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Characterization of primary and stray radiation produced in FLASH electron beams with Flex chip-assembly TimePIX3 pixel detectors

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New dosimetric challenges are imposed by the emerging modern cancer techniques, such as FLASH treatments [1]. Suitable detectors and dosimetry protocols need to be developed when dealing with ultra-high dose rate pulses (UHDpulse) such as ultra-short pulses of MeV-level electrons.

This work aims to characterize UHDpulse electron beams using the hybrid semiconductor pixel detector. The TimePIX3 ASIC chip [2] was used to measure the composition, spatial, time and spectral characteristics of the primary and secondary radiation fields at the Microtron electron Accelerator of the Nuclear Physics Institute CAS (UJF CAS), Prague, Czech Republic. The research's central idea is the desire to develop one detector that could extract spectrometric and dosimetric information on such high flux short-pulsed fields.

For secondary beam measurements, a PMMA plate of 8 cm thickness was placed in front of the electron beam, with a pulse duration of 3.5 μ s. The TimePIX3 detectors (with silicon sensors of 100 and 500 μ m) were placed on a shifting stage allowing for data acquisition at various angles and lateral positions to the beam core.

For primary beam measurements, a TimePIX3 ASIC chip-sensor assembly was mounted on a customized detachable Flex architecture (see Figure 1). Two types of detectors (with a GaAs sensor and a naked chip without sensor) were tested with pulsed electron fields in the range 5-23 MeV and dose rates exceeding 80 Gy/s (Figure 2) in order to study their suitability for the characterization of primary UHDpulse beams.

The results highlight the technique and the detector's ability to measure individual UHDpulses of electron beams in very short time, as well as the particles deposited energy and to estimate the particle types in mixed radiation fields.

References:

- [1] M. McManus et al., Scientific Report, 10 (2020)
- [2] T. Poikela, et al., Timepix3: a 65K channel hybrid pixel readout chip with simultaneous ToA/ToT and sparse readout, J. of Instrum. JINST 9 (2014) C05013

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