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Timepix3 Compton camera and its evaluation for selected application fields

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The Compton camera allows reconstructing the direction of gamma photons coming from a radiation source based on the Compton scattering occurring within the detector. The incoming gamma photon interacts with the sensor material producing a recoiled electron. The scattered photon is then detected by photoelectric absorption. For the reconstruction of the incident photons' trajectory, the energy and time of interaction of both Compton products - the recoiled electron and the scattered photon - is needed. This contribution presents the Compton camera using miniaturized semiconductor pixel detector based on Timepix3, which represents a new generation of chips developed by the Medipix3 collaboration.
The traditional approach assumes a double-layer detector, when the recoiled electron is detected in the first layer (usually thin, low-Z sensor), while the scattered photon is absorbed in the second layer (usually thick, high-Z sensor) [1]. However, it was verified that it is possible to implement the Compton camera principle in a single detection layer [2] where both of these events are recorded by the single Timepix3 chip. The third coordinate is determined by measuring the drift time for both events with an accuracy of 30 µm. Thus, it has been shown that the single Timepix3 detector can serve as a fully functional Compton camera. This solution offers many advantages over the two-layer variant: compactness, lower weight and consumption and higher detection efficiency.
Various configurations of the Compton camera were tested within several research projects. Four application fields are considered: autonomous searching and localization of radiation sources using drone(s) [3], static monitoring of the radiation situation, handheld mobile Compton camera for rescue operations and medical imaging for diagnostics and therapy. It was demonstrated experimentally that the 2 mm CdTe sensor has a good performance for the single-layer Compton camera. In addition, the new CdTe sensors with thicknesses of 3 mm and 5 mm were studied. The thicker sensors would significantly increase the detection efficiency of gamma rays. A brief overview of the application fields and the current results will be presented.

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