AbstractID: 8175 Title: The Impact of Longitudinal Breathing Randomness for Tomotherapy Delivery

Purpose: The Helical Tomotherapy Hi-Art™ system (TomoTherapy, Inc., Madison, WI) has recently been observed to exhibit unwanted longitudinal dose modulations in response to irregular breathing for some lung treatments. Regular breathing, by contrast, does not show this effect. The sensitivity to irregular breathing for superior-inferior dose profiles is explained.
Method and Materials: A theoretical explanation is illustrated with a one-dimensional on-axis model using a realistic and typical TomoTherapy beam. Both random and regular breathing functions are used. The breathing functions are simulated with cycle to cycle randomness, and also 100 spirometer readings are used to arrive at a scaling relation. This explanation is supported with radiochromic film studies using the Washington University 4D phantom in realistic treatment plans and with three-dimensional motion.
Results: The time dependence of the accumulated dose for any given voxel moving longitudinally in response to breathing, when plotted, one can observe the effects of randomness on the tens of breathing cycles that back into and out of the beam expressed in a couch speed dependence. Irregularities in the inhale amplitude and the exhale position translate into different total dose from one voxel to another. By contrast, regular breathing will show almost no difference from one voxel to another mostly because so many breathing cycles are totaled for typical parameters. Phasing information is at a much finer time scale, so leaf modulation is not relevant.
Conclusion: The unwanted dose modulations are the result of the interference of longitudinal positional irregularities with the jaws, not the leaves. The time scale of these variations is several tens of seconds, and it requires a significant amount of irregularity to show these dose modulations. Average breathing motion, if regular, will not need motion management.