esas

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Abstract

This document describes the Extended Source Analysis Software (XMM-ESAS) package for the analysis of EPIC MOS and PN observations. Originally ESAS was a stand-alone package, which relied on SAS, was comprised of FORTRAN 77 routines and Perl scripts. It is now incorporated into SAS. ESAS includes routines which create source and model particle background spectra and exposure-corrected, background-subtracted (particle, soft proton, and solar wind charge exchange) images. The spectra and images are produced for user-defined regions within an observation field of view. The output files are in standard FITS format. Software for mosaicking multiple observations of not necessarily co-aligned observations is included in this package. Note: This documentation is meant to complement the document **COOKBOOK FOR ANALYSIS PROCEDURES FOR** *XMM-NEWTON* **EPIC OBSERVATIONS OF EXTENDED OBJECTS AND THE DIFFUSE BACKGROUND[3].**

1 Instruments/Modes

Instrument	Mode
EPIC MOS	IMAGING
EPIC PN	IMAGING

2 Use

pipeline processing	no
interactive analysis	yes

3 Description

This package consists of a collection of *XMM-Newton* Extended Source Analysis Software (XMM-ESAS) tasks originally developed by Snowden, et al. and released as a stand-alone package in 2008. This package follows the methods outlined in Snowden et al. (2008)[1] for the analysis of extended objects and the diffuse background using *XMM-Newton* EPIC MOS and pn observations.

Two separate features are incorporated into ESAS; the capability of creating model quiescent particle background spectra (Kuntz & Snowden 2008)[2] for user defined regions of the detectors and the capability

of creating background subtracted and exposure corrected images. Also included in the XMM-ESAS package is software to mosaic multiple and not necessarily coaligned observations of regions on the sky.

SAS/ESAS Task Descriptions:

FORTRAN routines:

- *adapt* − FORTRAN

  adapt is an adaptive filtering routine used to create smoothed background subtracted and exposure corrected images for individual exposures or exposures from a single observation combined by the task *comb*. For each unmasked pixel, the program will average neighboring pixels within a circle of increasing radius until a selected number of counts is reached. The original pixel is then given the average surface brightness for the pixels within the circle. Images can also be binned before smoothing.

- *adapt_merge* − FORTRAN

  adapt_merge adaptively smooths background subtracted and exposure corrected mosaicked images using the output of *merge_comp_xmm*. For each unmasked pixel, the program will average neighboring pixels within a circle of increasing radius until a selected number of counts from the count image is reached. The original pixel is then given the average surface brightness for the pixels within the circle. The images can also be binned before smoothing.

- *bin_image* − FORTRAN

  bin_image produces binned count rate and count-rate uncertainty images of single observations. It can use either individual exposures or the output of the program *comb* which can merge all of the exposures associated with a single ObsID. For each unmasked and binned pixel, the program will determine the average count rate and the count rate uncertainty. The assumption is that the uncertainty is dominated by the counting statistics and the the systematics of the background modeling. Integer binning, including by 1 for no binning, is supported.

- *bin_image_merge* − FORTRAN

  bin_image_merge bins mosaicked images combined by the task *merge_comp_xmm* into count rate and count rate uncertainty images. For each unmasked and binned pixel, the program will determine the average count rate and the count rate uncertainty. The assumption is that the uncertainty is dominated by the counting statistics and the the systematics of the background modeling. Integer binning, including by 1 for no binning, is supported.

- *clean* − PERL

  clean deletes a number of intermediate and unneeded files after the processing is complete.

- *cheese* − PERL

  cheese does source detection and creates cheese masks for point-source masking during image processing. *cheese* allows the user to set a flux threshold over the field for the removal of the source contributions to the spectra as well as the images.

- *cheese-bands* − PERL

  cheese-bands does source detection and creates cheese masks for point-source masking during image processing in three bands: soft, hard, and combined. *cheese-bands* allows the user to set a flux threshold over the field for the removal of the source contributions to the spectra as well as the images.

- *comb* − FORTRAN

  comb combines co-aligned event, exposure, QPB, SP, and SWCX background images from different exposures and different instruments from the same ObsID.

