Treatment Dose Visualization with DoseRT

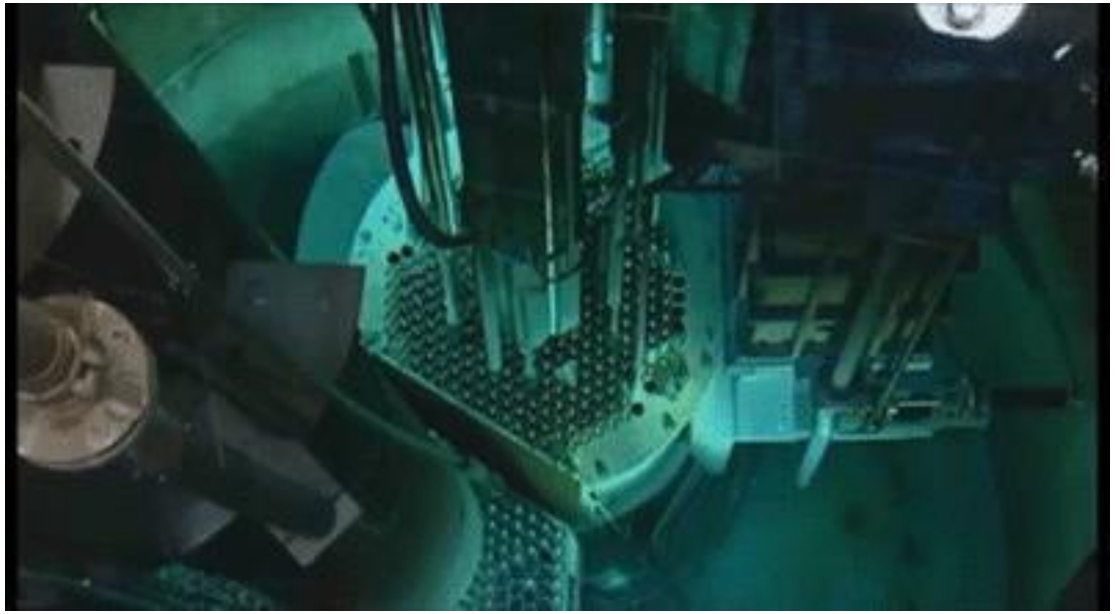
Adi Robinson Ph.D., DABR
AdventHealth Celebration

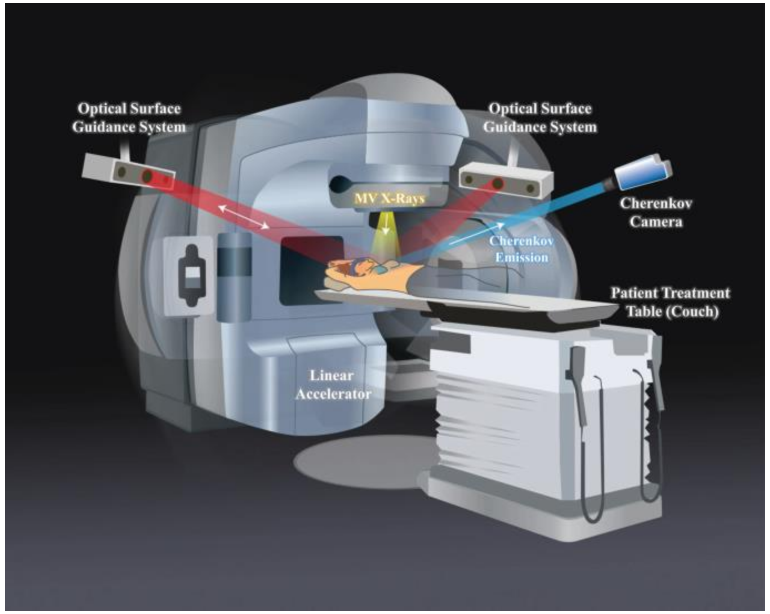
SGRT Workflow with DoseRT

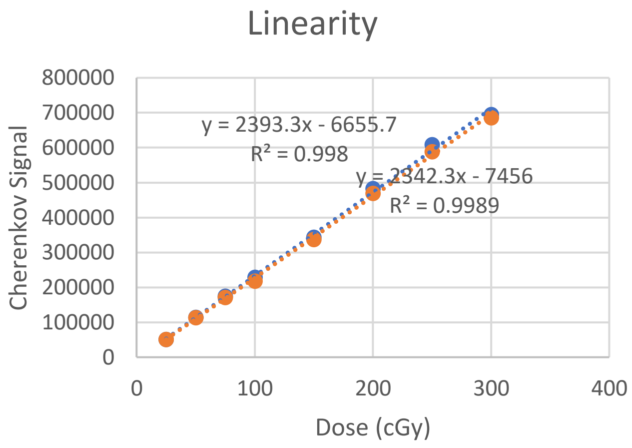
- DoseRT utilizes Cherenkov imaging to visualize dose during treatment delivery.
- DoseRT works alongside AlignRT to offer advance patient positioning and real-time dose delivery feedback.
- The combination enhances treatment accuracy and patient safety

Cherenkov Radiation

- Cherenkov light is emitted when a charged particle is moving faster than light in that medium.
- Cherenkov light has been shown to be proportional to the delivered dose*.

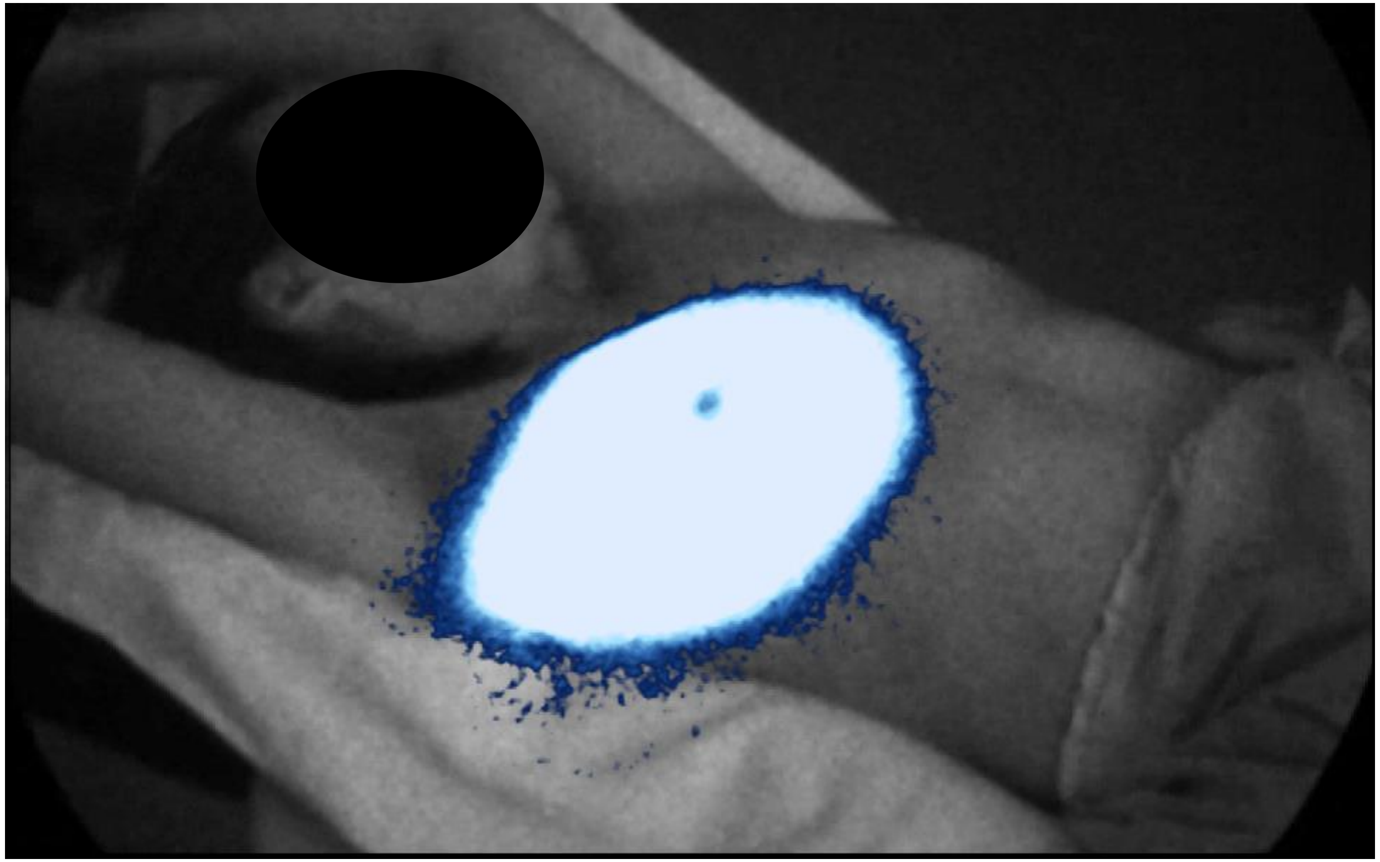






Cherenkov Imaging

- Cherenkov light can be seen on the patient's skin surface during treatment with special light sensitive cameras.
- That light is a result of the interaction of the entrance and exit beam during treatment.
- This allows us to visualize the radiation treatment directly on the patient's skin



Benefits of Cherenkov Imaging

Initial experience* suggests **~10% of patients** experience compliance, setup, plan or habitus issues;

- Chin irradiated during supraclavicular fields
- Arm irradiated during tangential breast fields
- Bolus misplacement
- Open MLC leaves

DoseRT™ can help detect, and prevent these cases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Physics Contribution

Initial Clinical Experience of Cherenkov Imaging in External Beam Radiation Therapy Identifies Opportunities to Improve Treatment Delivery

Lesley A. Jarvis, MD, PhD,* Rachael L. Hachadorian, MS,† Michael Jermyn, PhD,† Petr Bruza, PhD,† Daniel A. Alexander, MS,† Irwin I. Tendler, PhD,† Benjamin B. Williams, PhD,*,† David J. Gladstone, ScD,*,† Philip E. Schaner, MD, PhD,* Bassem I. Zaki, MD,* and Brian W.

