QUALITY ASSURANCE IN RADIOTHERAPY

THERAPY EQUIPMENT

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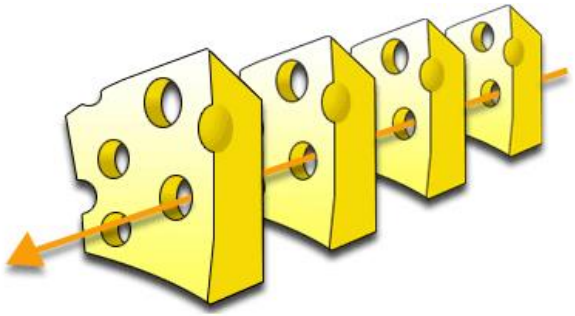
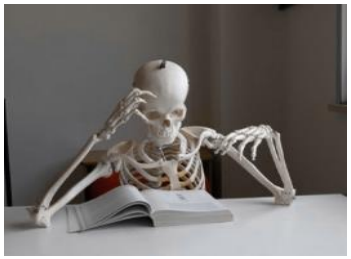


AGENDA

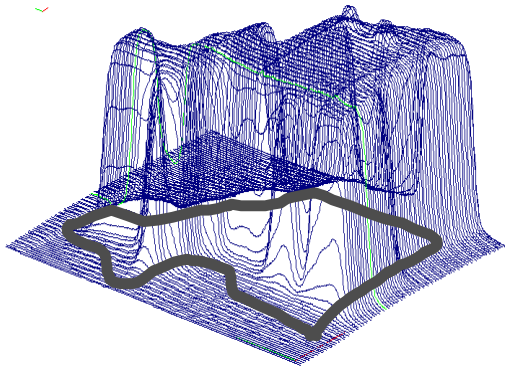
- Overview of the concept
- Documents and guideline
- Evolution of the equipment and of the QA programs
- Doubts and questions

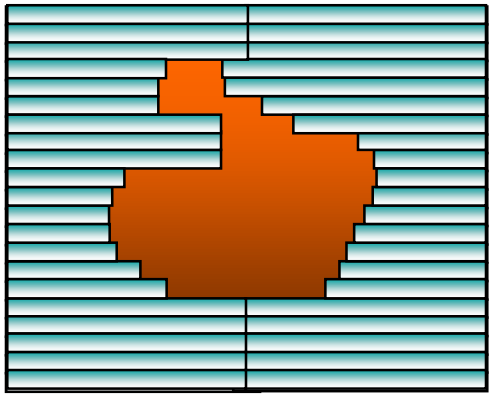
- Today, I will not provide methods for QA and specific tests… you can find multiple way for QA
- ….look into the problems!



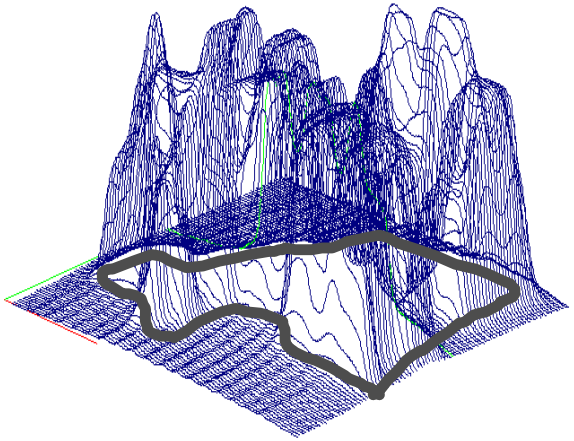
Basic differences in modern Radiation Therapy Delivery

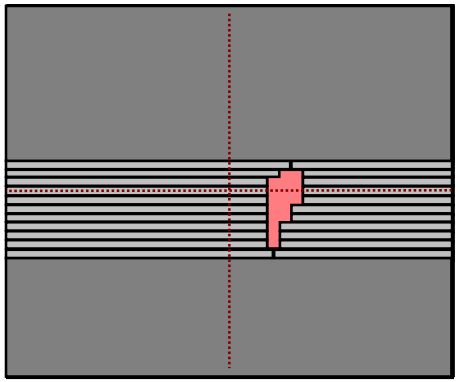
3D-Conformal Radiation Therapy (3D-CRT)

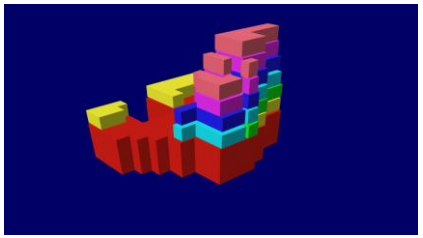




Intensity Modulated Radiation Therapy Volumetric Modulated Radiation Therapy (IMRT/VMAT)

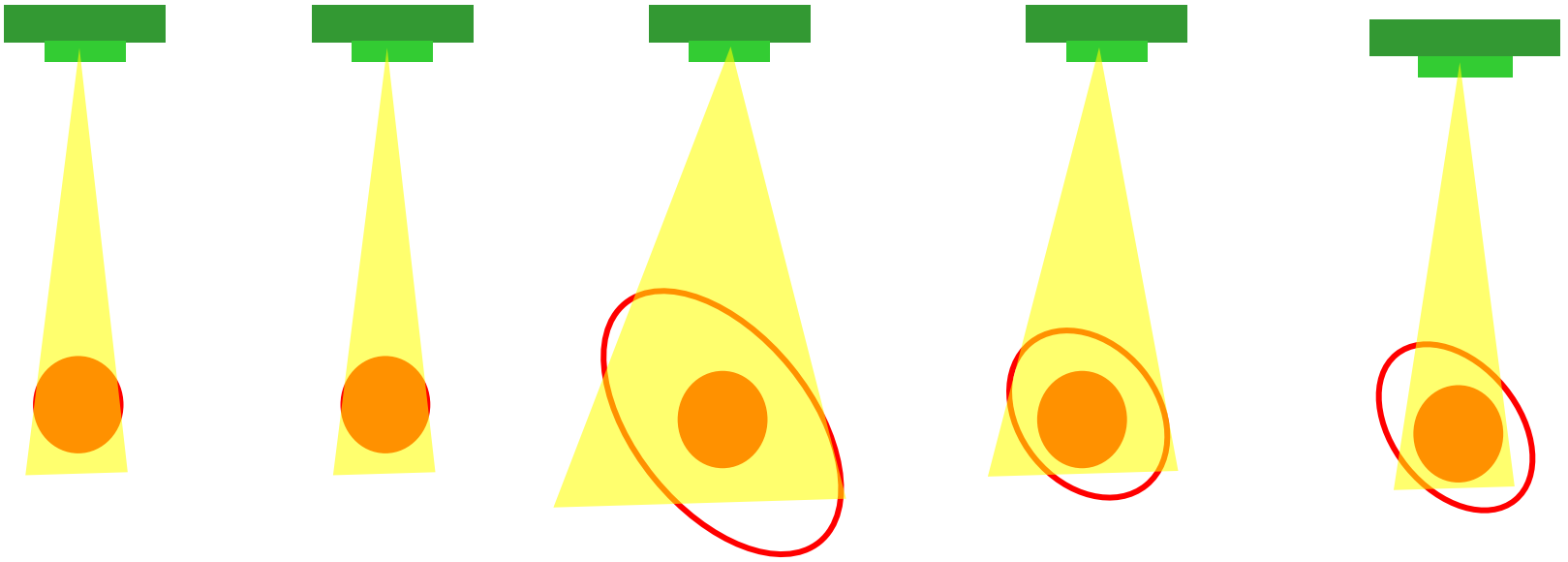






Fluence Map

DEFINE CLINICAL OBJECTIVES AND NEEDS FOR THE FUTURE



3DCRT
Static Target

3DCRT
Dynamic Target
NO Motion evaluation

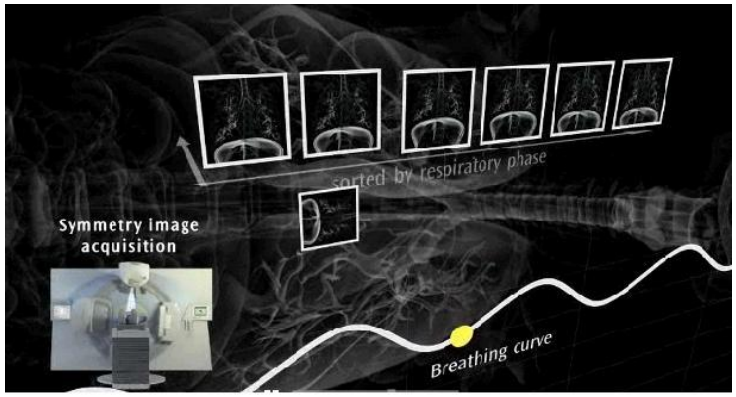
3DCRT
Dynamic Target
4DCT Motion Evaluation (ITV)

"4DRT"
Dynamic Target
4DCT Motion Limitation

Phases beam-on 20-60%
Abdominal Compressor
MIP 4DCT Reconstruction
Deformation analysis
Dose accumulation

4DRT
Dynamic Target
4DRT Technologies

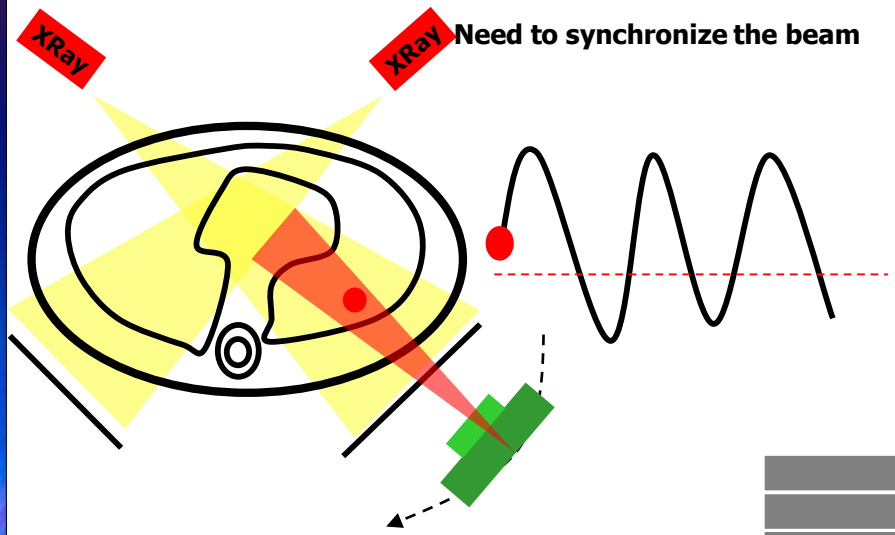
Internal Marker Tracking
Dynamic MLC
Robotic Couch
Organs Motion Compensation
Daily Adaptive RT
DIBH
Deformable Registration
Dose Accumulation



- Reduce margins
- Improve delivery efficacy and efficiency

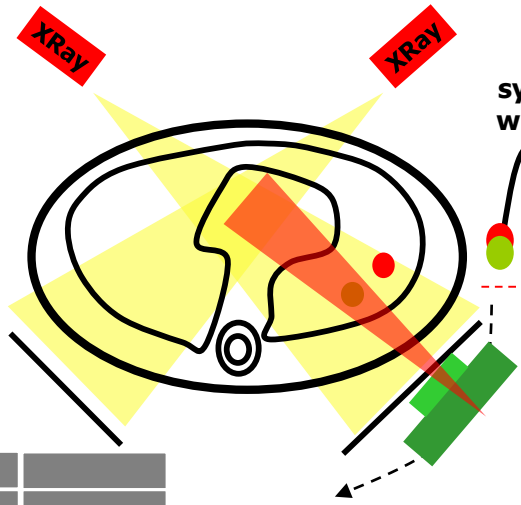
NEW CONCEPT FOR TECHNOLOGY AND TREATMENT

Outside Point Of View

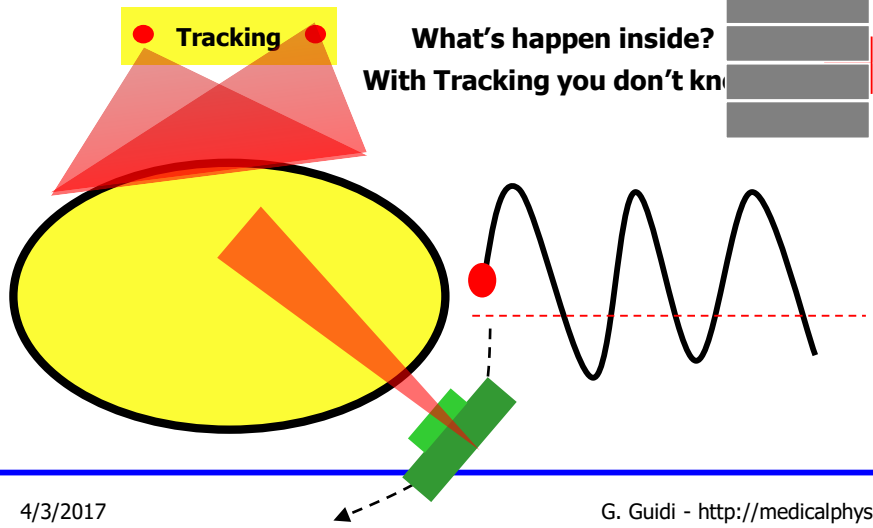


Need to synchronize the beam

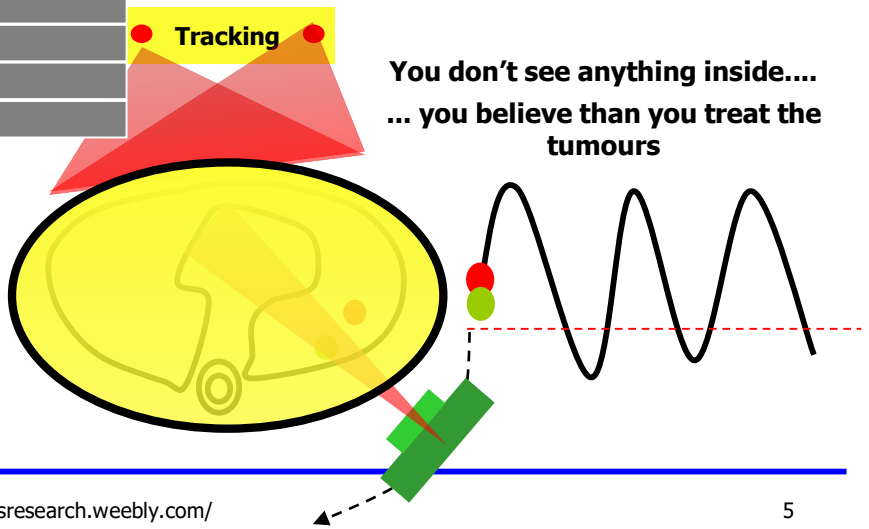
Inside Point Of View



If you lost the synchronization, than you will not treat any tumours

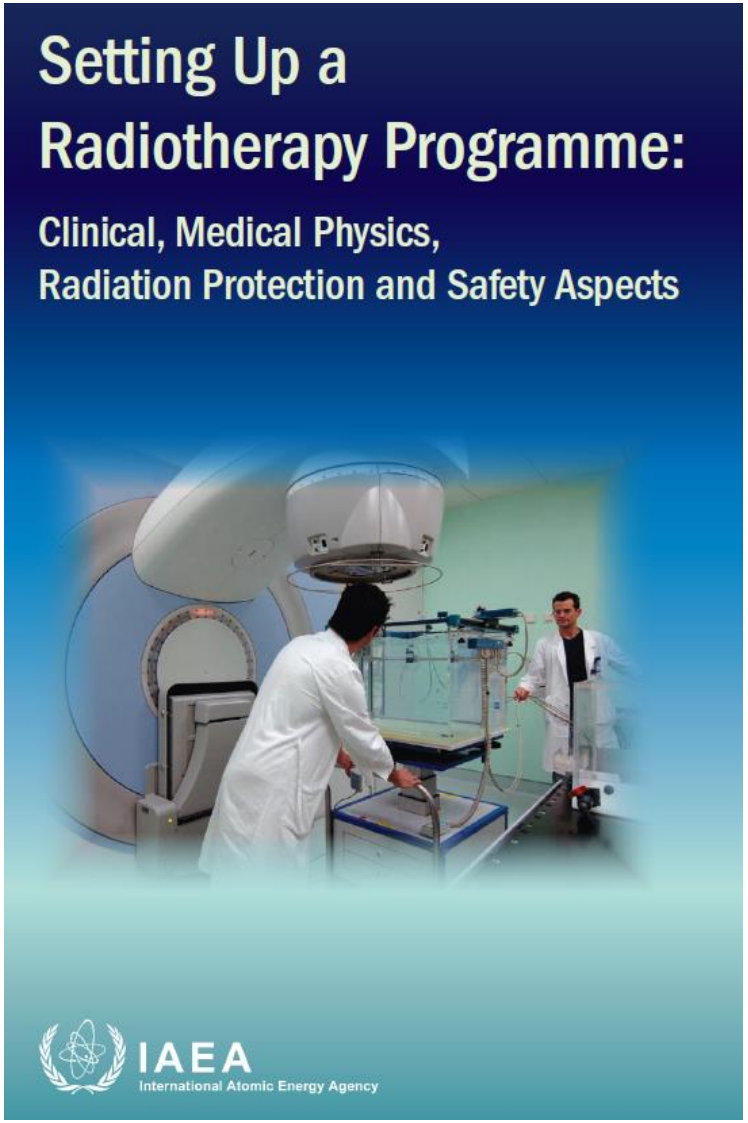


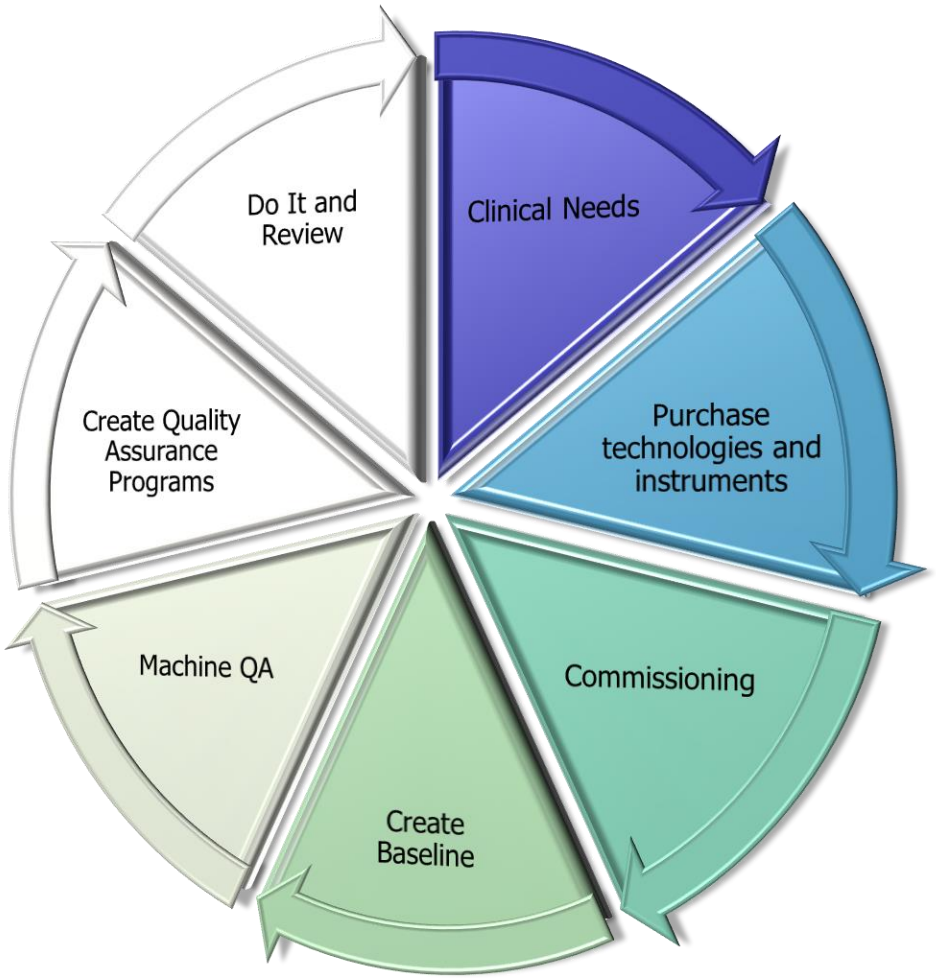
What's happen inside?
With Tracking you don't kn



You don't see anything inside....
... you believe than you treat the tumours

SETUP QA PROGRAMS AND DO IT!!





HAVE A LOOK (STUDY !) OF THE GUIDELINE….
ADJUST BASED ON YOUR REQUIREMENTS…YOU DO NOT NEED TO INVENT!

