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Measurement of neutron energy spectrum by ToF technique using triggered MiniPIX-Timepix3 detectors with Si and SiC sensors

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For fast neutron sources, such as compact neutron generators, it is desirable to have knowledge and ideally directly measure the energy spectrum of the generated neutrons. In particular, for neutrons, the produced radiation field at a specific location from the source, can be altered by the distance to the source and become even significantly distorted by surrounding material –e.g. walls and the floor of the laboratory. For this purpose, we apply the Time-of-Flight (ToF) technique on the Timepix3 ASIC chip [1] which makes use of the fast per-pixel response at the ns level. For this work we use the Timepix3 operated and readout by the miniaturized radiation camera MiniPIX-Timepix3 [2] to which the additional signal trigger-in electronic interface has been newly developed –see Fig. 1a. The pixel detector with the 300 μm silicon sensor was additionally equipped with a segmented neutron converter mask for thermal and fast neutrons [3]. A novel 65 μm silicon carbide (SiC) sensor without neutron converters has been tested as well. We performed measurements on a compact neutron generator (NG) at the VSB laboratory [4] which produces mono-energetic 14 MeV neutrons from the D-T reaction. The pixel detectors were placed at 2.76 m from the neutron source (Fig. 1b) and were triggered by the NG pulses produced with a frequency 100 Hz and a 5 % duty factor[4]. The setup and source-to-detector geometry are shown in Fig. 1b. The expected ToF neutron energy spectrum at the detector position was also calculated (see Fig. 1c) by Monte-Carlo (MC) simulations using MCNP6.2 and the MCNP model of the VSB laboratory [5]. The detection of the radiation field by 14 MeV neutrons at the detector position (Fig. 2a) can be decomposed into particle-type events [3] such as the neutron induced interactions in the detector sensor plus neutron converter mask (Fig. 2b). The measured ToF spectrum (Fig. 2c) is produced for a time range of 10 ms and contains also secondary and unwanted background components. Distinct neutron-energy components can be resolved: the fast (14 MeV) neutron component (narrow peak on the left at short times ≤ 0.1 ms), a partly slowed-down fast component (adjacent broad peak at short times ≤ 0.5 ms) and a broadened thermalized group (at larger times ≥ 7.7 ms). The assignments include accompanying secondary events which can be further filtered out by the spectral-tracking response of Timepix3 and extensive calibrations in well-defined radiation fields [3].

References:

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