

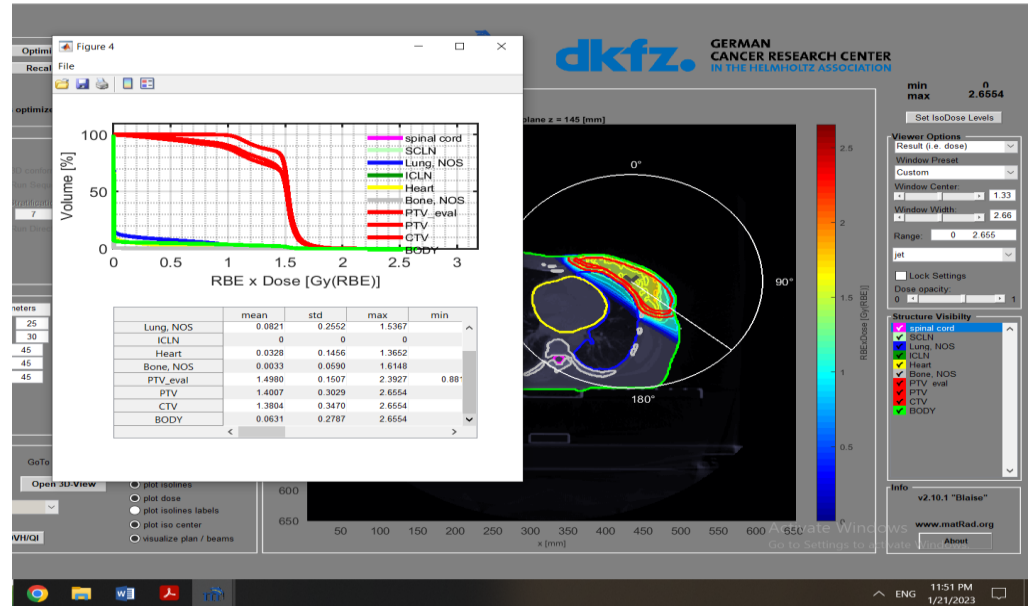
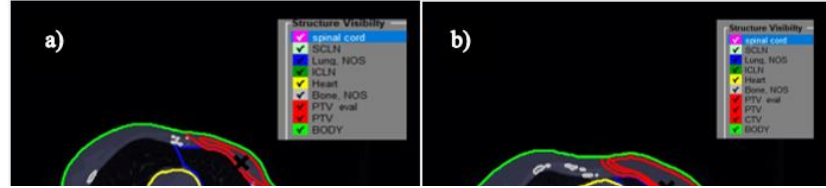
## Çfarë është matRad?

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University of Tetova  
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Slides by:  
Aris Mamaras  
Viridiana Badillo  
Enrique Sánchez  
Yiota Foka  
Updated by Nermine Muradi

## Particle Therapy Masterclass 2021

# Simulimi i planeve të trajtimit me rrezatim të kanceri i gjirit dhe krahasimi me rastet klinike



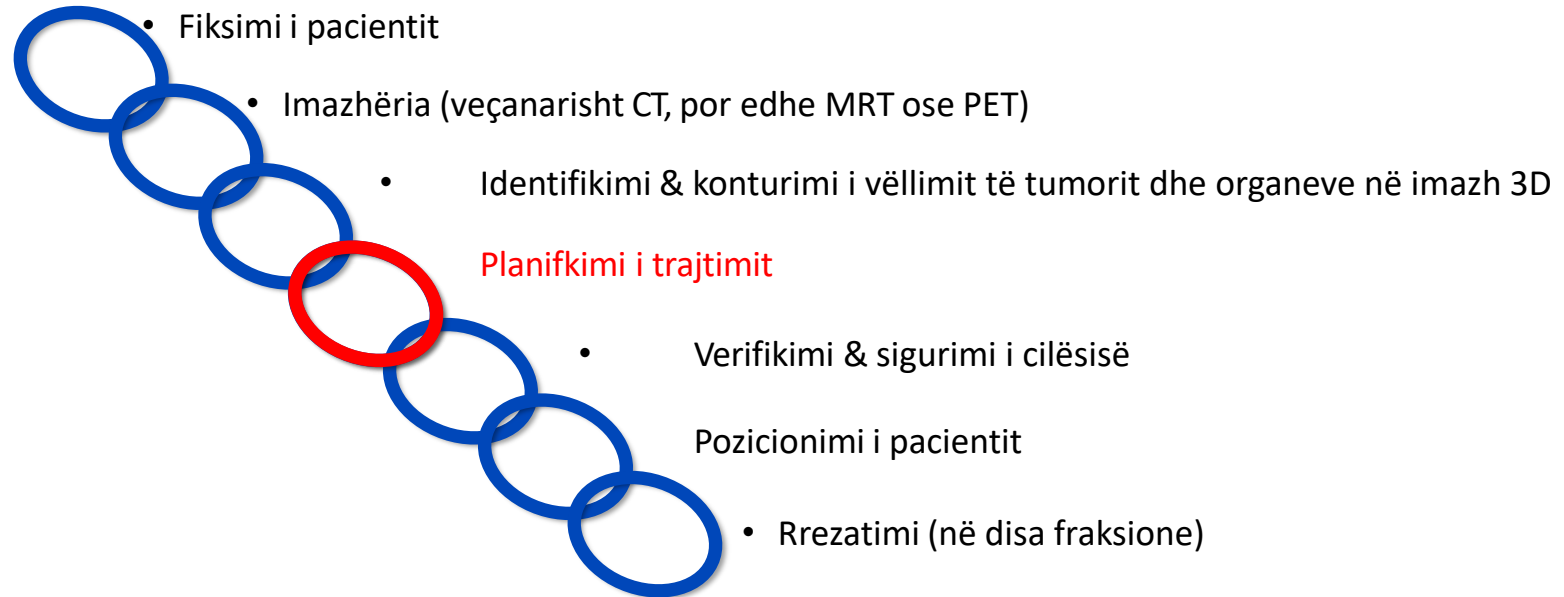
# Erasmus

+



Learning never  
exhausts the  
mind.





# Çfarë është MatRad?

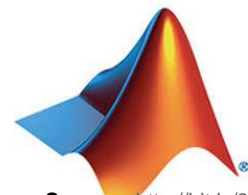


- MatRAD është një software open source, mjet për dizajnimin e planeve të trajtimit të teratpive me rrezatim me rreze të moduluara të fotoneve, protoneve dhe joneve të karbonit
- Emri rrjedh nga kombinimi i dy fjalëve:


matRad

matlab + radiation = matRad

MatLab + Radiation = MatRad



Source: <http://bit.ly/3sX756v>

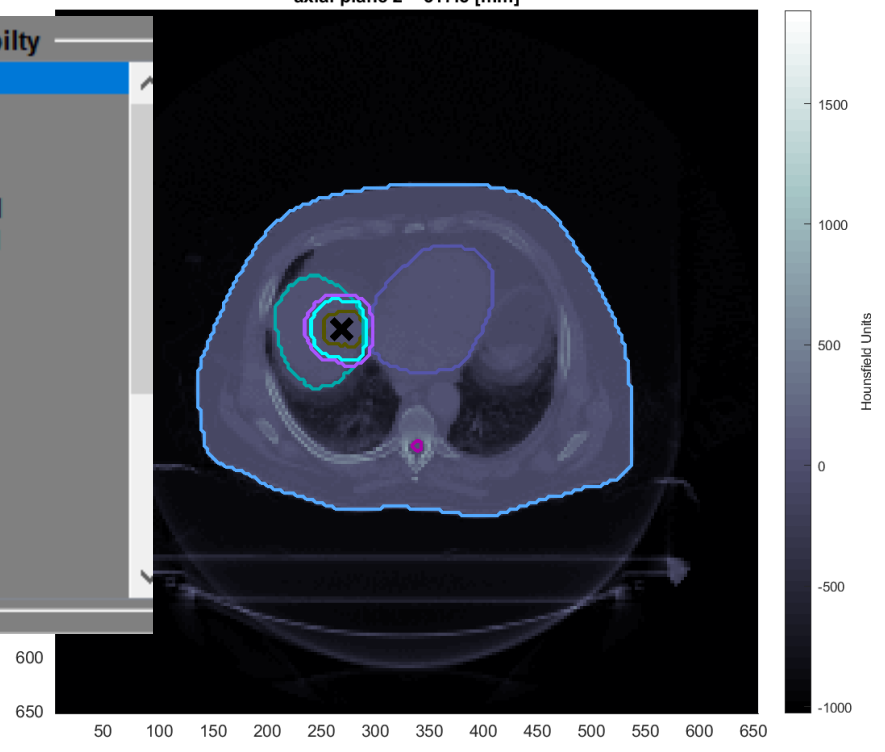
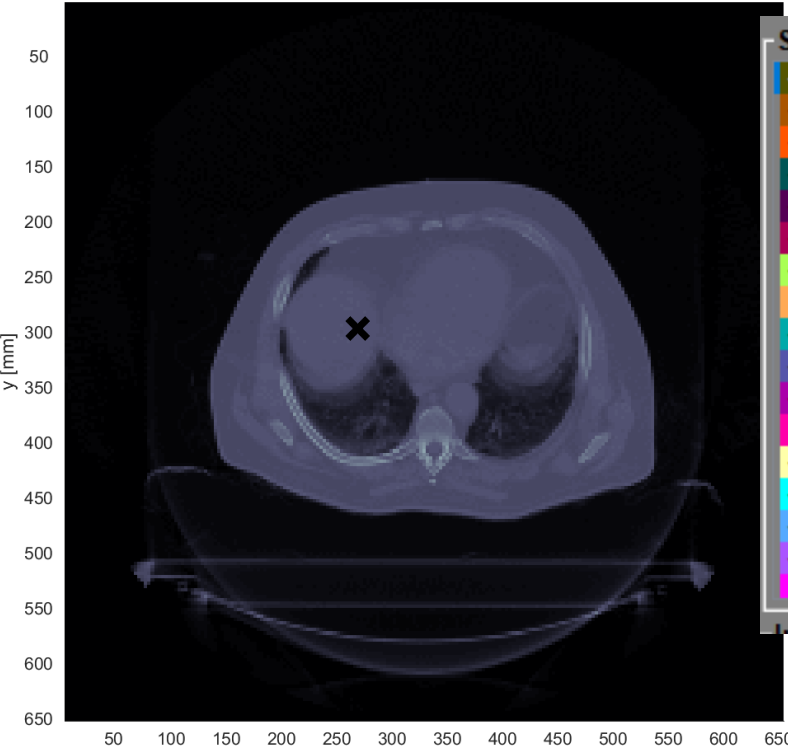
- E krijuar dhe zhvilluar nga shkenctarë në qendrën Gjermane për hulumtim të kancerit (German Cancer Research Center), DKFZ në Darmstadt.
- Përdoret ekskluzivisht për qëllime edukimi dhe  GERMAN CANCER RESEARCH CENTER IN THE HELMHOLTZ ASSOCIATION

