AIDA-NOTE-2012-004
AIDA
Advanced European Infrastructures for Detectors at Accelerators
Scientific / Technical Note

Test a prototype of a Micro Controller Unit (μCU) for the control and reading of the RADMON radiation detectors – LAAS 1600 and REM 250

1st October 2012

P. Iaydjiev, I. Vankov, L. Dimitrov and G. Mitev – INRNE, Sofia and
Bulgarian Science Fund – MEYS, Bulgaria

Abstract:

The final objective of the project is to develop and to produce a system for the control of the dose, absorbed by the different objects (detectors) irradiated at the GIF++.

The purpose of this irradiation test at CERN(at Gif) from 20 of June till 9 of July 2012, was to test a prototype of a Micro Controller Unit (μCU), developed at INRNE - Sofia for the control and reading of the chosen radiation detectors – LAAS 1600 and REM 250. A second task was to verify the characteristics and the producer's calibration of 2 types of radiation detectors – LAAS 1600 and REM 250. For the purpose two PCB, each containing one LAAS 1600 and one REM 250 were investigated consequently at GIF.

The research leading to these results has received funding from the European Commission under the FP7 Research Infrastructures project AIDA, grant agreement no. 262025. This work is part of AIDA Work Package 8: Improvement and equipment of irradiation and test beam lines.

Irradiation test of RADMON boards No 173 and 129 at Gif:

A. The board 173 test:

The first investigation is carried out from 22.06 to 4.07. In it a PCB (No 173) with two different detectors – LAAS 1600 and REM 250 is installed at 45 cm from the GIF radioactive source (fig. 1). At this point a dose rate of 195 mGy/hour was measured by Arnaud Jaunay from the CERN Radiation Protection Service.

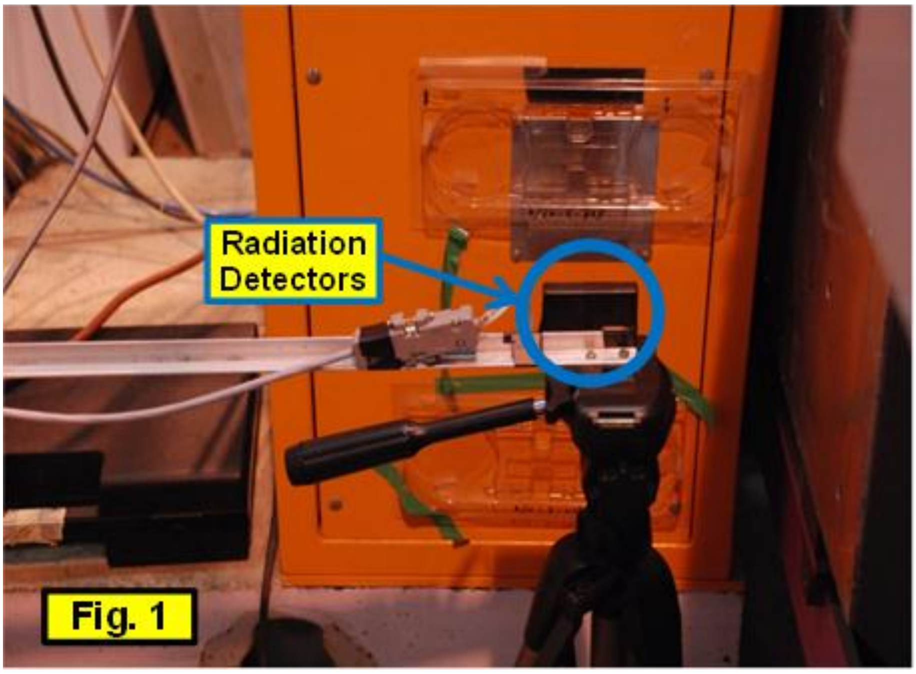


Fig. 1

By a 30 m long cable the detectors were connected to a Micro Controller Units (µCU) (fig. 2), which is controlled by a PC through an RS 485 interface.


Fig. 2

µCU
PC Board
(made at INRNE
Sofia)

During this long time measurement (about 240 hours) the detectors were irradiated with a total dose of 41,7 Gy (213,8 hours total irradiation time).

The main results from the board 173 test are:

1. The parameters of the current pulses, used for reading of the detector's threshold voltages V_T, corresponding to the absorbed dose D (100 μA, 1 s width for the LAAS 1600 and 160 μA, 5 s width for the REM 250) shows a sufficient stability of about 0,1 %. This precision is verified by a control measurement of the detector's threshold voltages by a specialized CERN system. (Thanks to Federico Ravotti and Maurice Glaser).

2. The measuring precision of the threshold voltages of about +/- 12,5 mV is not sufficient, (see for example fig. 6), because of the relatively low dose rate of the GIF. For these reason it was increase to 5 mV for LAAS 1600 and to 6,25 mV for REM 250, which can be seen from the last part of the plot on fig. 8.

3. Fig. 3 shows a plot for LAAS 1600 of the difference ΔV_E between measured values of the threshold voltage V_T and the ini**tial** threshold value V_{T0} ($\Delta V_E = V_T - V_{T0}$) as a function of the really absorbed dose D (calculated on the base of the measured dose/rate of 195 mGy/hour) – red line. The blue line, shows the

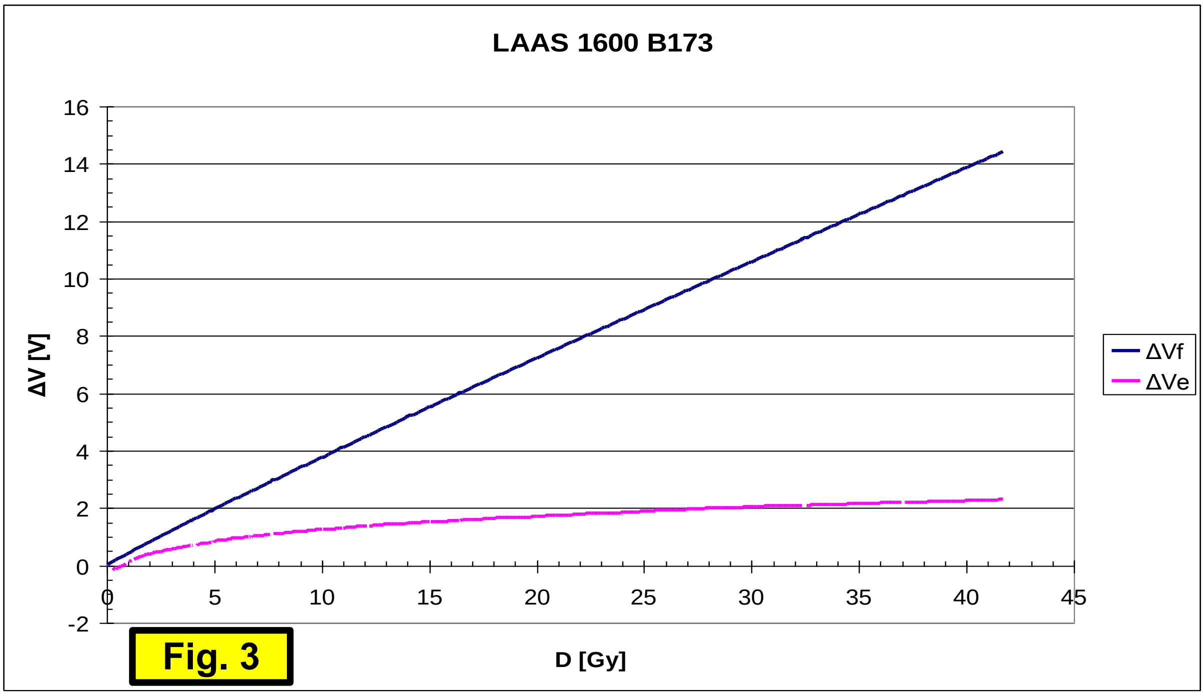


Fig. 3

values of the same voltage difference, calculated by the fit function recommended in [1] – $\Delta V_F = aD^b$ where a=0,432 V/Gy, b=0,9404. Although the fit function is valid only over the limited dose range (≤ 10Gy), the comparison between two results shows a large difference for the investigated LAAS 1600. A very strange fact is the presence of a negative part at the beginning of the dependence ΔV_E (D).

