

Update on the Suzaku/XIS Contamination: New Contamination Rate Function and Investigation of Temporal Deviations

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1 Introduction

This report summarizes recent analysis of the on-axis contamination history of the Suzaku/XIS OBFs, using observations of E0102. Data through 2008-12-14 are included. They have been reprocessed with the latest gain and response calibration, and a new functional form has been adopted which better traces the contamination rate, especially for XIS0. I propose that this form be adopted for use in the CALDB. The fit residuals remain significant, and after a cursory analysis of their correlation with various observables, they appear to be correlated with the time of year.

2 Effects of Reprocessing on Contamination Measurement

I have reprocessed all of the existing E0102 data to apply the latest gain and response parameters (using `ae_xi*_makepi_20080825.fits` and `ae_xi*_rmfparam_20080901.fits`). All E0102 data now have processing equivalent to rev 2.2.11.22. The inferred contamination still assumes C/O = 6 by number for all epochs; adoption of a new contamination model is underway. I also use the same E0102 emission model as previous, due to uncertainties with the model developed by the IACHEC¹ E0102 working group. See my memo dated 2008 June 12 for details of the data analysis.

The large residual gain offset previously seen has disappeared for XIS0 (see Figure 1). Note that the gain “offset” quoted is the best-fit value from the `gain fit` command in XSPEC, and is dominated by the bright O VII, O VIII, Ne IX, and Ne X lines between 0.5–1.0 keV. Gain offsets for all four detectors, SCI-on and -off, are now generally less than 5 eV. Residual linewidths, also measured from `gain fit`, appear to have increased with the new `makepi` and `rmfparam` parameters (see Figure 2). Deconvolved “extra” linewidths are up to 10 eV in sigma or 24 eV FWHM, again averaged over the bright lines in the 0.5–1.0 keV range.

The reprocessing changes the contamination values slightly for XIS1,2,3, well within the estimated systematic error and with no apparent systematic trend (i.e. all higher or all lower; see Figure 3). For XIS0, the inferred contamination has increased slightly for most of the points, and considering

¹International Astronomical Consortium for High Energy Calibration, <http://www.iachec.org>

that result and the most recent datapoints, the inflection point around April 2007 no longer seems real.

3 New Contamination Rate Function

I have adopted a new function to fit the contamination rate,

$$f(t) = A(1 + Ct)[1 - \exp -t/B],$$

where t is days since MJD 53595.4. This differs from the old form by the addition of the linear $(1 + Ct)$ factor. This is shown in the lower panel of 3. XIS0 is better fit than before, although it is showing very different asymptotic behavior from the other detectors. The fits are formally not acceptable, but statistically better than the previous exponentials. Note that XIS3 appears to be *decreasing* slightly at later times. The fit parameters are presented in Table 1.

XIS	A	B	C
0	1.5787	65.870	2.3527e-3
1	4.5424	199.74	6.2105e-7
2	4.8792	131.13	-3.1809e-4
3	5.7999	89.809	-2.2643e-5

Units: [A] = C atoms cm⁻²,
[B] = days, [C] = days⁻¹

Table 1 Contamination Rate Model Parameters

4 Correlation of Residuals

There remain large residuals in the inferred contamination rate, and a cursory inspection indicates that there is some correlation of the sign of these residuals between detectors (e.g. negative departures during Jan–Mar 2007 and 2008; also see Figure 4). It is not clear whether these are due to real contamination variations, variations in the observed E0102 spectrum, variations in the particle or X-ray background, or a systematic error in the instrument calibration. There has been at least one notice from a GO observer about errors in the effective area below 1 keV that may be partially due to this variation.

I have investigated possible correlations in a qualitative way by plotting the contamination and fit residuals (“wiggles”) against a number of observables. The remaining figures show these comparisons, which are:

Background Figure 5 shows the comparison to the total 2–8 keV background rate measured in an annulus around E0102. This includes contributions from the cosmic X-ray background and particle background. No correlation is seen.