Source: <http://bit.ly/3uXfNDt>

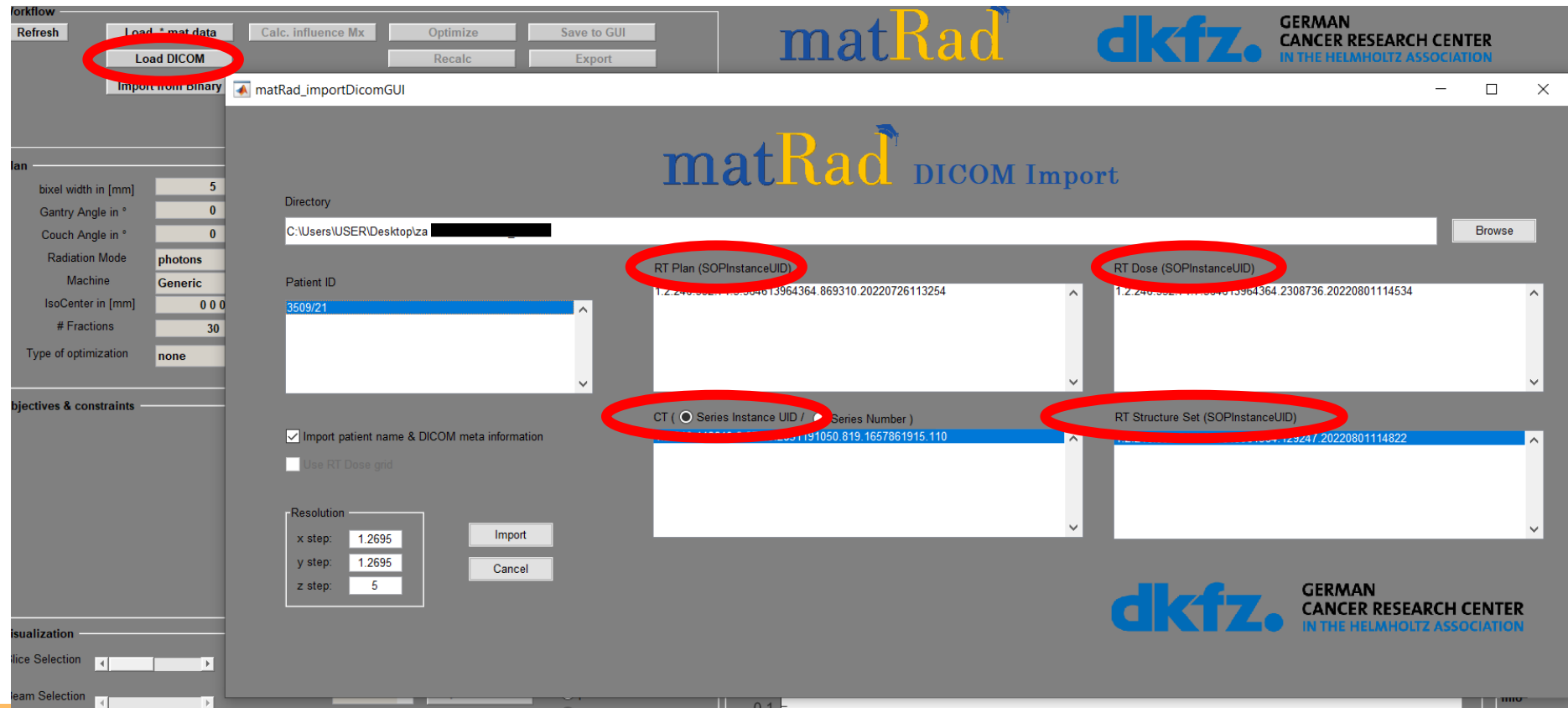
axial plane z = 317.5 [mm]

axial plane z = 317.5 [mm]

- Structure Visibility**
- GTV
  - Kidney R
  - Kidney L
  - Stomach
  - SmallBowel
  - LargeBowel
  - Celiac
  - SMA SMV
  - Liver
  - Heart
  - SpinalCord
  - DoseFalloff
  - duodenum
  - CTV
  - Skin
  - PTV
  - cord+5mm



# Import i imazheve, strukturave dhe planeve



The screenshot shows the matRad DICOM Import GUI. The interface includes a top toolbar with buttons for 'Refresh', 'Load \*.mat data', 'Load DICOM', 'Calc. influence Mx', 'Optimize', 'Save to GUI', 'Recalc', and 'Export'. The 'Load DICOM' button is circled in red. Below the toolbar, the window title is 'matRad\_importDicomGUI'. The main area is titled 'matRad DICOM Import' and contains several input fields and lists:

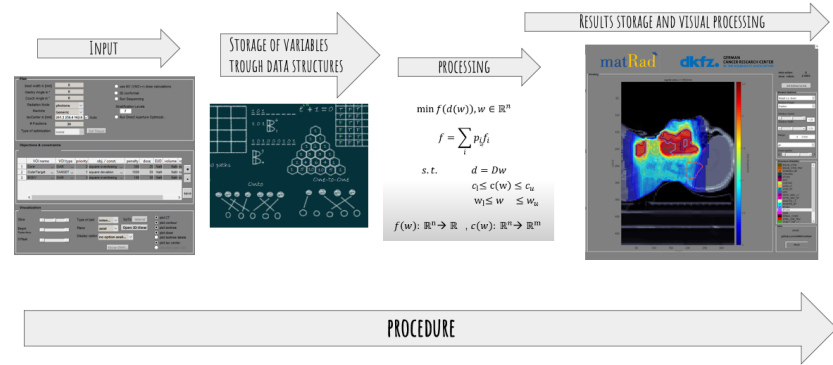
- Directory:** A text field containing 'C:\Users\USER\Desktop\za...' with a 'Browse' button to its right.
- Patient ID:** A list box showing '3509/21'.
- RT Plan (SOPInstanceUID):** A list box with one entry: '1.2.246.332.1.13964364.869310.20220726113254'. This label is circled in red.
- RT Dose (SOPInstanceUID):** A list box with one entry: '1.2.246.332.1.13964364.2308736.20220801114534'. This label is circled in red.
- CT (Series Instance UID / Series Number):** A list box with one entry: '1.2.246.332.1.191050.819.1657861915.110'. This label is circled in red.
- RT Structure Set (SOPInstanceUID):** A list box with one entry: '1.2.246.332.1.13964364.20220801114822'. This label is circled in red.

At the bottom left, there are checkboxes for 'Import patient name & DICOM meta information' (checked) and 'Use RT Dose grid' (unchecked). Below these are input fields for 'Resolution' (x step: 1.2695, y step: 1.2695, z step: 5) and 'Import'/'Cancel' buttons.

The bottom right corner features the 'dkfz. GERMAN CANCER RESEARCH CENTER IN THE HELMHOLTZ ASSOCIATION' logo.

# Sistemi i planifikimit të trajtimit – TPS matRad

- Fotone: Të dhënat bazë për algoritmin e llogaritjes së dozës së fotonit përshkruan komponentet e dozave për një përshpejtues linear 6 MV për burime të shumëfishta SSD.
- Protonet: Llogaritjet analitike përdoren për të përafuar profilet e integruara të dozës së thellësisë së protonit në ujë për 114 - të energjitë e rrezeve protonike që variojnë nga 31.72 MeV deri në 236.1 MeV që korrespondojnë me pozicionet e pykut nga 7 mm deri në 347 mm.
- Jonet e karbonit: Pjesë e skedarit të të dhënave të bazës së joneve të karbonit janë 121 profile dozash të ndara në mënyrë lineare nga 115.23 MeV deri në 398.84 MeV që përshkruajnë pozicionet e pyqeve nga 32 mm deri në 294 mm.





