omlcbuild

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Abstract

Constructs an OM OSW FITS source timeseries from separate source and background rates files produced by evselect

1 Instruments/Modes

Instrument	Mode
OM	FAST

2 Use

pipeline processing	yes
interactive analysis	yes

3 Description

This task constructs the PPS product OM OSW FITS source timeseries from two rate files (source and background) produced by separate runs of EVSELECT on a tracking-shifted, QE-corrected OM fast-mode event-list. The output timeseries has 4 columns (background subtracted source rate & error, background rate & error). All rates are in counts/s.

In addition to the two rate files, the two region files (generated by OMREGION) are read to deduce the extraction areas. The following procedure is performed for each time bin. The counts measured in the source and 'background' regions, together with the PSF function evaluated over the corresponding regions, are used to set up equations which are then solved to yield source and background rates evaluated for the nominal coincidence-loss region (r=12 pixels). If the parameter bkgfromimage was set to 'yes' then the task would read the Imaging-mode data file (image), remove all the sources from this image and calculate the average value of the background level. This value will be used in further processing, so the output background light-curve will be constant. Note that allowance is made for proximity of the source to the edge of the OSW - the fraction of PSF which falls out of the window is restored. These rates are separately corrected for coincidence losses. Subsequent background subtraction, followed by the corrections for dead-time and any PSF beyond 12 pixels, leads to the final source rate. The code allows for cases where the time-binning of the source and 'background' rate files differ a little - linear interpolation is employed and the binning and timing alignment of the emerging source light curve matches that of the input source rate file.

Errors are computed assuming Poisson statistics though a systematic error of 2% is later included as a measure of non-Poissonian effects at high count rates.

The basic procedure implemented in the task is as follows:

- 1. Get the photometry aperture radius from CAL
- 2. Get CAL aperture radius
- 3. Compute the correction factor in the case the photometry aperture radius is greater than the CAL aperture radius in order to later scale the counts to the CAL aperture radius.
- 4. Compute the count rate corresponding to the OM detection limit
- 5. If the use of the Imaging-mode window is requested for computing the background level, then read the image corresponding to this window, remove all the sources from this image, and calculate the average value of the Imaging-mode background.
- 6. Get the list of sources seen in the science window
- 7. For each of these sources:
- 7.1. Compute the source and background regions corresponding to the radii given in the source list (the background region is an annulus; the window size is not yet taken into account). These regions have been used by "Evselect" for extracting the events corresponding to the source and its background.
- 7.2. Check for the neighbouring sources which may contribute to the counts obtained by Evselect. These regions corresponding to these sources are avoided when computing the background.
- 7.3. Calculate the median value of the background (this value is used for representing the error bars in cases when the source and background rate columns are not present in the data set).
- 7.4. Check whether the MOD8FLAG is set to true
- 7.5. Compute the PSF map corresponding to the source
- 7.6. Compute the real source and background extraction areas (the neighbouring sources are avoided when computing the background area), as well as the PSF-fractions corresponding to these areas.
- 7.7. Compute the PSF-fractions within and outside of the OM science window
- 7.8. Compute the ratios (scaling factors) between the PSF-fractions corresponding to the extraction, CAL, and photometric radii (the extraction radius is not necessarily the same as the CAL radius, and the latter is not necessarily the same as the photometry radius).
- 7.9. Build the light-curves (loop through all of the time bins).
- 7.9.1. If the option bkgfromimage is set to " yes" then use the Imaging-mode background value, otherwise compute the background by solving the system of two equations with two unknowns, using the source and background extraction areas and PSF-fractions, and, of course, the counts from the source and background columns of the input data table. If the source is very bright and the count rates are badly affected by the coincidence losses and modulo-8 noise then nullify the background, assuming that neglecting the background in such cases is a more robust procedure than computing a wrong background value due to the modulo-8 noise pattern.

- 7.9.2. Subtract the background value from the data corresponding to the source column (initially, in this column we have the source+background counts).
- 7.9.3. Correct the source counts for the PSF-fraction outside of the science window. These will be the counts extracted from the region having the source extraction radius.
- 7.9.4. Convert the source and background counts to count rates by dividing them by the time bin value.
- 7.9.5. Scale the background counts to the area corresponding to the source extraction radius.
- 7.9.6. Scale the source and background count rates to the CAL aperture radius.
- 7.9.7. Compute the sum of the source and background count rates.
- 7.9.8. Correct the background value for the coincidence losses by using the CAL routine with the frame time and dead fraction as input parameters.
- 7.9.9. Correct the background value for the time-dependent sensitivity of the photodetector.
- 7.9.10. Correct the source+background value for the coincidence losses by using the CAL routine with the frame time and dead fraction as input parameters.
- 7.9.11. Correct the source+background value for the time-dependent sensitivity of the photodetector.
- 7.9.12. If the ratio of the coincidence-loss corrected count rate to the initial count rate exceeds 2.0 then flag this time bin as having high-coincidence losses.
- 7.9.13. Subtract the background
- 7.9.14. Compute the source and background magnitudes.
- 8.0. Compute average count rates and magnitudes for the entire light curve.
- 9.0. Perform the source variability tests for the entire light curve.