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Physics Contribution

Cherenkov Video Imaging Allows for the First Visualization of Radiation Therapy in Real Time

Lesley A. Jarvis, MD, PhD,*,† Rongxiao Zhang, BS,‡ David J. Gladstone, ScD,*,† Shudong Jiang, PhD,§ Whitney Hitchcock,‖ Oscar D. Friedman,§ Adam K. Glaser, BE,§ Michael Jermyn, PhD,§ and Brian W. Pogue, PhD†,§

*Department of Medicine, Geisel School of Medicine at Dartmouth College, Hanover, †Norris Cotton Cancer Center at the Dartmouth-Hitchcock Medical Center, Lebanon, ‡Department of Physics and Astronomy and §Thayer School of Engineering, Dartmouth College, Hanover, and ‖Geisel School of Medicine at Dartmouth College, Hanover, New Hampshire

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Summary

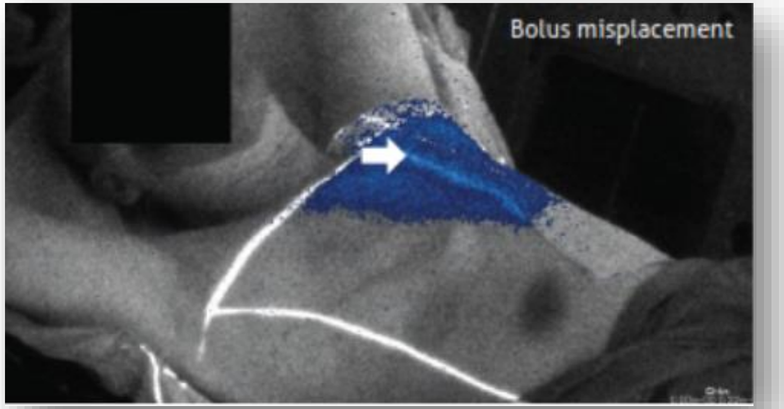
Cherenkov light imaging shows radiation therapy in real time and can be viewed at the treatment console or as a video after treatment delivery. Cherenkoscopy of breast radiation therapy is reproducible and provides information about surface dose and accuracy of treatment, and it verifies proper beam modulation. In summary, we demonstrate the first clinical use of Cherenkov imaging in external beam radiation therapy and hypothesize future technologic developments and clinical applications will improve radiation therapy.

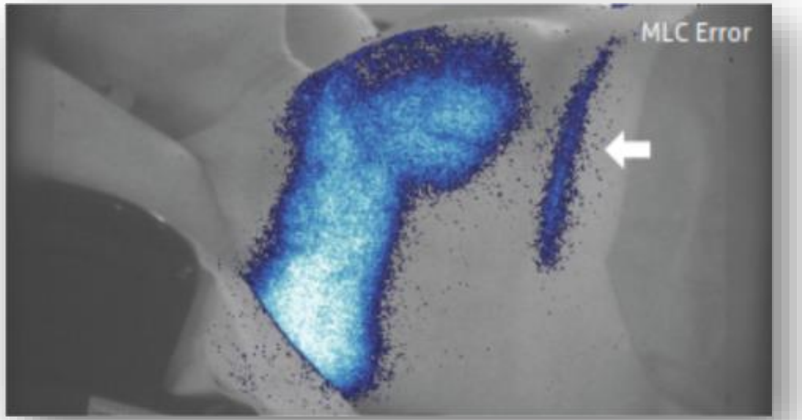
Purpose: To determine whether Cherenkov light imaging can visualize radiation therapy in real time during breast radiation therapy.

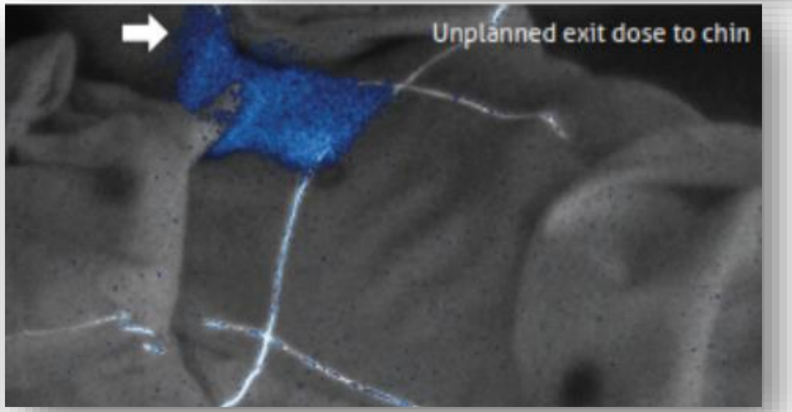
Methods and Materials: An intensified charge-coupled device (CCD) camera was synchronized to the 3.25-µs radiation pulses of the clinical linear accelerator with the intensifier set × 100. Cherenkov images were acquired continuously (2.8 frames/s) during fractionated whole breast irradiation with each frame an accumulation of 100 radiation pulses (approximately 5 monitor units).

Results: The first patient images ever created are used to illustrate that Cherenkov emission can be visualized as a video during conditions typical for breast radiation therapy, even with complex treatment plans, mixed energies, and modulated treatment fields. Images were generated correlating to the superficial dose received by the patient and potentially the location of the resulting skin reactions. Major blood vessels are visible in the image, providing the potential to use these as biological landmarks for improved geometric accuracy. The potential for this system to detect radiation therapy misadministrations, which can result from hardware malfunction or patient positioning setup errors during individual fractions, is shown.

Conclusions: Cherenkoscopy is a unique method for visualizing surface dose resulting in real-time quality control. We propose that this system could detect radiation therapy errors in everyday clinical practice at a time when these errors can be corrected to result in improved safety and quality of radiation therapy. © 2014 Elsevier Inc.







* Initial experience with 60 patients

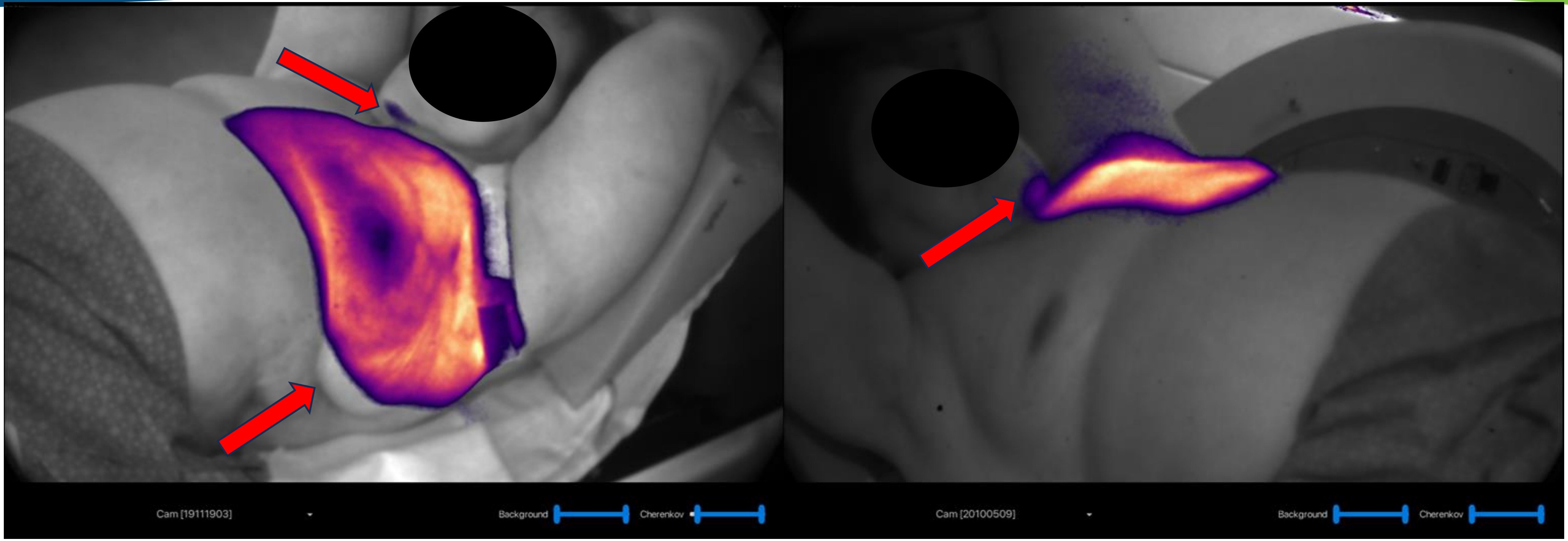
DoseRT Specifications

- Cherenkov signal can be visualized with most treatment plans, from the complex highly modulated VMAT to the simple 2D conformal.
- Compatible beam energies: 6 - 18 MV photons
- Compatible dose rates: 100 – 2400 MU/Min
- Minimum dose threshold to visualize signal: 10* MU
- Depth of Cherenkov imaging signal: up to 10mm

