The models of XIS OBF contamination

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Using day earth data of XIS, we investigated the time and positional dependence of the absorption due to the contamination on the optical blocking filter (OBF). Assuming the model produced by Eric-san as to the amount of contamination on the field center, we calculated the absorption of off-axis positions from the intensity ratio of the N and O lines of XIS1 (BI), and expressed them as the function of time and angle from the field center. Then, we confirmed that the model is applicable to three FI sensors by the day earth data and diffuse sources data such as Cygnus Loop. Note this model is only applicable to the data obtained by the end of February 2006.

1 Day Earth Data

The data are selected by the criteria of ELV< -5deg && NTE_ELV=120deg, and excluded saturated frames. We merged the data month to month, and extracted spectra from circular region with a radius of 2' and outer annular regions each 1'-radii described in Figure 1.

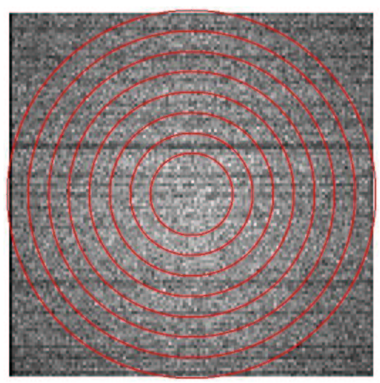

Figure 1: The XIS1 image of day earth data (0.35–0.6 keV).

Figure 2 shows the spectra of 0.35–0.6 keV. The spectra of top-left and top-right are extracted from the 2'-radius circle of the center and the annular region with inner and outer radii of 8' and 9' of September 2005, respectively. On the other hand, the spectra of bottom-left and bottom-right are extracted the same regions but the data are obtained on February 2006. The intensity ratio of the N and O lines of the two spectra of September 2005 are very similar, but the N line of field center is weaker than that of field edge in February 2006. It means that the non-uniformity of the contaminant had been developed and stronger absorption occurs at the field center on recent observations.

In the data of each month, the spectra of illuminating X-ray should be uniform, so we must only consider the effects of vignetting and absorption by contamination. In the range of 0.35–0.6keV band, the energy dependency of vignetting effect is negligible, we therefore can consider that the difference of intensity ratio of N and O lines in the field of view completely due to the non-uniformity of absorption by contaminant. Then, we measured the amount of absorption of each region using following process.

1. Here, we use "varabs" model to express absorption component in the same way to Eric-san's report (XOOPS 2006/2/1), and we assume the absorption of field center consists with the model produced by Eric-san.

