High Resolution Camera Stowed Background Study

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Introduction

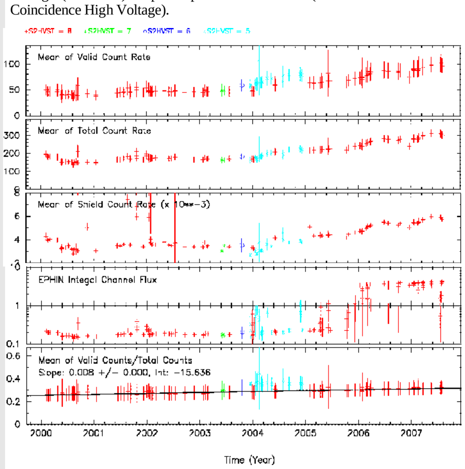
The High Resolution Camera (HRC) detectors are occasionally active while they are in a stowed position. Data taken during these active intervals can be used to study HRC backgrounds. Most "events" that HRC sees during the stowed position are cosmic rays which are missed by the anti-coincidence shield, and hence we can also use the stowed data to study changes in the anti-coincidence shield efficiency.

Time Evolution

When the HRC is in the stowed position it is usually in the next-in-line telemetry format; the amount of data telemetered to the Earth is very limited, and the data are usually telemetry-saturated. However, the HRC also reports three different count rates. The first rate is the total rate, which is the count rate of all Micro Channel Plate (MCP) events (X-rays and high-energy particles). The second rate is the valid rate, which counts the fraction of the "total" events that pass the on-board event validity tests (non-vetoed rate). The last rate is the shield rate, events due to high-energy particles counted by anti-coincidence shield, Since when the HRC is in the stowed position, the MCP rates (total and valid) are dominated by high-energy particles, we expect the three rates should closely follow the Electron Proton Helium Instrument (EPHIN) integral channel flux.

Temporal variations of the HRC-I valid, total, and shield rates, as well as those of the EPHIN integral channel flux and the valid/total rate ratio are shown in the plots below. Because of the modulation of the cosmic-ray flux due to the solar-activity cycle (see EPHIN integral channel flux), HRC anti-coincidence shield and MCP valid and total count rates change non-linearly with time.

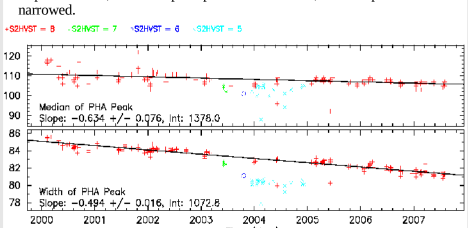
On the other hand, the valid/total ratio is probably free from the modulation of the cosmic rays. The fitted line on the ratio plot is computed using a robust method on the data with an anti-coincidence shield Photo Multiplier Tube High Voltage (PMT HV) output step level S2HVST=8 (see The Effects of Anti-Coincidence High Voltage).



The linear fit to the valid/total ratio is indicative of a change in the anti-coincidence shield response - the increase in the ratio with time reflects a degradation in the efficiency of the anti-coincidence detector. This decreasing efficiency could be due to lowered performance of the PMT or due to degradation of the optical qualities of the plastic scintillator or joints between sections or to the PMT.

The plots blow are temporal variation of PHA peak position and the width of the peak (a standard deviation of a Gaussian fit). Fitted lines are again computed with robust method.

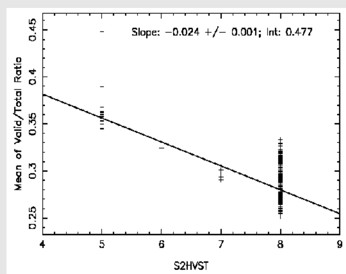
Interestingly, the PHA peaks and width also change with PMT HV step. As step is lowered, the PHA peak position is lowered, and the peak width is narrowed.



The Effects of Anti-Coincidence High Voltage

From mid March 2003 until early November 2004, the HRC anti-coincidence shield was operated at a reduced HV level for most of the time when the HRC was not observing the sky. The HRC anti-coincidence PMT HV level (output read-back S2HVLV) is controlled via commanding its step level, S2HVST. For example, S2HVST = 8 corresponds to a HV read-back level of 83 ADU or 1700V.

