Design and study of a tissue equivalent plastic dosimeter for applications in hadrotherapy and space

Objectivos
Introduction

Microdosimetry studies the effects of radiation at the cellular level to infer its effects on the scale of organs and tissues. Therefore, in experimental microdosimetry it is necessary to know the energy distribution at the scale of a cell, at which scale quantities such as the energy deposited per unit length and per unit mass are stochastic.

The design of an ideal microdosimeter shall take following criteria into account:
(i) the sensitive volume shall be well defined in order to be able to accurately determine the average length of the chord of that volume;
(ii) the detector walls must have densities similar to the sensitive volume (SV) in order to avoid secondary radiation contributions that do not exist in the actual tissues;
(iii) both the SV and the walls must be made of materials with similar compositions and tissue equivalents;
(iv) the dosimeter shall have excellent spatial resolution in order to allow the paths of μm-scale energy deposition to be followed.

The most common type of detector used for microdosimetry is the equivalent proportional tissue counter (TEPC). In these proportional counters, an equivalent fabric gas is used whose pressure (density) is equal to the energy lost in the volume of the cellular tissue. Although the existing TEPCs fulfill many of the above requirements, they have some important limitations: i) they are too large to model a cell matrix (limited spatial resolution); require the supply of a gas, which is expensive; iii) are affected by wall effects due to the difference in density between the SV gas and the plastic equivalent of fabric used on the walls; (iv) require high operating voltages; v) due to polarization effects, there is a dependence of the stopping power of the gas with the density, which makes equivalence with the energy deposited at the cellular scale impossible.

Since the late 1990s, Si-based detectors have been studied for the construction of microdosimeters that avoid some of the problems of TEPC: i) operate at low voltages; ii) do not require gas supply; and above all iii) can be implemented with SV at the μm scale in matrices that mimic a set of cells. Although there have been several advances in the design, implementation, and testing of medical applications and the space of Si-based microdosimeters in recent years, there are still important limitations: i) SV can not be as well defined as necessary; ii) the charge collection efficiency limits the quality of the detector response due to diffusion in the depletion regions; iii) the conversion of the energy deposited in Si to tissue equivalent is much more complex due to the strong dependence with energy of the ratio between stopping powers in Si and Tissue.

Objectives

The objective of this work is to explore the possibility of using optical fibres and plastic scintillators in microdosimetry, since these have characteristics that together can overcome Tissue Equivalent Proportional Counters and Si-based microdosimeters. These characteristics are:
i) their low voltage operation;
ii) no gas supply is required;
iii) the Sensitive Volume dimensions can be well characterized;

iv) their density (~1 g / cm 3) and composition are favourable in terms of wall effects and tissue equivalence;
v) the optical fibres and scintillators can be assembled into fibre bundles or plastic scintillator matrices, allowing for a good spatial resolution

Requisitos
Good programming skills (C++, GEANT4, etc.) are an advantage for this thesis

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