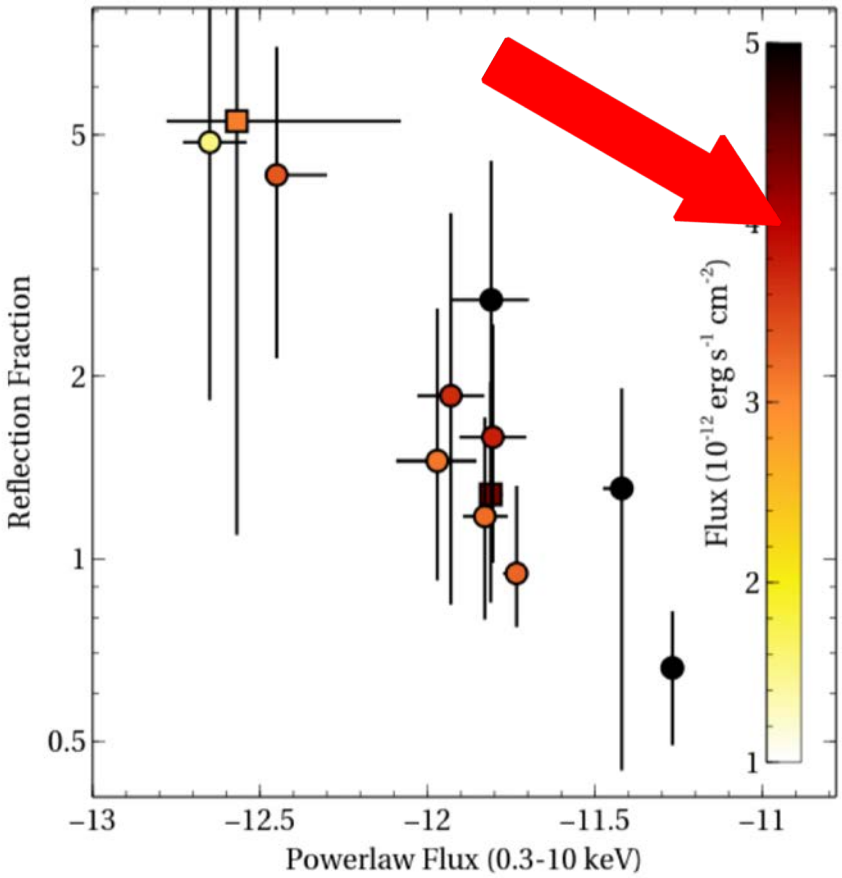
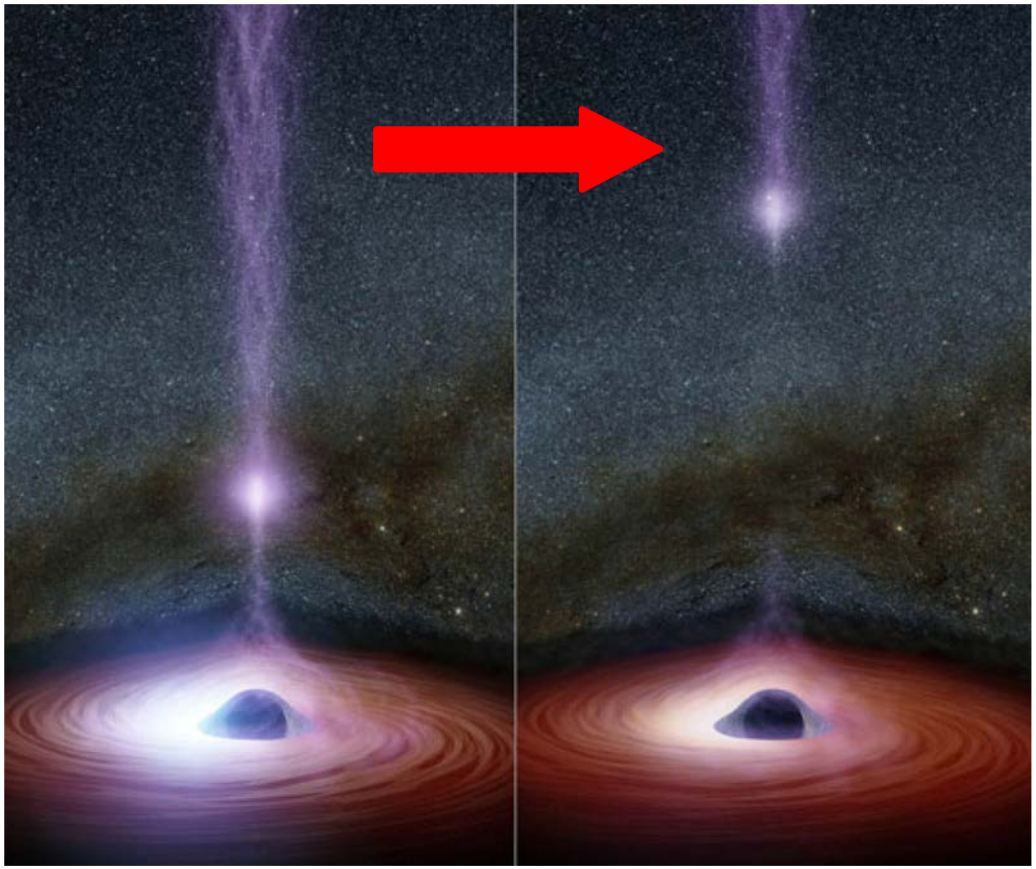
