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Laboratory Test Data on the Stability of the STIS MAMAs

Charles L. Joseph

Rutgers University

Overview

STIS has two MAMA detectors systems with distinctly different tube configurations. The first (designated BAND 1) has an opaque CsI photocathode deposited on the microchannel plate (MCP) providing wavelength coverage from 1150 Å to 1700 Å. The other MAMA (designated BAND 2) has a semitransparent Cs_2Te photocathode deposited on the faceplate in close proximity to the input of the MCP. It covers the 1650 Å to 3100 Å band pass and serves as a back up for the short wavelength detector.

Laboratory test data indicate both of these detectors have good sensitivity, have good uniformity and provide stable response, making each capable of collecting data with a signal-to-noise ratio in excess of 100 per STIS optical resolution element. See Joseph *et al.* (1995) for a general description as well as the performance of these subsystems. Over a multiyear development effort, a substantial body of laboratory test data (more than 6 GBytes spanning more than 6 years of collection) has accumulated on more than a dozen fabricated tubes. These tests even included a few destructive evaluations to examine the limitations and operating life. In addition, analyses where conducted regarding impact caused by the specified electronic tolerances and expected changes in the HST thermal environment. This latter analysis is being presented elsewhere (Joseph, Bybee, and Argabright 1997).

Perhaps the simplest test of stability is to collect a sequence of images, each with a uniform illumination, and use these individual "flat fields" to remove the pixel-to-pixel sensitivity in the other flat fields. These sequences typically spanned 3-5 weeks of time. As can be seen in Figure 1, the detectors are very stable, allowing the pixel-to-pixel sensitivity to be removed with good precision. The STIS specification for stability is 1% (sufficient for data with a S/N = 100) over a 1 week period and 2% over 30 days. All Engineering Model Units as well as Flight Detectors tested exceeded this specification.

Other measures of life time as well as bright scene testing have demonstrated the MAMA detectors to be robust and stable beyond all expectation. Figure 2 shows the results of one life test on a Ni-Tec C Plate equivalent to those used in both flight MAMAs. The gain of this MCP is plotted as a function of the total charge extracted from the MCP. There are several curves, each representing the gain produced by a given high voltage across the MCP. MCPs are notorious for their reduction in gain as a function of use. This exponential reduction is the result of contaminants as well as the chemicals responsible for the electrical properties of the MCP being scrubbed out of the MCP and deposited, for example, on the anode structure. Fortunately the gain requirements of the MAMA are about 2 orders of magnitude below that needed by most MCP-based detector systems. The charge amplifiers and discriminators require a minimum gain of approximately $2.0 \times 10^5 e^-$ for efficient detector operation. This low minimum requirement, shown as a horizontal dashed line in Figure 2, allows the MCPs used in MAMAs be preconditioned to a greater degree than most other MCP-based systems resulting in a greater stability in the detector performance.

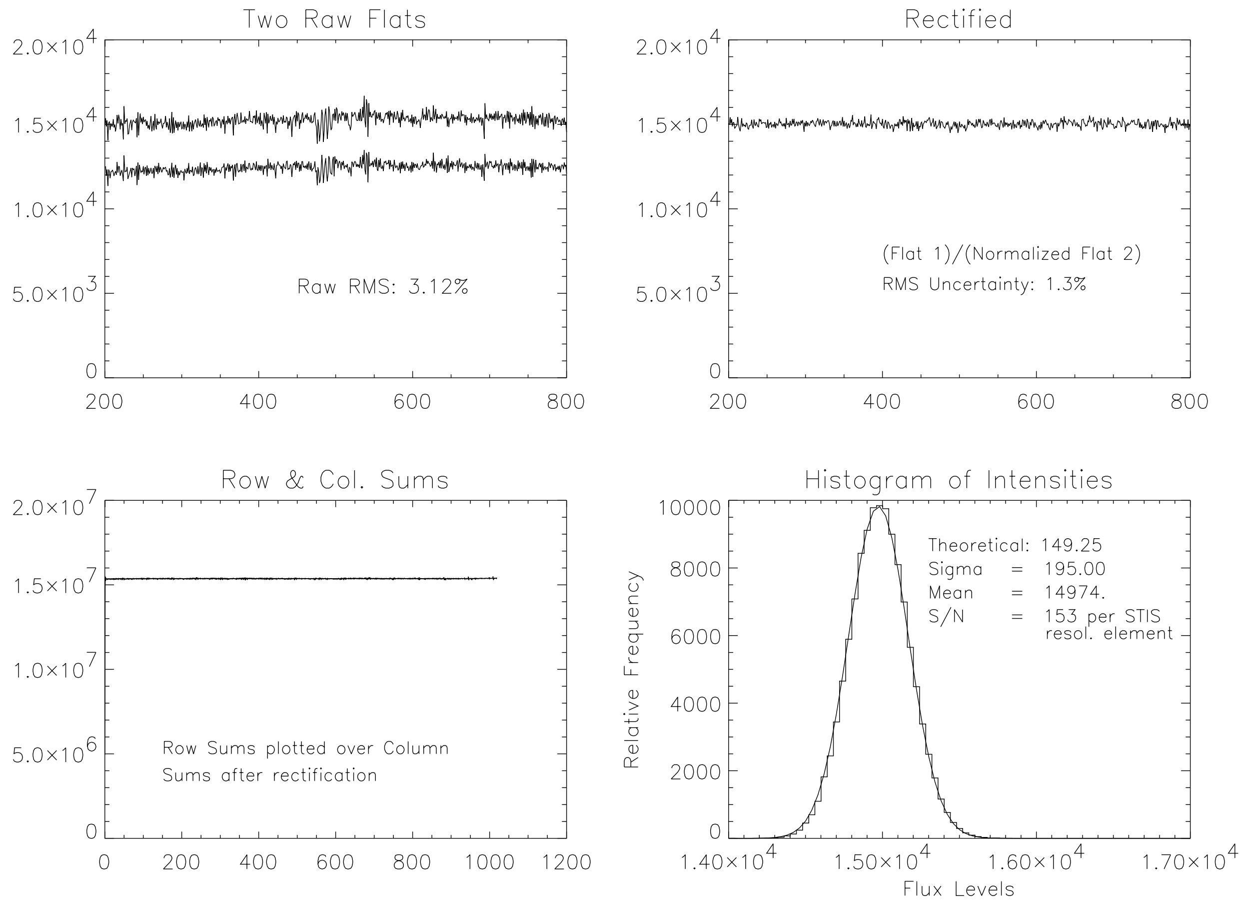

Figure 1. Revealing the stability of the response to a uniform illumination (Flat Field). The top left panel shows the raw pixel-to-pixel variations for a portion of a row, taken on 2 different days. Plotted in the top right panel is the results for same row where the pixel-to-pixel sensitivity from one image is used to remove the detector response of the other. The row and column sums of this corrected image, showing the broad scale stability, are shown at bottom left. A distribution of the intensities of the corrected image is plotted bottom right and is consistent with photon- noise-limited data for a signal-to-ratio of 153 per STIS resolution element. (A resolution element is taken to be 2x2 pixels.)

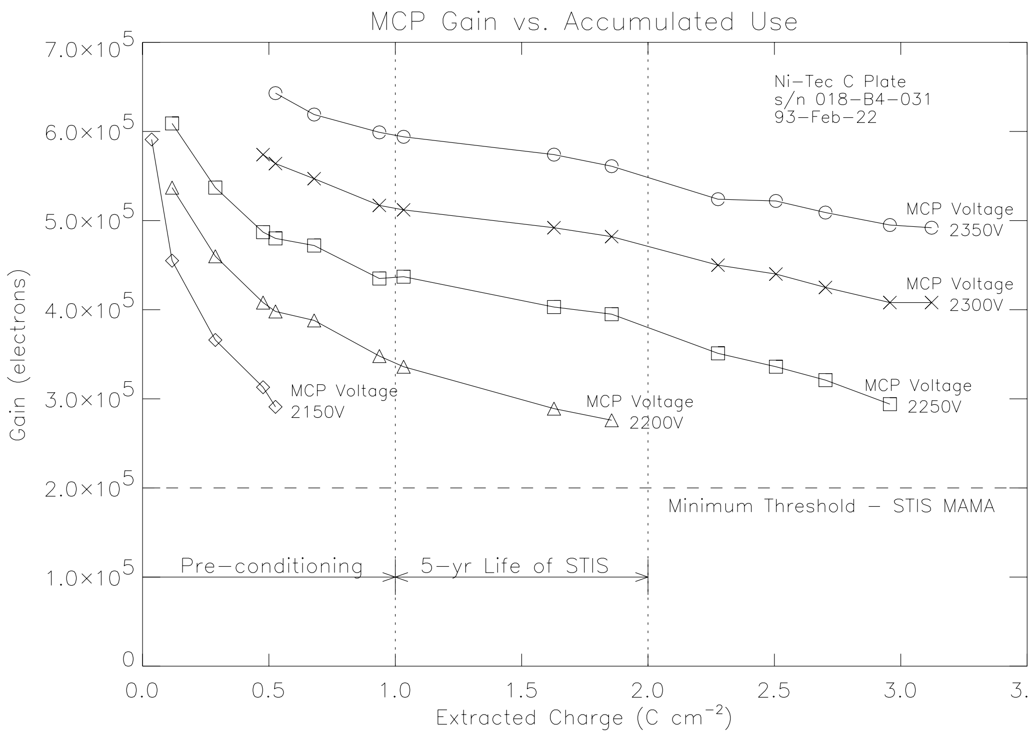

Figure 2. Showing the gain as a function of extracted charge, a measure of the total MCP use. Based on this one parameter alone, the STIS MAMAs should function well for more than 30 years!

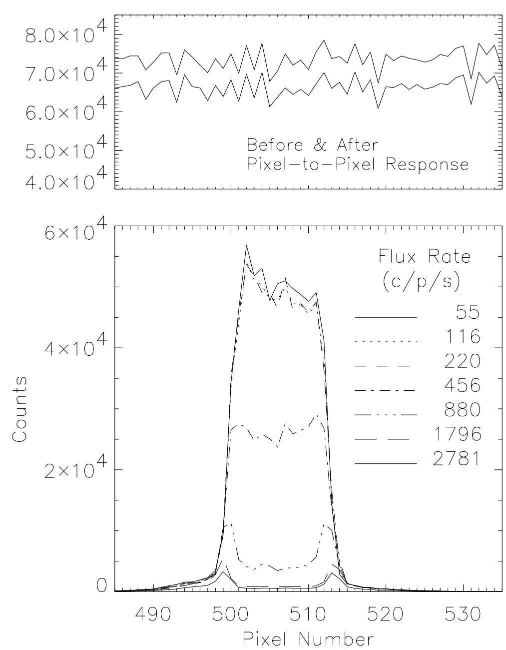

Figure 3. Showing the detector response to an image that is many times brighter than the local dynamic range. Localized gain sag within the MCP at the location of the image causes a temporary loss in counting efficiency leaving the rest of the detector uneffected. This test also demonstrates the safety and robustness of the MAMA detector to bright localized sources for brief periods of time.

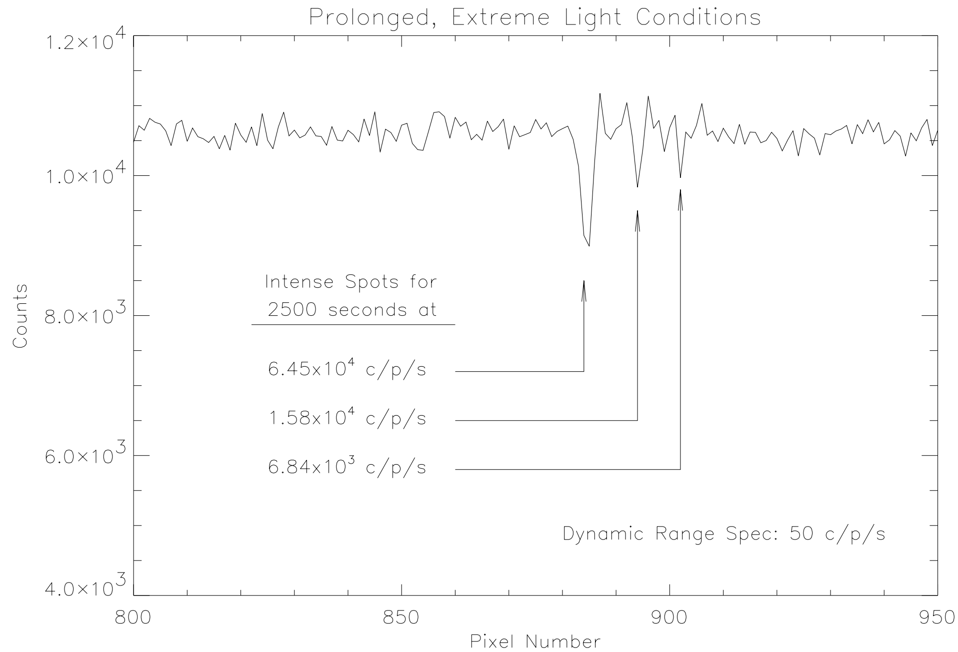

Figure 4. Showing the permanent change in the pixel-to-pixel response due to very-bright, localized illumination over extended periods of time. Three spots with the various count rates indicated were imaged onto three locations on the detector. A uniform illumination image (flat field) was used to remove the pixel-to-pixel response from a similar image taken after the exposure to the three bright spots. The dips indicate the relative losses in sensitivity due to preferential aging. Subsequent testing reveal this new pixel-to-pixel response to be very stable.

Figures 3 and 4 show the response of the MAMA detector to very bright localize illuminations. For flux levels up to approximately 1000 c/p/s, a factor of 20x over specification, the detector responds gracefully by becoming self limiting and there is no permanent change in the pixel-to-pixel response. For prolonged exposure to extreme flux levels (i.e. above 6,000 c/p/s sustained for 2500 seconds), preferential ageing of the MCP does occur. Once the bright source is removed, however, the pixel-to-pixel response is once again highly stable.

Finally, there is interest in pushing the detector beyond its inherent limitations and sampling the data at 1/2 pixel (hi-res) intervals. The motivation is to obtain the highest resolution data possible even at the sacrifice of some photometric stability. Laboratory testing indicate reasonable stability (sufficient for S/N>20 per hi-res sample) is maintained over periods of days or weeks, but that changes do occur abruptly and a new "fixed pattern" is established for another unspecified period. The nature of the instability is such that the sensitivity gained/losted in one half of the full pixel appears in the other half so that the sensitivity sampled at the full pixel size remains constant. In addition, nonlinearities are more severe when the data are sampled in the hi-res mode. These nonlinearities might be confused by some investigators as instabilities. Figure 5 shows raw images of a 2.5 mm diameter spot taken at various flux rates. The images are uncorrected for pixel-to-pixel sensitivities variations. As can be seen, the pixel-to-pixel sensitivity in the 50 c/p/s case is

