

# Charge Transfer Efficiency of the Wide Field Planetary Camera 2

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## Abstract

Observations of  $\omega$  Cen have been used to characterize the Charge Transfer Efficiency (CTE) of the Wide Field and Planetary Camera 2 (WFPC2) onboard the Hubble Space Telescope. A set of formulae has been developed to correct aperture photometry for CTE loss with dependencies on the X and Y positions, the background counts, the brightness of the star, and the time of the observation. The observations indicate that for very faint stars on a very faint background, the CTE loss from the top to the bottom of a chip has increased from about 3% shortly after the cool-down of WFPC2 (April 23, 1994) to roughly 40% in February 1999. In general, typical WFPC2 exposures are much longer than these short calibration images, resulting in higher background which significantly reduces the CTE loss and minimizes the CTE problem for most science exposures.

## Introduction

During the first year after launch the standard solution for correcting for CTE loss for the Wide Field and Planetary Camera 2 was to use a 4% linear ramp in cases with low background, and no correction for cases with high background. On-orbit data has provided a more detailed characterization (Whitmore and Heyer, 1997) with dependencies on the X and Y positions, background counts, and target background. In addition, a temporal dependence was reported in Whitmore (1998). This poster provides a summary of these two papers, plus an update based on data obtained in 1998 and February of 1999. The latest observations indicate that CTE loss can be as much as 40% from top to bottom of the chip for very faint stars on very faint backgrounds. The trapped electrons eventually free themselves, and it appears that some can be observed as residual images in subsequent exposures (Biretta, 1997). Very extended sources (e.g. flat fields) show little or no CTE loss. The apparent cause of the increase in CTE loss based on recent laboratory tests is radiation damage (Clampin, 1998). This is particularly important for space-borne CCDs such as the WFPC2 where the levels of radiation are significantly higher. CTE loss is especially critical for large format CCDs such as the Advanced Camera for Surveys (ACS), and the Wide Field Camera 3 (WFC3), both scheduled for HST, since these have more than 2.5 times the number of pixels to transverse during the read-out.

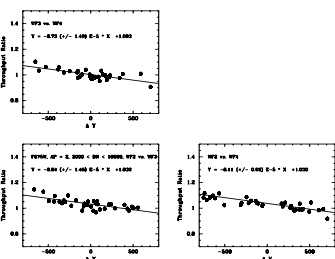


Figure 1: The ratio of the difference in the brightness of the same star (i.e. the throughput ratio) as a function of the difference in Y position for stars with counts in the range 2000 to 10000 DN. The three panels show comparisons between the three WF chips.

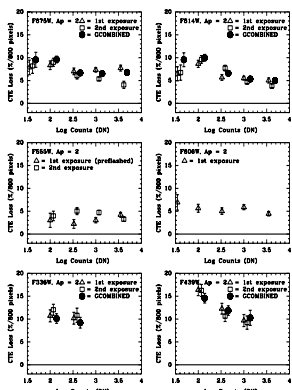


Figure 2: The values of CTE loss in units of % loss over 800 pixels vs. the brightness of the star in DN. The results from the first, second, and GCOMBINED images are included for the 2-pixel aperture measurements.

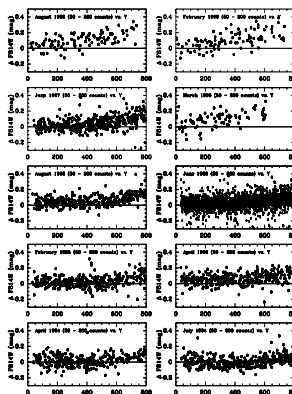


Figure 3: Throughput ratio (in mags) in F814W vs.  $\Delta Y$  as a function of time.

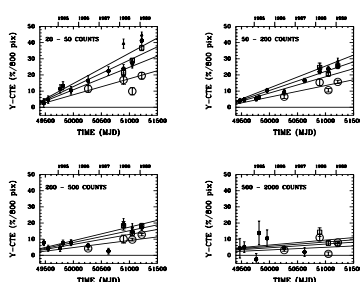


Figure 4: Y-CTE loss as a function of time for four different ranges of the target brightness. Triangles are for F439W (BKG=0.03 DN), squares are for F555W (BKG=0.05 DN), filled circles are for 14 sec exposures with F814W (BKG=0.10 DN), and open circles are for 100 sec exposures with F814W (BKG=0.38 DN). Smaller symbols are for observations with smaller backgrounds. The lines are from predictions from a paper in preparation (Whitmore et al., 1999).

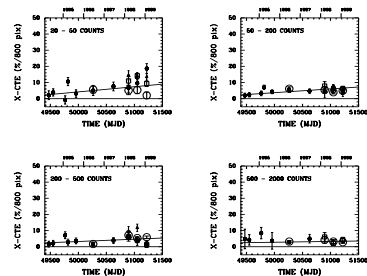


Figure 5: Same as Figure 4 for X-CTE.

## Summary

Analysis of calibration observations of  $\omega$  Cen lead to the following primary results concerning CTE on the WFPC2.

1. CTE loss is the same on all three WF chips, and appears to be the same on the PC, to the degree it can be determined. However, the effect of CTE on the PC is generally larger than on the WF due to the lower background.
2. While the main effect is CTE loss along the Y axis, there is also a weak CTE problem along the X-axis (i.e., the stars on the right side of the chip are fainter than on the left side).
3. There is a strong time dependence in the amount of CTE loss. In the worst cases (i.e. faint stars on faint backgrounds) CTE loss has increased from about 3% shortly after launch in 1994 to roughly 40% in February of 1999.
4. A set of formulae have been developed to correct for CTE loss when performing stellar aperture photometry with radii of 2 pixels. The formulae have dependencies on the X and Y position, the brightness of the star, the brightness of the background, and the time of observation.

## References

- Clampin, M., 1998, private communication.  
 Biretta, J. S., Mutchler, M., 1997, "Charge Trapping and CTE Residual Images in the WFPC2 CCDs", *WFPC2 Instrument Science Report 97-05*, (STScI)  
 Whitmore, B. C., Heyer, I., 1997, "New Results on Charge Transfer Efficiency and Constraints on Flat-Field Accuracy", *WFPC2 Instrument Science Report 97-08*, (STScI)  
 Whitmore, B. C., 1998, "Time Dependence of the Charge Transfer Efficiency" (STScI) (<http://www.stsci.edu/ftp/instrumentnews/WFPC2/wfpc2doc.html#star>)  
 Whitmore, B.C., Heyer, I., Casertano, S., 1999, in preparation.

The data presented in this poster are preliminary. The paper containing the final results will be submitted to PASP in the near future.