Pointing Offset Figure 6 shows the comparison to the pointing offset of each E0102 observation. Here we show the offset of the E0102 image centroid from the center of each CCD (not from the actual focal position). Pointing variations of $\sim 20''$ are seen; this could lead to variations in the inferred contamination as different parts of the OBF are sampled by the light path. No correlation is seen, implying this effect is small.

Confusing Neighbor Source Figure 7 shows the comparison to the emission model normalization

for the neighboring HMXB, RXJ0103, which is projected 2.2' away from E0102 and included in the source extraction region (see my memo dated 2008 June 08). This is a variable source, with most of the flux emitted above 3 keV, although there is a soft component with 0.5–2 keV flux less than 1% that of E0102. The variability of the soft and hard component appear correlated (Haberl & Pietsch, 2005). Variability in the count rate from this source could be inferred as changes in the contamination, but no correlation is seen in Figure 7, so this effect is small.

Day of Year Figure 8 shows the comparison to the day of the year (i.e. folded with a 365 day period). The residuals for XIS3 show a definite trend, although this is less apparent in the other sensors. This is an indication of some correlation with a yearly (or shorter) cycle.

References

Haberl, F. & Pietsch, W. 2005, *A&A*, 438, 211

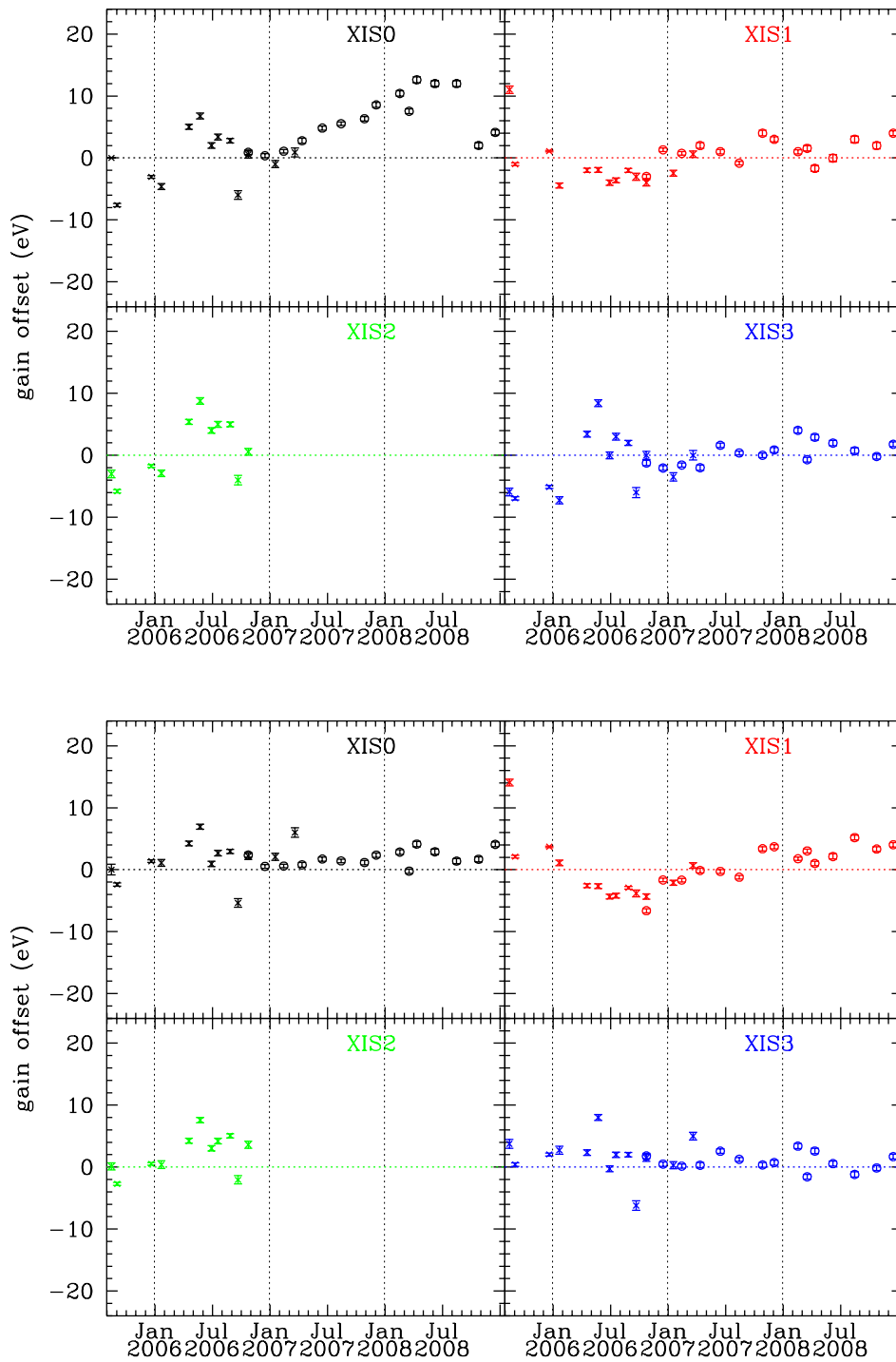


Figure 1 Residual gain offset for (top) the previous processing and (bottom) the latest processing and RMF parameters.

