spi_obs_adjust

User Manual

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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_obs_adjust` allows the adjustment of the energy resolution of the background model and the data in an observation group. This adjustment is required if empty field observations are used to build a background model, since in general, the empty field observations will show a different detector degradation than the observation that should be analysed. Two cases may occur. If the detector resolution is worse during data taking compared to the empty field observation, the background model should be degraded to fit the data. If, however, the detector resolution is better during data taking than during the observation of the empty field, the observation should be degraded. Of course, in this second case the spectral resolution of SPI is reduced, yet the analysis may benifit from reduced systematical biases.

`spi_obs_adjust` is written in the ANSI C++ language and has been developped under ISDC support platform 6.3. It requires `spi_toolslib` version 4.2.0 or higher.

2 Getting started

Before installing `spi_obs_adjust`, make sure that the ISDC support platform 6.3 or higher is installed on your system, and that you have installed the library `spi_toolslib` version 4.2.0 or higher.

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

```
$ gunzip spi_obs_adjust.tar.gz
$ tar xvf spi_obs_adjust.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
```

3 Parameter file

```
#############################################################################
#                                                                           #
#               Centre d'Etude Spatiale des Rayonnements                    #
#                     (in collaboration with ISDC)                          #
#                                                                           #
#                      SPI Observation Adjustment                           #
#                                                                           #
# ------------------------------------------------------------------------- #
#                                                                           #
#  File:      spi_obs_adjust.par                                            #
#  Version:   1.1.0                                                         #
#  Component: IA                                                            #
#                                                                           #
#  Author:    Juergen Knoedlseder                                           #
#             knodlseder@cesr.fr                                            #
#             CESR                                                          #
#                                                                           #
#  Purpose:   Parameter file for the SPI Observation Adjustment task        #
#                                                                           #
#  History:   1.1.0  28-Nov-2003  First release (Rev. 1)                    #
#                                                                           #
#############################################################################
#
# The input DOLs/filenames
#=========================
ingrpDOL,   s,q,"og_spi.fits",,,"Input Observation Group DOL or filename"
inebdsDOL,  s,h,            "",,,"Energy boundary DOL or filename"
inpntDOL,   s,h,            "",,,"Pointing DOL or filename"
ingtiDOL,   s,h,            "",,,"Good Time Interval DOL or filename"
indtiDOL,   s,h,            "",,,"Deadtime DOL or filename"
indspDOL,   s,h,            "",,,"Detector Spectrum DOL or filename"
inpefDOL,   s,h,            "",,,"PSD Efficiency DOL or filename"
inprfDOL,   s,h,            "",,,"PSD Response DOL or filename"
inbgmidxDOL,s,h,            "",,,"Background Model Index DOL or filename"
#
# The output DOLs/filenames
#==========================
outgrpDOL,   s,q,        "og_spi.fits",,,"Output Observation Group DOL or filename"
outdspDOL,   s,q, "evts_det_spec.fits",,,"Result Detector event spectra DOL or filename"
outbgmidxDOL,s,q,"back_model_idx.fits",,,"Result Background Model Index DOL or filename"
outbgmDOL,   s,q,    "back_model.fits",,,"Result Background Model filename"
#
# Task parameters
#================
engmin,     r,q, 1755.0,,,"Adjustment energy window minimum (keV)"
engmax,     r,q, 1790.0,,,"Adjustment energy window maximum (keV)"
dataDegrade,b,q,    yes,,,"Degrade data ?"
dataSmooth, b,q,     no,,,"Smooth data ?"
bgmShift,   b,q,    yes,,,"Shift background model ?"
bgmDegrade, b,q,     no,,,"Degrade background model ?"
bgmSmooth,  b,q,    yes,,,"Smooth background model ?"
```

```
fitGlobal,  b,q,    yes,,,"Adjust observation only globally ?"
statistics, s,h,   chi2,,,"Adjustment statistics"
degradation,s,h,    exp,,,"Degradation type"
maxIter,    i,h,   100,1,,"Maximum number of adjustment iterations"
fixBgm,     b,h,     no,,,"Fix background model levels ?"
normBgmFit, b,h,     no,,,"Normalise background model using fit parameters ?"
#
# Standard parameters
#====================
clobber,b,h,yes,,,"Overwrite existing output data ?"
verbose,i,h,3,0,4,"Information logging level"
```

