ACIS Memo #192

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To: ACIS Team
From: Catherine Grant & Steve Kissel
Subject: Column to column variations in squeegee mode
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Squeegee mode, described in ACIS Memo #184, has been shown to improve the performance of radiation damaged CCDs both in the lab and on the flight instrument. At lower energies (E < 1.5 keV), while squeegee improves the parallel CTI, there is little to no improvement in spectral resolution. This memo is an investigation of whether correcting for column to column variations in the trap density (and thus the effective gain) can improve the spectral resolution at low energies.

The data used are from a lab CCD (w459c1) in which Quad C was damaged by 102 keV protons with a fluence of 3.7 x 10^7 p/cm^2. Quad A remains undamaged and is used for comparison. The primary dataset was taken with a 16-row squeegee and standard clocking speeds (vanilla or simple squeegee mode). The X-ray source is the O-K line at 525 eV. More than 2.5 million photons were collected over 2225 exposures in the damaged quadrant. Individually for each column and again for the entire quadrant, a series of spectra were created as a function of row for every four rows. The O-K peak in each spectra was fit to a single Gaussian.

Figure 1 shows a histogram of the distribution of fitted O-K pulseheights close to and far from the framestore for both the damaged and undamaged quadrants. For the damaged quadrant, this distribution is much wider far from the framestore (σ = 3.9 ADU) than close to the framestore (σ = 1.5 ADU), while for the undamaged quadrant the distributions are almost indistinguishable (σ = 1.5 and 1.8 ADU, respectively). Figure 2 shows the fitted pulseheights of the O-K line versus row for two columns chosen from the extremes in Figure 1 for both the damaged and undamaged region. For the damaged quadrant, while the pulseheight of the O-K line is nearly the same at the framestore for both columns, far from the framestore the pulseheight is quite different. This variation is not seen in the undamaged quadrant. This implies that the larger distribution of pulseheights far from the framestore in the damaged quadrant is a the result of differences in the CTI between columns and thus differences in the electron trap distribution. Figure 3 shows that the column to column variation in the O-K peak pulseheight for the damaged quadrant is not a smooth function and is therefore uncorrected by current calibration products which are designed for variations on much larger scales.

The pulseheight versus row relation for each column and for the whole quadrant was fit to a third order polynominal. The results from this fit was then used to "correct" the pulseheight of each event. Figure 4 shows the spectral resolution of the O-K line versus row number for two cases; 1) pulseheight variation is corrected by an average quadrant calibration, and 2) pulseheight variation is corrected by a column specific calibration. Correcting for the column to column variation improves the FWHM by $\sim$ 18% near the top of the CCD. Figure 5 shows the distribution of fitted O-K pulseheights far from the framestore, with no correction ($\sigma = 3.9$ ADU) and with a quadrant-wide ($\sigma = 3.9$ ADU) or column-to-column correction ($\sigma = 2.3$ ADU). The quadrant-wide correction simply corrects for the charge loss due to CTI while the column-to-column correction decreases the size of this distribution as well. Figure 6 compares the size of the column-to-column corrected distribution far from the framestore ($\sigma = 2.3$ ADU) with that along a typical column ($\sigma = 1.8$ ADU). This shows that much of the remaining spread in the O-K peak distribution may be from "noise" within each column, either from physical irregularities or from inadequate data analysis, rather than from remaining column-to-column variations.

If the column to column variation is truly from physical differences between columns, then data at different energies should show the same performance differences for the same columns. A second set of data taken at N-K (392 eV) with a different squeegee mode (2 row squeegee with slower clocking) was analyzed in the same manner. A comparison of fitted pulseheights near the ACIS-I aimpoint for each column is shown in Figure 7. There is a clear correlation between the fitted peaks at the two energies. The remaining scatter may be a result of differences in the two squeegee modes used.

