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Medizinische Fakultät Mannheim
der Universität Heidelberg

Universitätsklinikum Mannheim

Latest Clinical Experience

with Dose RT and Beam Guide

PD Dr. sc. hum. Florian Stieler

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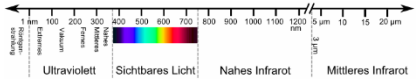
Dose RT – Cherenkov Imaging

PD Dr. sc. hum. Florian Stieler

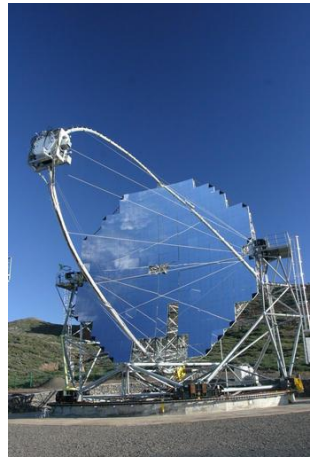
Basics – What is Cherenkov radiation?

- “Blue light”
- Electromagnetic radiation with wave length >300nm

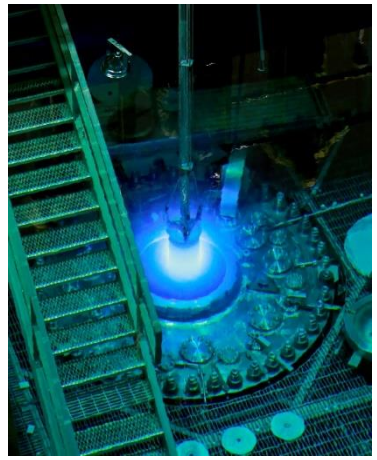


KIT

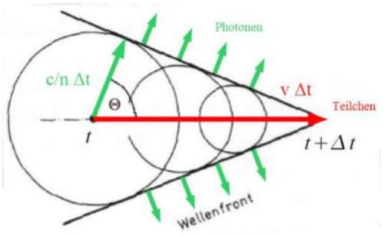
- If a charged particle (e.g. electron) moves in a medium faster than the speed of light in that medium, Cherenkov radiation arises. (Bartel et al. *Theoretische Physik*)
- The direction of the Cherenkov radiation along the beam describes a so called mach cone. Cherenkov-radiation is the optical analogy to the supersonic cone.



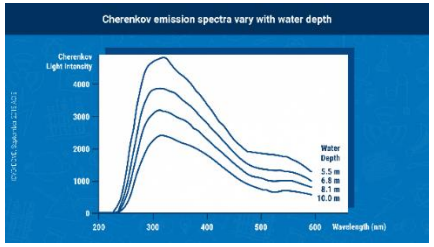
Cherenkov-Teleskop MAGIC



Oak Ridge National Laboratory



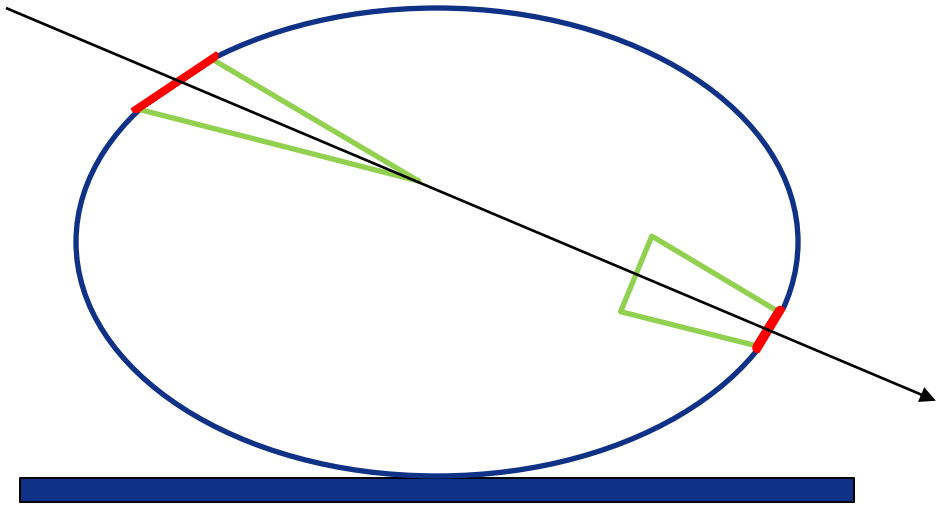
Reuter et al.



IAEA, Wave length in reactor

Basics - Cherenkov imaging in radiation therapy

- Cherenkov radiation arises along the photon beam in the patient, but is only visible at the surface.
  - The Cherenkov radiation arises right there, where we irradiate.



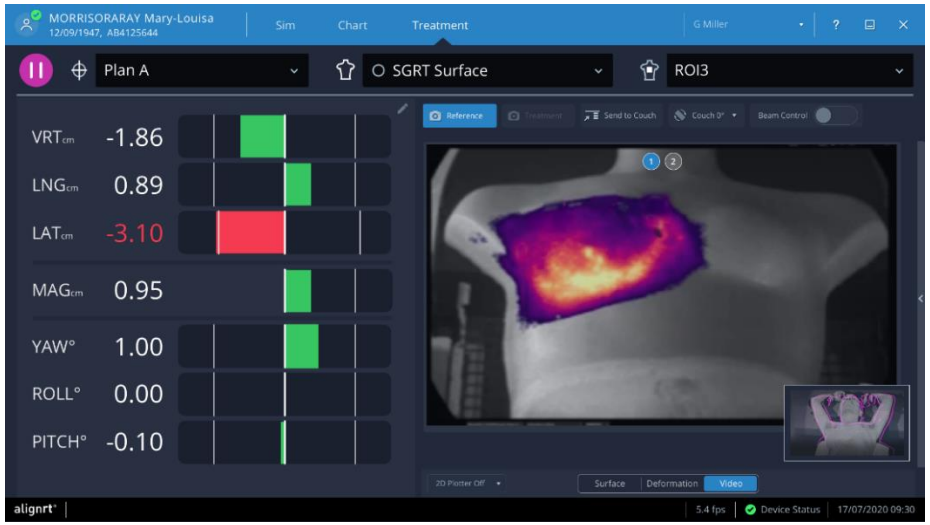
- The intensity of the Cherenkov radiation depends of the tissue density and the beam intensity.

- Very useful tool for risk management.

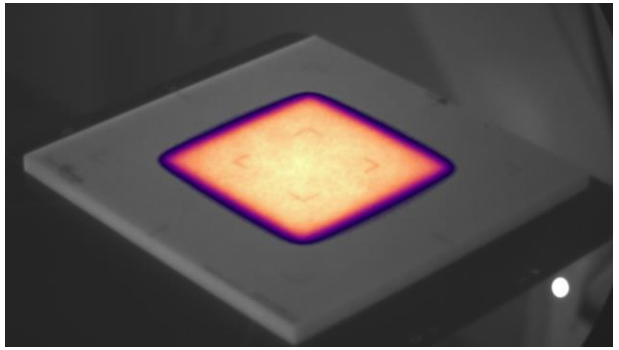
Basics - Dose RT (Vision RT, UK)

Dose RT:

- 2 additional cameras in the treatment room (Installation in Mannheim March 2024)
- Currently: Integration of Dose RT into Align RT version 7.3 (510k and CE)
- Special phantom plate to detect Cherenkov radiation



Align RT 7.3 (Vision RT)



