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Progress Report on a CBCT based 3D Image Guided Workflow on IOeRT

(There are no conflicts of interest)

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12th ISIORT Conference 7-8. November 2024

Overview

Introduction

- Current Status and Irradiated Patients
- Workflow - Image Guides Intraoperative Radiotherapy (Patient Preparation, Interfaces)

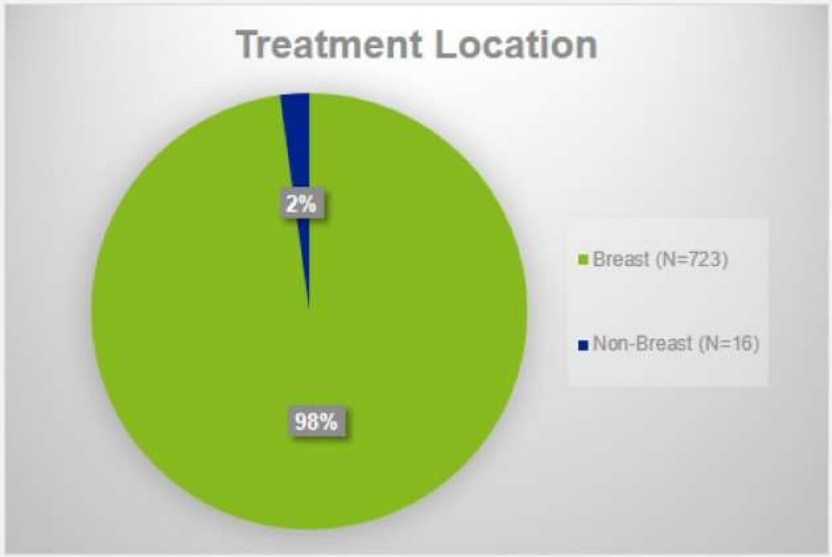
Material & Methods

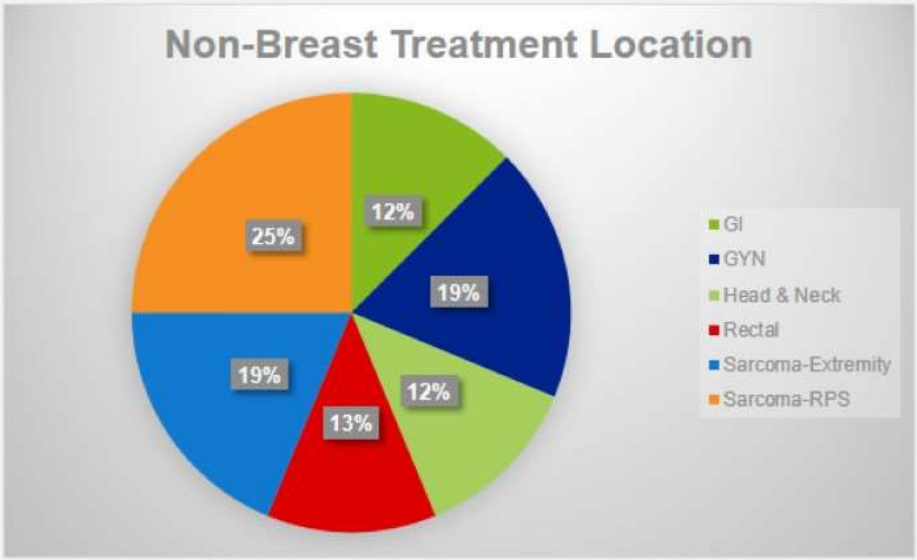
- CBCT Imaging System and Accessories
- Treatment Planning System – Radiance (GMV)
  - Monte Carlo Calculation (PSF)
  - Source-to-Skin Distance Correction
  - Artefacts and Dosimetrical Impact
- Clinical Aspects
  - Advanced Imaging Modalitys for IORT
  - Clinical Experience on Different Cases

Summary

Treated Patients

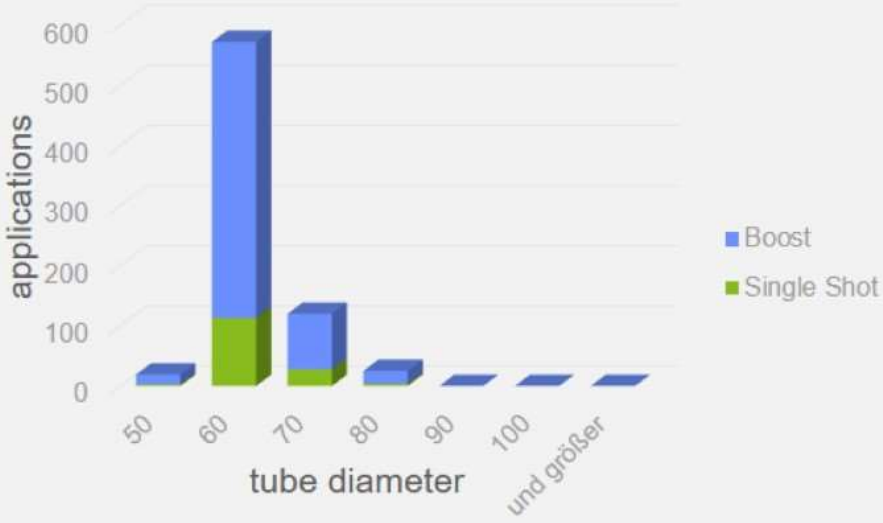
- More than 5700 Patient treated since 1997 (since 2020 740 Patients)
- 120 Patient treated with IG IORT
- 200 Patients/year

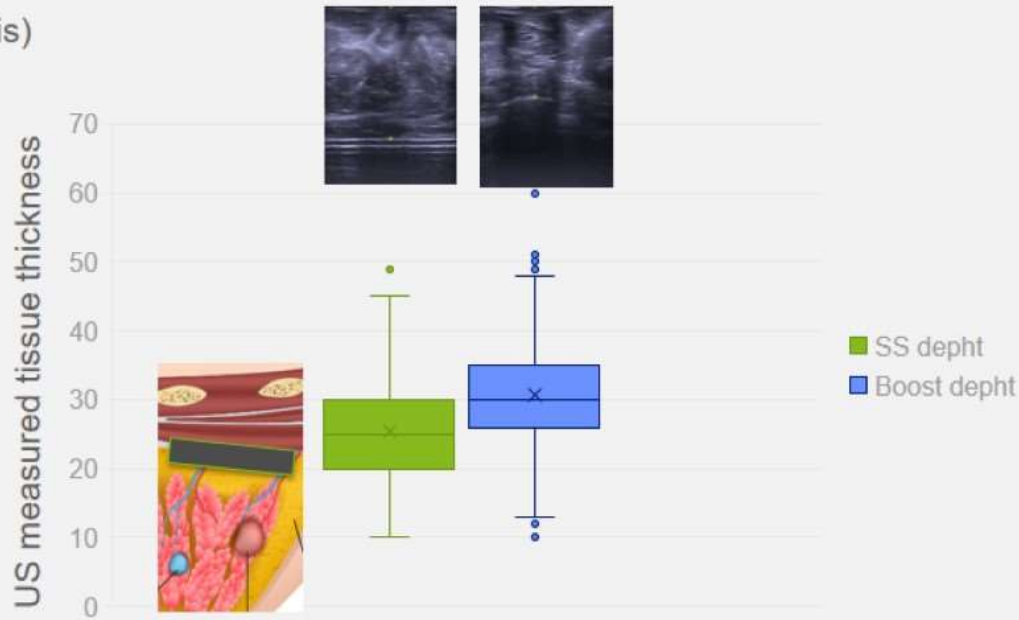




Treated Patients (Single-Shot / Boost)

- 740 beast cancer patients (148 single-shot, 592 boost)
- single-shot (IORT: 1x Dmax=23.33Gy); boost (IORT: 1x Dmax=11.11Gy + 15 x 2,7 Gy)
- single shot: max. 90% (21Gy) on the Chest Wall Protector (tissue)
- boost: max. 45% (5Gy) on the ribs (tissue + pectroalis)





Current Status - Operating Theater (2024)

1. mobile anesthesia system
2. Linac – Mobetron
3. mobile treatment couch
4. mobile CBCT
5. virtualized Software (Prelude, Radiance)
6. mobile US

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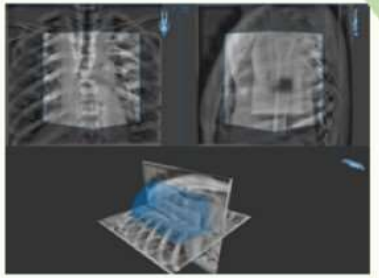
Workflow “online adaptive intraoperative Radiotherapy”

