

# Relative normalizations of XIS0-3 and PIN in revision 2 data

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## 1 Overview

In this document, we present relative normalizations of the Crab spectra taken on 2005 September 15 which are processed with the revision 2 pipeline (so-called rev-2 data).

The response functions of the XIS are made with the response builders `xisrmfgen` and `xissimarfgen` whose versions are 2007-05-14 and 2007-07-16, respectively. We adopt `ae_hxd_pin[hx/xi]nom_20060814.rsp` as the PIN response. The source integration regions of the XIS are taken large enough to cover the entire Crab nebula, and the background regions are set at the edge of each XIS so that the out-of-time events can properly be subtracted. See [1] for full detail about the source and background integration regions of the XIS. The NXB background spectrum of the PIN is created from the standard model NXB event file.

The results of the XIS nominal and HXD nominal pointing positions are summarized in § 2 and § 3, respectively. Each section consists of (1) the spectral parameters of individual detectors, (2) the power-law normalizations when the photon index is constrained to be the same, and (3) their variation when the PIN energy band used in fitting is changed. Cases with and without XIS2 are considered separately for (2) and (3).

**Spectral parameters from each detector** ... Photon-indices obtained from individual XIS detectors in the 1-10 keV band distribute in the range 2.05–2.08 and 2.03–2.09 at the XIS and HXD nominal positions (table 1 and table 4), respectively. That of the PIN in the 12-40 keV band is 2.09–2.10. Note that the photon index of XIS0 is significantly changed from rev-1.2 [1]. This is because the thickness of the depletion layer is updated for XIS0.

**Relative normalizations with a common photon index** ... A power-law model is fitted to all XIS and PIN spectra in the bands 1-10 keV and 12-40 keV, respectively, with the photon index being constrained to be common among all the detectors. The normalization of the PIN relative to XIS0 becomes 1.09 (table 2) and 1.13 (table 5) at the XIS and HXD nominal positions, respectively. These values are nearly unchanged when the XIS2 spectrum is omitted from the fit (table 3 and table 6). The relative normalizations of XIS1, 2, and 3 are within  $\pm 3\%$  from that of XIS0 at the XIS nominal position, whereas they are larger than that of XIS0 by 4-7% at the HXD nominal position.

**Relative normalizations when the PIN energy band is somewhat truncated** ... In many cases, the source may not be detected with the PIN up to 40 keV. When the PIN energy band is limited, such as 12-20 keV for example, the relative normalizations presented above may be different because the photon indices of the XIS and the PIN are different systematically. We thus have checked the normalization of the PIN relative to XIS0 and the photon index by changing the upper boundary of the PIN energy band used in fitting. The normalization are found to be reduced to  $\sim 1.06$  and  $\sim 1.11$  for the XIS and HXD nominal positions, respectively (fig. 3, 5, 8, and 10).

## References

- [1] Serlemitsos et al. 2007, PASJ **59**, 9

## 2 XIS nominal position

### 2.1 Fit to individual detectors

Table 1: Power-law fit to individual XIS and PIN spectra at the XIS nominal position. Used energy bands are XIS:1-10keV and PIN:12-40keV.

Detector hline	$N_{\text{H}}$ [ $10^{22}\text{cm}^{-2}$ ]	$\Gamma$	Norm <sup>a</sup>	Flux <sup>b</sup>	$\chi^2_{\nu}$ (dof)
XIS0	$0.288\pm 0.014$	$2.050\pm 0.016$	$9.51\pm 0.21$	2.207	1.42 (100)
XIS1	$0.287\pm 0.013$	$2.075\pm 0.016$	$10.09\pm 0.21$	2.256	1.77 (100)
XIS2	$0.277\pm 0.014$	$2.065\pm 0.015$	$9.69\pm 0.21$	2.202	1.66 (100)
XIS3	$0.295\pm 0.014$	$2.046\pm 0.016$	$9.31\pm 0.20$	2.173	1.61 (100)
PIN	0.3 (fix)	$2.101\pm 0.008$	$11.41\pm 0.26$	2.464	0.74 (72)

a: photons  $\text{cm}^{-2}\text{s}^{-1}\text{keV}^{-1}$  at 1 keV.

b:  $10^{-8}\text{erg cm}^{-2}\text{s}^{-1}$  in 2-10 keV.