Cherenkov signal on phantom plate

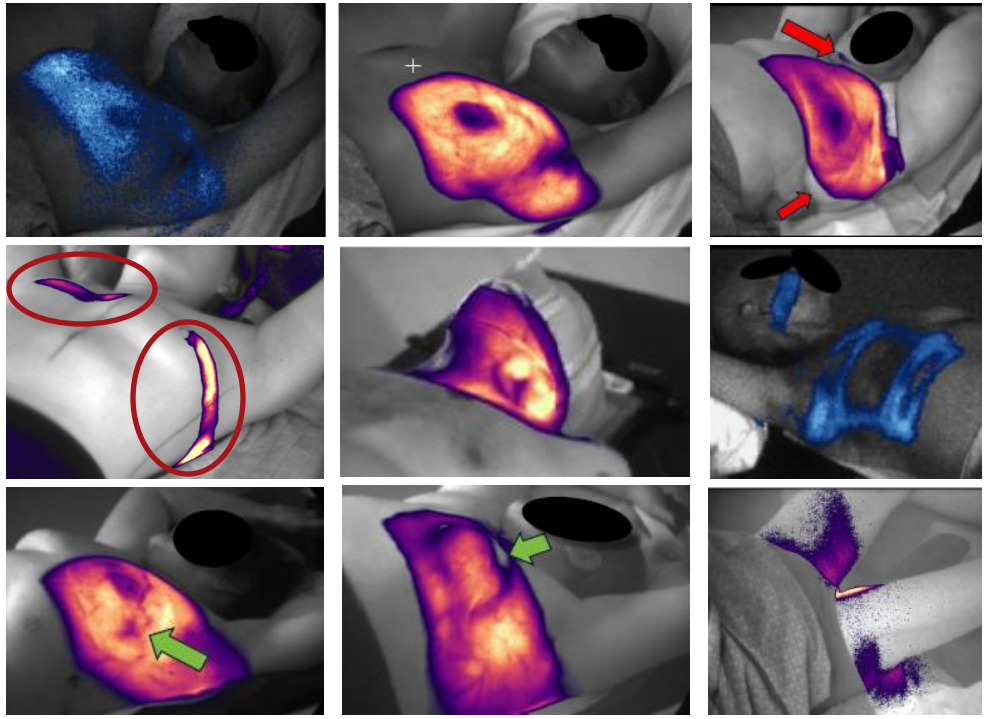
Dose RT camera in Mannheim

Horizon and Dose RT cameras in Mannheim

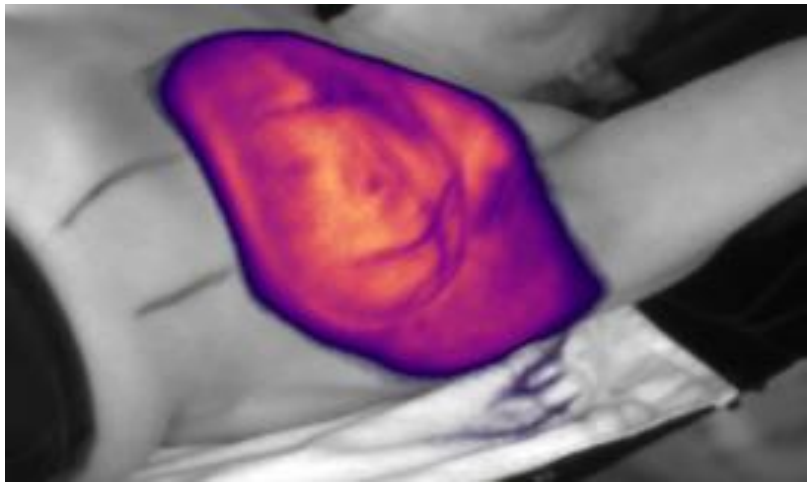
Basics – Current Applications of Cherenkov radiation in the field of radiation therapy

<u>Surveillance of radiation therapy in real-time</u>
(recognition of irradiation errors)

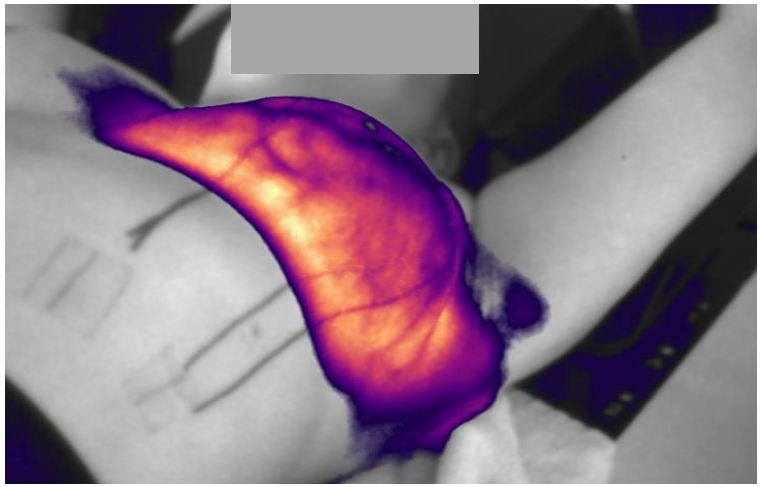
- Localization of irradiation
  - contra-lateral breast
  - arm, leg
  - chin, shoulder
- Beam geometry (beam direction, field size)
- Intensity of irradiation
- Correct bolus in correct position
- Seroma monitoring after lumpectomy



Clinical experience with Dose RT in our department

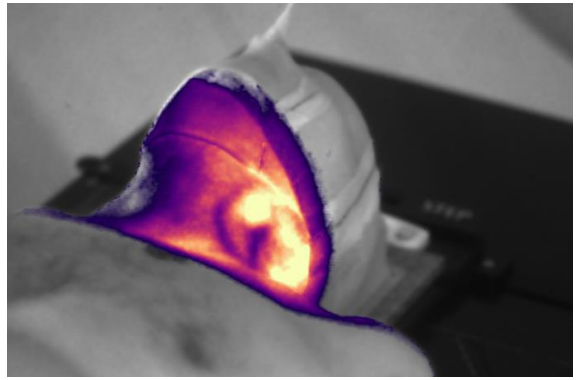


Breast: Tang. IMRT, FB

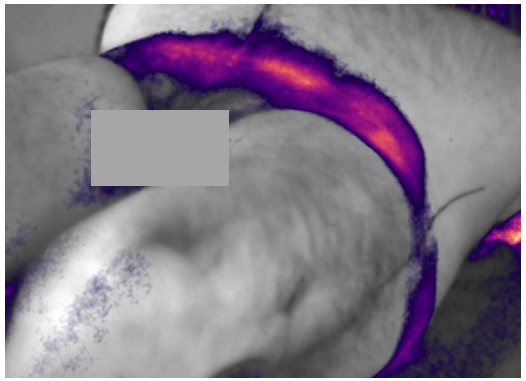


Breast incl. upper and mammaria interna lymph nodes: VMAT, DIBH with RTC

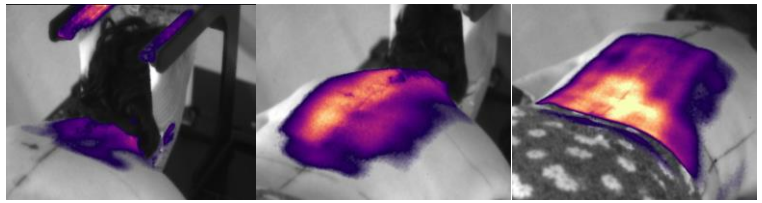
Lung met: SBRT, VMAT 6FFF



H&N: VMAT



Prostate: VMAT

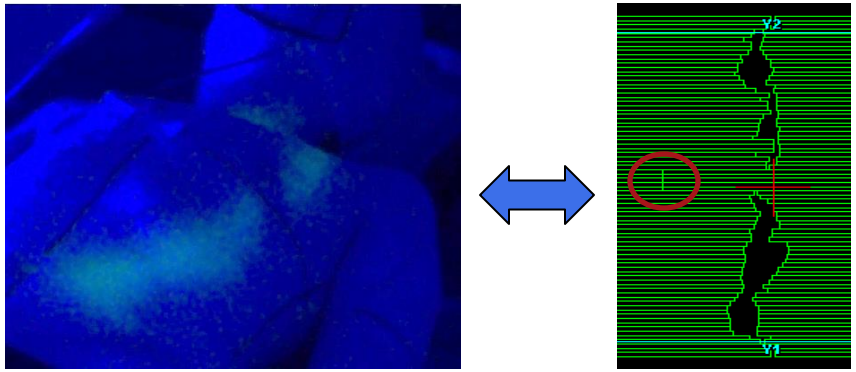


Cranio-Spinal:
3 isocenter, intersecting VMAT

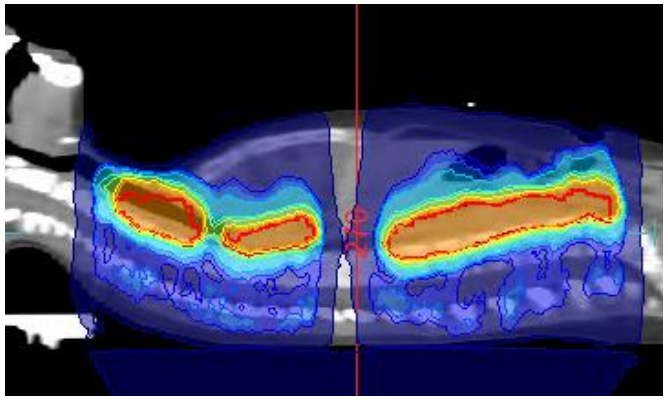
Dose RT: Validation of treatment planning

