Low energy electron beam dose calculation using eMC

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Introduction

In Eclipse (Varian Medical Systems) the electron Monte Carlo (eMC) dose calculation algorithm is based on the macro MC method [1, 2] and is able to accurately predict dose distributions for high energy electron beams. However, there are some limitations for low energy electron beams such as 4 and 6 MeV. The aim of this work is to improve the accuracy of the dose calculation for 4 and 6 MeV electron beams of Varian linear accelerators using eMC.

Material and Methods

The eMC algorithm implemented in Eclipse uses the initial phase space multiple source model (IPS) as beam model. The IPS consists of 4 sub-sources: a *main diverging source* representing the scattering foil; an *edge source of electrons* which accounts for electrons from the applicator or insert; a *source of transmitted photons* through the applicator or insert and a *second diverging source* which takes into account scatter radiation in the accelerator head.

In order to improve the accuracy of the dose calculations for low electron beams, the eMC implementation has been modified with respect to both the beam model and the transport code for the dose calculation. In this improved version of the beam model all the scrapers of the applicator are taken into account. Based on the geometric information of the scraper positions it is determined for each sampled electron from the main diverging source whether or not it intersects within a scraper. If there is an intersection the electron is rejected otherwise the particle is transported downstream for the dose calculation. In order to improve the accuracy of the energy spectrum for the electrons of the main diverging source, the resolution of the mono-energetic depth dose curves used during beam configuration has been increased. The modification of the transport code for the dose calculation has been performed by reducing the size of the spheres used for the electron transport according to the energy of the electron. Overall, spheres between 1 mm and 5 mm are available. Thresholds between 4 and 7.5 MeV have been introduced so that if the energy of the incident electron is below such a threshold the maximal size of the possible spheres is reduced.

The impact of these changes in eMC is investigated by comparing calculated dose distributions for 4 and 6 MeV electron beams with applicators ranging from 6x6 to 25x25 cm^2 of a Varian Clinac 2300C/D with the corresponding measurements.

Results

Dose differences between calculated and measured absolute depth dose curves are reduced from 6% to less than 1.5% for 4 and 6 MeV beams and all applicators considered. Using the old eMC implementation, absolute dose profiles at depths of 1 cm, d_{max} and R50 in water lead to dose differences of up to 8% for applicators larger than 15x15 cm^2. When the improved version of eMC is used, those differences are reduced to less than 2% for all dose profiles investigated.

Conclusion

In this work several enhancements were made in the eMC beam model and dose calculation algorithm leading to significant improvements in the accuracy of the dose calculation for 4 and 6 MeV electron beams of Varian linear accelerators. This work was supported by Varian Medical Systems.

References

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