Quality management in multidisciplinary care and radiotherapy

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Overview

-Impact of the technological innovation on RT and QA

-Quality Assurance in RT
    -Machine related QA
    -Patient specific QA
    -RT process QA

-link to radiology, nuclear medicine, oncology, surgery, palliative care, dietists, ...

Definition QA in RT

- In history: “Physical and technical aspects of equipment, dosimetry and treatment delivery”
- Now: “Broader than a restricted definition of technical maintenance and quality control of equipment and treatment delivery. QA has clinical, physical and administrative components”

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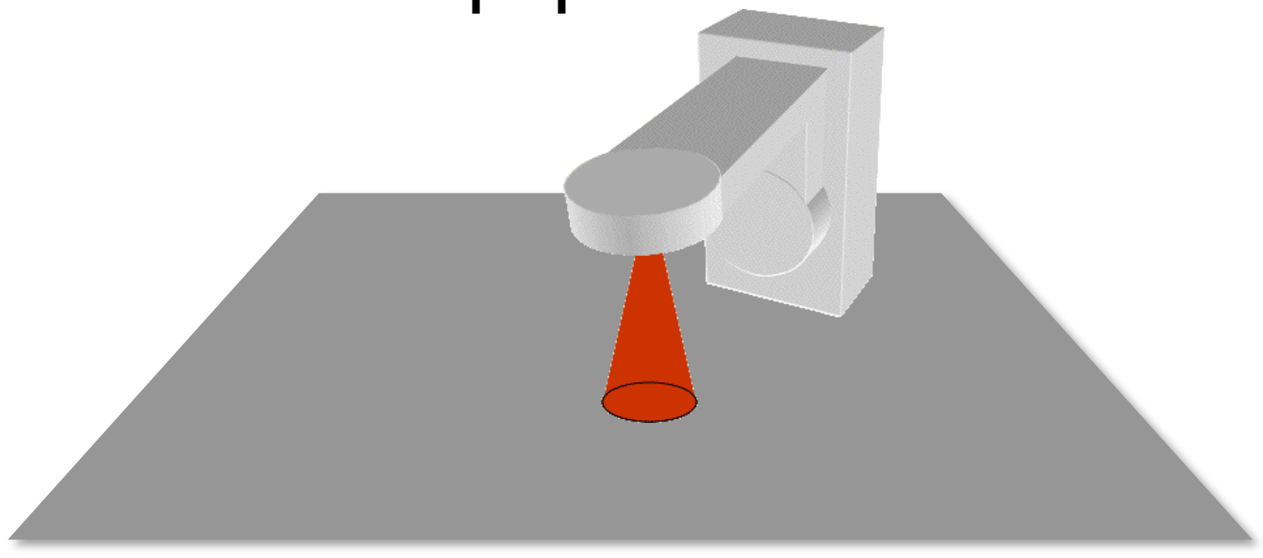
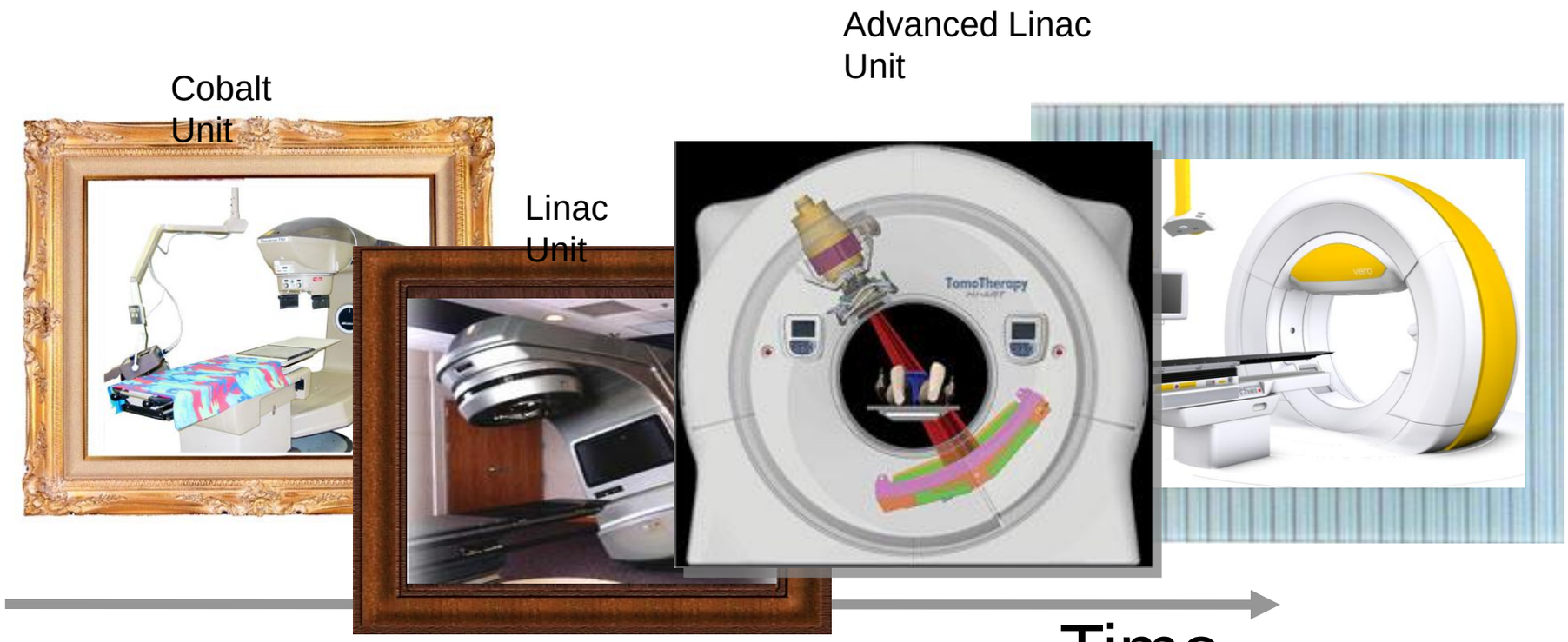
Increasing technological complexity

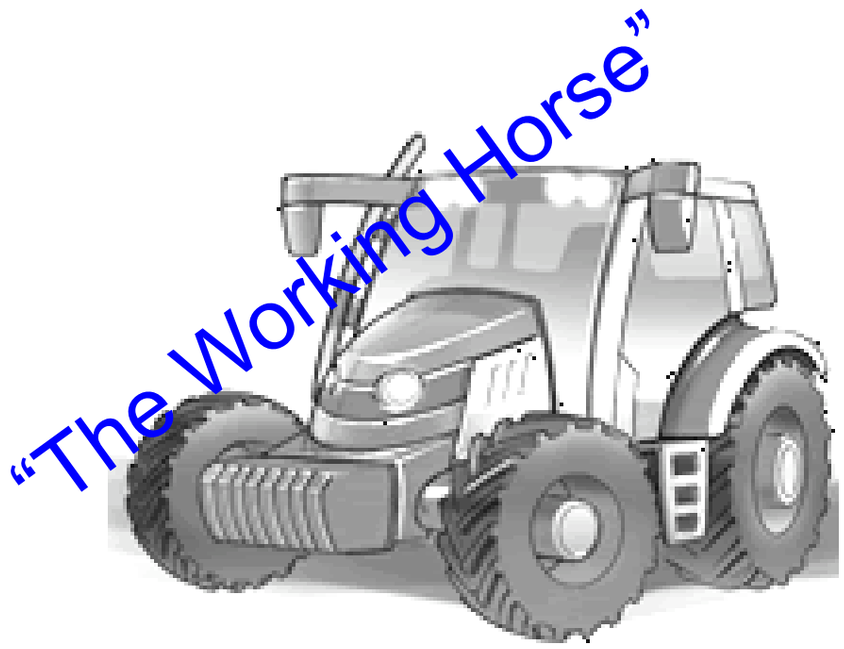
RT Equipment …-1990



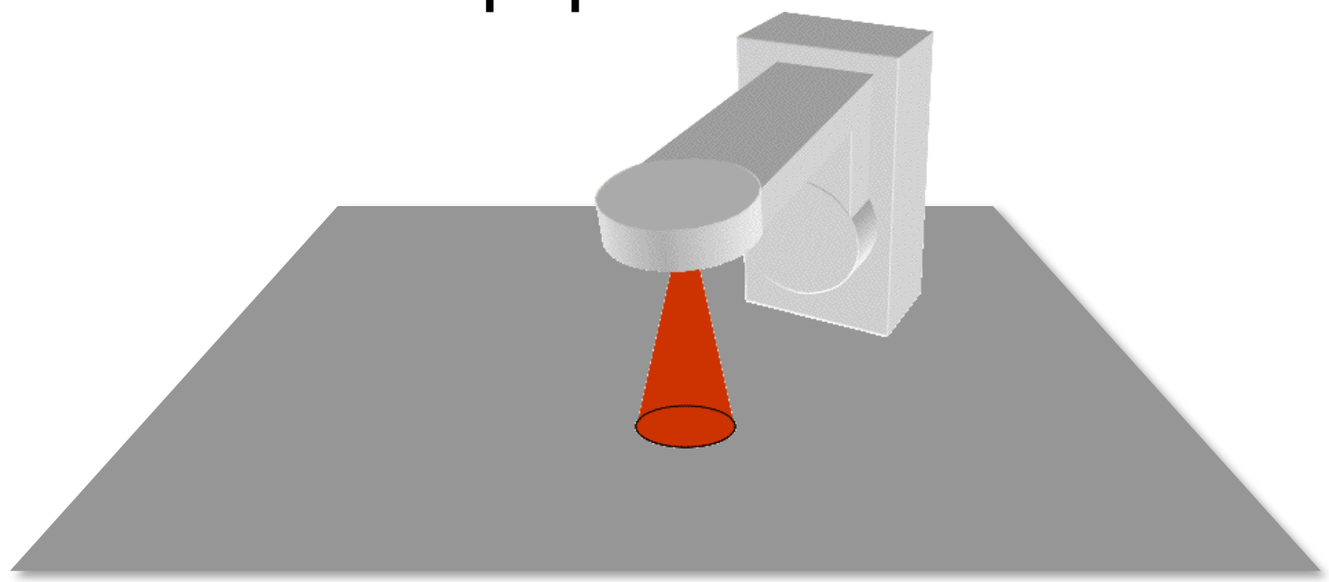
One Main System: The Treatment Unit



Increasing technological complexity



RT Equipment …-1990



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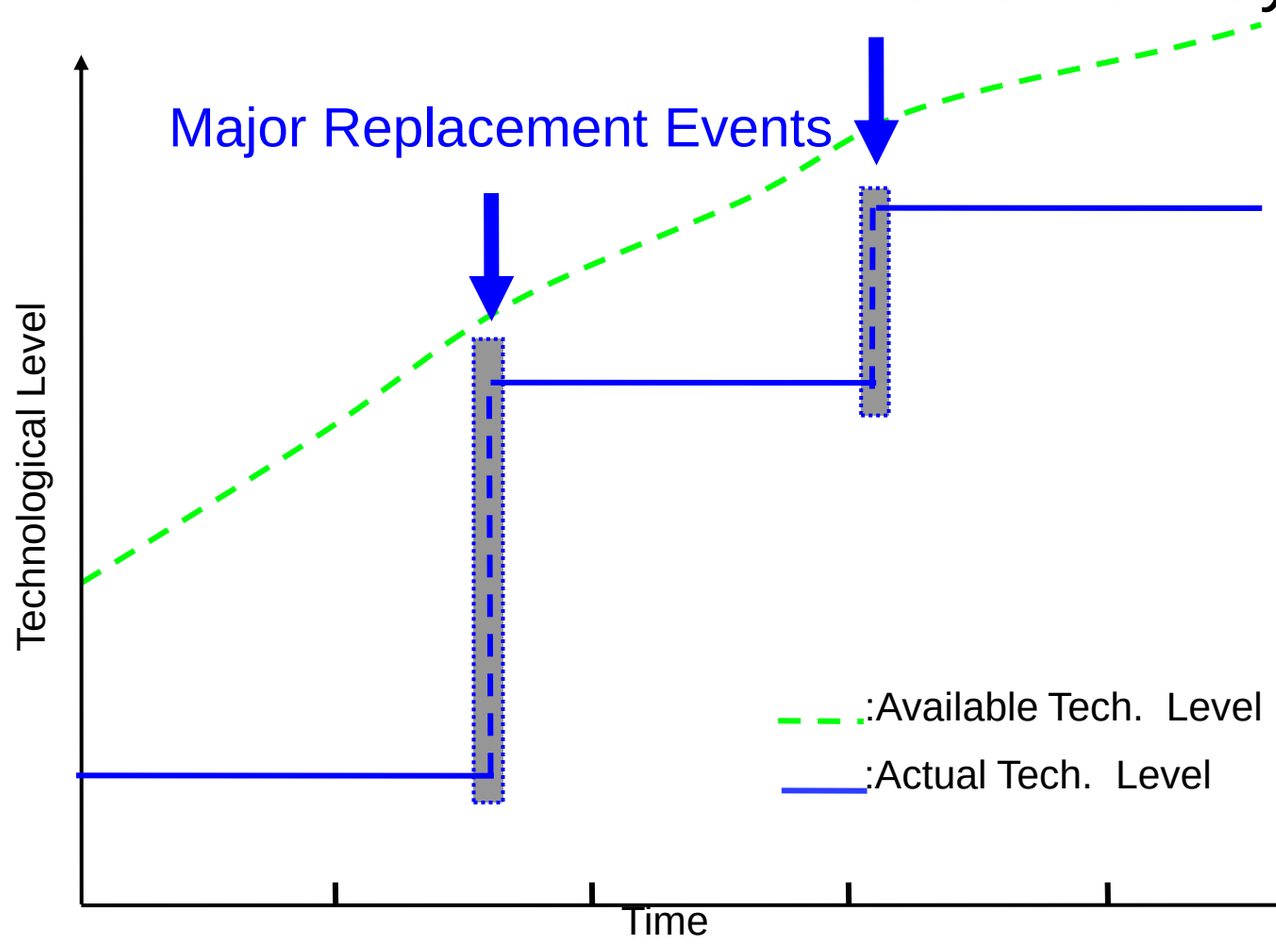
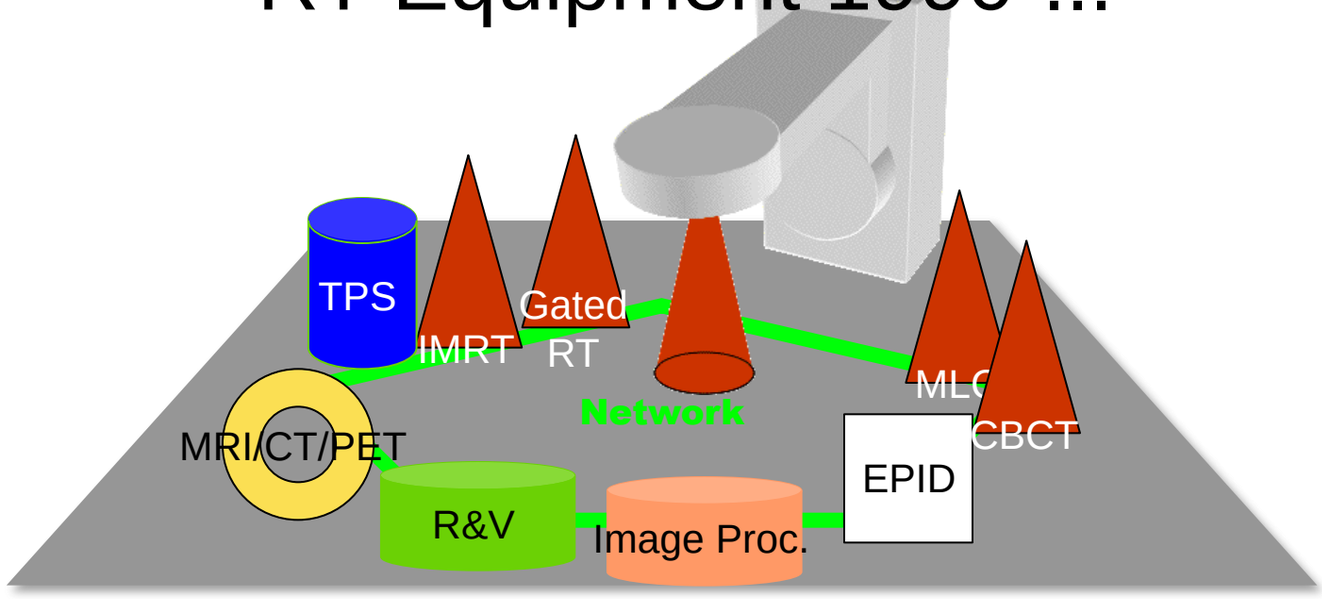


