M E D I C A L P H Y S I C S

in

C L I N I C A L P R A C T I C E

Sonja Petkovska

INTRODUCTION

Importance of physics/physicists in clinical practice increases necessity of MEDICAL Physicists when:

- ***Using radiation***
  - *diagnoses*
  - *treatment*
- ***Protection from radiation***

imaging

- ***diagnostic***

(2D radiographic; CT; MRI; PET)

- ***treatment***
  - ***treatment simulation***
  - ***treatment verification***
  - ***treatment evaluation***

uncertainties

- *commissioning*
- *calibration*
- *periodical measurements*
- *patient position*
- *patient dose*

imaging

- ***diagnostic***

(2D radiographic; CT; MRI; PET)

Calibrate the unit on the way to have:

- as usefulness as possible image

- as less as possible dose received to the patient

imaging

- ***diagnostic***

(2D radiographic; CT; MRI; PET)

adjust the parameters (e.g. kV, mA) on the way to

- perform the medical procedure in one step

- not to repeat the procedure

imaging

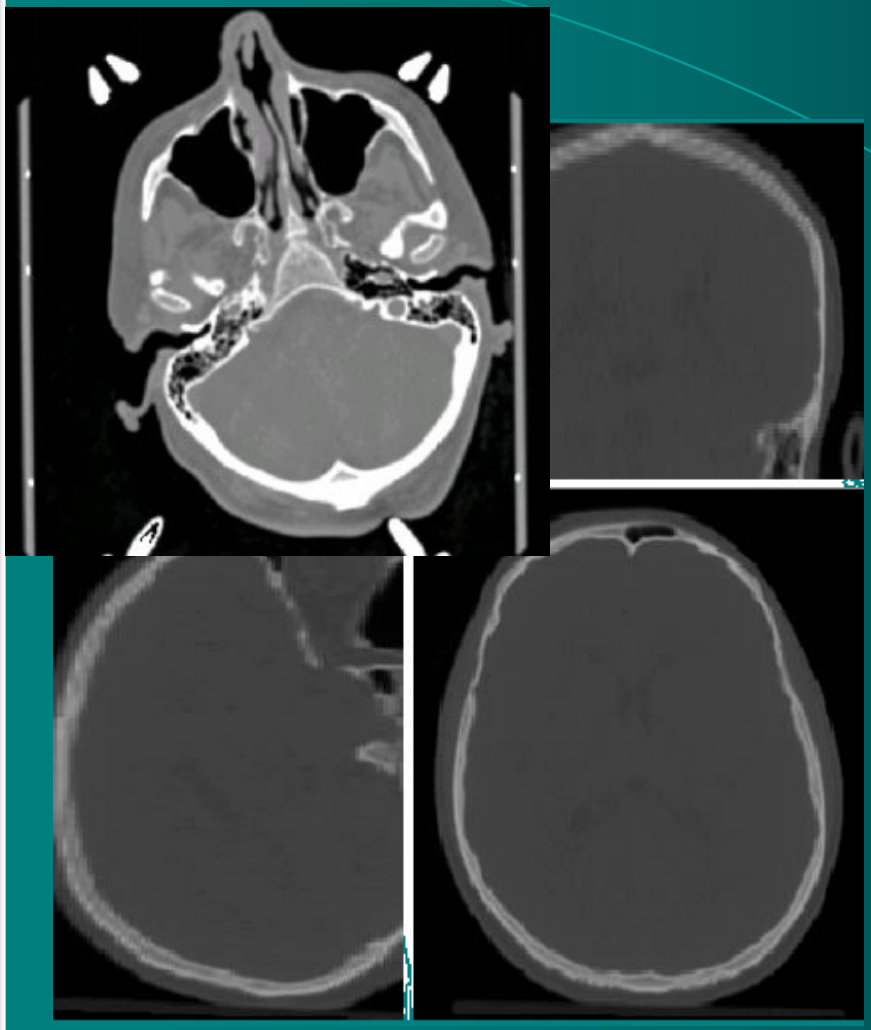
- ***treatment***
  - ***treatment simulation***
  - ***treatment verification***
  - ***treatment evaluation***

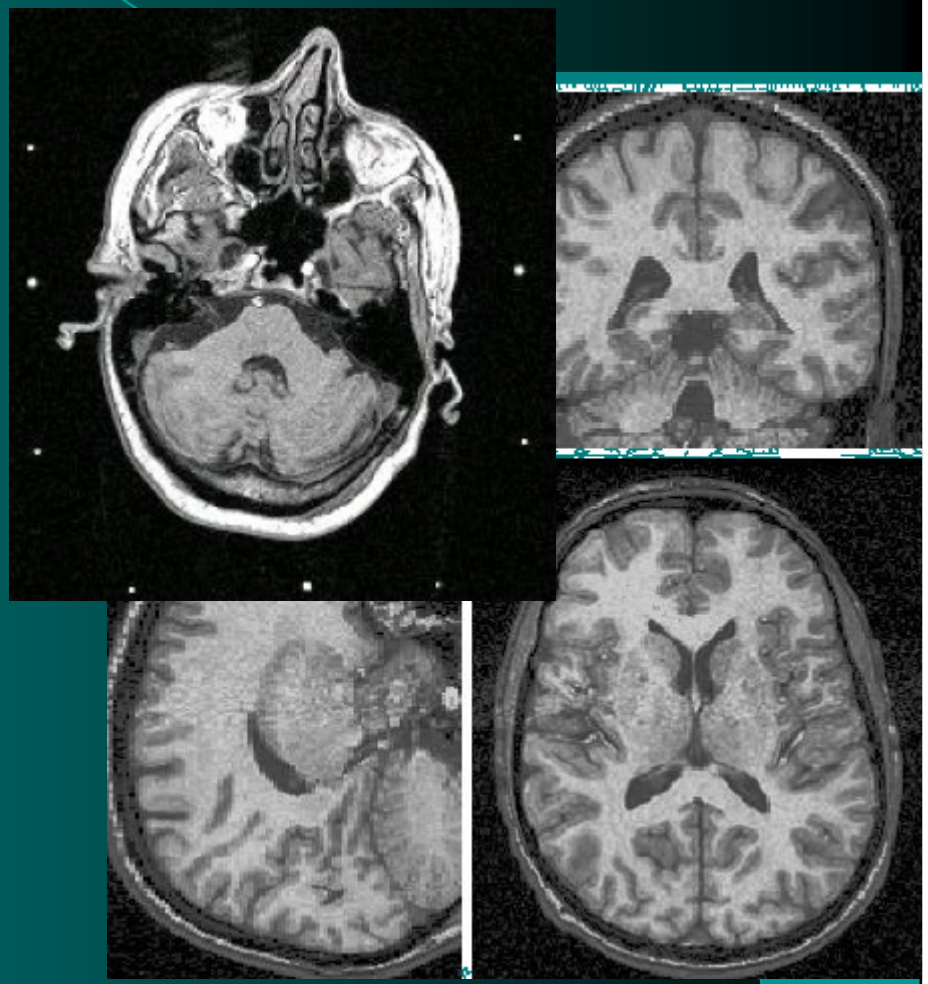
Pretreatment imaging

- *CT* *for planning*
- *MRI*
- *PET-CT*

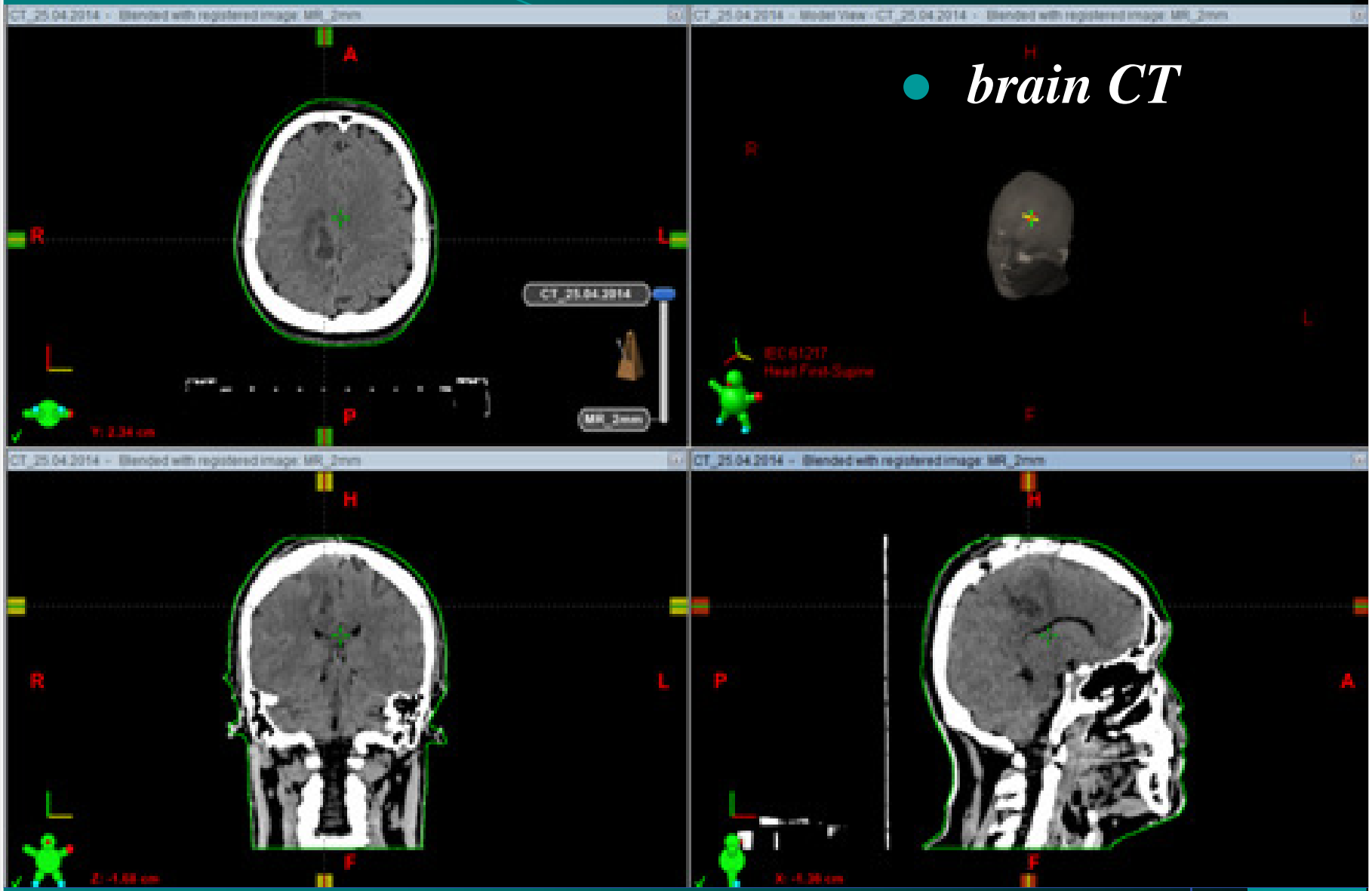
for registration

Why MRI?