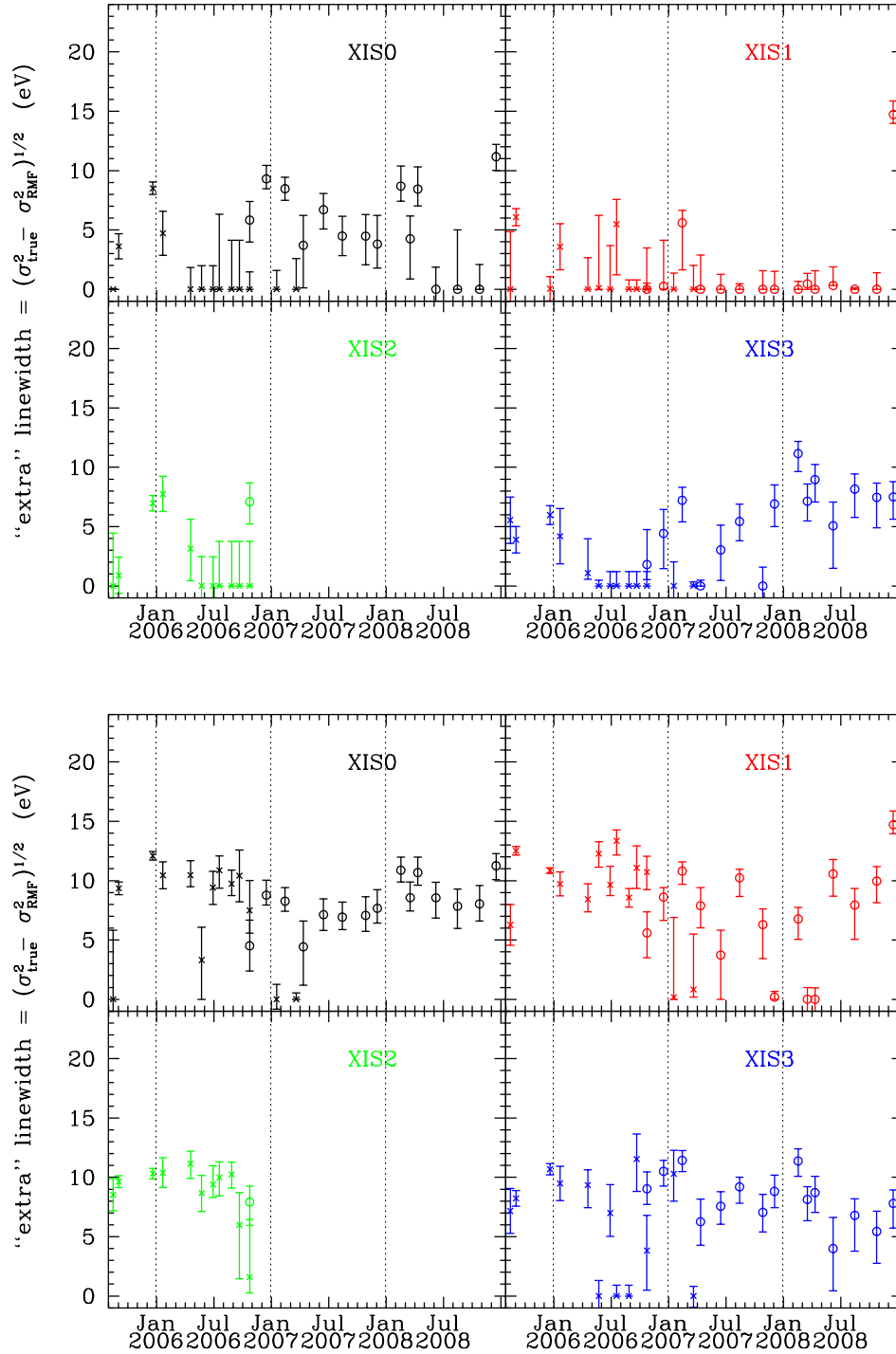


Figure 2 Intrinsic line width for (top) the previous processing and (bottom) the latest processing and RMF parameters.

