

Persistence in NICMOS: Results from Thermal Vacuum Data.

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ABSTRACT

This ISR presents an analysis of the System Level Thermal Vacuum (SLTV) persistence tests performed with NICMOS. In August 1996, persistence data was obtained as part of the SLTV, and further data were obtained in December 1996 after modifications had been made to the instrument operating procedures. The goal was to determine if NICMOS exhibits an “after-glow” or “persistence” when read out in the dark immediately after having been exposed to bright illumination; and then to characterize the behavior of such persistence. The results and analysis of the SLTV tests show that the NICMOS detectors do indeed exhibit a significant level of persistence. The level of persistence seems to decay following a power law. Furthermore, the comparison of data observed with different AUTO-FLUSH patterns verifies the efficiency of the procedure when AUTO-FLUSH is turned “on”. Quantitative analysis of the on-orbit performance of the NICMOS detectors with regard to persistence will be described in a later ISR.

1. Introduction

The measurement of the level of the persistence in NICMOS data is an important part of the System Level Thermal Vacuum (SLTV) tests. Not only will it help in determining NICMOS detector characteristics, but it will have an impact on the observing strategy as well as post-observing analysis. This test consists of taking a sequence of observations after purposely over-exposing a camera to light. The analysis of the data should lead to the calculation of the level of the persistence. Nevertheless, we stress the preliminary nature of this study and the fact that our understanding of persistence will certainly increase after the Servicing Mission Orbital Verification (SMOV) and the cycle 7 calibration plan are executed. The goal of the analysis presented in this report is to verify if persistence is present at all, and to characterize the nature of such effect. More definite conclusions about avoiding and compensating for persistence are expected after analysis of SMOV data.

For the purpose of understanding NICMOS persistence, the test was performed twice; first in August 1996, and then in December 1996. The major difference between the two tests resides in the AUTO-FLUSH pattern. "AUTO-FLUSH" is a state into which NICMOS places itself when it is idle: it consists of repeated resets, the aim being to prevent the detectors from saturating on background during such idle periods. In fact, the August data was obtained with the AUTO-FLUSH turned "off"; whereas for the December data it was turned "on". Furthermore, the December data was taken with two different flush patterns: resets only with no reads, and resets interspersed with reads. This change in the flush pattern had no effect on the persistence. The analysis shown here is a comparison between the August data and the December data for which the flush pattern was resets with no reads.

2. The Analysis

The Data

The persistence test data was obtained for each camera using both the ACCUM and MULTIACCUM readout modes.

For the August data, the plan consisted of three major stages: 1) A set of darks is taken without any pre-illumination; 2) 8 sets of MULTIACCUM (or ACCUM) exposures each were taken after 7 seconds of illumination corresponding to 4 times of saturation level; and 3) 2 sets of MULTIACCUM (or ACCUM) exposures were taken after 90 seconds of illumination leading to 40 times of saturation level.

For each exposure in the MULTIACCUM mode, the NREAD keyword was set to 21. The readouts were spaced apart by roughly 4 seconds, so the total exposure time for a set of post-illumination data was 84 seconds.

In the case of the ACCUM mode, NREAD was set to 1. Each exposure was repeated 20 times, and had an exposure time of about 9 seconds. So the total exposure time for a set of post-illumination data was about 180 seconds.

Since the main goal of the December test was to determine the effect of the AUTO-FLUSH pattern, the test was executed with only the MULTIACCUM mode and CAMERA 1. Furthermore, the exposure pattern was slightly different in the December test. First 10 MULTIACCUM patterns lasting about 76 seconds each were taken with NREAD fixed at 21. The illumination process was executed by turning on the internal flat field lamp and taking ACCUM exposures for about 92 seconds leading to about 3 times of saturation level in the most sensitive regions of the chip. After turning off the internal flat field lamp, 20 MULTIACCUM patterns were executed for 76 seconds each pattern with NREAD fixed at 21. This ISR presents the results of 6 sets of 20 MULTIACCUMS.

The Method

The goal of this test, as mentioned previously, is to observe the level of “excess dark current”, or persistence, in the post illumination sequences. The persistence is presented in the form of a count-rate for each readout. First the count-rate was calculated over different parts of the chip in order to observe the varying levels of light sensitivity across the face of the camera. Since the aim is to determine the nature of the persistence, the results shown present the average count-rate over the whole chip. This is repeated for each camera at each mode (only Camera 1 for the December data).

In the case of the MULTIACCUM mode, the persistence is represented by the count rate with respect to the exposure time. As mentioned before, a set of pre-illumination darks were taken during both tests. Figures 2 (August) and 5 (December) show the slopes of these exposures. It is easy to discern a decay in the count rate with respect to time. This is a similar effect to the persistence seen in the post-illumination data shown in figures 1 (August) and 4 (December). But since the data was taken before saturation, it is suspected to be background light resulting from “some stabilization phenomenon in the output amplifiers”. This suggests that, for the December data, much of the light seen in the post-illumination is the above mentioned background light. Figures 3 and 6 show the actual persistence after subtraction of the background exposures.

