ACIS Memo #195
Massachusetts Institute of Technology
Center for Space Research
Cambridge, MA 02139
Room NE80-6053/37-518A
cgrant@space.mit.edu

To: ACIS Team
From: Catherine Grant
Subject: Long-term stability of ACIS gain
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This memo examines the long-term stability of ACIS gain at a focal plane temperature of -120C. This is separate from position-dependent pulseheight changes as a result of radiation damage to the CCDs. The data used span from 30 Jan 2000 (after the focal plane temperature was reduced to -120C) to 04 Feb 2001 and are the same dataset as that used for CTI monitoring which excludes squeegee tests, focal plane temperatures above -119.5C and other non-nominal operating conditions. Only events in the the twenty rows closest to the framestore were used to eliminate the influence of CCD radiation damage on the gain measurement. The three primary lines of the external calibration source (Mn-Kα at 5.9 keV, Ti-Kα at 4.5 keV, and Al-K at 1.5 keV) were fit to a linear gain function. Figures 1 and 2 show the average slope and intercept (gain and offset) of the linear fit for each CCD as a function of time. The gaps in the data reflect times in which squeegee tests superseded normal CTI measurements or when the focal plane temperature was too warm.

Also shown in Figures 1 and 2 are the gain and offset measured during OAC with the ICM and FCM sources (ACIS memo #161). The illumination pattern and line energies of these sources are different than the external calibration source so some small differences in gain function are to be expected, particularly for the BI CCDs. The ICM illuminates only S2 and S3 when the ACIS door is closed. During that period the focal plane temperature was -120C. The data, shown as a dotted line, is consistent with the currently measured values. The FCM data, shown as a dashed line, was collected at -90C and shows some small shifts from the current data. FCM gain was not calculated for S0 and S1 because of insufficient photons.

For most of the ACIS CCDs both the gain and offset are relatively constant in time with some indication of a gradual gain decline of order 4×10^{-4} (ADU/eV), or a few tenths of a percent, per year. Two of the CCDs, I0 and I2, exhibit rapid changes in gain of order half of a percent over a few months time. In particular, the slope of I2's gain function seems to have permanently changed to a higher value. Figure 3 is a comparison of I2 to I3, which appears to have a constant gain function. Histograms of summed pulseheights of G02346 events from late in 2000 are subtracted from the same histograms from early in 2000 for both CCDs. No pulseheight corrections or count rate normalizations were applied. While the I3 difference spectrum is dominated by noise, the I2 spectrum shows a distinct profile indicative of a gain shift. The increase in line centroid is $\sim 0.5\%$ for all three lines.

Figure 4 reproduces the I2 gain versus time plot with added notation indicating the timing of some Chandra events (instrument safing or hardware/software problems, etc.) No single event seems

to be the cause of the change. In addition to the discrete events noted, the radiation environment was quite active during the period 2000:140-2000:320, so that while the safing thresholds may not have been crossed, the radiation dose was higher than at other times.

Figure 5 shows the gain versus time for each individual node on I0 and I2. Node 0 on I0 and node 3 on I2 seem to be unaffected by the gain jumps observed in the remaining nodes. Only the three affected I2 nodes have a permanent gain shift; the I0 nodes return to their previous values. The physical location of the I-array CCDs and the affected quadrants are shown in Figure 6. All other nodes on the remaining CCDs show featureless gain histories.

Figure 7 is a comparison of the bias maps of a pathological case, I2 Node 0, to a more normal case, I2 Node 3. In this figure the mean, median and RMS deviation of the overclock-corrected bias as well as the initial overclocks themselves are shown versus time. In general all of the values appear normal. The structure in the initial overclocks may be a result of switching the position, inbound or outbound, of the I-array CTI measurement (around days 87, 95, 103, 214). Otherwise, there is no obvious reason for the apparent gain shift.

