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Novel Detector Characterization for an Ultrafast Linac Commissioning

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ABSTRACT

Plastic scintillators offer fast data acquisition, small sensitive volumes suitable for small field dosimetry, and tissue equivalence, making them well suited for LINAC commissioning. This study characterizes the BluePhysics (BP) plastic scintillator detector for rapid commissioning workflows focusing on dosimetric performance and agreement with a standard ionization chamber

INTRODUCTION

LINAC commissioning is a time-consuming process that requires high precision during data acquisition and validation. While standard ionization chambers remain the gold standard, some face limitation in spatial resolution and tissue equivalence. Plastic scintillators has been shown as a promising alternative due to its small sensitive volume, tissue equivalence and energy independence.[1] The objective of this study is to characterize the BluePhysics (BP) plastic scintillator detector for an ultrafast LINAC commissioning workflow. We analyzed its dosimetric performance and simultaneously compared the results with a standard ionization chamber (IBA cc13).

METHODS AND MATERIALS

The BP plastic scintillator features a cylindrical active volume with a 1 mm diameter and a 1 mm length, yielding a sensitive volume of 0.785 mm^3 .[2] All measurements were in an IBA water tank using Varian TrueBeam photon and electron beams. The BP plastic scintillator was evaluated for repeatability, dose linearity, dose-rate dependence, and angular dependence. To test its viability for rapid commissioning, standard datasets such as percent depth dose (PDD), profiles and output factor (OF) measurements were acquired and compared against an IBA cc13 ionization chamber using gamma analysis criteria (2%/2mm, 10% threshold).
An empirical approach was used to optimize post-processing parameters for scintillator detector to best match conventional IC data

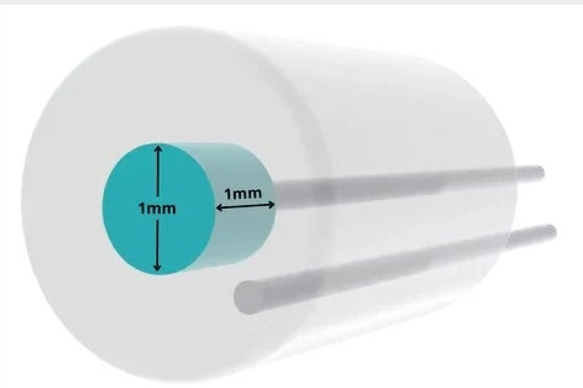

Figure 1. Cross sectional view of the dual-fiber PSD featuring a signal fiber and a background fiber for Cerenkov correction

RESULTS

The BP plastic scintillator shows excellent repeatability of 0.47% and 0.34% at 20MU and 200MU, respectively. Angular dependence showed a maximum deviation of 2.43%, while the detectors dose response was linear across low to high monitor units with R^2>0.999. Dose-rate dependence was minimal, with maximum variation of 0.71% for 6 MV FFF and 0.13% for 10 MV FFF beams. Output factors agreed with the cc13 detector within 0.3% down to 3cm × 3cm field size, as shown in Fig. 2. Table 1 indicates excellent agreement between BP and cc13 detector across several photon and electron beam profiles and PDDs, using Gamma pass criterion.

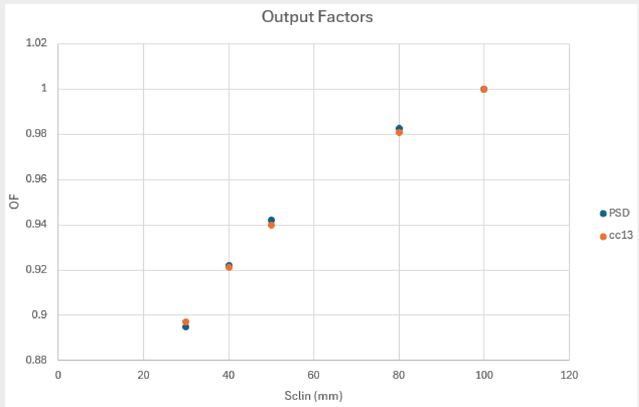

Figure 2. BP vs cc13 output factor

Table 1. BP vs. cc13 Gamma pass rates for profiles and PDDs across different energies

	Field Size (cm^2)	Depth (cm)	Gamma Pass Rate (%)
6MV Profile	10	10	100
10MV FFF Profile	10	10	100
6MV PDD	40	NA	96.18
10MV FFF PDD	40	NA	96.95
18MV PDD	10	NA	96.96
6 MeV PDD	20	NA	93.33

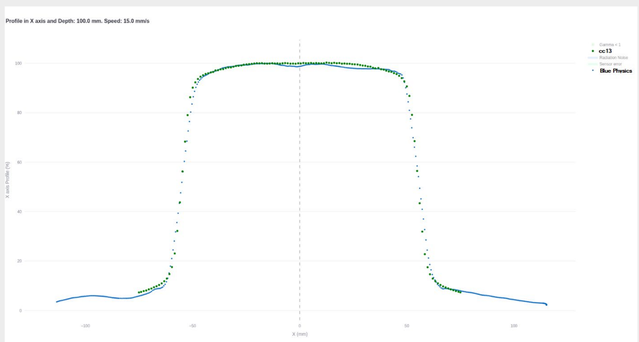

Figure 3. BP vs cc13 6MV profiles at a 10cm depth and 10cm*10cm field size

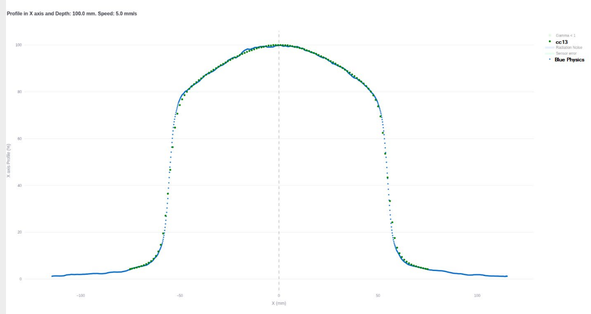

Figure 4. BP vs cc13 10 MV FFF profiles at a 10cm depth and 10c.*10cm field size

DISCUSSION

The BP plastic scintillator provides high accuracy, achieving gamma pass rate of >= 90% for both photon and electron beam profiles and PDDs, when compared with a standard IBA cc13 ion chamber. Excellent dose linearity and dose rate dependence simultaneously validates the scintillator detector. The detectors angular dependence stems from differential buildup material surrounding the active volume; therefore, further measurements will maintain a consistent angular setup. With its water equivalence, small volume, BP overcomes the volume averaging limitations of standard ionization chambers, thereby enabling fast high precision data acquisition

CONCLUSIONS

The BluePhysics Plastic Scintillator demonstrates suitable dosimetric performance for commissioning including good linearity, reproducibility and minimal dose rate dependence. Strong agreement with conventional ionization chamber supports its use for depth dose, profile measurements and output factors.

REFERENCES

1. International Atomic Energy Agency. *Dosimetry of Small Static Fields Used in External Beam Radiotherapy.* Technical Reports Series No. 483. Vienna: IAEA; 2017.
2. Das IJ, Sohn JJ, Lim SN, Sengupta B, Feijoo M, Yadav P. Characteristics of a plastic scintillator detector in photon beam dosimetry. *Journal of Applied Clinical Medical Physics. 2024;25(1):e14209*

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