Chandra Flight Note

FLIGHT NOTE NO.	408
SUBJECT	ACA High Background Anomaly: FDB Closeout
DATE	13 May 2002
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This report, along with some additional plots and data links, is available at `http://cxc.harvard.edu/mta/ASPECT/aca_hi_bgd/`

1 Summary

During a COMM pass on 2001:126 the background level (Figure 1) in ACA images was observed to be anomalously high for a period of about 100 seconds. Near the end of this interval two of the five guide stars were lost for 30-40 seconds as the star flux was overwhelmed by the high background. ACA telemetry for nearly the entire mission has now been examined to search for other similar events and to attempt to determine the cause. During the interval from launch to 2001:256 (which is the date when the first detailed analysis was done), approximately 17 high background events occurred, most of them (13) since 2001:126. The most severe occurred on 2001:185, when five out of eight guide stars were lost for over 60 seconds. From 2001:256 to the present, several high background events occurred, but none as severe as on 2001:185. As yet there is no clear explanation for these anomalies. This report presents the following:

- Method for extracting high background events
- Characterization of high background events
- Catalog of anomalous high background events
- Fault tree (courtesy RAC)
- Discussion and comments

2 Method for extracting high background events

The list of high background events for the mission was generated in the following way:

- Download all ACA Level-0 telemetry (i.e. ACA image telemetry) within the time period 1999-09-27 to 2001-07-31, one day at a time

- Extract relevant items within the ACA L0 telemetry such as average background, slot, and image status bits. These were highly compressed by storing only transitions, such as when a status bit flips or the background changes by more than 10 DN. Without this compression the data volume would be too great.

- A high background event is then defined by the following criteria:
  - An initial threshold crossing where the background in one slot is greater than 200 DN for one readout
  - Within the time interval (-100 : +300) seconds relative to the threshold crossing, calculate the total "slot-seconds" in which background > 100 DN, summing over *all* slots tracking stars or fids.
  - If this summed high background duration is greater than 20 seconds, flag a high background event and produce a plot.

All such high background events for 1999, 2000, and 2001 are available in postscript form from the Web report. In some cases (such as the Venus observation) numerous plots are associated with one particular observation.

3 Characterization of high background events

The majority of high background events defined this way fall into three categories (see below for an explanation of the plots):

- Displaced star (Figure 2), due to ionizing radiation, in which the star is in the "Lost, attempting to re-acquire" state for up to 120 seconds. During this time the star is offset by several pixels from the readout window center, thus causing the high background value. It is not immediately clear why the ACA fails to reacquire the star, nor why the OBC does not issue a new search command for the star. Hopefully Ball and TRW/FOT can shed light on these questions.

- Bombardment by ionizing radiation (Figure 3) during perigee causing displaced star and numerous short loss-of-track events

- Anomalous high background (Figure 1) in which the star remains in solid lock at the window center, but the background appears to rapidly flicker up and down. The event shown here is the prototype high background event.

In addition, two special cases were picked up in this processing:

- Accidental Earth transit (Figure 4)

- Venus observation (Figure 5): this is a snippet of a long period in which slot 4 had high background and was being lost from time to time

4 Catalog of anomalous high background events

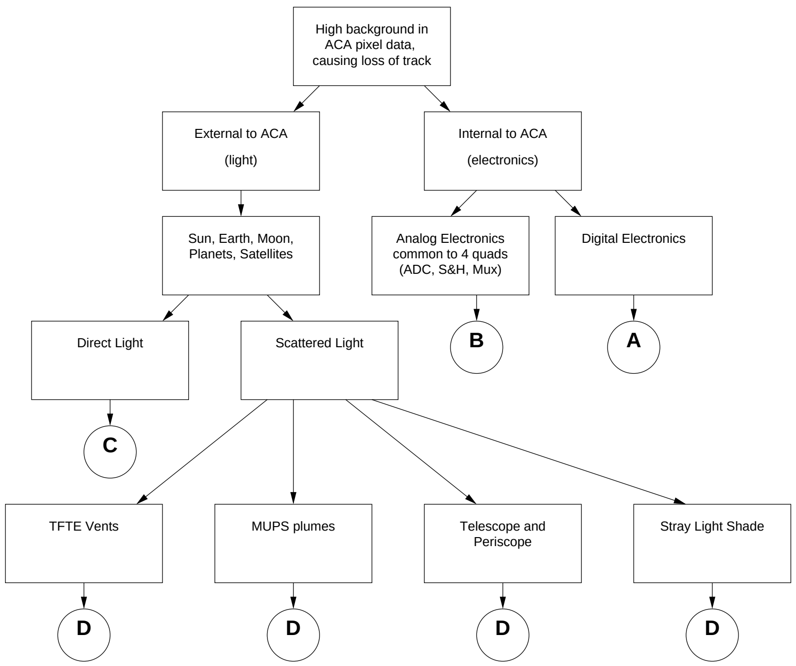
Postscript plots showing the background rate and various status bits for periods of anomalous high background are available for 1999, 2000, and 2001 (through day 256). In each plot, the horizontal axis shows time in seconds, and vertical shows the background in DNs as reported by the ACA in image telemetry. When the background trace is black, the star/fid is being tracked. When it is red, the star/fid is in the "Lost, attempting to re-acquire" or "Idle" state. In addition, a color "strip chart" at the top of each plot indicates when ACA status bits are set. The bits which are plotted are High Background (red), Ionizing Radiation (black), Defective Pixel (green), Saturated Pixel (blue), and Multiple Stars (Magenta).

