

Real-time imaging in prostate radiotherapy has value beyond SBRT: an examination of intrafraction motion

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Introduction

- Intrafraction motion (IFM) of the prostate commonly occurs during radiotherapy.¹
- While intrafraction imaging is recommended for prostate stereotactic body radiation therapy (SBRT)², its use in moderately hypofractionated regimens are less established.
- The aim of this study was to track fiducial marker (FM) positions using intrafraction imaging to assess IFM in moderately hypofractionated patients.

Methods

- The Varian intrafraction motion review (IMR) software was used to acquire kilovoltage (kV) images (Figures 1 and 3) every 3 seconds during VMAT delivery for 50 prostate patients prescribed 60 Gy in 20 fractions.
- A 5 mm tolerance was applied to FM position resulting in treatment interruption/intervention when any single FM exceeded this tolerance.
- IMR log files were retrospectively processed using in-house Python code to reconstruct FM position (Figure 2) and analyse IFM for 990 treatment sessions.
- Bladder and rectum volumes were contoured on daily cone-beam computed tomography (CBCT) images for 20 patients to assess any association with IFM.
- Additional features analysed in the IMR log filed included: frequency of mid-treatment interruptions/interventions, direction of IFM, inter-fiducial marker distance variation, and influence of time on treatment bed.

Results

- 74% of patients had at least 1 fraction where FM position exceeded a 5 mm tolerance.
- 12% of fractions required mid-treatment intervention due to FM(s) out of tolerance.
- The largest FM displacement recorded per fraction were most commonly in the Anterior/Posterior and Superior/Inferior directions (Figure 5).
- 25% of interventions occurred on the first triggered image (i.e. motion occurred between CBCT registration and beam-on). Fractions requiring intervention had a median time of 14 seconds longer between CBCT and the first image (Figure 6).
- 14 patients had at least one FM located at the periphery of the prostate which was found to result in variation in the inter-maker distance due to deformation of the prostate.
- Despite the use of bladder protocols, large variations in day-to-day volumes were observed (Figure 7).
- Rectal matter or gas was observed on some CBCTs (Figure 8) but association with treatment interruption was minimal.

Real-time imaging for prostate intrafraction motion has value in moderately hypofractionated radiotherapy.

