



# emdiag

January 27, 2025

## Abstract

Analyse EPIC-MOS diagnostic images. Compute line and column offsets and event lists.

## 1 Instruments/Modes

Instrument	Mode
EPIC MOS	DIAGNOSTIC

## 2 Use

pipeline processing	no
interactive analysis	yes

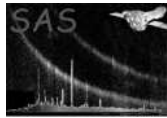
## 3 Description

**emdiag** emulates the on-board computation of the line and column offsets. It also emulates event analysis, and provides a masked CCD map, suitable to build a reference dark frame. Window keywords are accepted allowing to restrict the whole line of analysis to a part of the CCD map.

Two different coordinate systems are used in **emdiag**:

- The on-board coordinate system, used also in the ODF, runs from 0 to 609 (along **RAWX**) and 0 to 601 (along **RAWY**). It includes under and overscans. All ODF files (diagnostic map, offset/variance table, event list) refer to this system. In addition event coordinates (in the event list) are offset by (+2,+2).
- The CCD coordinate system used in the SAS (PIXCOORD in **cal**), runs from 1 to 600 along both **RAWX** and **RAWY** and does not include the under/overscans. All output maps (masked CCD map, bright pixels map), the bad pixels and the input window parameters refer to that system.

**emdiag** calls (in order) the following subroutines, all of which can be individually switched off:



- **OFFSET** emulates the on-board algorithm calculating the line and column offsets. It analyses the CCD locally to mask out high pixels (bad pixels, X-rays, cosmic-rays) standing out by more than **n****sigmas** times the local dispersion above the local median, and works only on that part of the CCD in view of the sky. The reference distribution to check each pixel is taken from the 16 pixels at distance 2 (in **RAWX** or **RAWY**) from the current pixel.  
If **selectfov** is set, a second pass will be performed, removing all pixels outside the field of view. This provides a better estimate of the offsets for the lines/columns within the field of view.  
The variance of the resulting map (with respect to that constructed from the line and column offsets, and limited to the field of view if **selectfov=yes**) is written in the **CCDVAR** keyword.  
The emulation also accepts as input a masked CCD map (with high pixels set to 0, output of a first run of **emdiag**). Pixels bad or set to 0 are then not used to compute the offsets. Because the on-board offset computation does not efficiently remove cosmic-ray patches, this is the way to get good offsets and variance.
- **EDUSOFT** performs on the ground the same pattern recognition performed in flight in **IMAGING** (or **TIMING**) mode, and outputs the same information (**RAWX**, **RAWY**, **ENERGYE1**, **ENERGYE2**, **ENERGYE3**, **ENERGYE4**, **PATTERN** and **PERIPIX**). If the diagnostic map was obtained in window mode (no overscan), no event may be found in the last two lines and columns (as in flight). The line and column offsets are taken either from an offset/variance file (if **offsets** is “read”) or from the result of the **OFFSET** subroutine. Beyond that, **EDUSOFT** rejects events with **ENERGYE1** + **ENERGYE2** above the upper **EMDH** threshold or below the lower **EMDH** threshold. In output, all pixels of the map belonging to events recognized by **EDUSOFT** are masked out (*i.e.* set to 0, not a valid value because of the electronic offset), except patterns 30 and 31 (usually associated with cosmic-rays).
- **THRESH** subtracts from the map the line and column offsets taken either from an offset/variance file or from the **OFFSET** result (like **EDUSOFT**). Then it looks for all events above the **EMDH** lower threshold. It creates optionally a map of all selected pixels (offset subtracted). If **EDUSOFT** was run before, this map will not contain any valid X-ray event. In output, all selected pixels are set to 0 in the masked CCD map (not offset subtracted).

