# eimchip2sky

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**Abstract**

The task takes a list of CHIPCOORD images and replots them onto a single image in sky coordinates.

## 1 Instruments/Modes

| Instrument | Mode |
|---|---|
| EPIC mos or PN | Imaging |

## 2 Use

| | |
|---|---|
| pipeline processing | maybe |
| interactive analysis | yes |

## 3 Description

In making a background map or exposure map in sky coordinates it is useful to be able to transform a CCD image of a particular quantity into these sky coordinates. This is the function of the present task. The task takes in a list of images in the CHIPCOORD coordinate system (which is described in the **cal** library documentation) and replots them to sky coordinates.

The template for the output sky coordinate image is supplied via the parameter `templateset`. This should contain WCS keywords to define the sky projection plane and the image pixel size; the image array itself supplies the numbers of pixels in the image X and Y directions. The values contained in this array are ignored: either an event image or an exposure map can for example be supplied as the template image. The data type of the template image array is therefore irrelevant. Also, the template image need not be from the same instrument as the chip images, or even an XMM image at all. Note however that the output image contains a copy of all keywords in the template image dataset and primary array headers. It is up to the user to ensure that these are appropriate to the output image.

In order to perform the correct coordinate transform, the task needs to know, for each input CCD image, which CCD of which instrument the image corresponds to. **eimchip2sky** determines the instrument from the `INSTRUME` keyword in each chip image dataset header. (Note that the chip images may come from more than one instrument.) The user has the choice of supplying a list of CCD numbers (in the standard

XMM EPIC numbering scheme) via the parameters `withccds` and `ccds`. If the user sets `withccds`='no' (the current default), the task looks for a `CCDNR` keyword in the header of each chip image dataset.

The algorithm used to rebin the CCD pixels onto a sky-coordinate pixel grid is slow but exact: the corners of each CCD pixel are first transformed to the sky frame; then the value of the pixel is divided up among the sky-image pixels according to the proportion of the resulting quadrilateral which overlaps a given sky-image pixel.

NOTE! At present the only WCS projection supported by **eimchip2sky** is RA/dec tangent.

### 3.1 Attitude variation

A complication to transforming from CHIPCOORD to sky coordinates is that the spacecraft attitude is never completely fixed, thus the exact transform varies with time. The projection from CHIPCOORD to sky coordinates over a period of time can therefore only be estimated by a sequence of transform samples, weighted by the duration of validity of the sample. The user has the facility to supply a dataset table containing a list of spacecraft attitude samples plus the boundary times between them. (The format of this list is described more fully in section 6.) This is done via parameters `withatttab` and `atttab`. Each chip image is subjected to multiple transforms, one per attitude bin; the output image consists of a weighted sum of these transformed images, the weights being proportional to the duration of each attitude bin (but see also section 3.2 below).

Notes:

- The format of the attitude sample table does NOT correspond to that of the output of **atthkgen** or with any other SAS product. Some time in the future a capability to produce such a table may be added to a SAS task such as **attcalc**.
- This scheme of weights is only accurate if the values in the input chip images are time-invariant. It may for example be unwise to make OOTE sky maps this way.

If `withatttab` is set to 'no' (the current default), the task obtains a representative spacecraft attitude for the entire duration from `RA_PNT`, `DEC_PNT` and `PA_PNT` keywords in the header of each chip image dataset. NOTE in this regard that under OGIP conventions these keywords OUGHT to represent the INSTRUMENT attitude not the spacecraft. At some point this situation may be rectified.

### 3.2 GTIs

If the projection from CHIPCOORD to sky coordinates is performed by a duration-weighted sum of transforms corresponding to the spacecraft attitude in a sequence of time bins, it may be desired to adjust the weights to correspond not to the durations of the attitude bins but to the total good time per bin. Hence a facility has been provided to provide a table of good time intervals (GTIs), via the parameters `withgtitab` and `gtitab`. If such a table is supplied, the task adjusts the transform weights accordingly. (Note that if `withatttab`='no', GTIs have no effect.)