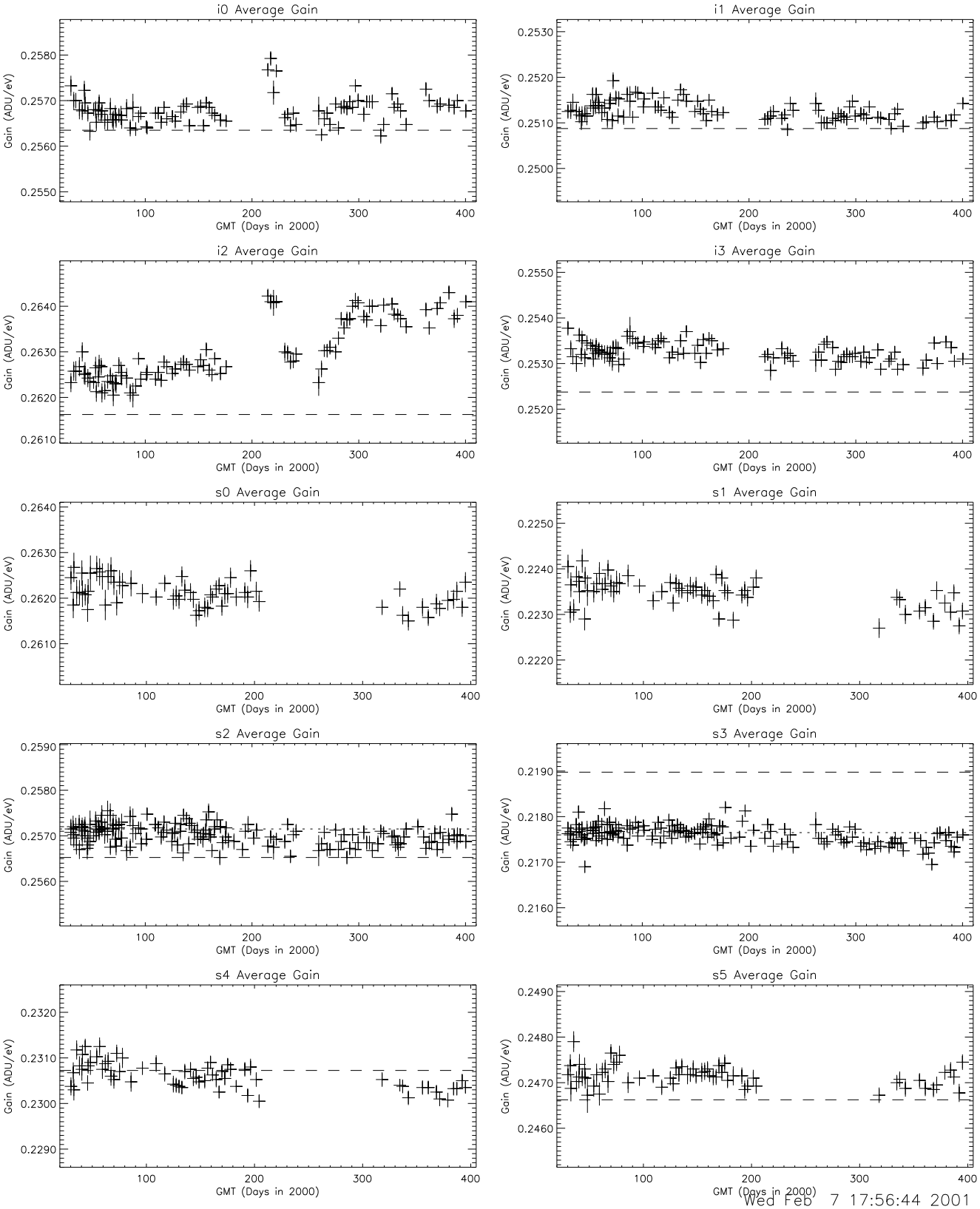

Figure 1: Average gain (ADU/eV) versus time. ICM (-120C) - dotted line. FCM (-90C) - dashed line.