Safety Reports Series

IAEA

ESTRO

AAPM

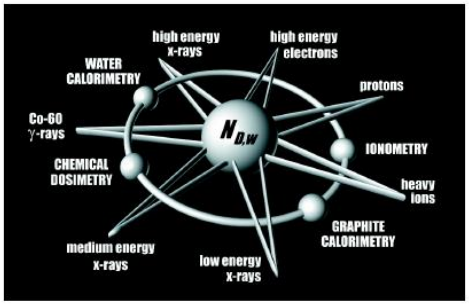
World Health Organization

BIR

IPEM

IAEA TRS-398

Absorbed Dose Determination in External Beam Radiotherapy: An International Code of Practice for Dosimetry based on Standards of Absorbed Dose to Water



Pedro Andreo, Dosimetry and Medical Radiation Physics Section, IAEA
David T Burns, Bureau International des Poids et Measures (BIPM)
Klaus Hohlfeld, Physikalisch-Technische Bundesanstalt (PTB), Braunschweig, Germany
M Saiful Huq, Thomas Jefferson University, Philadelphia, USA
Tatsuaki Kanai, National Institute of Radiological Sciences (NIRS), Chiba, Japan
Fedele Laitano, Ente per le Nuove Tecnologie L'Energia e L'Ambiente (ENEA), Rome, Italy
Vere Smyth, National Radiation Laboratory (NRL), Christchurch, New Zealand
Stefaan Vynckier, Catholic University of Louvain (UCL), Brussels, Belgium

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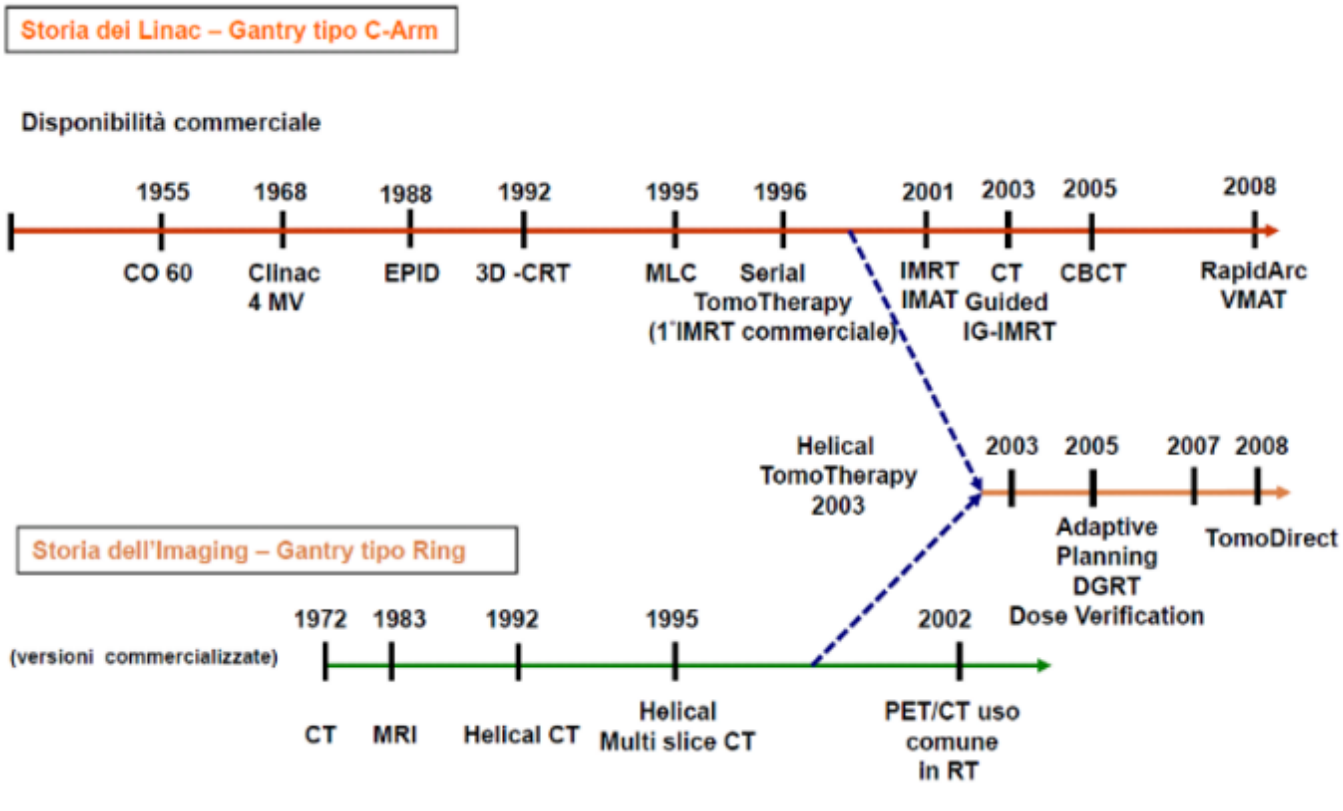
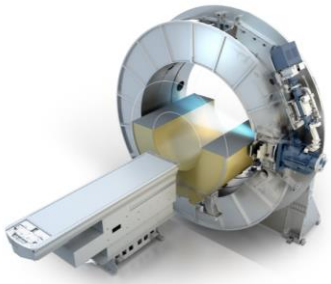
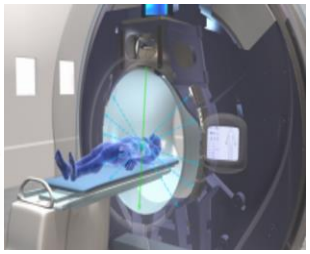
INTERNATIONAL ATOMIC ENERGY AGENCY IAEA

THERAPY : EQUIPMENT'S EVOLUTION



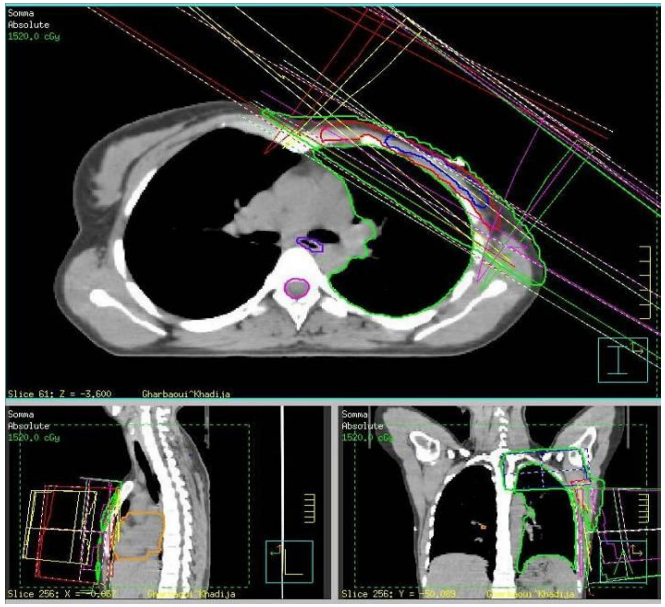


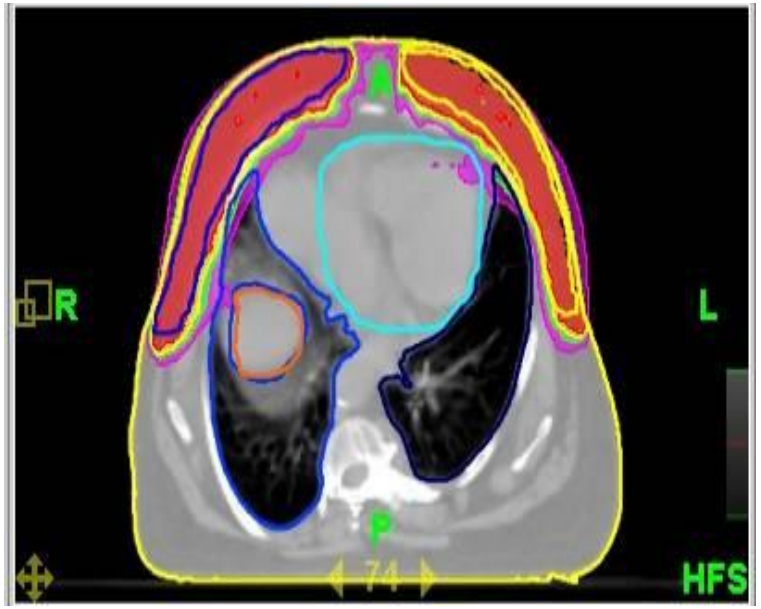


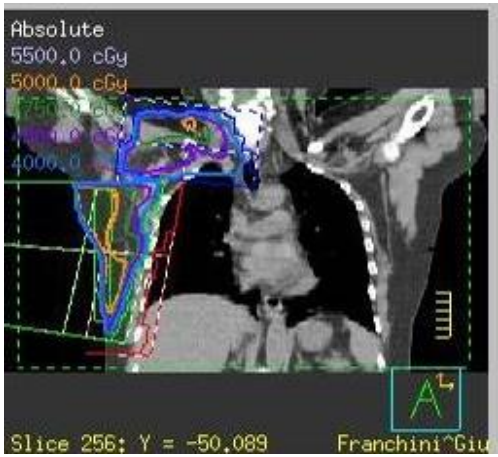
NEXT GENERATION
- **LINAC MRI**
- **LINAC PET**
- **PROTON AND CARBON**
- **…….THERAPY**

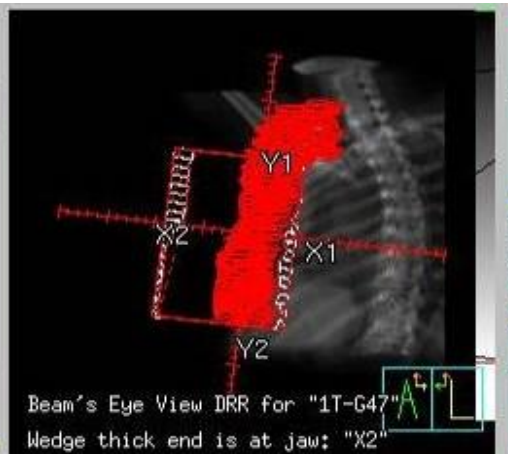
CLINICAL NEEDS

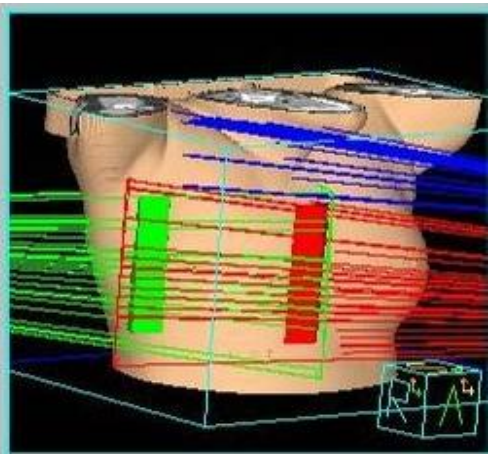
i.e. BREAST, SUPRACLAVEAR BREAST AND BILATERAL BREAST WITH INTERNAL MAMMARY



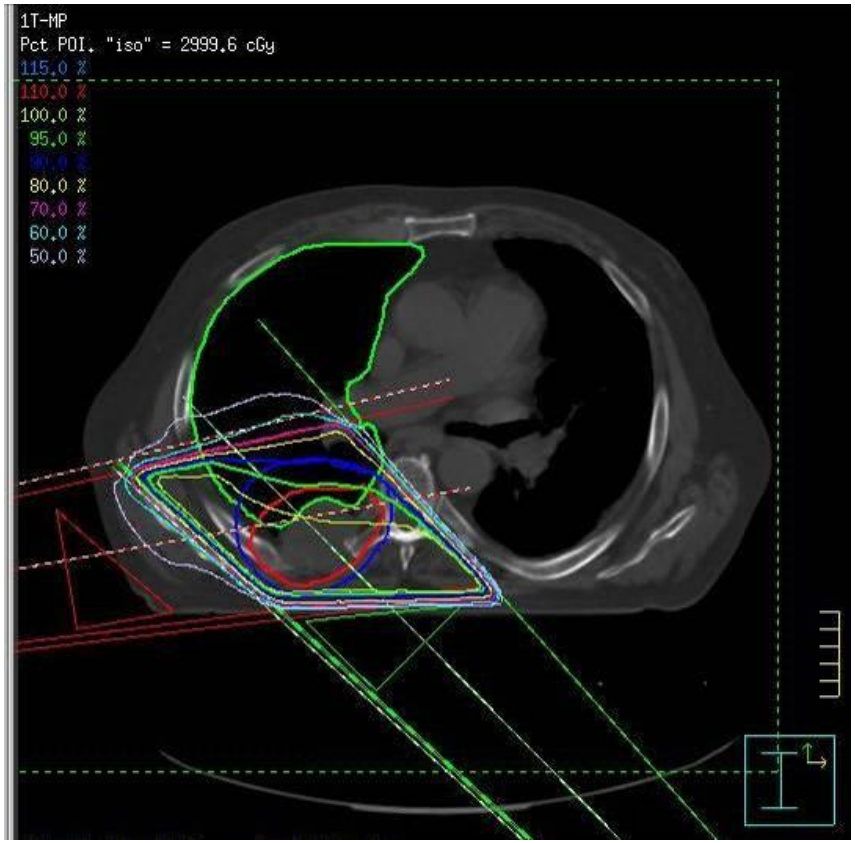


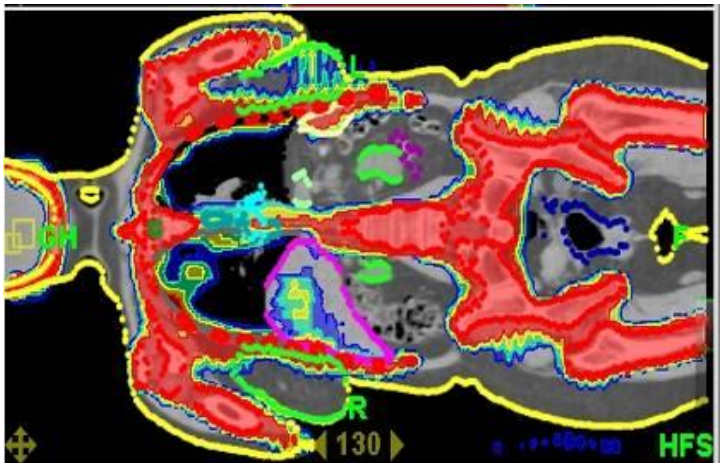


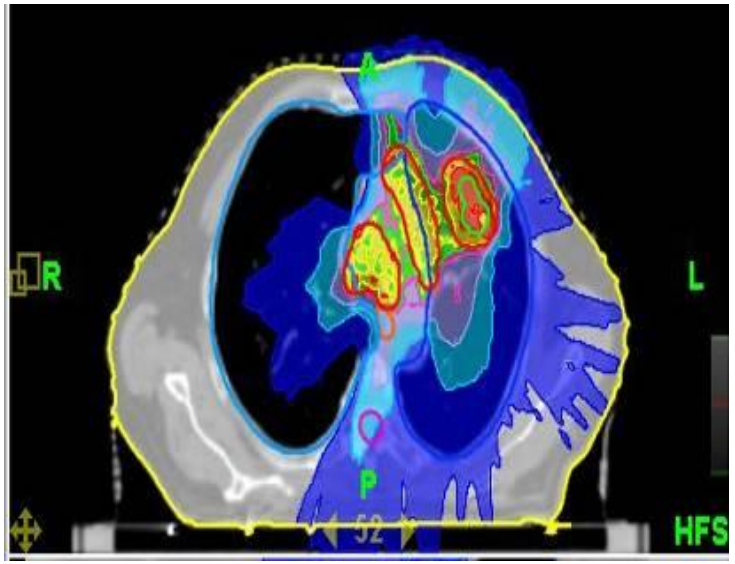




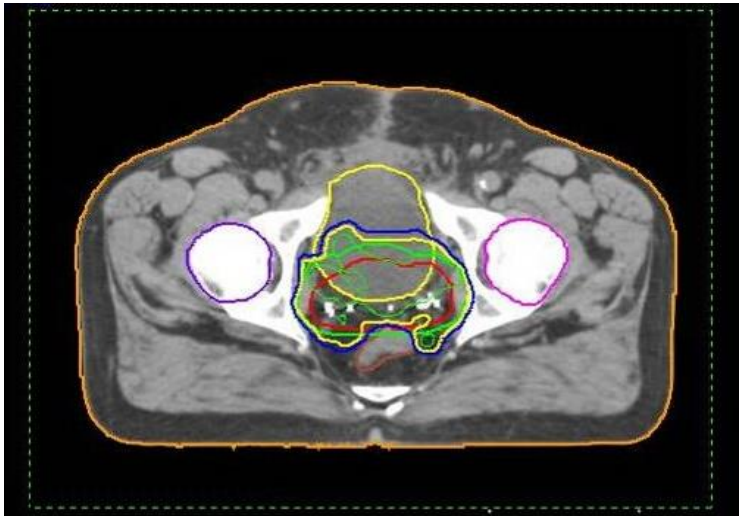
i.e. METS, MULTIPLE LESIONS AND TOTAL LYMPHOID IRRADIATION

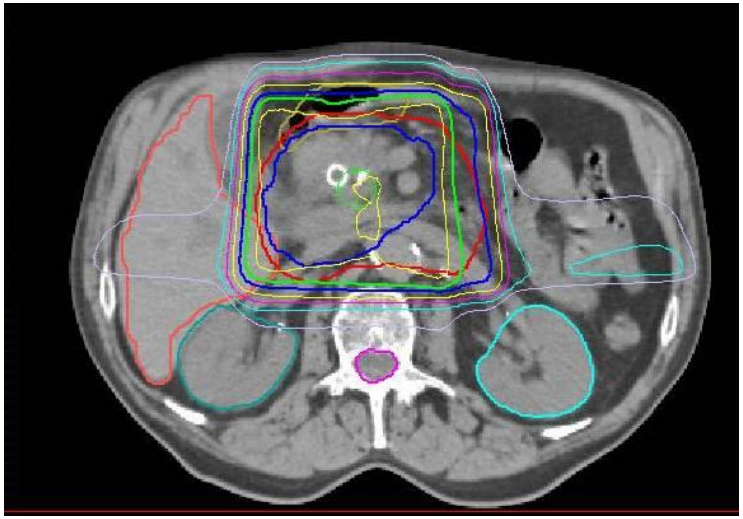


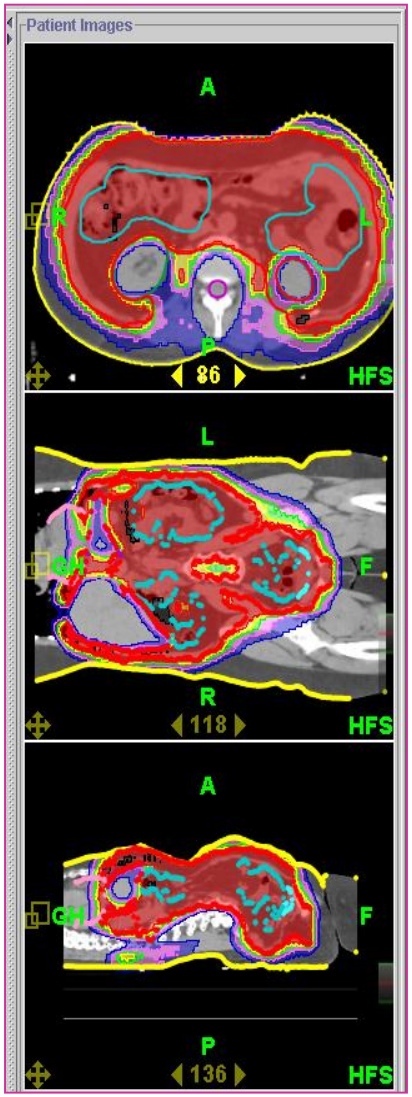


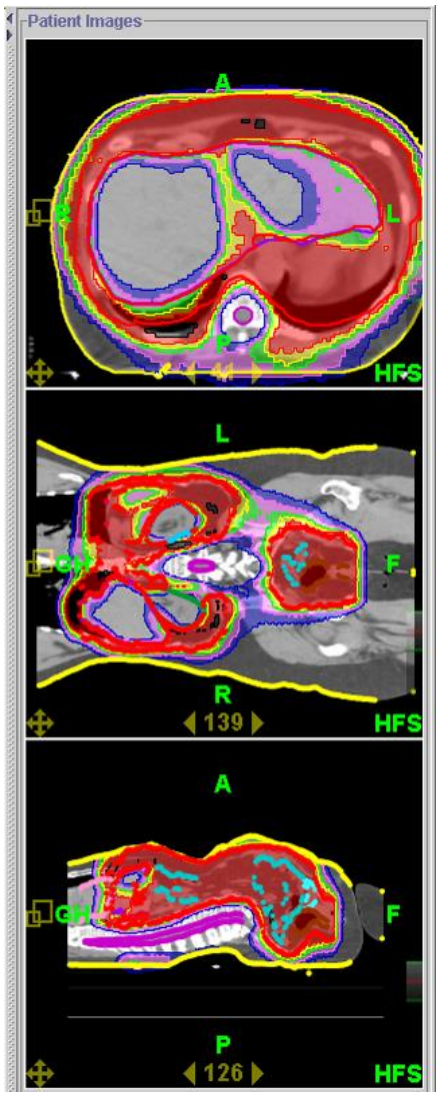


i.e. PROSTATE AND ABDOMINAL LESIONS

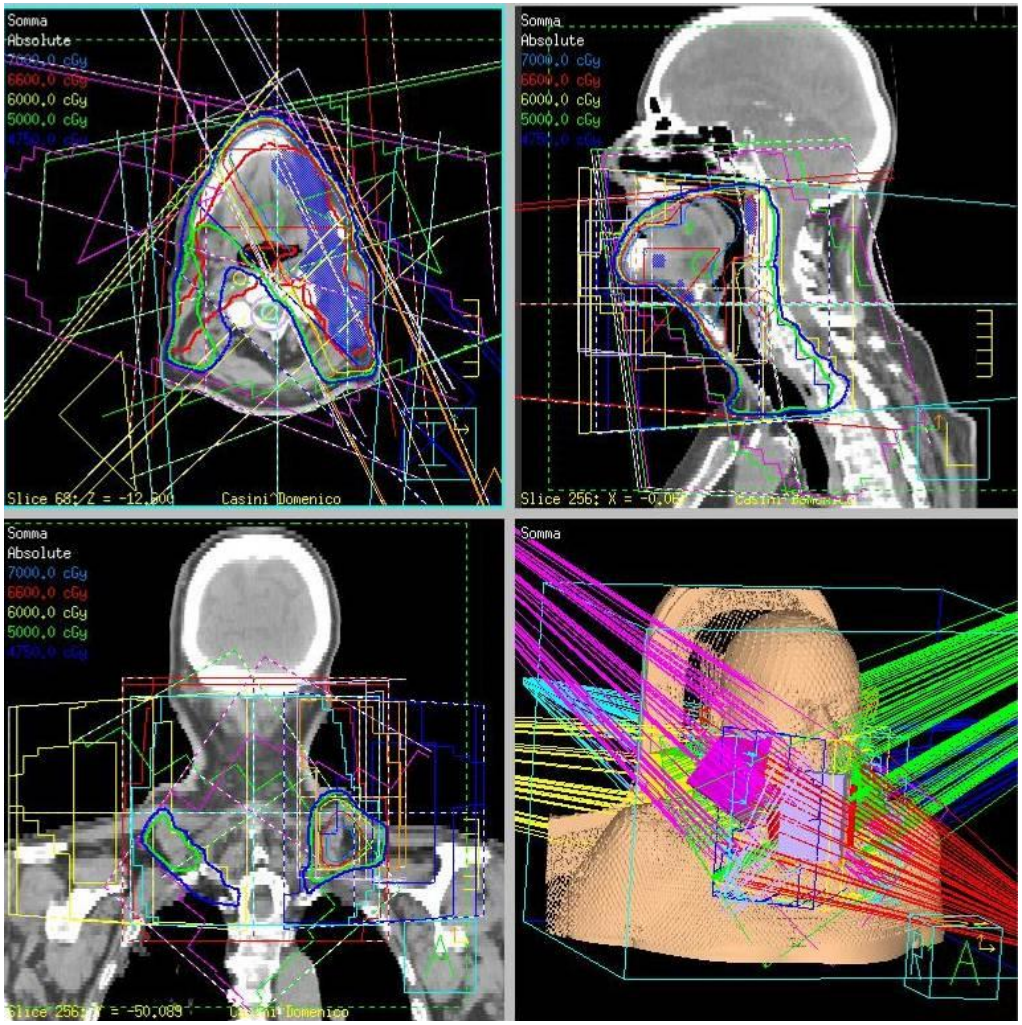


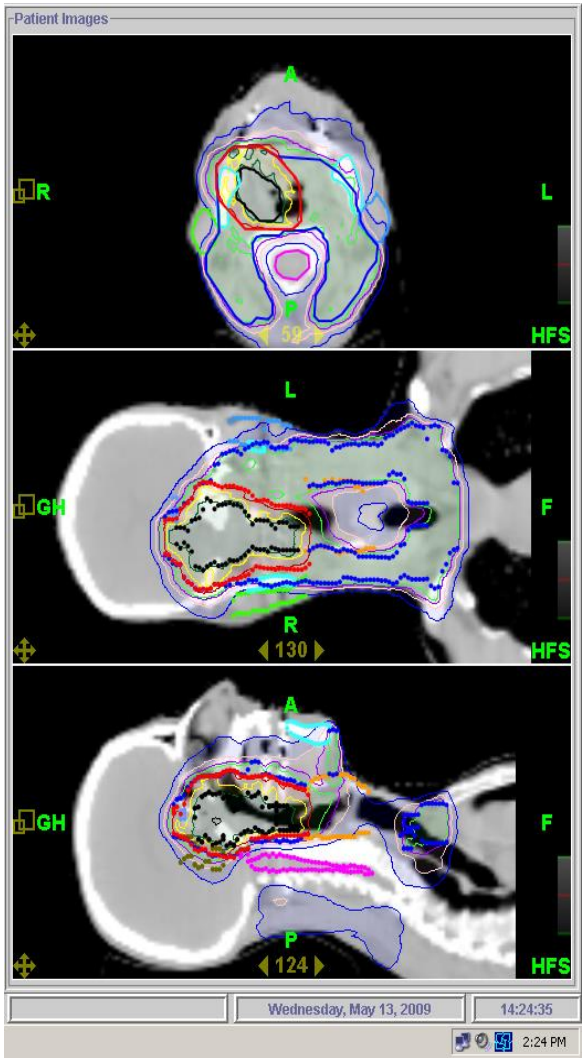




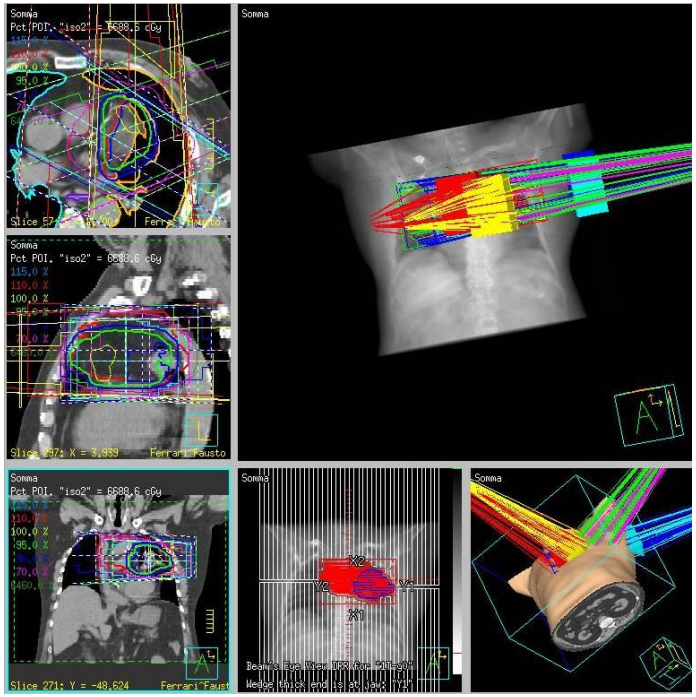
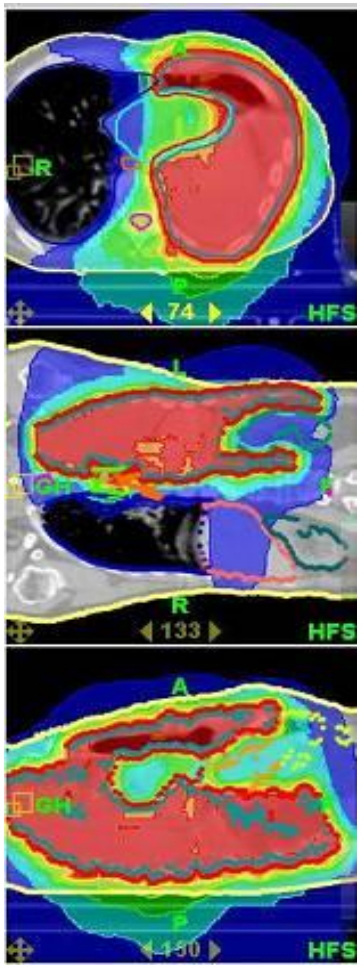


