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Investigation of High Absorbed Doses in the Intersections of the European XFEL Undulator Systems

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The European X-Ray Free Electron Laser (XFEL) operates three Undulator Systems to generate high-brilliance and high repetition X-ray pulses. Each System consists of multiple 5-m long undulator segments separated by 1.1-m long intersections. Such intersections contain vacuum systems, diagnostic and correction equipment for the electron's trajectory, and phase shifters (PS) [1] to match the phase of the electron beam and SASE photons. An array of Radfets monitors the absorbed doses at the entrance of each undulator segment since the start of operation in 2017 [2] but no dosimetry is available in the intersections. Recently, some SASE3 phase shifters stopped working and their motors had to be exchanged. This may have been caused by radiation damage. In this work we used Gafchromic films to measure radiation doses and its spatial profile in the intersections and PS vicinity. The measurements showed that significantly higher radiation doses are absorbed in the intersections as compared to the entrance of the next downstream undulator segment and significant radiation is also found near mechanical motors and electronic circuitry. We performed Monte Carlo simulations using the Geant4 code to investigate the composition of the radiation field in the intersections of the Undulator Systems and correlate it with the Gafchromic measurements and possible radiation damage to PS encoders and motors.

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