

Delta⁴: TomoTherapy Delivery Quality Assurance (DQA) for SBRT Treatments

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Purpose

To test the capabilities of the Delta⁴ 3D dose phantom with TomoTherapy[™] HiART II[™] for high dose per fraction treatments typically delivered with stereotactic body radiation therapy (SBRT) techniques. Implementation of the Delta⁴ system for SBRT delivery verification overcomes the current necessity to scale the DQA procedure in order to ensure that the maximum dose delivered is within the dynamic range of the film being utilized. By using the Delta⁴, scaling errors, primarily due to the MLC leaf latency, would be minimized or eliminated, and the un-scaled treatment plan would be verified.

Methods and Materials

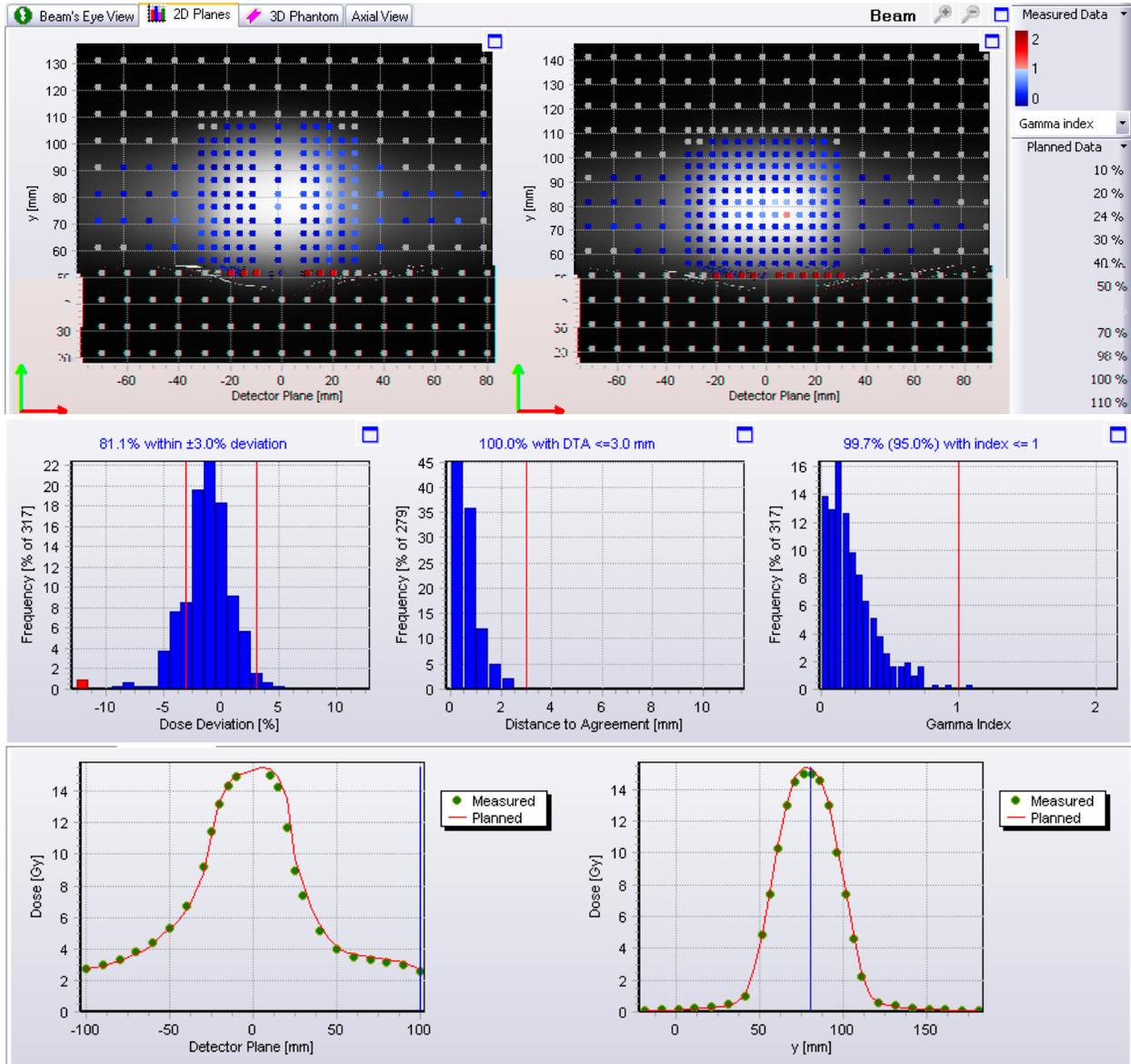
Five patients with single or multiple small lesions in either the lung or liver were treated with SBRT techniques using the Hi-Art II[™] unit in our Institution. Treatment plans delivered dose per fraction doses in the range of 10.0-20.0Gy. Corresponding DQA plans were generated and delivered on the ScandiDos Delta⁴ 3D phantom (Serial numbers: D0032 0096, D00320095, and D00310046). The Delta⁴ was calibrated relatively on a Varian 2100C/D[®] linear accelerator and absolutely on the tomotherapy unit using a 90 seconds static beam procedure with the MLCs closed for the first 30 seconds.

