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Benchmarking of FLUKA residual simulations for radiation protection at CERN's Large Hadron Collider

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The Large Hadron Collider (LHC) at CERN is the world's largest particle accelerator capable of accelerating protons beams up to 6.8 TeV. The operation of the LHC machine generates unavoidable high-energy mixed radiation fields due to the particle debris of proton-proton inelastic interactions and the consequent hadron/electromagnetic particle shower. Hence, this poses radiological challenges that the CERN Radiation Protection (RP) group needs to address. One of the challenges is the accurate prediction of the residual dose rate during the maintenance and intervention activities in the LHC tunnel to ensure that the exposure of personnel to ionizing radiation is as low as reasonably achievable (ALARA).

The reference simulation tool used for radiation protection aspects at CERN is the general-purpose particle interaction and transport FLUKA (version 4) [1] Monte Carlo code. FLUKA allows for predicting the activation levels and the associated residual ambient dose equivalent rate for a given source term and the corresponding irradiation profile. On the other side, the residual ambient dose equivalent rate levels at CERN are constantly monitored by a network of simple and robust ionization chambers that are installed inside CERN's accelerator tunnels, PMI [2] (trade name PTW, type 34031). These ionisation chambers are used for remote reading of ambient dose equivalent rate during beam-off periods.

A set of PMI positions inside the Long Straight Section of the LHC tunnel is selected to perform this study. These PMI are located in positions which are relevant for the most activated beam line elements in the LSS. Additionally, the RP group carries out the routine dose rate measurement surveys in the tunnel using the dose rate meter Automess 6150AD/6 (AD6) [3] unit. Hence, the comparison is also carried out for this type of instrument.

This paper provides a comparison of the residual dose rates simulated by FLUKA 4 and values measured by PMI and AD6 units. Specifically, the comparison focuses on the Long Straight Sections (LSS) 1,5,7 and 8 of the LHC. The LSS 1, 5 and 8 accommodate the experimental caverns of ATLAS, CMS and LHCb, respectively, while LSS 7 hosts the collimation section dedicated to betatron cleaning.

[1] C. Ahdida et al., New Capabilities of the FLUKA Multi-Purpose Code, Frontiers in Physics, Volume 9, 2022, https://doi.org/10.3389/fphy.2021.788253
[2] H. Vincke et al., Simulation and measurements of the response of an air ionisation chamber exposed to a mixed high-energy radiation field, Radiation Protection Dosimetry, Volume 116, Issue 1-4, 20 December 2005, Pages 380–386, https://doi.org/10.1093/rpd/nci088
[3] Dose rate meter 6150AD/6 (AD6), https://www.automess.de/en/products/productfamily-6150ad/dose-rate-meter-6150ad

Scientific Topic 1

Scientific Topic 2

Scientific Topic 3

Code benchmarking and intercomparison

Scientific Topic 4

Shielding and dosimetry

Scientific Topic 5

Scientific Topic 6

Scientific Topic 7

Scientific Topic 8

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