High spatial resolution microdosimetry with ΔE-E detector on ^{12}C beam: Monte Carlo simulations and experiment.

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Charge particle therapy with ^{12}C ions has the advantage of an enhancement in physical dose distribution due to the Bragg Peak (BP) related to higher Relative Biological Effectiveness (RBE) with respect to X-ray radiotherapy and proton therapy (2.5 for ^{12}C ions and 1.1 for protons) [1], [2]. The RBE of a ^{12}C therapeutic beam changes dramatically with depth, especially towards the end of the Spread Out Bragg Peak (SOBP), due to very high Linear Energy Transfer (LET) of the ^{12}C ions in this region. Additional complexity in the determination of the RBE is associated with the nuclear fragmentation process which leads to the production of lighter charged ions, with lower LET, and neutrons. Therefore, it is important to derive the RBE as well as study the fragments contribution of a therapeutic ^{12}C beam at the BP and SOBP.

The Centre for Medical Radiation Physics has proposed a method using a monolithic ΔE-E telescope fabricated at Politecnico di Milano, Italy for microdosimetry as well as for particles identification in ^{12}C therapeutic ion beam at HIMAC, Japan. The response of a silicon ΔE-E telescope in a PMMA phantom to 290MeV/u ^{12}C therapeutic ion beam was studied theoretically using Geant4 Monte Carlo toolkit and experimentally. The detector consists of ΔE and E stage with thicknesses of 1.8 μm and 500 μm, respectively. It provides microdosimetric spectra using separately the ΔE stage and primary, secondary charged particles identification when operating both stages of the detector in coincidence.

The measurements were carried out at different depths with 0.5 mm step. The microdosimetric spectra were derived from ΔE stage using an assumption that the average chord is 1.8 μm along with the 2D energy deposition plots (ΔE versus ΔE+E) for the same points. It was demonstrated that the microdosimetric spectra are changing dramatically within 0.5 mm depth increments close to and at distal part of the BP that is impossible to observe with TEPC due to its poor spatial resolution. Fragmentations produced in the distal part of the BP were observed with substantial contributions from ^{4}He, ^{3}He, ^{7}Li, ^{9}Be, ^{11}B. Dose weighted microdosimetric spectra for each type of fragments along with their contribution to the RBE will be presented.

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