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# Clinical Commissioning of Surface-Guided Manual Gating for Deep Inspiration Breath Hold (DIBH) Breast Radiotherapy on Ethos and Halcyon Systems


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## INTRODUCTION

Deep-inspiration breath-hold (DIBH) with surface-guided radiotherapy (SGRT) is widely used for cardiac-sparing breast radiotherapy, relying on automated beam gating to halt the beam whenever the monitored surface moves outside tolerance. Ethos and Halcyon (O-ring) platforms, however, lack an automated gating interface — without it, breast DIBH would otherwise be restricted to free-breathing technique. Manual gating, where a therapist holds the beam based on the AlignRT real-time delta (RTD), offers a workaround, but its response time — combining system latency and human reaction — is difficult to quantify.

This work commissions a manual beam-gating procedure for breast DIBH on Ethos and Halcyon, evaluating dosimetric consistency through an end-to-end (E2E) test and quantifying manual beam-hold response time through retrospective log-file analysis, to provide the empirical basis for defining safe gating windows.

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## METHODS AND MATERIALS

Following TG-142 guidance, beam output consistency was evaluated by comparing gated and static deliveries. A surface-guided manual gating procedure was developed and validated through an end-to-end (E2E) test using a representative breast VMAT DIBH plan (3 arcs, 520 cGy × 5 fraction).

Respiratory motion was simulated using the QUASAR motion platform driven by a patient breathing trace. A 2D array detector was placed on the platform to capture superior-inferior motion, while the associated anterior-posterior motion of a styrofoam surrogate was monitored using AlignRT.

During delivery, a radiation therapist (RTT) continuously monitored the AlignRT real-time delta (RTD) and manually held the beam when the gating tolerance (±3 mm in translational directions) was exceeded, resuming beam once the surface returned within tolerance.

**Dosimetric evaluation:** Isoplane doses of the reference (static phantom) and gated (moving phantom) deliveries were compared using gamma analysis (3%/2 mm criteria) and dose profiles along isocenter dose plane.

**Timing analysis:** RTD timestamps at out-of-tolerance states were compared with beam-hold events extracted from machine log files. Computer clocks were periodically calibrated, with both systems synchronized within 0.3 seconds, to ensure accurate retrospective timing analysis.

## DISCUSSION

The close temporal alignment between beam-on/off transitions and RTD trace excursions (Figure 1) confirms that manual beam-hold intervention responded reliably to AlignRT tolerance status, supporting the dosimetric equivalence observed in the gamma analysis (Figure 2).

Because the measured response time reflects both SGRT system latency and therapist reaction time, it represents a realistic, clinically achievable benchmark rather than a theoretical best case.

Timing analysis depended on keeping AlignRT and machine-log clocks synchronized, so periodic clock calibration was built into the workflow and can support ongoing QA using the same log-file comparison.

## RESULTS

**Beam output consistency:** The difference in beam output between gated and non-gated deliveries was ≤0.1%.

**Beam-hold response time:** Across nine manual beam-hold interventions, the average response time was 0.602 s (range: 0.179–0.905 s).

**Timing correlation:** The timestamp overlay of the AlignRT anterior-posterior RTD and the LINAC's beam-on/off status (Figure 1) showed close alignment between the beam-on edge and the drop of the RTD trace, demonstrating responsive manual beam-hold intervention based on AlignRT tolerance status.

**Dosimetric agreement:** Gamma analysis (3%/2 mm) comparing gated deliveries with the static reference showed Gamma passing rates of 100%, 98.5%, and 98.8% for the three fields of the breast VMAT plan (Figure 2).

