

# Modaliteti i tehnike radioterapije

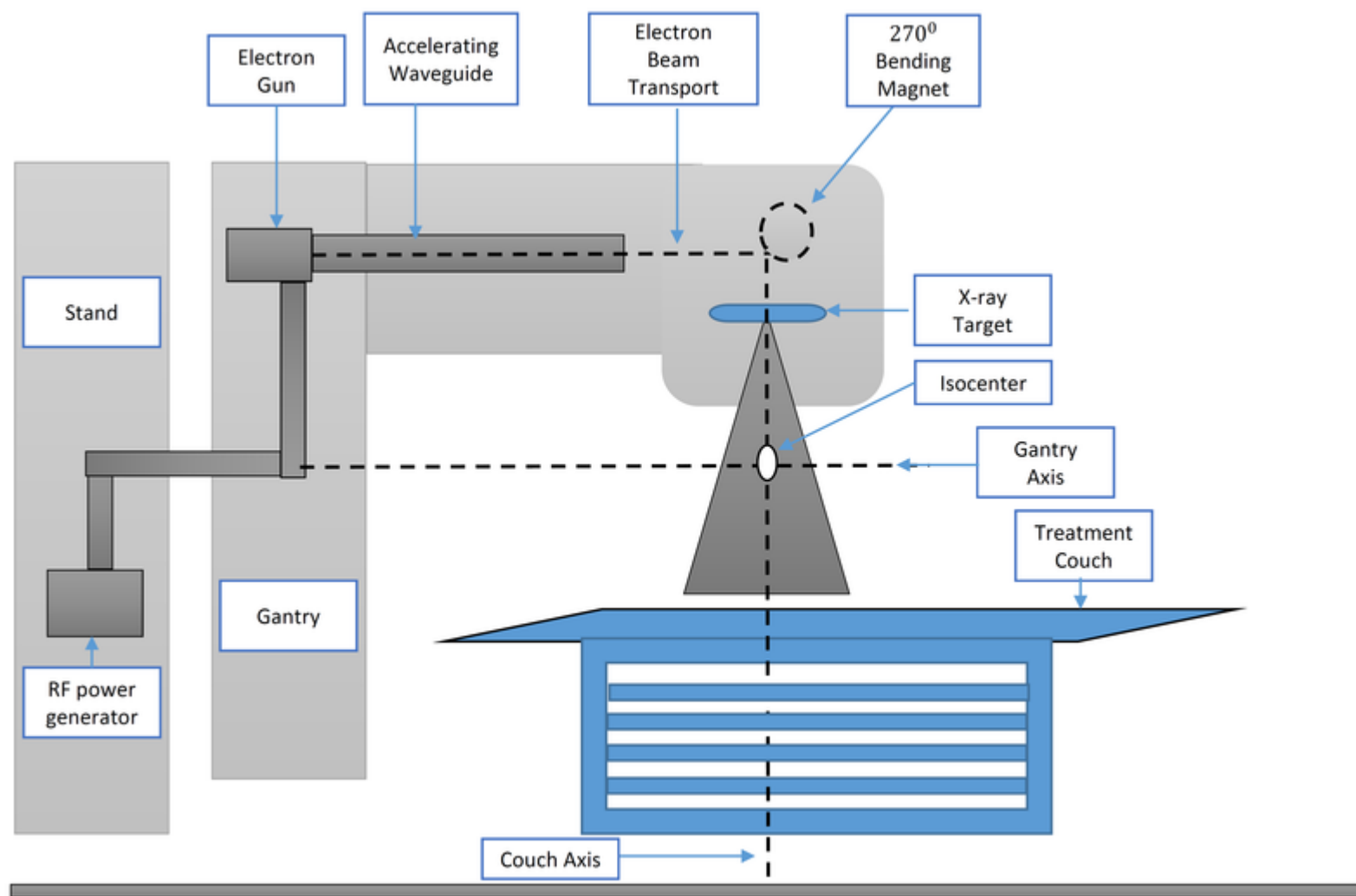


doc dr Neda Milosavljević  
doc dr Marija Živković Radojević

# PODELA RADIOTERAPIJE PREMA UDALJENOSTI IZVORA ZRAČENJA

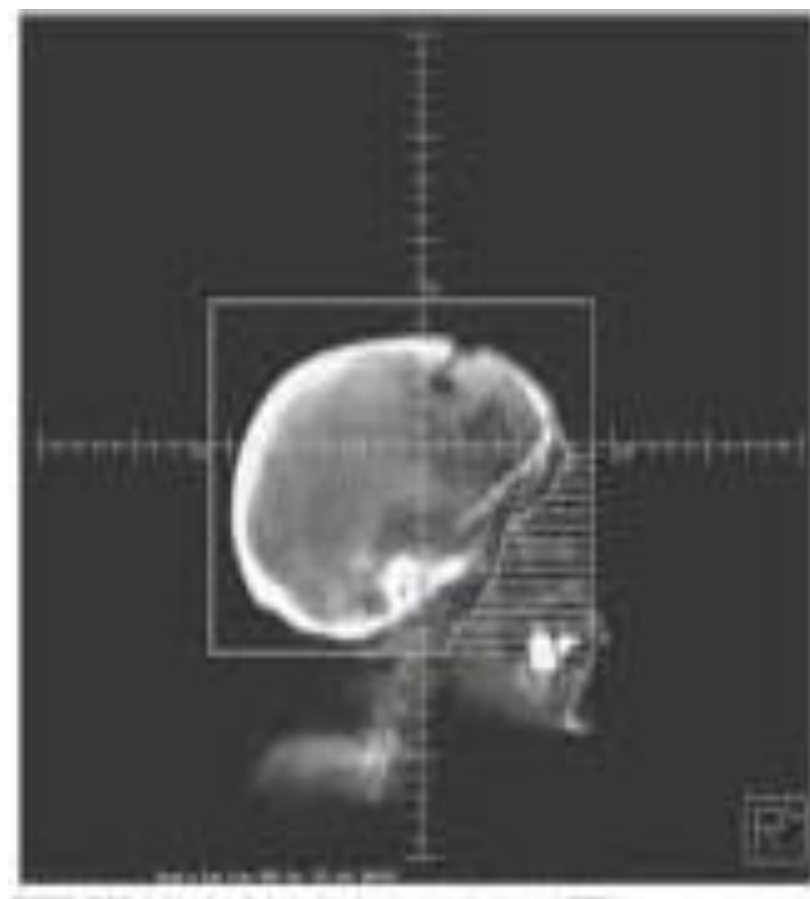
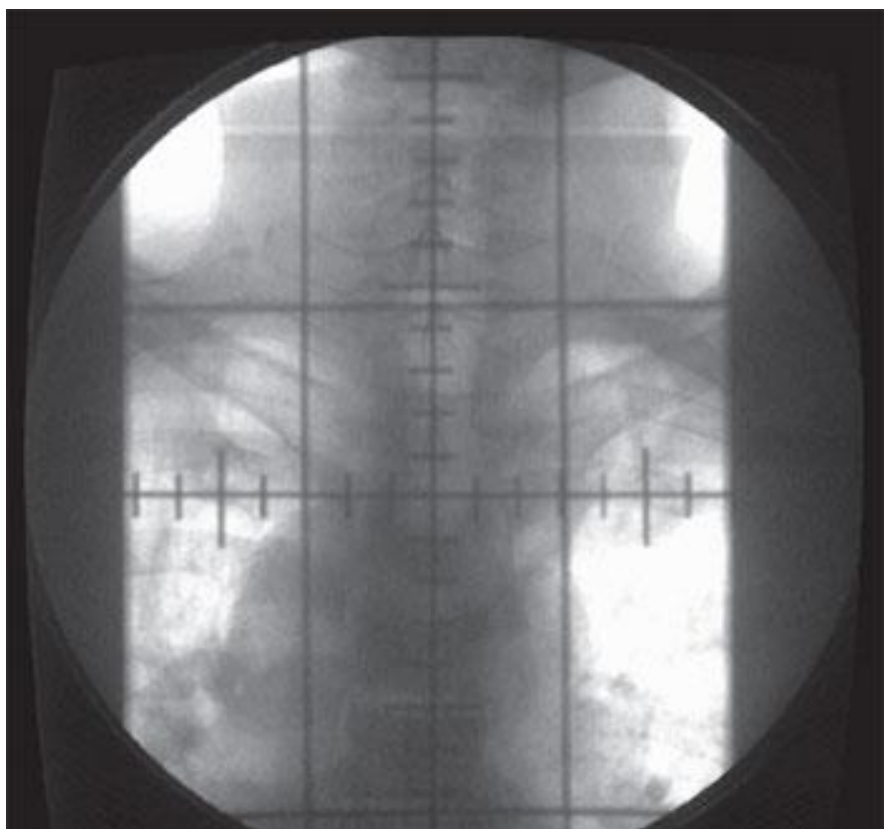
- Sa određene distance od površine tela i/ili tumora (teleradioterapija, transkutana radioterapija)
- Iz neposredne blizine (brahiterapija)

