

## esas

June 2, 2019

**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 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 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

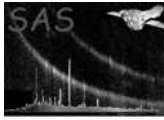
*proton\_scale* extracts the appropriate scale factors for the solid angle and relative SP contributions to include in spectral fitting.
- *rot\_det\_sky* – FORTRAN

*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
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1. Task adapt parameters:

<b>smoothingcounts</b>	yes	int	50	
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The number of counts to accumulate for the smoothing

<b>thresholdmasking</b>	yes	real	0.02	
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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.

<b>detector</b>	yes	int	0	0—1
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Detector, 1 for a specific instrument and exposure, 0 for the combined image (i.e., the output of comb).

<b>elow</b>	yes	int	400	
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The low energy for the band in eV

<b>ehigh</b>	yes	int	1250	
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The high energy for the band in eV

<b>binning</b>	yes	int	1	
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Binning control with 1 for no binning, and integers greater than 1 for binning that number of pixels in each dimension.

<b>withpartcontrol</b>	yes	bool	yes	
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Particle background control, "yes" to subtract the model particle background image.

<b>withsoftcontrol</b>	yes	bool	no	
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Soft proton background control, "yes" to subtract the soft proton background image.

<b>withswcxcontrol</b>	yes	bool	no	
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Solar wind charge exchange background control, "yes" to subtract the SWCX background image.

<b>withmaskcontrol</b>	yes	bool	no	
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Control for including an additional masking image.

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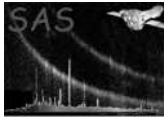
The file name for an image to provide additional masking if desired. If left blank then there will be no additional masking. The mask images must be the same size and projection as the other images.

<b>prefix</b>	yes	string	1S001	
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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.

<b>clobber</b>	no	boolean	yes	T/F
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Clobber existing files?



2. Task adapt\_merge parameters:

<b>smoothingcounts</b>	yes	int	100	
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The number of counts to accumulate for the smoothing

<b>thresholdmasking</b>	yes	real	0.02	
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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.

<b>elowlist</b>	yes	int	400 750	
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Low energy for successive bands in eV

<b>ehighlist</b>	yes	int	750 1250	
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High energy for successive bands in eV

<b>binning</b>	yes	int	1	
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Binning control, number of pixels (in both dimensions) to be binned.

<b>withpartcontrol</b>	yes	bool	yes	
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Particle background control, "yes" to subtract the model particle background image.

<b>withsoftcontrol</b>	yes	bool	no	
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Soft proton background control, "yes" to subtract the soft proton background image.

<b>withswcxcontrol</b>	yes	bool	no	
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Solar wind charge exchange background control, "yes" to subtract the SWCX background image.

<b>withoffsetbkgcontrol</b>	yes	bool	yes	
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Offset background control, "yes" to subtract the offset background image. This is a feature currently under development and is not yet functional.

<b>withmaskcontrol</b>	yes	bool	yes	
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Mask control, "yes" for using a mask image (pixel with 1 in image will be included, pixel with 0 will be excluded).

<b>mask</b>	yes	dataset	mask.fit	
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Mask image file name.

<b>fill</b>	yes	int	1	
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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.

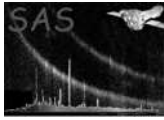
<b>clobber</b>	no	boolean	yes	T/F
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Clobber existing files?

3. Task bin\_image parameters:

<b>thresholdmasking</b>	yes	real	0.02	
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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.



<b>detector</b>	yes	int	0	
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Detector selection, 0: combined exposures, 1: MOS, 2: PN.

<b>prefix</b>	yes	string	1S001	
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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.

<b>elow</b>	yes	int	400	
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Low energy for band in eV

<b>ehigh</b>	yes	int	1250	
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High energy for band in eV

<b>binning</b>	yes	int	1	
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Binning control with 1 for no binning, other integers for binning.

<b>withpartcontrol</b>	yes	bool	yes	
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Particle background control, "yes" to subtract the model particle background image.

<b>withsoftcontrol</b>	yes	bool	no	
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Soft proton background control, "yes" to subtract the soft proton background image.

<b>withswcxcontrol</b>	yes	bool	no	
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Solar wind charge exchange background control, "yes" to subtract the SWCX background image.