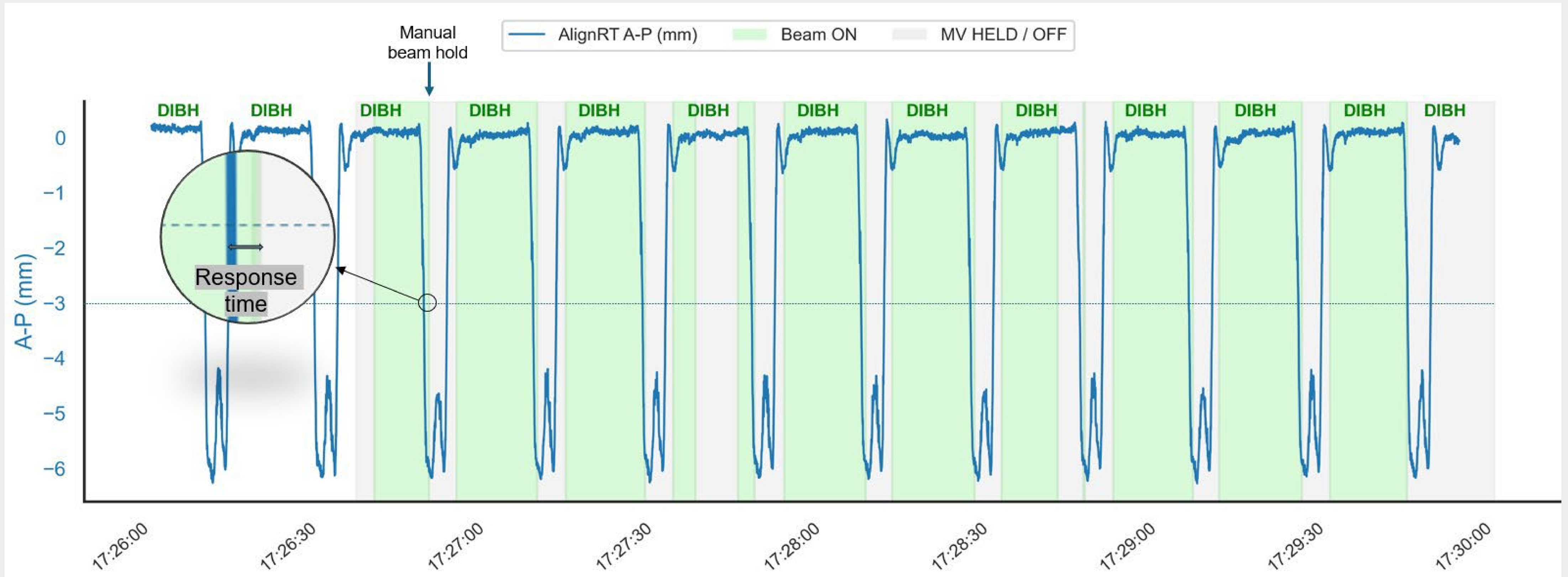


**Figure 1.** Beam On/Off status from the LINAC log file (green shaded area) and AlignRT vertical real-time delta (RTD, blue line) during the end-to-end testing of a manually gated delivery of a breast DIBH VMAT plan.

**Table 1.** Label in 24pt Arial.

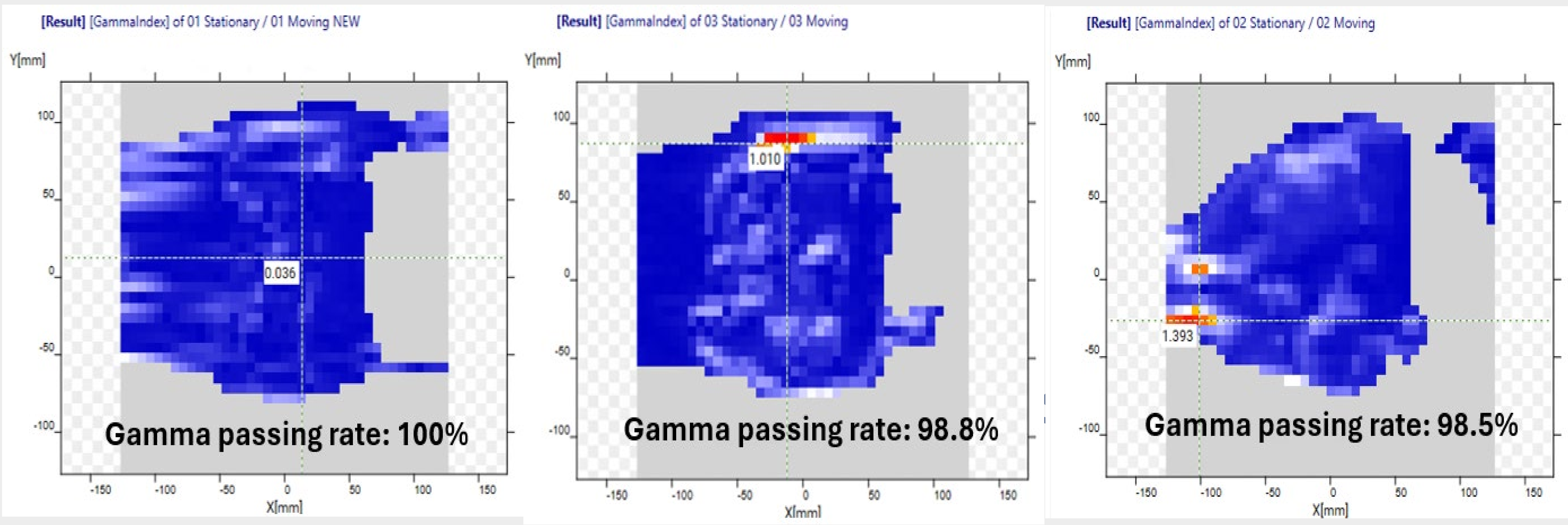


**Figure 2.** Gamma analysis and dose profiles along the selected axis comparing reference (stationary phantom) and gated (moving phantom) deliveries of three representative VMAT breast field.

## IMPLEMENTATION

In real patient treatment, a proactive delivery strategy was implemented, in which therapists preemptively paused the beam after a certain breath-hold duration — anticipating the onset of exhalation — and then instructed the patient to release breath-hold, further reducing reliance on reactive response time alone.

Since the workflow relies heavily on RTT operation at the machine, physicists and RTTs collaborated closely on developing, testing and implementation on RTT workflow.

Treatment delivery uses a two-RTT model — one controls the beam, one monitors AlignRT deltas and breath-hold stability.

## CONCLUSION

In the absence of automated beam control on O-ring platforms, commissioning of surface-guided manual gating is necessary for breast DIBH delivery. Manually gated DIBH demonstrated dosimetric equivalence to static delivery and sub-second response times, supporting its safety and clinical feasibility for breast DIBH treatments. Careful monitoring of manual beam-holds is required during clinical implementation, particularly for patients with inconsistent breath-hold reproducibility.

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