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MANNHEIM

Medizinische Fakultät Mannheim
der Universität Heidelberg

Universitätsklinikum Mannheim

Clinical Implementation and first experience with Dose RT

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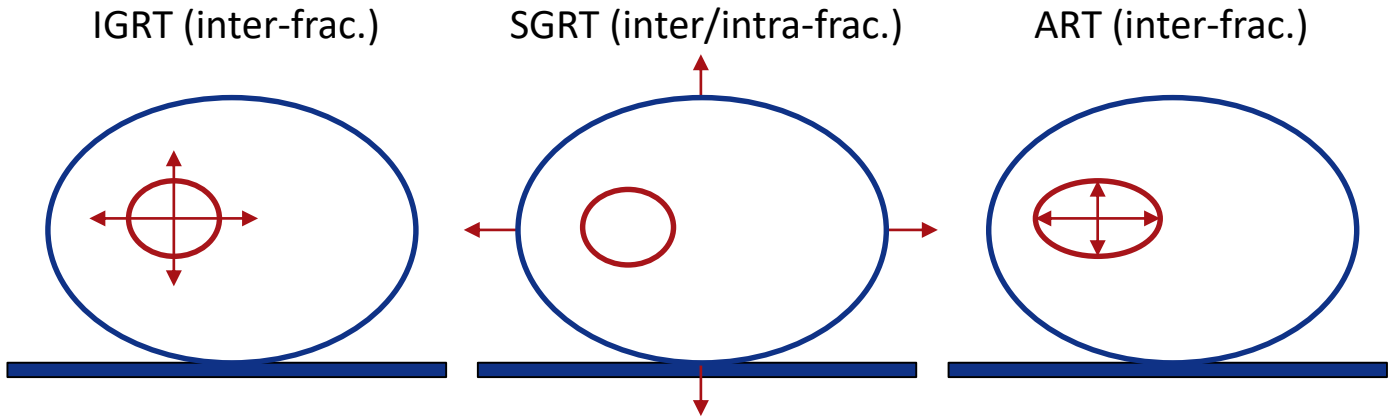
Disclosures

PD Dr. Florian Stieler received compensation for travel expenses from Vision RT.

Basics – What techniques exist for image guidance/plan adaption

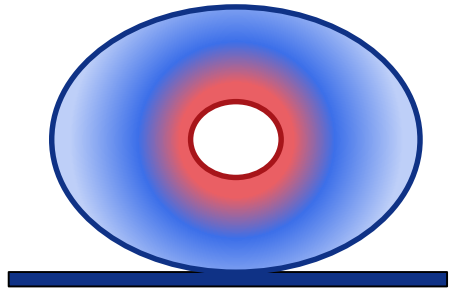
- Inter and intra-fraction image guidance systems (CBCT, Portal imaging (MV), MR, kV-imaging, SGRT, US, transponder, …)
- Adaptive Radiotherapy (ART)



What do we see or do:

- the location of the target/surface before and during RT.
- Adapt the plan to the daily situation (ART)

Dose (inter/intra-frac.)

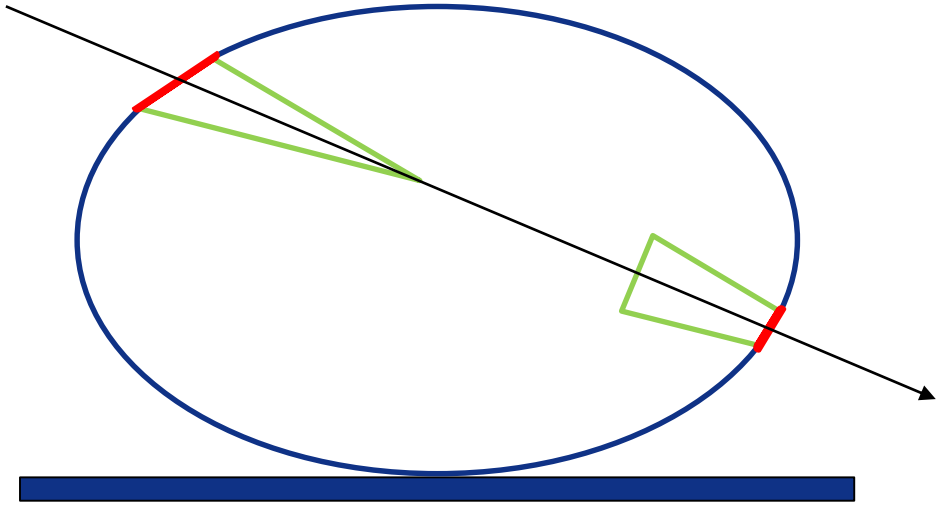


What do we want to see:

The deposition of the dose in/on the patient in real-time

Basics - Cherenkov radiation in radiation therapy

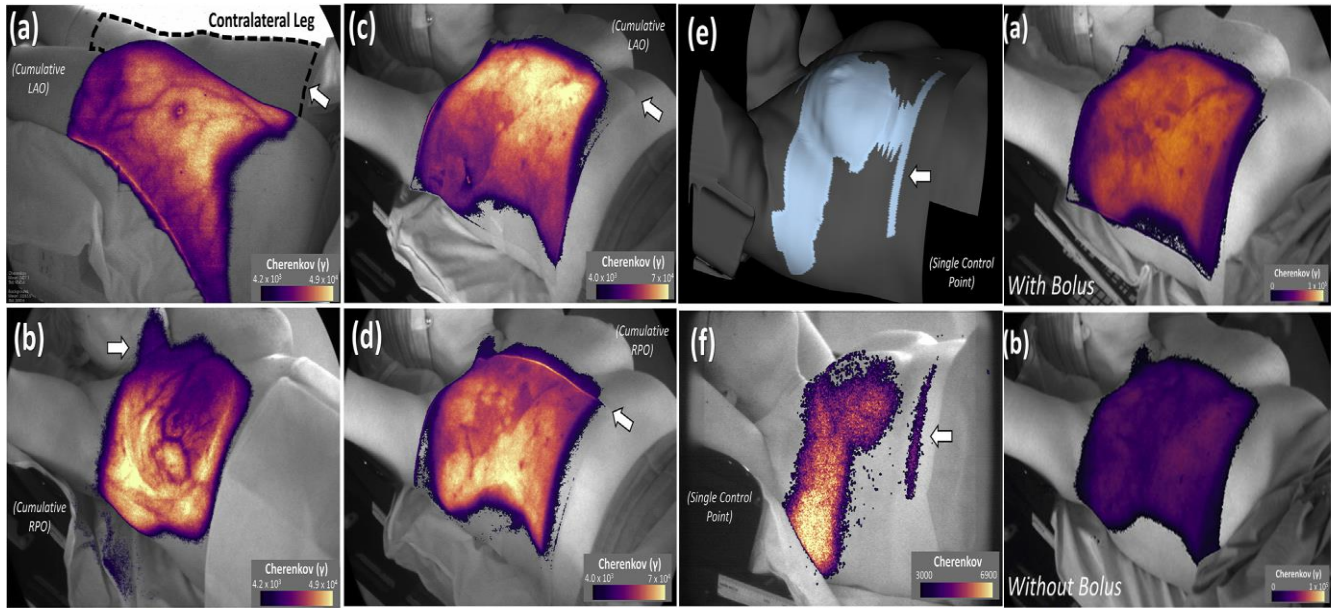
- Cherenkov radiation arises along the photon beam in the patient, but is only visible at the surface.
- The Cherenkov radiation arises right there, where we irradiate.
- The intensity of the Cherenkov radiation depends of the tissue density and the beam intensity.
  - Dense tissue (e.g. blood vessels, mamilla) → less signal
  - Thin tissue (fascia) → more signal



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

Surveillance of radiation therapy in real-time (recognition of irradiation errors)

- Localization of irradiation (contra-lat. breast, arm, chin)
- Beam geometry (beam direction, field size)
- Intensity of irradiation
- Correct bolus in correct position

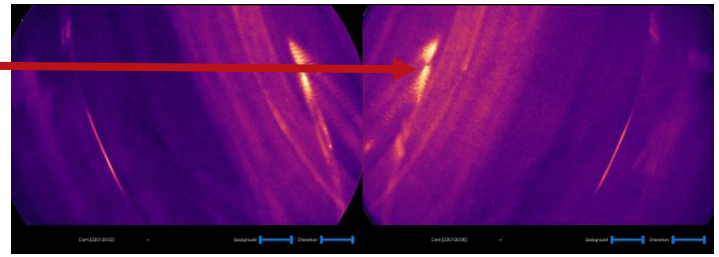


Jarvis et al. IJROBP 2020

Issue 1: Reflexion in the room

- Reflexions generate incorrect Cherenkov signals
- Locations of reflexions
  - Gantry (shining white)
  - MV and kV detectors
  - CBCT tube

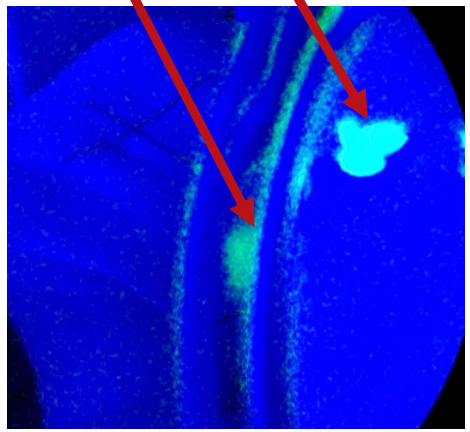
Sum image **without** room lights and object



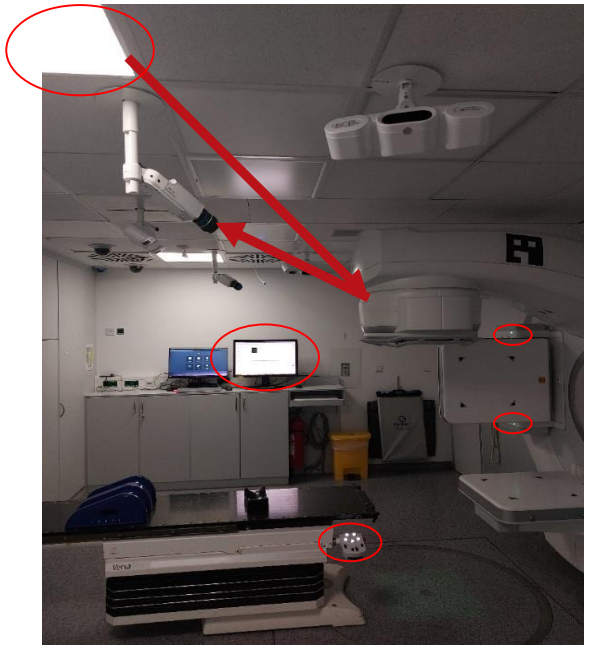
Sum image **with** room lights and object

- Source of reflexions:
  - 2 room lights on min dim level
  - Hand switch on table
  - Illuminated buttons on detectors
  - monitors

