International Nuclear Physics Conference INPC2013: 2-7 June 2013, Firenze, Italy

Simulation toolkit with CMOS detector in the framework of hadrontherapy

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"Hadrontherapy" is a collective word to describe the many different techniques of oncological radiotherapy which make use of fast non-elementary particles (mainly protons and carbon ions) to locally treat many types of tumors. Compared to conventional radiotherapy, this technique presents two main advantages: a precise ballistic, with a finite range and a maximum dose deposition at the end of the path of the ions (called Bragg peak) and an enhanced biological efficiency in the Bragg peak region. This allows one to better target the tumor while preserving the surrounding healthy tissues. However, nuclear fragmentation may occur, which causes a dispersion of the dose due to secondary particles. For carbon therapy, high energy charged particles like protons and alpha may escape the patient volume [1]. The tracking of such particles in the forward direction has been shown to provide an effective imaging technique of the Bragg peak position [2], [3].

The QAPIVI (Quality Assurance by Proton Interaction Vertex Imaging) project aims to perform a feasibility study on the real time monitoring of the dose deposition in the patient during a cancer treatment. The detection technique uses, as three-dimensional tracking system, a set of CMOS sensors planes [4]. The characteristics of this device are a high granularity (about 20 microns pitch) to reconstruct the tracks with a high spatial resolution (few microns) and a small thickness (about 50 microns) to minimize the Multiple Scattering effect. The trajectories of protons emerging from patients are reconstructed and the intersection between them and the direction of the beam allows one to measure the position of vertex fragmentation.

A new simulation package based on GEANT4 [5] and ROOT [6] has been developed. This package allows us to realize a simulation of several experimental setups considering geometrical solution in the hadrontherapy framework. Different reconstruction algorithms (clustering, tracking and vertexing) will be presented. Preliminary sensitivity of the proposed technique will be discussed in light of the information collection from outgoing particles, according to our simulation. In particular the distribution of kinematical quantities (particle charge, energy....) will be shown as well as the precision achieved on the estimation of Bragg peak position in the case of homogeneous target.

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