## 4 Parameters

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

Parameter	Mand	Type	Default	Constraints
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<b>diagnosticset</b>	yes	dataset	' '	none
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name of input file holding the CCD map(s)

<b>eduthreshold</b>	no	integer	1	> 0
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EDU threshold for event detection

<b>emdhlowerthreshold</b>	no	integer	0	$\geq 0$
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EMDH lower threshold for event detection

<b>emdhupperthreshold</b>	no	integer	4095	> 0
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EMDH upper threshold for event detection

<b>windowx0</b>	no	integer	1	1-600
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first column in the window



<b>windowy0</b>	no	integer	1	1-600
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first line in the window

<b>windowdx</b>	no	integer	600	1-600
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horizontal width of the window

<b>windowdy</b>	no	integer	600	1-600
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vertical width of the window

<b>findevents</b>	no	boolean	yes	yes/no
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activate EDUSOFT ?

<b>cutabovethreshold</b>	no	boolean	yes	yes/no
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activate THRESH ?

<b>offsets</b>	no	string	compute	compute/read
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compute the offsets or read them from a file

<b>nsigmas</b>	no	real	10.	$\geq 1$ .
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threshold for pixel rejection in OFFSET

<b>selectfov</b>	no	boolean	yes	yes/no
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select area within the field of view in OFFSET ?

<b>maskbadpix</b>	no	boolean	no	yes/no
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mask out the bad pixels from the CCF in OFFSET (not implemented) ?

<b>inoffvarset</b>	no	dataset	' '	none
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name of input offset/variance file. If this parameter is set, then **offsets**=read is automatically set

<b>writeoffvarset</b>	no	boolean	no	yes/no
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write offset/variance file ?

<b>outoffvarset</b>	no	dataset	'offvar.out'	none
---------------------	----	---------	--------------	------

name of output offset/variance file

<b>writemaskedccdset</b>	no	boolean	no	yes/no
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write masked CCD map ?

<b>maskedccdset</b>	no	dataset	'masked.out'	none
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name of output image file for masked CCD map

<b>writeeventset</b>	no	boolean	no	yes/no
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write event file ?

<b>eventset</b>	no	dataset	'event.out'	none
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name of output event file

<b>writebrightpixset</b>	no	boolean	no	yes/no
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write map of other pixels above threshold ?

<b>brightpixset</b>	no	dataset	'bright.out'	none
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name of output image file for map of other pixels above threshold



## 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.

**readmap02** (*error*)

input CCD map is not a 2-D array

**readmap03** (*error*)

input CCD map has too large dimensions

**readmap04** (*error*)

WINDOWDX keyword incompatible with array size

**readmap05** (*error*)

WINDOWDY keyword incompatible with array size

**readmap06** (*error*)

no WINDOWX0 keyword in CCD file

**readmap07** (*error*)

no WINDOWY0 keyword in CCD file

**readmap08** (*error*)

input CCD map has non-standard dimensions

**readmap09** (*error*)

window chosen by parameters outside the actual window in the data

**getoffvar02** (*error*)

offsets have wrong dimensions

**getoffvar03** (*error*)

offsets file incompatible with CCD file

**readmap10** (*warning*)

general ODF keywords not present

*corrective action:* continue

**getOffsets10** (*warning*)

no good pixels in some rows/columns. The corresponding offsets are set to 0

*corrective action:* set offsets manually in output offsets file

**getOffsets12** (*warning*)

less good pixels than there are offsets. Unreliable result

*corrective action:* try using another diagnostic image file

**thresh10** (*warning*)

Events larger than bipixels but below the EMDH lower threshold exist. They will be masked in the masked CCD map anyway



*corrective action:* Setting the EMDH lower threshold to more than twice the EDU threshold is non-standard. Unless this is voluntary, try lowering `emdhlowerthreshold` or increasing `eduthreshold`

**readmap11** (*warning*)

NPIXEL is not equal to the number of pixels in the image. Proceeding anyway

*corrective action:* This should not happen with a proper diagnostic image file. Check input image is not corrupted

**readmap12** (*warning*)

the EMDH upper threshold is lower than the EMDH lower threshold. EDUSOFT cannot find any event

*corrective action:* check this was intended

## 6 Input Files

1. EPIC MOS diagnostic mode image file (from ODF/SDF). Uses keywords WINDOWX0, WINDOWY0, WINDOWDX, WINDOWDY, EDUTHR, FRMTIME.
2. EPIC MOS offset/variance file for that CCD/node (from ODF/SDF)

The structure of files in the ODF is described in [1].