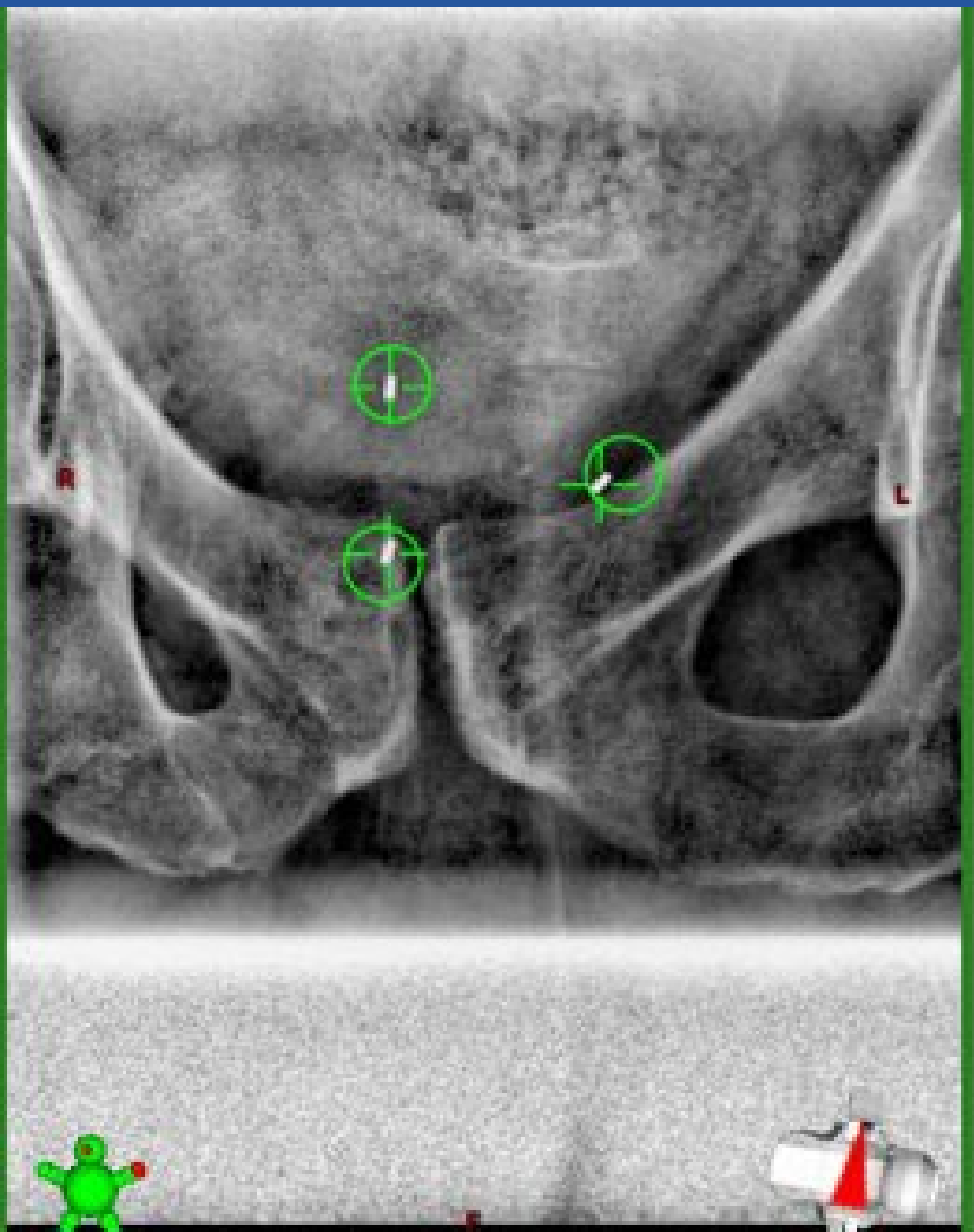


Figure 1: KV Triggered image within threshold. Green indicates prostate FM within threshold.

