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Simulations for the photo-nuclear production of therapeutic radioisotopes, with a focus on Cu-64 and Cu-67

In modern medicine, researchers are designing and testing radiopharmaceuticals for various cancers and tumors with targetable molecules on their cell surface and a good blood supply. Thus, cancer can be treated with targeted molecules that can carry potent radioactive compounds or isotopes for killing cancer cells and visualize them.
Cu-64 and Cu-67 are the most promising isotopes for both, treatment and visualization. Several methods for producing Cu-64 and Cu-67 have been described in the literature. Besides the classical production routes using cyclotrons, an alternative and/or complementary root can be the use of X-ray (gamma) induced reactions obtained with high-energy X-ray beams. As Cu-64 is being produced successfully with our TR-19 cyclotron the assessment of the Cu-64 and Cu-67 production yields and activities for both reaction routes were performed. Also, the choice of the most suitable target for irradiation, optimization of the irradiation parameters such as intensity of the proton (in case of Cu-64 only) and electron beams, irradiation time, target composition and geometry, focal spot and alignment, cooling and degraders used in the process were determined. Simulating a possible production for Cu-64 with an electron beam converted to high energy X-ray, it was found, that for comparable currents (protons or electrons) the yield was also comparably high. For Cu-67 simulations and measurements with various set-ups for the accelerators and conversion targets can be found in the literature, but there are also discrepancies between the measurements and simulations mentioned. In order to find the optimal set-up and clarify the above-mentioned discrepancies, future experiments at ELI-NP with nearly monochromatic X-rays from 1 up to 19 MeV form anti-Compton scattering and with bremsstrahlung X-rays form the planned Radioactive Ion Facility (RIF) accelerator from 20 up to 200 or even more MeV will be available.

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