Installation and Acceptance

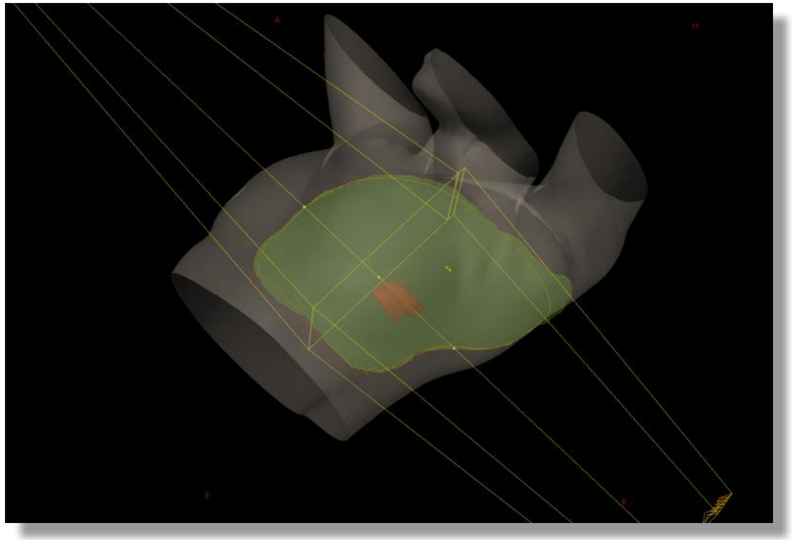
- AlignRT® Horizon camera system required
- Installation requires separate camera mounts for the Horizon and DoseRT cameras
- Additional standard power toggle switch will be required. This power cycles the DoseRT cameras.
- Camera location will be evaluated during site survey.
- Vault ambient light will be evaluated during site survey.
- Acceptance will verify visualization of Cherenkov signal for qualitative analysis.

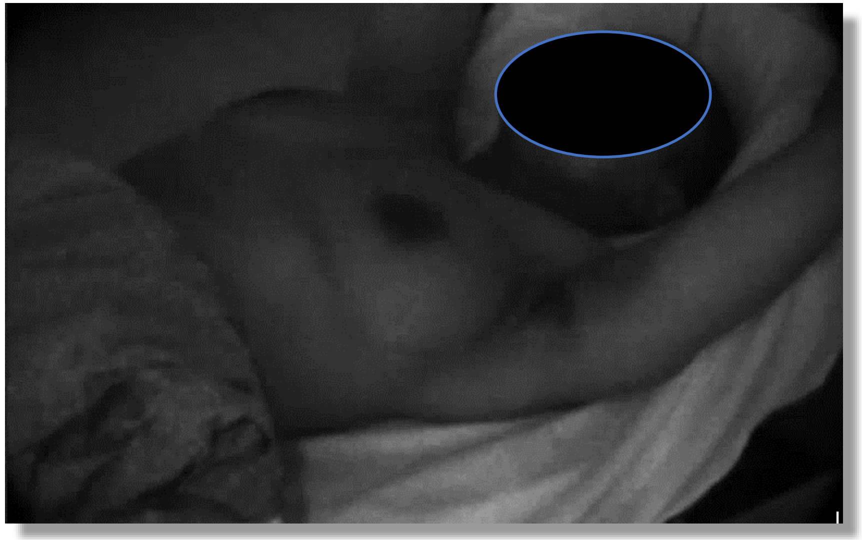
Case Study: Daily Patient Compliance

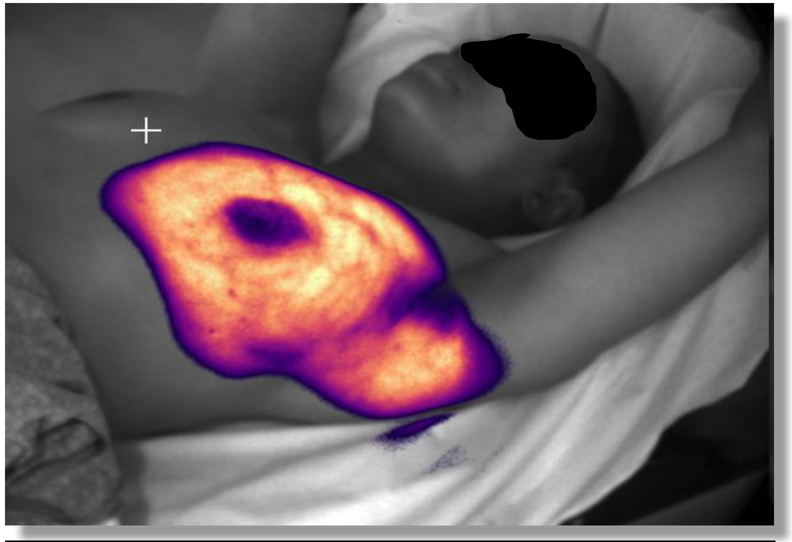


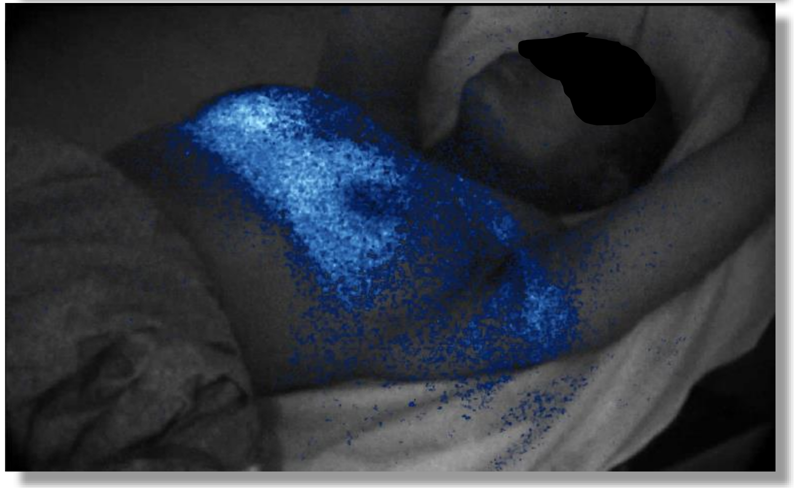
- 68 Year Old Female, Challenging body habitus
- Patient was noted as being very combative and non-compliant with simulation instructions (no DIBH)
- Patient refused to raise chin during Fx 1 resulting in need for plan modification
- Fx 1 it was noted it looks like the plan clipped the breast tissue

