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An Advanced Radiation Dose Estimation Tool for the Decommissioning of High Energy Physics Experiments

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As CERN prepares for the High Luminosity LHC upgrade (HL-LHC), several detectors & components of the experiments need to be replaced with upgraded versions designed to take full advantage of the increased luminosity.

We will present ongoing work for the creation of an integrated system for radiation intervention planning, to be used in the preparation for the decommissioning of the ATLAS Inner Detector (ID) in 2024 (LS3), which will be replaced by the new ATLAS Inner Tracker (ITk). We will discuss how the same software environment can be applied for various other radiation critical interventions, where detailed CAD drawings and dose maps are readily available.

Having been exposed to intense high energy beams for several years, creating a challenging radiation environment for personnel, the ATLAS ID will require significant manpower over several months for a complete removal of the detector and its associated services. Careful estimation and further optimization of the individual / collective dose for the personnel involved is therefore an essential part of the decommissioning planning. By combining existing CAD models of the detector with dose maps from an improved radiation simulation (FLUKA), we created a 3D virtual environment which monitors the instantaneous dose rate with respect to position within the environment. Various actions will be created in sequence, with intervention times attributed to each of them. As activated components are removed from the detector, the dose map is revised accordingly. The system then calculates the expected integrated dose for personnel following the intervention work process. Once a baseline integrated dose has been established, individual decommissioning steps can be analysed, and dose critical operations can be optimised.

Using a commercially available motion tracking system, we plan to capture the real-time position of multiple persons while training on a full-size mock-up. This will allow us to record a realistic 3D motion-path that can be imported back into the virtual environment. Importantly, stored positional data of each person during the deinstallation training can be used to directly test the potential efficiency of various shielding concepts before production, by applying a corresponding, modified radiation dose map to the existing virtual model and recalculation of the received radiation dose.

Ultimately the system can be used for the evaluation of ongoing interventions on a daily basis. Existing CERN operational dosimeters (DMCs), that are worn by personnel during interventions exposed to radiation, record the collected radiation dose throughout the day in several second intervals. With comparison of the actual collected dose during the day against the calculated dose based on the recorded positioning data, any mismatch between radiation simulation and the real intervention can be identified and corrective measures can be taken.

As radiation levels will sharply increase with HL-LHC luminosity (LS4 and beyond), the radiation protection aspects during interventions will become significantly more challenging and will need to influence the detector design even further. With the presented simulation tool, possible placement of shielding can be simulated, and the effect of each shielding element evaluated. Necessary mounting points could be included during the design to allow swift placement and efficient protection of personal intervening.

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