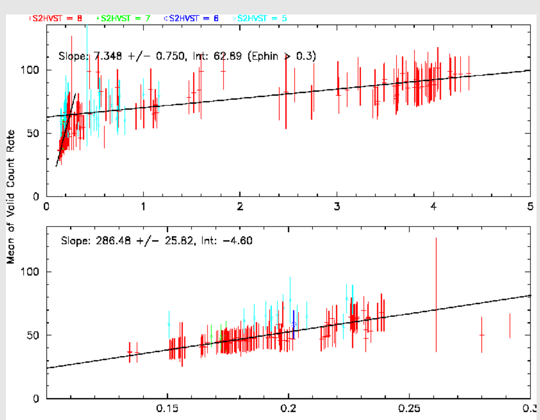
The figure below shows the plot of Valid/Total ratio against S2HVST. The temporal trend was removed from the data prior to the plotting. Since data are dominated by two values (5 and 8), the fitted line may not be accurate; still there is a clear trend. This linear relation might be used to determine a candidate update to the PMT HV step level to restore the Valid/Total ratio back to the start of the mission level in the future.



Comparison with EPHIN Integral Channel Flux

Valid and total count rates seem to modulate with the EPHIN integral channel flux. This does make sense, since all are affected by cosmic rays. The figures below show scatter diagrams of the valid count rate against EPHIN integral channel flux. There seems to be two components in these diagrams. The first panel shows all data points with two regression lines fitted: one for the data set with EPHIN integral channel flux >0.3, and the other with <=0.3. The second panel shows just between EPHIN integral channel flux between 0.1 and 0.3. The correlation statistics are significant for both data sets (p<0.01%). Two component elements are more prominent in HRC-S (not shown).

One thing to comment on with regard to the higher EPHIN integral channel flux is that there are two mechanisms involved. One is real higher fluxes above a nominal quiescent level due to solar activity, and the other is "false" higher flux readings due to the anomalous EPHIN +27V operation. The anomalous behavior started in November 2003 and became a near constant presence after December 2005. The first of these effects can lead to a change in the MCP Valid (or Total) rate vs EPHIN integral channel flux due to a change in the particle spectrum, with less penetrating particles contributing to the elevated EPHIN integral channel flux but not to the MCP rate. In the second case the "false" integral channel events are not expected to generate MCP events.

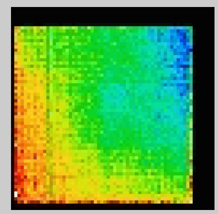


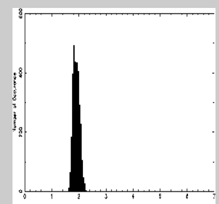
HRC Background Spatial Distribution

Although the isotropic flux of high-energy particles might lead one to expect the background to be spatially uniform, shielding by spacecraft and detector structures can be expected to produce some variations in the spatial distribution.

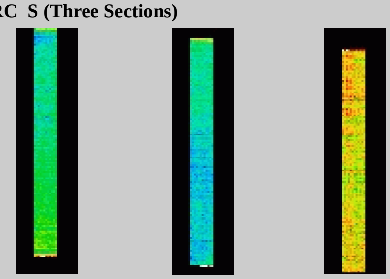
The background maps shown below are created by adding up all stowed observations from the beginning of Chandra mission till Aug 2007. The resolution of the maps are 256x256 for HRC I and 128x128 for HRC S. For the count rate distribution plots are, however, in count/pixel/sec. The red indicates higher count rates, and the blue indicates lower count rates.

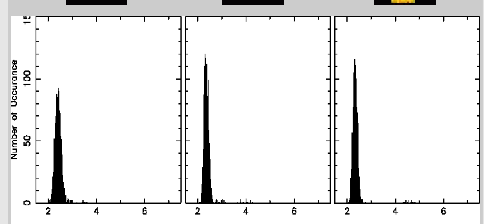
HRC I



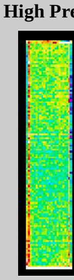


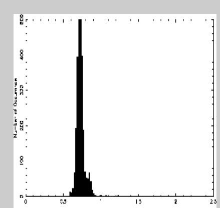
HRC S (Three Sections)





HRC S High Precision Timing





Reference
High Resolution Camera Stowed Background Study
http://cxc.harvard.edu/contrib/cxchrc/Stowed_study/hrc_stowed_position_study.html

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The stowed-background event-lists are available for download at the referenced web-site.