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Stereotactic Cone Commissioning for Flattening Filter Free Photons of a Linear Accelerator using a Plastic Scintillator Detector

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Abstract

Objectives: To describe a practical method of cone commissioning using a plastic scintillator detector (PSD) & diode detector and present the data for public reference.

Methods: Measurements performed with a 1mm x 3mm PSD and a 0.8 mm x 0.8 mm diode detector. Though the properties of PSD make it ideal for small field measurements, several challenges in its implementation had to be overcome. Custom 10 cm thick Cerrobend shield was used to minimize the effect of radiation incident on the photodiode component of PSD. Plastic c-clamp sleeve was used to protect the PSD sheath, allowing it to be mounted using standard chamber attachment accessory. CLR calibration was performed in water with PSD parallel to incident beam, following vendor recommended procedure. Maximum irradiated fiber condition was met by attaching a small weight to the fiber, keeping it submerged at a stable depth, while the minimum fiber configuration was achieved by pulling excess fiber out of the water. PSD centering was performed by acquiring a measurement at nominal beam center by the light field and determining the positions of the in-plane and cross-plane 50% signal through linear interpolation. The depth of measurement was determined with the vendor-provided cap with a white line indicating the effective POM. Output factors (OF) were measured for 6X-FFF and 10X-FFF photons and all cone sizes (4, 5, 7.5, 10, 12.5, 15, and 17.5 mm) with the PSD and diode detector at 95 cm SSD, a depth of 5.0 cm, and jaw setting of 5 cm x 5 cm. A daisy-chain correction was done with a 0.125 cc ion chamber at a junction field of 4 cm x 4 cm for both PSD and diode. TMR curves were measured up to 21 cm using the TPR acquisition package and a diode. TMR point checks were performed with the PSD. Depth dependent correction factors, determined through a linear fit, were applied to the TMR curves so that a close match to the PSD point data was achieved. End-to-end test was conducted for the 4 to 10 mm cones with a head phantom and triple channel films.

Results: PSD measured OFs for 6X-FFF were 0.576, 0.633, 0.725, 0.781, 0.817, 0.843, and 0.859 for 4 to 17.5 mm cones, respectively; for 10X-FFF, 0.484, 0.547, 0.656, 0.730, 0.784, 0.823, and 0.852. Diode detector measured OFs for 6X-FFF were 0.608, 0.668, 0.754, 0.798, 0.826, 0.846, and 0.859 for 4 to 17.5 mm cones, respectively; for 10X-FFF, 0.511, 0.582, 0.695, 0.763, 0.811, 0.844, and 0.868. The PSD OFs agree with Monte Carlo simulations by Cheng et al 2016 within 2.5% for both energies. Diode OFs agree with the vendor representative data within 1.0% and 1.5% for both energies. Differences in OFs as measured by diode and PSD range from 0.5% to 6.5% for various cone sizes, which is consistent with data reported by Franceson et al in 2014

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and Tanny et al in 2015. PSD TMRs at 10 cm depth for 6X-FFF (normalized to d=1.5cm) were 0.594, 0.602, 0.614, 0.623, 0.629, 0.636, and 0.641 for 4 to 17.5 mm cones, respectively; and for 10X-FFF (normalized to d=2.5cm), 0.693, 0.697, 0.711, 0.719, 0.726, 0.733, and 0.739. Diode TMR at 10 cm depth for 6X-FFF were 0.588, 0.599, 0.612, 0.616, 0.626, 0.628, and 0.635 for 4 to 17.5 mm cones, respectively; and for 10X-FFF, 0.687, 0.696, 0.708, 0.716, 0.725, 0.729, and 0.738. Film gamma analyses yielded passing rates of 97.5% to 99.3% for 4 to 10 mm cones at 1% and 1 mm with a 10% threshold.

Conclusion: With proper care, PSD is an accurate & practical tool for commissioning small fields, including stereotactic cones.