Characterization and functional test of a micro dosimeter of scintillating optical fibers

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Abstract

With growing demand for better and improved techniques for cancer treatment in Portugal, there is an ongoing discussion on the need to build a proton therapy center as well as to train skilled workers in this field. As a result, there is the need for high precision measurement instruments providing real-time absorbed dose measurements at tissue or DNA level.

The goal of the present work is to develop a new detector capable of measuring real-time absorbed dose with sub-millimeter resolution. The device is constructed using juxtaposed thin scintillating plastic optical fibers (SPOF) readout by a multi-anode photomultiplier (MAPMT, 64 channels) and a suitable data acquisition (DAQ) system. In this poster we discuss the characterization of the full detection chain: SPOFs, MAPMT and DAQ.

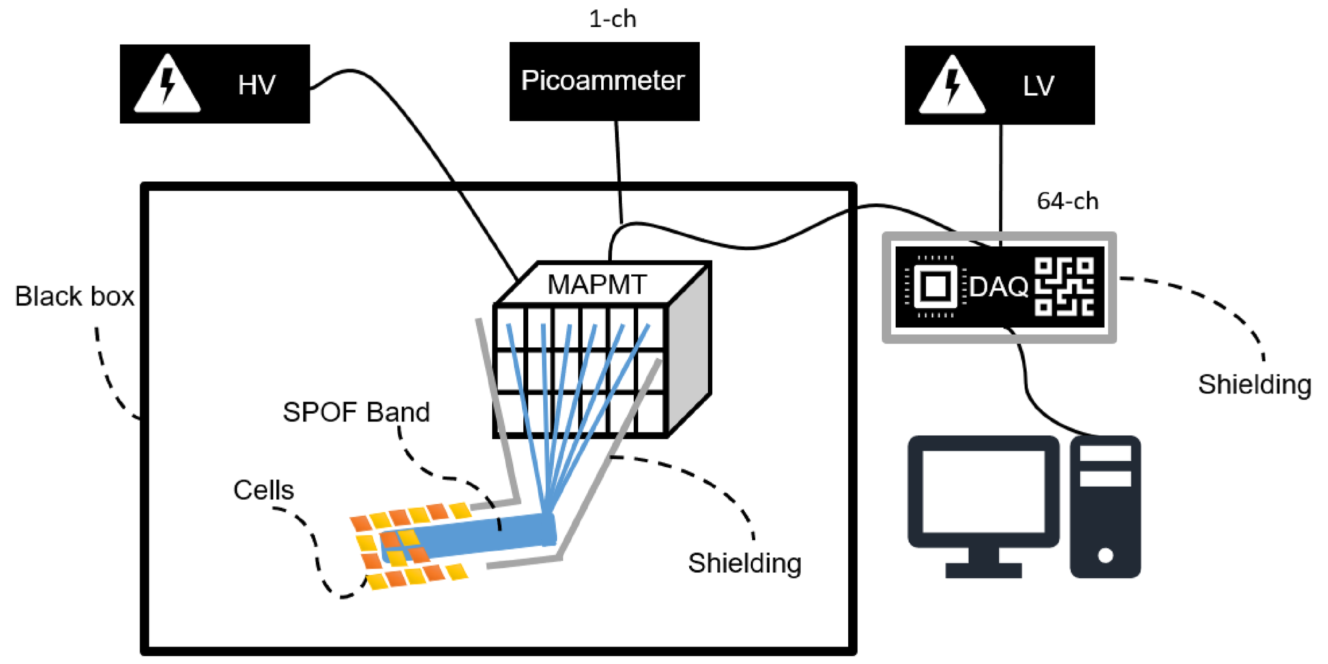

Fig.1: Concept of the micro dosimeter prototype.

