Dosimetric characterization of the HYPERSCINT scintillation dosimetry research platform for multipoint applications

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INTRODUCTION

Multipoint detectors are very interesting toward developing new phantoms and making measurements in constrained space. However, performing scintillation dosimetry using a multipoint plastic scintillator detector (mPSD) requires a highly sensitive array of photodetectors to collect the light emitted at different wavelengths from the scintillating elements and carried through a transport fiber [1-2] but also an optical system offering sufficient spectral resolution to deconvolve various overlapping spectra [3-4].

PURPOSE

Assessing the performance of the HYPERSCINT dosimetry research platform (Medscint inc., Québec, Canada) with a high spatial resolution 3-point plastic scintillation detector for application to high energy photon beam dosimetry.

Figure 1. HYPERSCINT dosimetry research platform connected with a 17 m long transport fiber ESKA GH-4001.

MATERIAL AND METHOD

- HYPERSCINT dosimetry research platform (Figure 1)
- 3 points mPSD (Figure 2)
- Orthovoltage unit (XStrahl 200) and LINAC (Varian Clinac iX)
- Pin-point ionization chamber (PTW TN31014)
- Solid water phantom

Scintillation spectra in absence of Cerenkov light were acquired with an orthovoltage unit to perform a deconvolution of the total signal using a hyperspectral approach. Dose calibration of each scintillator signal was accomplished with repeated irradiations of 100 cGy (6 MV). Using a solid-water phantom, measurements covering a wide range of doses and dose rates along with beam profile, percent depth dose and small field output factors were realized.

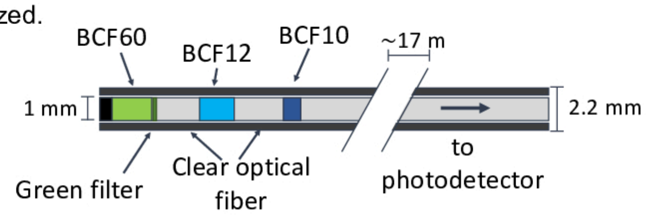

Figure 2. Design schematic of the mPSD showing the 3 scintillators used and the green filter position. The BCF60, BCF12 and BCF10 are respectively 2, 1.5 and 0.8 mm long and placed at 1 cm center-to-center distance.

RESULTS

Dose Linearity

The total signal emitted by each scintillator as a function of the dose deposited was found to follow a linear trend from 1 cGy up to 600 cGy using a constant dose rate as illustrated in Figure 3. The dashed lines represent the intensity calibration curve.

The scintillation signal suffers a discrepancy of the predicted dose that reaches 2.1% at 1 cGy. The difference falls within ± 0.7% above 10 cGy.

Relative Output Factors

Output factors were measured with the mPSD and the pin point ionization chamber for field sizes from 2 x 2 cm^2 to 15 x 15 cm^2. All measurements were then normalized to the 10 x 10 cm^2. For field sizes larger than 2 cm, there are no statistical differences between the **BCF10**, **BCF12** and the ionization chamber.

BCF60 systematically overestimates the dose while reaching a maximum deviation of only 1.7 % as shown in Figure 4.

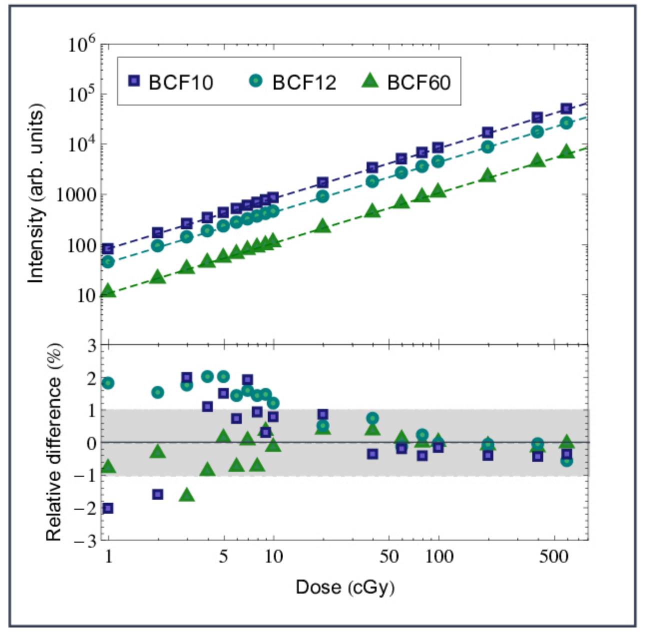

Figure 3. Signal emitted of each scintillator of the mPSD as a function of dose and the relative difference between measured and predicted dose.

