IBIS/PICsIT detector Housekeeping and science performance monitoring User Manual.

INAF/IASF-Bologna
Internal Report n. 525/2008

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July 7, 2009

Revision History	
v 1.0	First Version December 2008

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1 Introduction

IBIS/PICsIT detector monitoring is performed by means of a set of routines, written in IDL language, that read processed and housekeeping data to derive and visualize the main parameters characterizing the instrument performances. The aim of this document is to give a brief description of these routines and a scheme of their usage. It is divided in three parts:

- The first part is dedicated to general structure of the code, with a full description of the output files, and an example of a typical run is given.
- The second part outlines the data archive and how monitor parameters are derived.
- The third part of the document describes single routines at detail and outlines the basic calling sequence.

2 Requirements

In the following the reader is assumed to be familiar with INTEGRAL data structure and with the Off-line Scientific Analysis software (`OSA`) products. Since the code makes use of processed data the `OSA` software needs to be run before the monitoring procedure.

The monitoring program requires the following files: `monitor.pro` (main procedure), `big_counts.pro`, `big_temp.pro`, `compute_gain.pro`, `doing_maps.pro`, `gain_analysis.pro`, `gain_pix.pro`, `longplot.pro`, `make_arr.pro`, `pino_curvefit.pro`, `pino_gaussfit.pro`, `rate.pro`, `read_rev.pro`, `temperature.pro`, `write_summary.pro`.

Monitoring procedure and processed data (`OSA` products) are stored in the local machine `fermi@iasfbo.inaf.it`. To start up the monitoring procedure as new, the user must follow the preliminary steps:

- in the same folder where the `IDL` routines have been saved, create two directories, named *Data* and *Plots*, where the output will be addressed.
- check path for both precessed and housekeeping data (see all **pwd** settings in Sec.4) in routines: `doing_maps.pro`, `gain_deluxe.pro`, `make_arr.pro`, `write_summary.pro`.

The user must be aware that the output is pretty sized and requires a disk space of at least 4.5 G for 500 revolutions.

3 Part I - Cookbook

3.1 Monitoring Parameters and General Description

The code reads and plots the content of the revolution sample given in input. The instrument monitoring program analyzes the time evolution of the following parameters:

- Background count rate: derived from the total counts on the detector plane of scientific pointings (ScW) in Standard Mode. The code inspects processed data, organized in the eight standard energy bands for each multiplicity (single and multiple events). The code derives:

  - background rate at ScW level for the eight energy bands.
  - mean revolution background rate: total counts over all energy bins and over all revolution pointings, divided by the total revolution exposure.

- Temperature: the detector plane is provided with 32 sensors that are read every ~ 32 s during each ScW. The code inspects:
  - temperature at ScW level for each sensor: the mean of all acquisitions during the ScW.
  - mean revolution temperature: average over all sensors and all revolution pointings.
- Solar aspect: attitude data are continuously collected every $30 - 70$ s during revolutions, for both pointings and slews. The monitor procedure derives the sun aspect for each ScW as the mean value of all records for the pointing at hand.
- Calibration event rate: the on-board calibration source emits simultaneously one photon at 1275 keV and two photons at 511 keV. Decay events (S5 data type) are accumulated pixel by pixel by the on-board calibration unit (OBCU) in 64 non-linear energy channels over ~ 1800 s integration time. Calibration event rate is computed from the total count over all energy channels and over the detector plane. The code analyzes:
  - count rate at calibration file level, that is on time intervals of ~ 1800 s.
  - mean revolution count rate: total counts over all calibration files inside each revolution divided by the total acquisition time.
- Calibration line positions: position of lines at 511 and 1275 keV are derived by a gaussian fit of the S5 channel spectrum. For both lines the code computes and visualizes:
  - line position at calibration file level (S5 channel unit).
  - line position at revolution level (S5 channel unit).
  - line position at pixel level: by integrating channel spectra pixel-by-pixel over successive revolutions until a $\chi^2_{red} < 1$ is reached for the gaussian fit. The smallest increment is one revolution.
- Energy resolution: computed as the FWHM (in channel unit) divided by the line position channel, after converting S5 channels to linear scale. As for line position, for both lines the code visualizes :
  - energy resolution at calibration file level (%).
  - energy resolution at revolution level(%).
  - energy resolution at pixel level(%).
- Gain and Offset: derived respectively as the slope and intercept of best line fit of line positions, after converting S5 channels to linear scale. The code inspects:
  - gain and offset derived for each calibration file.
  - revolution gain and offset.
  - revolution gain and offset: as derived by the total channel spectrum over all calibration files for each revolution.
  - gain and offset at pixel level.

Quantities at revolution level are computed in two ways: 1) as the average over calibration files in each revolution, and 2) from the total revolution channel spectrum, after integrating shadowgrams over calibration files in each revolution.

Furthermore, the dependence of the background rate on the temperature is inspected as well as the cross-correlation of the temperature with the sun aspect and of the gain with temperature and offset.

Temperature, attitude data and calibration event counts are read from housekeeping data while the background is obtained from the shadowgrams of scientific pointings and therefore needs the Off-line Scientific Analysis software (`OSA`) to be run before starting the monitoring application.

Because of the huge amount of data involved in the analysis even for a few revolutions sample, the basic idea underlying the code structure is first to have a quick look to the whole data sample, recognizing unexpected events, and second to extract only good quality data and inspect monitor parameters at detail. Therefore the monitoring program proceeds through the two main steps, specified in the next paragraphs. After compiling the main procedure, the monitoring program call is done in the `IDL` prompt by typing the command line

```
monitor,N1,N2,/keyword1,/keyword2,..,
```

N1 and N2 are the numbers for starting and ending revolutions of the range that the user wants to analyze. Allowed keywords are:

analyze, **cross**, **log**, **maps**, **pix** and **ps**.

By default the code returns after the first, reading phase so that the user can check data quality and, in the case, discard damaged. If the keyword **maps** is activated, shadowgram maps for single and multiple events are produced and zipped in groups of ten revolutions. When the keyword **analyze** is provided the code proceeds through the second step of the analysis and, adding the keyword **cross**, the mutual parameters dependence is visualized. The **log** keyword activates the lin-log plots for background count rate evolution. With the keyword **ps** plots are produced for the revolution mean quantities in both reading and analyzing phases. Besides postscript files containing plots of the parameters evolution, a number of ASCII files is produced in output, to summarize encountered problem and values for good quality data.

3.1.1 Part I: reading phase and shadowgram maps creation

During the fist part of the analysis, the code reads and checks the data sample, keeping trace of the main properties and possible errors. The content of each single revolution is summarized in two text files:

- ***rev_N.txt*** file (where N is the revolution number) for event counting and temperature measurements,
- ***gain_N.txt*** file for calibration data (S5 event type).

The ***rev_N.txt*** file contains, for revolution number N, information at ScW level (Tab.2). The file is structured in a table, with one raw for each ScW. The columns contain:

- identification number of the ScW,
- event type (e.g. Single Events, Multiples),
- number of killed pixels,
- exposure time (s),
- detector temperature (°C)
- sun aspect angle (°).

Moreover flags are provided to warn about specific unexpected events occurred during the analysis, such as corrupted files for counts or temperature, unexpected exposures, too many pixels with null count, not simultaneous acquisitions of temperature and counts.

For the same revolution the ***gain_N.txt*** file (Tab.3) contains, for each calibration file:

- file ID,
- the total count rate of calibration events (ct/s),
- peak position for the two calibration lines (expressed in non-linear S5 channels),
- gain (keV/ch) and offset (ch),
- energy resolution at the two peak energies (%).

The last line in the file gives the above quantities computed after integrating the S5 events over the whole revolution. Again coded errors mark corrupted files, acquisitions with bad exposure, errors during parameters calculation. The number of null and saturated pixels is also specified.

In both ***rev_N.txt*** and ***gain_N.txt*** files the last column, named **Usr_flag**, allows the user to manually exclude files for the following analysis. The flag has the default value of 1, but it should be changed to 0 for those files where the user would recognize problems, neglected by the analyzing procedure, or, more generally, to restrict the data sample.

At the end of the reading phase the ***summary.dat*** file is created, resembling all the averaged parameters in each revolution (see Tab.4). If the **ps** keyword is set the procedure plots, in the ***long.ps*** file, monitor parameters included in the ***summary.dat*** file as a function of the revolution number. More precisely the ***long.ps*** file contains the following plots:

- Temperature (°C),
- Single events count rate (ct/s),
- Singles without the first bin (ct/s),
- Singles for the second bin only (ct/s),
- Multiples (ct/s),
- Gain (keV/ch),
- Offset (ch),
- total S5 count rate (ct/s),
- Gain as a function of Offset an Temperature.

N.B: In this phase no fine quality selection is applied for the computation of the revolution mean parameters. More precisely:

- Concerning the background count rate, the procedure excludes empty or corrupted files and photon-by-photon mode acquisitions. Conversely no check is performed on the exposure and shadowgram maps.
- For the revolution average temperature empty or corrupted files are neglected.

- A more tight condition is applied to calibration files: filters are set to expunge files with null or saturated pixels spread over more than a quarter of the detector surface.

During this first step, the application produces maps of calibration S5 events superimposed to the channel spectrum (***gain_spectraN.ps***) and, if the keyword **maps** is set, maps of shadowgrams for single and multiple events (***S/MmappeN.ps***). These files are created for check purpose so that the user can directly verify data quality of every single file. If any corrupted file passed the quality filters applied by the procedure, the user should remove it for the subsequent analysis by setting the **Usr_flag** to 0 in the ***rev_N.txt*** and ***gain_N.txt*** files.

If the keyword **analyze** is not set, the process ends at this point.

3.1.2 Part II: analysis phase

With the keyword **analyze** the program reads again the data set, selecting only good files and neglecting files marked as bad in the ***rev_N.txt*** and ***gain_N.txt*** files. For background counts and temperature the procedure derives detailed information by reading again processed data and housekeeping archive, while values for calibration parameters are extracted from ***gain_N.txt*** files. Besides the coarse screening of the previous phase, data are filtered as follows:

- files for background counts marked by **Usr_flag** = 0 are neglected. Moreover count shadowgrams having too many null pixels (more than a quarter than the detector surface) are excluded as well as files with unexpected exposure, that is with the exposure differing for more that 300 s from the the elapsed time corrected by the dead time.
- For temperature analysis, files are restricted to those ScW with information on the solar angle. Furthermore ScWs are neglected having mean detector temperature lower than the parameter **min_of_temp**, defined in the main procedure. The threshold can be changed by editing the new value of **min_of_temp** in the `monitor.pro` file.
- Calibration events are restricted to files with **Error** set to 0, so that acquisitions with more than 100 null or saturated pixels are discarded, as well as those giving undefined parameters during the line fit and those giving second line peak in unexpected channel positions. Moreover the procedure discards acquisitions with **Usr_flag** set to 0.

Quantities are then plotted as a function of the ScW or of the S5 histogram number. When the analysis is performed on the revolution range $[N1, N2]$, plots are produced showing:

- count rate (ct/s) for Single and Multiple events, at ScW level, for each energy bin (in ***S/MrateN1_N2.ps*** files),
- temperature (°C), at ScW level, for each sensor (***TemperatureN1_N2.ps***),
- sun aspect angle in degrees (***SunAngleN1_N2.ps***) at ScWs level,
- total count rate of calibration events (in unit of ct/s), at single acquisition level, integrated over all channels (***GainsN1_N2.ps***),
- peak position, for each calibration file, of the two calibration lines in units of non-linear S5 channels (***GainsN1_N2.ps***),
- gain (keV/ch) and offset (ch) values at file level (***GainsN1_N2.ps***),
- energy resolution ($\Delta E/E$) at both lines for each calibration file (***GainsN1_N2.ps***),

- for both calibration lines, histogram of S5 file distribution with respect to the energy resolution (***GainsN1_N2.ps***), on the group of revolutions from N1 to N2,
- gain variation as a function of temperature and offset (***GainsN1_N2.ps***),

By adding the keyword **log**, logarithmic scale for count rate is imposed in the ***S/MrateN1_N2.ps*** plots.

If the keyword **cross** is activated, variables are also cross correlated. Plots are created containing:

- single and multiple events count rate variation (ct/s) against temperature variation (°C), for each energy bin (in ***S/MCrossN1_N2.ps*** files),
- temperature against solar aspect (***TCrossN1_N2.ps***).

The user can provide counts and temperature intervals, that are activated only for the counts/temperature and temperature/sun aspect cross-correlation analysis. These are set in the body of the main routine `monitor.pro`.

Finally, the mean quantities on each revolution are updated on the restricted sample of good files according to above filtering. As in the first part of the process, with the keyword **ps** averaged values are printed to file and plotted as a function of the revolution number.

If the keyword **pix** is set, the procedure computes gain, offset and energy resolution for both lines at pixel level. Calibration events are summed pixel by pixel until parameters are derived with acceptable fits (see Sec.5.2.13). The integration is performed across multiples revolution with a minimum increment of calibration counts of one revolution. When all quantities are computed with sufficient precision, the **gain_pix_N.txt** file is produced in the *Data* directory, where N is the last added revolution. The file contains the numbers of involved revolutions and calibration files and, for each pixel, position and energy resolution at both lines, gain and offset together with errors and the χ^2_{red} of the fitting procedures.

Maps for line position, energy resolution, gain, offset are given in **gain_maps_N_D.ps**, where N is the last added revolution and D is the number of revolutions required to obtain reasonable parameters precision. The same file gives also histograms for the distribution of each parameters.

3.2 Output

At the end of the run, the code has created a number of output files, listed below and summarized in Tab.1. It is important to remind that the user must create the folders *Data* and *Plots* before running the code.

The following scheme describes the output files obtained by the activation of different keywords:

- NO KEYWORD: After running the code without keywords, the user should find the following files:
  - in the *Data* directory:
    - one ***gain_N.txt*** file for each revolution (N stands for the revolution number),
    - one ***rev_N.txt*** file for each revolution and
    - the ***summary.dat***.
  - in the *Plots* directory:
    - one ***gain_spectraN.ps*** for each revolution,

OUTPUT				
Output file	Parent routine	Keyword	Directory	Notes
GainsN1_N2.ps	gain_analysis	analyze	Plots	one file for all revolutions in the range [N1,N2]
gain_N.txt	compute_gain		Data	one file for each revolution
gain_pix_N.txt	gain_pix	analyze, pix	Data	one file for revolutions up to N; the number of involved revolutions is variable.
gain_maps_N_D.ps	gain_pix	analyze, pix	Plots	one file for D revolutions up to revolution number N.
gain_rev.ps	longplot	ps	Plots	one file for all revolutions
gain_spectraN.ps	compute_gain		Plots	one file for each revolution
long.ps	longplot	ps	Plots	one file for the whole sample
long_updt.ps	longplot	ps, analyze	Plots	one file for the whole sample
rev_N.txt	read_rev		Data	one file for each revolution
S/MCrossN1_N2.ps	big_counts	analyze, cross	Plots	one file for all revolutions in the range [N1,N2]
S/McountsN.dat	big_counts	analyze	Data	one file for each revolution
S/MmappeN.ps	doing_maps		Plots	one file for each revolution
S/MrateN1_N2.ps	big_counts	analyze	Plots	one file for all revolutions in the range [N1,N2]
SunAngleN1_N2.ps	big_temp	analyze	Plots	one file for all revolutions in the range [N1,N2]
summary.dat	write_summary		Data	one file for the whole sample
summary_updtd.dat	write_summary	analyze	Data	one file for the whole sample
TCrossN1_N2.ps	big_temp	analyze, cross	Plots	one file for all revolutions in the range [N1,N2]
TemperatureN1_N2.ps	big_temp	analyze	Plots	one file for all revolutions in the range [N1,N2]

Table 1: Output files. The parent routine is given for each file together with the keyword activating the file creation and the directory where the file is stored.