SPOF's characterization (Kuraray SCSF-78)

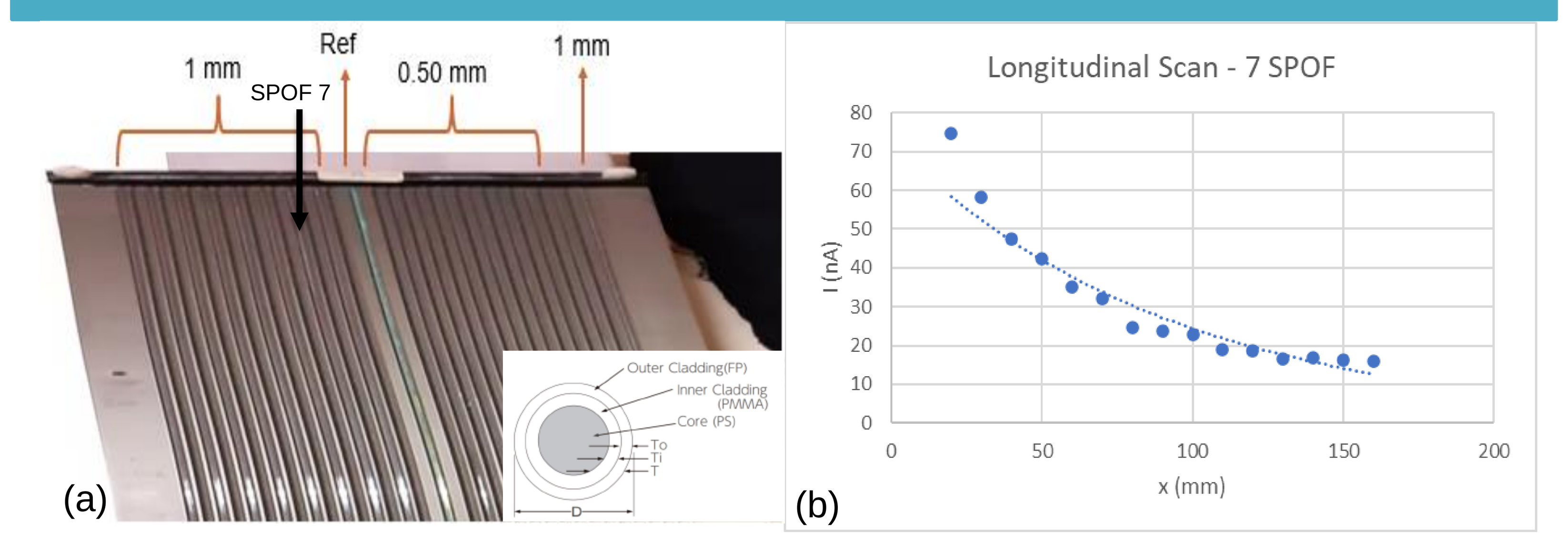

Fig.2: (a) SPOFs table used in the characterization of individualized fibers (LED+Single channel PMT). (b) SPOF response measured with a PMT as a function of the distance of the excitation source (LED) moves away from the PMT.