# Si mund të përdoret ky software?

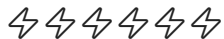
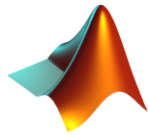


## ➤ Për qëllime hulumtimi:

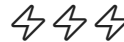
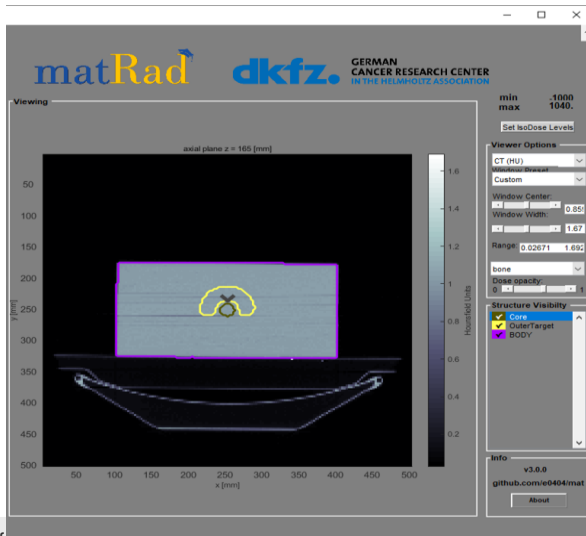
- Programi jep mundësinë për të pëdorur shumë parametra, për të fituar simulime sa më reale.
- Përdor kodin e plotë Mat Lab për analiza të detajuara.
- Kërkon kohë më të gjatë për ekzekutim të kodit.

## ➤ Për qëllime të edukimit:

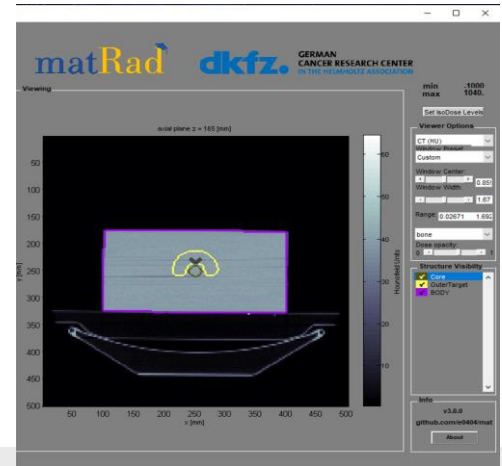
- Për qëllime të edukimit, përdoret forma e thjeshtë e softwareit në Windows, Linux ose Mac.
- Kërkon më pak hapësirë në memorie dhe fuqi më të vogël llogaritjeje.
- Nuk kërkohet mjedis të zhvillimit integral IDE për përdorimin e software ( matlab ose Octave)



+ COMPUTING POWER



- COMPUTING POWER



# Ku përdoret sot Matrad?

## matRad – community

more than 22 institutions use matRad



TECHNISCHE  
UNIVERSITÄT  
MÜNCHEN



MEDICAL UNIVERSITY  
OF VIENNA



大阪大学  
OSAKA UNIVERSITY



GERMAN  
CANCER RESEARCH CENTER  
IN THE HELMHOLTZ ASSOCIATION

THE UNIVERSITY OF TEXAS

MD Anderson  
~~Cancer Center~~

Proton Therapy



UNIVERSIDAD  
COMPLUTENSE  
MADRID

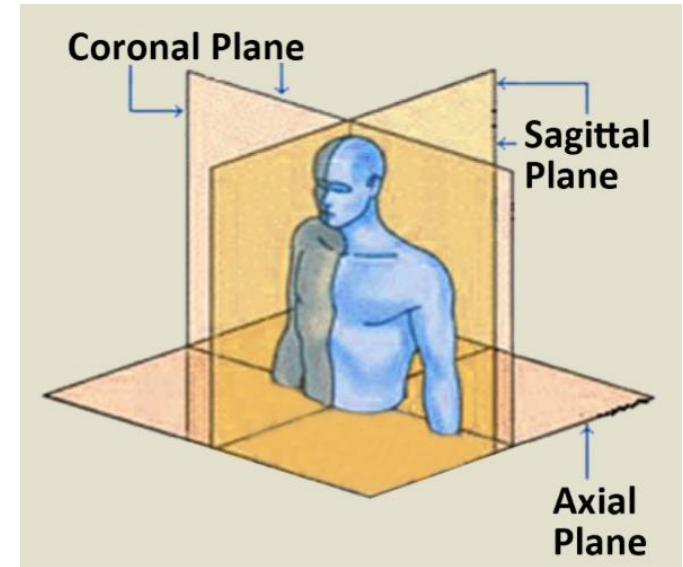


UNIVERSITY OF  
OXFORD



Universität  
Zürich<sup>UZH</sup>

- Paketa e instalimit të programit vjen bashkë me 6 raste studimi:
  - TG 119 ose fantoma C
  - Liver – Mëlçia
  - Prostata
  - Head & Neck (H&N) – Koka dhe qafa
  - Box phantom
  - Alderson case

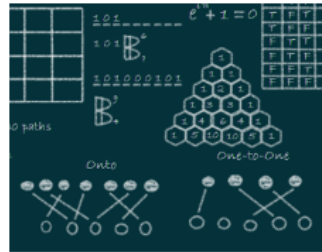


# Si ndodh procesimi i të dhënave?

INPUT



STORAGE OF VARIABLES  
THROUGH DATA STRUCTURES



PROCESSING

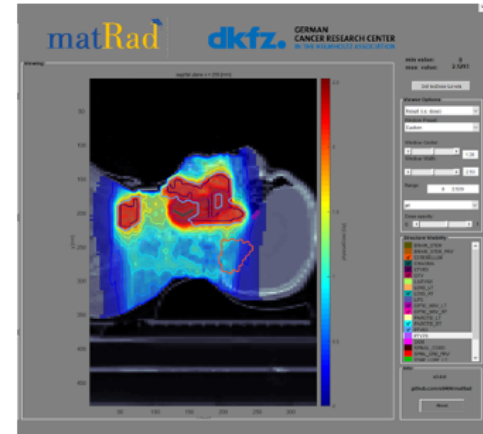
$$\min f(d(w)), w \in \mathbb{R}^n$$

$$f = \sum_i p_i f_i$$

$$\text{s. t.} \quad \begin{aligned} d &= Dw \\ c_l &\leq c(w) \leq c_u \\ w_l &\leq w \leq w_u \end{aligned}$$

$$f(w): \mathbb{R}^n \rightarrow \mathbb{R}, \quad c(w): \mathbb{R}^n \rightarrow \mathbb{R}^m$$

RESULTS STORAGE AND VISUAL PROCESSING



PROCEDURE

# Interfaqja grafike e matRad



The image displays the matRad GUI interface, which is used for treatment planning. It features several panels:

- Workflow:** Includes buttons for Refresh, Load \*.mat data, Calc. influence Mx, Optimize, Save to GUI, Load DICOM, Recalc, Export, Import from Binary, and Import Dose.
- Plan:** Contains input fields for beam width, gantry and couch angles, radiation mode (protons), machine (GeneSis), and isocenter. It also has checkboxes for MC simulation, 3D conformal, RAI-sequencing, and Risk-Driven Aperture Optimization.
- Objectives & constraints:** A table listing objectives with columns for name, type, priority, objective/constraint, penalty, dose, and EUD. The table contains three rows: Dose (priority 2, penalty 300), OvaryTarget (priority 1, penalty 1000), and BODY (priority 3, penalty 100).
- Viewing:** A large central area showing a 2D heatmap of the dose distribution. A color scale on the right indicates dose values from 0.2 to 0.6. Below the heatmap, a 3D wireframe model of the patient's anatomy is visible.
- Viewer Options:** A panel on the right for adjusting the view, including window center, width, height, and zoom.
- Structure Set:** A panel at the bottom right showing the selected structure set (Core, OvaryTarget, BODY).

Mund të përdoret me Matlab ose me matRad GUI

# Definime fundamentale të pëdrora nga MatRad

**GTV** or gross tumor volume definohet si tumori shenjës makroskopi dhe është lokacioni ekzakt i tumorit malinj, i evidentuar nga metodat e imazhërisë. Mund të përfshijë vetëm tumorin inicues ose edhe metastaza të tjera.

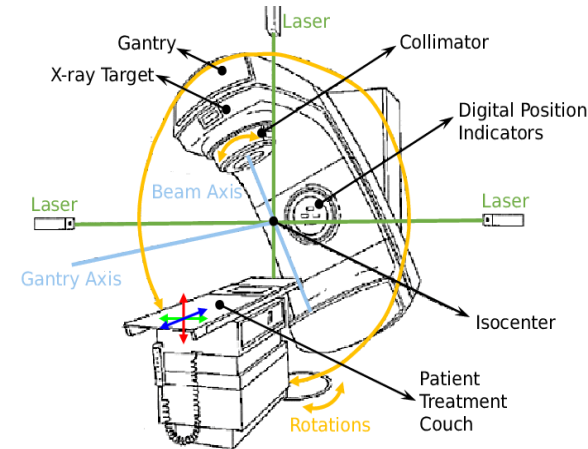
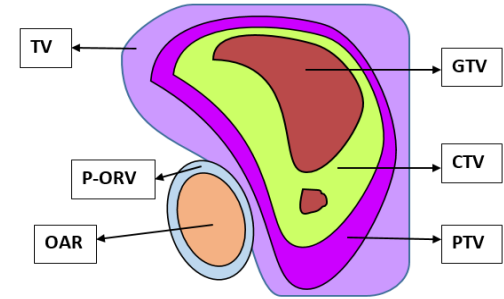
- **CTV** or clinical target volume definohet si tumori shenjës klinik, ku mendohet se qelizat kancerogjene ende janë prezente.

-  $CTV = GTV + 1\text{ cm} - 2\text{ cm}$ ,

- **PTV** or "Planning Target Volume« definohet si vëllimit shenjës që planifikohet të rrezatohet. Përfshin CTV me një margjinë shtesë në rast se tumori, pacienti lëviz, por edhe për të menjanuar gabimet e makinës.

- **OAR** or "Organs At Risk", janë organet më të ndjeshme, apo organet e shëndosha. Këto organe kërkojnë mbrojtje adekuate, ku duhet shtuar edhe një margjinë shtesë në rast të lëvizjes së tyre.

