The Multi-Mission Cross-Calibration Campaign on 3C 273

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3C 273

- Unabsorbed radio loud QSO, z = 0.1583

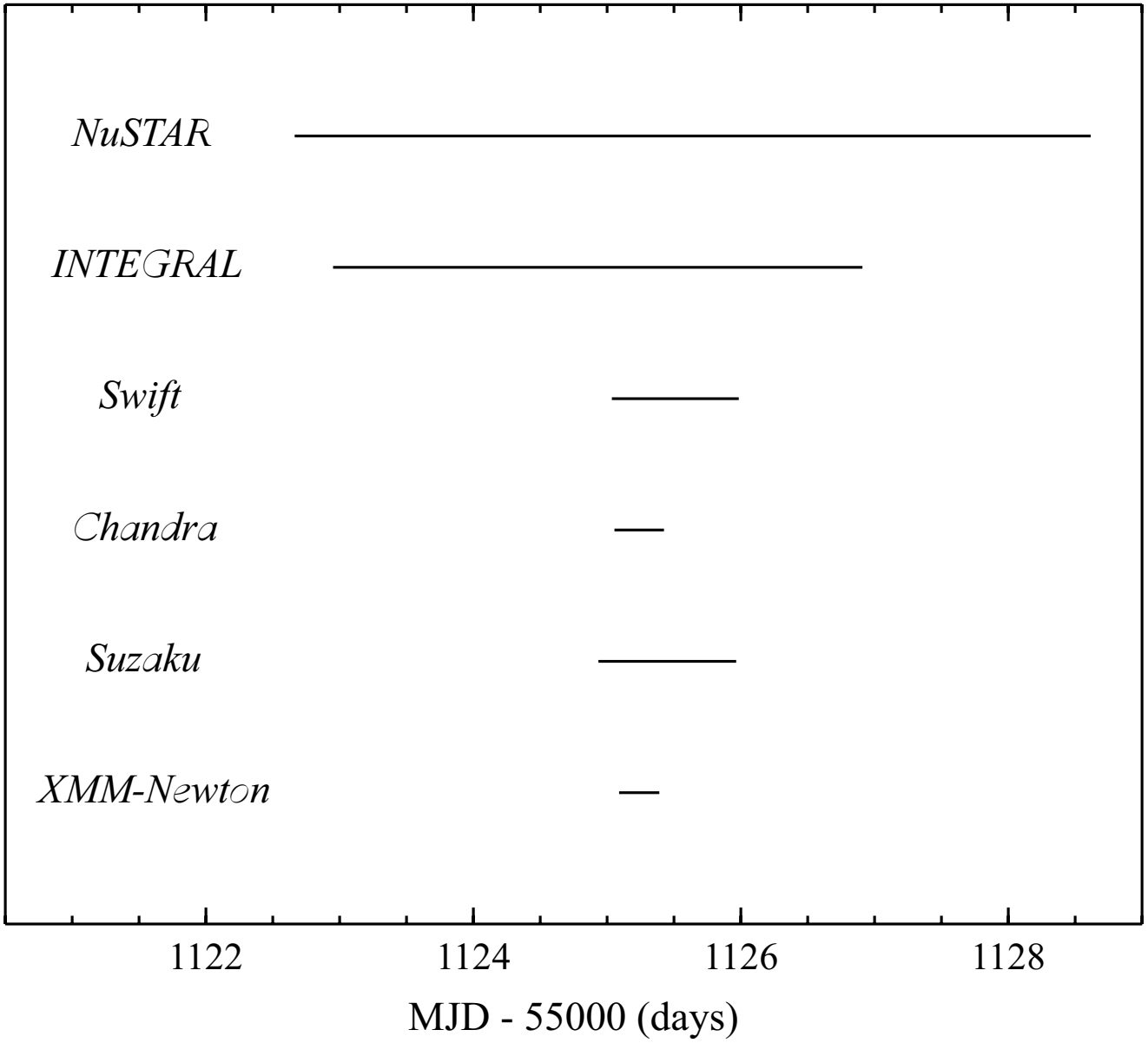
- X-ray spectrum is jet dominated >2 keV, synchrotron bump at >MeV energies

