6MV Photon Beam Commissioning in Varian 2300C/D with BEAM/EGS4 Monte Carlo Code

Sangroh Kim*[a], Jason W. Sohn [b], Byung Chul Cho [c], Tae Suk Suh[a], Bo-Yong Choe[a], and Hyoung-Koo Lee[a]

[a]Dept. of Biomedical Engineering, The Catholic University of Korea, Seoul, 137-040, Korea,
[b]Dept. of Radiation Oncology, Washington University in St. Louis, MO, USA,
[c]Dept. of Radiation Oncology, Hallym University, Anyang, Korea
corresponding author: Tae Suk Suh
e-mail: suhsanta@catholic.ac.kr, lynch829@catholic.ac.kr

ABSTRACT
The Monte Carlo simulation method is a numerical solution to a problem that models objects interacting with other objects or their environment based upon simple object-object or object-environment relationships. In spite of its great accuracy, It was turned away because of long calculation time to simulate a model. But, it is used to simulate a linear accelerator frequently with the advance of computer technology. To simulate linear accelerator in Monte Carlo simulations, there are many parameters needed to input to Monte Carlo code. These data can be supported by a linear accelerator manufacturer. Although the model of a linear accelerator is the same, a different characteristic property can be found. Thus, we performed a commissioning process of 6MV photon beam in Varian 2300C/D model with BEAM/EGS4 Monte Carlo code. The head geometry data were put into BEAM/EGS4 data. The mean energy and energy spread of the electron beam incident on the target were varied to match Monte Carlo simulations to measurements. TLDs (thermoluminescent dosimeter) and radiochromic films were employed to measure the absorbed dose in a water phantom. Beam profile was obtained in 40cm×40cm field size and Depth dose was in 10cm×10cm. At first, we compared the depth dose between measurements and Monte Carlo simulations varying the mean energy of an incident electron beam. Then, we compared the beam profile with adjusting the beam radius of the incident electron beam in Monte Carlo simulation. The results were found that the optimal mean energy was 6MV and beam radius of 0.1mm was well matched to measurements.

Keywords: Monte Carlo, radiochromic film, TLD.

1. INTRODUCTION
Hardware performance has increased dramatically during the last few years, thus the simulation time is reduced in general purpose Monte Carlo (MC) code like BEAM/EGS4 code (BEAM00, NRC, Canada). But, to simulate a linear accelerator head, there are many parameters needed to be input. For example, linear accelerator head geometry, materials, incident electron beam energy and spread, etc. These data are not easily obtained without the supports of manufacturer. We obtained Varian 2300C/D linear accelerator head data by the courtesy of Varian Medical Systems. The phantoms used in this study were made with solid waters to commission Monte Carlo simulations. 6MV photon beam was delivered to the phantoms with the field sizes 10cm×10cm, and 40cm×40cm at SSD 100cm. The absorbed doses were measured in solid water phantoms by using radiochromic films and TLDs. Radiochromic film is a useful device to measure relative doses that has a precise accuracy in dose measurements. A TLD was employed to measure an absolute dose. It has a good accuracy to measure an absorbed dose. We took two steps in this study. Firstly, depth dose was measured in 10cm×10cm field size with varying the mean energy of incident electron beam. Then we measured beam profile in 40cm×40cm field size to change the beam spread (radius) of incident electron beam

2. MATERIALS AND METHODS
2.1. Materials
The Varian 2300C/D linear accelerator (Varian Medical Systems, USA) has been used to investigate the small field effects. Accelerator head geometry was provided by the courtesy of manufacturer. The 6MV photon beam was irradiated in the solid water phantom and Monte Carlo simulation was performed with BEAM/EGS4 code The radiochromic films were used to measure the relative dose values, and TLDs were attached to measure the absolute dose

value. A solid water (ρ=1.046g/cm^3, ρ_e=0.54g/cm^3) phantom were used to perform the experiment. ρ means the nominal density and ρ_e is the mass electron density.

