The Chandra Source Catalog 2.0: CALIBRATIONS

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ABSTRACT

Among the many enhancements implemented for the release of Chandra Source Catalog (CSC) 2.0 are improvements in the processing calibration database (CalDB). We have included a thorough overhaul of the CalDB software used in the processing. The software system upgrade, called "CalDB version 4," allows for a more rational and consistent specification of flight configurations and calibration boundary conditions. Numerous improvements in the specific calibrations applied have also been added. Chandra's radiometric and detector response calibrations vary considerably with time, detector operating temperature, and position on the detector. The CalDB has been enhanced to provide the best calibrations possible to each observation over the fifteen-year period included in CSC 2.0. Calibration updates include an improved ACIS contamination model, as well as updated time-varying gain (i.e., photon energy) and quantum efficiency maps for ACIS and HRC-I. Additionally, improved corrections for the ACIS quantum efficiency losses due to CCD charge transfer inefficiency (CTI) have been added for each of the ten ACIS detectors. These CTI corrections are now time and temperature-dependent, allowing ACIS to maintain a 0.3% energy calibration accuracy over the 0.5-7.0 keV range for any ACIS source in the catalog. Radiometric calibration (effective area) accuracy is estimated at ~4% over that range. We include a few examples where improvements in the Chandra CalDB allow for improved data reduction and modeling for the new CSC.

The Chandra X-ray Observatory sets a significant standard for calibration accuracy.

- Cross-calibration source identification, including standard candles, e.g.:
  - CAS A, Crab, A1795, Cyg X-1, SGR A*, E0102-72.3
- Effective Area Accuracy within 4% (0.5-7 keV)
- ACIS Gain accuracy of 0.3% (0.5-7 keV)
- HRC-I Gain accuracy 2% with annual GMAP adjustment

The Chandra Calibration Database is the most extensive in HEASARC.

- Most detailed detector characterizations vs space and time
- Includes gains, quantum efficiencies and uniformities, background event compilations and spectra, CTI-corrections (ACIS) and OBF contaminant modeling (ACIS).

Key features of the Chandra calibrations:

- Time- and spatial-dependence of the detector properties
- Temperature-dependence of ACIS calibrations

CalDB 4 SOFTWARE (added in CSC 2.0):

- Flexible index design
  - Keyword configuration control by standard "key.config"
  - Index column-to-FITS keyword mapping
  - Backward compatibility via "mandatory keywords" specifications
- Two query levels allow for automated calibration parameter setting.
  - No prior knowledge of CalDB parameters needed
  - If a value is unavailable, the parameter is ignored.

CSC Operations and the CalDB:

- Gains and CTI Correction applied in Level 1 (re)processing pipeline.
  - ➢ PHA, PI, and ENERGY values
    - ➢ IN CSC 2.0: Source flux estimates
- Radiometry calibrations (HRMA AXEFFA, VIGNET, ACIS CONTAM, QE, QEU) are selected where effective areas need to be calculated.
  - ➢ Spectral fits
    - ➢ IN CSC 2.0: Derived model source parameters such as temperature, photon index, nH, and normalization.

See poster "Data Processing Pipelines," Miller, et al, this session.

Example calibration products upgraded for CSC Rel 2.0:

- ACIS
  - Temp-dependent CTI correction
  - T_GAIN
  - CONTAM
  - QE/QEU
- HRC-I
  - "SUMAMPS-based" GMAP
  - "SUMAMPS-based" RMF
  - Updated QE/QE Uniformity

Calibration properties:

Temperature-dependent CTI Correction

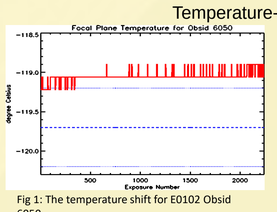

Fig 1: The temperature shift for E0102 Obsid 6050.

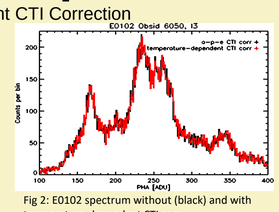

Fig 2: E0102 spectrum without (black) and with temperature-dependent CTI corr.

ACIS T_GAIN Correction

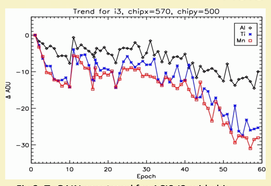

Fig 3. T_GAIN corr trend for ACIS-I3 mid-chip.

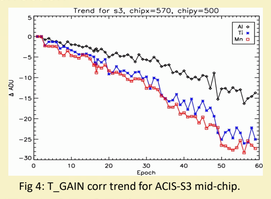

Fig 4: T_GAIN corr trend for ACIS-S3 mid-chip.

ACIS Effective Area (CONTAM, QE, QEU)

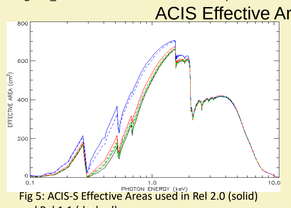

Fig 5: ACIS-S Effective Areas used in Rel 2.0 (solid) and Rel 1.1 (dashed).

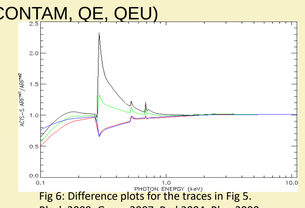

Fig 6: Difference plots for the traces in Fig 5. Black 2009, Green 2007, Red 2004, Blue 2000.

HRC-I GMAPs and time-dependence

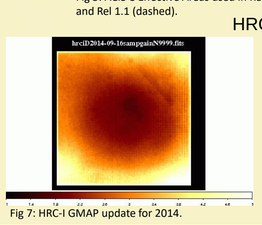

Fig 7: HRC-I GMAP update for 2014.

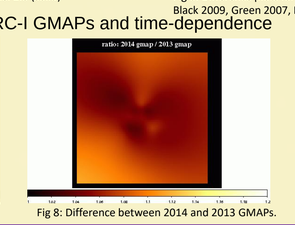

Fig 8: Difference between 2014 and 2013 GMAPs.

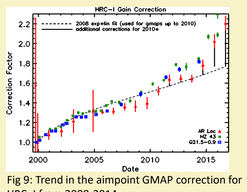

Fig 9: Trend in the aimpoint GMAP correction for HRC=I from 2000-2014.

CSC Catalog Products Generated:

ACIS OBIs:

- Source aperture fluxes:
  - flux_aper_u,s,m,h,b
- Source model fluxes
  - flux_powlaw_aper_?

(See poster "Estimating Source Fluxes," Primini et al, this session.)

- Model Spectral Fit values
  - Power-law, black-body, bremsstrahlung, APEC
- Spectral Hardness Ratios
  - Hard-medium, hard-soft, medium-soft ratios

(See poster "Spectral Properties," McCullough et al, this session)

HRC-I OBIs:

- Source aperture fluxes:
  - flux_aper_w
- Source model fluxes:
  - flux_powlaw_aper_w

(See poster "Estimating Source Fluxes," Primini et al, this session.)

CHANDRA SOURCE CATALOG

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