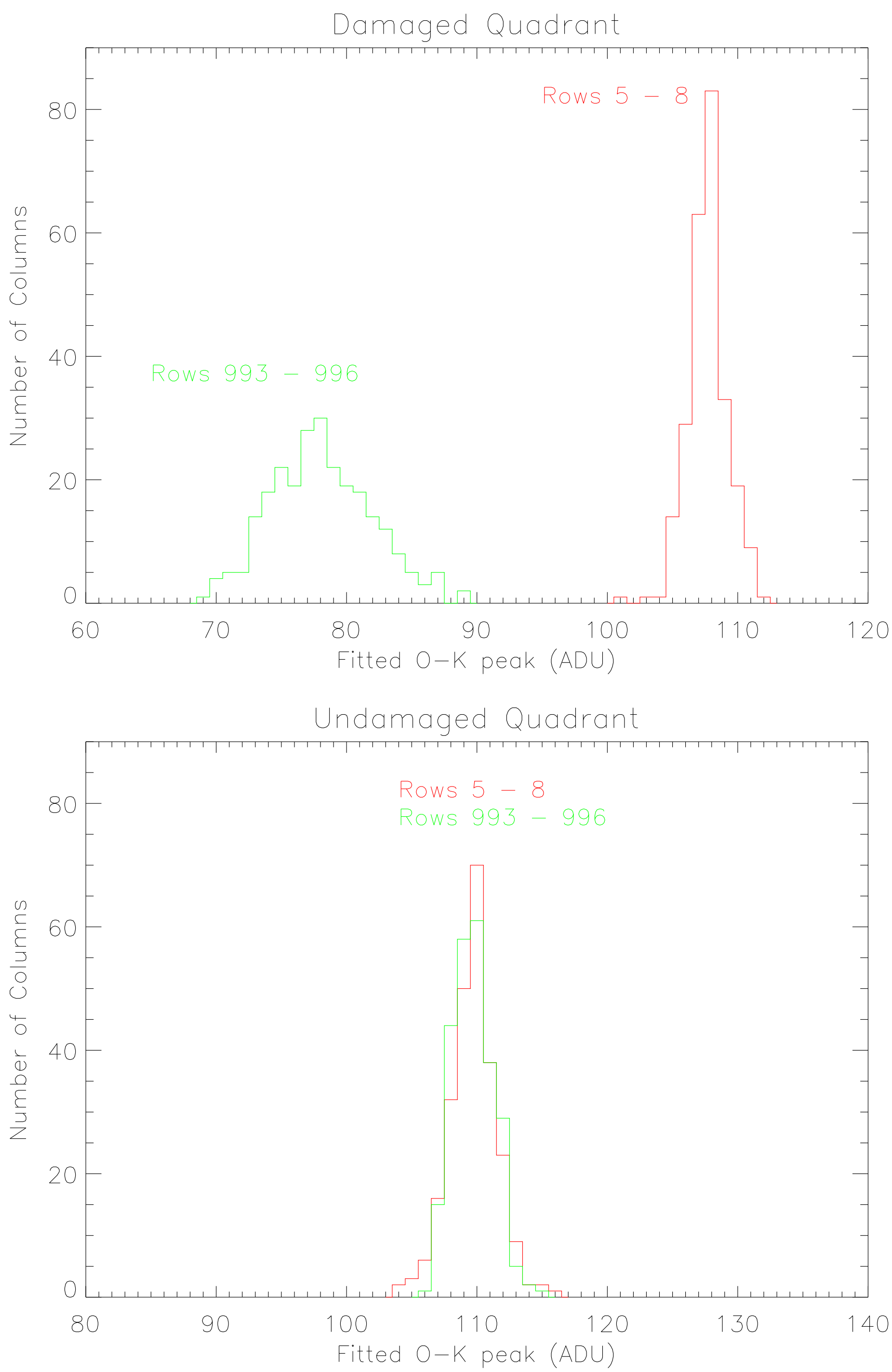

Figure 1: Distribution of fitted O-K pulseheights at rows 5-8 (near the framestore) and rows 993-996 (near the ACIS-I aimpoint) for the damaged quadrant (top) and the undamaged quadrant (bottom).