Patient signal and reflexion

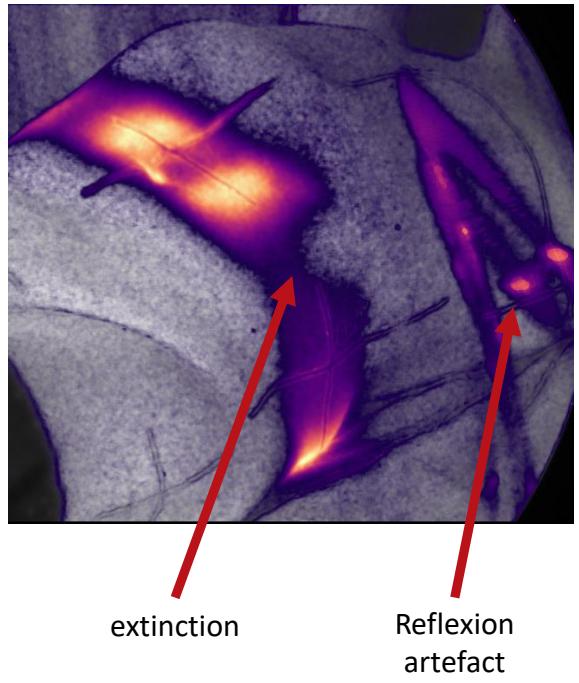


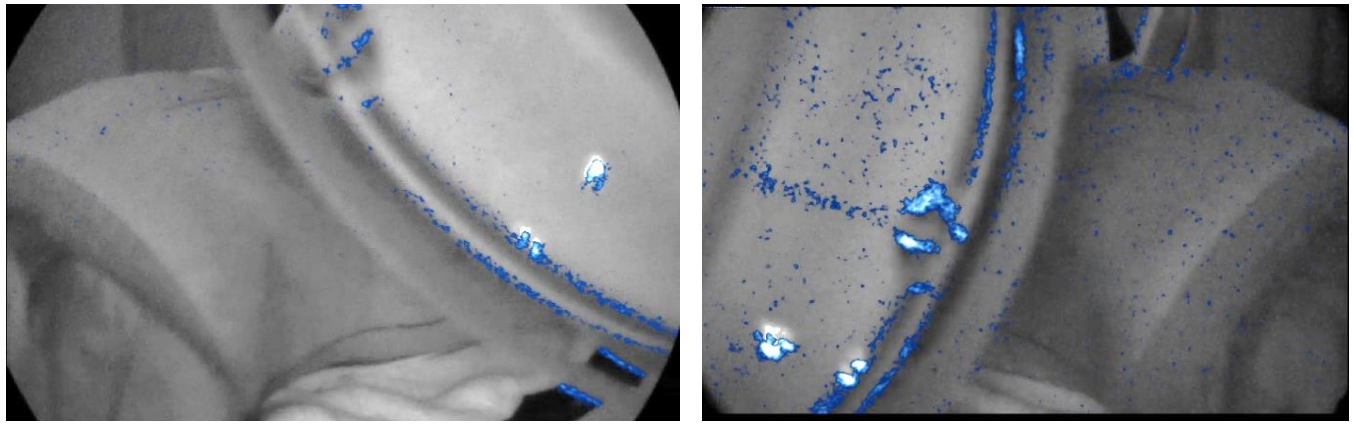
Screenshot of video



Issue 2: Blocked view

- Parts of the linac can block the view of the Dose RT cameras
- Thereby extinctions arise on the cumulated Cherenkov images
- Detectors und CBCT tube
  - After IGRT, detectors and CBCT tube must be parked manually (change of workflow).
- Gantry
  - Reposition Dose RT cameras



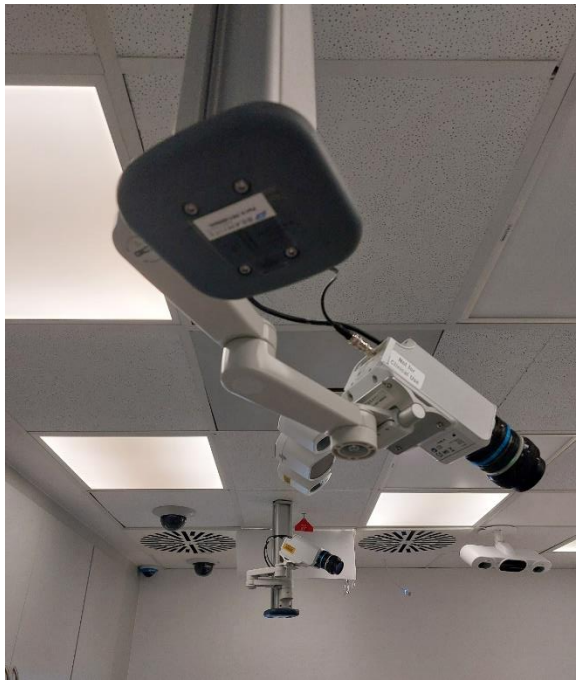


Extinction at Gantry angle 50 ° and 310°

Solutions for reflexions and blocked view

- Reposition Dose RT cameras
  - Version 1: 154 cm from Iso caudal, 88 cm lateral and 200+ cm above ground
  - GTX mounts for more flexibility
  - Version 2: closer to iso and closer to the center axis

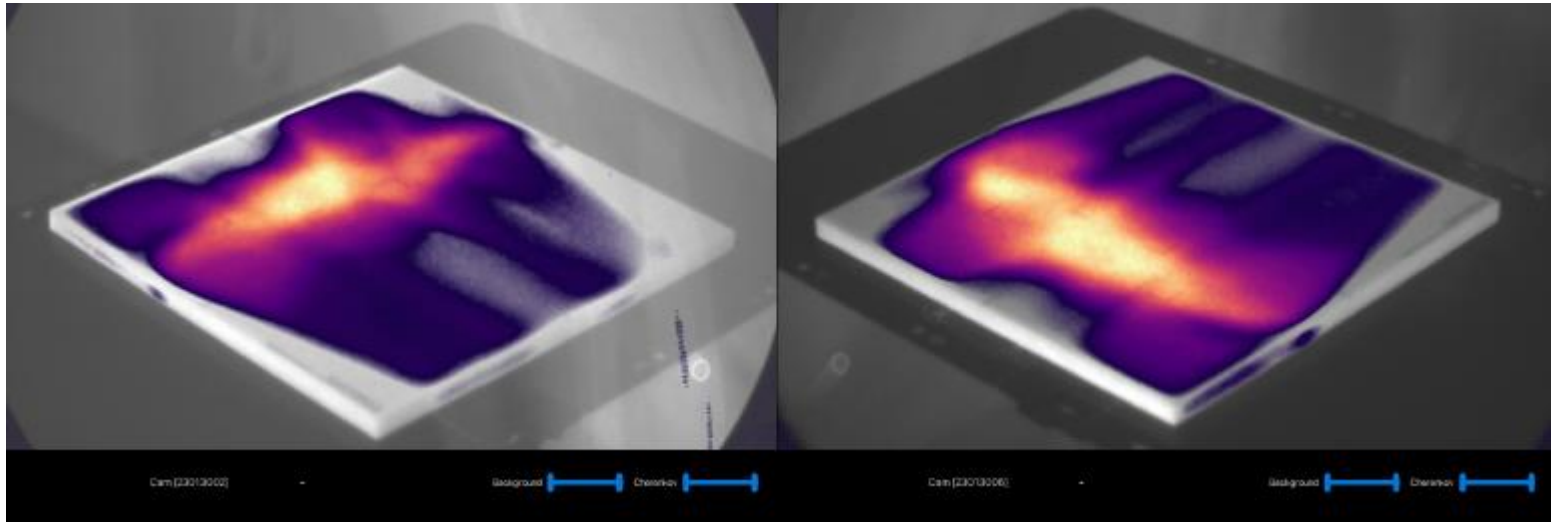
Repositioning version 1



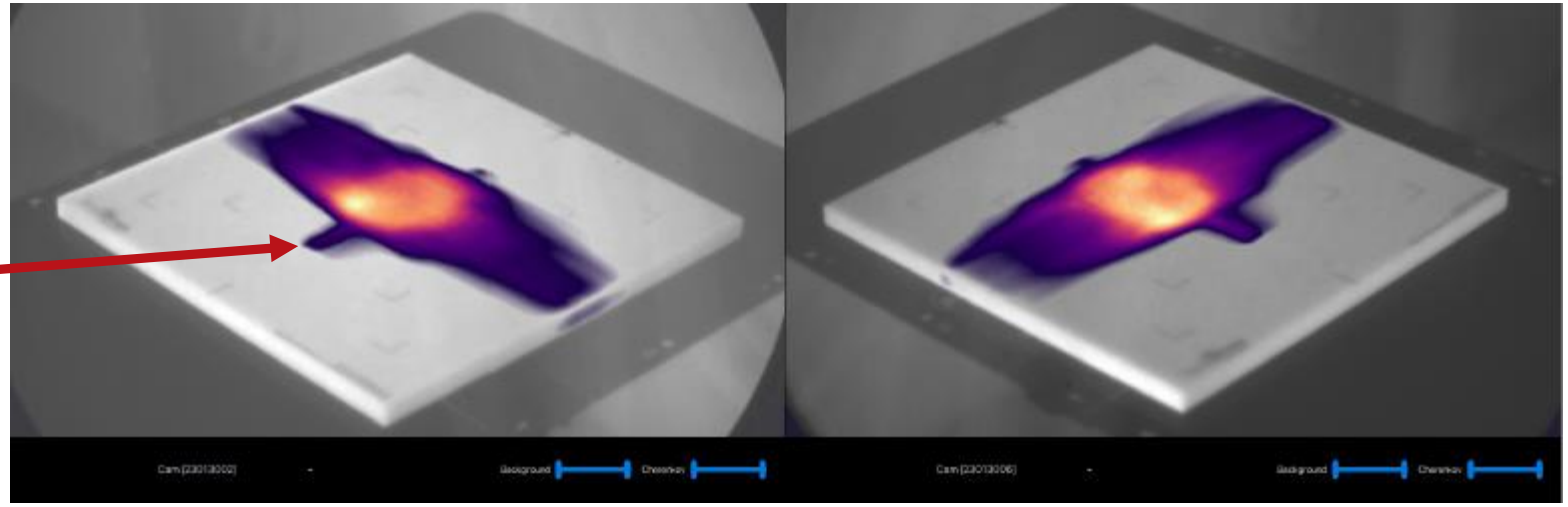
Repositioning version 2 (old vs. new)

Internal Acceptance - VMAT

- VMAT test case
- 6MV

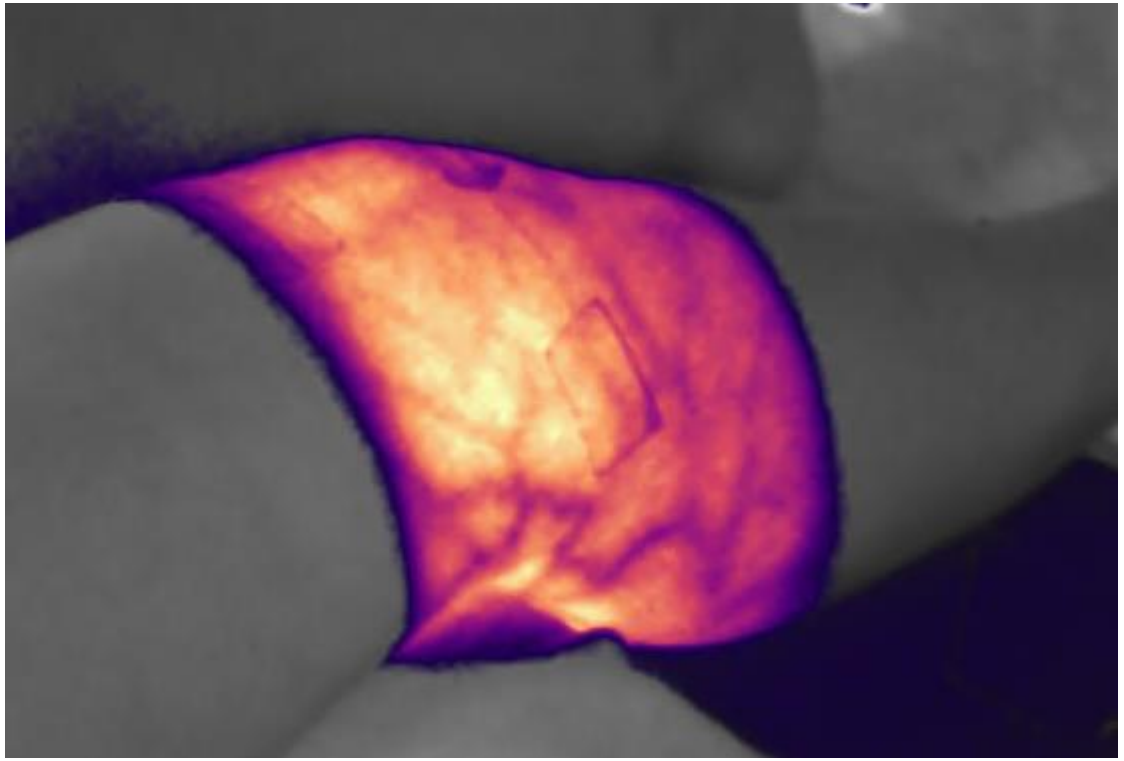


- Prostate test case leaves only
- 6MV
- Leaf Gap visible



Clinical experience: 1 (Knee)