- Single-isocenter VMAT boost of neck-abdomen with interruption. Arms down due to anesthesia.
- Standard procedure: 1st rotation focuses cran. target + 2nd rotation focuses caud. target because of dosimetric leaf-gap avoidance
- In this case: 2 rotations focused on both targets due to planning complexity and treatment efficiency (anesthesia)

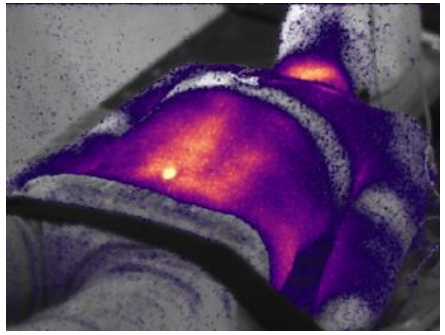
The validation of the TPS and Cherenkov-imaging showed no significant dose or Cherenkov signal in the leaf-gap region.



Cherenkov signal and corresponding segment with Leaf-Gap



Dose distribution



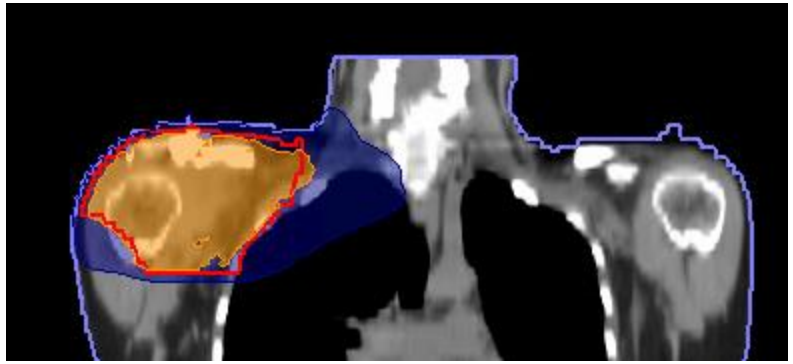
Cumulated Cherenkov image

Dose RT: Sarcoma shoulder

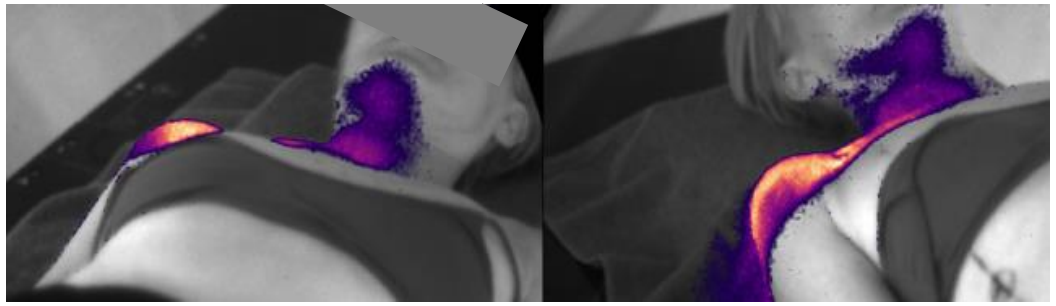
- Resected sarcoma in right shoulder
- 60 Gy in 30fx, partial VMAT 6 MV (180-35°)

- First fraction: Cherenkov signal in upper neck and chin (2 VMAT segments may hit the chin)

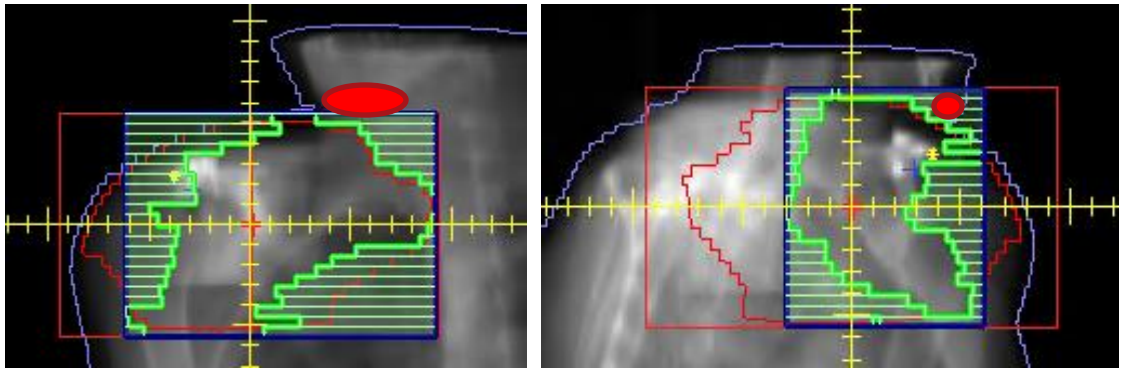
- Next fractions: chin up
- Further lesion learned: partial VMAT for this paradigms only until 0°



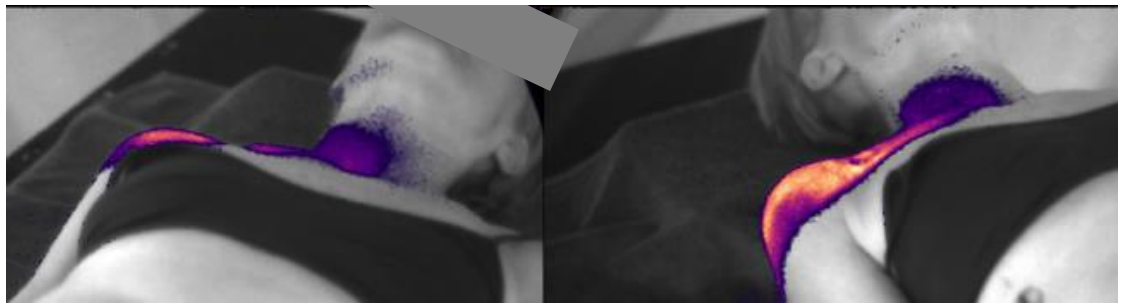
Dose distribution: blue volume 30% dose



Cumulated Cherenkov images of the first fraction



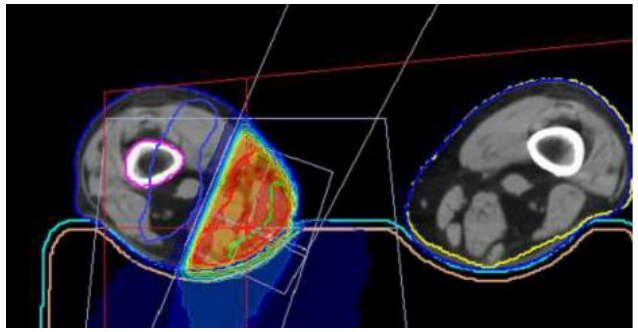
Relevant VMAT segments (35° and 243°) for dose in chin (red dot)

