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Abstract

Deriving Detector-Specific Correction Factors for Small Fields using a Scintillator Detector

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Abstract

Objectives: The goal of this study was to investigate small field output factors (OF's) for flattening-filter-free (FFF) beams on a dedicated stereotactic linear-accelerator-based system. From this data, detector-specific correction factors were generated for both square and rectangular fields.

Methods: Output factors for 16 jaw-collimated small fields (from 0.5 to 2 cm) were measured using 5 different detectors, including: an ion chamber (CC01), a stereotactic field diode (SFD), a diode detector (Edge), gafchromic film (EBT3), and a plastic scintillator detector (PSD, W1). Chamber, diodes, and PSD measurements were performed in a Wellhofer water tank, while films were irradiated in solid water at 100 cm source-to-surface distance and 10 cm depth. The collimator exchange effect was quantified for rectangular fields. Monte Carlo (MC) simulations of the measured configurations were also performed using the EGSnrc/DOSXYZnrc code.

Results: Output factors measured by the PSD, and verified against film and MC calculations, were chosen as the benchmark measurements. Compared with plastic scintillator detector (PSD), the small volume ion chamber (CC01) underestimated output factors by an average of -2.2±5.5% (max. = -14% for 0.5 cm square field). The stereotactic diode (SFD) overestimated output factors by 2.4±1.5% (max. = 5.3% for 0.5 cm rectangular field). The other diode detector (Edge) also overestimated the OFs by an average of 4.6±1.1% (max. = 6.7% for 0.5 cm rectangular field). Gafchromic film (EBT3) measurements and MC calculations agreed with the scintillator detector measurements within 0.7±1.6% and 1.2±1.6% respectively. Across all the X and Y jaw combinations, the average collimator exchange effect was computed: 3.1±2.3% (CC01), 4.2±3.7% (SFD), 5.7±5.5% (Edge diode), 3.7±4.9% (Monte Carlo), 3.9±4.7% (film), and 6.6±6.5% (PSD).

Conclusions: Small field detectors should be used with caution with a clear understanding of their behaviors, especially for FFF beams and small, elongated fields. The scintillator detector exhibited good agreement against gafchromic film measurements and MC simulations, over the range of field sizes studied. The collimator exchange effect was found to be important at these small field sizes. Detector-specific correction factors were computed using the scintillator measurements as the benchmark.

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