For the DQA plan creation, the Delta⁴ was scanned using the MVCT of the tomotherapy unit. MVCT images were imported into the tomotherapy database as a DQA phantom. Plans were created with the Delta⁴ shifted so that target volumes were placed in the center of the phantom. A “fine” dose grid resolution was used for the dose calculation. Once completed, the plan and dose were exported via DICOM RT. Prior to the delivery of each plan, a MVCT of the phantom was acquired to accurately position the Delta⁴ and to account for sag between the virtual and actual machine isocenter. Patient plan and dose were uploaded into the ScandiDos software, and the corresponding shifts to the calculated dose were applied. Profiles and gamma index analysis were obtained for plan validation.

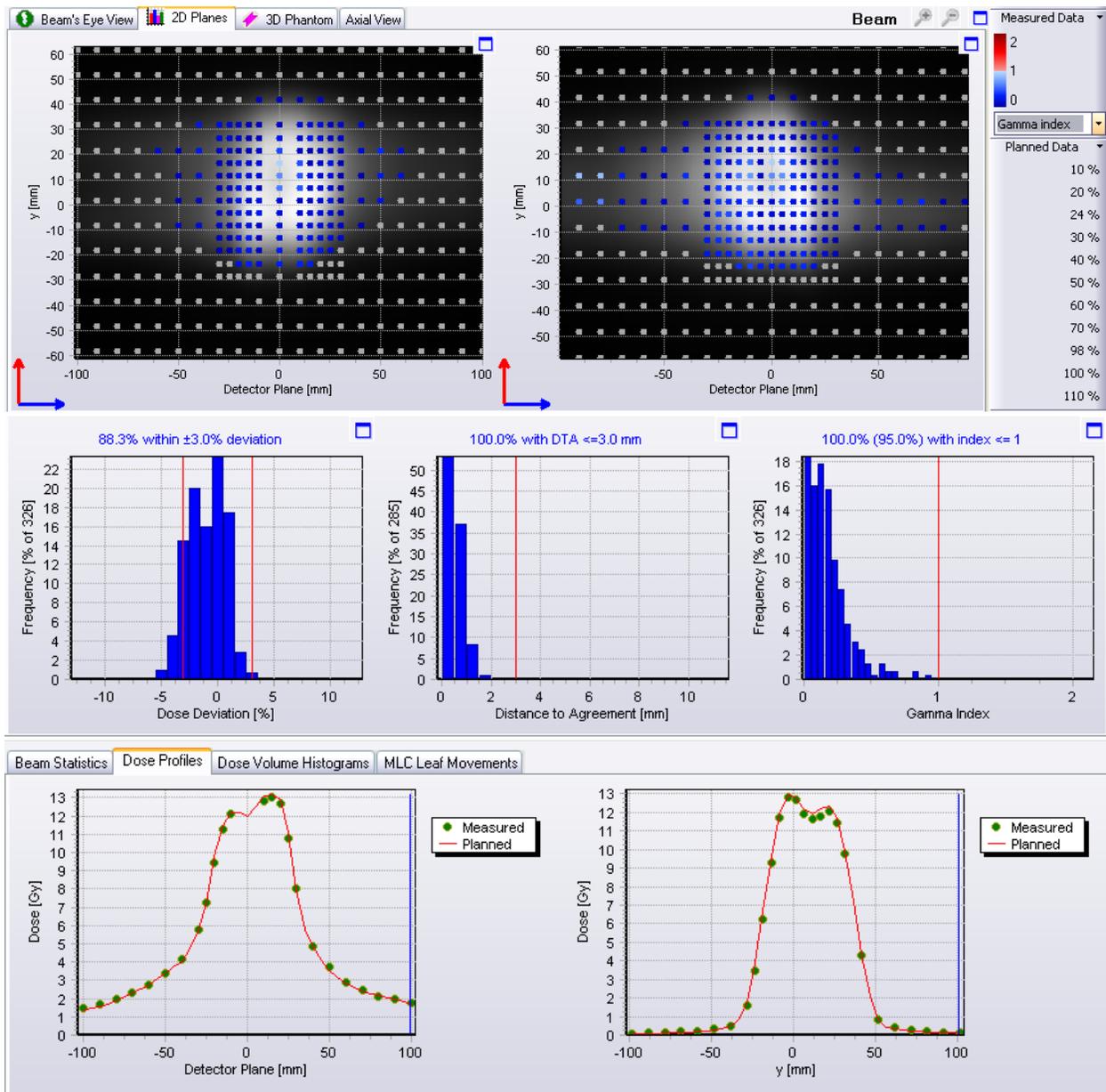
Five different patient DQA plans were delivered—3 liver patients and 2 lung patients—over the course of 4 months. Two of the liver patients were planned with a prescription of 50.0Gy in 5 fractions, and the third patient was planned with a prescription of 48.0Gy in 3 fractions. The two lung patients were planned with a prescription of 60.0Gy in 3 fractions.