- Right knee
- 6 MV

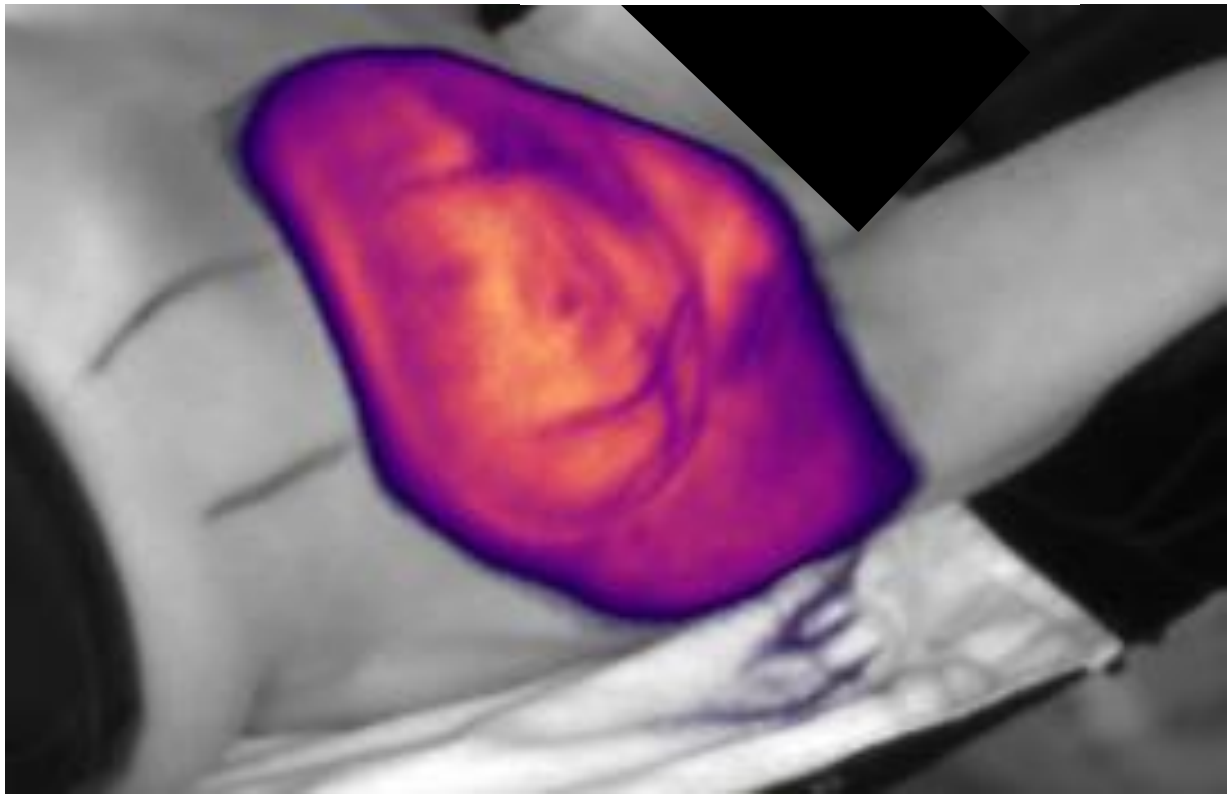


Clinical experience: 2a (left Breast)

- S&S IMRT left Breast
- 6 MV

- No blocked view/artefacts
- No radiation on the contra lateral breast
- No missing IMRT segments
- No hotspots
- Markers visible (work in progress)

  → Marker-less

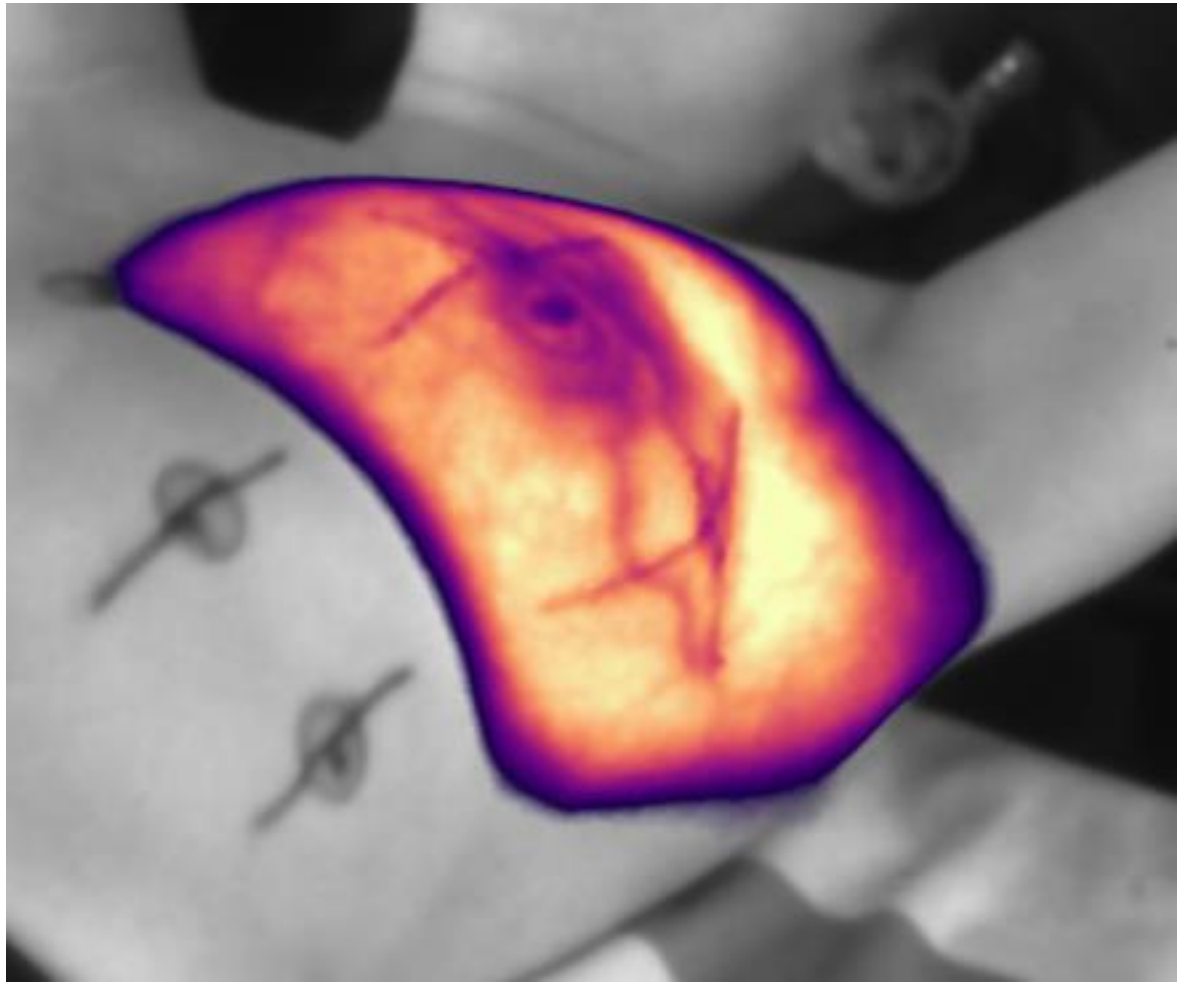


Cumulated Cherenkov image

Clinical experience: 2b (left Breast) - low dose rates

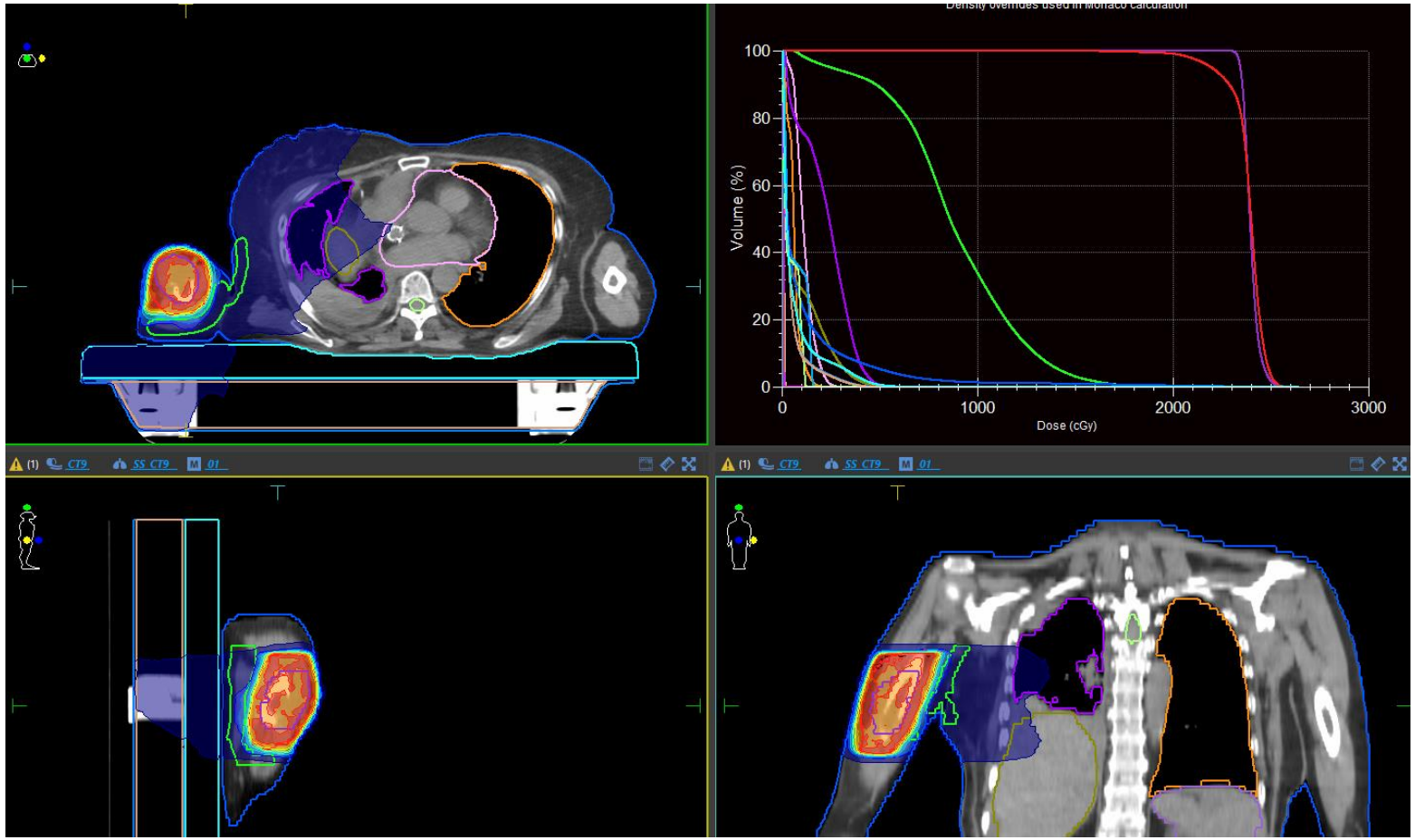
- Left breast
  - Left breast 40á2.5Gy + integrated boost 48á3Gy
  - Simultaneous 2 tangential beams + partial VMAT arc
  - Normo-fractionated