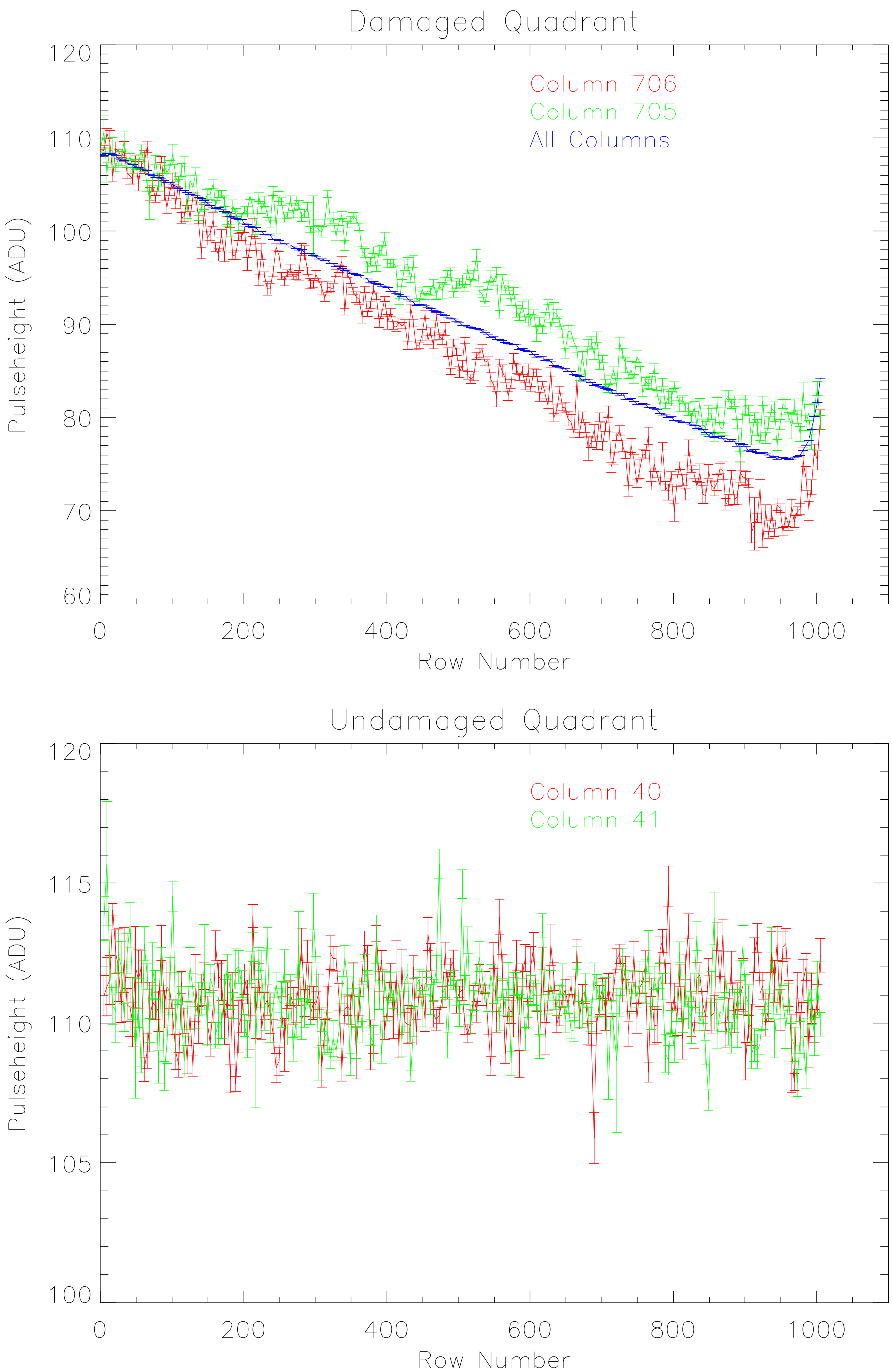

Figure 2: Fitted pulseheight of the O-K line versus row for two columns chosen from the extremes of Figure 1 for the damaged quadrant (top) and the undamaged quadrant (bottom). Note the suppressed zero on the y-axis.

