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Probe and Scanning System for 3D Response Mapping of Pixelated Semiconductor Detector with X-rays and the Timepix Read-out

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The development of new radiation detectors of different semiconductor materials (Si, CdTe, GaAs, ...) brings the necessity to test and evaluate their response and detection performance such as the spatial homogeneity and local charge collection efficiency. Similarly, such testing is desired as well in order to evaluate the extent of radiation damage in detectors. We built a detector scanning system allowing direct measurement of 3D distribution of basic sensor characteristic such as charge collection efficiency, charge diffusion etc. The principle of this system is based on the use of a highly collimated parallel X-ray beam with a perfect line profile. The beam is sent onto the pixelated sensor at a low angle, which allows determining, for a given angle and detector position, the depth of interaction for each pixel. Shifting the detector along the axis perpendicular to the plane of the beam we can obtain a 3D map of the detector response. Per-pixel signal read-out from the pixelated detector can be done by usage of the hybrid semiconductor device Timepix which allows per-pixel energy measurement. The Timepix chip contains an array of 256 × 256 square pixels (total over 65 k pixels) with pitch size 55 μm. Our method allows probing and scanning the charge collection at different depths across the pixelated sensor. Moreover, it allows determining the effect of radiation damage at μm scale. All these effects can be studied as well in the dependence on various detector parameters such as the sensor bias voltage or temperature. Results with specific detector materials will be presented.

Author: JAKUBEK, Jan (aInstitute of Experimental and Applied Physics, Czech Technical University in Prague (Horska 3a/22, CZ 12800 Prague 2, Czech Republic))

Presenter: JAKUBEK, Jan (aInstitute of Experimental and Applied Physics, Czech Technical University in Prague (Horska 3a/22, CZ 12800 Prague 2, Czech Republic))

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