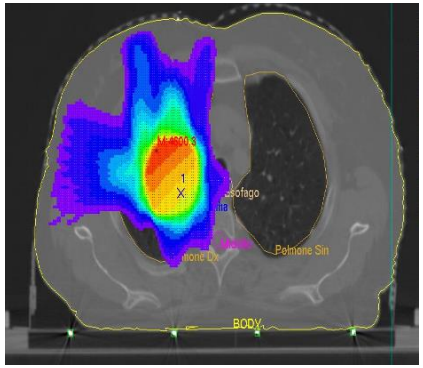
i.e. HEAD&NECK


Somma
Absolute
7000,0 cGy
6600,0 cGy
6000,0 cGy
5000,0 cGy
Slice 68; Z = -12,800
Casini Domenico
Somma
Absolute
7000,0 cGy
6600,0 cGy
6000,0 cGy
5000,0 cGy
Slice 256; X = -0,05
Somma
Absolute
7000,0 cGy
6600,0 cGy
6000,0 cGy
5000,0 cGy
Somma

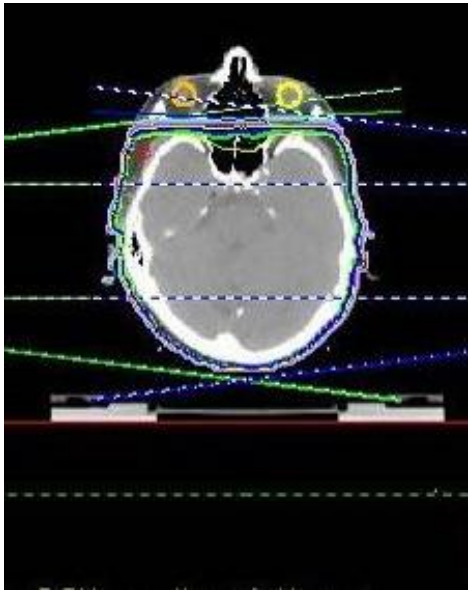

Patient Images
A
R
L
P
HFS
L
GH
F
R
130
HFS
A
GH
F
P
124
HFS
Wednesday, May 13, 2009
14:24:35
2:24 PM

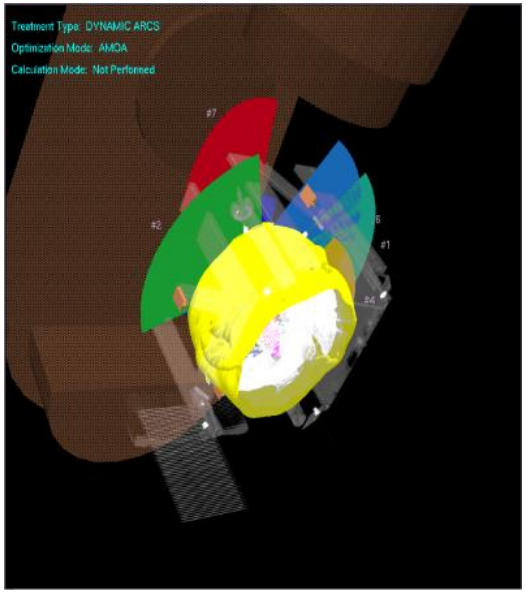
i.e. MESOTHELIOMA AND LUNG LESION

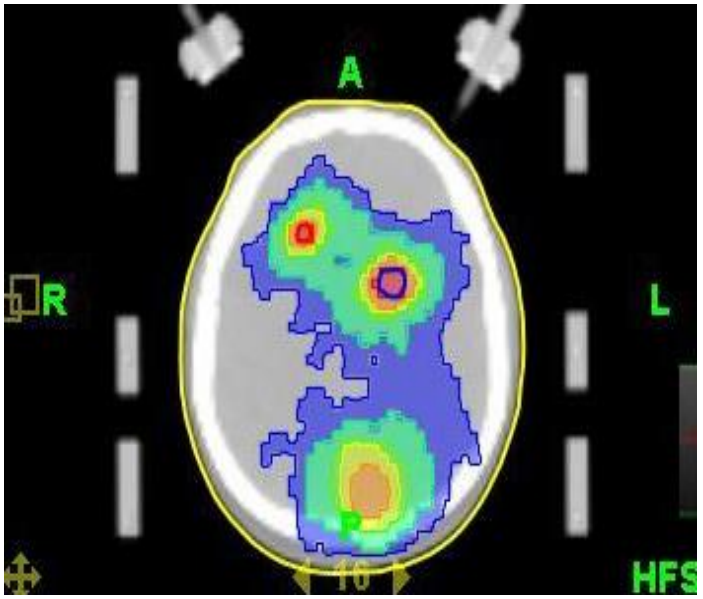




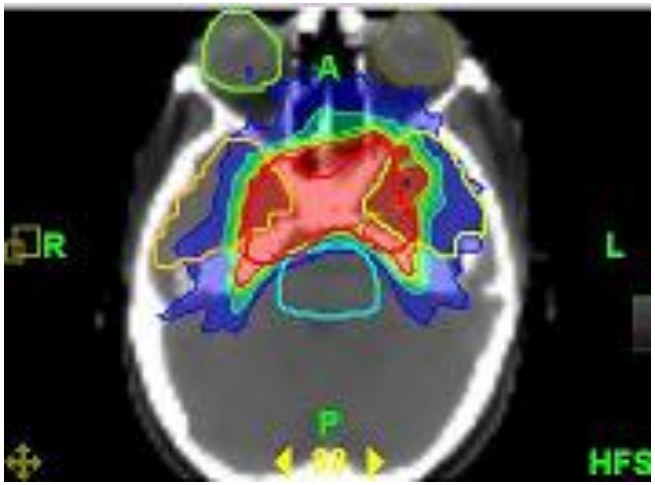


i.e. BRAIN AND RADIOSURGERY

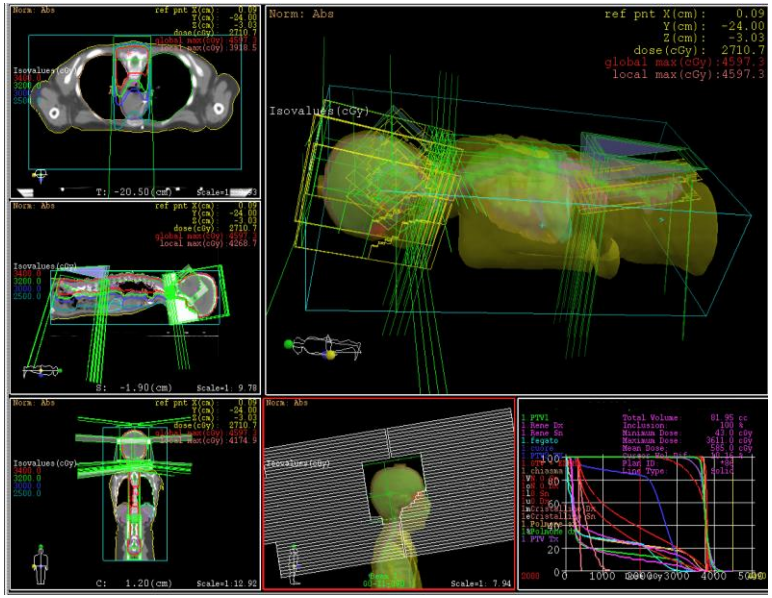


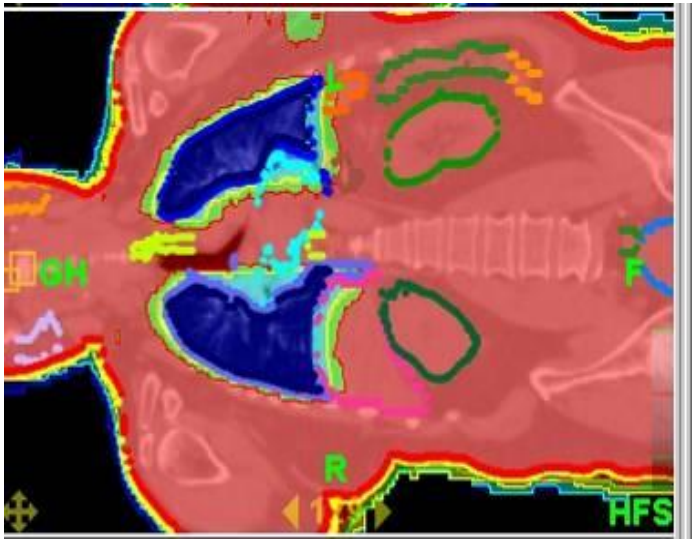


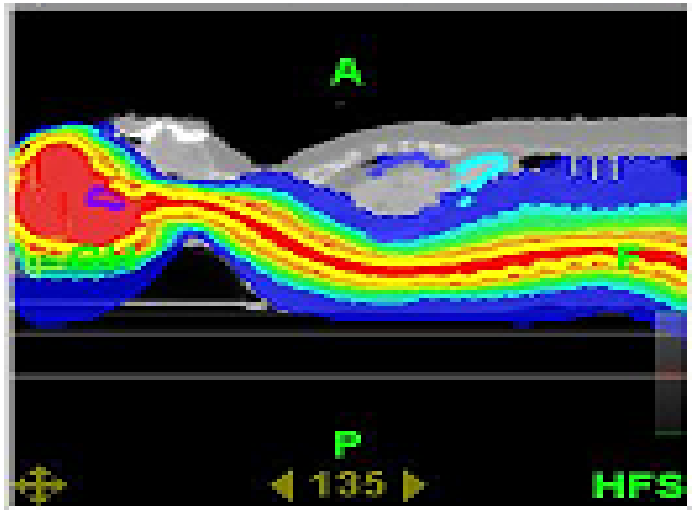




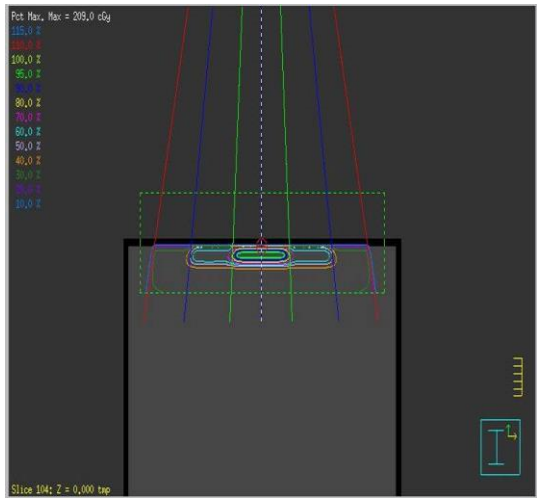
i.e. CRANIO SPINAL IRRADIATION AND TOTAL BODY IRRADIATION

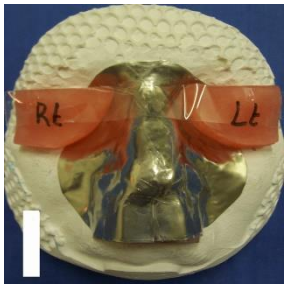


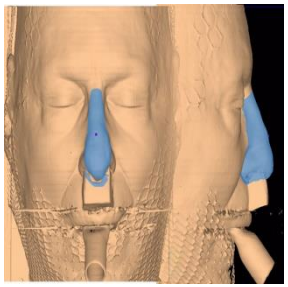




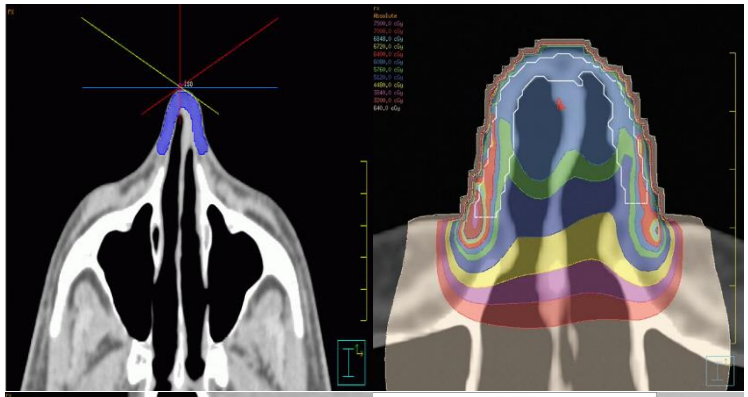
TOTAL SKIN ELECTRON & SKIN IRRADIATION (con Bolus) ….



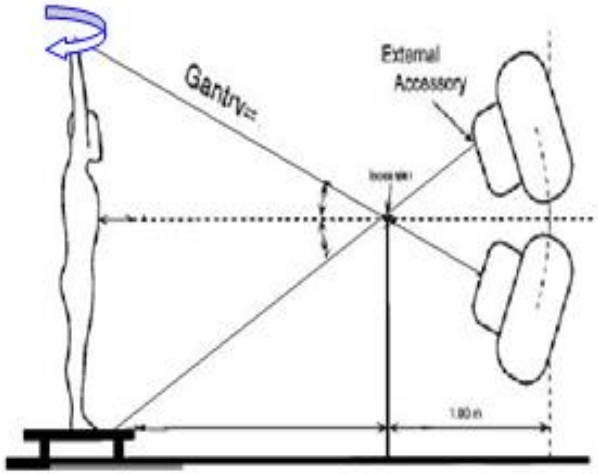


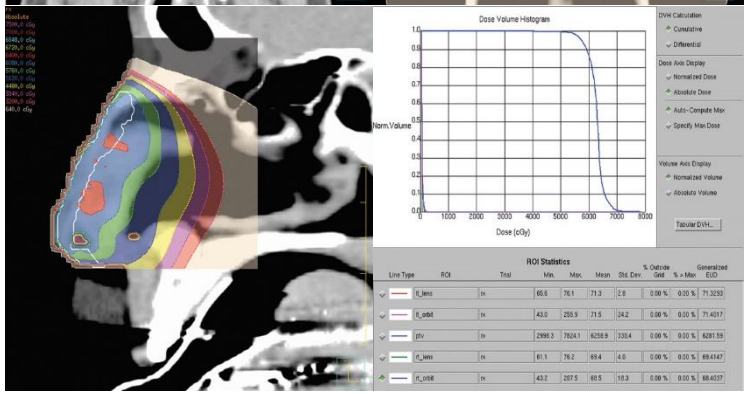


Skin Electron Irradiation (SEI)

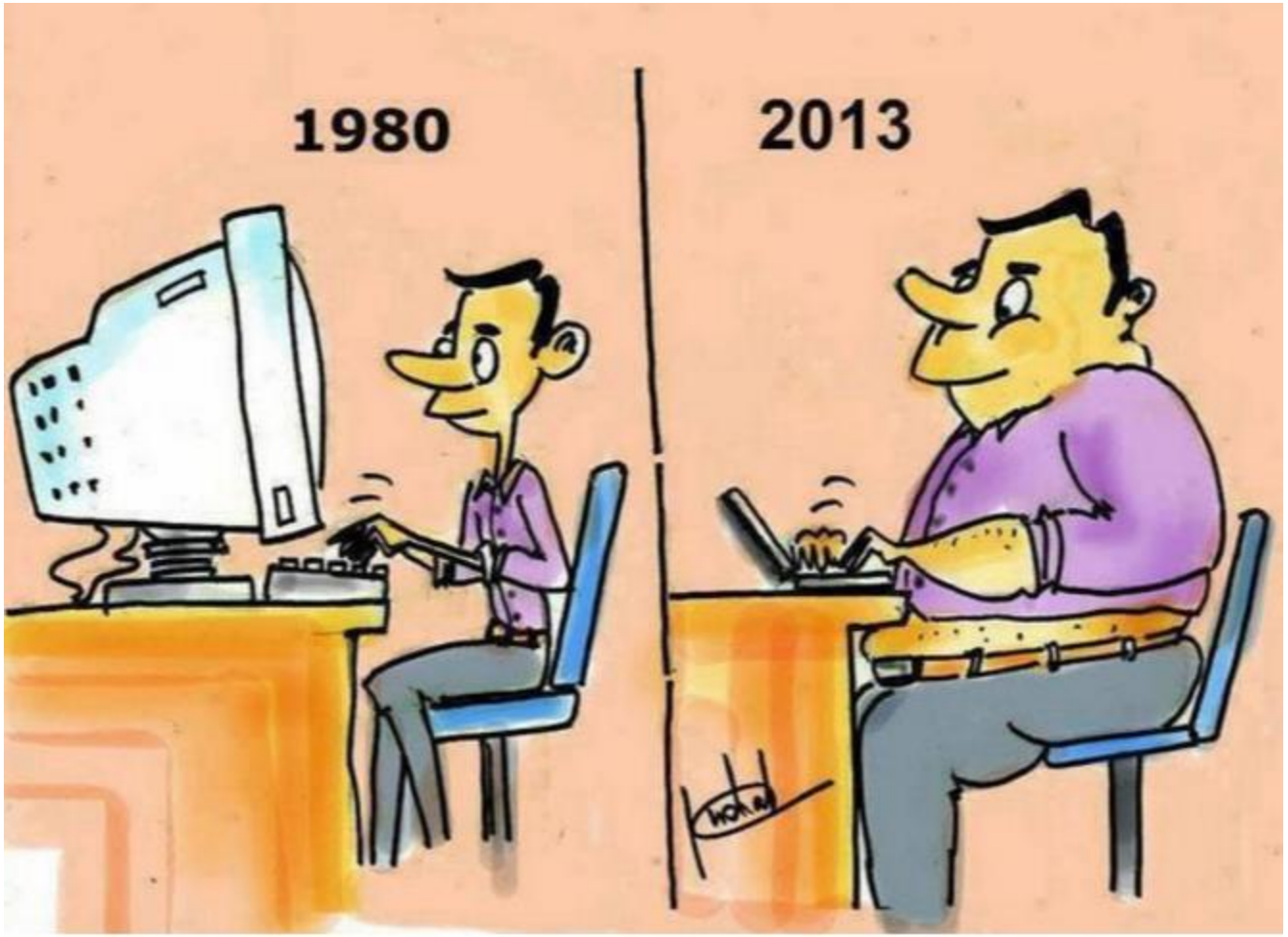


Total Skin Electron Irradiation (TSEI)

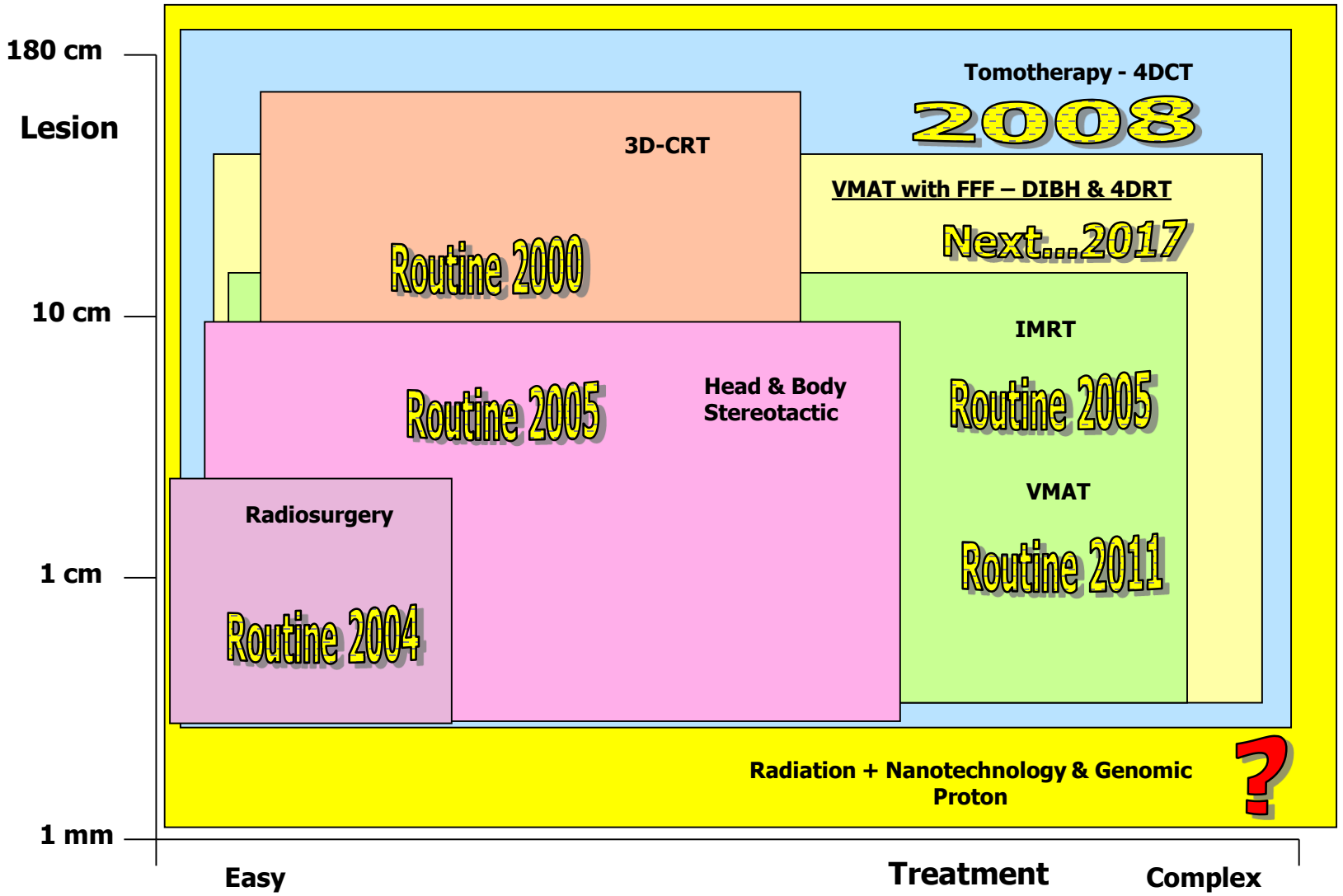




TECHNOLOGY EVOLUTION AND REQUIREMENTS



MODENA RADIATION ONCOLOGY … ROADMAP



2005 - NETWORK AND SYSTEMS

Hospital System

TPS
Treatment Planning System

RADIOSURGERY
(Ergo-3DLine)