Looking for the best fit we proceeded by two ways in order to avoid the ΔV_E negative values:

First option is to start from the minimal value of the ΔV_E, considering that it corresponds to D=0 and to fit* with the functions $\Delta V_F = aD^b$ (fig. 4) and $\Delta V_F = a + bD^c$ (fig. 5, the best fit); (the continuous line is the fit, yellow points – between ±σ and ±2σ and the red points – between ±2σ and ±3σ); as can be seen the second fit is acceptable;

The second option is to start from the crossing point with abscise considering that it corresponds to D=0 – fig. 6 and fig 7; in this case the fit $\Delta V_F = a + bD^c$ is a little better than the shown on fig. 5.

4.The comparison between the experimental data ΔV_E and the recommended fit $\Delta V_F = aD^b$ (the values "a" and "b" from [1]) for REM 250 are given on fig. 8. In this case the difference between the fit and the measured values is much smaller. The best fit (fig. 9) is found for other values of a and b. This difference probably is due to the fact that in [1] the fit is the best for all investigated type of radiation – gamma, neutrons and others. The big steps in ΔV_E show the low voltage sensitivity of the electronic device (25 mV steps). Therefore the step was decreased to 5 mV for LAAS 1600 and to 6,25 V for REM 250 (for D>32 Gy).

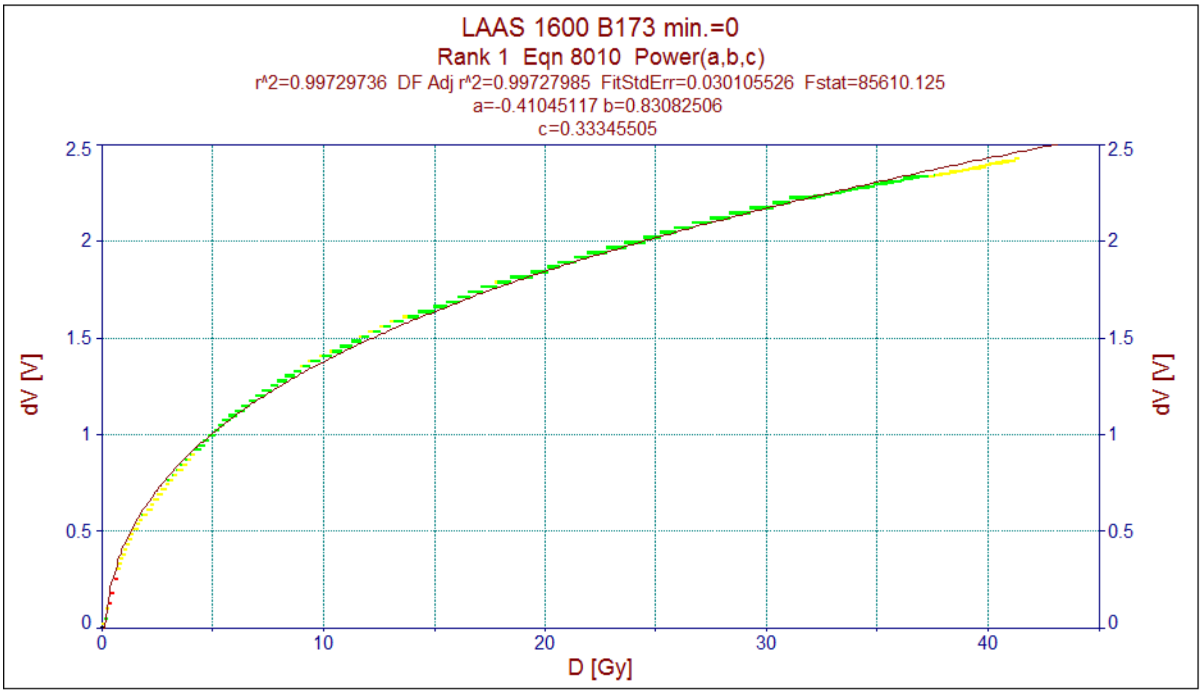

LAAS 1600 B173 min.=0
Rank 1 Eqn 8010 Power(a,b,c)
r^2=0.99729736 DF Adj r^2=0.99727985 FitStdErr=0.030105526 Fstat=85610.125
a=-0.41045117 b=0.83082506
c=0.33345505
dV [V]
D [Gy]

Fig. 4

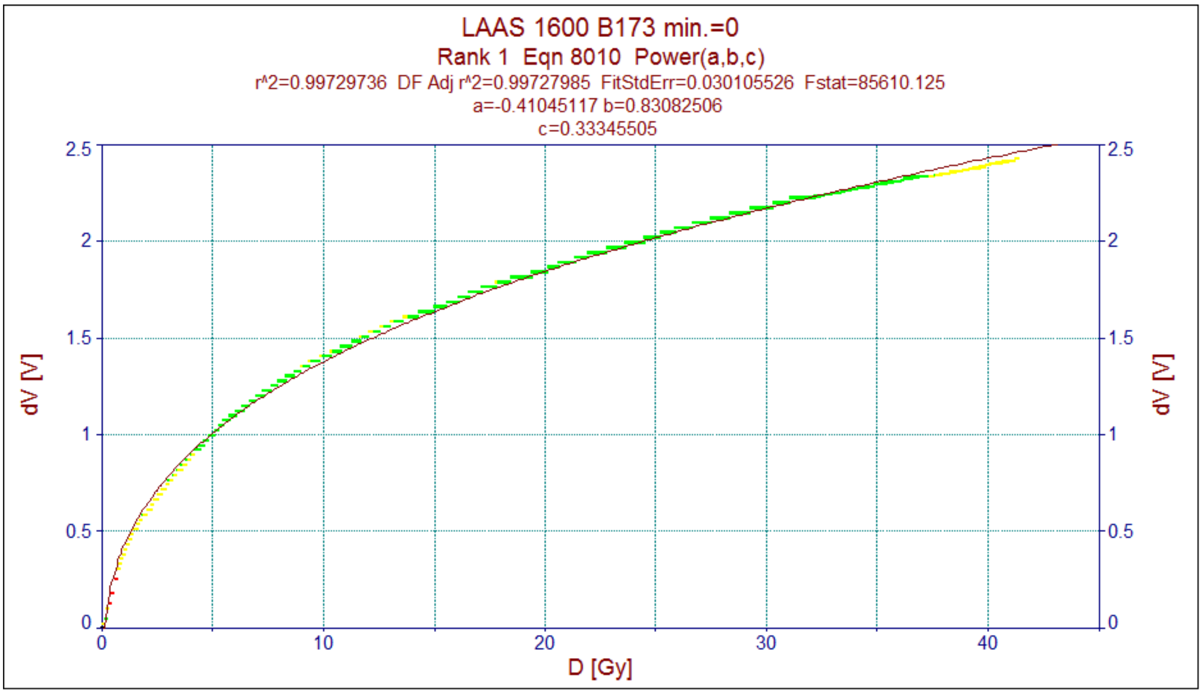

LAAS 1600 B173 min.=0
Rank 1 Eqn 8010 Power(a,b,c)
r^2=0.99729736 DF Adj r^2=0.99727985 FitStdErr=0.030105526 Fstat=85610.125
a=-0.41045117 b=0.83082506
c=0.33345505
dV [V]
D [Gy]