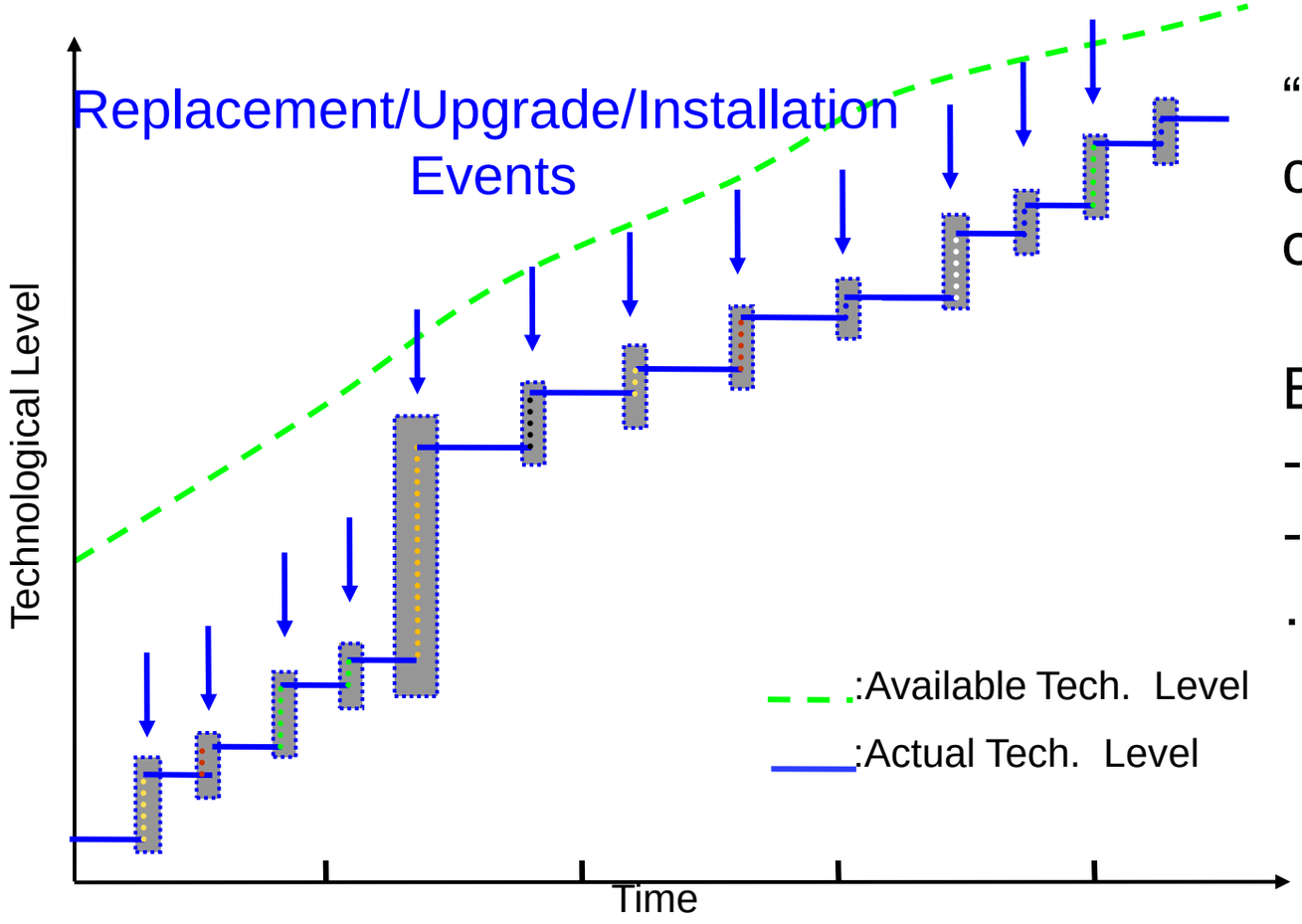
"Changes/Innovation mainly during major replacement events"

Increasing complexity

RT Equipment 1990-...



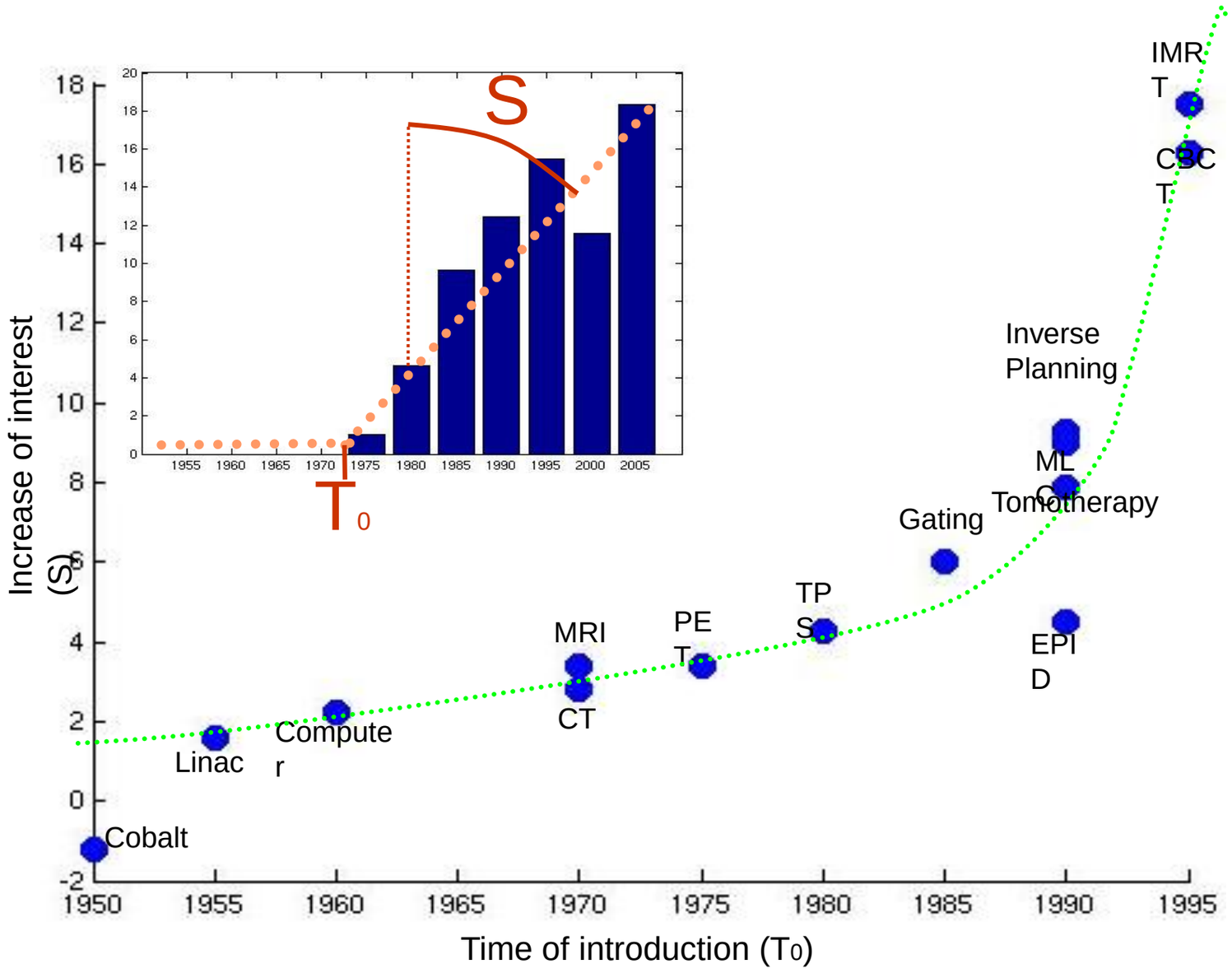
Many Connected Sub-systems



“Changes/Innovation as a continuous process consisting of minor subsequent events”

Example:
-> Software Upgrades
-> Sub-system installation
…

Increasing complexity

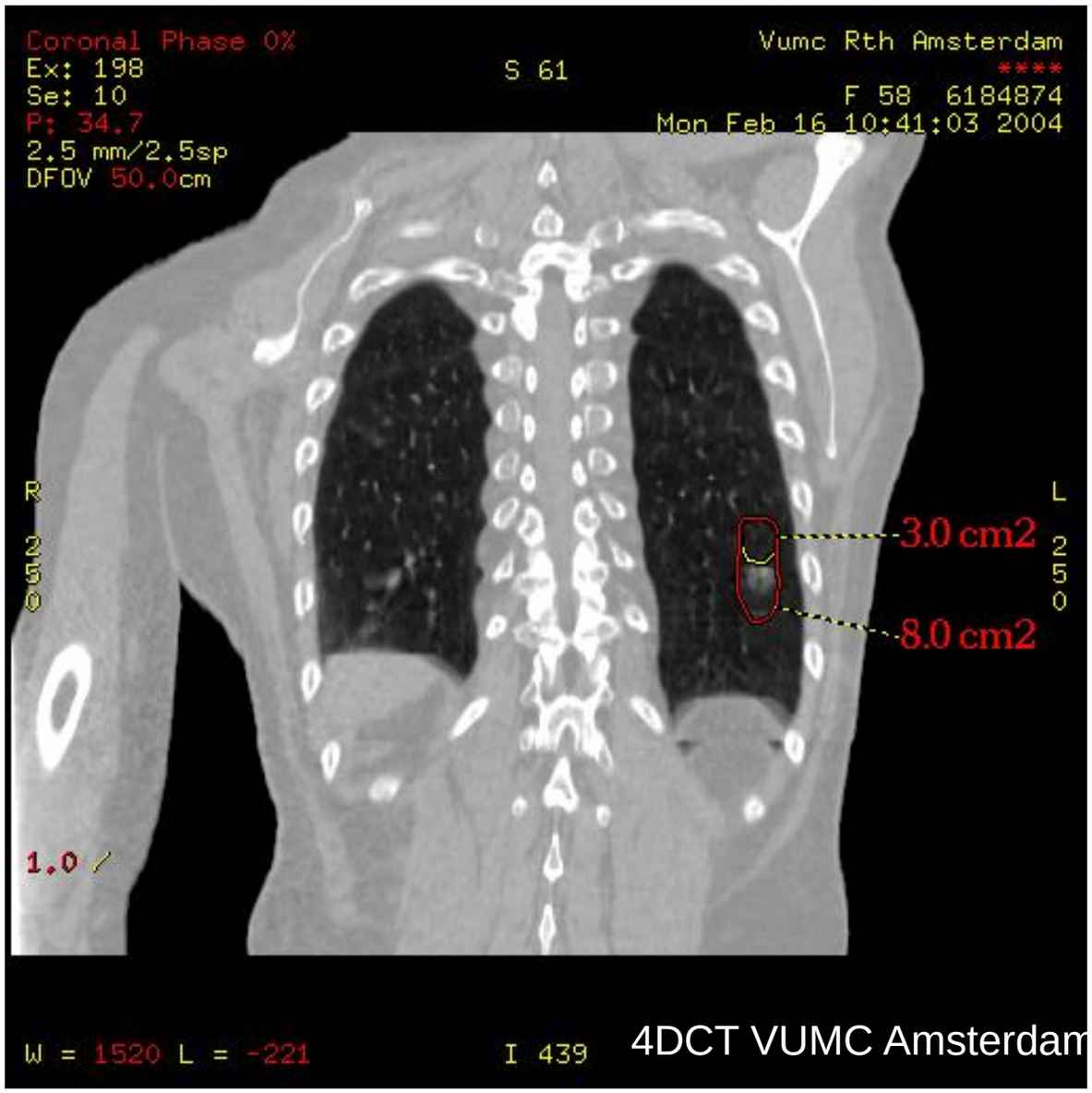


Conclusion:
RT is an increasingly complex environment
New technology is introduced increasingly faster

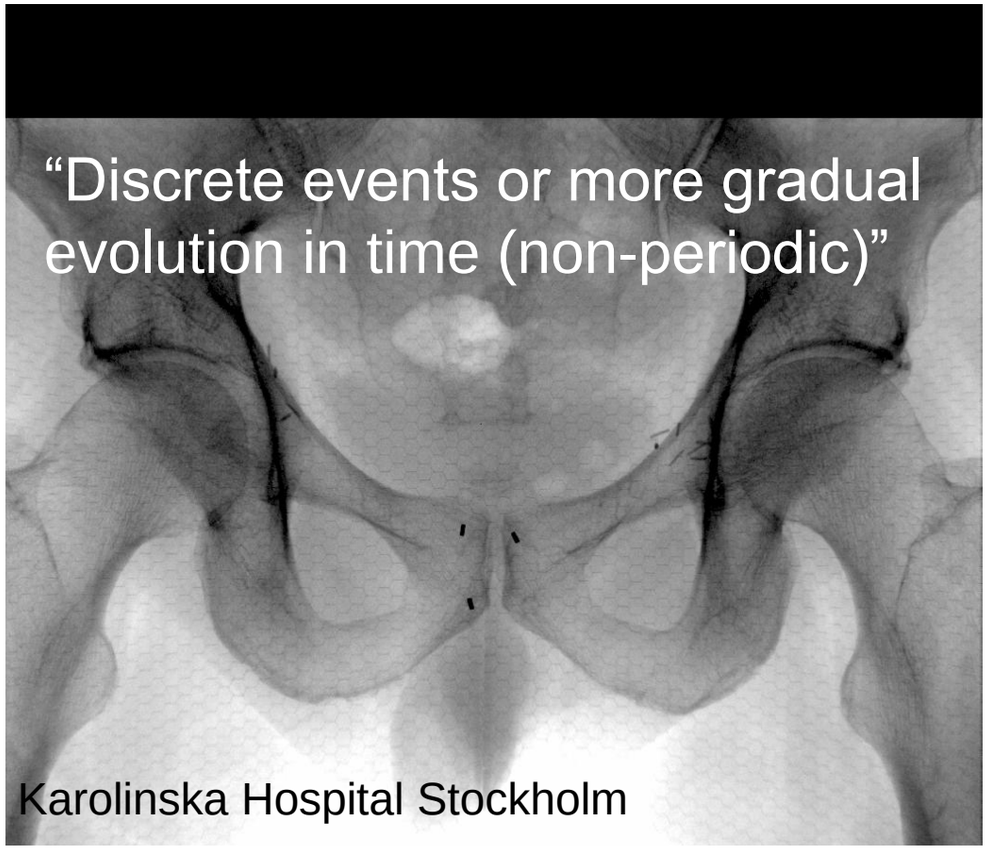
“Moving Tumor Problem: Intra-fraction motion ”

“Different types of intra-fraction motion”

“Quasi-periodic”



4DCT VUMC Amsterdam



Karolinska Hospital Stockholm

Intrafraction prostate movement (Calypso)

