

Alessandro Vai<sup>1</sup>, Alessio Pierelli<sup>1</sup>, Federica Locatelli<sup>1</sup>, Vittorio Vavassori<sup>2</sup>, Elisa Della Bosca<sup>2</sup>, Andrea Ravasio<sup>2</sup>,  
 Micaela Motta<sup>2</sup>, Viviana Manazzale<sup>2</sup>, Paolo Salmoiraghi<sup>1</sup>

<sup>1</sup> Medical Physics Department, <sup>2</sup> Radiotherapy Department, Humanitas Gavazzeni, Bergamo, Italy.

Physics track: Intrafraction motion management

## Introduction and objectives

Stereotactic Body Radiation Therapy (SBRT) for prostate cancer is a technically demanding treatment in terms of target localization. In this study, a temporary implanted wired electromagnetic tracking system was employed in prostate treatments with standard fractionation, to investigate the impact of motion for future SBRT prostate cancer treatments at our department.

## Methods

A group of 9 patients treated with radiation therapy (dose 70.0 Gy, 2.5 Gy/fraction) of the prostate gland was studied. Each patient was implanted with two gold seeds and an electromagnetic transmitter in the prostate gland, which was surgically removed at the end of therapy (Figure 1).

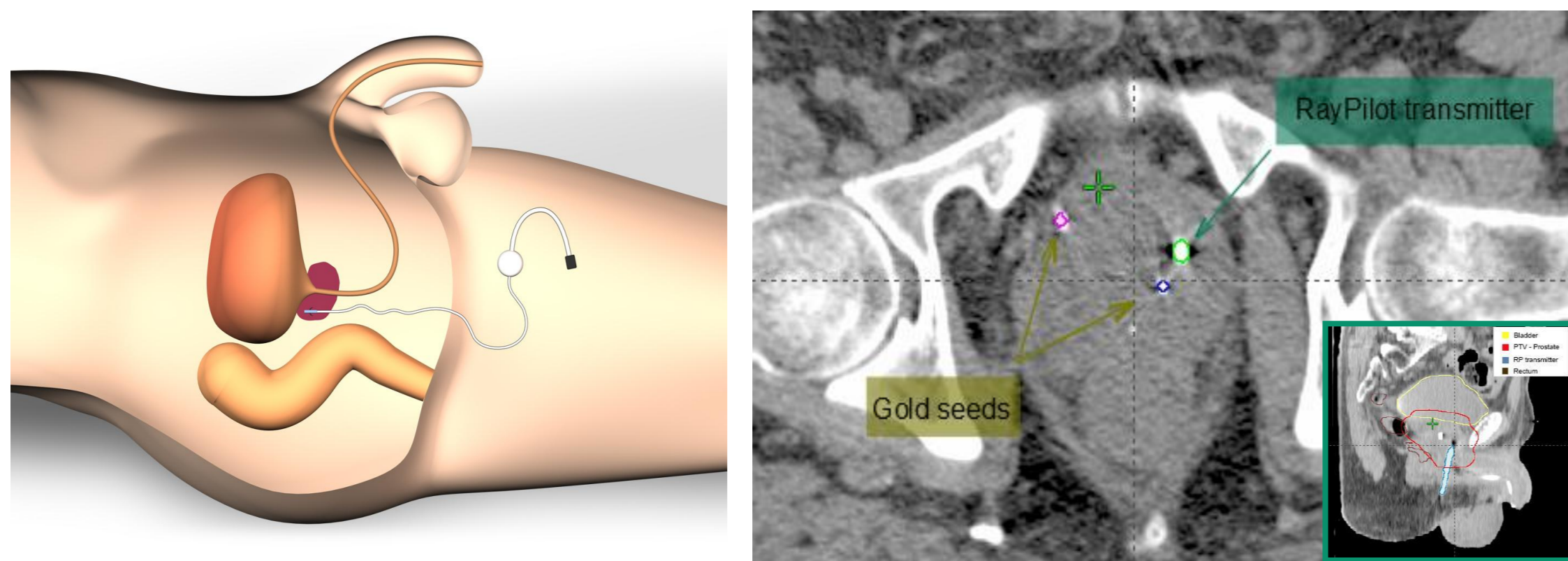


Figure 1. Images of the transmitter implant. The transmitter is connected to the external receiving system by a wire which passes through the patient perineum. The transmitter is implanted in the prostate gland and it is used as fiducial marker together with the two implanted gold seeds.

The tracking system (Raypilot System, Micropos Medical AB), an add-on device to the linear accelerator composed by the implanted transmitter and a flat receiver placed on the patient bed, provides the 3-D real-time position of the transmitter itself, which is passively employed as a surrogate of prostate motion (Figure 2). Target is monitored during every treatment fraction without affecting radiation beam delivery.

