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Spectral-tracking characterization of mixed-radiation fields with the miniaturized radiation camera MiniPIX Timepix2

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The semiconductor pixel detector Timepix2 [1] has been newly implemented in highly integrated readout electronics as a compact and portable detector [2] for radiation imaging and particle tracking. The device has plug-and-play connectivity for flexible measurements of a wide range of radiation fields and applications [2]. Power, control and readout require a single USB 2.0 cable providing online response with the integrated software tool PIXET. The detector is operated and readout in frame mode with data rate up to e.g., 31 fps (ToT 14 bit + ToA 14 bit) and 61 fps (ToT 14 bit). The resulting miniaturized radiation camera (Fig. 1) equipped with the Timepix2 ASIC chip provides extended spectral per-pixel response suitable for measurements of highly interacting (i.e., large energy loss) particles. For such particles Timepix2 makes use of the adaptive gain mode [1] to maintain proportionality in spectrometry measurements such as energy loss, deposited energy distributions and linear-energy-transfer (LET) spectra of ions, fission fragments and low-energy protons and light ions e.g., approaching the Bragg peak.
We evaluate the spectral-tracking response of MiniPIX TPX2 equipped with a 300 μm thick silicon sensor. The detector was energy calibrated per-pixel with discrete X ray and low-energy gamma rays [2]. Tests and spectrometry (energy loss) measurements are performed with well-defined radiation sources in terms of particle type (alpha particles –see Fig. 2, gamma rays, protons), energy (monoenergetic at selected energies, and broad spectrum) and direction (accelerator beam, secondary products from light target experiments). We analyse and describe the Timepix2 response and resolving power for particle-event type discrimination of radiation field components folded in terms of particle type, energy loss and direction [3]. Data products are produced in wide spectral range such as particle fluxes and dose rates (Fig. 3) also characterized in terms of particle-type classes. The results shown indicate the contributions of the main components of the radiation field used (a radionuclide source 241Am) in terms of low-LET particles (X rays, gamma rays, blue data points), high-LET heavy charged particles of low energy and perpendicular direction (PP) (alpha particles, red data points), and doublets of alpha particles resolved by pattern recognition and spectral-tracking analysis of the micro-scale tracks.
Data from well-defined radiation fields such as in-beam measurements of low-intensity accelerator beams are used to construct the detector response matrix for particle-type event discrimination [3]. We apply this technique to provide wide-spectral range LET spectra and composition characterization of unknown and mixed-radiation fields in proton radiotherapy environments using high energy (70 –225 MeV) protons incident on water-equivalent/PMMA targets.

[1] W Wong et al., Rad. Meas. 131 (2020) 106230
[2] J Jakubek, et al., this Workshop
[3] C. Granja et al., NIM-A 908 (2018) 60-71

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