2.6 File Structure: ACIS Contamination Transmission Function

New section, *Revision 1.61 — 18 Jan 2003*

Analysis of *Chandra* flight data over the first three years of operation has revealed absorption features due to contamination build-up on the ACIS filter For details, see Plucinsky et al 2002 (SPIE proceedings, URL TBD). This section defines files which contain tables defining the transmission function as a function of wavelength and time.

The transmission efficiency of contaminant, i, can be expressed as

$$\epsilon_i(E,t) = e^{-\alpha_i(E)\beta_i(t-t_0)}, \tag{1}$$

where E is photon energy, t is time, α is the absorption coefficient per unit thickness, and β is the thickness of the contaminant (in arbitrary units). The total absorption optical depth for N contaminants is given by the sum of individual optical depths,

$$\tau(E,t) = \sum_{i=1}^{N} \alpha_i(E)\beta_i(t-t_0), \tag{2}$$

assuming that each α_i has been normalized to the same relative unit thickness at the same fiducial time, t_0. Thus, the net transmissivity is

$$\epsilon(E,t) = e^{-\tau(E,t)}. \tag{3}$$

There is weak but yet inconclusive evidence that there are multiple contaminants, and that their time dependencies may be different. Hence, we have explicitly allowed for individual β_i for each α_i.

There is no dependence upon the ACIS CCD, nor upon the ACIS clocking mode.

The calibration file defined below will tabulate $\alpha(E)$ and $\beta(t)$. Each contaminant's data (both the absorption coefficient *and* the time depencence) will be stored as vector columns on one row of a FITS binary table. In order to avoid variable length tables, the column widths will be as large as the longest array required, and additional columns will tabulate the number of points in each array. Initially, we will have a one-row table for the single contaminant quantified to date. As more are needed, more rows will be added.

Both the time dependence and absorption coefficient will tabulated to some *a priori* specified accuracy to linear interpolation. The calibration scientist will specify end points suitable for interpolation over the time of the mission, or indicate that linear extrapolation is reasonable. Tabulation of the data supports arbitrary and multiple functional dependencies as determined by calibration.

The primary implementation of the file will be in `ardlib`, the *CIAO* software interface to the calibration database, as implemented by response programs such as `mkarf`, `mkgarf`, and `mkinstmap`.

2.6.1 File Names

The `CALDB` type for the mean contamination is `contam`. File names will be of the forms:

```
acisD1996-11-01contamN0001.fits
```

2.6.2 HDU Components

The following table describes the file structure by Header-Data Unit number, type, extension name, content, and HDU classes. An asterisk (*) denotes the principal HDU.

HDU	HDU Type	EXTNAME	EXTVER	CONTENT	HDUCLASS	Description
0	PRIMARY	N/A	N/A	N/A	N/A	NULL
1 (*)	BINTABLE	AXAF_CONTAM	1	CDB_ACIS_CONTAM	ASC DETCHAR CONTAM	Binary table describing the absorption coefficients vs energy vs time.

2.6.3 Columns and Coordinate Systems

Columns for ACIS contamination coefficients are given in the following table.

TTYPE	TUNIT	TFORM	TLMIN	TLMAX	Description
FEATURE		16A	N/A	N/A	Name of the feature, such as “CK” for Carbon-K-edge.
N_ENERGY		1I	2	N/A	Number of entries in the energy and α vectors. At least two points are required for interpolation and extrapolation.
ENERGY	keV	nE	0.0	N/A	Energy vector, of which the first *n_energy* elements are to be used.
ALPHA	invlength	nE	0.0	N/A	α vector, of which the first *n_energy* elements are to be used.
N_TIME		1I	2	N/A	Number of entries in the time and β vectors. At least two points are required for interpolation and extrapolation.
TIME	s	mD	TBD	N/A	Time vector, of which the first *n_time* elements are to be used. Units are seconds since `MJDREF`, as is used for event files. The default `MJDREF` is 50814, which corresponds to `1998-01-01T00:00:00 (TT)`, and $MJD = JD - 2400000.5$.
BETA	length	mE	0.0	N/A	Thickness of absorbing material, in arbitrary length units.

Array elements of `ENERGY` and `ALPHA` are in one-to-one correspondence and have the same width; n is less than or equal to the length of the widest row in those columns (if there are multiple rows). `ENERGY` is required to be monotonic and in ascending order.

Array elements of `TIME` and `BETA` are in one-to-one correspondence and have the same width; m is less than or equal to the length of the widest row in those columns (if there are multiple rows). `TIME` is required to be monotonic and in ascending order.

2.6.4 Relevant Header Keywords

The device and mode may be obtained from standard AXAF header keywords in the "Observation" component of the header, as defined by the ASC FITS Guide (Document 4; note that many keywords are not relevant to non-flight observations). The `CALDB` architecture guide (Document 3) also lists required keywords.

Relevant keywords are:

`INSTRUME`: The only allowed value is `ACIS`.

`TIMEZERO`: This is the t_0 in Equation 2. It is a standard FITS keyword used for time table data offsets.

`NAXIS2`: This is a mandatory FITS binary table keyword. Here is is also used to determine the number of contaminants whose data are tabulated, one per row.

`CIP`n: For configuration control, this keyword (or list if n is present to enumerate several keywords) names the input CIP, or Calibration Interface Product files delivered by calibration and formatted into this ARD.

`CIPREF`: For configuration control, this keyword cites a relevant calibration memo (or preferably, URL).

`INTRPACC`: specifies the accuracy to linear interpolation, in percent (for both α and β).

2.6.5 `CALDB` Keywords

The required `CALDB` keywords are as follows:

```
CCLS0001  'BCF'
CDTP0001  'DATA'
CCNM0001  'CONTAM'
CBD10001  'ENERG(0.06-12.0)keV'
CBD10002  'TIME(tbd-tbd)s'
CVSD0001  1996-11-01T00:00:00
CDES0001  'ACIS Filter Contamination Coefficients'
```

2.6.6 Size and File Number Estimates

There will be one ACIS contamination file which will cover the time of the mission. The energy vector will probably be about 1000 points, and the time vector 100. Each row will be less than about 10 kB. Initially, there will be one row for a single contaminant.