

PP07.10**IN-VIVO DOSE RECONSTRUCTION WITH EPID DETECTORS BY DEEP LEARNING**

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Introduction: Electronic Portal Imaging Devices (EPIDs) have gained prominence for pre-treatment dose verification and real-time monitoring in radiotherapy. However, leveraging EPIDs for *in-vivo* dosimetry requires modeling their response to estimate the two-dimensional dose distribution (Portal Dose, PD). Traditional methods (physical models and Monte Carlo techniques) are complex and time-consuming, making them impractical for clinical use. This research aims to develop a DL-based methodology to convert the actual EPID responses into PD images.

Materials & Methods: The dataset consists of hundreds of EPID-PD pairs of images. EPID images are acquired by irradiating phantoms of different shapes and inserts of different density. PD are generated by using Monaco TPS simulating EPID like a water equivalent device. We developed a U-net for transforming EPID images into PD. We track the mean absolute error as a metric to quantify the error in terms of difference between the model predictions and targets. Finally, the quality of the PD-predicted dose distributions with respect to PD is assessed through gamma analysis.

Results: An average gamma pass rate of 95% has been achieved for gamma-index analysis of 3%/3 mm on a simulated dataset. These results show the feasibility of the DL method to predict the dose delivered to EPID detectors for radiotherapy treatments, utilizing EPID image as input.

Summary: We introduced a methodology for *in-vivo* dosimetry based on EPID, combining the precision of traditional methods to the efficiency of deep learning networks. In this work, we present the results of our DL model, focusing on data acquisitions carried out at Careggi Hospital (Florence).

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PP07.11**SIMULATION OF A CLINICAL CBCT IMAGING SYSTEM WITH THE MONTE CARLO METHOD**

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Introduction: Monte Carlo (MC) methods serve as a potent tool for simulating x-ray imaging systems, enabling investigations on image quality, artifact determination, and protocol optimization. These play an important role to understand the results of computer-aided analyses of radiological images, such as radiomics. In this study, MC methods were applied to simulate a clinical CBCT imaging system.

Materials & Methods: CBCT acquisition modes of a Varian TrueBeam[®] on-board imager were simulated with the MC simulation platform

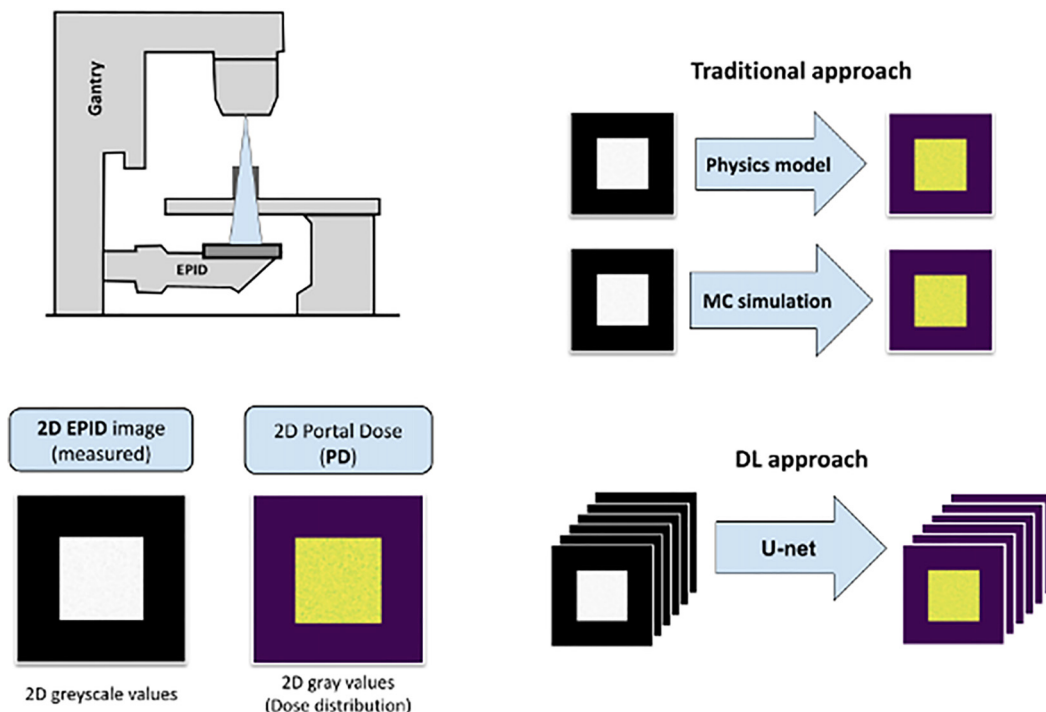


Figure (abstract PP07.10).

GATE [1], rebuilding imager and source geometries. The bowtie filter geometry was optimised with the help of transmission measurements. CT scans of an electron density phantom (CIRS M62) with known material composition and the acquisition of photon attenuation curves for PLA and Aluminium were used to verify the simulation set-up.

Results: Experimental and simulated transmitted photon intensity below the bowtie filter are in very good agreement (Figure 1). Phantom simulations in 2D revealed CT numbers comparable to the experimental values (within the overall uncertainty), although discrepancies of up to $\pm 30\%$ were observed for bone-equivalent materials. Simulated attenuation curves for PLA and Aluminium were in accordance with measurements within less than $\pm 8\%$.

