XMM-Newton

XMM-Newton Data Files Handbook

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1 Introduction

1.1 Purpose

The purpose of this document is to provide a detailed description of the data that are distributed from the XMM-Newton Science Archive (XSA), which is part of the Science Control System (SCS) archive.

The handbook deals with the format and structure used to distribute data from the archive and with the details of individual file contents. Instructions how to find and retrieve data from the XMM-Newton Science archive (XSA) and how to analyse the data with the Science Analysis Subsystem (SAS) can be found in the corresponding documentation ([17] and [10]).

Users are referred to section 11 for a list of useful links and documents that provide all the necessary information. In this document we use acronyms which are defined in section 9. We draw particular attention to the XMM-Newton Users Handbook (UHB), [16].

1.2 Document structure

Before individual files are described, a general introduction is given. The next section provides an overview to the different data subsystems, like the Observation Data Subsystem (ODS), the Pipeline Processing Subsystem (PPS), which uses some specific SAS tasks and the XMM-Newton Science Archive. Sect. 3 deals with the specification of the file formats.

The files are described in the order in which they are used in a systematic reduction, starting with the uncalibrated data in Sect. 4, continuing with the files needed to calibrate these data in Sect. 5, and then describing the calibrated events files in Sect. 6. In addition, the products from the Pipeline Processing Subsystem (PPS) are described in Sect. 8. Each of these sections begins with an outline of the naming convention which allows identification of each file encountered in the respective category.

The last three sections contain an acronym list and glossary, due acknowledgements, and a list of reference documents, respectively.

In Appendix A, the reference time system is explained.

1.3 A summary of the data flow

The XMM-Newton payload operations are run by the Science Operations Centre (SOC) at the European Space Astronomy Centre (ESAC) and include the pipeline data processing. The XMM-Newton Pipeline Processing System (PPS) is based on a dedicated pipeline reducing data from each of the EPIC, RGS and OM science instruments, using the same SAS software packages that are available for users to interactively analyse XMM-Newton data. The pipeline infrastructure used to carry out the processing has been developed by the Survey Science Centre (SSC) in Leicester, UK. Up to March 1st 2012, the SSC was responsible for systematically running and maintaining the pipeline, and processing responsibility was then transferred to the XMM-Newton SOC.

The SOC is responsible for all the services to the community associated with an observatory type science mission like XMM-Newton. In particular, the XMM-Newton SOC uses the re-formatted telemetry (Observation Data Files, ODF, and Slew Data Files, SDF) to generate pipeline data from the uncalibrated files (Sect. 4) and the Calibration Data (CCF, Sect. 5). The SOC archives raw, auxiliary, and processed data and enables access to the Guest Observers (GOs) and, after the end of any proprietary period, to the entire scientific community. In addition, the SOC is responsible for the calibration of the instruments and for the maintenance and optimisation of the Science Analysis Software (SAS), part of whose tasks are invoked by the PPS (Sect. 8).

The Mission Operation Centre (MOC), located at ESOC, Darmstadt, Germany, has the overall responsibility for the XMM-Newton spacecraft operations.

2 An overview of the XMM-Newton data file subsystems

The nomenclature used for activities performed by XMM-Newton is as follows: A **proposal** is a group of activities that pursue the same specific goal such as a science programme proposed by a Guest Observer (GO) or a calibration campaign proposed by an instrument team. Each proposal consists of one or more **observations** within which there are several measurements with different instruments, called **exposures**. An observation is defined to be the science data and required auxiliary information collected during a continuous period of time and registered under a common indentifier. It usually contains data from all science instruments (EPIC, RGS and OM), but not necessarily.

In the vast majority of cases, XMM-Newton is pointing to a fixed position in the sky during an observation. Exceptions are EPIC Mosaic, RGS Multipointing and slew observations. A **slew** is the period of time elapsed during a single manoeuvre between two sky pointings, and the EPIC-pn remains open with the medium filter and the observing mode of the previous observation. XMM-Newton slews through the sky at $\sim$ 90 degrees/hour, which means that a source passes through the detector field-of-view in about 15 seconds. Only the EPIC-pn camera allows slew sources to be imaged essentially as point sources while the EPIC-MOS cameras detects sources as streaks in the sky. The slew catalog therefore concentrates only on EPIC-pn data and ignores data taken in small window or timing mode. EPIC mosaic observations consist of several sky pointings with different coordinates during which data are continuously taken with the X-ray cameras. RGS multipointing observations consist of five pointings with slightly different sky positions for better sampling of the RGS spectra.

The time interval between the start and the end time of an observation is called the **duration** of the observation. In turn, an observation consists of a sequence of one or more exposures for each instrument. For an individual instrument, exposures form a non-overlapping sequence. During an exposure, the commanded state of the individual instrument is unchanged, no changes in data acquisition mode or filter (if applicable) occur, and the data thus have a fixed format. An exposure is necessarily a concept which refers to a single individual instrument.

For each observation period (*i.e.*, the period of time from the start of configuring the spacecraft and instruments for an observation until the end of the observation) or per slew period, a set of files is produced by the XMM-Newton Observation Data Subsystem (ODS). The ODS provides the facilities necessary to accept all inputs needed for the generation of the *Observation Data File* (ODF) and *Slew Data File* (SDF). These terms stand for a set of files generated for each specific observation or slew, respectively. They are stored in a single directory for each observation or slew and contain data from all operative instruments. Basically, their component files contain raw, uncalibrated science data from each active instrument mode and spacecraft information data.

Each ODF requires several components:

1. Spacecraft and science telemetry
2. Reconstructed attitude data
3. Reconstructed orbit data

For EPIC **mosaic observations**, the ODS creates a single ODF for the entire observation, out of which additional separate ODFs have been produced. These "pseudo ODFs" follow the same format as ODFs produced by the ODS. The coordinates quoted for each of the "pseudo ODFs" are the central coordinates of that pointing in the sequence. The contents are the normal ODF data corresponding solely to the observation during the time that pointing was stable. Typically, there is one exposure per instrument per pointing, except for OM, where several exposures could have been taken within a single pointing. ”Pseudo ODFs” can be recognised by the file names as shown in Sect. 4.1.1.

All scientific data included in the ODF/SDF (including the pseudo ODFs for mosaic observations) are systematically and automatically analysed by the Processing Pipeline Subsystem (PPS), and PPS products are generated for each instrument mode, using some specific SAS tasks.

The collection of calibration files necessary to reduce and analyse the data collected with the scientific payload of XMM-Newton is called *Current Calibration File* (CCF). A CCF contains all the calibration files *ever* created. The reason for keeping *all* files is that a given observation does not necessarily have to be calibrated with the *last* calibration files, but oftentimes with the files that are *nearest in time* to the time of the observation. Each file contains a time stamp to indicate the particular time for which it is valid.

For most purposes the PPS treats individual exposures separately, most PPS products are derived from data taken during a single exposure. However, there are some significant exceptions: all EPIC exposures are input to a joint source detection process; OM source information from different exposures are combined to provide colour information; potential OM counterparts to EPIC sources are identified; the RGS zero order position is determined from the EPIC source location. EPIC source lists are cross-correlated with multiwavelength archival data in the Archival Catalogue and Database Subsystem (ACDS) at the Observatoire Astronomique de Strasbourg (OAS).

The EPIC Radiation Monitor (ERM) is used for detailed monitoring of the space radiative environment, constituting a reference for the development of detectors to be used in future missions. ERM data could also be useful to define good-time intervals. Calibrated ERM data can be produced with SAS, version 9 or higher (see SAS manual for details) and will be included as part of the PPS products.

2.1 The XMM-Newton Science Archive

All data resulting from or pertinent to a given observation are archived, catalogued and linked in the XMM-Newton Science Archive (XSA):
`http://www.cosmos.esa.int/web/xmm-newton/xsa`
All relevant files, from the proposal abstract up to the processed data, catalogues and publications are stored and can easily be retrieved by means of a web based interface
`http://nxsa.esac.esa.int/nxsa-web/#search`
The data can also be retrieved directly via the AIO
`http://nxsa.esac.esa.int/nxsa-web/#aio`

The XSA archive constitutes the main interface to the scientific community. Alongside ODFs and PPS data products for all performed XMM-Newton pointed and slew observations, the XSA contains a wide range of information, such as:

- Links to Catalogues: `http://www.cosmos.esa.int/web/xmm-newton/xsa/#download`
  1. The XMM-Newton Serendipitous Source Catalogues
  2. The XMM-Newton Slew survey source catalogue
  3. The XMM-OM source catalogue
- Images, spectra and light curves that can be displayed with ds9 or with Aladin
- For each observation, access to refereed publications using the data, via a link to the SAO/NASA Astrophysics Data System (ADS)
- Access to proposal information (science abstract, instrument configuration)
- Links to XMM-Newton documentation
  `http://www.cosmos.esa.int/web/xmm-newton/documentation`
- `Link to EPIC Radiation Monitor data files`
  `http://www.cosmos.esa.int/web/xmm-newton/radmon-details`

For access to the XSA and download of files see the XSA web page:
`http://www.cosmos.esa.int/web/xmm-newton/xsa`

3 File formats

The majority of science data are stored in "Flexible Image Transport System" (FITS) format, with a few exceptions that are either ASCII or HTML files or in common display formats (e.g., PDF, PNG).

3.1 FITS format

All of the ODF/SDF component files, with the exception of the summary files, reconstructed orbit file, and raw attitude file, are FITS files and conform to the FITS standard. A description of the FITS format can be found in [5], which is accessible also at the URL
`http://fits.gsfc.nasa.gov/`
The calibration files and the bulk of the PPS products also conform to the FITS standard. Wherever possible and desirable the calibration files and the PPS products follow the conventions of the OGIP (Office of Guest Investigator Programs) FITS working group. The HEASARC FITS Working Group activities are described at the following URL:
`http://heasarc.gsfc.nasa.gov/docs/heasarc/ofwg/ofwg_intro.html`
For FITS files where OGIP FITS standards are not applicable or available, new standards closely following the OGIP approach are used.

The FITS format is primarily designed to store scientific data sets consisting of multidimensional arrays (1-D spectra, 2-D images or 3-D data cubes) and 2-dimensional tables containing rows and columns of data. A FITS data file is composed of a sequence of Header + Data Units (HDUs).

The general structure of a FITS file is as follows:

- a primary header;
- a primary data array of zero length;
- zero or more extensions

Each extension consists of an extension header and a data section. Extensions are named and can appear in any order. Only the following FITS extensions are used:

- ASCII table: `XTENSION=TABLE`
- binary table: `XTENSION=BINTABLE`
- image: `XTENSION=IMAGE`

The header consists of `keyword=value` statements, which describe the organisation of the data in the HDU and the format of the contents. It may also provide additional information, for example, about instrument status or the history of the data. The following block contains the data, which are structured as specified in the header. The data section of the HDU may contain a digital image, a table or a multidimensional matrix that is not an image. An HDU need not contain data.

3.2 Portable Data Format (PDF)

Intrinsically compressed PDF files are used for the display of line graphics. In some cases, these graphics files are derived, at least in part, from product files in FITS format. In these cases the PDF file is significantly smaller than the FITS file and/or contains annotations providing a user-friendly summary of the FITS file.

3.3 Portable Network Graphics (PNG)

Portable Network Graphics (PNG) format (see the PNG home page at the following URL `http://libpng.org/pub/png`) is used for the display of pixel images in the PPS products. PNG is an extensible file format for the loss-less, portable, well-compressed storage of images. PNG provides a patent-free replacement for GIF as the graphics file format of choice and can also replace many common uses of TIFF. Indexed-colour, grey-scale, and true-colour images are supported, plus an optional alpha channel for transparency. Sample depths range from 1 to 16 bits.

As with PDF graphics, in some cases, PNG graphics files are derived, at least in part, from PPS product files in FITS format. In these cases the PNG files are significantly smaller than their FITS files and/or contain annotations providing a user-friendly summary of the FITS file.

3.4 HTML

HTML is the standard format for files which provides overview or summary-type text information for PPS products. Important PPS results are not only presented in HTML files, and thus some information may be found in more than one type of file.

HTML files offer the possibility to provide structure to the collected PPS products of an observation through the use of hyperlinks. Web browsers can then provide a useful interface to the products. Links within the PPS products point to both external and internal services (or uniform resource locators, i.e., URLs)

- External URLs: URLs to external sites are limited to links to the SIMBAD family of servers only [for which the Centre de Données astronomiques de Strasbourg (CDS) ensures support throughout the life of the SSC]. These links provide reference data only, they do not provide access to bulk data.
- Internal URLs: internal links are those pointing to pipeline products within the pps directory. Its use provides a quick and user-friendly mechanism for navigating around a product set (i.e., those belonging to a single ODF or SDF).

Within a PPS product set HTML internal links are self-contained, i.e., apart from the external URLs described, there are no link destinations outside of the product set.

3.5 ASCII

ASCII files are used to present script and some tabular information. In particular, each ODF/SDF contains a single summary file, with a summary of the information relating to the observation or slew (see Sect. 4.1).

3.6 Compression

With few exceptions, all PPS products are supplied in compressed form, that is, each product is individually compressed using the Unix command `gzip`. The exceptions are:

- PNG product files. PNG is already an intrinsically compressed format.
- PDF product files. These are created intrinsically compressed.
- PPS run message product files, that are (small) ASCII files.
- HTML files. Browsers do not understand gzipped HTML files.

Note that fits file viewers like fv or ds9, as well as the SAS tasks can work on compressed FITS files, and it is therefore not necessary to uncompress. However, for very large files, the SAS tasks run significantly faster if the files are uncompressed beforehand.

4 Uncalibrated files

4.1 Observation/Slew data science, non-science, and spacecraft files

This section gives a basic description of the ODF/SDF component files for pointed and slew observations, respectively. The full information and details can be found in the ODF/SDF Interface Control Document [6]. There are six categories of ODF/SDF component files:

- Instrument science files are all files directly related to the scheduled observation time period. No calibration of the science telemetry is performed before it is stored in the instrument science files. The science parameters are extracted from the telemetry packets and stored in their raw form with, in general, no further processing being performed. If additional processing is required in order to generate an instrument science file, additional descriptions can be found in the relevant sections.
- Diagnostics files created during calibration observations
- Instrument housekeeping files:
  - Instrument periodic housekeeping files contain the calibrated instrument periodic housekeeping parameters and instrument-related derived parameters. The periodic housekeeping parameters are extracted from the telemetry packets and the derived parameters calculated. The parameters are then calibrated using the applicable calibration curves (as defined in the XMM-Newton telemetry data base) and stored, with the corresponding time key, in the relevant instrument periodic housekeeping file.
  - Instrument non-periodic housekeeping files
- Spacecraft files containing information of spacecraft attitude, orbit, housekeeping, and time conversion.
- EPIC Radiation Monitor (ERM) observation/slew period files. These are ERM science files which correspond to observation and slew periods. The ERM data are partitioned to correspond to observation and slew periods (see Sect. 4.1.9).
- ASCII Summary files, which contain a summary of the information relating to the observation or slew.

All the above files, except the Summary files (Sect. 4.1.2), the raw attitude file (Sect. 4.1.11.2), and the reconstructed orbit file (Sect. 4.1.11.3), are in FITS format. They come in two flavors: binary table files or image files. There are three types of binary table files, event lists, auxiliary files, and housekeeping files. An **event list** contains all the events detected in a specific CCD (EPIC, RGS) or defined window (OM). One file per exposure is defined. An **auxiliary file** contains frame/cycle information, plus other general information, generated by the CCD that was active during an exposure/observation, or bookkeeping information generated by the on-board software. A **housekeeping** file contains the calibrated instrument housekeeping parameters and instrument-related derived parameters. An ODF/SDF **image file** consists of a primary header unit, a primary data unit of zero length and one image extension HDU (see Sect. 3).

All the ODF/SDF files share a common primary header. The headers of the binary or image extensions of the other ODF/SDF files differ from each other, although sharing a set of common keywords (see [6]). For each header value an explanation is given next to the value in the header.

The ODF/SDF constituent files are described in the following sections, most of which are self-explanatory. Short descriptions of a few files are given in Sect. 10.

