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IBIS/PICsIT detector layer: Present performance status and possible outlook for the INTEGRAL mission extension

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1. Introduction and aim

This Technical Note summarizes the current status of the IBIS/PICsIT detector layer, and gives the predicted performance of the instrument in view of the possible INTEGRAL satellite extension up to the next Solar maximum expected for 2013.

The analysis has focussed on the key functional performance parameters of PICsIT, namely: detection unit stability, detector module temperature trends, background count rate, detector gain and offset, operative mode functionality and performance.

2. Detection plane

The operations of the PICsIT layer of the IBIS imager are going smoothly and no major degradation is foreseen in the next years.

The number and location of killed pixel is stable at 52 units (~1%), and their distribution is shown in Figure 1. During revolution 326, an error in the context upload process caused the restorations of an old context with 50 killed pixels (instead of 53, which was the previous value). The onboard software immediately switched off again 2 of the 3 pixels not contained in the wrong context. The third previously noisy pixel (29, 38) resulted to be working nominally and thus remained active, and is still performing well.

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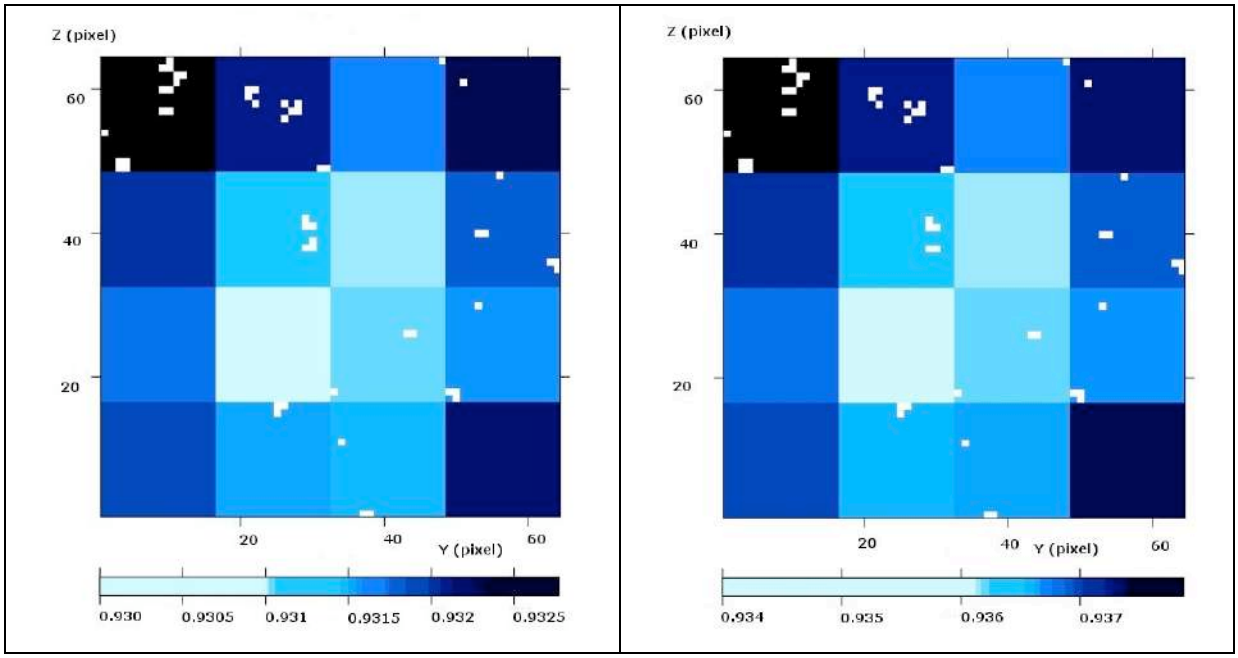


Figure 1 – PICsIT efficiency map in rev. 266 (left) and rev. 345 (right), that is before and after the wrong context upload. The killed pixels are in white, while other colours indicate the deadtime (measured at semi-module level). The restored pixel is in semimodule 6 (second row, second column).

3. Temperature trend analysis

PICsIT temperature is monitored by means of 32 thermistors placed, on the upper surface of the detection plane, in a position close to the corners of each module. The temperature value can be acquired, for each of the 32 sensors, at the beginning of every science window (ScW). Figure 2 shows the temperature profile from revolution 479 to revolution 483.

