



Servicio de Radiofísica

10 años **SBRT-HUVR**

Santiago Velázquez



HOSPITALES UNIVERSITARIOS
Virgen del Rocío

10 años

años

Repensamos

la SBRT





- Liturgia
+ Imagen
+ Precisión
+ Rápido

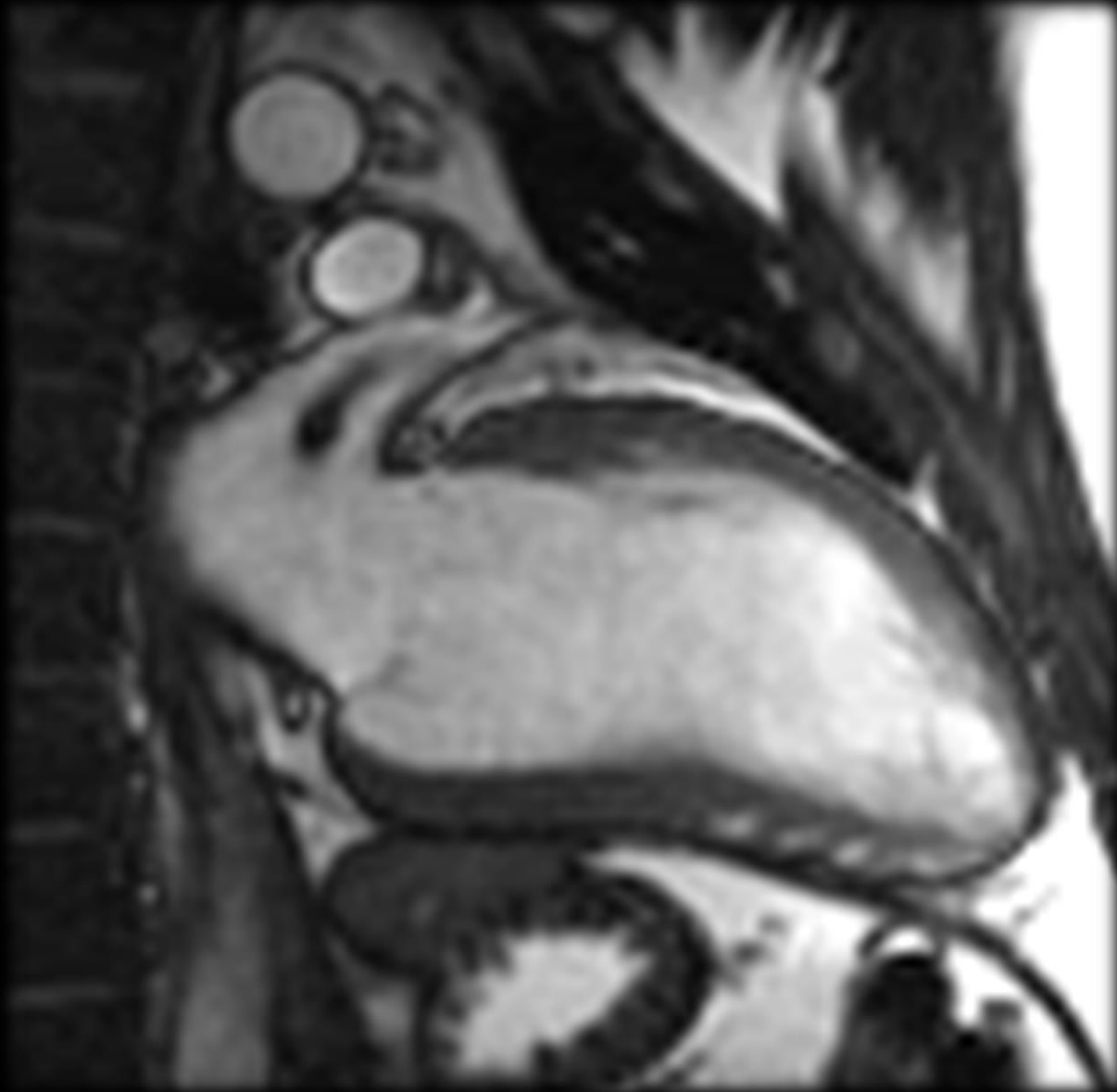
Imagen:

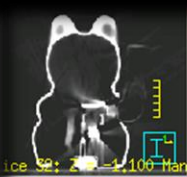
-Movimiento asincrónico

-Alta resolución

-MRI

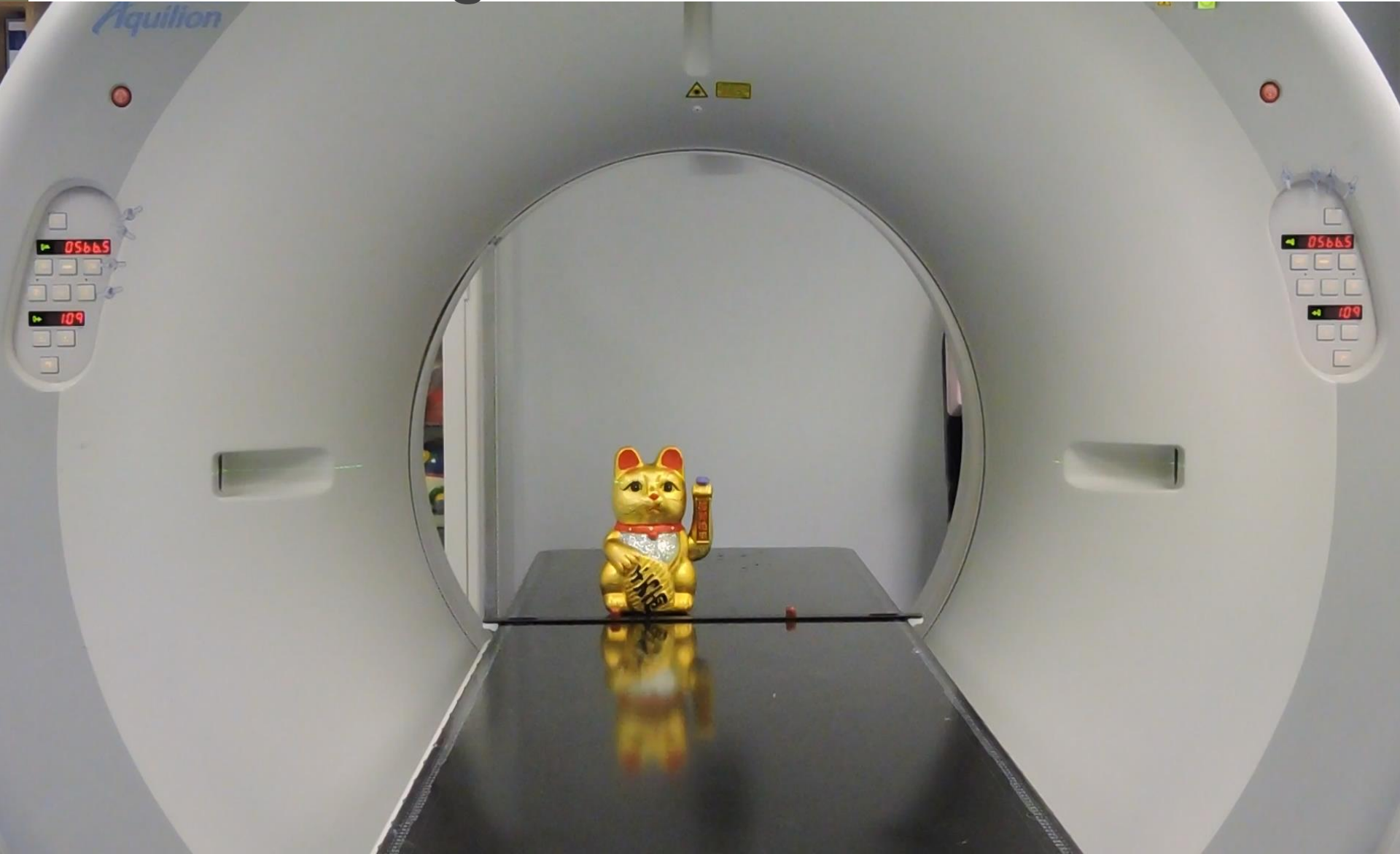
Asincronía diafragmática





SlowCT/CT Fusion

You can get more than 10cm movement



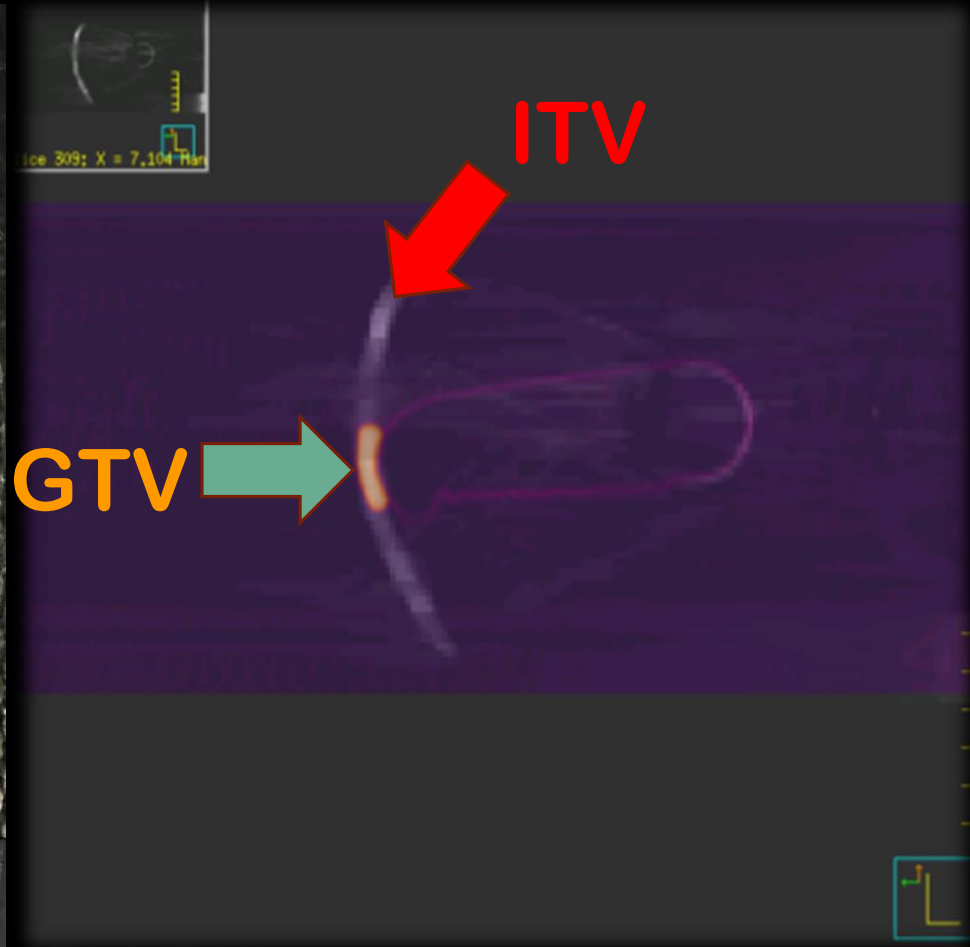
SlowCT

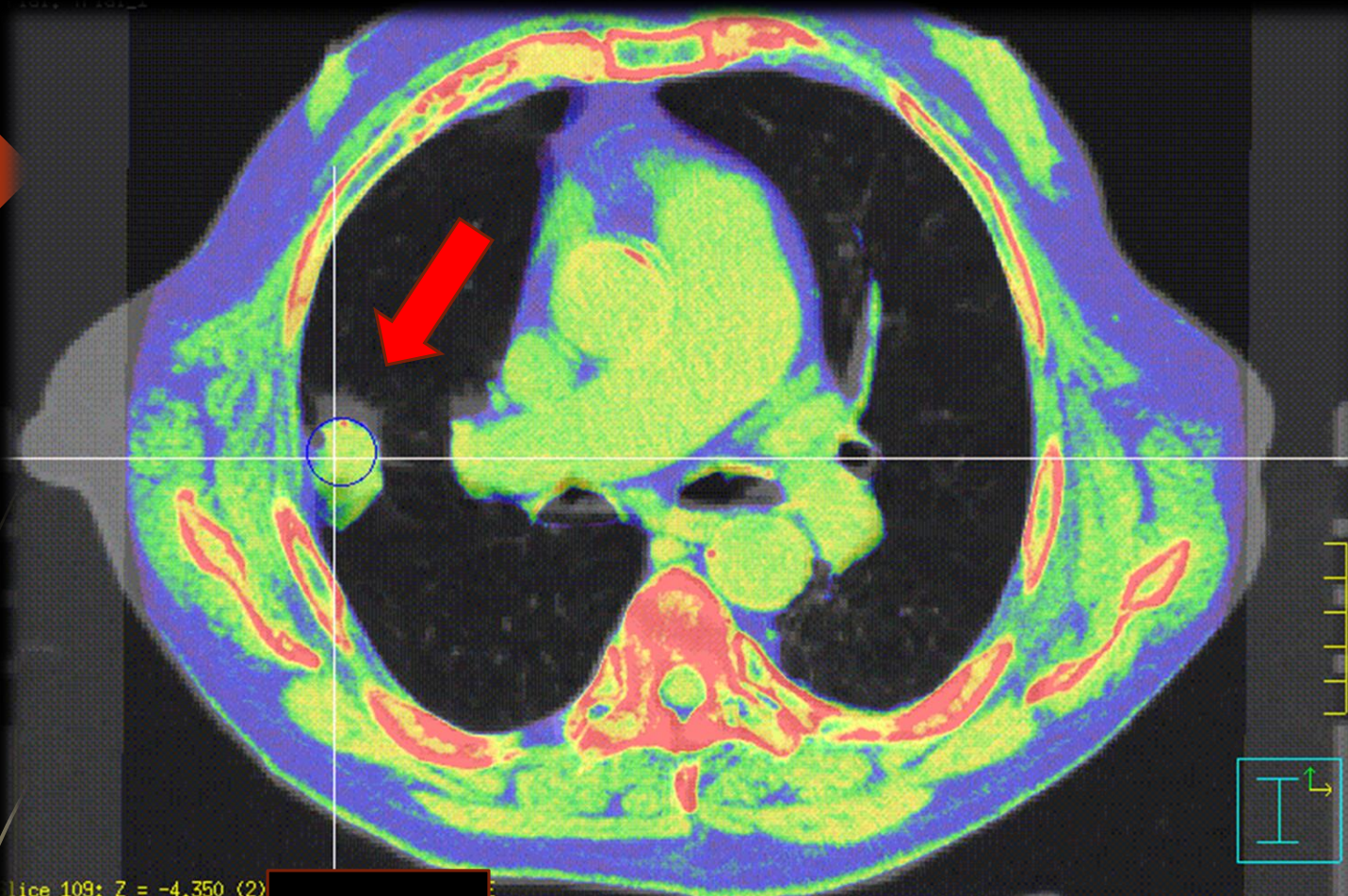


HRCT / TACAR

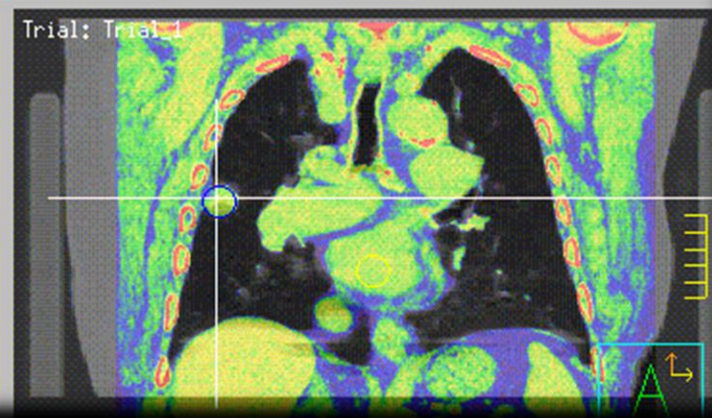
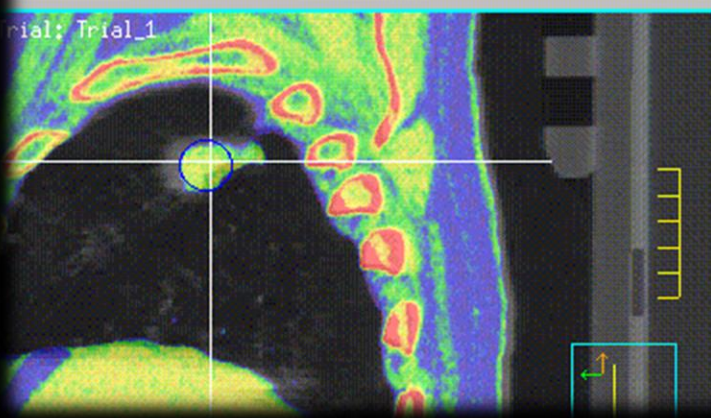


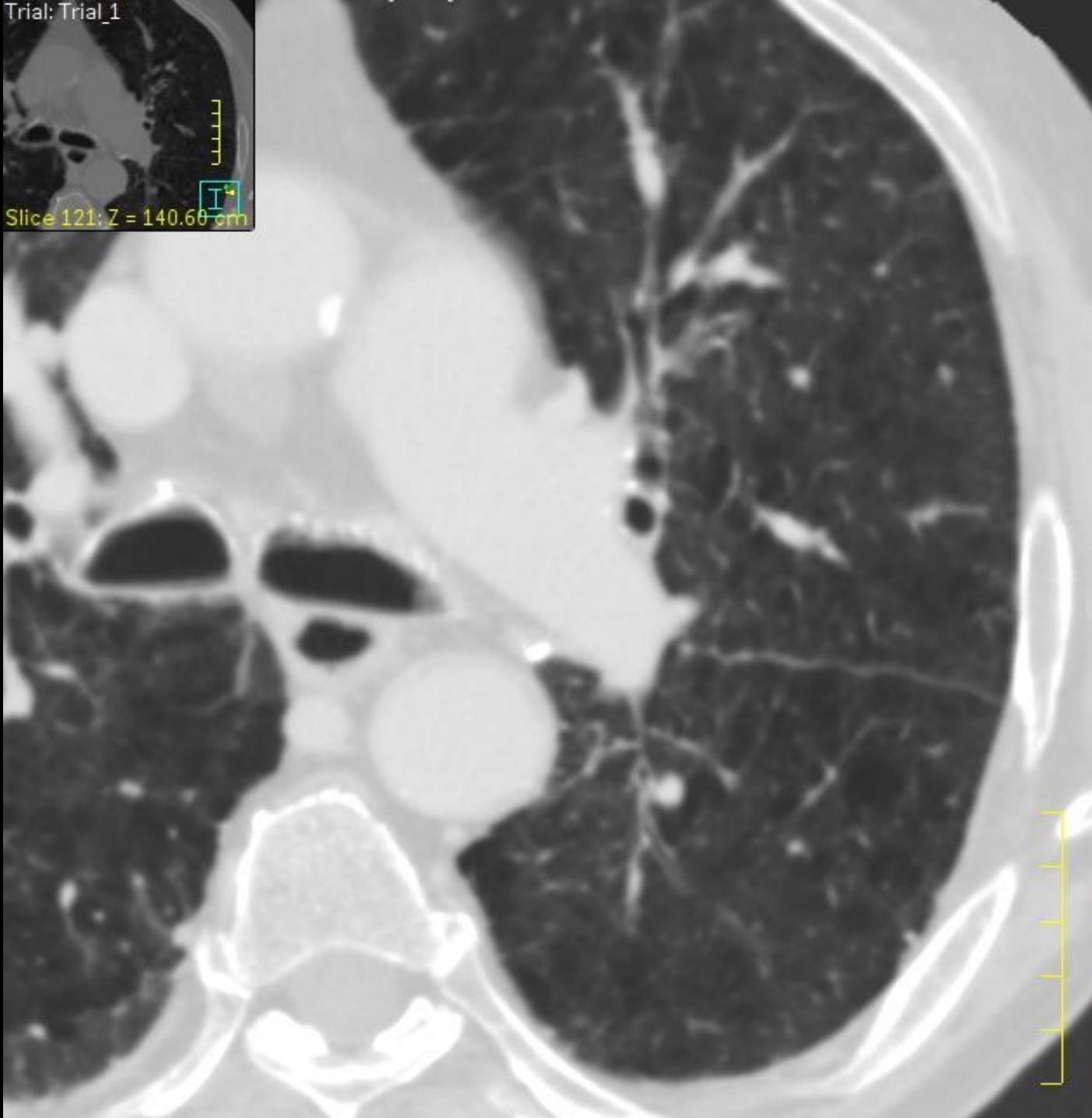
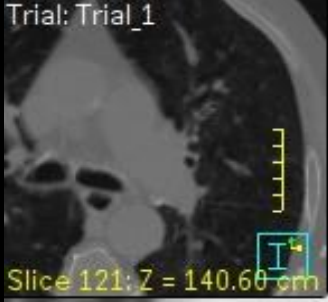
SlowCT/dCT Fusión





lice 109: Z = -4.350 (2)





GATING CT

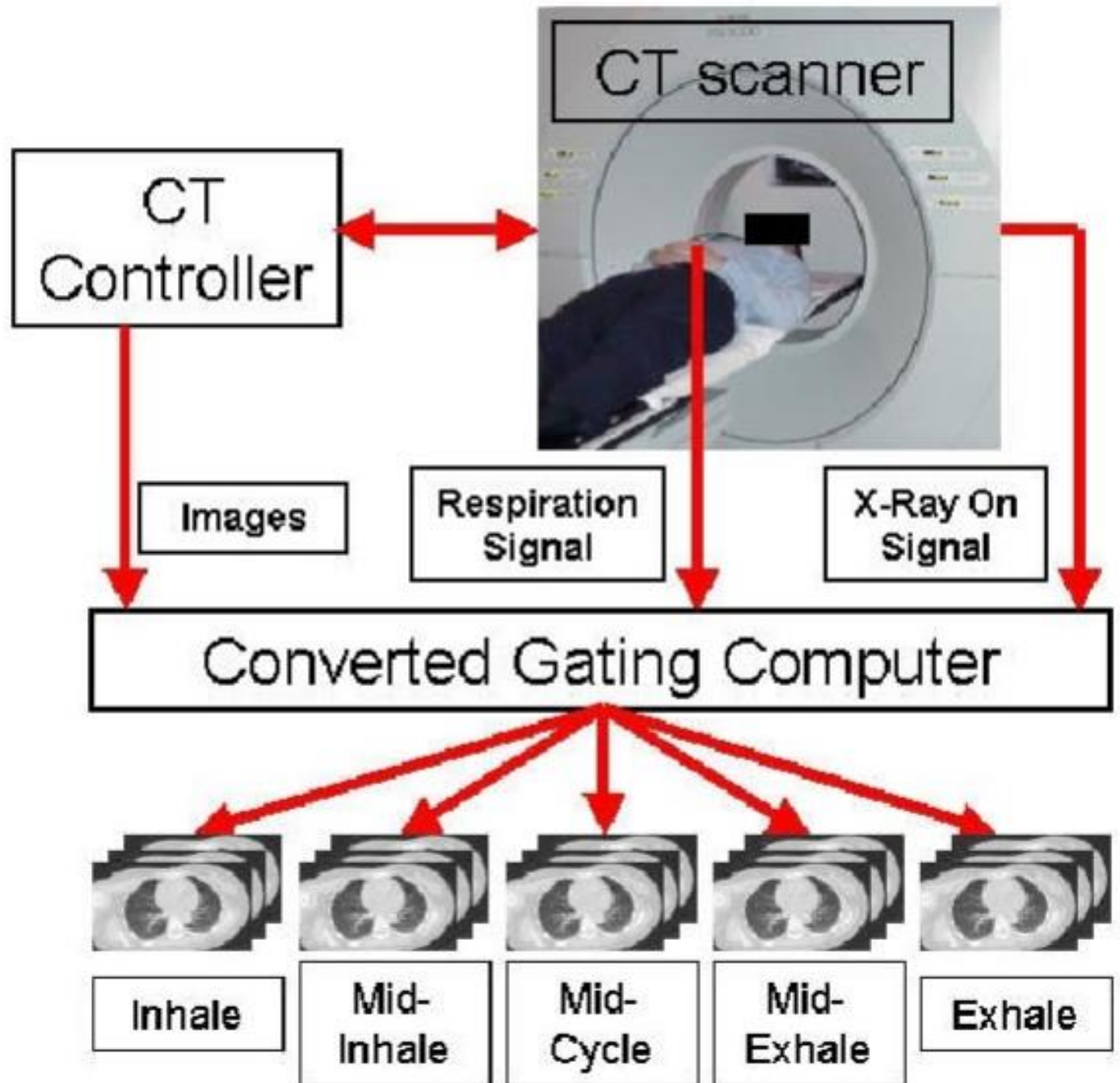
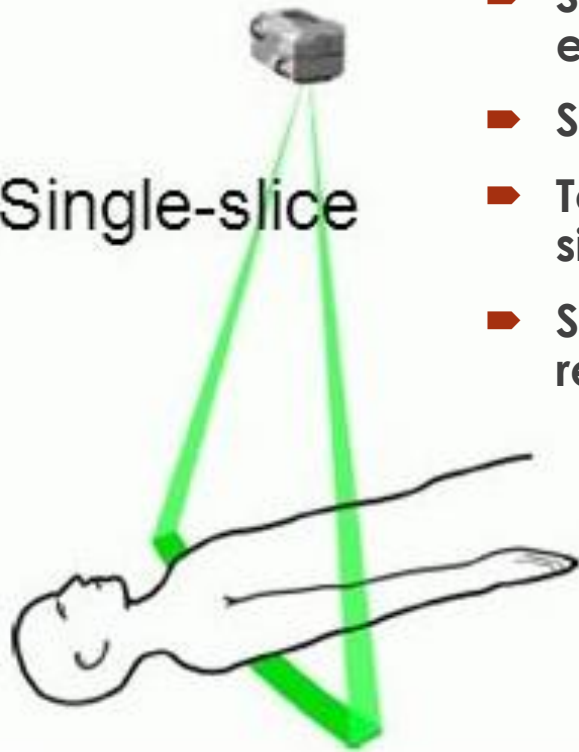


Imagen hepática: 4D Dinámico

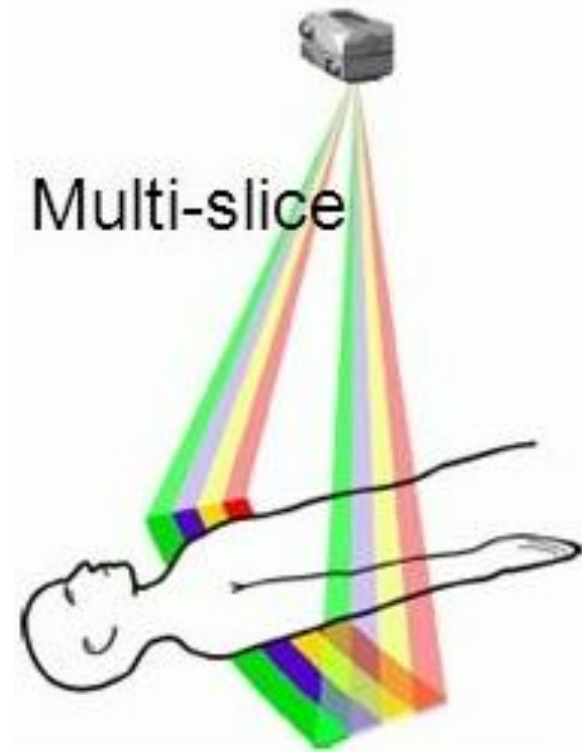
Single-slice

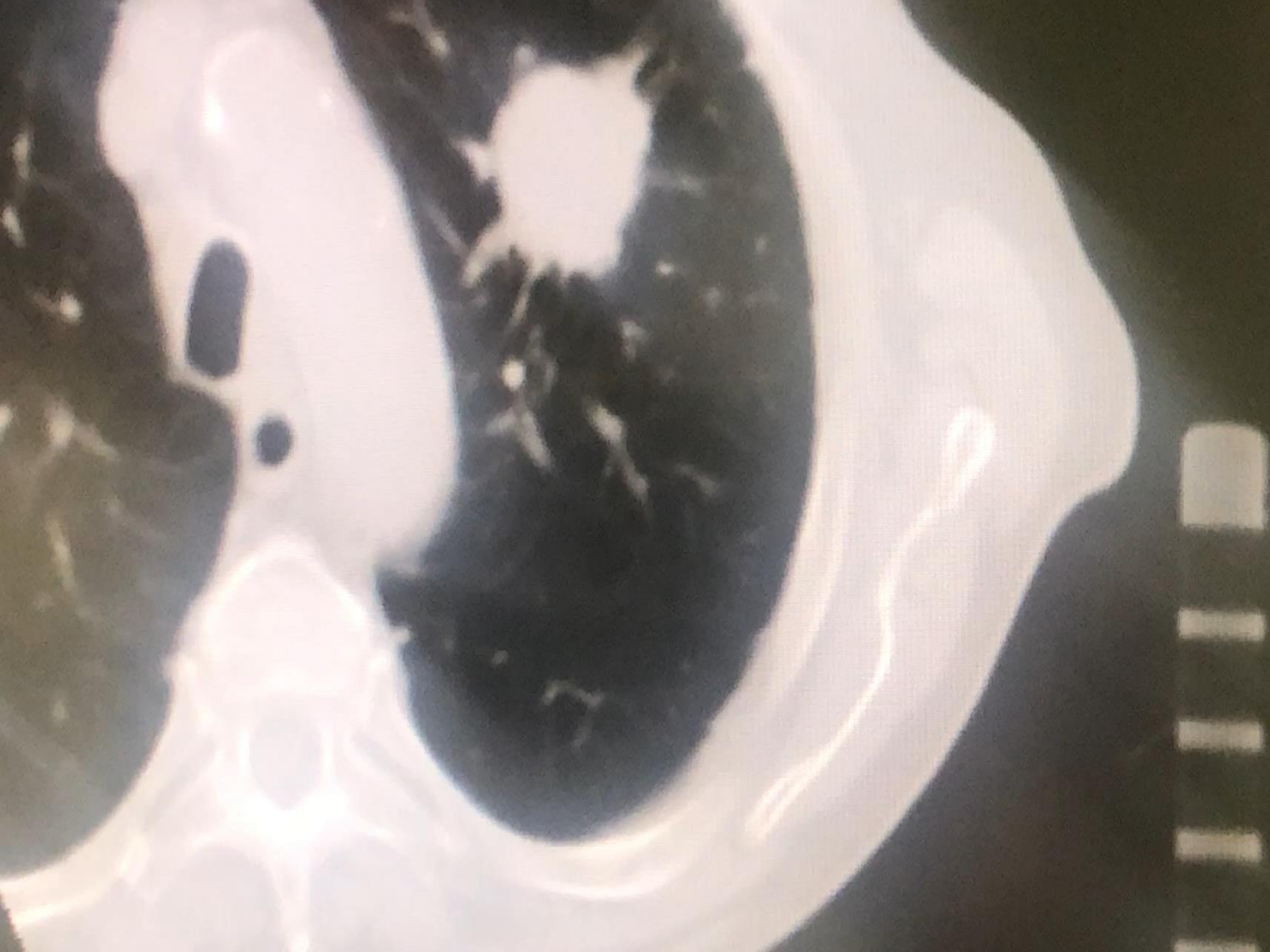


- Secuencia dinámica centrada en la lesión
- Sin desplazamiento de mesa
- Todas las coronas simultáneamente
- Sin correlación con la fase respiratoria

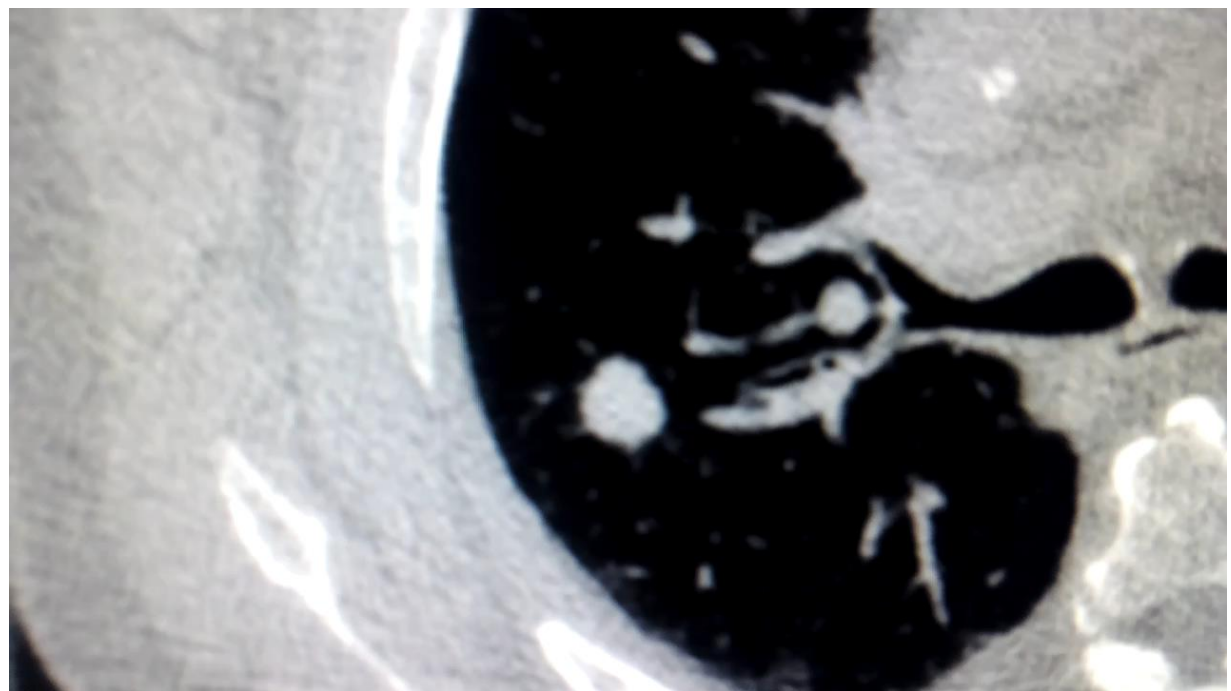
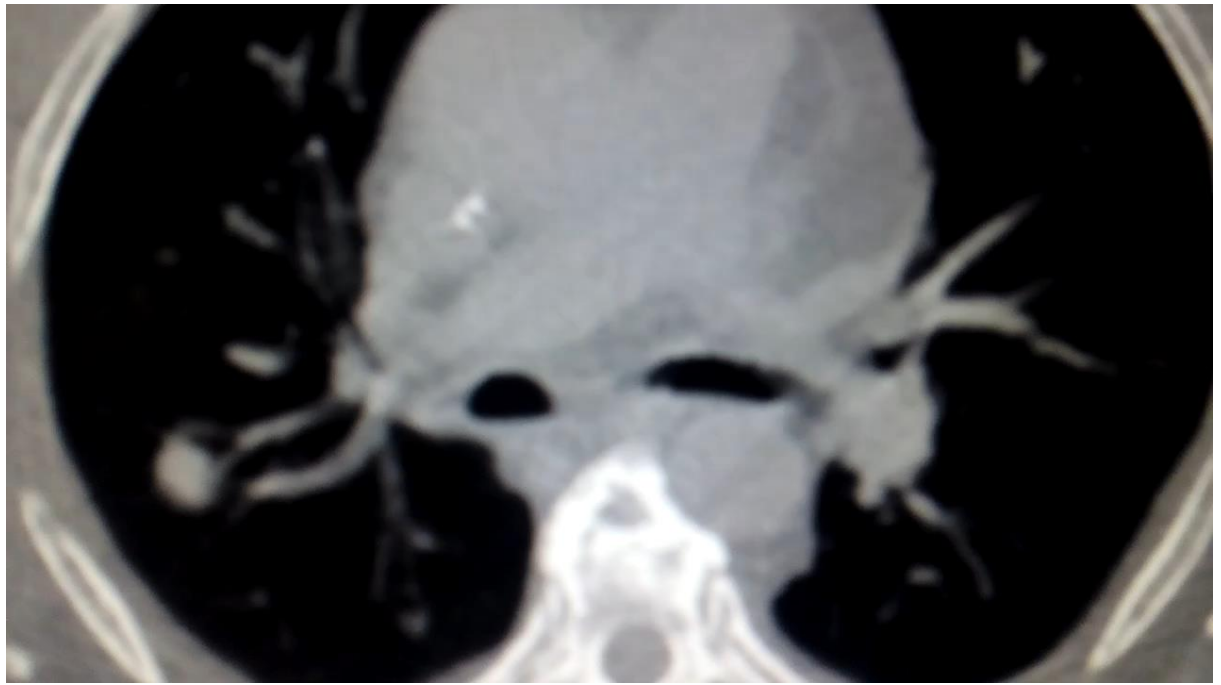
(multidampening, no gating)