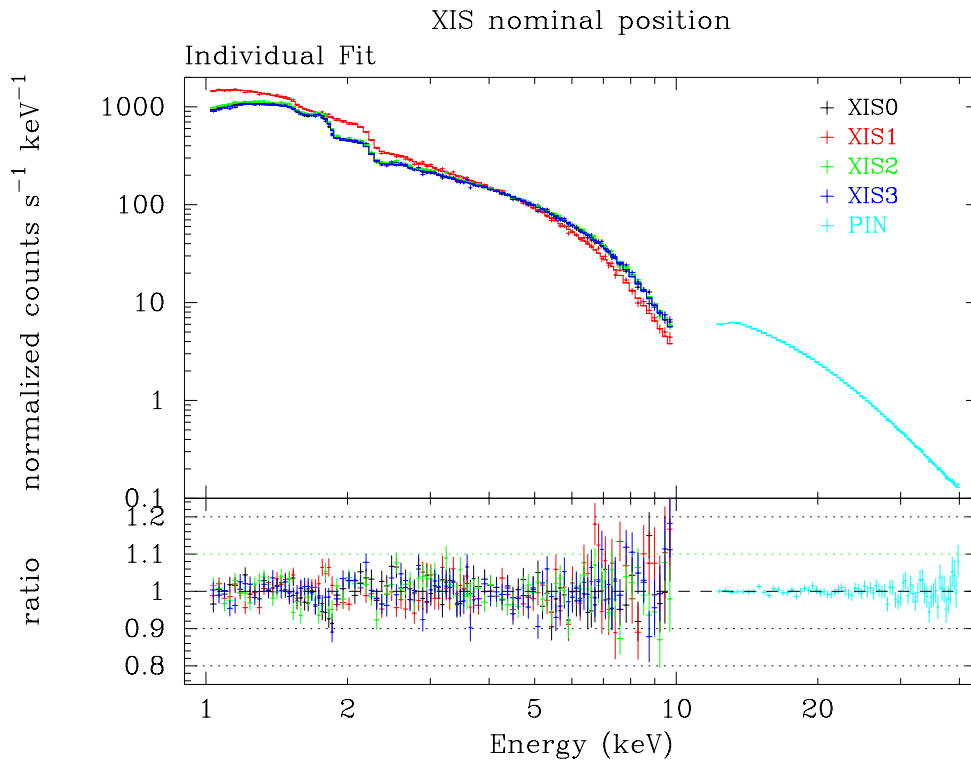


Figure 1: Power-law fit to individual XIS and PIN spectra at the XIS nominal position.

## 2.2 Fit with Common $\Gamma$

### 2.2.1 with all XIS modules

Table 2: Power-law fit with a common photon index to all XIS and PIN spectra at the XIS nominal position. Used energy bands are XIS:1-10keV and PIN:12-40keV.

Detector	$N_{\text{H}}$ [ $10^{22}\text{cm}^{-2}$ ]	$\Gamma$	const	Norm <sup>a</sup>	Flux <sup>b</sup>	$\chi^2_{\nu}$ (dof)
XIS0	$0.311\pm 0.008$	$2.080\pm 0.006$	1.000 (fix)	$9.89\pm 0.10$	2.190	1.56 (476)
XIS1	$0.290\pm 0.007$		$1.026\pm 0.009$			
XIS2	$0.288\pm 0.008$		$0.999\pm 0.009$			
XIS3	$0.321\pm 0.008$		$0.984\pm 0.009$			
PIN	0.3 (fix)		$1.086\pm 0.012$			

a: photons  $\text{cm}^{-2}\text{s}^{-1}\text{keV}^{-1}$  at 1 keV.

b:  $10^{-8}\text{erg cm}^{-2}\text{s}^{-1}$  in 2-10 keV.

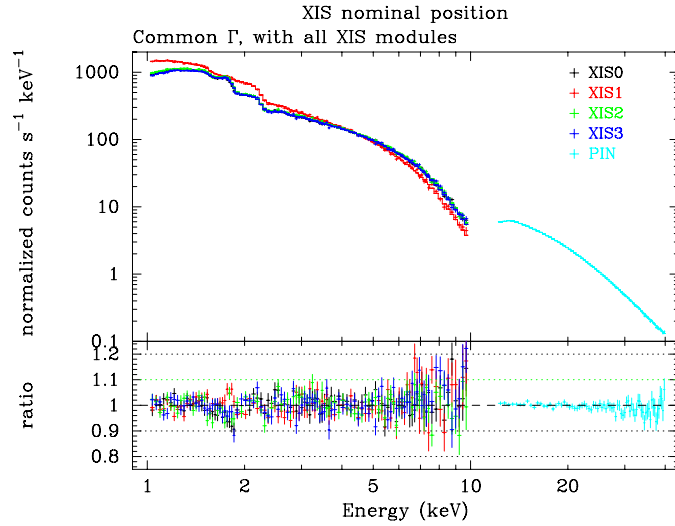


Figure 2: Power-law fit to all XIS and PIN spectra with a common photon index.

