Chandra Flight Note

FLIGHT NOTE NO.	**519**
SUBJECT	Monitoring ACA Flickering Pixels, 2002 - 2009
DATE	27-Jan-2011
AUTHOR	J. Connelly & Star Selection and Acquisition Working Group

Abstract

ACA image data reveals that ACA CCD pixels may demonstrate flickering behavior that appears to be independent of incoming photons. While the physical mechanism behind this behavior is not well understood, the behavior itself has been well characterized by the collection and analysis of a body of ACA flickering pixel data. These data show that the flickering behavior has remained stable from 2002 to 2009.

1 History

1.1 Early Mission

As noted in the initial report[1], the flickering behavior of ACA CCD pixels was first noticed during the analysis of early mission dark current calibration data. Subsequent analysis using available monitor window data revealed that that the amplitude of pixel flickering is often more that 100 e-/sec. That is a significant effect, in that it is enough to cause noticeable centroid errors in faint stars. The initial report prompted further study.

1.2 2002 Study

From April-2002 to August-2002, data was collected to improve understanding of the flickering pixel behavior. When possible, fixed-position monitor window data was collected during perigee pass observations. Fluctuating warm[2] pixels were detected in this data set and statistics providing insight into their behavior were gathered. See the 2002 Report[3]. The data collected were also used to create models of flickering pixels for calculating likely centroid errors. These models are used during the generation of the star selection error arrays used in SAUSAGE.

2 2008-2009 Follow-up Study

To confirm that the flickering pixel behavior of the CCD remains unchanged, and that the associated models of the behavior remain accurate, more recent data was required. In 2008, the Star Selection and Acquisition Working Group submitted a special activity request to gather data similar to the data gathered in the 2002 study. Data for this study was collected from 2008 to 2009. As in the 2002 study, monitor window data was collected when possible over a series of engineering observations during perigee passes.

[1] http://cxc.harvard.edu/mta/ASPECT/flicker/report.html
[2] with count rates greater than 100 e-/sec
[3] http://cxc.harvard.edu/mta/ASPECT/flicker_2002/index.html

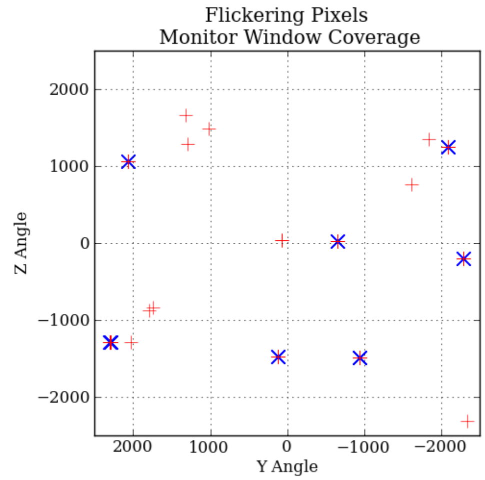


Figure 1: Monitor Window Placement on the ACA CCD (Red=2002, Blue=2008/9)

Monitor windows were selected to overlap a subset of the monitor windows used during the 2002 study (Figure 1). And as in the 2002 study, windows were selected from the set such that their position was unlikely to coincide with known stars in the field. When possible, the same monitor window was commanded during all of the engineering observations of a perigee pass. This was a change from the 2002 procedure.

3 Analysis

As seen in the 2002 Report[4], the 2002 data was analyzed using inspection of light curves and an IDL routine which marks pixel jumps where the pixel dark current value has a sudden and discrete change to a new steady value. At the time of this flight note, new analysis techniques had become available.

As in the 2002 analysis, we define a pixel as warm if the 50th percentile dark current exceeds 100 e-/sec. However, instead of using by-eye light curves and an IDL routine to mark pixel jumps, a Bayesian Blocks algorithm was applied to the pixel data. This algorithm results in similar jump detections to the previous method, but the new method may be totally automated. A comparison of the jump detection algorithms is shown in Figure 2. For consistency the 2002 data have been re-analyzed using this new Bayesian Blocks method.

4 Results

The Bayesian Blocks analysis of the data provides us with a set of time intervals, each with an associated count rate (e-/sec) and a jump delta to the next interval. See Figure 3 and Figure 4 for histograms which characterize these intervals in aggregate.

The jump fraction histogram (Figure 3) shows that the behavior seen in the 2008/2009 is very similar to the 2002 data. We see an expected dip around 0, as the Bayesian Blocks algorithm is insensitive to small jumps.

The differing slopes of the older and newer data in the duration histogram show that the 2008/2009 data appears to have more intervals of longer durations than the 2002 data. However, it is useful to note that the 2002 data was only collected during the first obsid of each perigee pass and the 2008/2009 data was collected over all of the available ERs in each perigee pass. Due to this use of longer raw data intervals in the 2008/2009 study, it

[4] http://cxc.harvard.edu/mta/ASPECT/flicker_2002/index.html

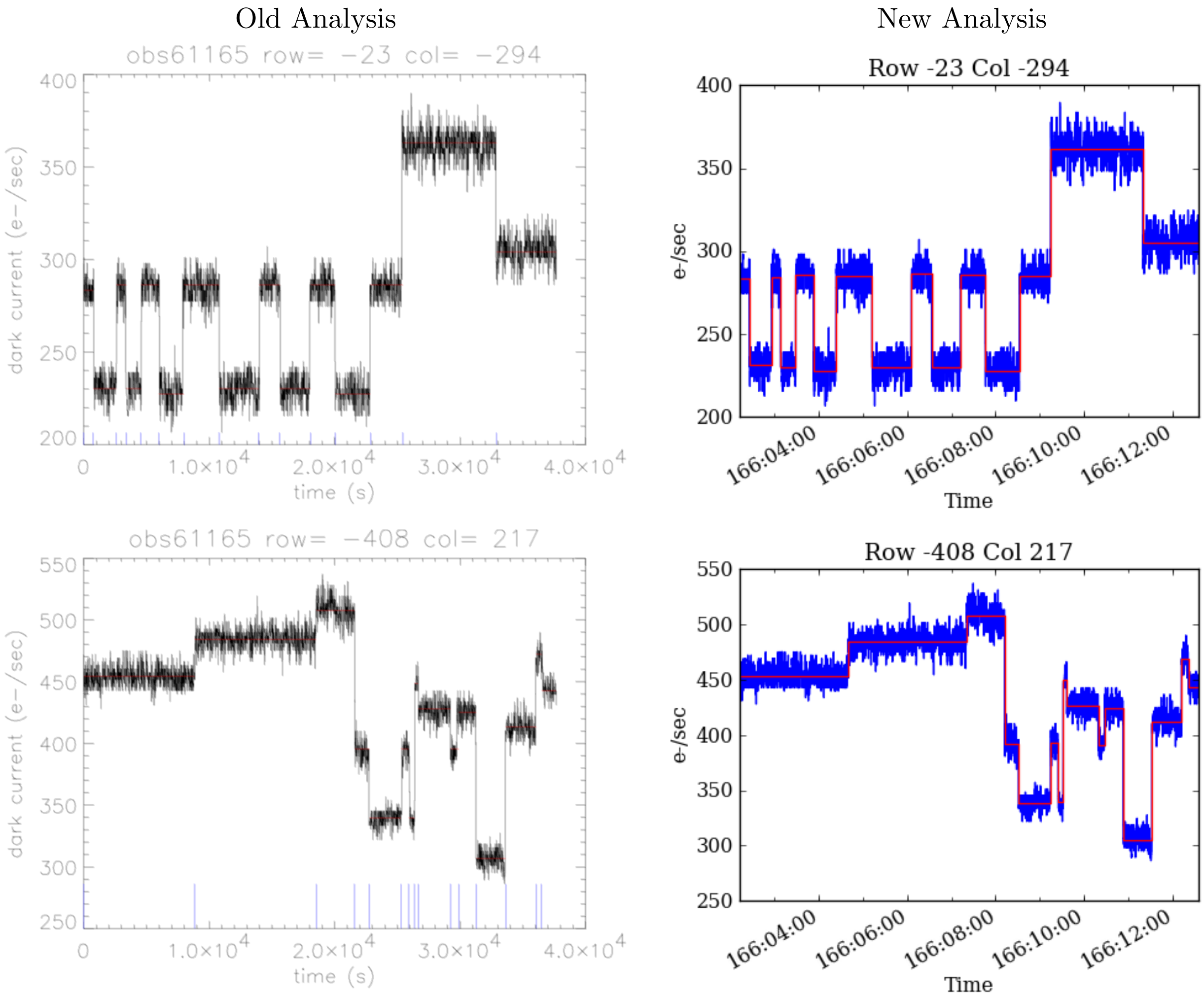


Figure 2: Comparison of the old IDL (left) and new Bayesian Blocks (right) detection techniques for two datasets from 2002. The results are consistent.

is not unexpected that there is a larger fraction of longer intervals in the analyzed data. This does not rule out other possible contributing factors, such as operating temperature and accumulated radiation exposure.

5 Caveats

While monitor windows for these studies were placed to avoid known faint stars, some data appears to be spoiled by dithering faint stars. Additionally, ionizing radiation may also cause count rate spikes. In both cases, the flickering behavior seen in the the data is not inherent to the pixel. Intervals which appear to be contaminated by stars have been manually marked and excluded from this analysis. See the Appendix B for an example with marked excluded regions.

The Bayesian Blocks analysis cannot distinguish small magnitude flickering from noise, and thus this analysis is not sensitive to any such behavior.

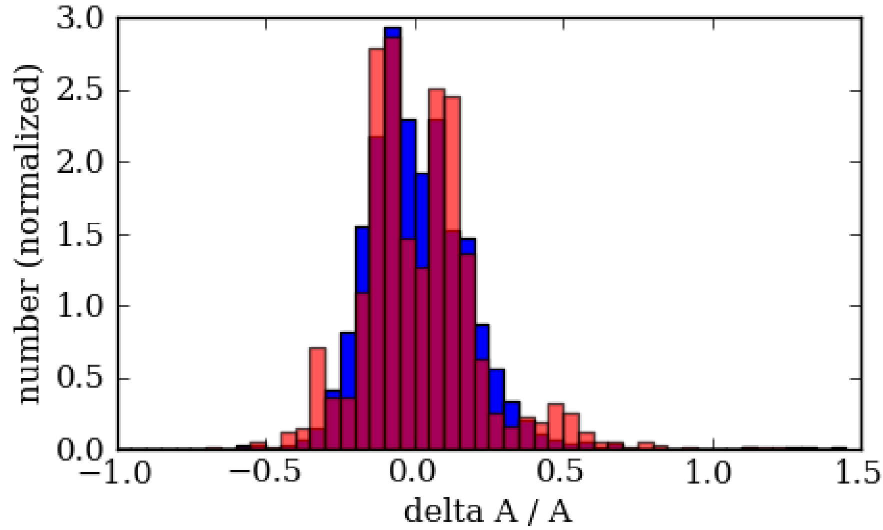


Figure 3: Histogram of jump fraction. Here “A” is the pixel count rate in e-/sec. 2002 data is red/salmon, 2008/2009 data is blue, overlapping sets display as plum.

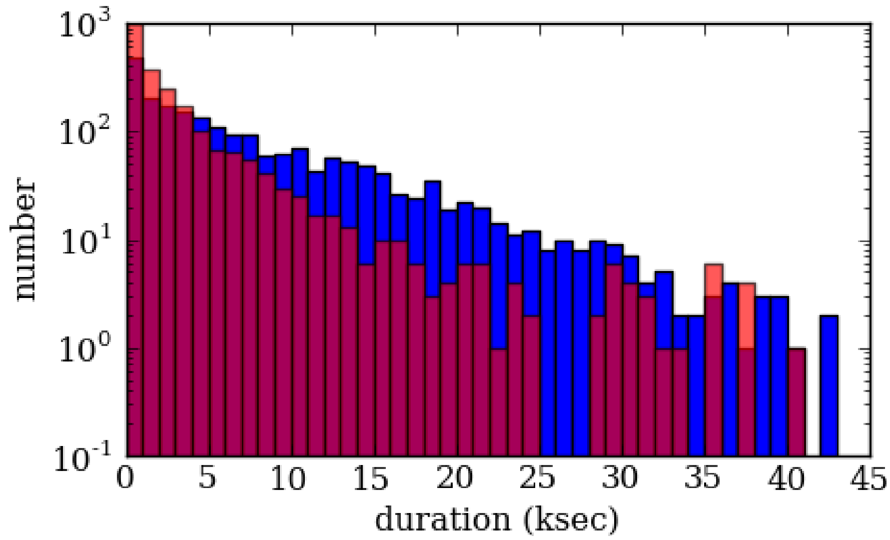


Figure 4: Histogram of unbroken interval durations before pixel jumps. 2002 data is red/salmon, 2008/2009 data is blue, overlapping sets display as plum.

