Effects of HRC event filtering

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Status bits and Standard filtering

Each event in Chandra High Resolution Camera event lists has 32 bits of digitized status information associated with it. These flags provide a wide array of information on the quality of each event. In standard processing between Level 1 and Level 2 data, a predetermined set of these bits are checked and flagged events removed from the event list. In HRC-I data, standard processing filters on eighteen of these bits, fifteen for the HRC-S (See Table 1). This screening allows non-X-ray events to be identified, reducing detector background, as well as detecting and filtering out misplaced or "bad" events that might otherwise degrade image quality. If a user chooses, hand processing using hrc_process_events allows for filtering on any combination of status bits.

Saturation and H-tests

Most rejected events are removed by bits 29-32, which corresponds to failure of either the Saturation Test or the H Test. The Saturation Test fails events whose tap values lie outside specified boundaries (two of the amplifiers in an axis do not lie between 20 and 4000 for amp_sf's 0 through 2 and between 20 and 3550 for amp_sf = 3). In Figure 1, events lying within the red box pass the Saturation test, those outside the box fail. The H Test fails events which lie outside of a hyperbolic region in a plot of Center Tap Fraction vs. Fine Position (see Figure 2). These are events that are likely to have poorly determined positions.

Effects of filtering

The effect of filtering on an image can be seen in Figures 3 and 4 and the adjacent tables of status bits for each file.

Figure 3 is an HRC-I calibration observation (obsid 1385) of AR Lacertae. The three frames (all with the same logarithmic color spread) are approximately one arcminute across, showing the unfiltered data, the same data after filtering, and the events removed by the filtering. While the spurious "jet," consisting of misplaced events, is removed, so are several bona fide source events (which likely lie very close to the rejection thresholds of either the Saturation or H tests).

Figure 4 is an HRC-I calibration observation (obsid 2878) of Cassiopeia A. The three frames (all with the same square-root color spread) are approximately ten arcminutes across. As with AR Lac, events due to source x-rays have been rejected along with charged particle and other bad events.

Filtering on flat fields

Prior to the launch of Chandra, laboratory flat field data were collected for the HRC at eight energies, from 0.18 to 6.4 keV. Filtering of events from these data shows pronounced position- and energy-dependent loss of events, mostly from the filtering of events flagged by the H-test and Saturation test. Figure 5 demonstrates these effects. Comparing the data with and without rejection for Saturation and H-test failure shows how these two flags are responsible for most of the non-uniform rejection of x-ray events, which becomes pronounced at high energies.

Filtering on flight data

However, the detector settings have been changed since Chandra's launch: the High Voltage settings were changed on the HRC-I in October 1999. In order to understand the effects of filtering on flight data, we made use of calibration observations of AR Lac "mini-maps" in which the star is imaged at 21 positions across the HRC-I detector. Events from the 21 source regions as well as background regions (annuli centered on the source positions) were studied.

Figure 6 plots AR Lac source data before and after HV change, alongside selected laboratory flat field data from the same regions of the detector as the AR Lac mini-map. The change in HRC-I High Voltage settings in October 1999 results in far fewer events being rejected by the standard filters than at the laboratory settings. Before 4 October 1999, 10-20% of source events were removed by filtering, and a more modest 2-10% afterward.

Figure 7 plots the filtered background counts for the AR Lac observations before and after HV change, normalized by the unfiltered counts. This demonstrates that background events prior to the HV change were reduced 60-80% by standard filtering. Presently, about half of background events are eliminated by the standard filter, mostly due to the Saturation and H-tests.

HRC-S

HRC-S voltages are set so as to make saturated events far less likely than with the HRC-I. Also, the Saturation and H-test flags are not included in the standard filtered for the HRC-S detector. Consequently, there is no substantial loss of events due to filtering, as there is in the HRC-I. AR Lac data from December 2000 show that there is little spatial variation due to filtering, and that while few source events are lost, background is reduced approximately 10-25%.

Conclusions

The selection of filters used in Level 2 products represents a good selection for most users and applications. Some users may want to select custom filters to apply to Level 1 data depending on what their application (such as high precision photometry, timing, or imaging). There is always a trade-off: filtering removes many unwanted background events, but will also remove some x-ray events with a spatial and energy- dependent bias.

