ecoordconv

June 2, 2019

Abstract

A routine to convert a position between coordinate systems

1 Instruments/Modes

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>EPIC</td>
<td>IMAGING, TIMING</td>
</tr>
</tbody>
</table>

2 Use

| pipeline processing | no |
| interactive analysis | yes |

3 Description

This task converts a position in an image from one coordinate system into positions in other coordinate systems. For example the routine can be used to convert a celestial sky position (RA, DEC) into detector coordinates (DETX, DETY), chip coordinates (RAFWX, RAWY), X/Y pixels, Image pixels and TelCoords (theta, phi). It also gives the numbers of the CCDs which are included within an input region.

3.1 Input

3.1.1 Source image

The source image may be input in detector or sky (X/Y) coordinates. The task expects to find astrometry keywords in a certain part of the primary header and will exit with an error if the keywords are not found. Standard images produced by evselect and xmmselect and the pipeline will process ok. The background spline maps produced by the pipeline source detection chain and the exposure maps produced by eexpmap need to be pre-processed before they can be used within ecoordconv (see section 8).
### Table 1: Output quantities

<table>
<thead>
<tr>
<th>Value</th>
<th>Units</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theta</td>
<td>Off-axis angle</td>
<td>arc seconds</td>
</tr>
<tr>
<td>Phi</td>
<td>Azimuthal angle</td>
<td>Radians</td>
</tr>
<tr>
<td>X</td>
<td>X sky coord</td>
<td>0.05 arcsec pixel</td>
</tr>
<tr>
<td>Y</td>
<td>Y sky coord</td>
<td>0.05 arcsec pixel</td>
</tr>
<tr>
<td>DETX</td>
<td>Detector X coord</td>
<td>0.05 arcsec pixel</td>
</tr>
<tr>
<td>DETY</td>
<td>Detector Y coord</td>
<td>0.05 arcsec pixel</td>
</tr>
<tr>
<td>IM_X</td>
<td>Image X coord</td>
<td>image pixel</td>
</tr>
<tr>
<td>IM_Y</td>
<td>Image Y coord</td>
<td>image pixel</td>
</tr>
<tr>
<td>RA</td>
<td>Right ascension</td>
<td>degrees</td>
</tr>
<tr>
<td>DEC</td>
<td>Declination</td>
<td>degrees</td>
</tr>
<tr>
<td>RAWX</td>
<td>X chip coordinate</td>
<td>pixel</td>
</tr>
<tr>
<td>RAWY</td>
<td>Y chip coordinate</td>
<td>pixel</td>
</tr>
<tr>
<td>CCD(s)</td>
<td>CCD number(s) in region</td>
<td>-</td>
</tr>
<tr>
<td>Central CCD</td>
<td>CCD at region centre</td>
<td>-</td>
</tr>
</tbody>
</table>

#### 3.1.2 Regions

Spatial regions may be entered in raw chip, detector, sky (X/Y) or celestial (RA, DEC, FK4 2000) coordinates. If raw coordinates are used the CCD must be given using the parameter `ccdno`. If the coordinates of the region are not the same as those of the image, e.g. a sky pixel region on a detector coordinate image, then the task will still function but will run more slowly. An error will result if the spatial region is not within the image. Any shape conforming to the `selectlib` rules may be used, except that RAW coordinates may currently only be entered using a circular selection.

#### 3.2 Output

The output text shown below is independent of the SAS _VERBOSITY_ setting. The strings shown may be searched for in a script and every effort will be made to keep them constant between versions of this task.

```
ecoordconv: - Region Centre:
    Theta: Phi: 105.768 2.17488
    X: Y: -1239.05 1711.11
    DETX: DETY: -1239.05 1711.11
    RA: DEC: 275.547 64.3216
    RAWX: RAWY: 54 167
    CCD(s): 1 2 4 5 7 8 10 11 centred on CCD: 4
```

#### 3.3 Examples

1. Convert a particular sky coordinate position

```
ecoordconv imageset=pnimagexy.ds x=27000 y=26900 coordtype=POS
```
2. Convert a detector coordinate region

ecoordconv srcexp="(DETX,DETY) in CIRCLE(100,1000,7000)" imageset=pnimagexy.ds

ecoordconv:- Region Centre:
Theta: Phi: 50.5951 1.40977
X: Y: 26280.112 27503.672
DETX: DETY: 124.823 968.882
RA: DEC: 275.498 64.3258
RAWX: RAWY: 37 176
CCD(s): 1 4 5 7 8 10 centred on CCD: 4

3. Convert a RAW coordinate

ecoordconv imageset=image.ds coordtype=raw x=32 y=191 ccdno=4

ecoordconv:- Region Centre:
Theta: Phi: 48.3652 3.84547
X: Y: 27095.5 27965.5
DETX: DETY: 546.171 -243.231
RA: DEC: 114.952 -85.6571
RAWX: RAWY: 32 191
CCD(s): 4 centred on CCD: 4

