

Dark Current of Ge:Ga detectors from FM-ILT/IST. IMT_502

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Req. IMT_502 Dark Current of Ge:Ga detectors

IMT_502 - A. History

Version	Date	Author(s)	Change description
1.0	August 20, 2007	Juergen Schreiber, Ulrich Klaas, Helmut Dannerbauer, Markus Nielbock, Jeroen Bouwman	First issue

IMT_502 - B. Summary

The derived dark currents of the red array exceed the specifications by a factor of 2 to 5. The values are in good agreement with those found at module level tests. Stray light due to non-optimal alignment of the image slicer may effect some edge modules.

The derived dark current of the blue array is very low and fulfills the specifications. The values are a about a factor of 2 lower than found at module level tests.

Weak cross-talk is found in both arrays. The ramps of the resistor channels of the supply groups 1 and 3 show non-nominal behaviour.

IMT_502 - C. Data Reference Sheet

Ref	Date	Archive filename
TM file 1	28/02/07	FILT_IST_502_20070409_DarkCurrentOnCs_10.tm
RD-1	13/02/06	DEC/MEC User Manual, PACS-CL-SR-002
RD-2	01/03/05	PACS CQM-ILT Analysis Report, Part II
RD-3	02/12/05	Detector Dark Current Test on Internal Calibration Sources during cold EQM-IMT, PICC-MA-TR-003
RD-4	16/03/07	PTD_1.2.6
RD-5	05/01/07	PACS Calibration Document PACS-MA-GS-001, draft 8
RD-6	10/08/06	Cold Performance Tests on FM High Stress Ge:Ga Detector Modules, PACS-ME-TR-063
RD-7	16/03/06	Summary of the cold performance tests on LS-FM Ge:Ga detector modules at MPIA, PACS-MA-TR-030
RD-8	29/01/02	Requirements for PACS-CRE, PACS-ME-RS-002

IMT_502 - D. Test Description

IMT_502 - D.1. Introduction

This test was a reference measurement for the IMT/IST tests. The goal of this test is to measure the dark current for each pixel. It also serves as reference for straylight assessment for different FPU environments (PACS test cryostat, Herschel cryostat for IMT/IST tests).

The specification for the dark signal is that the number of dark electrons per second should be less than $5 \times 10^4 \text{ e}^-/\text{s}$ (see RD-8).

IMT_502 - D.2. Test Overview

The FM-ILT/IST dark current measurements were carried out on 09 April 2007 during the final phase of the FM ILT. The measurements were performed by staring at the switched-off calibration source ($T = 4.677 \text{ K}$) by applying a constant chopper position of -21350. The grating position was constant at 500000 which corresponds to a wavelength of $179.7 \mu\text{m}$ for the red array and $89.8 \mu\text{m}$ (second order) for the blue array. The smallest capacitance of 0.14 pF (effective) was used for both arrays. Data acquisition was done in buffer transmission mode, that means raw ramps with 2 sec reset intervals (512 samples) for each pixel were recorded in 10 s intervals with breaks of 3 minutes. The bias voltage was set to 68 mV for the red array and 168 mV for the blue array. The voltage range of the 16 bit ADC was assumed to be 6.26 V. The red detector temperature was at 1.793 K while the blue one was at 2.477 K . The signals (slopes of the ramps) were calculated by a linear fit to the raw ramps. The first 2 samples of red array ramps were discarded, because they are known to deviate (starting hook) (see Fig. 1).