- **Gray (Gy)** është njësia matëse e energjisë që absorbohet nga rrezatimi jonizues.



# How does MatRad work?



WE ENTER THE PATIENT DATA

WE SET THE PARAMETERS OF THE TREATMENT PLAN (RADIATION GEOMETRY ETC.)

WE CALCULATE THE DOSE OF DISTRIBUTION TO THE CANCEROUS TISSUE THROUGH ALGORITHMS

VISUALIZATION OF THE PLAN WITH THE REVERSE PLANNING TECHNIQUE (INVERSE PLANNING)

COMPLETION OF SIMULATION

Data files:

- I. Test Sample (C-phantom)
- II. Liver
- III. Head n Neck

$$d(x, y, z_{rad}) = \sum_i Z_i(z_{rad}) \iint dx' dy' \Psi(x', y') F(x', y') K_i(x' - x, y' - y)$$

$$\min f(d(w)), w \in \mathbb{R}^n$$

$$f = \sum_i p_i f_i$$

$$\text{s. t. } \begin{aligned} d &= Dw \\ c_1 \leq c(w) &\leq c_u \\ w_1 \leq w &\leq w_u \end{aligned}$$

$$f(w): \mathbb{R}^n \rightarrow \mathbb{R}, c(w): \mathbb{R}^n \rightarrow \mathbb{R}^m$$

PROCEDURE

**Plan**

bixel width in [mm] 5  
 Gantry Angle in ° 0  
 Couch Angle in ° 0  
 Radiation Mode photons  
 Machine Generic  
 IsoCenter in [mm] 251.3 236.4 162.6  Auto  
 # Fractions 30  
 Type of optimization none

use MC (VMC++) dose calculations  
 3D conformal  
 Run Sequencing  
 Strahlungs Levels 7  
 Run Direct Aperture Optimiz...

**Objectives & constraints**

VOI name	VOI type	priority	obj. / const.	penalty	dose	EUD	volume	rc
1 Core	GAR	2	square overdosing	308	25	NaN	NaN	+
2 OuterTarget	TARGET	1	square deviation	1000	50	NaN	NaN	+
3 BODY	GAR	3	square overdosing	100	30	NaN	NaN	-

**Visualization**

Slice

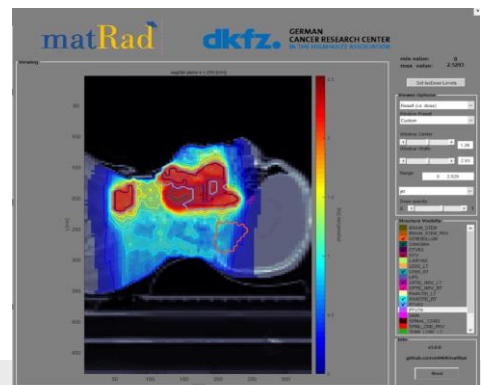
Beam

Offset

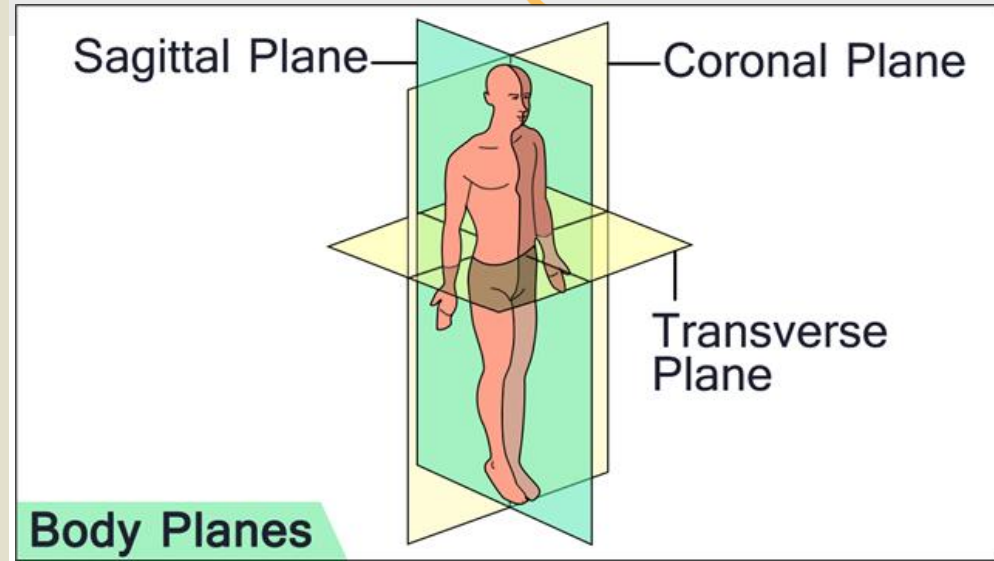
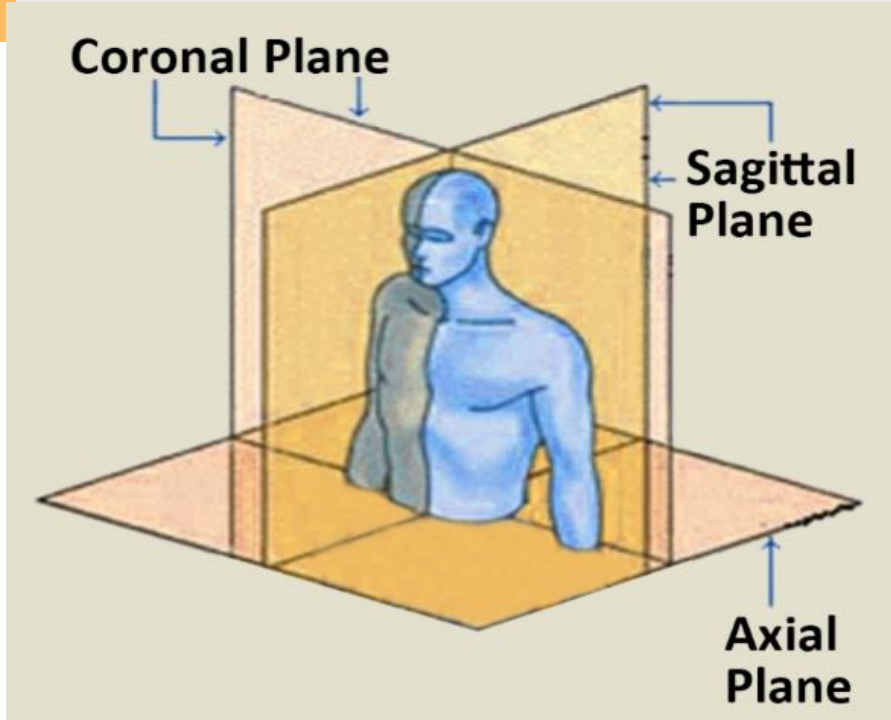
Type of plot  GoTo   plot CT  plot contour  plot isolines  plot dose  plot isocenter labels  plot iso center  show dose plot / Do...

Plane   Open 3D-View

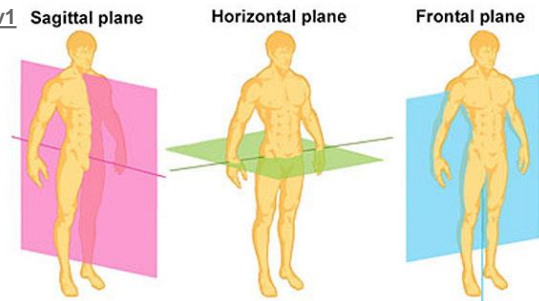
Display option



# Planes



Source: <https://bit.ly/3tY42v1>



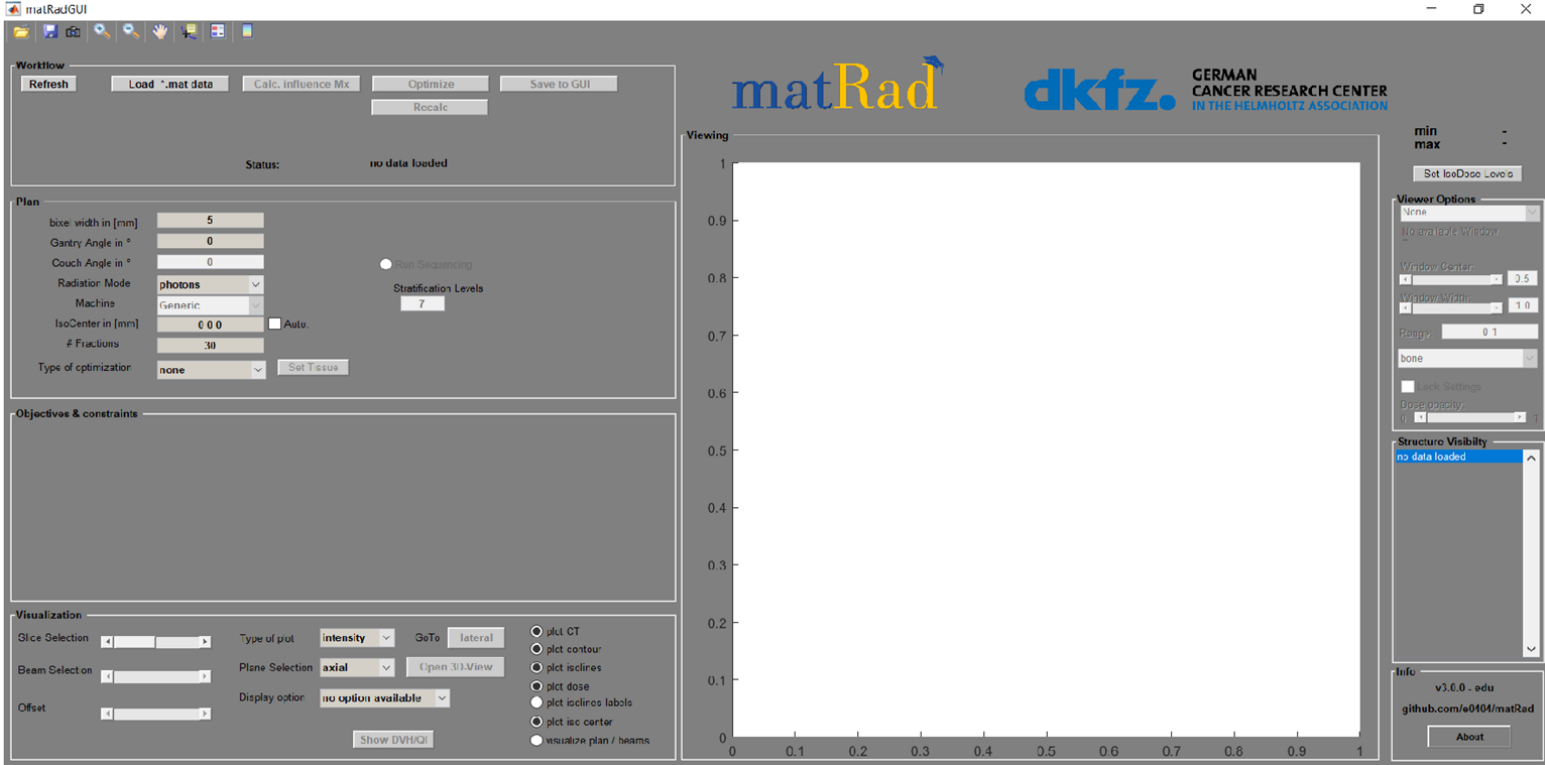
**Sagittal plane:** Ndan trupin në mënyrë të barabartë në anën e majtë dhe të djathtë.

