Event list manipulation and screening

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Abstract

In this *paper*, the basic principles of XMM-Newton event list screening and manipulation are briefly summarized

1 The concept of event lists

The SAS reduction tasks (either in their `proc` or in their `chain` flavor) produce *calibrated* and *concatenated event lists*. In this context, "calibrated" means, that calibration information and algorithms have been applied, and the event lists can be directly used to extract scientific products (images, spectra, light curves, source lists). "Concatenated" means that a *single* event list is generated, merging the event lists corresponding to the different chips.

In an event list file, the `EVENTS` extension[1] contains the information relevant to the photons detected by the cameras. Each row of this extension corresponds to a time-tagged event. Quantities such as the event position (in different coordinate systems: raw, detector and sky), energy, "shape" (the ASCA "grade": an important parameter to discriminate between X-ray and non X-ray events) and others (dispersion and cross-dispersion angles in the RGS, for instance) are registered for each individual photon as well. Other event list extensions contain the bad pixels and exposure maps, and Good Time Intervals (see below) for each individual chip.

2 Basic event list manipulation tools

The XMM-Newton event lists (as almost all the XMM-Newton data files) are in FITS format, and can therefore be manipulated with the FTOOLS/LHEASOFT package. Actually, some of the most common FTOOLS tasks (*e.g.*: *fdump*, *fkeyprint*, *fstatistics*, *fstruct*) can be run from the SAS GUI interface. Browsing an event lists with the GUI-driven FTOOLS `fv` may be a very convenient tool to analyze the event list

[1] In this paper, we use the standard FITS nomenclature to indicate the components of a FITS file. The user must be, however, aware that this nomenclature does not perfectly match the naming convention commonly adopted in the SAS documentation. For easiness of reference, a "conversion table" follows:

FITS name	**XMM-Newton data name**
Header	Header
Primary Header Data Units/Array	First Data Block/Primary Array
Extension	Data block
Image	Array
Binary Table	Table
Keyword	Attribute
Column/Rows	Column/Rows

structure, view and modify the content of a header or binary table, and create "quick-and-dirty" scatter plots.

SAS, however, provides a full set of XMM-Newton FITS files manipulation tools, based on a SAS-specific library: the *Data Access Layer* (DAL). Some of these tasks represent SAS "incarnations" of existing FTOOLS; others implement, however, completely new functionalities, taking full advantage of the higher flexibility of the DAL structure. The users may get a description on the properties of each tool by typing, *e.g.*:

```
sashelp doc="addattribute"
```

This command runs the URL, containing the description of the task (*addattribute*) to add keywords to a FITS file header[2]. Or:

```
sashelp doc="dsstats"
```

launches the description of the task (*dsstats*) to produce statistics on a dataset. A list of all the available SAS manipulation task can be found under the section "Utility packages" of the on-line SAS documentation.

3 Good Time Intervals

A *Good Time Interval* (GTI) file is the set of time intervals, on which a given scientific product (*e.g.*: an event list) has been accumulated. Structurally, each of these intervals corresponds to a record in a binary table, defined by the columns `START` and `STOP` only. As already mentioned, event lists produced by the SAS reduction pipelines contains one "GTI" extension for each chip, corresponding to "good events" accumulation intervals. GTIs play a crucial rôle, for instance, in the calculation of the exposure times.

SAS allows to select GTIs from housekeeping or scientific light curves through the SAS task *tabgtigen*. For instance:

```
tabgtigen table=my_lightcurve.fits gtiset=my_gti.fits expression="TIME.LE.9.5063E+07"
```

creates a GTI file `my_gti.fits`, containing one single interval: from the start of the observation to $T = 9,506,300$ s (provided that the observation starts earlier! otherwise `my_gti.fits` will be empty). This file can be applied to the SAS scientific product extractor, to generate, *e.g.*, spectra corresponding to this time interval only (cf. Guainazzi 2001).

4 Manipulation of event list columns

The SAS task *tabcalc* allows to produce new columns in a binary table or to modify existing columns, through logical, arithmetic or trigonometric operations on existing columns. For instance:

```
tabcalc tables=my_events.fits:EVENTS column=DISTANCE
    expression="SQRT((X-18000)**2+(Y-18000)**2)"
```

[2] Of course, the *sashelp* task can be used to launch the on-line help of all the SAS tasks

creates a new column `DISTANCE` in the `EVENTS` extension of the file `my_events.fits`, which contains the Eucledian distance from the sky pixel of coordinates (18000, 18000).

```
tabcalc tables=my_events.fits:EVENTS column=TIME expression="TIME-9.5062022"
```

applies an offset to the `TIME` column.

5 The *selectlib* operators

Logical, arithmetic and trigonometrical operations on event lists and/or data screening are based on the SAS-specific *selectlib* library. Its user-friendly syntax allows a user to apply several classes of operators:

- boolean
- arithmetic/trigonometric
- string manipulation
- definition of a complex selection expression in a file keyword
- bitwise
- spatial filter with regions of pre-defined shape
- GTI-based filters
- mask-based filters
- FITS region file-based filters

A full description of the syntax of all the above operators can be found in the on-line documentation of the SAS task *saslib*. Their most immediate application is the definition of screening expressions in *evselect*/*xmmselect*.

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References

Guainazzi M., 2001, available at the URL: `http://cosine.leidenuniv.nl/ gvacanti/xmmws/`

References