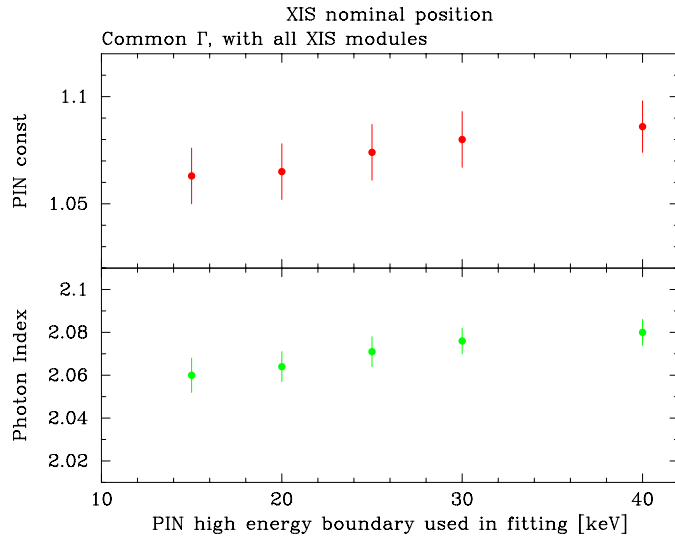


Figure 3: PIN normalization relative to that of XIS0 and photon index as a function of the PIN high energy boundary used in fitting. Abscissa value  $E_{\text{H}}$  implies the fit to PIN data is carried out in the 12- $E_{\text{H}}$  keV band.

### 2.2.2 without XIS2

Table 3: Power-law fit with a common photon index to XIS0, 1, 3 and PIN spectra at the XIS nominal position. Used energy bands are XIS:1-10keV and PIN:12-40keV.

Detector	$N_{\text{H}}$ [ $10^{22}\text{cm}^{-2}$ ]	$\Gamma$	const	Norm <sup>a</sup>	Flux <sup>b</sup>	$\chi^2_{\nu}$ (dof)
hline						
XIS0	$0.313 \pm 0.009$	$2.082 \pm 0.006$	1.000 (fix)	$9.92 \pm 0.10$	2.188	1.53 (375)
XIS1	$0.292 \pm 0.008$		$1.026 \pm 0.009$			
XIS3	$0.323 \pm 0.009$		$0.984 \pm 0.009$			
PIN	0.3 (fix)		$1.090 \pm 0.013$			

a: photons  $\text{cm}^{-2}\text{s}^{-1}\text{keV}^{-1}$  at 1 keV.

b:  $10^{-8}\text{erg cm}^{-2}\text{s}^{-1}$  in 2-10 keV.

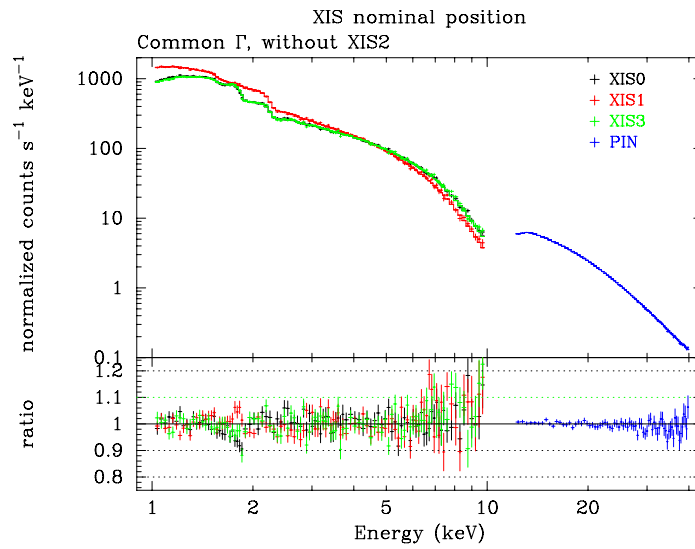


Figure 4: Power-law fit to XIS0, 1, 3 and PIN spectra with a common photon index.