  * one ***SmappeN.ps*** for each revolution and
  * one ***MmappeN.ps*** for each revolution.

  To save disc space, after 10 revolutions background maps are compressed and files ***ZS/MmappeR1_R2.tar.gz*** are created, where R1 and R2 are revolution numbers bracketing the decade.

- ANALYZE KEYWORD: When the code is run with the keyword **analyze**, in addition to the previous files, the following output is created:
  - in the *Data* directory:
    * one ***ScountsN.dat*** file for each revolution,
    * one ***McountsN.dat*** file for each revolution, and
    * the ***summary_updt.dat***.
  - in the folder *Plots* the following files are further created:
    * ***Gains_N1_N2.ps***,
    * ***Srate_N1_N2.ps***,
    * ***Mrate_N1_N2.ps***,
    * ***SunAngle_N1_N2.ps***,
    * ***Temperature_N1_N2.ps***.

REV_N.TXT	
Scw	ScW ID
Counts	type of events in the ScW (S = singles, M = multiples, All, None, PPM)
err	0 = no errors detected in reading counts, +1 = error in opening shadowgram file, +2 = error in opening efficiency file, +4 = unexpected number of energy bins, +10 = unexpected counts file dimension, +20 = unexpected acquisition mode. Note that error codes are additive .
Killed	number of killed pixels
Null_pix	= 1 if the number of null pixels is grater than 1024 for single or multiples events, at least in one energy bin; = 0 otherwise
ExpS	exposure time for Single Events
ExpM	exposure time for Multiple Events
Bad_expS	= 1 if the difference between exposure time for single events and elapsed time × dead time is greater than 300 s; = 0 otherwise
Bad_expM	same as Bad_expS, but for Multiple Events
Terr	= 0 no errors detected in reading temperature, = 1 error in opening file for temperature, = 5 NaN found in reading temperature
Temp	mean detector Temperature, averaged on all sensors and records
Tstd	standard deviation of temperatures at sensor level
T_C	= 0 if the start and end time for counts and temperature differ for more than 100 s; = 1 otherwise
Sun_asp	mean sun aspect angle of the ScW (in degrees); from the attitude files, values are selected to match the ScW ID and pointing mode
Sstd	standard deviation of sun aspect values
N-sa	number of values of attitude matching conditions of column Sun_asp
Usr_flag	= 1 default

Table 2: Scheme of the ***rev_N.txt*** file

One file is produced for the revolution group from revolution number N1 revolution number N2, up to a maximum of a fixed number of revolutions, set in the code by the parameter **delta_revmax**. The input revolution sample is divided in groups of **delta_revmax** and plots are produced for each group. At present **delta_revmax** is set to 50 and different size of the group can be chosen by editing the main routine.

- CROSS KEYWORD: If the keyword **cross** is added to **analyze**, also ***SCross_N1_N2.ps***, ***MCross_N1_N2.ps*** and ***TCross_N1_N2.ps*** are created in the directory *Plots*.
- PS KEYWORD: If the keyword **ps** is set, also the files ***long.ps***, with no other keyword, and ***long_updt.ps***, with the keyword **analyze**, are created in the *Plots* directory.
- PIX KEYWORD: If the keyword **pix** is added to **analyze**, the ***gain_pix_N.txt*** files are created in the directory *Data* and the ***gain_maps_N_D.txt*** files are created in the directory *Plots*.

In the following a description of each output file is given and examples can be found in the next section (Sec.3.3). Ordered by creation time, output files are:

GAIN_N.TXT	
File	(part of) number of *picsit_raw_cal_#* calibration file
Error	1 = empty or corrupted file
	2 = bad acquisition time
	3 = number of null/saturated pixel grater than 1024
	4 = errors in the fitting procedure for the first line
	5 = errors in the fitting procedure for the second line
	or unexpected second line position
	6 = no convergence in the second line fitting
	7 = errors in the gain and offset fitting procedure
	0 = otherwise.
Badpix	number of saturated or null pixels
Time	integration time of the calibration file
S5	rate of calibration events.
Pos1	channel position (in non linear units of S5 channels) of the 511 keV line peak;
	computed by gaussian fit around the peak
errPos1	fit error of Pos1
Pos2	channel position (in non linear units of S5 channels) of the 1275 keV line peak;
errPos2	same as errPos1 for the second line
Gain	gain at calibration file level (∼ScW); computed by simple linear fit
errGain	error on gain from the linear fit
Offset	offset at calibration file level; derived from the above linear fit
errOff	error on offset from the linear fit
EnRes1	energy resolution at the 511 keV line;
	computed from the FWHM of the best fit gaussian
errER1	fit error of EnRes1
EnRes2	same as EnRes1 for the second line
errER2	same as errER1 for the second line
U_flag	1 default

Table 3: Scheme of the ***gain_N.txt*** file

- ***rev_N.txt***: one file for each revolution created by the `read_rev` function in the *Data* directory. Referring to revolution number N the file contains information at ScW level for counts and temperatures (see Tab.2 for details and Tab.5 for an example). The event type (**Counts**) is read from the ***swg_ibis.fits*** file and the number of killed pixels (**Killed**) from the efficiency map. The number of pixels with null counts (**Null_pix**) is derived from the shadowgrams in the ***picsit_detector_shadowgram.fits*** file and the exposure times (**ExpS** and **ExpM**) for single and multiple events, respectively, is derived from the header of the first extension for singles and multiples of the ***picsit_detector_shadowgram.fits*** file. The exposure time is compared with the elapsed time of the pointing, corrected by the dead time. A difference greater than 300 s may indicate errors in the computation of the exposure time and the observation is marked with the **Bad_exp** flag. Temperature is derived from the ***ibis_mce.fits*** file. The temperature at each sensor is computed averaging on all acquisitions made during the pointing and the ScW temperature (together with the standard deviation) is then calculated as the mean value of temperatures at sensor level. An error is returned (**Terr**) for empty or corrupted files and if any temperature record is an undefined number. For ScWs with error code grater than 0 no values for temperature (**Temp**) are reported. To allow cross correlation in the following analysis, the keyword **T_C** gives a check on the simultaneity of counts and temperature acquisitions. When this flag is 1 the start and the end time of counts acquisition differ less than 100 s from the corresponding time boundaries of temperature acquisition. The sun aspect is the mean of the **N-sa** values, read from the ***attitude_historic.fits*** file for the pointing at hand. The standard deviation of these values is given for checking purpose, since the attitude is expected not to vary during

SUMMARY.DAT		
Header and General	Rev	revolution number
	Nfile	total number of ScWs in the revolution
	NfS	number of ScWs for Single Events
	NfM	number of ScWs for Multiple Events
	NfT	number of ScWs for Temperature
	Ng	total number of calibration files (S5 histograms)
	GoodG	number of not empty calibration files and with number of null pixels lower than 1024
Count Rate	S	revolution average count rate for Single Events Counts are integrated on all energy bands and all ScWs and then divided by the total revolution exposure time (sum of all ScW exposures)
	Smin	minimum Single Event count rate at ScW level
	Smax	maximum Single Event count rate at ScW level
	S1	same as S but without the first energy bin
	S1min	same as Smin without the first energy bin
	S1max	same as Smax without the first energy bin
	S2	revolution average count rate for single events in the second bin only
	S2min	same as Smin for the second bin only
	S2max	same as Smax for the second bin only
	M	same as S for Multiple Events
	Mmin	same as Smin for Multiple Events
	Mmax	same as Smax for Multiple Events
Temperature	T	revolution average Temperature Sum of detector mean temperatures at ScW level divided by NfT
	Tmin	minimum of detector mean temperatures at ScW level
	Tmax	maximum of detector mean temperatures at ScW level
Gain and Offset	Gain	mean value of gains computed at calibration file level
	GMin	minimum gain at calibration file level
	GMax	maximum gain at calibration file level
	Offset	mean value of offsets computed for each calibration file
	OfMin	minimum offset at calibration file level
	OfMax	maximum offset at calibration file level
Channel position	Pos1	mean value of channel positions for the 511 keV line at calibration file level
	MinPos1	minimum 511 keV channel position at calibration file level
	MaxPos1	maximum 511 keV channel position at calibration file level
	Pos2	same as Pos1 for the 1275 keV line
	MinPos2	same as MinPos1 for the 1275 keV line
	MaxPos2	same as MaxPos1 for the 1275 keV line
Energy Resolution	EnRes1	mean value of energy resolution at the 511 keV line
	MinERes1	minimum energy resolution at 511 keV computed at calibration file level
	MaxERes1	maximum energy resolution at 511 keV computed at calibration file level
	EnRes2	same as EnRes1 for the 1275 keV line
	MinERes2	same as MinERes1 for the 1275 keV line
	MaxERes2	same as MaxERes1 for the 1275 keV line
Calibration Histograms	S5t	total S5 counts divided by the sum of acquisition times
	MinS5	minimum of S5 count rate at calibration file level
	MaxS5	maximum of S5 count rate at calibration file level

Table 4: Scheme of the ***summary.dat*** file.

each scientific pointing. The **Usr_flag** has the default value 1 and should be edited to 0 to neglect any ScW (discarding both temperatures and counts).

It is important to note that the ***rev_N.txt*** file is created as new every time the ***summary.dat*** file is not existing or does not contain information on revolution N.

- ***gain_N.txt***: one file for each revolution created by `compute_gain` procedure in the *Data* directory. Different lines, for different calibration files, describe information for S5 counts and derived quantities (see Tab.3 for details and Tab.6 for an example). Calibration events are read from ***picsit_raw_cal*** files. In the first line of the ***gain_N.txt*** file, the total number of calibration files is given for revolution N and the **File** column gives the ID of each file. The error code **Error** is set to 1 if the file is empty or corrupted, 2 for null acquisition time of calibration data, 3 if more than a quarter of the detector surface has null or saturated pixels, 4 if the line fitting procedure around the first line returns undefined numbers, 5 if the best fit parameters for the second line include undefined numbers or if the second line position falls out of the [43,62] channel range, 6 if no convergence is achieved during the second line fit, 7 if the gain and offset fitting procedure returns undefined numbers, and 0 otherwise. For calibration files with error codes $\neq 0$ no parameters are reported. For checking purpose the number of null or saturated pixels is given in column **BadPix** and the integration time in column **Time**. Events counts are summed over all pixels and channels and the total counts divided by the integration time is written in column **S5**. Then calibration events are accumulated channel-by-channel over all detector pixels to produce the channel spectrum at file level. Channel position of both calibration lines is computed by a gaussian fit around each peak (background subtraction is performed by a polynomial). For the two calibration lines the best fit centroids (**Pos**) together with errors (**errPos**) are given in units of non-linear S5 energy channels. Energy resolution (**EnRes**) at each line is computed as ΔE/E from the Full Width at Half Maximum (FWHM) and the line centroid derived from the gaussian fit. Errors (**errER**) are obtained by fit parameters as well. **Gain** and **Offset**, with errors **errGain** and **errOff**, are straightforwardly computed by linear fit of the known energy of the two lines and their channel position, after converting the latter in linear energy-channel scale. The **Usr_flag** has the default value 1 and should be edited to 0 to neglect singles calibration files.

  No check on the existence of the file ***gain_N.txt*** is made, that is the file is created as new when the ***summary.dat*** file is not existing.

  The last line, named **Total**, contains the same quantities computed after integrating all calibration events over the whole revolution.

- ***summary.dat***: created by the `write_summary` procedure in the *Data* directory. One file for the whole data sample is produced. The header gives the number of analyzed revolutions and the number of both starting and final revolutions. The file summarizes for each revolution the average values of the key monitoring parameters (see Tab.4; see also the example in Tab.7) as derived from the first step of the main program, that is without a full screening of data quality. More precisely, averaged parameters are computed during the reading phase, using values that have error codes = 0 in the ***rev_N.txt*** and ***gain_N.txt*** files. For background count rate analysis only empty, corrupted ScWs and acquisitions not in Standard Mode are neglected (corresponding to **err**$\neq$ 0 in the ***rev_N.txt***), while bad exposure or partially downloaded histograms are included (see below). Analogously for temperature all files but empty/corrupted are considered (**Terr**= 0). Calibration files are neglected when empty, when more than a quarter of the detector surface has null or saturated counts and for errors during fitting procedures (**Error**= 0).

  For each revolution, whose number is written in the column **Rev**, the code annotates the total number of scientific pointings (ScW) in column **Nfile** and the total number of calibration acquisitions in column **Ng**. The number of files that have passed the coarse filtering of the reading phase (see previous section) is given in columns **NfS** and **NfM** for single and multiple events respectively, **NfT** for temperature and **GoogG** for calibration events. The revolution mean background rate for single events **S** is obtained by integrating counts over all pixels, energy bins and over the **NfS** ScWs and dividing the total counts for the total exposure time, integrated over the **NfS** ScWs. Columns **Smin** and **Smax**, respectively, give the minimum and maximum of the background rates computed at ScW level.

Analogue quantities are given in columns **S1** and **S2** respectively for background rate computed neglecting the first energy bin and considering the second bin only. The column **M** gives the revolution mean count rate for multiple events, computed as above. The means revolution temperature **T** is the average over the NfT temperature values computed at ScW level. Again **Tmin** and **Tmax** give the maximum and minimum of the NfT acquisitions. Analogously, **Gain**, **Offset**, lines position and resolution are computed as the mean value over the **GoodG** values. Revolution mean count rate (**S5**) of calibration events is the total counts over all pixels an channels and over the **GoodG** calibration files, divided by the integrated acquisition time.

If the file ***summary.dat*** has been previously created, it is updated during subsequent run on consecutive revolution intervals.

Warning: the file must contain all consecutive revolutions between the starting and the final ones.

- ***S/Mmappe_N.ps***: created by the `doing_maps` procedure in the *Plots* directory. For each revolution, one file for Single and one for Multiple Events contain shadowgram maps at ScW level. Images are produced for each non-empty ScW in the revolution number N, with parameters **Usr_flag** = 1 in the ***rev_N.txt*** file. Images for all energy bands are ordered in rows, labeled by the ScW ID (e.g. Fig.1). Moreover, the last plot of the file gives the map for the total counts over revolution N. In order to save computational time these files are created only once.

- ***gain_spectraN.ps***: created by `compute_gain` function for each revolution in *Plots* directory. This file includes plots of the channel spectrum and shadowgram maps for each calibration file. In each plot the upper maps correspond to channel integrated counts around the 511 keV (left) and the 1275 keV (right) peak. More precisely counts are integrated over S5 channels: [10,16] for the first line and [42,53] for the second line. The lower map refers to counts integrated over all channels (e.g. Fig.2).

- ***long.ps***: created by `longplots` function in *Plots* directory. One file for the whole data set, it comprises plots of all quantities of the ***summary.dat*** file, in order to visualize the long term variability of monitoring parameters (see Fig.3-5). It is worth reminding that no data quality selection is done at this step.

- ***gain_rev.ps***: created by `longplots` function in *Plots* directory. One file for the whole data set, it comprises plots for gain, offset and energy resolution at both lines as they are read from the **gain_N.txt** files and therefore computed after integrating calibration events over each revolution.

