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Improving the time resolution of large area LaBr3:Ce detectors with SiPM array readout

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LaBr3:Ce crystals have been introduced for radiation imaging in medical physics, with photomultiplier or single SiPM readout. An R&D was pursued with 1" LaBr3:Ce to realize compact large area detectors with SiPM array readout, aiming at high light yields, good energy resolution, good detector linearity and fast time response for low-energy X-rays.
A natural application was found inside the FAMU project at RIKEN-RAL muon facility, that aims at a precise measure of the proton Zemach radius to solve the so-called "proton radius puzzle", triggered by the recent measure of the proton charge radius at PSI. The goal is the detection of characteristic X-rays around 130 KeV. Other applications may be foreseen in medical physics, such as PET, and gamma-ray astronomy. A limiting factor, as compared to a photomultiplier (PMT) readout, is the poor timing characteristics of the detectors (especially falltime) due to the large capacity of the used SiPM arrays. With a standard parallel ganging typical risetime (falltime) of the order of 50 (300-400) ns are obtained. Long falltime are a problem in experiments as FAMU, where a "prompt" component must be separated from a "delayed" one in the signal X-rays to be detected. A dedicated R&D was pursued to settle this problem starting from hybrid ganging of SiPM cells, to development of a suitable zero pole circuit with increased overvoltage and to development of an ad-hoc electronics to split the 1" SiPM array in 4 quadrants, thus reducing the detectors' capacitance. The aim was to improve the timing characteristics, while keeping a good FWHM energy resolution. Reductions in falltime (risetime) up to a factor 3X were obtained with no deterioration of the energy resolution. A FWHM energy resolution better than 3% (8%) at the Cs137 (Co57) peak was obtained. These results compare well with the best results obtained with a PMT readout.

Summary

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