

## BACKGROUND

Real-time adaptation, also known as motion synchronization or MLC tracking, is a method for managing intra-fraction motion.

This approach is implemented on the Accuray Radixact treatment unit as **Synchrony**. During delivery, the position of the target is monitored and modelled using frequent x-ray imaging, and for respiratory motion, LED markers. Targets are identified using fiducials or HU contrast against surrounding lung tissue.

The position of the jaws and MLCs are adjusted in response to the modelled position of the target, while maintaining the planned beam shape.

The verification of accurate real-time adaptation is critical, particularly as it is generally accompanied by a reduction in treatment margins.

AAPM TG-264<sup>1</sup> recommends that log files describing treatment delivery be recorded for use in post-treatment quality assurance and monitoring of system performance.

The departmental analysis of these treatment log file data was an action identified by a prospective hazard analysis performed for the Radixact Synchrony system<sup>2</sup>.

This study describes the use of in-house software<sup>3</sup> in identifying an error in leaf adaptation, and the verification of estimates of dose impact by measurements<sup>4</sup>.

1. Keall, DOI: 10.1118/1.2349696
2. Hindmarsh, DOI: 10.1002/acm2.70478
3. Crowe, DOI: 10.1007/978-3-032-20287-1\_21
4. Kairn, DOI:10.7759/cureus.83023

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# Post-Treatment Quality Assurance of Real-Time Adaptation Deliveries

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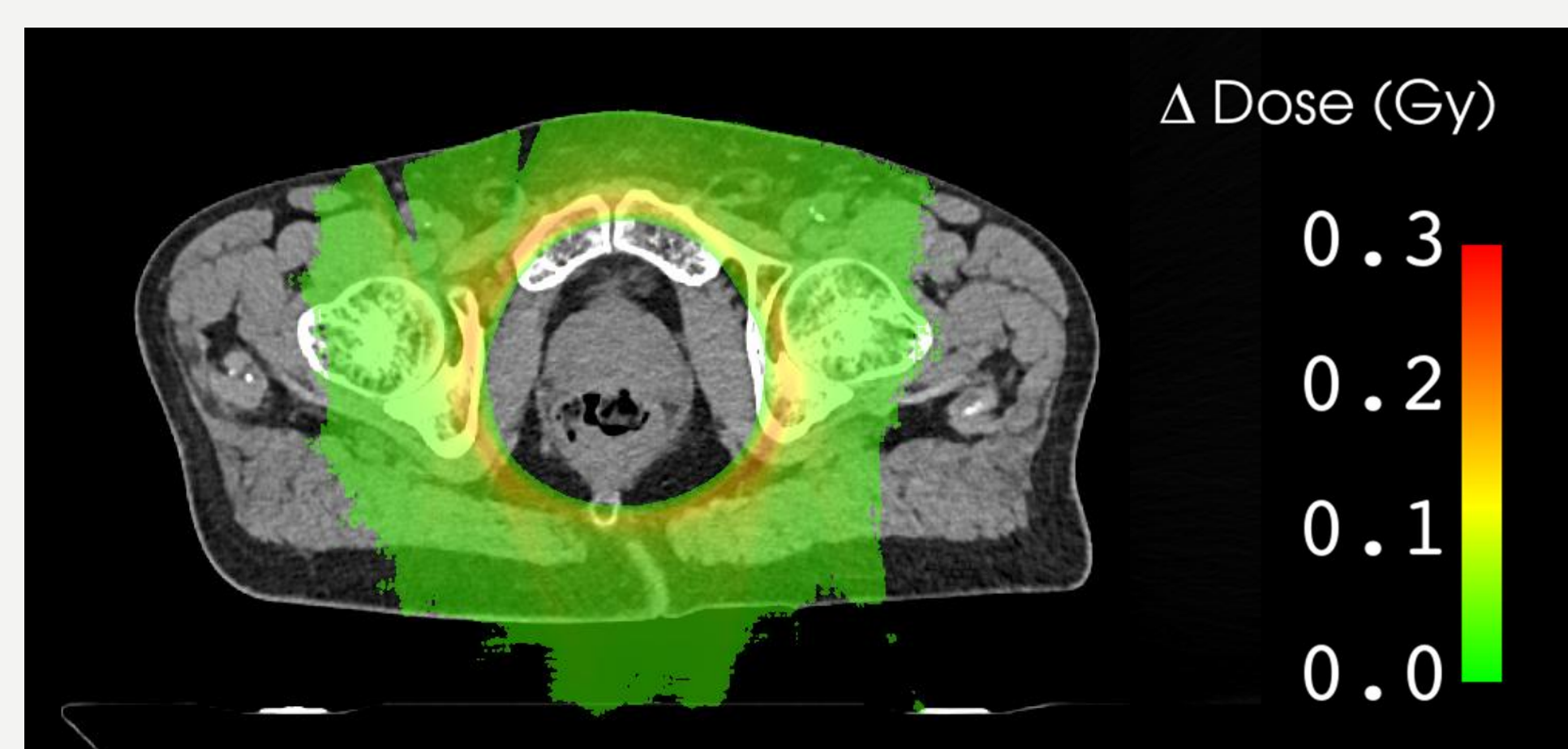
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## DATA ANALYSIS