# Radioterapijski aparati – linearni akceleratori



# Ro simulator

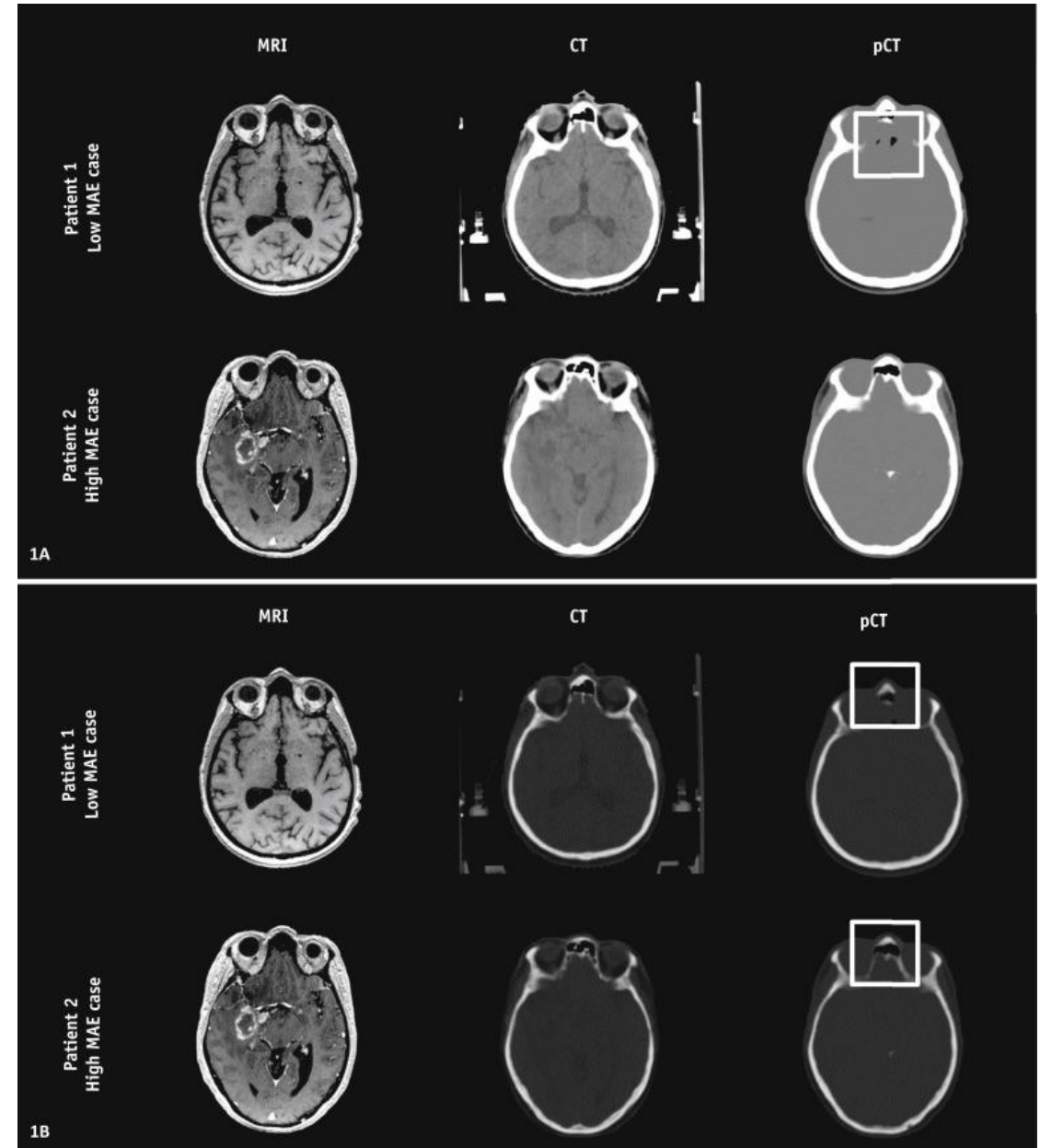




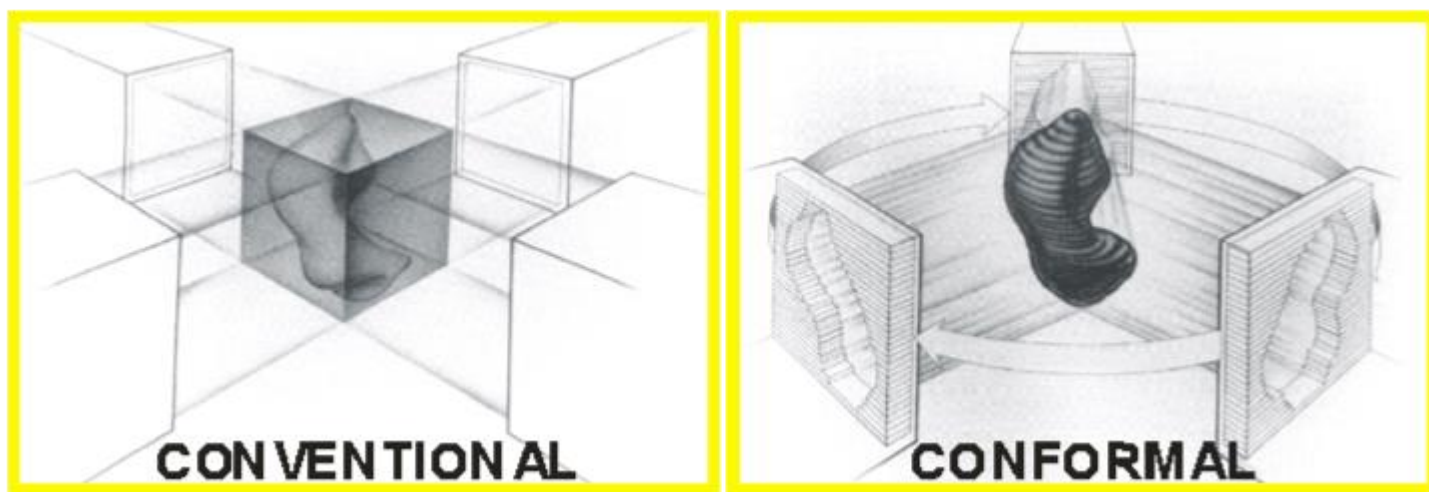
# CT/MR simulator



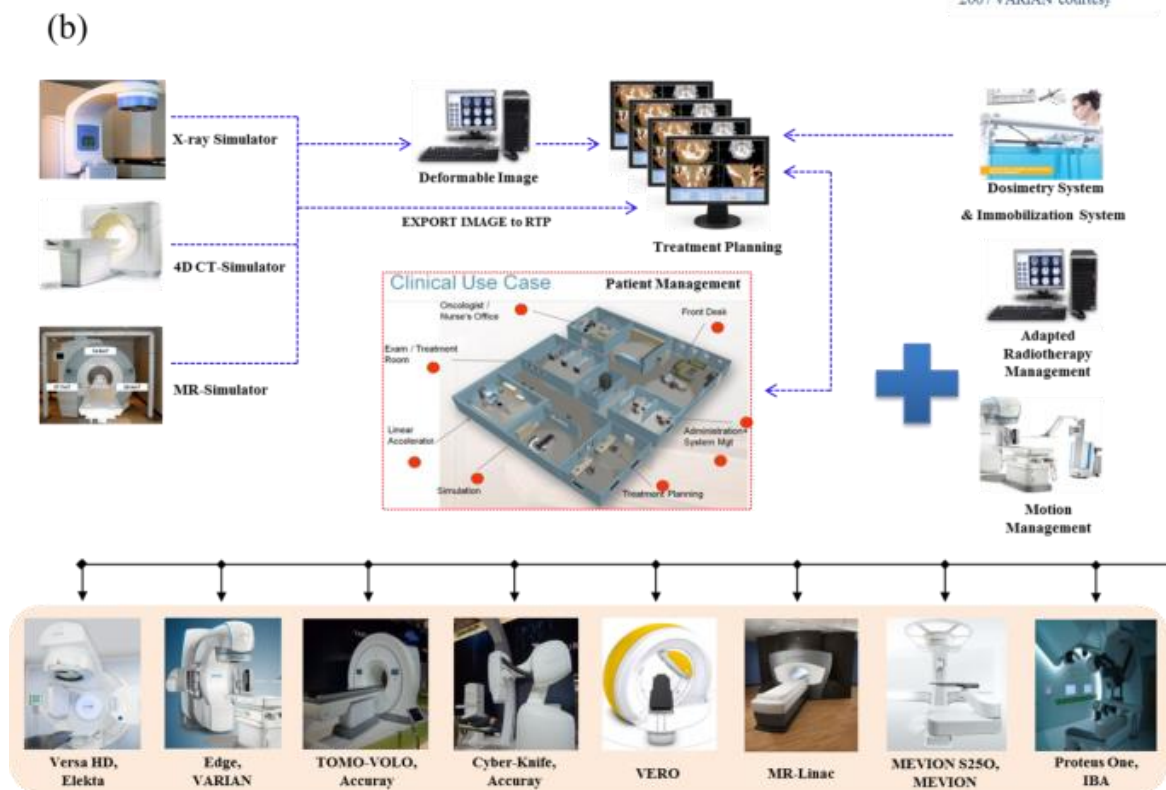
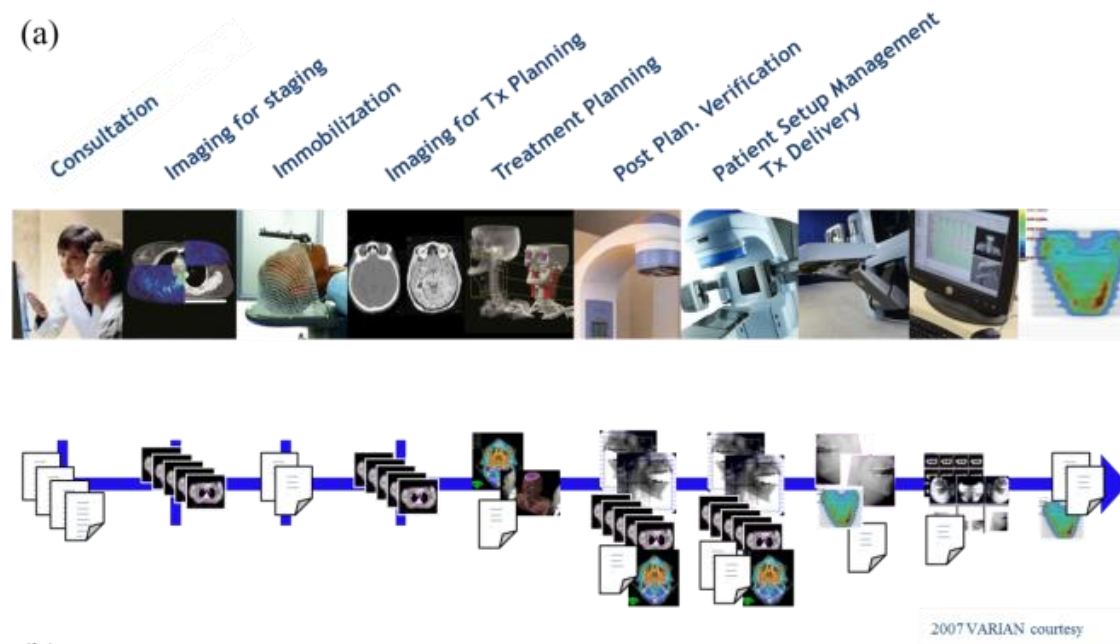
- Andres A. E. Int J of Radiation Oncology, Biology, Physics. , 2020.



# PRECIZNA ISPORUKA MAKSIMALNE RADIOTERAPIJSKE DOZE U TUMORSKOM TKIVU UZ MINIMALNO OŠTEĆENJE OKOLNOG, ZDRAVOG TKIVA

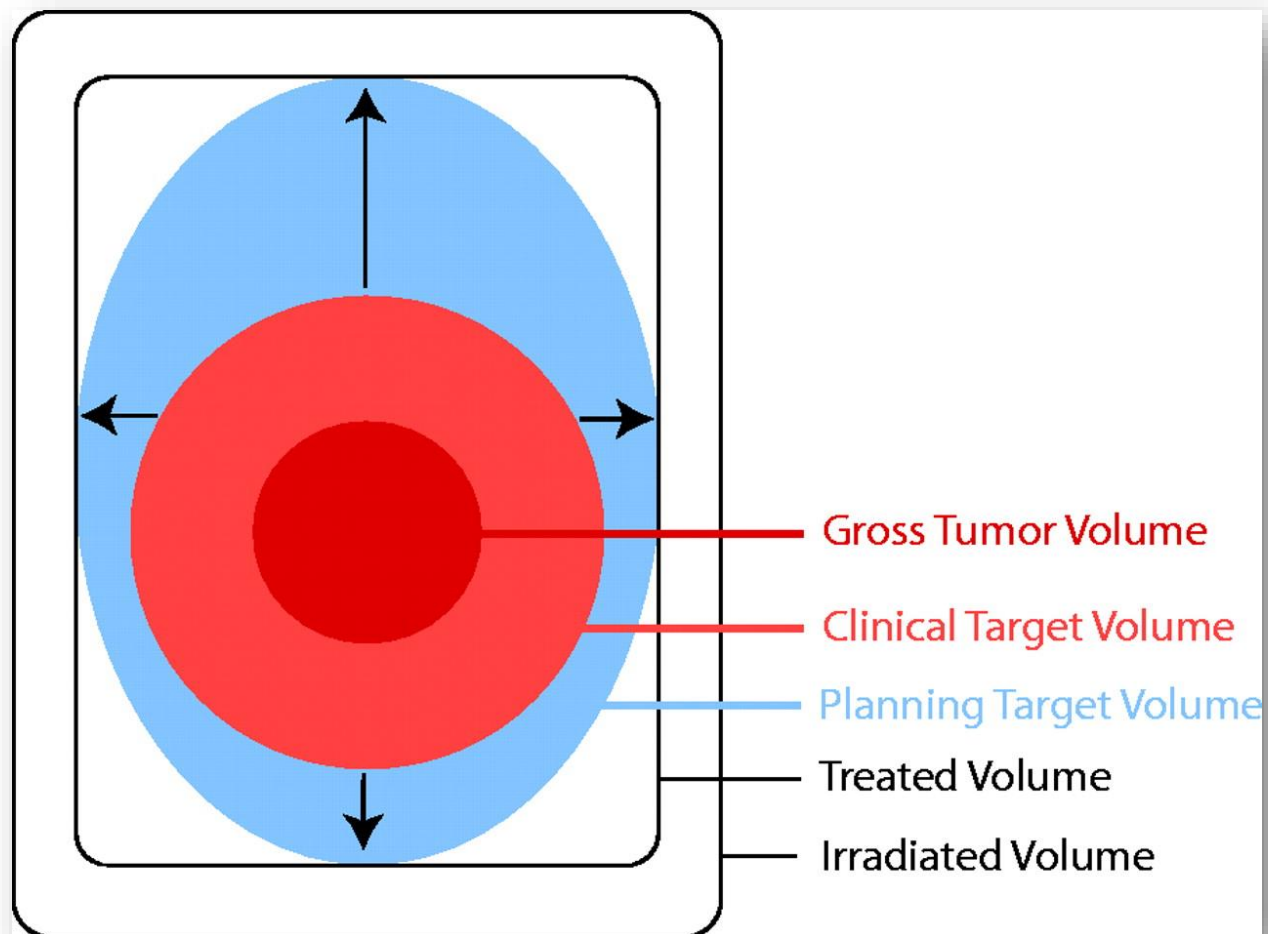






Lee S. 2014.  
Evolution of Ionizing Radiation Research





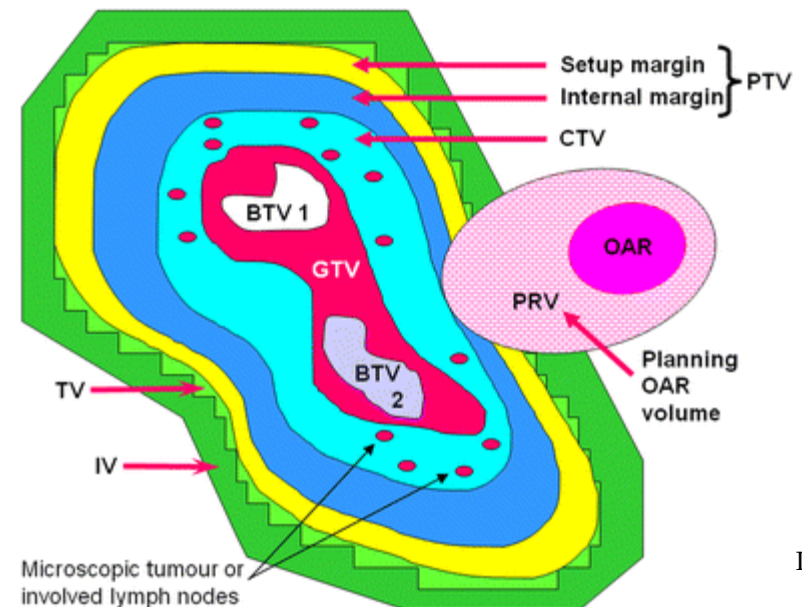
- Konformalna radioterapija (CRT) – počeci 1960.
- Razvoj imaging metoda (CT, MRI, PET), informacione tehnologije, savremeni radioterapijski uređaju - omogućen razvoj CRT
- Lokalna kontrola bolesti u funkciji isporučene doze
- Poštuda okolnih, zdravih tkiva
- Eskalacija doze

# Target volumeni

- Gross Tumor Volume (GTV): vidljivi deo tumora (ili limfnog čvora), Nakon radikalno operisanog tumora (R0 resekcija) GTV nije vidljiv.
- Clinical Target Volume (CTV): obuhvata zonu mikroskopskog širenja malignih ćelija oko vidljivog dela tumora.
- Planning Target Volume (PTV): margina koja pokriva varijacije položaja CTV-a a nastaje zbog: varijacija u preciznosti, fizioloških pokreta.

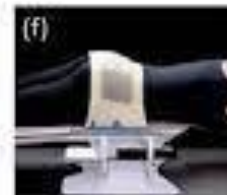
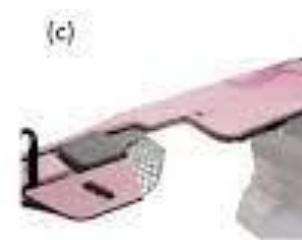
# Organs at Risk (OAR - organi pod rizikom)

- Zdrava, okolna tkiva, o čijoj poštedi/radiosenzitivnosti se vodi računa pri izradi plana zračenja i sprovođenju lečenja radioterapijom
- 3D model „virtuelnog pacijenta“, s volumnim prikazom geometrije ciljnog volumena i prostornih odnosa ciljnog volumena i OAR



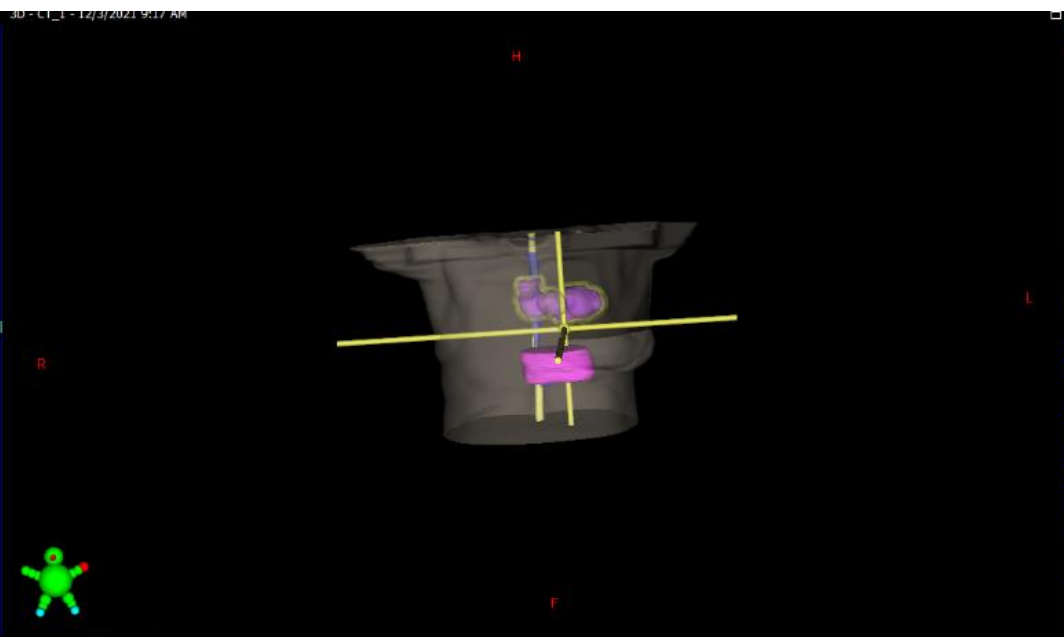
# POZICIONIRANJE I IMOBILIZACIJA PACIJENTA

- Prva odluka u procesu planiranja radioterapije je pozicioniranje
- Zavisi od lokalizacije tumora i imobilizacionih uređaja koji su na raspolaganju
- I više od 30 radioterapijskih frakcija tokom jednog tretmana - bitno adekvatno pozicioniranje i imobilizacija koji treba da omoguće visoku preciznost u sprovođenju planirane RT

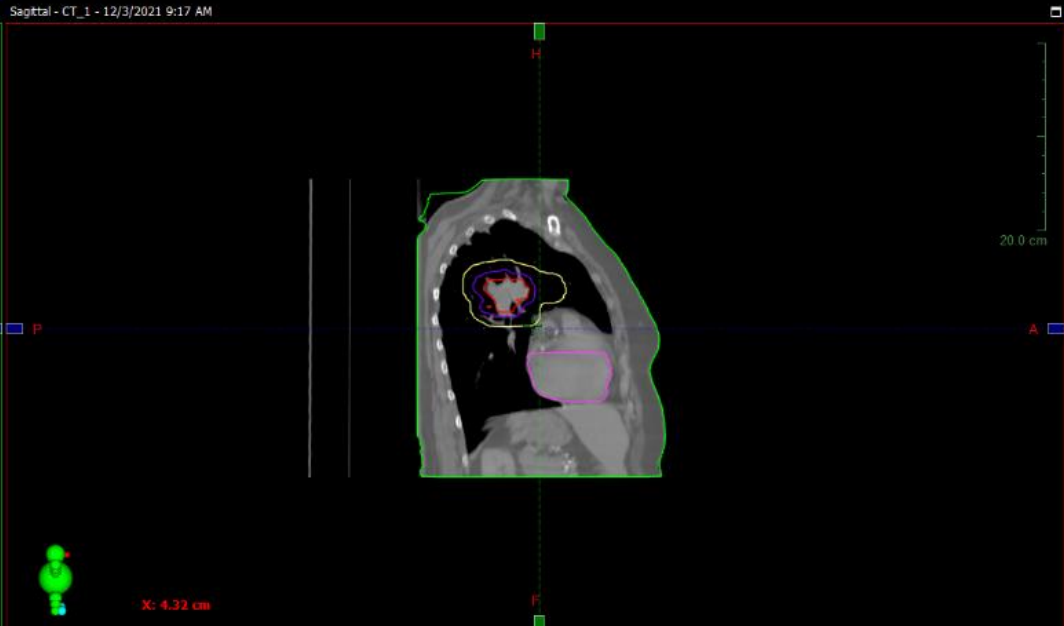


# 3D CRT

- Trodimenzionalna (3D) konformalna radioterapija je precizna tehnika, koja se bazira na trodimenzionalnom volumetrijskom definisanju tumora i okolnih zdravih organa.
- Predstavlja minimum standarda danas
- Koristi se prethodnih 20 godina