Instead of specifying complete DOLs (Data Object Locations), which are composed of a filename plus the data structure extension (HDU), `spi_obs_adjust` accepts also simple filenames and adds the appropriate data structure extensions. This means that **specified data structure extensions are ignored**. The only exception are the `model`*nn* parameters which need an extension in case that a skymap has been specified (see below).

The parameters have the following meaning:

- `ingrpDOL` (optional) specifies the DOL or filename of the input Observation Group (HDU `[GROUPING]`) for which the adjustment should be performed. The input group has to be of level `BIN_I`.

  If an output Observation Group has been specified (parameter `outgrpDOL`), the specification of this parameter is optional. If the parameter is left blank, the output Observation Group will then be used as input Observation Group. Otherwise, the input Observation Group will be copied into the output Observation Group.

- `inebdsDOL` (optional) specifies the DOL or filename of an energy boundary definition (HDU `[SPI.-EBDS-SET]`). This data structure specifies the energy boundaries of the binned data.

  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. Otherwise, the specified DOL will be attached to the output Observation Group. If left blank, it is assumed that a `[SPI.-EBDS-SET]` element exists already in the input Observation Group. If no such element is found, however, the task execution is aborted with an error message.

- `inpntDOL` (optional) specifies the DOL or filename of a Pointing definition (HDU `[SPI.-OBS.-PNT]`). This data structure specifies the SPI pointings during data taking.

  If a `[SPI.-OBS.-PNT]` element exists already in the input Observation Group, this element will be replaced by the specified DOL in the output Observation Group. Otherwise, the specified DOL will be attached to the output Observation Group. If left blank, it is assumed that a `[SPI.-OBS.-PNT]` element exists already in the input Observation Group. If no such element is found, however, the task execution is aborted with an error message.

- `ingtiDOL` (optional) specifies the DOL or filename of a Good Time Interval definition (HDU `[SPI.-OBS.-GTI]`). This data structure specifies the time intervals that have been used for data taking.

  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. Otherwise, the specified DOL will be attached to the output Observation Group. If left blank, it is assumed that a `[SPI.-OBS.-GTI]` element exists already in the input Observation Group. If no such element is found, however, the task execution is aborted with an error message.

- `indtiDOL` (optional) specifies the DOL or filename of a Deadtime data structure (HDU `[SPI.-OBS.-DTI]`). This data structure contains the livetime and the deadtime ratio for the binned data.

If a [SPI.-OBS.-DTI] element exists already in the input Observation Group, this element will be replaced by the specified DOL in the output Observation Group. Otherwise, the specified DOL will be attached to the output Observation Group. If left blank, it is assumed that a [SPI.-OBS.-DTI] element exists already in the input Observation Group. If no such element is found, however, the task execution is aborted with an error message.

- **indspDOL** (optional) specifies the DOL or filename of a Detector Spectra data structure (HDU [SPI.-OBS.-DSP]). This data structure contains the detector spectra for all pseudo-detectors and pointings.

  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. Otherwise, the specified DOL will be attached to the output Observation Group. If left blank, it is assumed that a [SPI.-OBS.-DSP] element exists already in the input Observation Group. If no such element is found, however, the task execution is aborted with an error message.

- **inpefDOL** (optional) specifies the DOL or filename of a PSD efficiency data structure (HDU [SPI.-OBS.-PEF]). This data structure contains the PSD efficiencies for the binned data.

