Proton therapy PBS plan real-time simulation and visualisation tool

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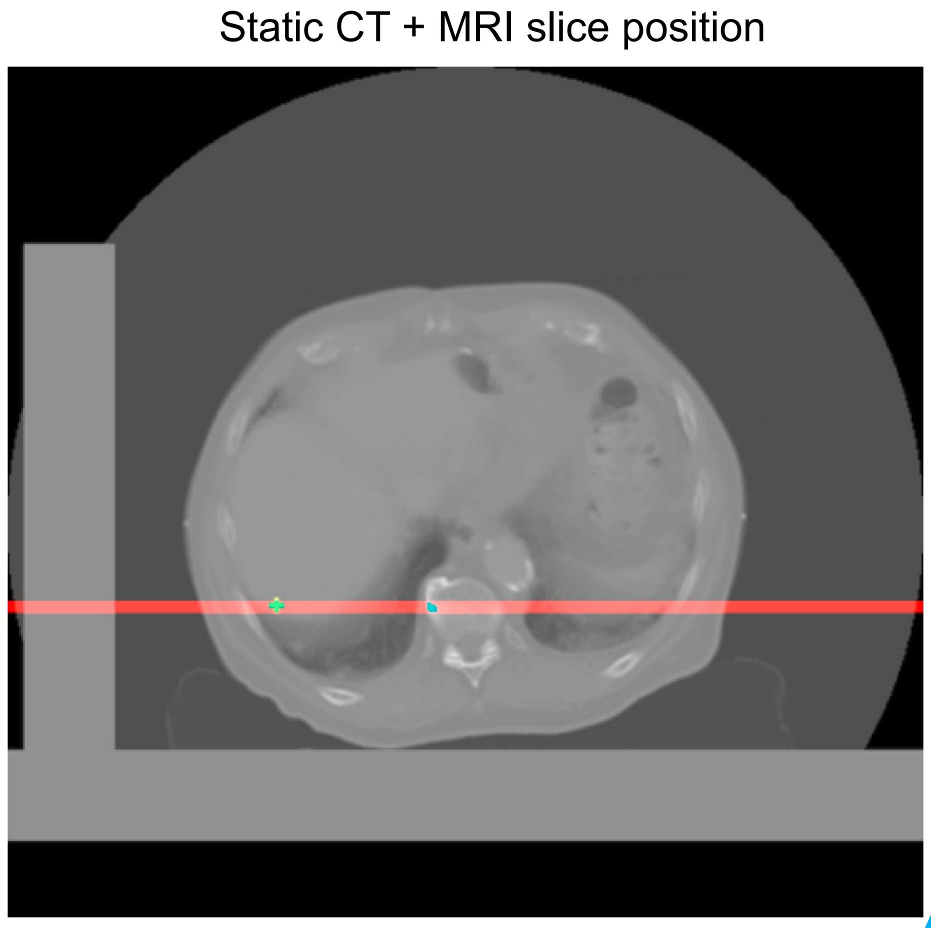
Highlight

The future of radiotherapy is going more and more towards the use of hybrid treatment-imaging solutions allowing online replanning, better inter fraction adaptive solutions or even real-time intra-fraction adaptive treatments in the future. For photons, this type of machine is already on the market [1-2] and for protons it is under serious consideration [3-4]. In this context, a real-time simulation and visualization tool was developed to observe and compare proton PBS treatment plans on dynamic MRI images to try to estimate the possible gains of building a Proton-MR machine.

