PICsIT gain and offset monitoring at pixel level.

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1. Introduction

The variation of PICsIT gain and offset have already been studied both with pre-launch tests, and also with in-flight data (Malaguti et al. 2003). However, in order to acquire enough statistics in a Science Window (ScW)[1], these tests were conducted by integrating over the entire detector plane the single pixel spectra available from the on-board calibration unit (OBCU) data. This allowed the study of the *average* gain and offset values of PICsIT during the course of each orbit, with a time resolution of the order of one ScW. On the other hand, the necessity to use an aggregate, all-pixel, spectrum prevented the analysis of the possible non-uniformities across the detection plane.

Aim of the present report has been, therefore, to study the variation of gain and offset at pixel level. This task is important in order to correct for possible systematic effects on the energy reconstruction, induced by temperature-driven gain and offset variations. This has been obtained by summing together single pixel OBCU spectra taken at the same temperature, even if corresponding to different ScW.

2. ScW Temperature Measurement

The mean PICsIT temperature for each ScW has been obtained by taking the average of the 32 values available from the thermistors placed on PICsIT detection plane. These data have been extracted for all ScW from revolution 30 to revolution 300.

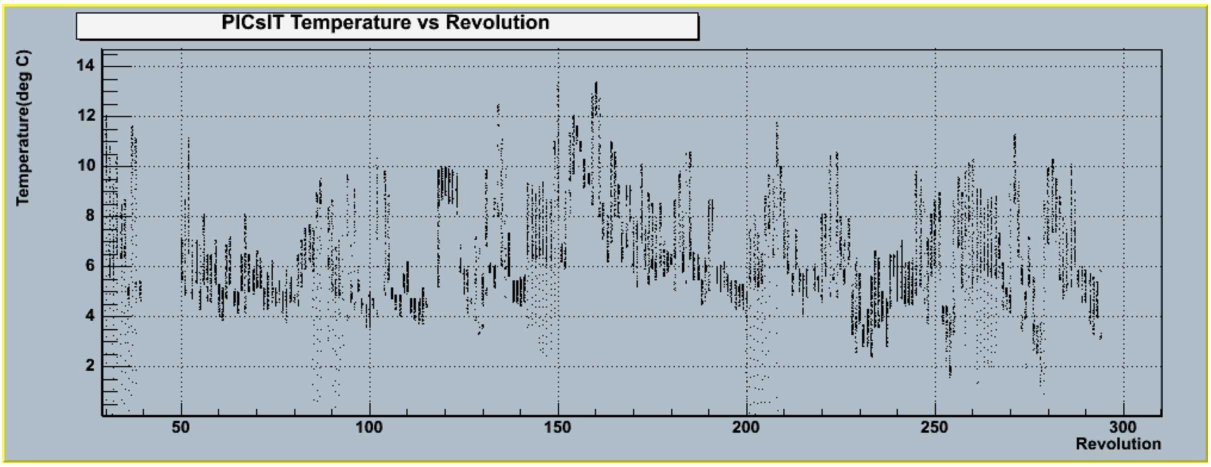

Figure 1: Average PICsIT temperature variation (from Rev. 30 to Rev. 300, each point corresponds to one ScW) obtained taking the mean of the 32 values measured from the thermistors placed on the detection plane.

Figure 1 shows the variation profile of the average PICsIT detector temperature in the interval Revolution 30-300. Figure 2 shows the differential distribution of all ScW mean temperatures in the

[1] The OBCU single pixel spectra are contained in data stream (S5 telemetry packets) which are not precisely simultaneous with the ScW. However, since the integration time of S5 histograms is of the same order of the duration of one ScW (1800 s), and since their time coordinate is stored, it is possible to associate each ScW with the corresponding S5 histogram, and therefore with the measured gain and offset values.

same revolution interval. PICsIT temperature goes from ~2°C to ~13°C, with a major peak at ~5°C, and a minor one at ~9°C.