4 Parameters

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

Parameter	Mand	Type	Default	Constraints

srcrateset	yes	string		

Source rates file (output from EVSELECT)

srcregionset	yes	string		

Source region (output from OMREGION)

bkdrateset	yes	string		

Background rates file (output from EVSELECT)

bkgregionset	yes	string		

Background region file (output from OMREGION)

sourcelistset	yes	string		

Source list filename (output from OMDETECT)

wdxset	yes	string		

OSW window data filename

outset	yes	string		

Name of output rates file

mod8corrupted	no	Integer	0	Constraint: positive value

To indicate by a non-zero value that the Fast image is affected by the modulo-8 noise

imageset	no	string		

Name of the auxiliary imaging window data file used for determining the background level around the source

bkgfromimage	no	Boolean	"no"	

To allow using the background obtained from the accompanying Imaging window data

subtractbkg	no	Boolean	"yes"	

To allow background subtraction

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.

Block RATE does not exist in the background rates file *(warning)*

corrective action: Issue a warning. Background corrections are not applied

Input background rates table is empty *(warning)* *corrective action:* Issue a warning. Background corrections are not applied

Source and background rates files from different exposures *(warning)*

corrective action: Issue a warning. Check the ODF files

Background rates and region files have different EXP_IDs *(warning)*

corrective action: Issue a warning. Check the ODF files

High value of the source rate *(warning)*

corrective action: Issue a warning; set the count rate to the maximal possible value corresponding to the current frame time.

Background subtracted rate has negative values *(warning)*

corrective action: Issue a warning

Block RATE does not exist in the source rates file *(warning)*

corrective action: Issue a warning. Check the ODF files

Wrong number of bins in the light curve table length *(warning)*

corrective action: Correcting the number of bins by using the length of the source RATE table

Impossible to get correct source rates table length *(error)*
Emergency stop

6 Input Files

1. OM source rates file (output from EVSELECT)
2. OM background rates file (output from EVSELECT)
3. OM OSW Imaging-mode window data file (ODF)
4. OM ASC compatible FITS detected source list file (output from OMDETECT)
5. OM ASC compatible FITS source region file (output from OMREGION)
6. OM ASC compatible FITS background region file (output from OMREGION)

7 Output Files

1. PPS product OM OSW FITS source timeseries

8 Algorithm

```
   subroutine omlcbuild

     read parameters

     if requested the use of the Imaging-window background:

get handle on the Imaging-mode window file

remove all the source from this image

calculate the average value of the remaining pixels
        and use this value as the background estimate

     loop i=0, nSources

       get handle on source rates file

       get handle on source region file
       if (exposure IDs are different) issue warning

       get handle on background rates file

       get handle on background region file
       if (exposure IDs are different) issue warning

       if (exposure ID source != exposure ID background) call fatal

       get source extraction radius = s_radius

       get CAL coincidence loss correction radius = cal_radius

       get photometry radius = ph_radius

       calculate the instrumental limiting magnitude from the
       detection limit count rate

       compute area of source region = s_area

       compute area of background region = b_area

       tStart = max(tBack[0], tSource[0])
       eEnd = min(tBack[nBack-1], tSource[nSource-1]
       tDel = (tEnd - tStart)/(nSource-1)

       determine the PSF fraction within the source extraction region
       determine the PSF fraction within the ‘background‘ extraction region
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```
      loop i = 0, nTimeBins

        newTime = tStars + i * tDel

        linear interp to get background rate for each source bin
        compute source rate error
        compute background rate error

if the use of the Imaging-mode background is requested,
use the earlier calculated background value,

otherwise:

   set up equations for counts recorded in each region. These allow
   for (point) source contamination of the ‘background‘ region:
   C(S+B) = PSF(S+B) *S   +   NPIX(S+B) * Bpix
   C(B)   = PSF(B)   *S   +   NPIX(B)   * Bpix

   solve these for S, the source counts over the coincidence loss (CL)
   region (ie the CAL aperture) and for Bpix, the background counts
   per pixel.

scale background to the CAL aperture area:
        bkgnd count rate = background count rate * cal_radius area / s_area

recombine these bkgnd and source rates (now determined for the
        CAL aperture)

        apply CL correction to the source+bkgnd rate

        apply CL correction to the bkgnd rate

        CL corrected source rate = source+bkgnd rate - bkgnd rate

correct result for dead time

correct for PSF beyond the 12 pixel Cal aperture (mainly for UV)

compute the source magnitude and insert it into the source
        list table

        perform the variability tests on rebinned net source
        counts ($\chi^2$ and Kolmogorov-Smirnov statistics) by

           calculating the mean count rate and variance;

           testing the null hypothesis (the source is not variable) by:
             - processing a $\chi^2$ fit  between the count distribution
               and constant distribution whose value is equal to the
               observed mean count
             - processing the Kolmogorov-Smirnov test between the
               cumulative probability functions of the observed count
               distributions and theoretical Gaussian distribution whose
               mean and variance are both equal to the observed
```

```
            mean count.

          calculate the maximal deviation of the light curve
          from its mean value and express this value
          in the number of r.m.s. $\sigma_1$.

        introduce the variability tests data into the source list table

       end loop

     write time keywords to header

     write output rates file

     release handle and memory

   end loop

   end subroutine omlcbuild
```

9 Comments

The variability tests are performed in the same way and using the same procedures as in the SAS plotting task *lcplot*.

The χ^2 statistics close to the bin number and a small Kolmogorov-Smirnov statistics with probabilities higher than 0.01 indicate that the source is unlikely to be variable.

10 Future developments

- Eventually the areas of the extraction regions will be available from the input rates file in the form of data subspace keywords.

References