Chandra Source Catalog
Requirements

Version 0.4

April 3, 2006

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I. Catalog Requirements

1. Catalog Contents

1.1. Master Source Object

The Master Source Object records the "best-estimate" merged source properties for a source. There is one Master Source Object for each distinct astronomical source in the catalog.

1.1.1. Source Name

The Source Name shall consist of a character string of the form "**`CXO Jhhmmss.s+ddmmss`**", where **`hhmmss.s`** is the ICRS Right Ascension in hours, minutes, seconds, and tenths of a second, and **`+ddmmss`** is the signed ICRS Declination in degrees, minutes, and seconds. The Source Name shall be updated in accordance with the recommendations of the *IAU Nomenclature Clearing-House*.

The Source Name field in the Master Source Object shall be identified by the field name "**`name`**".

1.1.2. Position and Position Errors

Performance Requirement:

The equatorial coordinates of each source shall be determined in the ICRS reference frame with an absolute uncertainty that is not to exceed 1.0 arcseconds (1 σ) for an isolated point source with at least 10 (TBR) counts located within 3.0 arcminutes of the optical axis, and 1.2 arcseconds (1 σ) for an isolated point source with at least 30 (TBR) counts located within 15.0 arcminutes of the optical axis. This requirement on the absolute position error shall be met by 95% of the detected point sources.

The relative positions of two isolated point sources shall be determined with a relative uncertainty that is not to exceed 0.9 arcseconds (1 σ) for a pair of isolated point sources with at least 10 counts (TBR) each located within 3.0 arcminutes of the optical axis, and 1.2 arcseconds (1 σ) for a pair of isolated point sources with at least 30 (TBR) counts each located within 15.0 arcminutes of the optical axis. This requirement on the relative position error shall be met by 95% of the detected point source pairs.

1.1.2.1. Equatorial Coordinates

The best estimate of the ICRS equatorial coordinates for a source shall consist of 5 double precision values that record the ICRS Right Ascension in decimal degrees, the signed ICRS Declination in decimal degrees, the major and minor axes of the 1 σ error ellipse of the source position in arcseconds, and the position angle of the major axis of the 1 σ error ellipse in degrees.

The Right Ascension and Declination fields in the Master Source Object shall be identified by the field names "**`ra`**" and "**`dec`**", respectively.

The major and minor axes and the position angle of the major axis of the 1 σ error ellipse shall be identified by the field names "**`err_ellipse_r0`**", "**`err_ellipse_r1`**", and "**`err_elipse_ang`**", respectively.

1.1.2.2. Galactic Coordinates

The Galactic coordinates corresponding to the source ICRS equatorial coordinates in section 1.1.2.1 (Equatorial Coordinates) shall consist of 2 double precision values that record the Galactic longitude, *l*, and latitude, *b*, for equinox J2000.0 and epoch J2000.0.

The Galactic latitude and Galactic longitude fields in the Master Source Object shall be identified by the field names "**`gal_b`**" and "**`gal_l`**", respectively.

1.1.3. Source Flags

The source flags highlight significant issues identified during processing that could affect cataloged source properties, or that may be useful search criteria. The flags are generally coded bytes, with specific meanings assigned to each bit. The codings are established so that the byte value 0 is **`FALSE`**.

1.1.3.1. Extent Flag

Performance Requirement:

The Extent Flag consists of a Boolean whose value shall be **TRUE** if the 2-D spatial fit to the PSF is not consistent with a point source at the 99% confidence level in all contributing observations and source detection energy bands with at least 30 counts (TBR) for sources located within 3.0 arcminutes of the optical axis, or at least 50 counts (TBR) for sources located within 15.0 arcminutes of the optical axis. Otherwise, the Extent Flag shall be **FALSE**. The interactions between the Extent Flag and the Confusion Flag [see section 1.1.3.2 (Confusion Flag)] are discussed in more detail in Appendix TBD.

The Extent Flag field in the Master Source Object shall be identified by the field name “**extent_flag**”.

1.1.3.2. Confusion Flag

The Confusion Flag consists of a Boolean whose value shall be **FALSE** if the 2-D spatial fits do *not* identify multiple point sources associated with the detect source regions in any contributing observations or source detection energy bands, *and* the detect source regions in all contributing observations and source detection energy bands do not overlap any other detect source regions. Otherwise, the Confusion Flag shall be **TRUE**. The interactions between the Confusion Flag and the Extent Flag [see section 1.1.3.1 (Extent Flag)] are discussed in more detail in Appendix TBD.

The Confusion Flag field in the Master Source Object shall be identified by the field name “**conf_flag**”.

1.1.3.3. Pile-up Flag

The Pile-up Flag consists of a Boolean whose value shall be **FALSE** if none of the values of the Pile-up Warning field [see section 1.2.2.4.3.1 (Pile-up Warning)] for all contributing ACIS observations and source detection energy bands exceed TBD counts per ACIS frame per pixel. Otherwise, the Pile-up Flag shall be **TRUE**.

The Pile-up Flag field in the Master Source Object shall be identified by the field name "**`pileup_flag`**".

1.1.3.4. Variability Flag

The Variability Flag consists of a coded byte whose value shall be 0 if variability is not detected either within any single observation, or between any pair of observations, in any source detection energy band. Otherwise, the Variability Flag coding shall be as follows:

1 = Intra-observation variability was detected in the broad (**`b`**) band,
2 = Intra-observation variability was detected in the soft (**`s`**) band,
4 = Intra-observation variability was detected in the medium (**`m`**) band,
8 = Intra-observation variability was detected in the hard (**`h`**) band,
16 = Inter-observation variability was detected in the broad (**`b`**) band,
32 = Inter-observation variability was detected in the soft (**`s`**) band,
64 = Inter-observation variability was detected in the medium (**`m`**) band,
128 = Inter-observation variability was detected in the hard (**`h`**) band.

The criteria for flagging variability within a single observation are identified in section 1.2.2.4.4 (Variability Flag). The criteria for flagging variability between two observations are TBD.

The Variability Flag field in the Master Source Object shall be identified by the field name "**`var_flag`**".

1.1.4. Source Extent and Errors

A parameterization of the best estimate of the deconvolved extent of each source shall be determined from the Kaplan-Meier median (TBR) of the 2-D spatial fits to source detections in all contributing observations and source detection energy bands. The parameterization shall consist of the best fit values for the major axis, minor axis, and position angle (and associated errors) of a rotated elliptical Gaussian that is convolved with the ray-trace local PSF and fit to the source spatial event distribution as defined in section TBD.

Performance Requirement:

The parameterization of a source that has 30% of its counts extended by 50% of the 90% Encircled Counts Fraction (ECF) radius is required exclude a point source model at the 1 σ confidence level if the source has at least 50 counts (TBR) and is located within 3.0 arcminutes of the optical axis, or if the source has at least 100 (TBR) counts and is located within 15.0 arcminutes of the optical axis. This requirement on the 2-D spatial fit extent parameterization shall be met by 95% of the matching sources.

The parameterization of a pair of close point source pairs that are separated by at least 50% of the local PSF FWHM is required to resolve the sources at the 1 σ confidence level if the source flux ratio is ≤ 2 *and* the faintest source has at least 30 (TBR) counts and is located within 3.0 arcminutes of the optical axis, or if the faintest source has at least 50 counts (TBR) and is located within 15.0 arcminutes of the optical axis. This requirement on the 2-D spatial fit resolution shall be met by 95% of close point source pairs.

If the source is detected in multiple contributing observations at different off-axis angles, then the off-axis angle of the source in the observation for that has the highest Flux Significance [see section 1.2.2.3.2 (Flux Significance)] shall be the defining off-axis angle for these performance requirements.

The best estimates of the parameter values for a source shall consist of 6 double precision values that record the major and minor axes of the rotated elliptical Gaussian fit to the source extent in arcseconds, and the position angle of the major axis of the rotated elliptical Gaussian in degrees.

The major axis, major axis error, minor axis, minor axis error, position angle of the major axis, and position angle error fields in the Master Source Object shall be identified by the field names "**`major_axis`**", "**`major_axis_err`**", "**`minor_axis`**", "**`minor_axis_err`**", "**`pos_angle`**", and "**`pos_angle_err`**", respectively.

1.1.5. Source Fluxes

Source fluxes shall be determined by two methods: (1) from the 2-D spatial fit to the source detections in each Source Detection Energy Band, and (2) by aperture photometry in each Aperture Photometry Energy Band. Aperture photometry measurements shall be obtained in the source region, and in elliptical apertures that include the 50% and 90% ECFs of the PSF at the source location, with corrections applied for the PSF aperture fraction. The correction factor shall be computed from the ray-trace local PSF under the assumption that the source spatial distribution matches the local PSF.

1.1.5.1. Energy Bands

1.1.5.1.1. ACIS Observations

The energy bands used for ACIS observations are split into two categories. Source Detection Energy Bands are used in the source detection and 2-D spatial fit processing to detect sources; they are chosen to maximize the source detection efficiency for different kinds of sources observed using the back- and front-side illuminated CCDs. Aperture Photometry Energy Bands are used for aperture photometry and are chosen to maximize the scientific utility of the catalog. The process by which the energy bands were chosen is documented in Appendix TBD.

1.1.5.1.1.1. Source Detection Energy Bands

The Source Detection Energy Bands for ACIS are a single *broad* band, covering 0.2–7.5 keV (TBR), and *soft*, *medium*, and *hard* bands covering 0.2–0.5 keV, 0.5–2.0 keV, and 2.0–7.5 keV, respectively (TBR).

The broad, soft, medium, and hard Source Detection Energy Bands are designated "**b**", "**s**", "**m**", and "**h**", respectively.

1.1.5.1.1.2. Aperture Photometry Energy Bands

The Aperture Photometry Energy Bands for ACIS are a single *broad* band, covering 0.2–7.5 keV (TBR), and *TBD* bands covering TBD keV.

The broad, and *TBD* Aperture Photometry Energy Bands are designated "**TBD**", and "**TBD**", respectively.

1.1.5.1.2. HRC Observations

The HRC does not have significant energy resolution. There is a single broad energy band for both source detection and aperture photometry. The broad energy band for HRC includes pulse heights 0 : 254 (TBR), and corresponds approximately to photon energies 0.1–10.0 keV.

The broad energy band is designated "**b**".

1.1.5.2. 2-D Spatial Fit Fluxes

The 2-D Spatial Fit Fluxes and associated errors shall consist of 2 double precision values for each Source Detection Energy Band that record the best estimates of the integrated fluxes and errors derived from the best fitting 2-D spatial fit models in units of photons s^{-1} cm^{-2}.

Performance Requirement:

> The fluxes in each Source Detection Energy Band determined from the 2-D spatial fit parameterization of an isolated point source, that has an actual spectrum matching an assumed power law spectrum with spectral index $\alpha = 1$ (TBR; defined as $F_\nu \sim \nu^{-\alpha}$), shall agree with the actual source flux at a 1 σ confidence level not to exceed 1.5 times the 1 σ Poisson error if the source has at least 30 counts (TBR) and is located within 3.0 arcminutes of the optical axis, or if the source has at least 50 counts (TBR) and is located within 15.0 arcminutes of the optical axis. This requirement on the 2-D spatial fit fluxes shall be met by 95% of isolated point sources.
>
> If the source is detected in multiple contributing observations at different off-axis angles, then the off-axis angle of the source in the observation for that has the highest Flux Significance [see section 1.2.2.3.2 (Flux Significance)] shall be the defining off-axis angle for these performance requirements.

