Monte Carlo Modeling and Commissioning of a Bi-Directional Micro Multi-leaf Collimator

S Stathakis, Y Liu, D Giantsoudi, C Shi, N Papanikolaou

Cancer Therapy and Research Center, San Antonio, TX and University of Texas Health Science Center at San Antonio, San Antonio, TX

Introduction

For stereotactic radiotherapy applications, a collimating system that can deliver narrow beams and in some cases of irregularly shaped fields, is necessary. The requirements for precision and accuracy in that cases are greater than those for traditional radiotherapy.

In order to realize this required accuracy in the beam delivery in our department, we are testing a new micro multileaf collimator (mMLC) (Acculeaf) attached on a Varian 600c linear accelerator.

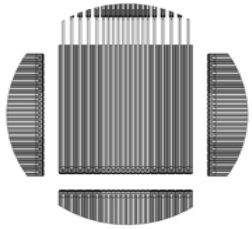

Figure 1

It consists of two levels of thin rounded leaves and each level has two banks of 24 leaves, ranging in width from 3.6 mm (inner leaves) to 5mm (10 outer leaves) at the isocenter (Figure 1). Having bi-directional collimating ability, this mMLC can shape small irregular fields with great accuracy that would be impossible to collimate with traditional MLC.

Accurate dose calculation for such small irregular shaped fields is challenging especially for stereotactic radiotherapy but Monte Carlo can be the solution.

Our goal in this study is to commission the mMLC for Monte Carlo dose calculations. Verification of the simulated/calculated data against measured ones for rectangular and irregular fields is necessary in order to complete the dosimetric commissioning of the mMLC.

Materials and Methods

The verification and commissioning of the system was done in two steps. First the Varian 600C linac was to be modeled using the EGSnrc/BEAMnrc and verified against measurements. The component modules that were used to build the linear accelerator treatment head in the EGS4/BEAM simulations consisted of the following: target (SLABS), primary collimator (CONS3), stainless steel flattening filter (FLATFILT), monitor chamber (FLATFILT), mirror (MIRROR), secondary collimator (JAWS) and reticle (SLABS). The geometry and the materials used were based on the specifications of the linear accelerator treatment head as provided by the manufacturer.

Phase space files for different field sizes of the Varian 600c 6 MV photon beam (from 5×5cm^2 to 30×30cm^2) were created using the EGSnrc/BEAMnrc system. The phase space files were scored below the secondary collimator and after the reticle. The results of the linac simulation were compared with the measured PDD curves and the dose profiles at various depths in water obtained with a 0.125 cc PTW-Freiburg ion chamber.

Having verified the Monte Carlo model of the linac, the second step involved the commissioning of the mMLC. Again we used the EGSnrc/BEAMnrc code to generate phase space files for various square field (from 1x1cm^2 to 9x9cm^2) and also for irregular shaped fields. The mMLC was modeled according to manufacturer specifications and the component modules used in this case were VARMLC for both levels of the multileaf banks and they were added below the modeled linac. The choice for the specific component modules used was made because the leaves of the mMLC are very similar to the Varian MLC ones.

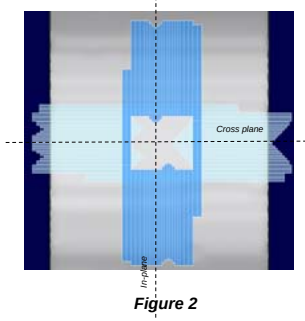

Figure 2

In each of the two steps of the simulations the dose was computed, using the EGSnrc/DOSXYZnrc code, for each field size that a phase space file was created. The simulations were made so that they would mimic the measurements. That is, the phase space files were incident on water phantoms and the source to skin distance (SSD) was kept the same as the measurements (100cm). The percent depth dose and the dose profiles calculated were compared against measurements for both parts of the commissioning.

Measurements for irregular fields (Figure 2) were made using EDR2 Kodac films. The films were placed tightly between solid water (manufacturer) at depth of 15cm and the SAD was set to 100cm. Monte Carlo calculations of the same geometry provided the data for comparison.

Results

Commissioning of the Varian 600C 6MV linac included the verification of the Monte Carlo calculation of several fields against measurements. The Monte Carlo calculations were made using the EGSnrc\DOSXYZnrc code. The results for the 10x10cm^2 field (that is the one that will be used for the commissioning of the mMLC) is shown in figure 3.

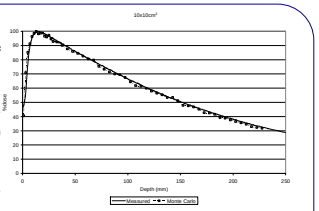

Figure 3

The 2x2cm^2, 5x5cm^2 and 9x9cm2 fields defined by the mMLC were then compared against measurements in water with ion chamber.

The results between the measurements and the Monte Carlo calculations are shown in figure 4. The statistical uncertainty in the Monte Carlo calculation in these cases was within 2% and the agreement was within 2% or 2mm in the penumbra region.

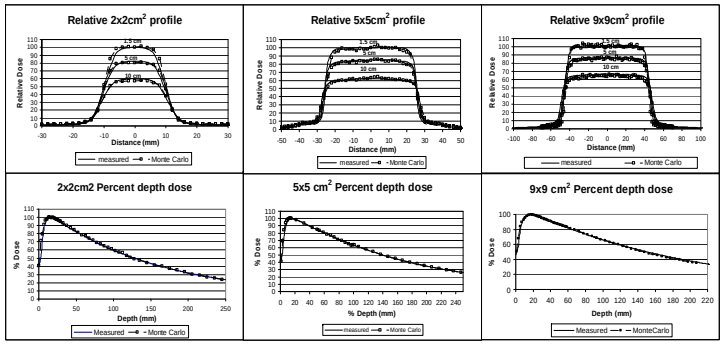

Figure 4

Further comparison between measurements and Monte Carlo calculations was carried for an irregular field (figure 2). The measurements were performed with EDR2 Kodak films.

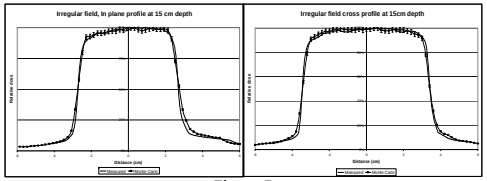

Figure 5

The Monte Carlo calculation was performed for the same setup geometry and the statistical uncertainty was within 1%. The results are shown in Figure 5.

Conclusions

A Monte Carlo dosimetric characterization has been performed for the bi-directional micro MLC in our department. Our model provides flexibility with complex multileaf geometries that can be achieved with the new mMLC. The commissioning of the mMLC model was done with clinical data acquired during the installation of the mMLC. Using the commissioned MLC model, we found that the calculated dose from the MC system agreed with the measured data within clinically acceptable criteria for low- to high-dose regions. Thus, this evaluated MC system can be an effective tool for IMRT dose calculation and dosimetry QA as well as for stereotactic radiotherapy plan verifications

References

[1] Kawrakow I 2000a Accurate condensed history Monte Carlo simulation of electron transport: I. EGSnrc, the new EGS4 version *Med. Phys.* 27 485–98

[2] Crop F *et al* 2007 Monte Carlo modeling of the ModuLeaf miniature MLC for small field dosimetry and quality assurance of the clinical treatment planning system *Phys. Med. Biol.* 52 3275-3290

49th AAPM SU-FF-T-306

Email: sstathak@ctrc.net