  => Bright, hard X-ray spectrum well represented with a simple powerlaw

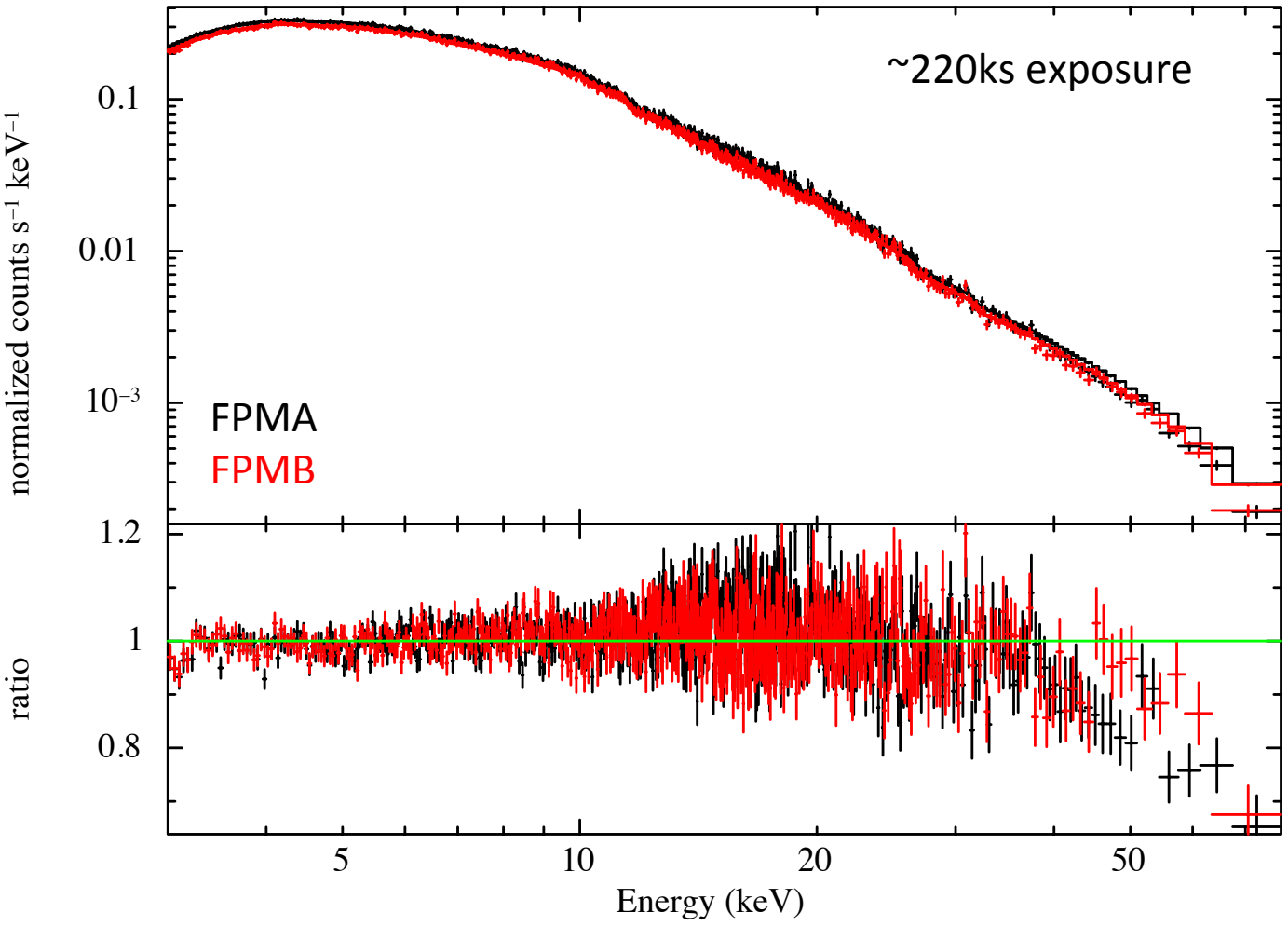
- Long term flux and mild spectral variability