4.1.1 Identification of individual ODF component files

A typical ODF/SDF directory contains several dozens of files. The purpose of each file can be identified from a combination of file name and content of the FITS header.

The filenames associated with ODFs and SDFs consist of up to 27 characters, followed by a '.' (dot), followed by 3 characters. All characters are upper case. The adopted naming convention is as follows:

RRRR_**obsidentif**_IIUEEECCMMF.ZZZ

This encoding uniquely specifies the instrument, the type of observation (scheduled or unscheduled), the exposure number, the CCD/OM window identifier, the file type, and the format. Descriptions of the each filename field are listed in Table 1.

Table 1: ODF/SDF *component filenames*

Field	Description
RRRR	The revolution (orbit) number
obsidentif	The observation identifier, 10 digit: PPPPPPOOLL
PPPPPP	the identifier of the proposal that contains the obs.
OO	identifier of the observations within the proposal
LL	extended identifier (usually 01)
Notes:	For slews the first of the six P is '9'
	For pseudo ODF components of mosaic pointings, the values of LL assume values (30+x), where x is the number of the mosaic pointing.
II	The instrument, or data source, identifier
OM	optical monitor
R1	RGS-1
R2	RGS-2
M1	EPIC MOS-1
M2	EPIC MOS-2
PN	EPIC PN
RM	EPIC radiation monitor
SC	Spacecraft
U	
S	Indicates that the observation was scheduled
U	Indicates that the observation was unscheduled
X	not applicable (because not science files)
EEE	The exposure number within the observation

	000	file does not correspond to an exposure period
	9XX	is used for diagnostic Q dumps (RGS spectroscopy+Q)
CC		The CCD identifier/OM Window identifier (2 digits)
		EPIC MOS CCD number (1-7) & CCD read-out mode (0,1)
		EPIC PN CCD number (01–12)
		RGS CCD number (01–09)
		Note: "00" is used for multi-CCD files
		OM science window identifier
	00	used for those files not having a corresponding CCD or science window
MM		The data contained within the file name
	AT	Spacecraft attitude
	AU	EPIC or RGS auxiliary
	BU	EPIC PN burst
	CC	EPIC counting cycle report (auxiliary file)
	CI	EPIC MOS compressed timing
	D1	DPP non-periodic Housekeeping
	D2	DPP non-periodic Housekeeping
	DI	EPIC MOS or RGS diagnostic
	DL	EPIC PN discarded lines data
	DP	RGS Digital Pre-Processor non periodic housekeeping
	EC	EPIC MOS extra heating configuration non-periodic housekeeping (if II=M1 or M2)
	EC	EPIC Radiation Monitor (ERC) count rate (if II=RM)
	En	OM engineering where $n = 1 - 7$
	ES	EPIC Radiation Monitor (ERC) spectra
	FA	OM fast
	HB	EPIC high bit rate interface buffer size non-periodic housekeeping
	HC	EPIC high bit rate interface configuration non-periodic housekeeping
	HT	EPIC MOS high bit rate interface threshold values non-periodic housekeeping
	HT	RGS high time resolution
	IM	EPIC or OM imaging
	NO	EPIC PN noise data
	NP	OM non-periodic housekeeping
	OF	RGS offset file
	OD	EPIC PN offset data
	OV	EPIC MOS offset / variance
	P1	Spacecraft housekeeping 1 periodic housekeeping
	P2	Spacecraft housekeeping 2 periodic housekeeping
	P3	Spacecraft Attitude 1 periodic housekeeping
	P4	Spacecraft Attitude 2 periodic housekeeping
	P5	Spacecraft SYS_HK_SID0 periodic housekeeping
	P6	Spacecraft SYS_HK_SID1 periodic housekeeping
	P7	Spacecraft SYS_HK_SID4 periodic housekeeping
	P8	Spacecraft SYS_HK_SID5 periodic housekeeping

	P9	Spacecraft SYS_HK_SID6 periodic housekeeping
	PA	EPIC PN additional periodic housekeeping
	PA	OM priority field acquisition (auxiliary file)
	PC	RGS CCD temperature periodic housekeeping
	PF	RGS full periodic housekeeping
	PF	OM priority fast (auxiliary file)
	PM	EPIC PN main periodic housekeeping
	PT	EPIC MOS bright pixel table non-periodic housekeeping
	PE	EPIC MOS or OM periodic housekeeping
	RA	Raw Attitude file
	RF	OM reference frame (auxiliary file)
	RI	EPIC MOS reduced imaging
	RO	Spacecraft reconstructed orbit
	SP	RGS spectroscopy
	SU	Summary information
	TC	Spacecraft time correlation
	TH	OM tracking history (auxiliary file)
	TI	EPIC timing
	TM	EPIC thermal monitoring limits non-periodic housekeeping
	WD	OM priority window data (auxiliary file)
F		The file type
	E	event list file
	I	image file
	X	auxiliary file
	H	housekeeping
	S	spacecraft
	M	summary
zzz		File format (3 characters)
	ASC	ASCII file
	ASZ	Compressed ASCII file
	FIT	FITS file
	FTZ	Compressed FITS file
	SAS	SAS output (not original ODF constituents)

The nature of science ODF/SDF FITS files can also be identified by inspection of the value of the respective binary table(s) extension. This coding is described in Table 2. The Unix convention to indicate multiple files is used; e.g.: `M[1,2]IME1` means `M1IME1` (MOS1) and `M2IME1` (MOS2).

Finally, the nature of a file can also be identified by the value of the keyword `DATATYPE` in the binary table header (see Table 3), although in this case only the file type can be unambiguously determined, whereas a degeneracy in the instrument remains.

As mentioned above, the housekeeping files cannot always be uniquely distinguished from their binary table extension. However, they can still be recognised by their file names.

4.1.2 Observation/slew summary file

Each ODF and SDF contains a summary file in ASCII format (*SUM.ASC). The summary file is structured in blocks, each containing the following information:

Table 2: *Binary table extension name(s) for the* ODF/SDF *files*

File type	BINTABLE ...
MOS Imaging Mode Event List File	M[1,2]IME1
MOS Timing Mode Event List File	M[1,2]TIE1
MOS Auxiliary File	M[1,2]AUX1
MOS Periodic Housekeeping File	PERIODIC_HK
PN Imaging Mode Event List File	PNIME1
PN Timing Mode Event List File	PNTIE1
PN Burst Mode	PNBUE1
PN Auxiliary File (first extension)	PNAUX1
PN Auxiliary File (second extension)	PNAUX2
PN Housekeeping (first file)	PERIODIC_HK
PN Housekeeping (second file)	MAIN_PERIODIC
RGS Spectroscopy Mode Event List File	R[1,2]SPE1
RGS High Time Resolution Event List File	R[1,2]HTE1
RGS Auxiliary File (first extension)	R[1,2]AUX1
RGS Auxiliary File (second extension)	R[1,2]AUX2
RGS Periodic Housekeeping Files	PERIODIC_HK
OM Imaging Mode Image File	OMIMI1
OM Fast Mode Event List File	OMFAE1
OM Tracking History Data Auxiliary file	OMTHX1
OM Reference Frame Auxiliary File	OMRFX1
OM Periodic Housekeeping File	OMPEH1
OM Non-Periodic Housekeeping File	OMNPH1
Spacecraft Attitude History File	SCATS1
Spacecraft Time Correlation File	SCTSC1

- OBSERVATION: Observation/slew information, revolution number, scheduled Start/Stop times
- FILE: List of all ODF constituent files with short descriptions
- CONFIGURATION: Configuration details (ODF version, prime instrument)
- PROPOSAL: Proposal summary (PI name and address, proposal type, target name, exposure time, target and boresight coordinates, position angle)
- DATA QUALITY: Quality information (one block for each exposure)

A detailed description of the summary file can be found in [6]. In addition, a SAS summary file (*SUM.SAS) is produced by the SAS task `odfingest` that is usually written into the ODF directory, but is not a standard ODF constituent.

4.1.3 EPIC MOS science files

The following EPIC MOS Science Files are defined:

1. Imaging Mode Event List Files (*M[1,2]*IME.FIT)
2. Timing Mode Event List Files (*M[1,2]*TIE.FIT)
3. Auxiliary Files (*M[1,2]*AUX.FIT)
4. Counting Cycle Report Auxiliary Files (*M[1,2]*CCX.FIT)
5. Offset/variance Mode Event List Files (*M1[1,2]*OVE.FIT)

These are all binary table files. For standard analysis, only types 1–3 are needed. Their content will be described below. Counting Cycle reports (type 4) will be included if the MOS telemetry is exceeded periodically during the observation. The cycle reports should already correspond with Bad Time Intervals, but the data contained indicate the fraction of events detected but lost in the on-board processing. Therefore, the information included in these files may be useful for detailed timing analysis. Offset files (type 5) are down-linked confirmation that the CCD Zero Bias signal level were applied.

We note that the above files do **not** map one-to-one with the instrument modes defined in [16]. In particular:

- the “Full Window” and “Small Window” (aka “Partial Window”) instrumental modes produce Imaging Mode Event List Files only. If the latter is used, the sensitive area of the central chip (CCD1) is reduced. The other CCDs still produce Imaging Mode Event Lists Files for the full 600×600 pixels area.
- the “Timing” instrumental mode produces *both* Image Mode Event List (in CCDs 2–7) *and* Timing Mode Event List files (from central CCD1)
- Auxiliary files are produced for every instrumental mode

The above files can be recognised by the value of the keyword `DATATYPE` in their binary table header, as indicated in Table 3.

Table 3: *Values of the* `DATATYPE` *keywords for the* MOS/PN *science data file types*

Data mode	value of `DATATYPE`
Imaging Mode	`IMAGE.EL`
Timing mode	`TIME.EL`
Burst mode (PN only)	`BURST.EL`
Auxiliary file	`AUX.EL`
Offset/Variance (MOS only)	`OFFVAR.EL`
Counting Cycle Report	`COUNT.EL`
Offset data image (PN only)	`OFFSET.IM`
Noise data image (PN only)	`NOISE.IM`
Discarded Lines Image (PN only)	`DISCLIN.IM`

4.1.3.1 EPIC MOS Imaging Mode Event List File

An EPIC MOS Imaging Mode Event List file (*M[1,2]*IME.FIT) is created for each CCD node which is producing imaging mode data. Each file consists of a single binary table. The binary table consists of the columns listed in Table 4.

Table 4: EPIC MOS *Imaging Mode Event List file* (*M[1,2]*IME.FIT) *binary table columns*

Name	Type[a]	Units	Description
FRAME	1J	COUNTER	Frame number
RAWX	1I	PIXEL	Event raw X position
RAWY	1I	PIXEL	Event Y position
ENERGYE1	1I	CHANNEL	Event energy (E1)
ENERGYE2	1I	CHANNEL	Event energy (E2)
ENERGYE3	1I	CHANNEL	Event energy (E3)
ENERGYE4	1I	CHANNEL	Event energy (E4)
PATTERN	1B		Pattern number
PERIPIX	1B		Peripheral pixels above Threshold Counter

[a]See Sect. 9 for convention

4.1.3.2 EPIC MOS Timing Mode Event List File

An EPIC MOS Timing Mode Event List file (*M[1,2]*TIE.FIT) is created for each CCD node which is producing timing mode data. Each file consists of a single binary table. The binary table consists of the columns listed in Table 5.

Table 5: EPIC MOS *Timing Mode Event List file* (*M[1,2]*TIE.FIT) *binary table columns*

Name	Type[a]	Units	Description
FRAME	1J	COUNTER	Frame number
RAWX	1I	PIXEL	Event raw X position
RAWY	1I	PIXEL	Event Y position
ENGYE1E2	1I	CHANNEL	Event energy (E1+E2)
PATTERN	1B		Pattern number
PERIPIX	1B		Peripheral pixels above Threshold Counter

[a]See Sect. 9 for convention

4.1.3.3 EPIC MOS Auxiliary File

An EPIC MOS Auxiliary file (*M[1,2]*AUX.FIT) is created for each exposure in which at least one CCD node is producing either timing or imaging mode data. Each file consists of a single binary table. A single file per observation is created, where each row is labelled according to the relevant frame and CCD. The binary table consists of the columns listed in Table 6.

Table 6: EPIC MOS *Auxiliary file* (*M[1,2]*AUX.FIT) *Binary table columns*

Name	Type[a]	Units	Description
FRAME	1J	COUNTER	Frame number
CCDID	1B		CCD identifier
CCDNODE	1B		CCD node identifier
FTCOARSE	1I	SECOND	Coarse frame time
FTFINE	1I	40μs	Fine time frame
NPIXEL	1J	PIXEL	Pixel count
NVALID	1I	COUNTS	No. of valid events
NBELOW	1I	COUNTS	No. of events rejected by lower thresholding
NABOVE	1I	COUNTS	No. of events rejected by upper thresholding
GATTIFLG	1B		Gatti flag
FIFOOVF	1B		FIFO Overflow Flag

[a]See Sect. 9 for convention

4.1.4 EPIC MOS diagnostics files

For non-science mode observations, e.g., calibration observations, Diagnostic Mode Image Files files (files by name *M[1,2]*DII.FIT; see Table 1) are created that can not be found in standard ODF directories. The diagnostic files are binary images of Cal-closed observations without any correction (e.g., cosmic rays are not removed). They are equivalent to a dark-current observation and are used to produce the detector offset maps.

4.1.5 EPIC PN science files

The following EPIC PN Science Files are defined:

1. Imaging Mode Event List Files (*PN*IME.FIT)
2. Timing Mode Event List Files (*PN*TIE.FIT)
3. Burst Mode Event List Files (*PN*BUE.FIT)
4. Auxiliary Files (*PN*AUX.FIT)
5. Offset Data Image Files (*PN*ODI.FIT)
6. Noise Data Image Files (*PN*NOI.FIT)
7. Discarded Lines Image Files (*PN*DLI.FIT)
8. Counting Cycle Report Auxiliary Files (*PN*CCX.FIT)

These are all binary table files. All except type 6 are used in the standard data analysis. The content of types 1–4 will be described below.

Type 5 (Offset Data Image) files contain the offset maps taken on board at the start of each exposure. The offset maps contain the per pixel energy offsets for each active CCD of the configured mode; during the exposure, these offsets are subtracted on board from the measured signals.

Type 6 (Noise Data Image) files are used for diagnostic purposes and are not required for standard data analysis. They contain the per pixel offset variance.

Type 7 (Discarded Lines Image) files are present in those cases where cosmic rays have hit a PN CCDs. They contain information on the number of lines blanked as a result of a detected cosmic ray interaction.

Type 8 (Counting Cycle Report) auxiliary files provide a summary record of the data lost when the telemetry rate is exceeded by the data rate produced by the PN cameras (i.e., when the PN is operated in so-called Counting Mode).

Types 7 and 8 are required in the standard data reduction for a proper exposure correction.

As for the other XMM-Newton instruments, the PN ODF files do not explicitly contain a column TIME. PN imaging, timing and burst modes contain a ”Frame Counter”, that increments monotonically in steps of 1 for the full detector. The ODF/SDF contain no time information in UT units, this has to be calculated using the time correlation file.

It is important to note that the above modes do **not** map one-to-one with the instrument modes defined in [16]. In particular:

- the “Full Window”, “Large Window”, and “Small Window” instrumental modes produce Imaging Mode Event List Files. While in Full and Large Window, all CCDs are used (for Large Window only half of the area of each chip is read out), only a part of CCD4 is used in Small Window.
- the “Timing” instrumental mode produces Timing Mode Event List data (from one chip). In the timing mode, imaging is made only in one dimension, along the column (RAWX) axis. Along the row direction (RAWY axis), data from a predefined area on one CCD chip are collapsed into a one-dimensional row to be read out at high speed. The RAWY axis is thus not a spatial coordinate, but is equivalent to time.
- A special flavour of the timing mode of the PN is the “burst” mode, which offers high time resolution of 7μs, but has a low duty cycle of 3%.
- Auxiliary files are produced for every instrumental mode

The above files can be recognised by the value of the keyword `DATATYPE` in their binary table header, as indicated in Table 3.