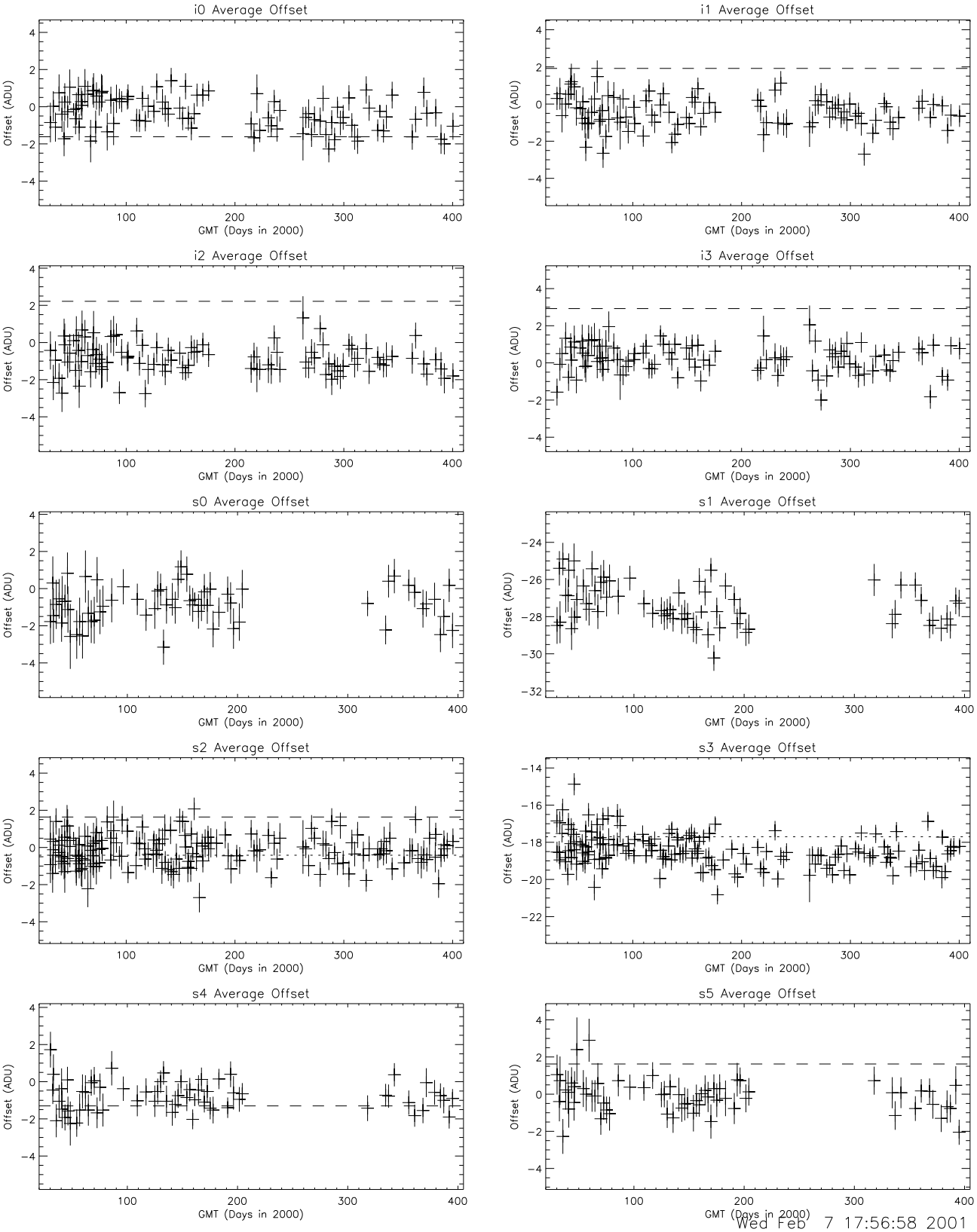

Figure 2: Average offset (ADU) versus time. ICM (-120C) - dotted line. FCM (-90C) - dashed line.