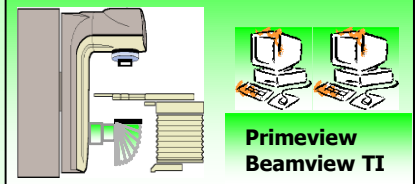
BRACHYTHERAPY
(Nucletron)

PLATO
(Nucletron)

Elekta Precise + aSi + MicroMLC

Desktop RT
iView GT
Ergo MicroMLC

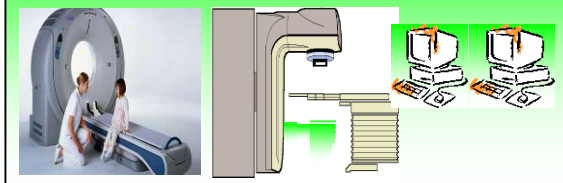
Siemens Primus + BeamviewTI



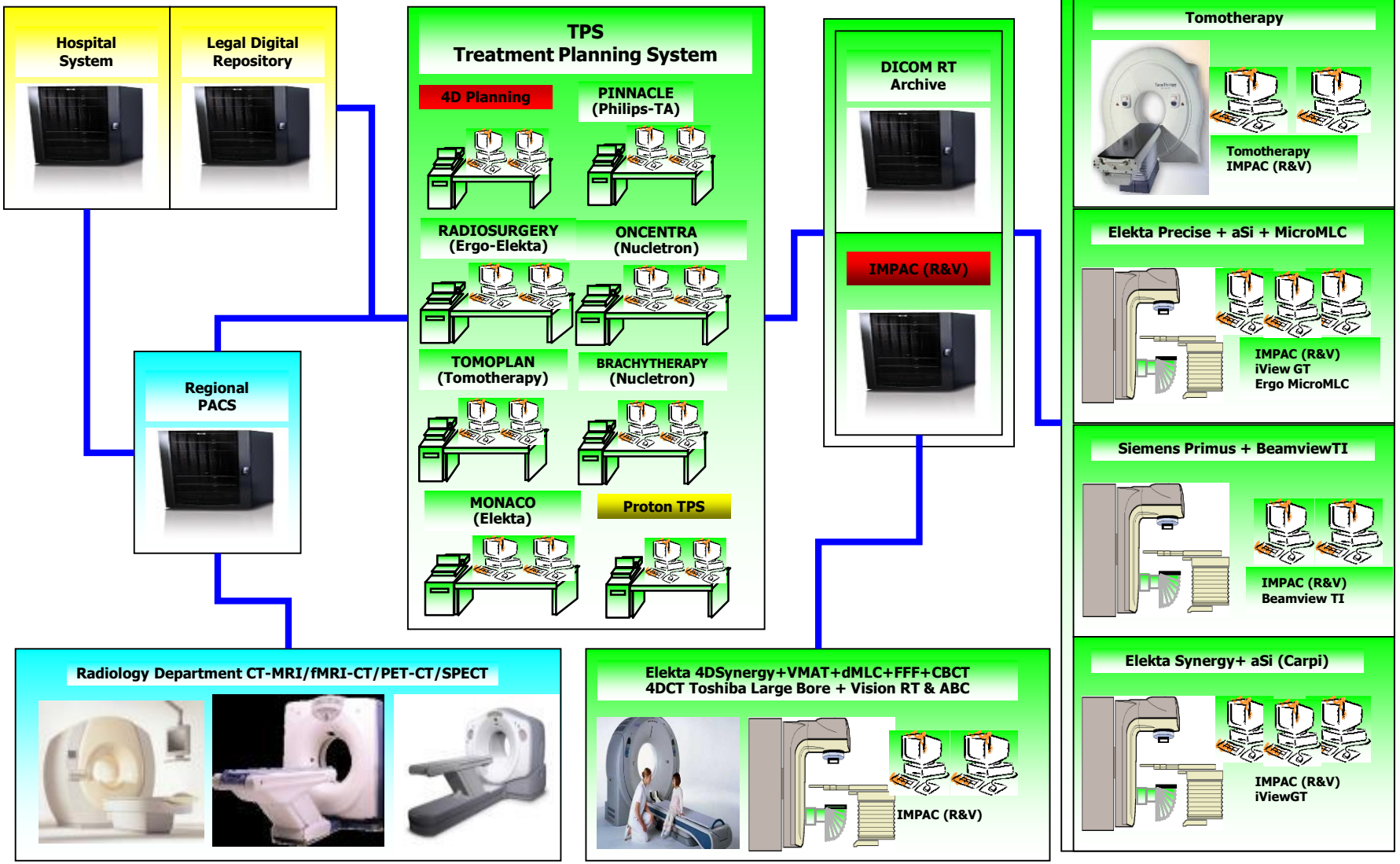
Primeview
Beamview TI

Radiology Department CT-MRI/fMRI

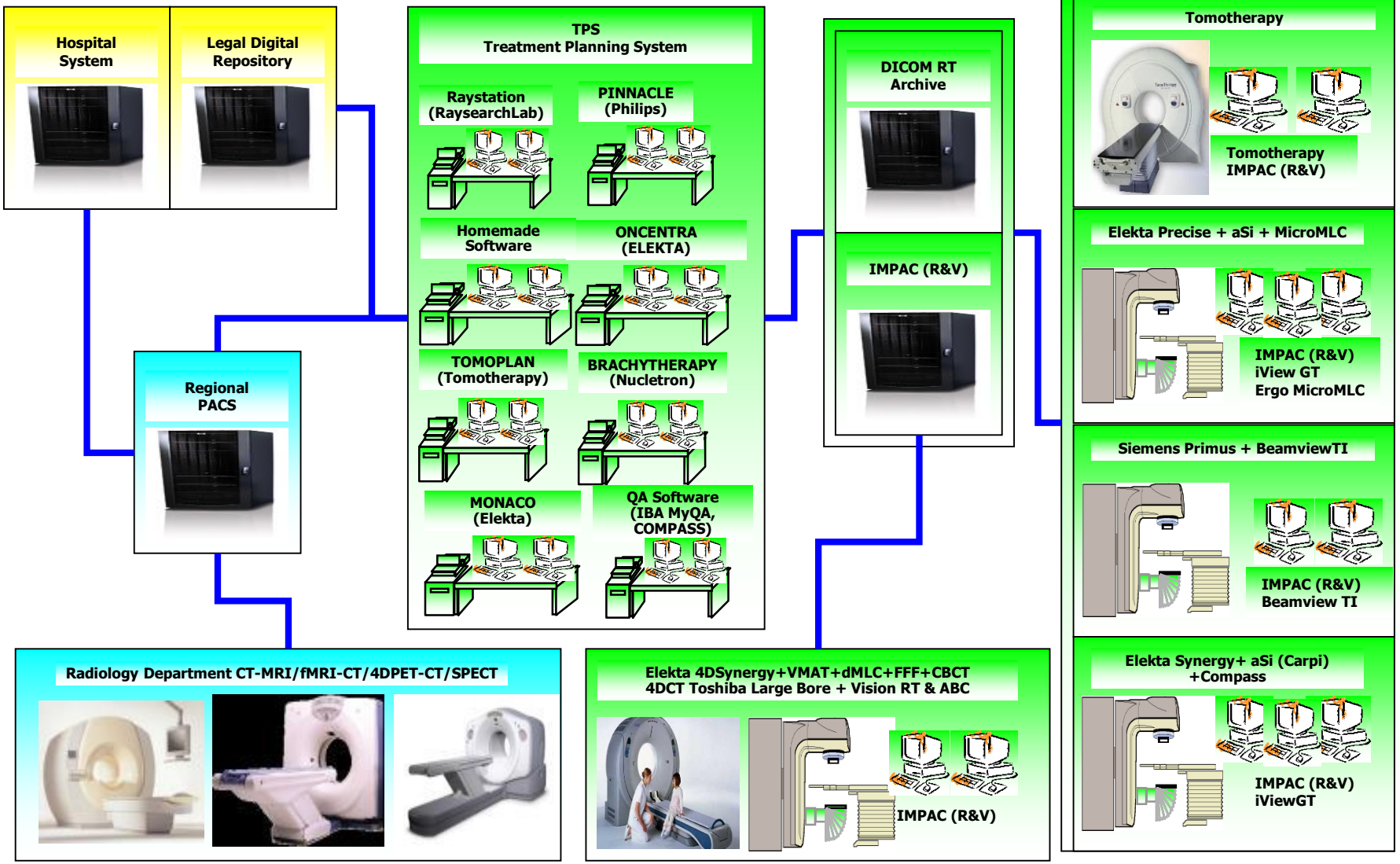
Regenerated CT + Cobalt



2011 - NETWORK AND SYSTEMS



2017 - NETWORK AND SYSTEMS



i.e Guideline for implementation

ESTRO EUROPEAN SOCIETY FOR THERAPEUTIC RADIOLOGY AND ONCOLOGY

ESTRO Booklet 4:

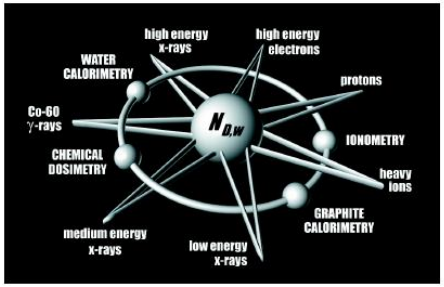
PRACTICAL GUIDELINES FOR THE IMPLEMENTATION OF A QUALITY SYSTEM IN RADIOTHERAPY

A project of the ESTRO Quality Assurance Committee sponsored by 'Europe against Cancer'

Writing party: J W H Leer, A L McKenzie, P Scalliet, D I Thwaites

IAEA TRS-398

Absorbed Dose Determination in External Beam Radiotherapy: An International Code of Practice for Dosimetry based on Standards of Absorbed Dose to Water



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PUBLISHED BY THE IAEA ON BEHALF OF IAEA, WHO, PAHO, AND ESTRO

INTERNATIONAL ATOMIC ENERGY AGENCY IAEA

QA for helical tomotherapy: Report of the AAPM Task Group 148[a)]

Task Group 142 report: Quality assurance of medical accelerators[a)]

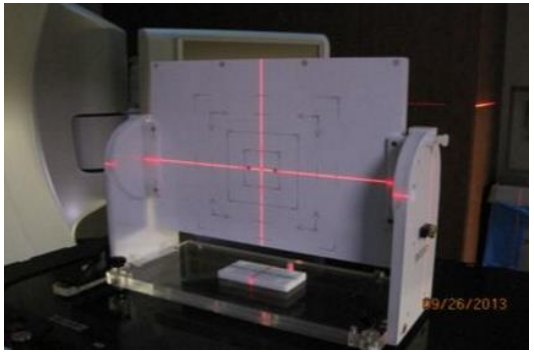
Quality assurance for image-guided radiation therapy utilizing CT-based technologies: A report of the AAPM TG-179

WHICH QA PROGRAMS? WHICH TESTS? i.e…..

- LINAC QA
  - Geometry and mechanical
  - Dosimetric
  - MLC
  - Safety and collision
  - Imaging
  - EPID/ CBCT
  - Couch
- Radiosurgery
  - Positioning (frame vs. frameless)
  - Accuracy
  - Rotational of gantry and collimator
- SBRT
  - Positioning (frame vs. frameless)
  - Accuracy
  - Rotational of gantry and collimator
- IMRT
  - Penumbra
  - Inter/interleafs
  - MLC Interdigitation
- VMAT
  - MLC Interdigitation
  - Leafs speed
  - Doserate
- Different Therapy
  - Low Doserate/Low MU
  - Low Dosedose/High MU
  - High Doserate/Low MU
  - High doserate /High MU

- 4D Therapy
  - Breath synch
  - Beam on/off and delivery (DIBH)
  - Ramp-up of the beam-on
- Gantry rotation speed
  - Constant
  - Variable
- Doserate
  - Constant
  - Variable
  - Discrete
- Complete procedure after interruption
  - 3DCRT
  - IMRT
  - dMLC or Sliding Windows
  - VMAT
  - Radiosurgery
  - SBRT
- Isocenter junction
  - Junction of the beam and divergence
- Non-Homogeneity condition
  - Cerrobend Block?
  - Tray
  - Real-time monitor systems
- Log files analysis
- Unpredictable cases (near missing or errors)
- Connectivity with IOS
- …….

Task Group 142 report: Quality assurance of medical accelerators[a)]



i.e. LINAC QA

CQ-ACCELERATORI LINEARI LINAC

DEFINE TOLERANCE …..

Procedure	Machine-type tolerance		
	Non-IMRT	IMRT	SRS/SBRT
Dosimetry			
X-ray output constancy Electron output constancy Backup monitor chamber constancy		2%	
Typical dose rate[a] output constancy	NA	2% (@ IMRT dose rate)	2% (@ stereo dose rate, MU)
Photon beam profile constancy		1%	
Electron beam profile constancy		1%	
Electron beam energy constancy		2%/2 mm	
Mechanical			
Light/radiation field coincidence[b]		2 mm or 1% on a side	
Light/radiation field coincidence[b] (asymmetric)		1 mm or 1% on a side	
Distance check device for lasers compared with front pointer		1mm	
Gantry/collimator angle indicators (@ cardinal angles) (digital only)		1.0°	
Accessory trays (i.e., port film graticle tray)		2 mm	
Jaw position indicators (symmetric)[c]		2 mm	
Jaw position indicators (asymmetric)[d]		1 mm	
Cross-hair centering (walkout)		1 mm	
Treatment couch position indicators[e]	2 mm/1°	2 mm/1°	1 mm/0.5°
Wedge placement accuracy		2 mm	
Compensator placement accuracy[f]		1 mm	
Latching of wedges, blocking tray[g]		Functional	
Localizing lasers	±2 mm	±1 mm	< ± 1 mm
Safety			
Laser guard-interlock test		Functional	
Respiratory gating			
Beam output constancy		2%	
Phase, amplitude beam control		Functional	
In-room respiratory monitoring system		Functional	
Gating interlock		Functional	

MAKE SENSE WITH NEW TECHNIQUES AND TECHNOLOGIES ? OR ARE YOU LOOKING FOR UNCOMMON ERRORS OR IMPROPER PATIENTS POSITIONS?

DEFINE FREQUENCY AND PARAMETERS

TABLE III. Annual.

Procedure	Machine-type tolerance		
	Non-IMRT	IMRT	SRS/SBRT
Dosimetry			
X-ray flatness change from baseline		1%	
X-ray symmetry change from baseline		±1%	
Electron flatness change from baseline		1%	
Electron symmetry change from baseline		±1%	
SRS arc rotation mode (range: 0.5–10 MU/deg)	NA	NA	Monitor units set vs delivered: 1.0 MU or 2% (whichever is greater) Gantry arc set vs delivered: 1.0° or 2% (whichever is greater)
X-ray/electron output calibration (TG-51)		±1% (absolute)	
Spot check of field size dependent output factors for x ray (two or more FSs)		2% for field size $<4\times4$ cm², 1% $\geq4\times4$ cm²	
Output factors for electron applicators (spot check of one applicator/energy)		±2% from baseline	
X-ray beam quality (PDD_{10} or TMR_{10}^{20})		±1% from baseline	
Electron beam quality (R_{50})		±1 mm	
Physical wedge transmission factor constancy		±2%	
X-ray monitor unit linearity (output constancy)	±2% ≥5 MU	±5% (2–4 MU), ±2% ≥5 MU	±5% (2–4 MU), ±2% ≥5 MU
Electron monitor unit linearity (output constancy)		±2% ≥5 MU	
X-ray output constancy vs dose rate		±2% from baseline	
X-ray output constancy vs gantry angle		±1% from baseline	
Electron output constancy vs gantry angle		±1% from baseline	
Electron and x-ray off-axis factor constancy vs gantry angle		±1% from baseline	
Arc mode (expected MU, degrees)		±1% from baseline	
TBI/TSET mode		Functional	
PDD or TMR and OAF constancy		1% (TBI) or 1 mm PDD shift (TSET) from baseline	
TBI/TSET output calibration		2% from baseline	
TBI/TSET accessories		2% from baseline	
Mechanical			
Collimator rotation isocenter		±1 mm from baseline	
Gantry rotation isocenter		±1 mm from baseline	
Couch rotation isocenter		±1 mm from baseline	
Electron applicator interlocks		Functional	
Coincidence of radiation and mechanical isocenter	±2 mm from baseline	±2 mm from baseline	±1 mm from baseline
Table top sag		2 mm from baseline	
Table angle		1°	
Table travel maximum range movement in all directions		±2 mm	
Stereotactic accessories, lockouts, etc.	NA	NA	Functional
Safety			
Follow manufacturer's test procedures		Functional	
Respiratory gating			
Beam energy constancy		2%	
Temporal accuracy of phase/amplitude gate on		100 ms of expected	
Calibration of surrogate for respiratory phase/amplitude		100 ms of expected	
Interlock testing		Functional	

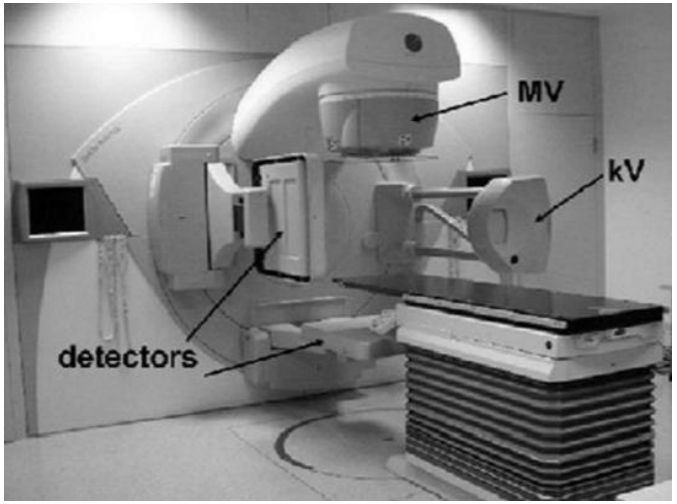
Could be better, split it?
Obviously increase the probability of error detected, but could increase the probability of inappropriate calibration

IMAGING QA

Procedure	Application-type tolerance: non-SRS/SBRT	Application-type tolerance: SRS/SBRT
Daily[a]		
Planar kV and MV (EPID) imaging		
Collision interlocks	Functional	Functional
Positioning/repositioning	≤2 mm	≤1 mm
Imaging and treatment coordinate coincidence (single gantry angle)	≤2 mm	≤1 mm
Cone-beam CT (kV and MV)		
Collision interlocks	Functional	Functional
Imaging and treatment coordinate coincidence	≤2 mm	≤1 mm
Positioning/repositioning	≤1 mm	≤1 mm
Monthly		
Planar MV imaging (EPID)		
Imaging and treatment coordinate coincidence (four cardinal angles)	≤2 mm	≤1 mm
Scaling[b]	≤2 mm	≤2 mm
Spatial resolution	Baseline[c]	Baseline
Contrast	Baseline	Baseline
Uniformity and noise	Baseline	Baseline
Planar kV imaging[d]		
Imaging and treatment coordinate coincidence (four cardinal angles)	≤2 mm	≤1 mm
Scaling	≤2 mm	≤1 mm
Spatial resolution	Baseline	Baseline
Contrast	Baseline	Baseline
Uniformity and noise	Baseline	Baseline
Cone-beam CT (kV and MV)		
Geometric distortion	≤2 mm	≤1 mm
Spatial resolution	Baseline	Baseline
Contrast	Baseline	Baseline
HU constancy	Baseline	Baseline
Uniformity and noise	Baseline	Baseline
Annual (A)		
Planar MV imaging (EPID)		
Full range of travel SDD	±5 mm	±5 mm
Imaging dose[e]	Baseline	Baseline
Planar kV imaging		
Beam quality/energy	Baseline	Baseline
Imaging dose	Baseline	Baseline
Cone-beam CT (kV and MV)		
Imaging dose	Baseline	Baseline

We are doing daily imaging of the patients for setup purpose and Adaptive RT purpose, which is the best frequency of my QA?

