flspec

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Abstract

Computes the spectrum of the background fluctuations for a specified spatial pixel size and different offaxis angles.

1 Instruments/Modes

Instrument	Mode
EPIC-MOS	Imaging
EPIC-pn	Imaging

2 Use

pipeline processing	yes
interactive analysis	yes

3 Description

flspec computes the spectrum of the background fluctuations in EPIC Imaging data in different offaxis annular regions.

The first step of the process is the 'flatfielding' (division) of the input image with the corresponding exposure map. Since the borders of the exposure map can be affected by counting statistics, it is previously 'cleaned' with the output of **emask** using a value of 0.1 as a threshold, i.e, only the area of the map with exposure time greater than 100% of maximum value is retained. Then the regions affected by the observed sources (listed in the input source list) are removed taking into account the sizes obtained with the task **region** (`radiusmode`=enfrac with an enclosed energy fraction of 95%).

Once the 'flatfielded' image is free from detected sources, its pixels are binned according to the input parameter `binsize` and classified as 'positive' (if they have more counts than the median in the image) and 'negative' pixels (less counts than the median). Those binned pixels with positive(negative) label will lead to pixels with "1" ("0") in the positive(negative) mask that **flspec** creates with the pixel size of the input image. Those pixels that have null value in the flatfielded image (0 secs. in exposure time or pixel inside a region source) are kept as "0" in both masks.

These masks are then used to filter the input event list and extract positive(negative) spectra from a number of equal-area annuli around the image centre, to account for variations of the effective area as a function of the offaxis angle. The positive and negative spectra are extracted with an spectral binning of 15 eV (MOS) and 5 eV (PN).

Once created, positive and negative spectra are subtracted to obtain the 'fluctuations' spectrum in each annular region (the number of offaxis regions is fixed by the number of output spectral files in the list `spectrumsets`).

The subtraction is performed normalising the solid angle in units of *detector pixels* (squared pixels of side 0.05 arcseconds) to that of the annular extraction region, i.e.,

```
difference= (TotSA/PosSA)*positive_spec - (TotSA/NegSA)*negative_spec.
```

where PosSA and NegSA are the 'positive' and 'negative' spectrum solid angles, and TotSA is the solid angle in the annular extraction region.

The `BACKSCAL` attribute in this difference spectrum will then keep the value of the solid angle for the full annular region. Provided one of these positive/negative spectra has zero area, a warning is raised and the difference spectrum stores the non zero area spectrum:

```
difference= (TotSA/PosSA)*positive_spec - 0.0*negative_spec
```

or

```
difference= 0.0*positive_spec - (TotSA/NegSA)*negative_spec
```

`BACKSCAL`=0 if both spectra have null extraction area.

The `OFFAXIS` attribute in the 'SPECTRUM' extension of each output spectral file stores the central offaxis of the annular extraction region in arcmin.

If the observation is confusion dominated (as will be the case in most of them), the fluctuation spectrum is related to the average spectrum of the sources that dominate the fluctuations (below the detection threshold). This is necessary to estimate the systematic errors in the spectra of the faint detected sources.

Otherwise, if the observation is counting-noise limited, the spectrum of the fluctuations gives the shapes of the errors in the spectra of the faint detected sources.

4 Parameters

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

Parameter	Mand	Type	Default	Constraints
sourcelistset	yes	string	`emllist.fits`	valid data set name

Name of the FITS file containing the list of observed sources

set	yes	string	`evtlist.fits`	valid data set name

Event list filename of the EPIC imaging observation

imageset	yes	string	`image.fits`	valid data set name

Image of `set` in a reference energy band

exposureset	yes	string	`expmap.fits`	valid data set name

Exposure map corresponding to image

tmpsrclistset	no	string	`src_list.ds`	valid file name

Name of the temporary file used by **region** during filtering of source list

tmpbkgregionset	no	string	`bkg.reg`	valid file name

Name of the temporary file containing the background regions for the sources.