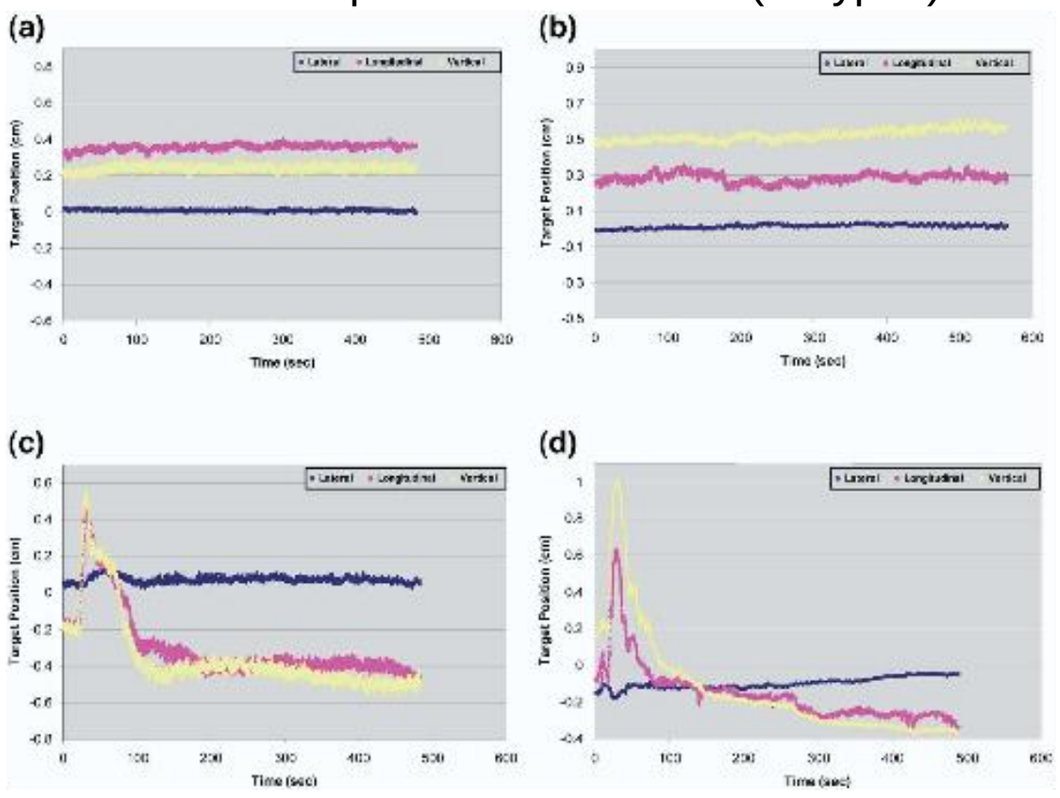


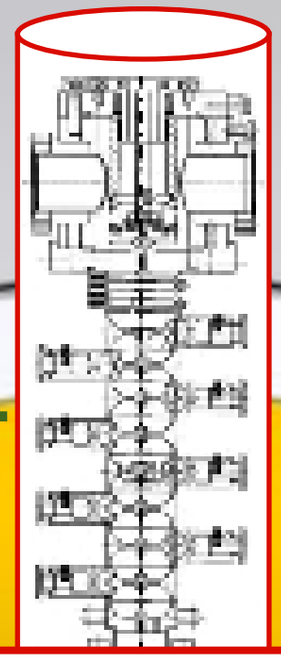
Fig. 3. Variation in X (lateral L/R, blue), Y (longitudinal S/I, yellow), and Z (vertical A/P, pink) locations over time for the entire 8-minute session in 4 of the 11 patients. (a) and (b) Patients in whom the prostate was relatively stable during the tracking period. (c) and (d) Patients in whom the prostate displayed significant excursion during the tracking period.

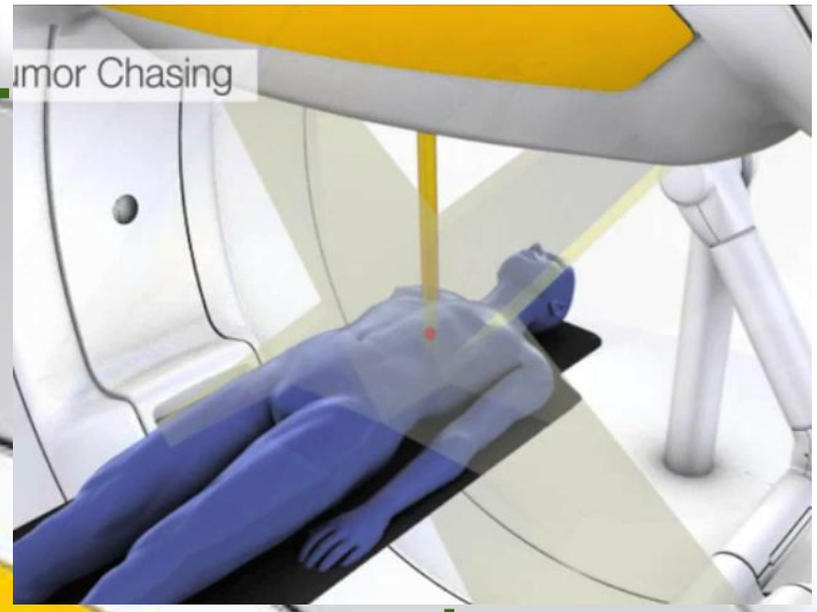
Willoughby et al. IJROBP **65**:2, 528-534 (2006)

Tracking with Fluoroscopy

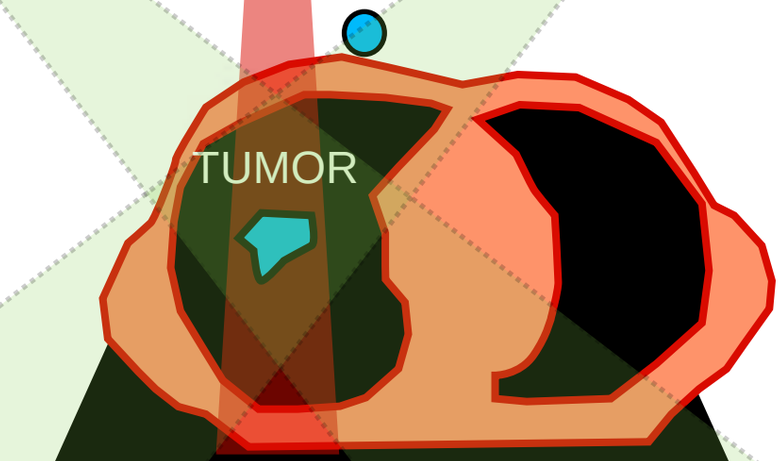
Fluoro Imaging System

Tracking Controller

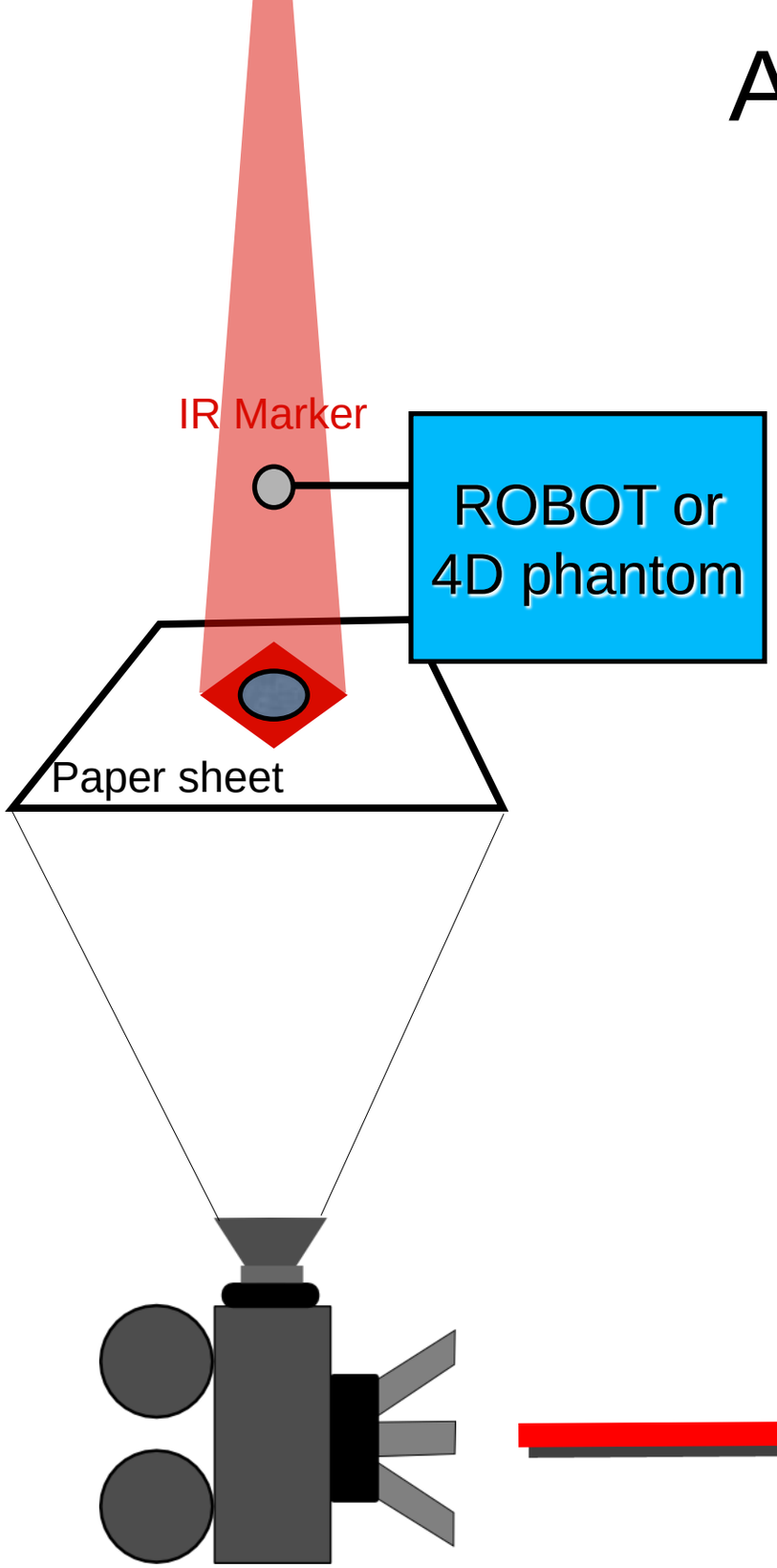




MLC



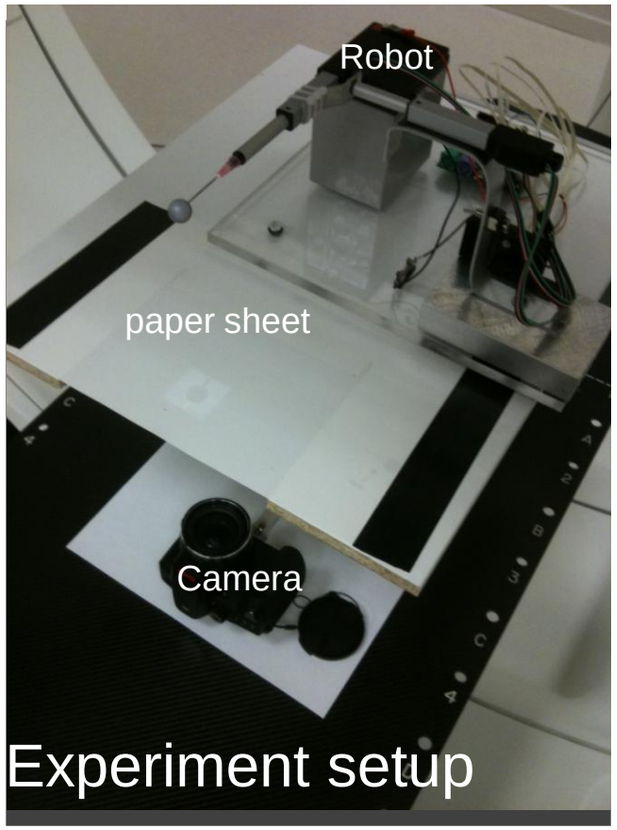
Adaptive Radiotherapy (ART) QA

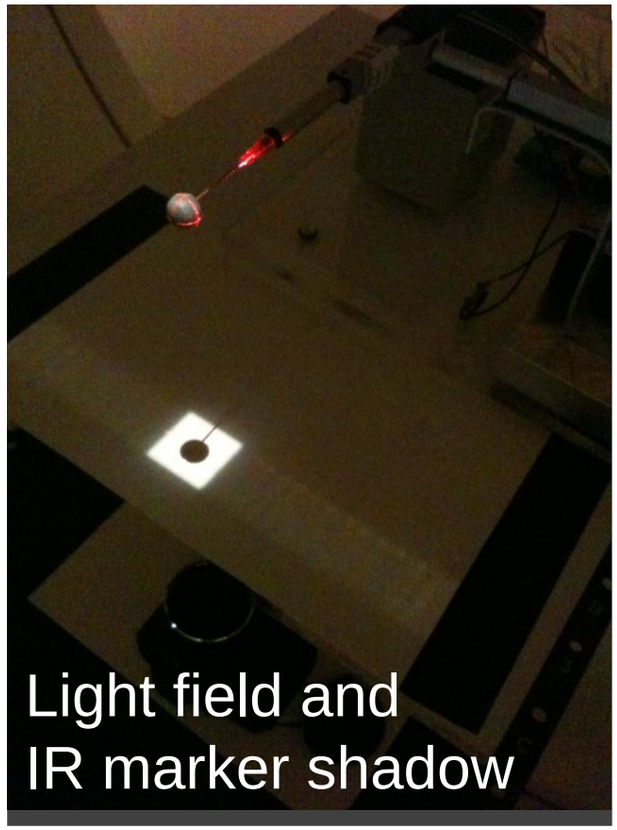


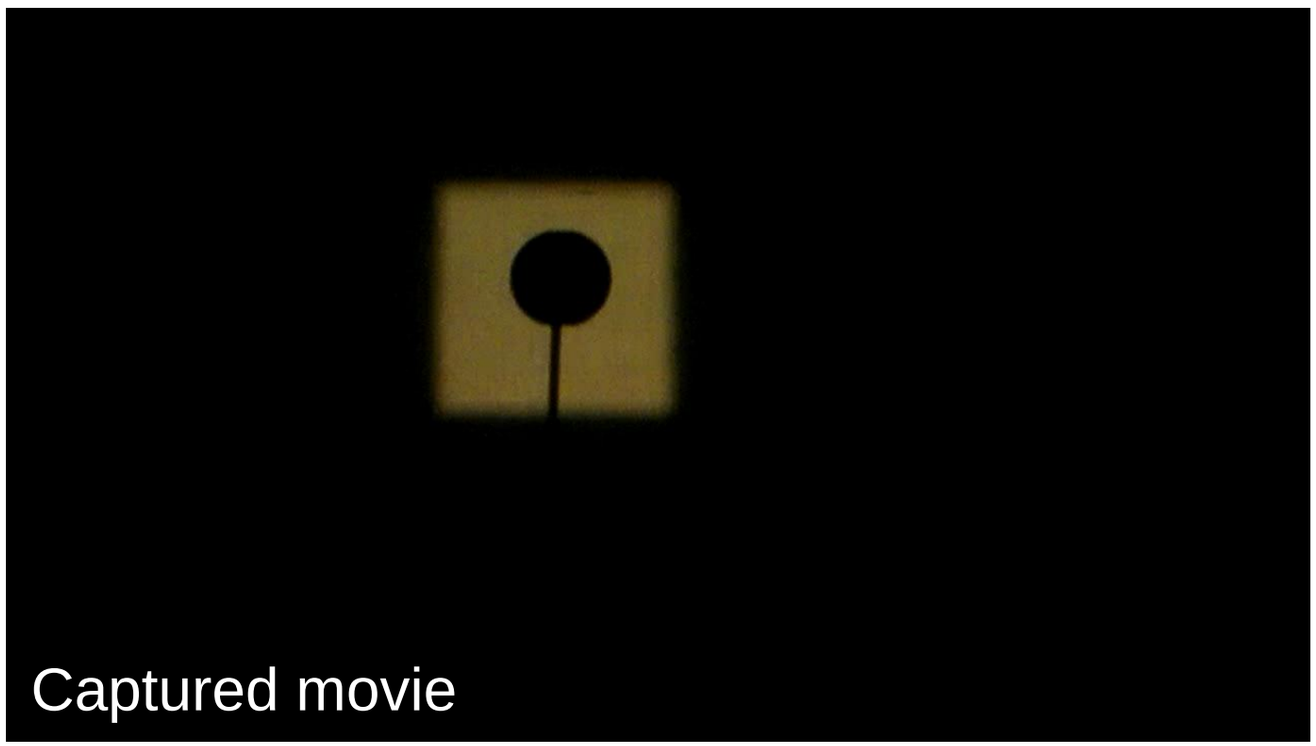
Video camera

*"**Independent** measurement of tracked object position **and** tracking beam position with **high resolution** and **high sampling rate**"*

Depuydt et al. 2010







ART QA

- With the possibilities for motion tracking getting commercially available, we are moving into an era where treatments are made and changed “in real time” based on autonomous machine desicions.

