Recent Updates to *Chandra* Calibration

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There were seven releases of the *Chandra* calibration database (CALDB) during the past year. In addition to the regularly scheduled updates to the detector gains (quarterly for ACIS and yearly for the HRC), the *Chandra* calibration team also released: 1) A revised extraction region for LETG/HRC-S spectra, 2) an updated version of the HRC-S QE to maintain cross-calibration between LETG/HRC-S and LETG/ACIS-S data, 3) an updated version of the HRC-I QE to maintain cross-calibration between the HRC-S and HRC-I, 4) an additional ACIS-QE to be used with CC-faint mode data taken prior to 2008 (i.e., without the telemetry of flight grade 66), and 5) an adjustment to the low energy gain calibration of S1. Each of these updates to the CALDB is discussed below along with a summary of current calibration projects.

Over the course of the *Chandra* mission, the dispersion axis of LETG/HRC-S data has undergone some shifts in orientation. Software has been developed that corrects any variations in the orientation of the dispersion axis which allows for the implementation of a narrower extraction region for LETG/HRC-S data. The use of a narrower extraction region reduces the background within the extraction region by up to 25% at the expense of only a few percent of the source photons. The implementation of a new extraction region required a re-calibration of the enclosed count fraction in LETG/HRC-S data (i.e., the fraction of total counts within the extraction region as a function of wavelength) and an adjustment to the HRC-S QE to maintain consistent source fluxes. The change in the HRC-S QE also required an adjustment to the HRC-I QE to maintain cross-calibration between these two instruments in imaging mode.

During an LETG/ACIS-S observation, photons with wavelengths between approximately 30 and 65 A are dispersed onto the backside-illuminated S1 CCD. In 2015, the calibration team released a revised gain table for S1 with improvements to the low energy gain (i.e., wavelengths longer than 20 Å) which affects order sorting in gratings observations. Older versions of the S1 gain table lead to some valid events being filtered out in the order sorting process which resulted in LETG/ACIS-S fluxes less than LETG/HRC-S fluxes in the wavelength band covered by the S1 CCD. The current version of the S1 gain table now produces consistent LETG/ACIS-S and LETG/HRC-S fluxes in this wavelength band.

The calibration team continues to monitor the build-up of molecular contamination onto the ACIS filters through periodic imaging observations of Abell 1795 and E0102-72 and gratings observations of Mkn 421, PKS 2155-304 and RXJ 1856-3754. Analysis of these observations over the past year shows that the CALDB version of the ACIS contamination model continues to predict the opacity of the contaminant to within 5-10% on all regions of ACIS-I and on all regions of ACIS-S except for the bottom and top 100-150 rows. Recent observations show that the spatial distribution of the contaminant on the ACIS-S filter has changed over the past few years. The calibration team is presently developing an ACIS contamination model that incorporates a time-dependent spatial model for the contaminant on the ACIS-S filter.

At present, the CALDB contains a single, time-independent, scatter matrix for ACIS (i.e., the probability that a photon of a given energy is detected in a given pulse height). Due to increasing CTI over the course of the mission, and to a lesser extent, warmer operating temperatures, the FWHM spectral resolution of ACIS has degraded by approximately 10-20%. To account for this change in the spectral resolution of ACIS, the calibration team is presently developing a set of time-dependent scatter matrices.

The *Chandra* calibration team continues to support the efforts of the International Astronomical Consortium for High Energy Calibration (IACHEC). The 11th annual IACHEC meeting recently took place in Pune, India on Feb. 29 through Mar. 3, 2016. These meetings bring together calibration scientists from all present and many future X-ray and γ-ray missions. Collaborations established at these meetings have led to a number of cross-calibration papers published in the Journal of Astronomy & Astrophysics. ■