RADIATION MONITORING AT GIF++

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Table 1

Max. expected Doses at sLHC	Equivalent time at GIF++ (at 50 cm from the source)
Si-trackers ~ MGy/y	>> years
Calorimeters ~ 20 kGy/y	< 1 year
Muon Systems ~ 0,1 Gy/y	~ minutes

In 2012 the construction of a new gamma-irradiation facility GIF++ was started at CERN. Its main function is the investigation of the radiation damages in the subdetectors used in LHC experiments – Table 1. The precise monitoring of the absorbed dose is essential for the subdetectors radiation damage estimation at LHC at high luminosity. The design of a system, controlling the absorbed doses during the detector tests at GIF++ is the purpose of our work in the frame of CERN-EU project AIDA – task 8.5.3 - GIF++ User Infrastructure.

The radioactivity of the source in GIF++ will be about 16 TBq providing a dose rate of about 2 Gy/h at a distance of 50 cm. After a detailed study two types of so called “RadFET” detectors [1,2] used already in TOTEM [3] and ATLAS [4] experiments are choosen: LAAS 1600 (manufactured by CNRS-LAAS, France) for relative low doses (till 10 Gy) and REM 250 (manufactured by REM, UK) for large doses (till 2000 Gy). The operation of both detectors is based on the same physical phenomenon – an increasing of the field-effect transistor’s threshold voltage proportional to the absorbed dose. The reading of this threshold voltage is performed by current pulses of 100-200 µA with duration of a few seconds.

