Improving the time resolution in large area LaBr3:Ce crystals, read by SiPM array with temperature gain drift control

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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 using 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. The drawbacks of these detectors in practical use are due both to SiPMs' gain drift with temperature and to a worse timing, as compared to a conventional readout with photomultipliers (PMTs). The gain drift with temperature has been studied in laboratory, inside a climatic chamber, with different SiPM arrays, including the new Hamamatsu S14161 with enhanced sensitivity in the UV region for PET detectors. Correction for this effect have been studied and an effective way was found by developing a custom 8-channels NIM module based on CAEN A7585D chips, with temperature feedback. The effect was reduced by a factor five, in the temperature range 10-40 °C. The poor timing characteristics of the detectors (especially falltime), due to the large capacity of the used SiPM arrays, were also studied and different solutions were implemented. With a standard parallel ganging typical risetime (falltime) of the order of 50 (300) 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 the development of a suitable zero pole circuit with a parallel ganging, using an increased overvoltage and to finally the develop-

ment of an ad-hoc electronics (1-4) 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 2-3X 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.