Fig. 5

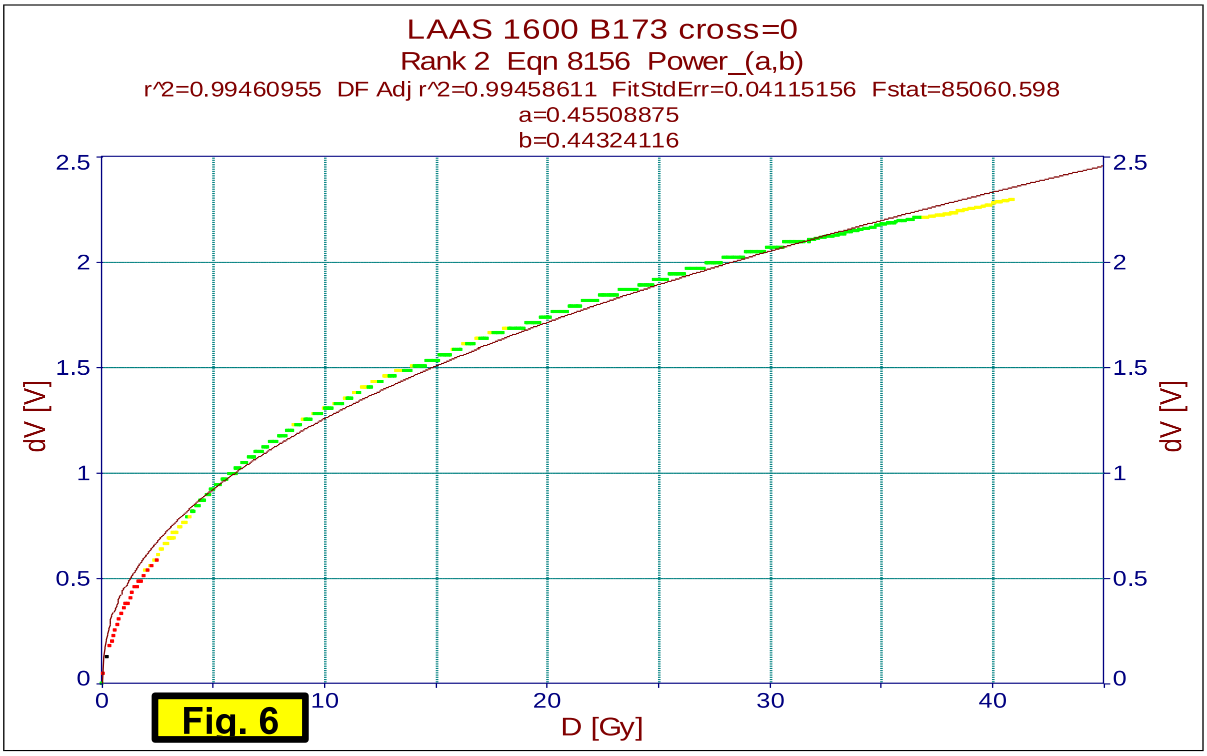

LAAS 1600 B173 cross=0
Rank 2 Eqn 8156 Power_(a,b)
r^2=0.99460955 DF Adj r^2=0.99458611 FitStdErr=0.04115156 Fstat=85060.598
a=0.45508875
b=0.44324116
dV [V]
D [Gy]
0
10
20
30
40
0.5
1
1.5
2
2.5