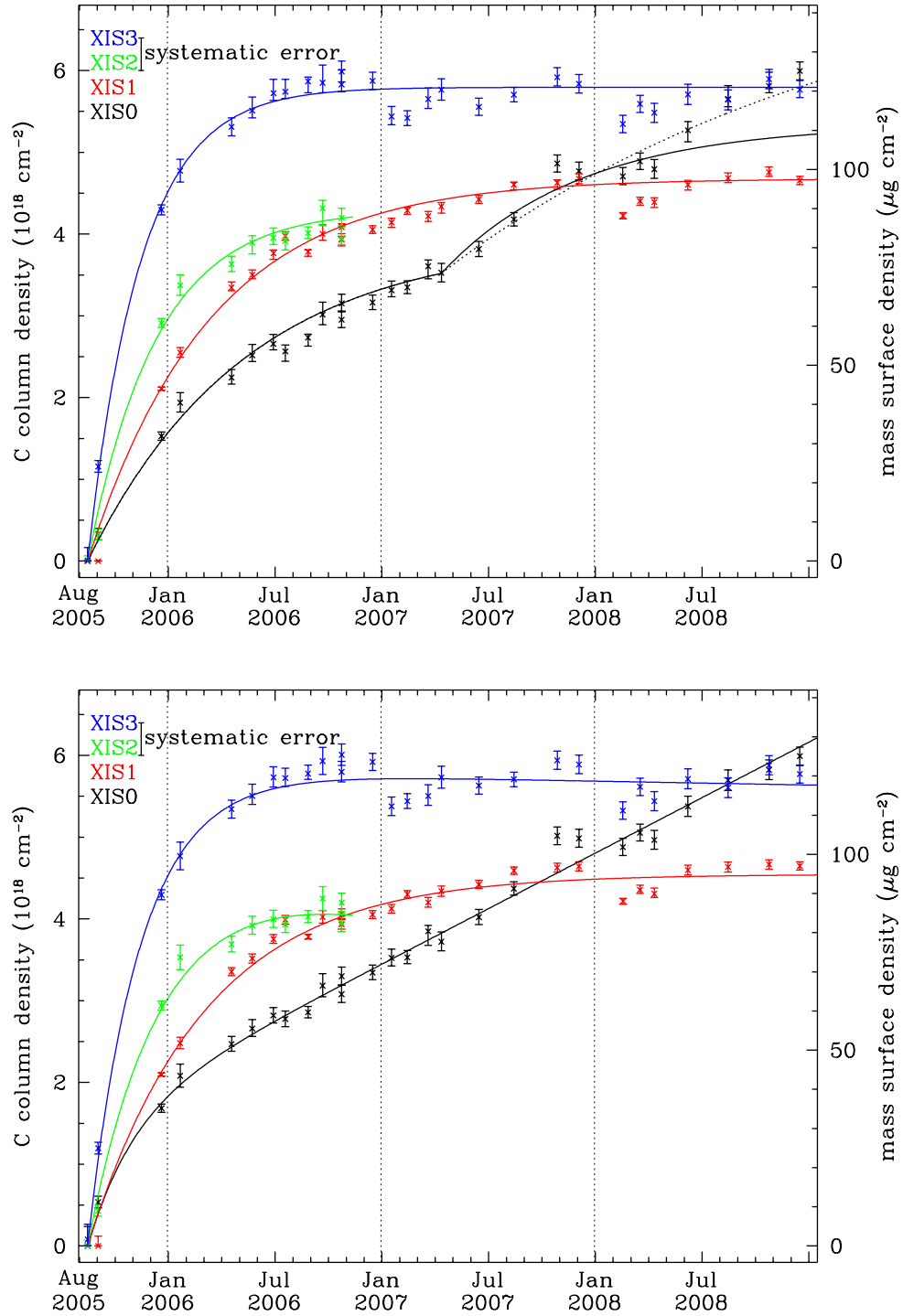


Figure 3 Contamination history for (top) the previous processing and (bottom) the latest processing and RMF parameters. The fits to the bottom plot have a new functional form incorporating a linear term, and