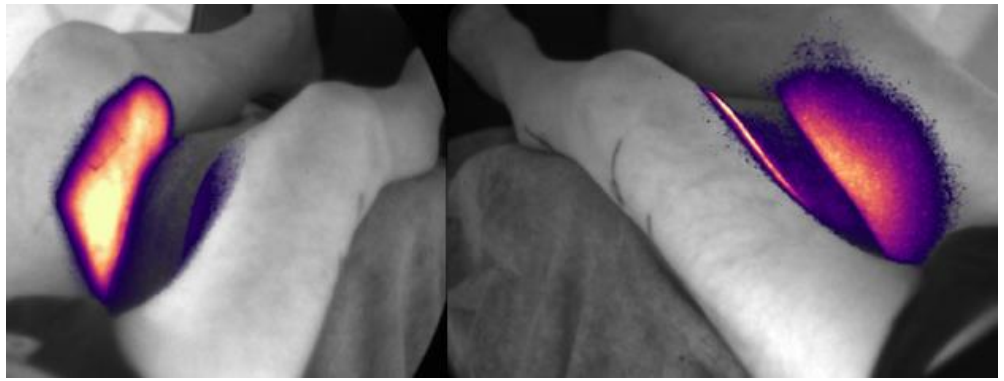


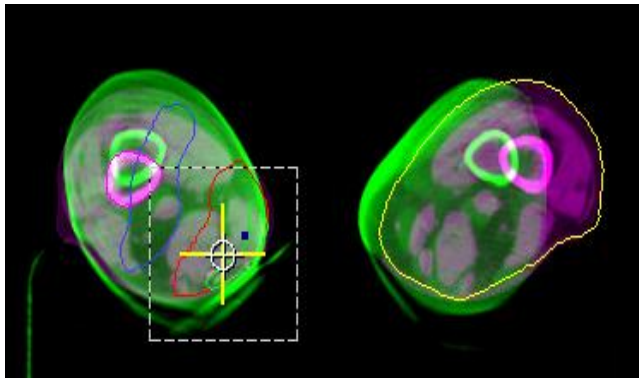
Cumulated Cherenkov images of the second fraction

Dose RT: Extremity

- Sarcoma in left leg
- 2 tangential dMLC beams

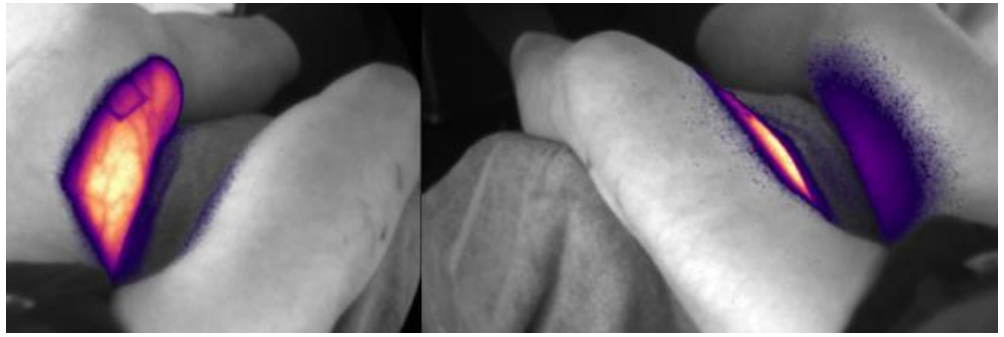


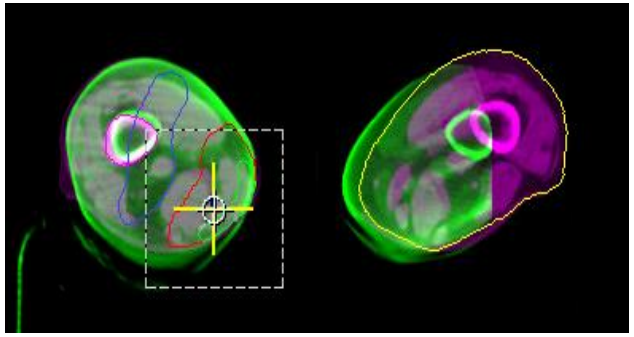




First fraction

- 1 Fx: RTT focus on PTV and not on contra-lateral leg.
- 2-x Fx: RTT focus on both legs





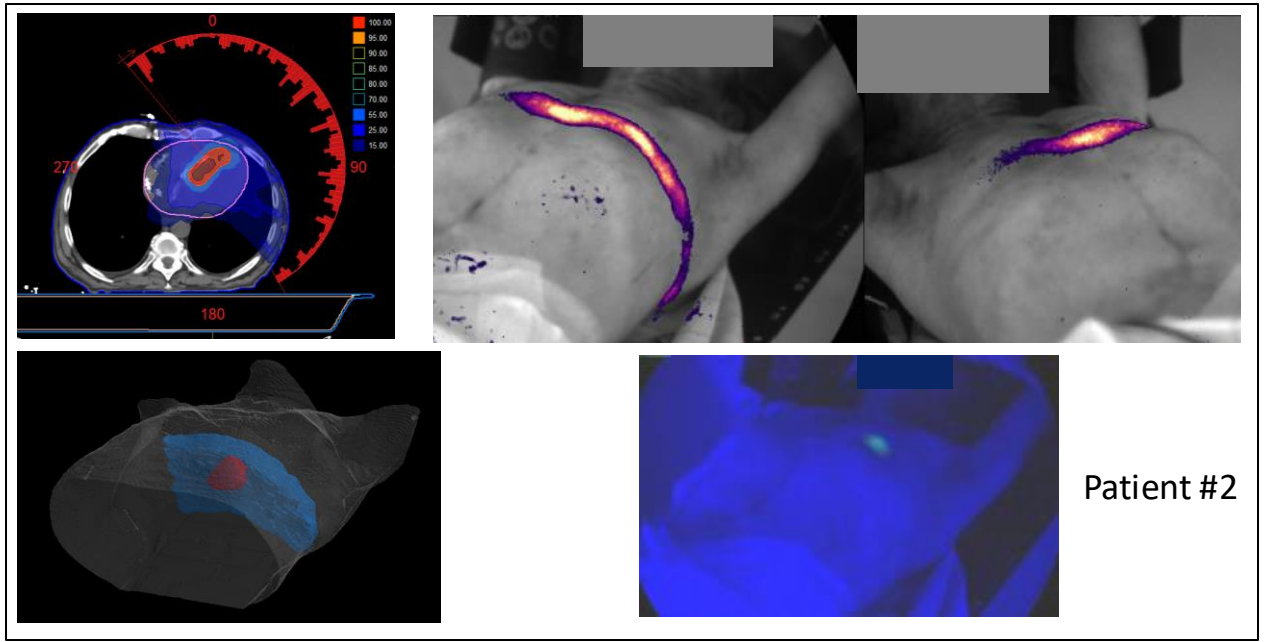
Second fraction

Dose distribution

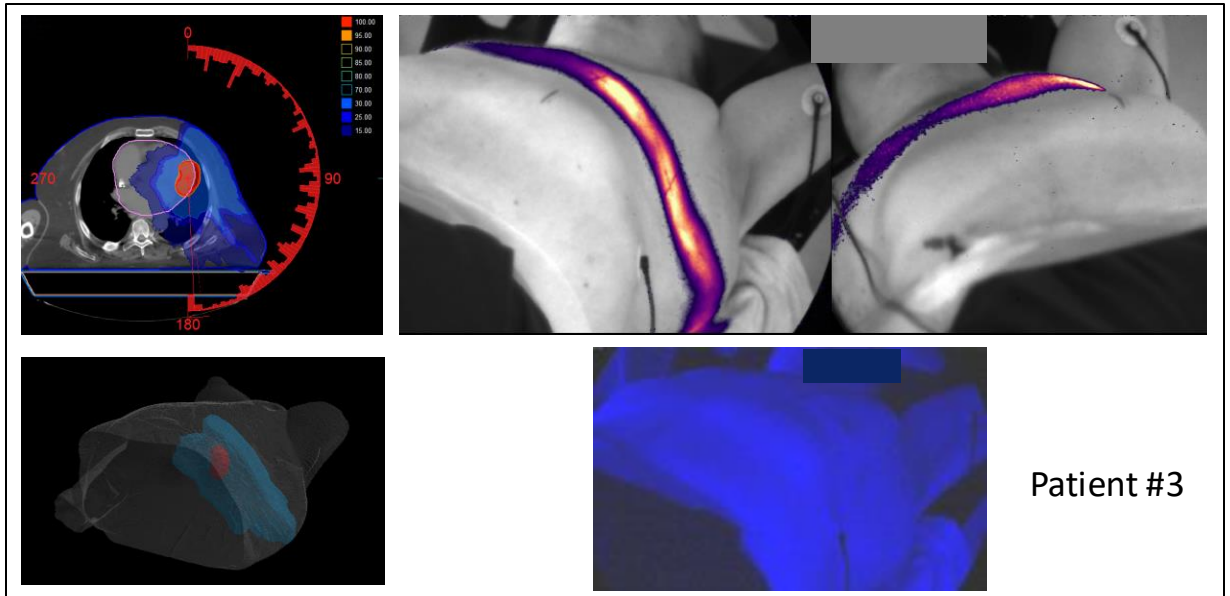
Dose RT: STOPSTORM

STOPSTORM

www.stopstorm.eu



Patient #2



Patient #3

Stereotactic Arrhythmia Radioablation (STAR) for ventricular tachycardia according to STOPSTORM consortium.