- Drawing Tools
- Select Structures
  - Draw Planar Contour
  - Brush
  - Eraser
  - Draw Geometrical Shape
  - Create or Edit Annotation
  - Draw Volumetric Contour
  - Transform Structure
  - Deform Structure
  - PET Subvolume Thresholding
  - Image Thresholding
  - Search Body
  - Segmentation Wizard
  - Flood Fill
  - Margin for Structure
  - Post Processing
  - Extract Wall
  - Crop Structure
  - Boolean Operators
  - Extend Segmentation
  - Interpolate Structure
  - Segment High Density Artifacts
  - Clear Structure
  - Move Marker or Isocenter Marker
  - Edit Reference Points
  - Draw Reference Line
  - Calypso Beacon Detection

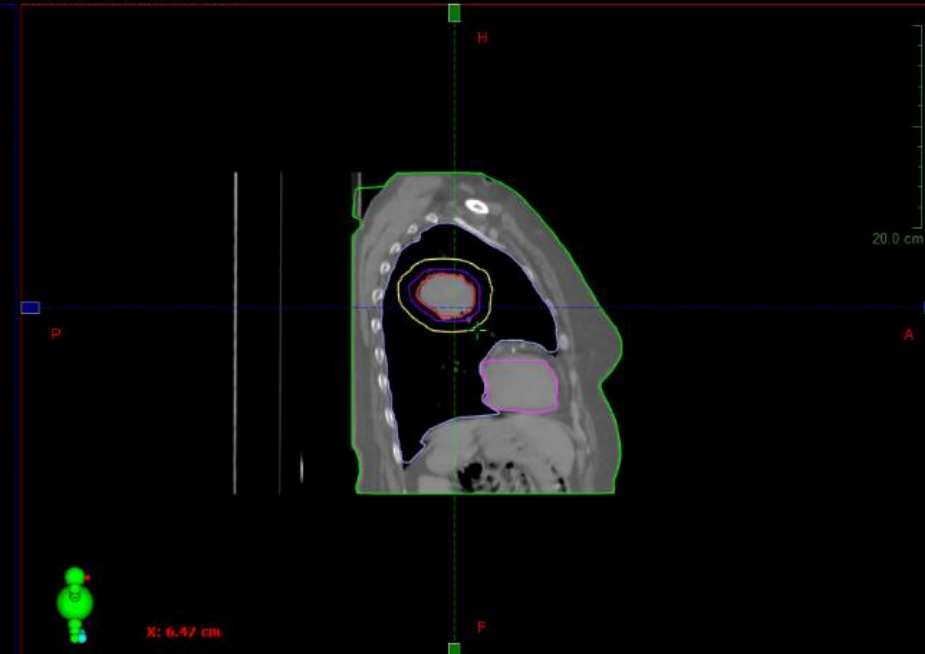




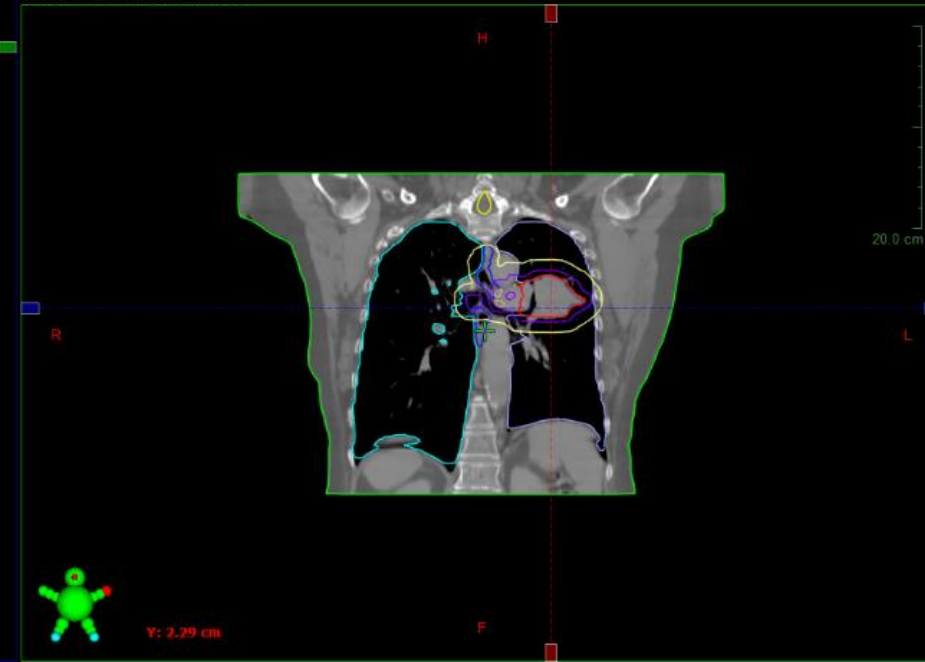
Transversal - CT\_1 - 12/3/2021 9:17 AM

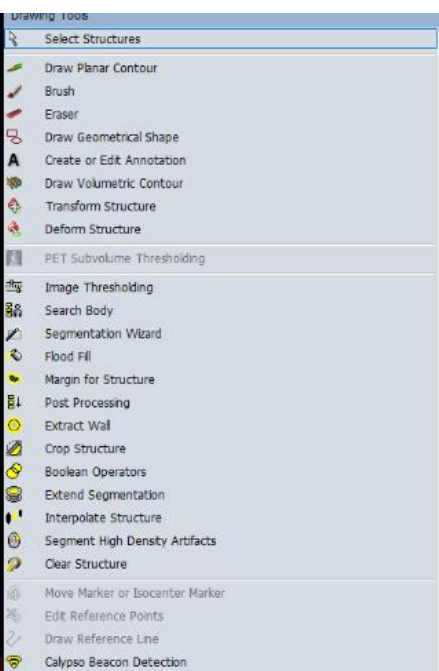
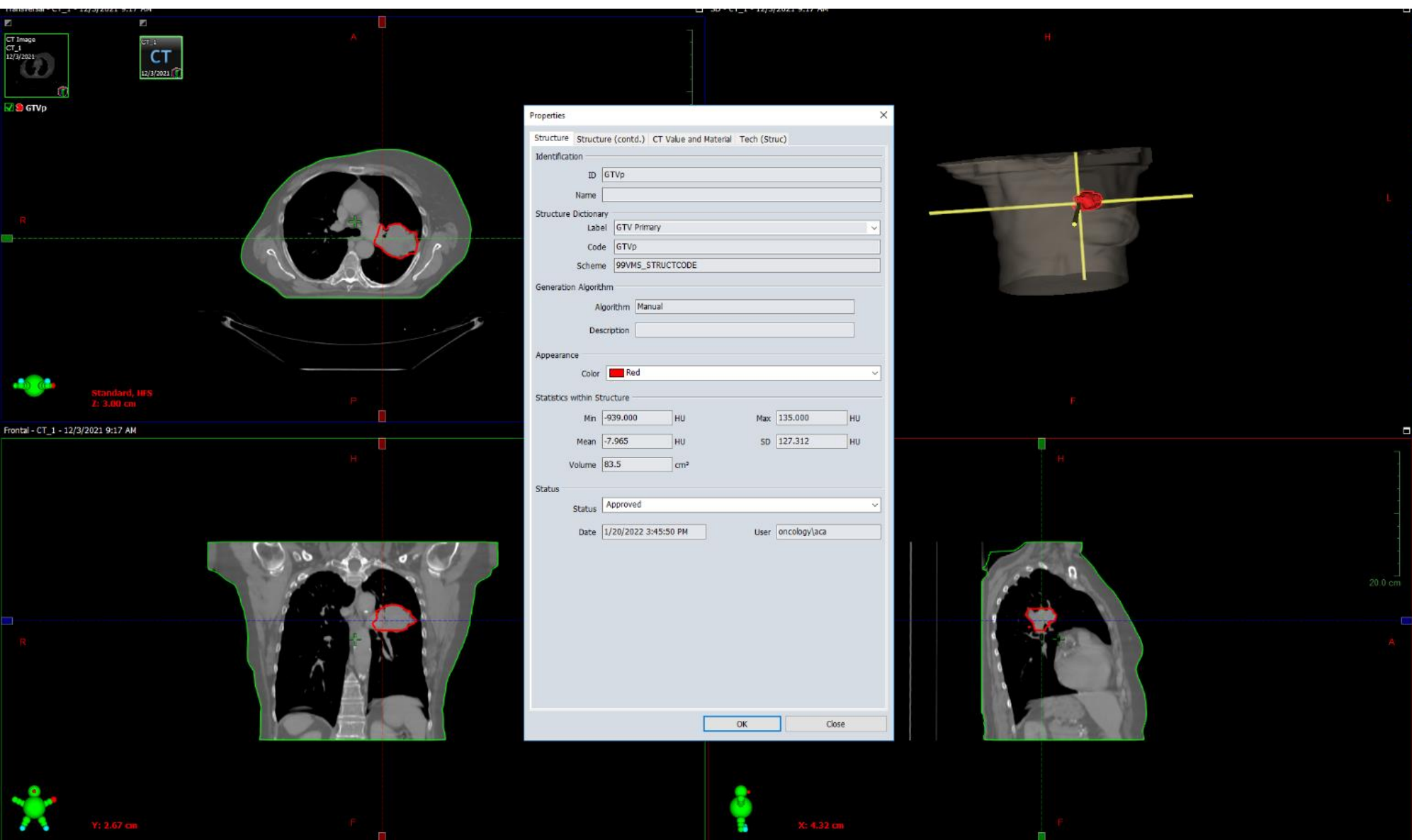


Sagittal - CT\_1 - 12/3/2021 9:17 AM



Frontal - CT\_1 - 12/3/2021 9:17 AM





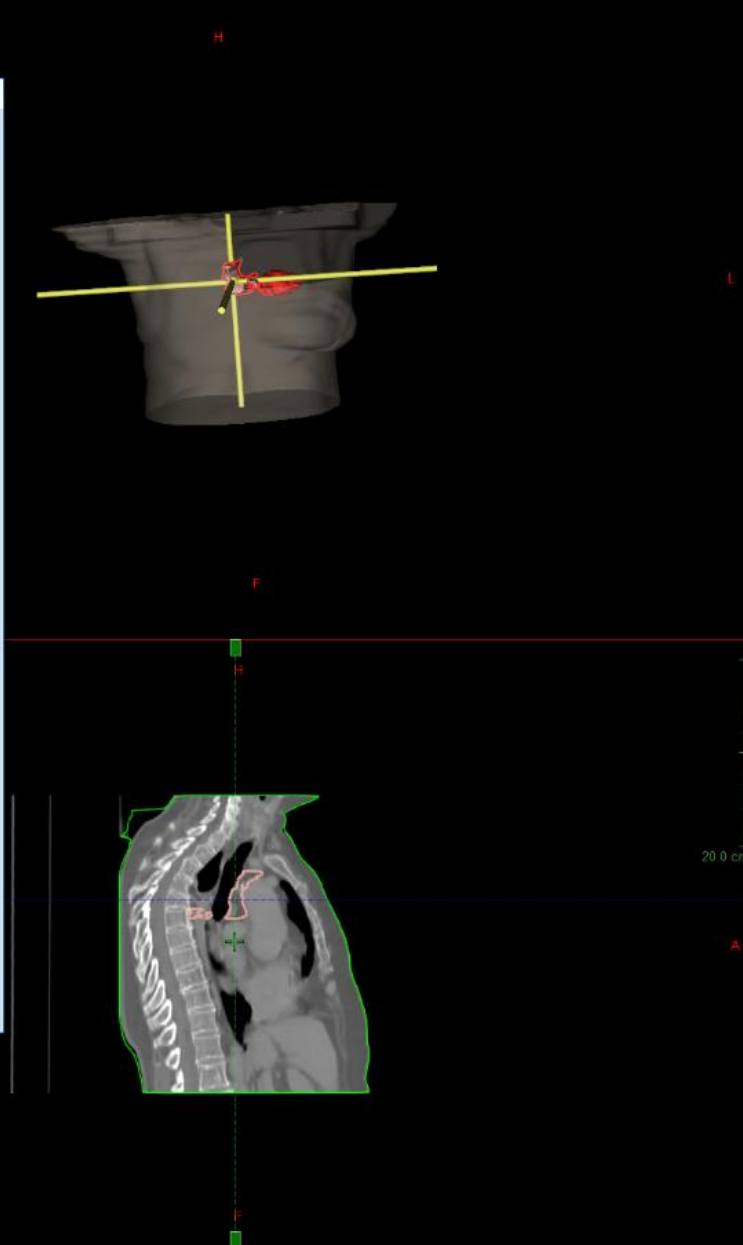
Transversal - CT\_1 - 12/3/2021 9:17 AM



Frontal - CT\_1 - 12/3/2021 9:17 AM



3D - CT\_1 - 12/3/2021 9:17 AM



Properties

Structure Structure (cont.) CT Value and Material Tech (Struc)

Identification

ID gtnv

Name

Structure Dictionary

Label GTV Nodal

Code GTVn

Scheme 99VMS\_STRUCTCODE

Generation Algorithm

Algorithm Manual

Description

Appearance

Color RGB223166159

Statistics within Structure

Min	-885.000	HU	Max	344.000	HU
Mean	-52.123	HU	SD	118.084	HU
Volume	27.3	cm <sup>3</sup>			

Status

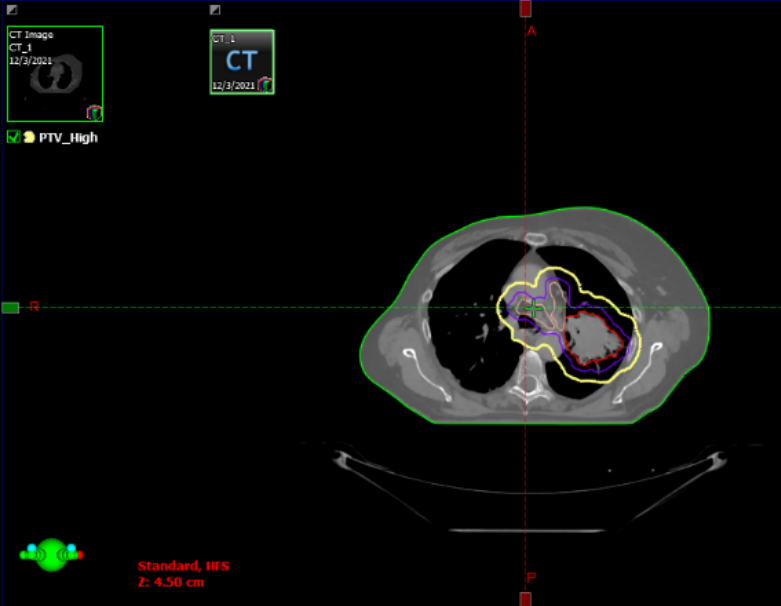
Status Approved

Date 1/20/2022 3:45:50 PM User oncology\aca

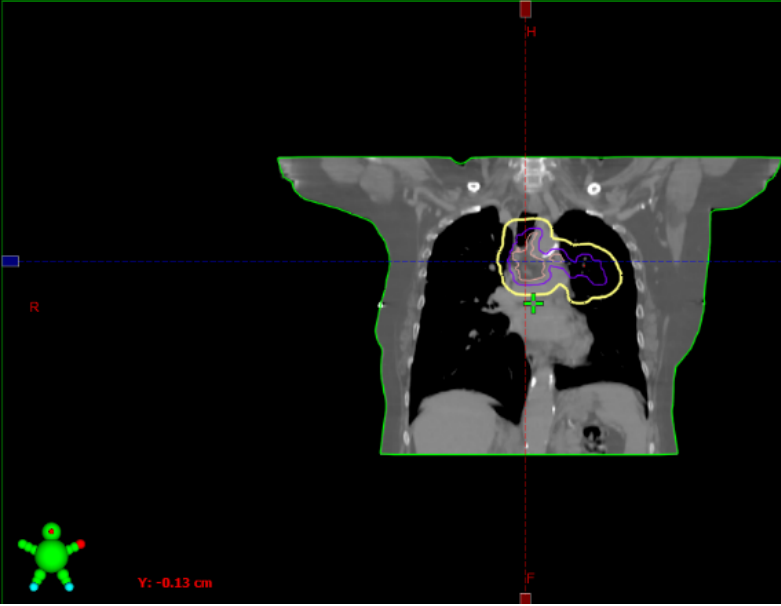
OK Close

- Drawing Tools
- Select Structures
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  - Brush
  - Eraser
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  - Segment High Density Artifacts
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  - Edit Reference Points
  - Draw Reference Line
  - Calypso Beacon Detection

