

Planning IOeRT FLASH treatments with a GPU-based Monte Carlo: the case of breast cancer

G. Franciosini

Sapienza University of Rome, Department of Basic and Applied Sciences for Engineering and INFN, Section of Rome I.

Purpose/Objective

Intra Operative Radiation Therapy with electrons (IOeRT) is a technique that, after the surgical tumor removal, delivers a dose of ionizing radiation (4-12 MeV electrons beam) directly to the surgery bed. During IOeRT treatments the beam is passively collimated by means of a PMMA hollow tube and whenever needed, temporary beam modifiers are used to protect the healthy tissues surrounding the target. Today, there is an increasing interest in this technique both due to the ESTRO-ACROP guidelines published in 2020 and 2021 and the perspective of being the first clinical implementation that could test and experience the benefit brought by the FLASH effect. Despite that, IOeRT suffers from an outdated planning technology, which has prevented to exploit its full potential. IOeRT, in fact, does not yet have a dedicated Treatment Planning System (TPS) capable to perform the new imaging of the surgical field, which has undergone a substantial morphological modification and the TPS computation, in the very limited amount of time available after the surgery. In this contribution, exploiting the new 3D real-time UltraSound (US) imaging acquisition, provided by the SIT (Aprilia (LT), Italy) company, and a GPU (Graphic Processing Unit)-based fast Monte Carlo (MC) called FRED (Fast particle thErapy Dose evaluator) we show the potential of a complete TPS dedicated to the planning and optimization of IOeRT treatments delivered in conventional and FLASH regime [1].

Material/Methods

The FRED MC has been developed to allow a fast optimization of TPS in Particle Therapy while keeping the dose release accuracy typical of an MC tool. FRED is already used as research tool at several clinical and research centers for proton beams while for carbon beams is under optimization. The electromagnetic implementation of photons and electrons has been completed recently [2]. Using FRED we have simulated in detail the LIAC HWL accelerator, produced by SIT, and using as an input an US breast imaging, we have explored different treatment configurations (beam energy, applicator dimension, position, and inclination). The expected outcomes of a conventional dose rate treatment and a FLASH one have been also compared and analyzed.

Results

The Dose Volume Histograms have been obtained for each treatment configuration and compared, allowing the selection of the best treatment configuration. The impact of different simulation statistics and scanning times has been studied. Results show that an IOeRT breast cancer treatment can be optimized within a few minutes, once the imaging is acquired. Moreover, the FLASH study demonstrates the effective potential of such an approach in the sparing of healthy tissues.

Conclusion

The obtained results are encouraging, confirming that a treatment plan can be optimised in few minutes. The implications of such findings in the context of IOeRT FLASH future applications will be discussed.

References

- [1] G. Franciosini, et al IOeRT conventional and FLASH treatment planning system implementation exploiting fast GPU Monte Carlo: The case of breast cancer, *Physica Medica*, Volume 121, 2024, 103346, ISSN 1120-1797, 10.1016/j.ejmp.2024.103346.
- [2] Franciosini G, et al. GPU-accelerated Monte Carlo simulation of electron and photon interactions for radiotherapy applications. *Phys Med Biol*. 2023 Feb 15;68(4). doi: 10.1088/1361-6560/aca1f2. PMID: 36356308.