2.2. BEAM/EGS4 code

BEAM/EGS4 code systems have utilized to simulate Varian 2300C/D linear accelerator head. The phase space file was obtained in history 10,000,000, ECUT=0.70MeV, PCUT=0.010MeV and the selective bremsstrahlung splitting parameters are as follows: the maximum splitting factor (N_{max}) is 250, the minimum splitting factor (N_{min}) is 25, and the field radius (R_f), needed to calculate the probability of photon emission into the field, is 45cm (for 40cm×40cm) and 15cm (for 10cm×10cm). After BEAM simulation was over, the phase space file was produced to get the absorbed dose in the phantoms.

To get the absorbed dose in the phantoms, DOSXYZ user-code was used. DOSXYZ code is a Monte Carlo EGS4 user-code for 3-dimensional absorbed dose calculations. The phase space file which was obtained from BEAM simulation was inputted in the 3-dimensional homogeneous voxel phantoms. The DOSXYZ phantom geometry was like this: -30.25cm ~ 30.25cm (voxel spacing: 0.5cm) for x-axis, -30.25cm ~ 30.25cm (the points of edges in voxel: –30.25cm, -1.00cm, 1.00cm, 30.25cm) and 0cm~28cm for z-axis (voxel spacing: 0.5cm). Because there are no need to see the profile of y-direction, we simplified y-axis geometry. The history of simulations in DOSXYZ was 100,000,000.

3. RESULTS

Beam commissioning process was performed from the two points of view with 6MV photon beam; Comparison of depth dose and beam profile. Depth dose comparison was carried out in 10cm×10cm field at the central axis of the water phantom and 40cm×40cm size of field was applied whether beam profile is matched exactly between dose measurements and Monte Carlo simulations at 1.5cm in depth which is the D_{max} point of 6MV photon beam.

3.1. Mean energy of incident electron beam and beam radius

Monte Carlo simulations were performed in 5.7MeV, 6MeV(nominal energy), and 6.3MeV of mean electron energy to fit depth dose with measurement data. In every case, FWHM(full width half maximum) of beam radius was varied from 0.05cm ~ 0.25cm. Beam radii were varied from 0.05cm ~ 0.25cm in each energy; 5.7MeV, 6MeV, and 6,3MeV to commission beam profiles.

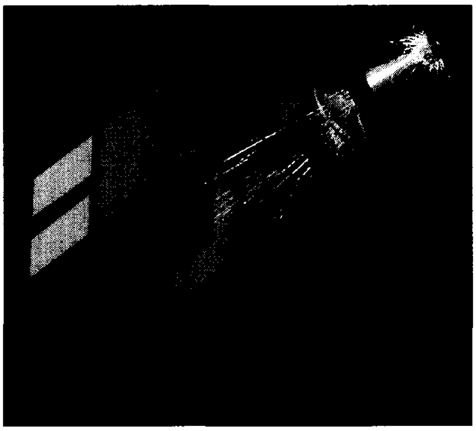

Fig.1. 3D Visualization of Varian 2300C/D linear accelerator head using by EGS Windows.

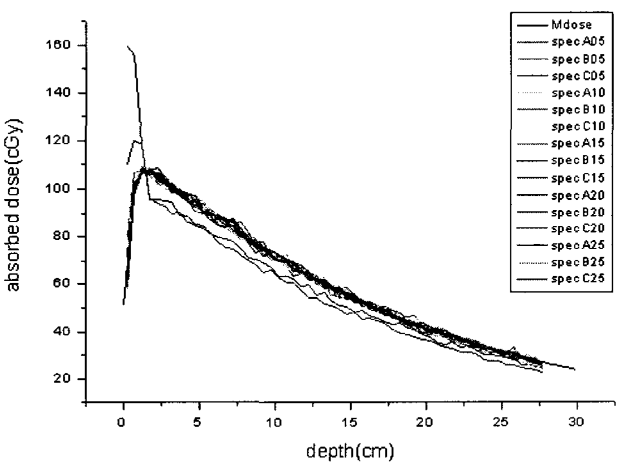

Fig. 2. Depth dose curves at all FWHM of incident electron energy and energy spectrum