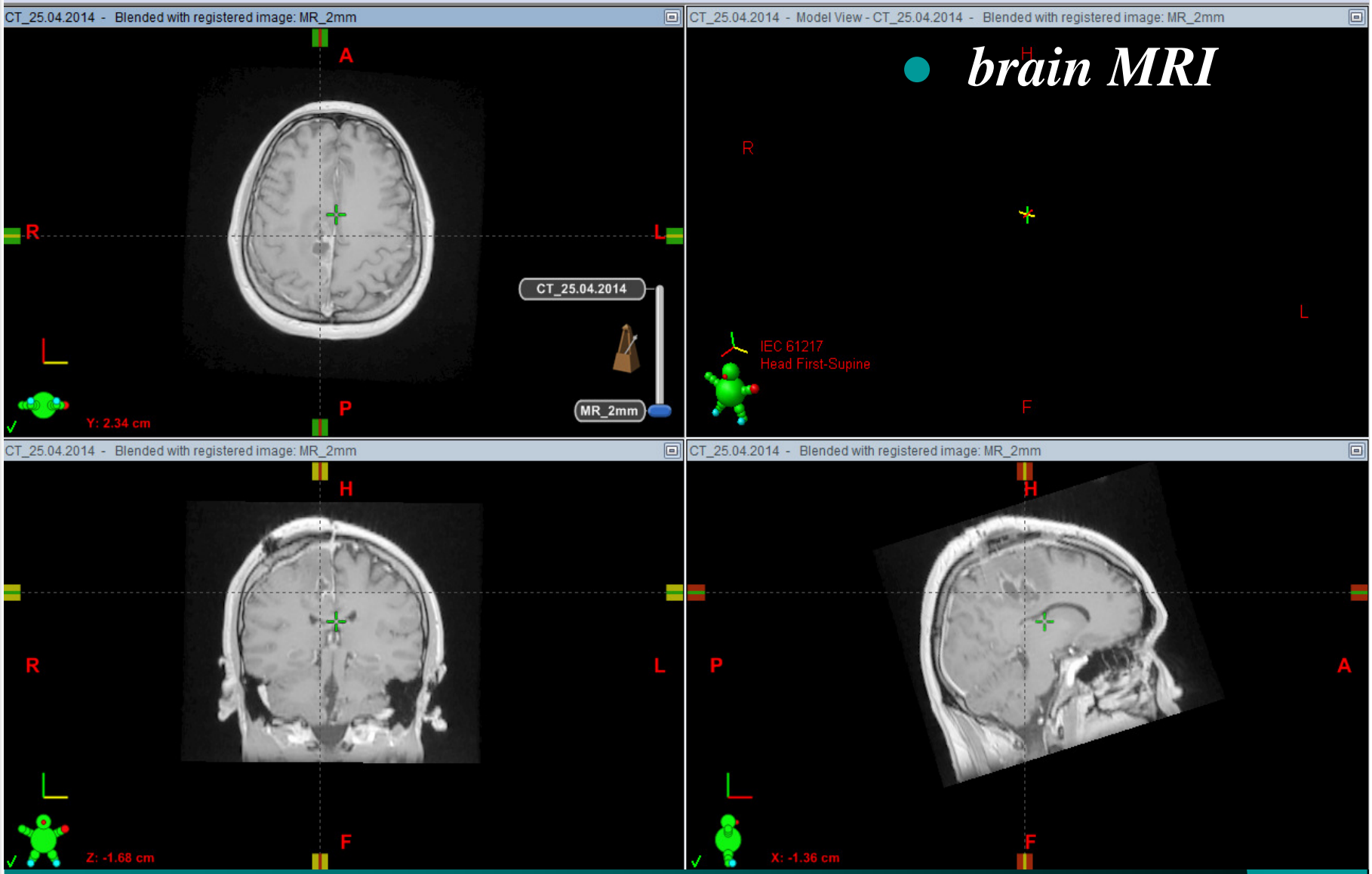


Pre - treatment imaging



- *brain CT*

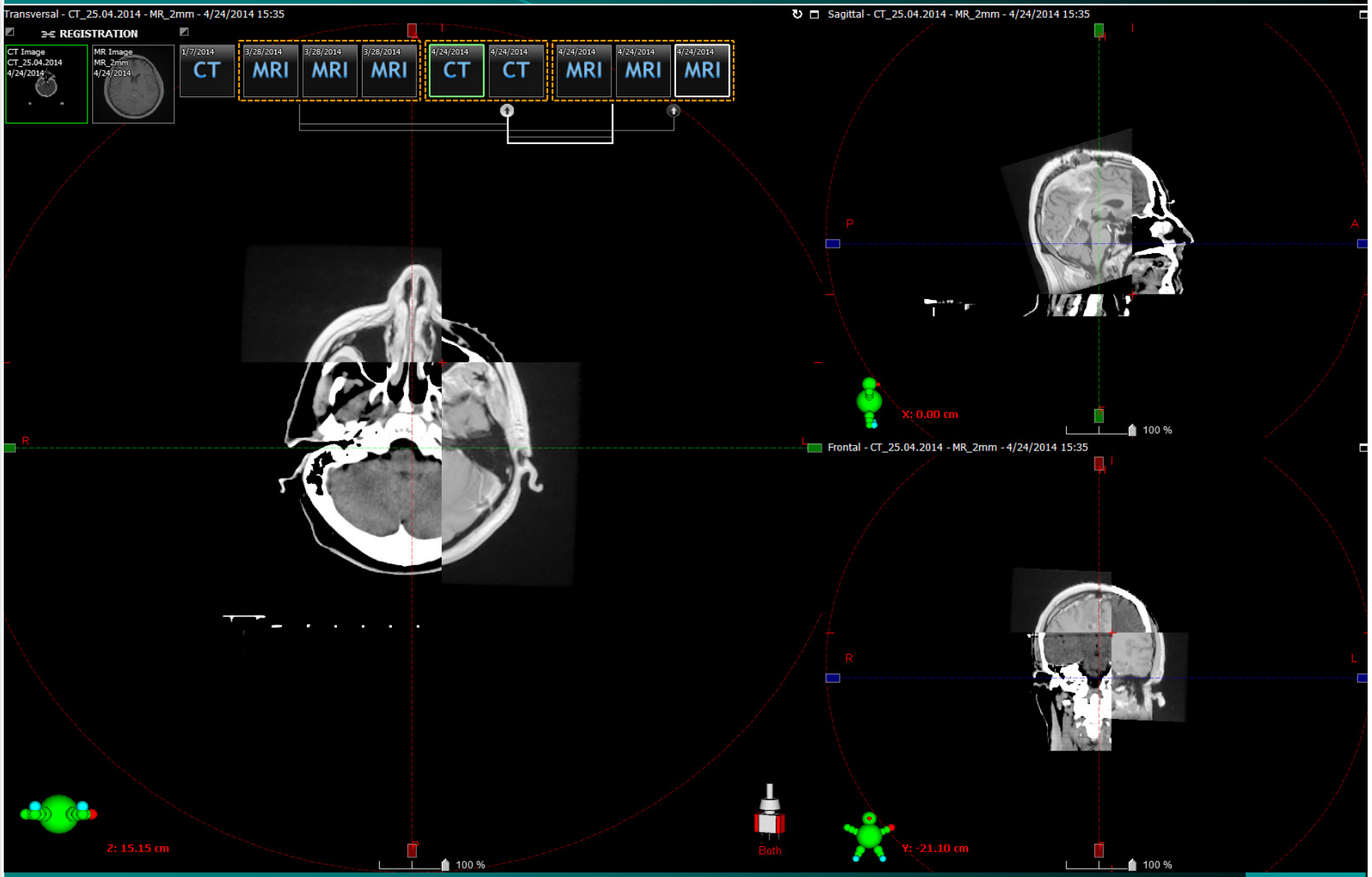
Pre - treatment imaging



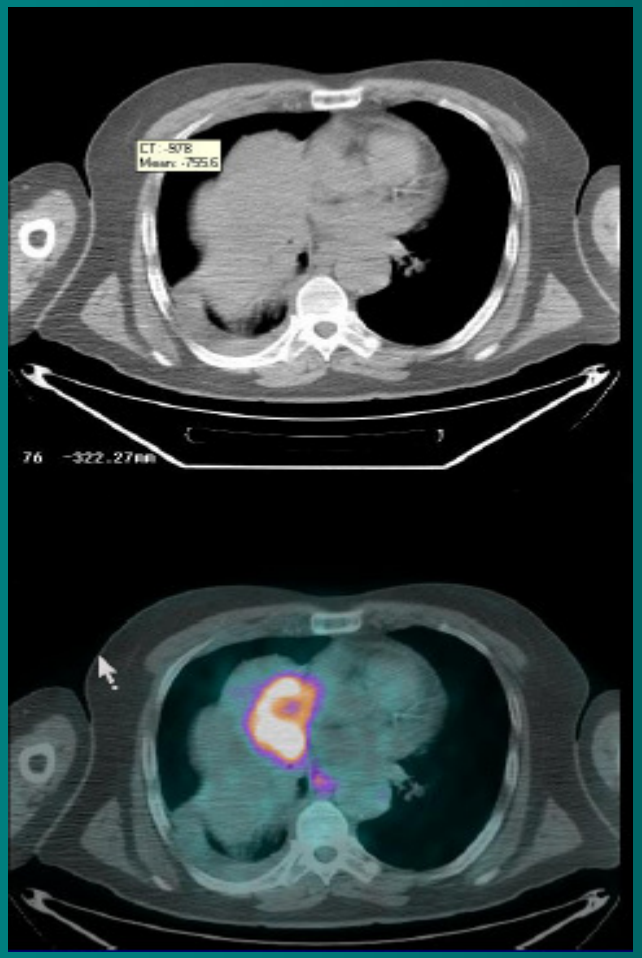
- *brain MRI*

images registration

- ***CT - MRI***



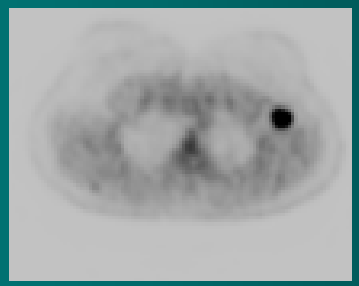
Why PET/CT?

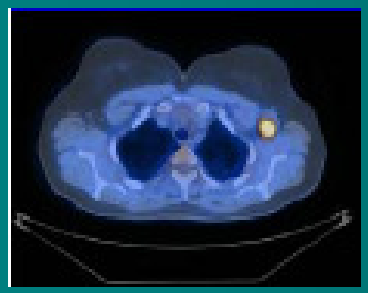


- *Primary: lung Ca patient with atelectasis that is visible on CT*
- *Right hilar mass is visible on onlyPET*