6 Conclusions

The behavior of flickering pixels in the ACA CCD appears largely unchanged from 2002 to 2008/2009. No new behaviors have emerged and the CCD appears to be very stable. As mentioned, the appearance of more intervals of longer duration in the new data set is likely a result of the data collection strategy, but as other causes cannot be ruled out with this analysis, it may be valuable to repeat the data collection strategy used for this study in a future study.

7 References

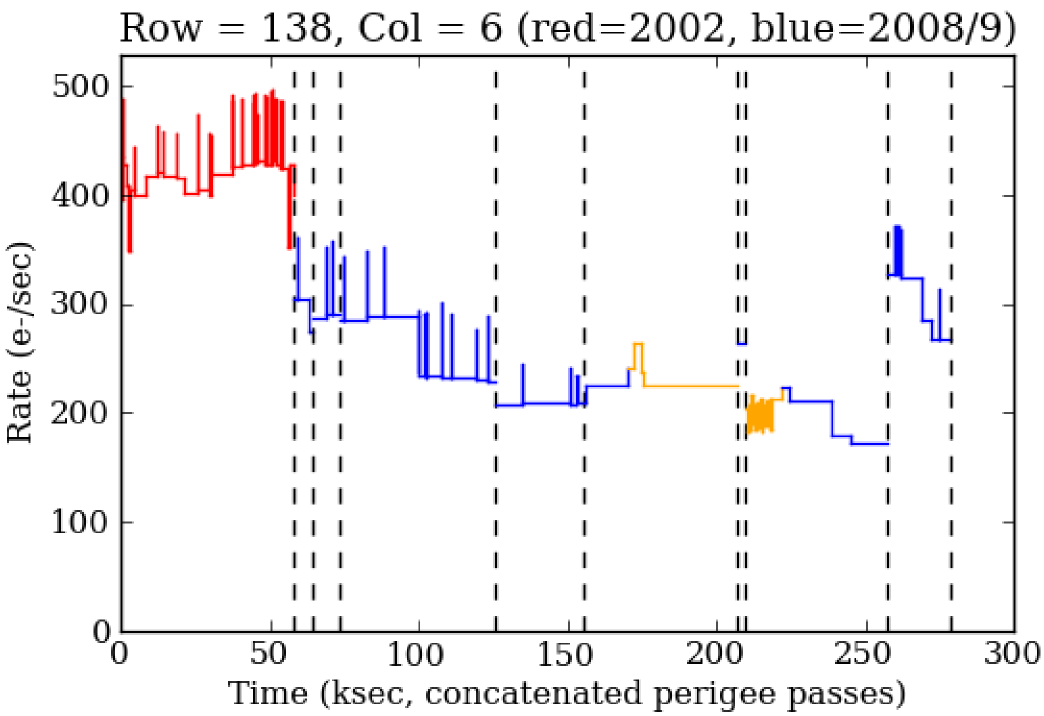
1. Flickering pixels in the ACA CCD,
   http://cxc.harvard.edu/mta/ASPECT/flicker/report.html, December 2000

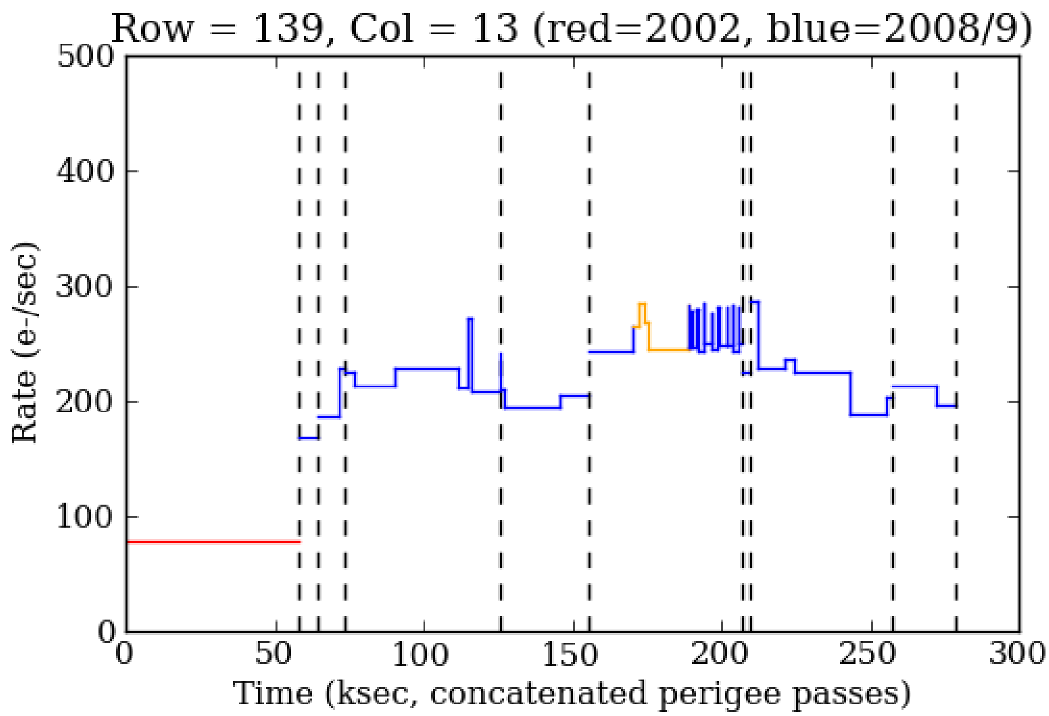
2. ACA Flickering Pixel Analysis 2002-Aug,
   http://cxc.harvard.edu/mta/ASPECT/flicker_2002/index.html, August 2002

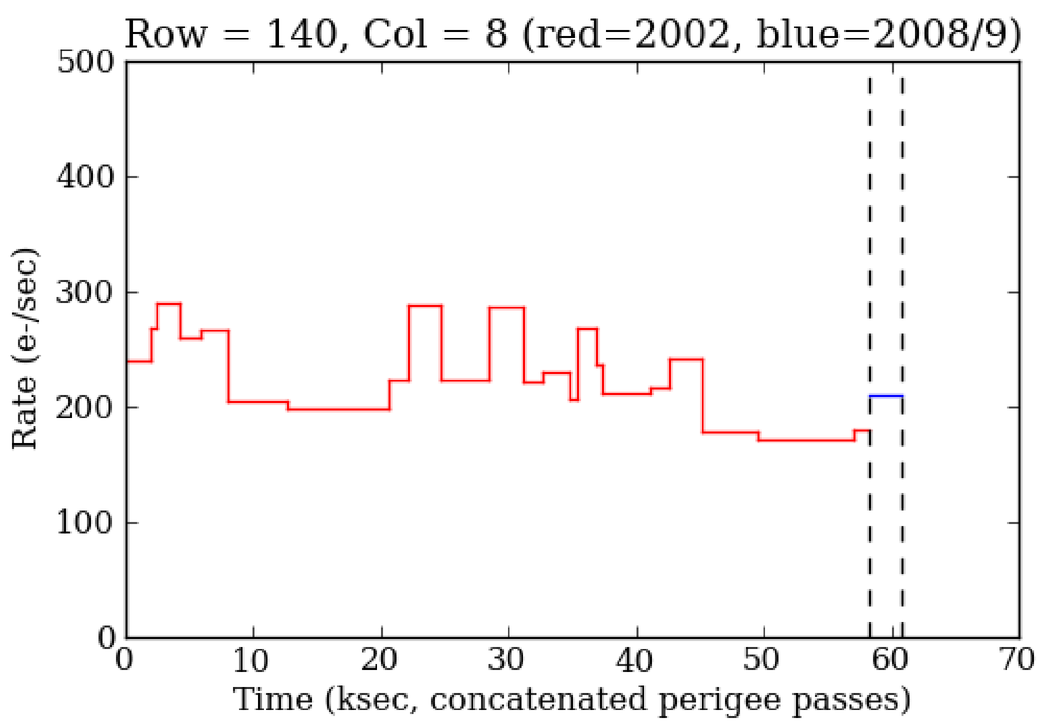
3. Flickering Pixels Follow-Up,
   http://cxc.harvard.edu/mta/ASPECT/flick_pix_2008/index.html, January 2011

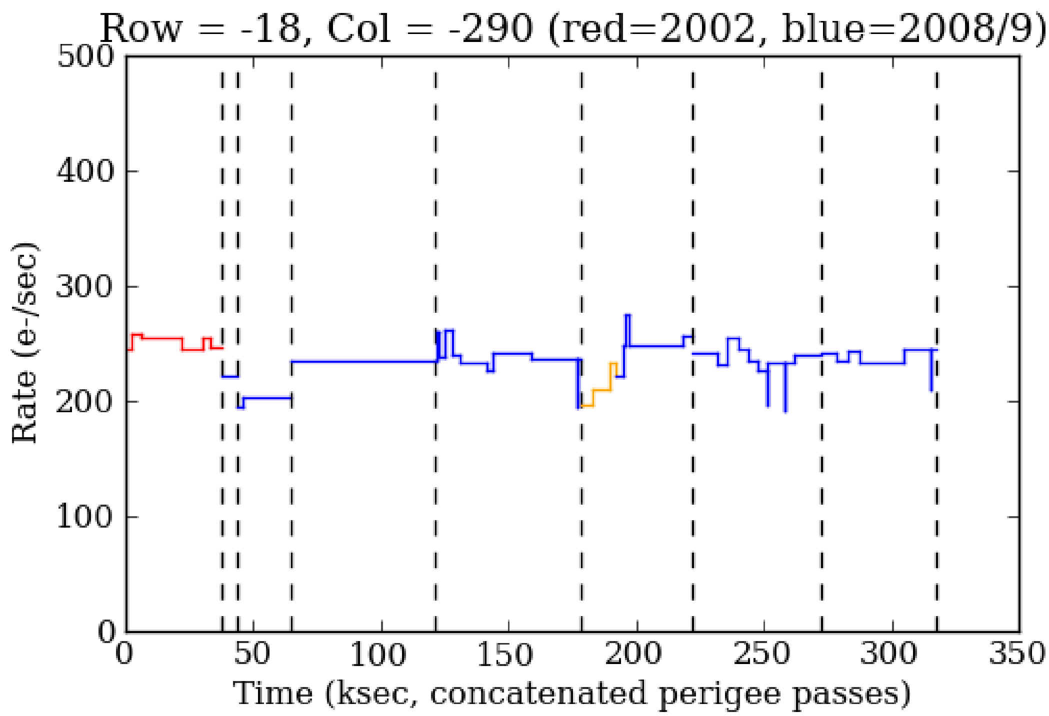
A Appendix: Common Pixel Plots

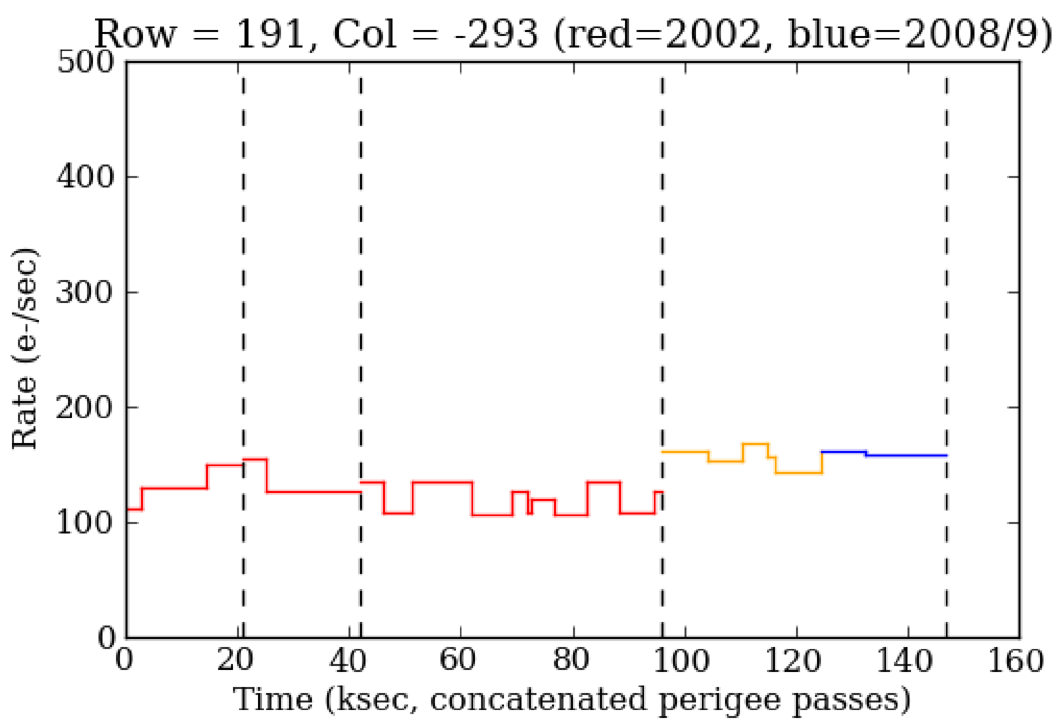
Some pixels appear warm in the 2002 and 2008/2009 data sets. The analyzed intervals from these pixels have been temperature scaled to adjust for the differing CCD setpoints (-10C in 2002 and -19C in 2008/2009) and the data have then concatenated to create the following plots. (Manually-marked bad data is plotted in orange. Perigee passes are separated with dotted vertical lines.)