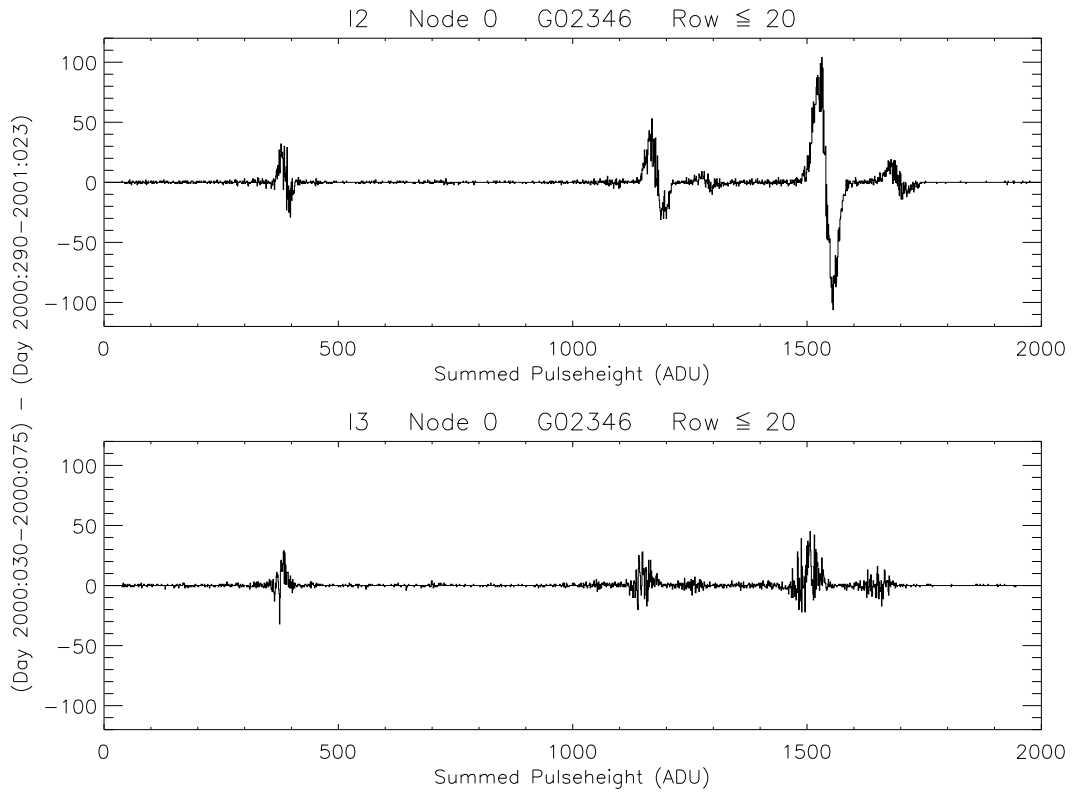

Figure 3: Comparison of data from the beginning of 2000 to the end of 2000 on I2 and I3. I2 exhibits symptoms of a gain shift.

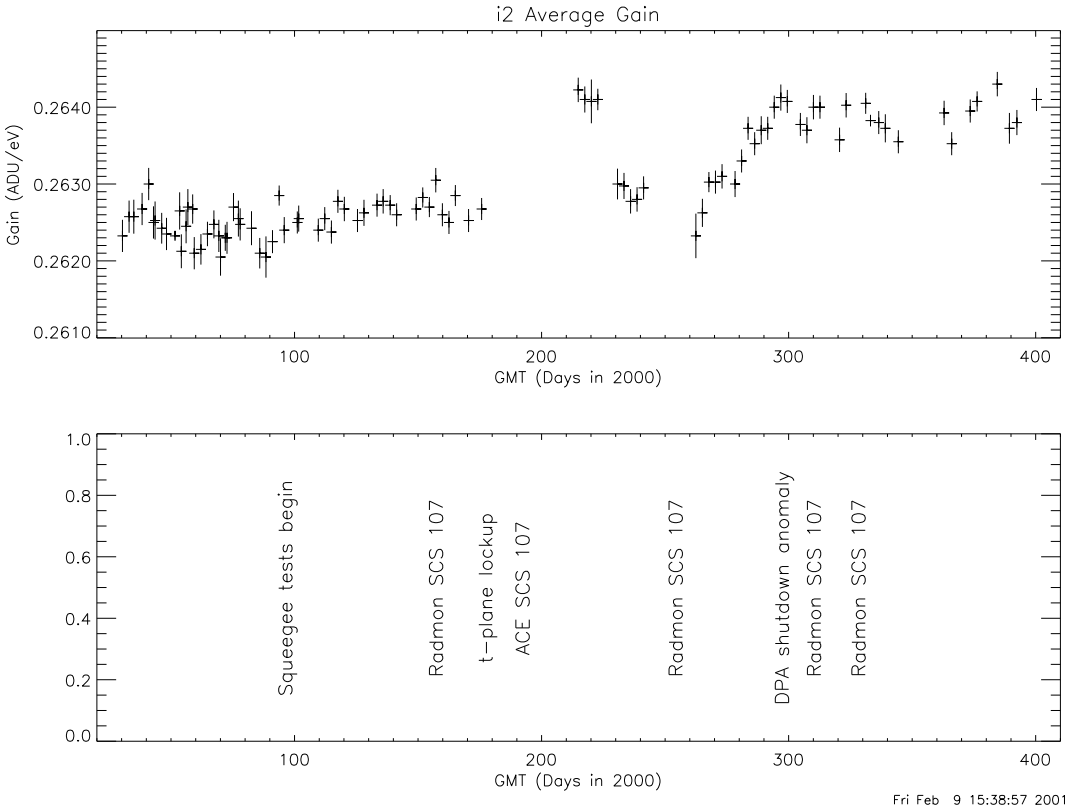

Figure 4: Comparison of I2 gain changes to Chandra events.