Multi-slice









+ Precisión

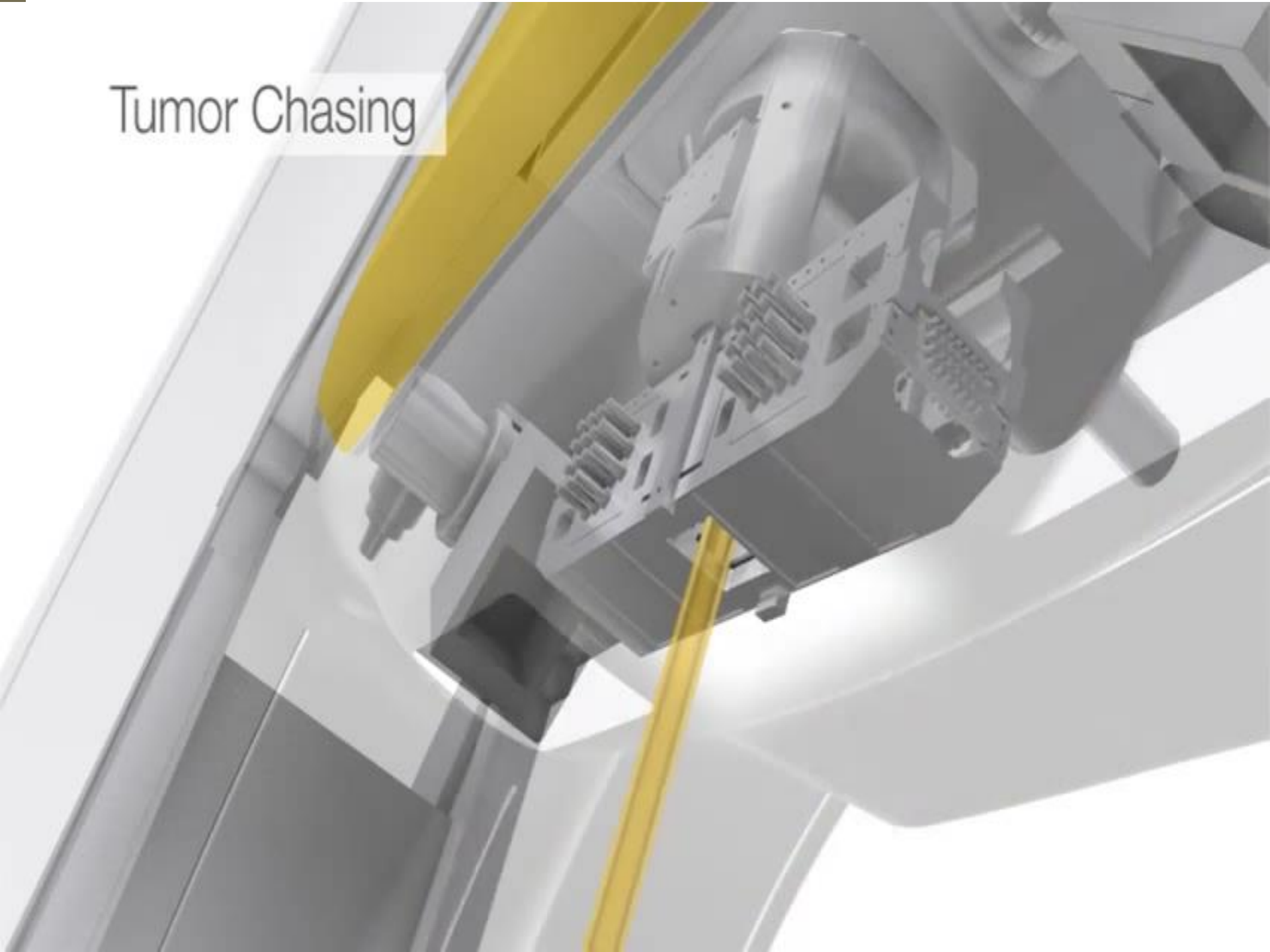
¿Cómo reducimos el ITV?

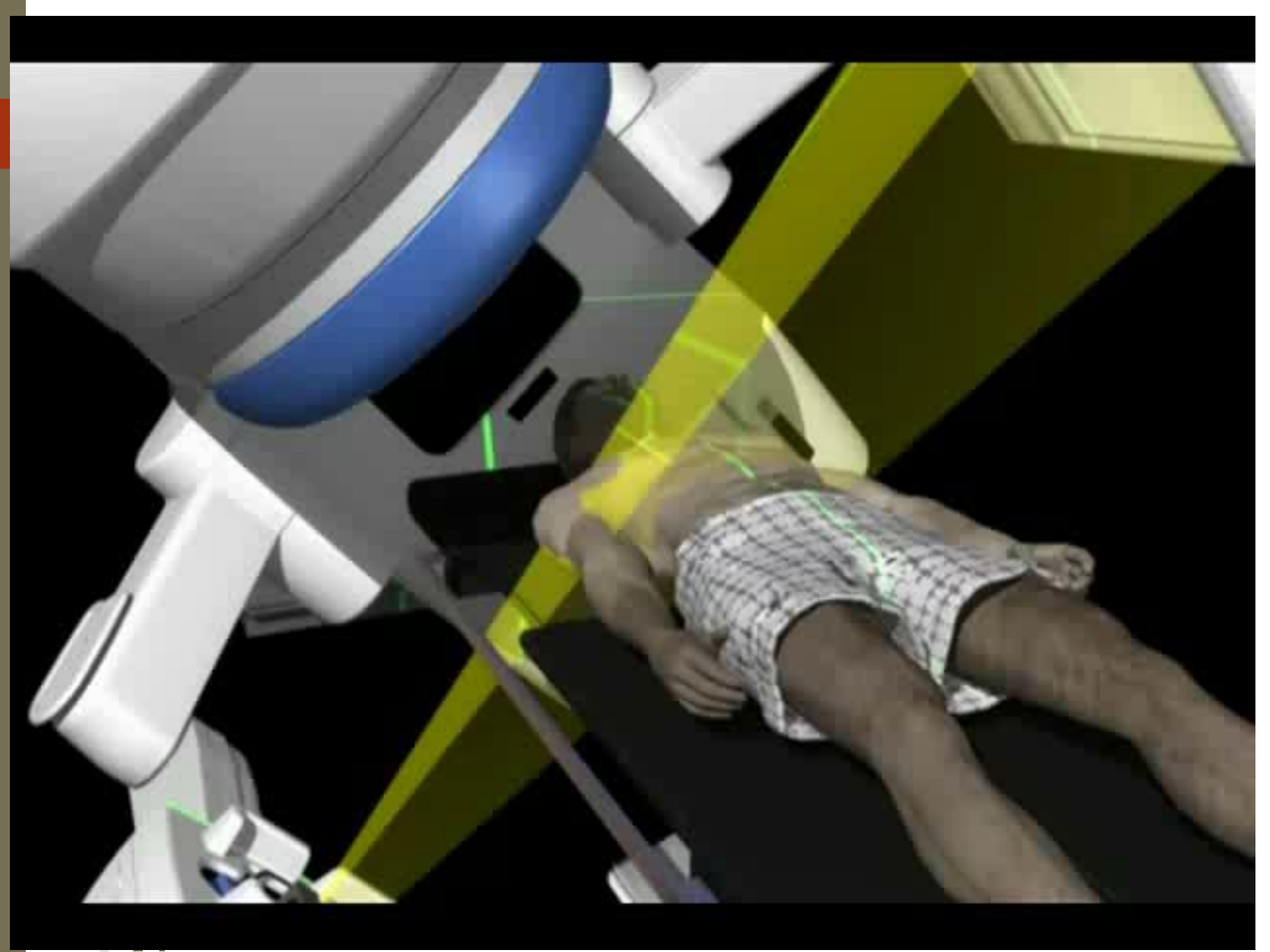
Tracking

Gating

Dampening

Tumor Chasing





SBRT AAPM TG101

4090 **Benedict *et al.*: Stereotactic body radiation therapy: The**

dose to normal tissue and underdosing the target.^{210–212} The efficacy of respiratory gating is affected by the reproducibility of a patient's breathing patterns from cycle-to-cycle and day-to-day. Respiratory gating increases treatment time as compared to nongated treatments; published duty cycles (ratio of beam on to total beam delivery time) range from 30% to 50%.^{213–215} Increasing the dose rate, if possible, would counteract the increase in treatment time. Another consideration is the amplitude of the respiratory motion. Several reports have shown that the benefit of gated beam delivery is minimal and does not outweigh the increase in treatment time and complexity for patients with motion amplitudes smaller than 2 cm.^{119,210,216}



SlowCT/CT Fusion

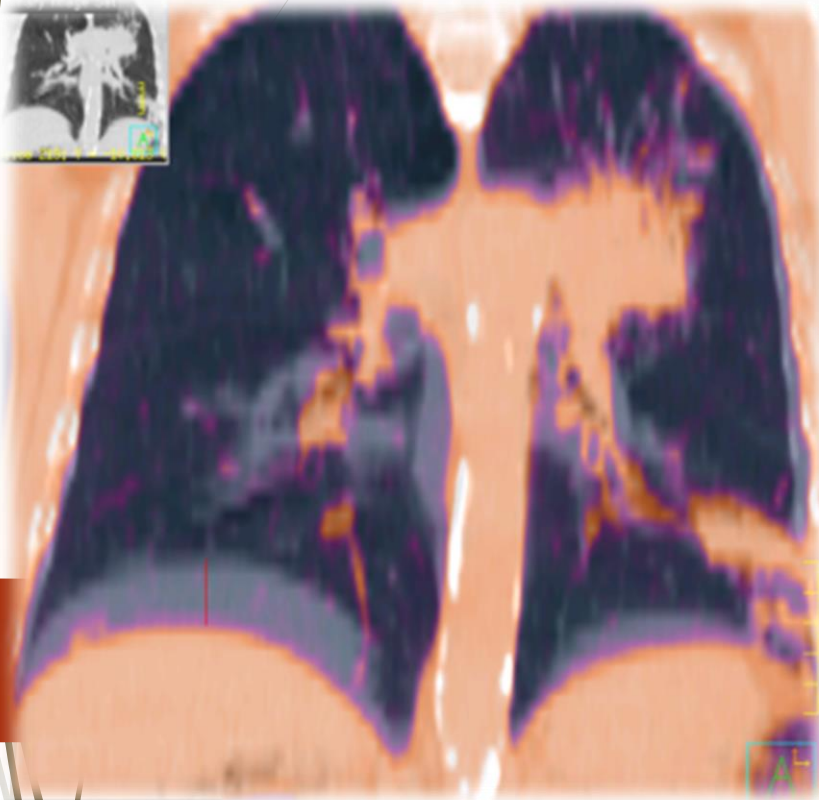


Fig. 1. The patient, in an anti-algic effort, tries to breath only with right hand side of the diaphragm, sustaining a marked costal breathing

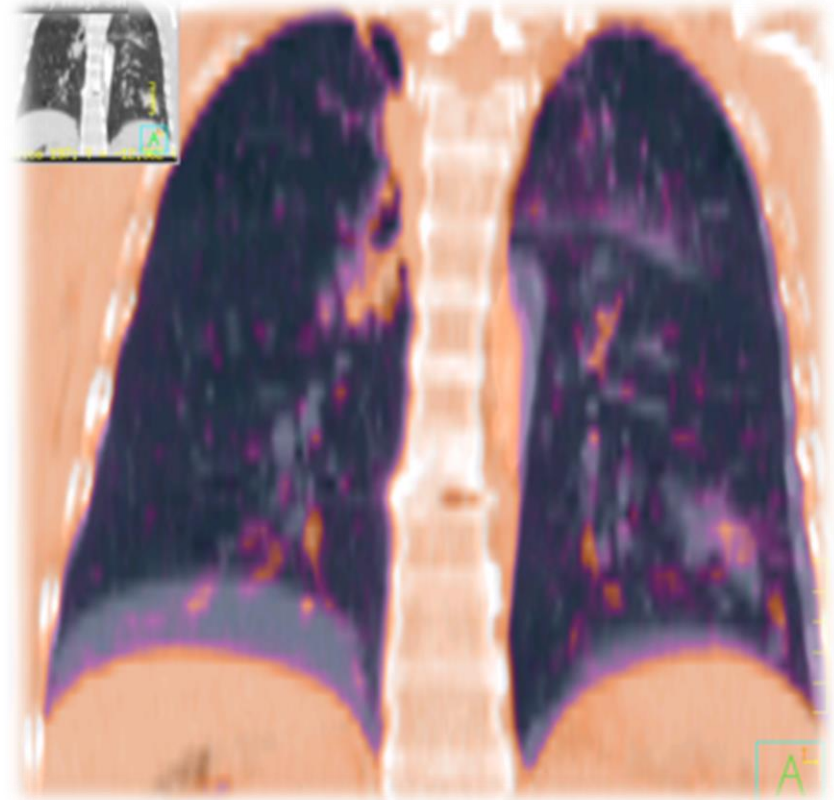


Fig. 2. In a coronal plane posterior to the tumor, the effect cited in Fig. 1. becomes notorious

SlowCT/CT Fusion

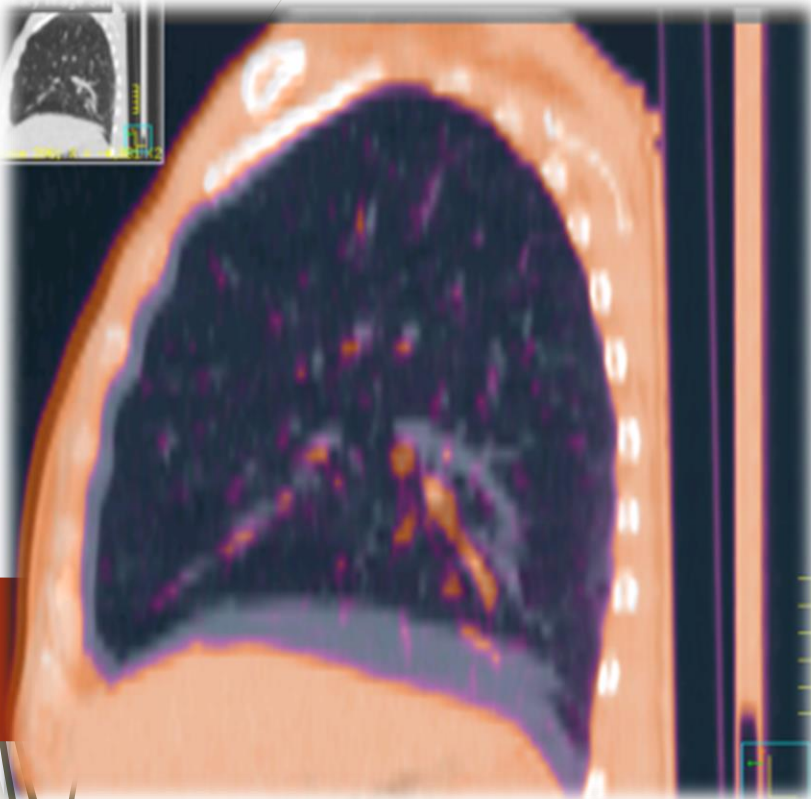


Fig. 3. The contralateral lung displays a marked caudo-cranial movement, even at bronchial level

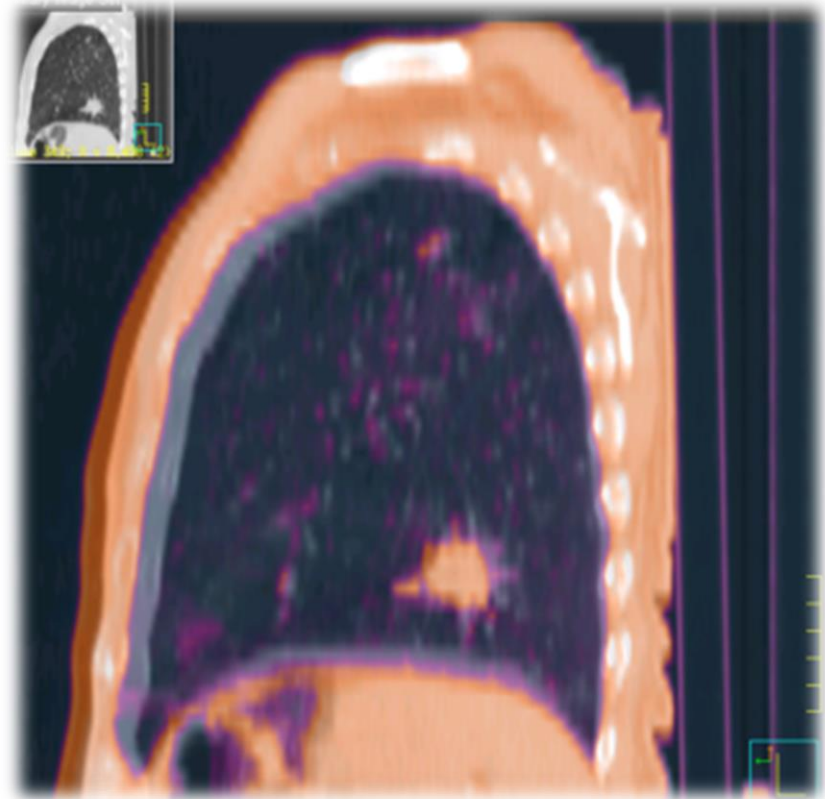


Fig. 4. On the ipsilateral lung, costal breathing is clearly noticeable with the diaphragm almost still. Its ITV is much lower than expected

SlowCT/CT Fusion

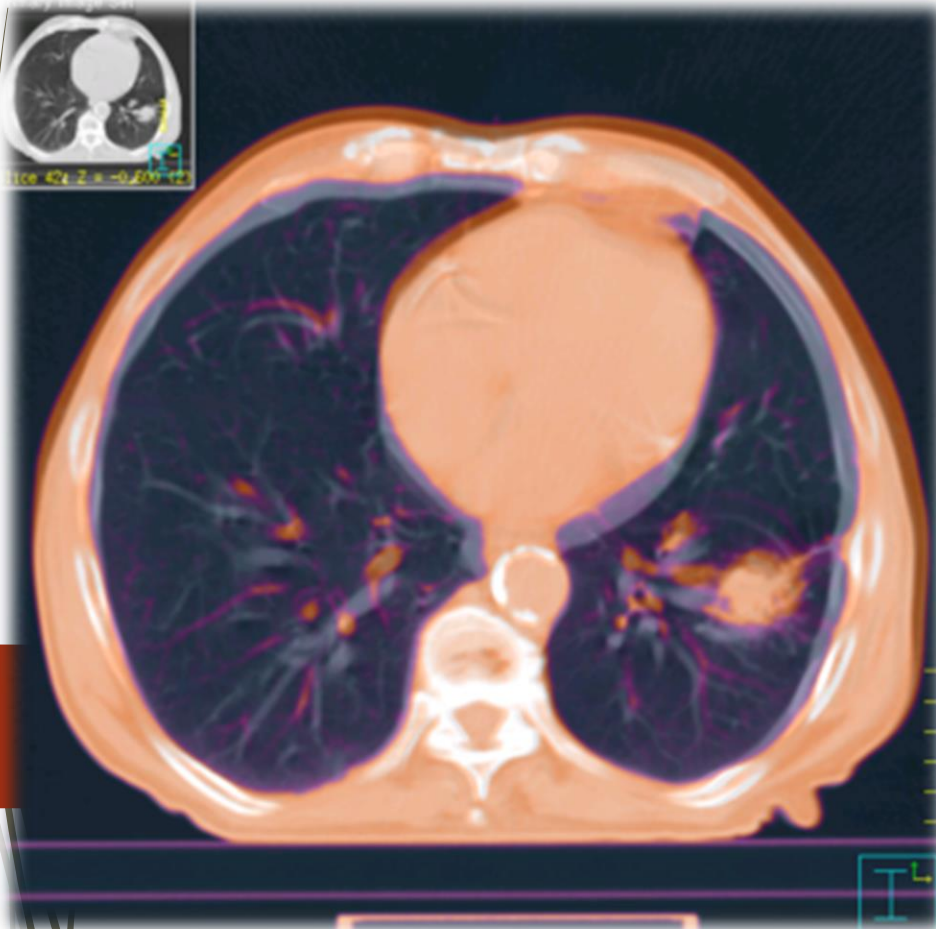


Fig. 5. The main movements in a tumour on the diaphragm are surprisingly anteroposterior. A diaphragm compression is the worst option.

William Tell Project

**High oxidative stress
ablative oncology
therapy group**



$$\text{PTV} = \text{ITV} + 2\text{mm}$$

- Indexación del propio paciente
- Sistema realmente estereotáctico
- CBCT diario

Es necesario pensar más y de manera comprometida para que la tecnología sea accesible y fácil





Así lo explicó el cliente



Así lo entendió el jefe del proyecto



Así lo diseñó el analista



Así lo escribió el programador



Así lo describió el de marketing



Lo que el cliente realmente necesita



We are here





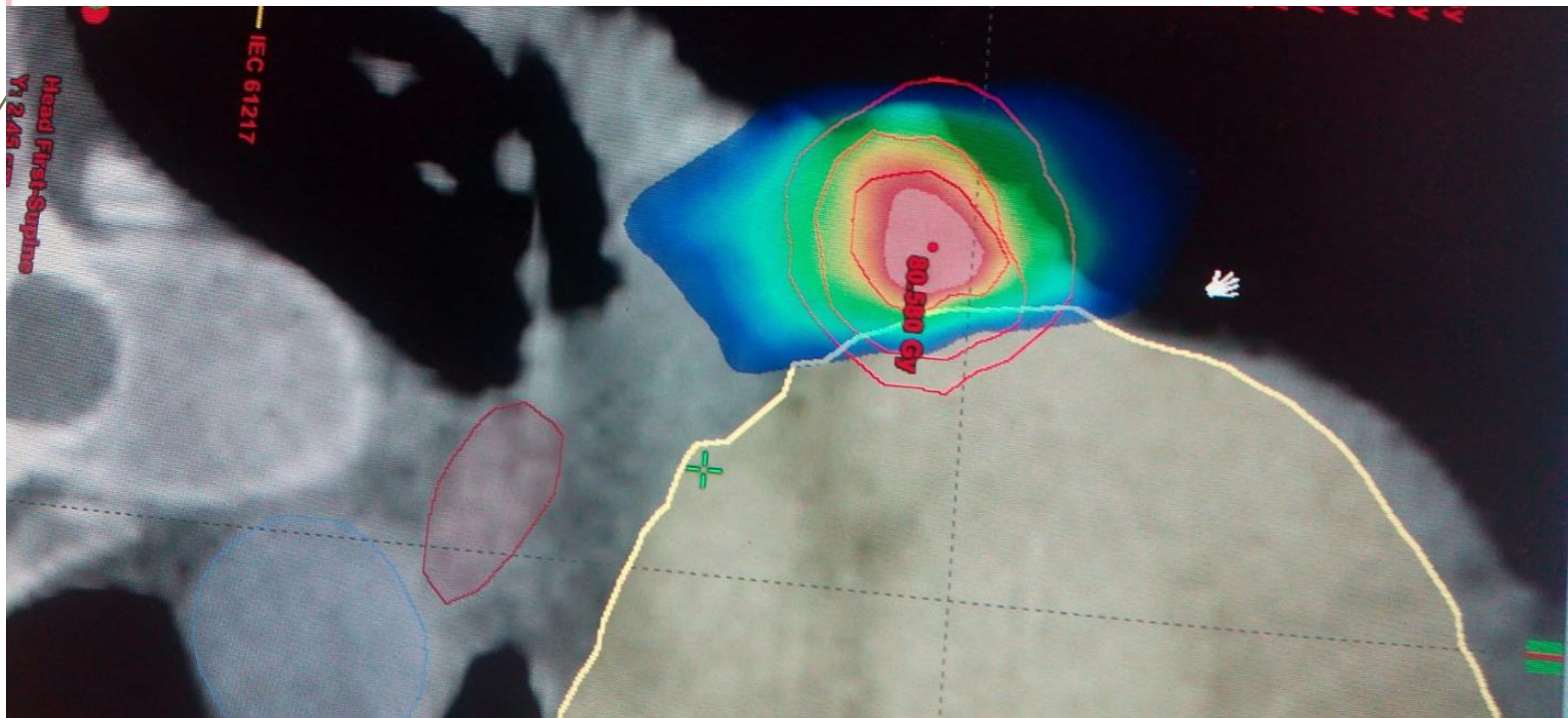
[< Previous Article](#)

[October 1, 2016](#) Volume 96, Issue 2, Supplement, Page E651

[Next Article >](#)

An Emerging Method of Faster Stereotactic Body Radiation Therapy Through Stereotactic Multidampening

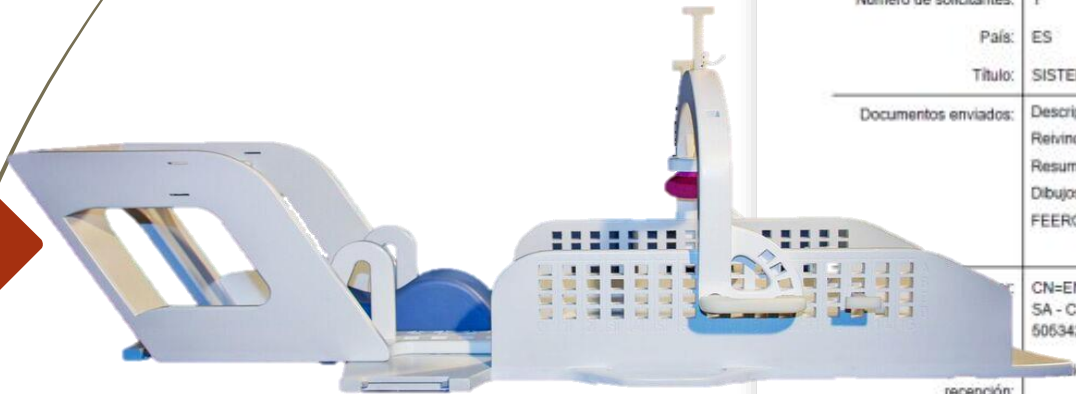
[S. Velázquez](#), [E. Montero](#), [M. Rubio](#), [M. Ortiz](#)





eXaCradle

Control of organs & tumors



Justificante de presentación electrónica de solicitud de patente

Este documento es un justificante de que se ha recibido una solicitud española de patente por vía electrónica, utilizando la conexión segura de la O.E.P.M. Asimismo, se le ha asignado de forma automática un número de solicitud y una fecha de recepción, conforme al artículo 14.3 del Reglamento para la ejecución de la Ley 11/1986, de 20 de marzo, de Patentes. La fecha de presentación de la solicitud de acuerdo con el art. 22 de la Ley de Patentes, le será comunicada posteriormente.

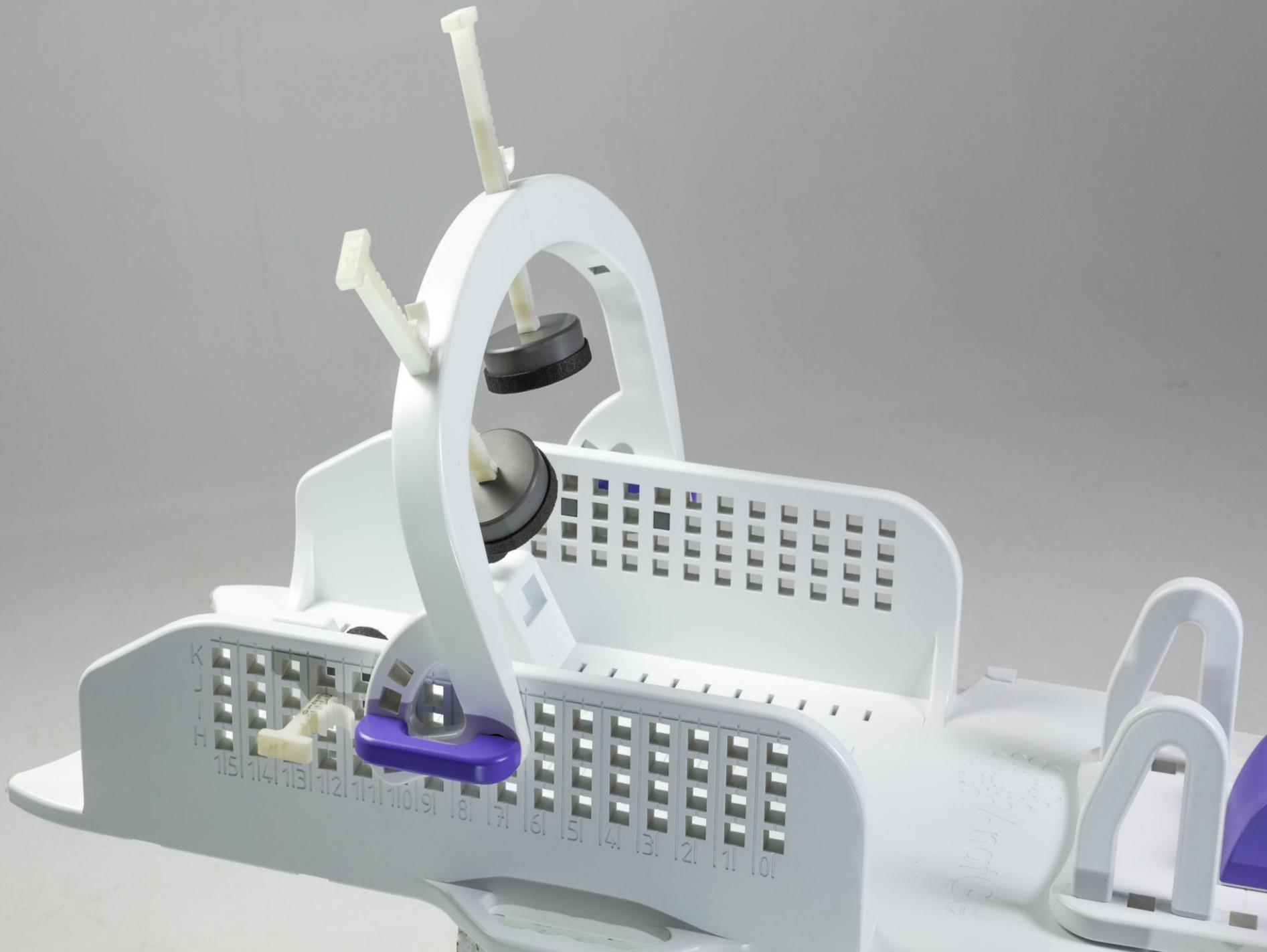
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Fecha de recepción:	17 diciembre 2009, 15:26 (CET)	
Oficina receptora:	OEPM Madrid	
Su referencia:	ES1985.42	
Solicitante:	FUNDACION ANDALUZA BETURIA PARA LA INVESTIGACION EN SALUD	
Número de solicitantes:	1	
País:	ES	
Título:	SISTEMA MODULAR DE COMPRESIÓN	
Documentos enviados:	Descripción-1.pdf (10 p.) Reivindicaciones-1.pdf (3 p.) Resumen-1.pdf (1 p.) Dibujos-1.pdf (5 p.) FEERCPT-1.pdf (1 p.)	package-data.xml es-request.xml application-body.xml es-fee-sheet.xml feesheet.pdf request.pdf
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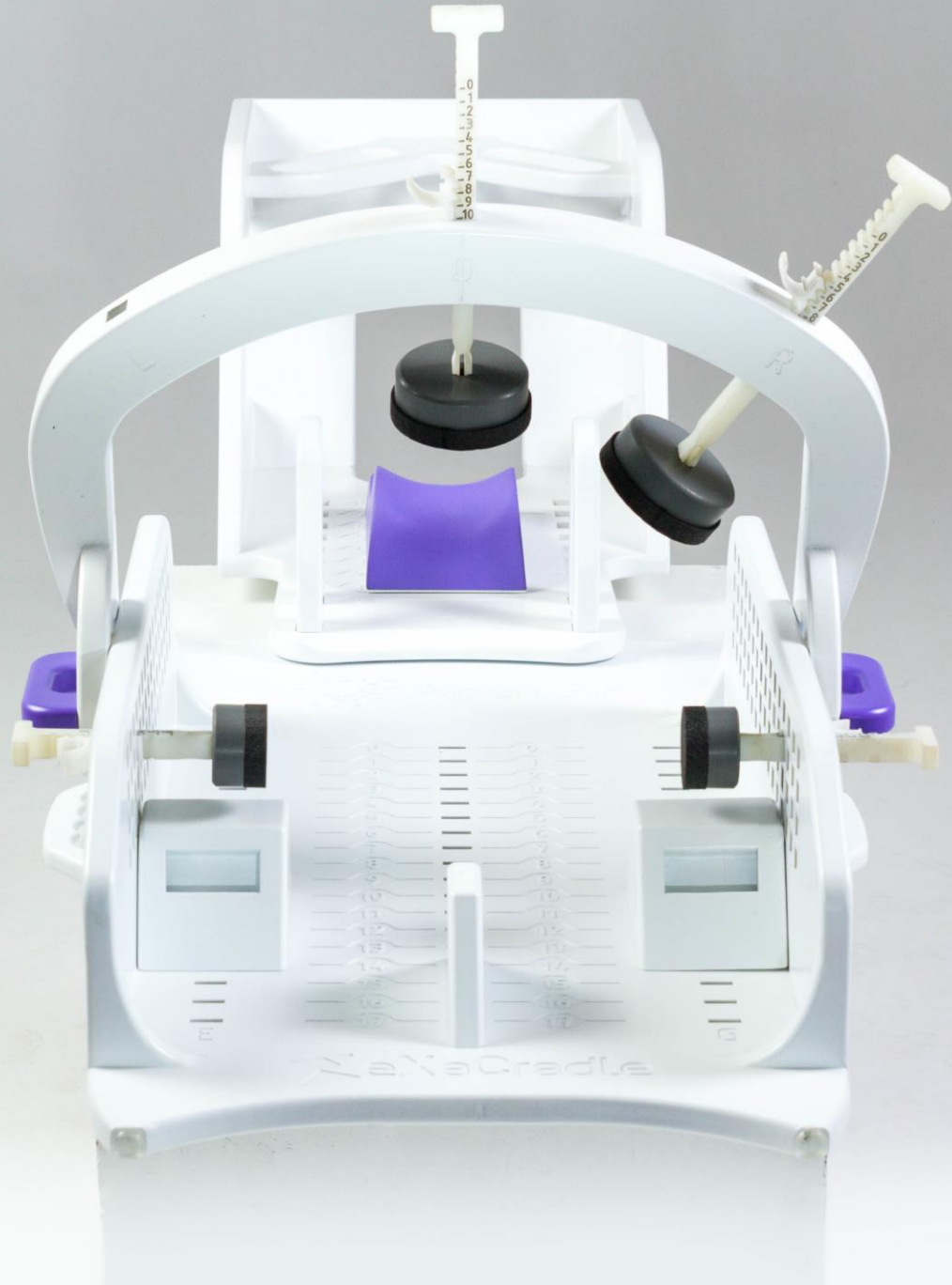
Anatomophysiology Relationship Modifier System for Organs and Tumors in Radiotherapy