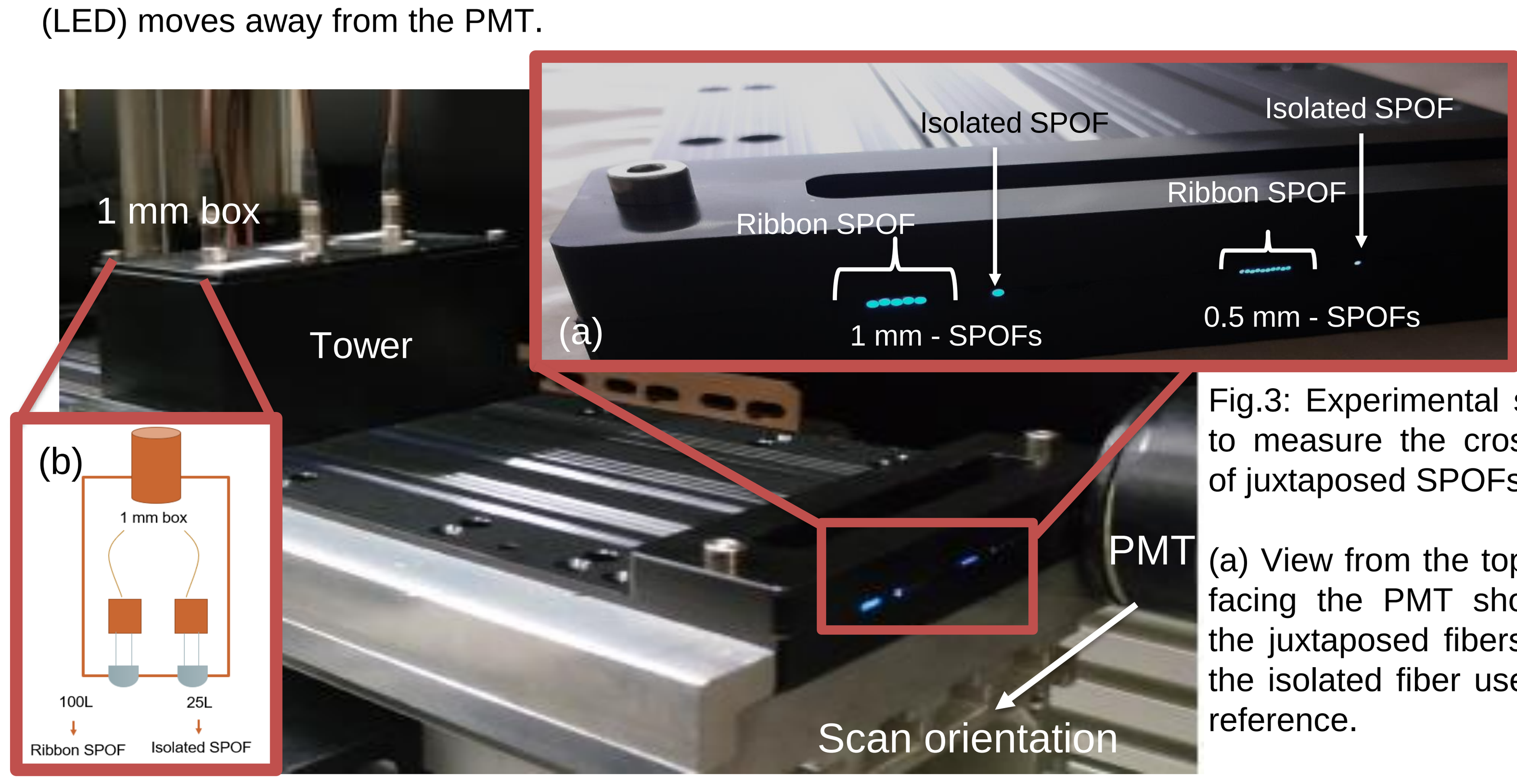

Fig.3: Experimental setup to measure the crosstalk of juxtaposed SPOFs.

(a) View from the top end facing the PMT showing the juxtaposed fibers and the isolated fiber used as reference.

(b) The tower holds three individual support boxes, each holding two LEDs (RLS-UV385) used to illuminate the isolated SPOF and only the first SPOF of the ribbon (scheme in fig 3b). The used LEDs have distinct voltage-current characteristic curves that require a further calibration during the analysis. The light from the LEDs illuminates the fiber through pinholes with half of the diameter of the SPOF.

