Optimization techniques and systematic robustness evaluation in proton-therapy

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Introduction

At the **Normandy particle therapy center**, patient treatments began in July 2018 using the **ProteusOne** (IBA) for **robust optimized** (RO) plan calculated via a **Monte Carlo** dose engine within the **RayStation** treatment planning system (RaySearch). Comparisons of planning strategies with **MFO/SFO- IMPT** delivery, with planning on **PTV** or **robust on CTV** were performed. **Robust evaluation** (RE) (taking into account **uncertainties** to the stopping power conversion and patient position, e.g. 3%/3mm) of plans under different clinical scenario, stemming from the patient **immobilization analysis** during the treatment course (for further details see poster: *Intracranial immobilization evaluation at the Normandy Particle Therapy Center*), including the **uncertainty on the spot position** (maximum tolerance or mean error from QA protocol), were analyzed.

Methods

Treatment optimization:

SFO-IMPT with RO on CTV (3%/3mm)
SFO-IMPT on PTV (3mm CTV isotropic extension)
MFO-IMPT with RO on CTV (3%/3mm)
MFO-IMPT on PTV

Robust Evaluation (as performed systematically):

Uncertainties parameters: 3%/3mm
100 scenarios

New Robust Evaluation Strategies from data analysis:

Positioning uncertainties:

- **3mm** from planning
- 1st beam images correction vectors (CV) + its standard deviation (StDev) + the Spot max position tolerance = **2.3mm**
- Last images CV + StDev + Spot max position tolerance = **1.5mm**
- Last images CV + StdDev + Spot position mean error = **1mm**

Density uncertainties: **3%**

Results

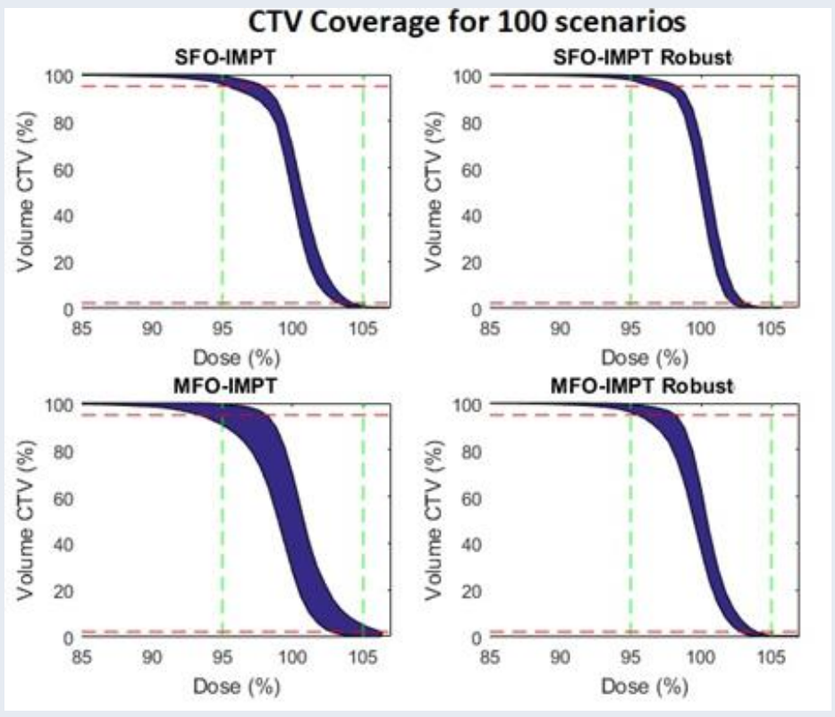
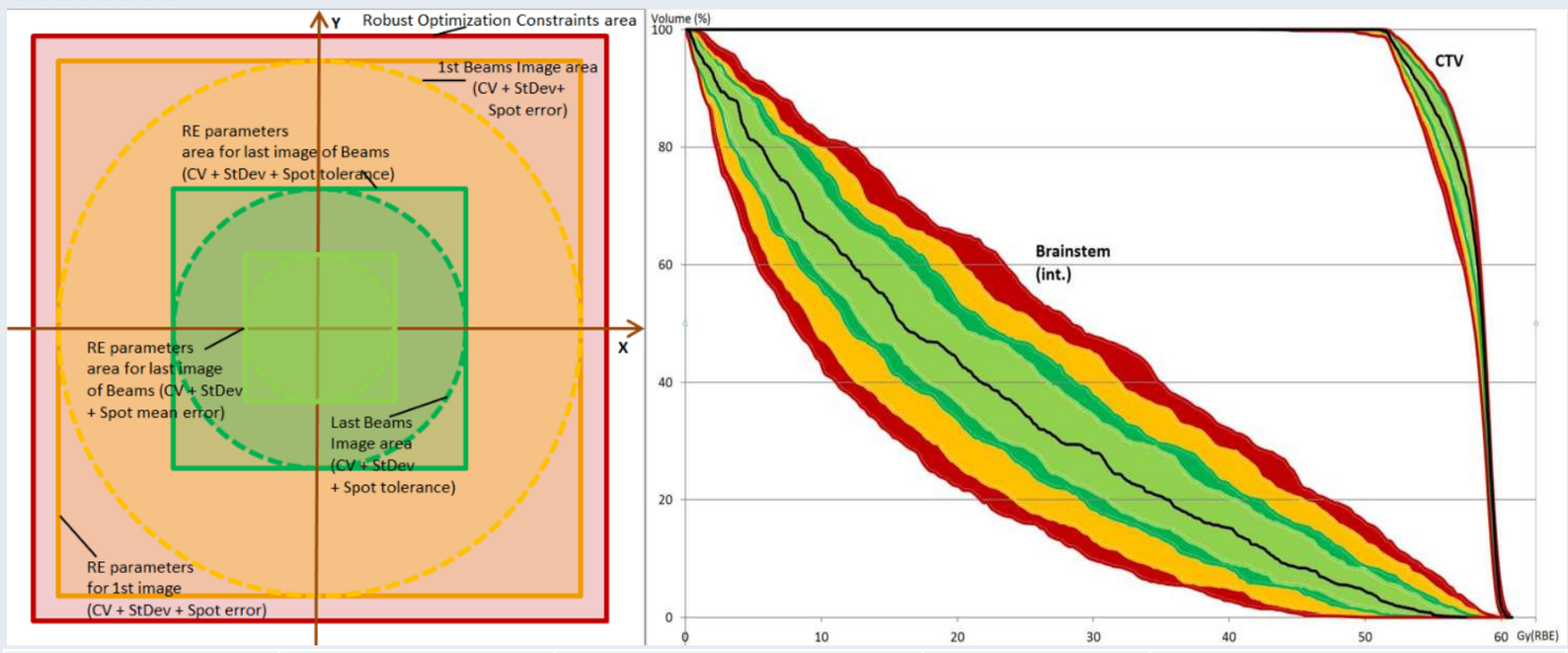


