AbstractID: 12937 Title: Oblique Incidence for Broad Monoenergetic Proton Beams

Purpose: This study investigates obliquely inclined broad proton beams of energy in the therapeutic region. Its purpose is to provide analytic modeling of the depth-dose distribution of such beams

Method and Materials: A new theory has been developed based on the work of Bortfeld (Med. Phys. **24**, 2024-2033, December 1997) for normally incident proton beams. Parabolic cylinder functions are used, and for each configuration (incident angle, initial energy, material penetrated) it is assumed that the r.m.s. lateral spread of a pencil beam (σ_x) is constant at all depths. MCNPX Monte Carlo simulations (10 or 20 million histories) are used to test and verify the accuracy of the theory in modeling the broad-beam depth dose. This comparison has been made for a total of eighty configurations: a homogeneous phantom composed of water, bone, aluminum, or copper; an initial energy of 50, 100, 150, 200, or 250 MeV; and an angle of incidence of 0°, 15°, 30°, or 45°.

Results: There is very close agreement between theory and Monte Carlo calculations, for water and bone phantoms; discrepancies are more pronounced for aluminum and, especially, for copper . Moreover, for a particular phantom material the optimal value of σ_x depends little on the angle of incidence. Furthermore, for each phantom material the optimal value of σ_x very closely follows a power law as a function of incident energy or of initial range of the protons.

Conclusion: The excellent results are rather surprising, given the gross approximation of σ_x being constant in depth for each configuration. The power-law dependence of σ_x as a function of incident energy or of initial range also comes as surprise. Further investigation is called for, in understanding this high accuracy, but presumably it occurs because the depth-dose curve varies only slowly before the Bragg peak region is reached.