4.1.5.1 EPIC PN Imaging Mode Event List File

An EPIC PN Imaging Mode Event List file (*PN*IME.FIT) is created for each CCD node which is producing imaging mode data. Each file consists of a single binary table. The header keyword `F1291` that can only be found for Full Frame observations, allows discrimination between ”Full Frame” (0) and ”Extended Full Frame” (3) Modes. The binary table consists of the columns listed in Table 7.

Table 7: EPIC PN *Imaging Mode Event List file* (*PN*IME.FIT) *binary table columns*

Name	Type[a]	Units	Description
`FRAME`	1J	`COUNTER`	Frame number
`RAWX`	1I	`PIXEL`	Event raw X position
`RAWY`	1I	`PIXEL`	Event Y position
`ENERGY`	1I	`CHANNEL`	Event energy

[a]See Sect. 9 for convention

4.1.5.2 EPIC PN Timing/Burst Mode Event List File

EPIC PN Timing/Burst Mode Event List files (*PN*$^{\text{TIE}}_{\text{BUE}}$.FIT) are created for each CCD node which is producing timing/burst mode data. Each file consists of a single binary table. The binary table consists of the columns listed in Table 8.

Table 8: EPIC PN *Timing/Burst Mode Event List file* (*PN*$^{\text{TIE}}_{\text{BUE}}$.FIT) *binary table columns*

Name	Type[a]	Units	Description
`FRAME`	1J	`COUNTER`	Frame number
`RAWX`	1I	`PIXEL`	Event raw X position
`RAWY`	1I	`PIXEL`	Event Y position
`ENERGY`	1I	`CHANNEL`	Event energy

[a]See Sect. 9 for convention

4.1.5.3 EPIC PN Auxiliary File

An EPIC PN Auxiliary file (*PN*AUX.FIT) is created for each exposure in which at least one CCD node is producing either timing or imaging mode data. Each file consists of two binary tables:

1. the first extension contains the frame information for all the active CCDs (see Appendix A.2 of [6] for a description of the relevant algorithm)
2. the second extension contains the statistical information which is produced by each quadrant after a certain number of cycles (see Appendix A.2 of [6] for a description of the relevant algorithm).

A single file per observation is created, where each row is labelled according to the relevant frame and CCD identifier (in the first extension). The binary tables consist of the columns listed in Table 9 and Table 10, respectively.

4.1.6 RGS science files

The following RGS Science Files are defined:

1. Spectroscopy Mode Event List Files (*R[1,2]*SPE.FIT)

Table 9: EPIC PN *Auxiliary file* (*PN*AUX.FIT) *binary table columns for the extension* `PNAUX1`

Name	Type[a]	Units	Description
`FRAME`	1J	`COUNTER`	Frame number
`CYCLE`	1J	`COUNTER`	Cycle Identifier
`FTCOARSE`	1I	`SECOND`	Coarse frame time
`FTFINE`	1I	20.48 μs	Fine time frame
`QUADRANT`	1B		Quadrant identifier
`CCDID`	1B		CCD identifier

[a]See Sect. 9 for convention

Table 10: EPIC PN *Auxiliary file* (*PN*AUX.FIT) *binary table columns for the extension* `PNAUX2`

Name	Type[a]	Units	Description
`CYCLE`	1J	`COUNTER`	Cycle Identifier
`QUADRANT`	1B		Quadrant identifier
`NABOVE`	1I	COUNTS	ATHR Counter
`NDEFA`	1I		DEFA Counter
`NEPDH`	1I		EPDH Counter
`NDISCLIN`	1I		Discarder Line Counters
`MCOMMODE`	I1		Mean Common Mode

[a]See Sect. 9 for convention

2. High Time Resolution Mode Event List Files (*R[1,2]*HTE.FIT)
3. Auxiliary File (*R[1,2]*AUX.FIT)

The above files can be recognised by the value of the keyword `DATATYPE` in their binary table header, as indicated in Table 11.

Table 11: *Values of the* `DATATYPE` *keywords for the* RGS *science data file types*

Data mode	value of `DATATYPE`
Spectroscopy Mode	`SPECT.EL`
High Time Resolution Mode	`HTR.EL`
Auxiliary file	`AUX.EL`

4.1.6.1 RGS Spectroscopy Mode Event List File

An RGS event file (*R[1,2]*SPE.FIT) is created for each CCD node, which is producing spectroscopy mode data. Each file consists of a single binary table. The binary table consists of the columns listed in Table 12.

Table 12: RGS *Spectroscopy Mode Event List file* (*R[1,2]*SPE.FIT) *binary table columns*

Name	Type[a]	Units	Description
FRAME	1J	COUNTER	Frame number
RAWX	1I	PIXEL	Event raw X position
RAWY	1I	PIXEL	Event Y position
ENERGY	1I	CHANNEL	Event energy
CCDNODE	1B		CCD node
SER	1B		Split Event Reconstruction

[a]See Sect. 9 for convention

4.1.6.2 RGS High Time Resolution Mode Event List File

An RGS High Time Resolution Mode Event List file (*R[1,2]*HTE.FIT) is created for each CCD node, which is producing high time resolution mode data. Each file consists of a single binary table. The binary table consists of the columns listed in Table 13.

Table 13: RGS *High Time Resolution Mode Event List file* (*R[1,2]*HTE.FIT) *binary table columns*

Name	Type[a]	Units	Description
FRAME	1J	COUNTER	Frame number
RAWX	1I	PIXEL	Event X position
ENERGY	1I	CHANNEL	Event energy
CCDNODE	1B		CCD node

[a]See Sect. 9 for convention

4.1.6.3 RGS Auxiliary File

An RGS file (*R[1,2]*AUX.FIT) is created for each exposure in which at least one CCD node is producing either spectroscopy or high time resolution data. A single file per observation is created, where each row is labelled according to the relevant frame and CCD. Each file consists of two binary tables:

- the first binary table contains the frame/cycle details and statistics for all the active CCDs
- the second binary table contains the CCD read-out sequence description

The binary tables consist of the columns listed in Tabs. 14 and 15, respectively.

4.1.6.4 RGS Diagnostic Mode Image File

The RGS diagnostic files (*R[1,2]*DII.FIT) are created for each CCD, which is producing diagnostic mode data. It consists of a single image table extension. Diagnostic data are identical to the "Q dumps" (the only difference being the naming convention; see Sect. 4.1.1). As it is

Table 14: RGS *Auxiliary file* (*R[1,2]*AUX.FIT) *first binary table columns*

Name	Type[a]	Units	Description
FRAME	1J	COUNTER	Frame number
FTCOARSE	1I	SECOND	Coarse frame time[b]
FTFINE	1I		Fine time frame[b]
EOSCOARS	1J	SECOND	Coarse readout interrupt latched time[b]
EOSFINE	1I		Fine readout interrupt latched time[b]
FRMTIME	1I		Frame Integration Time
CCDID	1B		CCD identifier
SEQINDEX	1I	COUNTER	CCD-N index[b]
NREJECTC	1J	PIXEL	No. of pixels exceeding rejection threshold (side C)[b]
NACCEPTC	1J	PIXEL	No. of pixels below acceptance threshold (side C)[b]
NUPPERC	1J	PIXEL	No. of pixels exceeding upper threshold (side C)[b]
NREJECTD	1J	PIXEL	No. of pixels exceeding rejection threshold (side D)[b]
NACCEPTD	1J	PIXEL	No. of pixels below acceptance threshold (side D)[b]
NUPPERD	1J	PIXEL	No. of pixels exceeding upper threshold (side D)[b]
NDPP	1J	PIXEL	Total number of pixels received by DPP frontend[b]
NLOSTEVT	1I	COUNTS	Lost event counter
ABORTFLG	1I		Abort flag

[a]See Sect. 9 for convention

[b]set to 0 (zero) in High Time Resolution Mode

Table 15: RGS *Auxiliary file* (*R[1,2]*AUX.FIT) *second binary table columns*

Name	Type[a]	Units	Description
SEQINDEX	1I	CONTER	Sequence index
CCDID	1B		CCD identifier
CCDNODES	1B		CCD Read-out node(s)
CCDOCB	1B		CCD OCB
CCDCSG	1B		CCD CSG
RTHRESHC	1I		CCD selection threshold (side C)
ATHRESHC	1I		CCD acceptance threshold (side C)
UTHRESHC	1I		CCD upper threshold (side C)
RTHRESHD	1I		CCD rejection threshold (side D)
ATHRESHD	1I		CCD acceptance threshold (side D)
UTHRESHD	1I		CCD upper threshold (side D)
WINDOWX0	1I	PIXEL	CCD X-start
WINDOWY0	I1	PIXEL	CCD Y-start
WINDOWDX	1H	PIXEL	CCD X-length
WINDOWDY	1H	PIXEL	CCD Y-length

[a]See Sect. 9 for convention

possible to have separate, distinct Q dump files associated with a SPECTROSCOPY+Q exposure, separate, distinct exposure numbers are allocated to these files. However, the exposure identifier (keyword EXP_ID) in the header of each file will be associated with the SPECTROSCOPY+Q exposure. Since the RGS uses CCD chips of the same fabrication type as MOS, the diagnostics files have the same structure as described in Sect. 4.1.4.

4.1.6.5 RGS Offset Files

An RGS offset (*R[1,2]*OFX.FIT) file is generated for each RGS camera. Each file consists of 18 images, 171 × 128 pixels in size, corresponding to the averaged diagnostic images for each CCD and readout node, accumulated during three neighbour orbits. The naming convention for the extension is: `CCDn_offset_[cd]`, where `n` indicates the CCD number, and `[cd]` the readout node.

4.1.7 OM science files

The following OM Science Files are defined:

1. Imaging Mode Data Image Files (*OM*IMI.FIT)
2. Imaging Mode (full frame high resolution) Data Image Files (*OM*E4I.FIT)
3. Fast Mode Event List Files (*OM*FAE.FIT)
4. Tracking History Data Auxiliary File (*OM*THX.FIT)
5. Reference Frame Data Auxiliary File (*OM*RFX.FIT)
6. Priority Field Acquisition Auxiliary Files (*OM*PFX.FIT)
7. Priority Window Data Auxiliary Files (*OM*WDX.FIT)
8. Priority Fast Auxiliary File (*OM*PAX.FIT)
9. Periodic Housekeeping file (*OM*PEH.FIT)
10. Non-periodic Housekeeping file (*OM*NPH.FIT)

These files are all binary table files, except the imaging data, which are written in a single `IMAGE` extension. Type 9 are engineering type data, which are not available for general users. The reader may refer to [6] for a detailed description of its structure and content.

The first two modes above map one-to-one the corresponding instrumental modes, as specified in [16]: the Imaging and the Fast mode, respectively.

The above files can be recognised by the value of the keyword `DATATYPE` in their binary/image table header, as indicated in Table 16.

4.1.7.1 OM Imaging Mode Data Image File

An OM image file (*OM*IMI.FIT) is produced for each imaging mode science window. It is an image file, with a single image extension containing a single image. For images taken in full frame high resolution mode, the image files are stored as *OM*E4I.FIT (see also Sect. 4.1.8).

The binning information is provided by the header keywords `BINAX1` and `BINAX2`. The header keywords `WINDOWX0`, `WINDOWY0`, `WINDOWDX`, `WINDOWDY` give the lower left corner and the size of the readout window in pixel units. For example, in "High-resolution" Full Frame Mode: `WINDOWX0=0`, `WINDOWY0=0`, `WINDOWDX=2048`, `WINDOWDY=2048`.

Table 16: *Values of the* `DATATYPE` *keywords for the* OM *science data file types*

Data mode	value of `DATATYPE`
Imaging Mode	`IMG.EL`
Full-frame low resolution	`IMG.EM`
Full-frame high resolution	`ENG.IM`
Fast Mode	`FST.EL`
Reference frame Auxiliary file	`REF.EL`
Tracking history Auxiliary File	`TRH.EL`

4.1.7.2 OM Fast Mode Event List File

OM fast event files (*OM*FAE.FIT) are created for each fast mode science window. Each file contains data from one exposure only and is constituted by one binary table. The binary table consists of the columns listed in Table 17. A more detailed description can be found in [14].

Table 17: OM *Fast Mode Event List file* (*OM*FAE.FIT) *binary table columns*

Name	Type[a]	Units	Description
`FRAME`	1J	`COUNTER`	Time slice number
`FTCOARSE`	1J	`SECOND`	Coarse Time Stamp
`FTFINE`	1I	10^{-3} SECONDS	Fine Time Stamp
`RAWX`	1I	`PIXEL`	Event X position
`RAWY`	1I	`PIXEL`	Event Y position

[a] See Sect. 9 for convention

4.1.7.3 OM Tracking History Data Auxiliary File

One OM tracking history file (*OM*THX.FIT) is created for each exposure of an observation if tracking occurred (lack of suitable tracking stars can in principle prevent this from happening). Each file consists of a single binary table, with each row representing one frame. It contains the coordinates, in detector pixels, of the guide stars found in the FOV as well as the offsets found in different tracking frames due to small jitters in the spacecraft pointing. These offsets are corrected by the shift-and-add algorithm on board. The binary table consists of the columns listed in Table 18. A more detailed description can be found in [14].

4.1.7.4 OM Reference Frame Data Auxiliary File

An OM reference frame file (*OM*RFX.FIT) is created for each exposure of an observation. Each file consists of a single binary table, with each row representing one frame. The binary table consists of the columns listed in Table 19. A more detailed description can be found in [14].

4.1.7.5 "Priority files"

Three kinds of OM "Priority" data exist:

Table 18: OM *Tracking History Data Auxiliary file* (*OM*THX.FIT) *binary table columns*

Name	Type[a]	Units	Description
FRAME	1J	COUNTER	Tracking number
NGGS	1J	COUNTS	No. of good guide stars found
DX	1J	1/1000th PIXELS	Drift in x direction
DY	1J	1/1000th PIXELS	Drift in y direction
ROLL	1J		Roll drift (in units $10^6 \sin(\theta)$)
QUALITY	1J		Quadratic sum of the x and y residuals
GSX	10J	PIXEL	Guide Star x coordinate
GSY	10J	PIXEL	Guide Star y coordinate
GSCTS	10J	COUNTS	Guide Star counts integrated over PSF

[a]See Sect. 9 for convention

- Priority Field Acquisition Auxiliary (*OM*PAX.FIT) File (the so-called "DP_FAQ" data)
- Priority Window Data Auxiliary (*OM*WDX.FIT) File (the so-called "DP_WDW" data)
- Priority Fast Auxiliary (*OM*PFX.FIT) File (the so-called "DP_BFAST" data)

They are called "priority", because they are issued with a higher priority by the Digital Processing Unit (DPU: 1024 sec) than the regular data. These files are created before the start of the actual science exposure.

DP_FAQ data contain information on the OM field acquisition made at the beginning of the observation. The purpose of the field acquisition exposure is to recenter the window for more accurate coordinates, which is fundamentally important for the fast mode. The coordinates of a set of uplinked Guide Star (GS) positions are compared to the actual measured positions in the field acquisition frame. From this comparison, the actual pointing direction of OM is derived as offset from the nominal position. Each instance of this file consists of a single binary table, whose columns are described in Table 20.

The main purpose of the DP_WDW (*OM*WDX.FIT) files is to determine the effective exposure time by correcting for dead time (time intervals during which no photons are recorded because of read out). DP_WDW data contain the position of the science window (up to 5) during an exposure and the associated memory window and detector windows, together with the position of the autonomously selected guide star windows (up to 16). The dataset also lists the tracking window positions and the finally calculated memory and detector window configurations. Each instance of this file consists of a single binary table, whose columns are described in Table 21.

The DP_BFAST data contain information on the fast mode data. A single file is produced for each exposure of the observation (excluding the Field Acquisition Exposure) if there are windows configured in fast mode. Conversely, this file is not present during exposures, where no fast windows are active. The file consists of a single binary table, whose columns are described in Table 22. There is one record per fast mode window.