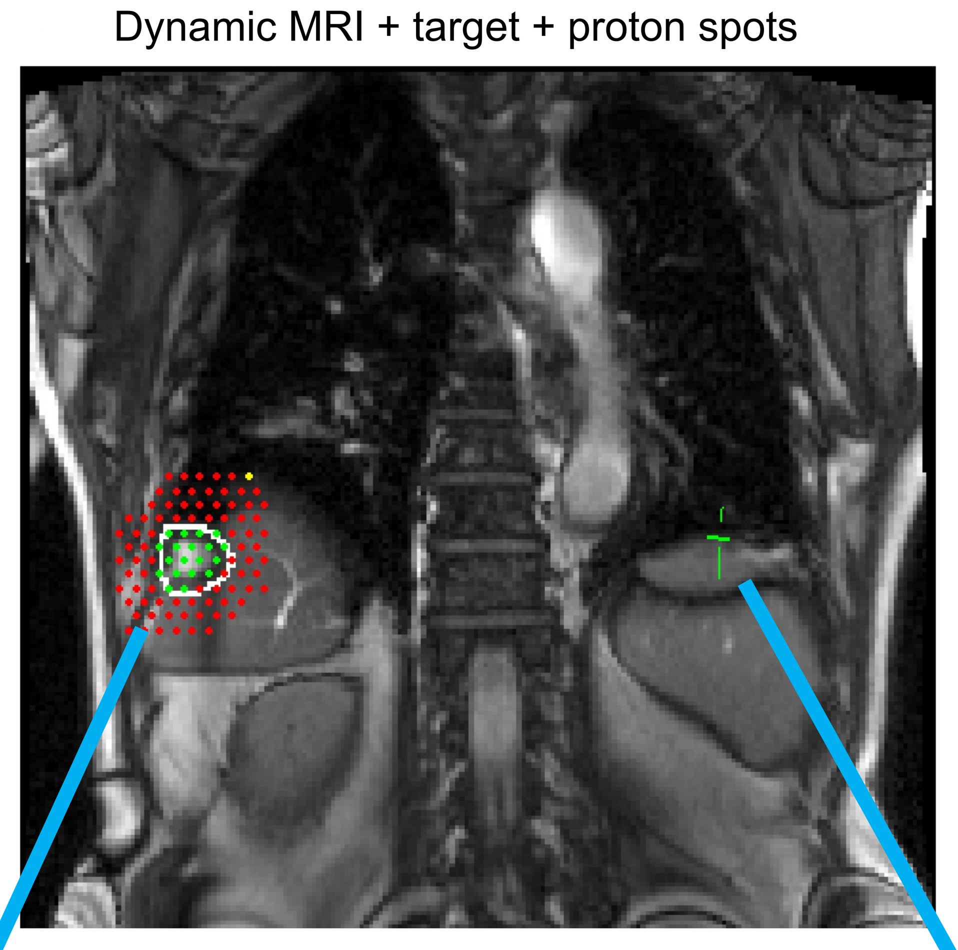
Hybrid
MRI + Protons
?

