



Georges Chicotot 1906

State of the art in Radiation Oncology

Prof. Dr. D. Verellen

Outline

- Technological evolution of Radiotherapy in fast forward
- Challenges for the Iridium Kankernetwerk

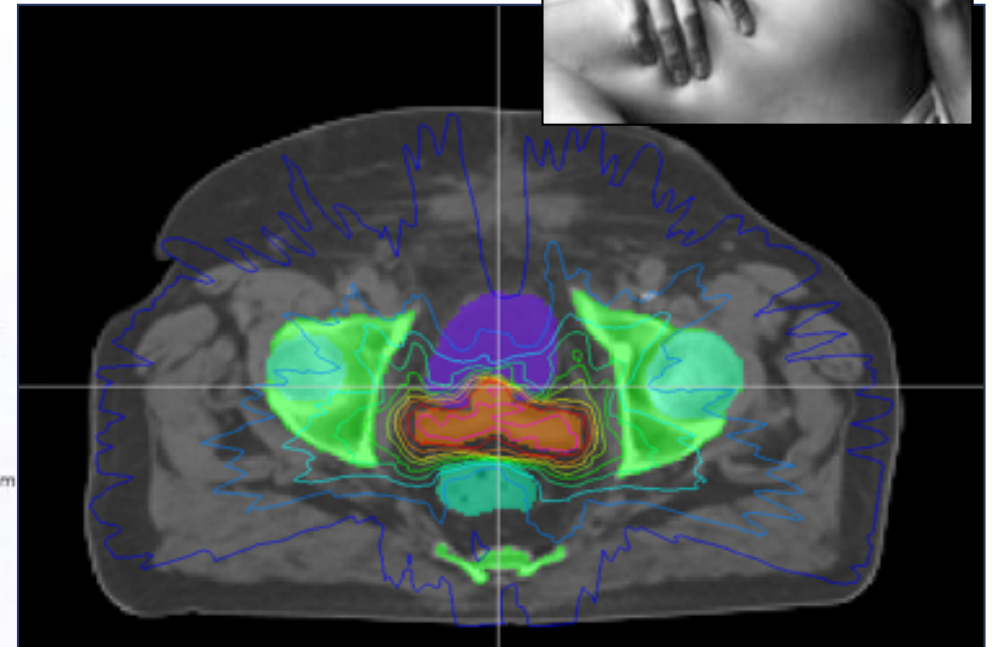
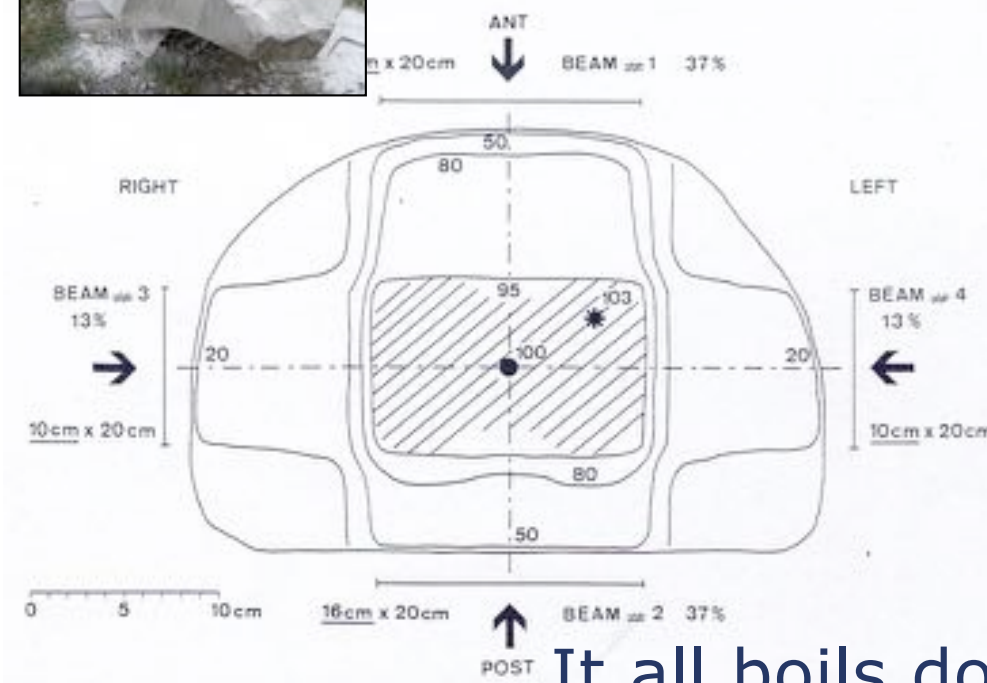


Monty Python: "The machine that goes ping"

The aim of radiotherapy

maximizing outcome

minimizing complications



It all boils down to “DOSE
SCULPTING”

Applying ionizing radiation

- Brachytherapy:
 - “brachy” close by
 - Also known as “Curie-therapie”
- Teletherapy or external beam radiotherapy:
 - γ -rays (tele-cobalt),
X-rays (linear accelerators)
 - Electrons
 - Protons, neutrons, light ions, ...



Applying ionizing radiation

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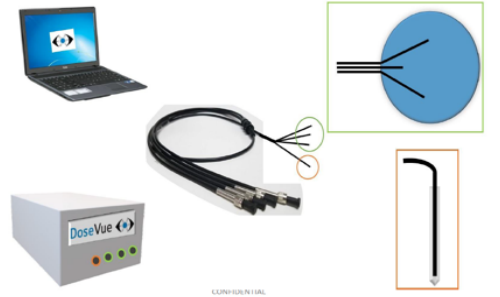


Intra-Operative RadioTherapy

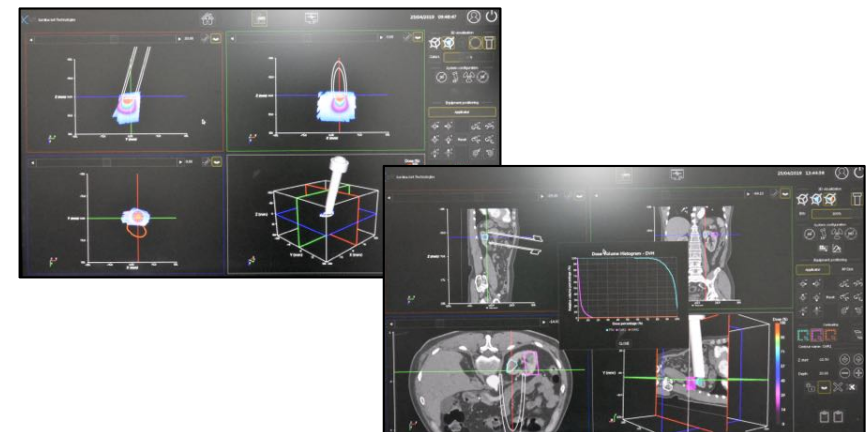
- *In vivo* dosimetry

DoseWire platform

Patents pending



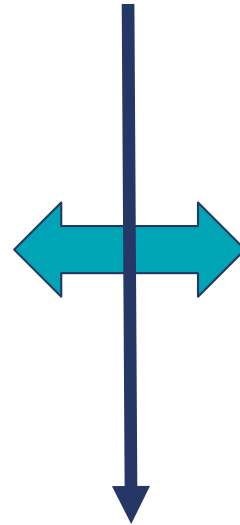
- Ultra Sound based treatment planning



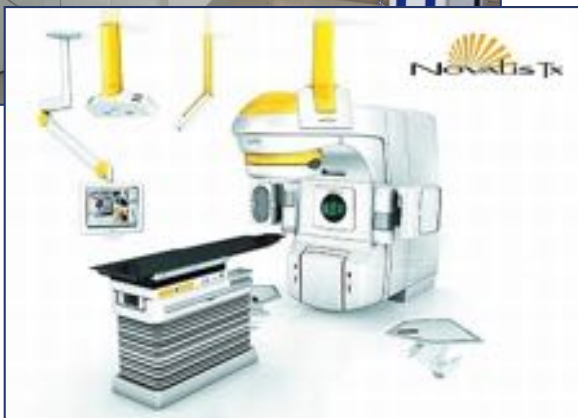
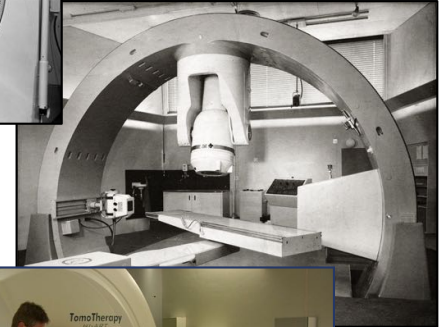
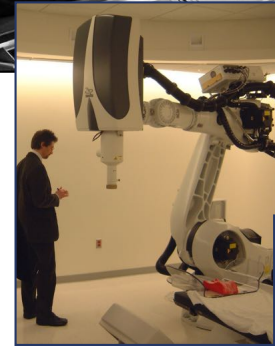
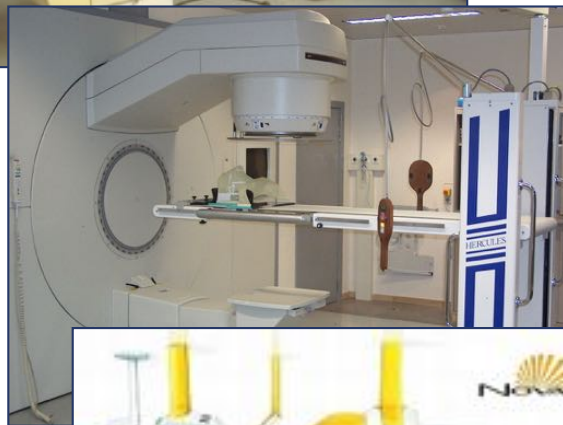
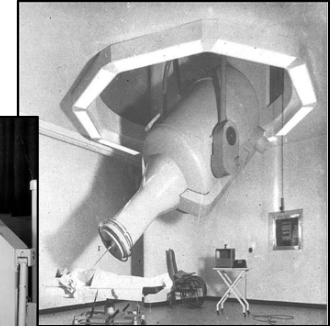
External Beam Radiation Therapy