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115 114 113 112 111 110 91 81 71 61 51 41 31 21 11 101

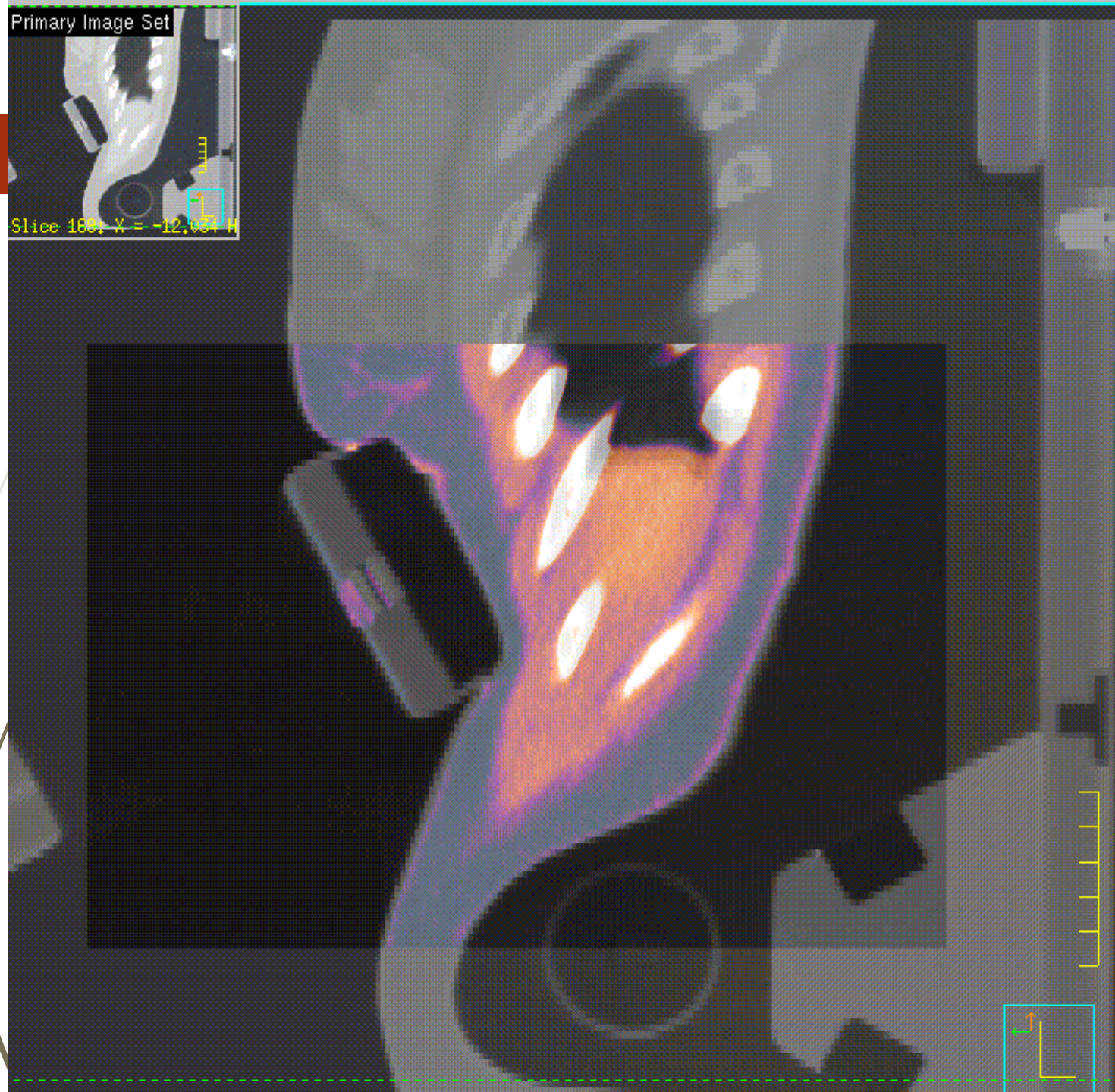
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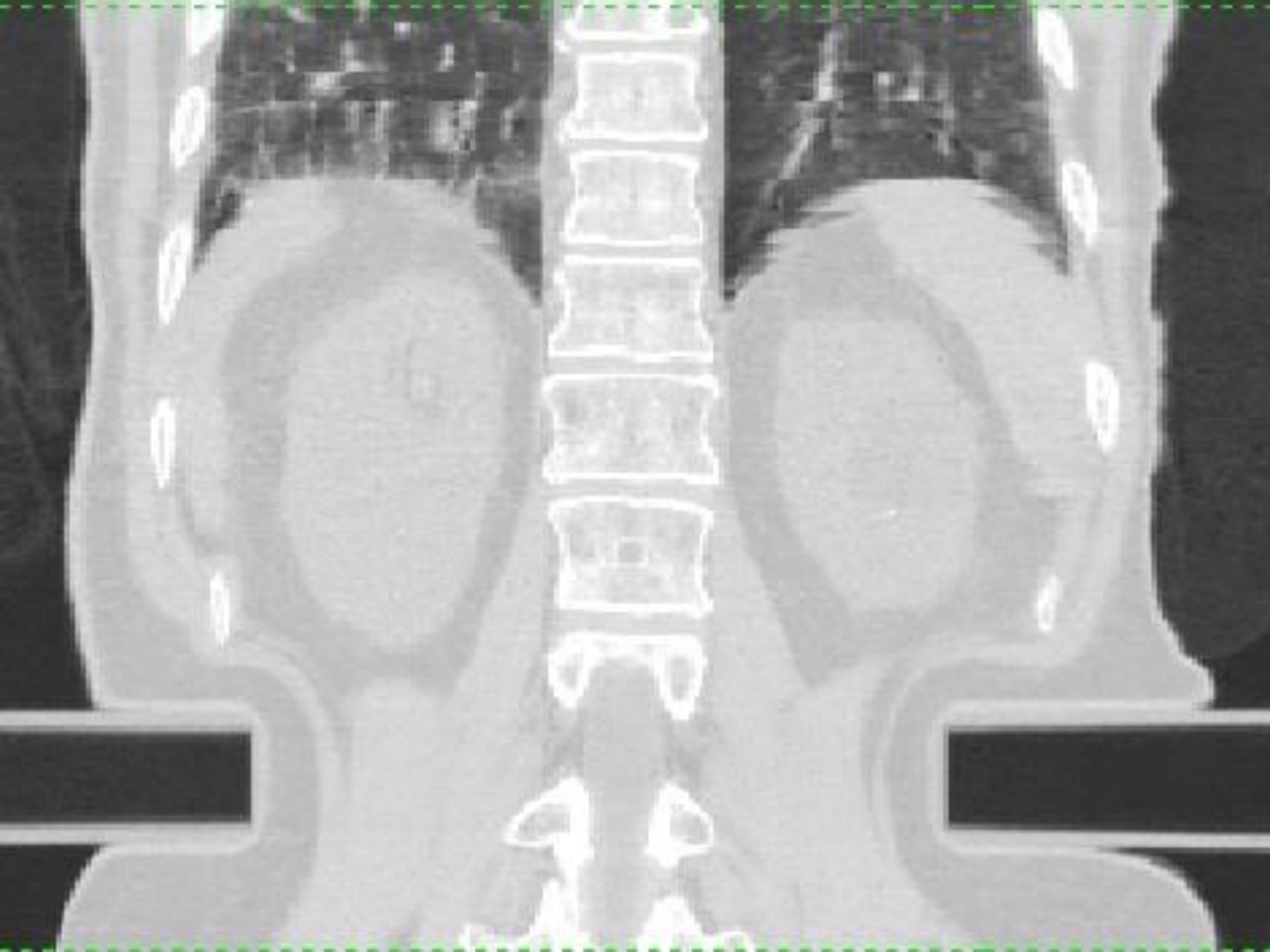


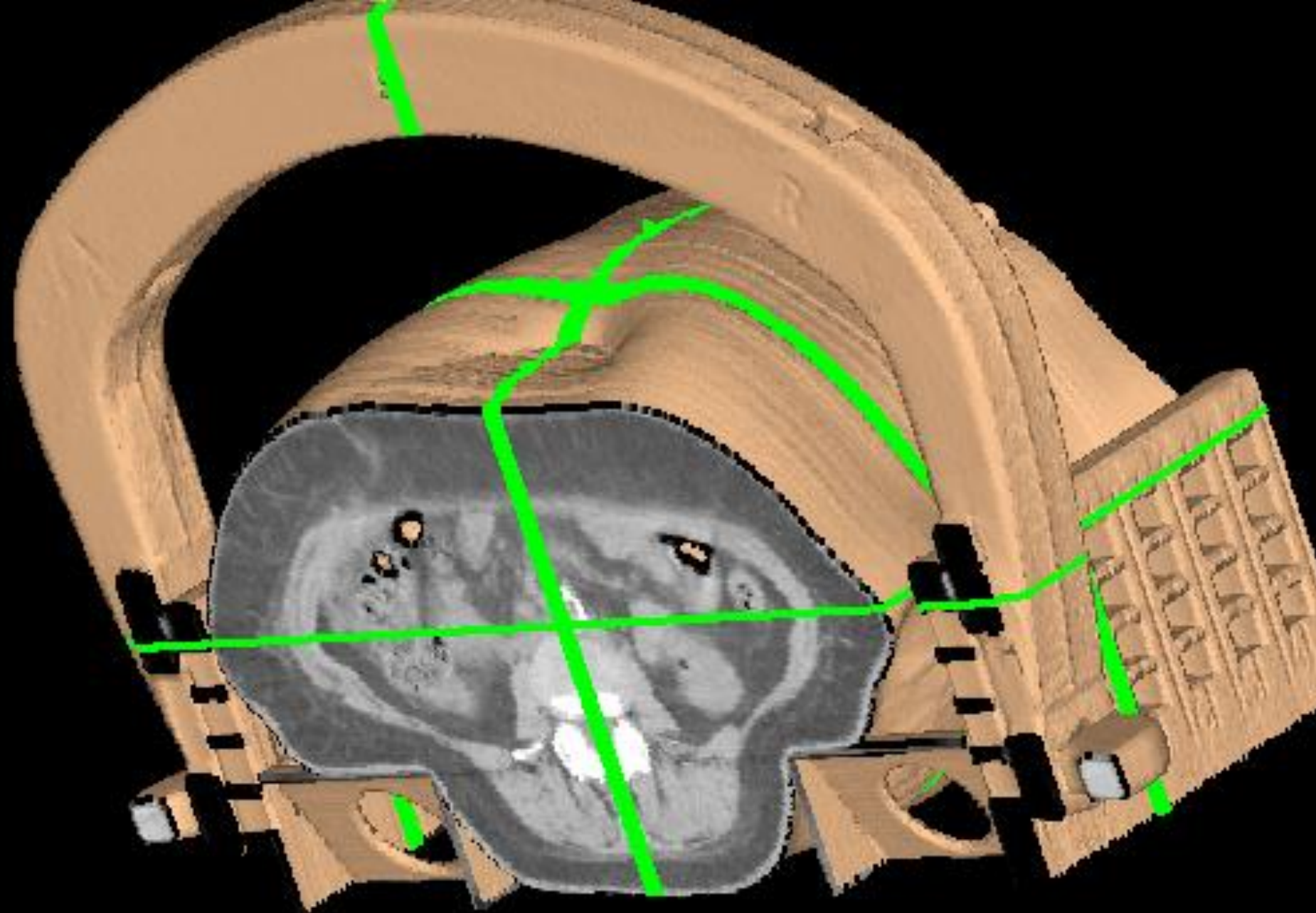


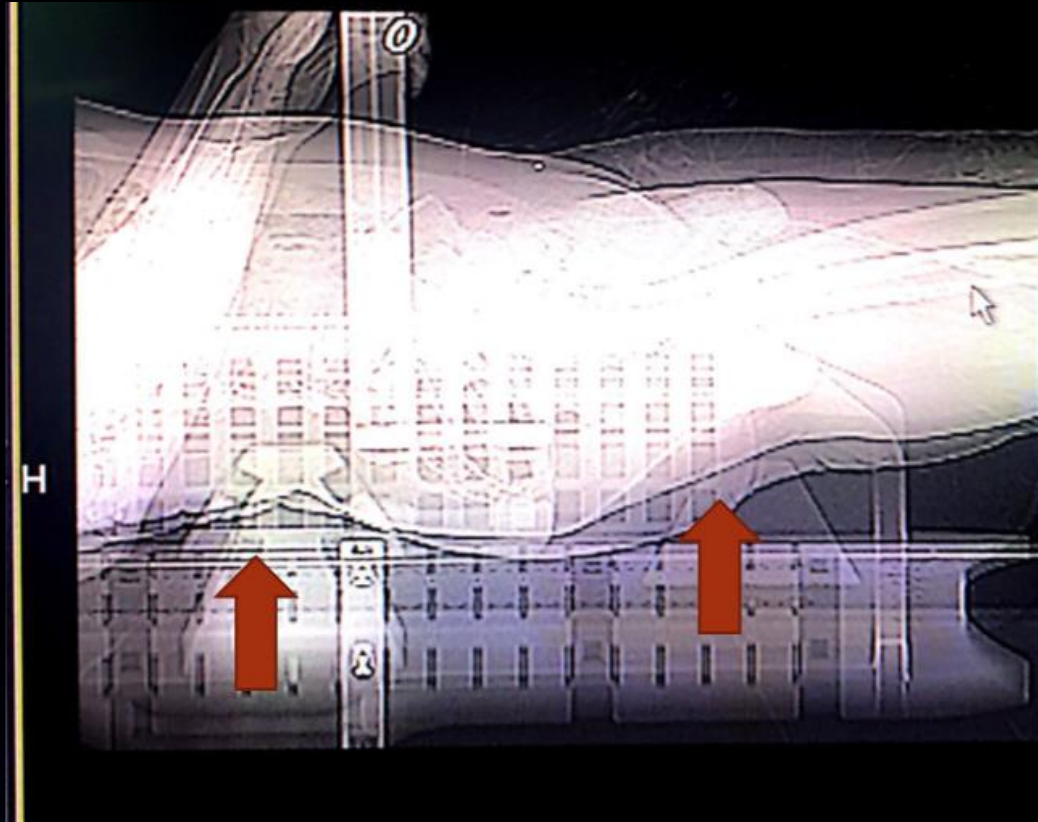
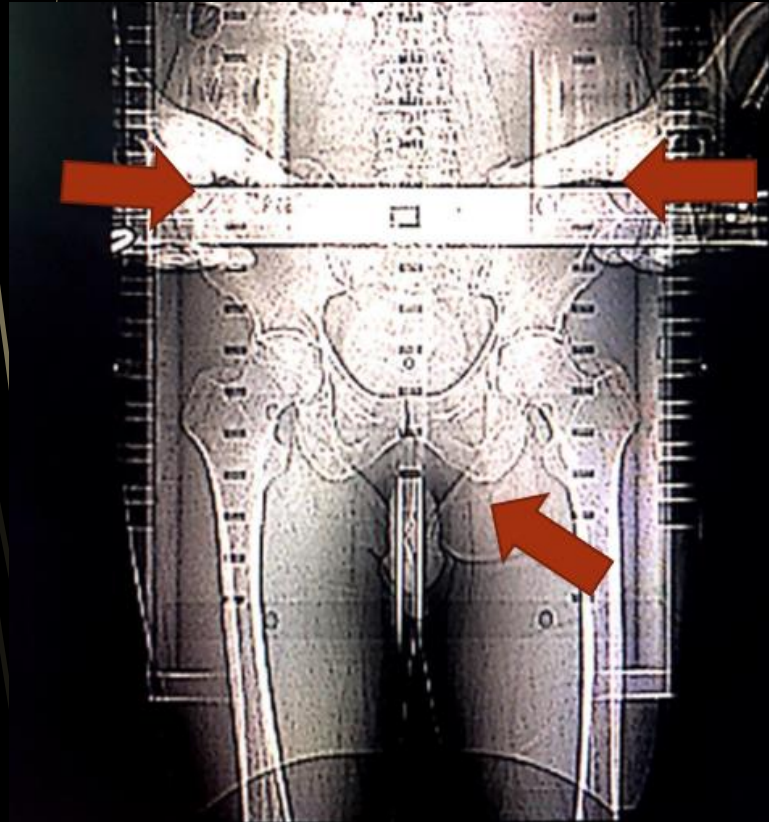
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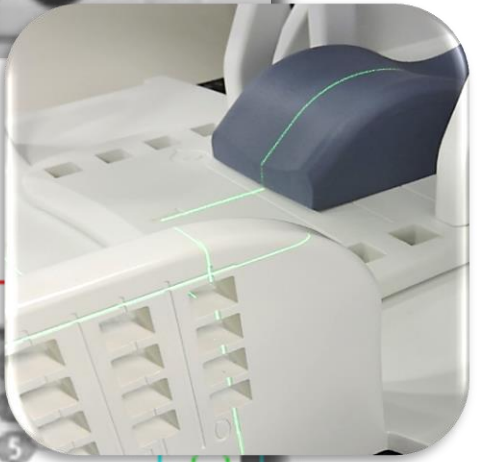
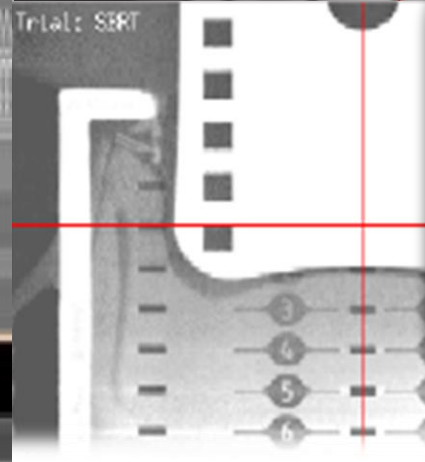
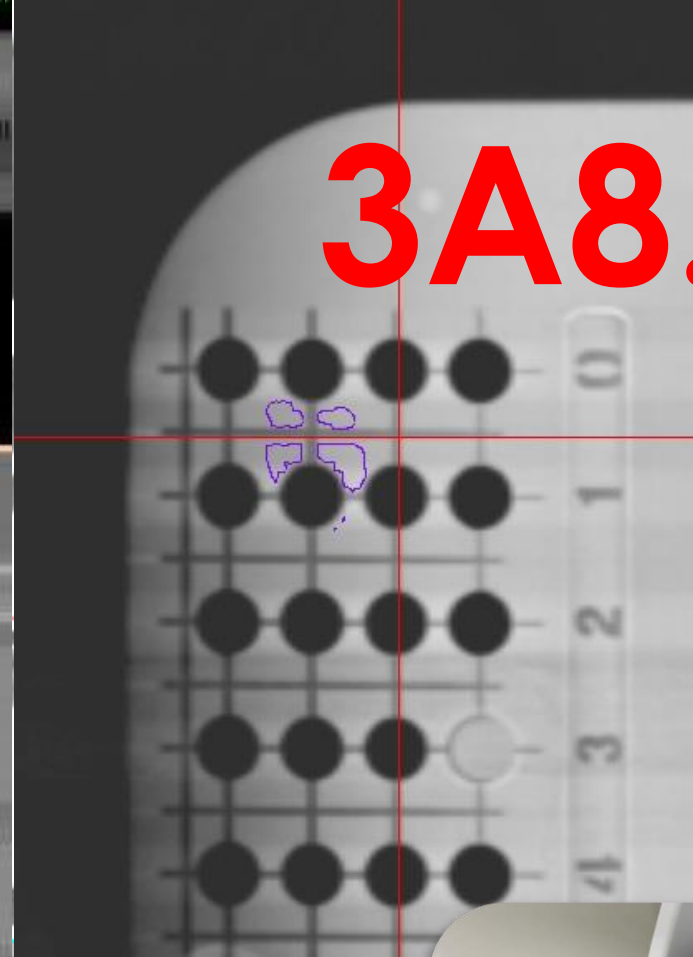
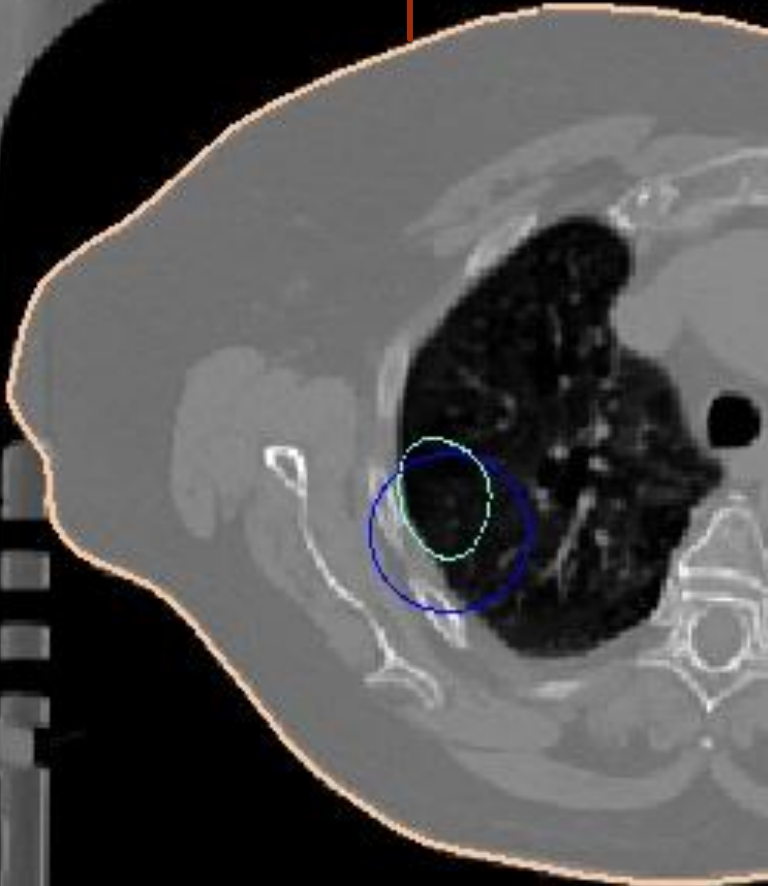






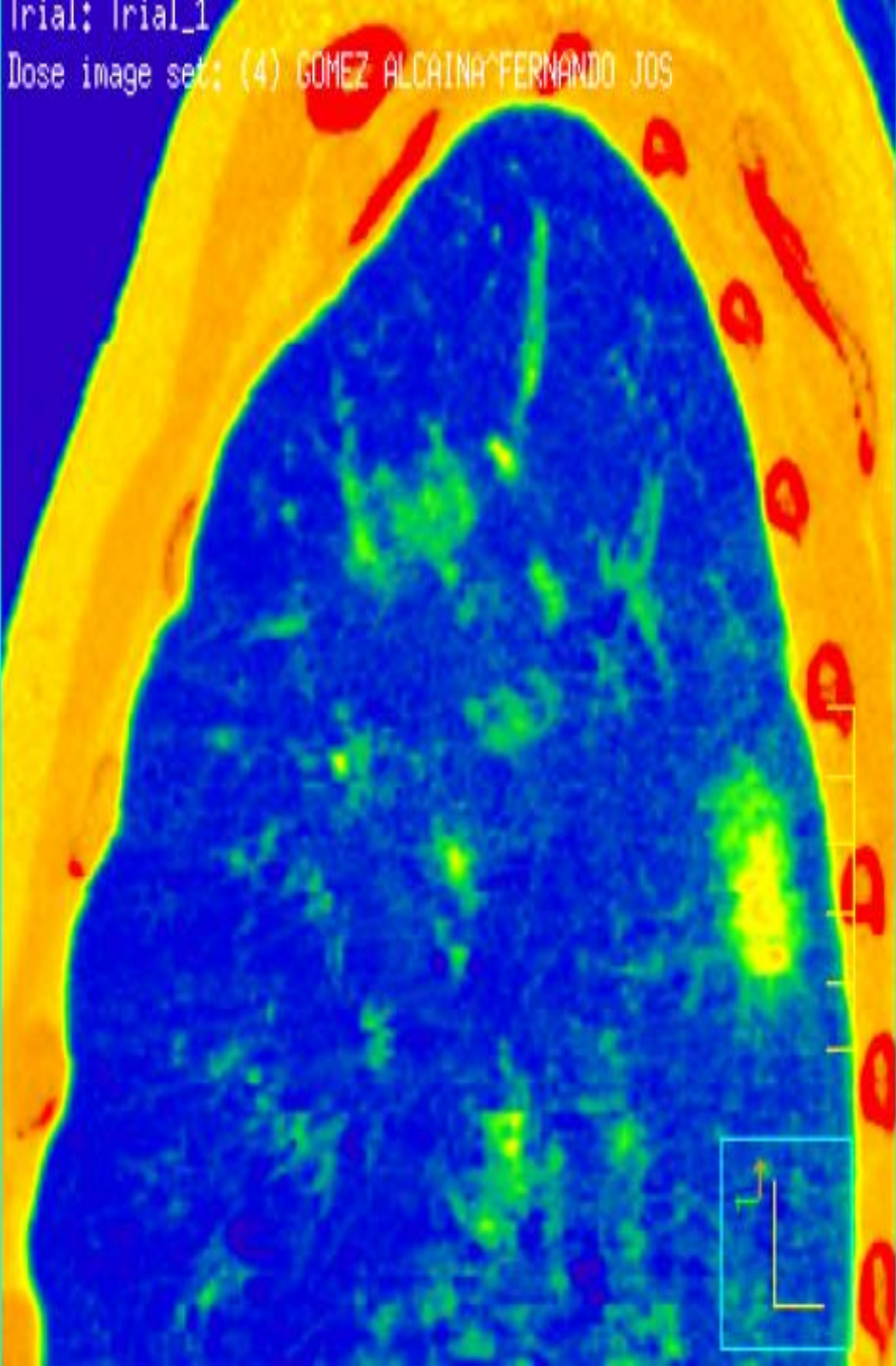


3A8.5

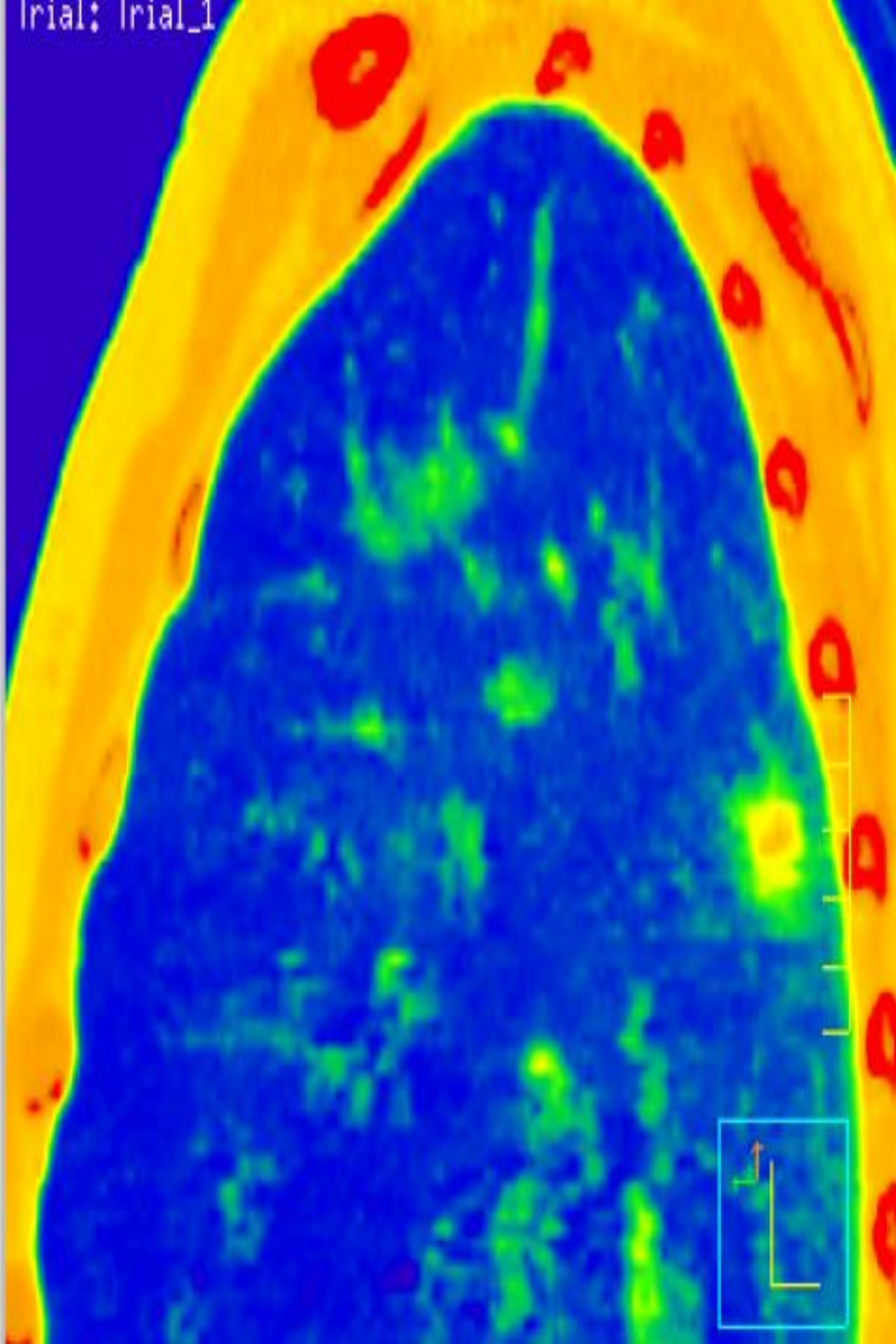


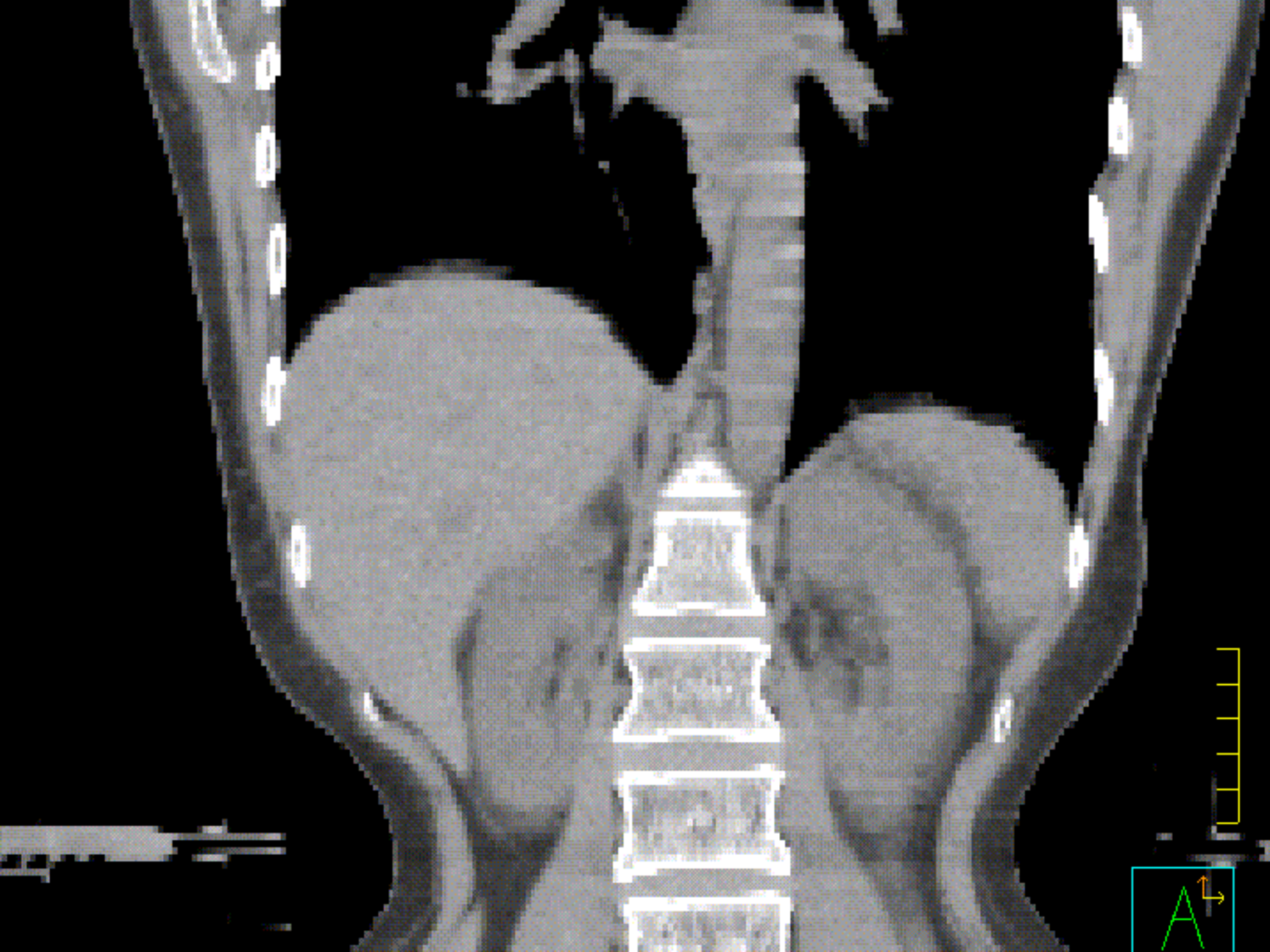
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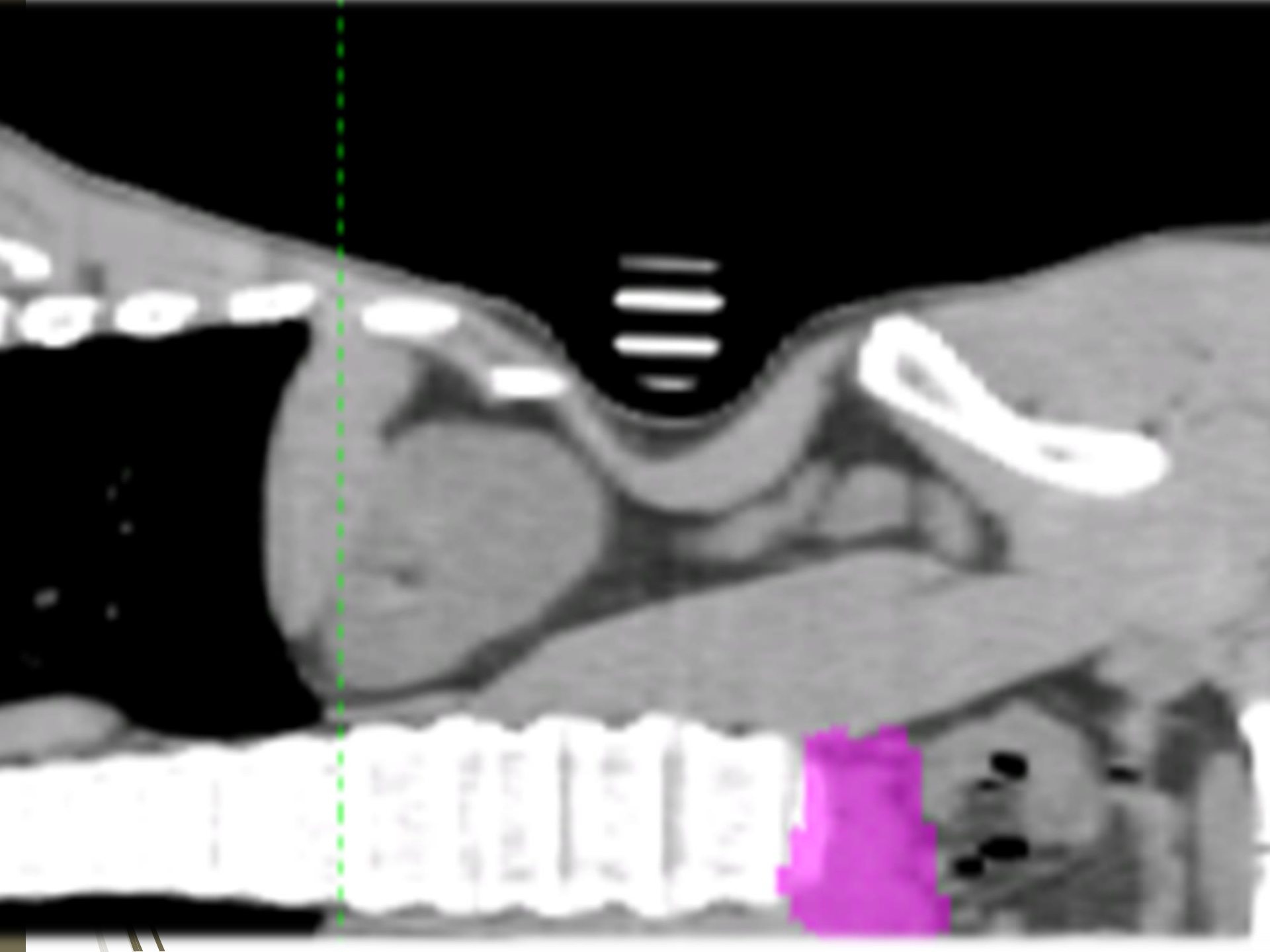
Dose image set: (4) GOMEZ ALCAINA^FERNANDO JOS

