

XMM

Interface Control Document: SAS Specific Products (SAS to AMS)

XMM-SOC-ICD-0014-SSD Issue Draft 1.0

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September 19, 1997

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DRAFT

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1 Introduction

The SAS is the central software system for offline data analysis. A number of products will be generated from the SAS that have to be used by other SOC sub-systems.

CCF constituents are provided by the SAS, as these files are the results of data analysis, which is performed in most cases interactively by members of the SOC calibration team.

SCISIM, being part of SAS, generates data files with identical structures to the ODF. Some of these files need to be stored in the AMS for future reference.

The QLA part of the PMS requires basic data structures such that the instrument performance as determined on-line, can be compared with expectations. The SAS products for this purpose will contain as a baseline the structure of FITS image and binary table formats. The keywords are mainly provided to store the parameters that were used for the simulations. The input for these will in many cases be generated by SCISIM.

Furthermore there will be products that may be results of some lengthy, or complicated analysis steps that are needed for future reference or are needed by other members of the SOC calibration team. It is therefore important to store these products in a controlled manner such that easy retrieval is supported.

1.1 Scope of the Document

The purpose of this document is to describe the structure of all SAS products that require storage in the AMS.

The output of the SAS includes the following products:

- CCF constituents for inclusion into the CCF
- ODF files that are generated by SCISIM
- SAS products of data generated by SCISIM ready to be used by the PMS QLA
- SAS special analysis products
- summary parameters that are passed to SPEVAL for use in trend analysis (not part of this ICD)

This document lists all products that are required for the interface with the first four products, those products containing the summary parameters will be described by a future ICD (TBW).

1.2 Documentation

- [1] ESA. Interface Control Document for the XMM Current Calibration File. XMM-SOC-ICD-0005-SSD, ESA/SSD, jul 1997. Issue 1.0.
- [2] ESA. XMM Interface Control Document: Observation and Slew Data Files (XSCS to SSC) (SciSIM to SOCSIM). XMM-SOC-ICD-0004-SSD Draft 2.0, ESA/SSD, July 1997.
- [3] SSC. XMM Survey Science Centre to Science Operations ICD for SSC Products. XMM-SOC-ICD-0006-SSC Issue 1.0, SSC, July 1997.
- [4] A. Rots I.M. George and K. Mukai. Guidelines for defining FITS formats for Event Lists. OGIP/94-003, NASA/GSFC, Dec 1994. Found at the URL: http://legacy.gsfc.nasa.gov/docs/heasarc/ofwg/summary/ogip_94_003_summary.html.
- [5] I.M. George K.A. Arnaud and A.F. Tennant. The OGIP Spectral File Format. OGIP/92-007, NASA/GSFC, Sept 1992. Found at the URL: http://legacy.gsfc.nasa.gov/docs/heasarc/ofwg/summary/ogip_92_007_summary.html.
- [6] W. Pence L. Angelini and A.F. Tennant. The Proposed Timing FITS File Format for High Energy Astrophysics Data. OGIP/93-003, NASA/GSFC, Nov 1993. Found at URL: http://legacy.gsfc.nasa.gov/docs/heasarc/ofwg/summary/ogip_93_003_summary.html.
- [7] E. W. Greisen and M. Calabretta. Representation of Celestial Coordinates in FITS. Astron. Astrophys., 1996. Found at the following URL: <ftp://fits.cv.nrao.edu/fits/documents/wcs/wcs.all.ps>.
- [8] ESA. XMM Interface Control Document Top Level File Transfer System (FTS). XMM-SOC-ICD-0007-DPD Draft A4, ESA/DPD, July 1997.

2 CCF Constituents

These are described in [1].

3 ODF Files Generated by SCISIM

These are described in [2].

4 SAS Products of Data Generated by SCISIM Ready to be Used by the PMS QLA

This section lists the products that will be produced by the SciSIM, and which may require storing in the AMS for use within the PMS QLA. The output of SciSIM will be in the form of an emulated ODF, which will be reduced by processing with SAS tools such that the result can be used for example in the PMS QLA as reference images and spectra for comparison with real-time data. It is in this latter form that we discuss SciSIM products for the purposes of this section.