The table below shows details for each high background event. The final column shows the number of stars in which tracking was lost.

Date	Obsid	High time	RA	Dec	Roll	# LOT
1999:310:02:31:14	400	32.8000	185.7445	15.8163	49.12	0
2000:052:19:30:49	344	22.5500	40.6514	-0.0028	281.64	0
2000:188:18:15:39	Perig	22.5500	334.1500	56.5500	136.47	0
2000:331:05:45:58	Perig	55.3500	208.5200	69.3800	31.25	0
2001:126:13:08:46	Perig	660.098	280.0000	25.0000	121.19	1
2001:126:22:17:36	Perig	344.400	232.0000	18.0000	166.64	3
2001:170:02:42:56	977	38.9500	271.1116	-24.3781	80.36	0
2001:170:04:49:06	"	32.8000	"	"	"	0
2001:170:06:05:36	2264	32.8000	311.8162	-36.4910	83.43	0
2001:176:19:12:16	Perig	65.6000	350.0000	30.0000	117.35	2
2001:182:10:27:16	Perig	399.750	295.0000	-30.0000	65.32	3
2001:182:10:32:26	"	153.750	"	"	"	3
2001:182:11:16:56	"	47.1500	"	"	"	2
2001:185:02:23:06	Perig	299.300	324.0000	-46.0000	68.94	5
2001:200:22:57:16	Perig	24.6000	289.0000	-37.0000	328.23	0
2001:200:23:40:56	"	22.5500	"	"	"	0
2001:202:22:01:46	2144	305.450	265.9912	27.9049	219.19	0

5 Fault tree

Rob Cameron has created the following fault tree:



Diagnostic tests for the ACA high background fault tree:

- **A: Digital Electronics**: not a likely cause, since the digital electronics processing of ACA data is common to all images, and the high background only affects some images.
- **B: Saturation effects:**While saturation effects can occur in the analog electronics common to all 4 CCD quadrants, Ball Aerospace has stated that these effects only persist for short amounts of time, i.e. the sampling and digitization of 1 or 2 unsaturated pixels may be affected by the immediately previous sampling and digitization of saturated pixels. Since high background events can affect multiple images over several readouts, analog electronics saturation is unlikely to be the cause.
- **C: Direct Light**: test for Sun, Earth, Moon, Planets in the ACA field of view at the time of high background. Of the planets, only Venus and perhaps Jupiter would be capable of affecting the background measurement in several image slots across different quadrants. Some satellites might be bright enough to saturate the ACA, but would presumably have small angular offsets from the Earth.
- **D: Scattered light**: correlate episodes of high background against (theta,phi) coordinates relative to the ACA line of sight, to try to identify scattering paths. Also correlate episodes of high background against angular sizes (i.e. distances to) Earth and Moon. Also correlate

episodes of high background against times of firing of MUPS thrusters, in case light can be scattered into ACA by MUPS exhaust plumes.

6 Discussion and comments

- To date, none of the high background events have resulted in an anomalous transition out of NPM because of lost guide stars. Nevertheless, several instances have come uncomfortably close. To prevent this from happening, a consistent effort is being made to schedule as many guide stars as possible during perigee.

- Most of the high background events (and all of the severe ones) occurred during perigee. This might be due to increased ionizing radiation, or perhaps scattered light from the relatively large Earth. Dan Shropshire has carried out the correlation analysis suggested in path D of the fault tree to look at Earth / Sun / Moon angles during high background events. No apparent correlation is found. The plots are shown in Figures 6-8. The data can be found on the Web page.