- *conv_reg* − FORTRAN

  conv_reg converts region information in celestial coordinates into region information in detector coordinates. It will do so for region fits files, ascii lists, or individual regions. **Development in progress.**

- *conv-region* − PERL

  conv-region converts a region file in celestial coordinates into regions files in detector coordinates for all active detectors in all observations in a list of ObsIDs. **Development in progress.**

- *make_mask* − FORTRAN

  make_mask is called by the task *cheese* to produce a cheese mask.

- *make_mask_merge* − FORTRAN

  make_mask_merge produces cheese masks in the total band (*cheese*) or soft, hard, and combined bands (*cheese-bands*) using a merged source list produced by the task *merge-source-list* from the maximum likelihood source lists produced by *cheese* or *cheese-bands*.

- *merge_comp_xmm* − FORTRAN

  merge_comp_xmm creates mosaicked count, exposure, QPB, SP, and SWCX background images for multiple observations and exposures.

- *merge_source_list* − FORTRAN

  merge_source_list creates a master list of sources detected from a list of observations which have been processed to the point of a creating an emldetect source lists produced by *cheese* or *cheese-bands*. Sources are compared and those within 2" of each other have the one with the lower flux thrown out.

- *mos_back* − FORTRAN

  mos_back takes the output of the perl script *mos-spectra* and creates quiescent particle background (QPB) spectra and images in detector coordinates, as selected, for EPIC MOS data.

- *mos-filter* − PERL

  mos-filter filters and cleans the event files of SP contamination using the SAS task *esp-filt*. Along with a filtered event file it produces a QDP plot file showing the observation light curves and indicates the accepted time intervals.

- *mos-spectra* − PERL

  mos-spectra processes the filtered event files from the task *mos-filter* to produce a set of intermediate files for the production of QPB background spectra and images. *mos-spectra* also produces source spectra and the appropriate Redistribution Matrix Files, RMFs, and Ancillary Region Files, ARFs, for spectral analysis.

- *pn_back* – FORTRAN

  pn_back takes the output of *pn-spectra* and creates QPB spectra and images in detector coordinates, as selected, for EPIC pn data.

- *pn-filter* – PERL

  pn-filter is the initial processing script for pn data and it performs the same tasks as *mos-filter* for MOS data. Each exposure is processed in both normal and out-of-time (OOT) modes.

- *pn-spectra* – PERL

  pn-spectra provides the same functions for pn data as *mos-spectra* provides for the MOS. However, it also creates spectra and images from the out-of-time processing.

- *point_source* – FORTRAN

  point_source calculates the appropriate Xspec normalization for the extragalactic background given the user-selected point-source exclusion threshold.

- *proton* – FORTRAN

  proton produces images in detector coordinates of the model residual soft proton (SP) contamination. To do so, it uses the fitted values of the SP component from Xspec and standard detector maps.

- *proton_scale* – FORTRAN

  proton_scale extracts the appropriate scale factors for the solid angle and relative SP contributions to include in spectral fitting.

- *rot_det_sky* – FORTRAN

  rot_det_sky is called by the *rot-im-det-sky* task. It does the heavy lifting of rotating the QPB images output from *mos_back* and *pn_back*, the SP images output from *proton*, and the SWCX output from *swcx* which are in detector coordinates, into images in sky coordinates.

- *rot-im-det-sky* – PERL

  rot-im-det-sky rotates both the model QPB, SP, and SWCX background images from detector coordinates to sky coordinates.

- *sp_partial* – FORTRAN

  sp_partial scales the SP spectral fit results from a limited region of the detector to the full field of view. This allows the user to fit for the SP contamination in regions of lower surface brightness (e.g., an outer annulus for a cluster of galaxies) which can significantly improve the accuracy of the fit.

- *swcx* – FORTRAN

  swcx produces images in detector coordinates of the model residual SWCX contamination. To do so, it uses the fitted values of the SWCX component from Xspec and standard detector maps.

4 Parameters

This section documents the parameters recognized by this task (if any).