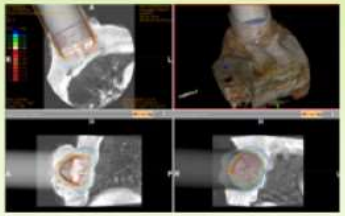
Patient Preparation

3D Imaging

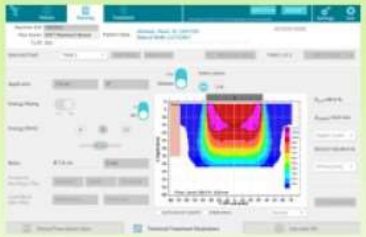


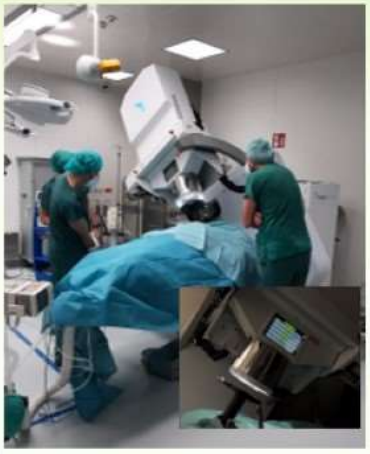
Dose Calculation

Repositioning



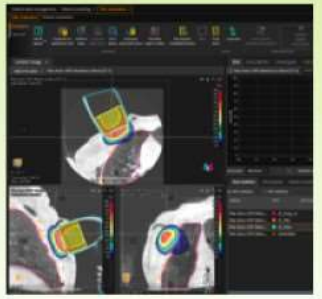
Treatment

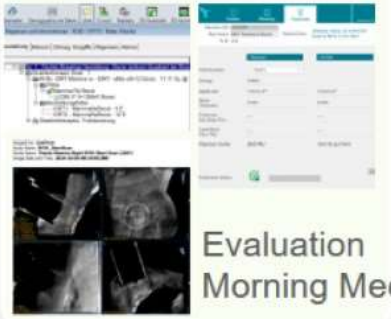




Documentation

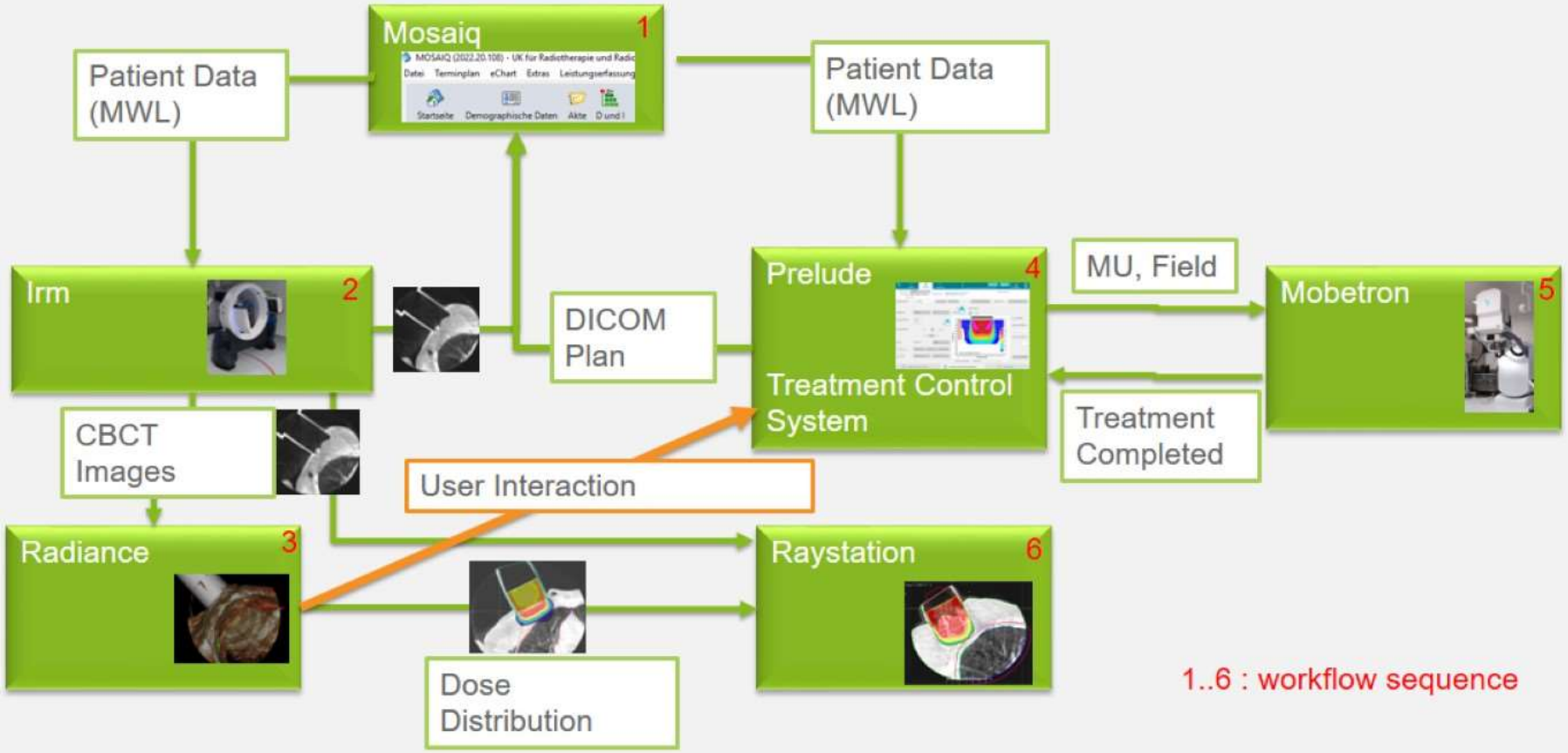
Mosaiq/Prelude/RS





Evaluation
Morning Meeting

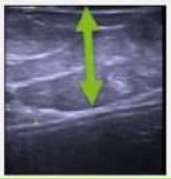
Interfaces and Softwaremodules

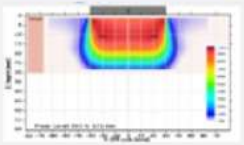


Material & Methods

US Workflow for Single Shots (25 min)

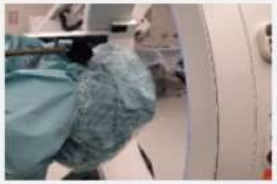
US Imaging → 2D Dose Calculation → Patient Positioning → Treatment Mobetron → Dokumentation

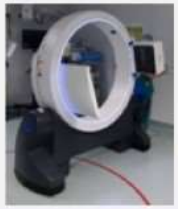


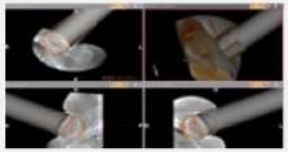


Onlinde Adaptive Image Guided Workflow (45 min)

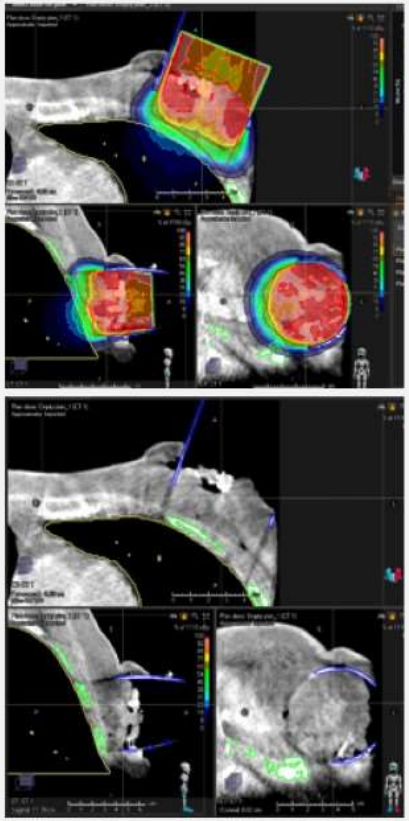
Patient Preparation → 3D Imaging → parking procedure IRm / 3D Dose Calculation → Patient Positioning → Treatment Mobetron → Dokumentation