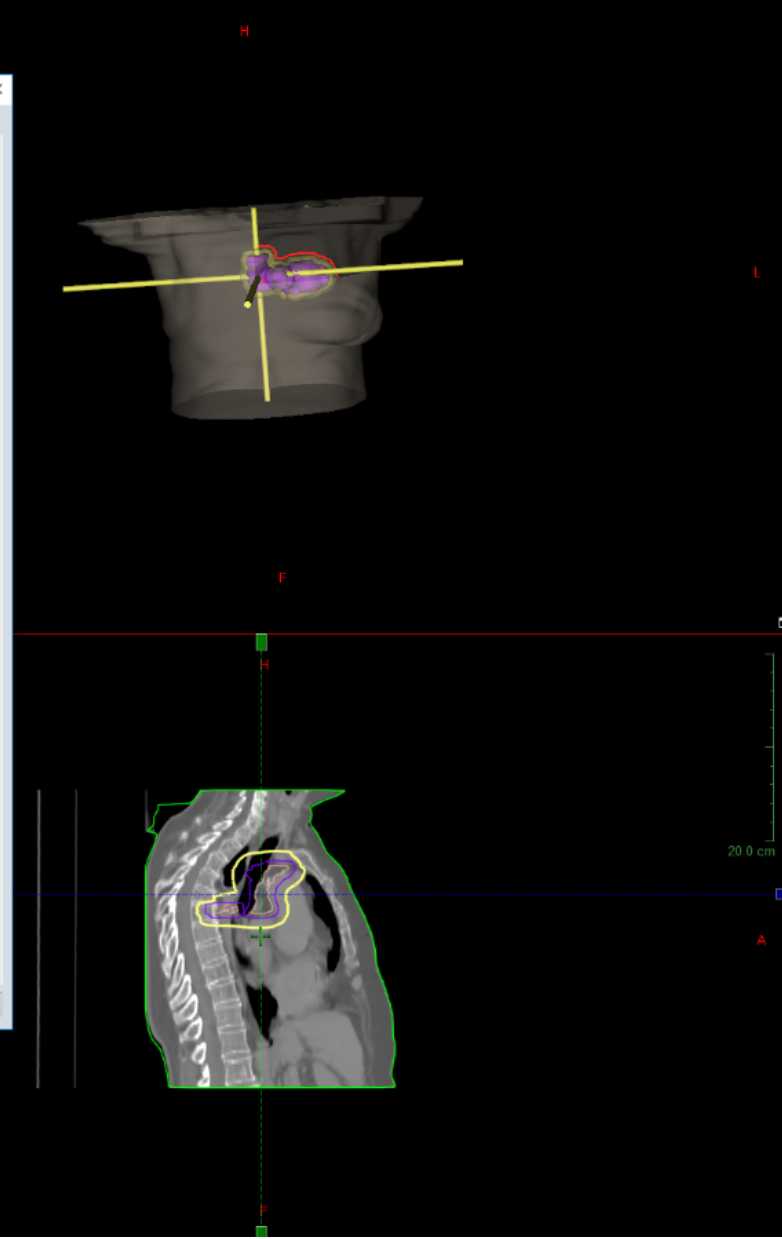
Transversal - CT\_1 - 12/3/2021 9:17 AM



Frontal - CT\_1 - 12/3/2021 9:17 AM



3D - CT\_1 - 12/3/2021 9:17 AM



Properties

Structure (contd.) CT Value and Material Tech (Struc)

Identification

ID PTV\_High

Name

Structure Dictionary

Label PTV High Risk

Code PTV\_High

Scheme 99VMS\_STRUCTCODE

Generation Algorithm

Algorithm Manual

Description

Appearance

Color Translucent : Yellow

Statistics within Structure

Min	-1000.000	HU	Max	1216.000	HU
Mean	-317.710	HU	SD	403.285	HU
Volume	710.4	cm <sup>3</sup>			

Status

Status Approved

Date 1/20/2022 3:45:50 PM

User oncology\aca

OK Close

- Drawing Tools
- Select Structures
  - Draw Planar Contour
  - Brush
  - Eraser
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  - Move Marker or Isocenter Marker
  - Edit Reference Points
  - Draw Reference Line
  - Calypso Beacon Detection



1

1: R0

Plan\_1

Plan\_1

CT\_1

Registered Images

CT\_1

BODY

CouchInterior

CouchSurface

CTV\_High

Esophagus

gtvn

GTVvp

Heart

Lung\_L

Lung\_R

PTV\_High

SpinalCord

User Origin

Reference Points

PTV\_High

Dose

Fields

Isocenter Group I

pi0

pi0-DRR (Live)

pi90

pi270-DRR (Live)

foto

foto-DRR (Live)

48

Field 3-DRR (Live)

MLC

48.0

Field3--DRR (Live)

MLC

79

Field 5-DRR (Live)

MLC

79.0

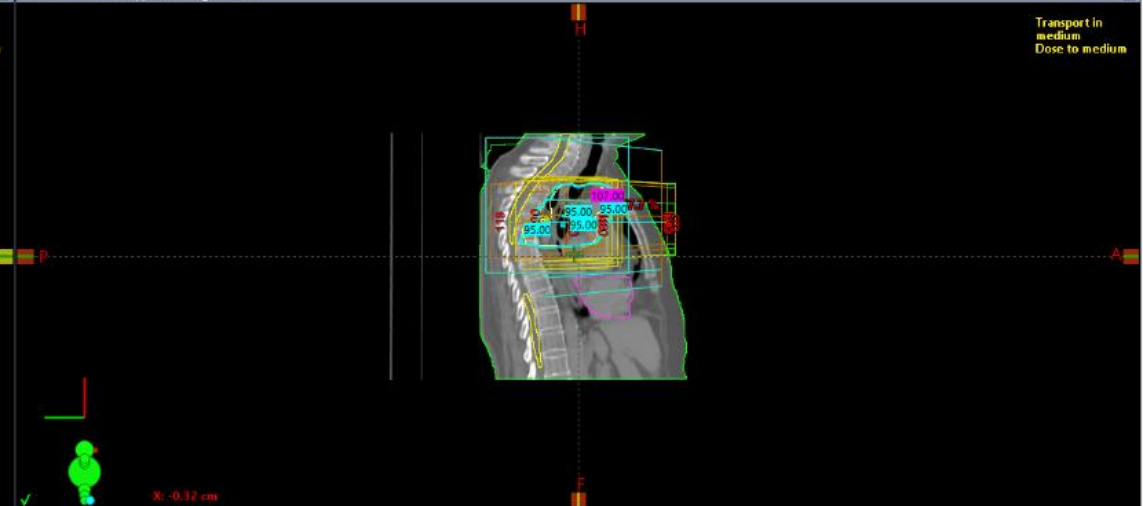
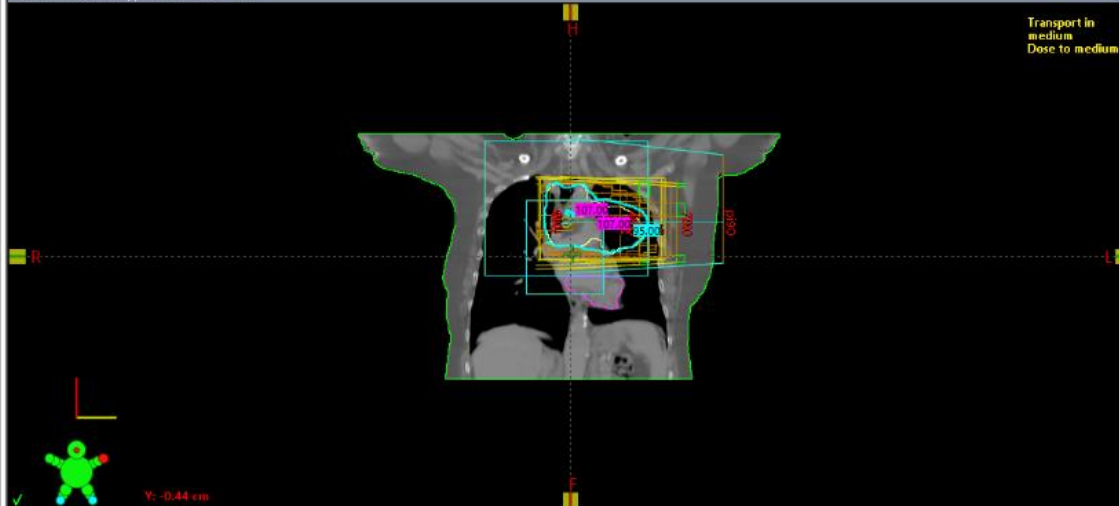
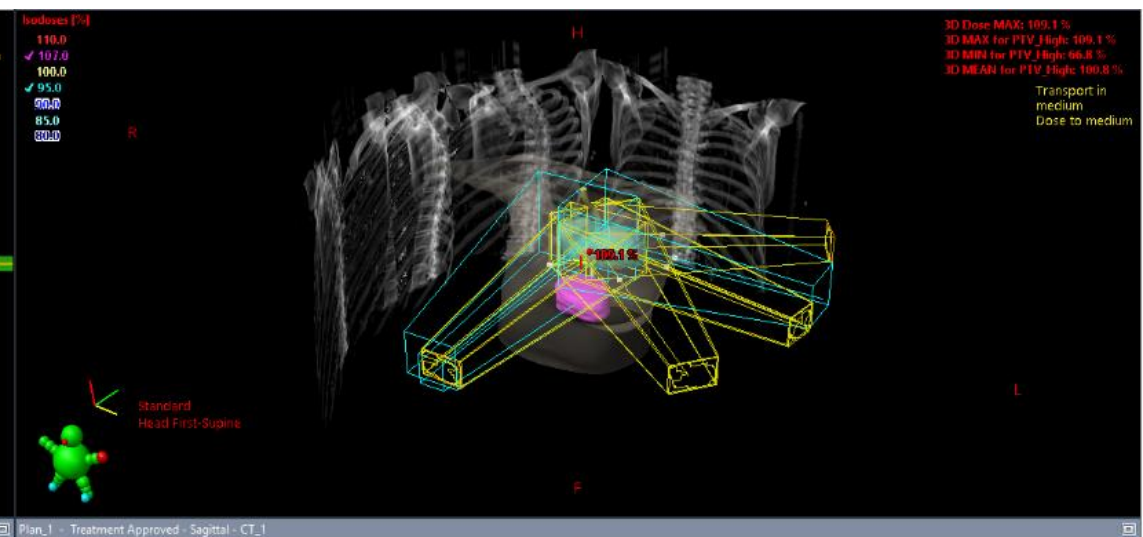
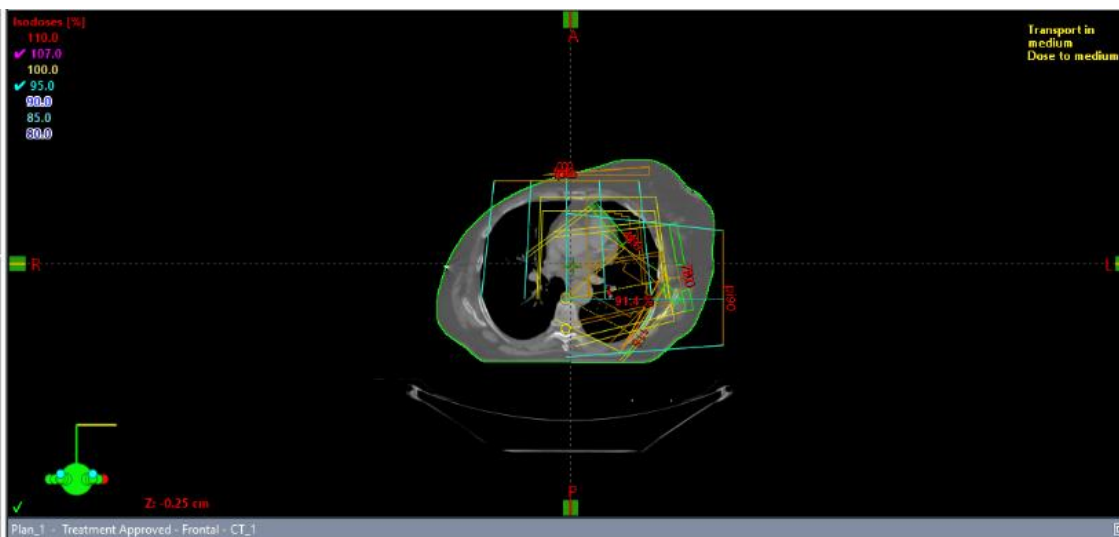
Field 5--DRR (Live)

Fields

Dose

Reference Points

Dose Statistics



Group	Field ID	Technique	Machine/Energy	MLC	Field Weight	Scale	Gantry Angle [deg]	Coll Rtn [deg]	Iso Rtn [deg]	Wedge	Field X [cm]	X1 [cm]	X2 [cm]	Field Y [cm]	Y1 [cm]	Y2 [cm]	X [cm]	Y [cm]	Z [cm]	Calculated SSD [cm]	MU	Ref. D [cGy]
I	pi0	STATIC-I	Elekta3 - 6X		0.000	IEC61217	0.0	0.0	0.0	None	22.0	-11.0	+11.0	18.1	-7.1	+11.0	-0.85	4.05	4.09	85.8		
I	pi90	STATIC-I	Elekta3 - 6X		0.000	IEC61217	90.0	0.0	0.0	None	18.5	-11.0	+7.5	17.5	-6.5	+11.0	-0.85	4.05	4.09	80.8		
I	foto	STATIC-I	Elekta3 - 6X		0.000	IEC61217	0.0	0.0	0.0	None	10.4	-5.4	+5.0	12.6	-9.6	+3.0	-0.85	4.05	4.09	85.8		
I	48	STATIC-I	Elekta3 - 6X	Static	0.419	IEC61217	48.7	0.0	0.0	None	18.3	-7.8	+10.5	11.2	-5.5	+5.7	-0.85	4.05	4.09	81.3	38	56.8
I	48.0	STATIC-I	Elekta3 - 6X	Static	0.081	IEC61217	48.7	0.0	0.0	None	18.2	-7.3	+10.9	12.0	-6.0	+6.0	-0.85	4.05	4.09	81.3	7	11.1
I	79	STATIC-I	Elekta3 - 6X	Static	0.329	IEC61217	79.2	0.0	0.0	None	15.0	-8.8	+6.2	10.5	-5.0	+5.5	-0.85	4.05	4.09	80.1	37	56.4
I	79.0	STATIC-I	Elekta3 - 6X	Static	0.071	IEC61217	79.2	0.0	0.0	None	13.3	-8.1	+5.2	12.0	-6.0	+6.0	-0.85	4.05	4.09	80.1	8	12.6



JOVVER211203

- 1
- R 1: R0
- Plan\_1

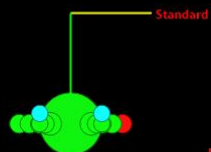
Plan\_1

- CT\_1
  - Registered Images
    - CT\_1
      - BODY
      - CouchInterior
      - CouchSurface
      - CTV\_High
      - Esophagus
      - gtvn
      - GTVp
      - Heart
      - Lung\_L
      - Lung\_R
      - PTV\_High
      - SpinalCord
    - User Origin
  - Reference Points
    - PTV\_High
  - Dose
    - Fields
      - Isocenter Group 1
        - pi0
          - pi0-DRR (Live)
        - pi90
          - pi270-DRR (Live)
        - foto
          - foto-DRR (Live)
        - 48
          - Field 3-DRR (Live)
        - MLC
        - 48.0
          - Field3--DRR (Live)
        - MLC
        - 79
          - Field 5-DRR (Live)
        - MLC