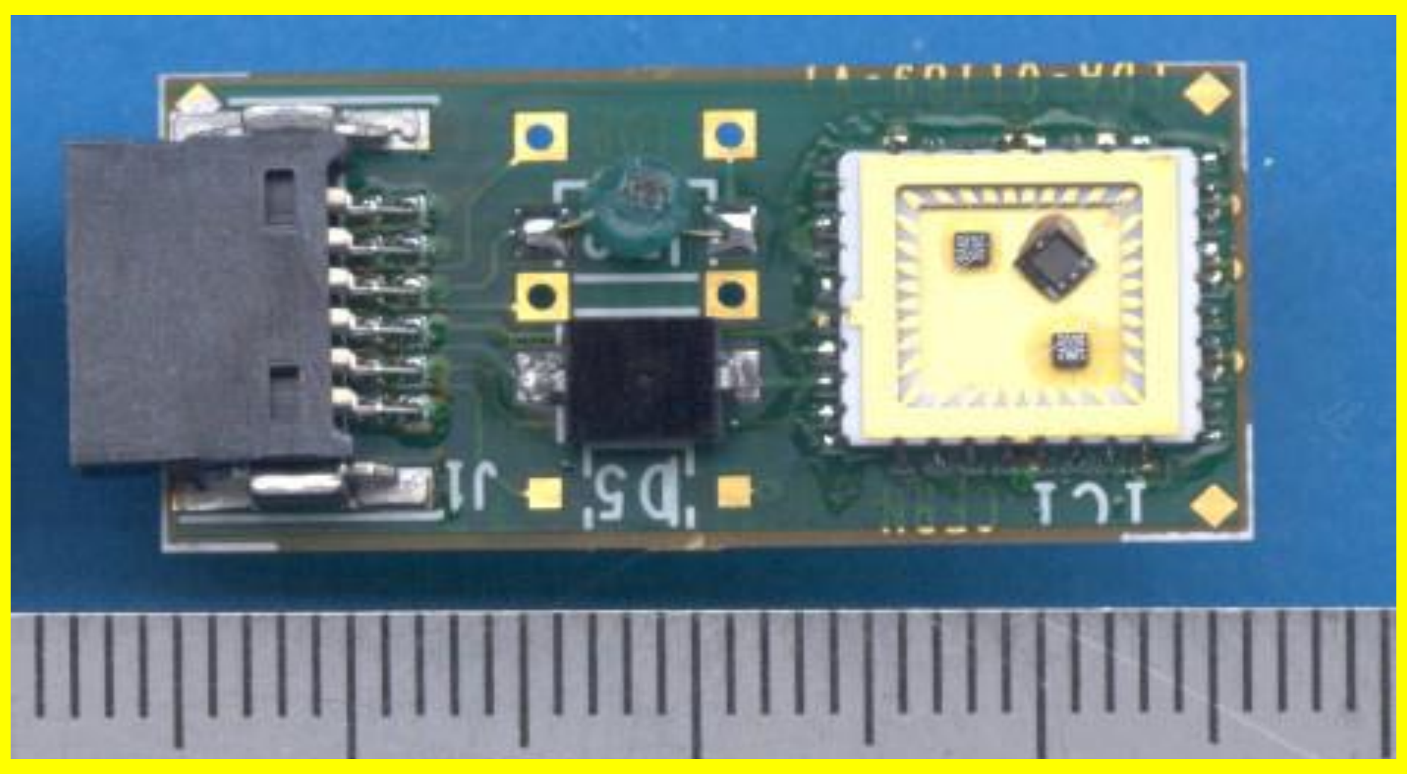


Fig. 1. TOTEM RadFET PCB.

For the radiation detector’s test a standard TOTEM PCB (fig. 1), containing only one LAAS 1600 and one REM 250 RadFET was used. A specialized controller was designed for the reading of the threshold voltages of both radiation sensors (fig. 2). The device uses a microcontroller unit (µCU) communicating with the host computer by an RS-485 interface. The reading current pulses are generated by the voltage-to-current convertors (V/I), each having the suitable parameters for the corresponding radiation detector: 100 µA, 1 s width – for the LAAS 1600 and 160 µA, 5 s width – for the REM 250, with an amplitude stability better than 0,1%. The pulse amplitudes are controlled by a digital to analog converter (DAC) receiving the corresponding serial code from µCU. The convertors V/I are switched ON consecutively by the µCU through the DECODER. They are supplied by 36 V, because the upper limit of the measured threshold’s voltages is about 30 V. During the pause between the reading pulses, the RadFETs are connected to 0 V, as it is recommended by the producer. The voltages readout from the radiation detectors are fed to the µCU analog-to-digital convertor (ADC) through a multiplexor (MUX). In addition the voltage on a thermistor (Rt) is also registered for temperature control.