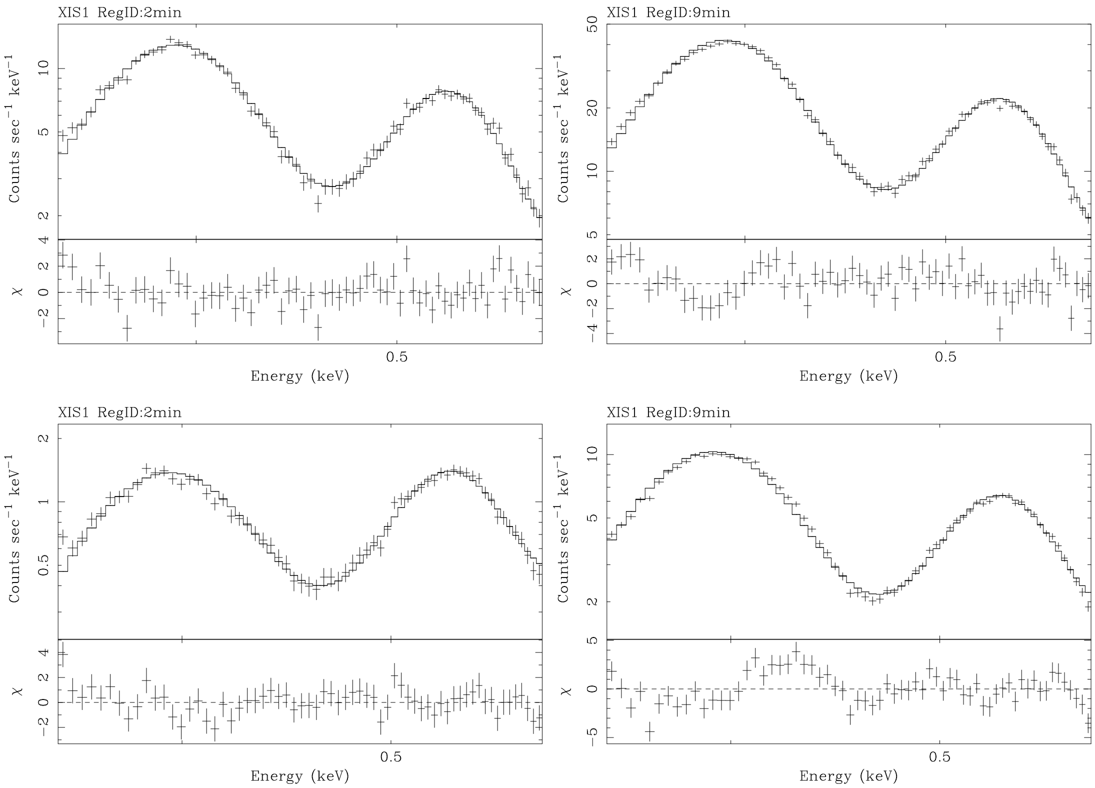

Figure 2: The spectra of day earth data in 0.35–0.6keV band. top-left: the field center of September 2005, top-right: the field edge of September 2005, bottom-left: the field center of February 2006, bottom-right: the field edge of February 2006. The difference of energy resolution between the center spectra and edge spectra is mainly due to incompleteness of CTI correction, and it couldn't be dissolved in this analysis.

2. Using varabsC parameter determined by Eric-san's model, we fitted spectra of field center by the models of varabs * (Gaussian + Gaussian + power-law). Then the spectral shapes of illuminating X-ray were determined.

3. We fitted the outer region spectra by the same model determined in (2), but the normalization of (Gaussian + Gaussian + power-law) and varabsC were treated as free parameter, and then obtained varabsC of each region.

All of the obtained varabsC values are plotted in Figure 3. We can see that the absorption decreases with the distance from field center, and fitted this dependence with the next function.

$$\mathrm{VarabsC}(t,r) = \frac{E(t)}{1 + (\frac{r}{A(t)})^{B(t)}} \tag{1}$$

Here, $E(t)$ equals to the time-dependent function $E(t) = 0.0073t - 0.026$ produced by Eric-san, and t and r means days after 2005-08-13 (following the Eric-san's report) and the distance from center of field of view (arcmin).

Although we, at first, fitted them treating $A(t)$ and $B(t)$ as free parameters, $B(t)$ are almost independent of time as shown in left panel of Figure 4. Therefore we fixed $B(t)$ to average value ($B = 2.89$), and fitted again with the function (1) but only $A(t)$ is set to be free. The result of fitting is shown in right panel of Figure 4, and it can be fitted with linear function of time shown as solid line in the panel. The best fit model can be expressed with $E(t)$,

$$A(t) = 2.54E(t) + 6.39. \tag{2}$$

In summary, The time and positional dependence of absorption is expressed by next function.

$$\mathrm{VarabsC}(t,r) = \frac{E(t)}{1+(\frac{r}{2.54E(t)+6.39})^{2.89}} \quad (3)$$

The solid lines shown in Figure 3 are results by applying this model to each month data.

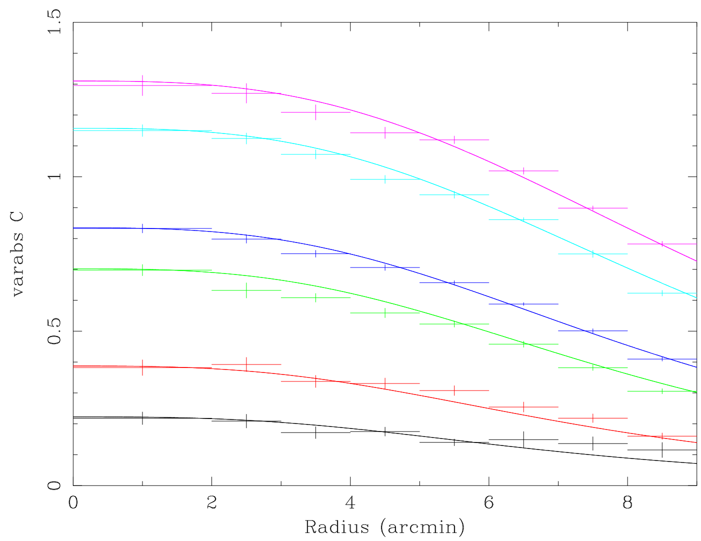

Figure 3: The time and positional dependence of contamination. Black, red, green, blue, light-blue, and magenta show the values of 2005/09 – 2006/02 in order. Solid lines mean results by applying the model shown as (3) to each month data.

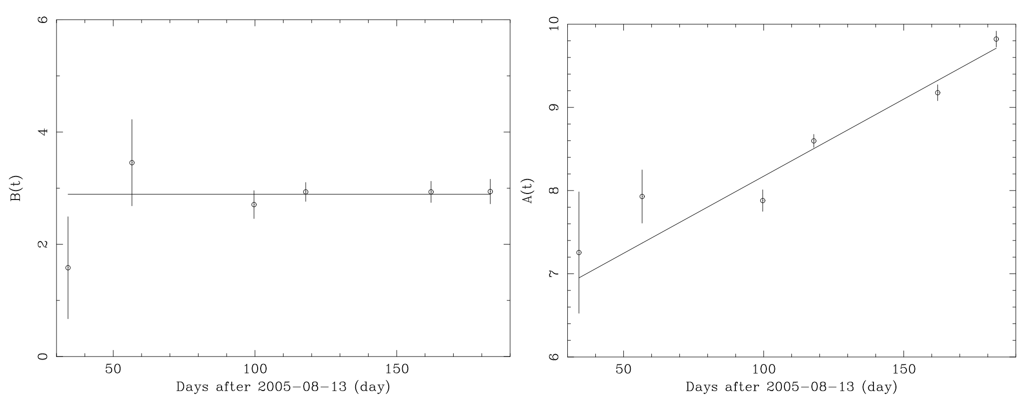

Figure 4: The time dependences of $B(t)$ (left) and $A(t)$ (right).

