eprejectti

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Abstract

Task **eprejecttiti** permits the flagging of soft flare events.

1 Instruments/Modes

Instrument	Mode
EPIC PN	TIMING

2 Use

pipeline processing	yes (?)
interactive analysis	yes

3 Description

3.1 Soft flare rejection for fast timing mode data

3.1.1 Background: motivation for developing this procedure

The EPIC-pn fast timing mode was designed so that a time resolution of 0.029 milliseconds can be achieved. This mode is important for observing bright variable sources with a very high time resolution. Up to now the it has only been possible to use the spectra down to 300 eV in this mode. Below this energy the data is affected by so-called soft flares which are caused by stack overflows generated by high energy particles.

These so-called soft flares have sharp rise (from 0 counts/sec to several thousand counts/sec in $\sim$0.10-0.15 sec) then decaying back to 0 counts/sec slightly slower in about 0.3-0.4 sec). In some cases (extremely bright flares) they can lead to a FIFO overflow thus causing a small gap in the data of about $\sim$0.08 sec. These gaps are statistically handled by the SAS in **epframes**

In this task we provide a method to mitigate the effect these flares have on the data for flagging such soft flare events so that they can later be screened off the data.

With this method it at last becomes possible to use the spectral information in the data down to the lowest energies detectable in this mode, i.e. 200 eV. This is particularly interesting for timing studies of isolated neutron stars, X-ray Binaries and other variable objects, such as magnetic CVs, with very soft spectra.

3.1.2 The implemented version for the screening:

In this version of **eprejectti** only the boxcar method for screening the soft flares has been implemented. This method has been proven to be very robust. In order to perform the soft flare event selection the program generates a lightcurve in 0.1 sec bins in the specified PHA range using the rawevents obtained from the epframes procedure. This lightcurve is then smoothed with a boxcar function. The width of the boxcar can be given as parameter `softflaresmoothparams` by the user. This smoothed lightcurve is then used to help perform the soft flare event selection. Here each photon is checked to see whether it has a PHA value in the user given PHA range (default: 40-50 adu) and the lightcurve is above the user given softflarethreshold1 (this absolute count per 0.1 sec bin value has to be optimized for each observation as the contribution of the source photons in the given PHA range varies a lot from observation to observation). The criteria above keep events above the upper PHA threshold during the softflare events as good events. A flag column labeled `FLARE` is added to the rawevents file. A "1" in the column denotes that is has been flagged as a soft flare event. This column can the be used to screen the data.

3.1.3 Caveats: things to take into account when using the screened data

Screening the data on the Flare column requires the user to keep several things in mind when interpreting the data down to 200 eV.

- **Spectra:** They are problematic as all photons in the given PHA range during soft flares are removed from the eventfile (both source and softflare events). Spectral fits to the screened data can be performed for PHA values greater than the upper PHA limit given by the user. Below that the total exposure time is reduced as a consequence of the flare removal. A correct handling for this would require energy dependent GTIs. In the future a method for statistically separating source and softflare events could correct this but could be problematic for strongly variable sources.
- **Timing:** There is no problem above the upper PHA limit. But below the upper PHA limit the same applies here as for the spectra. Here also as a consequence of the flare removal the total exposure time is reduced.

3.2 Usage

Task **eprejectti** is intended to be run immediately after task **epframes**, either in the PPS or alternatively as part of the offline analysis using the **epchain** script.

The **epchain** task parameters `runeprejectti`, `sigma`, `badcolumnset`, `noiseparameters`,and `screenrejected` are available to control the behavior of **eprejectti** and the subsequent event filtering. Care should be taken that parameter `screenlowthresh` is set to a sufficiently low value (120 eV) to preserve the noise-screened low energy events in the final calibrated event set. A typical **epchain** call to run **eprejectti** would look like this (see **epchain** task description for other epchain parameters):

```
epchain runeprejectti=yes ...
```

After running epchain, a noise screened low energy image may, e.g., be created by the following call

```
evselect expression='PHA>20 && PI in (120:200)' ...
```

Note, that events with PHA values below 20 need to be removed to create a clean image.

