Clinical Implementation of Monte Carlo Modeling of the Elekta VersaHD with Agility Collimator

H. PARENICA[1], C. KABAT[1], P. PAPACONSTADOPOULOS[2], N. KIRBY[1], P. MYERS[1], T. WAGNER[1], N. PAPANIKOLAOU[1], S. STATHAKIS[1]

(1) UT Health San Antonio, San Antonio, Texas, (2) Netherlands Cancer Institute, Amsterdam, Netherlands

Mays Cancer Center

UT Health San Antonio

MD Anderson Cancer Center

PURPOSE & OBJECTIVES

Monte Carlo methods are among the most accurate of dose calculation methods. They become increasingly valuable when simulating complex fields, particularly those involving high-Z materials and small fields. The purpose of this study was to develop and validate a Monte Carlo model of the Elekta VersaHD linear accelerator to be used for patient dose calculations. We consider this study to be impactful because it will allow us to accurately calculate dose for difficult geometries, particularly those where other dose calculation algorithms are insufficient, and measurements are difficult to perform.

METHODS

Commissioning measurements were performed using a PTW microDiamond chamber in water for field sizes ranging from 1.0 x 1.0 cm^2, to 30.0 x 30.0 cm^2. Phase-space files for the Elekta VersaHD 6 MV photon beams were created using the EGSnrc/BEAMnrc user codes for field sizes ranging from 2 cm x 2 cm to 20 cm x 20 cm. Doses were calculated in DOSXYZnrc and beam profiles, PDD curves, and output factors were verified with commissioning data. A script was created in MATLAB that generates the necessary sequence files for use in BEAMnrc/DOSXYZnrc from RTP files from the Pinnacle Treatment Planning System so that VMAT plans can be recalculated using DOSXYZ Source 21. Patient plan doses to the Octavius QA Phantom were recalculated in DOSXYZnrc was compared to the dose calculated in the Pinnacle Treatment Planning System using the PTW VeriSoft software using a gamma criterion of 3%/3mm.

RESULTS

All doses calculated in DOSXYZnrc had less than 1% statistical uncertainty. Percent depth-dose curves and beam profiles showed good agreement with the commissioning data. PDDs for all field sizes were within 1% and 1 mm of the measured values. Profiles agreed within 1% and 1 mm for all measured values. The simulated output factors were well within 1% of the measured values. Figure 1 displays the PDD curves for small field sizes, both measured and simulated. Likewise, Fig. 2 displays the PDD curves for large fields. Figure 3 displays the in-plane beam profiles of the small fields, both measured and simulated, at 10 cm depth. Similarly, Fig. 4 displays the in-plane beam profiles of large fields at 10 cm depth. All error bars shown for PDD and profile curves are 1% and 1 mm. All simulated output factors agreed with measured values within 1%. Figure 5 shows the dose calculated with the Pinnacle TPS from a prostate cancer patient. Figure 6 shows the same patient's dose, calculated using DOSXYZnrc. The dose calculated in DOSXYZ achieved a gamma score of 98.4% (seen in Fig. 7) when compared to the dose calculated in the Pinnacle TPS. Figure 8 shows the agreement between both doses for a single slice. All patient doses were calculated with less than 1% uncertainty.

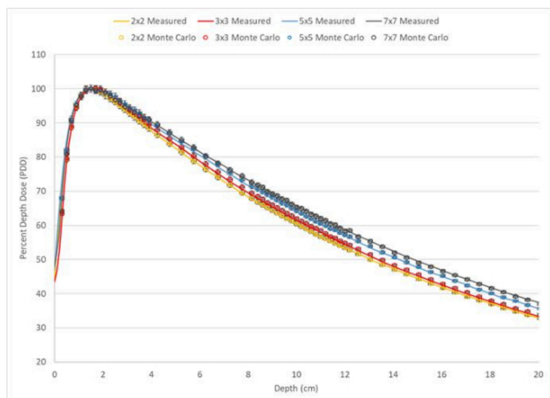

Figure 1. *PDD curves for small field sizes, both measured and simulated.*

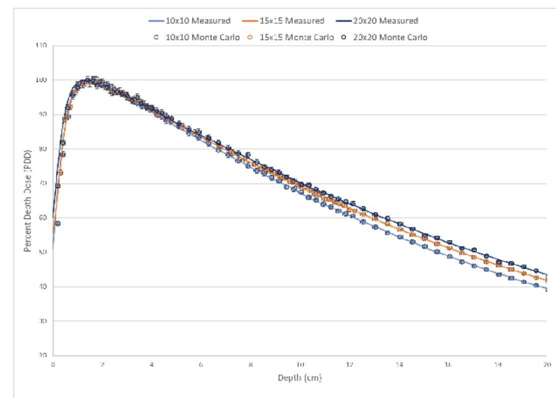

Figure 2. *PDD curves for large field sizes, both measured and simulated.*

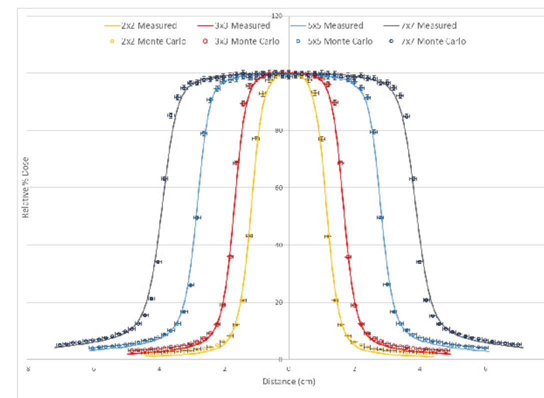

Figure 3. *In-plane beam profiles of the small fields, both measured and simulated, at 10 cm depth.*