Integrated PET/CT Imaging System

BENEFITS of COMBINED TECHNIQUE





anatomical localisation

attenuation correction

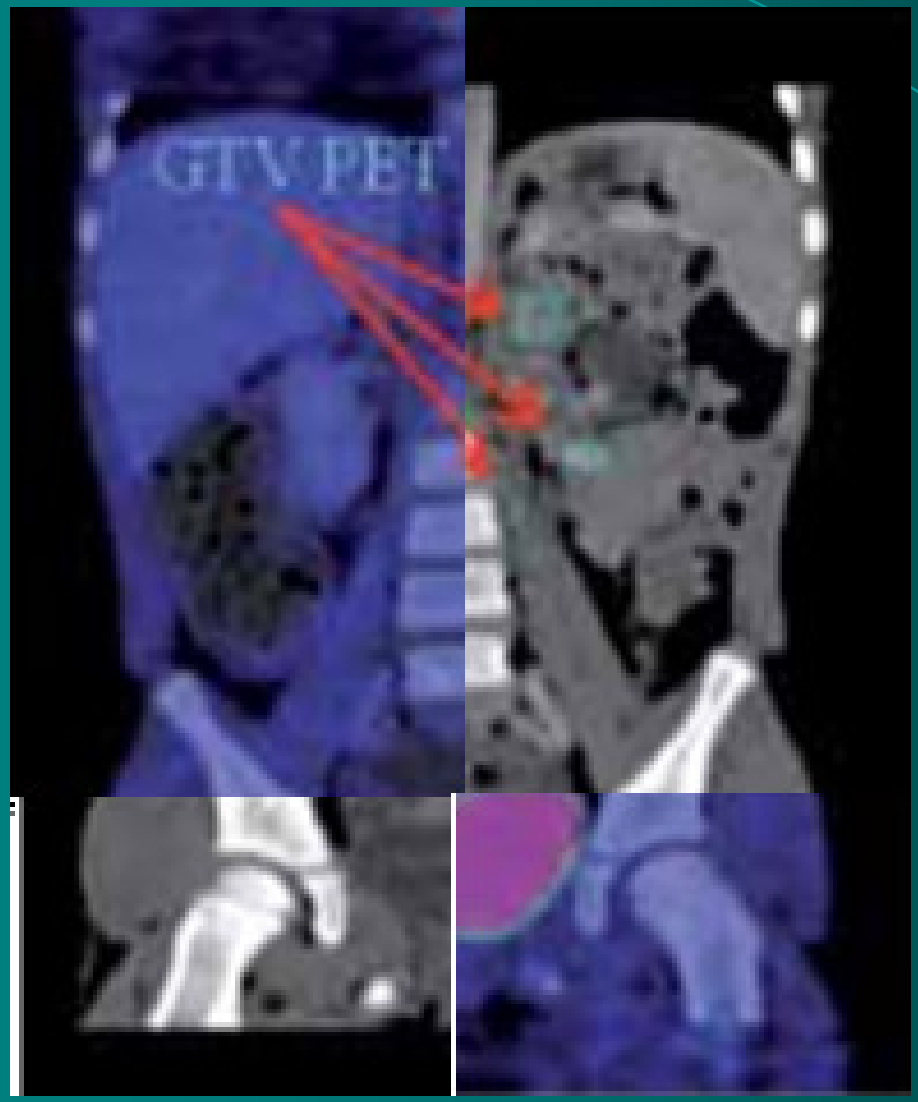
Pre - treatment imaging

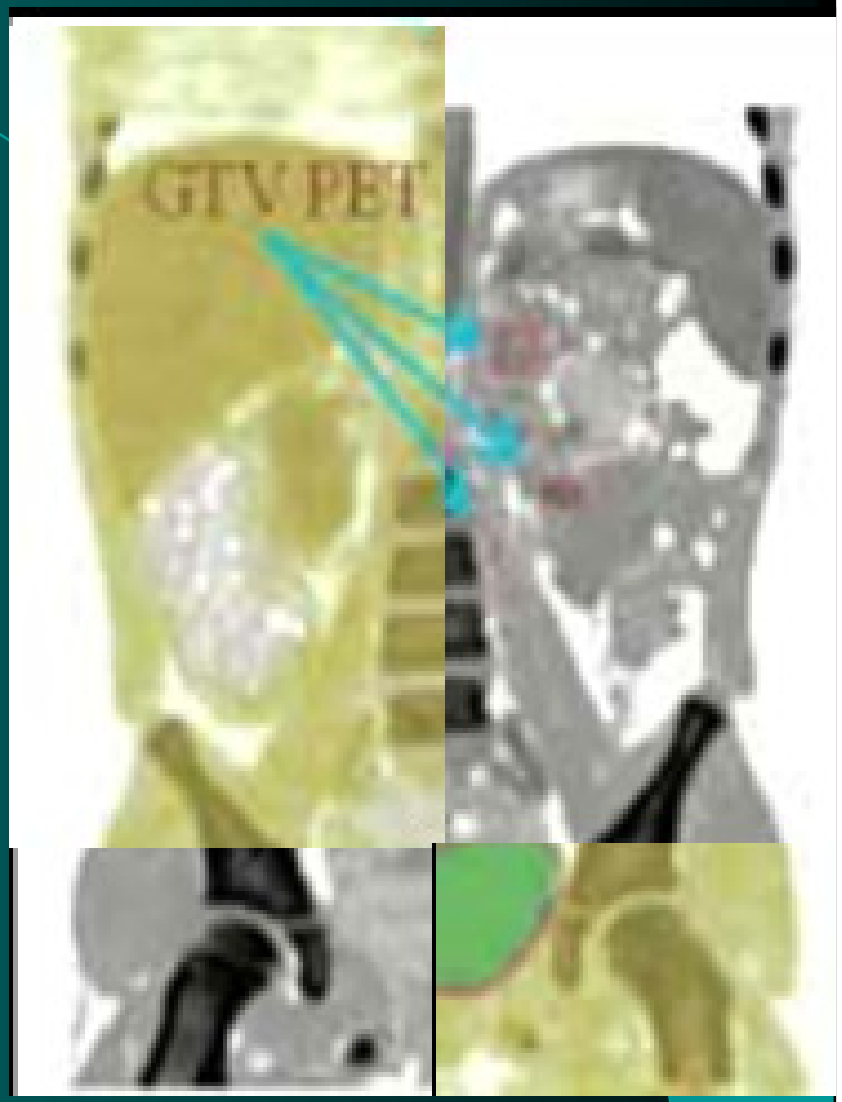
- *lung CT*

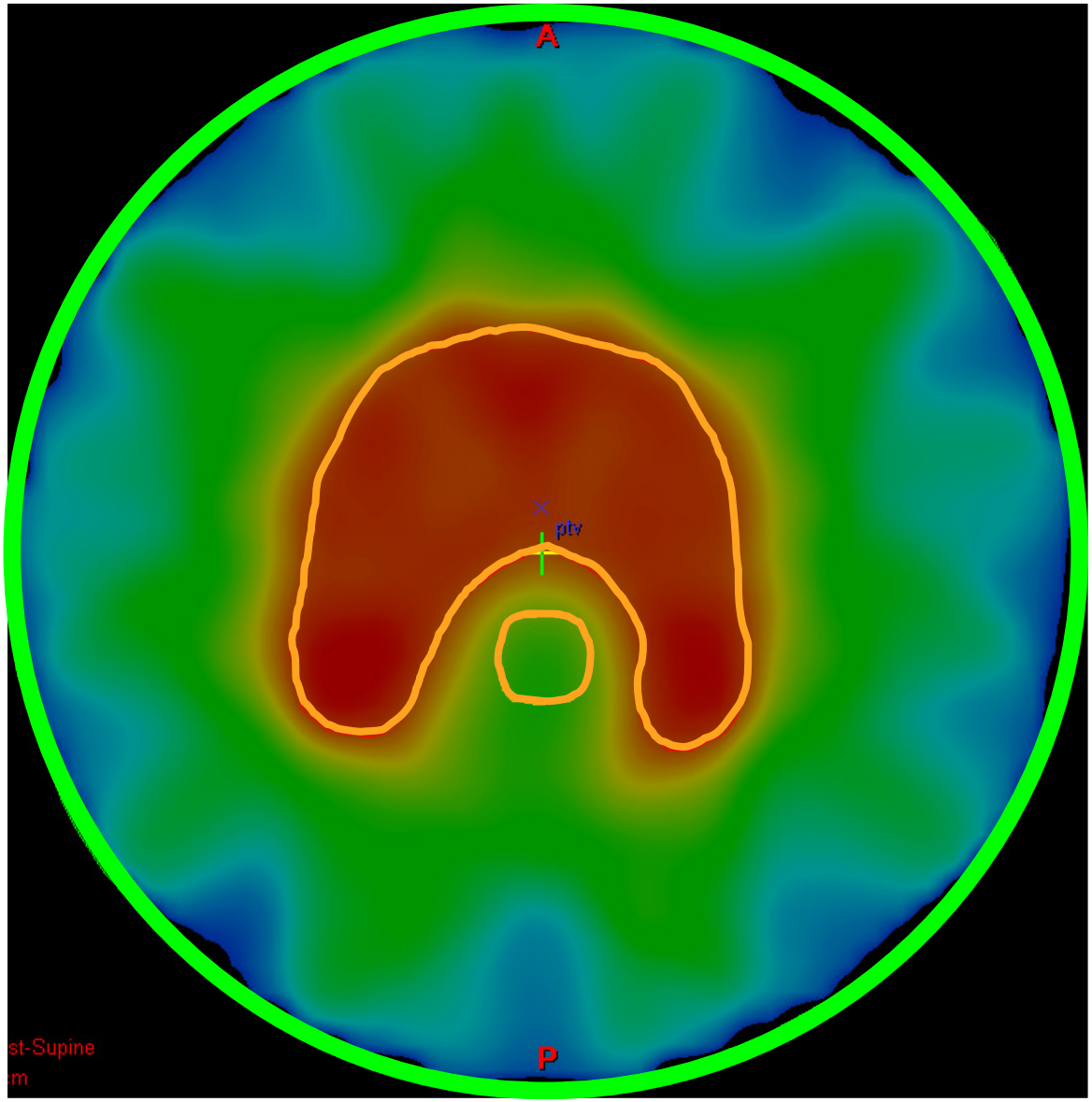
- *lung PET/CT*

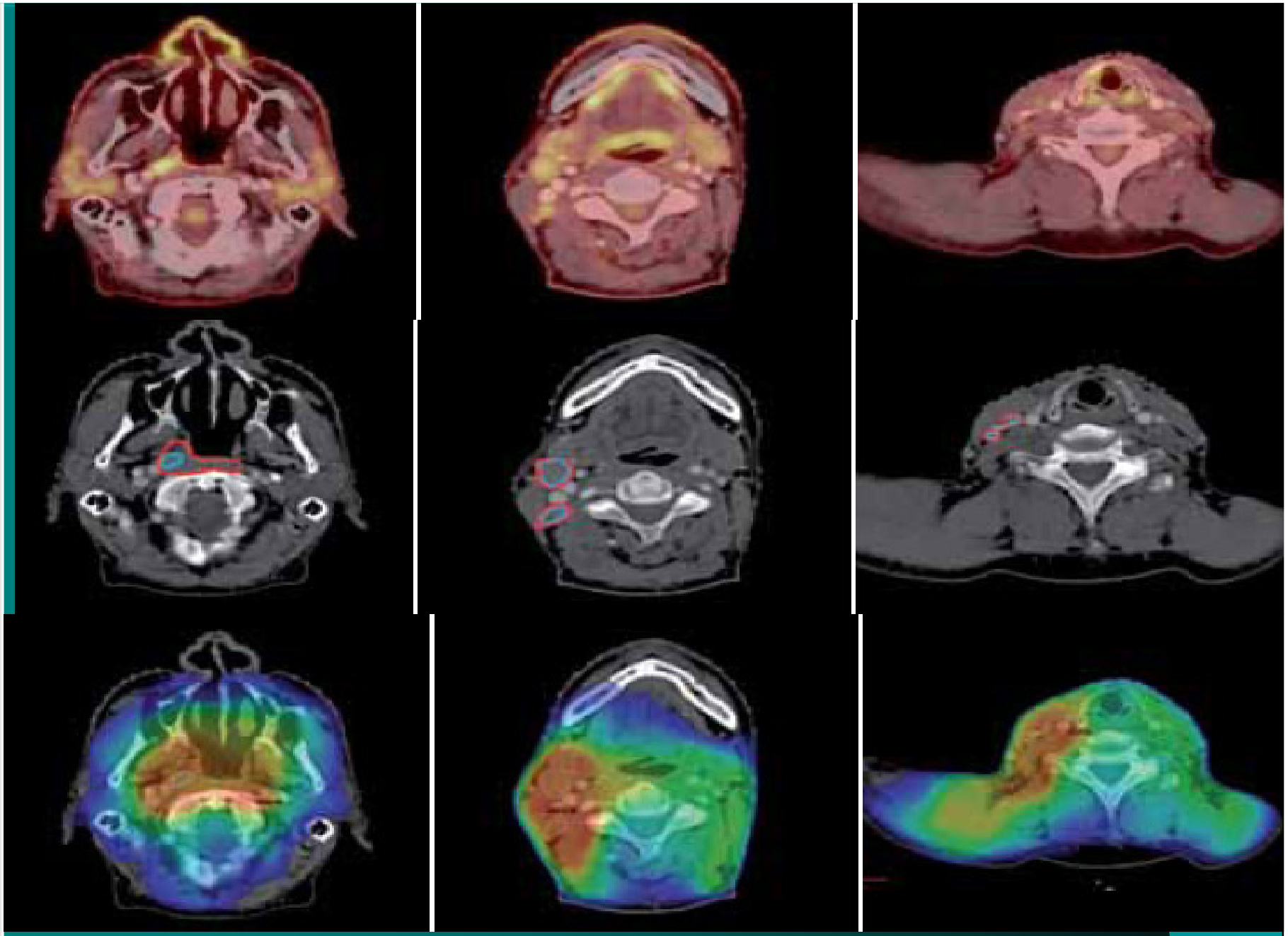
images registration

- ***CT - PET***





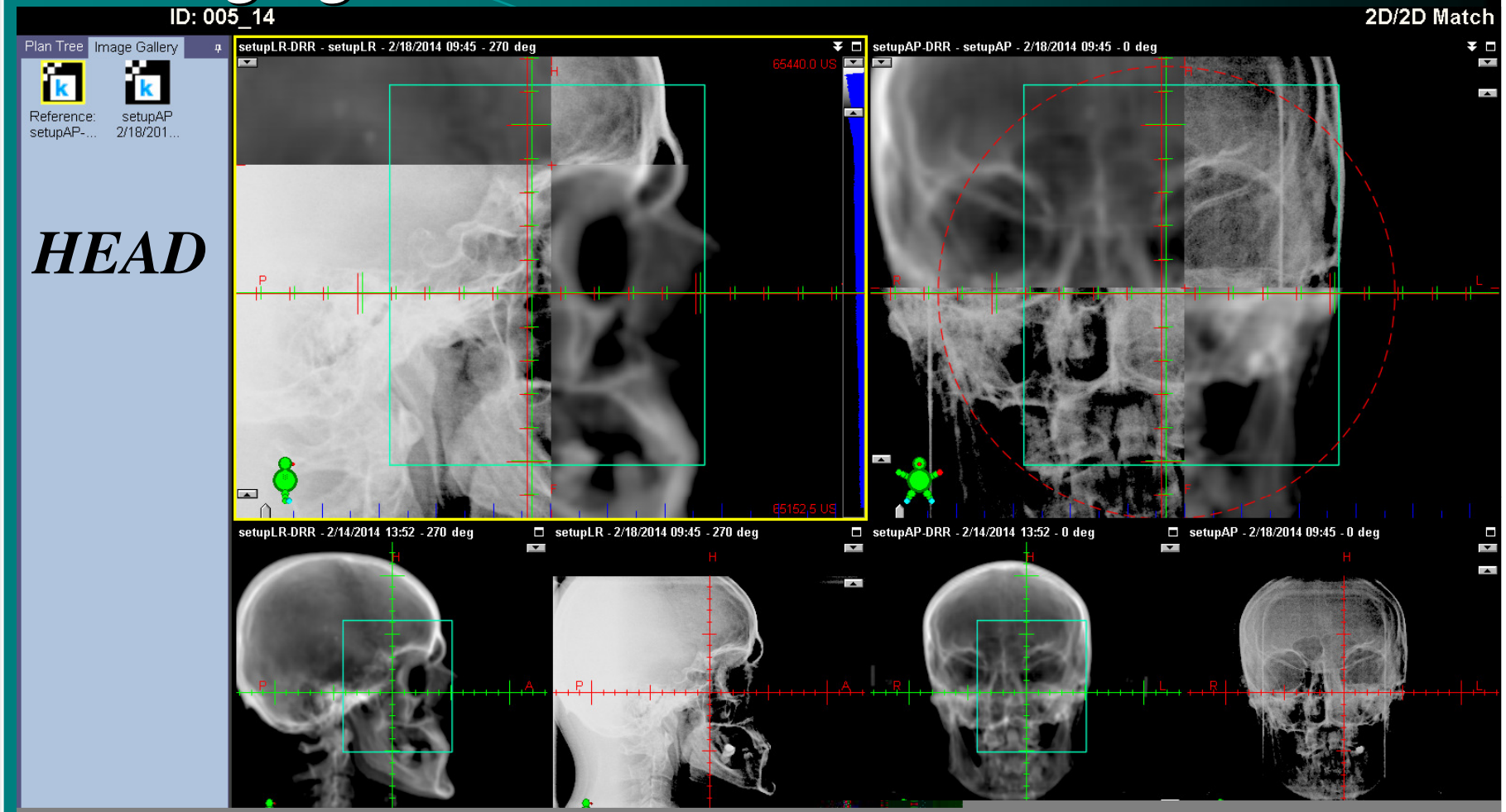

A
ptv
st-Supine
m
P



Imaging for treatment verification

- *geometry verification of the particular treatment*
  - *Patient position during the treatment which affect intrafraction dose distribution*
  -

Imaging for treatment verification kV-kV



Imaging for treatment verification CBCT

ID: 005_14

3D/3D Match

Plan Tree | Image Gallery

Reference: AP1-DR...