- Cherenkov signal shows only the 2 tangential beams. The partial VMAT arc for the integrated boost was not detected due to low dose rates (<100MU/Min = outside specs)

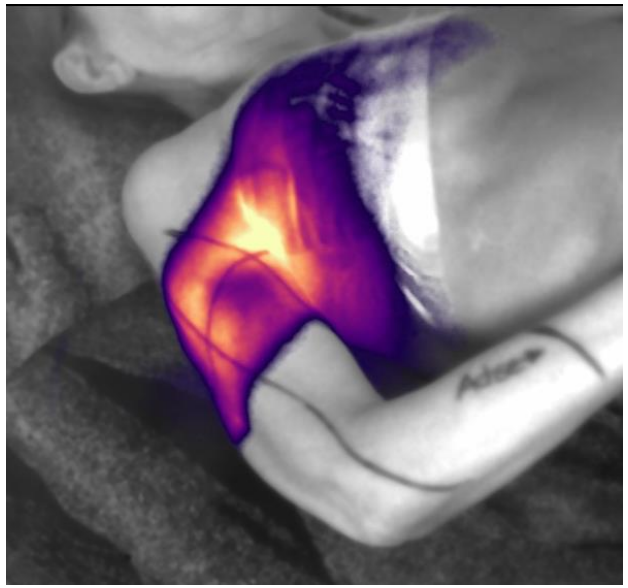


Clinical experience: 3 (Extremity)

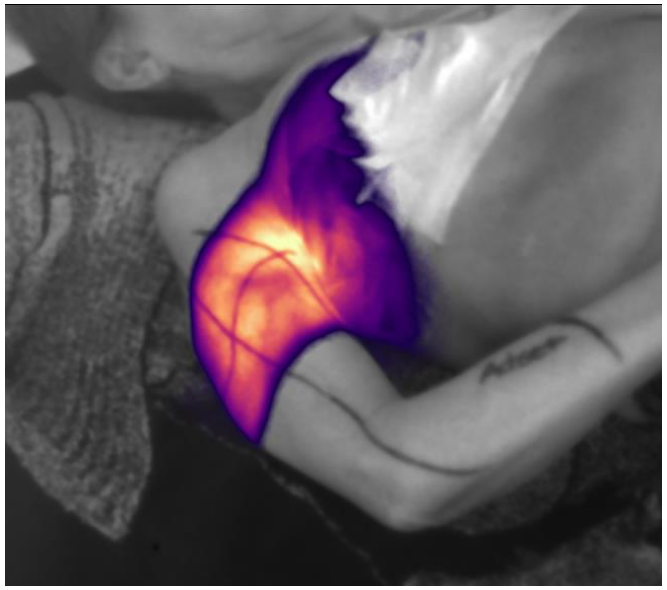
- VMAT upper arm right (6MV)
- 24 Gy in 6 fx
- Daily CBCT



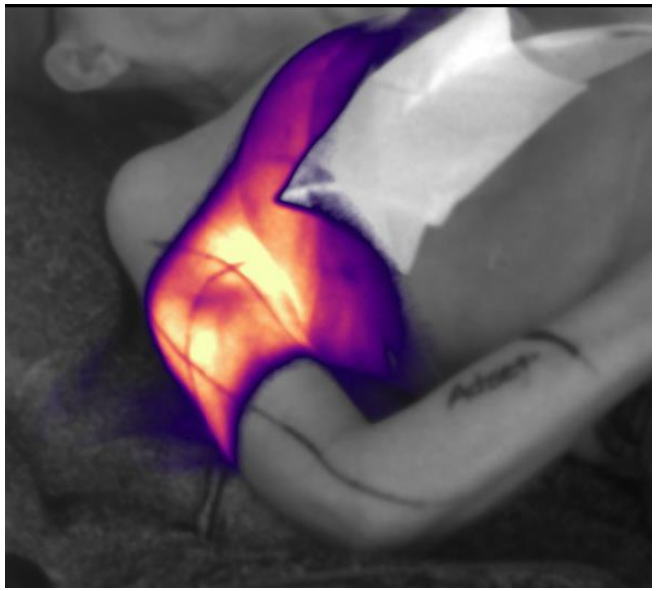
Clinical experience: 3 (Extremity)



Fraktion #1



Fraktion #2



Fraktion #3

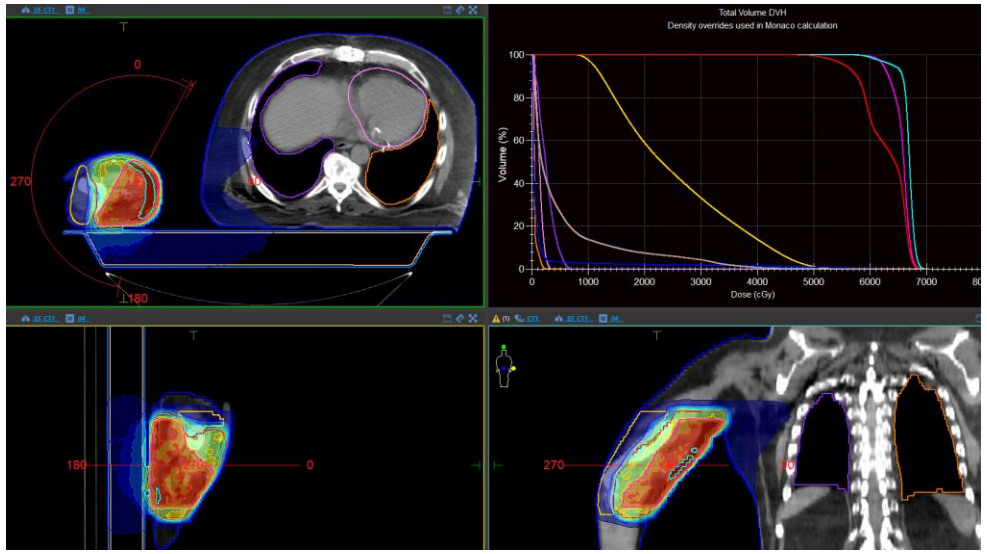
- Daily position and shape of cellotape was different and sophisticates the Cherenkov image
- Cherenkov signal is relative, an inter-fractional dosimetric comparison is difficult.

Clinical experience: 4 (Extremity)

- VMAT upper arm right, 66/60 Gy in 30 Fx
- Taped Bolus due to visibility for AlignRT
- Daily CBCT

