

Chandra Source Catalog

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Release 2.0 of the *Chandra* Source Catalog (CSC) includes tabulated properties and FITS format data products for almost 375,000 source detections associated with more than 315,000 distinct X-ray sources on the sky. The detections were extracted from more than 10,000 *Chandra* ACIS and HRC-I imaging observations that were released publicly through the end of 2014. Multiple observations of the same field (defined as pointings that are co-located within 60 arcsec and obtained using the same instrument) are co-added, or “stacked,” prior to source detection, to maximize detectability of sources. Stacked-observation exposures range from 1.4 ks to 5.8 Ms, with a median exposure of 14.3 ks. Compared to release 1.1, an improved source detection approach allows detection of point sources reliably down to roughly 5 net counts on-axis, for exposures shorter than roughly 15 ks (for longer exposures, background becomes increasingly important, raising the limit on detectable net counts). The sky coverage of CSC release 2.0, totaling ~ 560 deg², is shown in Figure 1.

CSC release 2.0 includes information on roughly 100 tabulated properties for each identified X-ray source, as well as for the individual source detections on both the stacked and individual observations. They include positions and position errors, significance, spatial extent, multi-band aperture photometry (total and net counts, count rates, photon and energy fluxes, and model-dependent fluxes calculated using several common spectral models), hardness ratios, multiple spectral model fits, and inter- and intra-ob-

servations temporal variability. All numeric properties have associated uncertainties, usually independent lower and upper confidence limits. Furthermore, most properties are evaluated in 5 energy bands (ultrasoft: 0.2–0.5 keV, soft: 0.5–1.2 keV, medium: 1.2–2.0 keV, hard: 2.0–7.0 keV, and broad: 0.5–7.0 keV) for ACIS, and 1 energy band (wide: ~ 0.1 –10.0 keV) for HRC-I. As a result of this multiplicity, the catalog includes approximately 1700 columns of information, split across several tables. A sample of the key tabulated properties are shown in Figure 2.

In addition to the tabulated properties, the catalog includes roughly 40 different types of science-ready FITS data products totaling some 25 million files (~ 32 TB). The science-ready data products include merged detection lists, detection region event lists, exposure maps, responses, spectra, light curves, aperture photometry probability density functions, position error Markov chain Monte-Carlo draws, aperture photometry, hardness ratios, and spectral model fits for each photometrically-homogeneous subset of observations of a source (grouped together by a Bayesian blocks variability analysis), and limiting sensitivity maps.

This last year has seen significant progress towards completing release 2.0 of the CSC. At the time of writing the final *source properties* phase of processing is about 60% complete, meaning ~ 2 months processing remains to complete the catalog.

An updated preliminary detections list (*CSC 2.0 pd2*) that included detections from all of the 7,287 observation stacks that will appear in the final catalog was published in September 2017. The preliminary detections list includes position, likelihood, and intensity estimates (the latter is a proxy for aperture photometry), together with associated confidence intervals, for each detection. The release of *CSC 2.0 pd2* marked the end of the major *source detection* phase of processing for CSC release 2.0.

Following the *source detection* phase, detections from overlapping stacked observations that include the same location on the sky were cross-matched in the *master match* phase of processing to identify distinct X-ray sources on the sky. This step is necessary because the size of the *Chandra* PSF is a strong function of off-axis angle, and a single off-axis detection may be resolved into multiple sources in overlapping on-axis observations. A pre-release source list (*CSC 2.0 pre1*) that included CSC 2.0 source names following IAU standard nomenclature and identified the detections from

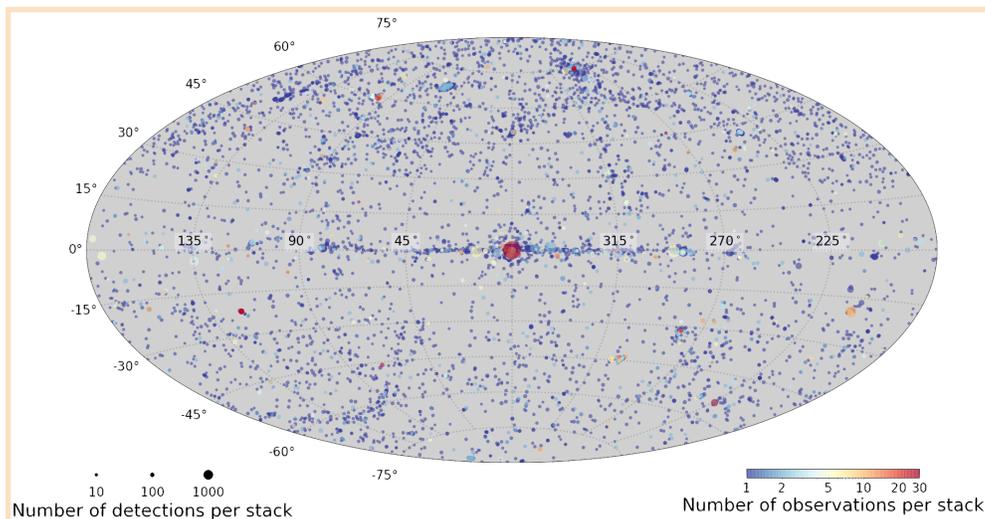


Figure 1. The sky coverage of CSC release 2.0, in Galactic coordinates. Each marker identifies the location of an observation stack on the sky. The size of the marker is proportional to the number of detections identified in the observation stack. The marker is color coded based on the number of observations that are co-added to construct the stacked-observation.