<b>withmaskcontrol</b>	yes	bool	no	
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Solar wind charge exchange background control, "yes" to subtract the SWCX background image.

<b>mask</b>	yes	dataset	mask.fit	
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Mask image file name (defaults to using exposure mask).

<b>clobber</b>	no	boolean	yes	T/F
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Clobber existing files?

4. Task bin\_image\_merge parameters:

<b>thresholdmasking</b>	yes	real	0.02	
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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.

<b>elowlist</b>	yes	int	350 800	
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Low energy for successive bands in eV

<b>ehighlist</b>	yes	int	800 1300	
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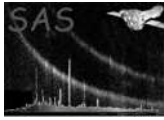
High energy for successive bands in eV

<b>binning</b>	yes	int	1	
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Binning control with 1 for no binning, 2,4,8,16,32 for binning by 2, 4,8,16,32.

<b>withpartcontrol</b>	yes	bool	yes	
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Particle background control, "yes" to subtract the model particle background image.



<b>withsoftcontrol</b>	yes	bool	yes	
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Soft proton background control, "yes" to subtract the soft proton background image.

<b>withswcxcontrol</b>	yes	bool	yes	
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Solar wind charge exchange background control, "yes" to subtract the swcx background image.

<b>withmaskcontrol</b>	yes	bool	yes	
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For masking with an additional image.

<b>mask</b>	yes	dataset	mask.fit	
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Mask image file name.

<b>clobber</b>	no	boolean	yes	T/F
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Clobber existing files?

5. Task cheese parameters:

<b>prefixm</b>	yes	string		
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Detector and exposure identifiers (eg. "1S001 2S002") for the MOS exposures (in the example MOS1 S001 and MOS2 S002) to be processed.

<b>prefixp</b>	yes	string		
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Detector and exposure identifiers (eg. "S003") for the PN exposures (in the example PN S003) to be processed.

<b>verb</b>	yes	int	4	
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SAS verbosity level.

<b>scale</b>	yes	real	0.5	
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Energy fraction, which sets the exclusion radius of point sources.

<b>rate</b>	yes	real	1.0	
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Flux threshold (in units of  $1.0E - 14cgs$  for the exclusion of point sources).

<b>dist</b>	yes	real		
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Minimum separation in arc seconds between masked sources.

<b>elow</b>	yes	int	400	
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The low energy for the band in eV

<b>ehigh</b>	yes	int	1250	
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The high energy for the band in eV

<b>clobber</b>	no	boolean	yes	T/F
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Clobber existing files?

6. Task cheese\_bands parameters:

<b>prefixm</b>	yes	string		
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Detector and exposure identifiers (eg. "1S001 2S002") for the MOS exposures (in the example MOS1 S001 and MOS2 S002) to be processed.

<b>prefixp</b>	yes	string		
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Detector and exposure identifiers (eg. "S003") for the PN exposures (in the example PN S003) to be processed.

<b>verb</b>	yes	int	4	
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SAS verbosity level.

<b>scale</b>	yes	real	0.5	
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Energy fraction, which sets the exclusion radius of point sources.

<b>ratet</b>	no	real	1.0	
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Total flux threshold for exclusion of pt srcs

<b>rates</b>	no	real	1.0	
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Soft flux threshold for exclusion of pt srcs

<b>rateh</b>	no	real	1.0	
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Hard flux threshold for exclusion of pt srcs

<b>dist</b>	no	real		
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Minimum separation in arc seconds between masked sources

<b>elowlist</b>	yes	int	400 2000	
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Lower energy limit list for the energy bands in eV

<b>ehighlist</b>	yes	int	1300 7200	
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Higher energy limit list for the energy bands in eV

<b>clobber</b>	no	boolean	yes	T/F
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Clobber existing files?

7. Task clean parameters: none

8. Task comb parameters:

<b>caldb</b>	yes	string		
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Directory containing all the ESAS specific calibration files

<b>withpartcontrol</b>	yes	boolean	true	
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Particle background flag, 'true' to include it.

<b>withsoftcontrol</b>	yes	boolean	true	
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Soft proton background flag, 'true' to include it.

