Brachytherapy
Quo vadis?

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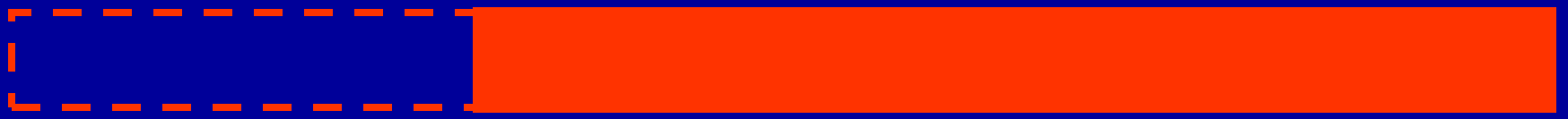
The Era of Adaptive Radiation Therapy

- IGRT (Image Guided..2D)
- VGRT (Volume Guided..3D)
- DGRT (Dose Guided …)
- ART (4D)
- BIG-ART (Biological …)

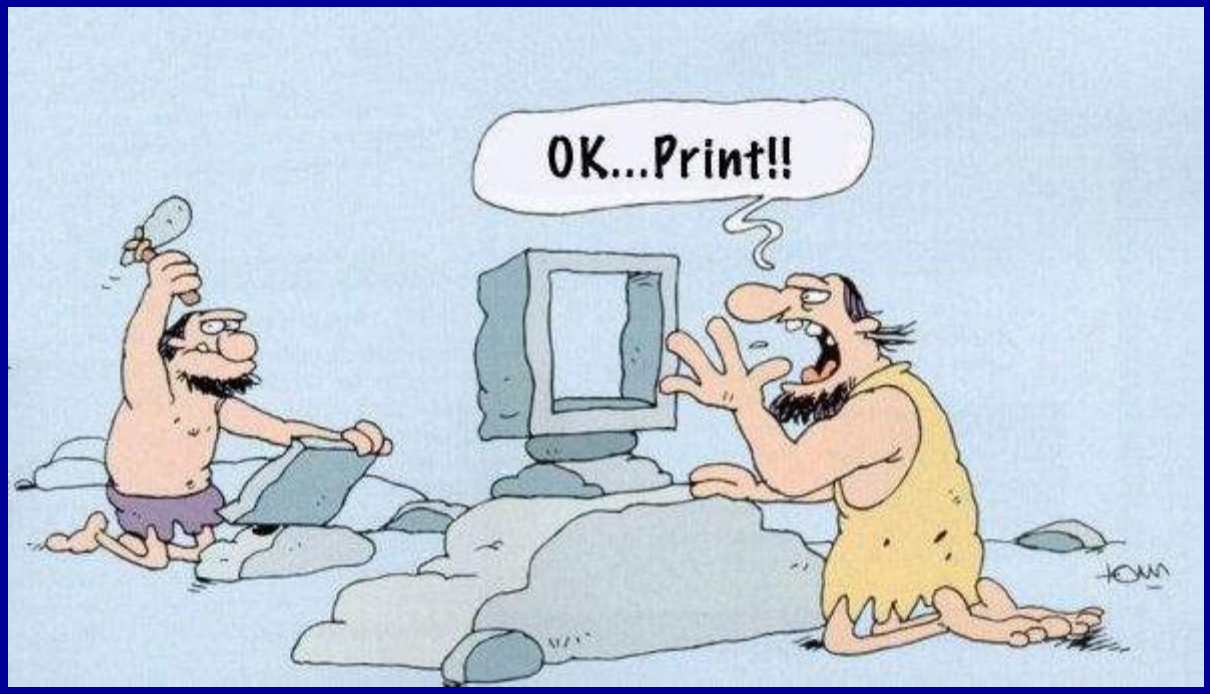
Adaptive Radiation Therapy: Advanced & New Technologies

Costs

- IMRT (X-rays)
- Cyberknife (X-rays)
- Tomotherapy (X-Rays)
- Protons (p^+)
- Heavy Ions (He, Li, C, ???)

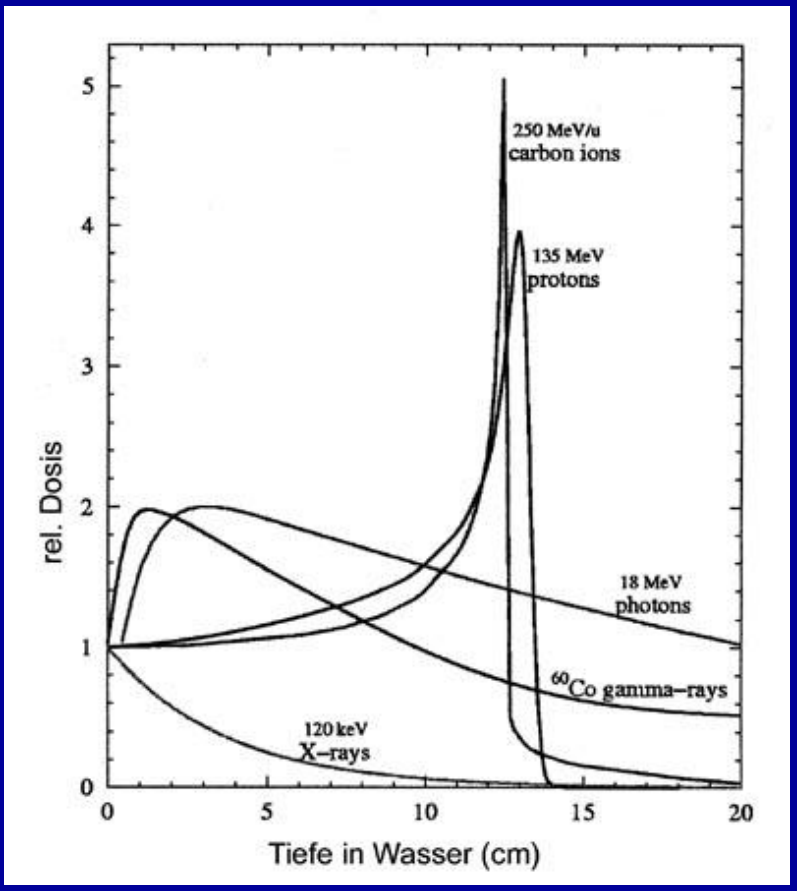


Where are we with Brachytherapy in the "Modern Times" of Radiation Oncology ?

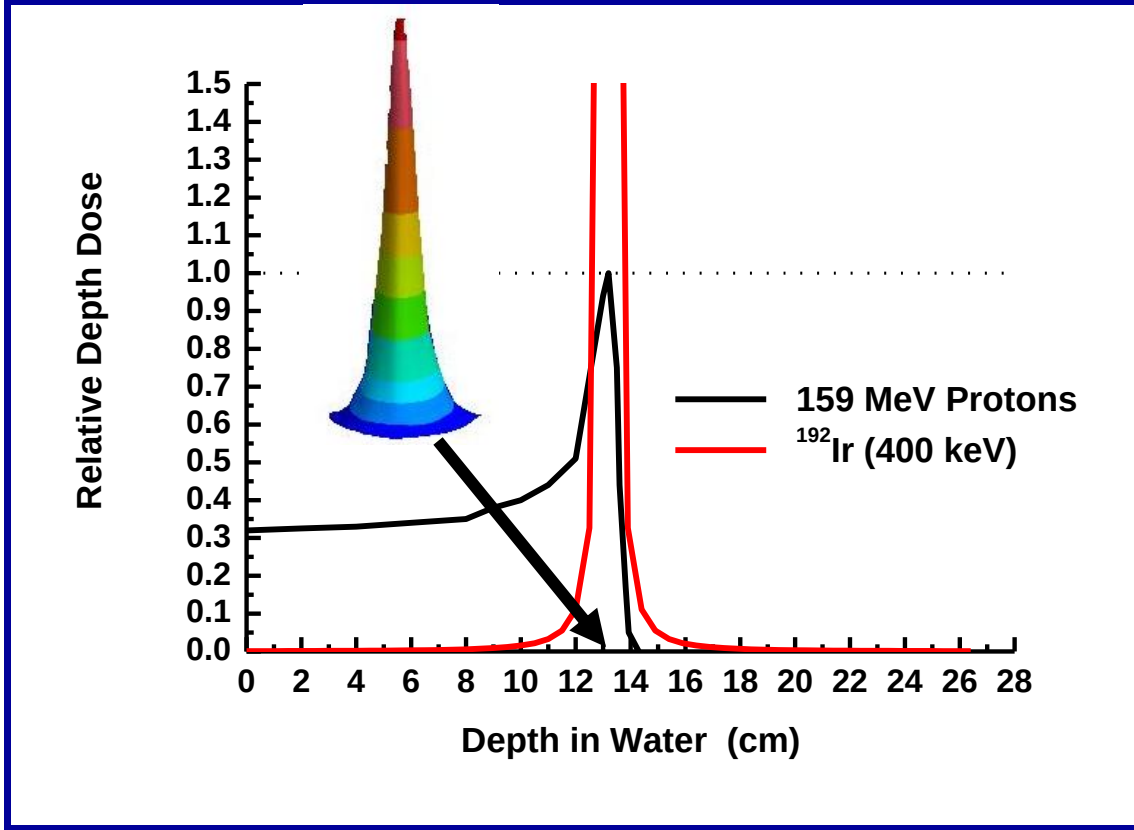


3D Conformal Brachytherapy (3D CFBRT)

Dosimetric Kernel: Depth

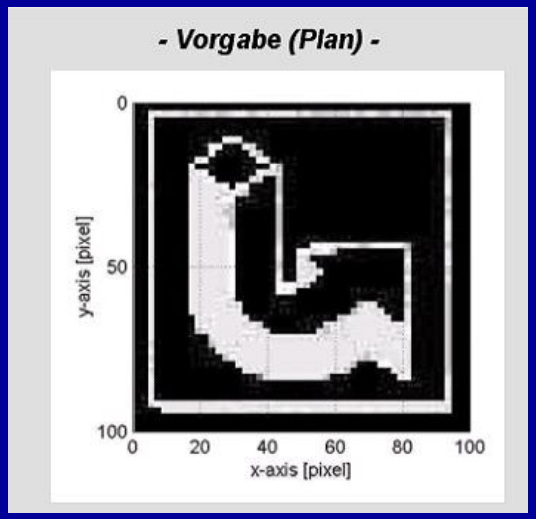


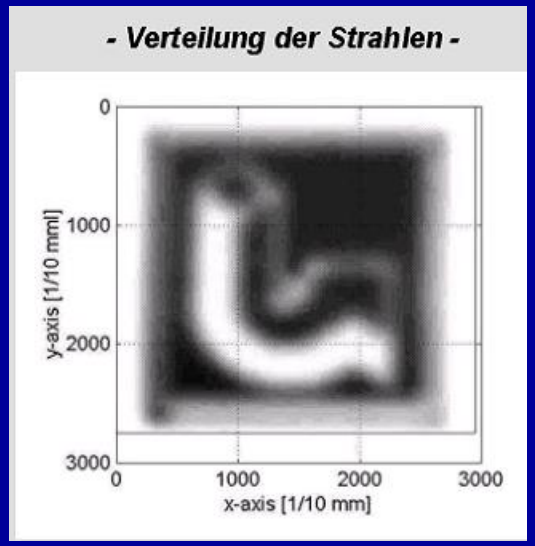
Protons vs. BRT



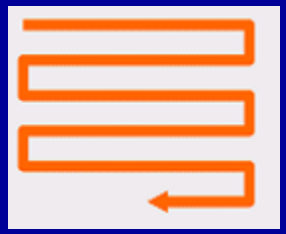
3D Conformal Radiation Therapy (3D CFRT)

Beam Shaping: Plane

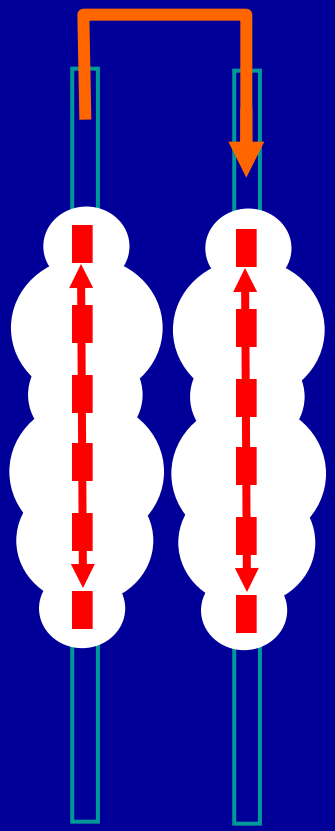




Ions:
Raster Scanning



BRT: Needle/Catheter



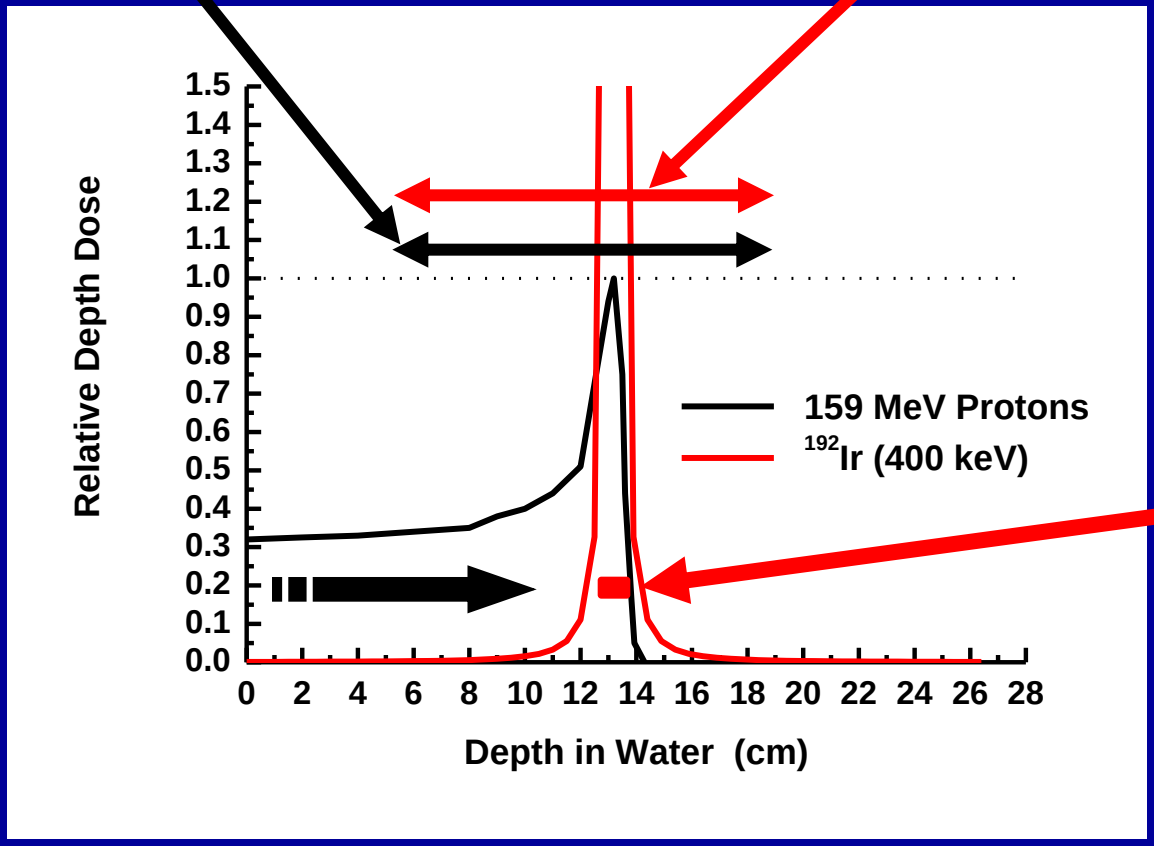
MSS

- 1.0 mm
- 2.5 mm
- 5.0 mm
- 10.0 mm
- ?? mm

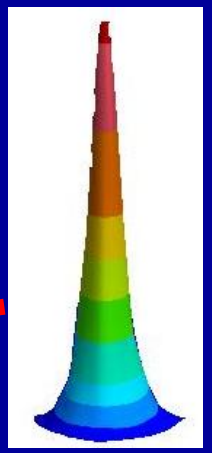
3D Conformal Brachytherapy (3D CFBRT)
Intensity/Fluence/Dose Modulation

Proton Energy Modulation

Step & Shot Technology

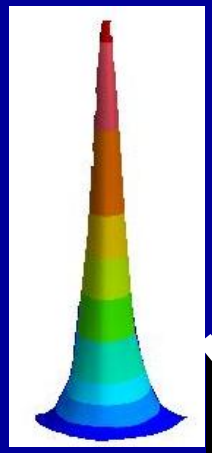


3D-Kernel



3D Conformal Brachytherapy (3D CFBRT): IMBRT Using Step & Shot Technology

Kernel

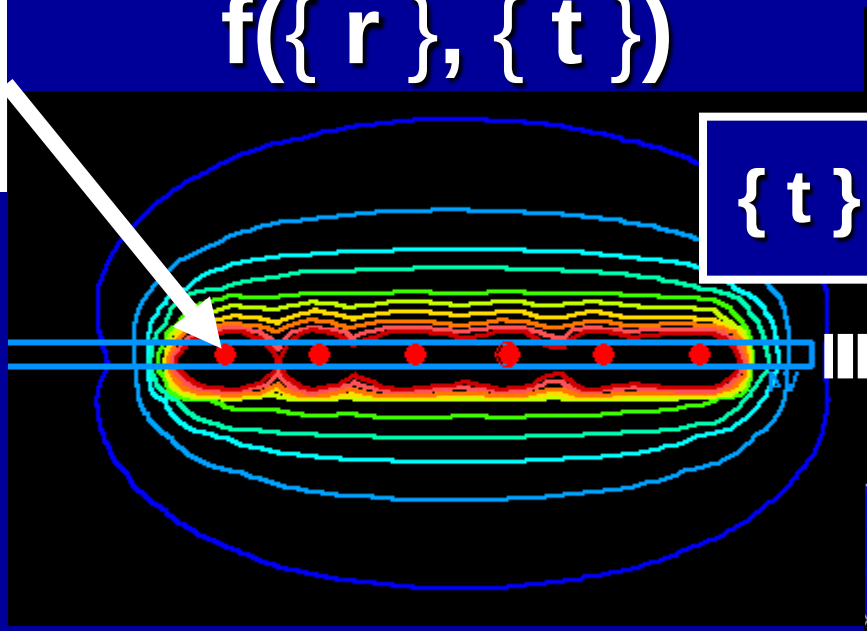


^{192}Ir

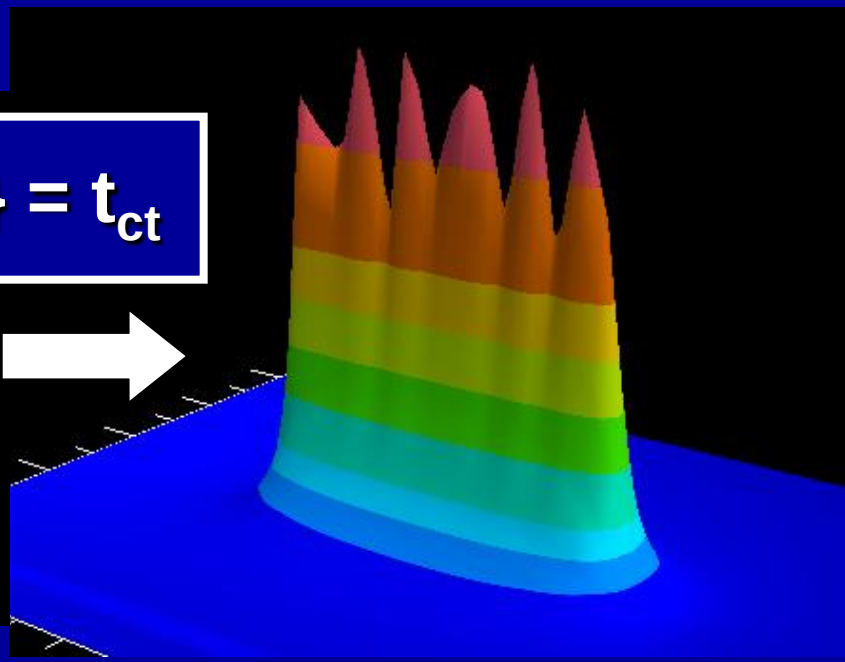
…

Propagation Function:

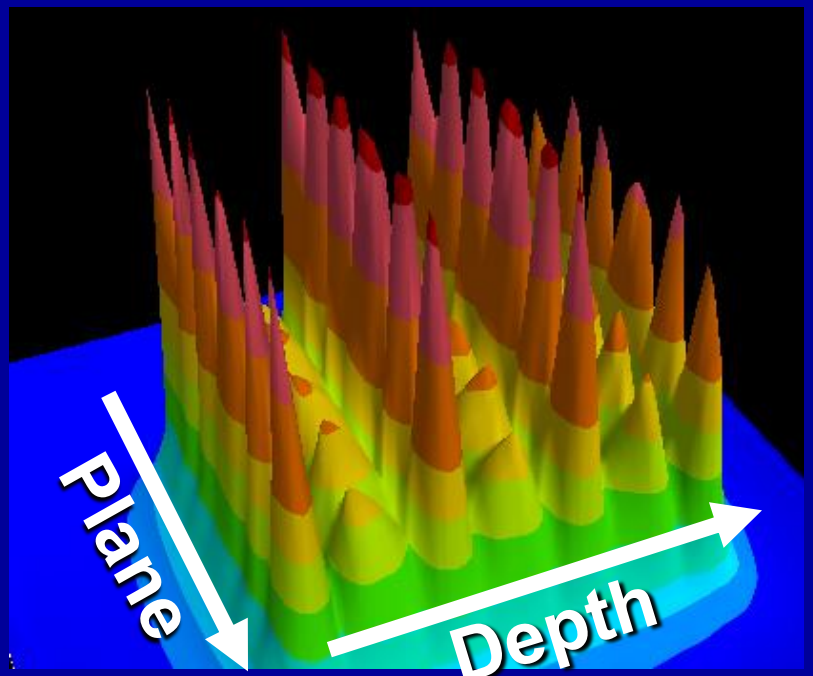
$$f(\{\vec{r}\}, \{t\})$$



$$\{t\} = t_{ct}$$



3D Conformal Radiation Therapy (3D CFRT)
Intensity/Fluence/Dose Modulation

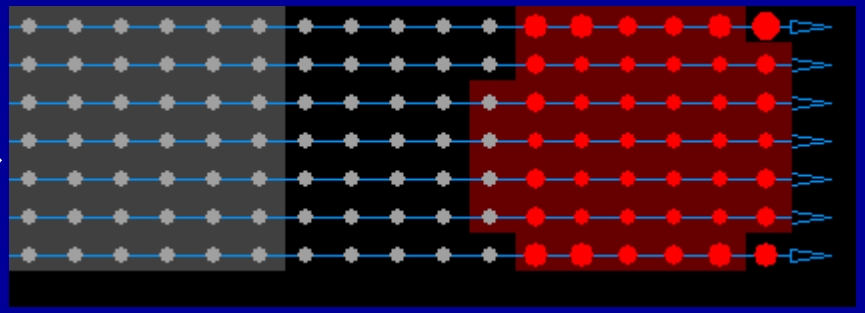
High Energy Particles	IMBRT (MSS & MC): Raster/ Vector Scanning	IMRT (MLC)
Plane: Raster Scanning **Depth:** Energy Modulation		**Plane:** Step & Shot or Dynamic MLC **Depth:** ?
3D/Volume	3D/Volume	2D ?

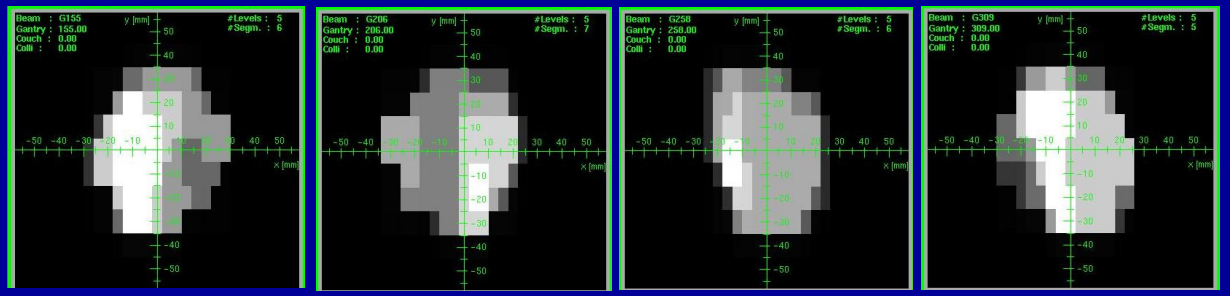
3D Conformal Brachytherapy (3D CFBRT): IMBRT Using Step & Shot Technology

Raster /
Vector Scanning

Propagation Function:

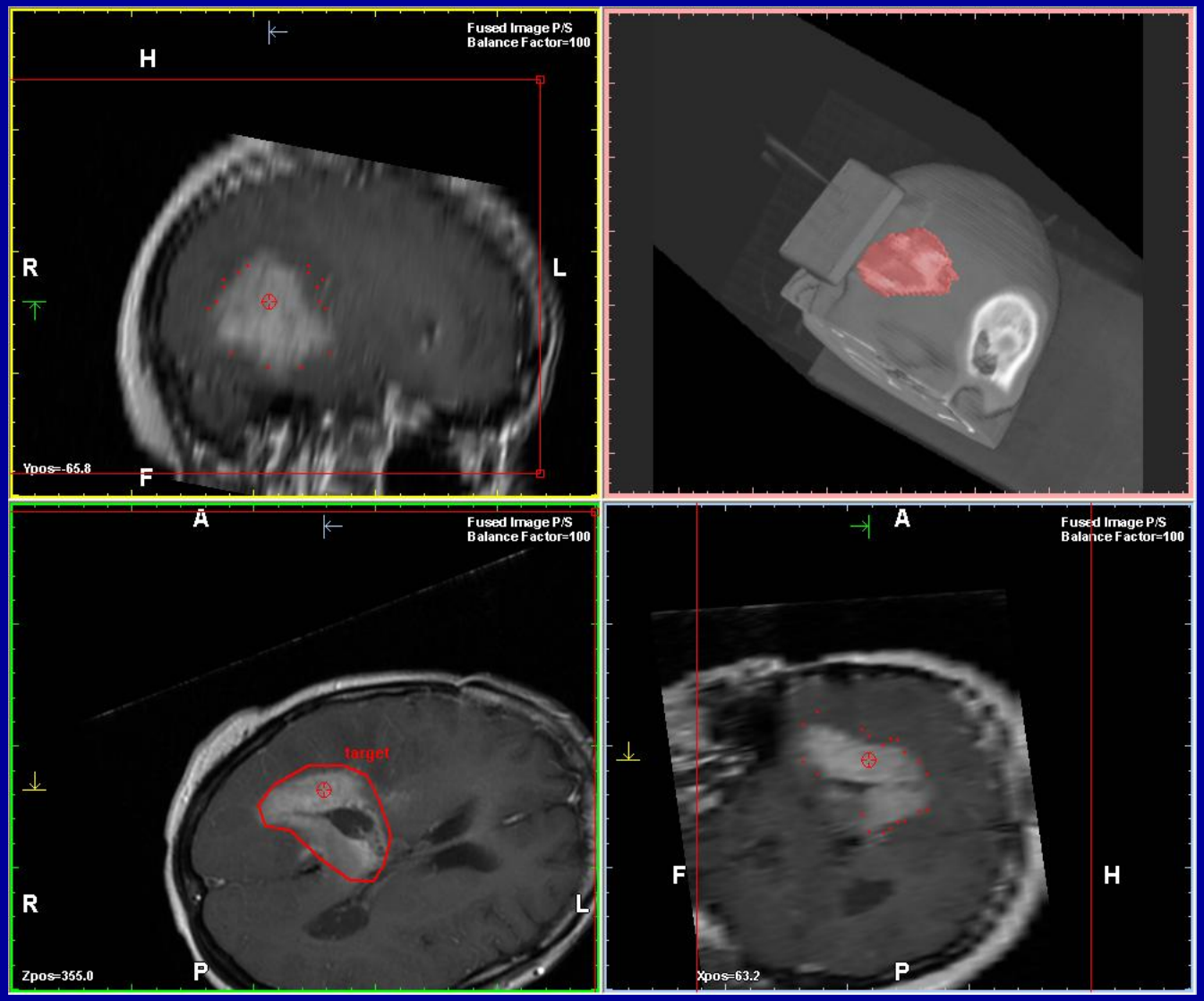
$$f(\{\vec{r}\}, \{t\})$$





The Era of Adaptive Brachytherapy

- IGRT (Image Guided..2D)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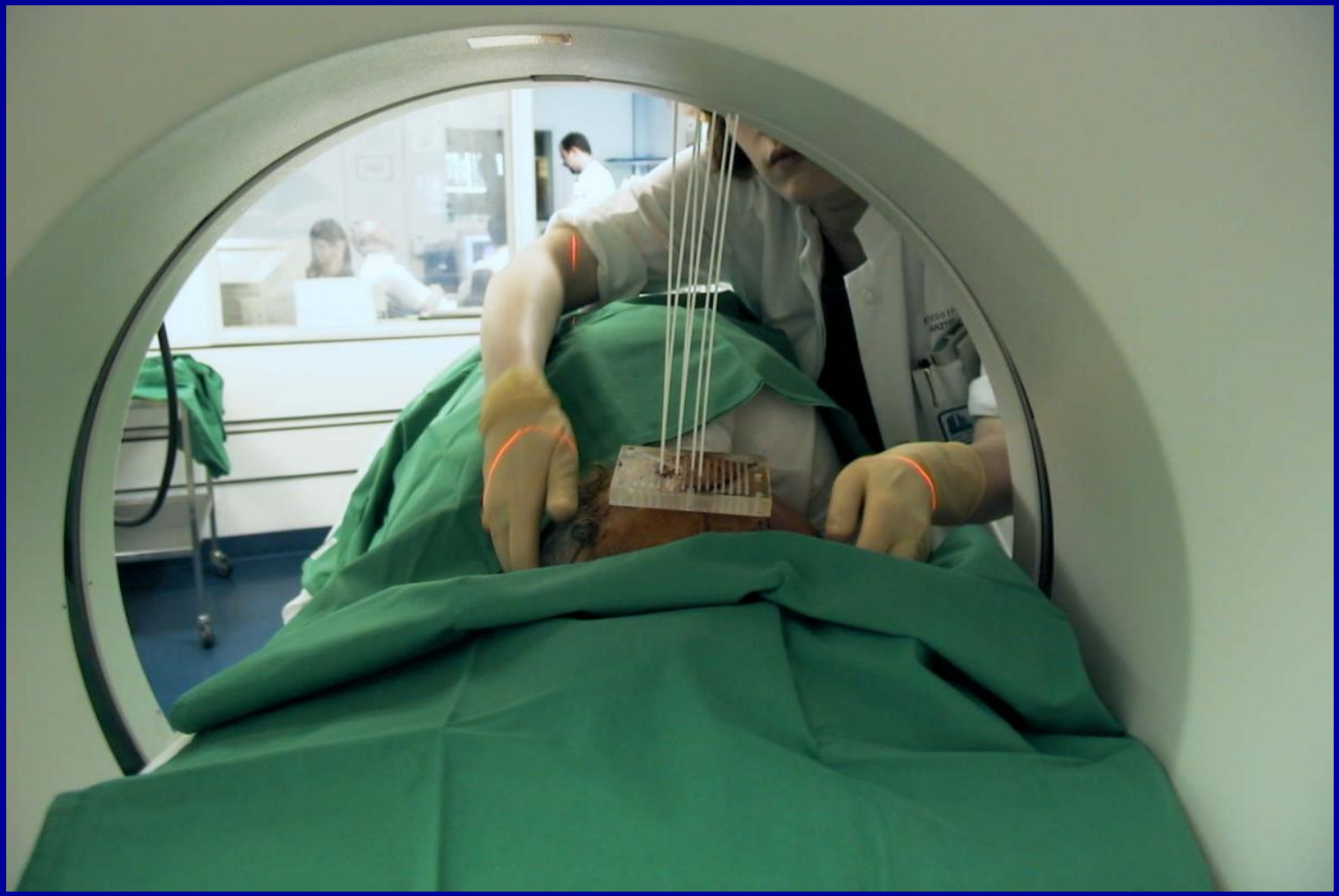
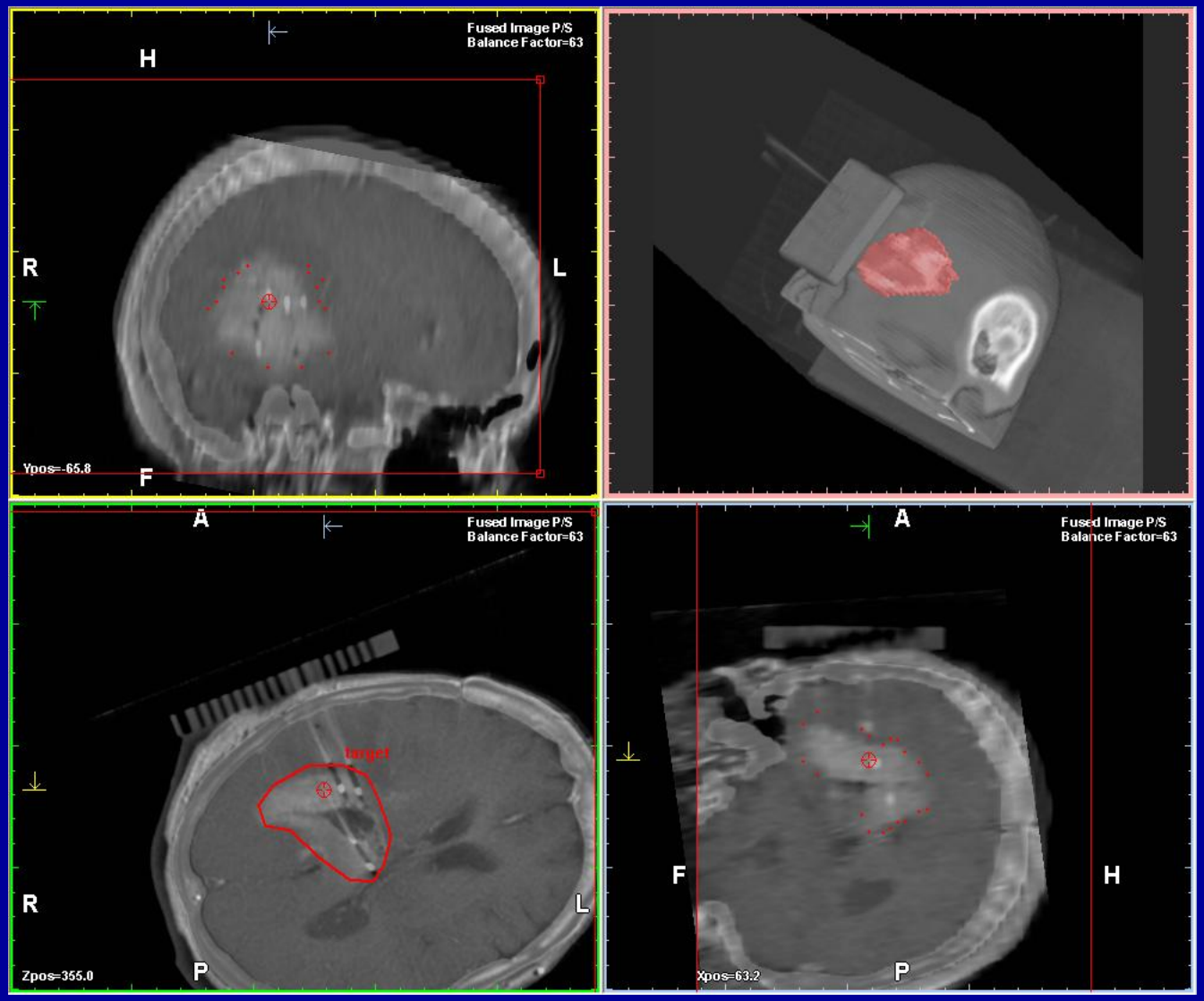
Balance Factor=100
H
R
L
F
Ypos=-65.8
A
Fused Image P/S
Balance Factor=100
target
R
L
P
Zpos=355.0
A
Fused Image P/S
Balance Factor=100
F
H
P
Xpos=63.2

IGRT in BT

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Fused Image P/S
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Zpos=355.0
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Fused Image P/S
Balance Factor=63
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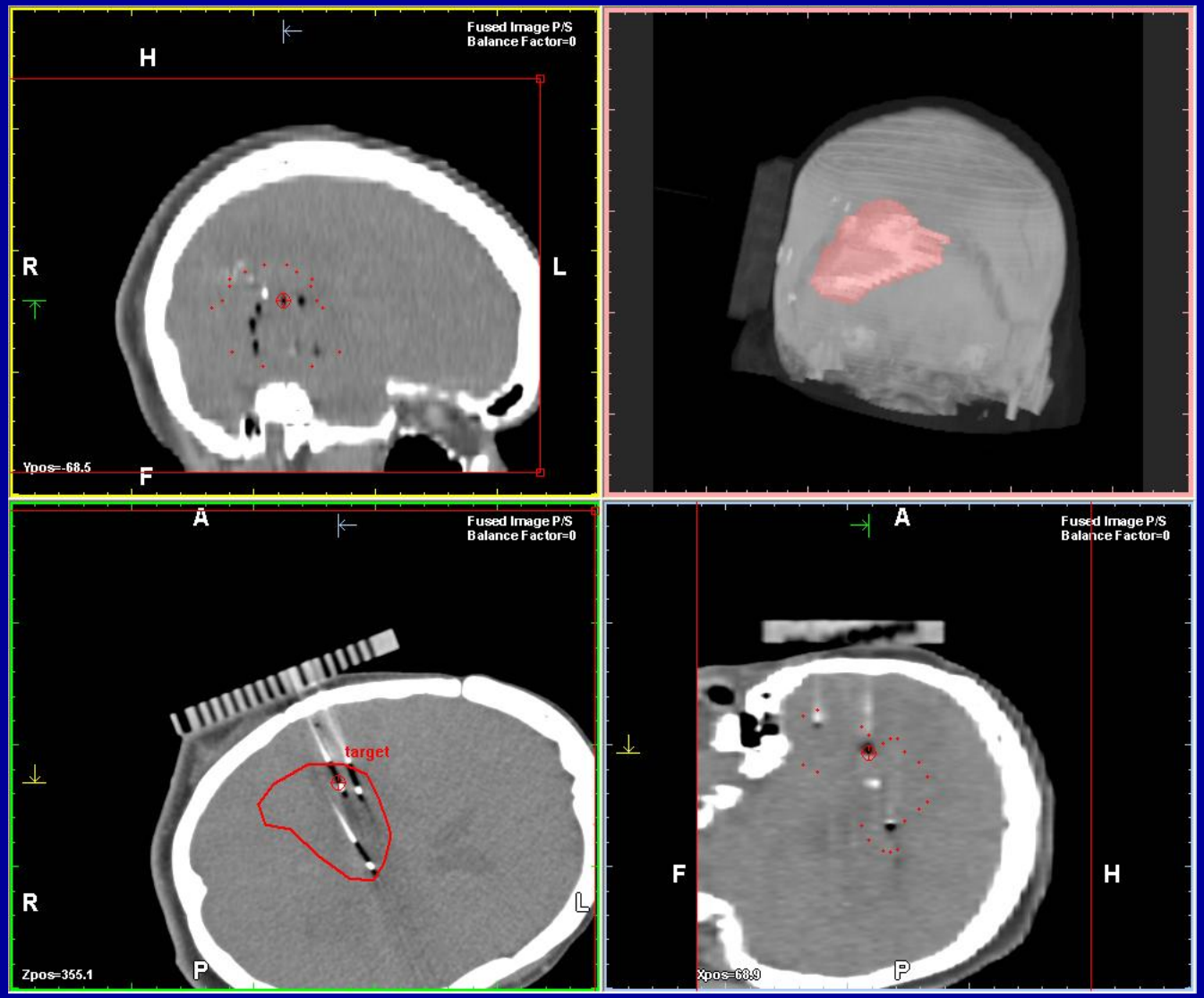
H
P
Xpos=63.2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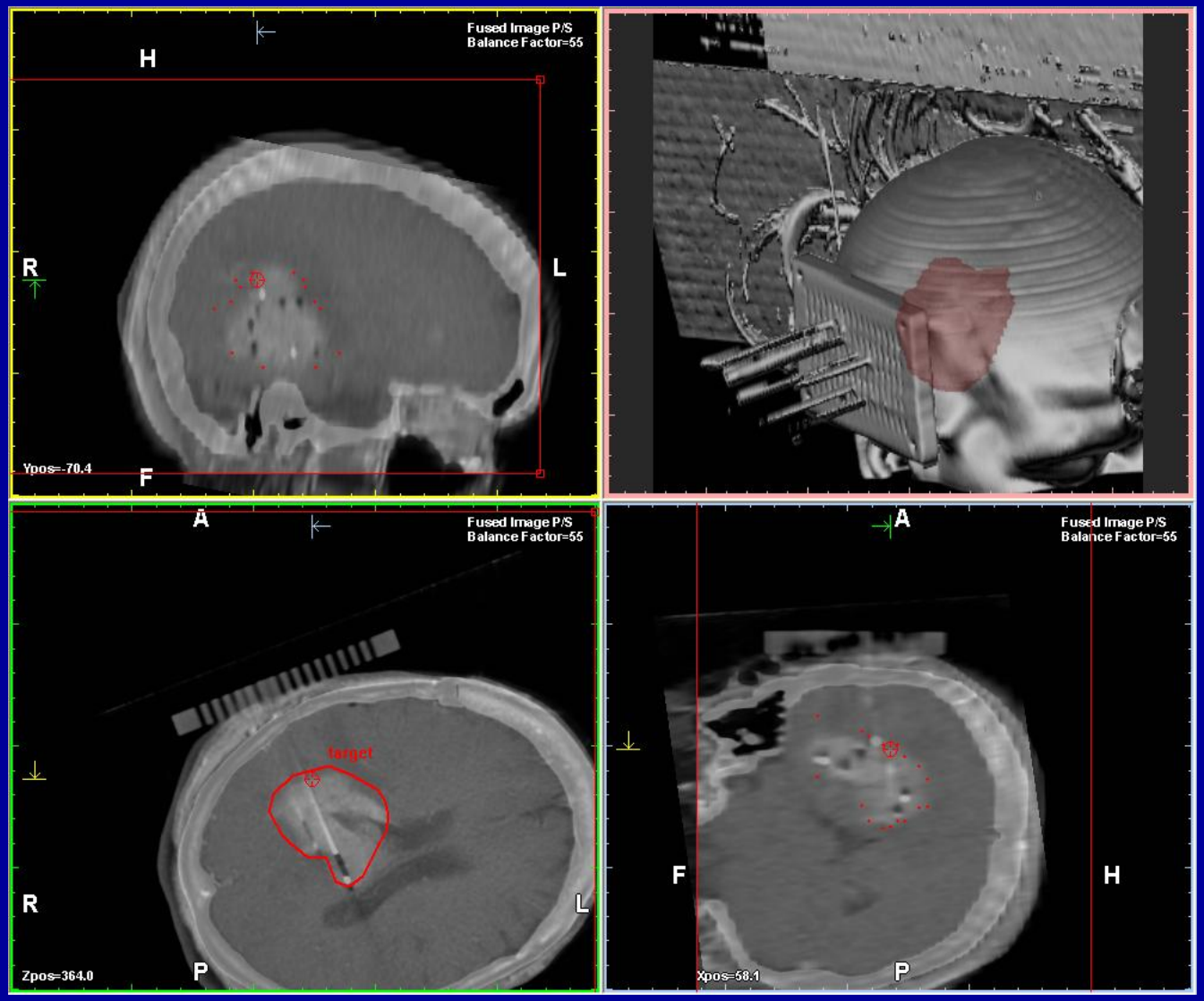
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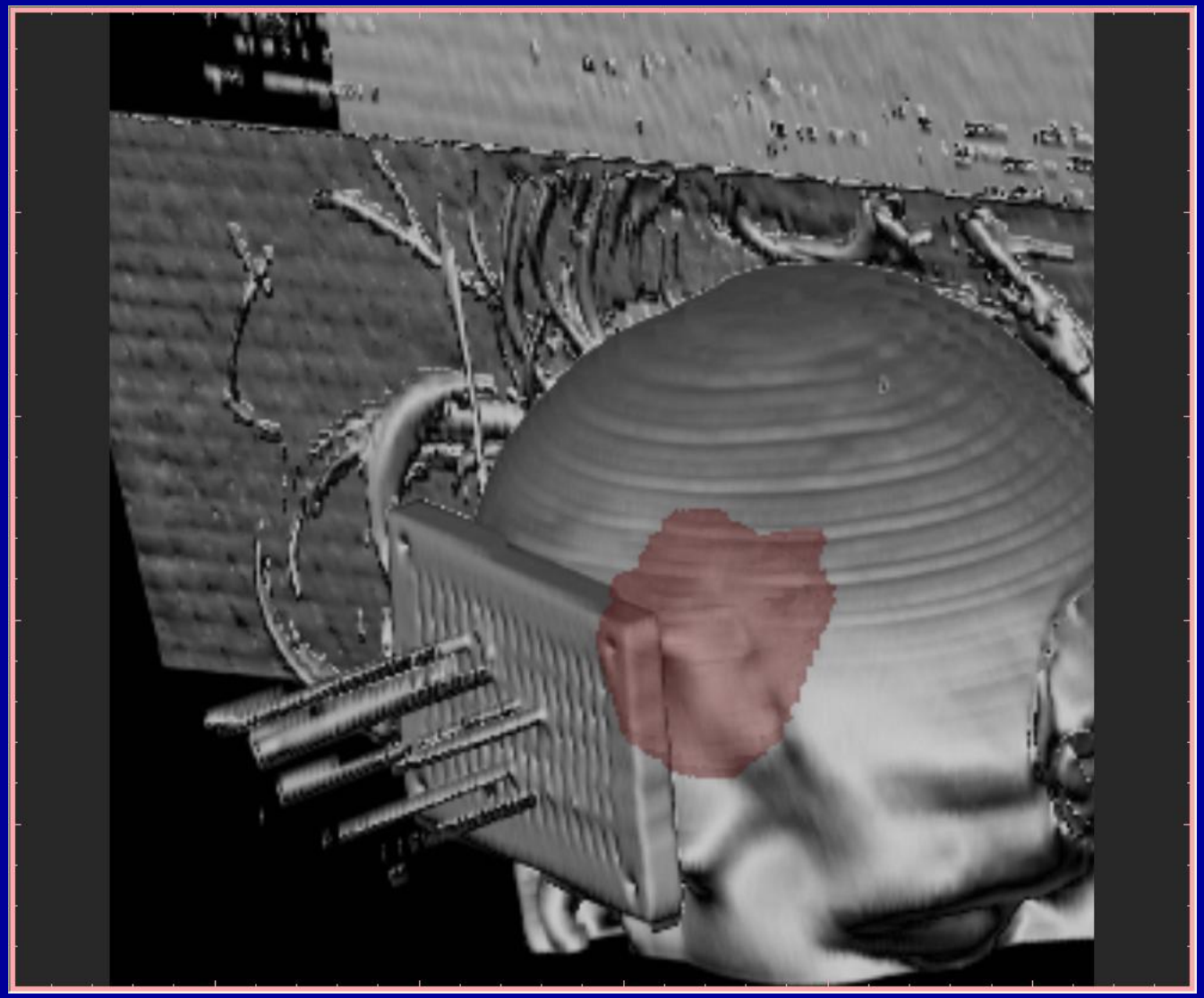

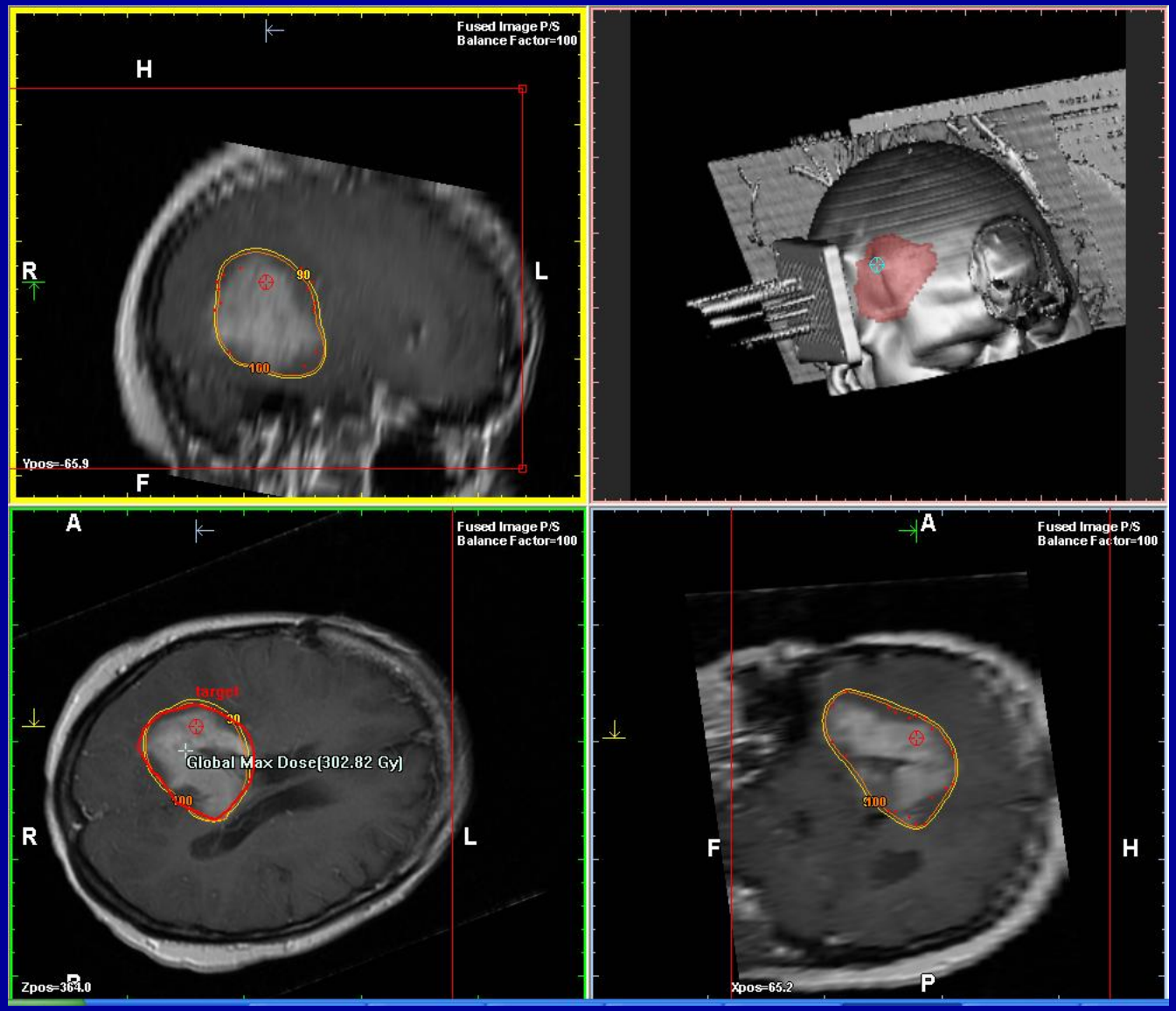
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H
R
L
F
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A
target
90
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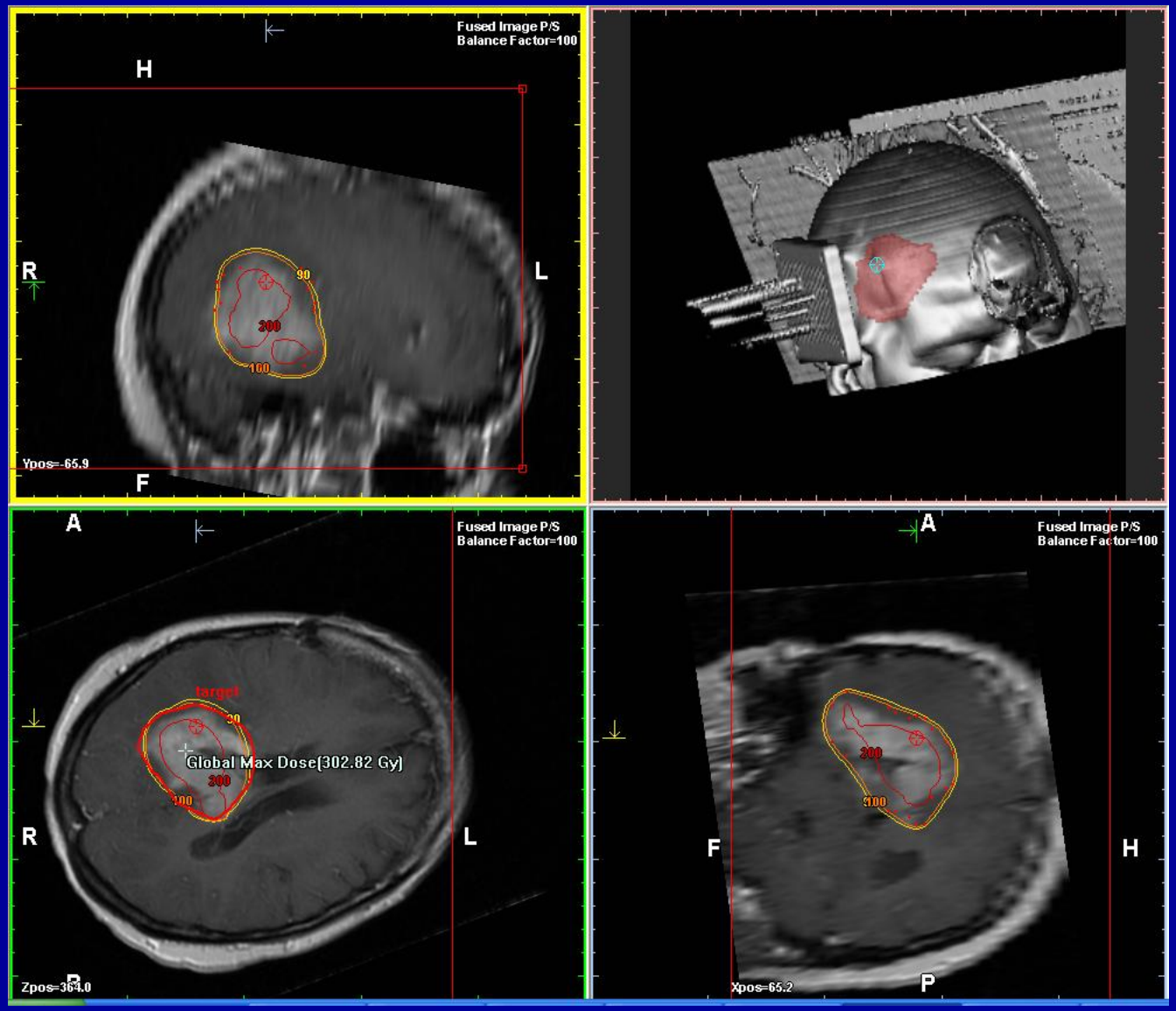
Global Max Dose[302.82 Gy]
Zpos=364.0
Xpos=65.2
P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target
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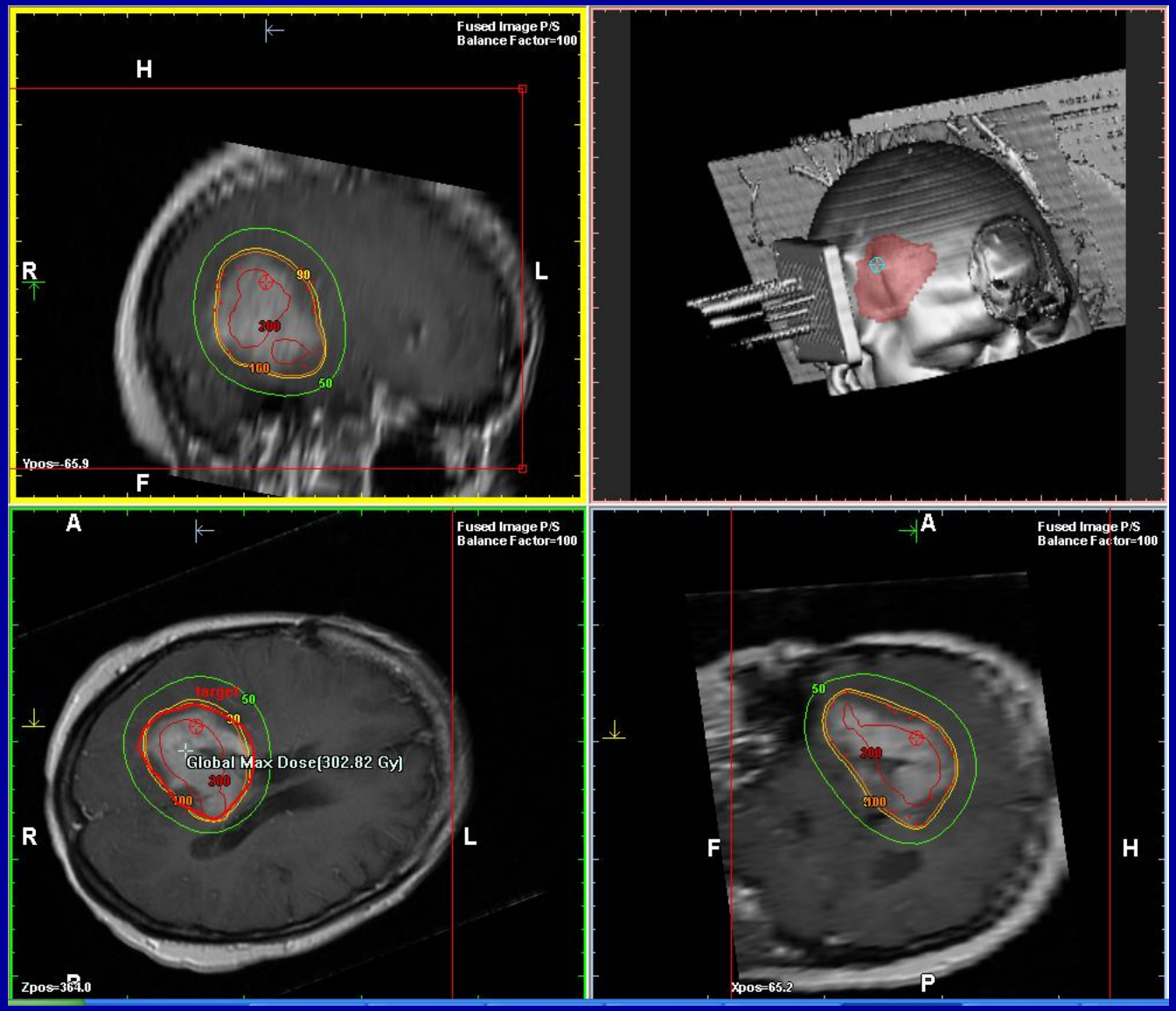
Xpos=65.2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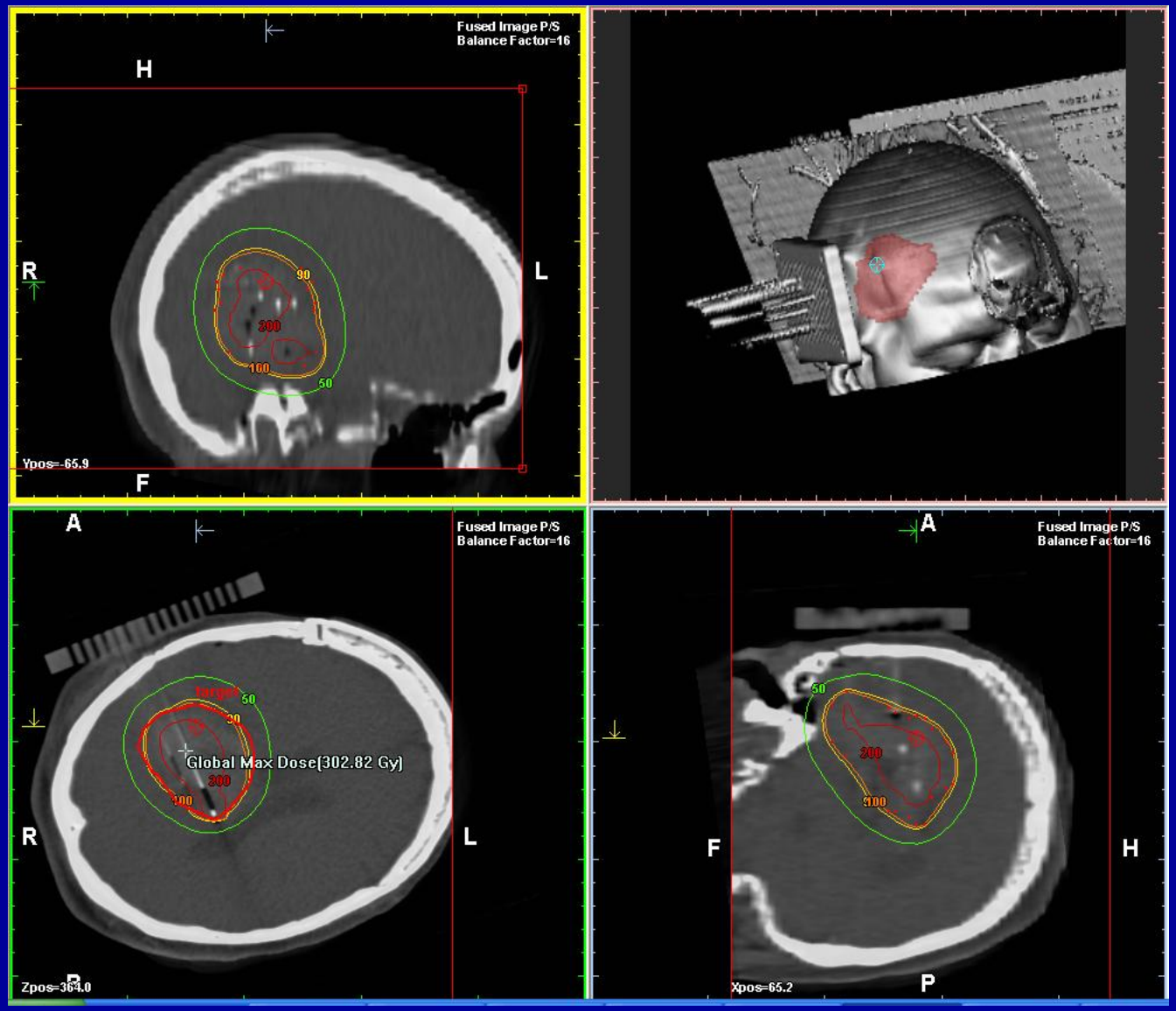
Balance Factor=100
target
50
90
200
100
Global Max Dose[302.82 Gy]
R
L
P
Zpos=364.0
A
Fused Image P/S
Balance Factor=100
50
200
100
F
H
P
Xpos=65.2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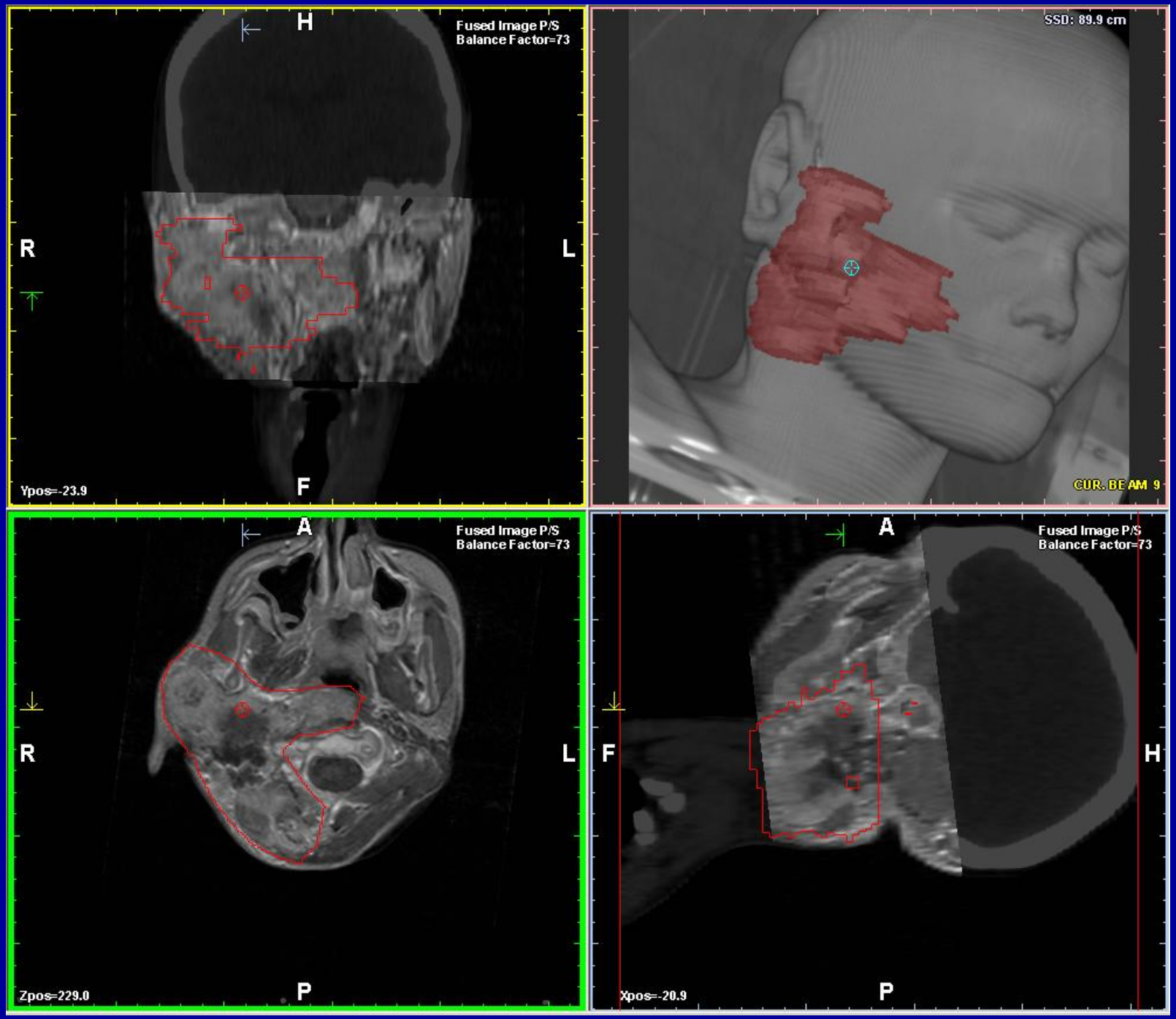
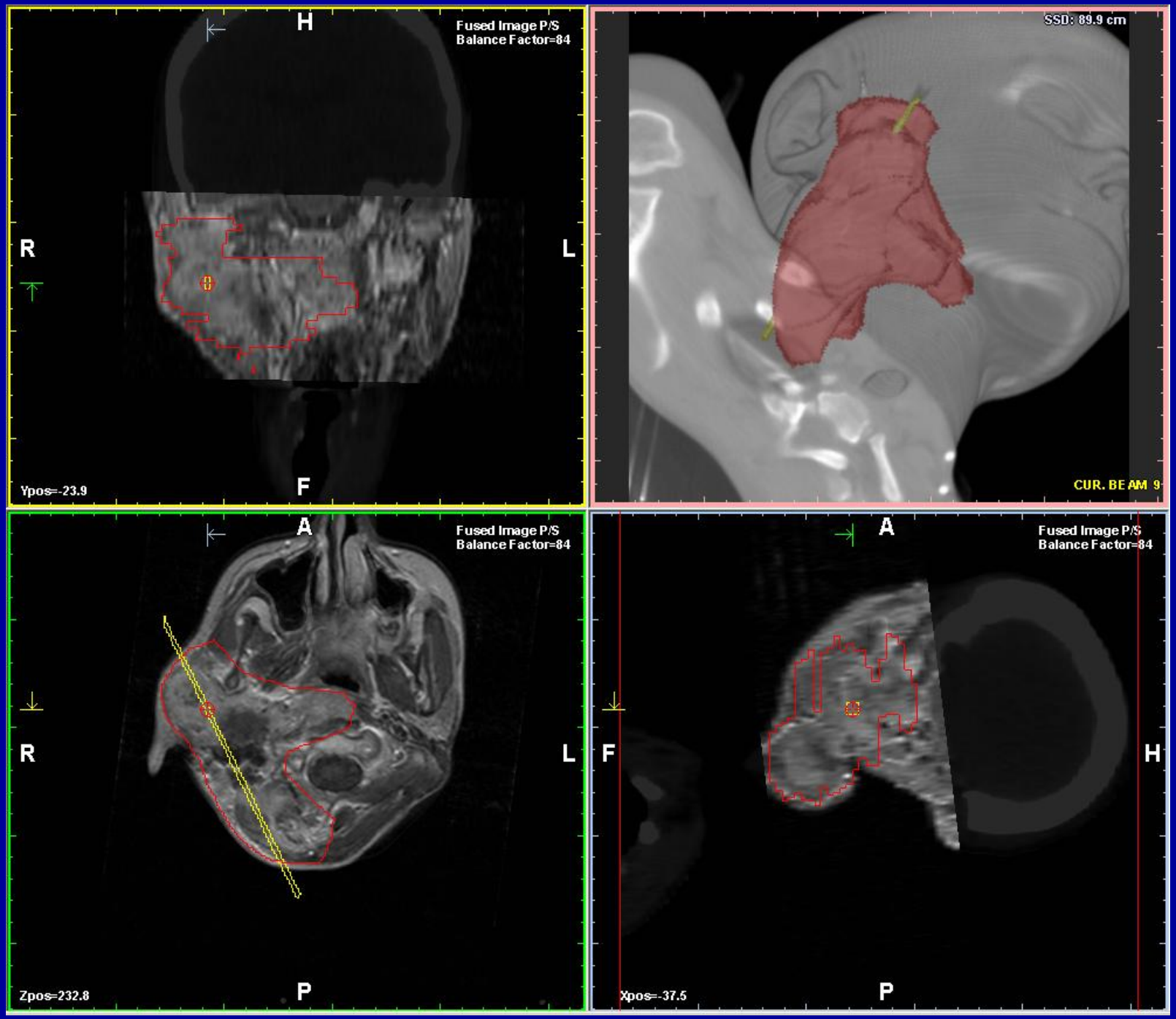
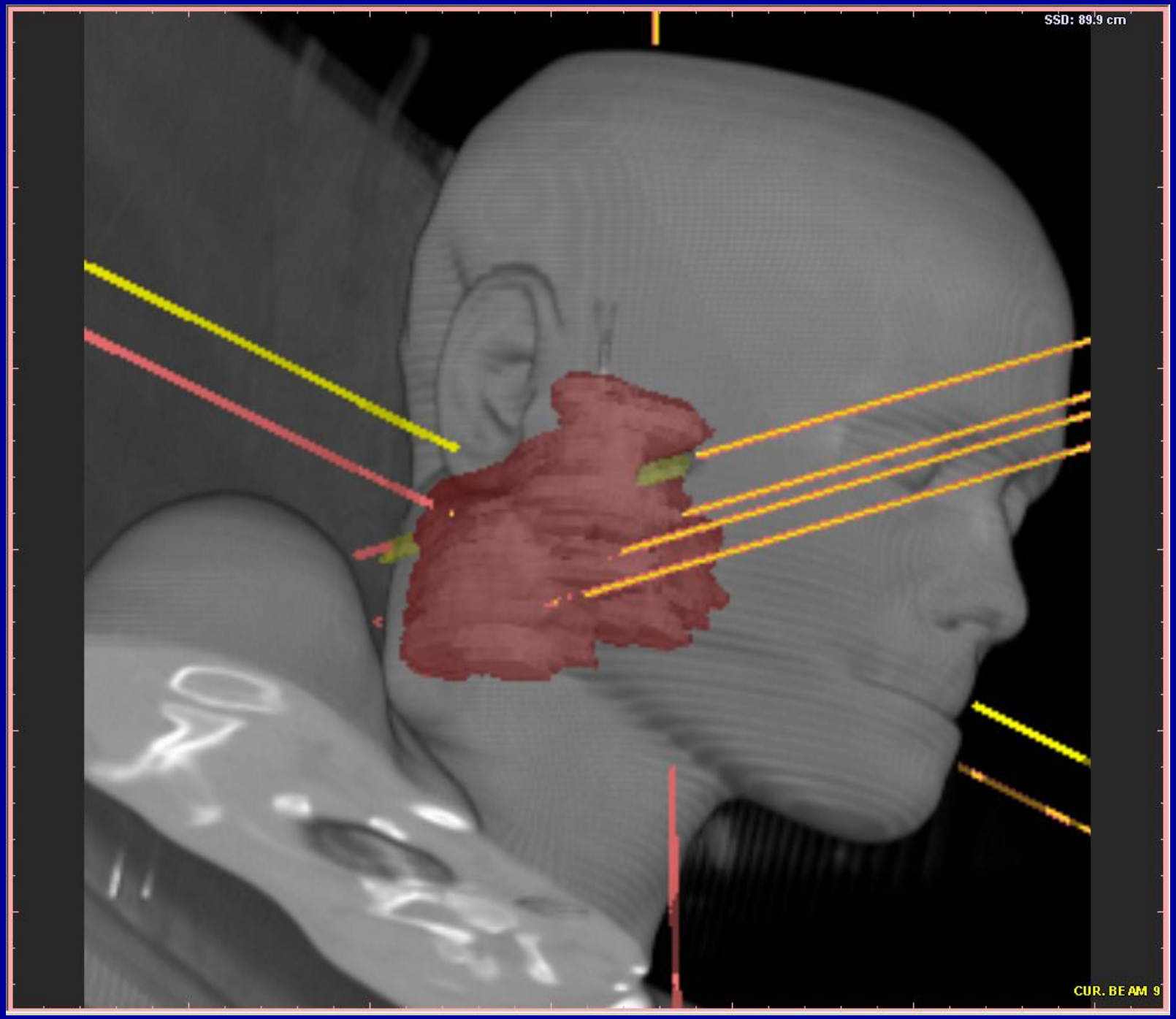
50
Ypos=-65.9
A
Fused Image P/S
Balance Factor=16
target
50
90
200
100
Global Max Dose[302.82 Gy]
R
L
Zpos=364.0
A
Fused Image P/S
Balance Factor=16
50
200
100
F
H
Xpos=65.2
P

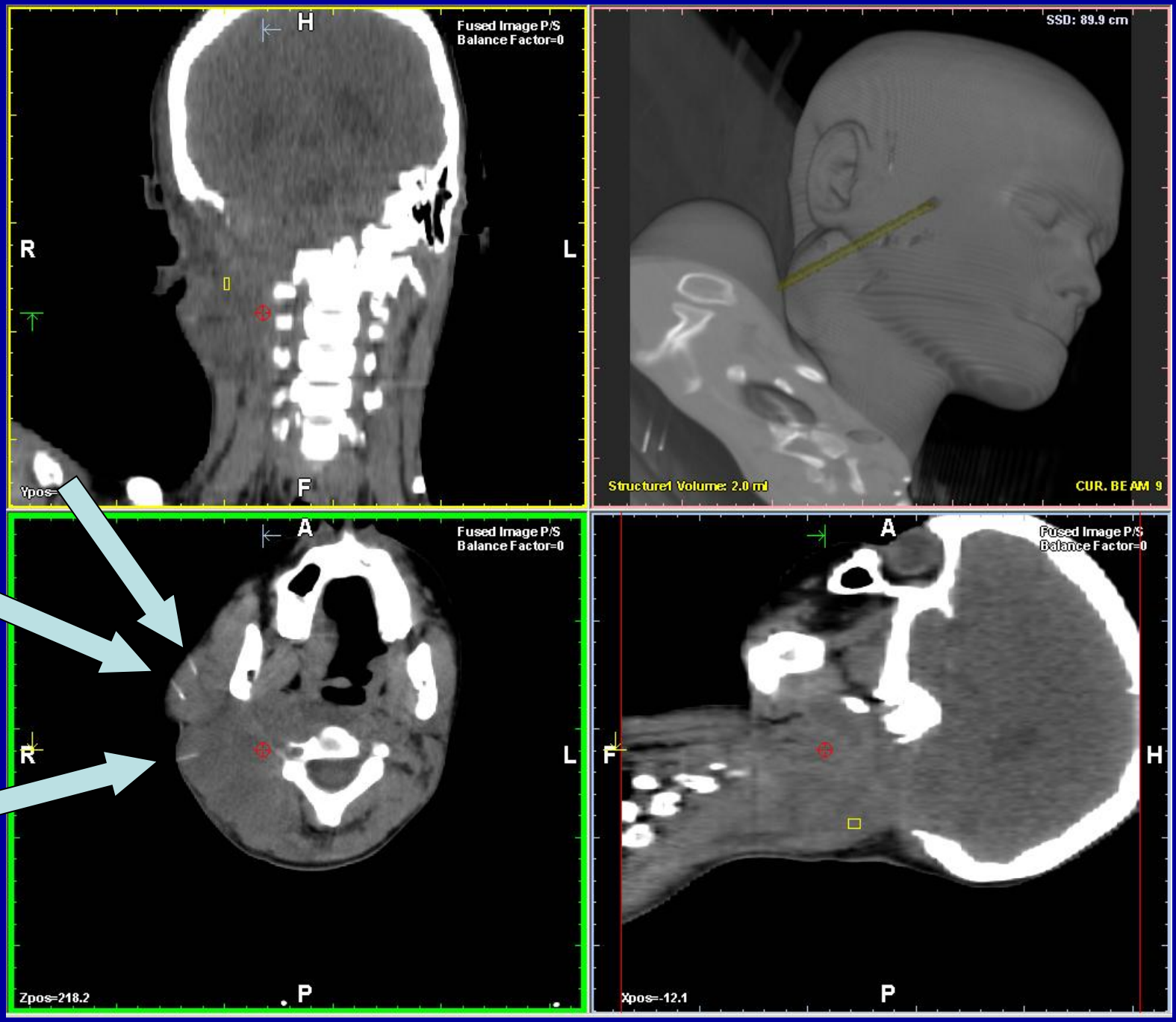
The Era of Adaptive Brachytherapy

- IGRT (Image Guided..2D)
- VGRT (Volume Guided..3D)


H
Fused Image P/S
Balance Factor=73
R
L
F
Ypos=-23.9
SSD: 89.9 cm
CUR. BEAM 9
A
Fused Image P/S
Balance Factor=73
R
L
P
Zpos=229.0
A
Fused Image P/S
Balance Factor=73
F
H
P
Xpos=-20.9


H
Fused Image P/S
Balance Factor=84
R
L
F
Ypos=-23.9
SSD: 89.9 cm
CUR. BEAM 9
A
Fused Image P/S
Balance Factor=84
R
L
P
Zpos=232.8
A
Fused Image P/S
Balance Factor=84
F
H
P
Xpos=-37.5