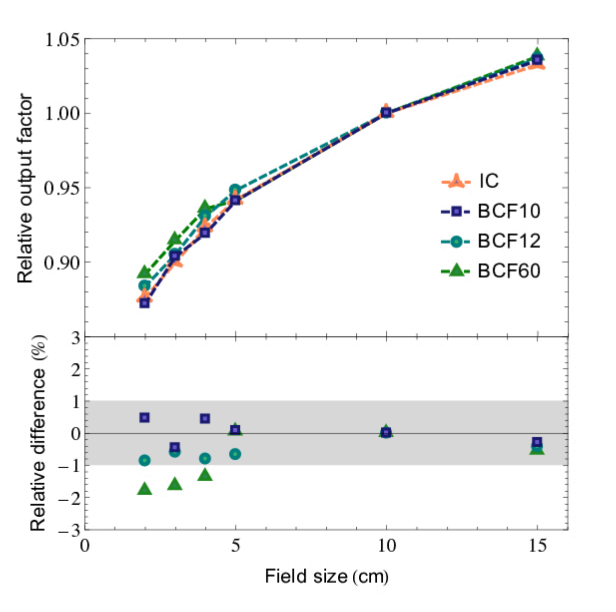

Figure 4. Relative output factors measured with the mPSD and a pin-point ionization chamber for various filed sizes normalized to the 10 x 10 cm².

A solid water phantom was used to perform depth dose and beam profile measurements. The set-up was then scanned in order to predict the dose deposited using a treatment planning system. The TPS predictions are shown in black dashed line in Figure 5 and 6.

Depth Dose

Depth dose measurements performed with the mPSD are all in agreement with the treatment planning system for a depth up to 15 cm. The maximal difference observed was 1.1 % for the BCF12 (Figure 5).

Beam Profile

Similarly, Full-Width-Half-Max region of the profile was accurately measured with a maximum deviation of 2.3% of the predicted dose. Of note, the relative difference between the dose obtained with the 3 scintillators and the TPS reaches more than 3 % in the penumbra region of the profile (Figure 6).

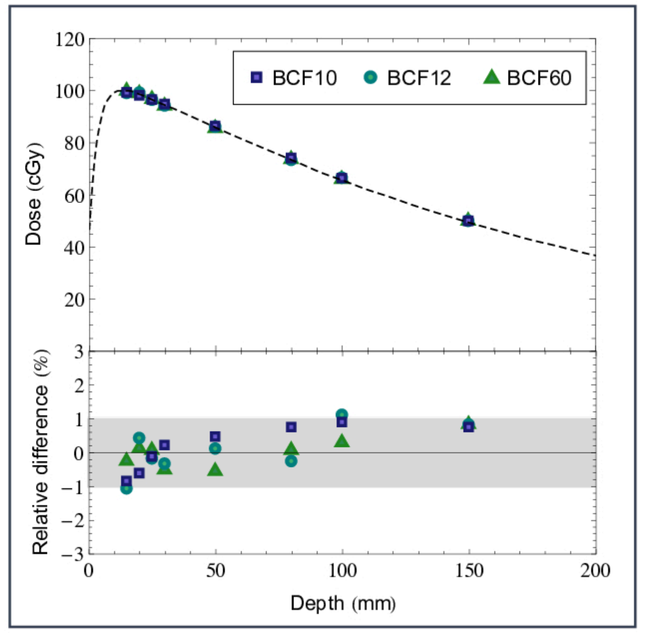

Figure 5. 10 x 10 cm² 6 MV depth dose measured with each point of the mPSD compared to the TPS predicted dose.

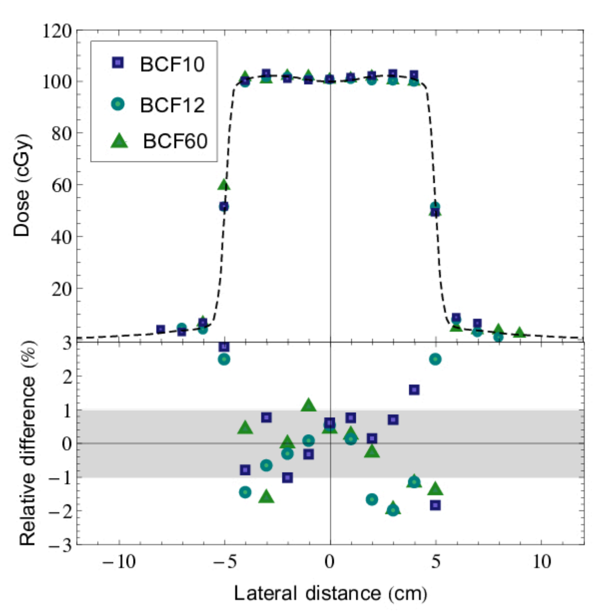

Figure 6. 10 x 10 cm² 6 MV beam profile measured with each point of the mPSD compared to the TPS predicted dose.

CONCLUSIONS

The purpose of this study was to evaluate the dosimetric performances of the HYPERSCINT, a commercially available scintillation dosimetry platform for multipoint applications.

The ability to measure dosimetric characteristics of a clinical photon beam using a high spatial resolution 3-point mPSD coupled to the HYPERSCINT platform was shown. Most of the discrepancies observed between the signal measured with the 3 scintillators of the mPSD and the predicted dose falls within a clinical acceptable range. Further investigations should be made to identify the cause of larger differences observed in the umbra region of the beam profile.

These results open up new perspectives for further multipoint applications, especially for small field dosimetry.

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