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Assessment of Monte Carlo Geant4 capabilities in prediction of photon beam dose distribution in a heterogeneous medium

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The aim of this study is the assessment of the Geant4 capabilities in accurately modeling of dose distribution in a heterogeneous water phantom. In this purpose, a Geant4 user code has been designed and developed to enable an accurate modeling of cross beam profiles in a heterogeneous water phantom deposited by a 12 MV photon beam emitted by a Saturn 43 Linac head and configuring a 10x10 cm^2 radiation field. The calculated cross beam profiles at two distinct depths (22 cm and 25 cm), were compared to the ones obtained with MCNPX code. Our findings show that the shapes of dosimetric curves at two distinct depths calculated with Geant4 code and the ones obtained by MCNPX code are in a very good agreement. However, the Geant4 code seems painfully slow when calculating those dosimetric curves and its associated statistical uncertainties don't seem to reach 1% after two weeks of calculations. To deal with this issue, we suggest that a new variance reduction technique specially addressed for dose calculation in a heterogeneous medium must be developed by the Geant4 collaboration, in order to decrease the required computing time and to improve the statistical of calculations.

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XPS study of single-crystal (111) UO2 thin film before and after Ar+ etching

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X-ray photoelectron spectroscopy was employed for determination of the oxygen coefficient k0 = 2+x and ionic (U4+, U5+ and U6+) composition k(%) of oxides UO_{2+x} formed on the surface of the UO_2 (111) thin film on YSZ (yttria-stabilised zirconia) substrates (111) before and after the Ar^+ etching. The oxygen coefficient and ionic composition of the sample surface was found on the basis of the core U 4f and O 1s intensities, as well as on the basis of the U 5f relative intensity. It was found that interaction of the single crystall UO2 film with atmospheric air leads to formation on the surface (several nm) of oxide $UO_{2.19}$, whose ionic composition is: 18% of U^{4+}, 61% of U^{5+} and 21% of U^{6+}. The 20 second Ar+ etching leads to formation of oxide $UO_{2.12}$, the 180 second Ar^+ etching leads to formation of oxide UO2.11. It was established that after the Ar+ etching the $UO_{2.12}$ structure self-reorganizes on the surface. This follows from the high-intensity (~30% of the basic peak intensity) shake-up satellites at 6.9 eV from the basic peak in the XPS spectra.

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