Are the three modes (Sbolo_only, Sref_only, Sbolo-Sref) correctly interpreted?

or

Does anyone really understand something about the PhFPU signal?

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Contents

1 Reference documents

	Doc. Number	Title	Version
RD1	SAp-PACS-MS-0616-06	PACS FM Photometer Focal Plane Unit User's Manual	Draft 7
RD2	SAp-PACS-CCa-0046-01	BOLC to DMC Electrical Interface Control Document	1.5
RD3	PICC-NHSC-TR-002	Req. FOV chopper scans, bolometer	0.8
RD4	SAp-PACS-MS-0652-06	Report on the FM ILT PhFPU functional tests	4.0

2 Introduction of the problem

As described in the PhFPU FM user's manual (RD1), there are three modes of "reading" the bolometer camera. "Reading" is in fact an inappropriate term: bolometers are always read in the same way, and the same thing always happen on the signal inside BOLC, it is just a question of what BOLC will send out. The three modes are:

- **Sref_only**: this mode is commanded with the hexadecimal code `P 09 01 00 01`. Contrary to what the name indicates, in this mode the data that is sent out of BOLC is the digital conversion of the bolometer data. Differenciation only occurs with `VH_BLIND`, and not with `VRL`.
- **Sbolo_only**: this mode is commanded with the hexadecimal code `P 09 01 00 02`. Here the data that is sent out is the digital conversion of the signal read on `VRL`. Differenciation only occurs with `VH_BLIND`.
- **Sbolo−Sref**: this mode is commanded with the hexadecimal code `P 09 01 00 00`. Here the data that is sent out is the difference between the signal read on the bolometers and the signal read on `VRL` (differenciation with `VH_BLIND` is still performed on both side).

Note: as of 05/12/06, there is an inversion within the PACS setup in the hexadecimal codes sent for **Sref_only** and for **Sbolo_only**. This is due to a confusing statement in the BOLC to DMC ICD which now corrected (see RD2) and needs to be propagated to the system.

Continuing with RD1, we find in its section 3, that the sign that is affected to the bolometer signal changes with the mode. More precisely, if `V_bolo` is the tension at the bolometer level, then the signal in **Sref_only** is proportional to −`V_bolo` while in **Sbolo−Sref** it is proportional to +`V_bolo`. Since the changes in `V_bolo` are *in principle* related to flux changes, the important point to note here is that **the measured signal variations induced by a given flux change should go in opposite direction between Sref_only and Sbolo−Sref.**

Going a little bit deeper in the physics, RD1 also states that as `V_bolo` is inversly proportional to the incoming flux, in **Sref_only** we should observe that the measured signal varies proportionally to the incoming flux, while the reverse is true in **Sbolo−Sref**.

Now the big question is: do we observe the behavior of the measured signal?

3 The problematic measurements

The PhFPU first light occured on November 15th with a series of complete field of view scans between and including the two calibration sources. In the first of these two scans, the two internal calibration sources where switched on, while the OGSE sources were off. We were thus in principle scanning a dark field of view bracketted by two very bright sources.

