**ACIS Memo #173**
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To: ACIS Team
From: Catherine Grant
Subject: Longer Term Stability of ACIS CTI
Date: 13 October 1999

This memo represents an attempt to put upper limits on the amount of CTI change observed in the ACIS CCDs since day 259 (16 Sept 99). The time history of the S2 CCD is shown in Figure 1. Figure 2 shows a portion of time history of S2 at -110 C since the detector CTI stabilized. There are four anomalous points. Between the first three points and the later points with lower CTI, the focal plane temperature was increased to -60 C for dark current measurements. The fourth point with much lower CTI was taken with a longer exposure time. These four points will not be considered in the long-term stability analysis. The data and CTI analysis are described in ACIS Memo #169. The error bars shown in Figures 1 and 2 include the formal errors in the CTI fit. The actual errors can be determined by examination of data from S2 and S3. Recently, CTI measurements have been made with both the I and S array before and after belt passage. The S2 and S3 devices are included in both arrays, so the CTI is measured twice in sequence. Examining these data yield a better error estimate of 3 $\times 10^{-6}$ for S2 and 1 $\times 10^{-6}$ for S3, an order of magnitude larger than the formal error estimates. All of the following analyses will assume this error value. Since we have 'stable' CTI measurements for about twenty days and nine belt passages, we are relatively insensitive to CTI changes less than 3 $\times 10^{-6}$ / 20 days = 1.5 $\times 10^{-7}$. This can be compared to the degradation experienced earlier in the mission of $\sim 1 \times 10^{-4}$ over 5 days and two belt passages.

Table 1 shows the mean and standard deviation for the CTI values for each CCD quadrant. The CTI from the whole CCD is derived by using the mean of CTI values in each observation and then the mean over the whole time period so that the standard deviation reflects the time variability, not the quadrant variability. In no case is the standard deviation of the CTI measurements as large as 3 $\times 10^{-6}$. The largest values are for S0 and S2 which also have the largest values of CTI. There does appear to be a small dependence of standard deviation on the CTI value. If the ACIS CCDs were degrading by the same mechanism as the original degradation, one might expect S0 and S2 to show a larger rate of change then the other FI CCDs. From these numbers, however, there is no evidence of significant variability in CTI.

To confirm this statement, I have also fit a linear function to the CTI data. The fitted rate of change of CTI in units of $10^{-7}$ / day is shown in Table 2. In no case is this value as large as 1.5 $\times 10^{-7}$ / day, our putative sensitivity to CTI change. The numbers are consistent with no CTI change at all in the last twenty days, however the mean value of CTI change for the FI CCDs is not zero. The BI CCDs show no change at all. In the upcoming weeks and months, it is vital that we continue to monitor CTI, in some fashion, so that any additional undetected source of CCD degradation is immediately recognized and removed.