Results

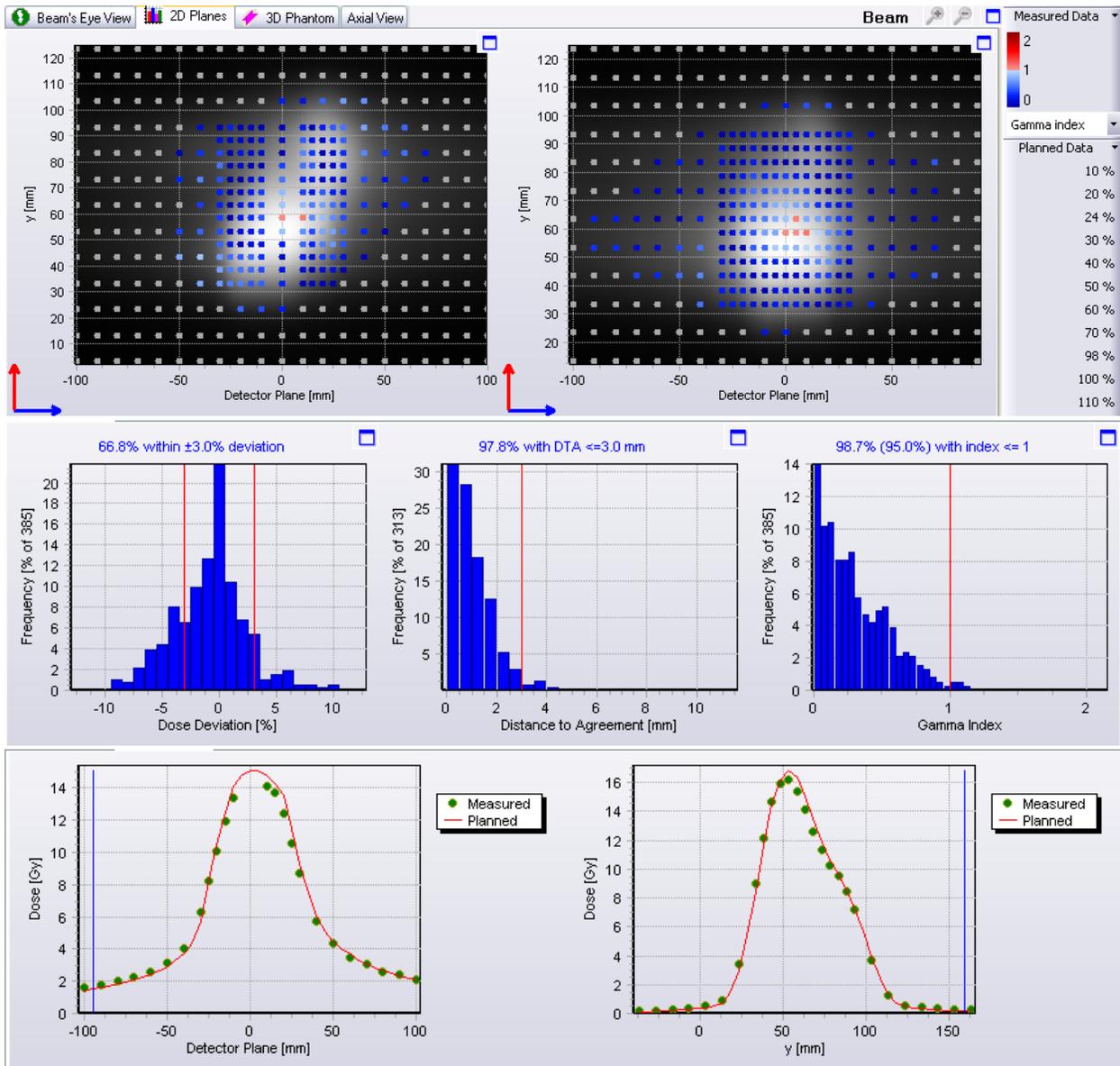
Case 1: SBRT of a single lesion in the liver with a plan consisting of 50.0Gy to be delivered in 5 fractions using helical tomotherapy.



