AbstractID: 11389 Title: The causes of the lateral envelop of low doses in scanning proton beamlets

Purpose: A known phenomenon in scanned proton beams is a low dose envelope, namely halo dose, which laterally extends far away from the beamlet axis. This effect leads to a dependence of the total delivered dose on the size of the target volume hence must be considered in dose calculation algorithms used by treatment planning systems (TPSs). In this work we investigated the causes of the halo dose using the Monte Carlo (MC) technique. **Method and Materials:** A validated MC model of the Proton Therapy Center, Houston (PTCH) scanning nozzle was used to investigate the contribution to the halo dose due to: i) secondary particles created in phantom; and ii) particles scattered in the beam line components. **Results:** For high energy beams, secondary particles produced by nuclear interactions (NIs) in the water phantom are the major contributors to the halo dose. For low energy beams, the halo dose is dictated by particles undergoing multiple Coulomb scattering in the beam line components. **Conclusion:** The halo dose is caused by two major effects, which depend on the beam energy and beam line components. On one hand, secondary particles produced in the water phantom are the major cause of the halo dose for high beam energies. On the other hand, particles scattered in the beam line components are the major cause of the halo dose for low beam energies. In the latter situation the halo dose depends directly on design features of the beam line. This is an important fact to consider because this effect is beam line specific and adds a challenging problem to analytical dose models used by TPSs. Furthermore, this work suggests that features in the design of the beam line can minimize the halo dose for low proton beam energies.