All data products from SciSIM to be used in the QLA will be provided in FITS format. For the purpose of the import into QLA, the output of SciSIM will be processed prior to submission such that it will only contain images (FITS images) and spectra (FITS binary tables). We make here an attempt to describe sample files of this type. It is TBD if there should be any other file types. For example one can envisage PostScript Level 2 files might be a more compact file, with ready-made annotation for display on the QLA workstations, but with the drawback that no actual data manipulation can be performed on the data represented. For SciSIM-produced image data (sky views for example?) there might be the option to use PNG format for pixellated images. Again this is a trade-off between file size, ease of display and any requirement for further data manipulation. Finally some small data sets such as histograms might be efficiently transported as ASCII, but again apart from the size advantage, we would lose the advantage of the FITS self description that would make access and further data manipulation more open.

In general descriptive file names will be provided. Most of these data products will only be kept in the PMS database for few specific observations. It is considered an implementation detail, whether the PMS database produces a filename, which is an expansion of the requested filename, upon receipt of a new file, or whether that filename will be used that is specified by the user during submission of the products.

Consistency checking on the contents will not be performed by the PMS prior to the display of these products. This is considered the responsibility of the user.

4.1 Common FITS headers and extensions

The format and structure of SciSIM product files will wherever possible follow the conventions adopted for the SSC Data Products (see [3]) which, in turn, are based on the guidelines for OGIP FITS events, spectral and rates files [4, 5, 6].

4.1.1 Standard primary header keywords

Every FITS file created by SciSIM for the purpose of usage by the PMS QLA will contain the following mandatory keywords in the primary header (the values shown are for example only)

```
SIMPLE =          T / file does conform to FITS standard
BITPIX =          32 / number of bits per data pixel
```

```
NAXIS      =          0 / number of data axes
EXTEND     =          T / FITS dataset may contain extensions
TELESCOP= 'XMM'       / mission name
INSTRUME= 'EMOS1'     / instrument name
DATAMODE= 'IMAGING'   / instrument mode (IMAGING, TIMING, FAST, etc.)
FILTER    = 'NONE'    / filter ID
OBS_MODE= 'POINTING'  / observ. mode: POINTING, SLEW, or CALIBRATION
OBS_ID    = '2323243' / observation identifier
EXP_ID    = '1'       / exposure identifier
CONTENT   = 'EPIC SIMULATED IMAGE' / content of file
ORIGIN    = 'XMM-SOC' / processing site
DATE      = '2000-10-13T12:00:00' / FITS file creation time (YYYY-MM-DDTHH:MM:SS)
OBJECT    = 'Cyg X-1 high state' / name of object pointed at
RA_PNT    =          299.59050 / [deg] RA of instrument pointing
DEC_PNT   =          35.20164 / [deg] DEC of instrument pointing
POS_PNT=          123.32434 / [deg] Position angle of instrument pointing
RADECSYS= 'FK5'      / World Coordinate System
EQUINOX   =          2000.0 / equinox of celestial coordinate system
CREATOR   = 'SciSIM v1.2.3' / name of code that generated this file
CATEGORY= 'XMMSciSIM' / this is an XMM SciSIM file
INHERIT   =          T / key words are inherited
DATE-OBS= '2010-12-23T12:00:00' / date of observation
DATE-END= '2010-12-24T00:11:22' / end of observation
EXPOSURE=          43882.0 / [s] exposure time
OBSERVER= 'Mr. SOC member' / who performed the simulations
```

- The syntax for the values of the keyword **DATE**, **DATE-OBS**, and **DATE-END** follows the new proposal for millennium-encompassing date related FITS keywords (see [1], App. 1 for details).
- Additional keywords specific to each instrument or each file type may also be defined in the primary header. This refers especially to the adding of commentary **COMMENT** and **HISTORY** keywords.
- The **EXPOSURE** keyword shall describe the effective exposure time as simulated with SciSIM. This will be used to scale the output from SciSIM with the actual exposure time of the QLA data.
- The source position in the FOV will be specified by equatorial J2000 coordinates (keywords **RA_OBJ** and **DEC_OBJ**). The position angle will be specified as rotation starting from 0.0 with the Z axis pointing north and rotating around the X axis by counting positive towards $-Y$.
- The values of the **INSTRUME** keyword will be identical to those described in [2]
- The **DATAMODE** keyword can take the values:
 - for EPIC: IMAGING, TIMING, FAST
 - for RGS: SPECTROSCOPY
 - for OM: IMAGING

4.1.2 Good-Time interval (GTI) extension

Every EPIC (4.2.2) and RGS (4.3.2) spectrum FITS file will in accordance with OGIP conventions contain a GTI extension:

- For the purpose of the files generated by SCISIM, this extension lists only one time interval during which valid data are present in the data file.
- The extension header contains the following keywords to identify the extension

```
EXTNAME = 'STDGTI' / name of this binary table extension
HDUCLASS= 'OGIP' / file conforms to OGIP/GSFC conventions
HDUCLAS1= 'GTI' / this is a Good-Time Interval file
HDUCLAS2= 'STANDARD' / in standard form
```

- The extension contains a binary table with the following columns:

Name	Type	Description
START	8-byte REAL	[s] start Time
STOP	8-byte REAL	[s] stop Time

- Times in the GTI extension are specified in seconds after a reference time given in the header keywords **TIMESYS** and **MJDREF**. Other time related keywords shall be present as well (the values shown are for example only):

```
TIMESYS = '2000 1 1 00:00:00' / all times measured from this reference date
TIMEUNIT= 's' / unit for TSTART, TSTOP, TELAPSE, ONTIME
TIMEREF = 'LOCAL' / reference frame for reported time values
TASSIGN = 'SATELLITE' / location of time assignment
CLOCKAPP= T / Time corrected for clock drift?
MJDREF = 49353.0 / [MJD] mission ref. time: 2000-01-01 00:00:00
MJD-OBS = 50288.024143518 / [MJD] observation UTC start time
TSTART = 80796278.18459 / [s] data start time relative to MJDREF
TSTOP = 81089027.33792 / [s] data end time relative to MJDREF
TELAPSE = 292749.153329998 / [s] difference: TSTOP - TSTART
DATE-OBS= '2010-12-23T12:00:00' / date of observation
DATE-END= '2010-12-24T00:11:22' / end of observation
EXPOSURE= 43882.0 / [s] exposure time
```

The last three keywords are duplicates from the primary header.

4.1.3 CCD modes extension

The CCD mode extension will be compatible with the one present in SSC products files [3].

- The data in this extension will identify the operating mode of each CCD within the (EPIC or RGS) camera, along with other important information which is required for the correct interpretation of the event data (e.g. window limits, threshold values, frame integration times, etc.)

- The extension will contain a binary table (one row per camera CCD ordered by CCD ID) with at least the following columns:

Name	Type	Description
MODE	4-byte INTEGER	Operation mode of CCD
WINDOWX0	4-byte INTEGER	Origin of CCD window
WINDOWY0	4-byte INTEGER	(pixels relative to bottom left)
WINDOWDX	4-byte INTEGER	Size of CCD window
WINDOWDY	4-byte INTEGER	(pixels)

- There will be seven table rows for the EPIC MOS, twelve for the EPIC p-n, nine for RGS.

4.1.4 SciSIM configuration extension

This extension provides the complete SciSIM configuration which was in effect for generating the relevant product file. The purpose of this extension is for traceability only, and this extension shall not be used by the PMS.

The extension consists of a Bintable with merely one column and as many rows as SciSIM configuration files were in effect.

```
XTENSION= 'BINTABLE'           / binary table extension
BITPIX   =                      8 / 8-bit bytes
NAXIS    =                      2 / 2-dimensional binary table
NAXIS1   =                      8 / width of table in bytes
NAXIS2   =                      2 / number of SciSIM config files
PCOUNT   =                   31786 / total size of SciSIM config files
GCOUNT   =                      1 / one data group (required keyword)
TFIELDS  =                      1 / number of fields in each row
EXTNAME  = 'SCISIMCONF'       / name of this binary table extension
HDUCLASS= 'OGIP'              / file conforms to OGIP conventions
HDUCLAS1= 'TEMPORALDATA'     / these are temporal data ...
HDUCLAS2= 'SCISIMCONF'       / ... forming the SciSIM config extension
...
TTYPE1   = 'SCISIMCONF'       / SciSIM configuration
TFORM1   = 'PA(65536)'        / variable-length ASCII array (max. 64 kByte)
```

Each Bintable row will consist of an entire SciSIM configuration file (see SciSIM documentation) stored as a variable-length ASCII array. The precedence of configuration settings increases with increasing row number of the corresponding configuration file.

4.2 EPIC FITS Files

The primary header of all EPIC products will contain the mandatory FITS keywords defined in section 4.1.1. The **DATAMODE** keyword will assume the value **IMAGING**.