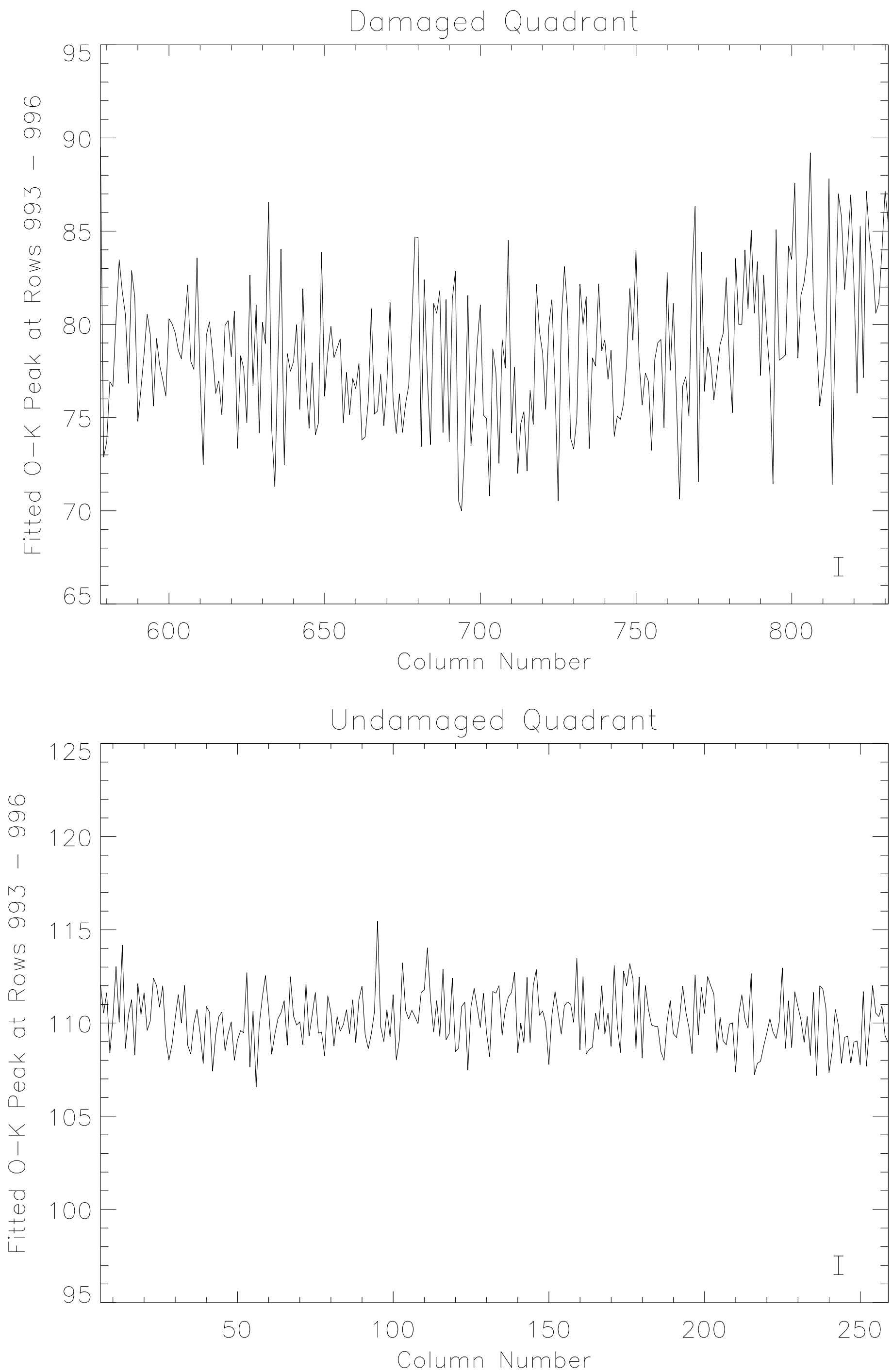

Figure 3: Fitted O-K pulseheights at rows 993-996 versus column number for the damaged quadrant (top) and the undamaged quadrant (bottom). The size of a typical error bar is shown in the bottom right-hand corner of each plot.