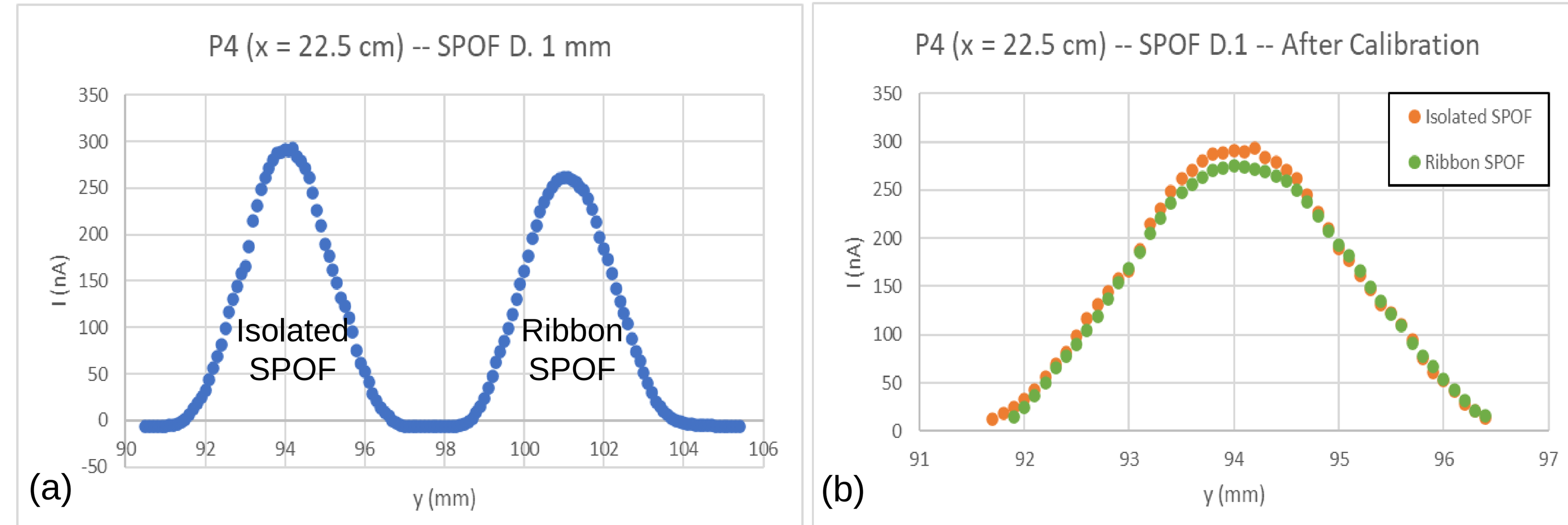

Fig.4: (a) PMT output as function of y-axis (transverse) table position. (b) Overlap of SPOFs fig 4a curves where a calibration factor CF = 1.05 was applied to the Ribbon SPOF compensating LED's intensities difference.

MAPMT's Characterization (Hamamatsu H8500D)