…i.e. QA FOR TREATMENT MACHINE USING FLAT PANEL



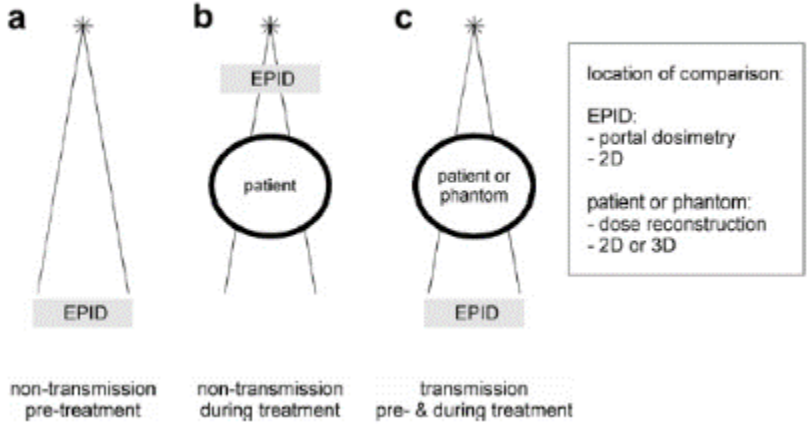


Table 2
List of key references on non-transmission based dose verification methods

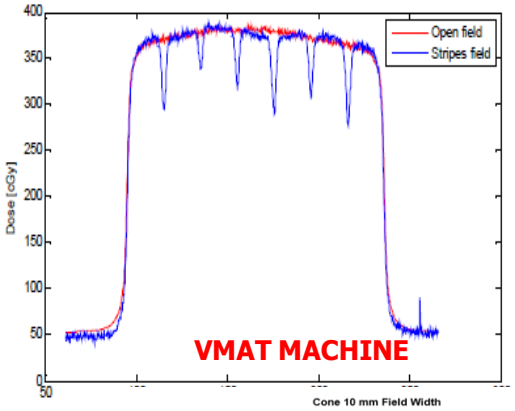
Verification procedure	Type of verification	Key references	Objective of verification or subject of the study
QA of treatment machine	QA	Prisciandaro [93]	Radiation-light field congruence
	QA	Dirkx [52,53], Budgell [80,87]	Linac output, beam profile flatness and symmetry
	QA	Baker [84], Yang [95], Samant [96], Parent [97]	MLC leaf position for step-and-shoot fields
	QA	Vieira [86]	MLC leaf position and absolute output for low MU segmented fields
	QA	Vieira [98], Partridge [99], Chang [88]	MLC leaf position during dynamic treatment

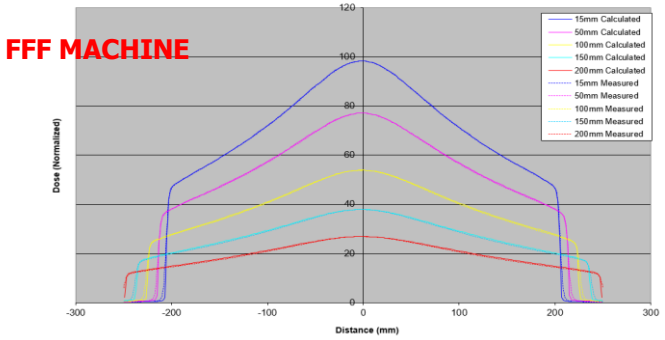
…DURING THE COMMISSIONING YOU NEED TO VERIFY THE TOLERANCE….
….. AND DEFINE THE FUTURE BASELINE

Code of Practice for the Quality Assurance and Control for Volumetric Modulated Arc Therapy

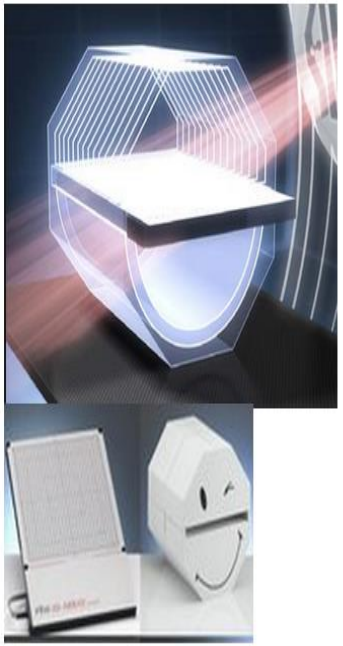
NEDERLANDSE COMMISSIE VOOR STRALINGSDOSIMETRIE

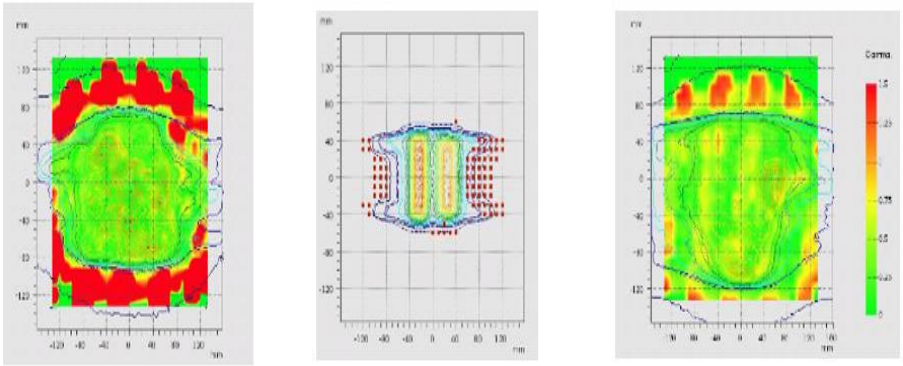
Report 24 of the Netherlands Commission on Radiation Dosimetry
February 2015





Riepilogo misure eseguite con 2DArray in Solido (RW3) e Octavius							Local dose %	Selected dose %	Selected dose Dose prescriz. (Gy)
ID	Paziente	TPS	Tecnica	Fantoccio	Piano	N°Fascio/Gantry Angle			
	TG119HN	MONACO	IMRT	Octavius		11	97,7	100	0,33
	TG119HN	MONACO	IMRT	Octavius		12	94	98,7	0,29
	TG119HN	MONACO	IMRT	Octavius		13	95	98,6	0,22
	TG119HN	MONACO	IMRT	Octavius		14	99,2	100	0,45
	TG119HN	MONACO	IMRT	Octavius		15	89,4	89,4	0,28
	TG119HN	MONACO	IMRT	Octavius		16	91,5	99,2	0,53
	TG119HN	MONACO	IMRT	Octavius		17	89,5	92,3	0,13
	TG119HN	MONACO	IMRT	Octavius		18	87,7	96,1	0,30
	TG119HN	MONACO	IMRT	Octavius		19	90,1	97,5	0,38
	TG119HN	MONACO	IMRT	Octavius		ALL	97,8	81,6	2,91
	F.....	MONACO	dMLC	RW3		1	100	100	2,43
	F.....	MONACO	dMLC	RW3		2	100	100	2,09
	F.....	MONACO	dMLC	RW3		3	100	100	3,27
	F.....	MONACO	dMLC	RW3		4	95,5	100	2,21
	F.....	MONACO	dMLC	RW3		5	100	100	3,88
	F.....	MONACO	dMLC	RW3		6	98,5	100	2,29
	F.....	MONACO	dMLC	RW3		7	100	100	1,67
	F.....	MONACO	dMLC	RW3		8	100	100	2,90
	F.....	MONACO	dMLC	RW3		9	98,9	100	1,69
	F.....	MONACO	dMLC	RW3		ALL	99,1	100	22,42
	TG119 Cshape	MONACO	VMAT	RW3		41	64	63,7	0,16
	TG119 Cshape	MONACO	VMAT	RW3		42	78,9	78,6	0,14
	TG119 Cshape	MONACO	VMAT	RW3		43	75,9	92,7	0,16
	TG119 Cshape	MONACO	VMAT	RW3		ALL	66,1	57	0,45
	S.....	MONACO	VMAT	RW3		31	80,6	98,6	0,79
	S.....	MONACO	VMAT	RW3		32	86,8	98,9	0,75
	S.....	MONACO	VMAT	RW3		ALL	83,3	95,8	1,53
	68229	MONACO	VMAT	Octavius		51	75,3	96,1	0,56
	68229	MONACO	VMAT	Octavius		52	72,5	90,2	0,56
	68229	MONACO	VMAT	Octavius		53	75,2	95	0,49





AGREEMENT TPS-PLAN-DELIVERY

i.e. POTENTIAL QA AND ERROR DETECTED

Table 4
Overview of the various errors that can be detected with EPID dosimetry

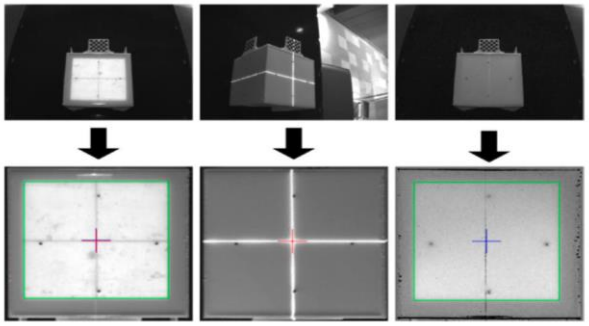
Potential errors	Pre-treatment verification				Treatment verification			
	2D/3D	2D		3D	2D			3D
	No phantom	Behind phantom	Inside phantom	Inside phantom	Before patient	Behind patient	Inside patient	Inside patient
Machine								
Wedge presence and direction	Yes (systematic errors)				Yes (systematic and random errors)			
Presence of segment	Yes (systematic errors)				Yes (systematic and random errors)			
MLC leaf position/speed	Yes (systematic errors)				Yes (systematic and random errors)			
Leaf sequencing	Yes (systematic errors)				Yes (systematic and random errors)			
Collimator angle	Yes (systematic errors)				Yes (systematic and random errors)			
Beam flatness and symmetry	Yes (systematic errors)				Yes (systematic and random errors)			
Linac output during treatment	No				Yes			
Gantry angle	No	Possible	Possible	Possible	No	Possible	Possible	Possible
Plan								
Transmission through leaves	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Steep dose gradients	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
TPS modelling parameters for MLC	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Delivery of wrong patient plan	Yes (if same plan is used for verification and treatment)				Yes	Yes	Yes	Yes
Dose calculation in phantom or patient	No	No	Yes	Yes	No	No	Yes	Yes

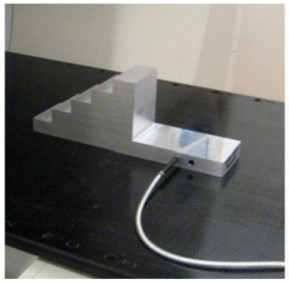
SOMETIME OBJECTS AND PHANTOM CAN HELP THE WORK-LIFE

IOP Publishing Institute of Physics and Engineering in Medicine Physics in Medicine & Biology
Phys. Med. Biol. 61 (2016) L29–L37 doi:10.1088/0031-9155/61/17/L29

Fast Track Communication

Automating quality assurance of digital linear accelerators using a radioluminescent phosphor coated phantom and optical imaging





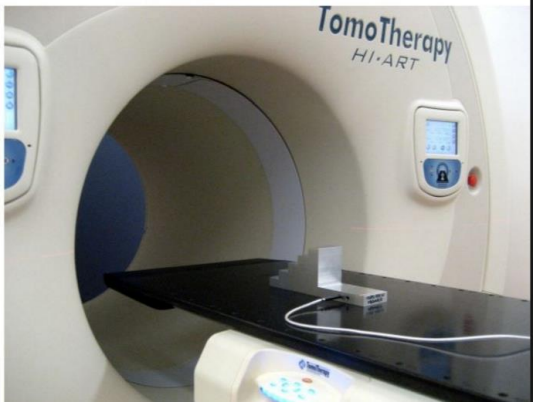
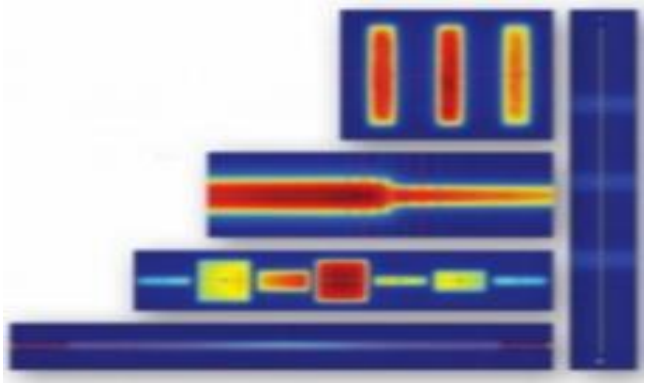


Table 2. System results compared to existing methods.

Light field/ radiation alignment	Symmetric beams	Center shift *X* (mm)	Center shift *Y* (mm)	Width difference (mm)	Height difference (mm)
Auto	5 × 5 cm	−0.02 ± 0.05	0.68 ± 0.11	−0.58 ± 0.05	−0.59 ± 0.09
Auto	10 × 10 cm	−0.21 ± 0.07	0.96 ± 0.12	−0.63 ± 0.15	−0.94 ± 0.31
FC-2	*15 × 15 cm*	*−0.19*	*0.40*	*−0.30*	*0.00*
	Asymmetric beams		Difference in position (mm)		
	(*X1*, *X2*, *Y1*, *Y2*)	*X1*	*X2*	*Y1*	*Y2*
Auto	(−3, 4, −3, 4) (cm)	0.23 ± 0.03	−0.39 ± 0.05	−0.26 ± 0.06	−0.95 ± 0.07
Jaw position indicators	Symmetric beams	Width Difference (mm)	Height Difference (mm)		
Auto	5 × 5 cm	−0.76 ± 0.02	−1.73 ± 0.06		
Auto	10 × 10 cm	−0.46 ± 0.16	−1.71 ± 0.19		
Iso-align	*5 × 5 cm*	*0.0*	*−2.0*		
Iso-align	*10 × 10 cm*	*0.0*	*−2.0*		
	Asymmetric beams		Difference in position (mm)		
	(*X1*, *X2*, *Y1*, *Y2*)	*X1*	*X2*	*Y1*	*Y2*
Auto	(−3, 4, −3, 4) (cm)	0.06 ± 0.06	0.80 ± 0.03	1.40 ± 0.16	0.63 ± 0.21
Iso-align	*(−5, 2.5, −5, −2.5) (cm)*	*0.0*	*1.0*	*1.0*	*1.0*
Cross-hair centering	Center shift *X* (mm)	Center shift *Y* (mm)	Walkout (mm)		
Auto	−0.35 ± 0.03	0.77 ± 0.01	0.87 ± 0.12		
FC-2/Iso-align	*−0.25*	*0.67*	*0.5*		
Couch position	Shifts (lat., long.) (mm)	Lat. (mm)	Long. (mm)		
Auto	(30, 30)	30.17 ± 0.25	30.22 ± 0.15		
Ruler	*(200, 300)*	*200.3*	*300.4*		
Laser localization (relative to cross hairs)	Center shift *X* (mm)	Center shift *Y* (mm)			
Auto	0.19 ± .30	−0.26 ± 0.13			
Iso-align	*0.25*	*−0.25*			

Note: Summary of tests performed by the autonomous system (mean ± standard deviation) and comparison to current QA techniques (shown in italics).

Phys. Med. Biol. 61 (2016) L29
L35
Fast Track Communications

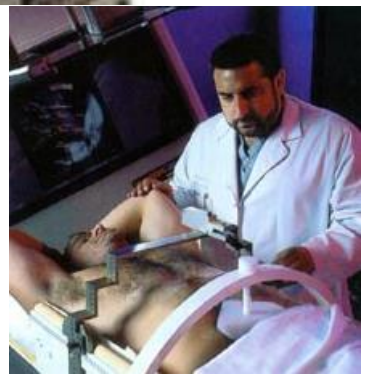


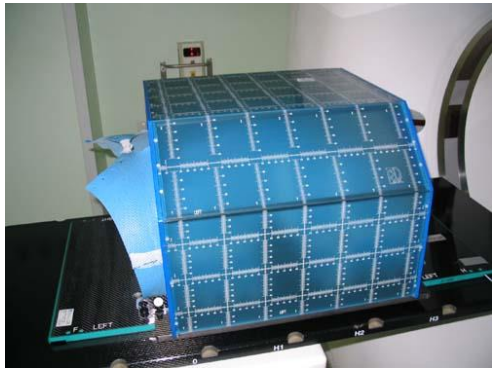
IDENTIFY OR PREVENT SOURCE OF ERRORS?

Look for:
Small or big errors?
Rare or frequent errors?
Random or systematic errors?
Unpredictable or newly errors?

To be accurate once a year (annual QA)
or to be adequate everyday (Daily QA)?:

IMMOBILIZATION DEVICE…QA OR NOT QA? LINAC COMPLIANT OR NOT?





..... IN PRACTICE? *«UMARELL CONCEPT»*

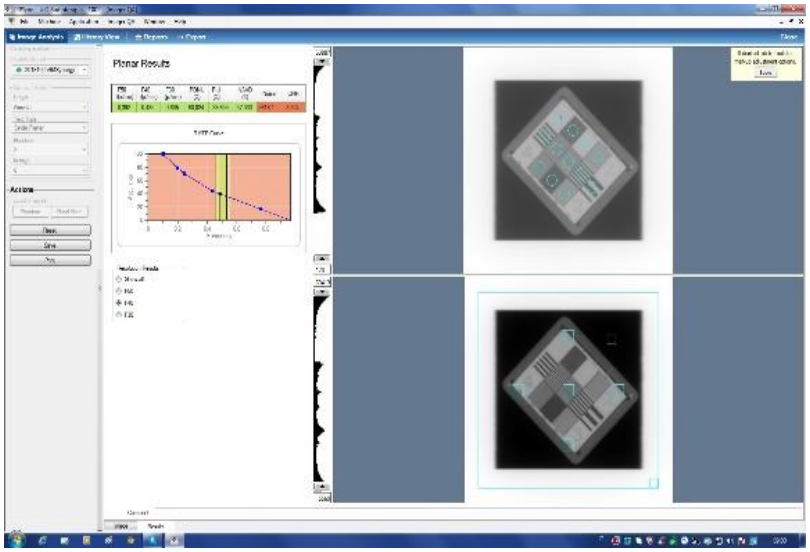
Expert Brainstorming- Multiple-criteria decision

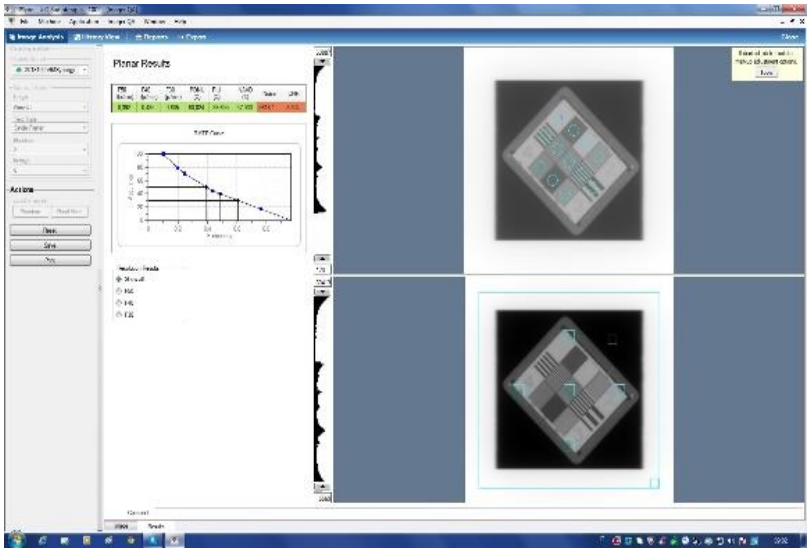
Decision Maker

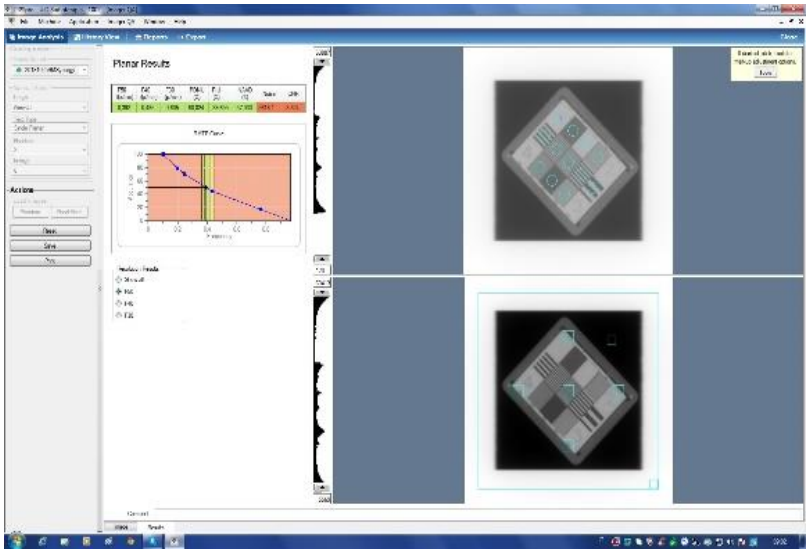
Wrong Workflow or Healthcare Model – Error investigation

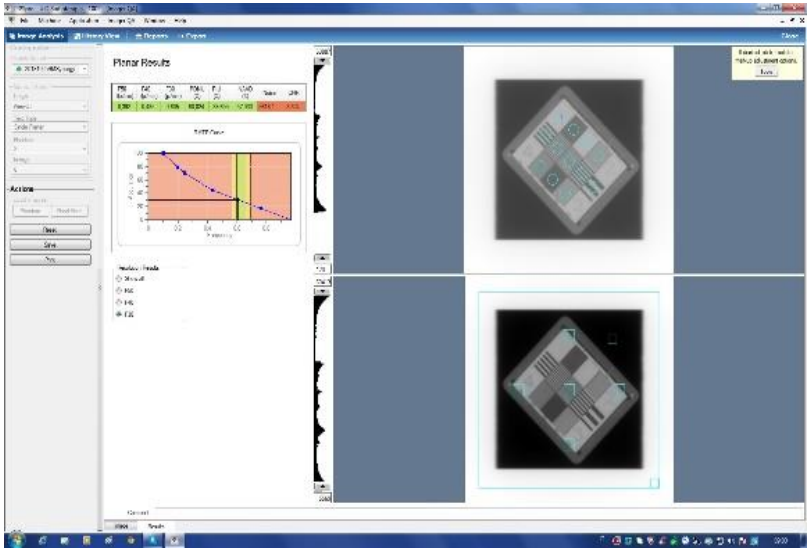
Results: Simplify and prevent accident

DEFINE THE BASELINE AND REPEAT FREQUENTLY (AS LOW AS REASONABLE) THE QA TEST

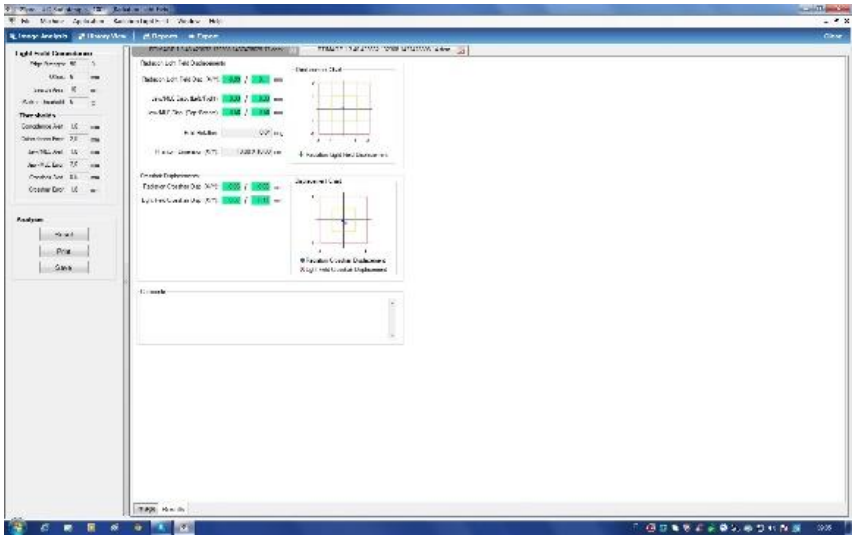


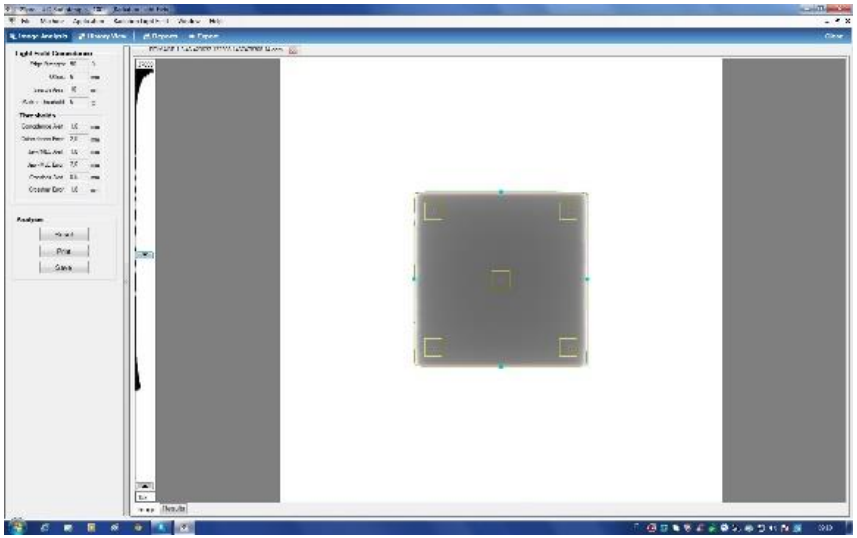


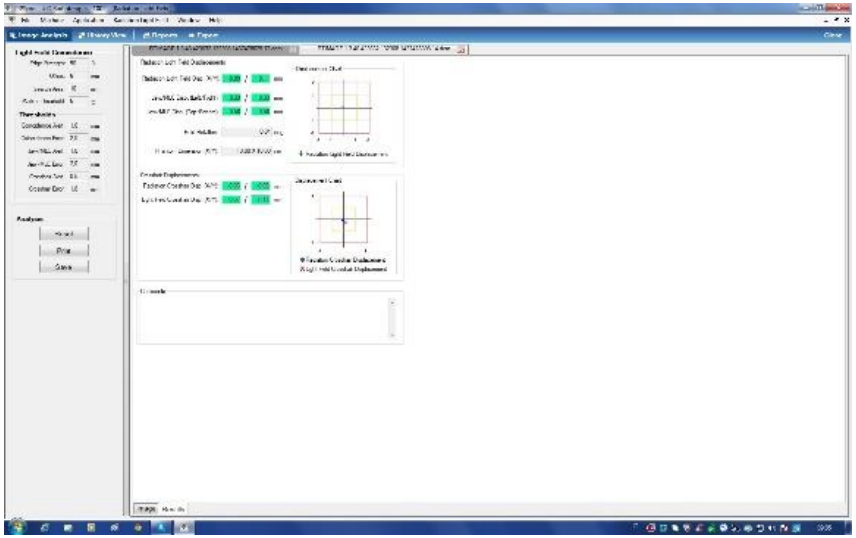




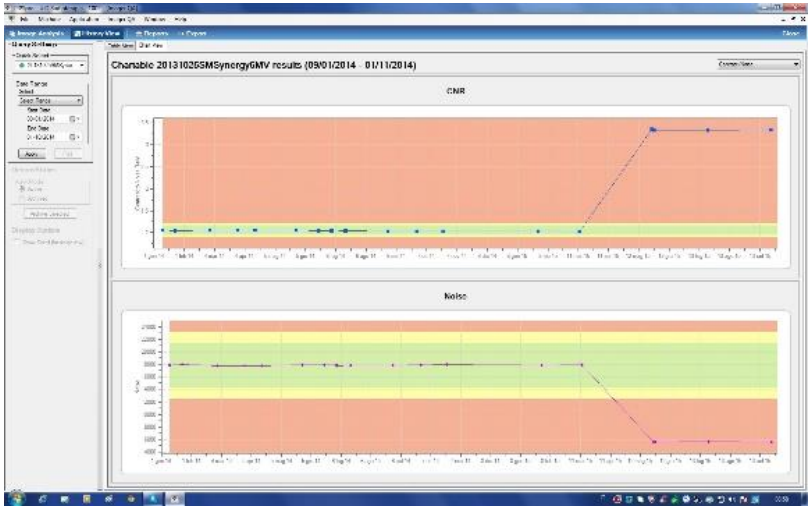
i.e. Isocenter and MLC position (Picket, Fence) Tests