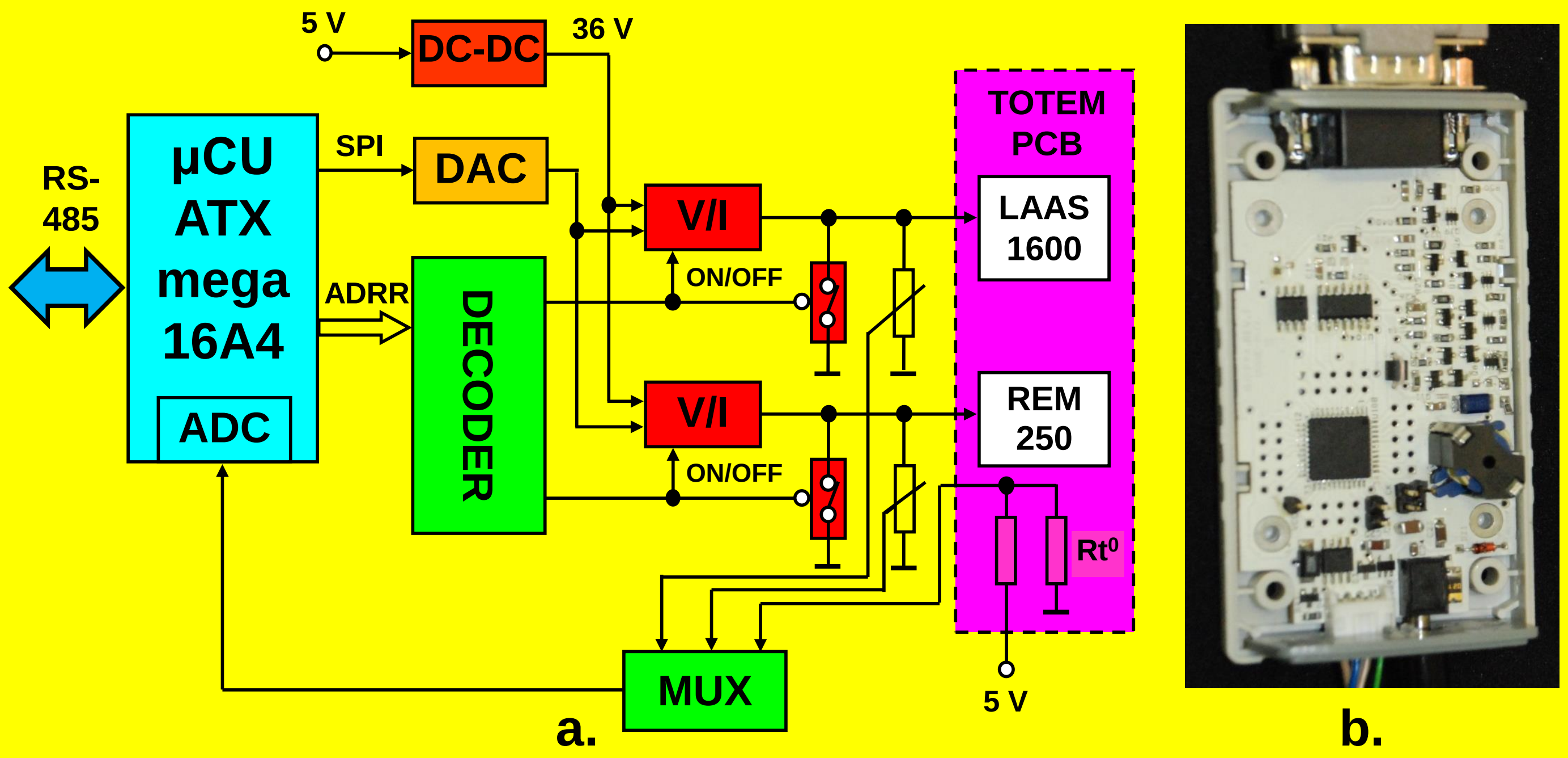


Fig. 2. Block diagram (a) and construction (b) of the controller.

