Secondary dose monitoring using scintillating fibers in proton therapy of prostate cancer: A Geant4 Monte Carlo Simulation

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Purpose: To monitor the secondary dose distribution originating from a water phantom during proton therapy of prostate cancer using scintillating fibers.

Method: The Geant4 Monte Carlo toolkit version 9.6.p02 was used to simulate prostate cancer proton therapy based treatments. Two cases were studied. In the first case, 8 X 8 = 64 equally spaced fibers inside three 4 X 4 X 2.54 cm³ Delrin® blocks were used to monitor the emission of secondary particles in the transverse (left and right) and distal regions relative to the beam direction. In the second case, a scintillating block with a thickness of 2.54 cm and equal vertical and longitudinal dimensions as the water phantom was used. Geometrical cuts were used to extract the energy deposited in each fiber and the scintillating block.

Results: The transverse dose distributions from secondary particles in both cases agree within <5% and with a very good symmetry. The energy deposited not only gradually increases as one moves from the peripheral row fibers towards the center of the block (aligned with the center of the prostate) but also decreases as one goes from the frontal to distal region of the block. The ratio of the doses from the prostate to the ones in the middle two rows of fibers showed a linear relationship with a slope (-3.55±2.26) x 10⁻⁵ MeV per treatment Gy. The distal detectors recorded a very small energy deposited due to water attenuation.

Conclusion: With a good calibration and the ability to define a good correlation between the dose to the external fibers and the prostate, such fibers can be used for real time dose verification to the target. And the rest of the fibers were not considered