Updates to the Performance of the Space Telescope Imaging Spectrograph


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Abstract

STIS remains a significantly used instrument on the Hubble Space Telescope, accounting for the most prime orbits (22%) after WFC3 in Cycle 19. We continue to monitor and improve upon the performance of the instrument since the revival of STIS in 2009, with two cycles of monitoring complete since Servicing Mission 4 (SM4). In this poster, we present updates to that monitoring. In general, most trends continue as they have in the past, including time dependent sensitivities. Here we present updated information on geometric distortion solutions for the STIS detectors, characterization of the STIS CCD charge transfer efficiency degradation, and monitoring of the STIS NUV-MAMA dark rates.

Geometric Distortion Corrections

We have investigated the accuracy of the geometric distortion solutions for the STIS CCD and NUV-MAMA as part of STIS routine calibration programs. We have identified stars in the registered STIS exposures and the astrometric reference, and computed the centroid positions of every star in each image. The COS/STIS Team will be implementing a geometric correction into calstis for the FUV using a similar approach which will reduce mean residuals to ~2.5 pixels.

STIS CCD CTI Characterization

The CCD of STIS continues to be degraded by the harsh radiation environment of space, namely in its ability to transfer charge. This degradation, called charge transfer inefficiency (CTI) impacts the S/N, photometry, and astrometry of fainter sources. The STIS team is in the process of characterizing the charge trapping behavior of the STIS CCD by investigating the CTI trails of warm pixels (WPs) in various dark exposures taken during routine calibrations. This analysis is similar to what has been done with the ACS instrument. Depending on the results and user interest, a pixel-based correction to CTI may be implemented in the future. Preliminary results show that the trail behavior of the STIS CCD is similar to ACS and not correlated with temperature.

Time and Temperature Dependent NUV Dark Rates

STIS CCD and FUV-MAMA dark rates continue previous trends. Analysis of the STIS NUV-MAMA dark rates has been revisited for the period since SM4 in May 2009. The rates have declined, but not in a consistent fashion. In the first 80 days of the measurements the dark rate declined rapidly but had large fluctuations. After this the fluctuations were reduced and the rate at which the rate declined was less. Between October and November 2011, STIS was switched off for a month and another discontinuity was seen. Since then the dark rate has steadily declined. Consequently the rates have been analyzed separately in the three periods. The behavior of the dark rate can be well described by a combination of an exponential time function and quadratic temperature dependence. Consequently we intend to incorporate this empirical model into the calstis pipeline.

Strategies for Mitigating CTI effects

Observers are cautioned to be careful when designing observations of faint objects with the STIS CCD. Faint object spectroscopy is no longer recommended at the nominal central position on the detector (see Figure 6). For many years, the “E1” position for most supported spectroscopic long slits was enabled to mitigate CTI effects by placing targets near row 900 of the detector, close to the readout amplifier. CTI can seriously degrade S/N (see Figure 7), but the presence of CTI trails from hot pixels and cosmic rays can impact S/N as well. Furthermore, the same trails impact the noise in dark images and add additional noise to observations. For these reasons, observers should dither and place faint science targets near the top of the detector. The COS/STIS team plans to implement estimates of these CTI effects in upcoming versions of the STIS ETC.

Figure 1: Mean residual positional offset between STIS and reference observations of NGC5339 (CCD, panel A) and NGC 6681 (FUV-MAMA, panel B; NUV-MAMA, panel C). In panels A and B, the black lines show the data without the geometric distortion solution, while red points are with the correction applied. In Panel C, the black points are the residuals with the correction applied. The typical accuracies of the geometric distortion solutions for the CCD, NUV-MAMA, and FUV-MAMA are typically 0.5, 2, and 2.5 pixels respectively. Previous to the corrections, the FUV-MAMA had mean residuals of 4 pixels.

Figure 2: Warm Pixel trail characterization. CTI trails depend on both flux and background level. In observing WPs in long darks, one can characterize the charge trapping behavior of a detector (Anderson & Beidn, 2010, PASP, 122, 895). In this Figure we show the trail behavior for four WP flux levels in counts. Significant counts exist >40 pixels away from a WP.

Figure 3: Trail dependence on temperature. Since the STIS CCD is not temperature controlled, we looked for any correlation between the amount of flux in the first pixel downstream of a WP and housing temperature of the CCD (a proxy for detector temperature). As shown in this Figure, no strong dependence is seen at the level of 5-10%.

Figure 4: Plot demonstrating the quadratic dependence of the NUV-MAMA dark rate on temperature. Green points represent dark rates determined for different temperatures, while the solid red line is a quadratic least squares fit to the data.

Figure 5: Plot of the NUV-MAMA dark rate as a function of time. Blue points represent the measured dark rate, while red crosses show temperature corrected dark rates, which aid in suppressing scatter in the measurements. The time dependent behavior of the dark rate is well fit by a double exponential function (solid red line) with both short and long term decay times.

Figure 6: Fully processed STIS long slit spectroscopic data of a V=21 globular cluster obtained in the middle of the CCD from Cycle 17 (GO 11703; kindly provided by M. Peacock). Even after dark subtraction and CR rejection, significant noise exists. Similarly, significant flux is lost at low count levels due to CTI. The observations do not attain the ETC calculated S/N.

Figure 7: Detector position can mean the difference between detection and non-detection. Zoomed in regions of two tungsten lamp spectra taken as part of routine calibrations on STIS (Program 12679) with the same exposure time and lamp flux. The color stretch is from -2 DN to +12 DN. The top spectrum corresponds roughly to the “E1” position for long slit spectra and the bottom spectrum roughly corresponds to the middle of the detector. The flux level is degraded from a mean of 50 DN and S/N of 5 to a mean of 13 DN and S/N of 1.3.