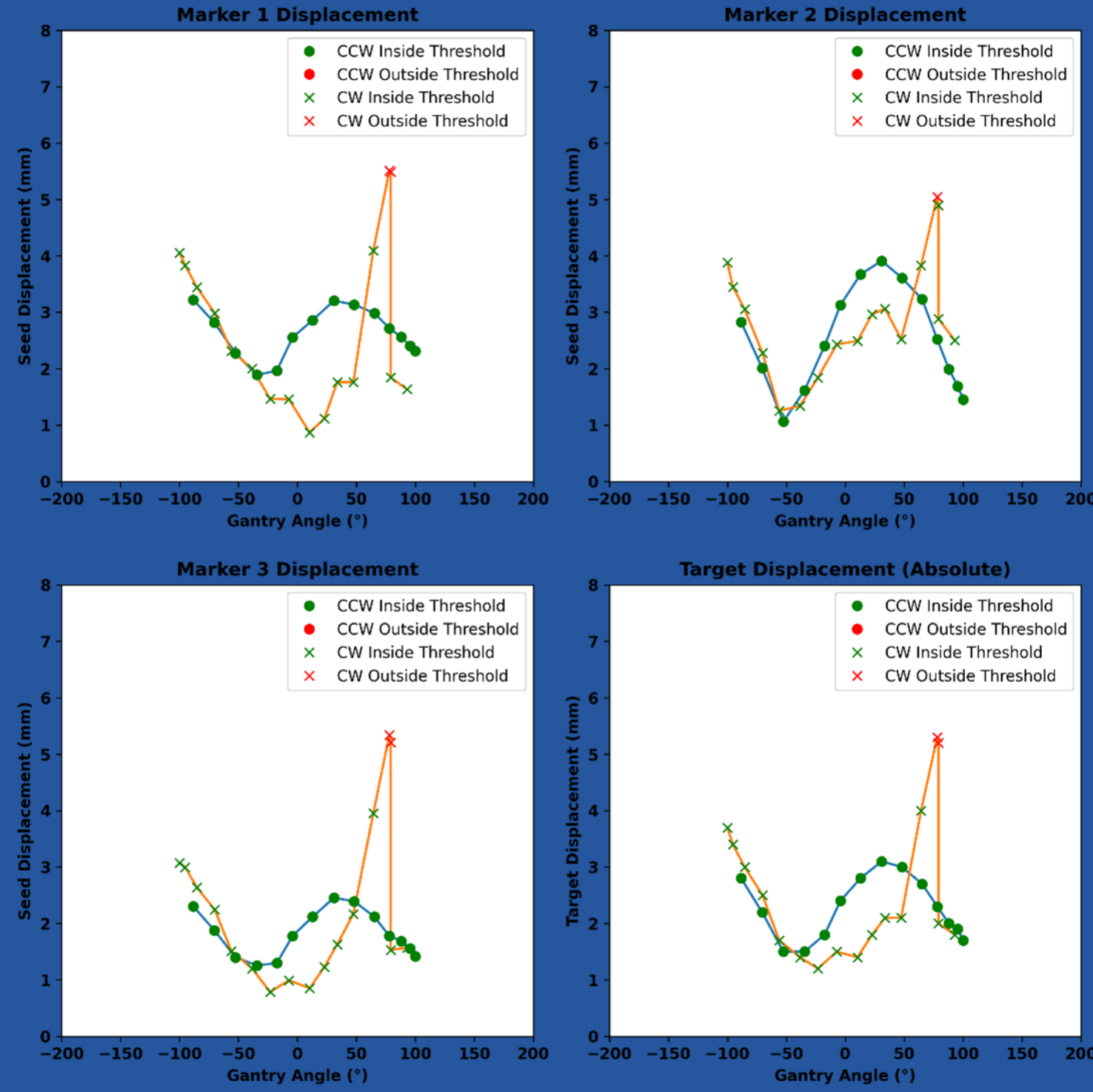


Figure 2: FM Displacement. Red indicates when FM went outside threshold, requiring an intervention to proceed treatment.

