Multicomponent calibration of plastic scintillation dosimetry on a CT-linac and MR-linac

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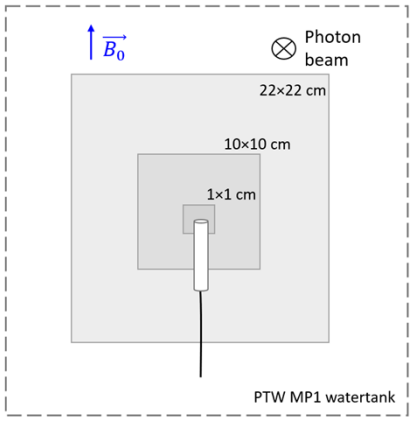
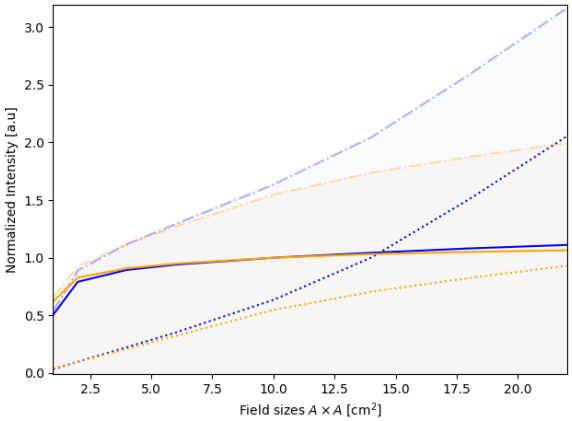
Purpose/objective:
Plastic scintillation dosimeters (PSDs) may facilitate accurate and fast dose measurements [1,2]. The scintillating material emits light when irradiated, proportional to the delivered dose. Additional light generated in the optical fibre is referred to as the stem-effect. A spectral-based method can be employed to separate scintillation from the total light [3]. Multicomponent calibration can correct for effects such as Cerenkov, fluorescence and optical attenuation. This study aims to provide a systematic investigation of a multicomponent calibration, comparing measurements on a cone-beam computed tomography (CT)-equipped C-arm linac and a 1.5 T magnetic resonance (MR)-linac.
Material/Method:
Measurements using HYPERSCINT PSD (Medscint, Quebec, Canada) were performed in water on a 6 MV FFF CT-linac and 7 MV FFF MR-linac. Eight field sizes were measured, delivering 100 MU from gantry angle 0°, figure 1(a). Output factor reference values were obtained with the treatment planning system (TPS). Angular dependence was measured by rotating the scintillator ($\Delta\varphi$ = 45°) delivering 100 MU to a 10×10 cm^2 field from gantry angle 0°, figure 1(c).
Results/Discussion:
Field size dependence showed dose differences <1% relative to the TPS for field sizes above 2×2 cm^2 for both linacs. For larger fields the stem-effect increases, surpassing scintillation on the MR-linac, figure 1(b). Dose comparison for the angular dependence resulted in a standard-deviation error of 2.3% for the CT-linac and 2.2% for the MR-linac. For multiple angles the stem-effect dominated scintillation, with an average stem-to-scintillation ratio of 1.2 for CT-linac and 1.4 for MR-linac, figure 1(d). The increase of stem-effect on the MR-linac is due to an increase in Cerenkov light which depends upon the orientation and the amount of irradiated fibre.
Conclusion:
Despite the differences in intensity of the stem-effect between CT and MR-linac across various field sizes and angles, multipoint calibration remains effective for estimation of the delivered dose.

Field size dependence

(a)

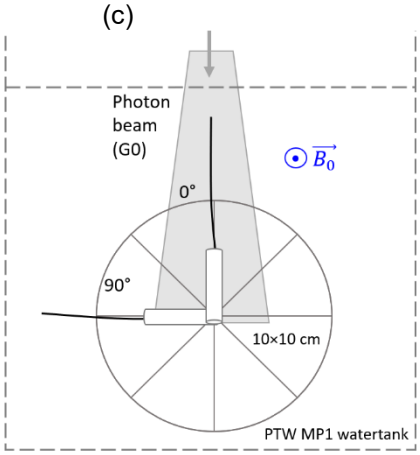


(b)



Scintillator angular dependence

(c)



(d)

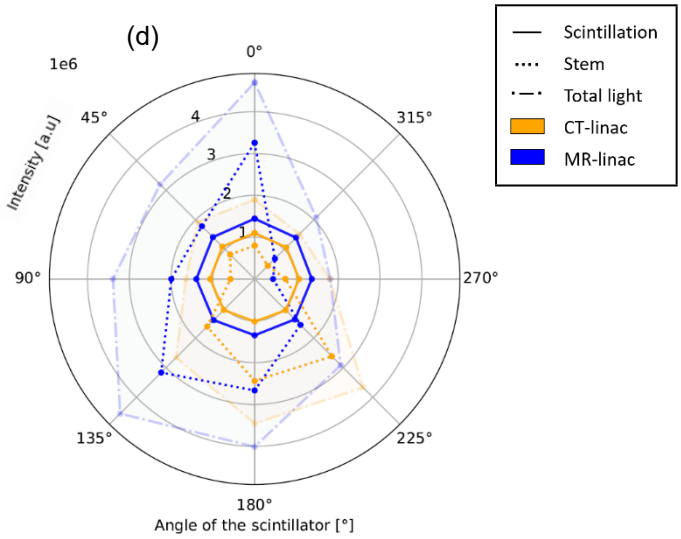


Figure 1. The field size dependence and angular dependence for measurements performed on the CT-linac and the MR-linac.
(a) Schematic view of the set-up for the field size dependence measurements.
(b) Results for the field size dependence showing the intensities of scintillation, stem and total light (normalized to scintillation at 10x10 cm^2) on both devices.
(c) Schematic view of the set-up for the scintillator angular dependence measurements.
(d) Results for the scintillator angular dependence showing the intensities of scintillation, stem and total light on both devices.

References

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[2] Beddar, A. S., Mackie, T. R., & Attix, F. H. (1992). Water-equivalent plastic scintillation detectors for high-energy beam dosimetry: II. Properties and measurements. *Physics in Medicine & Biology*, *37*(10), 1901.

[3] Archambault, L., Therriault-Proulx, F., Beddar, S., & Beaulieu, L. (2012). A mathematical formalism for hyperspectral, multipoint plastic scintillation detectors. *Physics in Medicine & Biology*, *57*(21), 7133.