Summary

Using calibration fields in the star clusters NGC6791 and NGC104/47 Tuc, we have been monitoring the evolution of the charge transfer efficiency (CTE) of the WFC3/UVIS detectors, starting 5 months after the WFC3 installation, ranging from October 2009 to the present; this program will continue through future cycles. Earlier epochs showed a strong evolution of the CTE, amounting to more than 0.1 mag CTE loss per year for stars with a total flux of 10000 electrons, at large distances from the readout amplifiers, in short-exposure zero sky background images. Brighter stars, and sources in longer exposures and/or higher backgrounds, are less severely affected. We find the previous trends to continue with time, although there is evidence for a flattening in the CTE evolution. We present an update to the CTE monitoring results, as well as an update to the empirical correction model that corrects CTE losses for point source aperture photometry as a function of observation date, source flux, local background level, and source distance on the detector from the readout amplifiers. The data we collect are also currently analyzed to independently test the pixel-based CTE correction algorithm for UVIS (Anderson et al.), and the efficiency of CTE mitigation through post-flash introduced into UVIS images. Updates of the UVIS CTE evolution and empirical model will be published on the UVIS CTE webpage (http://www.stsci.edu/hst/wfc3/ins_performance/CTE/).

Rationale of the External CTE Monitor: This calibration program provides an absolute measurement of the CTE effects on point source aperture photometry, on long time baselines, through repeated, consistent star cluster observations over the flight time of WFC3 UVIS. The mechanism of the CTE measurement is sketched in Figure 1 and detailed in Noeske et al. 2012, as well as the further analysis. The program measures CTE effects as a function of four principal parameters: observation epoch, source distance from the amplifier, source flux, and local image background, and provides a polynomial correction model for point source photometry based on the results (Figure 3).

Recent Changes to the Program: 1) Previous cycles had achieved a variation in image background through the use of both the F502N and F606W filter. Starting in Cycle 20, F606W was abandoned; a better background sampling is now achieved through the UVIS post-flash mode, applied to F502N images. 2) The smooth evolution of the UVIS CTE on long timescales led us to reduce the frequency of the calibration observations, from 3 to 2 epochs per year, starting in Cycle 21.

Recent Results: The evolution of the UVIS CTE continues to proceed smoothly. The rate of CTE degradation does not show significant rapid changes, however for fainter sources (less than approx. 1000 electrons), we see indication for a slowing of the initially rapid CTE degradation (Figure 2).

Upcoming Releases and Improvements: Near future updates from this program will provide a smooth parametrization of the CTE dependence on the image background level for point source aperture photometry. This work will also provide a measurement of residual CTE effects after the application of post-flash for CTE mitigation.

In progress are complementary measurements of the CTE correction through the pixel-based algorithm (J. Anderson, cf. the WFC3 UVIS CTE webpage), as well as an independent measurement of the CTE of both UVIS CCDs.

Fig. 1: The same star field is observed on both UVIS detectors, thus placing the same star once close and once far from the readout amplifiers. The magnitude difference as a function of detector Y provides an absolute CTE loss slope. Cf. Noeske et al. 2012. Note that the plot shows twice the actual CTE loss range.

Fig. 2: UVIS CTE evolution between October 2009 and July 2014, for stellar aperture photometry within 3 pixel radius apertures. Panels show the CTE loss slope in magnitudes per 2048 detector rows, taken from fits such as those shown in the examples in Figure 1, as a function of observation epoch MJD. Panels on the left and right side refer to short (60s) and long (420s) exposures, respectively, and are shown for the low-background F502N filter. The zero-background short exposures represent the worst possible scenario for CTE losses at the source fluxes shown. The colors of the symbols indicate stars in different flux ranges, given in the panels. Closed and open symbols refer to data from the sparse cluster NGC 6791 and the denser field in NGC 104/47 Tuc, respectively. Note the flatter slope of the CTE degradation for the 500 to 2000 electron sources during the recent two years, compared to the first two years; this is consistent with the expected radiation dependence on the solar cycle.

Fig. 3: CTE Correction model. Circles show CTE loss slope in magnitudes per 2048 detector rows vs log of stars’ fluxes, measured in r = 3 pixel apertures. Symbol colors refer to the MJD of each calibration observation, listed on the right in the same color, earliest MJD and data at the bottom of each panel. Filled symbols represent the sparse cluster NGC6791, open symbols the higher source density field in 47 Tuc/NGC104. Top left: F502N (low background), short exposures, ie. lowest background, worst CTE; top right: F502N, long exposures. Bottom left: F606W (high background), short exposures; bottom right: F606W, long exposures. The colored lines show the CTE correction model (2nd degree polynomial, cf. Noeske et al. 2012), fitted to all data points in the respective plot panel (all flux bins, all epochs) simultaneously.

References and Further Reading