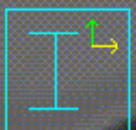
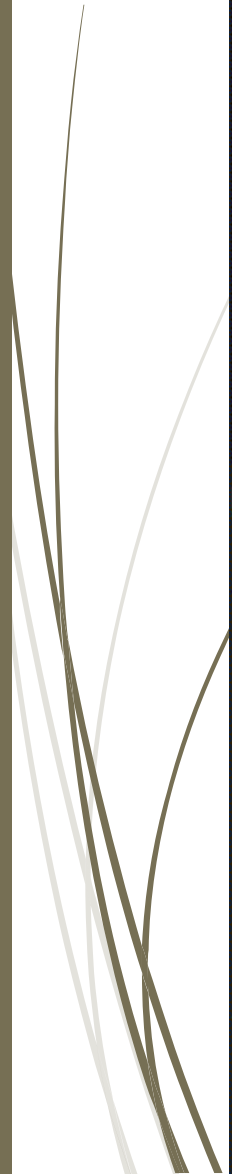
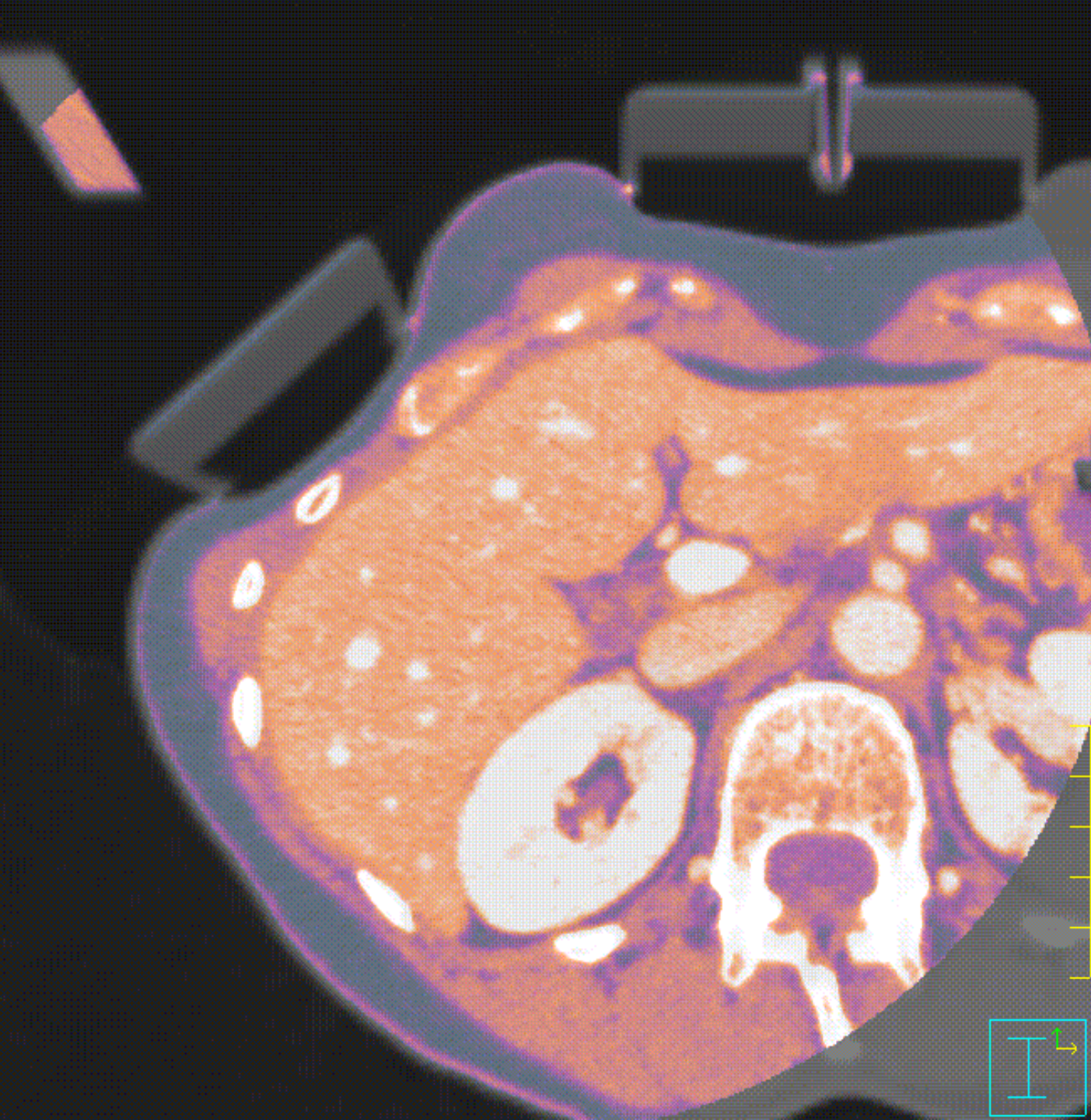


trial: trial_1

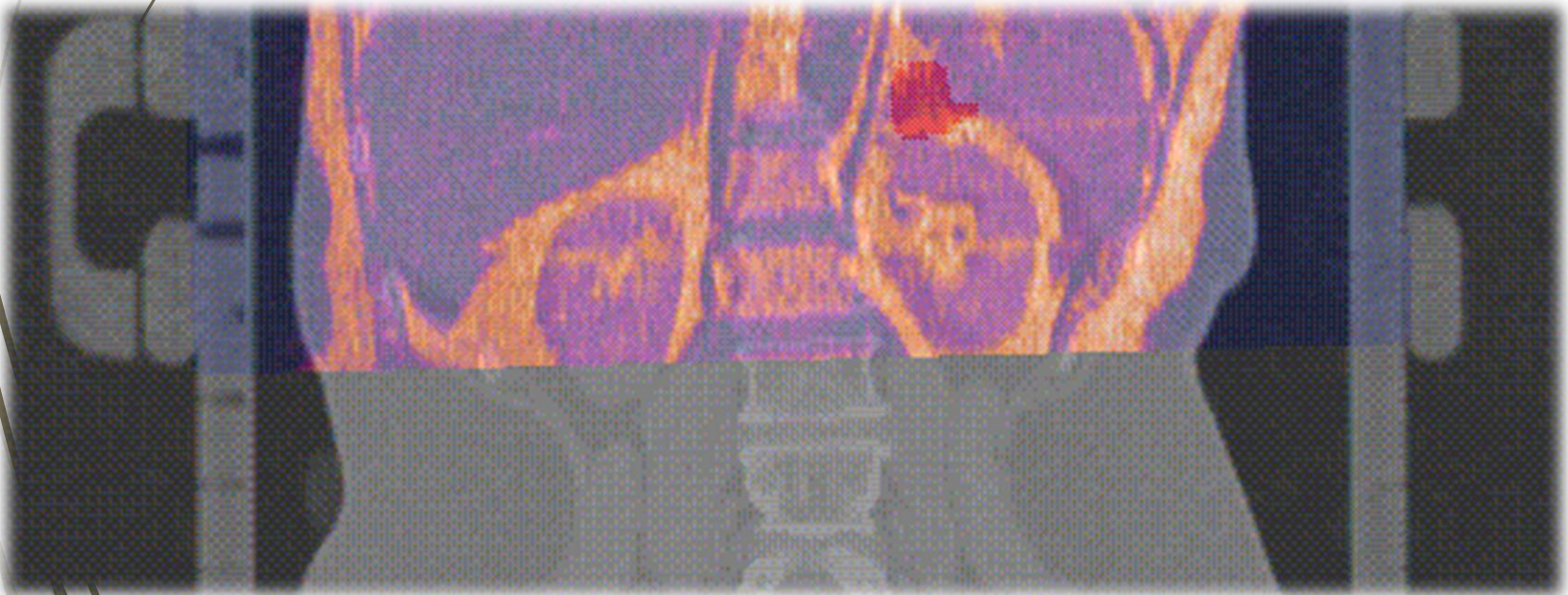
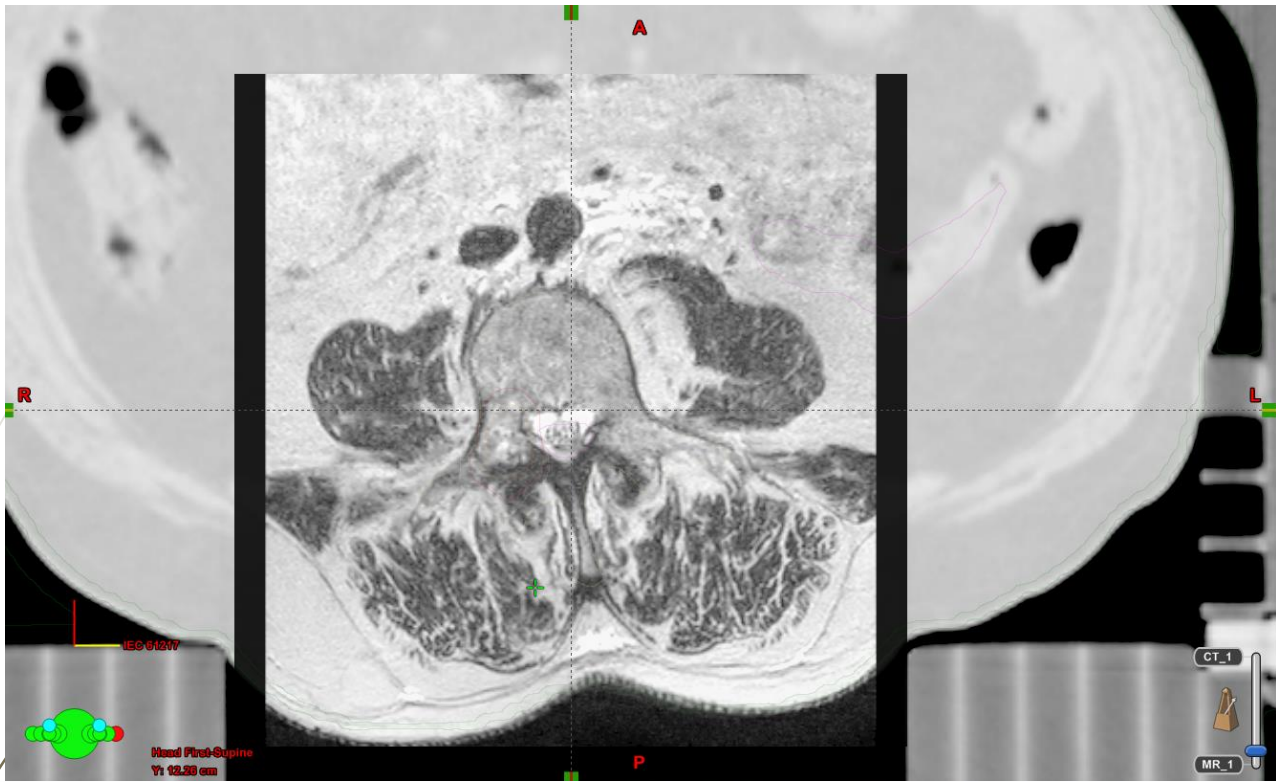




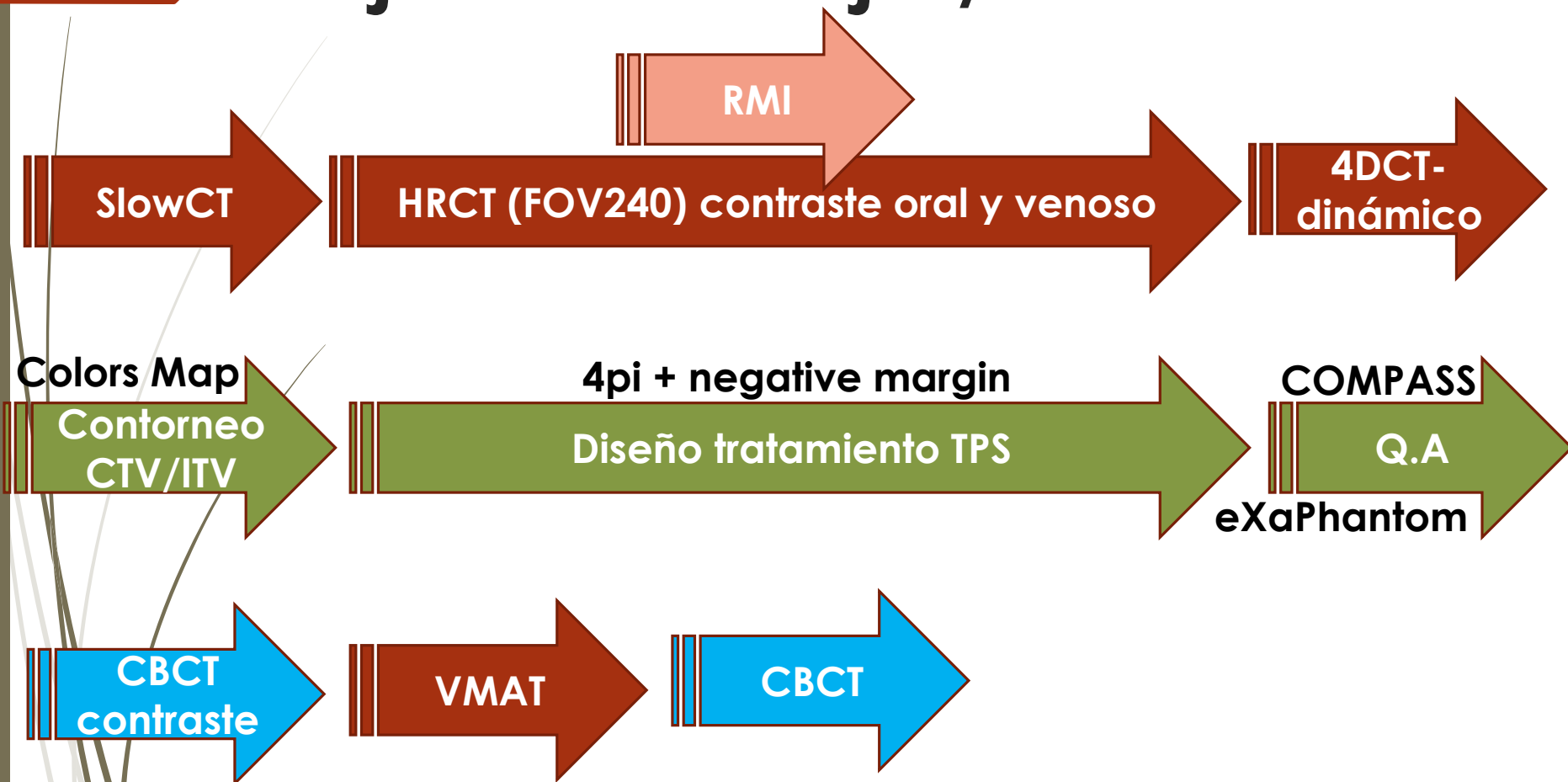








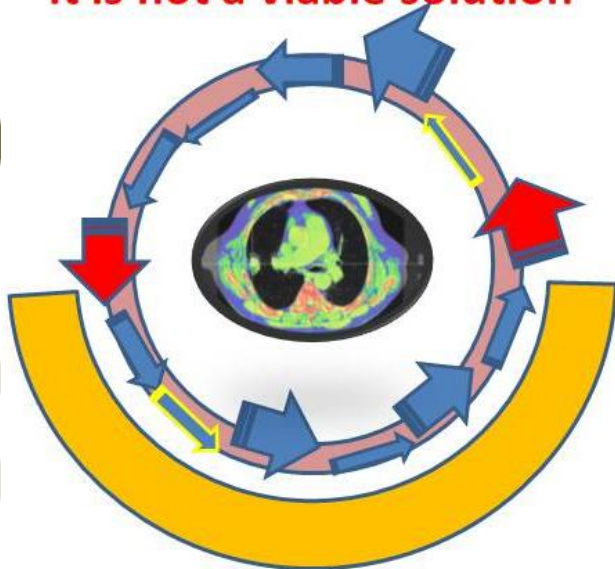
Flujo de trabajo / eXaCradle



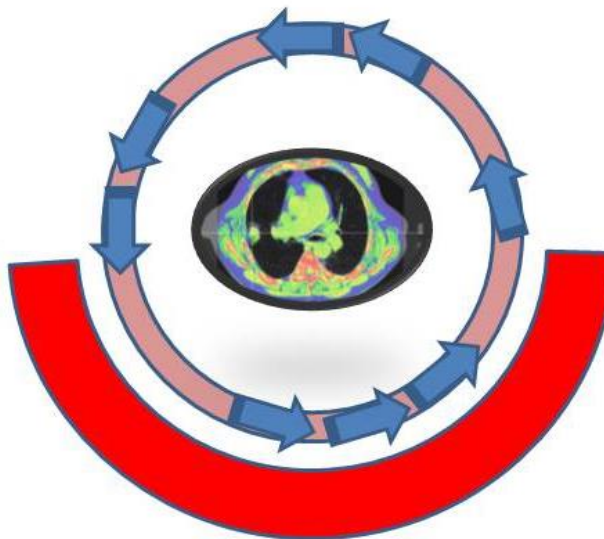


+ Rápido

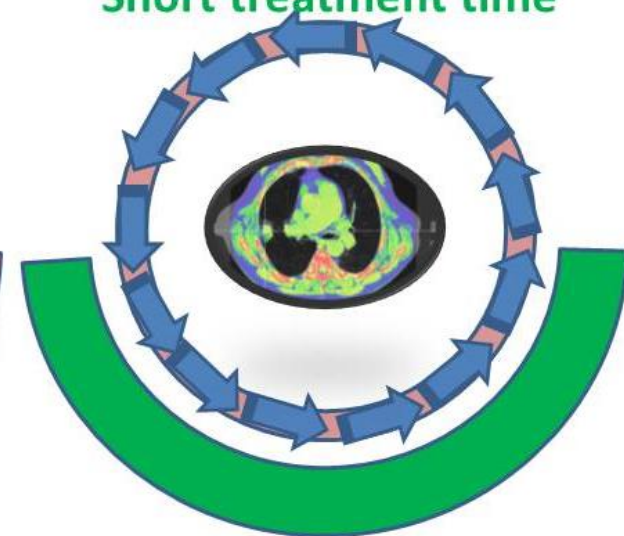
VMAT-Tracking
It is not a viable solution



VMAT-Gating
It is not a viable solution



VMAT-Dampening
Continuous radiation
Short treatment time





**SABR
repair**

Elkin 1960
Belli 1966
Ang 1987
Hall 1991
Fowler 2004
Ling 2010

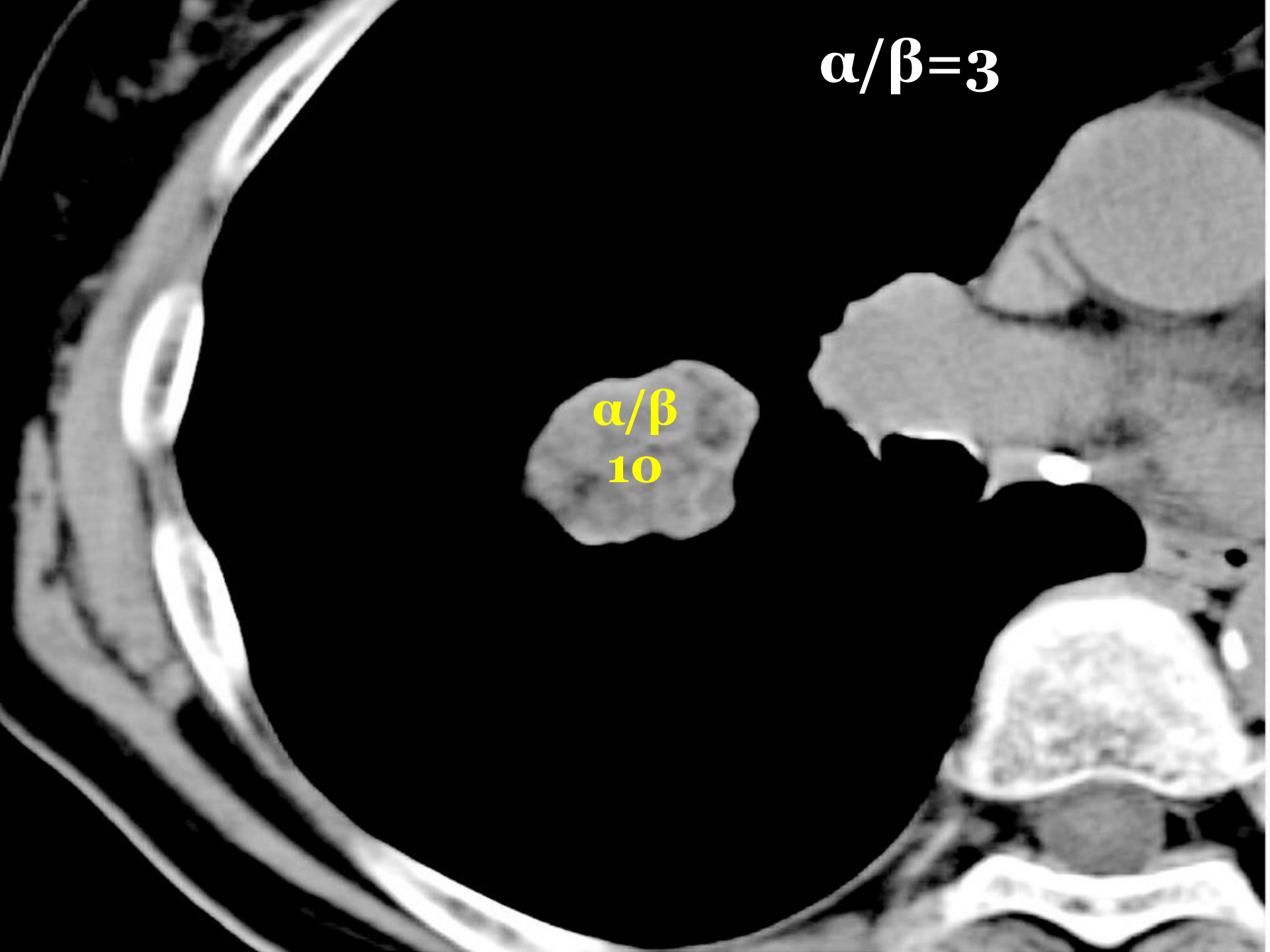
12min

**Fast
SABR**

**Slow
SABR**

$\alpha/\beta=3$

α/β
10





iSABR



8

3

7

Pulmón: monofracción 34GY, PATHY

Abdomen:

-mts hepática 47p

-hepatocarcinoma 10p

-CA de páncreas (tb normofraccionado) 12p

-Suprarrenales 51p

Pelvis:

-mts pélvicas monofracción 37p

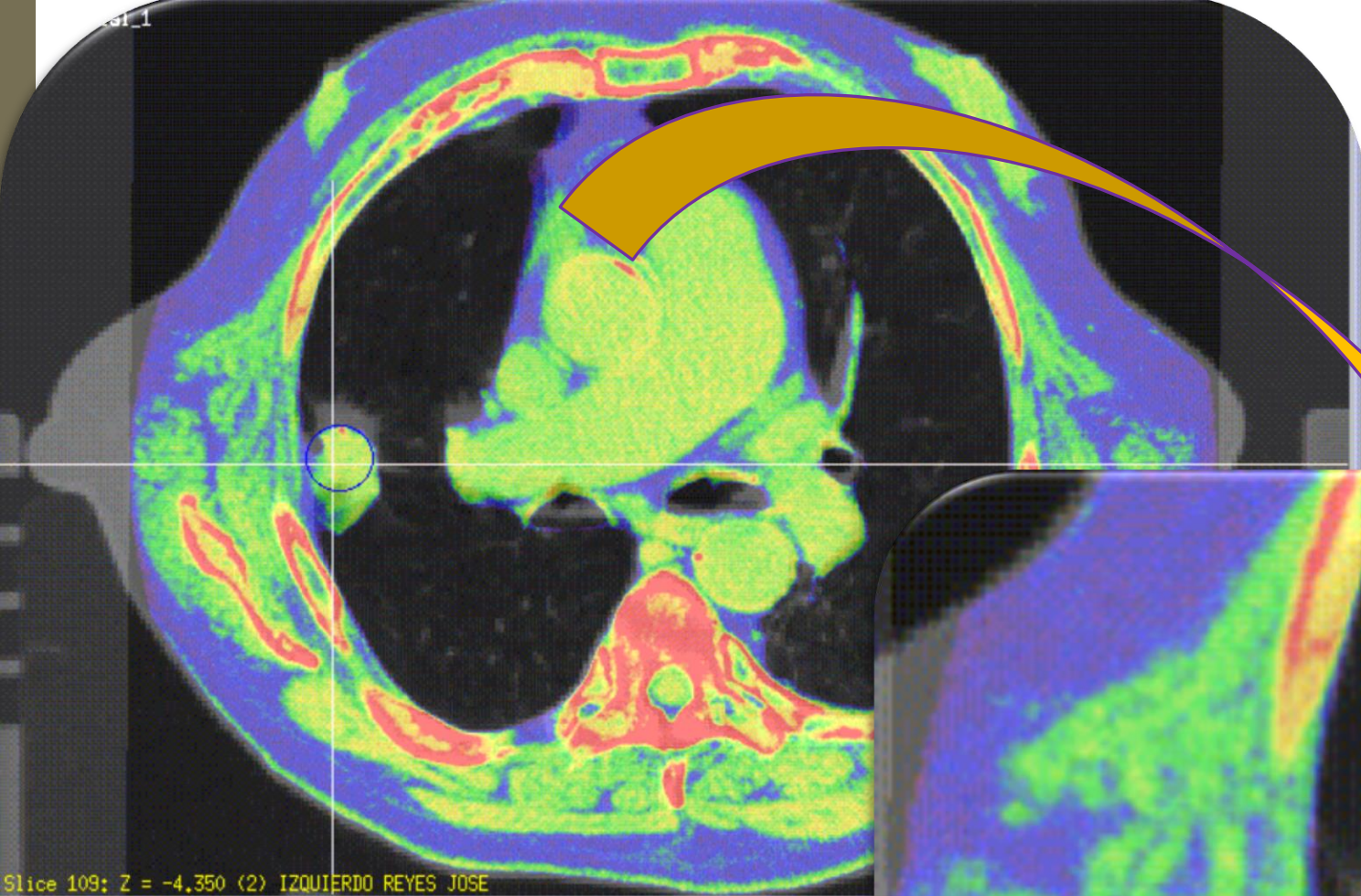
-Próstata 4 fracciones 4p

Paraespinales: Monofracción 55p

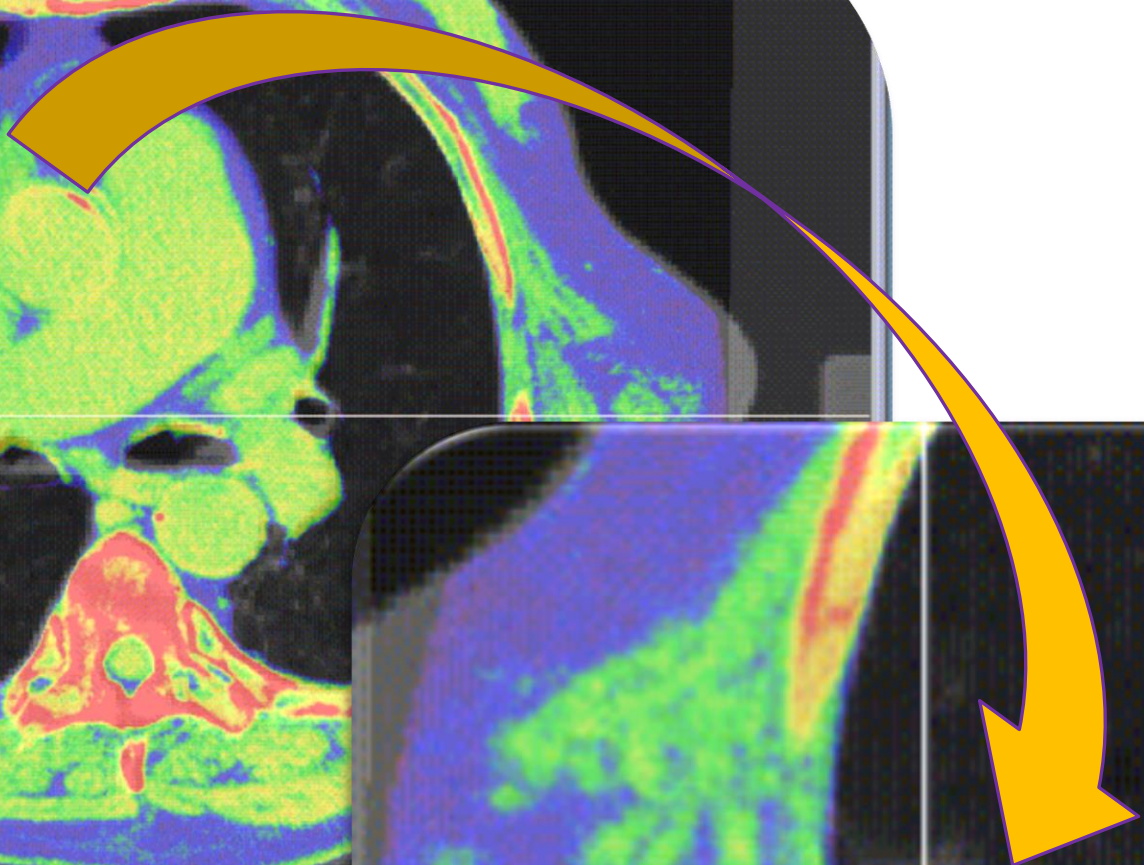
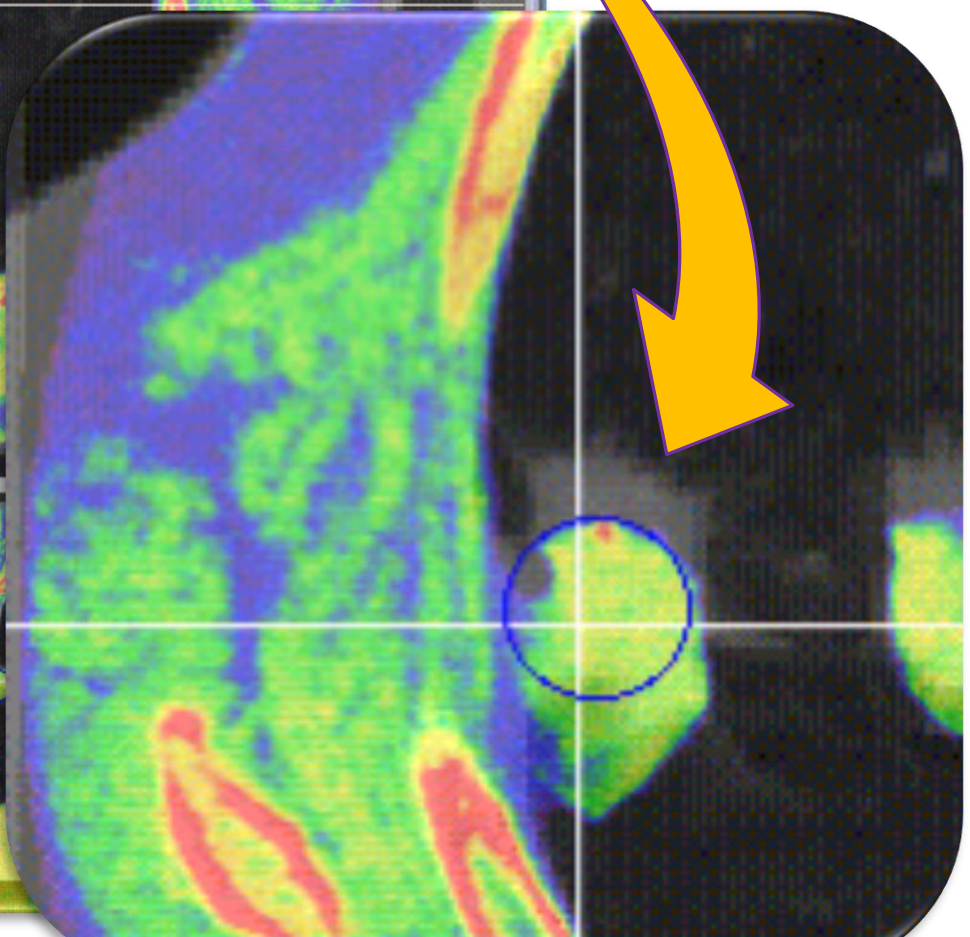
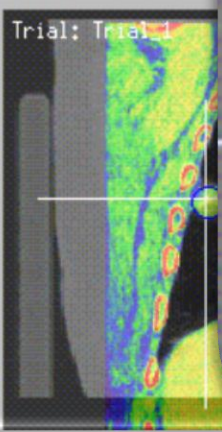
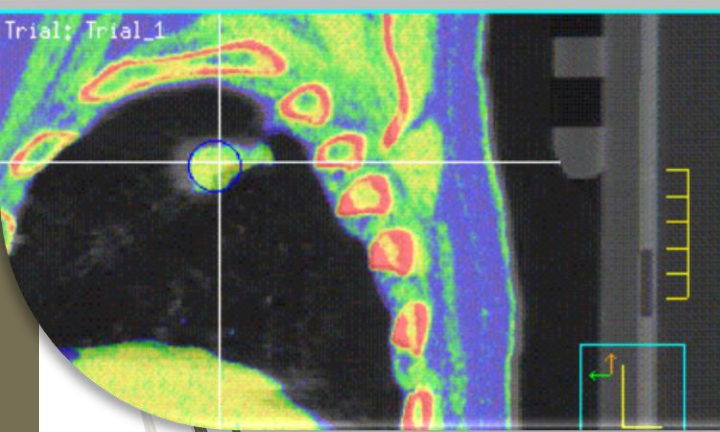
Mama*: Monofracción 14p