- ***Gains_N1_N2.ps***: the file is created if the keyword **analyze** is set by the `gain_analysis` function in the *Plots* directory. This file includes plots showing gain and related quantities at single calibration file level (see Fig.9-10). For all revolutions between N1 and N2, up to a maximum of **deltarev_max** (default = 50), S5 total rate, peak position and energy resolution for the two calibration lines, gain and offset are plotted as a function of the calibration file number. All quantities are selected from the ***gain_N.txt*** files according to the filtering applied to the second step of the program. Gain is also plotted as a function of offset and temperature. Moreover histograms showing the distribution of the S5 files with the energy resolution are given for both calibration lines.

- ***S/Mrate_N1_N2.ps***: the file is created if the keyword **analyze** is set by the `big_counts` function in *Plots* directory. It shows count rate for single/multiple events in each energy bin as a function of the ScWs number, for all revolutions between N1 and N2 (see Fig.7), up to a maximum of **deltarev_max** revolutions (default = 50). Counts are read from ***picsit_detector_shadowgram*** files after the data sample is cleaned from those files marked as bad in the ***rev_N.txt*** (**err**, **Null_pix**, **Bad_expS/M**, **Usr_flag**).

- ***S/McountsN.dat***: the file is created if the keyword **analyze** is set by the `big_counts` function in *Data* directory. This text file gives counts and exposure at ScW level, for all pointings in the revolution number N without error labels in the ***rev_N.txt*** (that is **err**=0, **Null_pix**=0, **Bad_expS/M**=0 and **Usr_flag**=1). These values are visualized in the previous plots.

- ***S/MCross_N1_N2.ps***: the file is created if the keywords **analyze** and **cross** are set by the `big_counts` function in the *Plots* directory. It shows (see the example given in Fig.11, upper panels) the count rate variation as a function of the temperature variation with respect to mean values computed on the revolution range between N1 and N2 (up to a maximum of **deltarev_max**). The figure contains 8 plots, one for each energy band, where every point represents a ScW. Counts are read from ***picsit_detector_shadowgram*** files after sample cleaning. Temperature are read from ***rev_N.txt*** files. Only files labeled with the flag **T_C** = 1 in the ***rev_N.txt*** are considered: these in fact are files with almost simultaneous acquisition of counts and temperature. Mean values for rate and temperature are reported in each plot. Different ranges for counts and temperature can be defined in the main routine to optimize the parameter intervals where exploring the correlation. Interval limits are defined in the `monitor.pro` procedure by variables **u_smin**, **u_smax**, **u_mmin**, **u_mmax**, **u_tmin**, **u_tmax**. Note that these boundaries are activated only for the visualization on the counts/temperature and temperature/sun aspect dependence and not for single variables inspection.

- ***Temperature_N1_N2.ps***: the file is created if the keyword **analyze** is set by the `big_temp` function in the *Plots* directory. Temperatures, recorded at each sensor, are plotted as a function of ScW number, for all revolutions between revolution number N1 and N2, up to a maximum of **deltarev_max** (default = 50) revolutions (see Fig.8). Different colors correspond to different modules (4 sensors per module). Temperature values at each sensor are read from the ***ibis_mce.fits.gz*** file, neglecting ScWs that have no sun aspect records and with **Terr** $\neq 0$ in the ***rev_N.txt*** files. Moreover the file gives histograms for temperature distribution at each sensor and module.

- ***SunAngle_N1_N2.ps***: the file is created if the keyword **analyze** is set by the `big_temp` function in *Plots* directory. Sun aspect is plotted as a function of the ScW number, for all revolutions between N1 and N2, up to a maximum of **deltarev_max** (default = 50) revolutions (see Fig.8). Values are read from ***rev_N.txt*** files.

- ***TCross_N1_N2.ps***: the file is created if the keywords **analyze** and **cross** are set by the `big_temp` function in *Plots* directory. The figure (see the example given in Fig.11, lower panel) shows the temperature of the first sensor as a function of the sun angle. Only one sensor is shown since thermistors are calibrated to temperature variation but they have different offset. Variables are read from ***rev_N.txt*** files for all the revolutions between N1 and N2, up to a maximum of **deltarev_max** (default =50). Temperature values are restricted to the same range [**u_tmin**, **u_tmax**] defined for the counts-temperature cross-correlation (see the description above for the ***S/MCross_N1_N2.ps*** file).

- ***summary_updt.dat***: created if the keywords **analyze** is set by the `write_summary` procedure in the *Data* directory. The same as ***summary.dat*** with updated values on the error-checked data sample. Note that constraints set on counts an temperatures to investigate their correlation do not intervene at this step and they do not influence the updated averaged quantities.

- ***long_updt.ps***: created if the keyword **analyze** is set by the `longplot` procedure in *Plots* directory. The same as ***long.ps*** with the updated values stored in the ***summary_updt.dat*** file.

- ***gain_pix_N.txt***: created if the keywords **analyze** and **pix** are set by the `gain_pix` procedure in the *Data* directory. The file contains position and energy resolution at both calibration lines, gain and offset, computed for each pixel. These quantities are derived integrating calibration spectra over consecutive revolutions until the $\chi^2_{red} < 1$ is obtained in the second line fit at pixel $(0, 0)$. N gives the final revolution involved in the integration.

Scw	Counts	err	Killed	Null_pix	ExpS	ExpM	Bad_expS	Bad_expM	terr	Temp	Tstd	T_C	Sun_asp	SunStd	N-sa	Usr_flag
00000020	None	20	0	0	0.00	0.00	0	0	0	-18.12	12.11	0	86.50	0.0	1	1
00010010	None	20	0	0	0.00	0.00	0	0	0	-6.08	4.40	0	61.10	0.0	24	1
00020010	None	6	0	0	0.00	0.00	0	0	0	-2.35	2.16	0	61.10	0.0	2	1
00030010	S	0	51	0	2167	0.00	0	0	0	-1.27	1.52	1	64.00	0.0	3	1
00040010	S	0	51	0	2167	0.00	0	0	0	-0.42	1.13	1	67.20	0.0	4	1
00050010	None	4	0	0	0.00	0.00	0	0	0	0.31	0.86	0	70.50	0.0	3	1
00060010	S	0	51	0	2167	0.00	0	0	0	0.97	0.68	1	74.10	0.0	1	1
00070010	All	0	51	0	2167	2167	0	0	0	1.56	0.59	1	77.70	0.0	3	1
00080010	M	0	51	0	0.00	2167	0	0	0	2.08	0.54	1	83.60	0.0	1	1
00090010	All	0	51	0	2167	2167	0	0	0	2.54	0.53	1	89.50	0.0	73	1
00100010	All	0	51	0	2167	2167	0	0	0	2.95	0.54	1	95.40	0.0	1	1
00110010	None	4	0	0	0.00	0.00	0	0	0	3.30	0.55	0	101.20	0.0	1	1
00120010	All	0	51	0	2303	2303	0	0	0	3.60	0.56	1	107.10	0.0	7	1
00130010	M	0	51	0	0.00	2167	0	0	0	4.00	0.58	1	113.00	0.0	1	1

Table 5: Beginning of the **rev_36.txt** file.

121																	
File	Err	Bad_pix	Time	S5	Pos1	errPos1	Pos2	errPos2	Gain	errGain	Offset	errOff	EnRes1	errER1	EnRes2	errER2	U_flag
20030201062443	0	53	1800	71.79	12.397	0.040	45.088	0.270	7.388	0.019	-26.69	1.49	17.223	0.257	9.826	2.159	1
20030201065451	0	53	1800	71.88	12.537	0.001	45.591	0.342	7.338	0.024	-25.25	1.76	17.755	0.006	10.767	2.723	1
20030201072459	0	53	1800	70.84	12.608	0.001	45.837	0.239	7.314	0.017	-24.52	1.23	17.284	0.006	9.911	1.809	1
20030201075508	0	53	1800	70.84	12.643	0.028	47.585	0.677	7.082	0.044	-7.99	3.28	17.132	0.144	6.230	5.779	1
20030201082518	0	53	1800	70.82	12.752	0.027	46.214	0.277	7.281	0.019	-24.22	1.45	17.924	0.138	11.385	2.192	1
20030201085526	0	53	1801	70.56	12.874	0.039	46.312	0.382	7.285	0.027	-26.23	2.01	17.684	0.247	12.315	3.099	1
20030201092535	0	53	1800	70.36	13.019	0.027	46.749	0.282	7.244	0.019	-25.35	1.48	17.569	0.139	10.350	2.099	1
20030201095543	0	66	1800	70.60	12.974	0.045	46.553	0.264	7.265	0.018	-26.26	1.46	17.896	0.381	9.336	1.908	1
20030201102551	0	66	1800	69.77	13.115	0.040	46.785	0.274	7.253	0.019	-27.35	1.49	17.369	0.254	10.874	2.108	1
20030201105600	0	53	1800	70.33	13.174	0.011	47.277	0.323	7.194	0.022	-23.83	1.62	18.061	0.050	10.817	2.460	1
20030201112609	0	53	1800	69.49	13.240	0.012	47.610	0.281	7.158	0.019	-22.09	1.41	16.983	0.055	9.651	2.025	1
20030201115618	0	66	1800	69.24	13.161	0.028	47.454	0.268	7.168	0.018	-21.74	1.39	17.710	0.145	9.829	1.978	1
20030201122626	0	66	1800	69.50	13.340	0.004	47.492	0.247	7.187	0.017	-25.75	1.25	17.470	0.018	9.606	1.764	1
....																	
TOTAL 121	0	52	212404	71.95	14.07	0.026	49.870	0.266	6.970	0.017	-19.67	1.33	17.498	0.132	9.586	1.959	1

Table 6: Example of the ***gain_37.txt*** file.

- ***gain_maps_N_D.txt***: created if the keywords **analyze** and **pix** are set by the `gain_pix` procedure in the *Plots* directory. The file contains detector maps for position and energy resolution at both calibration lines, gain and offset. Histograms show the distribution of these quantities in the revolution sample.
- ***Log_file.txt***: log file, continuously updated at each run by all routines. For check purpose, the file keeps memory of the run status, such as the analyzed revolution, the number of files for each acquisition mode, the name of bad files, etc.

3.3 Examples and Results

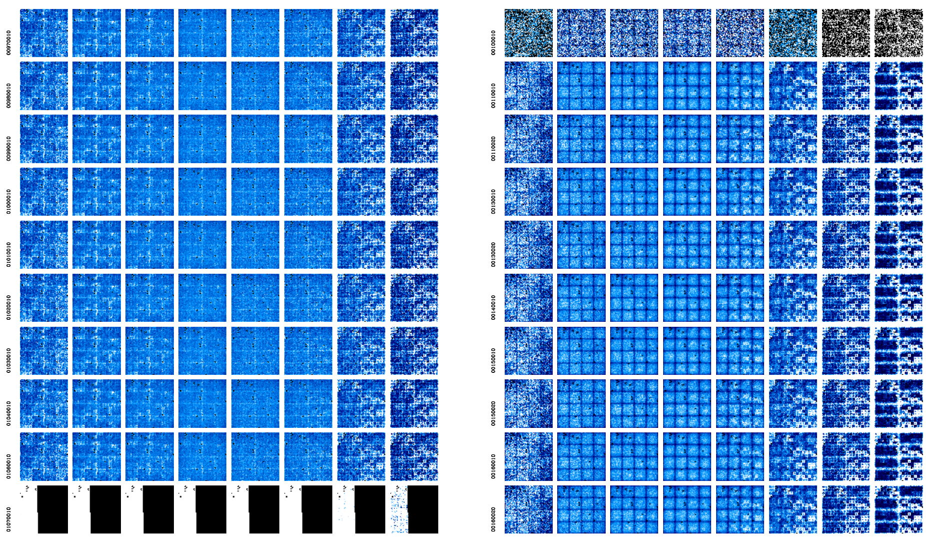

Figure 1: Example of files ***Smappe_47.ps*** (left) and ***Mmappe_42.ps*** (right)

N rev	From	To																			
650	36	685																			
Rev	Nfile	NfS	NfM	NfT	Ng	GoodG	S	Smin	Smax	S1	S1min	S1max	S2	S2min	S2max	M	Mmin	Mmax	T	Tmin	Tmax
36	98	23	30	98	121	121	2236.23	2197.40	2543.68	1613.41	1587.56	1814.94	474.26	460.51	578.94	611.55	593.94	627.44	3.55	-18.12	5.22
37	99	24	26	99	121	118	2232.12	2194.33	2377.83	1613.38	1587.37	1703.05	455.83	440.52	522.47	616.60	321.95	654.10	7.63	-18.38	11.59
38	69	13	18	69	79	75	2330.37	2313.61	2415.31	1689.90	1682.17	1739.22	481.27	467.74	543.38	676.24	645.22	689.55	5.86	-25.00	11.16
39	44	20	22	44	57	56	2352.67	2342.58	2367.29	1697.38	1690.42	1707.06	493.65	491.65	498.99	647.52	642.29	651.05	5.09	4.67	5.40
40	47	8	4	46	50	50	2319.44	2304.00	2347.47	1672.55	1661.18	1688.39	485.49	480.93	493.65	637.75	636.66	639.79	2.99	-100.00	5.38
41	55	6	5	55	120	119	2306.87	2298.59	2334.65	1663.00	1655.99	1682.83	483.65	479.91	492.38	636.45	633.33	639.82	4.97	4.51	5.32
42	55	47	41	54	113	113	2258.03	2206.69	2301.01	1628.58	1591.17	1649.03	472.59	459.17	479.55	622.56	609.31	631.62	3.38	-100.00	5.54
43	91	63	65	91	121	120	2033.89	1107.92	2231.43	1470.05	797.05	1606.76	427.44	231.54	468.22	568.06	405.14	612.81	5.19	4.69	5.32
44	98	69	73	97	120	116	2256.14	2230.04	2353.74	1624.58	1612.71	1687.50	473.44	470.34	505.54	618.85	610.89	628.79	3.90	-100.00	5.12
45	99	70	61	99	121	121	2253.21	1140.92	2299.72	1623.00	821.45	1656.24	473.04	239.86	484.12	626.07	622.55	630.07	4.76	4.30	4.94
46	95	65	64	95	107	107	2261.05	1147.38	2306.72	1630.60	827.36	1662.02	464.49	235.49	477.46	647.09	633.37	651.85	7.38	5.29	7.97
47	118	82	85	117	121	114	2306.16	836.98	2477.22	1661.12	605.74	1772.72	479.77	175.46	541.65	636.28	0.00	651.92	5.02	-100.00	6.30
48	99	74	73	99	122	122	2314.80	2305.16	2333.36	1669.54	1663.22	1680.48	474.66	465.49	486.87	656.24	634.80	673.34	7.96	4.75	10.31
49	98	65	58	97	99	94	2300.99	2275.66	2317.30	1656.52	1639.71	1667.26	476.87	462.99	482.36	639.50	632.02	652.62	5.60	-100.00	8.96
50	106	66	63	105	124	119	2281.72	1164.57	2347.51	1642.46	837.48	1688.91	473.63	241.85	491.21	642.37	493.10	648.93	5.12	-100.00	7.19
51	106	74	71	105	120	117	2304.23	2285.66	2333.37	1658.81	1645.38	1678.25	481.17	472.17	492.08	635.79	617.10	652.51	4.79	-100.00	8.67
52	92	37	39	92	91	86	2323.03	2236.65	2652.32	1673.02	1608.12	1908.54	476.44	459.12	630.53	660.97	625.84	689.96	9.15	6.55	11.06
53	114	76	81	114	120	118	2276.48	1150.51	2365.27	1636.45	824.53	1698.12	476.99	240.73	497.04	631.05	621.90	646.67	5.14	4.75	6.96
54	107	68	64	107	112	103	2326.92	2305.46	2385.82	1673.23	1661.60	1716.56	482.63	477.11	501.59	645.95	638.64	656.20	6.12	5.41	7.04
55	94	64	68	94	122	121	2306.25	2261.75	2374.68	1660.16	1644.54	1706.04	484.90	475.02	508.03	631.45	629.16	635.67	4.85	4.35	6.79
56	117	79	82	116	121	118	2272.56	2246.49	2604.31	1634.37	1619.53	1864.66	469.61	462.81	587.91	633.99	625.02	656.72	5.84	-100.00	8.02
57	101	71	74	101	122	122	2277.33	1157.17	2389.68	1638.47	831.40	1720.97	474.63	239.93	506.79	638.62	625.03	657.29	5.73	4.67	6.49
58	98	65	73	96	121	120	2298.37	2264.53	2443.32	1653.84	1640.58	1764.48	479.29	471.69	509.31	635.31	628.27	673.10	3.55	-100.00	6.48
59	102	70	81	100	122	120	2286.31	2243.44	2381.77	1643.87	1612.47	1710.41	476.48	468.22	503.67	632.78	616.40	650.98	4.04	-100.00	7.07
60	106	74	76	105	117	114	2227.10	2214.70	2257.42	1599.96	1591.25	1620.10	467.64	465.30	473.14	608.12	602.12	615.02	3.87	-100.00	5.19