<b>withswcxcontrol</b>	yes	boolean	true	
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SWCX background flag, 'true' to include it.

<b>alpha</b>	yes	real	1.7	
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Assumed spectral index for the filter correction scaling.

<b>elowlist</b>	yes	int	400 750	
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Energy low limit(s) (in eV) for the different bands.

<b>ehighlist</b>	yes	int	750 1250	
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Energy high limit(s) (in eV) for the different bands.



<b>mask</b>	yes	int	0	
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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**.

<b>prefixlist</b>	yes	string	1S001 2S002 S003	
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Exposure identifiers (eg. "1S001 2S002 S003") for the exposures (in the example MOS1 S001, MOS2 2S002, and PN S003) to be processed.

<b>clobber</b>	no	boolean	yes	T/F
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Clobber existing files?

9. Task **conv\_reg** parameters:

<b>detector</b>	yes	string		
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The instrument identifier (EMOS1, EMOS2, or PN).

<b>mode</b>	yes	int		
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**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

<b>imagefile</b>	yes	string		
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Filename image in sky coordinates – used to extract observation position angle.

<b>ra</b>	no	real		none
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mode=3 RA input

<b>dec</b>	no	real		none
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mode=3 Dec input

<b>shape</b>	no	real		none
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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”)

<b>radius</b>	no	real		none
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mode=3 radius for circular region input

<b>semimajor</b>	no	real		none
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mode=3 semimajor axis (in arc minutes) for elliptical region input

<b>semiminor</b>	no	real		none
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mode=3 semiminor axis (in arc minutes) for elliptical region input

<b>rotangle</b>	no	real		none
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mode=3 rotation angle (in degrees) for elliptical region input

<b>inputfile</b>	no	string		
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mode=1,2 input file name

<b>outputfile</b>	no	string		
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mode=1,2 input file name



10. Task `esfilt` parameters:

<b>eventset</b>	no	string		none
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list of event files

<b>method</b>	no	string		corner
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which method to use.

<b>withsmoothing</b>	no	boolean	N	Y/N
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Smooth data?

<b>smooth</b>	no	integer	50	> 1
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Smoothing factor in seconds

<b>withbinning</b>	no	boolean	N	Y/N
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Bin data?

<b>binning</b>	no	integer	50	> 1
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Bin width in seconds

<b>withspecranges</b>	no	boolean	N	Y/N
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Use upper/lower spec chans?

<b>specchanmin</b>	no	integer	2500	> 1 ev, < 32766
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Low Spectral Channel

<b>specchanmax</b>	no	integer	12000	> 2 ev, < 32767
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High Spectral Channel

<b>ratio</b>	no	real	1.2	> 0.01, < 10.0
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Flaring ratio of `annulus_cnts` `corn_area` `corn_cnst` `annu_area`

<b>clobber</b>	no	boolean	yes	T/F
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Clobber existing files?

11. Task `make_mask` parameters:

<b>inimage</b>	no	string	inimage.fit	
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Event image for the exposure

<b>inmask</b>	no	string	inmask.fit	
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Exposure mask

<b>outmask</b>	no	string	outmask.fit	
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The output file name for the cheese mask

<b>reglist</b>	no	string	reglist.fit	
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The filtered source region list.

<b>clobber</b>	no	boolean	yes	T/F
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Clobber existing files?

12. Task `make_mask_merge` parameters:



<b>srclist</b>	yes	string	merged-source-list.fits	
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Merged source list from `merge_source_list`

<b>prefix</b>	yes	string	1S001	
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Exposure identifier.

<b>inmask</b>	yes	string	mos1S001-mask-im-750-1250.fits	
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Input mask file name.

<b>flimtot</b>	yes	real		
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Combined band source flux threshold ( $10^{-14}$  cgs).

<b>flimsoft</b>	yes	real		
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Soft band source flux threshold ( $10^{-14}$  cgs).

<b>flimhard</b>	yes	real		
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Hard band source flux threshold ( $10^{-14}$  cgs).

<b>scale</b>	yes	real		
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Scale factor for W90 radius.

<b>seper</b>	yes	real		
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Minimum allowed source separation in arc second.