Parameter	Mand	Type	Default	Constraints

1. Task adapt parameters:

smoothingcounts	yes	int	50	

The number of counts to accumulate for the smoothing

thresholdmasking	yes	real	0.02	

The scale factor for excluding regions from the smoothing based on a mask image. In the default mode the average exposure is calculated and then any pixel with exposure less than fraction*average value is excluded.

detector	yes	int	0	0—1

Detector, `1` for a specific instrument and exposure, `0` for the combined image (i.e., the output of `comb`).

elow	yes	int	400	

The low energy for the band in eV

ehigh	yes	int	1250	

The high energy for the band in eV

binning	yes	int	1	

Binning control with `1` for no binning, and integers greater than 1 for binning that number of pixels in each dimension.

withpartcontrol	yes	bool	yes	

Particle background control, "yes" to subtract the model particle background image.

withsoftcontrol	yes	bool	no	

Soft proton background control, "yes" to subtract the soft proton background image.

withswcxcontrol	yes	bool	no	

Solar wind charge exchange background control, "yes" to subtract the SWCX background image.

withmaskcontrol	yes	bool	no	

Control for including an additional masking image.

maskfile	yes	dataset		

The file name for an image to provide additional masking if desired. If left blank then there will be no additional masking. The mask images must be the same size and projection as the other images.

prefix	yes	string	1S001	

Prefix defining the exposure used, with the `esas` nomenclature, eg. S003 means PN S003 exposure, while 1S002 and 2S003 mean MOS1 S002 and MOS2 S003 exposures, respectively.

clobber	no	boolean	yes	T/F

Clobber existing files?

2. Task adapt_merge parameters:

smoothingcounts	yes	int	100	

The number of counts to accumulate for the smoothing

thresholdmasking	yes	real	0.02	

The scale factor for excluding regions from the smoothing based on a mask image. In the default mode the average exposure is calculated and then any pixel with exposure less than fraction*average value is excluded.

elowlist	yes	int	400 750	

Low energy for successive bands in eV

ehighlist	yes	int	750 1250	

High energy for successive bands in eV

binning	yes	int	1	

Binning control, number of pixels (in both dimensions) to be binned.

withpartcontrol	yes	bool	yes	

Particle background control, "yes" to subtract the model particle background image.

withsoftcontrol	yes	bool	no	

Soft proton background control, "yes" to subtract the soft proton background image.

withswcxcontrol	yes	bool	no	

Solar wind charge exchange background control, "yes" to subtract the SWCX background image.

withoffsetbkgcontrol	yes	bool	yes	

Offset background control, "yes" to subtract the offset background image. This is a feature currently under development and is not yet functional.

withmaskcontrol	yes	bool	yes	

Mask control, "yes" for using a mask image (pixel with 1 in image will be included, pixel with 0 will be excluded).

mask	yes	dataset	mask.fit	

Mask image file name.

fill	yes	int	1	

Number of passes to fill in empty pixels. If a zero pixel has three or more non-zero neighbors, the pixel will be the average value of those neighbors.

clobber	no	boolean	yes	T/F

Clobber existing files?

3. Task bin_image parameters:

thresholdmasking	yes	real	0.02	

The scale factor for excluding regions from the smoothing based on a mask image. In the default mode the average exposure is calculated and then any pixel with exposure less than fraction*average value is excluded.

detector	yes	int	0	

Detector selection, 0: combined exposures, 1: MOS, 2: PN.

prefix	yes	string	1S001	

Prefix defining the exposure used, with the `esas` nomenclature, eg. S003 means PN S003 exposure, while 1S002 and 2S003 mean MOS1 S002 and MOS2 S003 exposures, respectively.

elow	yes	int	400	

Low energy for band in eV

ehigh	yes	int	1250	

High energy for band in eV

binning	yes	int	1	

Binning control with `1` for no binning, other integers for binning.

withpartcontrol	yes	bool	yes	

Particle background control, "yes" to subtract the model particle background image.

withsoftcontrol	yes	bool	no	

Soft proton background control, "yes" to subtract the soft proton background image.

withswcxcontrol	yes	bool	no	

Solar wind charge exchange background control, "yes" to subtract the SWCX background image.

withmaskcontrol	yes	bool	no	

Solar wind charge exchange background control, "yes" to subtract the SWCX background image.

mask	yes	dataset	mask.fit	

Mask image file name (defaults to using exposure mask).

clobber	no	boolean	yes	T/F

Clobber existing files?

