The High Resolution Camera

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It has been another quiet, routine year for HRC operations. The instrument continues to perform well with no anomalies or instrumental problems. The high voltage on the HRC-S was permanently increased during the past year to recover instrument gain that was lost due to charge extraction. The loss of gain was affecting the quantum efficiency of the MCPs unevenly, impacting the observer's ability to remove the instrumental response from spectra. The on-going work to calibrate the effect of the increase in operating high voltage is discussed in the LETGS section of this newsletter. The HRC-S is now run at this higher voltage as part of routine operation, and the lower setting is no longer used.

Two HRC-I observations of AR Lac (ObsIDs 1385 and 13182) have been used to study the system PSF at high count rates. The source flux varied during both of these observations and it was noticed that the PSF was broader during intervals of higher flux. In addition, observations of Capella, which produces a higher count rate than AR Lac, exhibited a broader PSF than AR Lac. During ground calibration at the XRCF data were taken to probe the linearity of the HRC count rate with flux, which also exhibited a broadening in the PSF with source rate. One analysis of those data compared the linearity of the core of the PSF with a surrounding annulus, showing that the rate in the core deviated from linearity at lower flux than the annulus. These measurements suggest that the increasing width of the PSF at higher count rates is due to a suppression of the peak in the core of the nominal PSF. The cascade down the channels of the MCP from an event extracts ~10^7 electrons from a very localized region. The glass in the plates has a high resistivity and the current flow required to replenish the charge lost to the event will take a finite time. Thus, it is expected that the channels will not produce the nominal response if a second event comes too soon after the first. This is an effect of event pile-up.

We can gauge the time-scale that it takes to replenish the local charge using the AR Lac and Capella observations, looking for changes in the size of the PSF as the time between successive events is decreased. Figure 1 plots the radius that encircles 85% of the source events, for events in bins of selected time since the previous source event, for three different observations. The data points in all three observations overlap and show the same trend in increasing radius as the time between events decreases. Roughly speaking, a second event in the local region arriving within 0.05 s of a previous event will have been impacted by the prior event.

More details on the effect can be found at http://cxc.harvard.edu/contrib/juda/memos/hrc_pileup/index.html. This web-page includes a link to a simple script that can be used to flag events that are affected proximity to a previous event in the same neighborhood, along with instructions for how to filter-out the affected events.

The HRC has been used in a wide variety of scientific measurements over the past year. In this article, we present results from an HRC-I observation of the dust-scattering halo of an X-ray binary in the Small Magellanic Cloud (SMC). Due both to its proximity and low metal abundances, the SMC provides a unique laboratory for studying the influence of metallicity and star formation on dust evolution in interstellar media beyond the Milky Way. Multiple studies have shown that the dust in the SMC is strikingly different from that in the Milky Way or even the Large Magellanic Cloud, with properties more similar to those in starburst galaxies.

This dust can be measured via the X-ray halo it creates around a bright point source, such as HMXB SMC X-1. The halo will be weak and concentrated

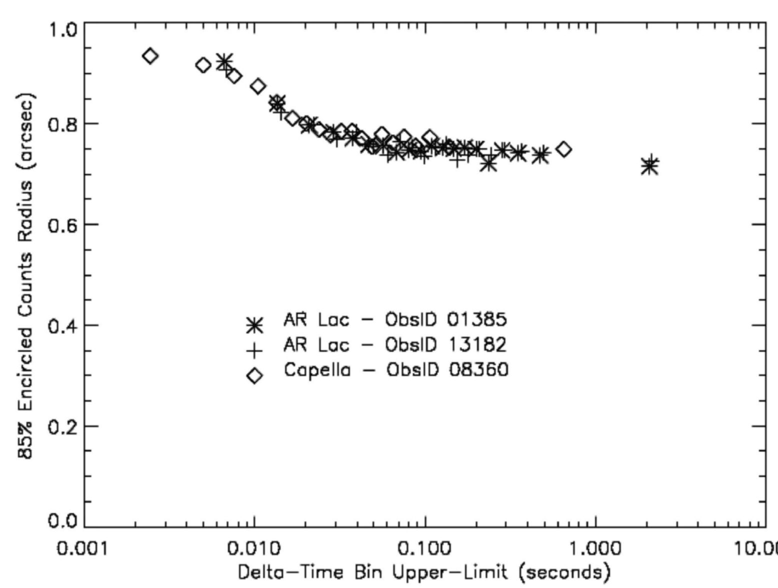

Fig. 1 - Radius in arcsec that encircles 85% of the source events, for events in bins of selected time since the previous source event, for two observations of AR Lac and one of Capella.

within 30 arcsec of the source, making the HRC-I the only choice as it has the required high spatial resolution while avoiding pileup. The expected total column density was $\sim 3\times10^{21}$ cm^{-2}, one-third of which is Galactic. The remainder should either be local to SMC X-1 (which would not create a halo) or in the SMC itself.

Surprisingly, however, a 77 ks observation (PI: Randall Smith) showed no significant halo from SMC dust at all, although as expected $\sim 10^{21}$ cm^{-2} of Galactic dust was detected. At most 5×10^{19} cm^{-2} of SMC dust was detected, 40× less than expected. The best fit value (shown in red) includes a PSF and background determined from a simultaneous fit to an HRC-I observation of 3C273, which had similar count rates and so should show a similar PSF. Although there is some excess in the observation from 30–60 arcsec, the 10–30 arcsec region that should be dominated by SMC-scattered dust (purple curve) shows no sign of any halo. This could be understood if SMC X-1's absorption is entirely local to the source and there is almost no foreground SMC dust. Alternatively, the SMC dust properties in this region would have to be quite different from the Weingartner & Draine (2001) SMC "bar" dust used in this calculation, although this SMC dust model is already significantly changed from standard Galactic dust models. More work on this is in progress to determine which alternative is more likely.

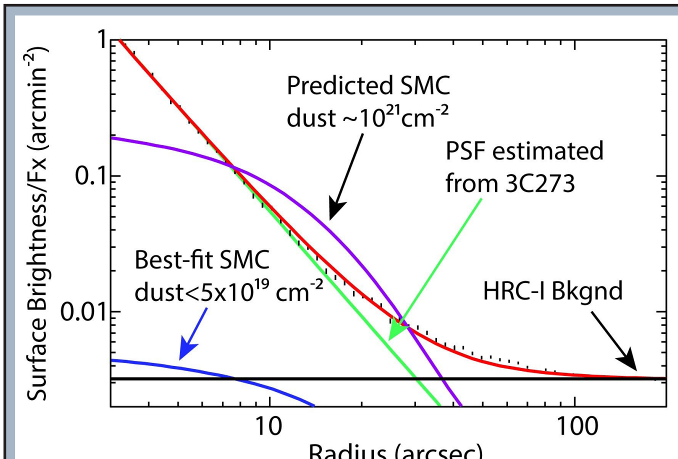

Fig. 2 - Surface brightness of dust at different SMC radii.