<b>maxlikelim</b>	yes	real		
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Minimum accepted value for the maximum likelihood detection parameter.

<b>clobber</b>	no	boolean	yes	T/F
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Clobber existing files?

13. Task `merge_comp_xmm` parameters:

<b>caldb</b>	yes	string		
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Directory containing all the ESAS specific calibration files

<b>dirfile</b>	yes	string	mydir	
----------------	-----	--------	-------	--

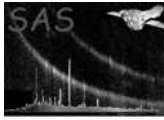
File containing the list of exposures, including the directory string, for data to be merged. For instance, if the merging processing is being done in the directory `/DATA/merge` and the individual observations are located in the parallel directories `/DATA/obs1/proc` and `/DATA/obs2/proc`, the file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

<b>coord</b>	yes	int	1	
--------------	-----	-----	---	--

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

<b>crvaln1</b>	yes	real		
----------------	-----	------	--	--



Central longitude of the projection.

<b>crvaln2</b>	yes	real		
----------------	-----	------	--	--

Central latitude of the projection.

<b>pixelsize</b>	yes	real		
------------------	-----	------	--	--

Pixel size of the projection in decimal degrees.

<b>component</b>	yes	int	1	
------------------	-----	-----	---	--

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

<b>alpha</b>	yes	real	1.7	
--------------	-----	------	-----	--

Assumed spectral index for the filter correction scaling.

<b>elow</b>	yes	int	400	
-------------	-----	-----	-----	--

Energy low limit (in eV) for the band.

<b>ehigh</b>	yes	int	1250	
--------------	-----	-----	------	--

Energy high limit (in eV) for the band.

<b>maskcontrol</b>	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**.

<b>xdim</b>	yes	int	2000	
-------------	-----	-----	------	--

X dimension of the output image

<b>ydim</b>	yes	int	2000	
-------------	-----	-----	------	--

Y dimension of the output image

<b>clobber</b>	no	boolean	yes	T/F
----------------	----	---------	-----	-----

Clobber existing files?

