

Calculation of Radioactive Isotope Production Cross-Sections in FLUKA and their Application to Radiological Studies

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During the lifetime of a high-energy accelerator estimations of induced radioactivity are important in all its phases, such as design, operation and decommissioning. FLUKA's capability of making accurate predictions for isotope production in hadronic and electromagnetic showers has been subject to extensive benchmark experiments carried out in the last years. The accuracy of these predictions steadily improved with the advancements of models implemented into FLUKA, in particular after the introduction of a new evaporation/fragmentation and the improvements and extensions of the PEANUT model.

Whereas former activation studies focused on samples of selected materials and representative source spectra typical for high-energy accelerators, this paper gives a more general analysis of calculated production cross-sections and their application to future radiation protection needs. A method is presented how to quantify calculation uncertainties and use pre-calculated cross sections in order to fold them with expected energy spectra as encountered around accelerators, thus leading to fast and accurate results. The application of this approach is understood to be an indispensable ingredient, for example in order to efficiently calculate radionuclide inventories needed for disposal of radioactive waste towards the final repositories.

Based on a list of materials and radioactive isotopes, possible reaction channels can be derived for a certain application and energy dependent isotope production cross sections are calculated and compared to experimental data. Depending on the amount and accuracy of the available experimental data sets, as well as the production mechanisms of the radioisotopes, respective uncertainty factors can be derived. These factors mainly depend on the production mechanism and the energy range of interest, thus allow quantifying uncertainties in isotope production as calculated with FLUKA in a more global way. Pre-calculated isotope production cross sections are used to estimate radionuclide inventories by folding the cross sections with expected particle energy spectra. Typical spectra as encountered in high-loss regions of the LHC accelerator are presented and compared to those used in previous benchmark experiments. Finally examples are given for folding the particle spectra with pre-calculated isotope production cross sections and their results are compared to benchmark measurements.