4. Task bin_image_merge parameters:

thresholdmasking	yes	real	0.02	

The scale factor for excluding regions from the smoothing based on a mask image. In the default mode the average exposure is calculated and then any pixel with exposure less than `fraction*average` value is excluded.

elowlist	yes	int	350 800	

Low energy for successive bands in eV

ehighlist	yes	int	800 1300	

High energy for successive bands in eV

binning	yes	int	1	

Binning control with `1` for no binning, `2,4,8,16,32` for binning by 2, 4,8,16,32.

withpartcontrol	yes	bool	yes	

Particle background control, "yes" to subtract the model particle background image.

withsoftcontrol	yes	bool	yes	

Soft proton background control, "yes" to subtract the soft proton background image.

withswcxcontrol	yes	bool	yes	

Solar wind charge exchange background control, "yes" to subtract the swcx background image.

withmaskcontrol	yes	bool	yes	

For masking with an additional image.

mask	yes	dataset	mask.fit	

Mask image file name.

clobber	no	boolean	yes	T/F

Clobber existing files?

5. Task cheese parameters:

prefixm	yes	string		

Detector and exposure identifiers (eg. "1S001 2S002") for the MOS exposures (in the example MOS1 S001 and MOS2 S002) to be processed.

prefixp	yes	string		

Detector and exposure identifiers (eg. "S003") for the PN exposures (in the example PN S003) to be processed.

verb	yes	int	4	

SAS verbosity level.

scale	yes	real	0.5	

Energy fraction, which sets the exclusion radius of point sources.

rate	yes	real	1.0	

Flux threshold (in units of $1.0E-14 cgs$ for the exclusion of point sources.

dist	yes	real		

Minimum separation in arc seconds between masked sources.

elow	yes	int	400	

The low energy for the band in eV

ehigh	yes	int	1250	

The high energy for the band in eV

clobber	no	boolean	yes	T/F

Clobber existing files?

6. Task cheese_bands parameters:

prefixm	yes	string		

Detector and exposure identifiers (eg. "1S001 2S002") for the MOS exposures (in the example MOS1 S001 and MOS2 S002) to be processed.

prefixp	yes	string		

Detector and exposure identifiers (eg. "S003") for the PN exposures (in the example PN S003) to be processed.

verb	yes	int	4	

SAS verbosity level.

scale	yes	real	0.5	

Energy fraction, which sets the exclusion radius of point sources.

ratet	no	real	1.0	

Total flux threshold for exclusion of pt srcs

rates	no	real	1.0	

Soft flux threshold for exclusion of pt srcs

rateh	no	real	1.0	

Hard flux threshold for exclusion of pt srcs

dist	no	real		

Minimum separation in arc seconds between masked sources

elowlist	yes	int	400 2000	

Lower energy limit list for the energy bands in eV

ehighlist	yes	int	1300 7200	

Higher energy limit list for the energy bands in eV

clobber	no	boolean	yes	T/F

Clobber existing files?

7. Task clean parameters: none

8. Task comb parameters:

caldb	yes	string		

Directory containing all the ESAS specific calibration files

withpartcontrol	yes	boolean	true	

Particle background flag, 'true' to include it.

withsoftcontrol	yes	boolean	true	

Soft proton background flag, 'true' to include it.

withswcxcontrol	yes	boolean	true	

SWCX background flag, 'true' to include it.

alpha	yes	real	1.7	

Assumed spectral index for the filter correction scaling.

elowlist	yes	int	400 750	

Energy low limit(s) (in eV) for the different bands.

ehighlist	yes	int	750 1250	

Energy high limit(s) (in eV) for the different bands.

mask	yes	int	0	

Masking control. *0*: No additional masking, *1*: uses the mask produced by the `cheese` task, *2*: uses the normal mask images produced by `eexpmap`, and *3*: uses the normal mask images produced by `eexpmap` modified by `make-mask`.

prefixlist	yes	string	1S001 2S002 S003	

Exposure identifiers (eg. "1S001 2S002 S003") for the exposures (in the example MOS1 S001, MOS2 2S002, and PN S003) to be processed.

clobber	no	boolean	yes	T/F

Clobber existing files?

