AXAF Science Center

mkgrmf LSF Input Data: Data Product Interface Document:

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Document and Change Control Log			
Date	**Version**	**Section**	**Status**
19 Mar 01	0.1.0	all	Initial Draft
23 Apr 01	0.1.1	all	Format Changes
02 May 01	0.1.2	all	Four columns added
21 Sep 01	0.2.0	all	Revised

Unresolved Issues

The following is a list of unresolved, un-reviewed, or un-implemented items:

1. Defocused data is not yet addressed

Contents

List of Tables

1 Introduction

This document describes the interface to be employed in accessing the PSF Library products, according to the requirements stipulated in Applicable Document 3.

1.1 Purpose

The purpose of this document is to define the input data for the Line Spread Function (generically referring to LSF) Library to be used in Level 2 processing for the grating RMF generator (mkgrmf).

1.2 Scope

This interface shall apply to all Grating specific LSF data products used by the tool `mkgrmf` and distributed to the CXC Data Archive (see Applicable Documents TBD) during the course of the Chandra mission.

2 Applicable Documents

The Applicable Documents required for background and detail on grating products are as follows:

1. AXAF Data Products Guide
   `http://hea-www.harvard.edu/asclocal/ds/arch_doc/EST/DataProd.html`
2. AXAF Coordinate Systems
   `http://hea-www.harvard.edu/ jcm/asc/coords`
3. ASC AMO-2400 (SE03)
   ASC Data System Requirements (ASC.302.93.0008)
4. ASC AMO-2401 (DS01)
   ASC Data System Software Design (ASC.500.93.0006)
5. HEASARC FITS Standards:
   `http://legacy.gsfc.nasa.gov/docs/heasarc/ofwg/`
   `docs/summary/ogip_93_001_summary.html`
6. ASC FITS File Designers' Guide
   `http://hea-www.harvard.edu/~arots/asc/fits/ascfits.ps`
7. HEASARC FITS CALDB Standards
   `http://heasarc.gsfc.nasa.gov/docs/heasarc/caldb/caldb_intro.html`
8. AXAF CALDB Architecture
   `http://hea-www.harvard.edu/~arots/asc/fits/caldb.txt`

3 Functional Description

3.1 Data Content Summary

All Grating LSF Library files shall consist of data files conforming to the FITS format (Applicable Document 5). These files contain header keyword entries and binary table (BINTABLE) extensions. These files will contain a primary header, possibly null, followed by a set of binary tables as described in Applicable Document 6. In addition, these files will conform to the HEASARC CALDB conventions (Applicable Document 7) and have CONTENT, EXTNAME,and HDUCLASS keywords that conform to Applicable Document 8.

3.2 Recipients and Utilization

The primary recipients, via distribution from the archive, of the LSF Library are Chandra observers, who will utilize these data products for scientific data analysis. The CXC may also make use of specific LSF Library data products for instrument calibration, instrument and/or spacecraft monitoring and trends analysis, and validation and verification of the Level 0, Level 1, and Level 1.5 software and of the data products themselves.

3.3 Pertinent Relationships with Other Interfaces

Changes to the definition of CXC FITS, as described in Applicable Documents 6, may affect the format of the PSF data products described in the current document.

4 Assumptions and Constraints

It is assumed that these products are placed into an exportable calibration database (CALDB) for users.

4.1 Products Not Covered

PSF products that are used for maintenance and diagnostic purposes (those that are not supplied to the user for scientific data analysis), or which are generic AXAF Level 2 products, are not currently included within the interface defined by this document.

4.2 Substructure Definition and Format

The header components for the primary header and all binary table extensions are defined and listed in the Applicable Documents. In general, the column or row numbers in the example FITS headers are arbirary unless otherwise indicated. It is the column name and its attributes that specify the requirment. Additional columns not specified here may be added to the file also long as they do not violate the interface. Software used to process the data can ignore the additional columns, copy them to the output file, or optional use them for data processing. Likewise, HDU order is arbitrary, except for the primary HDU which must be first. HDUs are intended to be referenced by name, not position.

