

A phantom validation of Deep Inspiration Breath Hold with Triggered Imaging for stereotactic body radiotherapy of mobile tumors in the thorax and abdomen

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Innovation/Impact:

To the best of our knowledge, for the first time we are able to combine the advantages of surface guided radiotherapy (SGRT), in particular, using DIBH, with the advantages of triggered imaging often applied when implanted fiducial markers are used in the stereotactic body radiotherapy of mobile abdominal/thoracic tumors. With DIBH, we can freeze the motion and therefore reduce the margins and with triggered imaging, we ensure that radiation is being delivered to the actual internal SBRT target. Very important given the magnitude of dose and gradients involved in SBRT.

Methods

Surface guided radiotherapy (SGRT) from LAP LUNA 3D and Triggered Imaging from Varian TrueBeam were utilized. A cosine trajectory with a 1cm amplitude and a DIBH amplitude of 2cm with a 20s breath hold was programed for a lung phantom target trajectory representative of a DIBH patient on the CIRS motion platform. At CT simulation, the primary image and reference breath-hold surface were acquired. The target fiducial was contoured and a Triggered-Fiducial-1mm contour generated, namely the contoured fiducial with a 1mm margin. A 2-arc VMAT plan was generated and delivered on the Varian TrueBeam. Initial setup was with respect to breath-hold CBCT which was then verified using surface guidance. Triggered imaging was set with image acquisition every 45 degrees. To ensure that a triggered image is acquired at the beginning of each breath-hold, beam off, rather than beam hold was implemented each time the BH duration elapsed before the planned MU could be delivered

Results

Initial setup using BH CBCT agreed well when compared with setup using SGRT DIBH to within 0.04cm, 0.04cm, -0.11cm in the vertical, longitudinal, and lateral directions and -0.3deg, 0.2deg, and -1.0deg in yaw, pitch and roll respectively. The entire treatment was delivered successfully with the acquired triggered images showing the visible fiducial always inside the Triggered-Fiducial-1mm contour and the SGRT parameters within threshold throughout.

Conclusion

We have successfully designed and validated a workflow combining DIBH and triggered imaging. The presented phantom validation has enabled us to successfully treat our first liver SBRT patient utilizing DIBH complemented with triggered imaging.

Purpose

Deep inspiration breath hold (DIBH) using surface guidance can be useful as a motion management strategy but for high dose, steep gradient modalities such as SBRT, it is important to compliment it with active motion management using triggered imaging of the internal target. In this study, we designed and validated a phantom study that accomplished this.