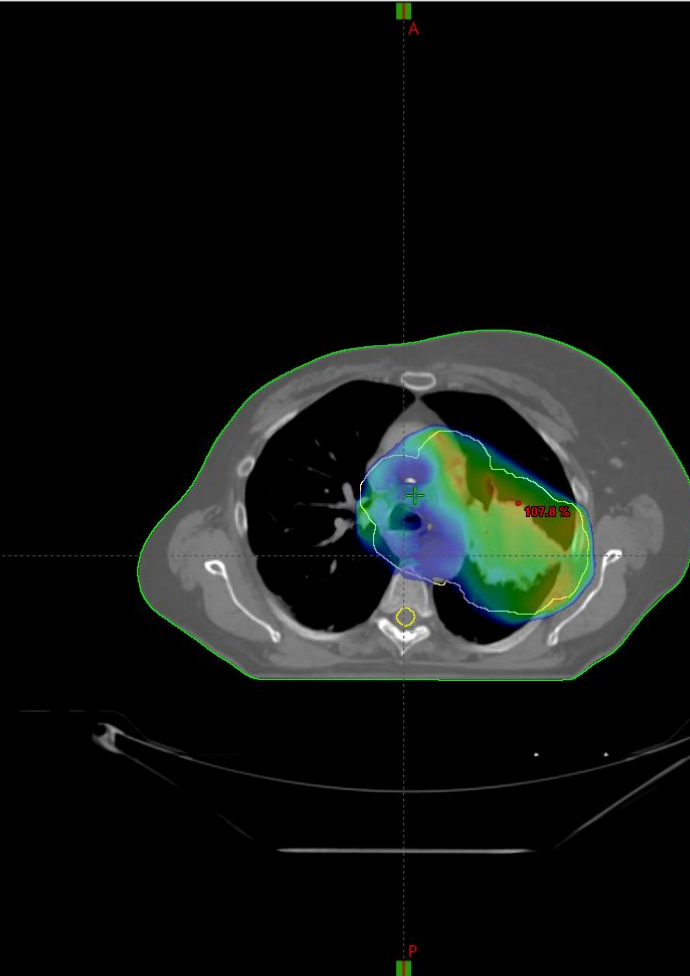
Plan\_1 - Treatment Approved - Transversal - CT\_1

109.1  
108.0  
107.0  
106.0  
105.0  
104.0  
103.0  
102.0  
101.0  
100.0  
99.0  
98.0  
97.0  
96.0  
95.0

R



Head First-Supine  
Z: 4.09 cm

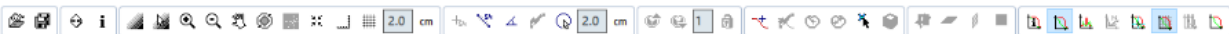


3D Dose MAX: 109.1 %  
3D MAX for PTV\_High: 109.1 %  
3D MIN for PTV\_High: 66.8 %  
3D MEAN for PTV\_High: 100.8 %

Transport in  
medium  
Dose to medium

Fields Dose Reference Points Dose Statistics

Plan ID	Dose per Fraction [cGy]	Number of Fractions	Total Dose [cGy]	Treatment Percentage [%]	Target Volume	Primary Reference Point			Plan Normalization Mode	Plan Normalization Value [%]
						ID	Planned Dose per Fraction [cGy]	Planned Total Dose [cGy]		
Plan_1	200.0	32	6400.0	100.00	PTV_High	PTV_High	200.0	6400.0	95.00% covers 95.00% of Target Volume	319.5



JOVVER211203

- 1
- 1 : R0
- Plan\_1

Plan\_1

- CT\_1
  - Registered Images
    - CT\_1
      - BODY
      - CouchInterior
      - CouchSurface
      - CTV\_High
      - Esophagus
      - gtvn
      - GTVP
      - Heart
      - Lung\_L
      - Lung\_R
      - PTV\_High
      - SpinalCord
      - User Origin
- Reference Points
  - PTV\_High
- Dose
- Fields
  - Isocenter Group I
    - pi0
      - pi0-DRR (Live)
    - pi90
      - pi270-DRR (Live)
    - foto
      - foto-DRR (Live)
    - 48
      - Field 3-DRR (Live)
    - MLC
    - 48.0
      - Field3--DRR (Live)
    - MLC
    - 79
      - Field 4.5-DRR (Live)

Dose Volume Histogram



Dose Reference Points Dose Statistics

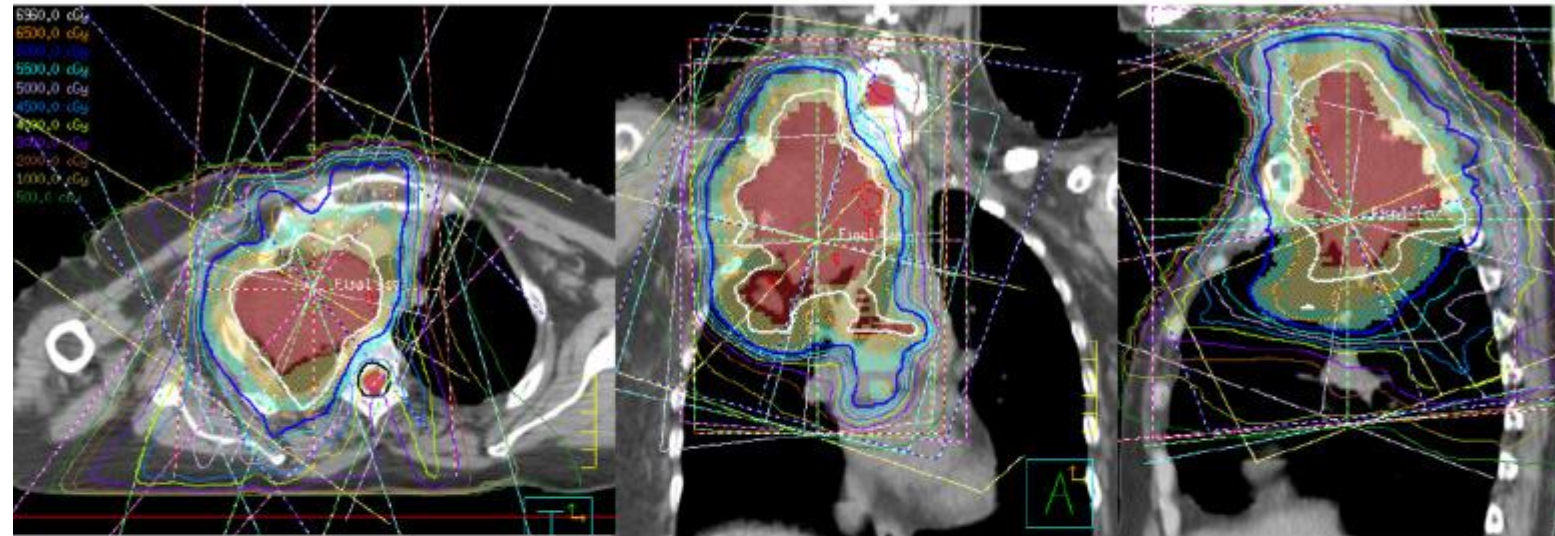
Show DVH	Structure	Approval Status	Plan	Course	Volume [cm <sup>3</sup> ]	Dose Cover [%]	Sampling Cover [%]	Min Dose [cGy]	Max Dose [cGy]	Mean Dose [cGy]	D5985.0% [%]	V95.0 [%]	V107.0 [%]	V107.0% [cm <sup>3</sup> ]	V5320.0cGy [%]	V5985.0cGy [%]	V5992.0cGy [%]	V6650.0cGy [%]
<input checked="" type="checkbox"/>	Lung_L	Approved	Plan_1	1	1720.1	100.0	100.0	35.3	6944.9	2876.0	0.0	18.6	0.1	1.3180	29.5	20.1	20.0	4.8
<input checked="" type="checkbox"/>	Lung_R	Approved	Plan_1	1	2523.3	100.0	100.0	43.2	6773.6	1331.9	0.0	1.9	0.0	0.0000	3.8	2.2	2.2	0.0
<input checked="" type="checkbox"/>	BODY	Approved	Plan_1	1	21699.8	100.0	100.2	1.0	6984.6	1137.3	0.0	4.1	0.0	6.6403	6.1	4.4	4.4	0.9
<input checked="" type="checkbox"/>	Esophagus	Approved	Plan_1	1	29.0	100.2	100.1	100.1	6723.9	3170.9	0.0	38.3	0.0	0.0000	41.8	39.3	39.3	0.1
<input checked="" type="checkbox"/>	SpinalCord	Approved	Plan_1	1	37.9	100.0	99.4	6.3	4685.6	1195.3	0.0	0.0	0.0	0.0000	0.0	0.0	0.0	0.0
<input checked="" type="checkbox"/>	Heart	Approved	Plan_1	1	363.5	100.0	100.0	101.0	535.7	232.4	0.0	0.0	0.0	0.0000	0.0	0.0	0.0	0.0
<input checked="" type="checkbox"/>	GTVP	Approved	Plan_1	1	83.5	100.0	100.0	6054.7	6944.7	6621.3	0.0	100.0	0.7	0.5707	100.0	100.0	100.0	44.8
<input checked="" type="checkbox"/>	gtvn	Approved	Plan_1	1	27.3	100.0	100.0	5954.0	6984.6	6366.0	0.0	96.5	0.6	0.1578	100.0	100.0	99.9	12.1
<input checked="" type="checkbox"/>	CTV_High	Approved	Plan_1	1	277.0	100.0	100.0	5604.9	6984.6	6523.2	0.0	99.0	0.6	1.7779	100.0	99.9	99.9	34.2
<input checked="" type="checkbox"/>	PTV_High	Approved	Plan_1	1	710.4	100.0	100.0	4273.5	6984.6	6453.5	0.0	95.0	0.6	4.2090	99.9	97.0	96.9	24.3
<input checked="" type="checkbox"/>	= (Lung_L OR Lung_R) S...	Approved	Plan_1	1	3946.6	100.0	100.0	35.3	6857.6	1619.8	1.5	1.5	1.5	1.#QNB	1.5	1.5	1.5	1.5



# INTENSITY MODULATED RADIATION THERAPY - IMRT

- Konformalna radioterapijska tehnika – eskalacija doze na jasno definisani ciljni volumen i strm gradijent doze prema kritičnim strukturama
- Moguće je da u okviru volumena (tumora) doza varira (nije homogena).
- Zasniva se na primeni više zračnih polja, podeljenih u segmentna polja

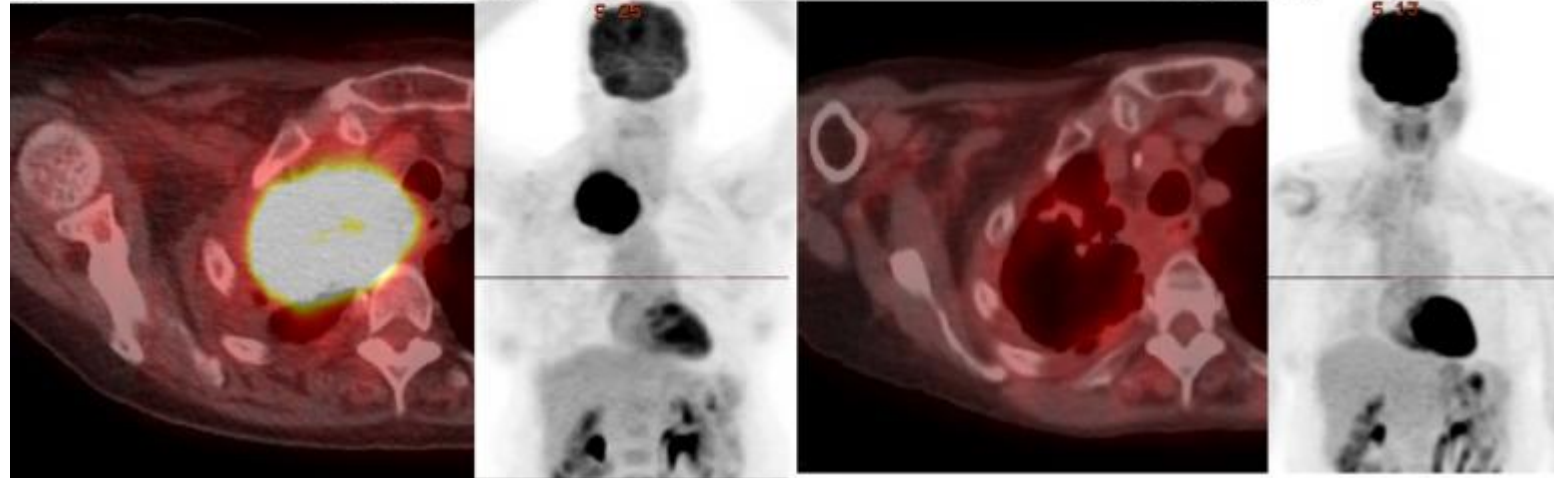
A.