Fig. 6

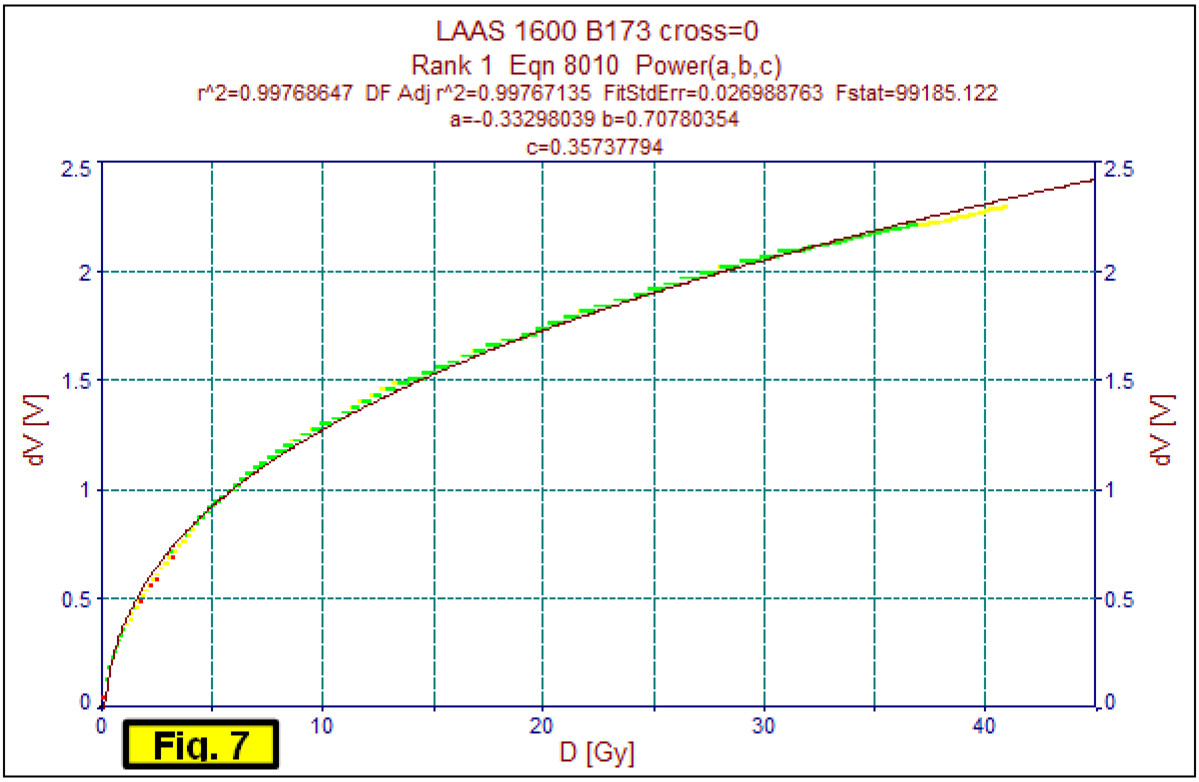
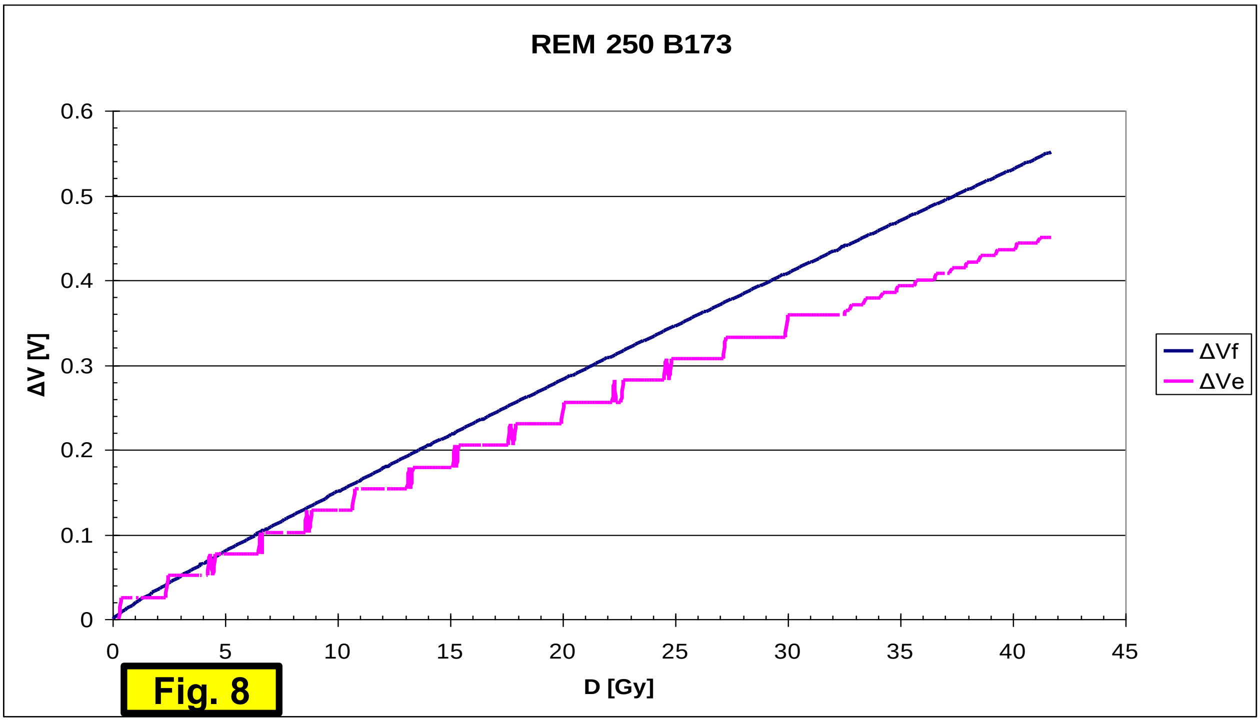
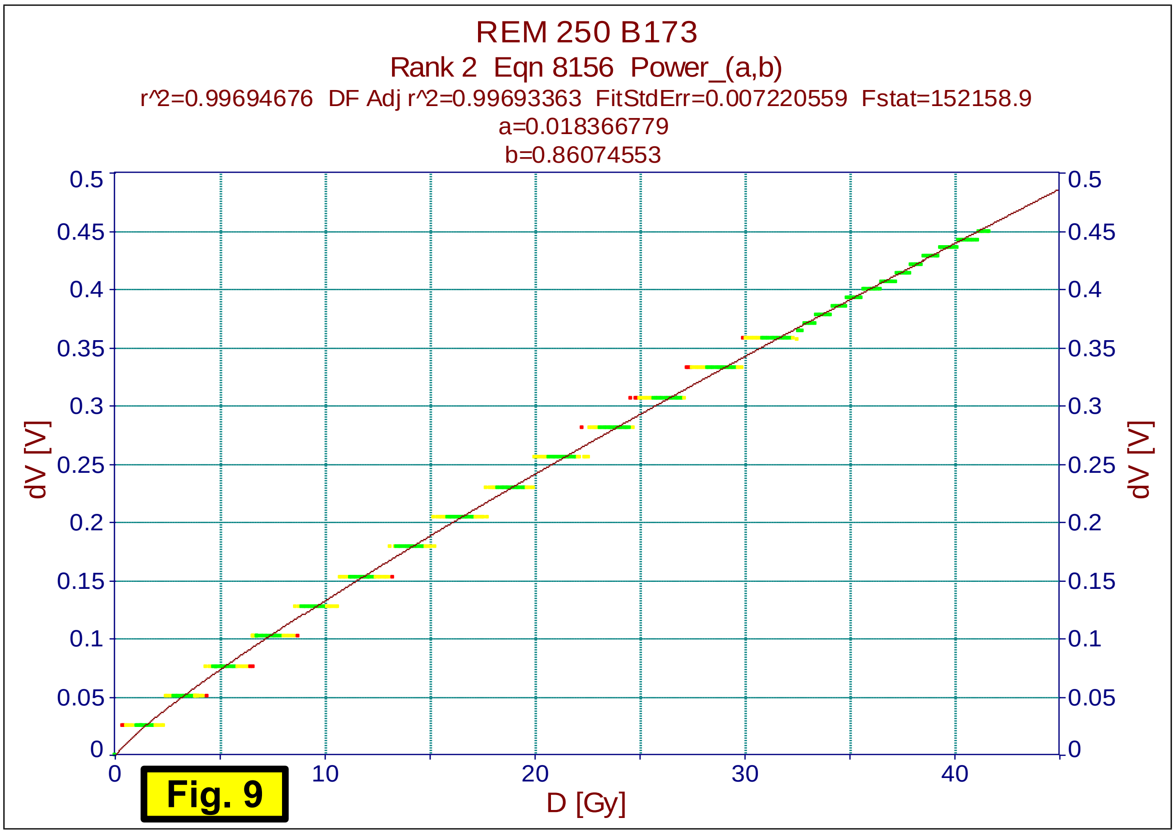

LAAS 1600 B173 cross=0
Rank 1 Eqn 8010 Power(a,b,c)
r^2=0.99768647 DF Adj r^2=0.99767135 FitStdErr=0.026988763 Fstat=99185.122
a=-0.33298039 b=0.70780354
c=0.35737794
dV [V]
D [Gy]
0
10
20
30
40
0.5
1
1.5
2
2.5

Fig. 7





B. The board 129 test:

In order to clarify the strange results received for the LAAS 1600 (negative part in the dependence $\Delta V_E(D)$) a new pair of detectors (LAAS 1600 and REM 250 – PCB No 129) is carried out from 4.07 to 9.07.

