Robust Planning Techniques Using Pinnacle³ TPS IMPT Module

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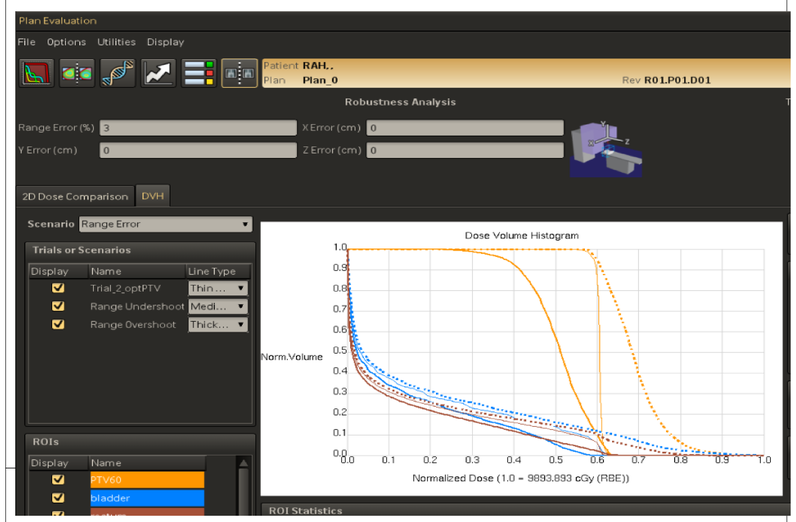
Introduction

Pinnacle³ TPS IMPT planning is now available in v16 release. The v16 proton licensing features robust analysis, robust optimization & it's own proprietary optimizer. This poster looks to identify techniques for qualitatively & quantitatively utilizing these tools for improved proton planning. Figure 1 below can be shown to respectively represent the use of the Robust Analysis tool within the software itself and the breakdown of the inherent features.

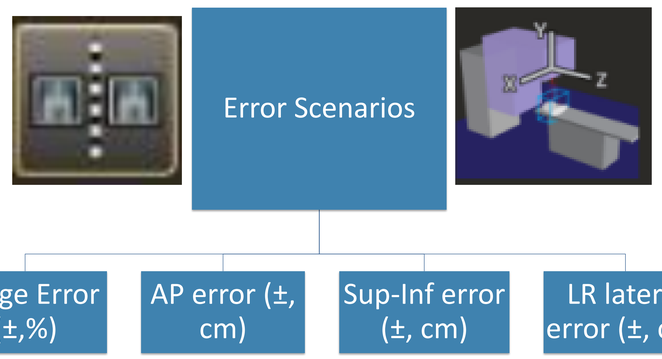
Figure 1. DVH: Nominal & Error Scenarios



Methods

As outlined in Figure 2, the robust analysis tool provides qualitative & quantitative feedback using 4 available variables: range uncertainty, and x, y, & z uncertainty; thus creating 9 plans (+/- each scenario & the nominal scenario).

Figure 2. Robust Analysis Error Scenario Summary



Results

The 2-up viewer & DVH tool provides user feedback to make plan assessment on PTVs & OARs on a voxel level. For example, 3% range error for an AP beam can be found to modulate 3% over/under with respect to PTV and the 2-up viewer quickly shows this result, as demonstrated in Figures 3 & 4. For example 32cm range nominal beam will look to show 97% x 20cm = 19.4cm & 103% x 20cm = 20.6cm.