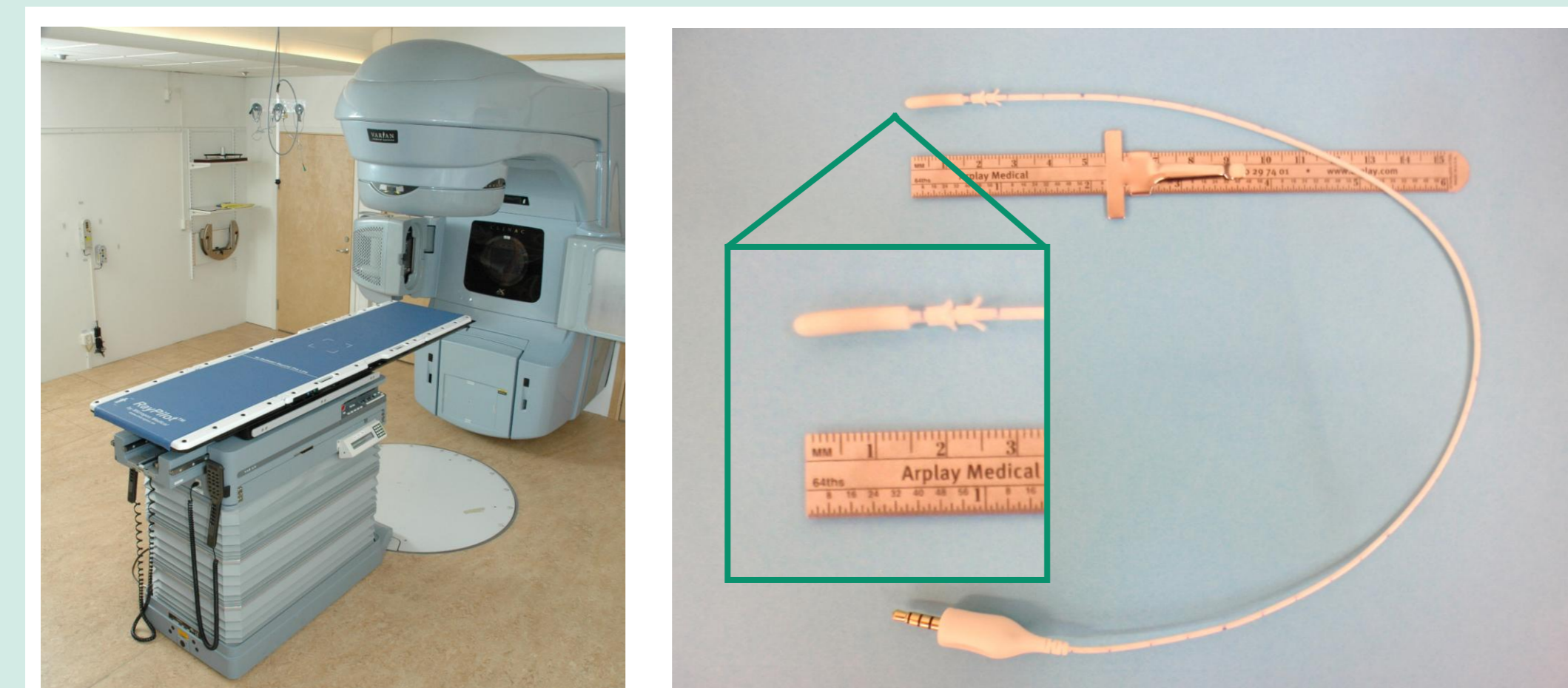


Figure 2. Layout of the system. The receiver consists in a flat bed placed on the usual linac treatment bed. The receiving antennas are located in an area in correspondence with the patient pelvis. The transmitter is a 17-mm long by 3-mm wide.

Both interfraction and intrafraction motion displacements were recorded (Figure 3).