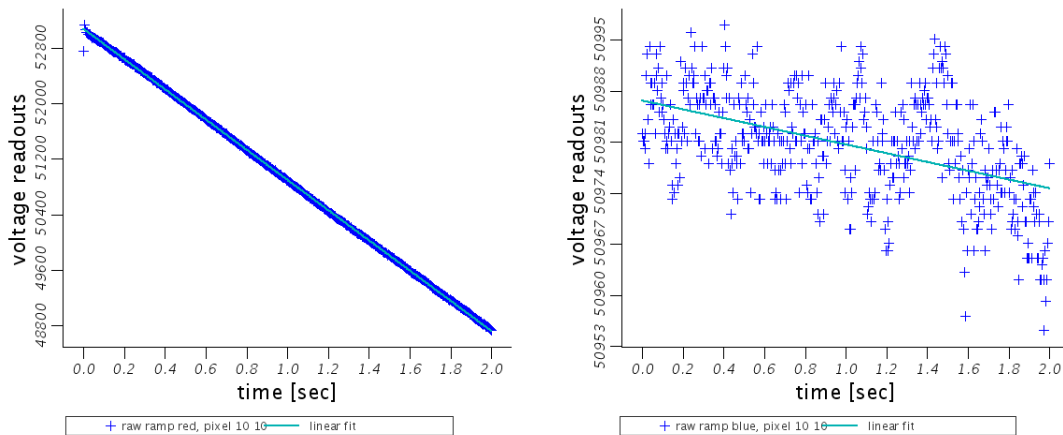


Figure 1: linear fit of raw ramps for red and blue pixel 10, 10

IMT_502 - E. Results

In Fig. 2 the median of all determined signals for all pixels are shown.

IMT_502 - E.1. Red Array

The 4 known dead pixels and 2 known low response pixels can be discerned clearly. The signals of the nominal pixels range between 70000 and 320000 e^-/s , that is a factor of 2 to 5 above the specifications! The mean value without open and resistor channel and known bad pixels is $139069 \pm 48627 e^-/s$. The resulting values are in very good agreement with the values measured at module level (see RD-6). There, the values varied between 100000 and 300000 e^-/s for a bias of 70 mV.

Remarkable are the columns 4, 9 and 19 which show a significantly higher signal. These modules are at the edge of the field of view and are known to be affected by a poor alignment of the image slicer. This could be a hint that these modules catch (stray) light from other directions than from the cold calibration source.

From the visual inspection of Fig. 2 there is the impression that column 10 is brighter than the average. This might be due to cross-talk from the high signal column 9. This impression is confirmed by the results of the module level tests described in RD-6. At module level column 9 (corresponding to module FM162) and column 10 (corresponding to module FM189) have both a rather moderate similar dark signal of about 150000 e^-/s at 70 mV bias while column 11 (corresponding to module FM196) has a high dark current. At FM-ILT/IST the central pixels of column 10 have a signal of about 190000 e^-/s which is significantly higher than at module level while column 11 is significantly weaker than at module level. This disagreement with the module level test results indicate that column 10 is enhanced by cross-talk from the bright neighboring module 9.

The bad resistor pixel in column 6 (FM168) seems to have an influence on the detector pixels by decreasing the dark current of the whole module. This cannot be confirmed by module level findings, where the neighboring column 7 (FM184) has also a significant higher dark current (see RD-6).

Overall the dark current of the modules on the right hand side (supply group 1), where the resistor pixel show very low (or even negative) signals, is on average lower than modules of supply group 2 (see also Fig. 3).

IMT_502 - E.2. Blue Array

The blue array has a very low dark current, the ramps cover a very small dynamic range and therefore look noisy (see Fig. 1). The values span a range from 700 to 2700 e^-/s and therefore clearly fulfill the requirements. The mean value without open and resistor channel and known bad pixels is $1595 \pm 605 e^-/s$. Overall, the resulting values are significantly lower (about a factor of 2) than measured in the module level tests (see RD-7). Remarkable is an alternating bright/dark pattern of columns that appears between columns 11 to 20, also the open channels show the same behaviour! In addition, a weak cross-talk from the resistor channel to the neighboring row 16 seems to exist, leading to a general elevation of the dark signal level in this row (see also Fig. 4). Additionally, the open channel seems to be influenced (cross-talk) by high signal modules. They show higher signals for modules with an overall higher dark signal. That means that we have correlated noise on the channels, which the subtraction of the open channel ramps from all signal ramps should remove. Overall the dark current of the modules on the right hand side (supply group 3), where the resistor pixel show very low (or even negative) signals, is on average higher than modules of supply group 2 (see also Fig. 4).