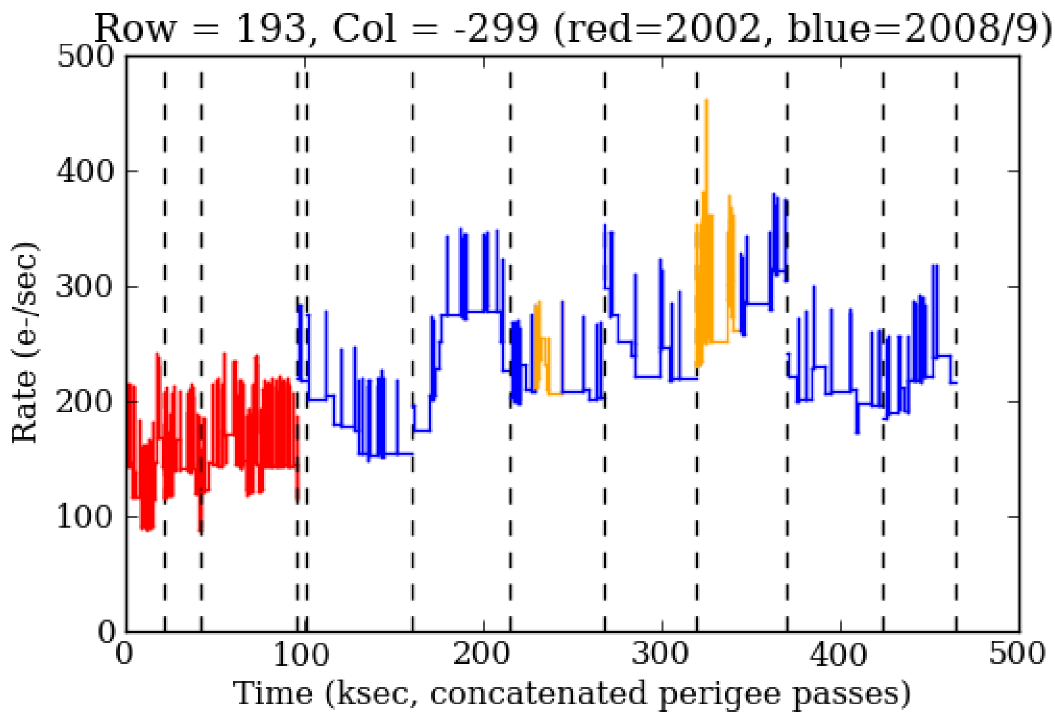


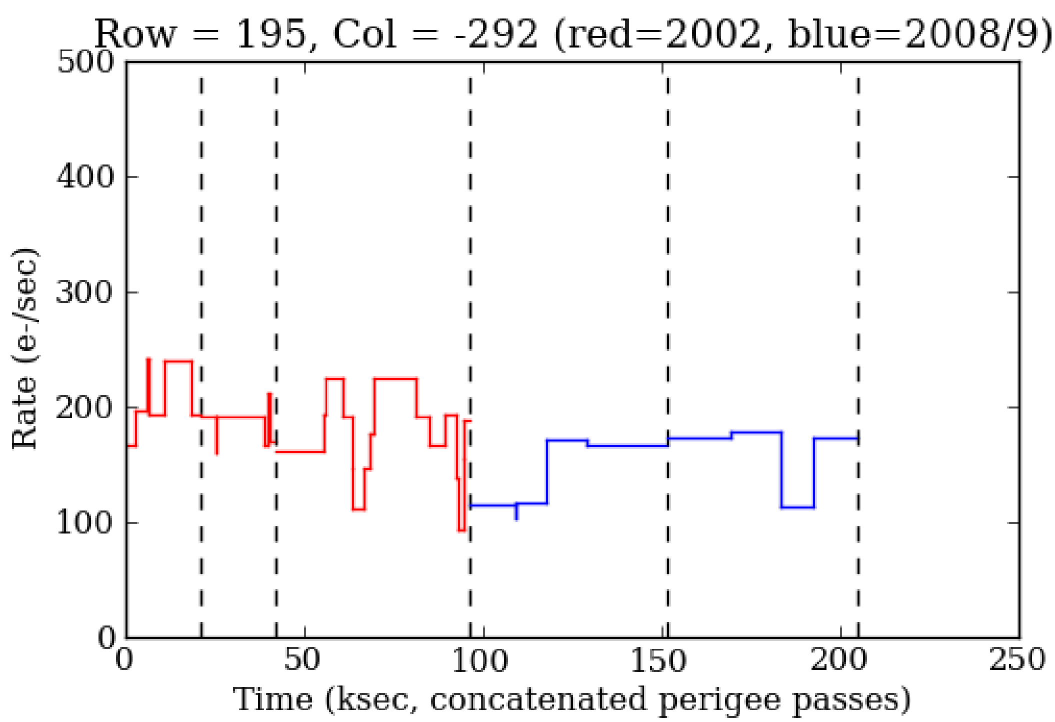

Row = 139, Col = 13 (red=2002, blue=2008/9)
Rate (e-/sec)
Time (ksec, concatenated perigee passes)
0
100
200
300
400
500
0
50
100
150
200
250
300

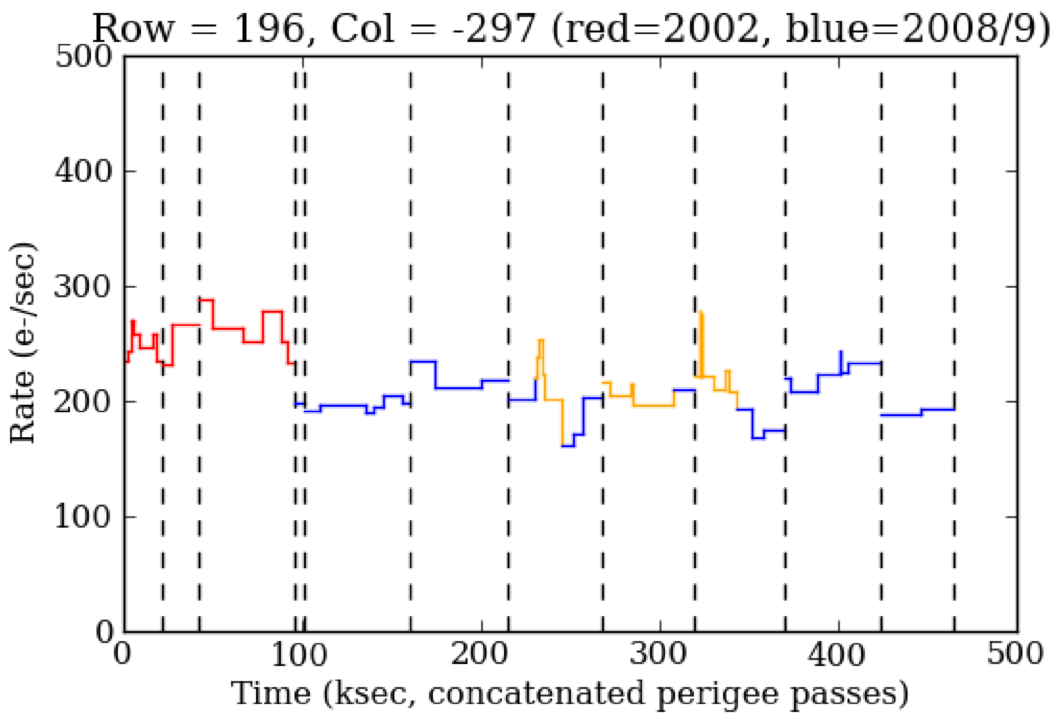

Row = 140, Col = 8 (red=2002, blue=2008/9)
Rate (e-/sec)
Time (ksec, concatenated perigee passes)
0
100
200
300
400
500
0
10
20
30
40
50
60
70

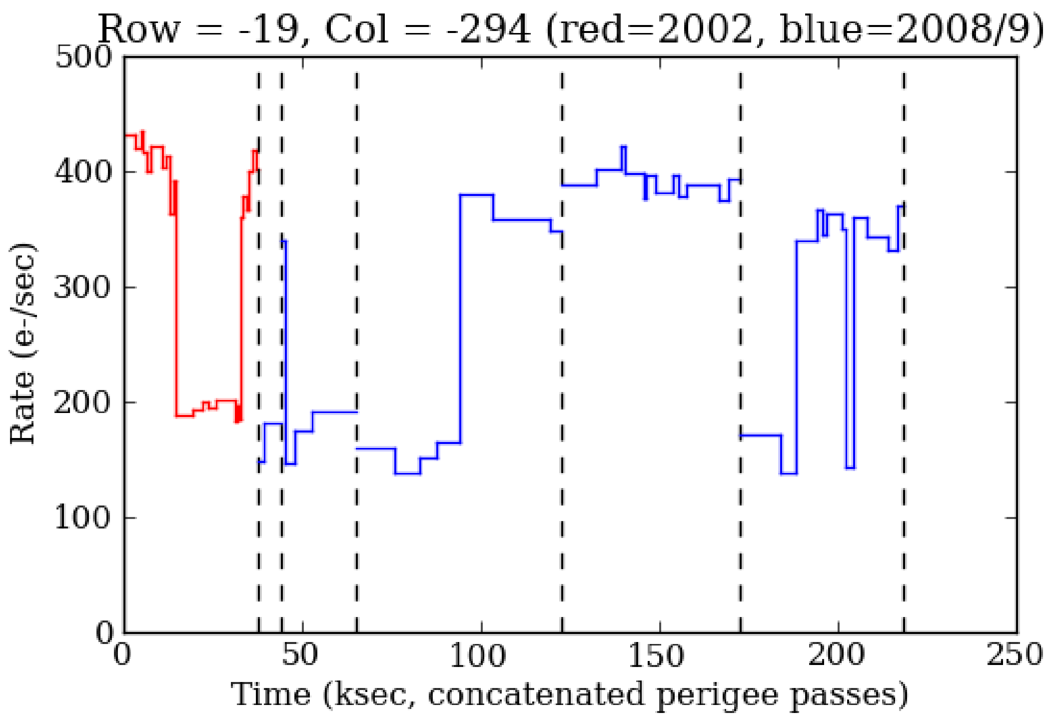

Row = -18, Col = -290 (red=2002, blue=2008/9)
Rate (e-/sec)
0
100
200
300
400
500
0
50
100
150
200
250
300
350
Time (ksec, concatenated perigee passes)

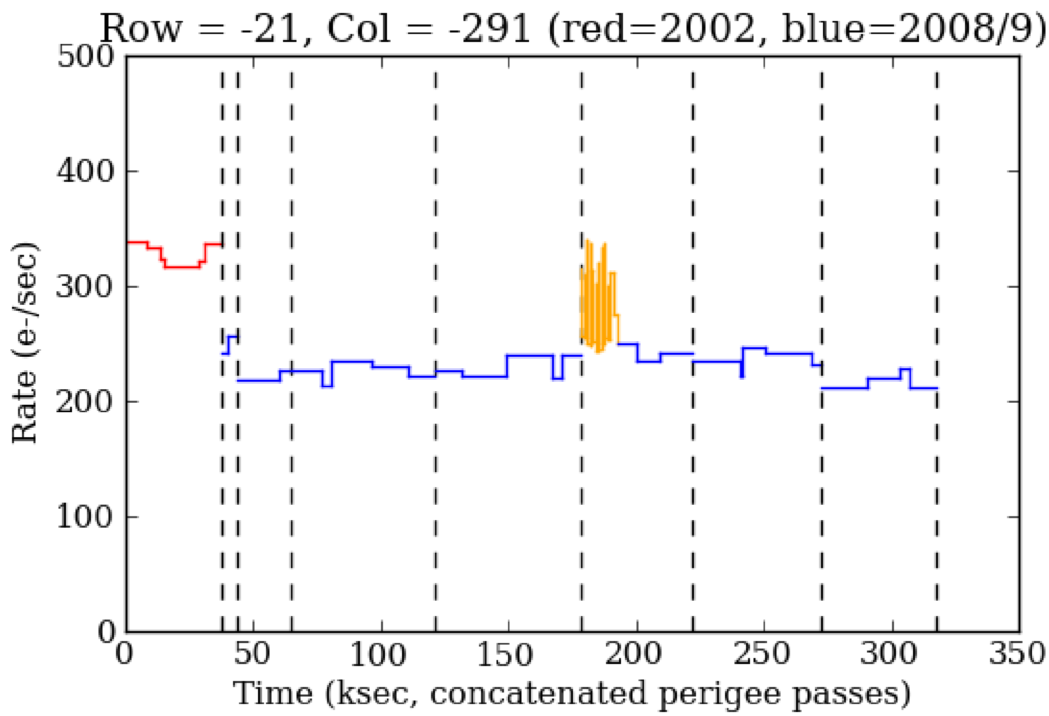

Row = 191, Col = -293 (red=2002, blue=2008/9)
Rate (e-/sec)
0
100
200
300
400
500
0
20
40
60
80
100
120
140
160
Time (ksec, concatenated perigee passes)

