Contribution ID : **521** Type : **not specified**

Monte Carlo simulations for proton beams supported by a Fano test

Monday, 21 March 2022 15:30 (15)

Abstract

-Introduction-

Monte Carlo simulations have been traditionally used to calculate ionization chamber dose responses for photons and electron beams in an accurate way. In these type of calculations, there are uncertainties that come from the physical models and uncertainties related to the transport algorithms. The latter can be estimated using self-consistency tests. One of them is the Fano test, which based on the Fano theorem.

In this work, a Fano test is implemented to prove the feasibility of different Monte Carlo codes for proton transport (PENH, TOPAS and FLUKA). Optimal simulation parameters in each case have been determined, and this permits to use these codes for the calculation of the correction factors of ionization chambers used in protontherapy.

-Materials & Methods-

Using the reciprocity theorem, a geometry has been designed according to Ref. [1], to implement the Fano test for proton beams of 50, 100, 150, and 200 MeV, using the last version of the three Monte Carlo codes considered (PENH, TOPAS and FLUKA). First of all, the depth dose distribution in the chamber cavity has been obtained in order to analyze the charge particle equilibrium. Next, the effects produced by changing the transport parameters in the different codes has been studied.

-Results-

All the codes considered pass the Fano test for proton beams provided the contribution of the nuclear reactions are fully neglected; otherwise the theoretical dose is overestimated and the Fano test is not fulfilled properly.

-Conclusions-

PENH, FLUKA and TOPAS fulfill the Fano test for monoenergetic proton beams from 50 to 200 MeV if nuclear reaction contributions are neglected in all the simulations. This result makes feasible using these Monte Carlo codes for the calculation of correction factors in ionization chambers used in protontherapy.

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Primary author(s) : DE LA TORRE GONZÁLEZ, Juan Alejandro (Universidad de Granada); ANGUIANO, Marta (Universidad de Granada); LALLENA, Antonio M. Lallena Rojo (Universidad de Granada)

Presenter(s) : DE LA TORRE GONZÁLEZ, Juan Alejandro (Universidad de Granada)

Session Classification : Red FNUC (Red Temática de Física Nuclear)

Track Classification : Red Temática de Física Nuclear (FNUC)