AbstractID: 6654 Title: Reducing the sensitivity of IMPT treatment plans to setup errors and range variations

Purpose: Intensity modulated proton therapy (IMPT) has the ability to deliver highly conformal dose distributions to tumors of complex shape. However, the accuracy of IMPT treatment plans is potentially compromised by various uncertainties, including setup errors and variations of the range of a proton beam in the patient.

Method and Materials: We present two treatment planning concepts for IMPT which incorporate uncertainties into the optimization. The first approach minimizes the expectation value of the deviation of delivered dose and prescribed dose, assuming the delivered dose depends on several random variables that model the uncertainty. The second approach minimizes the maximal dose deviation that can occur.

Results: It is shown that these methods can utilize the physical characteristics of the proton beam to make treatment plans relatively insensitive to a particular type of uncertainty.

A treatment plan optimized while accounting for range uncertainties avoids placing a bragg peak directly in front of the OAR. Instead, the lateral fall-off of the pencil beam is utilized in order to avoid the risk of overdosing the OAR. In addition, the dose distributions delivered by individual beams are relatively homogeneous in beam direction. This ensures tumor coverage and homogeneity.

On the other hand, treatment plans optimized by accounting for setup errors (modeled as a rigid translation of the entire patient) utilize the distal fall-off at a transition of OAR and tumor. In addition, the dose distributions delivered by individual beams avoid steep dose gradients perpendicular to the beam direction to ensure tumor homogeneity.

Robustness of a treatment plan with respect to both setup error and range variations is possible to a limited degree only, since both types or uncertainty favor conflictive treatment plans.

Conclusion: The presented methods are valuable to make IMPT treatment plans insensitive to various types of uncertainty.