References

- Murray et al., *Event Screening for the Chandra X-ray Observatory High Resolution Camera (HRC)*, **Proc. SPIE** vol 4140, pp 144-154 (12/2000)
- Juda et al., *Improving Chandra High Resolution Camera event positions via corrections to crossed-grid charge detector signals*, **Proc. SPIE** vol 4140, pp 155-165 (12/2000)

Table 1

HRC status bits
and bits selected for standard event filtering

Bit	Filter	I	S
1	U-axis ringing corrected		
2	V-axis ringing corrected		
3	*spare*		
4	*spare*		
5	Shifted event time		
6	Event from Next in Line Mode		
7	No Trigger (V axis)	●	●
8	No Trigger (U axis)	●	●
9	Outside of defined range (V axis)		
10	Outside of defined range (U axis)		
11	Width (V axis)		
12	Width (U axis)		
13	Antico Shield Active	●	●
14	*spare*		
15	Above ULD		
16	Below LLD		
17	Event in Bad Region	●	●
18	Amplifier Sum <= 0 (either axis)	●	●
19	Bad V Center (AV1 or AV3 > AV2)	●	●
20	Bad U Center (AU1 or AU3 > AU2)	●	●
21	PHA/Amplifier Sum Ratio Test failed	●	
22	PHA = 0 (either axis)	●	●
23	Ratio of V to U Amplifiers	●	●
24	Amplifier Sum	●	●
25	PI > 255		
26	Time Tag Out of Sequence	●	●
27	Flatness Test failed (V axis)	●	●
28	Flatness Test failed (U axis)	●	●
29	Saturation Test failed (V axis)	●	●
30	Saturation Test failed (U axis)	●	●
31	H-test failed (V axis)	●	
32	H-test failed (U axis)	●	

Figure 1

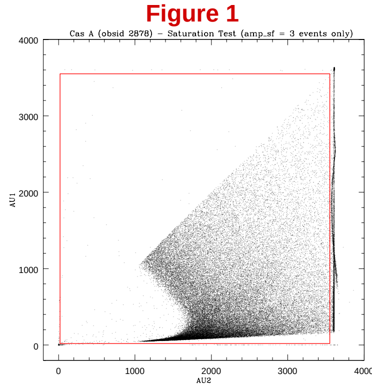


Figure 2

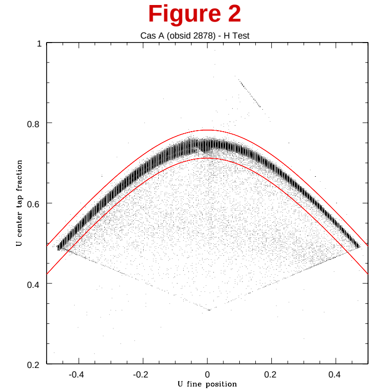
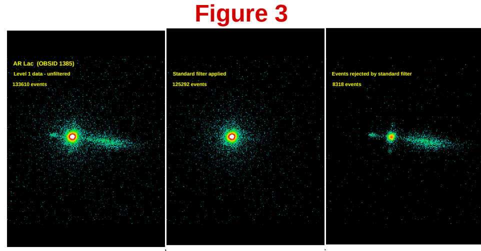