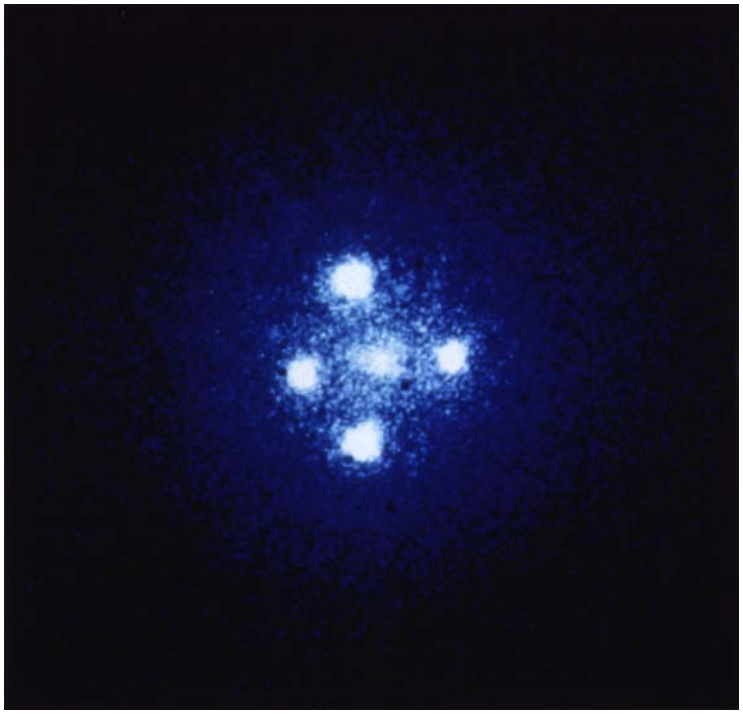
Disk Reflection

