eimageget

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Abstract

EPIC vignetting-corrected background-subtracted image production.

1 Instruments/Modes

Instrument	Mode
EPIC PN	FF, EFF
EPIC MOS	FF, CCD 2-7
RGS	NO

2 Use

pipeline processing	yes
interactive analysis	yes

3 Description

The meta-task **eimageget** allows a convenient creation of a set of images for one EPIC (pn or MOS) exposure. For individual energy bands, the task creates images of the observation, scaled out-of-time (OOT) images (EPIC-pn only), scaled filter-wheel-closed (FWC) images and vignetting corrected exposure maps and one mask (see Fig. 1). These images can be used to create background-subtracted and vignetting-corrected images latter on.

The OOT images are scaled according to the science mode of the exposure and can be subtracted from the observation images. The FWC images are scaled to have the same count rate in the shielded detector corners. Focused X-rays cannot reach these corners, thus events are basically caused by the detector background. After a subtraction of the detector background, which has a rather flat profile, the images can be corrected for vignetting using the exposure maps. Vignetting affects all X-rays that are focused by the telescopes, including e.g. the cosmic X-ray background or solar-wind charge exchange. Note, that the flaring detector background, caused by soft protons, shows some vignetting and should be removed by using a temporal filtering beforehand.

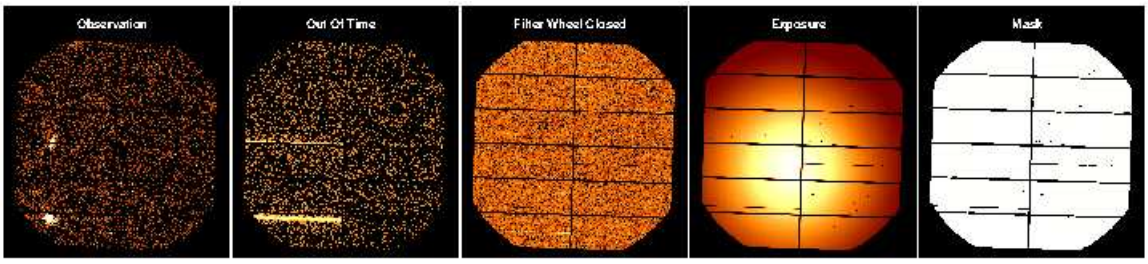

Figure 1: Output images.

3.1 Event selection from input files

The essential input files are the event file of the observation and, in case of EPIC-pn, an OOT event file (e.g. created with the **epproc** or **epchain** tasks), as well as a detector background event file, available at: https://www.cosmos.esa.int/web/xmm-newton/filter-closed
These are created from observations with closed filter wheel.

In most cases, images will be created from filtered event lists.

The filtering can be done beforehand and the filtered event files can be used as input for **eimageget**. Note that in this case, filtering should be applied homogeneously to all input event files. E.g., if events around the EPIC-pn Ni/Cu line complex (7.2−9.2 keV) will be removed, these events should be filtered from the FWC and OOT file as well. Also note, that events outside of the field of view (i.e. the detector corners) must be present for the scaling of the FWC images, which is e.g. not the case when selecting the `XMMEA_EM` flag or `FLAG==0` events.

Alternatively, **eimageget** parameters can be used for commonly used selections:

- Good-time intervals can be selected by giving a `gtifile`. This temporal selection will not be applied to the detector-background event file.
- Energy bands are defined by the `pimin` and `pimax` parameters. Output image sets can be created for several energy bands simultaneously. Default values are the five XMM-Newton standard energy bands (0.2−0.5, 0.5−1.0, 1.0−2.0, 2.0−4.5, and 4.5−12.0 keV)
- A pattern selection can be defined by the `patmin` and `patmax` parameters, for each energy band. Default values are pattern 0−12 (single- to quadruple-pixel events) for EPIC-MOS images, 0−4 (single- and double-pixel events) in the case of EPIC-pn for energy band above 0.5 keV and 0 (single-pixel events) for EPIC-pn energy bands that reach below 0.5 keV.
- Flags can be defined separately for the selection of the field-of-view region (the final images) and the detector corners (used for scaling).
- EPIC-MOS CCDs can show an anomalous state with enhanced low-energy background. The task **emtaglenoise** is used to remove events from affected CCDs. If only images above ∼1keV are of interest, this can be turned off by setting `withemtaglenoise` to "no".
- If additional bad pixels should be removed, it is sufficient to add them to the bad-pixel extension of one of the input event files. **eimageget** will apply all bad-pixel extensions to all images homogeneously, unless `withbadpixupdate` is set to "no". Especially, some CCD columns can be bright in the FWC data below 300 eV, but not in the data of the observation, which might cause an over-subtraction here.

Table 1: **Default pattern selections**

Parameter	Camera		
	MOS	PN (>0.5 keV)	PN (<0.5 keV)
PATTERN	0–12	0–4	0

Table 2: **Default flag selections**

Parameter	Camera	
	MOS	PN
FLAG (FoV)	(FLAG & 0x766ba000) == 0	FLAG == 0
FLAG (corner)	(FLAG & 0x766aa000) == 0	(FLAG & 0xcfa0000) == 0)

3.2 Image creation

To allow a flexible image format, the **evselect** parameters for the final image creation are passed by **eimageget**.

To allow a convenient creation of mosaic images, the image coordinates can be recalculated (using **attcalc**) by setting `withattcalc` = yes and using the `nominalra`, `nominaldec`, `imagesize` parameters. Note, that in this case, an attitude file must be given as input and the `SAS_ODF` variable must be set properly.

The final OOT images are scaled according to the science mode of the exposure by $f_{\rm oot}$ (6.3% for full frame mode, 2.32% for extended full frame mode).

The final FWC images are scaled to have the same average count rate in the shielded detector corners. Out-of-time events are respected here. Since the detector corners of EPIC-pn are not read out in large- and small-window modes, no images can be created in these cases. Also, if EPIC-MOS was not operated in full-frame mode, no image of the central CCD will be created.

This is not the most sophisticated method (see e.g. the ESAS package) but provides a robust and useful approximation for the detector background. Note however, that for narrow energy bands and/or short exposure times the statistics in the detector corners might be too small. The number of counts are given as output and can be checked.

This method assumes that the spectral variability of the detector background can be neglected within the individual energy bands. Using very broad energy bands can violate this assumption. E.g. the relative contribution of electronic noise below 0.5 keV is variable with time. To account for this, it is suggested to create an image for the 0.2-0.5 keV band independently and add the final images later on, if a wider energy band is needed.

3.3 Image usage

In principle, the OOT and FWC image can be subtracted directly from the observation images and the resulting image can be divided by the exposure map. However, the subtraction of the images is not done by **eimageget**, because in most cases the statistics will require some smoothing. In the case of adaptive smoothing, images from individual exposures should be combined first and be smoothed with the same smoothing template. The task **eimagecombine** can be used to conveniently combine the individual output images of **eimageget**.

3.4 Examples

3.4.1 Simple image creation

```
eimageget evtfile=P0601211301PNS003PIEVLI0000.FIT.gz \
    ootfile=P0601211301PNS003OOEVLI0000.FIT.gz \
    fwcfile=pn_closed_FF_2013_v1.fits \
    attfile=P0601211301OBX000ATTTSR0000.FIT.gz
```

Creates images in the standard energy bands with default flag and pattern selection.

