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Shielding aspects of the new nELBE photo-neutron source

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The radiation source ELBE at Forschungszentrum Dresden-Rossendorf (FZD) uses a superconducting LINAC to produce high brillance electron beams, that can be delivered with energies up to 40 MeV, intensities up to 1 mA and within a pulse width of less then 10 ps. With these parameters the electron beam is used also to produce an intense neutron beam, by stopping the electrons in a liquid lead radiator and producing then neutrons by bremsstrahlung photons through (gamma, n) reactions. The primary goal of the nELBE neutron beam-line is the measurement of neutron cross sections, of interest both for construction materials of fusion and fission reactors, where it is important to select materials with low activation cross sections, and for the handling of nuclear waste from GEN IV reactors, where a key point is the accurate knowledge of processes, that transmute long-lived radioactive nuclides into short-lived and finally stable ones.

To increase the neutron yield through an enhanced electron beam energy (up to 50 MeV) and to minimize several sources of background at the present time, a new neutron beam-line and a new, larger neutron experimental room have been designed. The optimization of the neutron/photon ratio, the elimination of external sources of radiation background, the minimization of the backscattered radiation from the walls and the possibility to have better experimental conditions inside the room are the main advantages of the new design.

To optimize the beam-line and to assess all the shielding aspects of the design, from the liquid lead target for the photoproduction until the last dump at the end of the photo-neutron beam-line, extensive simulations with the particle interaction and transport code FLUKA have been performed. Starting from the primary electron beam, the secondary radiation fields of photons and neutrons have been fully characterized. To have a cross-check of the results, the calculated values of the neutron yields at different energies of the primary beam have been compared with an independent simulation with the MCNP code, obtaining a very satisfactory agreement at the level of few percent .

The area around the photoproduction target has been studied in a mixed field condition, while, for statistical reasons, the penetration of the beam through the collimator and, finally, in the neutron experimental room has been studied by writing a separate "source term" for the photon and the neutron radiation component.

All the results for the nELBE shielding, together with some aspects of the optimization of the photo-neutron beam-line, are here presented and discussed.

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