ACIS Memo # 198

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To: ACIS Team
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Subject: Estimating the long time constant
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Since May 2001, ACIS has periodically been taking data in cuckoo format, a telemetry format that packs raw data such that many consecutive data frames can be telemetered. Only 16 columns on I3 node 3 are telemetered. This memo describes analysis of ACIS data in cuckoo format intended to study the influence of precursor charge from previous frames on CTI.

The raw data were processed as usual into a single "evprec" file, a variation on the standard ARV format eventlist, but with three extra 2x10 arrays for each event. These arrays contain the distance and pulseheight to precurors in the five preceeding frames above the event threshold for the left, center and right columns of the event. Only precursors that are larger than any preceeding precursors are included. Any event with more than 10 precursors in the five preceeding frames was rejected. Any exposure with excessive overclock noise was rejected. The first 100 exposures of each cuckoo run were ignored, with the next 15 exposures used to calculate the bias. The data used here include 24 cuckoo runs (through CL41), 63,703 frames (1162 were rejected because of noisy overclocks), and 606,080 events (75,976 events had more than 10 precursors and were rejected).

The cuckoo data was CTI corrected, then the events were grouped by the distance to the first precursor in the center column. All precursor pulseheights and locations were considered valid. A Gaussian plus a polynomial was fit to the center pixel pulseheights of events in the central 200 rows. The results are shown in Table 1.

First Precursor location	Gaussian peak at row 512	Events in fit	Mn-Kα events
Same frame	1507.36 ± 0.59	4739	22085
Previous frame	1499.54 ± 0.53	3431	18200
2nd previous frame	1495.27 ± 0.98	876	4585
3rd previous frame	1491.54 ± 1.94	216	1278
4th previous frame	1493.40 ± 7.09	55	328
5th previous frame	—	18	108
No precursor	—	0	38

Figure 1 shows the fitted Gaussian peak of the center pixel pulseheights versus the time between the precursor and the event. The line is from a fit to a sacrificial charge model. The standard sacrificial charge model is (see ACIS memo #177):

$$N_{loss}(x,d) = N_t\, d + N_t\, x\, (1 - e^{-t/\tau})$$

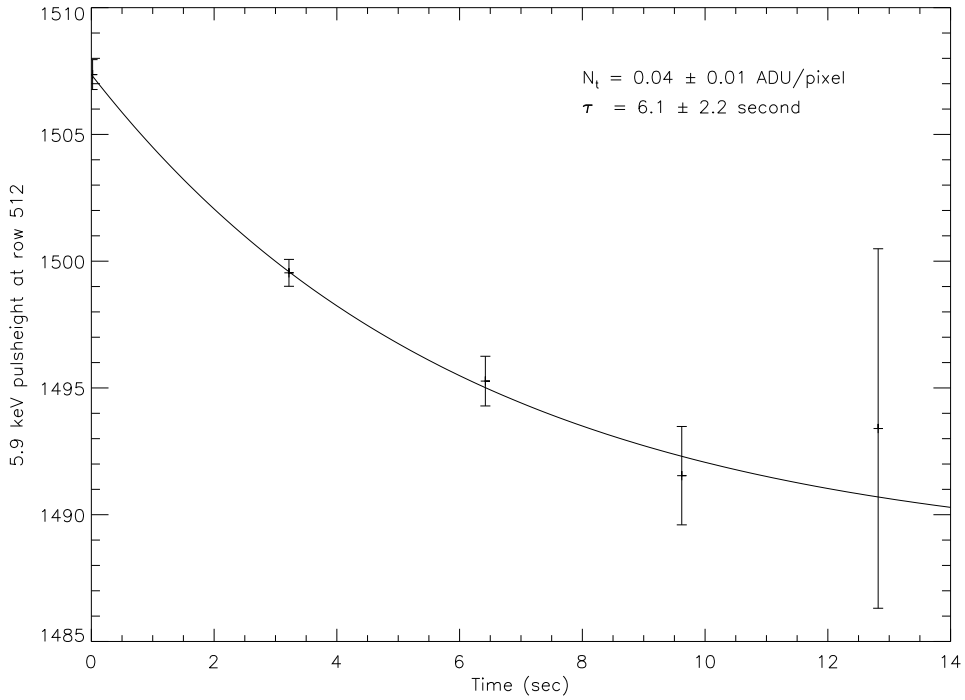

Figure 1: Fitted Gaussian peak of center pixel pulseheights at row 512 versus time between precursor and event. Data has been CTI corrected.

where N_t is the number density of traps per pixel, d is the distance the event travels unaffected by the sacrificial charge, x is the distance the event travels through pixels partially filled by the sacrificial charge, t is the time between the sacrificial charge interaction and the event interaction, and τ is the time constant of the trap. In the current case, we are assuming that d is zero, x is 512 and t is the time between the subsequent frames.

$$N_{loss} = 512\, N_t\, (1 - e^{-t/\tau})$$

The best fit parameters to the sacrificial charge model are:

$$\begin{aligned} N_t &= 0.0370 \pm 0.0085 \text{ ADU/pixel} \\ \tau &= 6.1 \pm 2.2 \text{ sec} \end{aligned}$$

The time constant is poorly constrained and is limited by the sparcity of photons with distant precursors. The fitted trap density is consistent with previous estimates of the long time constant trap parameters, i.e. ACIS memo # 177, $N_t = 0.030 \pm 0.042$ ADU/pixel. It is also consistent with the CTI improvement of squeegee mode which, presumably, erases the memory of the traps beyond a single frame and keeps these traps filled. The charge loss at Mn-Kα for squeegee cuckoo mode is 0.165 ± 0.001 ADU/pixel, while the charge loss for non-squeegee cuckoo mode is 0.195 ± 0.001 ADU/pixel. The difference, 0.030 ± 0.001 ADU/pixel, should represent the density of traps filled by the squeegee and is quite consistent with the trap density derived above.