HEAD

Transversal - CT_1 - CBCT_1 - 2/18/2014 09:54

Sagittal - CT_1 - CBCT_1 - 2/18/2014 09:54

X: 0.00 cm

Frontal - CT_1 - CBCT_1 - 2/18/2014 09:54

Y: -19.80 cm

Head First Supine
Z: -4.10 cm

Couch Position (IEC 61217 Scale) and Shift

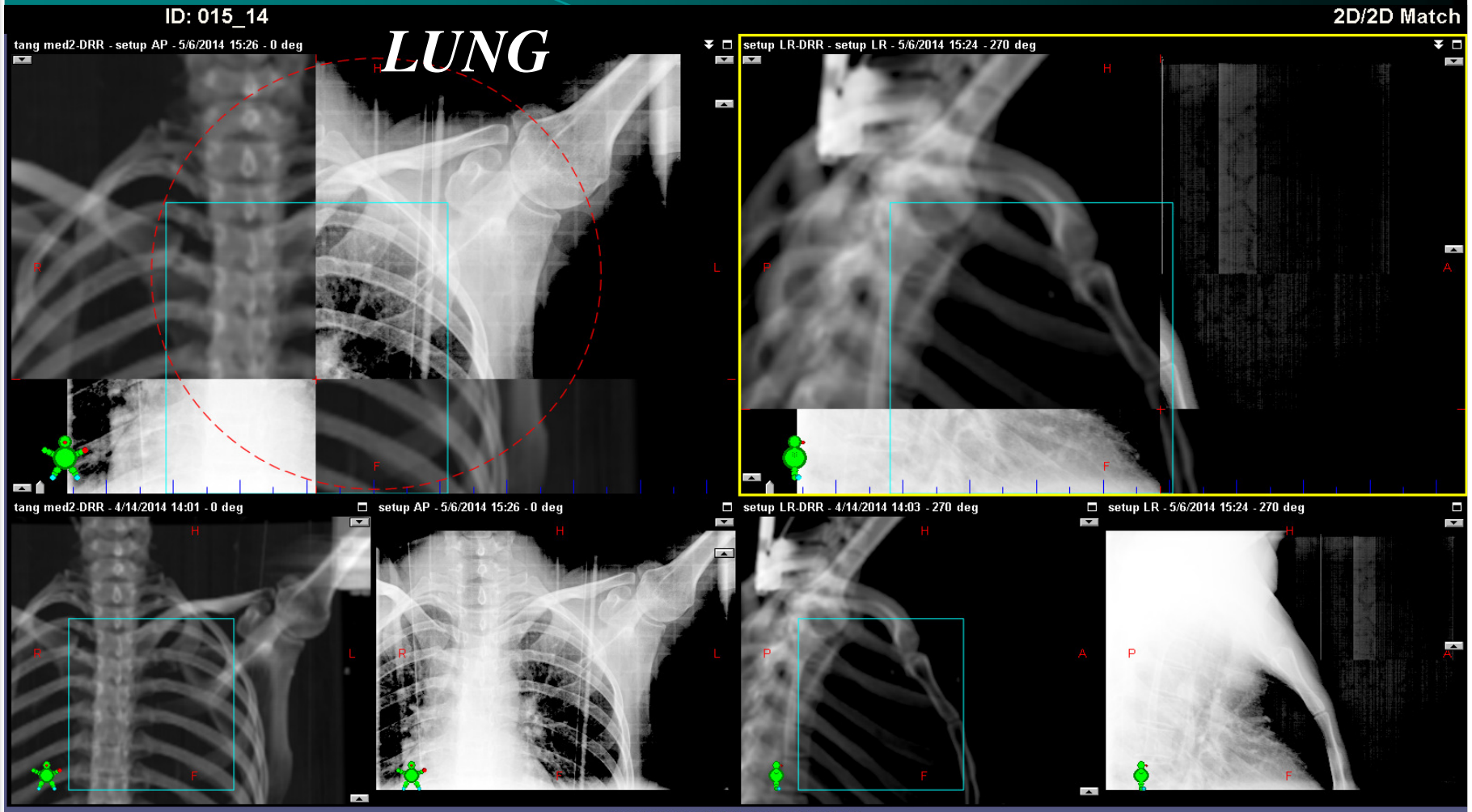
	TARGET	ACTUAL	SHIFT			TARGET	ACTUAL	SHIFT	
Couch Vrt	-17.4	-17.4	0.0	☑ Include	Couch Lat	-2.1	-2.2	+0.1	☑ Include
Couch Lng	117.1	117.1	0.0	☑ Include	Couch Rtn	0.0	0.0	0.0	☑ Include

Reset Shift

Save Match

Apply Shift

Imaging for treatment verification kV-kV



Couch Position (VAR IEC Scale) and Shift

	TARGET	ACTUAL	SHIFT			TARGET	ACTUAL	SHIFT	
Couch Vrt	23.7	23.8	-0.1	☑ Include	Couch Lat	995.1	995.2	-0.1	☑ Include
Couch Lng	116.0	116.0	0.0	☑ Include	Couch Rtn	0.0	0.0	0.0	☑ Include

All units in cm and degrees

Reset Shift
Save Match
Apply Shift

Imaging for treatment verification CBCT

3D/3D Match

Plan Tree | Image Gallery

Reference: setupCBC...

Transversal - CT_1 - CBCT_1 - 3/12/2014 13:35

LUNG

Head First-Supine
Z: 5.80 cm

Couch Position (IEC 61217 Scale) and Shift

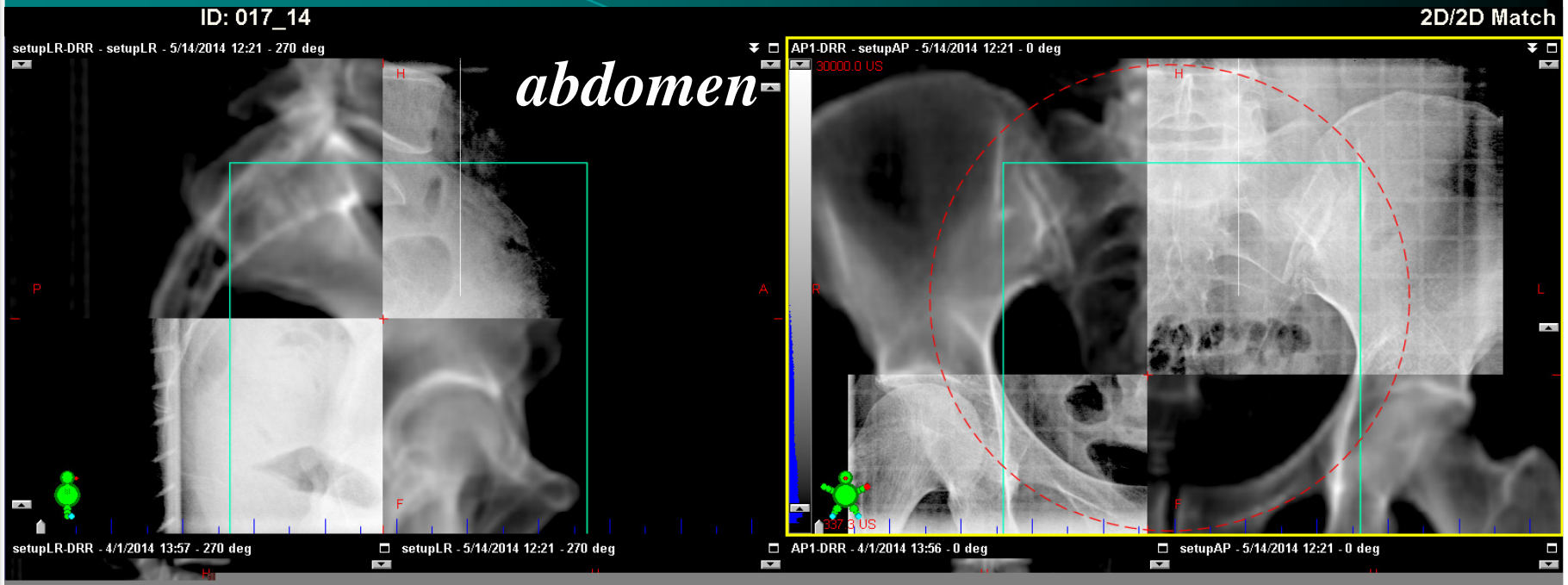
	TARGET	ACTUAL	SHIFT			TARGET	ACTUAL	SHIFT	
Couch Vrt	-8.5	-8.9	+0.4	☑ Include	Couch Lat	+4.3	+4.2	+0.1	☑ Include
Couch Lng	131.9	131.8	+0.1	☑ Include	Couch Rtn	359.9	359.9	0.0	☐ Include

