Quality assurance of electronic brachytherapy treatment units with a plastic scintillation detector

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Dose measurement: Physics – Dosimetry – QA of treatment units/sources

Purpose

Standardized quality assurance (QA) methods are limited in electronic brachytherapy (eBT) [1]. The purpose of this experiments was to design a simple and accurate method for verification of the relative absorbed dose to water distribution. For the first time, the dose distribution from an eBT source was measured in water using a small plastic scintillation detector (PSD).

Materials and methods

The Papillon 50 (P50; Ariane Medical Systems Ltd, UK) is an eBT source mainly used for rectal cancer treatment. It delivers 50 kVp X-rays (half value layer ~ 0.7mmAl). The beam is collimated using cylindrical steel applicators (Ø22-30 mm). The absorbed dose from the P50 source, with a Ø25 mm applicator, was measured with a PSD. The system consisted of a cylindrical plastic scintillator (Ø1 mm, L=0.5 mm) coupled to an optical fibre which transmitted the scintillation light to a photo multiplier tube (PMT) (H5783 SEL3, Hamamatsu). The PMT was coupled to an electrometer (Unidos Webline, PTW Freiburg Germany). The PSD was placed on a motorised stage in a water phantom (MP3, PTW), while the P50 applicator was pointed vertically downward, with the tip just breaching the water surface of the phantom. The applicator was rigidly fixed in a custom build frame. The PSD was moved to predetermined positions where the relative dose rate was measured. The movement and measurements were automated with the software Mephysto (PTW). The dose depth curves and dose profiles at various depths were measured in steps of 0.5-5 mm. The width of the dose profiles at 50% of the central dose were determined.

Results

Depth-dose curves: The measured percentage depth dose (PDD) shows an almost exponential decay with 1-order reduction every 25 mm (fig. 1). The measurements are in good agreement with Monte Carlo (MC) simulations performed by Croce et. al. [2].

Dose profiles:

The dose profile width increases and smears out for larger depths (fig. 2). The increase follows a linear behaviour (dashed lines in fig. 2 bottom right). There is no

significant directional dependency. The z=5, 10, and 20 mm profiles are asymmetric, with a shoulder to the right, likely due to the X-ray rod not being exactly centred inside the applicator.

Conclusion

The PDD and dose profiles, at various depth, of an eBT source have been measured under full scatter conditions in a water phantom for the first time with high spatial resolution. The measurements were performed with a novel PSD system, which offers a simple method for QA of the relative absorbed dose to water of eBT treatment units. The method can easily be transferred to other low energy X-ray sources.

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[1] Primary Standards and Traceable Measurement Methods for X-ray Emitting Electronic Brachytherapy Devices, Publishable Summary (2018):