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Quality Assurance Aspects in Radiotherapy

Machine related QA

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-linac performance
-imaging quality
-mechanics
-TPS
-...

Patient specific QA

"Related to the specific treatment of each patient"

-treatment plan delivery accuracy
-patient positioning
-...

RT Process QA

"Related to the process of providing RT service"

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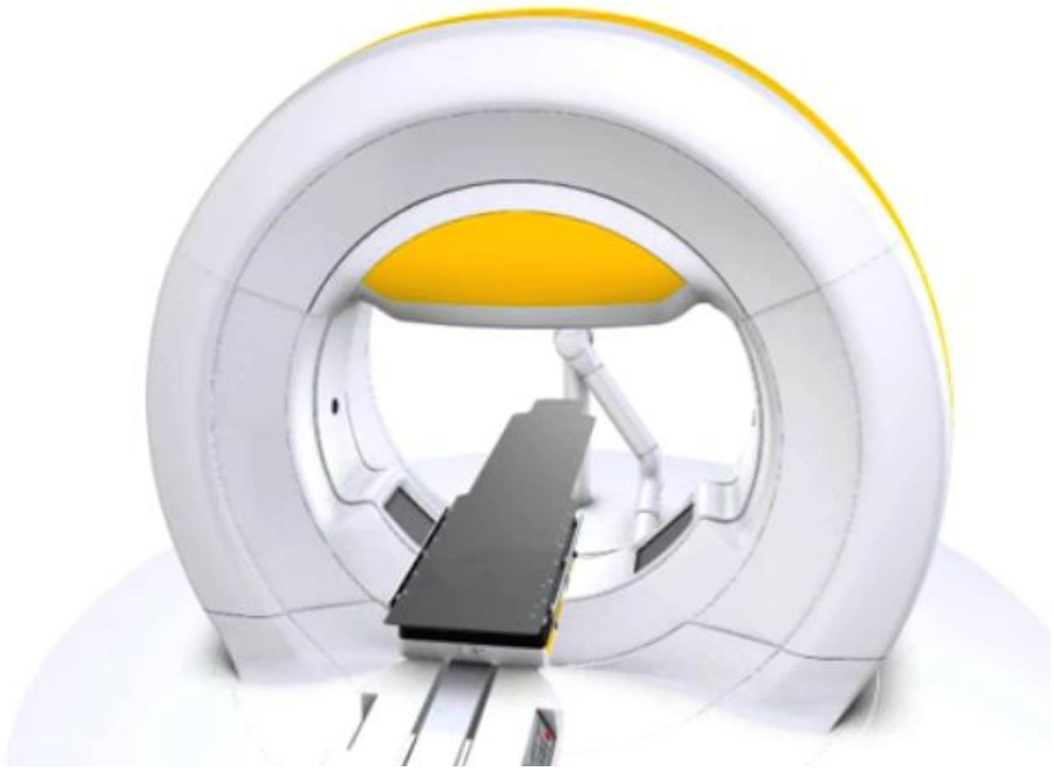
Machine related QA

Radiotherapy Treatment Unit



BrainLAB/MHI VERO Platform:
Gantry rotation (**A**): [-185°,185°] ± 1°
O-ring rotation (**B**) : [-60°,60°] ± 1°
Isocenter accuracy : ± 0.5 mm / **0.1 mm** (with tilt comp.)
Gantry bore : 125 cm at mMLC, 200 cm elsewhere
Couch : 5D (lat, long, vert, roll, pitch) ± 0.1 mm

"Classic" platform

C-arm
(360°)

Tomotherapy platform

CT-like
ring gantry
(helical)

Machine QA

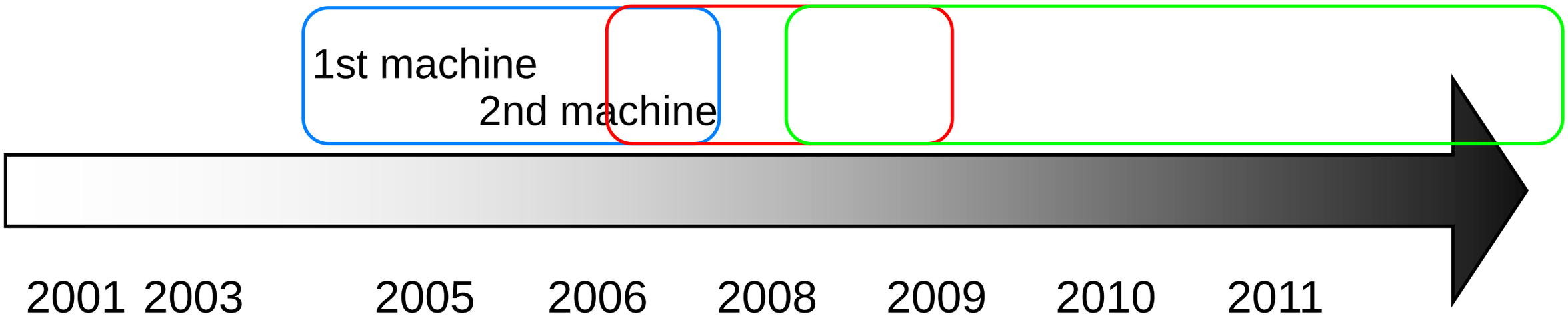
- Problem : New techniques are moving away from the standard dosimetry techniques (tomo, cyberknife)
- A gap has fallen between basic measurements and treatments (which are much less basic)
- Adaptation of protocols is a long and slow process.

Timeline (Tomo)

Extensive QA, audits, calibration

Development tomocheck-imrt2TC

Routine QA



2001 2003

1st clinical machines

2005

1st european machines

2006

ESTRO audits
GORTEC
NPL alanine

2008

adaptations commercial tools

2009

start TG148

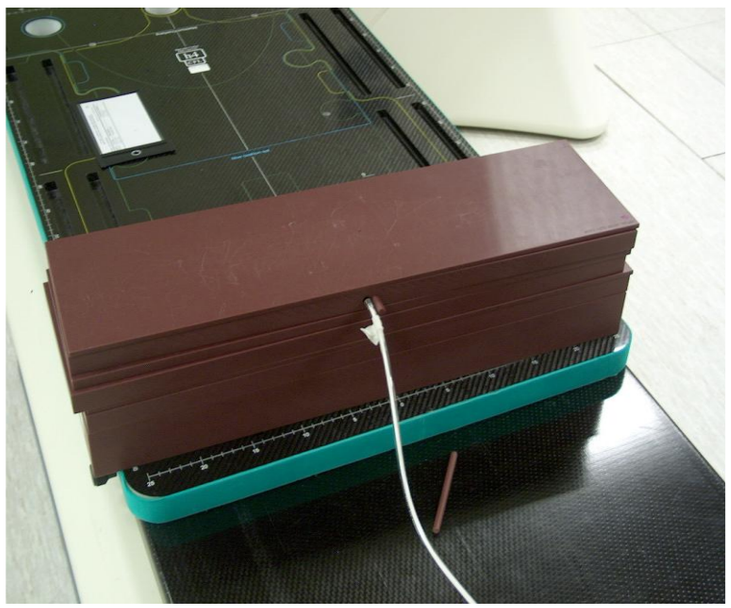
2010

start NCS tomo TQA

2011

Absolute dosimetry

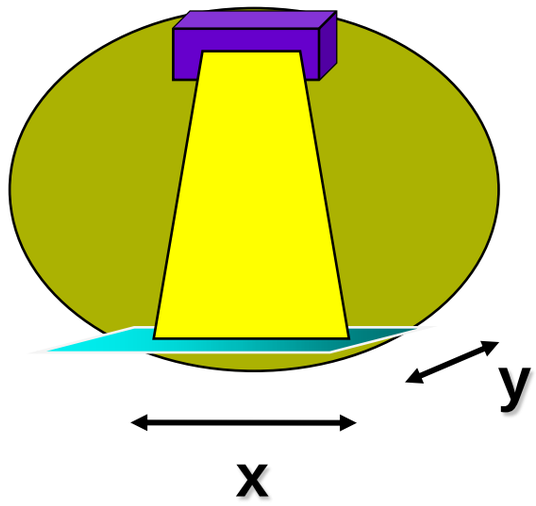
- TG51/TRS398 but without the standard conditions
- Adapted kq values
- Static measurement/rotational treatment
- only measurement of 5cm field possible



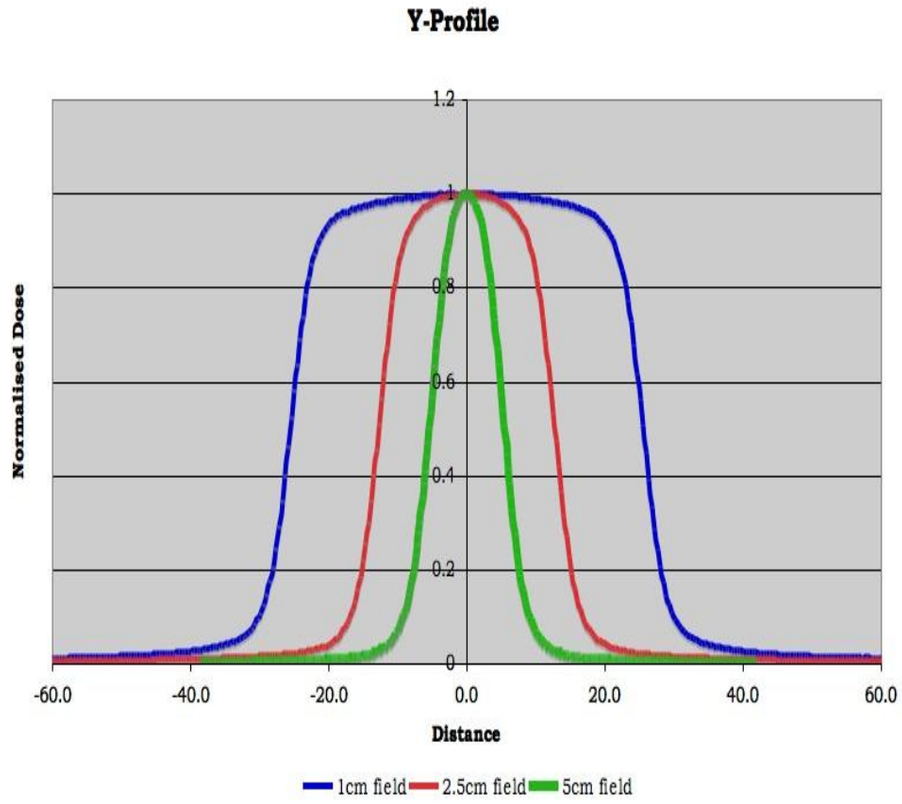
Exradin* A1SL, 0.056 cm^3

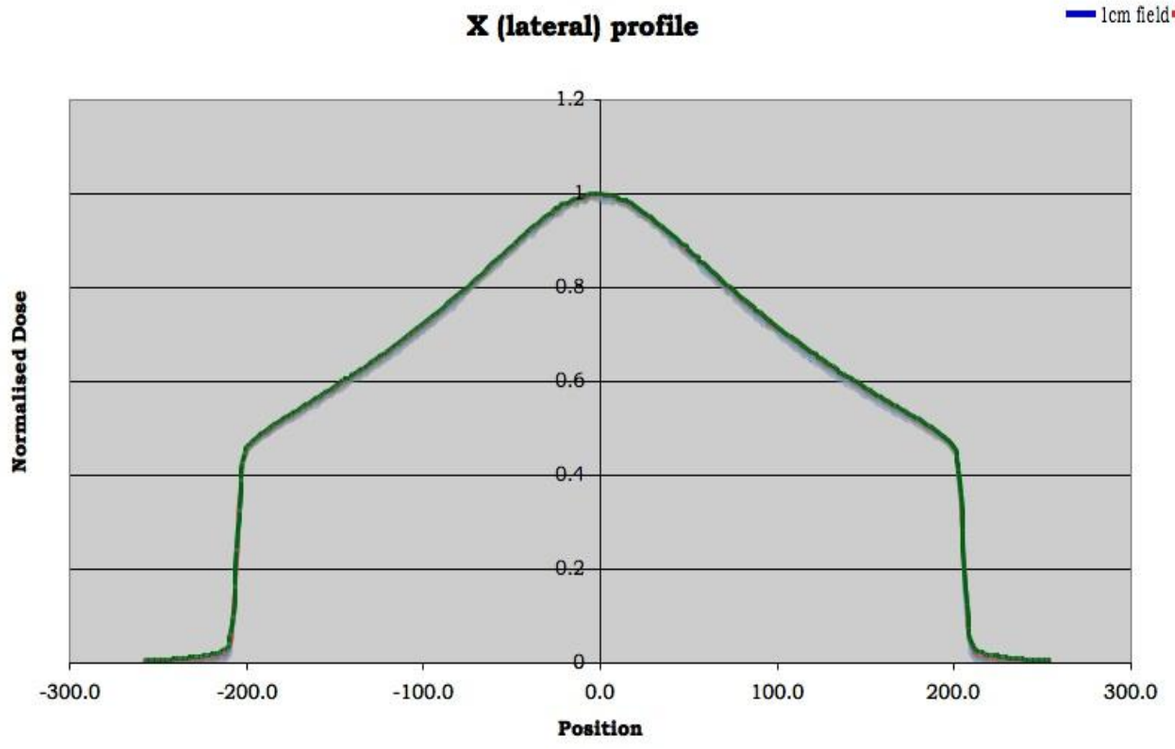
(cavity 4.05mm by 4.4mm)