- One possible diagnostic measure would be to track all guide stars using 8x8 readout windows during perigee passage. This would have no impact on spacecraft control nor CXC processing, but would provide important diagnostic ACA telemetry. To date this has not been implemented.

- The similar signature of the Venus observation background to several of the anomalous high background events could be an important clue.

- A monitoring system to catch high background events has been put in place. The rate of such events has not increased since the initial investigation. Figure 9 shows a plot of the event intensity versus time for all high-background events through May-2002. Clearly there was a peak for several months near the middle of 2001, while during the rest of the mission there have been only low-intensity events about once each few months.

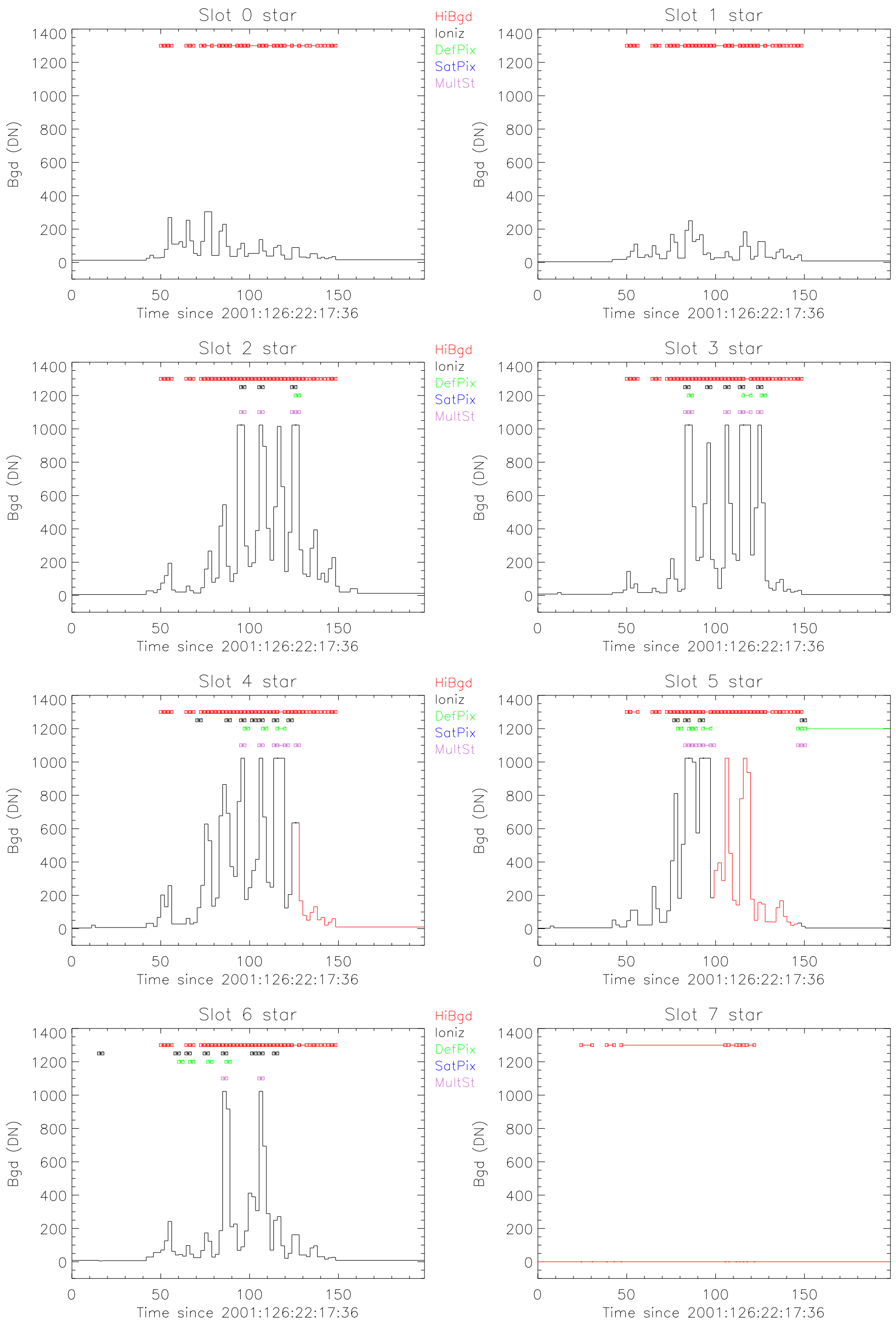


Figure 1: Example of an anomalous high background event with no clear explanation