**Coronal plane:** Ndan trupin në dy pjesë, në anterior dhe posterior.

**Transverse/Axial/Horizontal plane:** Ndan trupin në pjesën e sipërme dhe të poshtme.



# Nisja e programit



Workflow: Refresh, Load \*.met data, Calc. influence Mx, Optimize, Save to GUI, Recalc

Status: no data loaded

Plan:

- bice width in [mm]: 5
- Gantry Angle in °: 0
- Couch Angle in °: 0
- Radiation Mode: photons
- Machines: Generic
- IsoCenter in [mm]: 0 0 0 (Auto)
- # Fractions: 30
- Type of optimizer: none (Set Tissue)
- Plan Sequencing:  (checked)
- Stratification Levels: 7

Objectives & constraints

Visualization:

- Slice Selection: [dropdown]
- Beam Selection: [dropdown]
- Offset: [dropdown]
- Type of plot: intensity (GoTo: lateral)
- Plane Selection: axial (Open 3D View)
- Display option: no option available (Show DVH/G)
- Visualize plan / beams:  (checked)
- Other options:  plot CT,  plot contour,  plot isclines,  plot dose,  plot isclines labels,  plot iso center

Viewing: 0 to 1 on both axes

min max: [dropdown]

Set IsoDose Level: [dropdown]

Viewer Options:

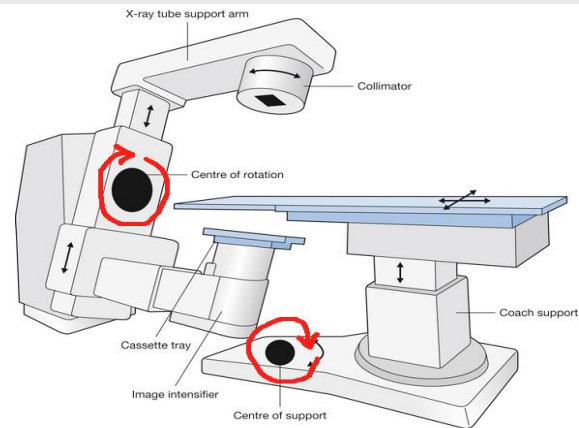
- Window Center: 3.5
- Window Width: 1.0
- Range: 0.1
- bone
- back Settings
- Dose opacity: [dropdown]

Structure Visibility: no data loaded

Info: v3.0.0 - edu, github.com/e0104/matRad, About

## Paneli: Plan

- ✎ **Bixel width:** square size.
- ✎ **Gantry and couch angles:** *Vendos vlerat e kendeve për Gantry dhe për couch (krevatin e pacientit). Nëse përdoren 5 kënde për Gantry, atëherë do të kemi 5 kënde edhe për krevatin. Këto kënde kanë vlera nga 0° deri 359°.*
- ✎ **Radiation mode:** çfarë grimce do të përdoret.
- ✎ **Isocenter:** Gjithmon verifiko që “automatic isocenter” është aktive. Është qendra ku kalon tufa e rrezatimit.
- ✎ **Fractions:** Numri i fraksioneve = numri “slices” apo fetave që do të përdoren për të vizualizuar 3D graphics.
- ✎ **Run sequencing:** përdoret për të kolimuar tufën (për rastin tonë nuk është aktive)



Plan

bixel width in [mm]	5
Gantry Angle in °	0 72 144 216 288
Couch Angle in °	0 0 0 0
Radiation Mode	photons
Machine	Generic
IsoCenter in [mm]	251.3 236.4 162.6 <input checked="" type="checkbox"/> Auto
# Fractions	30
Type of optimization	none <input type="button" value="Set Tissue"/>

Run Sequencing

Stratification Levels

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CANCER RESEARCH CENTER  
IN THE HELMHOLTZ ASSOCIATION

min value: -1000  
max 1040.

Get IsoDose Levels

Workflow

Refresh Load \*.mat data Calc. influence Mx Optimize Save to GUI

Recalc

Status: ready for dose calculation

Plan

beam width in [mm] 5

Gantry Angle in ° 0 72 144 216 288

Couch Angle in ° 0 0 0 0

Radiation Mode photons

Machine Generic

IsoCenter in [mm] 251.3 236.4 162.6

# Fractions 30

Type of optimization none

Stratification Levels 7

Plan Sequencing

Opt Target

Objects & constraints

VOI name	VOI type	OP	Function	p	Parameters
Core	OAR	2	Squared Overdosing	300	[g <sup>max</sup> ] 25
OuterTarget	TARG...	1	Squared Deviation	1000	[g <sup>ref</sup> ] 50
BODY	OAR	3	Squared Overdosing	100	[g <sup>max</sup> ] 30
Core					

Visualization

Plane Selection axial

Display option no option available

Plot options: plot CT, plot contour, plot isocenter, plot dose, plot isocenter labels, plot iso center, visualize plan/ beams

Viewing

axial plane z = 162.5 [mm]

min value: -1000  
max 1040.

Get IsoDose Levels

Viewer Options

CT (#L)