  => Simultaneity potentially important

2012 X-ray Observations



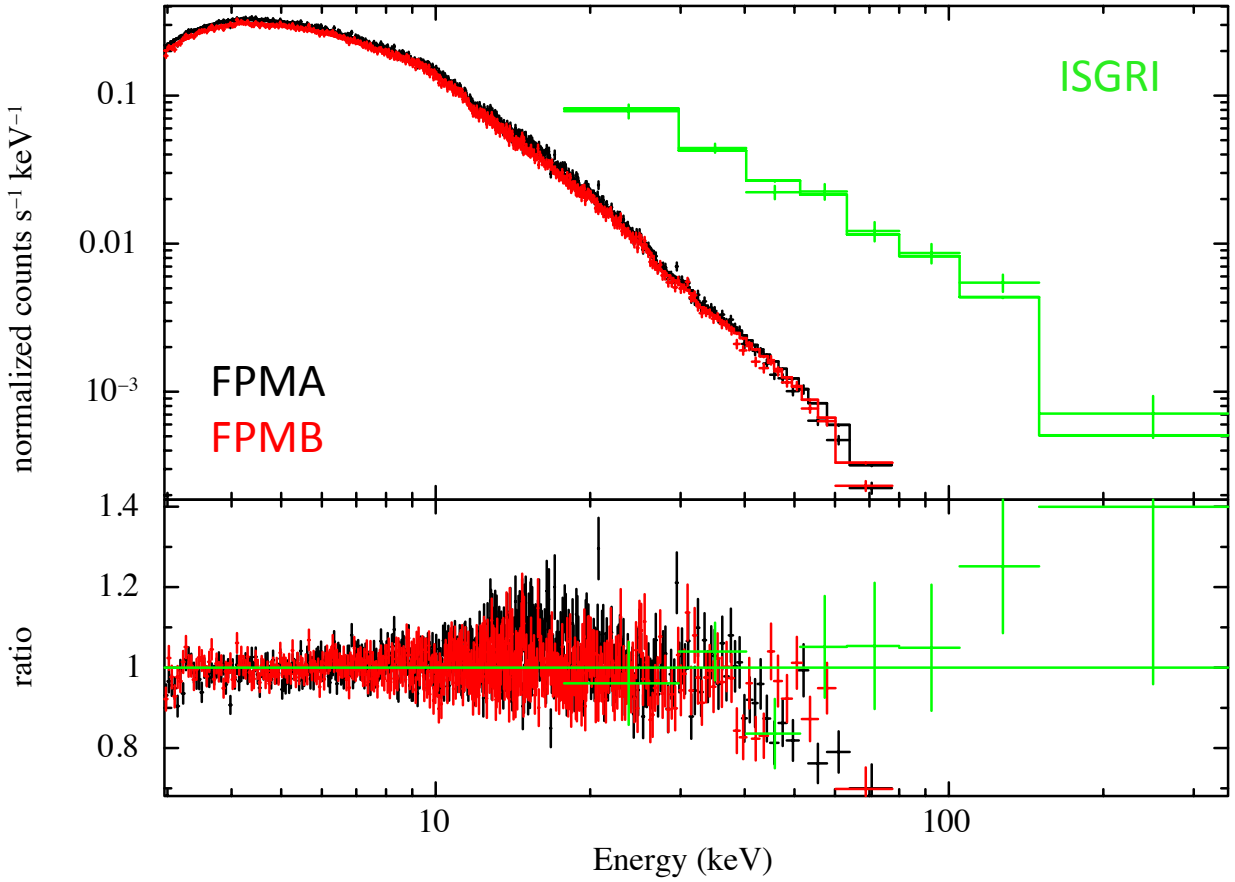
NuSTAR: Current CALDB ARFs



Powerlaw model results in residuals at high energies

NuSTAR and *INTEGRAL*

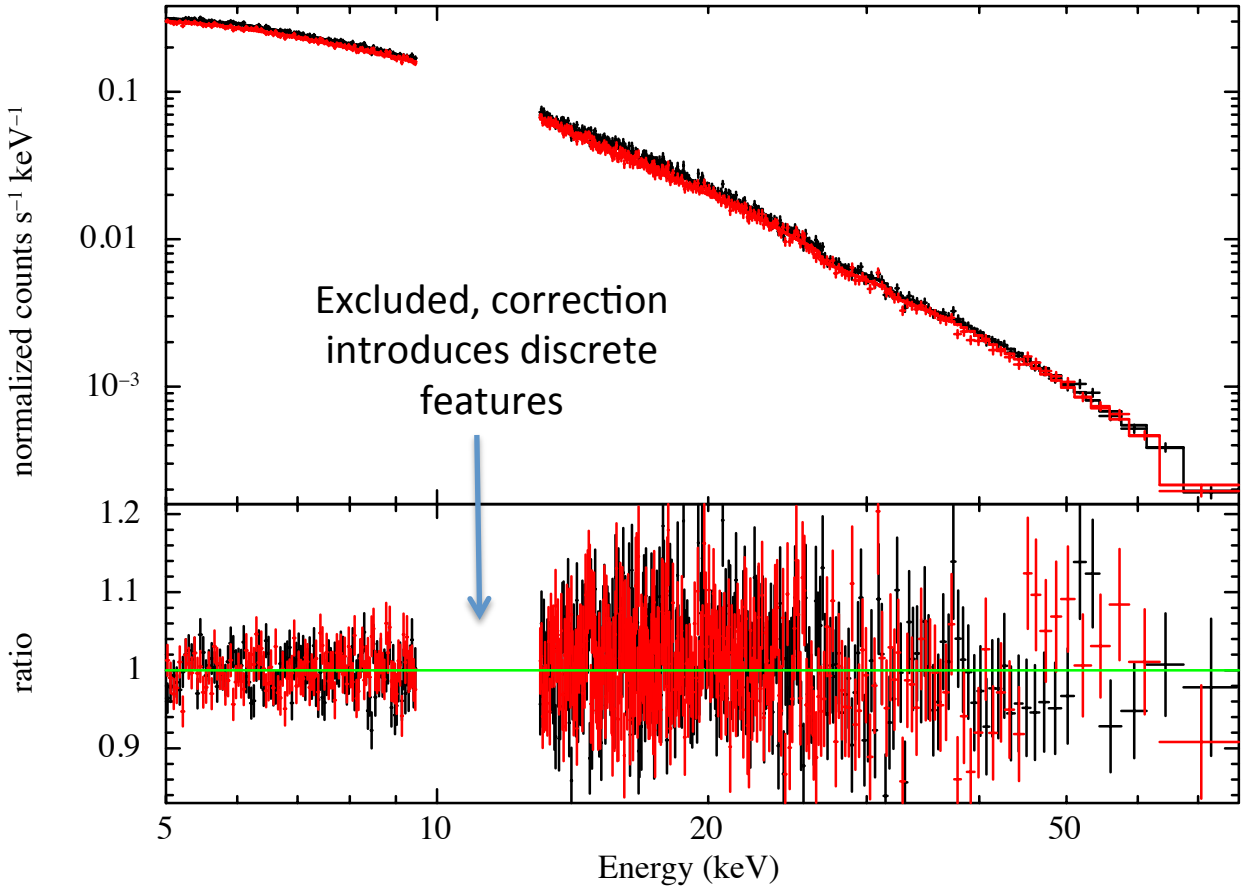
- *NuSTAR* data simultaneous with *INTEGRAL* observation
- ISGRI spectrum provided by *INTEGRAL* (although may be missing majority of data)
- Spectra modeled simultaneously



INTEGRAL spectrum continues to high energies

=> *NuSTAR* turnover not astrophysical

NuSTAR: Crab Corrected



FPMA

Γ = 1.683 +/- 0.005

N = (2.38 +/- 0.01) x 10^{-2}

FPMB

Γ = 1.689 +/- 0.006

N = (2.42 +/- 0.03) x 10^{-2}

(90% errors, 1 param)