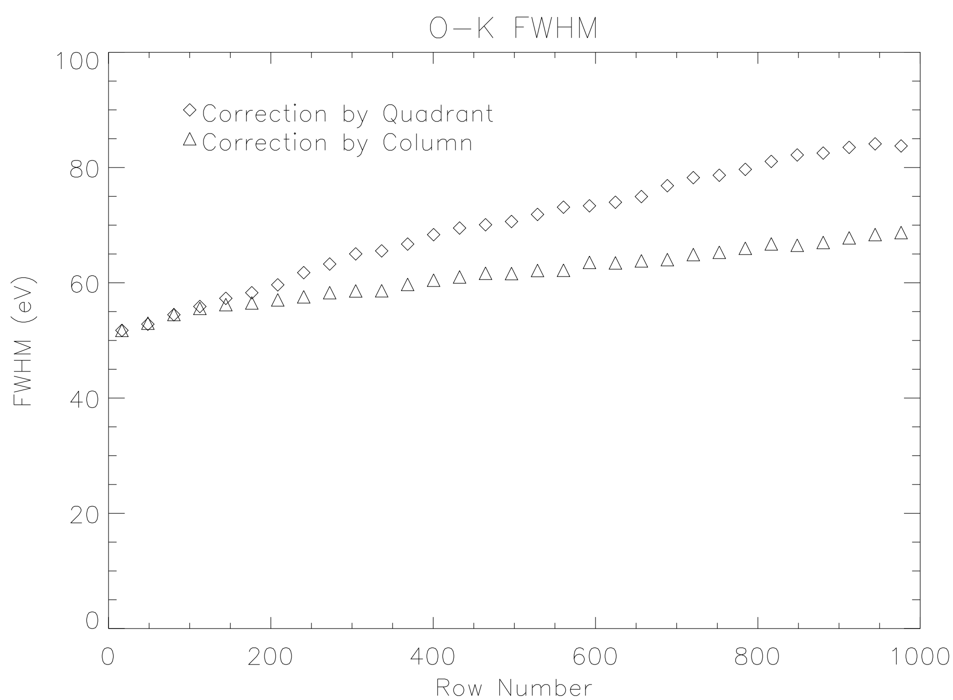

Figure 4: FWHM (eV) of the O-K line versus row number using a pulseheight correction calibrated for the entire quadrant and a pulseheight correction calibrated for each individual column.