Reset Shift

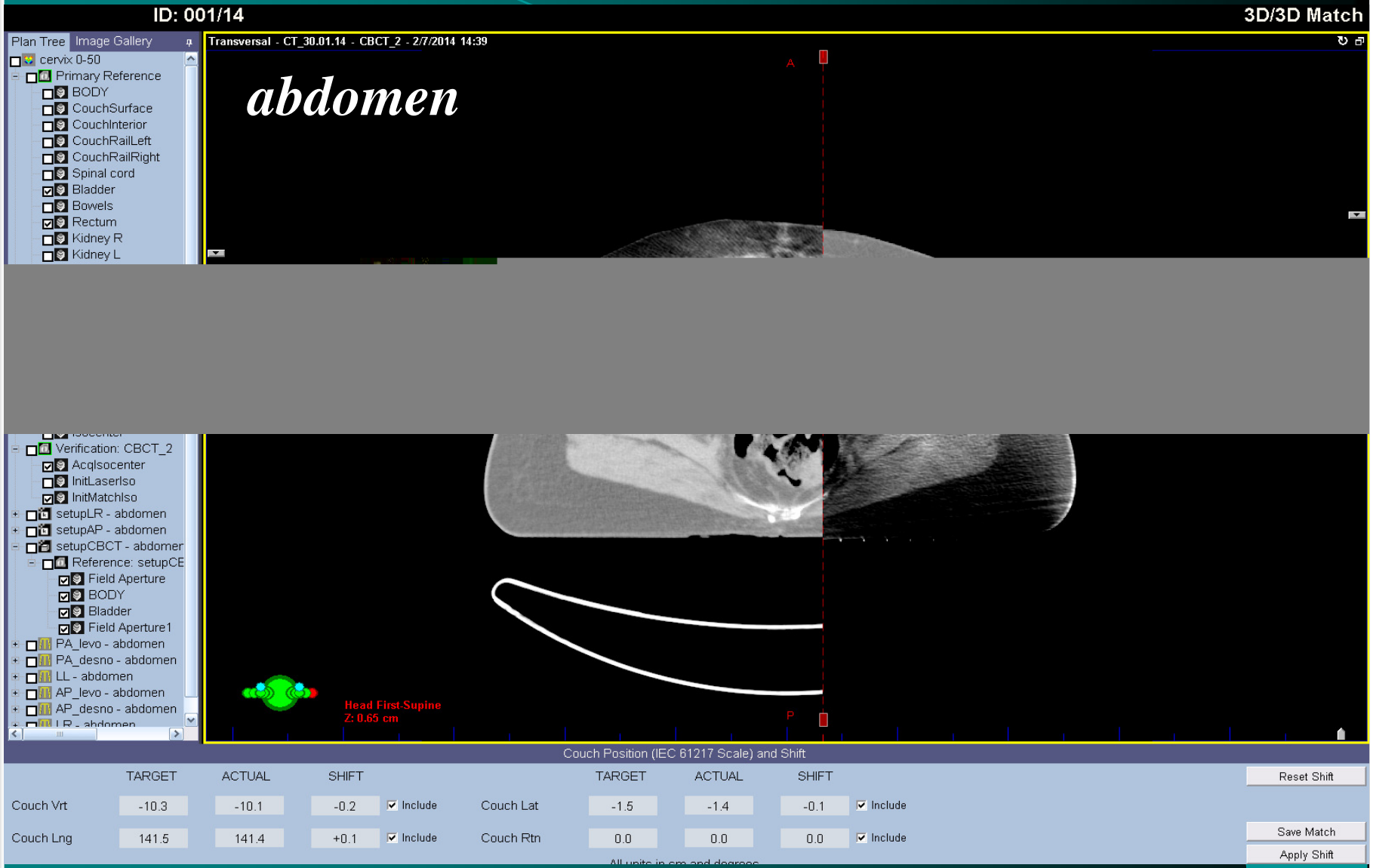
Save Match

Apply Shift

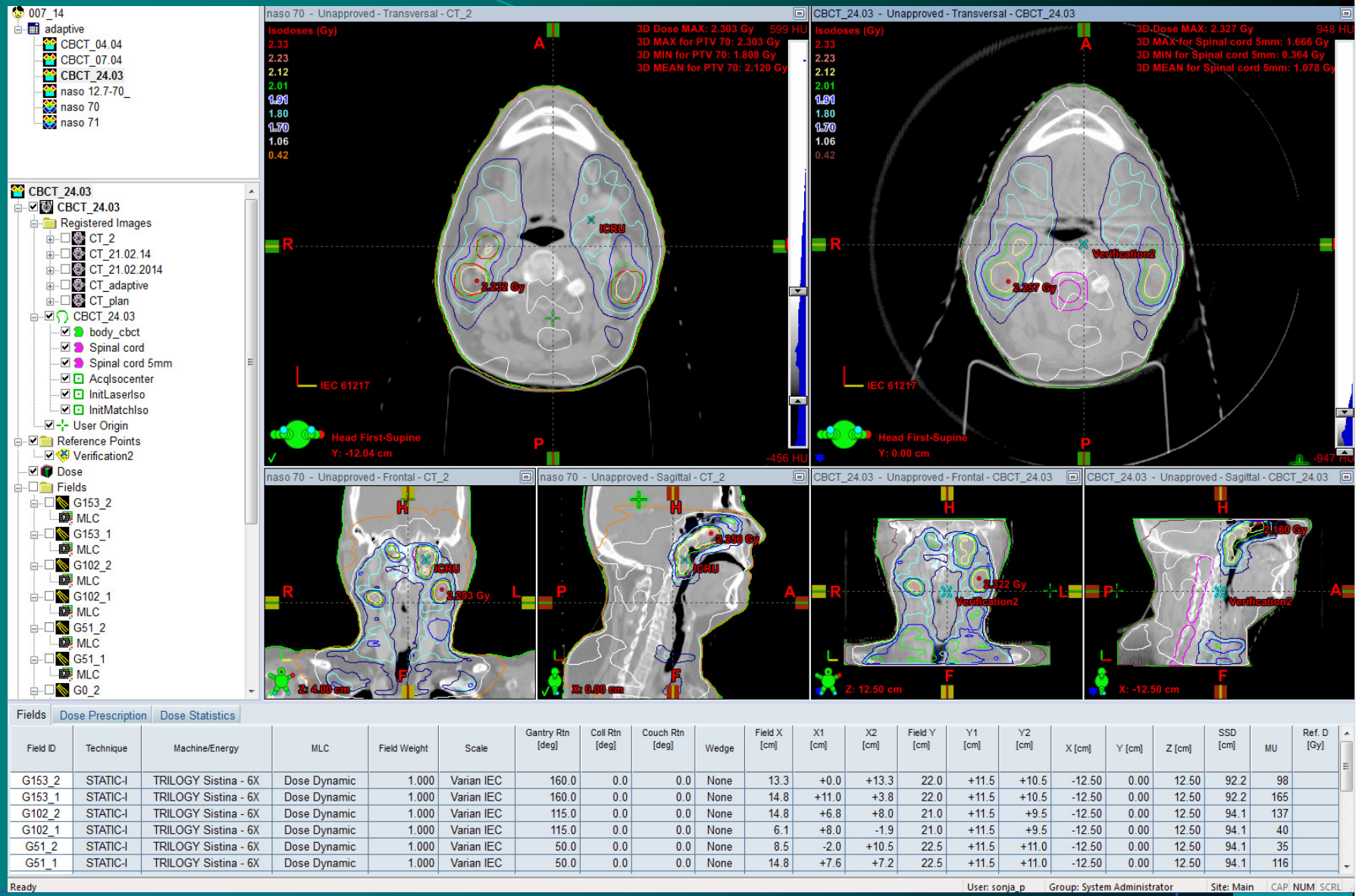
Imaging for treatment verification kV-kV



Imaging for treatment verification CBCT



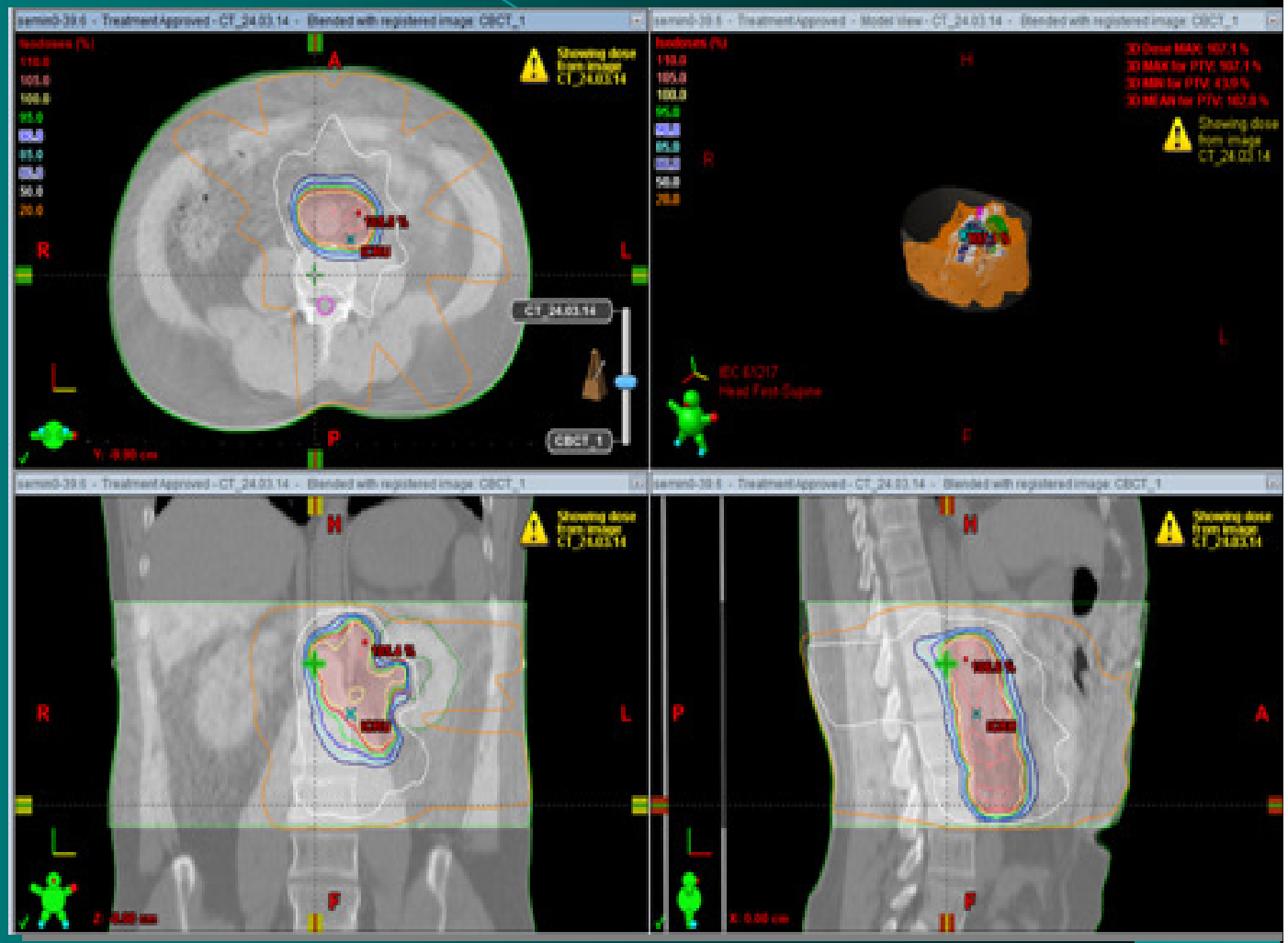
Imaging for treatment evaluation



Field ID	Technique	Machine/Energy	MLC	Field Weight	Scale	Gantry Rtn [deg]	Coll Rtn [deg]	Couch Rtn [deg]	Wedge	Field X [cm]	X1 [cm]	X2 [cm]	Field Y [cm]	Y1 [cm]	Y2 [cm]	X [cm]	Y [cm]	Z [cm]	SSD [cm]	MU	Ref. D [Gy]
G153_2	STATIC-I	TRILOGY Sistina - 6X	Dose Dynamic	1.000	Varian IEC	160.0	0.0	0.0	None	13.3	+0.0	+13.3	22.0	+11.5	+10.5	-12.50	0.00	12.50	92.2	98	
G153_1	STATIC-I	TRILOGY Sistina - 6X	Dose Dynamic	1.000	Varian IEC	160.0	0.0	0.0	None	14.8	+11.0	+3.8	22.0	+11.5	+10.5	-12.50	0.00	12.50	92.2	165	
G102_2	STATIC-I	TRILOGY Sistina - 6X	Dose Dynamic	1.000	Varian IEC	115.0	0.0	0.0	None	14.8	+6.8	+8.0	21.0	+11.5	+9.5	-12.50	0.00	12.50	94.1	137	
G102_1	STATIC-I	TRILOGY Sistina - 6X	Dose Dynamic	1.000	Varian IEC	115.0	0.0	0.0	None	6.1	+8.0	-1.9	21.0	+11.5	+9.5	-12.50	0.00	12.50	94.1	40	
G51_2	STATIC-I	TRILOGY Sistina - 6X	Dose Dynamic	1.000	Varian IEC	50.0	0.0	0.0	None	8.5	-2.0	+10.5	22.5	+11.5	+11.0	-12.50	0.00	12.50	94.1	35	
G51_1	STATIC-I	TRILOGY Sistina - 6X	Dose Dynamic	1.000	Varian IEC	50.0	0.0	0.0	None	14.8	+7.6	+7.2	22.5	+11.5	+11.0	-12.50	0.00	12.50	94.1	116	

Imaging for treatment evaluation

- *CBCT verification plan*



Assume:

The image registration Is perfect

The position of the patient is correct

The dose into volumes of interest displayed on the evaluation image is the same as the predicted one

Questions:

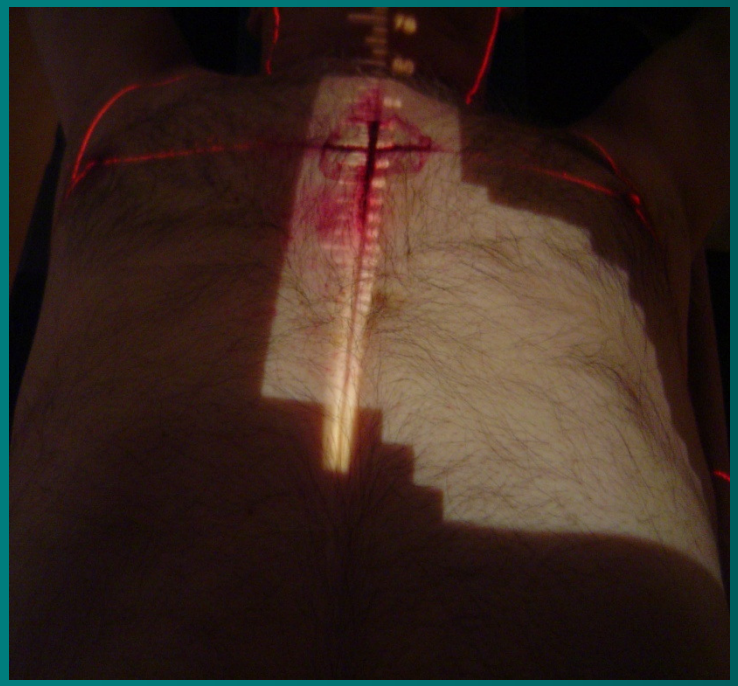
Is that enough to have a precise treatment?

How we are sure that the delivered dose is the same as the predicted one?

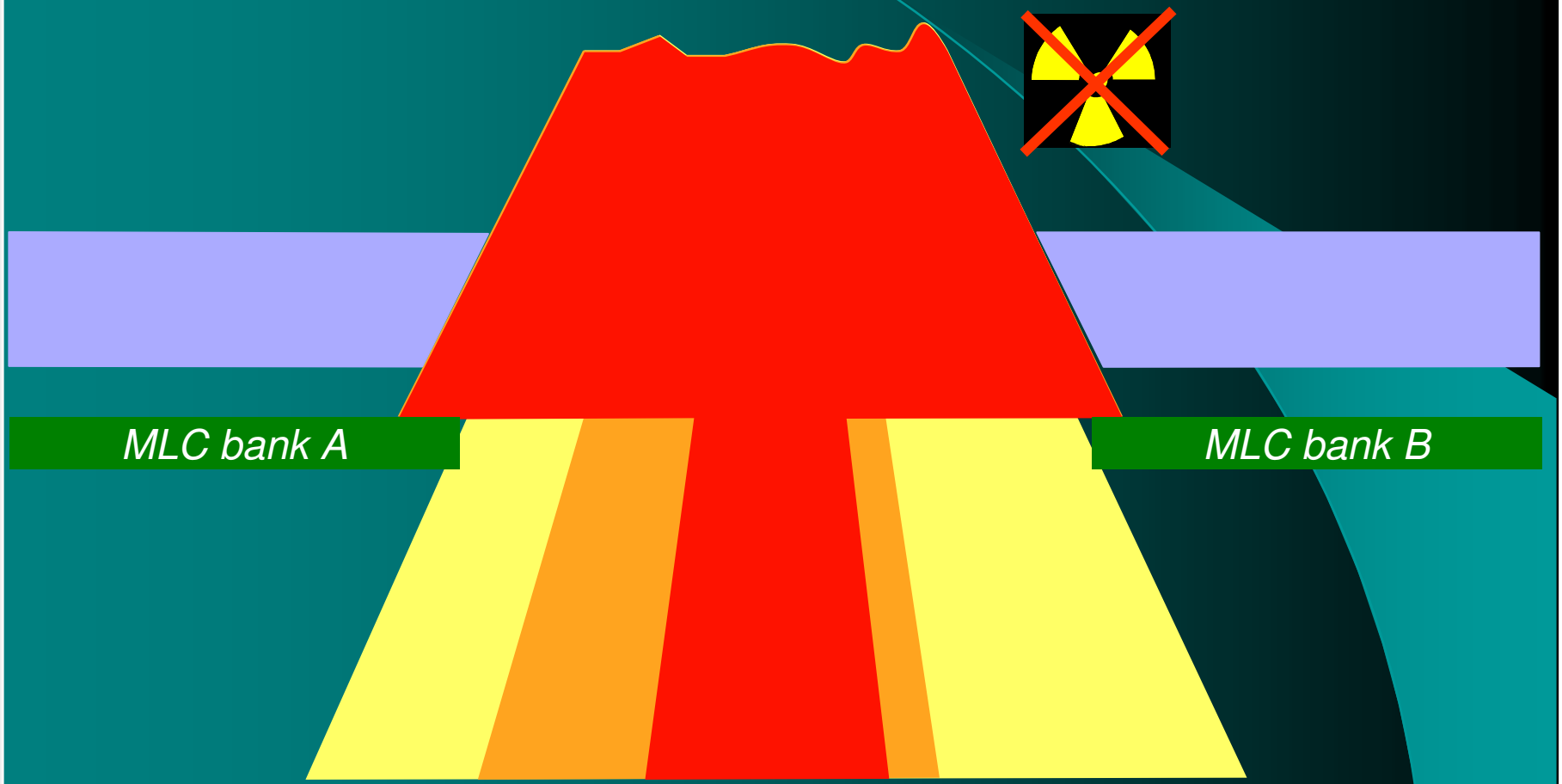
What about machine functionality?

