efftplot

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Abstract

efftplot first uses the FTOOLS *powspec* to compute the normalized Power Density Spectrum (PDS) of the EPIC source time series in different energy bands, then produces a plot containing the different PDS together with some information related to the observation.

1 Instruments/Modes

Instrument	Mode
EPIC MOS	IMAGING, TIMING
EPIC PN	IMAGING, TIMING

2 Use

pipeline processing	yes
interactive analysis	yes

3 Description

The bulk of **efftplot** is *powspec*, the FTOOLS package which computes the power density spectrum. The parameters of *powspec* are computed from the parameters of **efftplot**, such that for each energy band, only one time-averaged PDS is computed. Then for each energy band, **efftplot** reads the PDS into the FITS file produced by *powspec*, and plots it with the PGPLOT library. Different PDS can be formatted by adding items related to the observation.

In the PPS, **efftplot** produces and plots the PDS of the time series measured by EPIC, covering the three energy bands : 0.1 - 2.0, 2.0 - 10.0 and 0.1 - 10.0 keV (The 'EPIC FITS source timeseries'). Nevertheless, **efftplot** can process FITS files with 1 to 6 `RATE` columns.

The input FITS files contains either total or net count rates, background count rates and the associated errors. The user may also choose whether to use the total or net counts to produce the power density spectrum, via the parameter 'bkgsub'. The time series follow a regular binning scheme (i.e. equispaced time bins). The bin width is given by the keyword `TIMEDEL` which is measured in seconds. The user can also provide a GTI file that has been produced using the SAS task **tabgtigen**.

First, the task recovers the `TIMEDEL` keyword, the number of `RATE` columns in the FITS file (NCOLUMNS) and the number of bins in the light curves (NBINLC). Then, **efftplot** uses the FTOOLS *powspec* to compute successive PDS light curves (i.e. each `RATE` column). At the end of each *powspec* run, the PDS is saved on disk as a FITS file. The PDS is calculated in data segments of `Nbins` bins. If the last data segment is incomplete, **it is ignored**.

The `normalization` parameter indicates the way in which the PDS is normalized, as follows:

- 0 : PDS is normalized by dividing by the number of bins in each interval (`Nbins`).
- 1 : PDS is normalized such that the (white) noise level expected corresponds to a power value of 2.
- 2 : PDS is normalized such that its integral gives the squared rms fractional variability (therefore the power spectrum is in units of (rms)**2/Hz). The expected (white) noise level must be subtracted to obtain the rms fractional variability of the series.
- -1 : as =1, but the expected white noise level is subtracted
- -2 : as =2, but the expected white noise level is subtracted. Negative normalization flags should be used only after having established that the observed (white) noise level is as expected. If other normalization flag values are used, they are treated as =0.

When all the lightcurves have been processed, **efftplot** produces the final postscript file containing all the PDS plots, i.e. the "EPIC Source FFT plot" using the PGPLOT library. Finally, the temporary files are deleted.

Among the *powspec* parameters, the critical ones (e.g. rebintype, nbins, ...) are also **efftplot** parameters. Of course, many of them have a default value and should not be changed in a PPS run. This default is generally the standard default for *powspec*. Nevertheless, these default values are explicitly given to *powspec* by **efftplot** to avoid possible differences in behavior of the task, depending on the local FTOOLS installation.

3.1 Examples

To create a postscript plot, called plot.ps, with the power density spectra of the time series measured by EPIC covering the three energy bands: 0.1 - 2.0; 2.0 - 10.0; and 0.1 - 10.0 keV, from the FITS file 'lightcurve.ds', where there are 512 bins for each interval, a command such as,

```
efftplot infile="lightcurve.ds" plotdevice="/VPS" outfile="plot.ps" nbins=512
```

can be used. To create a similar output file, but with gaps in the input lightcurve to be filled by the running mean of 4 bins, with a polynomial trend of order 1 to be removed from the time series by subtraction and with the x-axis of the final output to be plotted on a logarithmic scale, and using a user provided GTI file called gti.ds, the following command could be used.

```
efftplot infile="lightcurve.ds" plotdevice="/VPS" outfile="plot.ps" nbins=512
 fillgaps=yes npoints=4 removetrend=yes polyorder=1 operation=1 xscale="log" gtis=yes gtiset=gti.ds
```

4 Parameters

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

Parameter	Mand	Type	Default	Constraints
infile	yes	Dataset	""	

Name of the FITS file containing the EPIC source time series. Case sensitive.

nbins	no	Integer	1	Constraint : must be a power of 2, `Nbins` $\leq$ NBINLC

Number of bins per interval. An interval is a segment of the light curve for which a PDS is calculated. Each PDS is averaged at the end of the run. The number of frequency bins of the output PDS plot is `Nbins`/2. In case `Nbins`=1 (the default value), `Nbins` is set to the maximum legal value (full resolution spectrum).

bkgsub	no	Boolean	no	

If the background should be subtracted (no =¿ total counts used or yes =¿ net counts used) to create the power density spectrum

nerrorpoints	no	Integer	5	Constraint : ≥ 5

This parameter defines the way in which the error bars on the plotted PDS are calculated. If the number of PDS averaged is higher than the `nerrorpoints` value (default=5), the error bars are evaluated by using the standard deviation of the average (based on the measured scatter). Otherwise the error bars are evaluated by propagating the theoretical error bars through an averaging process. The theoretical error bars are obtained from the relevant chi-square distribution. For example, with normalization = 1, the theoretical error value is 2 (Leahy normalization) for (white) noise. The theoretical error bar on the averaged and rebinned final spectrum is the theoretical error bar on a single interval divided by $\sqrt{MW}$, where M is the number of intervals averaged and W is the number of frequency bins combined.