SSD: 89.9 cm
CUR. BEAM 9


H
Fused Image P/S
Balance Factor=0
R
L
F
Ypos=
SSD: 89.9 cm
Structure1 Volume: 2.0 ml
CUR. BEAM 9
A
Fused Image P/S
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L
Zpos=218.2
P
A
Fused Image P/S
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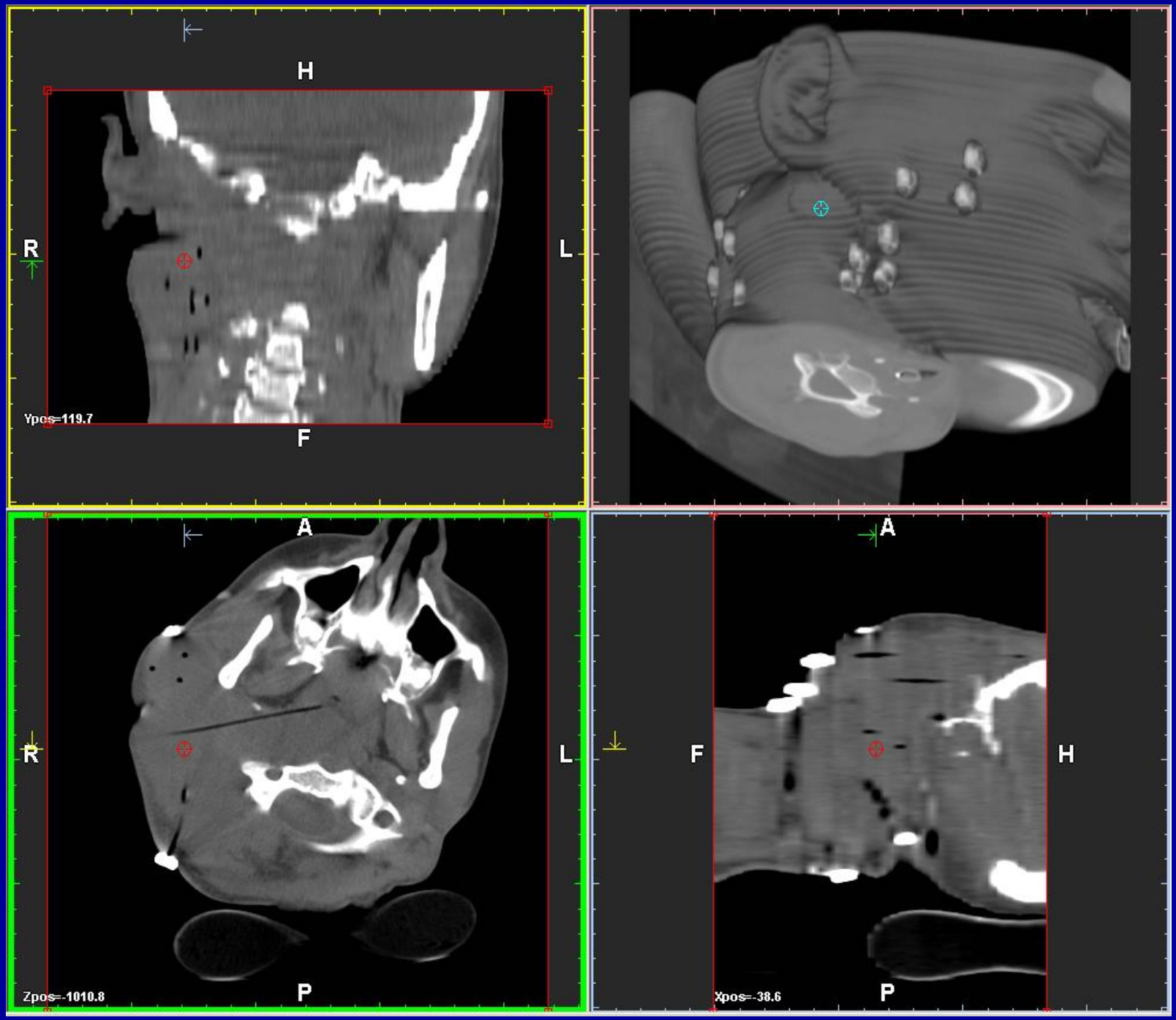
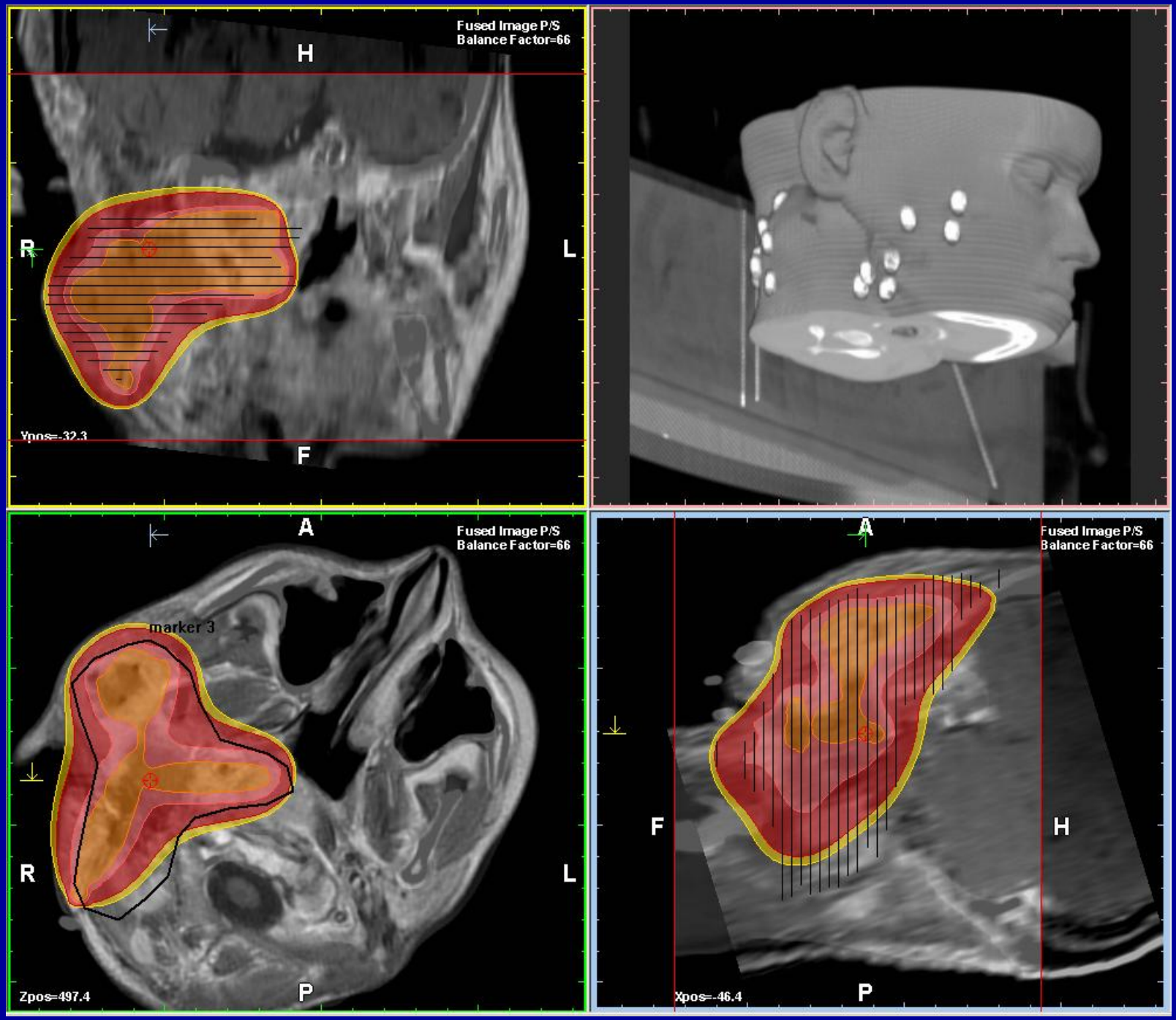
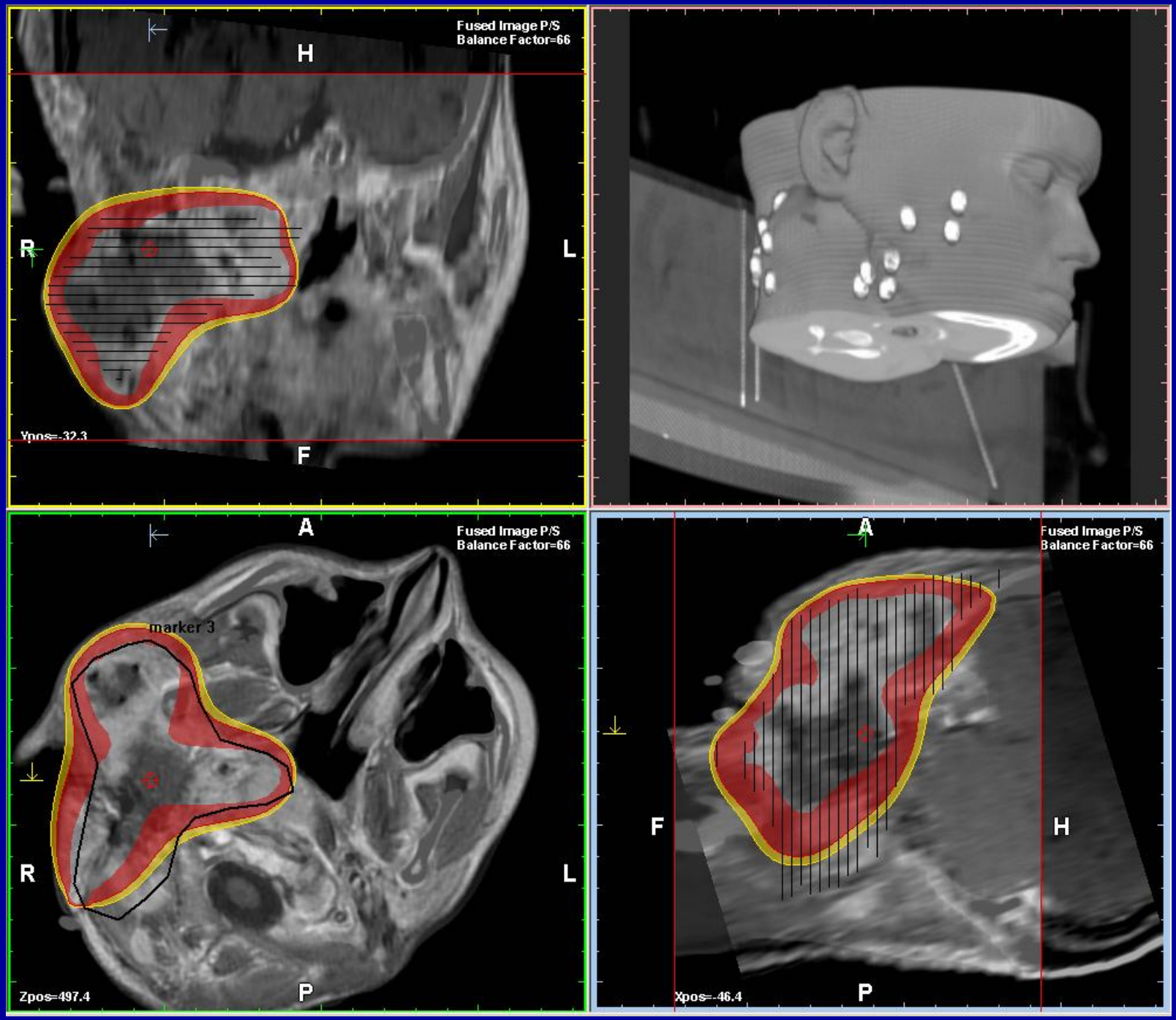

H
R
L
Ypos=-119.7
F
A
R
L
Zpos=-1010.8
P
A
F
H
Xpos=-38.6
P


H
Fused Image P/S
Balance Factor=73
R
L
F
Ypos=-23.9
SSD: 89.9 cm
A
Fused Image P/S
Balance Factor=73
R
L
F
P
Zpos=229.0
layed: Ext.Beam total dose as in RTS+ Brachy total dose in water Toward Gantry
n# 1
n Date: 23.05.2006 12:08:11
erapy: 1 plan loaded
Beam: Not loaded
nation: Calculated
A
200
400
800
1200
L
400
1200
800
200
Target
body


Fused Image P/S
Balance Factor=66
H
R
L
Ypos=-32.3
F
A
Fused Image P/S
Balance Factor=66
marker 3
R
L
Zpos=497.4
P
A
Fused Image P/S
Balance Factor=66
F
H
Xpos=-46.4
P


Fused Image P/S
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Fused Image P/S
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P
Zpos=497.4
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Fused Image P/S
Balance Factor=66
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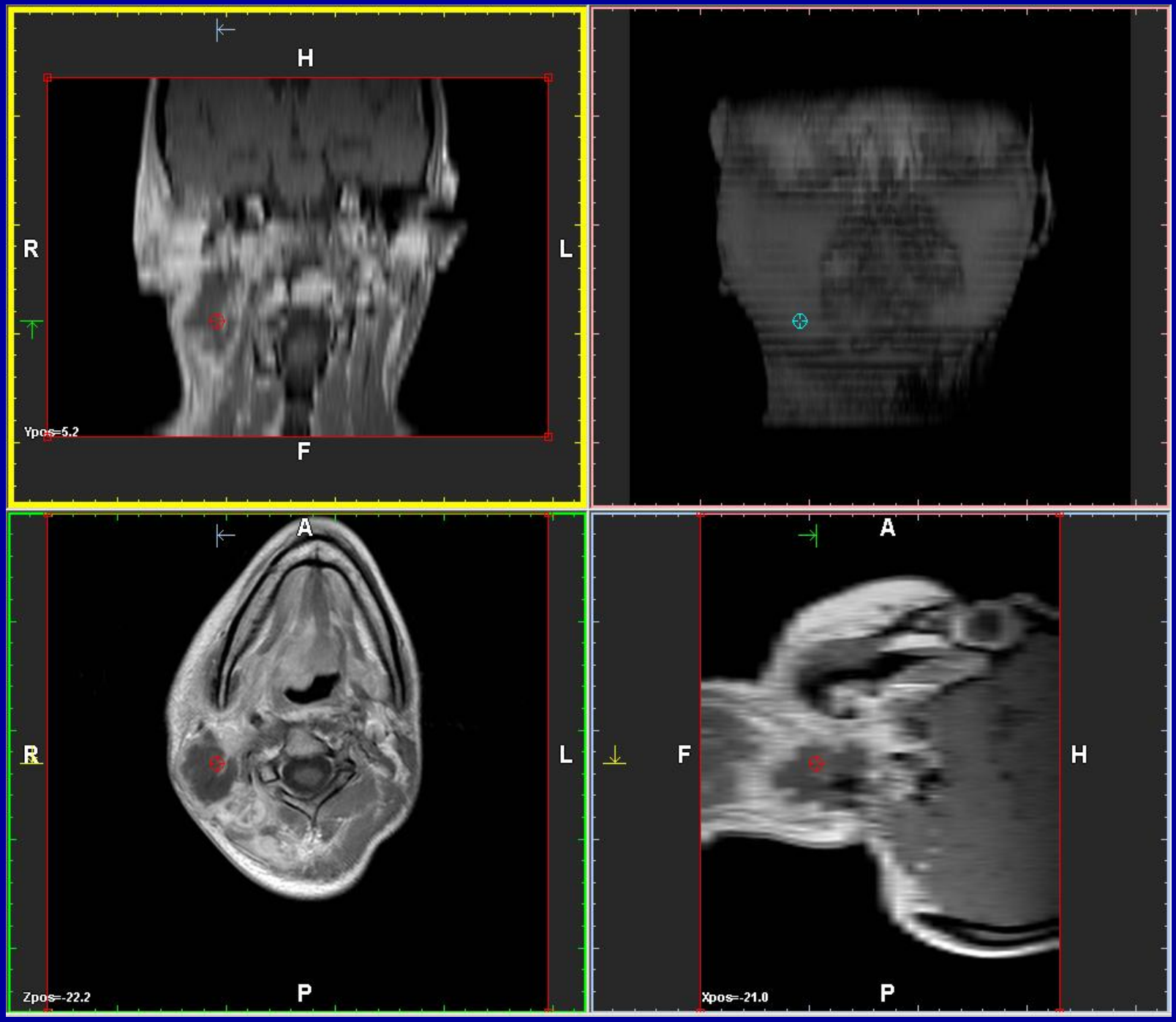
H
P
Xpos=-46.4

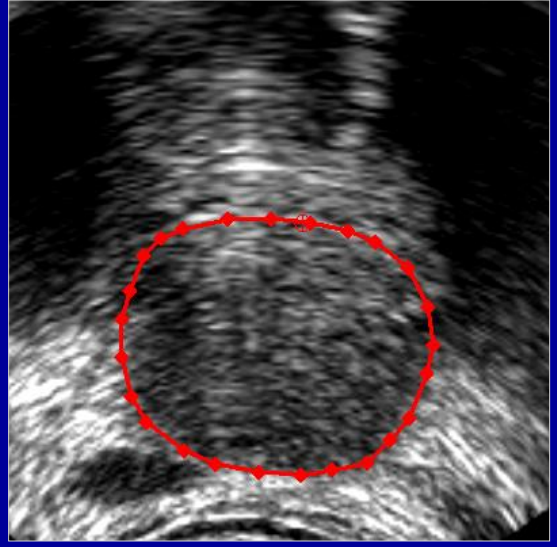

H
R
L
Ypos=-5.2
F
A
R
L
Zpos=-22.2
P
A
F
H
Xpos=-21.0
P

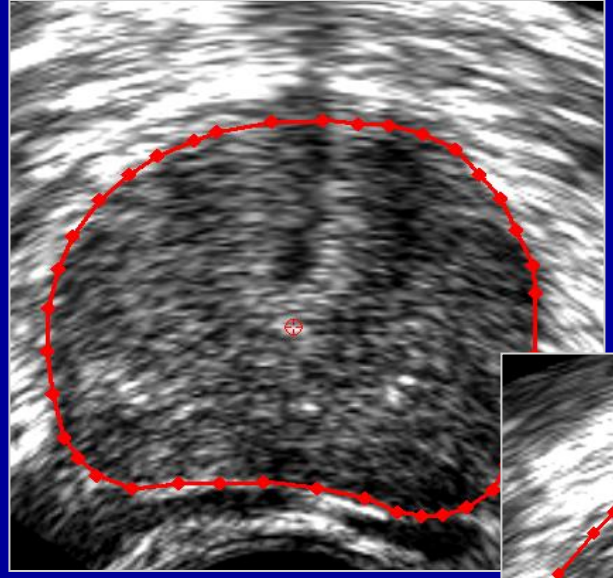
How we make the decision for the configuration of the catheters?

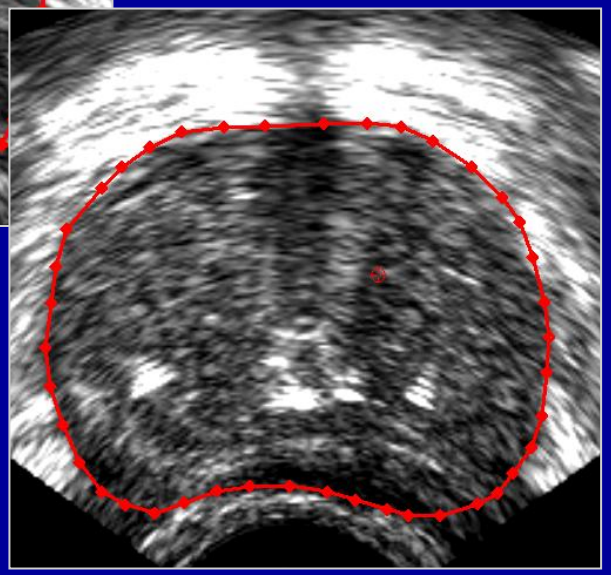
Example Prostate Ca Treatment

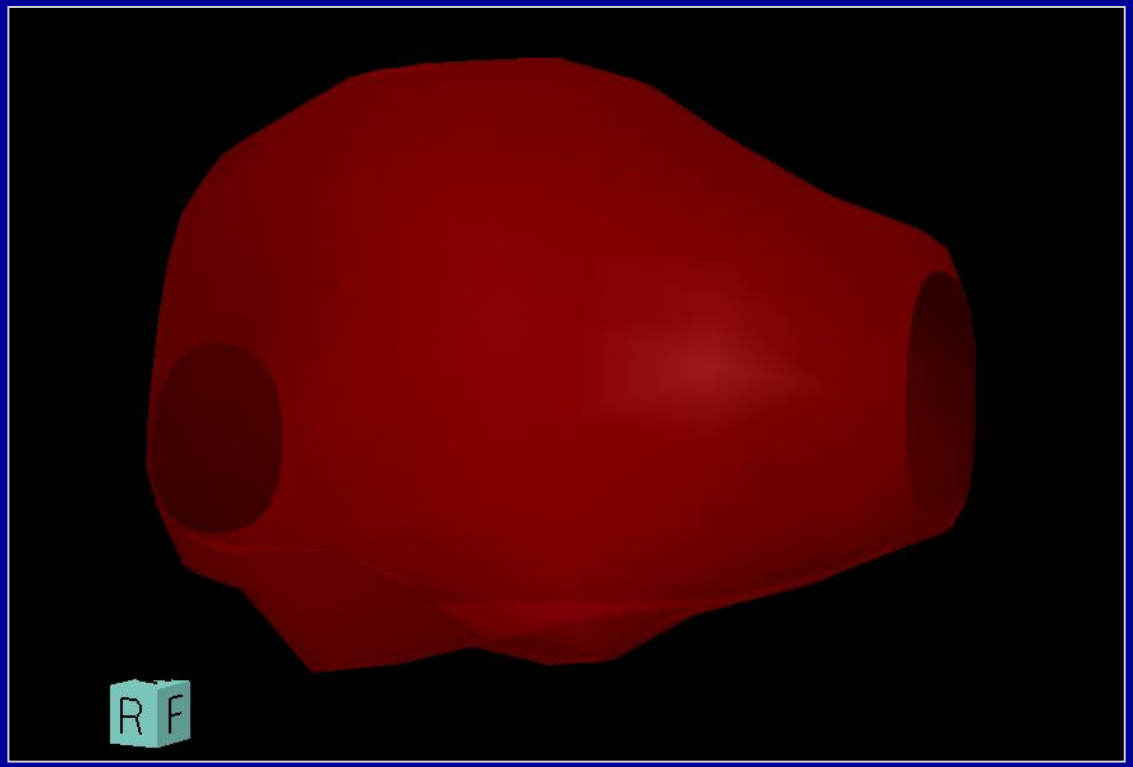
Example Prostate Ca Treatment Inverse Planning

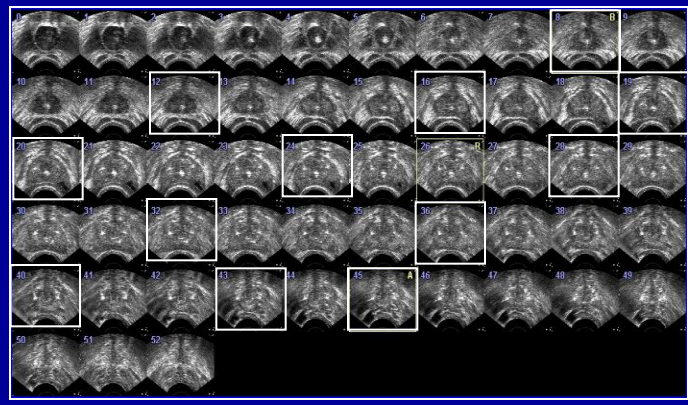

A B C D E F G
7 6 5 4 3 2 1



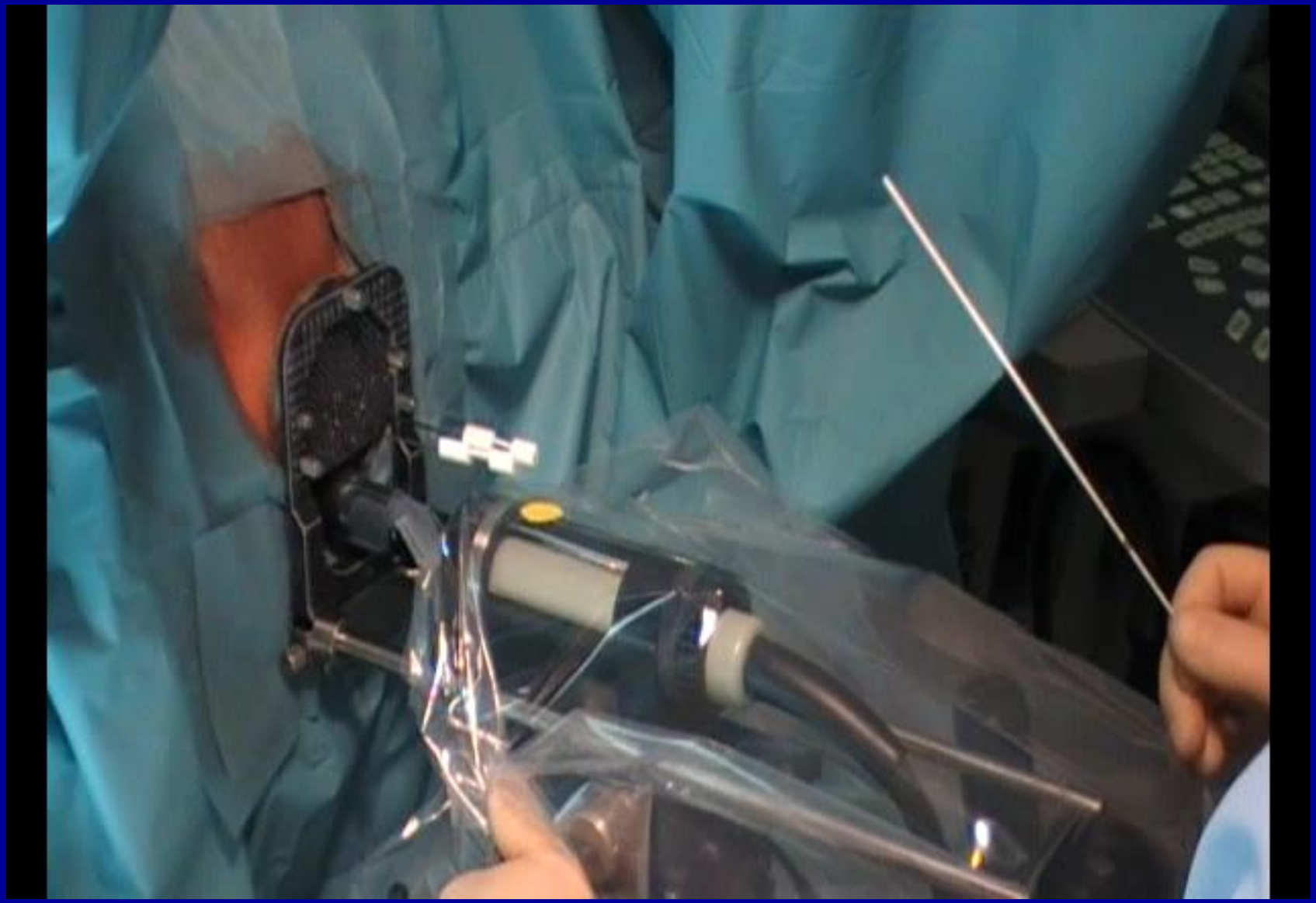




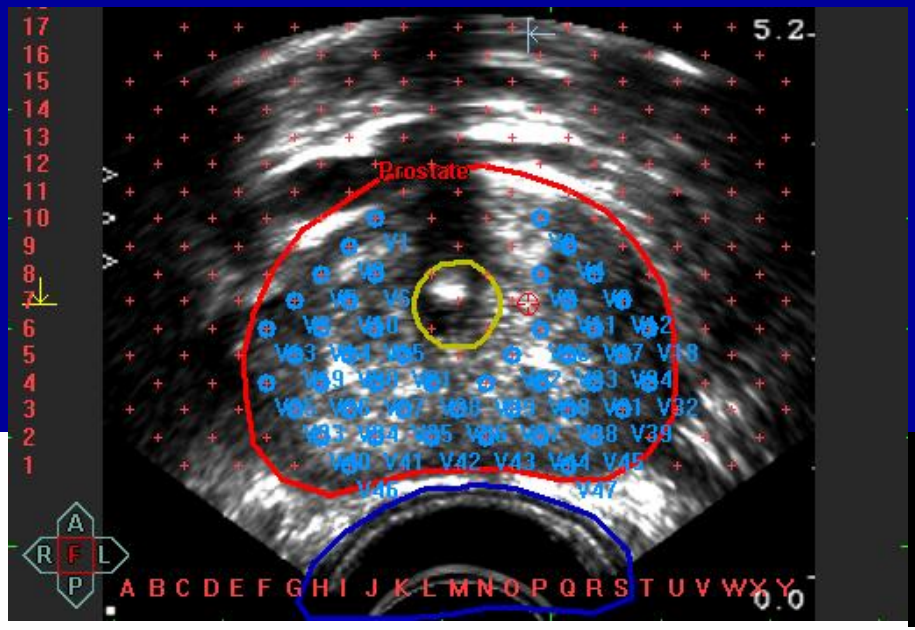

R
F



Which is the Optimal Implantation



HIPO: Inverse Planning Technology in OP



25 cm³ Prostate
2.5 mm Grid
47 x Feasible
14 x Catheters/Needles

For getting a feeling for the performance of HIPO, let discuss the example shown in the above Figures.

A template with 2.5 mm grid is used resulting in a total of 47 possible (feasible) catheters based on the placement rules defined. When asking HIPO to infer the 14 best catheters for the user-selected objectives and user-defined dose limits and penalties there exist in reality nearly $1/3 \times 10^{12}$ different catheter combinations that is the possible combinations of 47 catheters taken 14 at a time:

$$\frac{47!}{14! \times (47-14)!} \approx 0.34 \times 10^{12}$$

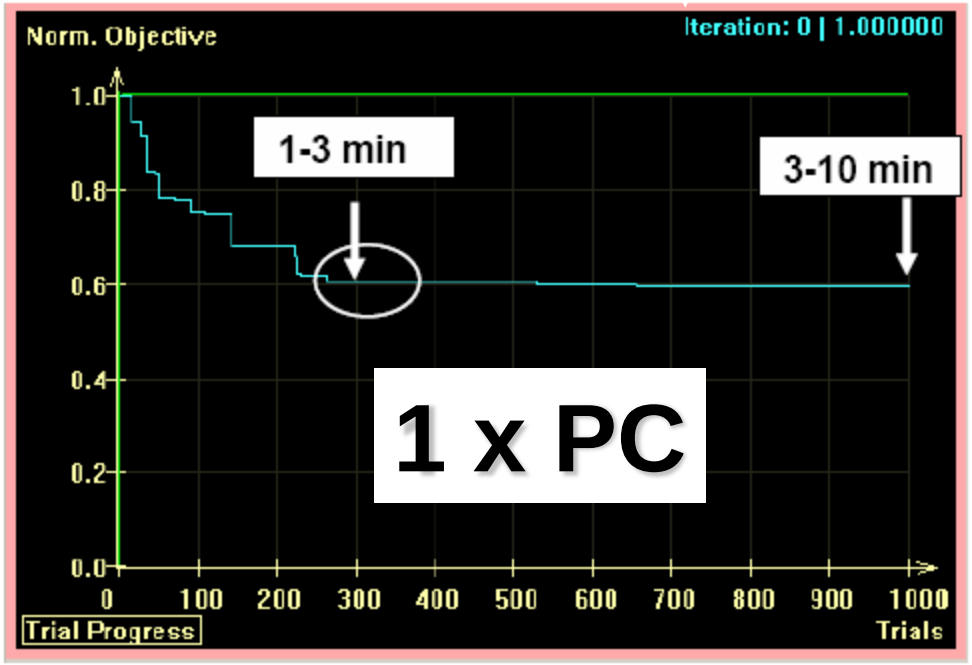
Trillion

When using a very fast PC (≥ 3.2 GHz) the DVHO inverse optimization run takes approximately 3 seconds. This means that for analyzing all these possible catheter combinations we should wait approximately **32,000 years** for getting the result.

1000 CPUs/PCs ....

32 Years ....

Advance Technology



Anatomy-based three-dimensional dose optimization in brachytherapy using multiobjective genetic algorithms

M. Lahanas
Department of Medical Physics & Engineering, Strahlenklinik, Städtische Kliniken Offenbach, 63069 Offenbach, Germany

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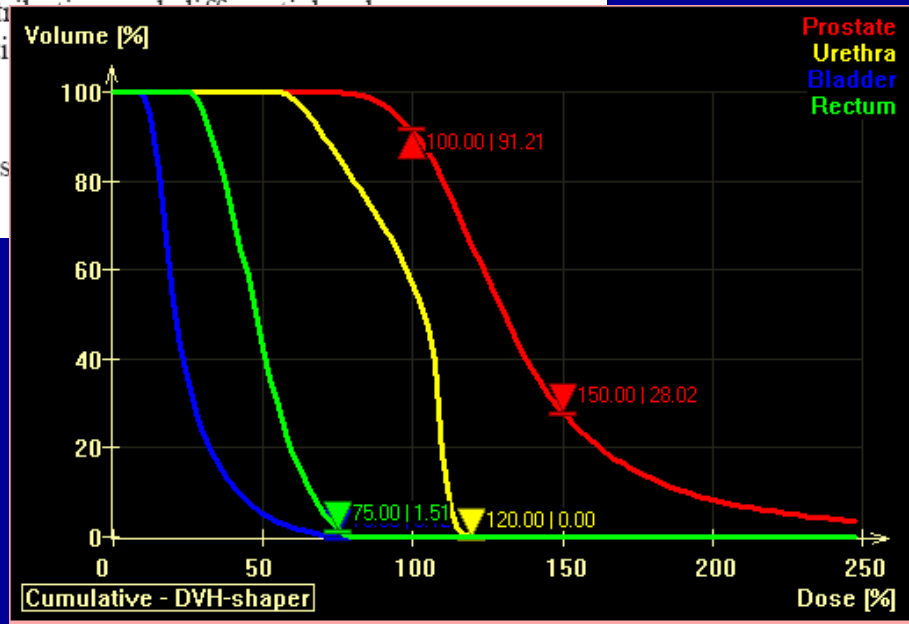
(Received 21 January 1999; accepted for publication 4 June 1999)

In conventional dose optimization algorithms, in brachytherapy, multiple objectives are expressed in terms of an aggregating function which combines individual objective values into a single utility value, making the problem single objective, prior to optimization. A multiobjective genetic algorithm (MOGA) was developed for dose optimization based on an *a posteriori* approach, leaving the decision-making process to a planner and offering a representative trade-off surface of the various objectives. The MOGA provides a flexible search engine which provides the maximum of information for a decision maker. Tests performed with various treatment plans in brachytherapy have shown that MOGA gives solutions which are superior to those of traditional dose optimization algorithms. Objectives were proposed in terms of the COIN distri... histograms, taking into account patient anatomy in the optimizati... *Association of Physicists in Medicine.* [S0094-2405(99)00309-0]

Key words: optimization, brachytherapy, COIN, dose-volume his... algorithms



INSTITUTE OF PHYSICS PUBLISHING PHYSICS IN MEDICINE AND BIOLOGY

Phys. Med. Biol. 48 (2003) 399–415 PII: S0031-9155(03)52023-1

A hybrid evolutionary algorithm for multi-objective anatomy-based dose optimization in high-dose-rate brachytherapy

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Received 6 August 2002
Published 22 January 2003
Online at stacks.iop.org/PMB/48/399

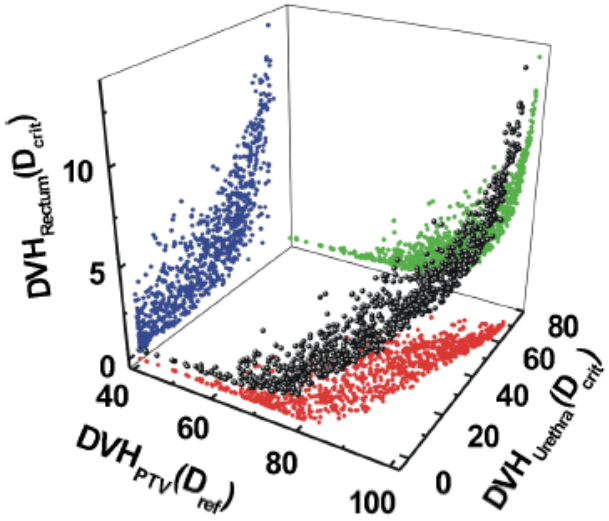

Figure 5. Trade-off between three objectives: PTV coverage, percentage of volume of urethra overdose and rectum overdose. The three two-dimensional projections are shown. These show the trade-off between two objectives.

40

HIPO: A hybrid inverse treatment planning optimization algorithm in HDR brachytherapy

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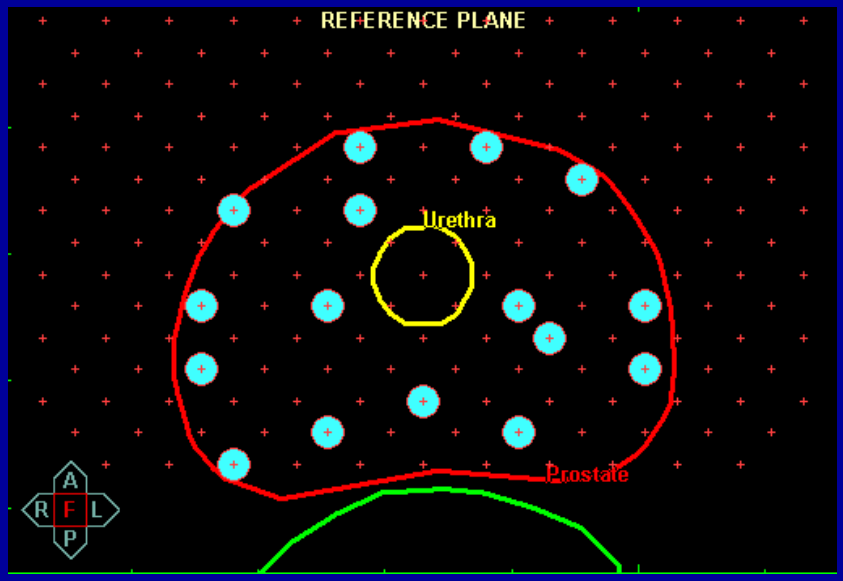
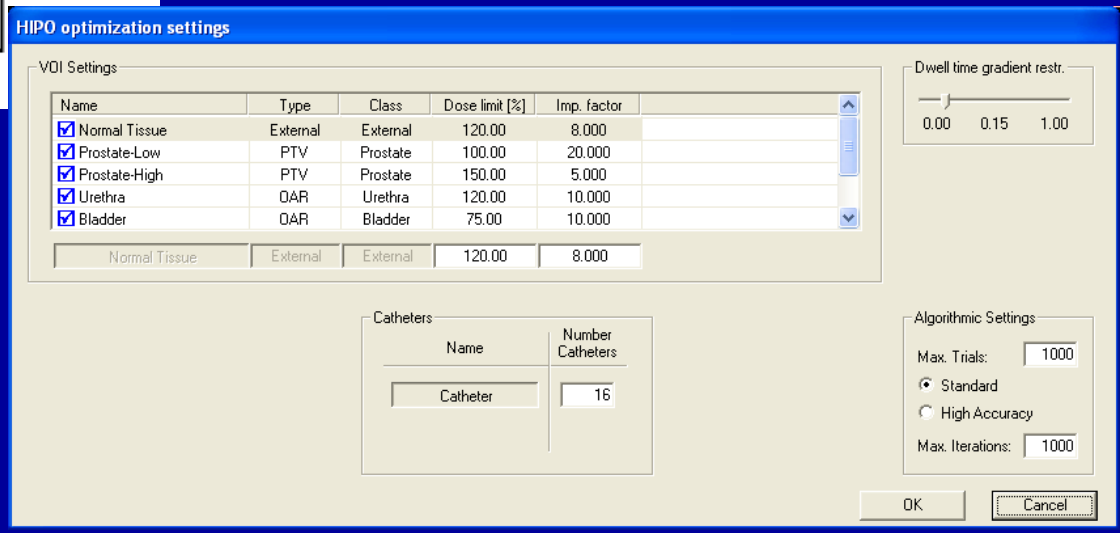
[2]Department of Medical Physics and Engineering, Strahlenklinik, Klinikum Offenbach, Offenbach, Germany

An advanced hybrid, inverse treatment planning optimization algorithm is introduced based on a stochastic method, Simulated Annealing (SA), for searching for the catheter placement and a deterministic method, LBFGS, for 3D dose distribution optimization.
The objective functions used [1].[2], have a common characteristic in that they penalize dose values above and/or below the specified upper and lower dose limits for the anatomical structures:

$$f_L = \frac{1}{N}\sum_{i=1}^{N}\left[\Theta\left(D_L - d_i(\mathbf{x})\right)\left[D_L - d_i(\mathbf{x})\right]^{\alpha}\right] \quad (1)$$

$$f_H = \frac{1}{N}\sum_{i=1}^{N}\left[\Theta\left(d_i(\mathbf{x}) - D_H\right)\left[d_i(\mathbf{x}) - D_H\right]^{\alpha}\right] \quad (2)$$



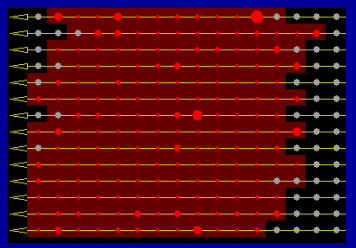


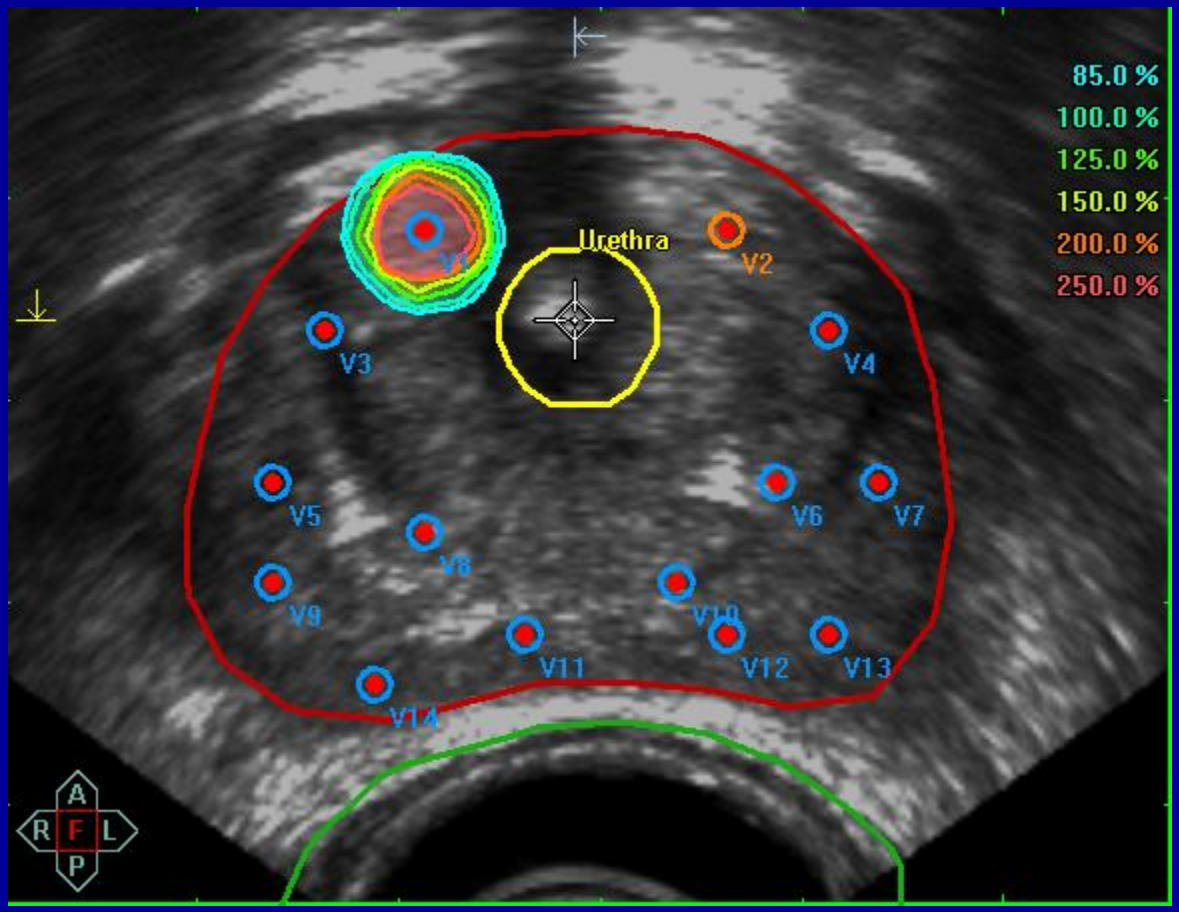
Prostate

The Era of Adaptive Brachytherapy

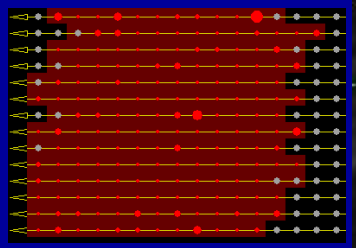
- IGRT (Image Guided..2D)
- VGRT (Volume Guided..3D)
- DGRT (Dose Guided …)

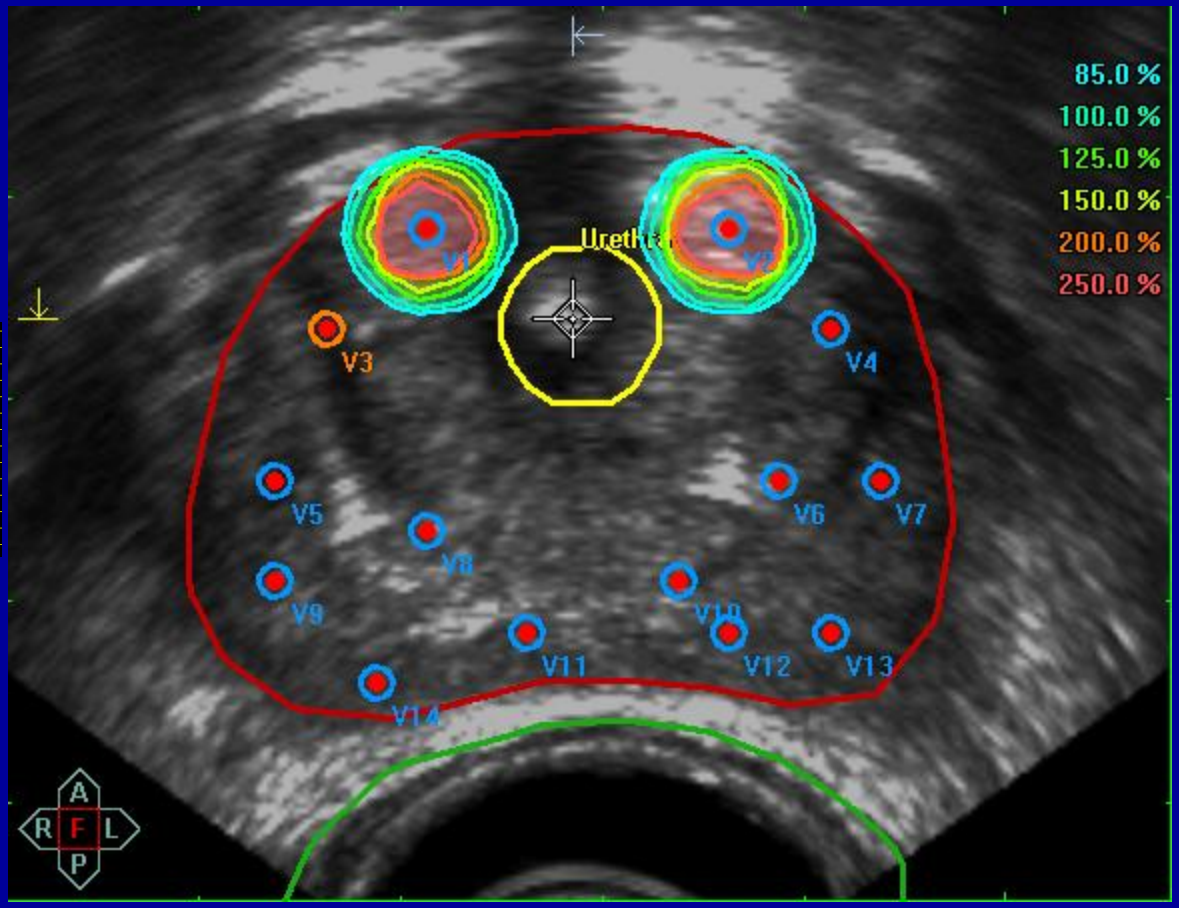
DGRT (Dose Guided …)





DGRT (Dose Guided …)





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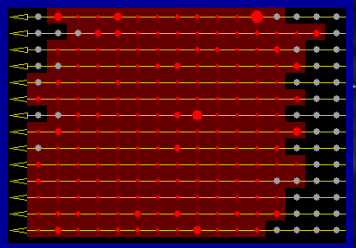

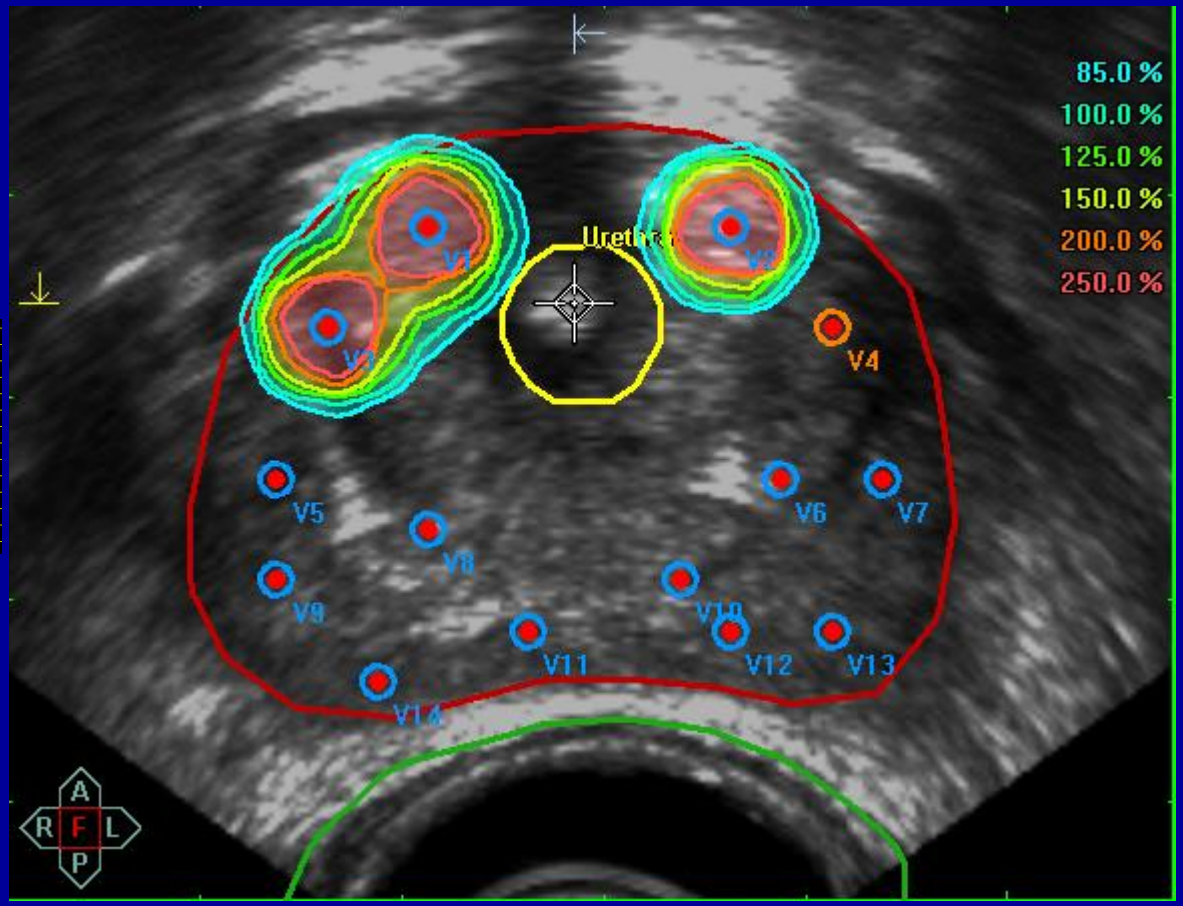

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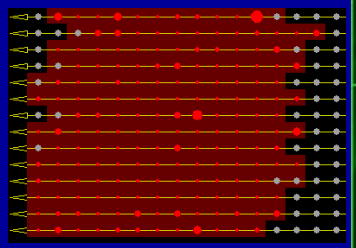

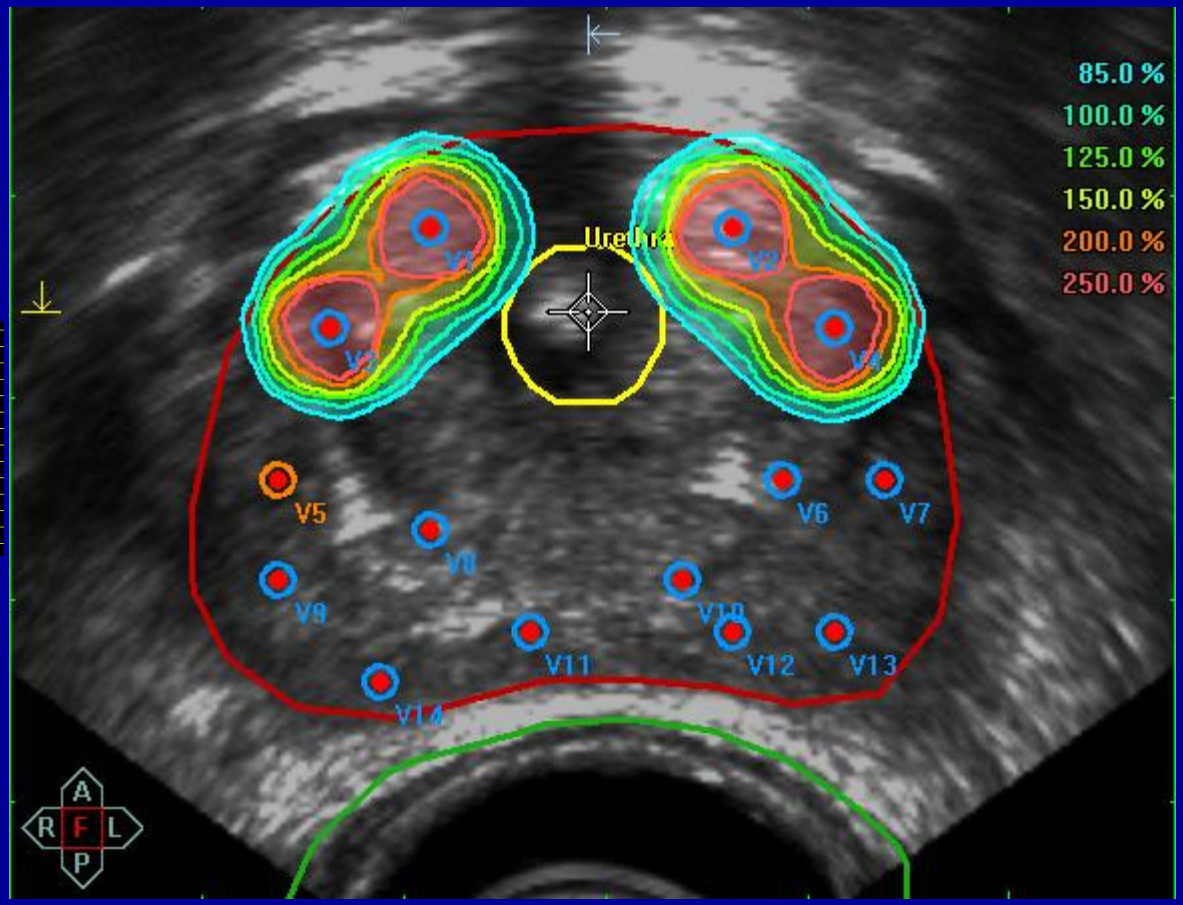

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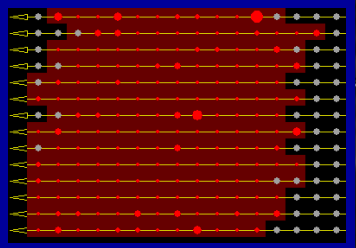
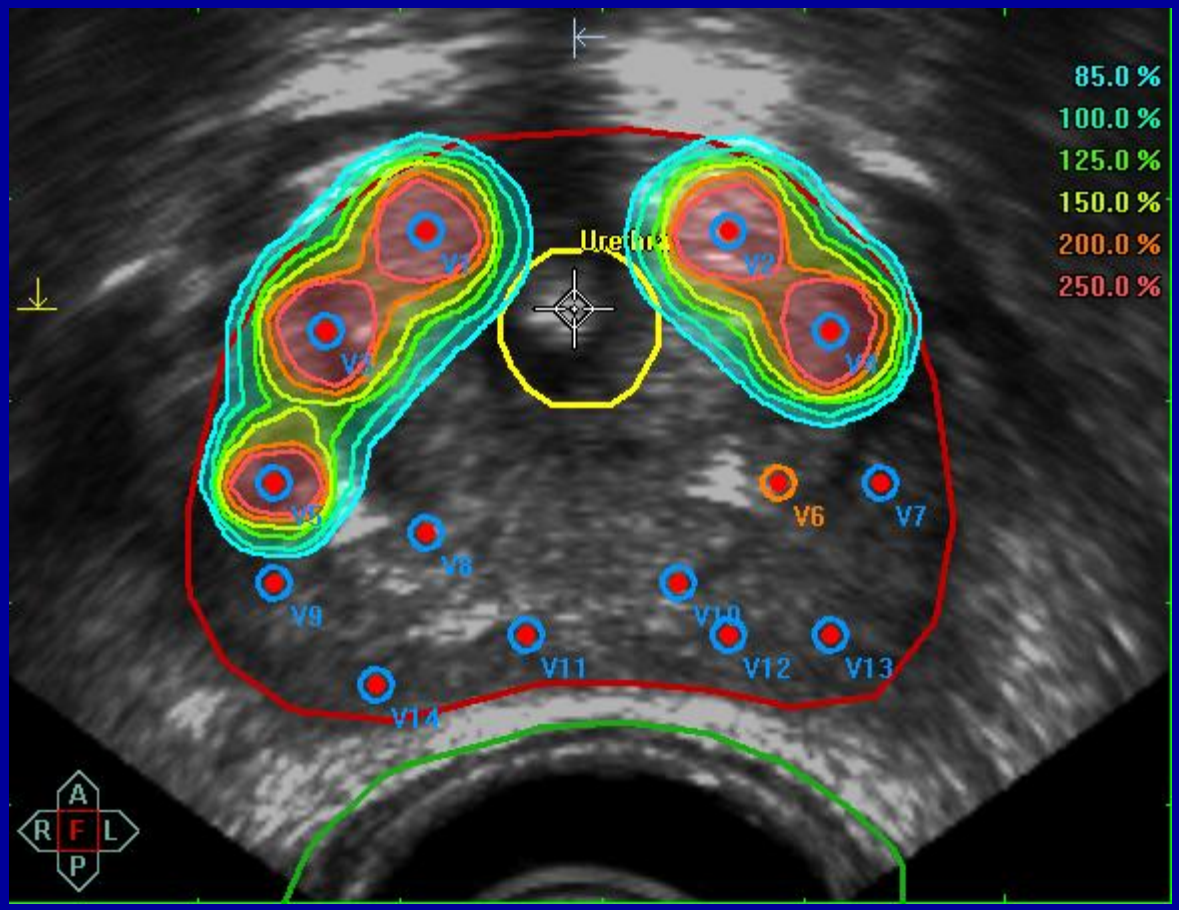
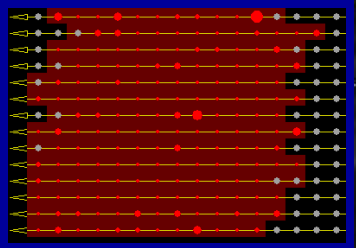
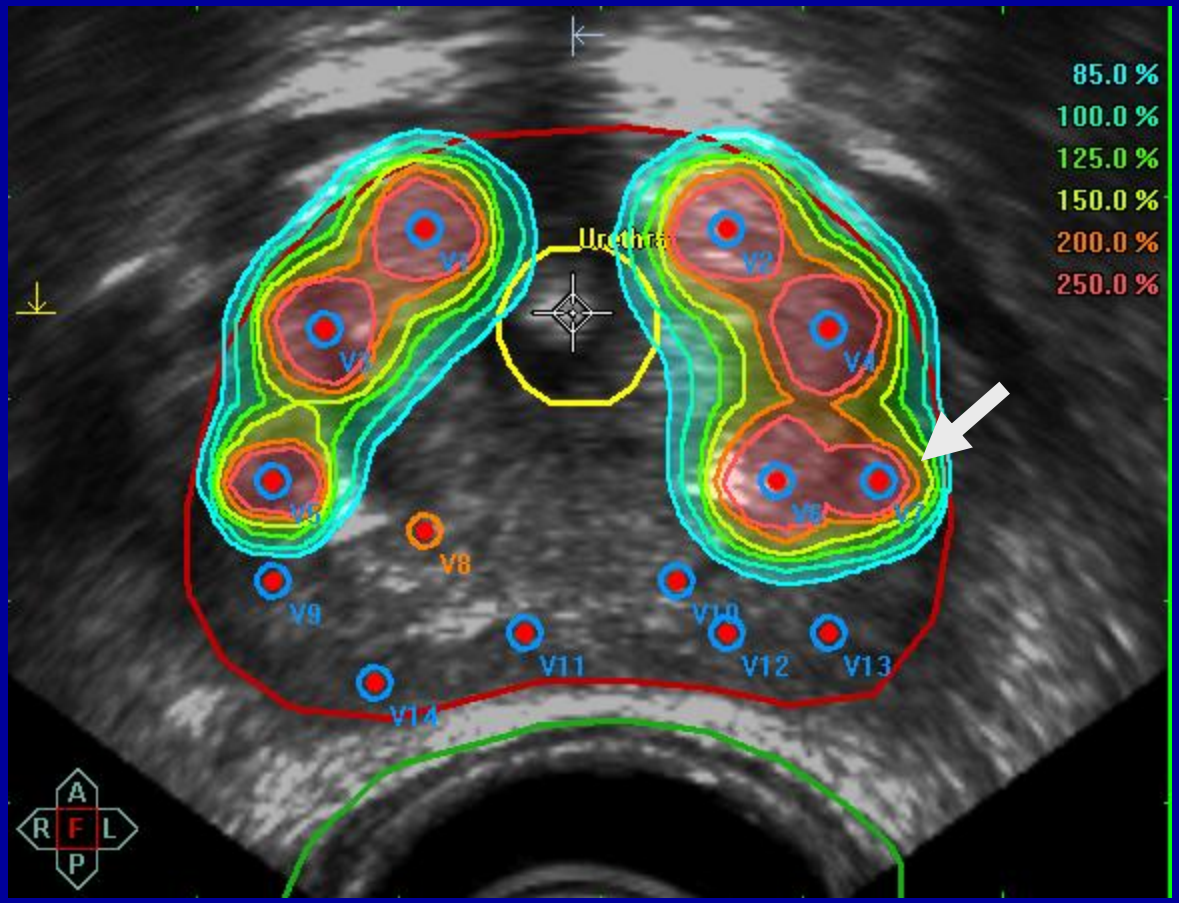




DGRT (Dose Guided …)





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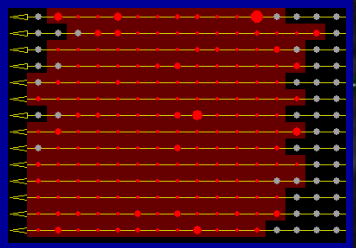

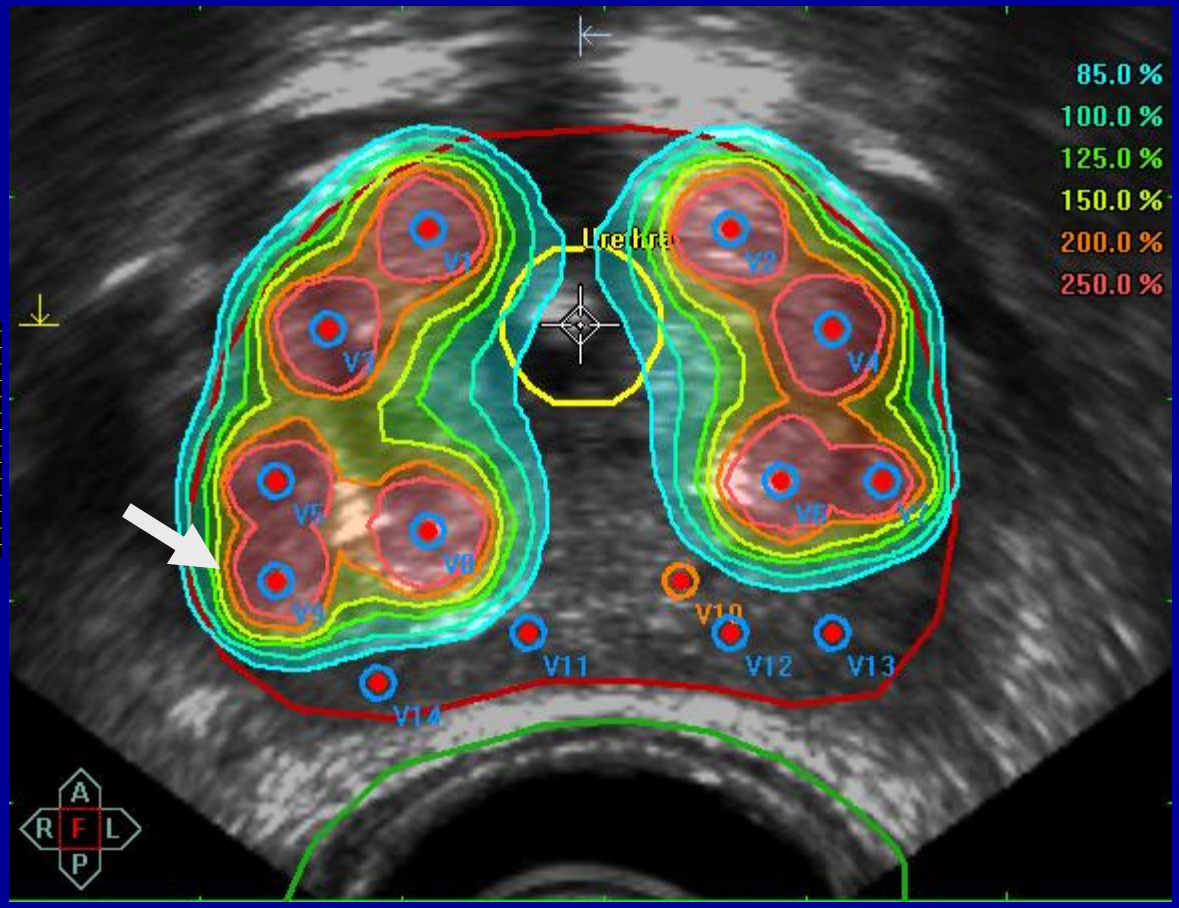

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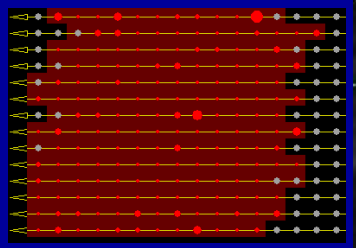

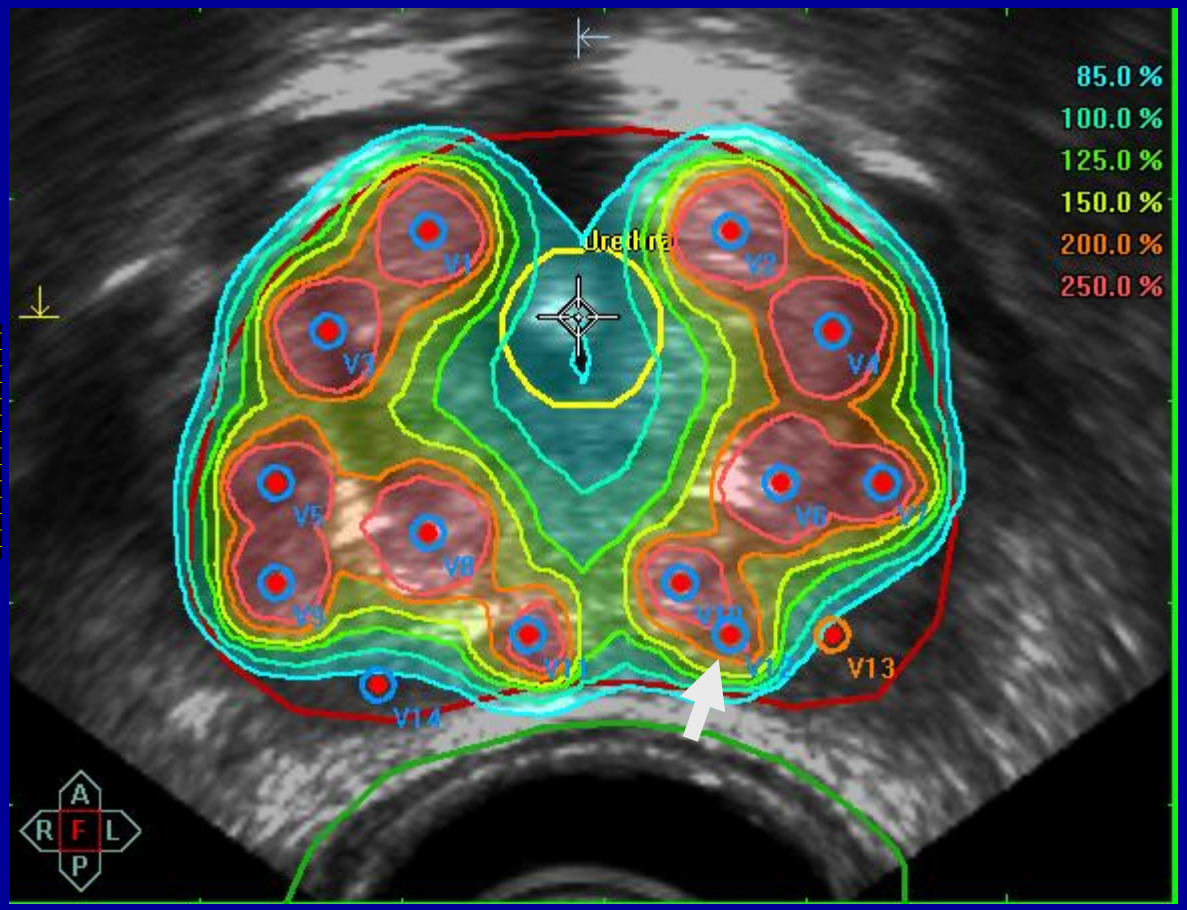

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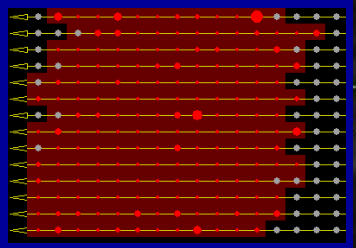
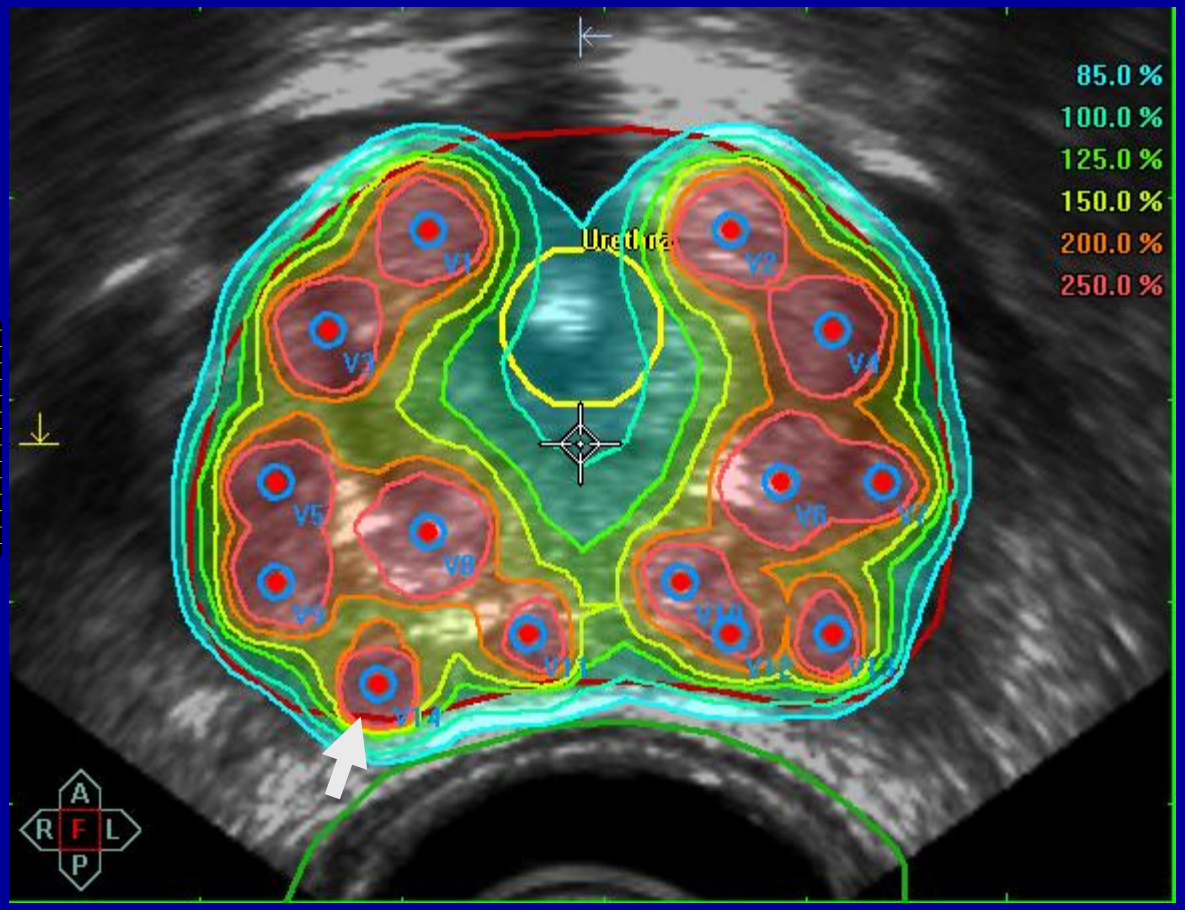
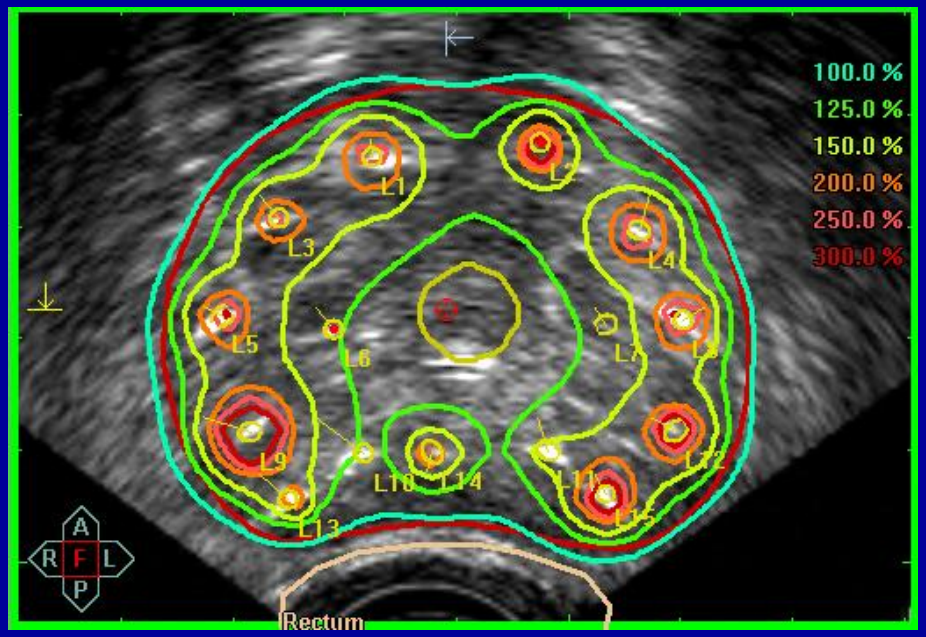
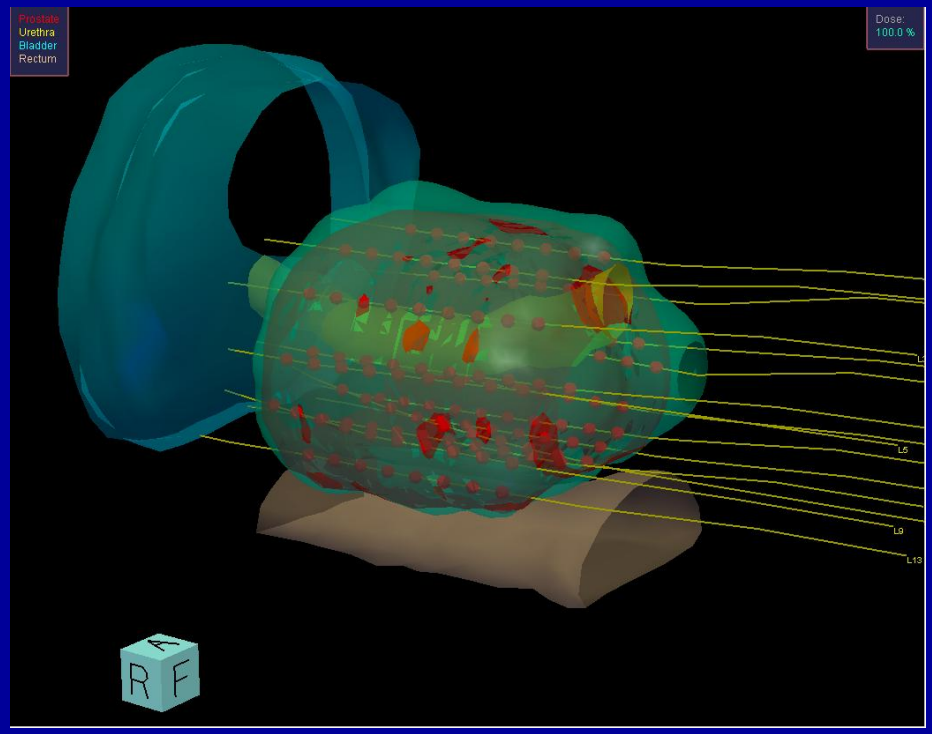




IMBRT - Today:

Highly Conformal 3D Dose Distributions …





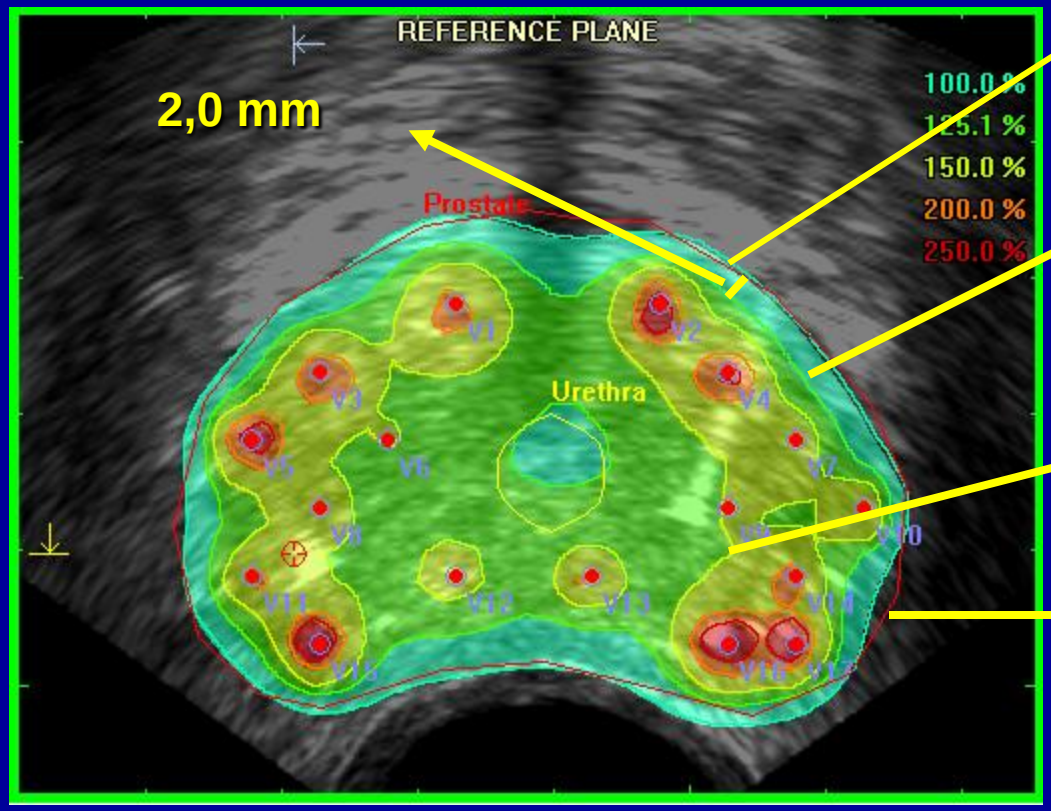
Brachytherapy is the Highest Conformal Treatment in Radiation Oncology

and

High Biological Effective Dose Can be Achieved

4 x 9,5 Gy => ???