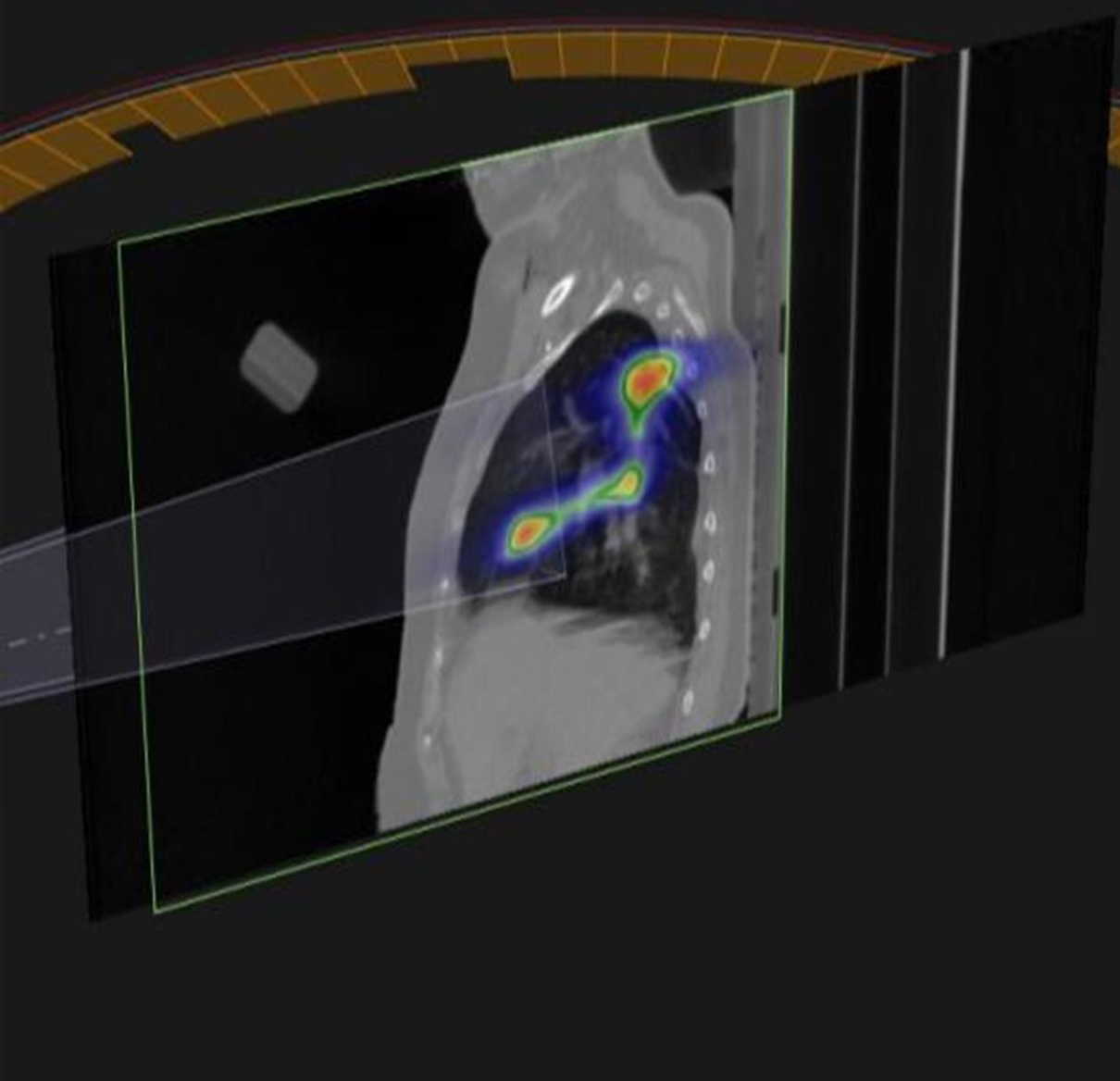
Pulmón



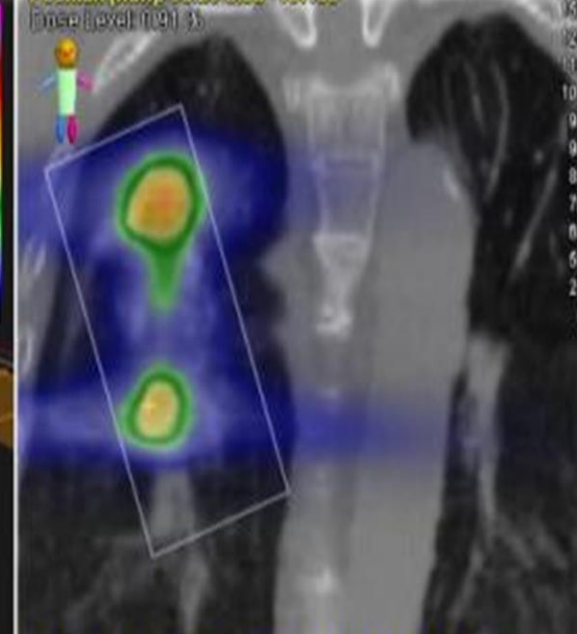
Slice 109: Z = -4,350 (2) IZQUIERDO REYES JOSE



Dose Level: 0.00 %



SBRT, (Gantry: 0.00° Collimator: 20.00° Couch: 0.00°)

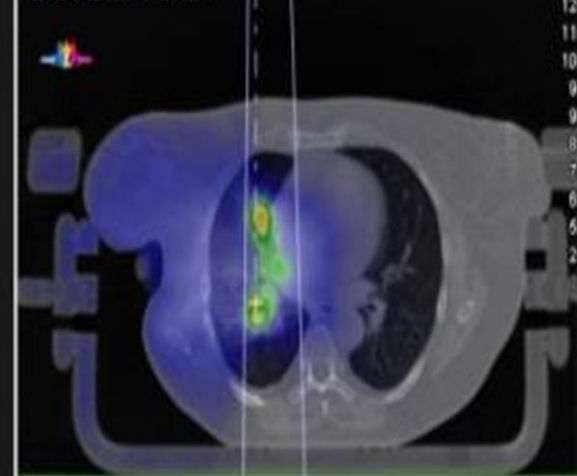


SBRT, (Gantry: 0.00° Collimator: 20.00° Couch: 0.00°)
Slice: y = 110.0 mm

TPS do

Position [mm]: 87.97 -255.91 -137.00
Dose Level: 0.00 %

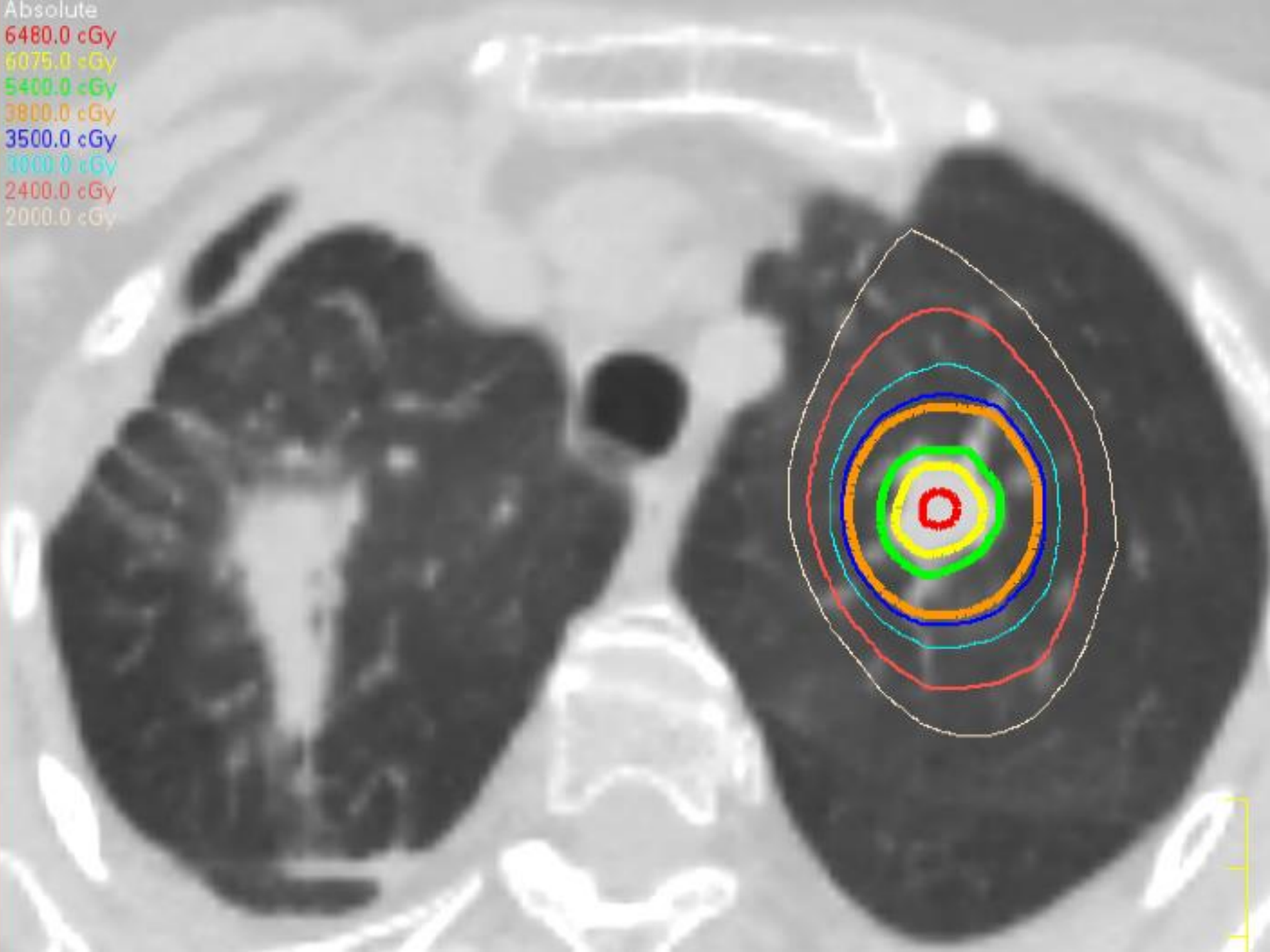
% of 5061.92 cGy



56

SBRT, (Gantry: 0.00° Collimator: 20.00° Couch: 0.00°)

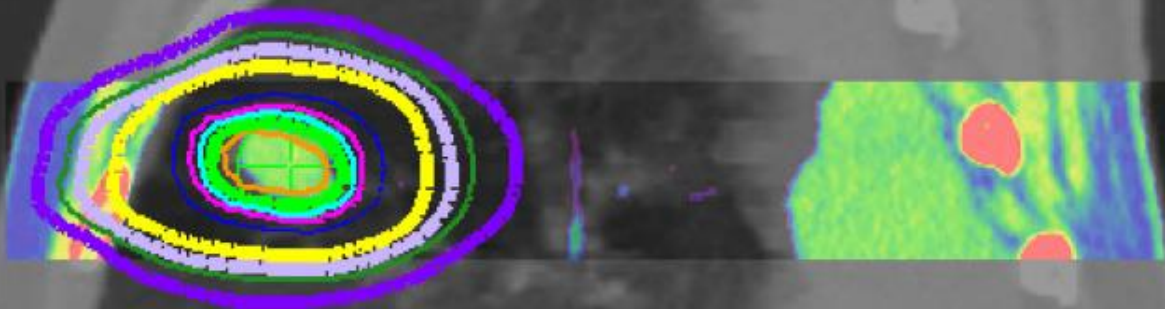
Absolute
6480.0 cGy
6075.0 cGy
5400.0 cGy
3800.0 cGy
3500.0 cGy
3000.0 cGy
2400.0 cGy
2000.0 cGy



Trial: SBRT def

Absolute

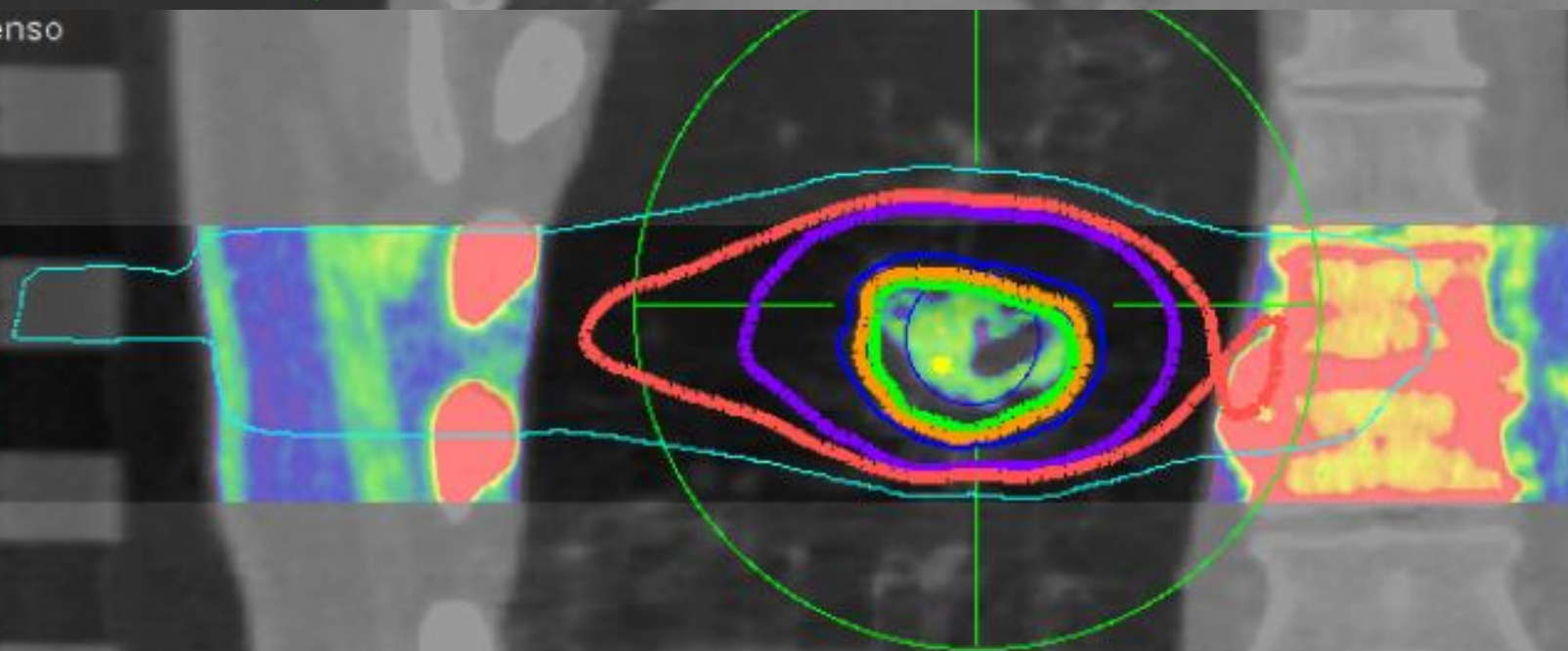
6000.0 cGy
5600.0 cGy
5400.0 cGy
5200.0 cGy
5000.0 cGy
4500.0 cGy
3000.0 cGy
2400.0 cGy
2000.0 cGy
1400.0 cGy



Trial: Normodensio

Absolute

6480.0 cGy
6075.0 cGy
5400.0 cGy
5130.0 cGy
4725.0 cGy
3000.0 cGy
2400.0 cGy
1400.0 cGy





PAPER

Motion induced interplay effects for VMAT radiotherapy

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² Department of Medical Physics and Biomedical Engineering, Sahlgrenska University Hospital, Gothenburg, Sweden

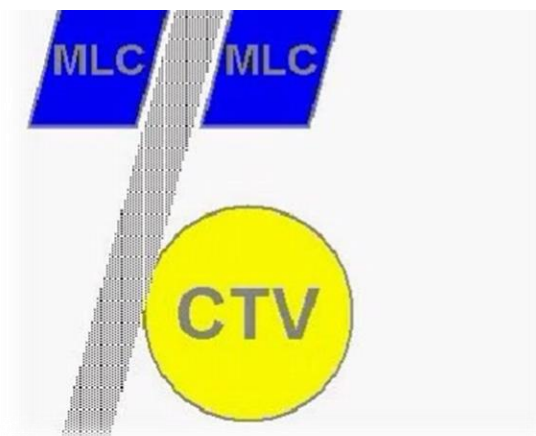
³ Department of Radiation Physics, Institute of Clinical Sciences, Sahlgrenska Academy at University of Gothenburg, Gothenburg, Sweden

⁴ Department of Hematology, Oncology and Radiation Physics, Skåne University Hospital, Lund, Sweden

⁵ Author to whom any correspondence should be addressed.

E-mail: anneli.edvardsson@med.lu.se

16%



RADIATION THERAPY ONCOLOGY GROUP

RTOG 0236

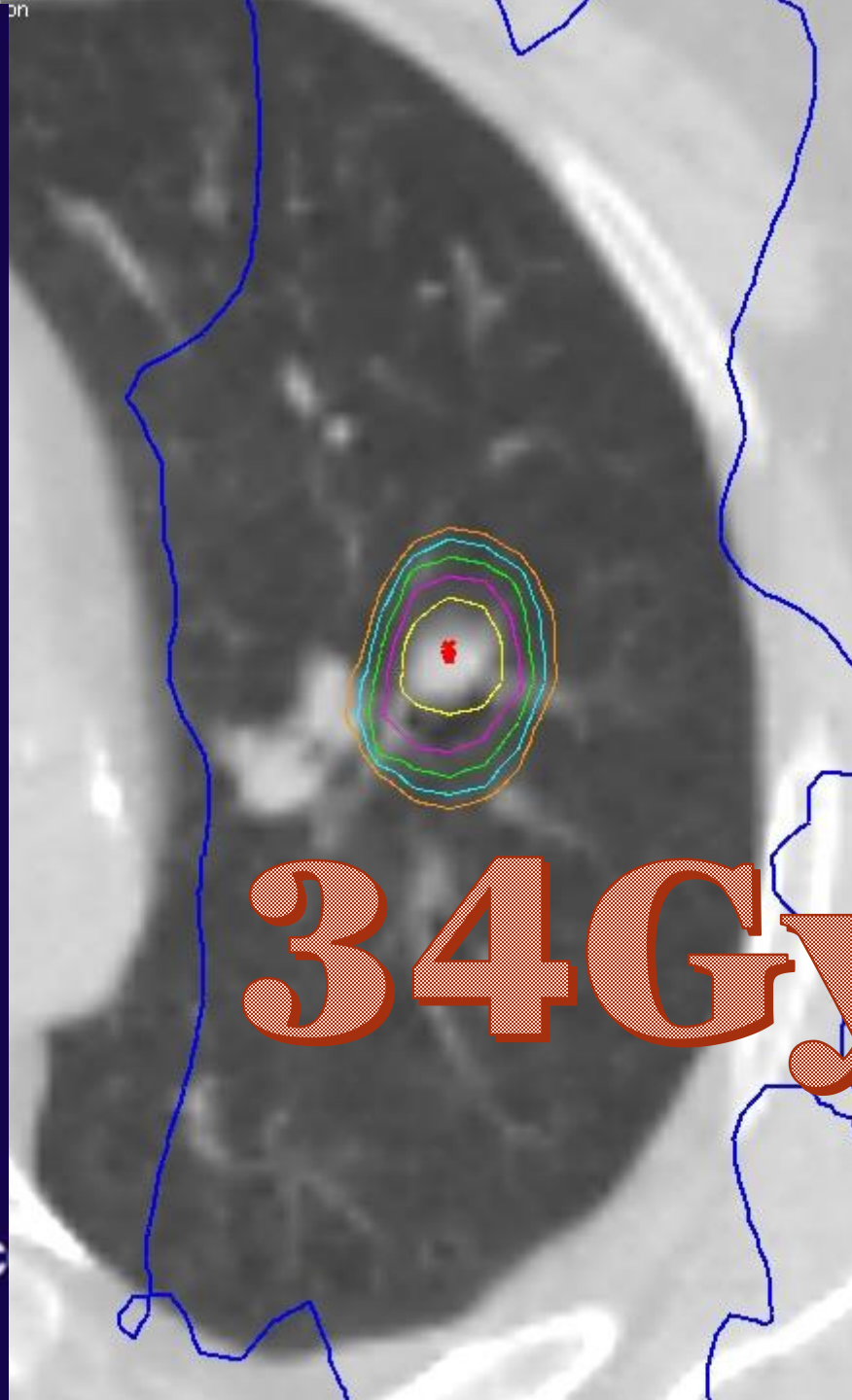
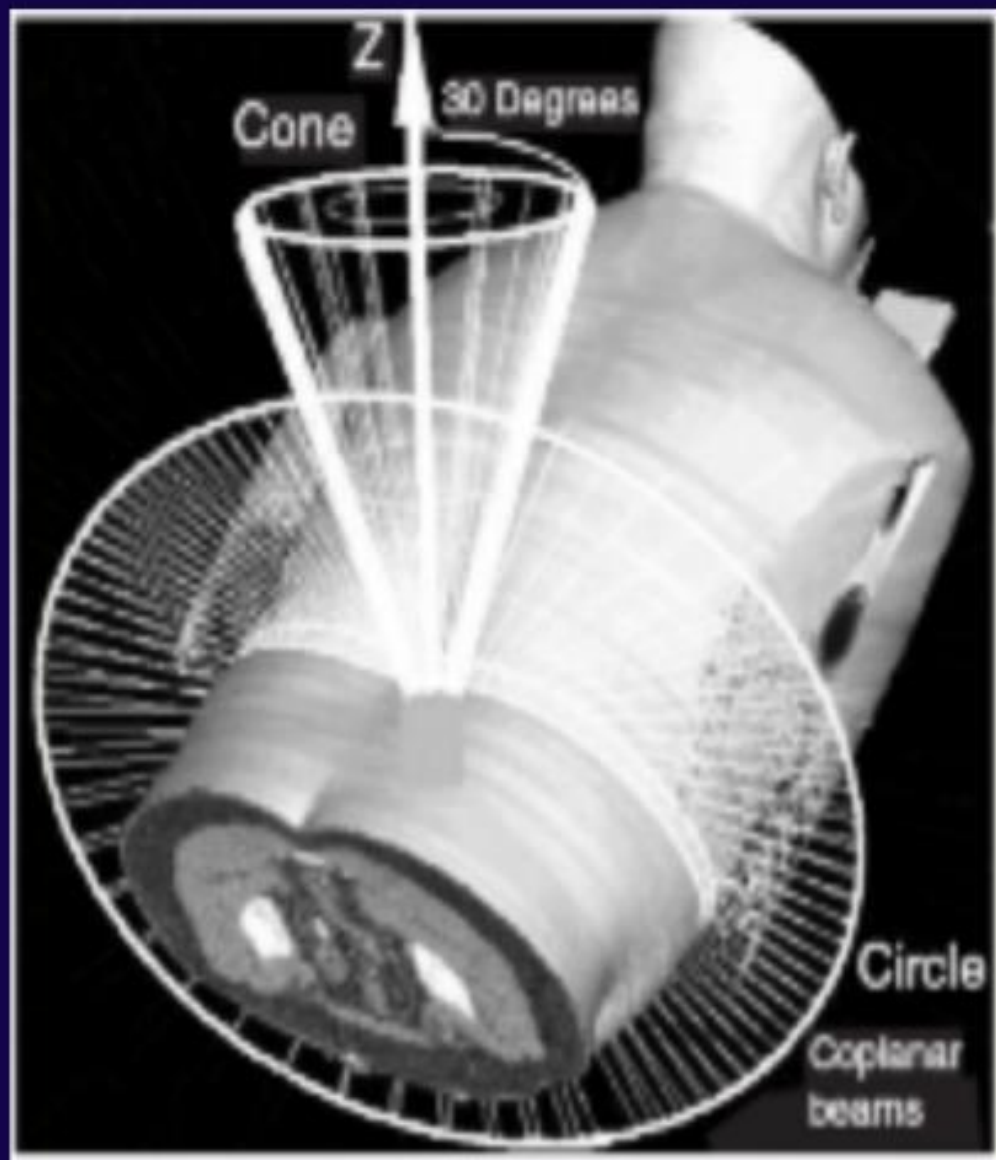
A Phase II Trial of Stereotactic Body Radiation Therapy (SBRT) in the Treatment of Patients with Medically Inoperable Stage I/II Non-Small Cell Lung Cancer

6.0 RADIATION THERAPY Note: Intensity Modulated RT (IMRT) Is Not Allowed

6.1 Dose Specifications

6.1.1 Stereotactic Targeting and Treatment

The term "stereotactic" for the purposes of this protocol implies the targeting, planning, and directing of therapy using beams of radiation along any trajectory in 3-D space toward a target of known 3-D coordinates. This differs from conventional radiation therapy in which therapy is directed toward skin marks or bony landmarks that are indirectly referenced to the tumor. This protocol will require treatments to be conducted with the use of a fixed 3-D coordinate system defined by fiducials. The coordinate system defined by the fiducials should be directly related to the radiation producing device (e.g., couch and gantry) in a reproducible and secure fashion. Capability should exist to define the position of targets within the patient according to this same 3-D coordinate system. As such, the patient is set up for each treatment with the intention of directing the radiation toward an isocenter or target according to the known 3-D coordinates as determined in the process of treatment planning. The nature of the fiducials themselves may



Restricted deliverable beam space
for SBRT(Liu et al PMB, 2004)

A decorative graphic on the left side of the slide. It features a solid brown arrow pointing to the right at the top. Below it, several thin, curved lines in shades of brown and grey sweep upwards and to the right, creating a sense of movement and framing the text.

Alteración de la densidad en SBRT

RADIATION THERAPY ONCOLOGY GROUP

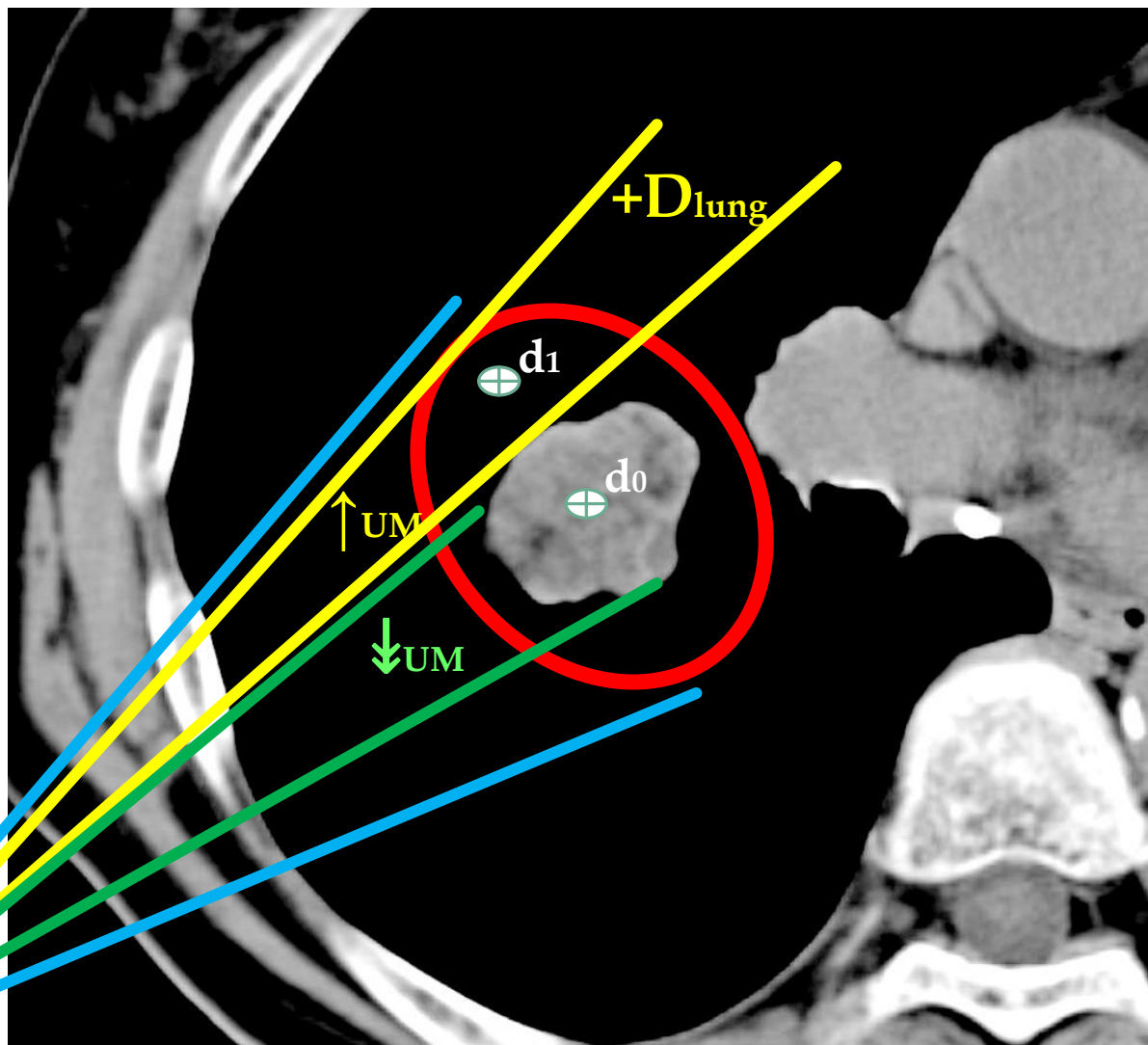
RTOG 0618

A Phase II Trial of Stereotactic Body Radiation Therapy (SBRT) in the Treatment of Patients with Operable Stage I/II Non-Small Cell Lung Cancer

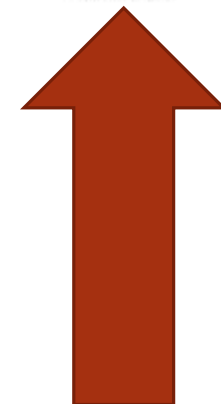
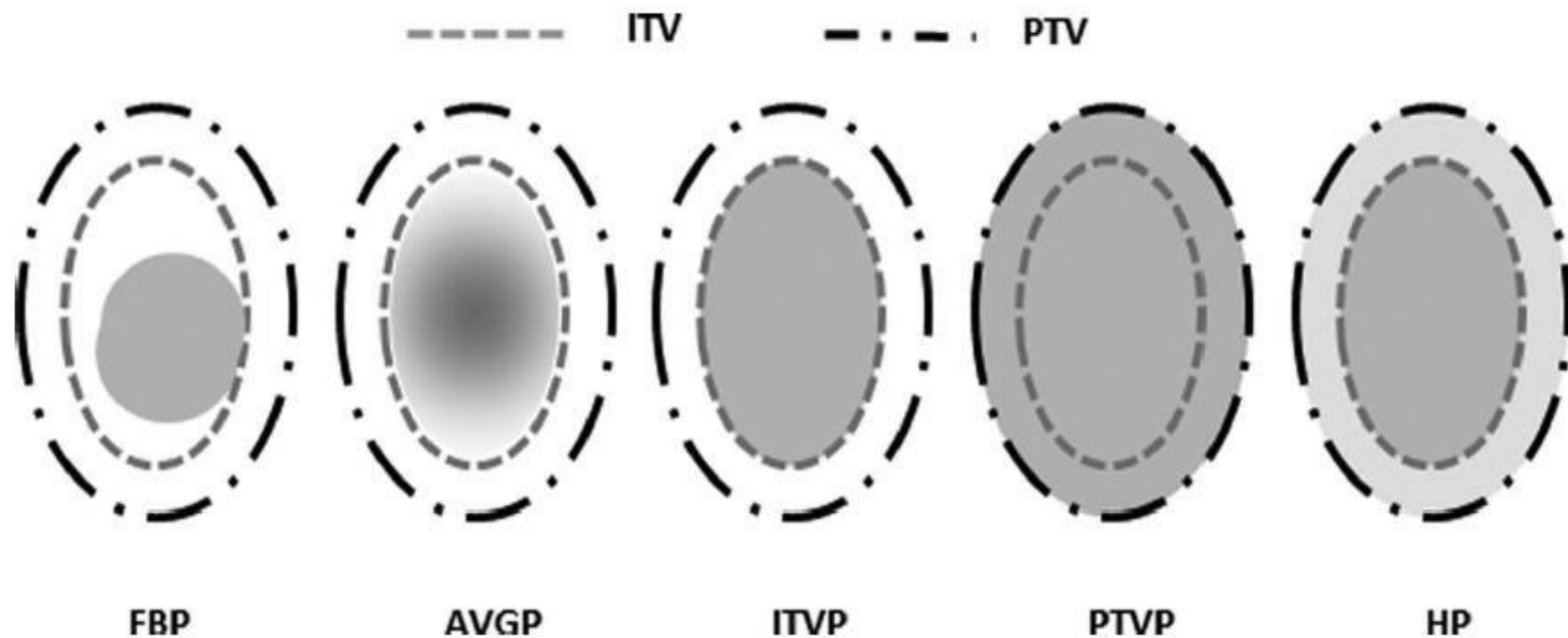
Study Team (10/25/12)


For purposes of dose planning and calculation of monitor units for actual treatment, all tissues within the body, including lung, will be assumed to have unit (water) density (no correction for tissue heterogeneity). However, for QA purposes, each plan should also be calculated with software vendor supplied heterogeneity corrections for density enabled. In order for ITC (the QA center) to make an accurate comparison between these plans, the computation using heterogeneity corrections should have beam weights manipulated such that the number of monitor units is the same for each beam between the plans. Both plans (with and without heterogeneity correction) will be submitted to the ITC for comparison. Again, calculation of the accelerator monitor units for the actual patient treatment should reflect the plan where all tissues are assumed to have unit (water) density.