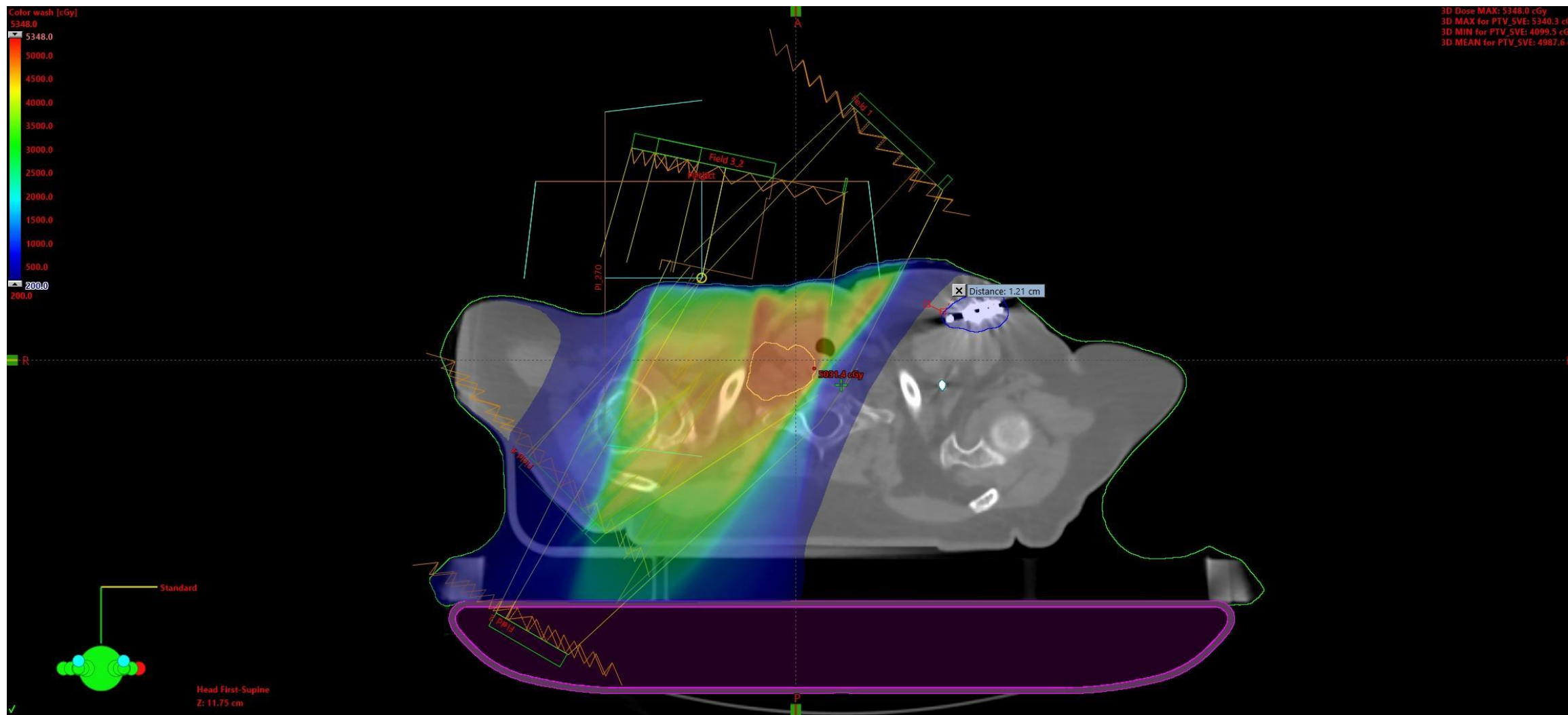


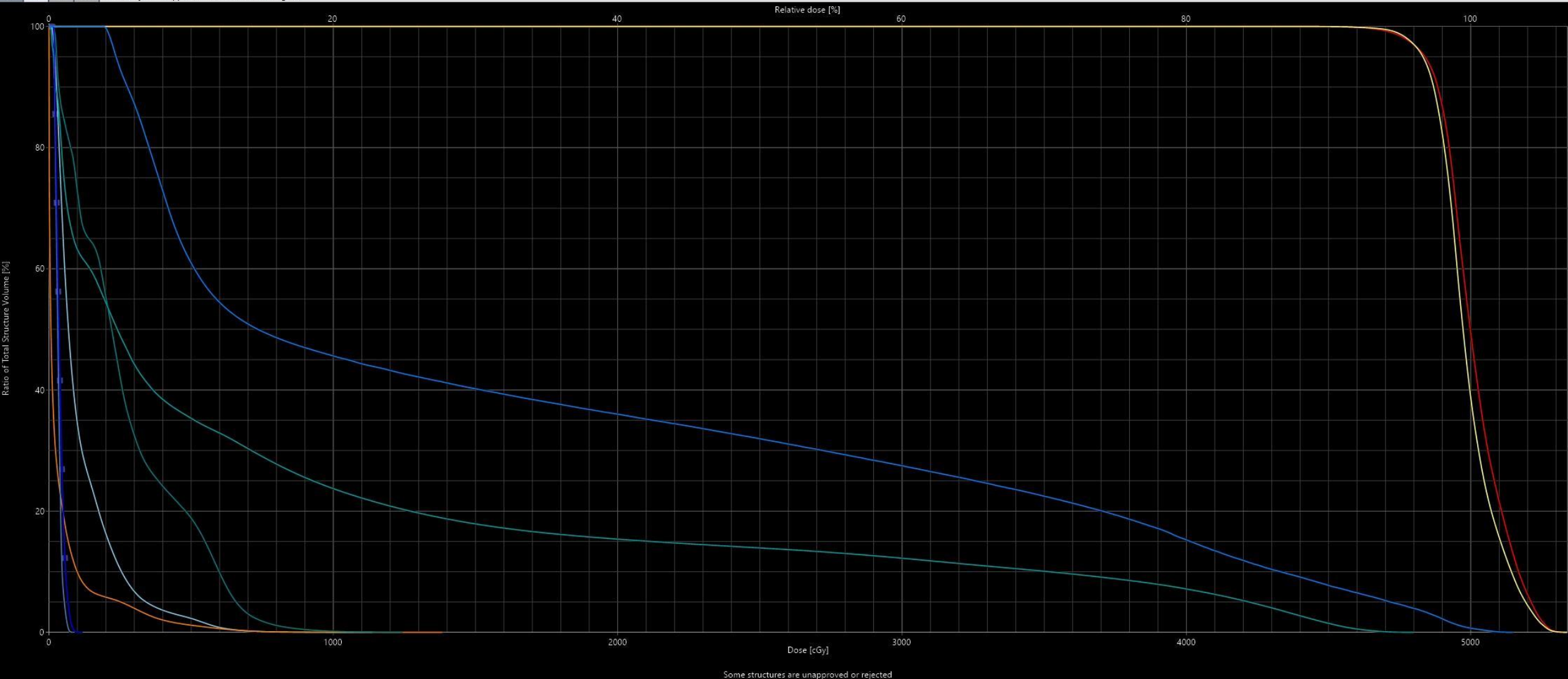
B.

Before IMRT

After IMRT





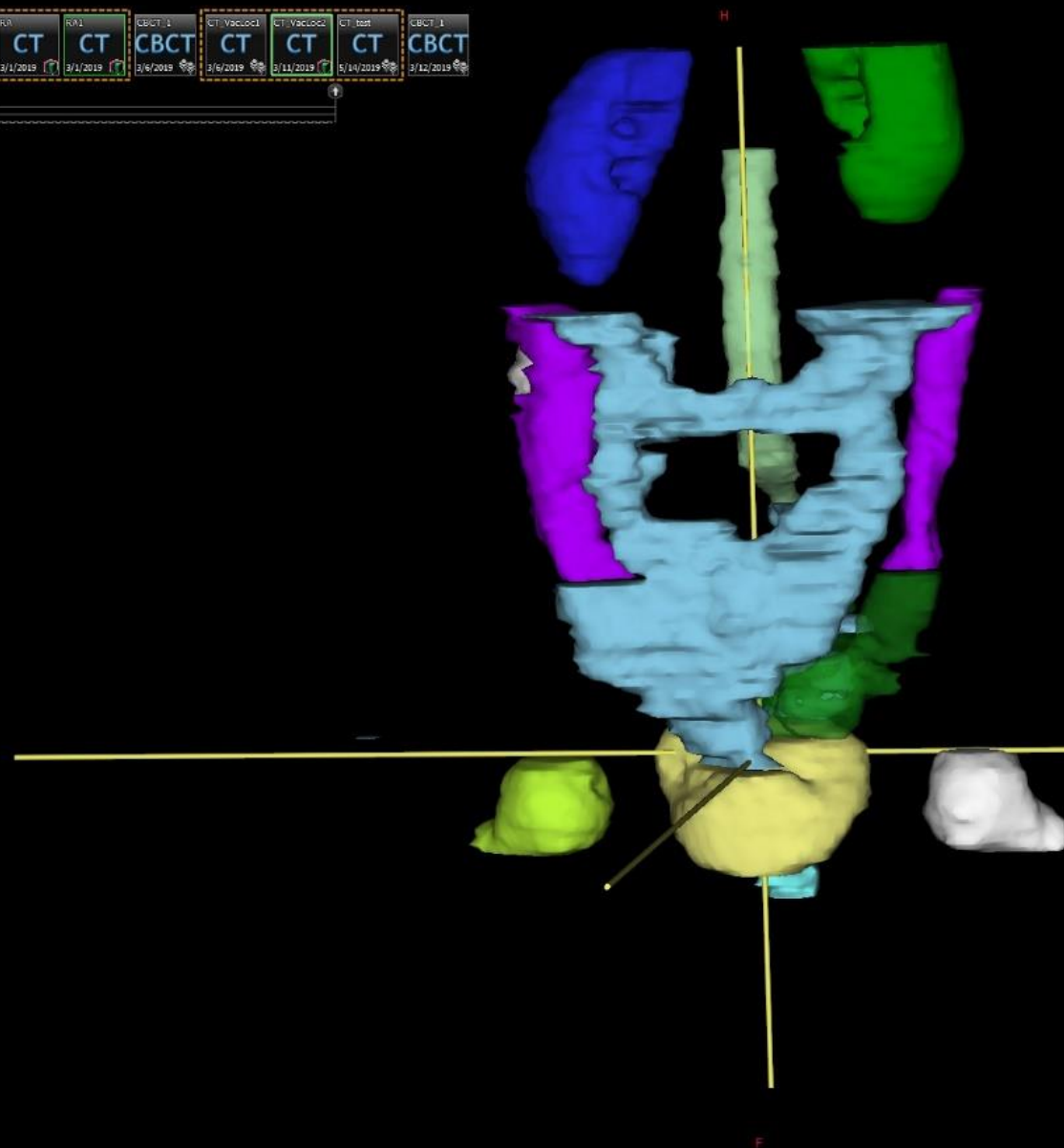
[illegible]

# Volumetric Modulated Arc Therapy, VMAT

- Omogućava isporuku visoke doze na metu, odnosno tumor, u jednom ili pola luka.
- Obezbeđuje najveću homogenost distribucije doze.
- U poređenju sa IMRT, ima bolju pokrivenost mete i kvalitetniju zaštitu organa od rizika.
- Kraće trajanje tretmana, što direktno smanjuje mogućnost za interfrakcijsko pomeranje organa.
- Mana VMAT tehnike je ta što veći deo zdravog tkiva koji se nalazi u zračnoj regiji prima manju dozu.



3D - CT\_VadLoc2 - 3/11/2019 9:16 AM



#### Drawing Tools

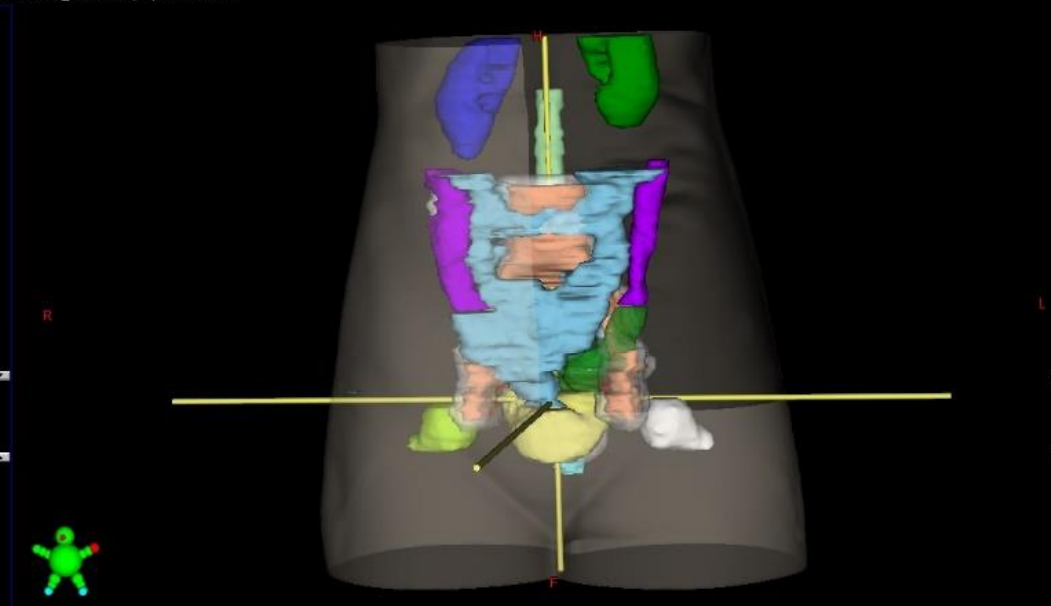
##### Select Structures

- Draw Planar Contour
- Brush
- Eraser
- Draw Geometrical Shape
- Create or Edit Annotation
- Draw Volumetric Contour
- Transform Structure
- Deform Structure
- PET Subvolume Thresholding
- Image Thresholding
- Search Body
- Segmentation Wizard
- Flood Fill
- Margin for Structure
- Post Processing
- Extract Wall
- Crop Structure
- Boolean Operators
- Extend Segmentation
- Interpolate Structure
- Segment High Density Artifacts
- Clear Structure
- Move Marker or Isocenter Marker
- Edit Reference Points
- Draw Reference Line
- Calypso Beacon Detection

Transversal - CT\_VadLoc2 - 3/11/2019 9:16 AM



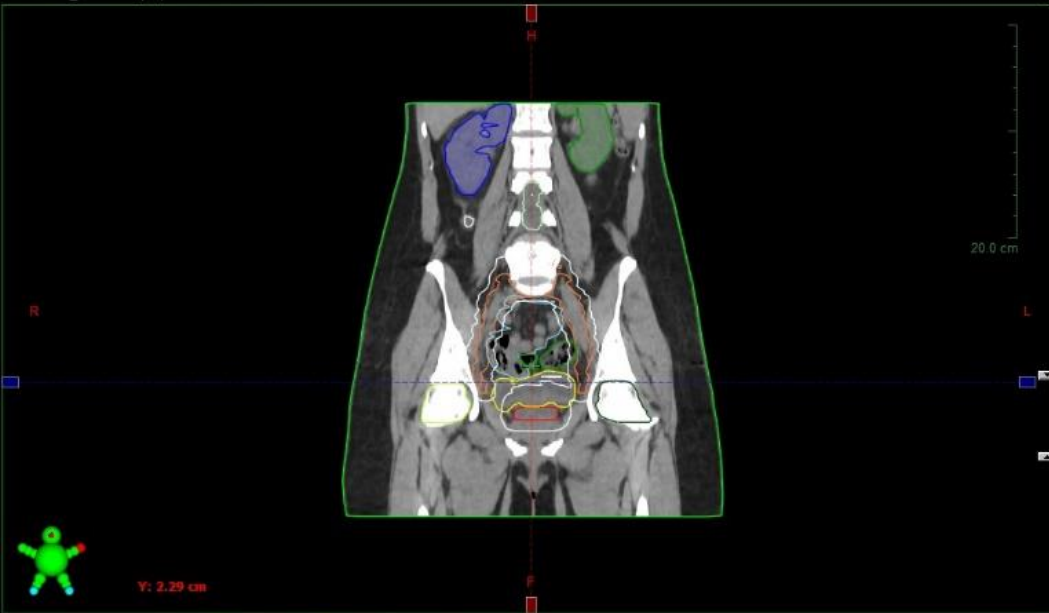
3D - CT\_VadLoc2 - 3/11/2019 9:16 AM



Drawing Tools

- Select Structures
- Draw Planar Contour
- Brush
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Frontal - CT\_VadLoc2 - 3/11/2019 9:16 AM

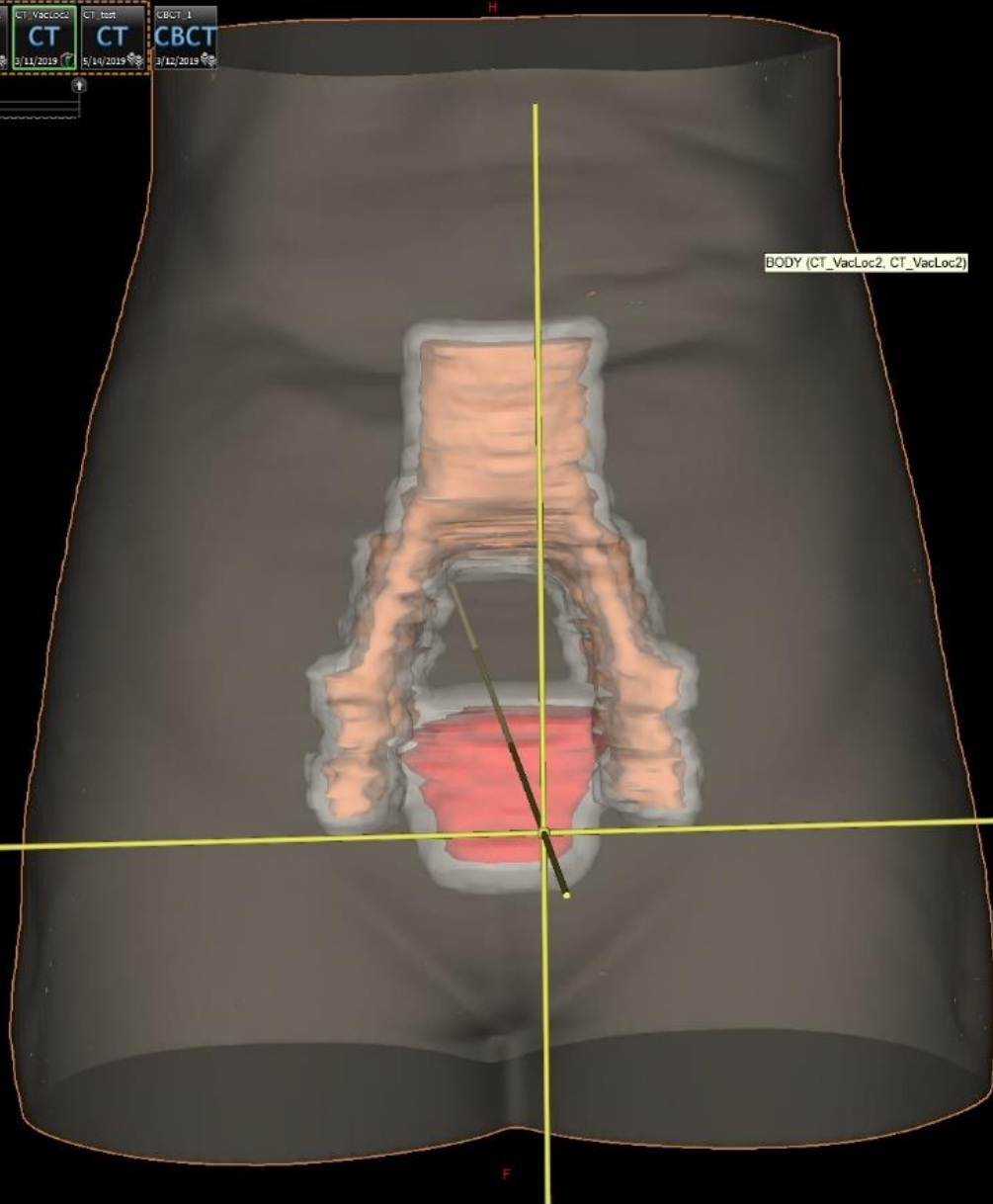


Sagittal - CT\_VadLoc2 - 3/11/2019 9:16 AM





3D - CT\_VacLoc2 - 3/11/2019 9:16 AM



- Drawing Tools
- Select Structures
  - Draw Planar Contour
  - Brush
  - Eraser
  - Draw Geometrical Shape
  - Create or Edit Annotation
  - Draw Volumetric Contour
  - Transform Structure
  - Deform Structure
  - PET Subvolume Thresholding
  - Image Thresholding
  - Search Body
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  - Extend Segmentation
  - Interpolate Structure
  - Segment High Density Artifacts
  - Clear Structure
  - Move Marker or Isocenter Marker
  - Edit Reference Points
  - Draw Reference Line
  - Calypso Beacon Detection