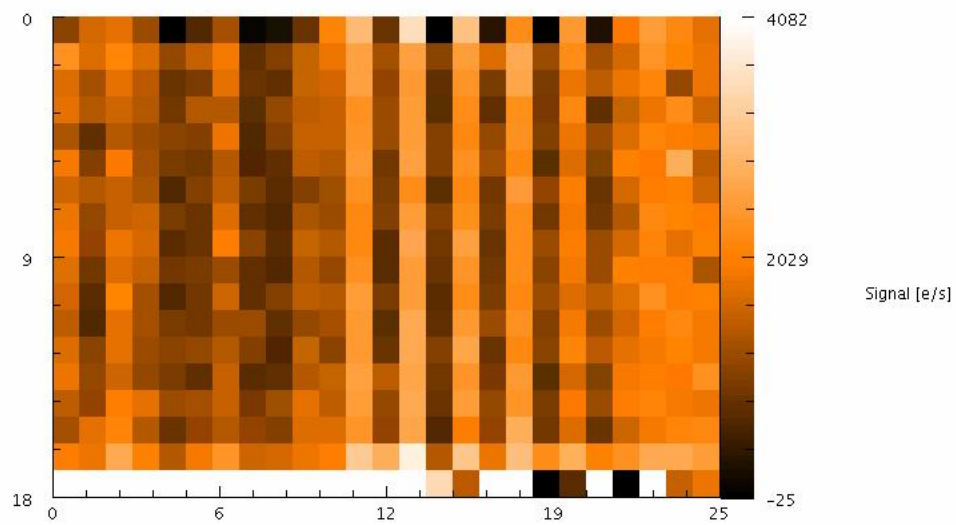
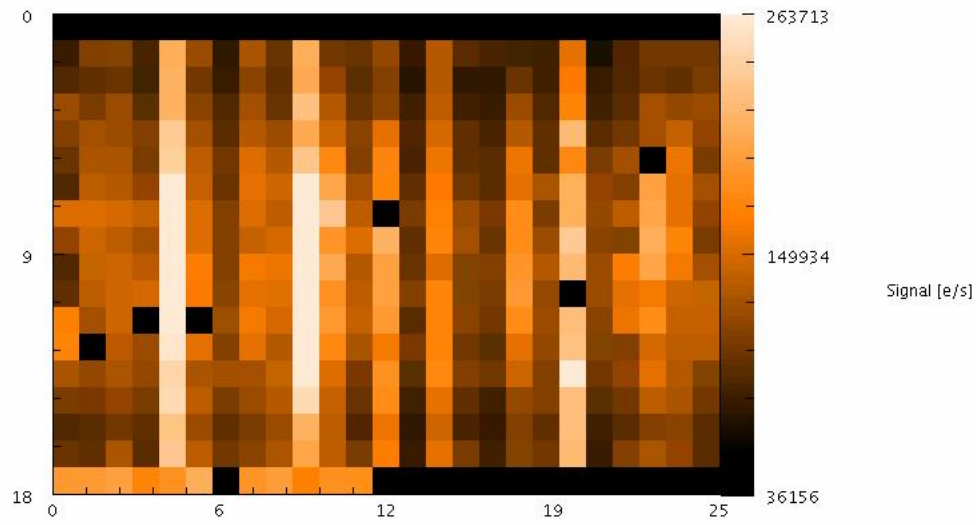


Figure 2: dark current signals of red (upper panel) and blue array (lower panel)