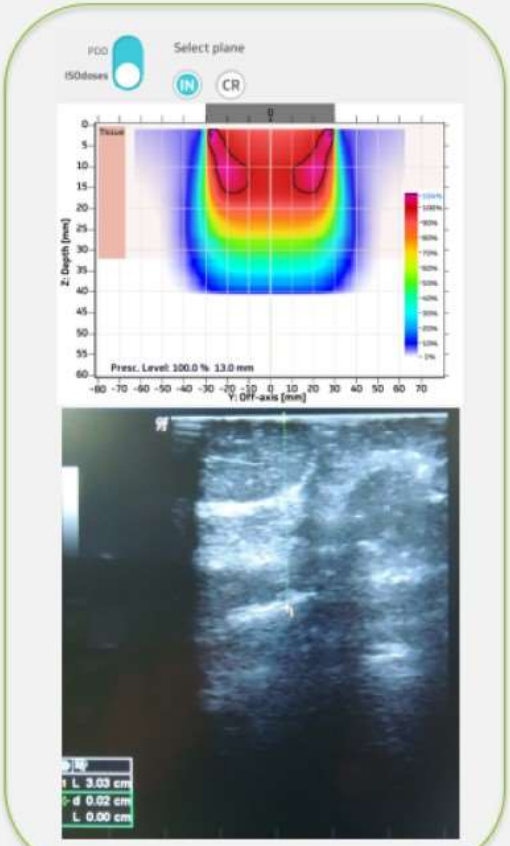




Why 3D CBCT Imaging for treatment planning?



vs.



pro 3D Imaging

- Uneven surfaces
- Inhomogeneity
- Dose (DVH) OAR?
- US image quality (air)
- compressed tissue by US head
- US not used for Non-Beast Surgery
- Absorption dabber
- accurate tissue measurement
- complex anatomy
- Summation of doses (Reirrad.)
- ….

Elements for new 3D Imaging Workflow

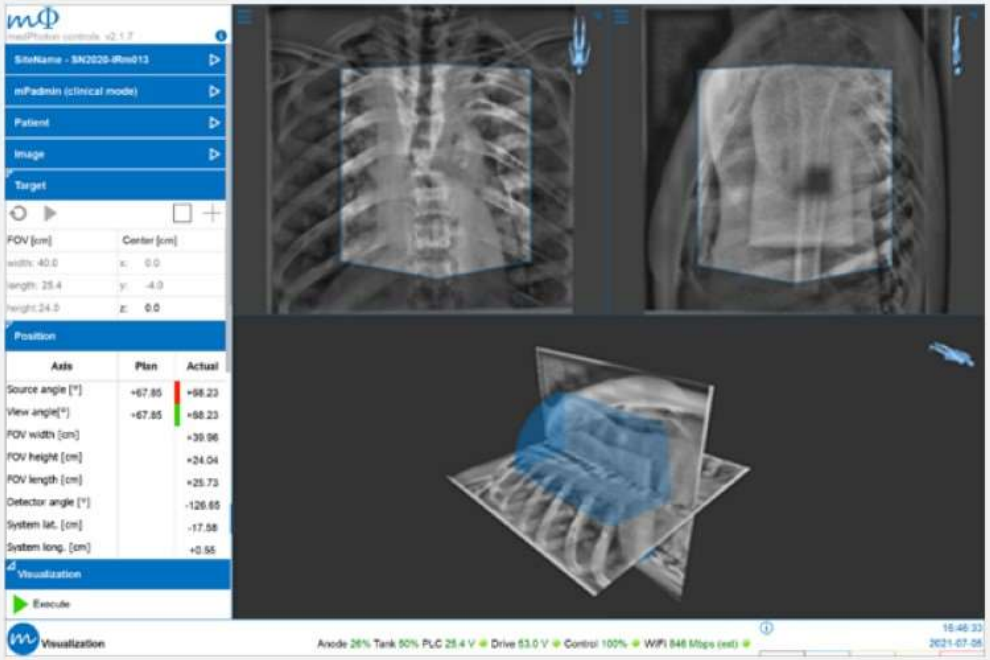
Clinical operational:

- Mobetron – Extended Range Addendum (extended DOF, no beamstoper)
- radiolucent IORT tubes (Ø 4-10, 0°, 30°)
- radiolucent tube holder
- radiolucent treatment couch
- mobile CBCT imaging System
- IORT 3D tretment planning system (radiance, GMV)
- virtualized software modules

Mobetron (IntraOp Medical) - Extended Range Addendum

IRm (MedPhoton)

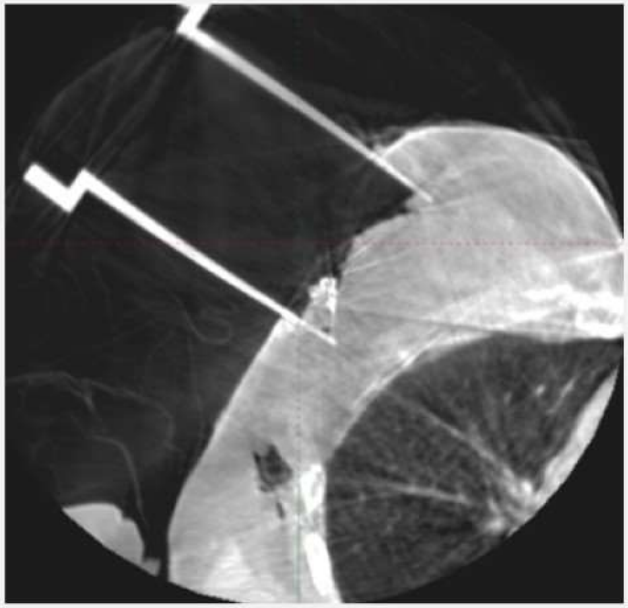
Imaging Procedure

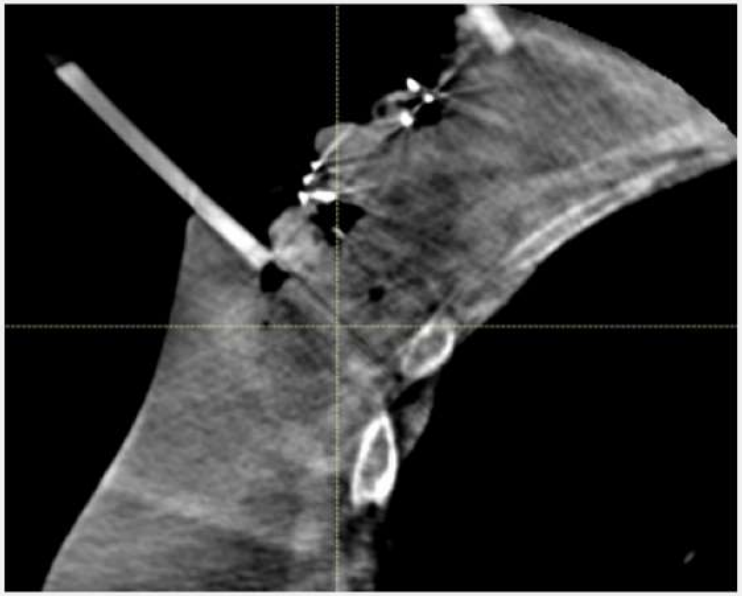


2 orthogonal kV images to define VOI

CBCT fucuse on predefined VOI

Image Quality – CBCT Imaging

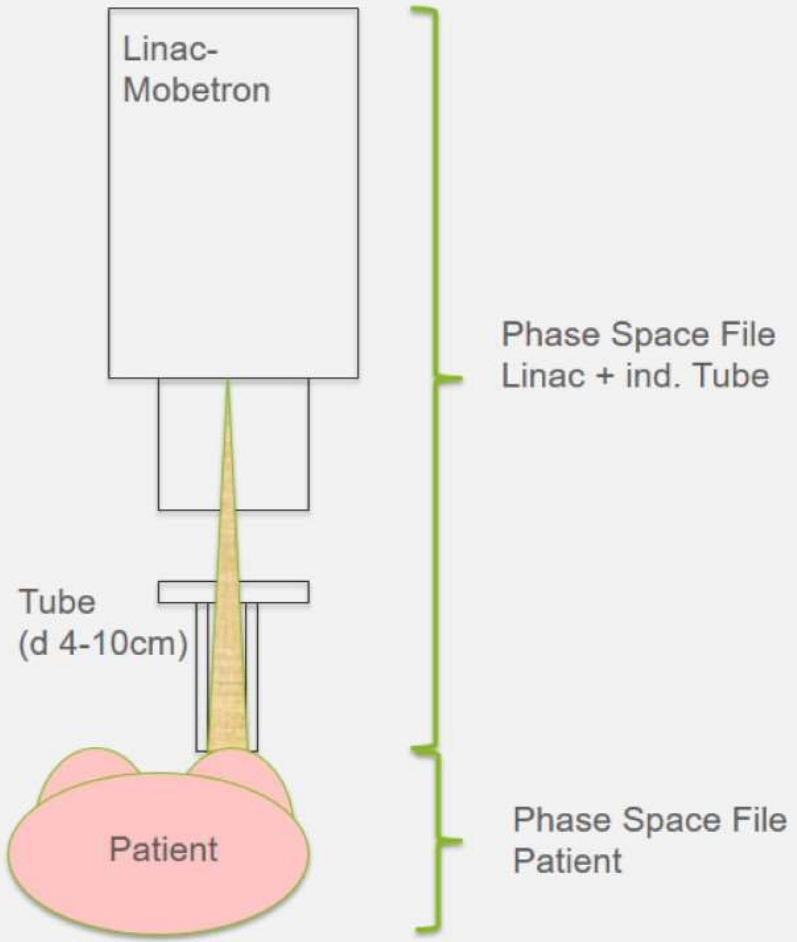




Treatment Planning System (TPS) – Radiance (GMV)