On the other hand, for the ACCUM mode data, the signal is the difference between the values of the initial and final reads of each exposure. The average count rate was therefore simply obtained by dividing by the exposure time. And since the background of the ACCUM mode (Figure 8) shows the same persistence-like behavior as the post-illumination darks (Figure 7), the calculated persistence (Figure 9) is obtained after subtraction of the background exposures. Because of the uncertainty over the time elapsed between exposures, the ACCUM mode results were presented with respect to number of exposures.

The Results

In MULTIACCUM, the results of the AUGUST persistence test show a high level of count rate. Even after subtracting the “pre-exposure” background, the count rate is about 30 ADU/second and takes more than 30 seconds to diminish to 2 ADU/second (Figure 3). Turning the AUTO-FLUSH feature “ON”, as was the case for the data obtained in December, is beneficial. As shown in figure 6, the persistence level is lower from the first read (~1 ADU/second) and after 30 seconds, it is ~0.45 ADU/second.

The data taken with the ACCUM mode shows the same behavior: a relatively higher level of persistence initially, followed by a decay leading to a negligible level of average

count-rate over the chip (Figure 9). For this mode, AUTO-FLUSH turned “ON” is suspected to have the same beneficial effect, but we have no data to verify this.

Figures 10 to 15 show the MULTIACCUM results from the August test for both Camera 2 and Camera 3. As seen for Camera 1, the pre-illumination darks (Figures 11 and 14 respectively for Camera 2 and Camera 3), show the so called persistence like behavior as well as the post-illumination darks (Figures 10 and 13 respectively). The actual persistence after the subtraction of the background is shown in figures 12 and 15 respectively.

Figures 22 to 25 represent the results of figures 3, 6, 12 and 15 respectively in a logarithmic scale. This scale gives a better idea about the behavior of the decay of persistence with respect to time. These figures indicate that if anything, the persistence follows a power-law decay, and hence the effects may be present over a substantial period of time. We will investigate on-orbit SMOV persistence data to see if the detectors continue to behave in this way.

The August results for the ACCUM mode are shown for both Camera 2 and Camera 3 in the figures 16 to 21. For this mode as well the actual persistence (Figures 18 and 21 respectively) is determined after the subtraction of the background (Figures 17 and 20 respectively).

3. Discussion

Comparing the results of the August persistence test and the December one leads to the conclusion that the AUTO-FLUSH procedure seems to be successful and beneficial. In fact, studying the results shown above, this procedure dramatically reduces the effect of persistence in post-illumination darks. Therefore, even though the calculated persistence for Camera 2 and Camera 3 is fairly high, we suspect it to have been within acceptance levels had the AUTO-FLUSH been turned “on”.

Although Camera 3 presents similar behavior to Camera 1, the study of persistence in Camera 2 shows a peculiarity. As demonstrated in figures 10 and 11, both pre and post-illumination frames show a disturbing effect; the “background” count-rate appears to oscillate during the first few seconds of the readout sequences. This behavior is persistence independent, and intrinsic to the electronics of the camera. This seems to be true for both MULTIACCUM and ACCUM modes. It is obvious that further study is needed and it is expected that more data from SMOV and Cycle 7, will lead to a better understanding of this characteristic.

One major hindrance to the interpretation of these data lies in the lack of timing information. We do not know when the post-illumination readouts began with respect to the time when the illumination was switched off. We therefore do not know the absolute level of the persistent signal as a function of time.

Furthermore, the persistence count-rate does not drop to zero during the post-illumination exposures. Therefore we do not know from these tests how long it takes for a persistence signal to totally disappear.

On the other hand, darks obtained in other tests such as the gain data did indeed suggested that illumination signature can last for at least 30 minutes. At this level it is obvious that more data needs to be obtained and analyzed.

4. Conclusion

In this ISR we have demonstrated that persistence is fairly high in the first 30 to 60 seconds of the exposure. This effect may present a problem to beware of for observations of bright sources. Using the AUTO-FLUSH procedure is very beneficial as it dramatically reduces the persistence effect. This procedure is therefore highly desirable and recommended for use.

During the persistence study, Camera 2 has demonstrated a different behavior than Camera 1 and Camera 3. This feature is suspected to be a result of the electronics of the camera. It is hoped to be better studied in further NICMOS calibration data.

