spi_psd_effigen

User Manual

Version 1.1.1
22 January 2003

Jürgen Knödlseder
Centre d'Etude Spatiale des Rayonnements
knodlseder@cesr.fr
http://www.cesr.fr./~jurgen/index.html

Note to the user

This software has been written to analyse data of the SPI telescope onboard INTEGRAL. Particular care has been taken in making the software user friendly and well documented. If you appreciated this effort, and if this software and User Manual were useful for your scientific work, the author would appreciate a corresponding acknowledgment in your published work.

Contents

1 Introduction

The executable `spi_psd_effigen` is part of the SPI scientific analysis preparation software component (SAP). It derives the SPI PSD efficiency, which is part of the SPI PSD response function, from the binned event spectra (data structure `SPI.-OBS.-DSP`). Consequently, `spi_psd_effigen` has to be executed after `spihist` but before the imaging or spectral analysis steps. `spi_psd_effigen` adds a data structure of HDU type `SPI.-OBS.-PEF` to the observation group.

`spi_psd_effigen` is written in the ANSI C++ language and has been developped under ISDC support platform 5.1. It requires `spi_toolslib` version 2.0.0 or higher.

2 Getting started

Before installing `spi_psd_effigen`, make sure that the ISDC support platform 5.1 or higher is installed on your system, and that you have installed the library `spi_toolslib` version 2.0.0 or higher.

After downloading the `spi_psd_effigen.tar.gz` file, step into a directory that should hold the distribution, move the `spi_psd_effigen.tar.gz` file into this directory and type after the UNIX prompt `$` (don't type this prompt):

```
$ gunzip spi_psd_respgen.tar.gz
$ tar xvf spi_psd_respgen.tar
```

The first command uncompresses the distribution file, the second unpacks the files.

Before configuration, the distribution needs to be reset to a clean state. To do this, type

```
$ make distclean
```

Then, configure the distribution. It is assumed here that you have previously installed the ISDC support platform, thus you should type

```
$ ~/bin/ac_stuff/configure
```

Finally, build the distribution by typing

```
$ make global_install
```

To perform a unit test, type

```
$ make test
```

Make sure that the test data `spi_test_data-1.0.tar.gz` are available at your site (they should reside in a directory whose name is defined by the `ISDC_TEST_DATA_DIR` environment variable).

3 Parameter file

```
#############################################################################
#                                                                           #
#               Centre d'Etude Spatiale des Rayonnements                    #
#                     (in collaboration with ISDC)                          #
#                                                                           #
#                     SPI PSD efficiency generation                         #
#                                                                           #
# ------------------------------------------------------------------------- #
#                                                                           #
#  File:      spi_psd_effigen.par                                           #
#  Version:   1.1.1                                                         #
#  Component: SAP                                                           #
#                                                                           #
#  Author:    Juergen Knoedlseder                                           #
#             knodlseder@cesr.fr                                            #
#             CESR                                                          #
#                                                                           #
#  Purpose:   Parameter file of the SPI PSD efficiency generation task#
#                                                                           #
#  History:   1.1.1  22-Jan-2003  First ISDC delivery (Rev. 1)              #
#                                                                           #
#############################################################################
#
# The input DOLs/filenames
#=========================
ingrpDOL,s,ql,"og_spi.fits",,,"Input Observation Group DOL or filename"
inebdDOL,s,ql,"",,,"Energy boundary definition DOL or filename"
ingtiDOL,s,ql,"",,,"Good Time Interval DOL or filename"
indspDOL,s,ql,"",,,"Detector spectrum DOL or filename"
#
# The output DOLs/filenames
#==========================
outgrpDOL,s,ql,"og_spi_pef.fits",,,"Output Observation Group DOL or filename"
outpefDOL,s,ql,"psd_efficiency.fits",,,"PSD efficiency DOL or filename"
#
# Task parameters
#================
min_bin, r,h, 250.0,0.0,,"Requested minimum number of events/bin"
navg,    i,h,    20,  1,,"Number of pointings to average"
eminexcl,r,h,1100.0,0.0,,"Minimum energy of window to exclude"
emaxexcl,r,h,1750.0,0.0,,"Maximum energy of window to exclude"
#
# Standard parameters
#====================
clobber,b,h,yes,,,"Overwrite existing output data ?"
verbose,i,h,3,0,3,"Information logging level"
```

Instead of specifying complete DOLs (Data Object Locations), which are composed of a filename plus the data structure extension (HDU), `spi_psd_effigen` accepts also simple filenames and adds the appropriate data structure extensions. This means that **specified data structure extensions are ignored**.

The parameters have the following meaning:

- `ingrpDOL` (optional) specifies the DOL or filename of the input Observation Group of HDU type `[GROUPING]` for which the SPI PSD efficiency should be derived. The specification of this parameter is optional **if an output Observation Group has been specified** (parameter `outgrpDOL`). If left blank, the output group will be used as input group. This option may be used if one wants to add-on to an existing Observation Group (in this case the `clobber` parameter has to be set to `yes`). For safety, however, it is recommended to create a new output Observation Group (which will take only little space on your disk). Only an Observation Group is accepted for this parameter, other data or group types (such as science window groups or index groups) will be rejected.