Is the beam really delivered on the way we predicted?

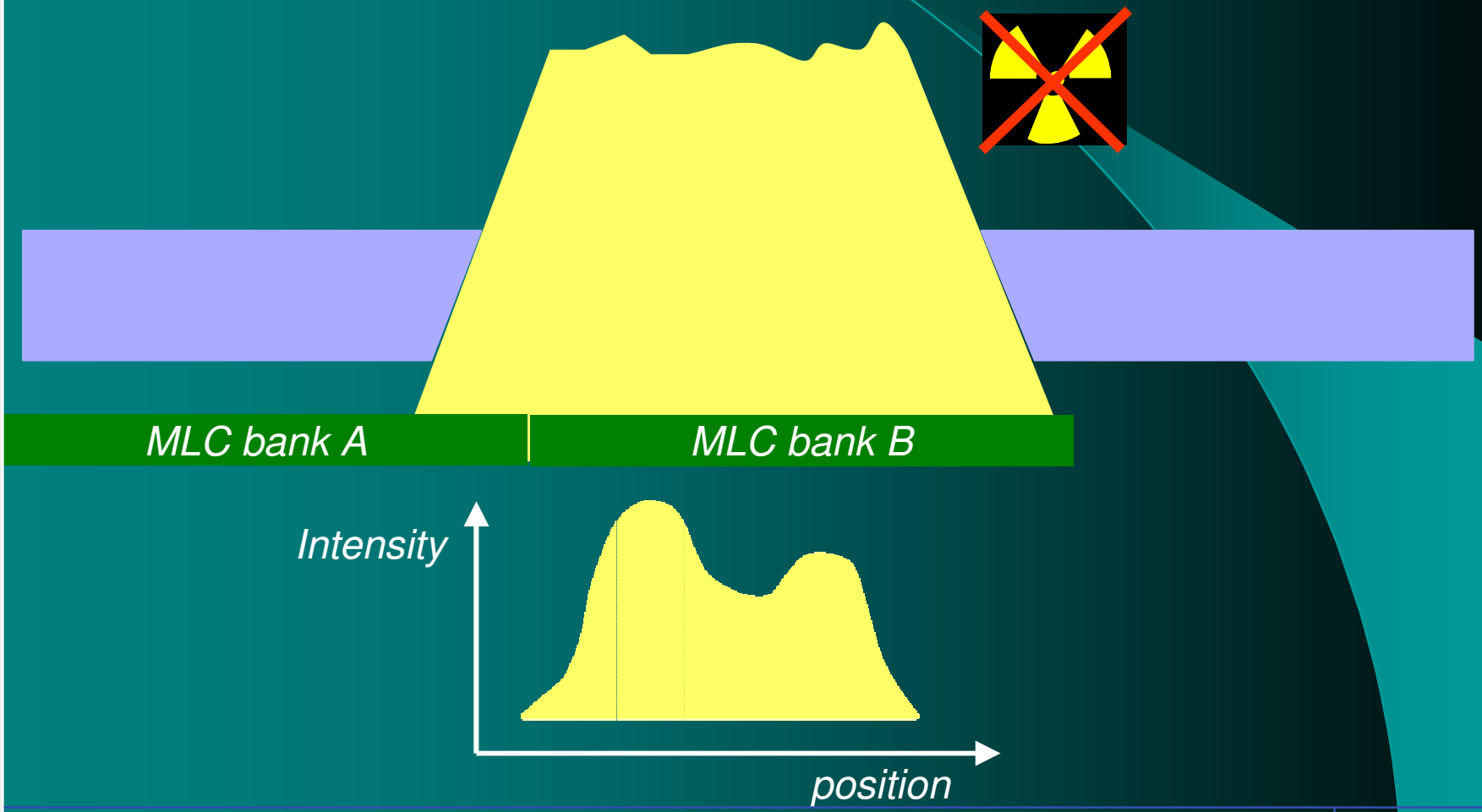
Static field:

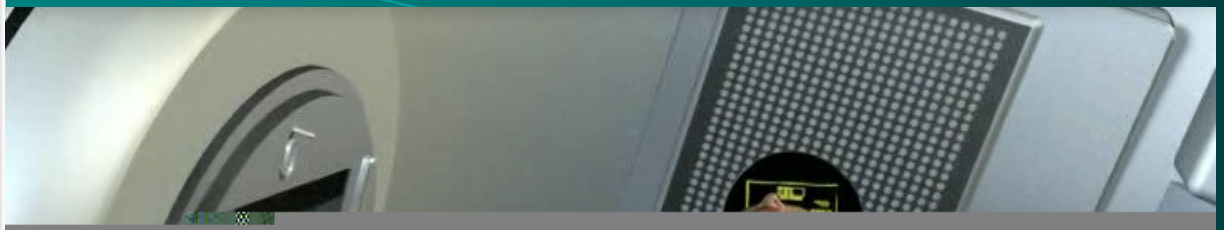


dynamic field, discret way of MLC moving:



dynamic field, continuing way of MLC moving:



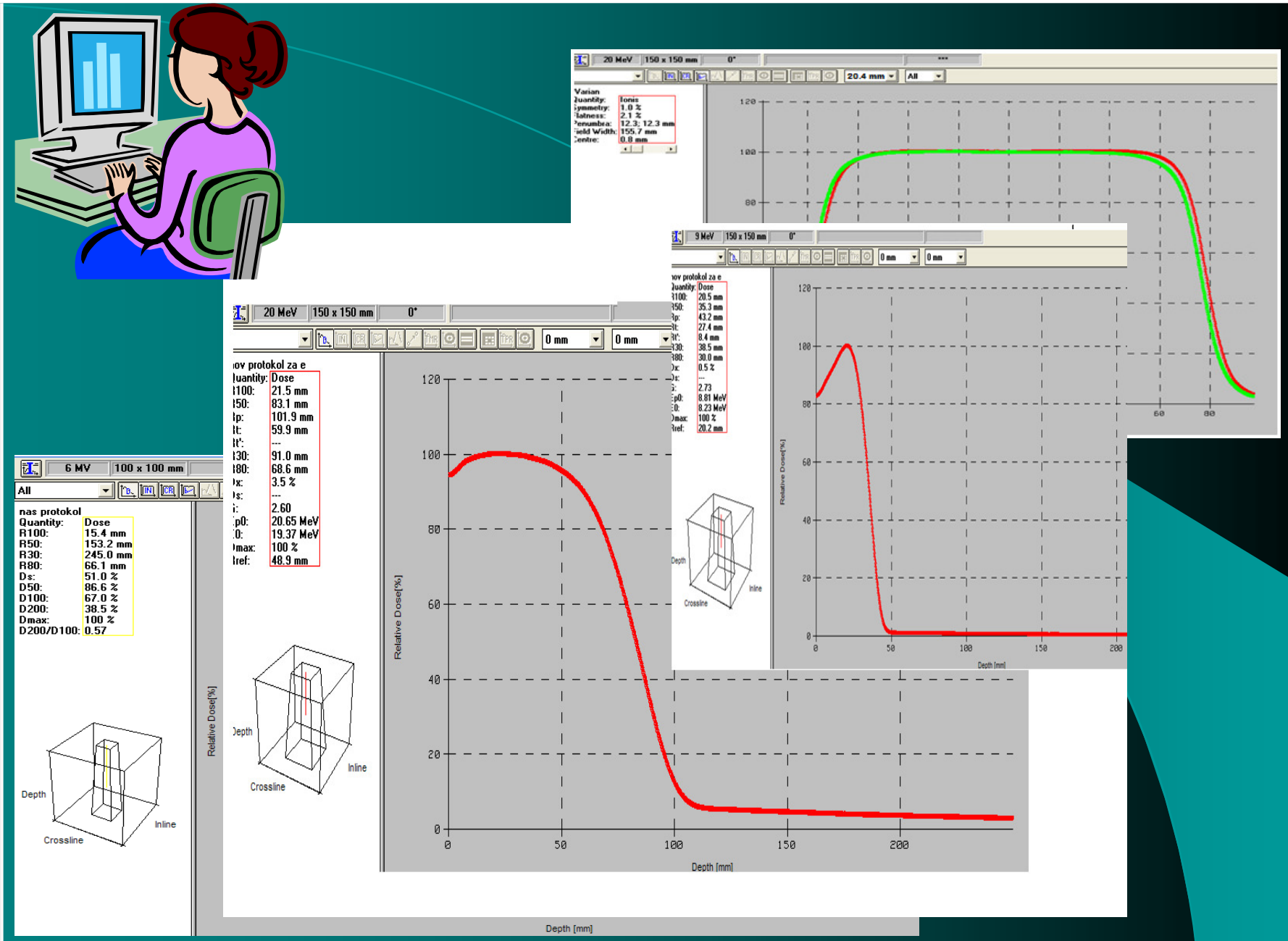


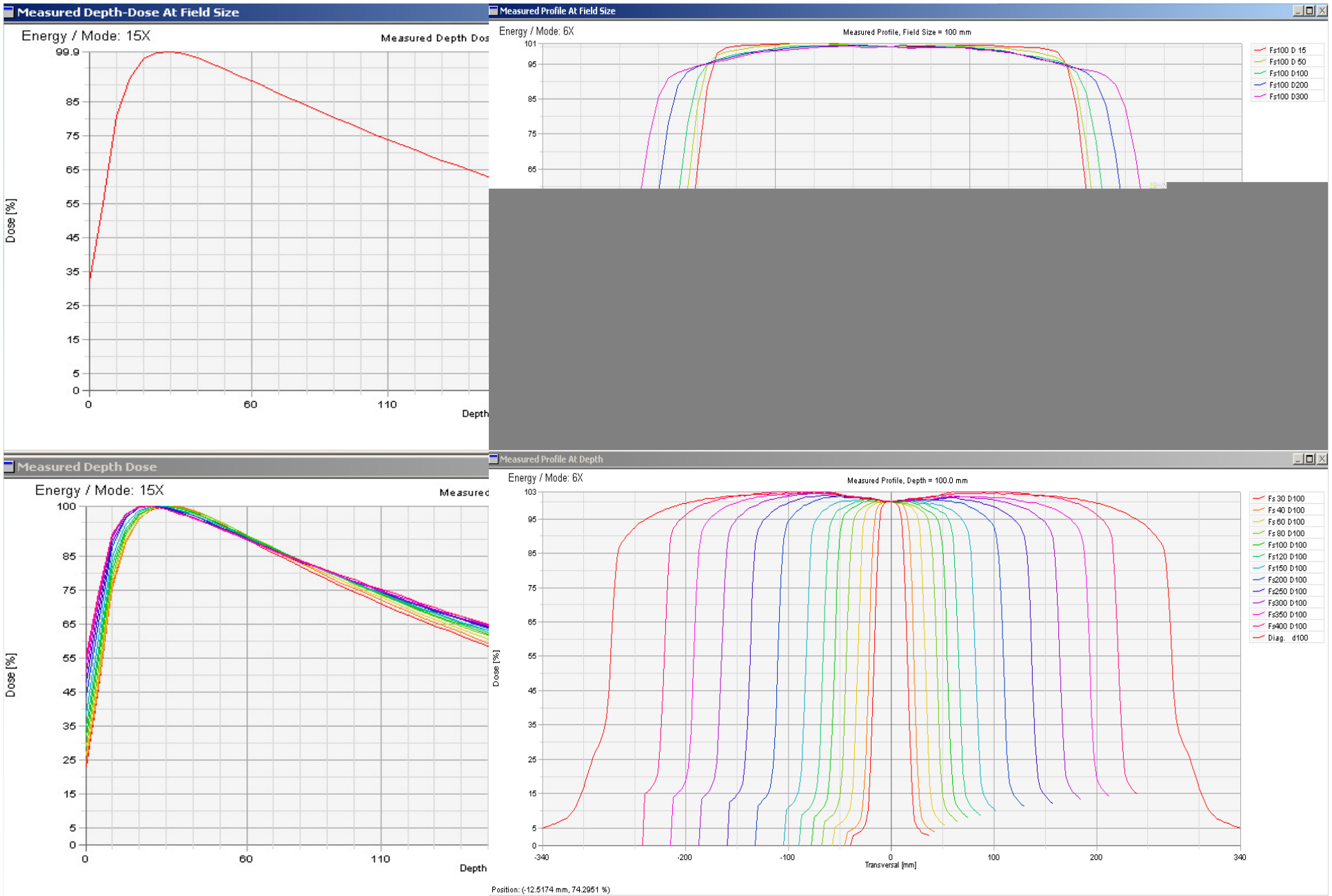
Commissioning

Prepare for clinical use:
- measure necessary parameters
- use them as reference values for calculation