- 3 partial VMAT, 1x 25 Gy, 6FFF
- CBCT + SGRT + Dose RT

Conclusion - Dose RT

- Dose RT provides real-time information's about the dose deposition depending on daily patient position and linac delivery.
- Confidence in delivery of complex and high dose treatment plans.
- RTT‘s can interrupt the treatment when noticeable problems occur.
- Physicians/Physicists can review the delivered treatment fractions.

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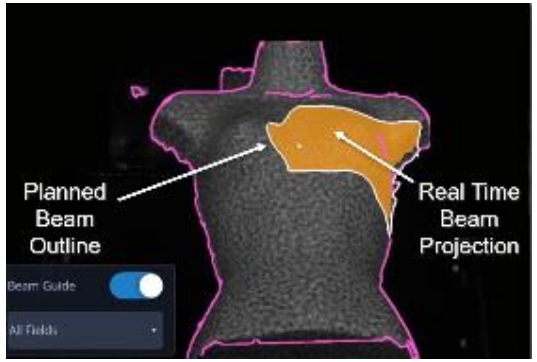
First Clinical Experience with Beam Guide

PD Dr. sc. hum. Florian Stieler

Basics – Beam Guide

New functionality in the real-time “postural video” feature of Align RT.



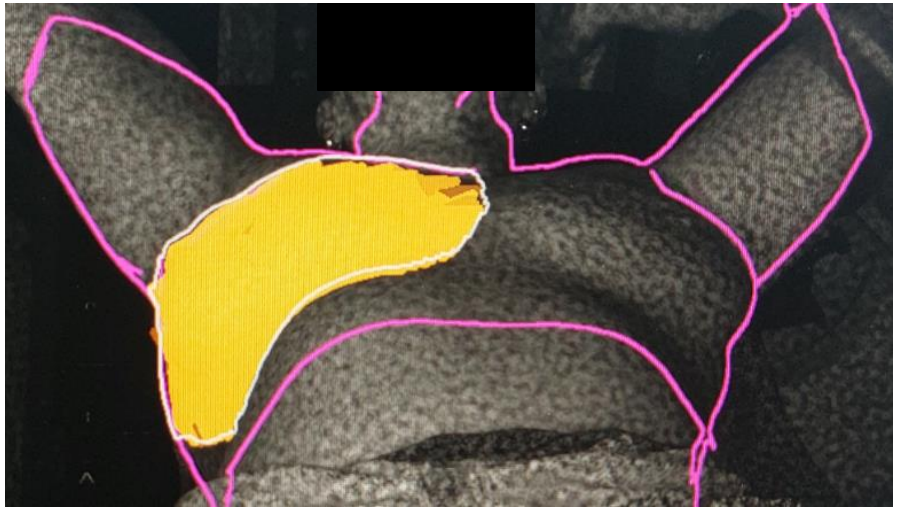
Vision RT Inc.

Beam Guide options

Beam Guide shows the following information on the patient:

1. Treatment field outline based on the RT-plan from the treatment planning system **(white outline)**

2. Real-time treatment field based on the actual patient position **(yellow volume)**

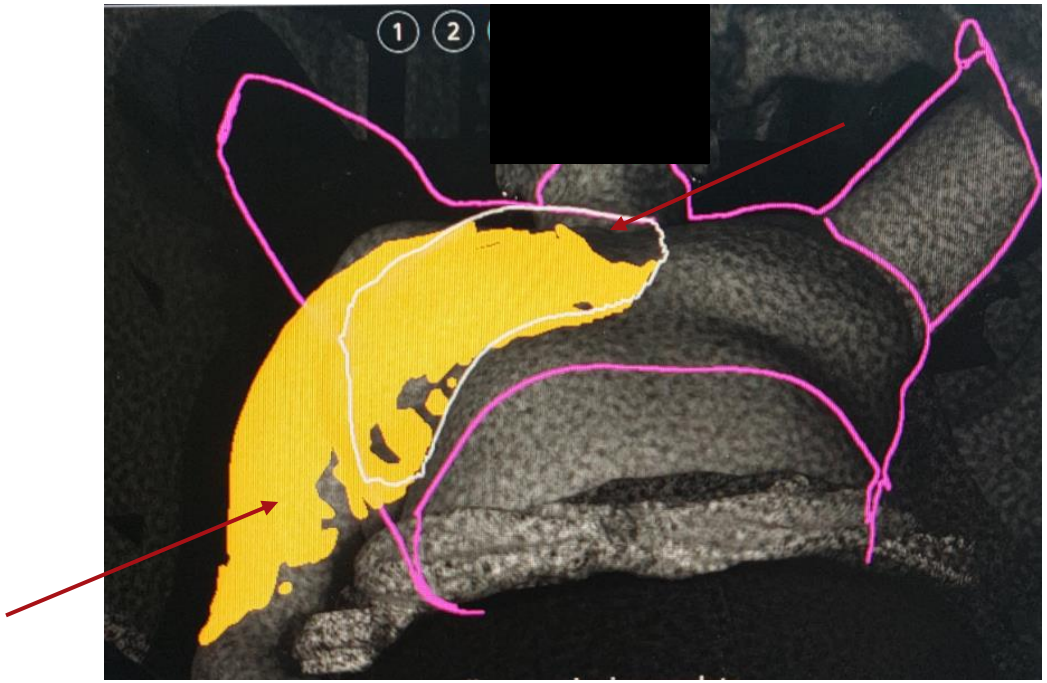


Postural video with Beam Guide

Beam Guide shows the RTTs the anatomically effect resp. the consequence of a patient misalignment (rigid and non-rigid) .

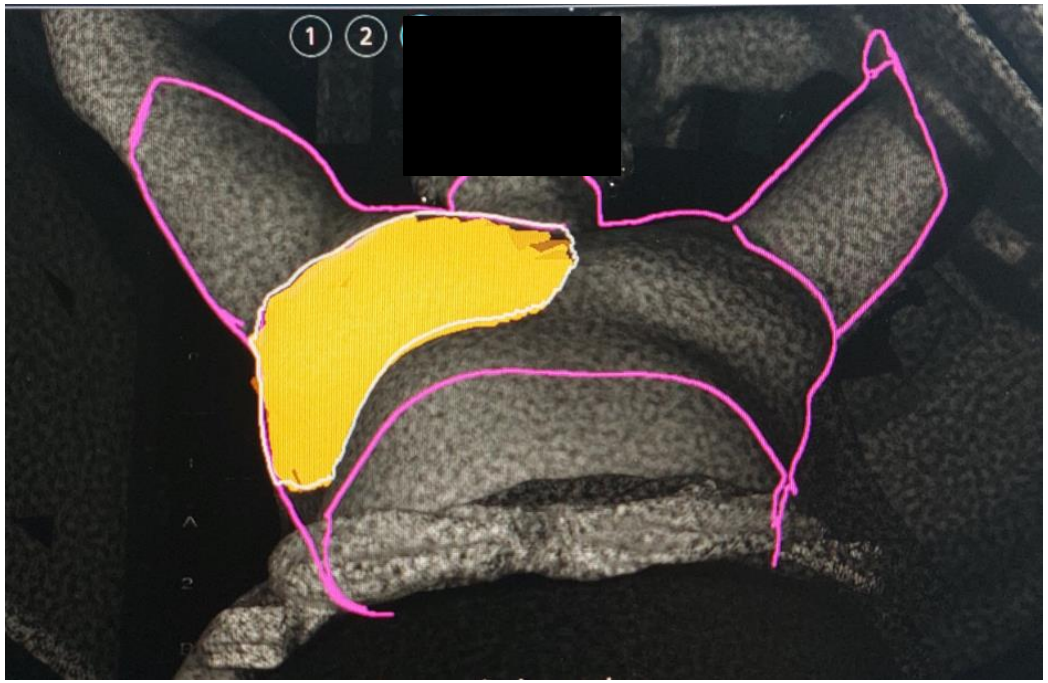
Patient 1: Right breast with tangential IMRT in free breathing (FB)