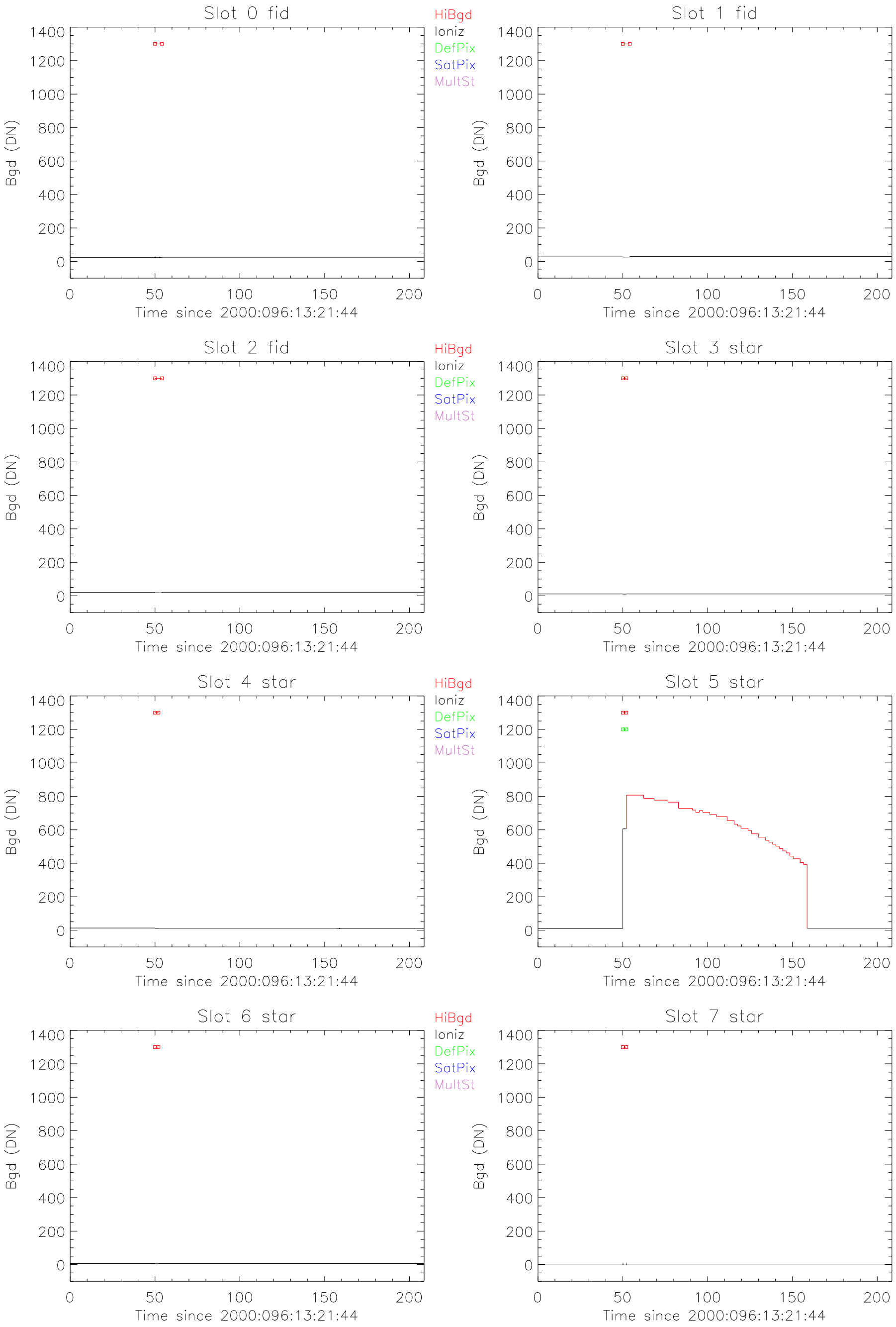


Figure 2: Example of high background event when star is lost for a period of time