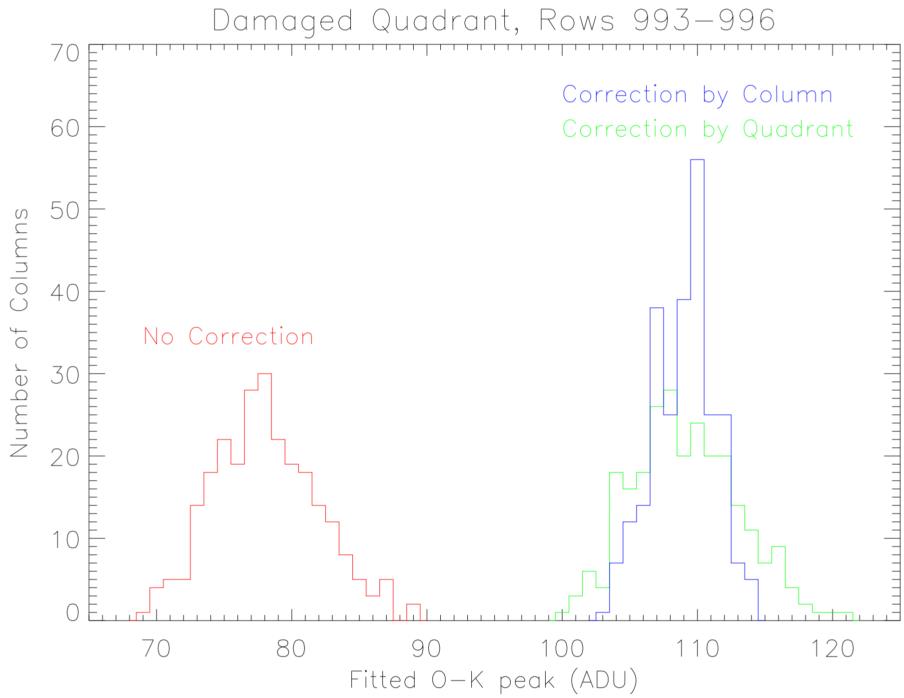

Figure 5: Distribution of fitted O-K pulseheights at rows 993-996 for the damaged quadrant for each of three cases; 1) No pulseheight correction (red), 2) pulseheight correction calibrated for the entire quadrant (green), and 3) pulseheight correction calibrated for each individual column (blue).

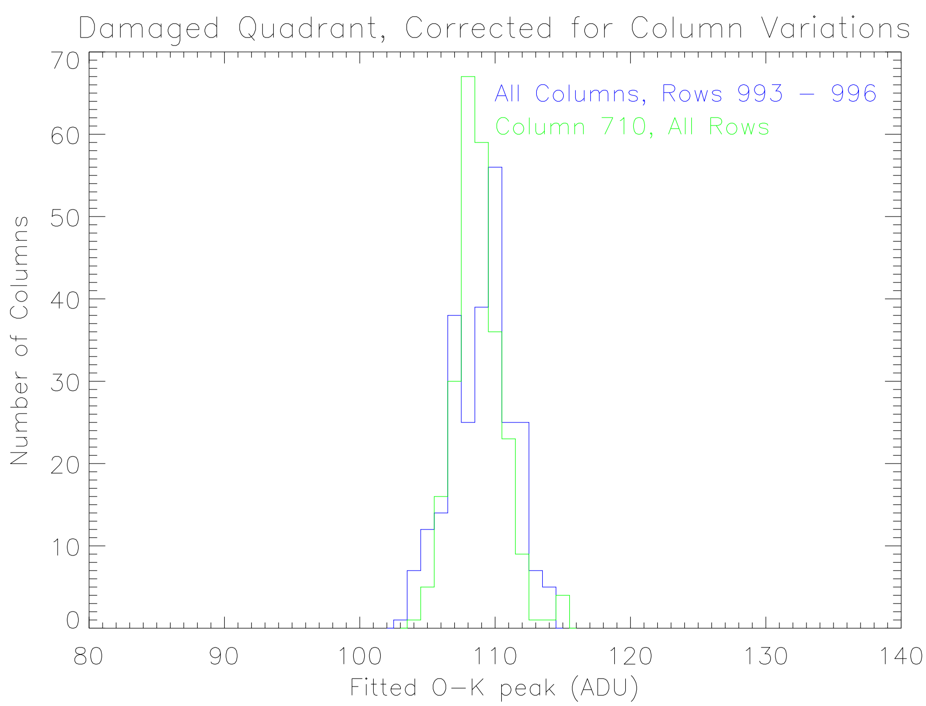

Figure 6: Distribution of fitted O-K pulseheights for all columns in the damaged quadrant at rows 993-996 (green) and at all rows for column 710 (blue). In both cases the event pulseheights have been corrected for column to column variations.