TRIIVA190225

C  
PI1RA

PI1RA

CT\_VacLoc2

Registered Images

CT\_VacLoc2

Bladder

BODY

Colon

CouchInterior

CouchSurface

CTV\_High

CTV\_Intermediate

FemoralJoint\_L

FemoralJoint\_R

Kidney\_L

Kidney\_R

PTV def

Rectum

seroma

SmallBowel

SpinalCord

sygma

User Origin

Reference Points

PTV def

Dose

Fields

Isocenter Group 1

pi270

pi270-DRR (Live)

pi0

pi0-DRR (Live)

piCBCT

piCBCT-DRR (Live)

Field 2

PI1RA - Treatment Approved - Transversal - CT\_VacLoc2

Color wash [%]

106.8

95.3

80.0

60.0

40.0

20.0

0.0

R

L

Standard

Head First-Supine

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3D Dose MAX: 106.8 %

3D MAX for PTV def: 106.8 %

3D MIN for PTV def: 29.6 %

3D MEAN for PTV def: 100.3 %

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3D MEAN for PTV def: 100.3 %

Dose Volume Histogram

Dose [cGy]

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450

900

1350

1800

2250

2700

3150

3600

4050

4500

4500

4500

4500

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Ratio of Total Structure Volume [%]

100

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60

40

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10

20

30

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50

60

70

80

90

100

100

100

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Relative dose [%]

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70

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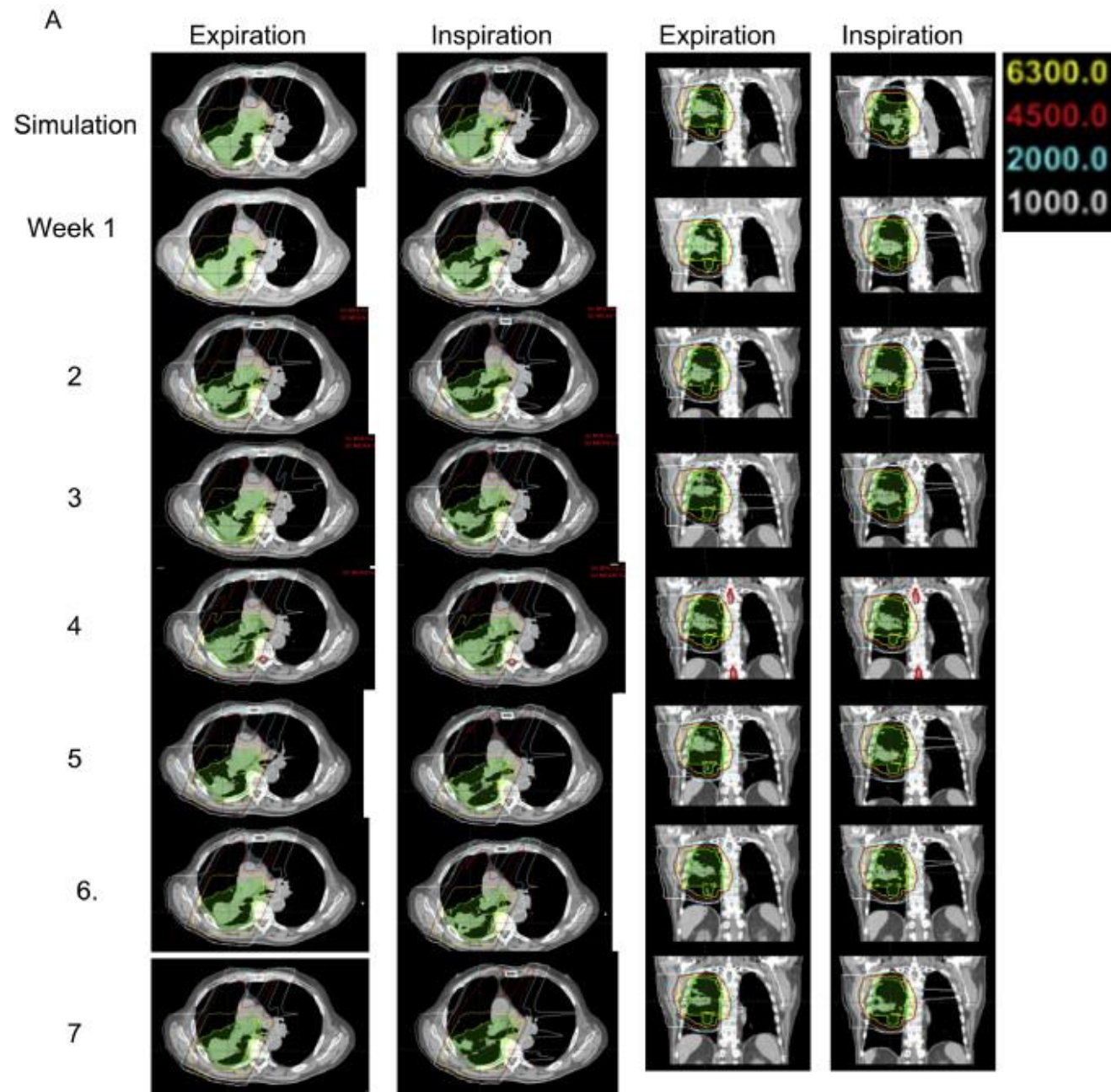
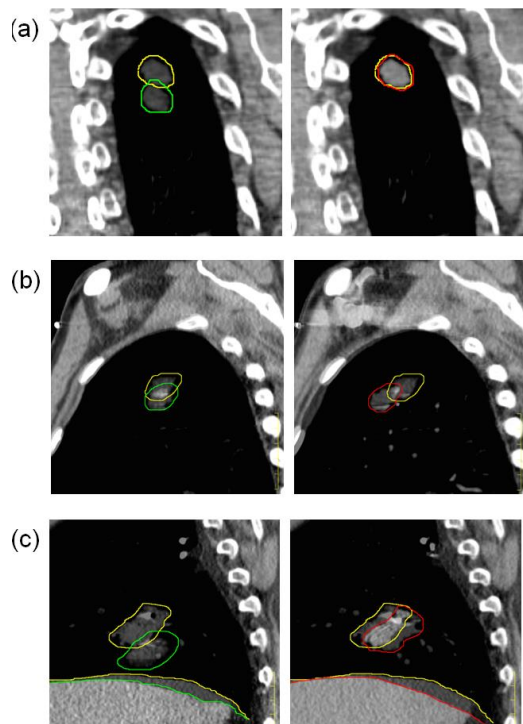
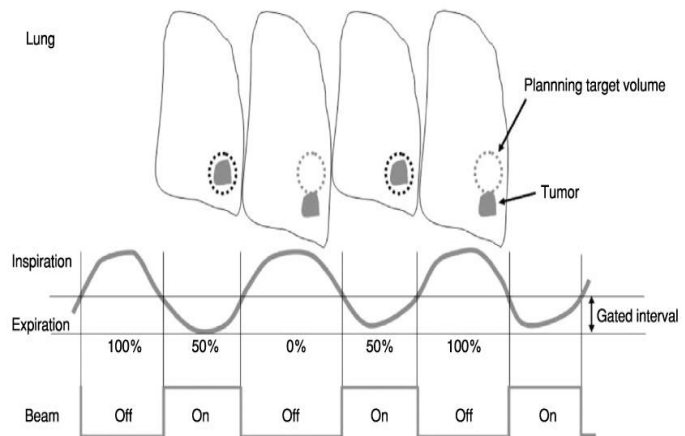
Fields Dose Reference Points Dose Statistics

Show DVH	Structure	Approval Status	Plan	Course	Volume [cm <sup>3</sup> ]	Dose Cover [%]	Sampling Cover [%]	Min Dose [%]	Max Dose [%]	Mean Dose [%]	
<input checked="" type="checkbox"/>	CTV_Intermediate	Approved	PI1RA	C	257.2	100.0	100.0	77.8	105.0	101.4	
<input checked="" type="checkbox"/>	CTV_High	Approved	PI1RA	C	57.0	100.0	100.0	97.0	105.1	100.9	
<input checked="" type="checkbox"/>	Colon	Approved	PI1RA	C	69.0	100.0	100.1	4.7	95.8	26.6	
<input checked="" type="checkbox"/>	Bladder	Approved	PI1RA	C	81.7	100.0	100.0	72.8	105.0	96.3	
<input checked="" type="checkbox"/>	BODY	Approved	PI1RA	C	17716.9	100.0	100.0	0.2	106.8	28.8	
<input checked="" type="checkbox"/>	FemoralJoint_L	Approved	PI1RA	C	42.5	100.0	100.0	16.9	98.6	43.7	
<input checked="" type="checkbox"/>	FemoralJoint_R	Approved	PI1RA	C	43.1	100.0	100.0	17.4	97.8	44.7	
<input checked="" type="checkbox"/>	Kidney_R	Approved	PI1RA	C	114.4	100.0	99.8	0.4	12.9	2.2	
<input checked="" type="checkbox"/>	Rectum	Approved	PI1RA	C	36.1	100.0	100.0	13.2	103.1	82.4	
<input checked="" type="checkbox"/>	SmallBowel	Approved	PI1RA	C	335.8	100.0	100.1	0.0	104.5	80.4	
<input checked="" type="checkbox"/>	SpinalCord	Approved	PI1RA	C	34.3	100.0	100.1	2.3	92.6	50.1	
<input checked="" type="checkbox"/>	sygma	Approved	PI1RA	C	117.9	100.0	100.0	42.3	103.9	90.7	
<input checked="" type="checkbox"/>	Kidney_L	Approved	PI1RA	C	84.7	100.0	99.8	0.4	4.8	1.6	
<input checked="" type="checkbox"/>	seroma	Approved	PI1RA	C	37.1	100.0	100.0	5.4	15.7	9.4	
<input checked="" type="checkbox"/>	PTV_def	Approved	PI1RA	C	880.1	100.0	100.0	29.6	106.8	100.3	



Dose		Reference Points		Dose Statistics								
Show DVH	Structure	Approval Status	Plan	Course	Volume [cm <sup>3</sup> ]	Dose Cover [%]	Sampling Cover [%]	Min Dose [%]	Max Dose [%]	Mean Dose [%]		
<input checked="" type="checkbox"/>	CTV_Intermediate	Approved	PI1RA	C	257.2	100.0	100.0	77.8	105.0	101.4		
<input checked="" type="checkbox"/>	CTV_High	Approved	PI1RA	C	57.0	100.0	100.0	97.0	105.1	100.9		
<input checked="" type="checkbox"/>	Colon	Approved	PI1RA	C	69.0	100.0	100.1	4.7	95.8	26.6		
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<input checked="" type="checkbox"/>	Kidney_L	Approved	PI1RA	C	84.7	100.0	99.8	0.4	4.8	1.6		
<input checked="" type="checkbox"/>	Seroma	Approved	PI1RA	C	37.1	100.0	100.0	5.4	15.7	9.4		
<input checked="" type="checkbox"/>	PTV_def	Approved	PI1RA	C	880.1	100.0	100.0	29.6	106.8	100.3		

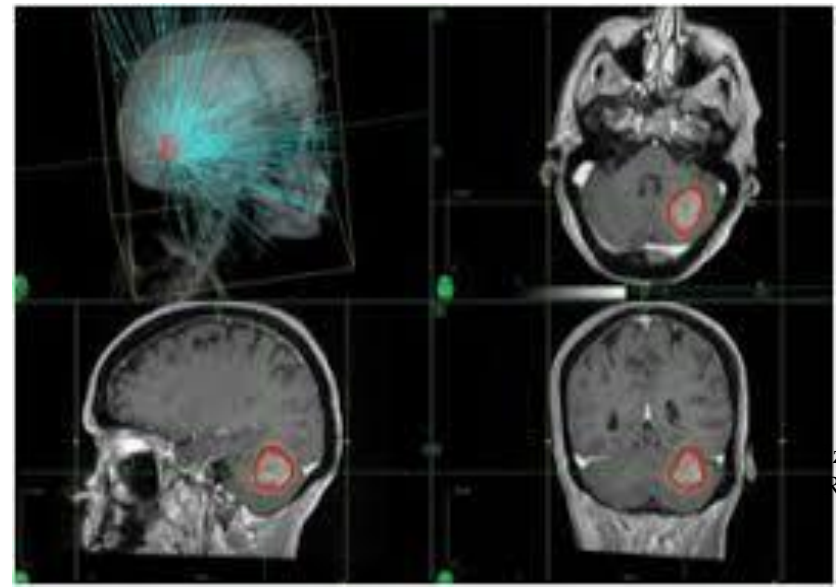
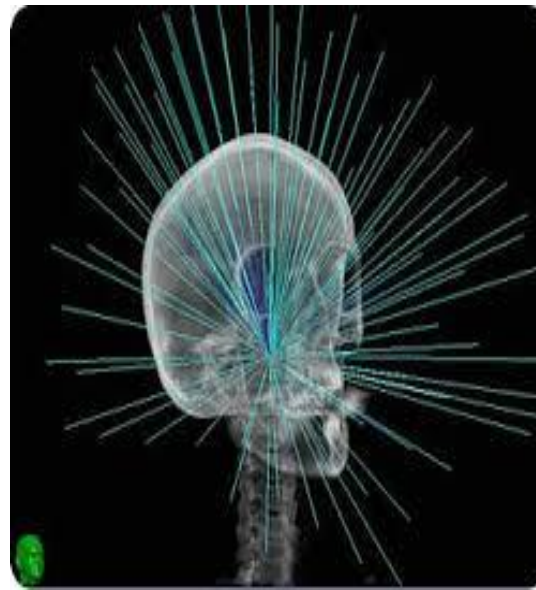
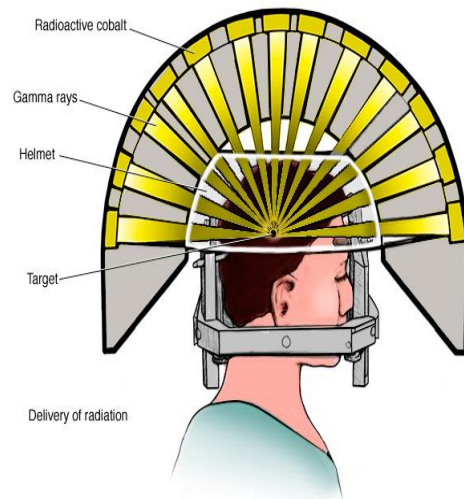
- Dodatna preciznost svih navedenih tehnika se postiže primenom jedne od sledećih tehnika tretmana:
  - **zadržavanje daha**
  - **adaptivno disanje (respiratory gating)**
  - **slobodno disanje**
- 
- **Respiratory gating** je tehnika kojom se koristi fiducijalni marker na zidu grudnog koša.