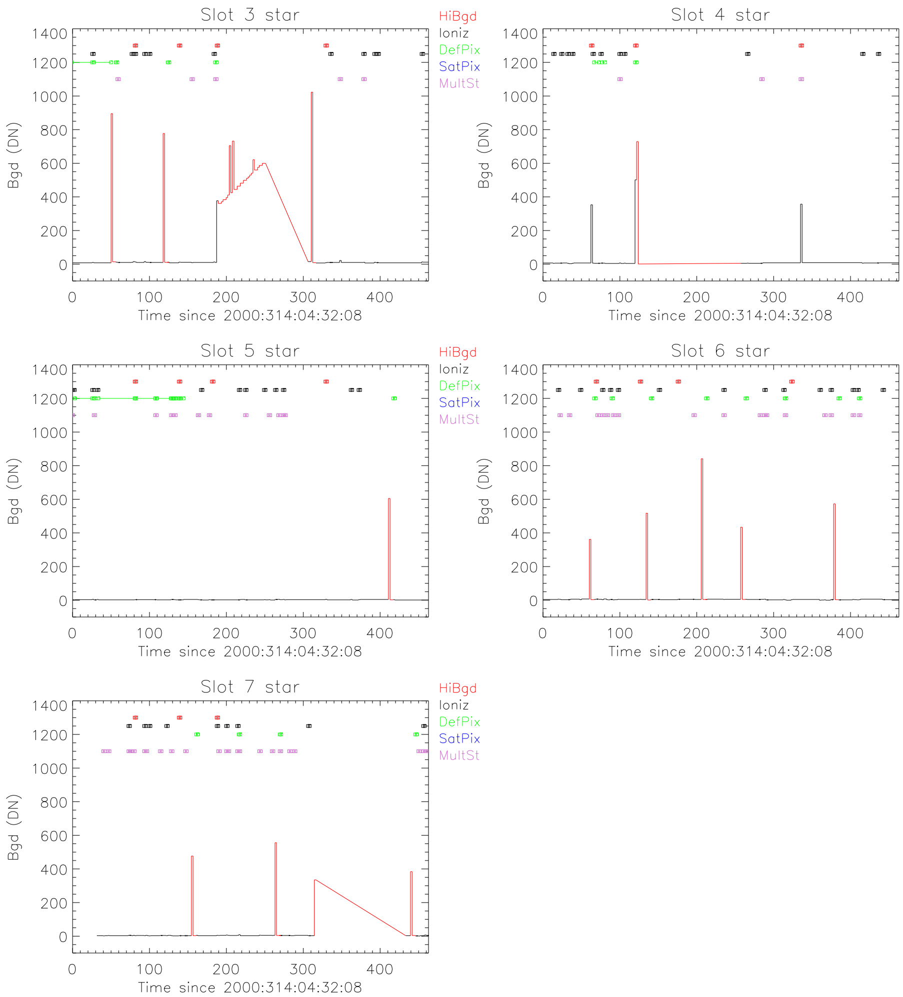


Figure 3: Example of high background event when many ionizing radiation particles are striking CCD