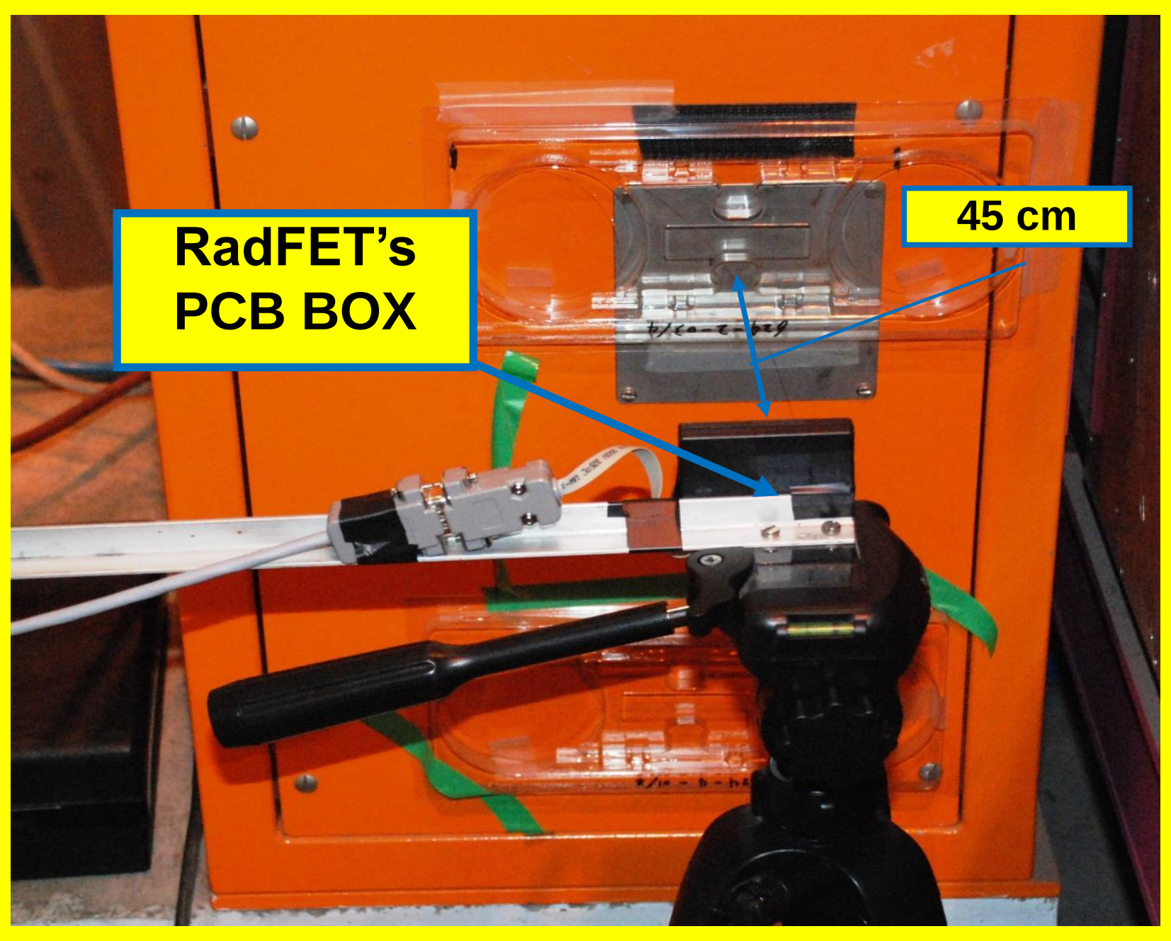


Fig. 3. Radiation detectors test.

The detector tests are performed at the actual CERN gamma-facility GIF in July 2012. For the purpose the RadFET PCB is installed at 45 cm from the GIF radioactive source (fig. 3), where a dose rate of 195 mGy/hour was measured. The results of the tests of two pairs of each type RADFETs shows good sensitivity’s identity of both REM 250 (fig. 4) and some difference in the sensitivity of both LAAS 1600 (fig. 5). Also they show an unexpected negative region at very low doses (fig. 6).

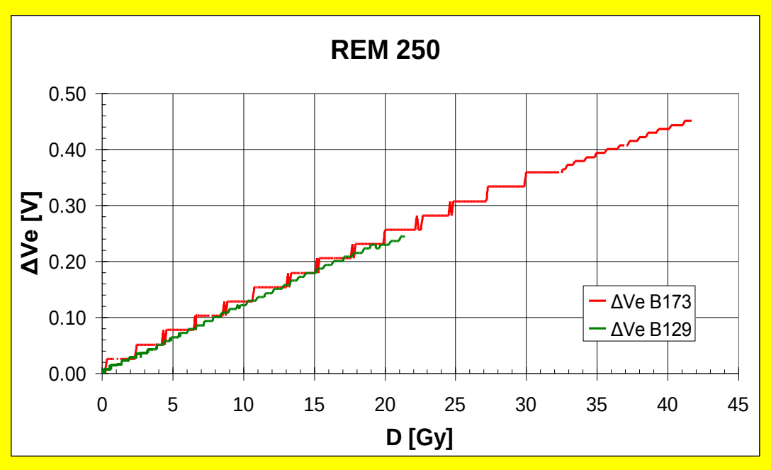


Fig. 4. Comparison of the results of both REM 250 RadFETs.

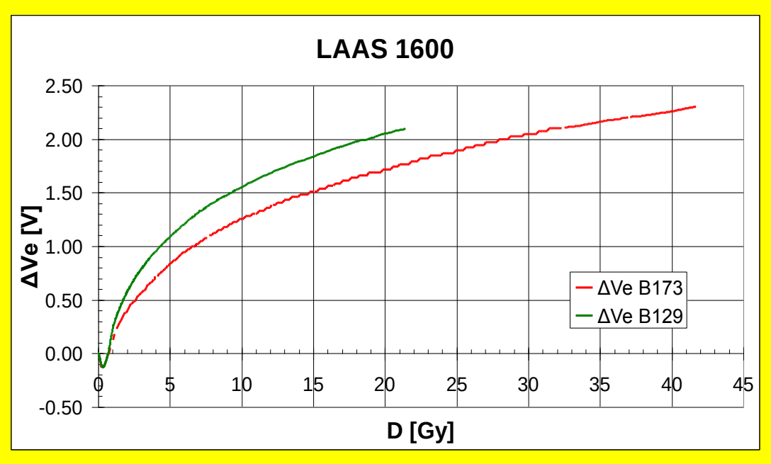


Fig. 5. Comparison between the ΔVe(D) functions of both LAAS 1600 RadFETs.