5 Access

5.1 Access Tools; Input/Output Protocol

Since LSF Library products obey the formatting rules described in Applicable Documents 6, they may be accessed by any software that conforms to those standards, including all versions of the FITSIO libraries that support the BINTABLE extension. In addition, since they adhere to HEASARC standards (Applicable Document 5), LSF data product files are compatible with the input/output routines that constitute the CXC data interface.

6 The File Structure for the Grating LSF Data

This section describes the LSF parameter library which is a FITS file containing the LSF fit parameters for the Chandra gratings. Each file will contain the parameters for one grating type. The * in the table below denotes the ASC principal HDU.

HDU	HDU TYPE	EXTNAME	EXTVER	CONTENT	HDUCLAS1	HDUCLAS3	Description
0	NULL	...	...	...	...	...	...
1 (*)	BINTABLE	MEG	1	LSF_PARAM	RESPONSE	LSF	LSF coefficients

Table 1: File structure for the table with the LSF fit coefficients

6.1 File Names

The filename convention shall be

$$\{det\}\{grat\}\{order\}D\{date\}lsfparmN\{version\}.fits$$

where $\{det\}$ is either *acis* or *hrcs*, and $\{grat\}$ is one of *leg*, *meg*, or *heg*. $\{date\}$ follows the date convention in Applicable Document 6.

As an example the lsf file for the HRC-S using the LETG grating should be of the form
hrcsleg1D1999-07-22lsfparmN0000.fits
while the file for the MEG using ACIS-S should be
acismeg1D1999-07-22lsfparmN0001.fits

6.2 Column Descriptions

#	TTYPE	TUNIT	TFORM	TLMIN	TLMAX	Comment
1	NUM_WIDTHS		I	0	TBD	Number of Extraction Widths
2	WIDTH	Degrees	3E	0	TBD	Extraction Width
3	NUM_LAMBDAS		J	0	TBD	Number of wavelength points
4	TG_LAM_LO	Angstroms	nD	0.0	TBD	Low wavelength of the extraction region
5	TG_LAM_HI	Angstroms	nD	0.0	TBD	High wavelength of the extraction region
6	LAMBDAS	Angstroms	nD	0.0	TBD	Input Photon Wavelength
7	EE_FRACS	N/A	mD	0.0	1.0	Encircled Energy fraction
8	GAUSS*i*_PARMS	N/A	kE	N/A	N/A	vector containing Gaussian parameters
9	LORENTZ*i*_PARMS	N/A	kE	N/A	N/A	vector containing Lorentzian parameters
10	THETA_MIN	degrees	E	0	N/A	min off-axis angle
11	THETA_MAX	degrees	E	0	N/A	max off-axis angle for which this is valid
12	PHI_MIN	degrees	E	0	N/A	min azimuthal angle for which this is valid
13	PHI_MAX	degrees	E	0	N/A	max azimuthal angle for which this is valid

Table 2: Binary table with the LSF fit coefficients

The i in parmeters 8 and 9 is currently set to 1 but multiple parameter sets are allowed. So for instance if future fits include a second Gaussian component along with the current parameters the lsf file structure supports that as an additional column, e.g. GAUSS2_PARM. Also n is the number of wavelengths, m is 3×n, and k is 3×n×NUM_WIDTHS.

6.2.1 Comments on the Columns

The `NUM_WIDTH` column give the number of widths for which the LSF was extracted and tabulated. In the current incarnation this value is three for the MEG and HEG files. For the LETG only one width is currently implemented.

The `WIDTH` column gives the width, in degrees, of the extraction region used to extract the LSF data. The next column gives the number of wavelengths at which the LSF is tabluated. Currently these must be the same for each extraction width and are assumed to be in angstroms. The columns `TG_LAM_LO` and `TG_LAM_HI` give that lower and upper wavelength of the box that was used to extract the LSF data. The `LAMBDA` column gives the wavelength of the peak position of the LSF.

The encircled energy fraction is tablulated in the `EE_FRAC` column. The vector column containing the EE_FRAC is a 2-dimensional vector with the ee_frac for each wavelength as a vector and additional rows are for the ee_frac for each different width as defined above. This means that the dimensionality of the vector will be num_lambdas × num_widths.