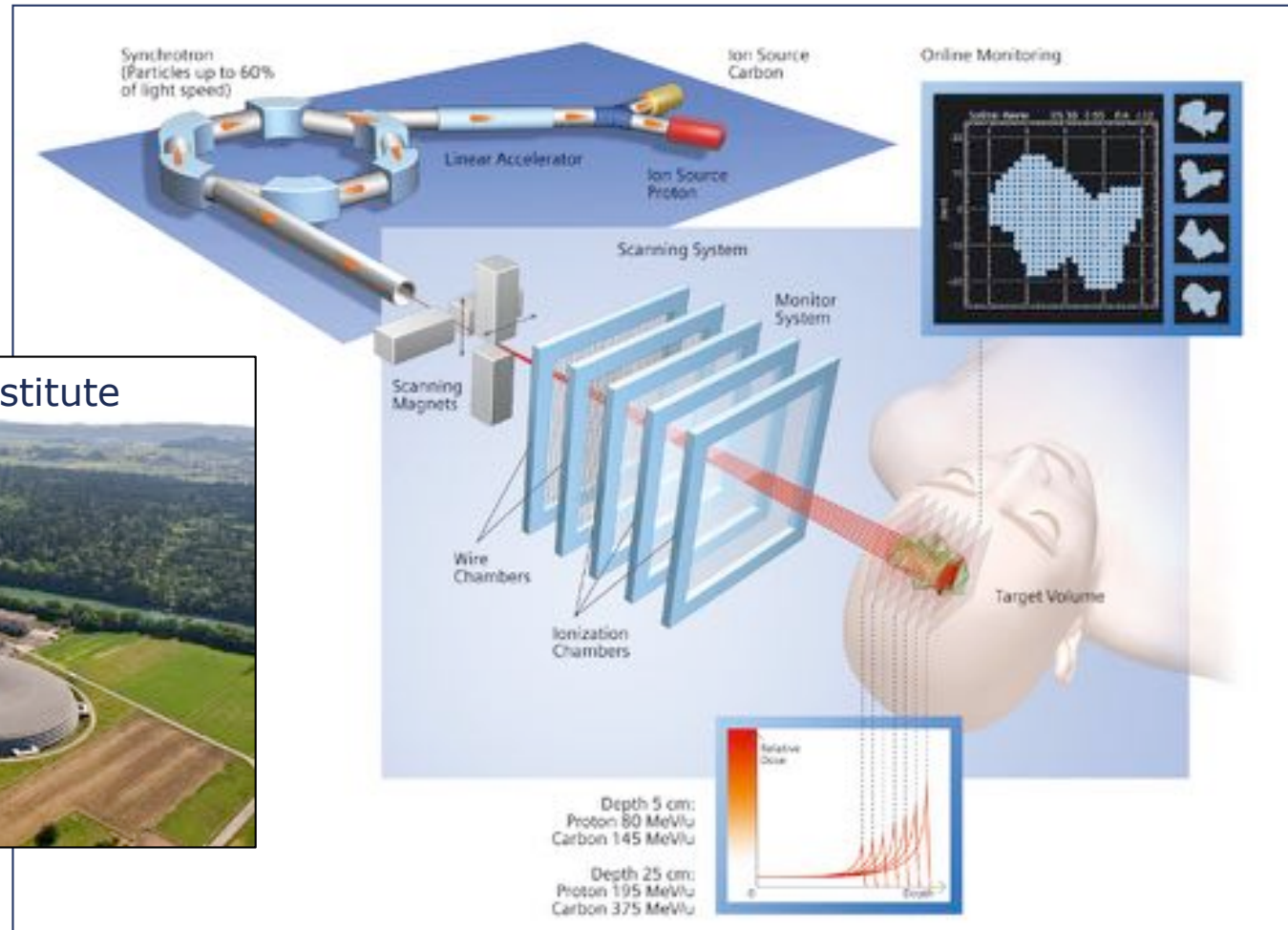
1950



2019

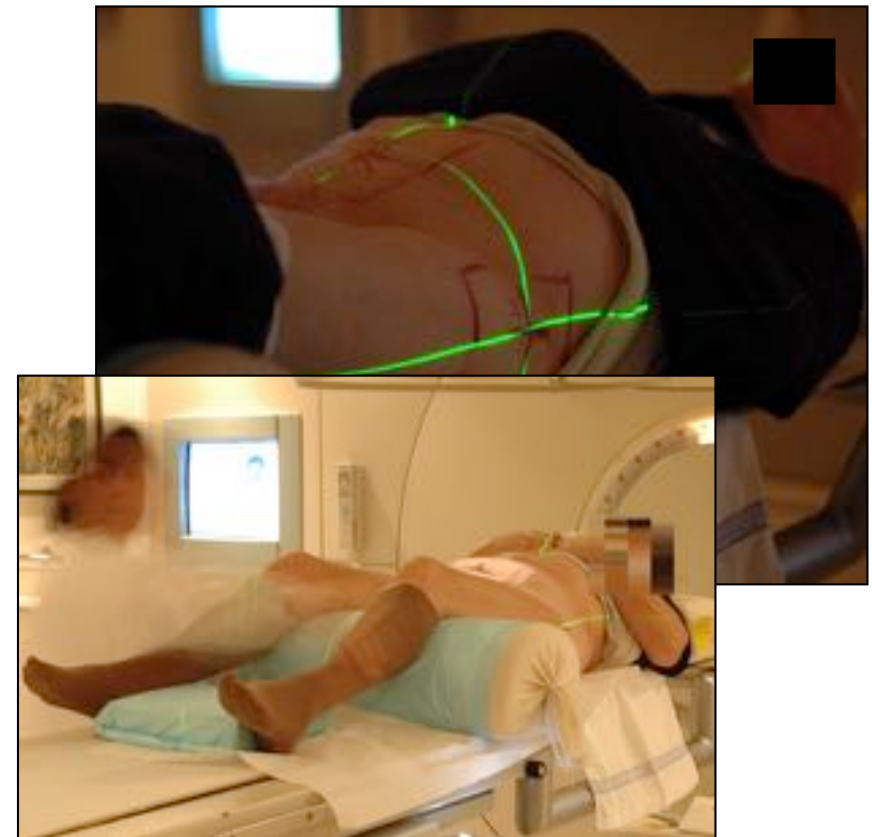
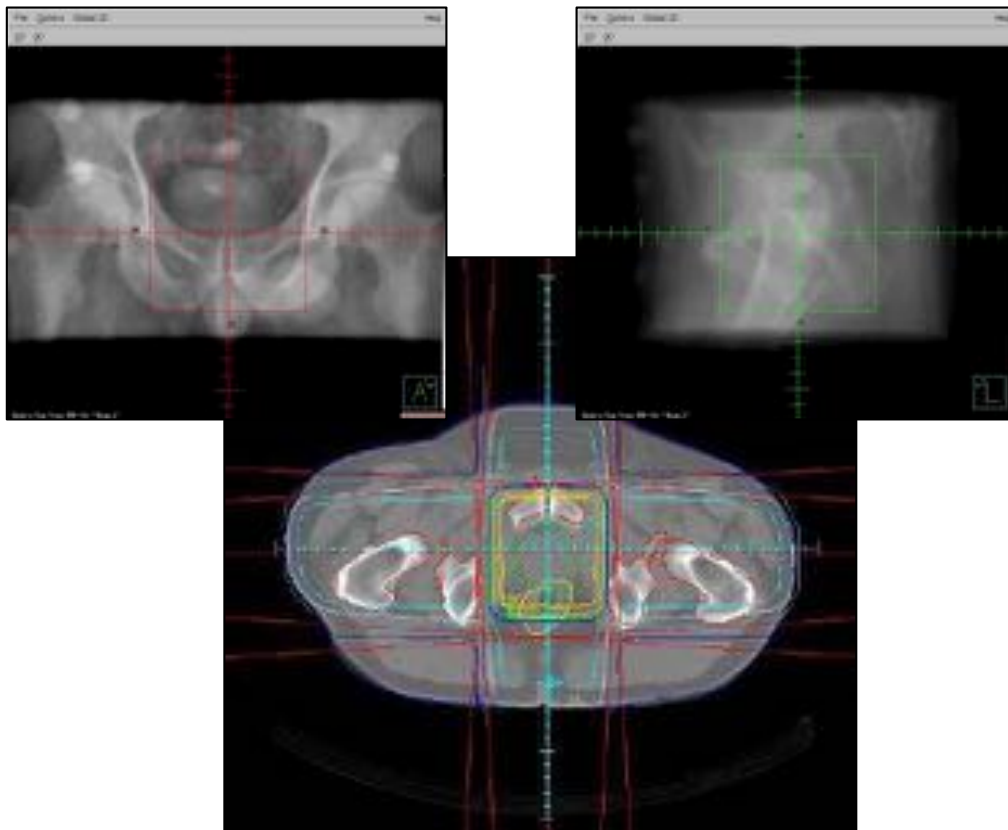


External Beam Radiation Therapy



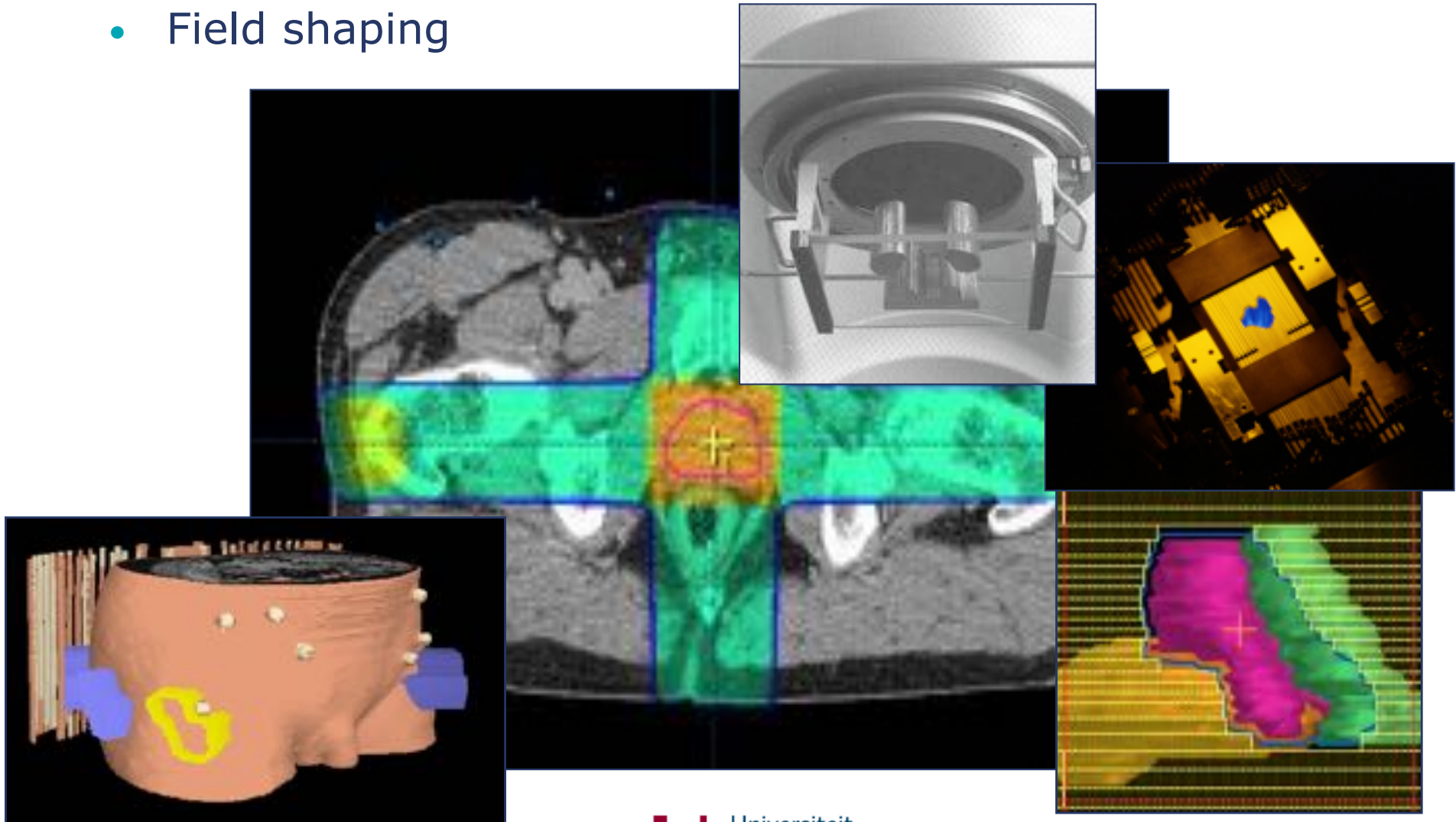
External Beam Radiation Therapy

- Simple dose distributions, large uncertainties in “target” localization



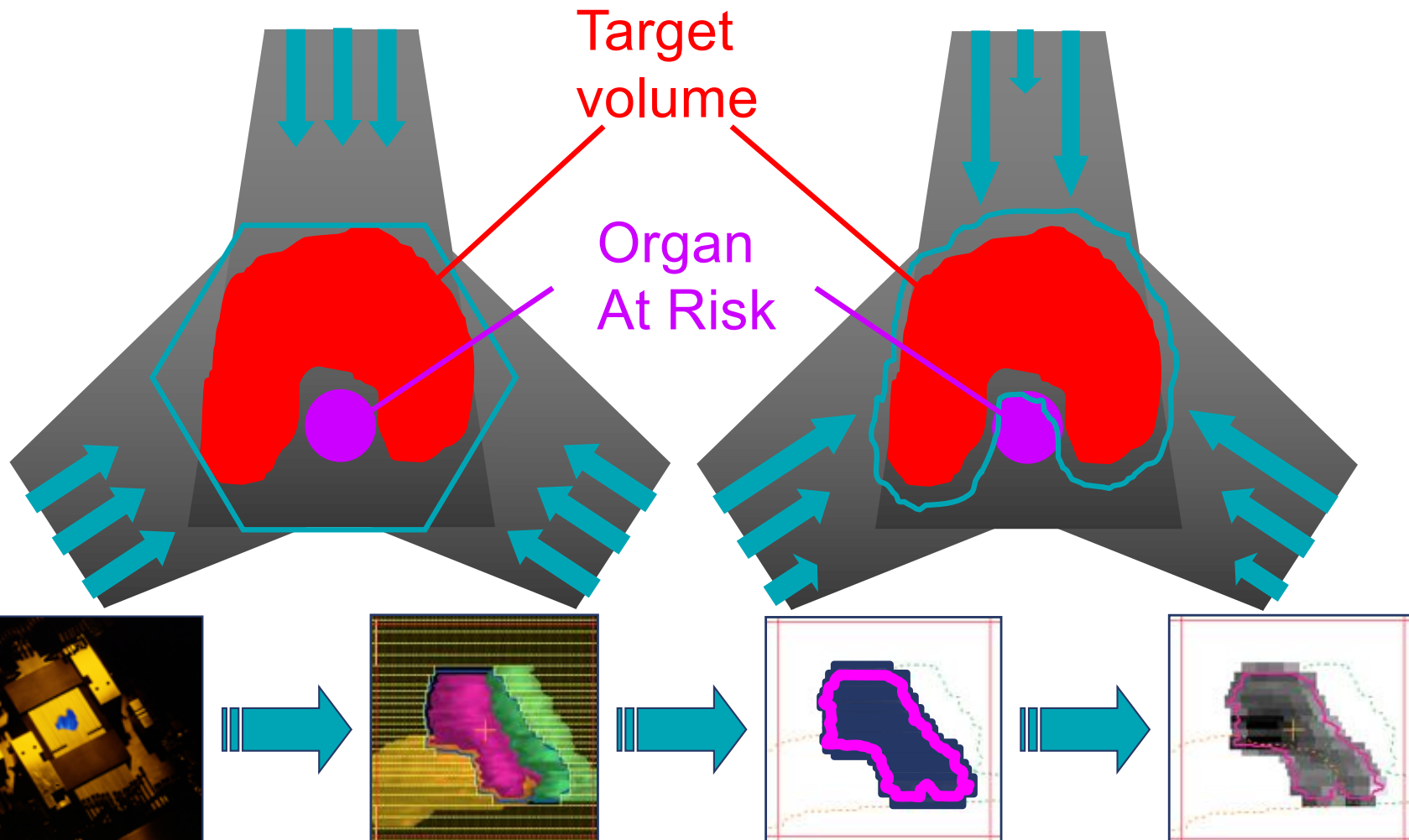
External Beam Radiation Therapy

- Field shaping

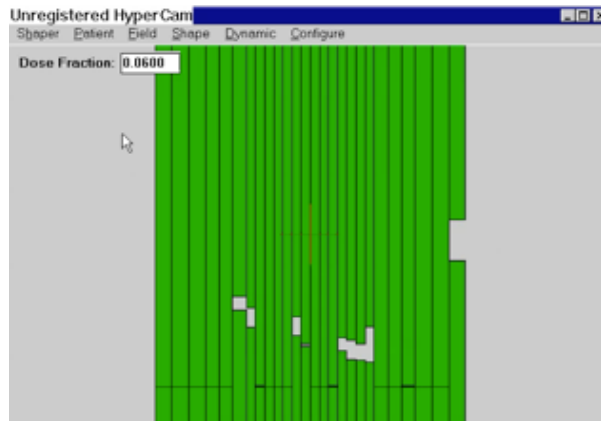


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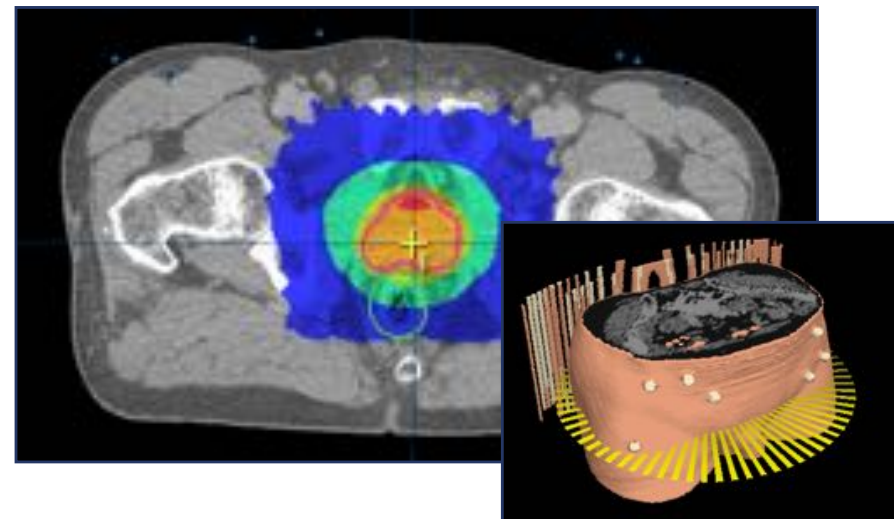
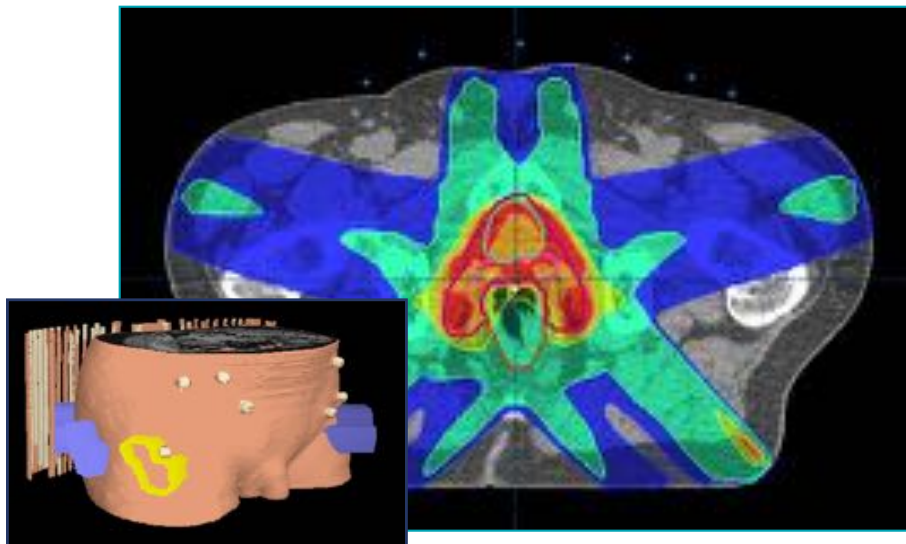
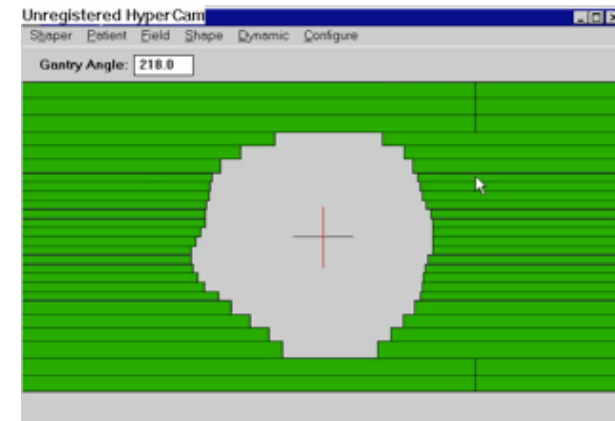
- Modulating the beam intensity