Summary: The results show that the CBCT imaging system implemented in GATE well reproduces the clinical system. The x-ray spectra in the MC simulation are being optimized to achieve better agreement for bone-equivalent materials. 3D simulations and the implementation of further phantoms are part of ongoing investigations.

Appendix:

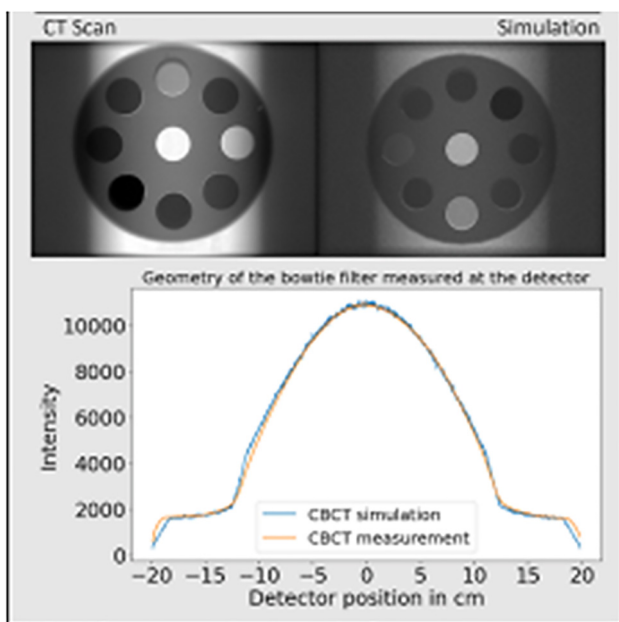


Figure 1: Above: Comparison between CT scan (left) and MC simulated image (right, rotated by 180°) of the electron density phantom, acquired with a head scan protocol (100 kV). Below: Comparison between simulation and measurement of the transmitted x-ray intensity below the bowtie filter for a voltage of 100 kV (distance between x-ray source and CBCT detector: 150 cm).

Reference:

- [1] Jan S, Benoit D, Becheva E *et al.* GATE V6: a major enhancement of the GATE simulation platform enabling modelling of CT and radiotherapy. *Phys. Med. Biol.* 56(4):881

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PP07.12

EXPERIMENTAL DOSIMETRY AND MC SIMULATION OF 6-MV FFF SMALL FIELDS ON VARIAN TRUEBEAM STX

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Introduction: This research investigated the dosimetric properties of a 6 MeV photon beam from a Varian TrueBeam STx LINAC equipped with a Flattening Filter Free (FFF). Monte Carlo (MC) simulations using the GEANT4 code were employed to determine the depth dose profiles and beam profiles within a water phantom for various jaw opening configurations. The accuracy of the simulations was subsequently assessed through comparison with experimental data.

Materials & Methods: Experimental Setup: The experiments employed the Source to Surface Distance (SSD) technique, consistently maintaining a distance of 100 cm between the radiation source and the water surface. Additionally, three different types of detectors were utilized: Semiflex, PinPoint, and EDGE.

Monte Carlo Simulations: The simulations were performed using the GEANT4 code with 2.1×10^{10} histories, mirroring the experimental setup geometry. The simulations aimed to evaluate the depth dose profiles and beam profiles of the 6 MV FFF photon beam and compare them with the experimental measurements.

Results: The Monte Carlo (MC) simulations exhibited remarkable alignment with the experimental data, producing depth dose profiles and beam profiles that closely mirrored each other. The optimal setup for the depth dose profile entailed a $3 \times 3 \text{ cm}^2$ jaw opening field, meeting stringent criteria of 100% agreement within 2% dose and 2 mm distance. Similarly, the most favorable beam profile was observed at a 10 cm depth in the water phantom using a $10 \times 10 \text{ cm}^2$ jaw opening field, achieving a 99% agreement within 3% dose and 3 mm distance. Furthermore, our calculations of the mini-beam correction factor adhered to the 2017 protocol outlined in the IAEA TRS-483, validating our results.

Summary: This research effectively utilized Monte Carlo (MC) simulations with GEANT4 to faithfully reproduce the depth dose profiles and beam profiles of a 6 MV Flattening Filter-Free (FFF) photon beam generated by a Varian TrueBeam STx linear accelerator (LINAC), a validation confirmed by the close correspondence with experimental observations. These results underscore the utility of MC simulations in characterizing clinical LINAC beams, providing a valuable resource for treatment planning and dosimetric validation. Additionally, our investigation concluded that opting for a Semiflex chamber is not advisable for small field sizes.

Reference:

- [1] Palmans H, Andreo P, Huq MS, Seuntjens J, Christaki KE, Meghzifene A. Dosimetry of small static fields used in external photon beam radiotherapy: Summary of TRS-483, the IAEA-AAPM international Code of Practice for reference and relative dose determination. *Med Phys.* 2018 Nov;45(11):e1123–e1145. doi: 10.1002/mp.13208. Epub 2018 Oct 17. PMID: 30247757.

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