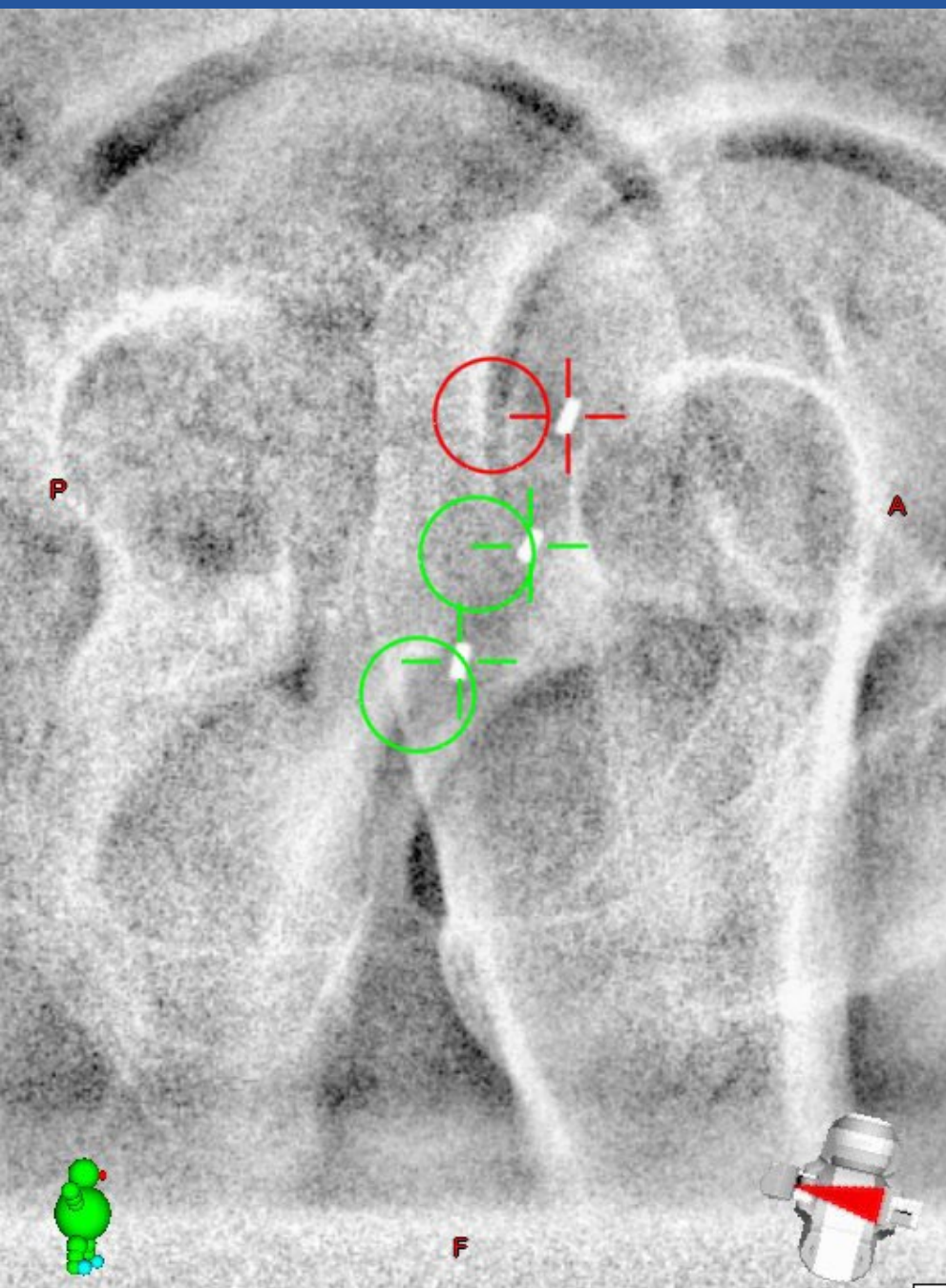


Figure 3: KV triggered image out of threshold. Red indicates prostate FM out of tolerance.

Delivery interruptions	Number of fractions (% of total fractions)
At least one intervention required	116 (12%)
Multiple interventions required	27 (3%)
Fiducial markers out of tolerance on first projection (start of Treatment)	29 (*25% of intervention fractions)
No. of patients with interruption on ≥ 1 #	37 / 50 (74%)
No. # with intervention per patient	0 - 11 #