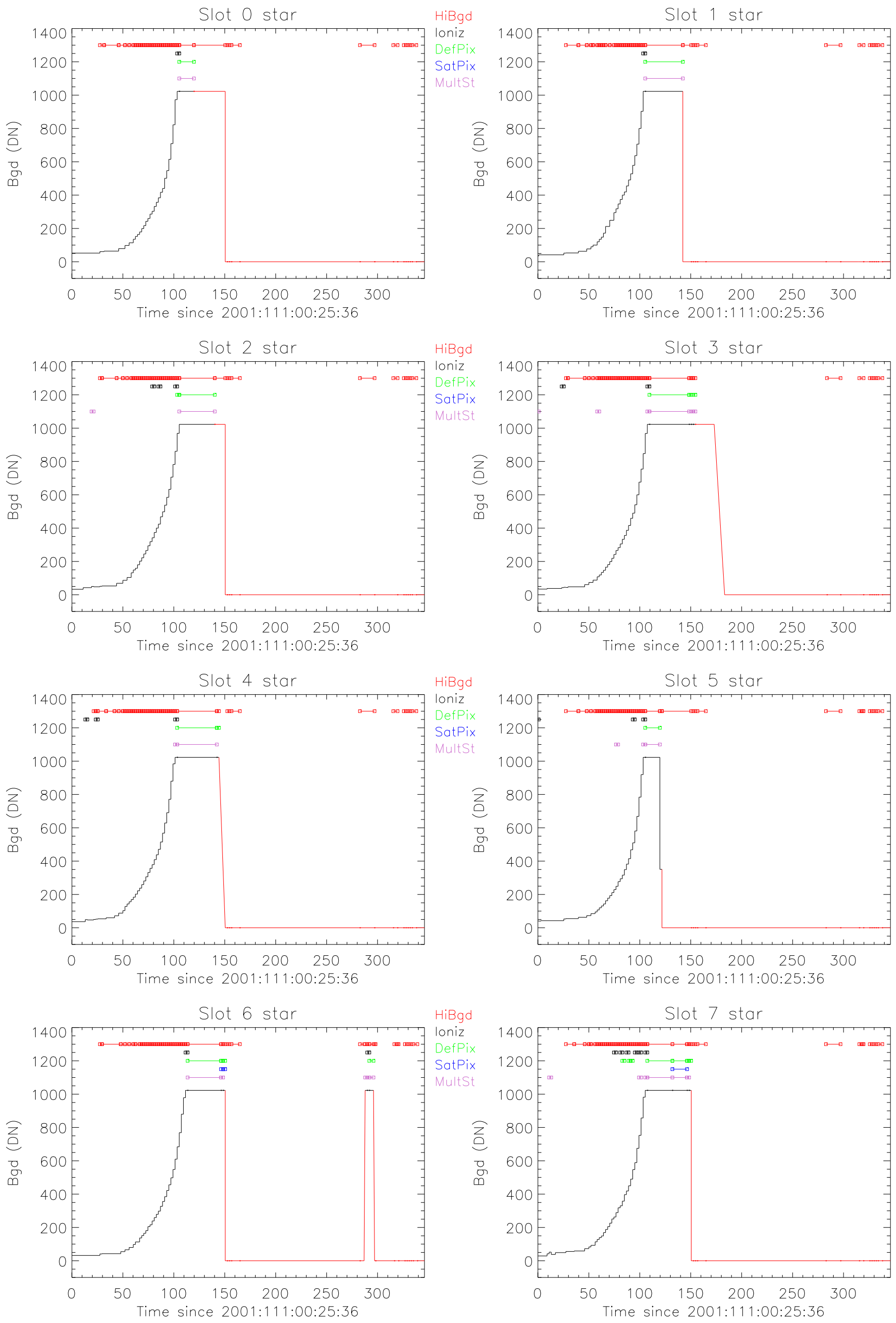


Figure 4: Example of high background event when commanding error allowed Earth to transit ACA FOV