External Beam Radiation Therapy

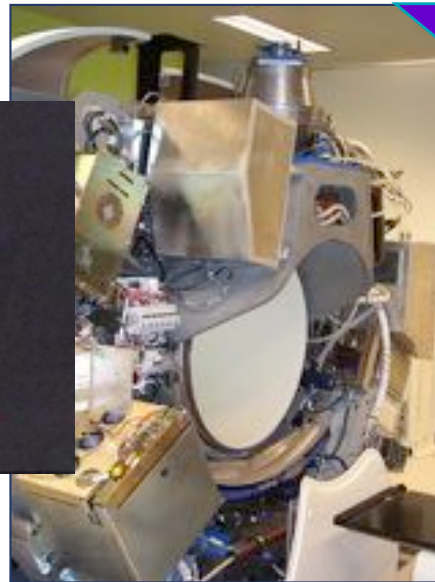
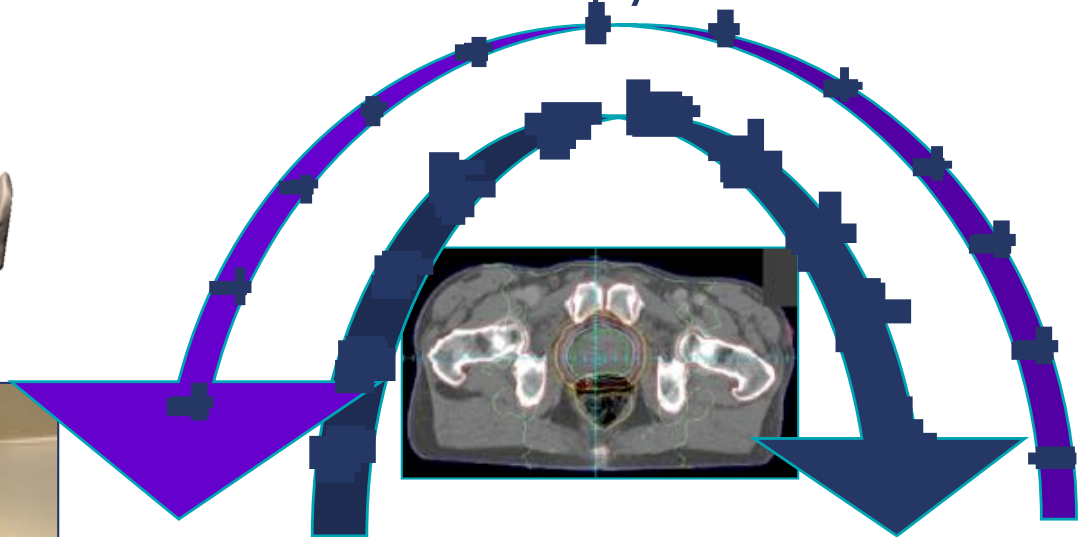
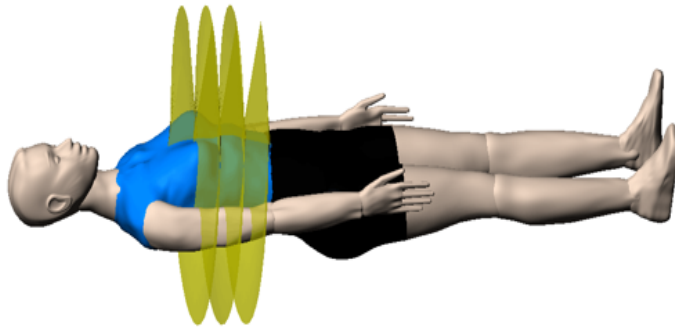


2 tracks:
IMRT – arcs

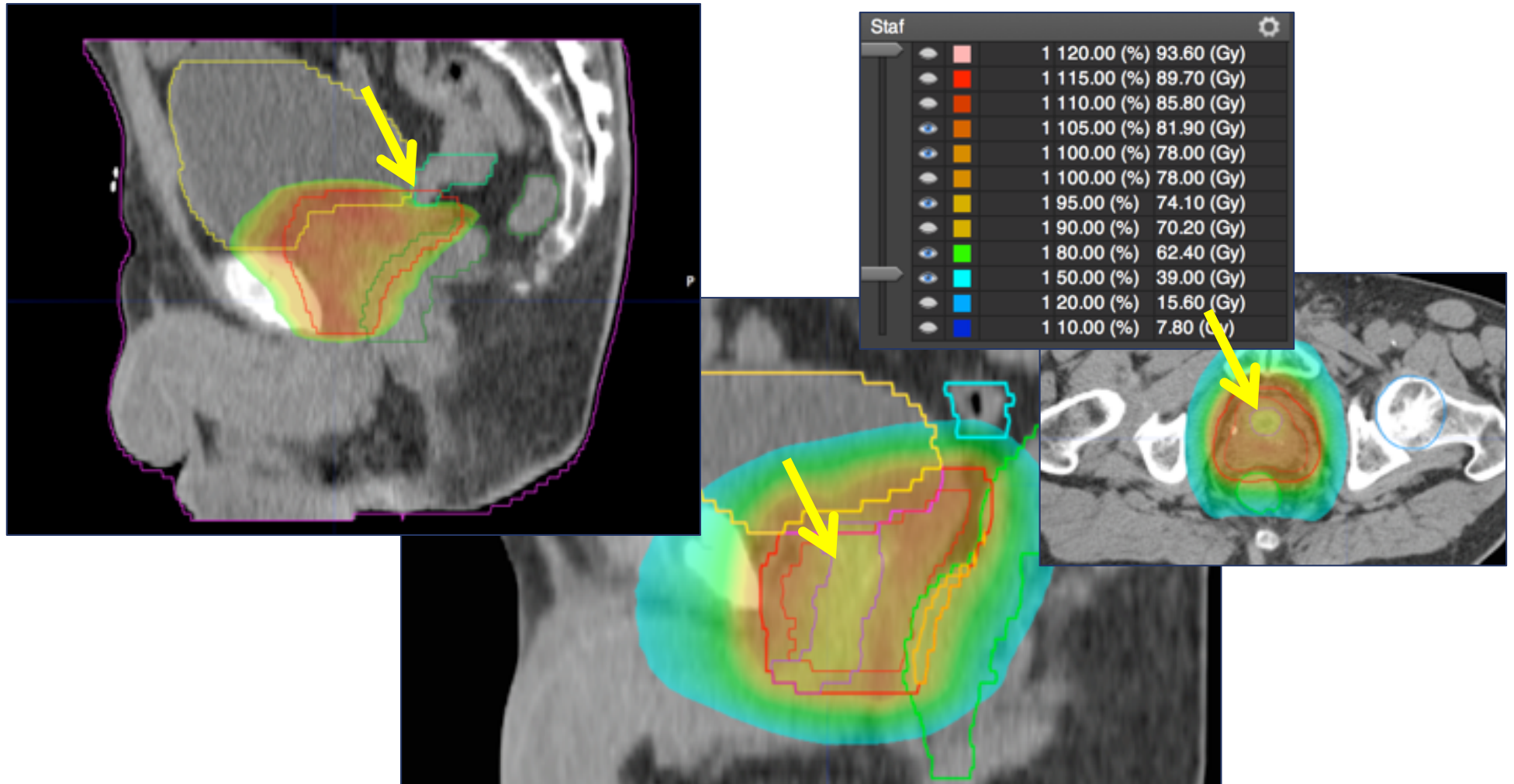


External Beam Radiation Therapy

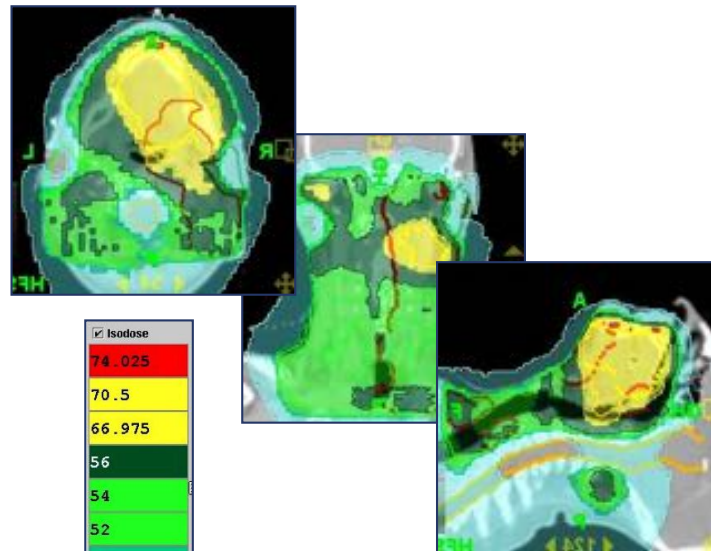
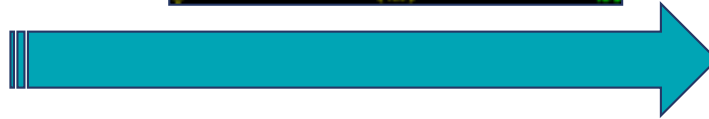
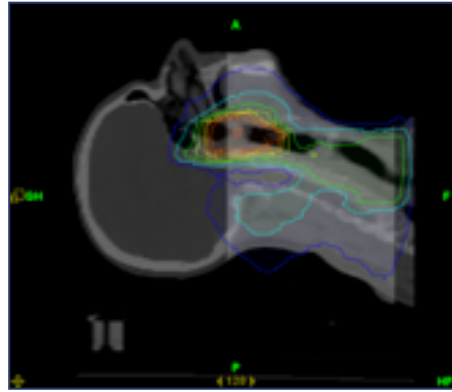
- Rotational intensity-modulated Radiotherapy



External Beam Radiation Therapy

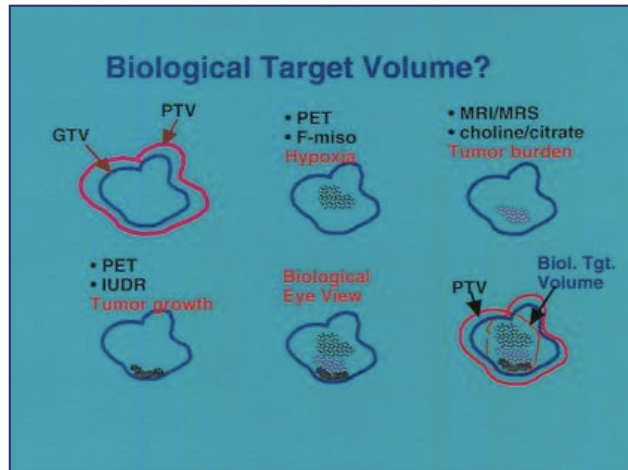


External Beam Radiation Therapy

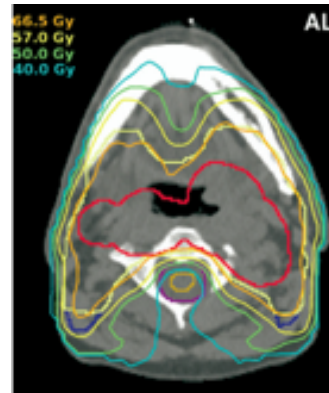


4 months after RT
no xerostomia

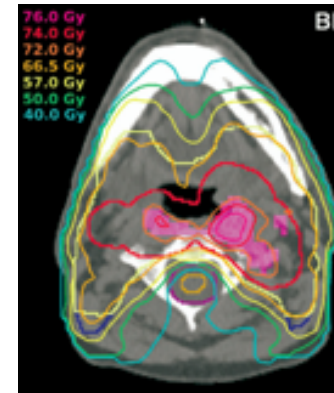
And then there is ... BCRT



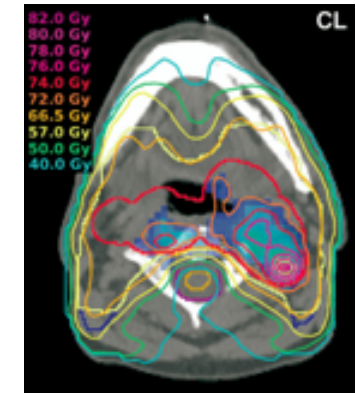
Ling *et al.*, IJROBP 2000



“conventional IMRT”
or
dose sculpting



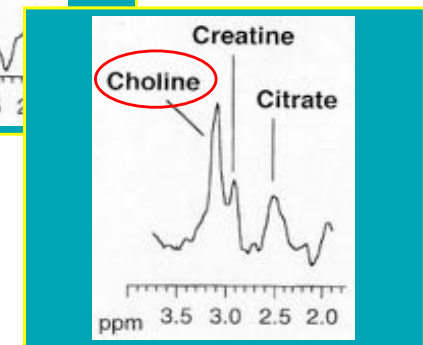
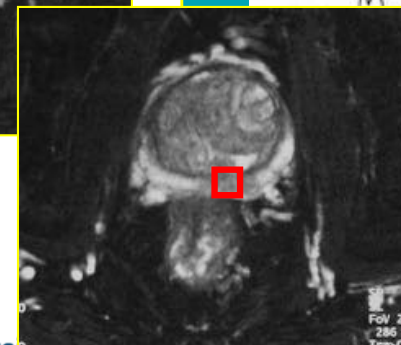
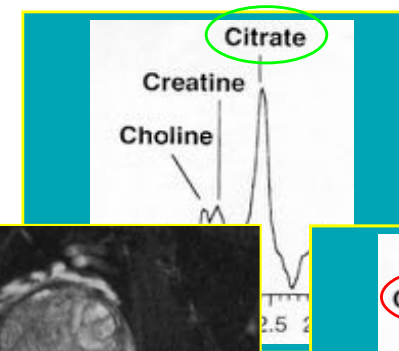
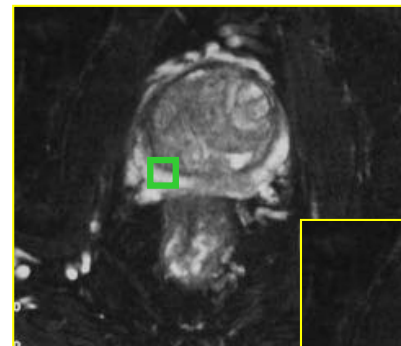
Dose escalation
based on
FDG-PET