(Rev)	Gain	GMin	GMax	Offset	OfMin	OfMax	Pos1	MinPos1	MaxPos1	Pos2	MinPos2	MaxPos2	EnRes1	MinERes1	MaxERes1	EnRes2	MinERes2	MaxERes2	S5t	MinS5	MaxS5
(36)	7.10	6.98	7.33	-22.21	-29.17	-13.11	13.54	12.49	13.72	48.32	45.67	49.24	17.72	15.54	19.13	9.79	8.26	11.58	71.07	59.88	73.93
(37)	6.99	6.85	7.39	-20.75	-27.43	-7.99	14.04	12.39	14.61	49.69	45.09	51.29	17.24	15.81	18.77	9.43	6.30	12.45	71.95	63.70	73.71
(38)	6.97	6.82	7.17	-20.54	-26.44	-11.78	14.11	13.28	14.47	49.90	47.58	51.31	17.16	15.87	19.16	9.31	7.76	11.32	71.21	33.86	72.95
(39)	7.09	7.00	7.17	-21.72	-28.84	-13.82	13.59	13.46	13.78	48.51	47.90	49.11	17.87	16.88	19.62	9.66	5.00	12.08	68.61	57.45	69.72
(40)	7.06	6.98	7.11	-20.87	-24.18	-12.76	13.64	13.54	13.84	48.72	48.30	49.31	17.77	16.92	18.93	9.68	8.43	11.45	68.41	55.90	69.40
(41)	7.08	6.96	7.20	-21.47	-29.58	-12.34	13.59	13.45	13.77	48.52	47.56	49.46	17.74	16.07	19.07	9.76	5.19	11.55	68.21	44.67	69.68
(42)	7.07	6.99	7.16	-21.20	-28.46	-15.51	13.63	13.49	13.85	48.66	48.02	49.46	17.77	15.81	19.28	9.80	4.91	11.63	69.49	56.93	70.90
(43)	7.08	6.98	7.21	-21.83	-31.09	-12.12	13.62	13.49	13.79	48.57	47.54	49.25	17.78	16.25	19.64	9.70	7.11	11.34	70.00	48.66	71.31
(44)	7.09	6.98	7.18	-21.68	-29.15	-13.03	13.58	13.44	13.70	48.48	47.83	49.25	17.69	16.42	19.47	9.77	7.93	11.67	69.64	64.43	70.43
(45)	7.09	6.97	7.18	-21.69	-28.70	-12.91	13.56	13.43	13.69	48.44	47.81	49.35	17.79	16.46	19.26	9.75	4.67	11.75	69.12	60.75	69.83
(46)	7.02	6.95	7.19	-21.68	-35.19	-16.63	13.93	13.64	14.10	49.32	48.08	49.97	17.49	15.97	19.53	9.47	3.39	11.68	69.97	62.52	71.02
(47)	7.05	6.93	7.13	-21.23	-26.99	-14.34	13.75	13.62	14.02	48.94	48.31	50.02	17.64	16.12	19.40	9.72	8.45	11.47	67.41	53.25	71.98
(48)	6.99	6.42	7.12	-19.87	-27.03	20.00	14.00	13.48	14.36	49.69	48.19	54.81	17.48	15.56	19.36	9.52	7.90	15.17	69.83	66.49	72.72
(49)	7.04	6.93	7.13	-21.38	-26.93	-15.11	13.79	13.57	14.34	49.03	48.22	50.26	17.72	16.58	19.35	9.67	8.12	11.86	68.10	53.45	71.04
(50)	7.05	6.94	7.16	-21.27	-30.21	-14.51	13.77	13.58	13.96	48.98	48.17	49.91	17.61	14.38	18.96	9.70	5.28	11.43	68.50	44.40	70.16
(51)	7.05	6.90	7.14	-21.02	-26.13	-12.84	13.71	13.49	14.26	48.86	48.13	50.36	17.62	16.26	19.36	9.65	7.75	12.41	67.68	35.31	70.59
(52)	6.96	6.84	7.11	-20.84	-28.10	-13.19	14.23	13.84	14.49	50.14	48.55	51.21	17.36	16.12	19.77	9.18	7.74	11.41	70.84	55.17	75.20
(53)	7.08	7.00	7.18	-21.75	-29.10	-15.05	13.62	13.47	13.93	48.58	47.82	49.36	17.81	16.13	19.58	9.61	3.67	12.60	68.13	53.16	70.07
(54)	7.06	6.96	7.92	-22.14	-91.48	-13.44	13.75	13.57	14.01	48.86	43.22	49.61	17.69	16.01	19.57	9.83	7.87	32.15	67.04	4.45	70.31
(55)	7.09	7.03	7.16	-21.91	-27.85	-16.54	13.57	13.42	13.79	48.43	47.84	49.05	17.78	16.24	20.02	9.76	7.92	11.62	68.02	54.03	69.25
(56)	7.03	6.95	7.15	-21.47	-28.37	-15.24	13.85	13.60	14.11	49.17	48.10	49.96	17.59	16.13	19.04	9.63	8.05	12.13	68.41	52.82	71.47
(57)	7.06	6.98	7.17	-21.66	-29.76	-14.14	13.70	13.50	14.02	48.78	47.78	49.45	17.69	16.30	19.19	9.65	3.91	12.72	68.60	66.00	69.82
(58)	7.07	6.96	7.17	-21.68	-28.23	-13.68	13.68	13.46	13.86	48.71	47.80	49.61	17.76	16.05	18.99	9.71	5.00	12.71	68.51	67.50	69.65
(59)	7.05	6.96	7.13	-21.52	-30.03	-15.26	13.75	13.58	13.99	48.92	48.27	49.76	17.68	16.16	19.30	9.56	7.85	12.24	68.49	55.85	69.86
(60)	7.10	6.98	7.19	-22.22	-30.09	-15.34	13.57	13.39	13.87	48.41	47.69	49.38	17.77	16.55	19.87	9.72	8.26	11.58	68.55	53.60	69.85

Table 7: Part of the ***summary.dat*** file. For sake of simplicity the file is split in two tables.

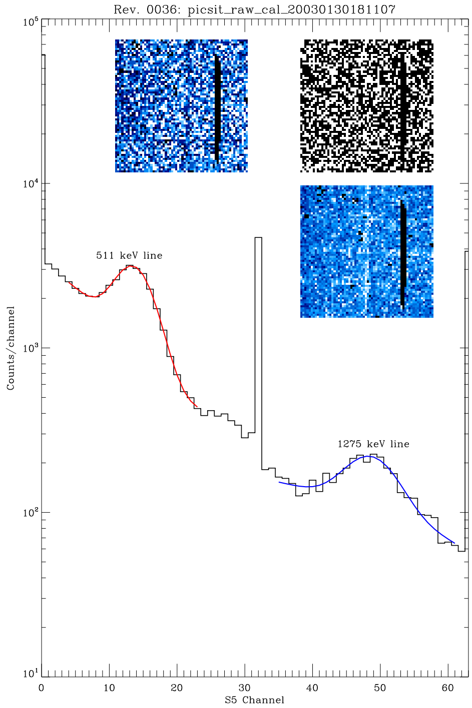

Figure 2: Spectrum and maps of detector shadowgrams for S5 data for one calibration file in revolution 36. This plot is included in the ***gain_spectra36.ps*** file. Calibration events distribution on S5 channels is plotted together with the best fit gaussian around the two calibration lines. Maps shows the pixel by pixel integrated counts around the 511 keV line (upper left), the 1275 keV line (upper right) and over all channels (bottom).

N	ScW	S1	S2	S3	S4	S5	S6	S7	S8	Exp
0	3600030010	1418459	1089108	693407	775631	452756	355484	132183	49828	2167
1	3600040010	1390093	1073959	683760	770795	455473	357048	133631	50478	2167
2	3600060010	1370294	1049535	671341	762162	457400	363576	137231	52469	2167
3	3600070010	1359891	1041427	666261	761636	457056	364524	138018	53159	2167
4	3600090010	1340608	1026574	658513	756831	460533	366922	140829	53886	2167
5	3600100010	1338292	1022859	656806	757077	459847	368696	141452	54541	2167

Table 8: Beginning of the **Scounts_36.dat** file.

The following example describes the code usage and behavior when driving the analysis over the sample of 50 revolutions from 36 to 85.

In the same directory where all routines have been saved, open IDL prompt and compile the main procedure:

```
>.r monitor.pro
```

Now, run the procedure without any keyword:

```
>monitor,36,85
```

Number of revolutions =			12														
Total number of files =			1251														
Pix1	Pix2	Line 1	Er	Chisq1	Line 2	Er	Chisq2	DeltaE1	Er	DeltaE2	Er	Gain	Er	Offset	Er	Chisq	ErCode
0	0	12.69	0.03	0.82	46.50	0.36	0.88	15.10	0.12	8.37	1.30	7.23	0.02	-19.78	1.83	0.00	0
0	1	13.73	0.08	1.85	48.35	0.28	1.57	16.90	1.05	6.64	0.90	7.12	0.02	-26.47	1.71	0.00	0
0	2	12.73	0.01	1.14	46.59	0.33	1.37	16.81	0.04	6.90	1.13	7.23	0.02	-19.84	1.64	0.00	0
0	3	12.80	0.05	0.64	46.77	0.29	1.24	16.85	0.28	6.94	0.99	7.21	0.02	-19.90	1.58	0.00	0
0	4	12.76	0.05	0.92	47.36	0.27	1.37	18.65	0.28	7.05	0.95	7.13	0.02	-12.88	1.49	0.00	0

Table 9: Beginning of the **gain_pix_36.dat** file.

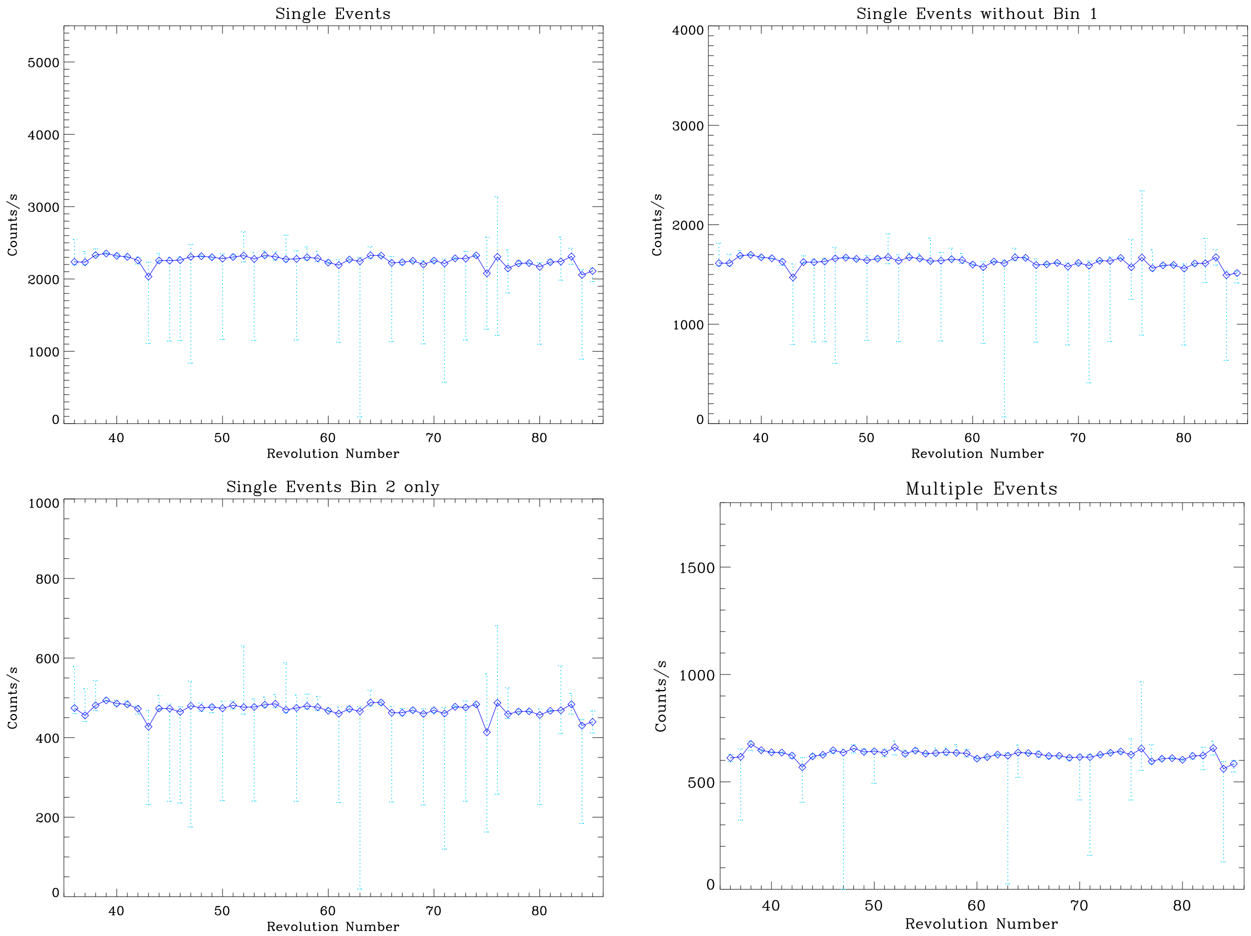

Figure 3: The ***long.ps*** file is given in output in the first part of the analysis. The file contains several plots giving revolution mean values for all key parameters of the monitor analysis. Here count rate is depicted for single events (upper left panel), single events without the first bin (upper right), single events in the second bin only (bottom left) and multiple events.