XIS0 no longer has an inflection point near April 2007.

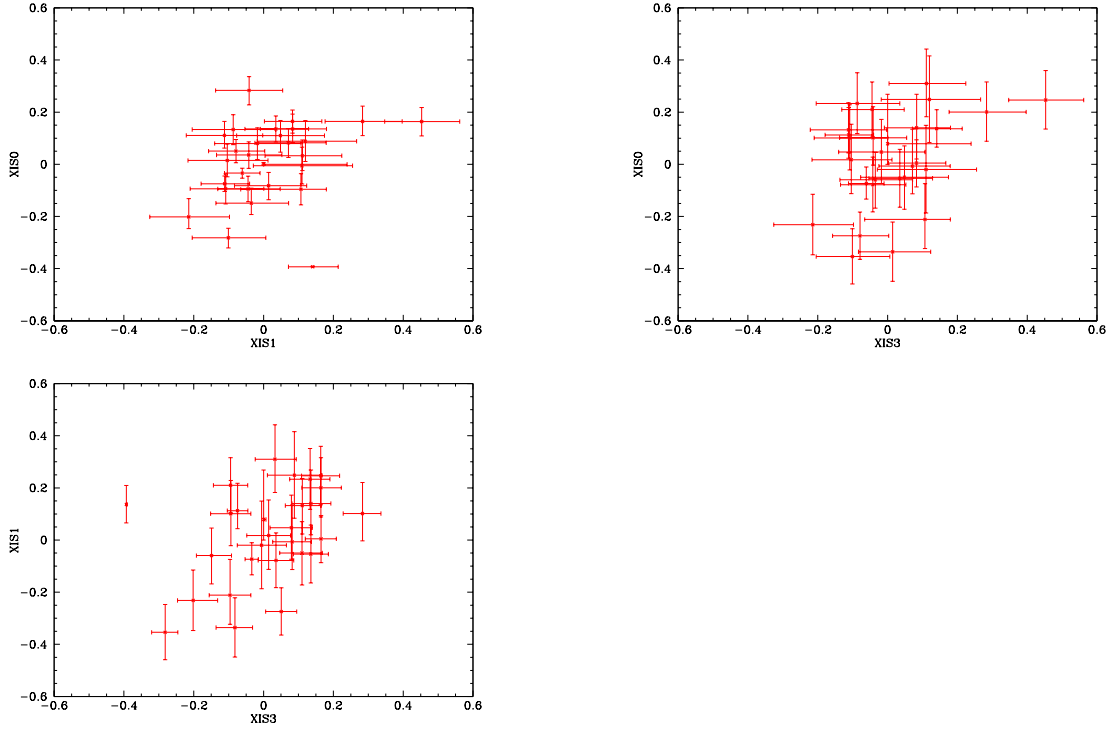


Figure 4 Contamination fit residuals plotted for one detector vs. another. The axes show ΔN_C in units of 10^{18} cm^{-2} . A mild correlation is seen.