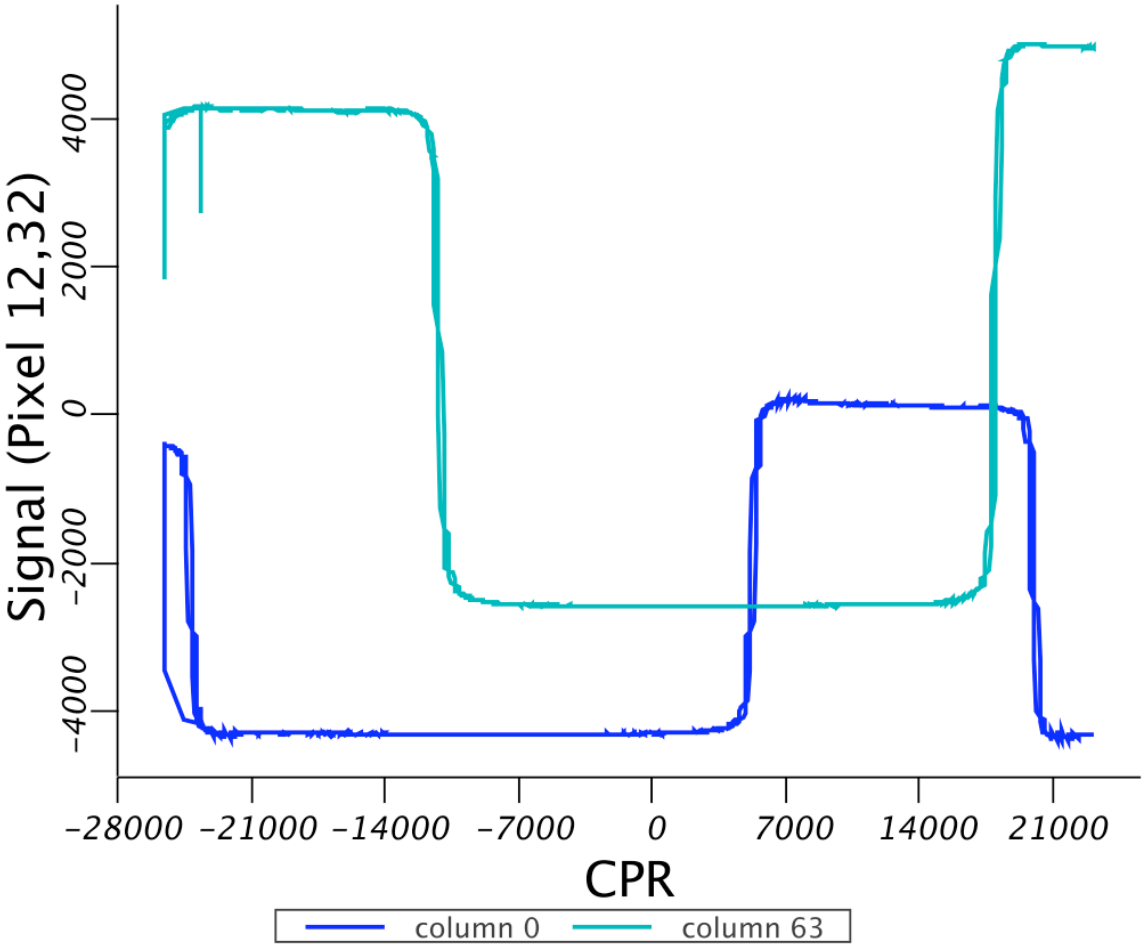

Figure 1: Signal measured on columns 0 and 63 of the blue array during a complete field of view scan where the two internal calibration sources as on and the OGSE sources are off (figure extracted from RD3). The abscissa is the chopper step readback index. Calibration sources are located at the extremes of this index's range.

Figure 1 shows the mean signal measured on columns 0 and 63 of the blue array during a complete scan between the two internal sources as a function of chopper position (I have taken this figure from

RD3). As all the field of view scans were performed in the **Sbolo−Sref** mode, it is clear that contrary to our expectations, *the measured signal varies proportionally to the input flux.*

4 Dedicated measurements

As this was a rather perturbing observation, we have performed a set of measurements dedicated to measuring the direction of signal variation in the different readout modes of the PhFPU. These were performed on November 20$^{\text{th}}$ where we set the internal calibration sources CS1 and CS2 at respectively 80 and 92 Ω (approximately 70 and 76 K), and the OGSE BB2 at 5.7 K (i.e. dark). We then used the internal chopper to chop between the OGSE field of view and CS2. We performed this measurement in the two photometer filters, and in the three readout modes of the PhFPU. It is during these measurements that we found out that there was a hexadecimal code inversion for the **Sbolo_only** and **Sref_only** modes. In the present document, I am using the name-code association of RD1, which is recalled in section 2.