χ^2/DoF = 1781/1639

=> Excellent agreement between FPMA and FPMB

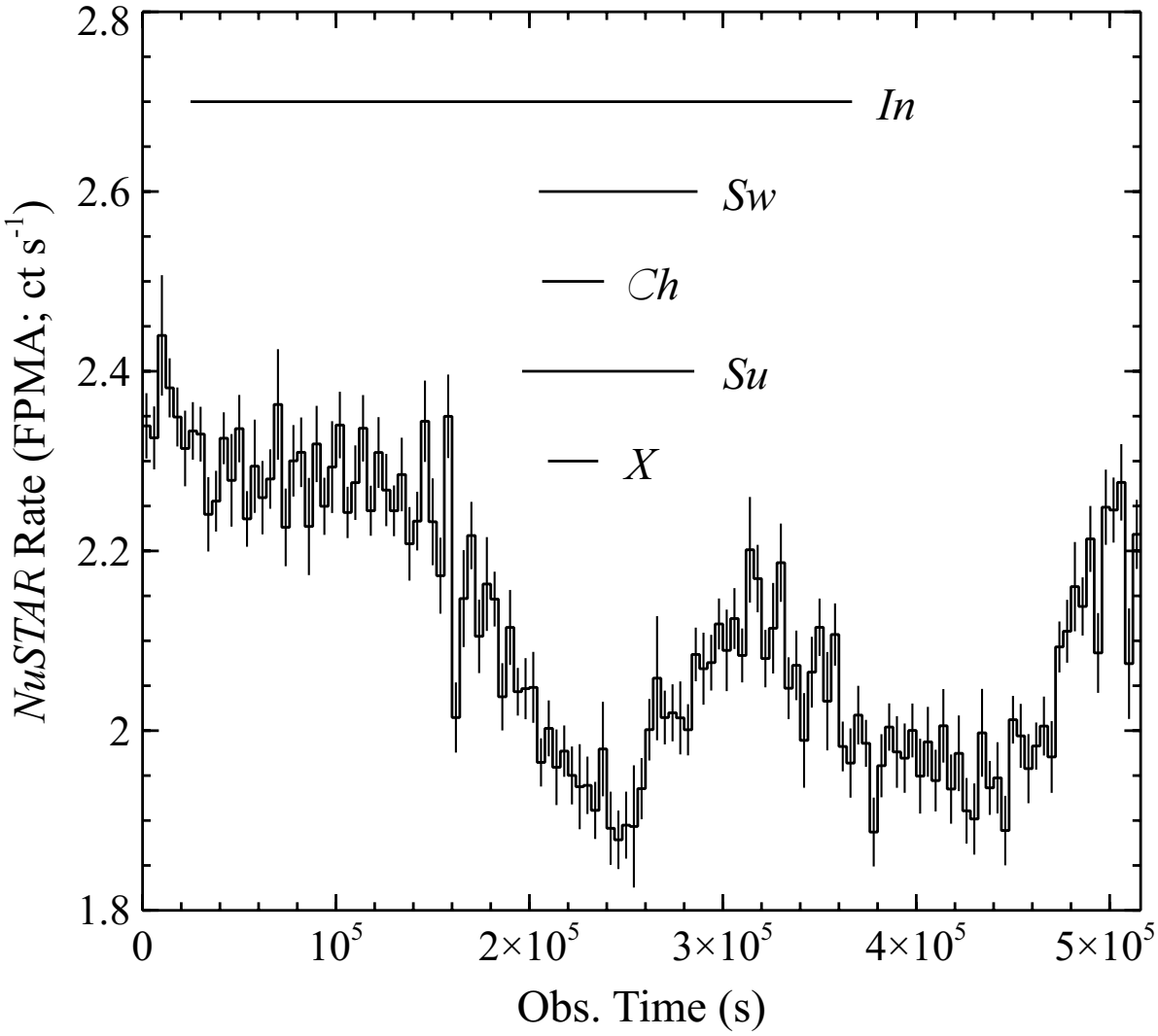
Photon Index Energy Dependence?

Comparison of *NuSTAR* photon indices from various energy bands (FPMA,B linked):

- Full band (4-79 keV): $\Gamma = 1.683$ +/- 0.003
- 4-10 keV: $\Gamma = 1.676$ +/- 0.009
- 10-25 keV: $\Gamma = 1.70$ +/- 0.02
- 25-79 keV: $\Gamma = 1.68$ +/- 0.04

=> Photon indices are consistent, although constraint naturally degrades at higher energies

Flux Variability



~10% variability around the mean count rate during the *NuSTAR* observation.