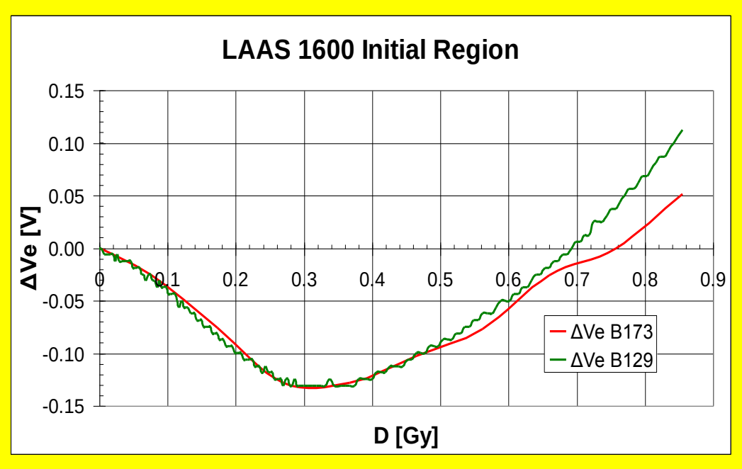


Fig. 6. Initial regions of the measured ΔVe(D) functions of both LAAS 1600 RadFETs.

The whole dosimetric system consists of two groups of 4 detectors – one group for each radiation zone (fig. 7). The main controller (fig. 8) uses a PIC type 24HJ64 with a 12 bits ADC for precise measuring of the detector’s signals. A CANBUS interface is provided too for the common GIF++ slow control system. Each group of 4 detectors is controlled by a separate node (fig. 9). A third (spare) node is included for unforeseen future application. The structure of the node is very similar to the test controller (see fig. 2a). The HSCS block generate a signal, controlled by the PIC, which confirms the normal function of the current generators for the reading of the RadFET’s threshold voltages. The connection to the detectors pass throw a splitter (fig. 10), from which 4 separate cables go the the radiation detectors (fig. 11), providing their flexible applications.