- `inebdDOL` (optional) specifies the DOL or filename of an energy boundary definition file of HDU type `[SPI.-EBDS-SET]`. If a `[SPI.-EBDS-SET]` element exists already in the input Observation Group, this element will be replaced by the specified DOL in the output Observation Group. If no `[SPI.-EBDS-SET]` element exists in the input Observation Group, the specified DOL will be attached to the output Observation Group. Leaving this parameter blank will lead `spi_psd_effigen` to search for this element in the input Observation Group. This is the recommended default method.

- `ingtiDOL` (optional) specifies the DOL or filename of a Good Time Interval list of HDU type `[SPI.-OBS.-GTI]`. If a `[SPI.-OBS.-GTI]` element exists already in the input Observation Group, this element will be replaced by the specified DOL in the output Observation Group. If no `[SPI.-OBS.-GTI]` element exists in the input Observation Group, the specified DOL will be attached to the output Observation Group. Leaving this parameter blank will lead `spi_psd_effigen` to search for this element in the input Observation Group. This is the recommended default method.

- `indspDOL` (optional) specifies the DOL or filename of an event spectra file of HDU type `[SPI.-OBS.-DSP]`. If a `[SPI.-OBS.-DSP]` element exists already in the input Observation Group, this element will be replaced by the specified DOL in the output Observation Group. If no `[SPI.-OBS.-DSP]` element exists in the input Observation Group, the specified DOL will be attached to the output Observation Group. Leaving this parameter blank will lead `spi_psd_effigen` to search for this element in the input Observation Group. This is the recommended default method.

- `outgrpDOL` (optional) specifies the DOL or filename of the output Observation Group of HDU type `[GROUPING]`. The output Observation Group will be a copy of the input Observation Group plus the resulting SPI PSD efficiency data structure `[SPI.-OBS.-PEF]` attached. The specification of this parameter is optional **if an input Observation Group has been specified** (parameter `ingrpDOL`). If left blank, the input group will be used as output group. This option may be used if one wants to add-on to an existing Observation Group (in this case the `clobber` parameter has to be set to `yes`). For safety, however, it is recommended to create a new output Observation Group (which will take only little space on your disk). Only an Observation Group is accepted for this parameter, other data or group types (such as science window groups or index groups) will be rejected.

- `outpefDOL` specifies the DOL or filename of the SPI PSD efficiency file of HDU type `[SPI.-OBS.-PEF]`. This file will be attached to the output Observation Group. Any existing DOL of the same type that may already exist in the output Observation Group will be detached before. If the specified DOL is identical to an already existing DOL, this DOL will be deleted if the `clobber` parameter is `yes` (otherwise an error will occur).

- `min_bin` specifies the minimum number of events per spectral bin that is required for SPI PSD efficiency determination. In order to have an accurate efficiency, values about ~ 1000 (**TBC**) or higher are recommended. Otherwise, the efficiency factors may be subject to considerable statistical fluctuations. `spi_psd_effigen` internally rebins the spectra to fulfill this requirement, losing inevitably some spectral resolution on the efficiency factors (yet, the SPI PSD efficiency is a slowly varying function of energy, hence this loss is generally not dramatic).

- **navg** specifies the number of pointings for which the SPI PSD efficiencies should be averaged in order to increase the event statistics. This effectively reduces the requested number of bins in a single pointing to fulfill the constraint imposed by **min_bin**, resulting in a better energy resolution, with the drawback of a loss in the time resolution. Depending on whether the SPI PSD efficiency is stable (in time) or not, **navg > 1** may be used to improve the energy resolution of the computed efficiency factors.

- **eminexcl** specifies the minimum energy of the energy window that should be excluded for PSD efficiency calculation. The energy window exclusion is needed to take into account the artefact in the single detector events between roughly 1100 - 1750 keV. **spi_psd_effigen** will interpolate the PSD efficiencies over this window by using energy bins adjacent to the specified window.

- **emaxexcl** specifies the maximum energy of the energy window that should be excluded for PSD efficiency calculation.

- **clobber** specifies if existing output data structures should be overwritten or not. If **yes** is specified, the executable will notify the user about the deletion of any file (if **verbose > 1**). If **no** is specified and the executable attempts to overwrite existing data (e.g. an existing output Observation Group or SPI PSD efficiency file), the task will exit with an error message.

- **verbose** specifies the verbose level of the executable. For **verbose=0**, no information will be logged in case of an error. For **verbose=1**, only errors will be logged, while for **verbose=2** also actions (such as DOL detachments and attachments and DOL deletion) will be logged. **verbose=3** provides a detailed report about the SPI PSD efficiency derivation.