[2] O. Croce, S. et al. Radiation Physics and Chemistry 81 (2012) 609-617

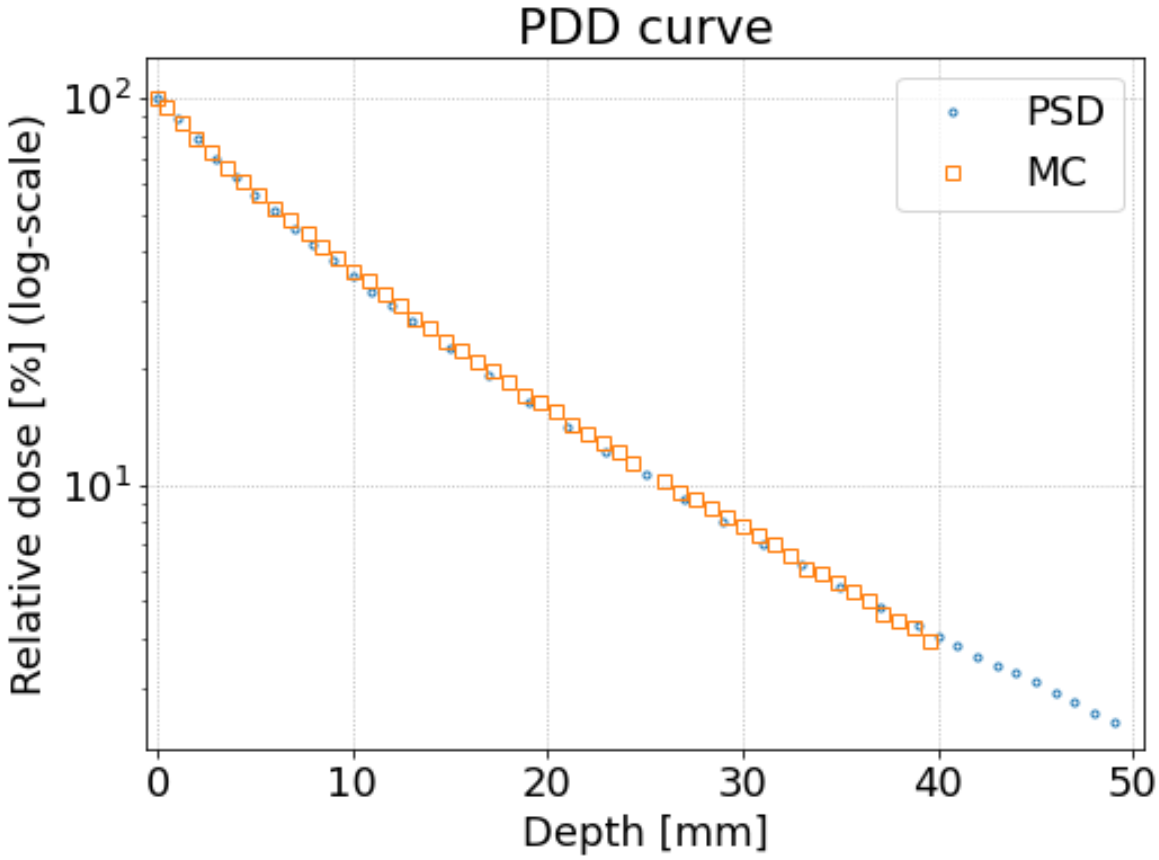

Figure 1: The percentage depth dose from the P50 source in water with a Ø:25mm applicator attached, as measured with the PSD system (blue dots) and from Monte Carlo simulations (orange squares). The Monte Carlo results are performed by Croce et. al. [2].

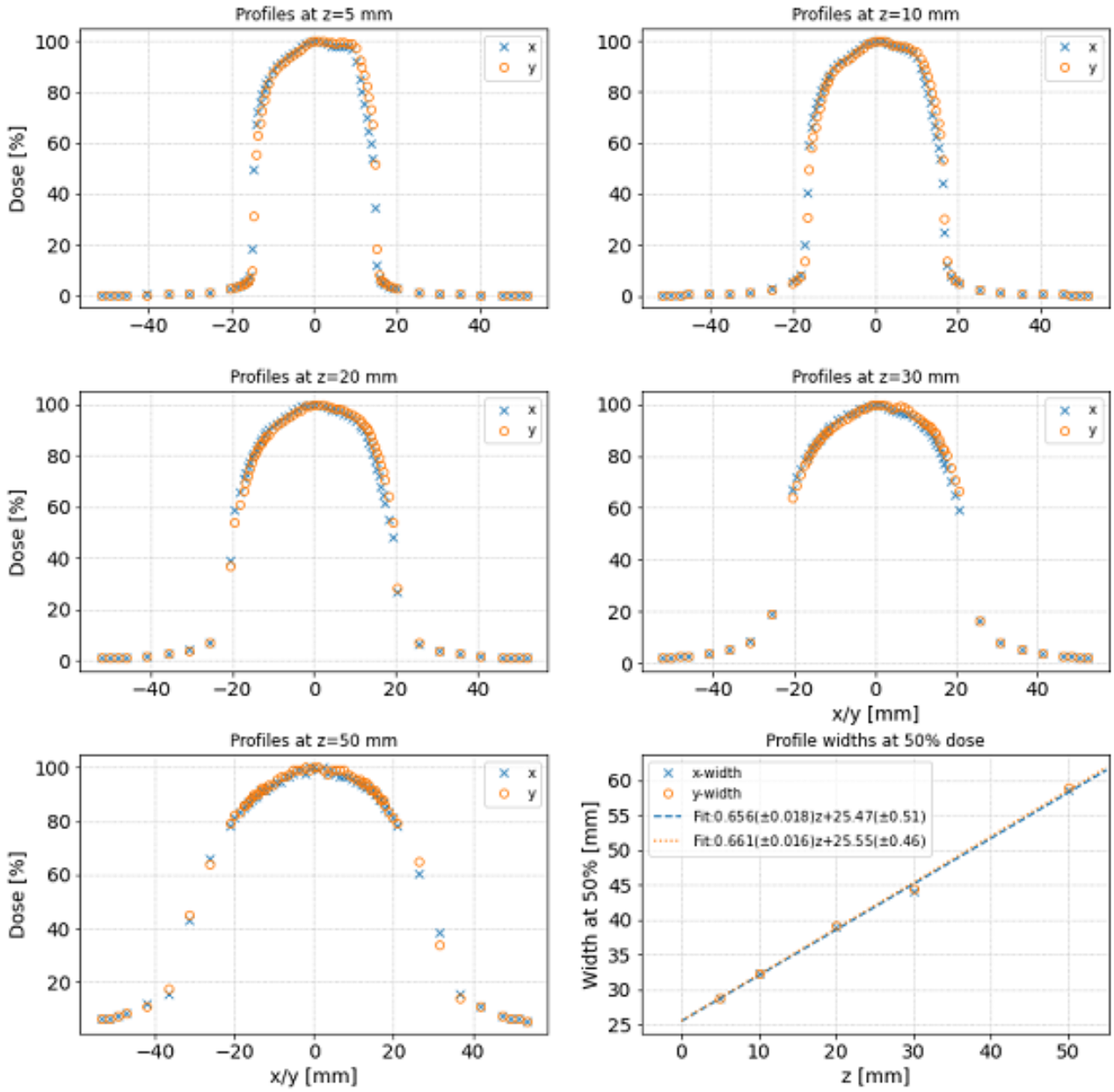

Figure 2: The relative dose profile of the P50 source in water with a Ø:25mm applicator attached, as measured with the PSD system at different depths (z). Measurements from two perpendicular axes are shown, x and y (blue crosses and orange circles respectively). The bottom right figure shows the width of the profiles at 50% of the central dose, as function of depth. A linear fit is shown as a dashed line.