GEANT4 Application for the Simulation of the Head of a Siemens Primus Linac

Cite as: AIP Conference Proceedings **1231**, 209 (2010); https://doi.org/10.1063/1.3428928
Published Online: 04 May 2010

M. A. Cortés-Giraldo, J. M. Quesada, and M. I. Gallardo

GEANT4 Application for the Simulation of the Head of a Siemens Primus Linac

M. A. Cortés-Giraldo, J. M. Quesada and M. I. Gallardo

Dep. Física Atómica, Molecular y Nuclear, University of Sevilla. Apdo. 1065 E-41080 Sevilla, Spain

Abstract. The Monte Carlo simulation of the head of a Siemens Primus Linac used at Virgen Macarena Hospital (Sevilla, Spain) has been performed using the code GEANT4 [1-2], version 9.2. In this work, the main features of the application built by our group are presented. They are mainly focused in the optimization of the performance of the simulation. The geometry, including the water phantom, has been entirely wrapped by a shielding volume which discards all the particles escaping far away through its walls. With this, a factor of four in the time spent by the simulation can be saved. An interface to read and write phase-space files in IAEA format has been also developed to save CPU time in our simulations [3-4]. Finally, some calculations of the dose absorption in the water phantom have been done and compared with the results given by EGSnrc [5] and with experimental data obtained for the calibration of the machine.

Keywords: Radiotherapy, Monte Carlo simulations.
PACS: 87.10.Rt, 87.55.kh, 87.56.B-

THE SIMULATION

A GEANT4-based simulation requires the user to code the geometry of the simulation, the so-called “physics list”, which is the list of physical interactions taken into account, and the generator of primary particles.

The simulation reproduces the head of the 6 MV photon mode of the Siemens Primus Linac used at Virgen Macarena Hospital (Seville, Spain). For this configuration, each module was modeled in the same way as indicated in the BEAMnrc User’s Manual. The phantom is a water tank (50 cm × 50 cm × 40 cm) divided into voxels of dimensions 2 mm × 2 mm × 2 mm and the SSD is 100 cm. To decrease the time spent by the simulation, all the geometry is wrapped by a volume which is used to kill all the particles escaping through the lateral walls (an ideal shield). This wrapper volume is created automatically once given the geometry. The inclusion of this volume doesn’t change the final result of the simulation, and the time spent by the simulation is reduced in a factor of four.

The primary particle generator simulates an electron beam whose spot size is 1.0 mm, and kinetic energy sampled by a Gaussian distribution (mean energy = 5.8 MeV and σ = 0.29 MeV). The electron beam hits the target perpendicularly.

The hadronic processes, like photo-nuclear reactions, don’t play an important role at energies below 6 MeV, so only the electromagnetic physics list based on the

CP1231, *La Rábida 2009, International Scientific Meeting on Nuclear Physics, Basic Concepts in Nuclear Physics: Theory, Experiments, and Applications,* edited by J. A. Caballero, C. E. Alonso, M. V. Andrés, J. E. García-Ramos, and F. Pérez-Bernal © 2010 American Institute of Physics 978-0-7354-0776-3/10/$30.00

Livermore Evaluated Data Libraries is considered. The production cut was 0.2 mm for electrons and positrons, and 1.0 mm for photons.

This application includes two C++ classes developed to allow the user to read phase-space files in IAEA format, and to write them as well. The main features of both classes were described in [4].

The Fig. 1 shows the modeled geometry of the simulation and a PDD curve obtained for a 5 cm × 5 cm square field. There is a good agreement between the experimental data, the GEANT4 calculations, and another GEANT4 simulation starting from a phase-space file (PSF) created by EGSnrc code.

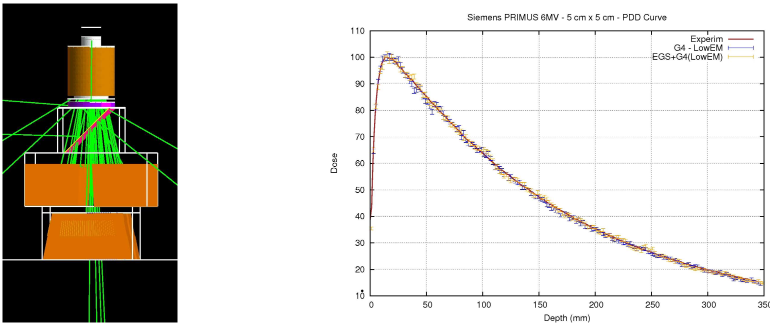

FIGURE 1. Left: modeled geometry of the head of the Siemens Primus linac visualized with OpenGL. Right: Percentage depth dose (PDD) curve for a 5 cm × 5 cm square field. The brown line shows the experimental data, the blue points correspond to the GEANT4 calculations and the orange points show the results obtained starting from a PSF created by EGSnrc.

FUTURE WORK: PRODUCTION OF NEUTRONS

Neutrons can be produced for radiotherapy treatments with photons at higher energies (about 15 MV) due to photo-nuclear reactions in the different elements of the machine. To simulate this situation, the "neutronHP" package and the photo-nuclear reactions are being tested in our physics list. For this case, the geometry of the simulation must be extended to the entire treatment room.

ACKNOWLEDGMENTS

This work was funded by the Spanish MEC (FEDER) and Junta de Andalucía.

REFERENCES

1. S. Agostinelli et al. (GEANT4 Collaboration), *Nucl. Instr. Methods* **A 506**, 250-303 (2003).
2. J. Allison et al. (GEANT4 Collaboration), IEEE Trans. Nucl Science **53** No. 1, 270-278 (2006).
3. R. Capote et al., *Phase-Space Database for External Beam Radiotherapy*. IAEA Technical Report 2006; INDC (NDS)-0484.
4. M. A. Cortés-Giraldo, R. Capote, J. M. Quesada, M. I. Gallardo and R. Arráns. XVII Congreso Nacional SEFM & XII Congreso Nacional SEPR. Alicante, Spain, June 2nd-5th, 2009 (*to be published*).
5. I. Kawrakow, *Med. Phys.* **27**, 485-498 (2000).