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P2.36: Detection of Secondary Neutrons in Proton and Gamma Radiotherapy Fields with the Pixel Detector Timepix3

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Mixed-radiation fields such as space radiation in LEO orbit, atmospheric cosmic rays, high-energy accelerator and particle radiotherapy environments can produce or contain neutrons as secondary radiation. The neutron energy spectrum can cover a wide range from keV level up to hundreds of MeV (referred as fast neutrons) in addition to a thermalized meV component. Their presence can contribute to the deposited dose and also distort the overall monitoring and dedicated measurement of other radiations (charged particles, gamma rays). At the same time, the detection and measurement of neutrons in such fields can be challenging due to the indirect detection mechanisms, low detection efficiency and limited discrimination from background and unwanted radiations (e.g., protons, electrons and gamma rays).

For the detection of neutrons in broad energy range, we use the semiconductor pixel detector Timepix3 [1] operated and readout in compact radiation camera MiniPIX Timepix3 [2] –Fig. 1a. The pixel detector with a 500 µm thick silicon sensor was equipped with a neutron converter mask of thermal (6Li, few µm thick) and fast (plastic of three thickness: 50, 100, 150 µm) segments [3] –Fig. 1b. The detector was tested and calibrated at fast neutron fields [3] and newly with thermal neutrons at CMI Prague. In this work we measure the neutron component in mixed-radiation fields produced in water-equivalent (WE) PMMA phantoms by energetic protons (100 and 190 MeV at radiotherapy cyclotrons at CCB Krakow and PTC Prague) and gamma rays (from 9 and 18 MeV electrons from a radiotherapy LINAC). The detector was placed in the forward direction behind the phantoms of size greater than the beam range –Fig. 1c.

The neutron induced signals in the pixel detector [4] are determined by the given chip-sensor-converter architecture configuration and exhibit a wide variability in terms of spectral-tracking morphology and detection efficiency [3]. The single-particle pixelated tracks are analyzed and classified according to particle-type classes [5] which can be used as neutron-sensitive detection channels [3] which are also partly spatially correlated to the neutron mask regions [3]. We apply this methodology and a calibration response function to detect and resolve the broad neutron component in the mixed-radiation fields studied. The response of the detector to one beam-phantom-detector configuration is shown in Fig. 2. The plots correspond to the mixed-radiation field decomposition in terms of components (three selected track-type classes are shown). The derived neutron detection efficiency is overall below 1% [3]. Data analysis and the results for various beam–phantom – detector configurations will be presented.

Primary author: GRANJA, Carlos (ADVACAM)

Co-authors: RUCINSKI, Antoni (Institute of Nuclear Physics, Polish Academy of Sciences); OANCEA, Cristina (ADVACAM); GAJEWSKI, Jan (Institute of Nuclear Physics, Polish Academy of Sciences); JAKUBEK, Jan (ADVACAM); VILIMOVSKY, Jan (Proton Therapy Center Prague); CUPAL, Lukas (University Hospital Bulovka, Prague); MAREK, Lukas (ADVACAM); DAVIDKOVA, Marie (Nuclear Physics Institute, Czech Academy of Sciences); RYDYGIER, Marzena (Institute of Nuclear Physics, Polish Academy of Sciences); STASICA, Paulina (Institute of Nuclear Physics Polish Academy of Sciences, Krakow, Poland); KUNDRAT, Pavel (Nuclear Physics Institute, Czech Academy of Sciences); VONDRACEK, Vladimir (Proton Therapy Center Czech); VYKYDAL, Zdenek (Czech Metrology Institute)

Presenter: GRANJA, Carlos (ADVACAM)

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