Planning and telemetry (or log file) data were collected for Synchrony patient and phantom treatments in the department, using the Accuray Patient Data Extractor tool. In-house software<sup>3</sup> was used to extract Synchrony parameters, including motion traces and sinograms (or leaf open times). Data were exported in various tabular and plotted forms for quality assurance checking.

## LEAF ERROR

Analysis of patient treatment fractions resulted in the identification of erroneous leaf behavior. During 4 of 1366 (0.3%) patient treatment deliveries there was an additional leaf open when it should be closed, or vice-versa. The duration of the error was generally 0.5 to 1 gantry rotations, or 10-20 seconds. This issue was reported to Accuray for investigation. Departmental and Accuray estimates of potential dose error associated with these clinical errors was 0.3 Gy, as in the example in Figure 1.



**Figure 1.** Example of dose difference for a clinical plan as calculated by Accuray using their internal research CalcZilla tool (0.03 Gy threshold).

## VALIDATION

To validate the dose estimates, measurements were repeatedly performed for a 2 Gy/fraction 1 cm jaw plan using a PTW Octavius 1000 SRS detector array in a custom Octavius II phantom on a CIRS 1D motion platform<sup>4</sup>. The motion was a  $\pm 10$  mm cos4 amplitude wave form with 4 s cycle time waveform, translating to approximately 8 mm IEC-Y and 5 mm IEC-X motion due to a 30° rotation of the platform. This motion was able to trigger the error with a frequency of approximately 3%. Results of 1 measurement are shown in Figures 2 and 3.