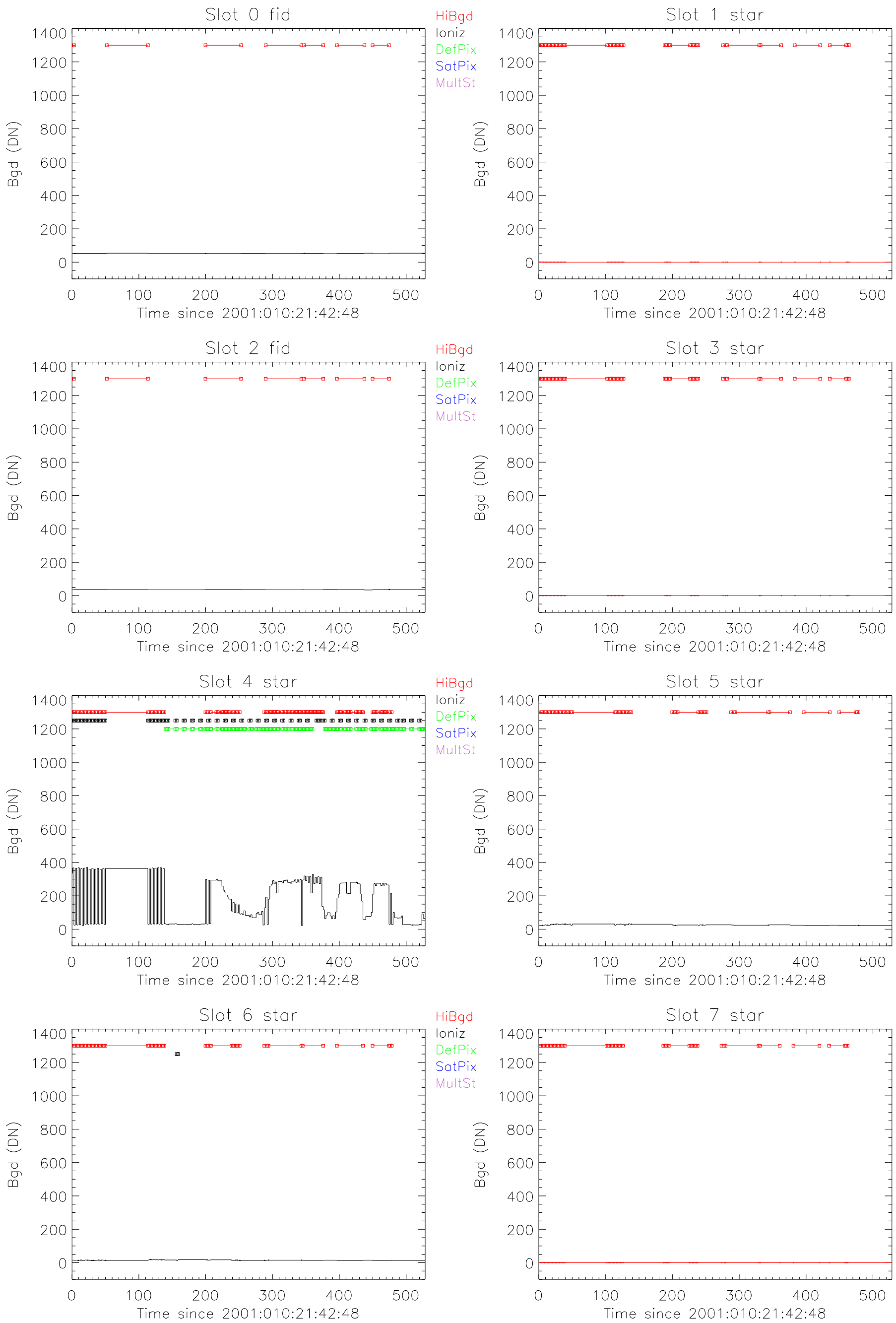


Figure 5: Example of high background event when Venus was causing bias problems in the ACA electronics

