Toward a new Treatment Planning System accounting for in-vivo proton range verification

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1. Background

- Proton therapy shows great potential in nowadays cancer treatment
- To reduce the effect of proton range uncertainty, prompt gamma (PG) could be monitored to estimate the dose delivery, as shown in Fig.1 (top)
- However, the PG signal is not always well correlated to the proton dose distribution, as shown in Fig.1 (bottom)

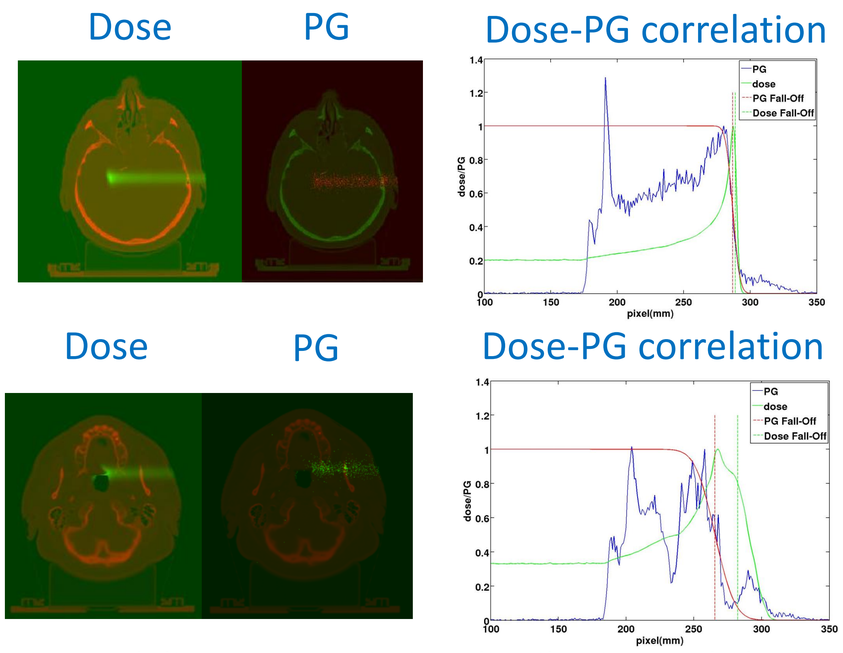

Fig. 1 The Dose delivery, PG emission distribution and the lateral integration curve for PG and dose signal of an individual pencil beam (subPB). Figure in top row shows a good PG-dose correlation while subPB in the bottom one has a poor correlation

2. Goal

- Optimize current Treatment Planning system (TPS), accounting for in-vivo proton range verification in terms of PG imaging
- Maintain the plan quality

3. Method

1. Set up an algorithm which automatically determines the fall-off position of prompt gamma profile
2. Quantify and evaluate the correlation between PG fall-off position and the proton range, defined by 80% distal dose fall off, for each subPB
3. The minimum particle number of each subPB is set up to 5×10^5 to make them well detectable.
4. Boost subPBs with good PG-dose correlation while reduce the weights of subPB which have poor PG-dose correlation (but still above 5×10^5)