Case Study: Improper Port Technique



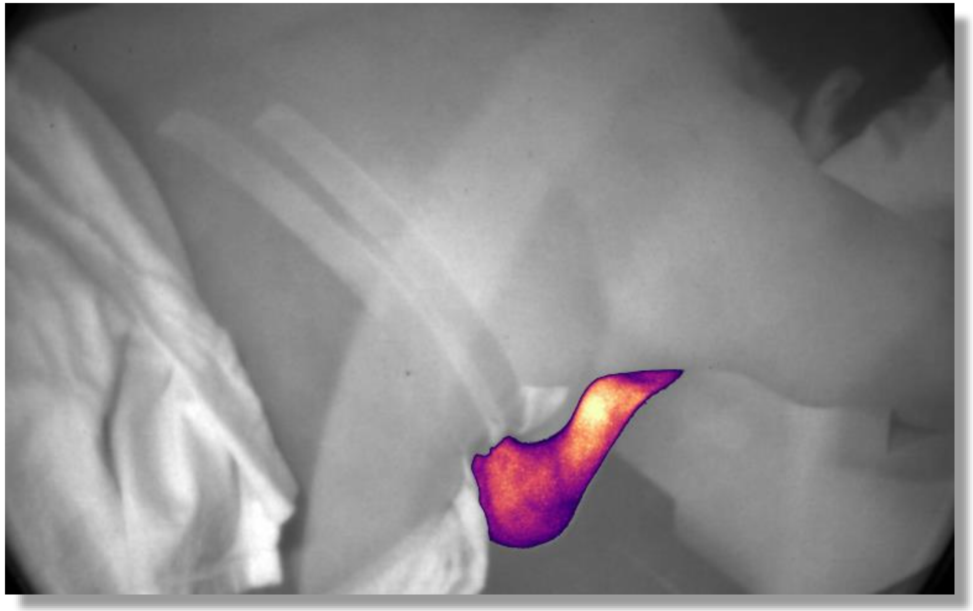


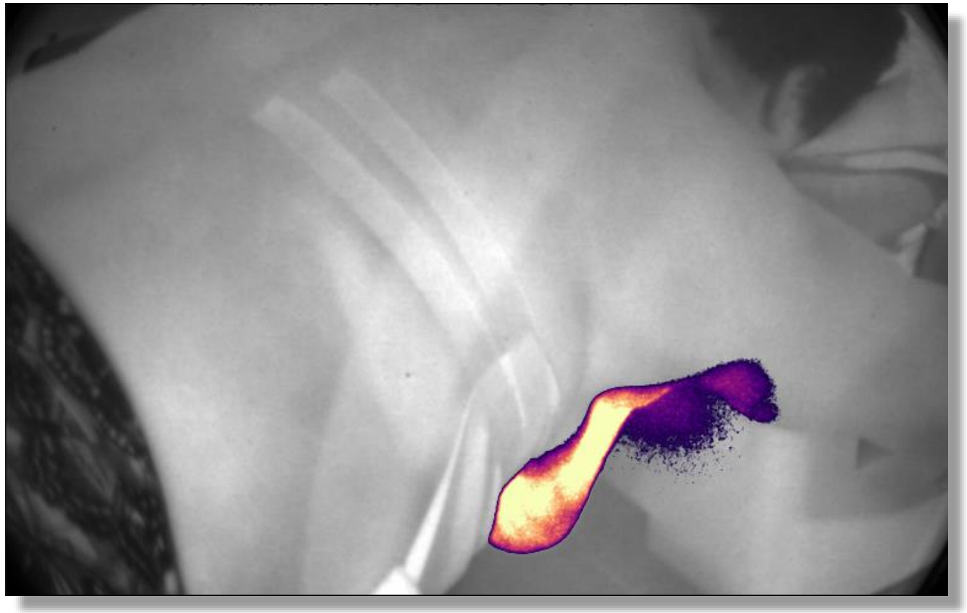




- 36 Year Old Female undergoing DIBH for left intact breast treatment
- Intended 3D surface dose rendering provided to treatment staff via the TPS
- Visual verification of treatment dose initiated from first day of treatment
- Identification of stray anomalous dose witnessed during video review of Fx1
- Incorrect port film technique found to have been assigned by staff
- Corrected for Fx2 and beyond

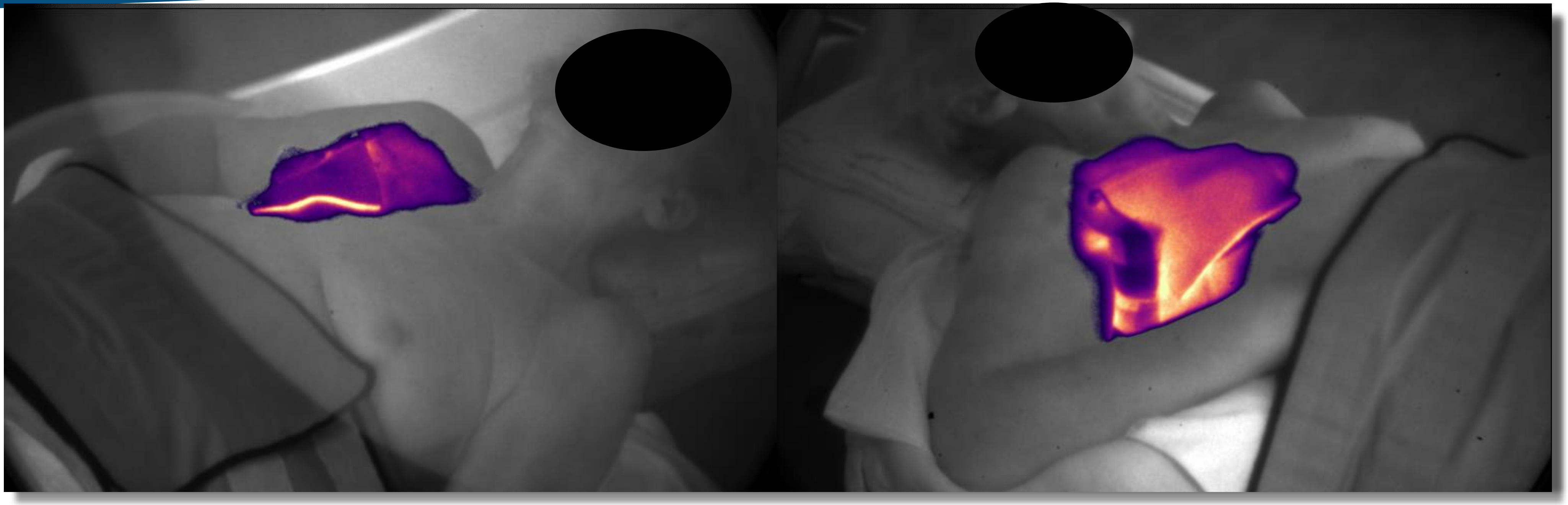
Case Study: Daily Positioning Variance





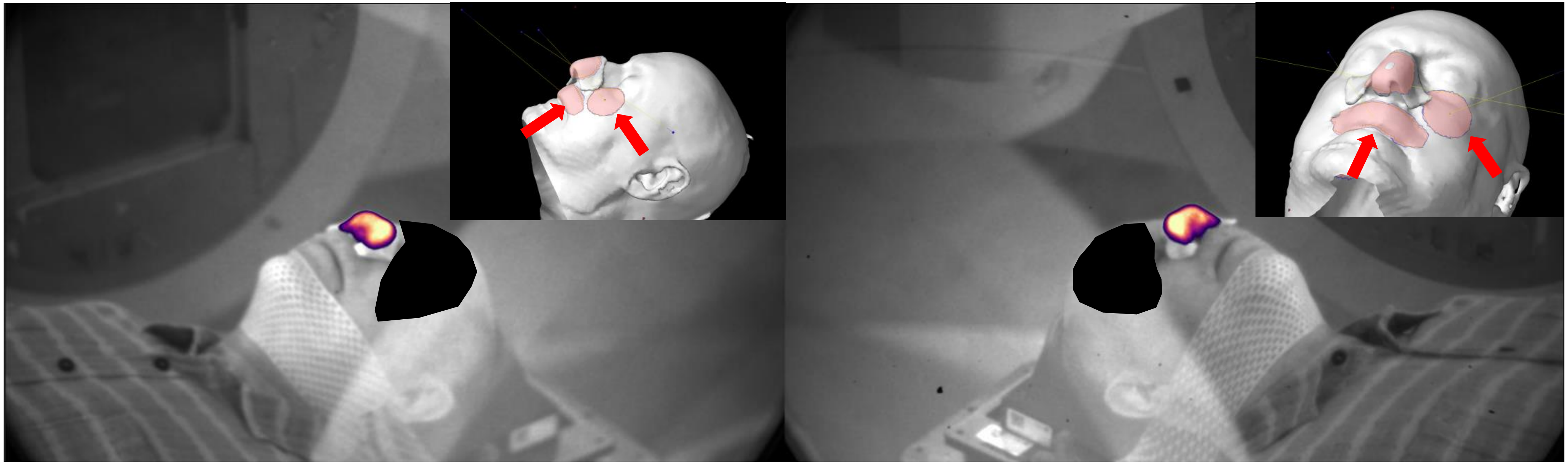
- 67 Year Old Female undergoing 3DCRT for Prone Breast
- Visual verification of treatment dose initiated from fraction 1 of treatment
- Fraction 3 - Exit dose through arm noted by physics team during daily review
  - Investigation showed prone pad indexing places slightly inferior resulting in wrong elbow position
  - Decreased arm extension resulted in beam exiting through upper arm.

Case Study: Confirmation of Limb Sparing



- 99 Year Old Female undergoing IMRT treatment for fungating mass in left intact breast / axilla
- Challenges from simulation
  - Partial bolus coverage of mass and involved skin margin
  - Bubble wrap spacer to address skin fold due to inability to raise ipsilateral arm
- Visual verification of treatment dose initiated from fraction 1 of treatment

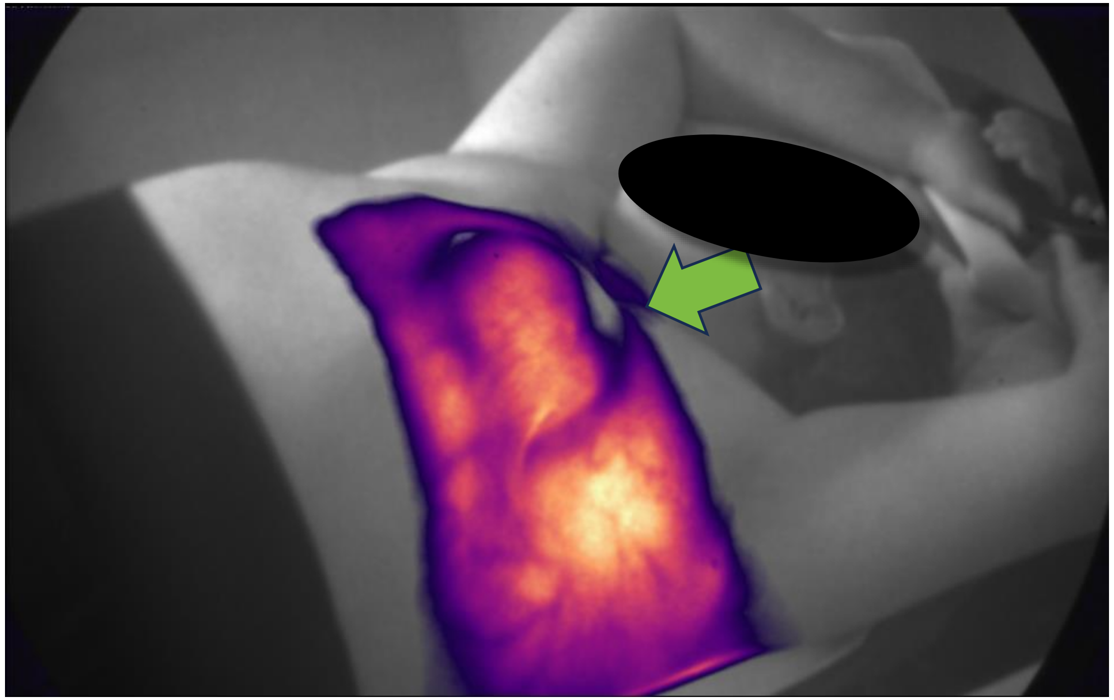
Case Study: Avoidance of Previously Treated Areas