3.4.2 More sophisticated

```
eimageget evtfile=P0601211301M1S001MIEVLI0000.FIT.gz \
    attfile=P0601211301OBX000ATTTSR0000.FIT.gz \
    fwcfile=mos1_closed_FF_2013_v1.fits.gz \
    gtifile=P0601211301_gti.fits \
    pimin="200 1000 2000" \
    pimax="1000 2000 4500" \
    patmin="0 0 0" \
    patmax="12 12 12" \
    withattcalc=yes \
    nominalra=12.2 \
    nominaldec=-73.2 \
    imagesize=1.0 \
    ximagemin=35000 \
    yimagemin=28000 \
    ximagemax=425000 \
    yimagemax=420000 \
    withxranges=1 \
    withyranges=1 \
    ximagebinsize=40 \
    yimagebinsize=40 \
    flag="(FLAG & 0x766ba000) == 0" \
    flagout="(FLAG & 0x766aa000) == 0" \
    withexposure=yes \
    withmask=yes
```

Images are created in 3 energy bands, GTI are applied, and the image coordinate frame is recalculated, allowing a combination with images from other observations that have been calculated for the same coordinates.

4 Parameters

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

Parameter	Mand	Type	Default	Constraints

evtfile	yes	string		

Input event list from which the images will be created.

ootfile	no	string		

Input out-of-time event list (only for EPIC-pn) from which the out-of-time images will be created.

fwcfile	no	string		

Input filter-wheel-closed event list from which the filter-wheel-closed images will be created. Needed if `withfwcimages` is set to "yes" (default)

attfile	no	string		

Input attitude file, needed if `withexposure` is set to "yes" (default) or if `withattcalc` is set to "yes".

gtifile	no	string		

Input good-time-interval file, if time selection will be done.

withemtaglenoise	no	boolean	true	true|false

boolean to choose whether or not noisy EPIC-MOS CCDs will be identified by **emtaglenoise** and removed from the output images.

withbadpixupdate	no	boolean	true	true|false

boolean to choose whether or not the bad-pixel extensions of all input event files will be conformed to each other.

withfwcimages	no	boolean	true	true|false

boolean to choose whether or not filter-wheel-closed images will be created.

withwindowmode	no	boolean	false	true|false

This parameter allows to include data of CCDs operated in large/small window mode. Note that in this case no filter-wheel-closed images are created for the CCDs that are in window mode!

pimin	no	integer list	'200 500 1000 2000 4500'	0,20000

Lower energy boundary in PI channels

pimax	no	integer list	'500 1000 2000 4500 12000'	0,20000

Upper energy boundary in PI channels

patmin	no	integer list		0,12

Lower boundary for PATTERN selection

patmax	no	integer list		0,12

Upper boundary for PATTERN selection

flag	no	string		

Flag to be used for the selection of the final images according to **selectlib**

flagout	no	string		

Flag to be used for the selection of events in the shielded detector areas according to **selectlib**

ximagemin	no	real	1	

evselect: If set, the lower limit of x coordinate for image extraction.

ximagemax	no	real	640	

evselect: If set, the upper limit of x coordinate for image extraction.

yimagemin	no	real	1	

evselect: If set, the lower limit of y coordinate for image extraction.

yimagemax	no	real	640	

evselect: If set, the upper limit of y coordinate for image extraction.

imagebinning	no	string	"imageSize"	"imageSize"|"binSize"

evselect: Parameter to choose to use either bin size or total image size to determine the binning factor for image extraction. If set to "binSize", values are taken from `ximagebinsize` and `yimagebinsize`. If set to "imageSize", values are taken from `ximagesize` and `yimagesize`.

ximagebinsize	no	real	1	> 0

evselect: If set, the binning factor for x axis in image creation

yimagebinsize	no	real	1	> 0

evselect: If set, the binning factor for y axis in image creation

ximagesize	no	integer	600	> 0

evselect: If set, the size of the image (i.e. number of image pixels) along the x axis; for extraction using integer valued columns, the extracted image size may be somewhat smaller than the requested image size.

yimagesize	no	integer	600	> 0

evselect: If set, the size of the image (i.e. number of image pixels) along the y axis; for extraction using integer valued columns, the extracted image size may be somewhat smaller than the requested image size.