4.2.1 EPIC FITS Image Files

This format can cover not just spatial images, but any EPIC data file generated by SciSIM, which is convenient to represent as a 2-d data set with a data content that can be displayed as pseudo-intensity. There will generally be 3 standard image sizes produced:

1. a whole camera field of view (but where some pixel contents might be null data in the case of selected windowing)
2. a whole CCD field of view, comprising an image formed by one MOS or one pn CCD, or
3. finally just the contents of an active window

Included amongst this category of “images” would be offset maps, CTI maps etc.

4.2.1.1 General conventions

- The simulated images will be supplied in FITS format following the OGIP guidelines whenever possible. The image data will be stored as the primary with 8-bit, 16-bit or 32-bit integer values depending on the maximum value of the data in the array.
- EPIC FITS image files will have the following structure:
 1. image data in the primary array
 2. good-time interval extension (see 4.1.2)
 3. CCD modes extension (see 4.1.3)
 4. SciSIM configuration extension (see 4.1.4)
- For celestial target simulations all images will be presented in tangent plane projection of equatorial sky coordinates (J2000) centered on the nominal pointing position. The image Y-axis will be aligned to the local celestial North Pole (TBC). The coordinate system will be defined by header keywords in accordance with the conventions in [7].
- Where appropriate, images will be produced in selected energy equivalent bands. The FITS header keyword **BAND** will be used to define the energy band of a data product. The default will be the full energy band of the instrument. For list of valid values for the keyword **BAND** see Sect. 7.5.2.1 in [3].
- EPIC image files will be identified using the keyword

```
CONTENT = 'EPIC SIMULATED IMAGE'
```

in the primary header. The OGIP file type will be defined by the keywords

```
HDUCLASS= 'OGIP      ' / Format conforms to OGIP/GSFC conventions
HDUCLAS1= 'IMAGE     ' / File contains an image
HDUCLAS2= 'TOTAL     ' / Total counts
```

in the primary header. In addition to the above listed primary header keywords, for each type of file we expect the following:

4.2.1.2 EPIC MOS full-field image file

```
INSTRUME= 'EMOS1/EMOS2' / instrument name
NAXIS    =           2 / a two-dimensional image
NAXIS1   =          1800 / X-size of datacube: CCD-X
NAXIS2   =          1800 / Y-size of datacube: CCD-Y
BUNIT    = 'count/pixel' / physical unit of primary array data
```

4.2.1.3 EPIC MOS CCD image file

```
INSTRUME= 'EMOS1/EMOS2' / instrument name
NAXIS    =           2 / a two-dimensional image
NAXIS1   =           600 / X-size of datacube: CCD-X
NAXIS2   =           600 / Y-size of datacube: CCD-Y
BUNIT    = 'count/pixel' / physical unit of primary array data
```

4.2.1.4 EPIC PN CCD image file

```
INSTRUME= 'EPN' / instrument name
NAXIS    =           2 / a two-dimensional image
NAXIS1   =           64 / X-size of datacube: CCD-X
NAXIS2   =          200 / Y-size of datacube: CCD-Y
BUNIT    = 'count/pixel' / physical unit of primary array data
```

4.2.1.5 EPIC PN full-field image file

```
INSTRUME= 'EPN'
NAXIS    =           2 / a two-dimensional image
NAXIS1   =          384 / X-size of datacube: CCD-X
NAXIS2   =          400 / Y-size of datacube: CCD-Y
BUNIT    = 'count/pixel' / physical unit of primary array data
```

4.2.2 EPIC FITS Spectrum File

This general class contains all generic forms of array data which can be displayed as histogrammed plots, with one column forming the abscissae values, and one or more columns of ordinate values.

4.2.2.1 General conventions

- Where FITS is specified as a file format, the OGIP standards defined by OGIP/92-007 (and amended by OGIP-92/007a) [5] will be followed where appropriate.
- EPIC spectral files will have the following basic structure:
 1. primary header will empty primary array (**NAXIS** = 0)
 2. an OGIP-compliant spectrum extension (**EXTNAME** = 'SPECTRUM')
 3. good-time interval extension (see 4.1.2)
 4. CCD modes extension (see 4.1.3)
 5. SciSIM configuration extension (see 4.1.4)
- These files will be identified using the keyword

```
CONTENT = 'EPIC SIMULATED SPECTRUM'
```

in the primary header. The OGIP file type will be defined by the keywords

```
HDUCLASS= 'OGIP      ' / Format conforms to OGIP/GSFC conventions
HDUCLAS1= 'SPECTRUM' / Extension contains an spectrum
HDUCLAS2= 'TOTAL'    / Gross PHA spectrum (source + bkg)
HDUCLAS3= 'COUNT   ' / Data stored as counts
```

in the header of the SPECTRUM extension.