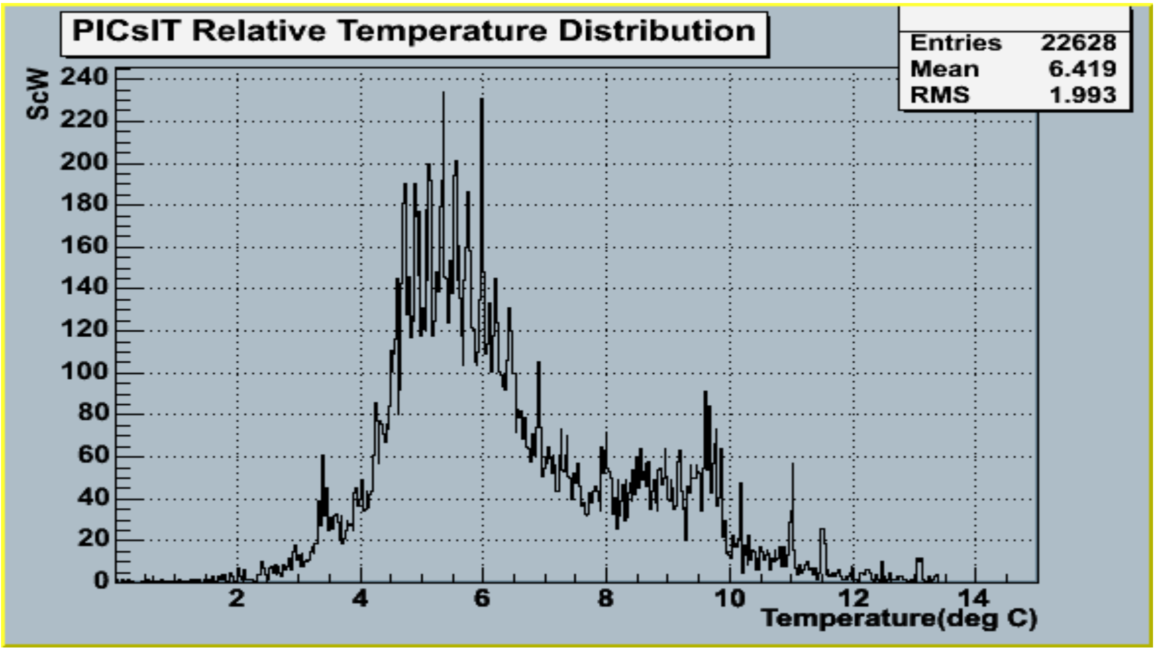

Figure 2: Differential distribution of PICsIT temperature from Rev. 30 to Rev. 300.

3. Calibration lines fits

The ScW have then been grouped together, according to their temperature, in bins of 0.5 °C. Two reference temperature bins have been selected: the first centered on the 5°C peak of the temperature distribution (4.75-5.25 °C) and the second centered on the second peak (8.75-9.25 °C). The OBCU spectra of each single pixel of the ScW belonging to the same temperature bin have been added together and then all the OBCU spectra of all the pixels have been integrated.