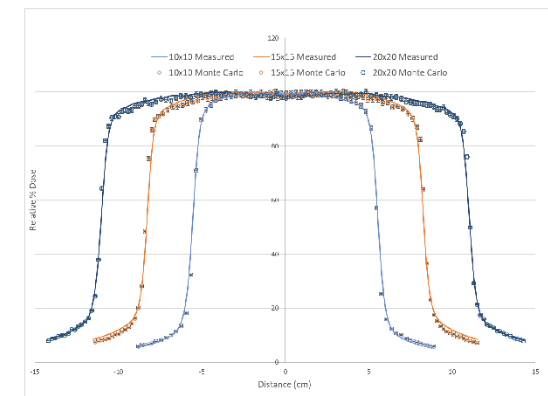

Figure 4. *In-plane beam profiles of the small fields, both measured and simulated, at 10 cm depth.*

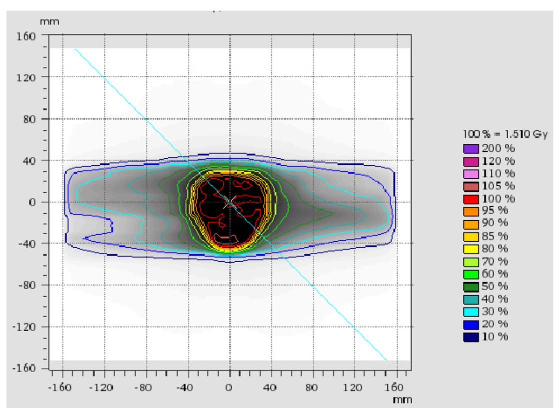

Figure 5. *Dose calculated in the Pinnacle TPS from a prostate cancer patient.*

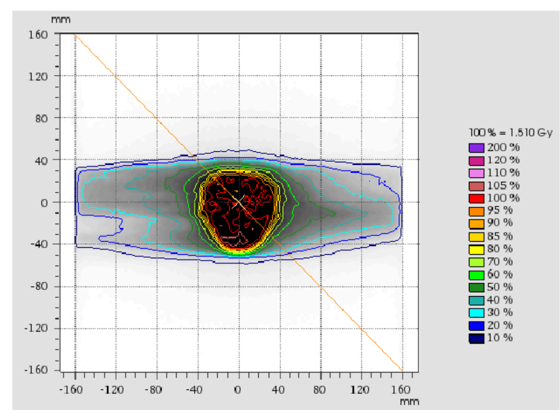

Figure 6. *Prostate patient dose recalculated in DOSXYZnrc.*

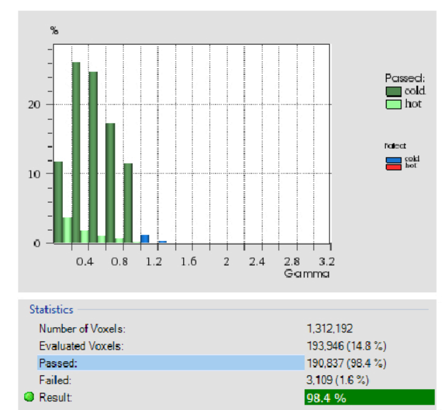

Figure 7. *Results of 3D Gamma Index.*

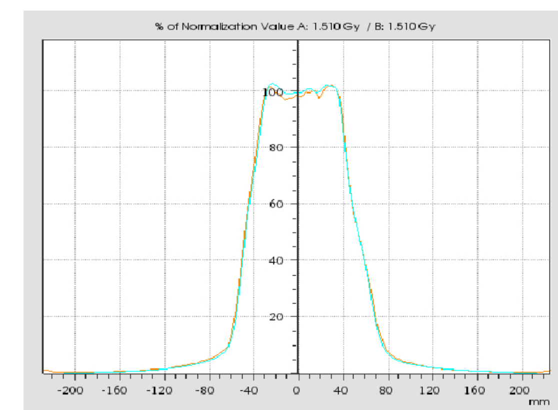

Figure 8. *Agreement between both doses for a single slice.*

CONCLUSIONS

A Monte Carlo model of the Elekta VersaHD linear accelerator has been tested and verified against commissioning data. The results of our Monte Carlo calculations are in good agreement with the measured data and the patient dose calculated in Pinnacle. Overall, the Monte Carlo model created in this study is an accurate representation of the Elekta VersaHD, and can be implemented in our clinic as part of our routine patient-specific quality assurance.

ACKNOWLEDGEMENTS

The project described was supported by the National Center for Advancing Translational Sciences, National Institutes of Health (Grant TL1 TR002647). This work is also supported by the Cancer Prevention and Research Institute of Texas (CPRIT) Research Training Award (RP170345).

CONTACT INFORMATION

Holly M. Parenica, Ph.D.
Medical Physics Resident
210-450-1107
parenica@livemail.uthscsa.edu