Inferring Water Equivalent Path Length in Transmission Proton Imaging From Two Dimensional Data

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Purpose: To investigate the possibility of using two dimensional dose deposition data obtained from a proton transmission pencil beam, to infer the water equivalent path length (WEPL). The two dimensional data consist of the total dose deposited in a film and shape of the pencil beam (width, symmetry, and tail).

Methods: Using a general Monte Carlo Simulation code (FLUKA) a proton pencil beam with nominal energy of 180MeV was directed at a CT of a pig's neck. The dose distribution for each angle impinging on a film downstream from the object was calculated. The total dose deposited in the film was calculated and the lateral scatter characteristics in the film were fit using stable distributions. In this effort we only considered scale (broadness of the beam) (γ) and a measure for the size of the tail (α). A fan beam was generated at every 9 degrees angle. In this paper we discuss results from the central fan only.

Results: We show that every parameters showed a relationship with the WEPLwhich could be described using 2nd and 3rd order polynomials. We also show that α and γ both show higher sensitivity to changes in WEPL at smaller values (3-4 cm), while D_tot performs better for larger values. Indeed a bland-altman analysis shows a standard deviation of the residuals of the central axis data of 1mm with a maximum difference of 2.3mm. This is for the central spoke in the fan beam.

Conclusion: The use of scatter characteristics in a film is a promising methodology to infer the WEPL in a clinical situation. Current solutions call for very sophisticated bulky detectors. From this work it is not clear yet how exactly to combine the parameters to increase performance over the full range of WEPL values