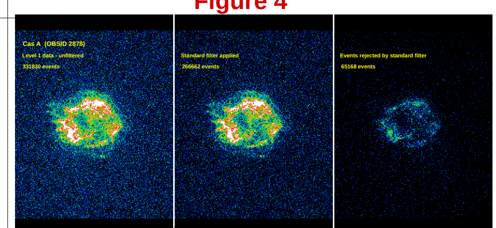
Figure 3



Checked 133610 events

Bit	Description	Number of Times Set
1	Ringing corrected, V-axis	54463
2	Ringing corrected, U-axis	49267
3	- spare -	0
4	- spare -	0
5	Shifted event time	0
6	Next-in-line mode telemetry	0
7	No-trigger, V-axis	0
8	No-trigger, U-axis	0
9	Center-blank, V-axis	0
10	Center-blank, U-axis	0
11	Width exceeded, V-axis	48
12	Width exceeded, U-axis	59
13	Antico-shield active	0
14	- spare -	0
15	ULD exceeded	5391
16	LLD not exceeded	63
17	Event in Bad Region	0
18	Tap total on U- or V-axis <= 0	55
19	Bad CRSV (AV1 or AV3 > AV2)	101
20	Bad CRSU (AU1 or AU2 > AU2)	117
21	PHA-ratio test failed	340
22	PHA on U- or V-axis = 0	37
23	Grid-ratio test failed	44
24	Sum of 6 taps = 0	55
25	PI > 255	0
26	Out of time-sequence	0
27	Flatness test failed, V-axis	33
28	Flatness test failed, U-axis	96
29	Saturation test failed, V-axis	6116
30	Saturation test failed, U-axis	3495
31	H-test failed, V-axis	1686
32	H-test failed, U-axis	3172

Figure 4



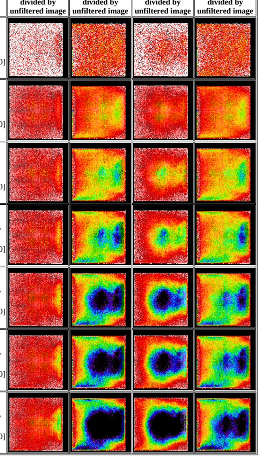
Checked 331830 events

Bit	Description	Number of Times Set
1	Ringing corrected, V-axis	110904
2	Ringing corrected, U-axis	106731
3	- spare -	0
4	- spare -	0
5	Shifted event time	0
6	Next-in-line mode telemetry	0
7	No-trigger, V-axis	0
8	No-trigger, U-axis	0
9	Center-blank, V-axis	0
10	Center-blank, U-axis	0
11	Width exceeded, V-axis	4220
12	Width exceeded, U-axis	26254
13	Antico-shield active	0
14	- spare -	0
15	ULD exceeded	42507
16	LLD not exceeded	320
17	Event in Bad Region	0
18	Tap total on U- or V-axis <= 0	1831
19	Bad CRSV (AV1 or AV3 > AV2)	2487
20	Bad CRSU (AU1 or AU2 > AU2)	1792
21	PHA-ratio test failed	4337
22	PHA on U- or V-axis = 0	1162
23	Grid-ratio test failed	1389
24	Sum of 6 taps = 0	1831
25	PI > 255	32132
26	Out of time-sequence	0
27	Flatness test failed, V-axis	451
28	Flatness test failed, U-axis	1604
29	Saturation test failed, V-axis	43074
30	Saturation test failed, U-axis	27668
31	H-test failed, V-axis	17870
32	H-test failed, U-axis	25828

Figure 5

HRC-I status bit filter ratio comparison

HRC-I laboratory flat field data from 1997, filtered using current processing standards.



	Standard filter *without* H-test or Saturation test divided by unfiltered image	Standard filter with H-test and Saturation test divided by unfiltered image	Standard filter with Saturation test (no H-test) divided by unfiltered image	Standard filter with H-test (no Saturation test) divided by unfiltered image
B Kα 183 eV [0.85 - 1.0]				
O Kα 525 eV [0.85 - 1.0]				
Ni Lα 852 eV [0.85 - 1.0]				
Al Kα 1487 eV [0.85 - 1.0]				
Ag Lα 2984 eV [0.85 - 1.0]				
Ti Kα 4511 eV [0.85 - 1.0]				
Fe Kα 6404 eV [0.85 - 1.0]				

Figure 6

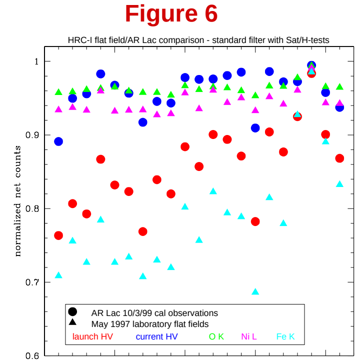


Figure 7