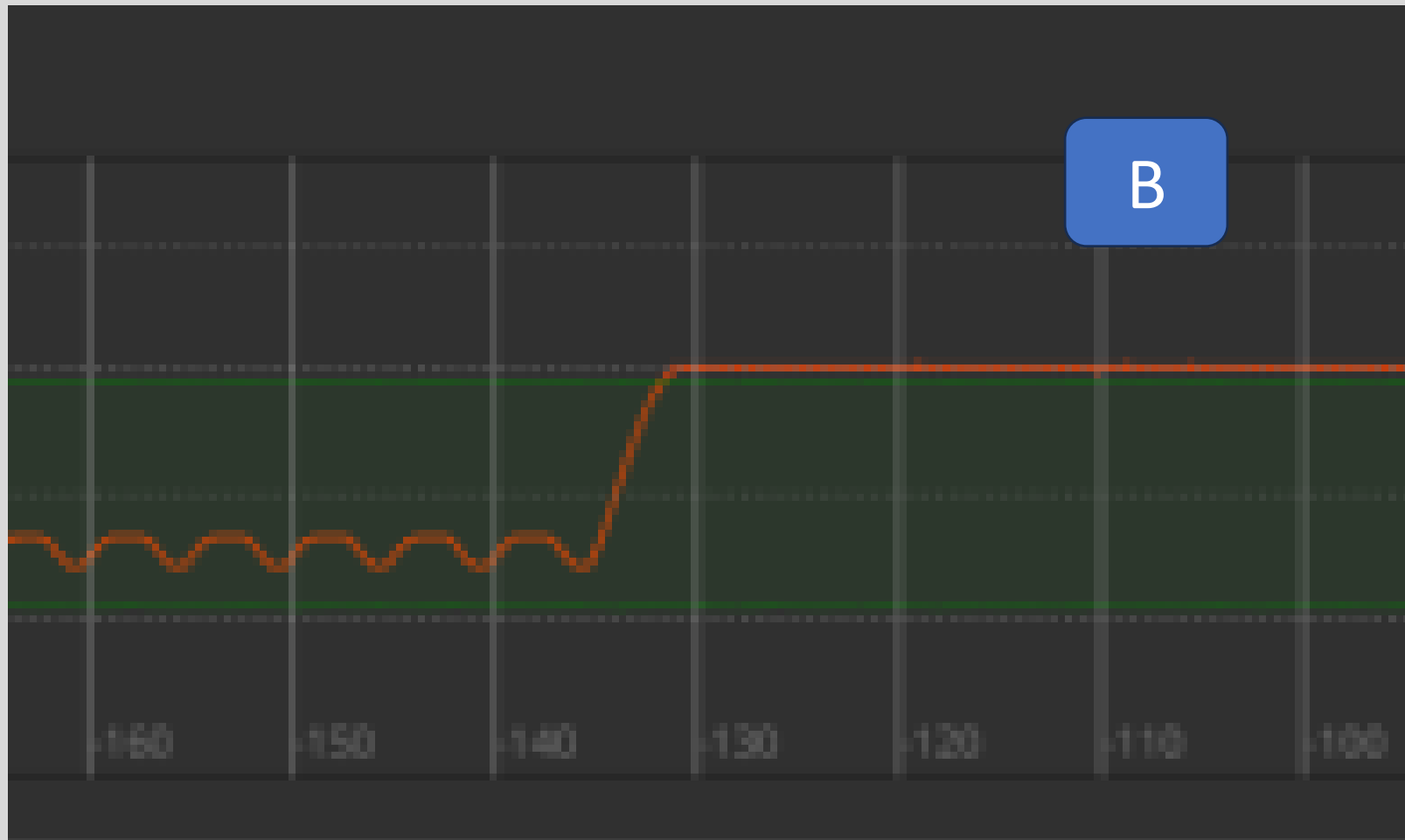
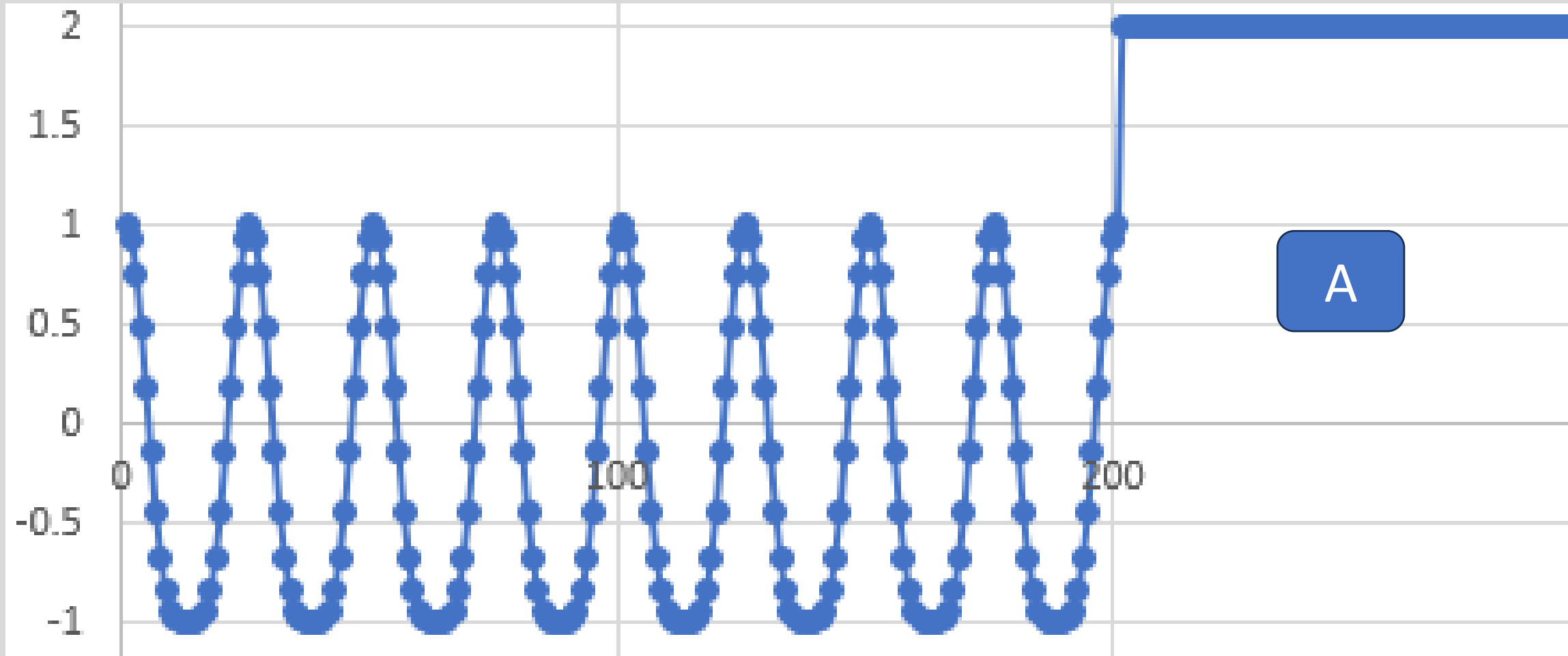