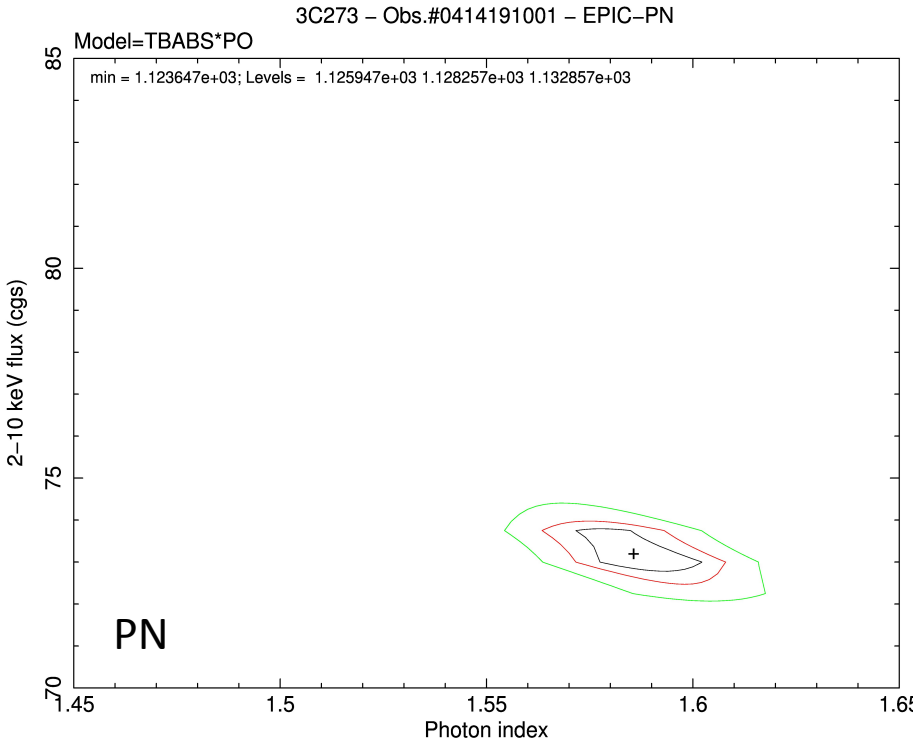
Temporal Spectral Variability?

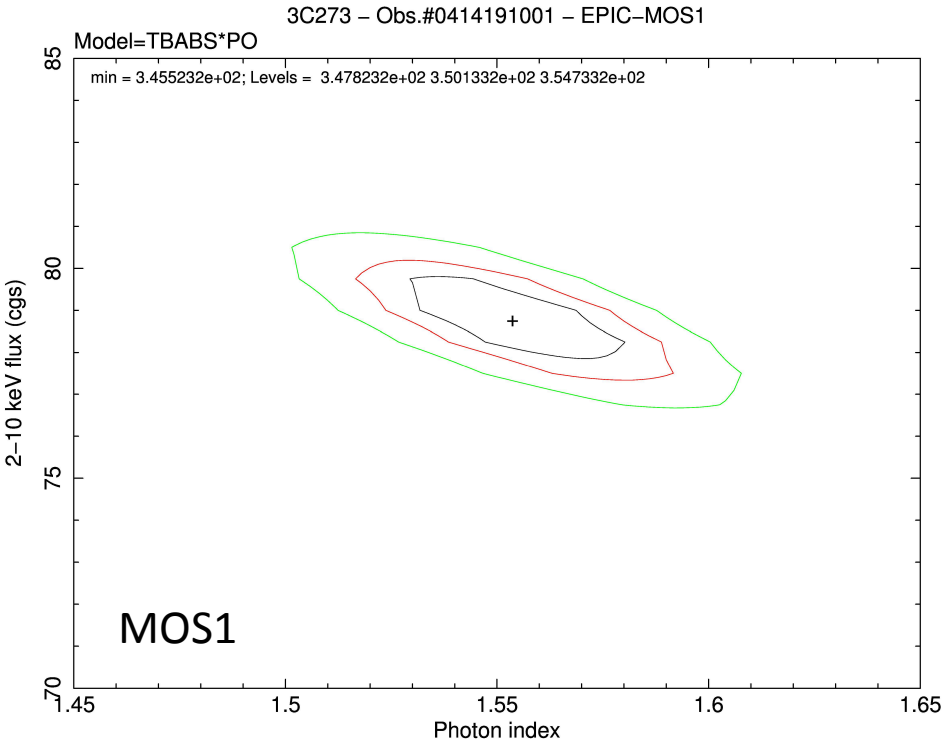
Comparison of *NuSTAR* photon indices from various intervals (FPMA,B linked):

- Full observation: $\Gamma = 1.683$ +/- 0.003
- Simultaneous with *INTEGRAL*: $\Gamma = 1.690$ +/- 0.004
- Simultaneous with *Suzaku*: $\Gamma = 1.706$ +/- 0.009
- Simultaneous with *XMM*: $\Gamma = 1.69$ +/- 0.02

=> Perhaps, but if so, not very much.