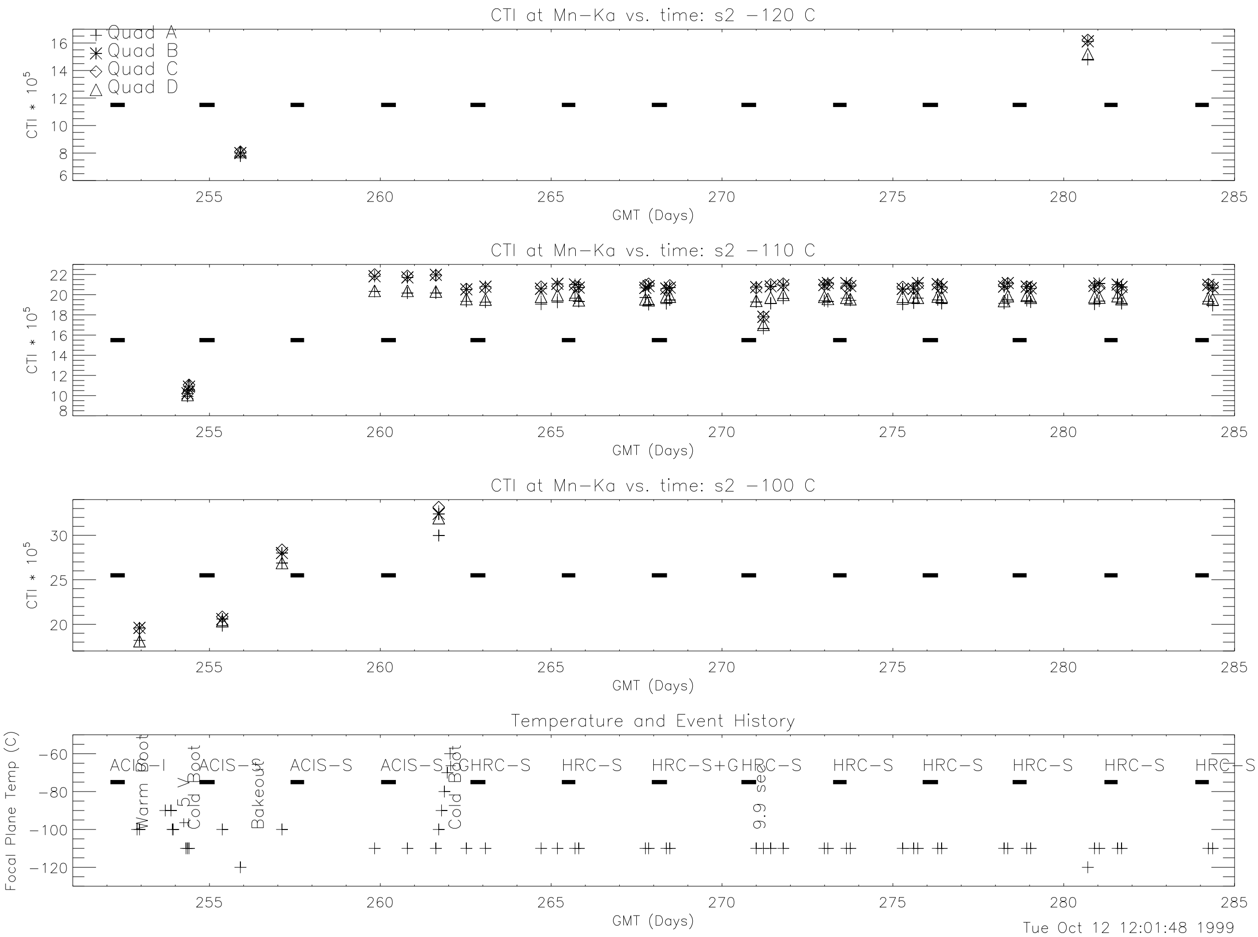


Figure 1: CTI measurements at the Mn-K$\alpha$ (5.9 keV) line at temperatures of -120, -110 and -100 C. The bottom panel represents a history of events and temperature changes. The solid horizontal lines represent when Chandra was passing through the Earth's radiation belts, a possible location of damaging particles.

Table 1: Mean and Standard Deviation of CTI Measurements at Mn-K$\alpha$

| CCD | Quad A | Quad B | Quad C | Quad D | Whole CCD |
|---|---|---|---|---|---|
| I0 | 12.45 ± 0.10 | 14.45 ± 0.14 | 14.56 ± 0.11 | 13.38 ± 0.11 | 13.71 ± 0.08 |
| I1 | 13.67 ± 0.13 | 14.62 ± 0.13 | 14.54 ± 0.11 | 12.98 ± 0.09 | 13.95 ± 0.08 |
| I2 | 16.04 ± 0.12 | 17.59 ± 0.13 | 17.46 ± 0.07 | 15.56 ± 0.11 | 16.66 ± 0.07 |
| I3 | 15.69 ± 0.12 | 17.52 ± 0.10 | 17.71 ± 0.12 | 16.24 ± 0.14 | 16.79 ± 0.06 |
| S0 | 21.75 ± 0.20 | 24.28 ± 0.25 | 25.20 ± 0.25 | 24.80 ± 0.27 | 24.01 ± 0.14 |
| S1 | 1.81 ± 0.11 | 1.81 ± 0.06 | 2.01 ± 0.09 | 2.06 ± 0.09 | 1.92 ± 0.04 |
| S2 | 19.32 ± 0.22 | 20.84 ± 0.19 | 20.82 ± 0.18 | 19.70 ± 0.17 | 20.17 ± 0.13 |
| S3 | 0.98 ± 0.06 | 0.98 ± 0.09 | 1.04 ± 0.08 | 1.10 ± 0.07 | 1.03 ± 0.04 |
| S4 | 15.87 ± 0.10 | 17.10 ± 0.19 | 16.96 ± 0.18 | 15.65 ± 0.16 | 16.39 ± 0.12 |
| S5 | 17.97 ± 0.15 | 19.10 ± 0.18 | 17.99 ± 0.19 | 15.71 ± 0.18 | 17.69 ± 0.11 |