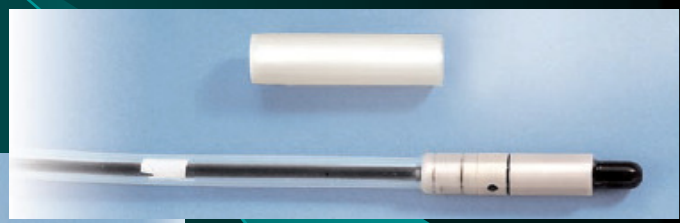
Calibration and Dosimetry checks

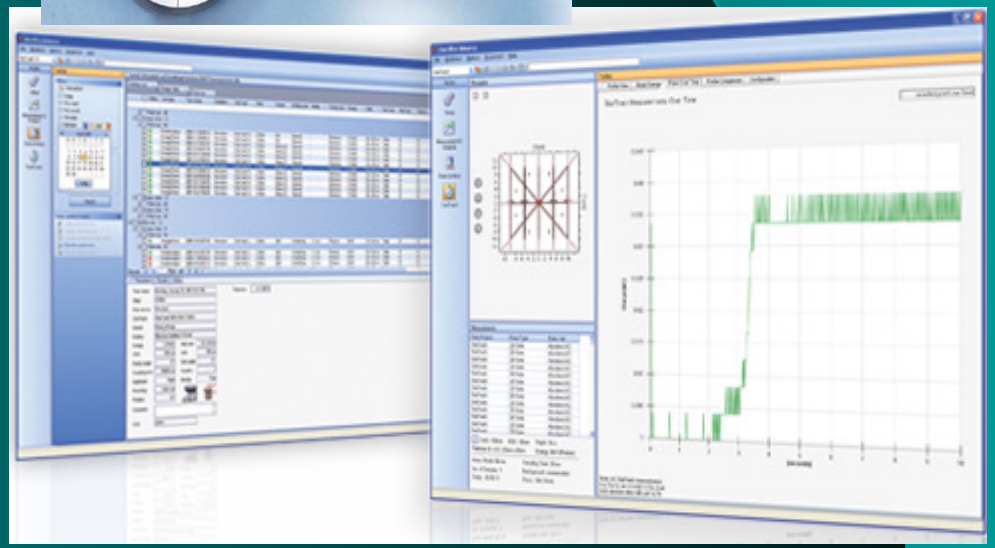
Periodically measurements of these parameters, comparing with the reference values and calibrate them if necessary

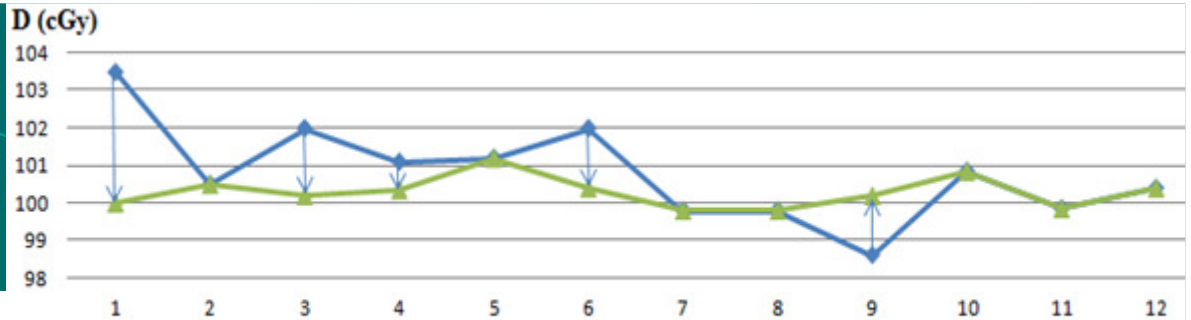

6 MV
100 x 100 mm
All
nas protokol
Quantity: Dose
R100: 15.4 mm
R50: 153.2 mm
R30: 245.0 mm
R80: 66.1 mm
Ds: 51.0 %
D50: 86.6 %
D100: 67.0 %
D200: 38.5 %
Dmax: 100 %
D200/D100: 0.57
Depth
Inline
Crossline
Relative Dose[%]
Depth [mm]
20 MeV
150 x 150 mm
0°
0 mm
0 mm
ov protokol za e
Quantity: Dose
R100: 21.5 mm
R50: 83.1 mm
Rp: 101.9 mm
Rt: 59.9 mm
R30: 91.0 mm
R80: 68.6 mm
Dx: 3.5 %
2.60
Rref: 48.9 mm
Depth
Inline
Crossline
Relative Dose[%]
Depth [mm]
9 MeV
150 x 150 mm
0°
0 mm
0 mm
ov protokol za e
Quantity: Dose
R100: 20.5 mm
R50: 35.3 mm
Rp: 43.2 mm
Rt: 27.4 mm
R80: 30.0 mm
Dx: 0.5 %
2.73
8.81 MeV
8.23 MeV
Dmax: 100 %
Rref: 20.2 mm
Depth
Inline
Crossline
Relative Dose[%]
Depth [mm]
20 MeV
150 x 150 mm
0°
20.4 mm
All
Varian
Quantity: Ions
Symmetry: 1.0 %
Flatness: 2.1 %
Penumbra: 12.3; 12.3 mm
Field Width: 155.7 mm
Centre: 0.8 mm

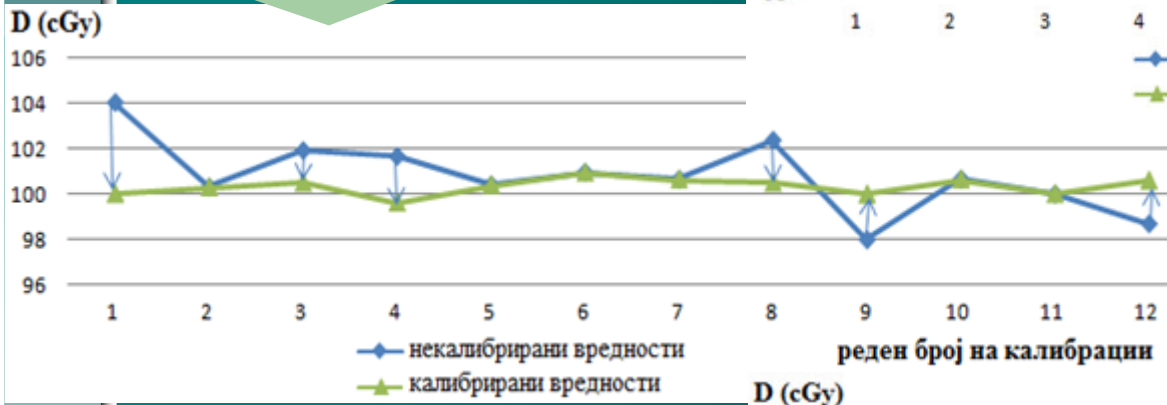

Measured Depth-Dose At Field Size
Energy / Mode: 15X
Measured Depth Dos
Dose [%]
Depth
Measured Profile At Field Size
Energy / Mode: 6X
Measured Profile, Field Size = 100 mm
Fs100 D 15
Fs100 D 50
Fs100 D100
Fs100 D200
Fs100 D300
Measured Depth Dose
Energy / Mode: 15X
Measured
Dose [%]
Depth
Measured Profile At Depth
Energy / Mode: 6X
Measured Profile, Depth = 100.0 mm
Fs 30 D100
Fs 40 D100
Fs 60 D100
Fs 80 D100
Fs100 D100
Fs120 D100
Fs150 D100
Fs200 D100
Fs250 D100
Fs300 D100
Fs350 D100
Fs400 D100
Diag. d100
Dose [%]
Transversal [mm]
Position: (-12.5174 mm, 74.2951 %)

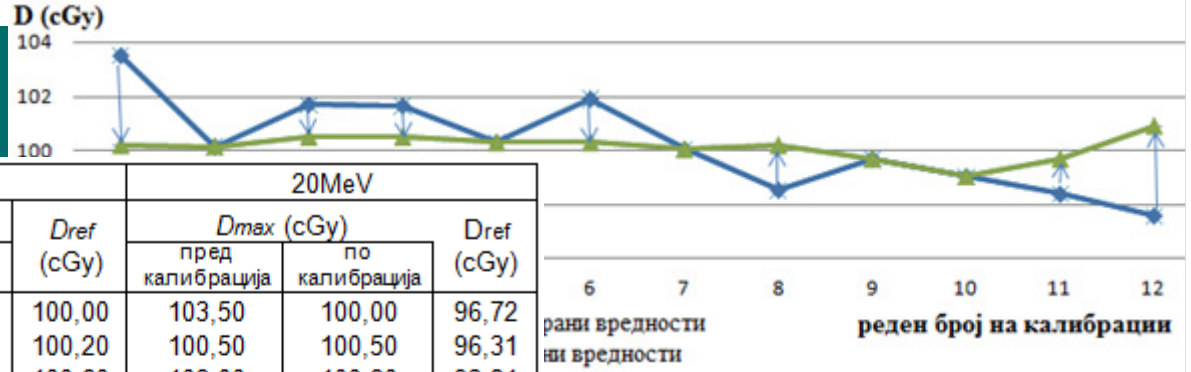
water phantom, ionizing chambers, electrometers, software for data collecting and analyzing… should also be calibrated



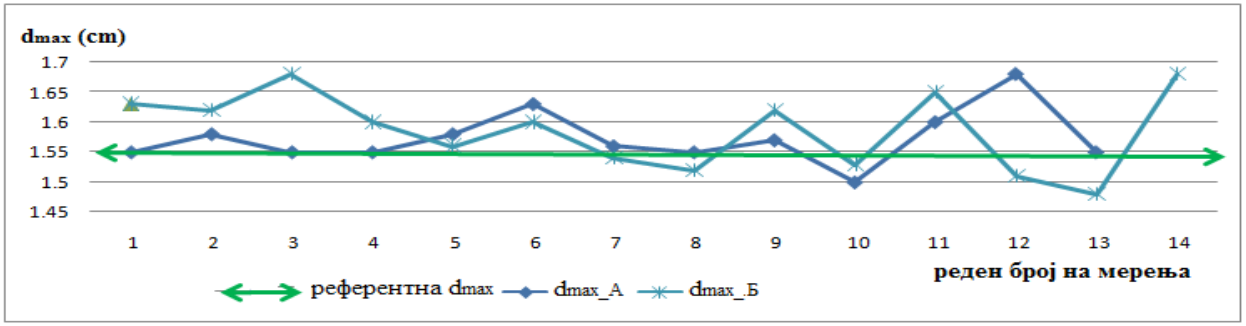




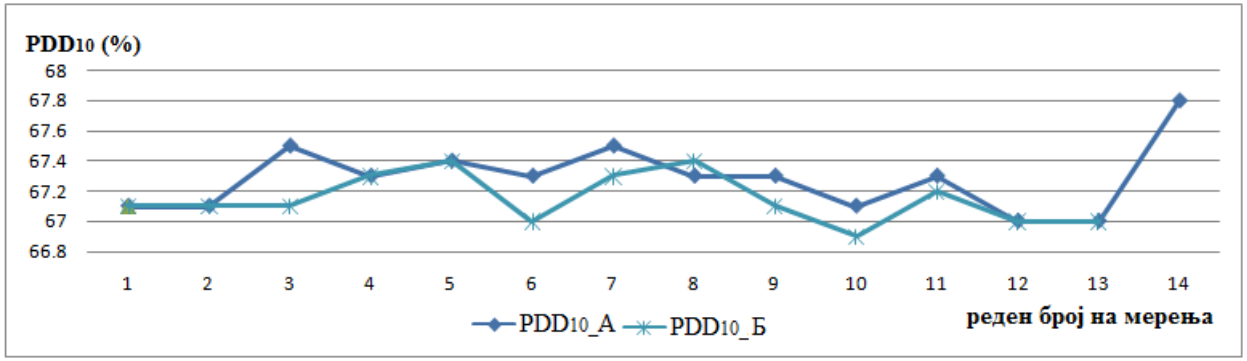




4MeV			9MeV			20MeV		
Dmax (cGy)		*Dref* (cGy)	*Dmax* (cGy)		*Dref* (cGy)	*Dmax* (cGy)		Dref (cGy)
пред калибрација	по калибрација		пред калибрација	по калибрација		пред калибрација	по калибрација	
103,50	100,20	100,20	104,00	100,00	100,00	103,50	100,00	96,72
100,15	100,15	100,10	100,30	100,30	100,20	100,50	100,50	96,31
101,70	100,50	100,50	101,90	100,50	100,60	102,00	100,20	93,81
101,65	100,50	100,00	101,65	99,61	99,66	101,10	100,35	93,89
100,30	100,30	100,50	100,40	100,40	100,30	101,20	101,20	94,50
101,90	100,30	100,10	100,95	100,95	100,75	102,00	100,40	93,70
100,05	100,05	100,30	100,65	100,65	100,55	99,80	99,80	93,25
98,55	100,20	100,00	102,35	100,50	100,20	99,80	99,80	92,90
99,70	99,70	99,67	98,00	99,99	99,86	98,60	100,20	93,50
99,05	99,05	99,00	100,65	100,65	100,55	100,85	100,85	93,98
98,40	99,70	99,70	100,00	100,00	99,80	99,85	99,85	93,40
97,60	100,90	100,80	98,70	100,60	99,99	100,40	100,40	92,68
D сред	100,13	100,07	*D сред*	100,35	100,21	*D сред*	100,30	94,05
DTPS	100,00	100,00	*DTPS*	100,00	100,00	*DTPS*	100,00	96,00