If we assume that the positional dependence can be expressed by function depending on only the amount of absorption of field center, we can apply the function of (3) to the other three FI sensors, only by replacing $E(t)$ with the other functions for each sensor produced by Eric-san. The $E(t)$ parameters for each sensor quoted from Eric-san's report are shown in Table 1.

In the case of FI sensors, N line can't be detected completely because of high event threshold. Therefore we can't calculate absorption value by the same way of BI. However, we confirmed the model is also usable to FI sensors with O line intensity only. (Details are omitted in this report.)

2 Confirmation with Cygnus Loop data

Using Cygnus Loop data, furthermore, we tested the accuracy of the model. This object was observed in late November 2005. Figure 5 shows the spectra of Cygnus Loop in 0.2–0.4keV (near the C-edge). We fitted

Table 1: VarabsC parameters of field center

	XIS0	XIS1	XIS2	XIS3
slope (varabsC/day)	0.0043	0.0073	0.0085	0.0114
intercept (varabsC)	0.012	-0.026	-0.009	0.148

them with the models of varabs * wabs * mekal, and fixed varabsC to the values obtained by the function (3). Only two parameters, kT and normalization were set to be free. The results are shown as residuals in Figure 5. At least, there are no conflict for FI sensors. Since residuals are conspicuous particularly in the field edge for BI, we thawed varabsC and fitted again. However the residuals were not much improved, so the inconsistencies between the model and data due to incompleteness of calibration (e.g. CTI correction). We also checked for another region, and we confirmed the model we built has no significant conflict.

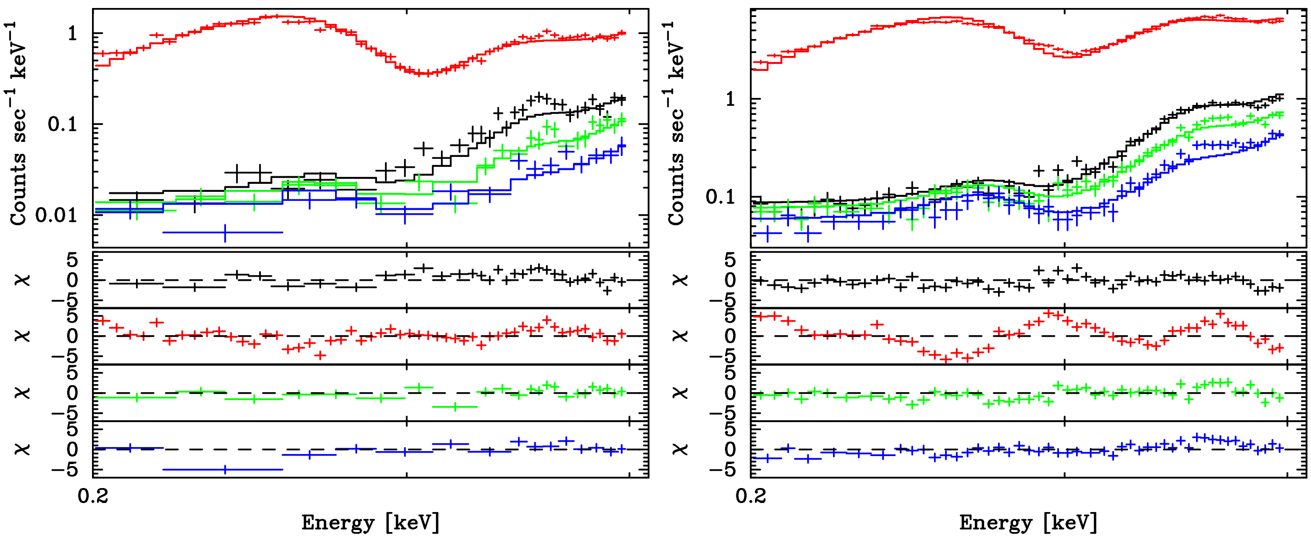

Figure 5: The spectra of Cygnus Loop in 0.2–0.4 keV band. left and right are extracted from the 1.4'radius circle of field center and annular region with inner and outer radii of 7' and 8.4', respectively. Black, red, green, and blue consist with XIS0, 1, 2, and 3, respectively.