Figure A shows the trajectory we programmed into the CIRS motion platform. Figure B shows how this trajectory was replicated as read by LAP LUNA 3D.

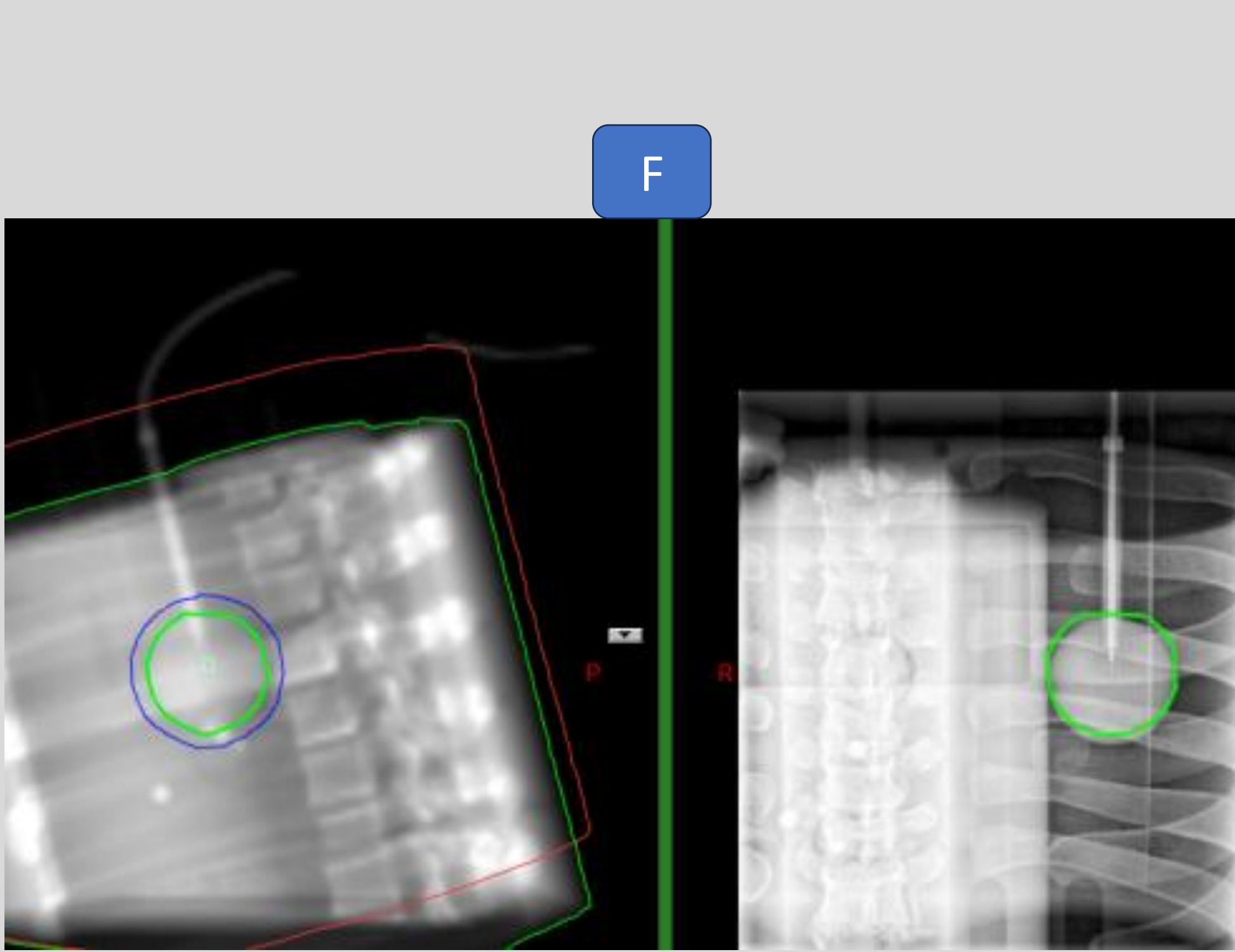