The SPECTRUM extension will contain a binary table (one row per channel) with the following columns:

Name	Type	Description
CHANNEL	2-byte INTEGER	Detector channel number
COUNTS	4-byte REAL	Observed counts
SYS_ERR	4-byte REAL	systematic errors
QUALITY	2-byte INTEGER	quality flag
GROUPING	2-byte INTEGER	channel grouping information

For the meaning of these columns please consult the corresponding OGIP documentation [5]. Please note: The columns **SYS_ERR** and **GROUPING** are merely present to ensure OGIP compliance but will not contain meaningful data. The actual statistical error will be defined by Poisson error on the counts in the channel (**POISSERR=T**).

- Spectra will consists of 2048 channels (**TLMIN1** = 0, **TLMAX1** = 2047) being of the PI (Pulse Invariant) type (**CHANTYPE='PI'**).

4.3 RGS FITS Files

The primary header of all RGS products will contain the mandatory FITS keywords defined in section 4.1.1. The **DATAMODE** keyword will assume the value **IMAGING**.

The files will provide header keywords which specify the contents. The OCB will be given in the header keyword **OCB**. The value of this keyword will only be used for scaling purposes, such that physical distances can be reconstructed. There will be no checking performed in the sense that inconsistent OCB values are rejected, on the consistency of the OCB factor between the image/spectrum generated by SciSIM and the actual QLA image/spectrum. Should the SciSIM image/spectrum and the QLA image/spectrum have a different OCB factor then the pixel/bin size of the SciSIM image/spectrum will be scaled such that it can be overlaid on the QLA image/spectrum.¹

Additionally, as a general rule to all files, it shall apply that the keyword **CCDID** may be in the range from 0 to 10:

CCDID=0 implies that the spatial coordinates (**RAWX**, **RAWY** are given in the camera coordinate frame;

CCDID=1–9 implies that the spatial coordinates (**RAWX**, **RAWY** are given in the CCD coordinate frame of the CCD given;

CCDID=10 implies that the data relate to the on-board test generator; the values of **RAWX** and **RAWY** are meaningless.

4.3.1 RGS FITS Image Files

The following possible files will be available for retrieval by the PMS QLA:

- a whole RFC camera (9 CCDs) with representative OCB (9*1024/OCB*384/OCB)
- a whole CCD with representative OCB (1024/OCB*384/OCB)
- a window of one CCD (XSTART/OCB, XLEN/OCB, YSTART/OCB, YLEN/OCB)

4.3.1.1 General conventions

- The simulated images will be supplied in FITS format following the OGIP guidelines whenever possible. The image data will be stored as the primary array with 8-bit, 16-bit or 32-bit integer values depending on the maximum value of the data in the array.
- RGS FITS image files will have the following structure:
 1. image data in the primary array
 2. good-time interval extension (see 4.1.2)

¹Clearly the OCB is only of relevance to those histograms that have a spatial scale on their abscissa.

3. CCD modes extension (see 4.1.3)
 4. SciSIM configuration extension (see 4.1.4)
- The size of the images (intrinsically 1024×384) may be reduced by the on-chip binning, which may be none, 2×2 , 3×3 , 4×4 , or 5×5 .
 - RGS images will be identified using the keyword

```
CONTENT = 'RGS SIMULATED IMAGE'
```

in the primary header.

- The OGIP type of the file will be defined by the keywords

```
HDUCLASS= 'OGIP'      / file conforms to OGIP/GSFC conventions
HDUCLAS1= 'IMAGE'    / the extension contains an image
```

- The files will hold images in detector coordinates with (X,Y) and an intensity. The value along the intensity may either be counts, or energy. The respective contents will be given by the FITS keywords **BUNT**.