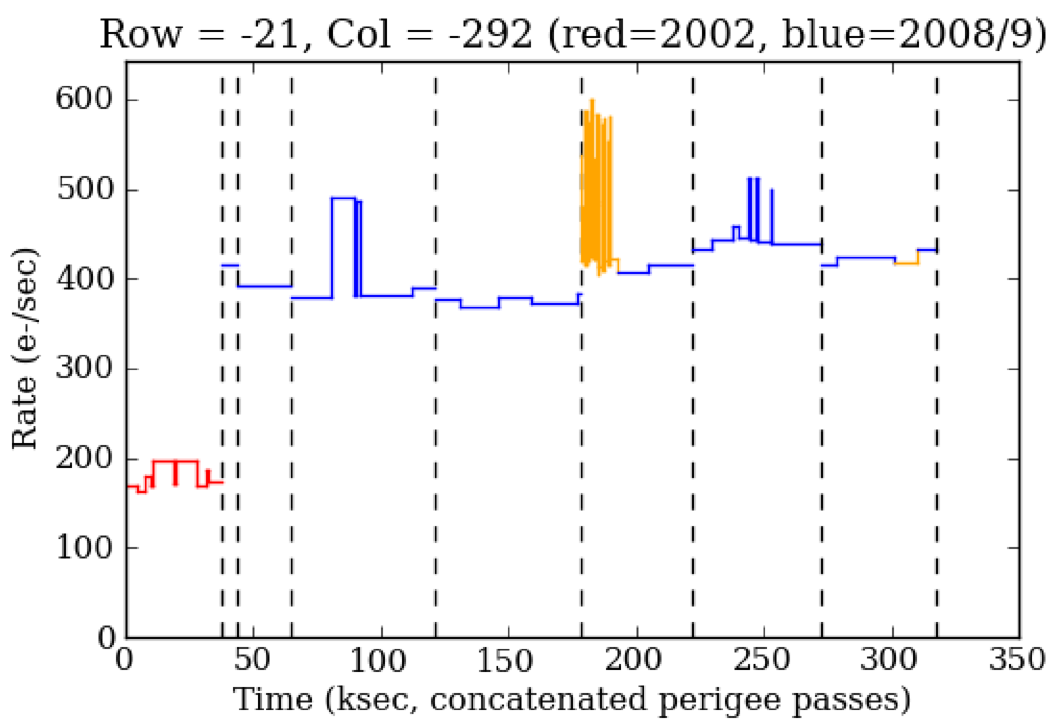

Row = 193, Col = -299 (red=2002, blue=2008/9)
Rate (e-/sec)
Time (ksec, concatenated perigee passes)
0
100
200
300
400
500

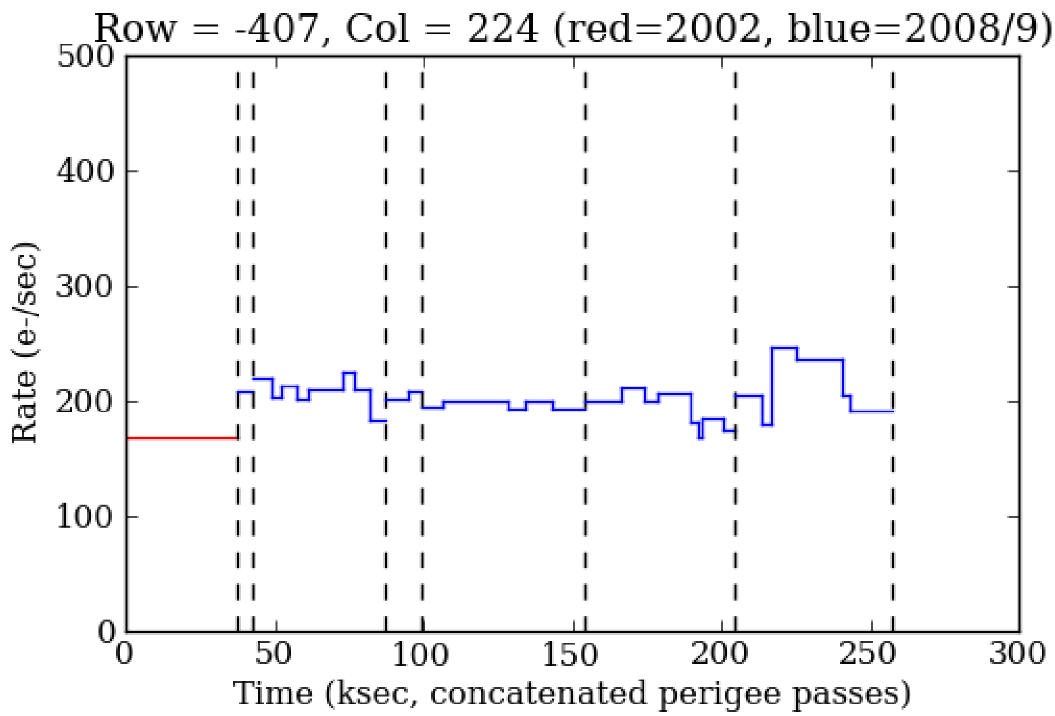

Row = 195, Col = -292 (red=2002, blue=2008/9)
Rate (e-/sec)
Time (ksec, concatenated perigee passes)
0
50
100
150
200
250
300
400
500

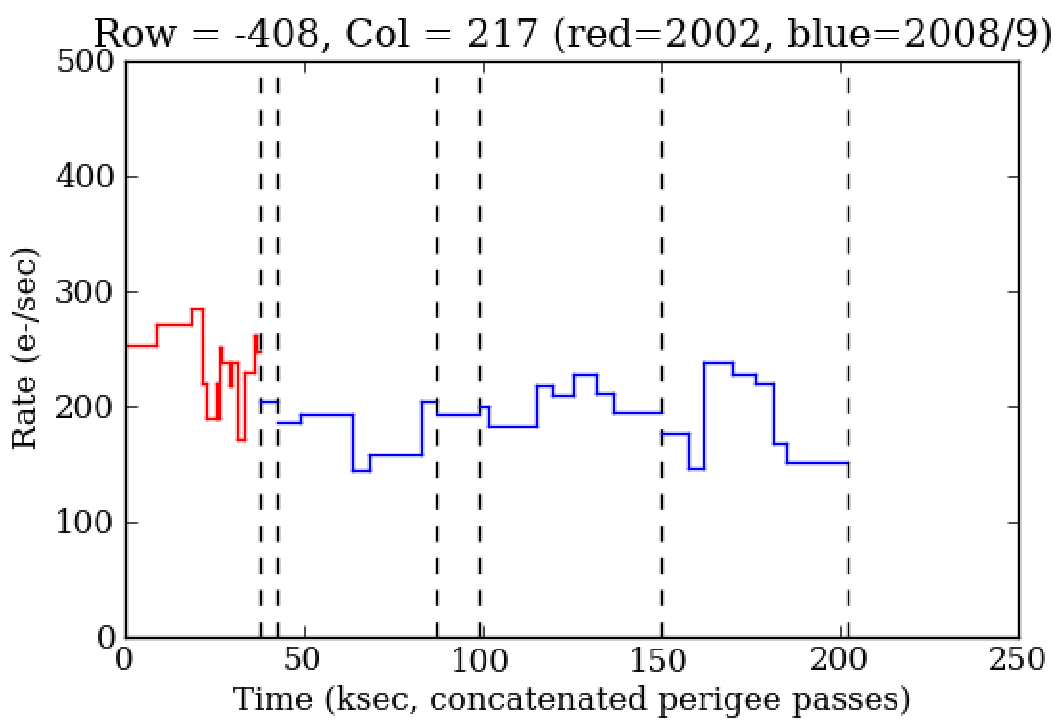

Row = 196, Col = -297 (red=2002, blue=2008/9)
Rate (e-/sec)
Time (ksec, concatenated perigee passes)
0
100
200
300
400
500

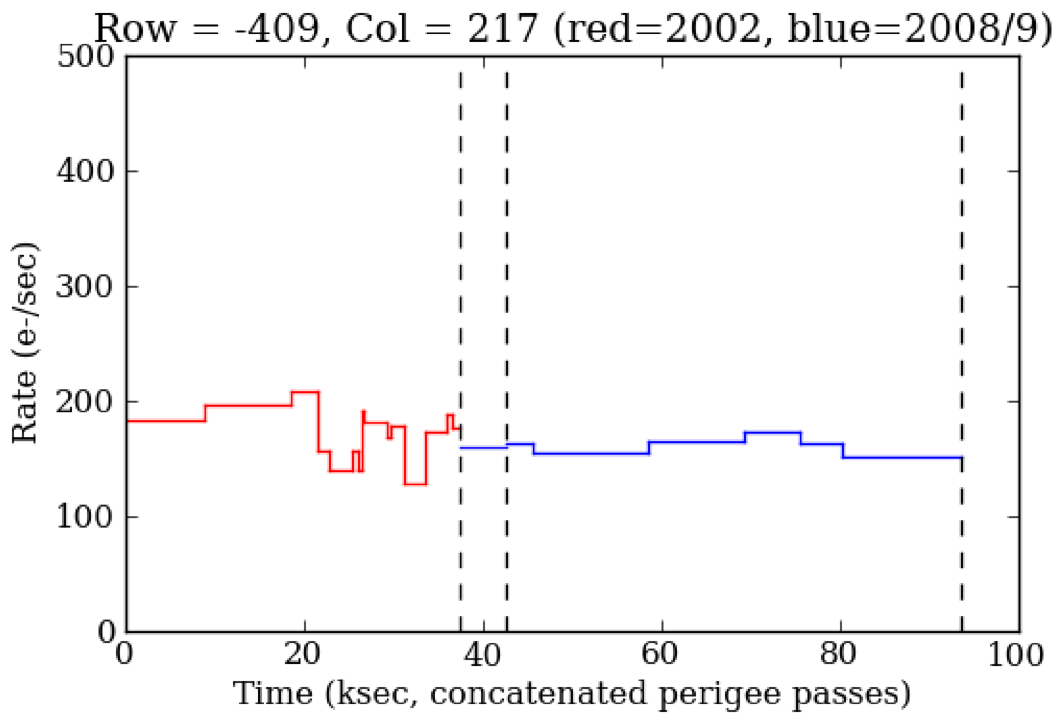

Row = -19, Col = -294 (red=2002, blue=2008/9)
Rate (e-/sec)
Time (ksec, concatenated perigee passes)
0
50
100
150
200
250
300
400
500

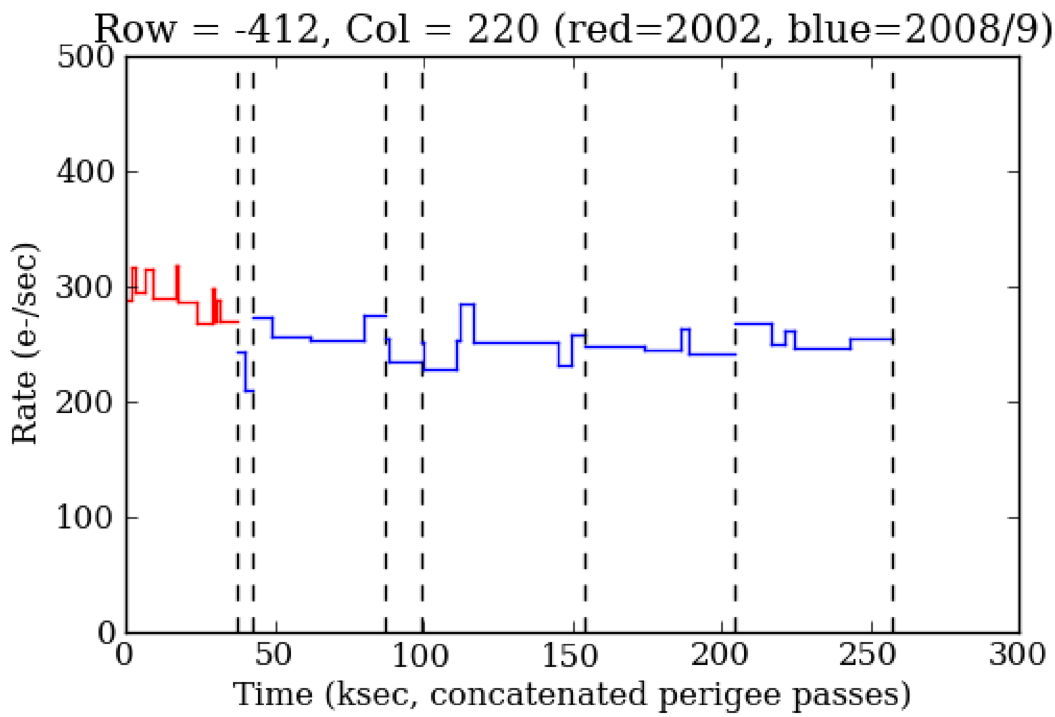

Row = -21, Col = -291 (red=2002, blue=2008/9)
Rate (e-/sec)
0
100
200
300
400
500
0
50
100
150
200
250
300
350
Time (ksec, concatenated perigee passes)