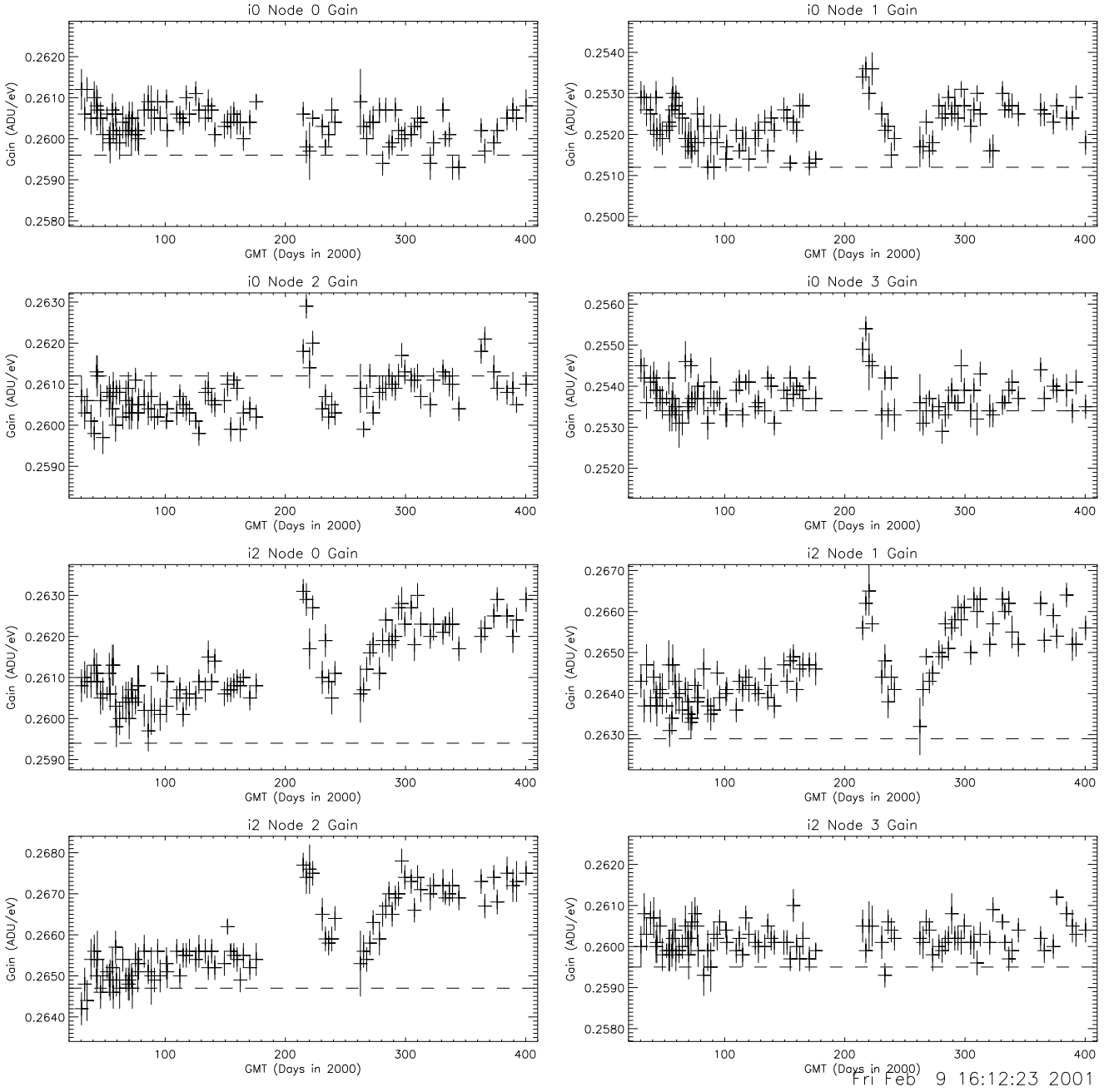

Figure 5: I0 and I2 gain in each node versus time. FCM (-90C) - dashed line.