Positioning procedure with SGRT and Beam Guide



Patient with lowered right arm

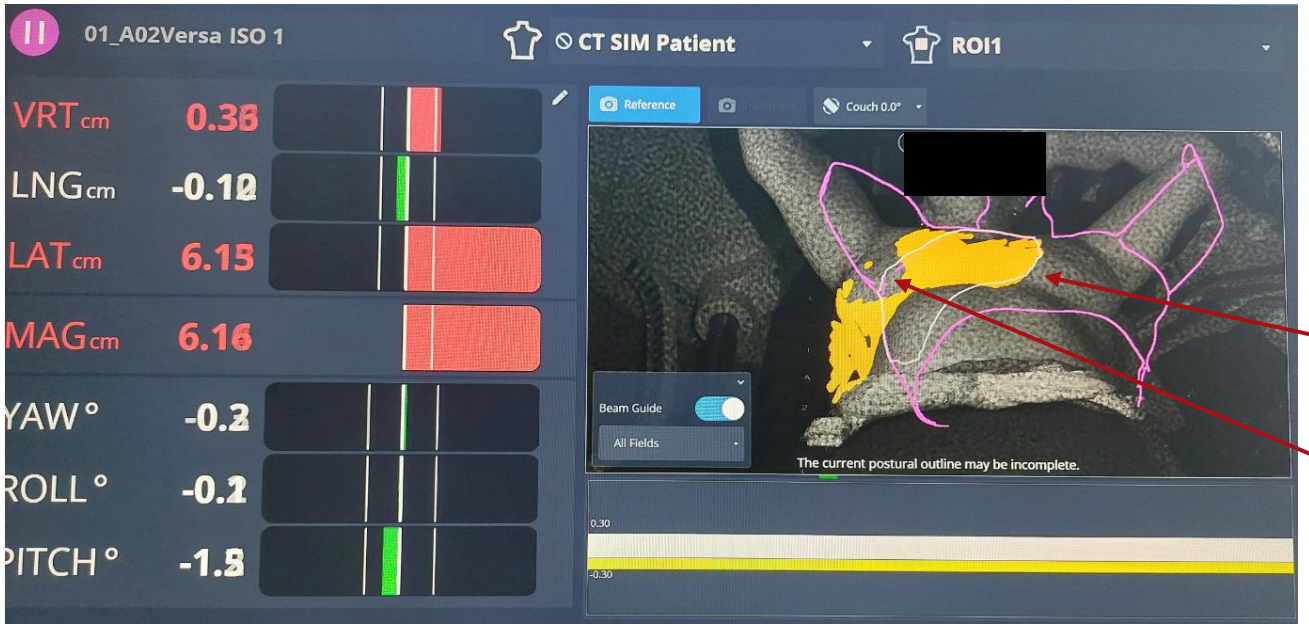
- Right arm receives light field/dose
- Less signal in central part of target volume



Patient in correct position

Patient 1: Right breast with tangential IMRT in free breathing (FB)

Position for CBCT



Positioning before CBCT: large lateral deviation because of CBCT clearance issues (isocenter is located off center)

- Light field is shown in contra lateral breast
- No light field due to wrong position

Patient 1: Right breast with tangential IMRT in free breathing (FB)

After CBCT

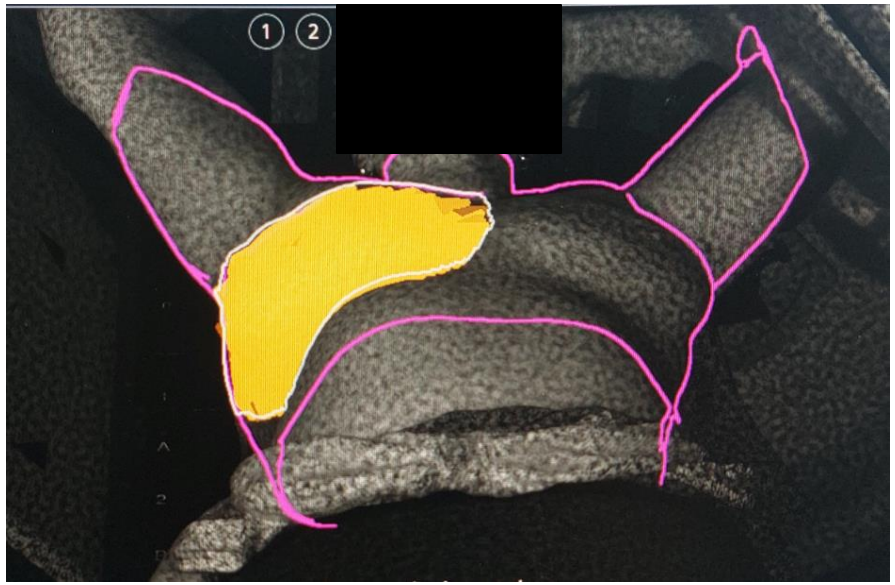
Video: Movement of patient after CBCT.

Video: Beam Guide agreement after CBCT positioning for the 3 horizon cameras.

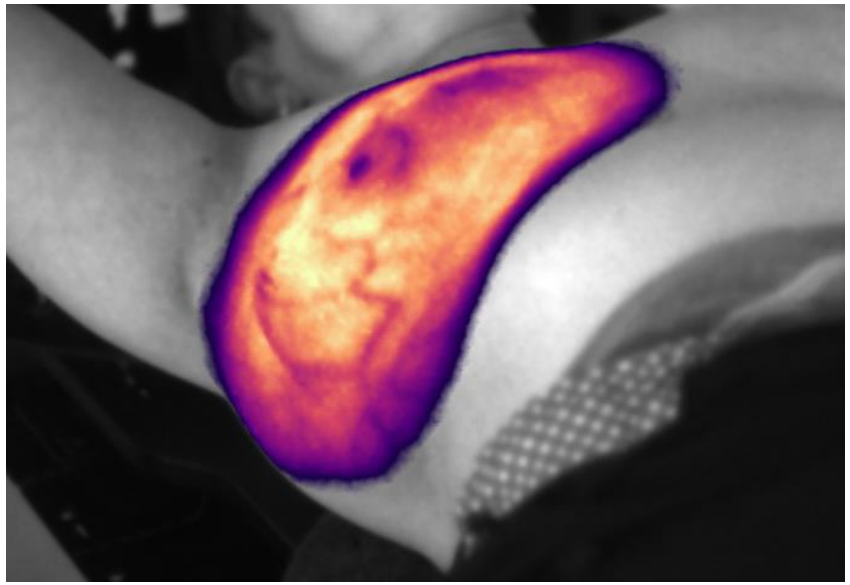
Patient 1: Right breast with tangential IMRT in free breathing (FB)

Beam Guide versus Dose RT:

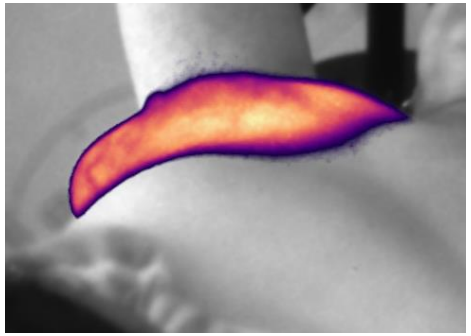
- Good anatomical agreement of “prediction” and “verification”.
- Currently, no quantitative analysis possible due to different camera positions and missing tools.



Beam Guide: Fx X



Dose RT: Fx X+1



Patient 2a: Right breast with tangential IMRT + VMAT Boost in FB

Video: Positioning procedure before RT for tangential IMRT treatment plan

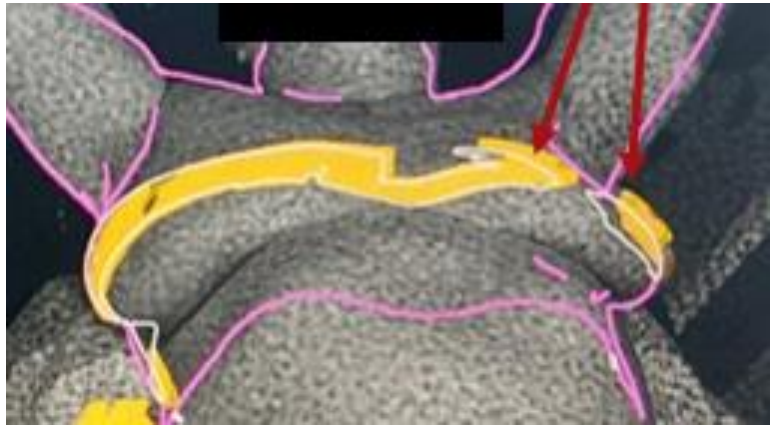
Beam Guide information for the tangential plan for the 3 Horizon cameras.

