Biocompatibility and MRI imaging of radiation microdosimeter

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INTRODUCTION: The use of microdosimeters for the specification of radiation quality has a fundamental role in the framework of cancer therapy performed with ion-beam [1].

The rationale is the accurate determination of the characteristics of the radiation beams that, together with the absorbed dose, allow the forecast of the biological effects. Microdosimeter allows determining the lineal energy spectra, which describe the release of the energy to the cells. Such parameter is correlated to the cellular damage and varies drastically at the end of particle path.

Among several microdosimeters based on gaseous or solid-state sensitive volume, synthetic diamonds where chosen in the first studies for their high tissue equivalence and capability of being reduced in both, overall size and sensitive volume (see Tab. 1). [2] A first prototype of miniaturized diamond based microdosimeter, 1 mm^2 in size, has been developed (see Fig.1(a)). The goal of this experiment was to test the compatibility of the device with MRI scanner for future in-vivo measurement. Such results will be used as input for the study of biocompatibility in living small animals.

METHODS: A first version of the detector has been implanted post-mortem in nude BALB/C mice (N=3) at the following positions: on the skin surface (right flank), subcutaneously (left flank) and in brain following the opening of the skull.

For each position, T1 and T2-weighted MRI images have been acquired using an animal MRI scanner (4.7T Bruker, Ettlingen) to evaluate the presence of artifact determined by the components of the detector: diamond sensor, metallic electrodes and wire. Acute damage of the tissue due to potential over-heating has been also visually inspected.

Table 1: Physical characteristics of the microdosimeter

sensitive volume	≥0.003 mm^3
detector area	1÷3 mm^2
electrode diameter	100µm÷2mm
electrode thickness	50 nm
wire diameter	25 µm

RESULTS: The images acquired with MRI scanner showed a substantial compatibility of the device at each position of the detector in the mouse body. The sensible volume (diamond plate) was well visible in all images and did not produce artefacts. Metallic elements, as electrodes and wires in our case, are extremely critical since they can produce artefacts and heating the surrounded tissue due to the interaction with MRI radio-frequency. In both cases we did not detected any kind of artefacts. This unexpected, but good results, is due to the reduce thickness and diameter of the electrodes (the largest 2mm-diameter was used) and wire, respectively (see Table 1).

No macroscopic tissue damaged due to overheating has been detected.

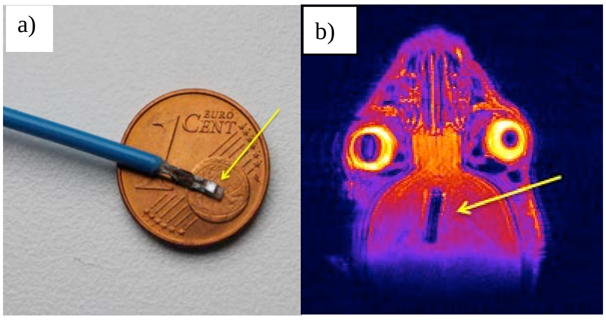

Fig. 1: a) Picture of the smallest microdosimeter (marked by the yellow arrow) compared to 1cent. b) MRI image of the mouse head showing the presence of the microdosimeter and the absence of artifacts.

DISCUSSION & CONCLUSIONS: the detector did not show any issue regarding the measurement in MRI scanner. Based on this preliminarily result, we are planning to use MRI to test biocompatibility during in-vivo experiments also considering miniaturized, silicon and gaseous detectors. Moreover, we are evaluating the possibility to substitute metallic wire with liquid metals (Ga-In alloy).

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