The 2-D Spatial Fit Fluxes and associated errors in the Master Source Object shall be identified by the field names "**`flux_fit`**" and "**`flux_fit_err`**", respectively.

1.1.5.3. Aperture Photometry Fluxes

The Aperture Fluxes and associated errors shall consist of 6 double precision values for each Aperture Photometry Energy Band that record the best estimates of the fluxes and errors in the source region and in elliptical apertures that include the 50% and 90% ECFs of the PSF at the source location, corrected by the PSF aperture fraction, in units of photons s^{-1} cm^{-2} and ergs s^{-1} cm^{-2}. The conversion from photons s^{-1} cm^{-2} to ergs s^{-1} cm^{-2} is performed by summing the photon energies for each incident source photon and scaling by the local value of the ARF at the location of the incident photon.

Performance Requirement:

> The fluxes in each Aperture Photometry Energy Band determined from the aperture photometry an isolated point source shall agree with the actual source flux of a point source measured through the same aperture at a 1 σ confidence level not to exceed 1.2 times the 1 σ Poisson error if the source has at least 30 counts (TBR) and is located within 3.0 arcminutes of the optical axis, or if the source has at least 50 counts (TBR) and is located within 15.0 arcminutes of the optical axis. This requirement on the aperture photometry fluxes shall be met by 95% of isolated point sources.
>
> If the source is detected in multiple contributing observations at different off-axis angles, then the off-axis angle of the source in the observation for that has the highest Flux Significance [see section 1.2.2.3.2 (Flux Significance)] shall be the defining off-axis angle for these performance requirements.

The Aperture Fluxes in the source region, and in elliptical apertures that include the 50% and 90% ECFs of the PSF at the source location, and their associated errors, in the Master Source Object shall be identified by the field names "**`photflux_aper`**", "**`photflux_aper50`**", "**`photflux_aper90`**", "**`photflux_aper_err`**", "**`photflux_aper50_err`**", and "**`photflux_aper90_err`**", respectively, for the photon fluxes, and "**`flux_aper`**", "**`flux_aper50`**", "**`flux_aper90`**", "**`flux_aper_err`**", "**`flux_aper50_err`**", and "**`flux_aper90_err`**", respectively, for the energy fluxes.

1.1.5.4. Source Significance

The Source Significance shall consist of a double precision value that records the highest Source Detection Energy Band flux significance (**flux_fit** / **flux_fit_err**) derived from the best fitting 2-D spatial fit models to the source.

The Source Significance in the Master Source Object shall be identified by the field name “**significance**”.

1.1.6. Spectral Properties

The spectral properties of a source observed by ACIS shall include a set of Hardness Ratios determined from (background-subtracted) source fluxes in a set of energy bands, and parameterizations determined from Spectral Model Fits to the (background-subtracted) source fluxes in a set of energy bands.

1.1.6.1. Hardness Ratios

Hardness Ratios shall consist of pairs of double precision values for each pair of Source Detection Energy Bands and each pair of Aperture Photometry Energy Bands, excluding the broad bands, that record the hardness ratios and associated errors. The Hardness Ratio for two bands with designations **<x>** and **<y>**, respectively, is defined as

hard_<x><y> = (*F*(<x>)-*F*(<y>)) / *F*(<broad>),

where ***F*(<x>)** is the (background-subtracted) source flux in band **<x>**, and ***F*(<broad>)** is the (background-subtracted) source flux in the appropriate broad energy band (either the broad Source Detection Energy Band or the broad Aperture photometry Energy Band, as appropriate). For Hardness Ratios constructed from Source Detection Energy Bands, the relevant flux values are **flux_fit**, as defined in section 1.1.5.2 (2-D Spatial Fit Fluxes). For Hardness Ratios constructed from Aperture photometry Energy Bands, the relevant flux values are **flux_aper**, as defined in section 1.1.5.3 (Aperture Photometry Fluxes).

The Hardness Ratios and associated errors in the Master Source Object shall be identified by the field names “**hard_<x><y>**” and “**hard_<x><y>_err**”, respectively, where **<x>** and **<y>** are the higher and lower energy band designations. For example, the Hardness Ratio and associated error for the hard-to-soft Source Detection Energy Bands shall be identified by the field names "**`hard_hs`**" and "**`hard_hs_err`**", respectively.

1.1.6.2. Spectral Model Fits

Power law and thermal (Black Body) model spectra are fitted to the Aperture Photometry Fluxes and associated errors (**`photflux_aper`** and **`photflux_aper_err`**) measured in the source region [see section 1.1.5.3 (Aperture Photometry Fluxes)] in the set of Aperture Photometry Energy Bands [see section 1.1.5.1.1.2 (Aperture Photometry Energy Bands)].

1.1.6.2.1. Power Law Model Spectral Fit

The Power Law Model Spectral Fit is performed as described in section 1.2.4.4 of part V (Spectral Fit). The number of free parameters to be fitted will be restricted according to the S/N of the data, and may include only the total integrated flux, or the total integrated flux and the total neutral Hydrogen absorbing column, or the total integrated flux, total neutral Hydrogen absorbing column, and power law spectral index.

1.1.6.2.1.1. Spectral Index

The Spectral Index shall consist of a pair of double precision values that record the best-fit power law spectral index (α, defined as $F_{\nu} \sim \nu^{-\alpha}$) and associated error from the Power Law Model Spectral Fit. If the spectral index is not varied as part of the fit, a value for the spectral index of 1 (TBR) shall be used in the fit and the associated error shall be set to 0.

The Spectral Index and associated error in the Master Source Object shall be identified by the field names "**`alpha`**" and "**`alpha_err`**", respectively.

1.1.6.2.1.2. Power Law Model Spectral Fit Flux

The Power Law Model Spectral Fit Flux and associated error shall consist of 2 double precision values that record the integrated 2–10 keV flux and error derived from the best fitting Power Law Model Spectral Fit in units of ergs s^{-1} cm^{-2}.

The Power Law Model Spectral Fit Flux and associated error in the Master Source Object shall be identified by the field names "**flux_powlaw**" and "**flux_powlaw_err**", respectively.

1.1.6.2.1.3. Power Law Model Spectral Fit N_H

The Power Law Model Spectral Fit N_H shall consist of a pair of double precision values that record the best-fit total neutral Hydrogen absorbing column and associated error from the Power Law Model Spectral Fit. If the N_H is not varied as part of the fit, the Galactic N_H [section 1.1.6.3 (Galactic N_H)] shall be used in the fit and the associated error shall be set to 0.

The Power Law Model Spectral Fit N_H and associated error in the Master Source Object shall be identified by the field names "**nh_powlaw**" and "**nh_powlaw_err**", respectively.

1.1.6.2.1.4. Power Law Model Spectral Fit Statistic

The Power Law Model Spectral Fit Statistic shall consist of a double precision value that records the value of the Cash statistic per degree of freedom for the best fitting Power Law Model Spectral Fit.

The Power Law Model Spectral Fit Statistic field in the Master Source Object shall be identified by the field name "**powlaw_stat**".

1.1.6.2.2. Thermal (Black Body) Model Spectral Fit

The Thermal (Black Body) Model Spectral Fit is performed as described in section 1.2.4.4 of part V (Spectral Fit). The number of free parameters to be fitted will be restricted according to the S/N of the data, and may include only the total integrated flux, or the total integrated flux and the total neutral Hydrogen absorbing column, or the total integrated flux, total neutral Hydrogen absorbing column, and Black Body temperature.

1.1.6.2.2.1. Temperature

The Temperature shall consist of a pair of double precision values that record the best-fit temperature (kT) in units of keV and associated error from the Thermal (Black Body) Model Spectral Fit. If the temperature is not varied as part of the fit, a value for the temperature of 0.5 keV (TBR) shall be used in the fit and the associated error shall be set to 0.

The Temperature and associated error in the Master Source Object shall be identified by the field names "**`kt`**" and "**`kt_err`**", respectively.

1.1.6.2.2.2. Thermal (Black Body) Spectral Fit Flux

The Thermal (Black Body) Spectral Fit Flux and associated error shall consist of 2 double precision values that record the integrated 2–10 keV flux and error derived from the best fitting Thermal (Black Body) Model Spectral Fit in units of ergs s^{-1} cm^{-2}.

The Thermal (Black Body) Spectral Fit Flux and associated error in the Master Source Object shall be identified by the field names "**`flux_bb`**" and "**`flux_bb_err`**", respectively.

1.1.6.2.2.3. Thermal (Black Body) Spectral Fit N_H

The Thermal (Black Body) Spectral Fit N_H shall consist of a pair of double precision values that record the best-fit total neutral Hydrogen absorbing column and associated error from the Thermal (Black Body) Model Spectral Fit. If the N_H is not varied as part of the fit, the Galactic N_H [section 1.1.6.3 (Galactic N_H)] shall be used in the fit and the associated error shall be set to 0.

The Thermal (Black Body) Spectral Fit N_H and associated error in the Master Source Object shall be identified by the field names "**`nh_bb`**" and "**`nh_bb_err`**", respectively.

1.1.6.2.2.4. Thermal (Black Body) Model Spectral Fit Statistic

The Thermal (Black Body) Model Spectral Fit Statistic shall consist of a double precision value that records the value of the Cash statistic per degree of freedom for the best fitting Thermal (Black Body) Model Spectral Fit.

The Thermal (Black Body) Model Spectral Fit Statistic field in the Master Source Object shall be identified by the field name "**`bb_stat`**".

1.1.6.3. Galactic N_H

The Galactic N_H shall consist of a double precision value that records the Galactic neutral Hydrogen column density (N_H) in the direction of the source, determined from the interpolated data of Dickey & Lockman (1990; Ann. Rev. Astron. Astrophys., 28, 215) [TBR].

The Galactic N_H in the Master Source Object shall be identified by the field name "**`nh_gal`**".

1.1.7. Source Variability

1.1.7.1. Intra-observation Source Variability

Intra-observation Source Variability within any contributing observations shall be assessed according to the highest level of variability seen within any single contributing observation [see section 1.2.2.8 (Source Variability)]. Handling background variability is currently TBD.

1.1.7.1.1. Intra-observation Kolmogorov-Smirnov (K-S) Test

The Intra-observation Kolmogorov-Smirnov (K-S) Test probability shall consist of a double precision value for each Source Detection Energy Band that records the maximum value of the Kolmogorov-Smirnov (K-S) Test probability, **`ks_prob`**, that is calculated for each of the contributing observations [see section 1.2.2.8.1 (Kolmogorov-Smirnov (K-S) Test)].

The Intra-observation Kolmogorov-Smirnov (K-S) Test probability in the Master Source Object shall be identified by the field name "**`ks_intra_prob`**".

1.1.7.1.2. Intra-observation Kuiper's Test

The Intra-observation Kuiper's Test probability shall consist of a double precision value for each Source Detection Energy Band that records the maximum value of the Kuiper's Test probability, **`kp_prob`**, that is calculated for each of the contributing observations [see section 1.2.2.8.2 (Kuiper's Test)].

The Intra-observation Kuiper's Test probability in the Master Source

Object shall be identified by the field name "**kp_intra_prob**".

1.1.7.1.3. Intra-observation Variability Probability

The Intra-observation Variability Probability shall consist of a double precision value for each Source Detection Energy Band that records the maximum value of the Variability Probability, **var_prob**, that is calculated for each of the contributing observations [see section 1.2.2.8.3 (Gregory-Loredo Variability Probability)].