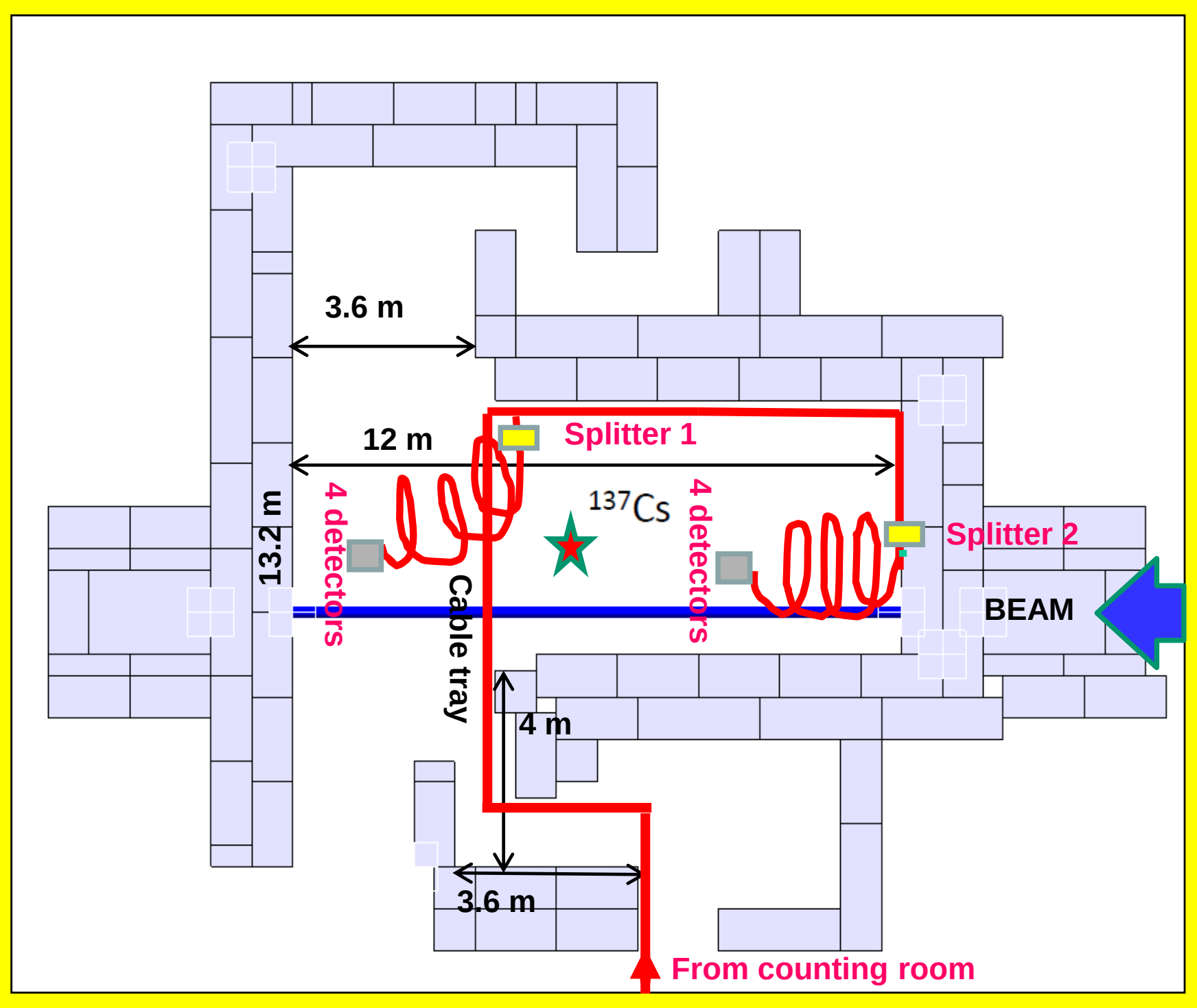


Fig. 7. Detector’s and cable configuration