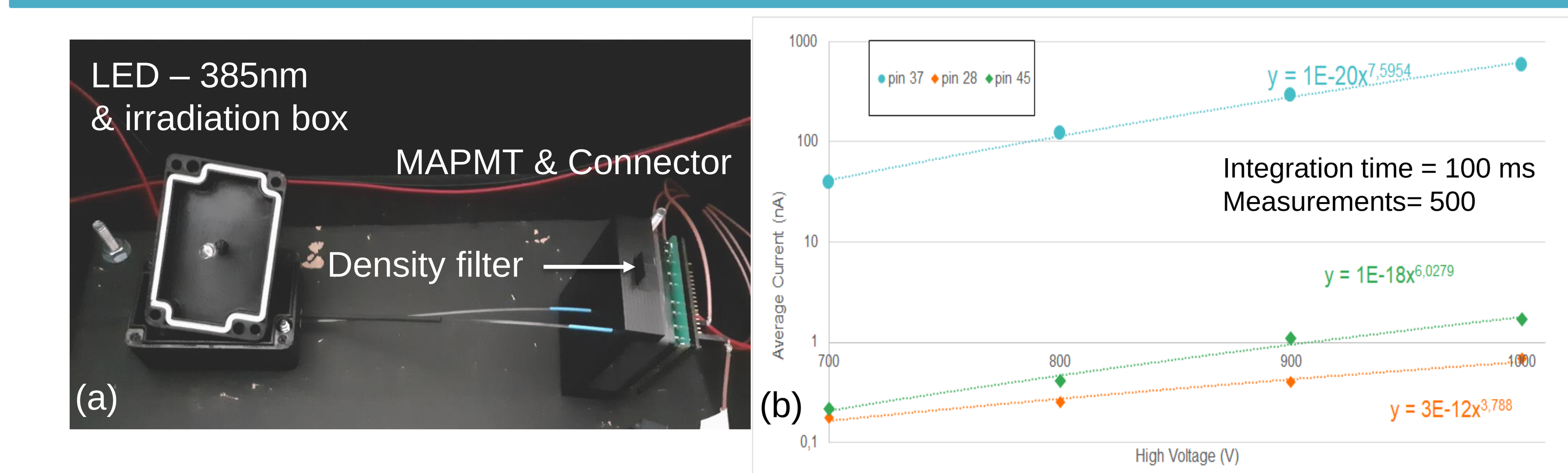

Fig.5:(a) Experimental setup for linearity measurements using neutral density filters. A connector with 64 pinholes (Ø1 mm) holds and positions the SPOF ~0.5 mm from the MAPMT window.(b) Picoammeter measured average and RMS for V_{LED} = 2.82 V for a channel with fiber (37) and two channels without a fiber (28,45).

- ❑ PMT Stabilization Time (~10min);
- ❑ Dark Current (for -900 V, (-143.1 ±1.75) pA);
- ❑ Electrical *Crosstalk* (fig 6a);
- ❑ PMT current vs HV (fig 5b);
- ❑ Linearity (see fig. 7).