## 7 Output Files

1. offset/variance file for that CCD/node in ODF format (for calibration purposes, [1])
2. masked CCD map(s) as a 600x600 image FITS file with additional EMDHLOW, EMDHUPP, MASKED and CCDMAP keywords (for calibration purposes)
3. event file simulating on-board processing in ODF format (for calibration purposes), with the additional CCDMAP keyword and an extension holding the auxiliary (frame) information (replaced by keywords if there is only one input map). In this format the event coordinates are as in the ODF, *i.e.* offset by (+6,+1) from the coordinates in the output maps (and the input window parameters).
4. map(s) of pixels above threshold outside events as a 600x600 image FITS file with additional EMDHLOW, EMDHUPP, BRIGHT and CCDMAP keywords (for calibration purposes)

Applicable keywords are propagated from the input diagnostic image file. The window keywords in the input file are converted to [1-600]x[1-600] and clipped following the window parameters set by the user. The EDUTHR keyword may be modified by the user (`eduthreshold` parameter). The offsets used to analyse the data are incorporated as an offset/variance OFFSETS0 extension in ODF format in the output map and event files.

## 8 Algorithm

subroutine emdiag



```
Read the file names of input and output files
```

```
Open files
```

```
Get keyword values
```

```
parameters read : choice of sub_tasks to execute
```

```
Loop over input task parameters
```

```
    Read the task parameter / yes to perform the procedure,  
                           no not to perform it /
```

```
End loop
```

```
Read CCD map
```

```
SUBROUTINE OFFSET
```

```
    if offset requested then
```

```
        mask out pixels with significant signal
```

```
        compute mean over rows and columns
```

```
        if selectfov then
```

```
            mask out pixels outside the field of view
```

```
            for all rows/columns with more than 4 pixels left
```

```
                recompute offset
```

```
        endif
```

```
        compute variance
```

```
    else
```

```
        read offsets from offset/variance file
```

```
    endif
```

```
SUBROUTINE EDUSOFT
```

```
    if edusoft requested then
```

```
        simulate EDU action
```

```
        simulate EMDH thresholding
```

```
        mask out pixels belonging to valid events
```

```
    endif
```

```
SUBROUTINE THRESH
```

```
    if thresh requested then
```

```
        subtract offsets
```

```
        identify pixels above EMDH lower threshold
```

```
        mask them out in map
```

```
    endif
```

```
Write output files
```

```
Close files
```

```
end subroutine emdiag
```

## 9 Comments

- To avoid contamination of the masked CCD map by leakage in pixels next to charge deposits, a more conservative approach would also mask out all neighbouring pixels.



- The reanalysis of events in EDUSOFT (and THRESH) calls a C routine (edusoft) which interfaces to the C routine (edu\_simu, written by M. Lortholary of the EPIC/Saclay team) which simulates the EDU recognition. This is described in **emsaplib**.

## 10 Future developments

- It could be a good idea to allow analysing several CCD maps together.
- It could be useful to allow masking out the bad pixels in the CCF.

## References

- [1] ESA. XMM Interface Control Document: Observation and Slew Data Files (XSCS to SSC) (SciSIM to SOCSIM). Technical Report XMM-SOC-ICD-0004-SSD Issue 2.5, ESA/SSD, June 2000. Found at the URL: [ftp://astro.estec.esa.nl/pub/XMM/documents/odf\\_icd.ps.gz](ftp://astro.estec.esa.nl/pub/XMM/documents/odf_icd.ps.gz).