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Time based event positioning in monolithic detectors

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MOLECUBES detectors use monolithic scintillation crystals. This detector architecture demands high-speed readout because all pixels of the photodetector must be processed when an event occurs. An often used approach is integration of the current pulses generated by every pixel, but such circuitry quickly becomes bulky, power consuming and expensive. Alternative approaches are often integrated in an ASIC. Here we investigate if the task of event positioning can be accomplished by making use of time only. We propose the use of timing information, in the form of time-over-threshold (ToT), rather than energy information, in the form of integration, for the positioning of the interaction position in the crystal. There are multiple advantages to this approach. Firstly, the electronics are less complex and an off-the-shelf comparator for every pixel of the array would suffice. Secondly, timing information is inherently present in this approach. From the readout we will obtain as many timestamps as there are comparators and several studies showed the advantage in terms of timing performance when multiple are available. We evaluated the positioning accuracy and uniformity of a ToT detector with optical GATE simulations. For event positioning mean nearest neighbour (mNN) was used. We investigated the ability to position the events with ToT information (mNNToT) and the impact of the threshold. The results were compared to an integrating detector (mNNint), which has already proven to allow sub-mm resolution. We showed minimal degradation in spatial resolution (SR) and bias compared to mNNint. The highest threshold results in the worst SR performance but degradation remained below 0.1 mm. Bias is largely constant over different thresholds and close to identical to mNNint. Also, we showed that ToT performs well in terms of uniformity. This study indicates that a monolithic detector with timing information on all pixels is capable of providing high SR event positioning.

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