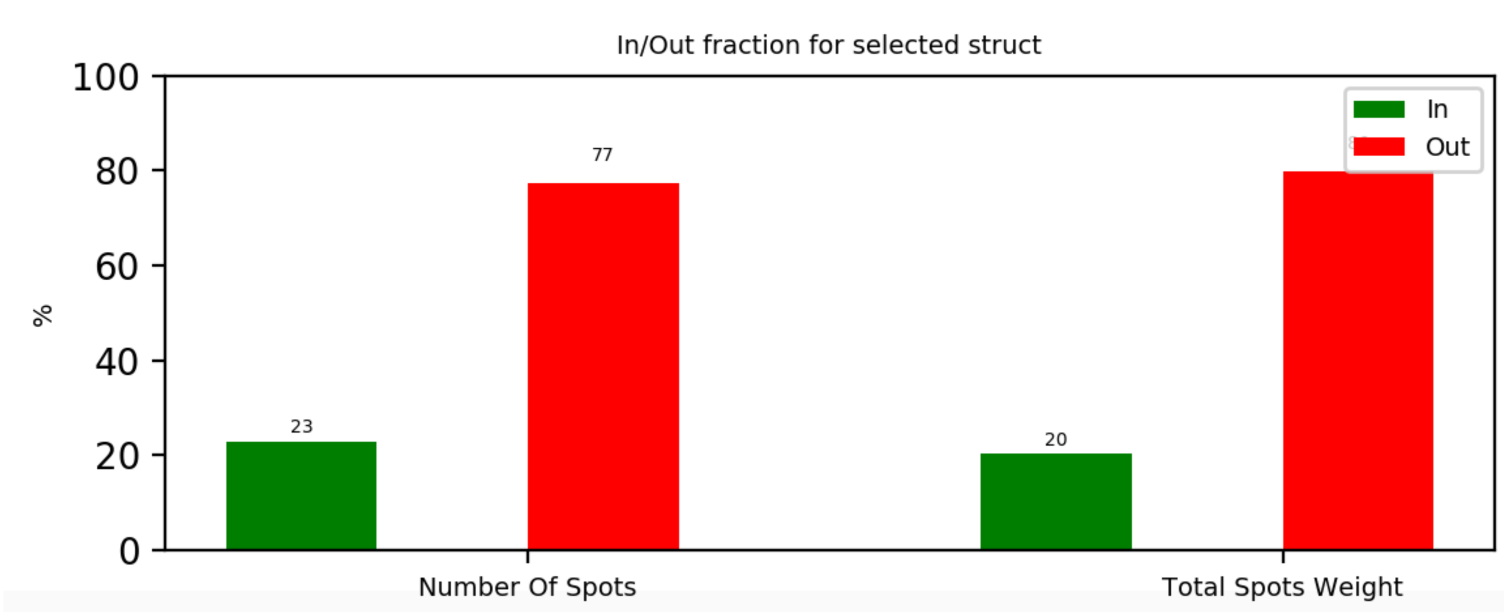
Materials and Methods

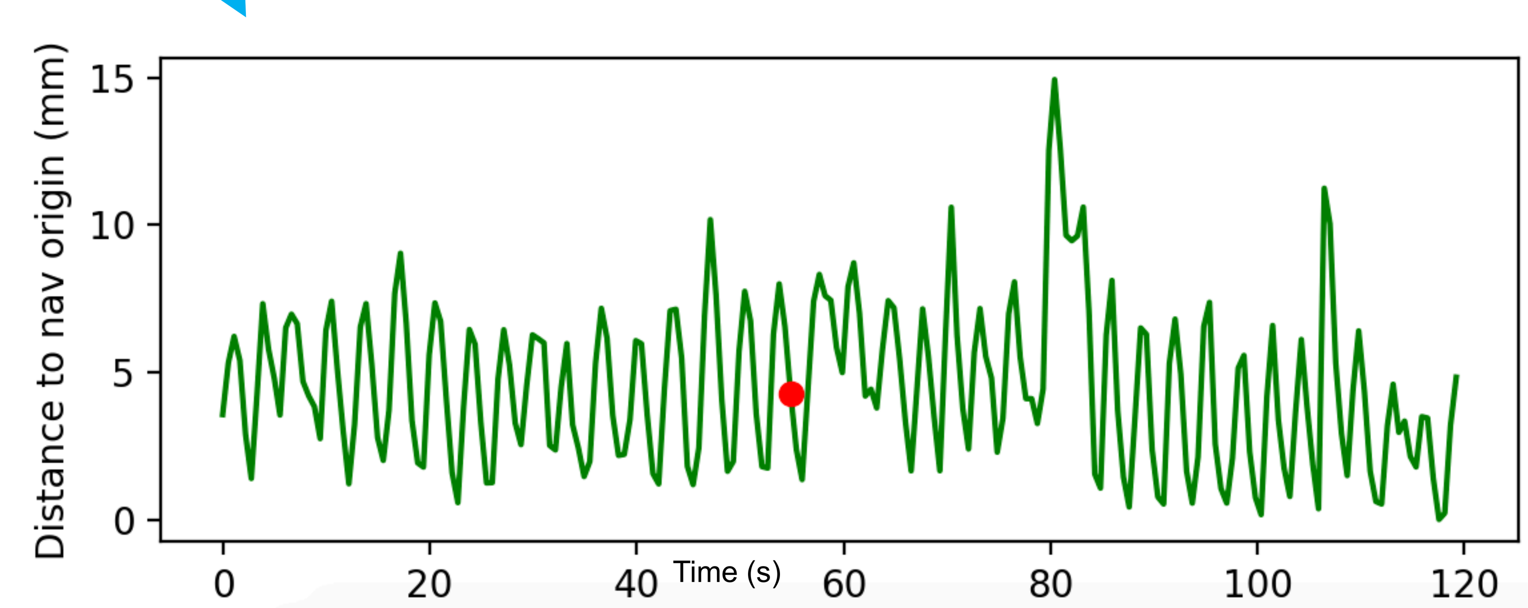
Static CT + MRI slice position



Dynamic MRI + target + proton spots







Data sets of real patient data available containing:

- 4DCT with contours
- Dynamic MRI sequences of 1 to 3 slices (1 to 4 images /s)
- Target contours on the dynamic MRI sequences
- PBS Treatment plans computed on the Raystation 6

These data, coming from different sources, were linked together and imported in an home made program coded in Python in which:

- The PBS treatment plan delivery can be observed spot by spot in real time. The spots are labeled IN or OUT the target, regarding they are shot in the direction of the target or not.
- The breathing motion can be observed and tracked in real time (amplitude, frequency, irregularities, …)

Results

Preliminary results shows that, as expected for the treatment strategy used today, a large fraction of the spots is delivered outside the clinical target volume. The main reason is that currently, the motion is included by adding large motion margins at the treatment planification to assure the target coverage. Our goal in the future will be to compare this strategy with more advanced strategies using the real-time MRI sequence as an input to improve the treatment (multi-gating, tracking possibilities, …).

Results for 10 observations of the same plan with random time shift for the starting point. The dynamic MRI sequence last 120 seconds and the plan delivery takes only around 30s. It is then possible to shift the plan delivery start to observe the results with several starting points.

Orientation of the MRI slices	% IN target (in # of spots)	% IN target (in spot weights)
Sagittal	21 to 23% (mean = 22%)	17 to 19% (mean = 18%)
Coronal	22 to 24% (mean = 24%)	19 to 22% (mean = 20%)

Conclusion

The tool will allow us to compare and evaluate the quality of different treatment strategies and also study different approaches to improve treatment plans by simulating the existence of an hybrid MRI-Protontherapy machine allowing simultaneous imaging and treatment. At the end, the goal will be to evaluate the potential gain of designing such a machine and define the necessary constraints in imaging quality and speed for it to be really useful.

References

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