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Real-time 3D scintillation dosimetry using organic liquid scintillators for proton therapy

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We have recently developed a novel application for organic liquid scintillator detectors in Radiation Oncology to measure or image the radiation absorbed dose from external radiation therapy beams in 3D. Initial feasibility studies¹ using one charge-coupled device (CCD) were investigated by Beddar et al in 2009. The present study will be focused only on scanning proton beams used for patient treatments. The basic concept is to use a 3D volume of a liquid scintillator material to measure or image² the dose distributions from proton beams in three dimensions. In this configuration, the scintillator material fulfills the dual role of being the detector and the phantom material (mimicking a patient) in which the measurements are being performed. In this case, dose perturbations caused by the introduction of a detector within a phantom will not be at issue. A larger liquid scintillator (LS) detector system was recently developed and consists of a transparent acrylic tank (20x20x20 cm3) filled with a water equivalent, commercially available liquid scintillator that when irradiated with protons generates scintillation light. To track rapid spatial and dose variations in spot scanning proton beams we use three high speed scientific-complementary metal-oxide semiconductor (sCMOS) imagers (2560x2160 pixels) that collect the scintillation light signals from three orthogonal projections in cine mode at up to 30 frames per second. The system that will be presented has been fully developed and characterized at the Proton Therapy Center at MD Anderson Cancer Center in Houston, Texas. The various optical artefacts that arise as the light propagates from the scintillator through the optical chain will be briefly presented³. The presentation will show that such systems can provide fast and accurate measurements of the range, lateral profile, and lateral position for scanned proton beams with higher spatial resolution (˜ 2.5 mm) than other commercially available detectors. We will also show the ability of such detectors to rapidly measure or image proton beam characteristics and intensities at multiple energies which makes them particularly promising as a tool for scanned proton beam quality assurance as well as the verification of patient treatment delivery (i.e. prostate cancer).

¹Beddar S, Archambault L, Sahoo N, Poenisch F, Chen GT, Gillin MT, Mohan R. Exploration of the potential of liquid scintillators for real-time 3D dosimetry of intensity modulated proton beams. Med Phys 36(5):1736-1743, 5/2009.

²Hui C, Robertson D, Beddar S. 3D reconstruction of scintillation light emission from proton pencil beams using limited viewing angles - a simulation study. Phys Med Biol 59(16):4477-4492, 8/2014.

³Robertson D, Hui C, Archambault L, Mohan R, Beddar S. Optical artifact characterization and correction in volumetric scintillation dosimetry. Phys Med Biol 59(1):23-42, 1/2014.

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