The Intra-observation Variability Probability in the Master Source Object shall be identified by the field name "**var_intra_prob**".

1.1.7.1.4. Intra-observation Variability Index

The Intra-observation Variability Index shall consist of a double precision value that records the maximum value of the Variability Index, **var_index**, that is calculated for each of the contributing observations [see section 1.2.2.8.4 (Variability Index)]. A detailed description of the computation of the Variability Index, and its interpretation, is documented in Appendix TBD.

The Intra-observation Variability Index in the Master Source Object shall be identified by the field name "**var_intra_index**".

1.1.7.1.5. Intra-observation Flux Variability

The Intra-observation Flux Variability shall consist of a double precision value for each Source Detection Energy Band that records the maximum value of the Flux Variability, **var_sigma**, that is calculated for each of the contributing observations [see section 1.2.2.8.5 (Flux Variability)], in units of ergs s^{-1} cm^{-2}.

The Intra-observation Flux Variability in the Master Source Object shall be identified by the field name "**var_intra_sigma**".

1.1.7.2. Inter-observation Source Variability

Inter-observation Source Variability between any contributing observations shall be assessed by application of a χ^2 hypothesis test applied to the source region photon fluxes observed in the contributing observations. Handling background variability is currently TBD.

1.1.7.2.1. Inter-observation Variability Probability

The Inter-observation Variability Probability shall consist of a double precision value for each Source Detection Energy Band that records the probability that the source region photon flux varied between the contributing observations based on the χ^2 distribution of the count rates and the standard deviations of the individual observations.

The Inter-observation Variability Probability in the Master Source Object shall be identified by the field name "**`var_inter_prob`**".

1.1.7.2.2. Inter-observation Variability Index

The Inter-observation Variability Index shall consist of a double precision value that records an index in the range [0.0, 10.0] that combines (TBR) (a) the Inter-observation Variability Probability [see section 1.1.7.2.1 (Inter-observation Variability Probability)] with (b) the fractions of the contributing observation source region photon fluxes that are within 3 σ and 5 σ of the average inter-observation source region photon fluxes, to evaluate whether the source region flux is uniform between the observations. The Variability Index recorded in the catalog is the maximum value of the variability indices computed for each Source Detection Energy Band. A detailed description of the computation of the Inter-observation Variability Index, and its interpretation, is documented in Appendix TBD.

The Inter-observation Variability Index in the Master Source Object shall be identified by the field name "**`var_inter_index`**".

1.1.7.2.3. Inter-observation Flux Variability

The Inter-observation Flux Variability shall consist of a double precision value for each Source Detection Energy Band that records the 1 σ statistical variability of the source region photon flux between contributing observations in units of ergs s^{-1} cm^{-2}.

The Inter-observation Flux Variability in the Master Source Object shall be identified by the field name “**`var_inter_sigma`**”.

1.1.8. Observation Summary

Summary information about the number of observations and total exposure times for various instrument configurations are recorded.

1.1.8.1. ACIS Observations

The ACIS observation summary information shall consist of 3 integer values that record the total numbers of ACIS imaging, ACIS/HETG, and ACIS/LETG observations, and 3 double precision values that record the total ACIS imaging, ACIS/HETG, and ACIS/LETG exposure times (seconds good time), for all ACIS observations contributing to the Master Source Object record for a source.

The total numbers of ACIS imaging, ACIS/HETG, and ACIS/LETG observations, and the total ACIS imaging, ACIS/HETG, and ACIS/LETG exposure times, in the Master Source Object shall be identified by the field names “**`acis_num`**”, “**`acis_hetg_num`**”, “**`acis_letg_num`**”, “**`acis_time`**”, “**`acis_hetg_time`**”, and “**`acis_letg_time`**”, respectively.

1.1.8.2. HRC Observations

The HRC observation summary information shall consist of 3 integer values that record the total numbers of HRC imaging, HRC/HETG, and HRC/LETG observations, and 3 double precision values that record the total HRC imaging, HRC/HETG, and HRC/LETG exposure times (seconds good time), for all HRC observations contributing to the Master Source Object record for a source.

The total numbers of HRC imaging, HRC/HETG, and HRC/LETG observations, and the total HRC imaging, HRC/HETG, and HRC/LETG exposure times, in the Master Source Object shall be identified by the field names “**`hrc_num`**”, “**`hrc_hetg_num`**”, “**`hrc_letg_num`**”, “**`hrc_time`**”, “**`hrc_hetg_time`**”, and “**`hrc_letg_time`**”, respectively.

1.2. Source-by-Observation Objects

1.2.1. Observation Object

1.2.1.1. Observation Identification

The Observation Identification fields shall consist of two integers that record the observation identification (*ObsId*) and observation interval identification (*ObI*) of the observation in which the source was detected.

The *ObsId* and *ObI* in the Observation Object shall be identified by the field names "**`obsid`**" and "**`obi`**", respectively.

1.2.1.2. Pointing Information

1.2.1.2.1. Target Designation

The Target Designation field shall consist of a character string value that records the target name *specified by the observer* in the original proposal under which the observation was obtained.

Note that the target name specified by the observer will match the target name in the *Chandra* Observation Catalog, but may be unrelated to the current source (or indeed any source in the field of view), and is not required to comply with any naming conventions.

The target name in the Observation Object shall be identified by the field name "**`targname`**".

1.2.1.2.2. Target Coordinates

The Target Coordinates field shall consist of 2 double precision values that record the target right ascension in decimal degrees and the signed target declination in decimal degrees, *as specified by the observer* in the original proposal under which the observation was obtained.

Note that the target coordinates specified by the observer will match the target coordinates in the *Chandra* Observation Catalog, but may be unrelated to the current source (or indeed any source in the field of view). The accuracy of the target coordinates specified by the observer is indeterminate.

The target right ascension and declination in the Observation Object shall be identified by the field names **`ra_targ`**" and "**`dec_targ`**", respectively.

1.2.1.2.3. Mean Pointing

The Mean Pointing of telescope during the observation shall consist of 3 double precision values that record the ICRS right ascension in decimal degrees, the signed ICRS declination in decimal degrees, and the roll angle of the optical axis of the telescope.

The Mean Pointing right ascension, declination, and roll angle fields in the Observation Object shall be identified by the field names "**`ra_pnt`**", "**`dec_pnt`**", and "**`roll_pnt`**", respectively.

1.2.1.2.4. Tangent Plane Reference

The Tangent Plane Reference shall consist of 3 double precision values that record the ICRS right ascension in decimal degrees, the signed ICRS declination in decimal degrees, and the roll angle that are the reference for the tangent plane projection of the world coordinates onto the SKY coordinate plane for the observation.

The Tangent Plane Reference right ascension, declination, and roll angle fields in the Observation Object shall be identified by the field names "**`ra_nom`**", "**`dec_nom`**", and "**`roll_nom`**", respectively.

1.2.1.3. Timing Information

1.2.1.3.1. Mission Elapsed Time

The Mission Elapsed Time fields shall consist of 3 double precision values that record the start and stop times of valid data (Good Time Intervals) for the observation, and the total elapsed time of the observation, in seconds Mission Elapsed Time (MET). MET is the standard time system for *Chandra* data, and counts the number of seconds TT since 1998-01-01T00:00:00 TT. Note that the total elapsed time of the observation is *not* equal to the total exposure time in the general case where there bad time may be present within the observation.

The Mission Elapsed Time start and stop times of valid data, and total elapsed time fields in the Observation Object shall be identified by the field names "**`gti_start`**", "**`gti_stop`**", and "**`gti_elapse`**", respectively.

1.2.1.3.2. FITS Standard (ISO 8601) Format

The FITS Standard (ISO 8601) Format fields consist of 2 character string values that record the FITS Standard (ISO 8601) Format equivalents to the start and stop times of valid data, in the format "**`<YYYY>-<MM>-<DD>T<HH>:<MM>:<SS>`**", where **`<YYYY>`** is the 4 digit year, and **`<MM>`**, **`<DD>`**, **`<HH>`**, **`<MM>`**, and **`<SS>`** are the 2 digit month, day of month, hours, minutes, and seconds TT corresponding to the equivalent MET, *truncated* to integer seconds.

The FITS Standard (ISO 8601) Format start and stop times of valid data in the Observation Object shall be identified by the field names "**`gti_obs`**" and "**`gti_end`**", respectively.

1.2.1.3.3. Modified Julian Date

The Modified Julian Date fields consist of 2 double precision values that record the MJD (TT) corresponding to the start of valid data, and the reference MJD (TT) corresponding to zero seconds MET (*i.e.*, MJD 50814.0 TT).

The Modified Julian Date of the start of valid data and the reference MJD in the Observation Object shall be identified by the field names "**`gti_mjd_obs`**" and "**`mjd_ref`**", respectively.

1.2.1.4. Instrument Information

1.2.1.4.1. Instrument and Grating Selection

The Instrument and Grating Selection fields consist of 2 character string values that record the instrument selection (**`ACIS`** or **`HRC`**), grating selection (**`NONE`**, **`HETG`**, or **`LETG`**), and datamode used to obtain the observation.

The instrument, grating, and datamode in the Observation Object shall be identified by the field names “**instrument**”, “**grating**”, and “**datamode**” respectively.

1.2.1.4.2. ACIS-specific Configuration Parameters

The ACIS-specific Configuration Parameters consist of 2 character string values that record the readout mode (**TIMED** for TIMED readout mode, **CONTINUOUS** for CONTINUOUS-CLOCKING readout mode), cycle for alternating exposure (interleaved) mode observations (**P** for the primary cycle, **S** for the secondary cycle), and 1 double precision value that records the CCD frame time (exptime) in seconds.

The readout mode, cycle, and frame time in the Observation Object shall be identified by the field names “**readmode**”, “**cycle**”, and “**exptime**” respectively.

1.2.1.4.3. HRC-specific Configuration Parameters

The HRC-specific Configuration Parameters consists of a Boolean whose value shall be **TRUE** if the HRC was in a high precision timing mode (all vetoes disabled) for the observation and **FALSE** otherwise.

High precision timing mode in the Observation Object shall be identified by the field name “**timing_mode**”.

1.2.1.5. Processing Information

The Processing Information consists of 3 character string values that record the processing system software and calibration database versions used to create the Level 3 event (evt3) file for the observation, and the creation date/time (UTC) of the Level 3 event (evt3) file for the observation. The latter is recorded in FITS Standard (ISO 8601) Format [see section 1.2.1.3.2 (FITS Standard (ISO 8601) Format)].

The processing system software version, calibration database version, and Level 3 event (evt3) file creation date/time in the Observation Object shall be identified by the field names “**ascdsver**”, “**caldbver**”, and “**crdate**” respectively.

1.2.2. Source Object

1.2.2.1. Source Identification

Each source detected within an observation shall be identified by means of an ordinal source region identifier and an ordinal source identifier within the source region. When combined with 1.2.1.1 (Observation Identification), the region identifier and source identifier (**`1`** or **`2`**) uniquely identify a source/observation pair. A Source Name is assigned when the individual observation source detection is merged to construct the Master Source Object.

The region identifier and source identifier in the Source Object shall be identified by the field names "**`region_id`**" and "**`source_id`**" respectively.

1.2.2.2. Position and Position Errors

The equatorial coordinates of a source in each source detection energy band shall be determined in the ICRS reference frame from the 2-D spatial fit to the source region in that energy band.