No Dose RT information available

Patient 2b: Right breast with tangential IMRT + VMAT Boost in FB

Beam Guide information for the partial VMAT boost plan.

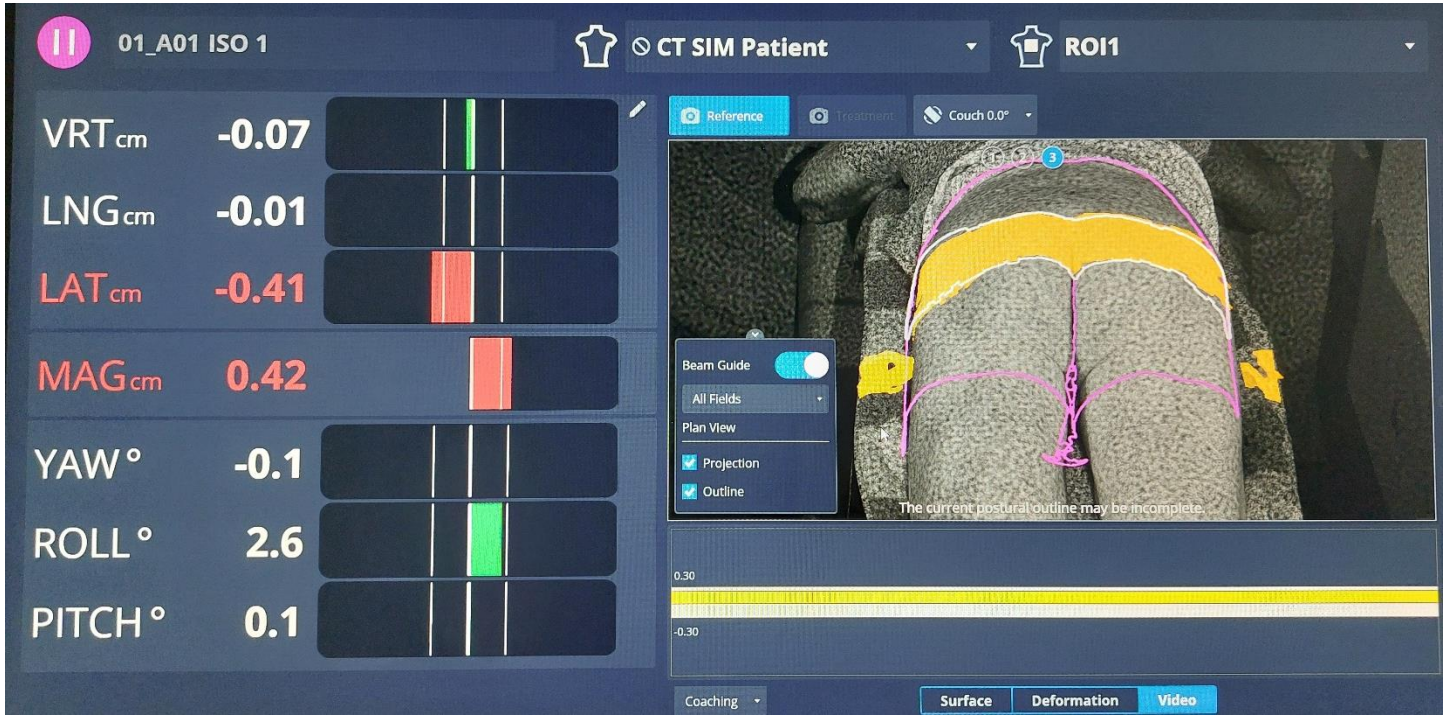
Roll = 2.7° → slight deviation in the contra lateral breast

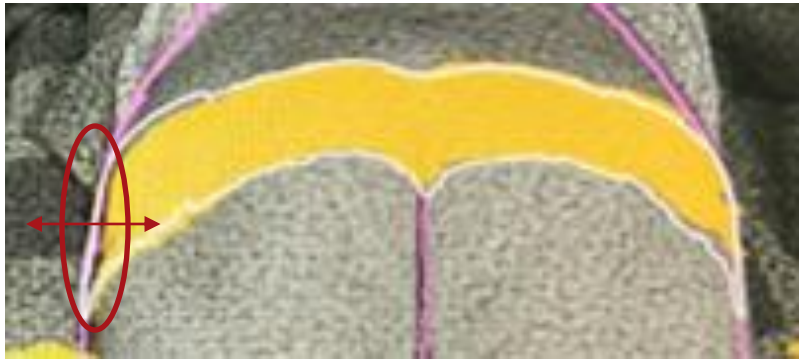


Patient 3: Prostate VMAT

2 full VMAT arcs, patient in prone position.

1. Lateral deviation is visible in BG

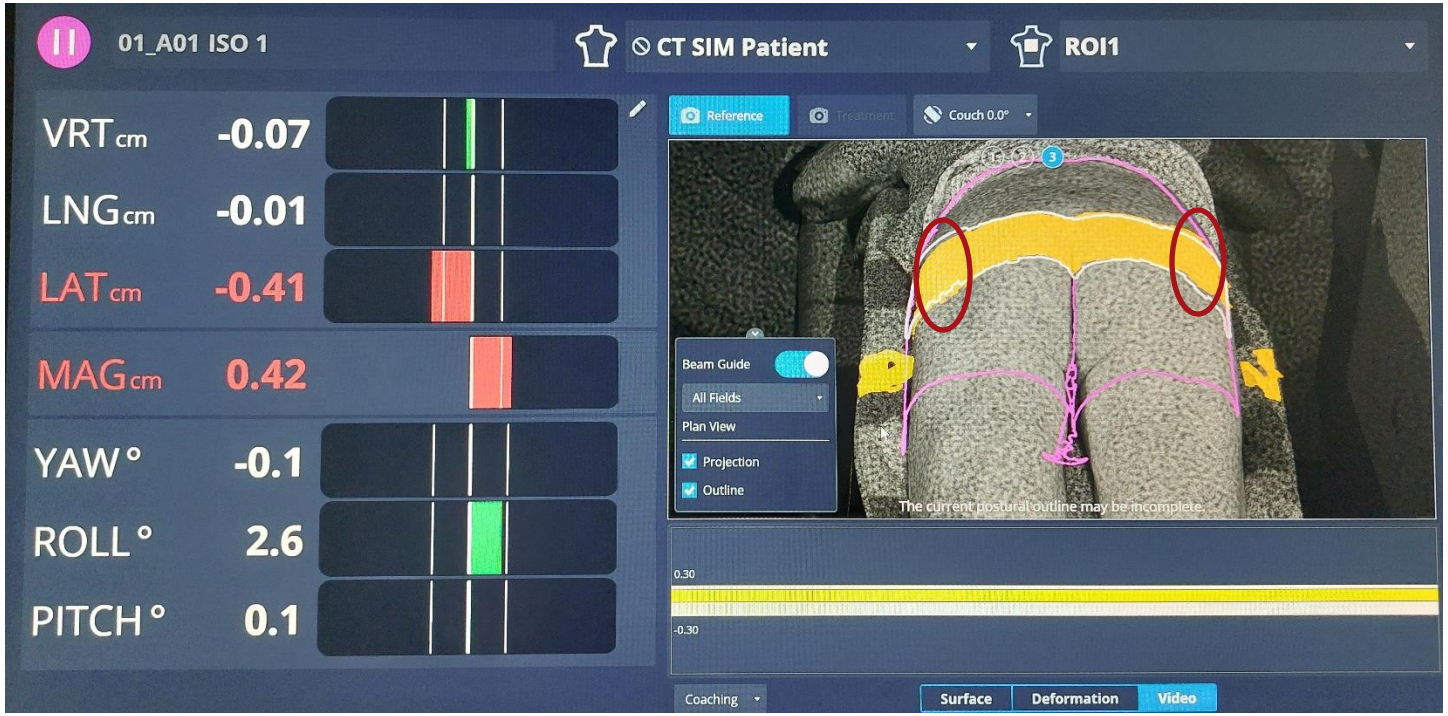


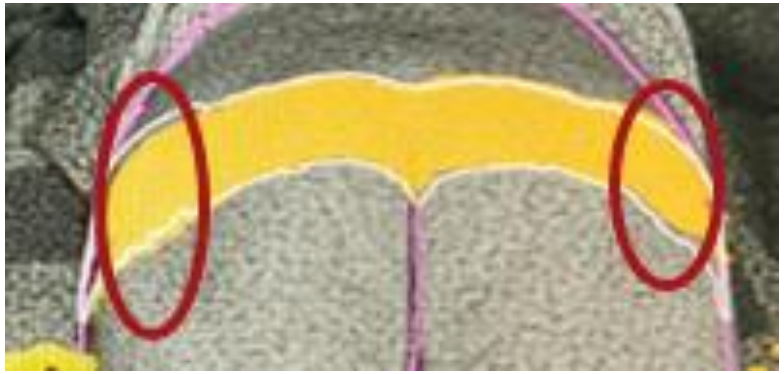


Patient 3: Prostate VMAT

2 full VMAT arcs, patient in prone position.