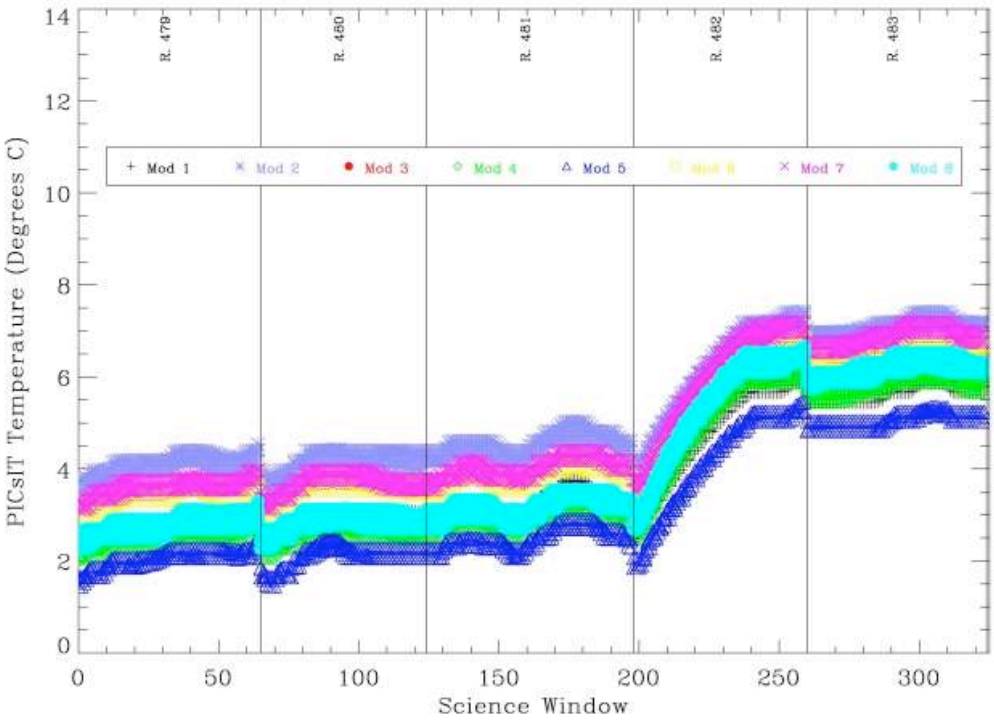


Figure 2 – PICsIT semimodules temperatures along the latest 5 revolutions.

The temperature of the detector is generally stable, within 2-3 degrees, with occasional variations. These have been analyzed and resulted to be mainly due to Solar aspect angle variations.

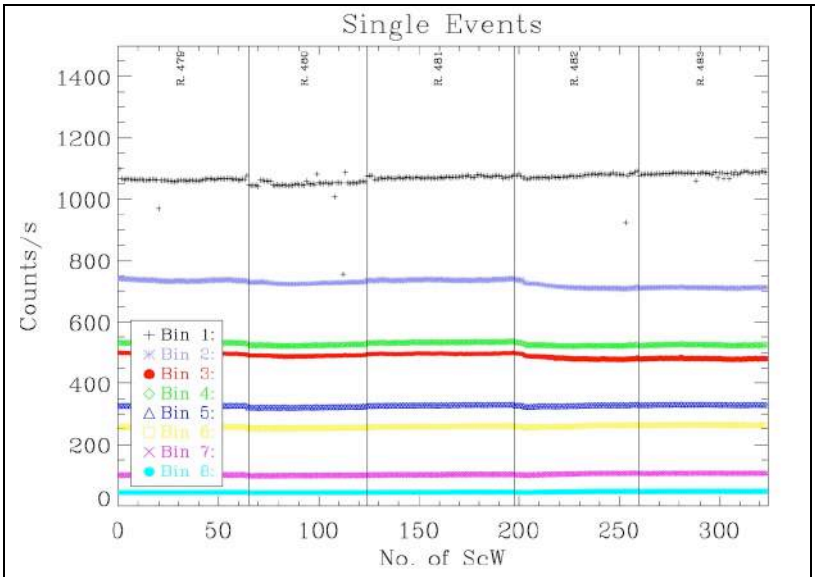
Figure 2 also shows that, in general, temperature values are grouped for each module, and different modules appear to have different temperature. This does not necessarily correspond to a temperature gradient across PICsIT detection layer, but might instead be ascribed to the uncertainty on the inter-calibration between the sensor, and to their measurement accuracy (~0.5 °C).