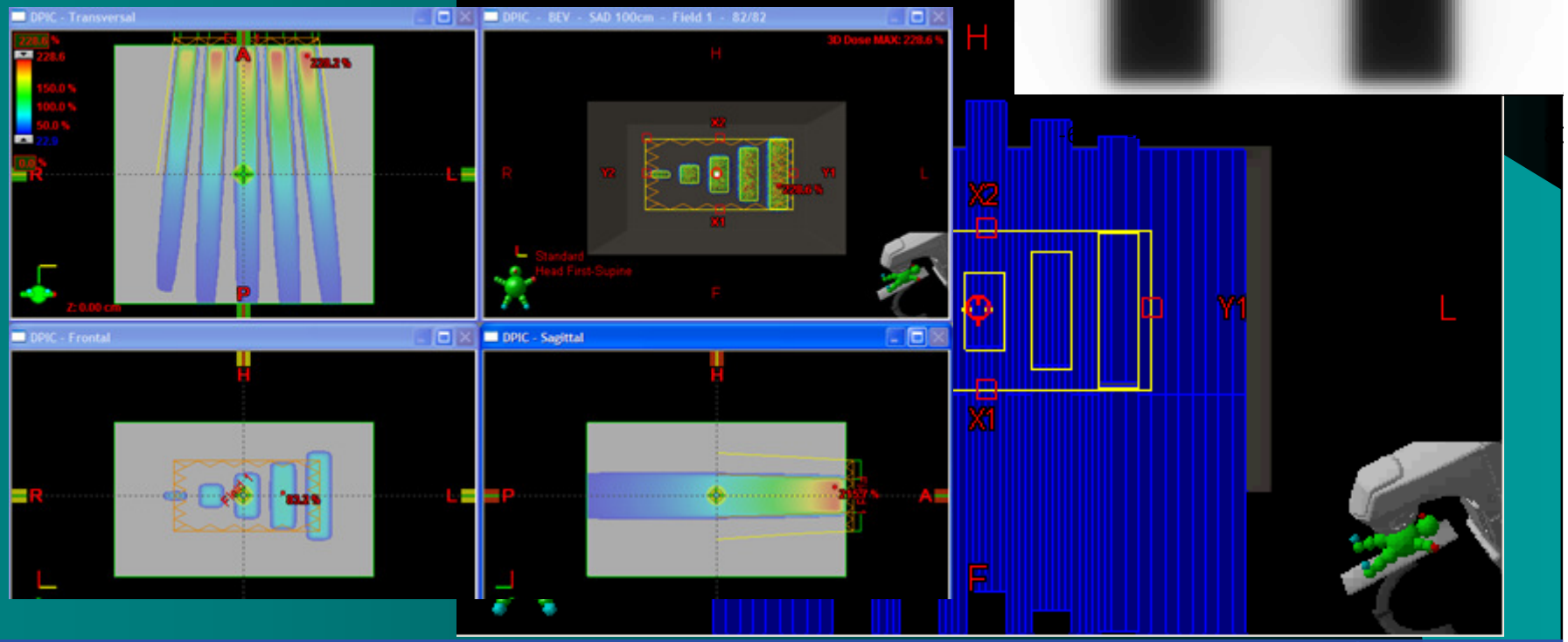
$$QI = TPR_{20,10} = 1,2661 * PDD_{20,10} - 0,0595$$

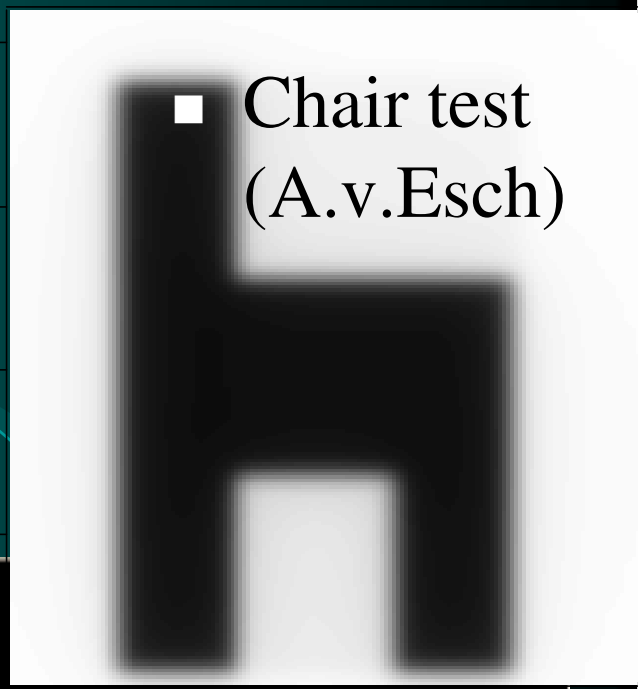


10 x 10	6MV фотони / апарат А			
	dmax (cm)	PDD_{10} (%)	$PDD_{20,10}$ (%)	QI (%)
мере	1,54	67,0	0,58	0,670
	1,55	67,1	0,58	0,675
	1,58	67,1	0,57	0,662
	1,55	67,1	0,58	0,675
	1,55	67,3	0,58	0,675
	1,58	67,4	0,58	0,675
	1,63	67,0	0,58	0,675
	1,56	67,3	0,58	0,675
	1,55	67,4	0,58	0,675
	1,57	67,1	0,58	0,675
	1,50	66,9	0,58	0,675
	1,60	67,2	0,58	0,675
	1.68	67,0	0,57	0,662
	1,55	67,0	0,57	0,662
	dmax (cm)	PDD_{10} (%)	$PDD_{20,10}$ (%)	QI (%)
мерења	1,55	67,0	0,58	0,670
	1,63	67,1	0,58	0,675
	1,62	67,1	0,57	0,662
	1,68	67,5	0,58	0,675
	1,60	67,3	0,58	0,675
	1,56	67,4	0,58	0,675
	1,60	67,3	0,58	0,675
	1,54	67,5	0,58	0,675
	1,52	67,3	0,58	0,675
	1,62	67,3	0,58	0,675
	1,53	67,1	0,58	0,675
	1,65	67,3	0,58	0,675
	1,51	67,0	0,58	0,675
	1,48	67,0	0,57	0,662
	1,68	67,8	0,58	0,675

uncertainties

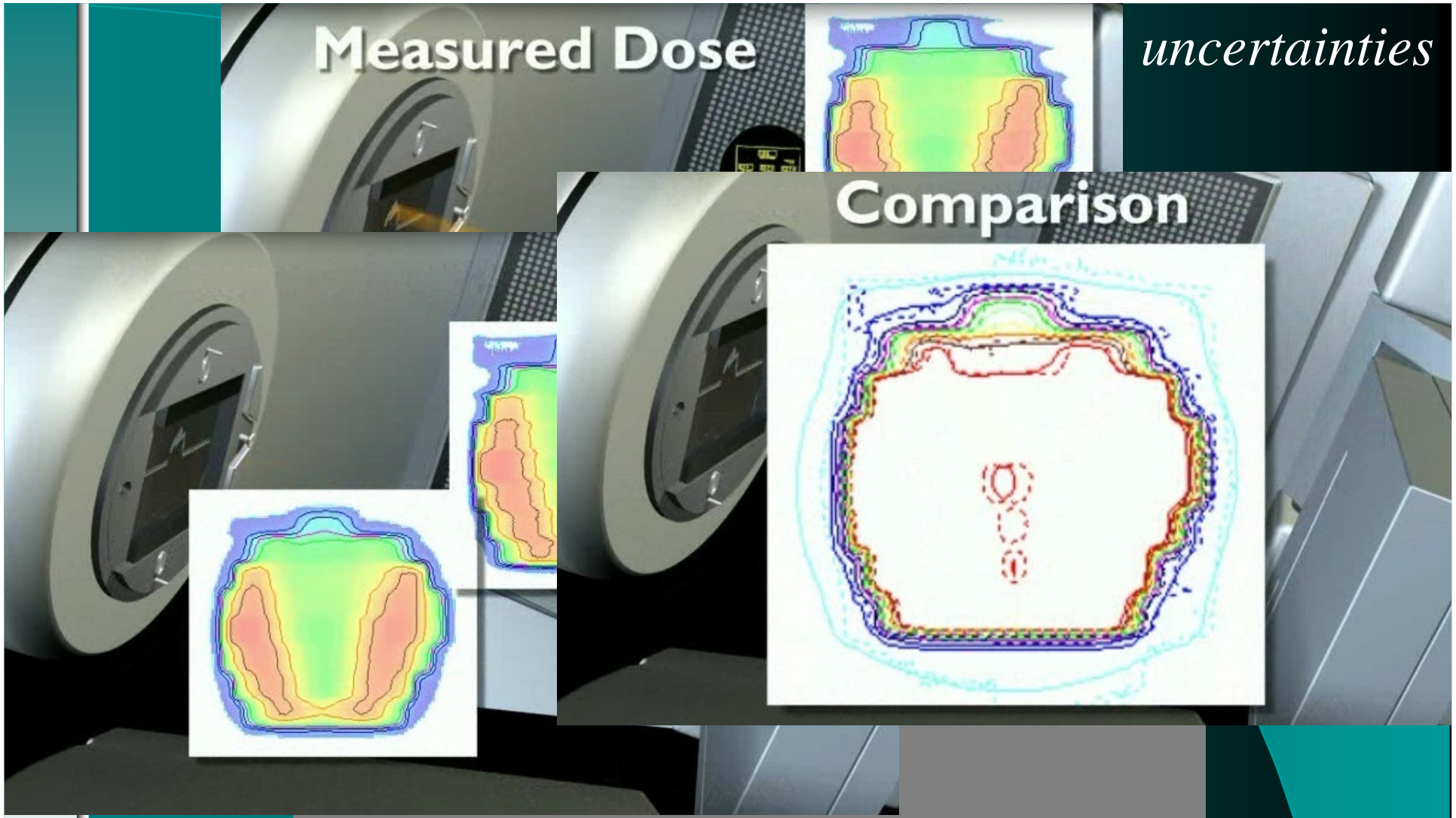
- **patient dose delivered**



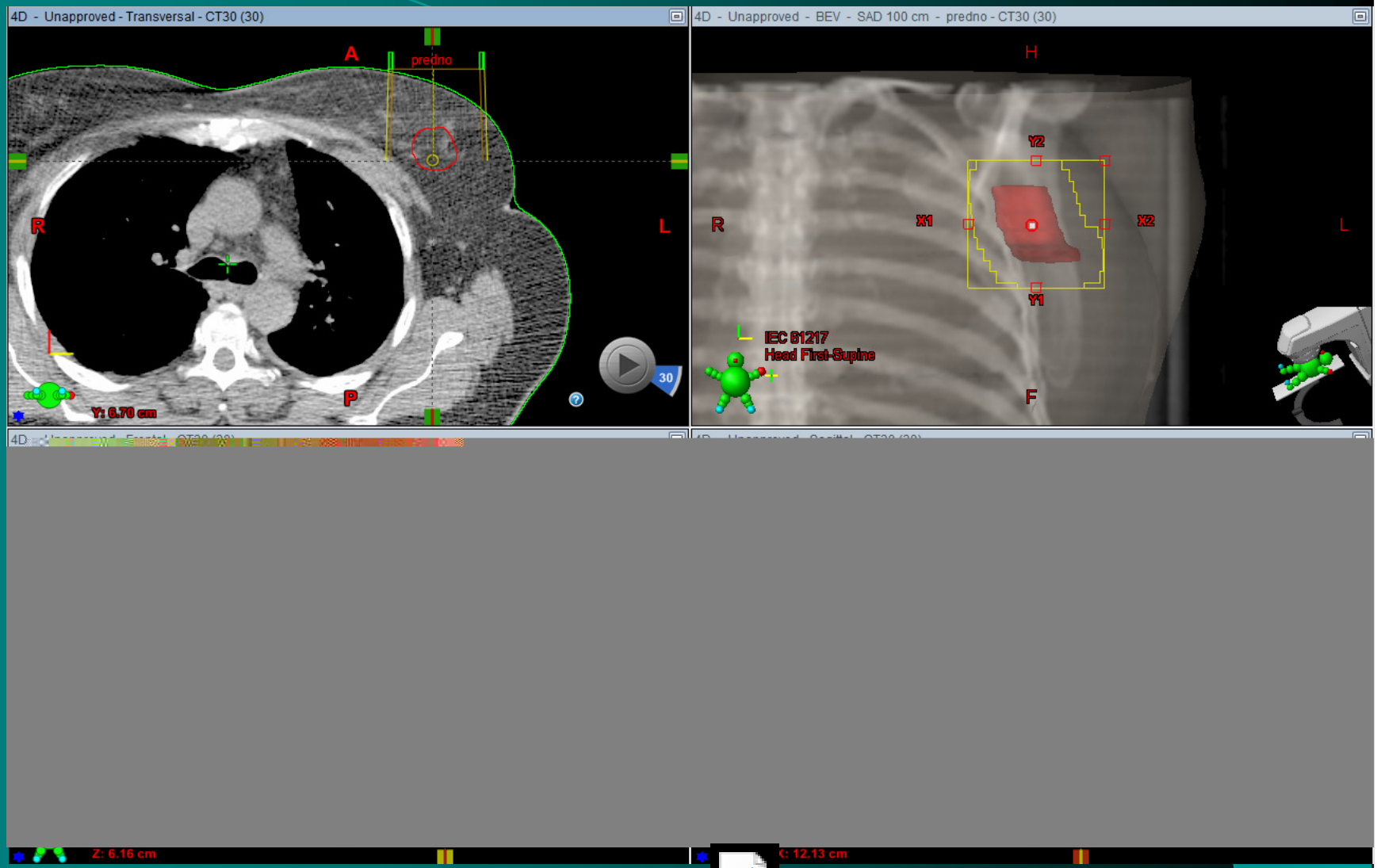


- Chair test (A.v.Esch)

uncertainties



uncertainties



- **patient breathing**

VIDEO0099.3gp


Z