Dose Calculation in Biological Samples in a Mixed Neutron-Gamma Field at the TRIGA Reactor of the University of Mainz

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Introduction: Boron Neutron Capture Therapy of liver metastases is investigated at the University of Mainz, Germany. For a successful treatment, a reliable dosimetry system is crucial. After the failure of first attempts with Thermoluminescent Dosimeters, we started dose measurements using alanine dosimeters. The project in Mainz is focussed on the irradiation of explanted livers in the thermal column of the TRIGA reactor of the University. In this column, high fluxes (10^{10} particles per cm^2 s) of neutrons as well as of gamma quanta are preserved. This mixed field makes it difficult to measure the dose. Alanine dosimeters seem to be one effective approach.

Experimental: The irradiations took place in the thermal column of the TRIGA Mainz. A detailed description of the reactor can be found elsewhere [1]. The thermal column is made out of graphite, it has a width and height of 1.18 m and a length of 1.61 m. Several channels can be generated by removing parts of the graphite. For the actual experiment, a 20 cm x 20 cm channel has been used. The used position in it was the closest one to the core, with the highest neutron flux (2 x 10^{10} n/cm^2s). It is 0.92 m away from the core.

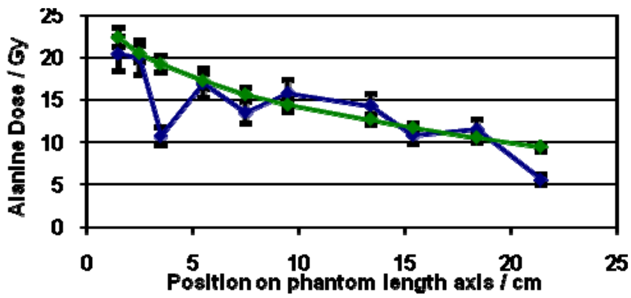
Two experiments have been performed. Alanine dosimeters have been irradiated in a Polymethyl-methacrylate (PMMA) phantom and in liver tissue received in a preclinical trial [2].

The alanine pellets [3] are made of 90 % alanine microcrystals and 10 % paraffin wax. When alanine is irradiated with ionizing radiation, it forms the stable radical CH3–ĊH–COOH. Using an electron spin resonance (ESR) spectrometer, the unpaired electron at the carbon atom can be detected. The value of the ESR signal correlates directly with the number of radicals. All alanine pellets which we have used in our experiments are read out at the Primary Standard Laboratory at the National Physical Laboratory (NPL), in the United Kingdom, where a long experience with alanine dosimetry in photon fields and well established readout protocols exist [4].

The signal in each pellet correlates to an equivalent ^{60}Co gamma dose by a factor called the relative effectiveness (RE). To determine the RE values and to predict the dose for each pellet, we use the Hansen & Olsen alanine detector response model [5] together with FLUKA [6], a multipurpose transport Monte Carlo code able to treat particle interactions up to 10,000 TeV, and MCNP [7]. For the simulations performed, we implemented a 2 dimensional surface source of photons and neutrons, located perpendicular in the thermal column, 63 cm away from the centre of the core. The graphite of the column is surrounded by the aluminium lining and 1 m concrete in every direction for the calculation geometry.

Results: Figure 1 a) and b) shows the results of the dose measurements and the connected simulations with the two codes. The RE value was determined to be 0.83 ± 0.07. The presented data is preliminary, the calculations are still being improved.

a)



b)

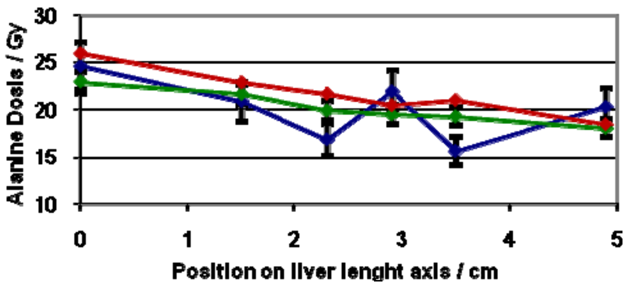


Figure 1. Results of the dose measurements (green) and simulations (MCNP – red, FLUKA – blue) for the phantom (a) and liver (b) experiment

References

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