4. Background count rate

The background rate is still increasing, according to the modulation probably to related to a decrease of the Solar activity (Fig. 3-4). If this is confirmed a decrease of the background rate

after 2008, when there will be the Solar minimum and the activity of the Sun will begin to increase again, can be expected.

Since PICsIT operates in the hundreds of keV – few MeV region, where the background dominates, this reduction, coupled with a more stable and complete OSA version, will imply for PICsIT the possibility to reach performances better than the beginning of the mission.



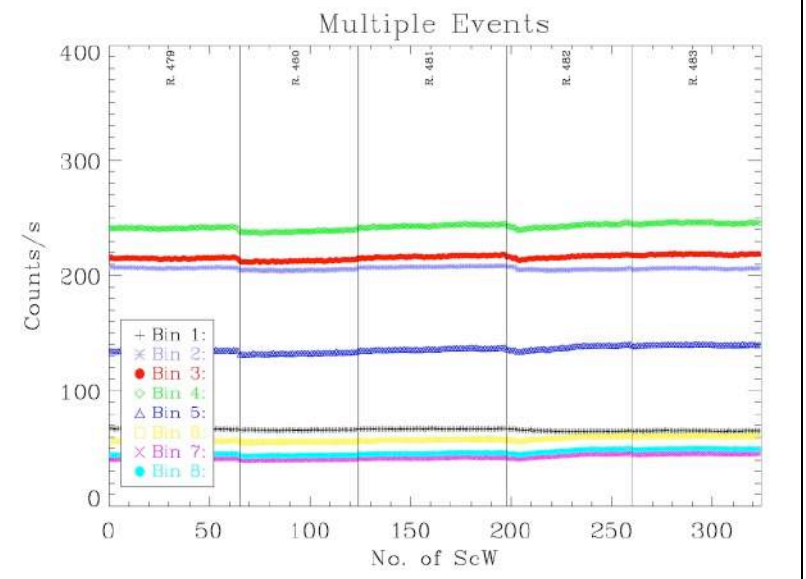


Figure 3 – PICsIT Background rates in the default energy bands during the latest available 5 revolutions (consolidated data).

Bands for single events:
1: 203-252 keV;
2: 252-336 keV;
3: 336-448 keV;
4: 448-672 keV;
5: 672-1036 keV;
6: 1036-1848 keV;
7: 1848-3584 keV;
8: 3584-6720 keV.

Bands for multiple events:
1: 336-448 keV;
2: 448-672 keV;
3: 672-1036 keV;
4: 1036-1848 keV;
5: 1848-3584 keV;
6: 3584-6720 keV;
7: 6720-9072 keV;
8: 9072-13440 keV.

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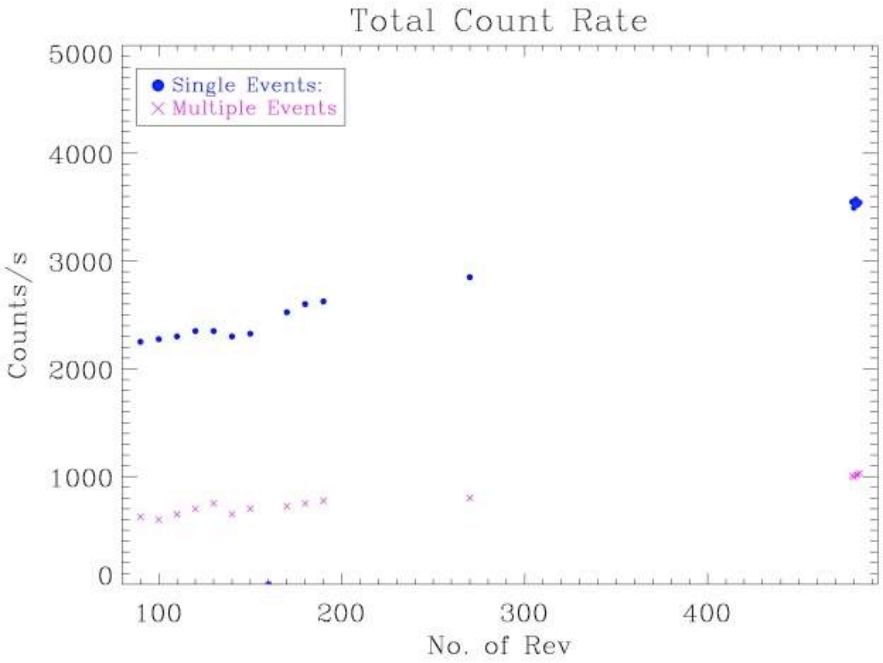