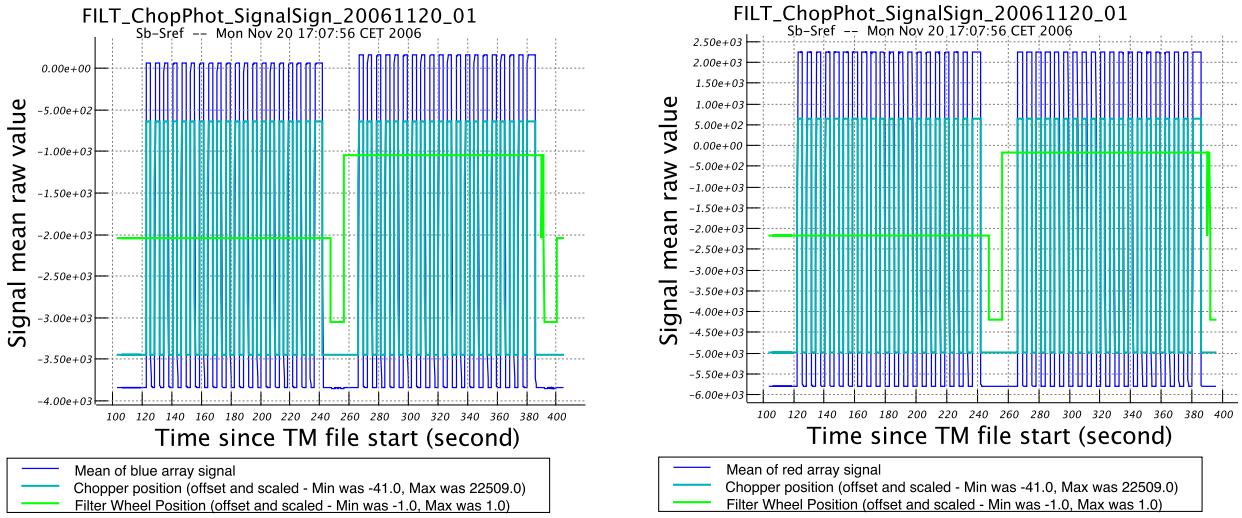

Figure 2: Evolution of the mean signal on the blue (left) and red (right) arrays during the chopped measurement performed between the dark OGSE field of view and the bright internal calibration source CS2 in **Sbolo−Sref** mode. The mean signal is the violet line. The green line is the filter wheel position readback (and has no effect on the red data...) and the turquoise line is the chopper position readback. These two counters are offset and scaled so that they fall on the same dynamics of the signal, but the scale is kept positive. On this figure it is quite clear that the signal is higher when the chopper is on the CS2 position.

Figure 2 shows the evolution of the mean signal on the blue and red arrays as a function of time. Overlaid to this evolution I have plotted the chopper position (CPR) and the filter wheel position (WPR). The latter two are offset and scaled so that they fall on the same dynamical range as the signal, but the scaling factor is kept positive (the original dynamical range is given in the legend of the plot).

It is quite clear on this figure that the measured signal is proportional to the incoming flux: when the chopper is in its high position (corresponding to CS2) we see much more signal than when it is on its low position (corresponding to OBSE BB2, dark). This confirms that what we saw on the field of

view scan is a feature of the instrument and not an accident.

We have also performed the same measurement in the **Sref_only** mode which, I recall, is a mode where only the signal measured on the bolometer is downlinked.