withxranges	no	boolean	false	true|false

evselect: boolean to choose whether or not to use the `ximagemin` and `ximagemax` values for the x coordinate ranges for image extraction - if true, the parameter ranges are used; if false, the ranges are determined from the data

withyranges	no	boolean	false	true|false

evselect: boolean to choose whether or not to use the `yimagemin` and `yimagemax` values for the y coordinate ranges for image extraction - if true, the parameter ranges are used; if false, the ranges are determined from the data

squarepixels	no	boolean	false	true|false

evselect: When `ximagesize` and `yimagesize` are set, forces the x and y bin sizes to be the same. The larger of the two bin sizes is used.

raimagecenter	no	real	0	

evselect: If set, right ascension for the center of the output image, in decimal degrees.

decimagecenter	no	real	0	

evselect: If set, declination for the center of the output image, in decimal degrees.

withcelestialcenter	no	boolean	false	true|false

evselect: Boolean to determine if the image is shifted so that it is centered on the sky position specified by `raimagecenter` and `decimagecenter`.

withattcalc	no	boolean	no	

boolean to choose whether or not to new image coordinates will be calculated according to `nominalra`, `nominaldec`, and `imagesize`

nominalra	no	real	0.0	0−360

attcalc: Celestial RA coordinate of central reference point (If `withattcalc` = yes)

nominaldec	no	real	0.0	-90−+90

attcalc: Celestial Dec coordinate of central reference point (If `withattcalc` = yes)

imagesize	no	real	0.36	

attcalc: Half-size of final image (in degrees) (If `withattcalc` = yes)

withexposure	no	boolean	true	true|false

boolean to choose whether or not exposure maps will be created with **eexpmap**.

withmask	no	boolean	true	true|false

boolean to choose whether or not a mask will be created. (If `withexposure` = yes).

threshold1	no	float	0.01	[0.0<param<1.0]

emask: Threshold parameter 1: fraction of maximum exposure. (If `withmask` = yes).

threshold2	no	float	0.5	[0.0<param<10.0]

emask: Threshold parameter 2: threshold for gradient of exposure. (If `withmask` = yes).

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.

error1 *(error)*

warning1 *(warning)*

corrective action:

6 Input Files

1. an EPIC event list from the pipeline (PPS, e*proc, or e*chain tasks)
2. an EPIC filter-wheel-closed events list, available at https://www.cosmos.esa.int/web/xmm-newton/filter-closed
3. an EPIC out-of-time events list (only for EPIC-pn, **epproc** or **epchain** tasks)

4. optionally, a good-time-interval file (e.g. from **tabgtigen**)
5. an attitude file (only needed if exposure maps will be created or the coordinate frame is changed)

7 Output Files

1. P0601211301PNS003_ima_0.fits
2. P0601211301PNS003_ima_0oot.fits
3. P0601211301PNS003_ima_0fwc.fits
4. P0601211301PNS003_ima_0exp.fits
5. P0601211301PNS003_ima_mask.fits
6. P0601211301PNS003_counts.dat

8 Algorithm

```
- Check input
- Filter event file and Out-of-Time event file for GTI
- Remove noisy MOS CCDs
- Adjust bad pixels
- Calculate sky coordinates
- Create scaled images
     - Filter for events outside the FoV
     - for each energy band [
          - for each used CCD:
             get exposure and counts in corners of the event- oot- and fwc- file
             (E_obs, E_fwc, C_obs, C_fwc, C_oot)
          - for each used CCD: calculate ratio of count rates
             w_ccd =  (C_obs-f_oot*C_oot)/E_obs  /  (C_fwc/E_fwc)
          - calculate weight by averaging the count-rate ratios  W=avg(w_ccd)
          - create image from the eventfile
          - create image from the OOT eventfile and scale it with f_oot
          - create image from the FWC eventfile and scale each CCD by W*E_obs/E_fwc
       ]
- Create vignetted exposure maps
- Create mask
- Remove temporary files
```

References