At the end of the process the user can check the content of each revolution in the ***rev_N.txt*** files in the *Data* directory. An example is given in Tab.5, where part of the file ***rev_36.txt*** is reported. Revolution 36 is found to include several files for counts that are empty (None in column **Counts**), a number of ScWs for single or multiples only (S/M); all other files are complete ScWs for both single and multiple events (All) and no acquisition has been done in Photon by Photon Mode (PPM). In few ScWs errors are found in the reading phase. In the **err** column error codes are given according to Tab.2: for example an error value of 20 is expected at the beginning of revolutions when instruments are still switched in Stand By Mode. In the example table no ScWs contain shadowgrams with number of dark pixels greater of 1024 (**Null_pix** = 0) and all have exposure time ($\sim$ 2000 s) differing less than 300 s from the product of the elapsed time with the dead time (**Bad_expS/M** = 0). Moreover in those observations where both counts (S, M or All) and temperature are found, the parameter **T_C** = 1 indicates that the acquisition for counts and temperature is almost simultaneous. It is worth noting that negative fluctuations for the temperature at the beginning of the revolution are due to IBIS being switched off during the radiation belts passage.

The user can check shadowgram maps for both single and multiple events from ***S/MmappeN.ps*** files. An example is given in Fig. 1, for several pointings with single events in revolution 47 and multiple events in revolution 36. Maps are produced for all ScWs with **err** = 0 in the ***rev_N.txt*** file. Each raw shows 8 shadowgrams, one for each energy band, for the ScW with ID written on the left border. Note the

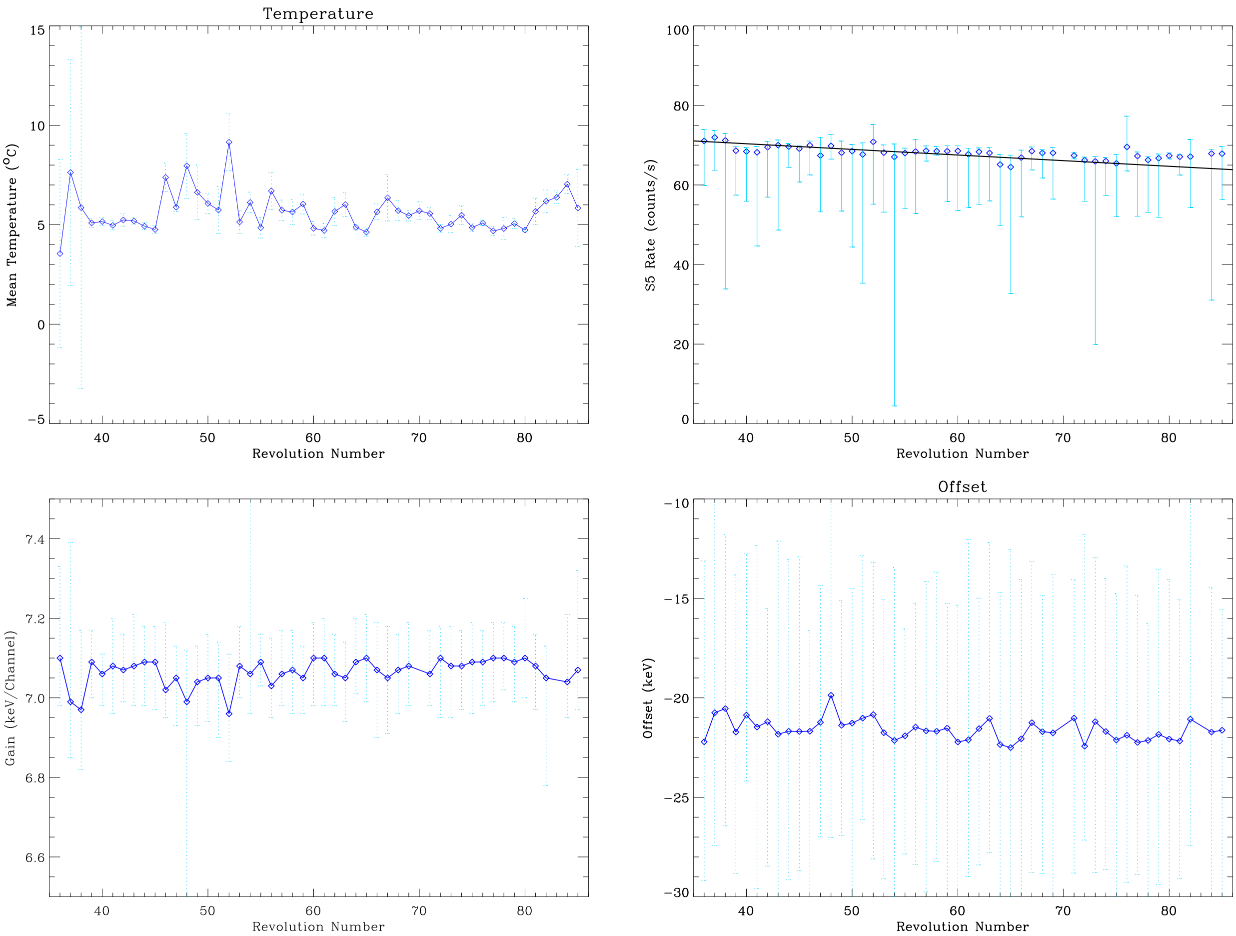

Figure 4: The ***long.ps*** file includes plots showing the revolution mean values for temperature (upper left panel), count rate of calibration events (upper right), gain (bottom left) and offset (bottom right)

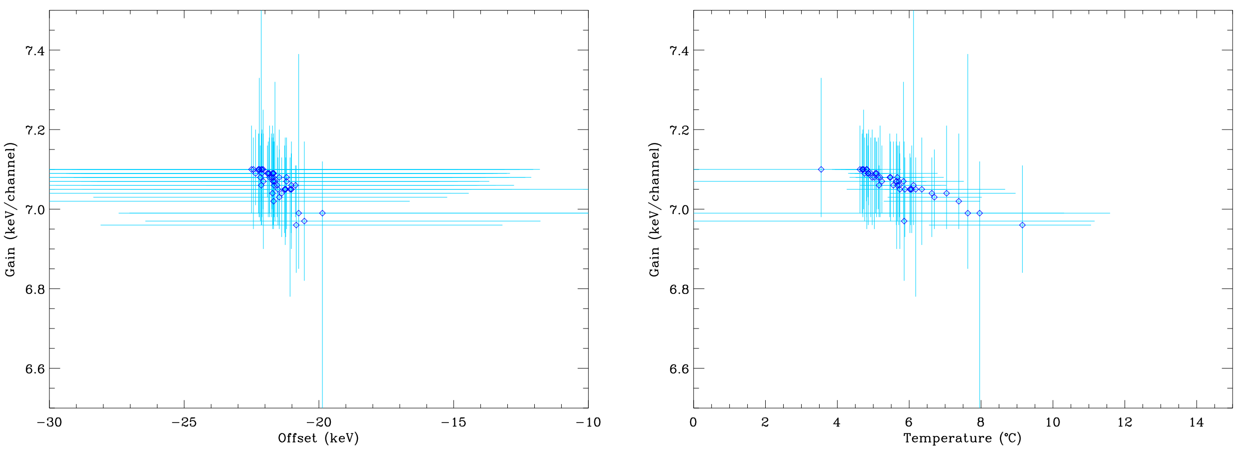

Figure 5: Mean revolution gain as a function of offset (left panel) and temperature (right panel), given in the ***long.ps*** file.

killed pixel pattern and the detector module structure. Maps visualization allows to check shadowgrams quality for those ScWs marked with **Null_pix** =1 or with low exposure. For instance the **Null_pix** =1 parameter in ScW number 107 of revolution 47 for single events (Fig.1, left panel), is due to the

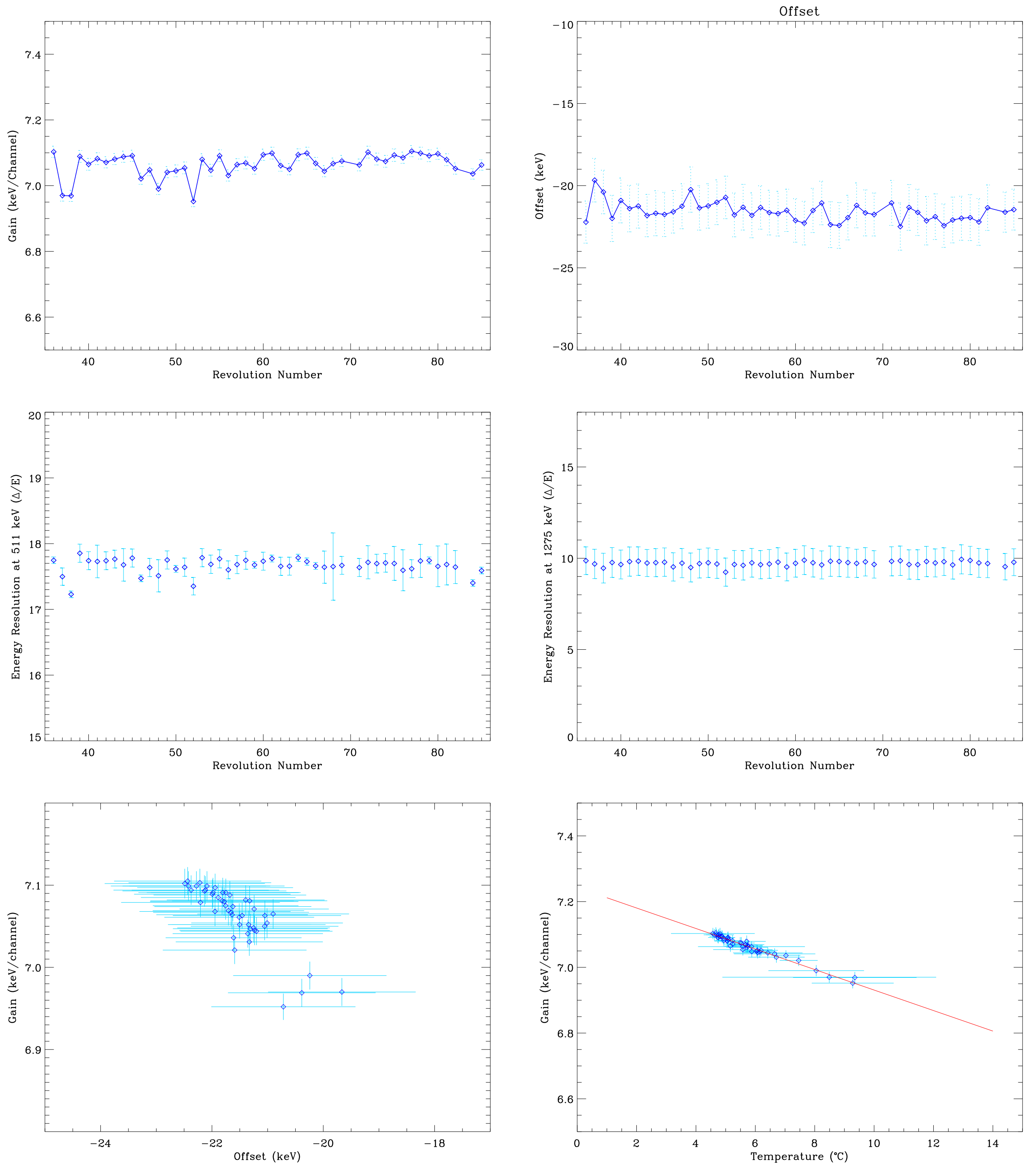

Figure 6: ***gain_rev.ps*** file: gain, offset, energy resolution at 511 and 1275 keV lines and gain/offset dependence, when quantities are derived after the integration of the calibration data over each revolution.

partially histograms download at all energies that was not recognized by the software during the data preprocessing phase.

Another example comes from ScW number 10 of revolution 42 for multiple events (Fig.1, right panel), where the **Null_pix** =1 parameter is due to an exposure time of 95 s. More generally shadowgram visualization allows to recognize possible problems missed by the monitoring code or by the preprocessing

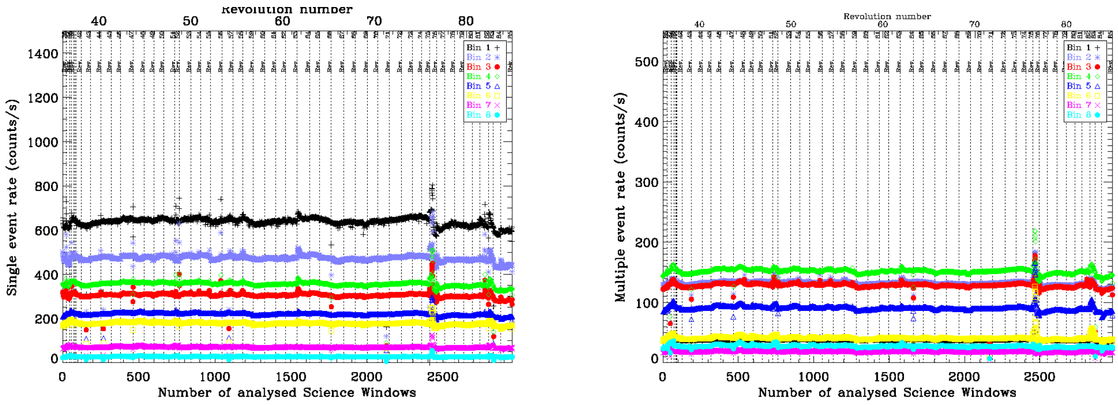

Figure 7: Example of background count rate short variability for single events (file ***Srate36_85.ps***, left panel) and for multiple events (file ***Mrate36_85.ps***, right panel)

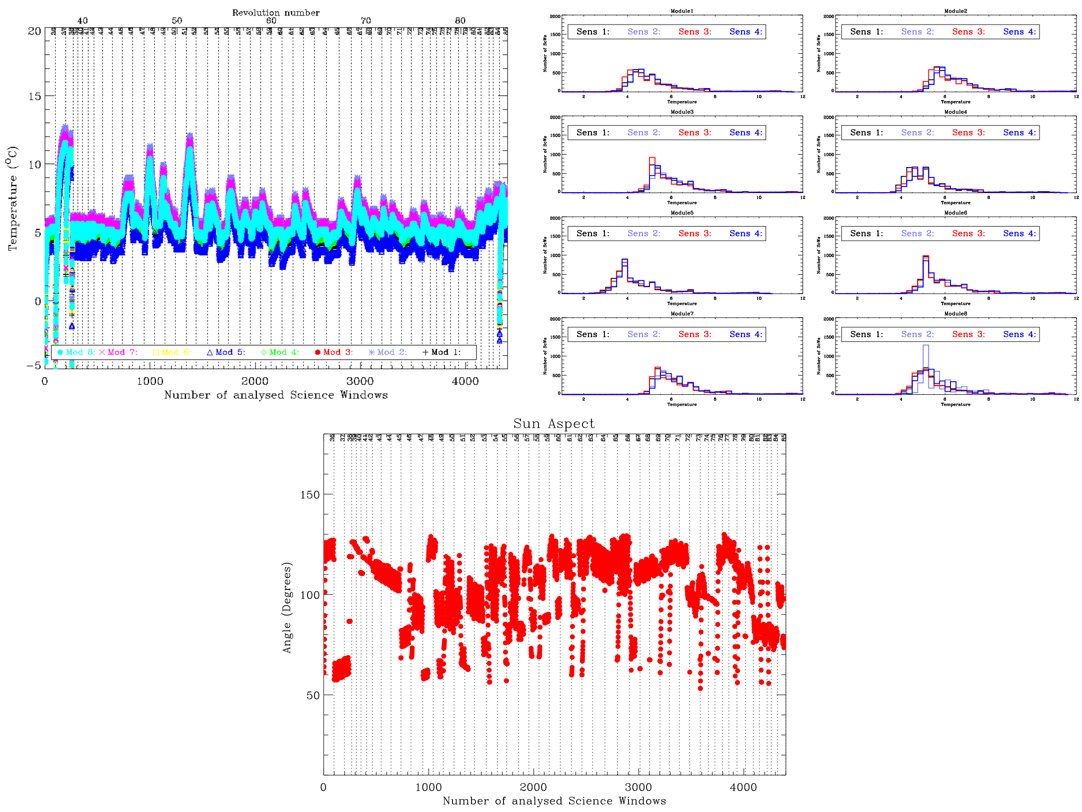

Figure 8: Example of files ***Temperature36_85.ps*** (upper panels) and ***SunAngle36_85.ps*** (lower panel)

analysis. In this case, the **Usr_flag** flag of the corresponding ScW in the ***rev_N.txt*** file should be changed to 0, in order to neglect the corrupted file during the subsequent analysis.