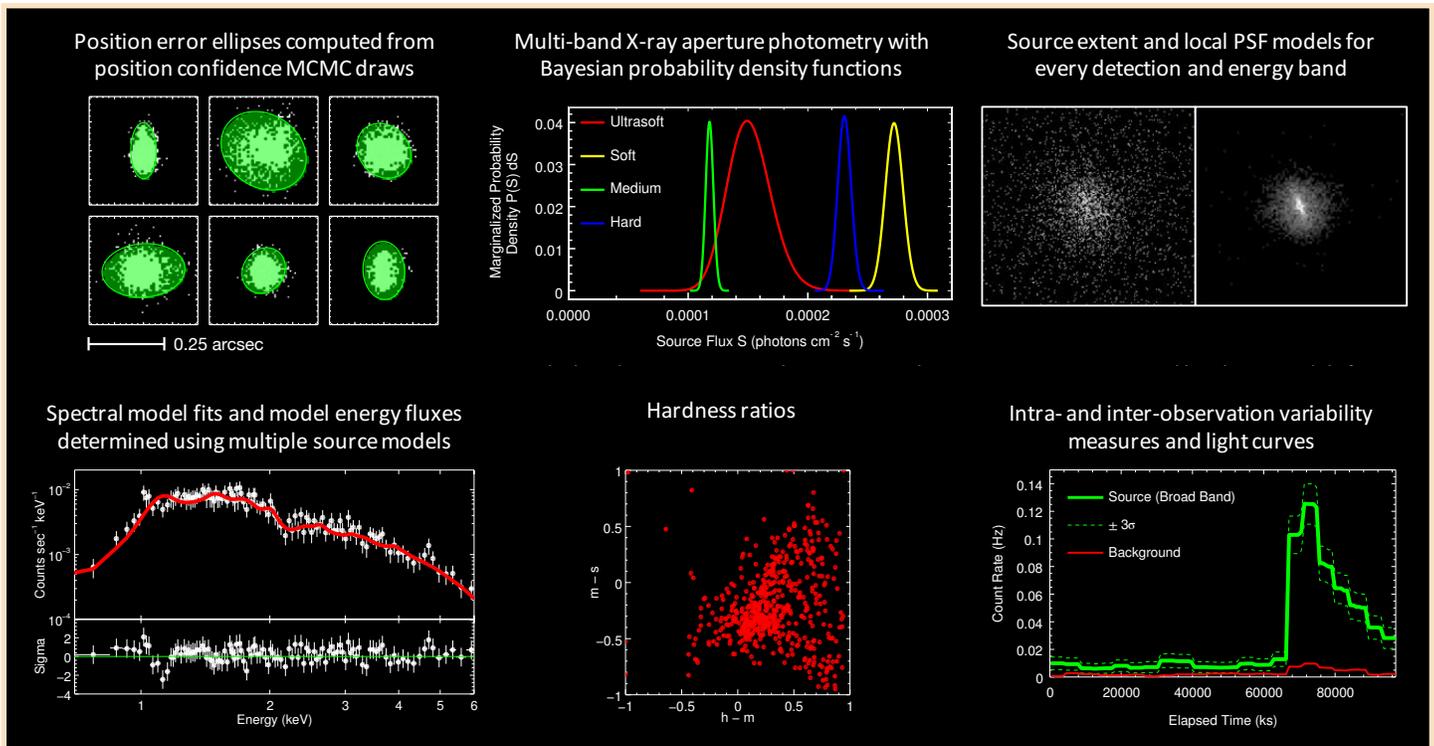


Figure 2. Examples of key source and detection properties that are included in CSC release 2.0. All numeric properties have associated independent lower and upper confidence limits, and most properties are evaluated in 5 energy bands for ACIS, 1 for HRC-I.

CSC 2.0 pd2 associated with each source, was published in mid-November 2017. The source names in the pre-release source list will not change in the final catalog release.

Both the *CSC 2.0 pd2* preliminary detections list and the *CSC 2.0 pre1* pre-release source list can be accessed through the CSC release 2.0 web site.

The *source properties* phase computes a detailed set of properties for each detection and source, generates limiting sensitivity maps, and populates the catalog databases. This processing phase is currently underway. The results of this phase are being made available to the community through the *CSCView* catalog interface. This allows users to see the tabulated properties and FITS format data products through the *CSCView* “current database” view as soon as processing completes for each overlapping group of stacked observations.

Once this last processing phase completes there will be a brief full catalog quality assurance review, after which the catalog will be frozen and the official CSC release 2.0 will be made available through multiple catalog user interfaces. The quality assurance review *could* result in the rejection of a very small (<0.1%) fraction of the detections identified in the *CSC 2.0 pd2* preliminary detections list and the *CSC 2.0 pre1* pre-release source list. The final CSC 2.0 release is expected around the end of the 1st quarter of 2018 and will be announced through multiple outlets.

Data access and documentation for CSC release 2.0 is available through the release 2 web site (<http://cxc.cfa.harvard.edu/csc2/>). The documentation describes the content

and organization of the catalog in detail and lists important caveats and limitations that should be reviewed prior to using the catalog data. Updates and news about release 2.0 will continue to be added to the website through the end of production. The current (release 1.1) version of the catalog may be accessed through the release 1 website site (<http://cxc.cfa.harvard.edu/csc/>), and this version will continue to be available indefinitely. ■