edet2sky

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Abstract

Converts between XMM detector coordinates and sky coordinates.

1 Instruments/Modes

Instrument	Mode
MOS	imaging
PN	imaging

2 Use

pipeline processing	yes
interactive analysis	yes

3 Description

The task converts camera-centric positions on the detector, specified either in DETX/Y or RAWX/Y coordinates, into sky (X/Y) coordinates and celestial, RA/DEC positions. RAWX/Y coordinates must be specified together with a CCD number.

The DETX/Y focal-plane coordinates are the same system as the CAMCOORD2 system described in the Calibration Access and Data Handbook, except that the units of DETX/Y are 0.05 arcseconds rather than the millimetres of CAMCOORD2. RAWX/Y coordinates correspond to the PIXCOORD1 system and thus have units of CCD pixels. The position in this system depends on the readout node, which is specifiable via the parameter `mosccdnode`. (Note that this parameter is ignored if the instrument is PN, since its CCDs only have one readout node.) The default setting `mosccdnode`='primary' reflects the fact that nearly all the XMM EPIC MOS data has been taken with that node setting.

The source positions may either be specified one at a time on the command line (ie, 1 source per invocation of **edet2sky**; `datastyle`=user) or in bulk via a FITS file (`datastyle`=set). These two formats are described in more detail below.

3.1 Command-line position entry.

The detector position of a single source may be entered via the parameters X, Y, where the coordinate system is specified by `inputunit` which can be either "raw" or "det" for RAW or DETECTOR coordinates. If `inputunit`="raw" then the CCD number must be entered with the parameter `ccd`. Eg:

```
edet2sky datastyle=user inputunit=raw X=32 Y=190 ccd=4 calinfoset=imagepnxy.ds
```

or

```
edet2sky datastyle=user inputunit=det X=-10000 Y=10000 calinfoset=imagemos1.ds
```

See the task **param** documentation for further details.

In this mode, the output positions are printed to the standard output. The format of the output lines is as follows irrespective of the units of the input coordinates.

```
# Instrument: EPN
# RA (deg)   DEC (deg)
187.7579    64.0481
#
# rawX      rawY    ccd    On chip?
  28.95     66.46    2       T
#
# detX          detY
 -10000.00     10000.00
#
# Image X    Y pixel
  343.86     140.33
#
# Sky X        Y pixel
  29872.94     12165.86
```

Ouput contains coordinates in the systems, RA/DEC, RAW and Detector. If WCS information has been obtained from an input file (`calinfoset`='set') then the output includes the Image pixel and Sky pixel (POS). The 'Image pixel' coordinates refer to the pixel position in the input file given by the `calinfoset` parameter.

If you want to display the numbers only, add `withheader`='no' to the command line. In the case above, this would give

```
187.7579    64.0481
  28.95     66.46    2       T
 -10000.00     10000.00
  343.86     140.33
  29872.94     12165.86
```

For the convenience of script authors, the number fields for the output are given below:

```
# Instrument: EPN
# RA (deg)   DEC (deg)

187.7579    64.0481
#
# rawX       rawY    ccd    On chip?
+xxx.xx    +xxx.xx    xx       x
#
# detX          detY
+xxxxx.xx      +xxxxx.xx
#
# Image X    Y pixel
 xxxx.xx     xxxx.xx
#
# Sky X         Y pixel
+xxxxx.xx      +xxxxx.xx
```

If inputunit='det' and the source does not fall on a CCD a warning message is issued; however the task still prints a RAWX/Y position, this being the position of the source in the RAWX/Y coordinate system of the nearest CCD. In this case the value of the 'On chip?' column is 'F' rather than 'T'.

If inputunit='raw' and the source does not fall on a CCD then the position is translated without a warning message.

3.2   FITS file positions

A list of input positions may be supplied in a FITS table by setting intab=file:table. In this case the task attempts to read positions from columns DETX and DETY, if inputunit='det' or columns RAWX, RAWX and CCDNR if inputunit='raw', from a file and table specified by the parameter intab.