Similar files for gain are produced in output. As an example part of ***gain_37.txt*** file is written in Tab.6. The first line gives the total number of calibration files (***picsit_raw_cal_n.FITS***) in the revolution at hand. For each file the ID (which specifies date and acquisition time) is written on the **File** column. All files in Tab.6 seem consistent: according to values in column **err**, no errors are found and the number of saturated pixels remains lower than 1024 (see also column **Bad_pix**).

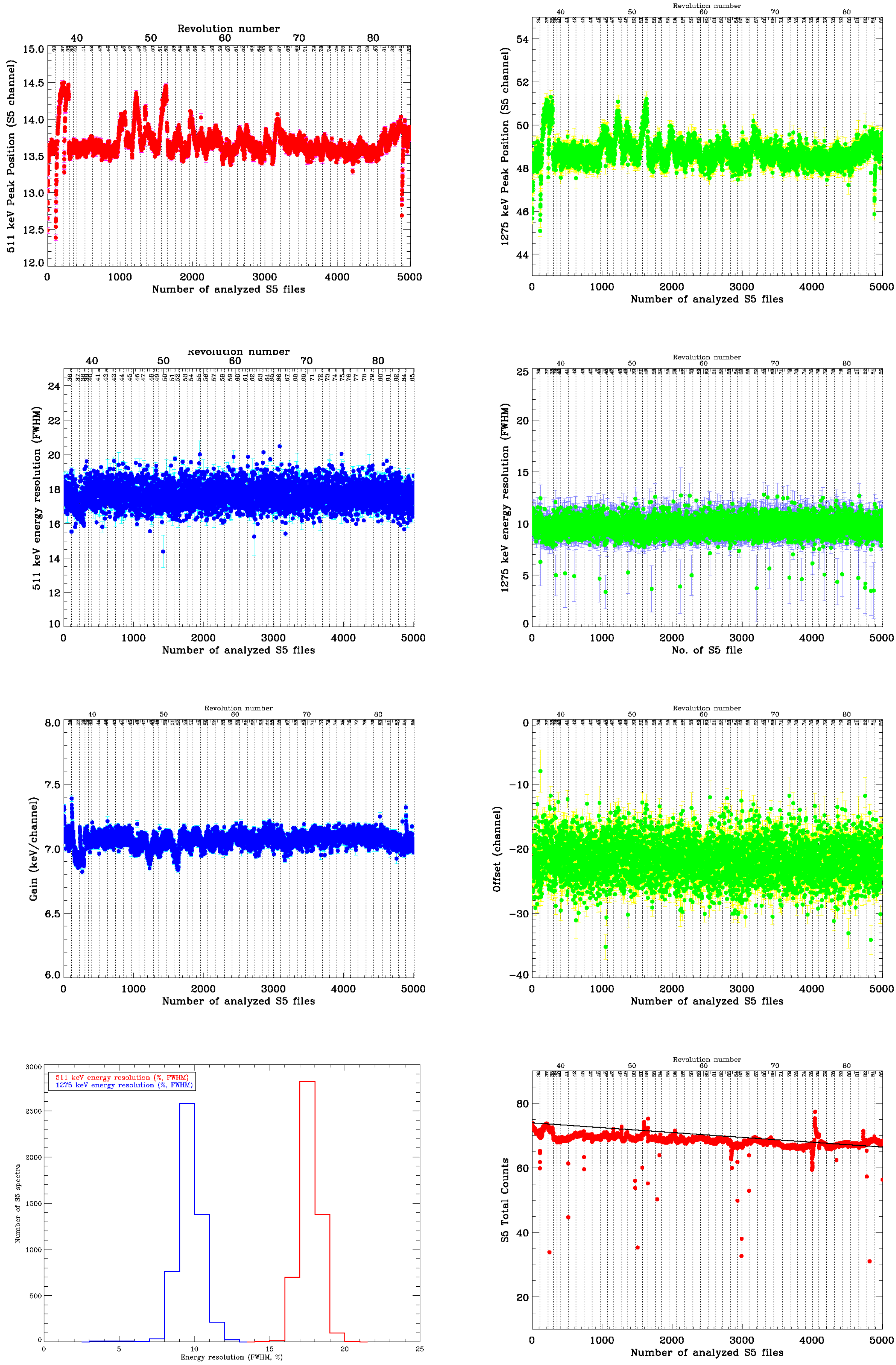

Figure 9: Example of ***Gains36_85.ps*** file

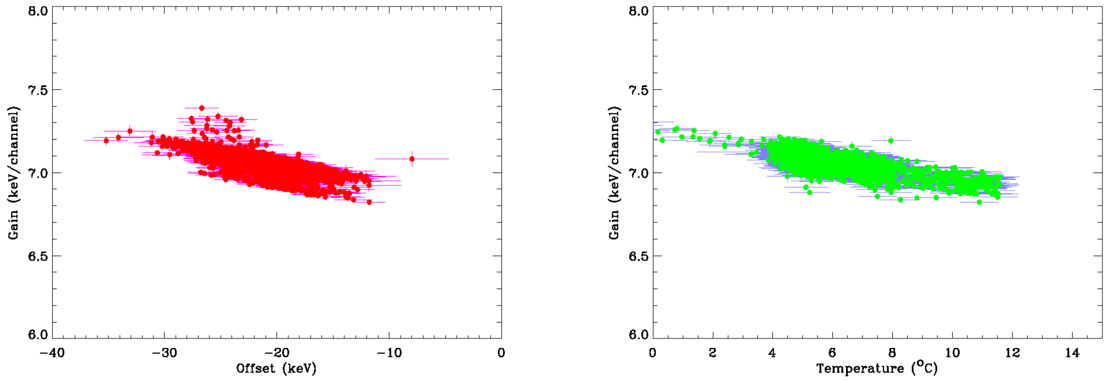

Figure 10: Example of gain-temperature dependence (left panel) and gain-offset dependence (right panel) in file ***Gains36_85.ps***

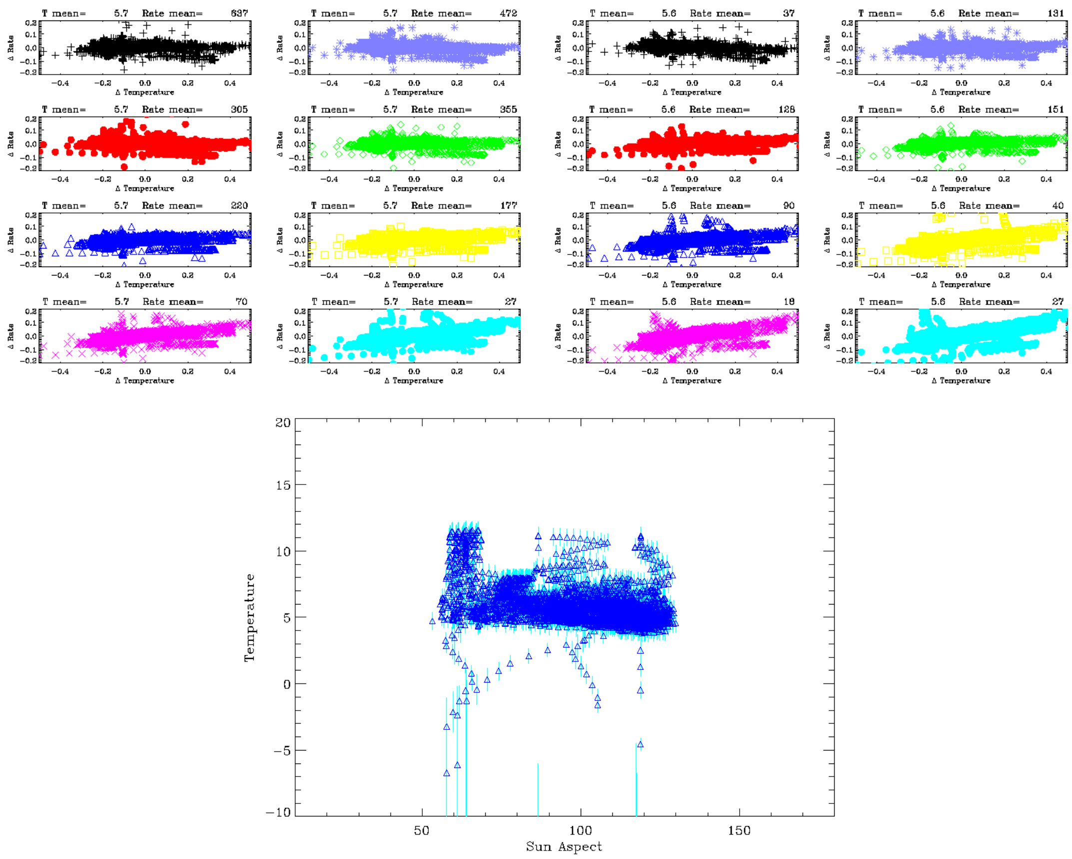

Figure 11: Example files ***SCross36_85.ps*** (upper left), ***MCross36_85.ps*** (upper right) and ***TCross36_85.ps*** (lower panel)

Calibration events quality can be checked in the ***gain_spectraN.ps*** files: as an example Fig.2 shows channel spectra and detector shadowgrams for the file ***picsit_raw_cal_20030130181107.FITS*** of revolution 36 (the file ID is written on the top). Upper maps refer to S5 integrated counts around the two calibration lines, while the lower map is the total count shadowgram. Note that the color scale is not proportional to intensity, but the maximum level is set to 1.5 times its average value because the aim of maps is only to offer evidence of null pixels. Note that the procedure reset saturated pixels to 0, so

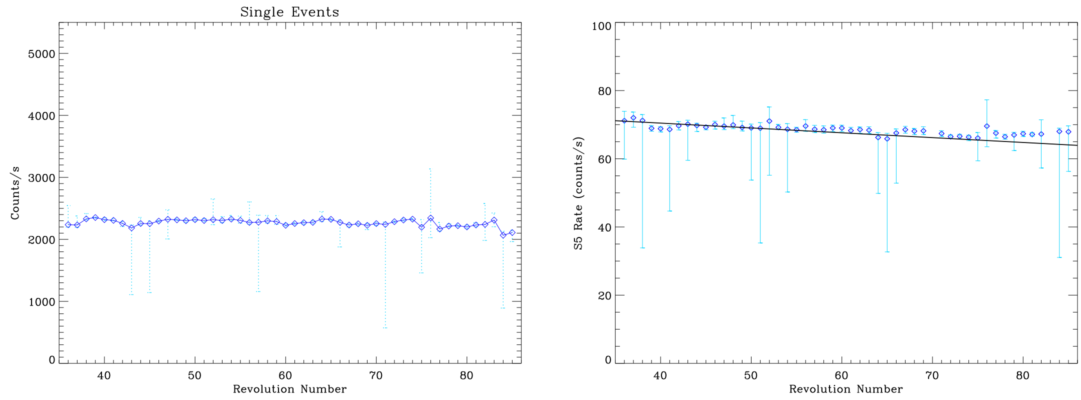

Figure 12: Count rate for single events (left panel) and for calibration event (right panel) in the ***long_updt.ps*** file

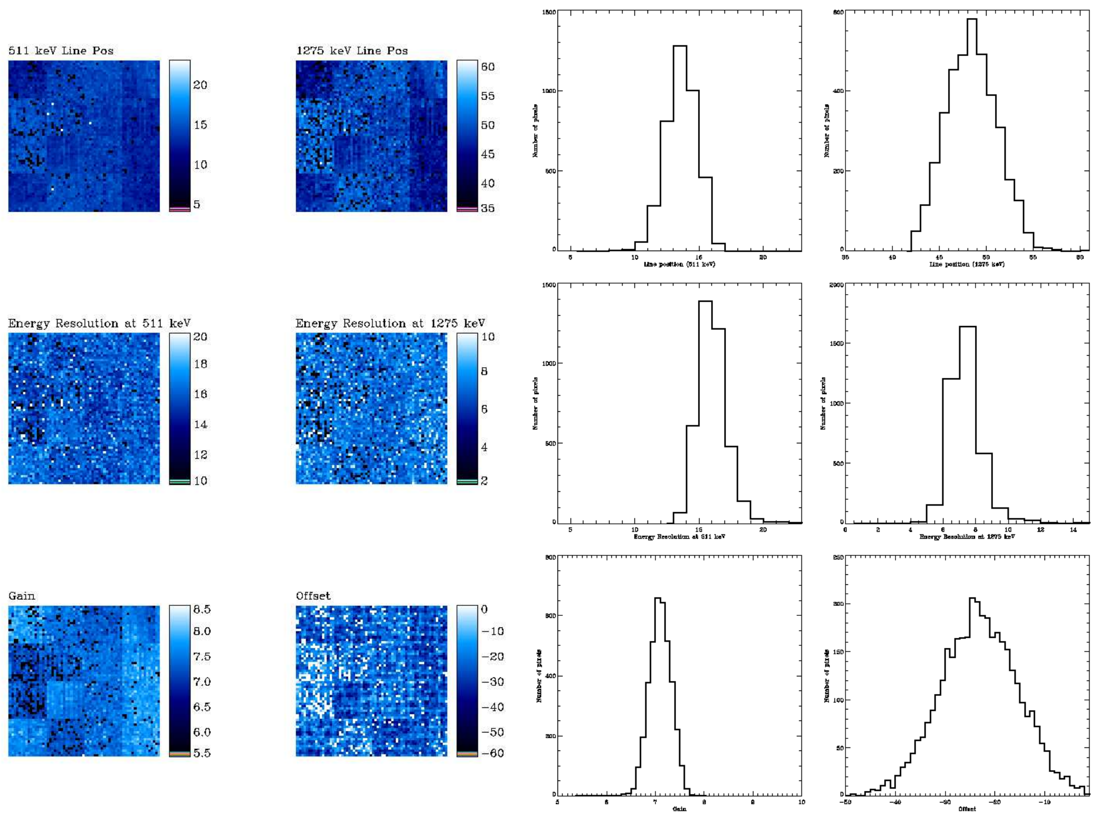

Figure 13: Example of the ***gain_maps_47_12.ps*** file.

that they appear as null in the shadowgram maps. Current shadowgrams show a small region in the detector of null/saturated pixel. Even if they are less than 1024, the user may want to exclude this file from the subsequent analysis, by changing the **Usr_flag** value to 0 for the line with ID 2003013018110 in the ***gain_37.txt*** file. Channel spectrum is plotted together with gaussian fits around the two line peaks. Besides the null pixel region, no problems seem to affect spectrum and fit. Note that excesses at channels number 0, 32 and 63 are due to the large energy interval covered by these channels (see Tab.11).