4. Convert from sky to celestial coordinates only

ecoordconv imageset=image.ds coordtype=POS x=25500 y=26200 pos2eqpos=yes

ecoordconv:- Region Centre:
RA: DEC: 115.012 -85.6611

5. Convert an image pixel coordinate

ecoordconv imageset=image.ds coordtype=impix x=100 y=200

ecoordconv:- Region Centre:
Theta: Phi: 1527.7808 1.9310338
X: Y: 14390026 14373032
DETX: DETY: -9487.2015 28977.154
IM_X: IM_Y: 100 200
RA: DEC: 233.08007 41.629175
RAWX: RAWY: -42.554876 -163.20573
CCD(s): 3 centred on CCD: 3

6. Convert from image pixel to celestial coordinates only

```bash
ecoordconv imageset=image.ds coordtype=IMPIX x=100 y=262 im2eqpos=yes
```

```bash
ecoordconv:- Region Centre:
RA: DEC: 233.1230 41.6234
```

4 Parameters

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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Mand</th>
<th>Type</th>
<th>Default</th>
<th>Constraints</th>
</tr>
</thead>
<tbody>
<tr>
<td>imageset</td>
<td>yes</td>
<td>string</td>
<td>image</td>
<td></td>
</tr>
<tr>
<td>srcexp</td>
<td>no</td>
<td>string</td>
<td></td>
<td></td>
</tr>
<tr>
<td>withcoords</td>
<td>no</td>
<td>boolean</td>
<td>false</td>
<td>none</td>
</tr>
<tr>
<td>x</td>
<td>no</td>
<td>real</td>
<td></td>
<td></td>
</tr>
<tr>
<td>y</td>
<td>no</td>
<td>real</td>
<td></td>
<td></td>
</tr>
<tr>
<td>coordtype</td>
<td>yes</td>
<td>string</td>
<td>eqpos</td>
<td>eqpos pos det raw impix</td>
</tr>
<tr>
<td>pos2eqpos</td>
<td>no</td>
<td>boolean</td>
<td>false</td>
<td>none</td>
</tr>
</tbody>
</table>

The coordinate system for which the source position, specified by the parameter x and y, is defined. If coordtype is set to eqpos, then x, y correspond to RA and DEC respectively in decimal degrees. If coordtype = pos, then x, y correspond to POS coordinates. (Note that the POS coordinates are defined relative to a nominal pointing position; this is taken from the global attributes REFXCRVL and REFYCRVL of the image dataset.) If coordtype = det, then x, y are the x and y positions of the source centre, in DET coordinates. If coordtype = impix, then x, y are the x,y values of a pixel in the input image. Finally, if coordtype = raw, then x, y are the raw chip positions of the source centre. In this case the CCD number must be specified using the ccdno parameter.
im2eqpos | no | boolean | false | none

If true, then only the conversion from image pixel to ra/dec coordinates is made. This option is only active when withcoords=true and coordtype=impix.

withccd | no | boolean | false | none

If true, the ccd number must be specified via the parameter ccdno, x, y. This is mandatory if the position has been specified in raw chip coordinates.

ccdno | yes | int

The CCD number on which the RAW chip position falls.

theta_out | no | double

Output parameter that contains the off-axis angle, in units of arc seconds.

phi_out | no | double

Output parameter that contains the azimuthal angle, in units of radians.

ra_out | no | double

Output parameter that contains the right ascension.

dec_out | no | double

Output parameter that contains the declination.

posx_out | no | double

Output parameter that contains the POS, X position.

posy_out | no | double

Output parameter that contains the POS, Y position.

detx_out | no | double

Output parameter that contains the X position in detector coordinates.

dety_out | no | double

Output parameter that contains the Y position in detector coordinates.

rawx_out | no | double

Output parameter that contains the X position in raw, chip coordinates.

rawy_out | no | double

Output parameter that contains the Y position in raw, chip coordinates.

ccd_out | no | int

Output parameter that contains the number of the CCD which the input position falls on.

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.
InvalidExpression (error)  
The input expression for this spatial region was not valid.

InvalidRegion (error)  
The centre of the source or background region lies outside of the image

invalidArraySize (error)  
The image is not two dimensional.

InvalidWCSType (error)  
The image axes specified in the CTYPE1 and CTYPE2 keywords are not compatible.

invalidCoordType (error)  
The input coordinate system is not recognised.

noCCDNumber (error)  
A position has been given in RAW chip coordinates but no CCD number has been supplied. Use ccdno=nn on the command line.

UnknownModeString (warning)  
If the spectrum contains an observing mode (in the keyword SUBMODE) which is not recognised then the software assumes that the common PrimeFullWindow mode was in use.

corrective action: PrimeFullWindow

NoInstrument (warning)  
If the INSTRUME keyword is not set in the image header a warning is issued and the default of MOS-1 is taken. The instrument determines the PSF used and the position of the optical-axis.

corrective action:

InvalidPosWCSInfo (warning)  
The REFerence keywords in the image header, e.g. REFXCRPX, REFXCRVL, REFXCDLT are incomplete. Defaults are chosen but there is likely to be a problem later.

corrective action:

6 Input Files

- an EPIC image produced by evselect or xmmselect or the pipeline.

7 Output Files

8 Algorithm

9 Comments

The routine now gives the exact translation between coordinate systems. It no longer returns the coordinates of the centre of the nearest image pixel.
References