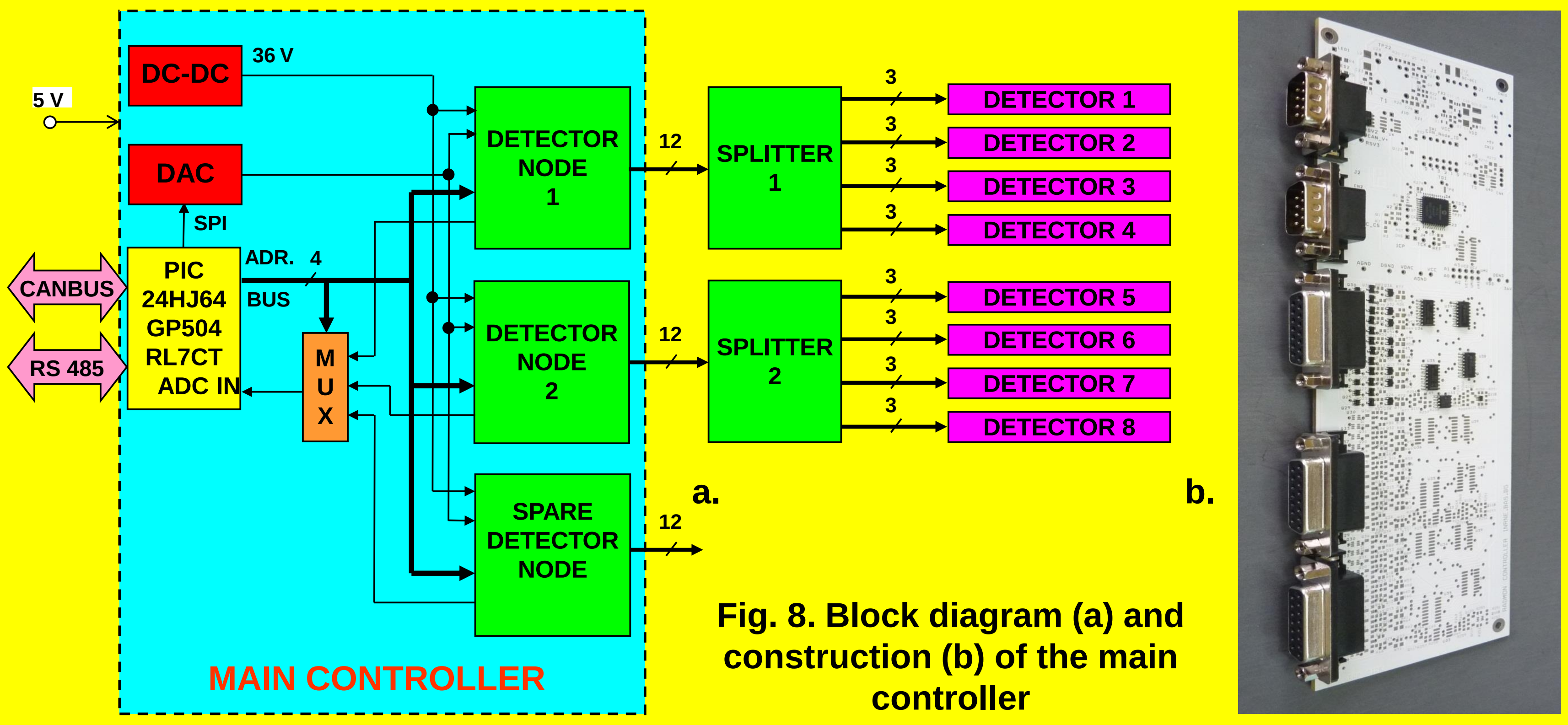
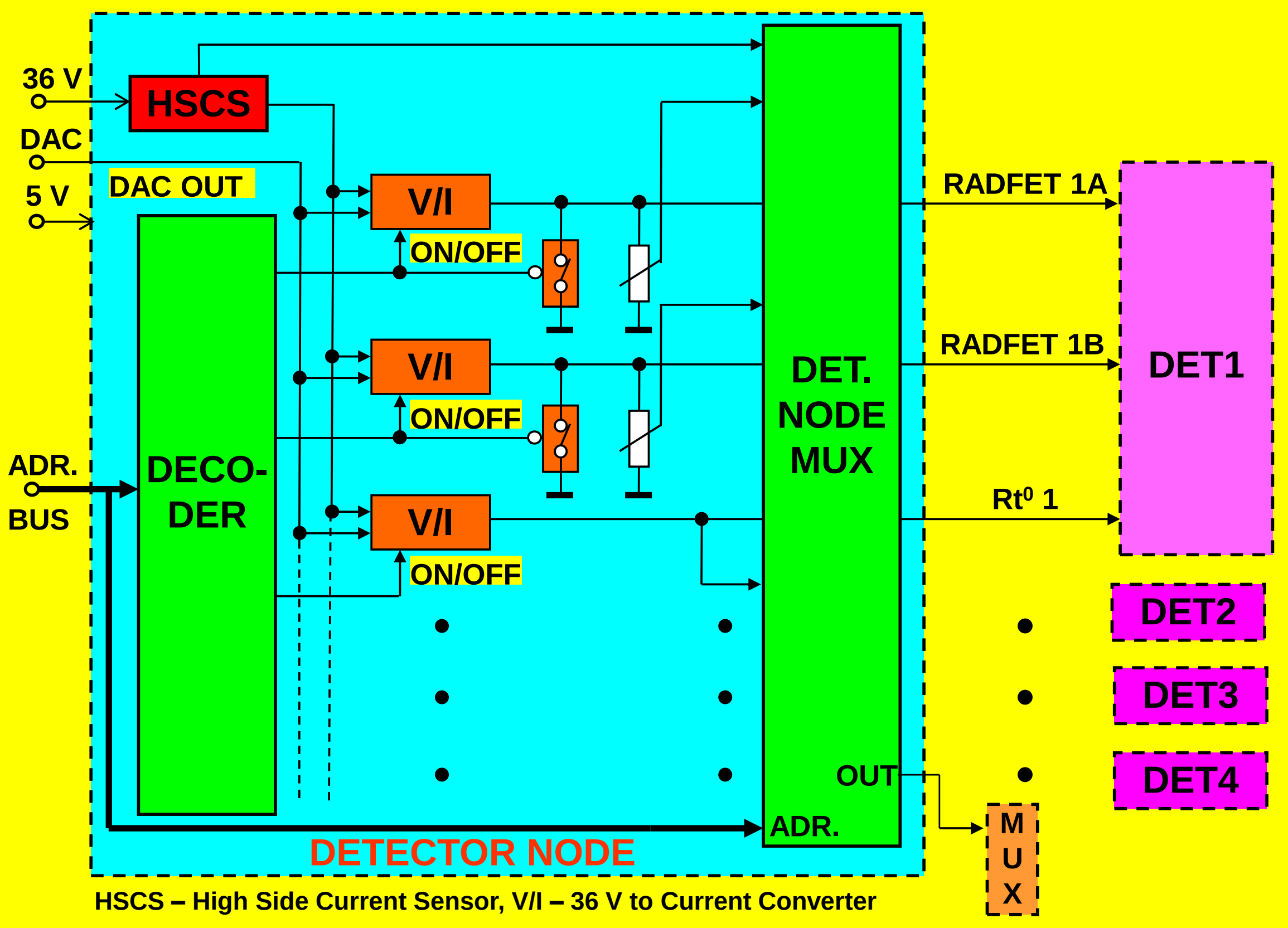