Figure 4: Frequency of treatment interruption

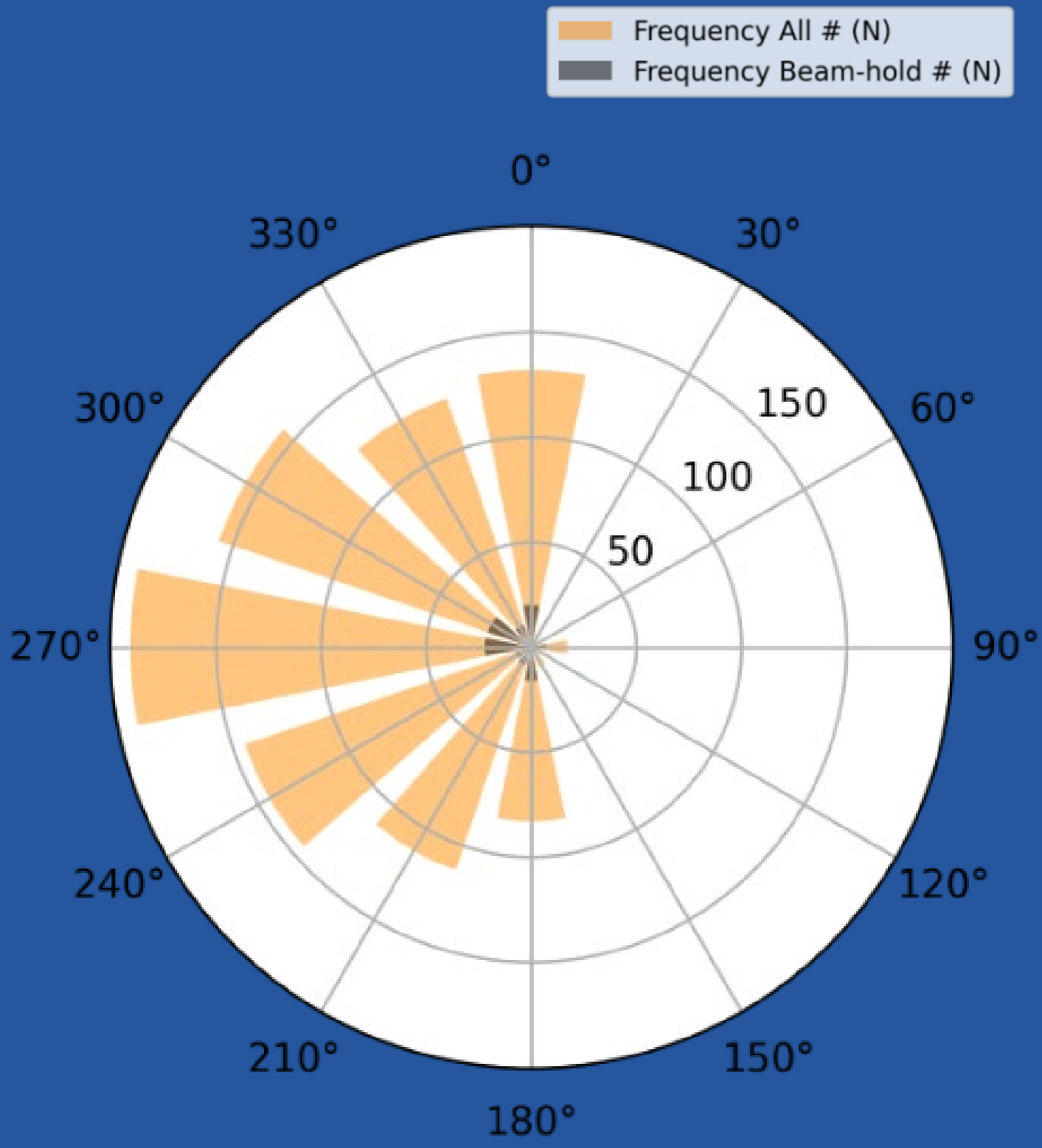


Figure 5: KV angles of maximum FM displacement.