→ Different Cherenkov signal due to bolus taping

→ Cherenkov dose in thoracic wall similar in the range of the relative signal



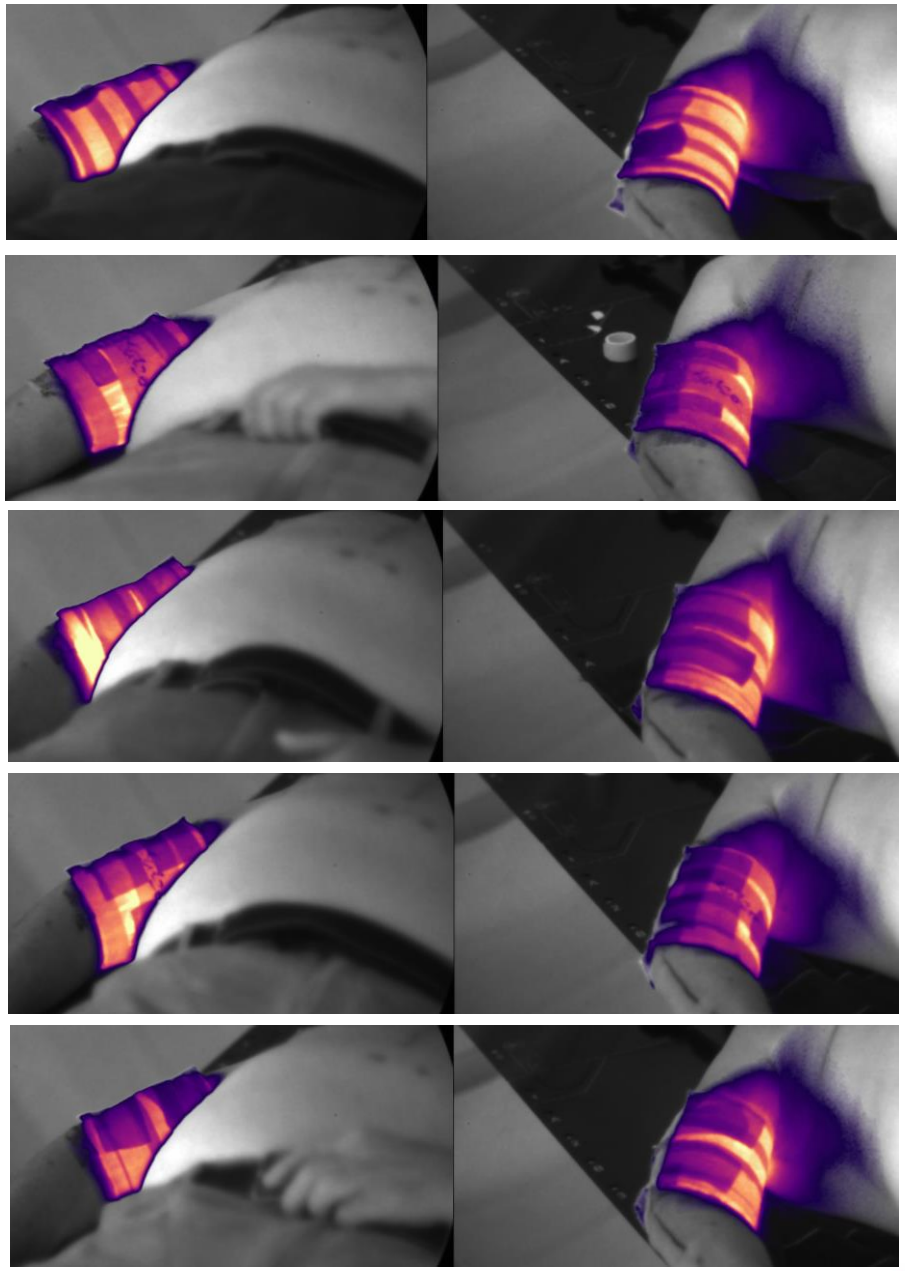
Fx 1

Fx 2

Fx 3

Fx 4

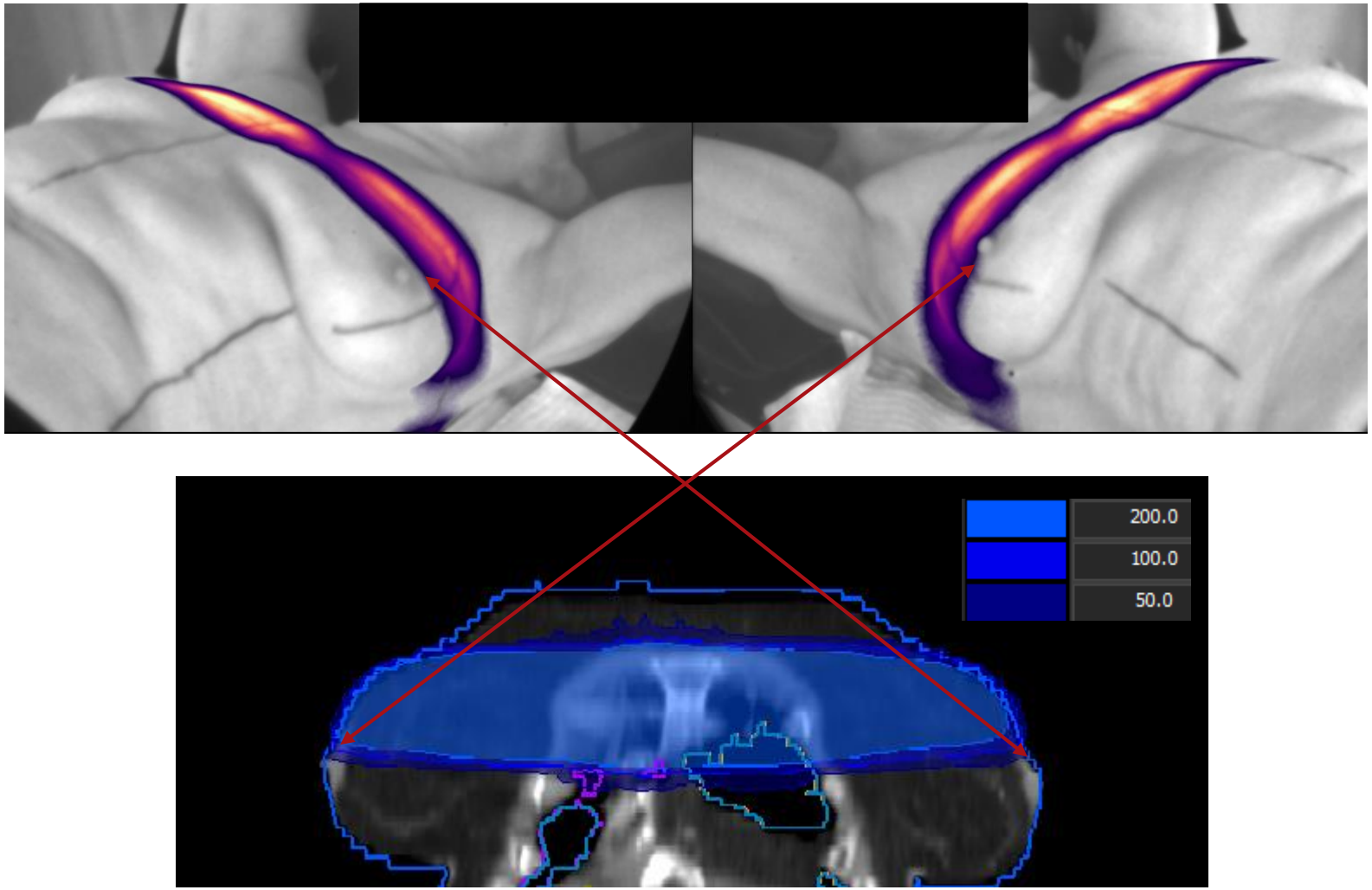
Fx 5



Clinical experience: 5 (Mediastinum)

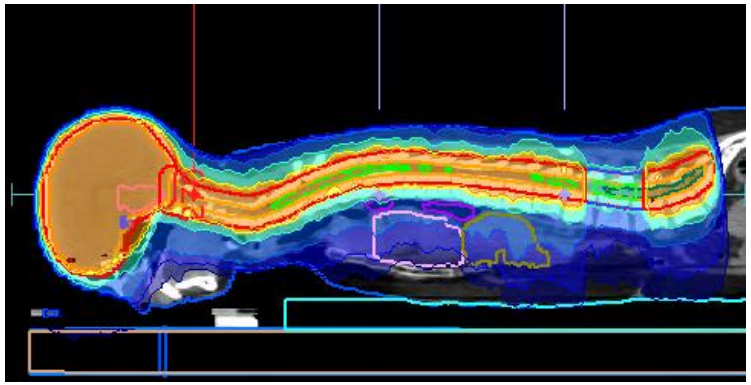
- VMAT mediastinum (6FFF)
- 35 Gy in 5 fx
- Daily CBCT

- Good geometrical agreement to TPS (position of mamilla to planned dose)

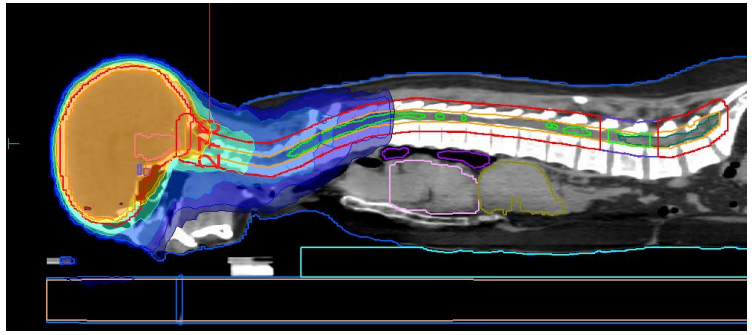


Clinical experience: 6 (Cranio-spinal)

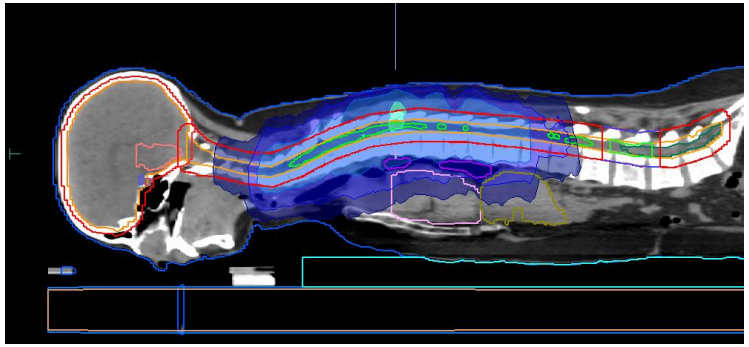
- Cranio-spinal irradiation
  - Including dose reduction due to former RT
- 36 Gy in 20 fx
- Daily CBCT of head isocenter and linear table shifts
- Prone position
- VMAT with 3 Isocenter
  - Posterior Rotations
  - Overlapping Rotations



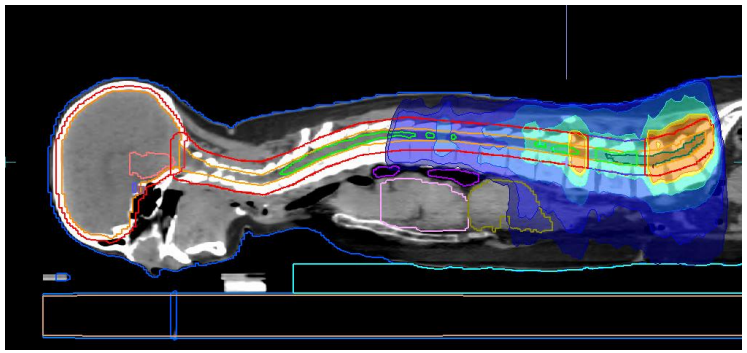
Total dose distribution



Dose distribution for upper Isocenter only



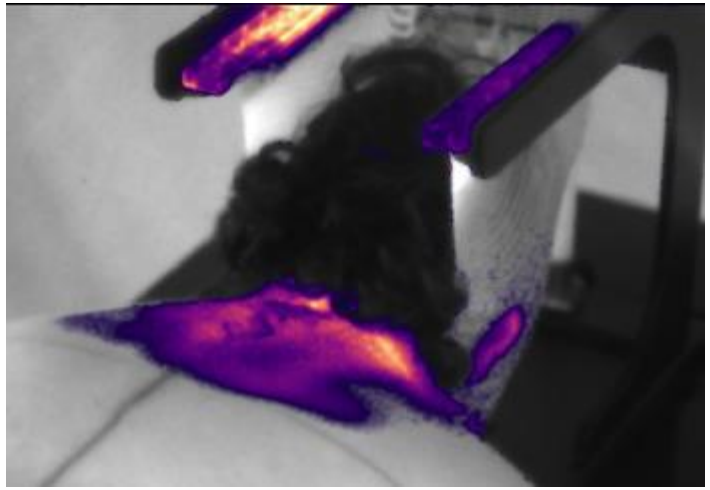
Dose distribution for middle Isocenter only



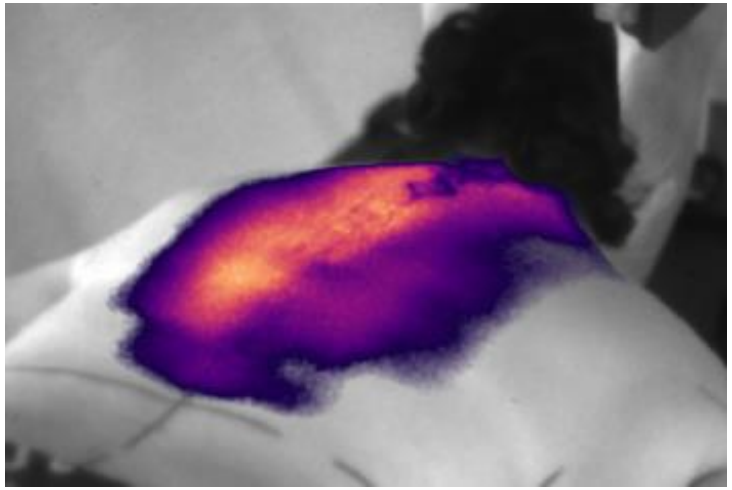
Dose distribution for lower Isocenter only

Clinical experience: 6 (Cranio-spinal)

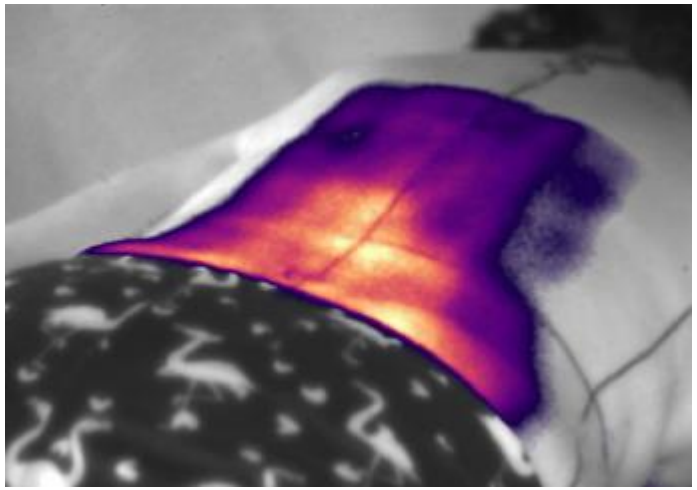
- First fraction



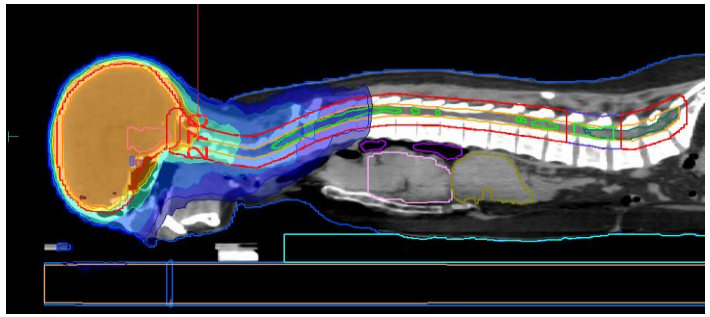
Cherenkov radiation for upper Isocenter only

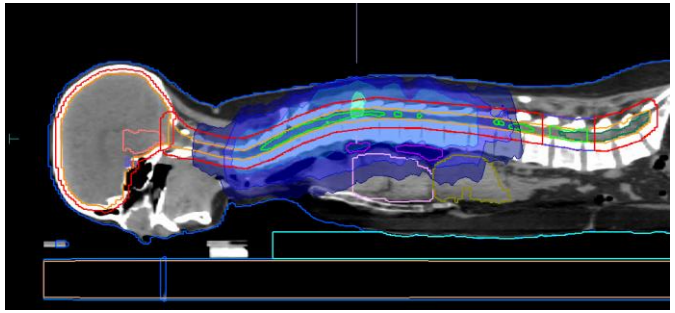


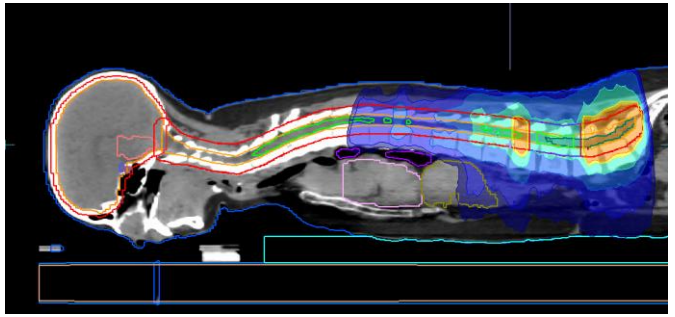
Cherenkov radiation for middle Isocenter only