TPS – Phase Space Files (1)

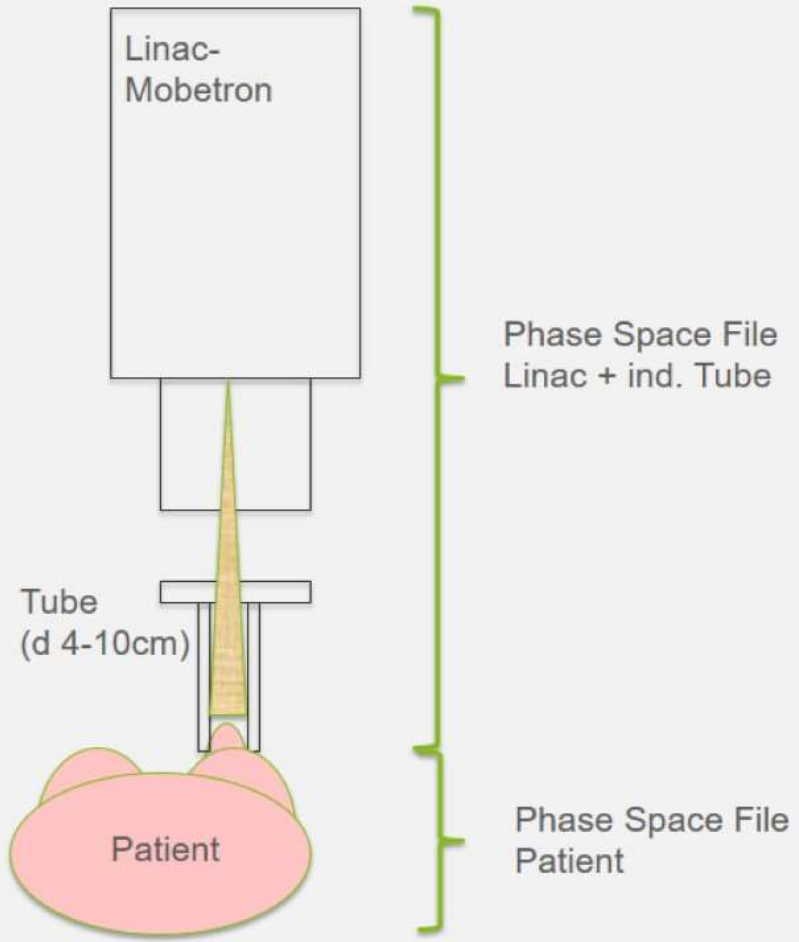
- Monte carlo dose algorithm uses phase space files to reduced calculation time
- every tube/energy combination are pre-calculation
- Individual phase space file for patient
- Tissue (uneven surfaces) within the tube would be neglect!



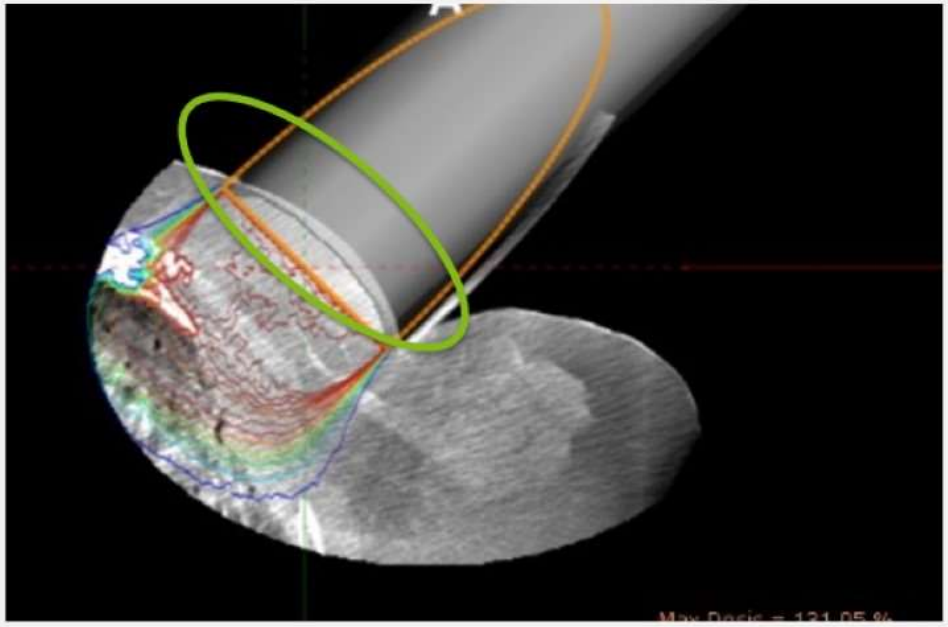
TPS – Phase Space Files (2)

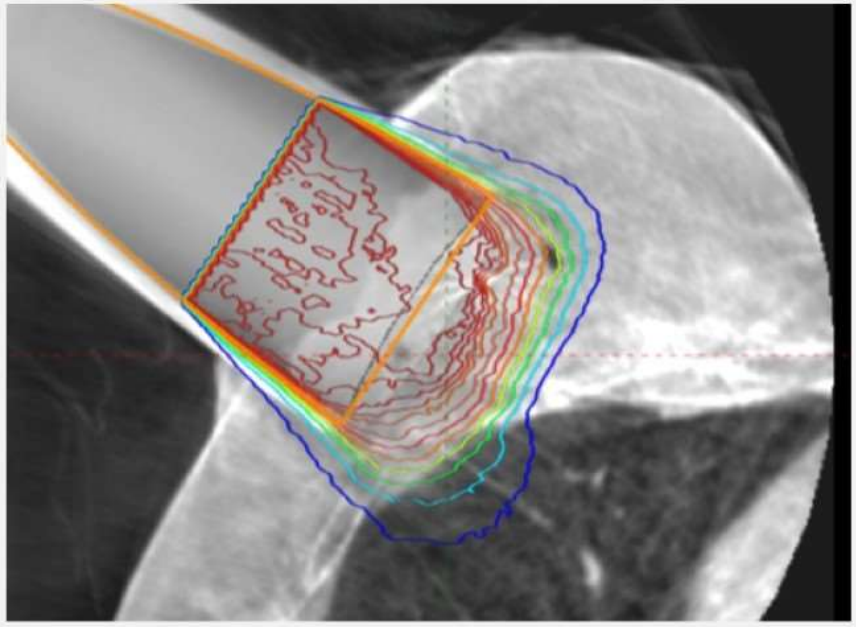
- Solution: shortened phase space file (tubelength -4cm)
- Dose in the Air is visualized

calculation time <1min!