1.2.2.2.1. Equatorial Coordinates

The ICRS equatorial coordinates if each source in each source detection energy band shall consist of 5 double precision values that record the ICRS Right Ascension in decimal degrees, the signed ICRS Declination in decimal degrees, the major and minor axes of the 1 σ error ellipse of the source position in arcseconds, and the position angle of the major axis of the 1 σ error ellipse in degrees.

The Right Ascension and Declination fields in the Source Object shall be identified by the field names "**`ra`**" and "**`dec`**", respectively.

The major and minor axes and the position angle of the major axis of the 1 σ error ellipse shall be identified by the field names "**`err_ellipse_r0`**", "**`err_ellipse_r1`**", and "**`err_elipse_ang`**", respectively.

1.2.2.2.2. Galactic Coordinates

The Galactic coordinates corresponding to the source ICRS equatorial coordinates in each source detection energy band in section 1.2.2.2.1 (Equatorial Coordinates) shall consist of 2 double precision values that record the Galactic longitude, *l*, and latitude, *b*, for equinox J2000.0 and epoch J2000.0.

The Galactic latitude and Galactic longitude fields in the Source Object shall be identified by the field names "**`gal_b`**" and "**`gal_l`**", respectively.

1.2.2.2.3. Off-Axis Angles

The location of the source region that includes a source relative to the optical axis shall consist of 2 double precision values that record the off-axis angle, θ, in units of arcminutes, and the azimuthal angle, ϕ, in units of decimal degrees.

The off-axis angle and azimuthal angle in the Source Object shall be identified by the field names "**`theta`**" and "**`phi`**", respectively.

1.2.2.3. Source Significance

1.2.2.3.1. Detection Significance

The Detection Significance shall consist of a double precision value for each Source Detection Energy Band that records the significance of the detection *in the source region*, as determined by **`wavdetect`**, by dividing the net source counts in the source region by the Gehrels error of the estimated background counts in each pixel of the source region.

The Detection Significance in the Source Object shall be identified by the field name "**`detect_significance`**".

1.2.2.3.2. Flux Significance

The Flux Significance shall consist of a double precision value for each Source Detection Energy Band that records the flux significance (**`flux_fit`** / **`flux_fit_err`**) derived from the best fitting 2-D spatial fit model to the source.

The Flux Significance in the Source Object shall be identified by the field name "**`flux_significance`**".

1.2.2.4. Source Flags

1.2.2.4.1. Extent Flag

The Extent Flag consists of a coded byte whose value shall be 0 if the 2-D spatial fit to the source region is consistent with a point source at the 90% confidence level in all source detection energy bands. Otherwise, the Extent Flag coding shall be as follows:

1 = Forward fitting is not consistent with point source at the 90% confidence level in the broad band,
2 = Forward fitting is not consistent with point source at the 90% confidence level in the soft band,
4 = Forward fitting is not consistent with point source at the 90% confidence level in the medium band,
8 = Forward fitting is not consistent with point source at the 90% confidence level in the hard band,
16 = Forward fitting is not consistent with point source at the 99% confidence level in the broad band,
32 = Forward fitting is not consistent with point source at the 99% confidence level in the soft band,
64 = Forward fitting is not consistent with point source at the 99% confidence level in the medium band,
128 = Forward fitting is not consistent with point source at the 99% confidence level in the hard band.

The interactions between the Extent Flag and the Confusion Flag [see section 1.2.2.4.2 (Confusion Flag)] are discussed in more detail in Appendix TBD.

The Extent Flag field in the Source Object shall be identified by the field name "**`extent_flag`**".

1.2.2.4.1.1. Extent Statistic

The Extent Statistic shall consist of a double precision value for each Source Detection Energy Band that records the value of the Cash statistic per degree of freedom for the best fitting 2-D spatial fit to the source region that consists only of a single 2-D PSF model above the background.

The Extent Statistic field in the Source Object shall be identified by the field name “**`extent_stat`**”.

1.2.2.4.2. Confusion Flag

The Confusion Flag consists of a coded byte whose value shall be 0 if the 2-D spatial fit to the source region does *not* identify multiple point sources associated with the detect source regions in any source detection energy bands, *and* the detect source regions in all source detection energy bands do not overlap any other detect source regions. Otherwise, the Confusion Flag coding shall be as follows:

1 = Forward fitting detected multiple sources within the source region,
2 = Source region overlaps another source region,
4 = Source region overlaps another background region,
8 = Background region overlaps another source region,
16 = Background region overlaps another background region.

The interactions between the Confusion Flag and the Extent Flag [see section 1.2.2.4.1 (Extent Flag)] are discussed in more detail in Appendix TBD.

The Confusion Flag field in the Source Object shall be identified by the field name “**`conf_flag`**”.

1.2.2.4.3. Pile-up Information (ACIS)

1.2.2.4.3.1. Pile-up Warning

The Pile-up Warning field consists of a double precision value that records the total number of counts per ACIS frame in the source region, normalized by the number of pixels in the source region, averaged over the observation. Users can correlate this value with pile-up models to crudely estimate the pile-up fraction sources identified within the source region.

The Pile-up Warning field in the Source Object shall be identified by the field name “**`pileup_warning`**”.

1.2.2.4.4. Variability Flag

The Variability Flag consists of a coded byte whose value shall be 0 if variability is not detected either within the observation in any source detection energy band. Otherwise, the Variability Flag coding shall be as follows:

1 = Intra-observation variability was detected in the broad (**`b`**) band,
2 = Intra-observation variability was detected in the soft (**`s`**) band,
4 = Intra-observation variability was detected in the medium (**`m`**) band,
8 = Intra-observation variability was detected in the hard (**`h`**) band.

The criteria for flagging variability within a single observation are TBD.

The Variability Flag field in the Source Object shall be identified by the field name "**`var_flag`**".

1.2.2.4.5. Chip Edge Flag

The Chip Edge Flag consists of a coded byte whose value shall be 0 if the source position, source region, and background region do not dither off a chip boundary (ACIS CCD edge or HRC micro-channel plate segment edge) during the observation. Otherwise, the Chip Edge Flag coding shall be as follows:

1 = Source position dithers off any chip edge during the observation,
2 = Source region dithers off any chip edge during the observation,
4 = Background region dithers off any chip edge during the observation,
8 = Source position dithers off any chip edge for at least 50% of the time during the observation,
16 = Source region dithers off any chip edge for at least 50% of the time during the observation,
32 = Background region dithers off any chip edge for at least 50% of the time during the observation.

The Chip Edge Flag field in the Source Object shall be identified by the field name "**`edge_flag`**".

1.2.2.4.6. Multi-chip Flag

The Multi-chip Flag consists of a coded byte whose value shall be 0 if the source position, source region, and background region do not dither between two chips (ACIS CCDs or HRC micro-channel plate segments) during the observation. Otherwise, the Multi-chip Flag coding shall be as follows:

1 = Source position dithers across two chips during the observation,
2 = Source region dithers across two chips during the observation,
4 = Background region dithers across two chips during the observation,
8 = Source position dithers across more than two chips during the observation,
16 = Source region dithers across more than two chips during the observation,
32 = Background region dithers across more than two chips during the observation.

The Multi-chip Flag field in the Source Object shall be identified by the field name "**`multi_chip_flag`**".

1.2.2.5. Source Extent and Errors

1.2.2.5.1. Source Extent

The Source Extent is a rotated elliptical Gaussian parameterization of the raw extent of a source, and shall consist of 3 double precision values that record the major and minor axes of a rotated elliptical Gaussian in arcseconds on the detector, and the position angle of the elliptical Gaussian in degrees. The parameterization is computed from a moments analysis of the counts in the (elliptical) source region [see section 1.2.2.6.3.2 (Elliptical Aperture Sizes)].

The major axis, minor axis, and position angle of the major axis of the source ellipse fields in the Source Object shall be identified by the field names "**`mjr_axis_raw`**", "**`mnr_axis_raw`**", and "**`pos_angle_raw`**", respectively.

1.2.2.5.2. Point Spread Function Extent

The Point Spread Function Extent is a rotated elliptical Gaussian parameterization of the raw extent of the point spread function (PSF) at the location of a source, and shall consist of 3 double precision values for each source detection energy band that record the major and minor axes of a rotated elliptical Gaussian in arcseconds on the detector, and the position angle of the elliptical Gaussian in degrees, that the detection process would assign to a monochromatic PSF at the location of the source, and whose energy is the effective energy of that energy band. The parameterization of the PSF is computed from a moments analysis of the PSF counts in the (elliptical) source region [see section 1.2.2.6.3.2 (Elliptical Aperture Sizes)] and can be compared with the parameterization of the detected source to determine whether the latter is consistent with a point source.

The major axis, minor axis, and position angle of the major axis of the point spread function ellipse fields in the Source Object shall be identified by the field names "**`psf_mjr_axis_raw`**", "**`psf_mnr_axis_raw`**", and "**`psf_pos_angle_raw`**", respectively.

1.2.2.5.3. Deconvolved Source Extent

A parameterization of the deconvolved extent of each source shall be determined in each source detection energy band. The parameterization shall consist of the best fit values for the major axis, minor axis, and position angle (and associated errors) of a rotated elliptical Gaussian *that is convolved with the ray-trace local PSF* and fit to the source spatial event distribution as defined in section TBD.

The best estimates of the parameter values for a source shall consist of 6 double precision values that record the major and minor axes of the rotated elliptical Gaussian fit to the source extent in arcseconds, and the position angle of the major axis of the rotated elliptical Gaussian in degrees.

The major axis, major axis error, minor axis, minor axis error, position angle of the major axis, and position angle error fields in the Source Object shall be identified by the field names "**`major_axis`**", "**`major_axis_err`**", "**`minor_axis`**", "**`minor_axis_err`**", "**`pos_angle`**", and "**`pos_angle_err`**", respectively.

1.2.2.6. Source Fluxes

Source fluxes shall be determined by two methods: (1) from the 2-D spatial fit to the source detections in each Source Detection Energy Band, and (2) by aperture photometry in each Aperture Photometry Energy Band. Aperture photometry measurements shall be obtained in the source region, and in elliptical apertures that include the 50% and 90% ECFs of the PSF at the source location, with corrections applied for the PSF aperture fraction. The correction factor shall be computed from the ray-trace local PSF under the assumption that the source spatial distribution matches the local PSF.

1.2.2.6.1. Energy Bands

1.2.2.6.1.1. ACIS Observations

The energy bands used for ACIS observations are split into two categories. Source Detection Energy Bands are used in the source detection and 2-D spatial fit processing to detect sources; they are chosen to maximize the source detection efficiency for different kinds of sources observed using the back- and front-side illuminated CCDs. Aperture Photometry Energy Bands are used for aperture photometry and are chosen to maximize the scientific utility of the catalog. The process by which the energy bands were chosen is documented in Appendix TBD.

1.2.2.6.1.1.1. Source Detection Energy Bands

The Source Detection Energy Bands for ACIS are a single *broad* band, covering 0.2–7.5 keV (TBR), and *soft*, *medium*, and *hard* bands covering 0.2–0.5 keV, 0.5–2.0 keV, and 2.0–7.5 keV, respectively.

The broad, soft, medium, and hard Source Detection Energy Bands are designated "**`b`**", "**`s`**", "**`m`**", and "**`h`**", respectively (TBR).

1.2.2.6.1.1.2. Aperture Photometry Energy Bands

The Aperture Photometry Energy Bands for ACIS are a single *broad* band, covering 0.2–7.5 keV (TBR), and *TBD* bands covering TBD keV.