4.3.1.2 Countrate images

This file will contain an image of the countrates in detector coordinates which may be restricted by a selected window. In addition to the mandatory keywords specified in 4.1.1 the following keywords are present in the primary header:

```
OCB      =          1 / On-Chip Binning factor
MODE     = 'SPECTROS' / one of SPECTROS, HTR, DIAG
```

Please note that the dimensions of the active exposure windows are given in the CCD modes extensions (4.1.3) present in each RGS image file. The following keywords denote the name of the physical coordinates of the image stored in the primary array:

```
CTYPE1  = 'RAWX' / detector pixels in X (X-component of image)
CTYPE2  = 'RAWY' / detector pixels in Y (Y-component of image)
CTYPE3  = 'COUNTS' / counts at bin (image intensity)
```

4.3.1.3 Energy images

This file will contain an image of the mean expected energy at each pixel. In addition to the mandatory keywords specified in 4.1.1 the following keywords are present in the primary header:

```
OCB      =          1 / On-Chip Binning factor
MODE     = 'SPECTROS' / one of SPECTROS, HTR, DIAG
```

Please note that the dimensions of the active exposure windows are given in the CCD modes extensions (4.1.3) present in each RGS image file. The following keywords denote the name of the physical coordinates of the image stored in the primary array:

```

CTYPE1 =      'RAWX' / detector pixels in X (X-component of image)
CTYPE2 =      'RAWY' / detector pixels in Y (Y-component of image)
CTYPE3 =      'ENERGY' / energy at center of bin (image intensity)
BUNIT   =      'keV' / energy unit

```

4.3.2 RGS FITS Spectrum File

A spectrum will be provided in form of a FITS binary table, with the abscissa values in the first column (either in energy/wavelength or in detector channels), and a following column holding the contents per bin. Current values of the on-chip binning factor and instrument mode will be provided in the keywords **OCB** and **MODE** respectively.

4.3.2.1 General conventions

- Where FITS is specified as a file format, the OGIP standards defined by OGIP/92-007 (and amended by OGIP-92/007a) [5] will be followed where appropriate.
- RGS spectral files will have the following basic structure:
 1. primary header will empty primary array (**NAXIS** = 0)
 2. an OGIP-compliant spectrum extension (**EXTNAME** = 'SPECTRUM')
 3. good-time interval extension (see 4.1.2)
 4. CCD modes extension (see 4.1.3)
 5. SciSIM configuration extension (see 4.1.4)
- The RGS spectral files will be identified using the keyword

```
CONTENT = 'RGS SIMULATED SPECTRUM'
```

in the primary header. The OGIP file type will be defined by the keywords

```

HDUCLASS= 'OGIP      ' / Format conforms to OGIP/GSFC conventions
HDUCLAS1= 'SPECTRUM' / Extension contains an spectrum
HDUCLAS2= 'TOTAL'   / Gross PHA spectrum (source + bkg)
HDUCLAS3= 'COUNT  ' / Data stored as counts

```

in the header of the SPECTRUM extension. The SPECTRUM extension will contain a binary table (one row per channel) with the following columns:

Name	Type	Description
CHANNEL	2-byte INTEGER	Detector channel number (along X, energy, or wavelength - see below)
COUNTS	4-byte REAL	Observed counts
SYS_ERR	4-byte REAL	systematic errors
QUALITY	2-byte INTEGER	quality flag
GROUPING	2-byte INTEGER	channel grouping information

For the meaning of these columns please consult the corresponding OGIP documentation [5]. Please note:

1. Due to the diversity of the RGS from conventional spectral instruments the **CHANNEL** column has a broader meaning than implied by the OGIP conventions, i.e., PHA or PI channel numbers - see the description of the various subtypes of RGS spectral file below.
 2. The columns **SYS_ERR** and **GROUPING** are merely present to ensure OGIP compliance but will not contain meaningful data. The actual statistical error will be defined by Poisson error on the counts in the channel (**POISSERR=T**).
- The RGS spectra are integrated over the entire exposure.

4.3.2.2 Dispersion direction spectrum

This type of spectrum represents a histogram of countrates as a function of CCD bin along the dispersion coordinate. The mandatory keywords specified in 4.1.1 are present in the primary header and in addition the following keywords shall be present in the spectrum extension:

```

OCB      =          1 / OCB factor
MODE     =      SPECTROS' / one of SPECTROS, HTR, DIAG
CCDID    =          3 / number of CCD on the focal plane.
CHANTYPE=      'RAWX' / type of channels in columns 1
TUNIT1   =      'pixel' / 'pixel' channels
TUNIT2   =      'count' / counts at bin

```

4.3.2.3 Energy spectrum

The following file describes a histogram of counts as a function of energy. The mandatory keywords specified in 4.1.1 are present in the primary header and in addition, the following keywords shall be present in the SPECTRUM extension:

```

OCB      =          1 / OCB factor
MODE     =      SPECTROS' / one of SPECTROS, HTR, DIAG
CCDID    =          3 / number of CCD on the focal plane.
CHANTYPE=      'RAWX' / type of channels in columns 1
TUNIT1   =      'chan' / energy channels
TUNIT2   =      'count' / counts at bin

```

The abscissa values at the centers of the bins will be stored as an additional column named **ENERGY**.

