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Status of the development of FLUKA MC dedicated radiation sources and estimators for the design and commissioning support of the high-power, high rep-rate LCLS-II electron accelerator

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Since the inception of the Linac Coherent Light Source (LCLS) at SLAC in 2009, significant advances in multidisciplinary science have been achieved with hard X-ray Free Electron Lasers (FELs). In such facilities, a low emittance electron beam from a linac goes through an array of undulators, where bright and coherent light is generated via self-amplified synchrotron emission. The next evolution, aimed at maximizing data-taking, among other features, involves increasing the average laser brightness through more powerful linacs, typically utilizing superconducting cavities to meet high RF demands. This is the case of the European XFEL (since 2017), LCLS-II (currently under commissioning), or SHINE (under construction). Computational models to describe some of the radiation challenges that can arise with these facilities are described here.

High RF fields at LCLS-II and especially LCLS-II-HE will enhance undesired electron extraction from superconducting cavities' surfaces via the tunnel effect. These field-emitted electrons, lacking the correct phase and energy for full acceleration, are eventually swept away by magnets or lost at apertures and chicanes, thus leading to radiation terms that can be dominant in some contexts. Source routines with interfaces via input cards to the FLUKA input file have been developed and refined for FLUKA to help predict such hazards. These computational capabilities are also crucial for designing dedicated cryomodule test facilities.

Ion chambers, whether point or elongated detectors, can experience pile-up and self-screening due to relatively low ion mobility compared to the high repetition rate and power of LCLS-II-type accelerators. Consequently, new beam loss monitors, such as synthetic diamonds based on hole-electron pairs generation, or Cherenkov optical fibers coupled to photomultipliers, have been adopted for LCLS-II and its successors. In the context of the ongoing LCLS-II commissioning, alongside attention to the aforementioned field-emitted electrons, recent developments of the FLUKA models that predict the response of such detectors while addressing the intrinsic statistical challenges of such small detectors are presented.

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Code status, development and model converters

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