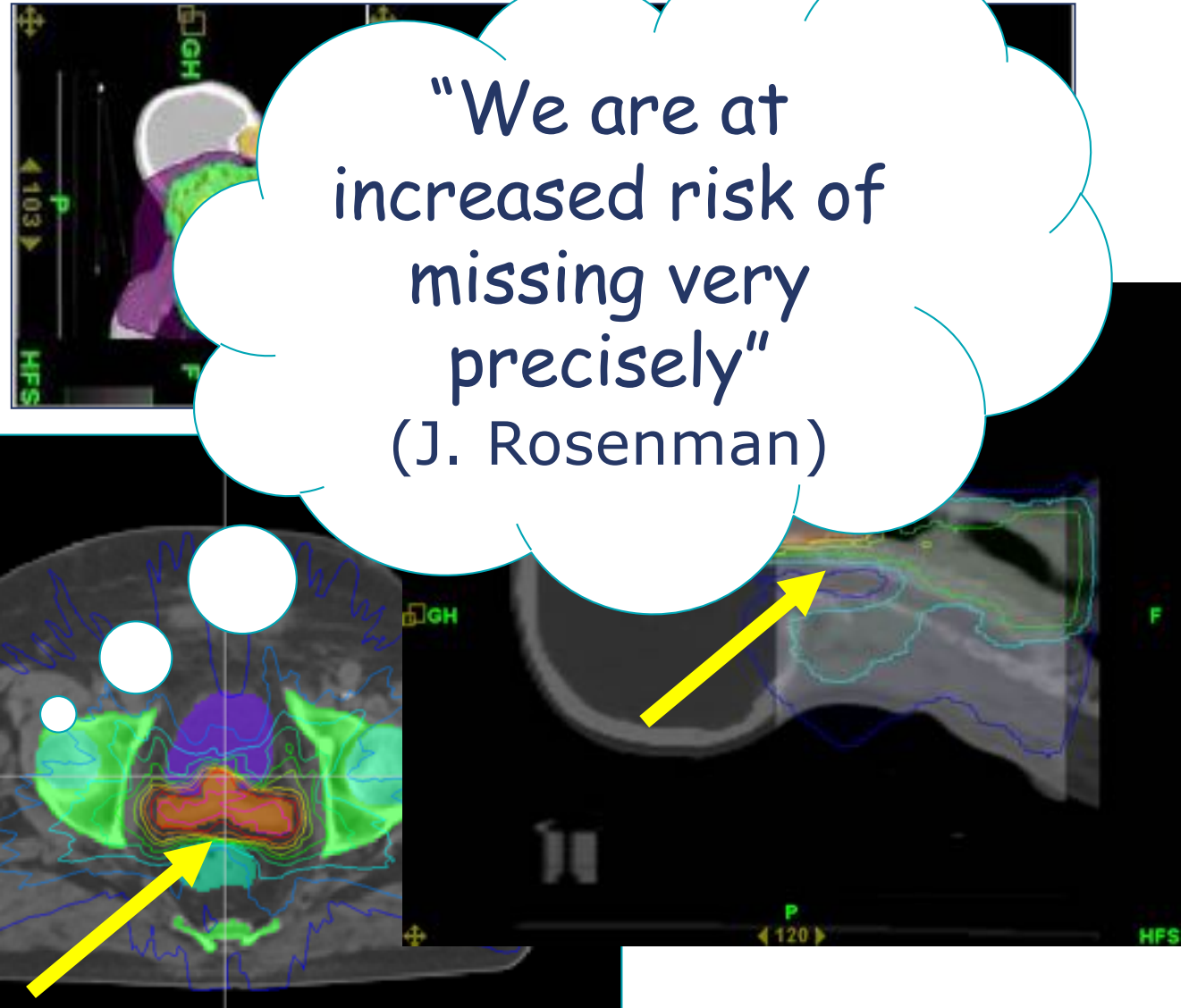
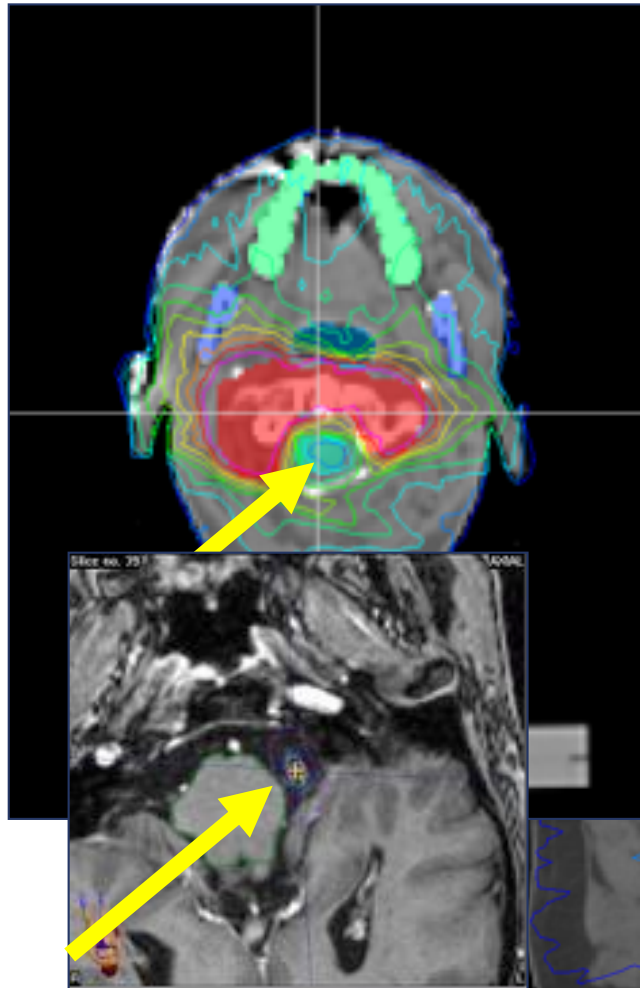
Dose-painting
Based on
Dynamic F-MISO



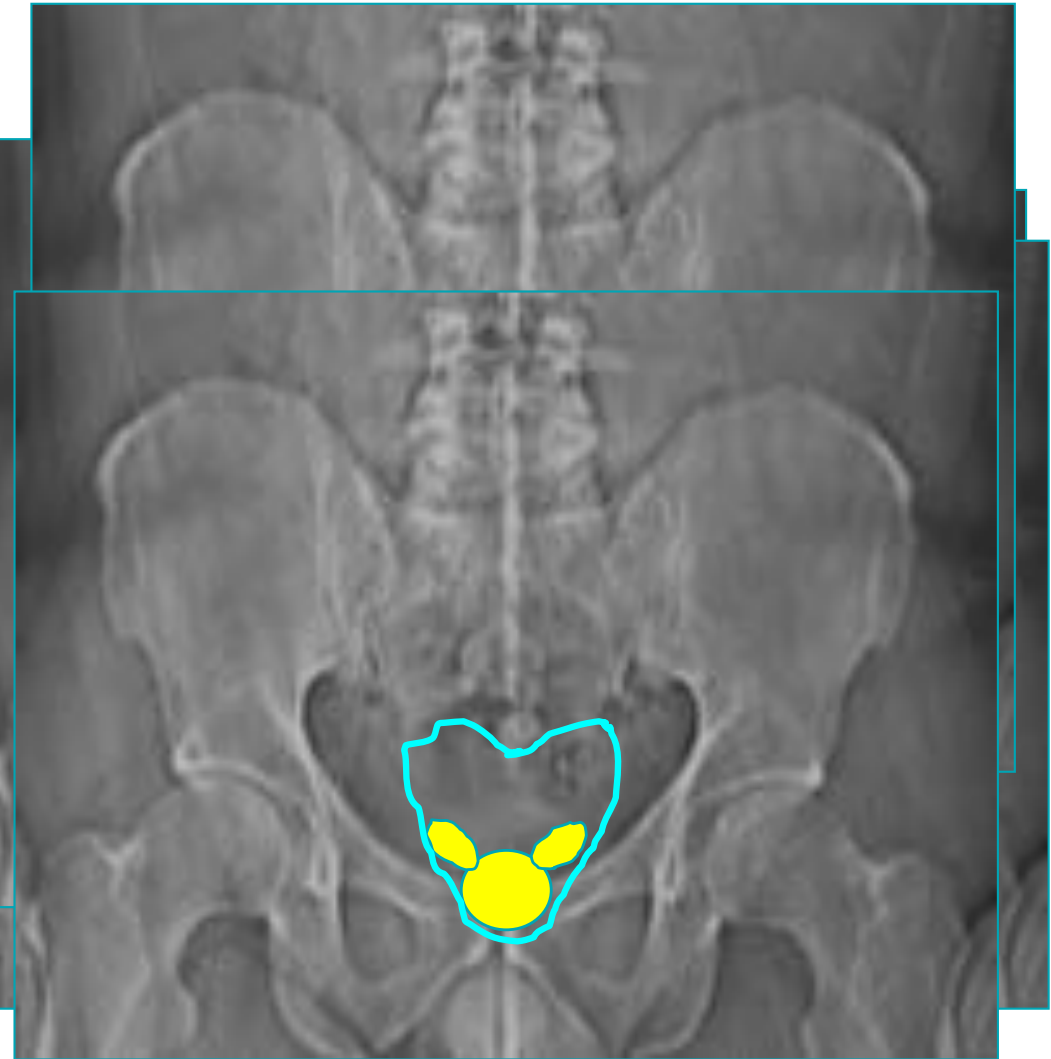
Paint by numbers, Warhol 1962



Why IGRT?



Margins ...



“The dancing prostate”

Image-guided radiotherapy

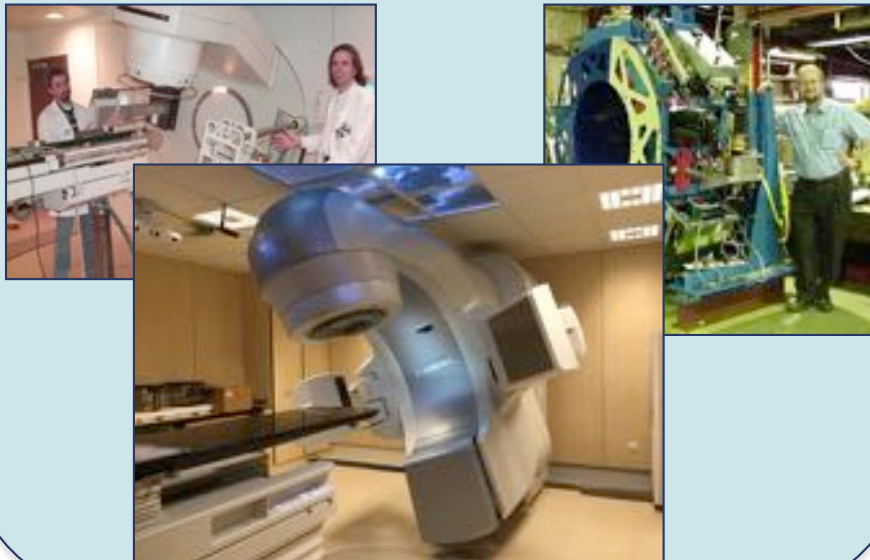


Verellen *et al.*
Nature Reviews Cancer, 2007

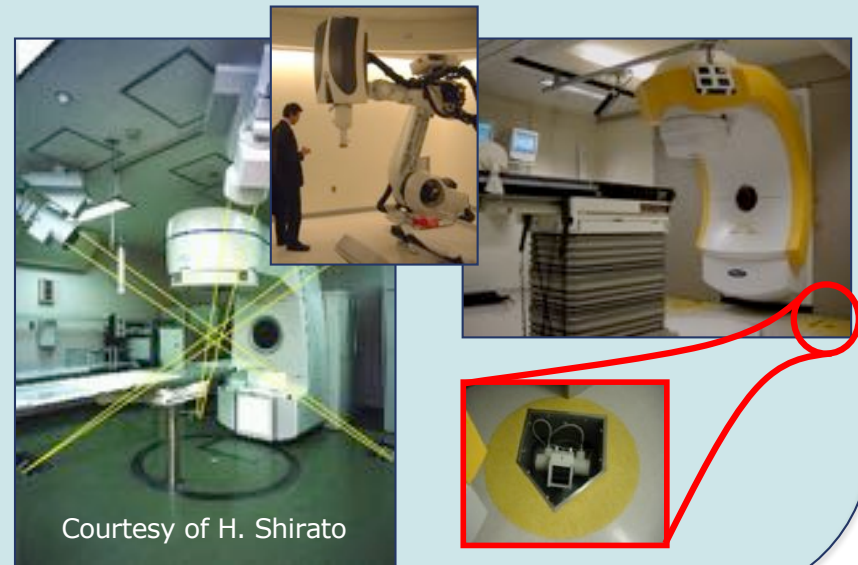
Image-guided radiotherapy



On-board volumetric imaging



On-board planar imaging



Courtesy of H. Shirato

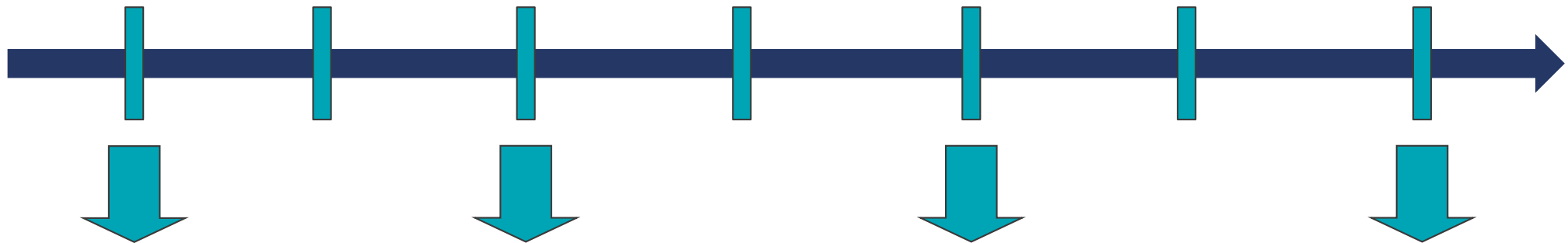
Motion management: the variables

Seconds

Minutes

Days

Weeks

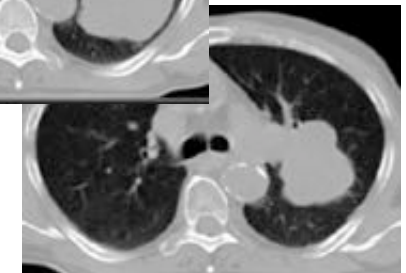
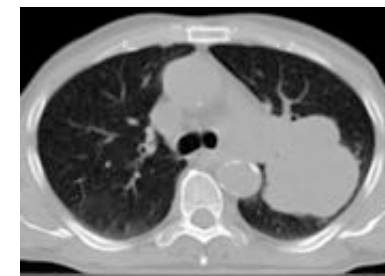
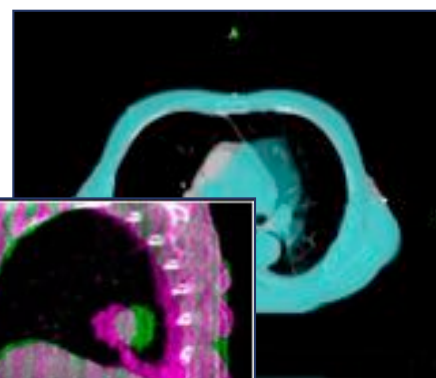
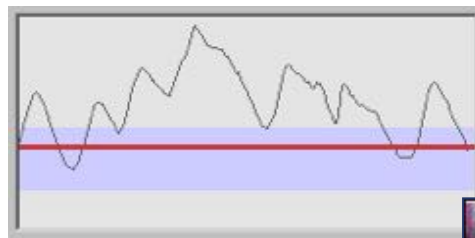
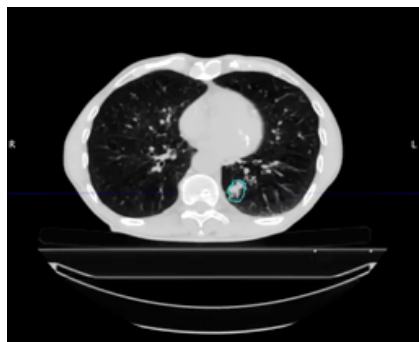


- Breathing
- Peristaltic
- Heart Beat

- Patient motion
- Tumor drifts

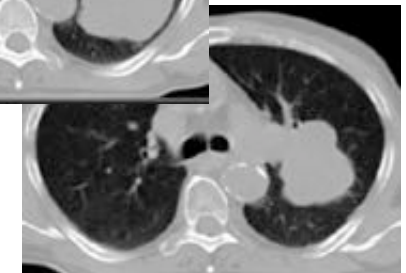
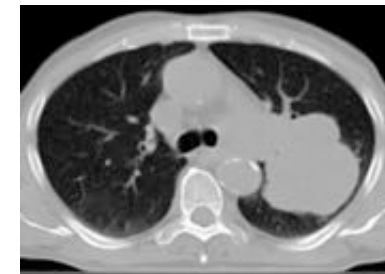
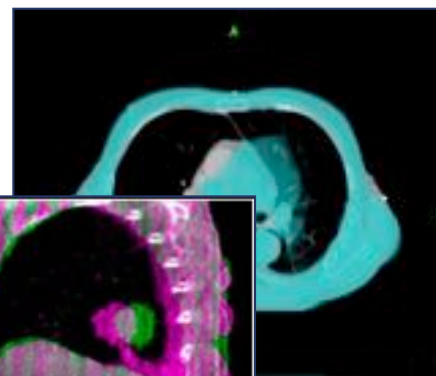
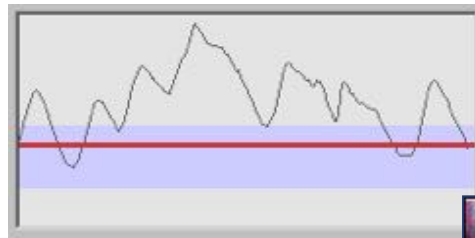
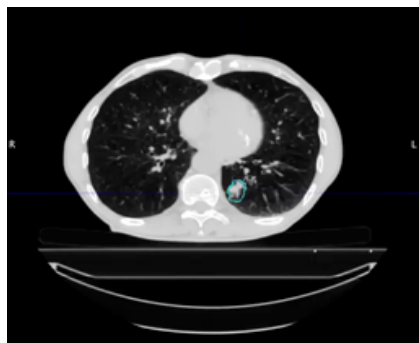
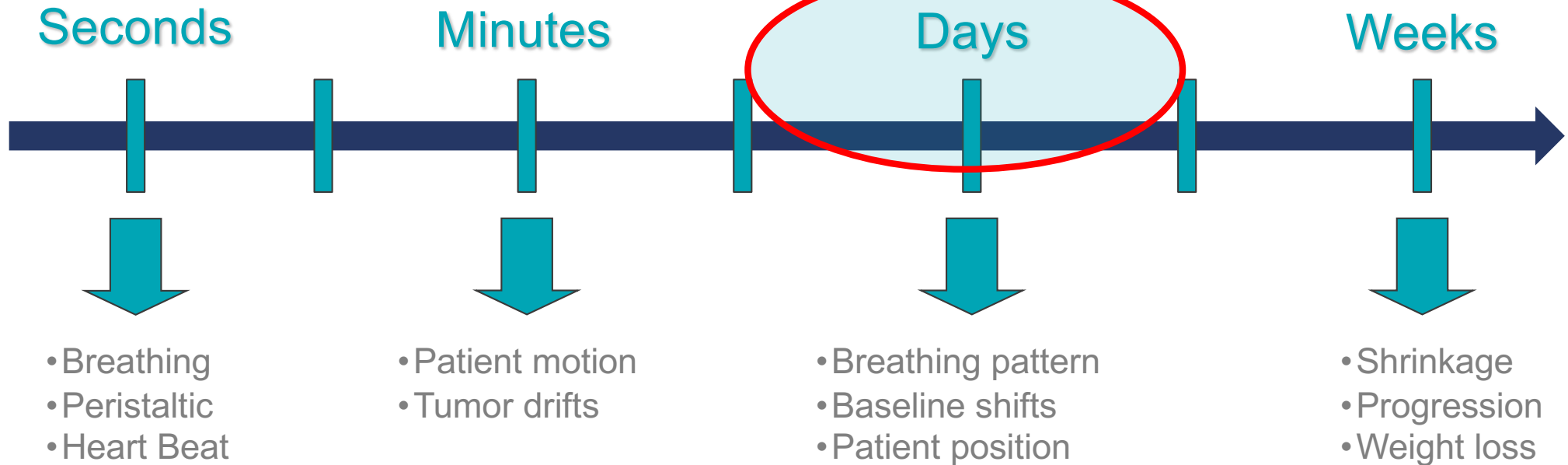
- Breathing pattern
- Baseline shifts
- Patient position

- Shrinkage
- Progression
- Weight loss

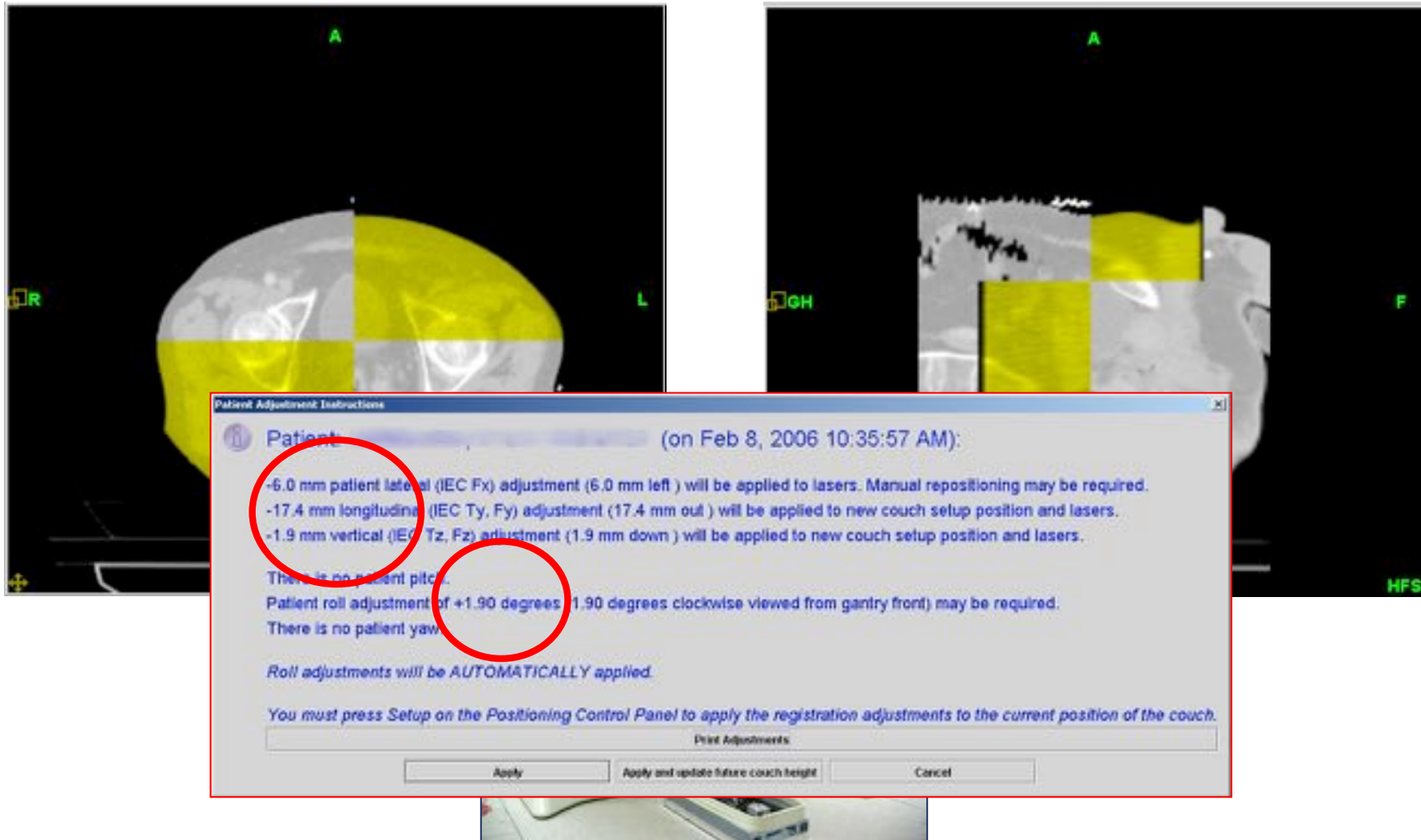


Courtesy of
J.J. Sonke

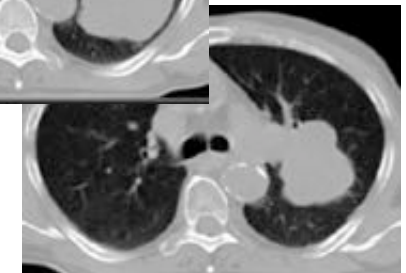
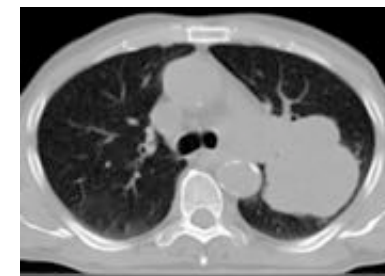
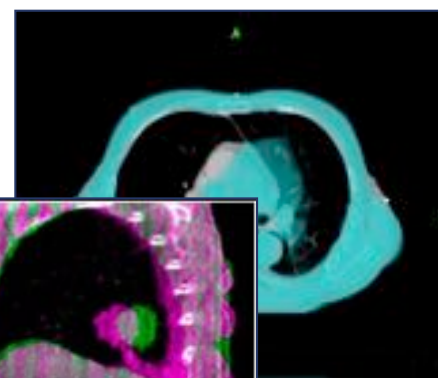
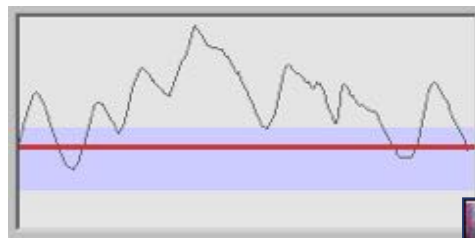
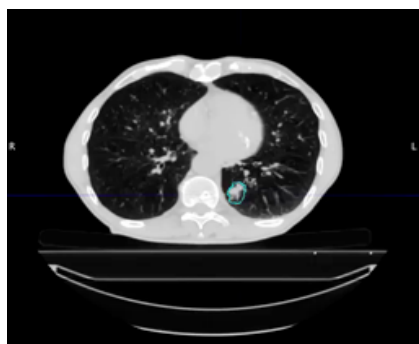
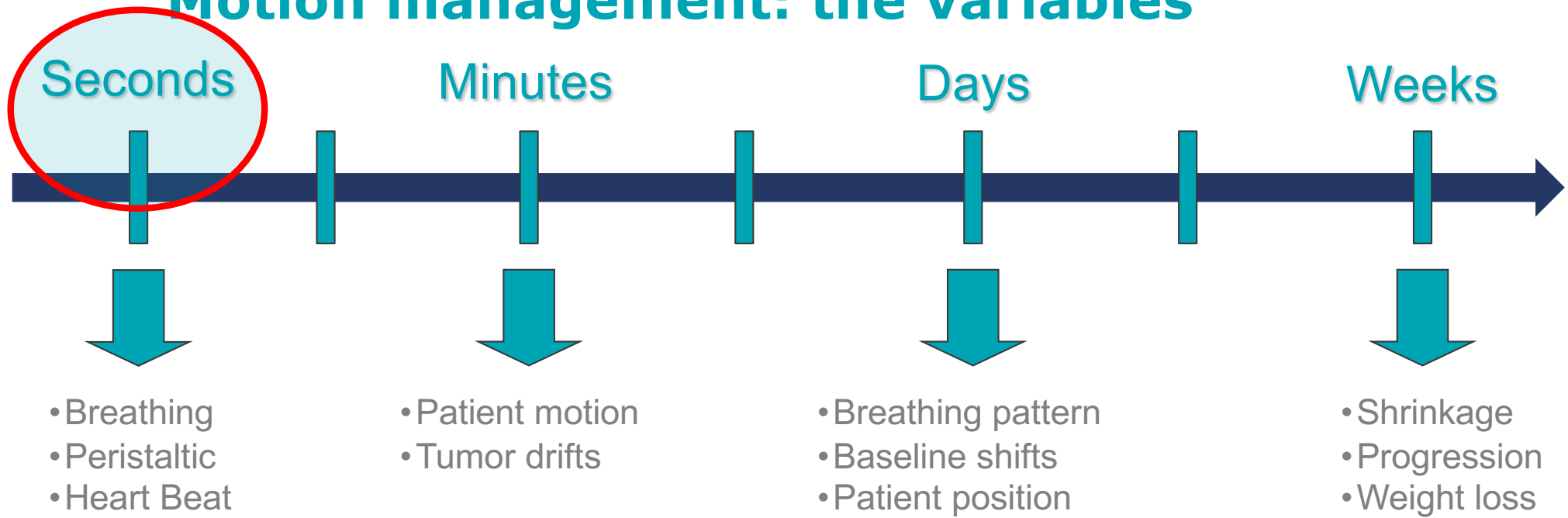
Motion management: the variables



Inter-fraction motion

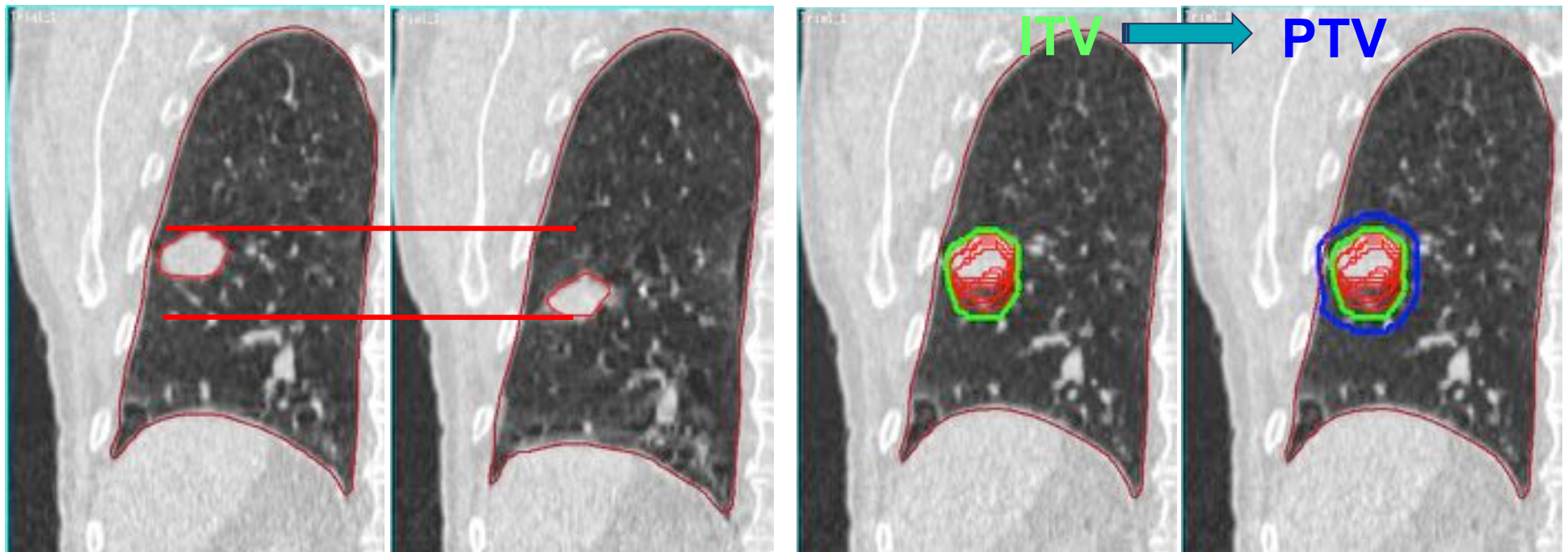


Motion management: the variables



Intra-fraction motion management

- Internal Target Volume (ITV) concept

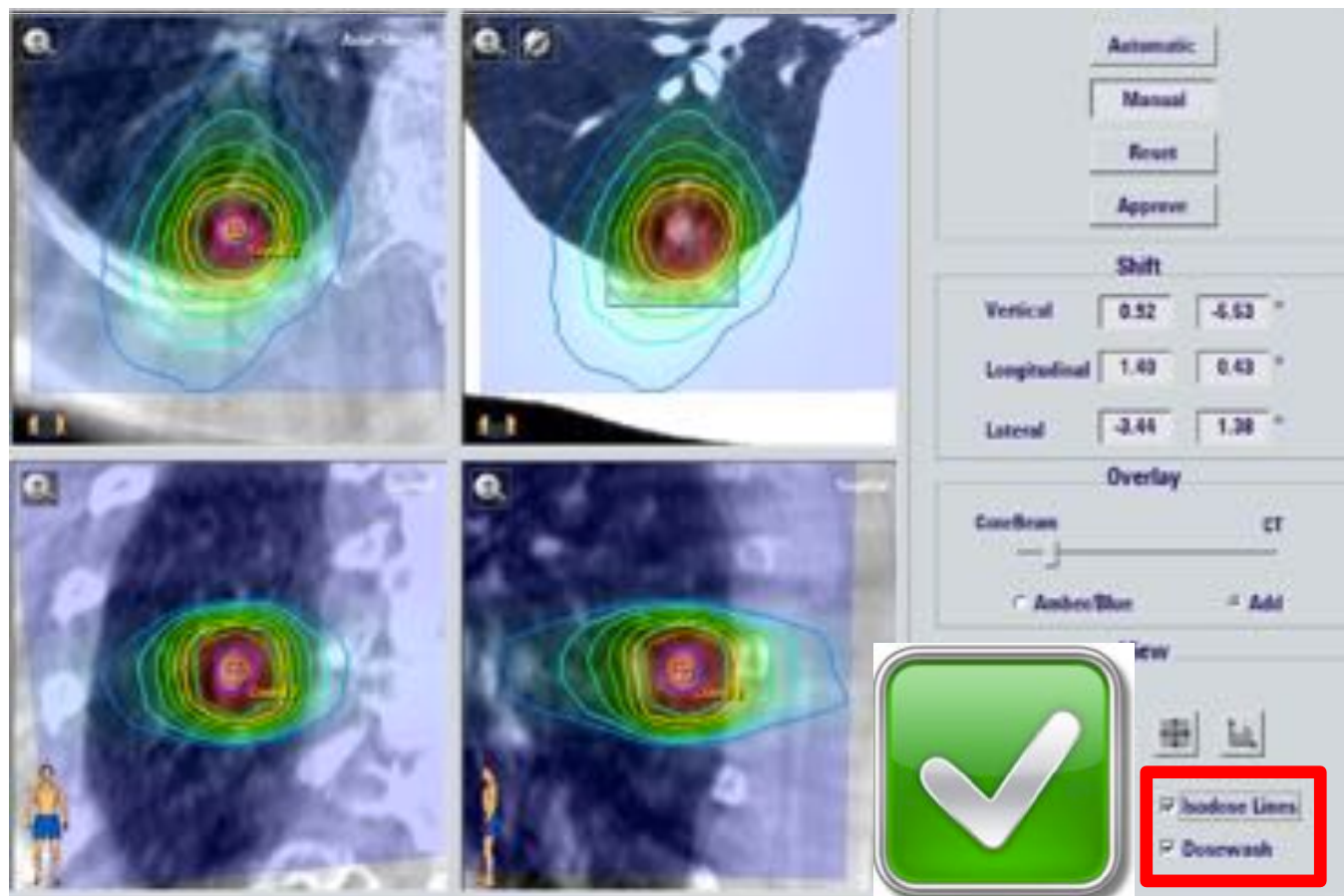


$$M_r = \alpha \sqrt{\Sigma^2} + \beta \sqrt{\sigma^2 + \sigma_p^2} - \beta \sigma_p$$

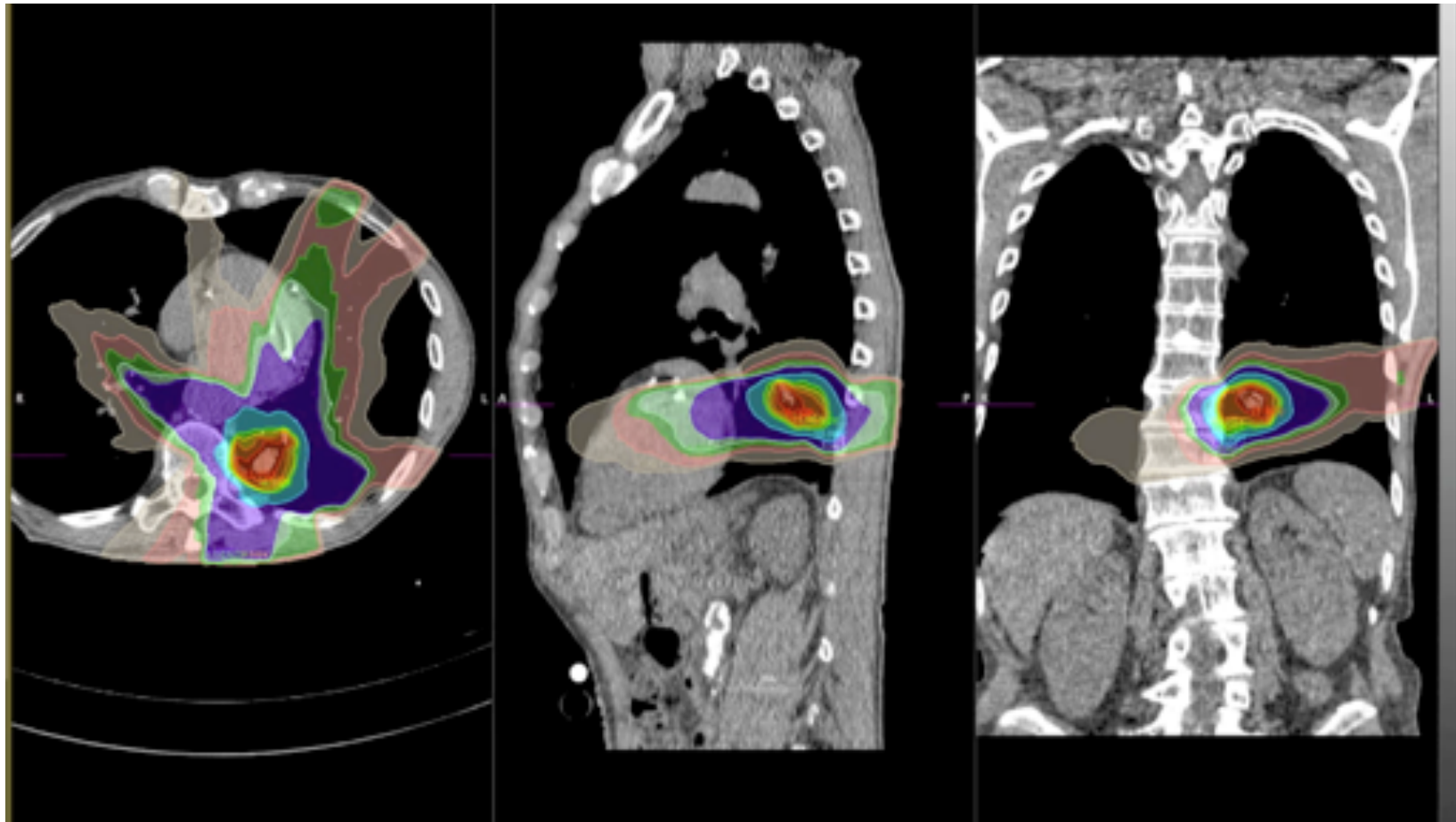
~~CTV → ITV → PTV ?~~

Intra-fraction motion management

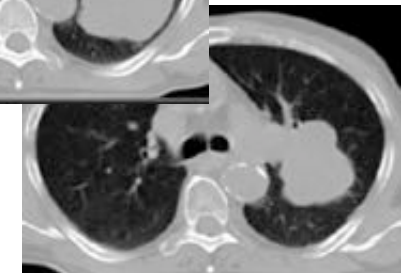
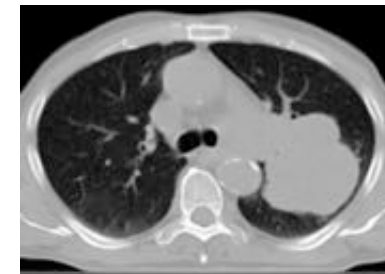
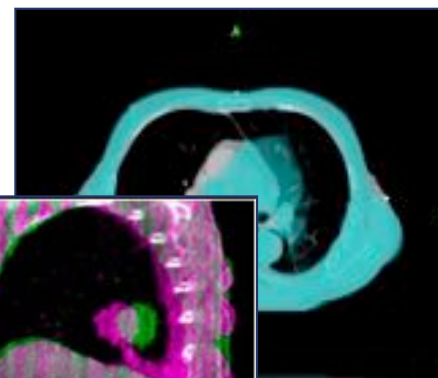
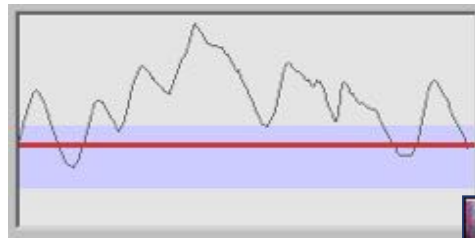
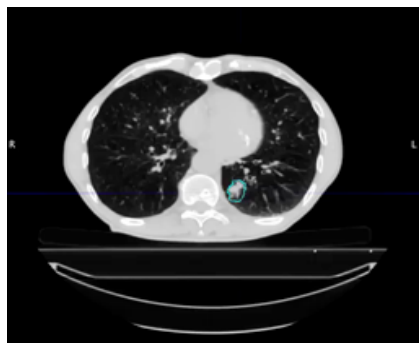
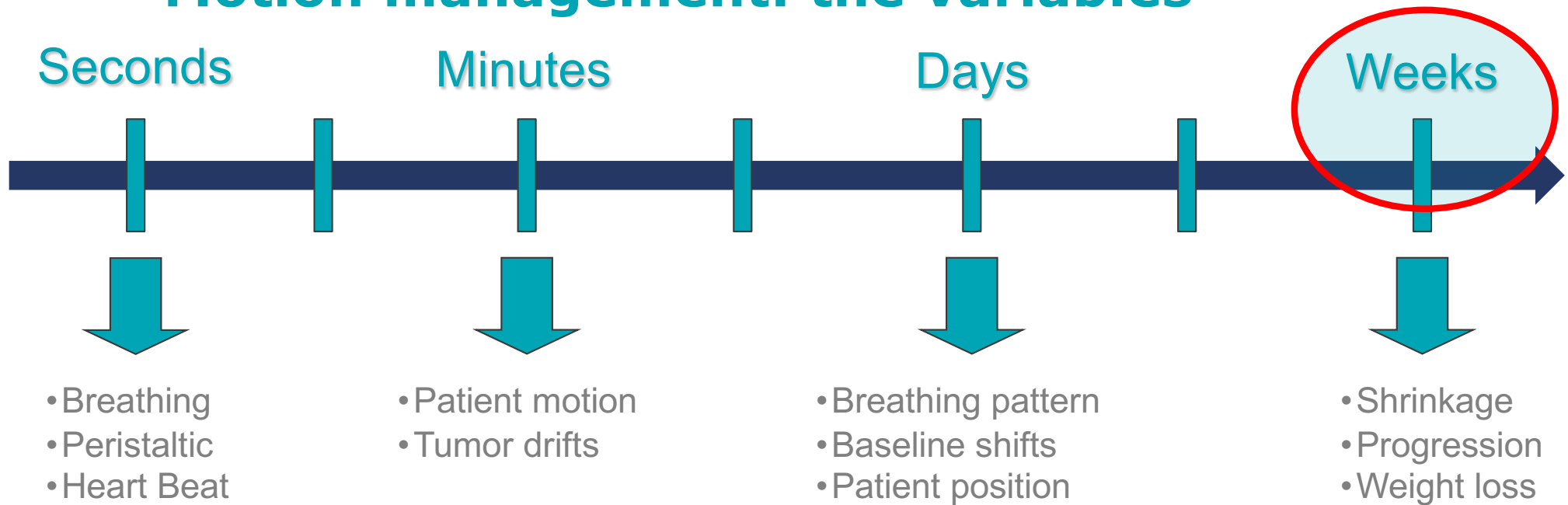
- Internal Target Volume (ITV) and on-line CBCT