α/β = 1,5 Gy



119,0 Gy

182,0 Gy

257,0 Gy

98,0 Gy

The Era of Adaptive Brachytherapy

- IGRT (Image Guided..2D)
- VGRT (Volume Guided..3D)
- DGRT (Dose Guided …)
- ART (4D)

Influence of the Patient Movement and Anatomy Alteration on DVH Parameters in Prostate IRO

4D analysis of influence of patient movement and anatomy alteration on the quality of 3D U/S-based prostate HDR brachytherapy treatment delivery[a)]

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Nikolaos Tselis
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Nikolaos Zamboglou
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(Received 6 April 2011; revised 24 June 2011; accepted for publication 11 July 2011; published 10 August 2011)

 0094-2405/2011/38(9)/4982/12/$30.00

Patients n=25

This is a 4D-Study based on the following image sets:

[1] Clinical 3D image set

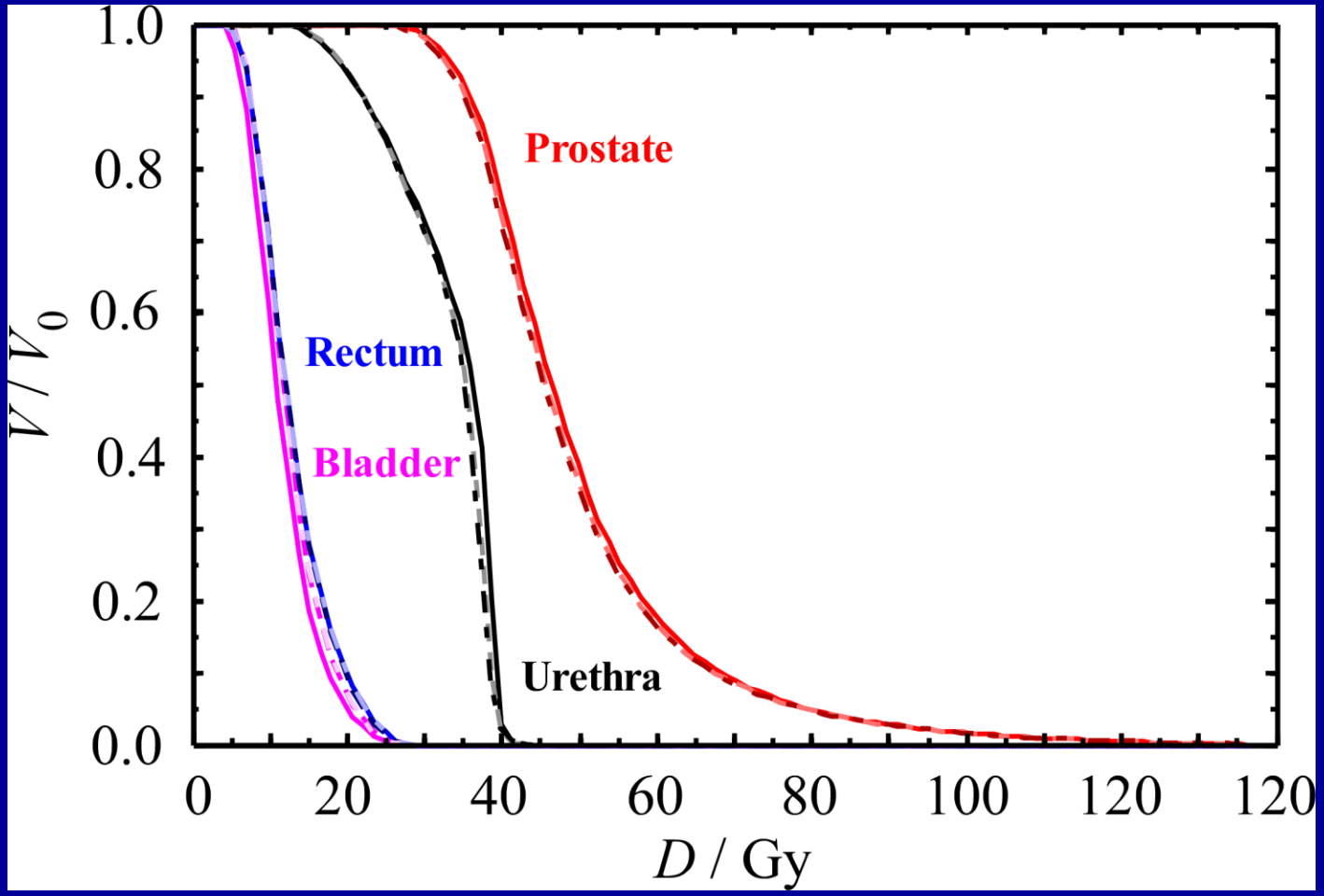
Patient irradiation plan is based on clinical image set (live plan)
Acquisition of images for this image set is made just after finalization of the implantation.

[2] Pre-irradiation 3D image set

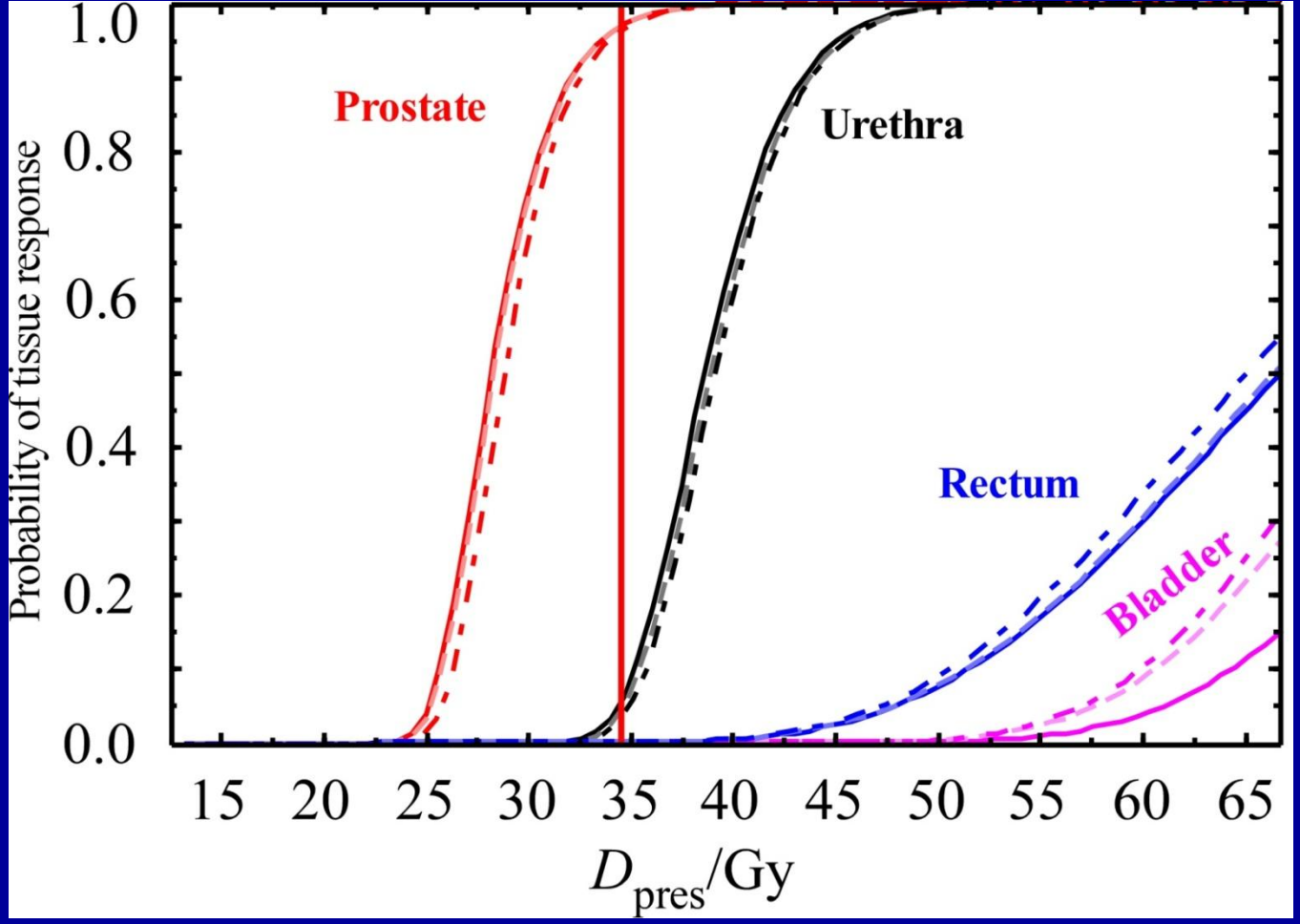
It is acquired just before the patient treatment/irradiation.

[3] Post-irradiation 3D image set

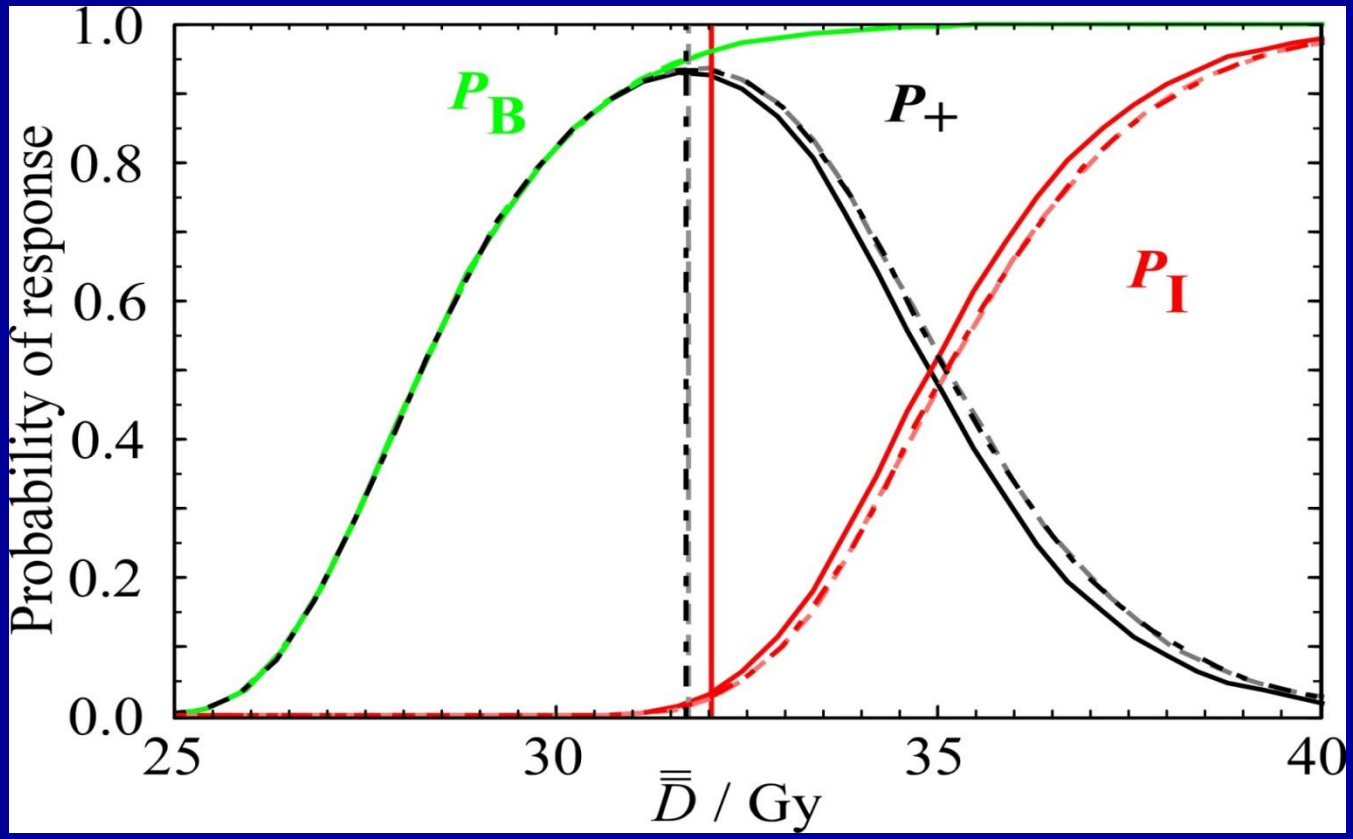
Acquisition of this image set was done after the patient irradiation.



The average DVHs of the prostate gland (red), urethra (black), bladder (pink) and rectum (blue) are presented for the three HDR treatment plans, namely 1: after implantation (clinical acquisition) (solid), 2: just before starting the treatment execution (pre-irradiation acquisition) (dashed) and 3: just after finishing the treatment delivery (post-irradiation acquisition) (dotted-dashed). Here, the total dose of 34.5 Gy delivered by three fractions of 11.5 Gy is considered to be the total prescription dose (100%).

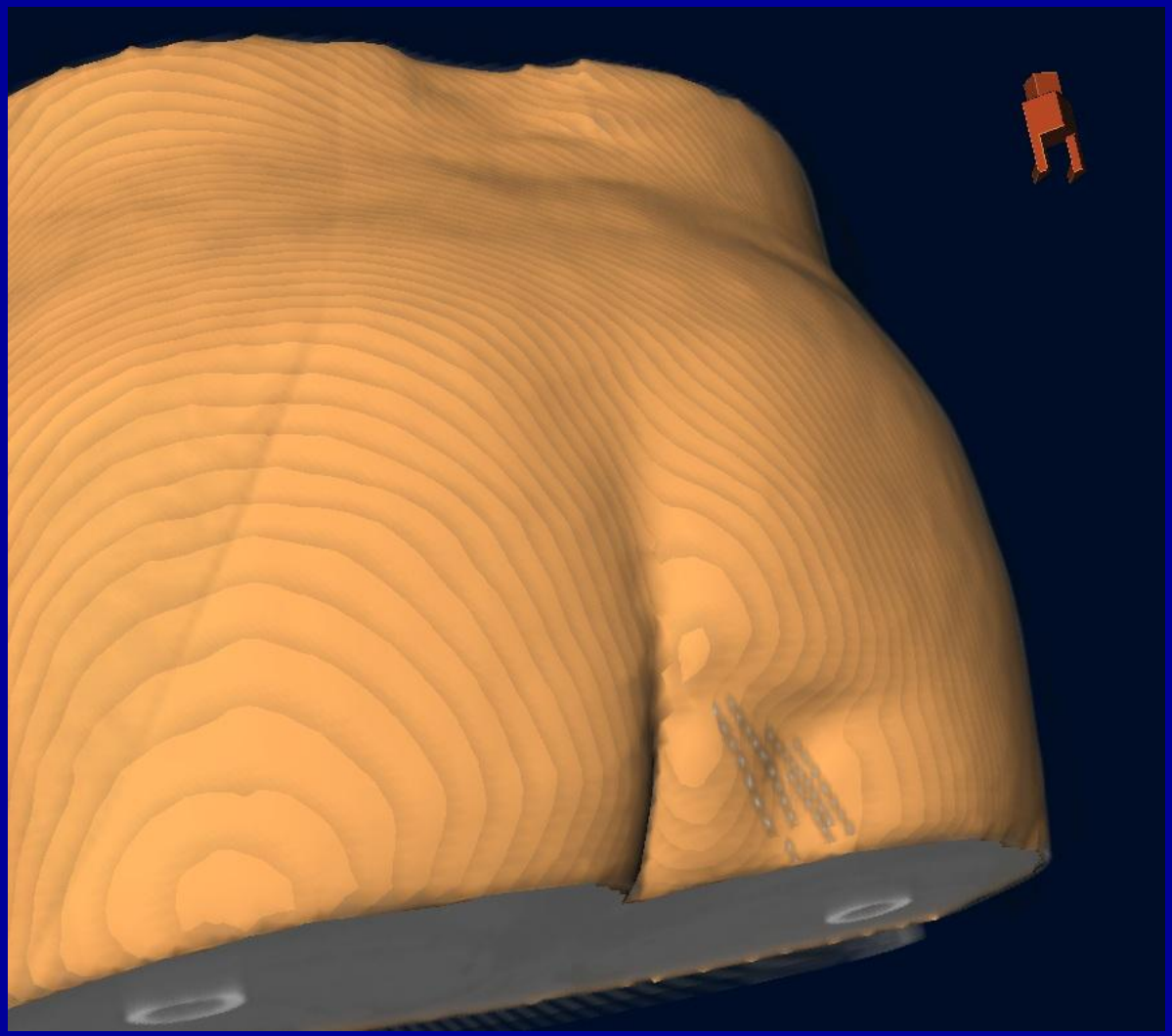


The average dose-response curves of the prostate (red), urethra (black), bladder (pink) and rectum (blue) are presented for the three HDR treatment plans, namely 1: after implantation (clinical acquisition) (solid), 2: just before starting the treatment execution (pre-irradiation acquisition) (dashed) and 3: just after finishing the treatment delivery (post-irradiation acquisition) (dotted-dashed), regarding different prescription doses. The vertical line indicates the clinical prescribed dose level of the dose distributions. Here, the total dose of 34.5 Gy delivered by three fractions of 11.5 Gy is considered to be the total prescription dose (100%).

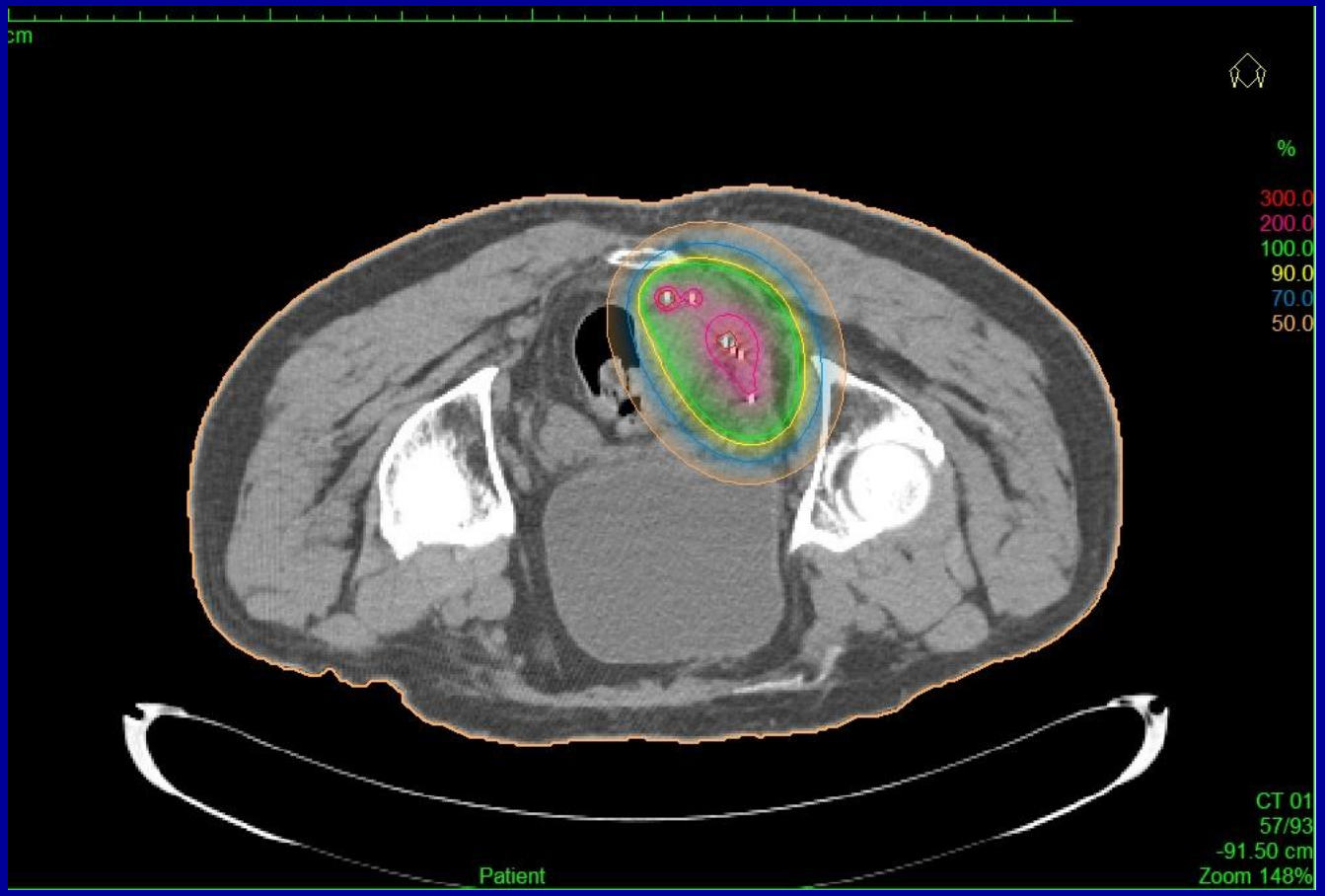


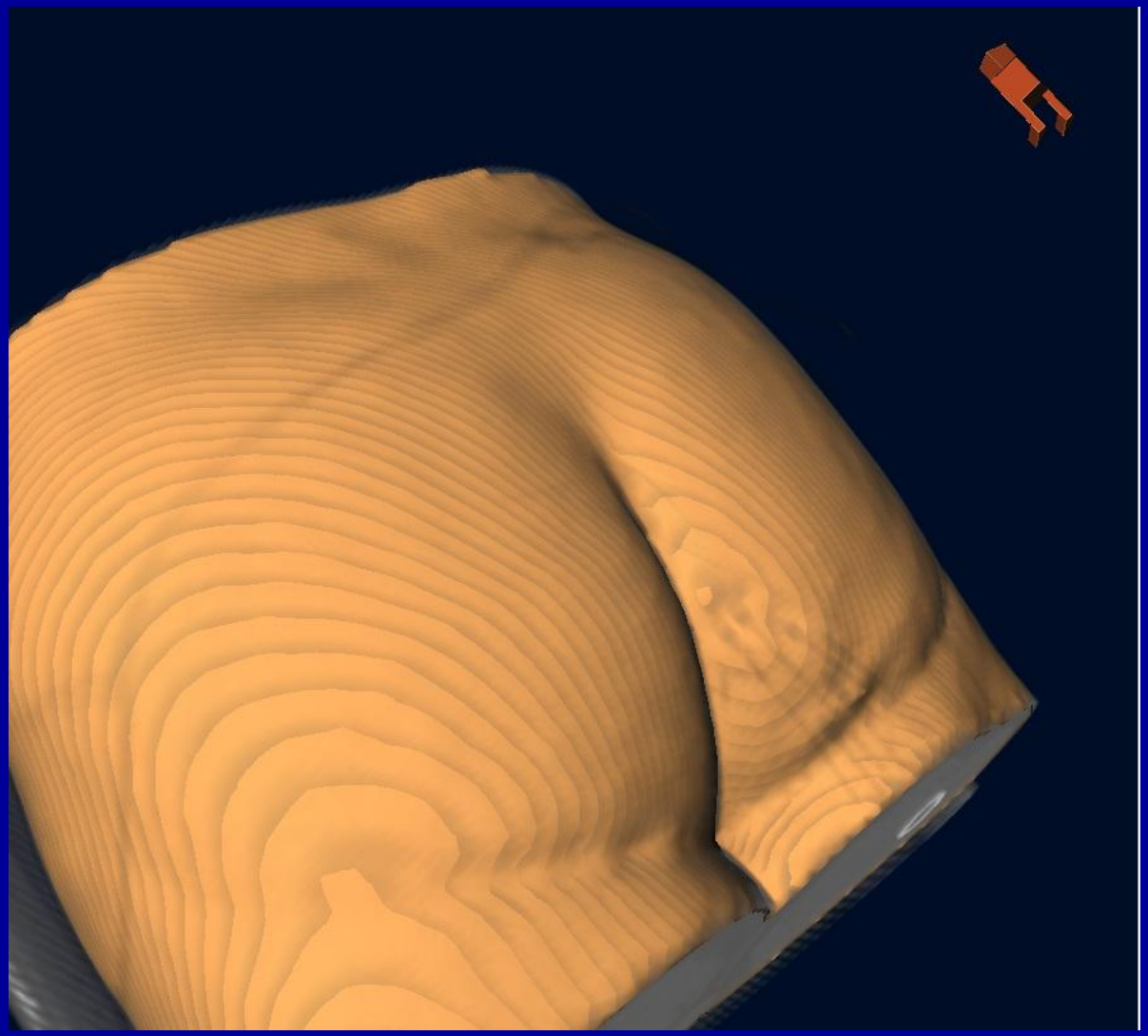
The average curves of the total tumor control probability, P_B (green), total normal tissue complication probability, P_I (red) and complication-free tumor control probability, P_+ (black) are presented for the three series of HDR treatment plans, namely 1: after implantation (clinical acquisition) (solid), 2: just before starting the treatment execution (pre-irradiation acquisition) (dashed) and 3: just after finishing the treatment delivery (post-irradiation acquisition) (dotted-dashed), regarding different prescription doses. The solid and dashed vertical lines indicate the radiobiological dose levels of the clinically prescribed dose distributions, respectively. Here, the total dose of 34.5 Gy delivered by three fractions of 11.5 Gy is considered to be the total prescription dose (100%).

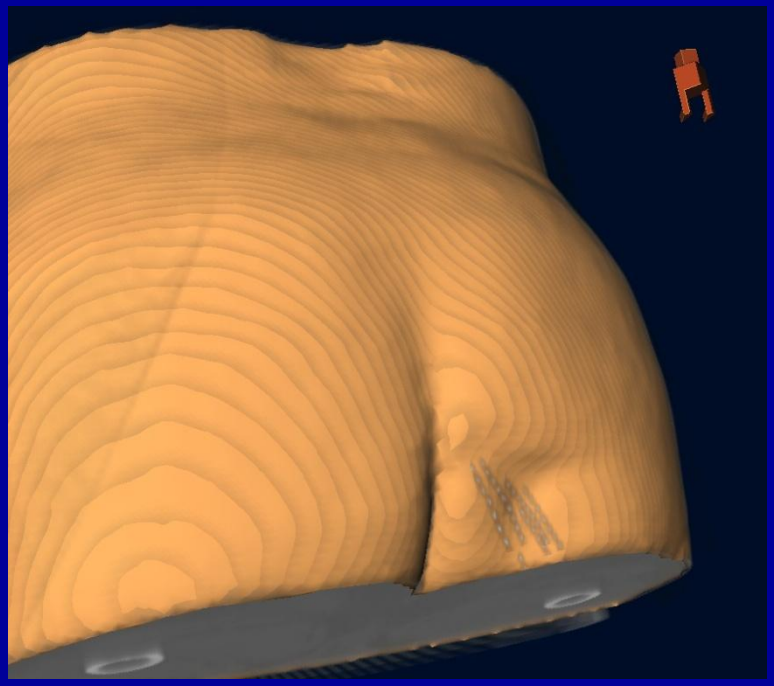
Influence of the Catheter Movement and Anatomy Alteration VERIFICATION

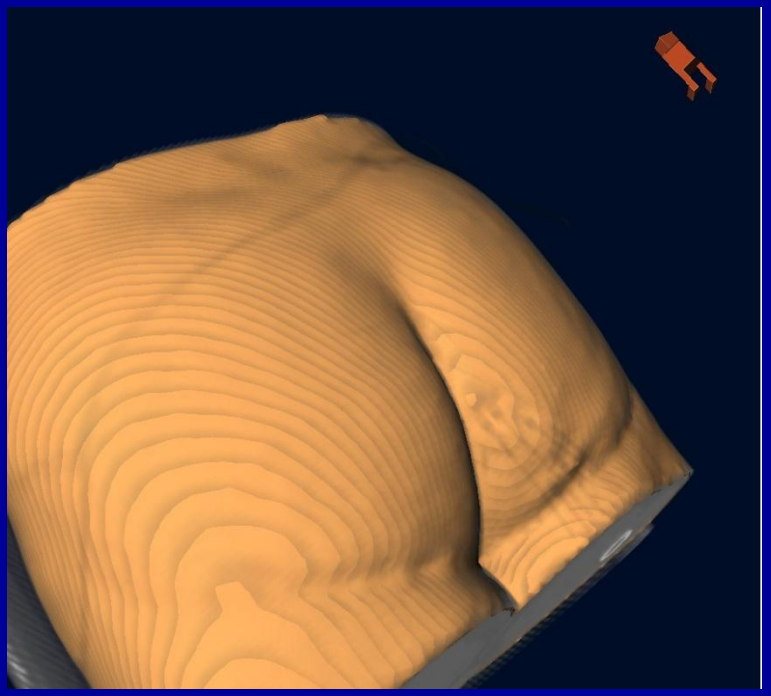


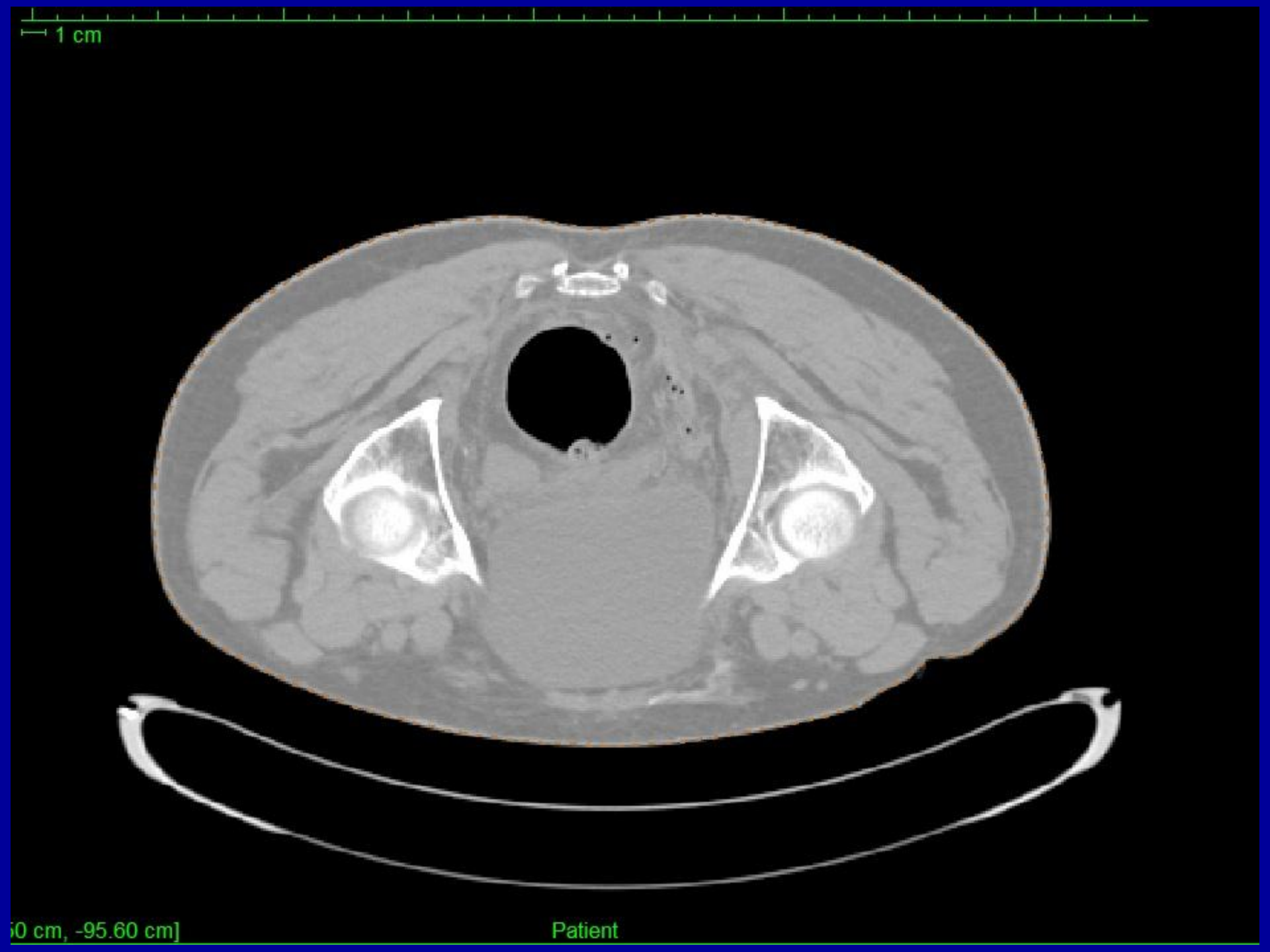

1 cm
Patient

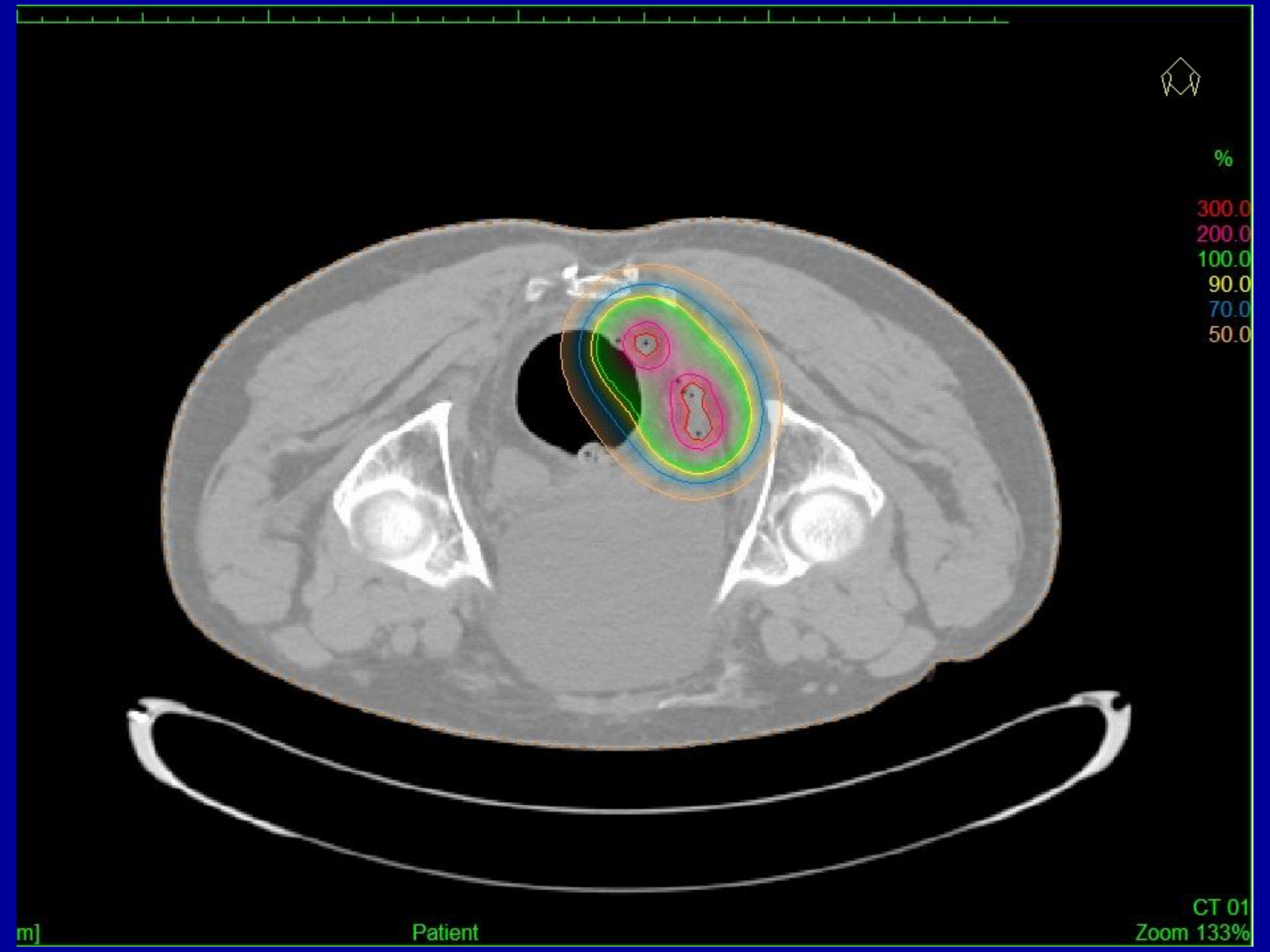

cm
%
300.0
200.0
100.0
90.0
70.0
50.0
CT 01
57/93
-91.50 cm
Zoom 148%
Patient

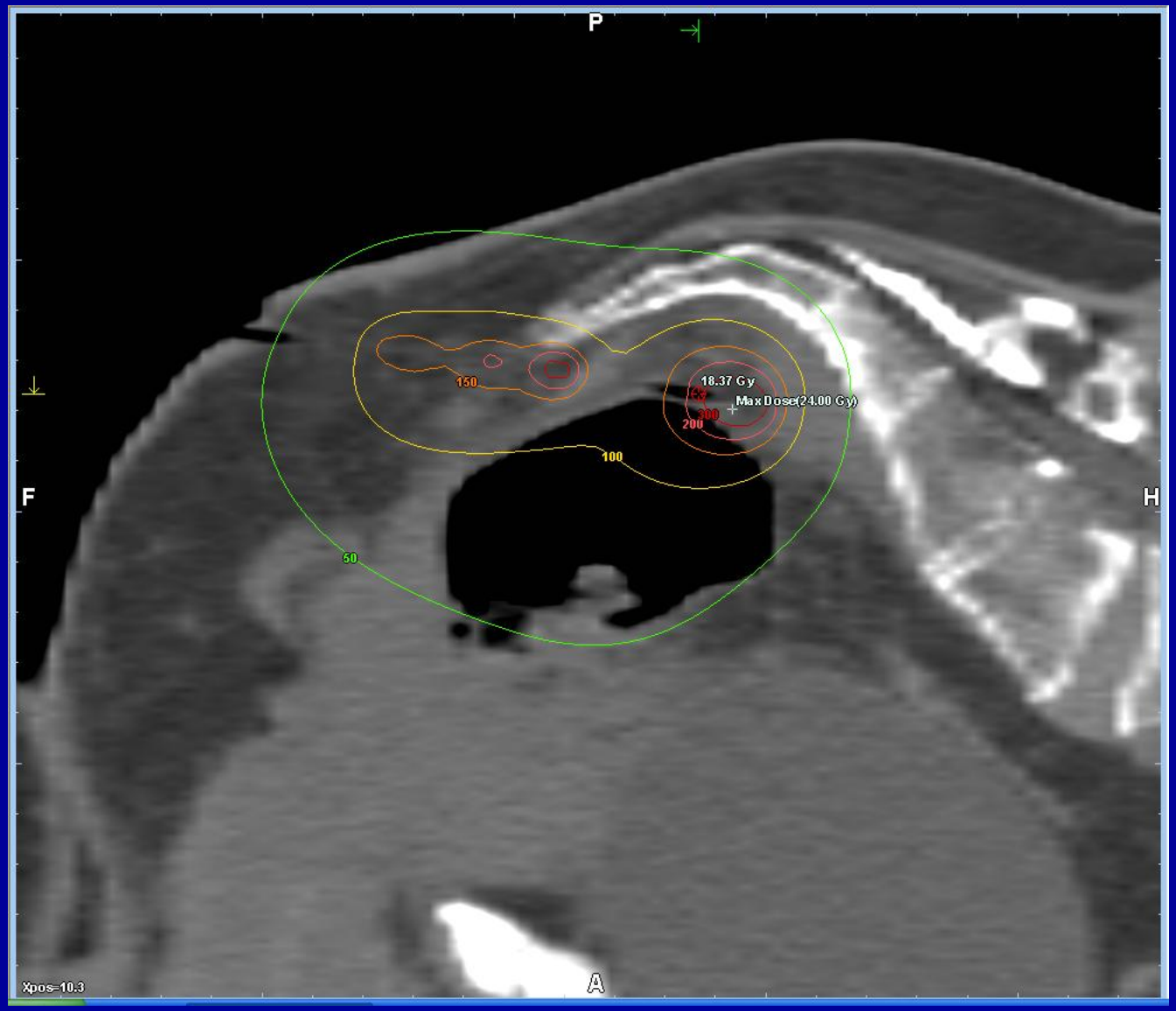


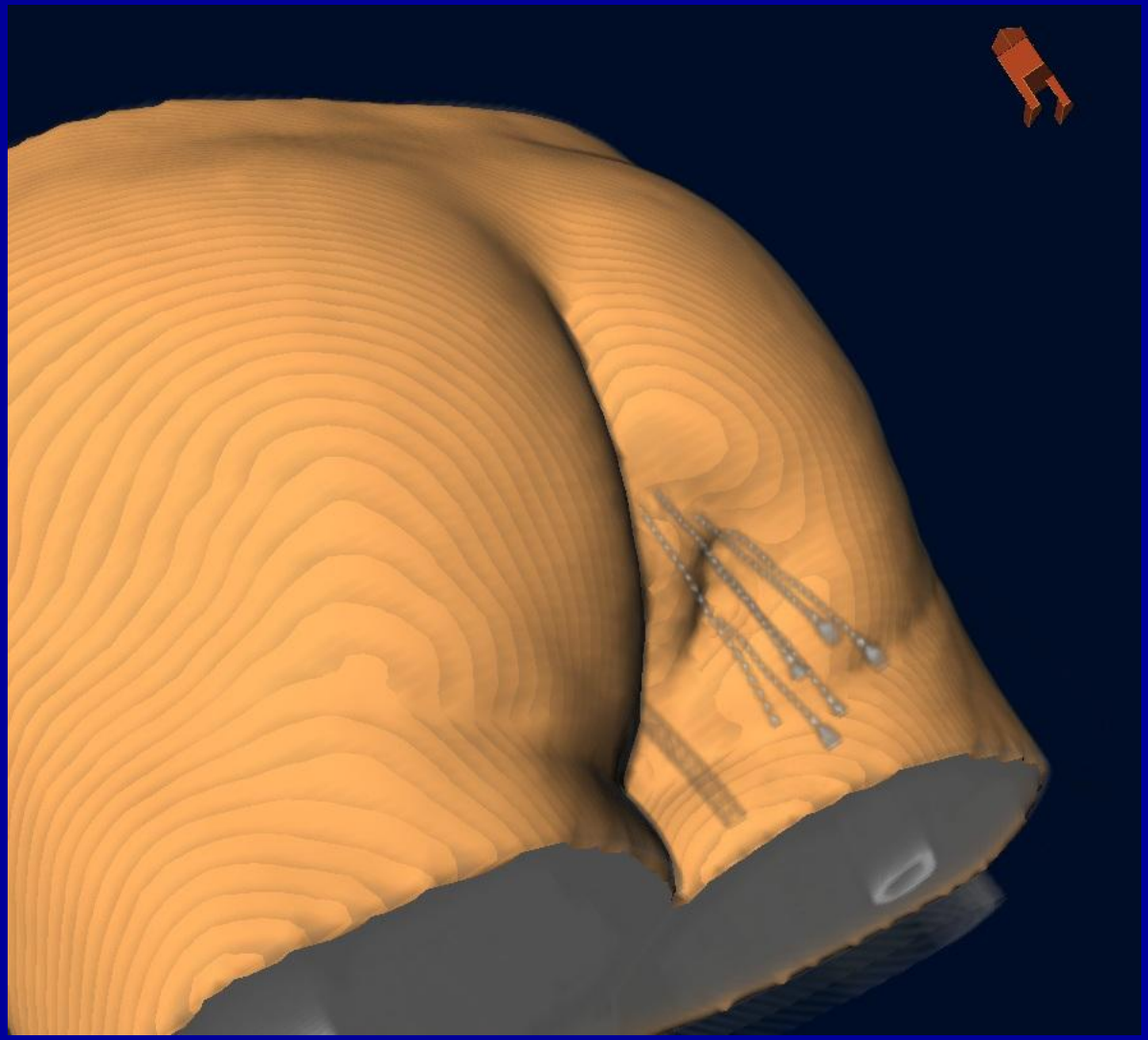


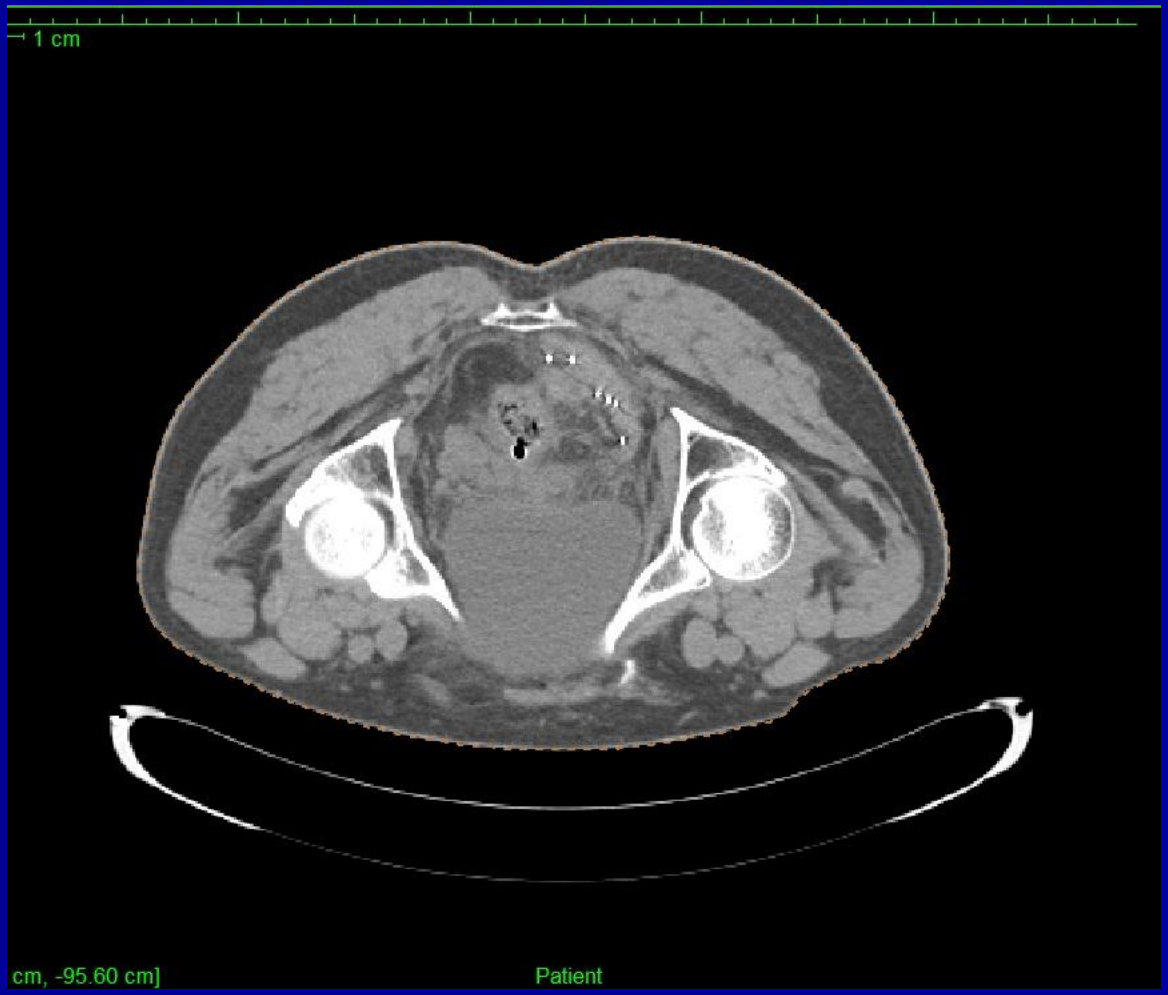


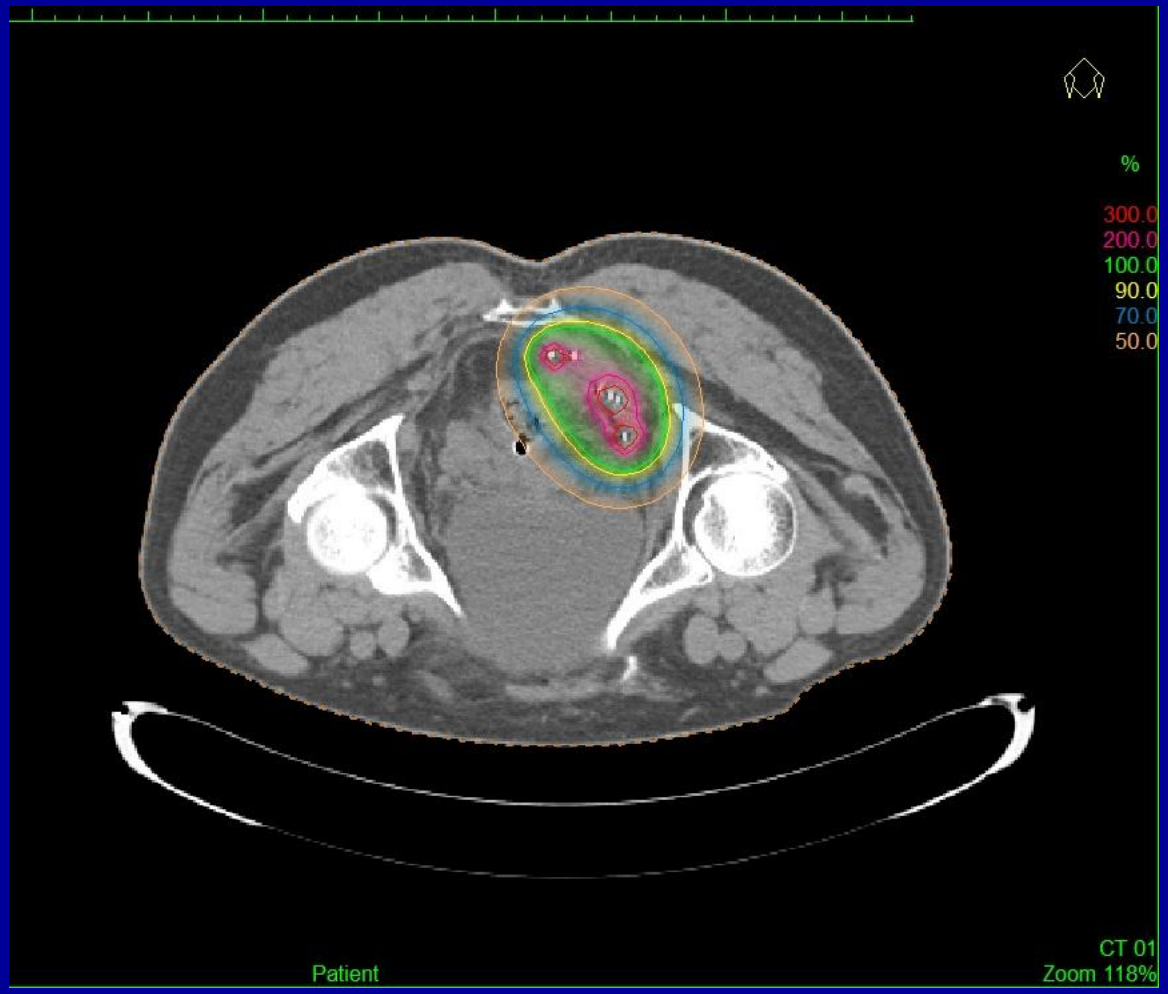

1 cm
0 cm, -95.60 cm]
Patient


%
300.0
200.0
100.0
90.0
70.0
50.0
CT 01
Zoom 133%
m]
Patient


P
F
H
A
150
18.37 Gy
Max Dose(24.00 Gy)
200
100
50
Xpos=10.3



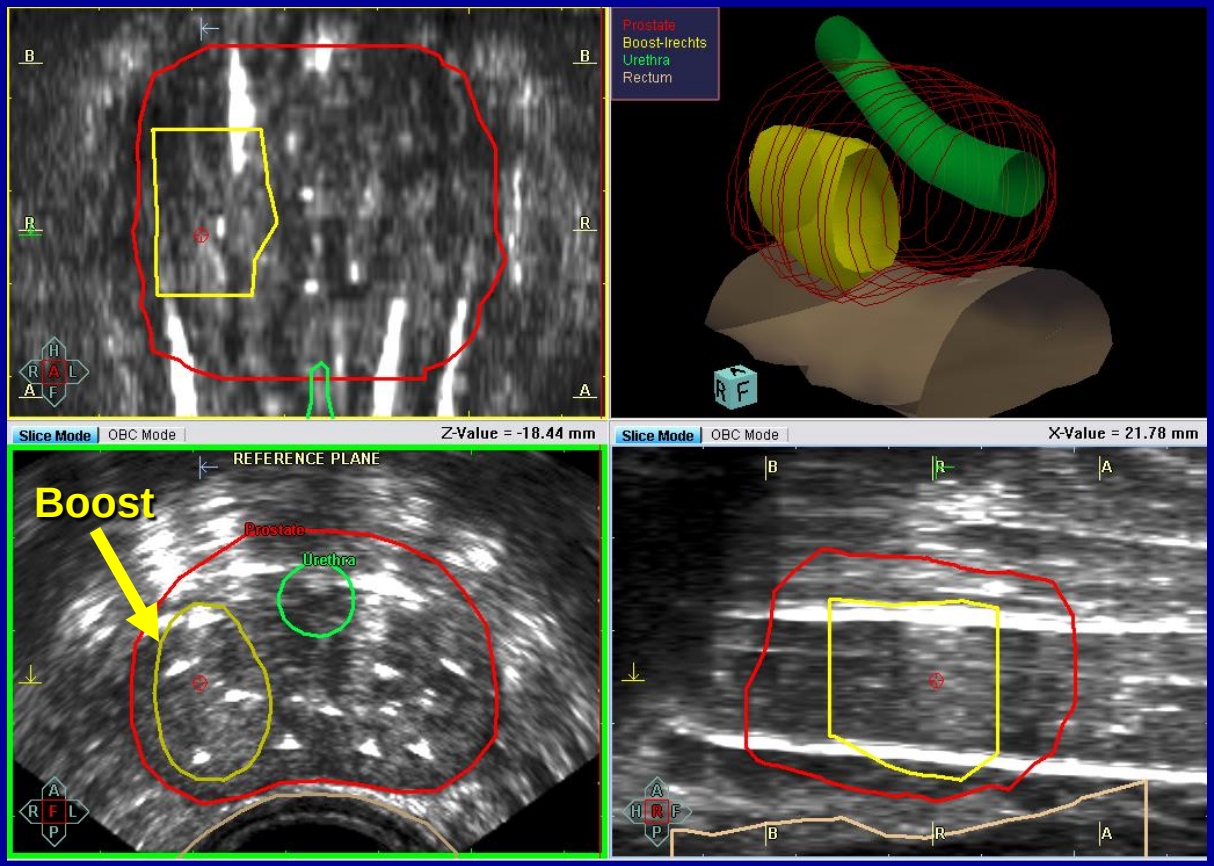

1 cm
cm, -95.60 cm]
Patient

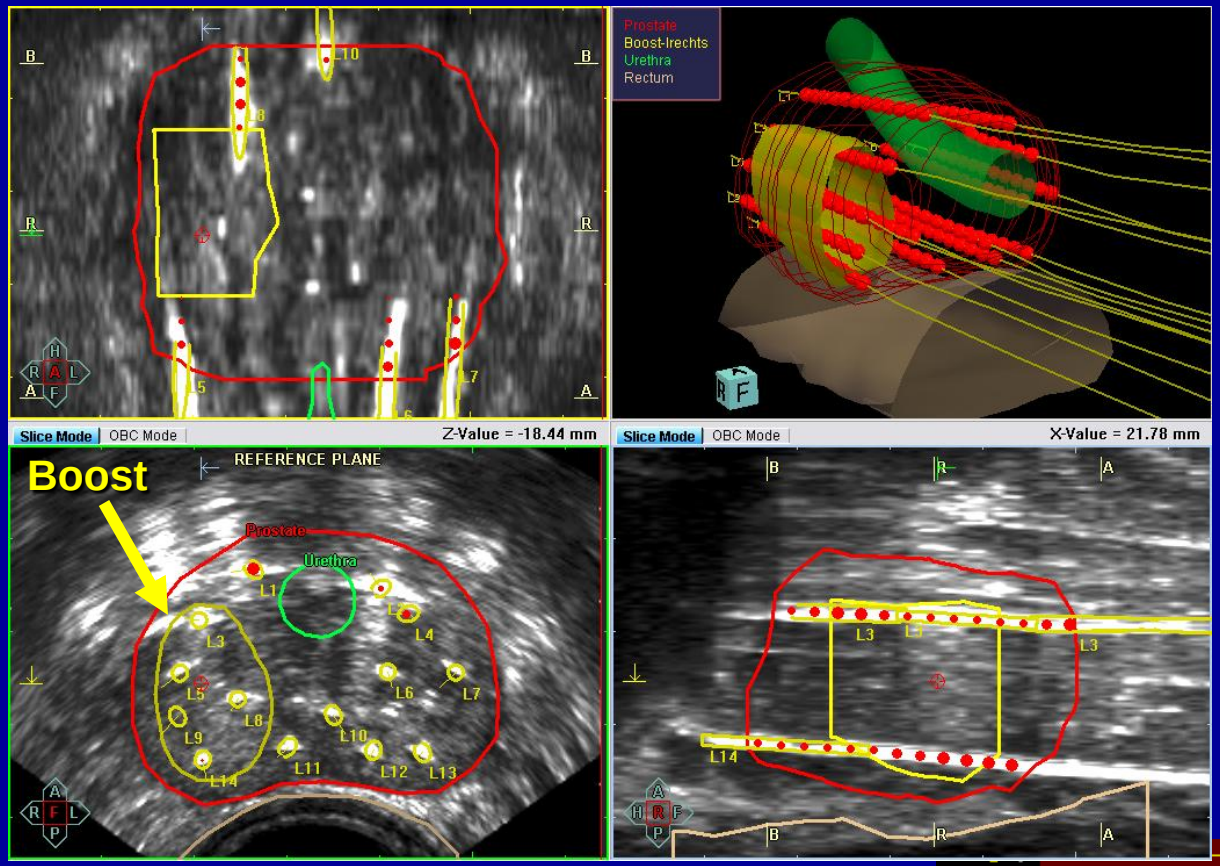

%
300.0
200.0
100.0
90.0
70.0
50.0
Patient
CT 01
Zoom 118%

The Era of Adaptive Brachytherapy

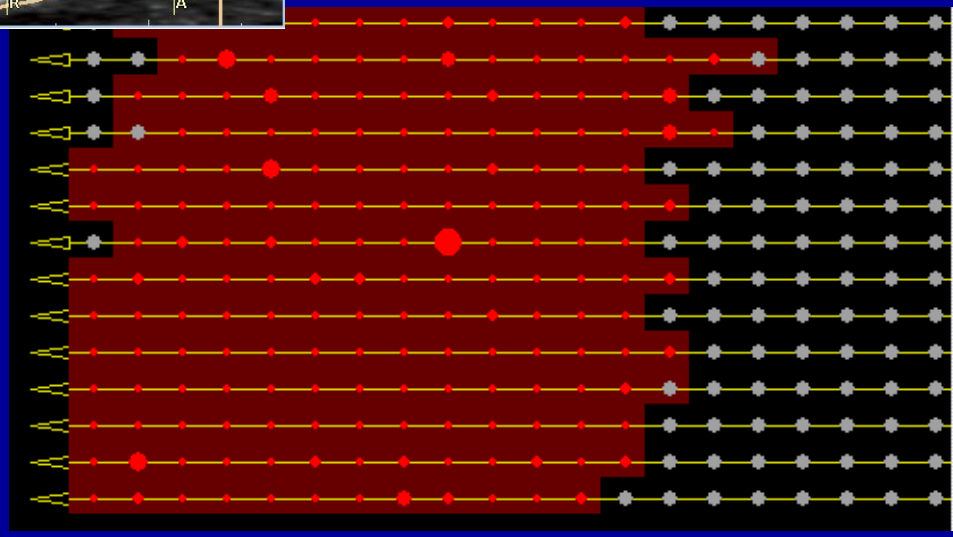
- IGRT (Image Guided..2D)
- VGRT (Volume Guided..3D)
- DGRT (Dose Guided …)
- ART (4D)
- BIG-ART (Biological …)

Boost
Definition



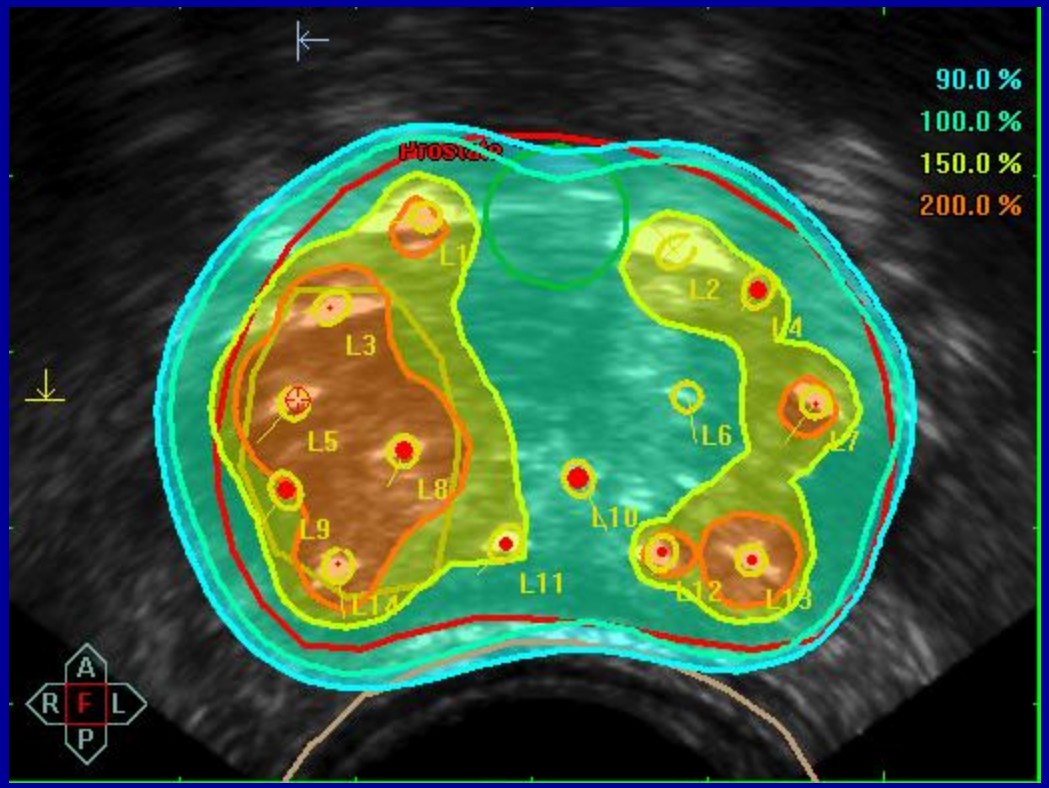


Dwell Position

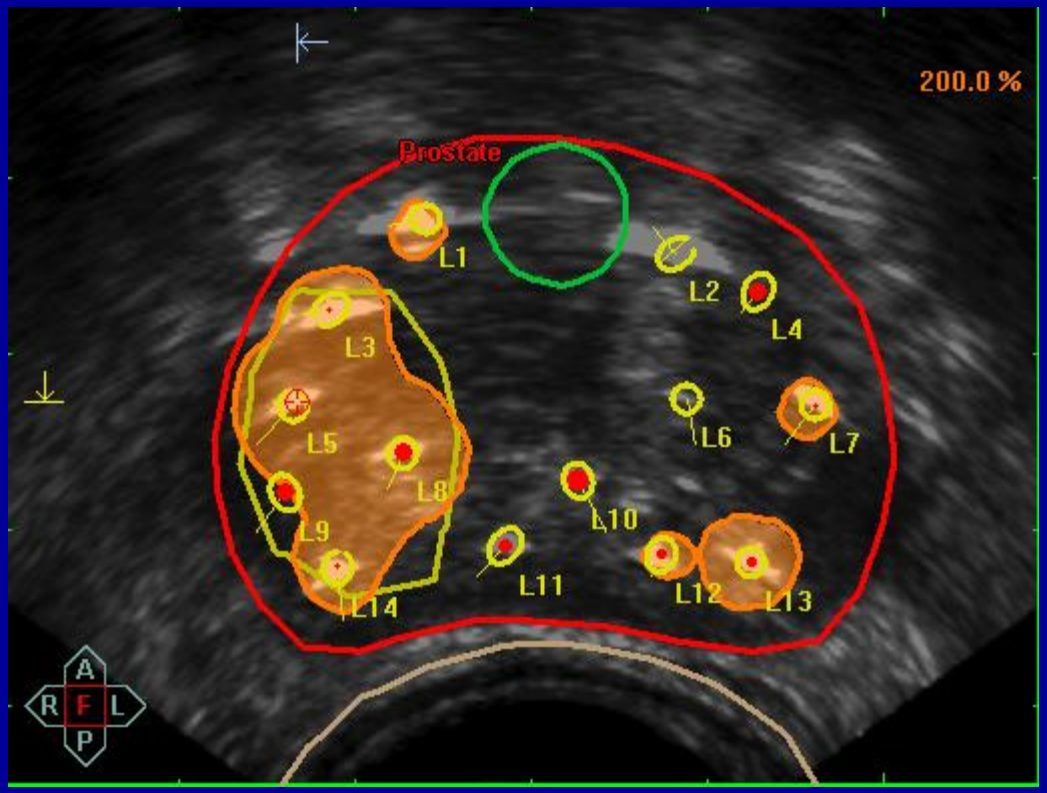


Duration of Loading

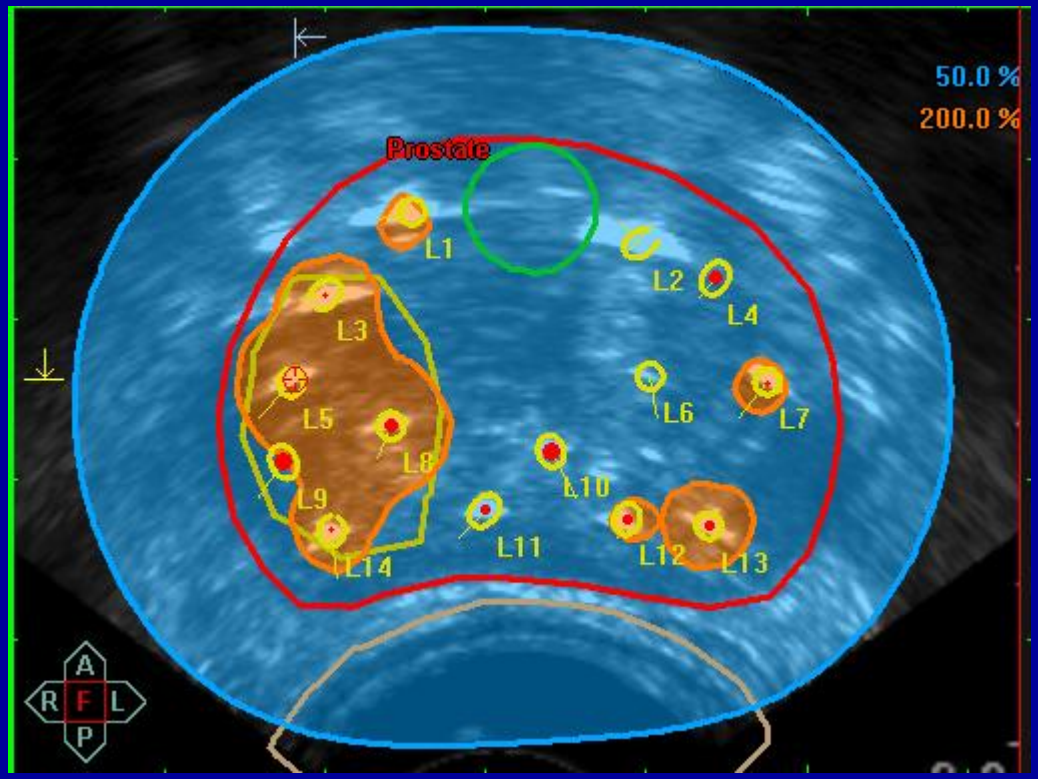
Dose Painting



200% - ISODOSE


200.0 %
Prostate
L1
L2
L3
L4
L5
L6
L7
L8
L9
L10
L11
L12
L13
L14
A
R
F
L
P

50% - ISODOSE


50.0 %
200.0 %
Prostate
L1
L2
L3
L4
L5
L6
L7
L8
L9
L10
L11
L12
L13
L14
A
R
F
L
P

Quo vadis

- Elite
- Representation
- Support
- Education
- Reimpursement

Quo vadis ?