4.3.2.4 Wavelength spectrum

The following file describes a histogram of counts as a function of wavelength. The mandatory keywords specified in 4.1.1 are present in the primary header and, in addition, the following keywords shall be present in the SPECTRUM: extension:

```

OCB      =          1 / OCB factor
MODE     =      SPECTROS' / one of SPECTROS, HTR, DIAG
CCDID    =          3 / number of CCD on the focal plane.
CHANTYPE=      'RAWX' / type of channels in columns 1
TUNIT1   =      'chan' / energy channels
TUNIT2   =      'count' / counts at bin

```

The abscissa values at the centers of the bins (in nm) will be stored as an additional column named **WAVELEN**.

4.3.2.5 Wavelength histogram

The following file describes a histogram of mean wavelengths as a function of camera coordinate in the dispersion direction. This file shall not be suitable for spectral fitting using Xspec and, therefore, the SPECTRUM extension will not be OGIP-compliant. It will simply consists of two columns:

Name	Type	Description
RAWX	2-byte INTEGER	Detector pixel number (dispersion direction)
WAVELEN	4-byte REAL	[nm] average wavelength at bin

The mandatory keywords specified in 4.1.1 are present in the primary header and, in addition, the following keywords shall be present in the SPECTRUM: extension:

```

OCB      =          1 / OCB factor
MODE     =      SPECTROS' / one of SPECTROS, HTR, DIAG
CCDID    =          3 / number of CCD on the focal plane.
TUNIY1   =      'pixel' / detector pixels in dispersion direction
TUNIT2   =      'nm' / wavelengths in nanometer

```

4.3.2.6 Energy histogram

The following file describes a histogram of counts as a function of energy. This file is related to the energy information of the CCDs, and it is very likely that a particular window on the

surface of the CCDs will be selected. The SPECTRUM extension will not be OGIP-compliant but and consists of a Bintable with two columns:

ENERGY	4-byte REAL	energy in keV at center of bin
COUNTS	4-byte REAL	counts at bin

The mandatory keywords specified in 4.1.1 are present in the primary header and, in addition, the following keywords shall be present in the SPECTRUM: extension:

```

OCB      =          1 / OCB factor
MODE     =          SPECTROS' / one of SPECTROS, HTR, DIAG
CCDID    =          3 / number of CCD on the focal plane.
TUNY1    =          'keV' / energy in keV at center of bin
TUNIT2   =          'count' / counts at bin

```

4.4 OM FITS Files

The primary header of all OM files will contain the mandatory FITS keywords defined in Sect. 4.1.1. The following instrument specific header keywords will also be present:

```

DETNAME = 'PRIME'          / PRIME or REDUNDANT
BPEBIN  =          T / BPE binning on/off
DPUAX1  =          1 / DPU binning x-axis 2** N
DPUAX2  =          2 / DPU binning y-axis 2** N
BINAX1  =          4 / total binning x-axis
BINAX2  =          8 / total binning y-axis
PLTSCALE=          0.5 / arcsec/subpixel - centroided pixel -> arcsec

```

The **DETNAME** keyword in the primary header will assume the values **PRIME** or **REDUNDANT**, and the **DATAMODE** keyword will always be **IMAGE**.

As the OM is an optical instrument, the OGIP FITS standards are not strictly applicable (being defined for use with data from high-energy astrophysics experiments). The SciSIM products defined here follow the spirit of the OGIP conventions as closely as possible, and **HDUCLAS_n** keywords are included where the OM file is thought sufficiently similar to OGIP analogue.

4.4.1 OM FITS Image Files

4.4.1.1 General conventions

- The simulated images will be supplied in FITS format following the definitions made for EPIC FITS images (4.2.1) whenever possible. The image data will be stored as the primary with 8-bit, 16-bit or 32-bit integer values depending on the maximum value of the data in the array.