The broad, and *TBD* Aperture Photometry Energy Bands are designated "**`TBD`**", and "**`TBD`**", respectively.

1.2.2.6.1.2. HRC Observations

The HRC does not have significant energy resolution. There is a single broad energy band for both source detection and aperture photometry. The broad energy band for HRC includes pulse heights 0 : 254 (TBR), and corresponds approximately to photon energies 0.1–10.0 keV.

The broad energy band is designated "**`b`**".

1.2.2.6.2. 2-D Spatial Fit Fluxes

The 2-D Spatial Fit Fluxes and associated errors shall consist of 2 double precision values for each Source Detection Energy Band that record the integrated fluxes and errors derived from the best fitting 2-D spatial fit models in units of photons s^{-1} cm^{-2}.

The 2-D Spatial Fit Fluxes and associated errors in the Source Object shall be identified by the field names "**`flux_fit`**" and "**`flux_fit_err`**", respectively.

1.2.2.6.3. Aperture Photometry Fluxes

1.2.2.6.3.1. Aperture Counts

1.2.2.6.3.1.1. Aperture Total Counts

The Aperture Total Counts shall consist of 4 double precision values for each Aperture Photometry Energy Band that record the total number of source plus background counts in the source region, background region, and in elliptical apertures that include the 50% and 90% ECFs of the PSF at the source location, uncorrected by the PSF aperture fraction.

The Aperture Total Counts in the source region, background region, and in elliptical apertures that include the 50% and 90% ECFs of the PSF at the source location, in the Source Object shall be identified by the field names "**`cnts_aper`**", "**`cnts_aperbkg`**", "**`cnts_aper50`**", and "**`cnts_aper90`**", respectively.

1.2.2.6.3.1.2. Aperture Source Counts

The Aperture Source Counts shall consist of 4 double precision values for each Aperture Photometry Energy Band that record the number of background-subtracted source counts in the source region, background region, and in elliptical apertures that include the 50% and 90% ECFs of the PSF at the source location, corrected by the PSF aperture fraction.

The Aperture Source Counts in the source region, background region, and in elliptical apertures that include the 50% and 90% ECFs of the PSF at the source location, in the Source Object shall be identified by the field names "**`src_cnts_aper`**", "**`src_cnts_aperbkg`**", "**`src_cnts_aper50`**", and "**`src_cnts_aper90`**", respectively.

1.2.2.6.3.2. Elliptical Aperture Sizes

The parameter values that define the (elliptical) source and background regions, and the elliptical apertures that include the 50% and 90% ECFs of the PSF at the source location used to extract the Aperture Counts, Count Rates, and Energy Fluxes shall consist of 12 double precision values that record the major and minor axes of the (elliptical) source and background regions, and the elliptical apertures that include the 50% and 90% ECFs of the PSF at the source location in arcseconds, and the position angles of the major axes of the elliptical apertures in degrees. The source and background regions are determine by scaling and merging the individual source detection regions resulting from all of the source detection process (**`wavdetect`**) spatial scales and source detection energy bands in which the source is detected. The merging and scaling process is described in section 1.1.4.4 of part V (ROI Generation).

The major axis, minor axis, and position angle of the major axis fields that define the (elliptical) source and background regions, and the elliptical apertures that include the 50% and 90% ECFs of the PSF at the source location in the Master Source Object shall be identified by the field names "**`mjr_axis_aper`**", "**`mnr_axis_aper`**", "**`pos_angle_aper`**", "**`mjr_axis_aperbkg`**", "**`mnr_axis_aperbkg`**", "**`pos_angle_aperbkg`**", "**`mjr_axis_aper50`**", "**`mnr_axis_aper50`**", "**`pos_angle_aper50`**", "**`mjr_axis_aper90`**", "**`mnr_axis_aper90`**", and "**`pos_angle_aper90`**", respectively.

1.2.2.6.3.3. Aperture Source Count Rates

The Aperture Source Count Rates and associated errors shall consist of 8 double precision values for each Aperture Photometry Energy Band that record the background-subtracted source count rates and count rate errors in the source region, background region, and in elliptical apertures that include the 50% and 90% ECFs of the PSF at the source location, corrected by the PSF aperture fraction, in units of Hz.

The Aperture Source Count Rates in the source region, background region, and in elliptical apertures that include the 50% and 90% ECFs of the PSF at the source location, and their associated errors, in the Source Object shall be identified by the field names "**`src_rate_aper`**", "**`src_rate_aperbkg`**", "**`src_rate_aper50`**", "**`src_rate_aper90`**", "**`src_rate_aper_err`**", "**`src_rate_aperbkg_err`**", "**`src_rate_aper50_err`**", and "**`src_rate_aper90_err`**", respectively.

1.2.2.6.3.4. Aperture Source Energy Fluxes

The Aperture Source Energy Fluxes and associated errors shall consist of 6 double precision values for each Aperture Photometry Energy Band that record the fluxes and errors in the source region and in elliptical apertures that include the 50% and 90% ECFs of the PSF at the source location, corrected by the PSF aperture fraction, in units of photons s^{-1} cm^{-2} and ergs s^{-1} cm^{-2}. The conversion from photons s^{-1} cm^{-2} to ergs s^{-1} cm^{-2} is performed by summing the photon energies for each incident source photon and scaling by the local value of the ARF at the location of the incident photon.

The Aperture Source Energy Fluxes in the source region, and in elliptical apertures that include the 50% and 90% ECFs of the PSF at the source location, and their associated errors, in the Source Object shall be identified by the field names "**`photflux_aper`**", "**`photflux_aper50`**", "**`photflux_aper90`**", "**`photflux_aper_err`**", "**`photflux_aper50_err`**", and "**`photflux_aper90_err`**", respectively, for the photon fluxes, and "**`flux_aper`**", "**`flux_aper50`**", "**`flux_aper90`**", "**`flux_aper_err`**", "**`flux_aper50_err`**", and "**`flux_aper90_err`**", respectively, for the energy fluxes.

1.2.2.7. Spectral Properties

1.2.2.7.1. Spectral Model Fits

Power law and thermal (Black Body) model spectra are fitted to the Aperture Source Energy Fluxes and associated errors (**`photflux_aper`** and **`photflux_aper_err`**) measured in the source region [see section 1.2.2.6.3.4 (Aperture Source Energy Fluxes)] in the set of Aperture Photometry Energy Bands [see section 1.2.2.6.1.1.2 (Aperture Photometry Energy Bands)].

1.2.2.7.1.1. Power Law Model Spectral Fit

The Power Law Model Spectral Fit is performed as described in section 1.2.4.4 of part V (Spectral Fit). The number of free parameters to be fitted will be restricted according to the S/N of the data, and may include only the total integrated flux, or the total integrated flux and the total neutral Hydrogen absorbing column, or the total integrated flux, total neutral Hydrogen absorbing column, and power law spectral index.

1.2.2.7.1.1.1. Spectral Index

The Spectral Index shall consist of a pair of double precision values that record the best-fit power law spectral index (α, defined as $F_{\nu} \sim \nu^{-\alpha}$) and associated error from the Power Law Model Spectral Fit. If the spectral index is not varied as part of the fit, a value for the spectral index of 1 (TBR) shall be used in the fit and the associated error shall be set to 0.

The Spectral Index and associated error in the Source Object shall be identified by the field names "**`alpha`**" and "**`alpha_err`**", respectively.

1.2.2.7.1.1.2. Power Law Model Spectral Fit Flux

The Power Law Model Spectral Fit Flux and associated error shall consist of 2 double precision values that record the integrated 2–10 keV flux and error derived from the best fitting Power Law Model Spectral Fit in units of ergs s^{-1} cm^{-2}.

The Power Law Model Spectral Fit Flux and associated error in the Source Object shall be identified by the field names "**`flux_powlaw`**" and "**`flux_powlaw_err`**", respectively.

1.2.2.7.1.1.3. Power Law Model Spectral Fit N_H

The Power Law Model Spectral Fit N_H shall consist of a pair of double precision values that record the best-fit total neutral Hydrogen absorbing column and associated error from the Power Law Model Spectral Fit. If the N_H is not varied as part of the fit, the Galactic N_H [section 1.1.6.3 (Galactic N_H)] shall be used in the fit and the associated error shall be set to 0.

The Power Law Model Spectral Fit N_H and associated error in the Source Object shall be identified by the field names "**`nh_powlaw`**" and "**`nh_powlaw_err`**", respectively.

1.2.2.7.1.1.4. Power Law Model Spectral Fit Statistic

The Power Law Model Spectral Fit Statistic shall consist of a double precision value that records the value of the Cash statistic per degree of freedom for the best fitting Power Law Model Spectral Fit.

The Power Law Model Spectral Fit Statistic field in the Source Object shall be identified by the field name "**`powlaw_stat`**".

1.2.2.7.1.2. Thermal (Black Body) Model Spectral Fit

The Thermal (Black Body) Model Spectral Fit is performed as described in section 1.2.4.4 of part V (Spectral Fit). The number of free parameters to be fitted will be restricted according to the S/N of the data, and may include only the total integrated flux, or the total integrated flux and the total neutral Hydrogen absorbing column, or the total integrated flux, total neutral Hydrogen absorbing column, and Black Body temperature.

1.2.2.7.1.2.1. Temperature

The Temperature shall consist of a pair of double precision values that record the best-fit temperature (kT) in units of keV and associated error from the Thermal (Black Body) Model Spectral Fit. If the temperature is not varied as part of the fit, a value for the temperature of 1.0 keV (TBR) shall be used in the fit and the associated error shall be set to 0.

The Temperature and associated error in the Source Object shall be identified by the field names "**`kt`**" and "**`kt_err`**", respectively.

1.2.2.7.1.2.2. Thermal (Black Body) Spectral Fit Flux

The Thermal (Black Body) Spectral Fit Flux and associated error shall consist of 2 double precision values that record the integrated 2–10 keV flux and error derived from the best fitting Thermal (Black Body) Model Spectral Fit in units of ergs s^{-1} cm^{-2}.

The Thermal (Black Body) Spectral Fit Flux and associated error in the Source Object shall be identified by the field names "**`flux_bb`**" and "**`flux_bb_err`**", respectively.

1.2.2.7.1.2.3. Thermal (Black Body) Spectral Fit N_H

The Thermal (Black Body) Spectral Fit N_H shall consist of a pair of double precision values that record the best-fit total neutral Hydrogen absorbing column and associated error from the Thermal (Black Body) Model Spectral Fit. If the N_H is not varied as part of the fit, the Galactic N_H [section 1.1.6.3 (Galactic N_H)] shall be used in the fit and the associated error shall be set to 0.

The Thermal (Black Body) Spectral Fit N_H and associated error in the Source Object shall be identified by the field names "**`nh_bb`**" and "**`nh_bb_err`**", respectively.

1.2.2.7.1.2.4. Thermal (Black Body) Model Spectral Fit Statistic

The Thermal (Black Body) Model Spectral Fit Statistic shall consist of a double precision value that records the value of the Cash statistic per degree of freedom for the best fitting Thermal (Black Body) Model Spectral Fit.

The Thermal (Black Body) Model Spectral Fit Statistic field in the Source Object shall be identified by the field name "**`bb_stat`**".

1.2.2.8. Source Variability

Source variability within an observation shall be assessed by three methods: (1) application of the Kolmogorov-Smirnov (K-S) Test to the (unbinned) source region events, (2) application of the Kuiper's Test to the source region counts, and (3) computation of the Gregory-Loredo Variability Probability from the source region counts. Handling background variability is currently TBD.