Intra-fraction motion management

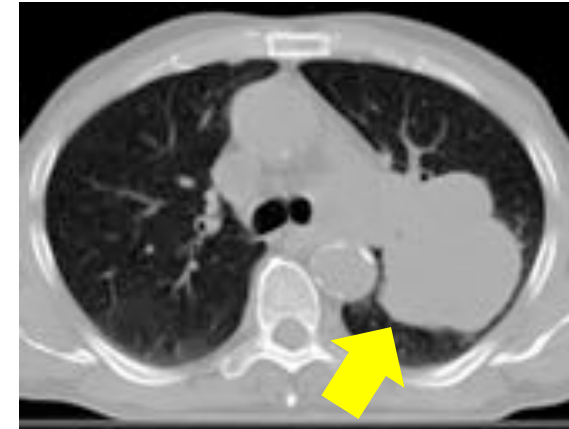
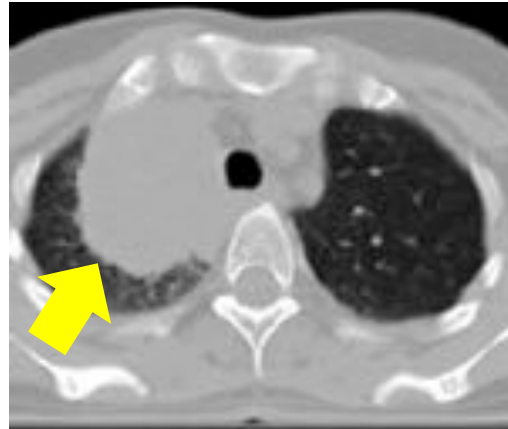
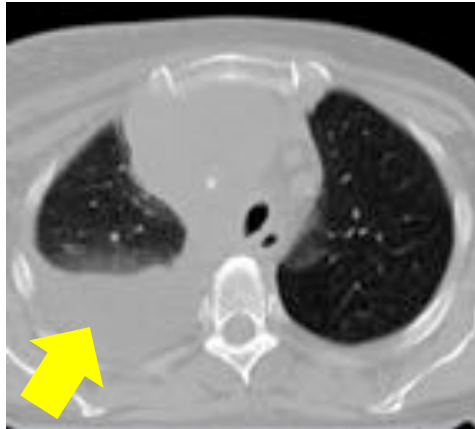


Motion management: the variables

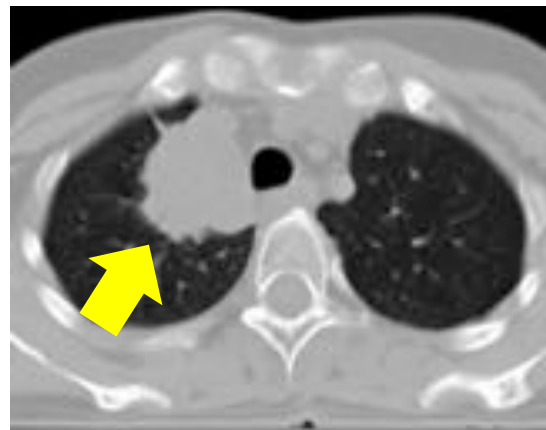


Adaptive Radiotherapy

Plan



Week 6



Normal tissue: pleural effusions, atelectasis, weight loss

Tumour: shrinkage, progression

Adaptive Radiotherapy

Plan

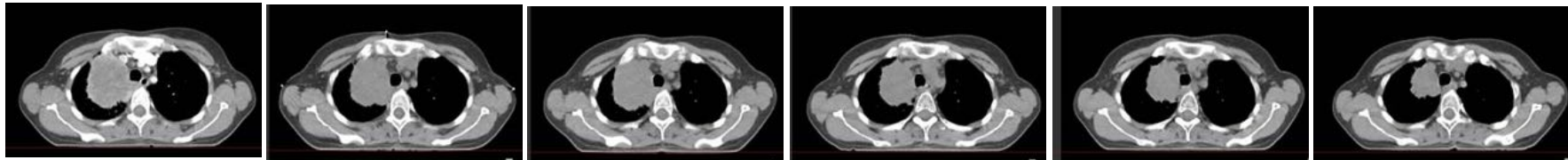
Week 2

Week 3

Week 4

Week 5

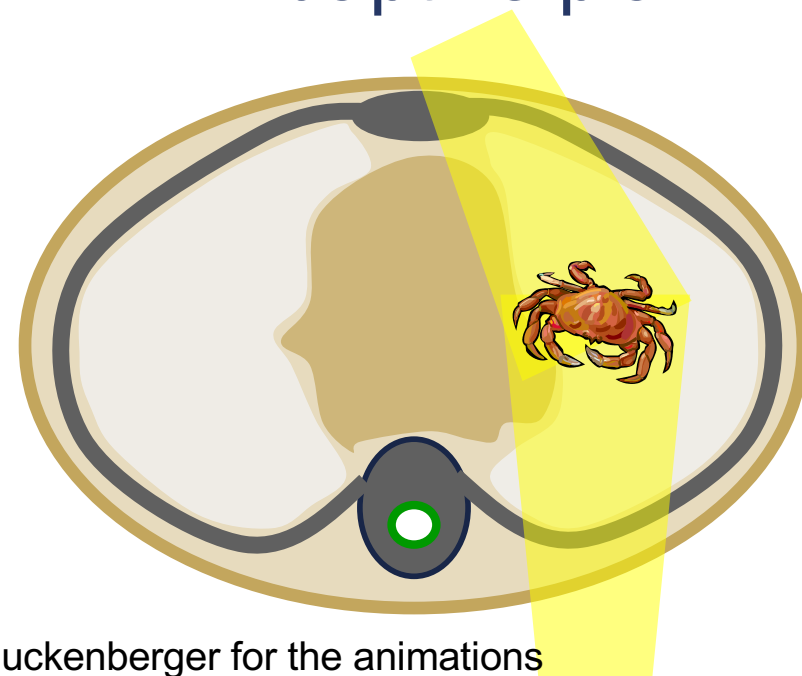
Week 6



Initial plan

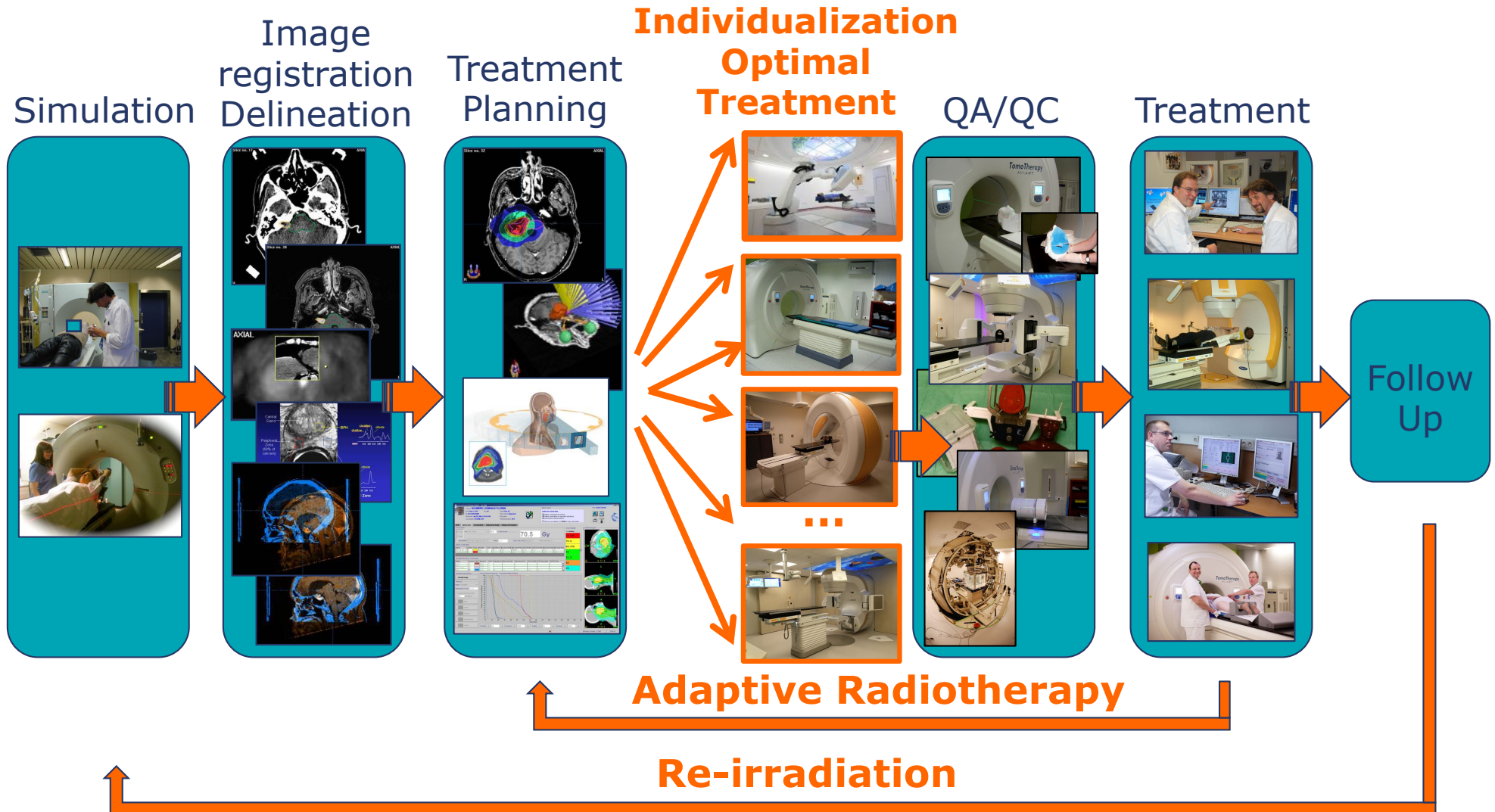


Adaptive plan



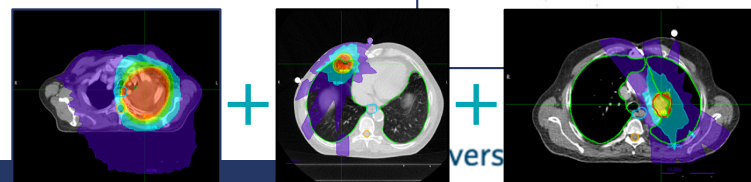
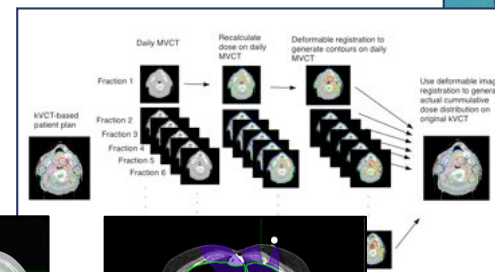
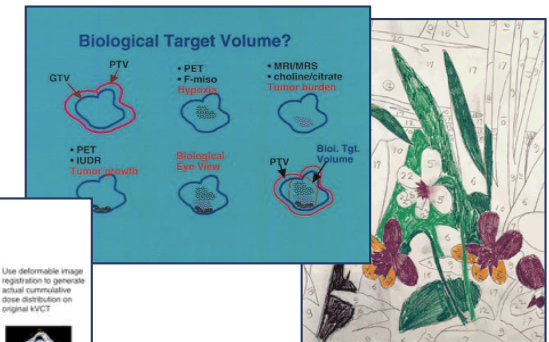
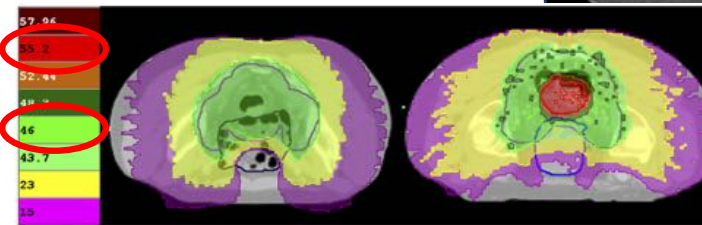
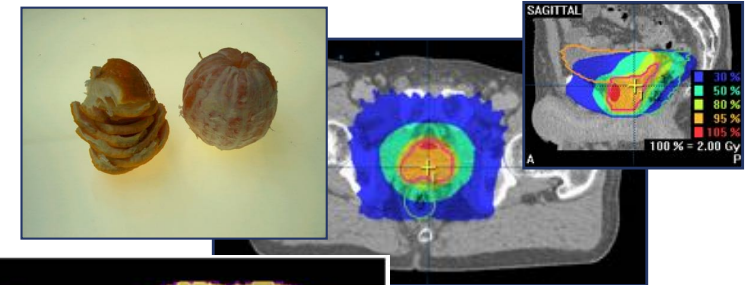
Many thanks to Matthias Guckenberger for the animations

Radiotherapy Workflow



Radiotherapy ... Today

- Margin reduction
 - Dose escalation
 - Conformal avoidance
- Simultaneous Integrated Boost (SIB)
- Reviewed dose fractionation (SBRT)
- Biological Conformal Radiation Therapy (BCRT)
- Adaptive Radiation Therapy (ART)
- Re-irradiation



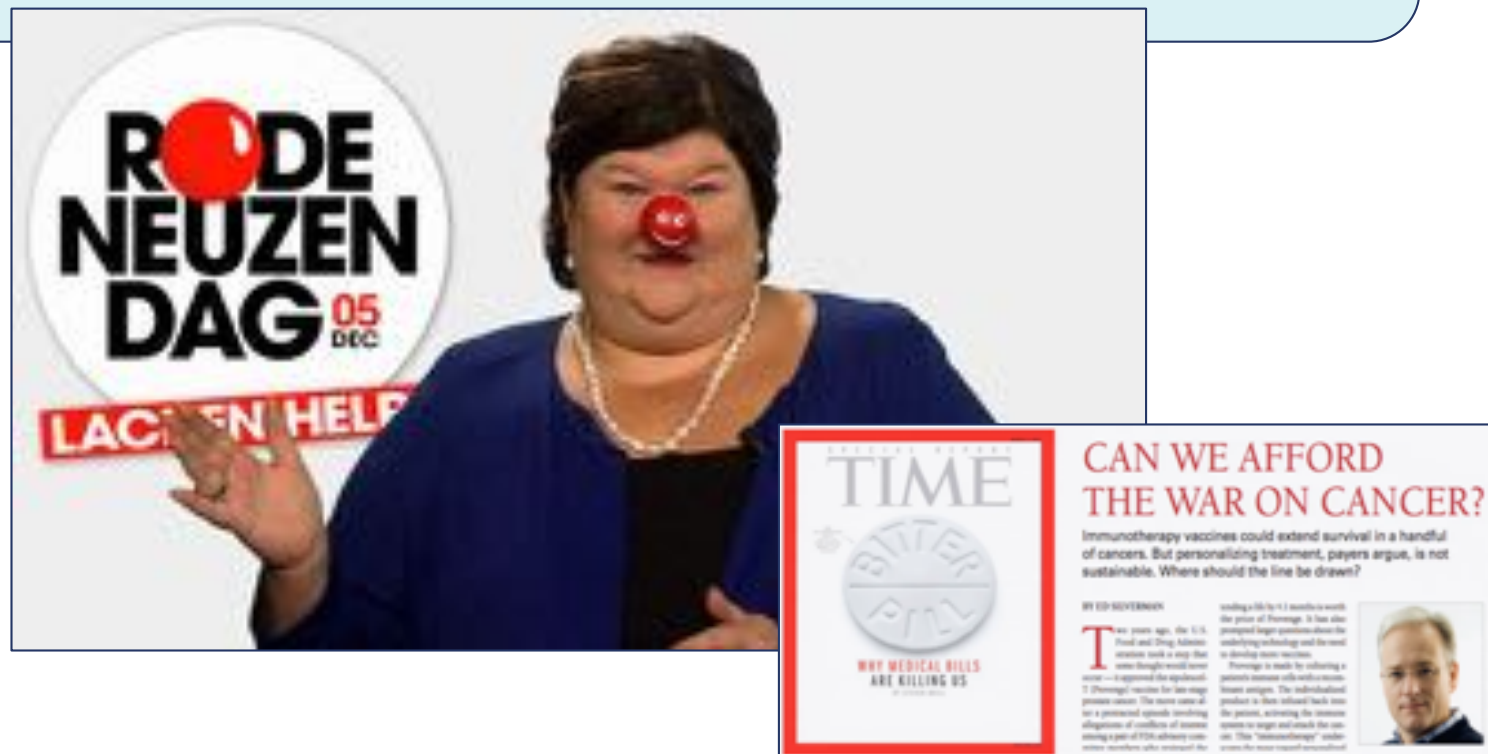
Iridium Kankernetwerk: Challenges



Every cancer patient in Europe will have access to state of the art radiation therapy, as part of a multi-disciplinary approach where treatment is individualized for the specific patient's cancer, taking account of the patient's personal circumstances.