Getting ICRU
homogeneity:
 $d_1=d_0$



Med Phys: 41:081707 (2014):





From the results we can
recommend
alteration of the density
only between
3cm to 10cm
of PTV diameters.



The mean overall correction values of post-treatment IGRT were:

lateral $1.0 \pm 1.3 \text{mm}$,

longitudinal $0.9 \pm 1.2 \text{mm}$ and

vertical $1.1 \pm 1.5 \text{mm}$,

time from star to end irradiation was

7.6 ± 2.0 minutes

for 18-20Gy per fraction,

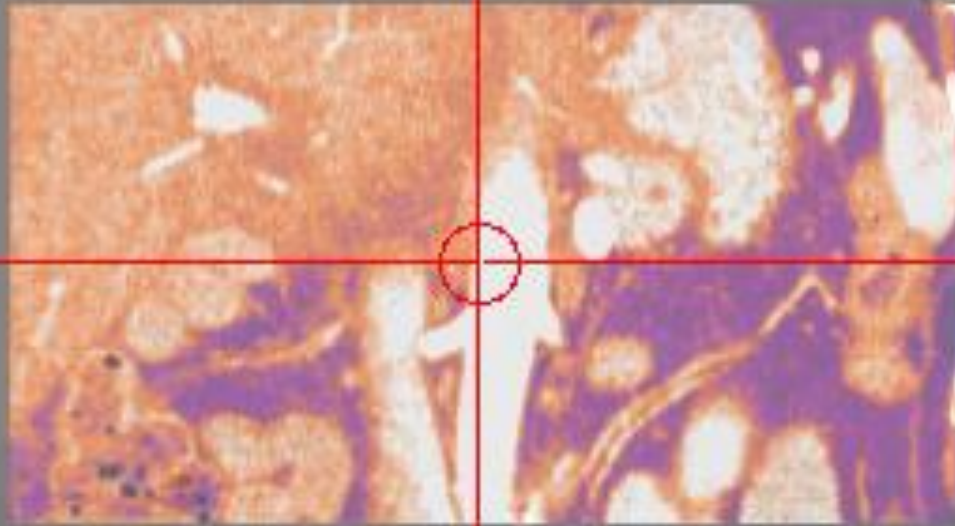
and relative increase in volume between

GTV and ITV was 33.9% .



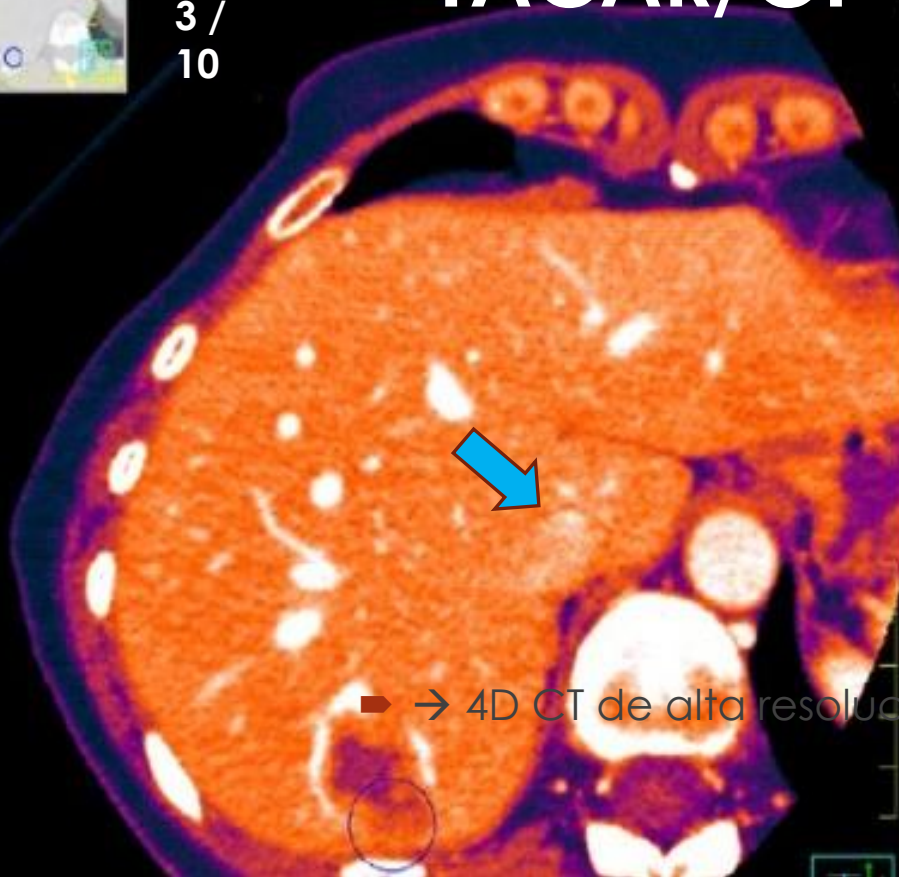
Abdomen

Contraste oral e intravenoso sincronizado

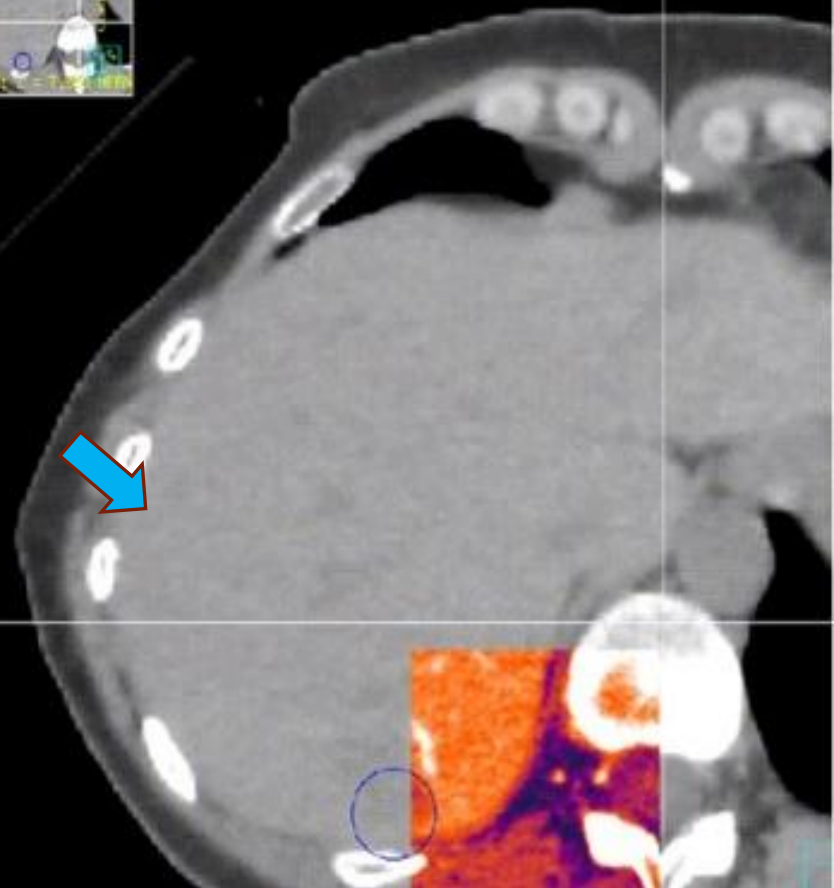


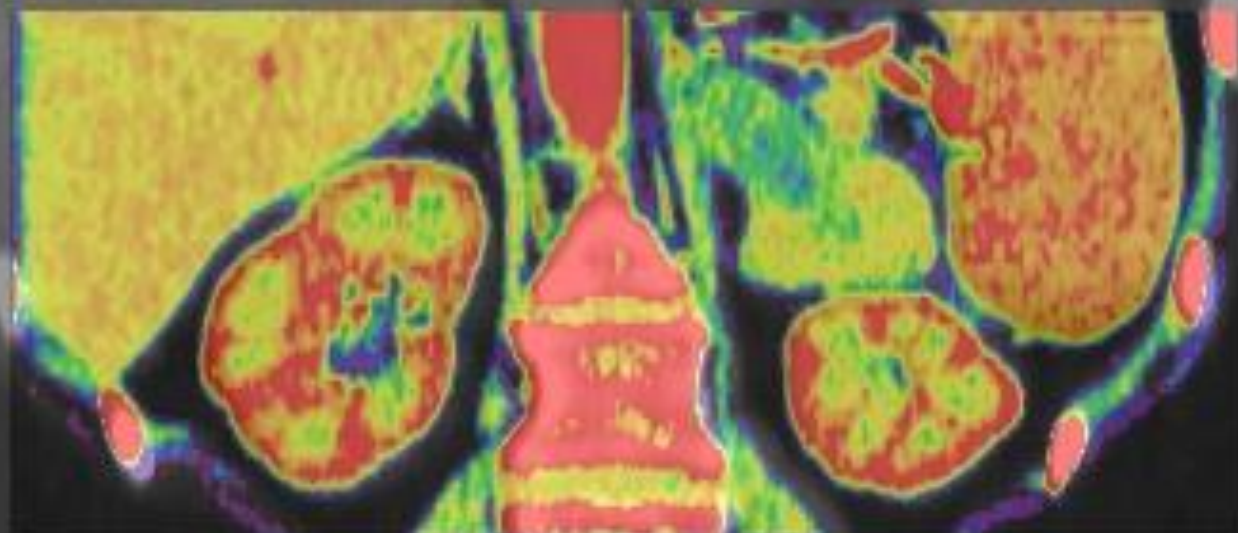
TACAR/CT

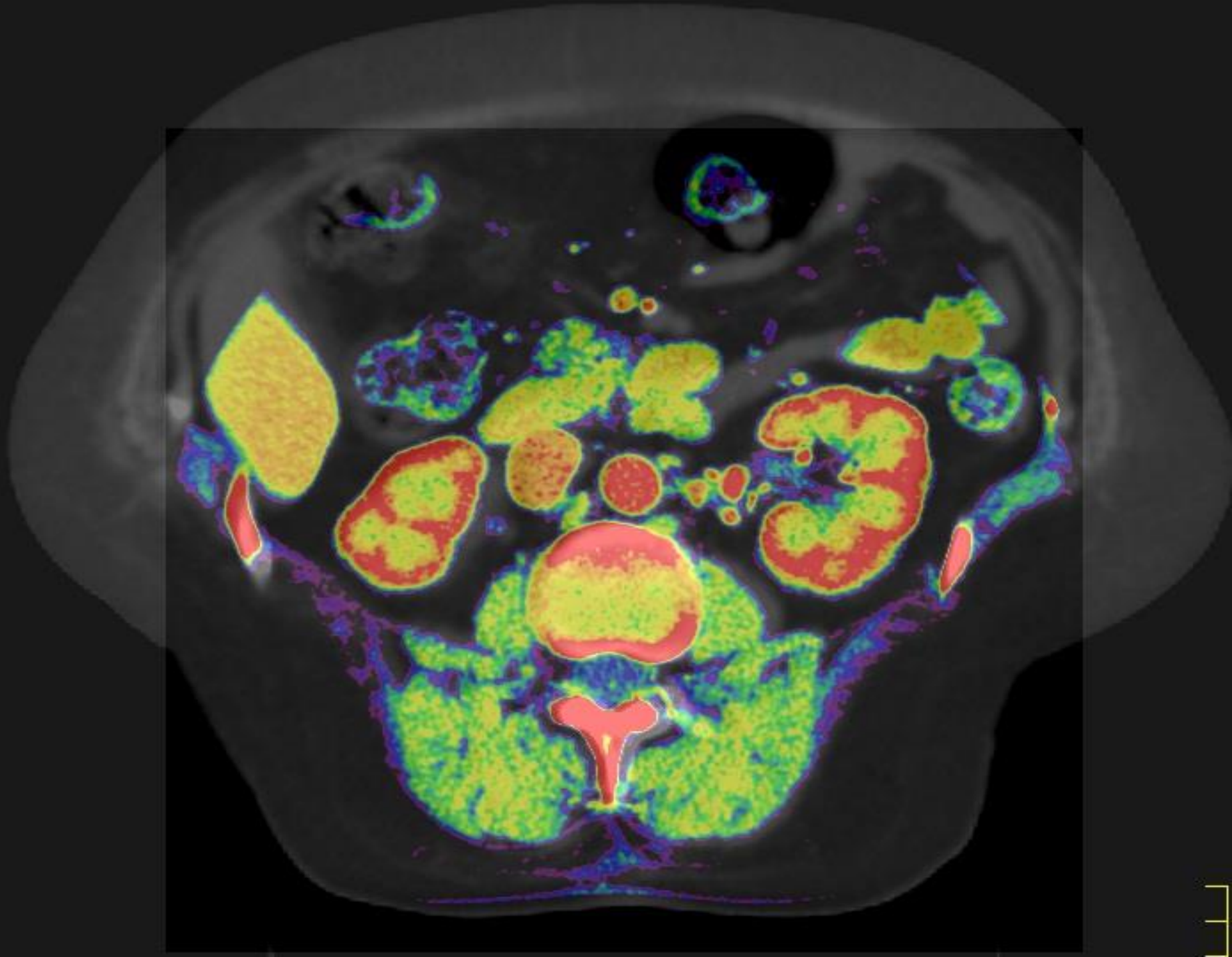
3 /
10



→ 4D CT de alta resolución







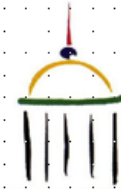


Velázquez Miranda, S^{1*},
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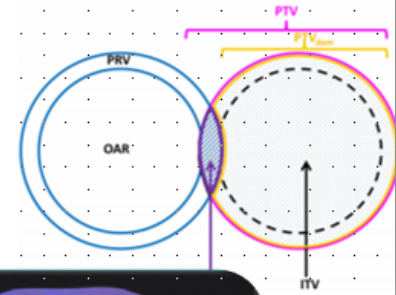
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Virgen del Rocío

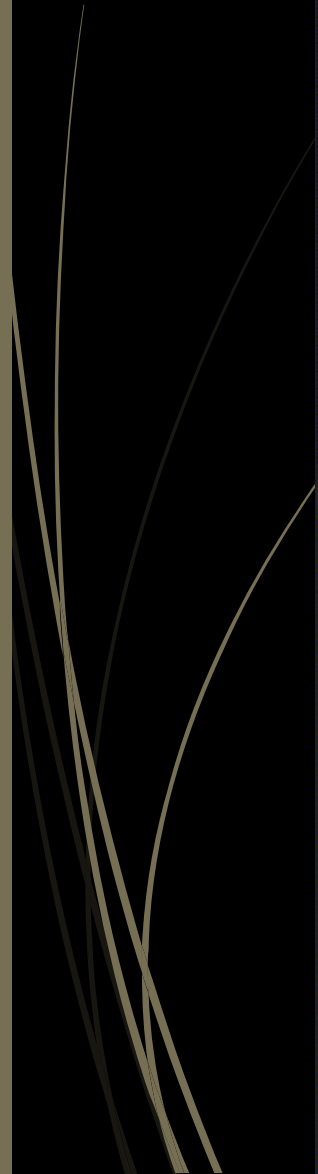
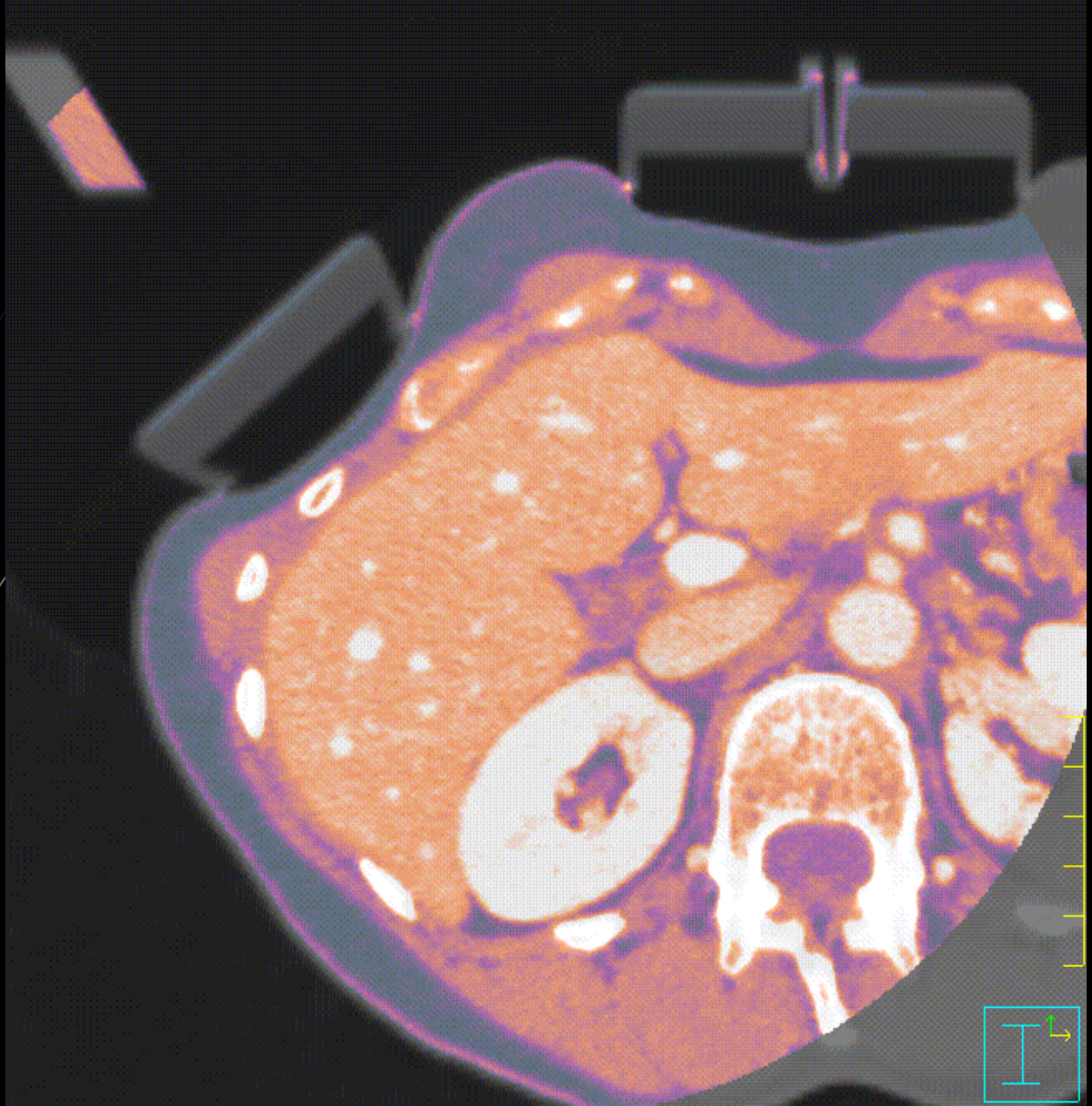
MULTIDAMPENING Y MÁRGENES NEGATIVOS EN SABR PANCREÁTICA CON PRESCRIPCIONES SIP

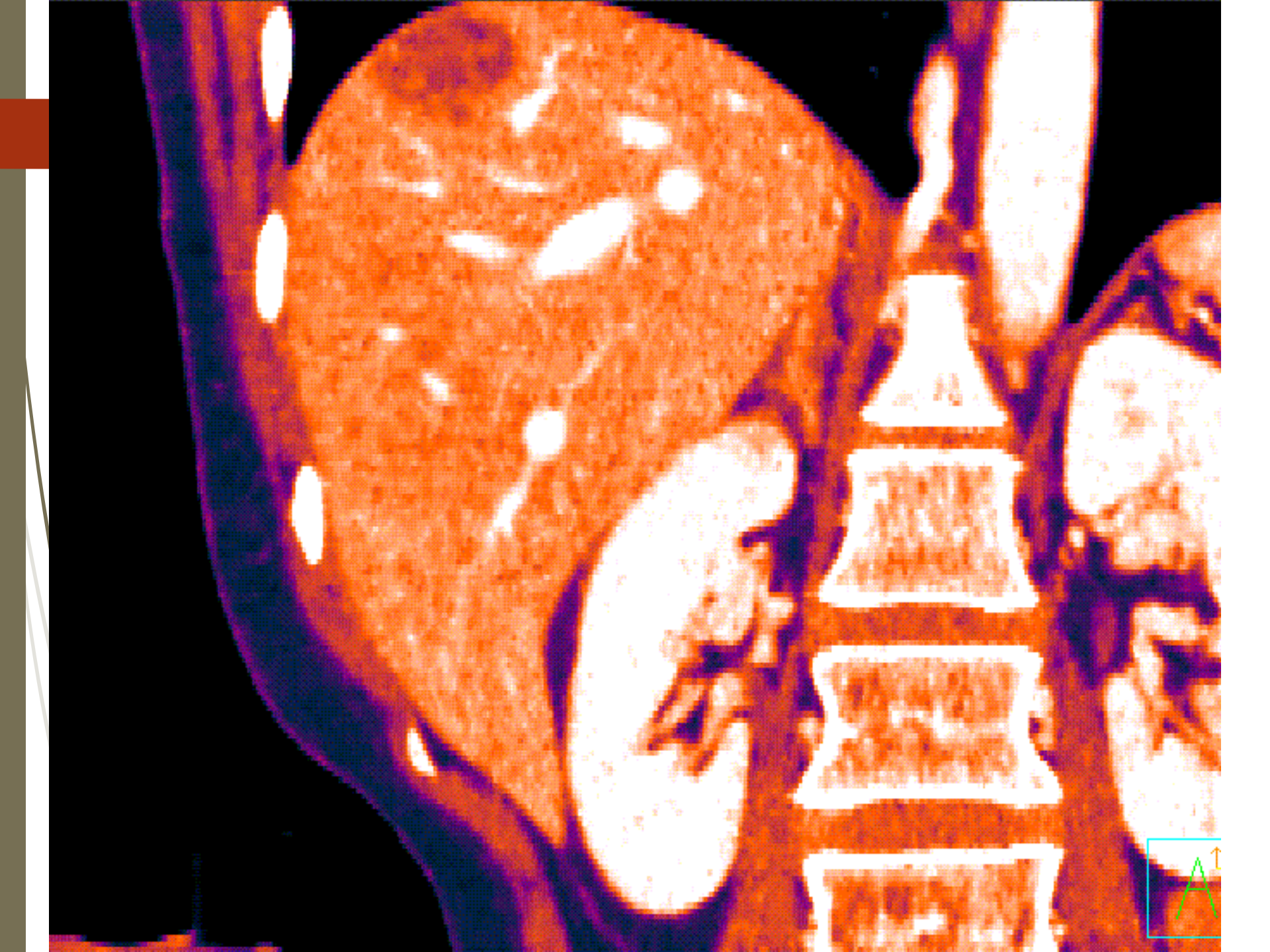
Introducción y Objetivos

La SABR en cáncer pancreático se ve condicionada en muchas ocasiones por la presencia de órganos de riesgo (OAR) adheridos a las lesiones, lo que no permite las prescripciones ablativas propias de la técnica.

En este trabajo se describe tanto el procedimiento de simulación con multidamping como la class solution implementada en nuestro hospital en SABR pancreática con prescripciones SIP (Simultaneous Integrated Protection), que se focaliza en las interacciones no poissonianas de la muerte celular para permitir salvar las tolerancias del tejido sano y cubrir los objetivos de control tumoral.







Scientific Article

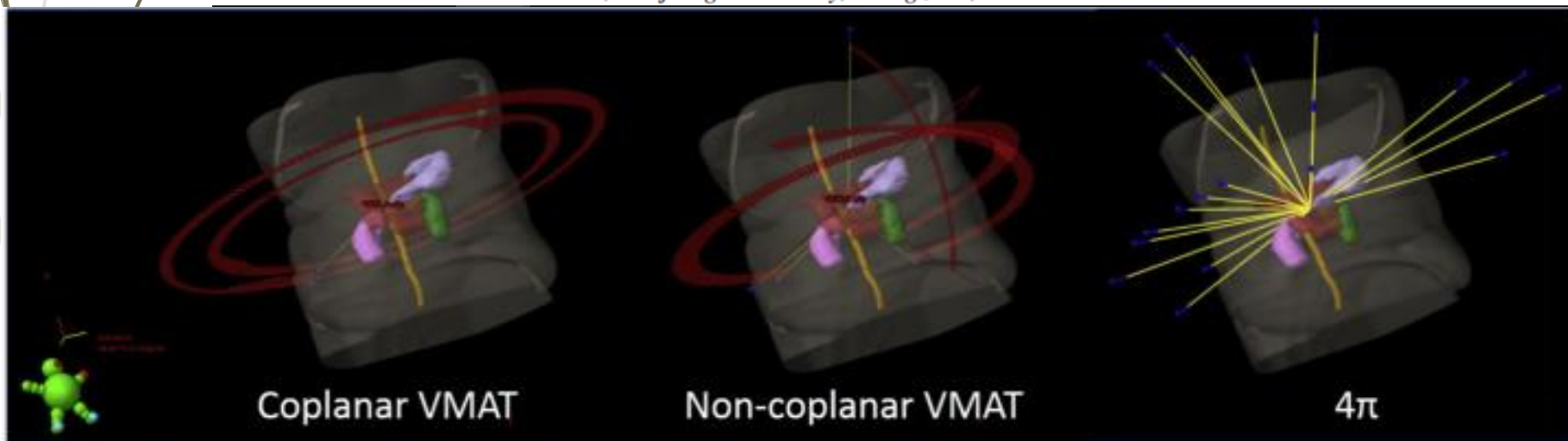
Viability of Noncoplanar VMAT for liver SBRT compared with coplanar VMAT and beam orientation optimized 4π IMRT

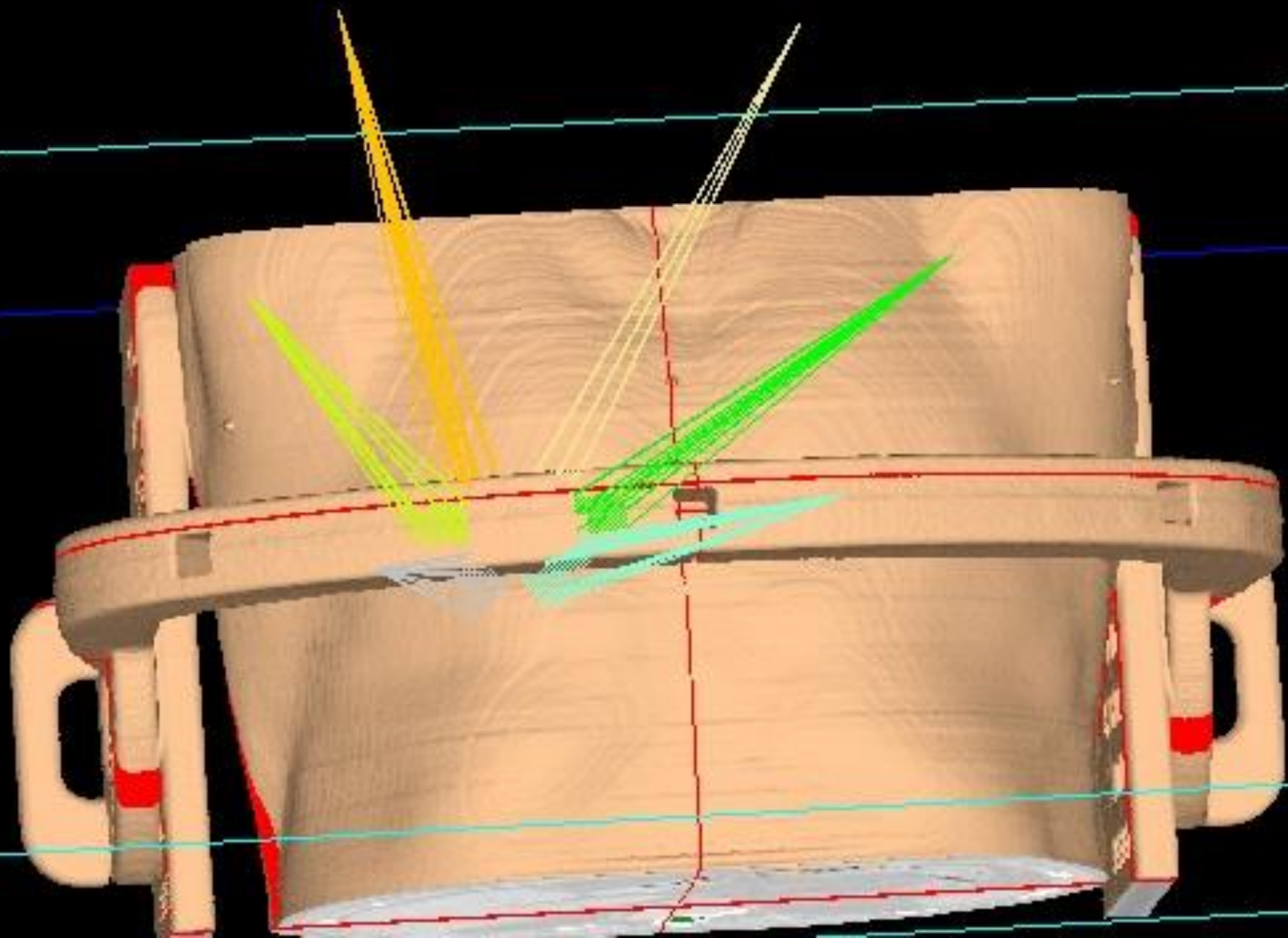
Kaley Woods BS ^a, Dan Nguyen BS ^a, Angelia Tran BS ^a,
Victoria Y. Yu BS ^a, Minsong Cao PhD ^a, Tianye Niu PhD ^b,
Percy Lee MD ^a, Ke Sheng PhD ^{a,*}

^a Department of Radiation Oncology, University of California, Los Angeles, California

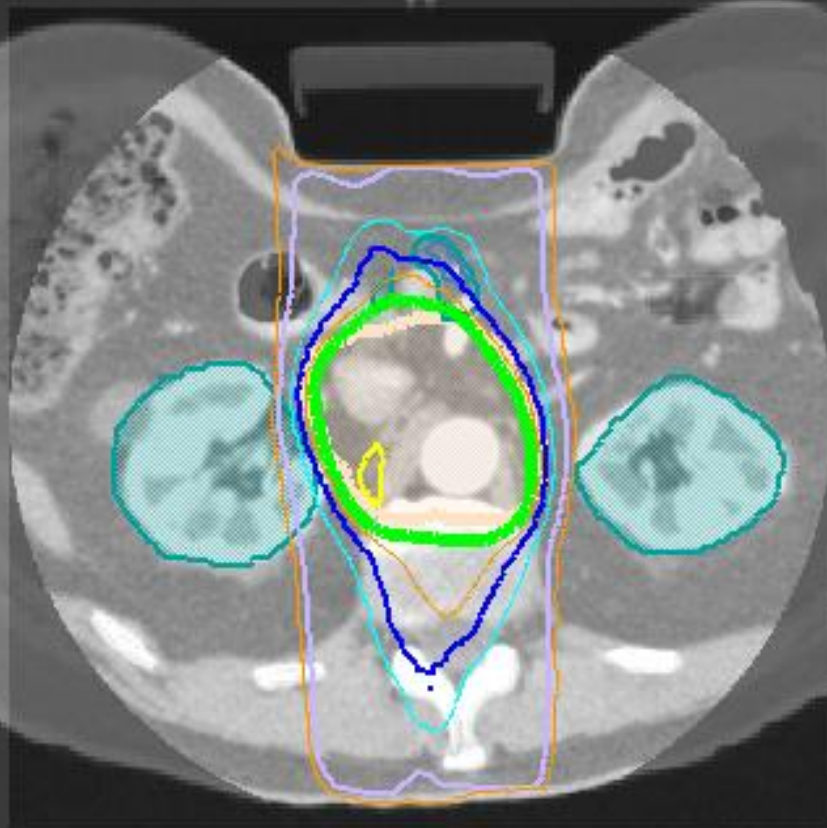
^b Translational Medicine Institute, Zhejiang University, Hangzhou, P.R. China