Iridium Knife

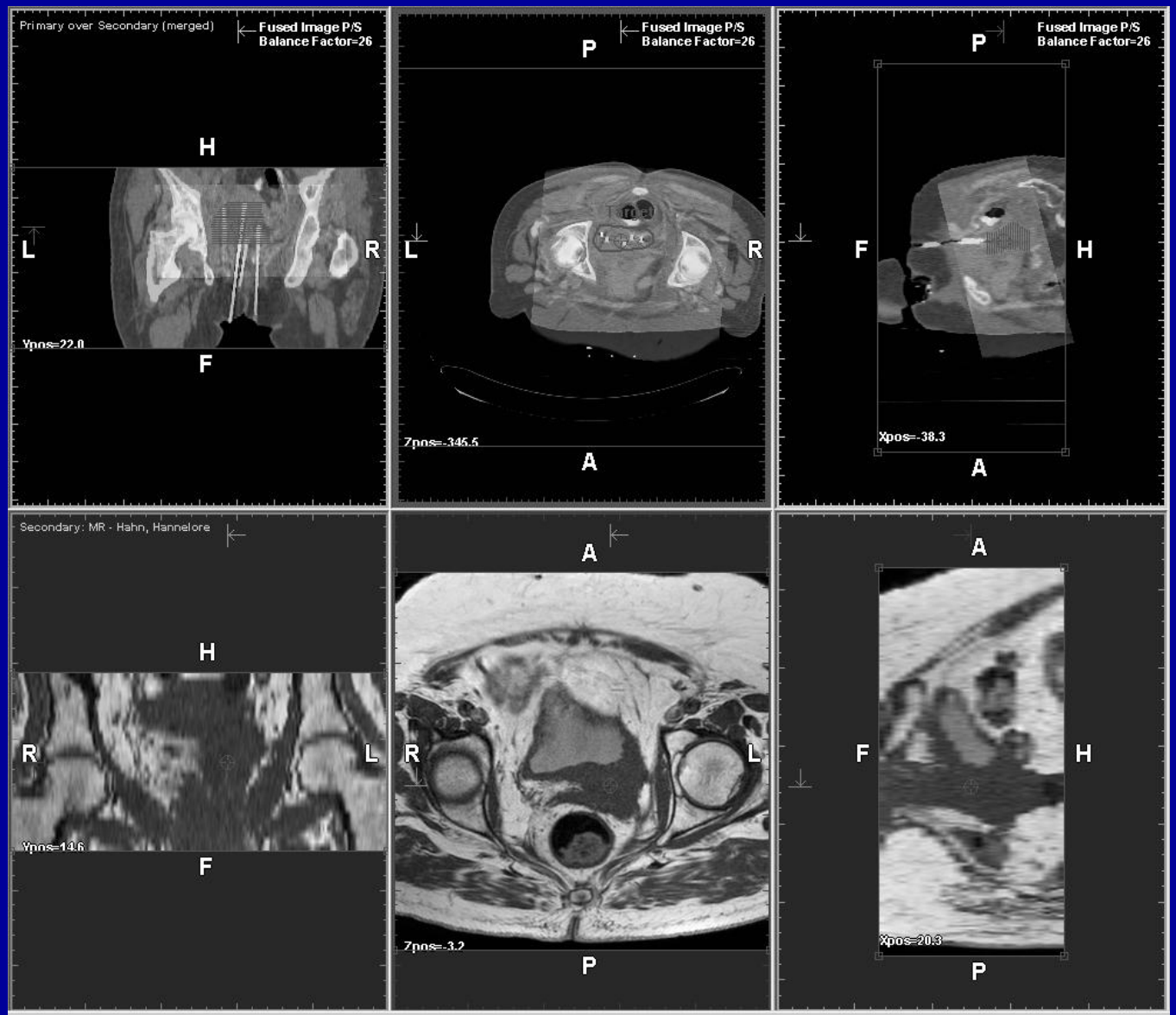
Curative Setting

- Cervix Carcinoma

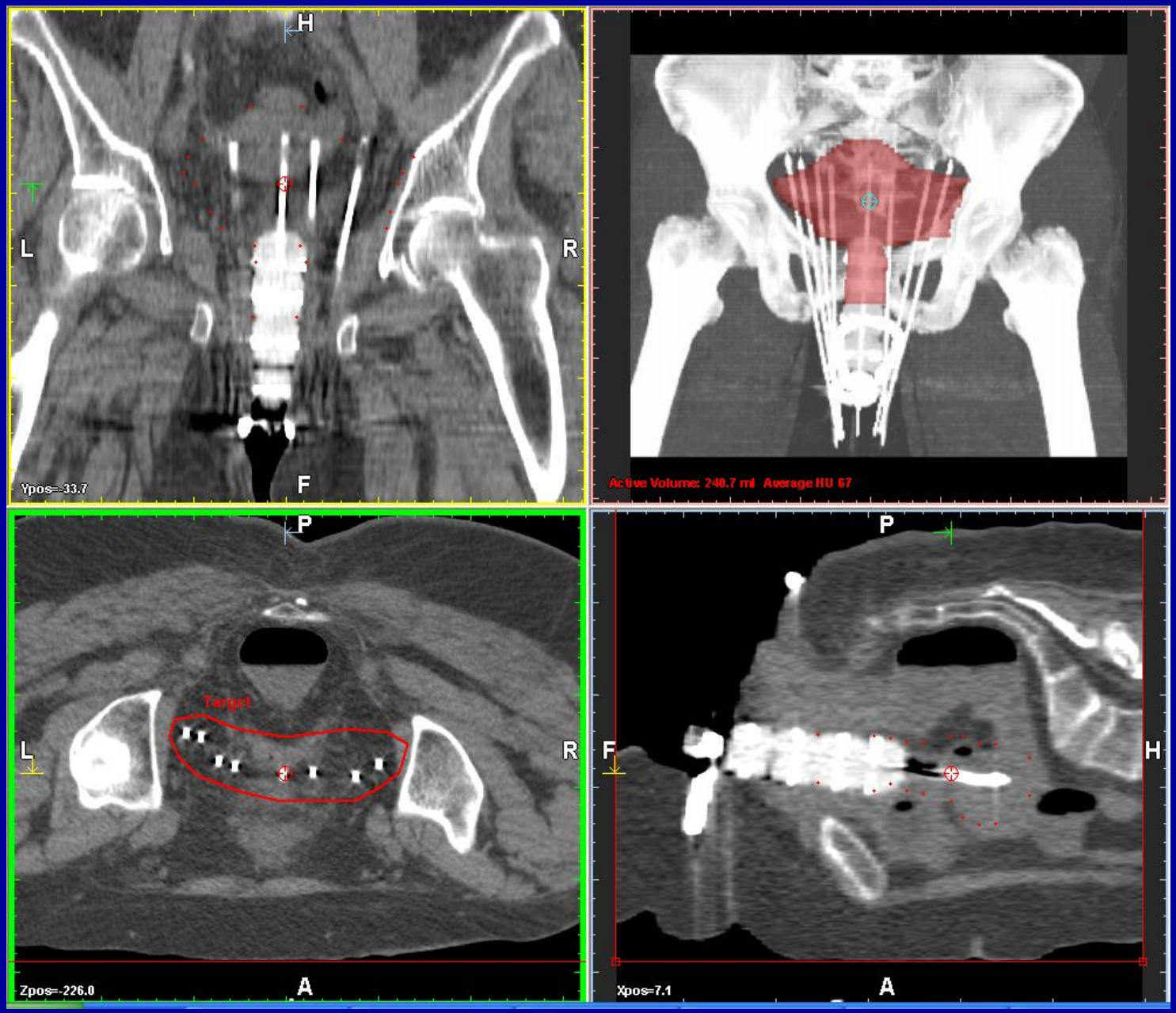
Fusion CT – MRI (Prone)

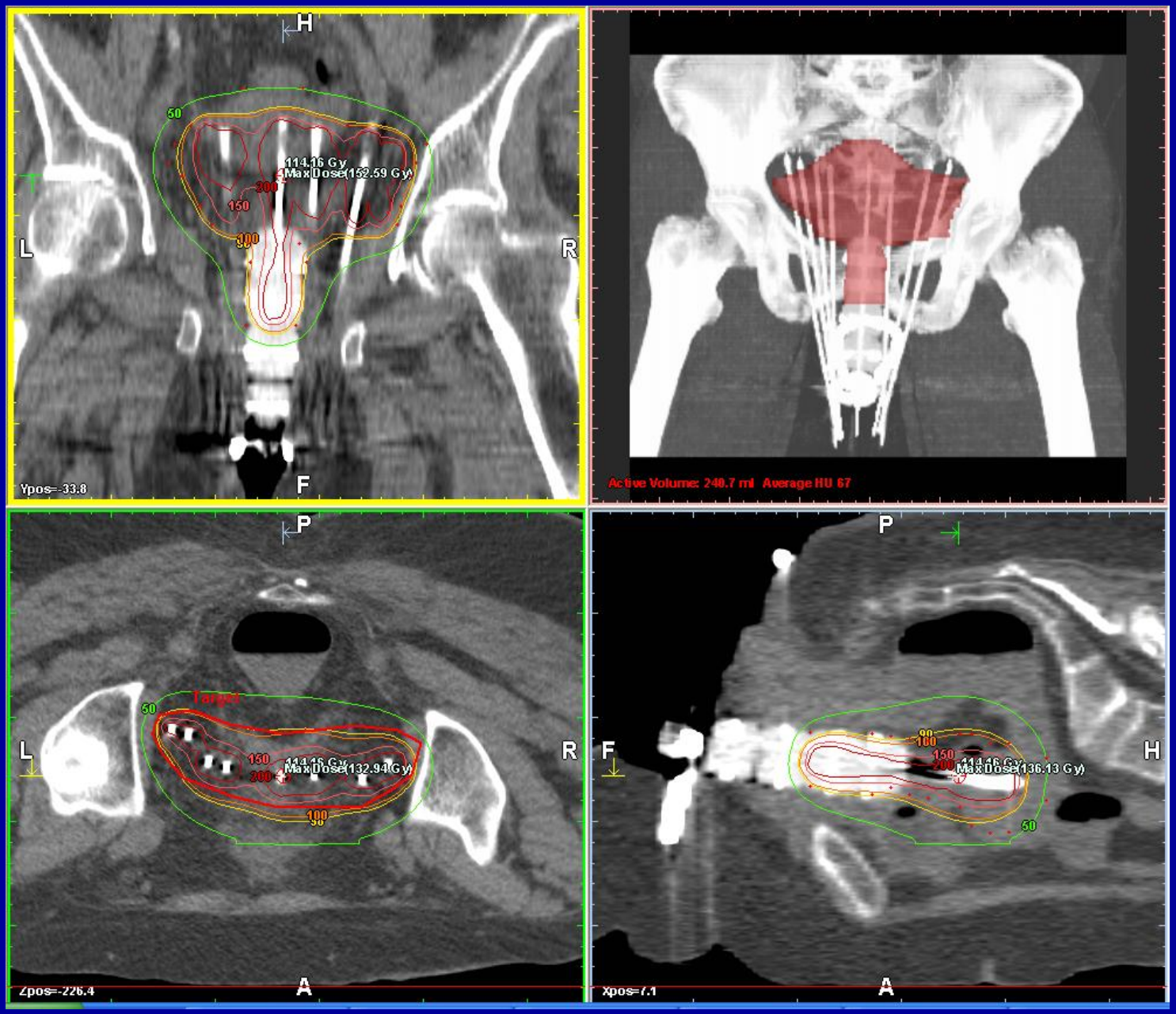
Post-Implant

Pre-Implant (Supine)



Fusion CT – MRI (Prone)


H
L
R
F
Ypos=-33.7
Active Volume: 240.7 ml Average HU 67
P
Target
L
R
A
Zpos=-226.0
P
F
H
A
Xpos=7.1


H
L
R
F
50
114.16 Gy
Max Dose(152.59 Gy)
200
150
100
Ypos=-33.8
Active Volume: 240.7 ml Average HU 67
P
L
R
A
Target
50
150
200
100
Max Dose(132.94 Gy)
Zpos=-226.4
P
F
H
A
90
100
150
200
Max Dose(136.13 Gy)
50
Xpos=7.1

Curative Setting

- Cervix Carcinoma
- Prostate Cancer

Prostate Cancer

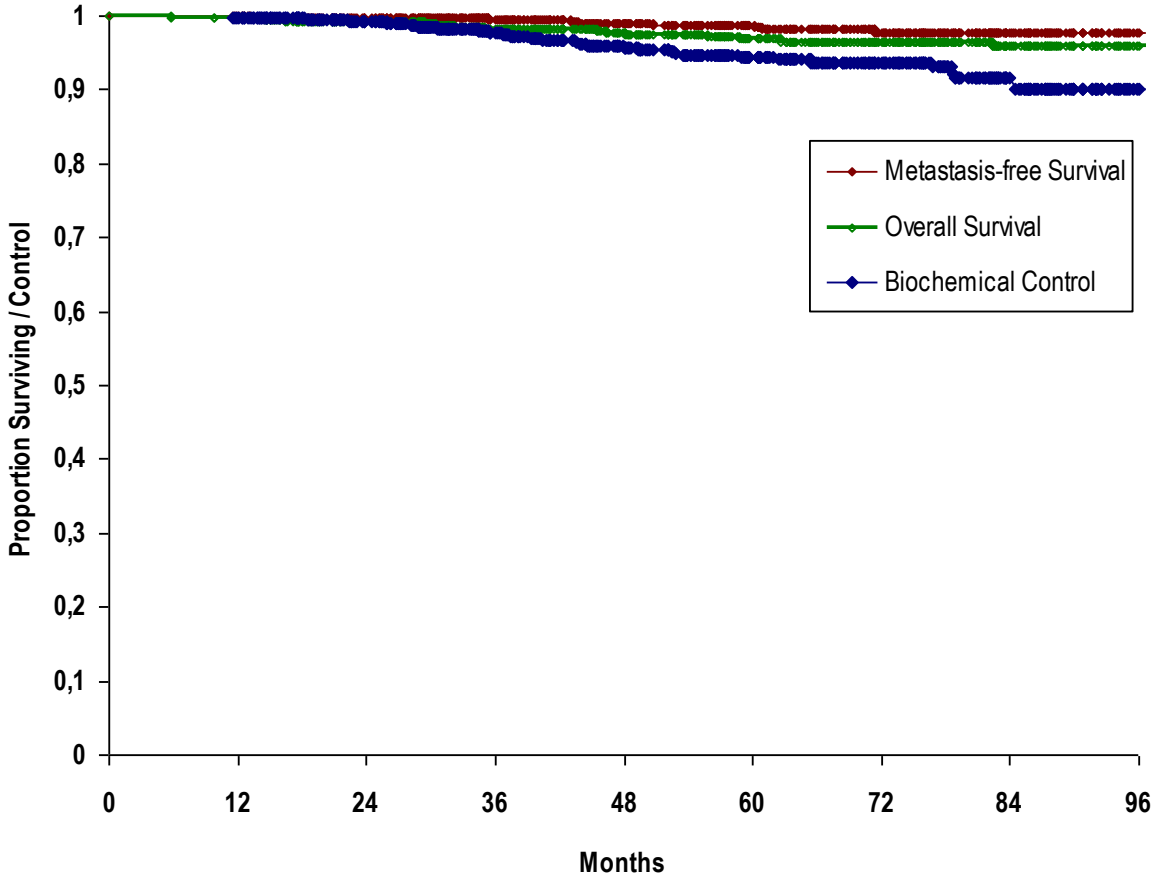
Brachytherapy is the Highest Conformal Treatment in Radiation Oncology

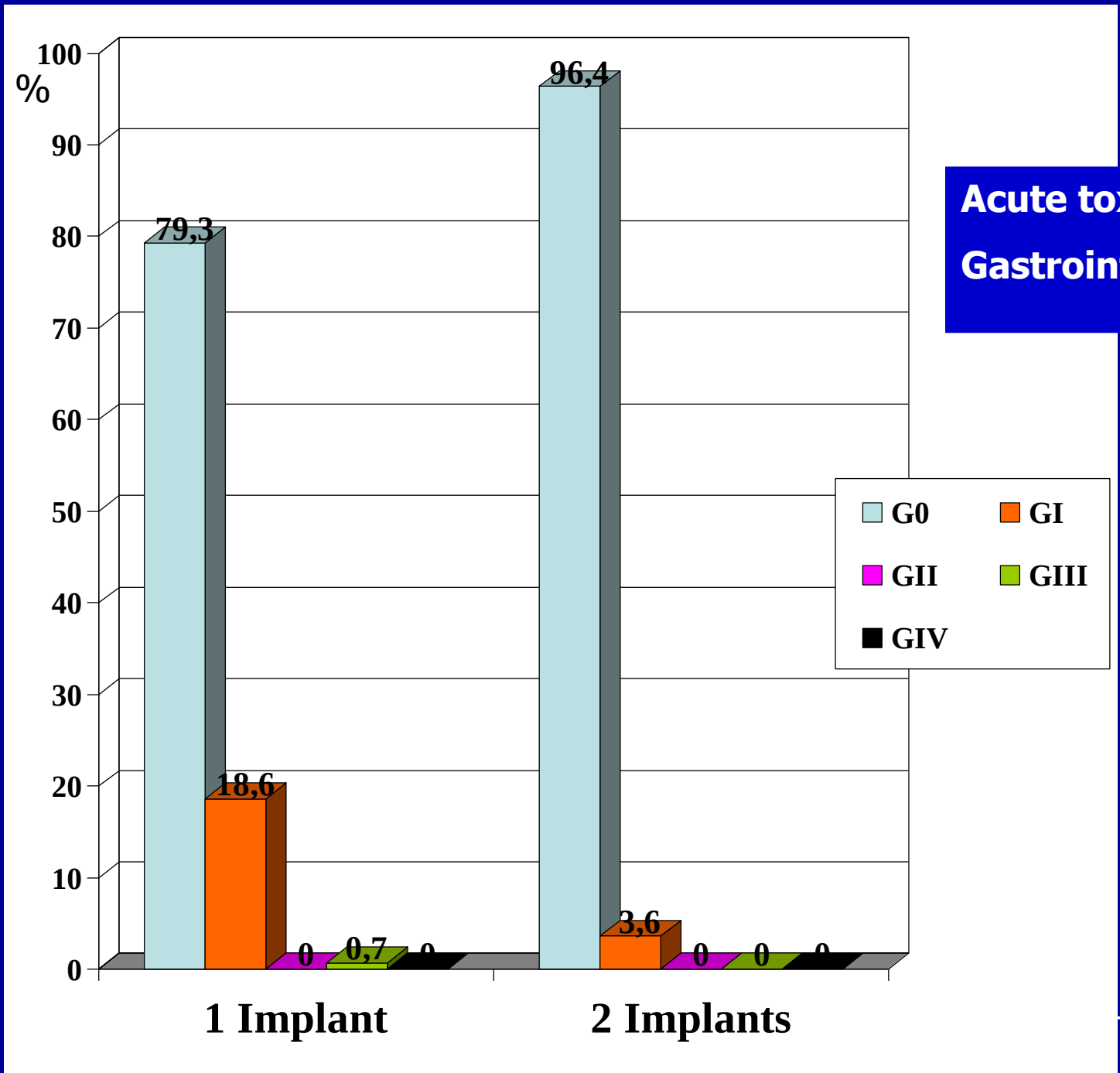
Results

Offenbach Study HDR-Monotherapy

08/1999-10/2010: 718 patients

(Published in IJROBP 2012)


1
0,9
0,8
0,7
0,6
0,5
0,4
0,3
0,2
0,1
0
Proportion Surviving / Control
0
12
24
36
48
60
72
84
96
Months
Metastasis-free Survival
Overall Survival
Biochemical Control

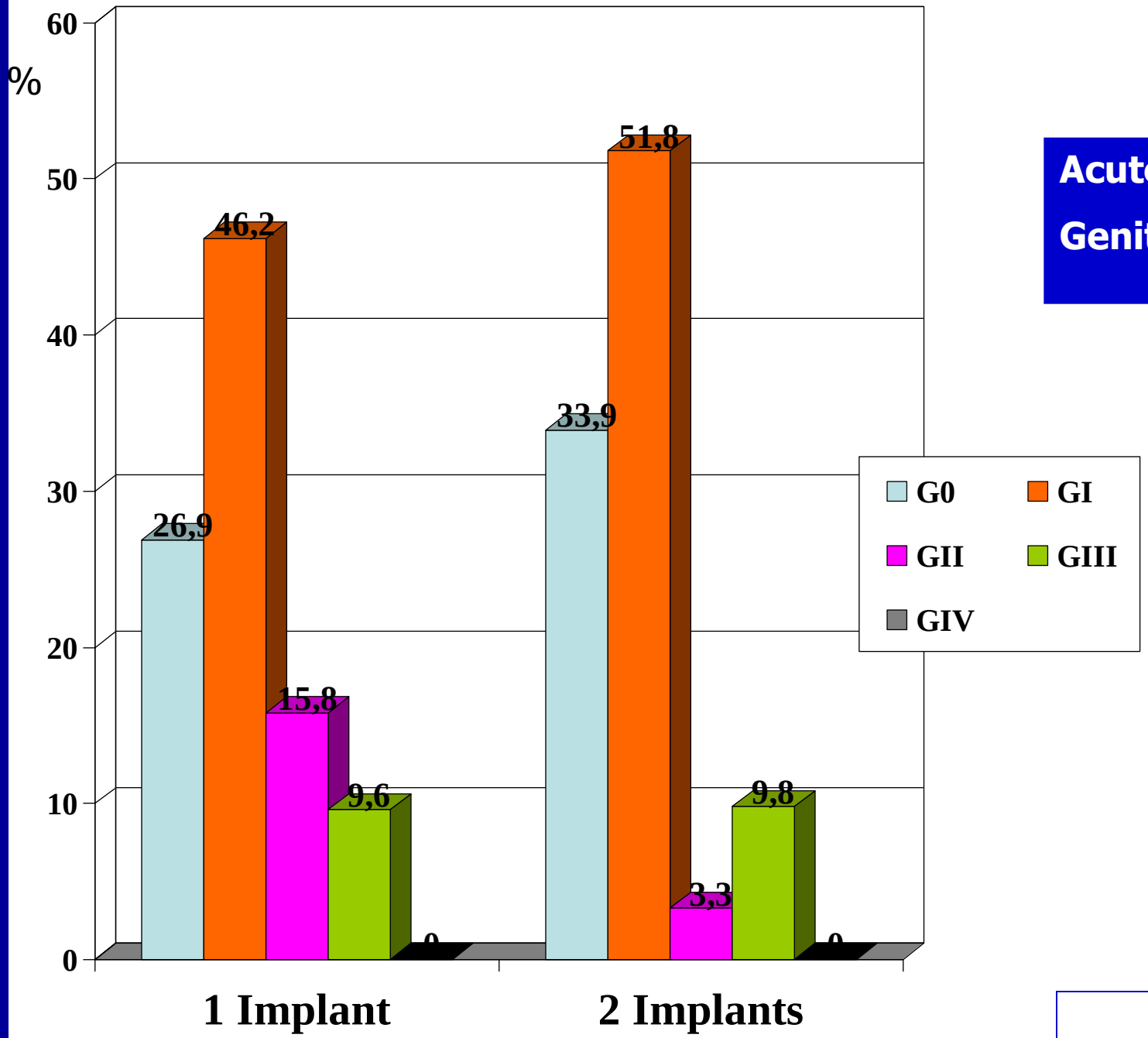


Acute toxicity

Gastrointestinal

TC vers. 3.0

Acute toxicity
Genitourinary



HDR-Monotherapy: Chronic Toxicity

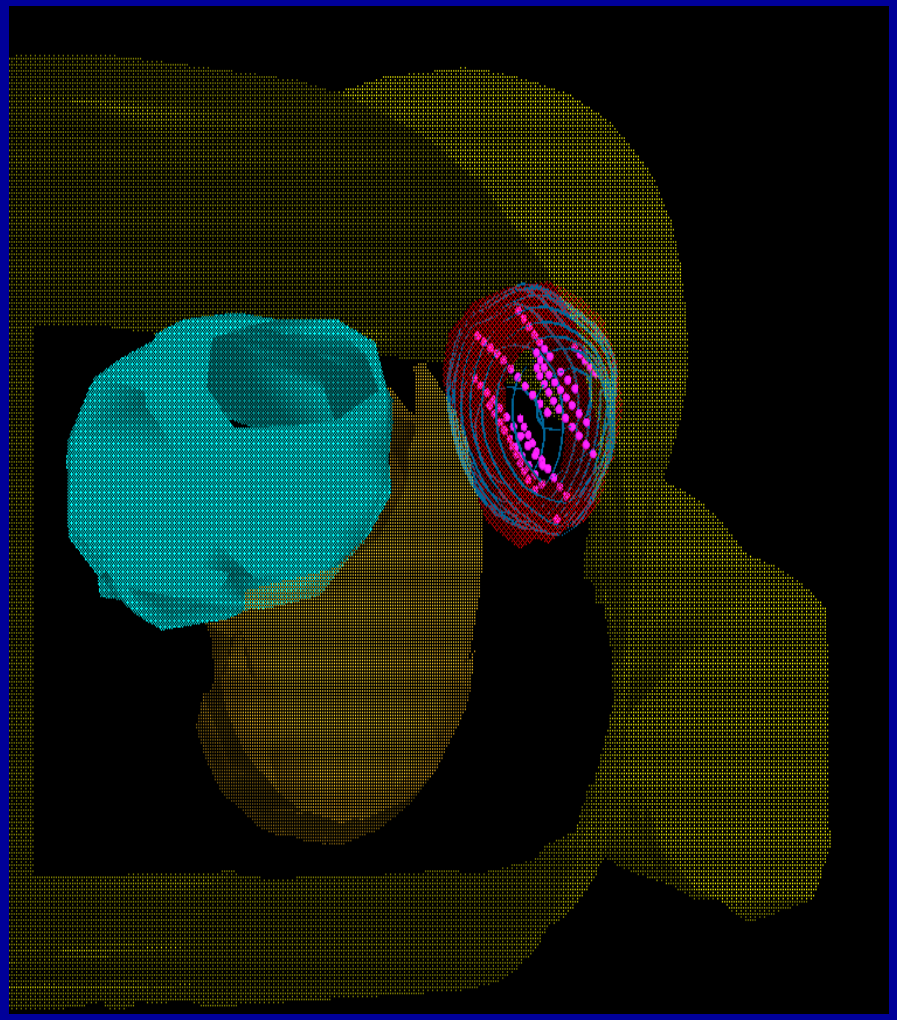
After median 52 months

85,0 %	Grade 0 toxicity
84,0 %	Potency preservation
0,1 %	Incontinence

Curative Setting

- Cervix Carcinoma
- Prostate Cancer
- Breast Cancer

3D Target



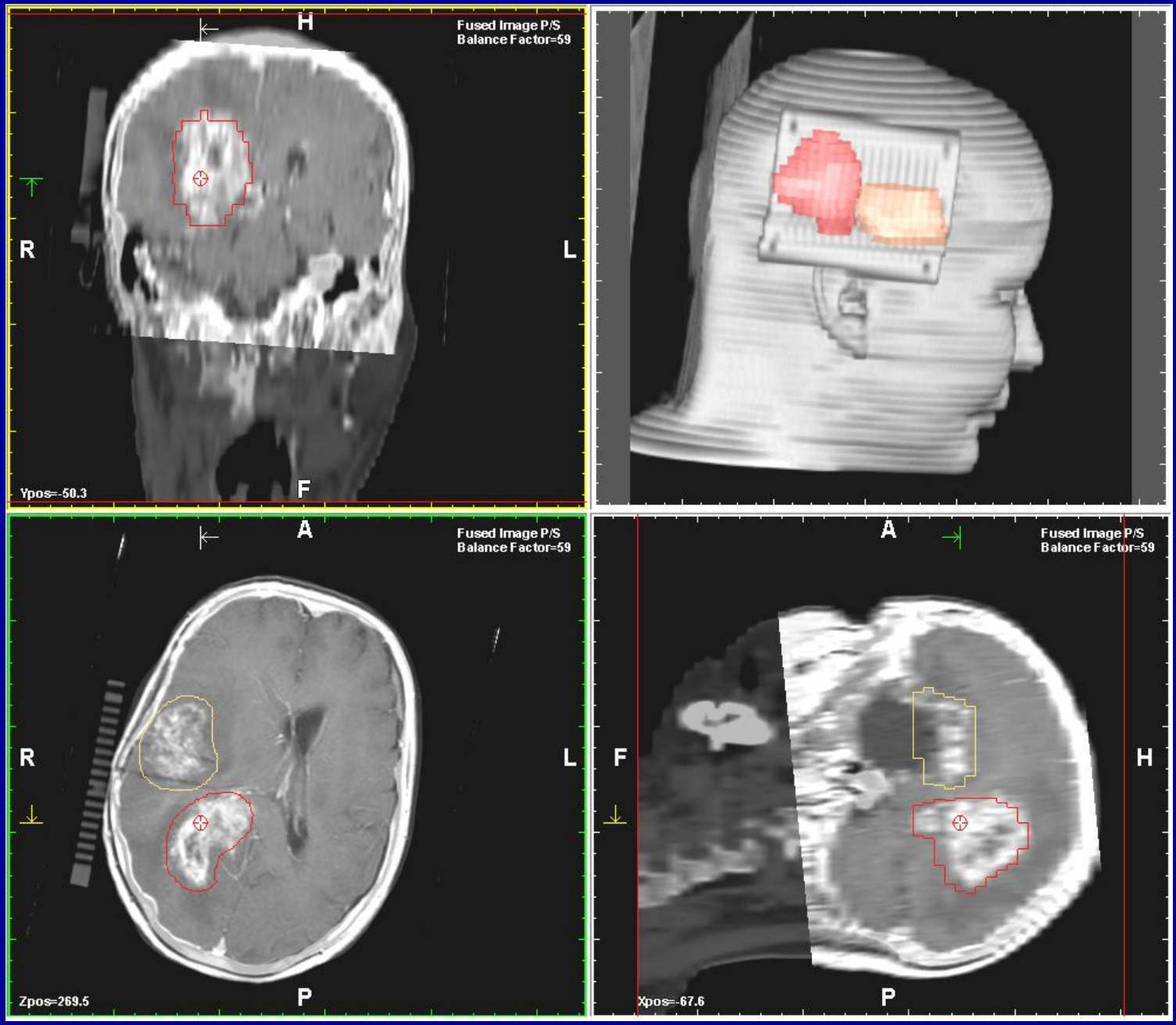
HDR Brachytherapy Palliative Setting

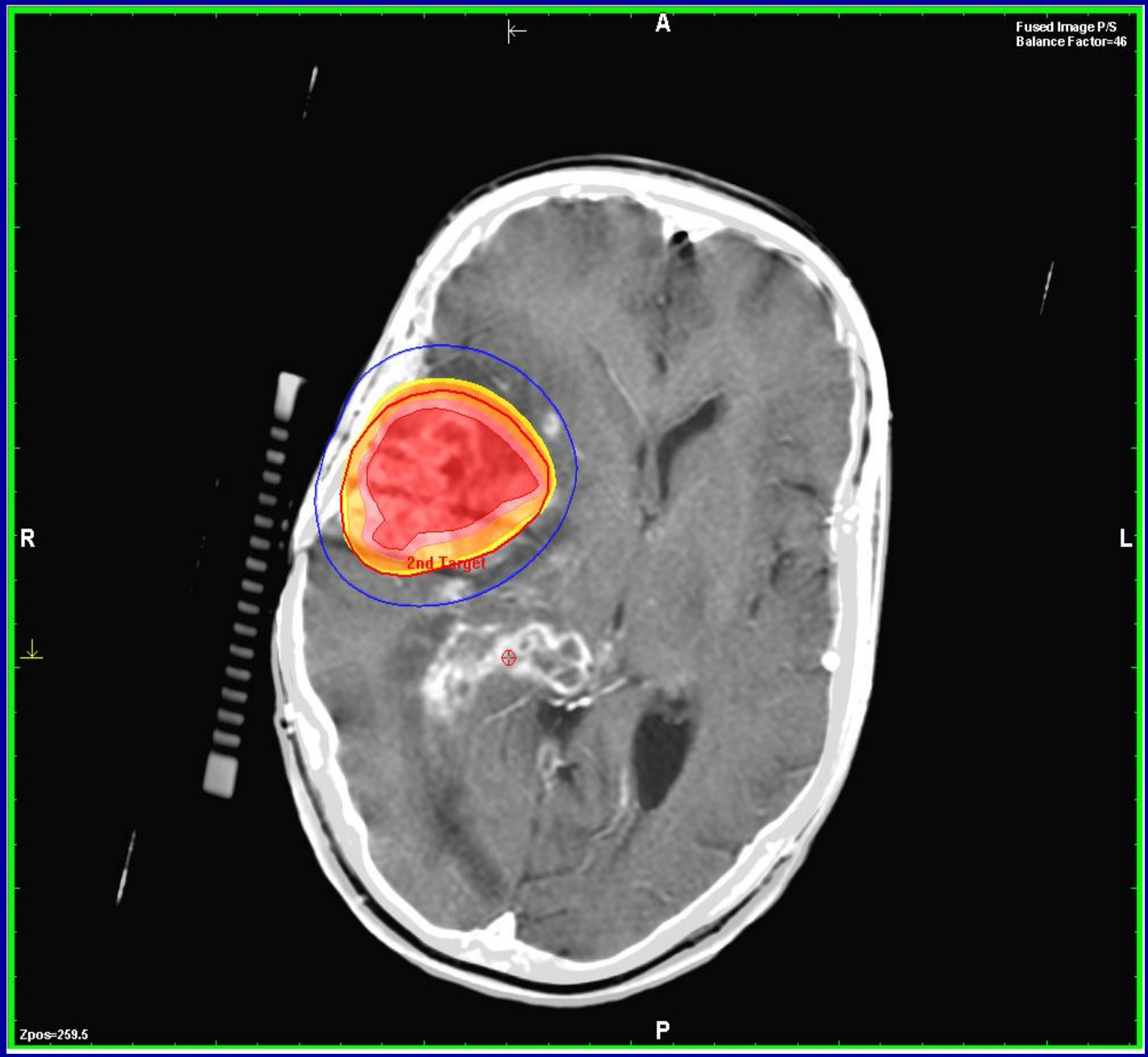
Brain

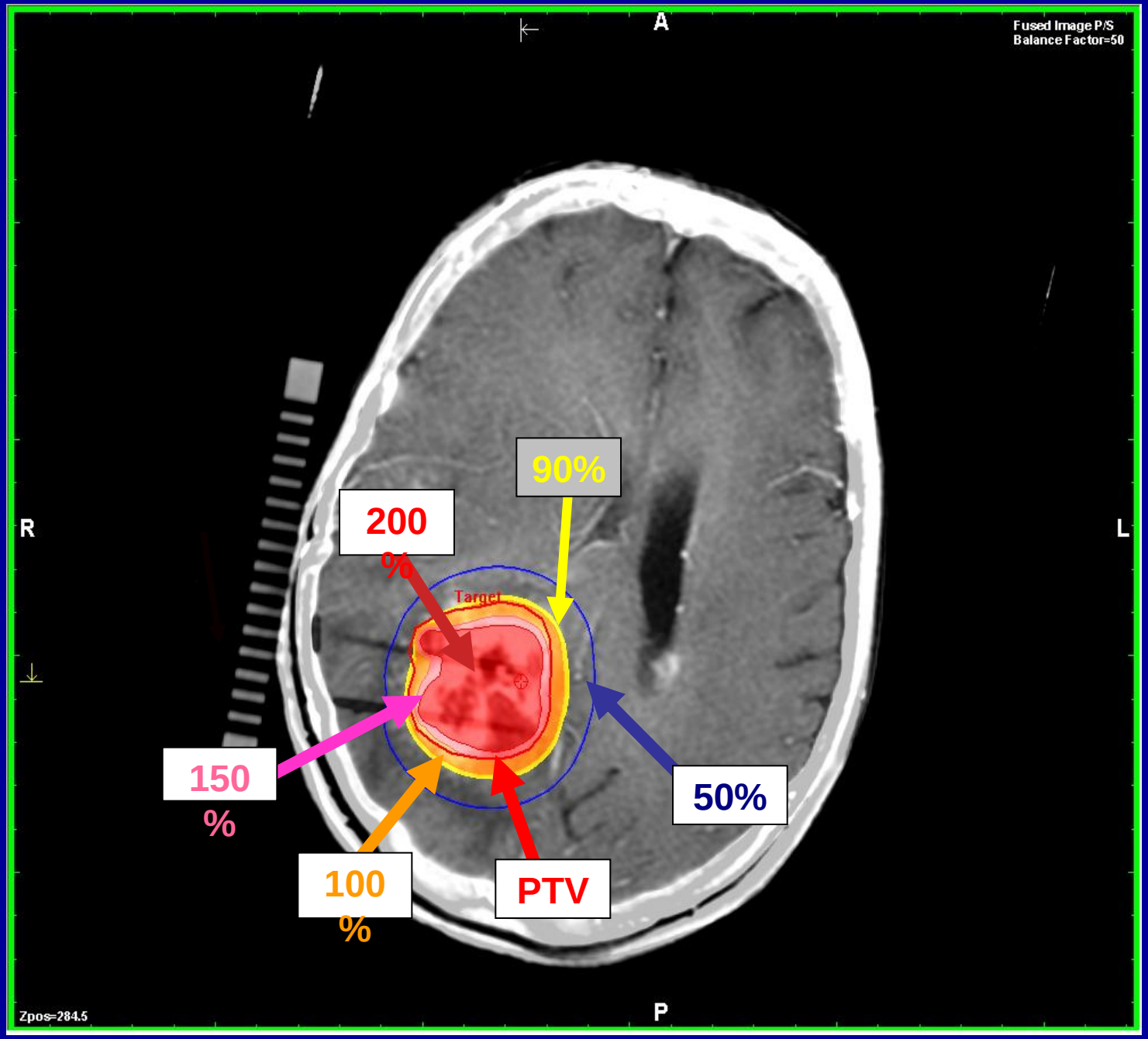
Patient characteristics

1995-2010: 179 patients with recurrent malignant gliomas

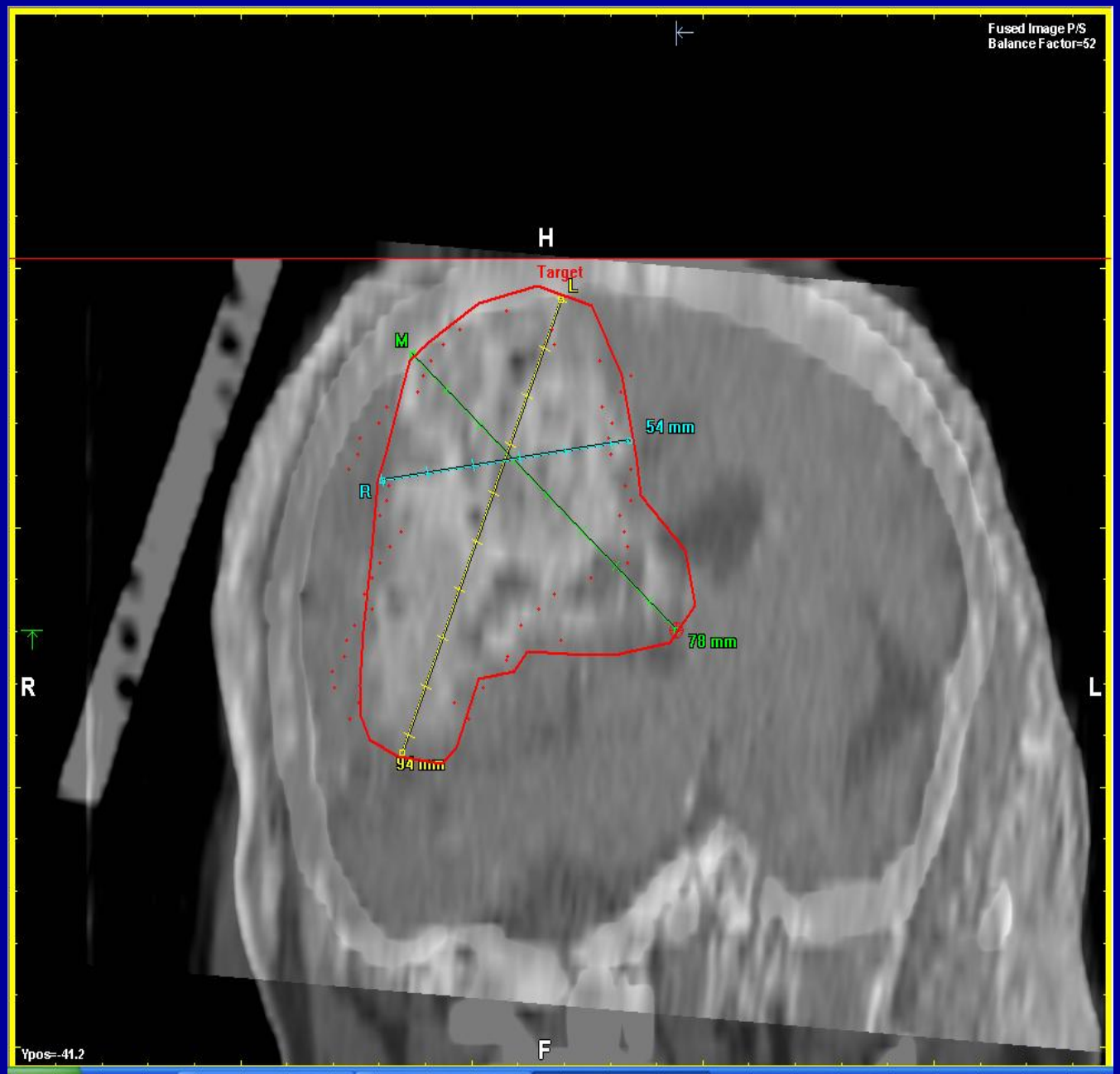
All patients had unresectable recurrent disease after primary surgery with adjuvant EBRT (54-60Gy) and showed progression under palliative chemotherapy


H
Fused Image P/S
Balance Factor=59
R
L
F
Ypos=-50.3
A
Fused Image P/S
Balance Factor=59
R
L
P
Zpos=269.5
A
Fused Image P/S
Balance Factor=59
F
H
P
Xpos=-67.6

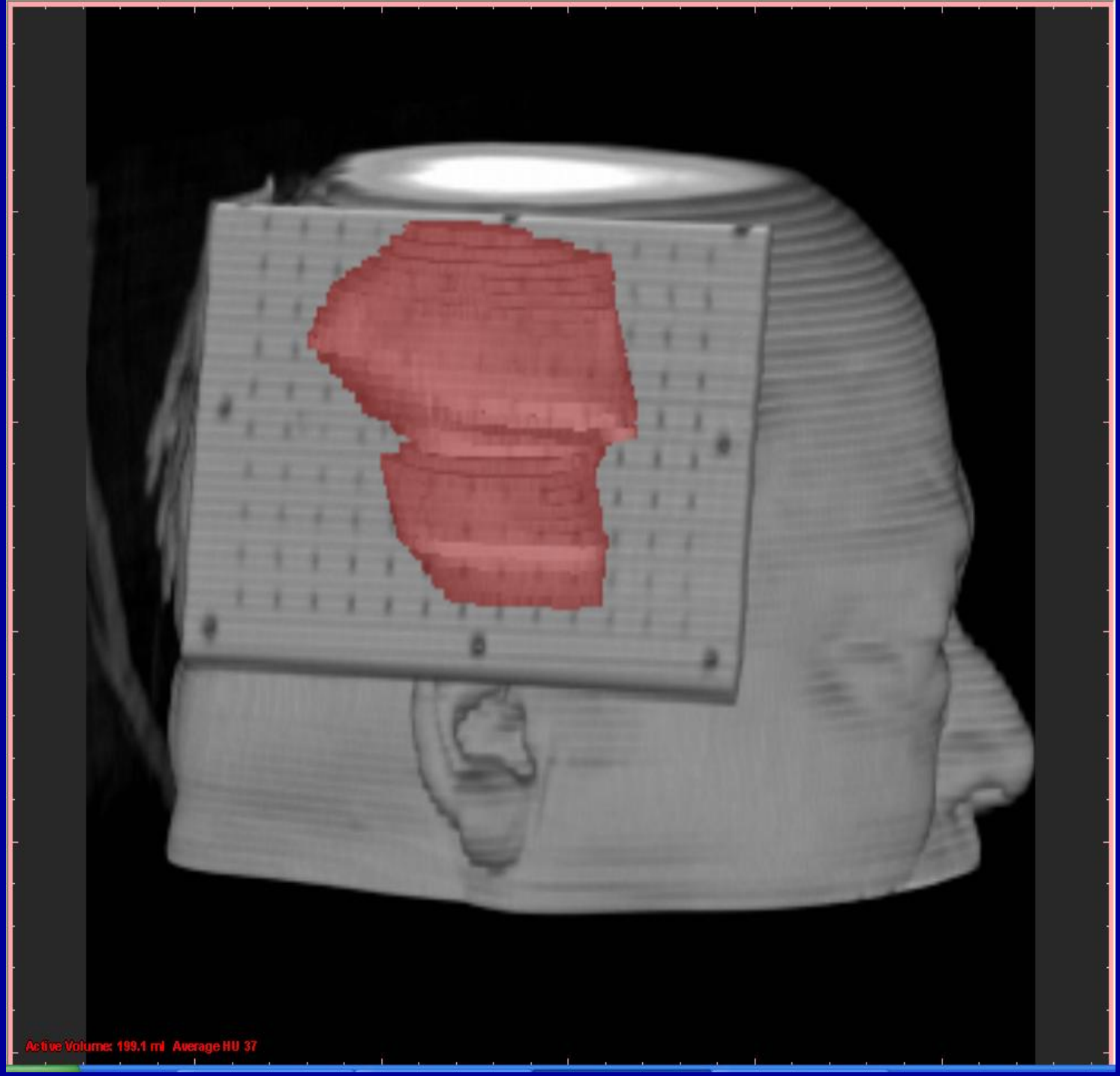

A
Fused Image P/S
Balance Factor=46
R
L
2nd Target
Zpos=259.5
P

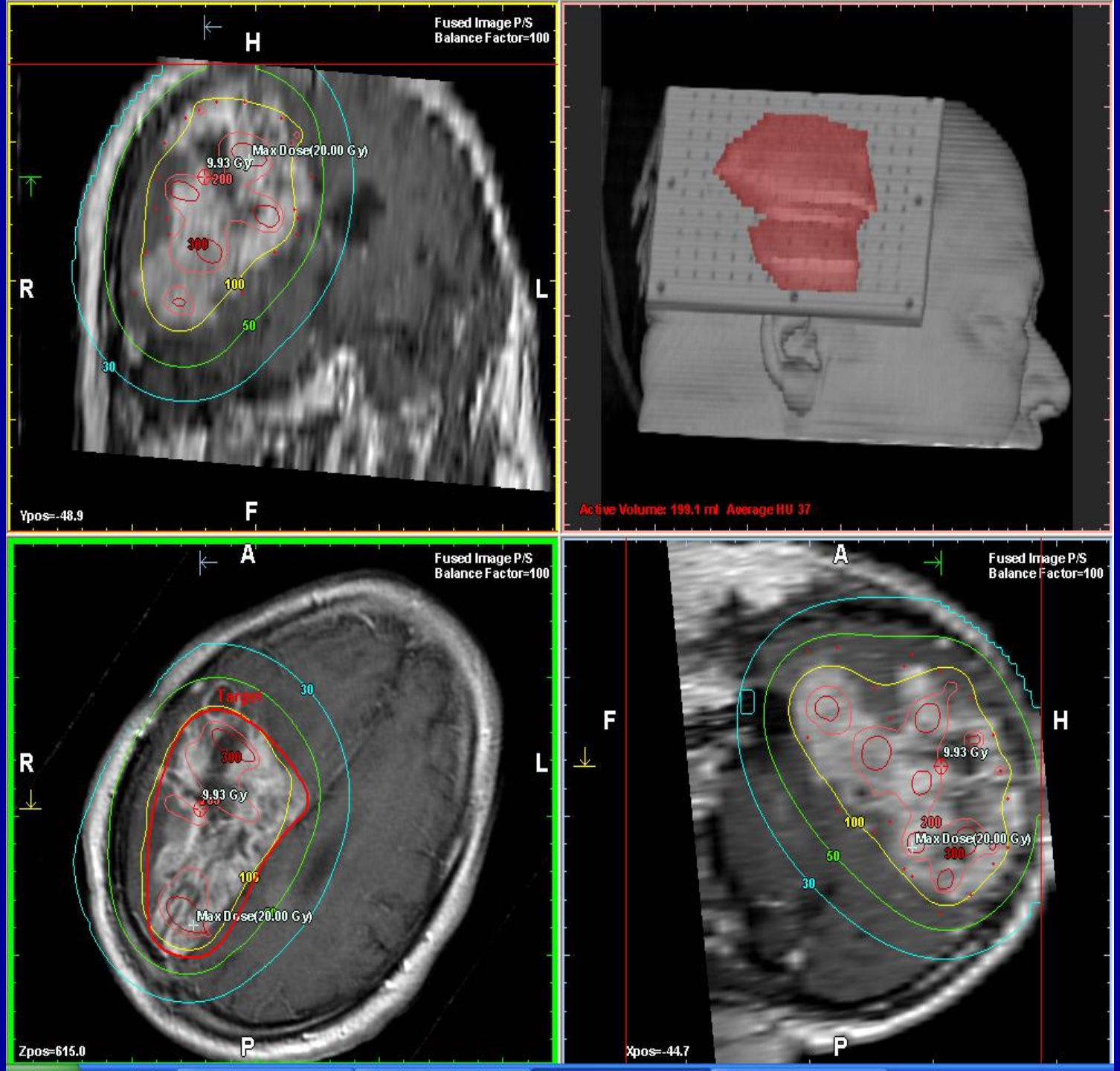

A
Fused Image P/S
Balance Factor=50
R
L
P
Zpos=284.5
90%
200
%
Target
150
%
50%
100
%
PTV


A
Fused Image P/S
Balance Factor=51
Larget
R
65 mm
M
54 mm
103 mm
R
L
P
Zpos=615.0


Fused Image P/S
Balance Factor=52
H
Target
L
M
54 mm
R
78 mm
R
L
94 mm
Ypos=-41.2
F


A
Fused Image P/S
Balance Factor=16
Target
M
R
F
H
63 mm
93 mm
89 mm
P
Xpos=-35.1


Active Volume: 199.1 ml Average HU 37

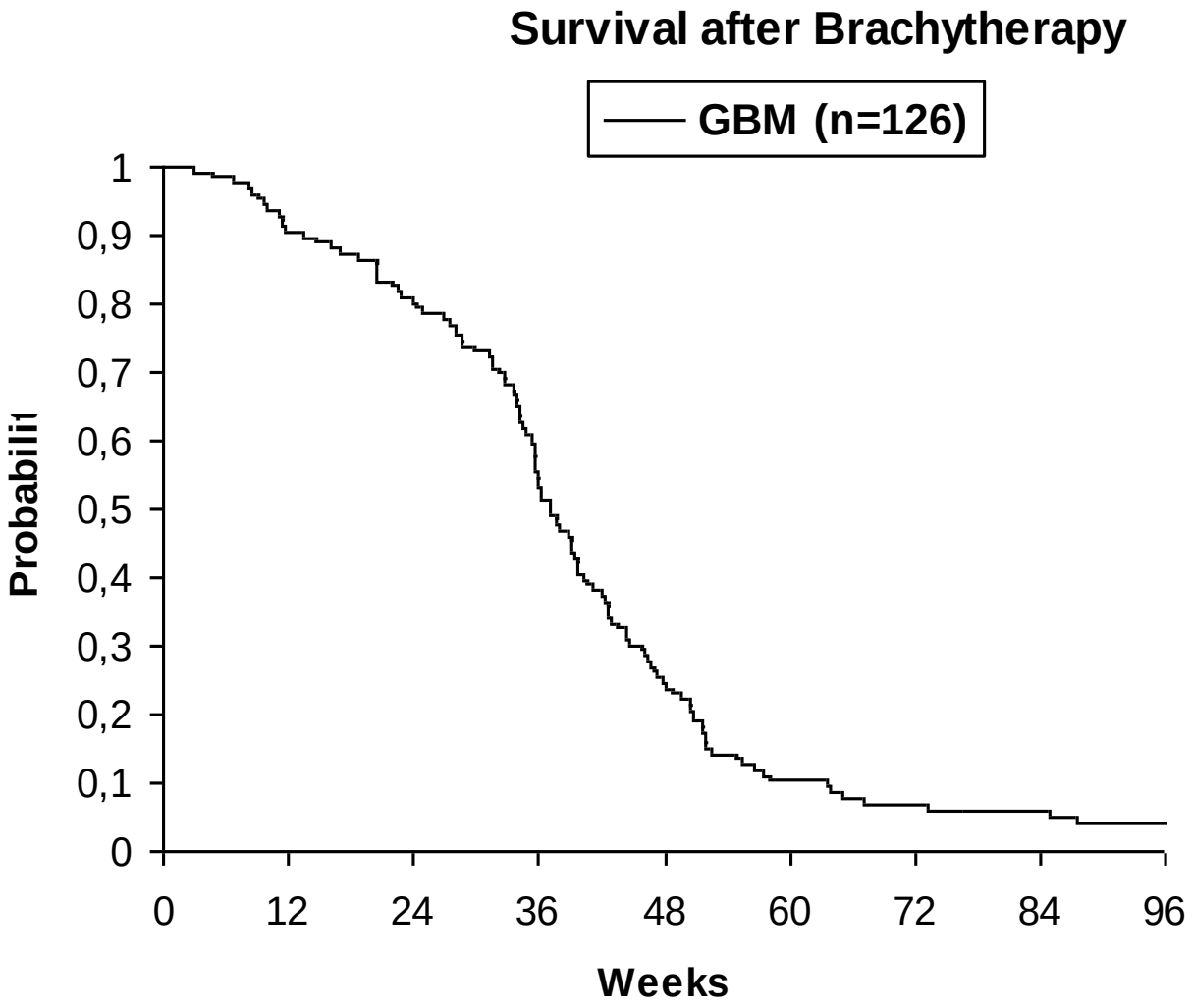

H
Fused Image P/S
Balance Factor=100
Max Dose(20.00 Gy)
9.93 Gy
200
300
100
50
30
R
L
F
Ypos=-48.9
Active Volume: 199.1 ml Average HU 37
A
Fused Image P/S
Balance Factor=100
Target
30
300
9.93 Gy
100
Max Dose(20.00 Gy)
R
L
P
Zpos=615.0
A
Fused Image P/S
Balance Factor=100
F
H
9.93 Gy
100
200
Max Dose(20.00 Gy)
300
50
30
P
Xpos=-44.7


Boris in Sorge
Der edle Zug.
West
TEST IT.

Patient characteristics
n=179

Primary Histology

- 126 Glioblastoma Multiforme (GBM)
- 53 Non-Glioblast. Multiforme (13 Astro II and 40 Astro III)


Survival after Brachytherapy
GBM (n=126)
Probabilit
1
0,9
0,8
0,7
0,6
0,5
0,4
0,3
0,2
0,1
0
0
12
24
36
48
60
72
84
96
Weeks

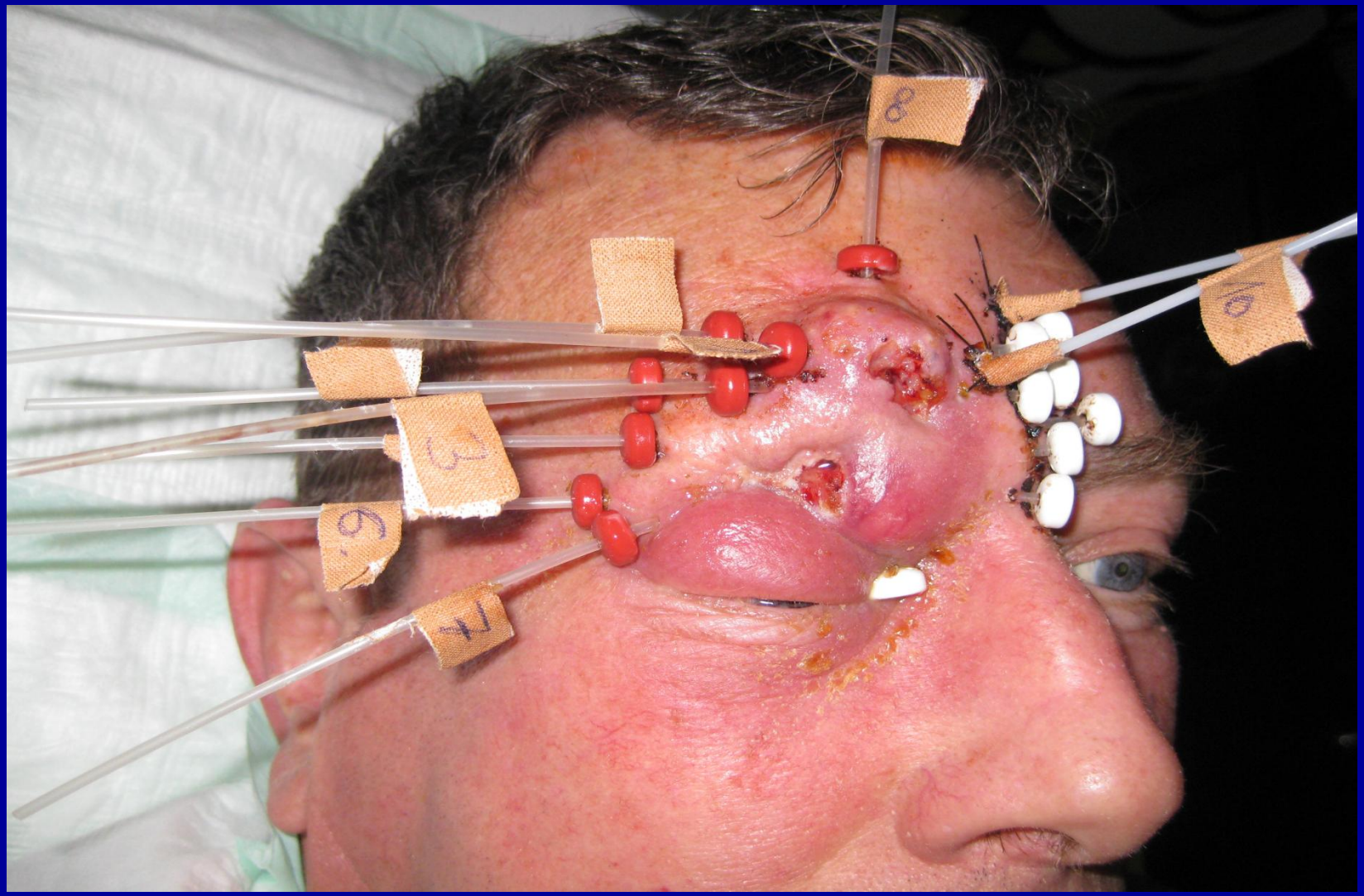
IRO in H&N Ca

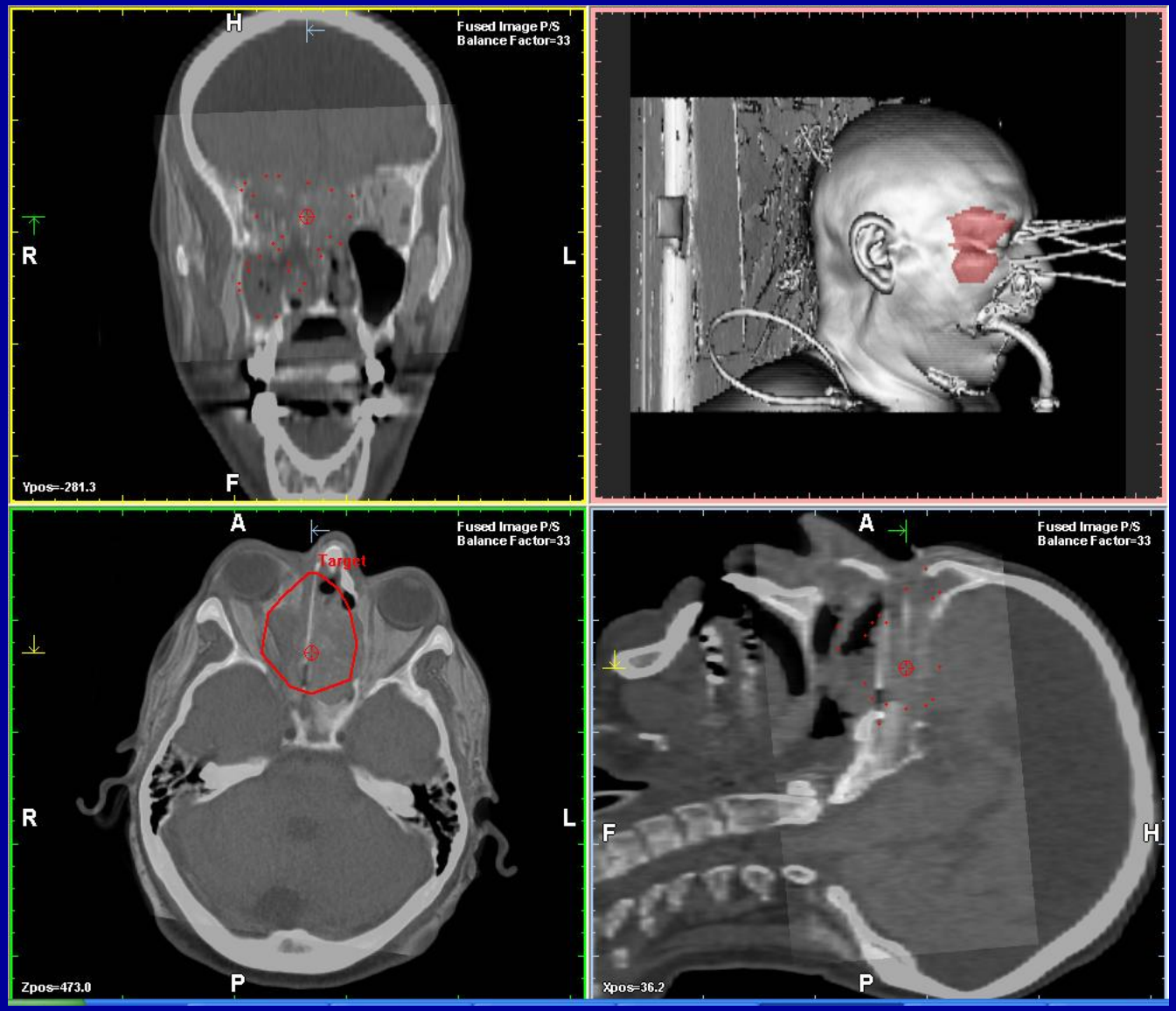
Palliative treatment

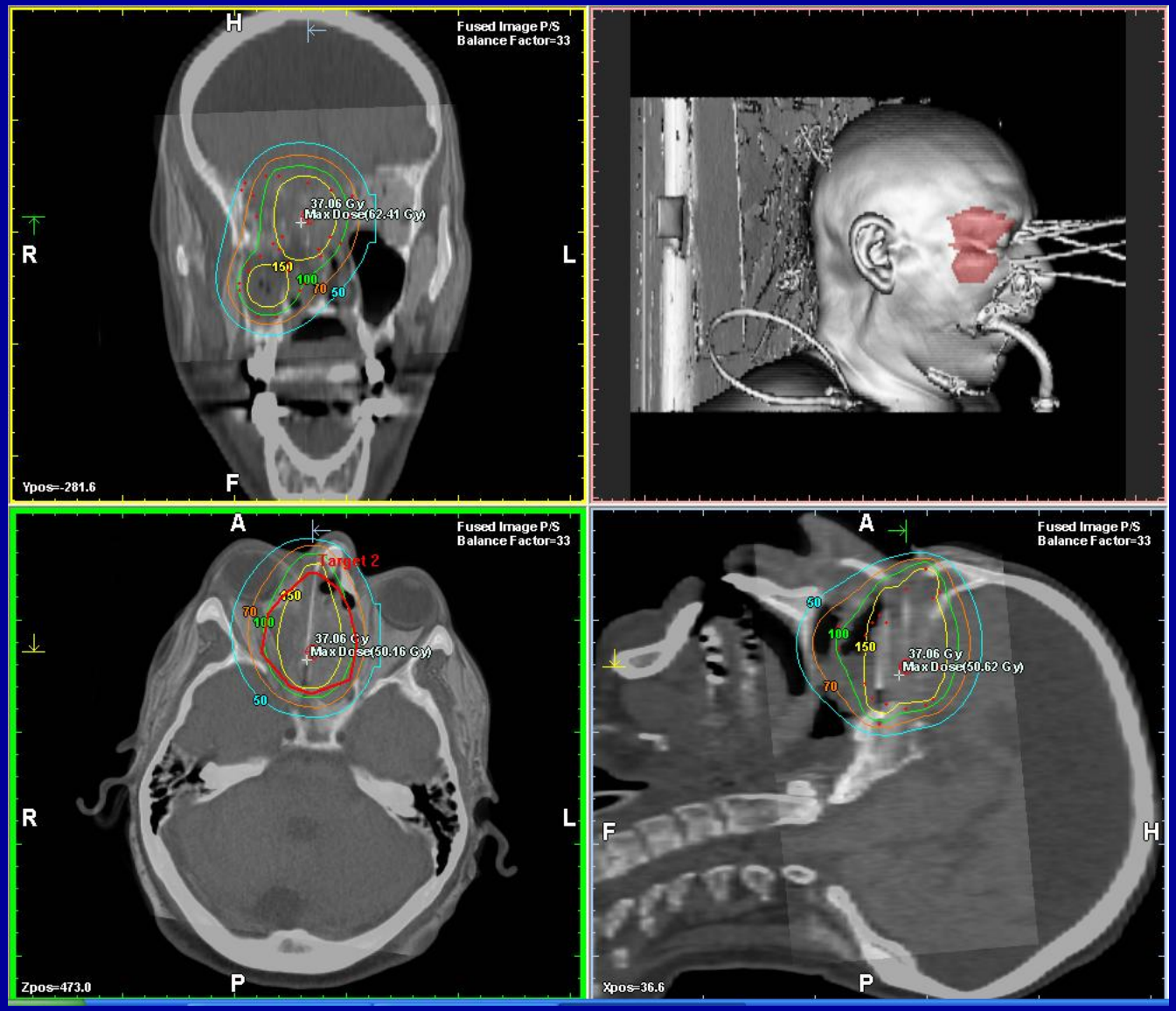
Site of relapse

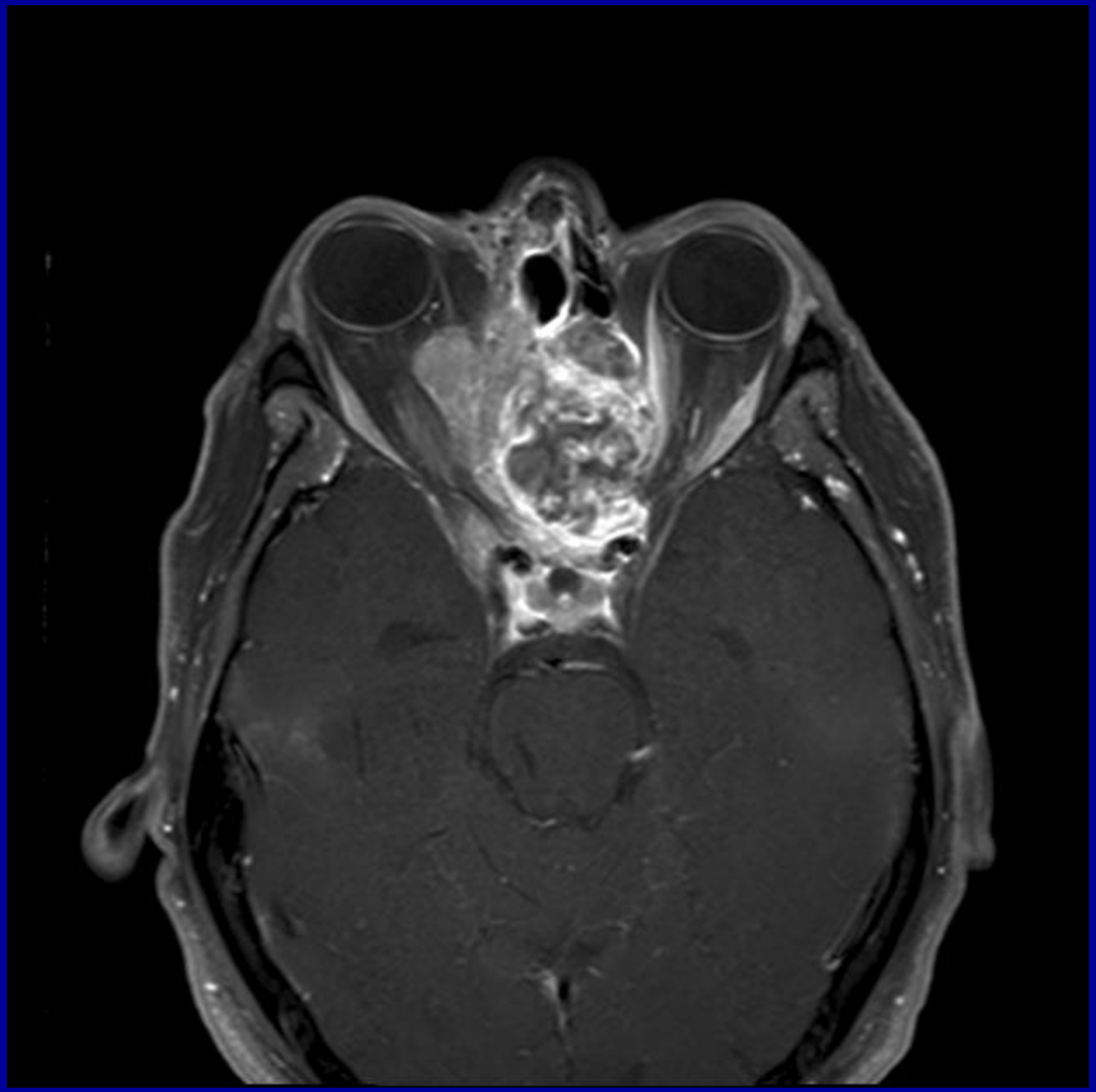
- **Facial :**

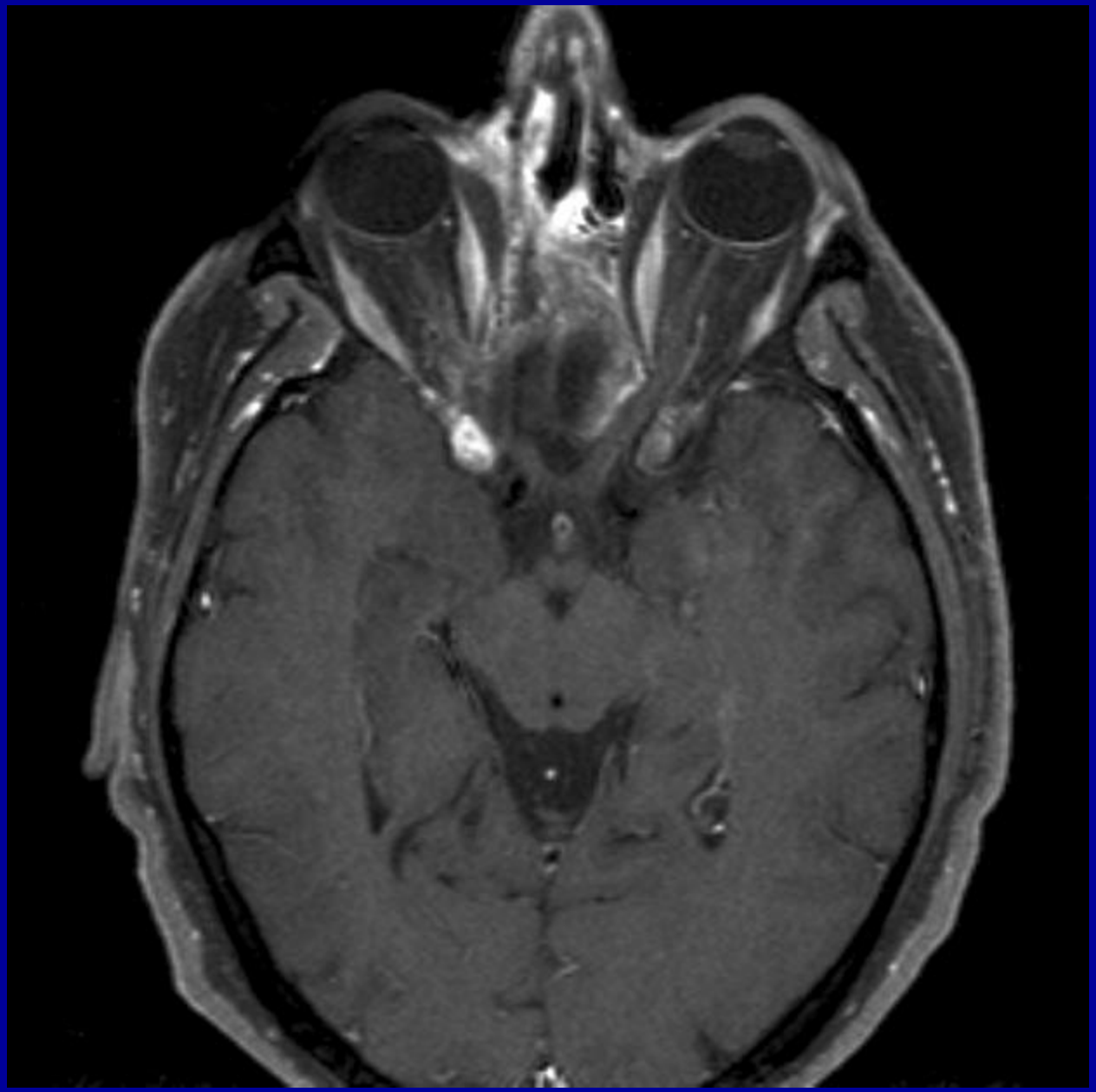
Orbita

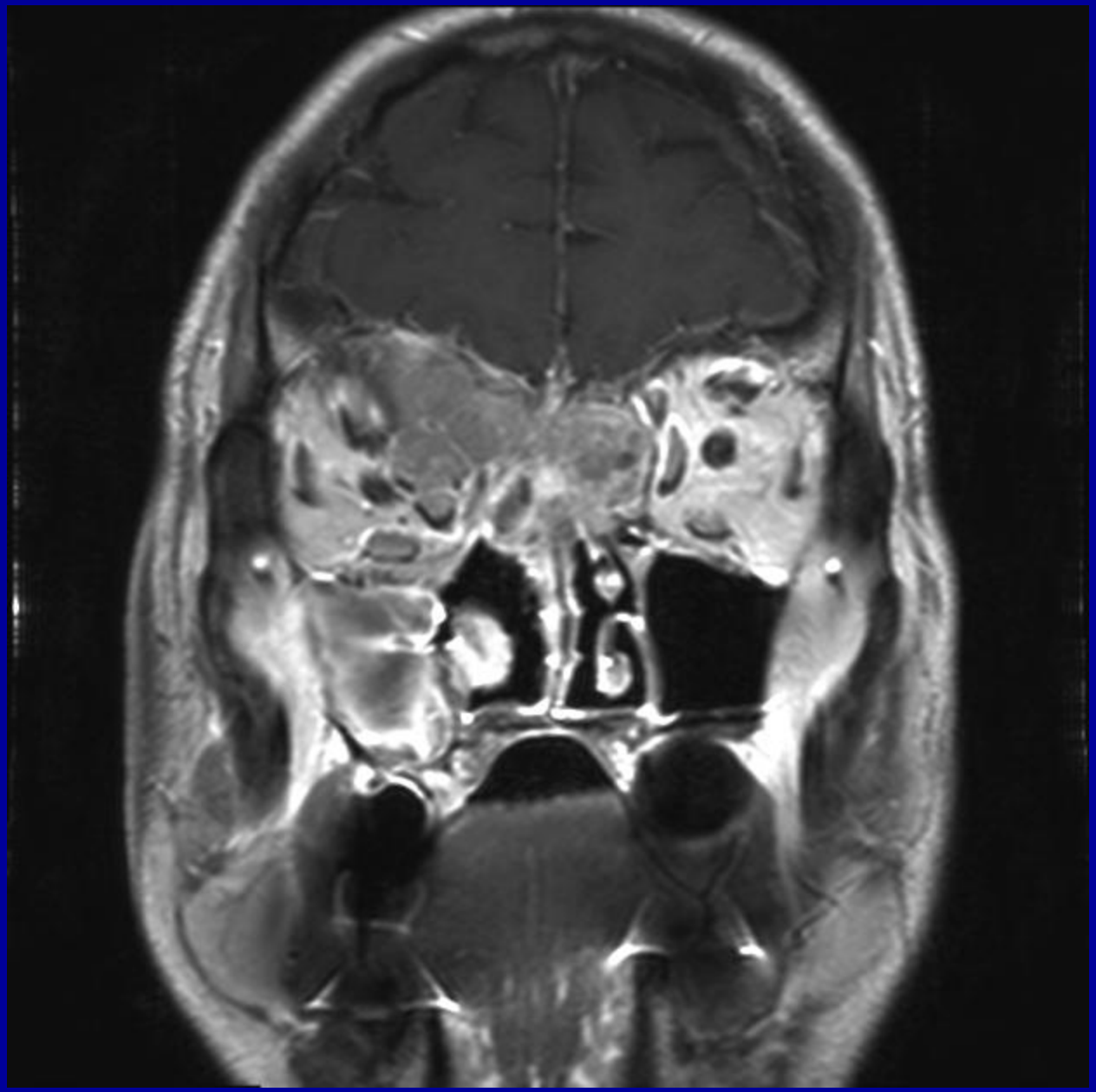

8
10
6
7

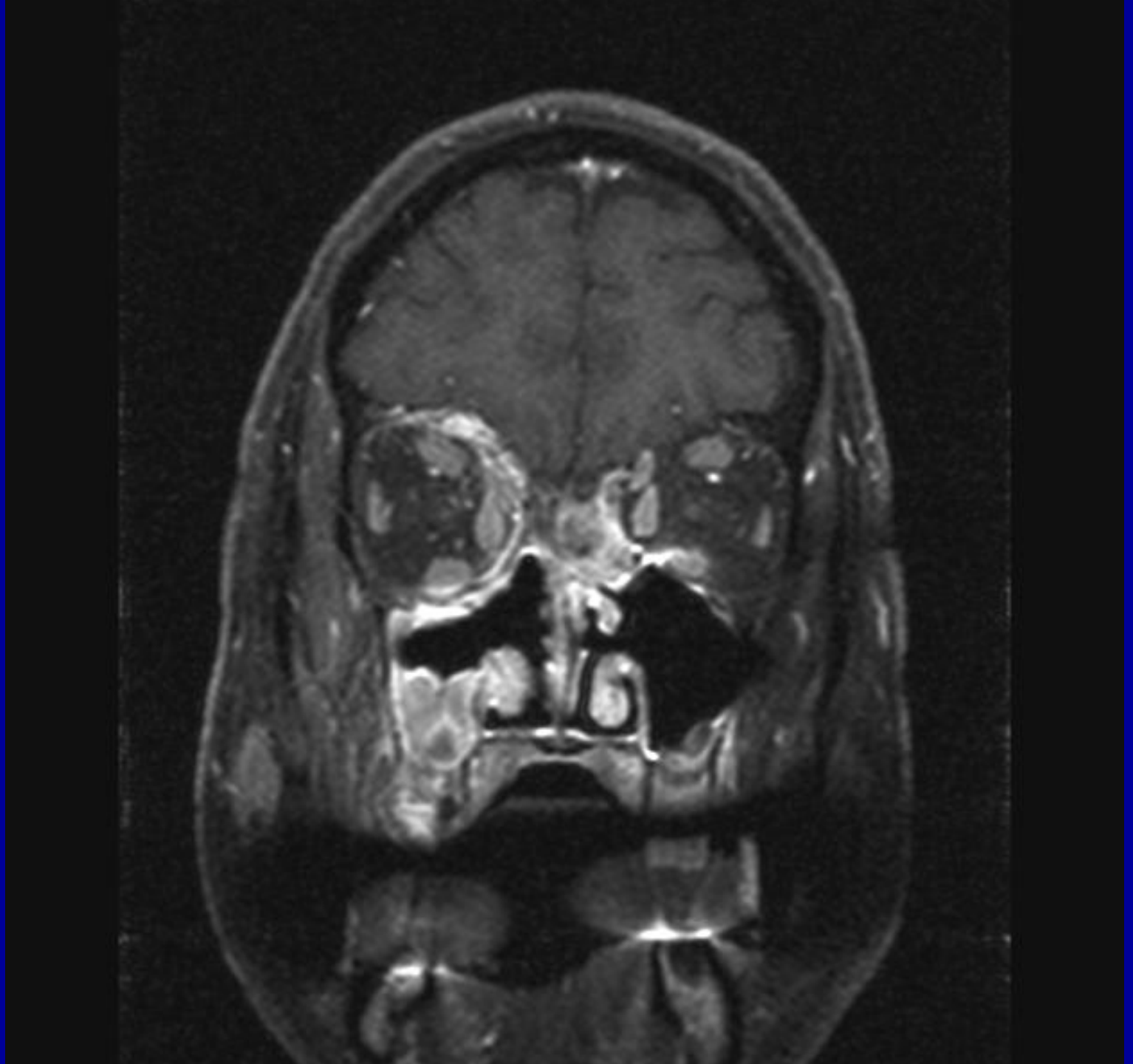

H
Fused Image P/S
Balance Factor=33
R
L
Ypos=-281.3
F
A
Target
Fused Image P/S
Balance Factor=33
R
L
Zpos=473.0
P
A
Fused Image P/S
Balance Factor=33
F
H
Xpos=36.2
P


H
Fused Image P/S
Balance Factor=33
37.06 Gy
Max Dose(62.41 Gy)
150
100
70
50
R
L
F
Ypos=-281.6
A
Target 2
150
70
100
37.06 Gy
Max Dose(50.16 Gy)
50
R
L
P
Zpos=473.0
A
Fused Image P/S
Balance Factor=33
50
100
150
37.06 Gy
Max Dose(50.62 Gy)
70
F
H
P
Xpos=-36.6