Figure 4 – Trend of total detector count rates (single and multiple events).

5. Gain and Offset

Gain and offset are generally stable, depending only on the temperature, with a distribution of values peaked to 7.1 keV/ch, for the gain, and -2 channels, for the offset (Di Cocco et al., IASFBO Internal Report 437/2005, 30 December 2005). The above mentioned report also shows that it will possible to perform a pixel-by-pixel study of the gain variation, by means of in-flight S5 spectra accumulation, integrating science windows at constant temperature, also by taking into account the foreseen decrease of the calibration source activity (half life ≈ 2.6 yr).

6. Operative modes

As from revolution 441, the spectral timing mode has been set to 8 channels (covering the energy band between 200 keV and 2.6 MeV) and 16 ms of time resolution, so to have the "best" (within the limited available telemetry budget) spectral capabilities in studying gamma-ray burst (GRB) in the MeV energy range. The time evolution during the latest

revolutions confirms the small variability (less than 3%) displayed in spectral imaging data (Fig. 5).

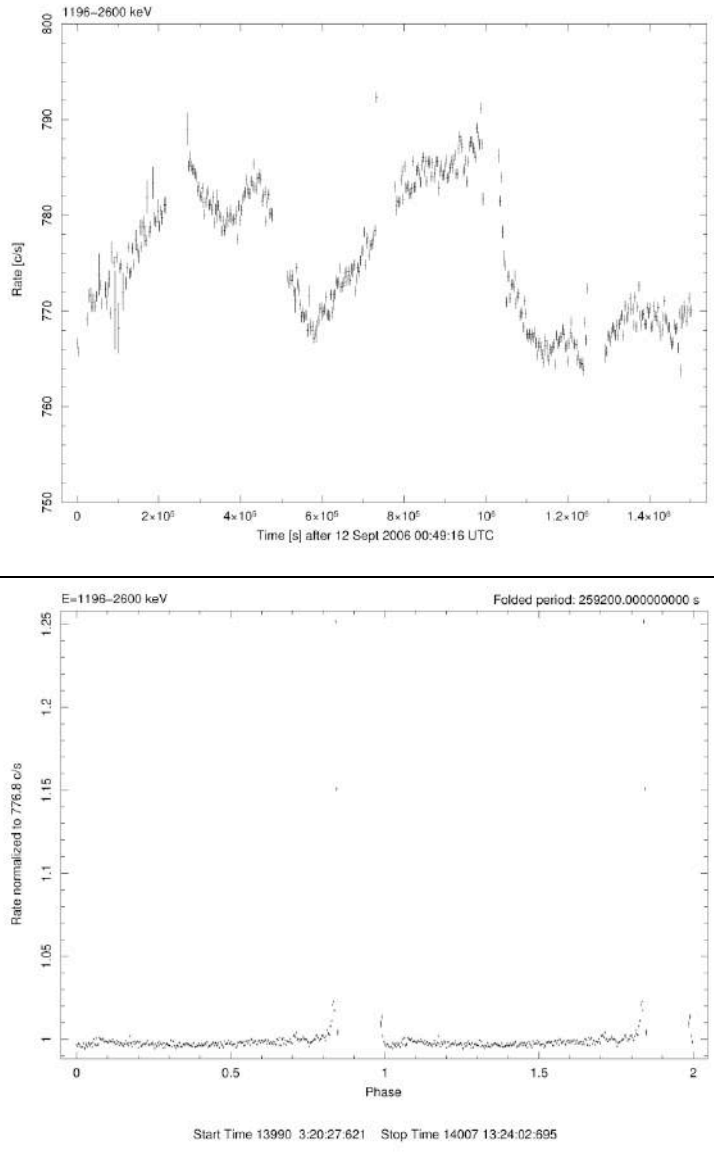

Figure 5 – Spectral timing data in the 1196-2600 keV energy band lightcurve (top), and folded over the orbital period of INTEGRAL (right). Strong increase of count rate is visible when the INTEGRAL satellite is approaching the Earth's magnetic belts.