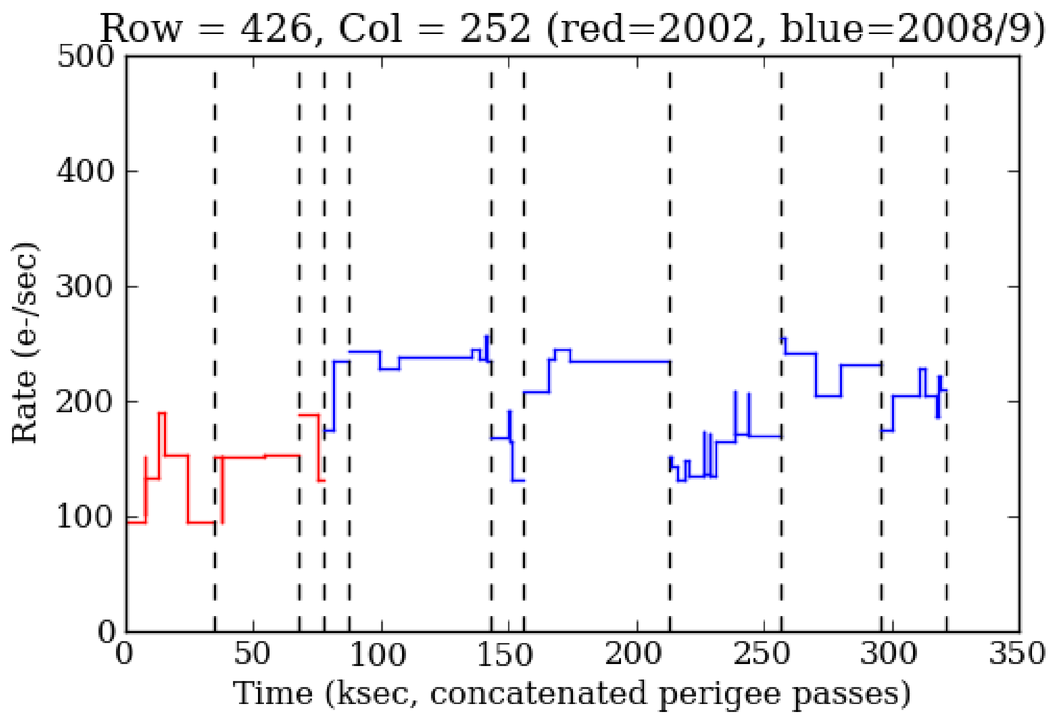

Row = -21, Col = -292 (red=2002, blue=2008/9)
Rate (e-/sec)
0
100
200
300
400
500
600
0
50
100
150
200
250
300
350
Time (ksec, concatenated perigee passes)

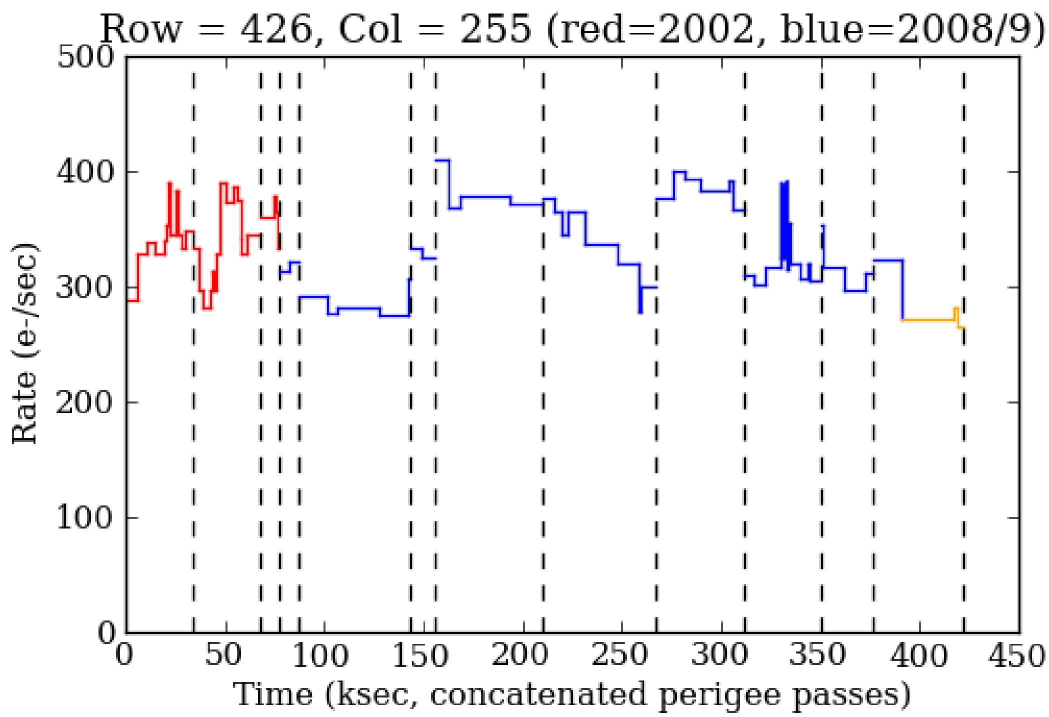

Row = -407, Col = 224 (red=2002, blue=2008/9)
Rate (e-/sec)
Time (ksec, concatenated perigee passes)
0
100
200
300
400
500
0
50
100
150
200
250
300

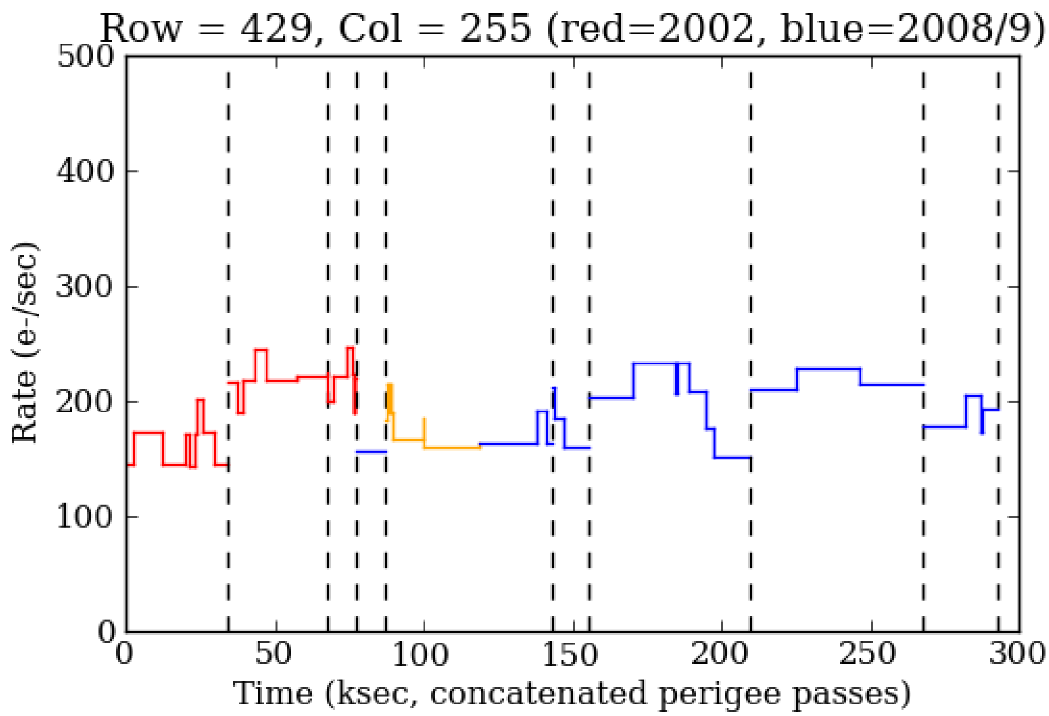

Row = -408, Col = 217 (red=2002, blue=2008/9)
Rate (e-/sec)
Time (ksec, concatenated perigee passes)
0
100
200
300
400
500
0
50
100
150
200
250

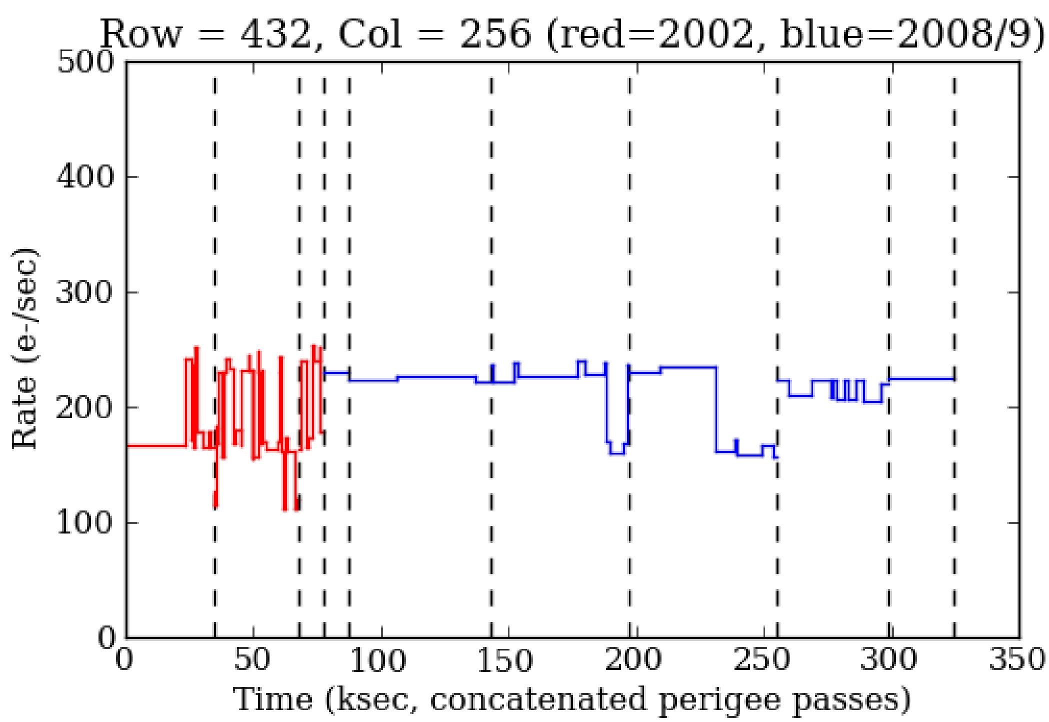

Row = -409, Col = 217 (red=2002, blue=2008/9)
Rate (e-/sec)
0
100
200
300
400
500
0
20
40
60
80
100
Time (ksec, concatenated perigee passes)

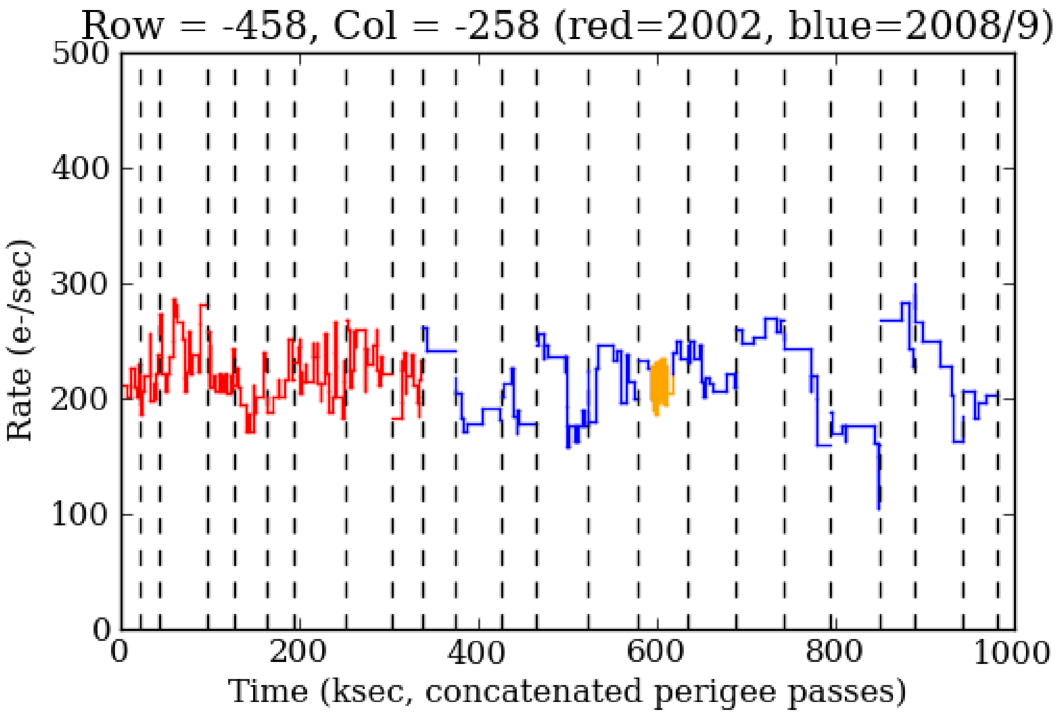

Row = -412, Col = 220 (red=2002, blue=2008/9)
Rate (e-/sec)
0
100
200
300
400
500
0
50
100
150
200
250
300
Time (ksec, concatenated perigee passes)