1.2.2.8.1. Kolmogorov-Smirnov (K-S) Test

The Kolmogorov-Smirnov (K-S) Test probability shall consist of a double precision value for each Source Detection Energy Band that records the probability that the receipt times of the events within the source region are consistent with a uniform source region flux throughout the observation. The probability shall be computed from a one-sample, two-sided K-S test applied to the unbinned event data, with corrections applied for good time intervals and for the source region dithering across regions of variable exposure during the observation.

The Kolmogorov-Smirnov (K-S) Test probability in the Source Object shall be identified by the field name "**`ks_prob`**".

1.2.2.8.2. Kuiper's Test

The Kuiper's Test probability shall consist of a double precision value for each Source Detection Energy Band that records the probability that the receipt times of the events within the source region are consistent with a uniform source region flux throughout the observation. The probability shall be computed from a one-sample Kuiper's test applied to the unbinned event data, with corrections applied for good time intervals and for the source region dithering across regions of variable exposure during the observation.

The Kuiper's Test probability in the Source Object shall be identified by the field name "**`kp_prob`**".

1.2.2.8.3. Gregory-Loredo Variability Probability

The Gregory-Loredo Variability Probability shall consist of a double precision value for each Source Detection Energy Band that records the probability that the source region flux is not uniform throughout the observation based on the odds ratio calculated from a Gregory-Loredo analysis of the receipt times of the events within the source region.

The Gregory-Loredo Variability Probability in the Source Object shall be identified by the field name "**var_prob**".

1.2.2.8.4. Variability Index

The Variability Index shall consist of a double precision value that records an index in the range [0.0, 10.0] that combines (a) the Gregory-Loredo Variability Probability [see section 1.2.2.8.3 (Gregory-Loredo Variability Probability)] with (b) the fractions of the multi-resolution light curve output by the Gregory-Loredo analysis [section 2.2.6 of part III (Light Curve Object)] that are within 3 σ and 5 σ of the average count rate, to evaluate whether the source region flux is uniform throughout the observation. The Variability Index recorded in the catalog is the maximum value of the variability indices computed for each Source Detection Energy Band. A detailed description of the computation of the Variability Index, and its interpretation, is documented in Appendix TBD.

The Variability Index in the Source Object shall be identified by the field name "**var_index**".

1.2.2.8.5. Flux Variability

The Flux Variability shall consist of a double precision value for each Source Detection Energy Band that records the 1 σ statistical variability of the source region flux derived from the multi-resolution light curve output by the Gregory-Loredo analysis [section 2.2.6 of part III (Light Curve Object)] in units of ergs s^{-1} cm^{-2}.

The Flux Variability in the Source Object shall be identified by the field name "**var_sigma**".

1.2.2.9. Timing Information

1.2.2.9.1. Livetime

The Livetime field shall consist of a double precision value that records the livetime for the observation, in seconds. The livetime is the effective exposure time after applying the good time intervals (GTIs) and the deadtime correction factor (**dtcor**).

The livetime in the Source Object shall be identified by the field name "**livetime**".

1.2.2.10. Instrument Information

1.2.2.10.1. Detector Name

The Detector Name field consist of a character string value that records the name of the detector elements that the source region dithers over during the observation. For HRC-I, the recorded values shall be "**HRC-I**", and for HRC-S, the recorded values shall be "**HRC-S**". For ACIS, the recorded value shall be "**ACIS-<n>**", where **<n>** is the string representation of the set of ACIS CCDs over which the source region dithers, identified by CCD number (0–9) in numeric order. For example, if the source dithered across the boundary of all 4 ACIS-I chips (I0–I3), then the recorded value would be "**ACIS-0123**", and if the source region dithered across the boundary of ACIS-S chips S3 and S4, then the recorded value would be "**ACIS-78**".

The Detector Name in the Source Object shall be identified by the field name "**detector**".

2. Criteria for Source Inclusion

Master Source Objects and Source-by-Observation Objects that are included in the database shall only be candidates for inclusion in the catalog if they meet certain requirements, listed in this section. Candidate sources that meet these requirements are included in the catalog by following the procedures documented in section 5 (Release Process).

2.1. Master Source Objects

Each Master Source Object that is included in the catalog shall *only* include contributions from Source-by-Observation Objects that meet the requirements for inclusion in the catalog.

2.1.1. Source Significance

The Master Source Object for a source must have a minimum flux significance [**significance** in section 1.1.5.4 (Source Significance)] of 3.0 to be a candidate for inclusion in the catalog.

2.2. Source-by-Observation Objects

All Source-by-Observation Objects that contribute to the merge processing used to generate a Master Source Object *that is included in the catalog* shall be included in the catalog. Source-by-Observation Objects that *do not* contribute to the merge processing used to generate a Master Source Object that is included in the catalog may be present in the database, but shall not be included in the catalog.

All sub-objects (*e.g.*, Observation Object, Source Object) of the Source-by-Observation Object for a given source and observation shall be treated as a single unit when applying this requirement.

2.2.1. Flux Significance

The Source-by-Observation Object for a source and observation must have a minimum flux significance [**`flux_significance`** in section 1.2.2.3.2 (Flux Significance)] in the Source Object of 3.0 (TBR) to be a candidate for inclusion in the catalog.

2.3. Observation Selection

2.3.1. Observation Background

Observations whose mean background value, after background flare removal and averaged over 50% of the observation interval, is more than 5 times the average total background rate for the instrument (TBR), with ACIS back-illuminated and front-illuminated CCDs considered separately, shall not be included in the catalog.

2.3.2. Extended Source Fields

Observations that include sources that are extended on 5 arcminute (TBR) or larger size scales that have an average count rate that is more that 10 times the average total background rate for the instrument (TBR), with ACIS back-illuminated and front-illuminated CCDs considered separately, shall not be included in the catalog.

2.4. Quality Assurance Process

Only Master Source Objects and Source-by-Observation Objects that meet the requirements of part VI (Quality Assurance Requirements) shall be candidates for inclusion in the catalog.

3. Catalog Characterization (Statistical)

3.1. Source Detection Efficiency

Characterization of Source Detection Efficiency shall be performed for each instrument (ACIS-I, ACIS-S, HRC-I, and HRC-S) assuming that the nominal instrument aim-point and default SIM offset positions are used for the observation. The characterization shall apply to the complete source detection process, including 2-D Spatial Fitting.

Where the characterization depends on the source spectral energy distribution, the characterization shall be performed assuming an unabsorbed power-law spectral energy distribution with power law indices $\alpha = 1$ (TBR), where $F_\nu = \nu^{-\alpha}$, and a thermal spectral energy distribution with a black-body temperature $T = 10^6$ K (TBR).

Where the characterization is performed per (Source Detection or Aperture Photometry) Energy Band, then the source shall be assumed to have a monochromatic spectrum with an energy equal to the equivalent monochromatic energy of the Energy Band.

3.1.1. Limiting Sensitivity

Characterization shall record the limiting flux of a point source that can be detected at the catalog flux significance limit [see section 2.1.1 (Source Significance)] as a function of off-axis angle, total background integrated over the duration of the observation, and instrument configuration.

Off-axis angles from 0 to 15 arcminutes (TBR) shall be characterized. Total (X-ray plus instrumental) backgrounds, which include contributions of ½, 1, and 5 times the average instrumental background rate derived from stowed observations for ACIS (TBR), and TBD for HRC, shall be characterized, with ACIS back-illuminated and front-illuminated CCDs considered separately.

3.1.1.1. Sky Coverage

Characterization shall record the total sky coverage in square degrees sensitive to detection of a point source at the catalog flux significance limit [see section 2.1.1 (Source Significance)] as a function of source flux and instrument configuration. ACIS back-illuminated and front-illuminated CCDs considered separately.

3.1.2. Completeness

Characterization shall record the fraction of point sources that are detected at the catalog flux significance limit [see section 2.1.1 (Source Significance)] as a function of source flux, off-axis angle, total background integrated over the duration of the observation, and instrument configuration.

Off-axis angles from 0 to 15 arcminutes (TBR) shall be characterized. Total (X-ray plus instrumental) backgrounds, which include contributions of ½, 1, and 5 times the average instrumental background rate derived from stowed observations for ACIS (TBR), and TBD for HRC, shall be characterized, with ACIS back-illuminated and front-illuminated CCDs considered separately.

3.1.3. False Source Rate

Characterization shall record the number of false sources per square degree that are erroneously detected at the catalog flux significance limit [see section 2.1.1 (Source Significance)] as a function of source flux, off-axis angle, total background integrated over the duration of the observation, and instrument configuration. Image artifacts (e.g., readout streaks, unscreened bad pixels, ...) that are not rejected by the detection process shall be included in the determination of the false source rate.

Off-axis angles from 0 to 15 arcminutes (TBR) shall be characterized. Total (X-ray plus instrumental) backgrounds, which include contributions of ½, 1, and 5 times the average instrumental background rate derived from stowed observations for ACIS (TBR), and TBD for HRC, shall be characterized, with ACIS back-illuminated and front-illuminated CCDs considered separately.

3.2. Photometric Uncertainty

3.3. Astrometric Uncertainty

3.3.1. Absolute Source Position Uncertainty

Characterization shall record the uncertainty in measured absolute source positions of un-piled-up point sources in the ICRS reference frame as a function of source flux, off-axis angle, total background integrated over the duration of the observation, and instrument configuration.

Off-axis angles from 0 to 15 arcminutes (TBR) shall be characterized. Source fluxes from 10 to 100,000 counts, and total (X-ray plus instrumental) backgrounds, which include contributions of ½, 1, and 5 times the average instrumental background rate derived from stowed observations for ACIS (TBR), and TBD for HRC, shall be characterized.

3.3.2. Relative Source Position Uncertainty

Characterization shall record the uncertainty in measured relative source positions of pairs of un-piled-up point sources in the ICRS reference frame as a function of source fluxes, off-axis angles, total background integrated over the duration of the observation, and instrument configuration.

Source pairs with separations of 0 to 30 arcminutes (TBR), and source off-axis angles from 0 to 15 arcminutes (TBR) shall be characterized. Source fluxes from 10 to 100,000 counts, and total (X-ray plus instrumental) backgrounds, which include contributions of ½, 1, and 5 times the average instrumental background rate derived from stowed observations for ACIS (TBR), and TBD for HRC, shall be characterized.

3.4. Source Extent

Characterization shall record the uncertainty in the measured source extent parameterization for point sources and extended sources with an elliptical flux distribution as a function of source flux, off-axis angle, total background integrated over the duration of the observation, and instrument configuration.

Point sources and extended sources with size scales up to 1 arcminute (TBR), located at off-axis angles from 0 to 15 arcminutes (TBR), shall be characterized. Source fluxes from 10 to 100,000 counts, and total (X-ray plus instrumental) backgrounds, which include contributions of ½, 1, and 5 times the average instrumental background rate derived from stowed observations for ACIS (TBR), and TBD for HRC, shall be characterized.

3.4.1. Close Source Pairs

Characterization shall record the uncertainty in measured source extent parameterizations for close pairs of un-piled-up point sources as a function of source separations, fluxes, off-axis angles, total background integrated over the duration of the observation, and instrument configuration.