Click on image to zoom

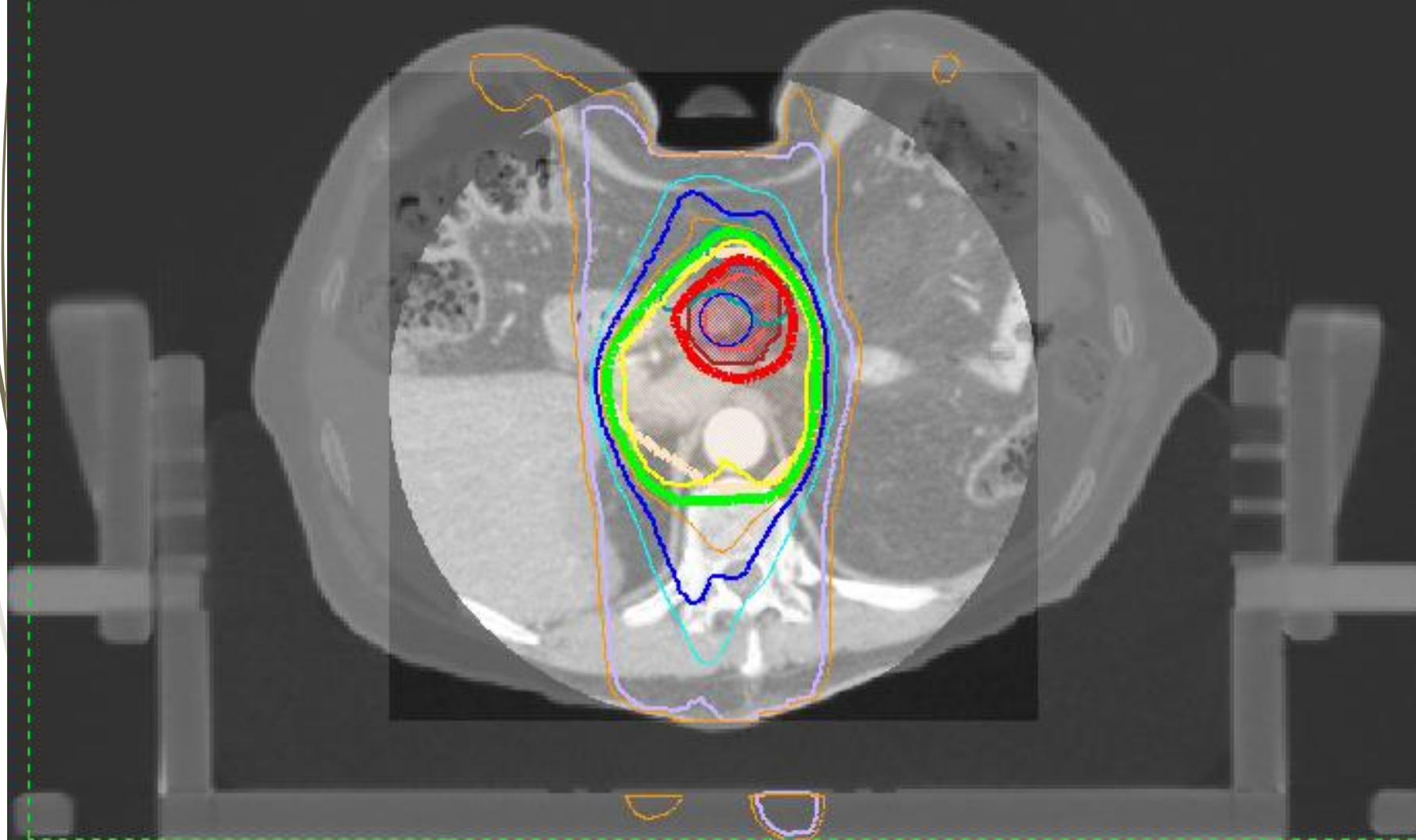


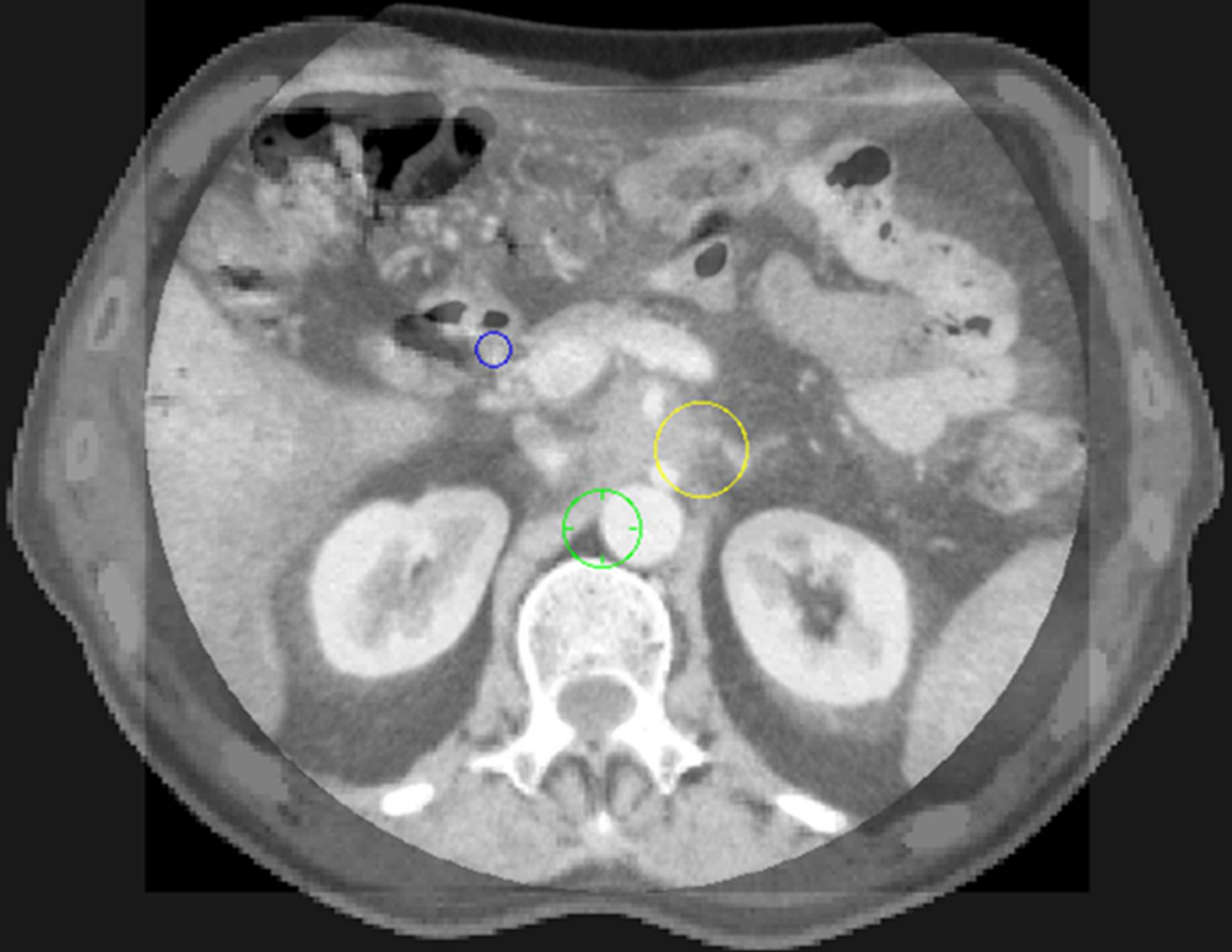


5800,0 cGy
5400,0 cGy
5200,0 cGy
5000,0 cGy
4800,0 cGy
4600,0 cGy
4000,0 cGy
3000,0 cGy
2600,0 cGy



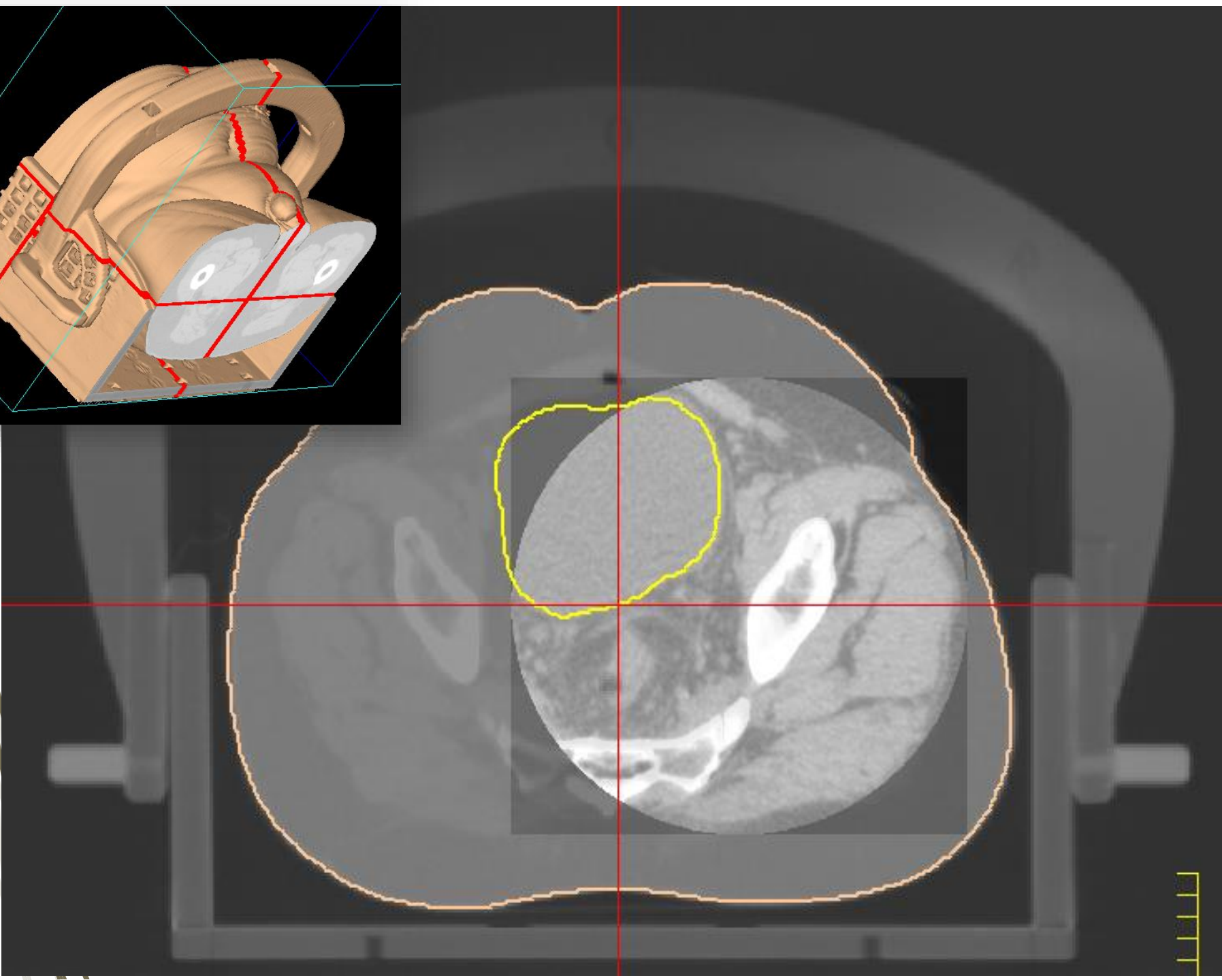
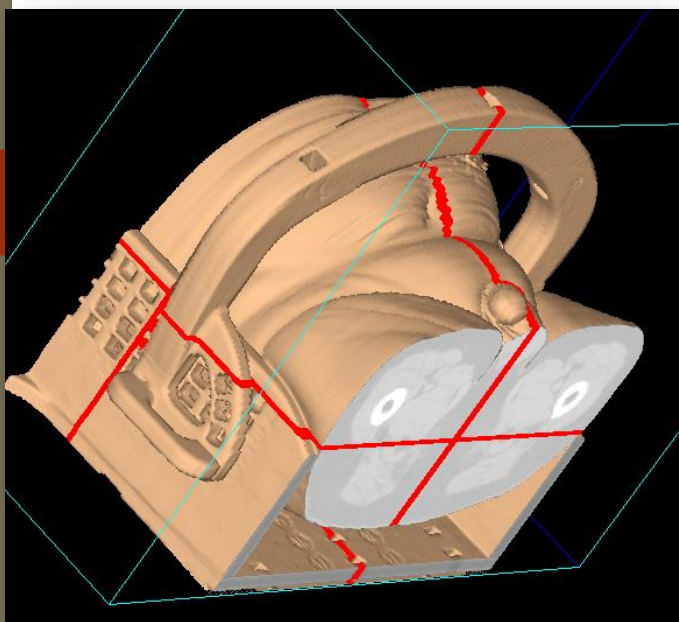
5800,0 cGy
5400,0 cGy
5200,0 cGy
5000,0 cGy
4800,0 cGy
4600,0 cGy
4000,0 cGy
3000,0 cGy
2500,0 cGy

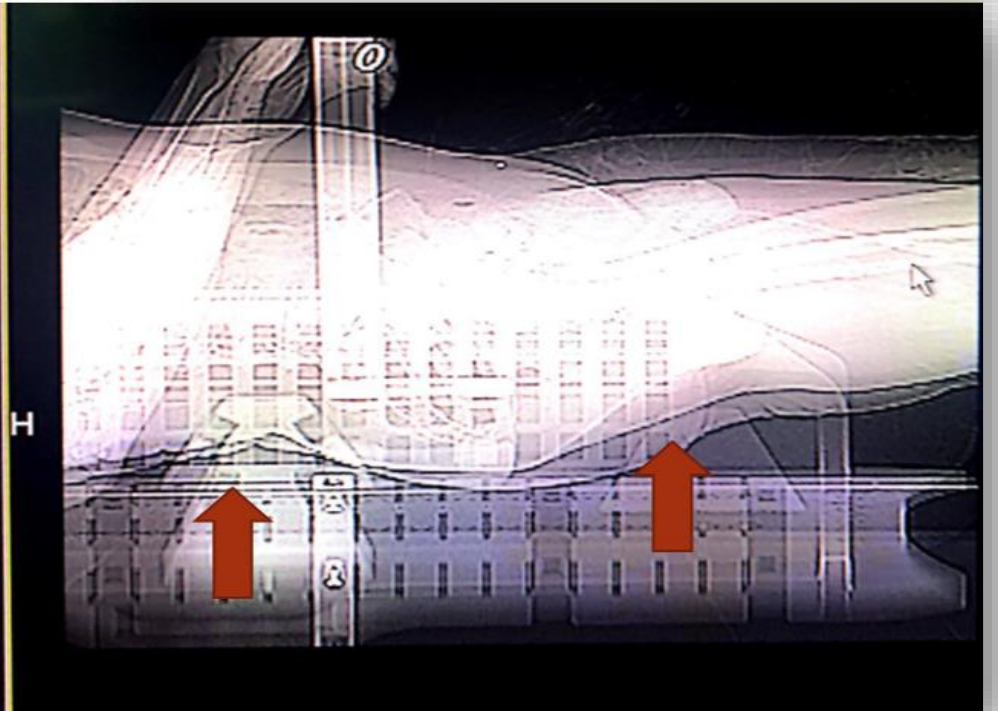
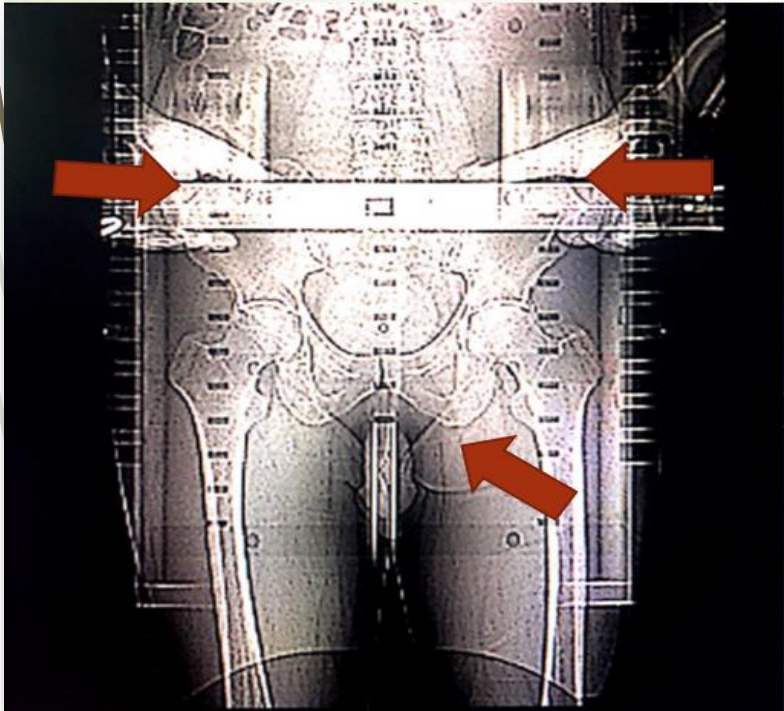
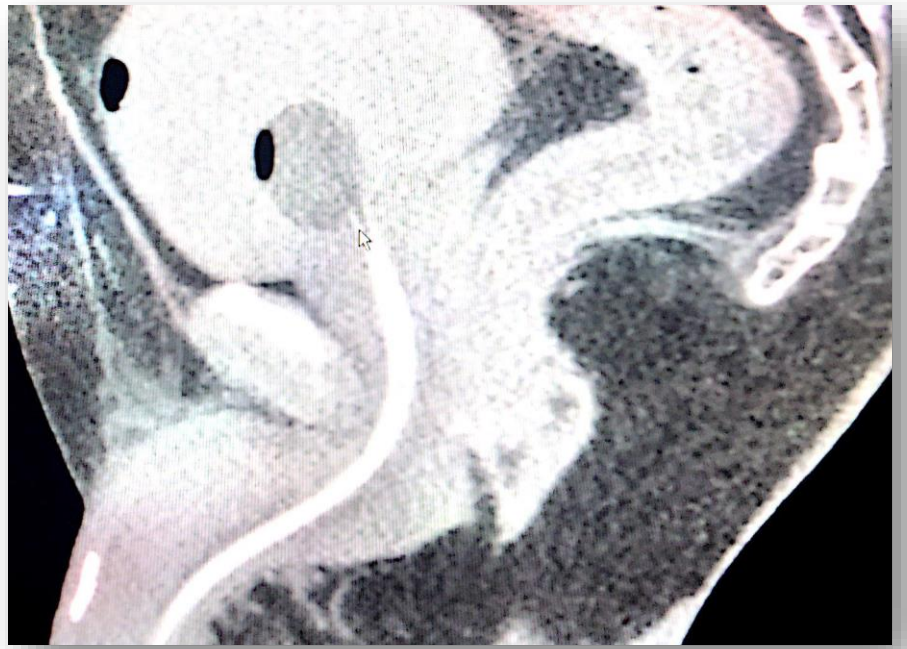
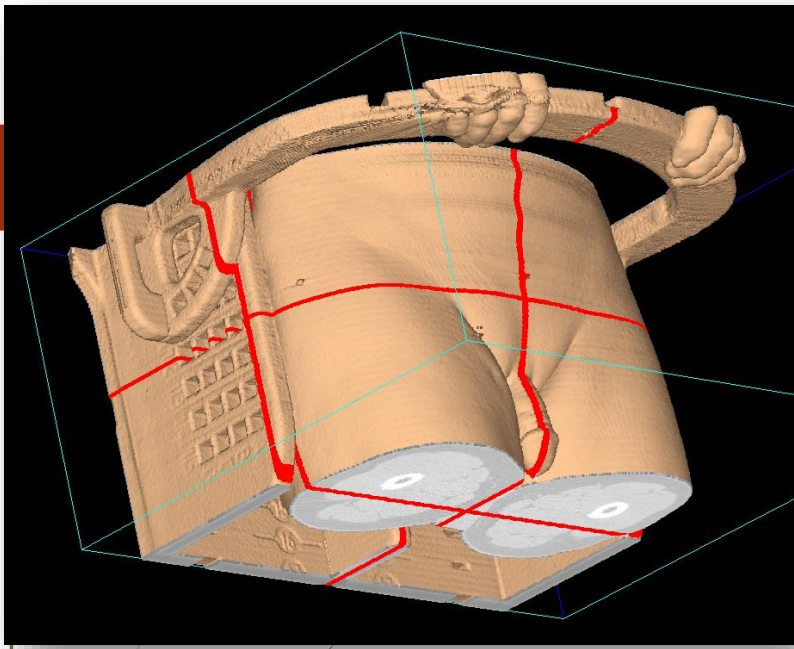




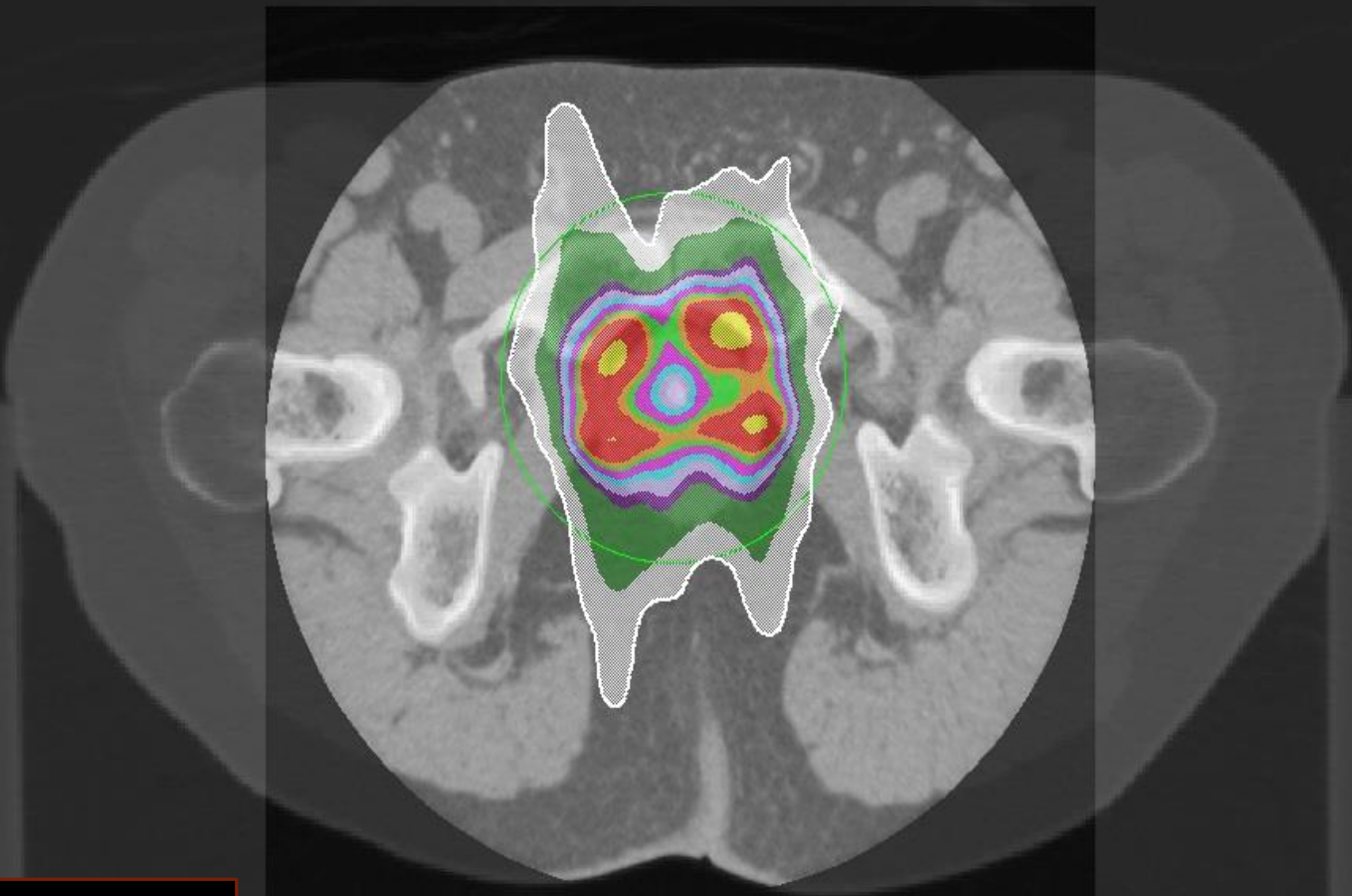


Pelvis





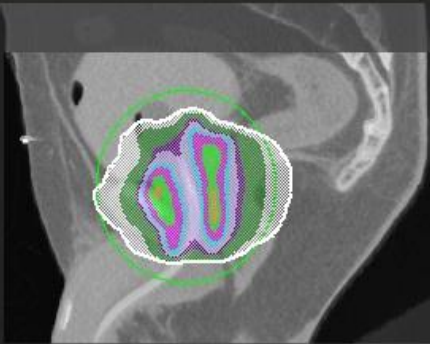
Trial: Trial_1
Absolute
3700.0 cGy
3400.0 cGy
3300.0 cGy
3200.0 cGy
3000.0 cGy
2880.0 cGy
2700.0 cGy
2500.0 cGy
2000.0 cGy
1600.0 cGy



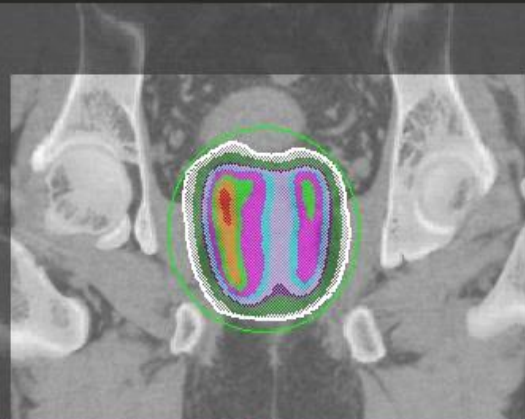
Slice 431: Z = 160.25



Trial: Trial_1
Absolute
3700.0 cGy
3400.0 cGy
3300.0 cGy
3200.0 cGy
3000.0 cGy
2880.0 cGy
2700.0 cGy
2500.0 cGy
2000.0 cGy
1600.0 cGy

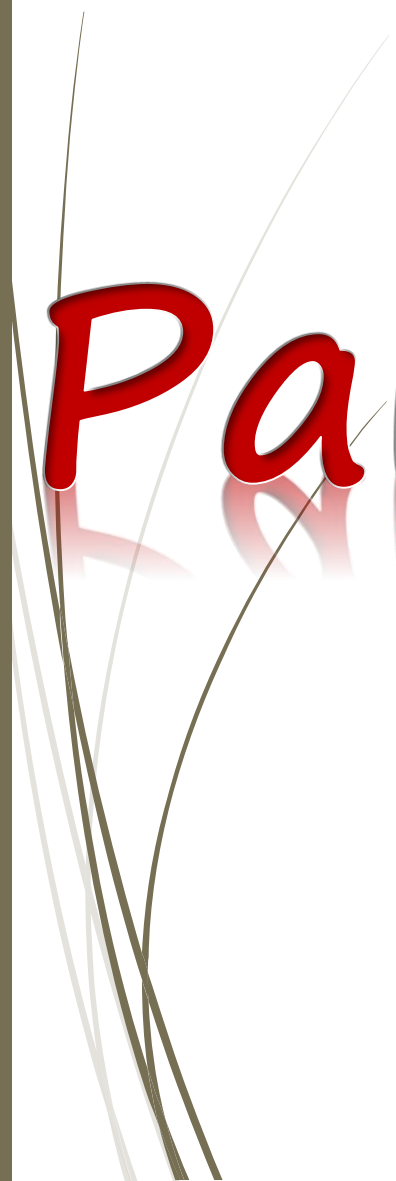


Trial: Trial_1
Absolute
3700.0 cGy
3400.0 cGy
3300.0 cGy
3200.0 cGy
3000.0 cGy
2880.0 cGy
2700.0 cGy
2500.0 cGy
2000.0 cGy
1600.0 cGy





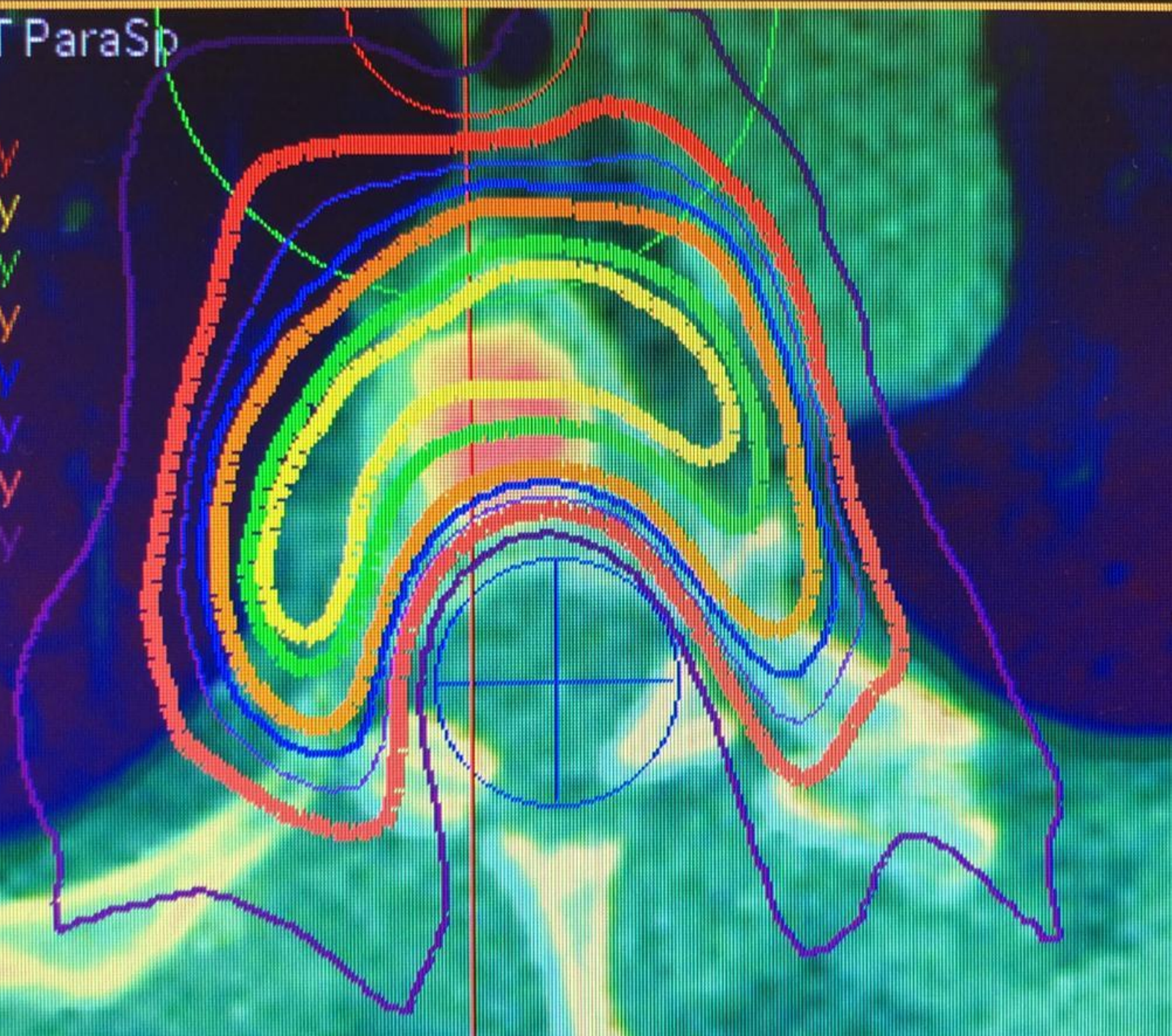
Paraespinales



Trial: SBRT ParaSp

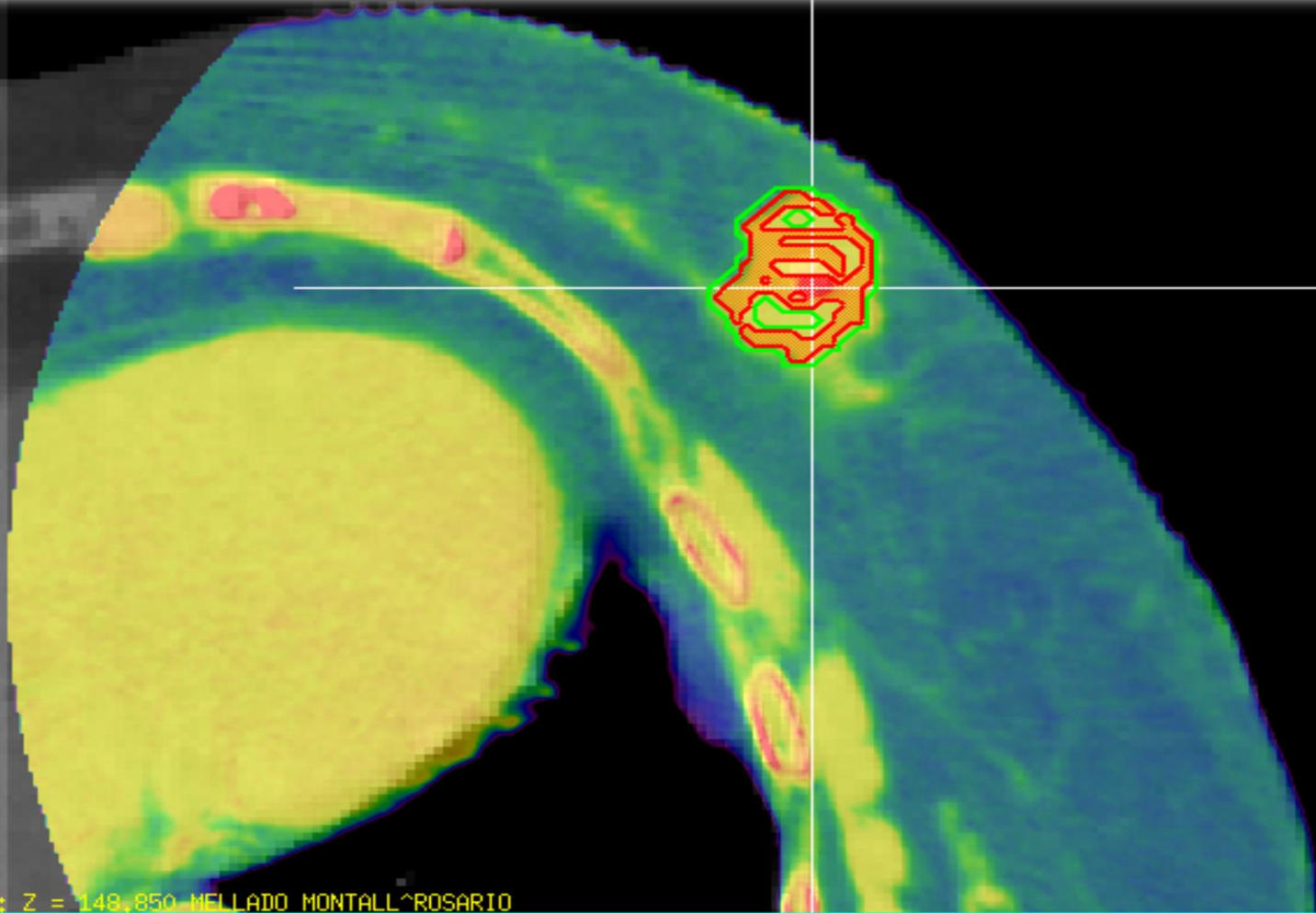
Absolute

- 3000.0 cGy
- 2600.0 cGy
- 2400.0 cGy
- 2000.0 cGy
- 1800.0 cGy
- 1600.0 cGy
- 1400.0 cGy
- 1000.0 cGy