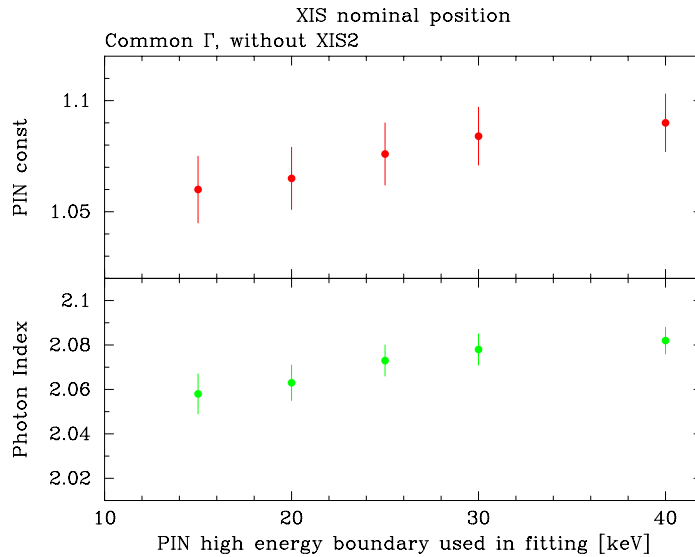


Figure 5: PIN normalization relative to that of XIS0 and photon index as a function of the PIN high energy boundary used in fitting. Abscissa value  $E_{\text{H}}$  implies the fit to PIN data is carried out in the 12- $E_{\text{H}}$  keV band.

### 3 HXD nominal position

#### 3.1 Fit to individual detectors

Table 4: Power-law fit to individual XIS and PIN spectra at the HXD nominal position. Used energy bands are XIS:1-10keV and PIN:12-40keV.

Detector hline	$N_{\text{H}}$ [ $10^{22}\text{cm}^{-2}$ ]	$\Gamma$	Norm <sup>a</sup>	Flux <sup>b</sup>	$\chi^2_{\nu}$ (dof)
XIS0	$0.279\pm 0.016$	$2.046\pm 0.019$	$8.89\pm 0.23$	2.078	1.81 (100)
XIS1	$0.294\pm 0.015$	$2.093\pm 0.019$	$10.05\pm 0.25$	2.186	0.99 (100)
XIS2	$0.265\pm 0.015$	$2.057\pm 0.017$	$9.33\pm 0.22$	2.150	1.40 (100)
XIS3	$0.265\pm 0.015$	$2.031\pm 0.017$	$9.31\pm 0.22$	2.226	1.63 (100)
PIN	0.3 (fix)	$2.090\pm 0.009$	$10.93\pm 0.27$	2.400	0.82 (72)

a: photons  $\text{cm}^{-2}\text{s}^{-1}\text{keV}^{-1}$  at 1 keV.

b:  $10^{-8}\text{erg cm}^{-2}\text{s}^{-1}$  in 2-10 keV.