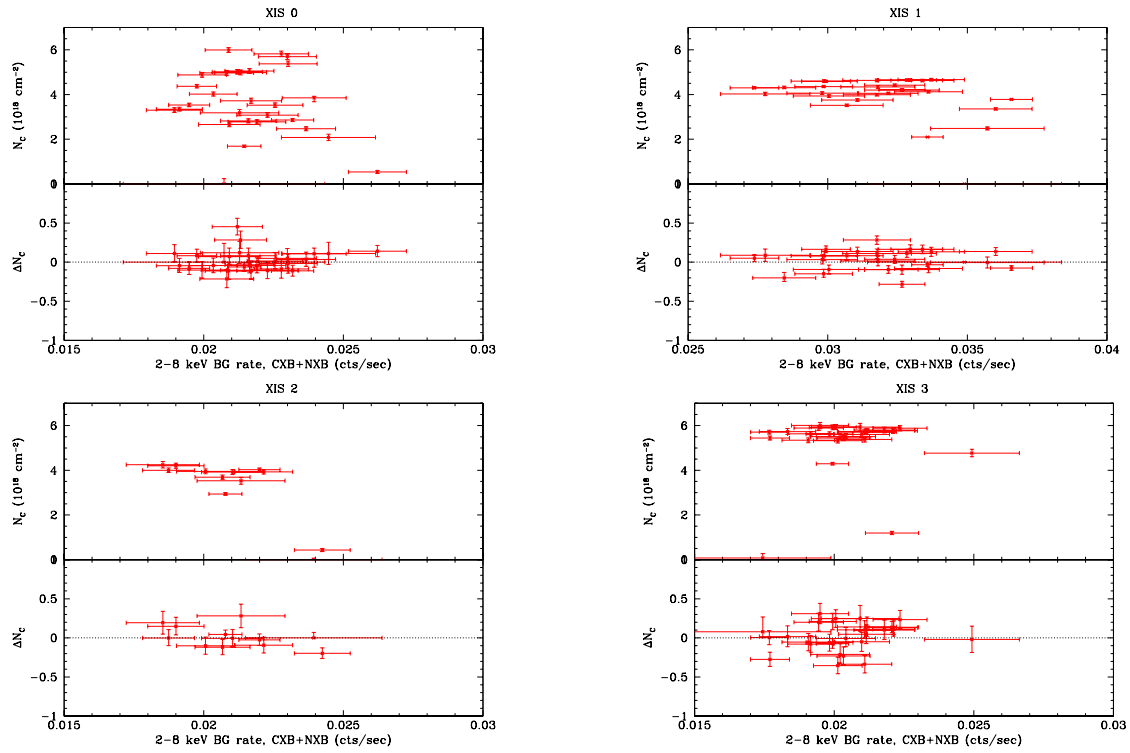


Figure 5 Contamination and fit residuals as a function of total background count rate, measured in the 2–8 keV band in an annulus around the source.