4. Result

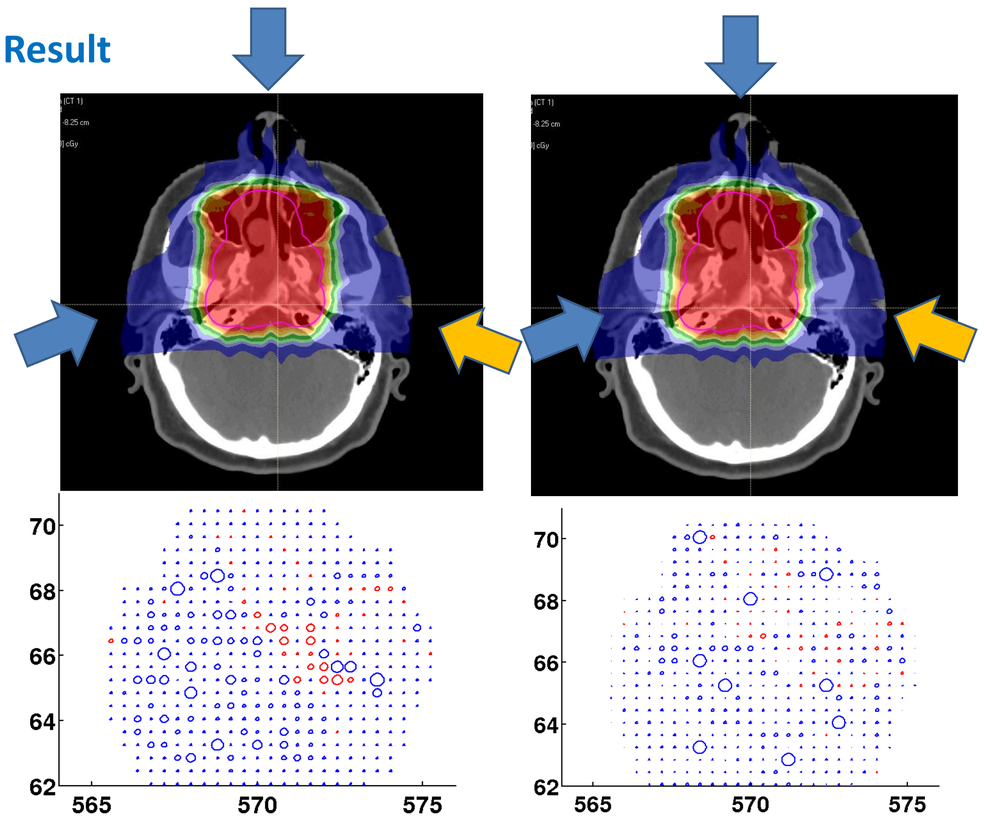

Fig. 2 Comparison between original plan (left) and optimized plan (right). Figure in the top shows the CT and dose distribution, as well as beam directions. Figure in the bottom is the beam eye view from the distal spots of the right bottom field (marked by the orange arrow). The radius of each spot is linearly proportional to the particle intensity of corresponding subPB. A blue spot means good correlation while a red one represents poor correlation.

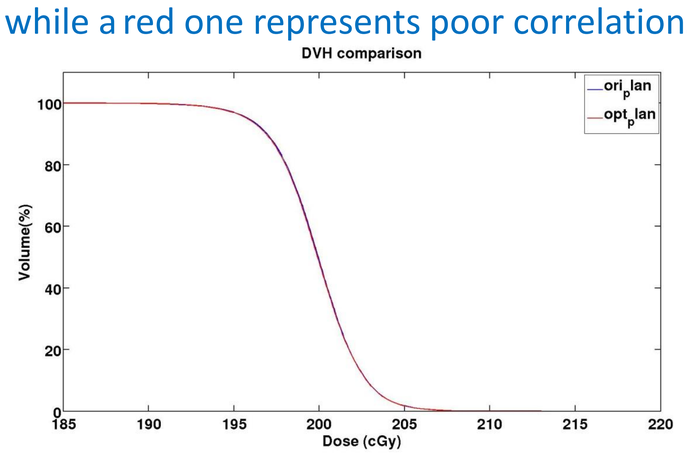

Fig. 3 The Dose-Volume-Histogram (DVH) comparison between initial plan and the optimized plan

5. Conclusion & Outlook

- In this work, an automated algorithm for evaluation of PG-dose correlation was developed and validated
- A research TPS, CERR, was extended to include the above mentioned correlation by using additional constraints in the TP optimization process to enhance subPBs with good PG-dose correlation, while penalizing those with bad correlation
- A more reliable in-vivo monitoring system could be set up by introducing this treatment planning implementation

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