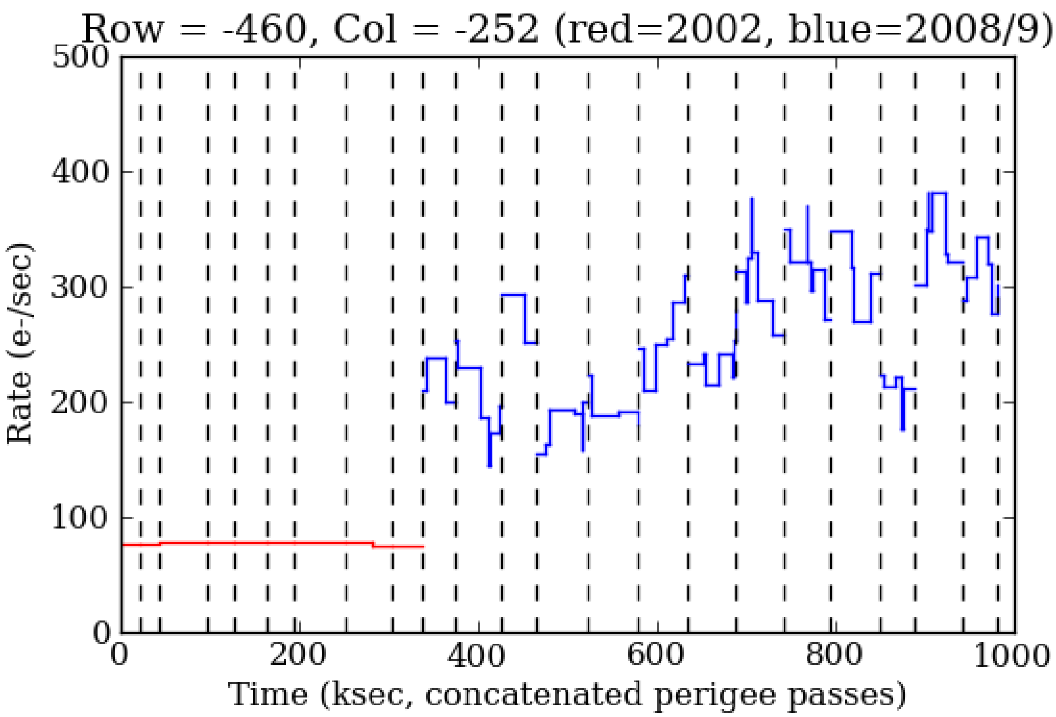

Row = 426, Col = 252 (red=2002, blue=2008/9)
Rate (e-/sec)
Time (ksec, concatenated perigee passes)
0
100
200
300
400
500
0
50
100
150
200
250
300
350

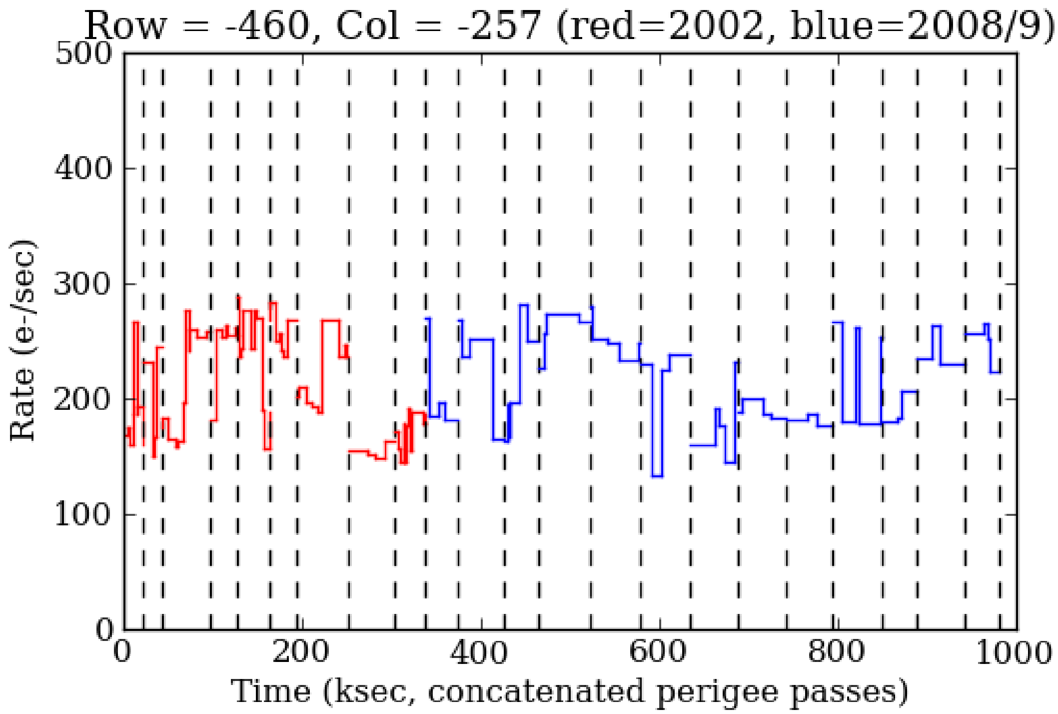

Row = 426, Col = 255 (red=2002, blue=2008/9)
Rate (e-/sec)
Time (ksec, concatenated perigee passes)
0
100
200
300
400
500
0
50
100
150
200
250
300
350
400
450

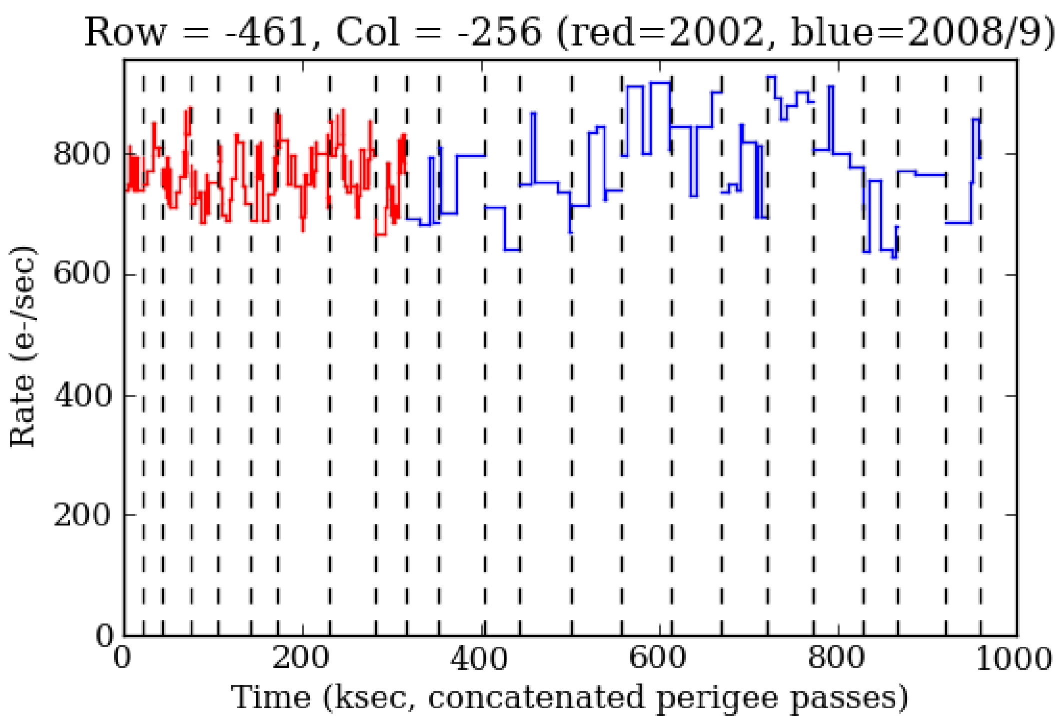

Row = 429, Col = 255 (red=2002, blue=2008/9)
Rate (e-/sec)
Time (ksec, concatenated perigee passes)
0
100
200
300
400
500
0
50
100
150
200
250
300

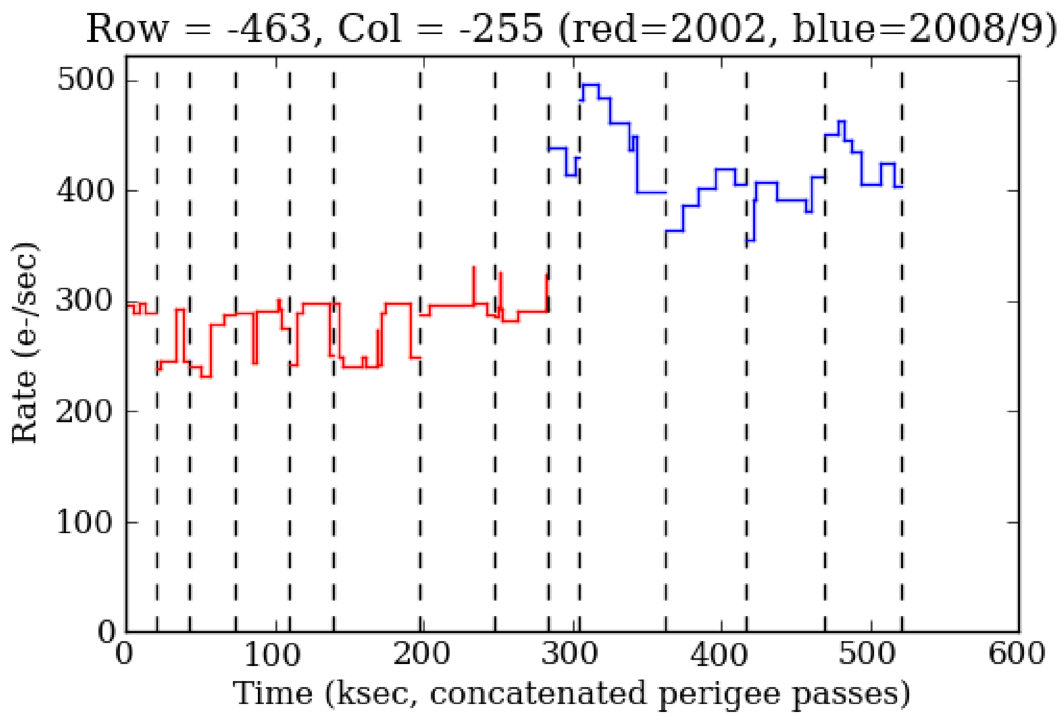

Row = 432, Col = 256 (red=2002, blue=2008/9)
Rate (e-/sec)
Time (ksec, concatenated perigee passes)
0
100
200
300
400
500
0
50
100
150
200
250
300
350

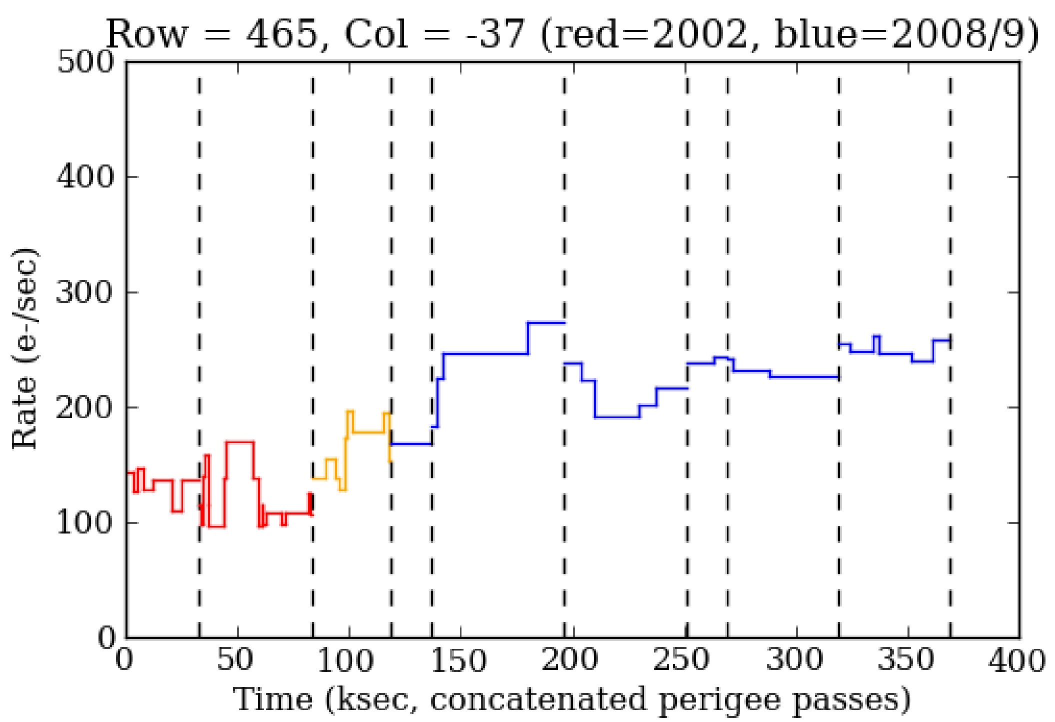

Row = -458, Col = -258 (red=2002, blue=2008/9)
Rate (e-/sec)
Time (ksec, concatenated perigee passes)
0
100
200
300
400
500
0
200
400
600
800
1000