Table 19: OM *Reference Frame Auxiliary file* (*OM*RFX.FIT) *binary table columns*

Name	Type[a]	Units	Description
XROLL	1J	PIXEL	Roll centre x coordinate
YROLL	1J	PIXEL	Roll centre y coordinate
GOODSTAR	1J	COUNTER	No. of good guide stars
BADSTAR	1J	COUNTER	No. of bad guide stars
GGSX	16J	PIXEL	Good guide star x coordinate
GGSY	16J	PIXEL	Good guide star y coordinate
GGSCNTS	16J	COUNTS	Good guide star counts
GGSXMIN	16J	PIXEL	Good guide star box minimum X
GGSXMAX	16J	PIXEL	Good guide star box maximum X
GGSYMIN	16J	PIXEL	Good guide star box minimum Y
GGSYMAX	16J	PIXEL	Good guide star box maximum Y
GGSX2MNT	16J	PIXEL	Good guide star X 2nd momentum
GGSY2MNT	16J	PIXEL	Good guide star Y 2nd momentum
GGSXYMNT	16J	PIXEL	Good guide star XY 2nd momentum
GGSPKCO	16J	PIXEL	Good guide star peak coordinates
GGSPKCNT	16J	COUNTS	Good guide star peak counts
GGSQUAL	16J		Good guide star quality
BGSX	16J	PIXEL	Bad guide star x coordinate
BGSY	16J	PIXEL	Bad guide star y coordinate
BGSCNTS	16J	COUNTS	Bad guide star counts
BGSXMIN	16J	PIXEL	Bad guide star box minimum X
BGSXMAX	16J	PIXEL	Bad guide star box maximum X
BGSYMIN	16J	PIXEL	Bad guide star box minimum Y
BGSYMAX	16J	PIXEL	Bad guide star box maximum Y
BGSX2MNT	16J	PIXEL	Bad guide star X 2nd momentum
BGSY2MNT	16J	PIXEL	Bad guide star Y 2nd momentum
BGSXYMNT	16J	PIXEL	Bad guide star XY 2nd momentum
BGSPKCO	16J	PIXEL	Bad guide star peak coordinates
BGSPKCNT	16J	COUNTS	Bad guide star peak counts
BGSQUAL	16J		Bad guide star quality

[a]See Sect. 9 for convention

4.1.8 OM diagnostics files

Some ODFs may contain OM calibration files of the following types:

- Flat fields and dark frames with filename
  - *OM*IMI.FIT if obtained as full frame low resolution
  - *OM*E4I.FIT if obtained as full frame high resolution

  These files can be distinguished from normal science images only by the `FILTER` keyword in the fits file header. For calibration files, the OM filter wheel is in the blocked position (FILTER=1200).

Table 20: OM *Priority Field Acquisition Auxiliary file* (*OM*PAX.FIT) *binary table columns*

Name	Type[a]	Units	Description
ITERATN	1J	COUNTER	No. of iterations to solution
XCOMMAND	1J	PIXEL	Commanded X coordinate
YCOMMAND	1J	PIXEL	Commanded Y coordinate
DX	1J	1/1000th PIXEL	Pointing error in x
DY	1J	1/1000th PIXEL	Pointing error in y
SINTHETA	1J		Absolute roll error [1/1000th $\sin(\theta)$]
NGSUP	1J	COUNTER	No. of uplinked guide stars
NGSFOUND	1J		No. of guide stars found
GSX	16J	PIXEL	X coordinates of the guide stars
GSY	16J	PIXEL	Y coordinates of the guide stars
RSX	16J	PIXEL	X coordinates of the reference stars
RSY	16J	PIXEL	X coordinates of the reference stars

[a]See Sect. 9 for convention

- Intensifier and CCD characteristics (also called engineering 6). The names of these files are *OM*E6I.FIT, and they provide a characterisation of the detector response.
- Centroiding table confirmation (also called engineering 3 and 7). The names of these files are *OM*E3I.FIT and *OM*E7I.FIT, and they are used by the on-board and ground software to compute the look-up tables used in the pixel centroiding algorithm.

The OM diagnostics files can only be used with special software and are of no use to the general user.

4.1.9 EPIC Radiation Monitor science files

The ODS creates two sets of ERM science files: the ERM fixed configuration period files and the ERM observation/slew period files. The former are ERM science files created for each ERM fixed configuration period (see Sect. 4.2). The ERM operates independently of the other XMM-Newton instruments and has fixed configuration periods which do not correspond to the observation/slew period concept. These files are a separate data type within the archive and do not constitute part of an ODF/SDF. In order to have the information of the radiation environment available for the time period of a given observation, an extract from the fixed configuration period files is made available with each ODF/SDF, and these files are described in this section. The two sets of files have the same format and structure. The only difference between them is the time periods covered.

The following files are created from the ERM observation/slew period telemetry packets:

- ERM radiation monitor count rate files (`DATATYPE = COUNTS.EL`)
- ERM spectra files (`DATATYPE = SPECTRA.EL`)

One file for slew or observation is created.

Table 21: OM *Priority Field Window Data Auxiliary file* (*OM*WDX.FIT) *binary table columns*

Name	Type[a]	Units	Description
DETWINS	1J		No. of detector windows
SCIWIND	1J		No. of science windows
MEMWIND	1J		No. of memory windows
DWX0	16J	PIXEL	Bottom left X coordinate of detector window
DWY0	16J	PIXEL	Bottom left Y coordinate of detector window
DWXSIZE	16J	PIXEL	X dimension of detector window
DWYSIZE	16J	PIXEL	Y dimension of detector window
DWMMWID	16J		Identificator of corresponding memory window
DWKOMPX	16J		MIC data decoder parameter
DWBB	16J		MIC data decoder parameter
DWAA	16J		MIC data decoder parameter
DWKOMPY	16J		MIC data decoder parameter
SWX0	16J	PIXEL	Bottom left X coordinate of science window
SWY0	16J	PIXEL	Bottom left Y coordinate of science window
SWXSIZE	16J	PIXEL	X dimension of memory window
SWYSIZE	16J	PIXEL	Y dimension of memory window
SWMODE	16J		Science window operating mode (0 = Imaging; 1 = Fast)
			15: placeholder for non-science windows
SWP1	16J		Science window mode dependent parameter[b]
SWP2	16J		Science window mode dependent parameter[c]
SWP3	16J		Science window mode dependent parameter[d]
SWP4	16J		Science window mode dependent parameter[e]
SWBASE	16J		Science window data storage address
SWMMWID	16J		Science window identificator of the corresponding memory window
MWX0	16J	PIXEL	Bottom left X coordinate of memory window
MWY0	16J	PIXEL	Bottom left Y coordinate of memory window
MWXSIZE	16J	PIXEL	X dimension of memory window
MWYSIZE	16J	PIXEL	Y dimension of memory window
MWBASE	16J		Memory window retrieval address

[a] See Sect. 9 for convention

[b] If Imaging mode: Pixel binning factor in X ($2^{\mathtt{SWP1}}$); If Fast mode: sampling time (in DPU units: 1024 sec)

[c] Only if imaging mode: Pixel binning factor in Y ($2^{\mathtt{SWP2}}$)

[d] Not used

[e] Starting address in DPU global memory to which the accumulated image is written

4.1.9.1 ERM Count Rate Files

The ERM Count Rate files (*RM*ECX.FIT) are produced to cover every observation and slew period. Each file consists of a single binary table, where each entry (frame) corresponds to a telemetry packet. The binary table consists of the columns listed in Table 23.

Table 22: OM *Priority Fast Auxiliary file* (*OM*PFX.FIT) *binary table columns*

Name	Type[a]	Units	Description
BFASTID	1J		Blue DSP 1 or 2
SAMPTIME	1J		Sample time
NFASTPIX	1J		No. of pixels for fast time slice
FASTDEST	1J		Memory address of fast mode data stream
FASTEND	1J		Termination address of fast mode data
NFASTEVT	1J		Total no. of events in mode data
FASTADDR	503J		Fast addresses

[a]See Sect. 9 for convention

Table 23: *ERM Count Rate files* (*RM*ECX.FIT) *binary table columns*

Name	Type	Units	Description
FTCOARSE	1J	SECONDS	Coarse frame time
FTFINE	1I		Fine frame time
FRAME	1J	COUNTER	Frame identifier
NLE0	1I		Counting LE0[a]
NLE1	1I		Counting LE1[a]
NLE2	1I		Counting LE2[a]
NHE0	1I		Counting HE0[a]
NHE1	1I		Counting HE1[a]
NHE2	1I		Counting HE2[a]
NHEC	1I		Counting HEC[a]
WFSTAT	1I		Warning flag status
EVALCADD	1I		EVALCOMP address
EVALCNO	1I		EVALCOMP number

[a]these values are compressed, with a pseudo-logarithmic compression method ([2])

4.1.9.2 ERM Spectra Files

ERM Spectra files (*RM*ESX.FIT) are produced to cover every observation and slew period. They contain the spectra created in the ERM. The ERMS data consist of three measurements per readout, two spectra from the High Energy Detectors (HEDs) and one from the Low Energy Detector (LED). 256 spectral bins are available in the LED and HED. The HEDs are sensitive to electrons above 200 keV and protons above 10 MeV, while the LED is sensitive to electrons with energies above 50 keV. The two high energy spectra are the “HE detector spectrum” (HES), with events from either one or both HE detectors, and the “coincidence HE spectrum” (HEC), in which only events detected by both HEDs will be recorded. Each entry (frame) corresponds to a complete spectrum. The spectra are accumulated every 2 telemetry packets, if the ERM is operated in *fast mode* and every 128 telemetry packets if the ERM is operated in *slow mode*. Each ERM file consists of a single binary table, whose columns are specified in Table 24.

Table 24: *ERM Spectra files* (*RM*ESX.FIT) *binary table columns*

Name	Type	Units	Description
FTCOARSE	1J	SECONDS	Coarse frame time
FTFINE	1I		Fine frame time
FRAME	1J	COUNTER	Frame identifier
SPLE	256I	COUNTS	SP_LE Accumulated spectrum[a]
SPHES	256I	COUNTS	SP_HES Accumulated spectrum[a]
SPHEC	256I	COUNTS	SP_HEC Accumulated spectrum[a]

[a]See Sect. 4.1.9.2 for definition

4.1.10 Instrument Housekeeping Files

Two types of instrument housekeeping parameter files are defined:

1. Periodic Housekeeping File
2. Non-periodic Housekeeping File

At least one housekeeping file of each type can be found in an ODF/SDF for each instrument. All instrument periodic housekeeping files are FITS files. They consist of a primary header unit, a primary data unit of zero length and a binary table extension header data unit. Each calibrated instrument housekeeping parameter or derived parameter being represented by a column of the binary table. All operational housekeeping parameters are given as a function of time. The time units can be converted to UT using the Time Correlation file (see Sect. 4.1.11.1). The column names are generic, and the exact specification of the periodic housekeeping parameters, how they are calibrated and how they are stored within the periodic housekeeping files is to be found in the Operational Database definition.

Some details on the housekeeping parameters can also be found in the ODF/SDF control document [6].

The *periodic* housekeeping file contains the calibrated instrument periodic housekeeping parameters and instrument-related derived parameters. The periodic housekeeping parameters are extracted from the telemetry packets and the derived parameters calculated. The parameters are then calibrated using the applicable calibration function (as defined in the XMM-Newton telemetry database) and stored, with the corresponding time key, in the relevant instrument periodic housekeeping file.

4.1.11 Spacecraft files

The spacecraft files contain information relating to an observation or slew period. The following spacecraft files are defined:

1. Time Correlation file (*SC*TCS.FIT)
2. Reconstructed Time Correlation file (*SC*TCX.FIT)
3. Raw Attitude History file (*SC*RAS.ASC)

4. Attitude History file (*SC*ATS.FIT)
5. Reconstructed Orbit file (*SC*ROS.ASC)
6. Periodic Housekeeping file (*SC*P[1...9]S.FIT)

4.1.11.1 Spacecraft Time Correlation File

The Spacecraft Time Correlation file (*SC*TCS.FIT) contains the On-Board Data Handler (OBDH) time and the corresponding UTC. The epoch for UTC time reference is: 1958, January 1. More details about the definition of the time packets is given by [12] and [13]. One file is created for each observation and for each slew period. Each file consists of a single binary table whose columns are listed in Table 25.

The UTC is calculated as follows:

$$\mathrm{UTC} = \mathrm{CORRPARA} \times \mathrm{OBT} + \mathrm{CORRPARB} \tag{1}$$

The UTC is expressed in units of 100 nanoseconds from the epoch 1858-11-17T00:00:00.000 (base date of the U.S. Naval Observatory's ephemerides). The number is then split in its day, ms, and μs units, as indicated in Table 25.

Alongside the Spacecraft Time Correlation file, a Spacecraft *Reconstructed* Time Correlation file (*SC*TCX.FIT) is available as well and has been used by the SAS since version v6.0 (March 2004). The Reconstructed Time Correlation data is Time Correlation Data corrected for known anomalies in the correction of Earth Reception Time (ERT) for signal propagation delay and corrected for symmetric discontinuities in Corrected ERT introduced by differences in Ground Station Clocks. The binary table columns are given in Table 25. The first 12 columns are the same as in the *SC*TCS.FIT file, and six additional columns are present. Details of the orbit files are provided in [11].

4.1.11.2 Spacecraft Attitude History File

The Spacecraft Attitude History file (*SC*ATS.FIT) contains the attitude data extracted from flight dynamics. A single file is created for the whole revolution, when the observation/slew period occurred. All information is expressed with respect to the mean geocentric equatorial reference system of Equinox J2000.0. Each file consists of a single binary table, whose columns are described in Table 26.

The Spacecraft Raw Attitude History file (*SC*RAS.ASC) contains a subset of the quantities in the Spacecraft Attitude History files, sampled, however, at the maximum possible rate (0.5-1 s). Each file (in ASCII format) consists of a single table, whose columns are described in Table 27.

4.1.11.3 Spacecraft Reconstructed Orbit File

The Reconstructed Orbit file (*SC*ROS.ASC) contains the orbit position of the spacecraft. A single ASCII file is created for each observation and slew period. The numbers are Chebyshev Polynomial coefficients from which the orbit position can be calculated as a function of time. Details of the orbit files are provided in [11]. For faster delivery, predicted orbit information is used if no reconstruction data are available. These are usually available within two weeks after an observation. The letter 'R' in the first column indicates that reconstructed orbit data are

Table 25: *Spacecraft Time Correlation file* (*SC*TCS.FIT) *binary table columns. The Reconstructed Time Correlation file* (*SC*TCX.FIT) *has the same columns plus those in the bottom part.*

Name	Type[a]	Units	Description
`FRAME`	1J	`COUNTER`	
`OBTCOARS`	1J	`SECOND`	Coarse COBT
`OBTFINE`	1J		Fine COBT
`UTCDAY`	1I		UTC day corresponding to COBT
`UTCMILLI`	1J		UTC ms of day corresponding to COBT
`UTCMICRO`	1I		UTC μs of day corresponding to COBT
`CORRPARA`	A39		Slope of least squares fit
`CORRPARB`	A39		Abscissa of least square fit
`UTCFLAG`	1I		UTC quality flag
`ERTIME`	27A		Corrected Earth received time
`GSID`	5A		Ground station identifier
`ERTIMERAW`	27A		RAW Earth received time
Additional columns only in reconstructed file			
`UTCREAL`	D		UTC
`OBTREAL`	D		COBT
`PASS`	I		Pass Number
`GS`	I		Ground Station Identifier
`PREDUTC`	D		
`RESIDUAL`	D		

[a]See Sect. 9 for convention

given, while a 'P' indicates that predicted data are given. The entries with letter 'P' are being replaced in the Reconstructed Orbit file as the reconstructed information comes in, and entries with 'P' should only occur in ODF data that are less than two weeks old.

4.1.11.4 Spacecraft Periodic Housekeeping File

The Periodic Housekeeping files (*SC*P[1...9]S.FIT) contain periodic housekeeping telemetry packets concerning:

- Experiment housekeeping
- Spacecraft temperature
- Attitude

Housekeeping files contain a plethora of parameters which can not all be listed in this document. Details of content and format are given in: [3], [4], and [15].