  If a [SPI.-OBS.-PEF] element exists already in the input Observation Group, this element will be replaced by the specified DOL in the output Observation Group. Otherwise, the specified DOL will be attached to the output Observation Group. If left blank, it is assumed that a [SPI.-OBS.-PEF] element exists already in the input Observation Group. If no such element is found, however, the task execution is aborted with an error message.

- **inprfDOL** (optional) specifies the DOL or filename of a PSD response data structure (HDU [SPI.-OBS.-PRF]). This data structure contains the PSD response for the binned data.

  If a [SPI.-OBS.-PRF] element exists already in the input Observation Group, this element will be replaced by the specified DOL in the output Observation Group. Otherwise, the specified DOL will be attached to the output Observation Group. If left blank, it is assumed that a [SPI.-OBS.-PRF] element exists already in the input Observation Group. If no such element is found, however, the task execution is aborted with an error message.

- **inbgmidxDOL** (optional) specifies the DOL or filename of a Background Model index data structure (HDU
  [SPI.-BMOD-DSP-IDX]). This data structure contains pointers to the components of the instrumental background model.

  If a [SPI.-BMOD-DSP-IDX] element exists already in the input Observation Group, this element will be replaced by the specified DOL in the output Observation Group. Otherwise, the specified DOL will be attached to the output Observation Group. If left blank, it is assumed that a [SPI.-BMOD-DSP-IDX] element exists already in the input Observation Group. If no such element is found, however, the task execution is aborted with an error message.

- **outgrpDOL** (optional) specifies the DOL or filename of the output Observation Group (HDU [GROUPING]). The output Observation Group will be a copy of the input Observation Group for which the detector spectra and the background model index and files have been replaced.

  If an input Observation Group has been specified (parameter **ingrpDOL**), the specification of this parameter is optional. If the parameter is left blank, the input Observation Group will then be used as output Observation Group.

- **outdspDOL** specifies the DOL or filename of the adjusted detector spectra (HDU [SPI.-OBS.-DSP]).

- **outbgmidxDOL** specifies the DOL or filename of the background model index (HDU [SPI.-BMOD-DSP-IDX]). After execution of the task, this index will contain pointers to the background model components that have been adjusted.

This index will be attached to the output Observation Group. Any index 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 the task will abort with an error).

- `outbgmDOL` specifies the filename of the background model data structure (HDU `[SPI.-BMOD-DSP]`). **Note that this filename is relative to the background model index (parameter `outbgmidxDOL`), and that no HDU extension should be provided for this parameter.** After execution of the task, this file will contain the background model components that have been adjusted.

- `engmin` specifies the lower boundary of the range of the data-space energy bins that should be considered for adjustment. All data-space energy bins that overlap with the interval `[engmin,engmax]` will be used for the adjustment.

- `engmax` specifies the upper boundary of the range of the data-space energy bins that should be considered for adjustment. All data-space energy bins that overlap with the interval `[engmin,engmax]` will be used for the adjustment.

- `dataDegrade` specifies if the data should be degraded or not. Set this parameter to `yes` if the energy resolution during the empty field observation has been worse than during the observation of interest. Otherwise set this parameter to `no`.

- `dataSmooth` specifies if the data should be smoothed or not. Data smoothing may help in some cases to reduce the difference between the energy resolution of the observation and the empty field.

- `bgmShift` specifies if the background model should be shifted in energy. This shifting is often required as a result of a difference in energy resolution and degradation. By default it is recommended to set this parameter to `yes`.

- `bgmDegrade` specifies if the background model should be degraded or not. Set this parameter to `yes` if the energy resolution during the empty field observation has been better than during the observation of interest. Otherwise set this parameter to `no`.

- `bgmSmooth` specifies if the background models should be smoothed or not. Background smoothing may help in some cases to reduce the difference between the energy resolution of the observation and the empty field.