Studies are ongoing to improve the instrument response, specifically for the spectral timing data. Since PICsIT detected several GRB with this instrument mode (e.g. Fig. 6), the availability of a RMF/ARF for this type of data would significantly improve the scientific return of PICsIT.

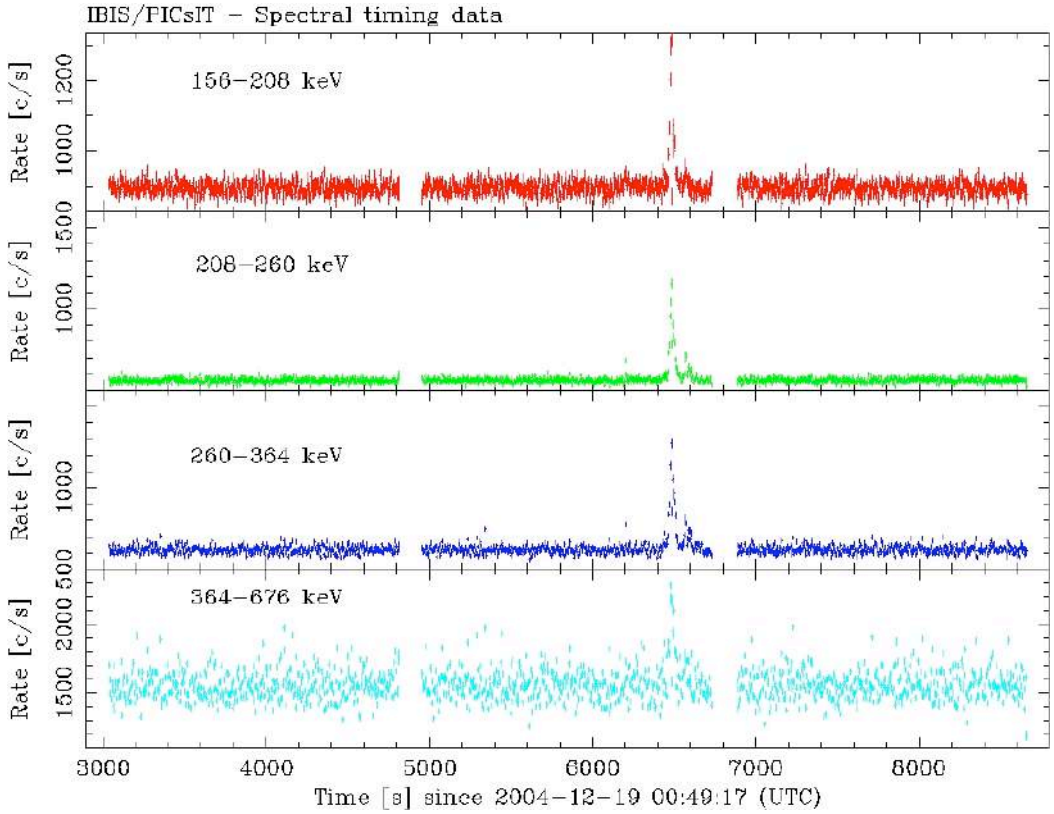

Figure 6 – GRB041219 with IBIS/PICsIT spectral timing data.

More information are available on the PICsIT web site at:

http://www.iasfbo.inaf.it/Research/INTEGRAL/index.html

7. Conclusions

This reports shows that the behaviour of the PICsIT layer in terms of detection area, gain and background, is overall nominal. This clearly implies that PICsIT will benefit of an extension of the *INTEGRAL* mission, also because a more stable and complete OSA version will be operated with the expected (Solar max) low background environment.