There are two options for the output: either the output positions can be written to columns in the same file, or a new file can be created to contain them. If the former is desired, set withouttab='no'; if the latter, set withouttab='yes' and provide the name of the new dataset and table in outtab. The transformed position values are written to the columns RAWX, RAWY, CCDNR, FLAG, DETX, DETY, RA, DEC, IMAGEX, IMAGEY, X and Y (see section 7 for a detailed description of the output format).

The value of FLAG is set to 0 unless a source does not fall on any CCD, in which case FLAG is set to 1. In these cases the values of RAWX, RAWY and CCDNR represent positions relative to the nearest CCD.

An example of input from a file *mos_raw.fits*, containing a set of raw coordinate positions in an extension called POSITIONS and writing the output coordinates into a table *output* in a file *fullpos.ds*, would be:

```
edet2sky intab=mos_raw.fits:POSITIONS calinfostyle=set calinfoset=mos_rev2730_im.ds
         inputunit=raw outtab=fullpos.ds:output
```

3.3   Task requirements.

The task clearly needs to know the direction in space of the focal axis of the relevant instrument at the time of the observation of interest. There are three necessary pieces of information: the name of the

instrument, the date-time of the observation and the spacecraft pointing direction (attitude) at this time. The task processes these as follows: the instrument identification and the observation date-time are used together to calculate (from values stored in the CCF) the instrument boresight correction at the time of the observation; this correction is then applied to the spacecraft pointing.

There are two ways to pass the 'cal' information to **edet2sky**, governed by the parameter `calinfostyle`:

1. `calinfostyle` = 'set': the information is sought from `INSTRUME`, `DATE-OBS` etc keywords in the header of the source list specified by `calinfoset`. These should be found in the primary headers of all XMM product data sets. It is recommended to use the source list itself as the `calinfoset`, provided it is an XMM product, and from the same instrument.

2. `calinfostyle` = 'user': the information must be provided by the user via the parameters `instrument`, `datetime`, `scattra`, `scattdec` and `scattapos`.

In order to be able to apply the correct boresight correction, as well as to have access to the instrument specifications, the task requires access to the CCF components relevant to the dates of observation and analysis. This is achieved in the usual way by constructing a cif file with **cifbuild** and pointing to it with the environment variable SAS_CCF.

4 Parameters

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

Parameter	Mand	Type	Default	Constraints

datastyle	no	string	set	user—set

By use of this parameter, the user can specify the style of input and output desired. If `datastyle`='user', the task looks for position information for a single source in the parameters `ra` and `dec`. If `datastyle`='set', the task looks for the source positions stored in columns `RA` and `DEC` of a FITS table specified by the parameter `intab`.

intab	no	table	inset.ds:INPUT	

Name of the FITS table that contains the sky positions. Active only if `datastyle`='set'.

withouttab	no	boolean	no	

Active only if `datastyle`='set'. If `withouttab`='yes', the task looks for `outtab` and writes the output to this file. Otherwise the output is written to columns in the `intab`.

outtab	no	table	outset.ds:OUTPUT	

Name of the FITS table that is to contain the camera-centric positions. Active only if `datastyle`='set' and `withouttab`='yes'.

X	yes	double	0.0	

The X coordinate of the input position. Active only if `datastyle`='user'. This refers to a detector coordinate if `inputunit`='det' or a raw chip coordinate if `inputunit`='raw'.

Y	yes	double	0.0	

The Y coordinate of the input position. Active only if `datastyle`='user'. This refers to a detector coordinate if `inputunit`='det' or a raw chip coordinate if `inputunit`='raw'.

ccd	yes	integer	1	

The CCD number relevant for an input RAW coordinate. Active only if `datastyle`='user' and `inputunit`='raw'.

withheader	no	boolean	yes	

Active only if `datastyle`='user'. If `withheader`='yes', the task prints some lines of header information before printing the source position lines; if 'no', this is omitted. The 'no' setting is convenient for those wishing to run **edet2sky** from a script.