#### 14. Task `merge_source_list` parameters:

<b>dirfile</b>	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/
```

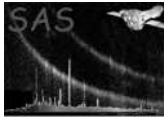
<b>maxlikelim</b>	yes	real		
-------------------	-----	------	--	--

Minimum accepted value for the maximum likelihood detection parameter.

<b>clobber</b>	no	boolean	yes	T/F
----------------	----	---------	-----	-----

Clobber existing files?

#### 15. Task `mos_back` parameters:

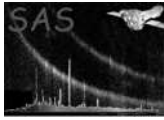


<b>prefix</b>	yes	string	S003	
Detector and exposure identifier,(e.g., 1S001 for MOS1 S001 exposure).				
<b>caldb</b>	yes	string		
Directory containing all the ESAS specific calibration files				
<b>diag</b>	yes	int	1	
Controls the amount of diagnostic output (0 low, 1 medium, 2 high)				
<b>elow</b>	yes	int	400	
Energy low limit (in eV) for the band.				
<b>ehigh</b>	yes	int	1250	
Energy high limit (in eV) for the band.				
<b>ccd[1-7]</b>	yes	int	1	
Selects which ccd's should be included.				
<b>clobber</b>	no	boolean	yes	T/F
Clobber existing files?				

16. Task mos-filter parameters: None

17. Task mos-spectra parameters:

<b>prefix</b>	yes	string	1S001	
Detector and exposure identifier (eg. "1S001") for MOS1 S001 exposure to be processed.				
<b>caldb</b>	yes	string		
Directory containing all the ESAS specific calibration files				
<b>region</b>	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 <code>&amp;&amp;((DETX,DETY) IN circle(201,-219,3600))</code> 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.				
<b>mask</b>	yes	int	0	
Flag to mask out point sources. 0 selects no masking while 1 will cause <code>mos-spectra</code> to use the output filtered source region file from <code>cheese</code> or <code>cheese-bands</code> .				
<b>elow</b>	yes	int	400	
Energy low limit (in eV) for the band. If <code>elow</code> and <code>ehigh</code> are set to 0, the image processing will be eliminated and only spectral files will be produced.				
<b>ehigh</b>	yes	int	1250	
Energy high limit (in eV) for the band. If <code>elow</code> and <code>ehigh</code> are set to 0, the image processing will be eliminated and only spectral files will be produced.				
<b>ccd1-7</b>	yes	int	1	
Flag to include individual CCDs. 1 to include, 0 to not.				



18. Task pn\_back parameters:

<b>prefix</b>	yes	string	S003	
---------------	-----	--------	------	--

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

<b>caldb</b>	yes	string		
--------------	-----	--------	--	--

Directory containing all the ESAS specific calibration files

<b>diag</b>	yes	int	1	
-------------	-----	-----	---	--

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

<b>elow</b>	yes	int	400	
-------------	-----	-----	-----	--

Energy low limit (in eV) for the band.

<b>ehigh</b>	yes	int	1250	
--------------	-----	-----	------	--

Energy high limit (in eV) for the band.

<b>quad[1-4]</b>	yes	int	1	
------------------	-----	-----	---	--

Selects which PN quadrants should be included.

<b>clobber</b>	no	boolean	yes	T/F
----------------	----	---------	-----	-----

Clobber existing files?

19. Task pn-filter parameters: None

20. Task pn-spectra parameters:

<b>prefix</b>	yes	string	1S001	
---------------	-----	--------	-------	--

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

<b>caldb</b>	yes	string		
--------------	-----	--------	--	--

Directory containing all the ESAS specific calibration files

<b>region</b>	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.

<b>mask</b>	yes	int	0	
-------------	-----	-----	---	--

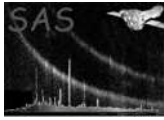
Flag to mask out point sources. 0 selects no masking while 1 will cause pn-spectra to use the output filtered source region file from cheese-bands.

<b>elow</b>	yes	int	2000	
-------------	-----	-----	------	--

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

<b>ehigh</b>	yes	int	7200	
--------------	-----	-----	------	--

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



<b>quad1-4</b>	yes	int	1	
----------------	-----	-----	---	--

Flag to include individual quadrants.

21. Task point\_source parameters:

<b>func</b>	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)

<b>min_src_flux</b>	yes	real	1.0e-14	
---------------------	-----	------	---------	--

Source flux cutoff in erg/cm2/s.

<b>cxrb_norm</b>	yes	real	10.6	
------------------	-----	------	------	--

Normalization of the cosmic X-ray background.

<b>index</b>	yes	real	1.46	
--------------	-----	------	------	--

Photon power law index.

22. Task proton parameters:

<b>prefix</b>	yes	string		
---------------	-----	--------	--	--

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

<b>caldb</b>	yes	string		
--------------	-----	--------	--	--

Directory containing all the ESAS specific calibration files

<b>ccd[1-7]</b>	yes	string	1	
-----------------	-----	--------	---	--

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

<b>elow</b>	yes	int	400	
-------------	-----	-----	-----	--

The low energy for the band in eV

<b>ehigh</b>	yes	int	1250	
--------------	-----	-----	------	--

The high energy for the band in eV

<b>spectrumcontrol</b>	yes	int	1	
------------------------	-----	-----	---	--

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

<b>pindex</b>	no		0	