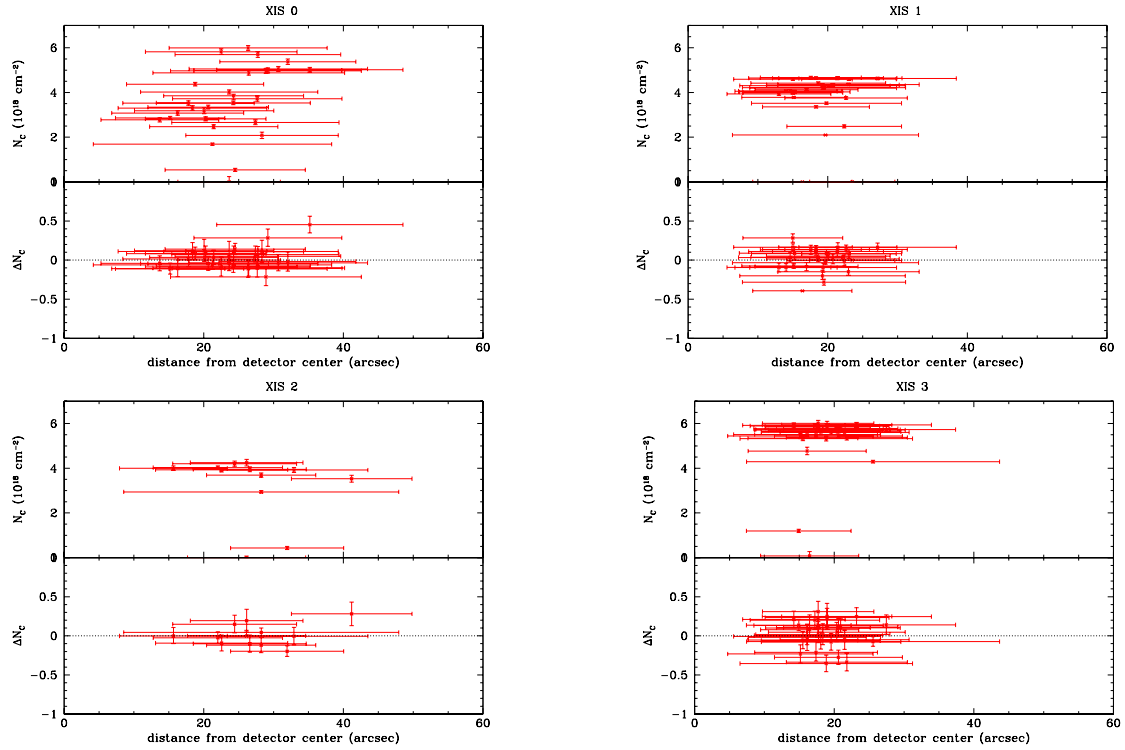


Figure 6 Contamination and fit residuals as a function of pointing offset, measured from the image centroid.