TPS – Phase Space Files (3)

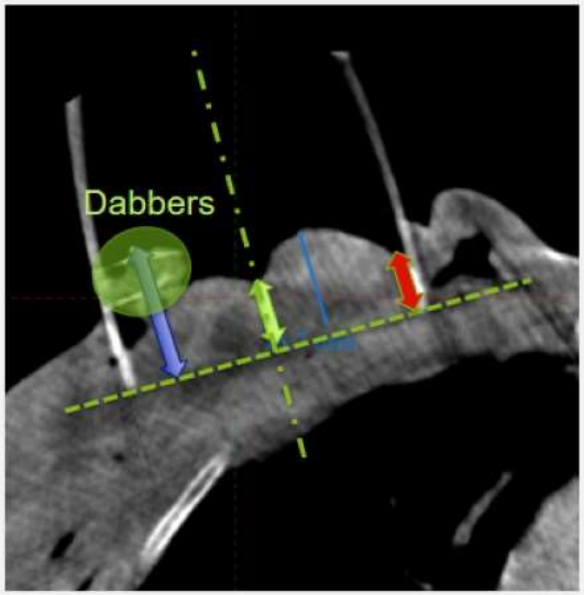


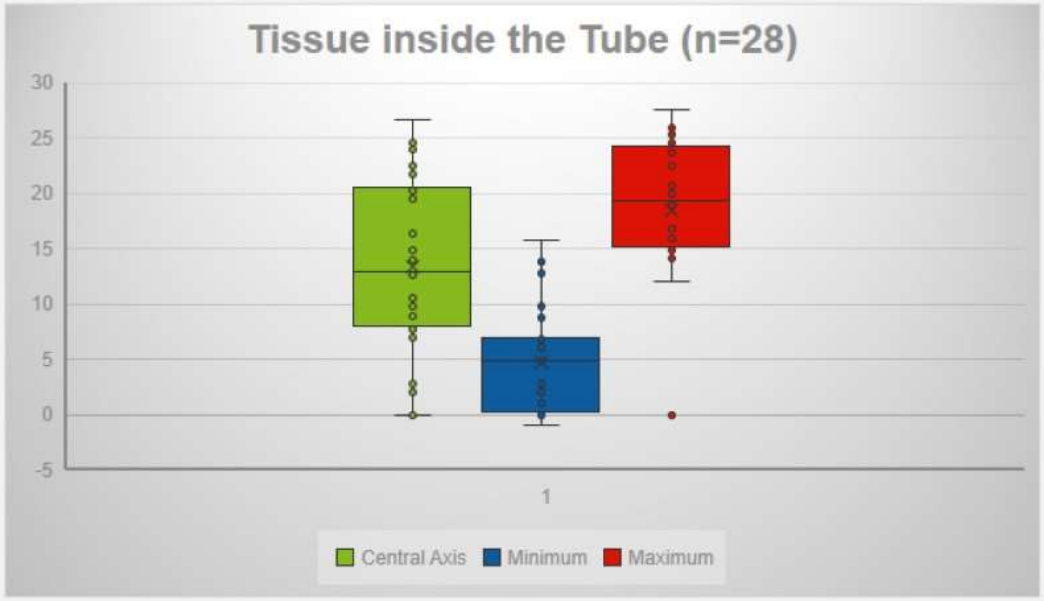


-> We never had a flat surface at the end of the tube!

-> We never had SSD100, if you don‘t use a bolus!

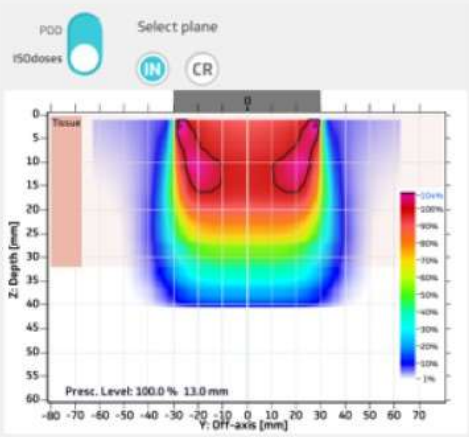
Clinical Aspekts: Tissue inside the Tube



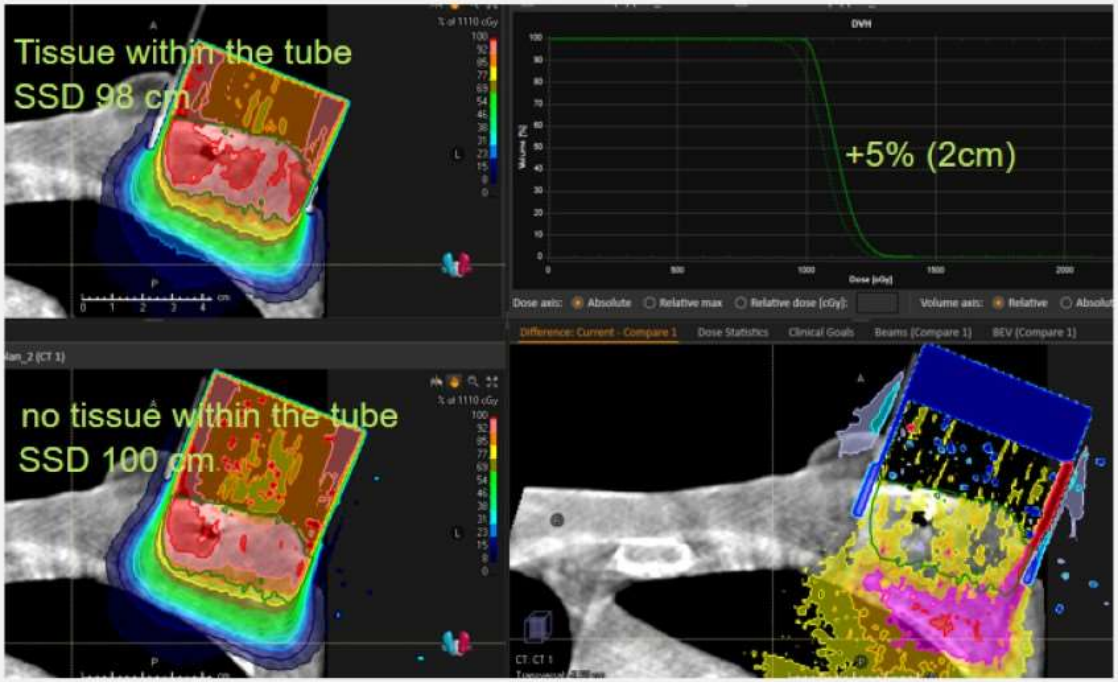


- In each analysed breast case -> uneven surfaces (despite dabbers)
- Dosimetrical effect (< SSD 100)

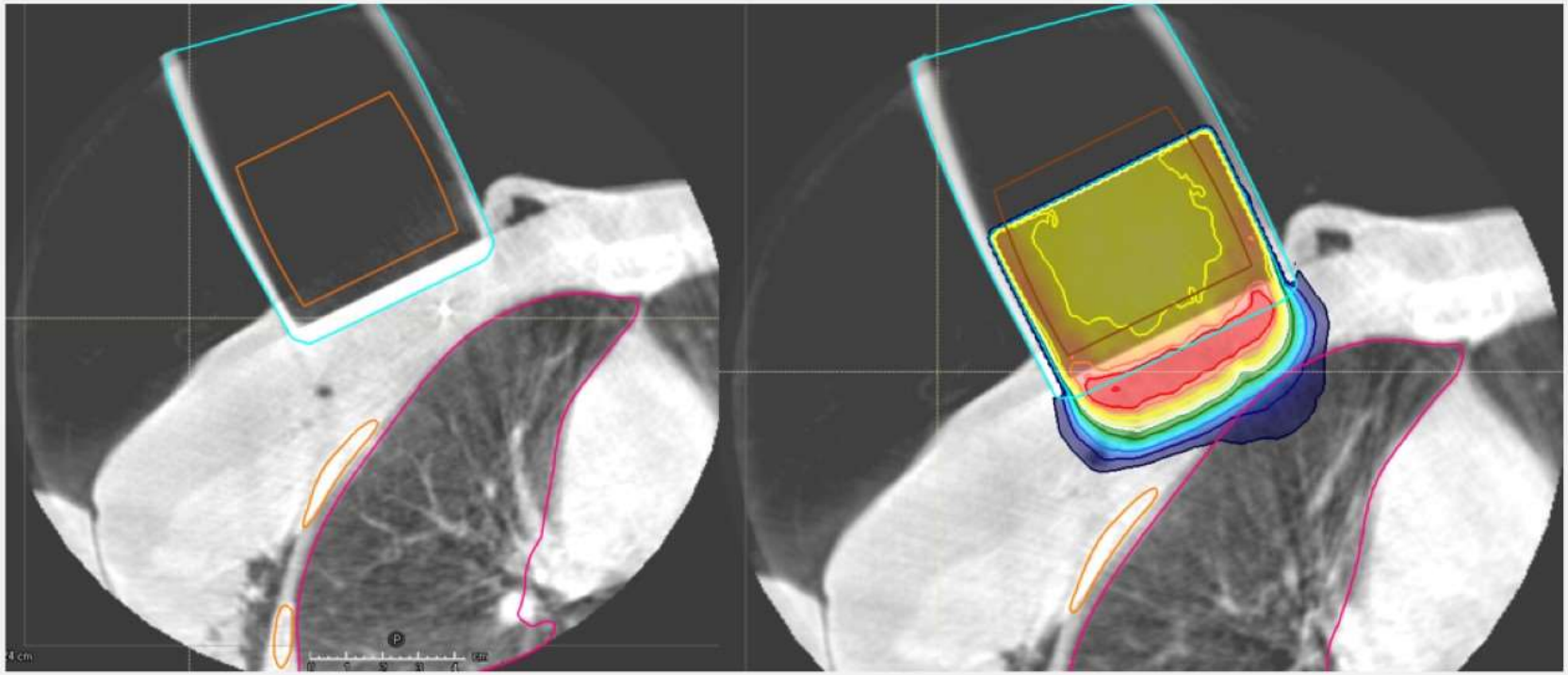
Dosimetrical Impact: Tissue inside the tube