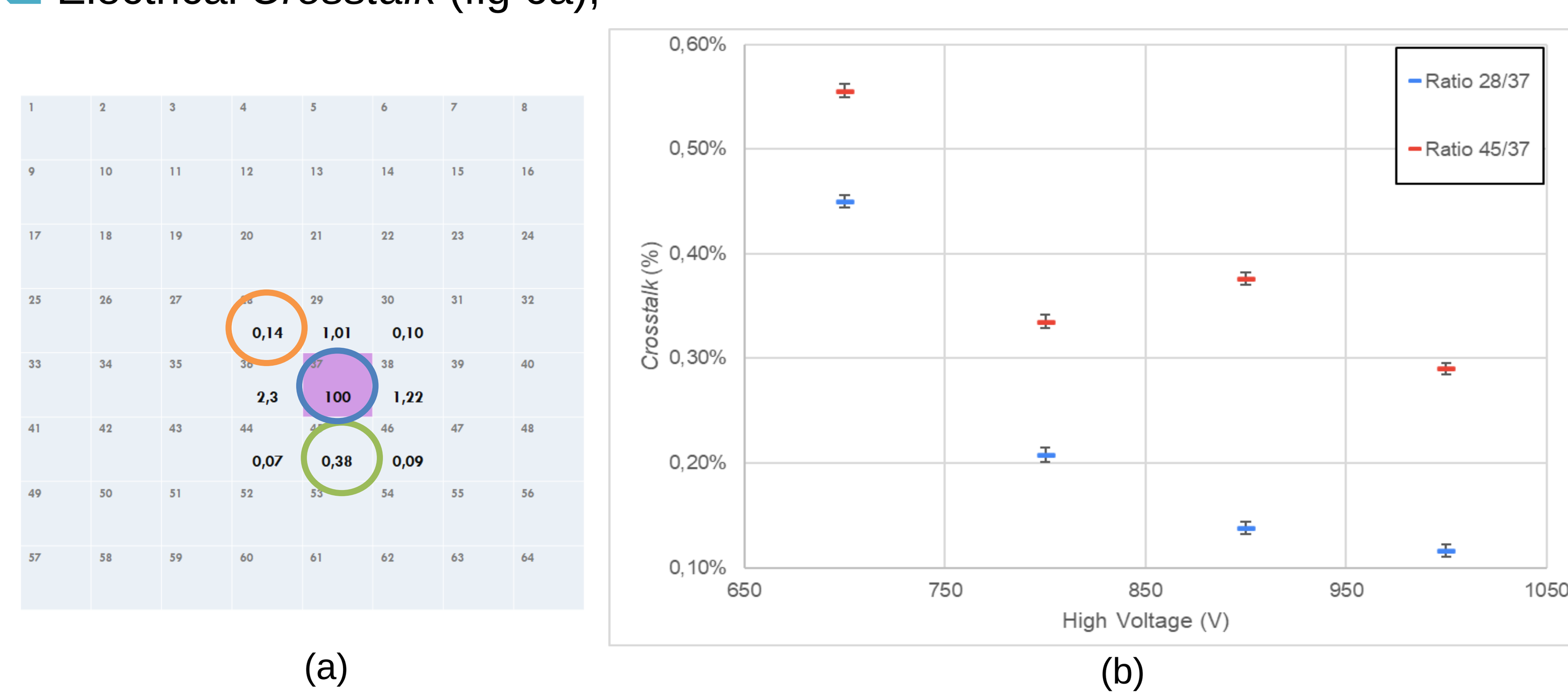

Fig.6:(a) Crosstalk values of the MAPMT. The purple square represents the cell being stimulated with a SPOF (cell 37 its value considered 100 u.a.).(b) *Crosstalk* (%) measured for HV=[-700,-1000] V and powering the LED with 2.82 V.

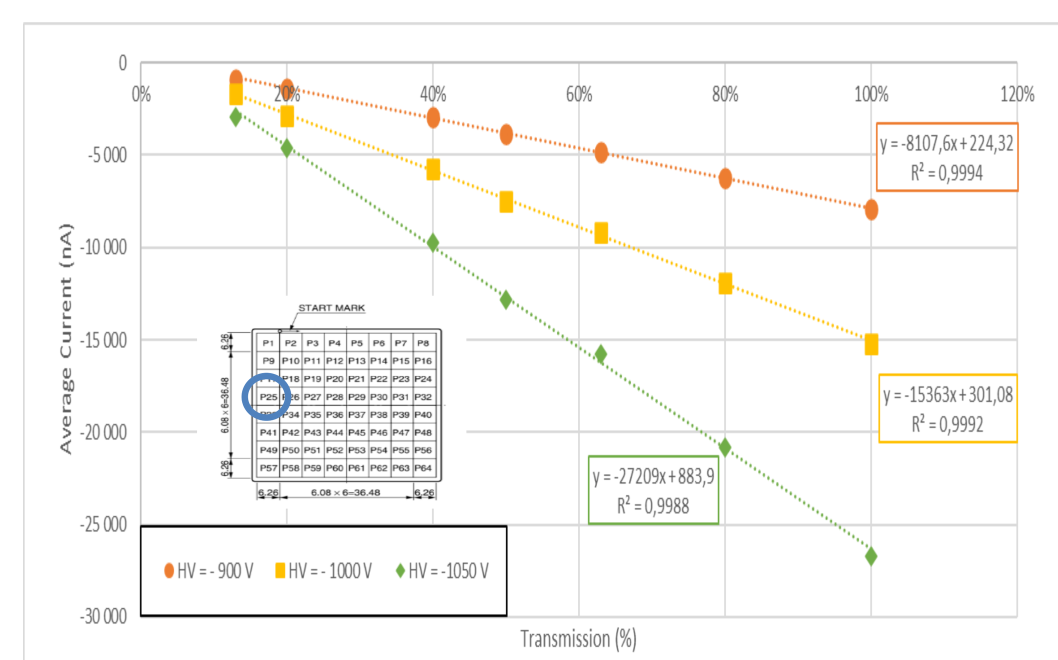

Fig.7: MAPTM Linearity measurement using neutral density filters for V_{LED} = 2.85 V and HV = [-900, -1050] V for channel 25 (other channels went through the same procedure).