Beam Profiles

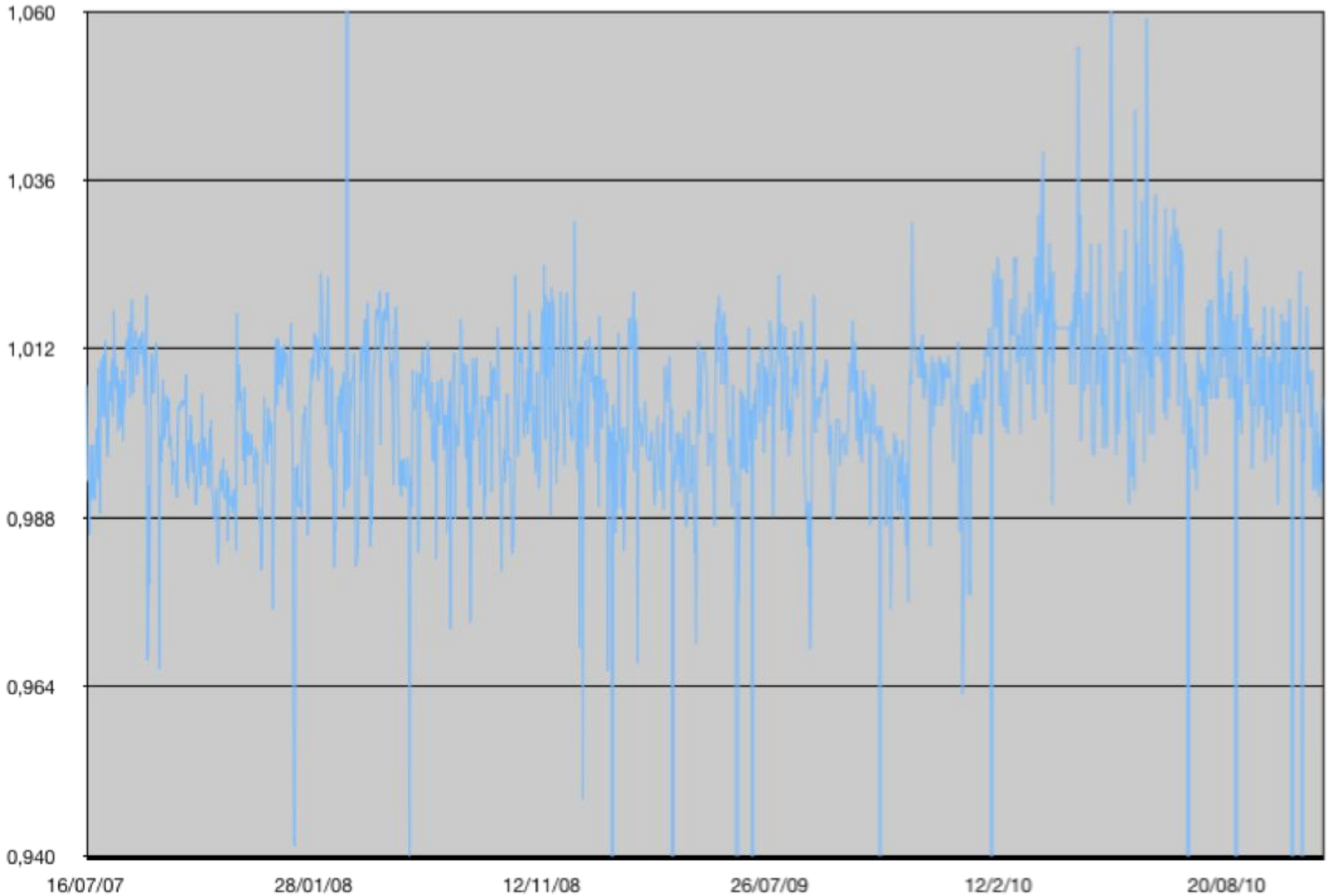


40cm x (1,2.5,5)cm

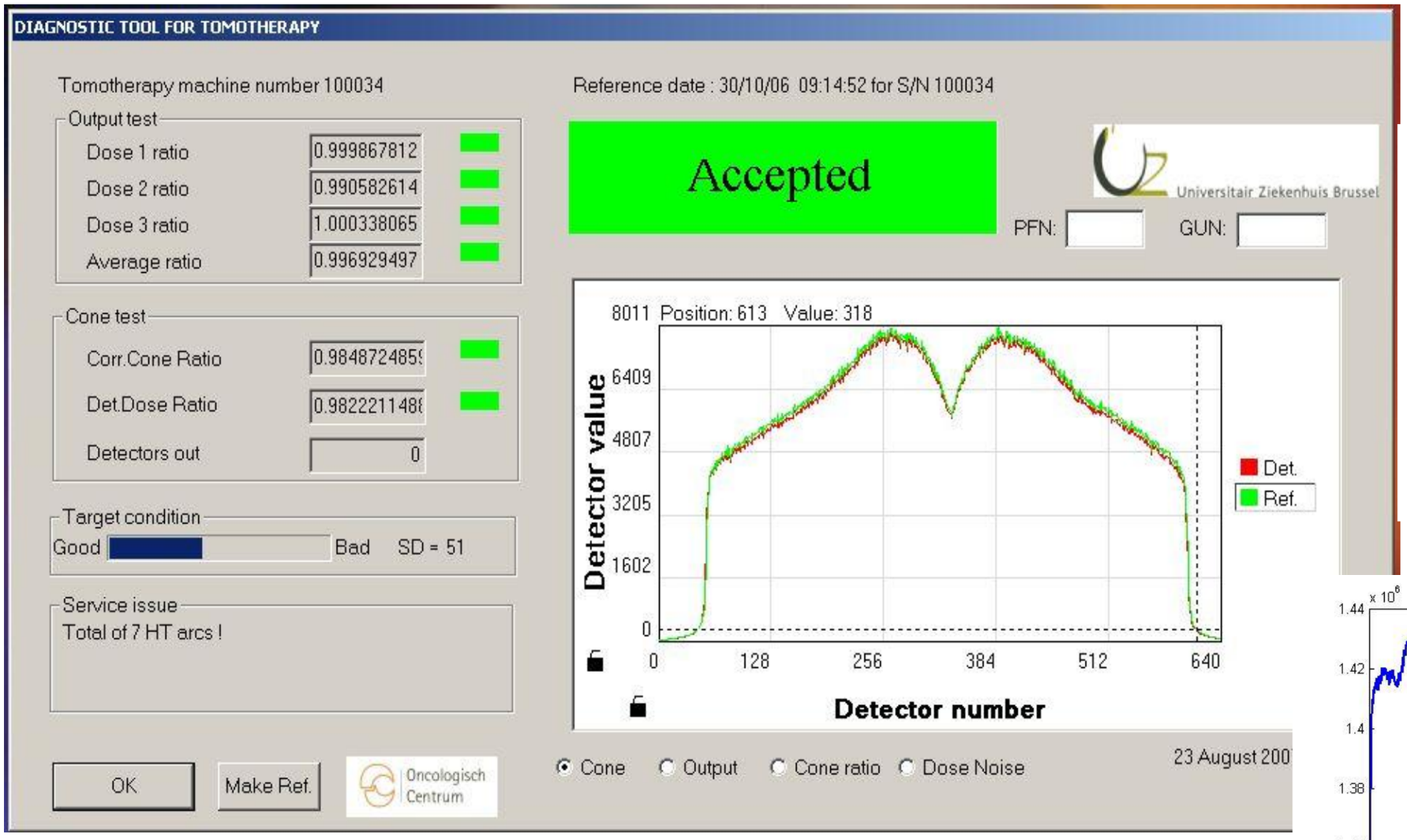


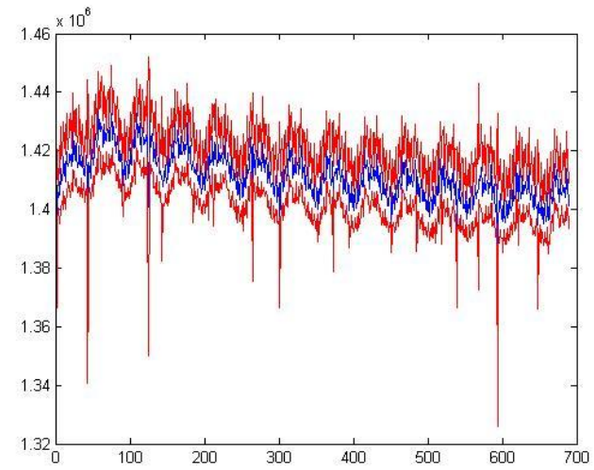


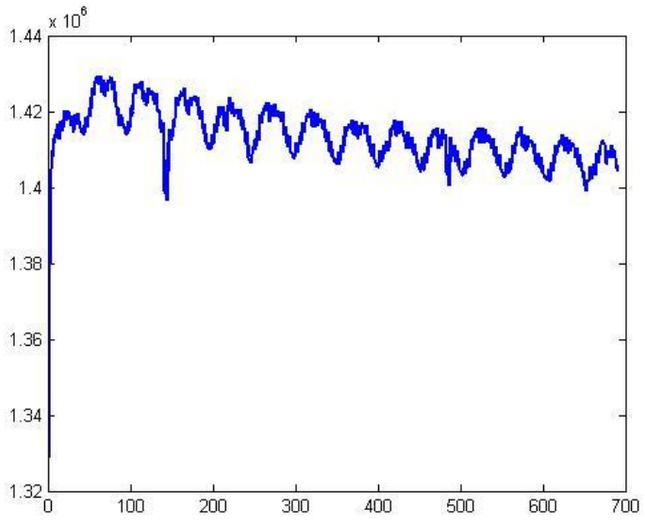
Output

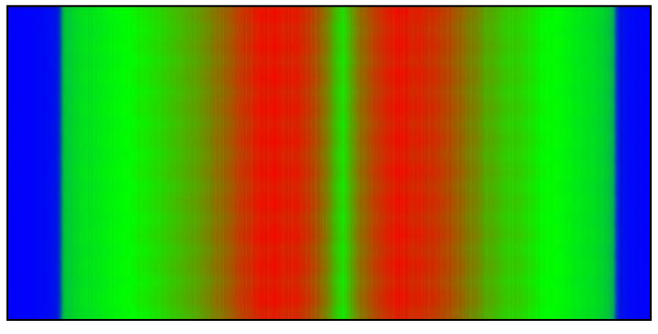

1,060
1,036
1,012
0,988
0,964
0,940
16/07/07
28/01/08
12/11/08
26/07/09
12/2/10
20/08/10

Example : Detector Dosimetry





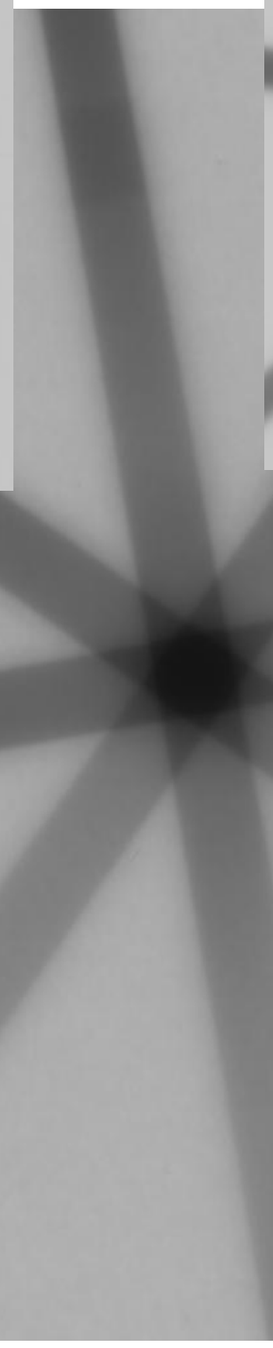




High Mechanical Precision Equipment

Determination of Radiation Isocenter Size with Star Shot film

VERO Wobble Starshot



Novalis Couch Starshot

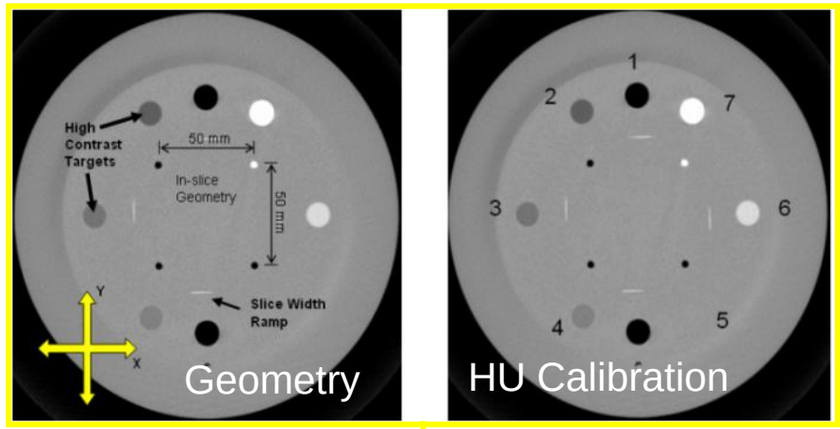
VERO Gantry Starshot

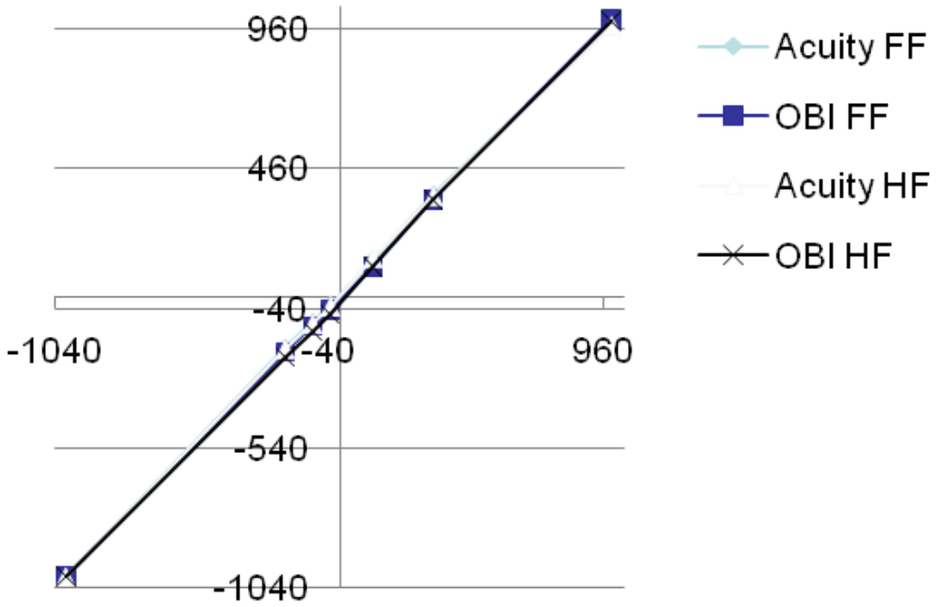
IG-QA

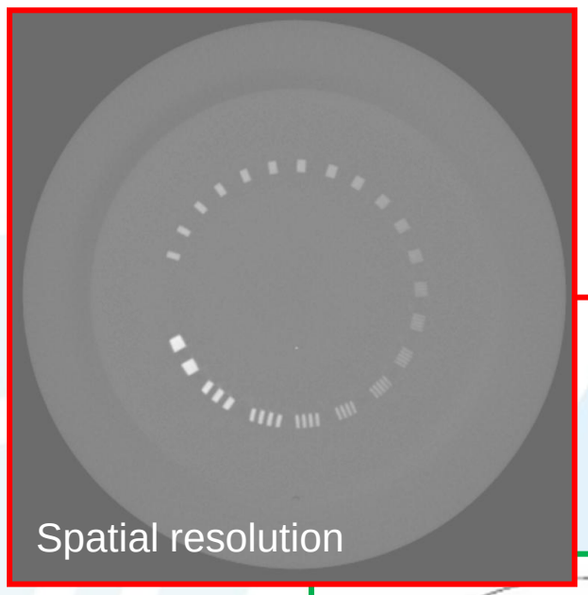
- Compared to radiology, QA schedules for IG-techniques are only in the first stage of development
- Since ART is the new buzz word...one should realize that this is completely linked to proper QA of the images.