Source pairs with separations from 20% to 150% (TBR) of the 90% circular Encircled Counts Fraction (ECF) radius, and source off-axis angles from 0 to 15 arcminutes (TBR) shall be characterized. Source fluxes from 10 to 100,000 counts, and Total (X-ray plus instrumental) backgrounds, which include contributions of ½, 1, and 5 times the average instrumental background rate derived from stowed observations for ACIS (TBR), and TBD for HRC, shall be characterized.

3.5. Source Variability

4. Traceability

4.1. Revision History Tracking

4.1.1. Data History

The history of every data element within the catalog shall be maintained, including a record of date and time of the insertion, revision, or deletion of any data element. Changes to the catalog shall only be performed according to the requirements of section 5 (Release Process).

4.1.2. Catalog Releases

Each catalog release shall correspond to a view of the state of the catalog corresponding to a specified (predefined) date and time. New releases of the catalog shall take place according to the requirements of section 5

(Release Process).

5. Release Process

5.1. Timing and Notification

Notification of the planned timing of catalog releases shall be provided to the user community at least 1 month (TBD) prior to the scheduled date of the release.

Except in exception circumstances, catalog releases shall not be scheduled to occur between the release of a *Chandra* Announcement of Opportunity (AO) and the AO deadline.

5.2. Frequency

Catalog releases shall occur no more frequently than every 6 months, with no more than every year being the goal after 2 years following the first release of the catalog.

5.3. Atomicity of Releases

From the point of view of the user, each catalog release shall occur in an atomic manner. User views of a partially updated catalog shall not be permitted.

5.4. Characterization

The statistical characterization of the properties of the contents of a catalog release [see section 3 (Catalog Characterization (Statistical))] shall be provided to the user community at the same time as the catalog release, with the exception that the catalog release shall not be held up if a preliminary statistical characterization is available for all of the statistical properties, and the characterization of each property is largely complete, well-understood, and stable.

II. Database Requirements

1. Database Contents

III. Archive Requirements

1. Archive Contents

1.1. Data Format

1.1.1. FITS Files

The Data Objects defined in section 2 (Data Object Definitions) shall be recorded in data files that are formatted in accordance with the requirements of the NOST FITS standard, version 2.0 or later. The headers of these files shall comply with the requirements of the ASC FITS File Designers' Guide, version ASC-FITS-2.1.0, as amended.

FITS file contents and header metadata contents shall include all information needed to enable the files to be manipulated by data analysis tools appropriate to the type of data product that are part of the CXC *CIAO* data analysis package. Data products shall support compatible use with other astronomical data analysis software to the extent possible given implementation constraints, provided that such compatibility is not inconsistent with the requirements of the tools that comprise the *CIAO* data analysis package.

2. Data Object Definitions

2.1. Full Field Objects

A set of Full Field Objects is created for each observation that is processed through the Level 3 pipeline that is described in part V. The Full Field Objects are identified by the observation identification (*ObsId*) and observation interval identification (*ObI*) of the observation [see section 1.2.1.1 of part I (Observation Identification)], and by cycle [see section 1.2.1.4.2 of part I (ACIS-specific Configuration Parameters)] for ACIS alternating exposure (interleaved) mode observations.

2.1.1. Full Field Event Object

The Full Field Event Object consists of single FITS format event file for each observation that results from Level 3 processing described in part V. The observation event file will have been reprocessed through

acis_process_events or **hrc_process_events** (as appropriate) to apply the latest instrument calibrations, and will have has the standard event status and event grade (ACIS only) filters applied. In addition, the ACIS-S4 CCD will have the **destreak** algorithm applied. Good time intervals will be revised to eliminate periods of background flares.

The Full Field Event Object FITS file shall be named

<i><s><obs>_<obi>N<v>[_<c>]_evt3.fits

where **<i>** is the instrument designation, **<s>** is the data source, **<obs>** is the observation identification, **<obi>** is the observation interval identification, **<v>** is the data product version number, and **<c>** is the cycle. The optional discriminator identified in square brackets is included only for ACIS alternating exposure (interleaved) mode observations.

2.1.1.1. Good Time Intervals

The Good Time Intervals (GTIs) record the start and stop times (in MET seconds) of intervals during which time the quality of the event data is usable. The GTIs associated with the Full Field Event Object [see section 2.1.1 (Full Field Event Object)] are included as additional HDUs in the Full Field Event Object FITS format event file. There is a single GTI for an event file containing HRC data. For an event file containing ACIS data, there is a GTI for each ACIS CCD included in the full field observation.

2.1.2. Full Field Image Object

The Full Field Image Object consists of a set of FITS format image files, one for each Source Detection Energy Band, for each observation. Each Full Field Image Object is the image equivalent of the Full Field Event Object [section 2.1.1 (Full Field Event Object)] filtered by the appropriate Source Detection Energy Band, blocked at TBD resolution in SKY coordinates. The images are recorded in flux units of photons s^{-1} cm^{-2} by dividing the filtered and blocked Full Field Event Object event data by the Full Field Exposure Map [section 2.1.4 (Full Field Exposure Map)].

The Full Field Image Object FITS files shall be named

<i><s><obs>_<obi>N<v>[_<c>]_<r><b>_img3.fits

where **<i>** is the instrument designation, **<s>** is the data source, **<obs>** is the observation identification, **<obi>** is the observation interval identification, **<v>** is the data product version number, **<r>** is the region identifier, **<b>** is the energy band designation, and **<c>** is the cycle. The optional discriminator identified in square brackets is included only for ACIS alternating exposure (interleaved) mode observations.

2.1.3. Full Field Background Image Object

The Full Field Background Image Object consists of a set of FITS format image files, one for each Source Detection Energy Band, for each observation. Each Full Field Background Image Object is the background counts image in the appropriate Source Detection Energy Band that is used in the source detection process as described in section 1.1.4 of part V (Source Detection), scaled to flux units of photons s^{-1} cm^{-2} by dividing by the Full Field Exposure Map [section 2.1.4 (Full Field Exposure Map)].

The Full Field Background Image Object FITS files shall be named

<i><s><obs>_<obi>N<v>[_<c>]_<r><b>_bkgimg3.fits

where **<i>** is the instrument designation, **<s>** is the data source, **<obs>** is the observation identification, **<obi>** is the observation interval identification, **<v>** is the data product version number, **<r>** is the region identifier, **<b>** is the energy band designation, and **<c>** is the cycle. The optional discriminator identified in square brackets is included only for ACIS alternating exposure (interleaved) mode observations.

2.1.4. Full Field Exposure Map

The Full Field Exposure Map object consists of single FITS format event file for each observation and energy band that results from Level 3 processing described in part V. A full field instrument map is generated at the equivalent monochromatic energy for each energy band (TBR), and the exposure map is computed by applying the aspect histogram sampled at TBD resolution as described in part V.

The Full Field Exposure Map object FITS file shall be named

<i><s><obs>_<obi>N<v>[_<c>]_<b>_exp3.fits

where **<i>** is the instrument designation, **<s>** is the data source, **<obs>**

is the observation identification, **<obi>** is the observation interval identification, **<v>** is the data product version number, **<b>** is the energy band designation, and **<c>** is the cycle. The optional discriminator identified in square brackets is included only for ACIS alternating exposure (interleaved) mode observations.

2.2. Source Region Objects

A set of Source Region Objects is created for each detected source region in each observation that is processed through the Level 3 pipeline that is described in section V . The Source Region Objects are identified by the region identifier [see section 1.2.2.1 of part I (Source identification)], observation identification (*ObsId*) and observation interval identification (*ObI*) of the observation [see section 1.2.1.1 of part I (Observation Identification)], and by cycle [see section 1.2.1.4.2 of part I (ACIS-specific Configuration Parameters)] for ACIS alternating exposure (interleaved) mode observations.

2.2.1. Source Region Event Object

The Source Region Event Object consists of a single FITS format event file for each observation and detection source region. The source region event file is the result of applying a rectangular SKY region filter that has a size equal to the bounding box of the background region of interest (ROI) corresponding to the detected source region.

The Source Region Event Object FITS files shall be named

<i><s><obs>_<obi>N<v>[_<c>]_<r><b>_regevt3.fits

where **<i>** is the instrument designation, **<s>** is the data source, **<obs>** is the observation identification, **<obi>** is the observation interval identification, **<v>** is the data product version number, **<r>** is the region identifier, **<b>** is the energy band designation, and **<c>** is the cycle. The optional discriminator identified in square brackets is included only for ACIS alternating exposure (interleaved) mode observations.

2.2.1.1. Good Time Intervals

The Good Time Intervals (GTIs) record the start and stop times (in MET seconds) of intervals during which time the quality of the event data is usable. The GTIs associated with the Source Region Event Object [see section 2.2.1 (Source Region Event Object)] are included as additional HDUs in the Full Field Event Object FITS format event file. There is a single GTI for an event file containing HRC data. For an event file containing ACIS data, there is a GTI for each ACIS CCD included in the source region.

2.2.2. Spectrum Object

2.2.2.1. PHA Spectrum

The PHA Spectrum object consists of single FITS format file for each observation and detection source region that records the low resolution spectrum of the source extracted from the source region for an ACIS observation, resulting from Level 3 processing described in part V. The PHA spectrum is constructed using weighted responses for the areas of the detector over which the source region dithers.

The PHA Spectrum object FITS file shall be named

`<i><s><obs>_<obi>N<v>[_<c>]_<r>_pha3.fits`

where **`<i>`** is the instrument designation, **`<s>`** is the data source, **`<obs>`** is the observation identification, **`<obi>`** is the observation interval identification, **`<v>`** is the data product version number, **`<r>`** is the region identifier, and **`<c>`** is the cycle. The optional discriminator identified in square brackets is included only for ACIS alternating exposure (interleaved) mode observations.

2.2.2.2. Auxiliary Response File

The Auxiliary Response File object consists of single FITS format file for each observation and detection source region that records the weighted ARF for the areas of the detector over which the source region dithers.

The Auxiliary Response File object FITS file shall be named

`<i><s><obs>_<obi>N<v>[_<c>]_<r>_arf3.fits`

where **`<i>`** is the instrument designation, **`<s>`** is the data source, **`<obs>`** is the observation identification, **`<obi>`** is the observation interval identification, **`<v>`** is the data product version number, **`<r>`** is the region identifier, and **`<c>`** is the cycle. The optional discriminator identified in square brackets is included only for ACIS alternating exposure (interleaved) mode observations.

2.2.2.3. Redistribution Matrix File

The Redistribution Matrix File object consists of single FITS format file for each observation and detection source region that records the weighted RMF for the areas of the detector over which the source region dithers.

The Redistribution Matrix File object FITS file shall be named

<i><s><obs>_<obi>N<v>[_<c>]_<r>_rmf3.fits

where **<i>** is the instrument designation, **<s>** is the data source, **<obs>** is the observation identification, **<obi>** is the observation interval identification, **<v>** is the data product version number, **<r>** is the region identifier, and **<c>** is the cycle. The optional discriminator identified in square brackets is included only for ACIS alternating exposure (interleaved) mode observations.

2.2.3. Source Region Image Object

The Source Region Image Objects consist of a set of FITS format image files, one for each Source Detection Energy Band, for each observation and detection source region. Each Source Region Image Object is the image equivalent of the Source Region Event Object [section 2.2.1 (Source Region Event Object)] filtered by the appropriate Source Detection Energy Band, blocked at single pixel resolution in SKY coordinates. The images are recorded in flux units of photons s^{-1} cm^{-2} by dividing the filtered and blocked Source Region Event Object event data by the Source Region Exposure Map [section 2.2.4 (Source Region Exposure Map)].

