PMT saturation due to large dynamic range

Bruni, G.; Díaz Fernández, P.; Johansson, H. T.; Heinz, A.; Nilsson, T.; Tengblad, O; Alvarez-Pol, H.; Cederkäll, Joakim; Casarejos, E.; Cortina-Gil, D.; Galaviz Redondo, D.; Gernhäuser, R.; Heiss, B.; Klenze, P.; Golubev, Pavel; Hartig, A.-L.; Knyazev, Alexander; Kröll, T.; Park, J.; Perea, A.; Rhee, H.-B.; Teubig, P.; Zieblinski, M.

Published in:
GSI-FAIR Scientific Report 2017

DOI:
10.15120/GSI-2017-01856

2018

PMT saturation due to large dynamic range

Califa Collaboration; Park, Joochun

2018

LUND UNIVERSITY

PO Box 117
221 00 Lund
+46 46-222 00 00

PMT saturation due to large dynamic range

G. Bruni[1], P. Díaz Fernández[1], H.T. Johansson[1], A. Heinz[1], T. Nilsson[1], O. Tengblad[2], H. Alvarez-Pol[3], J. Cederkäll[5], E. Casarejos[6], D. Cortina Gil[3], D. Galaviz Redondo[7], R. Gernhäuser[4], B. Heiss[4], P. Klenze[4], P. Golubev[5], A.-L. Hartig[8], A. Knyazev[5], T. Kröll[8], J. Park[5], A. Perea[2], H.-B. Rhee[4], P. Teubig[7], M. Zieblinski[9], for the CALIFA /R^{3}B working group.

[1]Chalmers Tekniska Högskola, Göteborg, Sweden; [2]Instituto de Estructura de la Materia, CSIC, Madrid, Spain, [3]University of Santiago de Compostela, Santiago de Compostela, Spain;[4]Technische Universität München, Garching, Germany;[5]Lund University, Lund, Sweden; [6]University of Vigo, Vigo, Spain;[7]FCU Lisbon, Lisbon, Portugal;[8]Technische Universität Darmstadt, Darmstadt, Germany;[9]Institute of Nuclear Physics, Kraków, Poland.

Phoswich detectors, composed of optically coupled $LaBr_3$ and $LaCl_3$ scintillating crystals will be used at the most forward angles in the CALIFA calorimeter at the R^{3}B setup [1]. These crystals offer ideal conditions for detection of gamma radiation, as well as for charged particles at relativistic energies, with high efficiency, and excellent energy and time resolution [2-5].

The goal of this study is to verify the performance of the CEPA4 prototype, consisting of four phoswich crystals with individual photo-multiplier tubes (PMTs) for readout, attached to the $LaCl_3$. A particular challenge, especially for the PMTs and read-out electronics, is the large dynamic range needed to cope with signals from gamma radiation (up to 20 MeV) and charged particles (up to 270 MeV). The TDR [5] specifies the use of the Hamamatsu R7600U-200 PMTs. These tests have been performed using the commercial digitisers CAEN DT5751 and DT5730.

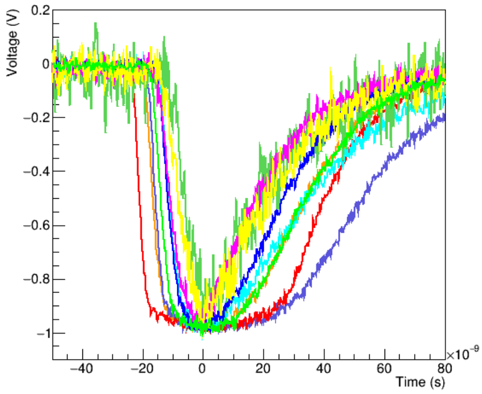

Figure 1: Photomultiplier tube signals of cosmic muons, normalized to the maximum amplitude, showing saturation.

The investigations performed with the crystals revealed a good energy and time resolution for both gammas and muons. While it is relatively easy to obtain good energy resolution for either gamma rays or protons by selecting an appropriate bias voltage, it was not possible to find a bias voltage, which allowed for a good resolution for both, because the PMTs displayed clear signs of saturation already around 20 MeV of deposited energy (see Figure 1). As a first attempt at improving this situation, a new base was used for the R7600U-200 PMTs, providing also a second lower-gain signal from the last dynode in addition to the anode readout (with a gain ratio of ~2.5). This was not sufficient. Therefore, a new PMT, R11187, has been tested. Results are shown in Figure 2, where the saturation starts at the same pulse amplitude independently of the applied bias voltage. This indicates that saturation occurs in the final stages of the PMT.

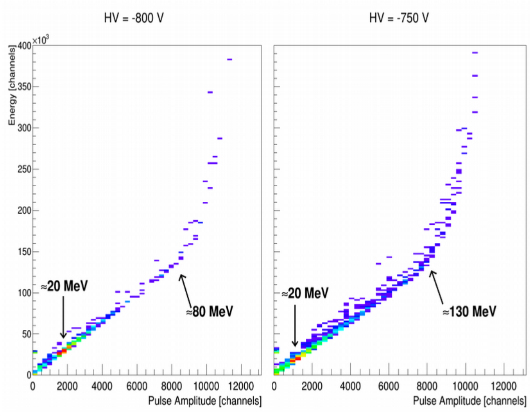

Figure 2: Energy versus pulse amplitude for two high voltages. The degradation of the signals starts at about the same signal amplitude, indicating that saturation occurs in the final stages of the PMT.

To cope with the large dynamic range we want to implement an improved double read-out with a higher gain ratio between the two branches [6].

References

[1] Technical Design Report for the Design, Construction and Comissioning of the CALIFA Endcap, (2015).

[2] O. Tengblad et al., Nucl. Instr. Meth. Phys. Res. A 704, 19 (2013).

[3] E. Nácher et al., Nucl. Instr. Meth. Phys. Res. A 709, 105 (2015).

[4] M. Mårtensson, Master thesis, Chalmers Univ. Tech. (2013).

[5] G. Bruni, Master thesis, Chalmers Univ. Tech. (2017).

[6] Hongkui Lv et al., Nucl. Instr. Meth. Phys. Res. A 781, 34-38 (2015).

Experiment collaboration: NUSTAR-R3B.
PSP codes: 1.2.5.1.2.3.2
Grants: supported by the Swedish Research Council, ENSAR2 (project Nr. 654002) and BMBF (contract Nr. 05P15WOFNA)
Strategic university co-operation with: contract Nr. TMLFRG1316