Basic performance of MPPCs and PMTs

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Upgrading an already existing detector system is usually a challenging task because of constraints in terms of, e.g., available space for a new device. In the case of the JET Gamma-ray Camera, limited space was the main reason to use, as a photodetector, a multi-pixel photon counter (MPPC), also known as a silicon photomultiplier or SiPM. If space were not a limiting factor, a photomultiplier tube (PMT) is a good alternative. We present a comparison of full width at half maximum (FWHM) values and overall detector efficiency for solutions based on MPPCs and PMTs.

In both detector setups ϕ25.4×16.9 mm $LaBr_3$:Ce scintillators were installed. One scintillator was coupled to an MPPC from Hamamatsu connected to a transimpedance amplifier (TIA), the MTCD@NCBJ and the FilterBox@NCBJ [1]. The other was coupled to a Hamamatsu photomultiplier tube with an active voltage divider.

Since the energy resolution of scintillators coupled to MPPCs is strongly dependent on the operational voltage, an optimum MPPC voltage was experimentally determined, see Fig. 1.

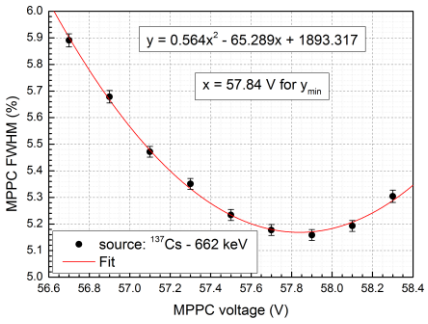

Fig. 1. Optimal operational voltage for the MPPC.

It was found that the optimum voltage of 57.84 V had to be decreased to 57.70 V to register gamma rays with an energy of about 6.1 MeV, see FEP (full energy peak) in Fig. 2.

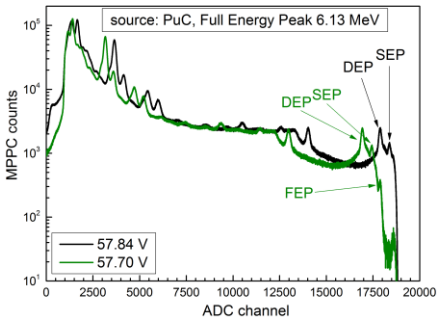

Fig. 2. Two operational voltages of the MPPC.

Both detectors were placed at the same distance from the source and measurements were performed at the same controlled room temperature. Spectra were registered with a CAEN DT5730 digitizer. For ^{137}Cs, ^{22}Na and ^{60}Co sources acquisition time was 5 minutes, for PuBe, and PuC – 16 hours. In Fig. 3 measured energy resolution values for eleven gamma-ray energies are shown.

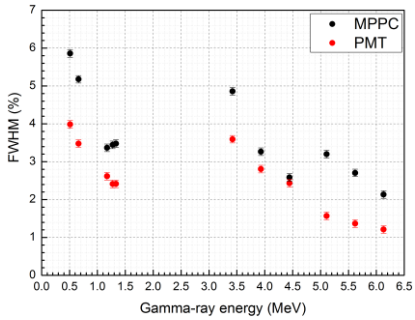

Fig. 3. Energy resolution for eleven measured gamma-ray energies.

A detector coupled to a PMT has a higher overall efficiency by a factor of ~30 than when coupled to an MPPC, see Fig. 4.

So, if space is not a limiting factor, a detector system solution with a photomultiplier tube is a better one, if FWHM and overall detector efficiency are important parameters.

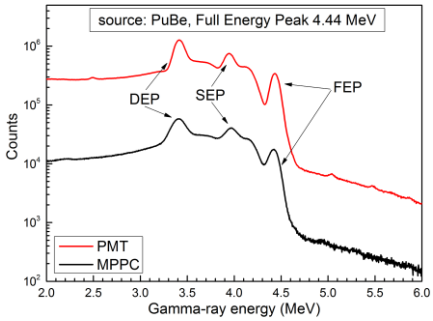

Fig. 4. Spectra registered in 16 h measurement with a PuBe source emitting a 4.44 MeV gamma line with both detectors.

Reference

[1] G. Boltruczyk et al., *Development of MPPC-based detectors for high count rate DT campaigns at JET*, Fus. Eng. Design **123** (2017) 940–944.

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