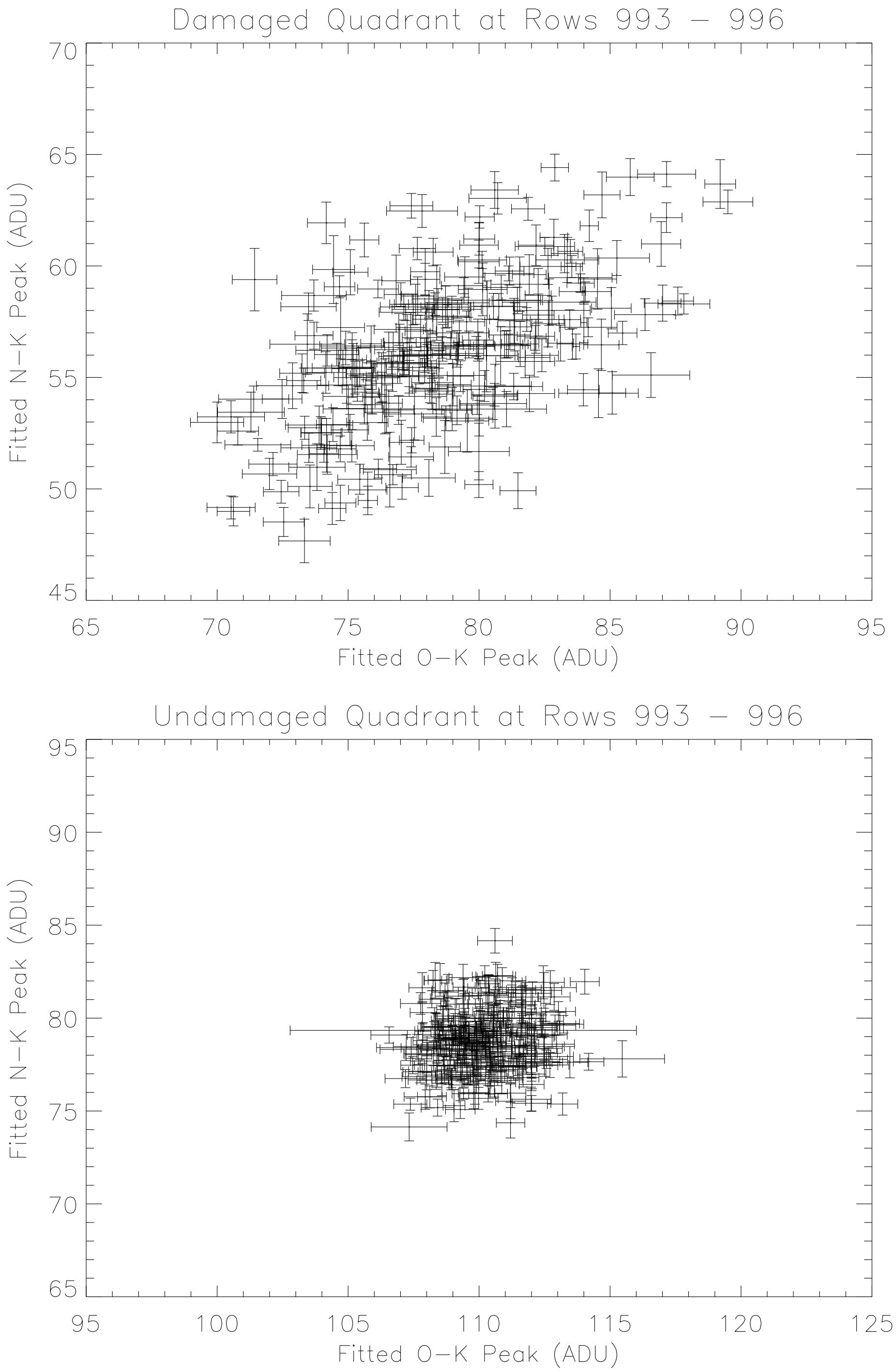

Figure 7: The fitted pulseheight for each column near the top of the CCD at 525 eV and 392 eV for the damaged quadrant (top) and the undamaged quadrant (bottom).