- 54 Year Old Male undergoing 3DCRT with small fields after previous radiation to surrounding area
- Challenges from simulation
  - Custom bolus coverage of mass and involved skin margin
  - Previous irradiation of upper lip and right cheek – desire to avoid overlap with previous areas of treatment and other sensitive structures
- Visual verification of treatment dose initiated from fraction 1 of treatment

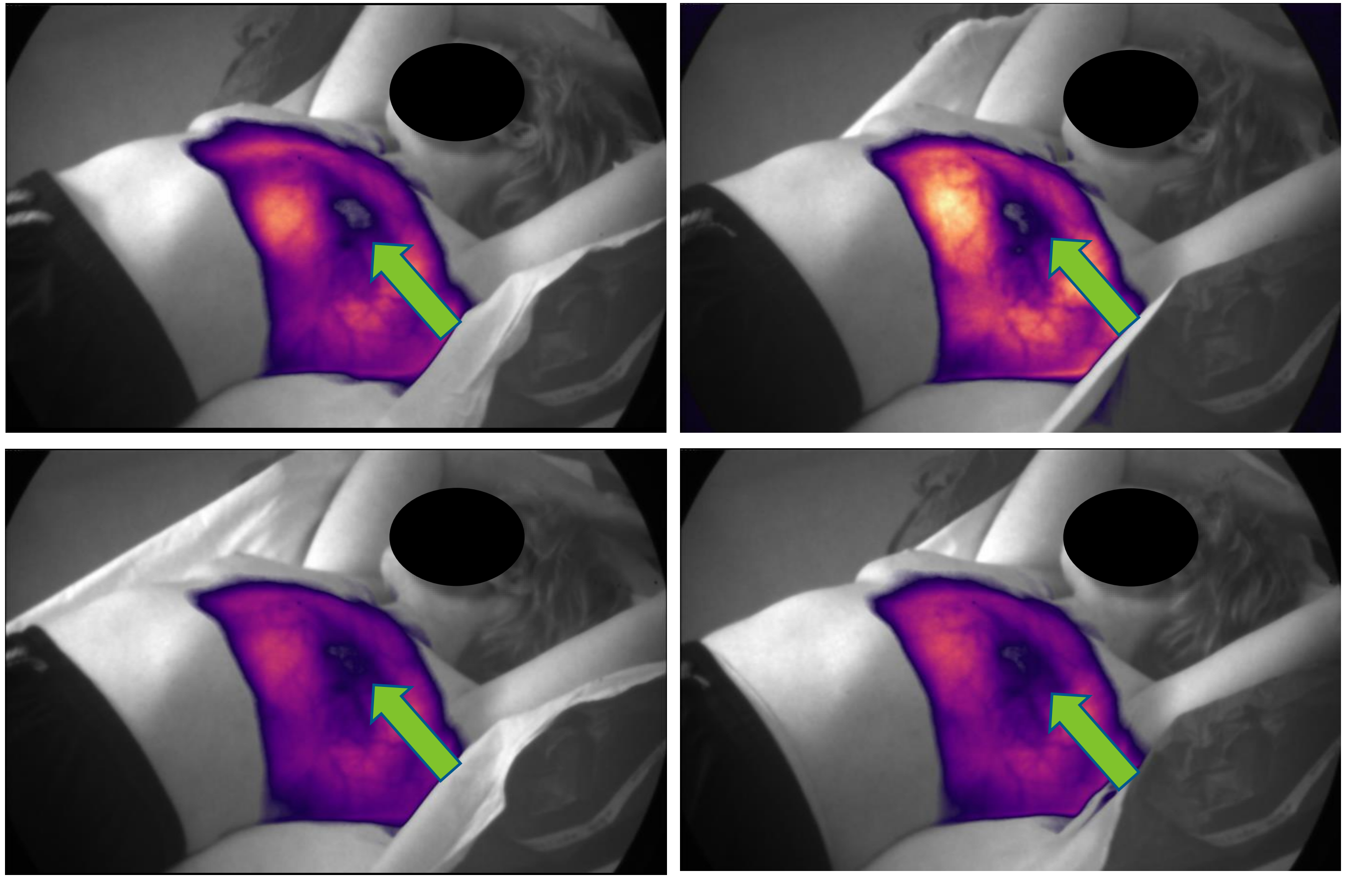
Case Study: Data Interpretation

- 45 Year Old Female undergoing VMAT DIBH breast treatment for malignant neoplasm of overlapping sites of the left breast
- Upon dose visualization an area with no Cherenkov signal was observed.
- The case was presented to the Cherenkov Consortium users for comment
- Consortium users suggested that the hole was a result of attenuation from the chest wall expander.
- Review of TPS data showed that the expander was not in the plane of the hole and therefore was probably not the source of the anomaly.
- Use of tighter SGRT margins appeared to reduce the size of the hole.
- Thresholding of the composite image in combination with a lower dose was expected as the root cause of the issue



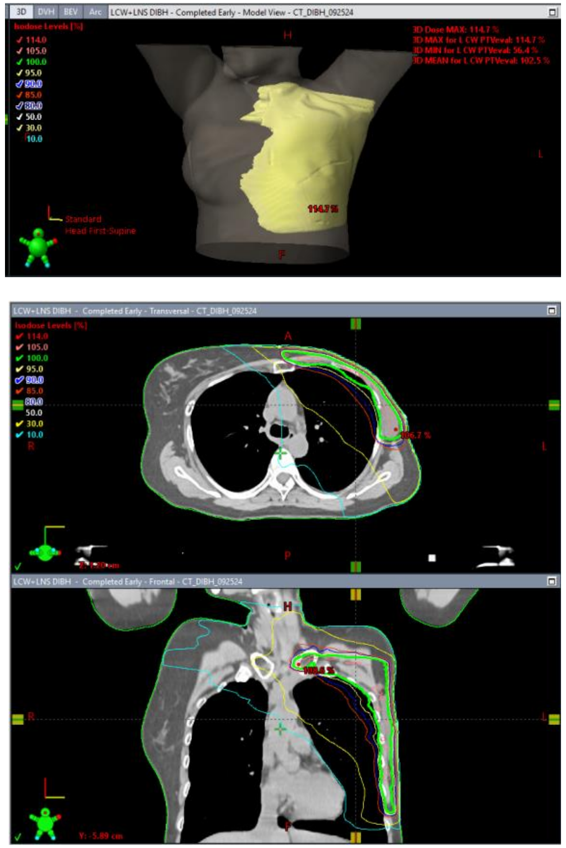
Case Study: Mismatch between Plan and Treatment

- Another patient presents with an unexplained hole in the composite image
- This time the patient has no reconstruction or expander in the treatment area.
- Case is presented for review with experienced user
- DIBH Plan is reviewed and found to be VMAT with no flash allowance which was not a common technique at the secondary site.

