

CHANG-1: Dose Calculation Algorithm for Neutron Capture Therapy with Pre-Calculated TEGMA

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In order to develop BNCT treatment planning system (TPS) for clinic, a faster dose calculation algorithm is necessary to replace current Monte Carlo-based system with less computing-power dependent system. A convolution/superposition algorithm commonly used for conventional TPS system was applied for this purpose. TEGMA (total energy generated per mass) was defined as total energy generated from neutron interactions such as $^{10}\text{B}(n, \alpha) ^7\text{Li}$, $^{14}\text{N}(n, p) ^{14}\text{C}$, $^1\text{H}(n, n') ^1\text{H}$. The new quantity was similar to TERMA (total energy released per mass) for photon dosimetry. Since charged particles from these interactions have very short ranges of less than 10 μm in tissues, Q-values of these interactions were assumed to deposit locally. In a rectangular phantom consisting of Cartesian voxel, TEGMA for a pencil beam of mono-energy was pre-calculated by using MCNP6.2. The neutron energy grouped for TEGMA ranged from thermal to 10 MeV. Depending on a field size and energy of incident neutron beam, the convolution/superposition (CS) of pencil beam was implemented over the energy groups and multiple pencil beams at the irradiation port. In addition, full Monte Carlo (MC) calculations using PHITS were carried out to verify accuracy of the algorithm developed in this study. Depth doses along the central beam axis and dose profiles crossing a normalized voxel were compared between the developed CS and MC results. Except for the build-up region, the depth dose distributions up to 10 cm depth between CS and MC agreed within 10%. Since the lateral dimension of pre-calculated TEGMA was limited to 2 cm from the central axis, the cross-profiles of CS for a large field (> 5 cm diameter) were not matched well with MC data. The calculation time of developed CS was extremely shorter (< a few minutes) than that of MC. Overall, the developed algorithm was feasible for BNCT dose calculations in terms of accuracy and computation time in clinic.

Keywords: TEGMA, Convolution/superposition, Monte Carlo