Figure 3. Prostate LLat: Nominal vs. 3% Range Undershoot

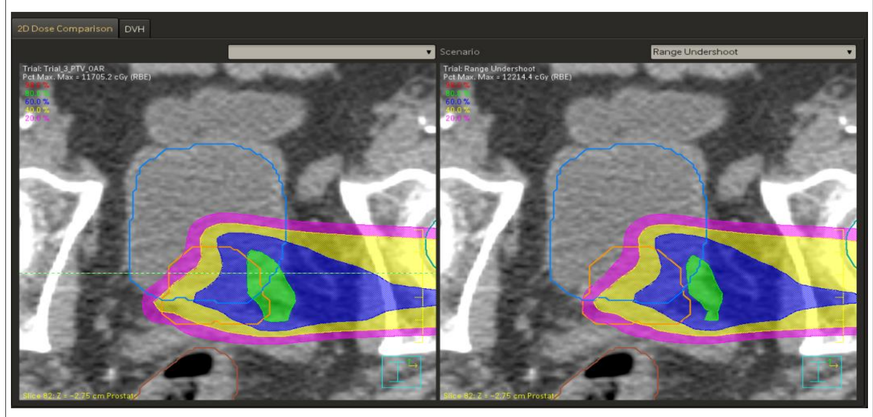
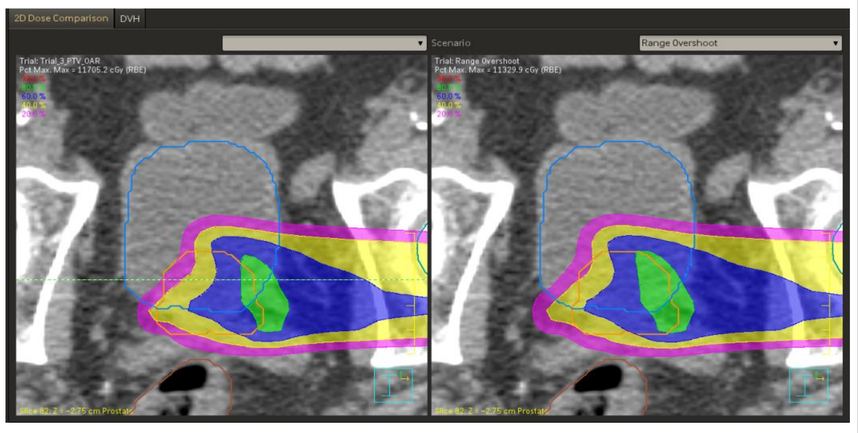


Figure 4. Prostate LLat: Nominal vs 3% Range Overshoot



A prostate case at 60Gy/20# with parallel opposed lateral beams with 3% range error will show improved results with RO vs. without RO, as seen in Table 1.

Table 1. With RO vs. Without RO

PTV60 Dose (cGy-RBE)	Overshoot	Undershoot
Without RO	67.14	51.09
With RO	61.00	57.00
% Improve (relative to nominal 60Gy)	10.23%	10.00%

Results continued

In Figure 5, Notice the tightening the gap between nominal & range uncertainties and providing confidence in prescribed dose under this error example. Figure 6 pictorially shows the small deviation between nominal and overshoot, much improved compared to Figure 4. The bladder & rectum OARs have acceptable statistics for all scenarios without RO and thus provide further confidence to planner using RO.

Figure 5. RO Constraints Applied & Re-Optimized

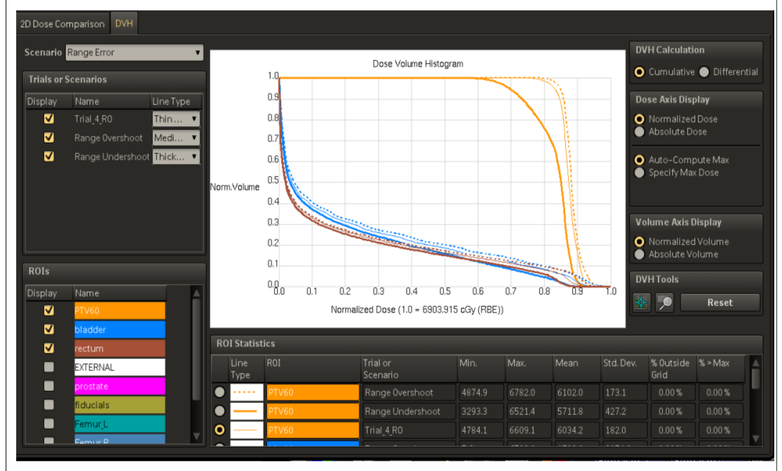
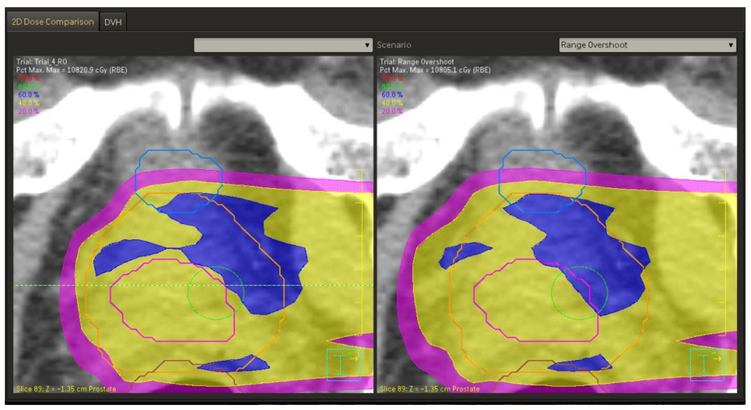


Figure 6. 2-uip RO Constraints Applied & Re-Optimized



Conclusions

Robust techniques in Pinnacle³ TPS adequately provide feedback & plan decision making capability using robust analysis tool and closed loop application using robust optimization.