At the end of this phase, average revolution parameters are summarized in the ***summary.dat*** file, stored in the *Data* directory. For the example at hand. part of the file is given in Tab.7, up to revolution 60. Note that here the table is split in two part while the ***summary.dat*** contains all parameter in a single raw.

Since no keyword is set the code returns after the reading phase.

If the user then gives the command

`>monitor,36,85,/ps`

the code makes nothing more than reading the ***summary.dat***, written in the previous run and plot the content in the ***long.ps*** file, shown if Fig.3-5. The same routine creates the ***gain_rev.ps*** file that shows the evolution on the revolution sample of gain, offset, energy resolutions and gain/offset dependence where these parameters have been derived from the total spectrum on each revolution (Fig.6).

The parameters short variability, that is at ScW/calibration file level, is then inspected, by typing the command:

`>monitor,36,85,/analyze`

Data are selected according to the quality flags in the ***rev_N.txt*** and ***gain_N.txt*** files. Since the input data sample is 50 revolution large, the same value of the parameter **delta_revmax**, all revolutions are treated in one group and one plot for short variability is produced for each parameter.

Short variability for the background is found in the ***Srate_36_85.ps*** for Single Events and in ***Mrate_36_85.ps*** for Multiple Events (see Fig.7). Background data are chosen with null values for **err**, **Bad_exp** and **Null_pix** and with **Usr_flag** = 1 in the ***rev_N.txt*** files. For ScWs matching the above conditions, counts and exposure times are read again from the archive, keeping separately information at each energy bin. In Fig.7 the count rate for each energy band (see legend) is plotted as a function of the ScW number, with vertical lines to separate each revolution. Since the keyword **log** is not set plots are produced with linear abscissas. Note that, since the procedure plots consecutively all selected values, possible gaps in the acquisition are not visible in the plots and have to be checked in the ***rev_N.txt*** files.

Moreover at this phase the files ***S/Mcounts_N.dat*** are produced for testing purpose (see Tab.8). One file for each revolution is recorded with exposure time and counts at each energy bin for all files analyzed in this phase. These are exactly the values used for the above plots.

The variability of temperature at ScW level is displayed in the file ***Temperature_36_85.ps*** (see Fig.8 upper-left panel). Data selection is performed according to the ***rev_N.txt*** files, including ScWs with null **terr** values, with attitude information and with detector mean temperature greater than the parameter **min_of_temp**, set in the main procedure. Note than in this example internal parameters have not been changed and the default lower limit for temperature is set to -100. For files matching these conditions, temperature is read again from the archive, keeping information on each sensor. Left panel in Fig.8 shows the temperature recorded at each sensor for each ScW. Different colors refer to sensors on different detector modules. As for background rate, gaps due to neglected files are not displayed and have to be checked on the ***rev_N.txt*** files. The temperatures distribution is also visualized (upper-right panel) at each sensor and module. For the same ScWs sample, the aspect angle is plotted as a function of the ScW number in the ***SunAngle_36_85.ps*** file (see Fig.8 right panel). Values are read from the ***rev_N.txt*** files.

Calibration events and derived quantities are plotted at detail in the ***Gains_36_85.ps*** file (Fig.9). In the ***gain_N.txt*** files corresponding to the revolution sample, values are selected with **Err** =0 and **Usr_flag** = 1 and plotted for progressive calibration acquisitions. In the same ***Gains_36_85.ps*** file the gain, at single file level, against the offset and temperature is shown (Fig.10). Good values for temperature are read from the ***rev_N.txt*** files. In this first version of the monitoring procedures the gain/temperature relation is treated in a simplified way. Scientific pointings and calibration acquisitions counts are accumulated over different times ($\sim$ 2000 s and $\sim$ 1800 s respectively), however the different integration times is neglected and the n-th ScW is assumed to be simultaneous to the n-th calibration acquisition. Gain and temperature arrays are built by selecting values respectively from the ***gain_N.txt*** and the ***rev_N.txt*** files, such that both the n-th calibration unit and the n-th pointing satisfy the above quality flags.

Temperature and count rate relation is analyzed by giving the following command:

```
>monitor,36,85,/ps,/analyze,/cross
```

During the detailed reading phase the code selects, from the ***rev_N.txt*** files, count rate and temperature that are almost simultaneous (**T_C flag** = 1). Counts are read from the shadowgram files at each energy bin, while temperature is obtained by the ***rev_N.txt*** files. The code calculates the mean value for rates and temperature and plots count rate variation as a function of temperature variation. Results are given in Fig.11, showing ***SCross_36_85.ps*** for single events and ***MCross_36_85.ps*** for multiple events.

The code also produces plots for the temperature dependence on the sun aspect in the ***TCross_36_85.ps*** (Fig.11, lower panel). Temperatures are the detector average values selected for the short variability plots and sun aspect angles are derived from the ***rev_N.txt*** files.

It is useful to remind that flags are provided in the main routine body that can be edited to change the range of temperature and counts for the counts/temperature and temperature/sun aspect relations. In this example flags have the default values in order to include the whole data set and precisely they are set to: **u_smin** = 0, **u_smax** = 10000, **u_mmin** = 0, **u_mmax** = 10000, **u_tmin** = -100, **u_tmax** = 100.

At the end of this step the ***summary_updt.dat*** file is created with the same structure of the ***summary.dat*** file given in Tab.7 but with mean values computed on the restricted data sample according to quality flags. The keyword **ps** makes the routine plot the updated quantities. For a comparison with the same quantities in Fig.3 and Fig.4, in Fig.12 the left and right panel respectively gives count rate for single and calibration events.

If the user is interested in the gain computation at pixel level, then should enter the command:

```
>monitor,36,85,/analyze,/pix
```

When the code returns, besides all files described above, in the *Data* directory the user should find the text files: ***gain_pix_36.txt*** (see Tab.9), ***gain_pix_48.txt*** and ***gain_pix_59.txt***, corresponding to files: ***gain_maps_47_12.ps*** (see Fig.2), ***gain_maps_58_11.ps*** and ***gain_maps_72_14.ps***.

In the example different keywords are activated at different runs in order to describe the effect of each one. However, since here we used default parameters and the **Usr_flag** have not be changed in the ***rev_N.txt*** and ***gain_37.txt*** files, the same results are obtained by typing the command:

```
>monitor,36,85,/ps,/analyze,/cross,/pix
```

Tip: Since the analysis procedure is time consuming and the complete process over 500 revolutions requires more than one day it can useful to launch the procedure in batch mode. For this purpose, edit the *run.pro* file with the idl commands:

```
 .r monitor.pro
monitor,36,535,/ps,/analyze,/cross,/pix
exit
```

then enter the shell command:

```
nohup nice /usr/local/bin/idl < run.pro > & outfile.out &
```

and logout. The commands in the *run.pro* will be execute and the prompt output will be addressed on the *outfile.out*.

4 Part II - Data reduction

4.1 Data Acquisition and Archive

Once transmitted to the ground, raw data are organized in the standard structure for the following scientific analysis. A detailed description of the data repository structure is beyond the aim of this document and can be found at the *ISDC* web page[1]. Nevertheless it is useful to outline here the structure of the standard repository and data allocation in the local archive. In the following we adopt the notation *RRRR* for revolution number and *RRRRPPPP0010.001* for Science Window number, where *0010.001* labels scientific pointing acquisitions. The standard repository is organized in the following folders, required by the `OSA` analysis software:

- *aux*: spacecraft information such as attitude, orbit, time conversion of the on-board time to physical units.
- *cat*: source catalog information.
- *ic*: instrumental calibration and settings.
- *idx*: indexes of files required by the scientific analysis.
- *obs*: products of the Offline Scientific Analysis.
- *scw*: data prepared for the scientific analysis, stored in directories *RRRR*, with subdirectories *RRRRPPPP0010.001* for each pointing and *rev.001* for instrument configuration and calibration;

During the monitoring procedure, each parameter is read in the archive with path:

Background events	→	obs/RRRR/scw/RRRRPPPP0010.001/
Temperature	→	scw/RRRR/RRRRPPPP0010.001/
Calibration events	→	scw/RRRR/rev.001/raw/
Sun Aspect	→	aux/adp/RRRR.001

The local archive is maintained on the machine `fermi@iasfbo.inaf.it`. Processed data are stored in disk partition for the user *picsit*, where the scientific analysis has been performed. Raw data and housekeeping are allocated as follow[2]:

aux	→	/nas_data3/env_osa_rev_2/aux
cat	→	/nas_data3/env_osa_rev_2/cat
ic	→	/nas_data3/env_osa_rev_2/ic
idx/ic	→	/nas_data3/env_osa_rev_2/idx/ic
scw	→	/dischi/gammanas1/data2/arc/rev_2/scw[3]

[1] http://isdc.unige.ch/index.cgi?Support+documents

[2] http://www.iasfbo.inaf.it/Research/INTEGRAL/Restricted/index.html

[3] Data of revolutions from 0194 to 0357 and symbolic links to all other revolutions.

4.2 Background Count Rate

The IBIS/PICsIT instrument operates in two fundamental modes: Photon-by Photon (PPM) and Standard Mode (SM).

In PPM the complete event list is transmitted to the ground but, due to the high background level in the instrument operational energy range and the on-board telemetry limitations, this mode is activated only during Slews or for calibration purpose.

Scientific observations are acquired in SM. Before transmission signals are equalized according to gain and offset of the LUT and integrated into histograms. Standard Mode is the combination of two sub-modes: Spectral Imaging (SI) and Spectral Timing (ST). In SI, data are integrated over the pointing acquisition time ($\sim$ 2000 s) and rebinned to 256 energy channels (from the original 1024), but the full spatial information is kept on the detector plane (64×64 pixels). IBIS/PICsIT events are treated separately according to their multiplicity, so that single and multiple events are stored in two different data sets. Multiple events are on-board associated with a single aggregate energy deposit and the incident pixel is calculated by means of an on-board algorithm. It is important to remind that energy deposit across semimodule borders are not recombined into a single event because of the electronic separation between semimodules. Multiple events that trigger more than one semimodule are seen as "n" single events, where "n" is the number f triggered semimodules.

In conclusion, the information for a single SM pointing is organized in one array of 64×64 (pixels) $\times256$ channel spectra equalized by means of the on-board LUT and integrated over ScW duration ($\sim$2000 s).

Before running the monitoring procedure, the whole sample of PICsIT data must be processed by means of the Offline Scientific Analysis specific software (here we used the software version `OSA version 7.0`), limited to level BIN_I when the module `ip_si_shadow_build` generates shadowgrams and efficiency maps in eight standard energy bands. For more details on PICsIT analysis see Foschini et al. (2007).

Counts for the *RRRRPPPP0010.001* pointing of the *RRRR* revolution are derived from the file ***picsit_detector_shadowgram.fits*** with path:

/dischi/fermi/data3/picsit/OSA/obs/RRRR/scw/RRRRPPPP0010.001/

The ***picsit_detector_shadowgram.fits*** file contains one extension **PICS_DETE_SHD** for each energy band for both single and multiples events. The OSA software has been run on the eight standard energy intervals for Single and Multiple events, given in Tab.10. Therefore complete shadowgram files contain 16 extensions: 8 for single event counts in each energy bin and the 8 for multiple events. In some cases only single or multiple events are available. When only eight extensions are found in the ***picsit_detector_shadowgram.fits*** the event type is derived from the field **HIS_TYPE** in the **Grouping** extension.

The extension for each energy band contains a 64×64 array with counts accumulated in each pixel during the ScW. For both single and multiple events the monitoring procedure reads the total counts over the detector plane for each energy band (extension). Counts are corrected for the dead time and divided for the exposure time to obtain the background event rate. Exposure and dead times are retrieved, respectively, by the parameters **EXPOSURE** and **DEADC** in the header of the first extension for single and multiple events. The first and last times of the pointing, to be compared with analogue times for temperature acquisition, are derived from the **OBTSTART** and **OBTEND** parameters.

Before reading counts, the code searches for the ScW acquisition mode, defined in the ***swg_ibis.fits***. The **IBISMODE** parameter in the header of the **Grouping** extension can get the following values: 41 if the ScW is acquired in Standard mode (STD), 43 for acquisition in Photon-by-Photon Mode (PPM), 98 or 22 for Slews and standby. Counts are read only for **IBISMODE** = 41.

Single Events		**Energy**	**Multiple Events**	
bin	channel	keV	bin	channel
1	10-16	203 - 252		
2	17-28	252 - 336		
3	29-40	336 - 448	1	5-12
4	41-56	448 - 672	2	13-28
5	57-82	672 - 1036	3	29-45
6	83-140	1036 - 1848	4	46-74
7	141-198	1848 - 3584	5	75-136
8	199-254	3584 - 6729	6	137-194
		6720 - 9072	7	195-215
		9072 - 13440	8	216-254

Table 10: Standard energy bins for single and multiple events.

The number of killed pixels is derived from ***picsit_efficiency_shadowgram.fits***. The **PICS-EFFI-SHD** table is read and the number of pixels with null counts is retrieved.

4.3 Temperature

Temperature data are stored in the ***ibis_mce.fits.gz*** files. For the ScW number RRRRPPPPSSSF.001 of revolution number RRRR, temperature file has path:

/dischi/gammanas1/data2/arc/rev_2/scw/RRRR/RRRRPPPPSSSF.001/

In the **IBIS-HARD-CNV** extension, the **POE_MM(1÷8)TEMP(1÷4)** fields give temperatures acquired by each of the 4 sensors in each of the 8 modules (32 sensors in total). Different rows correspond to different acquisitions during the ScW, as temperature values are read out at time intervals of $\sim$ 32 s. The first and last time of acquisition are read from **OBTSTART** and **OBTEND** fields in the extension header. These parameters are used to check the simultaneity of temperature and count acquisitions.

4.4 Sun aspect

Attitude information for revolution number RRRR is recorded in the file ***attitude_historic.fits.gz***, in

/nas_data3/env_osa_rev_2/aux/adp/RRRR.001

In the **AUXL-ATTI-HIS** extension, the attitude data are collected for all ScWs, whose number is given in the **POINTING_ID** column of the extension, named **POINTING_ID**. Attitude data are recorded every $30 \div 70$ s (**TIME** field) and acquisitions are made continuously over the revolution, during both pointings and slews (P, S in the field **POINTING_TYPE**). The monitor routine selects those values of the sun angle from the column **SUN_ASPECT** for the ScW at hand and labeled as pointings (P in the **POINTING_TYPE** column). The sun aspect associated to the current ScW is then computed as the mean of selected values.

4.5 Gain

The on-board calibration unit (OBCU) includes a 0.4μCi (at launch) ^{22}Na radioactive source (half live 2.6 yrs), placed at 220 cm above the instrument. ^{22}Na decays in one photon at 1275 keV (emitted isotropically) and one e^+ which then annihilates in two photons at 511 keV (emitted 180° apart). One of the two 551 keV photons is detected by the OBCU detector (a modified element of the IBIS/PICsIT BGO anticoincidence), thus providing the necessary tag to recognize calibration events. Calibration events are on-board integrated over $\sim$ 1800 s into 64 energy channels for the 64 $\times$ 64 pixel array.