Cherenkov radiation for lower Isocenter only

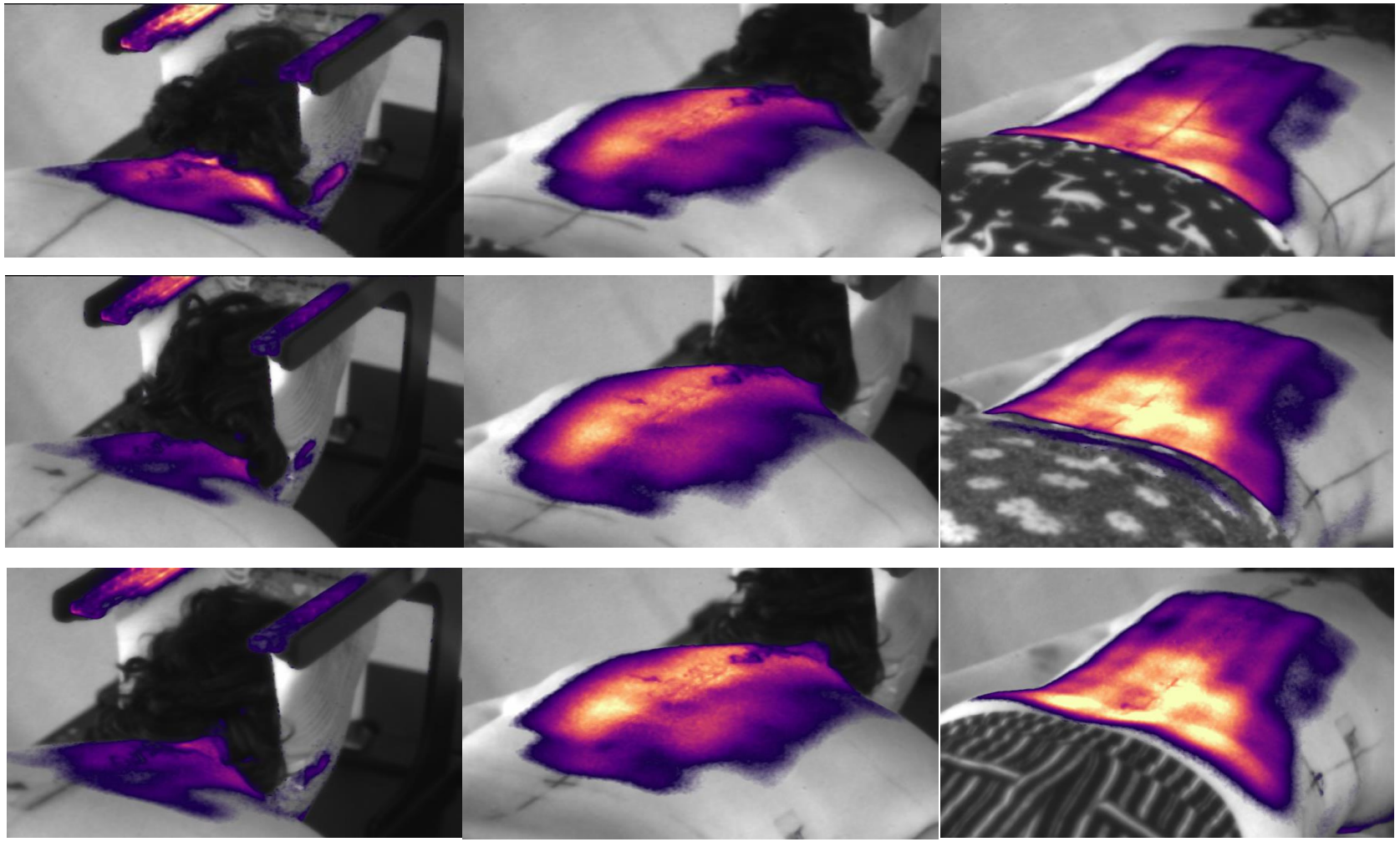






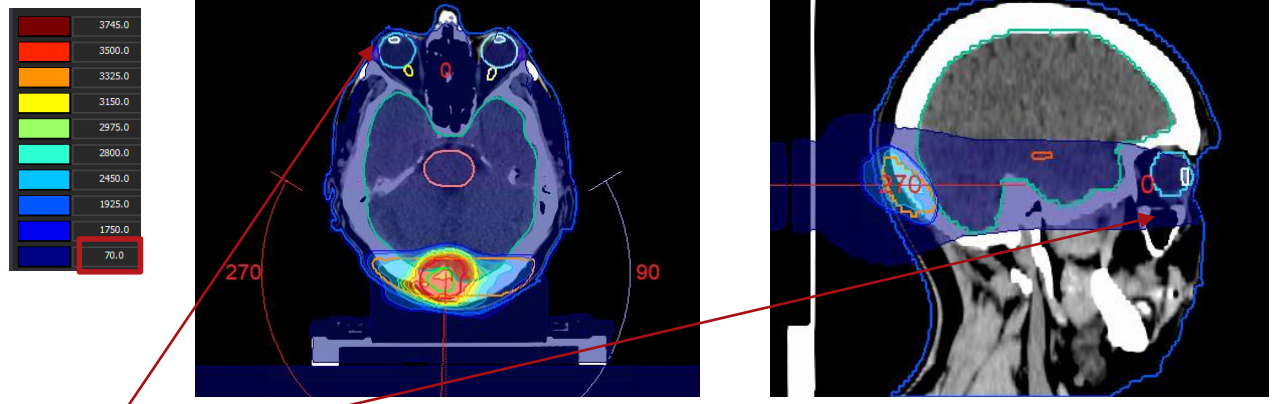
Clinical experience: 6 (Cranio-spinal)

- Relative Cherenkov signal
- Signal depends on windows-level settings

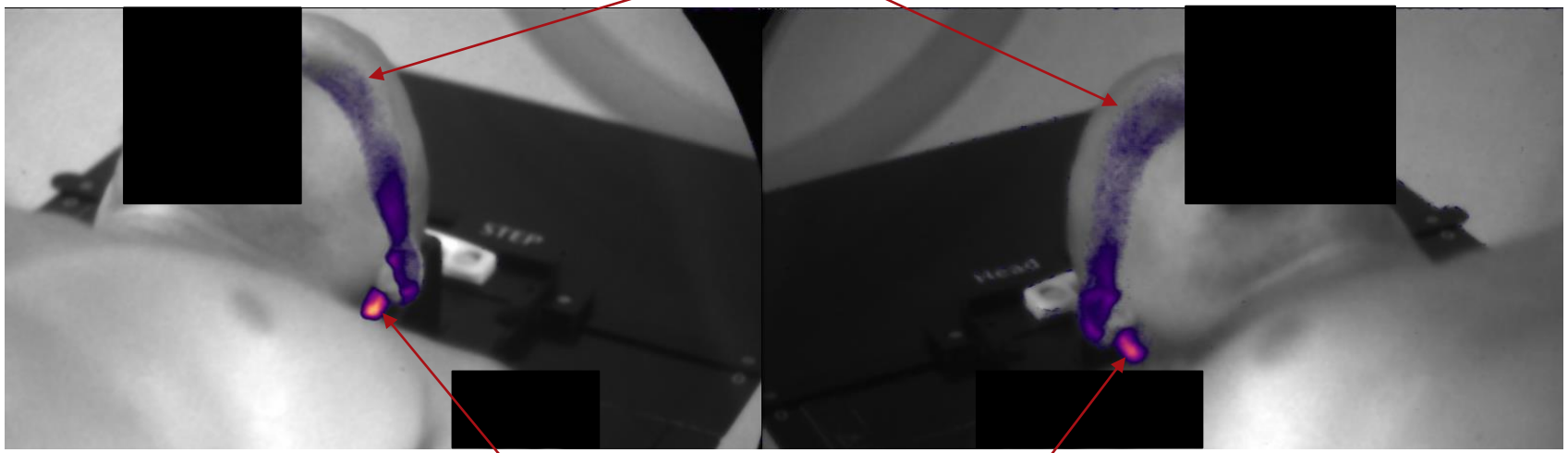


Clinical experience: 7 (Met)

- Osseous metastasis 35 Gy in 7fx
- Posterior VMAT rotation
- Mask-less due to patient conditions
- (Exit) dose in eyes 70cGy



Exit Cherenkov radiation



Primary Cherenkov radiation

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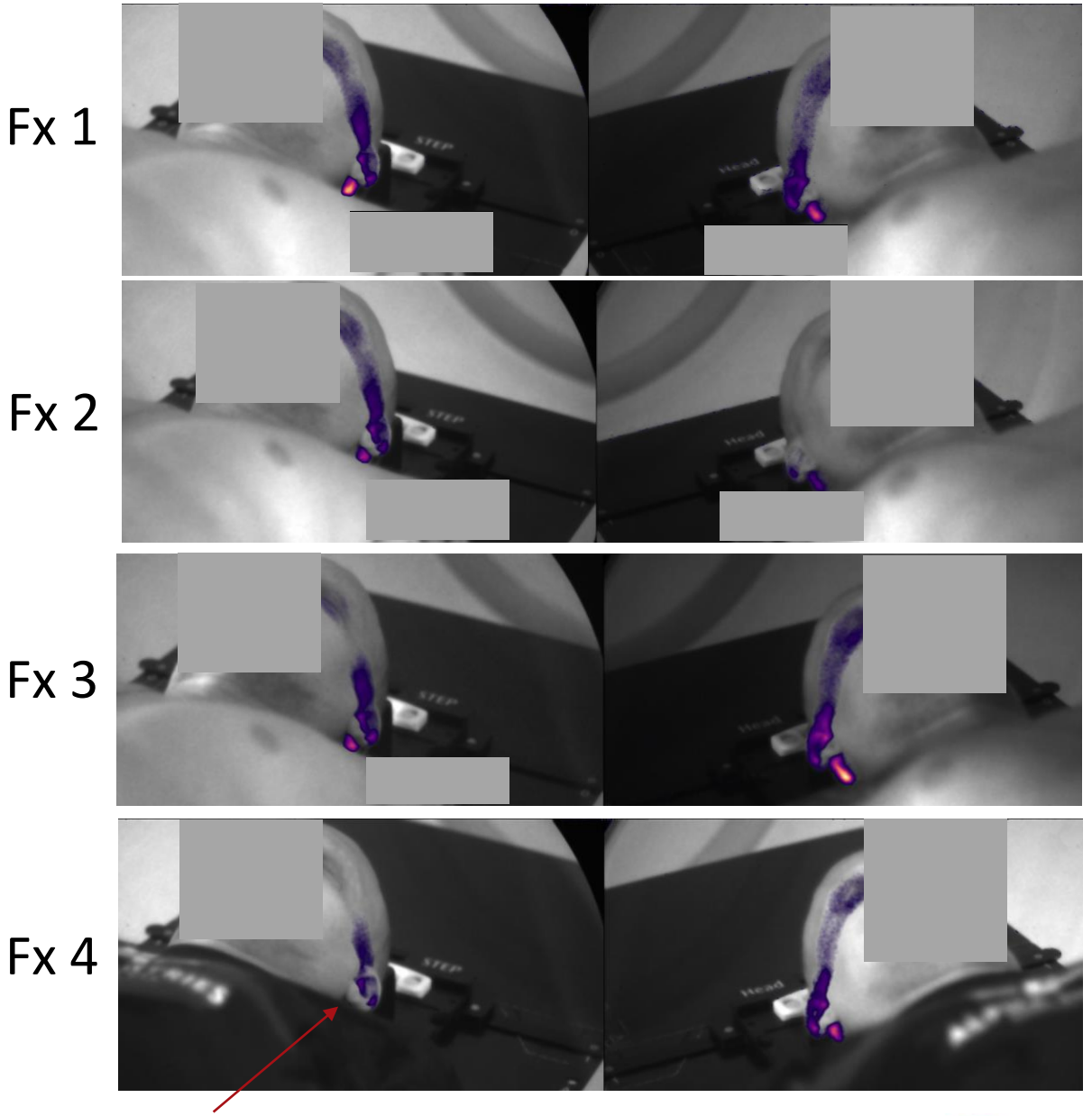
Clinical experience: 7 (Met)