Window Preset Custom

Window Center 20.2

Window Width 2.04e

Range -1000 1040

bone

Lock Settings

Dose opacity: 1

Structure Visibility

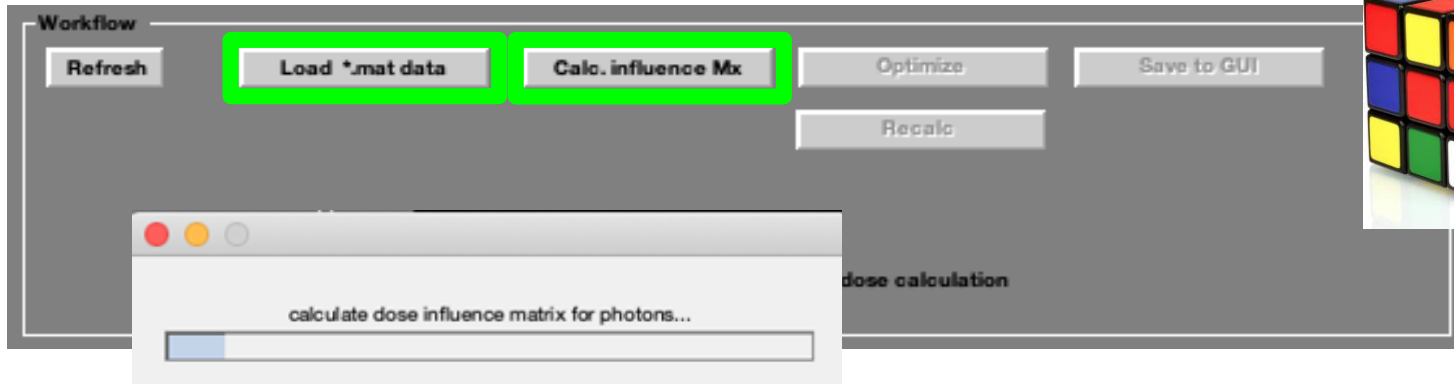
- Core
- OuterTarget
- BODY

Info

v3.0.0 - edu

github.com/e0404/matRad

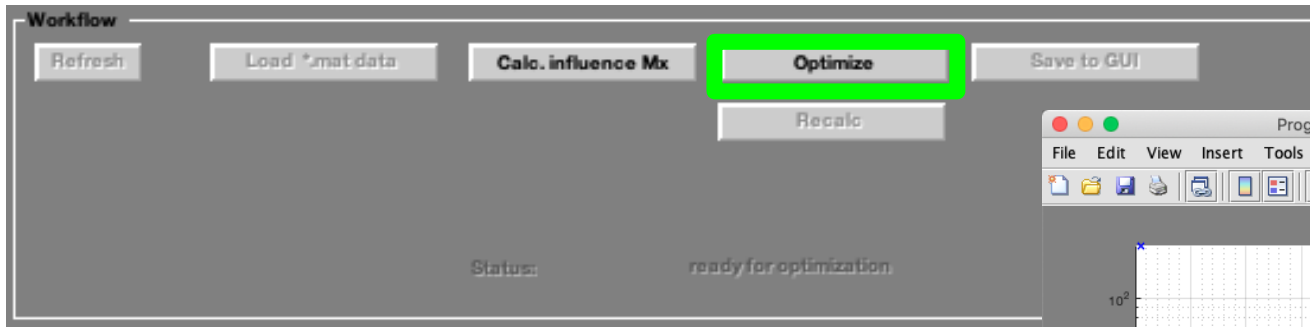
About



Load > This PC> WIN (C)> program files>matrad>application

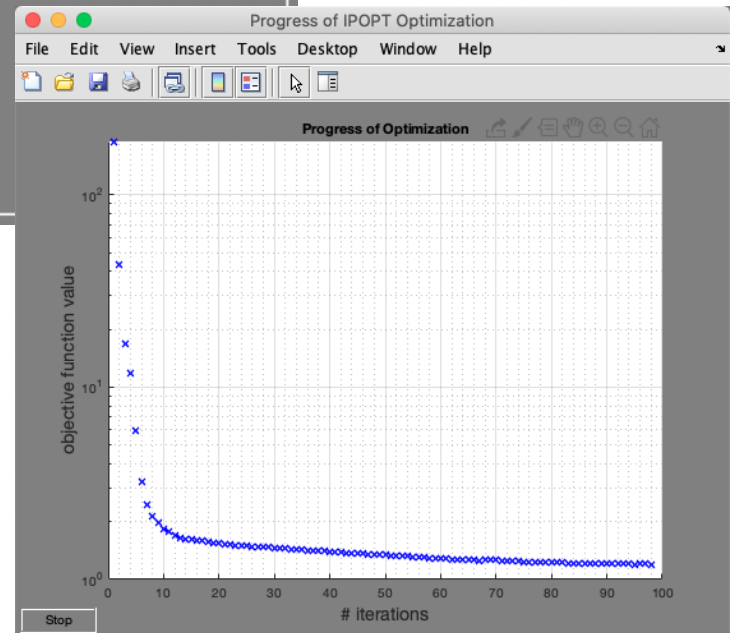
Load > My computer> (LOCAL DISK c)>program files>matrad>application

## Paneli: Workflow

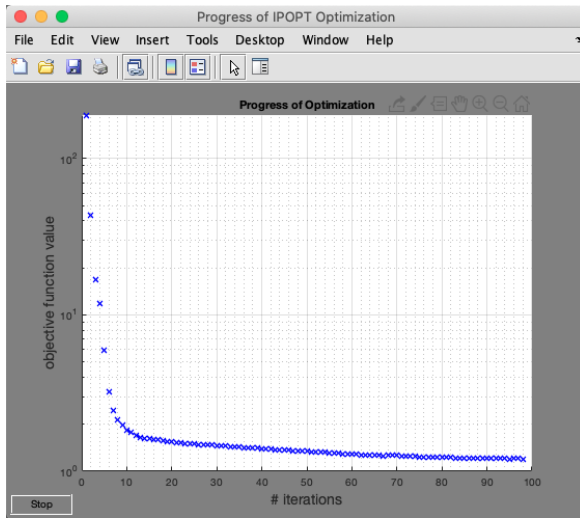


Këtu programi do të kërkojë fluksin e rrezatimit minimal per bixel

Here the program will look for the minimum radiation flux per bixel.



# Workflow – Shpërndarje eksponenciale



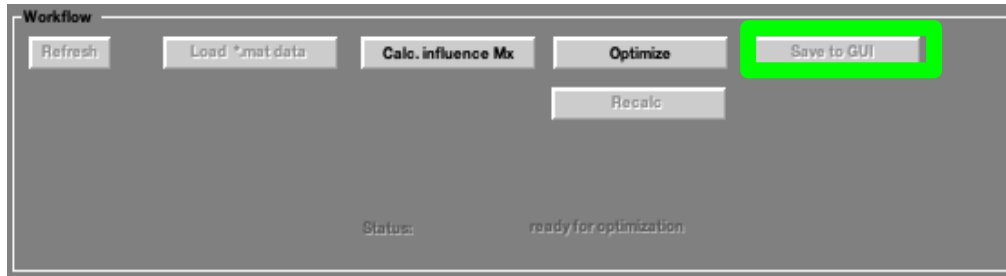
- The optimizer optimizes a non-linear constrained optimization problem with an interior-point algorithm. The objective function and constraint functions are built from the specific objectives one can set in the table.

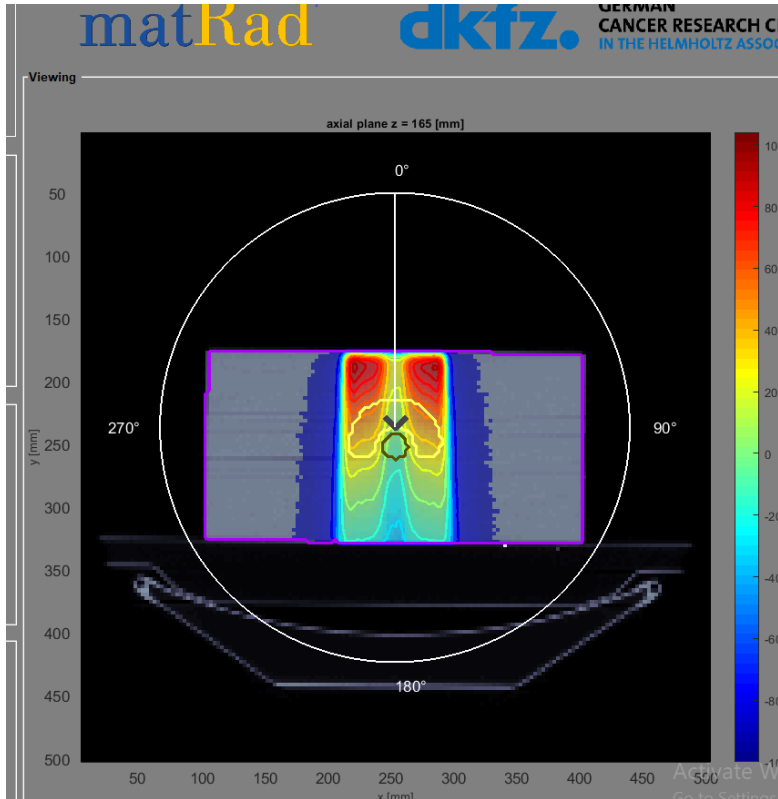
Objectives & constraints						
+/-	VOI name	VOI type	OP	Function	p	Parameters
-	Core	OAR	2	Squared Overdosing	300	$d^{\max}$ , 25
-	OuterTarget	TAR...	1	Squared Deviation	1000	$d^{\text{ref}}$ , 50
-	BODY	OAR	3	Squared Overdosing	100	$d^{\max}$ , 30
+	Core					

Objectives and constraints include the organs of interest (e.g target), as well as the organs at risk (e.g body, core etc.) that are about to be irradiated and also, we want to avoid obtaining more dose.

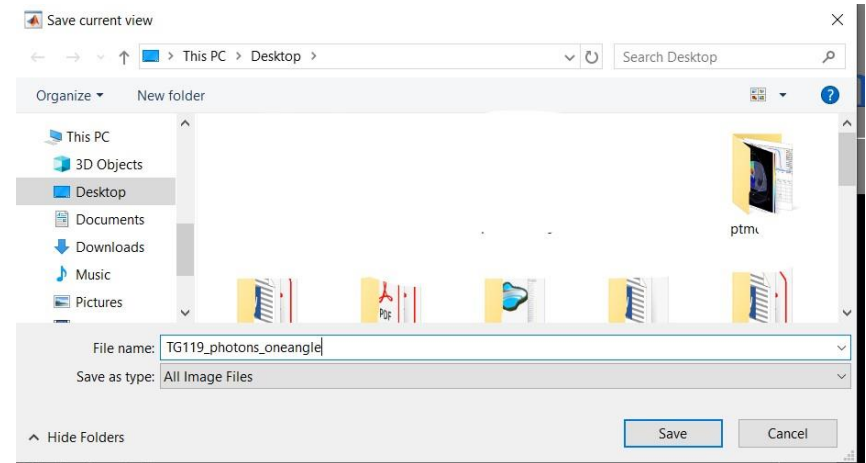
## Workflow: Save to GUI

Kjo komand ruan set-up e krijuar dhe kërkon që ti vendosësh një emër.  
Zakonisht emrin e fantomës, llojin e rrezatimit dhe numrin e këndeve.  
Psh. TG119\_Photons\_oneangle  
Ky hap është i rëndësishëm për shfaqjen e DVH.





matRadGUI





Show DVH/QI: tregon dose-volume histogram që i korrespondojnë planit që krijon.

