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Feasibility of a photodiode-based dosimeter use in protontherapy: study of the angular dependence using Monte Carlo simulation.

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Ionization chambers are the devices most commonly used as dosimeters in radiotherapy. They show, however, some limitations compared to other systems based in semiconductors: large sizes, high voltage requirement for biasing, etc. Some current-mode semiconductor devices have been studied for the same purpose, such as photodiodes and phototransistors. For these devices, the absorbed dose is proportional to the current integrated over the exposure time.

Nevertheless, one of the most important features of this type of dosimeters is its angular dependence. This characteristic refers to the possible change in the sensitivity of the dosimeter according to the direction of the incident radiation. The angular dependence of dosimeters can be important, especially in situations where the radiation source is not isotropic or when they are not positioned in the direction of the radiation. In such cases, dosimeters may not accurately measure the radiation dose received by the patient.

Using the Monte Carlo codes PENH [1,2] and FLUKA [3,4], we have analyzed the response of a BPW34S photodiode, because this kind of sensor presents good properties for radiation measurements [5]. In the simulations, a monoenergetic 10x10 cm2 square field proton beam impinges in a water phantom, where the dosimeter is situated. A wide range of energies have been used: 50, 100, 150, 200 and 250 MeV. An air layer is considered between the phantom and the radiation source. The incidence angle of the radiation is changed to study the angular dependence. The angles considered in our analysis were 0º, 15º, 30º, 45º, 60º, 75º and 90º. The implemented geometry aims to reproduce the experimental setup that would be used to characterize the angular dependence of the device.

The considered photodiode was modeled as a plastic housing with an internal silicon die according to the dimensions provided by the manufacturer. The energy deposited in the silicon die was calculated as a function of the incidence angle and compared to the response for the normal incidence that is considered as the reference value. Our results show a reduce angular dependence for the device for low energy protons. Besides, for high energy protons, a significant angular dependence is only found for large angles (close to 90º).

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