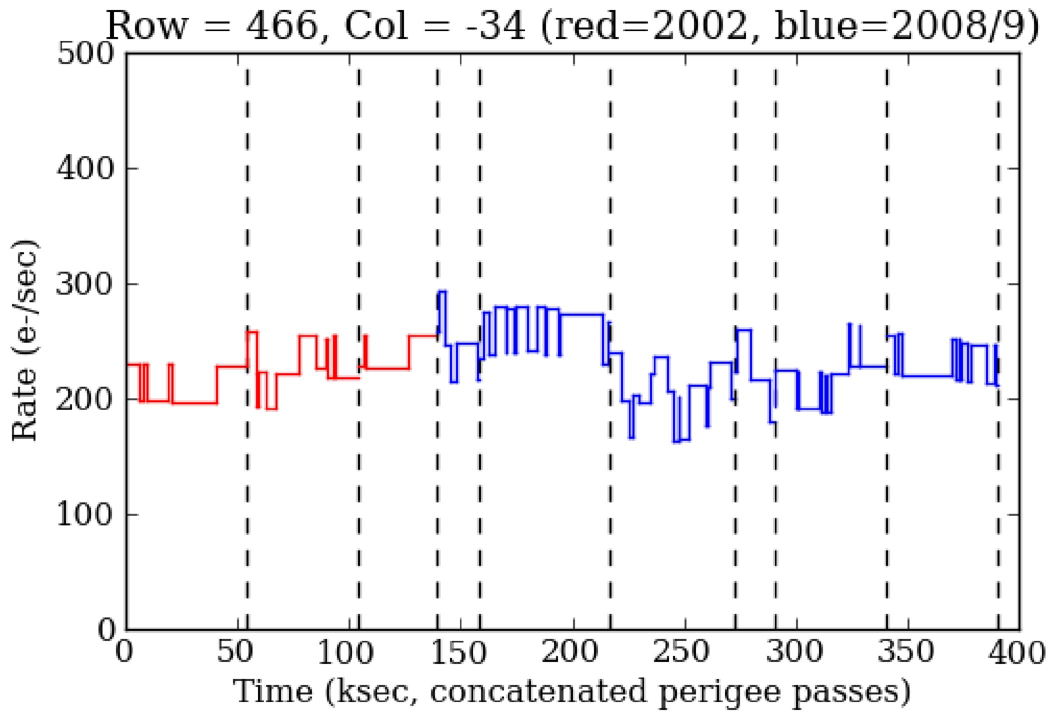

Row = -460, Col = -252 (red=2002, blue=2008/9)
Rate (e-/sec)
Time (ksec, concatenated perigee passes)
0
100
200
300
400
500
0
200
400
600
800
1000


Row = -460, Col = -257 (red=2002, blue=2008/9)
Rate (e-/sec)
Time (ksec, concatenated perigee passes)
0
100
200
300
400
500
0
200
400
600
800
1000

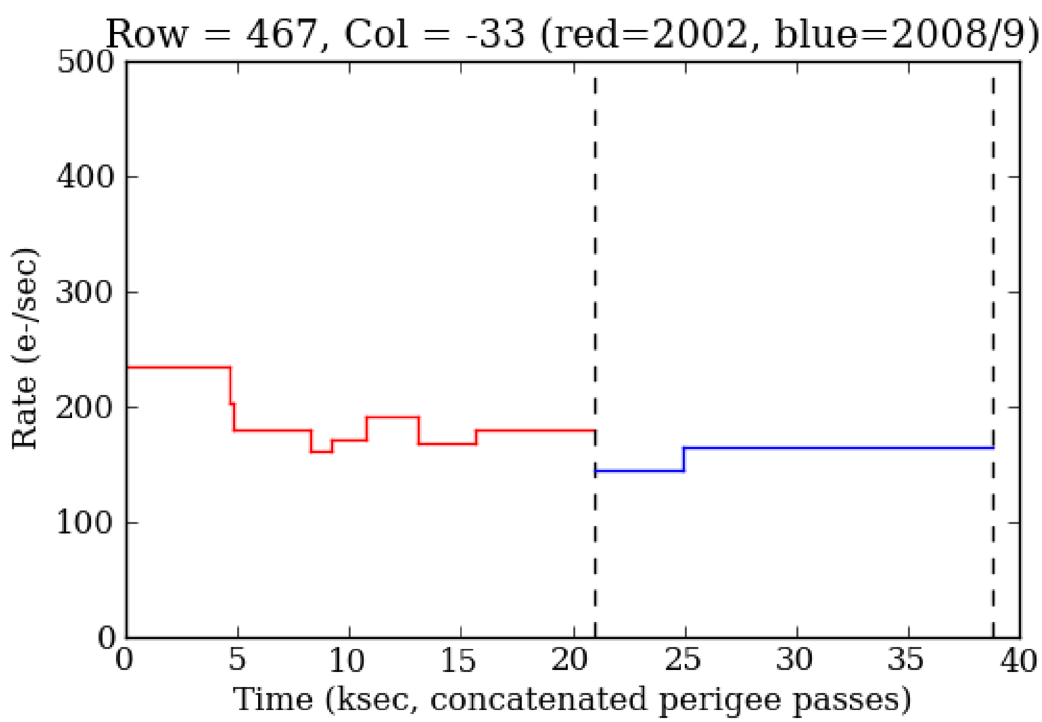

Row = -461, Col = -256 (red=2002, blue=2008/9)
Rate (e-/sec)
Time (ksec, concatenated perigee passes)
0
200
400
600
800
0
200
400
600
800
1000


Row = -463, Col = -255 (red=2002, blue=2008/9)
Rate (e-/sec)
Time (ksec, concatenated perigee passes)
0
100
200
300
400
500
600

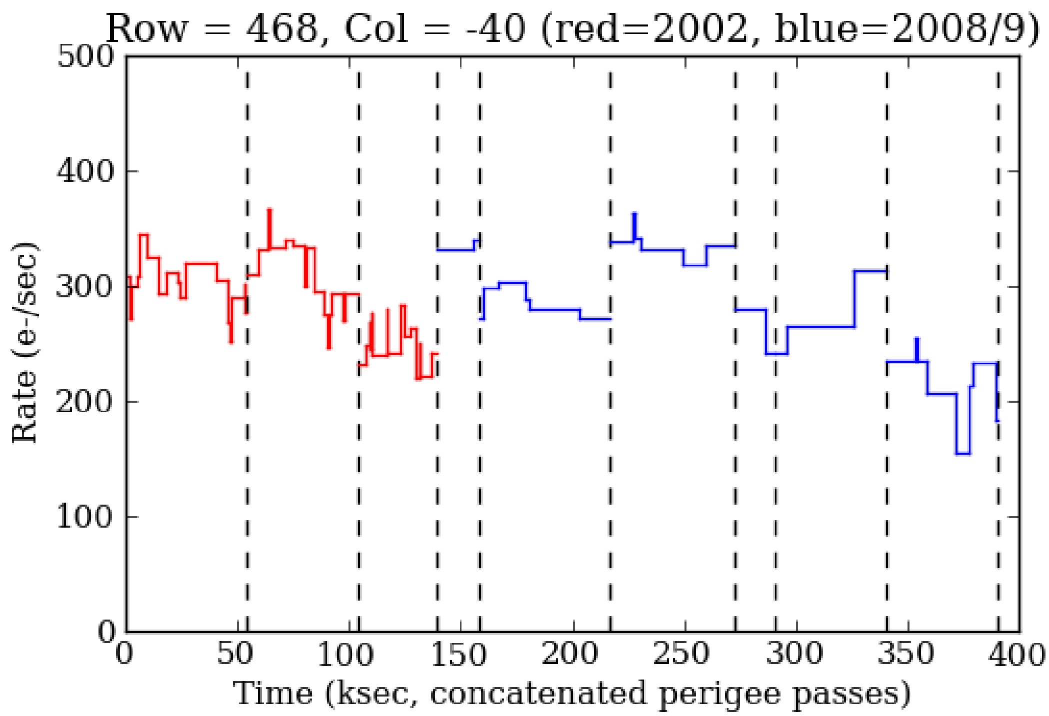

Row = 465, Col = -37 (red=2002, blue=2008/9)
Rate (e-/sec)
Time (ksec, concatenated perigee passes)
0
50
100
150
200
250
300
350
400
500

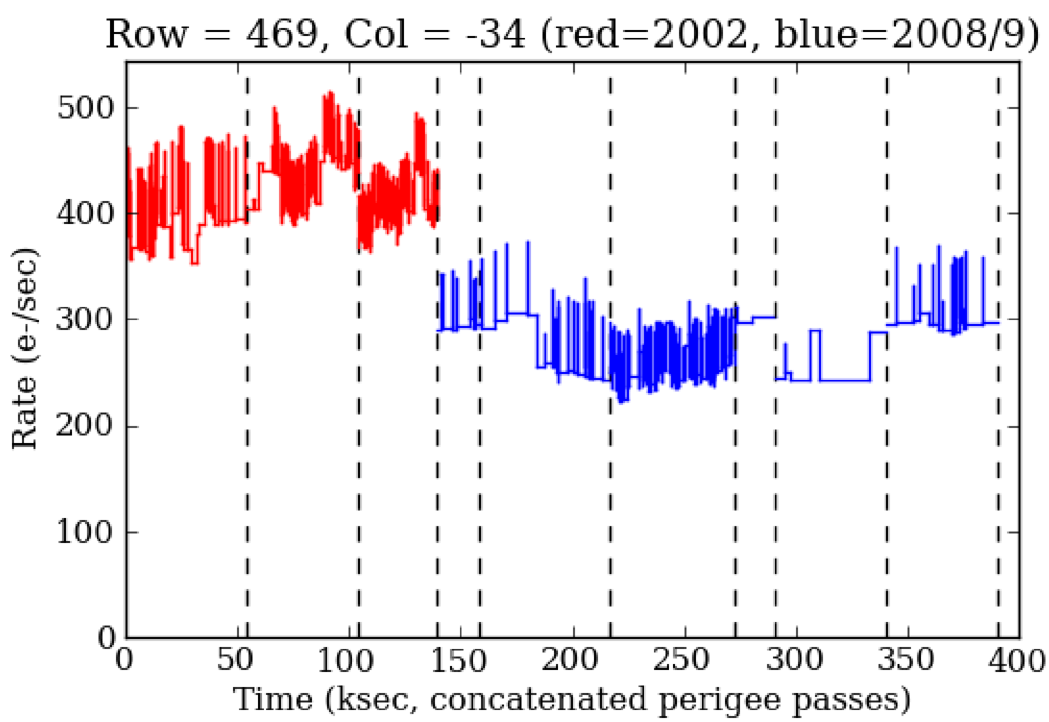


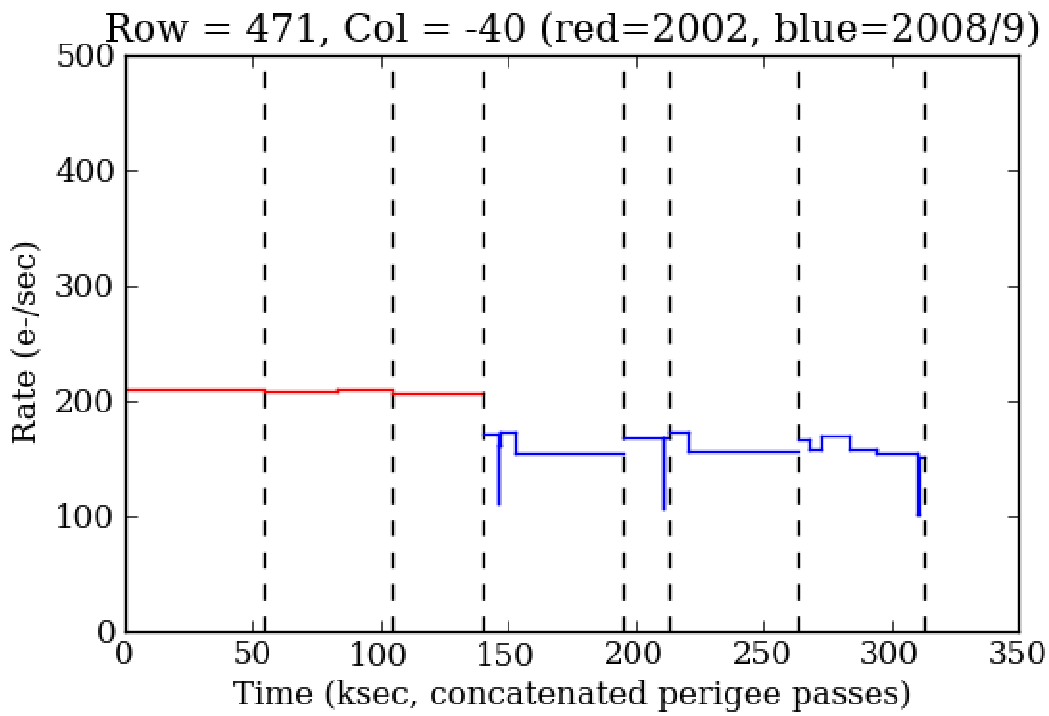
Row = 466, Col = -34 (red=2002, blue=2008/9)
Rate (e-/sec)
0
100
200
300
400
500
0
50
100
150
200
250
300
350
400
Time (ksec, concatenated perigee passes)