Figure 1: AUGUST DATA with AUTO-FLUSH turned OFF:

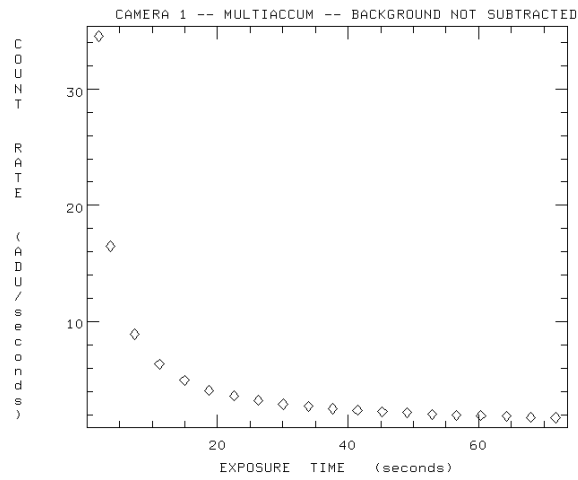


Figure 2: AUGUST DATA with AUTO-FLUSH turned OFF:

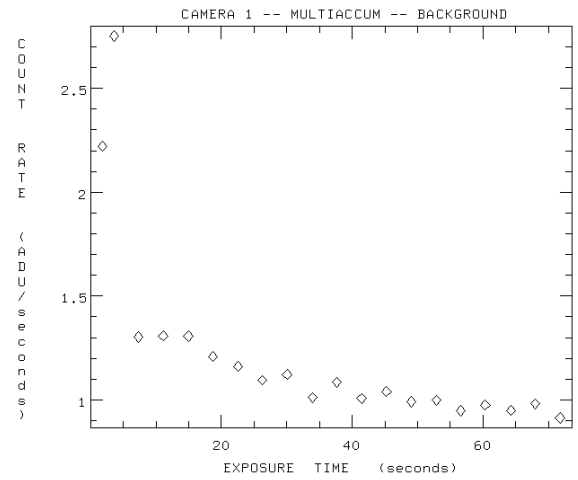


Figure 3: AUGUST DATA with AUTO-FLUSH turned OFF:

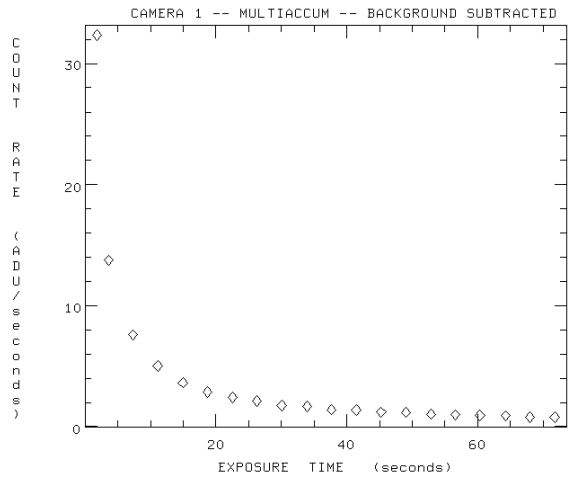


Figure 4: DECEMBER DATA with AUTO-FLUSH turned ON:

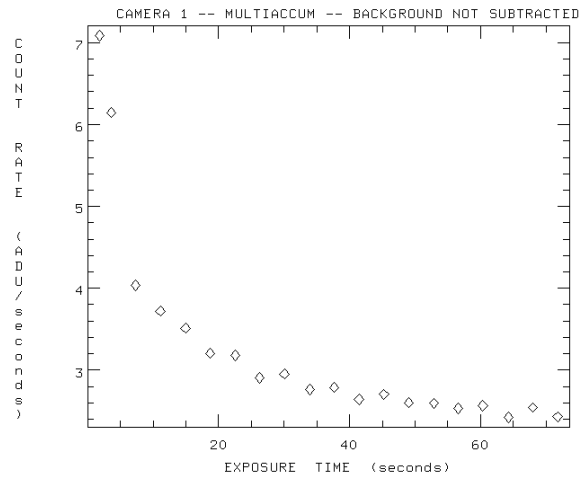


Figure 5: DECEMBER DATA with AUTO-FLUSH turned ON:

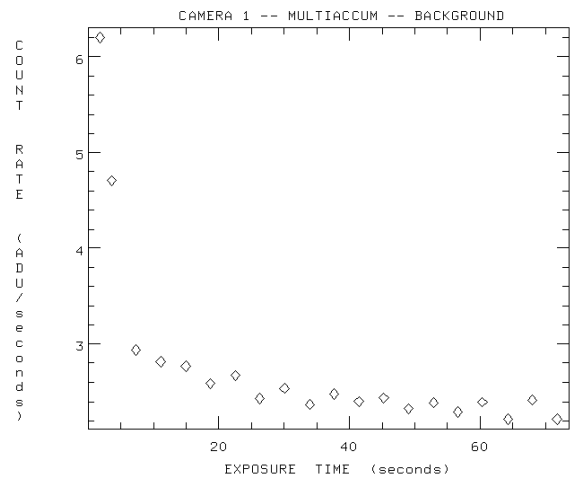


Figure 6: DECEMBER DATA with AUTO-FLUSH turned ON:

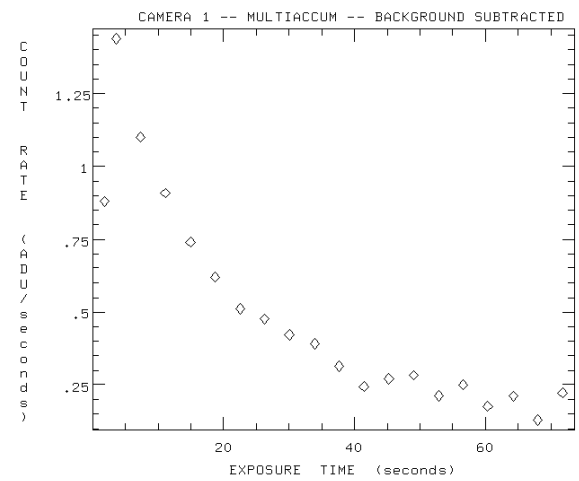


Figure 7: AUGUST DATA with AUTO-FLUSH turned OFF:

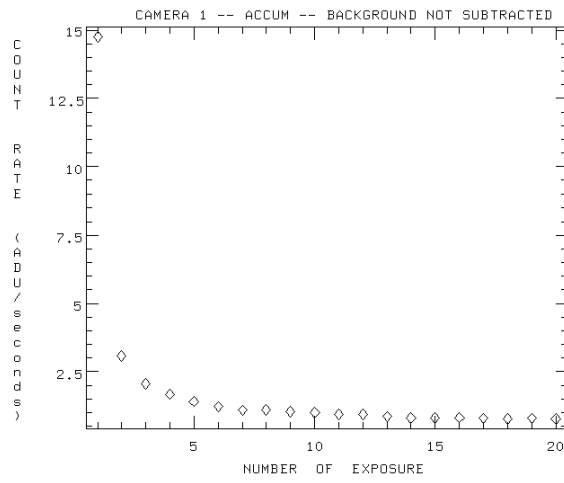


Figure 8: AUGUST DATA with AUTO-FLUSH turned OFF:

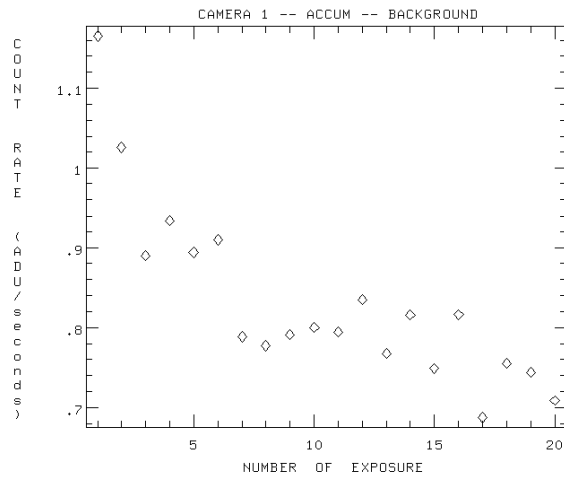


Figure 9: AUGUST DATA with AUTO-FLUSH turned OFF:

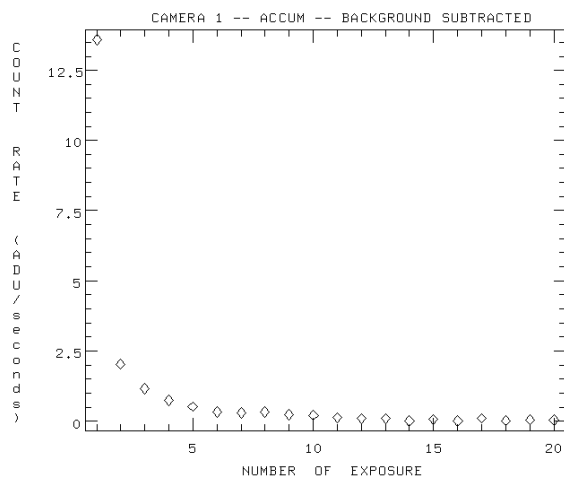


Figure 10: AUGUST DATA with AUTO-FLUSH turned OFF:

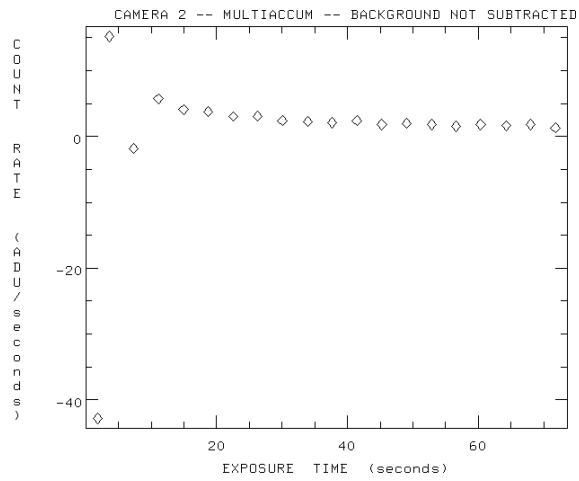


Figure 11: AUGUST DATA with AUTO-FLUSH turned OFF:

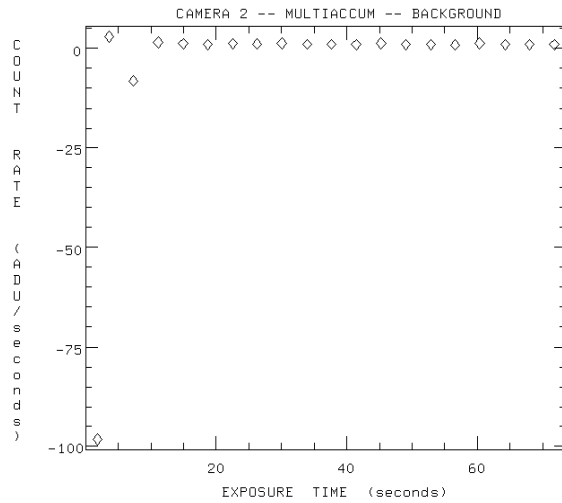


Figure 12: AUGUST DATA with AUTO-FLUSH turned OFF:

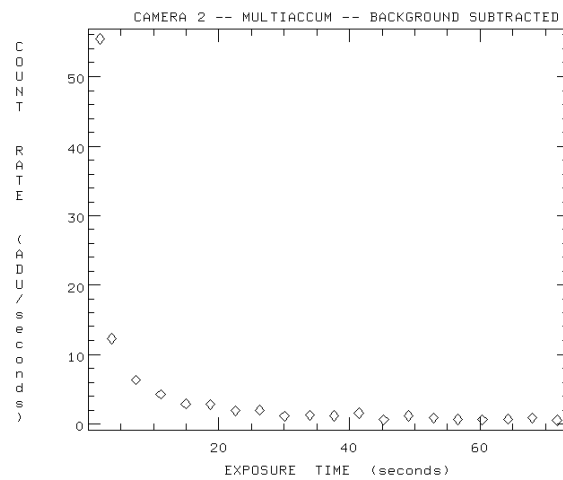


Figure 13: AUGUST DATA with AUTO-FLUSH turned OFF:

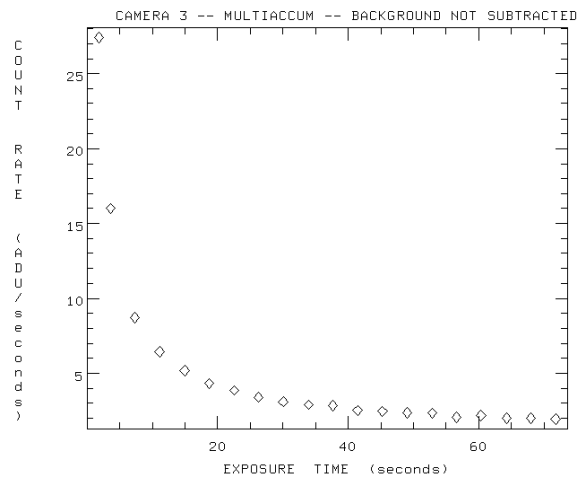


Figure 14: AUGUST DATA with AUTO-FLUSH turned OFF:

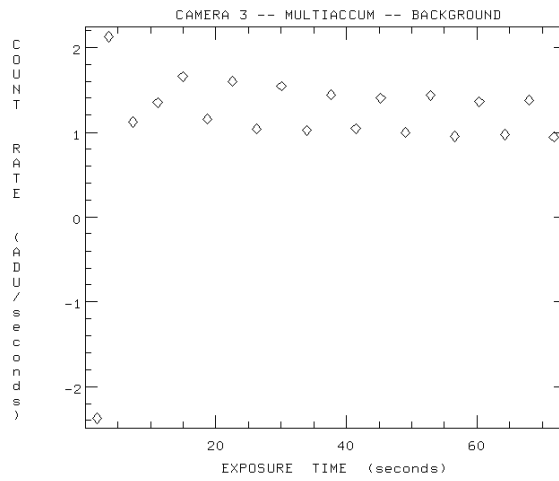


Figure 15: AUGUST DATA with AUTO-FLUSH turned OFF:

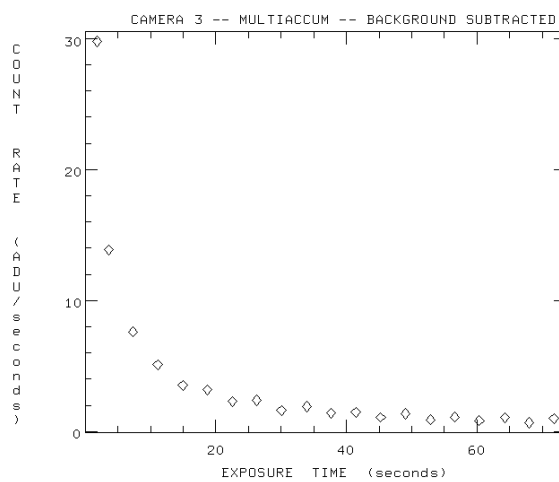


Figure 16: AUGUST DATA with AUTO-FLUSH turned OFF:

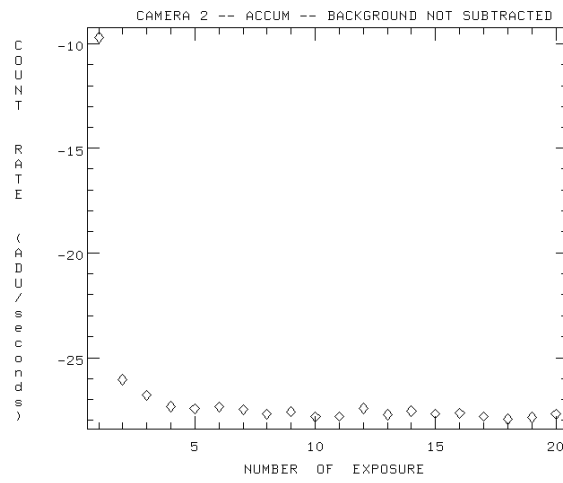


Figure 17: AUGUST DATA with AUTO-FLUSH turned OFF:

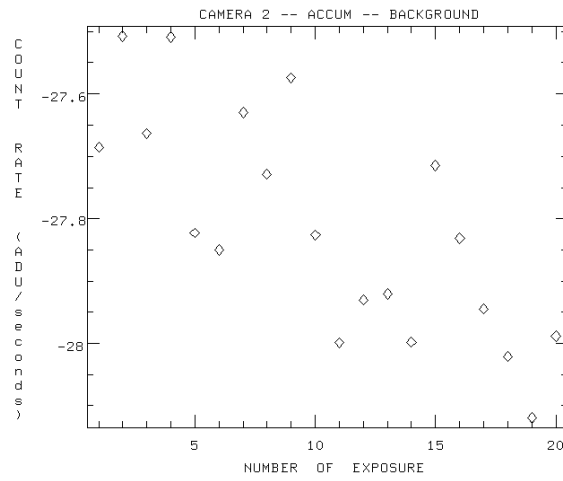


Figure 18: AUGUST DATA with AUTO-FLUSH turned OFF:

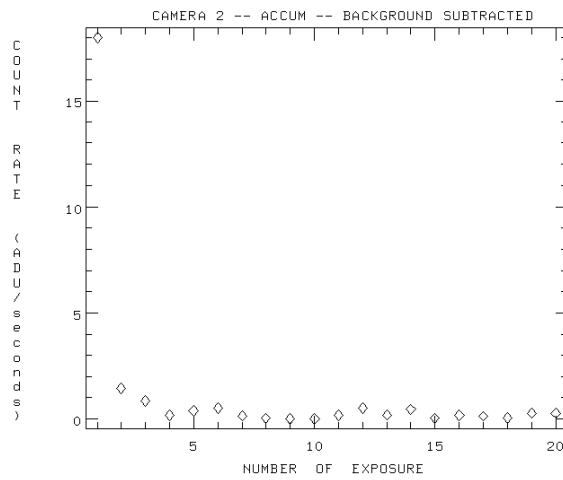


Figure 19: AUGUST DATA with AUTO-FLUSH turned OFF:

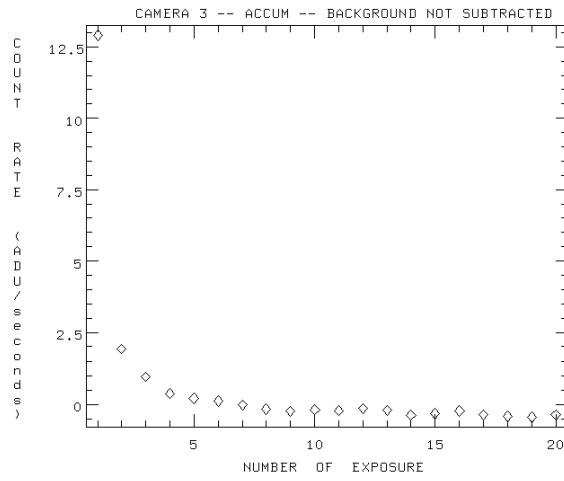


Figure 20: AUGUST DATA with AUTO-FLUSH turned OFF:

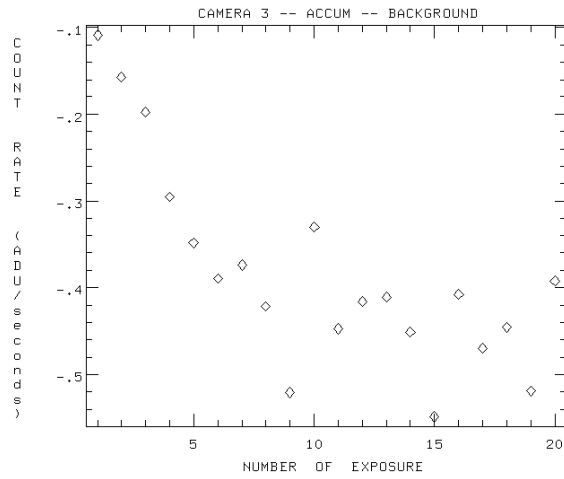


Figure 21: AUGUST DATA with AUTO-FLUSH turned OFF:

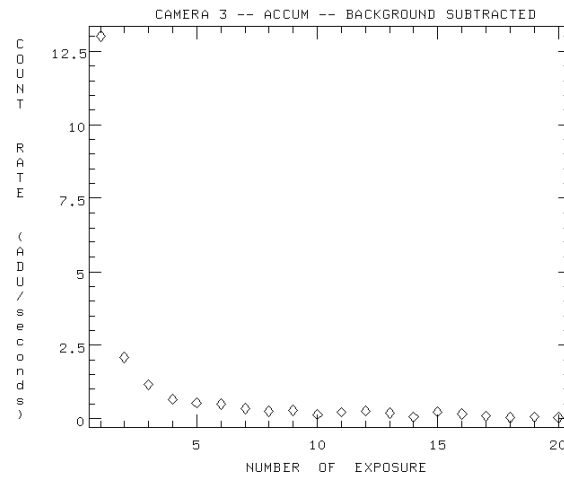


Figure 22: AUGUST DATA with AUTO-FLUSH turned OFF:

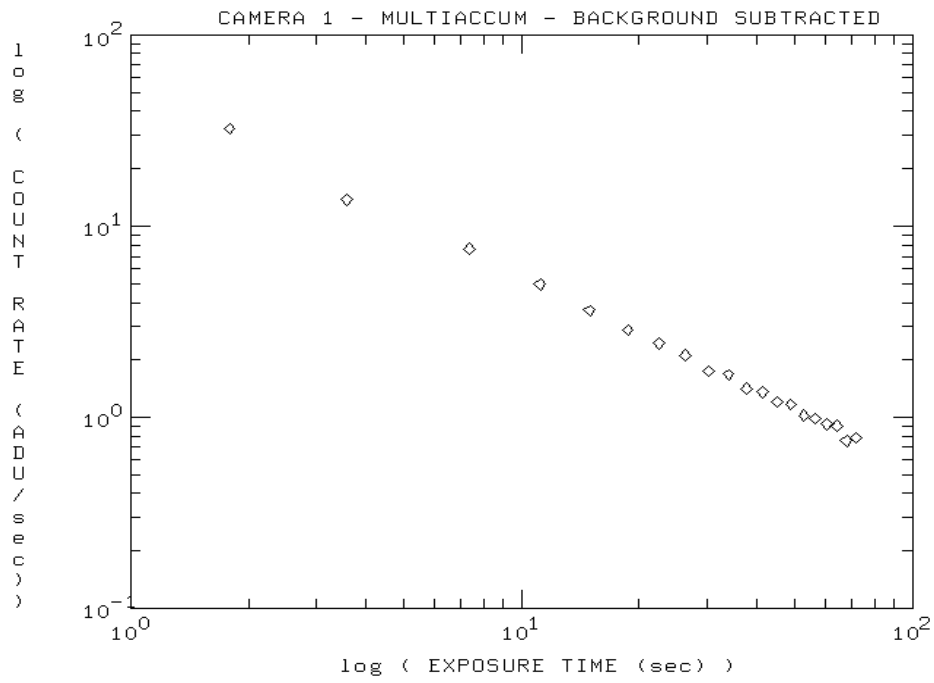


Figure 23: DECEMBER DATA with AUTO-FLUSH turned ON:

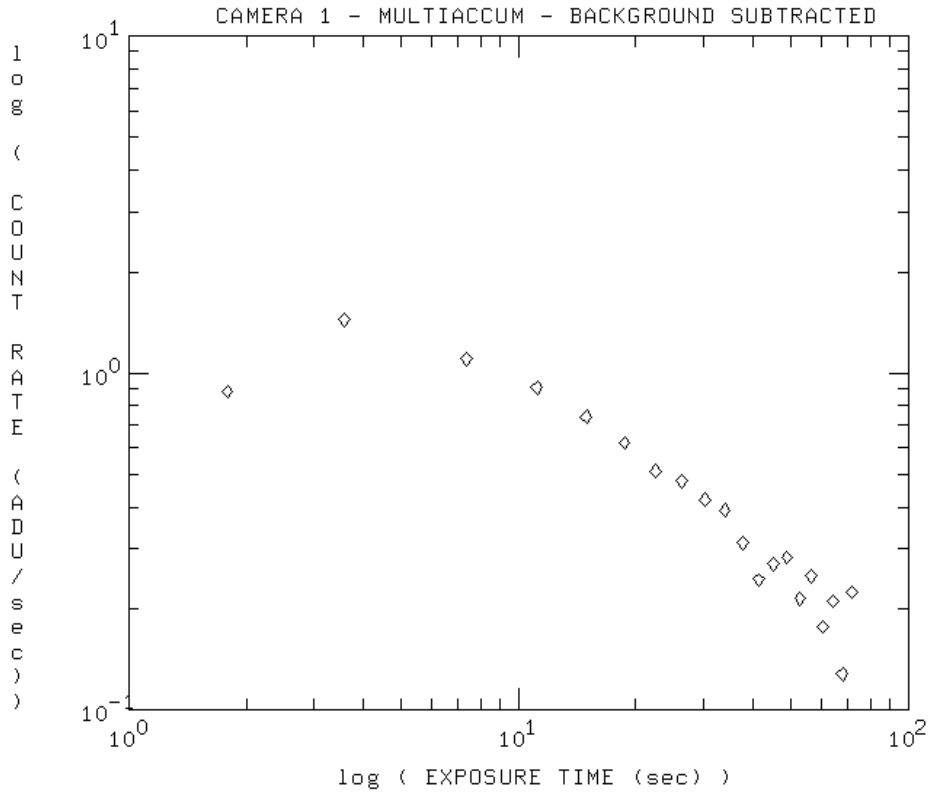


Figure 24: AUGUST DATA with AUTO-FLUSH turned OFF:

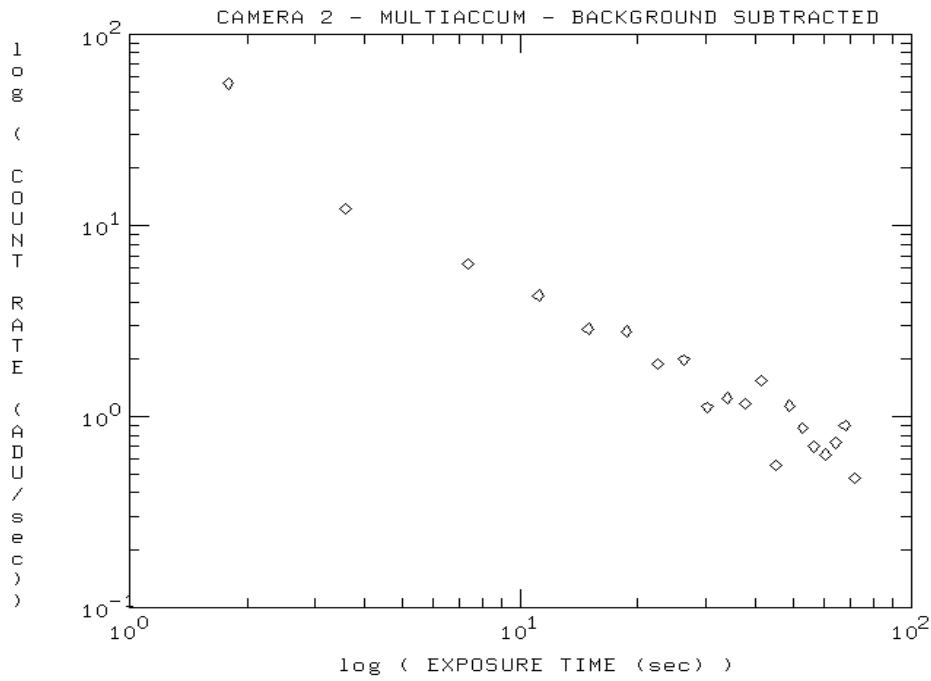


Figure 25: AUGUST DATA with AUTO-FLUSH turned OFF:

