

MR-Linac the Present, and Where We are Heading

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Agenda

1. What is an MR Linac
2. Which MR Linac we have at USZ
3. What and how we are treating now
4. Adaptive procedure
5. What are the daily difficulties
6. Where we are heading

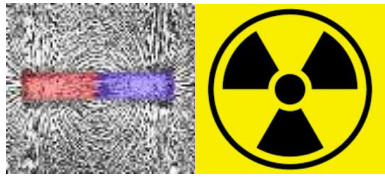


Disclaimer / Conflicts of Interest

Viewray
MRIdian in
USZ



MR Linac



- It is a Magnetic Resonance Linear Accelerator
- Combines a Linac and MRI together
- All MR Linac's have the capability of adaptive treatment
- All MR Linac's have real-time visualization of the anatomy during beam on
- There is a range of magnet strength from 0.35 T to 1.5 T

2 Main MR Linac's

- Elekta Unity
- Viewray MRIdian



Viewray MRIdian

- 6MV FFF
- 0.35 T
- Real-time Gating
- Isocenter Distance: 90cm
- Maximum Field size: 27.2cmx24.1cm
- The couch has limited shifts

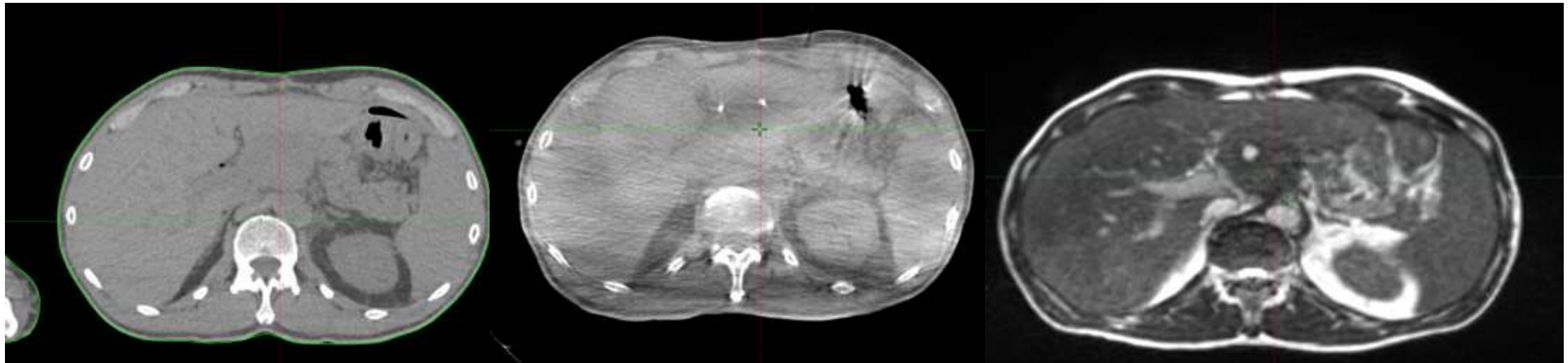
Elekta Unity

- 7MV FFF linear accelerator, high speed slip ring gantry
- 1.5 T
- Real-time MR visualization with diagnostic quality MRI scanner throughout the treatment
- Tumor response assessment with biological MRI capabilities in the online environment

Benefits of the MR Linac

- Image quality for soft tissue is significantly better than on a CT Linac
- Smaller margins due to daily adaptive
- No imaging dose
- No need for fiducials

Take home message: Able to irradiate certain tumours with a SBRT dose because of better Imaging Quality, Daily Adaption & Gating



PLCT

CBCT

MR

Benefits of Gating

- Real Time tissue Tracking & Gating
- Can coach the patient visually & vocally
- Reassure the patient that the Linac only beams on when the target is within limits
- Abdomen anatomy changes quickly, this tools guides us to more precise treatment and better decisions

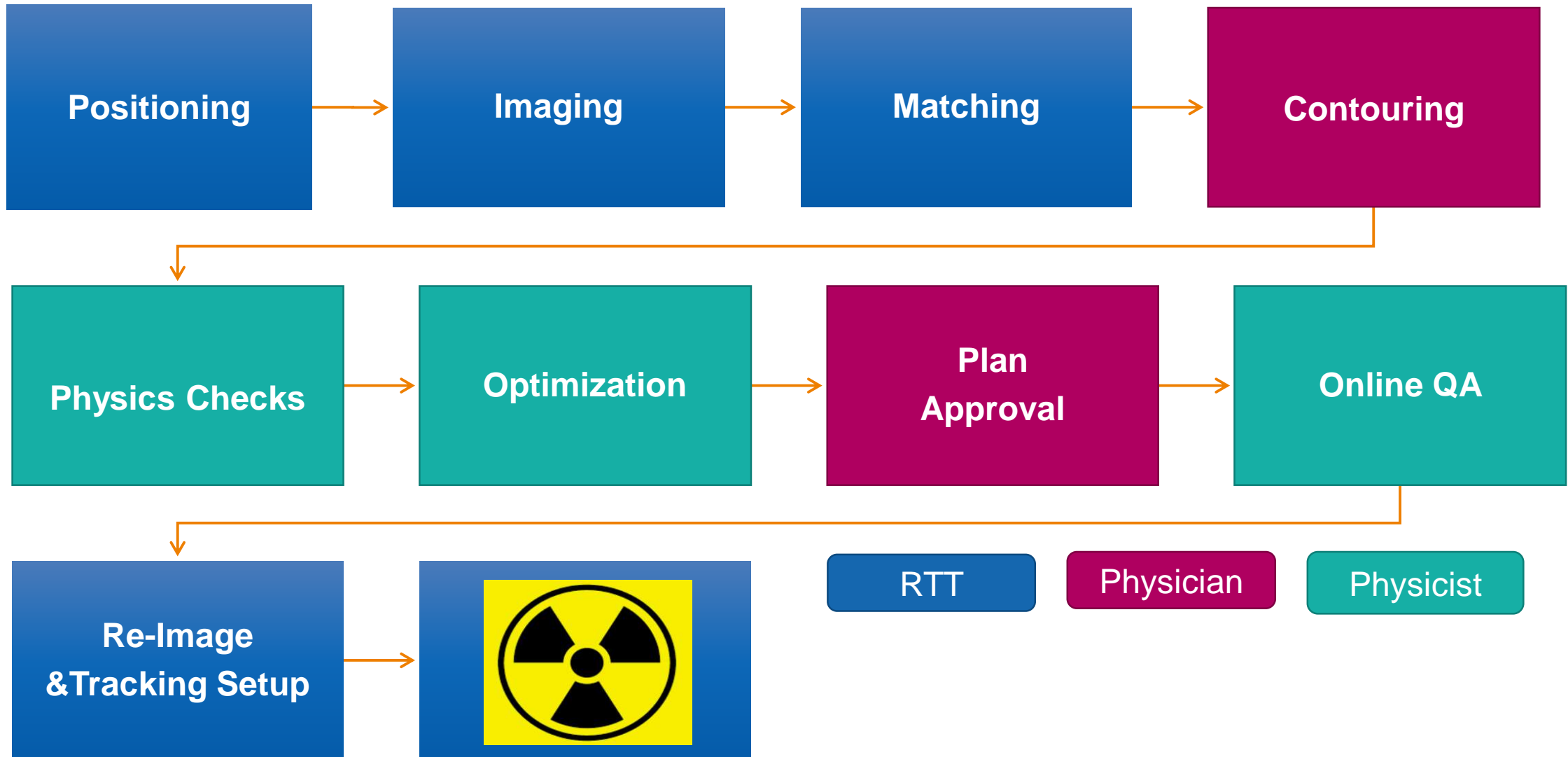


2 Options for Treatment at USZ

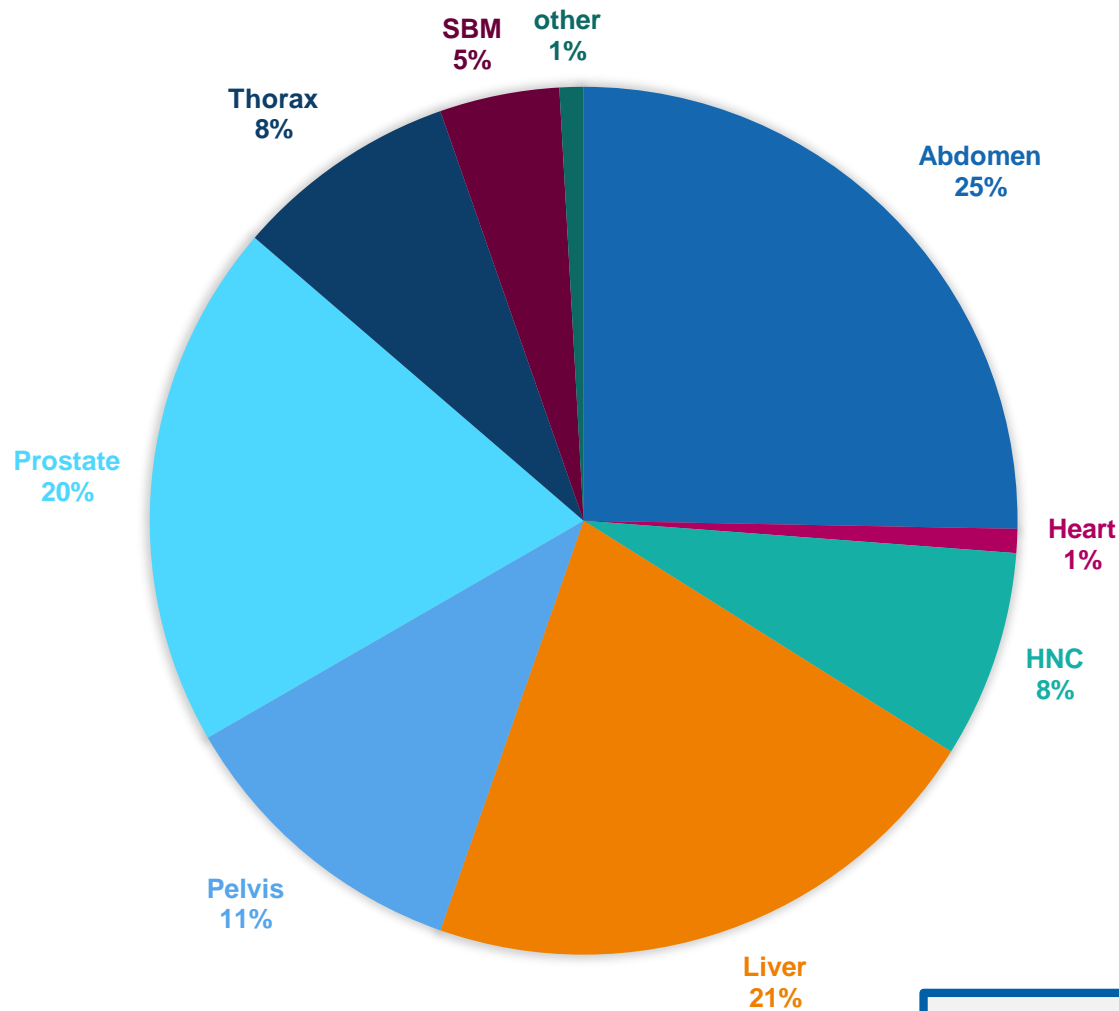
1. Weekly Adaptive

2. Daily Adaptive

Adaptive Workflow



Sites That We Treat and Goal

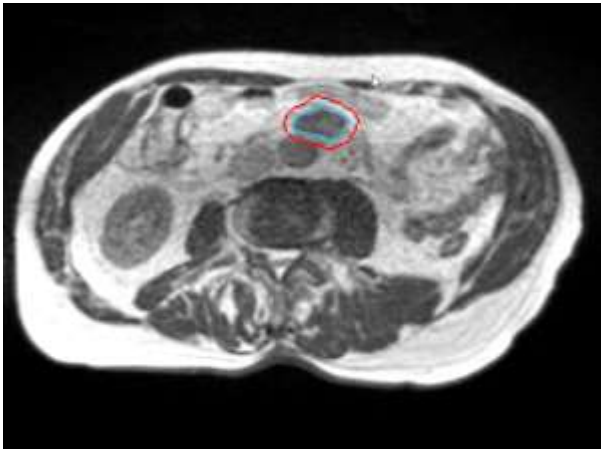


Indication	Goal of Therapy
SBRT Prostate Pancreas Kidney	<ol style="list-style-type: none"> 1. Cure 2. Shorter treatment length
SBRT Oligo-metastasis	<ol style="list-style-type: none"> 1. Give a curative dose 2. Reduce toxicities
SBRT Lunge	<ol style="list-style-type: none"> 1. Cure 2. Reduce Toxicities
HNO & Abdominal-Tumor	<ol style="list-style-type: none"> 1. Reduce Toxicities
Sarkomas	Reduce safety margins

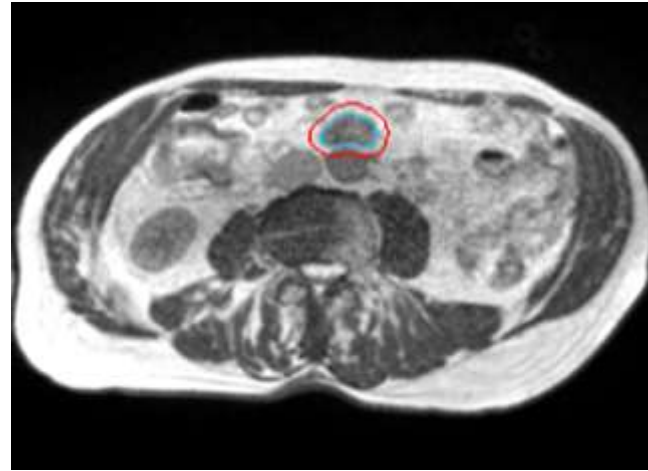
Data from
400 patients

Tumor Movement in Each Fraction

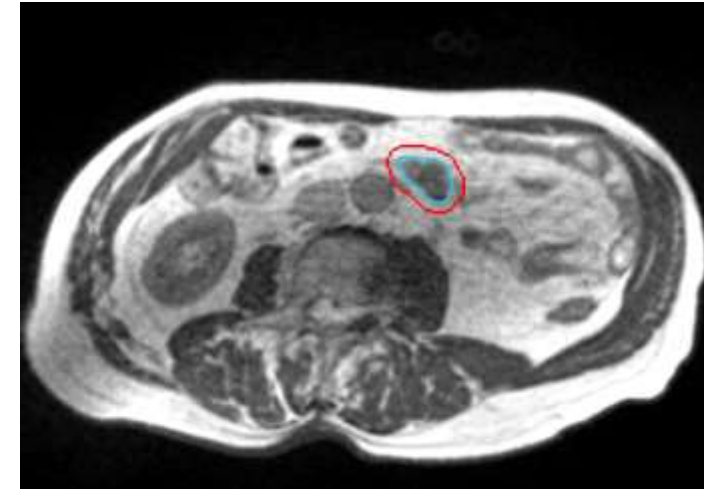
Credit for slide and Case: Dr. H. Garcia



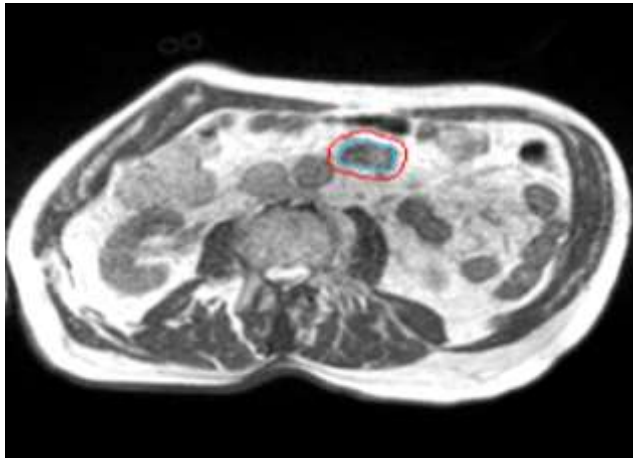
Fraction 1



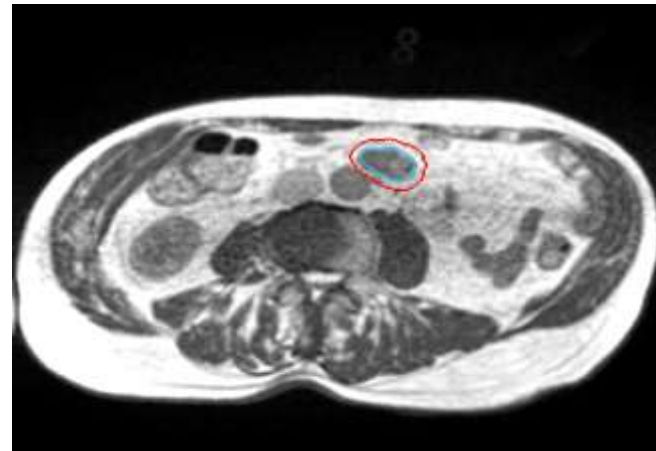
Fraction 2



Fraction 3



Fraction 4



Fraction 5

77 years old, male

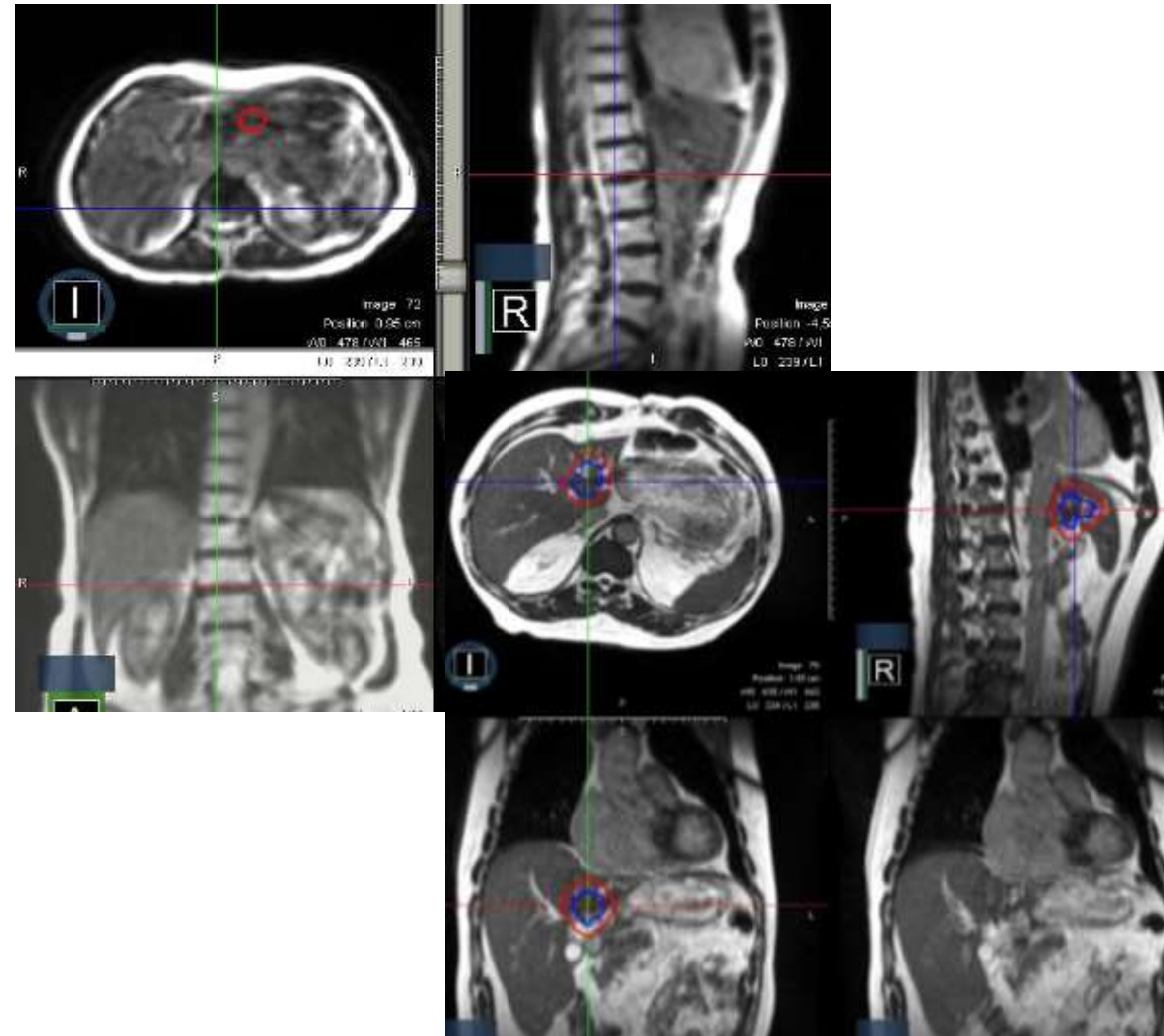
History of disease

- Lentigo maligna **Melanoma of the left cheek St. IV (pT1a N2 (2/29) M1)** First diagnosed 11/2012
- PET/CT 17.04.19 :**Progression of the mesenterical node, no further signs of disease**

Adaptive Workflow

Imaging

- 15s Low Res scan (in free breathing)
- 17s High Res scan (with breathing commands)
 - Inspiration for thorax
 - Expiration for abdomen
- Check the scan quality and length
- Matching usually on the GTV
- Physician approves matching



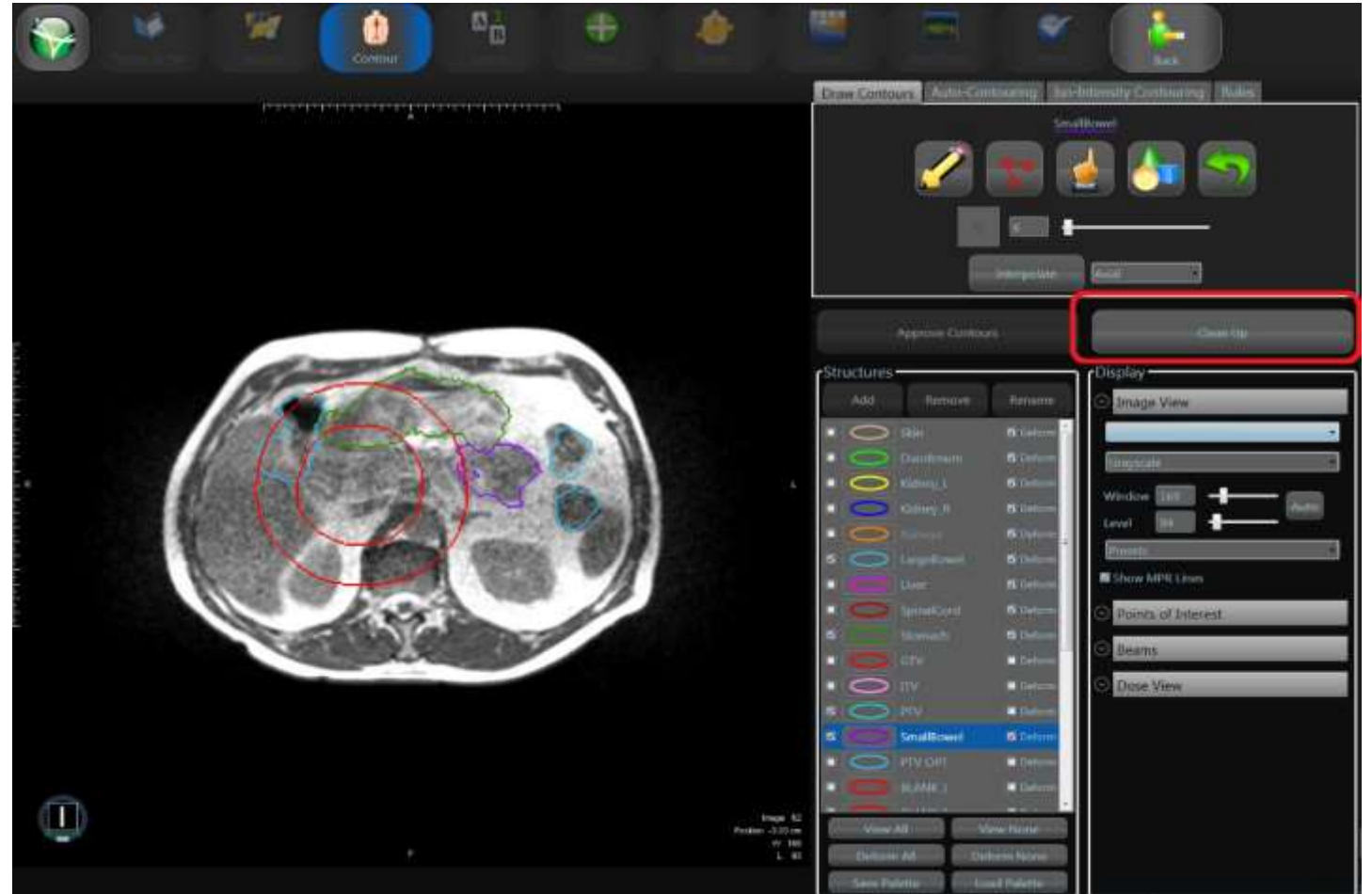
Adaptive Workflow

Contouring

1. First step is to control the automated contours
2. Physician does all the contours

There are some rules to make adaptations quicker:

e.g. We have 2 cm Ring extended from PTV which means we only need to correct the OARs inside the ring.

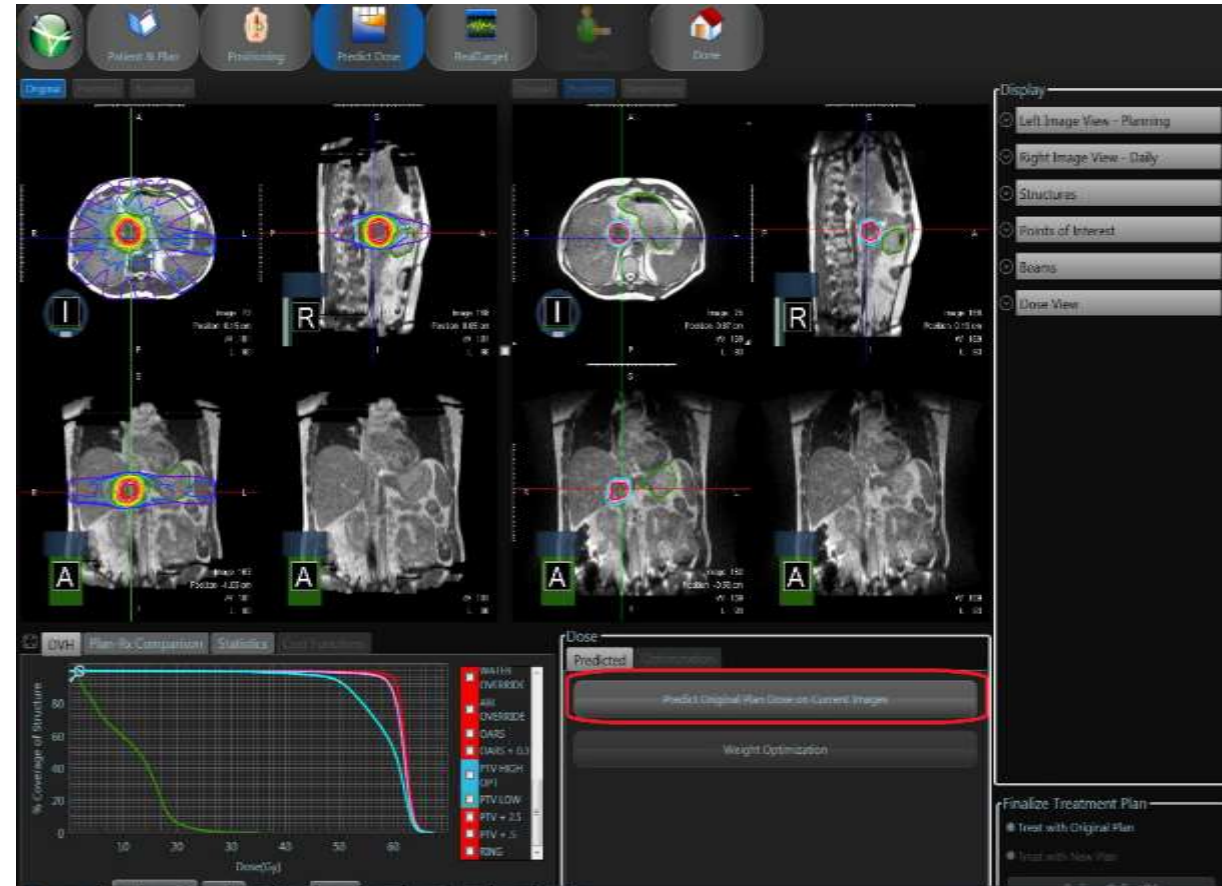


Adaptive Workflow

Physics Calculations of New plan

There are 2 options for Adaption:

- **Weight Optimization:** Very quick 1-2 min
- **Full Optimization:** We perform maximum 3-4 per fraction due to time needed to run each full adaption



Adaptive Workflow

Reimage and Gating Setup

- Reimage, match and check that anatomy has not changed

Next step

Gating Set up:

- Picking a Gating structure- we prefer the GTV
- Gating Toleranz- *3 mm*
- 2D image 4 frames per second
- Gating feasibility check
- Beam on time



Adaptive Workflow

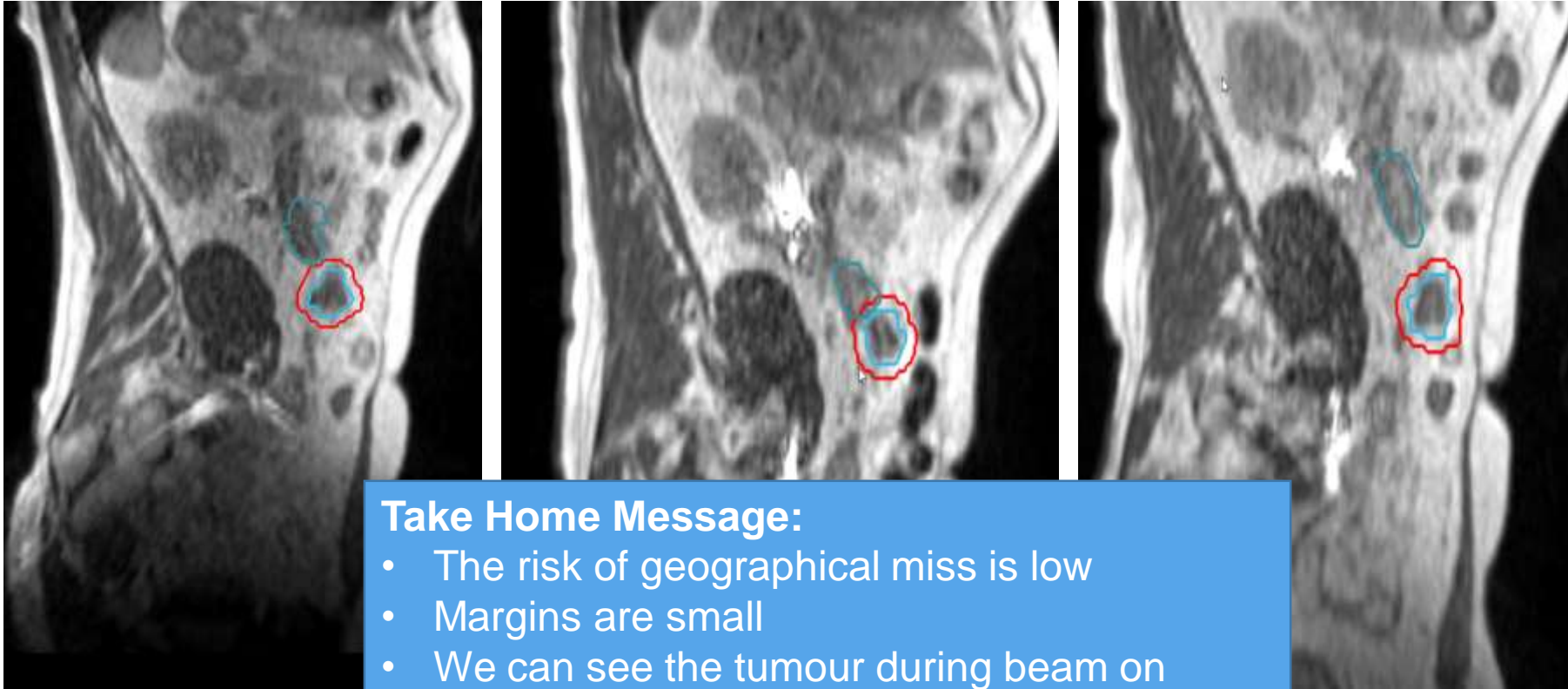
Radiation

- IMRT Step and Shoot only
- It beams on automatically when the target is in tolerance
- Cannot pause the beam
- But of course, we can stop the beam