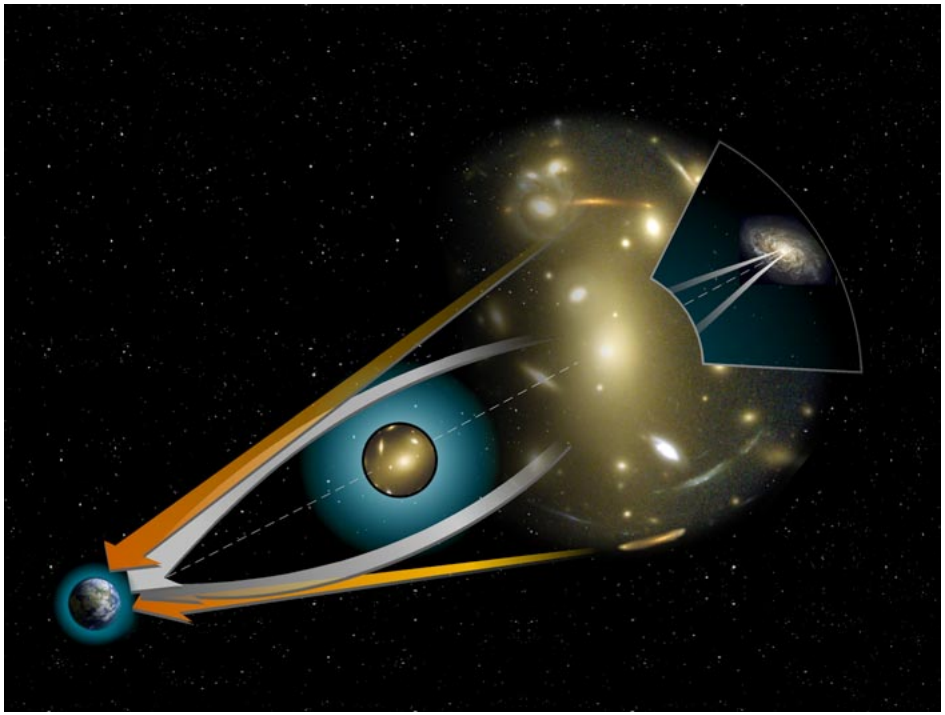




Jiang+18

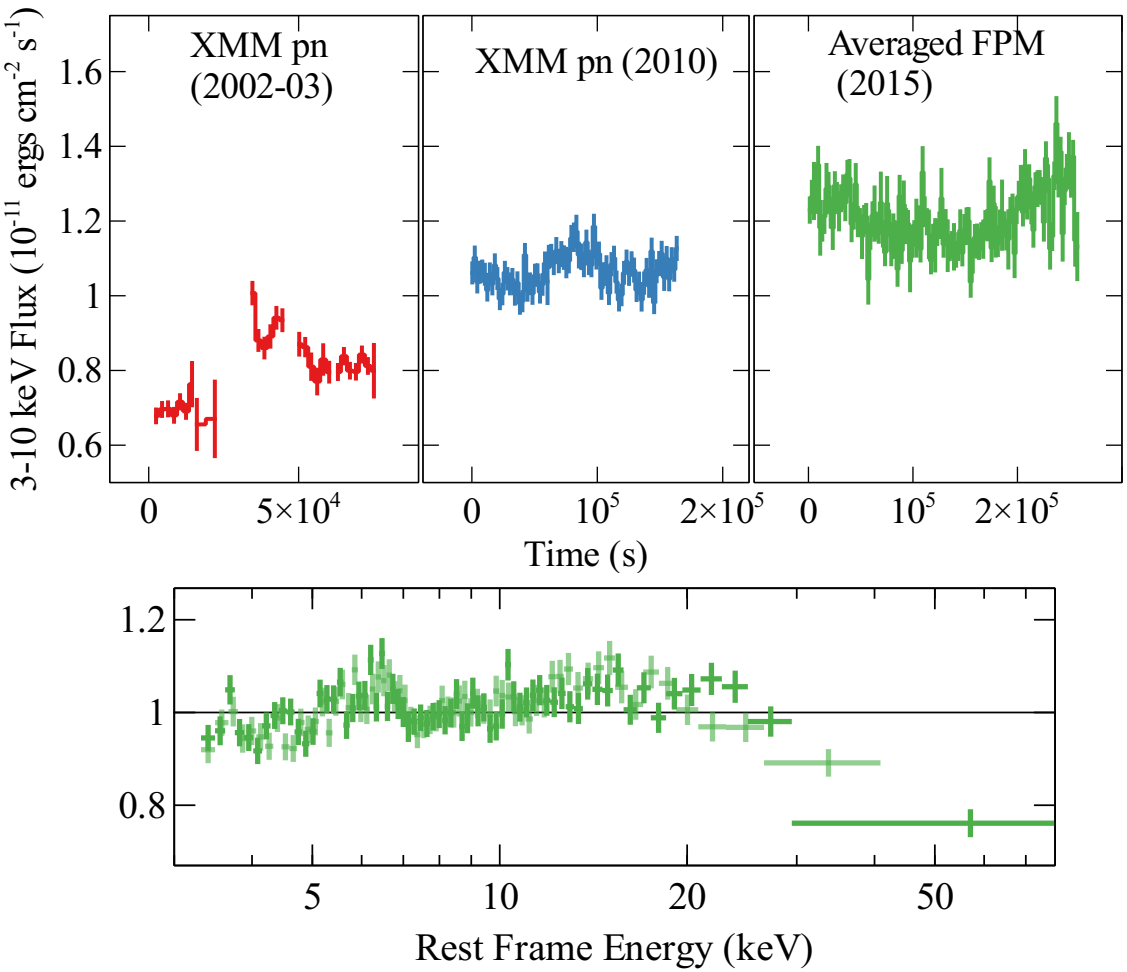
Light-Bending in the Universe





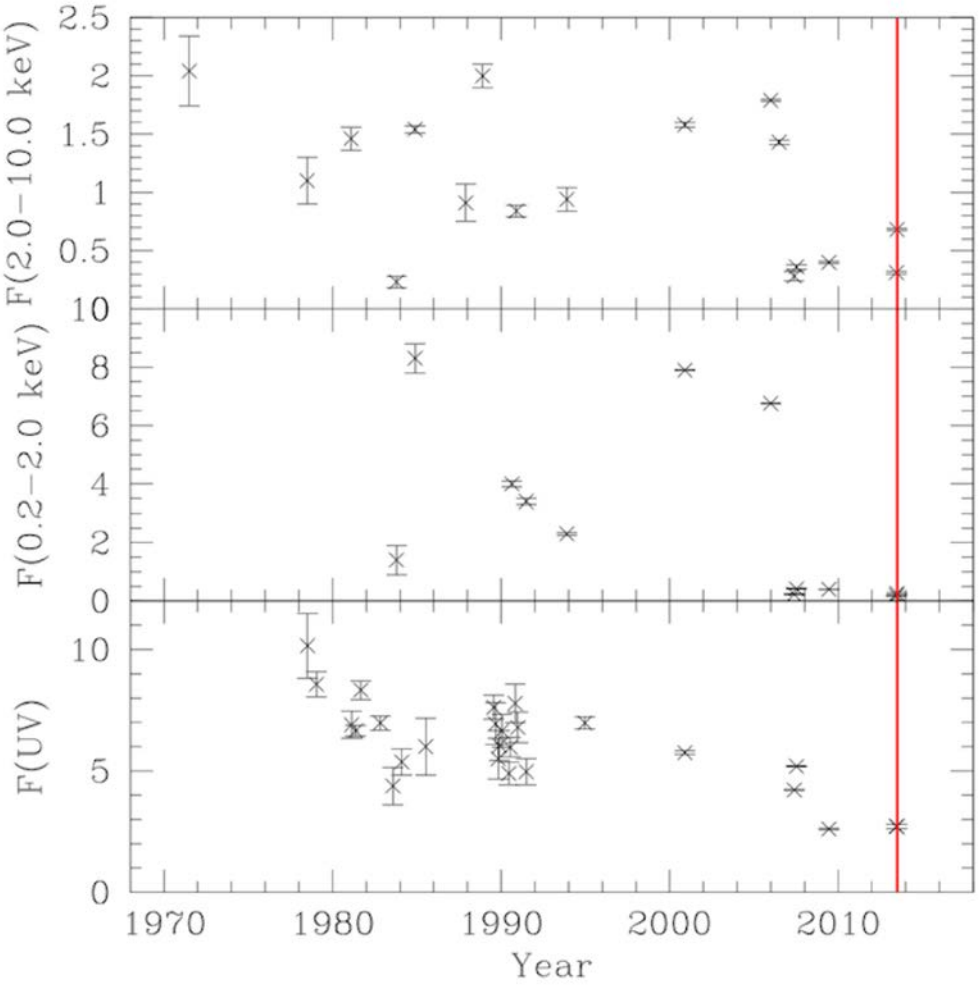
Lensed quasar G2237+0305
Credit: Hubble

Other AGNs

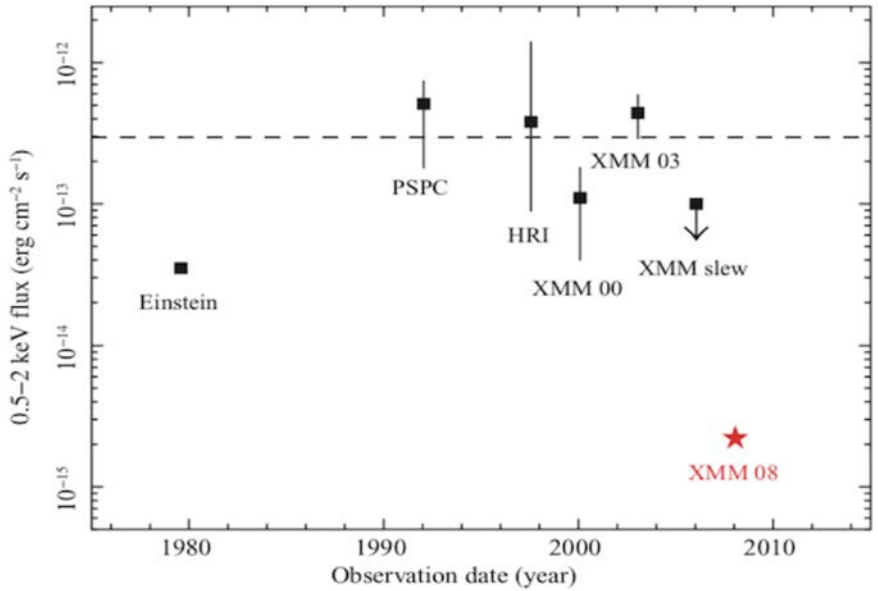


Jiang+18

Other AGNs



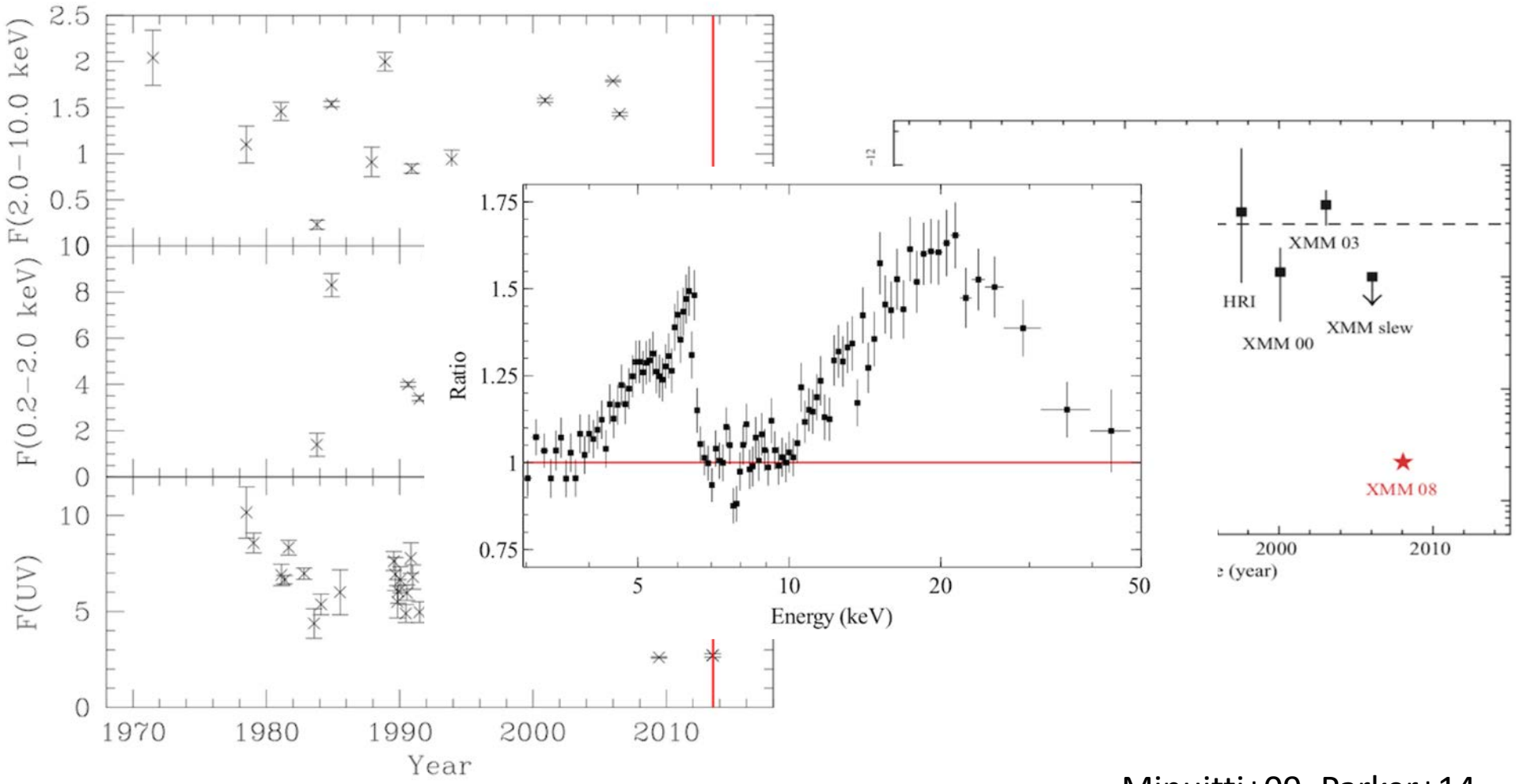