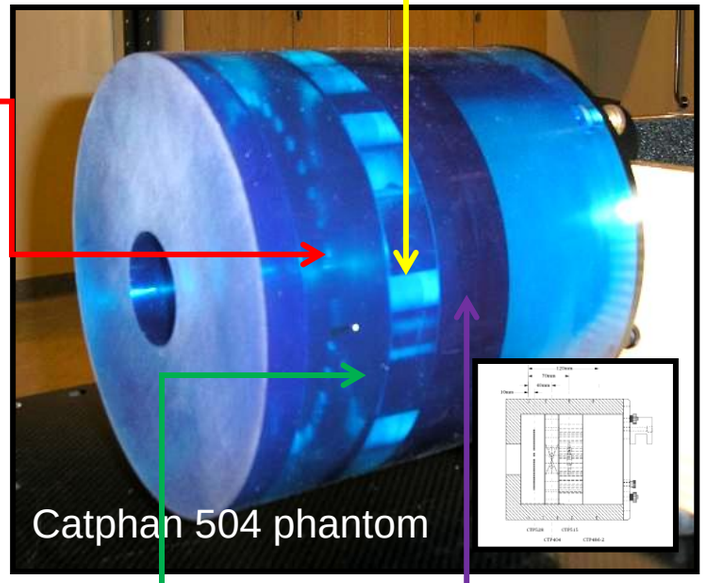
Image Guided Radiotherapy (IGRT) QA

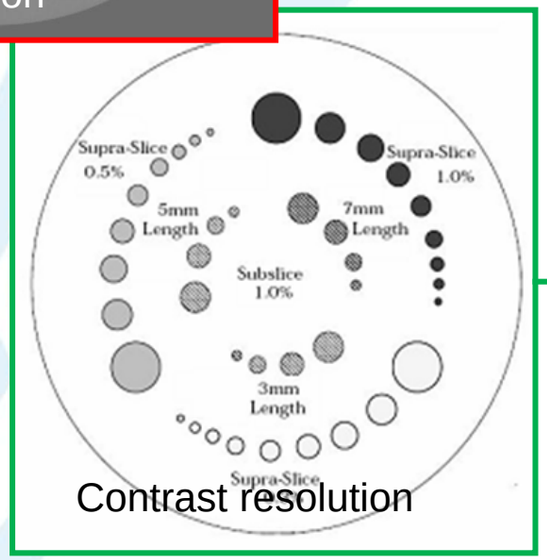
Image Quality: CBCT

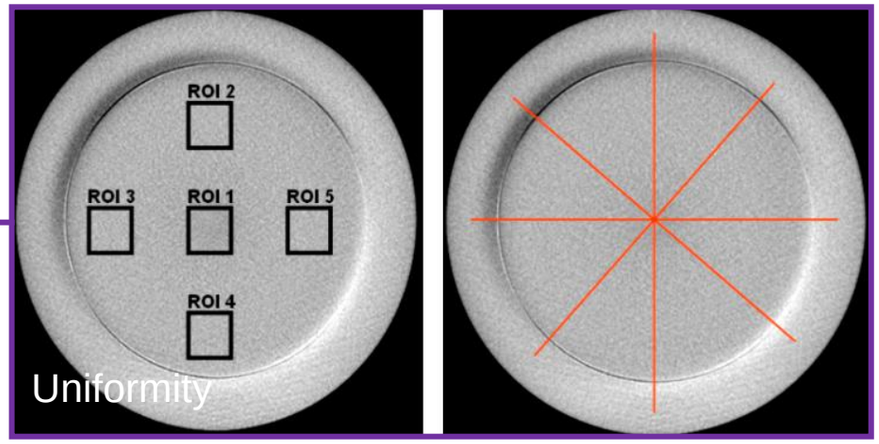




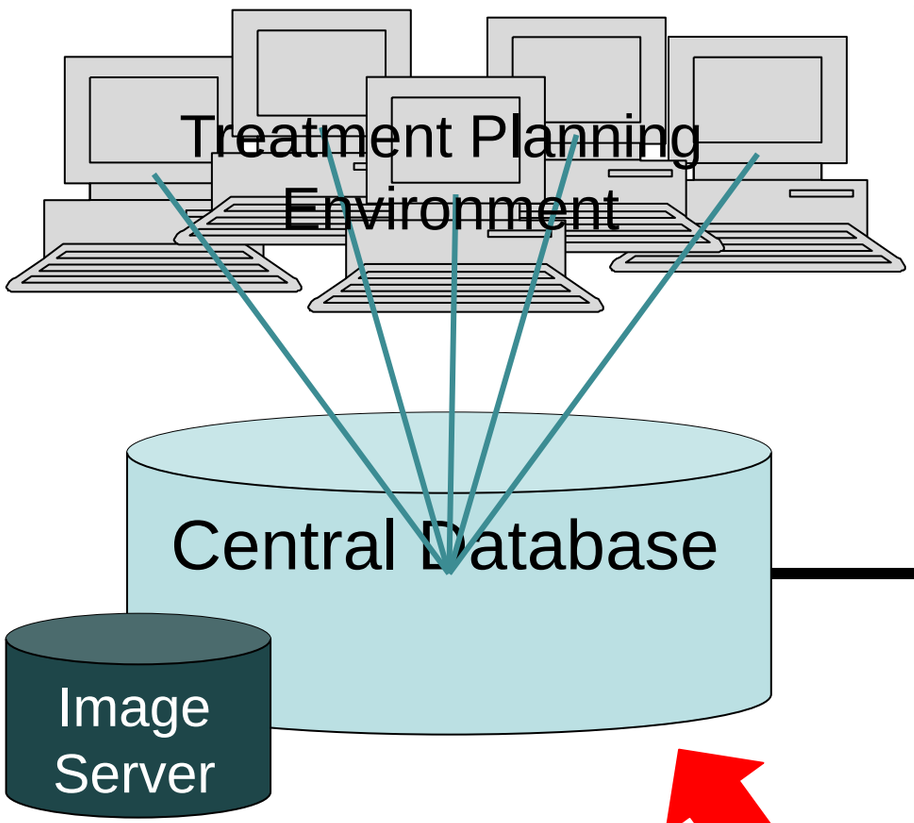








Quality Assurance of a computer network ?!

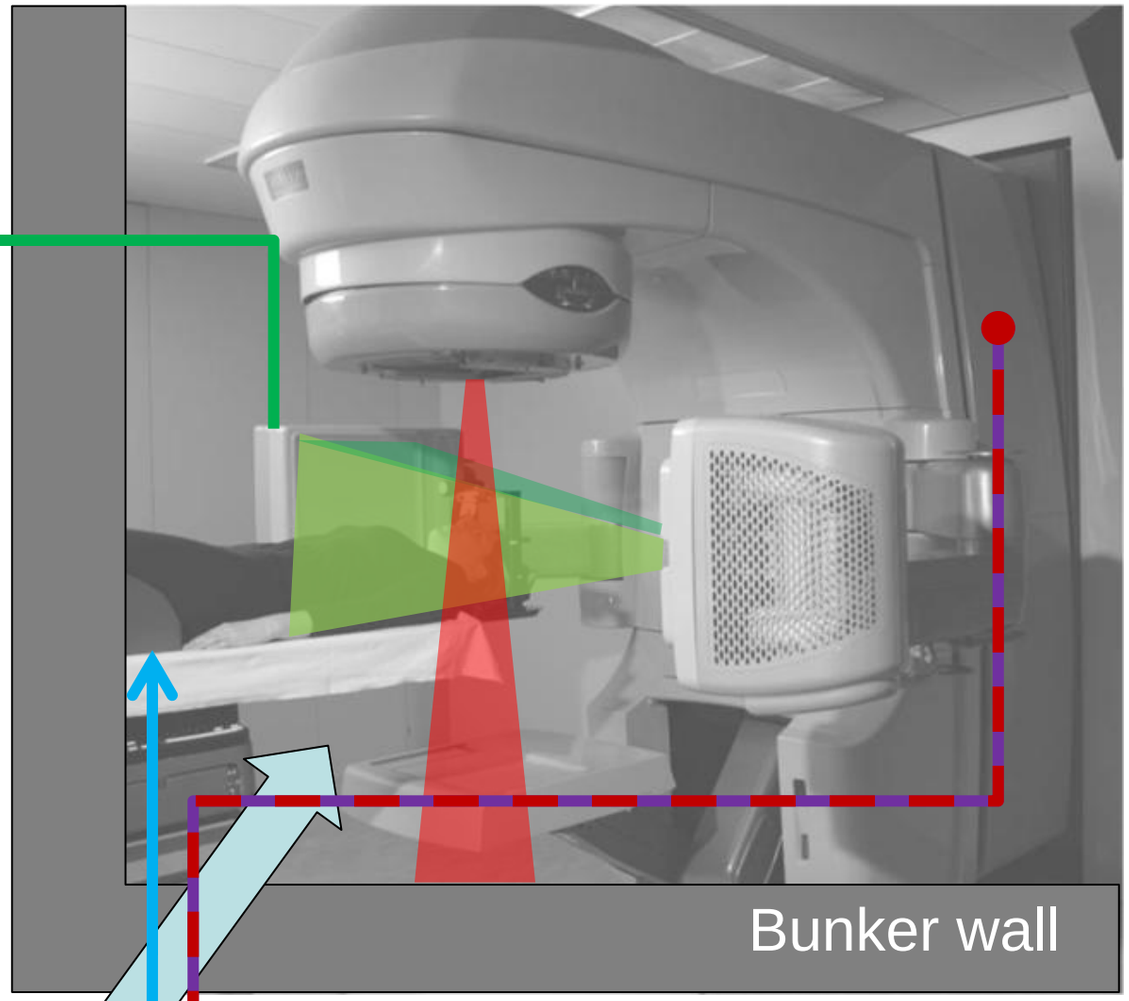


Central Database

Image Server

Firewall

DICOM



Downloading Plan + reference images

Uploading parameters to linac/OBI

Image acquisition with OBI

Image analysis (comp. ref. images)

Sending calculated shifts to linac console

Applying couch shifts

Treatment

Conclusions

- With increasing complexity of RT procedures the range of QA procedures also has to increase demanding specialization of personnel
- The existing QA procedures sometimes reach their limit, demanding some creativity from the physicists
- A “leap of faith” in dynamic treatments like gating/tracking : we have to trust a machines judgement while operating....

Quality Assurance Aspects in Radiotherapy

Machine related QA

"Related to the performance/constancy of the equipment used for imaging, treatment preparation and treatment delivery"

-linac performance
-imaging quality
-mechanics
-TPS
-...

Patient specific QA

"Related to the specific treatment of each patient"

-treatment plan delivery accuracy
-patient positioning
-...

RT Process QA

"Related to the process of providing RT service"

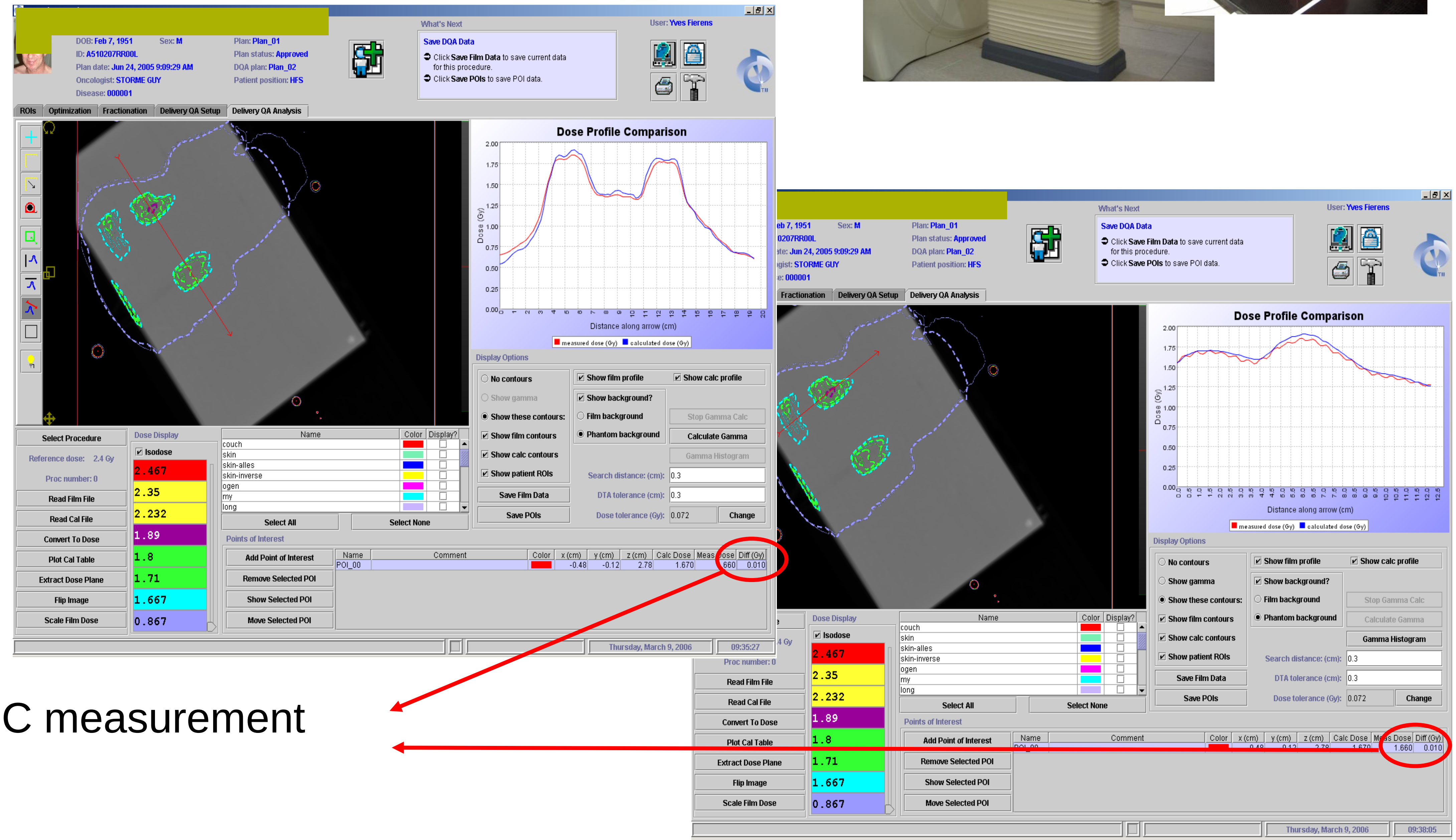
-Definition of procedures
-Organisation Department
-Error logging
-ISO 9000
-...

link to radiology, nuclear medicine, oncology, surgery, palliative care, dietists, ...

Patient QA...