The columns for the fit parameters shall be a matrix of n×j×k where n is the number of parameters and their order is
gauss_parms(0,j,k) = Gaussian amplitude,
gauss_parms(1,j,k) = Gaussian σ in Å,
gauss_parms(2,j,k) = peak position in Å.

The number of elements is given by j and the maximum value of j is NUM_LAMBDAS. The number of widths is given by k. The function parameters at a given j must be for the wavelength range TG_LAM_LO(j) and TG_LAM_HI(j) and the maximum value of j is given by NUM_WIDTHS.

For the Lorenzian parameters the order of the parameters in the matrix shall be
lorentzian_parms(0,j,k) = Lorentzian amplitude,
lorentzian_parms(1,j,k) = Lorentzian width in Å,
lorentzian_parms(2,j,k) = peak position in Å,
with the other elements obeying the convention for the Gaussian parameters above.

6.3 Allowed Functional Forms

The functional forms that are allowed for the LSF in mkgrmf are currently a Gaussian and a Lorentzian.

$$G(r) = \frac{1.}{(2\pi\sigma^2)} e^{\frac{-(r-r_0)^2}{(2\sigma^2)}}$$

where σ is the Gaussian width in angstroms and r_0 is the peak of the LSF.

$$L(r) = \frac{L_0}{2\pi} \frac{\Gamma}{(r-r_0)^2 + \Gamma^2)}$$

where , r_0 is the peak position of the Lorenztian, which need not be the same as the center of the Gaussian, and Γ is the half-width of the line profile.

6.4 Size Estimates

The ASC primary extension of each file will have 13 columns to describe the LSF parameters at each energy. The vector columns are real floating point numbers so the size of the file can be estimated by the number of entries × 11 (the number of vector columns). So for a typical MEG LSF file with ∼2500 entries the size of the data area should be 27500 bytes (11×2500).

7 FITS Header Templates

The following header sections have been taken from the ASC FITS file specifications. The example FITS headers given here are examples only, the column numbers, axis numbers, and keyword values are *not* necessarily those in the LSF data files.

7.1 Header Components with No Changes

- Mandatory component for the Image Primary Header (M)
- Mandatory component for Null Primary Header (M)
- Mandatory component for Binary Table extension (M)
- Mandatory component for Image extension (M)
- Full configuration control component (CC)
- Short configuration control component (Short CC)
- Configuration control component for null primary HDU (Null CC)

7.2 Header Components with Changes

7.2.1 Full Timing Component (T)

```
DATE    = '0000-00-00T00:00:00' / Date and time of file creation
TIMEUNIT= 's       '           / Time unit
```

7.2.2 Short Timing Component (Short T)

```
DATE    = '0000-00-00T00:00:00' / Date and time of file creation
TIMEUNIT= 's       '           / Time unit
```

7.2.3 Full Observation info Component

```
MISSION = 'AXAF    '           / Mission
INSTRUME= 'ACIS    '           / Instrument
DETNAM  = 'ACIS-S  '           / Detector
GRATING = 'HETG    '           / Grating
GRATTYP = 'MEG     '           / Grating Type
```

7.2.4 Grating Specific Components

```
GRATING = 'HETG    '           /Grating in use
GRATTYP = 'HEG     '           /Grating data
TG_M    = 1
ORDER   = 1
CDTP0001= 'DATA    '           /Virtual data set
CCLS0001= 'CPF     '           /Basic Calibration file
CDES0001= 'MEG LSF parameters input for mkgrmf'/Description
CBD10001= 'GRATING(HETG)'
CBD20001= 'GRATTYPE(MEG)'
CBD30001= 'TG_M(1) '
CBD40001= 'SHELL(0011)'
CBD50001= 'ORDER(1)'
CVSD0001= '1999-07-22T00:00:00'
```

```
CVST0001= '00:00:00'
CCNM0001= 'LSFPARM'
CBD10001= 'Energy(5)keV'       /Energy range for PSF
CBD20001= 'THETA(0 - 2)arcmin'     /Distance from optical axis for PSF
CBD30001= 'PHI(0.0 - 360.)deg'        /Azimuthal angle for PSF
```