9. Task conv_reg parameters:

detector	yes	string		

The instrument identifier (EMOS1, EMOS2, or PN).

mode	yes	int		

conv_reg operational mode:
mode=1 – region fits files are both input and output
mode=2 – ascii files with region parameters are both input and output
mode=3 – command line input of individual region parameters and screen output

imagefile	yes	string		

Filename image in sky coordinates – used to extract observation position angle.

ra	no	real		none

mode=3 RA input

dec	no	real		none

mode=3 Dec input

shape	no	real		none

mode=3 region shape input, only circle and ellipse at this time (either all upper or all lower case, along with their "nots", e.g., "!ELLIPSE")

radius	no	real		none

mode=3 radius for circular region input

semimajor	no	real		none

mode=3 semimajor axis (in arc minutes) for elliptical region input

semiminor	no	real		none

mode=3 semiminor axis (in arc minutes) for elliptical region input

rotangle	no	real		none

mode=3 rotation angle (in degrees) for elliptical region input

inputfile	no	string		

mode=1,2 input file name

outputfile	no	string		

mode=1,2 input file name

10. Task espfilt parameters:

eventset	no	string		none

list of event files

method	no	string		corner

which method to use.

withsmoothing	no	boolean	N	Y/N

Smooth data?

smooth	no	integer	50	> 1

Smoothing factor in seconds

withbinning	no	boolean	N	Y/N

Bin data?

binning	no	integer	50	> 1

Bin width in seconds

withspecranges	no	boolean	N	Y/N

Use upper/lower spec chans?

specchanmin	no	integer	2500	> 1 ev, < 32766

Low Spectral Channel

specchanmax	no	integer	12000	> 2 ev, < 32767

High Spectral Channel

ratio	no	real	1.2	> 0.01, < 10.0

Flaring ratio of annulus_cnts corn_area corn_cnst annu_area

clobber	no	boolean	yes	T/F

Clobber existing files?

11. Task make_mask parameters:

inimage	no	string	inimage.fit	

Event image for the exposure

inmask	no	string	inmask.fit	

Exposure mask

outmask	no	string	outmask.fit	

The output file name for the cheese mask

reglist	no	string	reglist.fit	

The filtered source region list.

clobber	no	boolean	yes	T/F

Clobber existing files?

12. Task make_mask_merge parameters:

srclist	yes	string	merged-source-list.fits	

Merged source list from `merge_source_list`

prefix	yes	string	1S001	

Exposure identfier.

inmask	yes	string	mos1S001-mask-im-750-1250.fits	

Input mask file name.

flimtot	yes	real		

Combined band source flux threshold (10^{-14} cgs).

flimsoft	yes	real		

Soft band source flux threshold (10^{-14} cgs).

flimhard	yes	real		

Hard band source flux threshold (10^{-14} cgs).

scale	yes	real		

Scale factor for W90 radius.

seper	yes	real		

Minimum allowed source separation in arc second.

maxlikelim	yes	real		

Minimum accepted value for the maximum likelihood detetion parameter.

clobber	no	boolean	yes	T/F

Clobber existing files?

13. Task merge_comp_xmm parameters:

caldb	yes	string		

Directory containing all the ESAS specific calibration files

dirfile	yes	string	mydir	

File containing the list of exposures, including the directory string, for data to be merged. For instance, if the merging processing is being done in the directory */DATA/merge* and the individual observations are located in the parallel directories */DATA/obs1/proc* and */DATA/obs2/proc*, the file *dirlist* could have entries such as:

```
/DATA/obs1/proc/mos1S001
/DATA/obs1/proc/mos2S002
/DATA/obs1/proc/pnS003
/DATA/obs2/proc/mos1S001
/DATA/obs2/proc/mos2S002
/DATA/obs2/proc/pnS003
```

coord	yes	int	1	

Selects which coordinate system should be used, 1: ecliptic, 2: equatorial, 3: galactic.

crvaln1	yes	real		

Central longitude of the projection.

crvaln2	yes	real		

Central latitude of the projection.

pixelsize	yes	real		

Pixel size of the projection in decimal degrees.

component	yes	int	1	

Component to be cast, 1: count image, 2: exposure, 3: QPB counts, 4: SP counts..

alpha	yes	real	1.7	

Assumed spectral index for the filter correction scaling.

elow	yes	int	400	

Energy low limit (in eV) for the band.

ehigh	yes	int	1250	

Energy high limit (in eV) for the band.

maskcontrol	yes	int	1	

Mask control, 0: no masking, 1: point source masking using the output from `cheese`, 2: good area masking using the masks produced by `mos-spectra`, 3: mask from merged source list output from `make_mask_merge`.

xdim	yes	int	2000	

X dimension of the output image

ydim	yes	int	2000	

Y dimension of the output image

clobber	no	boolean	yes	T/F

Clobber existing files?