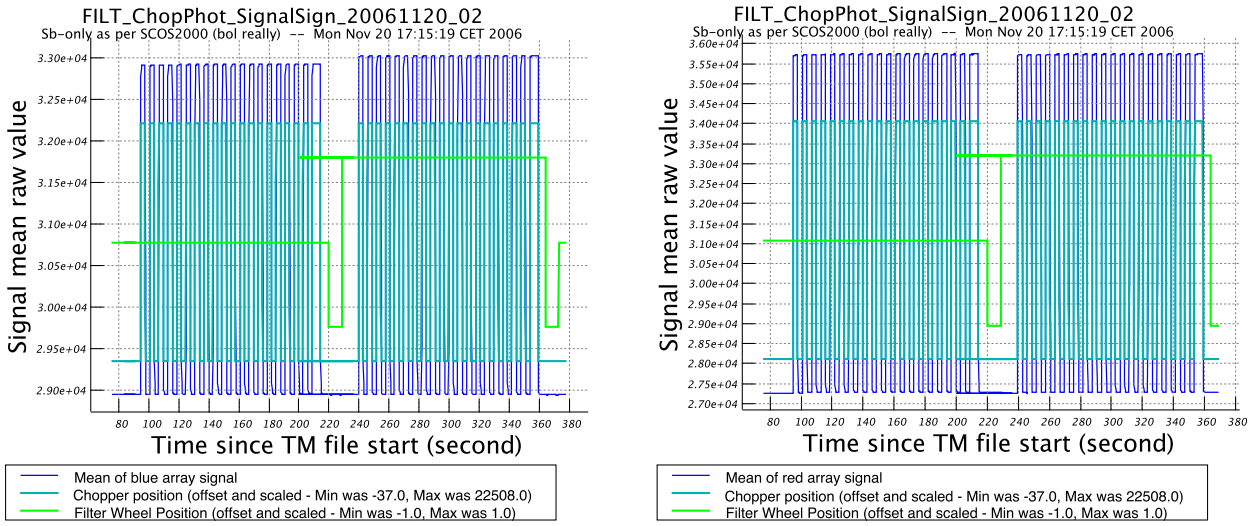

Figure 3: Evolution of the mean signal on the blue (left) and red (right) arraus during the chopped measurement performed between the dark OGSE field of view and the bright internal calibration source CS2 in **Sref_only** mode. Note that the subtitle indicates that we have commanded **Sbolo_only** but remember that at that time, there was an inversion of the name-code relation. Thus we are really in **Sref_only** mode as of the present document. We see that the measured signal is directly proportional to the incoming flux. Note as well the presence of an incorrect time value in the middle of the measurement (seen as a horizontal line segment on the signal, chopper and filter data).

Figure 3 is, contrary to the expectation, very similar to figure 2: the measured signal is seen to follow directly the incoming flux. As mentioned in section 2 this is the behavior of the **Sref_only** mode as described in RD1, but according to RD1, it was not expected that the sign of the proportionality between the measured signal and the input flux would be the same in **Sref_only** mode and in **Sbolo−Sref** mode.

Therefore at that stage it is as if the data in **Sbolo−Sref** mode as affected by an extra minus sign at the exit of BOLC. Following this experiment I raised `SPR-0632`. In this SPR I was rather prompt to accuse the different software layers to be responsible for this extra sign. I was thus also asked to compare LTU-acquired data with PACS-acquired data to see if indeed the two systems, performing identical measurements, would give different results.

For this test I have used the 4 K level functional tests. These were performed on October 31st with the LTU and on November 2nd with the regular PACS set-up. Both tests execute exactly the same commands (i.e. the CUS script uses the correct hexadecimal codes for the readout modes). Those unfamiliar with the functional tests can consult RD4. At the end of the functional test sequence, we successively set the readout mode to **Sbolo_only**, **Sref_only**, and **Sbolo−Sref**. I have thus compared the measured signal output during this sequence for the two different setups. Note that this is really an "end-to-end" comparative test: the LTU-driven test is analysed with our private IDL package, while the PACS-driven test is analysed with PCSS.

