VALIDATED MONTE CARLO SIMULATION OF TRIODE- ELECTRON GUN EQUIPPED ELECTRONFLASH LINAC

J. H. Pensavalle [1,2,3], M. G. Bisogni[1,2,4], S. Capaccioli [2,4], D. Del Sarto [3,4], G. Felici[5], F. Galante[5], G. Mariani[5], M. Pacitti[5], F. Paiar[4,6], F. Romano[7], F. Di Martino[1,3,4]

[1]INFN, Sezione di Pisa, Largo B. Pontecorvo 3 I-57127 Pisa, Italy.

[2]Department of Physics, University of Pisa, Largo B. Pontecorvo 3 I-57127 Pisa, Italy.

[3]Fisica Sanitaria, Azienda Ospedaliero Universitaria Pisa AOUP, ed.18 via Roma 67 Pisa, Italy.

[4]Centro Pisano ricerca e implementazione clinica Flash Radiotherapy (CPFR@CISUP), Presidio S. Chiara, ed. 18 via Roma 67 Pisa Italy.

[5]SIT S.p.A., Aprilia 04011, Latina, Italy.

[6]Radiation Oncology Unit, Dipartimento di ricerca traslazionale università di Pisa, VIA SAVI 10 56126 PISA.

[7]Istituto Nazionale di Fisica Nucleare, Sezione di Catania, Via Santa Sofia 64 95123 Catania, Italy.

Background: Monte Carlo simulations are a powerful tool to integrate into clinical practice [1]. These simulations are used to calculate energy spectrum dependent corrective factors in non-reference conditions, which are difficult or impossible to evaluate experimentally. In this work, we present a GEANT4 simulation code of the Triode-Electron Gun equipped ElectronFLASH [2] available at the CPFR (Centro Pisano ricerca e implementazione clinica Flash Radiotherapy) in the Santa Chiara hospital in Pisa.

Material and Methods: We accurately replicated the most relevant components of the Linac, all the beam optics by following the manufacturing specifications and we implemented the energy spectrum provided by Sordina SIT. We simulated a 30x30x30cm^3 water phantom, the beam with SSD=100cm and the 10 cm diameter PMMA applicator. We validated the simulations with gafchromic measurements of the PDD and dose profiles.

Preliminary results: Simulations were performed with 10 million electrons and dose values are averaged over three simulation runs with different seeds. Uncertainties are evaluated as the standard

deviation of the dose in these runs. Figure 1 shows the simulated PDD superimposed on the experimental one. Figure 2 shows the dose profiles, both horizontal and vertical, plotted with the experimental validation data. From both the PDD and dose profiles, we can see a good agreement between simulation and validation. Uncertainties are kept under 2%. We also compared the simulated and experimental R50 values. We found that the simulated R50 = 31.94 ± 0.11mm is in good agreement with the experimental R50 = 32 ± 2mm. In conclusion, the simulation code reliably replicates with high level of accuracy the experimental set-up. This is further proven by the agreement with the data. Additional experimental dose measurements with the triode-Electron Gun equipped ElectronFLASH Linac are under way. The code will be integrated in the GEANT4 release as an upgrade to the advanced example *iort_therapy*, so that users can simulated the ElectronFLASH Linac.

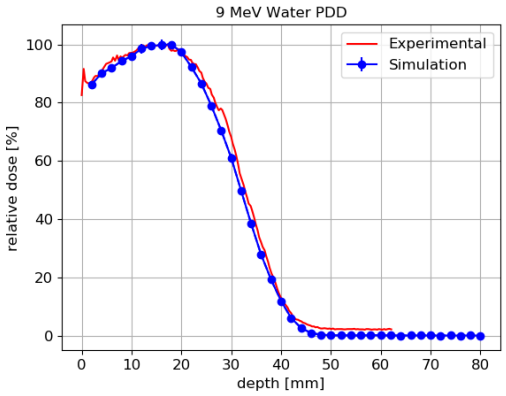

Figure 1: Simulated PDD superimposed on experimental gafchromic data.

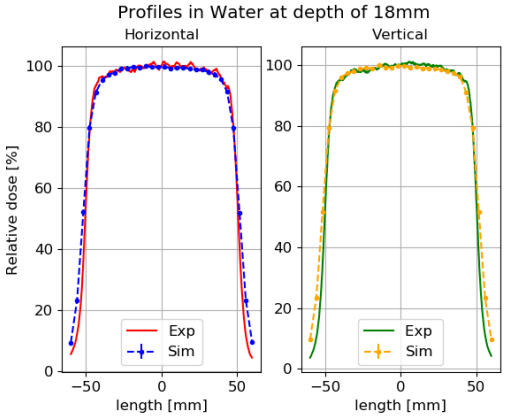

Figure 2: Simulated horizontal and vertical dose profiles plotted with experimental gafchromic data.

[1] Righi S, Karaj E, Felici G, Di Martino F. Dosimetric characteristics of electron beams produced by two mobile accelerators, Novac7 and Liac, for intraoperative radiation therapy through Monte Carlo simulation. Journal of Applied Clinical Medical Physics. 2013 Jan;14(1):6-18.

[2] Faillace L, Barone S, Battistoni G, Di Francesco M, Felici G, Ficcadenti L, Franciosini G, Galante F, Giuliano L, Grasso L, Mostacci A. Compact S-band linear accelerator system for ultrafast, ultrahigh dose-rate radiotherapy. Physical Review Accelerators and Beams. 2021 May 17;24(5):050102.