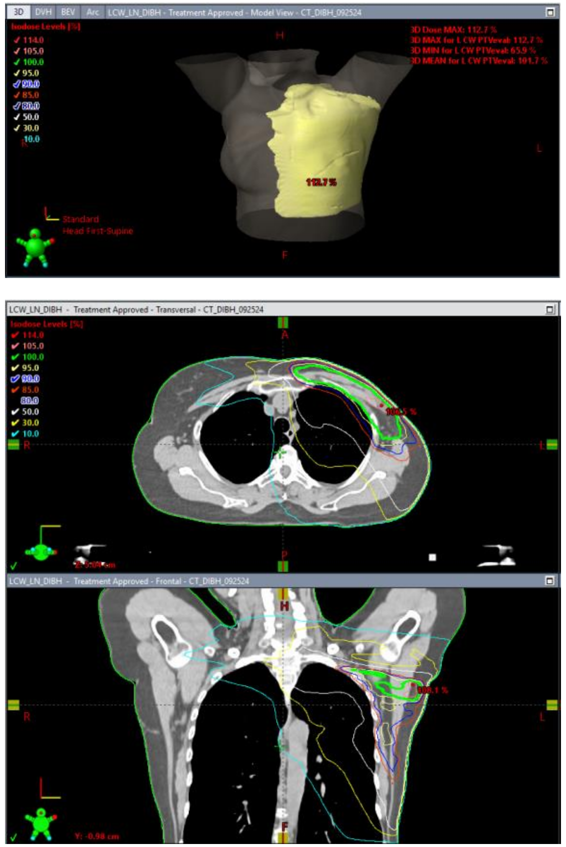


Case Study: Mismatch between Plan and Treatment

Original Plan Without Flash

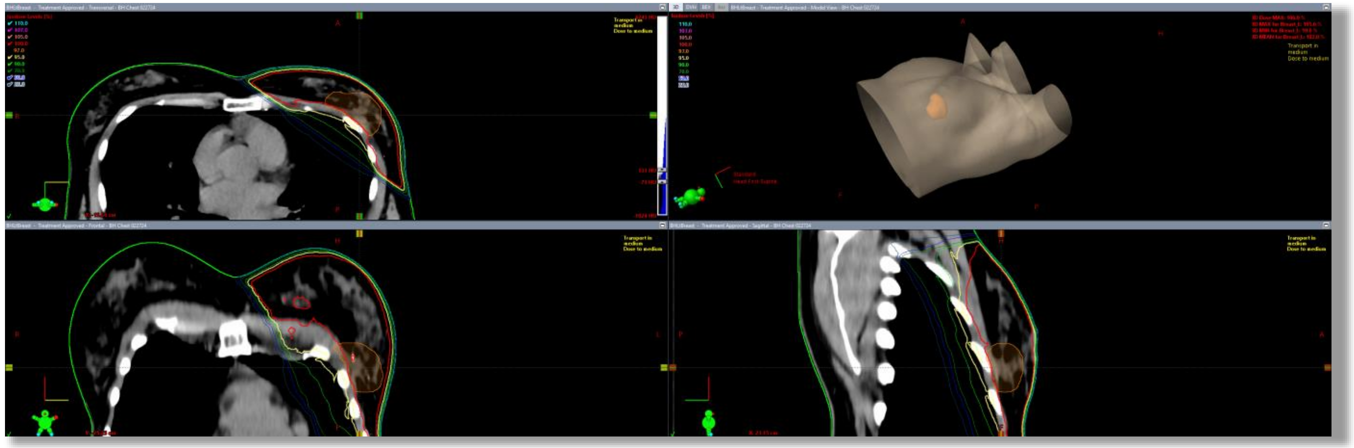


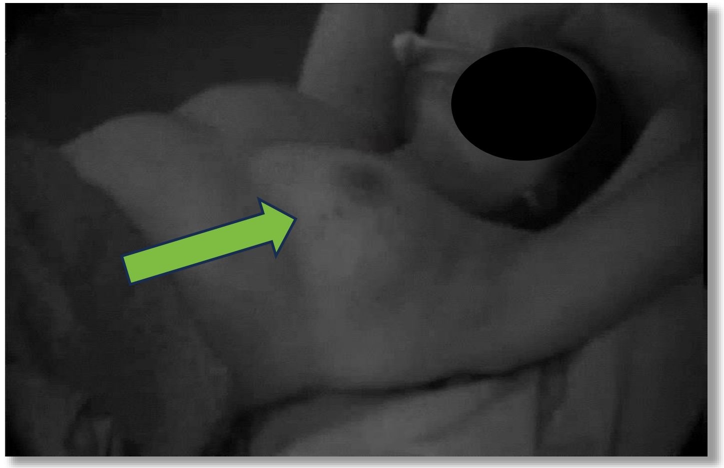
New Plan With Flash

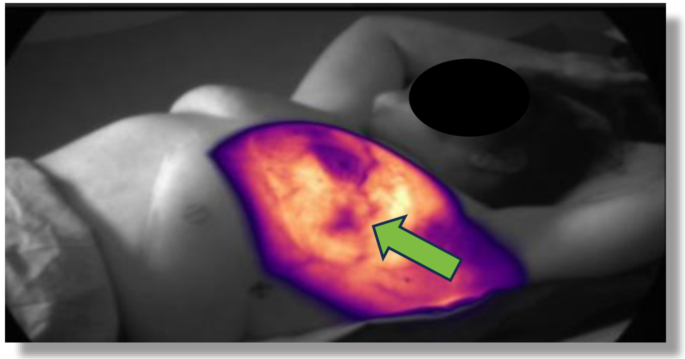


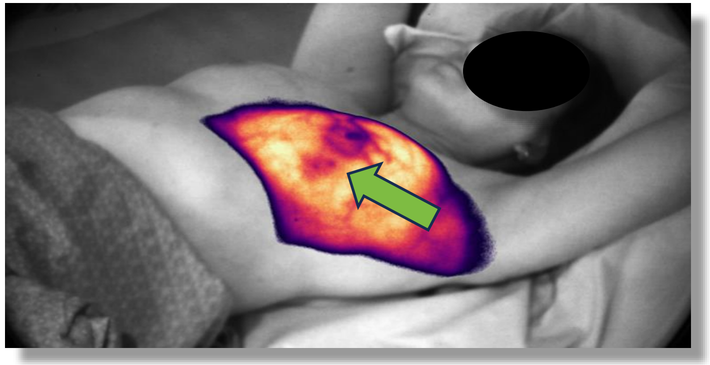
- Determination to use TLDs from UW Madison to verify in vivo dose was made.
- While waiting on TLD results the patient was replanned using flash to mimic traditional breast flash.
- Patient was moved to the new DIBH plan and new TLDs were ordered to verify the dose in the region after plan change
- TLD results suggested a discrepancy of 30-43cGy per fraction or 7.5-11Gy for the full course (lower) in this region when comparing the with and without flash plans