- OM FITS image files will have the following structure:
 1. image data in the primary array
 2. SciSIM configuration extension (see 4.1.4)
- OM image files will be identified using the keyword

```
CONTENT = 'OM SIMULATED IMAGE'
```

in the primary header. The OGIP file type will be defined by the keywords

```
HDUCLASS= 'OGIP      ' / Format conforms to OGIP/GSFC conventions
HDUCLAS1= 'IMAGE     ' / File contains an image
HDUCLAS2= 'TOTAL     ' / Total (source+background) counts
```

in the primary header.

4.4.1.2 OM full frame image

This type of image file is equivalent to an EPIC MOS full-field image (4.2.1.2). In addition to the mandatory keywords defined above, the following keywords will be present in the primary header:

```
NAXIS    =          2 / a two-dimensional image
NAXIS1   =          2048 / X-size of datacube
NAXIS2   =          2048 / Y-size of datacube
BUNIT    = 'count/pixel' / physical unit of array data
CTYPE1   =          'RAWX' / detector pixels in X (X-component of image)
CTYPE2   =          'RAWY' / detector pixels in Y (Y-component of image)
CTYPE3   =          'INTENSITY' / image intensity
```

4.4.1.3 OM window image

This file contains an sub-window image of the OM full-frame. The format will be identical to the latter and, in addition, the following keywords will be present in the primary header:

```
NAXIS    =          2 / a two-dimensional image
NAXIS1   =          300 / X-size of datacube
NAXIS2   =          400 / Y-size of datacube
BUNIT    = 'count/pixel' / physical unit of array data
CTYPE1   =          'RAWX' / science window pixel in X direction
CTYPE2   =          'RAWY' / science window pixel in Y direction
CTYPE3   =          'INTENSITY' / image intensity
X0       =          100 / start of image mode window x-address
Y0       =          100 / start of image mode window y-address
FRAMETIME =          9.5 / OM MIC-CCD frame time [msec]
```

4.5 Detector Description Extensions/Keywords

The Detector Description Extension will be identical to the corresponding extension in SSC product files (cf. [3], Sect. 7.2.3. At the time of writing the contents and structure of this extension is still TBD.

4.6 AMS Index Keywords

The AMS gives access to files on the basis of their AMS keyword values. These AMS keyword values are provided by the SOC in the index file defined in the FTS ICD [8]. These keywords are defined in this section. The following conventions should be noted:

1. Integers should be treated as signed.
2. Reals will be formatted in free-format, there will not be a pre-defined number of digits before or after the decimal point. All real numbers are assumed to have the range and precision of an IEEE double precision floating point type.
3. Keywords left blank should be interpreted as NULL according to the FITS conventions.
4. Logicals will take the values 'T' (true) or 'F' (false).
5. String lengths defined defined are maximum lengths.

Keyword	Type	Max. length	comment
BINAX1	Integer	4	CCD x-axis binning
BINAX2	Integer	4	CCD y-axis binning
CATEGORY	String	10	always XMMSciSIM
CONTENT	String	40	content of file
CREATOR	String	20	name and version of code that generated this file
DATAMODE	String	12	instr. mode (IMAGING , TIMING , FAST , etc.)
DATE-END	String	24	end of observation
DATE-OBS	String	24	date of observation
DATE	String	24	file creation date
DEC_PNT	Real	8	[deg] DEC of instrument pointing
DETNAM	String	10	PRIME or REDUNDANT
EXPOSURE	Real	8	[s] exposure time
EXP_ID	Integer	4	exposure identifier
FILTER	String	16	filter ID
INSTRUME	String	5	instrument name (see [1], Table 1)
OBJECT	String	40	name of (simulated) celestial object
OBSERVER	String	40	name of observer or principal investigator
OBS_ID	String	10	observation identifier
OBS_MODE	String	8	obs. mode: POINTING , SLEW , CALIBRATION
ORIGIN	String	40	processing site
RA_PNT	Real	8	[deg] RA of instrument pointing
ROLL_PNT	Real	8	[deg] ROLL angle of instrument pointing
TWIXEL	Logical	1	binning flag

4.7 SciSIM products file naming convention

SciSIM product files will be named according to the convention:

`sim_inst_type_subtype.fits`

where:

- inst** is the instrument identifier (lower case, at most 5 characters long - see [1], Table 1 for a list of allowed values)
- type** is either `image` or `spectrum`
- subtype** subtype file identifier - integer, ≥ 0 and ≤ 99 - no padding

5 SAS Special Analysis Products

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