14. Task merge_source_list parameters:

dirfile	yes	string	mydir	

File containing the list of ObsID directory strings for source lists to be merged. For instance, if the merging processing is being done in the directory `/DATA/merge` and the individual observations are located in the parallel directories `/DATA/obs1/proc` and `/DATA/obs2/proc`, the file *dirlist* could have entries such as:

```
/DATA/obs1/proc/
/DATA/obs2/proc/
```

maxlikelim	yes	real		

Minimum accepted value for the maximum likelihood detetion parameter.

clobber	no	boolean	yes	T/F

Clobber existing files?

15. Task mos_back parameters:

prefix	yes	string	S003	

Detector and exposure identifier,(e.g., 1S001 for MOS1 S001 exposure).

caldb	yes	string		

Directory containing all the ESAS specific calibration files

diag	yes	int	1	

Controls the amount of diagnostic output (0 low, 1 medium, 2 high)

elow	yes	int	400	

Energy low limit (in eV) for the band.

ehigh	yes	int	1250	

Energy high limit (in eV) for the band.

ccd[1-7]	yes	int	1	

Selects which ccd's should be included.

clobber	no	boolean	yes	T/F

Clobber existing files?

16. Task mos-filter parameters: None

17. Task mos-spectra parameters:

prefix	yes	string	1S001	

Detector and exposure identifier (eg. "1S001") for MOS1 S001 exposure to be processed.

caldb	yes	string		

Directory containing all the ESAS specific calibration files

region	yes	int	reg.txt	

the selection expression for the desired region for the generation of the model background spectrum. If no file with the input name exists, or if the file is empty, then the default is to model the data from the entire field of view. If a specific region is desired, the region expression must be in detector coordinates. For example, a file containing `&&((DETX,DETY) IN circle(201,-219,3600))` would extract the central $3'$ of the cluster Abell 1795. Note that the leading "`&&`" are required as the selection expression is added to other constraints.

mask	yes	int	0	

Flag to mask out point sources. `0` selects no masking while `1` will cause `mos-spectra` to use the output filtered source region file from `cheese` or `cheese-bands`.

elow	yes	int	400	

Energy low limit (in eV) for the band. If `elow` and `ehigh` are set to `0`, the image processing will be eliminated and only spectral files will be produced.

ehigh	yes	int	1250	

Energy high limit (in eV) for the band. If *elow* and `ehigh` are set to `0`, the image processing will be eliminated and only spectral files will be produced.

ccd1-7	yes	int	1	

Flag to include individual CCDs. `1` to include, `0` to not.

18. Task pn_back parameters:

prefix	yes	string	S003	

Detector and exposure identifier,(e.g., S003 exposure).

caldb	yes	string		

Directory containing all the ESAS specific calibration files

diag	yes	int	1	

Controls the amount of diagnostic output (0 low, 1 medium, 2 high)

elow	yes	int	400	

Energy low limit (in eV) for the band.

ehigh	yes	int	1250	

Energy high limit (in eV) for the band.

quad[1-4]	yes	int	1	

Selects which PN quadrants should be included.

clobber	no	boolean	yes	T/F

Clobber existing files?