Full Detector Chain Characterization

All measurements taken with a **picoammeter** during both SPOF's and MAPMT's characterization (1-ch). For 64-ch, a DAQ-board is used. As excitation sources were used:

- ❑ LEDs
- ❑ Radioactive sources (^{137}Cs, ^{60}Co, ^{204}Tl, ^{241}Am)

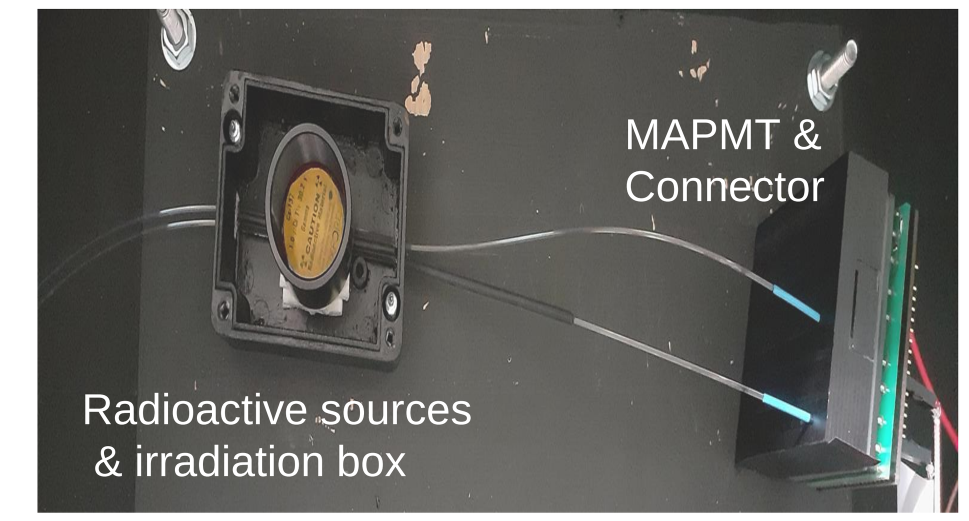

Fig.8: Experimental setup used to characterize the DAQ-board, using a radioactive source. Only two channels could be connected at the DAQ board. A dedicated interface board is being developed for the 64 channels readout.

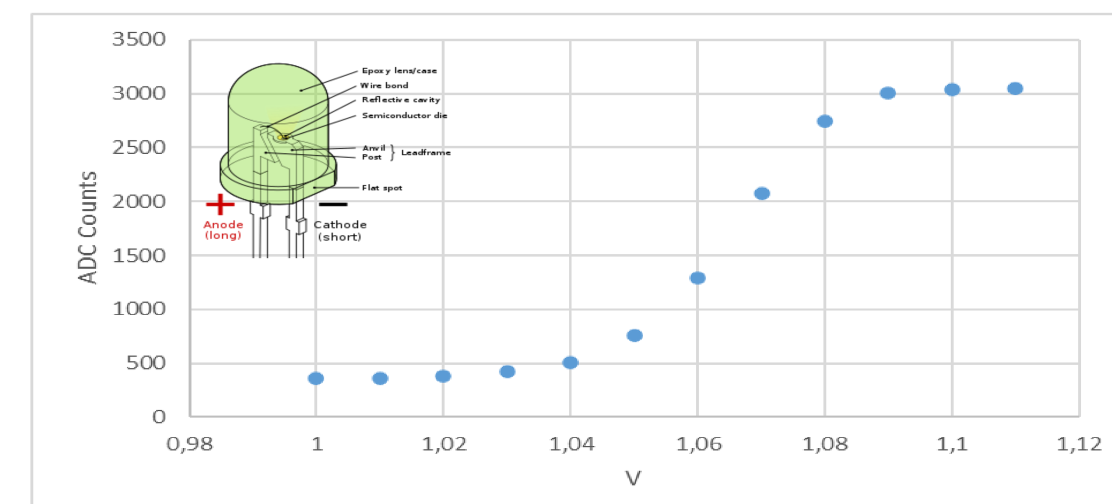

Fig.9: Charge (ADC Counts) as function of LED voltage using a LED as light source for the DAQ-board channel 44.