- Very good geometrical agreement

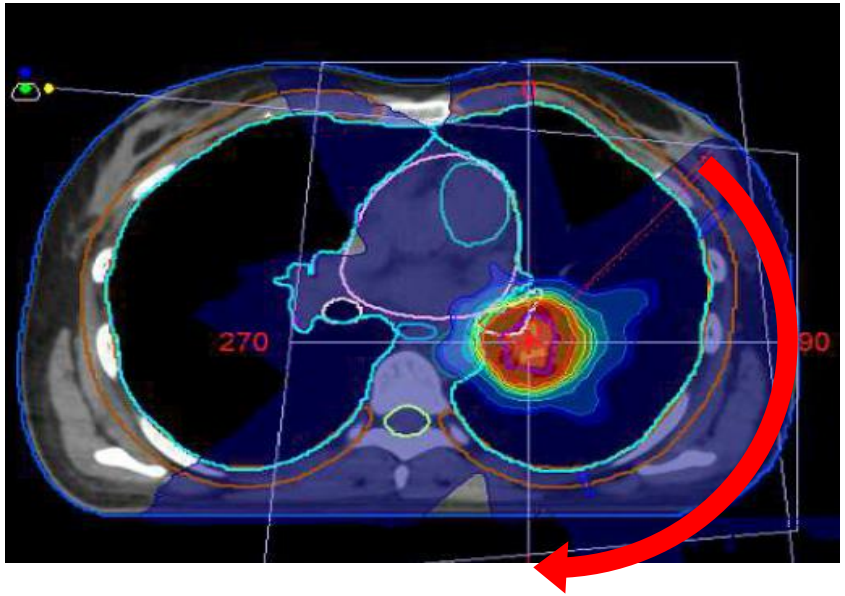
- In some fractions, no entry „dose“ visible due to different shoulder position which is irrelevant for RT (not the black shirt).

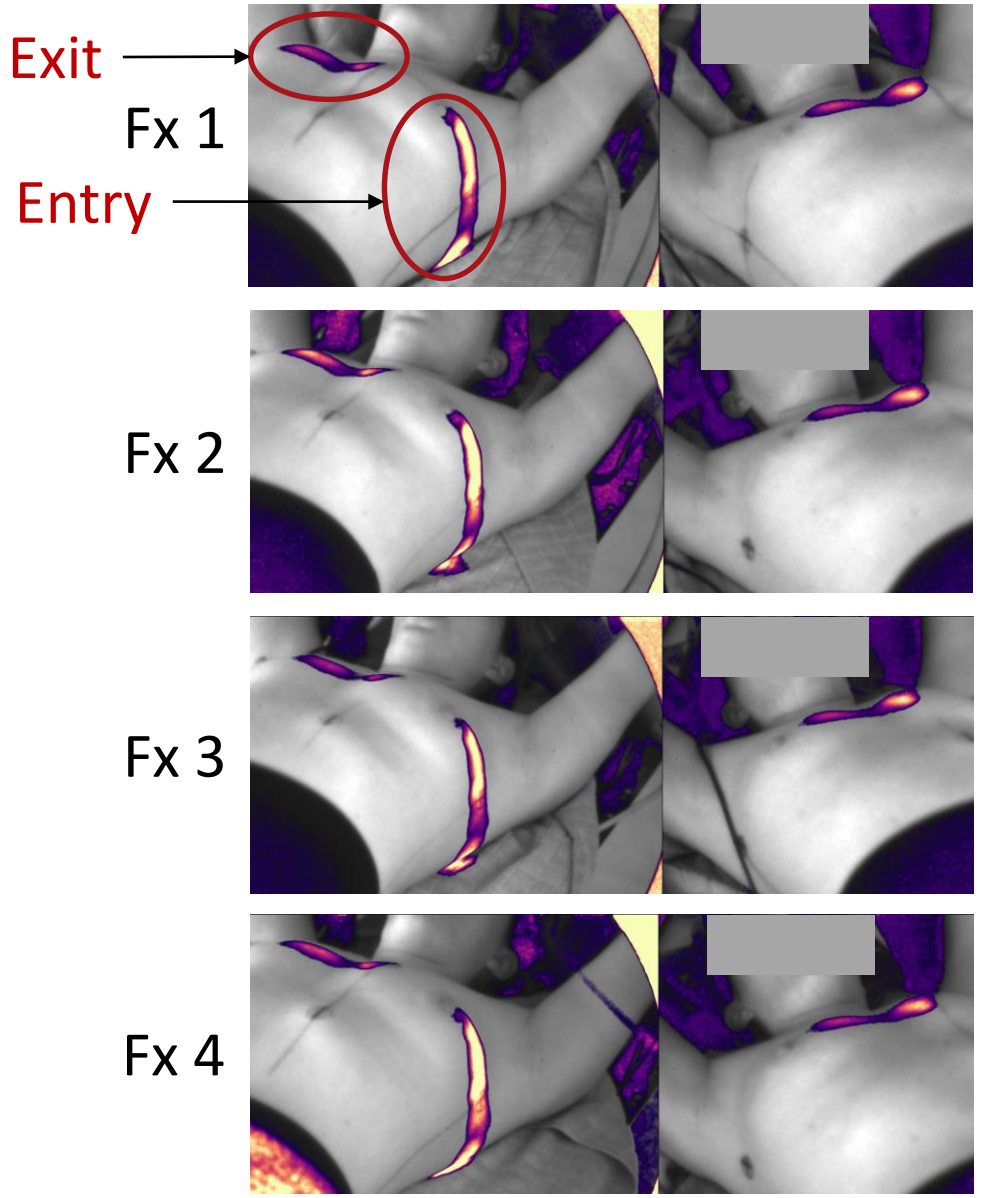


Clinical experience: 8 (Lung with DIBH)

- Lung metastases 35 Gy in 7fx
- Partial VMAT rotation, 6 FFF
- DIBH with ABC (spirometry)

- Separated entry and exit signal
- Very good geometrical agreement



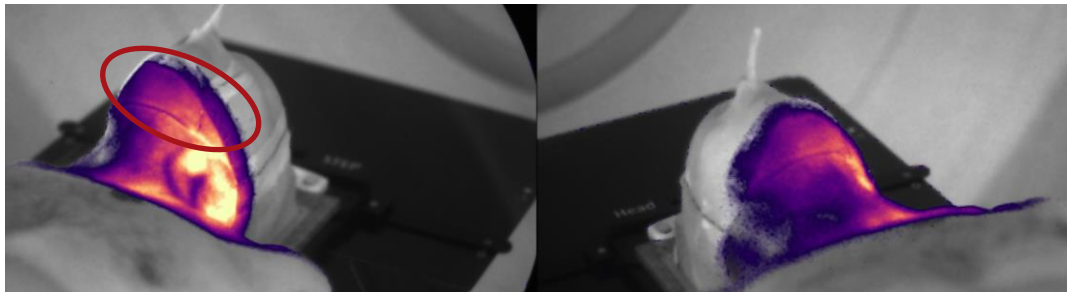


Clinical experience: 9 (H&N)

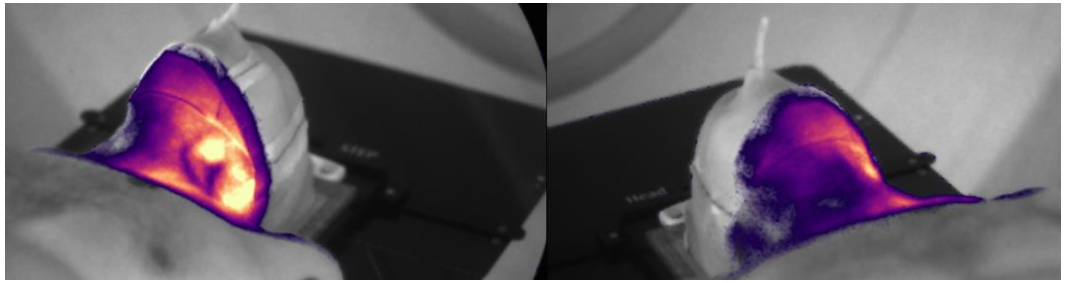
- Head and neck irradiation for lymph nodes (left)
- 39 Gy in 13fx, partial VMAT 6 MV

- Excellent inter-fractional agreement
- Limitations in mask region due to tape not mask material

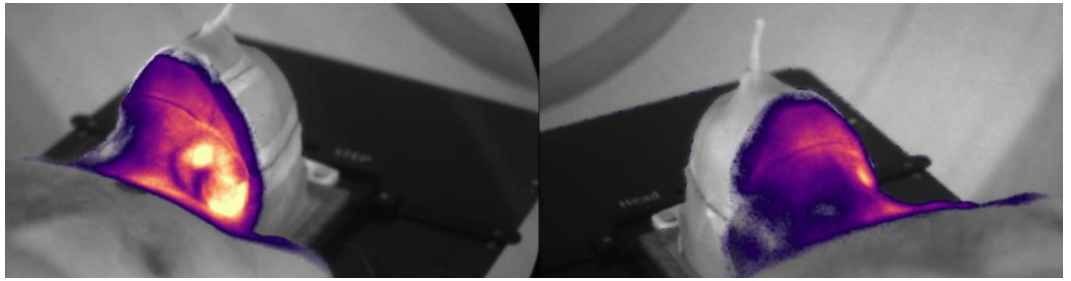
Fx 1



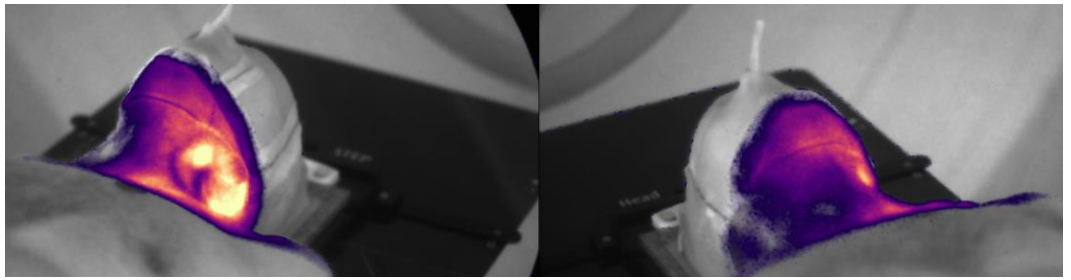
Fx 2



Fx 3



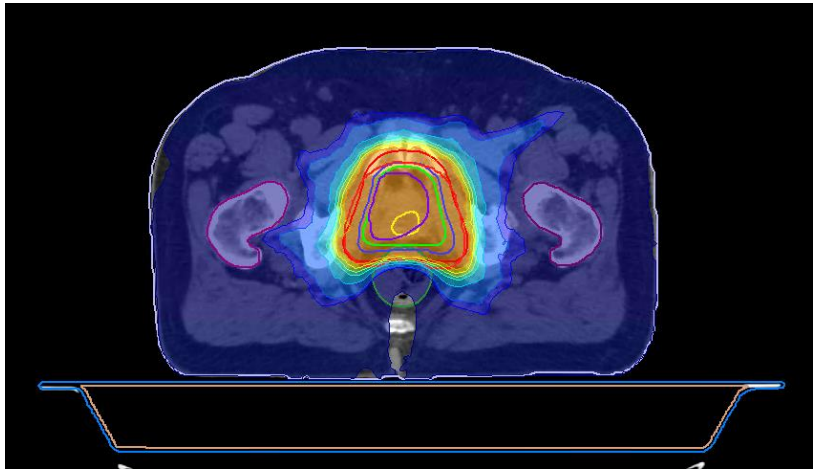
Fx 4

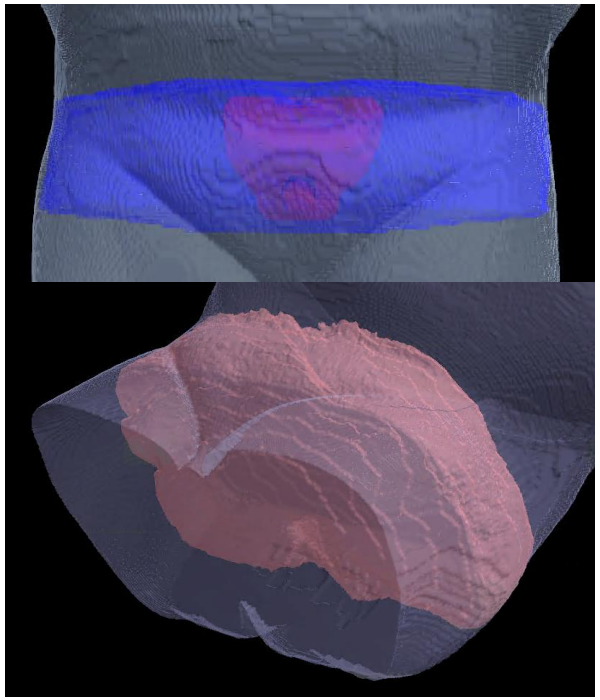


Clinical experience: 10 (Prostate)