Row = 467, Col = -33 (red=2002, blue=2008/9)
Rate (e-/sec)
0
100
200
300
400
500
0
5
10
15
20
25
30
35
40
Time (ksec, concatenated perigee passes)


Row = 468, Col = -40 (red=2002, blue=2008/9)
Rate (e-/sec)
Time (ksec, concatenated perigee passes)
0
100
200
300
400
500
0
50
100
150
200
250
300
350
400

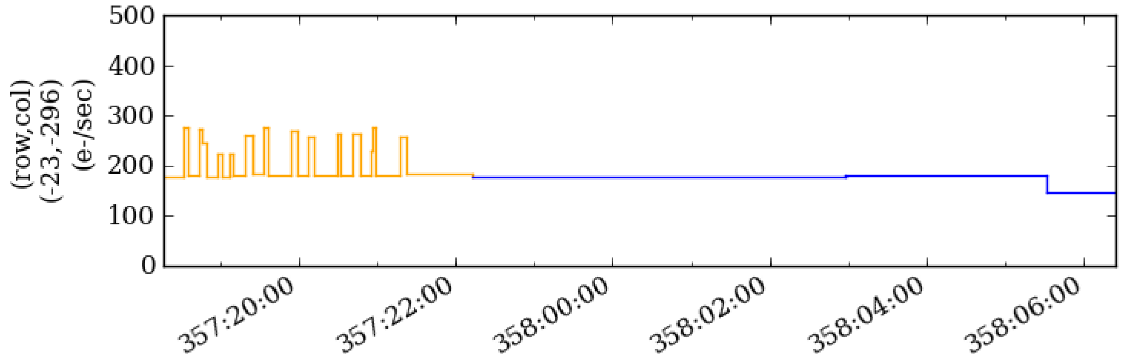

Row = 469, Col = -34 (red=2002, blue=2008/9)
Rate (e-/sec)
Time (ksec, concatenated perigee passes)
0
100
200
300
400
500
0
50
100
150
200
250
300
350
400

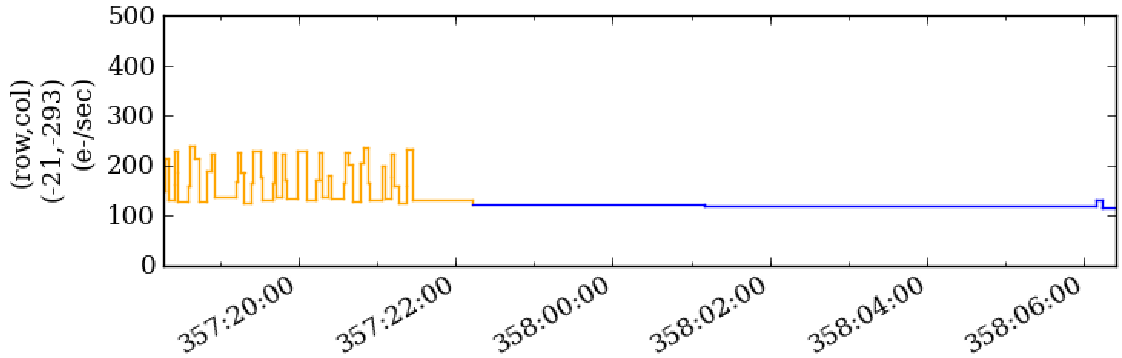


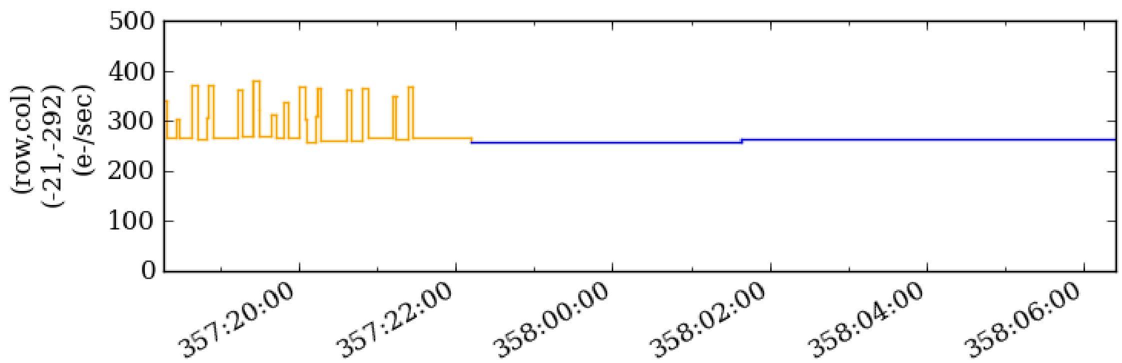
Row = 471, Col = -40 (red=2002, blue=2008/9)
Rate (e-/sec)
Time (ksec, concatenated perigee passes)
0
100
200
300
400
500
0
50
100
150
200
250
300
350

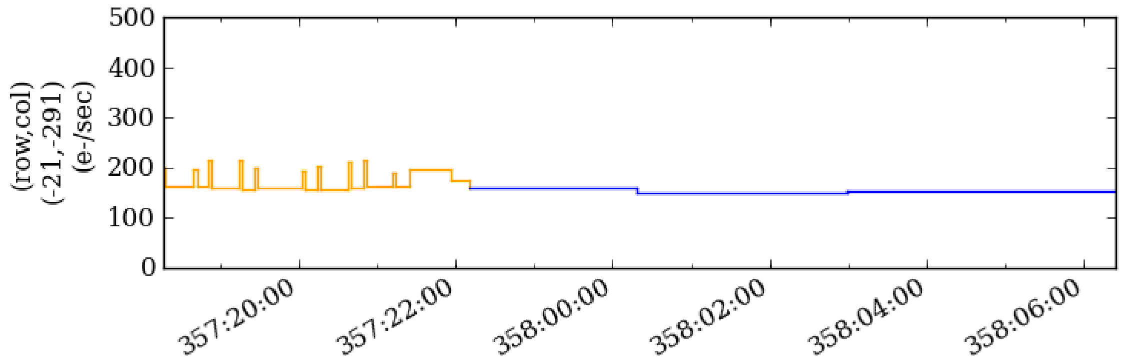
B Appendix: Pass 2008:357

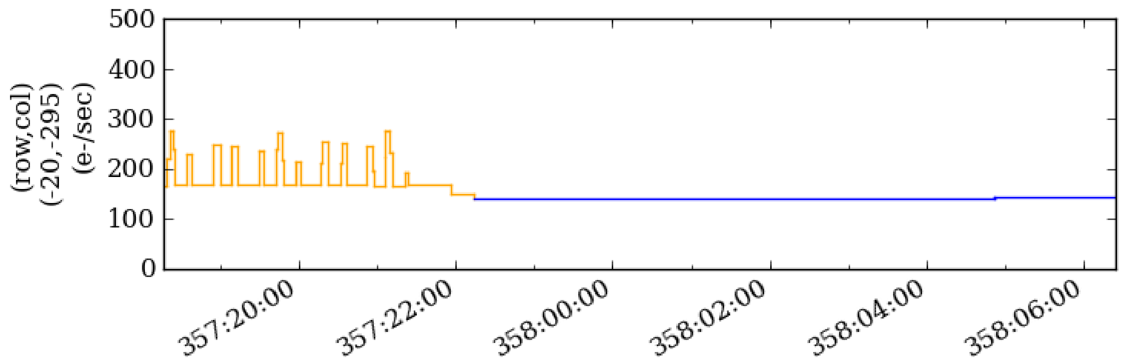
The Bayesian Blocks analyzed data from the perigee pass at 2008:357:16:05:09.574 appears spoiled by a star during the first 4 hours of the pass. These data, and data like them, have been manually marked in the database of intervals as spoiled data and are not included in the aggregate histograms.

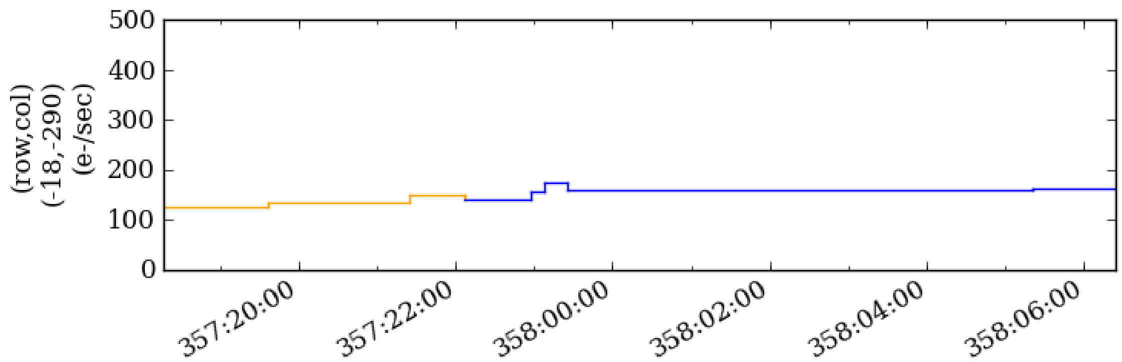


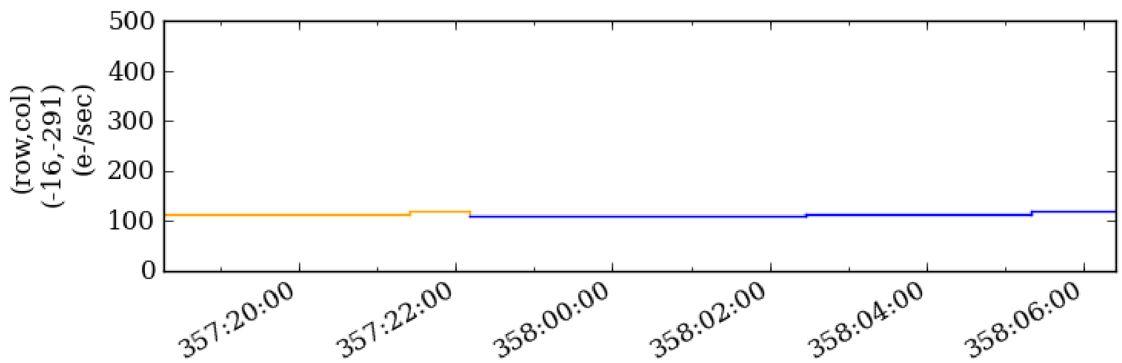





500
400
300
200
100
0
(row,col)
(-21,-291)
(e-/sec)
357:20:00
357:22:00
358:00:00
358:02:00
358:04:00
358:06:00


500
400
300
200
100
0
(row,col)
(-20,-295)
(e-/sec)
357:20:00
357:22:00
358:00:00
358:02:00
358:04:00
358:06:00


500
400
300
200
100
0
(row,col)
(-18,-290)
(e-/sec)
357:20:00
357:22:00
358:00:00
358:02:00
358:04:00
358:06:00


500
400
300
200
100
0
(row,col)
(-16,-291)
(e-/sec)
357:20:00
357:22:00
358:00:00
358:02:00
358:04:00
358:06:00

C Appendix: All Data

- Plots of all of the raw pixel data with the overlaid Bayesian analysis, organized by perigee pass, are available at:
  http://cxc.cfa.harvard.edu/mta/ASPECT/flick_pix_2008/per_pass_raw_plots/index.html
- All of the analyzed intervals, plotted simultaneously per perigee pass are available at:
  http://cxc.cfa.harvard.edu/mta/ASPECT/flick_pix_2008/per_pass_plots/index.html