SSD 100 cm

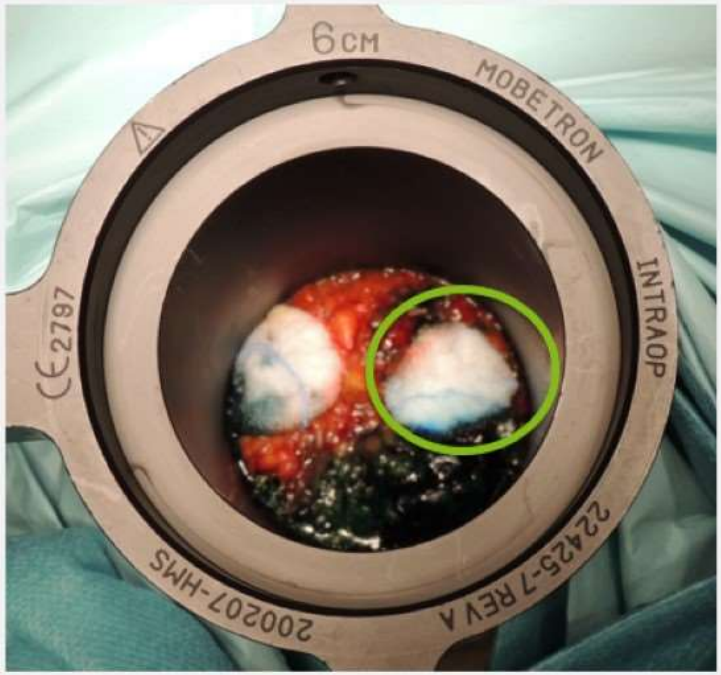


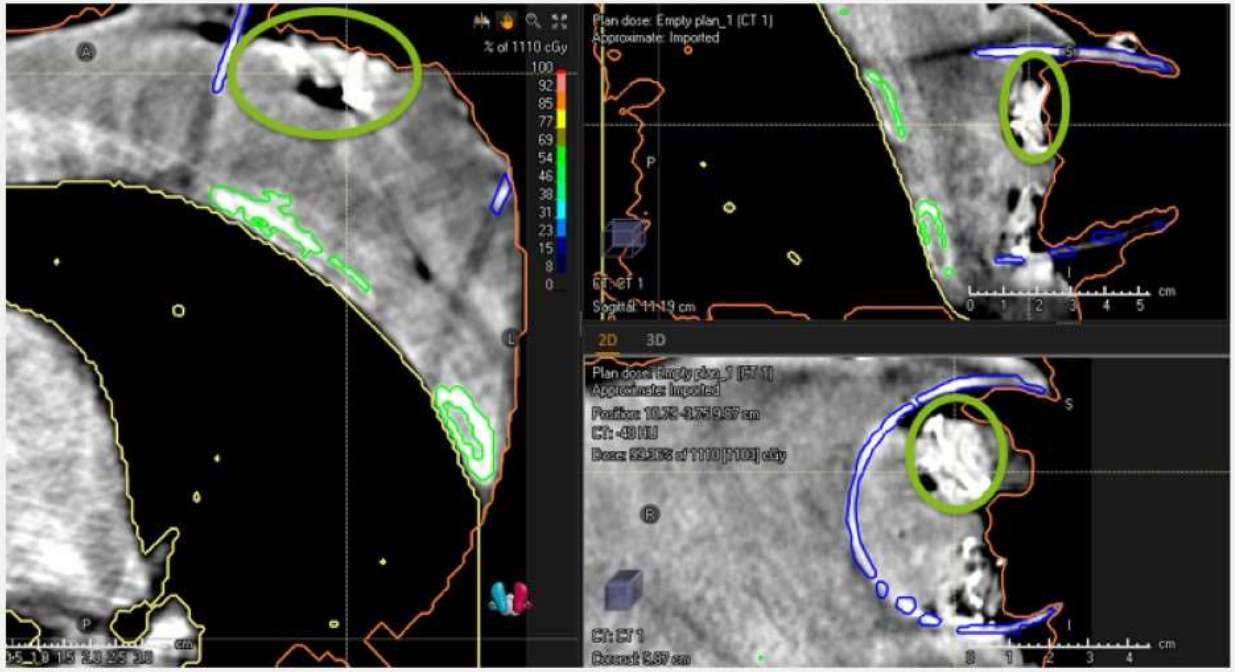
Treatment with Bolus



Dosedistribution with bolus and small brest tissue and overdosage of OAR (Ribs, Lung))

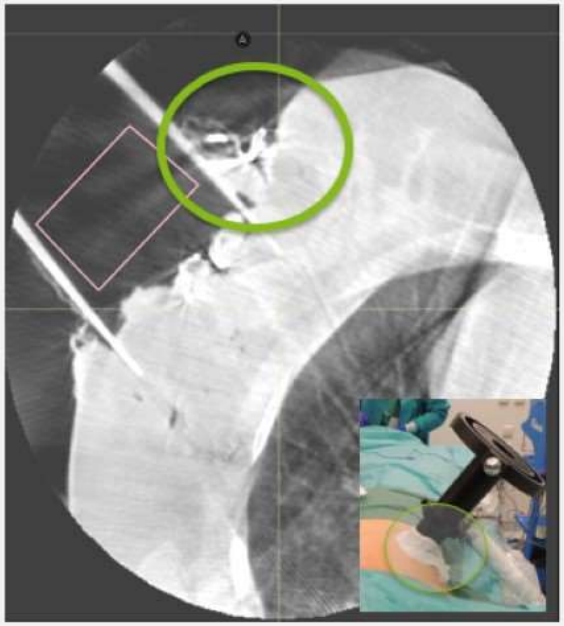
Clinical Aspekts: Metal Artefacts – dabber with metalweaving

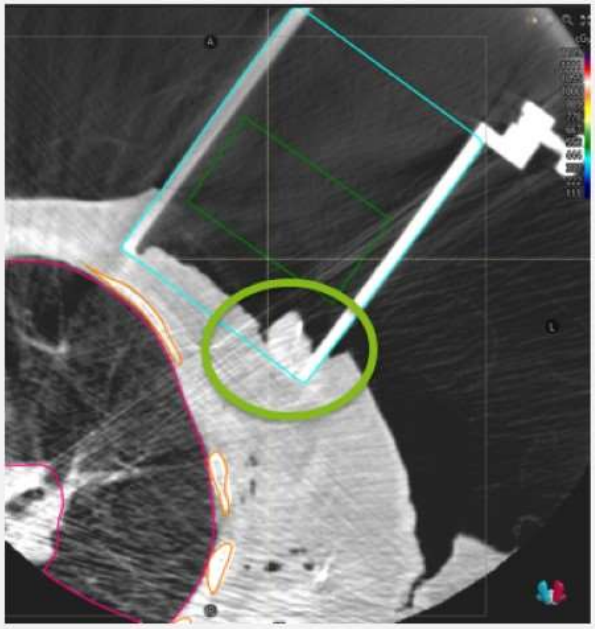


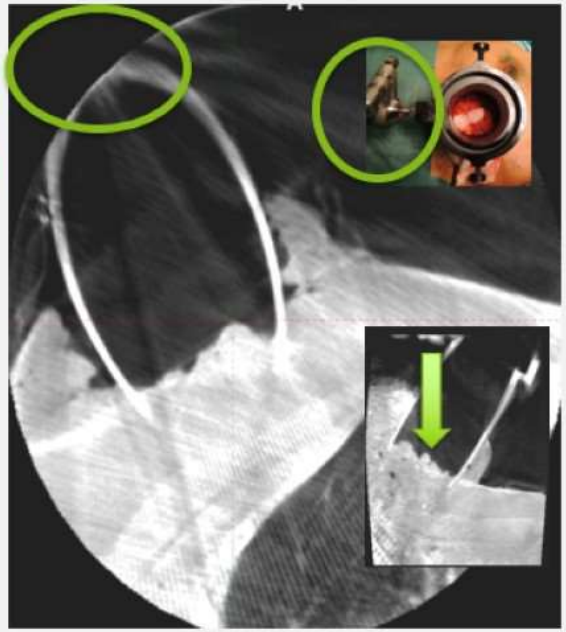


In order to create a flat surface, dapper has been uses -> this method also causes uncertainties