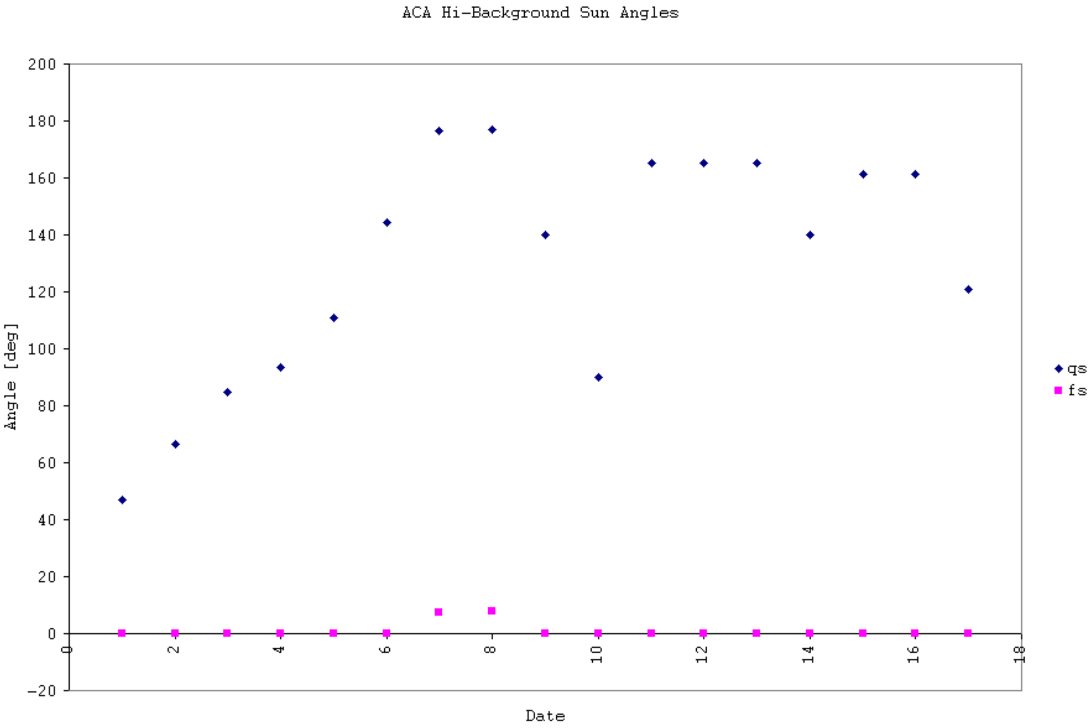


Figure 6: Plot of Sun angle for high background events

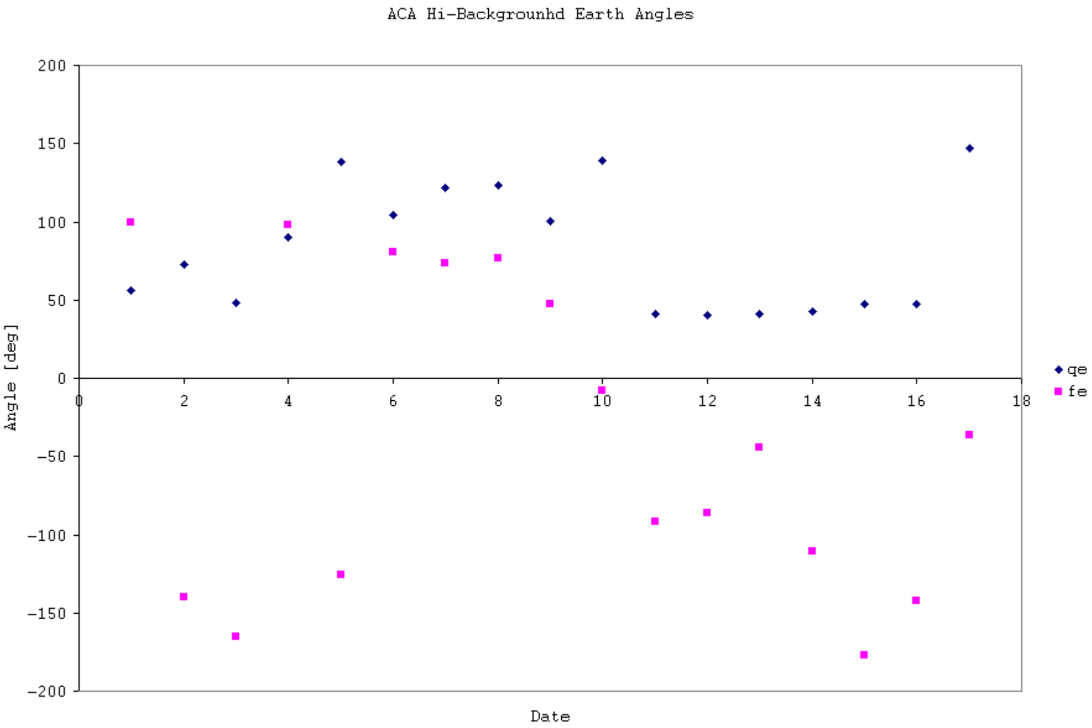


Figure 7: Plot of Earth angle for high background events

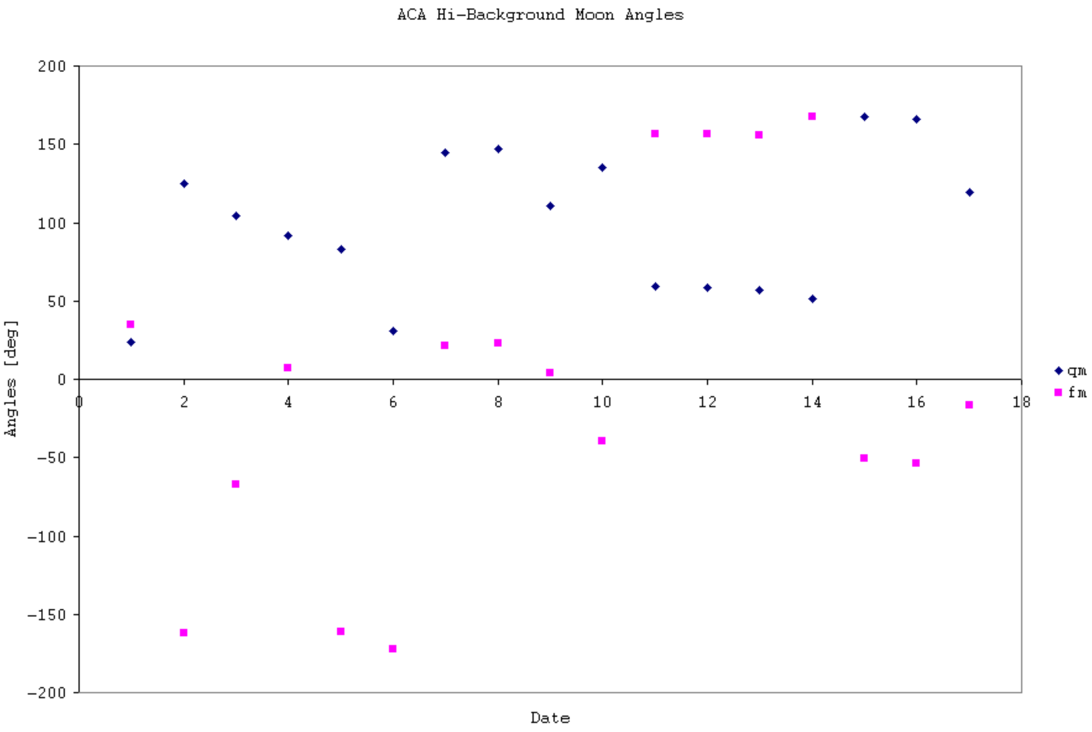


Figure 8: Plot of Moon angle for high background events

Figure 9: Intensity of high-background events versus time