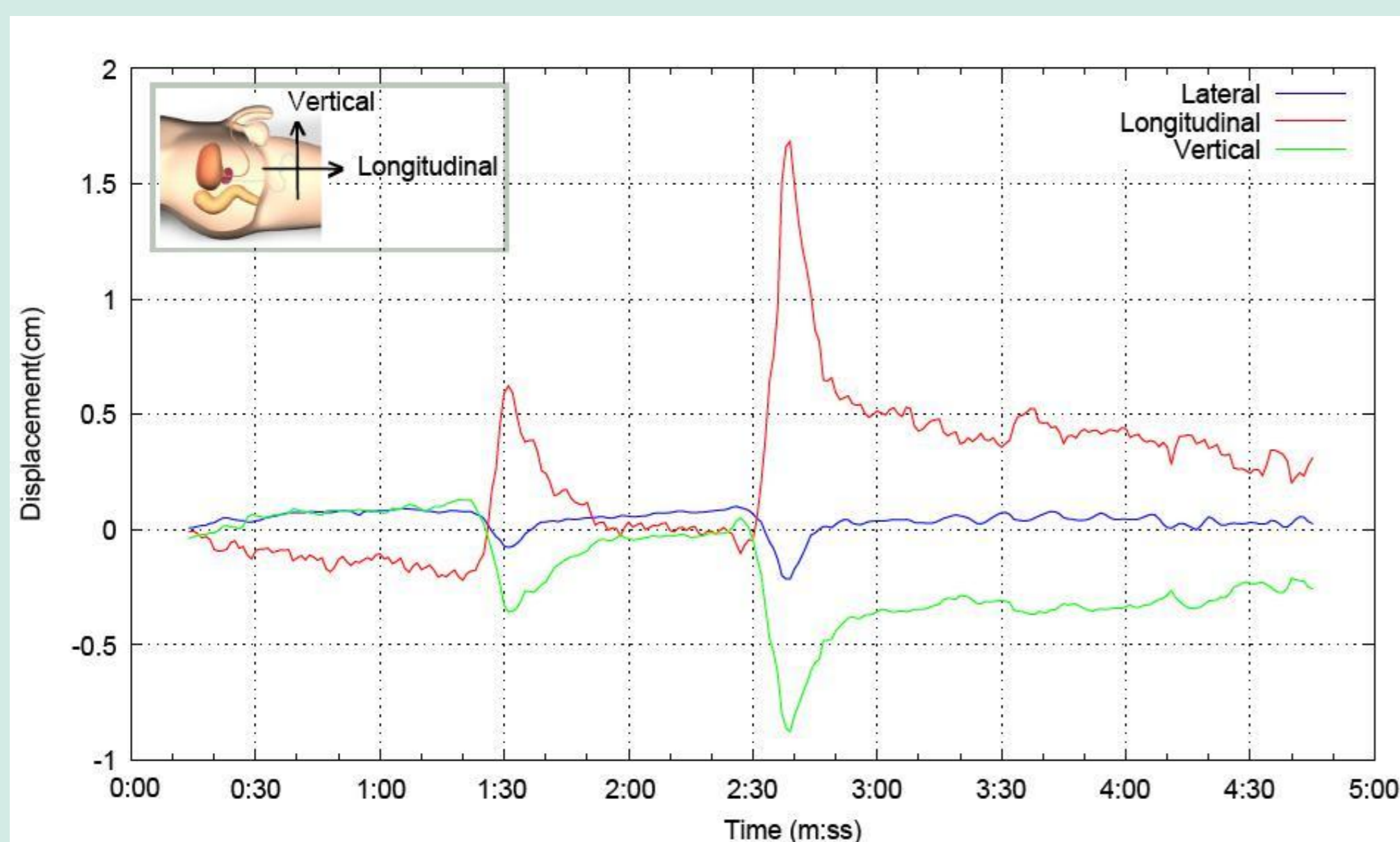


Figure 3. Recorded intrafraction displacement. A transient excursion of about 20 seconds duration is shown.

The plan robustness analysis function in CERR (Computational Environment for Radiotherapy Research, Washington University) was used to simulate the DVH uncertainty with measured systematic and random shifts. PTV coverage and dose ranges were evaluated for a set of Organs At Risk (Figure 4).