Figure 1: Example of Results obtained with RE while comparing CTV DVH for different optimization strategies on 100 scenarios

→ **RO** appear **superior** in most of the cases investigated with **MFO-IMPT** compared to classic PTV optimization

→ **RO** and **classic SFO-IMPT** can be **equivalents**

→ Time cost is in the favor of PTV optimization



Robustness parameters		Dose Objectif (Gy RBE)	% of scenario passing Dose Objectif	Dose (GyRBE)for 95% of scenario passing
3mm/3%	CTV (D95%)	52,7	60	52,2
	CTV (D2%)	63,5	100	60,2
	Bst (D2%)	54	64	57,6
2,3mm/3%	CTV (D95%)	52,7	71	52,4
	CTV (D2%)	63,5	100	60,2
	Bst (D2%)	54	70	56,5
1,5mm/3%	CTV (D95%)	52,7	71	52,4
	CTV (D2%)	63,5	100	60,2
	Bst (D2%)	54	80	55,3
1mm/3%	CTV (D95%)	52,7	79	52,5
	CTV (D2%)	63,5	100	60,1
	Bst (D2%)	54	87	54,4

Figure 2: 2D Schematic representation of the different area/volume investigated by the position uncertainties and its impact on DVH for an example with Brainstem (Bst) and CTV. Classic representation of RE results is presented. Red area correspond to the 3%/3mm RE, Orange area to the 3%/2.3mm area, Green to the 3%/1.5mm area, Light Green to the 3%/1mm area. The Orange and Green area seems to be the more clinical like scenarios.

→ For intracranial cases, **3%/2.3mm** or **3%/1.5mm RE uncertainties** seems to be realistic choices for further evaluations

Conclusion

RO shows promise in fully exploiting the benefits of proton-therapy with an optimal treatment quality. However in some cases classic PTV optimization could be foreseen for large tumors if treated in SFO-IMPT.

Systematic RE (3%/3mm) were performed for all cases treated so far at the proton center with SFO-IMPT to validate the planning with clinicians. New RE strategies are being discussed to be more representative of clinical scenario during the treatment courses.

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