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The HRC−I Gain Map

Charles Wilton, Jennifer Posson−Brown, Michael Juda, Vinay Kashyap

Chandra X−Ray Center   Smithsonian Astrophysical Observatory

We have derived a new gain map for the HRC−I based on laboratory and flight data. We use lab flat−field data to obtain median values of the gain, and combine to construct an average gain uniformity map. This gain map is then modified to match the on−axis PHA profile of AR Lac, using a raster of off−axis AR Lac calibration observations carried out at current flight voltage settings. The final gain correction map has been released and will be available in the Chandra CALDB.

Laboratory flat−field images at eight energies were taken with the HRC−I in the Spring of 1997. A Pulse Height Amplitude (PHA) based on the total charge collected by the Cross−Grid Charge Detector is assigned to each event in each event list. Median gain maps were constructed by calculating a median PHA value for events in each bin of the image, with image bins of 128x128 pixels. Mean values for the central regions (central ninth) of each median gain map were calculated (see table) and used to normalize each map.

Line	Energy	central mean PHA
B Kα	183 eV	97.55
C Kα	277 eV	98.06
O Kα	525 eV	127.24
Al Kα	1487 eV	151.36
Ti Kα	4511 eV	157.30
Fe Kα	6404 eV	174.61

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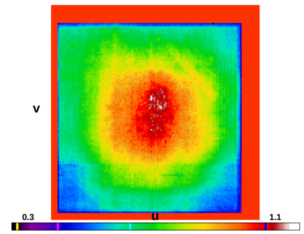
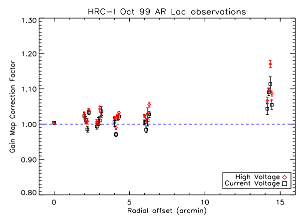
The six center−normalized median maps were then averaged to create this mean gain map. A flat−field gain map may be used to correct for non−uniform gain across the detector, by dividing data images by the map. The hrc_process_events tool used in processing of HRC data makes use of a gain correction file (parameter GAINFILE) to generate "flattened" PHA values, which are stored as PI (Pulse Invariant) values in Level 1 event lists. The gain correction file is actually the mathematical reciprocal of the mean gain map, since hrc_process_events multiplies instead of divides. This map is hrciD1998−10−30gainN0001.fits in the CALDB.



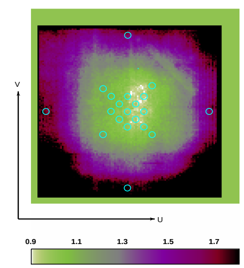
2

On October 4, 1999, the HRC−I microchannel plate High Voltage was lowered, affecting the overall gain and gain uniformity. A new gain map has been made to compensate for these changes. At the time the voltages were changed, a full set of AR Lac calibration observations was collected at both high (launch) and low (current) voltage settings. Using the October 1999 AR Lac calibration observations, we converted source PHA to PI for each of the 21 pointings, by dividing by the mean gain map. We then tested the map by comparing the PI profiles at offset locations to the PI profile at the aimpoint and asking if the offset would better match the aimpoint (as measured by chi−square) if the gain at that location where adjusted by a multiplicative factor in the range 0.8−1.2. For each offset location, we found the percentage by which the value from the gain correction map should be modified in order for the PI profile at that location to best match the PI profile at the aimpoint. This plot shows these AR Lac based correction factors to the mean gain map as a function of off−axis distance. The red diamonds are for the set of AR Lac observations done at the high voltage setting, and the black squares are for the set done at the low voltage setting. (The error bars derive from doing 1000 simulations of the offset/aimpoint chi−square test, adding Poisson noise to the offset PI values in each trial.)



3

Next, we fit a minimum curvature surface the set of low voltage correction factors (i.e. the black points in the Panel 3 plot). We then multiplied this surface with the gain correction map (i.e. the reciprocal of the gain map) to produce a new gain correction map.



This plot shows the new gain correction map with a scale bar, and with small circular regions showing the locations of the AR Lac pointings. This map is hrciD1999−10−04gainN0001.fits in the CALDB.

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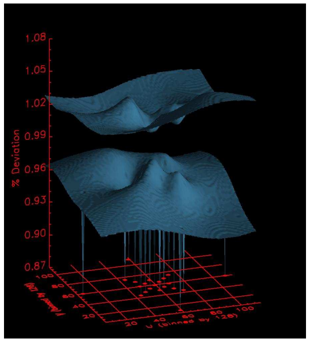

This plot shows the error on the gain correction map as percentage deviations. Errors are derived from matching the shapes of the PHA distributions as shown in Panel 6. The surface is determined as the minimum curvature surface for the 3−sigma deviations from the best−fit correction to the gain correction map. The circles indicate the locations of the AR Lac pointings.

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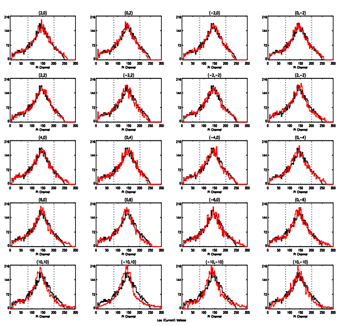

This plot shows the AR Lac PI profiles (again from the October 1999 low voltage set) at offset locations (red histograms) calculated from PHA with the new gain correction map, compared to the aimpoint PI profile (black histograms). The dashed vertical lines in each plot show the region, defined by the median PI value of the aimpoint profile, where we calculated chi−square when testing the goodness of the offset to aimpoint match. Note that here, as when doing the chi−square tests, we have normalized the offset profile to the aimpoint profile, based on the counts in the range shown by these vertical dashed lines (+/− 60 channels around the median aimpoint PI).

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HRC−I gain monitoring of AR Lac