Visualization

Slice Selection

Beam Selection

Offset

Type of plot: intensity

Plane Selection: axial

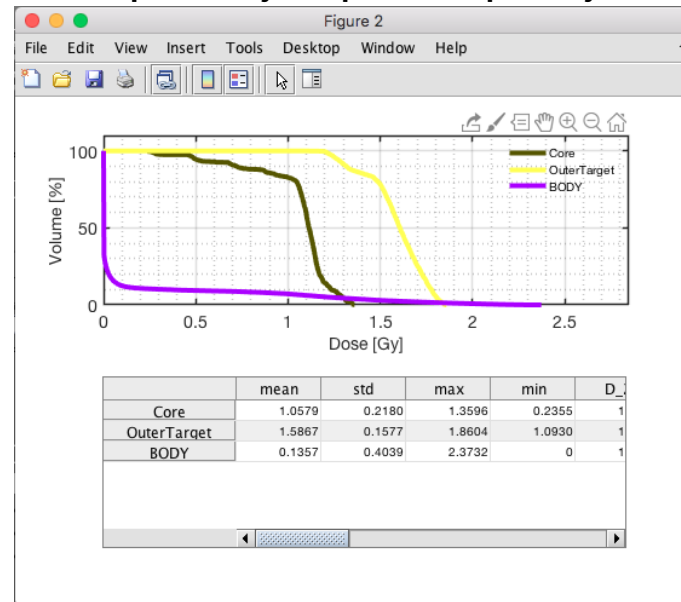
Display option: physicalDose

GoTo: lateral

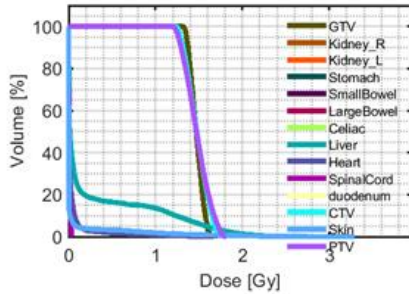
Open 3D-View

Show DVH/QI

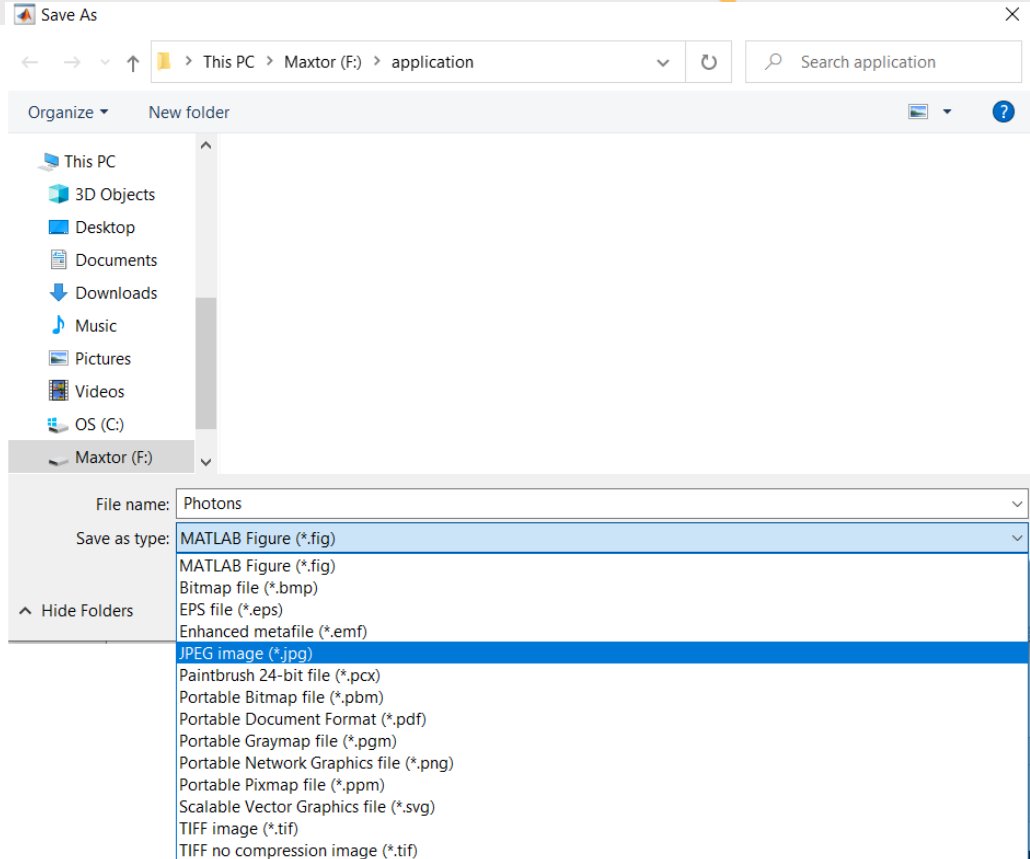
- plot CT
- plot contour
- plot isolines
- plot dose
- plot isolines labels
- plot iso center
- visualize plan / beams



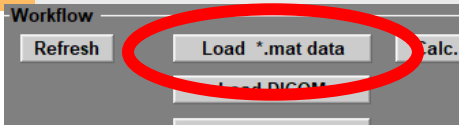
# DVH për çdo rast studimi



	max	min	mean
GTV	1.6394	1.3173	1.4714
Kidney_R	0	0	0
Kidney_L	0	0	0
Stomach	0	0	0
SmallBowel	0	0	0
LargeBowel	0	0	0
Celiac	0	0	0
Liver	2.6394	0	0.2547
Heart	1.6706	0	0.0370
SpinalCord	0.0383	0	0.0053
duodenum	0	0	0



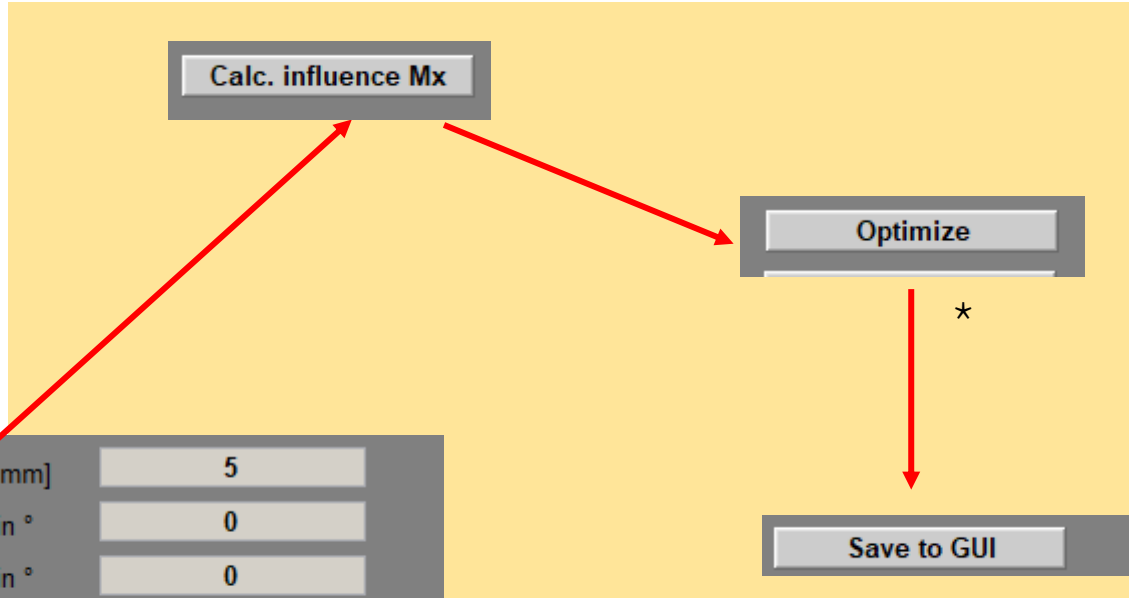
# Përmbledhje e proceseve



Zgjedhni një rast studimi

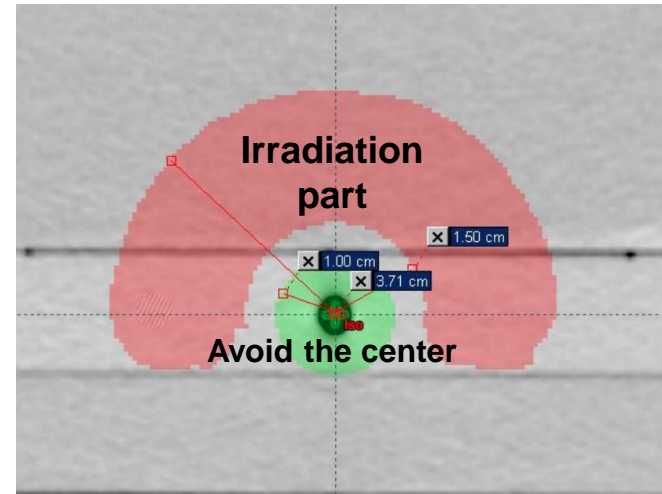
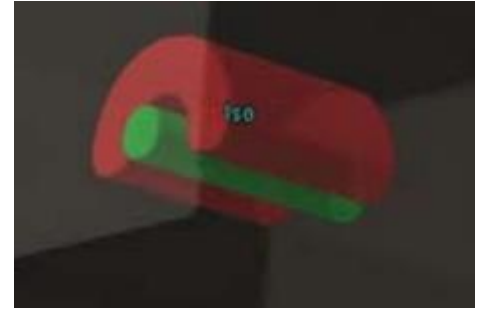
Vendosni parametrat (këndet, llojin e grimcave të rrezatimit

bixel width in [mm]	5
Gantry Angle in °	0
Couch Angle in °	0
Radiation Mode	photons
Machine	Generic
IsoCenter in [mm]	263.3 265.9 124