Case Study: Target Coverage Visibility



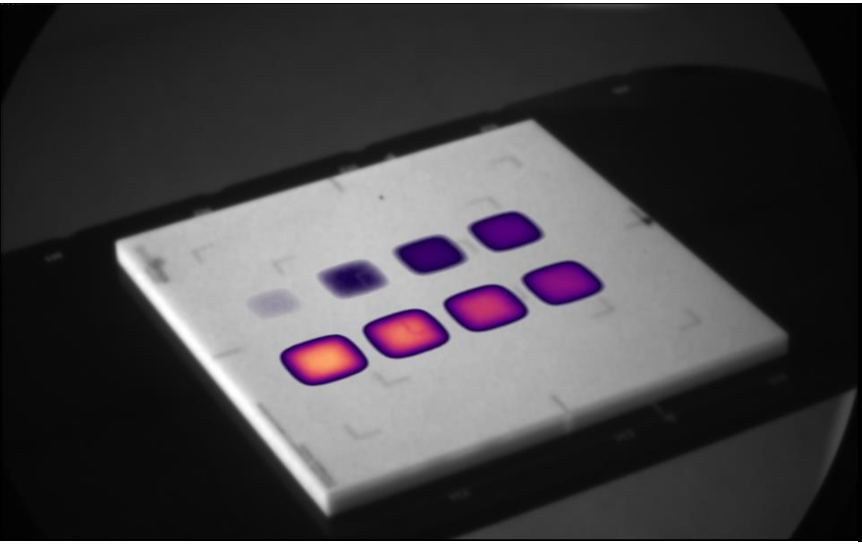


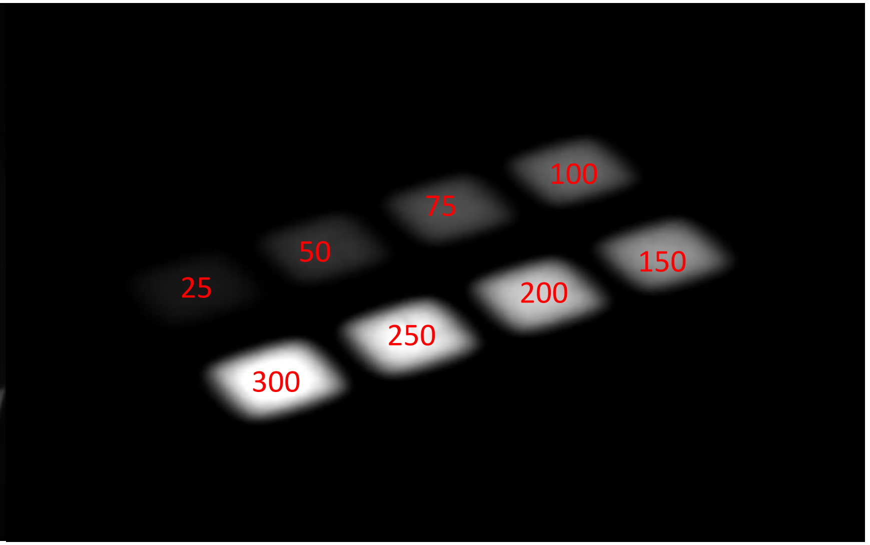


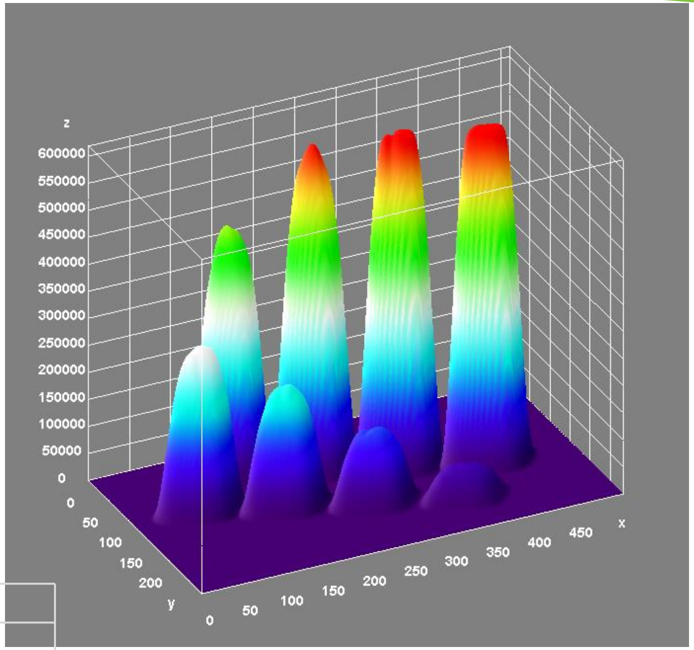


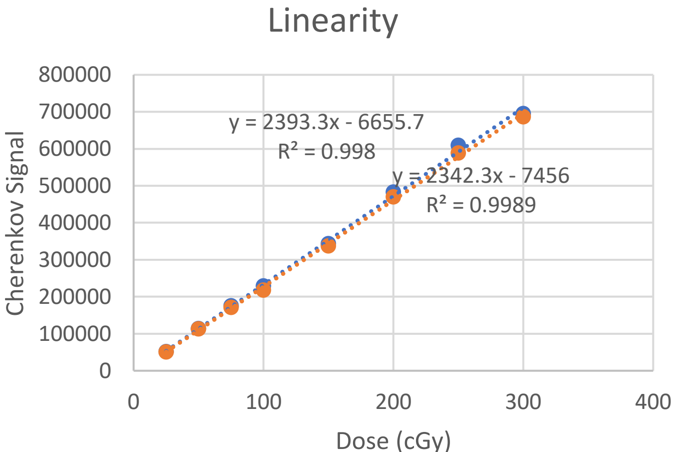
- Potential evaluation of large seroma changes for replanning
- Cone down boost targeting