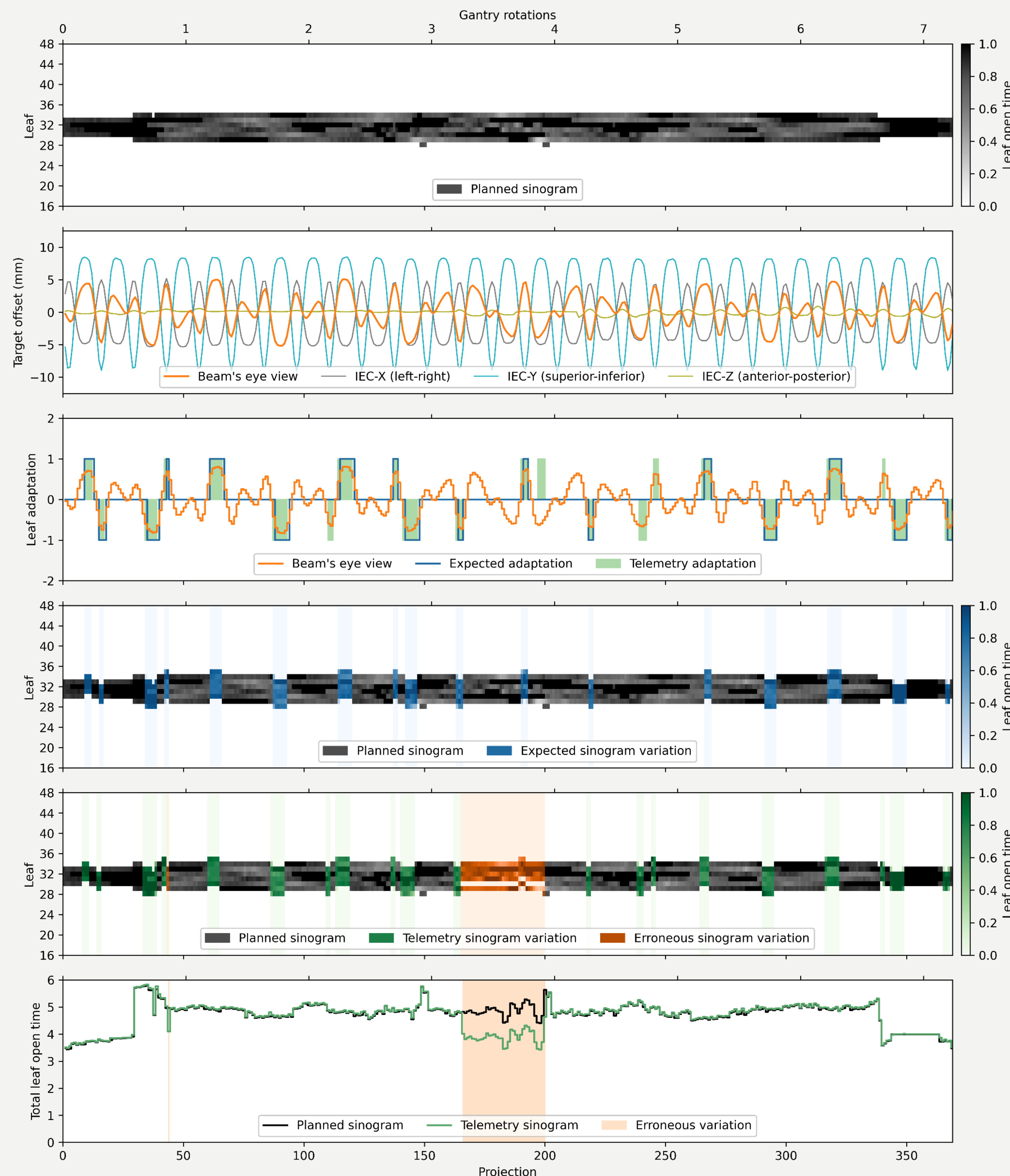
## CONCLUSION

Accuray have implemented an interlock since , to prevent more than 500 ms of leaf error (typically 2 projections). The performance of this fix has been validated within the department using the same phantom approach as used in validating the dose impact estimates. The identification of this error highlights the importance of continuing quality assurance over the course of treatments.

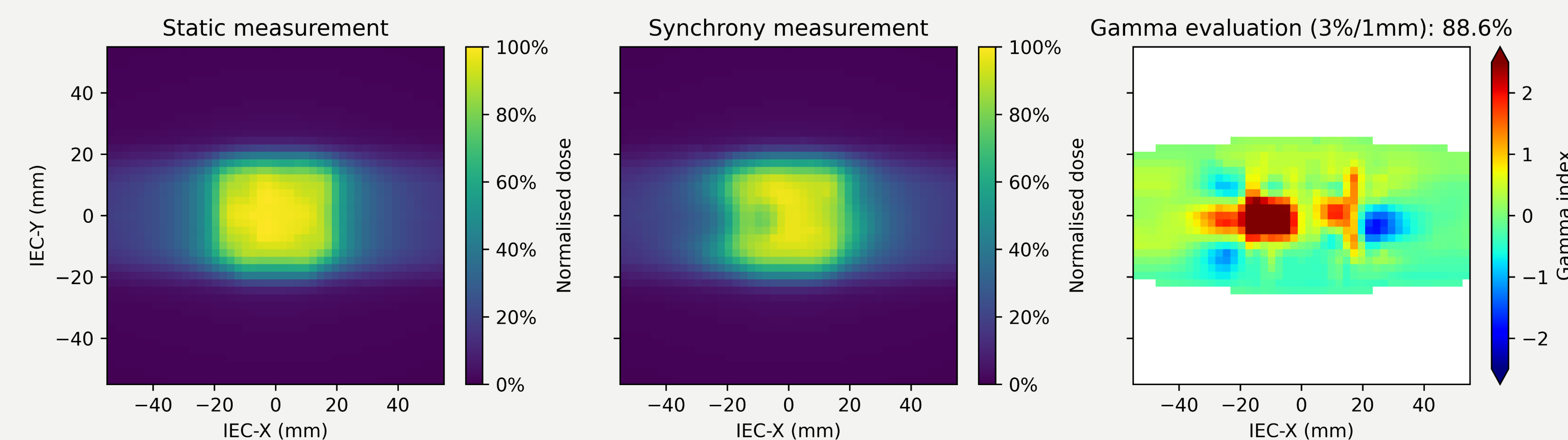
## ACKNOWLEDGEMENTS

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## PHANTOM EXAMPLE



**Figure 2.** Example of an erroneous leaf projection for a phantom delivery to a customized PTW Octavius phantom<sup>4</sup>. From top to bottom: (1) the leaf sinogram, showing how long each leaf is open for a 7° projection or control point; (2) target motion observed by the Synchrony system; (3) independently calculated expected adaptation and adaptation reported in telemetry or delivery log files; (4) the independently calculate expected sinogram variation; (5) the telemetry or delivery log sinogram; and (6) the variation in total fractional leaf open time in each projection.



**Figure 3.** Results of a comparison of measurements performed with and without motion and Synchrony adaptation, for the delivery shown in Figure 2. The dose error is 0.3 Gy, or 15% of the 2 Gy fractional dose, consistent with departmental and Accuray estimates of dosimetric impact to patient treatments.