The main results from the board 129 test are:

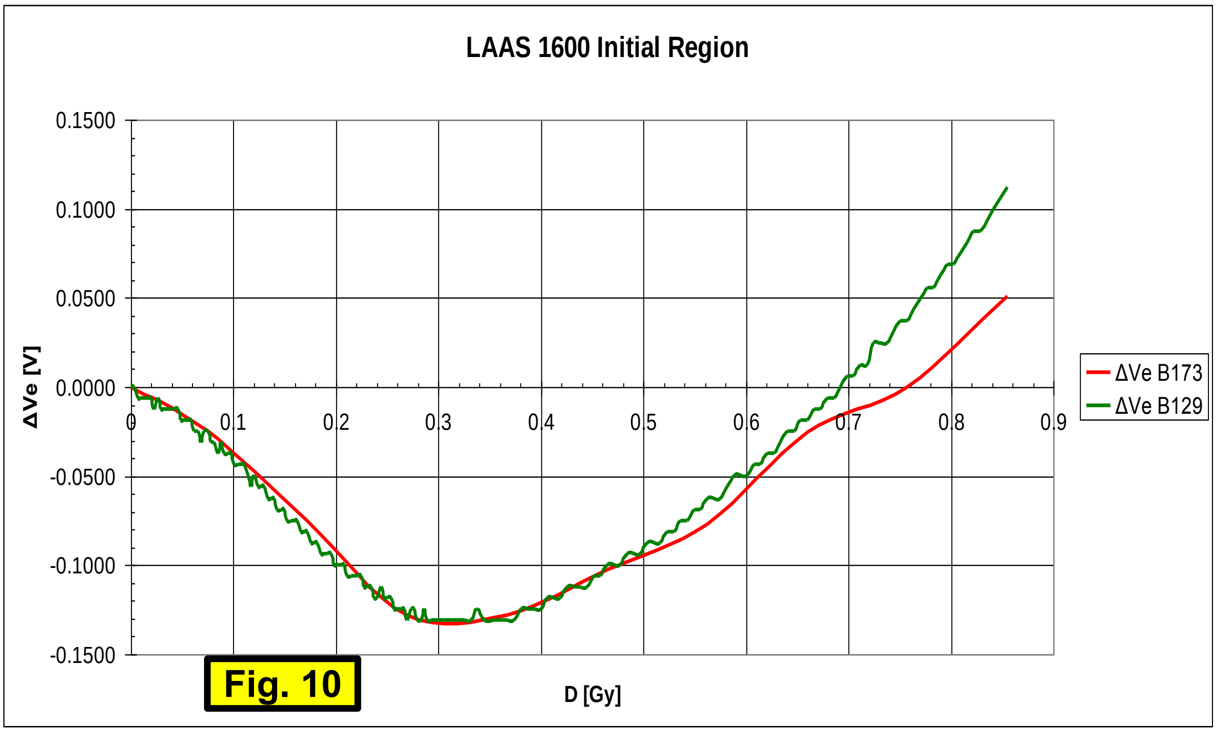


Fig. 10

1. The negative part of the dependence $\Delta V_E(D)$ was confirmed – on fig.10 the initial part of for both LAAS 1600 are shown. The plot for the second LAAS 1600 (B129) is much more detailed because of the increased sensitivity (5 mV) and the decreased intervals between the readouts (1 and 2 minutes, instead of 30 min). The comparison between two units LAAS 1600 shows approximately the same parameters of the initial regions of their ΔV_E (D) dependences: the minimal value is $\Delta V_E \approx$-130 mV and corresponds to a dose D ≈ 0,37 Gy; the crossing of the abscise is at D ≈ 0,7 Gy.

The full data however (fig. 11) shows that the second LAAS 1600 (B129) has higher radiation sensitivity – its dependence passed higher. We find out later that B173 was exposed with its back-side facing the photon source while the B129 was in front-side. The different amount of scattering material can probably justify the difference between the two measured curves. The two tested detectors most probably have the same radiation sensitivity for D > 0.7 Gy.

The fits are done in the same manner as for the LAAS 1600 of PCB 173. On fig. 12 and 13 are shown the fits, when the minimum of the dependence ΔV(D) is considered as 0 and on fig. 14 and 15 – when the cross point with the abscise is the 0. The comparison between them shows that in both cases the better fit is three-parametric.