4.2 EPIC Radiation Monitor archive

In addition to the ERM files that are present in each ODF/SDF directory (see Sect. 4.1.9), an archive of all ERM files can be used to extract radiation data for any period of time without the

Table 26: *Spacecraft Attitude History file* (*SC*ATS.FIT) *binary table columns*

Name	Type[a]	Units	Description
VALTIME	19A	yyyy-mm-ddThh:mm:ss	Time from which data in this record are valid
VALDUR	1E	SECOND	Duration for which data in this record are valid
OTFTHRES	1E	ARCSEC	On target flag threshold
VIEWRA	11A	HH:MM:SS.S	R.A. of viewing direction
VIEWDECL	11A	±DD:MM:SS.S	Declination of viewing direction
ASTPOS	1E	DEGREE	Astronomical position angle
ROLLANG	1E	DEGREE	Roll angle
GSREFNO	12A		Guide Star reference number in catalogue
GSRA	11A	HH:MM:SS.S	Guide Star right ascension
GSDEC	11A	±DD:MM:SS.S	Guide Star declination
ASPANGLE	1E	DEGREE	Solar aspect angle
ACFLAG	1B		Attitude contingency flag
APDAMP	5A	ARCSEC	Observable APD amplitude
DIFFVRA	11A	HH:MM:SS.SS	Difference between reconstructed and commanded viewing direction right ascension
DIFFVDEC	11A	±DD:MM:SS.S	Difference between reconstructed and commanded viewing direction declination
DIFFPOS	11A	DEGREE	Difference between reconstructed and commanded viewing direction position angle
PREQID	14A		Pointing request identifier
TYPEID	1A		Type identifier
SOURCEID	1A		Source identifier
ATTSEQNO	1A		Attitude sequence number
SLEWTIME	19A	yyyy-mm-ddThh:mm:ss	Start time of slew to the pointing request
PTTIME	19A	yyyy-mm-ddThh:mm:ss	Start time of stable pointing period

[a]See Sect. 9 for convention

need to access the corresponding ODF/SDF directories. This set of data is planned to be part of the XMM-Newton Science Archive (XSA). At this time, the data are available via a dedicated web page
`http://www.cosmos.esa.int/web/xmm-newton/radmon`
For each XMM-Newton revolution there will be a compressed tarball file (radmon_RRRR.tar.gz) containing the following information:

1. Up to 4 files containing the Radiation Monitor data gathered during the revolution RRRR. These ERM files have table columns as described in Sect. 4.1.9, but in addition have been time correlated with the available Fitted Time Correlation data (see below).
   The files are named RRRR_SPED_EME.FIT where
   - RRRR = revolution number
   - SPED = Speed (FAST or SLOW)
   - EME = Mode (ESE for spectra Mode or ECE for Counting mode)

Table 27: *Spacecraft Raw Attitude History file* (*SC*RAS.ASC) *ASCII table columns*

Name	Type[a]	Units	Description
VALTIME	15.9F	MJD2000	Time from which data in this record are valid
REQUESTID	10A		Pointing request identifier
VIEWRA	12.9F	RAD	R.A. of viewing direction
VIEWDECL	12.9F	RAD	Declination of viewing direction
ASTPOS	9.6F	RAD	Astronomical position angle
ASPANGLE	9.6F	RAD	Solar aspect angle
ROLLANG	9.6F	RAD	Roll angle
SUSEFLAG	1A		Sensor usage flag[b]
POINTYPE	1A		Pointing type identifier[c]
ATRETYPE	2A		Attitude reconstruction method[d]

[a] See Sect. 9 for convention

[b] "T" ("F") indicates that sun solar sensor has (has not) been used for attitude determination

[c] "O" = open-loop slew; "C" = closed-loop slew; "S" = settling-period attitude; "P" = stable pointing attitude

[d] "MO" for attitude determination based on a map; "Gn" for attitude determination based on n tracked stars

For instance: 1278_FAST_ESE.FIT, 0679_SLOW_ECE.FIT, ect.
The Radiation Monitor files contain, in addition to the standard XMM-Newton time column, extra columns providing the correlated time in UT and MJD formats (see Appendix A of the Data Files Handbook for details on the time systems).

2. RRRR_orbit.FIT This file is the result of the SAS orbit task executed with a sample interval of 1 sec and making use of the Reconstructed Orbit (not the Predicted Orbit) data.

3. RTX_RRRR_VVVV.FIT This file is the Fitted Time Correlation file for revolution RRRR (VVVV indicating the file version). It has been used to correlate the Radiation Monitor data frame counter with time.

4. Raw Attitude File (RAF) RRRR_VVVV.RAF.tgz This (compressed ASCII) file contains the Raw Attitude for the given revolution. The format of this file is the same as that of the *SC*RAS.ASC file described in Table 27 (see Sect. 4.1.11).

5 Calibration data: CCF

The Current Calibration File, CCF, is the collection of data sets that are available with observation data files to allow science analysis, i.e., to reduce and analyse the data collected with the scientific payload of XMM-Newton. Dedicated software (Calibration Access Layer, CAL) is available in the SAS distribution to access or visualise CCF files. The reader may refer to [10] for a detailed description of the CAL structure and functions.

The nomenclature used here is as follows:

- Current Calibration File (CCF): the collection of all the calibration files that are valid at a particular time. This is different from the collection of all the calibration files stored in the CCF repository.
  The current calibration file does not have a version number, and it should be seen as a view of what calibration files are valid for a time and for a specific observation date.
- Calibration data type: Broad classification of relevant function
- Calibration file or Constituent: one instance of a given calibration data type.
  A calibration file has an issue number and a start-of-validity date, by which it can be uniquely identified.
  Several calibration files can refer to the same calibration data type. They may refer to different instruments (or scope), or to different issues of the same data. Each triplet {scope, calibration type, issue} is unique.

The decision of which calibration files are relevant to a given observation is solely based on the time when the observation was made and the time of the analysis. A repository of all the CCF constituents can be found at
ftp://xmm.esac.esa.int/pub/ccf/constituents.

A more detailed description of the calibration file contents can be found in [1].

5.1 The Calibration Index File

In order to make use of calibration files during the data analysis, the information of relevant calibration files and the location of the directory holding the calibration files has to be provided.

The Calibration Index File (CIF) provides this information for a given observation. This file is provided as part of the pipeline products. Moreover, it can be rebuilt during any SAS session through the `cifbuild` SAS task, specifying the observation date, the analysis date and the directory where the CCF are located (cf. [10]).

The CIF is a single binary table with the columns specified in Table 28. A CIF can also be generated based on the content of the XMM_CALINDEX File. This file contains a list of all CCF constituents released from the start of the mission until the date specified in the `SUBDATE` column.

5.2 File naming convention

The constituents of the current calibration file are named as follows:

Table 28: CIF *binary extension columns*

Name	Type[a]	Description
`TELESCOP`	4A	`XMM`
`SCOPE`	6A	see Table 29
`TYPEID`	32A	Calibration file type
`ISSUE`	1I	Sequential number
`VALDATE`	19A	Validity date (start)
`VALDATE-END`	19A	Validity date (end)
`FNAME`	256A	File name
`DATE`	19A	Creation date
`FSIZE`	1J	File size (in bytes)
`SUBDATE`	19A	Submission date
`EXTSEQU`	32A	Extension sequence
`EXTSEQID`	256A	Extension sequence identifier
`MD5`	32A	MD5 digital signature
`CREATOR`	64A	File creator

[a]See Sect. 9 for convention

scope_calname_issue.ccf

where:

scope indicates the scope of the calibration file. While 6 characters are reserved (see Table 28), no scope identifier is longer than 5 characters. The list of scope identifiers is given in Table 29.

calname is the calibration data type identifier. While 32 characters are reserved (see Table 28), no data type identifier is longer than 17 characters. The list of data type identifiers is given in Table 30.

issue is the file issue number (integer $\geq$ 0000 and $\leq$ 9999, zero padded).

File names are all upper case, but in this document they are type set with upper and lower case letters for readability.

Table 29: *Allowed scope identifiers*

XMM	general files or files shared by more than one instrument
OM	Optical Monitor files
XRT1, XRT2, XRT3	X-ray Telescope files
EMOS1, EMOS2	European Photon Imaging Camera MOS files
EPN	European Photon Imaging Camera PN files
RGS1, RGS2	Reflection Grating Spectrometer files

Table 30: *Calibration data types by scope. A '+' indicates that calibration files for the respective scope is present and is explained in Sect. 5.3*

	XMM	XRT	EMOS	EPN	RGS	OM
AbsCoefs	+					
ADUConv			+	+	+	
AstroMet						+
Background			+	+	+	
BadPix			+	+	+	+
BoreSight	+					
CalIndex	+					
CalSourceData			+	+	+	
ClockPatterns					+	
ColorTrans						+
Contamination			+			
CoolPix					+	
CrossPSF					+	
CTI			+	+	+	
DarkFrame			+	+	+	+
DiffuseGala						+
EffAreaCorr					+	
Efficiency			+	+		
EXAFS					+	
FilterTransX			+	+		
GrismCal						+
HKParmInt			+	+	+	+
LargeScaleSens						+
LinCoord			+	+	+	+
LineSpreadFunc					+	
MiscData	+					
ModeParam			+	+	+	
PatternLib			+			
PhotToNat						+
PixToPixSens						+
PSF1DRB						+
QuantumEf			+	+	+	
QuickMag						+
Redist			+	+	+	
Reject				+		
SaaCorr					+	
SpecQual	+					
TemplateBckgnd					+	
TimeCorr			+	+		
TimeJump				+		
XAreaEf		+				
XEncirEn		+				
XPSF		+				
Zodiacal						+

5.3 File description

In this Section, a brief description of all constituents of a CCF is given. For detailed descriptions, the reader is referred to [4]. In all the following subsections **calibration type** indicates both the calibration data type identifiers, as listed in Table 30, and the value of the keyword `TYPEID` in each file.

5.3.1 Scope: xmm

There will be one instance of each of these files.

Calibration type: *AbsCoef*
Description: Elemental absorption coefficients

Calibration type: *BoreSight*
Description: Alignment of individual instruments with respect to XMM-Newton's reference frame in terms of Euler angles

Calibration type: *CalIndex*
Description: Master index file for all possible current calibration file constituents

Calibration type: *MiscData*
Description: Miscellaneous data

Calibration type: *SpecQual*
Description: Spectral Quality-related CCF constituent

5.3.2 Scope: xrt

There will be three instances of each of these files.

Calibration type: *XAreaEf*
Description: X-ray effective area of a single mirror module versus energy, field angle, and azimuth

Calibration type: *XEncirEn*
Description: X-ray encircled energy function of a single mirror module versus energy, field angle, and azimuth

Calibration type: *XPSF*
Description: X-ray point spread function of a single mirror module versus energy, field angle, and field azimuth

5.3.3 Scope: emos

There will be two instances of each of these files, one for each MOS camera.

Calibration type: *ADUConv*
Description: Conversion factors of the digitised signal to pulse invariant, and further to observed energy units (keV), not accounting for charge transfer efficiency, GATTI and redistribution

Calibration type: *Background*
Description: Calibrated event list of low background data

Calibration type: *BadPix*
Description: Table of dead/hot/flickering pixel

Calibration type: *CalSourceData*
Description: Spectrum and intensity maps of the on-board calibration sources (Not yet available)

Calibration type: *Contamination*
Description: MOS contamination correction

Calibration type: *CTI*
Description: Average charge transfer inefficiency values for the relevant clock shifts, needed to calculate the charge loss as a function of event coordinates and observing mode

Calibration type: *DarkFrame*
Description: Average dark image and raw/column offset vectors

Calibration type: *Efficiency*
Description: EPIC MOS to RGS effective area ratio

Calibration type: *FilterTransX*
Description: Filter (X-ray) transmission curves. Includes coefficients to characterise spatial distribution as a function of stepper motor position

Calibration type: *HKParmInt*
Description: Housekeeping parameter ranges used to generate good time intervals

Calibration type: *LinCoord*
Description: Contains the transformation matrix to convert CCD pixel coordinates into angular and linear offsets from the boresight

Calibration type: *ModeParam*
Description: Provides the most important fixed parameters for the observation modes

Calibration type: *PatternLib*
Description: EPIC MOS pattern library

Calibration type: *QuantumEf*
Description: Spatially varying CCD quantum efficiency

Calibration type: *Redist*
Description: Analytical model for the CCD energy redistribution

Calibration type: *TimeCorr*
Description: Time offset correction to convert spacecraft time stamps to mean photon absorption time

5.3.4 Scope: epn

There will be one instance of each of these files.

Calibration type: *ADUConv*
Description: Conversion factors of the digitised signal to pulse invariant, and further to observed energy units (keV), not accounting for charge transfer efficiency and redistribution

Calibration type: *Background*
Description: Spectrum and scalar modifiers for correlation to the EPIC radiation monitor spectra

Calibration type: *BadPix*
Description: Table of bad columns/pixels including reference to the actual on-board table. Includes true flickering pixels (which cannot be reliably characterised by a noise value)

Calibration type: *CTI*
Description: Average Charge Transfer Inefficiency values for the relevant clock shifts, needed to calculate the charge loss as a function of event coordinates and observing mode

Calibration type: *CalSourceData*
Description: Spectrum and intensity maps of the on-board calibration sources

Calibration type: *DarkFrame*
Description: Average dark frame and image of statistical dark fluctuations for the default set of observing modes. Primarily used to estimate probability of false signal. Includes "flickering pixels" showing a large but quantifiable fluctuation

Calibration type: *Efficiency*
Description: EPIC PN to RGS effective area ratio

Calibration type: *FilterTransV*
Description: Filter (optical) transmission curves

Calibration type: *HKParmInt*
Description: Housekeeping parameter ranges used to generate good time intervals

Calibration type: *LinCoord*
Description: Contains the transformation matrix to convert CCD pixel coordinates into angular and linear offsets from the boresight

Calibration type: *ModeParam*
Description: Observation mode fixed parameters

Calibration type: *QuantumEf*
Description: Spatially varying CCD quantum efficiency

Calibration type: *Redist*
Description: Analytical model for the CCD energy redistribution

Calibration type: *Reject*
Description: Low energy rejection refinement. Correction for incorrect offset shifts

Calibration type: *TimeCorr*
Description: Frame time per CCD mode. Provides the time offset corrections to convert spacecraft time stamp to mean photon absorption time

Calibration type: *TimeJump*
Description: EPIC-pn time jump parameters

5.3.5 Scope: rgs

There will be two instances of each of these files for RGS1 and RGS2, respectively.

Calibration type: *ADUConv*
Description: Coefficients tables and model to convert PHA to energy

Calibration type: *Background*
Description: Background model; superseded by TemplateBckgnd (see below)

Calibration type: *BadPix*
Description: Table of bad (hot/dead/flickering/pin hole) CCD pixels

Calibration type: *CalSourceData*
Description: Data relative to the on-board calibration sources: energies, reference pulse heights intensity maps, CCD images

Calibration type: *ClockPatterns*
Description: CCD read out clock patterns

Calibration type: *CoolPix*
Description: List of Y Columns that do not always record the full energy (=Cool Columns)

Calibration type: *CrossPSF*
Description: Parametrised point spread function in the cross dispersion direction

Calibration type: *CTI*
Description: Coefficients to correct for the CCD charge transfer inefficiency

Calibration type: *DarkFrame*
Description: Dark frame images of A CCD (on a per node basis) for the baseline frame time, with associated statistical information

Calibration type: *EffAreaCorr*
Description: Effective area model as a function of time (in MJD units)

Calibration type: *EXAFS*
Description: Table of relative correction factors for the CCD quantum efficiency as a function of energy

Calibration type: *HKParmInt*
Description: Housekeeping and auxiliary science parameter ranges used to generate good time intervals

Calibration type: *LinCoord*
Description: Data required to transform from pixel to physical coordinates on the CCD

Calibration type: *LineSpreadFunc*
Description: Parametrised line spread function

Calibration type: *MiscData*

Description: Miscellaneous coefficients

Calibration type: *ModeParam*
Description: Summary of observation mode parameters

Calibration type: *PatternLib*
Description: RGS pattern library

Calibration type: *QuantumEf*
Description: CCD quantum efficiency and grating plates reflection efficiency, RGA intercept and obscuration factors

Calibration type: *TemplateBckgnd*
Description: Background Spectra Templates. The 16 extensions (spec_1 for 1st and spec_2 for 2nd order) stand for 16 defined levels of background.

