Chandra Calibration Update

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The calibration team continues to monitor the build-up of molecular contamination onto the ACIS filters through imaging observations of the rich cluster of galaxies Abell 1795 and the oxygen-rich supernova remnant E0102-72 and gratings observations of the blazar Mkn 421. These observations are designed to track the time-dependence of the condensation rate onto the ACIS filter, the chemical composition of the contaminant, and the spatial distribution of the contaminant on the ACIS filters. Abell 1795 is observed semi-annually at the ACIS-I and ACIS-S aim-points. In addition, a more extensive raster scan of Abell 1795 on ACIS-I and ACIS-S is performed annually to map out the spatial distribution of the contaminant. A set of LETG/ACIS-S observations of Mkn 421 are carried out semi-annually in "Big Dither" mode (i.e., with a large enough dither to cover approximately one-fourth of the ACIS-S array). *All of these observations showed that the current build-up rate of contaminant is less than that predicted by the previous ACIS contamination model.* Thus, the calibration team released new ACIS-I and ACIS-S contamination models during 2018 with updated time-dependencies. The most recent contamination measurements (ACIS-I and ACIS-S observations of Abell 1795 in November 2018) are fully consistent with the current version of the ACIS contamination model in the CALDB.

The ACIS detector gain continues to be calibrated in six month intervals by co-adding observations of the ACIS external calibration source (ECS). ACIS is exposed to the ECS whenever it is in the stowed position, which occurs during each radiation belt passage. The ECS flux has declined significantly since launch due to the 2.7 year half life of ^{55}Fe. However, even with the significant decline in ECS flux, the calibration team is still able to calibrate the ACIS gain in six month intervals within 16″ by 16″ regions to within 0.3%, on average. Within the next few years it will probably become necessary to broaden the region over which the gain is calibrated. The calibration team has also completed a study of potential astronomical sources for use as gain calibration targets once the ECS flux has faded even further.

A re-analysis of previous ACIS gain calibration revealed that there is a 32 pixel column region on both sides of the central node boundary of the front-illuminated (FI) chips where the ACIS gain droops by up to 1-2%. This gain droop is present in the ACIS "det_gain" file, which was derived from the first three months of ECS data taken after ACIS was cooled to -120C. All subsequent time-dependent gain corrections are computed relative to the ACIS "det_gain" file. Work is underway to correct this problem by calibrating the ACIS gain on smaller scales in the region close to the central node boundary. These corrections will be applied to the "det_gain" file which will automatically correct the ACIS gain at all subsequent times.

Gain calibration only requires the measurement of line centroids, while QE calibration requires the measurement of the total flux in a line. The latter requires considerably better photon statistics. In the past, the calibration team has released QE Uniformity (QEU) maps every two years by co-adding ECS data. Due to the fading of the ECS source, the next set of QEU maps, which are under development, will cover a four year interval.

Both the HRC-I and HRC-S continue to undergo a steady decline in detector gain. In addition, the HRC-S has also shown a continuous wavelength-dependent decline in QE. The calibration team corrects for these effects by releasing annual updates to the HRC-I and HRC-S detector gains and the HRC-S QE. The calibration team monitors the HRC-I QE with annual observations of HZ43 (a soft source) and G21.5-09 (a hard source). Throughout most of the *Chandra* mission, the count rate of these two sources has been constant. Recently, the HZ43 count rate has begun to decline, while the G21.5-09 count rate remains constant. In 2018, the calibration team released the first set of time-dependent HRC-I QE files to correct for the low energy QE loss. At present, all four focal plane detectors have a set of time-dependent QE files in the CALDB. CIAO default processing automatically corrects for the time-dependent gain and QE losses. The detector effective area files used by PIMMS will continue to be updated prior to each cycle.

During the recent safe mode event in October 2018, the HRMA warmed up to temperatures (~76 F) significantly greater than its nominal operating temperature (71 F). The calibration team monitors the imaging properties of *Chandra* with semi-annual HRC-I observations of AR Lac. Due to potential detrimental effects on the HRMA due to running warm during the recent safe mode, the calibration team scheduled an HRC-I observation of AR Lac for December 2018. The AR Lac PSF obtained during this observation is fully consistent with previous AR Lac observations. Thus, the recent safe mode event did not have any effect on the imaging properties of *Chandra*.