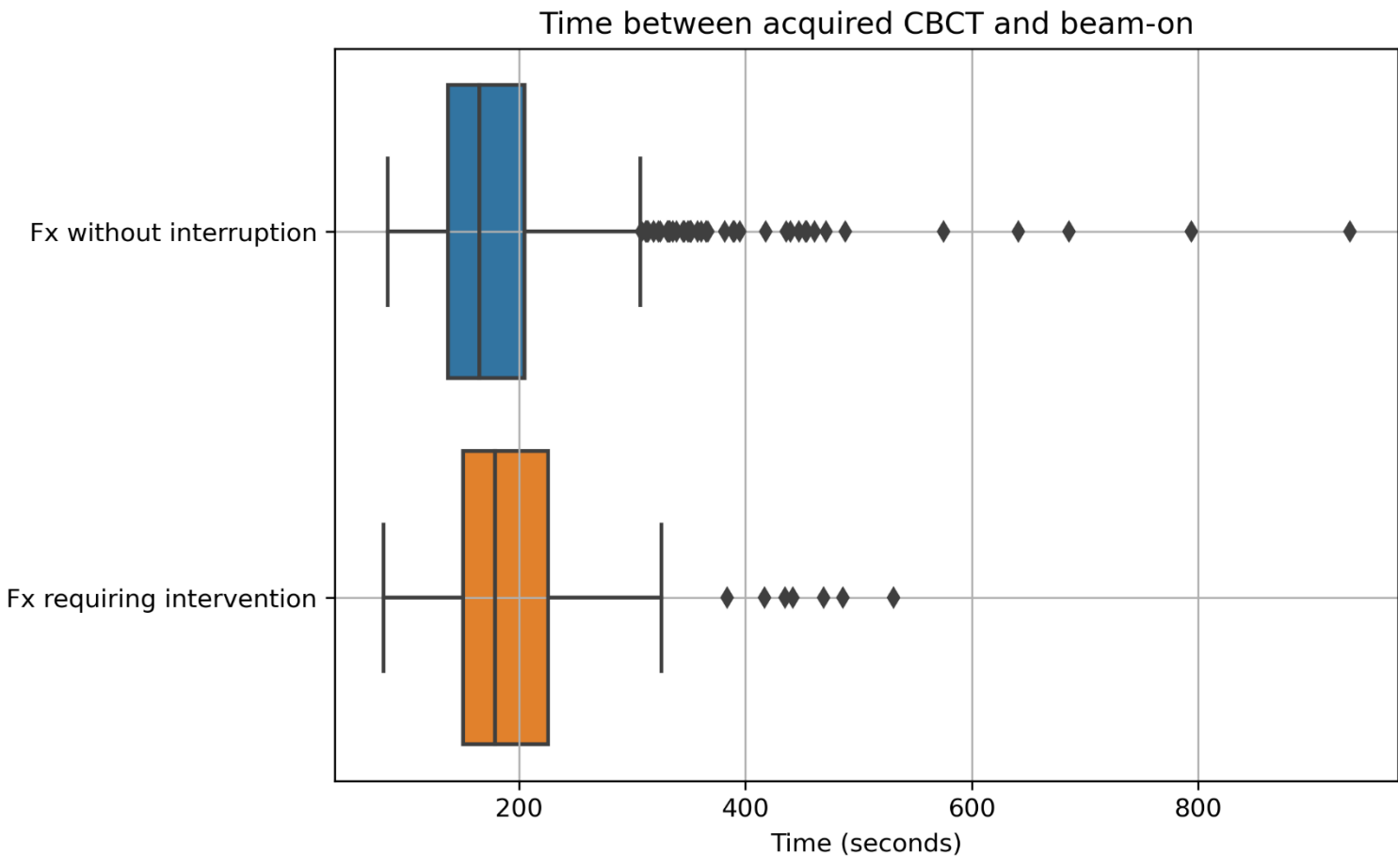


Figure 6: Time on bed. Time between CBCT match and first triggered image.