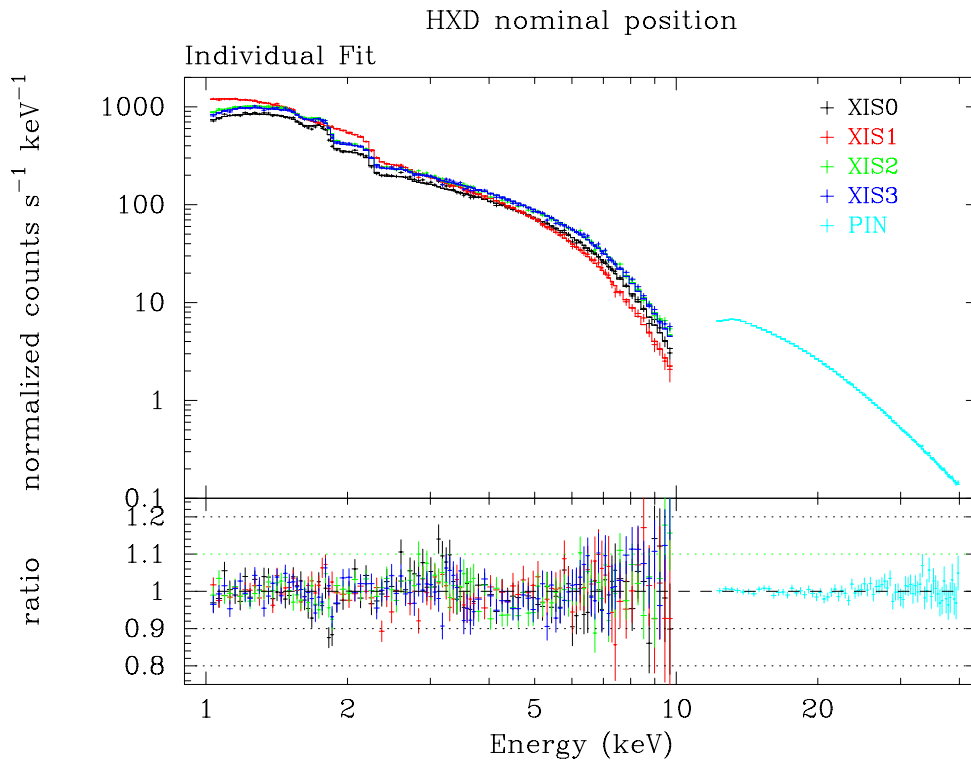


Figure 6: Power-law fit to individual XIS and PIN spectra at the HXD nominal position.

## 3.2 Fit with Common $\Gamma$

### 3.2.1 with all XIS modules

Table 5: Power-law fit with a common photon index to all XIS and PIN spectra at the HXD nominal position. Used energy bands are XIS:1-10keV and PIN:12-40keV.

Detector	$N_{\text{H}}$ [ $10^{22}\text{cm}^{-2}$ ]	$\Gamma$	const	Norm <sup>a</sup>	Flux <sup>b</sup>	$\chi^2_{\nu}$ (dof)
XIS0	$0.300\pm 0.010$	$2.073\pm 0.006$	1.000 (fix)	$9.21\pm 0.10$	2.063	1.43 (476)
XIS1	$0.282\pm 0.008$		$1.065\pm 0.011$			
XIS2	$0.278\pm 0.009$		$1.035\pm 0.011$			
XIS3	$0.297\pm 0.009$		$1.067\pm 0.011$			
PIN	0.3 (fix)		$1.132\pm 0.014$			

a: photons  $\text{cm}^{-2}\text{s}^{-1}\text{keV}^{-1}$  at 1 keV.

b:  $10^{-8}\text{erg cm}^{-2}\text{s}^{-1}$  in 2-10 keV.

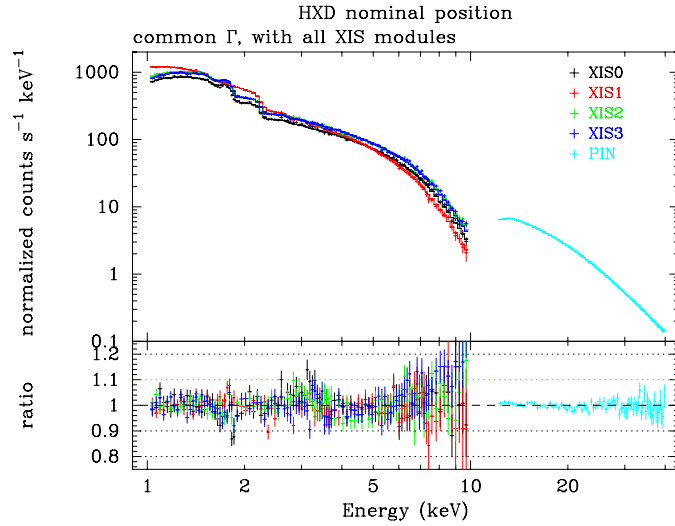


Figure 7: Power-law fit to all XIS and PIN spectra with a common photon index.

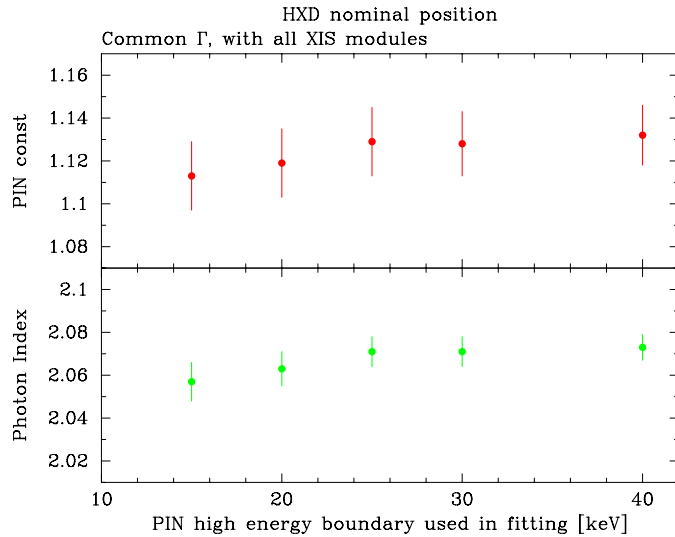


Figure 8: PIN normalization relative to that of XIS0 and photon index as a function of the PIN high energy boundary used in fitting. Abscissa value  $E_{\text{H}}$  implies the fit to PIN data is carried out in the 12- $E_{\text{H}}$  keV band.