Note: All CTI values are multiplied by $10^5$

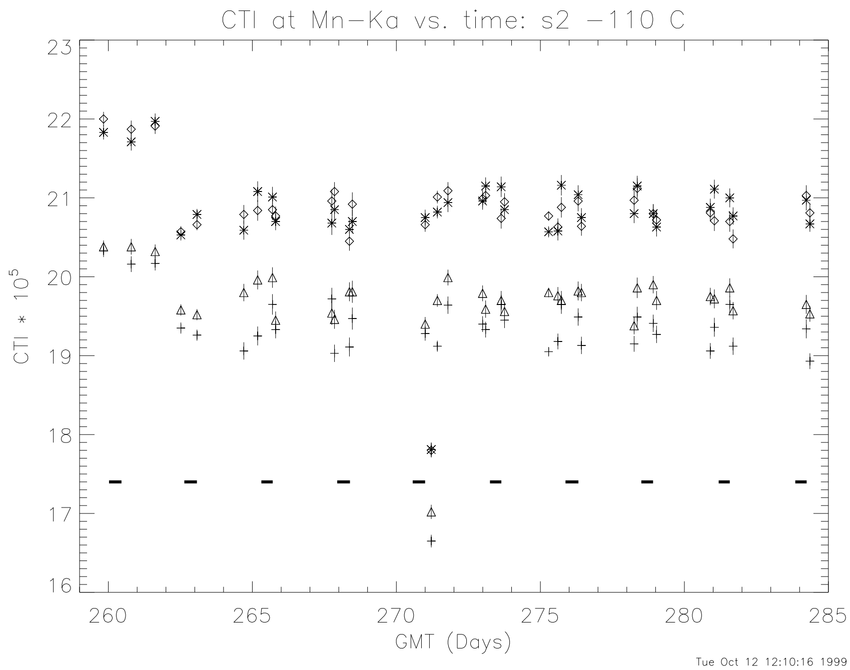


Figure 2: Same as Figure 1, concentrating on the more recent 'stable' data.

Table 2: Rate of Change of CTI at Mn-K$\alpha$

| CCD | Quad A Slope | Quad B Slope | Quad C Slope | Quad D Slope | Whole CCD Slope |
|---|---|---|---|---|---|
| I0 | +0.8 | +0.7 | +0.7 | –0.3 | +0.5 |
| I1 | –0.2 | +0.2 | +0.3 | –0.3 | –0.0 |
| I2 | +0.3 | +1.0 | –0.2 | –0.6 | +0.1 |
| I3 | +0.6 | –0.4 | +0.0 | +0.2 | +0.1 |
| S0 | +1.3 | +0.9 | +0.2 | –0.5 | +0.5 |
| S1 | +0.4 | –0.2 | –0.2 | –0.2 | -0.0 |
| S2 | –0.3 | +0.7 | +0.1 | +0.1 | +0.2 |
| S3 | +0.1 | –0.4 | –0.6 | +0.5 | –0.1 |
| S4 | +0.1 | –0.6 | +0.6 | +0.1 | +0.1 |
| S5 | –0.7 | +0.9 | +0.7 | +1.1 | +0.5 |

Note: Slope is in units of (CTI $\times \mathbf{10^7}$/day)