---------------	----	--	---	--

Fitted power law index, only if spectrumcontrol=1

<b>pnorm</b>	no		0	
--------------	----	--	---	--

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

<b>binds</b>	no		0	
--------------	----	--	---	--

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

<b>bbreak</b>	no		0	
---------------	----	--	---	--

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





<b>bindh</b>	no		0	
Fitted hard broken power law index, only if spectrumcontrol=2				
<b>bnorm</b>	no		0	
Normalization for broken power law, only if spectrumcontrol=2				
<b>clobber</b>	no	boolean	yes	T/F
Clobber existing files?				

23. Task proton\_scale parameters:

<b>caldb</b>	yes	string		
Directory containing all the ESAS specific calibration files				
<b>mode</b>	yes	int	1	
mode - 1: do a single region, 2: do multiple regions with the required input provided in a text file (parameter spfile).				
<b>det</b>	yes	int	1	1-2-3
FOR MODE=1 - Detector, 1 for MOS1, 2 for MOS2, and 3 for PN				
<b>maskfile</b>	yes	string	region	
FOR MODE=1 - File name for the mask file. This is the <i>mosprefix-obj-im-sp-det.fits</i> file produced for the region by <i>mos-spectra</i> .				
<b>specfile</b>	yes	string	specfile	
FOR MODE=1 - File name for the spectral file for the region.				
<b>spfile</b>	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:

<b>mode</b>	yes	int	1	
Selection on particle (1), soft proton (2), SWCX (3) backgrounds, (4) MASK, (5) MASKIT.				
<b>prefix</b>	yes	string	1S001	
Detector and exposure identifiers (eg. "1S001") for the MOS exposure S001) to be processed.				
<b>elow</b>	yes	int	350	
The low energy for the band in eV				
<b>ehigh</b>	yes	int	800	
The high energy for the band in eV				
<b>detx</b>	yes	int	0	
The DETX reference pixel location				
<b>dety</b>	yes	int	0	
The DETY reference pixel location				



<b>skyx</b>	yes	int	0	
-------------	-----	-----	---	--

The X location of the reference pixel

<b>skyy</b>	yes	int	0	
-------------	-----	-----	---	--

The Y location of the reference pixel location

<b>maskfile</b>	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.

<b>clobber</b>	no	boolean	yes	T/F
----------------	----	---------	-----	-----

Clobber existing files?

25. Task rotimdetsky parameters:

<b>prefix</b>	yes	string	1S001	
---------------	-----	--------	-------	--

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

<b>mask</b>	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.

<b>elow</b>	yes	int	400	
-------------	-----	-----	-----	--

The low energy for the band in eV

<b>ehigh</b>	yes	int	1250	
--------------	-----	-----	------	--

The high energy for the band in eV

<b>mode</b>	yes	int	1	
-------------	-----	-----	---	--

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

<b>clobber</b>	no	boolean	yes	T/F
----------------	----	---------	-----	-----

Clobber existing files?

26. Task sp\_partial parameters:

<b>caldb</b>	yes	string	1S001	
--------------	-----	--------	-------	--

Directory containing the ESAS calibration files.

<b>detector</b>	yes	int	1	
-----------------	-----	-----	---	--

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

<b>fullimage</b>	yes	string	mos1S001-sp-ps.fits	
------------------	-----	--------	---------------------	--

Image from the full field of view.

<b>fullspec</b>	yes	string	mos1S001-obj-ps.pi	
-----------------	-----	--------	--------------------	--

Spectrum from the full field of view.



<b>regionimage</b>	yes	string	mos1S001-sp-nps.fits	
--------------------	-----	--------	----------------------	--

Image from the selected region.

<b>regionspec</b>	yes	string	mos1S001-obj-nps.pi	
-------------------	-----	--------	---------------------	--

Spectrum from the selected region.

<b>rnorm</b>	yes	real	0.05	
--------------	-----	------	------	--

Xspec normalization of the SP component.

27. Task swcx parameters:

<b>prefix</b>	yes	string		
---------------	-----	--------	--	--

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

<b>caldb</b>	yes	string		
--------------	-----	--------	--	--

Directory containing all the ESAS specific calibration files

<b>ccd[1-7]</b>	yes	string	1	
-----------------	-----	--------	---	--

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

<b>elow</b>	yes	int	400	
-------------	-----	-----	-----	--

The low energy for the band in eV

<b>ehigh</b>	yes	int	1300	
--------------	-----	-----	------	--

The high energy for the band in eV

<b>elinelist</b>	yes		1 2	
------------------	-----	--	-----	--

Energies of SWCX lines to be included

<b>gnormlist</b>	yes		0.1 0.03	
------------------	-----	--	----------	--

Gaussian normalizations from Xspec

<b>objrmf</b>	yes	string		
---------------	-----	--------	--	--

RMF for the region

<b>objarf</b>	yes	string		
---------------	-----	--------	--	--

ARF for the region

<b>objspec</b>	yes	string		
----------------	-----	--------	--	--

Spectrum for the region

<b>clobber</b>	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

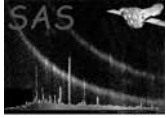
**label** (*warning*)  
explanation  
*corrective action*: this is the corrective action

## 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](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](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