4 Parameters

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

Parameter	Mand	Type	Default	Constraints
eventset	yes	dataset	rawevents.dat	

Name of input EPIC-pn raw event file

set	no	dataset	odfset	

input EPIC-pn ODF dataset name (actual or symbolic); see description of task **epframes** for details

badcolumnset	no	dataset	badcolumns.tab	

Name of optional ASCII file containing pairs of <ccd nr.> <bad column nr.> (one per line), to be omitted from the offset correction

sigma	no	real	4.0	

Sigma threshold for offset correction

withnoisehandling	no	boolean	no	

enables noise flagging scheme

noiseparameters	no	real	0.98 12 × 1.0	

Noise fraction parameters (cutoff parameter and 12 chip specific correction factors; only for expert use)

withoffsetmap	no	boolean	yes	

enables use of offset map to calculate energy shifts

withxrlcorrection	no	boolean	no	

turns on X-ray loading correction code for TI+BU modes, only meaningful if offset maps are availbale in the ODF and use of offset map is not switched off.

withsoftflarescreening	no	boolean	no	

enables soft flare screening

softflarethreshold1	no	real	10.0	

threshold for flare screening in units of counts/0.1 s

softflarethreshold2	no	real	1.0	

threshold for flare screening

softflaresmooth	no	string	BOX	

smoothing method for flare screening

softflareenergyrange	no	list of int	40 50	

energy range for flare screening (in adu units)

softflaresmoothparams	no	list of real	2 0 0	

smoothing parameters

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.

noEvents *(error)*
No EVENTS extension in input data set

wrongEventSet *(error)*
Single CCD event file required

wrongSubMode *(warning)*
Could not read SUBMODE keyword; FF mode assumed
corrective action: check eventset SUBMODE keyword

wrongRawCoords *(warning)*
Invalid RawX, RawY
corrective action: check event set

missingFilter *(warning)*
ofset map FILTER keyword not present
corrective action: check eventset OTFILTER keyword

XRLcorrFastModeOnly *(warning)*
Algorithm only works for TI and BU modes, for IMAGING modes use **epxrlcorr** instead
corrective action: Continue without XRL correction

6 Input Files

EPIC-pn raw event list (output of task **epframes**); if present the `OFFSET` and `BADPIX` extensions will be read.

7 Output Files

EPIC-pn raw event list; two new columns, `OFF_COR`, containing the offset correction, and `NOISE`, which flags events as noise events are added to the event table. Column `PHA` is updated by task **eprejectti** (the original PHA value can be restored by adding the value in the `OFF_COR` column). If soft flare screening is enabled, an additional flag column, `FLARE`, will be created.

8 Algorithm

```
Energy scale correction:

** bin 20 adu and 30-40 adu images from input event file

** determine chip mask area on which to perform offset correction
     o remove offset columns (read from offset extension) from mask
     o remove 10 sigma excesses (3x3 pixel sliding box) in 30-40 adu image
       due to soft sources or optical loading from mask

** inside mask area,

     if offset map is available and -withoffsetmask=true

       o create residual offset map by subtracting median
         from each column and row

     else

       o subtract 20 adu calibration reference image from 20 adu image
       o if statistically significant excesses are found on 4x1 pixel grid
         look up offset correction value corresponding to the
           observed excess in each pixel

     end if
```

```
** loop over input event file and

     o apply offset correction value to PHA value of each event
     o copy correction value into newly created OFF\_COR column

Suppression of detector noise:

** create averaged low energy spectra for each chip row

** determine median spectrum for each +/- 10 rows range

** for each row and each spectral bin determine the ratio of the
     calibration noise spectra divided by the accumulated median spectra

** apply cutoff value and chip specific correction factors to noise ratios

** loop over the event file and randomly flag the events according
     to the noise ratio of the corresponding chip row and energy channel
```

9 Comments

References