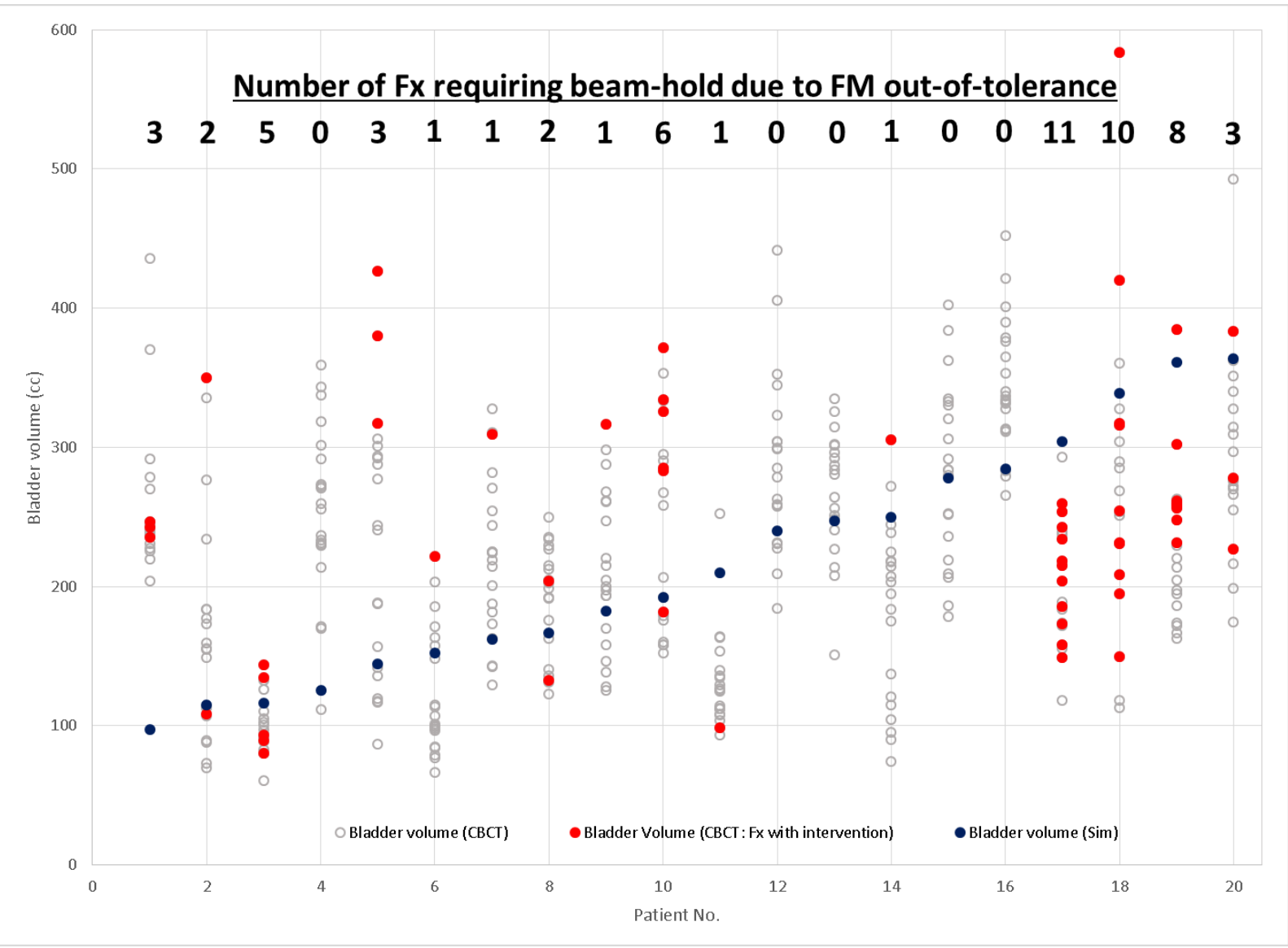


Figure 7: Bladder volume. Blue indicates volume of bladder at CT. Red indicates the bladder volumes when beam-holds occurred during treatment.