Iridium Kankernetwerk: Challenges

Rationalization of health care – cancer care within the context of budget cuts.



Iridium Kankernetwerk: Challenges

The Iridium Kankernetwerk is the largest radiotherapy network in Belgium and “major league” in Europe.

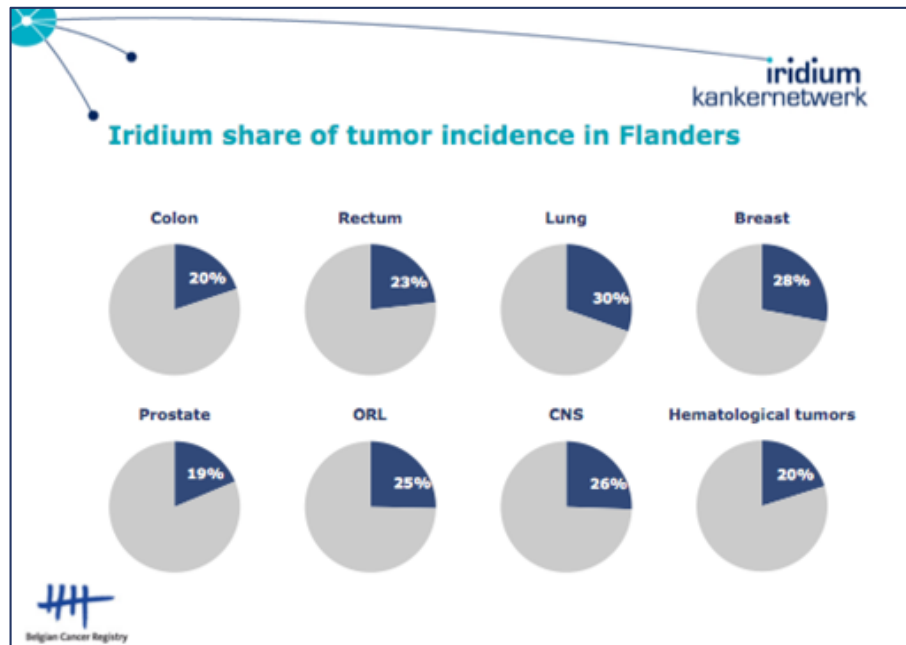
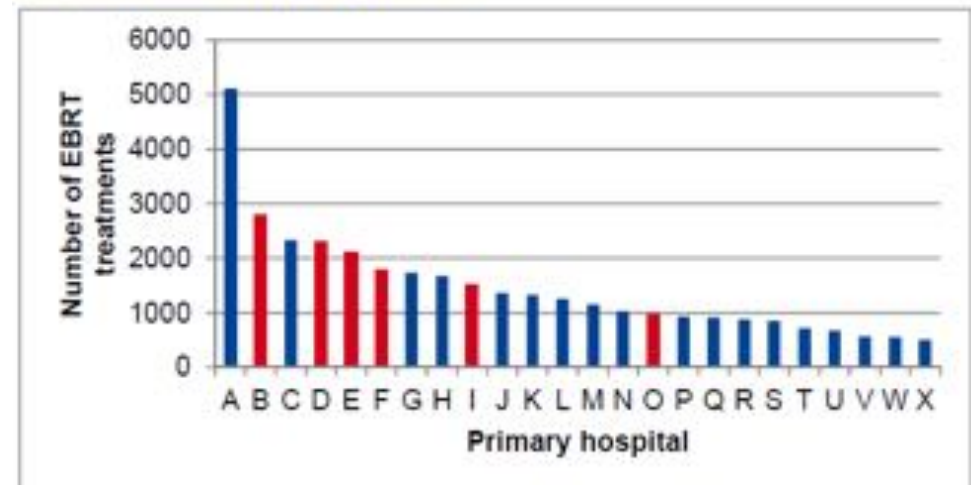


Figure 81 – Total number of EBRT treatments for the 24 primary hospital radiotherapy departments



Data based on the 2015 QI project data collection except for two centres for which 2016 activities data was used (Centre A and Centre K). University hospitals are highlighted in red.

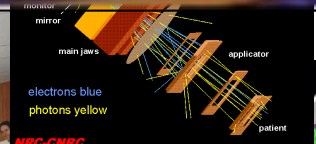
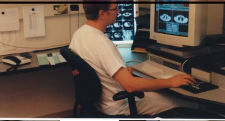
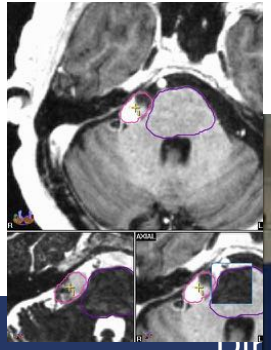
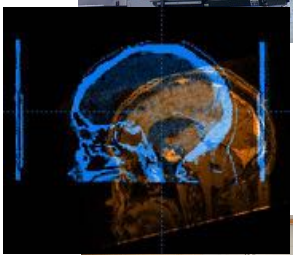
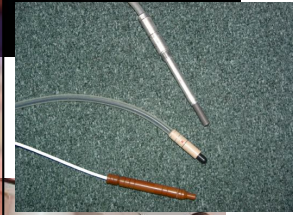
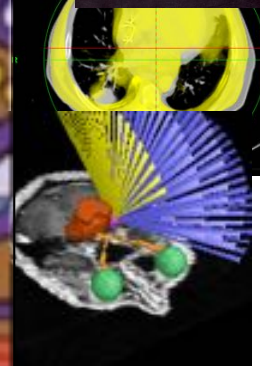
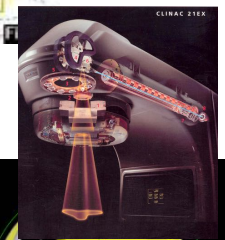
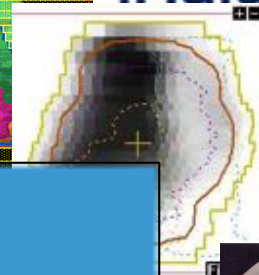
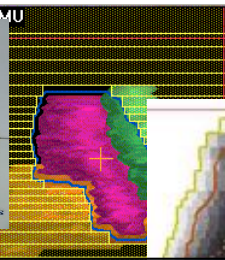
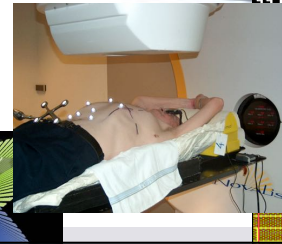
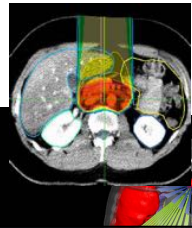
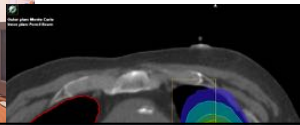
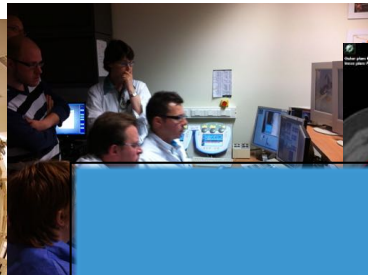
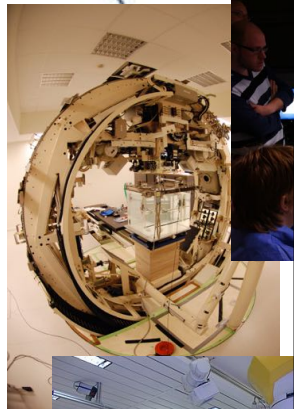
Iridium Kankernetwerk: Challenges

- Positioning Radiotherapy as a driver in the multidisciplinary care of the patient.
- Scientific research and education
- Increasing complexity of radiotherapy
 - Ensuring safety and quality
 - Fast uptake of innovative techniques and technology

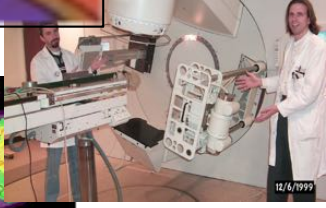
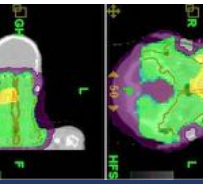


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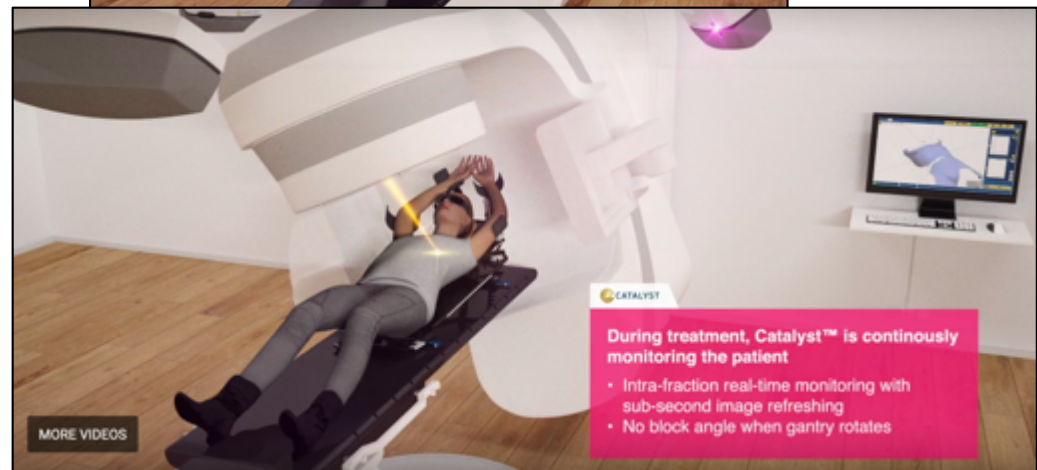
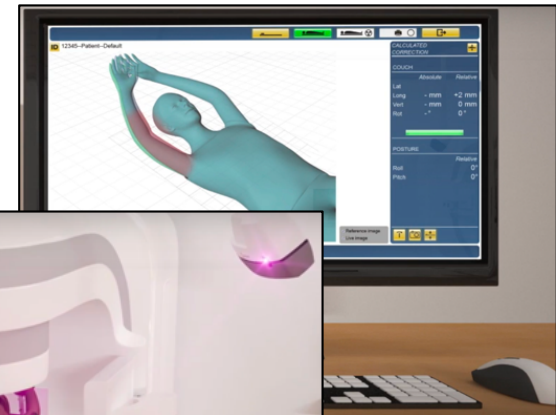
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Iridium Kankernetwerk: Challenges

- Automate or perish ...



Iridium Kankernetwerk: Challenges

- Automate or perish ...

Standardization
&
Automation



Efficiency & Optimization



Safety & Quality



Iridium Kankernetwerk: Challenges

- We need standardization to allow for individualization!
 - The answer to individualization (**ART**) is **deep learning**, knowledge engineering, data mining, and shared decision making.
 - The answer to DL is standardization (not only ICRU!).



The image shows the cover of a report. At the top, there are logos for euroCAT, GROW (School for Oncology & Developmental Biology), and MAASTRO. The title is 'Knowledge Engineering in Radiation Oncology – A real-world application of Semantic Web technology'. Below the title, there is a blue box with the name 'Andre Dekker, PhD' and his titles: 'Medical Physicist', 'Information & Services Head', 'Knowledge Engineering Head', and 'MAASTRO Clinic'. On the right side, there is a grid of logos including the European Union flag, interreg, MAASTRO, AACHEN, CHU, Maastricht University, province limburg, and SIEMENS.

Iridium Kankernetwerk: Challenges

- Do we need state-of-the-art **mainstream** equipment **for many** patients or **dedicated** equipment **for a few**?



- Do we need **standardized** treatment or **individualized** treatment tailored to the patient?

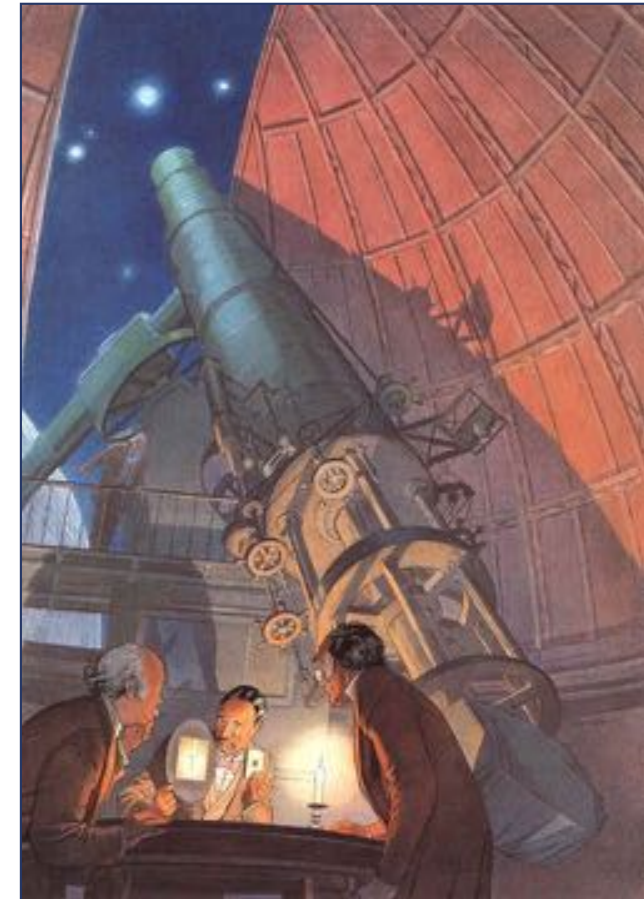


Not necessarily the same question

Not necessarily a contradiction

Iridium Kankernetwerk: Challenges

- The most important thing to a patient **is not** the availability of some high technology device, rather **it is** the ability of a team of physicians, physicists, dosimetrists and therapists to use a technology with skill for the benefit of the patient.
 - Dr. Marc Edwards
- The **true challenge** is to develop the wisdom to know when to select which treatment modality in the clinic.
 - Dr. Steve Webb



L'expérience cruciale, F. Schuiten

Mission Iridium Kankernetwerk

**Samen participeren
in een innoverend expertisecentrum radiotherapie
voor integrale zorg**