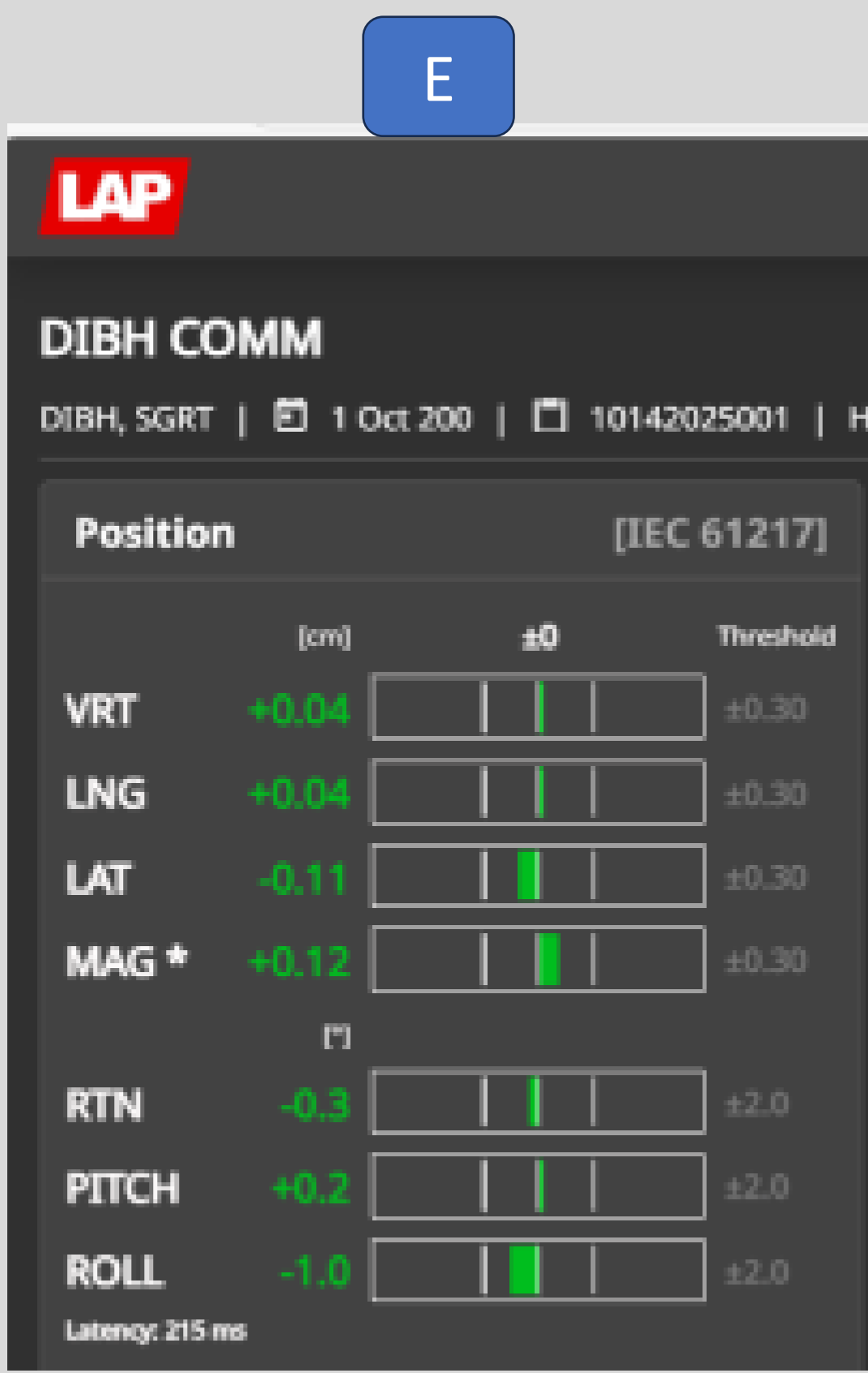
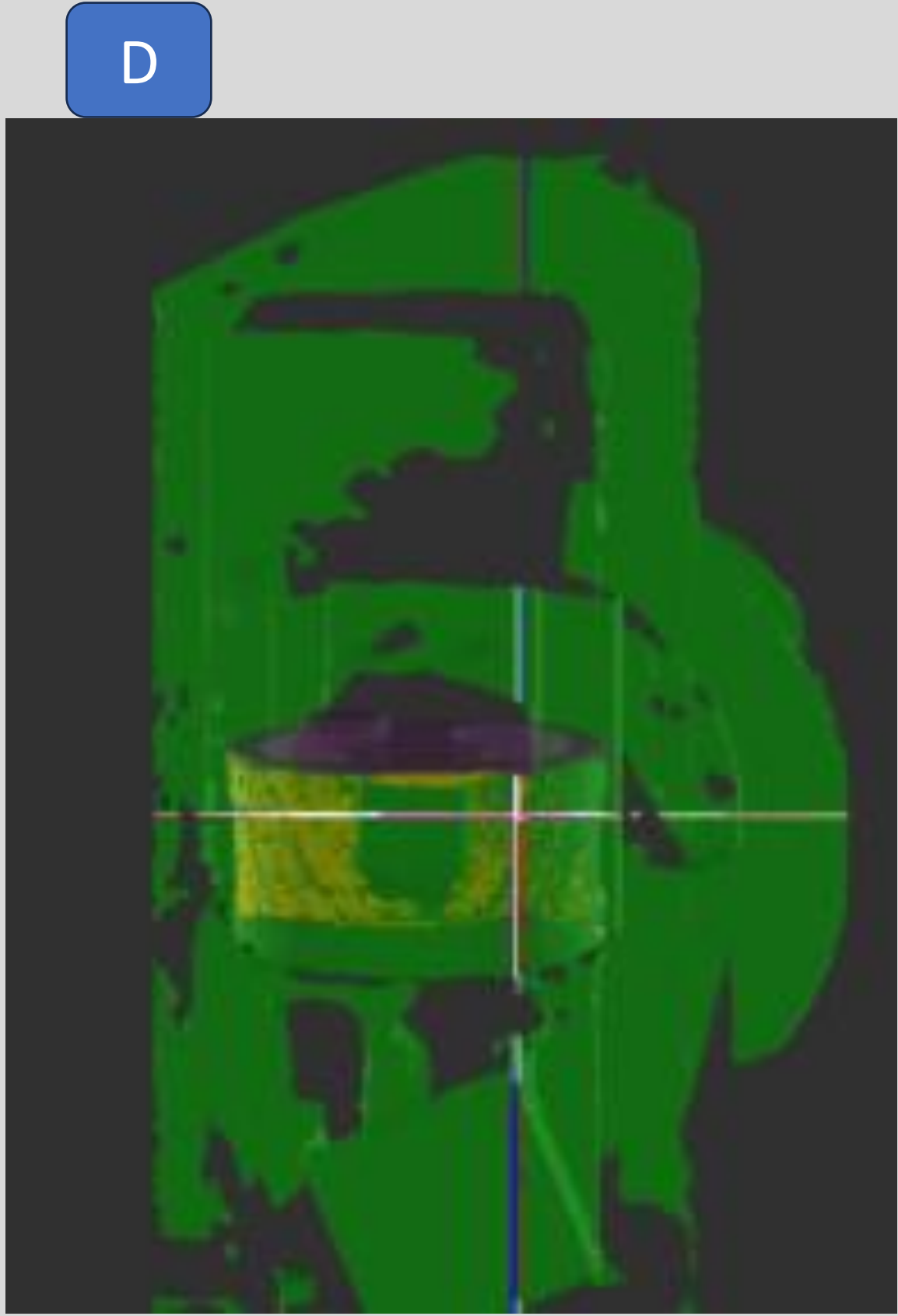
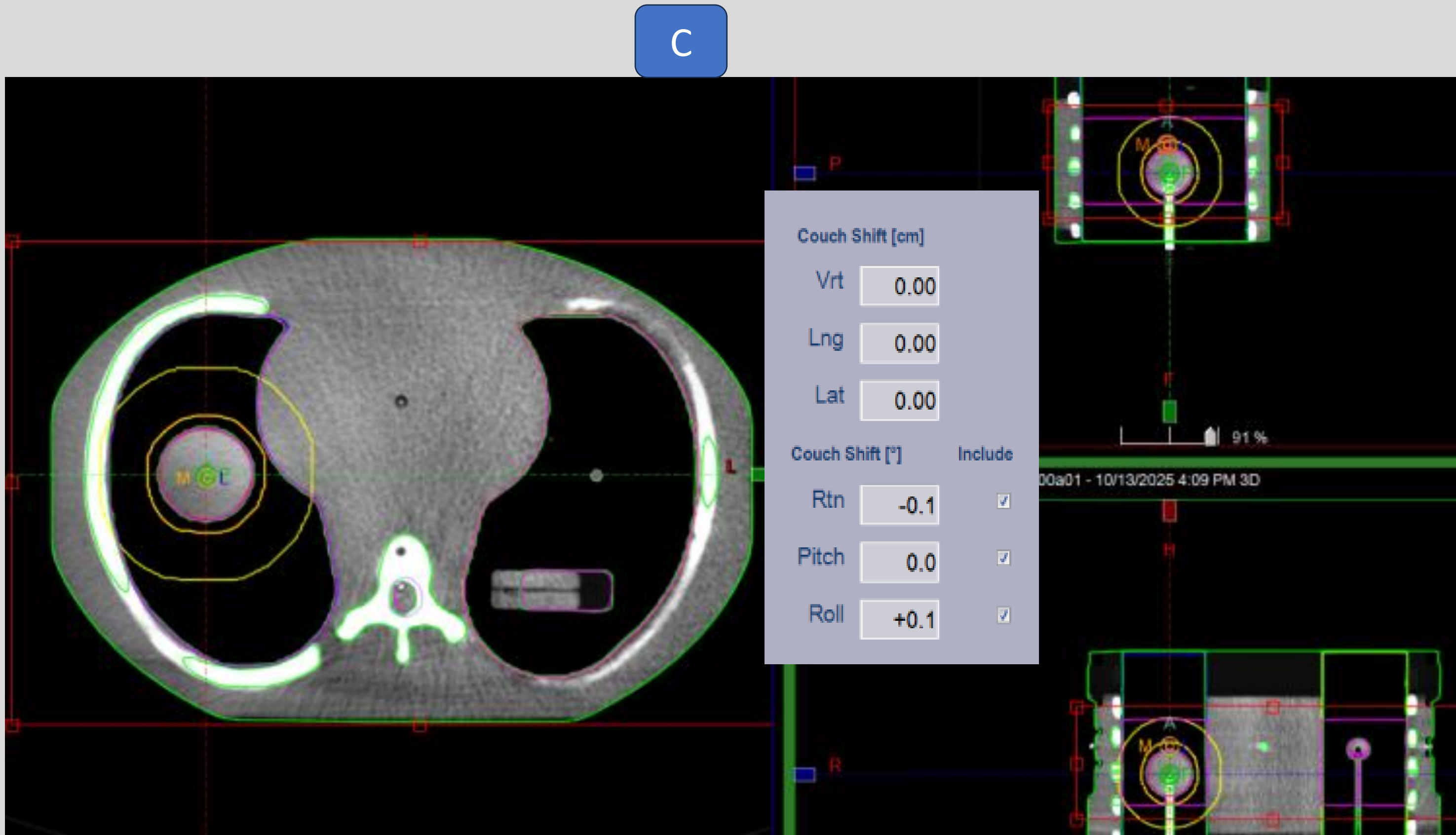


Figure C shows the CBCT setup using breath hold. Figure D shows the acquired breath-hold surface using LAP LUNA 3D. Figure E shows the results of surface setup verification thus showing that it agrees with the CBCT set up. Figure F shows a sample acquired triggered image showing that the fiducial is within the Triggered-Fiducial-1mm contour. Note that we used the visible lung tumor as our fiducial for the phantom study.