XMM-Newton





(Courtesy of M. Guainazzi; 2-10 keV)

Observed in small window mode, 18 ks exposure

Mild pile-up in pn, more severe pileup in MOS, so spectra extracted from annular regions

Suzaku

Observed in ¼ window mode, 40 ks exposure

Individual

XIS0: $\Gamma = 1.62$ +/- 0.02
XIS1: $\Gamma = 1.65$ +/- 0.02
XIS3: $\Gamma = 1.64$ +/- 0.02
PIN: $\Gamma = 1.7$ +/- 0.1

(XIS: 2-10; PIN: 15-70 keV)

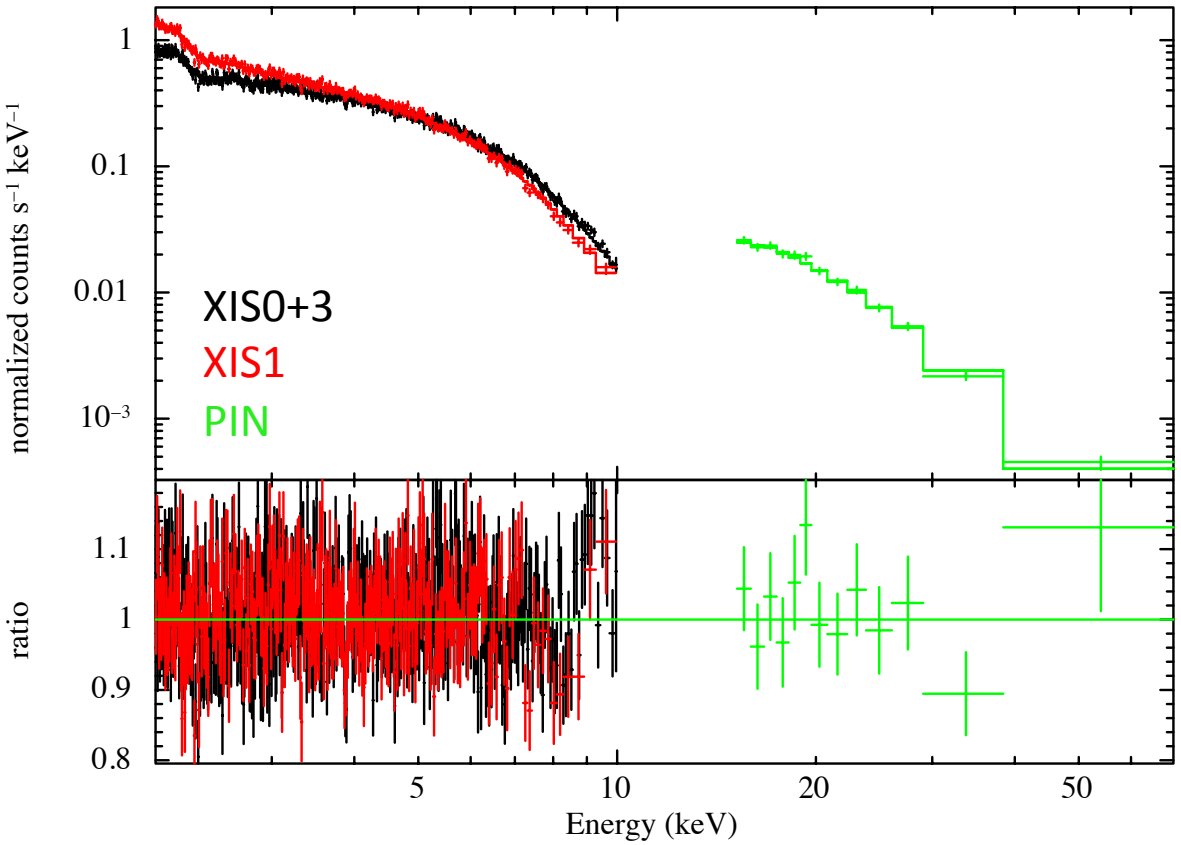
Combined

$\Gamma = 1.642$ +/- 0.009

(2-70 keV)