## 4 Parameters

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

| Parameter | Mand | Type | Default | Constraints |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| **chipimgsets** | yes | dataset list | | |

A list of names of input images (in chip coordinates).

| | | | | |
|---|---|---|---|---|
| **templateset** | yes | dataset | | |

The name of the input template image. This supplies information about the projection plane and pixel size (via WCS keywords) and pixel dimensions (via the array dimensions) of the output image.

| | | | | |
|---|---|---|---|---|
| **ccds** | yes | integer list | | 1 $\leq$ccds$\leq$ 12 |

This parameter is only mandatory if `withccds`='yes'. The parameter should contain a list of CCD numbers (in the standard XMM EPIC numbering scheme; see **cal** documentation for a description of this). The elements of this list should correspond in number and order to those of `chipimgsets`.

| | | | | |
|---|---|---|---|---|
| **atttab** | yes | table | | |

This parameter is only mandatory if `withatttab`='yes'. The parameter should give the name of a dataset plus table (eg: 'mySet.ds:ATT_TAB'). The table should contain samples of the XMM spacecraft attitude in time bins (see full description in section 6).

| | | | | |
|---|---|---|---|---|
| **gtitab** | yes | table | | |

This parameter is only mandatory if `withgtitab`='yes'. The parameter should give the name of a dataset plus table (eg: 'mySet.ds:STDGTI01'). The table should contain a list of good time intervals (GTIs).

| | | | | |
|---|---|---|---|---|
| **outimgset** | no | dataset | outImage.ds | |

Name of the output image.

| | | | | |
|---|---|---|---|---|
| **withccds** | no | boolean | no | yes—no |

This parameter should be set to 'yes' if the user desires to supply the CCD numbers via the list parameter `ccds`. Otherwise the task looks for these numbers in `CCDNR` keywords in the headers of the input chip images.

| | | | | |
|---|---|---|---|---|
| **withatttab** | no | boolean | no | yes—no |

This parameter should be set to 'yes' if the user desires to supply a table of attitude samples via the parameter `atttab`. Otherwise the task obtains a single representative attitude per CCD image from `RA_PNT`, `DEC_PNT` and `PA_PNT` keywords in the headers of the input chip images.

| | | | | |
|---|---|---|---|---|
| **withgtitab** | no | boolean | no | yes—no |

This parameter is only active if `withatttab` is set to 'yes'. The user should set `withgtitab`='yes' if he/she desires to supply a table of GTIs via the parameter `gtitab`.

# 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)*
explanantion
*corrective action:* this is the corrective action

# 6 Input Files

1. A list of FITS images in the CHIPCOORD coordinate system. (See the documentation for the **cal** task for a description of the XMM coordinate systems.) These images are supplied via the `chipimgsets` parameter. Each image array must contain the following:
   - An `INSTRUME` keyword, which must be one of the three EPIC instruments. Note that the chip images don't have to come from the same instrument.
   - If `withccds` is set to 'no' (the current default), each chip image array header must also contain a `CCDNR` keyword.
   - If `withatttab` is set to 'no' (the current default), each chip image array header must also contain `RA_PNT`, `DEC_PNT` and `PA_PNT` keywords.
   - The image array must be the correct size for CCDs of the given instrument. Task **eimchip2sky** obtains these from variables (those with names such as EMOS_MAX_X) in module caloaldefs.f90 in SAS package **caloalutils**.
   - The image array may be of any **dal** data type.
2. A template image. Its array header must contain WCS keywords (see [**?**] for a recent description of these). The output image will be the same size as the template image and projected onto the same celestial projection plane. Note that the data contained in the template image are not read by **eimchip2sky**.
3. (Optional.) A dataset containing a table of samples of the spacecraft attitude. The table must contain the following:
   - A `TIMEZERO` keyword, which defines the start time of the first attitude bin.
   - An 8-byte real-valued column `RA`, containing samples of the spacecraft right ascension in decimal degrees.
   - An 8-byte real-valued column `DEC`, containing samples of the spacecraft declination in decimal degrees.
   - An 8-byte real-valued column `PA`, containing samples of the spacecraft position angle in decimal degrees.
   - An 8-byte real-valued column `TIME`. The $i$th entry of this column contains the end time of the $i$th attitude bin.

   NOTE! This style of recording time-varying information does not (yet) correspond to any format recognized by OGIP. Also, the format of the attitude sample table does NOT correspond to that of the output of **atthkgen** or with any other SAS product - the user will have to 'roll their own.'
4. (Optional.) A dataset containing a table of good time intervals.

# 7 Output Files

1. The output file contains an image array, which has the same pixel size and dimensions, and is projected onto the same plane, as the input template image. The data type of the output image is 4-byte real. The output image contains a copy of all the keywords in the template image.

# 8 Algorithm

# 9 Comments

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# References