Master’s Thesis Engineering Technology

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Optimalisation of a Monte Carlo model regarding skin treatment using the XOFT® AXXENT® ELECTRONIC BRACHYTHERAPY (EBX®) SYSTEM®

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1. Introduction

Brachytherapy has emerged as a promising treatment modality for nonmelanoma (NMSC) **skin lesions** due to its excellent **dose conformality**.

Nevertheless, the **radioactive** nature of the **sources** typically used in brachytherapy entails several inherent disadvantages including:

- a high potential **risk** for the patient in case of system failure;
- the inability to account for **inhomogeneities and differences in radiosensitivity** between different tissues.

In response, electronic brachytherapy (**eBT**) systems replaces these sources with **x-ray tubes**.

This thesis aims to **improve** an existing Monte Carlo (**MC**) **model** of the **XOFT** Axxent Electronic Brachytherapy (**eBx**) **System** to **produce simulated transversal dose profiles** that are within 10% of **measured transversal dose profiles**.

2. Materials & methods

EBT3 films were used to **measure** the **absorbed dose** by the **skin** during a treatment, while a **virtual scorer calculated** the absorbed dose in the skin from a simulated treatment.

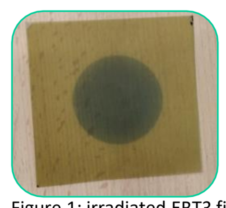
Figure 1: irradiated EBT3 film

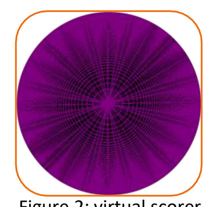
Figure 2: virtual scorer

Both real and simulated treatments were conducted in three setups: (1) in **air**, (2) on the **surface** of a 10x10x4 cm **Plastic Water LR phantom**, and (3) at a depth of 1 cm inside the phantom.


Figure 3: Experimental setups

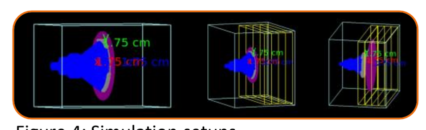
Figure 4: Simulation setups

Transversal dose profiles were evaluated at radii **every 1 mm**, with the **centre** aligned with the **x-ray beam axis**. After **comparing corresponding** measured and simulated **profiles**, the TOPAS MC model was **iteratively refined** by changing the design of the **electron beam.**

3. Results

The final TOPAS MC model included a **circular electron beam** with :

- a diameter of 1.596944 mm;
- a **Gaussian angular distribution** of the electrons with a mean (μ) of 0° and a standard deviation (σ) of 45°;
- a **smaller particle cutoff** equal to 1 μm.

Figure 5, 6 and 7 show the measured and simulated transversal dose profiles for the setups in air, on the phantom surface and at 1 cm depth inside this phantom. The **maximal discrepancies** were **6.3%** at 12.5 mm in air, **5.0%** at 11.7 mm on the phantom surface, and **3.0%** at 12.5 mm at 1 cm depth inside the phantom.

