



Application of Monte Carlo Simulation for the Medical Linear Accelerator in Radiotherapy

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بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

وَقُلْ رَبِّ زِدْنِي عِلْمًا

In the Name of Allah, the Most Gracious, the Most
Merciful

“..And Say: My Lord! Increase me in Knowledge”

“TAHA/114, the Glorious Quran”

To

Mother

Father in God's mercy

Brothers

Sisters

And

My fiancée Ola

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ABSTRACT

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GATE (Geant4 Application for Tomographic Emission) is a general purpose simulation platform for PET, SPECT and radiotherapy applications. Built on top of the Geant4 simulation toolkit, it provides multiple new features with the objective to ease use of Geant4 in the field of medical physics. Handling Gate is carried out by scripting via a command language instead of C++ coding. In this study, gantry of a 6 MV photon beam of medical linear accelerator (LINAC), based on the manufacturer's detailed information was simulated using GATE/GEANT4. This simulation was performed by using more than 2×10^9 primary electrons. The simulation process is divided into two main stages. The first stage is to run the code to simulate photons and electrons transport through the Linac head, and record the information of the simulated hits crossing a scoring plane above the secondary collimator in a phase space file (PhS). The second stage is to generate hits histories from a given phase space file, and calculate dose distributions in a phantom relative to reference depth 1.5 cm at the isocenter. Evaluation of percentage depth dose distribution (PDD) and flatness symmetry (lateral dose profiles) in water phantom were performed. Comparison between experimental data and simulated were carried out for three field sizes 5×5 , 10×10 and 15×15 cm². Results show good agreement between computed and measured PDD, Moreover the lateral dose profiles at 15, 50, and 100 mm depth are compatible with the measured values. Overall, GATE/GEANT4 code is a promising applicable Monte Carlo program in radiotherapy applications.

SUMMARY

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Most of commercial Treatment Planning System (TPS), use an analytical calculation for estimating dose to patient, Such methods are less accurate in practice. In alternative, Monte Carlo calculation using GATE/GEANT4, can be used for accurate dose calculation. This technique represents a powerful tool for simulation of complex geometrical shapes and material composition by using different physics models.

In the present work, a Monte Carlo simulation for 6 MV high energy photon medical linear accelerator (Linac), using GATE/GEANT4 was introduced. The gantry of a VARIAN 600C LINAC was simulated according to the manufacturer's detailed information was simulated. The simulation processes were performed on two stages. The first stage includes simulation of the accelerator gantry resulting to phase space file (PhS) formation, the phase space file (PhS) was generated by using more than 2×10^9 primary electron. Such a phase space file records all information of the simulated hits crossing a scoring plane, such as energy, orientation, type, charge and position of the particles crossing the scoring plane. While the second stage was executed by interactions of recorded hits from a given (PhS) file, with a water phantom of dimensions $48\text{cm} \times 48\text{cm} \times 35\text{cm}$ at source-surface distance (SSD) = 100 cm, were the percentage depth dose (PDD) and the flatness symmetry for different field sizes were calculated relative to reference depth 1.5 cm at the isocenter. A macro files were created for the purposes analysis of beam characteristic at two stations in the treatment head.

During the physics setting construction, the geometrical specification of the accelerator , as well as the beam energy were taken into consideration. A 6 MV circular electron beam with a gaussian energy distribution accelerated down to hit the tungsten and copper target were bremsstrahlung photons are generated. These photons and secondary particles are interacting with the flattening filter, monitor chamber, mirror and a pair of Jaws.

III

Experimental dose measurements were carried out by the aid of a dosimetry system include computerized welhofer WP 700 water phantom version 3.5. This phantom consisting of a water-filled tank with a scanning volume of $48 \times 48 \times 48 \text{ cm}^3$ and two cylindrical water proof ion chambers each of sensitive volume 0.147 cm^3 and wall thickness of 0.4 mm (RFA 300 Scanditronix) were used.

The computed percentage depth dose (PDD) for three field sizes 5×5 , 10×10 and $15 \times 15 \text{ cm}^2$ and the flatness symmetry for each fiels size at 15, 50, and 100 mm depths in water phantom , are compared with experimental measurements. Results show good agreement between computed and measured PDD. Moreover the lateral dose profiles at 15, 50, and 100 mm depth are compatible with the measured values.

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