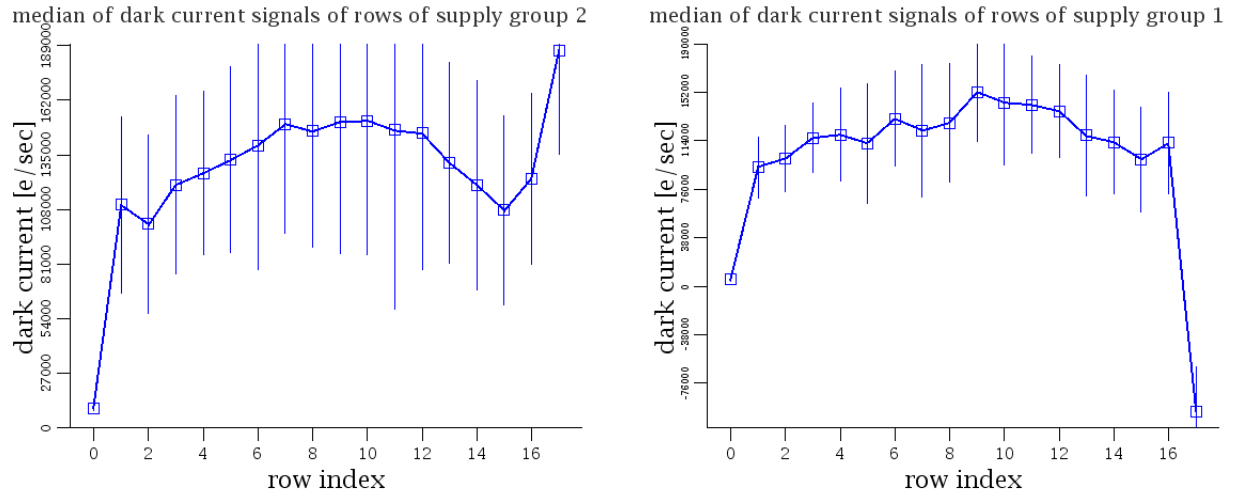


Figure 3: left panel: median dark current spectrum of supply group 2 of red array, right panel: median dark current spectrum of supply group 1 of red array. The error bars reflect the dispersion of pixel values.

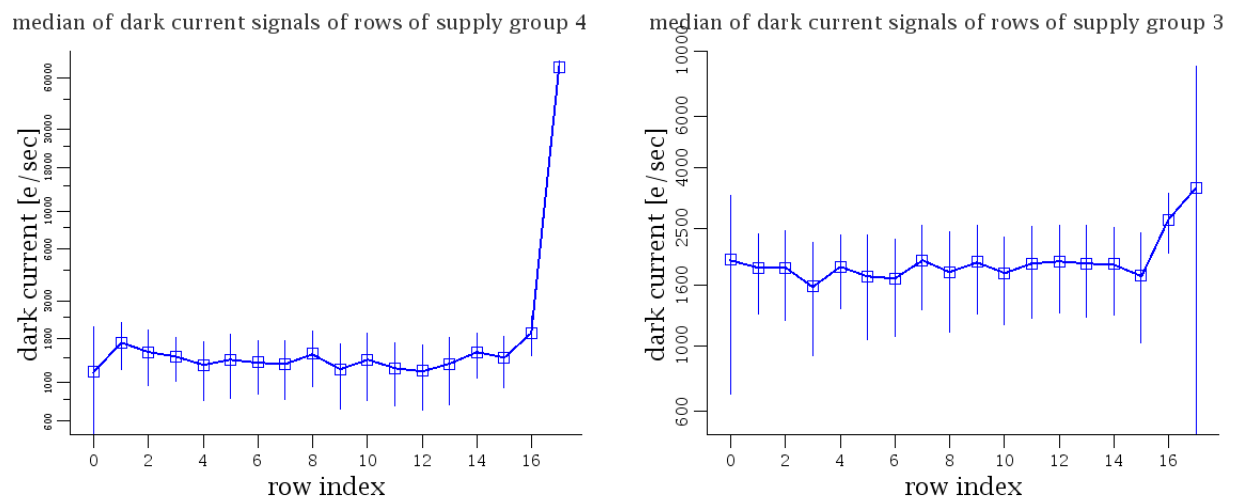


Figure 4: left panel: median dark current spectrum of supply group 4 of blue array, right panel: median dark current spectrum of supply group 3 of blue array. The error bars reflect the dispersion of pixel values.

IMT_502 - E.3. Effects by Supply Group

Another effect was discovered by the signal analysis of the resistor dummy channels. The checkout voltage was set to 0.3 mV. Fig. 2 shows that the signals of the left side of the arrays (powered by supply group 2 (red) and 4 (blue)) are much higher than on the right side of the arrays (powered by supply group 1 (red) and 3 (blue)) where some of them are even negative (pixel in column 6 of red array is known to be faulty)! Therefore, some ramps of the resistor pixels were inspected (see Fig. 5). The ramps of the left sides show a more or less nominal behaviour, while the ramps of the right sides show even positive slopes! This behaviour could mean that the power supplies provide different check-out voltages to the left and right sides of the arrays, possibly even a negative voltage to the right hand sides.