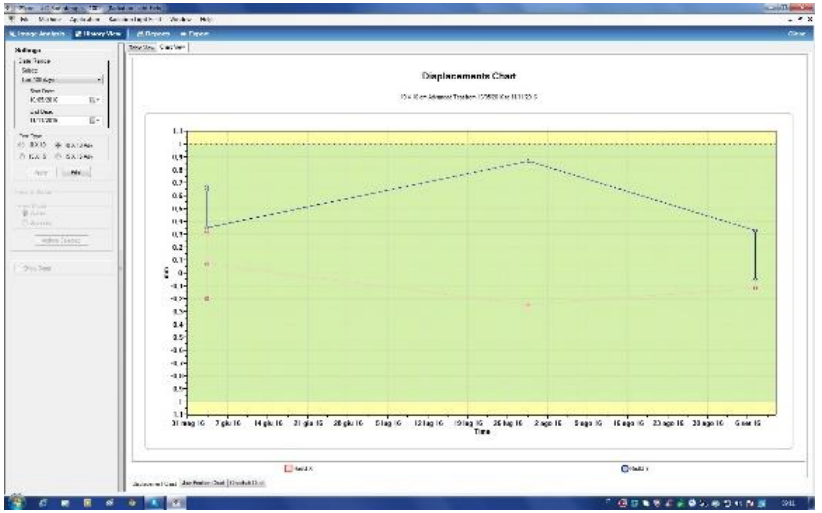


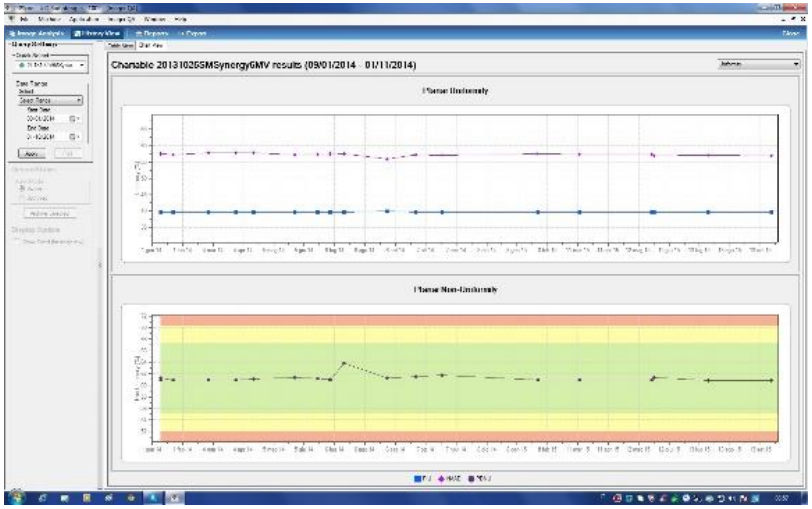


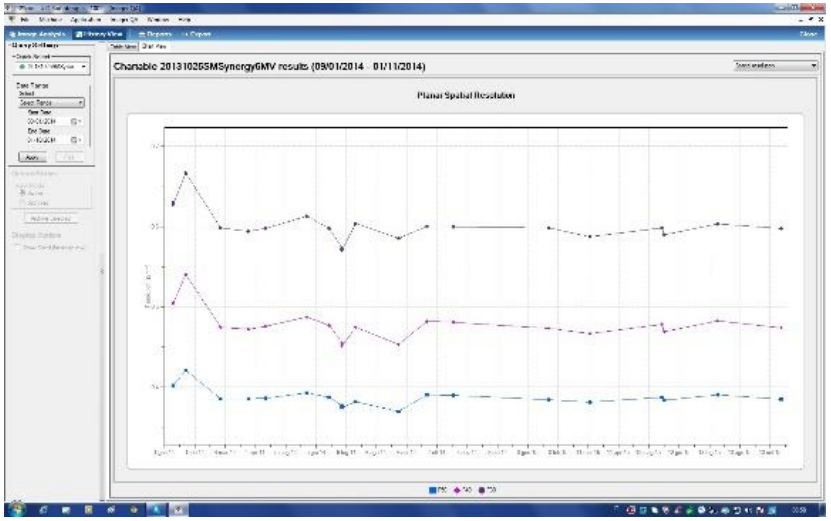


Analyze and look at the trends vs. the baseline…..

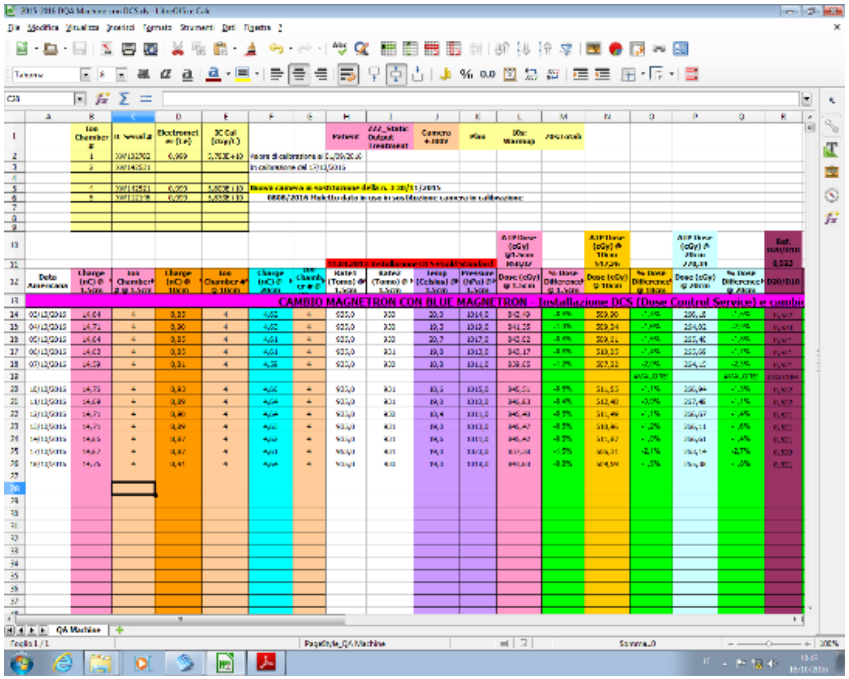


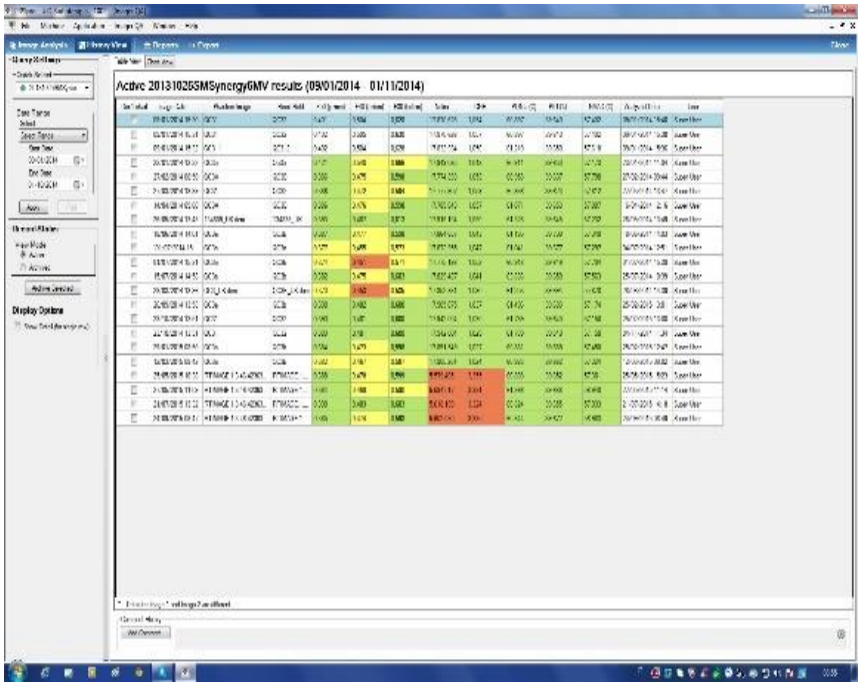




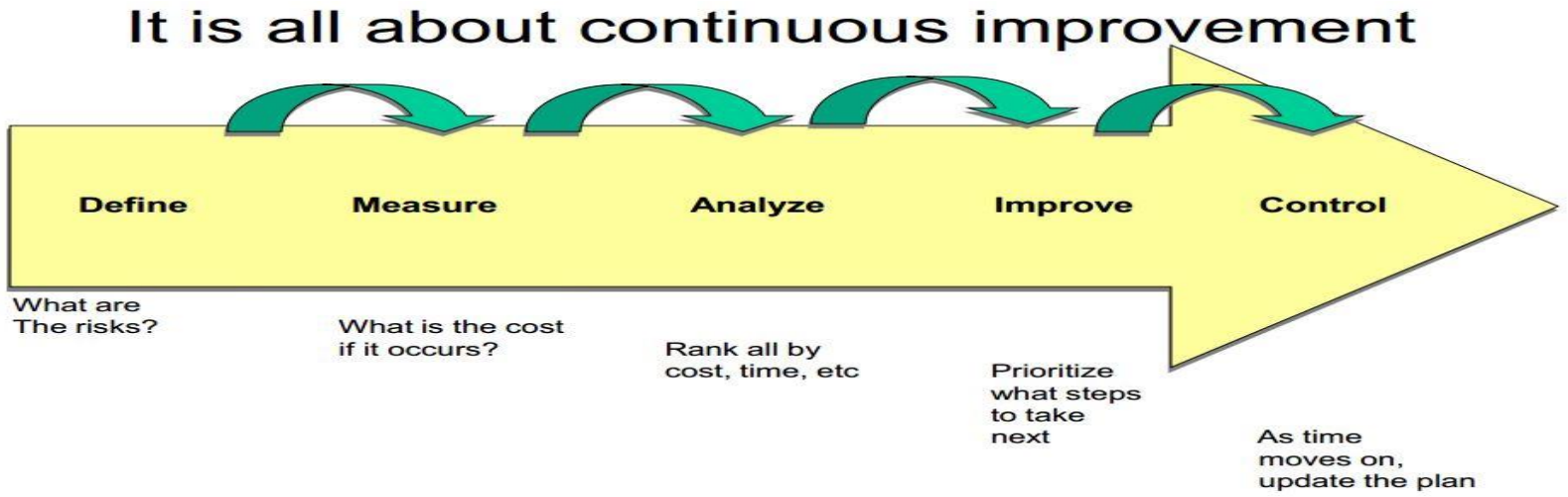


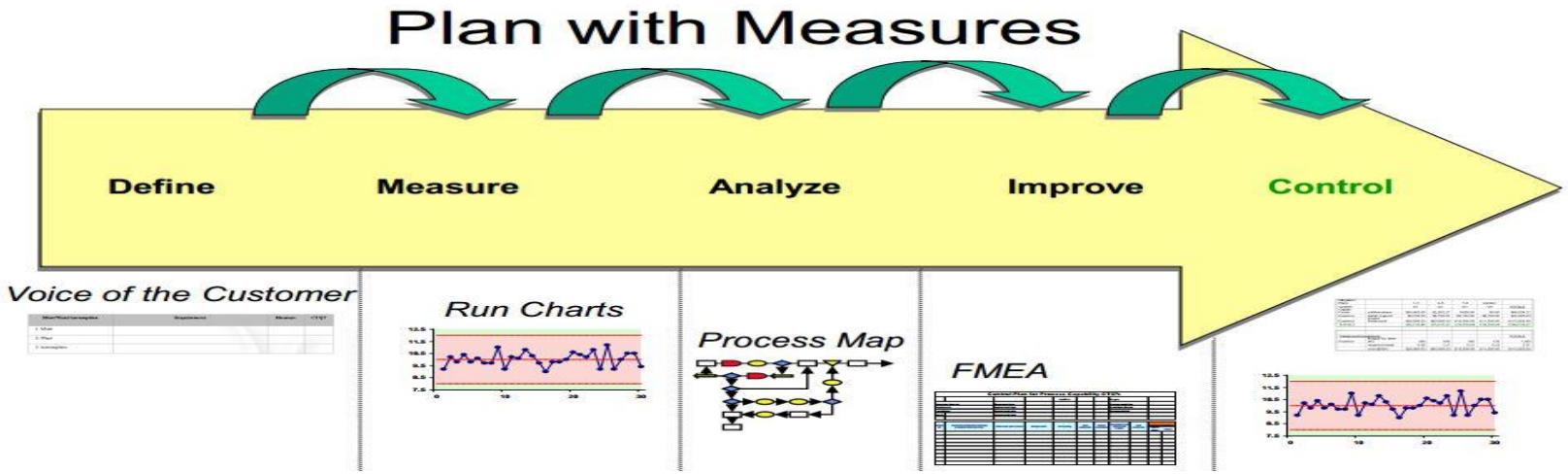
Trace and Record any Data





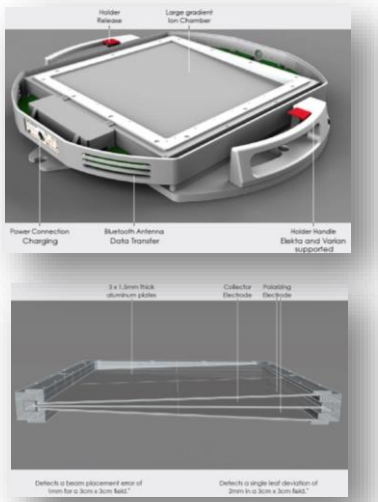
Simplify theory (i.e. Six Sigma)

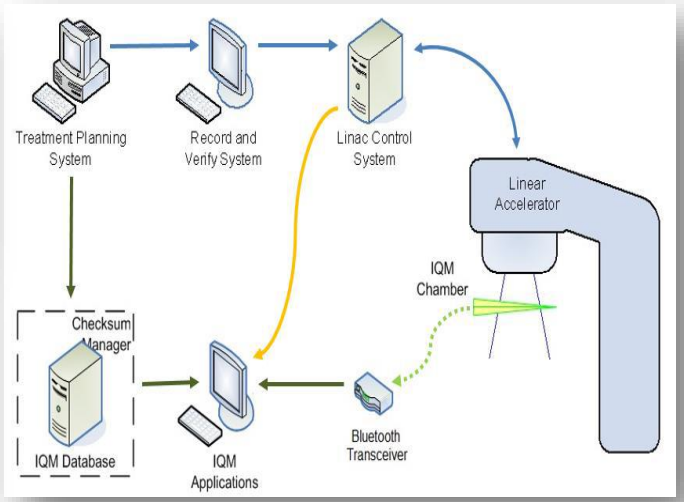




ALTERNATIVE - INDEPENDENT REAL-TIME BEAM MONITOR SYSTEM

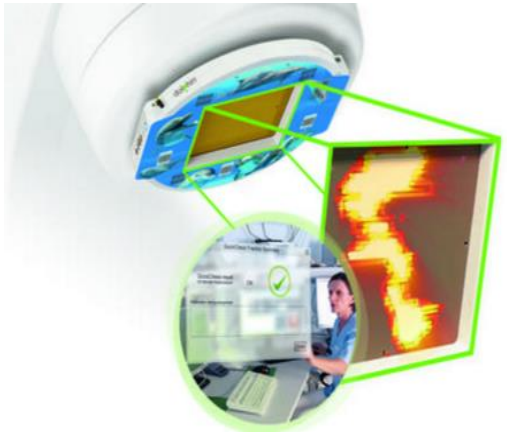
Beta-Tested @ Modena Hospital

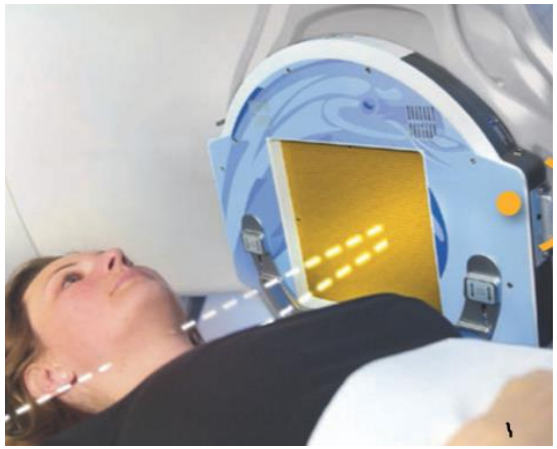




Courtesy of Andrew Jongho Jung Princess Margaret Cancer Centre (Toronto)

- Possible QA of the LINAC
- Pre-Treatment QA activities
- Error prevention instead of error management
- Intra-fractional verification system
- Real-Time user interaction
- Automated monitoring of every single treatment fraction
- Patient delivery and safety improved in real-time
- In-Vivo evaluation

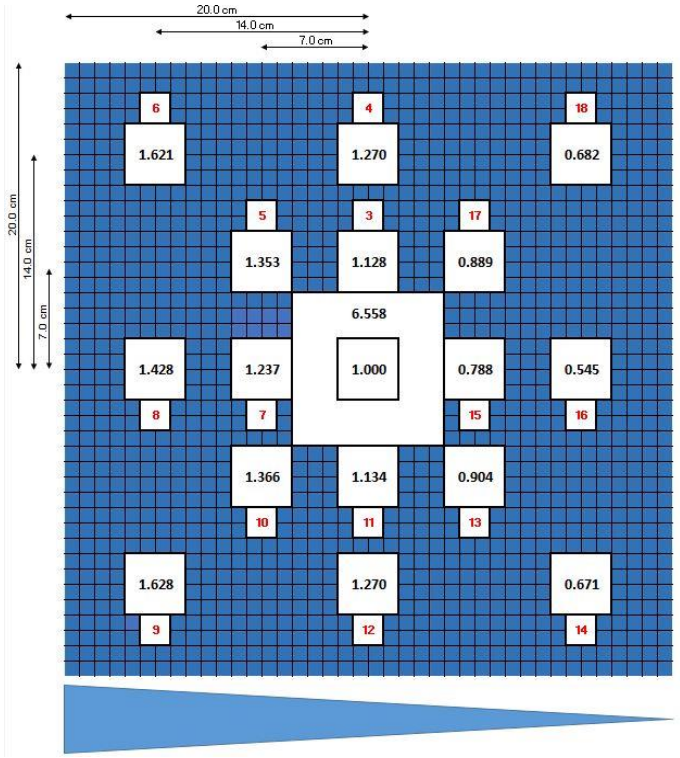




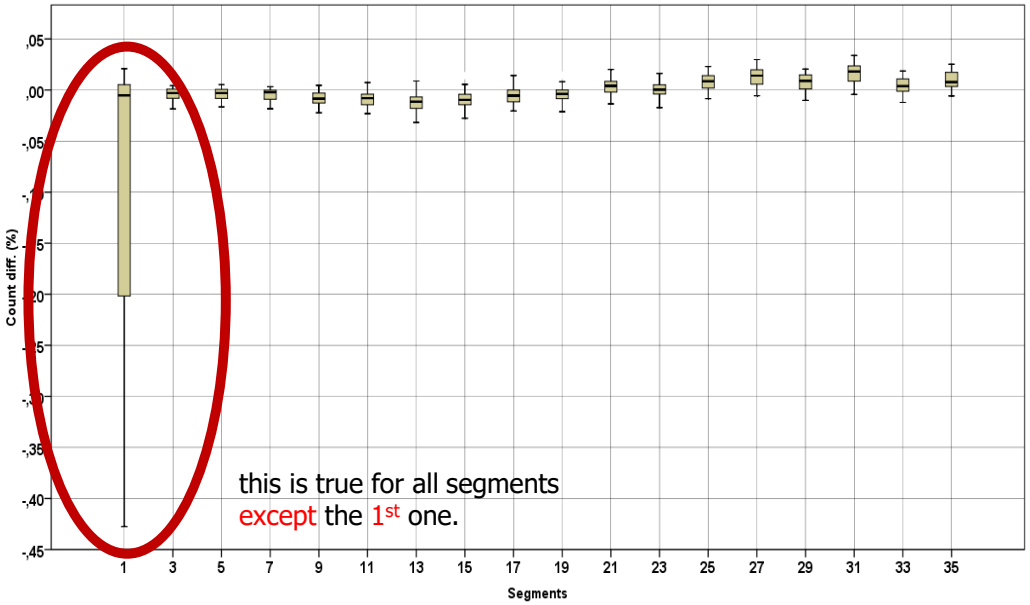
Installed @ Modena Hospital

IQM MAP QA - DAILY QA TEST FIELDS

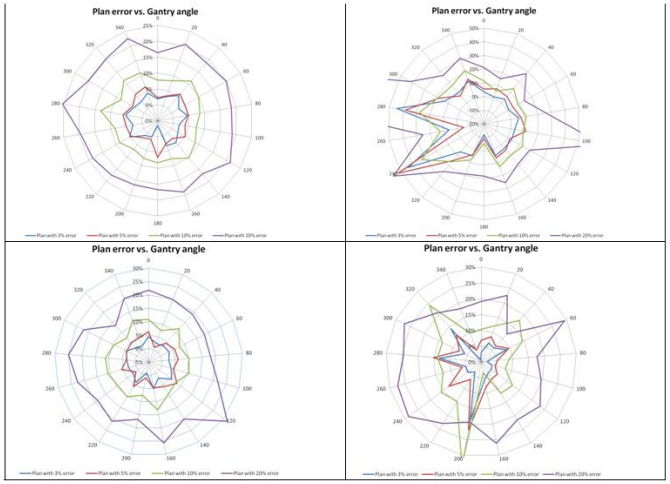
- IMRT plan
- 18 segments
- Irradiated with 6 MV photon
- Constant 50 MU/segment dose output