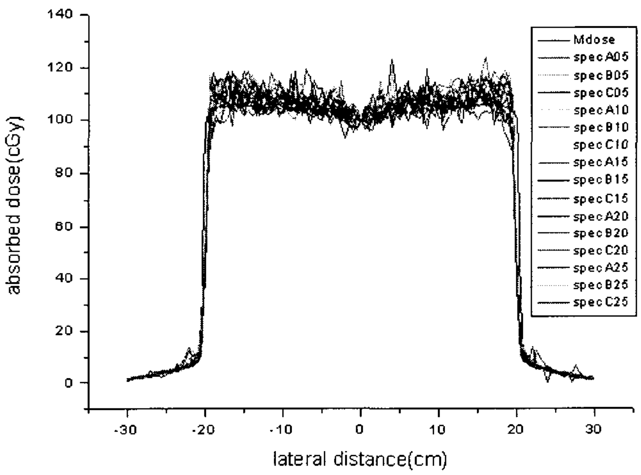

Fig. 3. Beam Profiles at all FWHM of incident electron energy and energy spectrum

The best fitting parameter was obtained like this: nominal electron energy : 6MeV, beam radius: 0.1cm

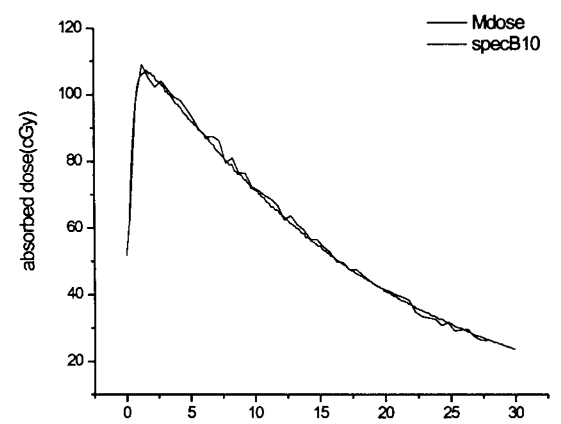

Fig. 4. Depth dose curves at mean electron energy of 6Me and FWHM=0.10cm of beam radius

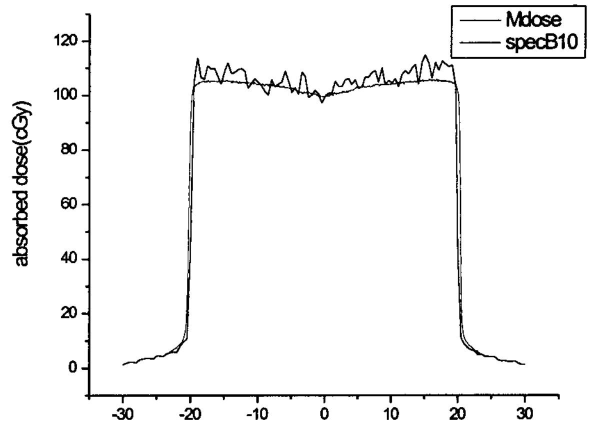

Fig. 5. Beam Profiles at mean electron energy of 6MeV an FWHM=0.10cm of beam radius

4. DISCUSSIONS AND CONCLUSION

We have performed the beam commissioning process to compare dose measurement and Monte Carlo simulations in various conditions of incident electron. A 6MV photon beam by the Varian 2300C/D linear accelerator was irradiated in solid water phantom. As the results, 6MV incident electron energy and beam radius of 0.1cm case were proved to be the best fitting parameters. But, there were no significant difference in each case except 2 case of depth dose curve. In that cases, the statistical error was very large comparing to the other cases.

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