Investigation of a novel method to quantify respiratory-gated beam-latency on TrueBeam Linear Accelerators

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INTRODUCTION

- Respiratory motion introduces target position uncertainty during thoracic and abdominal radiotherapy
- Respiratory gating synchronizes radiation delivery with selected phases of the patient's breathing cycle
- Beam latency is the delay between a gating signal and radiation beam response[1]
- Excessive latency reduces gated treatment accuracy
- Motion assessment using on-board kV imagers allows for day-of motion verification, but suffers from poor tumour contrast

A modified QUASAR respiratory motion phantom can enable direct measurement of respiratory gating beam latency

OBJECTIVES

1) **Demonstrate a novel method of quantifying respiratory gating beam-on and beam-off latency for Siemens/Varian TrueBeam linear accelerators**
2) **Assess the impact of dose rate and machine-specific factors on overall timing performance.**

METHODS

- Figure 1 outlines the components of the Gating Latency System
- Modified QUASAR Respiratory Motion Phantom (IBA QUASAR, London, Canada) used to simulate clinically relevant respiratory motion.
- Phantom was driven by sinusoidal motion (20mm peak-to-peak and 15 breaths per minute
- A proprietary pulse conditioning circuit receives a target pulse from the TrueBeam system and the signal is converted into a TTL beam-status signal.
- TTL output synchronized beam status with phantom motion for latency measurements.
- New QUASAR Programmable Motion Phantom software used to control the phantom and to specify the "beam-on" and "beam-off" trigger amplitudes (Figure 2 Left).
- During gated Beam delivery, the triggers are representative as ticks on the waveforms (Figure 2 Centre).
- Latency = Time (Intended Trigger) – Time Actual Trigger (Figure 2 Right)
- Five TrueBeam linacs tested using gated 6FFF delivery at varying dose rates. Results shown in Figure 3.

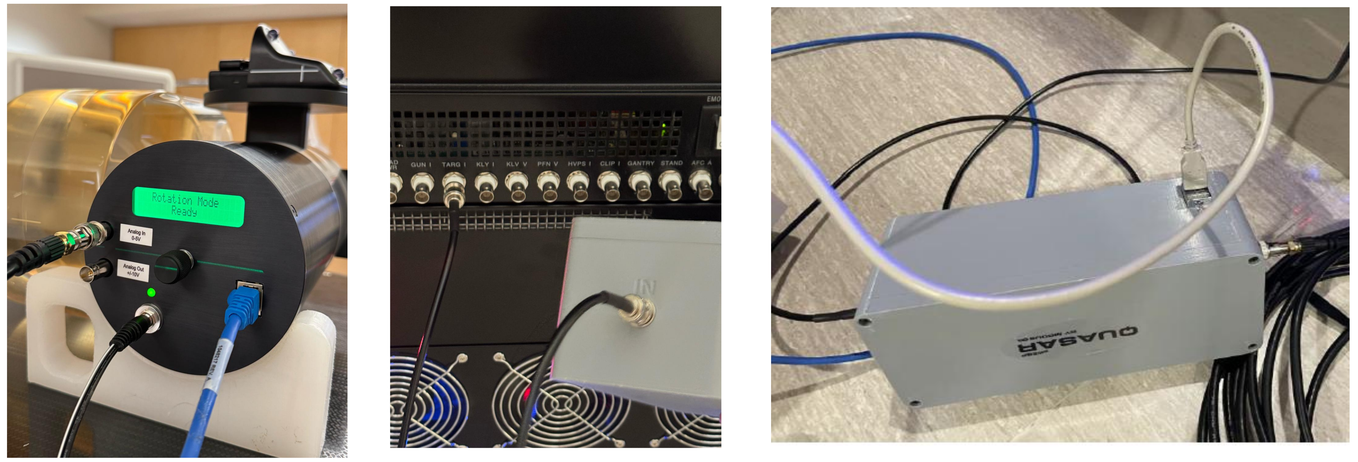


Figure 1: Left: The Modified QUASAR Respiratory Motion System; Centre: Coax Cable connecting TARG I OUT to the pulse conditioning circuit; Right: The Pulse Conditioning Circuit.

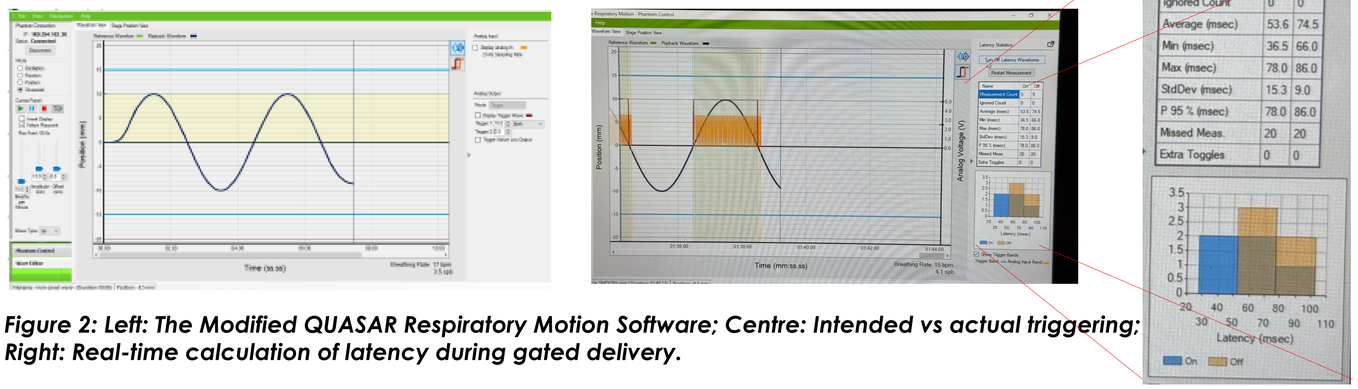
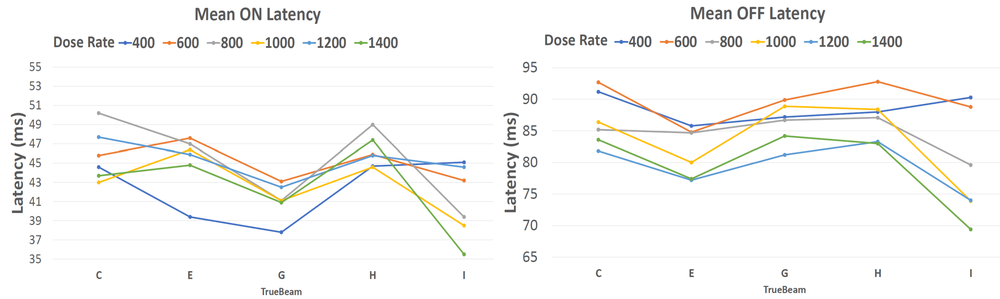


Figure 2: Left: The Modified QUASAR Respiratory Motion Software; Centre: Intended vs actual triggering; Right: Real-time calculation of latency during gated delivery.

RESULTS

Figure 3: Mean Beam-On (left) and Beam-Off latency measurements (left) for five different TrueBeams. Results indicate that beam-off latency is consistently higher than beam-on latency but all fall within the AAPM TG-142[2] consensus threshold of 100ms.



CONCLUSIONS

- Novel measurement technique enables robust characterization of respiratory gating latency
- Provides a framework for routine verification and multi-institutional comparisons

REFERENCES

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ACKNOWLEDGEMENTS

MODUS QA an IBA Dosimetry Company

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