mosccdnode	no	string	primary	primary—redundant

This allows the user to specify the readout node for positions on the MOS instruments. It is enabled only if `outunit`='raw', and ignored for PN.

calinfostyle	no	string	set	set—user

If 'set' the task obtains information about the instrument and spacecraft pointing from `calinfoset`; if 'user', this information is obtained from parameters `instrument`, `datetime`, `scattra`, `scattdec` and `scattapos`.

calinfoset	yes	dataset	calinfo.ds	

The name of the dataset in which information about the instrument and spacecraft pointing etc is stored in keywords.

instrument	yes	string	EMOS1	EMOS1—EMOS2—EPN

Active only if `calinfostyle`='user'. The name of the relevant XMM instrument.

datetime	yes	string	0000-00-00T00:00:00	

If `calinfostyle`='user', the date and time are expected via this string parameter.

scattra	yes	angle	0.0	$0 \leq$ `attra` ≤ 360

The right ascenscion (in any of the allowed angle-parameter formats) of the spacecraft pointing. Active only if `calinfostyle`='user'.

scattdec	yes	angle	0.0	$-90 \leq$ `attdec` ≤ 90

The declination (in any of the allowed angle-parameter formats) of the spacecraft pointing. Active only if `calinfostyle`='user'.

scattapos	yes	angle	0.0	$0 \leq$ `attapos` ≤ 360

The position angle (in any of the allowed angle-parameter formats) of the spacecraft pointing. Active only if `calinfostyle`='user'.

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.

badCalInfoStyle *(error)*
>   The value of the `calinfostyle` parameter was not recognised.

badNodeStr *(error)*

The value of the `mosccdnode` parameter was not recognised.

badInpUnit *(error)*

The value of the `inputunit` parameter was not recognised.

badDataStyle *(error)*

The value of the `datastyle` parameter was not recognised.

emptyTableName *(error)*

Parameter `outtab` was not given in the form dataSetName:tableName.

notOnChip *(warning)*

The calculated raw XY position does not fall on any ccd
corrective action: The task (i) calculates the RAWX/Y position relative to the nearest chip; (ii) either sets the `FLAG` column to 1 or writes F under 'On chip?' in the output, depending on the value of `datastyle`.

6 Input Files

1. Required only if `datastyle`='set': a source list in the form of a FITS table `intab` containing the following columns:

   - `DETX`.
   - `DETY`.

   if `inputunit`='det' or

   - `RAWX`.
   - `RAWY`.
   - `CCDNR`.

   if `inputunit`='raw'. All data types may be either REAL32 or REAL64.

2. Required only if `calinfostyle`='set': an XMM product file containing keywords `INSTRUME`, `DATE-OBS`, `RA_PNT`, `DEC_PNT` and `PA_PNT`. It also needs to contain the WCS keywords, CRPIX1 etc. to allow conversion to image pixels. A further set of keywords, REFXCRPX etc. allow translation to an X/Y tangential plane coordinate system.

7 Output Files

Written only if `datastyle`='set': a FITS table containing the following columns:

- A 32-bit real column `RAWX`, in units of CCD pixels.
- A 32-bit real column `RAWY`, in units of CCD pixels.
- An 8-bit integer column `CCDNR`
- A 32-bit integer column `FLAG`
- A 32-bit real column `DETX`, in 0.05 arcsec.
- A 32-bit real column `DETY`, in 0.05 arcsec.
- A 64-bit column `RA`, in degrees.
- A 64-bit column `DEC`, in degrees.
- A 32-bit real column `IMAGEX`, in units of image pixels
- A 32-bit real column `IMAGEY`, in units of image pixels.
- A 32-bit real column `X`, in units of sky pixels
- A 32-bit real column `Y`, in units of sky pixels.

If `withouttab`='yes', a new dataset `outtab` is constructed to hold these columns; if 'no', they are written to the `intab`.

8 Algorithm

```
Coordinate transformations are implemented using the appropriate cal calls
and the routines in ssclib.
```

9 Comments

This is an adaption of esky2det, written by Ian Stewart and Masa Sakano.

References