- `fitGlobal` specifies if the adjustment should only be done globally, i.e. all pseudo-detectors have the same adjustment parameters (option `yes`) or locally, i.e. for each pseudo-detector individually (option `no`).

- `statistics` specifies the statistics that should be used to optimise the data-background adjustment. The following options are available: `CHI2` specifies Chi-squared statistics (the default), `KS` specifies a Kolmogorov-Smirnov test, and `KUIPER` specifies the Kuiper statistics.

- `degradation` specifies the functional form that should be used for spectral degrading. The following options are available: `EXP` specifies an exponential function (the default), `GAUSS` specifies the negative wing of a Gaussian function.

- `maxIter` specifies the maximum number of adjustment iterations. To assure convergence, a typical number of 10 iterations is required. Setting the maximum to about `100` (the default) should assure convergence in all cases.

- `fixBgm` specifies if the background model level should be fixed (option `yes`) or should be fitted (option `no`) during the adjustment. For bias-free adjustment, `no` is the recommended default value. Note that if multiple background model components exist, each component will have its own scaling factor.

- `normBgmFit` specifies if the background model scaling factors, that were eventually derived from fitting (if `fixBgm = no`), should be used to normalise the background model.
- `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 `no` is specified and the executable attempts to overwrite existing data, 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 task execution, while `verbose=4` logs all adjustment trials (which could be a huge number leading to a huge log file).

4 Interface definition

TBW

5 Algorithm

TBW

6 Error codes

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

```
SPI_OBS_ADJUST_ERROR_MEM_ALLOC                  -233700
SPI_OBS_ADJUST_ERROR_BAD_PARAMETER              -233701
SPI_OBS_ADJUST_ERROR_ITER_EXCEED                -233702
SPI_OBS_ADJUST_ERROR_NO_EBIN_OVERLAP            -233703
SPI_OBS_ADJUST_ERROR_DATASPACE_MISMATCH         -233704
SPI_OBS_ADJUST_ERROR_DATASPACE_EMPTY            -233705
SPI_OBS_ADJUST_ERROR_TOO_MANY_PDET              -233706
SPI_OBS_ADJUST_ERROR_TOO_MANY_BGM               -233707
```

They have the following meaning:

- `SPI_OBS_ADJUST_ERROR_MEM_ALLOC` : the allocation of dynamical memory has failed. Probable your system resources are too limited to run this task.
- `SPI_OBS_ADJUST_ERROR_BAD_PARAMETER` : an invalid input parameter has been specified, such as an invalid statistics type or an invalid degradation type. Please use only valid task parameters.
- `SPI_OBS_ADJUST_ERROR_ITER_EXCEED` : the number of adjustment iterations has been exceeded. Please increase the `maxIter` parameter to allow for more iterations.
- `SPI_OBS_ADJUST_ERROR_NO_EBIN_OVERLAP` : no energy bin of the data-space overlaps with the specified energy interval `[engmin,engmax]`, hence no adjustment can be performed. Please specify a valid energy interval.
- `SPI_OBS_ADJUST_ERROR_DATASPACE_MISMATCH` : an internal data-space mismatch has been detected. This error should never occur and signifies a bug in the software. Please report to the author.

- `SPI_OBS_ADJUST_ERROR_DATASPACE_EMPTY` : the data-space of the observation group was empty, i.e. either there were no pointings, no pseudo-detectors, no energy bins, or no background models. Please provide a data-space that contains data.
- `SPI_OBS_ADJUST_ERROR_TOO_MANY_PDET` : the data-space contains more than `MAX_PDET` pseudo-detectors, where `MAX_PDET` is fixed in the file `spi_obs_adjust.h` to `142`. Please increase this number an re-compile the executable.
- `SPI_OBS_ADJUST_ERROR_TOO_MANY_BGM` : the data-space contains more than `MAX_BGM` background model components, where `MAX_BGM` is fixed in the file `spi_obs_adjust.h` to `5`. Please increase this number an re-compile the executable.

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.