# STEREOTAKTIČNA RADIOTERAPIJA

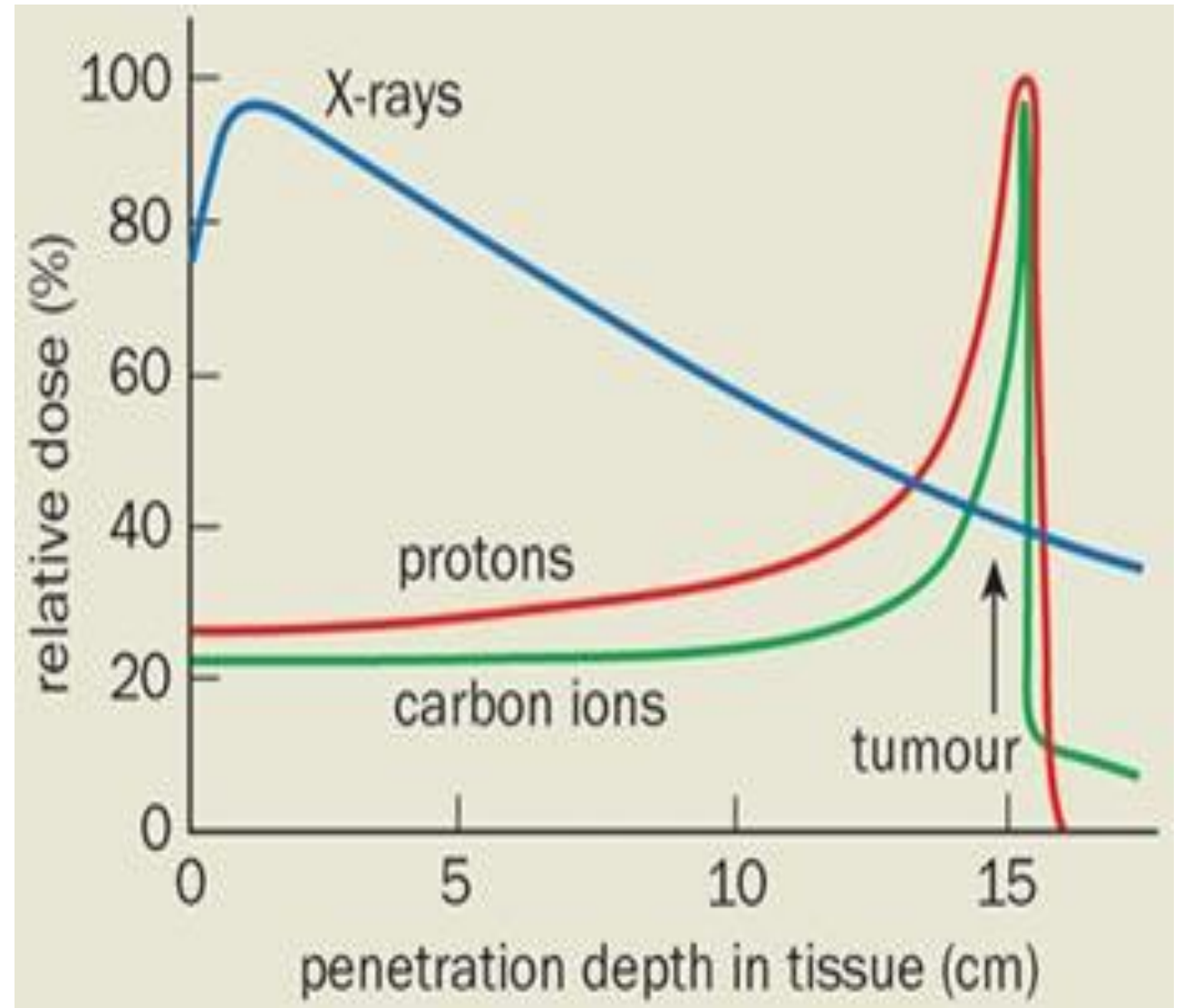
- Visoko fokusiran tretman na male, dobro definisane mete bilo u jednoj frakciji (20Gy), ili u 1-4 frakcije (6Gy, 7Gy, 8Gy)
- Najčešće kod solitarnih meta promena, reiradijacija



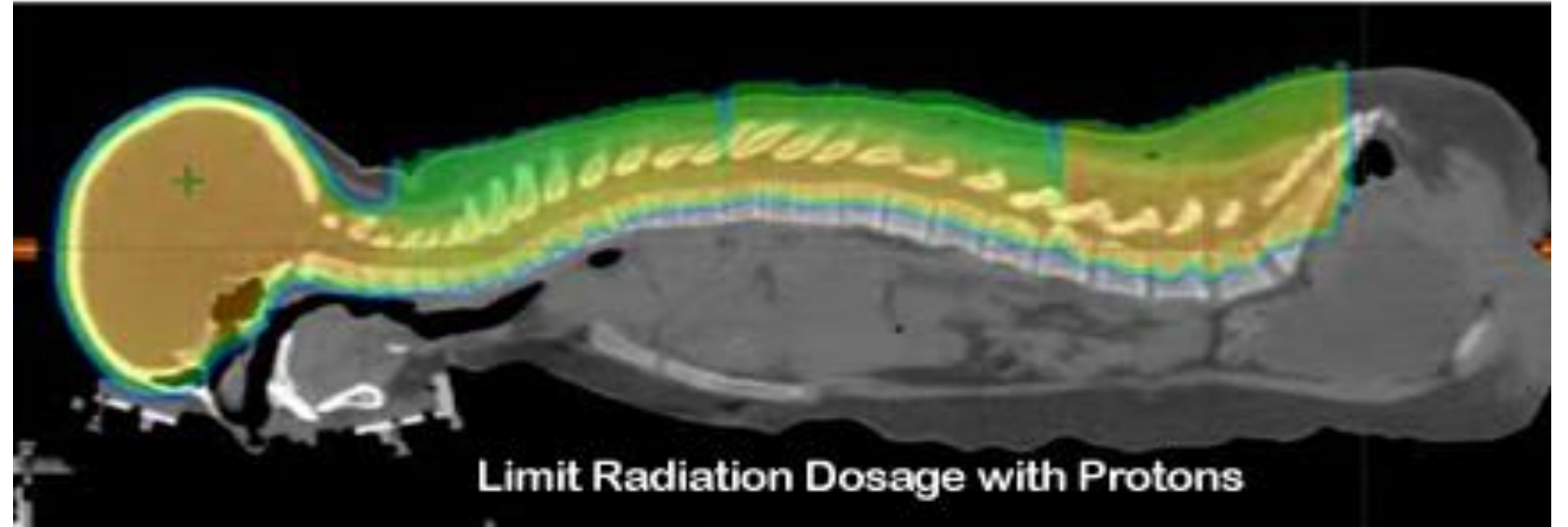
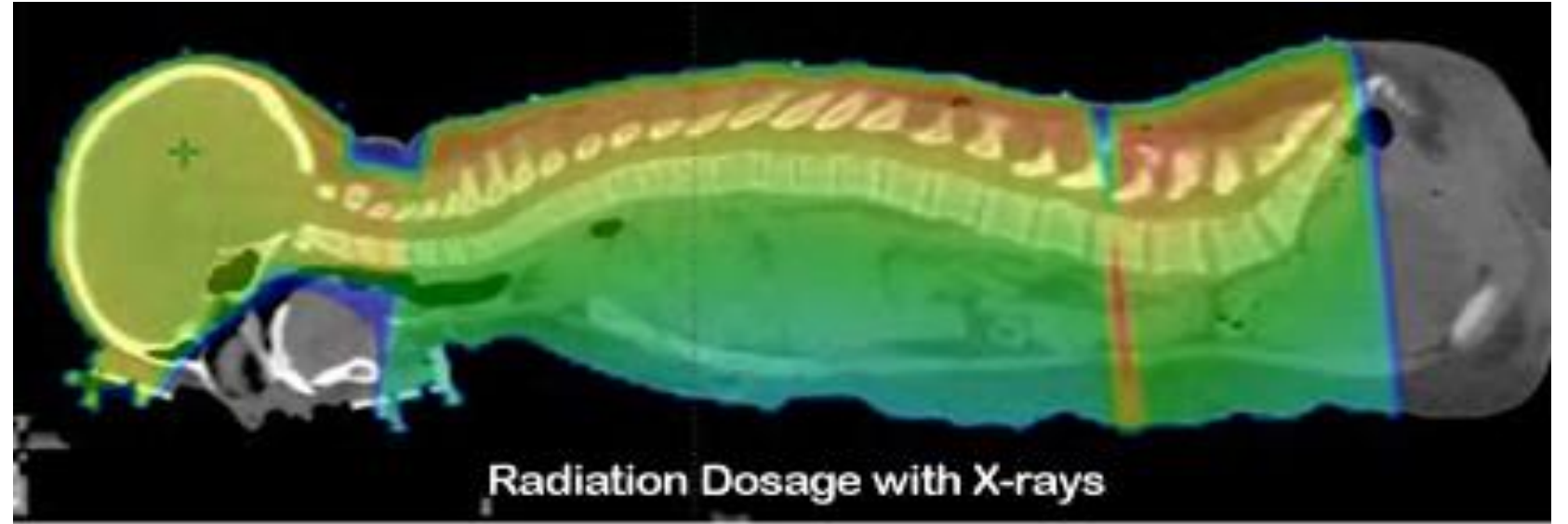
zvor: Mayo Clinic. SRS.  
Radiosurgery.gr

# PROTONSKA TERAPIJA

- Karakteristična distribucije doze u ciljnom volumenu omogućava postizanje tumorske doze na određenoj dubini u tkivu uz poštedu normalnih struktura ispred i iza.
- Indikacije za zračenje tumora određenih lokalizacija – baza lobanje, CSI, retretman
- Nedostatak - cena mašine

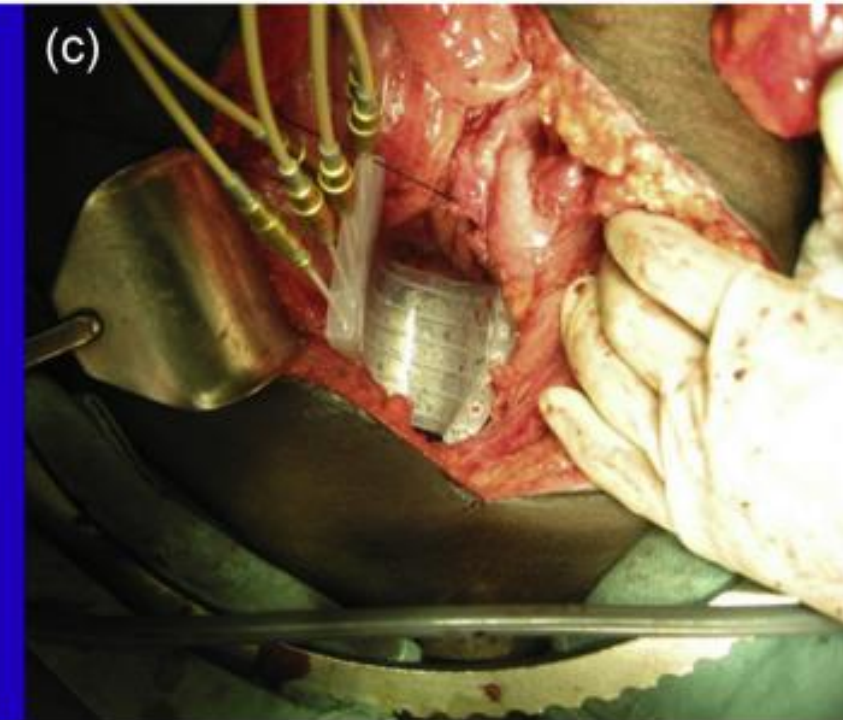
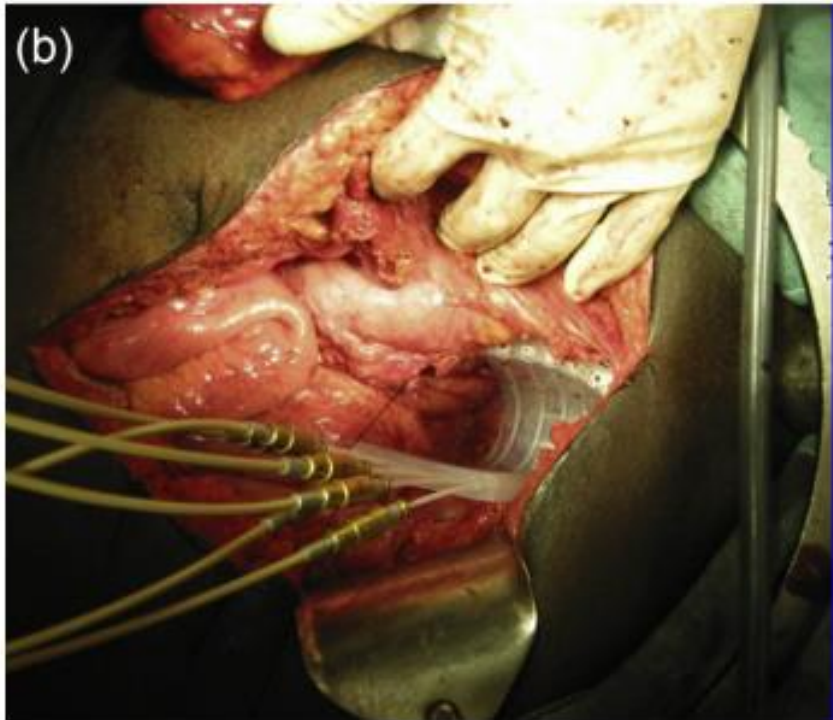
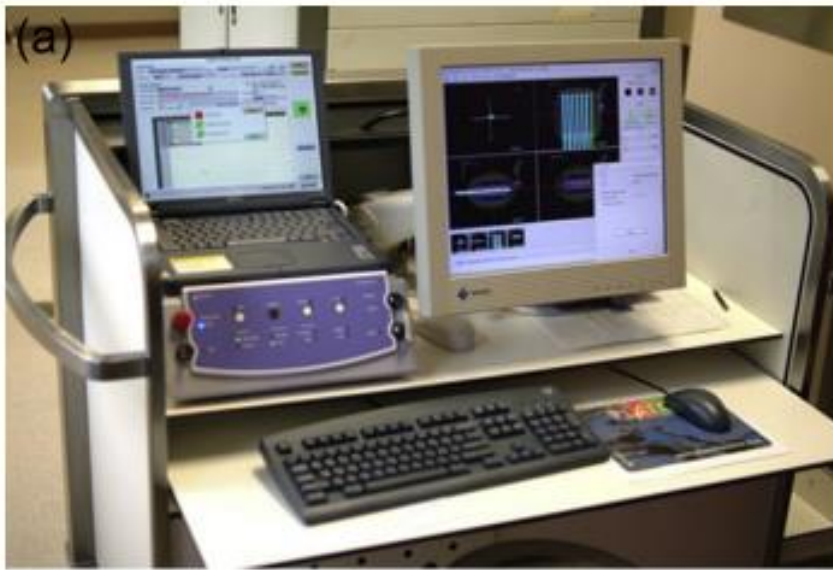






# INTRAOPERATIVE RADIOTHERAPY (IORT)

- Intraoperativna radioterapija (IORT) podrazumeva isporuku radioterapijske doze u jednoj frakciji direktno na ležište tumora tokom operativnog zahvata.
- Radioterapija se sprovodi direktnom vizualizacijom ležišta tumora tokom hirurške intervencije.
- Nedostatak IORT je što je definitivni Ph nalaz dostupan nakon sprovedene intervencije, te se ne mogu sa sigurnošću definisati resekcione margine





# BRAHITERAPIJA

- Preciznim pozicioniranjem radioaktivnog izvora u neposrednoj blizini tumora (do 2 cm) moguće je aplikovanje visoke doze zračenja na ciljni volumen.
- Zbog strmog perifernog pada doze, zdravo tkivo u neposrednoj blizini, je manje ozračeno od tumora, pa je i njegovo oporavljanje lakše
- Volumna doza je manja od one u transkutanoj radioterapiji, pa su rizici za lokalno i sistemsko oštećenje organizma znatno manji.

# Podela brahiterapije prema mestu aplikovanja izvora zračenja

- Površinska (kontaktna) brahiterapija izvodi se dovođenjem izvora u neposrednu blizinu, za zračenje tumora lokalizovanih na koži i vidljivim sluzokožama.
- Intrakavitarna (intraluminarna/endoluminalna) uvođenjem radioizotopa u prirodne tjelesne šupljine pomoću vodiča/aplikatora.
- Intersticijalna brahiterapija gdje se izvori zračenja uvode direktno u tumor, kroz šuplje vodiče u obliku igala, koje se zabađaju u tumorsko tkivo ili ubacivanjem radioaktivnih zrnaca u tumor.