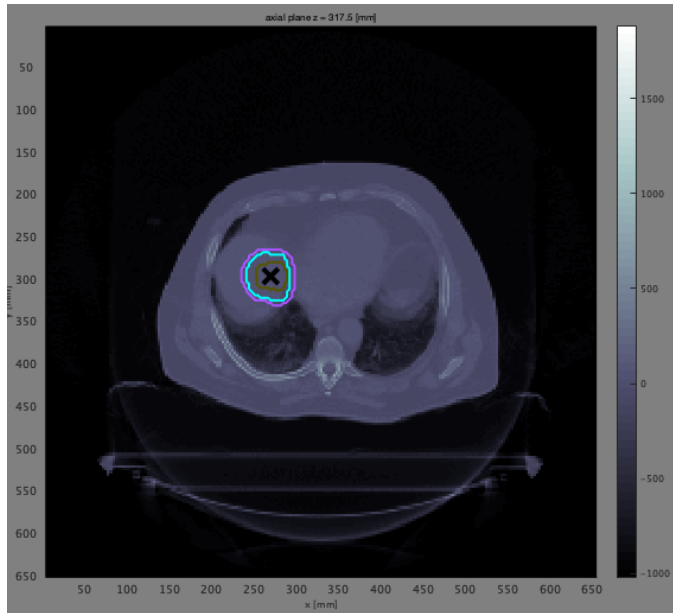


Repeat every time you change a setting

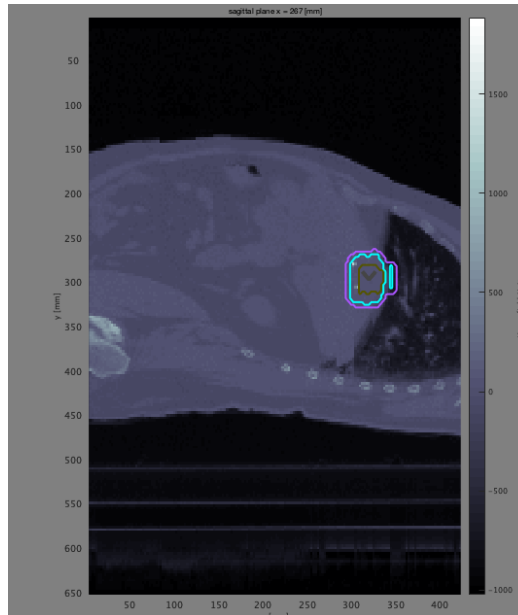
- Fantoma TG119 apo fantoma C përdoret nga profesionistë për të verifikuar të paisjet funksionojnë siç duhet. Kanë formë dhe dimensione standarde.
- Qëllimi i përdorimit është rrezatimi i zonës në formë “C” dhe evitimi i zones qendrore



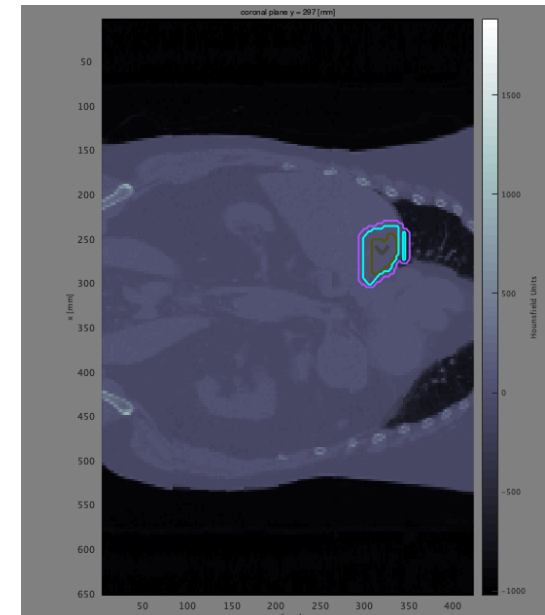
# Liver case



Axial  
view

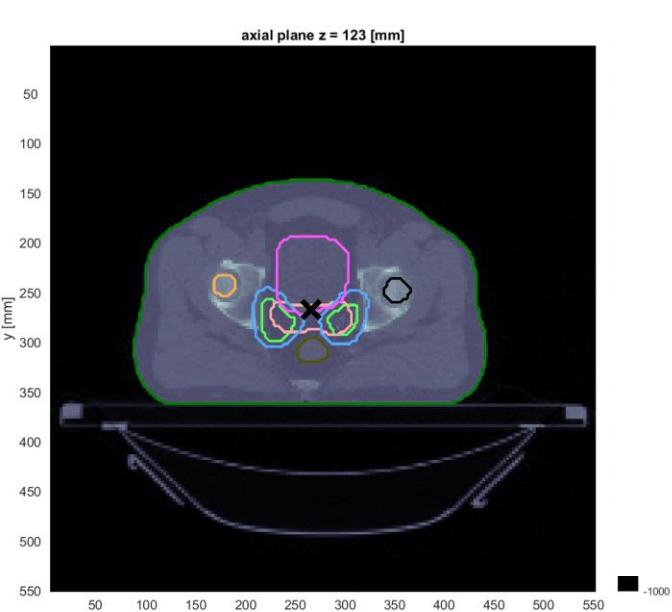


Sagittal  
view

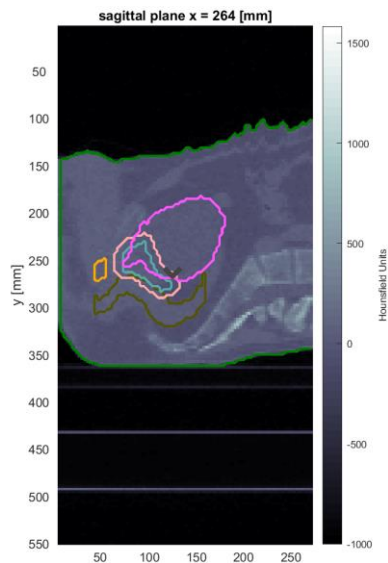


Coronal  
view

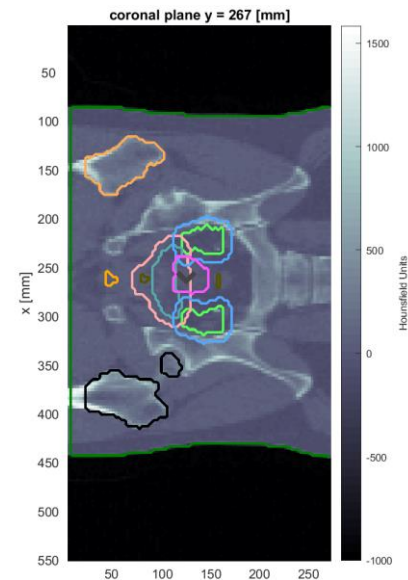
# Prostate case



Axial  
view

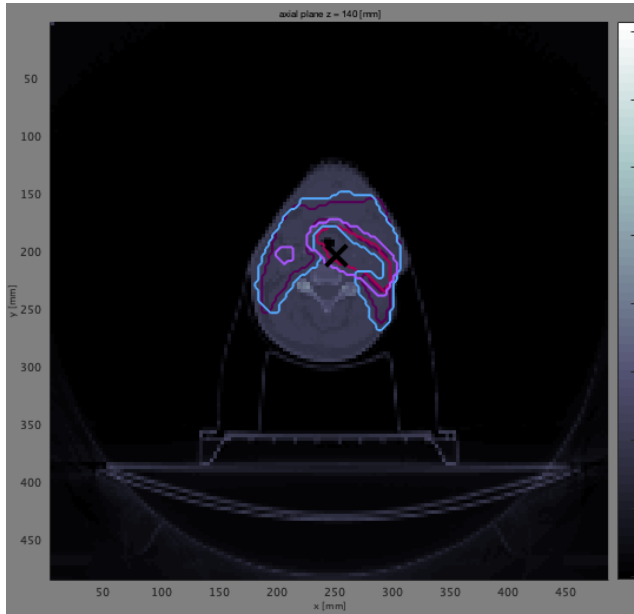


Sagittal  
view

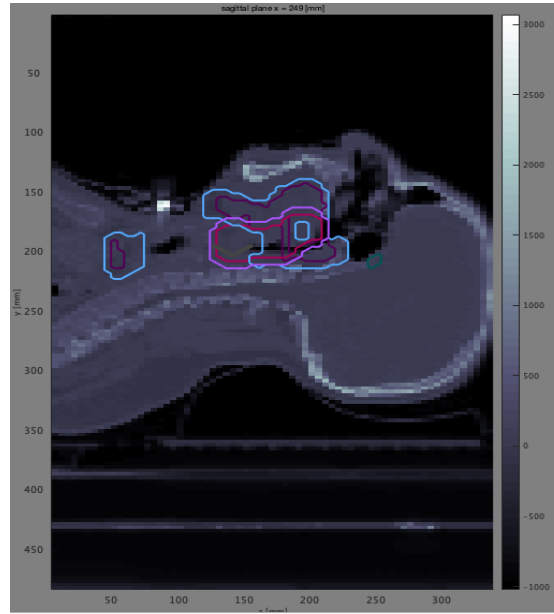


Coronal  
view

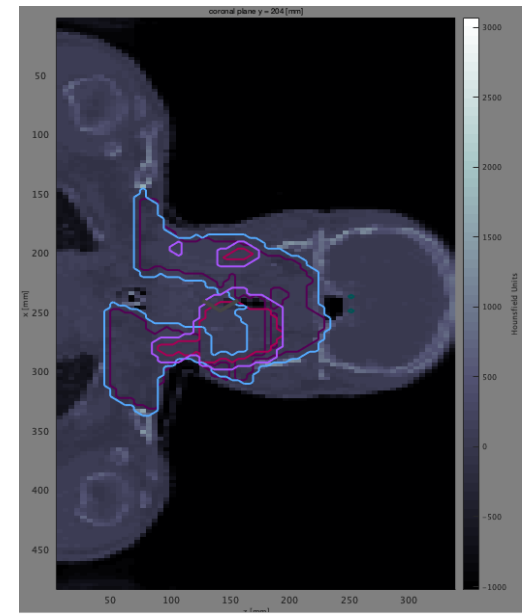
# Head & Neck case



Axial  
view



Sagittal  
view



Coronal  
view