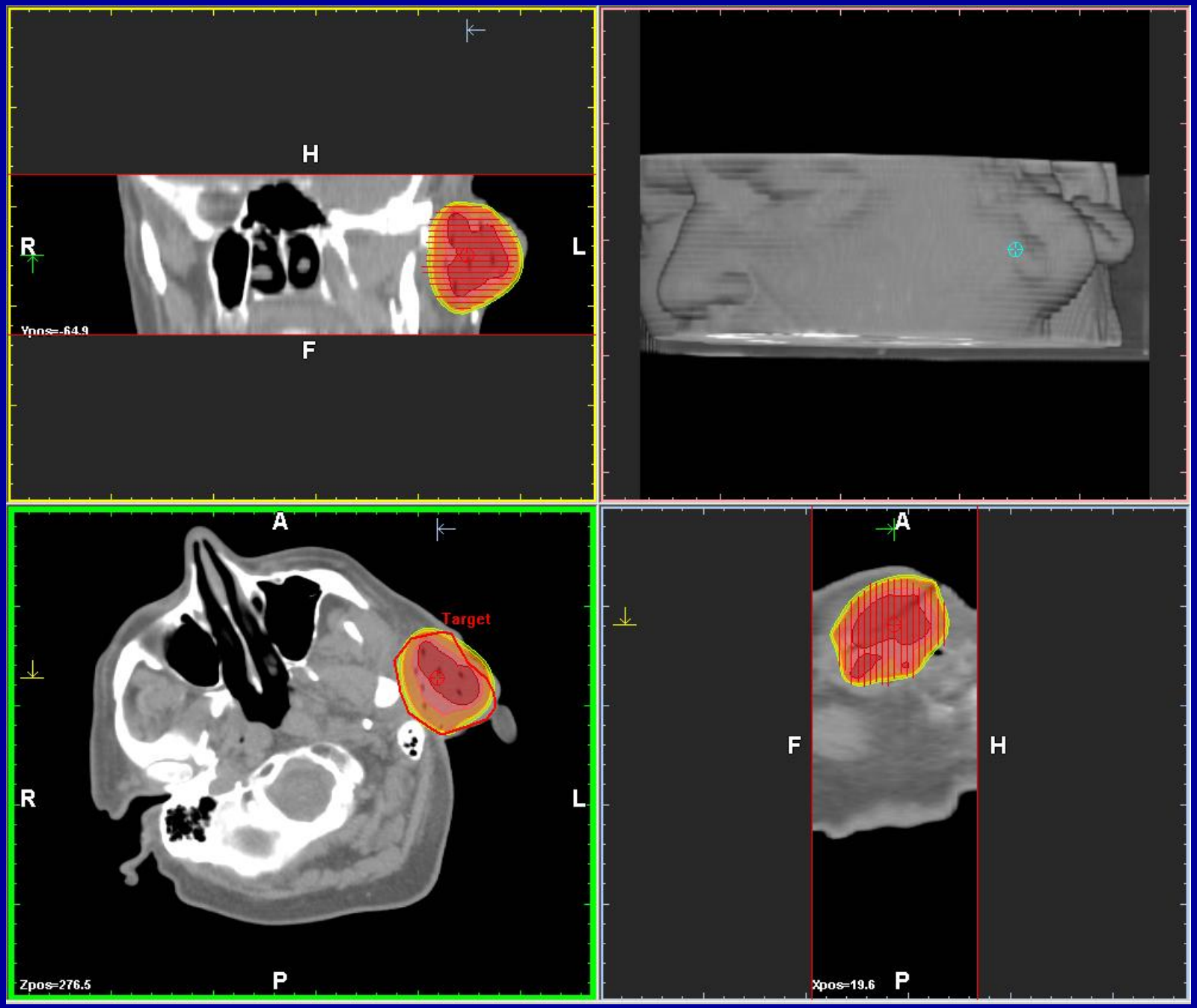


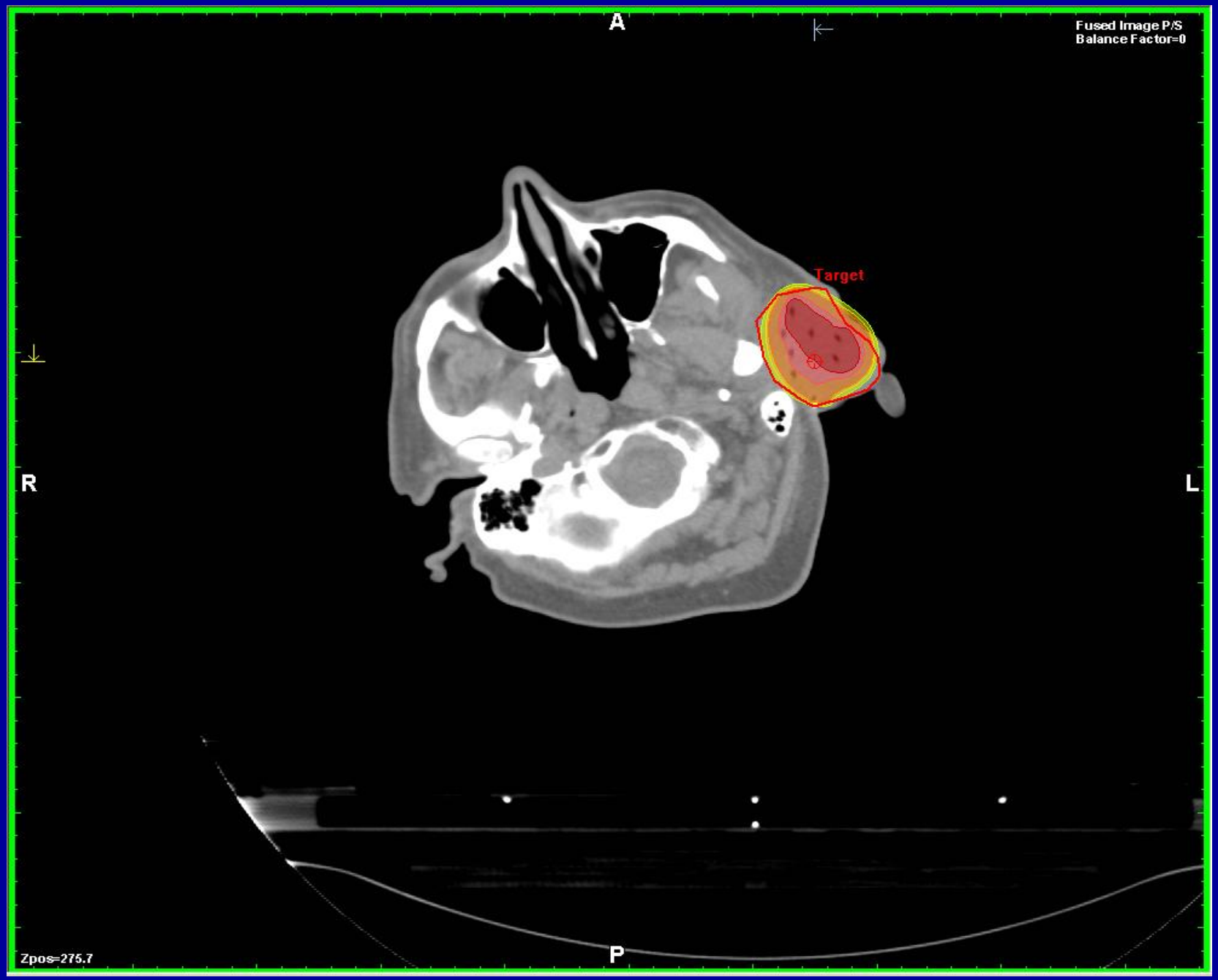
Site of relapse

- **Facial :**

Orbita

Parotis


H
R
L
Ypos=-64.9
F
A
Target
R
L
Zpos=276.5
P
A
F
H
Xpos=19.6
P


A
Fused Image P/S
Balance Factor=0
Target
R
L
P
Zpos=275.7


A
Fused Image P/S
Balance Factor=100
R
L
P
Zpos=258.5

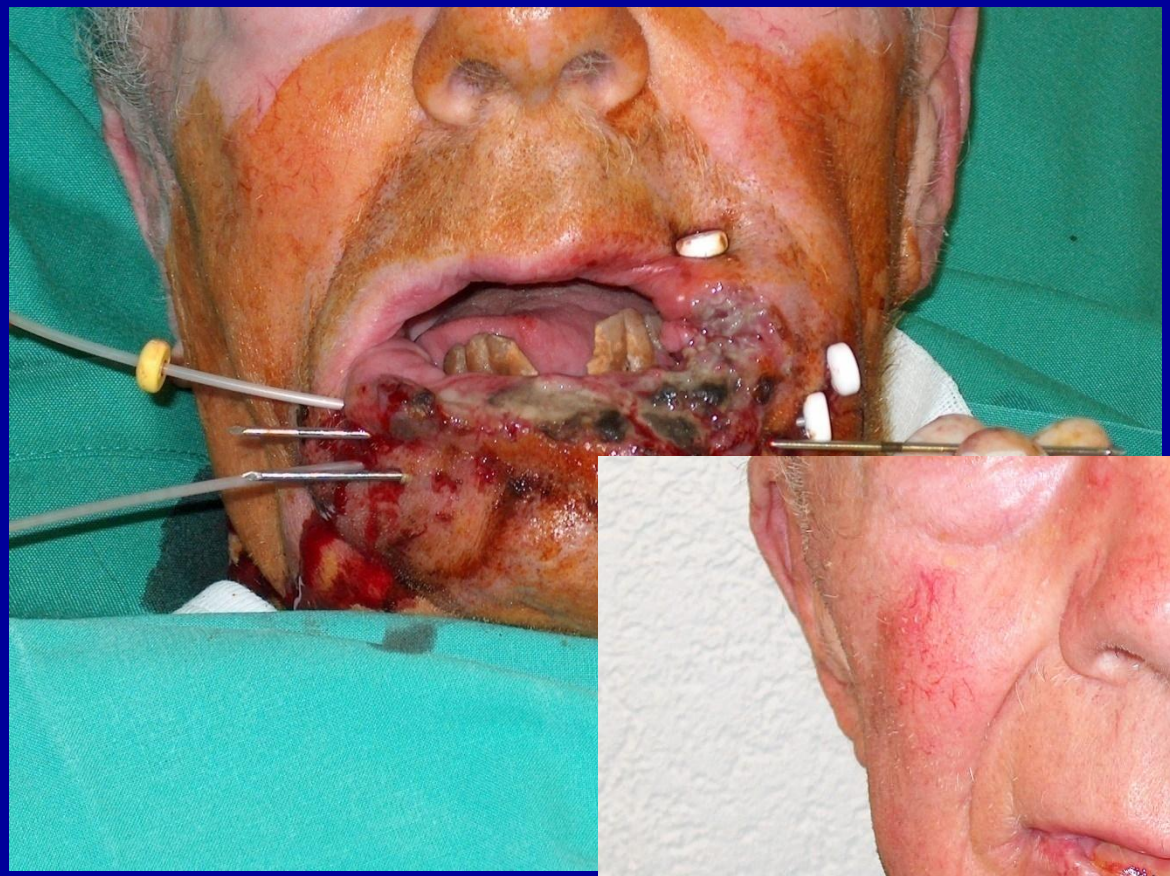
Site of relapse

- **Facial :**

Orbita

Parotis

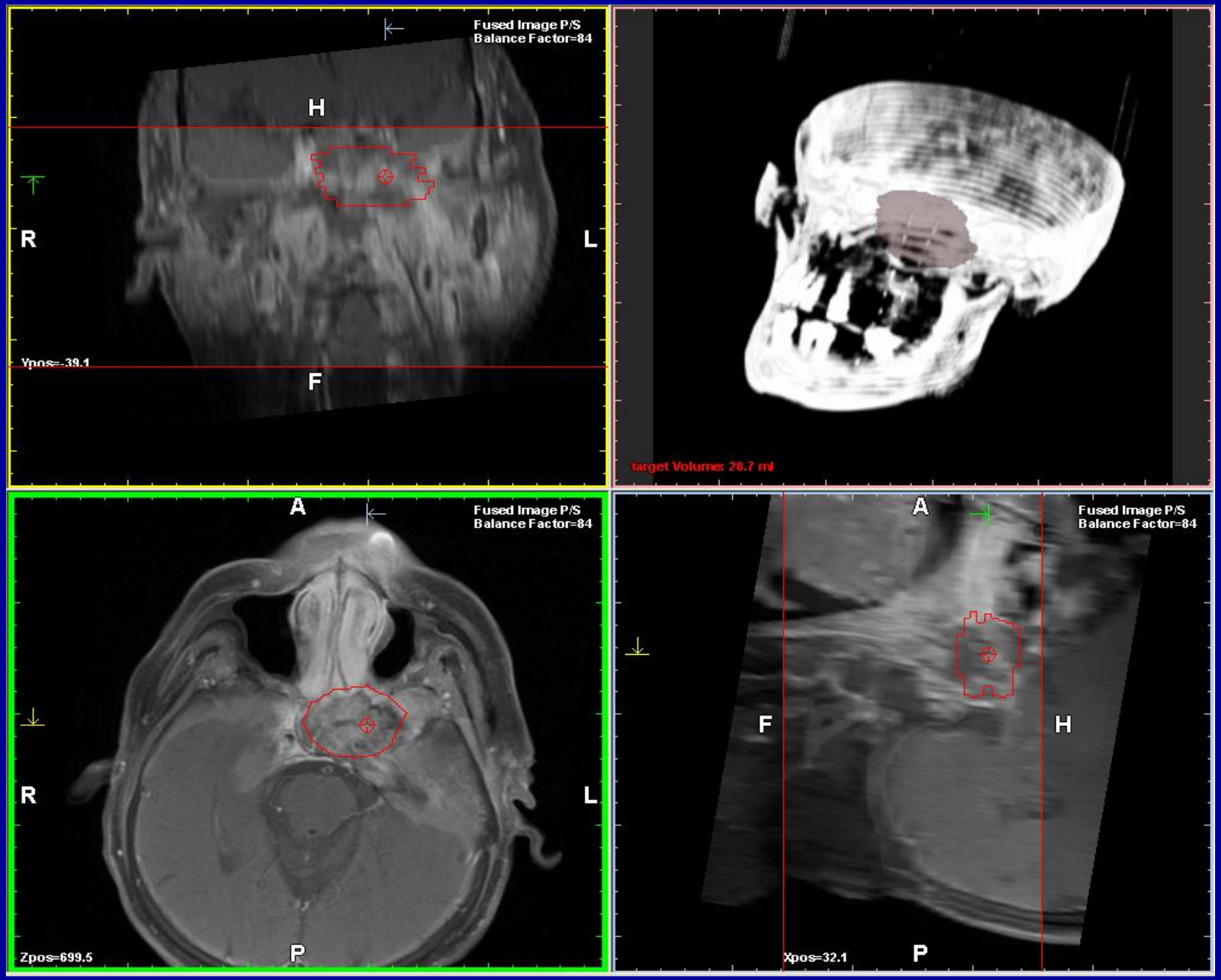
Lips

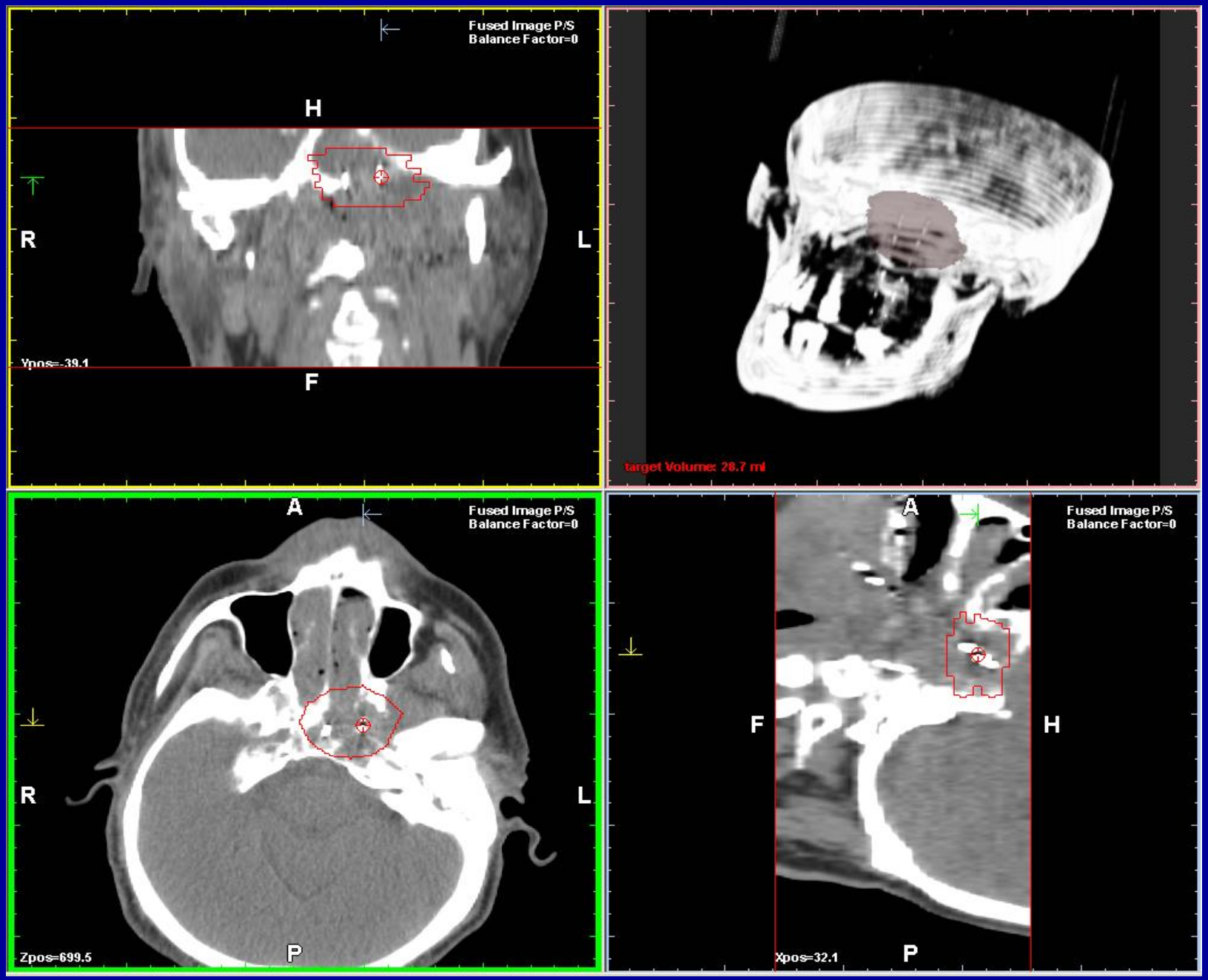


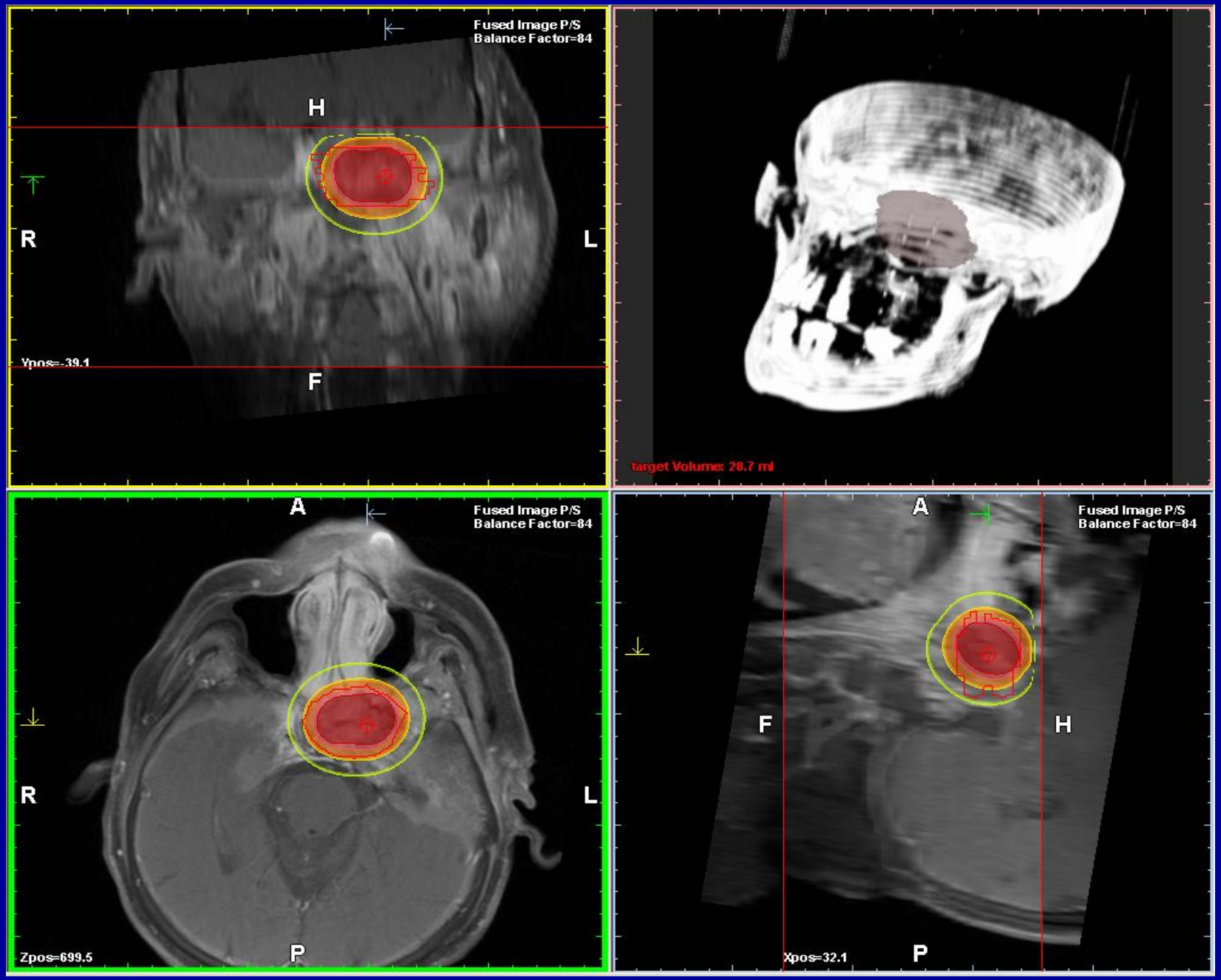
Site of relapse

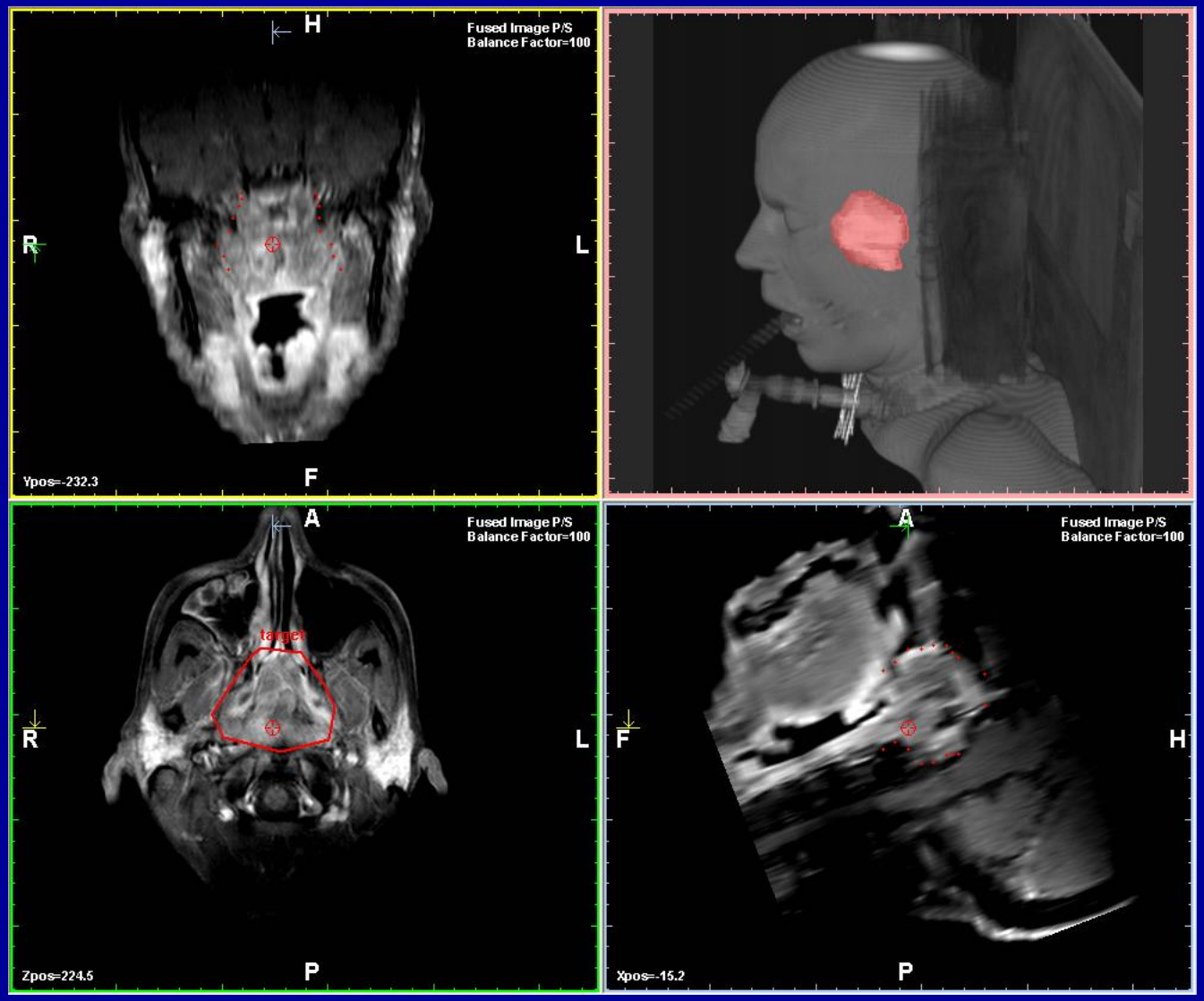
- **Head and Neck mucosal structures**

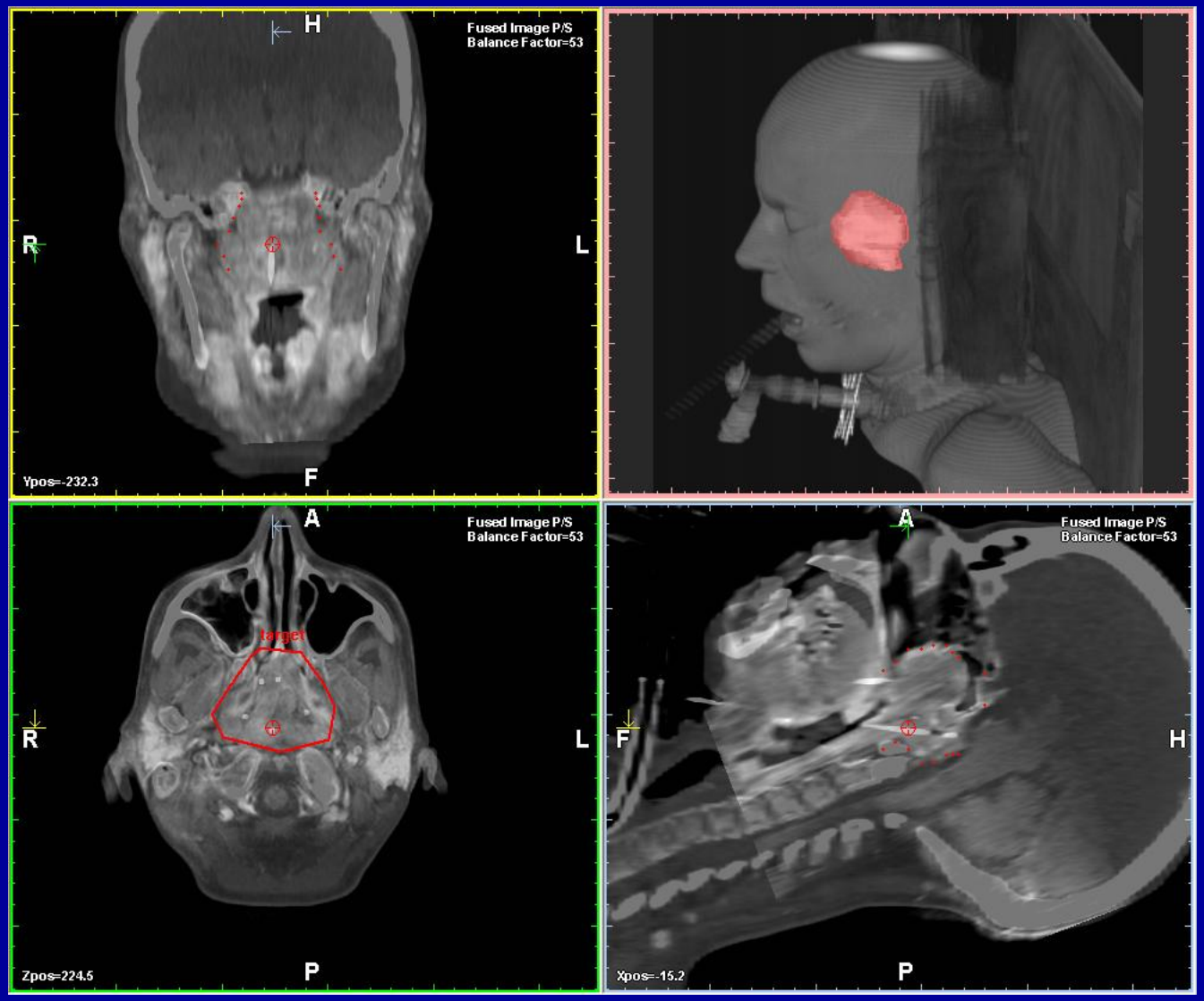
Epipharynx

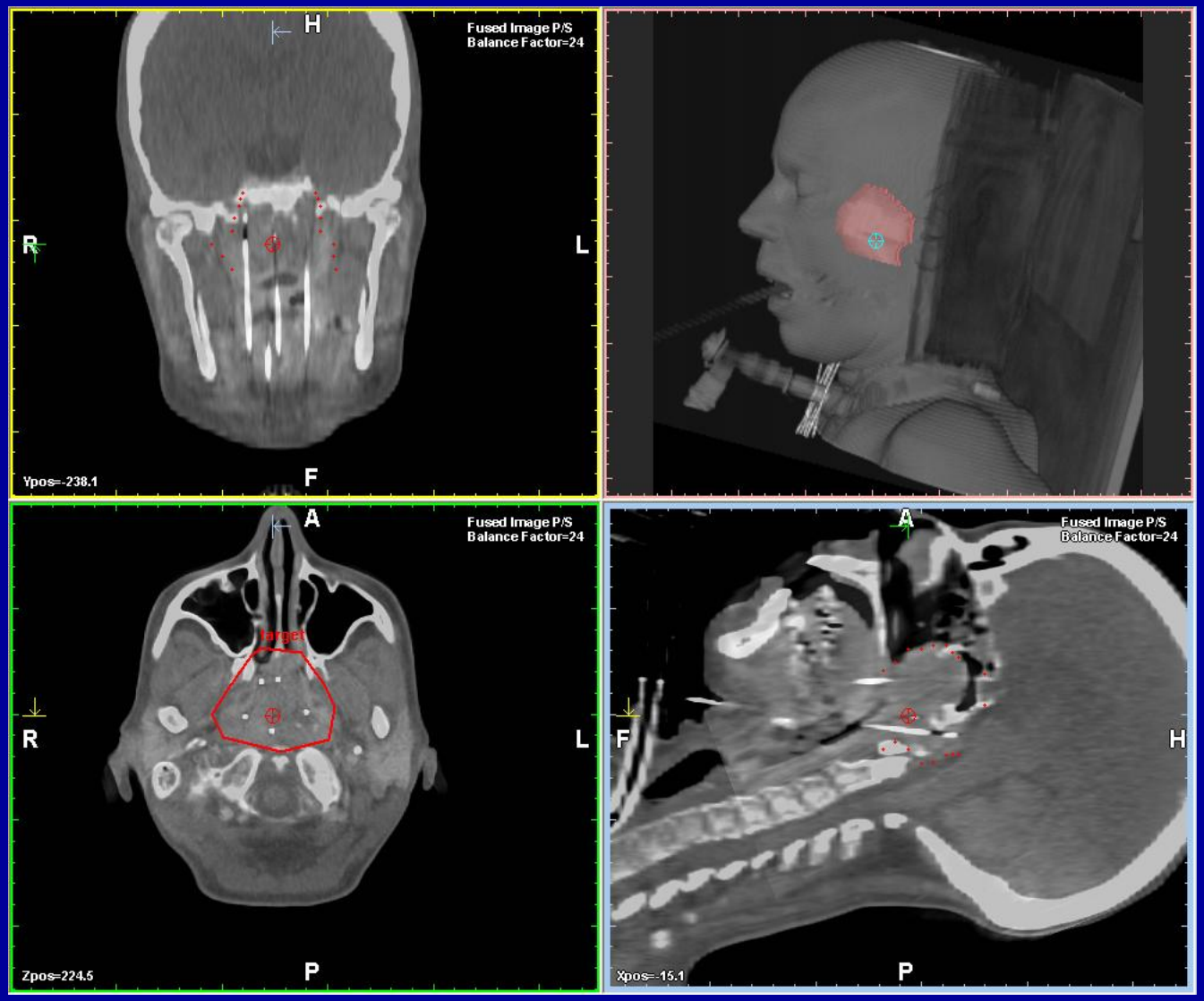

Fused Image P/S
Balance Factor=84
H
R
L
F
Ypos=-39.1
target Volume: 28.7 ml
A
Fused Image P/S
Balance Factor=84
R
L
P
Zpos=699.5
A
Fused Image P/S
Balance Factor=84
F
H
P
Xpos=32.1

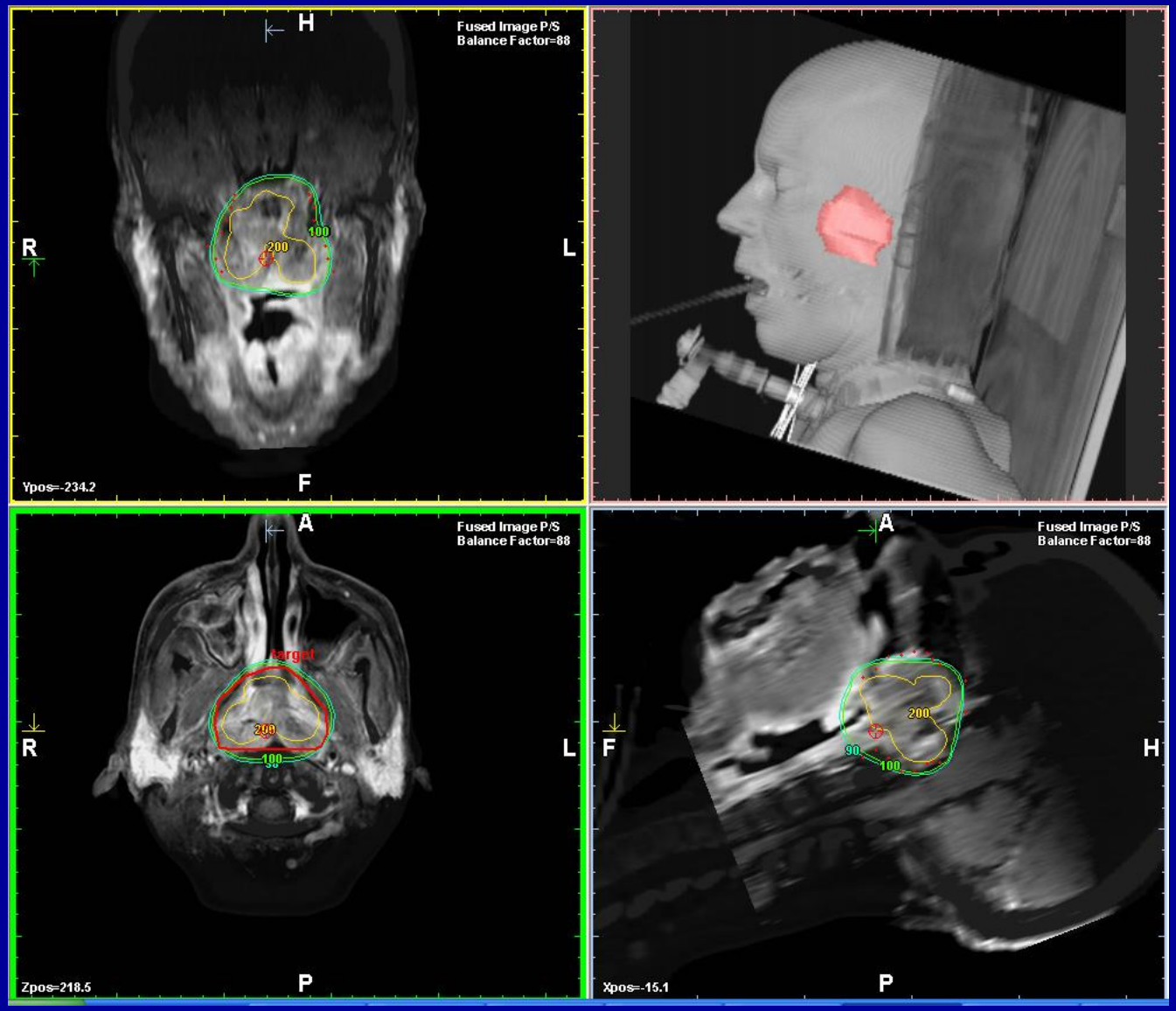

Fused Image P/S
Balance Factor=0
H
R
L
F
Ypos=-39.1
target Volume: 28.7 ml
A
Fused Image P/S
Balance Factor=0
R
L
P
Zpos=699.5
A
Fused Image P/S
Balance Factor=0
F
H
P
Xpos=32.1

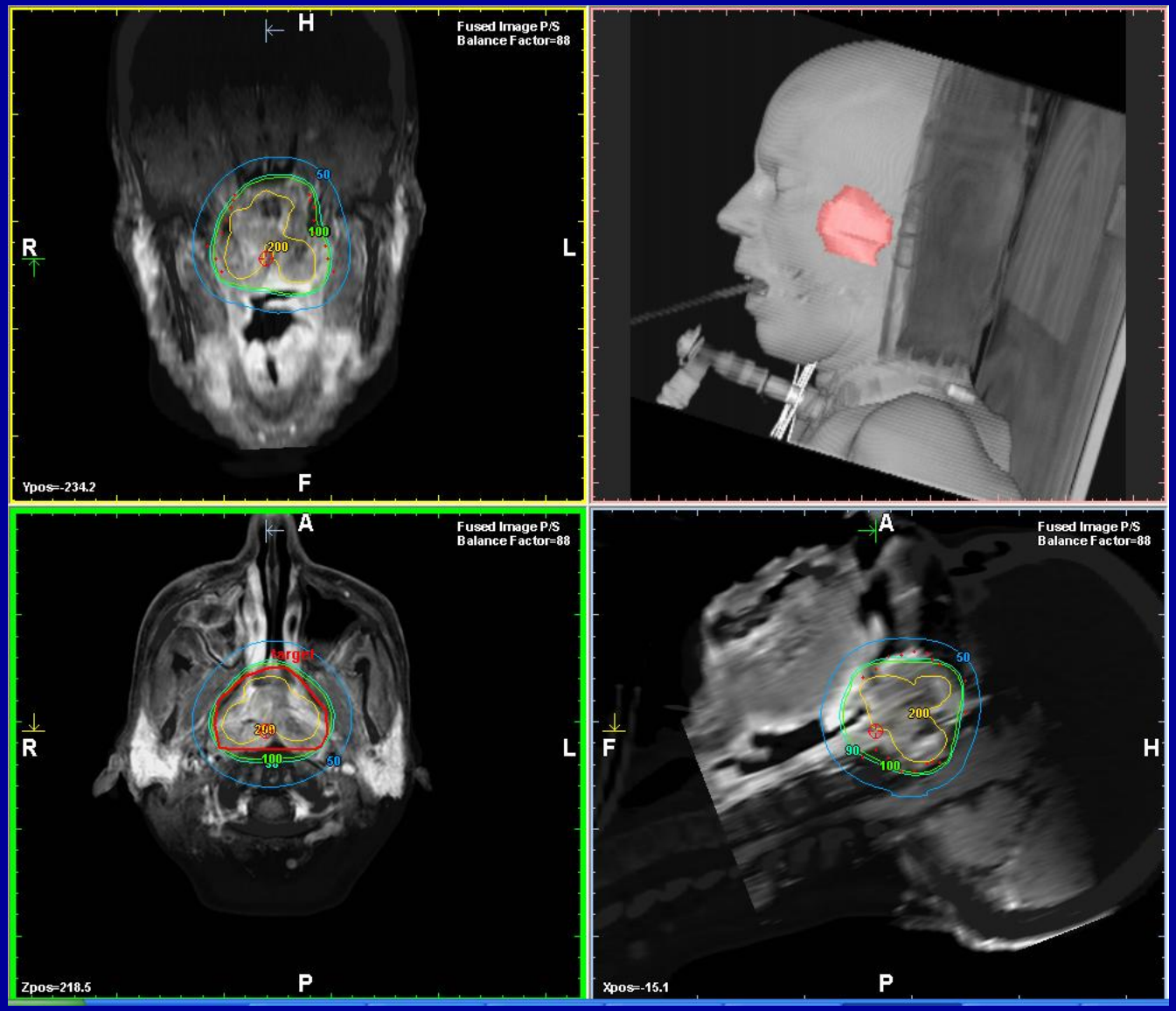

Fused Image P/S
Balance Factor=84
H
R
L
Ypos=-39.1
F
target Volume: 28.7 ml
A
Fused Image P/S
Balance Factor=84
R
L
Zpos=699.5
P
A
Fused Image P/S
Balance Factor=84
F
H
Xpos=32.1
P

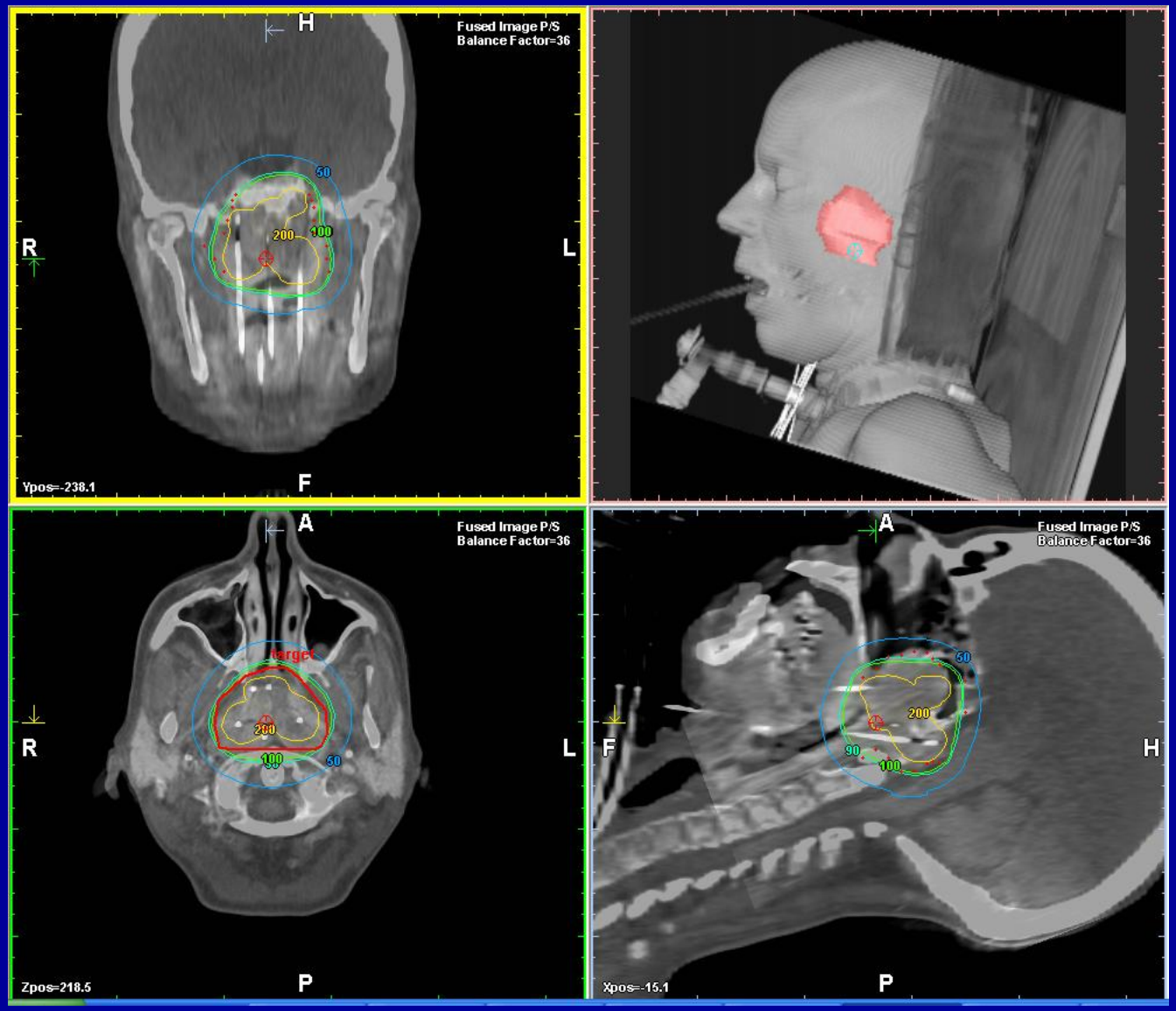

H
Fused Image P/S
Balance Factor=100
R
L
F
Ypos=-232.3
A
Fused Image P/S
Balance Factor=100
target
R
L
P
Zpos=224.5
A
Fused Image P/S
Balance Factor=100
F
H
P
Xpos=-15.2


H
Fused Image P/S
Balance Factor=53
R
L
F
Ypos=-232.3
A
Fused Image P/S
Balance Factor=53
target
R
L
P
Zpos=224.5
A
Fused Image P/S
Balance Factor=53
F
H
P
Xpos=-15.2


H
Fused Image P/S
Balance Factor=24
R
L
F
Ypos=-238.1
A
Fused Image P/S
Balance Factor=24
Target
R
L
P
Zpos=224.5
A
Fused Image P/S
Balance Factor=24
F
H
P
Xpos=-15.1


H
Fused Image P/S
Balance Factor=88
R
L
100
200
F
Ypos=-234.2
A
Fused Image P/S
Balance Factor=88
target
200
100
R
L
P
Zpos=218.5
A
Fused Image P/S
Balance Factor=88
200
90
100
F
H
P
Xpos=-15.1


H
Fused Image P/S
Balance Factor=88
50
100
200
R
L
Ypos=-234.2
F
A
Fused Image P/S
Balance Factor=88
Target
200
100
50
R
L
Zpos=218.5
P
A
Fused Image P/S
Balance Factor=88
50
200
90
100
F
H
Xpos=-15.1
P

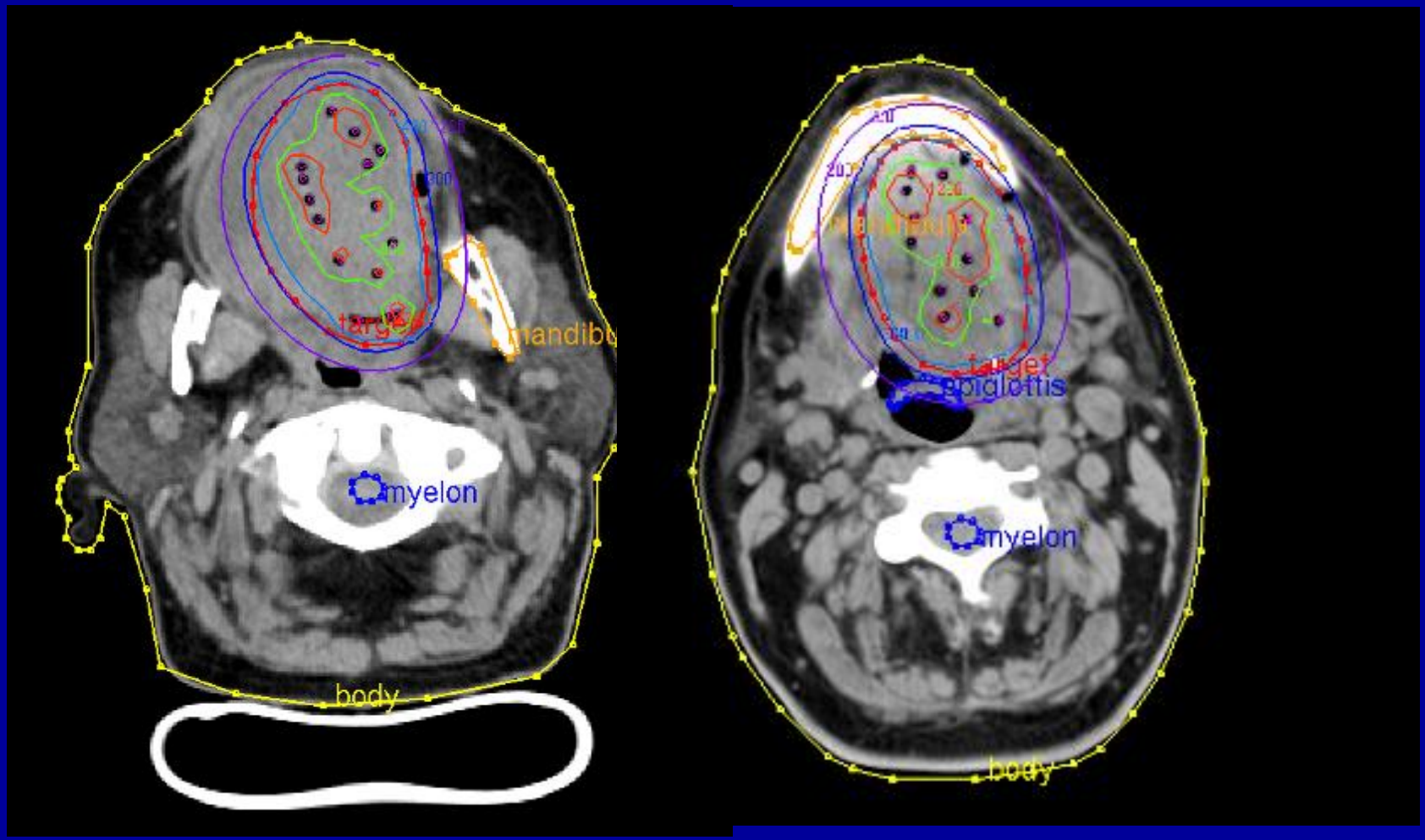

H
Fused Image P/S
Balance Factor=36
50
200
100
R
L
Ypos=-238.1
F
A
Fused Image P/S
Balance Factor=36
target
200
100
50
R
L
Zpos=218.5
P
A
Fused Image P/S
Balance Factor=36
50
200
90
100
F
H
Xpos=-15.1
P

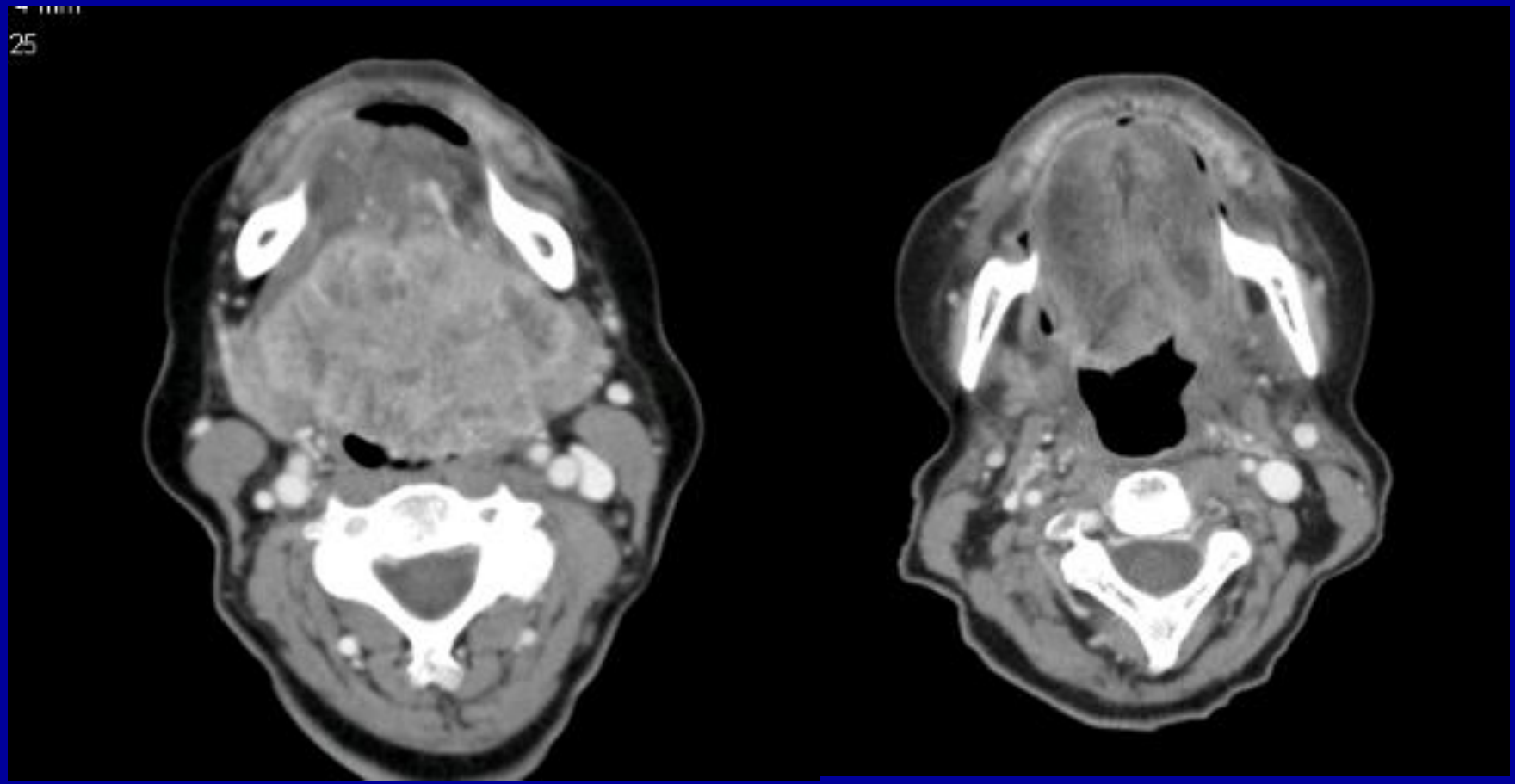
Site of relapse

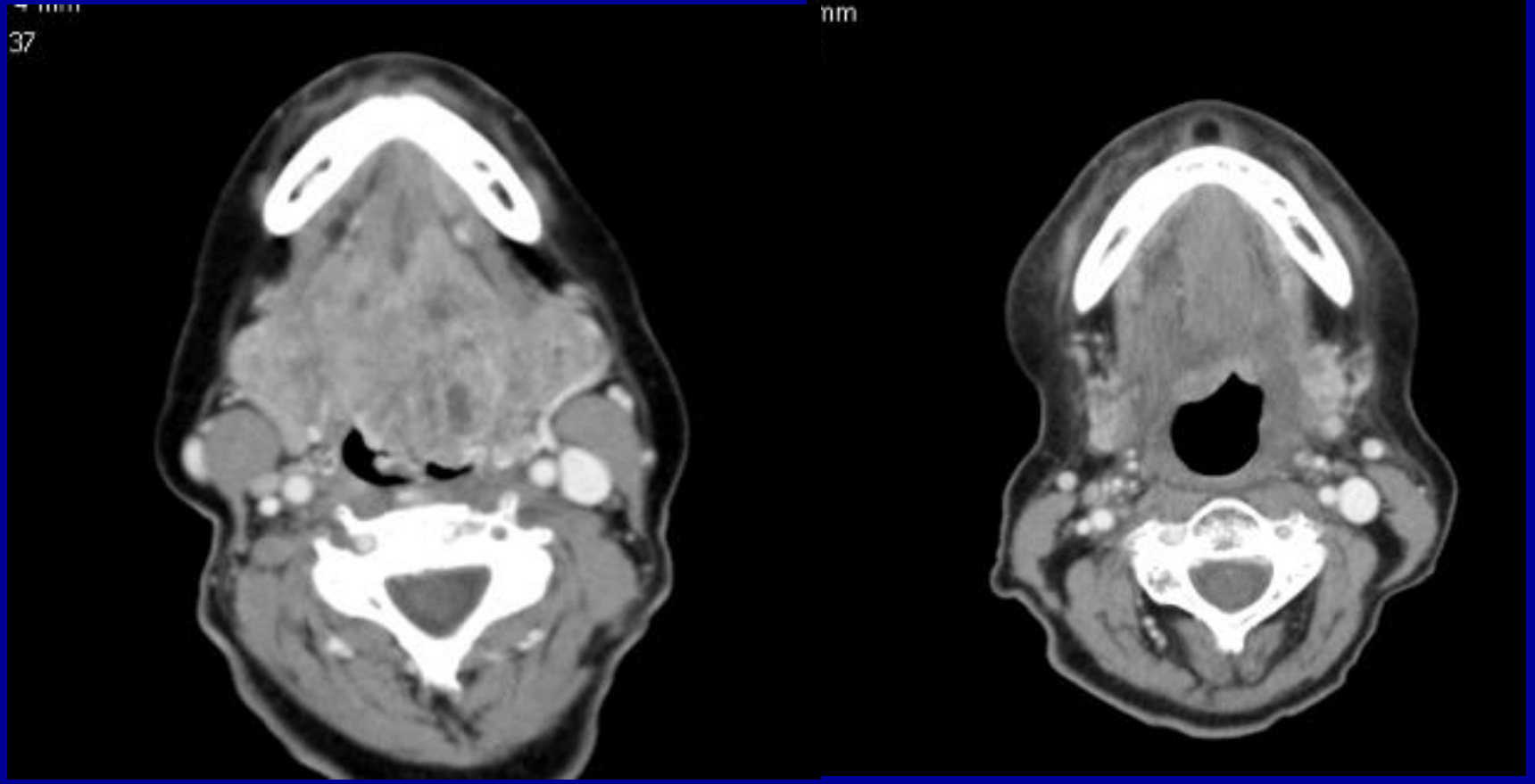
- **Head and Neck mucosal structures**

Epipharynx

oral cavity


target
mandibu
myelon
body
target
epiglottis
myelon
body


25


37
nm

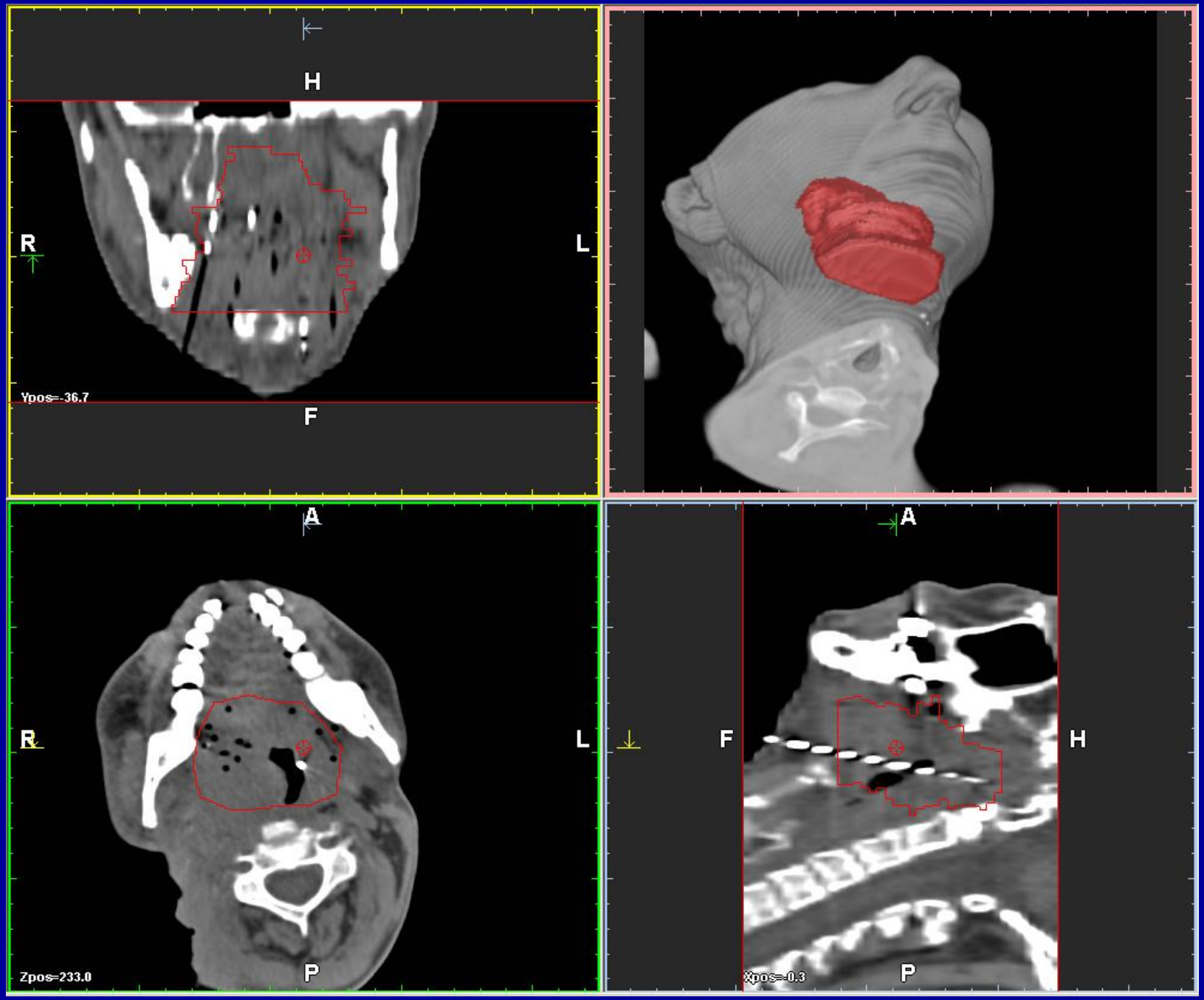
Site of relapse

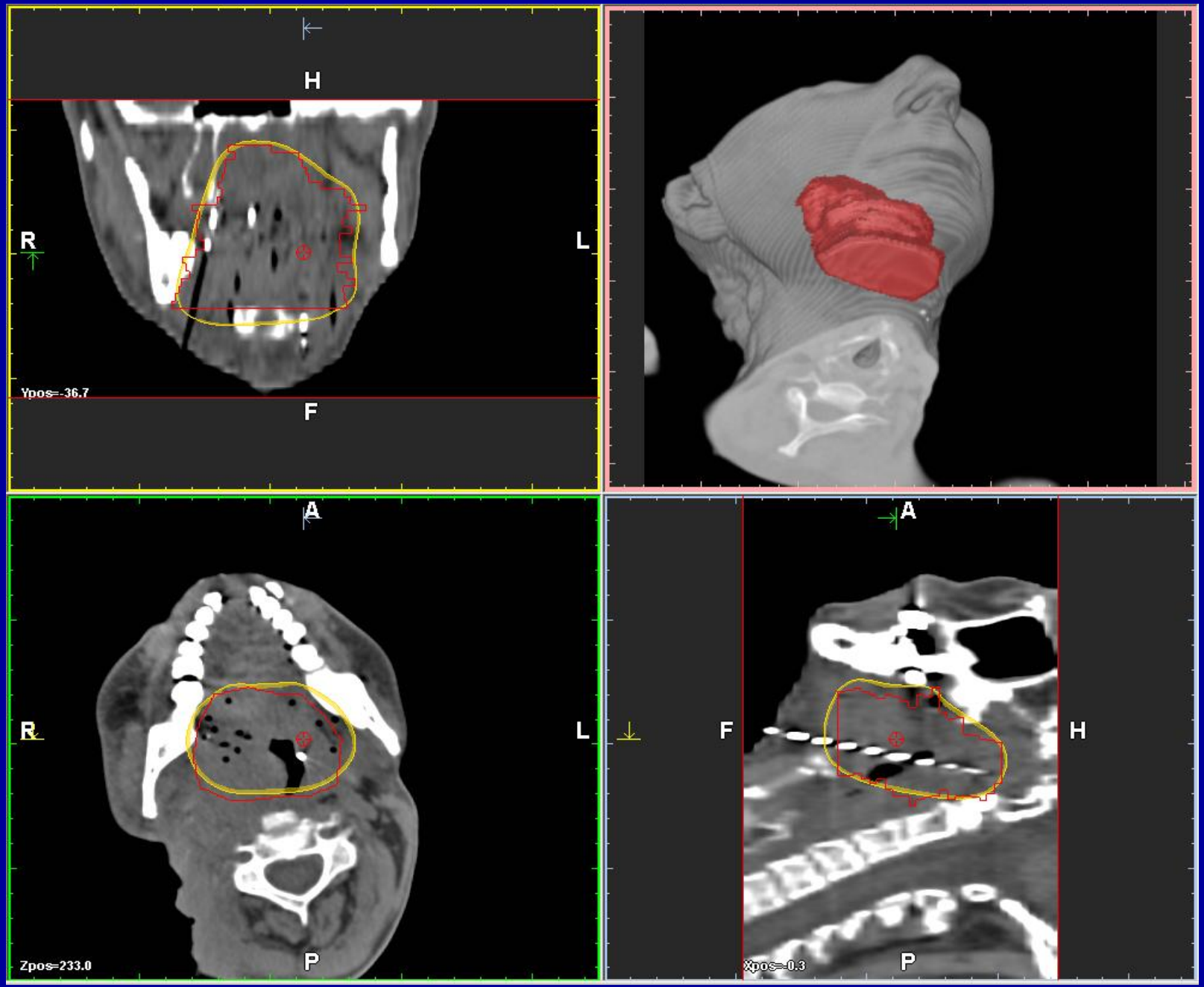
- **Head and Neck mucosal structures**

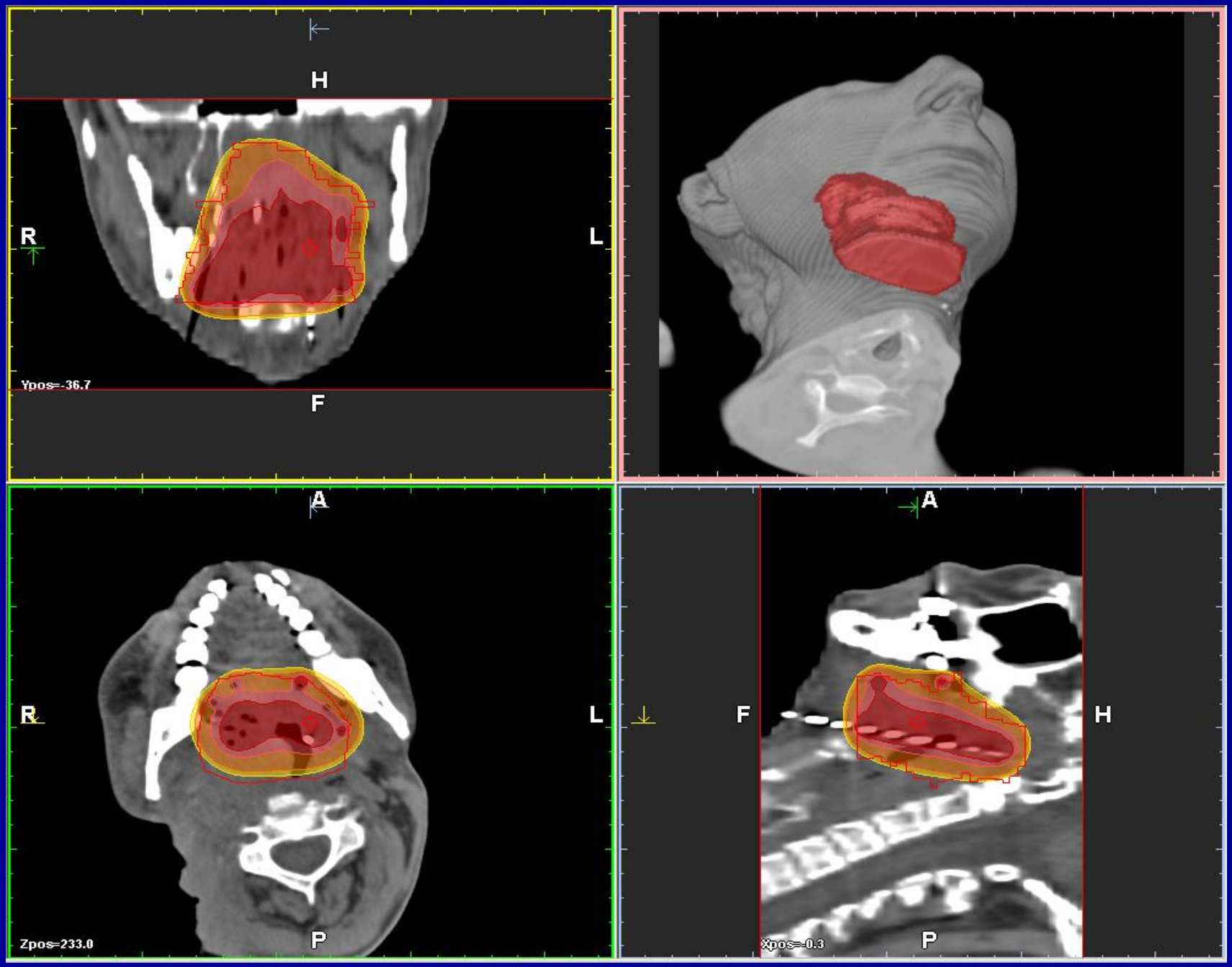
Epipharynx

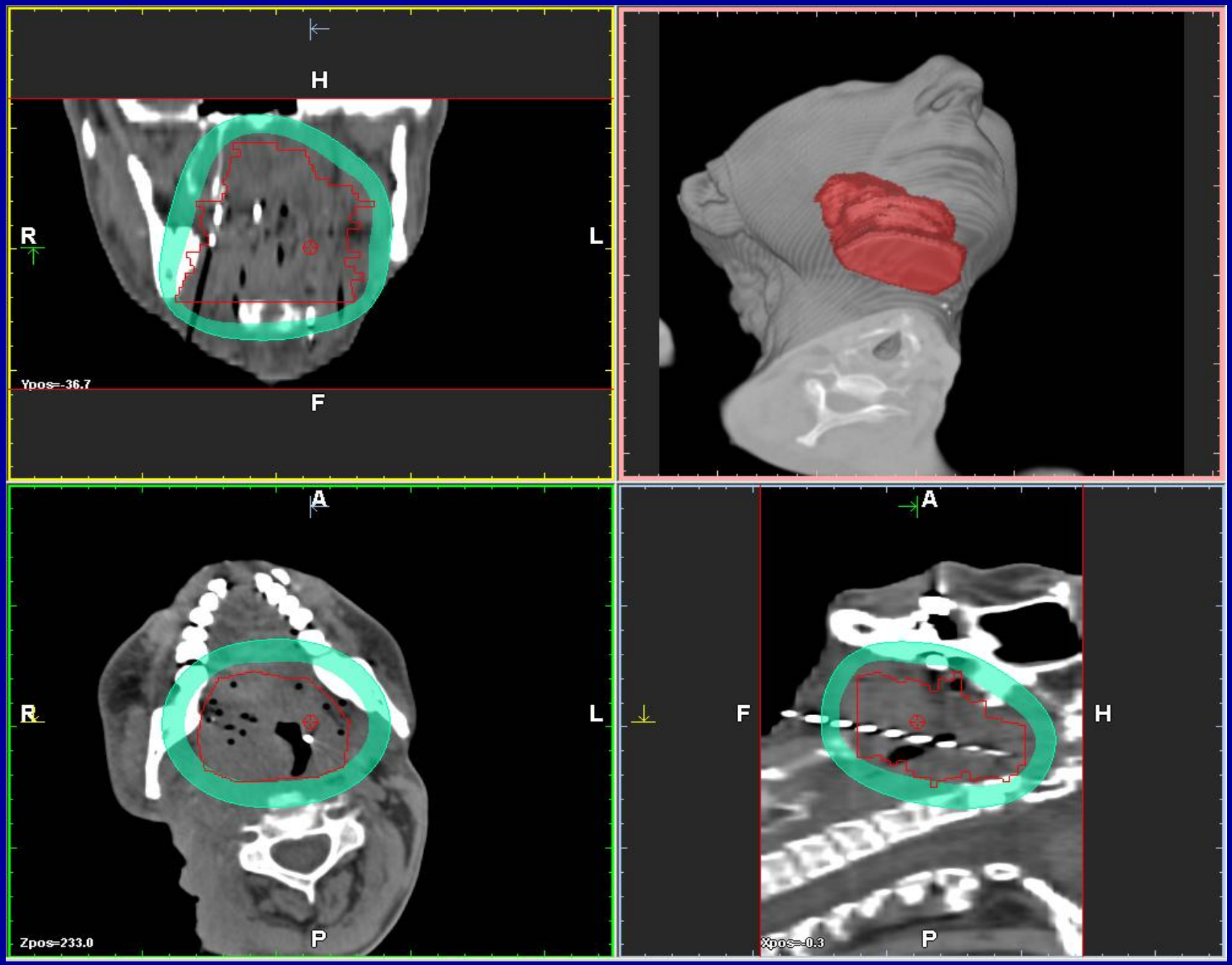
oral cavity

oropharynx


H
R
L
Ypos=-36.7
F
A
R
L
Zpos=233.0
P
A
F
H
Xpos=-0.3
P


H
R
L
Ypos=-36.7
F
A
R
L
Zpos=233.0
P
A
F
H
Xpos=-0.3
P


H
R
L
Ypos=-36.7
F
A
R
L
Zpos=233.0
P
A
F
H
Xpos=-0.3
P


H
R
L
Ypos=-36.7
F
A
R
L
Zpos=233.0
P
A
F
H
Xpos=-0.3
P

Site of relapse

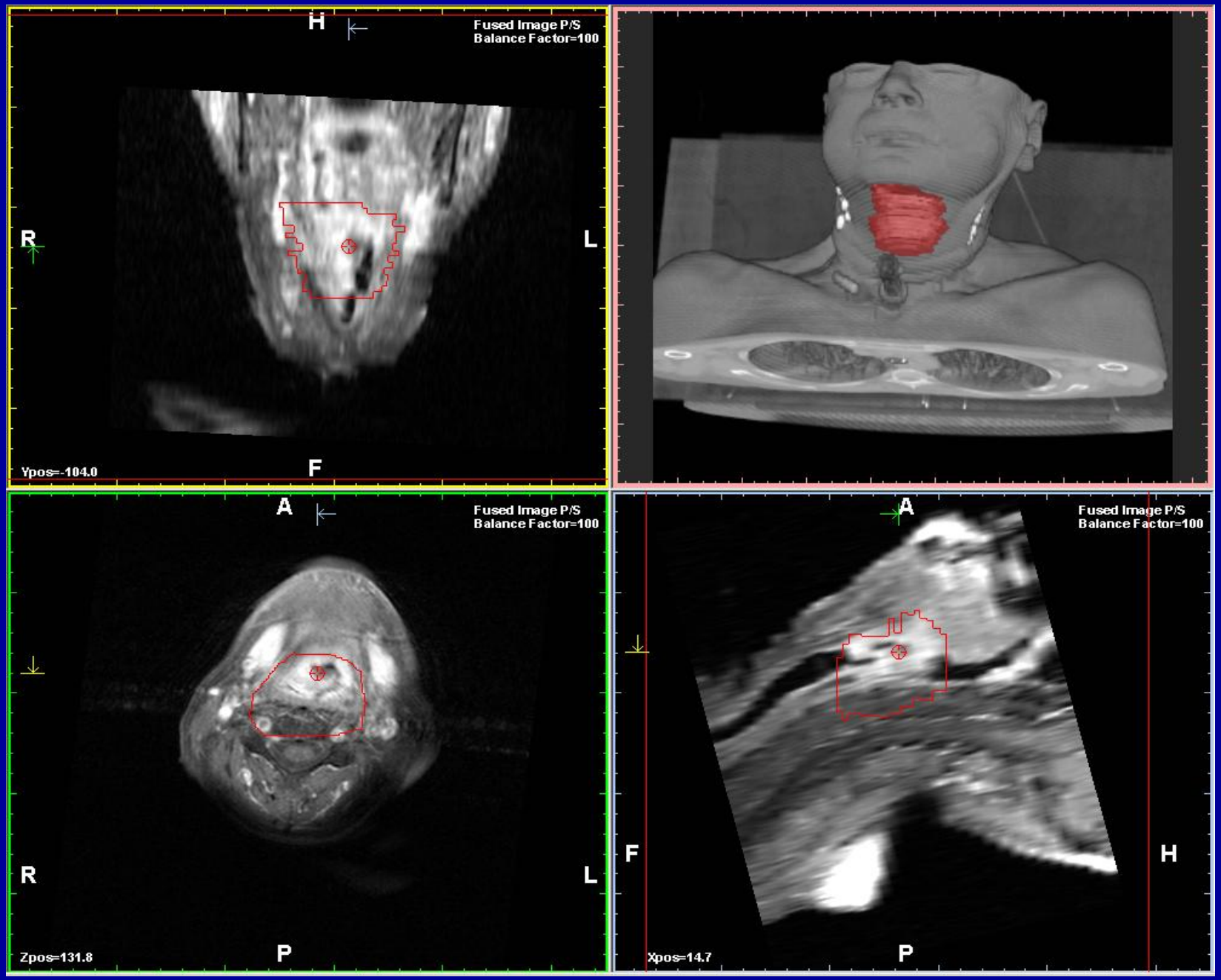
- **Head and Neck mucosal structures**

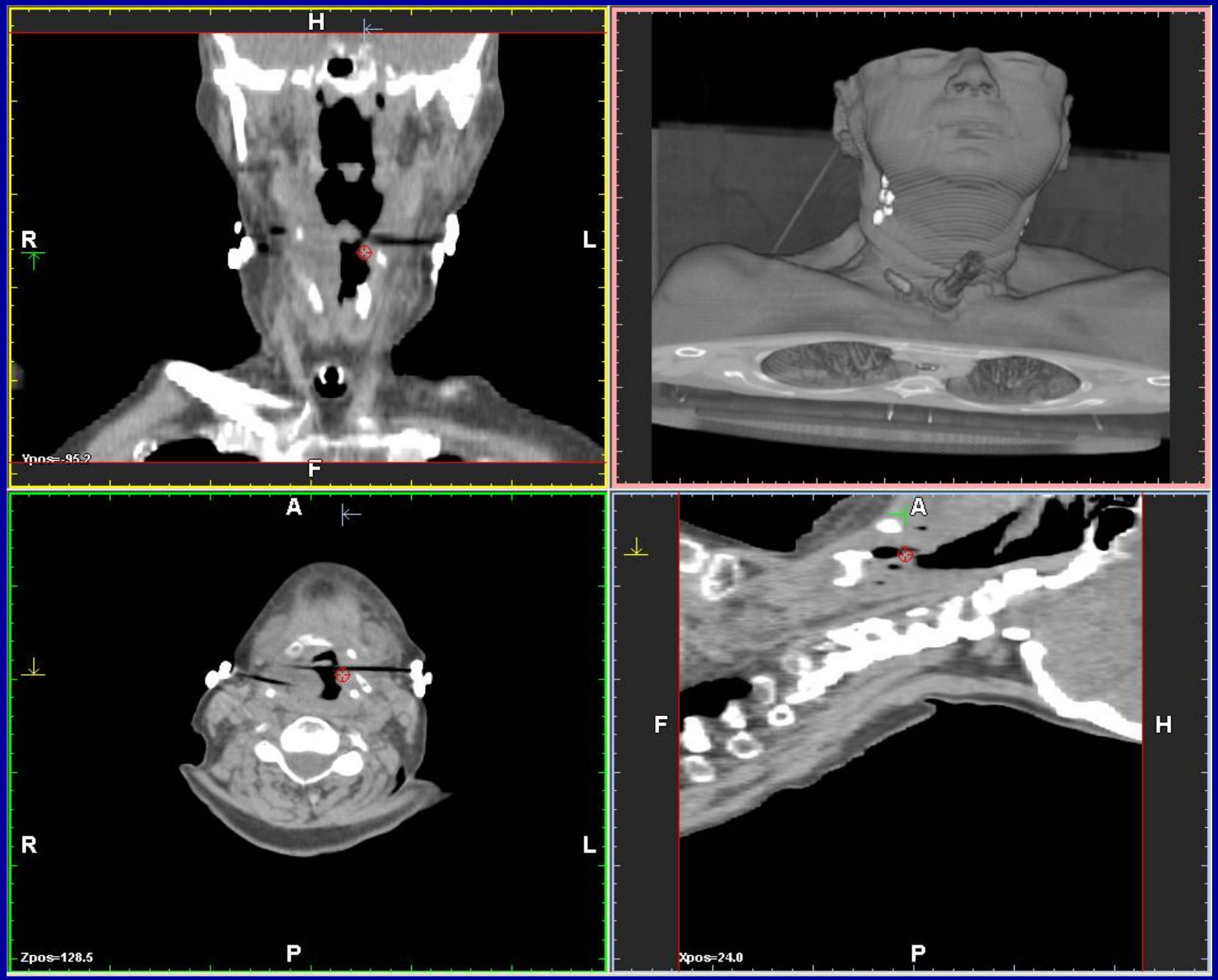
Epipharynx

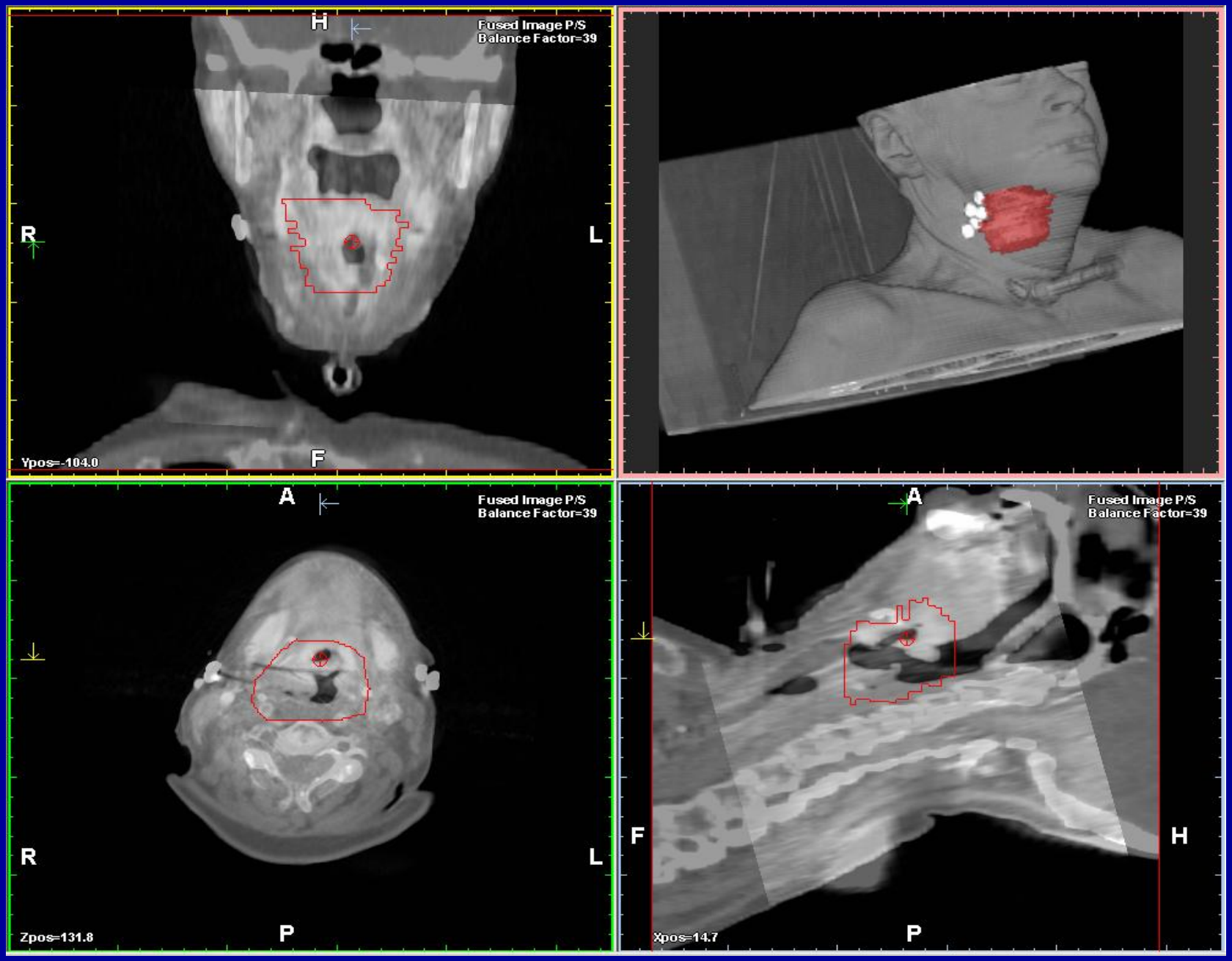
Oral cavity

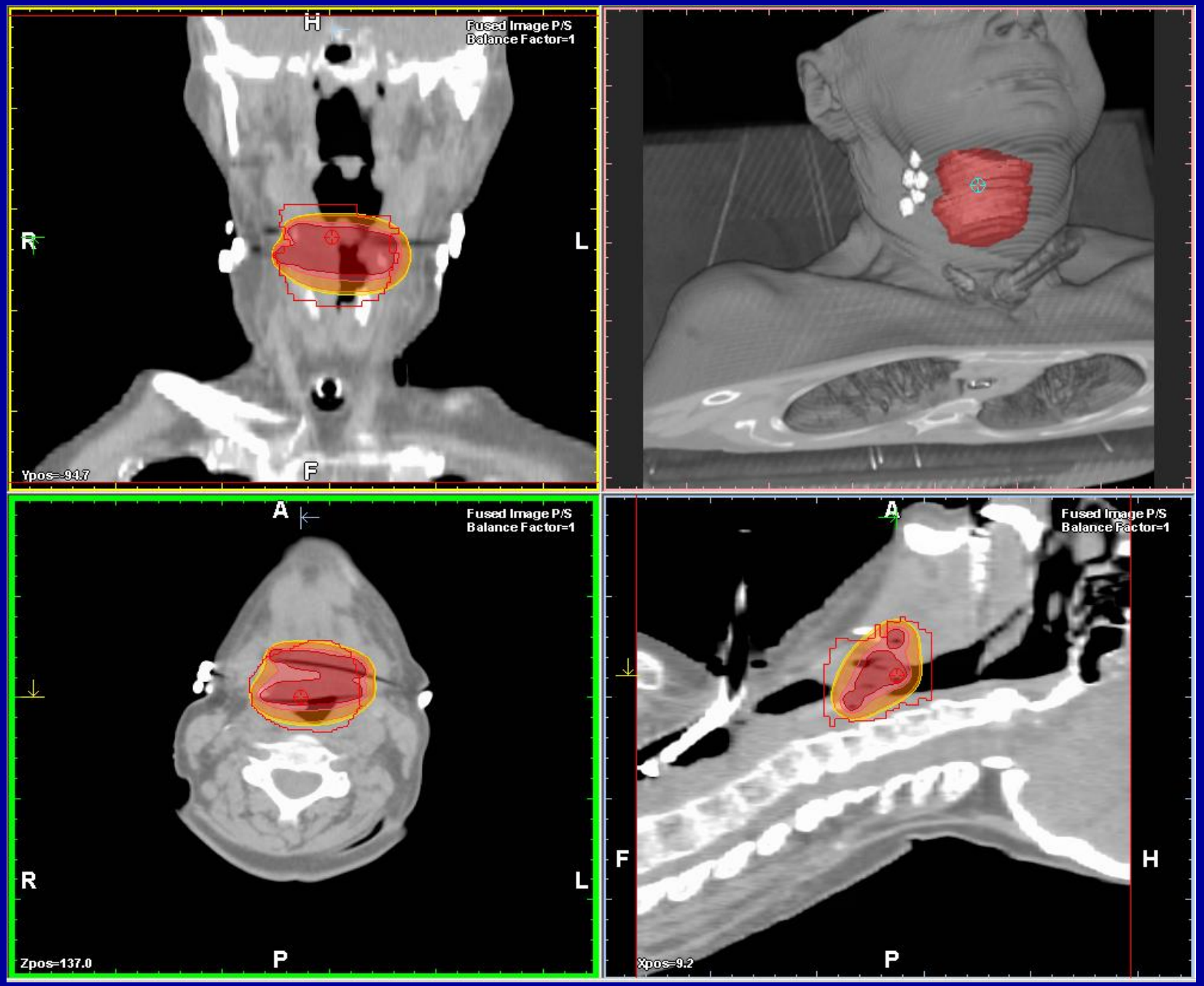
Oropharynx

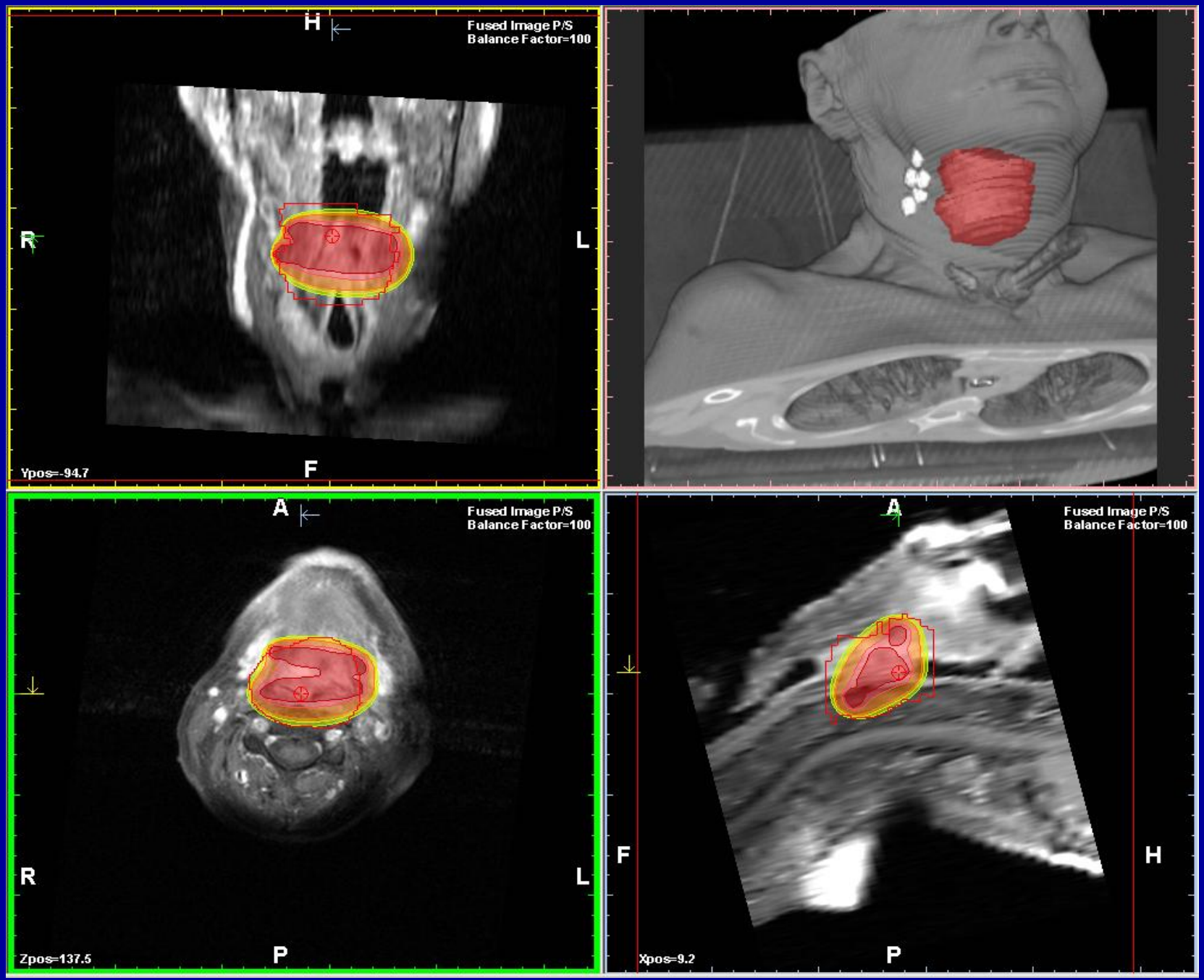
Hypopharynx - Larynx

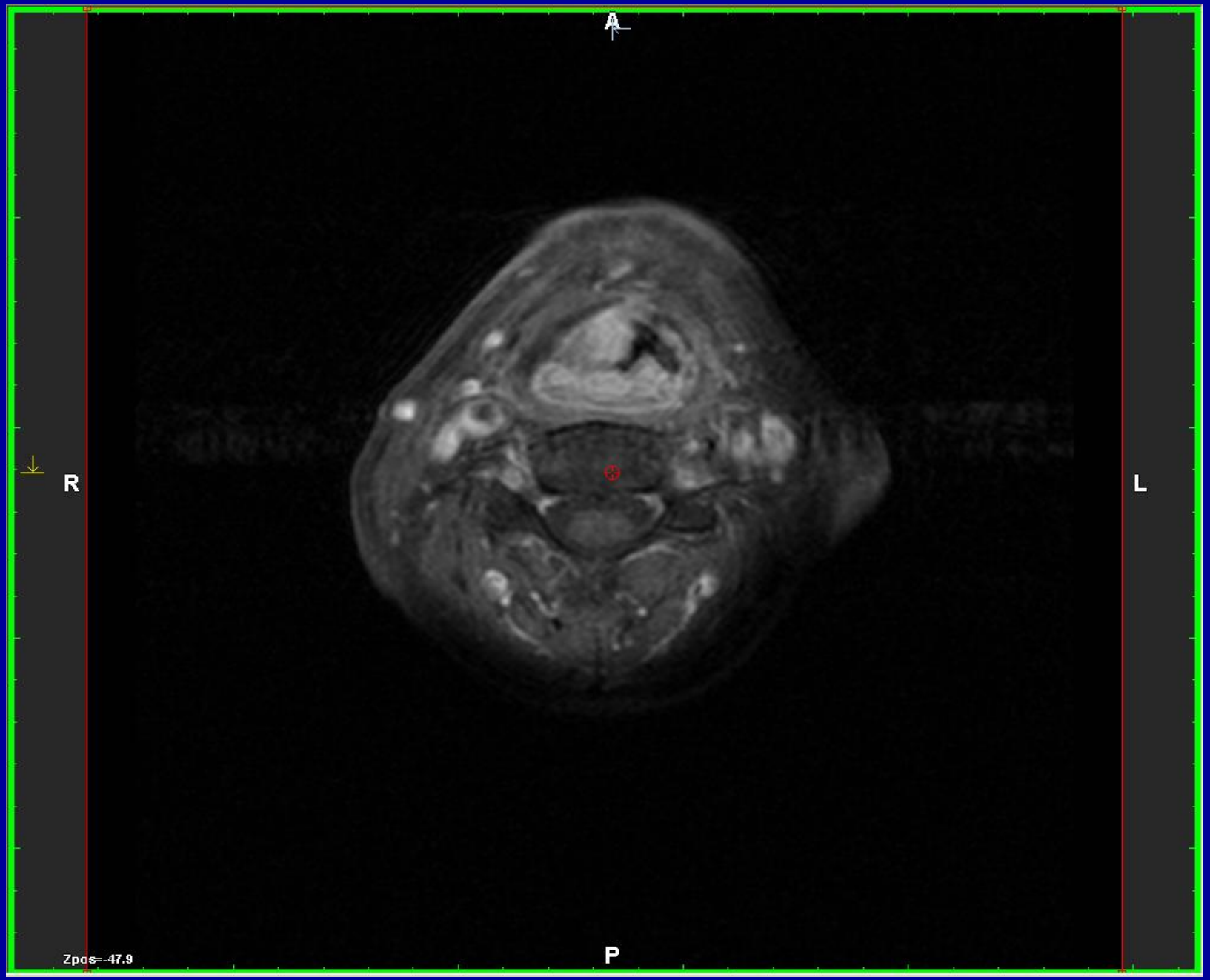

H
Fused Image P/S
Balance Factor=100
R
L
F
Ypos=-104.0
A
Fused Image P/S
Balance Factor=100
R
L
P
Zpos=131.8
A
Fused Image P/S
Balance Factor=100
F
H
P
Xpos=14.7