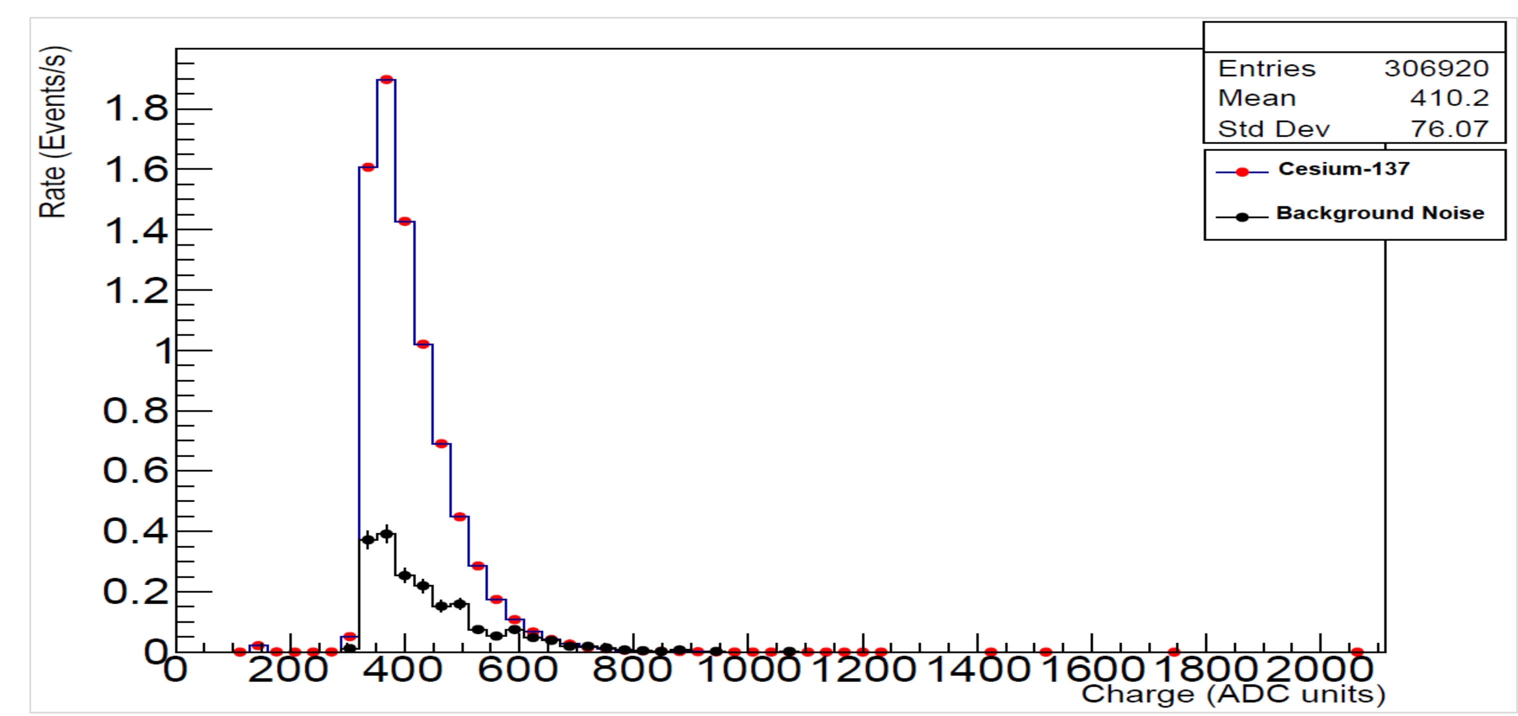

Fig.10: Events rate as function of charge for a radioactive source ^{137}Cs (blue line) and the background noise (black line).

Next Steps

Detector construction is on the way

- ❑ Detector assembly and volume going through final drawing revisions;
- ❑ 64 channels interface board design is being concluded.

Testing in beam facilities

- ❑ Test prototype performance with x-ray and proton beams.

Bibliography

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More information at D. R. Guerreiro presentation "**Scintillating array for real – time high – resolution ion therapy dosimetry – Initial Design and Simulations**"