Karlsruhe Institute of Technology

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Enhancement of Electron Dose in Thin Layers of Skin-Equivalent Material Caused by Foreign Bodies: A Monte-Carlo Study Using MCNP

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IRPA Congress, 13-18 May 2012, Glasgow, Scotland

Introduction

Foreign bodies in the skin can can affect the absorbed dose when irradiated with electrons. They can enhance the dose due to backscattering and production of secondary electrons. On the other hand, they can also lead to a reduction of the absorbed dose by means of their scattering and shielding characteristics. We focussed on thin layers with a thickness of 0.002 cm which is in the order of magnitude of the average diameter of human cells. The thin layers required a careful usage of MCNP.

Objectives

Calculation of dose enhancement F, F:= $D_m(x)$ / D(x) {notations: D_m : dose in layer with presence of a foreign-body material; D: dose got without any foreign-body material; x: layer position}, for these 2 scenarios:

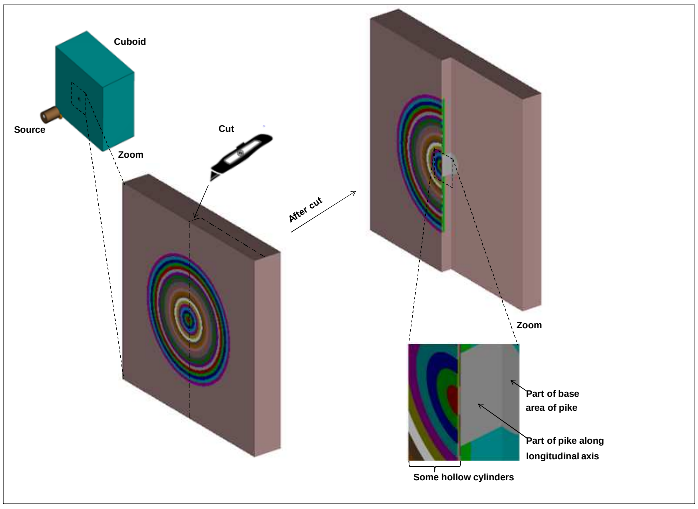

Fig.1. Scenario No.1. Source and cuboid (target). Cuboid contains pike of lead as well as hollow scoring cylinders.

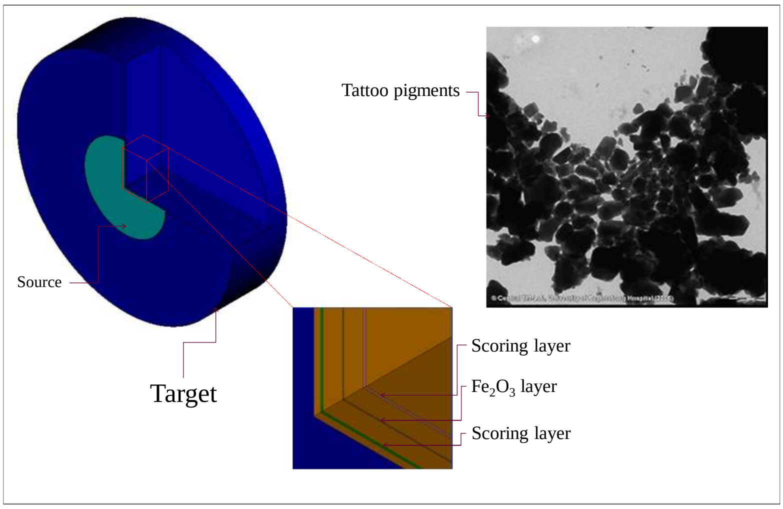

Fig.2. Scenario No.2. Left: Source (green) and target (blue). Right: TEM image of red tattoo pigments, taken from Engel [1].

Methods

MCNP5 with energy-loss mode of H. Grady Hughes (dbcn 17j 2) and method of Schaart et al. [2]. Monoenergetic broad electron beams and isotropic surface sources (Pm-147, Kr-85, and Sr-90/Y-90).

Results (selection)

Scen. No. 1: **Dose enhancement of more than a factor 2 visible at a depth of 0.007 cm.**
Substantial dose enhancements for a slab with a cross-section area of 0.025 cm^2.
All dose enhancements almost not noticeable for a (1.0 cm^2)-slab (normally used in rad. prot.).

Scen. No. 2: **Fe_2O_3 layer does not cause significant dose enhancement.**
Fe_2O_3 layer causes a shieldung of about 1/3 for a Pm-147 emitter.

Discussion and Conclusions

Results should be repeated by a class II algorithm. Experimental measurements would be desirable.

References

[1] E. Engel: Tattoo pigments in Skin: Determin. … Dissertation. University of Regensburg, Germany, 2007.
[2] Dennis R. Schaart et al. A Comparison of MCNP4C Electron … Phys. Med. Biol. 47, 1459 – 1484 (2002).