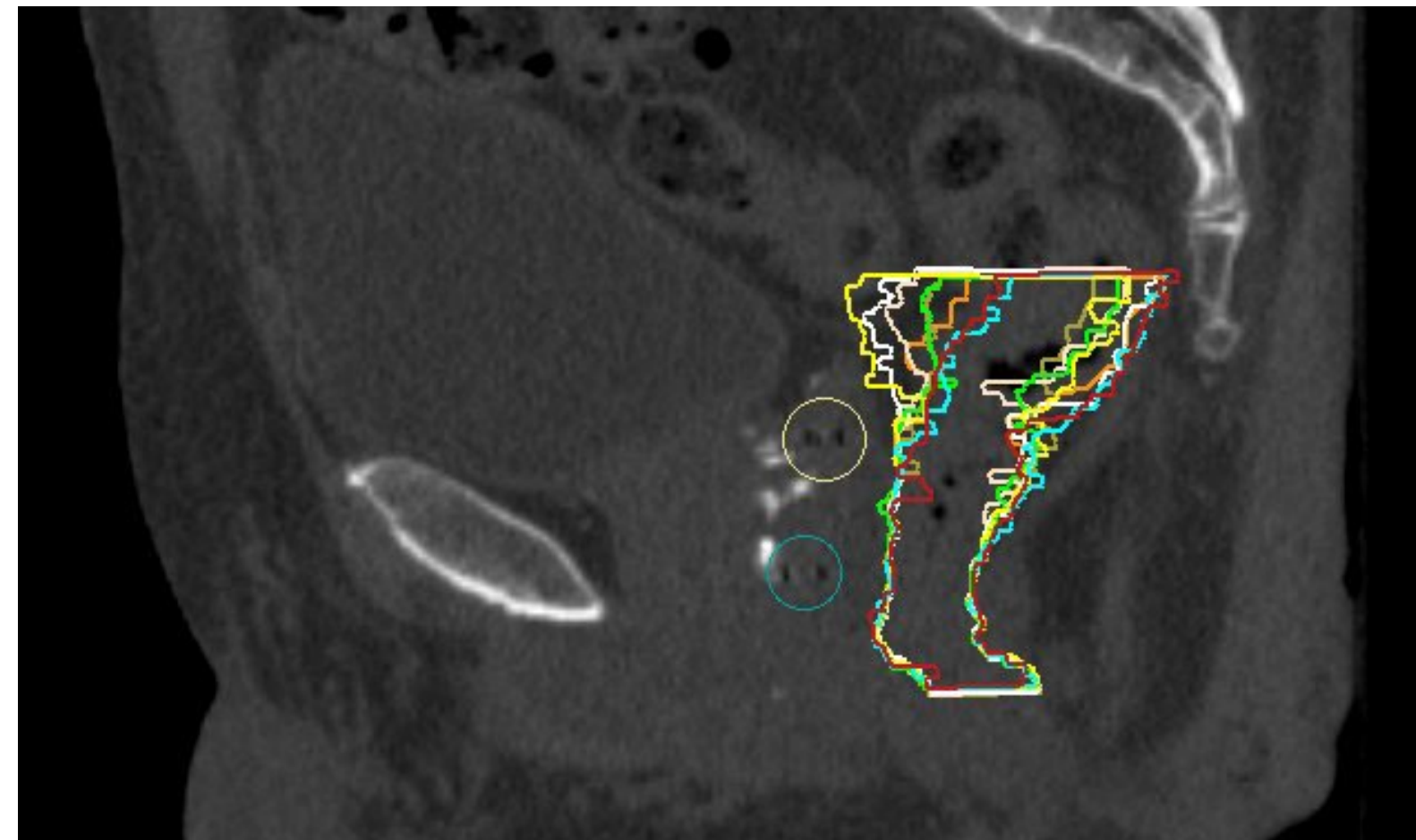


Figure 8: Rectum volumes. Rectal contours for each treatment CBCT.

Conclusion

- Despite larger planning target volume margins than SBRT, the frequency of interventions observed in our study support real-time imaging in moderately hypofractionated prostate treatment.
- Examining CBCT information with FM positional data allowed a robust analysis of potential influences on IFM.
- Our study observed more frequent interventions for very large and small bladder volumes. This is consistent with evidence supporting the aim of a consistently "comfortably full" bladder.^{3,4}

References

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