Air

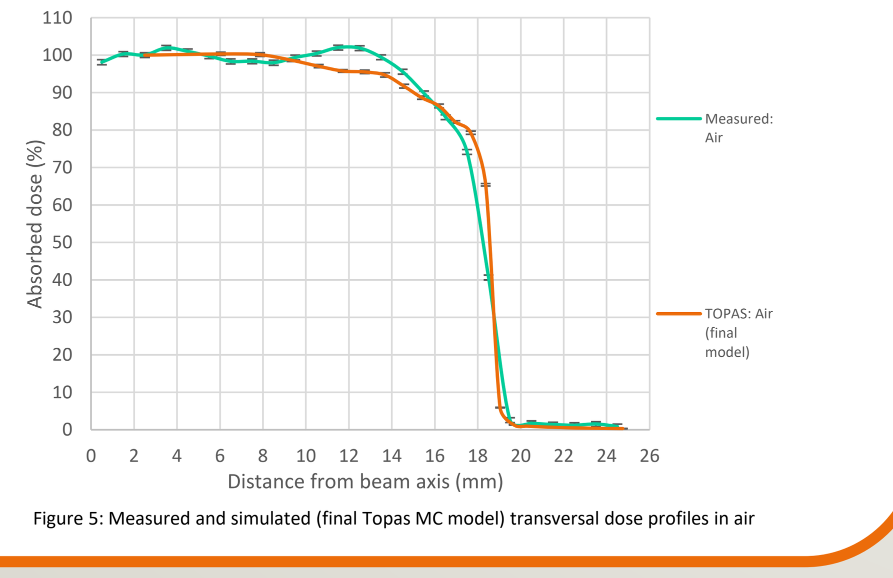

Figure 5: Measured and simulated (final Topas MC model) transversal dose profiles in air

Phantom surface

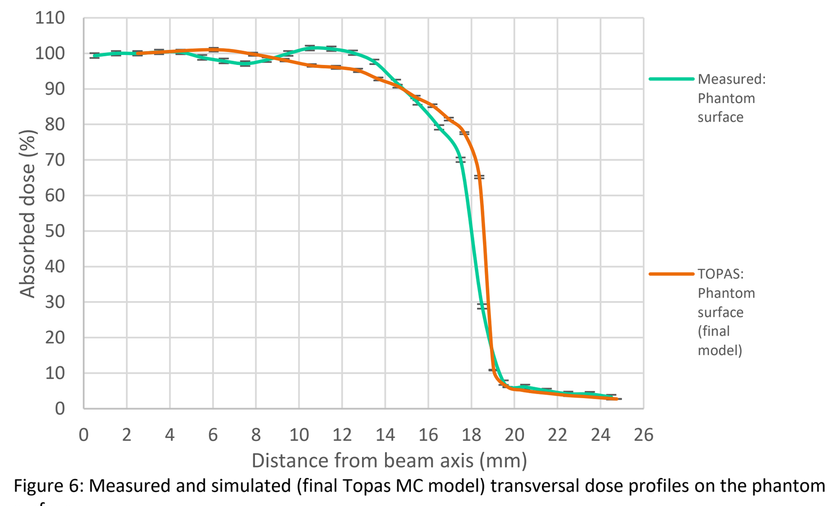

Figure 6: Measured and simulated (final Topas MC model) transversal dose profiles on the phantom surface

1 cm depth

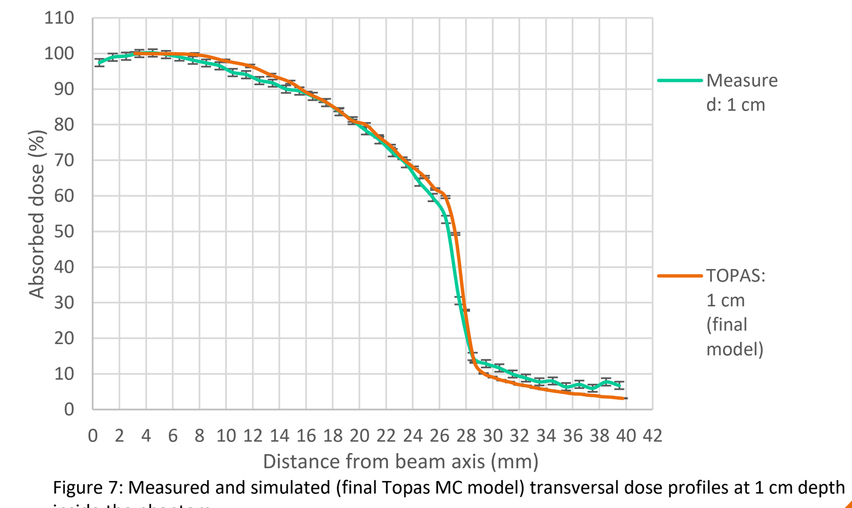

Figure 7: Measured and simulated (final Topas MC model) transversal dose profiles at 1 cm depth inside the phantom

4. Conclusion

The differences between the measured transverse dose profiles using EBT3 films and the simulated dose profiles using the final TOPAS MC model **do not exceed the limit of 10%**. Therefore, the final TOPAS MC model has been **successfully validated** for predicting transverse dose profiles.

Supervisors / Co-supervisors / Advisors

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