AbstractID: 4620 Title: Simultaneous multi-pencil fan-beam-based intensity-modulated proton therapy.

Purpose:
Intensity-modulated proton therapy (IMPT) will improve the conformality of proton radiotherapy while preserving target homogeneity and low integral dose characteristics. IMPT is currently delivered using a single scanned pencil beam by placing Bragg peak spots at predetermined points in the patient. Very short pulse lengths and low repetition rates will characterize inexpensive compact proton beam systems of the future such as the dielectric wall accelerator. Their pulse structure is not amenable to scanning a single spot. The use of multiple intensity-modulated pencil beams delivered in a fan beam is a simple approach to IMPT that can be used to upgrade current proton systems or with future accelerators.

Methods and Materials:
A fan beam is created with a pair of quadrupole magnets aligned so that the second magnet amplifies beam divergence initiated by the first magnet. A set of multiple range-shifters simultaneously adjusts penetration of multiple pencil beams. The actuation for the range-shifters is done out of the plane of the fan beam. The intensity is modulated for any pencil beam by placing a thickness, greater than the range in the protons, in that portion of the fan beam. This achieves binary (on-off) modulation as is used in x-ray tomotherapy.

Results:
Calculations show that a spot delivery rate increase of 8 times can be achieved with this system which would allow larger target volumes to be practically delivered with IMPT or used with pulsed systems with low repetition rates. The system could be used to deliver spot scanning with multiple pencil beams simultaneously or used to deliver proton tomotherapy.

Conclusions:
An intensity-modulated proton therapy system, based on multiple pencil beams issuing from a fan beam geometry, would decrease the delivery time for either continuous or low repetition pulse systems.