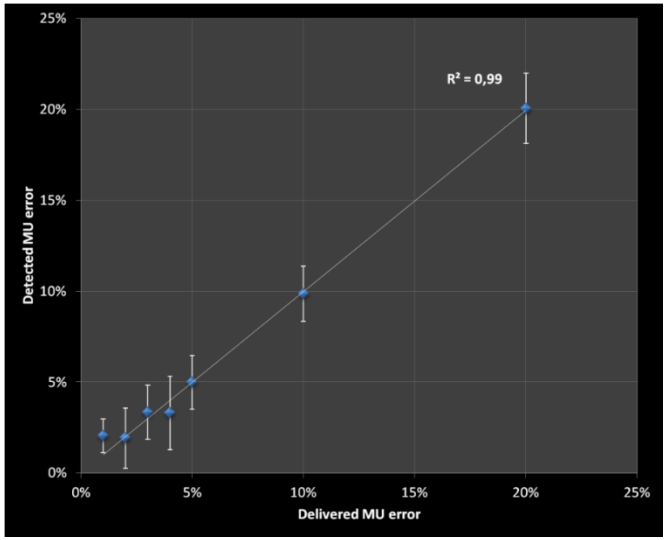


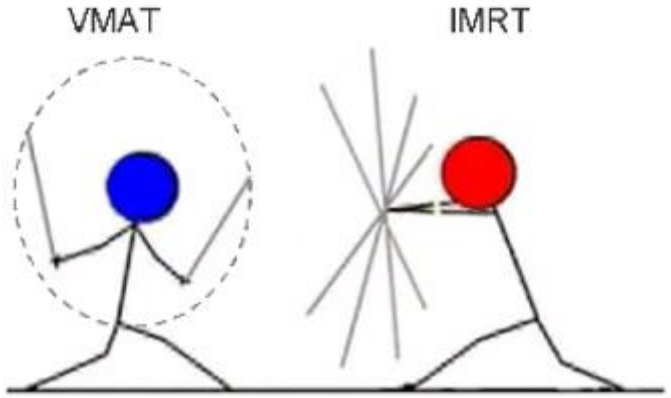
mean variability (for all segments) 0,7% and standard deviation of 4,7%



VMAT RESULTS

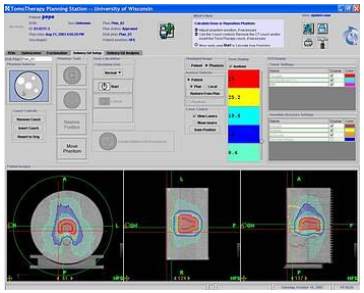




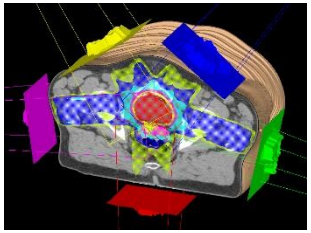


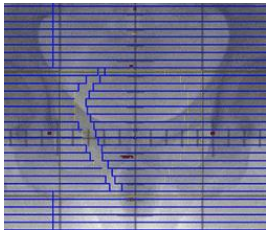
Gantry angle (°)	MU error						
	1%	2%	3%	4%	5%	10%	20%
0	0,2%	1,0%	2,1%	1,8%	2,9%	7,9%	16,8%
20	2,5%	2,4%	3,1%	5,4%	4,1%	9,1%	21,1%
40	3,6%	4,6%	6,2%	5,6%	6,7%	12,3%	20,4%
60	1,4%	2,4%	3,1%	4,0%	5,4%	10,0%	20,3%
80	1,3%	0,8%	4,4%	2,7%	5,1%	9,1%	19,1%
100	2,4%	2,3%	3,5%	2,2%	4,5%	9,3%	19,6%
120	2,8%	1,2%	3,4%	3,6%	5,6%	9,3%	21,9%
140	1,6%	1,6%	4,8%	2,1%	4,4%	11,9%	18,9%
160	2,9%	2,8%	3,5%	3,3%	4,5%	8,4%	19,9%
180	1,8%	-1,8%	-0,3%	-0,4%	6,1%	9,2%	18,3%
200	1,8%	-0,4%	2,1%	0,9%	2,5%	9,3%	19,2%
220	0,9%	1,0%	1,4%	1,6%	2,5%	8,6%	18,7%
240	1,9%	1,7%	4,6%	3,3%	5,3%	8,9%	19,5%
260	2,8%	2,6%	3,8%	2,5%	5,6%	9,1%	20,1%
280	4,0%	5,2%	5,0%	8,0%	7,8%	12,9%	25,8%
300	2,1%	3,4%	3,1%	5,3%	4,5%	9,8%	20,5%
320	2,0%	3,4%	3,6%	4,5%	6,4%	12,0%	21,2%
340	2,0%	2,4%	4,6%	5,1%	6,8%	11,7%	22,4%

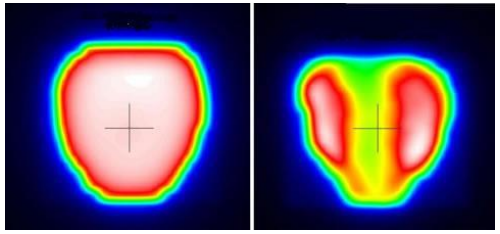
WE NEED INSTRUMENTS TO PREVENT ACCIDENT AND FOR QA… YOU MUST PRETEND IT!



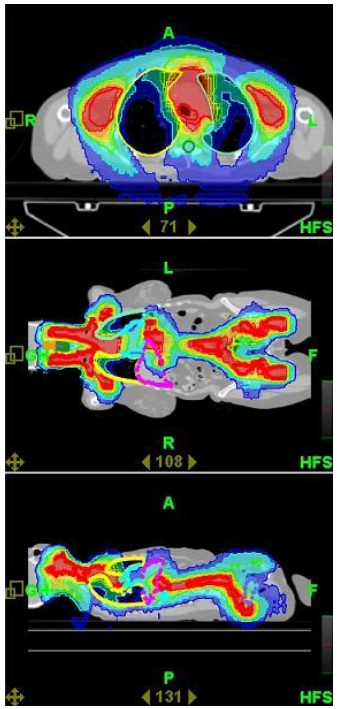
IMRT - Intensity Modulated Radiation Therapy

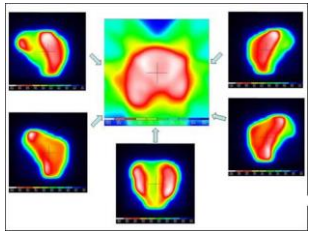




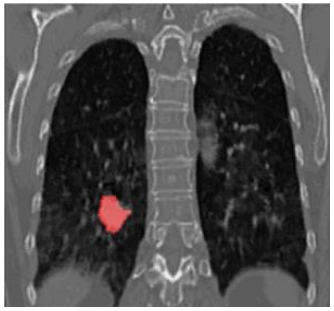


Tomotherapy
Total Lynphoid Irradiation

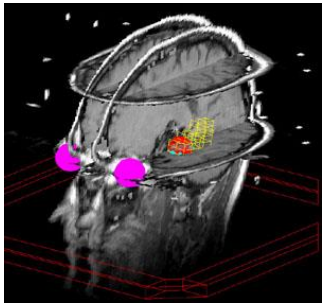




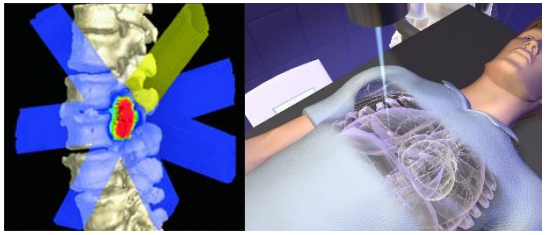
4D-Radiation Therapy



Radiosurgery

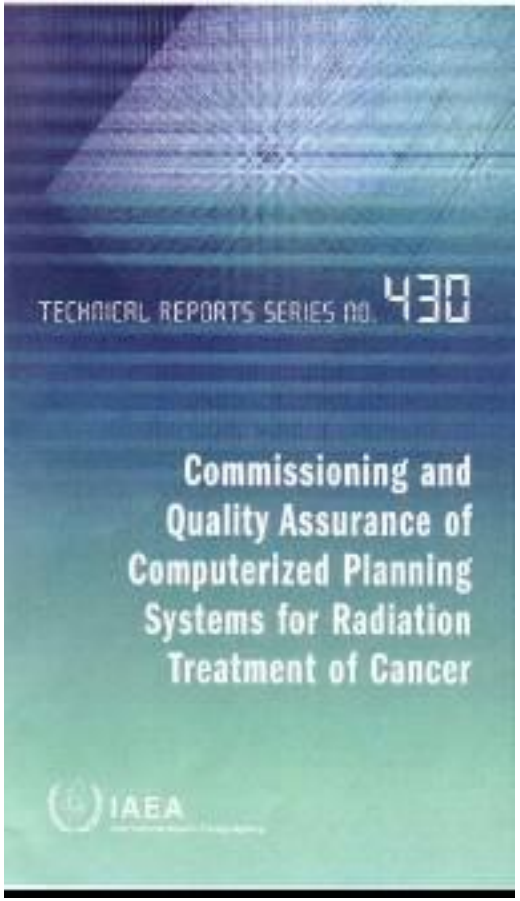


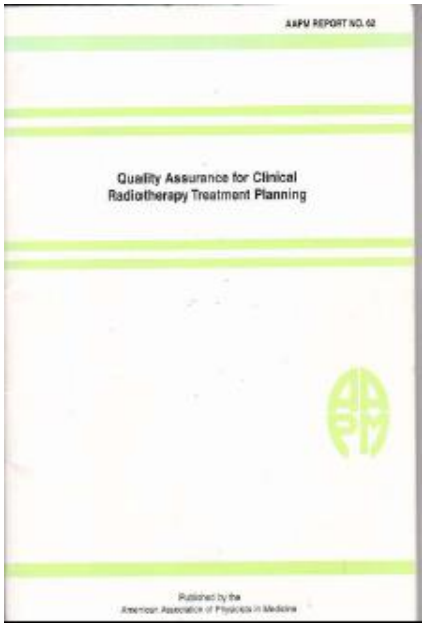
SBRT

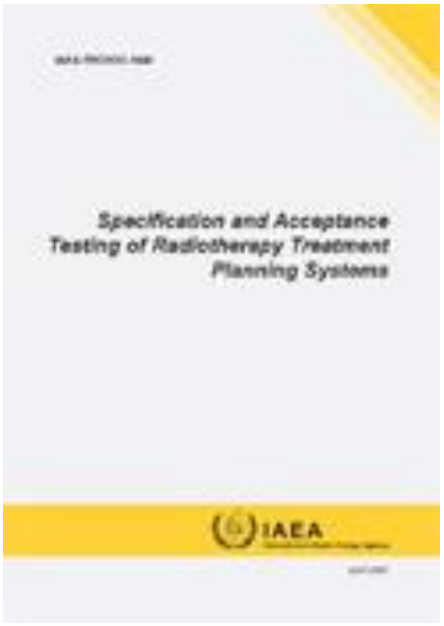


SOME OTHER DOCUMENTS TO TEST THE AGREEMENT BETWEEN PLAN AND DELVERY

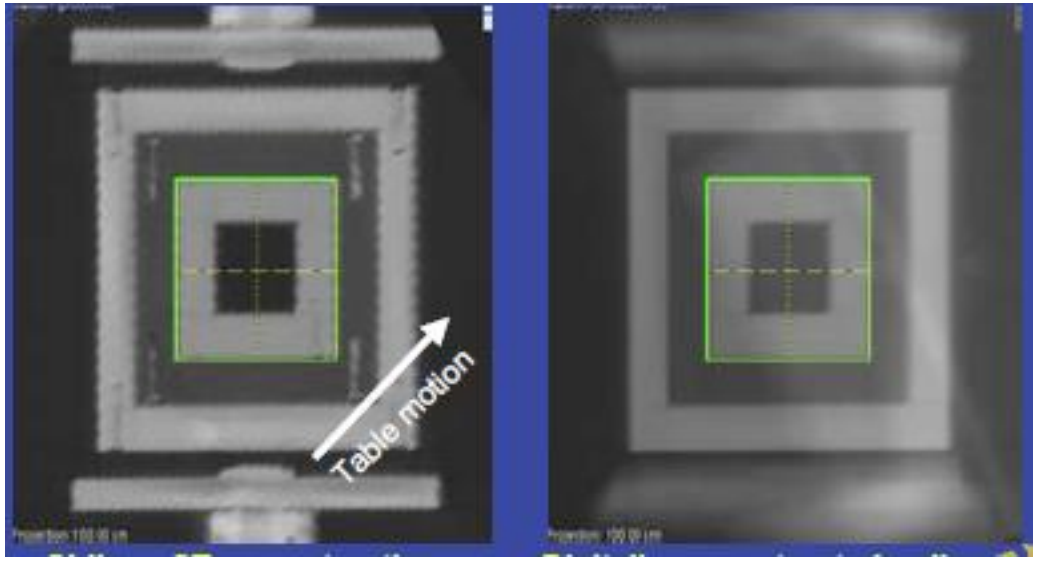
- AAPM Report No. 62: Quality Assurance for Clinical Radiotherapy Treatment Planning (December 1998)
- IAEA Technical Report Series No. 430 : Commissioning and Quality Assurance of Computerized Planning Systems for Radiation Treatment of Cancer (October 2004)
- IAEA TEC-DOC No 1540: Specification for Acceptance Testing of Radiotherapy Treatment Planning Systems

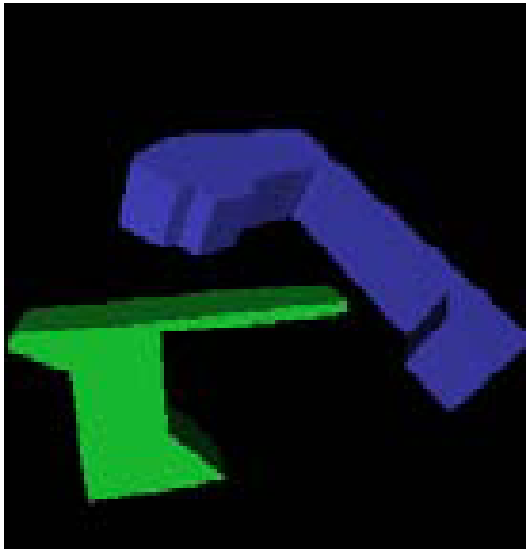


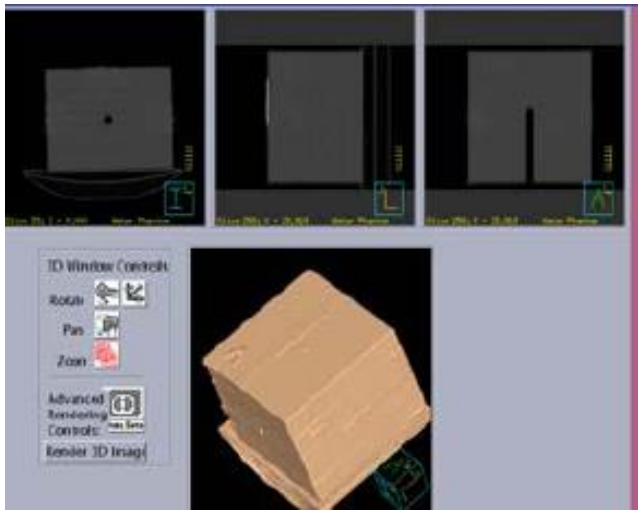


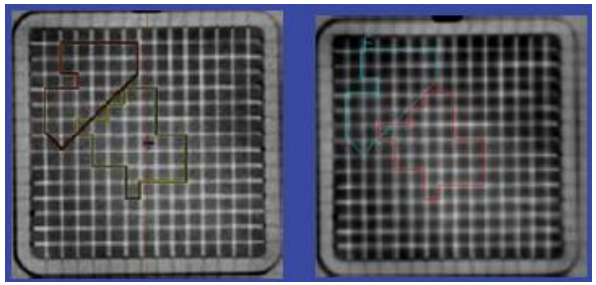


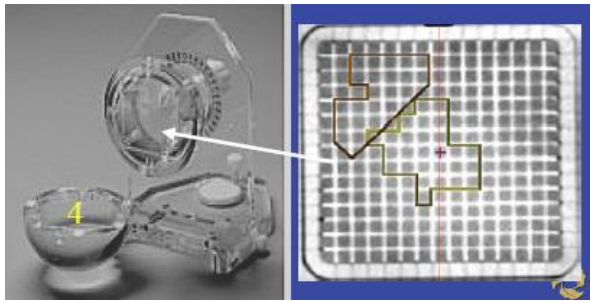
i.e. SPATIAL EVALUATION AND IMAGING QA



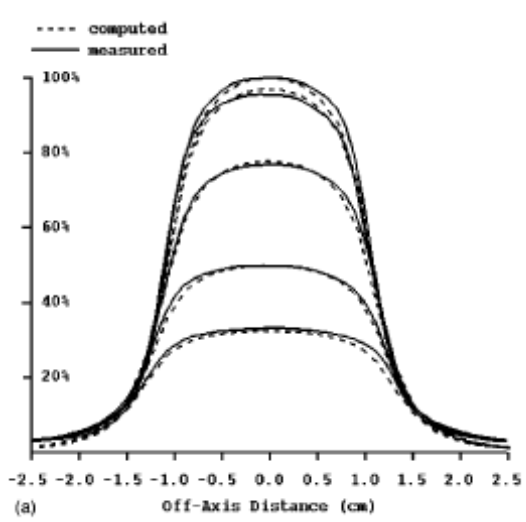


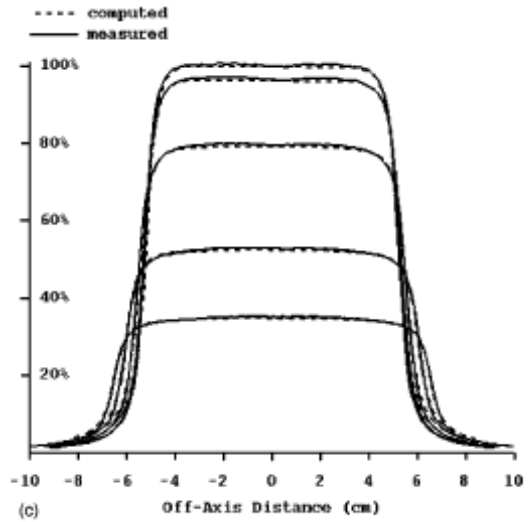


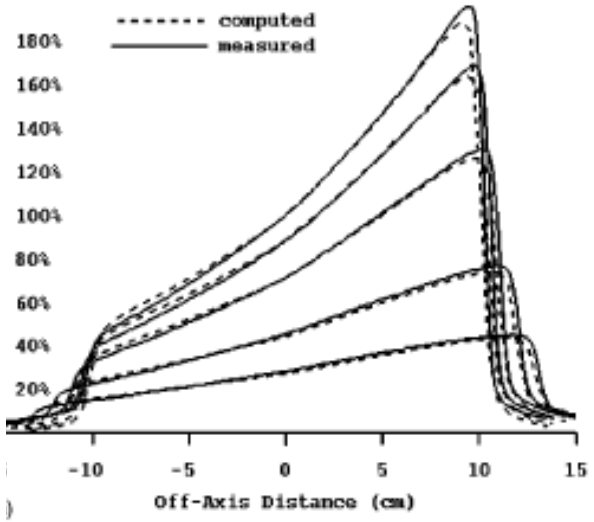


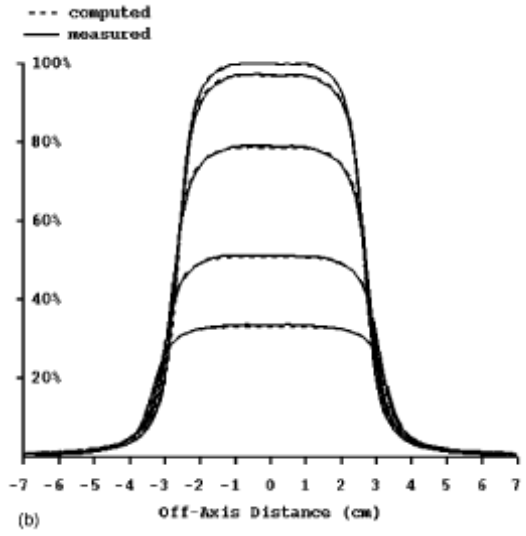


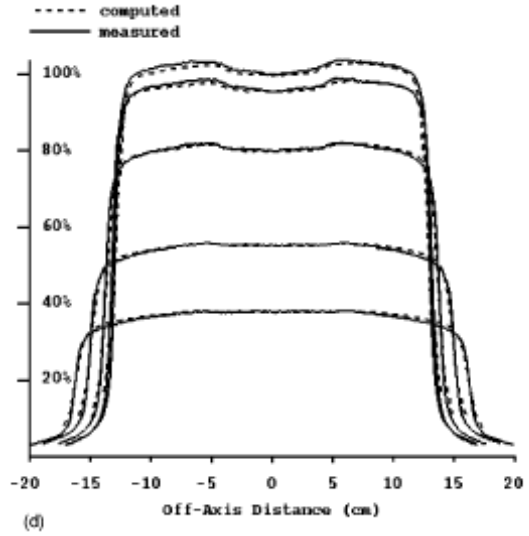
Modeling of the measures (Theory vs. Practice)