### 3.2.2 without XIS2

Table 6: Power-law fit with a common photon index to XIS0, 1, 3 and PIN spectra at the HXD nominal position. Used energy bands are XIS:1-10keV and PIN:12-40keV.

Detector	$N_{\text{H}}$ [ $10^{22}\text{cm}^{-2}$ ]	$\Gamma$	const	Norm <sup>a</sup>	Flux <sup>b</sup>	$\chi^2_{\nu}$ (dof)
hline						
XIS0	$0.302 \pm 0.010$	$2.076 \pm 0.007$	1.000 (fix)	$9.25 \pm 0.10$	2.061	1.43 (375)
XIS1	$0.284 \pm 0.008$		$1.065 \pm 0.011$			
XIS3	$0.299 \pm 0.009$		$1.067 \pm 0.011$			
PIN	0.3 (fix)		$1.137 \pm 0.015$			

a: photons  $\text{cm}^{-2}\text{s}^{-1}\text{keV}^{-1}$  at 1 keV.

b:  $10^{-8}\text{erg cm}^{-2}\text{s}^{-1}$  in 2-10 keV.

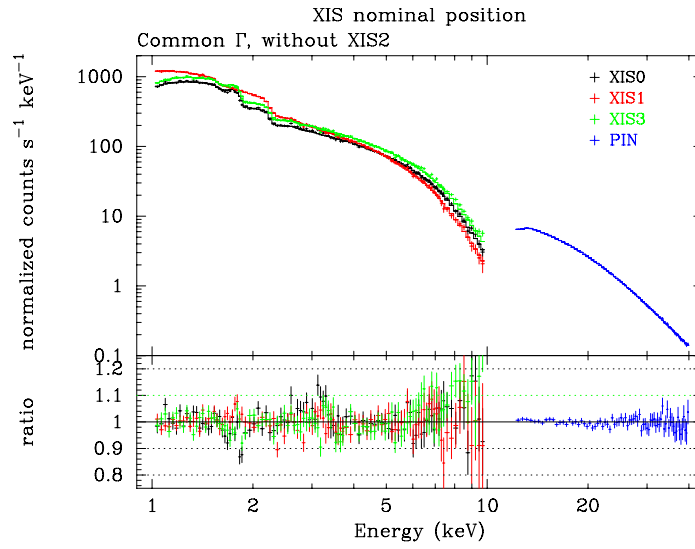


Figure 9: Power-law fit to XIS0, 1, 3 and PIN spectra with a common photon index at the HXD nominal position.

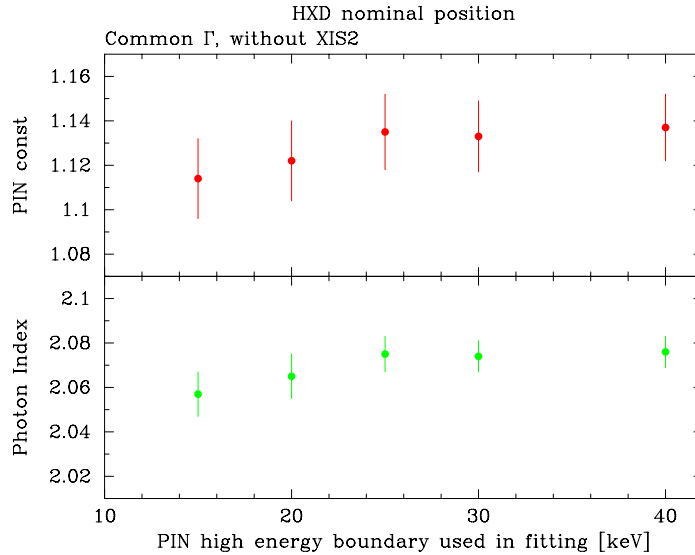


Figure 10: PIN normalization relative to that of XIS0 and photon index as a function of the PIN high energy boundary used in fitting. Abscissa value  $E_{\text{H}}$  implies the fit to PIN data is carried out in the 12- $E_{\text{H}}$  keV band.