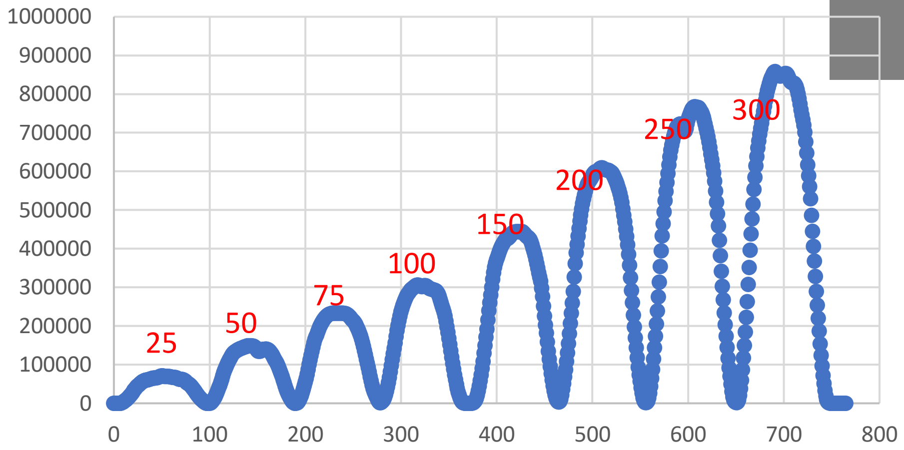
Physics Tests: Signal Linearity





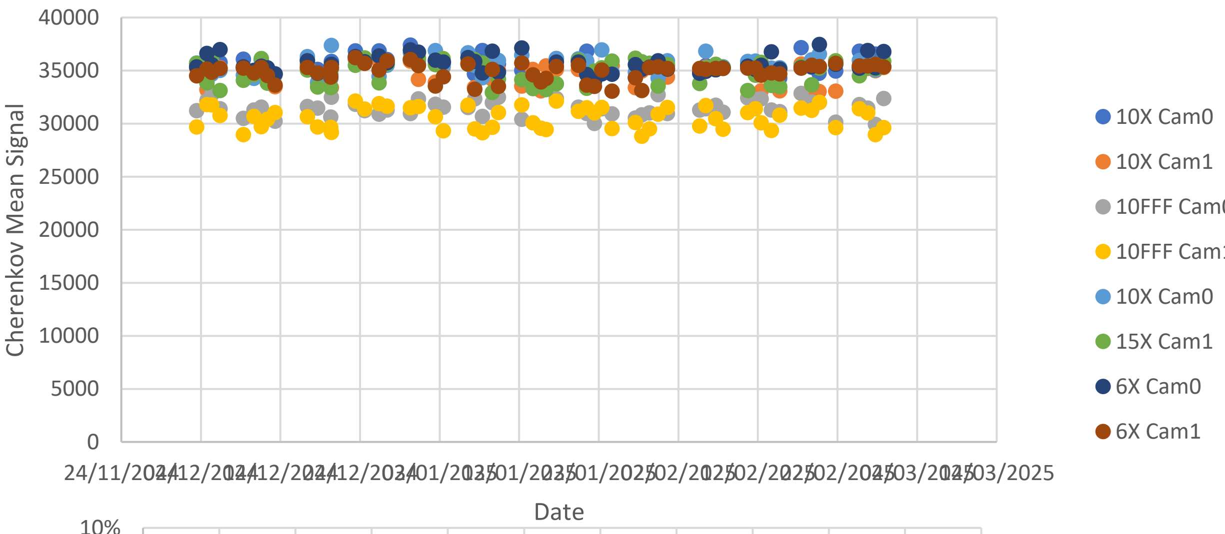


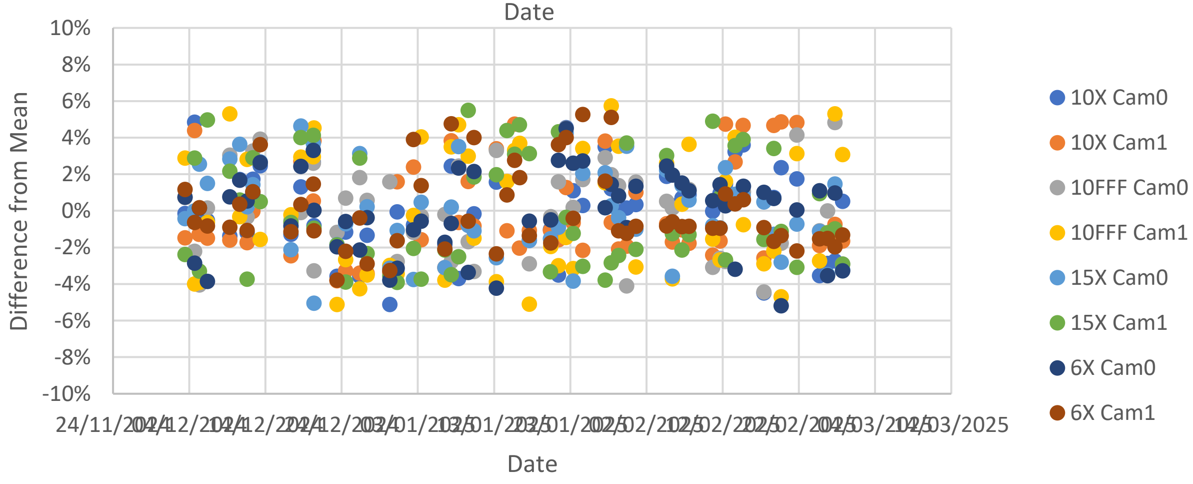




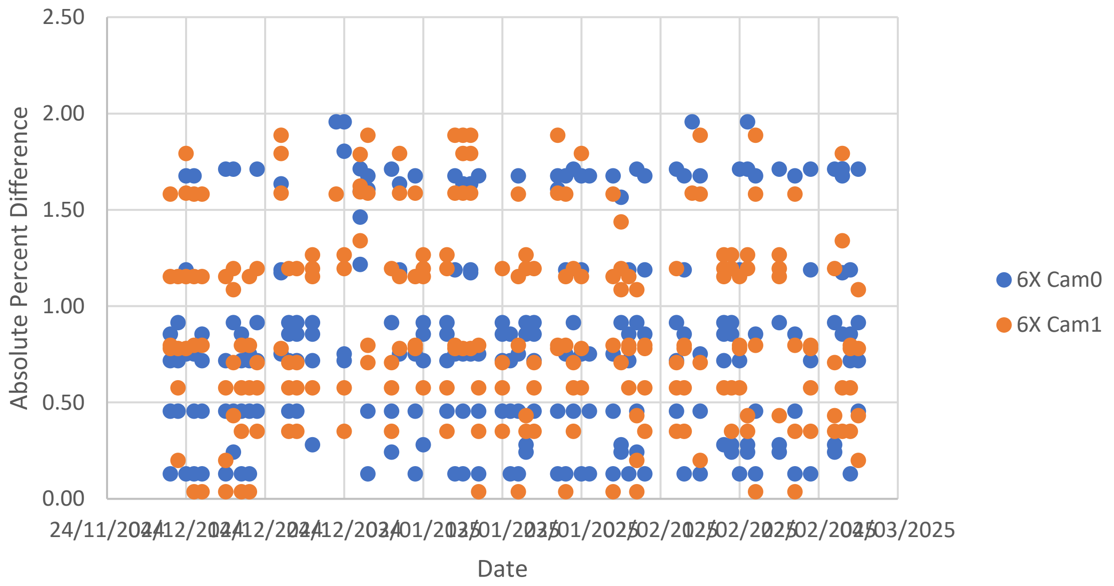
Physics Tests: Signal Constancy

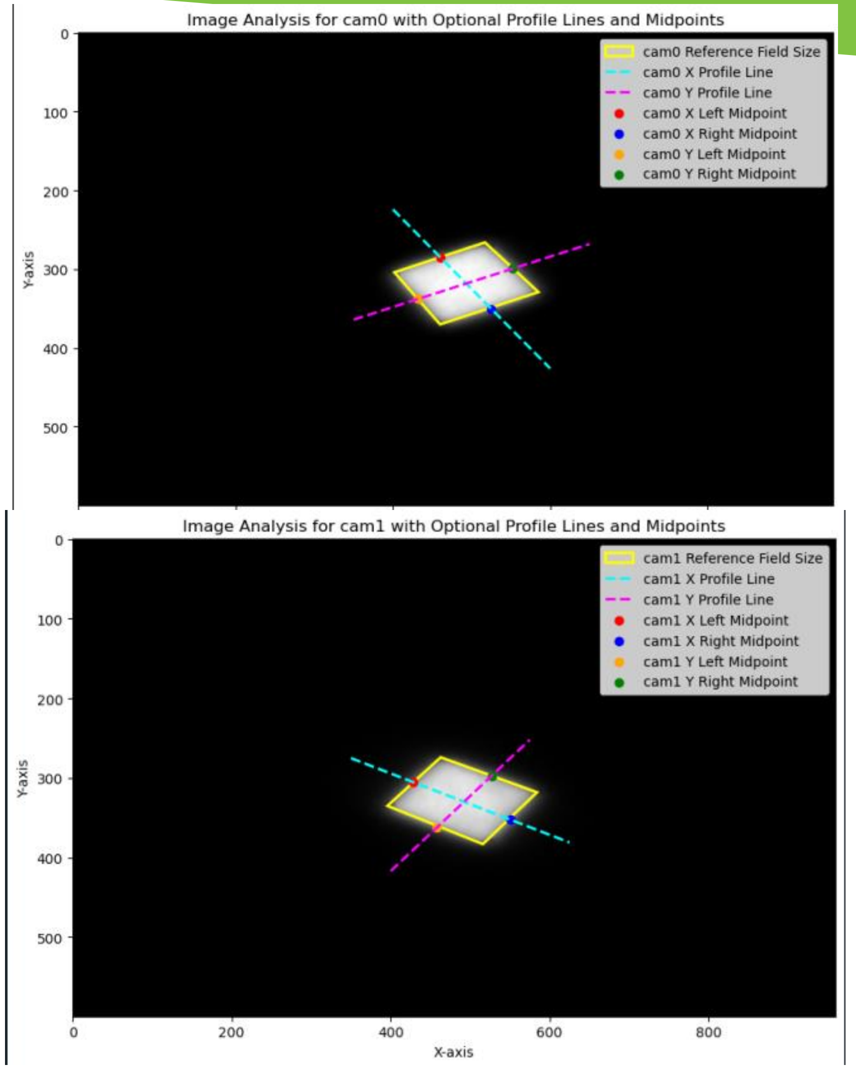
- Singal constancy check daily for 3 months.
- All photon energies (except 6FFF)
- Variation from mean does not exceed +/-6%





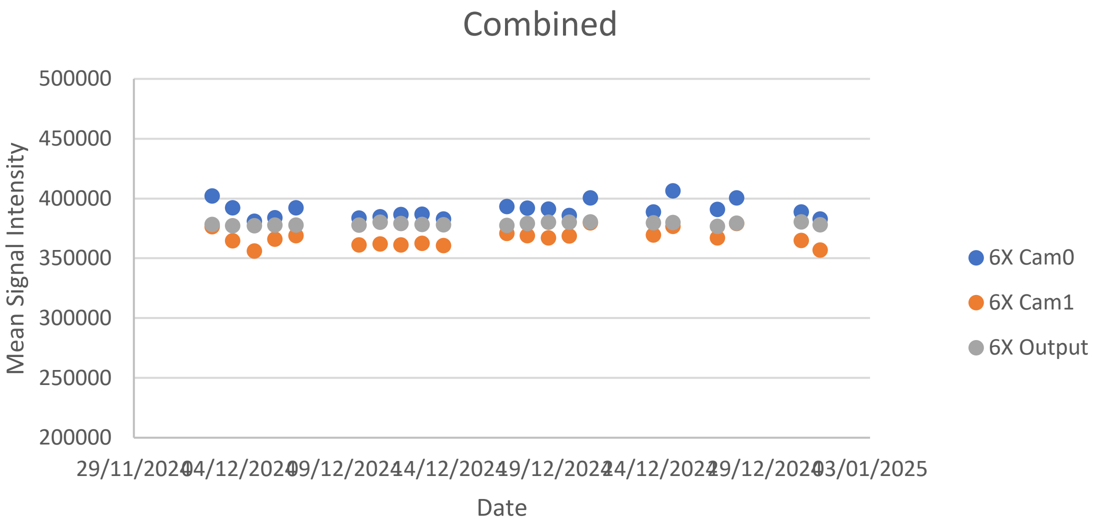
Physics Tests: Geometrical Constancy

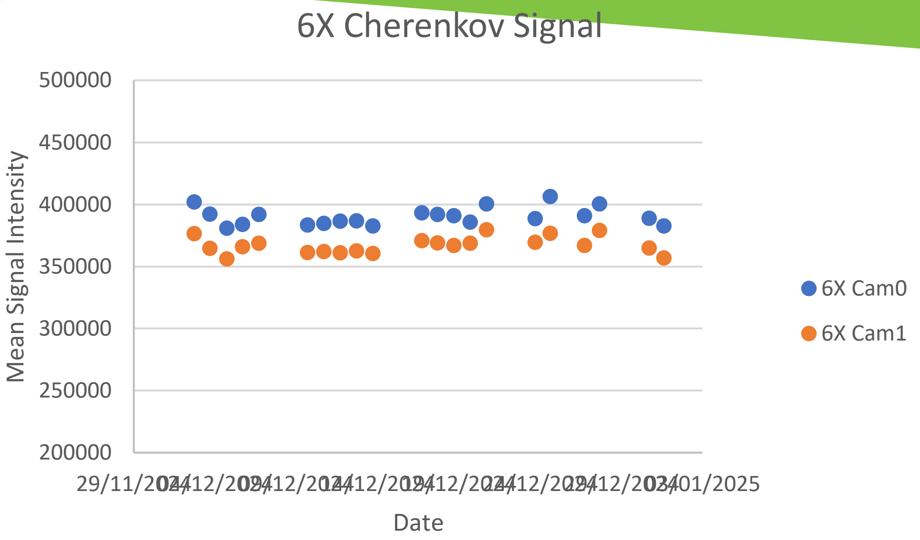


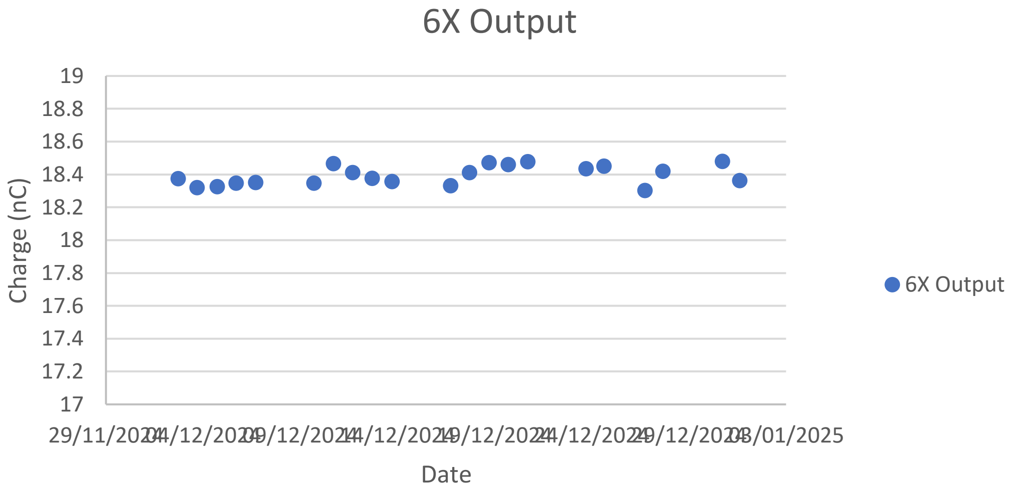


- Field size check for 3 months
- 6MV
- All measurements under 2% following TG-142.

Physics Tests: Signal vs Output Correlation







- Output was measured under 3cm buildup (1cm block with chamber cavity and 2cm Cherenkov plate). Measurements were corrected for temperature and pressure. 10x10 field at 100cm SSD with 100MU delivered.
- Cherenkov signal was measured for a 10x10 ROI at the same time.

Summary

- The SGRT workflow with DoseRT can improve
  - Plan quality and safe delivery
  - Detection of unexpected or stray dose during or after delivery
  - Evaluation of plan robustness, specifically regarding patient body habitus and compliance issues.
- DoseRT can assist in re-plan decisions and adjustments
- DoseRT provides a unique perspective on treatment delivery

Thank you!
Questions?

Email: Adi.Robinson@adventhealth.com