DEVELOPMENT OF $LaBr_3$(Ce) DETECTORS WITH APD READOUT*

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New fast scintillator materials like $LaBr_3$(Ce) which have been developed during the last some years have gained a lot of interest in both fundamental research and applications, e.g. nuclear medicine (PET). Compared to well-known materials they offer a better energy resolution combined with very good timing properties. Our interests are the Forward-Endcap of the CALIFA spectrometer and calorimeter for R^3B at FAIR [1] and the use in ultra-fast timing experiments to determine lifetimes of nuclear states in the range of some ps up to some ns. Many applications require the operation in magnetic fields or within limited space where traditional photomultiplier tubes (PMT) cannot be used.

As alternative readout device, avalanche photodiodes (APD) are insensitive to magnetic fields and small in size. We investigated the readout of $LaBr_3$(Ce) crystals, 13 mm $\times$ 30 mm, 20 mm $\times$ 30 mm and 1.5" $\times$ 1.5" (BrilLanCe380 from Saint Gobain), with a 10 $\times$ 10 mm^2 Hamamatsu APD S8664-1010 [2]. For γ-rays energy resolutions slightly inferior to the results with PMTs have been obtained, 3.6% (FWHM) at 1332 keV. This is caused by the smaller sensitive area of the APDs currently available in the order of 100 mm^2 and the non-perfect matching of the peak sensitivity of the APDs at around 600 nm to the emission spectrum peaking at 380 nm.

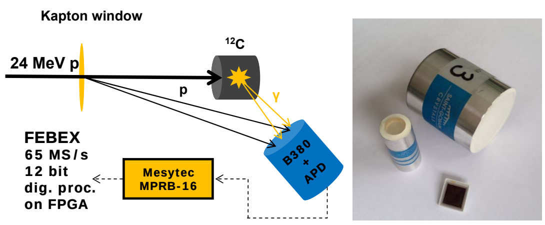

Figure 1: Sketch of the experimental setup (left) and the crystals and the APD (right).

In R^3B, CALIFA will be used as detector for both γ-rays and light charged particles. In forward direction covered by the Forward-Endcap, the energies are higher compared to the region covered by the CALIFA Barrel because of the Lorentz boost and the use of a more dense material than CsI(Tl) is envisaged. In order to study the response to protons, our prototype detectors have been irradiated at MLL with both protons and γ-rays. The simultaneous detection enables the investigation of possible quenching effects for the protons as it is well known for other materials like CsI(Tl). The scattering of 24 MeV protons on the Kapton window of the scattering chamber allowed for the measurement of "low" energy protons at different energies depending on the scattering angle. The setup is sketched in Fig. 1 (left). As it will be used for the CALIFA barrel, the signals from the preamplifier have been sampled by a FEBEX board and processed online on a FPGA.

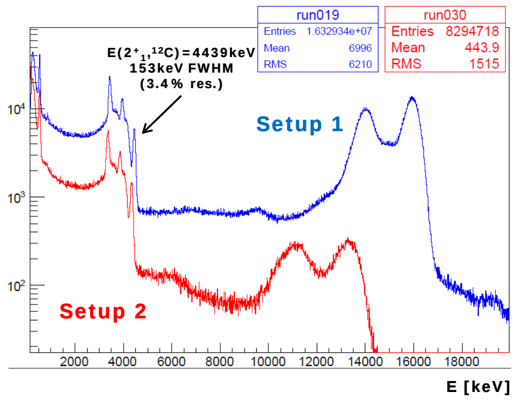

Figure 2: Observed energy spectra for two different scattering angles. Clearly visible are γ-rays from the de-excitation of ^{12}C and the protons scattered from hydrogen and the heavier components of Kapton.

Fig. 2 shows typical spectra obtained. The energy deposits have been calibrated with sources and the high-energy γ-rays emitted in the decay of excited ^{12}C nuclei. An additional energy loss of the protons has been observed which could be due to an additional layer of material not reported by the manufacturer or a quenching effect [3].

Newer materials like $CeBr_3$ as well as silicon photomultipliers (SiPM) for readout have been tested too, although only with standard γ-ray sources [4, 5]. For March 2014, a further inbeam test at MLL is planned. In order to prepare for a full digital processing of signals from fast scintillators including fast timing, signals will be collected also by a fast 5 GSamp/s ADC (CAEN V 1742 B). The recorded signals will be analysed offline with newly developed algorithms.

REFERENCES

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