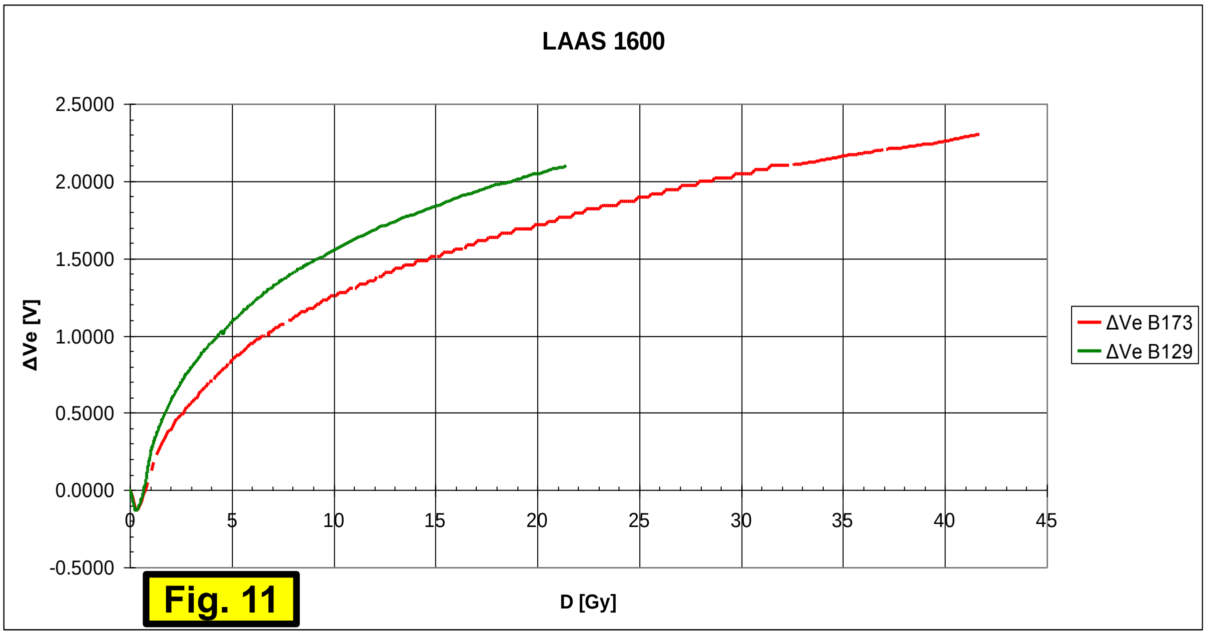
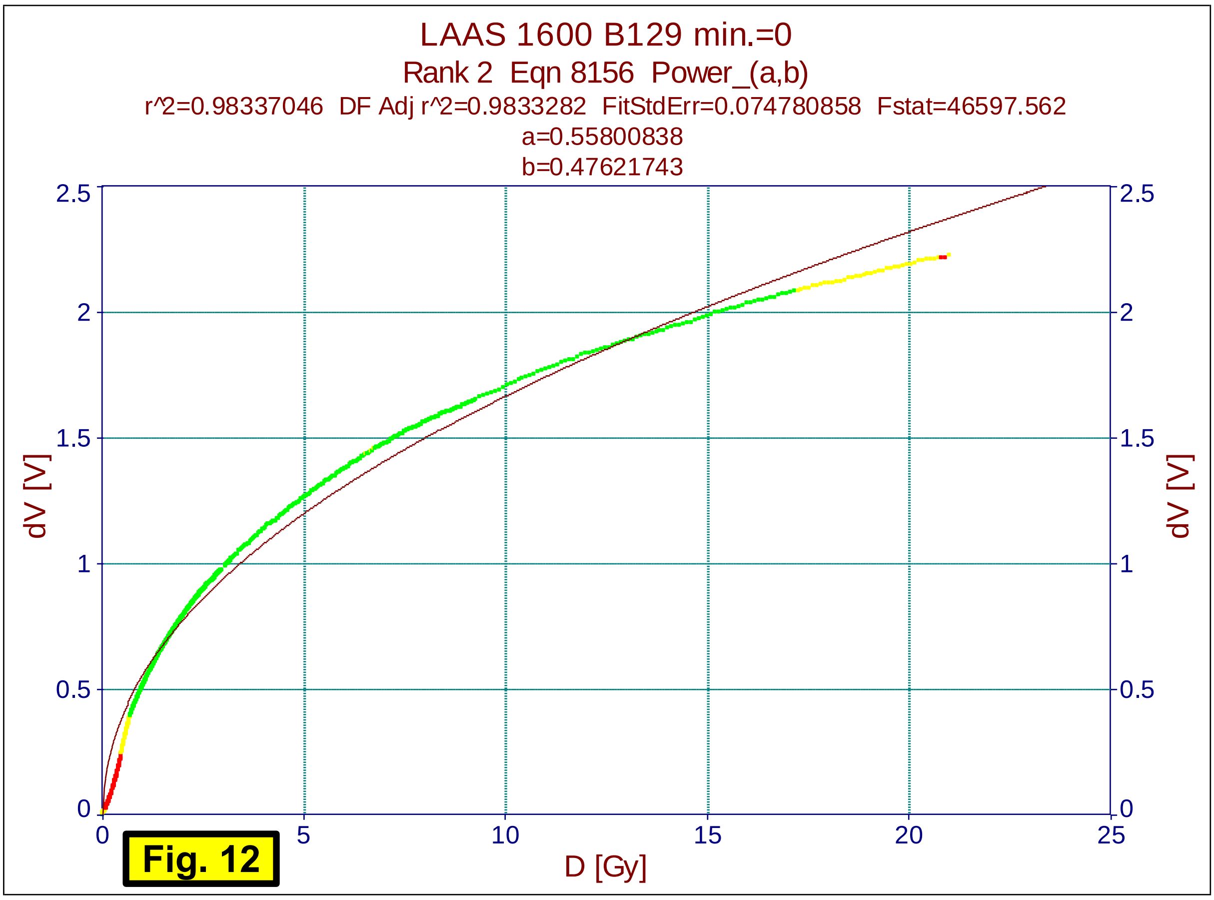
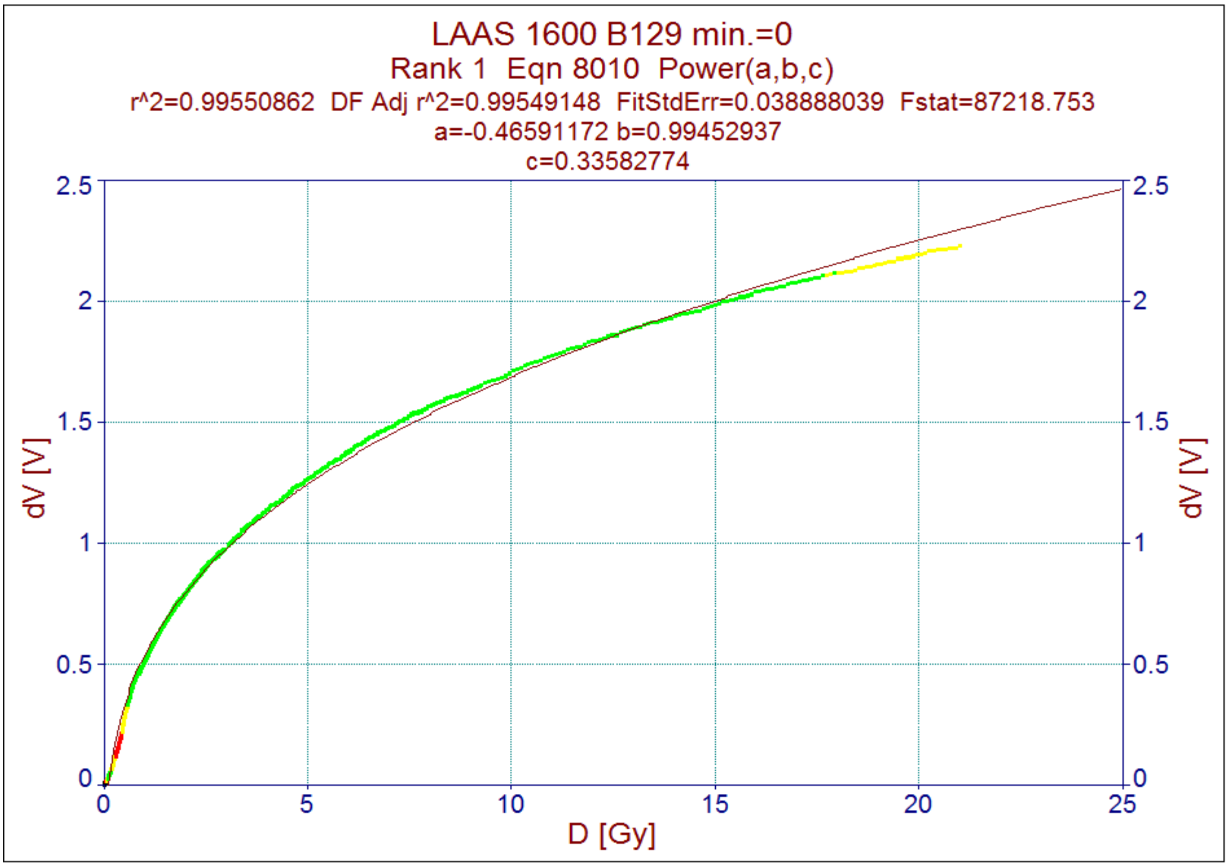


Fig. 11



LAAS 1600 B129 min.=0
Rank 2 Eqn 8156 Power_(a,b)
r^2=0.98337046 DF Adj r^2=0.9833282 FitStdErr=0.074780858 Fstat=46597.562
a=0.55800838
b=0.47621743
dV [V]
D [Gy]

Fig. 12



LAAS 1600 B129 min.=0
Rank 1 Eqn 8010 Power(a,b,c)
r^2=0.99550862 DF Adj r^2=0.99549148 FitStdErr=0.038888039 Fstat=87218.753
a=-0.46591172 b=0.99452937
c=0.33582774
dV [V]
D [Gy]