Fig. 8. Block diagram (a) and construction (b) of the main controller



HSCS – High Side Current Sensor, V/I – 36 V to Current Converter

Fig. 9. Block diagram of the detector node

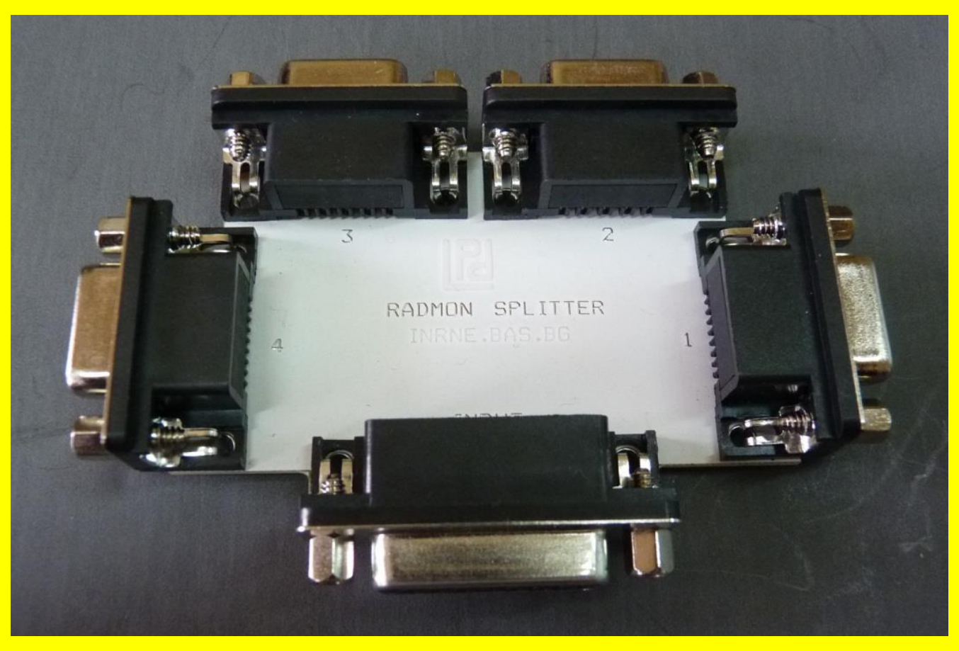


Fig. 10. Splitter

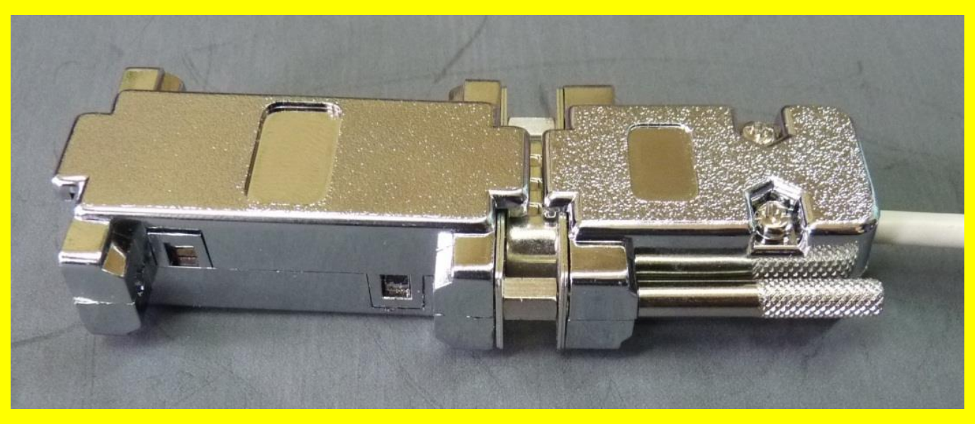


Fig. 11. Detector box with connector

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