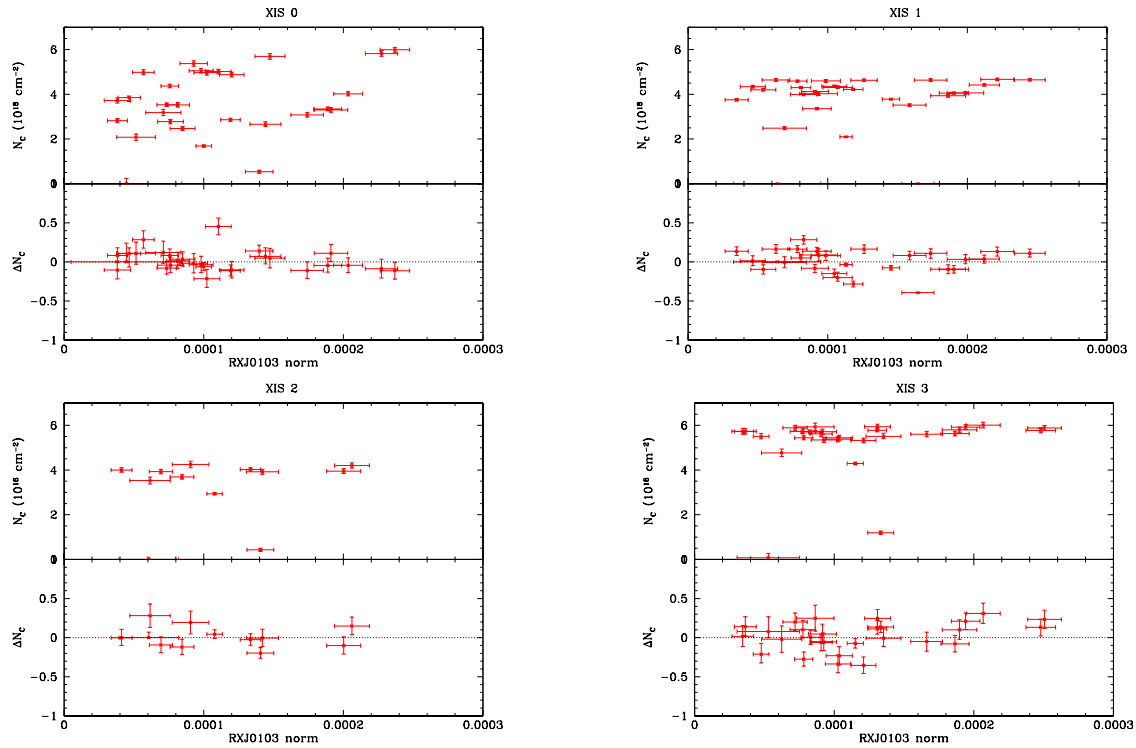


Figure 7 Contamination and fit residuals as a function of the flux of the model normalization of the neighboring source, RXJ0103.

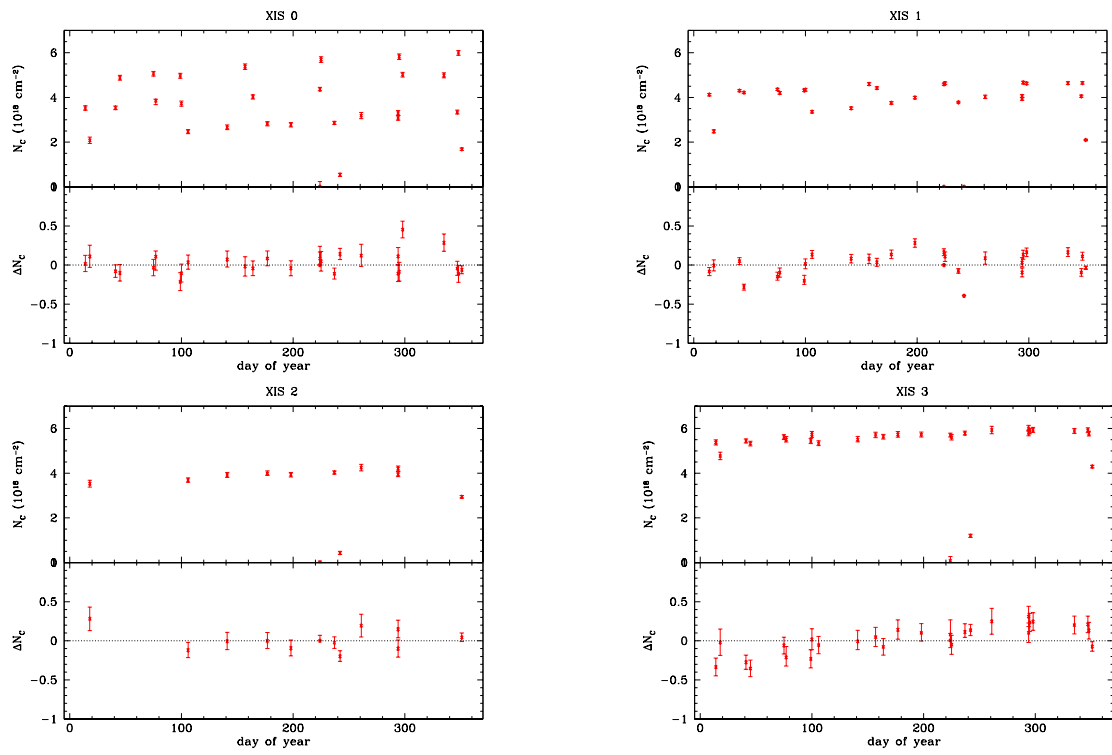


Figure 8 Contamination and fit residuals as a function of day of year.