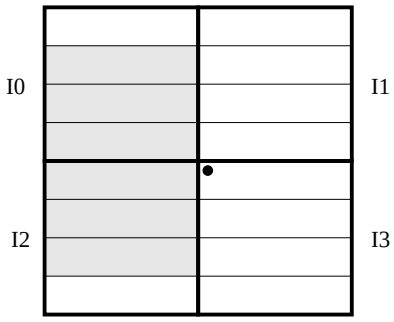

Figure 6: Relative positions of the I-array CCDs. The nodes affected by the gain jump around day 210 are shown in grey. The dot is the I-array aimpoint.

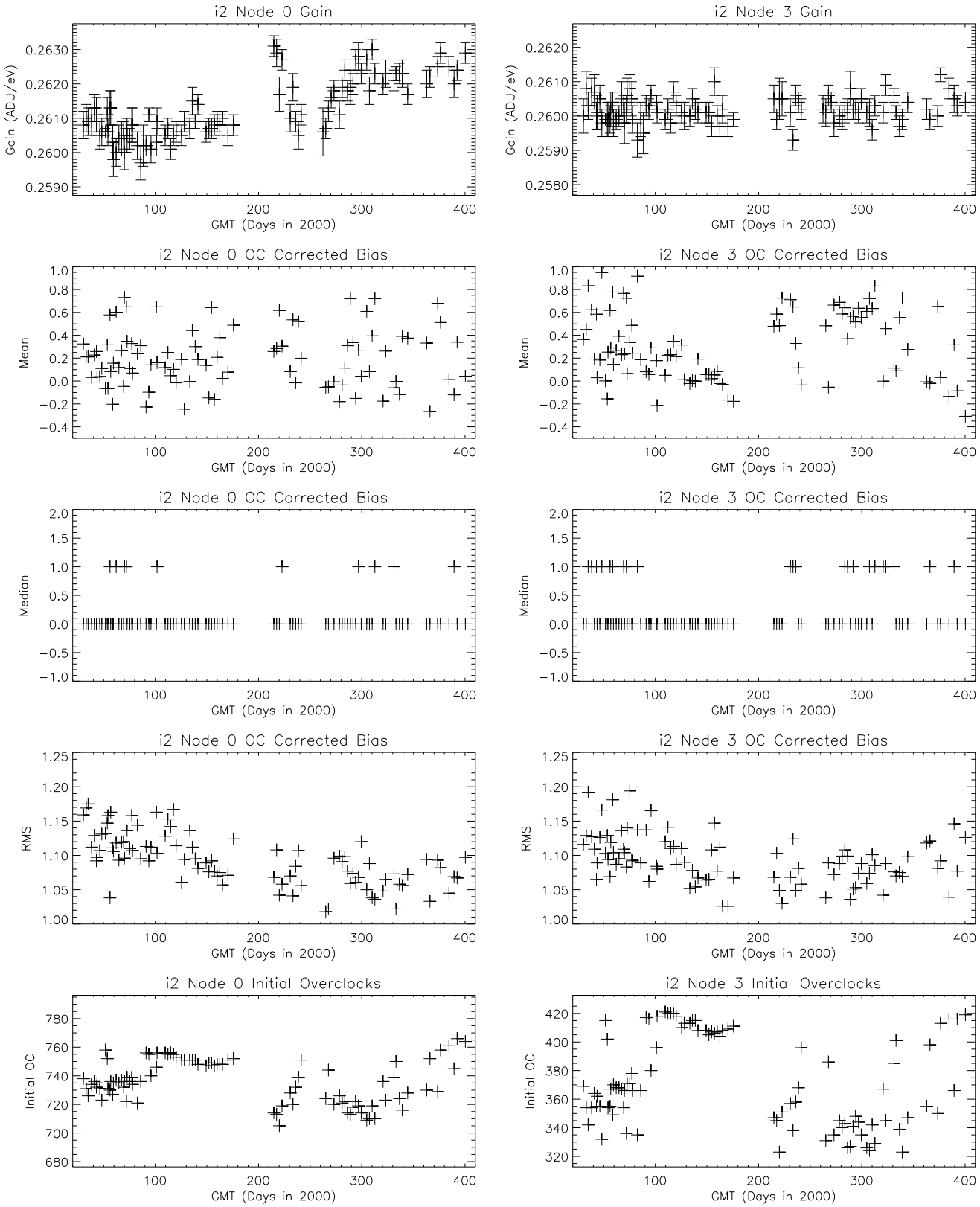

Figure 7: Gain, mean, median and RMS deviation of the bias, and initial overclocks versus time. I2 node 0 (left) is compared to I2 node 3 (right), as representatives of nodes affected and unaffected by the gain shift.