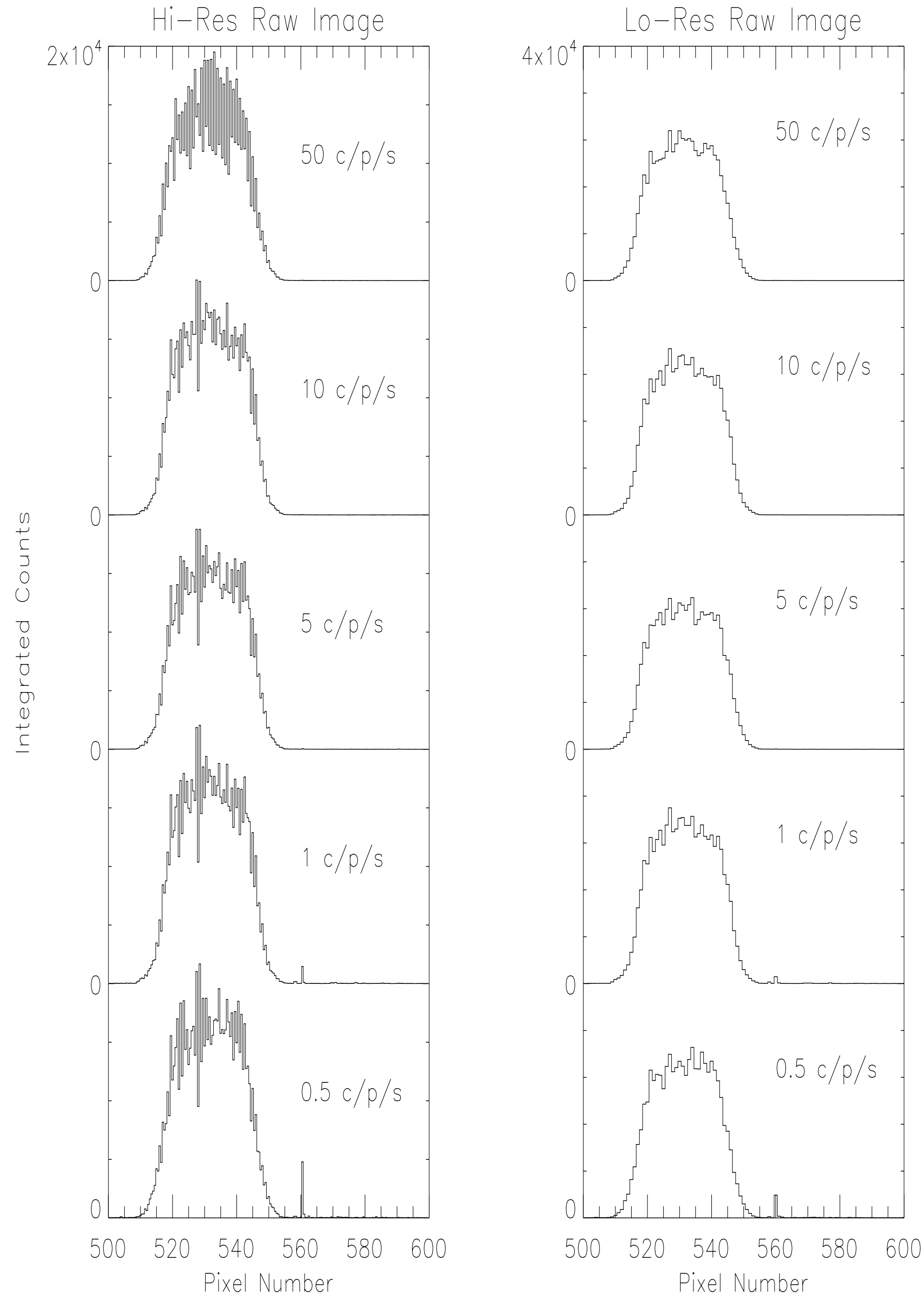

Figure 5. Showing the pixel-to-pixel response to a 100-pixel diameter spot imaged onto the detector as a function of various count rates. Nonlinearities in the individual pores of the MCP caused a change in the pixel-to-pixel response of the sub-pixel sampling (hi-res) case at the higher flux rates. This is not an instability, although some investigators may mistake it as such. As can be seen at the right, the images formed on standard MAMA pixel sampling (lo-res) are more robust, maintaining the pixel-to-pixel sensitivity much better.

significantly altered in the hi-res but not the lo-res mode.

Acknowledgement

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References

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