normalization	no	Integer	1	Constraint : 0, ± 1 or ± 2

Flag to specify the type of normalization to apply to the PDS.

fillgaps	no	Boolean	no	

If the gaps have to be filled, value must be yes.

npoints	no	Integer	2	Constraint : 1, 2, 3 or 4

Replace the gaps in the input series with the running mean (available only if fillgaps is "yes"). If gapfill = `n`, data gaps in the input series are filled with the running mean values calculated over `n` bins.

removetrend	no	Boolean	no	

Indicate if a polynomial trend has to be removed from the time series.

polyorder	no	Integer	1	Constraint : 1, 2, 3 or 4

A polynomial trend, up to 4th-order, can be removed from input time series. Setting the parameter `polyorder` equal to 1, 2, 3 or 4 removes a 1st, 2nd, 3rd or 4th-order polynomial trend, respectively (available only if removetrend is "yes").

operation	no	Integer	1	Constraint : ≥ 2

Specify how the removal trend is applied to the data (available only if removetrend is "yes"). The trend can be subtracted from the time series (operation = 1), or the time series can be divided by the trend (operation = 2), or the time series can be replaced with the trend (operation = 3). By default the trend is subtracted (value set to 1).

rebin	no	Boolean	no	

Indicate if the final PDS has to be rebinned or not.

rebintype	no	String	1	

The final PDS can be rebinned either with a constant rebinning factor or as a geometric series (to produce nearly equispaced bins in a logX representation). Values greater than 1 indicate a constant rebinning factor. Geometric series rebinning is obtained by entering a value less than -1, whose modulus represents the step of the geometric series. The range of allowed values for a negative rebinning parameter is limited (-1$\geq$ rebintype >-3).

plotdevice	no	String	"/PS"	Constraint : valid device type

Name of a valid output device. Not case sensitive.

outfile	no	String	"default.ps"	less than 1024 char

Name of the output file containing the plot. Case sensitive.

xscale	no	String	"lin"	Constraint : "log" or "lin"

Use a logarithmic or a linear scale on the X-axis.

yscale	no	String	"lin"	Constraint : "log" or "lin"

Use a logarithmic or a linear scale on Y-axis. Where yscale="log" negative values are omitted.

gtis	no	Boolean	no	

Indicate whether to provide a GTI file.

gtiset	no	dataset	No default	

Name of the FITS file containing the GTIs. Case sensitive.

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.

Device not recognized *(error)*
Unavailable default device type and/or output file

Output file cannot be overwritten *(error)*
The output file exists, and the variable SAS_CLOBBER=0

GTI file does not exist *(error)*
The GTI file supplied does not exist

NotEnoughBins *(error)*
There are not enough good bins to create the power density spectrum, no output plot file created

Unavailable device type and/or output file *(warning)*

corrective action: Action : the device type and output file are set to defaults.

nbins must be a power of two lower than NBINLC (the number of bins in the light curve) *(warning)*
nbins must be a power of two lower than NBINLC (the number of bins in the light curve)
corrective action: nbins is set to nearest power of 2 lower than NBINLC

rebintype is positive but not an integer *(warning)*
rebintype is positive but not an integer
corrective action: The value is set to the nearest positive integer

rebintype is negative and outside the allowed range. *(warning)*
rebintype is negative and outside the allowed range.
corrective action: rebintype is set to 1 (no rebinning)

Some header keywords are missing or inconsistent *(warning)*
Some header keywords are missing or inconsistent
corrective action: A warning is raised and the task attempts to proceed

6 Input Files

1. EPIC FITS Source Time Series ([1]) (e.g. generated by **elcbuild**).

7 Output Files

1. EPIC Source FFT Plot. ([1]) (Deliverable PPS product).

8 Algorithm

```
Subroutine efftplot

  Recover the parameters

  Read source time series FITS file :
     Get dataset and table.
     Get the number of RATE columns (NCOLUMNS)
     Get the number of bins in the lightcurve (NBINLC)

  Check if the device type and output file parameters are valid

  If not, then
      Set the device type and the output file to the default values
      Check if the default values are valid
      If not, raise an error and exit

  Open device

  For each RATE column :

     Create a command line for POWSPEC
     Run POWSPEC with the following options (the relevant ones are given):
            - Nbint is the closest power of 2 lower than the number
              of bins of the input light curve (computed from Nbins)
            - rebin=0 (rebin=no)
            - itre=0 (removetrend=no)
            - gapfill=0 (fillgaps=no)
            - normalization=1
            - Nbintfm = NBINLC/Nbint (i.e the last incomplete
              data segment is ignored).

     Read the PDS so produced
     Draw the PDS with the help of the PGPLOT library
```

```
    Endfor

    Close device
    Release memory.
    delete POWSPEC temporary files

  End subroutine  efftplot
```

9 Comments

- The valid output devices are those of the PGPLOT library.

10 Future developments

None

10.1 CAL usage

- None

References

[1] SSC. XMM Survey Science Centre to Science Operations ICD for SSC Products. Technical Report XMM-SOC-ICD-0006-SSC Issue 2.1, SSC, Mar 2000.