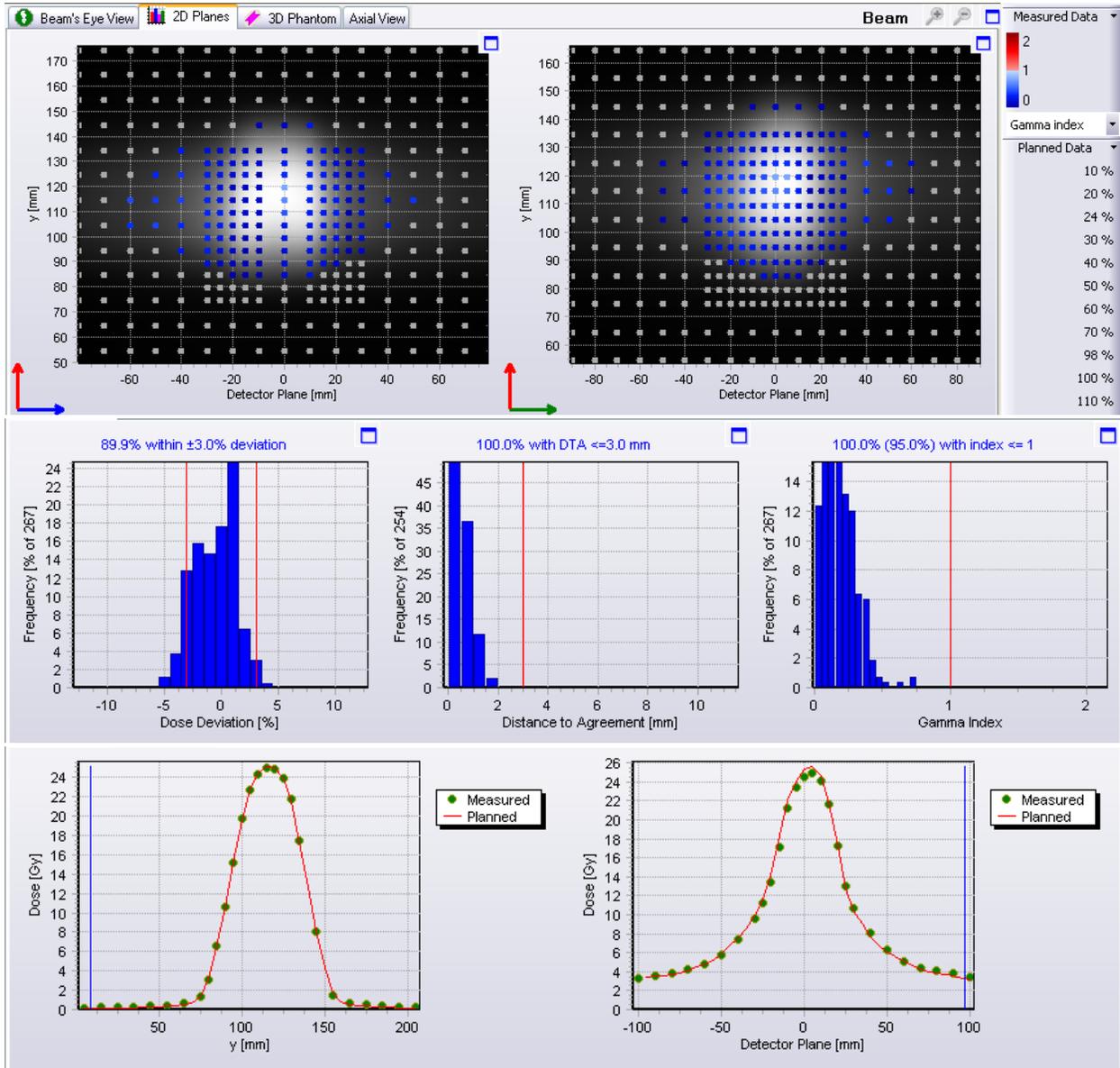
Case 2: SBRT of a single lesion in the liver with a plan consisting of 48.0Gy to be delivered in 3 fractions using helical tomotherapy.