- Prostate irradiation
- 60 Gy in 30fx, 2 VMAT rotations 10MV

- (PRF issue solved after update)
- Low dose rates reduce the intensity of the Cherenkov signal





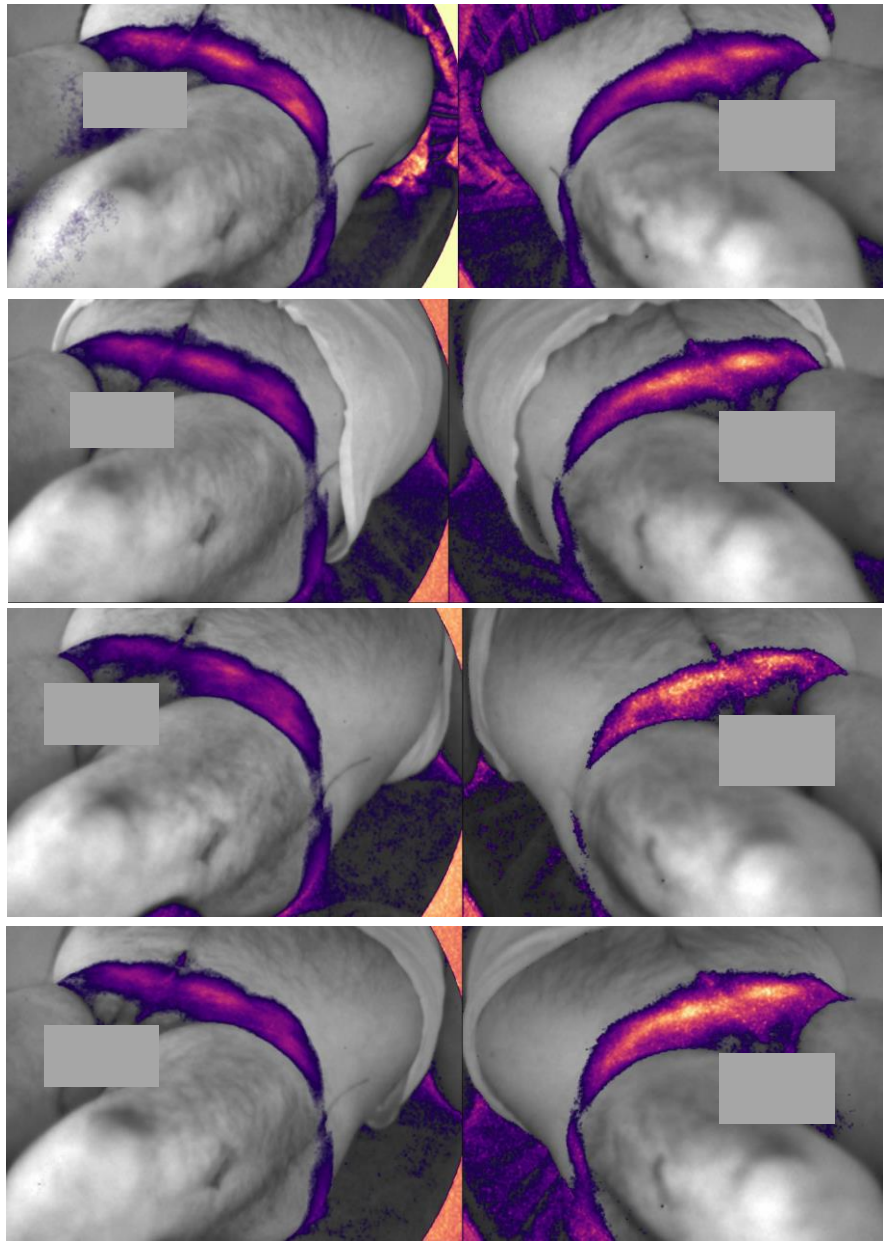
15% of prescription dose

Fx 1

Fx 2

Fx 3

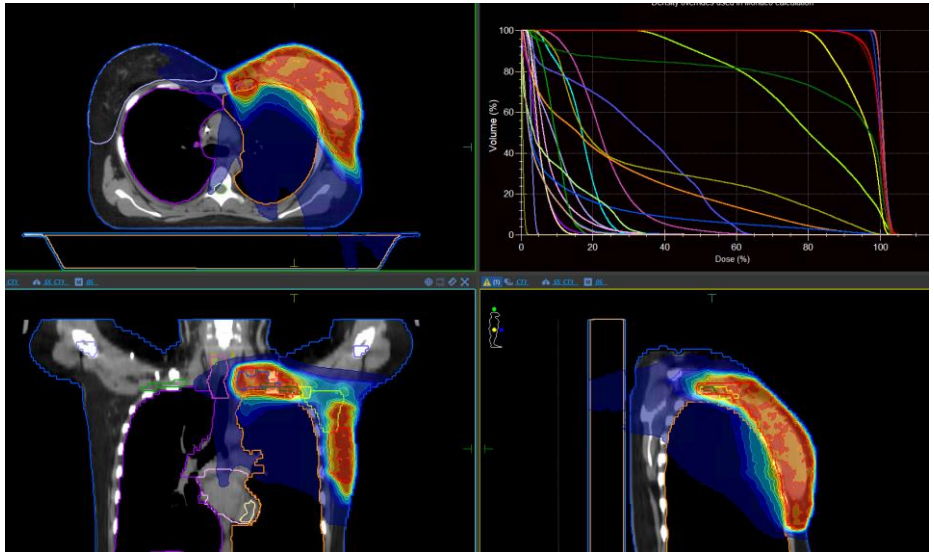
Fx 4



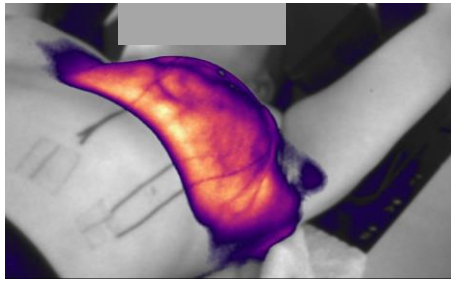
Clinical experience: 11 (Breast)

- Breast irradiation
  - including upper and mammaria interna lymph nodes
- 50.4 Gy in 28fx, 2 partial VMAT rotations
- DIBH with real time coach

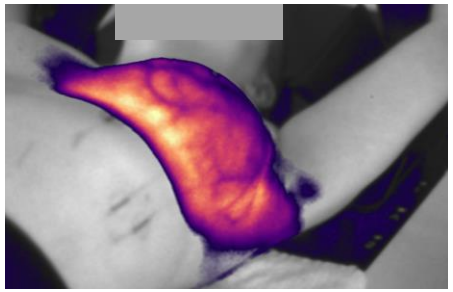
- Excellent geometrical agreement (DIBH)



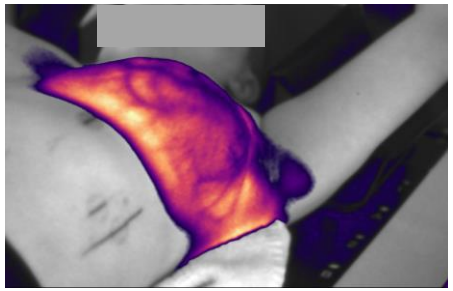
Fx 1



Fx 2



Fx 3



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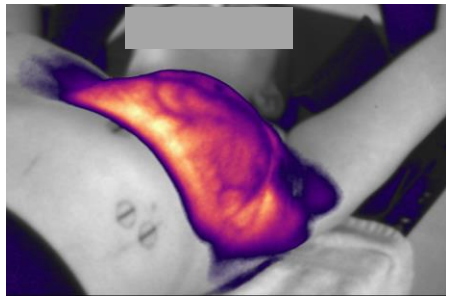

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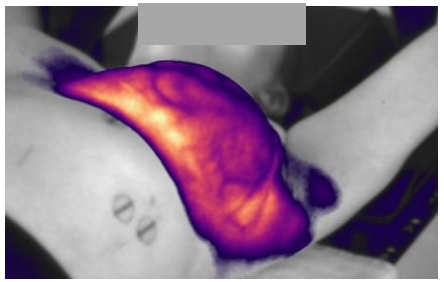

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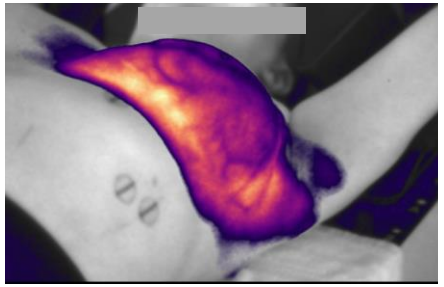

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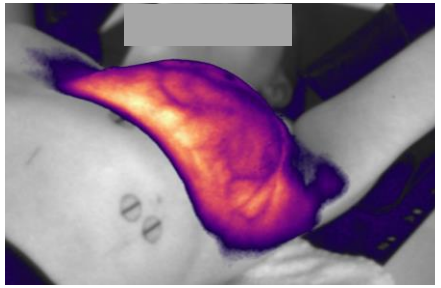

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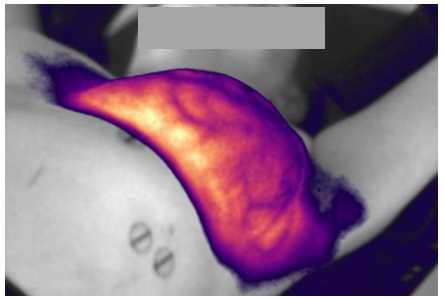

Conclusion

- Preparation of the linac room before installation (space for 5 cameras, room lights)

- Adaption of the clinical workflow
  - Turn off room laser/SSD-display
  - Reduce room light level to minimum

- So far, no irradiation errors detected
- Cherenkov-Tracking of different photon energies works

- Cherenkov signal is (currently) relative
- Low dose rates are (currently) not detected

Outlook

- Visualization inter-fractional differences (→ possible compensation before the end of radiation therapy)
- Visualization of intra-fractional differences (MLC-positions of RT-plan vs. real time Cherenkov image) and intra-fractional patient motion (→ SBRT)
- Detection of possible future skin reactions ?
- Risk management (protocol of real treated location)
- Dosimetry (IMRT QA, small-field-dosimetry)

Thank you for your attention

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