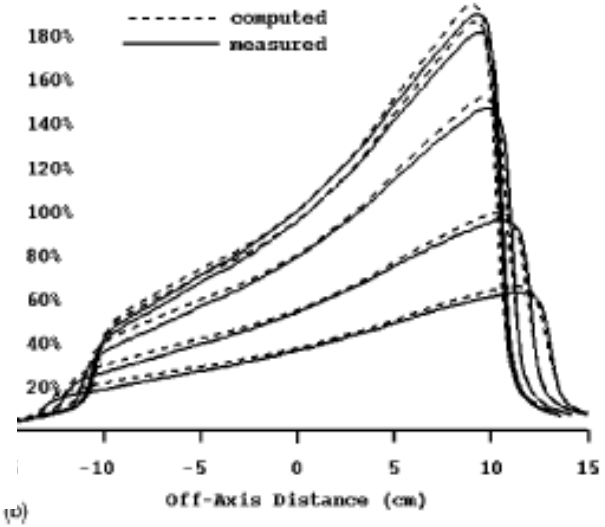






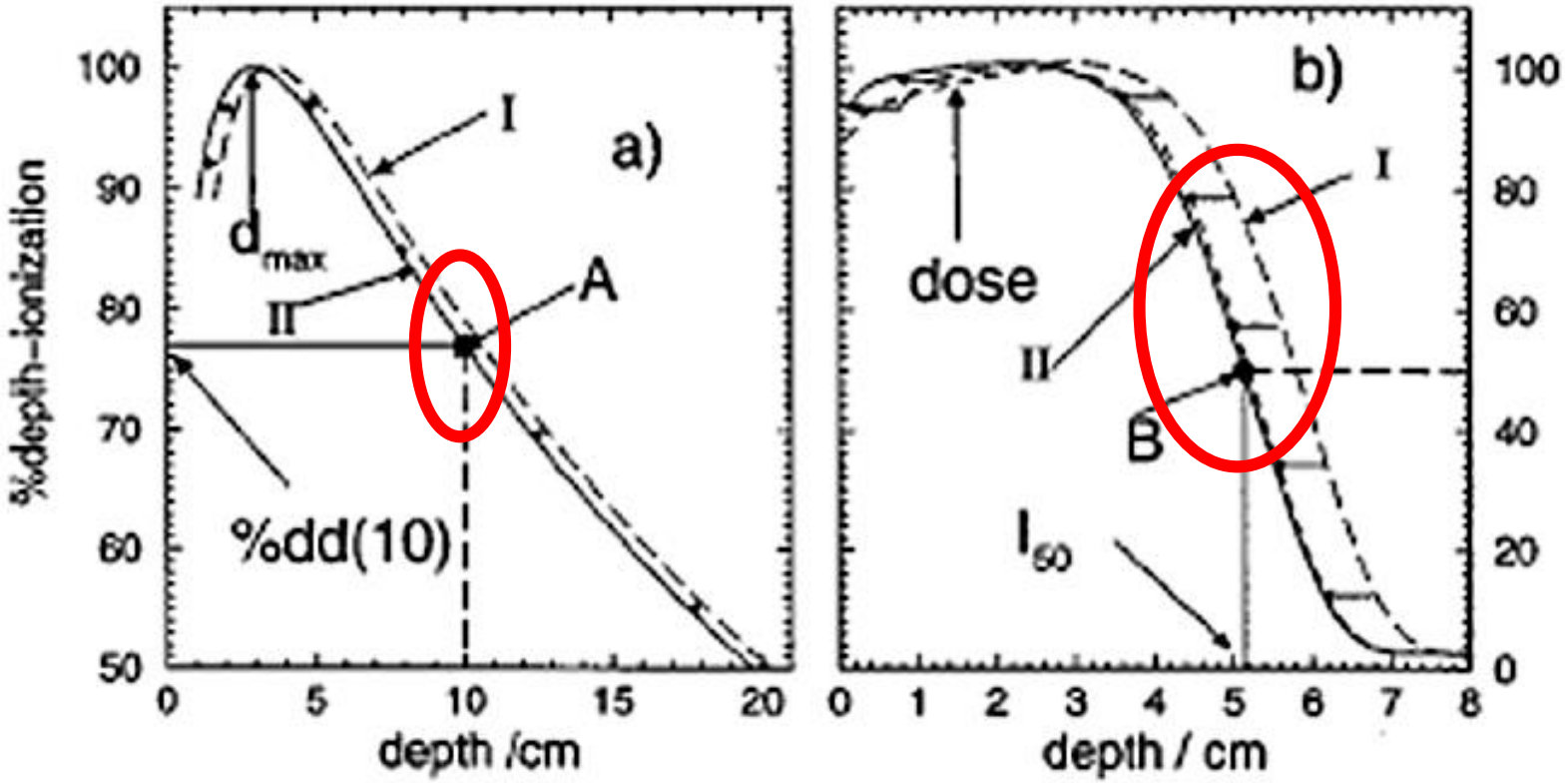






MEASURE MISTAKE EFFECTS

Effect of shifting depth-ionization data measured with cylindrical chambers upstream by 0.6 r_{cav} for photon beams and 0.5 r_{cav} for electron beams (with r_{cav} = 1.0 cm). For the electron beams, (b), further corrections are applied to obtain the *%dd*(*x*) curve shown.



SCATTER KERNEL

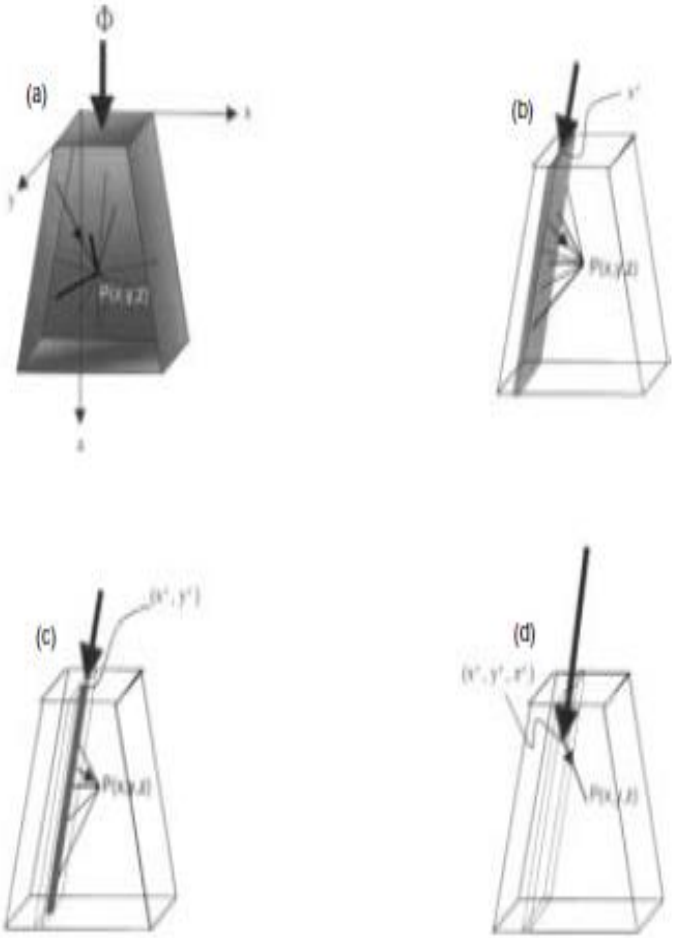
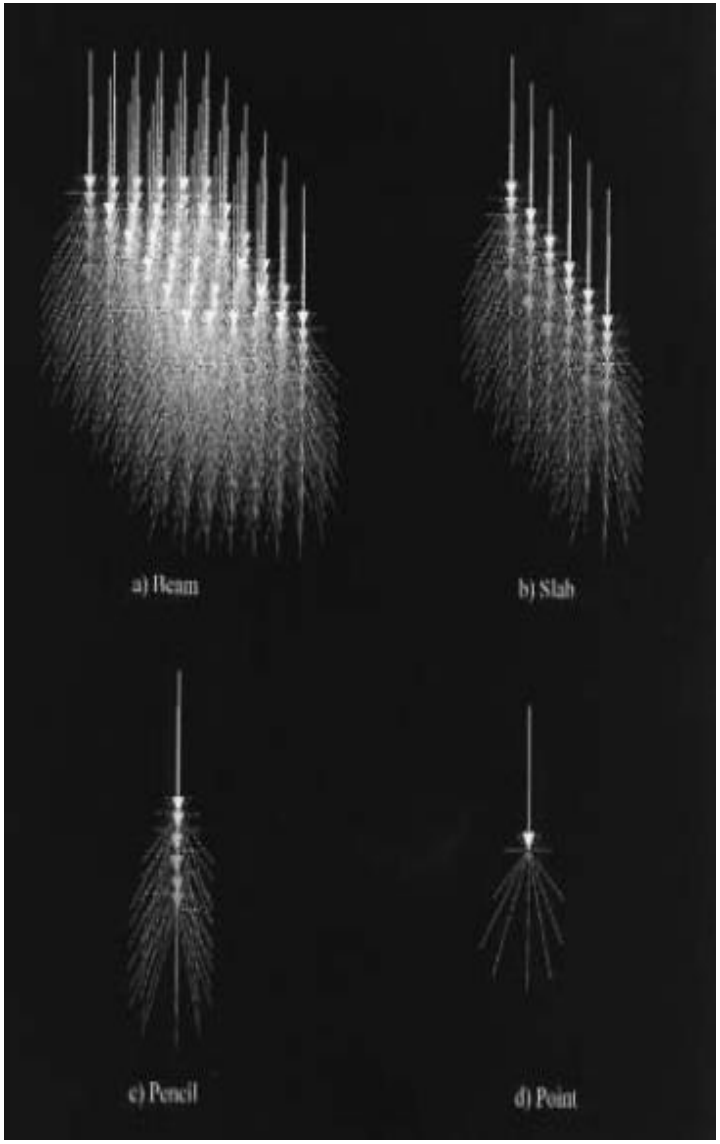
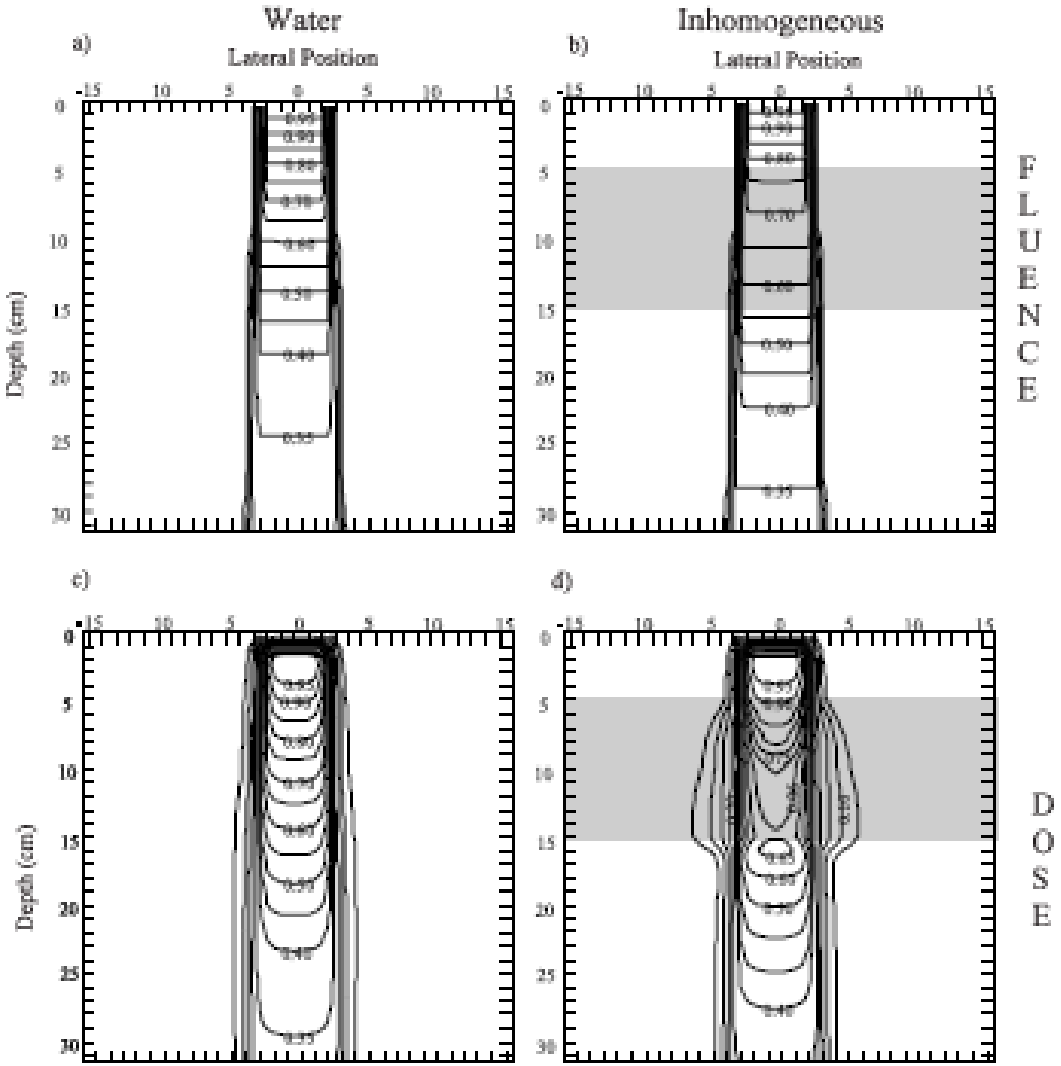


Figure 8.2
The summation of dose contribution from various scatter kernels, K. (a) Beam kernel, (b) Slab kernel, (c) Pencil beam kernel, (d) Point kernel. [Adapted with permission from reference [12].]

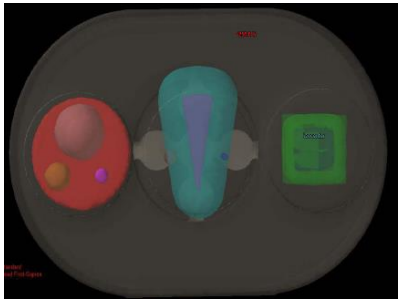


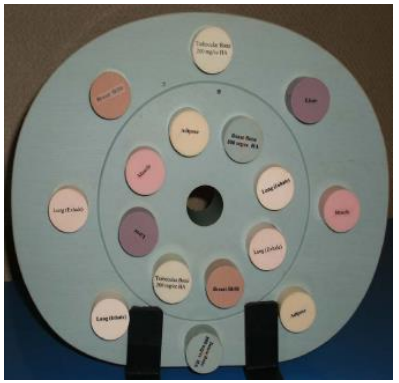
Fluence vs. Dose (Water vs. Inhomogeneous)

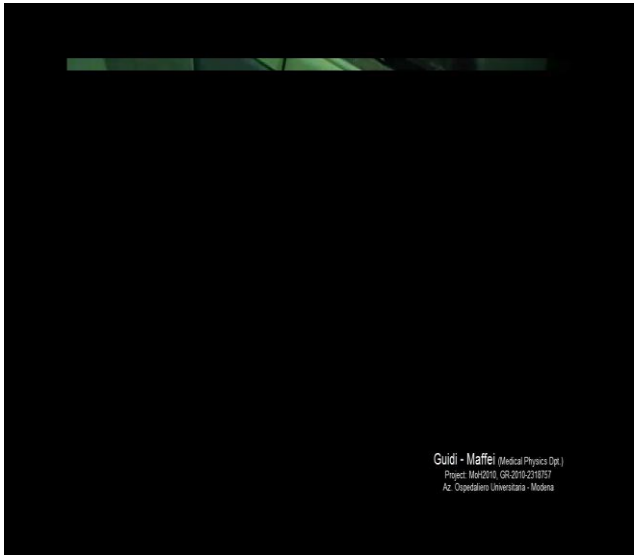


QA – QUALITY ASSURANCE INSTRUMENTS
(i.e. Adaptive RT could based on CBCT calculation or we could need phantom for gating verification)

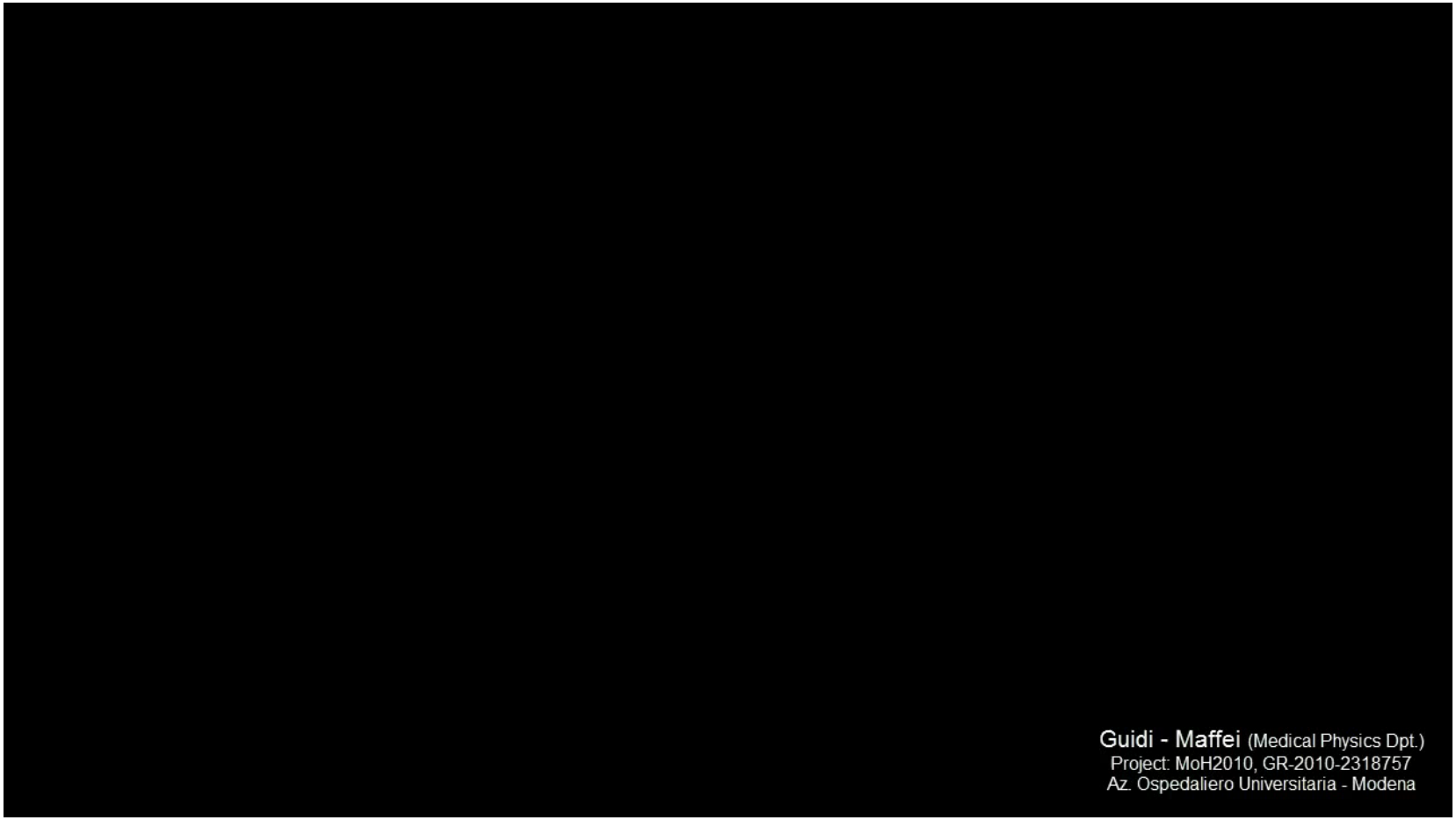
	Region	*Homogenous, simple geometry*	*Complex geometry (wedge, inhomogeneity, asymmetry, blocks / MLC)*	*More complex geometries*****
δ_1	Central beam axis data - high high dose, low dose gradient	2%	3%	4%
δ_2*	Build-up region of central axis beam, penumbra ragion of the profiles - high dose, high dose gradient	2 mm or 10%	3 mm or 15%	3 mm or 15%
δ_3	Outside central beam axis region - high dose, low dose gradient	3%	3%	4%
δ_4**	Outside beam edges – low dose, low dose gradient	30% (3%)	40% (4%)	50% (5%)
RW_{50} ***	Radiological width – high dose, high dose gradient.	2 mm or 1%	2 mm or 1%	2 mm or 1%
δ_{50-90}	Beam fringe – high dose, high dose gradient	2 mm	3 mm	3 mm



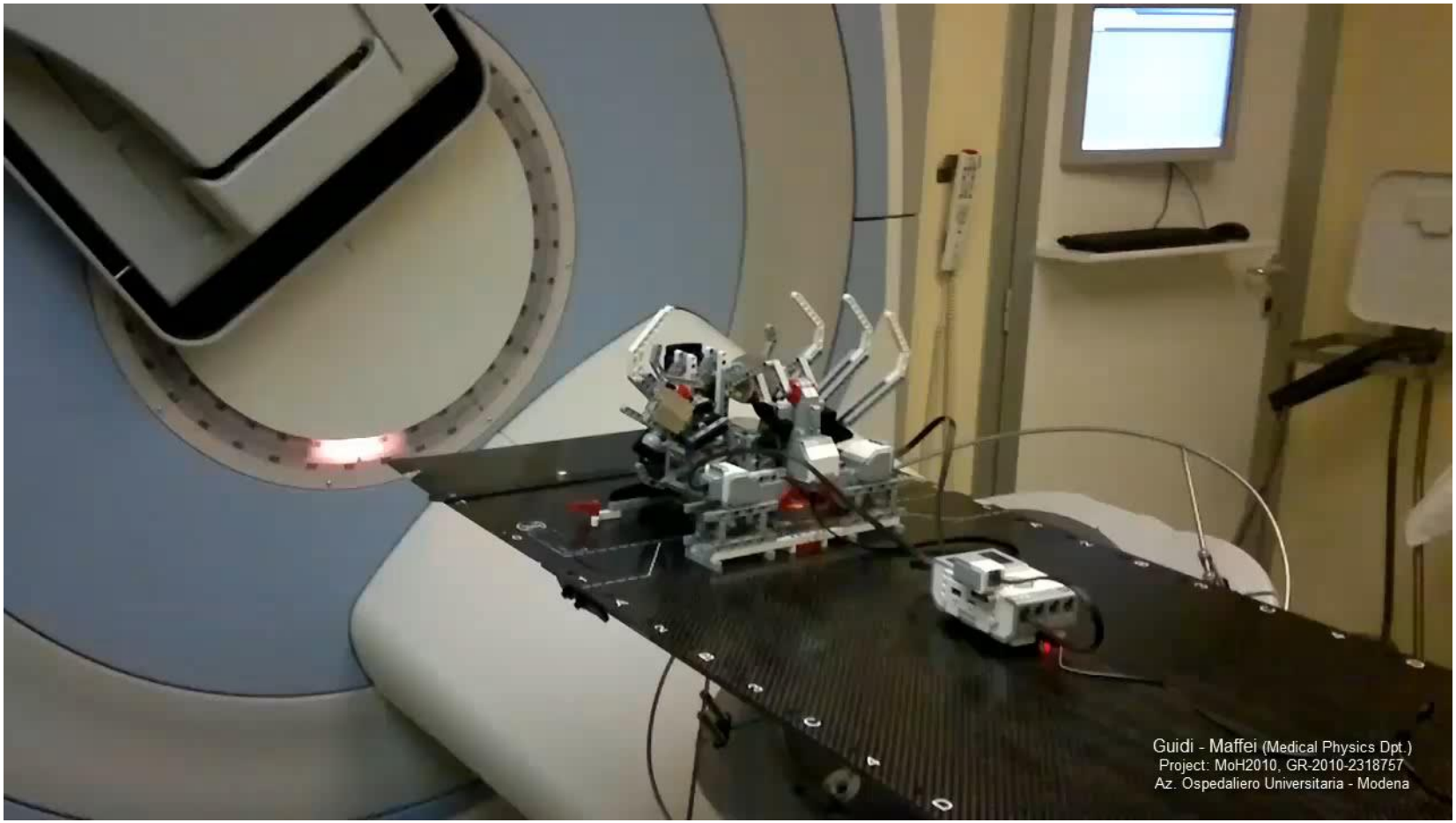




i.s. Experimental QA in Tomotherapy for Gating QA



i.s. Experimental QA in LINAC for Gating QA



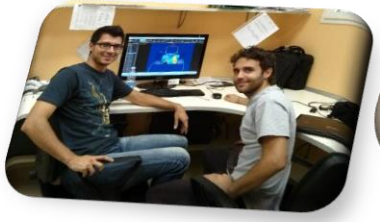
DOUBTS AND QUESTIONS?



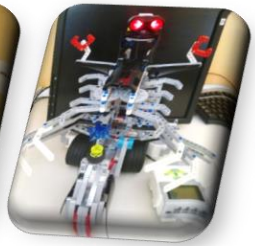












Un maestro in pensione…

"That's too much!!!"

(Praha 2009 : Tomotherapy Meeting)