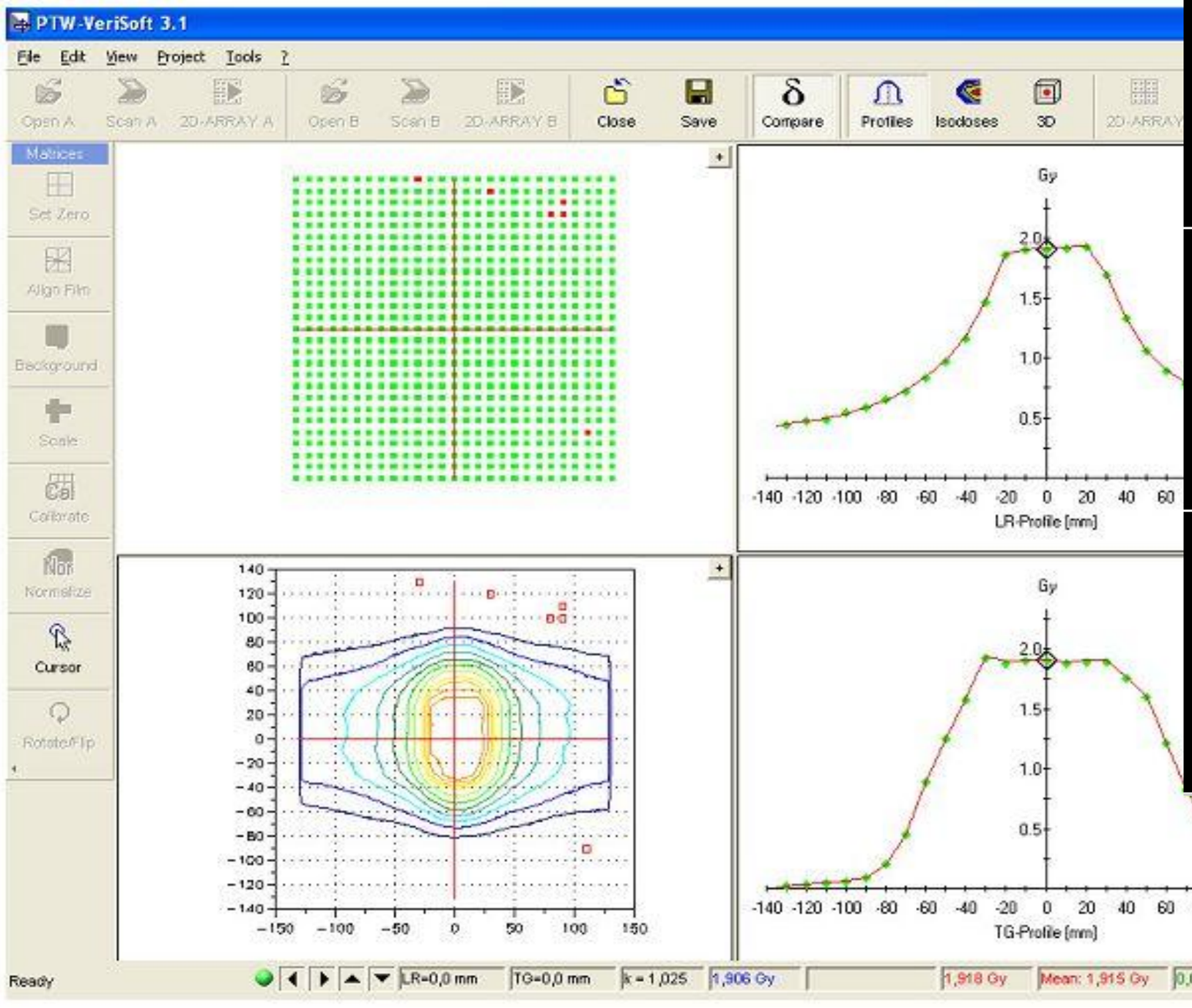
- is not a problem (we know how to do that) as long as the results are OK.
- is demanding a lot of time in the resources

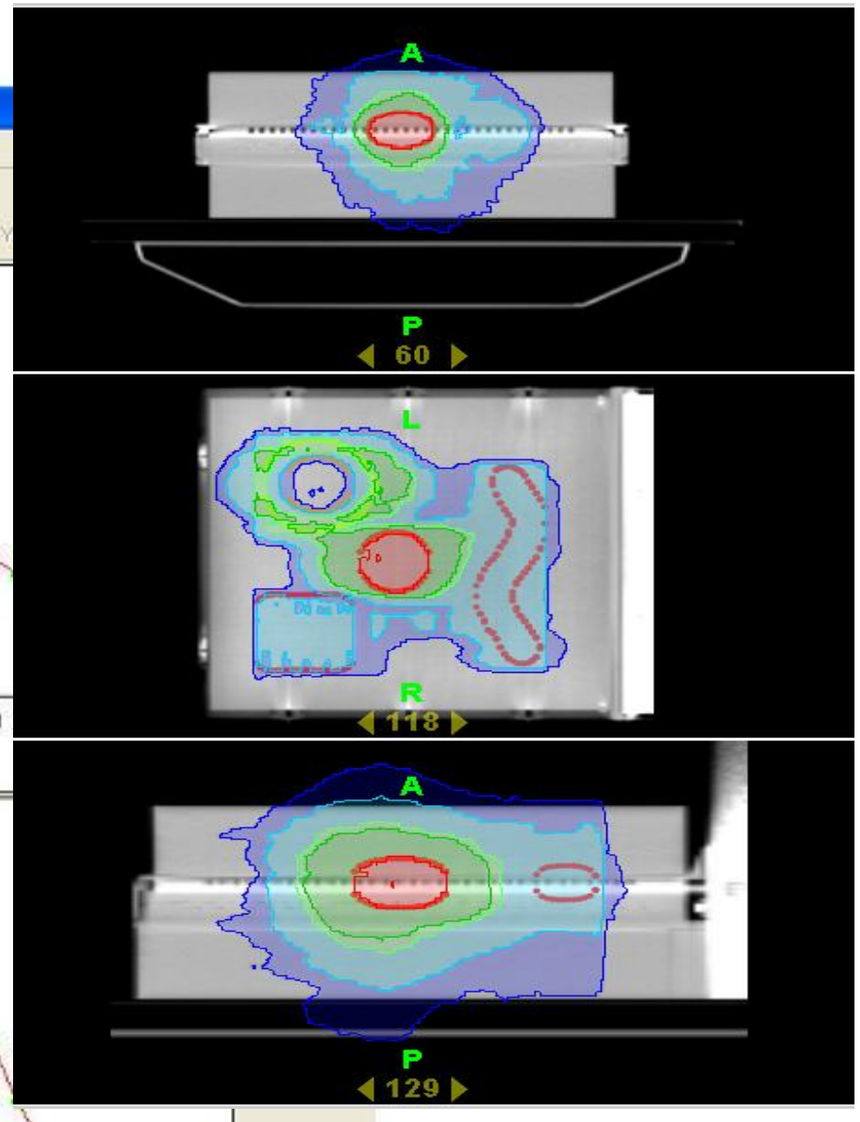
Film verification

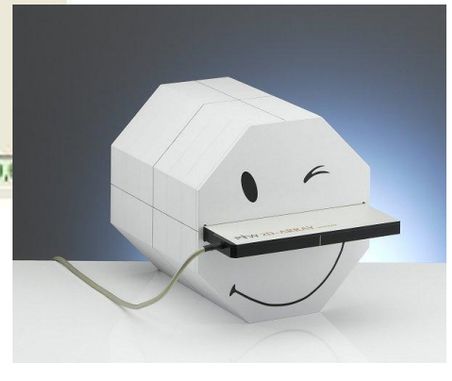


IC measurement

Commercial solutions







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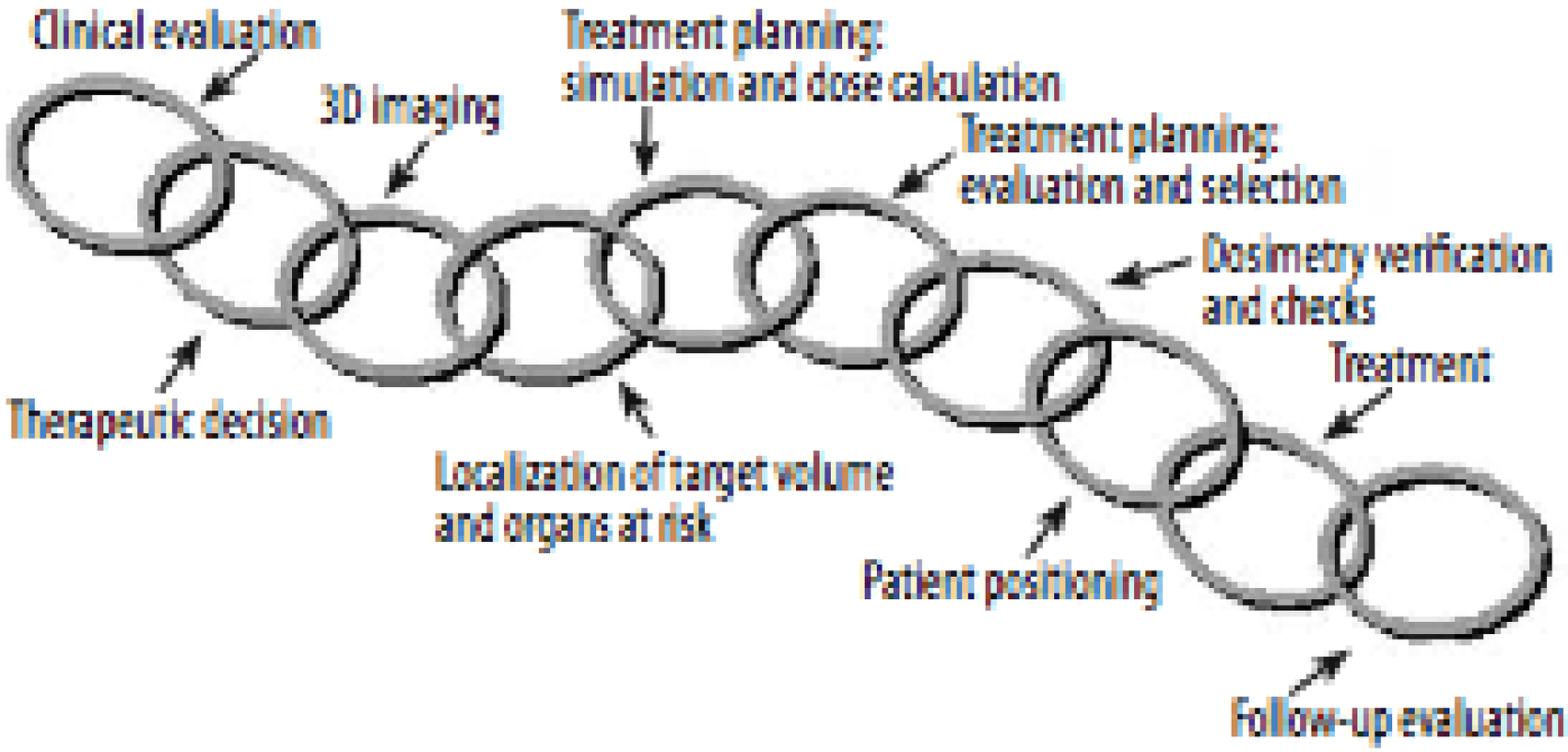
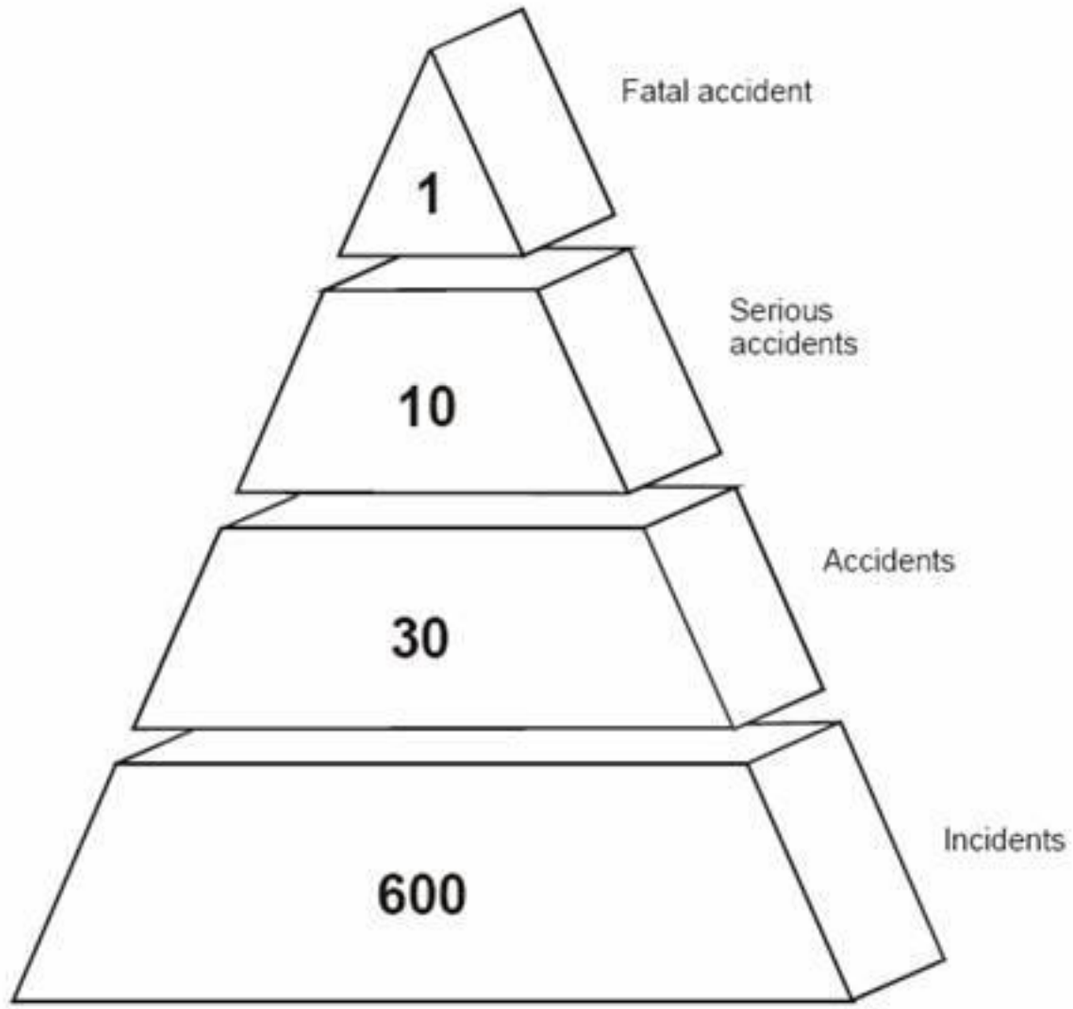


definition of procedures

- dose prescription
- planning
- patient positioning
- treatment
- dosimetry
- follow-up

error logging

- incident manageme
- reporting is essentia
- open culture



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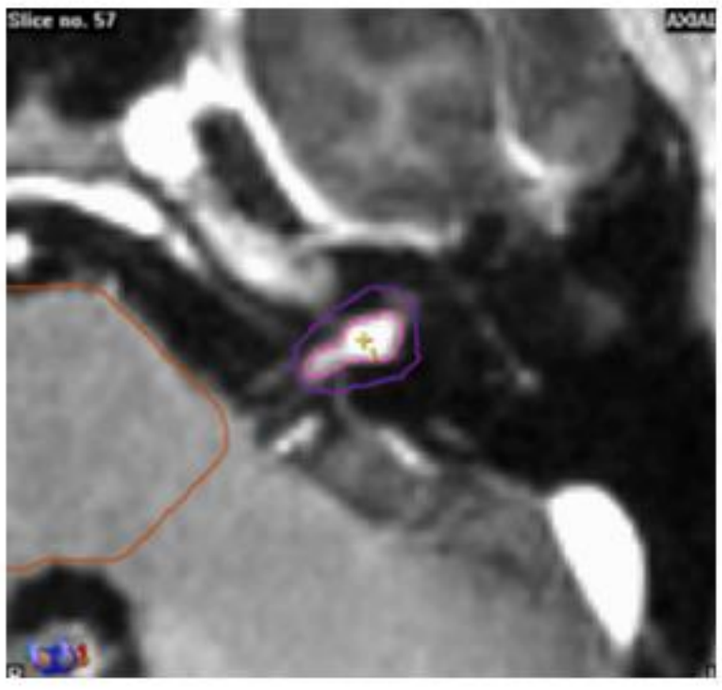
-...

link to radiology, nuclear medicine, chemotherapy, surgery, palliative care, dietists, ...

link RT to radiology and nuclear medicine

- QA images (resolution, calibration, ...)