19. Task pn-filter parameters: None

20. Task pn-spectra parameters:

prefix	yes	string	1S001	

Detector and exposure identifier (eg. "S001") for the PN S001 exposure to be processed.

caldb	yes	string		

Directory containing all the ESAS specific calibration files

region	yes	int	reg.txt	

the selection expression for the desired region for the generation of the model background spectrum. If no file with the input name exists, or if the file is empty, then the default is to model the data from the entire field of view. If a specific region is desired, the region expression must be in detector coordinates. For example, a file containing `&&((DETX,DETY) IN circle(201,-219,3600))` would extract the central 3′ of the cluster Abell 1795. Note that the leading "`&&`" are required as the selection expression is added to other constraints.

mask	yes	int	0	

Flag to mask out point sources. *0* selects no masking while *1* will cause `pn-spectra` to use the output filtered source region file from `cheese-bands`.

elow	yes	int	2000	

Energy low limit (in eV) for the band. If *elow* and *ehigh* are set to *0*, the image processing will be eliminated and only spectral files will be produced.

ehigh	yes	int	7200	

Energy high limit (in eV) for the band. If *elow* and *ehigh* are set to *0*, the image processing will be eliminated and only spectral files will be produced.

quad1-4	yes	int	1	

Flag to include individual quadrants.

21. Task point_source parameters:

func	yes	string	mateos	

Name of logN-logS function.
hms (Hasinger, Miyaji, & Schmidt 2005)
mushotzky (REF TBD)
cappelluti (Cappelluti et al. 2008)
mateos (Mateos et al. 2008)

min_src_flux	yes	real	1.0e-14	

Source flux cutoff in erg/cm2/s.

cxrb_norm	yes	real	10.6	

Normalization of the cosmic X-ray background.

index	yes	real	1.46	

Photon power law index.

22. Task proton parameters:

prefix	yes	string		

Detector and exposure identifiers (eg. "1S001") for the MOS exposure S001) to be processed.

caldb	yes	string		

Directory containing all the ESAS specific calibration files

ccd[1-7]	yes	string	1	

Flag to include (1) or not (0) a CCD.

elow	yes	int	400	

The low energy for the band in eV

ehigh	yes	int	1250	

The high energy for the band in eV

spectrumcontrol	yes	int	1	

1 for a power law model, 2 for a broken power law

pindex	no		0	

Fitted power law index, only if spectrumcontrol=1

pnorm	no		0	

Scale factor for power law index, only if spectrumcontrol=1

binds	no		0	

Fitted soft broken power law index, only if spectrumcontrol=2

bbreak	no		0	

Break energy for broken power law model, only if spectrumcontrol=2

bindh	no		0	

Fitted hard broken power law index, only if spectrumcontrol=2

bnorm	no		0	

Normalization for broken power law, only if spectrumcontrol=2

clobber	no	boolean	yes	T/F

Clobber existing files?

23. Task proton_scale parameters:

caldb	yes	string		

Directory containing all the ESAS specific calibration files

mode	yes	int	1	

mode – 1: do a single region, 2: do multiple regions with the required input provided in a text file (parameter spfile).

det	yes	int	1	1—2—3

FOR MODE=1 - Detector, `1` for MOS1, `2` for MOS2, and`3` for PN

maskfile	yes	string	region	

FOR MODE=1 - File name for the mask file. This is the `mos`*prefix*`-obj-im-sp-det.fits` file produced for the region by *mos-spectra*.

specfile	yes	string	specfile	

FOR MODE=1 - File name for the spectral file for the region.

spfile	yes	string		

FOR MODE=2 - ASCII text file with the input for multiple regions. The file should contain, on separate lines, the detector number (det), mask file name (mask), and spectral file name (spec) for each region.

24. Task rot_det_sky parameters:

mode	yes	int	1	

Selection on particle (1), soft proton (2), SWCX (3) backgrounds, (4) MASK, (5) MASKIT.

prefix	yes	string	1S001	

Detector and exposure identifiers (eg. "1S001") for the MOS exposure S001) to be processed.

elow	yes	int	350	

The low energy for the band in eV

ehigh	yes	int	800	

The high energy for the band in eV

detx	yes	int	0	

The DETX reference pixel location

dety	yes	int	0	

The DETY reference pixel location

skyx	yes	int	0	

The X location of the reference pixel

skyy	yes	int	0	

The Y location of the reference pixel location

maskfile	yes	string		

The file name for an image to provide additional masking if desired. If left blank then there will be no additional masking. The mask images must be the same size and projection of the other images.

clobber	no	boolean	yes	T/F

Clobber existing files?