4 Interface definition

spi_psd_effigen extracts the SPI PSD efficiency function from a binned event spectra of HDU type **SPI.-OBS.-DSP**. In addition to this HDU, it also requires a **SPI.-EBDS-SET** and a **SPI.-OBS.-GTI** HDU to determine the energy boundary definition of the event spectra, and the Good Time Intervals and pointings that are present in the Observation Group.

spi_psd_effigen stores the calculated SPI PSD efficiency function in a data structure of HDU type **SPI.-OBS.-PEF** where it creates the column **PSD_EFF** with the same number of column bins than the event spectra have (i.e. the column size is set by the executable). For each pointing, **SPI.-OBS.-PEF** contains 19 rows, one for each SPI detector (with detector identifiers in the order **0 - 18**).

From the input Observation Group, the following HDUs are required:

- **SPI.-EBDS-SET** Energy boundary definition of the observation
- **SPI.-OBS.-GTI** Good Time Intervals
- **SPI.-OBS.-DSP** Binned event spectra

All members of the input Observation Group become members of the output Observation Group. In addition, the following additional HDU is attached to the output Observation Group (or replaced if it exists already):

- **SPI.-OBS.-PEF** PSD efficiency function

If no output Observation Group is specified, **spi_psd_effigen** attempts to make the input Observation Group to the output Observation Group, which is only possible if the **clobber** parameter is set to **yes**. Vice versa, if no input Observation Group is specified, **spi_psd_effigen** uses the output Observation Group as

input Observation Group. For more details on the group logic, the user is referred to the discription of the group API in the `spi_toolslib` User Manual.

`spi_psd_effigen` makes extended usage of the `SPISpec` and `SPISpecSet` classes of `spi_toolslib`, and of `spi_toolslib` functions that allow to determine Good Time Intervals and pointings. Eventually, these functions may also return error codes. Please refer to the `spi_toolslib` User Manual for more details.

5 Algorithm

The SPI PSD efficiency function is defined by

```
PSD_EFF = PE / (SE + PE)
```

where `SE` is the number of single detector events, and `PE` is the number of PSD events, which both are functions of energy. By definition, `PSD_EFF` is comprised between $0 - 1$.

For the limited event statistics in a single pointing, `PSD_EFF` is subject to considerable statistical fluctuations, in particular if the selected energy binning is rather fine. To reduce these fluctuations, `spi_psd_effigen` rebins the `SE` and `SE + PE` spectra internally to a binning that is such that

```
SE + PE > min_bin / navg
```

`min_bin` is the minimum requested number of events in a single energy bin, leading to a spectral binning that generally becomes automatically larger for increasing energies. `navg` specifies the number of pointings that should be averaged, reducing effectively the number of required events per bin in a single pointing, and hence increasing the resulting energy resolution. If the number of pointings is smaller than `navg`, `navg` will be set automatically to the number of pointings. Pointings which are empty (i.e. which contain no events) will be excluded from the averaging. Both `min_bin` and `navg` are task parameters.

Inflight, the single detector events show artifical events within the energy range $1100 - 1750$ keV of yet unknown origin. These artifical events lead to an effective drop of the formal PSD efficiency within this energy range, which however is not real. To take this instrumental artefact into account, an energy window may be specified by the parameters `eminexcl` and `emaxexcl` which allows to exclude this critical interval from the analysis. Within this interval, the PSD efficiency is then linearly interpolated from the values found adjacent to the interval.

6 Error codes

The executable `spi_psd_effigen` may stop with the following error codes:

```
SPI_PSD_EFFIGEN_ERROR_MEM_ALLOC                -232000
SPI_PSD_EFFIGEN_ERROR_OVERWRITE                -232001
SPI_PSD_EFFIGEN_ERROR_INVALID_ETYPE            -232002
SPI_PSD_EFFIGEN_ERROR_INVALID_BINS             -232003
```

They have the following meaning:

- `SPI_PSD_EFFIGEN_ERROR_MEM_ALLOC` : the allocation of dynamical memory has failed. Probable your system resources are too limited to run this task.
- `SPI_PSD_EFFIGEN_ERROR_OVERWRITE` : the task attempted to overwrite a data structure while the `clobber` parameter was set to `no`. Either avoid overwriting existing data structure or specify `clobber=yes`.

- `SPI_PSD_EFFIGEN_ERROR_INVALID_ETYPE` : an invalid energy type was detected. Valid energy types are either raw channels (`CHNATYPE=PHA`) or calibrated (pulse invariant) energies (`CHNATYPE=PI`). For raw channels, the `E_RANGE` column in the `SPI.-EBDS-SET` column may either take the value `0` (corresponding to `PHA0`) or `1` (corresponding to `PHA1`). Probably, your `SPI.-EBDS-SET` data structure is corrupted.
- `SPI_PSD_EFFIGEN_ERROR_INVALID_BINS` : the number of energy bins in the `SPI.-EBDS-SET` and `SPI.-OBS.-DSP` data structure seem not to match. This error should never occur since it should be detected before by the `spi_toolslib` functions, hence in case of non-matching data structure, a `spi_toolslib` error should occur.

In addition, all errors that may occur in calls to ISDC support functions (such as for example DAL, RIL or PIL) are forwarded. Please consult the ISDC web pages for getting information about these error codes. Also `spi_toolslib` errors may occur, in particular if the input data structure does not match the expected format. Please refer to the corresponding User Manual in case of problems.