H
R
L
F
Ypos=-95.2
A
R
L
P
Zpos=128.5
A
F
H
P
Xpos=24.0


H
Fused Image P/S
Balance Factor=39
R
L
F
Ypos=-104.0
A
Fused Image P/S
Balance Factor=39
R
L
P
Zpos=131.8
A
Fused Image P/S
Balance Factor=39
F
H
P
Xpos=14.7


H
Fused Image P/S
Balance Factor=1
R
L
F
Ypos=-94.7
A
Fused Image P/S
Balance Factor=1
R
L
P
Zpos=137.0
A
Fused Image P/S
Balance Factor=1
F
H
P
Xpos=9.2


H
Fused Image P/S
Balance Factor=100
R
L
F
Ypos=-94.7
A
Fused Image P/S
Balance Factor=100
R
L
P
Zpos=137.5
A
Fused Image P/S
Balance Factor=100
F
H
P
Xpos=9.2


A
R
L
P
Zpos=-47.9


A
R
L
P
Zpos=-65.7

Site of relapse

- **Head and Neck mucosal structures**

Epipharynx

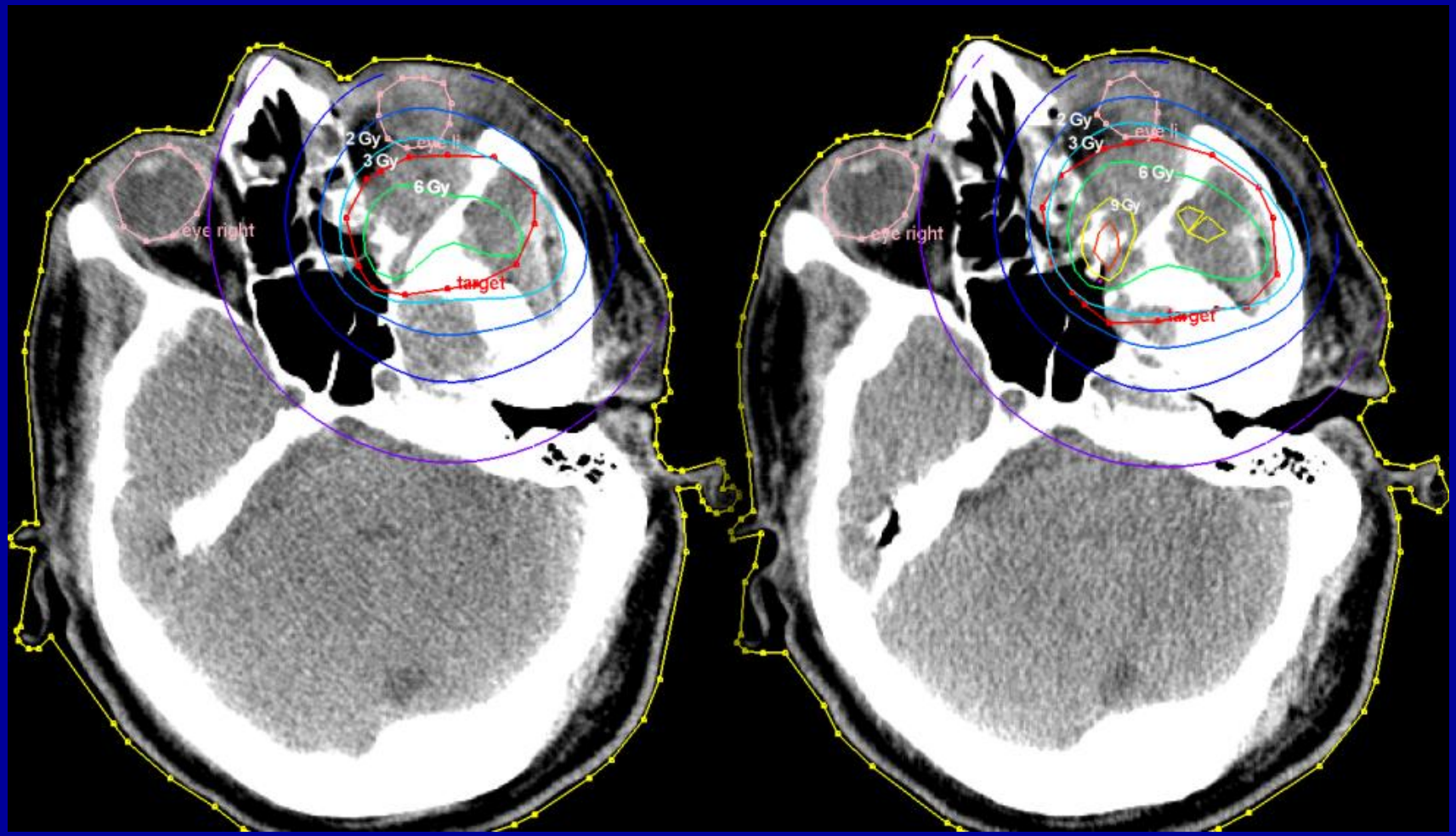
Oral cavity

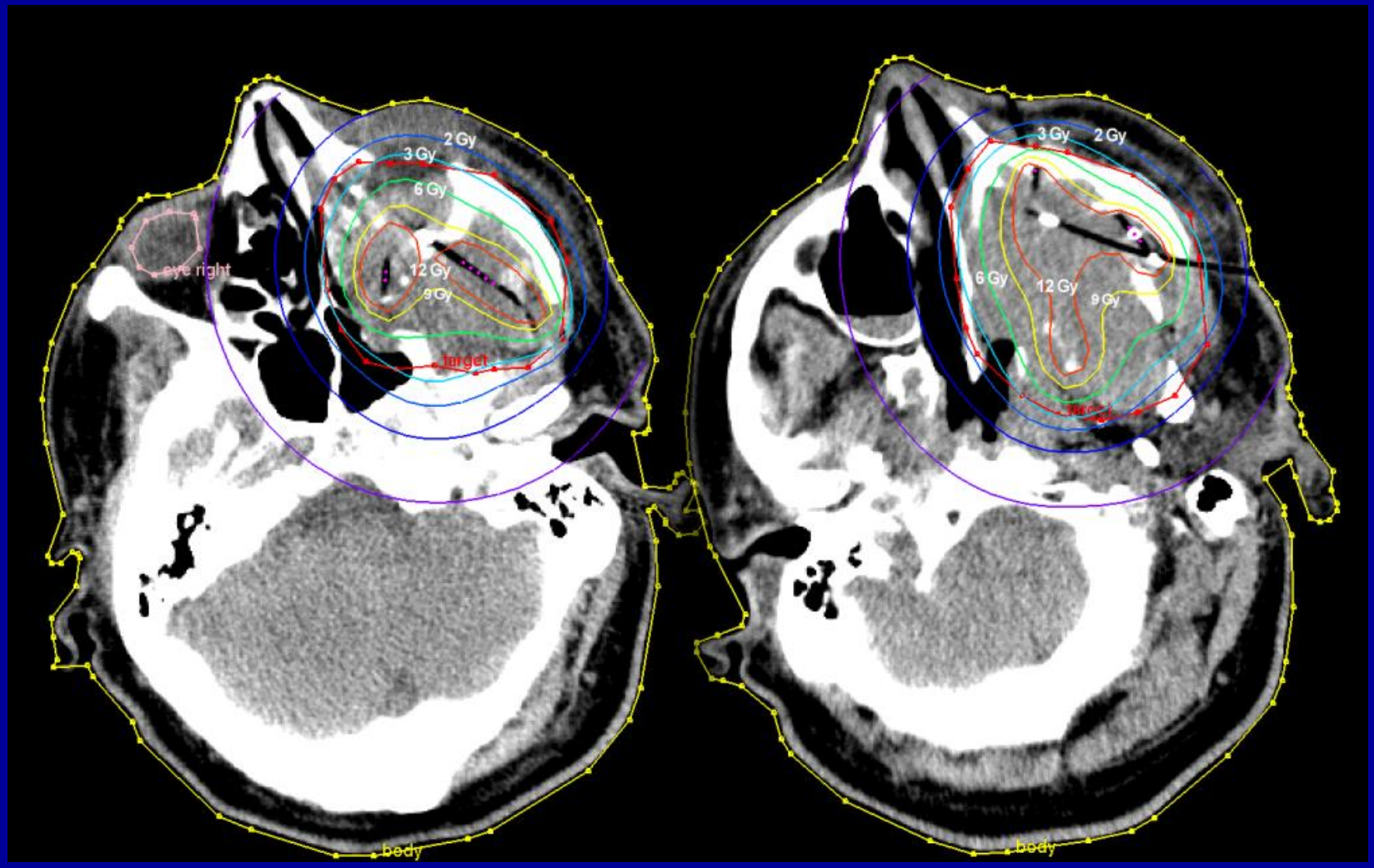
Oropharynx

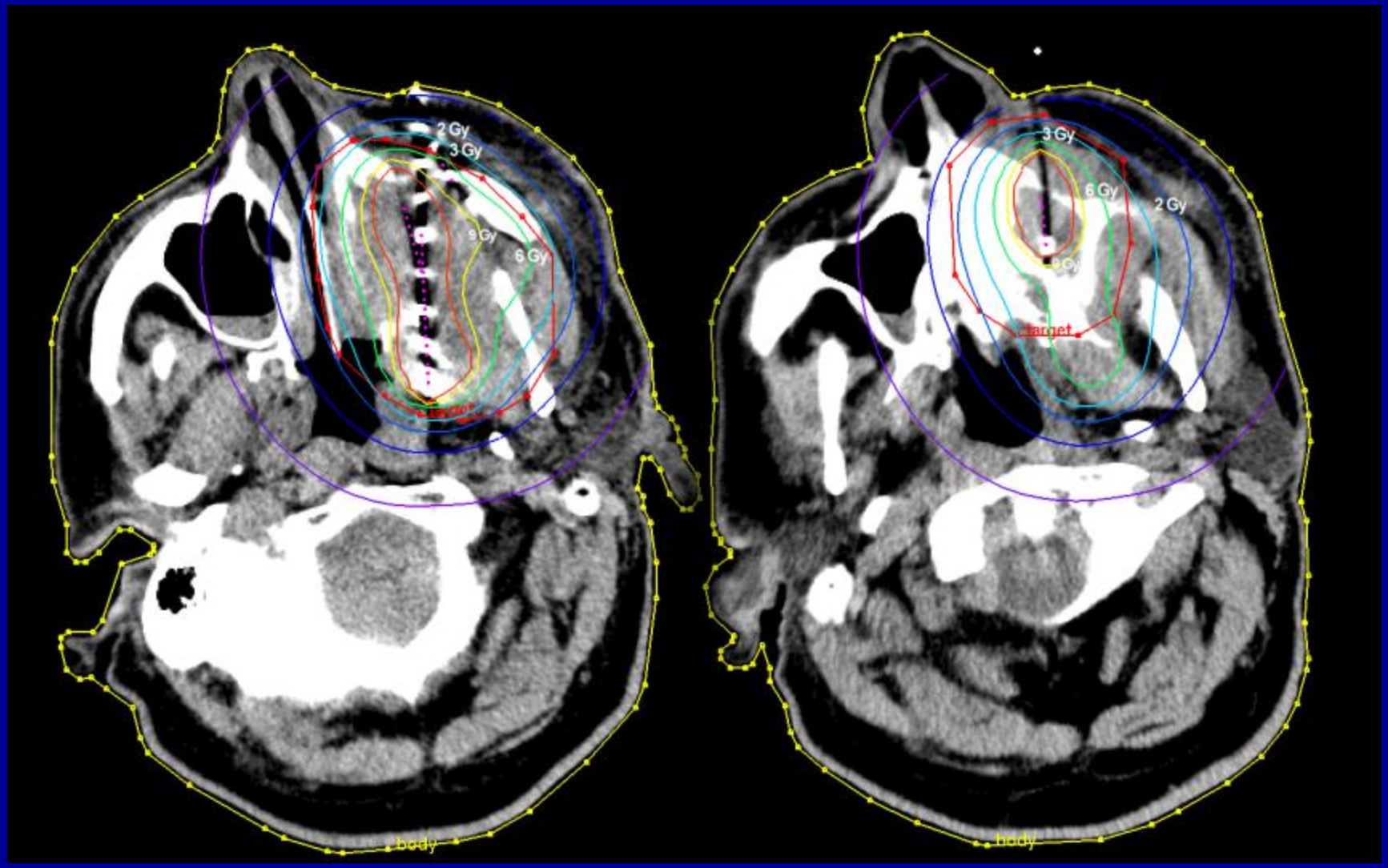
Hypopharynx – Larynx

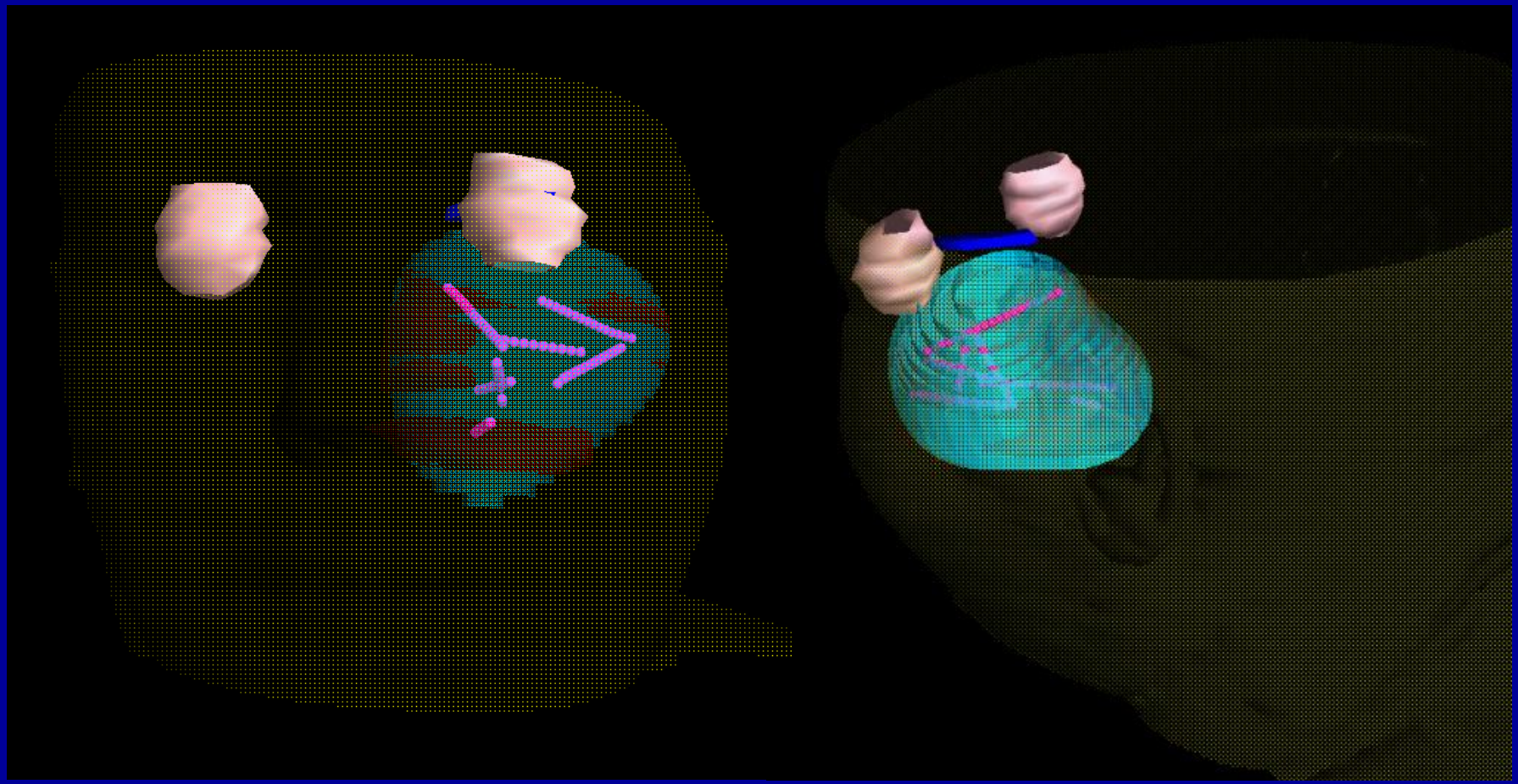
Sinus Maxillaris

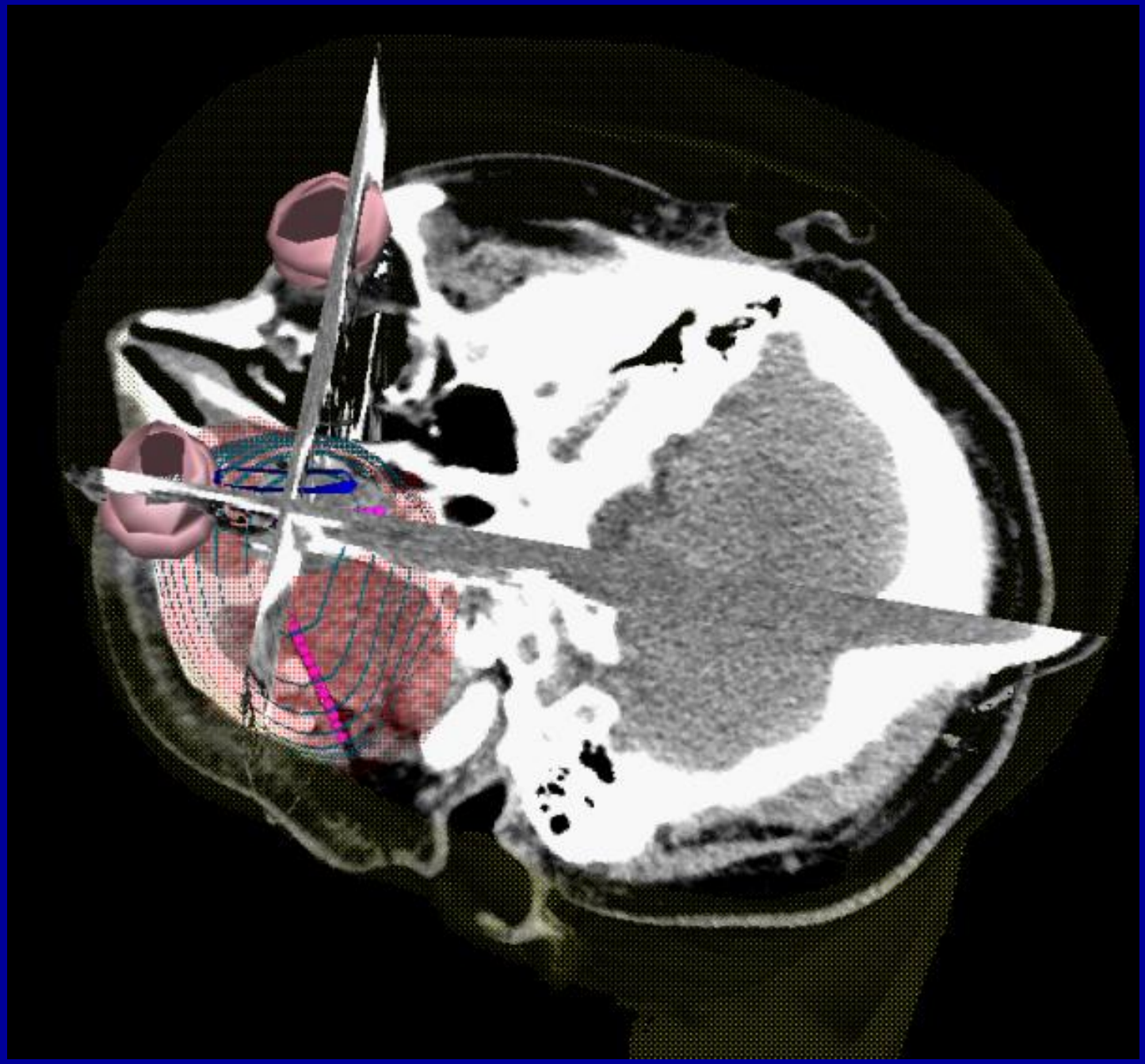
Implant for recurrence of a sinus maxillaris tumour




2 Gy
3 Gy
6 Gy
12 Gy
9 Gy
eye right
target
body
3 Gy
2 Gy
6 Gy
12 Gy
9 Gy
body


2 Gy
3 Gy
9 Gy
6 Gy
target
body
3 Gy
6 Gy
2 Gy
9 Gy
target
body





Site of relapse

- **Head and Neck mucosal structures**

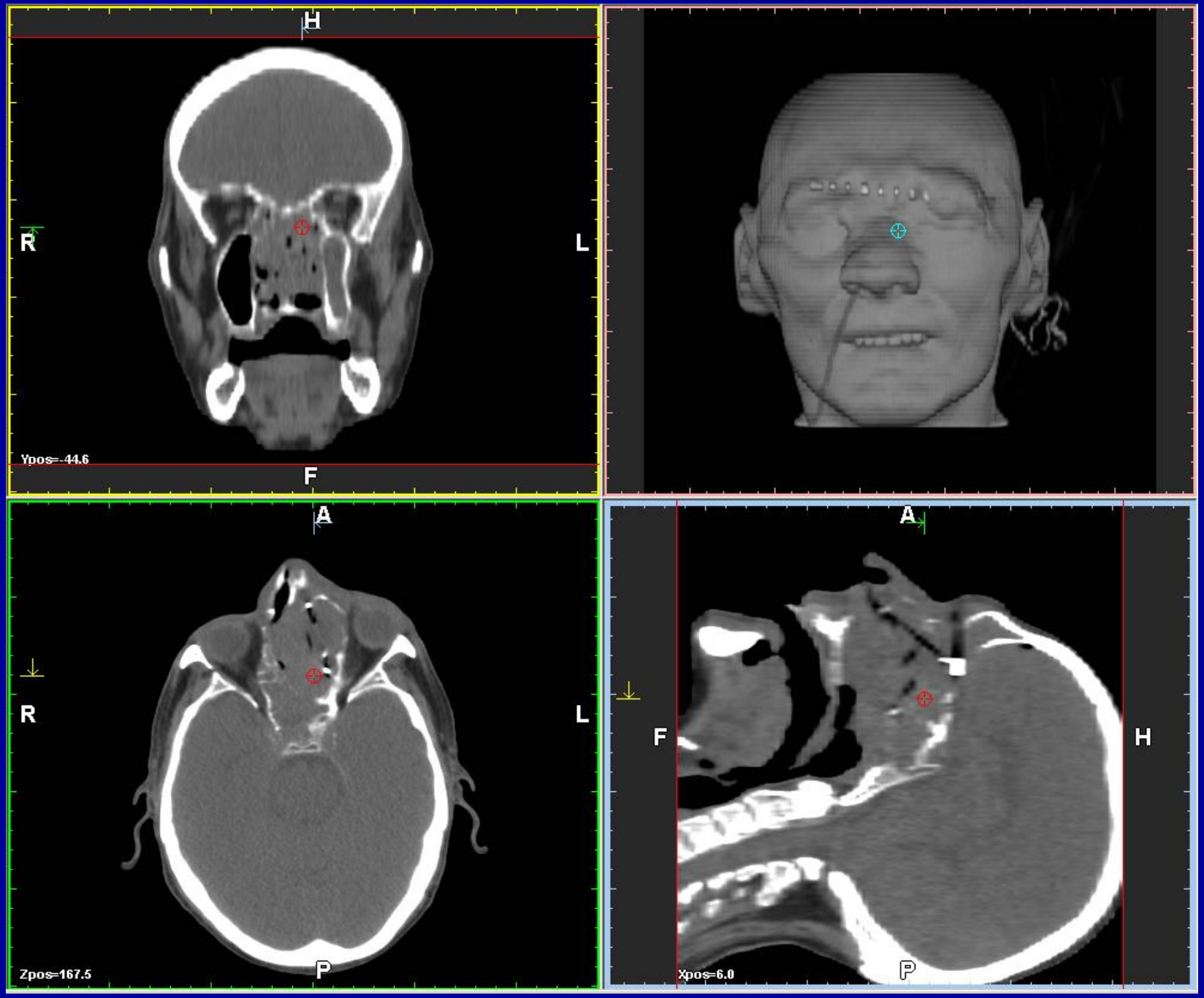
Epipharynx

Oral cavity

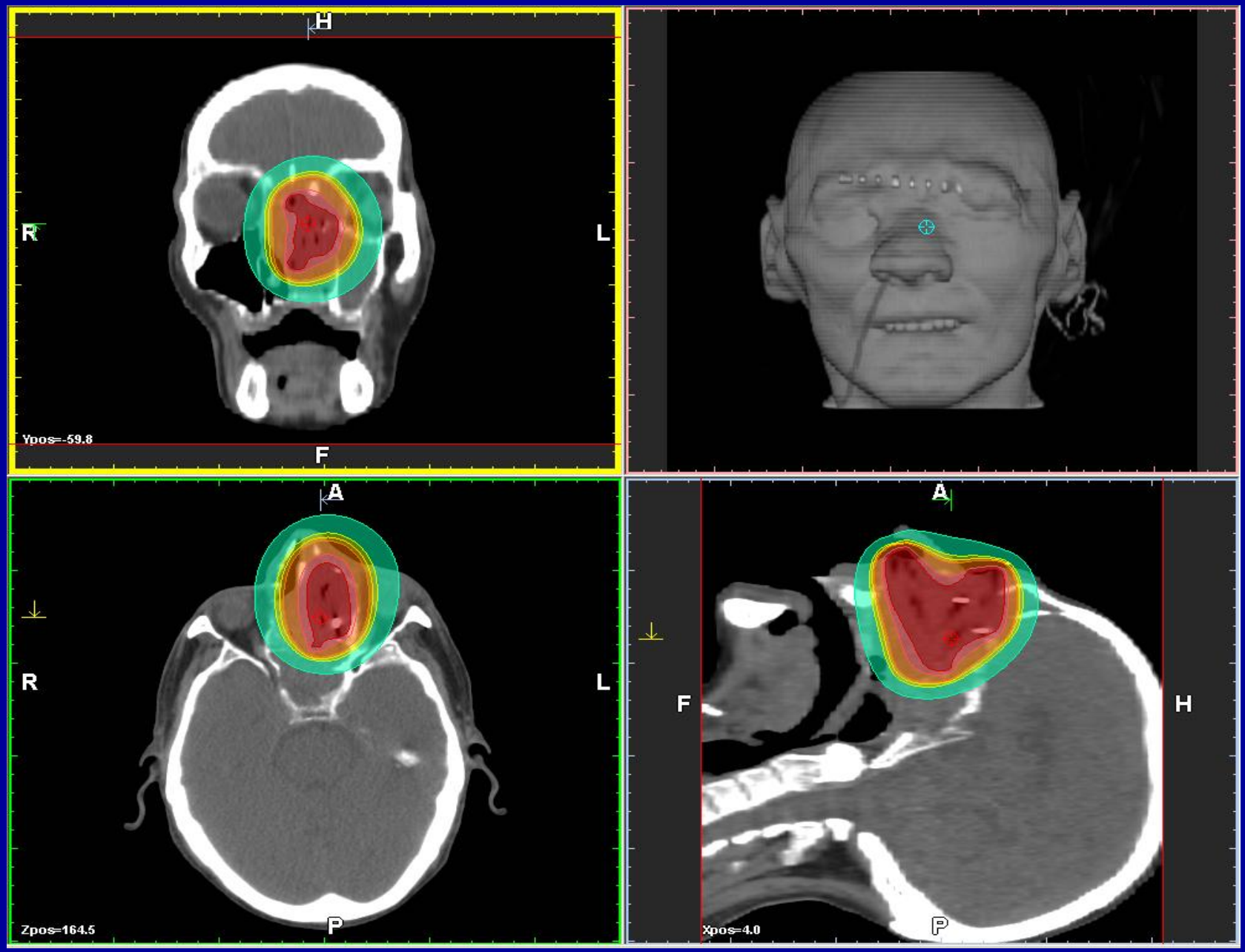
Oropharynx

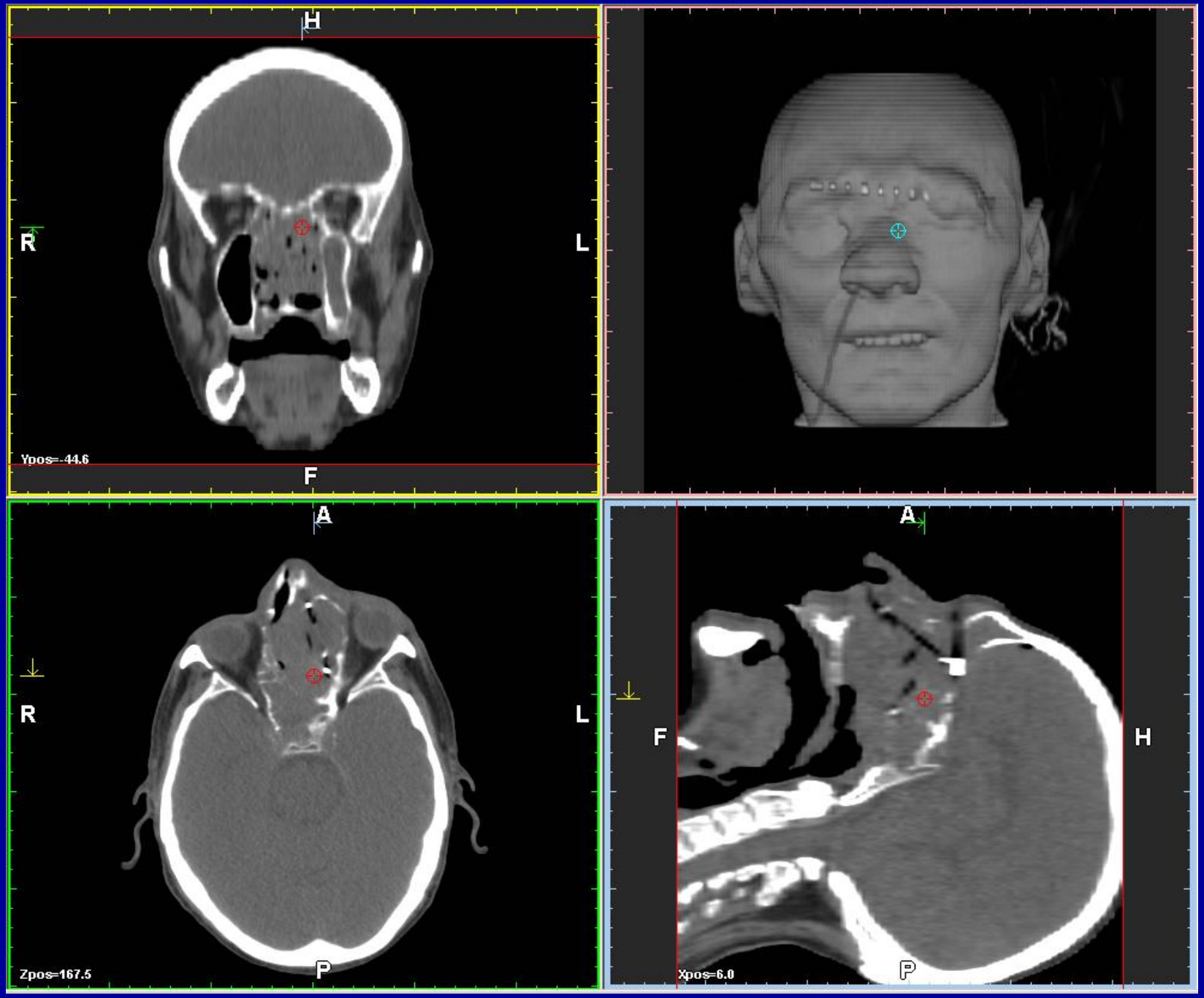
Hypopharynx – Larynx

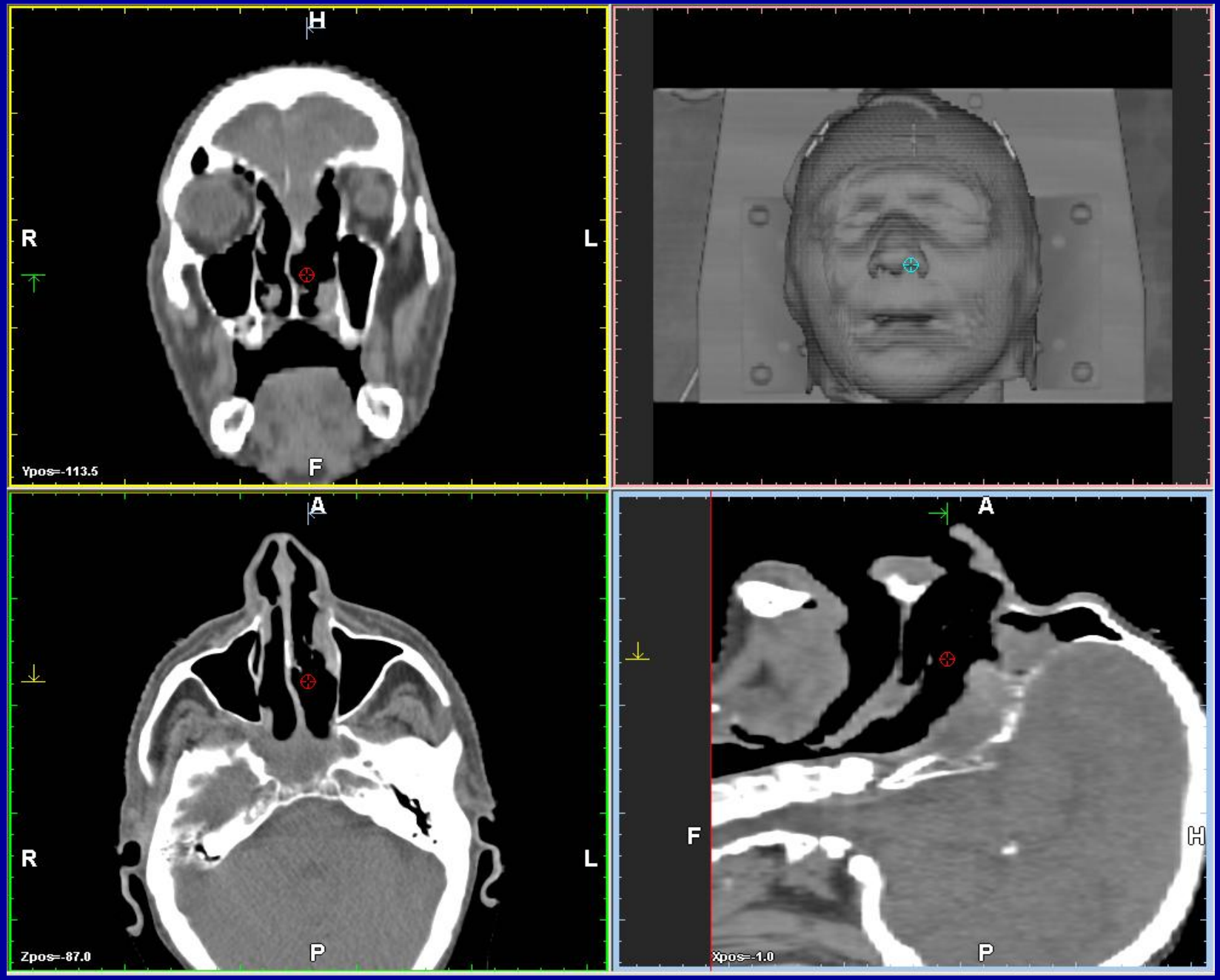
Sinus Maxillaris - Nasalis


H
R
L
F
Ypos=-44.6
A
R
L
P
Zpos=167.5
A
F
H
P
Xpos=6.0


A
R
L
P
Target
Max Dose[4629.695 cGy]
Zpos=149.5


H
R
L
F
Ypos=-59.8
A
R
L
P
Zpos=164.5
A
F
H
P
Xpos=4.0

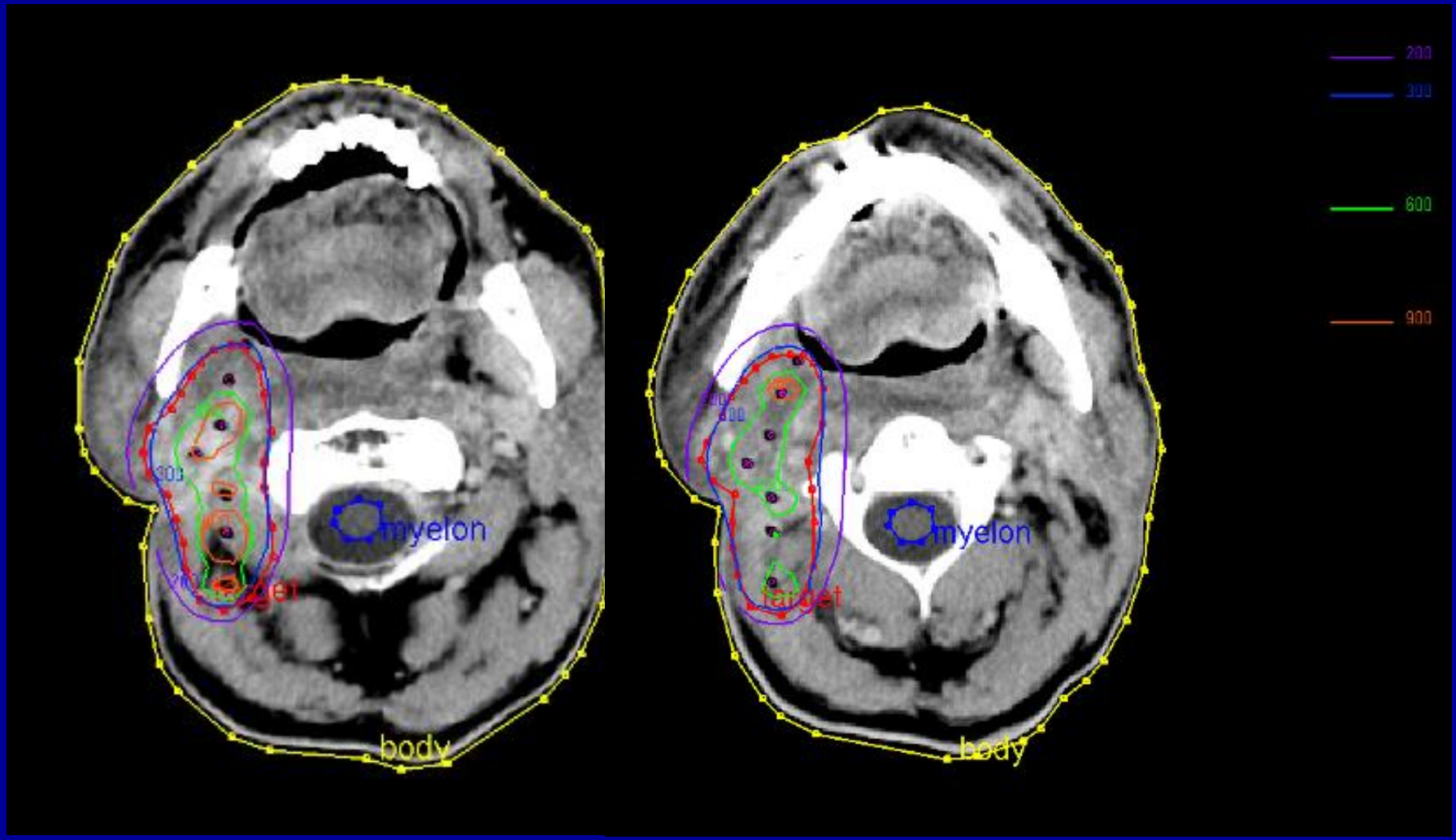

H
R
L
F
Ypos=-44.6
A
R
L
P
Zpos=167.5
A
F
H
P
Xpos=6.0


H
R
L
F
Ypos=-113.5
A
R
L
P
Zpos=-87.0
A
F
H
P
Xpos=-1.0

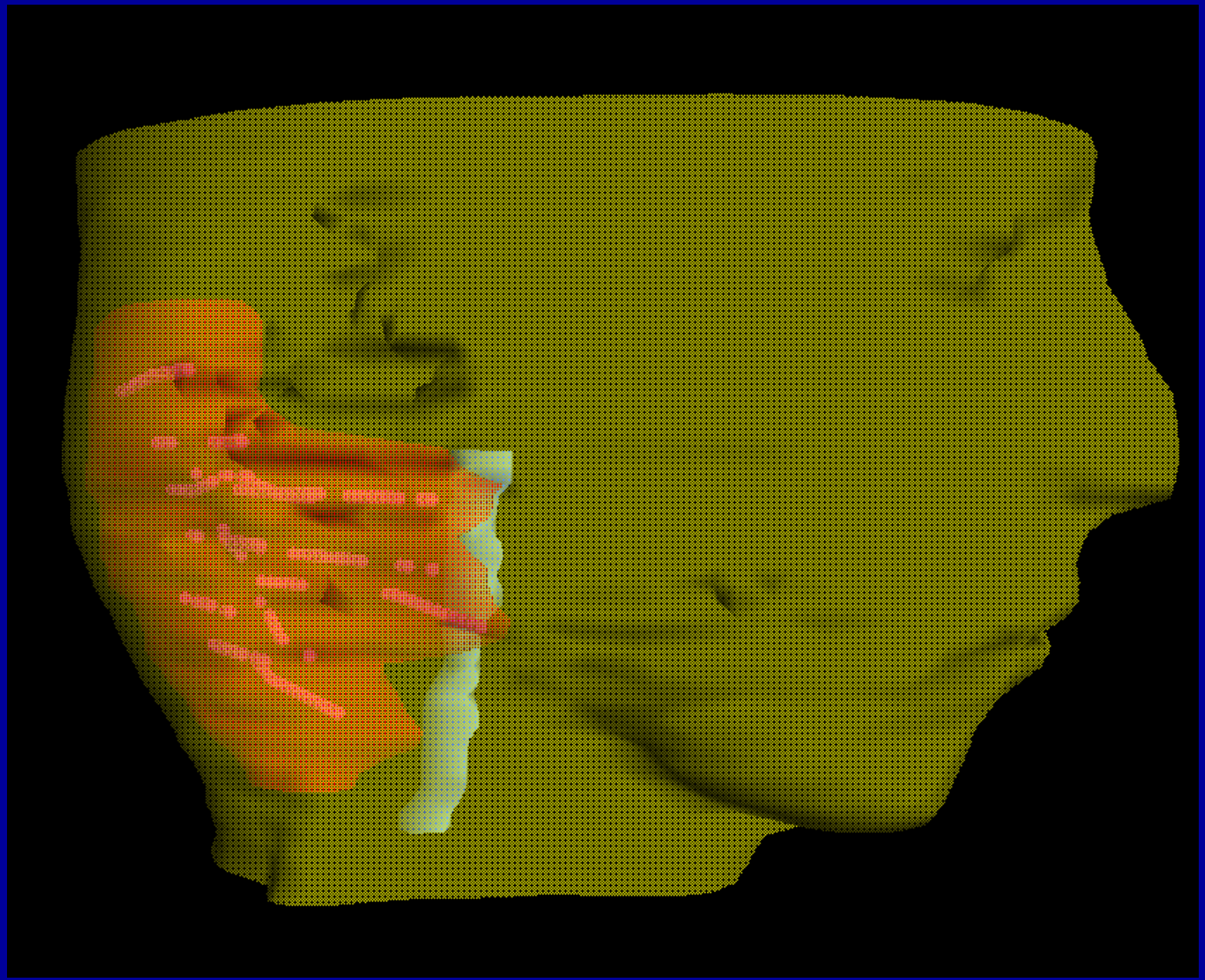
Site of relapse

- Neck lymphadenopathy

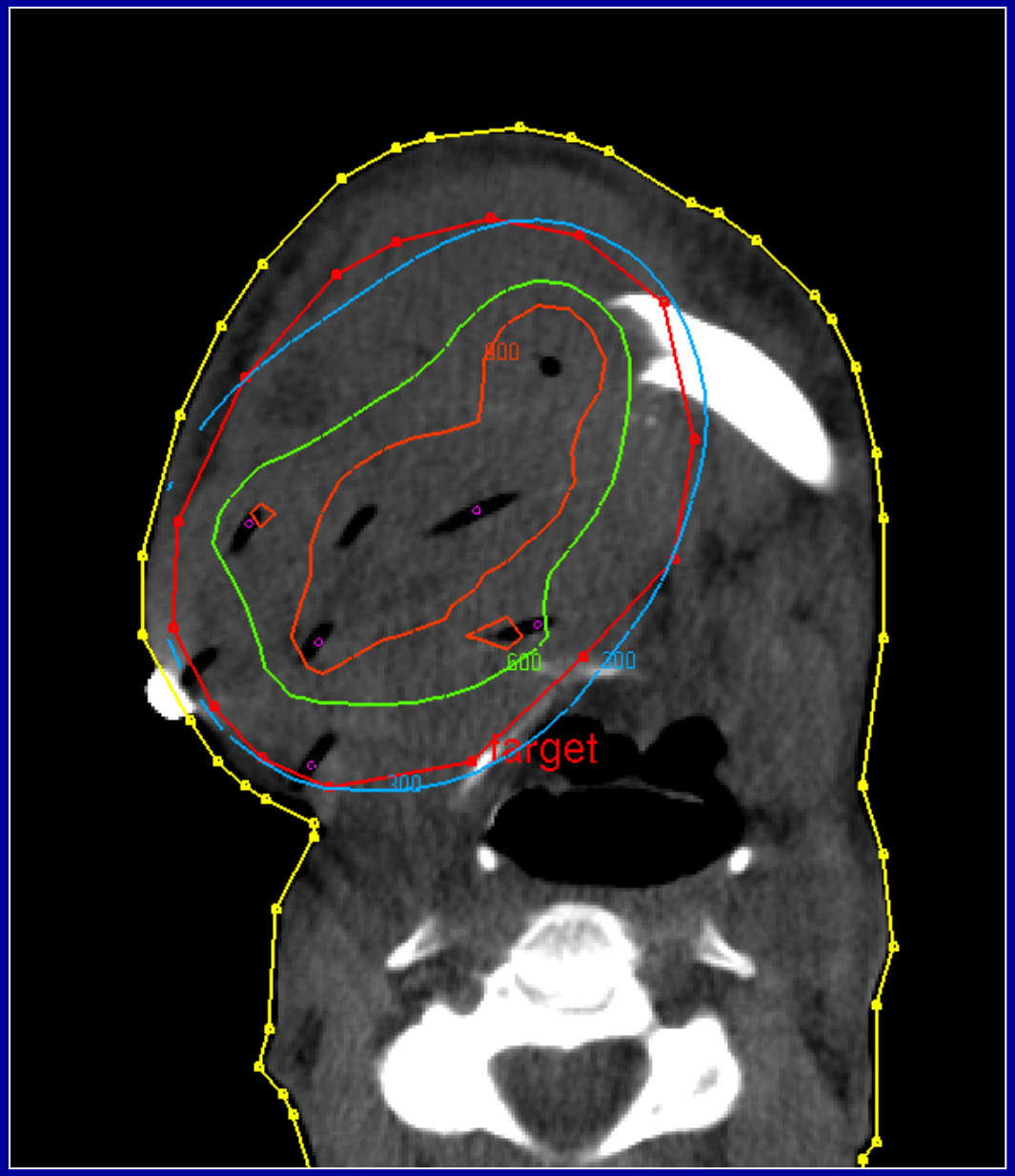
Cervical



Nuchal



Retroauricular



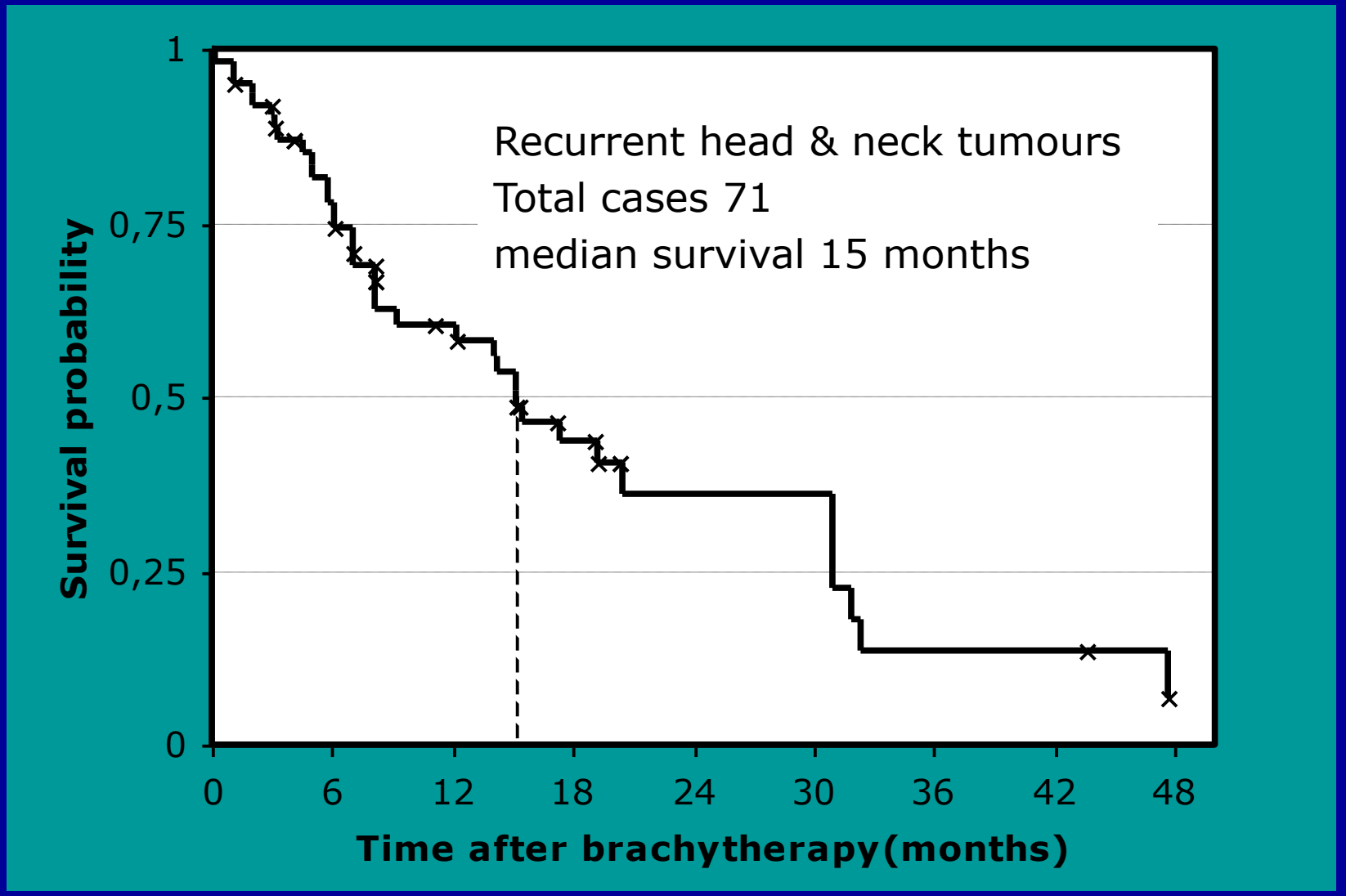
Submental

isodoses

9 weeks after BRT

10 weeks after BRT

Results


Recurrent head & neck tumours
Total cases 71
median survival 15 months
Survival probability
1
0,75
0,5
0,25
0
0
6
12
18
24
30
36
42
48
Time after brachytherapy(months)

Fractionation: twice daily 3 Gy

n=74 Patients

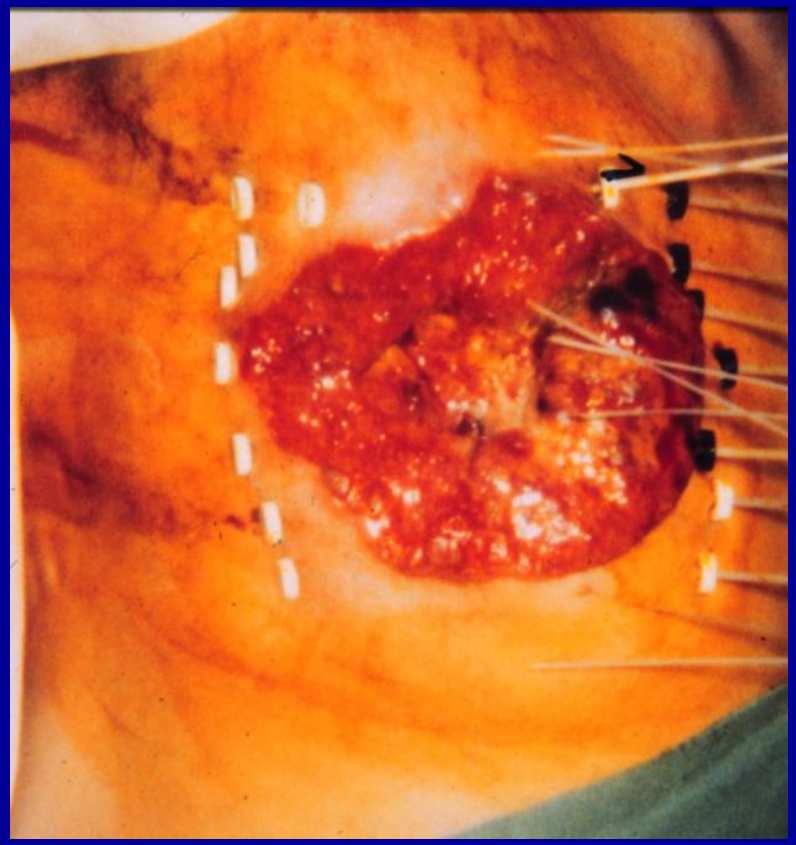
Total brachytherapy dose:

30 Gy 2x3Gy / day

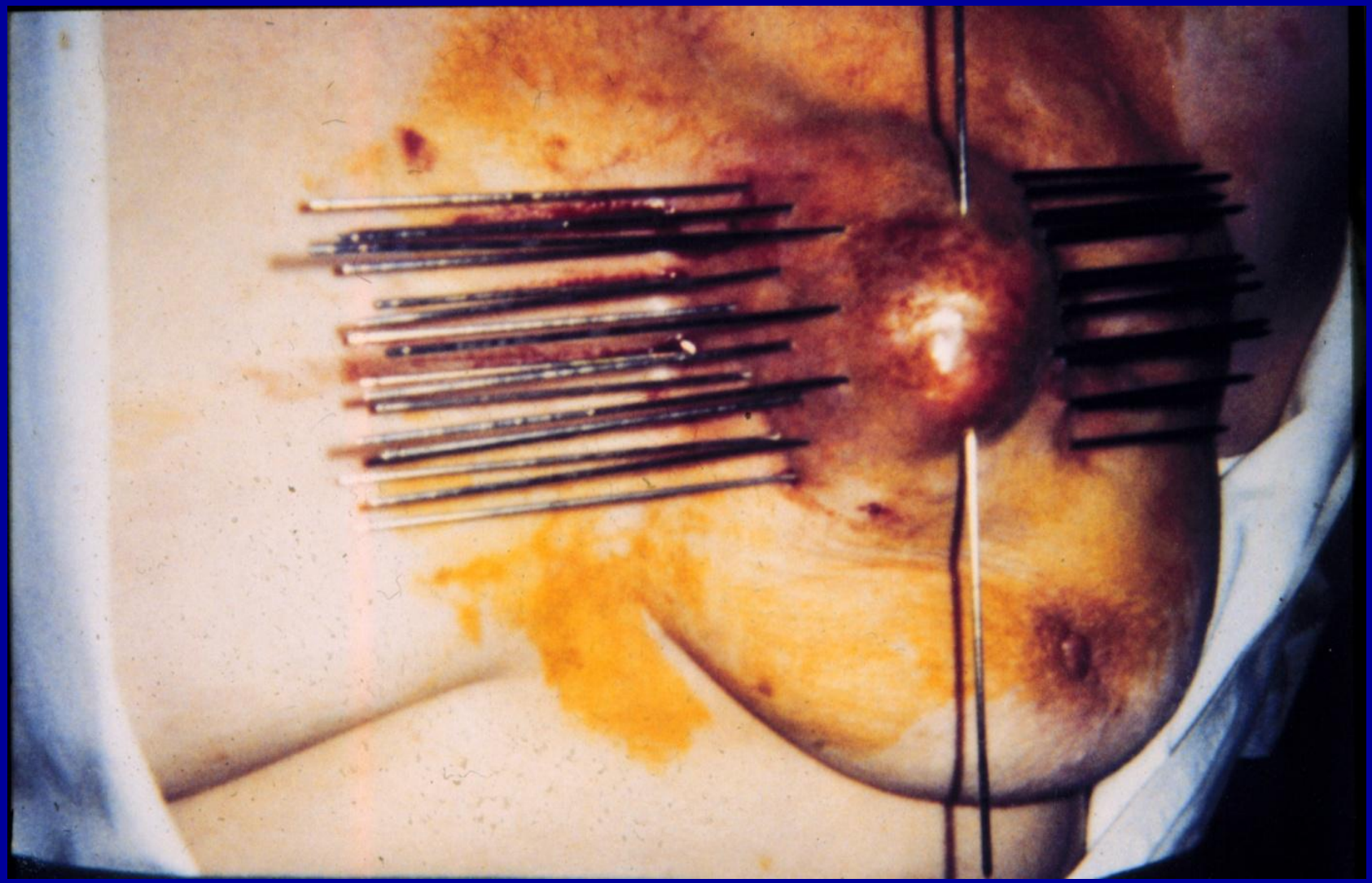
Tselis N, ……Zamboglou N.
Radiother Oncol. 2011 Jan;98(1):57-62. Epub 2010 Dec 2.

