Development of a Novel Dosimeter for Spatial-Temporal Dose Rate Measurements of Ultra-High Dose Rate Radiotherapy Beams

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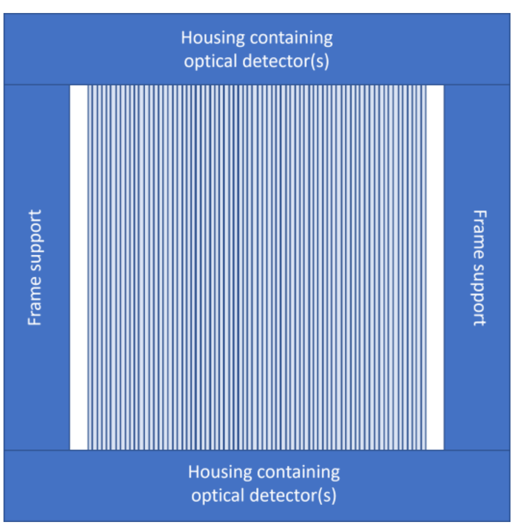
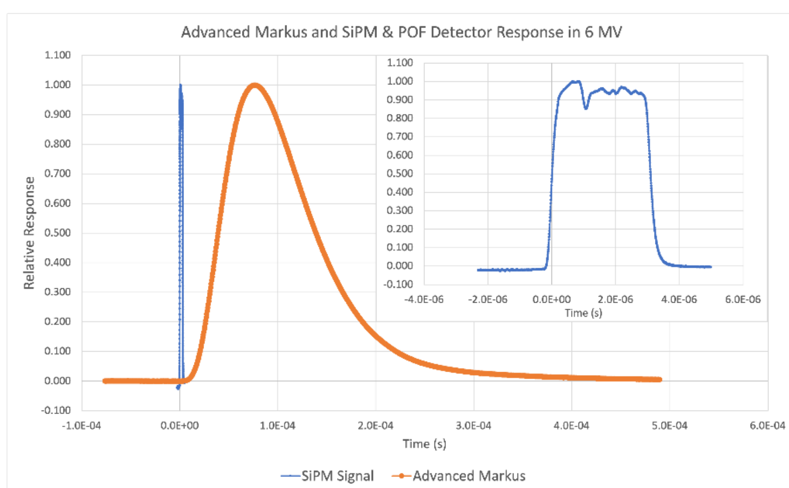
Ultra-high dose-rate radiotherapy or FLASH therapy is a novel treatment technique which has gained traction in the field of medical physics and radiation therapy in recent years due to its capability to deliver treatments which result in similar local tumor control with increased normal tissue sparing at dose rates greater than 40 Gy/s. Since these normal tissue sparing effects are only seen using dose rates over 40 Gy/s, it is imperative to ensure the target areas are being irradiated at dose rates over this threshold. As a result, the goal of this project is to develop a dosimeter using ionization chamber and optical dosimetry methods that is capable of tracking the dose rate both spatially and over the duration of the treatment delivery for quality assurance purposes.

One of the novel approaches in this project is the use of light generated in plastic optical fibers alone to record the dose deposited at a temporal resolution high enough to capture individual beam pulses. As FLASH therapy treatments are delivered over a substantially lower time than conventional treatments, there are a fewer number of pulses delivered, and each pulse delivers considerably more dose, requiring the need for pulse-by-pulse monitoring of FLASH treatments, an approach not necessary in conventional radiotherapy.

The form this device will take will include two orthogonal arrays of optical fibers similar to the simple model below, and a small-gap ionization chamber for accurate and traceable dose measurements. Once completed, the device will be tested in both electron and proton beamlines and will output a 2D map of doses and dose rates indicating which areas received how much dose and how much of that dose was delivered over 40 Gy/s.



A mockup of one of two orthogonal arrays of optical fibers



An example of the two signals generated by the device from one pulse of radiation. The blue optical fiber signal captures the pulse shape whereas simultaneously the integrated ion chamber signal in orange results in an accurate dose reading delivered from that pulse.