tmpflatset	no	string	`img_flat.fits`	valid file name

Name of the file containing the temporary flatfielded image.

tmpposmaskset	no	string	`mask_pos.fits`	valid file name

Name of the file containing the temporary positive image mask

tmpnegmaskset	no	string	`mask_neg.fits`	valid file name

Name of the file containing the temporary negative image mask

tmpposspecset	no	string	`spec_pos.pi`	valid file name

Name of the file containing a temporary positive spectrum

tmpnegspecset	no	string	`spec_neg.pi`	valid file name

Name of the file containing a temporary negative spectrum

binsize	yes	real	0.016666666	> 0.0

Size of the rebinned pixels in degrees to define positive and negative regions. It will be rounded to the nearest integer multiple of the pixel size in the input image

spectrumsets	yes	list of data-sets	`specfl0.fits`
			`specfl1.fits`
			`specfl2.fits`
			`specfl3.fits`
			`specfl4.fits`
				list of valid data sets

List of output FITS files containing the spectrum of the background fluctuations extracted in equal-area annular regions at different offaxis values (between 0. and 12 arcmin).

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.

NotImg *(fatal)*

The input image does not contain an EPIC image

NotExpMap *(fatal)*
The input exposure map does not contain an EPIC exposure map

NonStandardInput *(fatal)*
The WCS keyword `CDELT1` is missing in the input image

InvalidData *(fatal)*
Input image does not have valid data

ErrStat *(fatal)*
It cannot calculate statistics for input Event List File using FTOOLS task `fstatistic`

ErrFarith *(fatal)*
The FTOOLS task `farith` cannot be run in the process explained by the associated message

ErrFcolpar *(fatal)*
The FTOOLS task `fcolpar` cannot be run in the process explained by the associated message

ErrFimgstat *(fatal)*
The FTOOLS task `fimgstat` cannot be run in the process explained by the associated message

ErrFkeypar *(fatal)*
The FTOOLS task `fkeypar` cannot be run in the process explained by the associated message

ErrCphead *(fatal)*
The FTOOLS task `cphead` cannot be run in the process explained by the associated message

ErrFparkey *(fatal)*
The FTOOLS task `fparkey` cannot be run in the process explained by the associated message

ErrFpartab *(fatal)*
The FTOOLS task `fpartab` cannot be run in the process explained by the associated message

ErrFstruct *(fatal)*
The FTOOLS task `fstruct` cannot be run in the process explained by the associated message

ErrFappend *(fatal)*
The FTOOLS task `fappend` cannot be run in the process explained by the associated message

ErrMathpha *(fatal)*
Error raised while trying to run the FTOOLS task `mathpha` to subtract positive and negative spectra

ErrRegion *(fatal)*
The task **region** cannot be run on the input source list

ErrFlmask *(fatal)*
Mask files cannot be created

ErrEvselect *(fatal)*
Problem raised while trying to run the task **evselect** in the process described by the associated message

ErrPseudo *(fatal)*
Cannot create Pseudo Event List

ErrEmask *(fatal)*
Error raised while trying to run the **emask**

BadParamValue *(fatal)*
The requested binsize in parameter `binsize` is smaller than the input image bin size, larger than the input image size or it results in a meaningless binned image with only one pixel

NoPixLeft *(fatal)*
The binned image does not have any pixels left after source subtraction

NullSpecPos *(warning)*
Positive spectrum has null extraction area for offaxis value and fluctuations spectrum number given in the message
corrective action:

NullSpecNeg *(warning)*
Negative spectrum has null extraction area for offaxis value and fluctuations spectrum number given in the message
corrective action:

NullSpec *(warning)*
Positive and Negative spectrum have null extraction area for offaxis value and fluctuations spectrum number given in the message
corrective action:

NullExpos1 *(warning)*
Exposure value for positive and negative spectra cannot be properly updated by **evselect** in a given fluctuations spectrum (number specified)
corrective action: `EXPOSURE` is updated to 1.000 s

