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Systematic study of innovative hygroscopic and non-hygroscopic crystals with SiPM array readout

LaBr3:Ce crystals and later CeBr3, PrLuAG and Ce:CAAG have been introduced for radiation imaging in medical physics, with photomultiplier or single SiPM readout (up to 3x3 mm2). An R&D was pursued with different types of crystals to realize compact large area detectors (up to some cm2) 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”, triggered by the recent measure of the proton charge radius at PSI. For this, 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. For our aims, it is essential to detect X-rays in the range 100-700 KeV with a compact detector. Different types of crystals (hygroscopic such as LaBr3:Ce and CeBr3 or non-hygroscopic such as PrLuAg and CeCAAG from different manufacturers) were used, together with different SiPM arrays, from Hamamatsu, Advansid and SENSL. Results were obtained both with a standard spectroscopic chain and with a direct readout based on a CAEN FADC, more suitable for direct experimental applications. Different experimental key factors, such as crystal intrinsic activity, crystal wrapping, SiPM temperature monitoring will be discussed. Results on energy resolution, detector linearity, ... will be presented. As an example an energy resolution ˜ 3.6%, at the Cs137 peak, was obtained with LaBr3:Ce crystals with Hamamatsu S13361 array readout, that compares well with best available results.

Experimental Collaboration

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