χ^2/DoF = 1768/1768

$C_{PIN/XIS} = 1.08$ +/- 0.04



Simultaneous with *XMM*

$\Gamma = 1.65$ +/- 0.02

More Photon Indices

INSTRUMENT	EN. RANGE (keV)	PHOTON INDEX	NOTES
NuSTAR (FPMA,B)	4-79	1.683 +/- 0.003	Crab-corrected
XMM-pn	2-10	1.59 +/- 0.01	Mild pile-up, annulus
XMM-MOS1	2-10	1.56 +/- 0.02	Piled-up, annulus
XMM-MOS2	2-10	1.56 +/- 0.02	Piled-up, annulus
Swift-XRT	2-9	1.60 +/- 0.06	Piled up, annulus
Suzaku (combined)	2-70	1.642 +/- 0.009	Tuned PIN background
INTEGRAL-ISGRI	~18-350	1.6 +/- 0.1	
Chandra-HEG (ord. -1,1)	2-8	1.55 +/- 0.05	

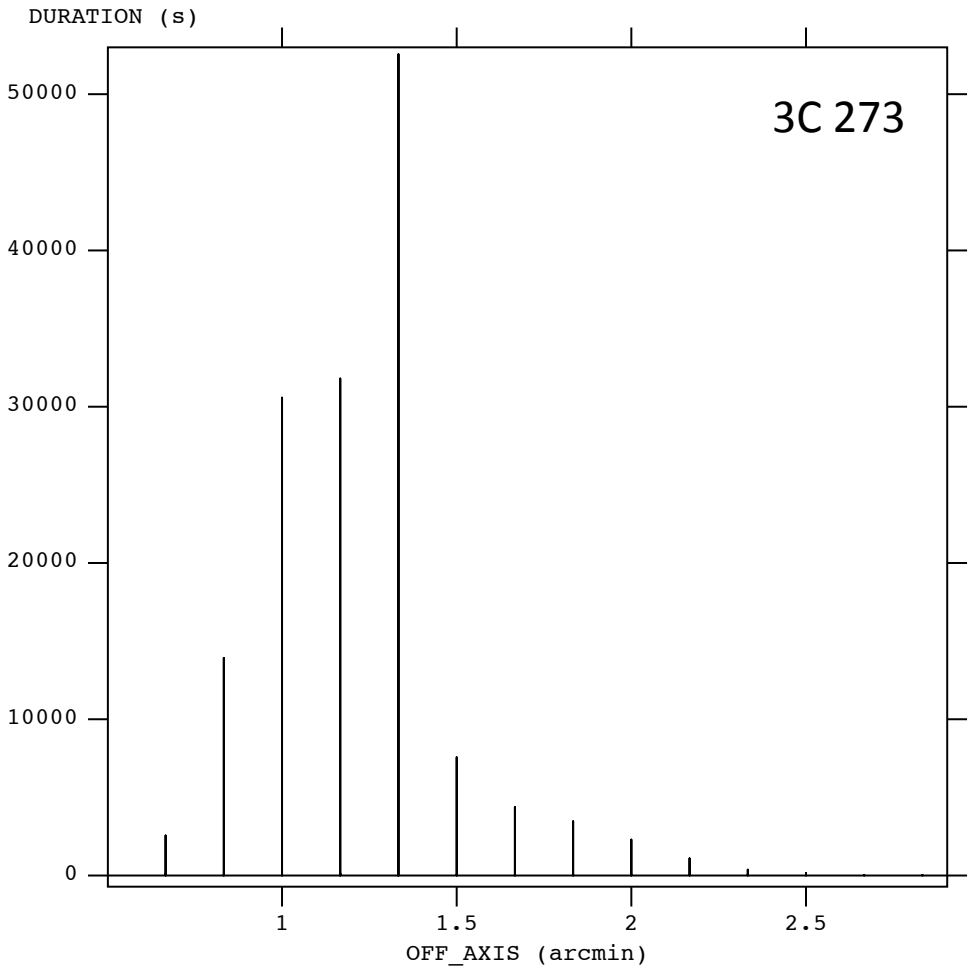
Generally good agreement between most of the missions

But

NuSTAR looks a little soft, as does *Suzaku* (to a lesser extent)

NuSTAR Offaxis Distribution

- Mast motion results in a distribution of offaxis angles throughout an observation
- This distribution is unique for each FPM, and for each observation
- Damn
  (although not surprising)
- More complex correction procedure probably required



Future Plans

- Do more stuff.

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- Examples of more stuffs to be done:
  - Confirm *NuSTAR* optical axis alignment
  - Improve corrections based on the crab, with more specific treatment of different offaxis-angles
  - In parallel, improve ray-traced ARFs (rather time consuming)
  - Take a more strict approach to simultaneity with the other missions (but this may not change much)