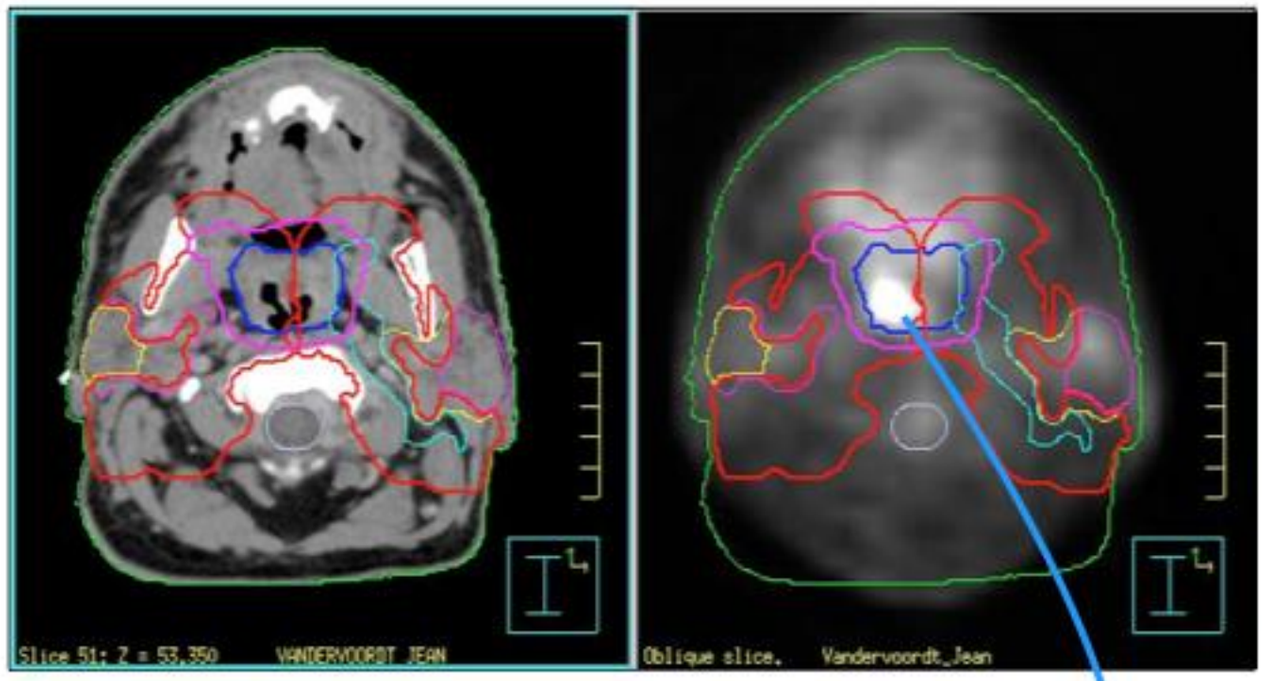
MR 2008



MR 2009

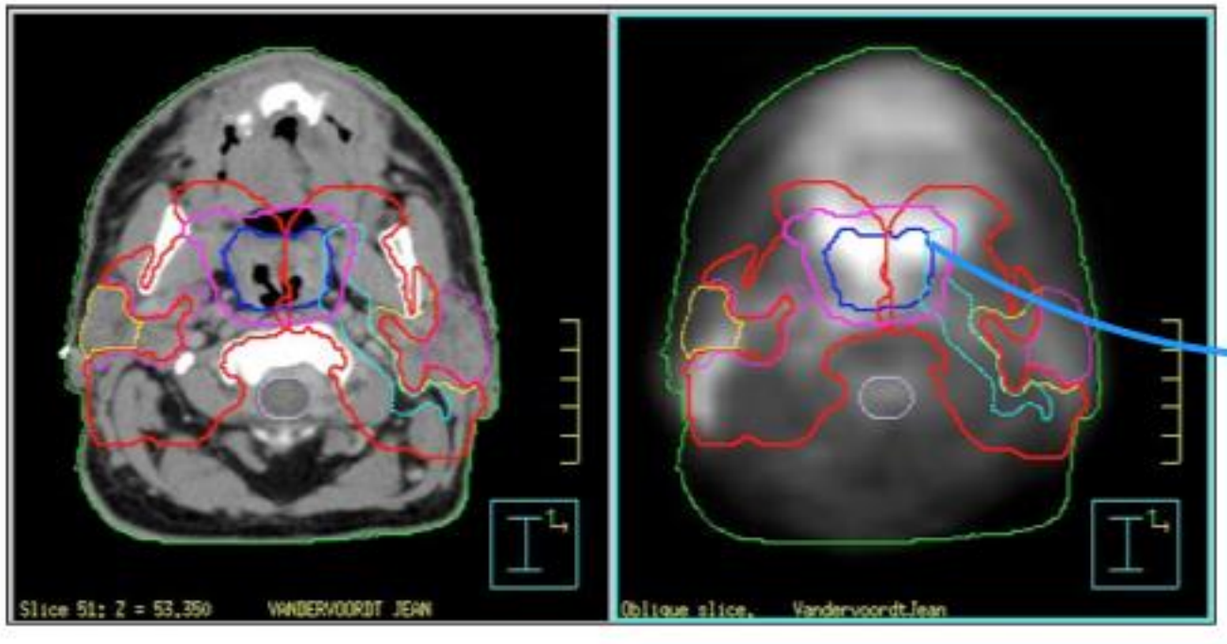
Petscan :WYSIWIG?

Voor RT



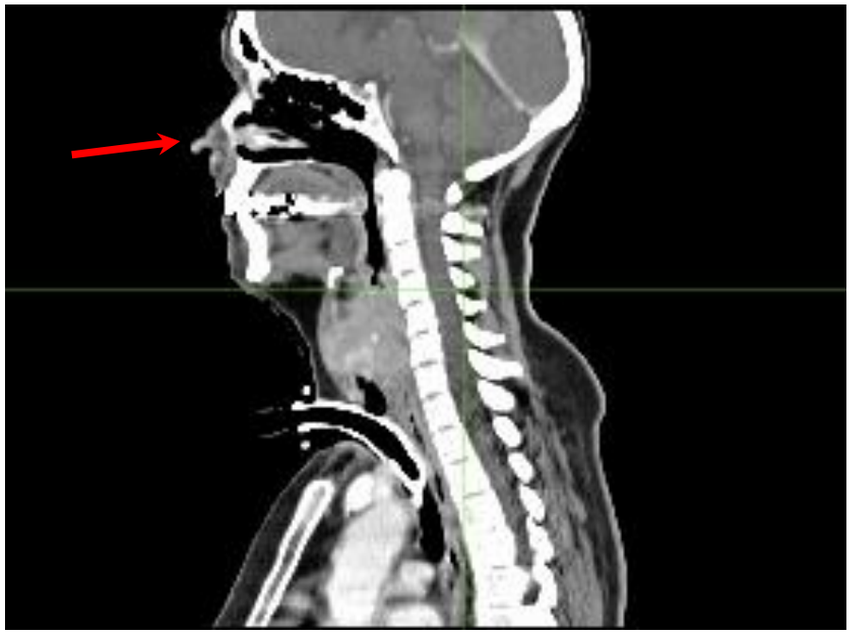
Tumor

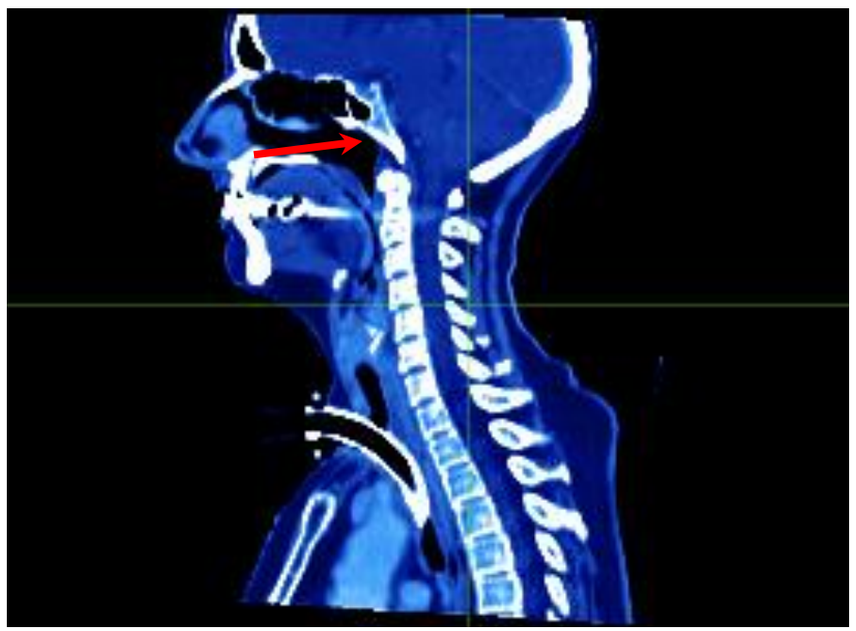
Na RT



Mucositis

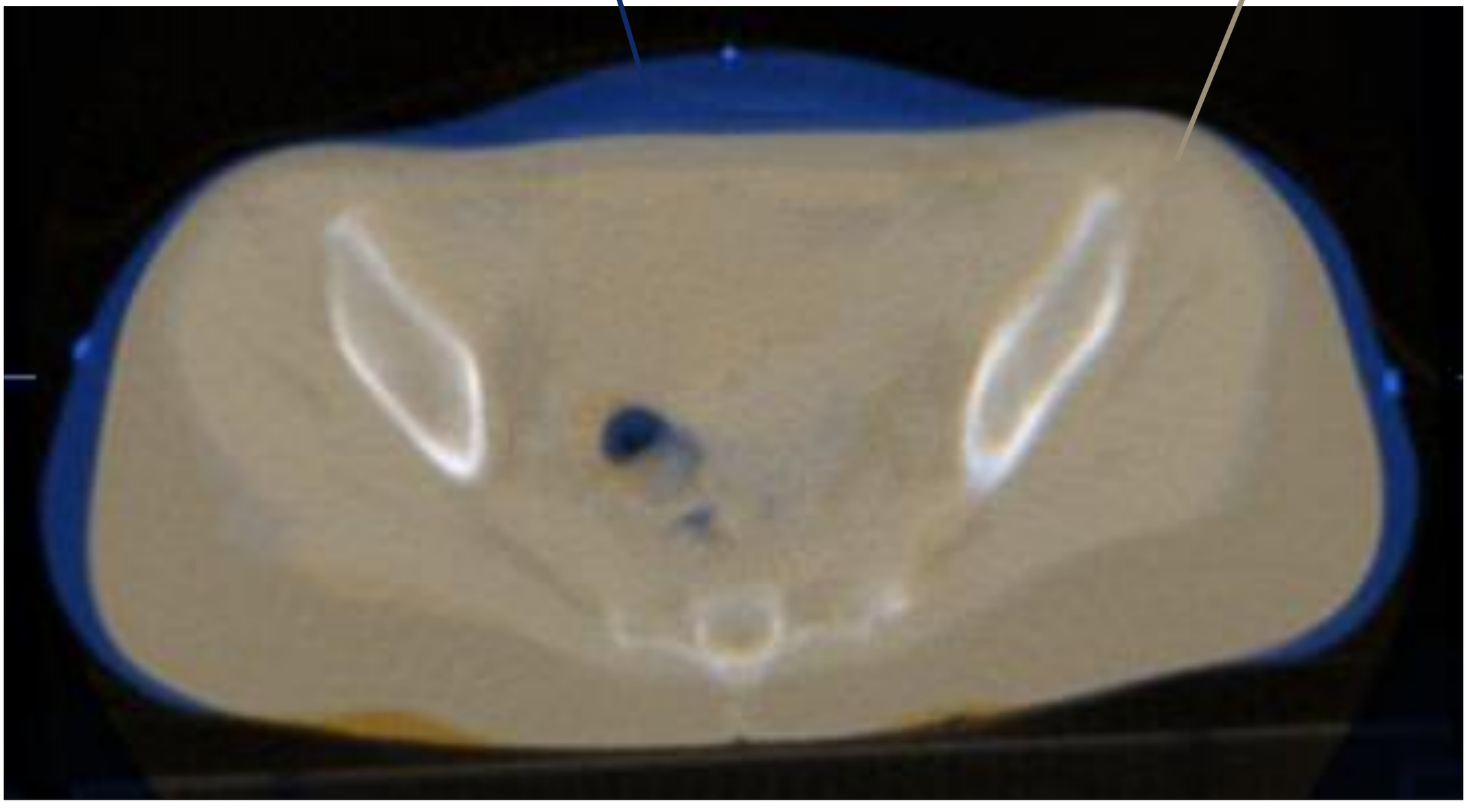
Adaptive RT

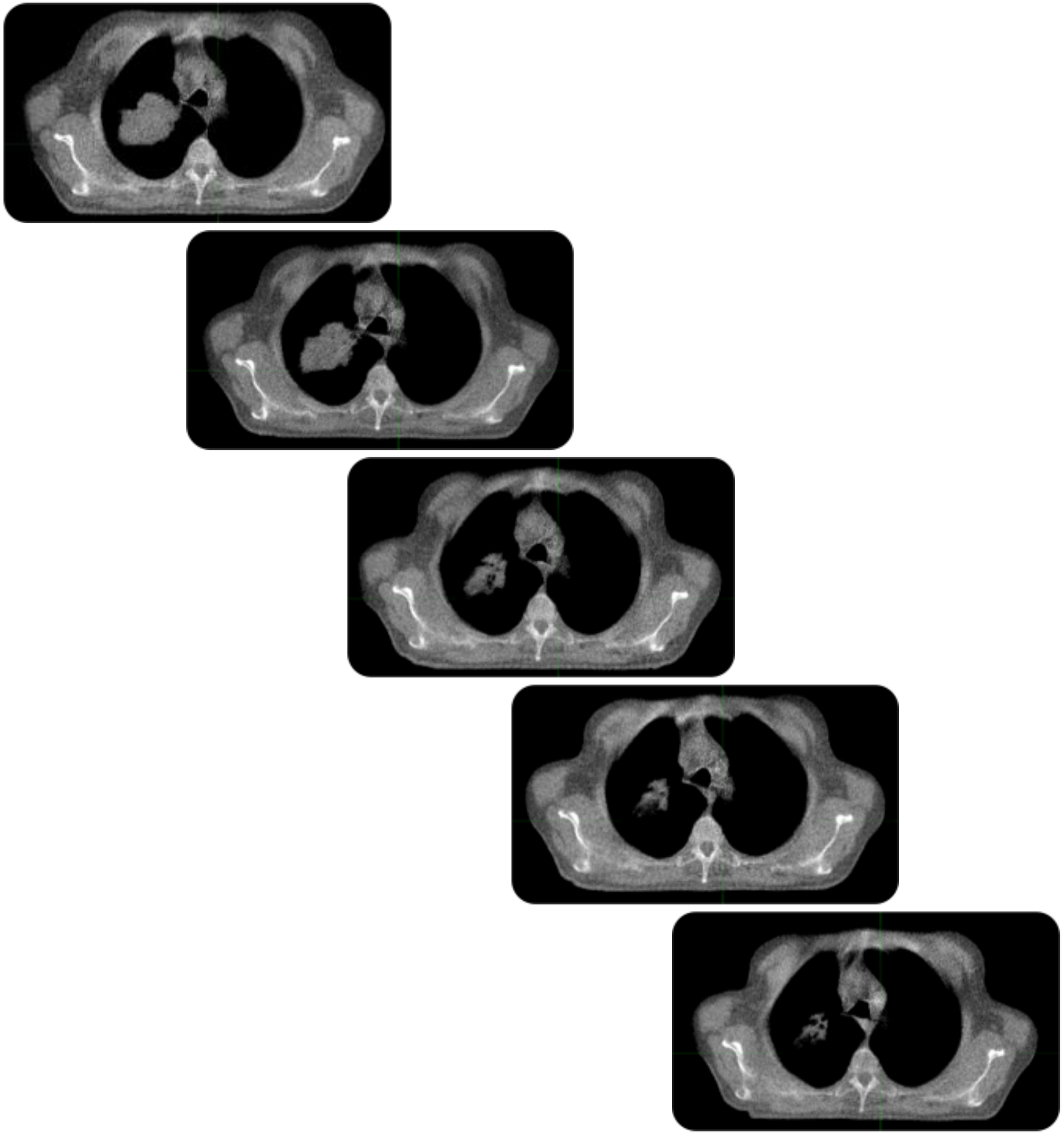




kV planning CT

MVCT





link RT to chemotherapy

- linac breakdown => concommitant chemo
- dose RT
- Patient appointments

link RT to dietists

- communication doctor with dietist
- IGRT/IMRT => less toxicity
  - adaptation of dietary protocols
- RT Dose

link RT to surgeons

- Time between surgery and RT
- Dose (boost)
- MOC (multidisciplinary oncological consult)

Conclusions

- QA doesn’t stop at the border of your department
- QA methods should evolve together with your technology
- QA has clinical, physical and administrative components

Thanks to...

- UZ Brussel physics team