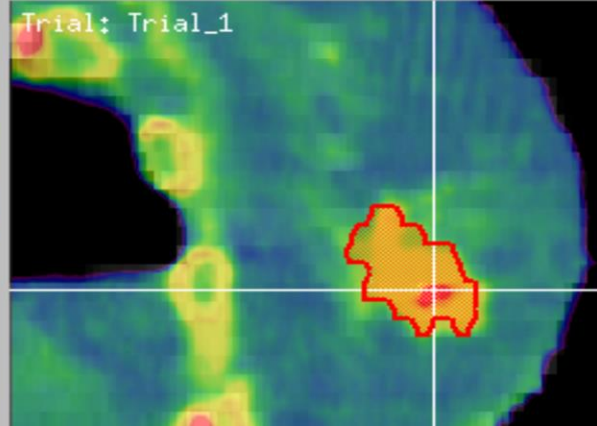
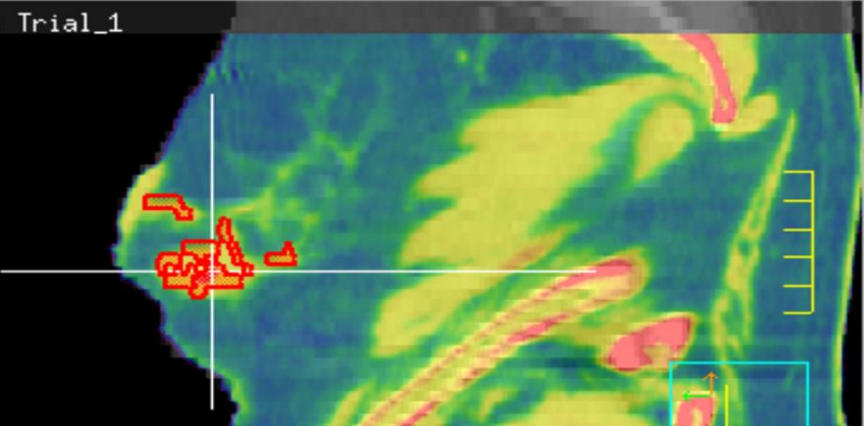
Mama

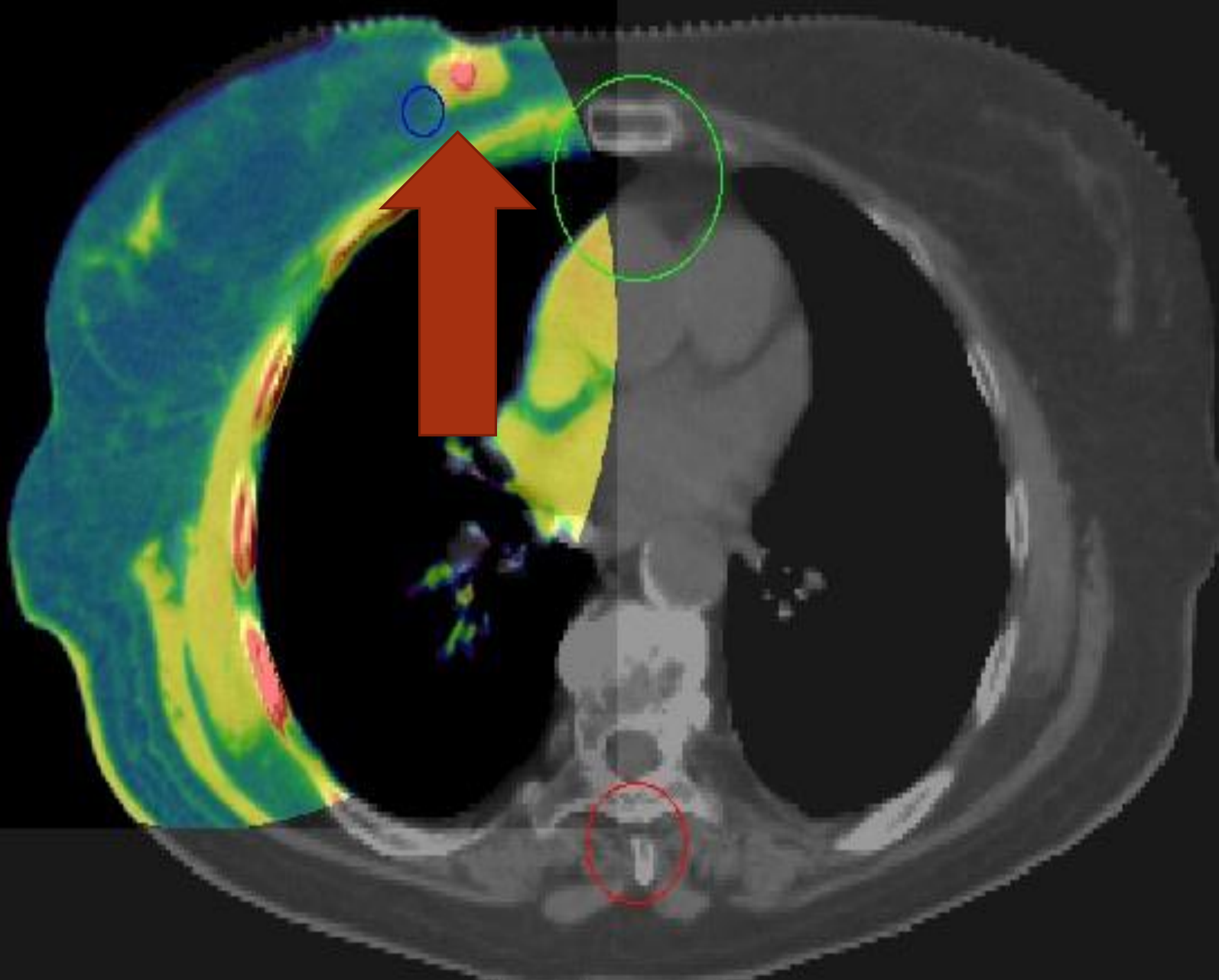


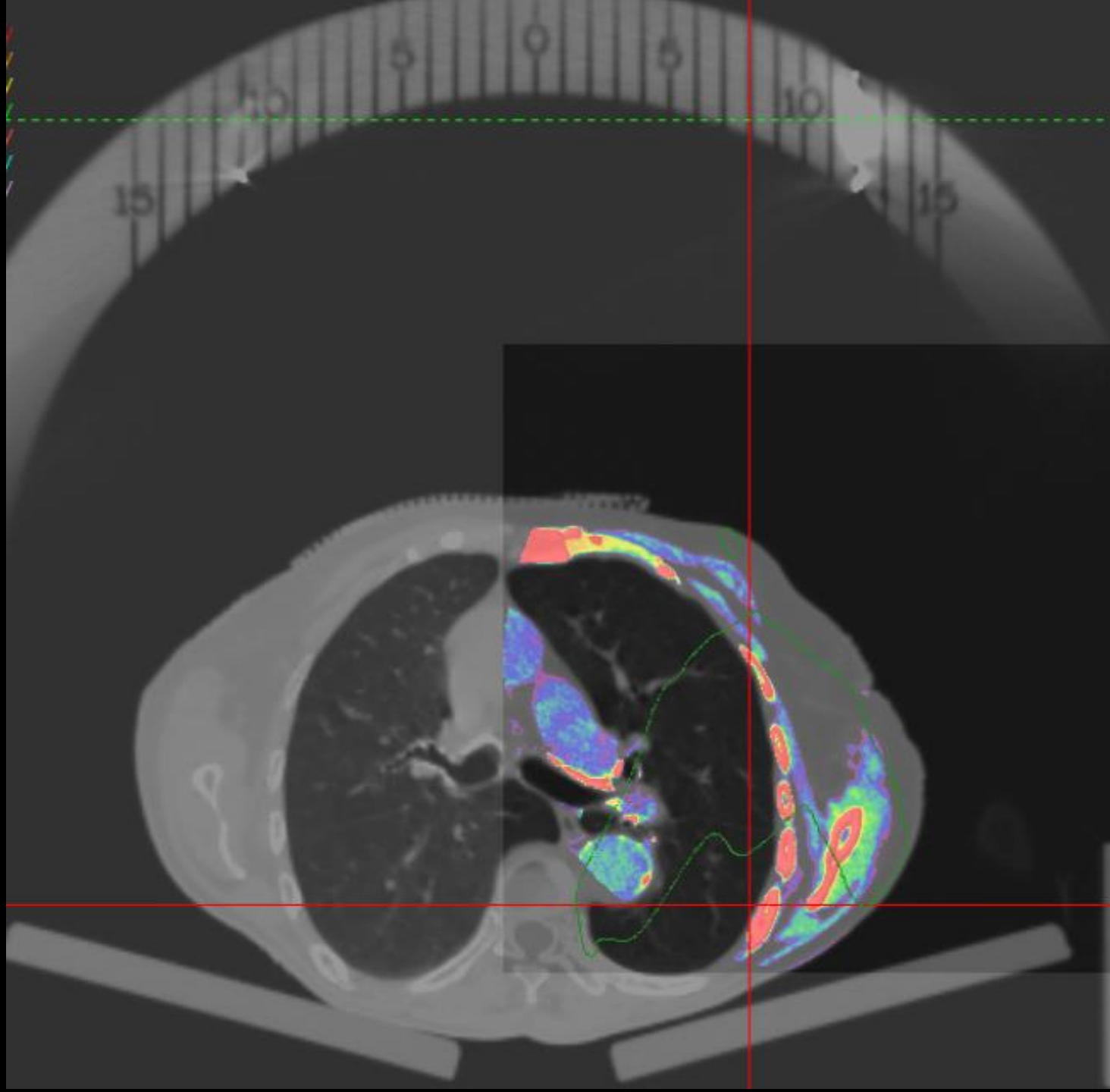
lice 37: Z = 148,850 MELLADO MONTALLA ROSARIO

rial: Trial_1

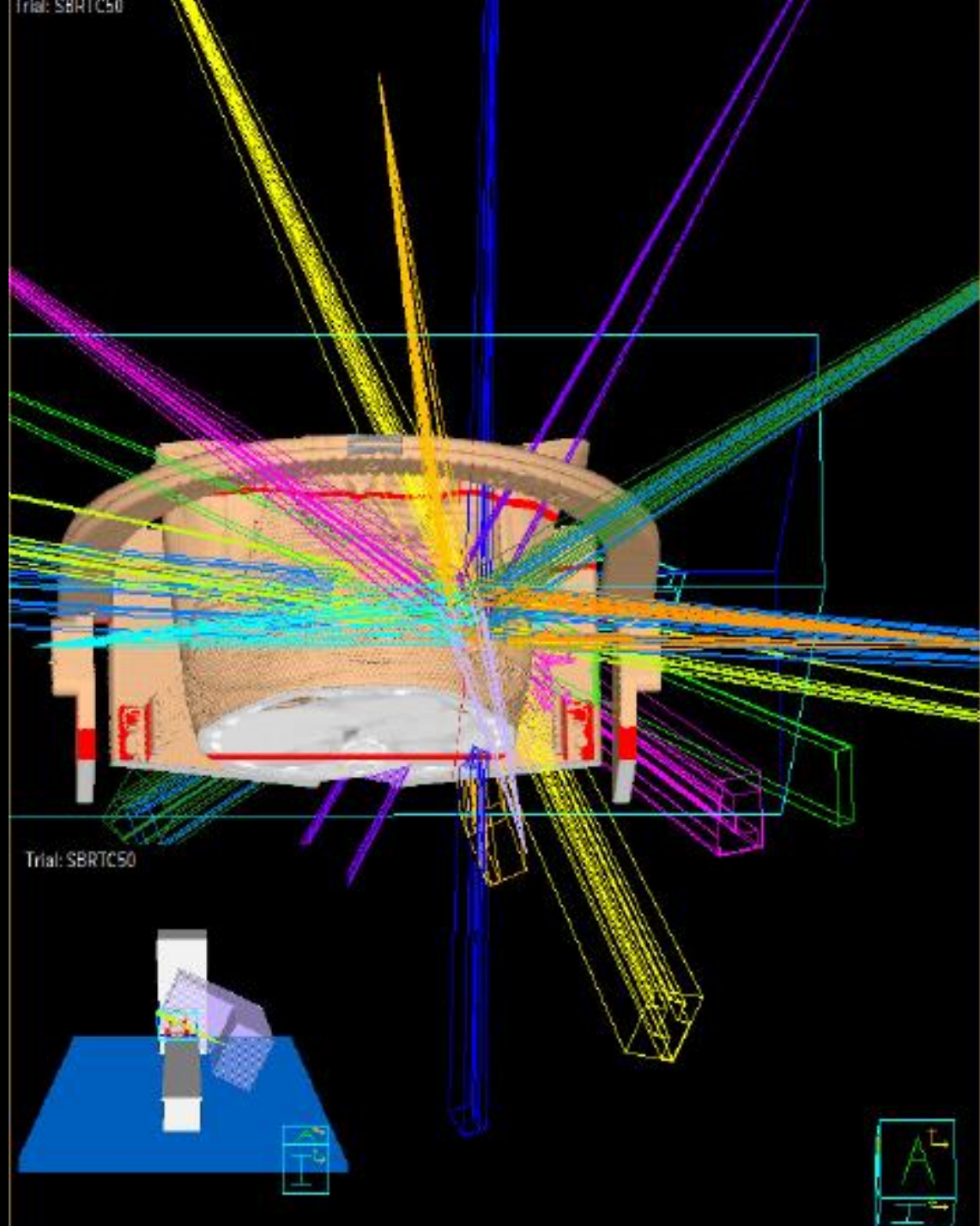
Trial: Trial_1

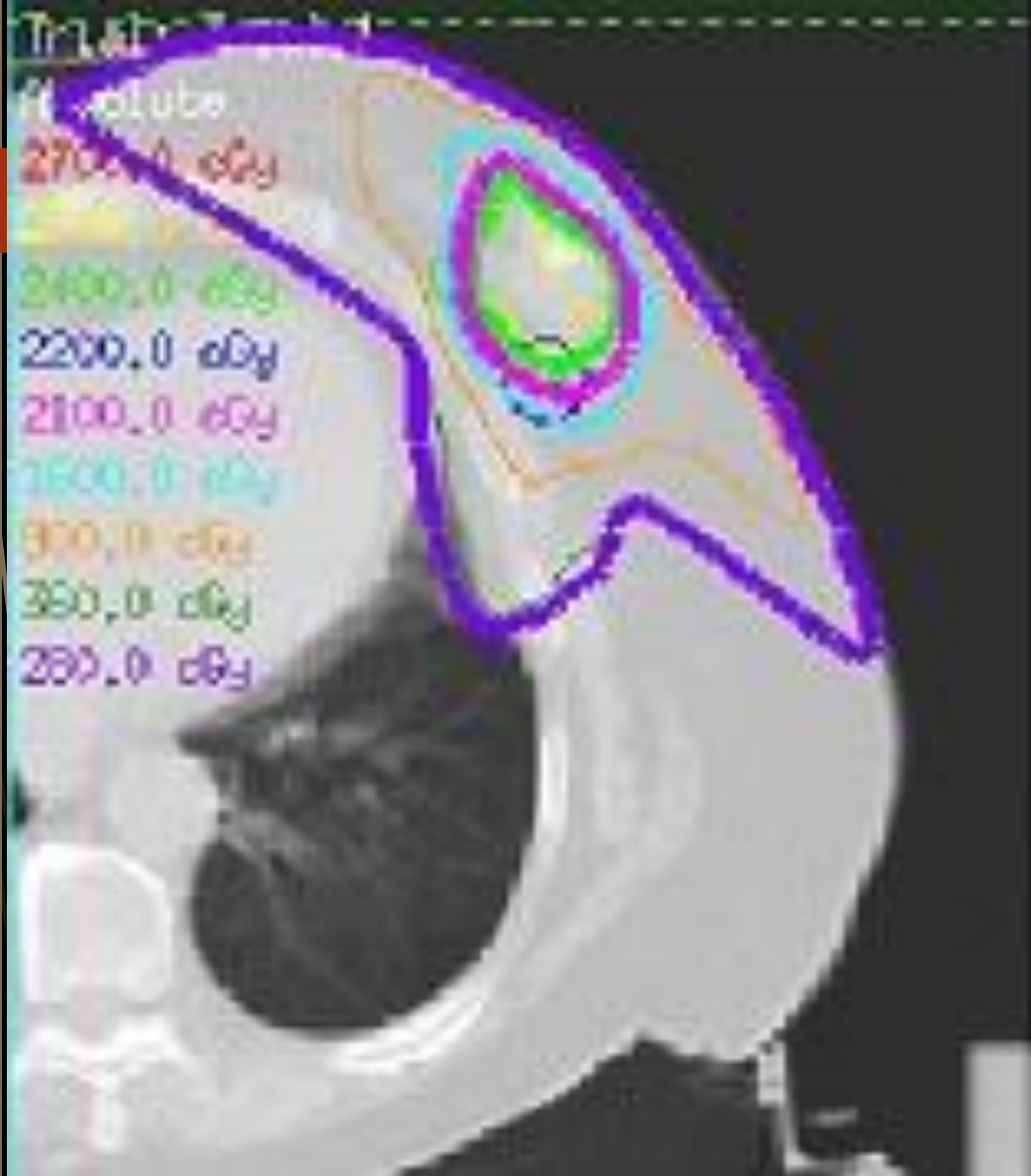






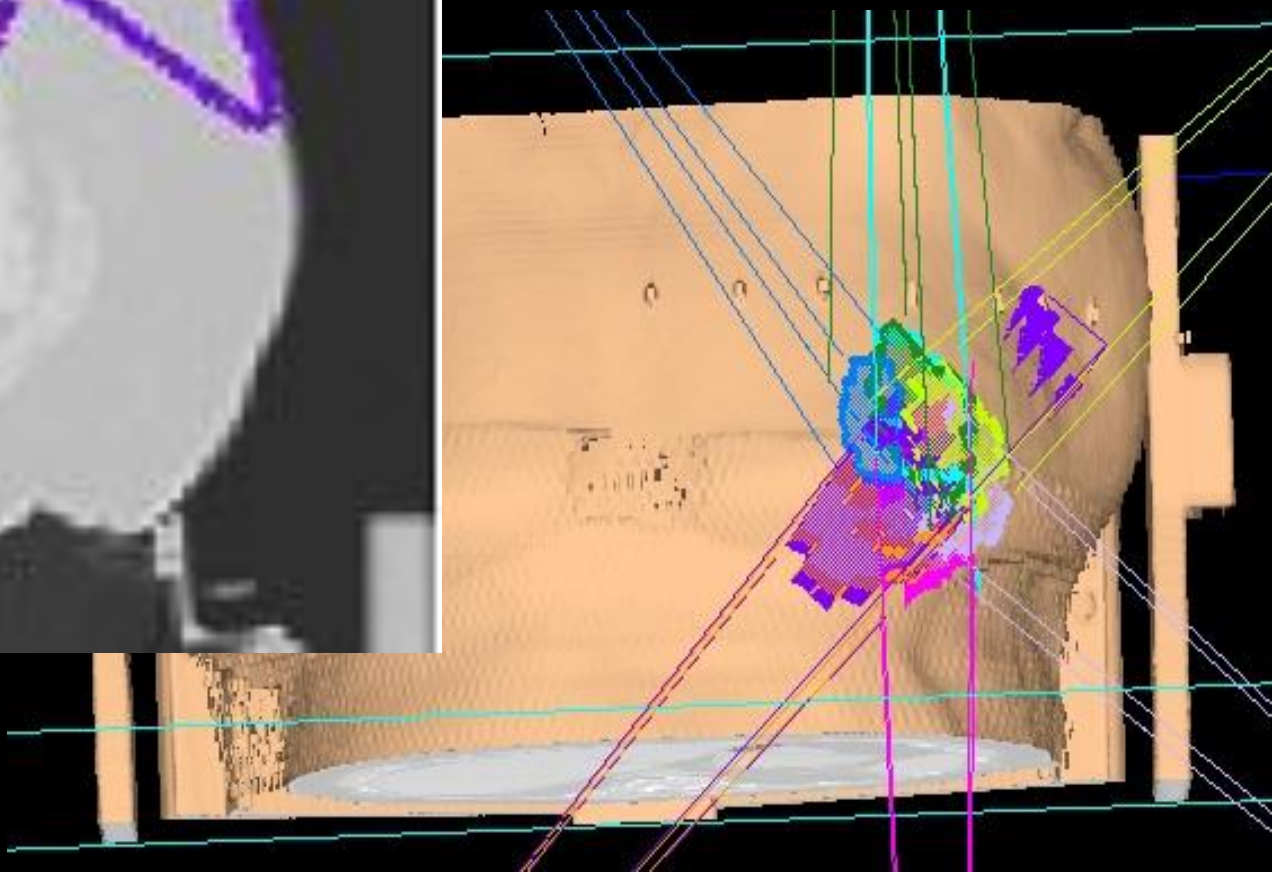
4π
—margen



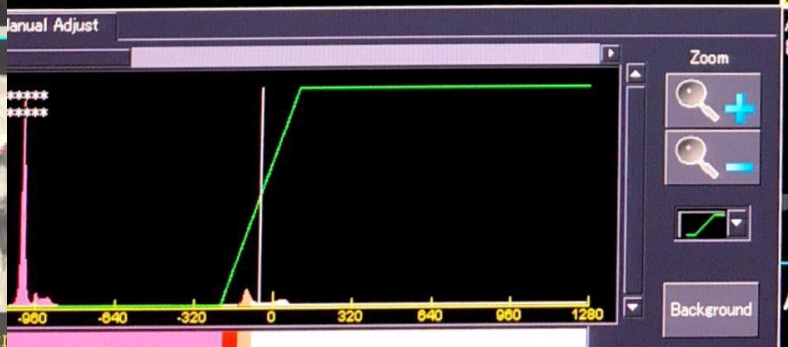
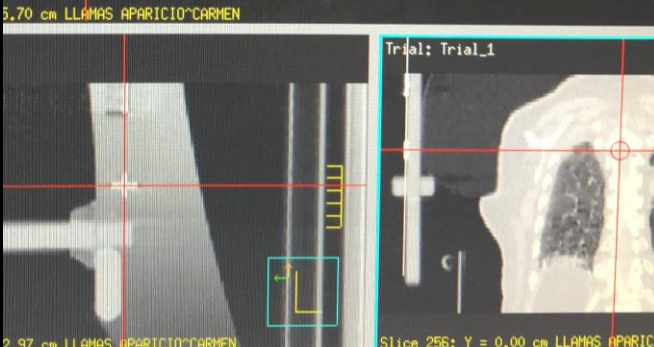
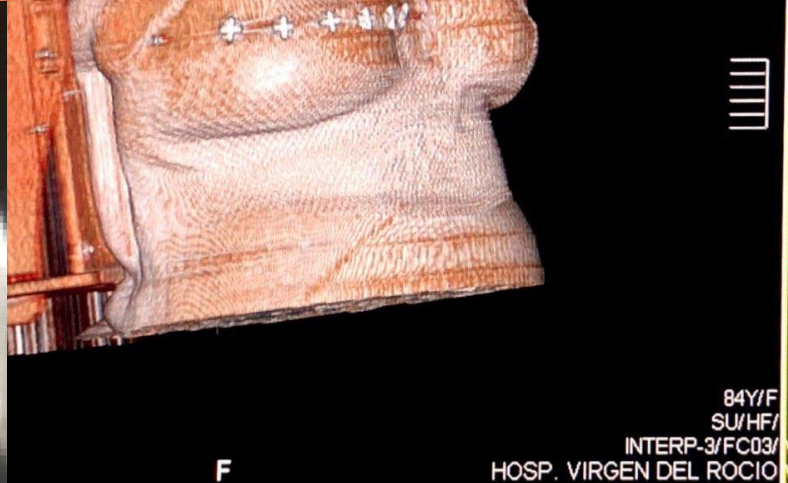


4π

-margen



lateral 1.0 ± 1.8 mm,
longitudinal 0.8 ± 1.4 mm
vertical 1.2 ± 1.7 mm



Level -57 Scanned with CamScanner

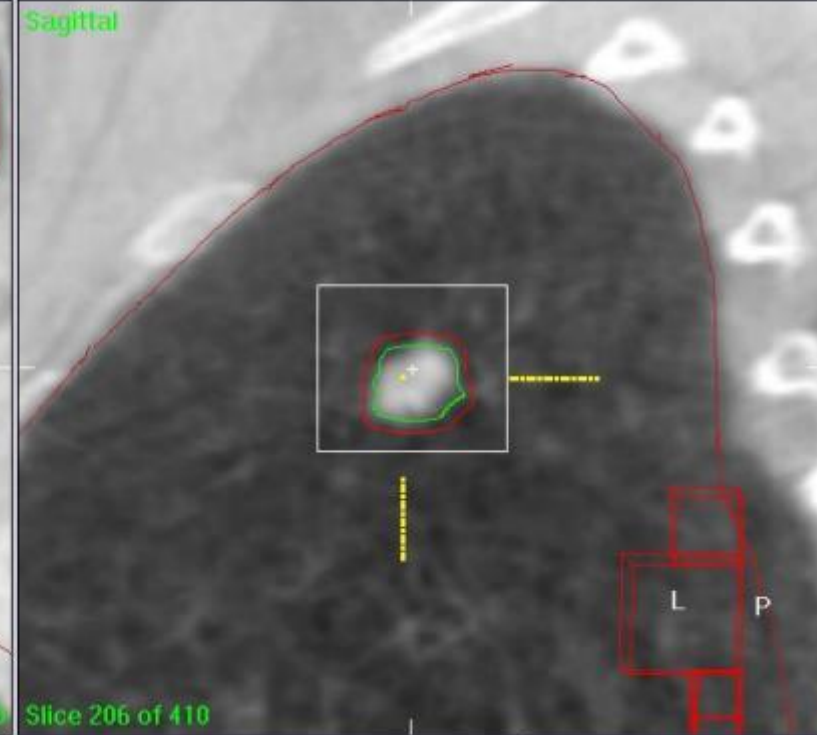
Lower -212

Upper 97



CBCT-FOV 240





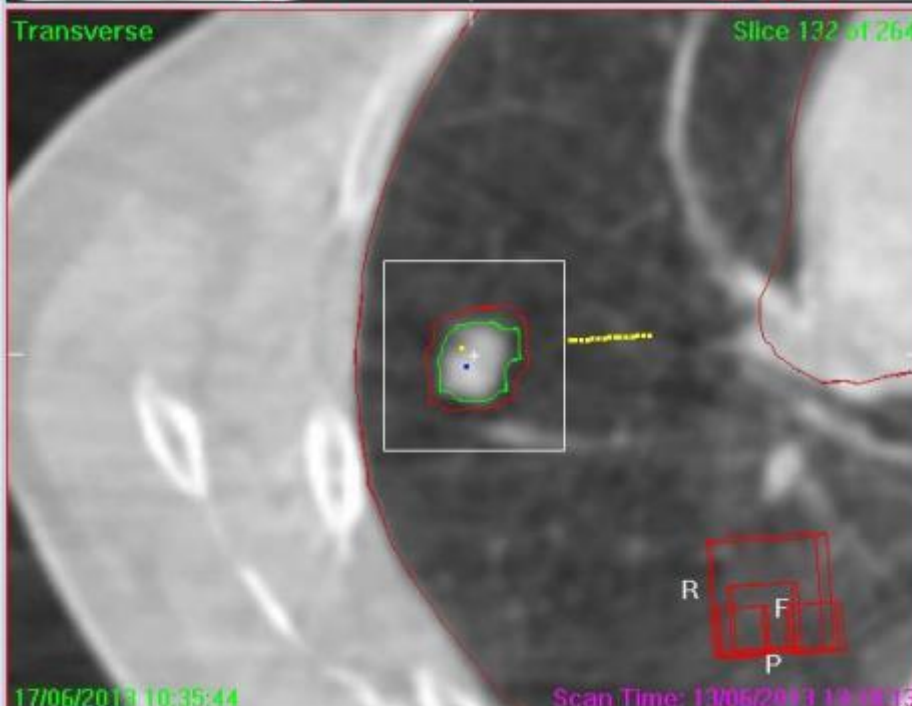
Image

Slice Averaging
none

Display Mode

Localization on

GoTo...



Reference Preset [Cor Ref Point...](#)

Scan

Alignment Clipbox

Structures ..

Alignment

Automatic | Grey value

Reset

Convert To Correction

Position Error

Translation (cm)	Rotation (dg)
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Y: -0.17	Y: 356.4
Z: 0.34	Z: 356.2

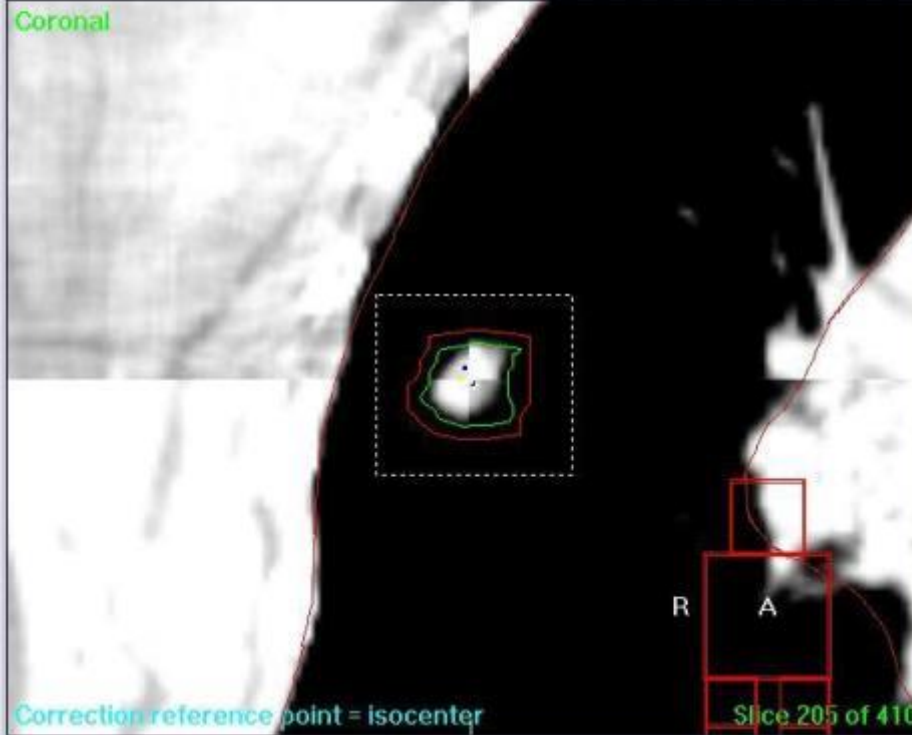
Table Correction (cm)

Lateral	-
Longitudinal	-
Vertical	-

Dismiss

Accept

Coronal

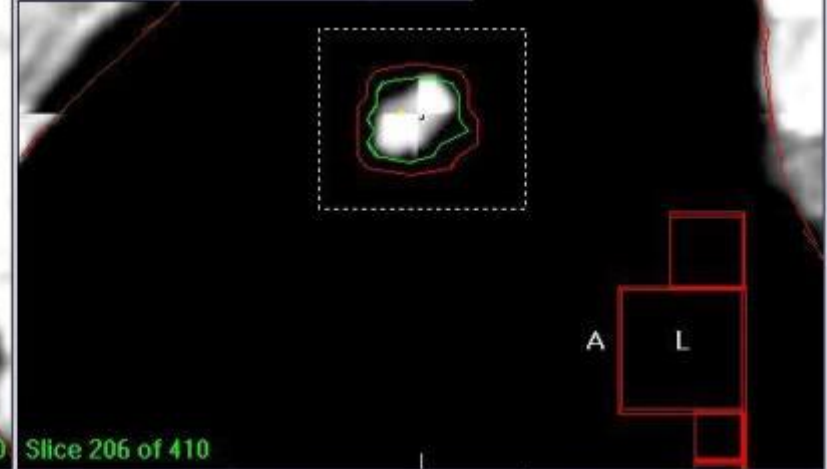


Correction reference point = isocenter

Slice 205 of 410

Display controls [x]

Level Loc	[Slider]	800
Window Loc	[Slider]	200
Slice	[Slider]	206
Zoom	[Slider]	4
Level Ref	[Slider]	800
Window Ref	[Slider]	200



Slice 206 of 410

Image

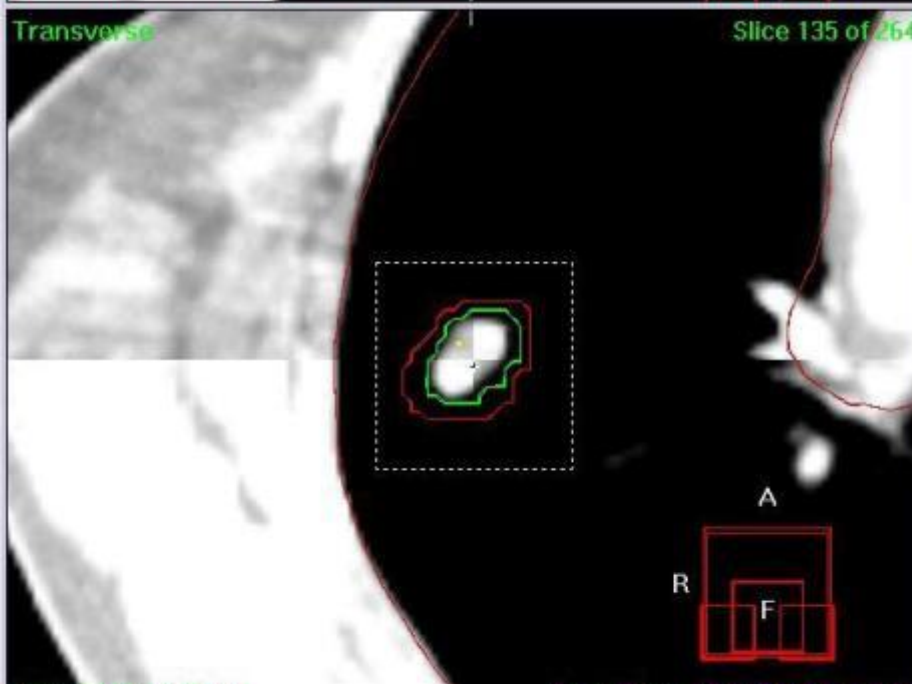
Slice Averaging: none [v]

Display Mode: Cut [v]

[+] [-]

GoTo...

Transverse



Slice 135 of 264

Reference Preset [Cor Ref Point...]

Scan

Alignment Clipbox

Structures...

Alignment

Automatic [v] Grey value [v]

Reset

Convert To Correction

Position Error

Translation (cm)	Rotation (dg)
X: [-0.11]	X: [0.0]
Y: [-0.17]	Y: [0.0]
Z: [0.35]	Z: [0.0]

Table Correction

	(cm)
Lateral	0.11
Longitudinal	0.17
Vertical	-0.35

Dismiss [] Accept []

17/06/2013 10:35:44

Scan Time: 13/06/2013 13:18:13



HUVR



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eXaCradle

eXaPhantom

eXaFrame

eXaSim

eXaSkin

InMold

eXaBreast

eXaEyes

eXaKid

BraquiVirtual

**anatomical
GEOMETRY**



Ideas para llevar a casa de la SBRT-HUVR



- ¡Rápida!
- Realmente estereotáctica
- VMAT compatible
- MRI compatible
- Tórax, abdomen, CC, pelvis
- Sistema altamente personalizable
- Gran potencial para proyectos de investigación conjuntos



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Virgen del Rocío

When a thing was new
people said: **"It's not true"**

Later, when its truth became obvious,
people said:

"Anyway, it's not important"

And when its importance could not be
denied, people said:

"Anyway, it's not new"