25. Task rotimdetsky parameters:

prefix	yes	string	1S001	

Detector and exposure identifiers (eg. "1S001") for the MOS exposure S001) to be processed.

mask	yes	string	none	

The file name for an image to provide additional masking if desired. If left blank then there will be no additional masking. The mask images must be the same size and projection of the other images.

elow	yes	int	400	

The low energy for the band in eV

ehigh	yes	int	1250	

The high energy for the band in eV

mode	yes	int	1	

Selection on particle (1), soft proton (2), SWCX (3) backgrounds, (4) MASK, (5) MASKIT.

clobber	no	boolean	yes	T/F

Clobber existing files?

26. Task sp_partial parameters:

caldb	yes	string	1S001	

Directory containing the ESAS calibration files.

detector	yes	int	1	

Detector to be processed 1-MOS1, 2-MOS2, and 3-PN.

fullimage	yes	string	mos1S001-sp-ps.fits	

Image from the full field of view.

fullspec	yes	string	mos1S001-obj-ps.pi	

Spectrum from the full field of view.

regionimage	yes	string	mos1S001-sp-nps.fits	

Image from the selected region.

regionspec	yes	string	mos1S001-obj-nps.pi	

Spectrum from the selected region.

rnorm	yes	real	0.05	

Xspec normalization of the SP component.

27. Task swcx parameters:

prefix	yes	string		

Detector and exposure identifiers (eg. "1S001") for the MOS exposure S001) to be processed.

caldb	yes	string		

Directory containing all the ESAS specific calibration files

ccd[1-7]	yes	string	1	

Flag to include (1) or not (0) a CCD.

elow	yes	int	400	

The low energy for the band in eV

ehigh	yes	int	1300	

The high energy for the band in eV

elinelist	yes		1 2	

Energies of SWCX lines to be included

gnormlist	yes		0.1 0.03	

Gaussian normalizations from Xspec

objrmf	yes	string		

RMF for the region

objarf	yes	string		

ARF for the region

objspec	yes	string		

Spectrum for the region

clobber	no	boolean	yes	T/F

Clobber existing files?

5 Errors

This section documents warnings and errors generated by this task (if any). Note that warnings and errors can also be generated in the SAS infrastructure libraries, in which case they would not be documented here. Refer to the index of all errors and warnings available in the HTML version of the SAS documentation.

label *(error)*
explanation

label *(warning)*
explanation
corrective action: this is the corrective action

6 Input Files

1. adapt: maskfile (Input file for additional masking).
2. adapt_merge: maskfile (Input file for additional masking).
3. bin_image: maskfile (Mask file name).
4. make_mask: inimage (The event image for the exposure).
5. make_mask: inmask (Exposure mask).
6. make_mask: reglist (The filtered source region list).
7. mos-spectra: region (File with additional region information).
8. proton_scale: region (Mask image file name).
9. proton_scale: specfile (Spectrum file name).
10. proton_scale: spfile (ASCII text file with the input for multiple regions).
11. rot_Det_Sky: maskfile (Input file for additional masking).
12. sp_Partial: fullimage (Full region image file name).
13. sp_Partial: fullspec (Full region spectrum file name).
14. sp_Partial: regionimage (Selected region image file name).
15. sp_Partial: regionspec (Selected region spectrum file name).

7 Output Files

See individual routine documents in this directory for output file descriptions.

8 Algorithm

9 Comments

We would like to thank members of the MOS and pn hardware and software teams, the *XMM-Newton* SOC at the European Space Astronomy Center (ESAC), and other members of the EPIC Background Working Group for their contributions which ranged from helping us to understand instrument and software issues to the identification of filter-wheel closed observations in the archive. Users of this package should be aware of the informational web pages covering the background issues of EPIC observations at:
`http://xmm.esac.esa.int/external/xmm_sw_cal/background/index.shtml`
and the EPIC Calibration Status document at:
`http://xmm.esac.esa.int/external/xmm_sw_cal/calib/index.shtml`.

References

[1] Snowden, S. L., Mushotzky, R. F., Kuntz, K. D., and Davis, D. S. 2008, A&A, 478,615

[2] Kuntz, K. D., & Snowden, S. L. 2008, A&A, 478, 575

[3] Snowden, S. L., Kuntz, K. D., Cookbook for Analysis Procedures for XMM-Newton EPIC MOS Observations of Extended Objects and the Diffuse Background, 2008, Vol 3.0.

References