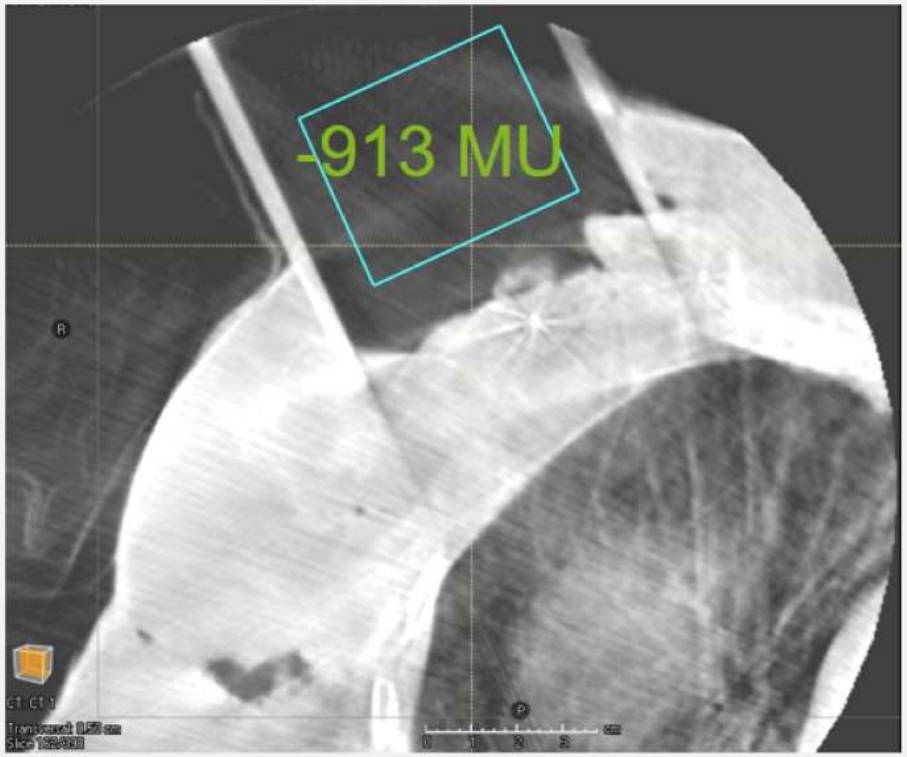
Metal artefacts can influence dose calculation