The Source Region Image Object FITS files shall be named

<i><s><obs>_<obi>N<v>[_<c>]_<r><b>_regimg3.fits

where **<i>** is the instrument designation, **<s>** is the data source, **<obs>** is the observation identification, **<obi>** is the observation interval identification, **<v>** is the data product version number, **<r>** is the region identifier, **<b>** is the energy band designation, and **<c>** is the cycle. The optional discriminator identified in square brackets is included only for

ACIS alternating exposure (interleaved) mode observations.

2.2.4. Source Region Exposure Map

The Source Region Exposure Map object consists of single FITS format event file for each observation, detection source region, and energy band that results from Level 3 processing described in part V. A full resolution instrument map that covers the detected source region bounding box is generated at the equivalent monochromatic energy for each energy band (TBR), and the exposure map is computed by applying the aspect histogram sampled at TBD resolution as described in part V.

The Source Region Exposure Map object FITS files shall be named

`<i><s><obs>_<obi>N<v>[_<c>]_<r><b>_regexp3.fits`

where **`<i>`** is the instrument designation, **`<s>`** is the data source, **`<obs>`** is the observation identification, **`<obi>`** is the observation interval identification, **`<v>`** is the data product version number, **`<r>`** is the region identifier, **`<b>`** is the energy band designation, and **`<c>`** is the cycle. The optional discriminator identified in square brackets is included only for ACIS alternating exposure (interleaved) mode observations.

2.2.5. Point Spread Function

The Point Spread Function objects consist of a set of FITS format image files, one for each Source Detection Energy Band, for each observation and detection source region. Each Point Spread Function object records the normalized PSF computed at the equivalent monochromatic energy of the appropriate Source Detection Energy Band, sampled on the same pixel grid as the Source Region Image Object [see section 2.2.3 (Source Region Image Object)].

The Point Spread Function object FITS files shall be named

`<i><s><obs>_<obi>N<v>[_<c>]_<r><b>_psf3.fits`

where **`<i>`** is the instrument designation, **`<s>`** is the data source, **`<obs>`** is the observation identification, **`<obi>`** is the observation interval identification, **`<v>`** is the data product version number, **`<r>`** is the region identifier, **`<b>`** is the energy band designation, and **`<c>`** is the cycle. The optional discriminator identified in square brackets is included only for

ACIS alternating exposure (interleaved) mode observations.

2.2.6. Light Curve Object

The Light Curve Objects consist of a set of FITS format files, one for each Source Detection Energy Band, for each observation and detection source region. Each Light Curve Object records the the multi-resolution light curve output by the Gregory-Loredo analysis of the receipt times of the (background-subtracted) source events within the source region. A detailed description of the computation of the multi-resolution light curve is documented in Appendix TBD.

The Light Curve Object FITS files shall be named

`<i><s><obs>_<obi>N<v>[_<c>]_<r><b>_lc3.fits`

where **`<i>`** is the instrument designation, **`<s>`** is the data source, **`<obs>`** is the observation identification, **`<obi>`** is the observation interval identification, **`<v>`** is the data product version number, **`<r>`** is the region identifier, **`<b>`** is the energy band designation, and **`<c>`** is the cycle. The optional discriminator identified in square brackets is included only for ACIS alternating exposure (interleaved) mode observations.

2.2.7. Region Objects

The Region Objects consist of a pair of FITS format region files for each observation and detection source region that record the region description for the source region and the corresponding background region.

The Light Curve Object FITS files shall be named

`<i><s><obs>_<obi>N<v>[_<c>]_<r>_srcreg3.fits`

for the source region, and

`<i><s><obs>_<obi>N<v>[_<c>]_<r>_bkgreg3.fits`

for the background region, where **`<i>`** is the instrument designation, **`<s>`** is the data source, **`<obs>`** is the observation identification, **`<obi>`** is the observation interval identification, **`<v>`** is the data product version number, **`<r>`** is the region identifier, and **`<c>`** is the cycle. The optional discriminator identified in square brackets is included only for ACIS alternating exposure (interleaved) mode observations.

IV. Non-Catalog Deliverables Requirements

1. Sensitivity Analysis Tool

The Sensitivity Analysis Tool described in these requirements shall be included in the *CIAO* data analysis system.

1.1. Limiting Sensitivity

The Sensitivity Analysis Tool shall provide the means to allow the user to determine the limiting sensitivity for including a point source in the catalog (part I) or, optionally, in the database (part II), in any Source Detection Energy Band or Aperture Photometry Energy Band at a user-specified location that is included in the field of view of one or more observations that is included in the catalog.

The limiting sensitivity shall be determined in units of photons s^{-1} cm^{-2}, unless the user specifies a source spectrum. In the latter case, the limiting sensitivity shall be determined in units of ergs s^{-1} cm^{-2}.

1.2. Source Flux Upper Limit

The Sensitivity Analysis Tool shall provide the means to allow the user to determine the flux upper limit in any Source Detection Energy Band or Aperture Photometry Energy Band above a local user-specified background region for a user-specified source region centered at a user-specified location that is included in the field of view of one or more observations that is included either in the catalog (part I) or, optionally, in the database (part II). The user-specified source and background regions shall be restricted to be no larger than TBD.

The source flux upper limit shall be determined in units of photons s^{-1} cm^{-2}, unless the user specifies a source spectrum. In the latter case, the source flux upper limit shall be determined in units of ergs s^{-1} cm^{-2}.

2. Mosaics

2.1. Sensitivity Mosaic

2.2. Sky Mosaics

V. Data Processing Requirements

1. Per-Observation Pipelines

1.1. Source Detection Pipeline

1.1.1. Observation Calibration

1.1.2. Data Cleaning

1.1.2.1. Background Flare Removal

1.1.2.2. ACIS Destreak

1.1.3. Observation Product Generation

1.1.3.1. Aspect Histogram

1.1.3.2. Instrument Map

1.1.3.3. Field of View

1.1.4. Source Detection

1.1.4.1. Energy Bands for Source Detection

1.1.4.1.1. ACIS Observations

1.1.4.1.2. HRC Observations

1.1.4.2. Exposure Map

1.1.4.3. Background Map

1.1.4.3.1. ACIS Readout Streak Correction

1.1.4.4. ROI Generation

1.1.4.4.1. Combine Detections

1.2. Source Properties Pipeline

1.2.1. ROI Events

1.2.2. Spatial Analysis

1.2.2.1. “Postage Stamp” Image

1.2.2.2. Exposure Map

1.2.2.3. Point Spread Function (PSF)

1.2.2.4. 2-D Spatial Fit

1.2.3. Variability Analysis

1.2.3.1. Aperture Fraction

1.2.3.2. Gregory-Loredo Analysis

1.2.3.3. Light Curve

1.2.3.4. Kolmogorov-Smirnov (K-S) Test

1.2.3.5. Kuiper's Test

1.2.4. Spectral Analysis (ACIS)

1.2.4.1. PHA Spectrum

1.2.4.2. ARF

1.2.4.3. RMF

1.2.4.4. Spectral Fit

1.2.4.4.1. Galactic N_H

2. Merge Pipeline

3. Processing System

3.1. Automated Processing

3.2. Hardware Configuration

3.3. Performance Requirements

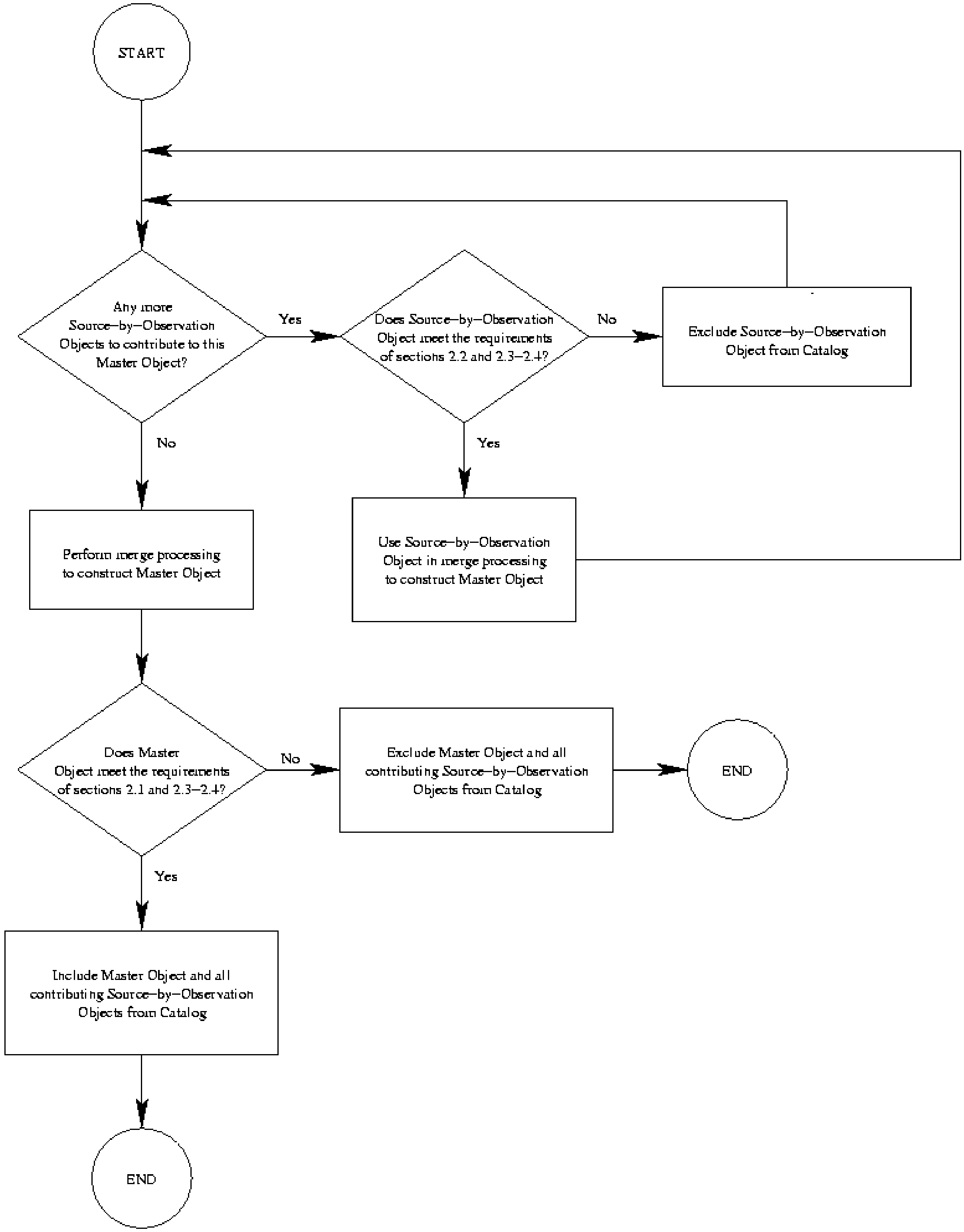

Figure V.2.1: High level flow used for determining which Master objects and Source-by-Observation Objects are included in the catalog, and which Source-by-Observation objects contribute to the merge processing that generates the catalog version of a Master Object.

VI. Quality Assurance Requirements

1. Automated Quality Assurance

1.1. Validation Steps

2. Manual Quality Assurance

2.1. Trigger Criteria

2.2. Manual Actions

VII. User Interface Requirements

1. Graphical User Interface

2. Application Programming Interface

3. Retrieval Formats