Calibration type: *SaaCorr*
Description: Sun Angle correction to the RGS Wavelength scale

5.3.6 Scope: om

There will be one instance of each of these files.

Calibration type: *AstroMet*
Description: Contains the definition of the linear detector grid as keywords in the extension headers and the deviations of pixel positions from ideal (i.e., flat grid) locations

Calibration type: *BadPix*
Description: Table of bad pixels, listing the position, the type of defect and the severity level

Calibration type: *ColorTrans*
Description: Contains the coefficients for the colour transformation, i.e., the transformation from the natural into a standard system, including the instrument zero point

Calibration type: *DarkFrame*
Description: Contains the dark current map. It comprises one image extension holding a map at full resolution

Calibration type: *DiffuseGala*
Description: Contains information (image and spectrum) on diffuse galactic emissions

Calibration type: *GrismCal*
Description: Grism Calibration (Wavelength and flux)

Calibration type: *HKParmInt*
Description: House keeping parameter ranges used to generate good time intervals

Calibration type: *LinCoord*
Description: Data required to transform from pixel to physical coordinates on the CCD

Calibration type: *LargeScaleSens*

Description: Contains the non-uniformity correction maps describing the large-scale sensitivity variations of the combination filter plus detector

Calibration type: *PhotToNat*
Description: Conversion curve coefficients to correct count rates for detector effects

Calibration type: *PixToPixSens*
Description: Contains map, describing the non-uniformity of the detector flatfield response

Calibration type: *PSF1DRB*
Description: Describes the radial point spread function for each filter at 10 different ratios of count-rate/framerate

Calibration type: *QuickMag*
Description: Lookup table for a rough count to magn. conversion for different spectral types

Calibration type: *Zodiacal*
Description: Contains the intensity map and average spectrum of the zodiacal light

6 Calibrated event lists

The XMM-Newton Science Analysis System (SAS) for the X-ray instruments can be broadly described as a two-stage process (each of these stages eventually sub-divided into further sub-processes). The first one (called "**reduction**" hereinafter) produces **calibrated concatenated event lists** from the uncalibrated chip-based event lists that are included in the ODF/SDF. To perform this task, the SAS makes use of the information contained in the auxiliary and housekeeping files, as well as the calibration algorithm/files, which constitute the CCF. In this context, *calibrated* means that the raw quantities, which characterise the detection of each photon by the X-ray detectors are converted to physical quantities (or quantities which can be equivocally mapped into physical quantities); *concatenated* means that a *single* event file is produced, containing photons detected by different chips of the same detector from different exposures, provided that the experimental configurations are mutually consistent. Event lists corresponding to different detectors (*e.g.*: MOS1 and MOS2) are *not* concatenated. The second stage is the **extraction of scientific products** (images, light curves, spectra, sub-event lists selected according to different scientific and/or instrumental criteria) from the calibrated concatenated event lists.

Given the above structure, the calibrated concatenated event lists (simply "event lists" hereinafter) play a fundamental role in the scientific analysis of XMM-Newton data. The event lists are the starting point of the analysis and interpretation of XMM-Newton data.

This Section deals with a short description of the structure of the event files, which are produced by the SAS reduction tasks (`epproc, emproc`, `rgsproc` meta-tasks) for EPIC and RGS scientific modes. "Diagnostic" or "engineering" modes produce direct images and can therefore not be encompassed in the above scheme. Calibrated and concatenated event lists are also delivered as PPS products. The detailed format of such event lists can differ slightly from that of the files produced by the `epproc`, `emproc`, and `rgsproc` meta-tasks. A detailed description of the PPS-generated calibrated concatenated event lists is given by [7]. In Sect. 8 a summary of all PPS products is given. For the OM, events files are only produced for the fast mode by the SAS task `omfchain`. The OM fast mode event file is an intermediate product and is not delivered with the pipeline.

Event timing is provided as seconds elapsed since the mission reference time. See Appendix A for more details.

6.1 Event list structure in the MOS Imaging Mode

The MOS Imaging Mode event file produced by `emproc` is named

REVN_OBSID_EMOS[1,2]_SEEE_ImagingEvts.ds

with REVN the 4-digit revolution number, OBSID the 10-digit observation ID, and EEE the exposure number. It has the following extensions:

- 1 `PRIMARY` extension, which contains no data
- 1 `EVENT` extension, which contains all the events which have passed the non-destructive filters of the reduction procedures/algorithms
- 1 `OFFSETS` extension, which contains column and row offset values of patched offsets (as applied through the on-board offset table) or anomalous offsets (e.g., as a result

of bit flips in the EDU memory or other serendipitous events) as determined by the SAS event processing.

- 7 `EXPOSU0`n extensions (one for each chip; $n = 1, 2, ..., 7$), which contain the exposure fractions (0–1) for each chip as a function of time. In timing mode, chip #1 is used for timing, and only extensions $n = 2, ..., 7$ are present.
- 7 `BADPIX0`n extensions (one for each chip; same as for `EXPOSU0`n), which contain a map of the bad pixels, with some associated properties
- 1 `CALINDEX` extension, which contains the CIF employed to reduce the data
- 7 `STDGTI0`n extensions, which contain the Good Time Intervals (GTIs) applied to produce the event list. n as for `EXPOSU0`n
- In addition, any number of extensions `GTI00`n`ZZ` may be included in the evens file, written by any non-standard time filtered expression, mainly in evselect. n is the same as for `EXPOSU0`n but starting at 0, thus $n = 0, 1, ..., 6$.
  `ZZ` is a sequence number in the Data Subspace corresponding to a TIME filter expression. If the event list was filtered using more than one TIME expression, consecutive GTI extensions are added starting with `ZZ=02`, thus 00n02, 00n03, etc...

An overview of the columns in each of the above extensions is given in Table 31.

Table 31: MOS *Imaging Mode event list column*

Name	Units	Description
BINTABLE EVENT		
TIME	SECONDS	
RAWX	PIXELS	Event X coordinate as measured by the detector
RAWY	PIXELS	Event Y coordinate as measured by the detector
DETX	0.05 ARCSECONDS	Linearised X detector coordinate
DETY	0.05 ARCSECONDS	Linearised Y detector coordinate
X	0.05 ARCSECONDS	Sky X detector coordinate
Y	0.05 ARCSECONDS	Sky Y detector coordinate
PHA	CHANNELS	Pulse-Height-Analyser (uncalibrated spectral channel)
PI	CHANNELS	Pulse-Invariant (calibrated spectral channels)
FLAG		
PATTERN		Event pattern
CCDNR		CCD identifier (1–7)
BINTABLE OFFSETS		
RAWX	PIXELS	Row/Column# of offset (if OFFSET-Y/X> 0)
OFFSETX	CHANNEL	Column offset value (0 if row offsets) in ADU
OFFSETY	CHANNEL	Row offset value (0 if column offsets) in ADU
CCDNR		CCD identifier (1–7)
BINTABLE EXPOSU0n		
TIME	SECONDS	Frame central time
TIMEDEL	SECONDS	Frame integration time

FRACEXP	FRACTION	Effective time fraction
BINTABLE BADPIX0n		
RAWX	PIXEL	Bad pixel X-coordinate
RAWY	PIXEL	Bad pixel Y-coordinate
TYPE		1: Hot 2: Flickering 3: Dead
YEXTENT	PIXEL	# of pixel in y column
BADFLAG		1: uplinked bad pixels; 2: CCF origin; 3: file origin
BINTABLE CALINDEX		
TELESCOP		XMM
SCOPE		EMOS[1,2], EPN, RGS[1,2], OM, XRT[1,2,3], XMM
TYPEID		CCF constituent type
ISSUE		Issue number
VALDATE		Start of validity date
VALDATE-END		End of validity date
FNAME		Name of applied calibration file
DATE		Production date of calibration file
FSIZE		File size (bytes)
SUBDATE		Submission date
EXTSEQU		Extension sequence
EXTSEQUID		Extension sequence identifiers
MD5		MD5 signature of constituents
CREATOR		CCF constituent creator
BINTABLE STDGTI0n		
START		GTI start time
STOP		GTI stop time
BINTABLE GTI00nZZ		*only if additional time filters applied*
START		GTI start time
STOP		GTI stop time

6.2 Event list structure in the MOS Timing Mode

In Timing Mode, only the central chip, CCD1, operates in timing mode, while the peripheral chips, CCDs 2-7, operate in imaging mode. Thus, for Timing mode observations, an imaging events file is still being produced, but with only 6 extensions for EXPOSU0n, BADPIX0n, and STDGTI0n, representing CCDs 2-7 as described in Sect. 6.1.

The MOS Timing Mode event file is produced by emproc only for CCD1 and is named

REVN_OBSID_EMOS[1,2]_SEEE_TimingEvts.ds

with REVN the 4-digit revolution number, OBSID the 10-digit observation ID, and EEE the exposure number.

This file is similar to the Imaging file described in Table 31 with differences in the EVENT, OFFSET and GTI00nZZ extensions:

- EVENT extension: As in Table 31, but without the columns RAWY, DETX, DETY, X, and Y.
- OFFSET extension: As in Table 31, but without the column OFFSETY

- If additional time filters have been applied, there will only be one type extension `GTI000ZZ`, thus as in Table 31, but only for $n = 0$.

The extensions `EXPOSU01`, `BADPIX01`, and `STDGTI01` are identical to the imaging mode.

6.3 Event list structure in the PN Imaging Mode

The naming and structure of the PN Imaging Mode event lists is very similar to that of the corresponding MOS files (see Sect. 6.1 and Table 31). The main differences are:

- The name of the file is Revn_ObsID_EPN_Seee_ImagingEvts.ds
- the number of `EXPOSU`xy, `BADPIX`xy, `DLIMAP`xy, and `STDGTI`xy extensions is maximal 12 (equal to the number of PN chips) instead of 7 for MOS.
- DLIMAP`xy` extension, where `xy` is the CCD number (01-12):

  The number of rejections of a CCD column (default) or row from the on-board Minimum Ionizing Particle (MIP) rejection algorithm is stored a DLI file (Discarded Lines Image File). One DLI file per CCD is produced and included in the ODF (see Sect. 4.1.5).
- the units for the quantity `PI` in the `EVENTS` extension are eV.
- the columns `PAT_ID` and `PAT_SEQ` are present in the `EVENTS` extension.
- an extension `DLIMAP`xy (=Discarded Line Map) is present if certain lines have been discarded (xy stands for chip number 1-12). This extension is needed to create the exposure map.
- the `OFFSETS` extension contains column offset values of patched offsets (as applied through the on-board offset table) or anomalous offsets (e.g., as a result of bit flips in the EDU memory or other serendipitous events) as determined by the SAS event processing.
- the `EXPOSU`xy extension contains the following additional values in the header: `MODE`, `WINDOWX0`, `WINDOWY0`, `WINDOWDX`, `WINDOWDY` (left-bottom corner coordinates and length of the science window).
- the `STDGTI`xy extension contains the standard Good Time Intervals (GTIs) applied to produce the event list. xy as for `EXPOSU`xy.
- In addition, any number of extensions `GTI0`xy`ZZ` may be included in the events file, written by any non-standard time filtered expression, mainly in evselect. xy is the same as for `EXPOSU`xy but starting at 00, thus $xy = 00, 01, ..., 11$.
  `ZZ` is a sequence number in the Data Subspace corresponding to a TIME filter expression. If the event list was filtered using more than one TIME expression, consecutive GTI extensions are added starting with `ZZ=02`, thus 0xy02, 0xy03, etc...

A short description of the column in each of the above extensions is given in Table 32.

Table 32: PN *Imaging Mode event list column*

Name	Units	Description
BINTABLE EVENT		
TIME	SECONDS	
RAWX	PIXELS	Event X-coordinate as measured by the detector
RAWY	PIXELS	Event Y-coordinate as measured by the detector
DETX	0.05 ARCSECONDS	Physical camera X detector coordinate
DETY	0.05 ARCSECONDS	Physical camera Y detector coordinate
X	0.05 ARCSECONDS	Sky X detector coordinate
Y	0.05 ARCSECONDS	Sky Y detector coordinate
PHA	CHANNELS	Pulse-Height-Analyser (uncalibrated spectral channel)
PI	CHANNELS	Pulse-Invariant (calibrated spectral channels)
FLAG		
PATTERN		Event pattern
PAT_ID		
PAT_SEQ	PIXELS	Distance from neighbouring event in same frame & column
CCDNR		CCD identifier (1–12)
TIME_RAW	SECONDS	raw time stamps
BINTABLE OFFSETS		
RAWX	PIXELS	Column number of the offset
OFFSETX	CHANNEL	Column offset in ADU
CCDNR		CCD identifier (1–12)
BINTABLE EXPOSUxy		
TIME	SECONDS	Frame central time
FRACEXP	FRACTION	Fraction of effective time
BINTABLE BADPIXxy		
RAWX	PIXEL	Bad pixel X-coordinate
RAWY	PIXEL	Bad pixel Y-coordinate
TYPE		1: Hot 2: Flickering 3: Dead
YEXTENT	PIXEL	# of pixel in y column
BADFLAG		1: uplinked bad pixels; 2: CCF origin; 3: file origin
BINTABLE DLMIMAPxy		Discarded columns (default) or rows
DLIODF	PIXEL	- identified by the DLI files in the ODF
DLISAS	PIXEL	- identified by the SAS
BINTABLE CALINDEX		
TELESCOP		XMM
SCOPE		EMOS[1,2], EPN, RGS[1,2], OM, XRT[1,2,3], XMM
TYPEID		CCF constituent type
ISSUE		Issue number
VALDATE		Start of validity date
VALDATE-END		End of validity date
FNAME		Name of applied calibration file
DATE		Production date of calibration file

FSIZE		File size (bytes)
SUBDATE		Submission date
EXTSEQU		Extension sequence
EXTSEQUID		Extension sequence identifiers
MD5		MD5 signature of constituents
CREATOR		CCF constituent creator
BINTABLE STDGTIxy		
START		GTI start time
STOP		GTI stop time
BINTABLE GTI0xyZZ		*only if additional time filters applied*
START		GTI start time
STOP		GTI stop time

6.4 Event list structure in the PN Timing Mode

In timing mode, only chip #4 is operated, and the PN Timing Mode event file is produced by `epproc` only for CCD4. It is named

REVN_OBSID_EPN_SEEE_TimingEvts.ds

with REVN the 4-digit revolution number, OBSID the 10-digit observation ID, and EEE the exposure number.

In contrast to the MOS timing mode, no additional image events files are produced. The PN Timing Events file is similar to the PN Imaging Events file as described in Table 32, with the following differences:

- Only the extensions `EXPOSU04`, `BADPIX04`, and `STDGTI04` exist plus optional `GTI000ZZ` extensions if additional time filters were applied. Note that the CCD number 4 is not reflected in the name of the GTI extension.
- The `EVENT` extension does not contain the columns `DETX`, `DETY`, `X`, `Y`, and `TIMERAW`.
- `OFFSET` extension only contains the column `CCDNR`

Note that the `RAWY` coordinate (which for MOS is omitted) is not a spatial column but corresponds to time. Filtering on `RAWY` is thus equivalent to cutting the time axis of the extracted light curve.

6.5 Event list structure in the RGS Spectroscopy Mode

The event list for the RGS Spectroscopy Mode consists of 2 extensions:

- 1 `PRIMARY` extension, which contains no data
- 1 `EVENTS` extension, which contains all events, which have passed the non-destructive filters of the reduction procedures/algorithms

A short description of the column in the `EVENTS` extension is given in Table 33.