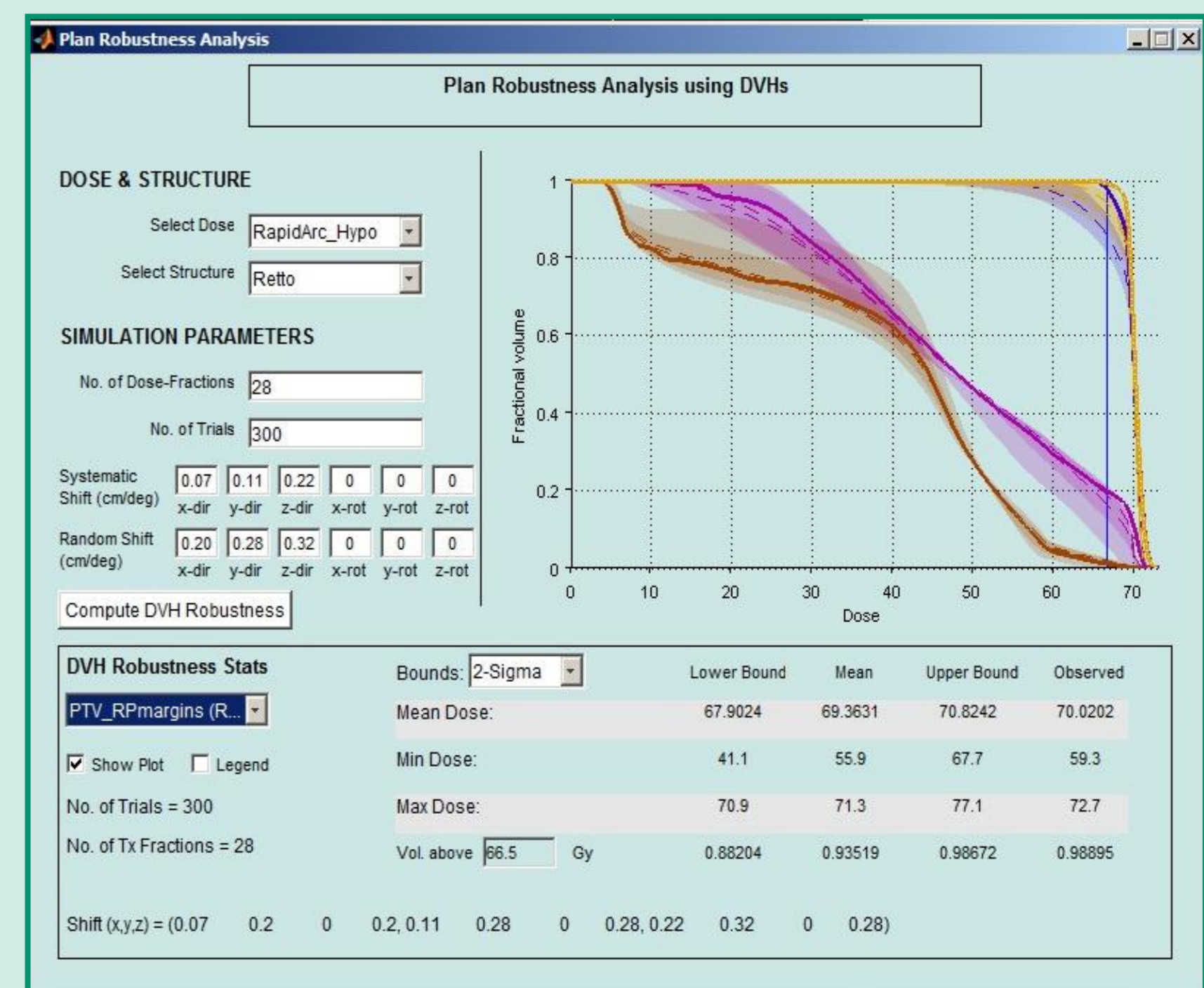


Figure 4. Example of plan robustness analysis with CERR.

## Results

Transient excursions, typically within 20 seconds duration, and drifts of the prostate gland were observed during treatment. Spatial displacements > 11 mm in the cranial-caudal direction were identified in 1 patient, > 4 mm in the cranial-caudal and anterior-posterior directions in 3 patients, < 4 mm in the remaining patients. Evaluated CTV-to-PTV margins are shown in Table 1. Concerning robustness plan analysis, more than 98% of PTV is covered by 95% of prescription dose. The mean values of the DVH uncertainty ranges (upper / lower range bound with respect to the planned dose) is (+1.5% ; -2%) and (+2.7%; -13.1%) at  $V_{68Gy}$  for rectum and at  $V_{60Gy}$  for bladder respectively.

Measured interfraction motion (cm)				Measured intrafraction motion (cm)			
	AP	CC	LR		AP	CC	LR
Mean	-0,027	-0,075	0,026	Mean	0,005	0,011	0,008
$\Sigma_{inter}$	0,098	0,222	0,072	$\Sigma_{intra}$	0,044	0,027	0,026
$\sigma_{inter}$	0,221	0,296	0,183	$\sigma_{intra}$	0,188	0,123	0,084
Margins (cm)							
	AP	CC	LR		AP	CC	LR
Excluding intrafraction motion	0,401	0,763	0,309				
Including intrafraction motion	0,472	0,784	0,333				
Difference	0,071	0,021	0,024				

Table 1. Evaluated prostate margins for a group of 9 patients. AP= anterior - posterior; CC = cranial - caudal; LR = left - right.  $\Sigma$  = systematic error,  $\sigma$  = random error

## Conclusions

This prospective study suggests: a) intrafraction motion impact on treatment margins should be considered; b) variation in DVH analysis for bladder and rectum are not negligible. Therefore target repositioning or beam-gating techniques should be considered in the therapy execution protocol.

## References

- [1] van Herk et al, *The probability of correct target dosage: Dose population histograms for deriving treatment margins in radiotherapy*. Int J Radiat Oncol Biol Phys 2000;47:1121-1135
- [2] Litzenberg D et al, *Influence of intrafraction motion on margins for prostate radiotherapy*, Int J Radiat Oncol Biol Phys 2006;65, 2:548-553