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PMT saturation due to large dynamic range

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PMT saturation due to large dynamic range

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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 R³B 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.

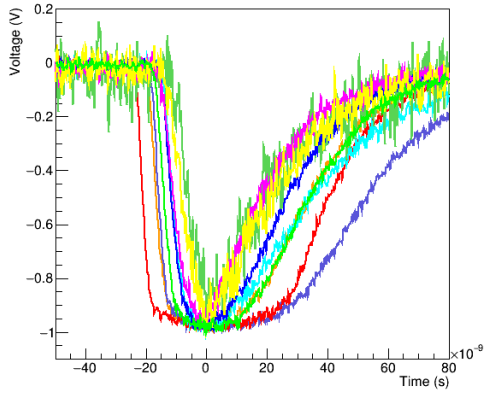
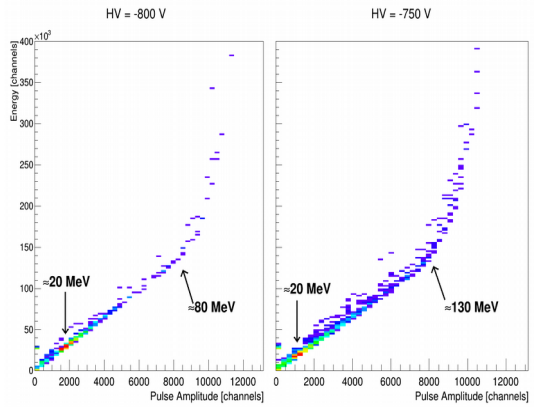


Figure 1: Photomultiplier tube signals of cosmic muons, normalized to the maximum amplitude, showing saturation.

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].

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PSP codes: 1.2.5.1.2.3.2
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