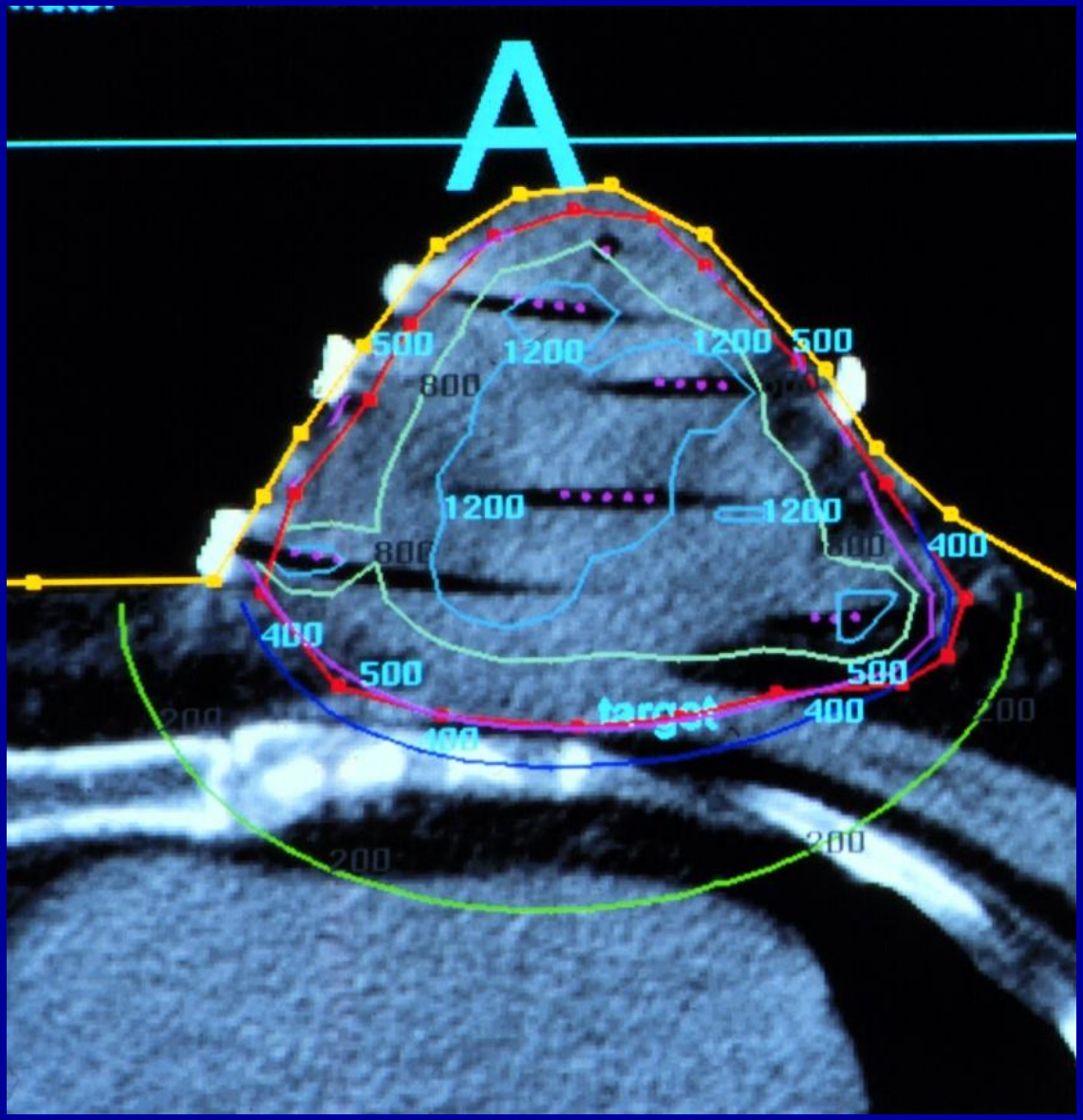
Thoracic Wall

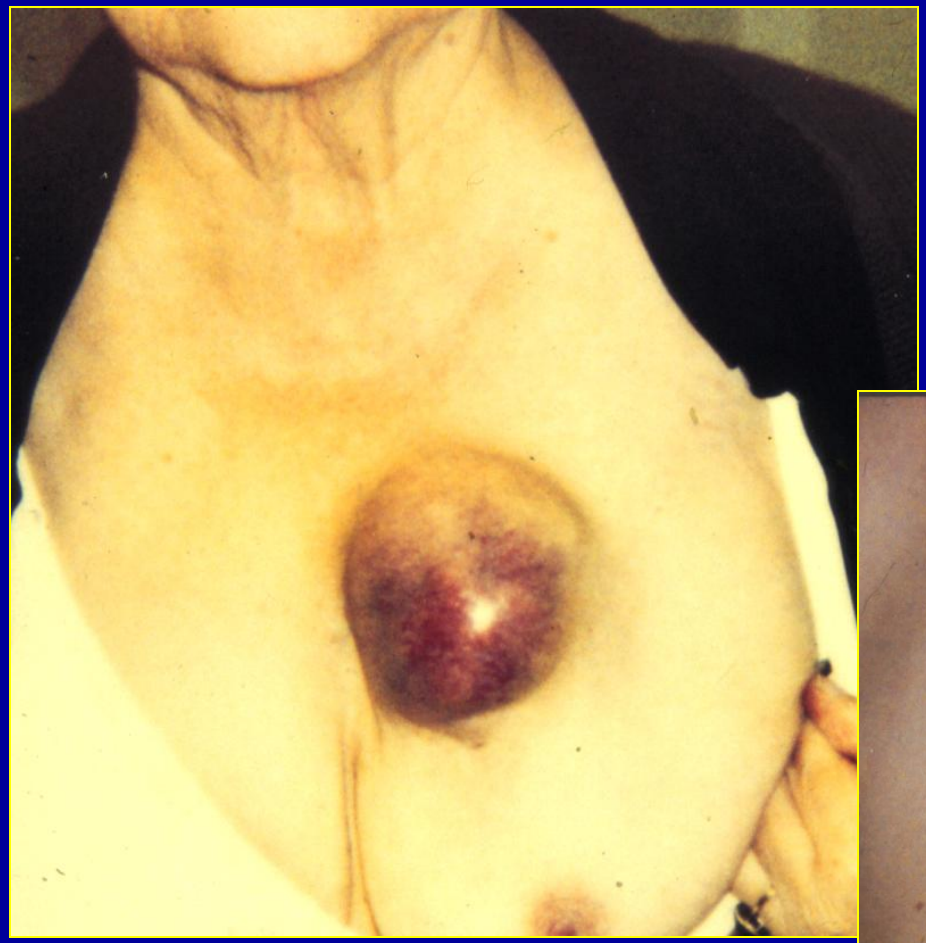
Breast cancer



Breast cancer recurrence

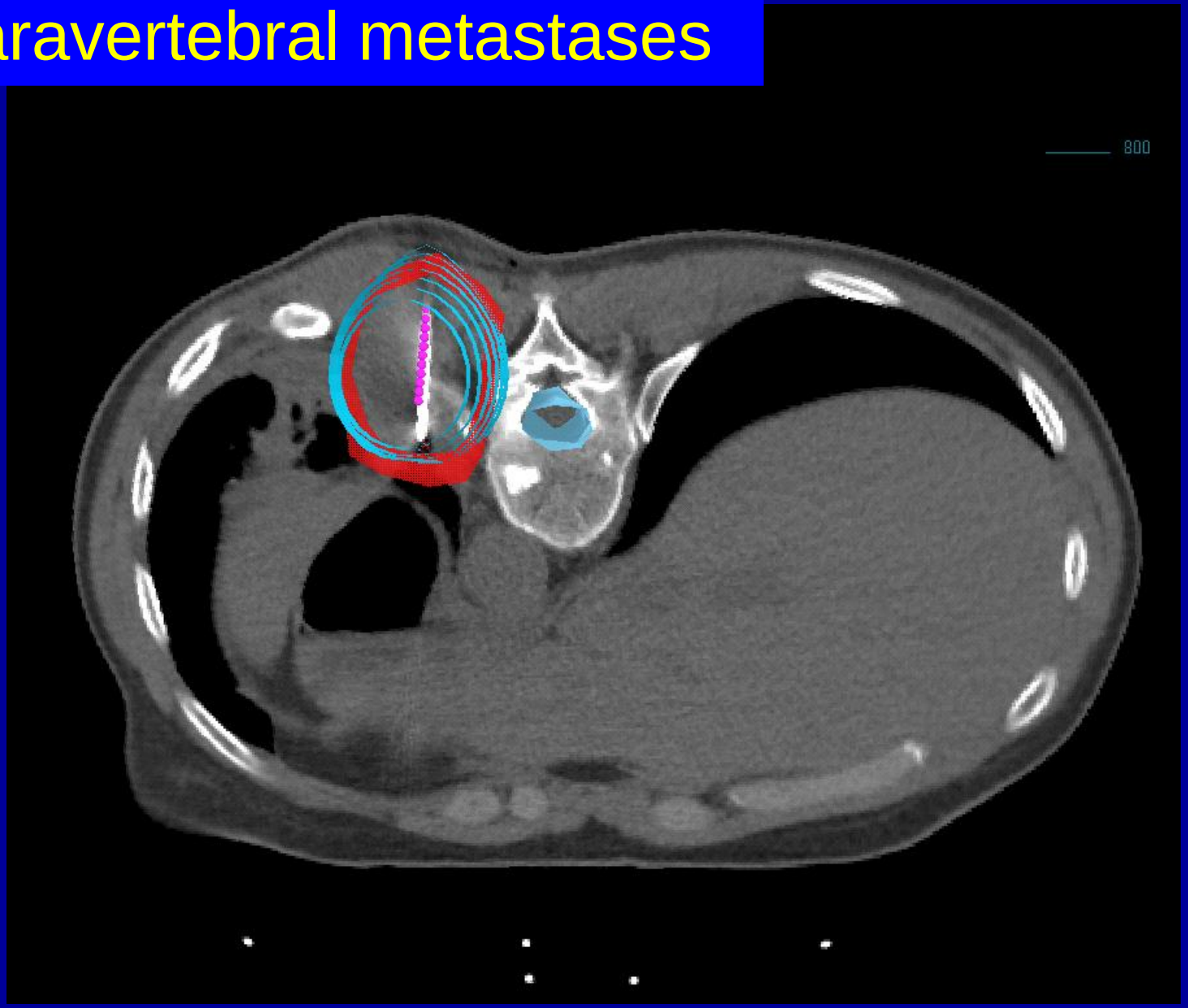


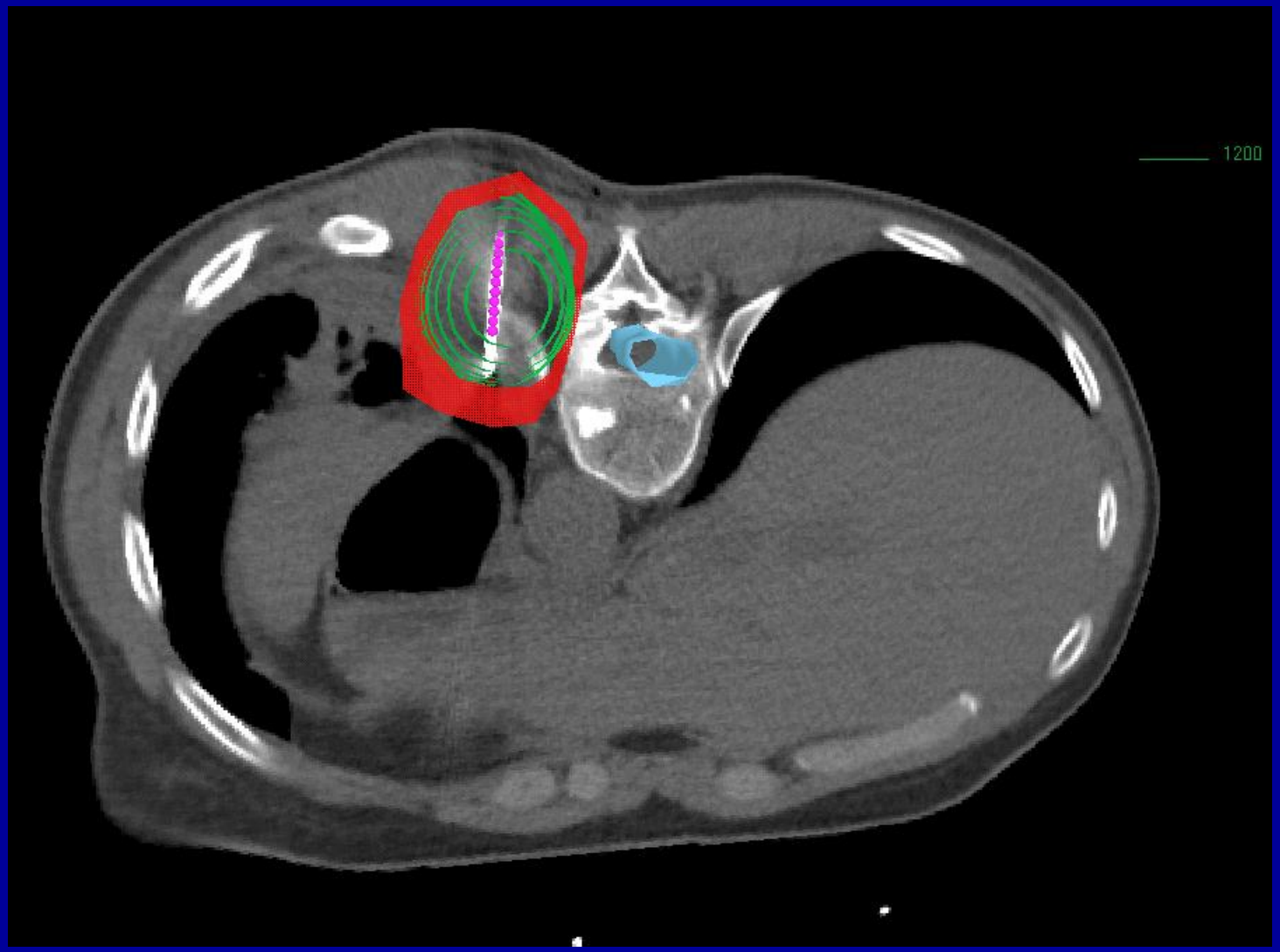

A
500
1200
1200
500
800
1200
1200
400
800
400
500
500
target
400
400
200
200
200

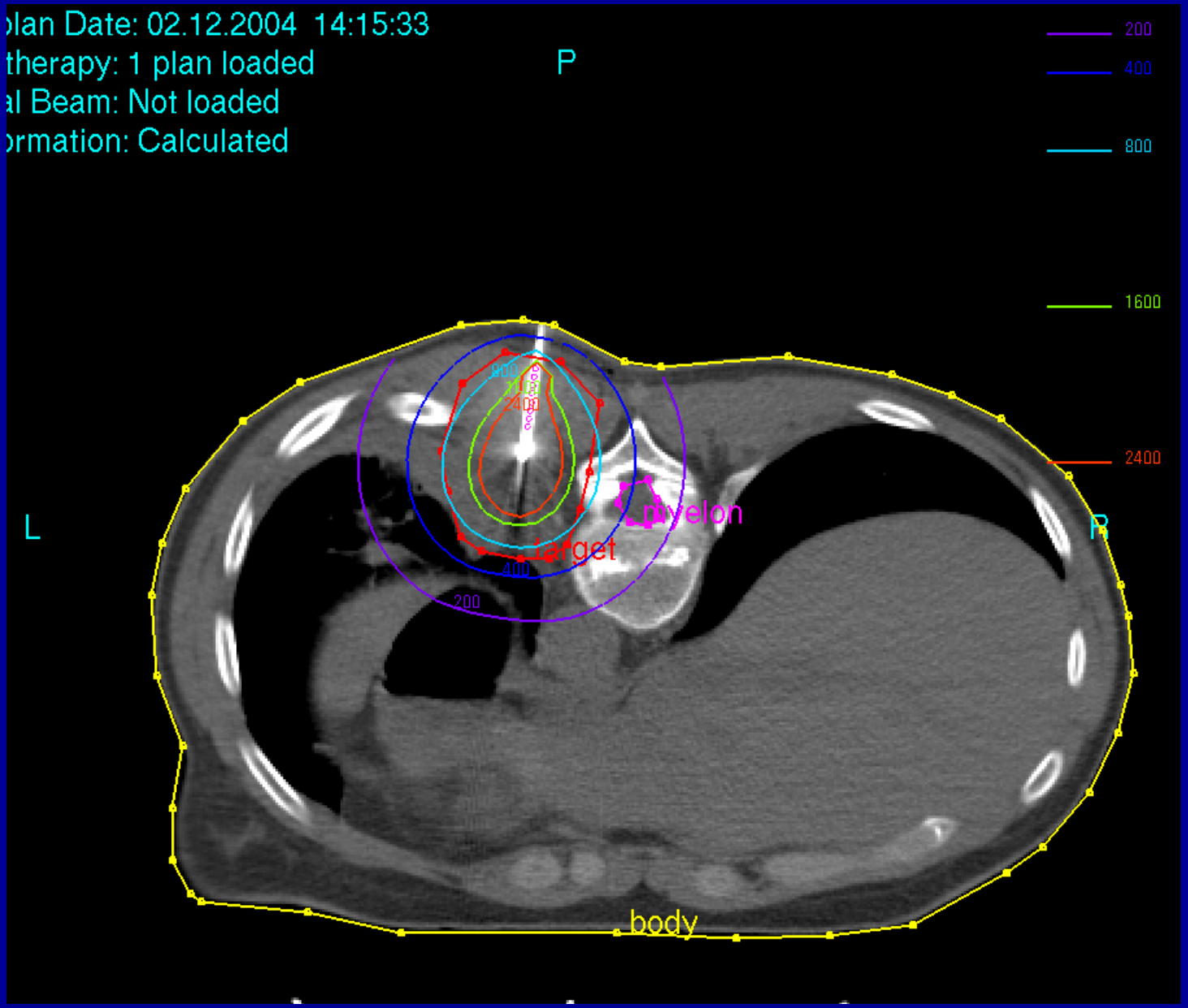


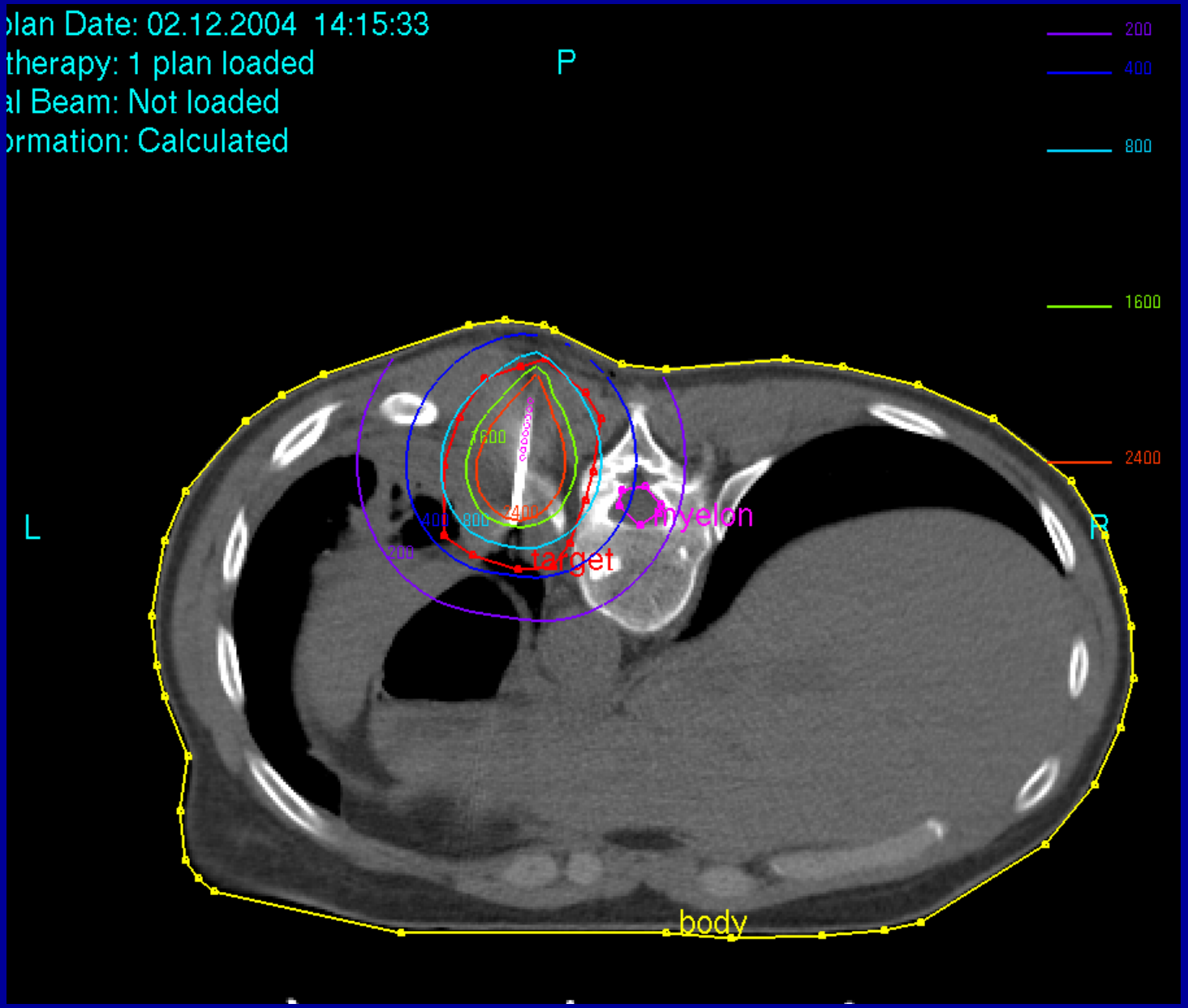
sarcoma

paravertebral metastases

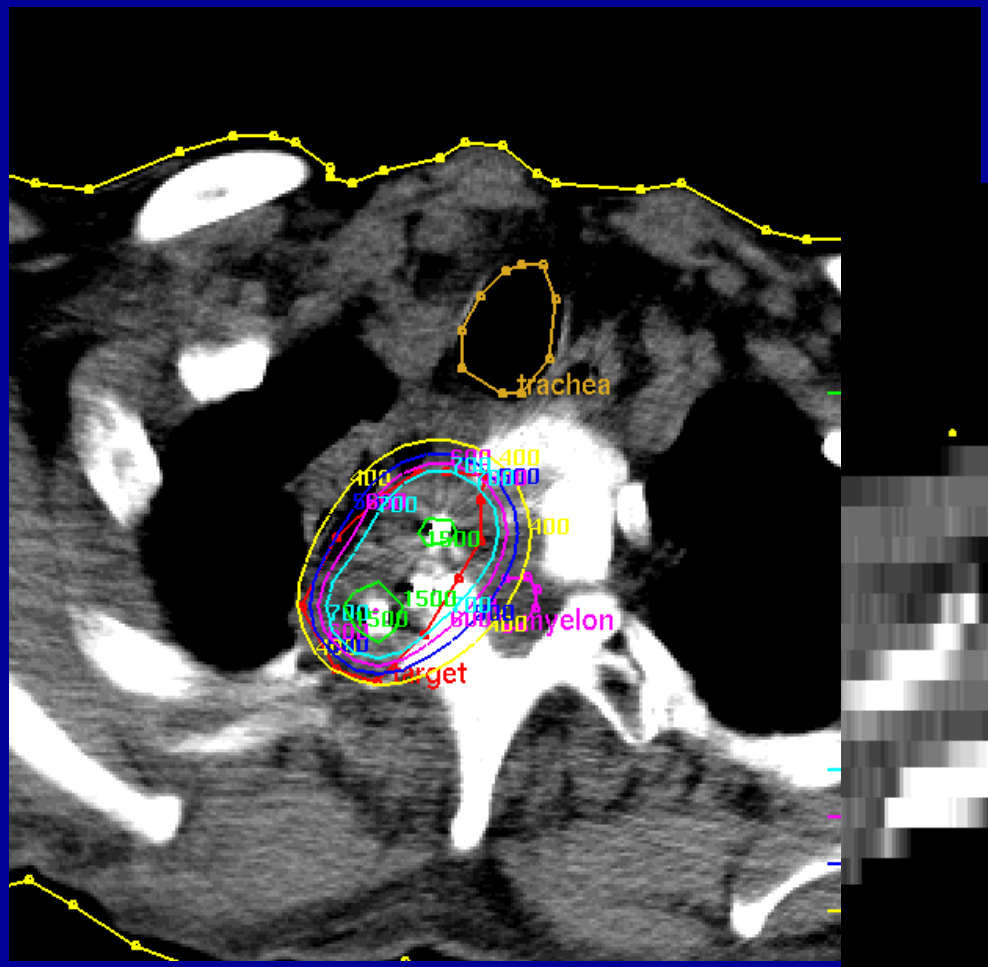


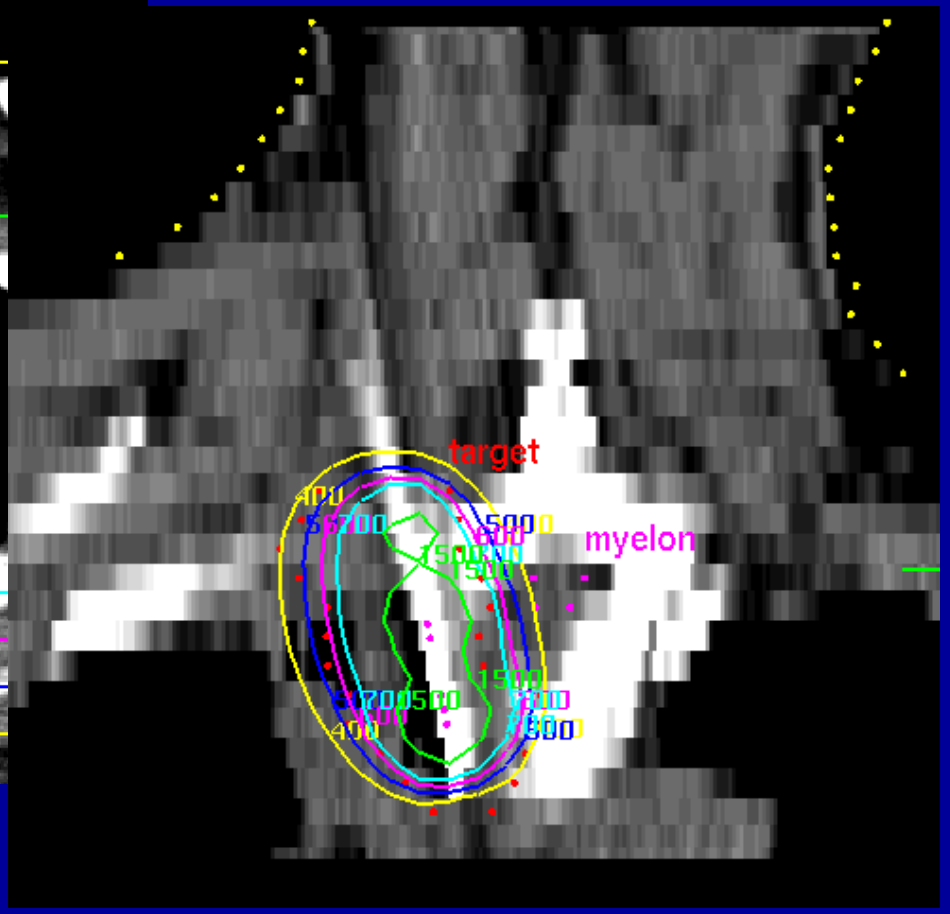

1200


lan Date: 02.12.2004 14:15:33
therapy: 1 plan loaded
al Beam: Not loaded
rmation: Calculated
P
200
400
800
1600
2400
L
R
myelon
target
body

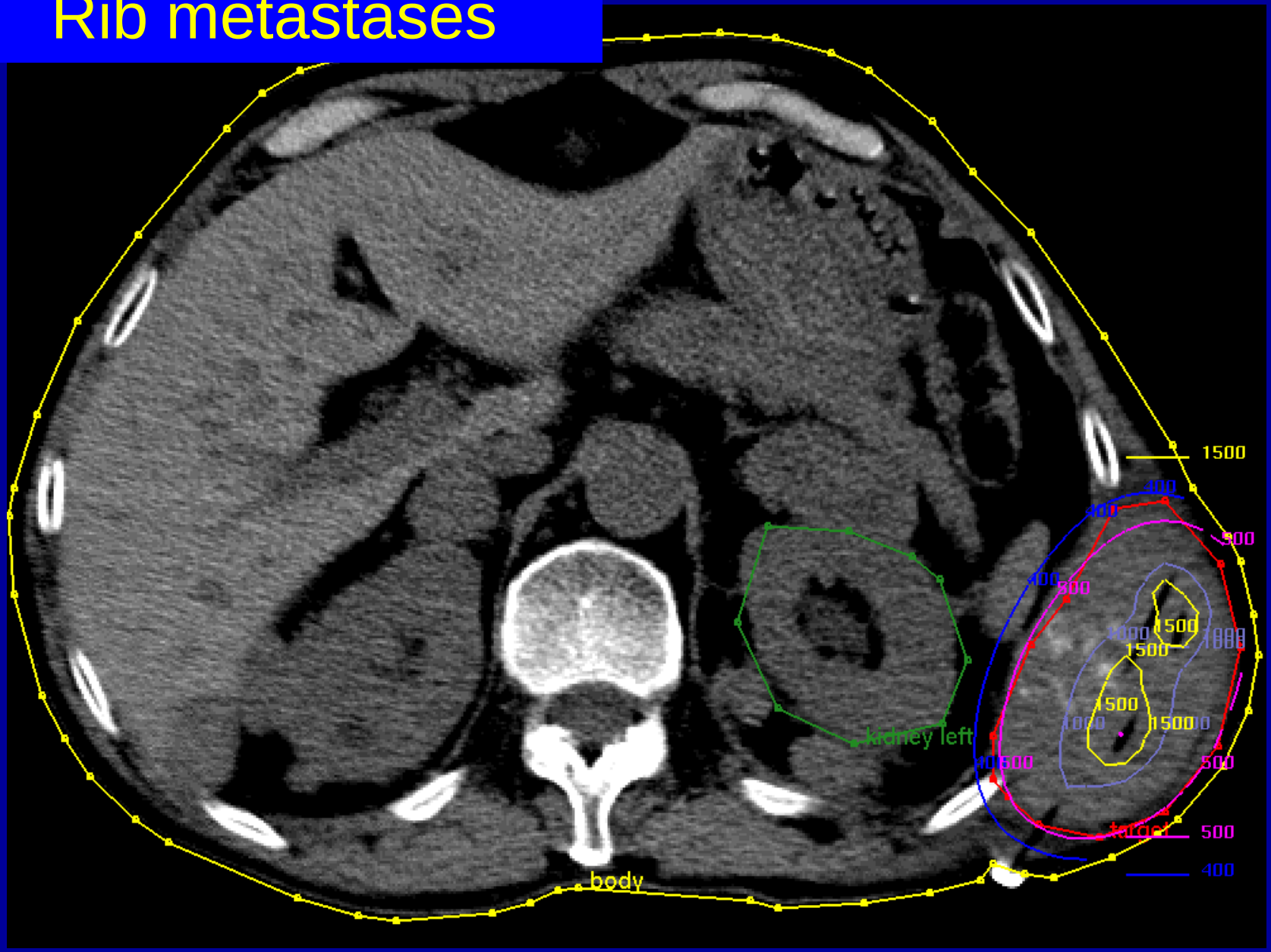

lan Date: 02.12.2004 14:15:33
therapy: 1 plan loaded
al Beam: Not loaded
rmation: Calculated
P
200
400
800
1600
2400
L
R
myelon
target
body

Preirradiated metastasis

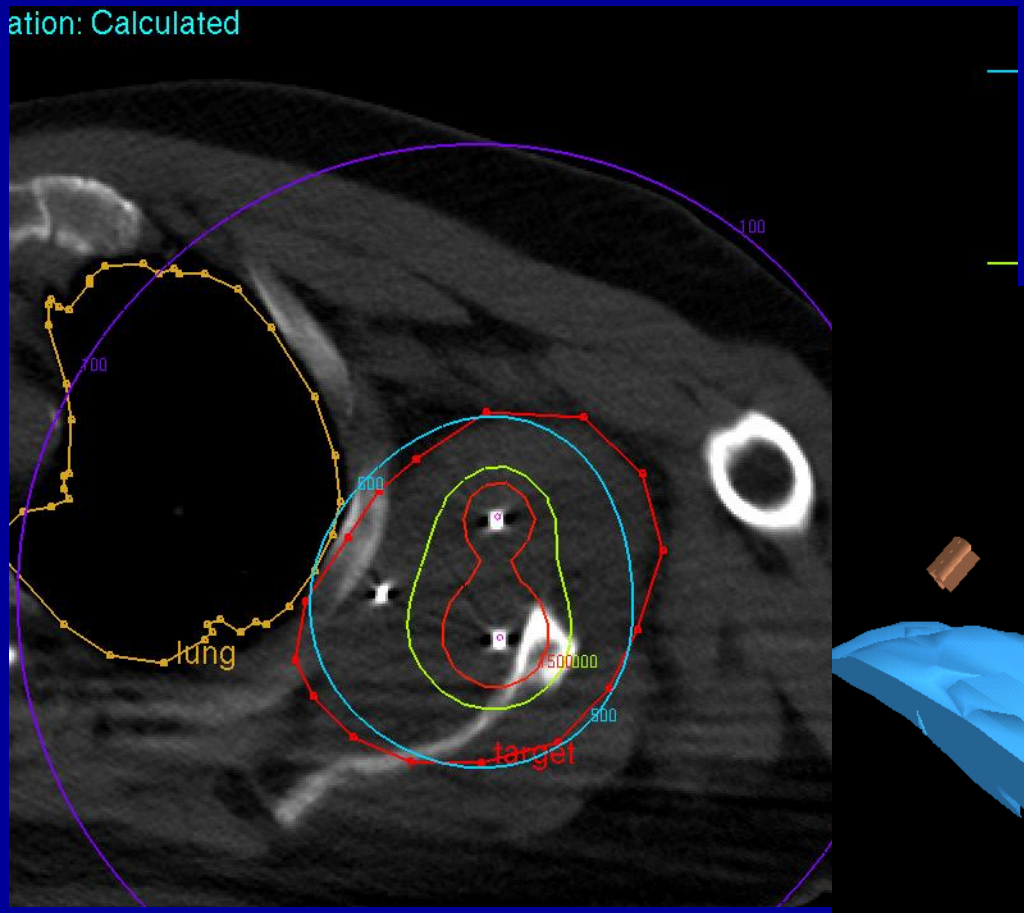


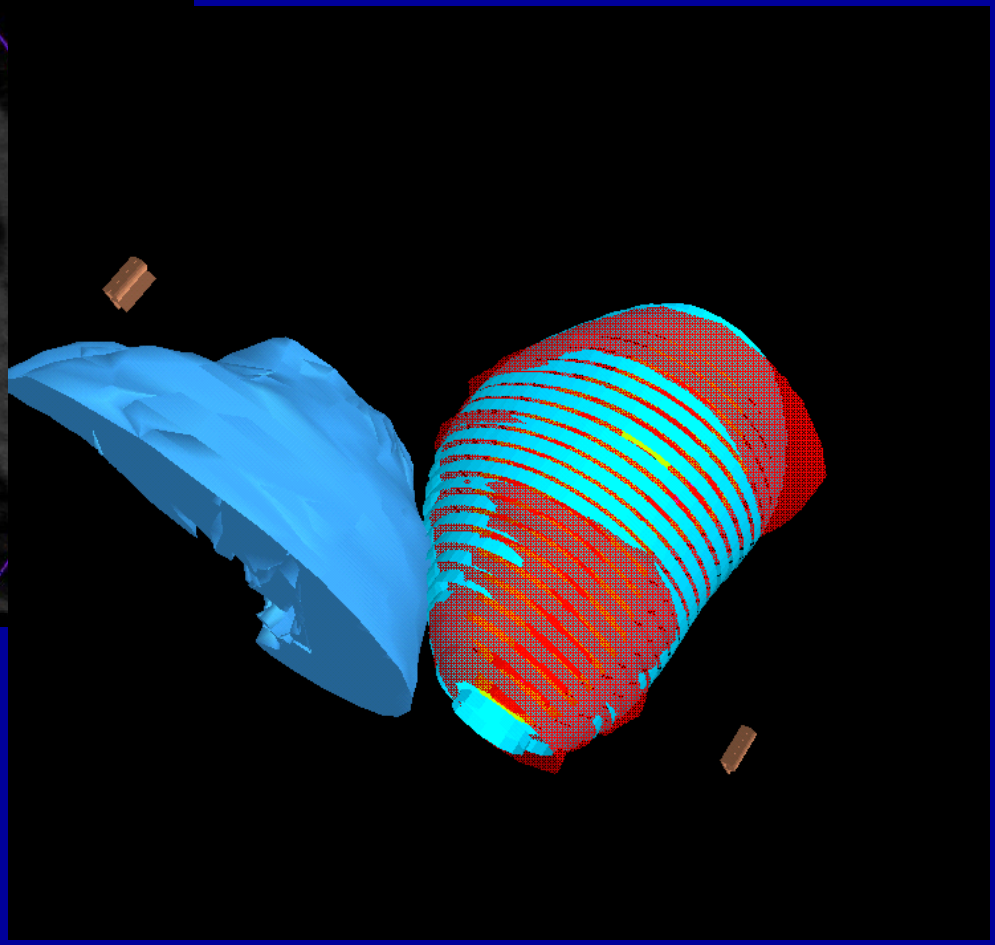


Rib metastases

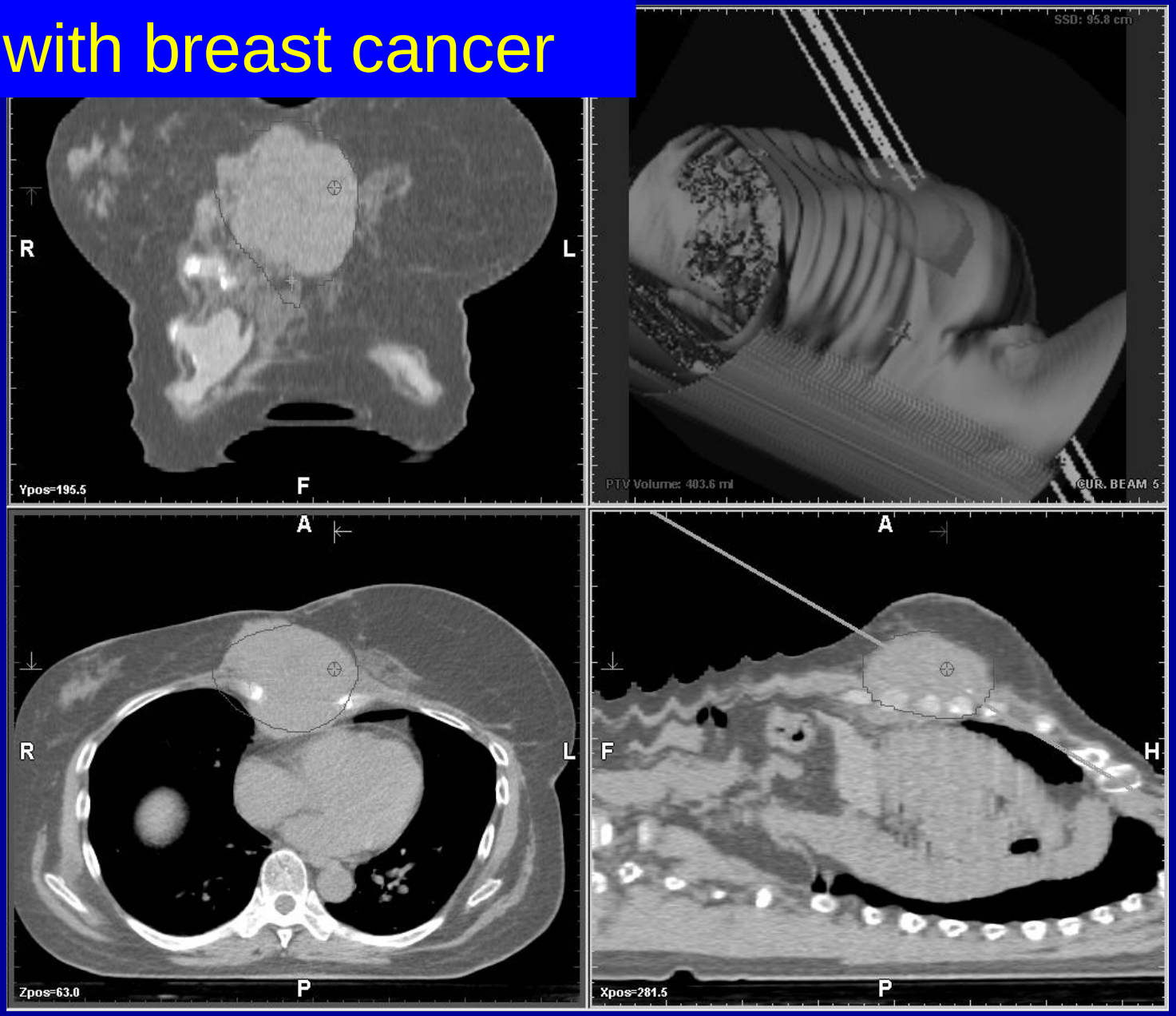


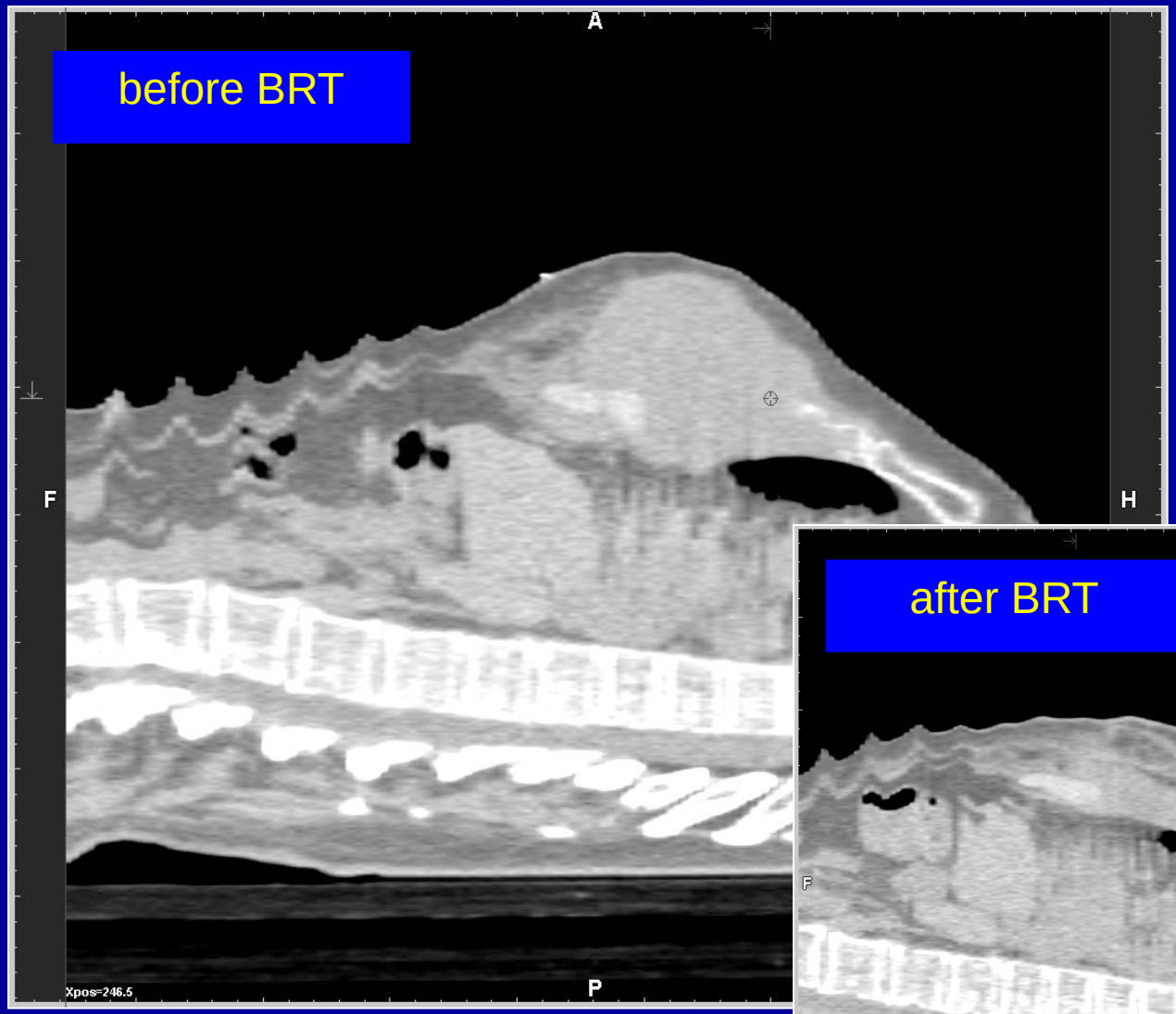
Axilla Metastasis



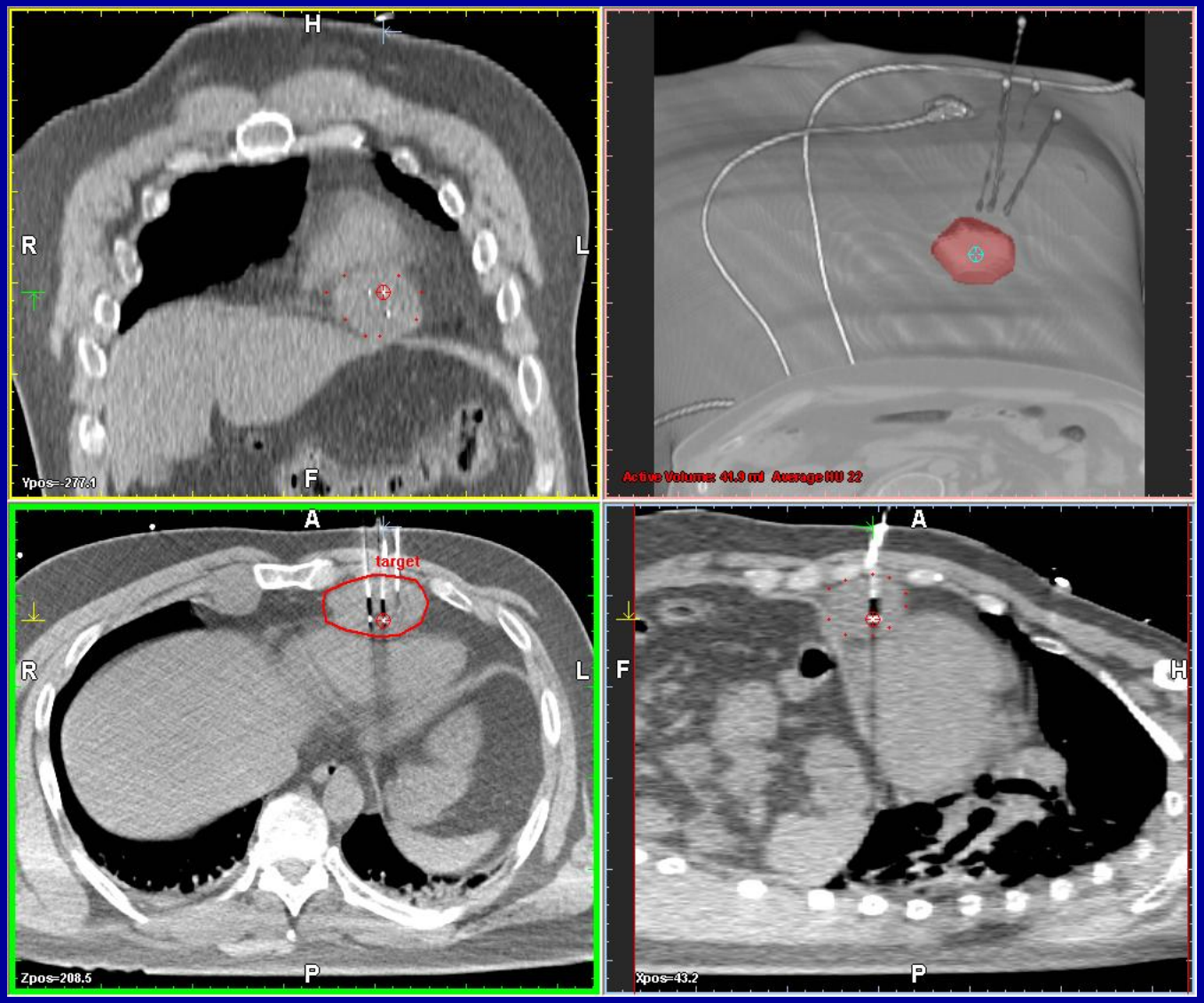


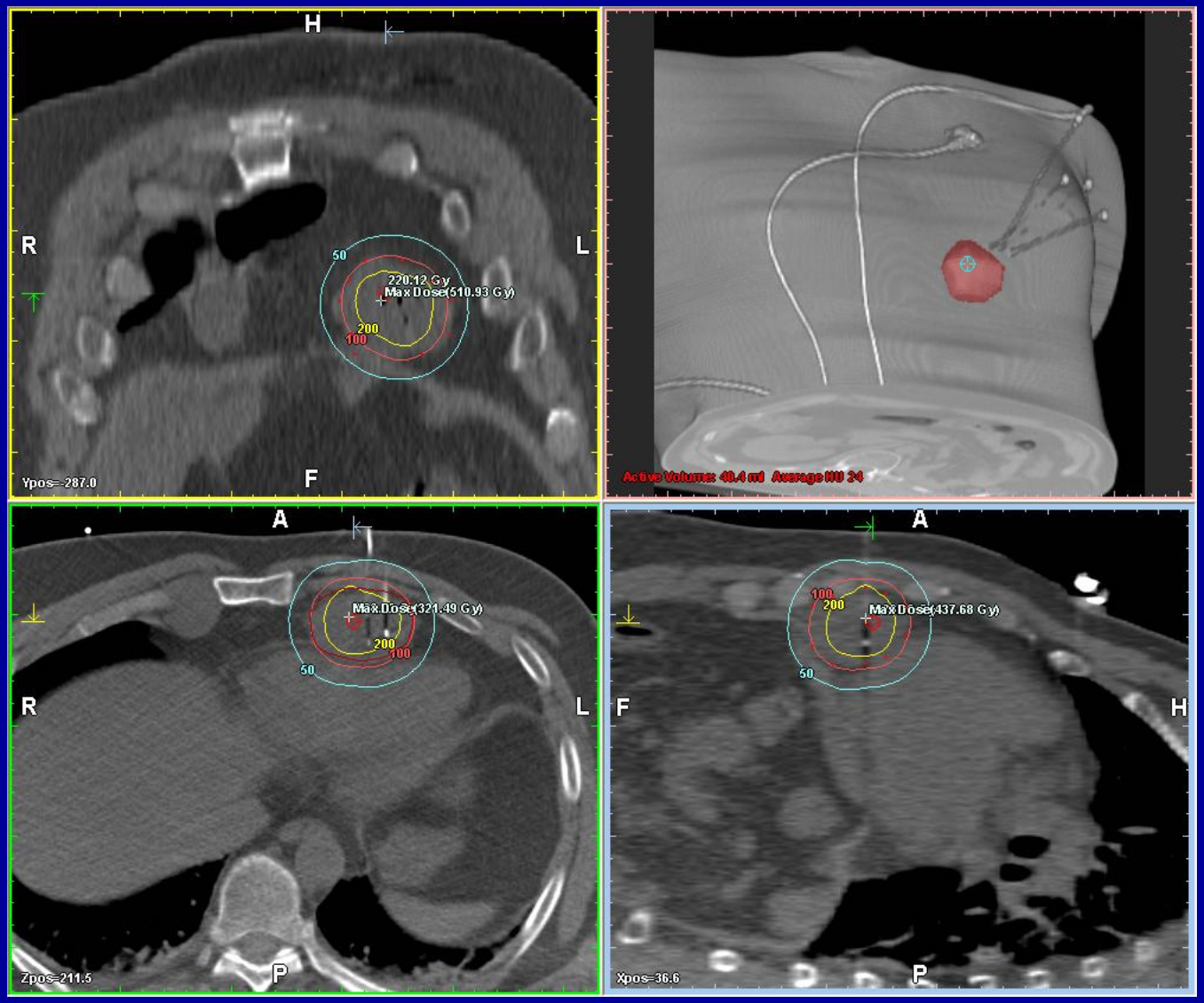
Sternal metastases in a patient with breast cancer

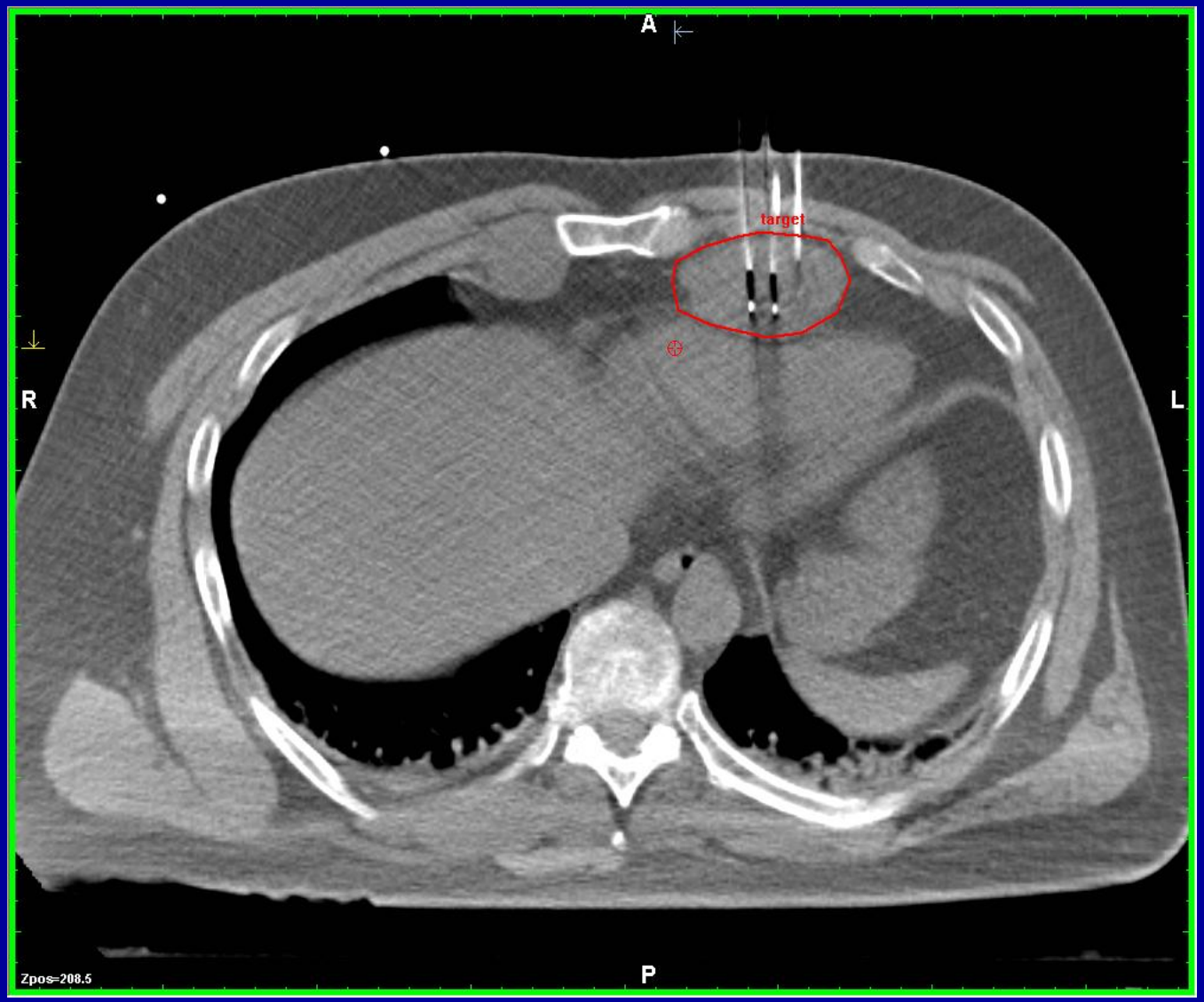


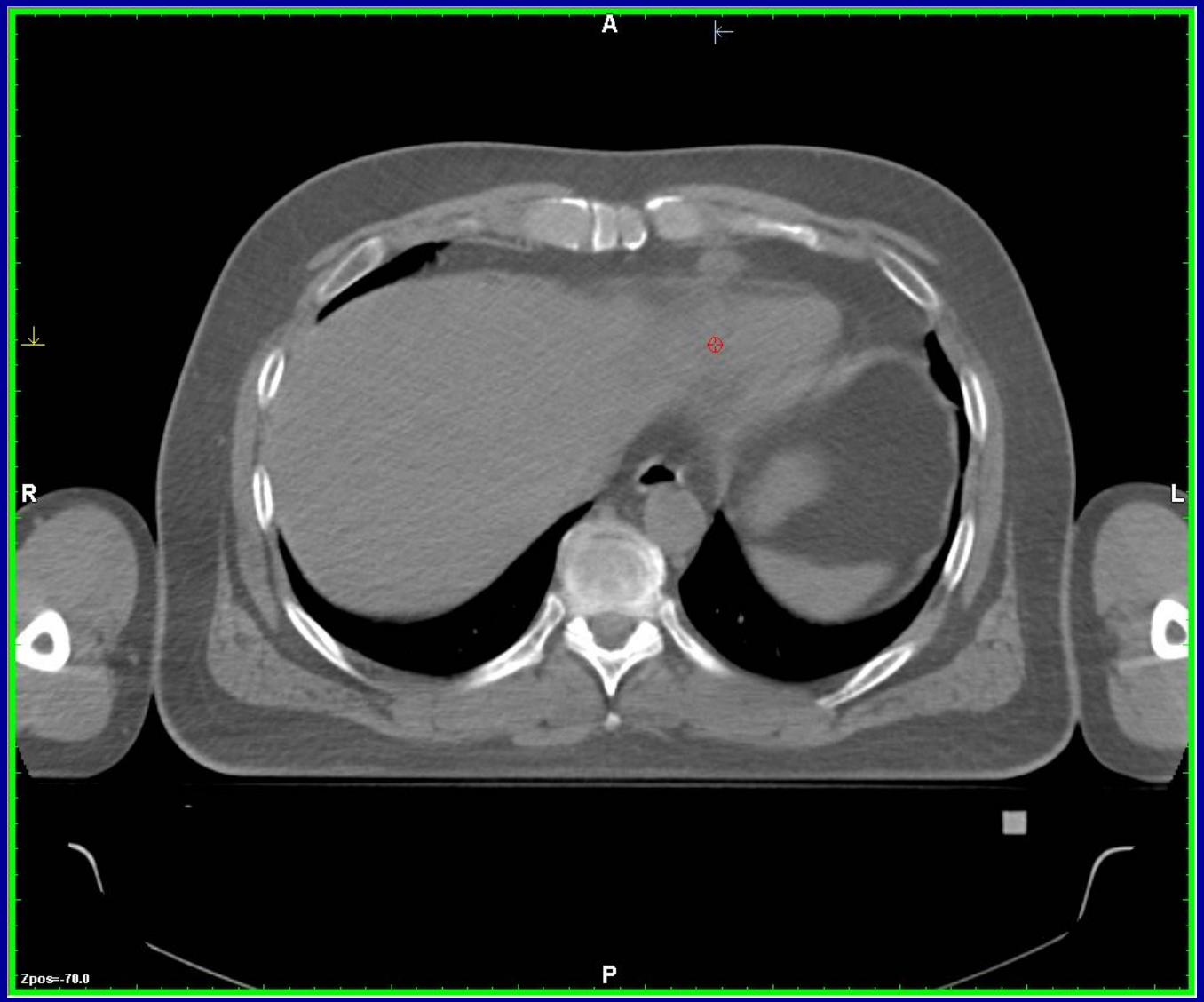

before BRT
A
F
H
P
Xpos=246.5


after BRT
A
F
H
P
Xpos=263.6


H
R
L
F
Ypos=-277.1
Active Volume: 41.9 ml Average HU 22
A
target
R
L
Zpos=208.5
P
A
F
H
Xpos=43.2
P


H
R
L
F
50
220.12 Gy
Max Dose(510.93 Gy)
200
100
Ypos=-287.0
Active Volume: 48.4 ml Average HU 24
A
R
L
P
Max Dose(321.49 Gy)
200
100
50
Zpos=-211.5
A
F
H
P
100
200
Max Dose(437.68 Gy)
50
Xpos=-36.6


A
target
R
L
P
Zpos=208.5


A
R
L
P
Zpos=-70.0

Brachytherapy in Thoracic Wall Recurrences

CR 18/38 pat. PR 19/38 pat.

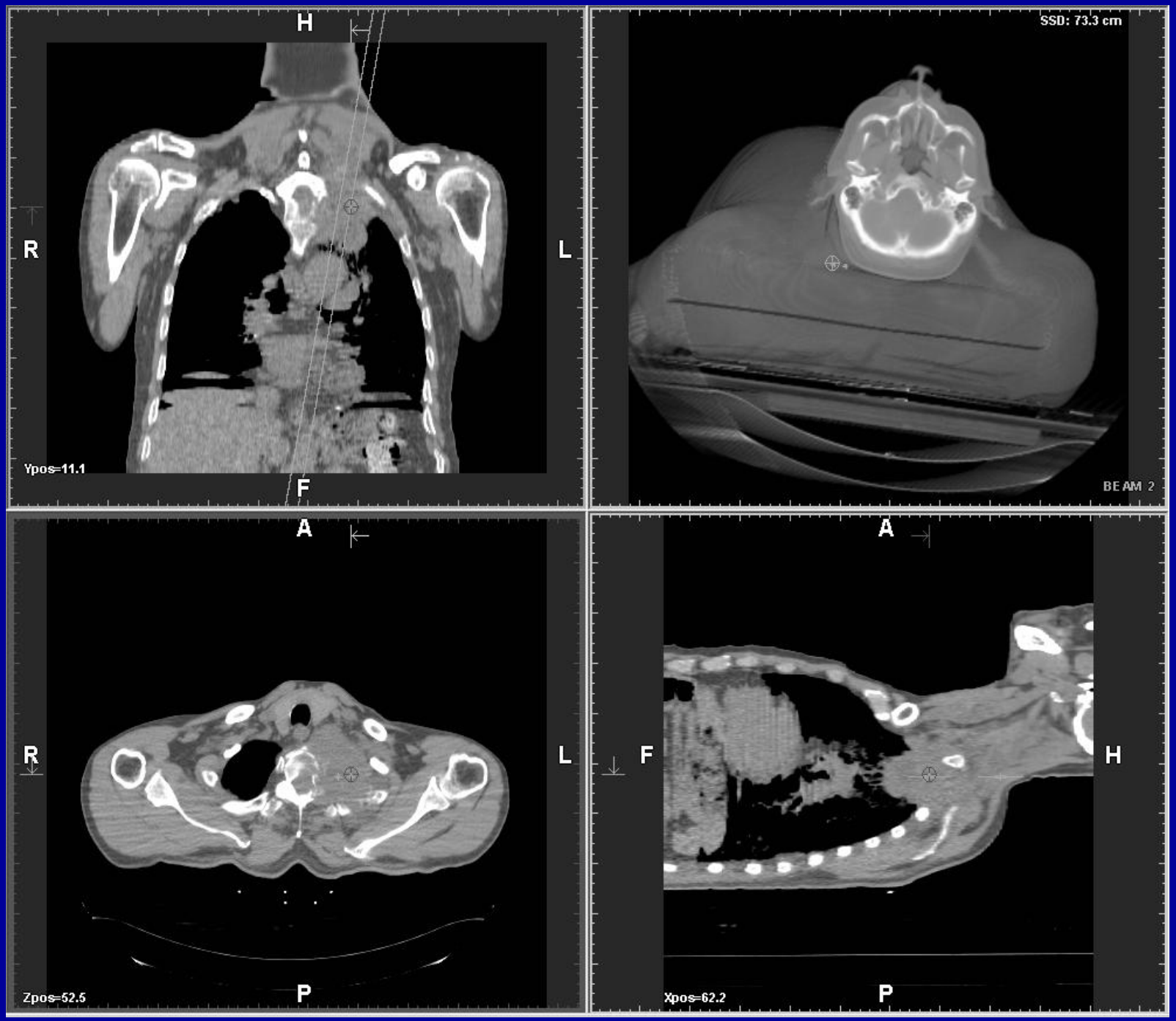
Local Control after 6 months : 34/38 patients

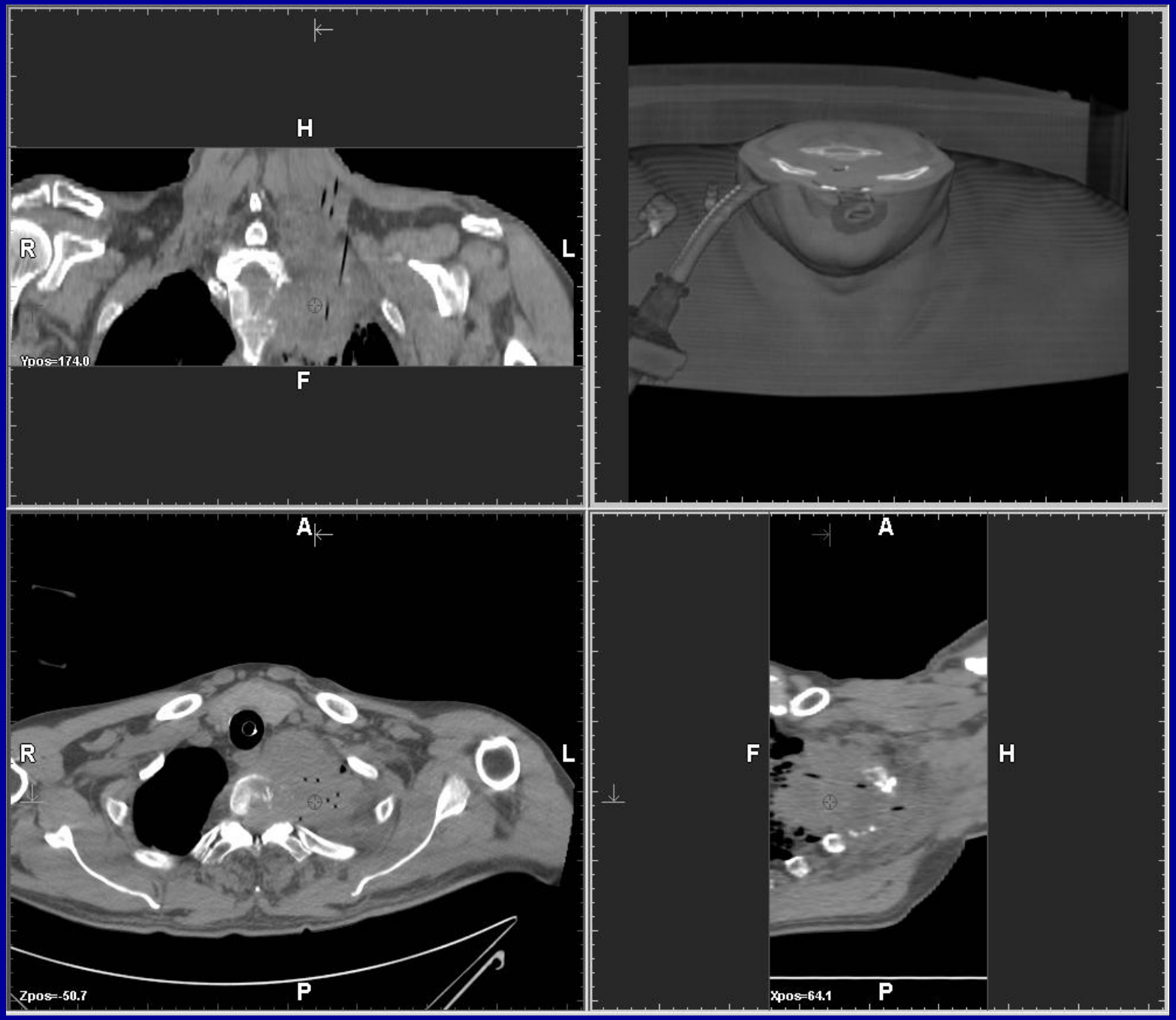
Pain releaf 37/38pat.

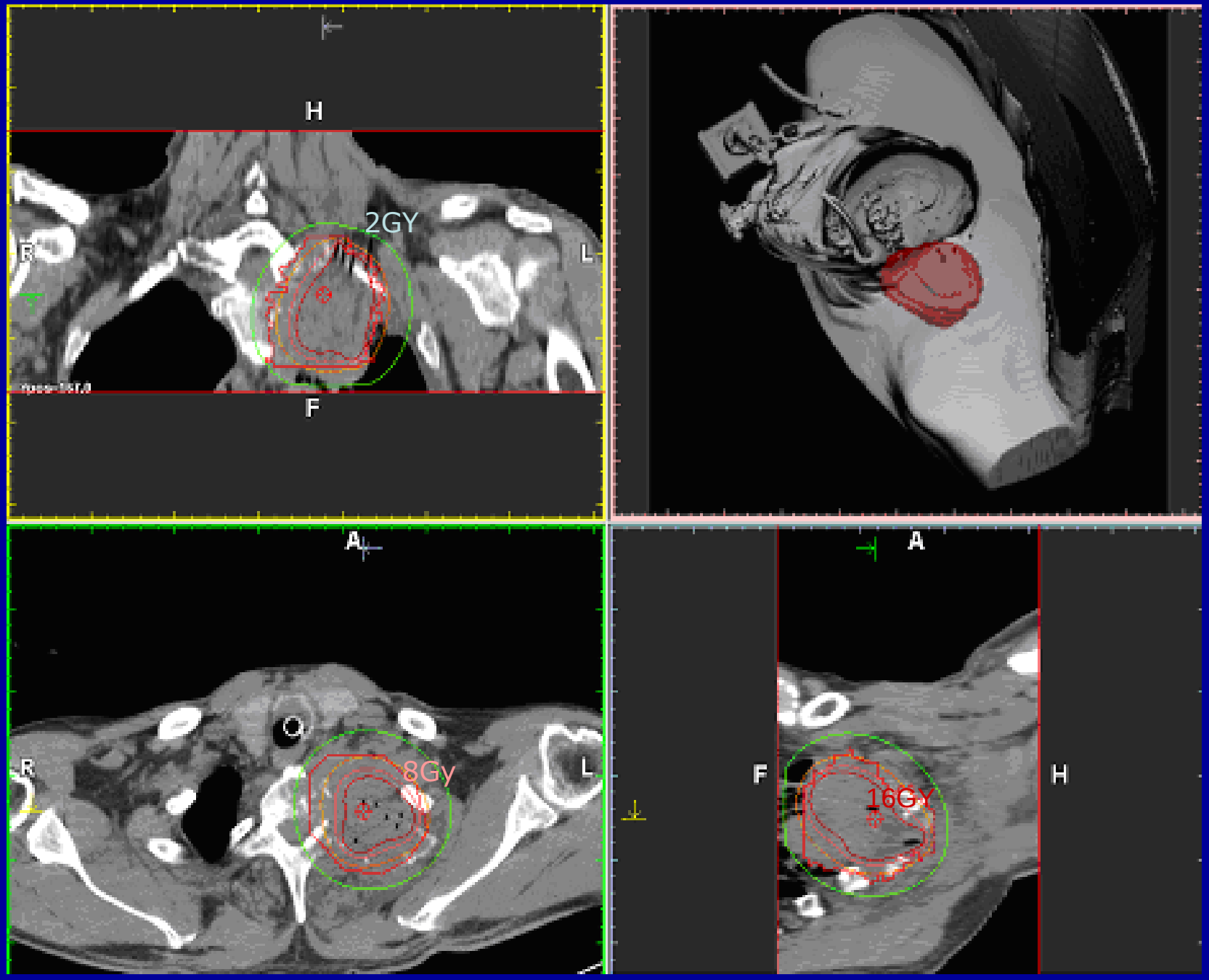
Lung

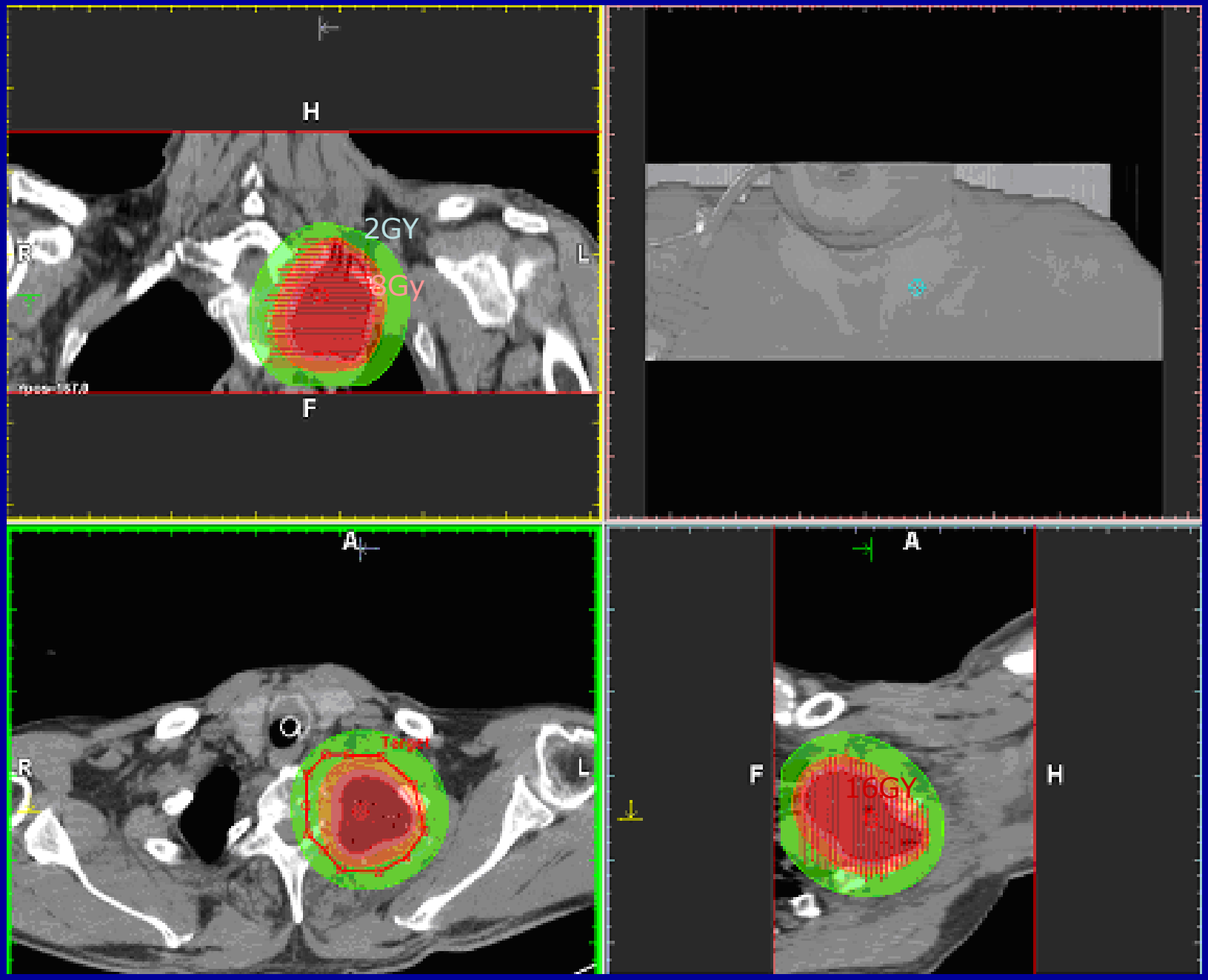
Method

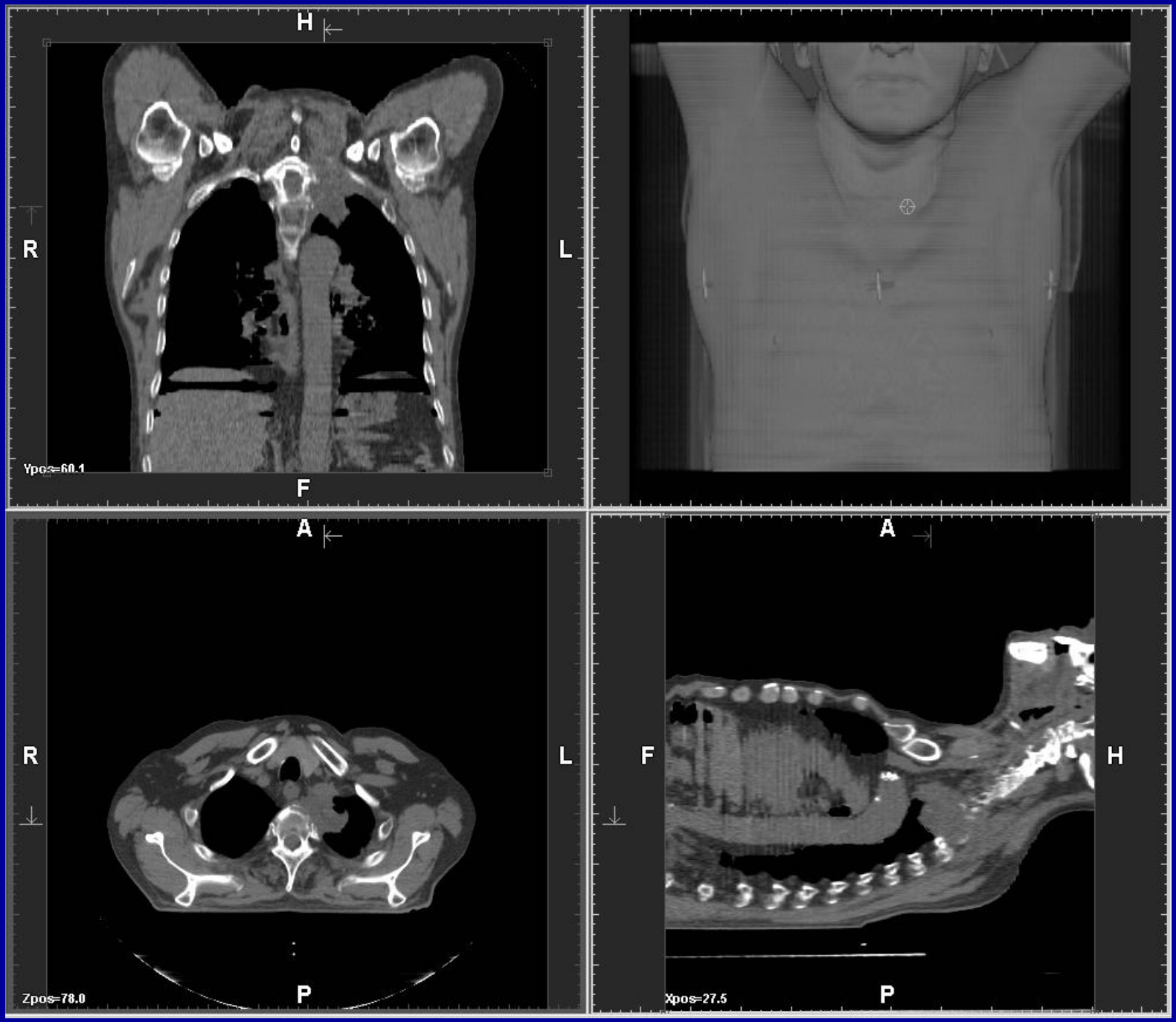
Preplanning

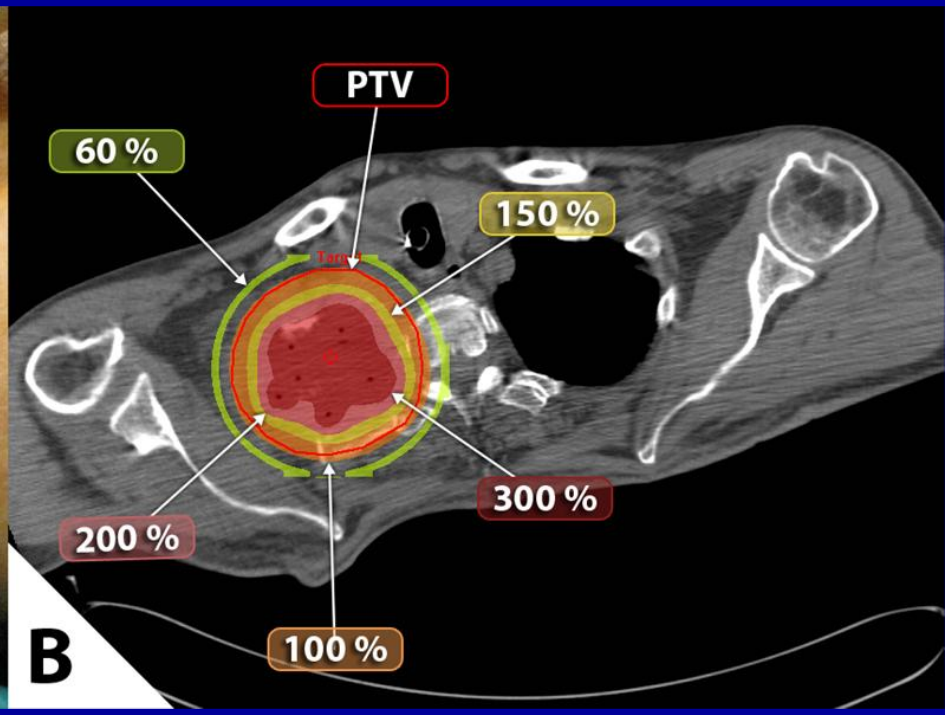

H
R
L
F
Ypos=11.1
SSD: 73.3 cm
BEAM 2
A
R
L
P
Zpos=52.5
A
F
H
P
Xpos=62.2

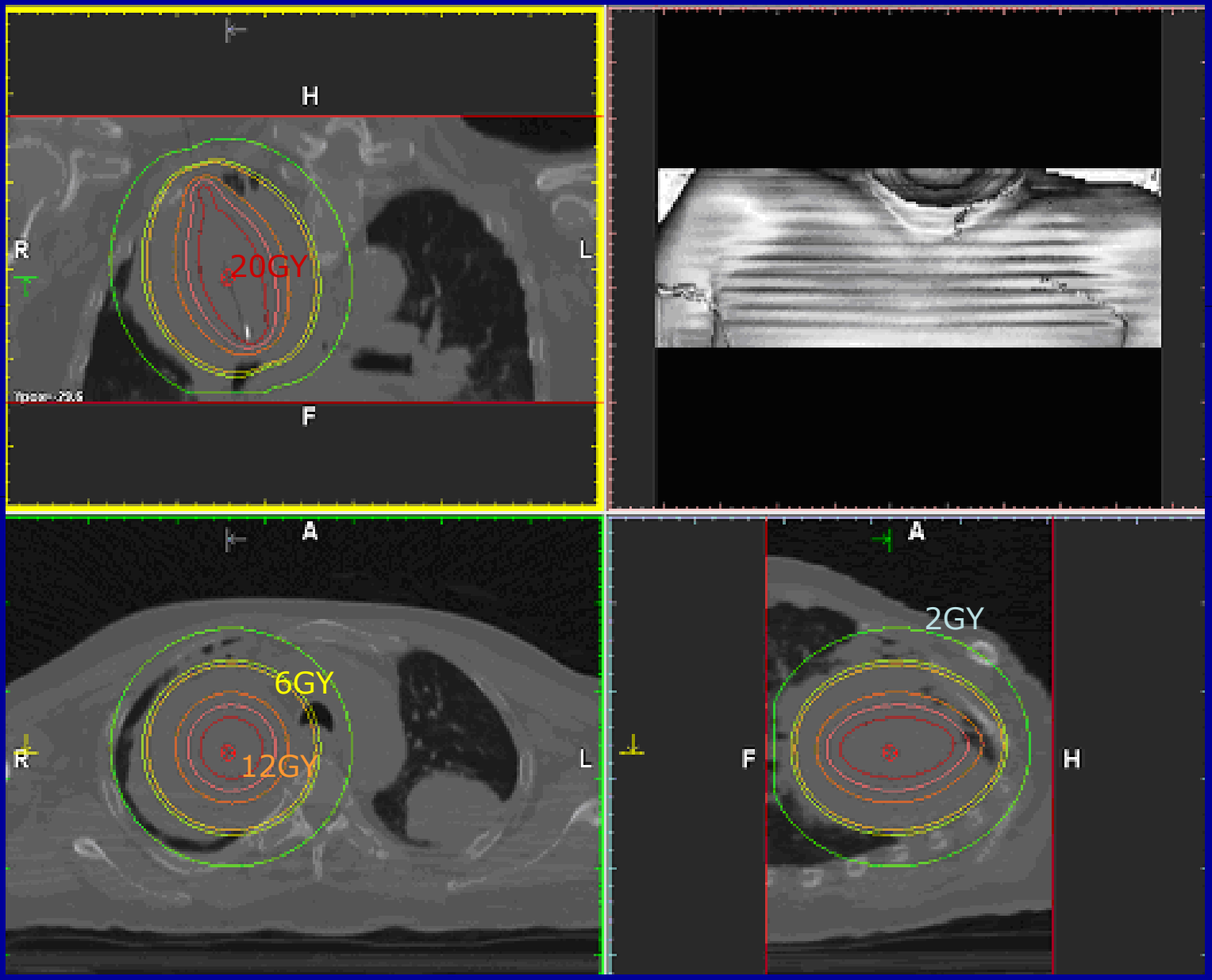

H
R
L
Ypos=174.0
F
A
R
L
Zpos=-50.7
P
F
A
H
Xpos=64.1
P


H
2GY
R
L
F
A
8Gy
R
L
A
F
H
16GY

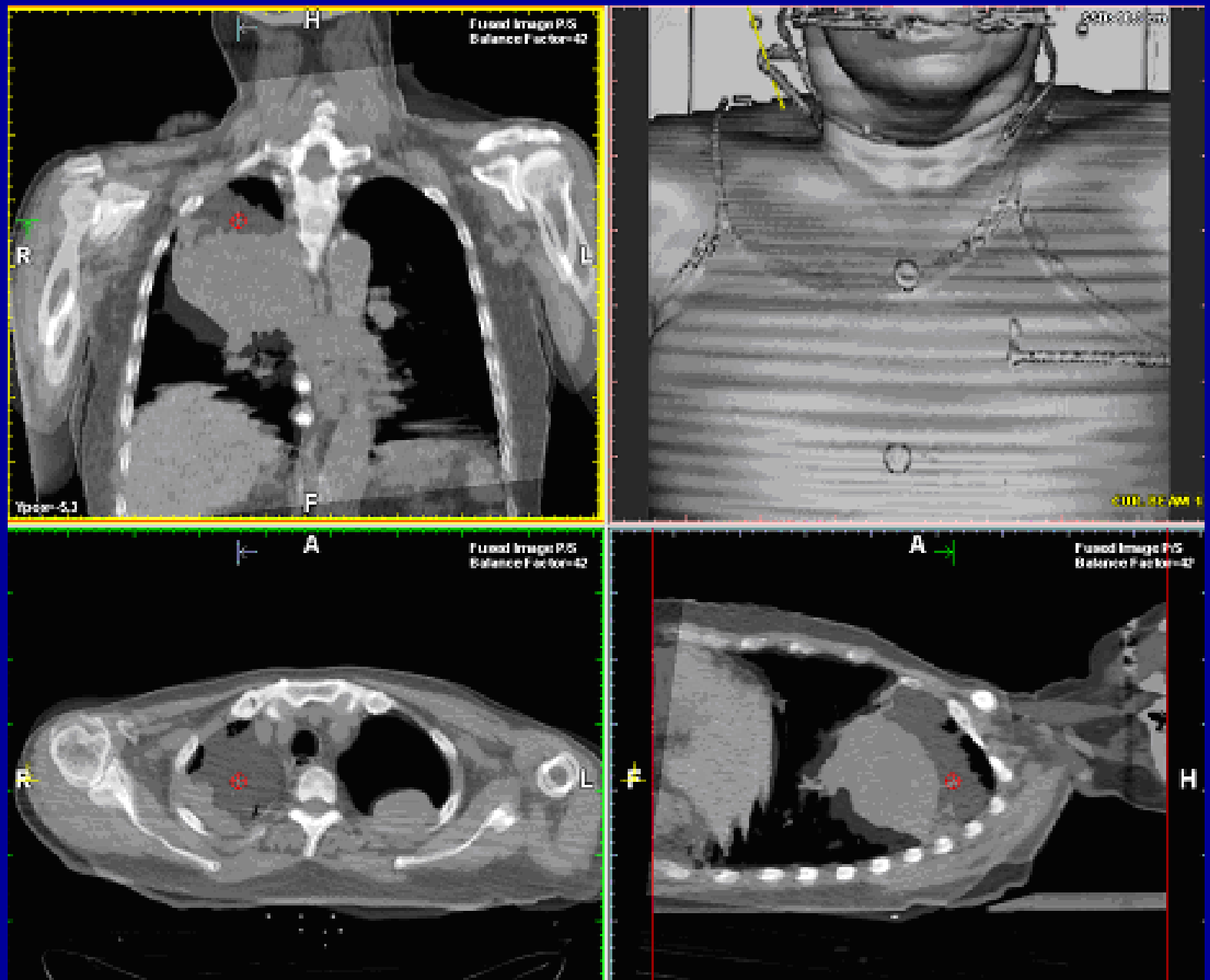

H
2GY
8Gy
R
L
F
A
Target
R
L
A
F
16GY
H


H
R
L
F
Ypos=60.1
A
R
L
P
Zpos=78.0
A
F
H
P
Xpos=27.5

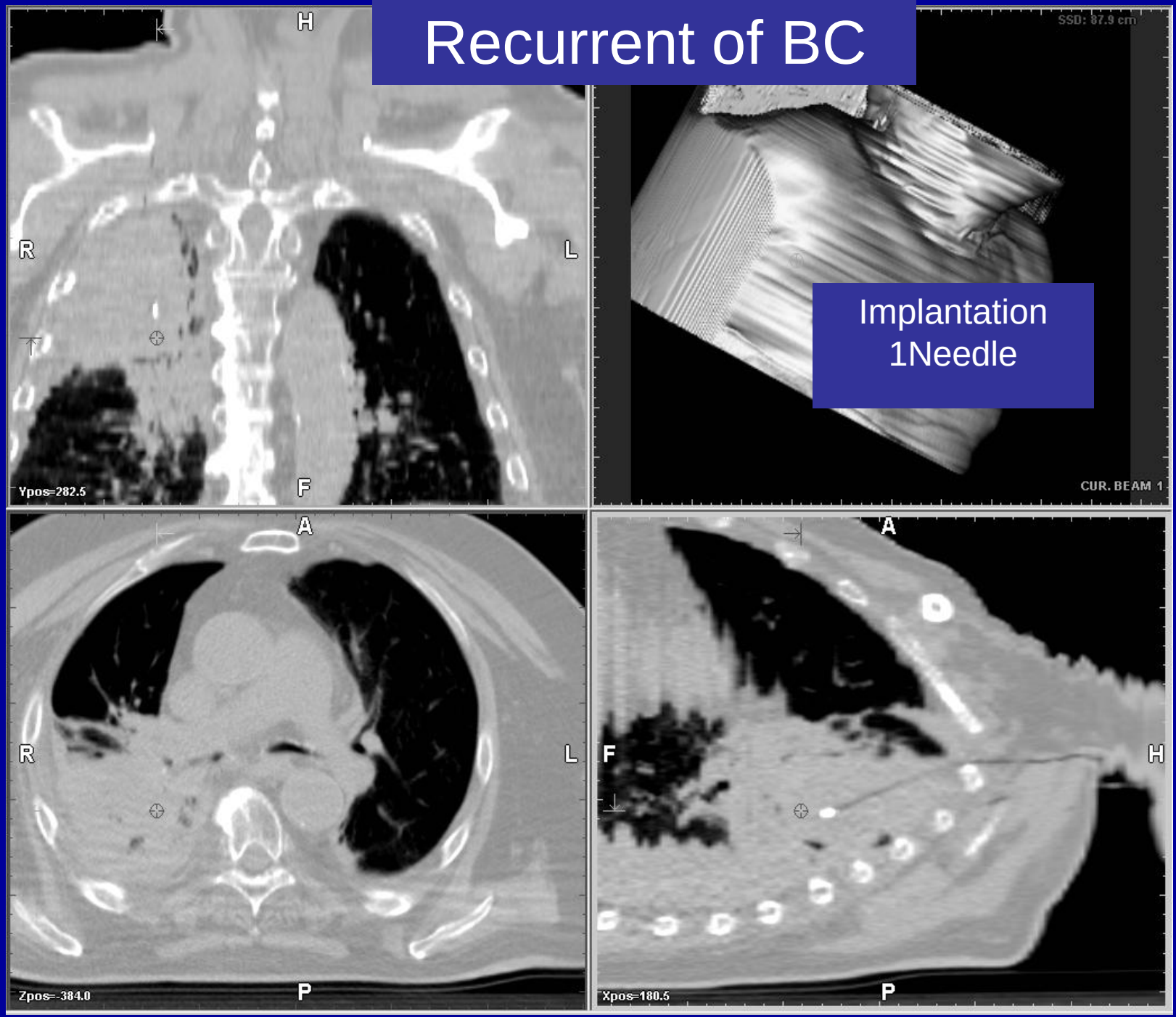

PTV
60 %
150 %
300 %
200 %
100 %
B


H
R
L
20GY
F
A
6GY
12GY
R
L
A
2GY
F
H

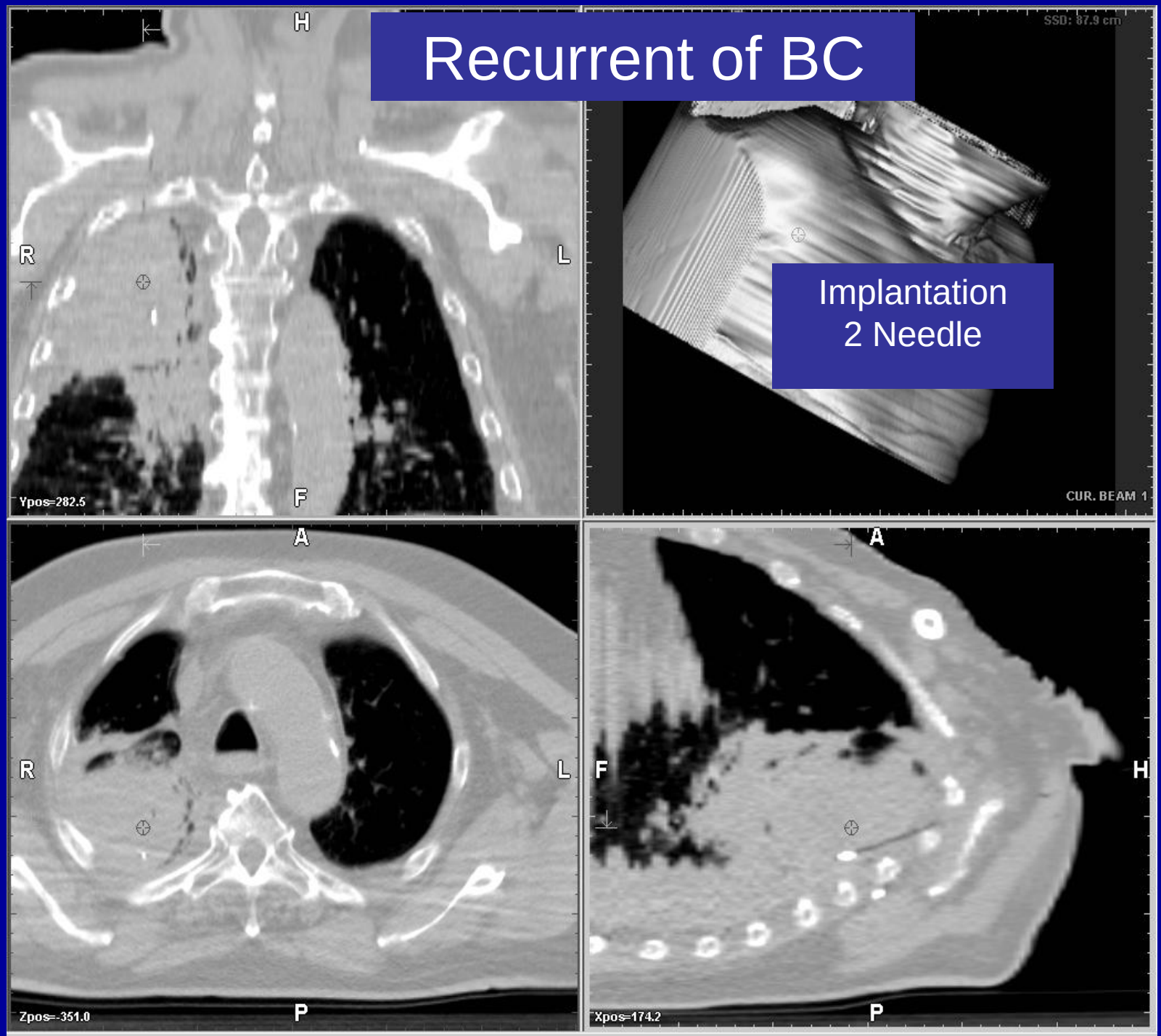
CT-Fusion: before Vs 12days after 32 Gy IRT