Table 33: RGS *Spectroscopy Mode event list columns. The placeholders xy are readout node (x =0-1) and CCD number (y =1-9).*

Name	Units	Description
BINTABLE EVENT		
TIME		Time stamps of events
FLAG		Event attribute flag
BETA		Dispersion angle before aspect drift correction
XDSP		Cross-dispersion angle before aspect drift correction
CHIPX	PIXEL	Raw row number from telemetry
CHIPY	PIXEL	Raw column number from telemetry
PHA	eV	Total telemetered energy
SHAPE		Number of pixels combined into event on-board
GRADE		total number of pixels
PI	eV	Gain corrected PHA
CCD_NR		CCD number
BETA_CORR	RADIANS	Aspect drift corrected dispersion (β) angle
XDSP_CORR	RADIANS	Aspect drift corrected cross-dispersion angle
M_LAMBDA	Ångstroem	$\vert$Channel Wavelength $\times$ order$\vert$
MLAMBDA_CHANNEL	Ångstroem	Channel number of binned M_LAMBDA
BETA_CHANNEL		Channel number of binned BETA_CORR
XDSP_CHANNEL		Channel number of binned XDSP_CORR
BINTABLE EXPOSUxy		
NLOSTEVT	COUNTS	Lost event counter
ABORTFLAG		Abort Flag
FLAG		Frame attributes
TIMEDEL	SECONDS	Frame integration time
TIME	SECONDS	Frame central time (s since MJDREF)
FRACEXP0	FRACTION	Effective time fraction for node 0
FRACEXP1	FRACTION	Effective time fraction for node 1
ASPCDSP		Aspect correction of BETA
ASPCXDSP		Aspect correction of XDSP
FRAME		frame identifier
BINTABLE BADPIXxy		
CHIPX	PIXEL	Bad pixel X-coordinate
CHIPY	PIXEL	Bad pixel Y-coordinate
YEXTENT	PIXEL	# of pixel in y column
TYPE		1: Hot 2: Flickering 3: Dead
BADFLAG		1 for uplinked bad pixels; 2 for a CCF origin; 3 for a file origin
BINTABLE STDGTIxy		
START		GTI start time
STOP		GTI stop time
REJPIXxy		
FRAME		frame identifier
FLAG		event attribute flag
CHIPX	PIXEL	X-coordinate

CHIPY	PIXEL	Y-coordinate
EXPMAP*xy*		Image

6.6 Event list structure in the RGS High Resolution Timing Mode

The structure of the RGS HTR Mode event lists is analogous to the Spectroscopy Mode ones. However, only the following columns are contained in the EVENTS extension: TIME, CHIPX, BETA, BETA_CORR, BETA_CHANNEL, PHA, PI, FLAG (cf. Sect. 6.5 and Table 33).

6.7 Event list structure in the OM Fast Mode

The output files from the OM reduction chains have the extension '.FIT'. The names of the files start with 'P' for the products and with 'F' for the intermediate images and time series. The PPS products (Sect. 8) consist only of the products, while the omfchain and omichain tasks preserve the intermediate files. Event files are only produced in Fast mode, and one file is created for each exposures. The names of the event files are:

FiiiiiiiiiiOMSeeeEVLIST1000.FIT

with iiiiiiiiii the 10-digit observation ID and eee the exposure number. An event file of this kind has the following extensions:

- 1 PRIMARY extension, which contains no data
- 1 OMFAE1 extension, which contains the raw and corrected information for each event. The first columns are a copy of the ODF *FAE* files.
- 1 MODES extension, which contains the physical coordinates of the Fast Window in unbinned pixels. Their meaning are:
  - MODE: observation mode, which could be either imaging (0) or event (1). For the Fast data it is always 1.
  - WINDOWX0: the X-coordinate (in pixels) of the lower left corner of the OM window;
  - WINDOWY0: the Y-coordinate (in pixels) of the lower left corner of the OM window;
  - WINDOWDX: width of the OM window in the horizontal direction (in pixels);
  - WINDOWDY: width of the OM window in the vertical direction (in pixels)

An overview of the columns in each of the above extensions is given in Table 34.

Table 34: OM *Fast Mode event list column*

Name	Units	Description
BINTABLE EVENT		
FRAME	COUNTER	Frame count number
FTCOARSE	SECONDS	Coarse Time from the beginning of exposure
FTFINE	MILLISECONDS	Fine Frame Time
PHA		Dummy for compatibility with SAS `evselect` task
RAWX	PIXELS	Event X coordinate as measured by the detector
RAWY	PIXELS	Event Y coordinate as measured by the detector
TIME	SECONDS	Time relative to `TIMEZERO`
CORR_X	PIXELS	X coordinate corrected for spacecraft drift
CORR_Y	PIXELS	Y coordinate corrected for spacecraft drift
WIN_FLAG		(0/1) outside window after drift correction
FACTOR	PIXELS	bin factor
BADPIX		Bad Pixel Flag (0/1)
BINTABLE MODES		
MODE		0=Image; 1=Fast
WINDOWX0	PIXELS	chip x-coordinates of lower left corner of Fast Window
WINDOWY0	PIXELS	chip y-coordinates of lower left corner of Fast Window
WINDOWDX	PIXELS	size of Fast Window in x
WINDOWDY	PIXELS	size of Fast Window in y

7 Instrument Mode and Filter names in XSA and file headers

The recommended method to find exposures utilizing certain instrument modes and/or filters is to define the desired instrument configuration in the XSA interface. The uncalibrated files (ODF, Section 4) do not contain the information about instrument modes or filters except for some non-scientific modes, see Sections 4.1.4 and 4.1.8. The SAS task `odfingest` (with the parameter set `findinstrumentmodes=yes` which is default) produces a SAS summary file (*SUM.SAS, see last row in Table 1) that contains the names of instruments and filters which are then written into the file headers of SAS and pipeline products (such as events files) using the header keywords `SUBMODE` (`DATAMODE` for OM) and `FILTER`, respectively. In this section, the names of instrument modes that can be found in the *SUM.SAS file (and consequently in the file headers of high-level science products) are given for scientific modes and for non-scientific modes. For the latter, no pipeline products are produced and the only way (apart from an XSA search) to identify the instrument mode and filter for a given exposure is the *SUM.SAS file.

7.1 Scientific Modes

For scientific exposures, instrument modes and filters are given with the fits header keywords `SUBMODE` and `FILTER`, respectively. These header keywords can be found in fits files of calibrated products (e.g., events files) and PPS files. As described above, the same names are used in the *SUM.SAS file. For the OM, there are only two instrument modes, IMAGE and FAST, which are indicated in the header keyword `DATAMODE`. Specific OM readout modes for IMAGE mode that affect the size and resolution can not be derived from header keywords nor file names. In Table 35 all scientific mode names and filter names are listed.

7.2 non-Scientific Modes

Since for non-scientific exposures no PPS products are produced, these mode names are only listed in the *SUM.SAS file. The non-scientific mode names searchable in XSA and used in the *SUM.SAS file are listed in Table 36.

Table 35: *Naming of scientific instrument modes and filters in XSA and header keywords*

Instrument	mode names in XSA	values of SUBMODE	Filter names
MOS	Full Frame	PrimeFullWindow	Open
	Refresh Frame Store	PrimePartialRFS	Thin1
	Small Window	PrimePartialW2	Thin2
	Large Window	PrimePartialW3	Medium
	Small Window Free Running	PrimePartialW4	Thick
	Large Window Free Running	PrimePartialW5	
	Full Frame Two Nodes	PrimePartialW6	
	Timing	FastUncompressed	
	Timing Compressed	FastCompressed	
pn	Full Frame	PrimeFullWindow	Open
	Extended Full Frame	PrimeFullWindowExtended	Thin1
	Large Window	PrimeLargeWindow	Thin2
	Small Window	PrimeSmallWindow	Medium
	Timing	FastTiming	Thick
	Burst	FastBurst	
	ModifiedTiming	ModifiedTiming	
	Mosaic	Large Offset	
RGS	Spectroscopy	Spectroscopy	
	Spectroscopy+Q	Spectr+Q	
	Spectroscopy HER	HighEventRate	
	Spectroscopy HER + SES	HighEventRateWithSES	
	Spectroscopy HER + SER	HighEventRateWithSER	
	HighTimeResolutionSingleCcd	HighTimeResolutionSingleCcd	
	HighTimeResolutionMultipleCcd	HighTimeResolutionMultipleCcd	
	Multipointing	Multipointing	
	Small Window	Small Window	
		values of DATAMODE	
OM	Image	Image	V
	Fast	Fast	B
	Image+Fast	Image+Fast	U
		MOSAICED	UVW1
			UVM2
			UVW2
			White
			Magnifier
			Grism1
			Grism2
			BarredU

Table 36: *Naming of non-scientific instrument names and filters in XSA and *SUM.SAS file*

Instrument	mode names in XSA	SUM.SAS	Filter names
MOS	Diagnostic 3x3	Diagnostic3x3	Closed
	Diagnostic 1x1	Diagnostic 1x1	CalOpen
	CCD Diagnostic	CcdDiagnostic	CalClosed
	Diagnostic 1x1 Reset per Pixel	Diagnostic1x1ResetPerPixel	CalThin1
			CalThin2
			CalMedium
			CalThick
pn	Diagnostic	Diagnostic	Closed
	Noise	Noise	CalOpen
	Offset	Offset	CalClosed
	Full Frame Low Gain		CalThin1
			CalThin2
			CalMedium
			CalThick
RGS	Diagnostic1x1	Diagnostic1x1	
	Diagnostic3x3	Diagnostic3x3	
	HTR Single CCD	HighTimeResolutionSingleCcd	
	HTR Multiple CCD		
OM	Centroiding Conf.	CentroidingConfirmation	Blocked
	Enineering 3	CentroidingData	Unknown
	Dark High	DarkHigh	
	Dark Low	DarkLow	
	Flat High	FlatFieldHigh	
	Flat Low	FlatFieldLow	
	Inten.Char.		

8 Pipeline data products: PPS

Extensive documentation of the PPS products for a given observation can be found in the associated index file in html format, named INDEX.HTM, which is delivered in the same directory. It allows manoeuvring through the entire set of files with explanations of purpose and content of each file. A complete general description of the PPS products is given in [7]. Here, only a quick overview is given.

Pipeline data product filenames consist of up to 27 characters, followed by a '.' (dot), followed by 3 characters. All characters are upper case. The filenames take the 27.3 character form:

X**obsidentif**IIUEEETTTTTTSXXX.ZZZ

The descriptions of each of the filename fields are listed in Table 37.

Table 37: *Pipeline product filenames*

Field		Description
X		
	P	PPS product files
	C	2XMM catalogue-specific files
obsidentif		The observation identifier, 10 digit: PPPPPPOOLL
	PPPPPP	the identifier of the proposal that contains the obs.
	OO	identifier of the observations within the proposal
	LL	extended identifier (usually 01)
	Notes:	For slews the first of the six P is '9'
		For pseudo ODF components of mosaic pointings, the values of LL assume values (30+x), where x is the number of the mosaic pointing.
II		The instrument, or data source, identifier
	OM	optical monitor
	R1	RGS-1
	R2	RGS-2
	RG	RGS combined
	M1	EPIC MOS-1
	M2	EPIC MOS-2
	PN	EPIC PN
	EP	EPIC
	CA	Catalogue cross-correlation
	OB	Observation
U		Exposure flag (1 character)
	S	scheduled
	U	unscheduled
	X	not applicable
EEE		The exposure number within the observation
		'000' means that the file does not correspond to an exposure period
		'9XX' is used for diagnostic Q dumps (RGS spectroscopy+Q)
TTTTTT		The product type (6 digits)

	3COLIM	EPIC three-colour image (FIT,PNG)
	ATTTSR	Attitude Time Series (FTZ)
	BGMODL	RGS Background Model (FTZ)
	BGSPEC	EPIC Source Background Spectrum (FTZ, if II=[M[1,2], PN])
	BGSPEC	RGS Source Background Spectrum (FTZ, if II=R[1,2])
	BKGMAP	EPIC Merged Background Map (FTZ,PNG)
	CALIND	Calibration Index File (FTZ)
	CATPLT	Catalogue Plot (PDF)
	CDSLG1	CDS Logo 1
	CDSLG2	CDS Logo 2
	CDSLG3	CDS Logo 3
	DETMSK	EPIC Detection Mask (one per instrument per band, FTZ,PNG)
	DSPHIS	RGS Cross-Dispersion Histogram (FTZ)
	DXXXXA[1,3]	Catalogue Descriptors (HTM)
	EVENLI	RGS Event List (FTZ)
	EXPMAP	EPIC Exposure Map (FTZ,PNG, if II=[M[1,2], PN])
	EXPMAP	Slew step Exposure Map (FTZ, only PN)
	EXPMAP	RGS Exposure Map (FTZ, if II=R[1,2])
	FBKTSR	EPIC Flare Background Timeseries (FTZ,PNG, if II=[M[1,2], PN]))
	FBKTSR	RGS Flare Background Timeseries (FTZ,PDF, if II=R[1,2])
	FCHART	Finding Chart (PDF)
	FIMAG_	OM Full-Frame Image (FTZ)
	FLAFLD	OM Flatfield (FTZ)
	FLUXED	RGS Fluxed Spectrum (FTZ,PDF)
	FOVRES	EPIC Field Of View Cross-Correlation Results (HTM)
	FOVSUM	EPIC Field Of View Cross-Correlation Summary (HTM, FTZ)
	FSIMAG	OM Full-Frame Sky Image (FTZ,PNG)
	FYYYYA[2,3]	EPIC Field Of View Cross-Correlation Results (FTZ)
	GIMAGE	OM Grism-Aligned (spectra vertical) Image (FTZ,PNG)
	HSIMAG	OM Full-Frame Hires Sky Image Mosaic (FTZ,PNG)
	HSISWS	OM Full-Frame Hires Source List Mosaic (FTZ,ASC)
	IMAGEF	OM Fast Mode OSW Image (FTZ)
	IMAGE_	EPIC Image (FTZ,PNG, if II=[M[1,2], PN])
	IMAGE_	Slew step Image (FTZ, only PN)
	IMAGE_	OM OSW Image (FTZ, if II=OM)
	IMAGE_	RGS Image (FTZ,PNG, if II=R[1,2])
	LSIMAG	OM Full-Frame Low-Res Sky Image Mosaic (FTZ,PNG)
	LSISWS	OM Full-Frame Low-Res Source List Mosaic (FTZ,ASC)
	MEXPMP	EPIC exposure-merged exposure map (FTZ)
	MIEVLI	EPIC MOS Imaging Mode Event List (FTZ)
	OBKGMP	EPIC Observation Background Map (FTZ,PNG)
	OBLSLI	EPIC Observation Box-Local Source List (FTZ)
	OBMSLI	EPIC Observation Box-Map Source List (FTZ)

	OBSMLI	EPIC Summary Source List (FTZ,HTM, if II=[M[1,2], PN])
	OBSMLI	OM Observation Source List (FTZ, if II=OM)
	OBSMOS	OM Observation Source List Mosaic (FTZ,ASC)
	OEXPMP	EPIC Observation Exposure Map (FTZ,PNG)
	OFTPRT	EPIC ASC footprint region (ASC)
	OIMAGE	EPIC Observation Image (FTZ,PNG)
	OMSRLI	EPIC Observation ML Source List (FTZ)
	OMSSLI	EPIC FITS summary source list file for slew data (FTZ)
	ORDIMG	RGS Energy-Dispersion Image (FTZ,PNG)
	OSNSMP	EPIC Observation Sensitivity Map (FTZ)
	PIEVLI	EPIC PN Imaging Mode Event List (FTZ)
	PIEVLI	Slew single raw event list (FTZ, only PN)
	PINDEX	PPS Product Index (FTZ)
	PPSMSG	PPS Run Message (ASC)
	PPSSUM	PPS Run Summary (HTM)
	REFCAT	USNO, 2MASS and SDSS Ref. Catalogues for EPIC field (FTZ)
	REGION	EPIC Source DS9 Regions (ASC)
	ROSIMG	XMM-ROSAT Image (PDF)
	RSIMAG	OM Rudi-5 Sky Image Mosaic (FTZ,PNG)
	RSISWS	OM Rudi-5 Source List Mosaic (FTZ,ASC)
	RSPMAT	RGS Response Matrix (FTZ)
	SBSPEC	RGS Source Spectrum without Background subtraction (FTZ)
	SCRLOG	PPS Script Log (ASC)
	SFFTPL	EPIC Source FFT Plot (PDF)
	SFSREG	OM OSW Fast Region File (ASC)
	SFSRLI	OM OSW Fast Source List (FTZ)
	SGSREG	OM Grism DS9 Regions (ASC)
	SGSRLI	OM OSW Grism Source List (0th and 1st orders; FTZ)
	SIMAGE	OM OSW Sky Image (FTZ,PNG)
	SIMAGF	OM Fast Mode OSW Sky Image (FTZ,PNG)
	SLEVLI	Slew step event list file (FTZ, only PN)
	SPCPLT	EPIC Source Spectrum Plot (PDF)
	SPCPLP	(x=C) EPIC source spectrum (PNG)
	SPCREG	OM Grism DS9 Spectrum Regions (0th and 1st orders; ASC)
	SPECLI	OM Grism Spectra List (for target only; FTZ)
	SPECTR	OM Grism Source Spectrum (FTZ,PDF)
	SRCARF	EPIC Ancillary Response Function (FTZ)
	SRBTSR	RGS Background Timeseries (FTZ)
	SRCHD_	Searched Catalogues (FTZ, HTM)
	SRCIMG	(x=C) EPIC source thumbnail (total band, PNG)
	SRCIMW	(x=C) EPIC location image (total band, PNG)
	SRCLI_	RGS Source List (FTZ)
	SRCREG	EPIC Source DS9 Region (ASC)