2. Roll deviation is visible in BG

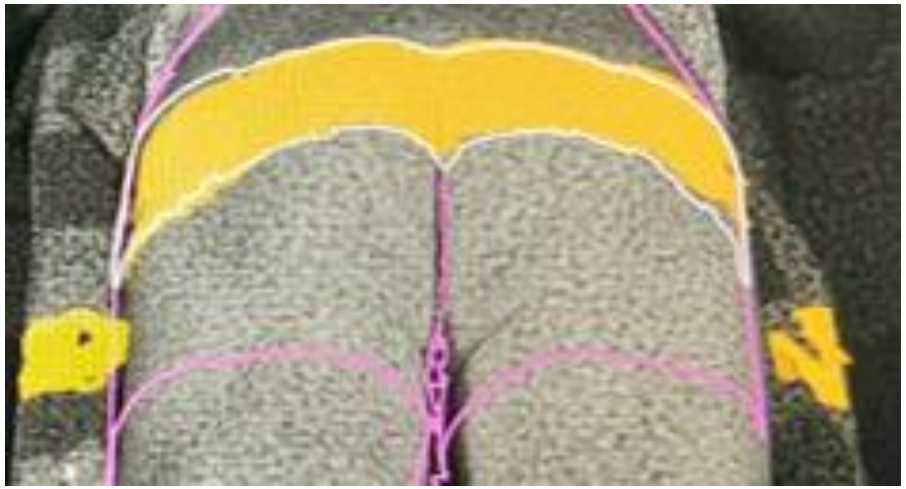




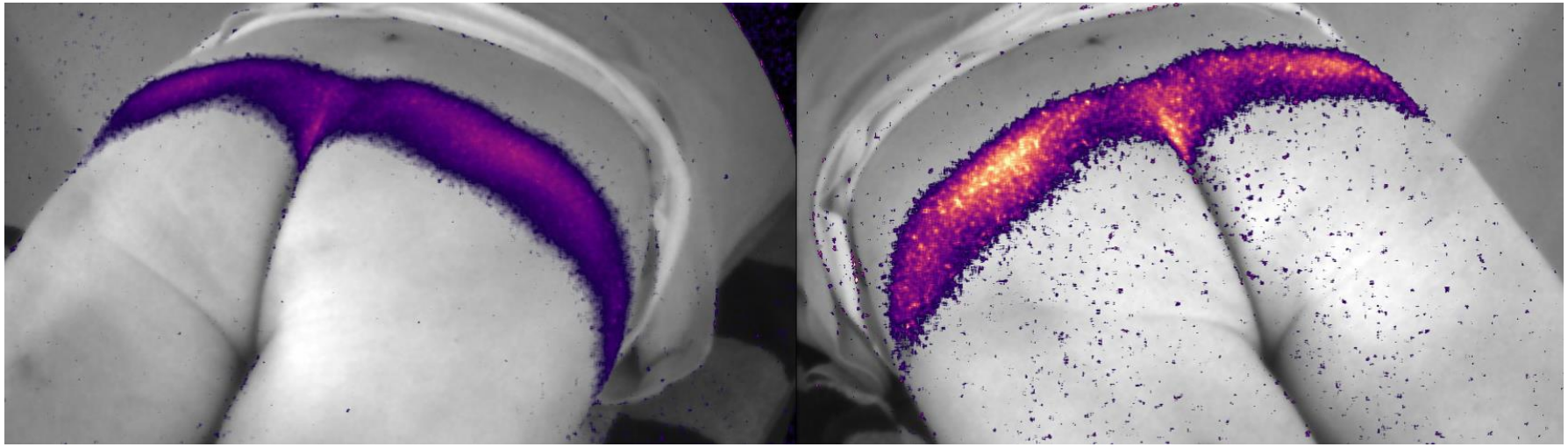
Patient 3: Prostate VMAT

Beam Guide versus Dose RT:

Good anatomical agreement of “prediction” and “verification”.



Beam Guide



Dose RT

Patient 4: Iliac Bone right partial VMAT

Partial VMAT on right patient side

Good agreement depending on breathing.

Less BG signal on patients left side seen on right camera

No Dose RT information available

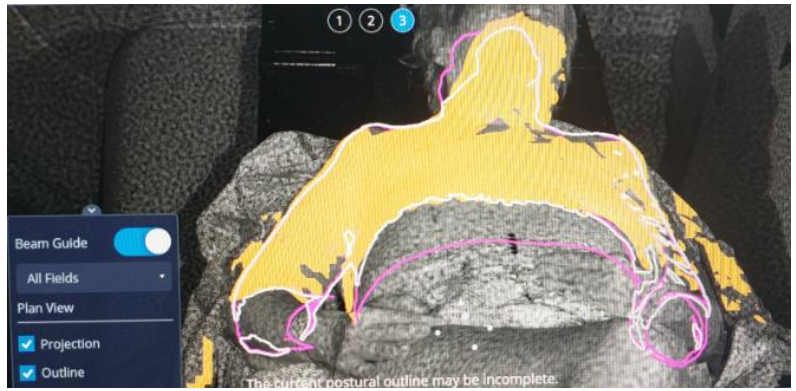
Video: Positioning

Video: Beam Guide information from 3 directions

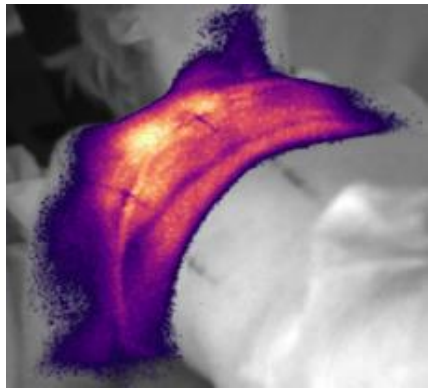
Patient 5: Thoracic wall (FAST-Forward trial)

Partial VMAT irradiation of thoracic wall according FAST-Forward trial (26Gy in 5 fractions).

Beam Guide showed a deviation in the neck/chin region but unfortunately it was not possible to reposition the patients chin due to patient conditions. Check of treatment delivery quality with Dose RT.

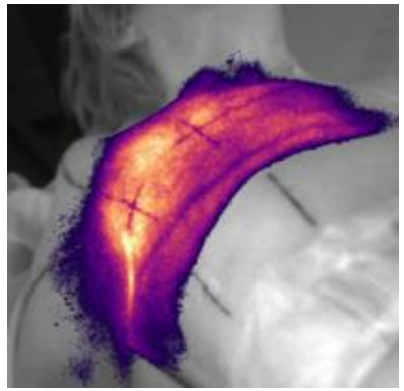


Beam Guide for positioning of Fx 3



Dose RT of Fx 3

Comparison to former fractions



Dose RT of Fx 2

Conclusion Beam Guide (+ Dose RT)

- Beam Guide provides real time positioning and monitoring information's to the RTTs.
- Deviations of the patient position in translations and rotations are recognizable with Beam Guide.
- The RTTs receive more information's on the treatment location and the region-of-interest which helps to position the patients.
- Beam Guide provides monitoring information's for conventional radiotherapy and DIBH/gated treatments.

The combination of Beam Guide for treatment prediction

and Dose RT for treatment verification increases the safety in radiotherapy.

Thank you for your attention

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