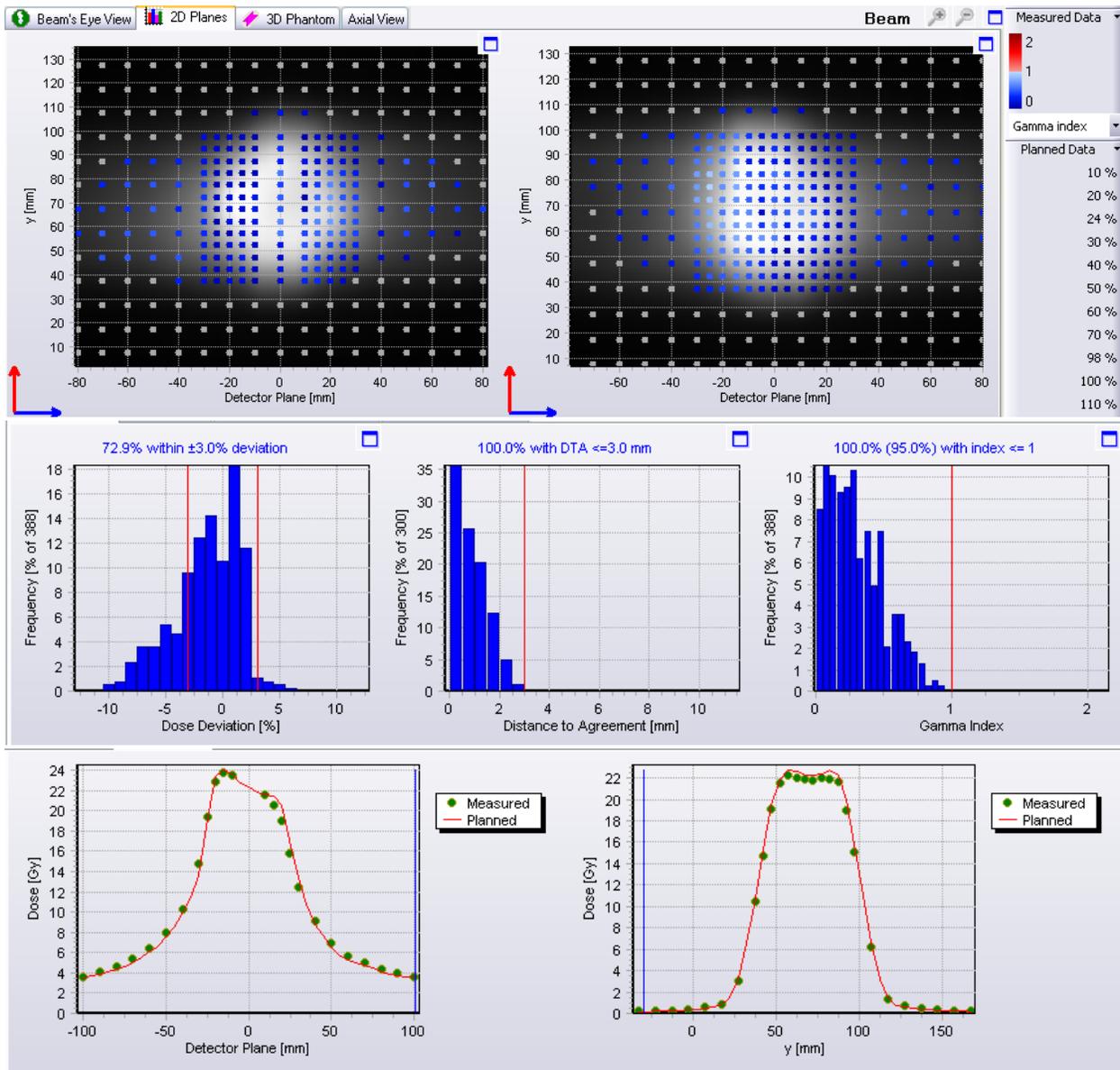
Case 3: SBRT of two lesions in the liver with a plan consisting of 50.0Gy to be delivered in 5 fractions using helical tomotherapy.



Case 4: SBRT of a single lesion in the lung with a plan consisting of 60.0Gy to be delivered in 3 fractions with helical tomotherapy. In order to deliver the 20.0Gy per fraction, two sequential 10.0Gy fractions were delivered. The Delta⁴ was not interrupted and continued to sample between the two fractions.



Case 5: SBRT of a single lesion in the lung with a plan consisting of 60.0Gy to be delivered in 3 fractions with helical tomotherapy. In order to deliver the 20.0Gy per fraction, two sequential 10.0Gy fractions were delivered. The Delta⁴ was not interrupted and continued to sample between the two fractions.



Summary

Overall, the Delta⁴ performed exceptionally well, and the results were consistent among the five different treatment plans evaluated over a period of four months. For all the cases, very good agreement in the high dose and low dose regions were observed. All of the plans passed with at least 95% of the diode measurements within the gamma analysis specification of 3%/3mm. The ScandiDos software was easy to use and provides additional analysis tools not currently available within the tomotherapy DQA analysis software. Because of this, measurements were analyzed within the ScandiDos platform. Additionally, a 20-30 minute time saving per DQA was noted using the Delta⁴ system as opposed to film and ion chamber measurements. The reduction primarily occurs during post-delivery processing since the analysis can be performed instantly after the measurement is recorded.