Calibration events, named S5, are stored in the ***picsit_raw_cal_id*** files, where the identification number ***id*** gives the acquisition date and time. Calibration files for revolution *RRRR* are found in:

/dischi/gammanas1/data2/arc/rev_2/scw/RRRR/rev.001/raw/

In each ***picsit_raw_cal_*** file, the **PICS-CSI.-CRW** extension is a 64 $\times$ 64 $\times$ 64 array, containing events at pixel level, in 64 channels, integrated over the acquisition time that is specified in the **INT_TIME** parameter, in the extension header. In order to maintain the key spectral information, calibration data are collected using a non linear energy binning table, having the best sampling around the two emission lines. The correspondence between S5 and scientific data channels (S40) is given in Tab.11.

S5 channels	S40 channels
channel 0	1-48
1	49-50
2	51-52
.....	
31	109-110
32	111-150
33	151-152
34	153-154
.....	
62	209-210
63	211-1024

Table 11: Calibration (S5) and scientific (S40) channel relation.

Gain and offset are obtained as follows. The channel spectrum is fitted around the two lines at 511 and 1275 keV to obtain the position of the two peaks. The fitting function is composed by a gaussian line and a polynomial background. The gaussian fit returns line centroid in channel units and line resolution, computed as the Full Width at Half Maximum divided by the channel position. Line centroids are then converted in S40 energy channels and gain and offset are then obtained by linear fit.

5 Part III - Code in Details

In this section all routines are briefly described ordered as they are called by the main procedure.

5.1 Calling Sequence Scheme

The calling sequence scheme is shown in Fig.14. Three areas separate the main procedure actions from the subroutine calls, with the activating keywords, and from the output files.

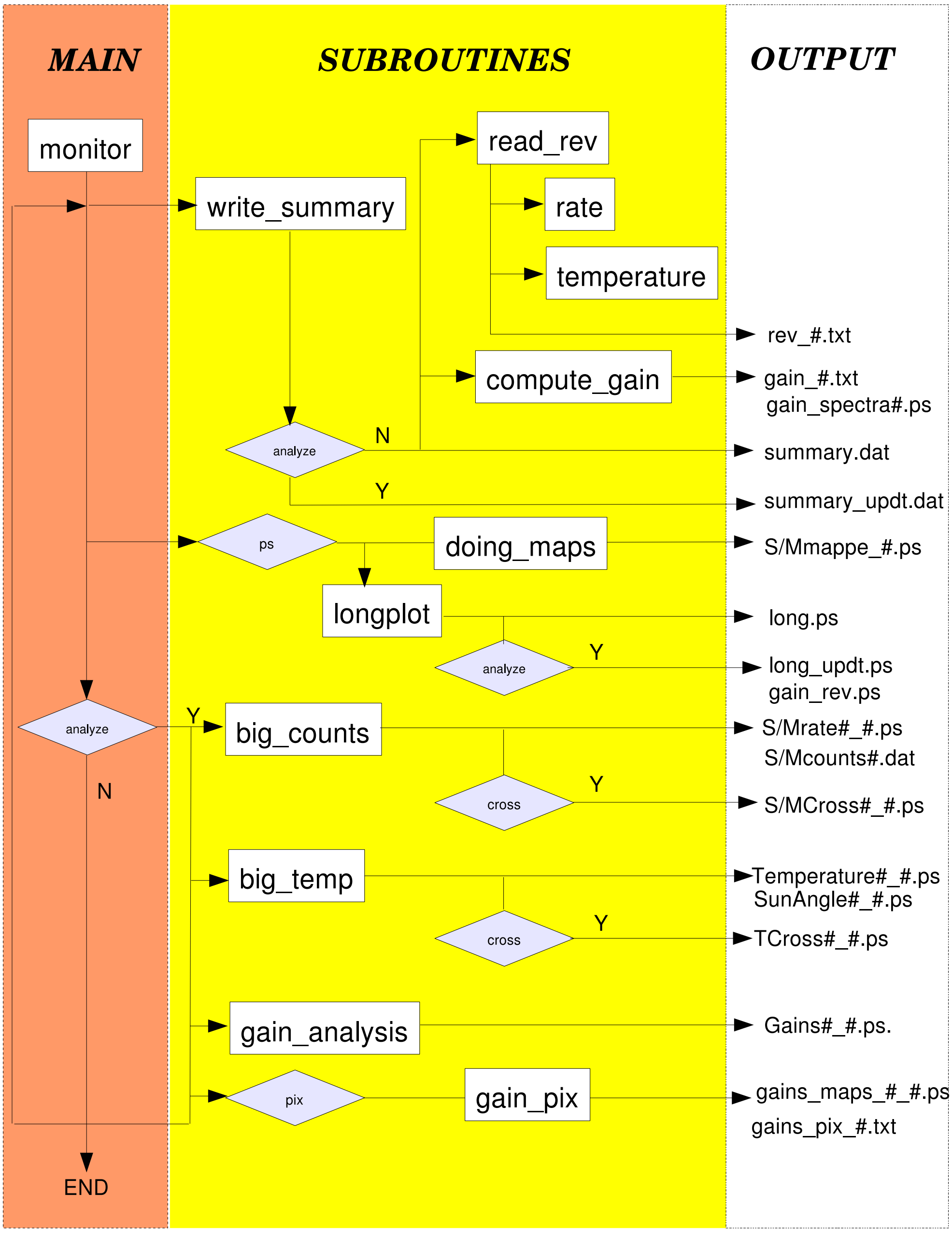

Figure 14: Calling sequence for the monitoring procedure

5.2 Procedures & Functions in detail

In the following a brief description of the monitoring procedures and functions is given.

5.2.1 monitor

Main procedure for PICsIT monitoring. The routine requires in input the boundaries of the revolution range to be analyzed and a number of optional keywords.

The calling sequence is as follows:

- Calls the procedure `write_summary` to build/update the ***summary.dat*** file for all the revolutions in the data set.
- The main routine calls the `doing_maps` procedure which plots shadowgrams for Counts and S5 data for each acquisition (***S/Mmaps_N.ps*** and ***gain_spectra_N.ps***). For S5 data channel spectrum is also given.
- If the keyword **ps** is set, the `longplot` procedure produces the ***long.ps*** and ***gain_rev.ps*** files that shows the long term variability of monitor parameters (at revolution level).

If the keyword **analyze** is set, the calling sequence proceeds through the following steps:

- Data set is divided in blocks of **deltarev_max** revolutions each.
- For each block the routine `gain_analysis` is called to produce the short variability plots for gain and revolution mean parameters are updated.
- The call to `make_arr` function builds up the big arrays of file names for Single, Multiple Counts and Temperature as filtered from ***rev_N.txt*** files.
- The function `big_counts` is called for Single and for Multiple events and returns short variability plots for Counts. Revolution mean parameters are updated. If the keyword **log** is set plots are made in lin-log scale. If the keyword **cross** is set also plots for Counts as function of Temperature are created.
- The function `big_temp` is called to produce short variability plots and distribution histograms for Temperature at sensor level and to update revolution mean values.
- `write_summary` is called again to print/update the file ***summary_updt.dat*** with mean revolution parameters screamed from bad files and,
- with the keyword **ps** the `longplot` procedure plot the final results (***long_updt.ps***).
- Finally, if the keyword **pix** is active, the `gain_pix` is invoked for the gain analysis at pixel level.

5.2.2 write_summary

Routine for the creation/update of the files ***summary.dat*** and ***summary_updt.dat***.
If files exist but contain a smaller sample of revolutions the procedure keeps the content of the preexistent files and makes the real work only on new revolutions. Note that if ***summary.dat*** has been deleted all ***rev_N.txt*** files are recomputed (so that the **Usr_flag** must be restored). When building the ***summary.dat***, the procedure, for each revolution in the sample, calls the routines `read_rev` and `compute_gain` to obtain mean parameters. When building the ***summary_updt.dat***, the procedure receives in input the parameter array to be stored in the file and computed by `big_counts`, `big_temperature` and `gain_analysis`.

5.2.3 read_rev

Function called by the `write_summary` procedure for each revolution. The routine reads information for counts and temperature, and returns the ***rev_N.txt*** file and the revolution mean parameters. The function finds out all ScWs (**10.001*) in the revolution directory and, for each, proceeds in this way:

- calls function `rate` that reads Single and Multiple events at ScW level and returns in output counts and exposure times;
- calls function `temperature`;
- reads the FITS file for sun aspect and compute the mean value for single pointings;
- print to file ***revN.txt*** information for the single ScW.

Average parameters on revolution are passed to `write_summary`.

5.2.4 rate

This routine derives information for counts at single ScWs. It is called for each pointing by `read_rev` and by `big_counts`.

When called by `read_rev`, the routine reads the instrument acquisition mode from the header of ***swg_ibis.fits***. If data acquisition occurred in Standard Mode (IBISMODE = 41) the routine reads counts, performs dead time correction, reads exposure from file ***picsit_detector_shadowgram.fits*** for processed data, and derives the number of killed pixels from the file ***picsit_efficiency_shadowgram.fits***.

When called by `big_counts` the data sample has already been cleaned and the routine knows what type of data it has to read (Single or Multiple events). It reads again data file, integrate over pixels corrects for dead time and returns the array of counts at each energy bin and the related exposure.

5.2.5 temperature

The routine provide temperature information at ScW level. It is called by `read_rev` and by `big_temp`. From the **IBIS-HARD-CNV** extension of the file ***ibis_mce.fits.gz***, the routine reads all temperature acquisitions made by each sensor during the pointing. The ScW temperature is computed as the average of all these values.

When called by `read_rev` the function returns the ScW mean temperature, start and end time of the acquisition and parameter for occurred problems.

When called by `big_temp` the function reads only files that passed the quality selection and returns the ScW mean temperature at each sensor and the average over all sensors.

5.2.6 compute_gain

Routine for writing calibration parameters at file level to ***gain_N.txt*** and to obtain mean parameters on the revolution.

The routine retrieves number and names of calibration file for one revolution in input. In each file the S5 shadowgram is read. Saturated pixel, with counts grater than 200, are reset to 0 for all energy channels. Counts are integrated to obtain the channel spectrum. Around both calibration lines the channel spectrum is modeled by a gaussian added with a background term. Channel intervals are $[4, 23]$ for 511 keV line and $[35, 61]$ for the 1275 keV line. An iterative fit method is applied to the dimmer second line. From best fit parameters the line position and the FWHM are derived together with errors. When line positions are known and channels are converted to S40 scale, gain and offset are obtained from a linear fit.

This procedure is applied to all files with acquisition time > 0 and number of saturated pixels lower than a quarter of the detector plane. Otherwise an error code is given in output.

Parameters at file level are printed to file ***gain_N.txt***.

Revolution parameters are computed in two ways:

- Calibration parameters at revolution level are computed as the mean values over good files that passed the quality selection. During parameters computation at file level, trace is kept of maxima and minima of the mentioned parameters to define their existence interval. These values are returned as output and written in the ***summary.dat*** and ***summary_updt.dat*** files.
- Calibration parameters at revolution level are computed by the same fit procedures (described above) applied to the total channel spectrum, integrated over all calibration files in one revolution. These values are stored in the last line of the file ***gain_N.txt***.

5.2.7 doing_maps

Procedure for detector background maps visualization. The routine is called by main procedure after reading the data set if the keyword **maps** is active. For each revolution in the input interval the procedure reads shadowgrams for those ScWs having **error =0** and **Usr_flag = 1** in the ***rev_N.txt*** file. Shadowgrams for revolution number N are then imaged in the ***S/Mmaps_N.ps*** file. For each ScW, 8 aligned images show the detector plane, viewed at the 8 standard energy bands.

5.2.8 make_arr

Function for building arrays of names for good files for Single Events, Multiple Events and Temperature. The routine is called by the main procedure when the keyword **analyze** is set. Big arrays will be subsequently passed to `big_counts` and `big_temp` functions to obtain short variability plots and updated revolution mean parameters. In order to build the array for counts the function reads all the ***rev_N.txt*** in the given revolution range and selects ScWs with null value for **error**, **Bad_exp** and **Null_pix** and with **Usr_flag = 1**. Moreover the respective temperatures and **T_C** values are saved in output arrays.

A similar procedure is adopted to make the array of ScW names for temperature, selecting files with temperature grater than the input value **min_of_temp** with associated sun aspect.

5.2.9 big_counts

Function for short variability plots of count rate at each energy bin and temperature correlation. The routine is called by the main program if the keyword **analyze** is active and generates files ***S/MratesN1_N2.ps*** in the *Plots* directory. Plots in linear-logarithmic scale are obtained with the keyword **log**. When the keyword **cross** is activated the routine also produces ***S/MCrossN1_N2.ps*** files for the same blocks of revolutions. It works both for single and for multiple events. The input variable is a string array of names of all ScWs that was previously built by `make_arr` function. For each ScW name the `rate` function is called and detailed (energy dependent) count rate are then plotted for progressive ScWs. Averaged parameters on each revolution are updated.

With the **cross** keyword the code calculates the average values of counts and temperature on the given revolution range and displays rate variation as a function of temperature variation in each energy bin. Temperature values are given in input.

5.2.10 big_temp

Function for short variability plots of temperature at each sensor. The routine is called by the main program if the keyword **analyze** is active and generates files ***TemperatureN1_N2.ps*** in the *Plots* directory. For each ScW, given as input in a string array, the `temperature` function is called and temperatures at each sensor are then plotted for progressive ScWs, with different colors for different modules. Also sun aspect angles are plotted as a function of ScWs in the ***SunAngleN1_N2.ps*** file, as they are read from ***rev_N.txt*** and passed as an input array. Temperature mean parameters for each revolution are updated.

With the **cross** keyword the code cross-correlates temperature and sun aspect.

5.2.11 gain_analyze

Function for short variability plots of gain, offset, line positions, energy resolutions and total counts. The routine is called by the main program if the keyword **analyze** is active and generates files ***GainsN1_N2.ps*** in the *Plots* directory. Values for S5 counts and related quantities are read from ***gain_N.txt*** files, including only those with user flag equal to 1 and error codes set to 0. Plots for Gain-Offset and Gain-Temperature correlation are also created.

Revolution mean parameters are updated.

5.2.12 longplot

Routine for long variability plots of main monitoring parameters at revolution level. The routine plots the content of ***summary.dat*** and ***summary_updt.dat*** in the ***longplot.ps*** and ***longplot_updt.ps***, respectively, in the *Plots* directory. Moreover the file ***gain_rev.ps*** is produced to inspect calibration parameters computed after integrating S5 spectra over each revolution.

5.2.13 gain_pix

The routine calculates at pixel level position and energy resolution at both lines together with gain and offset. Calibration counts are summed at pixel level until the χ^2 of the second line fit at the pixel $(4,4)$ is lower than 10. The procedure is called by the main routine when the keyword **pix** is activated. Maps and histograms are produced in the *Plots* directory in files *gain_mapsN*, where N is the number of the final revolution.

6 Known Bugs

- `longplot.pro` does not work for a single revolution.
- `write_summary.pro` updates the number of revolutions under analysis before calling `read_rev`. If something wrong occurs, the **summary.dat** file is not completed and in a subsequent run the code crushes.
- The **summary.dat** file must contain all consecutive revolutions between the starting and the final ones, since it does not check the revolution number in the file. If the case, the user must complete the **summary.dat** file by inserting rows of 0.

- The code crushes if the **summary.dat** file is complete but files **rev_..** and/or **gain_..** are missing.
- `gain_analysis` works properly only if files for temperature are found.

References

Foschini et al., 2007, *IBIS/PICsIT Instrument Specific Software Scientific Validation Report*