Fig. 13

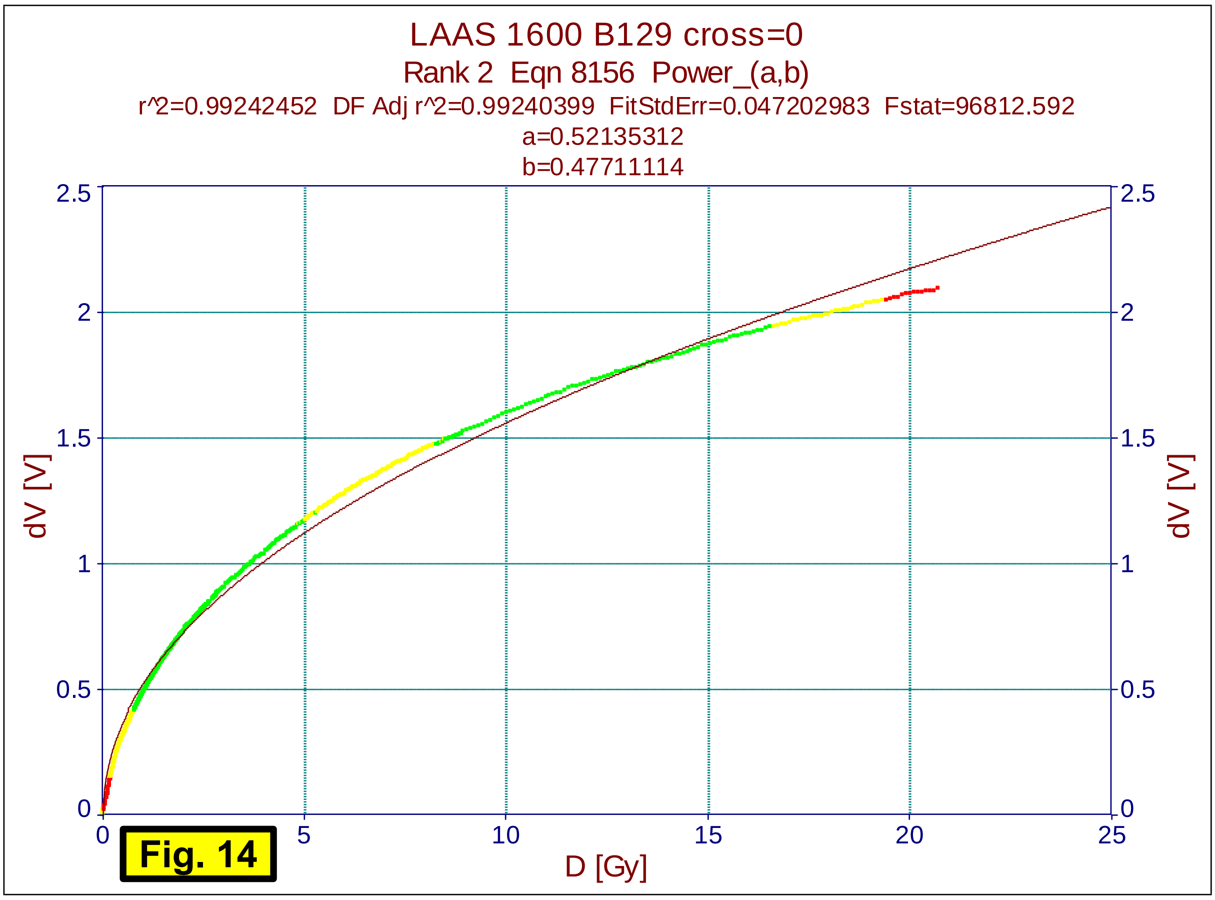

LAAS 1600 B129 cross=0
Rank 2 Eqn 8156 Power_(a,b)
r^2=0.99242452 DF Adj r^2=0.99240399 FitStdErr=0.047202983 Fstat=96812.592
a=0.52135312
b=0.47711114
dV [V]
D [Gy]
0
0.5
1
1.5
2
2.5
5
10
15
20
25

Fig. 14

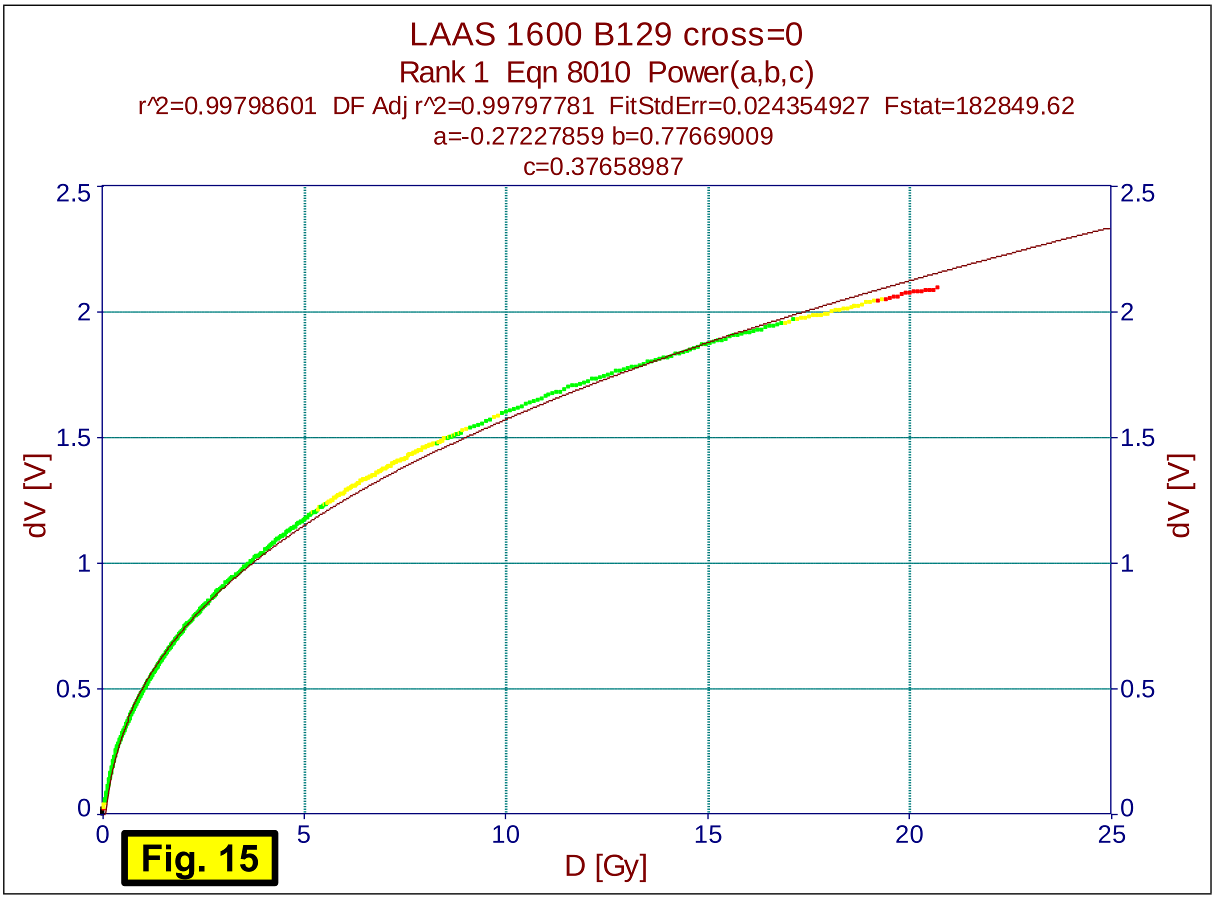

LAAS 1600 B129 cross=0
Rank 1 Eqn 8010 Power(a,b,c)
r^2=0.99798601 DF Adj r^2=0.99797781 FitStdErr=0.024354927 Fstat=182849.62
a=-0.27227859 b=0.77669009
c=0.37658987
dV [V]
D [Gy]
0
0.5
1
1.5
2
2.5
5
10
15
20
25

Fig. 15

2. The comparison between the $\Delta V_E(D)$ dependences for both REM 250 detectors (fig. 16) shows that they are practically identical. There is a decreasing of all ΔV_E in the curve of REM B129 (after around D=21,5 Gy). Most probably it is due to an annealing of the detector, because at that time it was out of radiation, but with free electrodes.
The best fit for this REM 250 is with the same function – $\Delta V_F = aD^b$ (fig.17). Though the practically identical