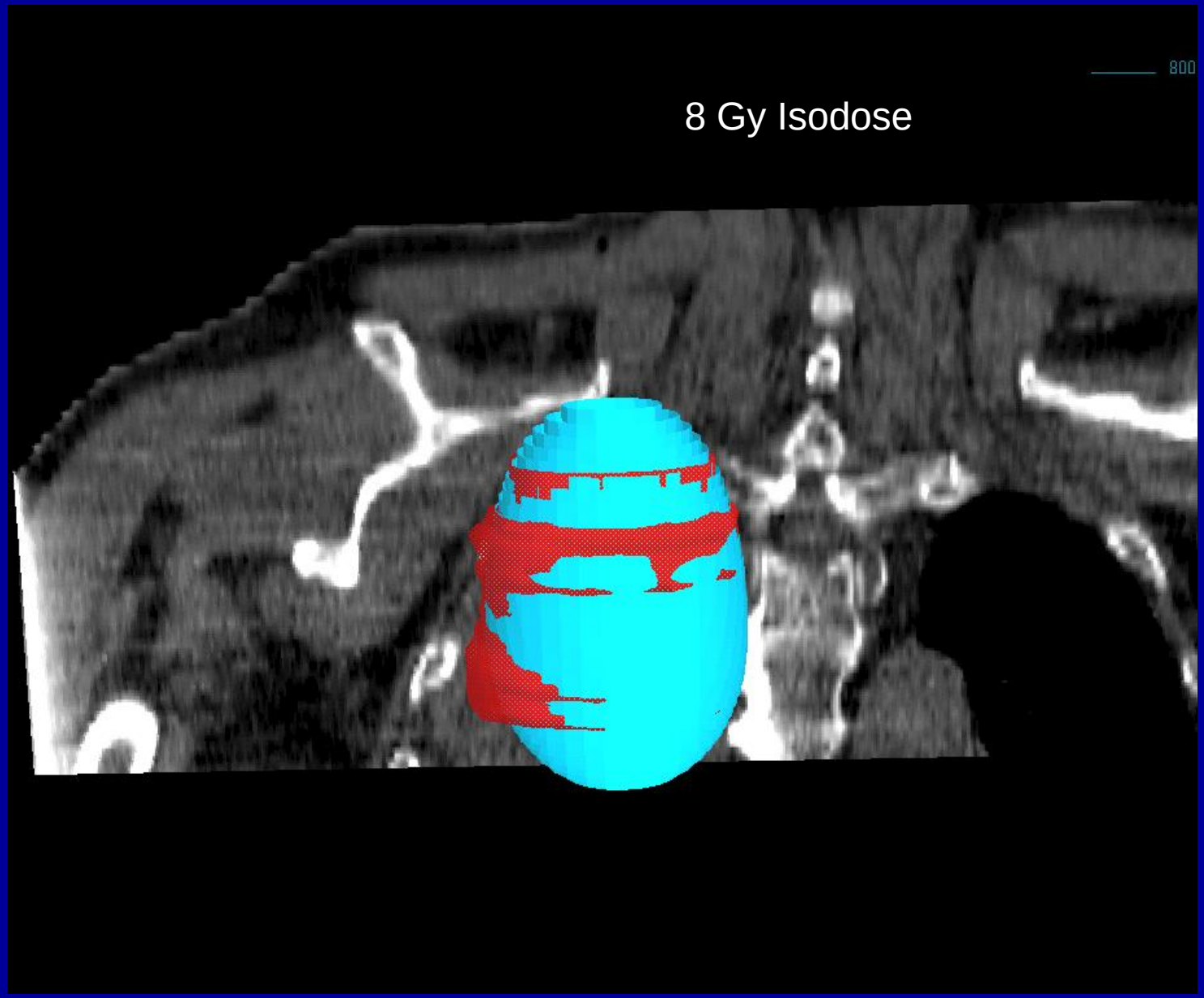
Recurrent of BC



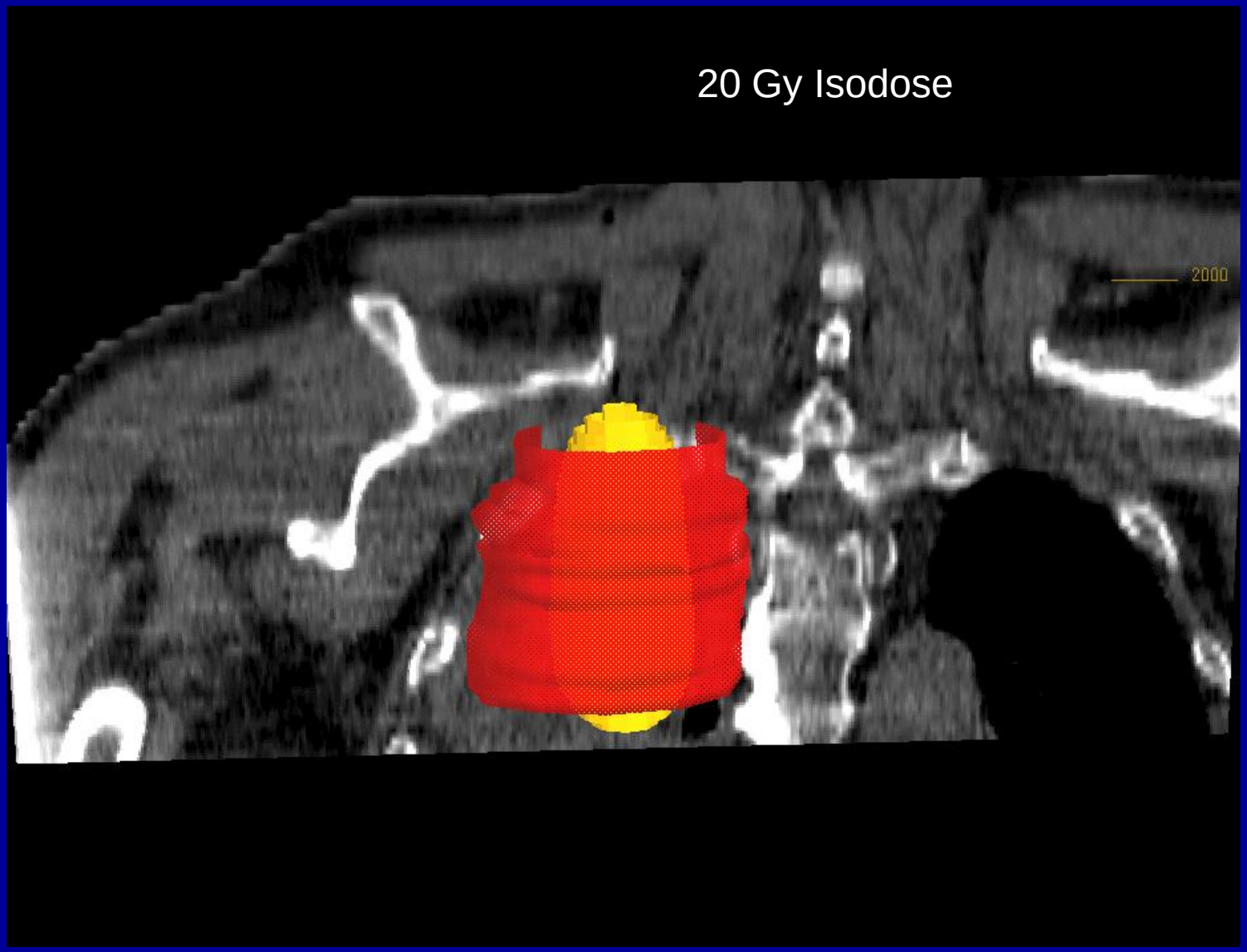
Recurrent of BC

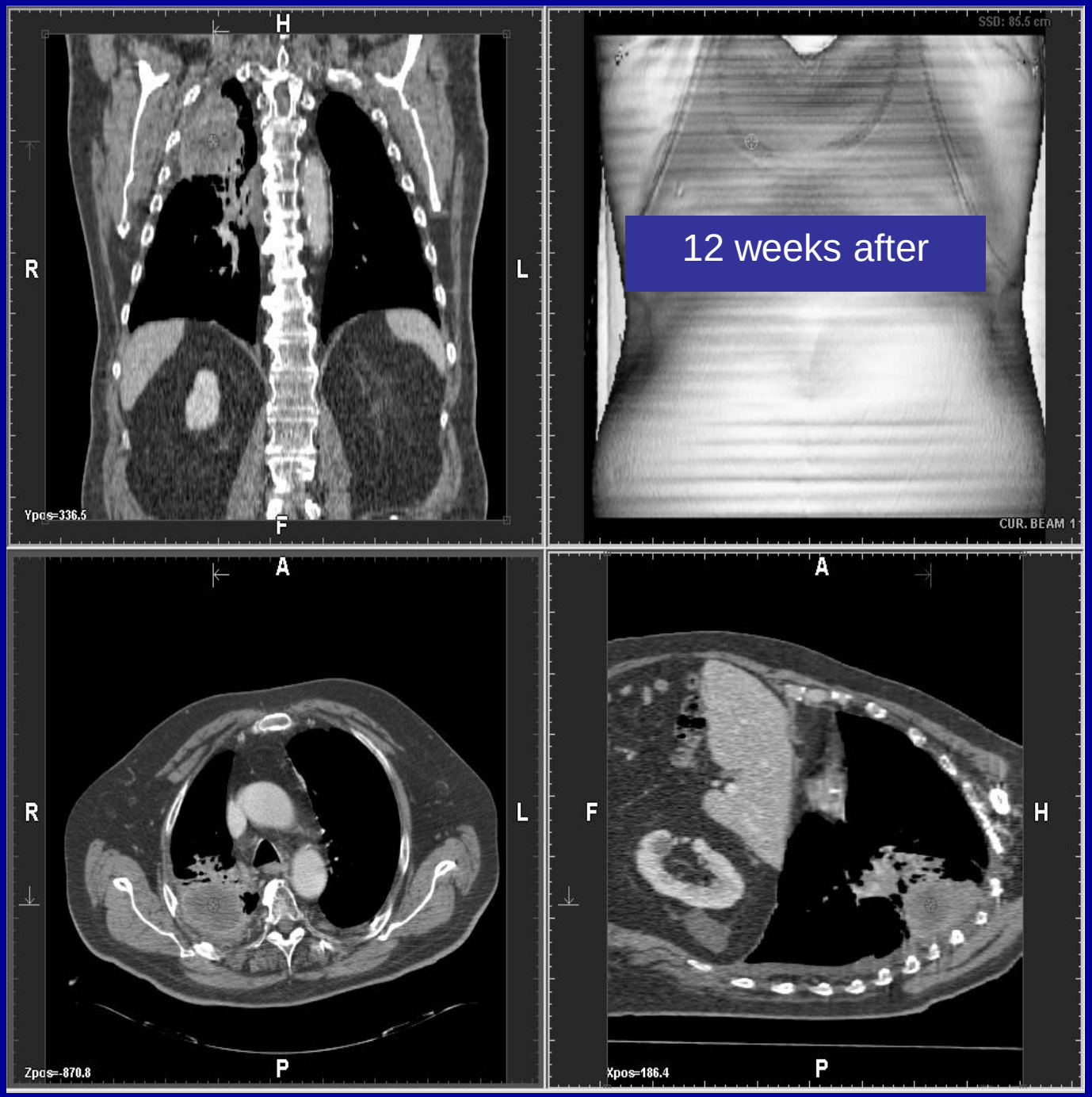


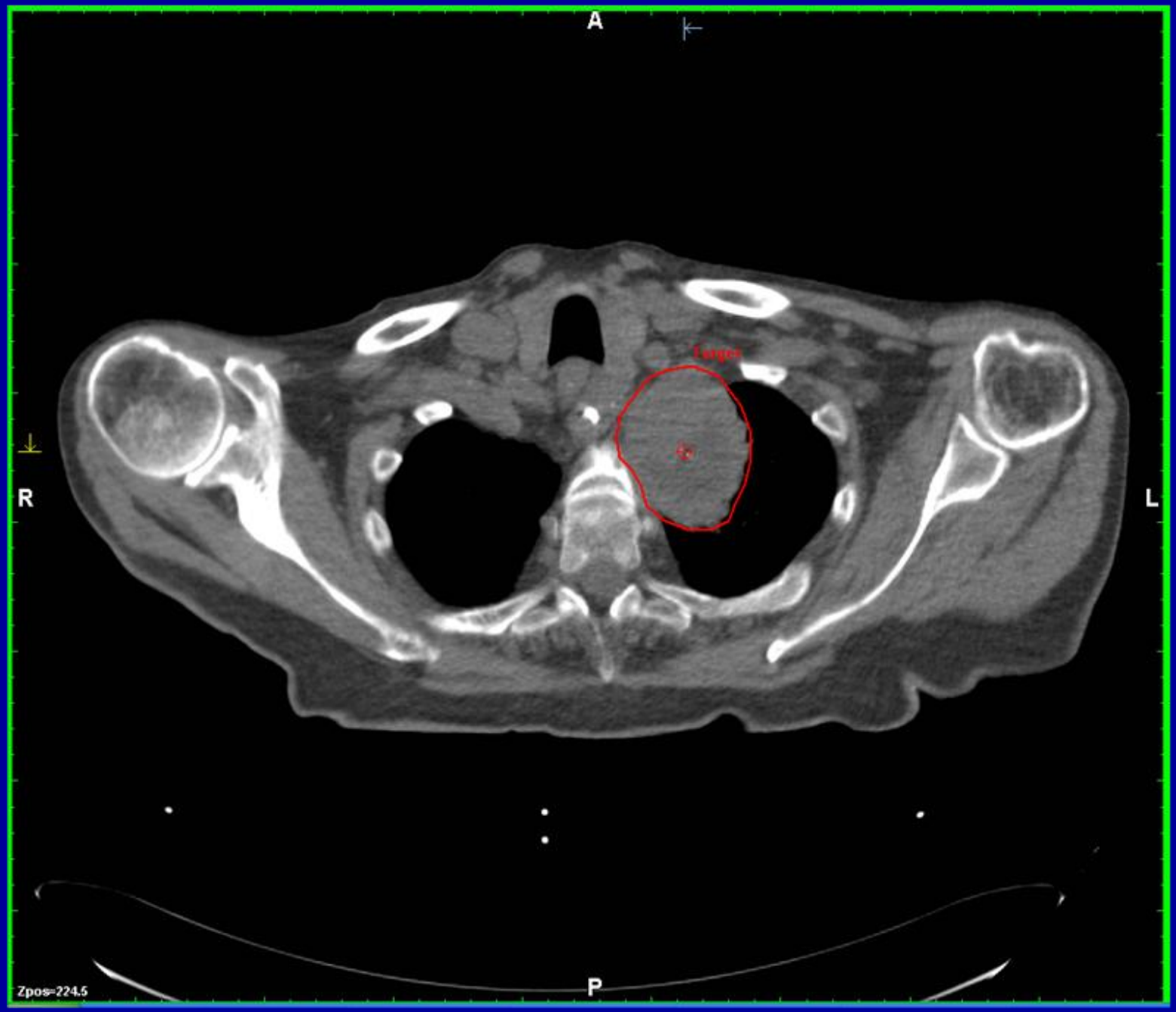
Implantation
2 Needle

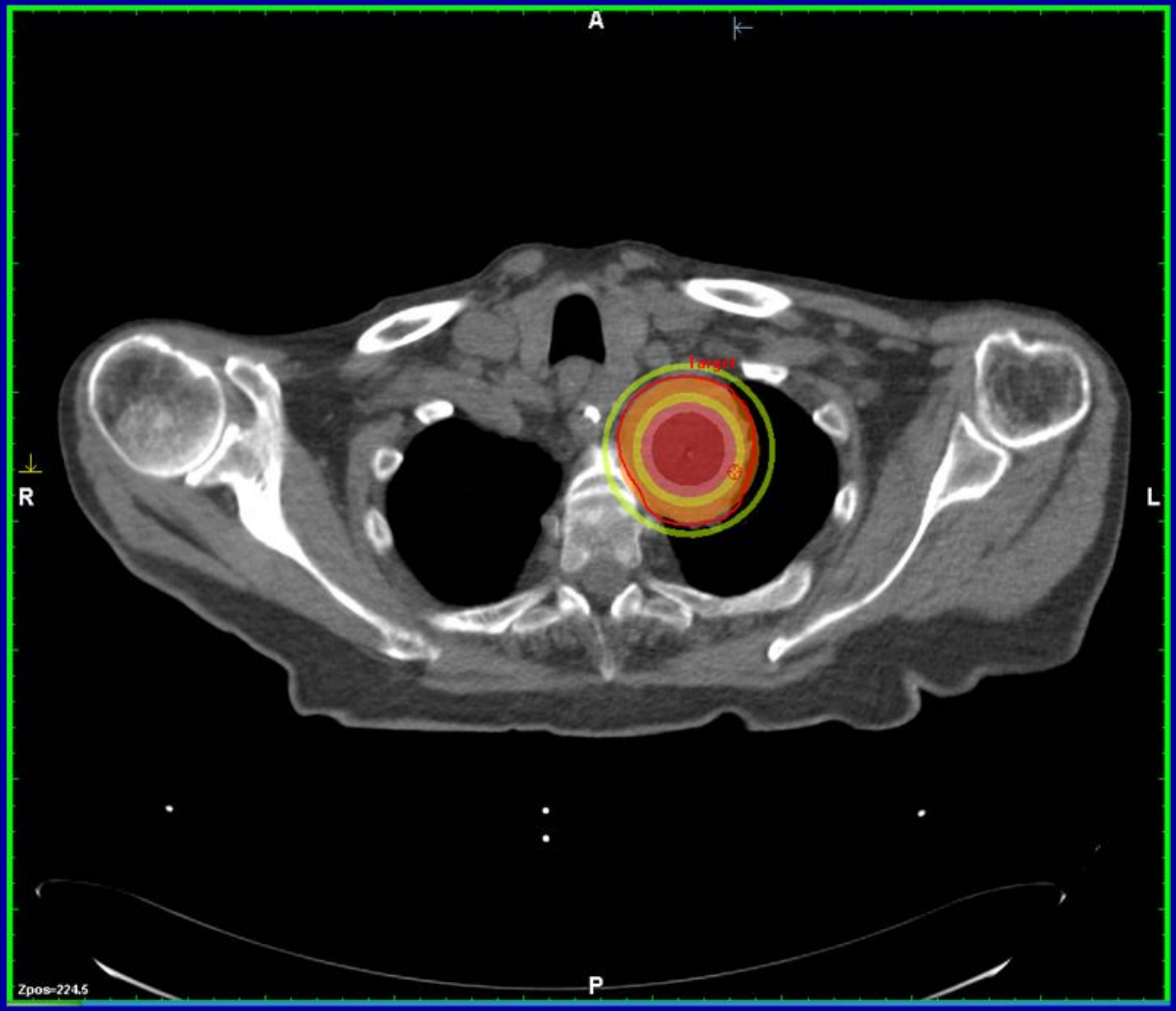

800
8 Gy Isodose

20 Gy Isodose

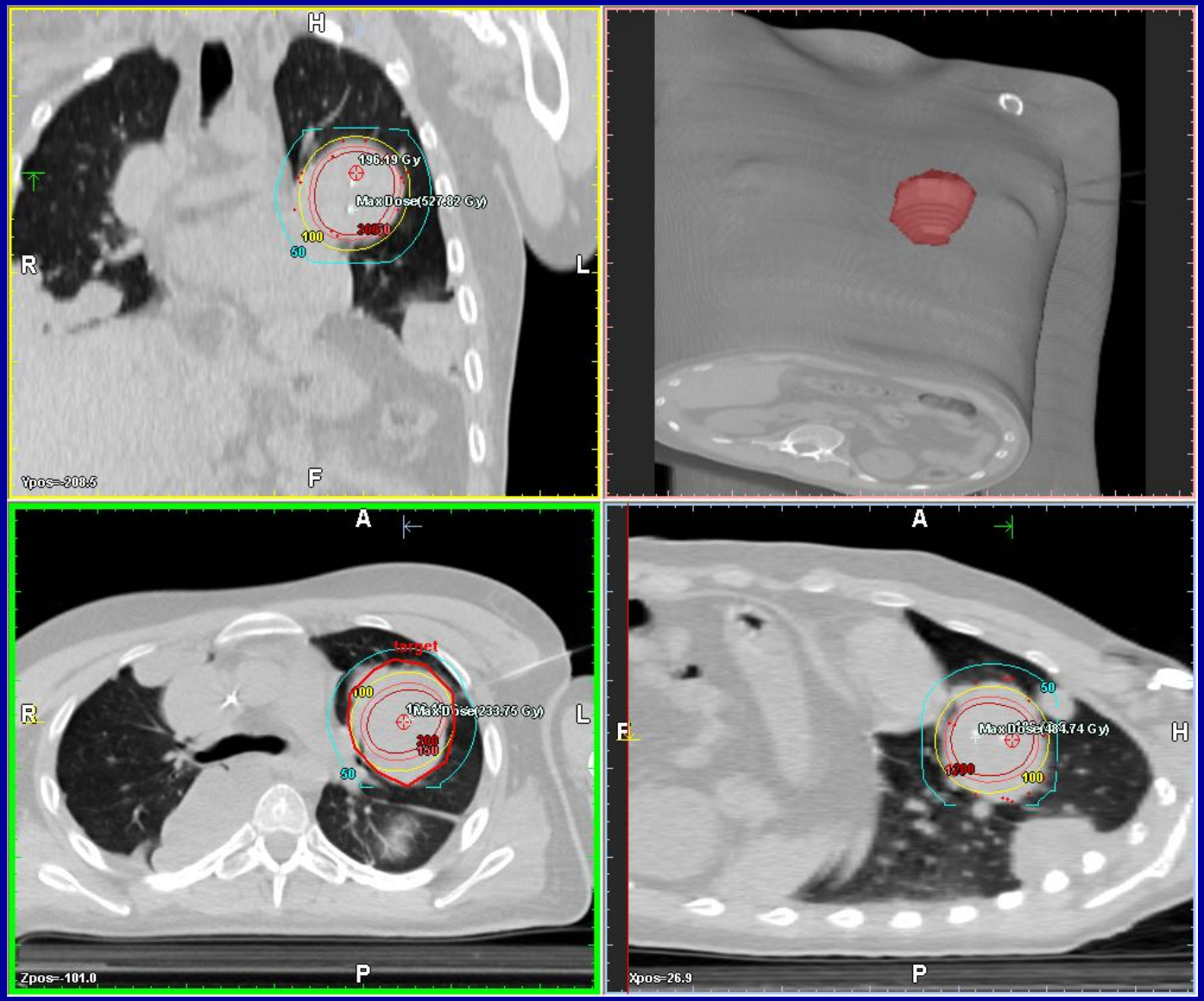



H
R
L
F
Ypos=336.5
SSD: 85.5 cm
12 weeks after
CUR. BEAM 1
A
R
L
P
Zpos=-870.8
A
F
H
P
Xpos=186.4


A
R
L
P
Target
Zpos=224.5


A
R
L
P
Target
Zpos=224.5


A
R
L
P
Zpos=438.0


H
196.19 Gy
MaxDose(527.82 Gy)
3000
100
50
R
L
Ypos=-208.5
F
A
target
100
MaxDose(233.76 Gy)
300
150
50
R
L
Zpos=-101.0
P
A
50
MaxDose(484.74 Gy)
1300
100
F
H
Xpos=-26.9
P

Brachytherapy in Pulmonary Tumours

- Pancoast tumour N= 18
- BC recurrents N= 15
- Pleura mesothel. N= 5
- Metastasis N= 24

Tselis N., …..Zamboglou N.
J Thorac Oncol. 2011 Mar;6(3):545-52.

Brachytherapy in Pulmonary Tumours

Side Effects

N=62

- No bleedings
- No Infections
- Pains with analgetics tolerable
- 1 Patient Pneumothorax asymptomatic

Brachytherapy in Pulmonary Tumours

Duration

Mean time of hospitalisation

5 days

Brachytherapy in Pulmonary Tumours

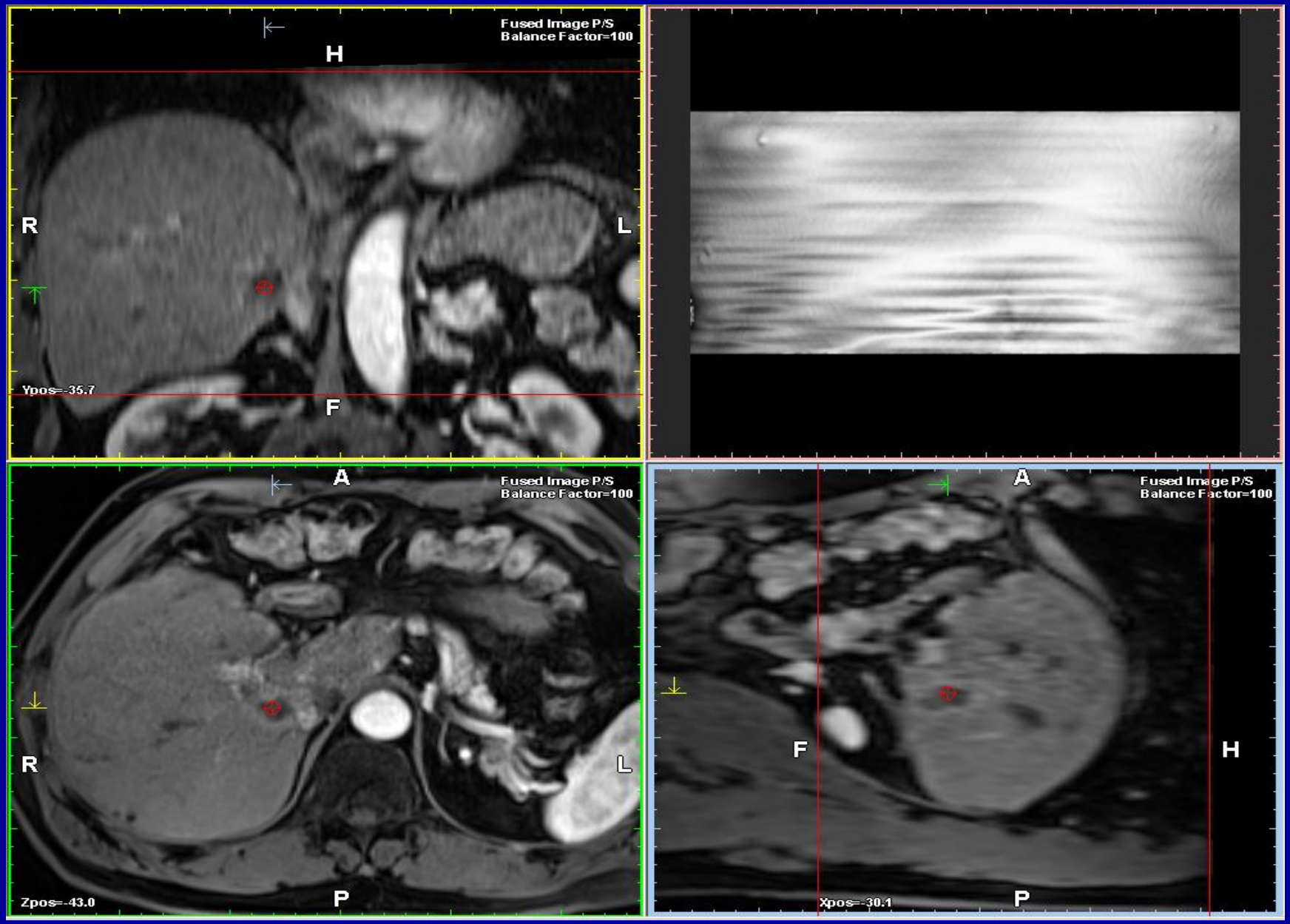
Symptoms

Pain releaf :
58/62 patients

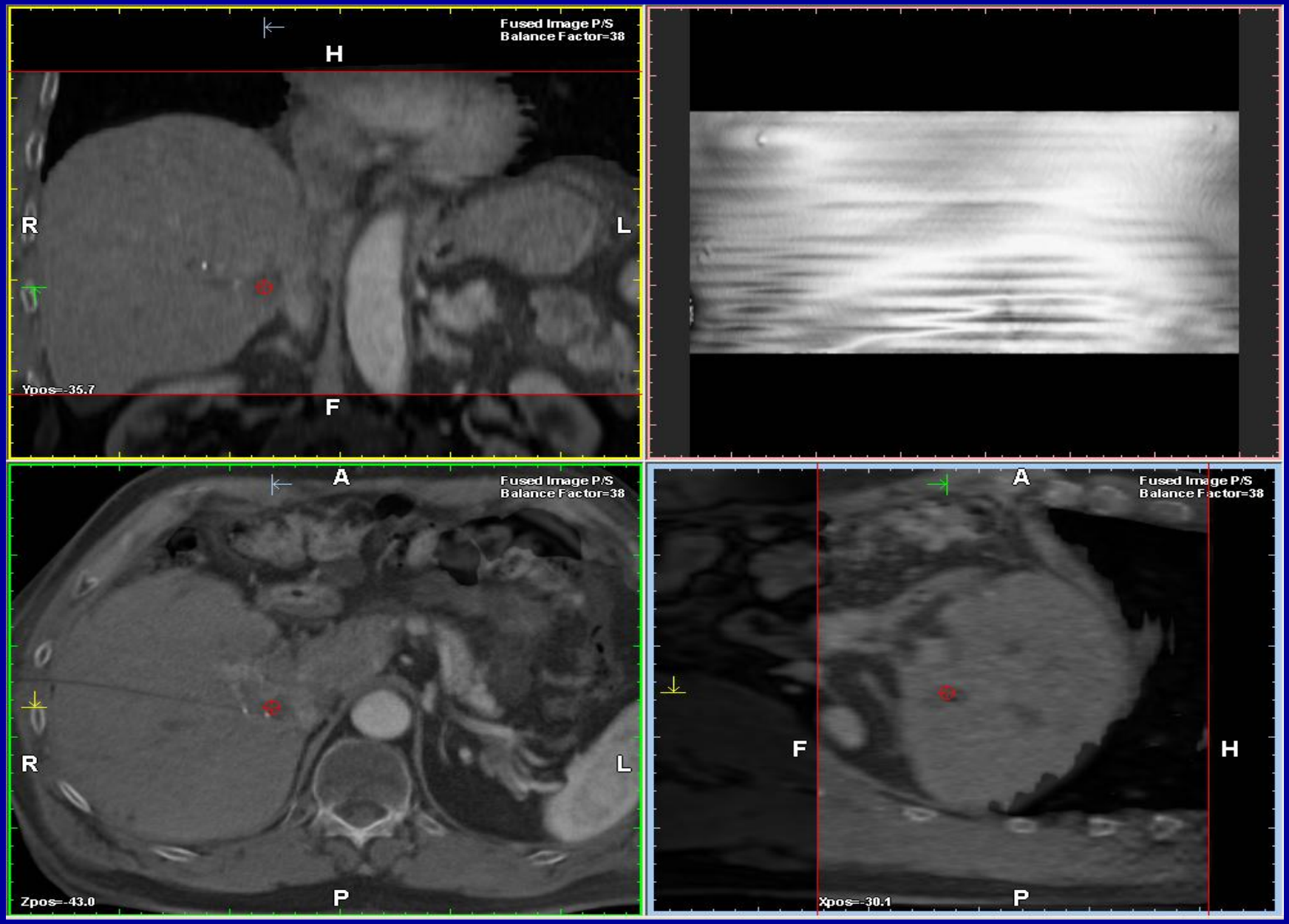
Improvement of respiratory function:
30/62 patients

Liver

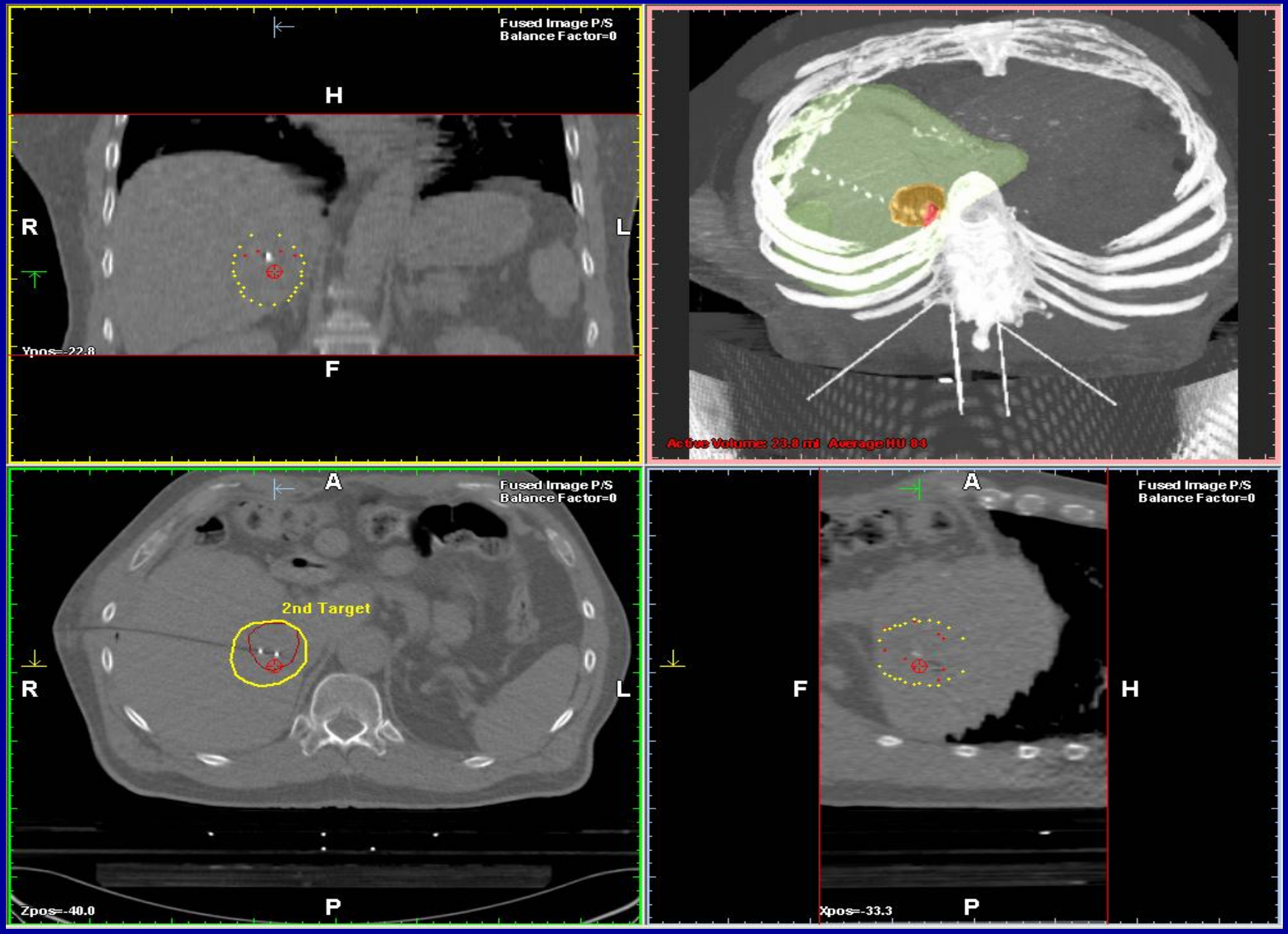
Liver Metastasis CT-MRI Fusion



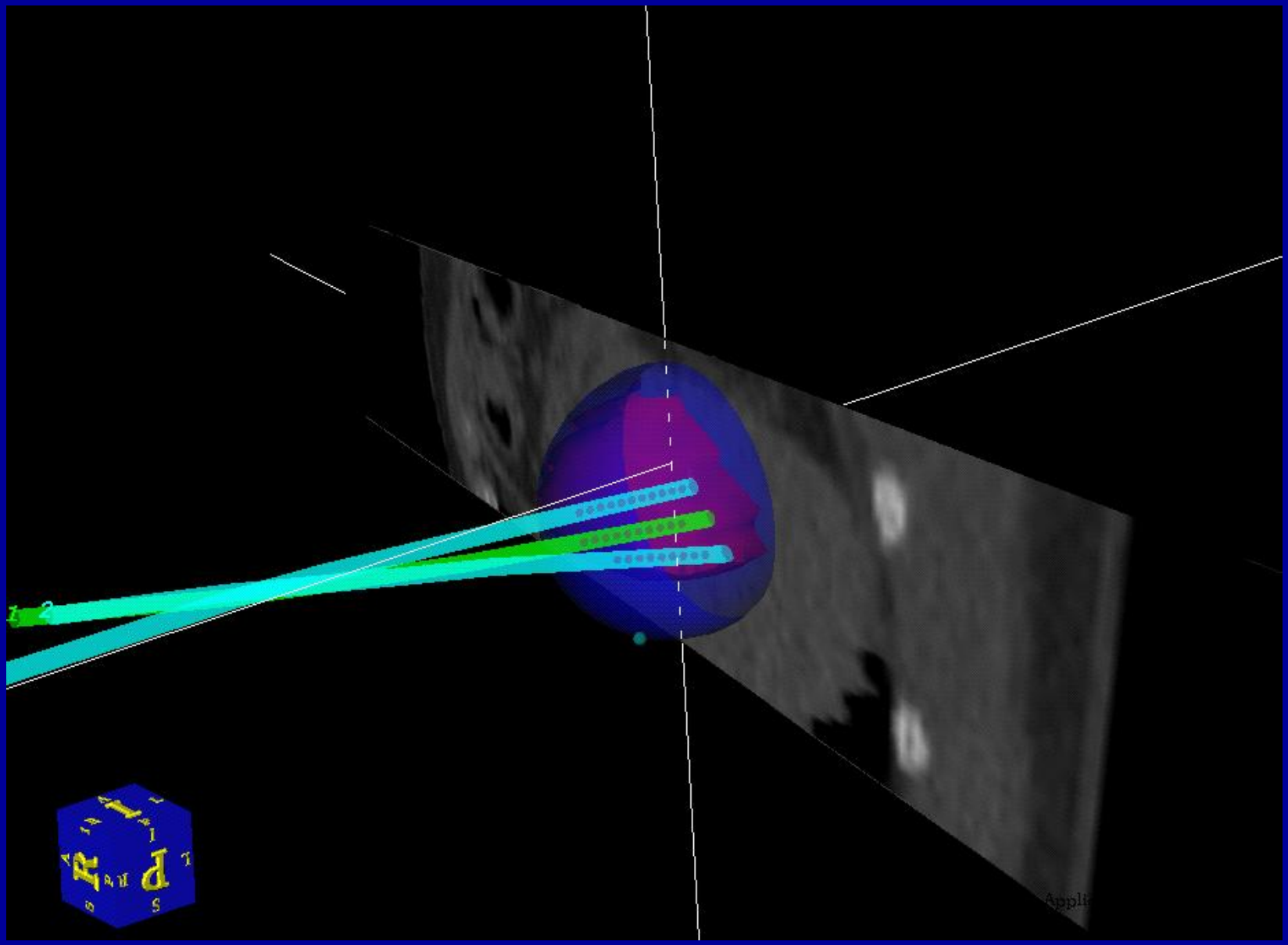
Needles Implantation



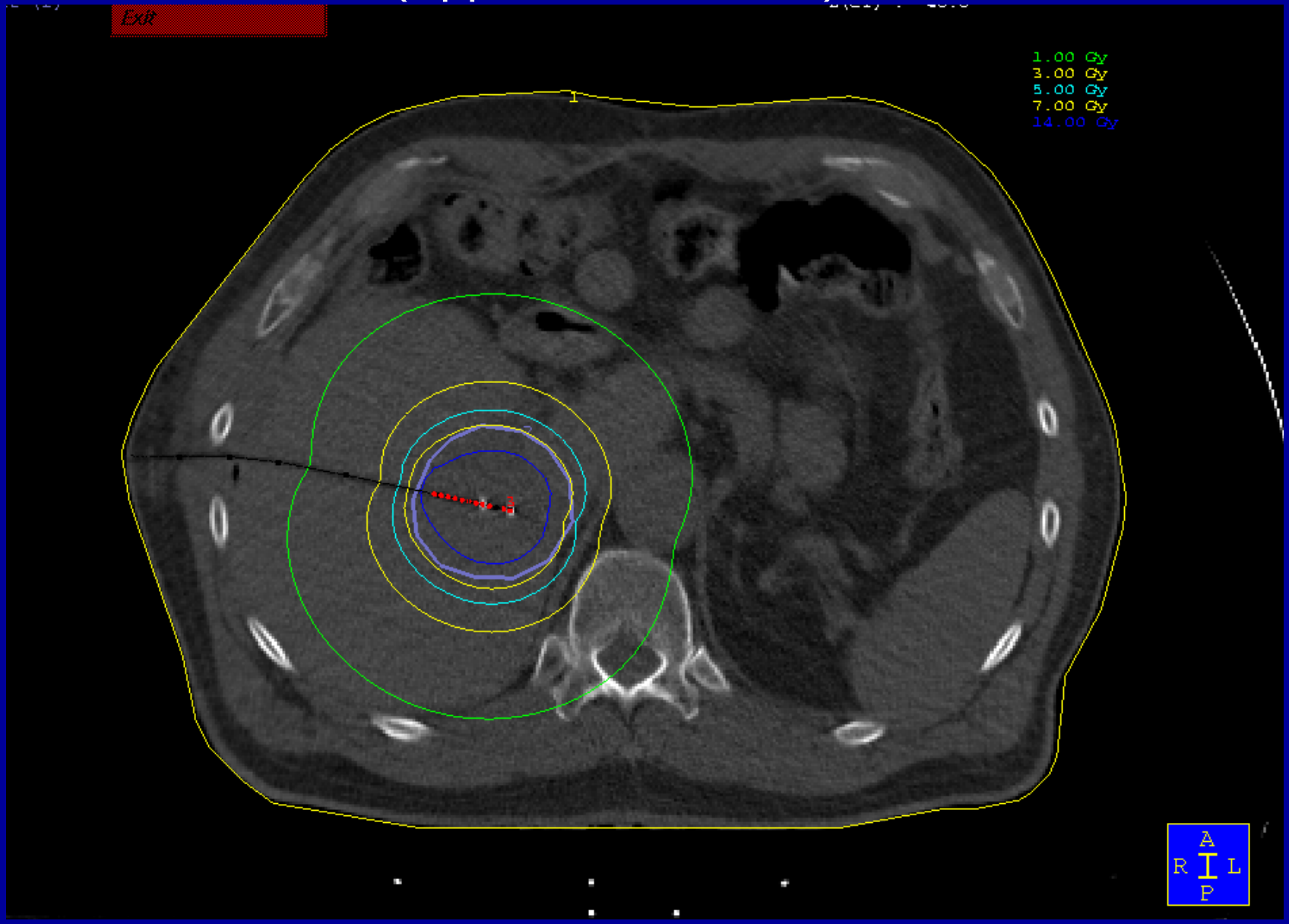
Needles Documentation



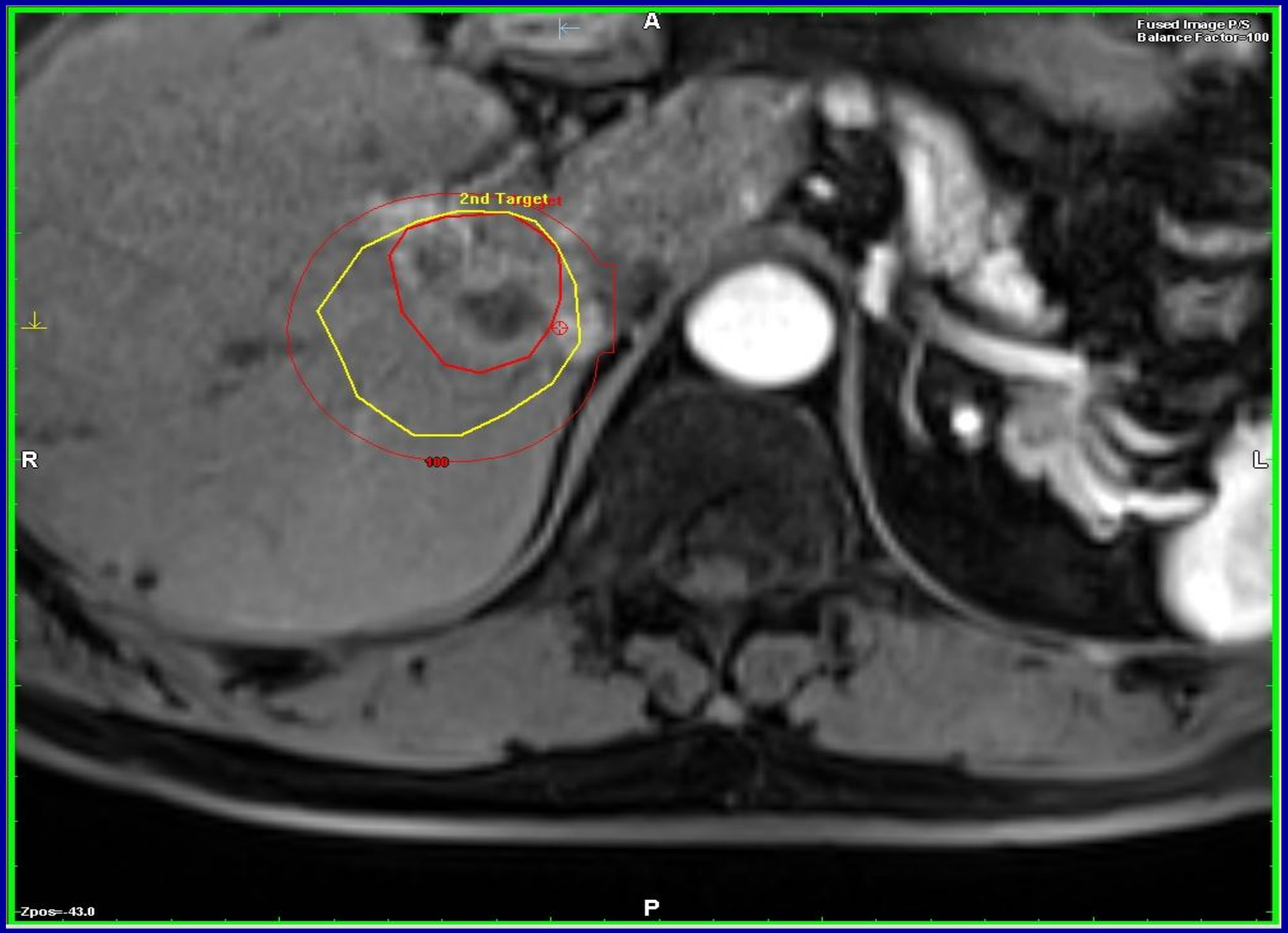
Needles Reconstruction 3D



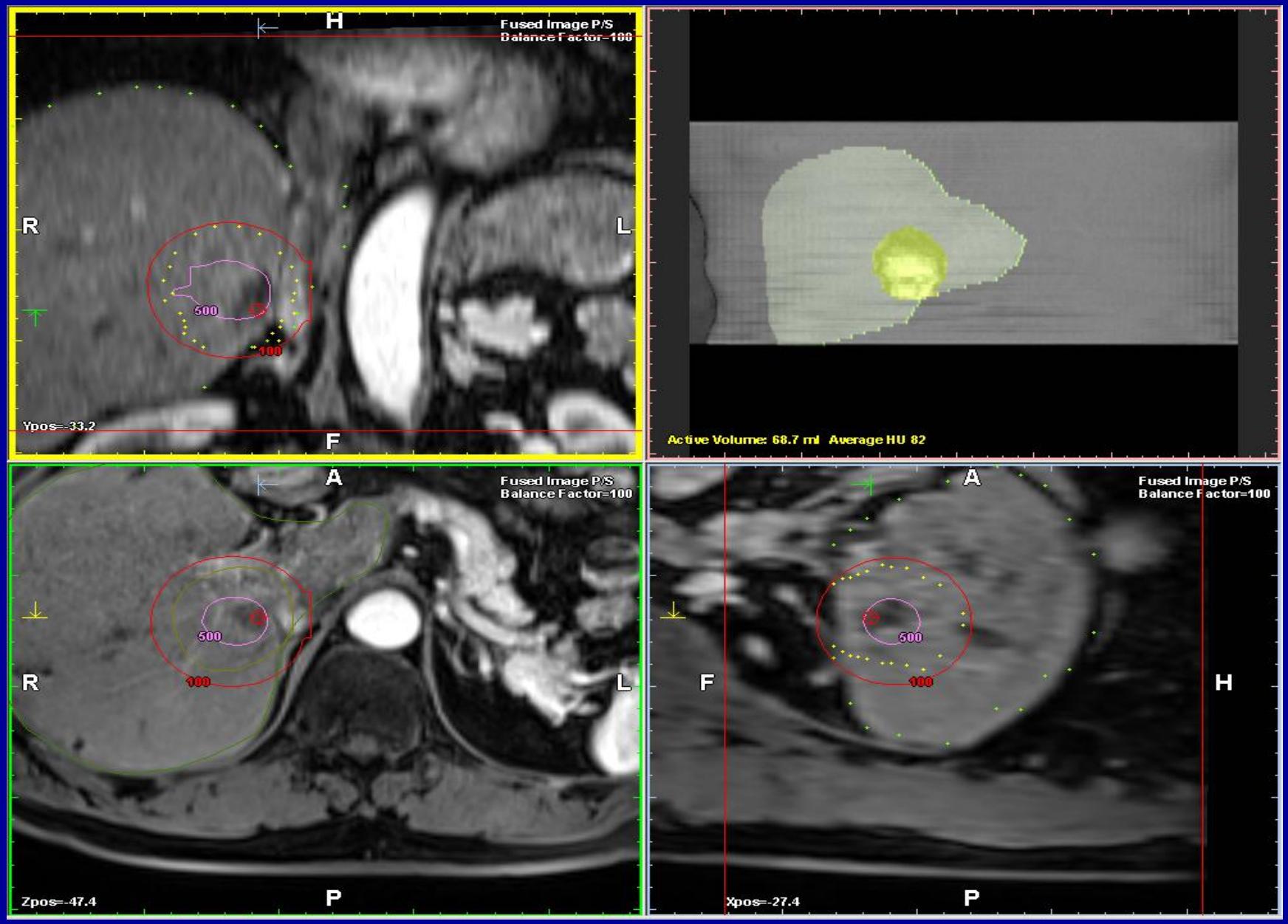
Dose Distribution Gy/per Fraction (Applied 3 Fractions)



Dose Distribution on MRI (100% = 7 Gy per Fraction)



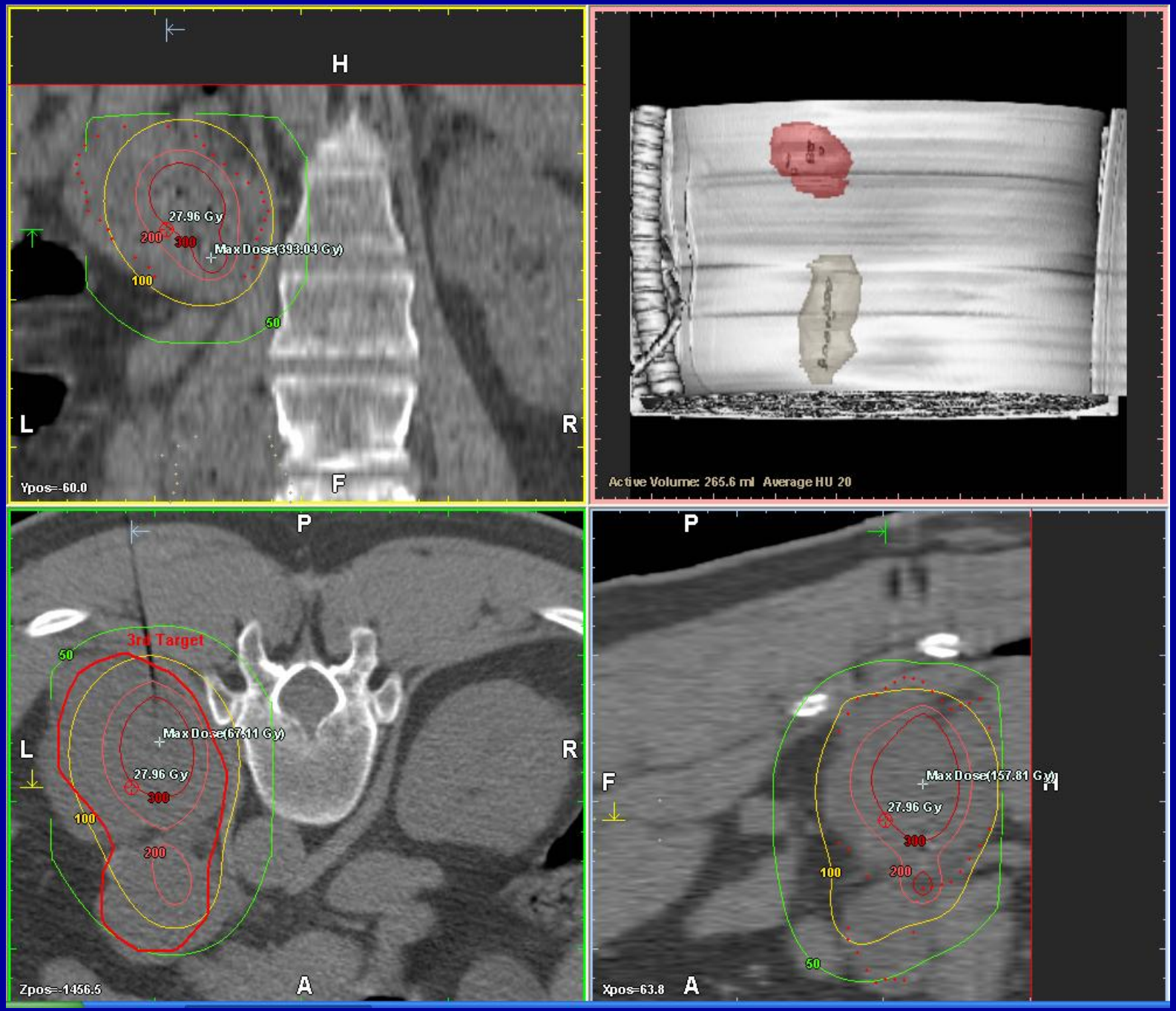
Dose Distribution (500% = 35 Gy per Fraktion)

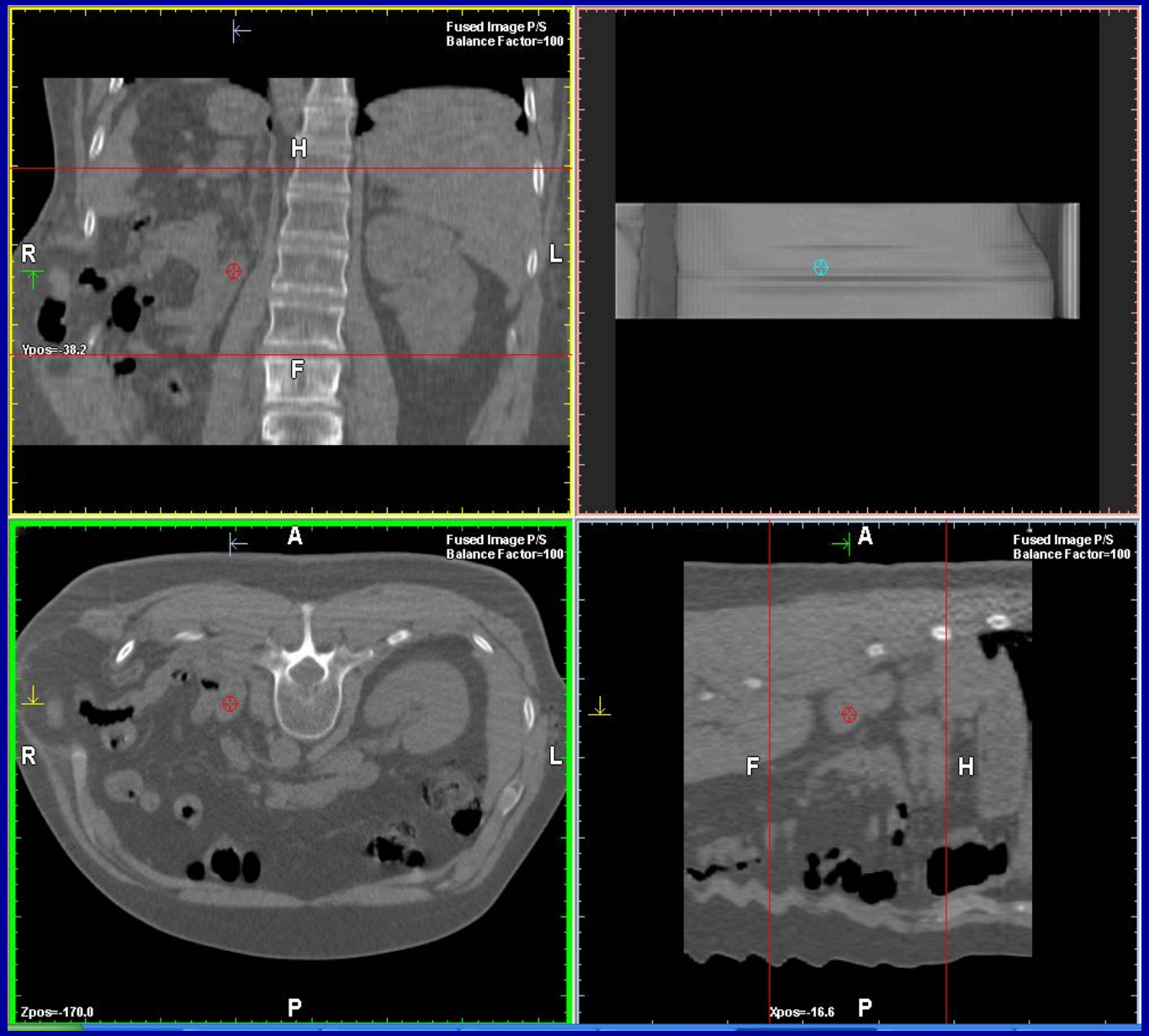


- **Hypofractionated accelerated computed tomography-guided interstitial high-dose-rate brachytherapy for liver malignancies.**
- Tselis N. …….. Zamboglou N.

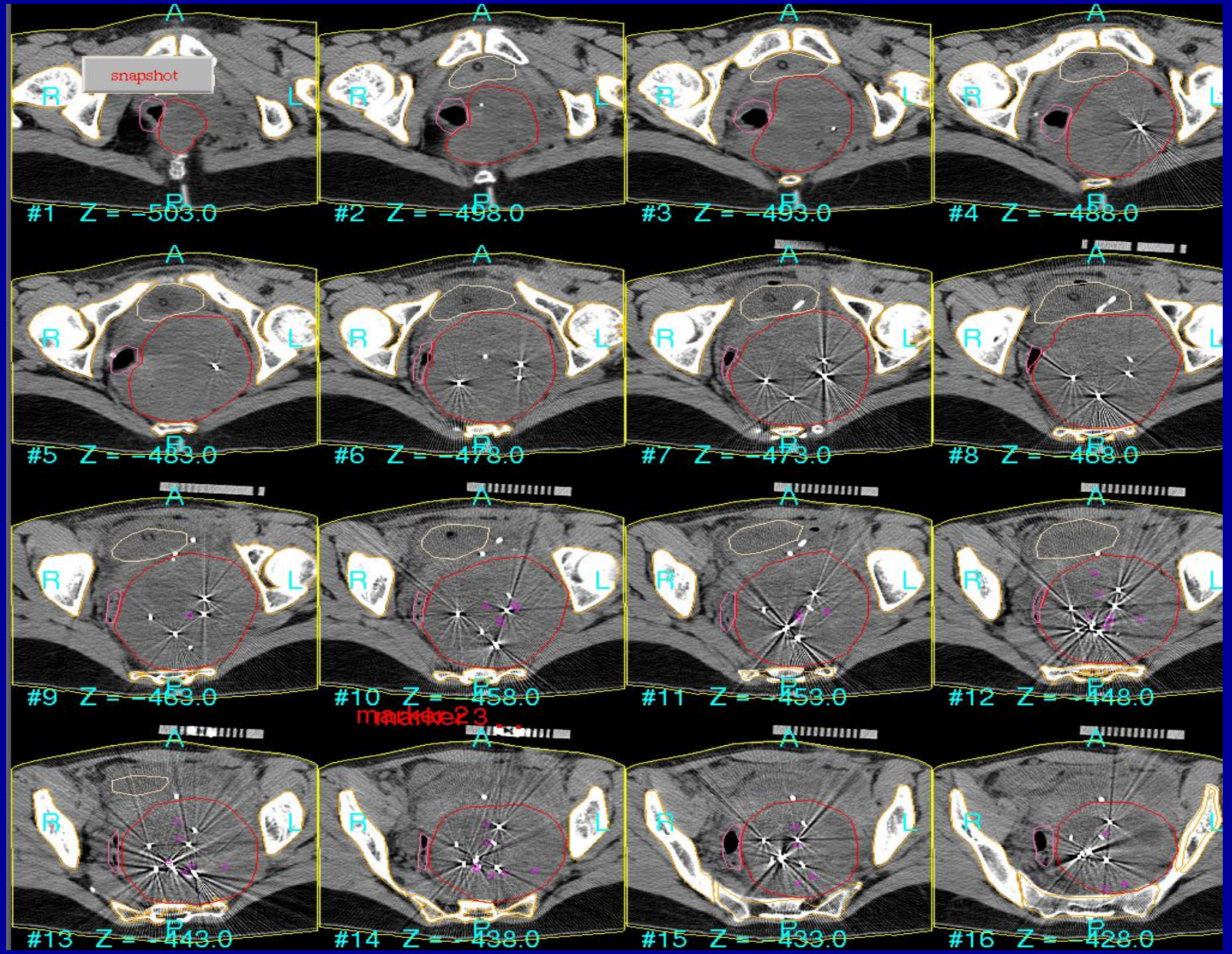
  Brachytherapy, 2012 May 8

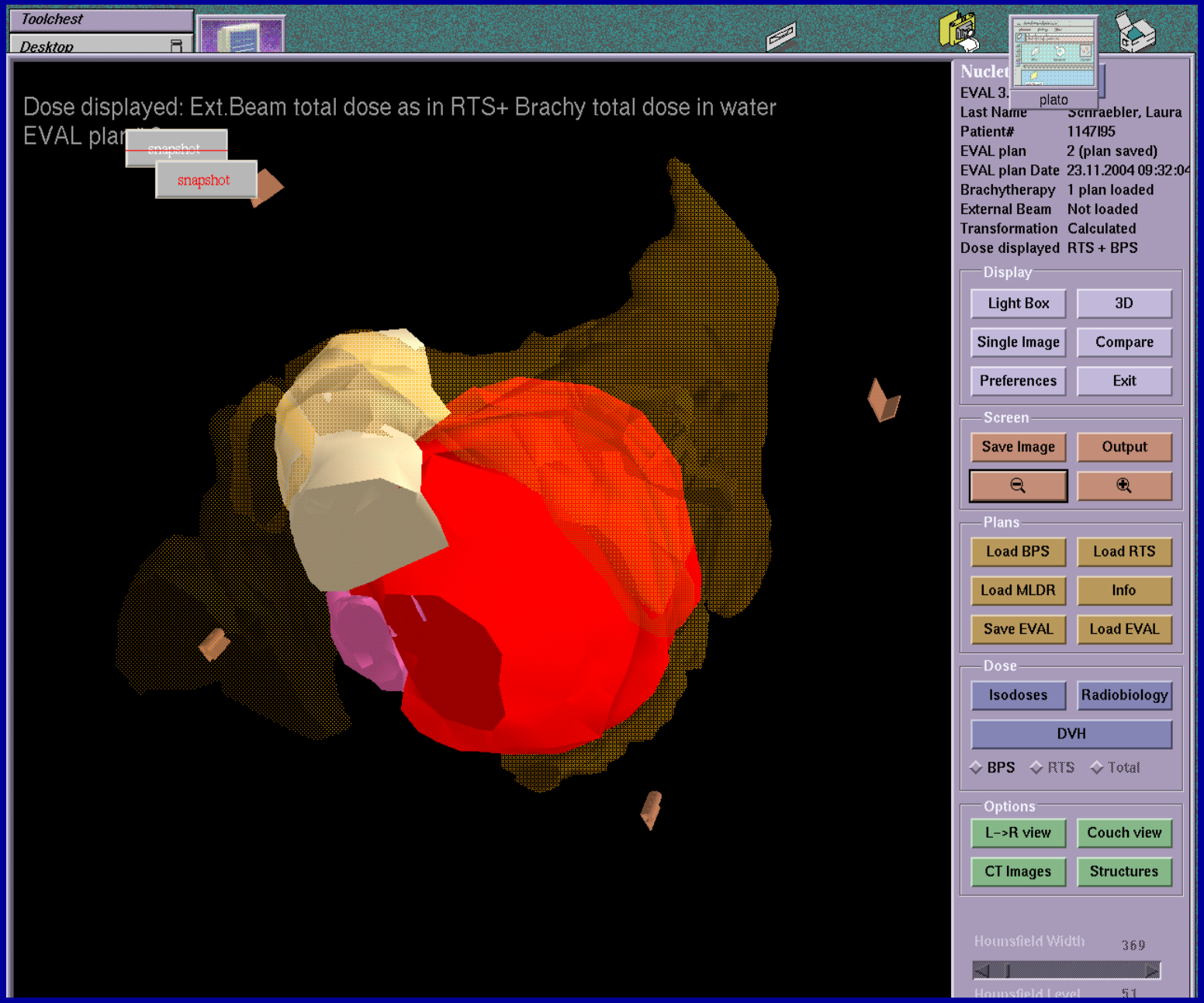
Retroperitoneum

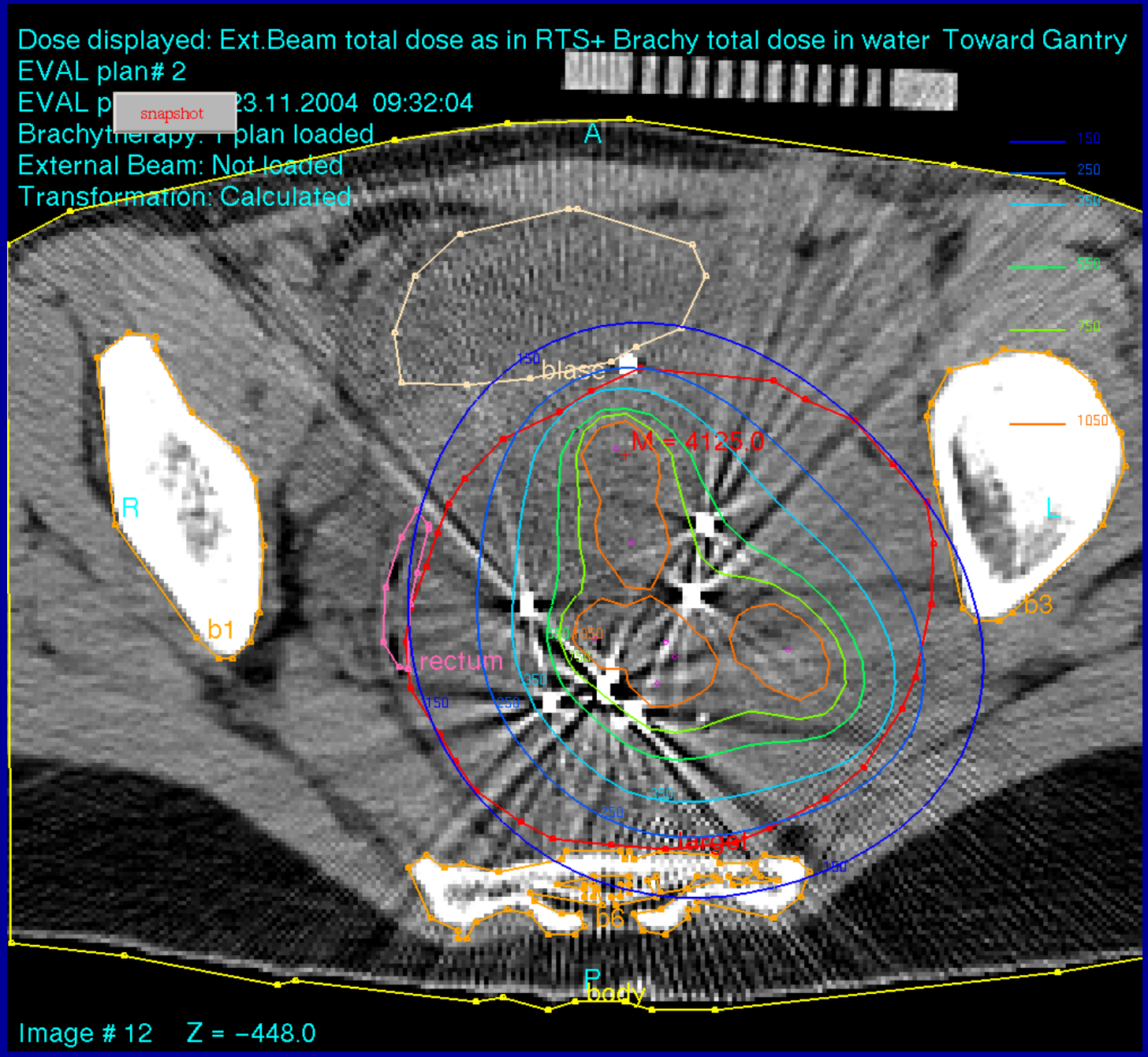

H
27.96 Gy
200
300
Max Dose(393.04 Gy)
100
50
L
R
F
Ypos=-60.0
Active Volume: 265.6 ml Average HU 20
P
3rd Target
50
Max Dose(67.11 Gy)
L
R
27.96 Gy
300
100
200
Zpos=-1456.5
A
P
F
H
Max Dose(157.81 Gy)
27.96 Gy
300
100
200
50
Xpos=-63.8
A


Fused Image P/S
Balance Factor=100
H
R
L
Ypos=-38.2
F
A
Fused Image P/S
Balance Factor=100
R
L
Zpos=-170.0
P
A
Fused Image P/S
Balance Factor=100
F
H
Xpos=-16.6
P

Pelvis


snapshot
A
R
L
P
#1 Z = -503.0
#2 Z = -498.0
#3 Z = -493.0
#4 Z = -488.0
#5 Z = -483.0
#6 Z = -478.0
#7 Z = -473.0
#8 Z = -468.0
#9 Z = -463.0
#10 Z = -458.0
#11 Z = -453.0
#12 Z = -448.0
#13 Z = -443.0
#14 Z = -438.0
#15 Z = -433.0
#16 Z = -428.0


Toolchest
Desktop
plato
Dose displayed: Ext.Beam total dose as in RTS+ Brachy total dose in water
EVAL plan
snapshot
snapshot
Nuclet
EVAL 3.
Last Name Schraebler, Laura
Patient# 1147195
EVAL plan 2 (plan saved)
EVAL plan Date 23.11.2004 09:32:04
Brachytherapy 1 plan loaded
External Beam Not loaded
Transformation Calculated
Dose displayed RTS + BPS
Display
Light Box
3D
Single Image
Compare
Preferences
Exit
Screen
Save Image
Output
Plans
Load BPS
Load RTS
Load MLDR
Info
Save EVAL
Load EVAL
Dose
Isodoses
Radiobiology
DVH
BPS
RTS
Total
Options
L->R view
Couch view
CT Images
Structures
Hounsfield Width
369
Hounsfield Level
51


Dose displayed: Ext.Beam total dose as in RTS+ Brachy total dose in water Toward Gantry
EVAL plan# 2
EVAL p 23.11.2004 09:32:04
Brachytherapy: 1 plan loaded
External Beam: Not loaded
Transformation: Calculated
snapshot
A
150
250
350
550
750
1050
blase
M = 4125.0
R
L
b1
b3
rectum
target
b6
Body
Image # 12 Z = -448.0

10 Years after

Ευχαριστώ