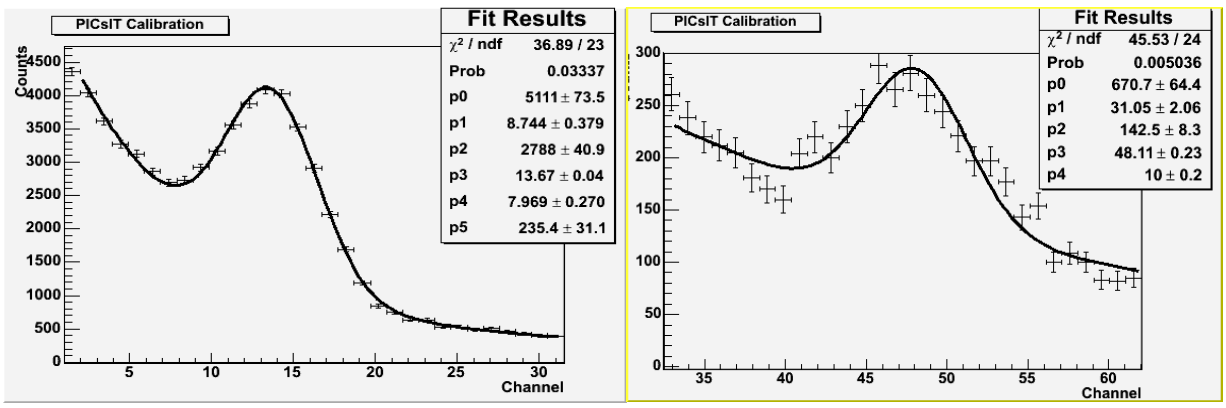

Figure 3: Fits of the 511 keV and 1275 keV OBCU spectral line regions integrated over all the pixels of the detector in the temperature bin 4.75-5.25 °C.

Fig. 3 shows the 511 keV and 1275 keV line fits with all the ScW and pixels integrated together. From an analysis of the data available, it resulted that ≈400 S5 histograms to have statistics to constrain the spectrum successfully.

Figure 4 shows the 511 keV (left panel) and 1275 keV (right panel) spectral regions, for an example of a single pixel spectra, obtained by integrating, pixel by pixel, all the ScW at constant temperature. These single pixel spectra are characterized by a smaller statistics, but still more than sufficient to perform a good quality fit on the 511 keV line. On the other hand, the fit of the 1275 keV in the single pixel case is clearly worse and it is hard to identify and constrain the line (see Fig. 4, right panel).

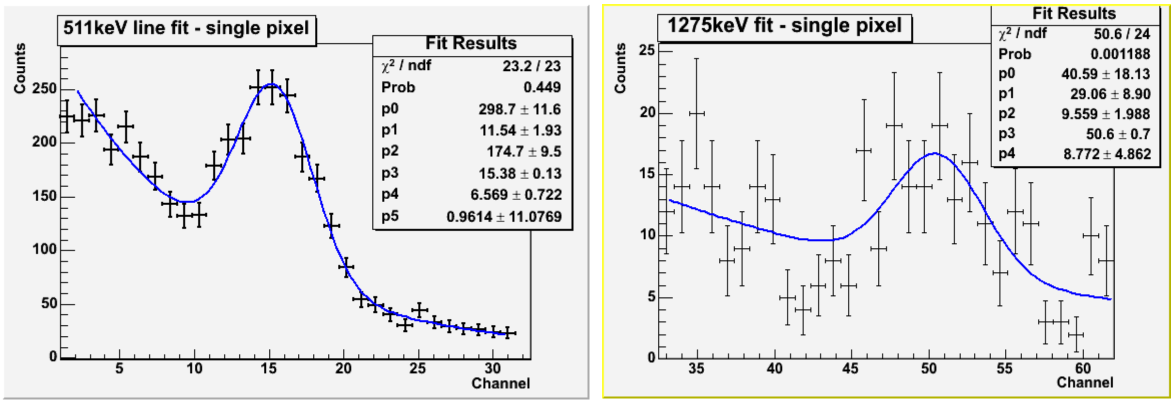

Figure 4: Fits of the 511 keV (left panel) and 1275 keV (right panel) OBCU spectral line regions at single pixel level. The spectra have been obtained by summing together, pixel by pixel, the calibration spectral obtained in the temperature bin 4.75-5.25 °C.

By using the single pixel fit results, it has been possible to obtain an indirect gain uniformity check of all PICsIT pixels, by taking as key parameter the 511 keV line peak position. This was also shown by the analysis of the early in-flight calibration data performed after the launch of INTEGRAL (Malaguti et al. 2003).

In this way, the 511 keV line position channel, integrated for each pixel, can be used to inspect the detector plane non uniformities, as shown in Fig. 5.

