A DAQ Scheme for BaF_2 Detectors

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The detector development for the ELBE nToF project involves a BaF_2-detector array for efficient detection of neutron-capture reactions [1]. BaF_2 is one of the fastest known scintillation materials. It has the special property of having two scintillation-light components with very different decay times ($\tau_{fast} = 0.6\,\text{ns}$, $\tau_{slow} = 0.6\,\mu\text{s}$). The relative intensity of the two components depends on the incoming particle. Thus pulse-shape discrimination (PSD) can be employed to distinguish e.g. photon events from intrinsic detector background due to α decay of ^{226}Ra. We have developed a read-out system that in principle allows PSD measurements for all our BaF_2 detectors [2]. The read-out electronics is sketched in Fig. 1. It is based on multi-channel VMEbus modules manufactured by CAEN. The PMT (THORN EMI 9954QB) signals are integrated by two CAEN V792 QDCs [3], one set to a short gate length (72 ns), the other set to 2.98 μs by a CAEN V486 gate generator [3].

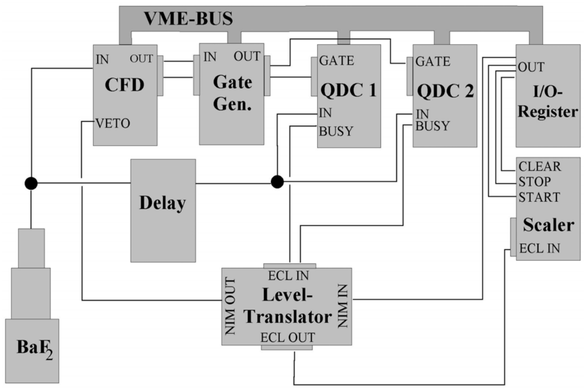

Fig. 3 *Diagram of the read-out electronics set-up for pulse-shape discrimination of a* BaF_2 *detector.*

The VME crate is controlled by a PC running the graphical programming language LABVIEW via a Wiener PCI-VME bus master [4]. A LABVIEW programm performs the synchronized read out of the two QDCs and produces listmode data as well as a two dimensional histogram of the BaF_2-detector signals. The QDCs are vetoed whenever one of them is not ready to accept data, because of dead time of the QDC or the read-out program.

Fig. 2 shows a background spectrum measured with a BaF_2 detector and the set up described above. The four peaks are from different α-decay energies in the ^{226}Ra-decay chain. Radium is chemically similar to Barium and is an impurity in the crystal. The count rate of α decays in a BaF_2 crystal depends on the detector and is in the range from 10 - 100 s^{-1}. In addition, the γ-emission rate of a BaF_2 crystal was measured with a well shielded HPGe detector and characteristic lines from the ^{226}Ra-decay chain were found.

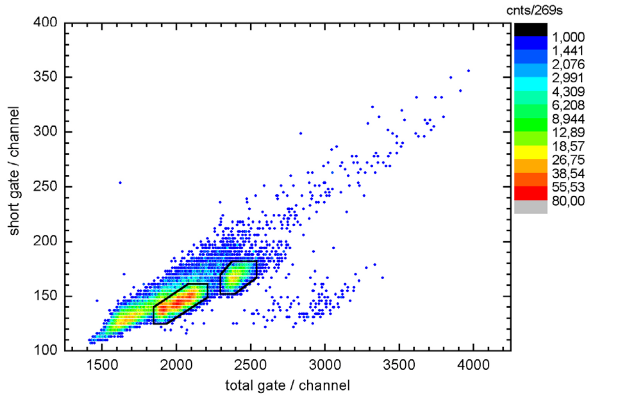

Fig. 2 *Background spectrum of the* BaF_2 *detector. The area surrounded by the black lines marks events due to* α *decay from* ^{226}*Ra impurities. The background from natural* γ*-emitters has been shielded with a lead housing of 5 cm thickness.*

The PSD is illustrated in Fig. 3, where the detector was not shielded against background in the laboratory. The α-decay events are lying systematically lower than the γ induced signals. The discrimination is not as good as expected. A potential source for this is that the short gate was approx. 70 ns long. A length of only 40 ns would have allowed for a better separation of the fast and slow components. Unfortunately, the gate generators used were not capable of delivering a shorter gate.

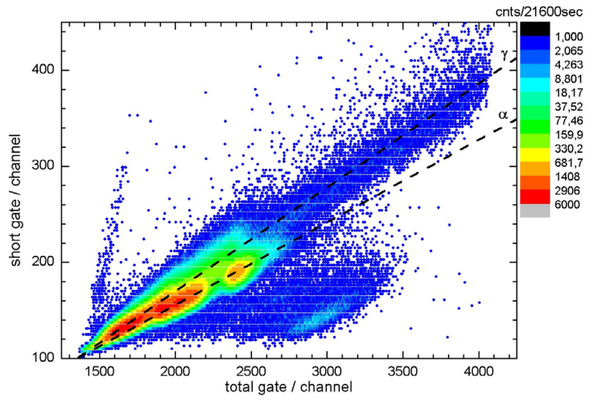

Fig. 3 *Discrimination of intrinsic detector background stemming from* α *decay of* ^{226}*Ra impurities. Here, the detector has not been shielded with a lead housing. The lines mark the regions where events due to* α *decays in the crystal and* γ *ray signals are located.*

The read-out system developed allows to test fast scintillators comfortably in the laboratory in general, and also has demonstrated the ability of PSD in BaF_2 at low energies.

[1] A. R. Junghans et al., this report, p. 19
[2] R. Beyer, Supplement Lab report, Institut für Kern- und Hadronenphysik, 2004, unpublished
[3] CAEN S.p.A., http://www.caen.it
[4] Wiener, Plein & Baus GmbH, http://www.wiener-d.com