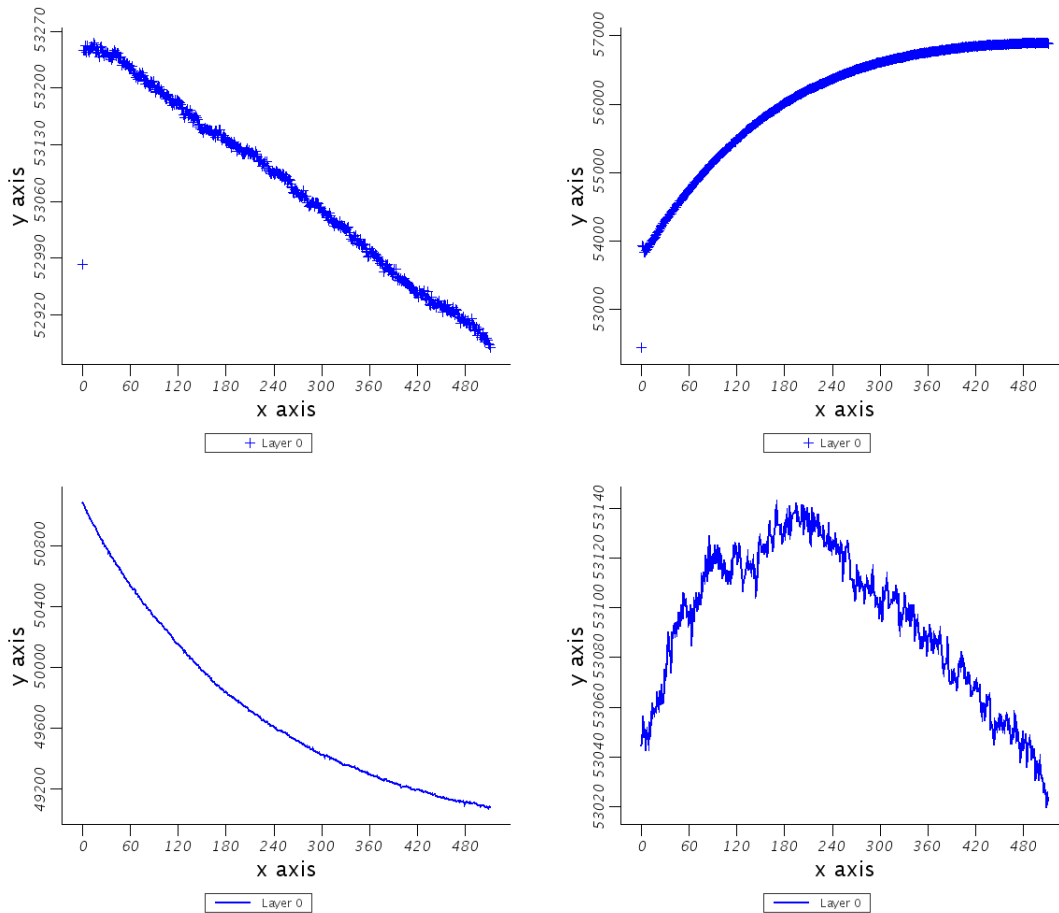


Figure 5: example resistor pixel ramps of one resistor pixel in the left side of the red array (upper left) the right side of the red array (upper right), the left side of the blue array (lower left) and the right side of the blue array (lower right), y-axis are the voltage readouts, x-axis are the sample indices

IMT_502 - F. Conclusions

The tests were carried out successfully and meaningful dark signals could be derived for both arrays with the applied set-up.

The red array shows an excess dark signal. The dark signal of some edge modules might be affected by stray light due to remaining misalignment of some image slicer elements. There is cross-talk from the resistor pixels which depends on the level of the applied check-out voltage, e.g the switch-off of the checkout voltage should

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be taken into account if the resistor signals are not used for data analysis. The applied check-out voltage of this test might however be so low, that different settings/inputs of the supply groups may have a larger effect.

IMT_502 - G. IA scripts used / remarks on PCSS

CAP_1.2.6.py

IMT_502 - H. Lessons learned for IMT/IST/PV