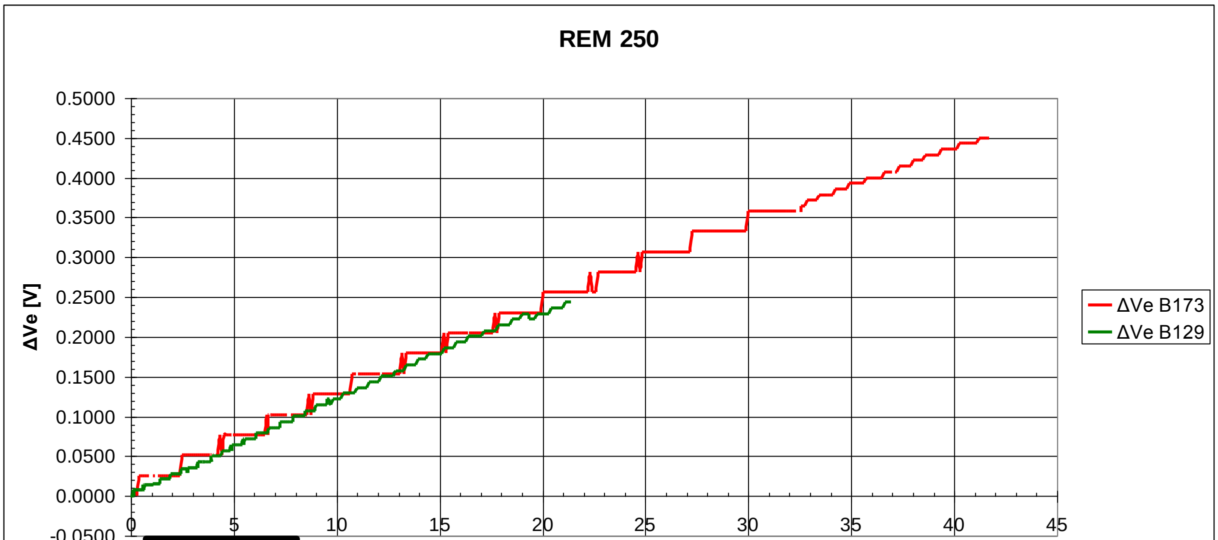


Fig. 16

dependences $\Delta V_E(D)$ of both REM, this fit has different values of the parameters "a" and "b". The reason probably is, that for B173 the fit is based on all data till 41 Gy (see fig. 9), while for B129 we have data only till 22 Gy.

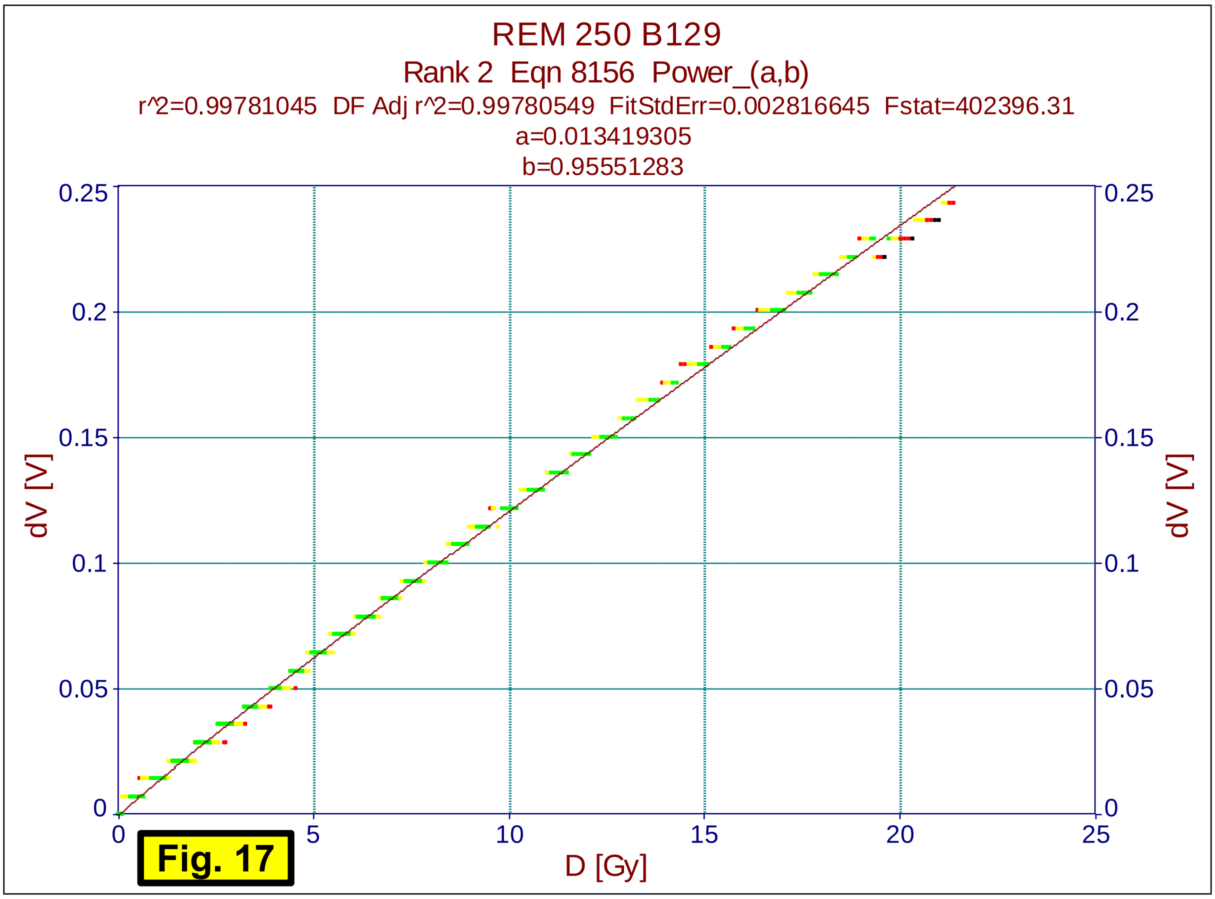


Fig. 17

*All fits are done by the "Table Curve" program.

BIBLIOGRAPHI:

[1] Ravotti F. Development and Characterization of Radiation Monitoring Sensors for the High Energy Physics Experiments of the CERN LHC Accelerator. Montpelier University, 2006 and "SENSOR CATALOGUE" DATA COMPILATION OF SOLID-STATE SENSORS FOR RADIATION MONITORING F. Ravotti (TS-LEA), M. Glaser, M. Moll (PH-DT2) TS-Note-2005-00213 May 2005

CONCLUSIONS

1. The developed microcontroller unit operate stable and is very suitable for the detector's control at the GIF++. Some corrections can be introduced in order to provide suitable voltage sensitivity.
2. Both type of detectors - LAS1600 and REM 250 are suitable for the expected dose rate and total dose at GIF++.
3. The difference in the LAAS 1600 detectors tested at Gif is most probably due to the difference in photon scattering for back-side front-side positioning. The two devices tested most probably have the same radiation sensitivity for D > 0.7 Gy.
4. The parameters of the REM 250 detectors correspond to the producer's data. A dedicated calibration with gamma photons only is advisable for their future applications at Gif++.