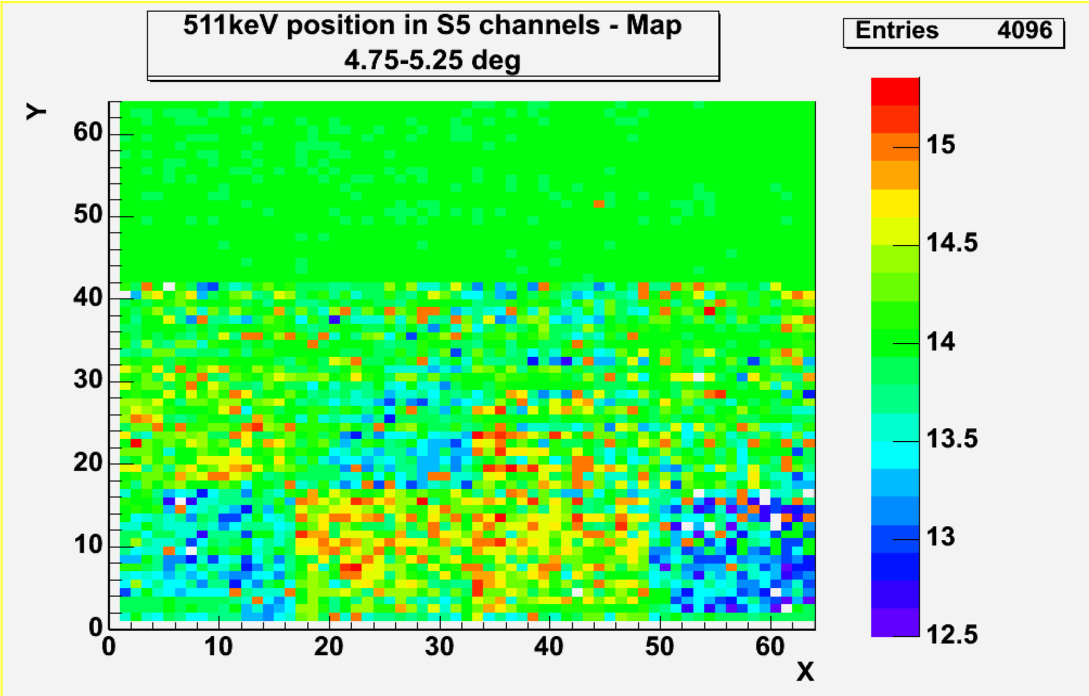

Figure 5: Detector map of the 511 keV line peak channel in the S5 data for the temperature bin 4.75-5.25 °C.

Indeed, it is known that the two main sources of non uniformities in the PICsIT detector plane during its operations in space are[2]:

1. Photons at different energies interact with the CsI in different ways, single pixel event or multiple pixel events; the multiple events reconstruction is performed on board by taking into account the data on each single semimodule. Therefore, if a multiple event is crossing two semimodules is not recognized as multiple, but as two different single events. This leads to an excess of single events on the borders of each semimodule and a corresponding deficit of multiple events.
2. Instrument temperature variations, mainly dependent on the solar aspect angle of the INTEGRAL satellite, are correlated with changes in count rates, with different intensity depending on the energy band.

By analyzing the Fig. 5 it is clear the presence of patterns in the distribution of pixel gains, which correspond to the 16 PICsIT semi-modules. The resulting gain non-uniformity can therefore be ascribed to the fact that the PICsIT detector plane has been populated with pixels coming from different manufacturing ingots, and that pixels of the same ingot have been inserted, in order to minimize the non-uniformity, in the same semi-module.

[2] See several presentations on the status of IBIS/PICsIT detector available at the web site in IASF-Bologna: `http://www.bo.iasf.cnr.it/Research/INTEGRAL/Presentations.html`

4. Final remarks

This report summarizes the latest calibrations of the PICsIT layer of the IBIS imager onboard INTEGRAL. The main novelties with respect to previous studies are:

i. pixel-by-pixel study of the gain variations by means of OBCU spectra accumulation performed integrating ScW at constant temperature;
ii. study of the intrinsic detector non-uniformities by means of the detector map of the 511 keV channel position.

The first point has shown that the 511 keV line is most effective to study the single pixel behaviour, while the 1275 keV line has not sufficient statistics for a useful fit on the single pixel. The second point has shown that the PICsIT detector layer displays intrinsic non-uniformities at semi-module level, probably due to different quality of the pixels used.
The knowledge of this intrinsic non-uniformity amplitude at pixel level, will allow to perform correction to the recorded shadowgram, in order to improve the image quality, and therefore the PICsIT sensitivity.