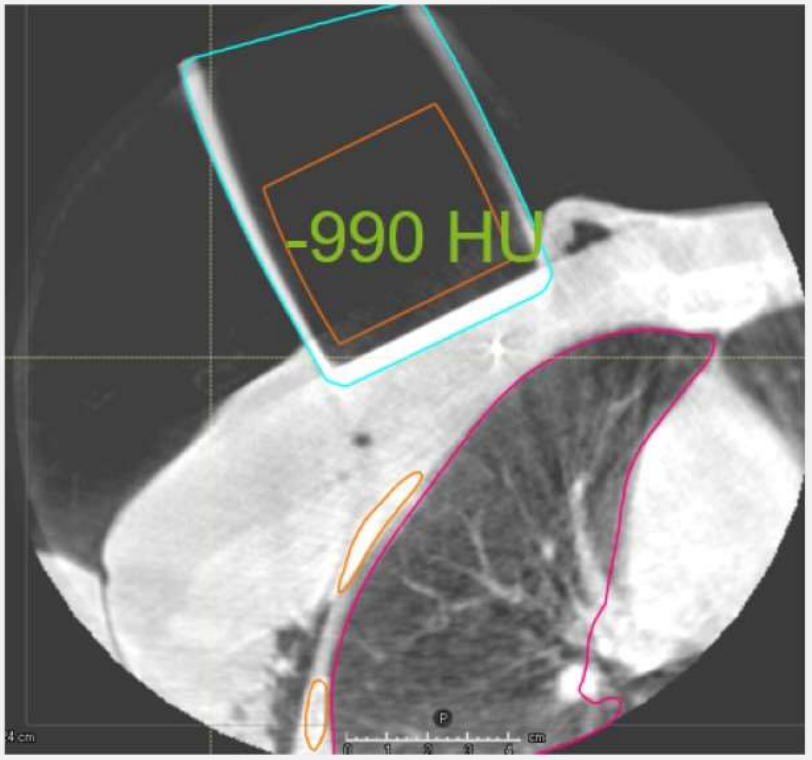




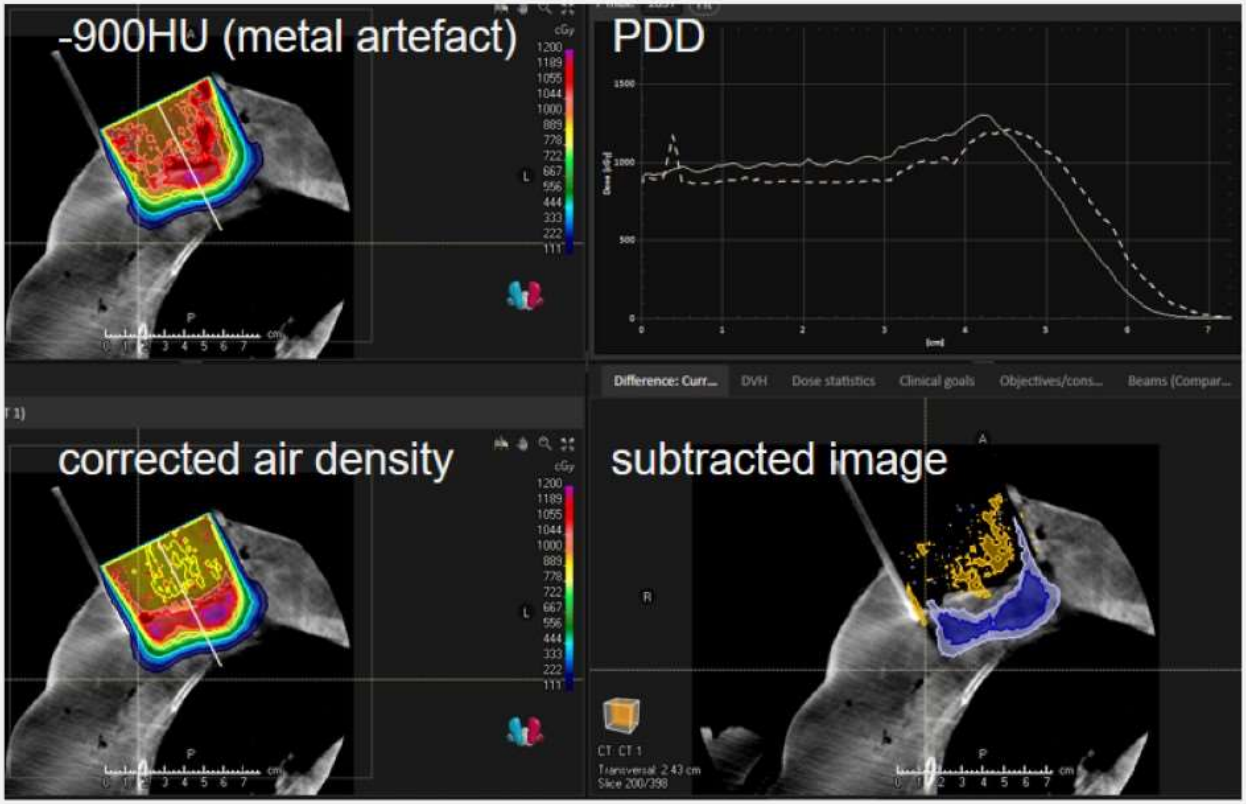


Clinical Aspekts: Metal Artefacts

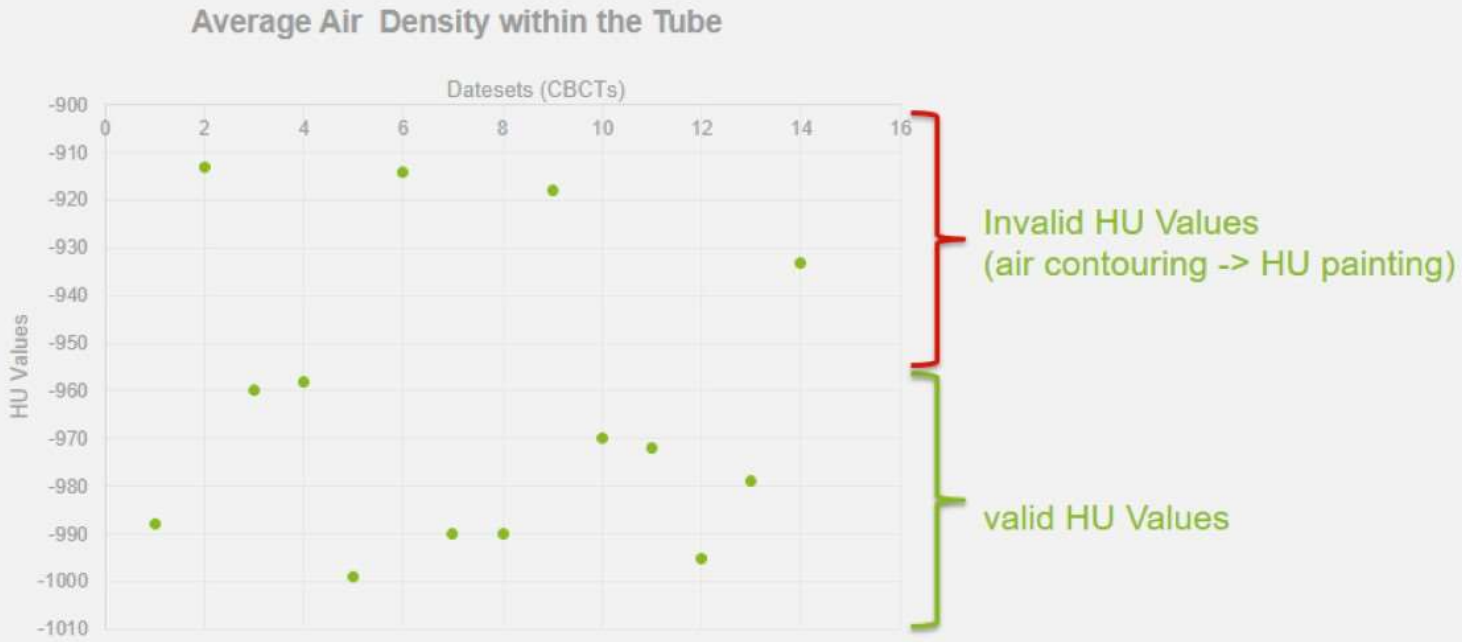




Metal artefacts can influence dose calculation



HU Deviation



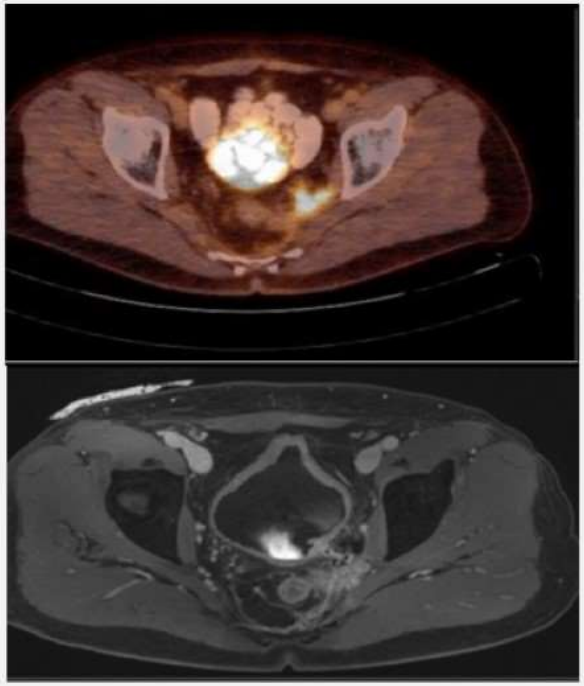
Clinical Cases

Targeted IORT

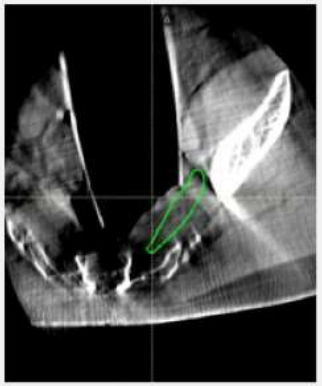
RESEARCH Open Access

First clinical application of image-guided intraoperative electron radiation therapy with real time intraoperative dose calculation in recurrent rectal cancer: technical procedure

Falk Roeder[1*], Gerd Fastner[1], Christoph Fuss[2], Rita Sedlmayer[1,3], Markus Stana[1], Johannes Berchtold[1], Tarkan Jäger[1], Jaroslav Pesl[1], Philipp Schmidt[1], Klaus Emmanuel[1], Daniela Colleselli[1], Gabriel Kokolakis[1], Philipp Scherer[1], Philipp Steininger[2] and Christoph Gaisberger[1,3]

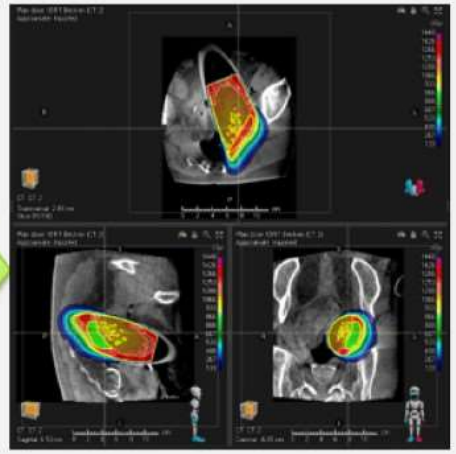


Pro IORT PETCT/MR Imaging



Tube Misalignment identified by image fusion

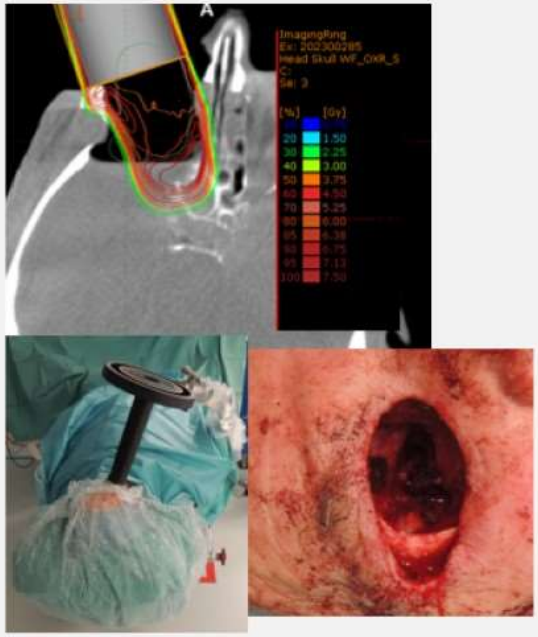
Corrected Tube positioning



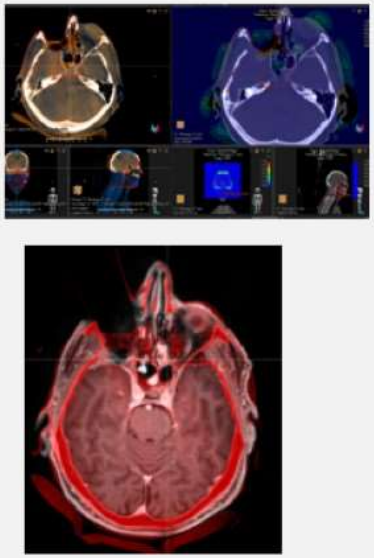
Treatment planning and radiation

IORT (H&N) Dose Summation

IORT (IG IORT)



Deformable Registration
MRT / PET / CBCT / CT



Conclusion

- 3D Imaging shows us revealed hidden inaccuracies in dose calculation
- Geometrical and dosimetrical precision can be increased
- To solve one problem (tissue in the tube), other problems were aggravated (metal artifacts in the air)
- On the way to a perfect plan there are some problems (metal artifacts) that still need to be solved.

Thanks for the attention