OAR Variability & Movement

Credit for slide and Case: Dr. Garcia



Take Home Message:

- The risk of geographical miss is low
- Margins are small
- We can see the tumour during beam on
- We could compensate for OAR and tumour change on a daily basis

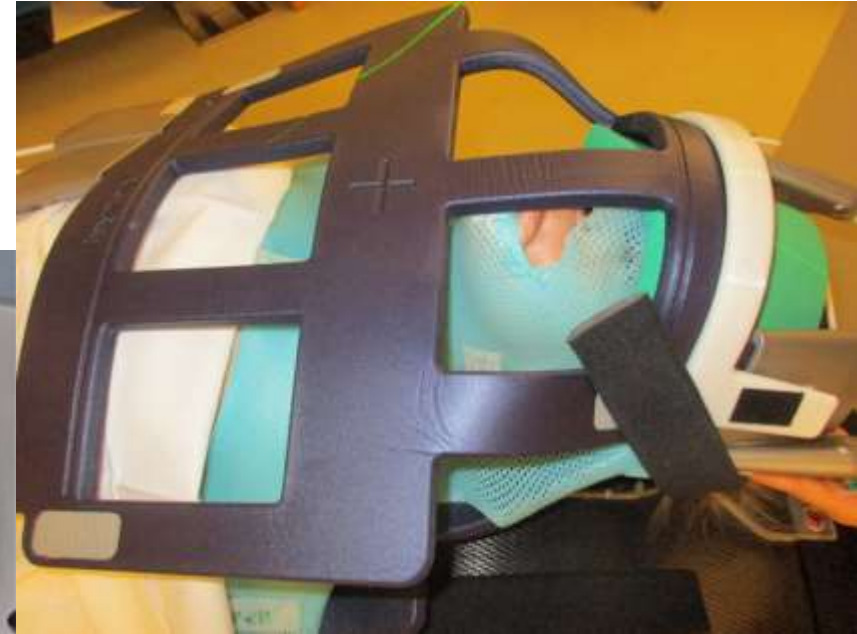
Daily Difficulties

- Time is our biggest “enemy “
- It takes a village to perform daily adaptive radiation
- Education
- Case specific



Daily Difficulties

Patient positioning to be “comfortable” and stable for long periods of time



Where we are Heading

- More efficient software
- Better AI with auto contouring
- Gating in different planes
- Remote access for contouring

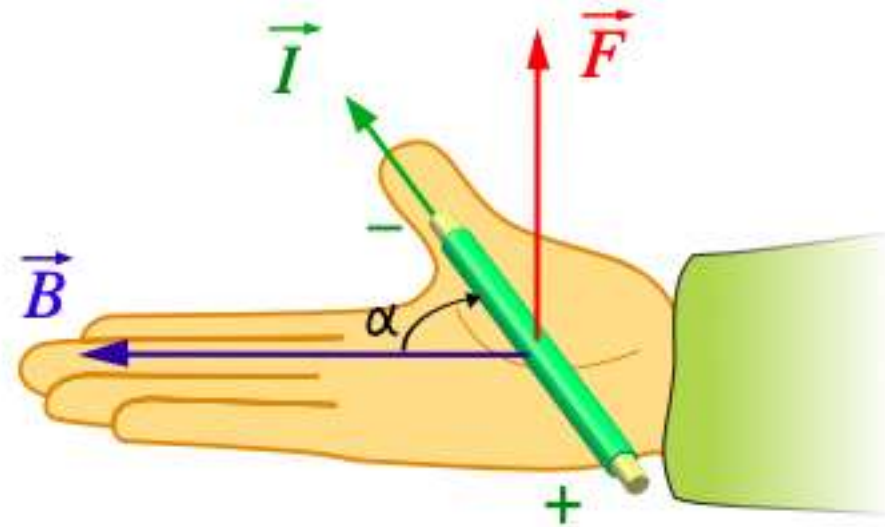
All these 4 are already implemented in the USA, waiting for approval in the EU




- RTT lead adaptations
- Smart positioning material
- Optimizing procedure

Lorenz Force

- All charged particles are effected by the electromagnetic field
- Secondary electrons are effected
- Secondary electrons are influenced by the Lorenz force and it makes them travel in a circle
- Can increase dose in Air Cavities
- Important to contour air and it is important that it stays in the same position





Every time you are tempted to react in the same old way, ask if you want to be a prisoner of the past or a pioneer of the future. - Deepak Chopra

Wherever the art of Medicine is loved, there is also a love of Humanity. – Hippocrates

Thank you for your attention!

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