NullExposDs *(warning)*
Exposure value for positive and negative spectra cannot be properly updated by **evselect** in a given fluctuations spectrum (number specified) but Dataset has an `EXPOSURE` keyword
corrective action: `EXPOSURE` is updated to value in Dataset

6 Input Files

1. `sourcelistset`: FITS file containing the list of observed sources. This is a PPS product called "EPIC OBSERVATION SOURCE LIST".
2. `set`: Event list of the EPIC imaging observation. This is a PPS product called "EPIC IMAGE MODE EVENT LIST".
3. `imageset`: Image of `set` in a reference energy band. This is a PPS product called "EPIC IMAGE".
4. `exposureset`: Exposure map corresponding to `imageset`. This is a PPS product called "EPIC EXPOSURE MAP".

7 Output Files

1. `spectrumsets`: List of output FITS spectral files containing the spectrum of the background fluctuations at different offaxis angles. This is a PPS product called "EPIC FLUCTUATIONS SPECTRUM".

8 Algorithm

flspec is a perl task which does the following:

1. Read input parameters
2. Run **region** on the observation source list to obtain a FITS file with the source free region.
3. Run the F90 module `createpseudoevt` to create a pseudo event list with one event in all the X/Y and THETA positions of the input image:

```
module createpseudoevt

read input image and source-free region file

create output pseudo event file with X,Y and THETA (offaxis angle) columns
fill in X(Y) column with X(Y) position of input image pixels

calculate RA,DEC for each pixel

calculate THETA for each pixel from RA,DEC values

fill in THETA column

end module createpseudoevt
```

4. Filter pseudo event list with output of **region** and create mask with sources position hidden.
5. Cut exposure map borders with the output mask of **emask**
6. Run the FTOOLS task `farith` to flatfield the input image with the exposure map and mask source positions.
7. Run the F90 module `flmask` to create masks selecting areas with intensity above and below the median:

```
module flmask

Read input flatfielded (source masked) image and parameters

Rebin the image

Compute median intensity of rebinned image

Define positive and negative rebinned pixels above and below the median

Create and write out image mask for positive regions
```

```
Create and write out image mask for negative regions

end module flmask
```

8. Filter pseudo event list with annular regions to create a mask
9. Combine positive/negative masks with the annular regions mask
10. Run **evselect** to filter input event list with the positive combined mask and extract the spectra of positive fluctuations in standard spectral ranges.
11. Calculate solid angle of extraction area.
12. Run **evselect** to filter input event list with the negative combined mask and extract the spectra of negative fluctuations in standard spectral ranges.
13. Calculate solid angle of extraction area.
14. Set `EXPOSURE` keyword (equal to 1.0) in positive and negative spectra in case **evselect** cannot do it properly.
15. Run the FTOOLS task `mathpha` to subtract both sets of spectra (one for each annular region). The resulting spectrum is the 'EPIC FLUCTUATIONS SPECTRUM' at given offaxis value.

9 Comments

- Rounds up rebinned pixel size to the nearest integer multiple of the elementary size of the input image
- Ignores pixels on the edges that do not fit in an integer number of rebinned pixels
- The ancilliary response file for the output spectra should be created with SAS task **arfgen**. When dealing with filter masks, **arfgen** works by averaging the ARF in a number of grid elements on an internal map, thus, it is necessary to allow a large number of elements in the internal arfgen map:

  arfgen spectrumset=specfl0.fits arfset=specfl0.arf extendedsource=yes detxbins=100 detybins=100
- Temporary files are created with the names specified in the parameters `tmpsrclistset`, `tmpbkgregionset`, `tmpflatset`, `tmpposmaskset`, `tmpnegmaskset`, `tmpposspecset`, `tmpnegspecset`, and are deleted when they are no longer needed, at the end of the task.

10 Future developments

References