Mrk 335



PHL 1092

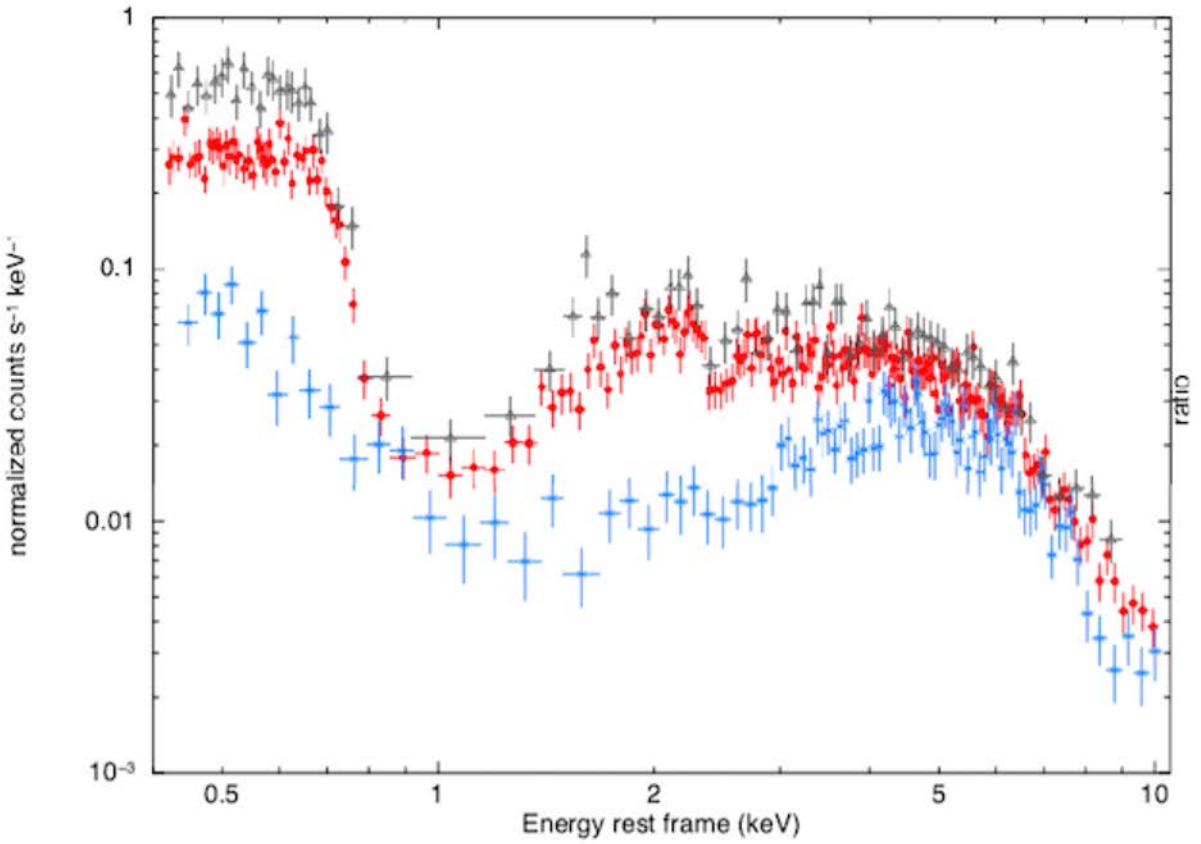
Minuitti+09, Parker+14

Other AGNs



Minuitti+09, Parker+14

Variable Absorber



Variable absorber
PG1535+547

Gallo+08

Conclusions

1. The intrinsic X-ray variability of unobscured AGN is dominated by the coronal emission. The disk reflection spectrum changes correspondingly.

2. The Fe emission line shape change and the reflection fraction change can all be explained by the strong light-bending effects in the vicinity of the central black hole.

Others

Broad band spectral analysis	(Jiang et al, 2018)
UV/X-ray variability study	(Buisson et al, 2017)
X-ray variability study	(Alston et al, 2018)
X-ray lag analysis	(Alston et al, in prep)
Flux-dependent outflow	(Parker et al, 2017; Pinto et al, 2017)
Disk absorption modelling	(Fabian et al, 2018)
High density reflection	(Jiang et al, in prep)
Emissivity profile measurement	(Wilkins et al, in prep)