In figure 4 I compare the mean signal level on the central 4×4 pixels of matrix 1 (a blue matrix)

observed for the LTU-driven test and the PACS driven test. I am using matrix 1 as an example, but the results are the same for all 10 matrices. As can be seen from the figure, the signal levels are identical, i.e. *there is no inversion of the signal sign in* **Sbolo−Sref** *mode between the LTU and PACS*. It is thus clear that the problem, if indeed there is a sign problem in the **Sbolo−Sref** mode, is not due to the software, but rather to the hardware, i.e. the photometer itself.

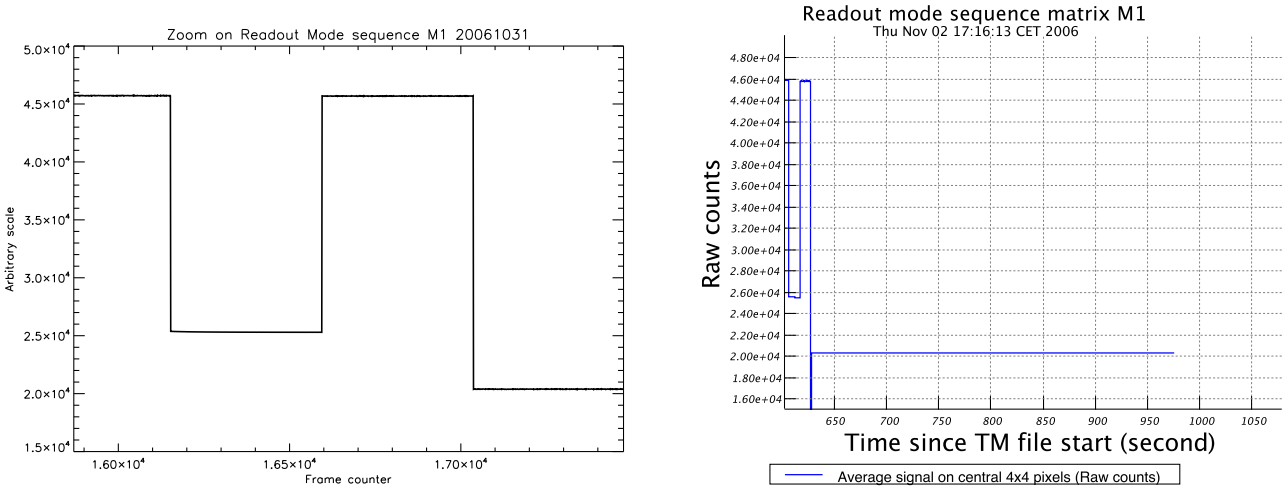

Figure 4: A comparison on the central 4×4 pixels of matrix 1 of the signal level observed during the **Sbolo_only**, **Sref_only**, and **Sbolo−Sref** mode sequence, during the LTU-driven test and analysed with our IDL package (left) and during the PACS-driven test and analysed with PCSS (right). Note that the plots start a little bit before the sequence. We see that the signal levels are exactly the same.

We therefore went back to the laboratory where fortunately we are currently testing a relatively identical version of the bolometers (made for a ground-based prototype instrument) which are commanded by BOLC QM2. We performed an experiment similar to the chopped measurement described here and discovered that indeed, and contrary to what RD1 states:

- In **Sbolo−Sref** mode the measured signal is directly proportional to the incoming flux.
- The sign of the proportionality between the measured signal and the incoming flux is the same in **Sbolo−Sref** and in **Sref_only** mode.

The elements that lead us to think otherwise are being investigated. All the SAp people that have experimented with the photometer in its different incarnations in the SAp laboratory "swear" they have seen the measured signal decrease when the flux increased, although they cannot precisely identify when they last saw it. It is clear that BOLC FM and QM2 show an identical behaviour, so the change could have occured between BOLC QM1 and BOLC QM2, although BOLC QM1 was used during CQM and I remember observing the same signal behavior during field-of-view scans...

5 Conclusion

The observed behavior of the measured signal with respect to the incoming flux in the different readout modes is thus correct. It is the description of this made in RD1 and possibly in RD2 which is incorrect. These two documents will be reviewed to make all the necessary changes.