	SRCRES	EPIC sources Cross-Correlation results (HTM)
	SRCSUM	EPIC Source Cross-Correlation Summary (FTZ, HTM)
	SRCTSR	EPIC Source Timeseries (FTZ)
	SRCTSR	RGS Source Timeseries (FTZ)
	SRSPEC	EPIC Source Spectrum (FTZ, if II=[M[1,2], PN])
	SRSPEC	RGS Background-subtracted Source Spectrum (FTZ,PDF, if II=R[1,2])
	SSCLG1	SSC Logo 1 (PNG)
	SSCLG2	SSC Logo 2 (PNG)
	STSPLT	EPIC/RGS Source Timeseries Plot (PDF)
	STSPLS	(X=C) Instrument-specific time series plot (PNG)
	SUMMAR	EPIC Observation Summary (HTM)
	SUMMAR	OM Observation Summary (HTM)
	SUMMAR	PPS Observation Summary (HTM)
	SUMMAR	RGS Observation Summary (HTM)
	SWSREG	OM OSW Region File (ASC)
	SWSRLI	OM OSW Source List (FTZ)
	SXXXXA[1,3]	EPIC Source Cross-Correlation Results (FTZ)
	TIEVLI	EPIC Timing Mode Event List (FTZ)
	TIMESR	OM OSW Source Timeseries (FTZ,PDF)
	TSHPLT	OM Tracking History Plot (PDF)
	TSTRTS	OM Tracking Star Timeseries (FTZ,PDF)
	UNFDAT	EPIC unfiltered FITS image (slew only) (FTZ)
	USIMAG	OM User Windows Sky Image Mosaic (FTZ,PNG)
	USISWS	OM User Windows Source List Mosaic (FTZ,ASC)
	WFSPEC	RGS Whole-field Spectrum (FTZ,PDF)
	WREMAT	RGS Whole Field Response Matrix (FTZ)
	XCORRE	Main Cross Correlation Page (HTM)
S		Data subset number (1 character, differentiates energy bands, OM science windows, etc.)
		Taken from the OM science window id for OM products at the OM science window level
		Taken from the OM science window id for OM products at the individual source level
		Taken from the EPIC band for EPIC products at the observations, exposures and individual source level
		Taken from the RGS order for RGS products at the individual source level
XXX		Source number or slew step number (3 characters, hexadecimal)
ZZZ		File format (3 characters)
	ASC	ASCII file
	FTZ	Gzipped FITS file
	HTM	HTML file
	PDF	PDF file
	PNG	Portable Network Graphics file

[1] XXXXX will take values according to the names of the (∼ 100) catalogues searched
[2] YYYYY will take different values according to the names of the (∼ 15) catalogues searched

[3] A will take value T if the results are drawn from a table, and A, B, C, etc. to represent real catalogue numbers

No PPS products are generated for exposures, where "non-scientific" modes are employed. They include, e.g., `CAL_CLOSED` and `CLOSED` filters for the EPIC cameras or `BLOCKED` filter and engineering modes for the OM. Intermediate products are also not delivered, e.g., the OM fast mode events file. PPS and SSC products files are summarised in Table 38.

Table 38: *Pipeline product files*

Product	Format	Nr.[a]	Notes
Observation summary product			
Observation summary	HTML	1	
Attitude time series	FITS	1	
OM products			
Science window image	FITS	WE	
Science window sky image	FITS	WE	Rotated and rebinned to North-aligned sky coordinates
Science window source time series	FITS	SWE	Only for `FAST` mode
Science window source time series plot	PDF	SWE	Created from above
Tracking star time series	FITS	1	
Tracking star time series plot	PDF	1	Created from above
Science window source list	FITS	WE	
Observation source list	FITS	1	Merging of the above
Grism spectra	FITS	SWE	Images, source lists, and spectra
Tracking history plot	PDF	1	Vector diagram of the spacecraft jitter
Mosaiced image source list	FITS, ASC	B	Source lists and regions
Summary page	HTML	1	
EPIC products			
Raw image	FITS	C	
Unfiltered Image	FITS	1	Slew only
Annotated raw image	PNG	C	Created from the above, with sky grid, camera, energy band, and observation identifiers
Observation image	FITS	1	Exposure-corrected. Data from all cameras operating in `IMAGE` mode
Observation image plot	PNG	1	Created from above
Exposure map	FITS	CB	
Sensitivity map	FITS	1	The same as above at the observation level
EPIC three-colour image	FIT,PNG	1	Combining all IMAGING mode data from all EPIC cameras; not for slew data.
Source time series	FITS	SB	1 per unconfused, bright (> 100 counts) source in the 0.1-0.5, 0.5-2.0, and 2.0-10.0 keV energy bands
Source time series plot	PDF	SB	Created from above
Source FFT plot	PDF	SB	Created from each source light curve
Global background time series	FITS	EB	FOV time series, after masking the detected point sources
Source spectrum	FITS	SC	1 per unconfused, bright source
Source background spectrum	FITS	SC	1 for each of the above
Source spectrum plot	PDF	SC	Background-subtracted and exposure-corrected
Observation box-local source list	FITS	1	Sources detected by running `eboxdetect` ("local" mode) on the entire EPIC exposures

Observation box-map source list	FITS	1	Sources detected by running `eboxdetect` ("map" mode) on the entire EPIC exposures
Observation ML source list	FITS	1	Sources detected by running `emldetect` on the entire EPIC observation
Summary source list	FITS	1	
Observation source list	HTML	1	
MOS `IMAGING` mode event list[b]	FITS	E	
PN `IMAGING` mode event list[b]	FITS	E	
`TIMING` mode event list[c]	FITS	E	
Summary page	HTML	1	
RGS products			
Image	FITS	E	Wavelength vs. cross-dispersion angle
Image plot	PNG	E	Created from above
Energy-dispersion image	FITS	E	PI vs. cross-dispersion angle
Energy-dispersion image plot	PNG	E	Created from above
Exposure map	FITS	E	In wavelength vs. cross-dispersion angle
Source spectrum	FITS	S[d]	With and without background subtraction. For the brightest point source. 1st and 2nd dispersion order
Background spectrum	FITS	S[d]	One for each of the above spectra
Background model spectrum	FITS	S[d]	Expected background spectrum
Cross-dispersion histogram	FITS		
Spectrum plot	PDF	S	Background-subtracted, with wavelengths and energy scales
Event list	FITS	E	
Source list	FITS	E	EPIC-detected bright sources in the RGS FOV
Whole field spectrum	FITS	S[d]	Spectrum of the whole FOV, without background subtraction. For first and second order.
Response matrix	FITS	S[d]	Response matrix for the brightest point source. For first and second order.
Whole field response matrix	FITS	S[d]	Response matrix for the whole FOV. Only for first order.
Source timeseries	FITS	S[d]	Background-subtracted source timeseries for the brightest point source. First and second order together.
Timeseries plot	PDF	S[d]	Created from above
Background timeseries	FITS	S[d]	Background timeseries.
Summary page	HTML	1	
Catalogue and archive products[e]			
Main CC page	HTML	1	
Searched catalogues	HTML	1	
Catalogue description	HTML	1	
Source raw position cross-correlation results	FITS	1	
Source cross-correlation summary	FITS	1	
Source cross-correlation results	HTML	1	
Source cross-correlation results	HTML	1	

Find chart	PDF	1	
FOV summary	HTML	1	All SIMBAD and X-ray catalogued objects in the FOV
FOV summary			Same as above
FOV cross-correlation results	HTML	T	
FOV cross-correlation results	FITS	T	
Catalogue plot	PDF	1	
XMM-Newton/ROSAT image	PDF	1	EPIC source position and flux contours overlaid over a ROSAT image
PPS run products			
Script log	ASCII	1	
Run message	ASCII	1	
Run summary	HTML	1	
Index	HTML	G	
Product index	FITS	1	
Calibration index file	FITS	1	Index file for the CCF
SSC logo 1	PNG	1	Image of the XMM-Newton telescope front end
SSC logo 2	PNG	1	Graphic with the words “XMM-Newton SSC”
CDS logo 1	PNG	1	Graphic with the word “NED”
CDS logo 2	PNG	1	Graphic with the word “Vizier”
CDS logo 3	PNG	1	Graphic with the word “Simbad”
XMM-Newton logo 1	PNG	1	
ESA logo 1	PNG	1	
XID products			
Observation summary	HTML	1	
Reduced image	FITS		Flatfielded, bias- and dark frame-corrected, filtered image
Reduced image plot	PNG		North-aligned image of the field containing the target, with EPIC flux contours and source boxes overlaid
Fluxed spectrum	FITS		
Fluxed spectrum plot	PDF		Created from above
Finding chart	PNG	S	
Magnitude table	FITS		
Magnitude table	HTML		Created from above
Index	HTML	G	

[a]If an integer, number of product files per observations. Otherwise: “S” = 1 file per source; “W” = 1 file per OM science window; “E” = 1 file per exposure; “C” = 1 file per camera; “B” = 1 file per energy band; “T” = 1 file per catalogue; “G” = 1 file per product group

[b]for `IMAGING` mode exposure only

[c]for `TIMING` mode exposures only

[d]2 files per brightest source in the RGS FOV

[e]files in this group refer to the EPIC, if not specified otherwise

9 Acronym list

AHF	Attitude History File
APD	Absolute Pointing Drift
BSM	Basic Spectroscopy Mode
CAL	Calibration Access Layer
CC	Cross-Correlation
CCD	Charged Couple Device
CCF	Current Calibration File
CDS	Centre de Données astronomiques de Strasbourg
CSG	Clock Sequence Generator (how a CCD is read out)
COBT	Computed On Board Time
DPP	Data Pre Processor
DPU	Data Processing Unit
DPU	Digital Processing Unit (OM: 1024 sec)
DSP	Digital Signal Processor (OM)
EDU	Event Detection Unit
EPDH	EPIC Data Handling
EPEA	EPIC Event Analyser
EPIC	European Photon Imaging Camera
ERM	EPIC Radiation Monitor
ERT	Earth Reception Time
ESA	European Space Agency
ESOC	European Space Operation Centre
EXAFS	Extended X-Ray Absorption Fine Structure
FIFO	First-In, First-Out
FITS	Flexible Image Transport System
FOV	Field-of-view
FFT	Fast Fourier Transform
GO	Guest Observer
GS	Guide Star
GT/O	Guaranteed Time/Observer
HDU	Header Data Unit
HEASARC	High Energy Astrophysics Science Archive Research Centre
HTML	Hyper-text Mark-up Language
HTR	High Time Resolution
HTRM	High Time Resolution Mode
MIP	Minimum Ionizing Particle
MOC	Mission Operation Centre
No.	Number
OBDH	On-Board Data Handler
OBT	On Board Time
OCB	On Chip Binning
ODF	Observation Data Files
ODS	Observation Data Subsystem
OGIP	Office of Guest Investigator Programs
OM	Optical Monitor
OSW	Observation Science Window

PDF	Portable Data Format
PSF	Point Spread Function
PI	Principal Investigator
PNG	Portable Network Graphics
PPS	Processing Pipeline Subsystem
RGS	Reflection Grating Spectrometer
ROSAT	RÖntgenSATellit
SAS	Science Analysis Subsystem
SCS	Science Control System
SDF	Slew Data Files
SIMBAD	Set of Identifications, Measurements, and Bibliography for Astronomical Data
SL	Source list
SOC	Science Operation Centre
SSC	Survey Science Centre
SWP	Science Window Parameter
TS	Time Series
URL	Uniform Resource Locators
UTC	Coordinated Universal Time
XID	X-ray IDentifier
XMM-Newton	X-ray Multi-Mirror Mission

In Tabs. 4, 5, 6, 7, 8, 9, 10, 12, 13, 14, 15, 17, 18, 19, 21, 22, 25, 26, 27, and 28, the following convention is used for the column "Type": 1J = `INTEGER*4`; 1I = `INTEGER*2`; 1B = `BYTE`, XXA = `CHARACTER*XX`; XX.YF = `FLOAT` with XX digits total, Y digits of significance

10 Glossary of binary table column descriptions

ATHR Counter (PN): Above Threshold Counter – Number of pixels found by EPEA above the programmed threshold

Coarse frame time (MOS, PN, RGS, ERM): – End time of a frame integration (expressed in seconds). The granularity may differ from instrument to instrument.

Coarse/Fine readout interrupt latched time (RGS): Time at the start of the readout. *Coarse* is in seconds, whereas *Fine* is equal to an equal division of 1 second in 16 bits (15.258789 μs)

DEFA Counter (PN): DEFA Read Counter – Number of pixel read by EPEA

Discarder Line Counter (PN): – Number of discarded pixel lines (frames) when the line (frame) rejection mode is selected

DSP (OM): – Digital Signal Processor

FIFO overflow flag (MOS): – Flag for a FIFO overflow

Fine frame time (MOS, PN, RGS, ERM): – End time of a frame integration (expressed in 1/40th of seconds)

Gatti flag (MOS): – Differential non-linearity in the analog-to-digital conversion is minimised with a sliding Gatti scale. The flag is set at the end of each sliding scale cycle

MIC (OM): – Microchannel plate intensified CCD

Number (No.) of events rejected by lower thresholding (MOS): – Number of events whose energy is below the programmed threshold (noise) counted by the EMDH, within a frame or cycle, and therefore not sent to ground

Number (No.) of events rejected by upper thresholding (MOS): – Number of events whose energy is above the programmed threshold (cosmic rays) counted by the EMDH, within a frame or cycle, and therefore not sent to ground

Number (No.) of valid events (MOS): – Number of valid events

Pattern number (MOS): – Pattern type of a recognised event

Peripheral pixel above Threshold Columns (MOS): – Number pf pixels, belonging to the peripheral ring of the 5×5 matrix, whose energy is above the EDU threshold

Sequence/CCD-N index (RGS): read-out sequence to be used for the exposure

Split Event Reconstruction (SER) (RGS): see [9]

The exact definition of the count rates in the Low Energy (**L[012C]**) and high energy (**H[012C]**) detectors and the boundaries for the accumulated spectra (**SP_[LH]E[CS]**) of the ERM are given in [2].

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A Time scale and Reference Time

The Time System used in XMM-Newton is Terrestrial Time or TT (`TIMESYS` keyword in FITS files headers):

TIMESYS = 'TT '

The Reference or zero time used (`MJDREF` keyword in FITS files headers) has been defined as:

MJDREF = 50814.0 (Modified Julian Date)

corresponding to:

1998.0 TT = 1998-01-01T00:00:00.00 TT = 1997-12-31T23:58:56.816 UTC

The conversion from TT to UTC can be found in The Astronomical Almanac. For this reference date it is:

$$TT = UTC + 63.184 \text{ sec}$$

The difference between TT and UTC depends, among other things, on the leap second. As of July 1, 2015 we have:

$$TT = UTC + 68.184 \text{ sec}$$

The use of this scale for XMM-Newton data gives rise to time values of the order of 1.0E+08 s. Detailed information on time scales can be found, among other references in [18], http://aa.usno.navy.mil/publications/docs/Circular_179.php

A time conversion tool can be found under
http://heasarc.gsfc.nasa.gov/cgi-bin/Tools/xTime/xTime.pl