

A new scintillator-based dosimetry system for real-time UHDR electron beam monitoring

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Background & Objectives

While conventional radiotherapy is delivered at rates of 0.1~Gy/s, FLASH therapy utilizes ultra-high dose rates (>40~Gy/s) to trigger healthy tissue sparing. This shift to UHDR creates a significant dosimetry gap: standard ionization chambers calibrated for low dose-rate beams suffer from high ion recombination, and therefore are not reliable for real-time and 2D monitoring of ultra-high dose rate (UHDR) beams. There is a need to develop a dosimetry solution specifically designed for UHDR applications (1). Scintillator-based dosimeters have demonstrated promising potential for real-time monitoring of electron UHDR beams, making them strong candidates for future system development (2). The goal of this study was to monitor UHDR electron-beam parameters in real time using the BrightEye TM (3) dosimetry system, which includes a BrightLeaf TM scintillator (4), a Fast machine-vision camera (BOA1936-400cc), and image-processing software.



Figure 1. BrightEye dosimetry system setup tested on the IntraOp capable of delivering 6MeV and 9MeV UHDR beams, equipped with two beam current transformers (BCTs) .

Results

Linear response to Pulse Number & accumulated Charge:

The system demonstrates a near-perfect linear relationship between the sum brightness intensity collected from the grey value of a region of interest in the images and the number of delivered pulses, ranging from 1 to 10 pulses. There is an exceptionally strong correlation between the brightness intensity and the accumulated charge collected from internal Beam current transformers (BCT).

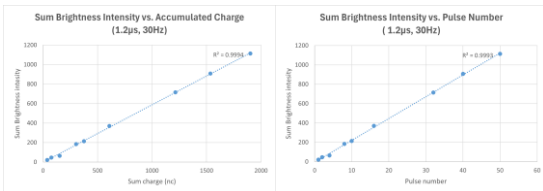


Figure 2. Linear relation between the Brightness intensity and the A) pulse number (left) and accumulated charge (right)

Pulse repetition independent response: The system showed a highly stable response and was not significantly influenced by the Pulse Repetition Frequency (PRF) across the tested range of 30 Hz to 120 Hz when delivering 10 pulses.

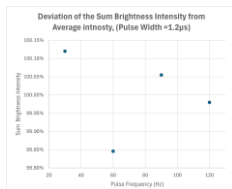


Figure 3. Pulse repetition independent response

Pulse width dependent response: The accumulated sum brightness intensity increases linearly as the average pulse width is varied from 1 µs to 3.6 µs. This has been tested at 30 and 120Hz, and the results have been shown to be PRF-independent. The results have been compared with the accumulated charge BCT data and showed a linear response for the same ranges of Pulse width and Frequencies.

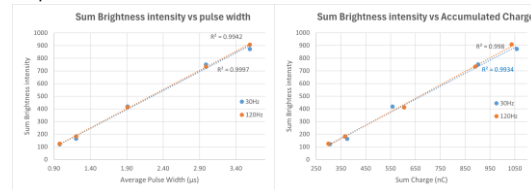


Figure 4. Pulse width-dependent response and linear response to the collected charges

Negligible Beam disturbance: The scintillator films (200-600µ) showed between 2-5% beam disturbance, where Gafchromic film (EPT-XD, Ashland) was used as a reference.

Conclusion and Outlook

This study is the first report on the capability of the BrightEye TM system for real-time beam monitoring of electron UHDR beams. This system could be a potential solution for in-line beam monitoring of the UHDR LINAC. A Linac-embedded system is under testing for potential upcoming (pre) clinical trials.

References

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