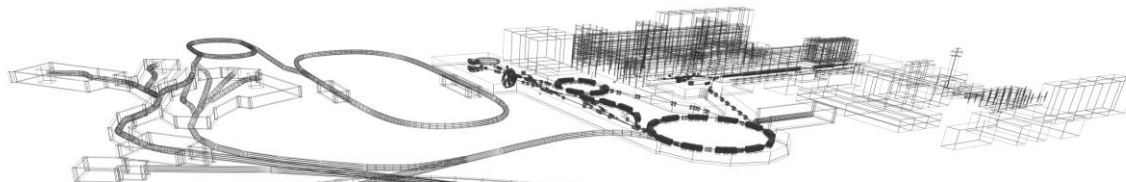
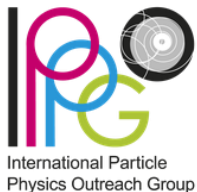


# Particle Therapy MasterClass



## Çfarë është matRad?

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Slides by:  
Aris Mamaras  
Viridiana Badillo  
Enrique Sánchez  
Yiota Foka

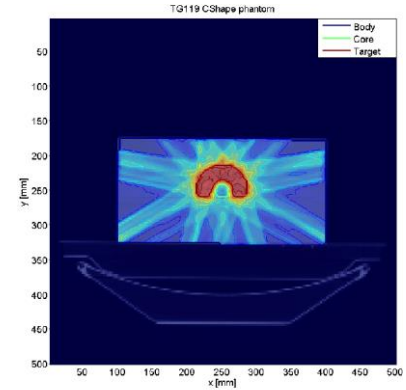
# matRad

matlab + radiation = matRad

- Open source software toolkit for radiation treatment planning of intensity modulated photon, proton and carbon ion therapy
- Implemented for educational and research purposes

# Pse bazohet në Matlab?

- User friendly and easy data visualization functionalities
- Convenient debugging
- Allows for rapid prototype developments
- Well known tool in the medical physics community
- Simple syntax compared to higher abstract programming languages like C++
- Standalone (matRad.exe) can be used without license
- An open source independent development environment (IDE) is given by octave



## 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



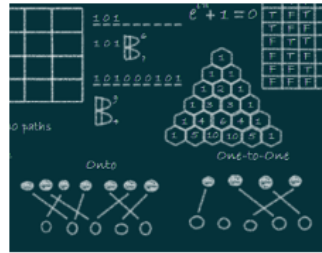
Universität  
Zürich<sup>UZH</sup>

# Si ndodh procesimi i të dhënave?

INPUT



STORAGE OF VARIABLES THROUGH DATA STRUCTURES



PROCESSING

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

$$f = \sum_i p_i f_i$$

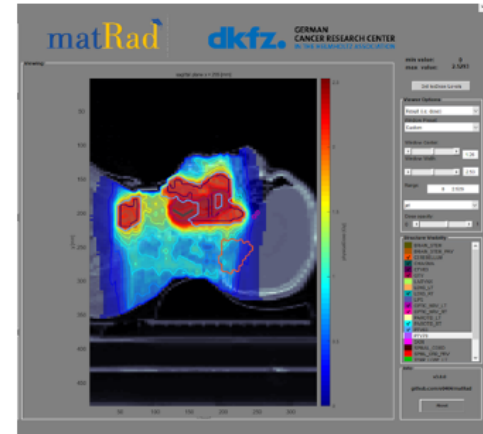
$$s. t. \quad d = Dw$$

$$c_l \leq c(w) \leq c_u$$

$$w_l \leq w \leq w_u$$

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

RESULTS STORAGE AND VISUAL PROCESSING



PROCEDURE

# Interfaqja grafike e matRad



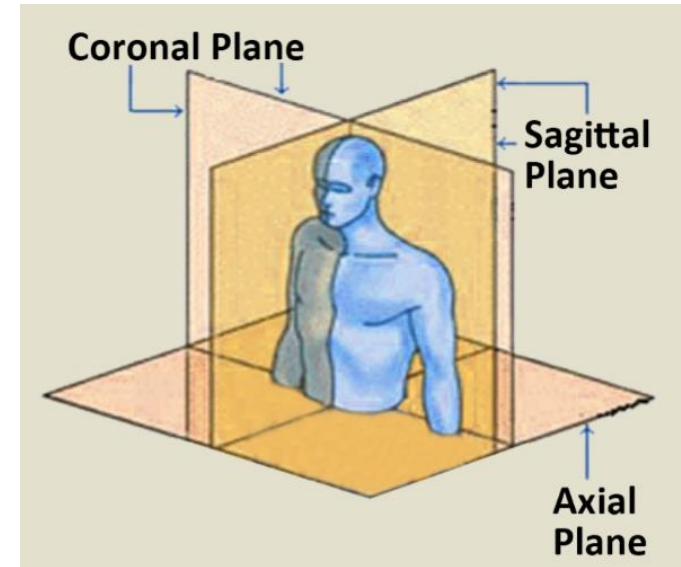
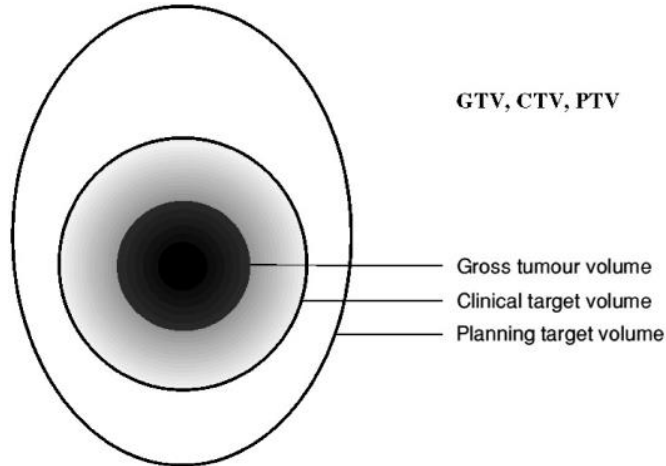
The image displays the matRad GUI interface, which is used for radiation therapy planning. The interface is divided into several sections:

- Workflow:** Contains buttons for Refresh, Load \*.mat data, Calc. influence Mx, Optimize, Save to GUI, Load DICOM, Recalc, Export, Import from Binary, and Import Dose.
- Plan:** Includes input fields for beam width, gantry and couch angles, rotation mode, machine, isocenter, and number of fractions. It also has radio buttons for MC simulation, 3D conformal, and RAI-sequencing, and a checkbox for RAI-Direct Aperture Optimization.
- Objectives & constraints:** A table listing objectives and constraints for the plan.
- Visualization:** A 3D view showing the radiation dose distribution in a cross-section of a patient's head and neck. A color scale on the right indicates the dose in Gy, ranging from 0.2 to 1.6.
- Viewer Options:** A panel on the right for adjusting the viewer settings, including window/level, window center, window width, range, dose quality, and window/level validity.

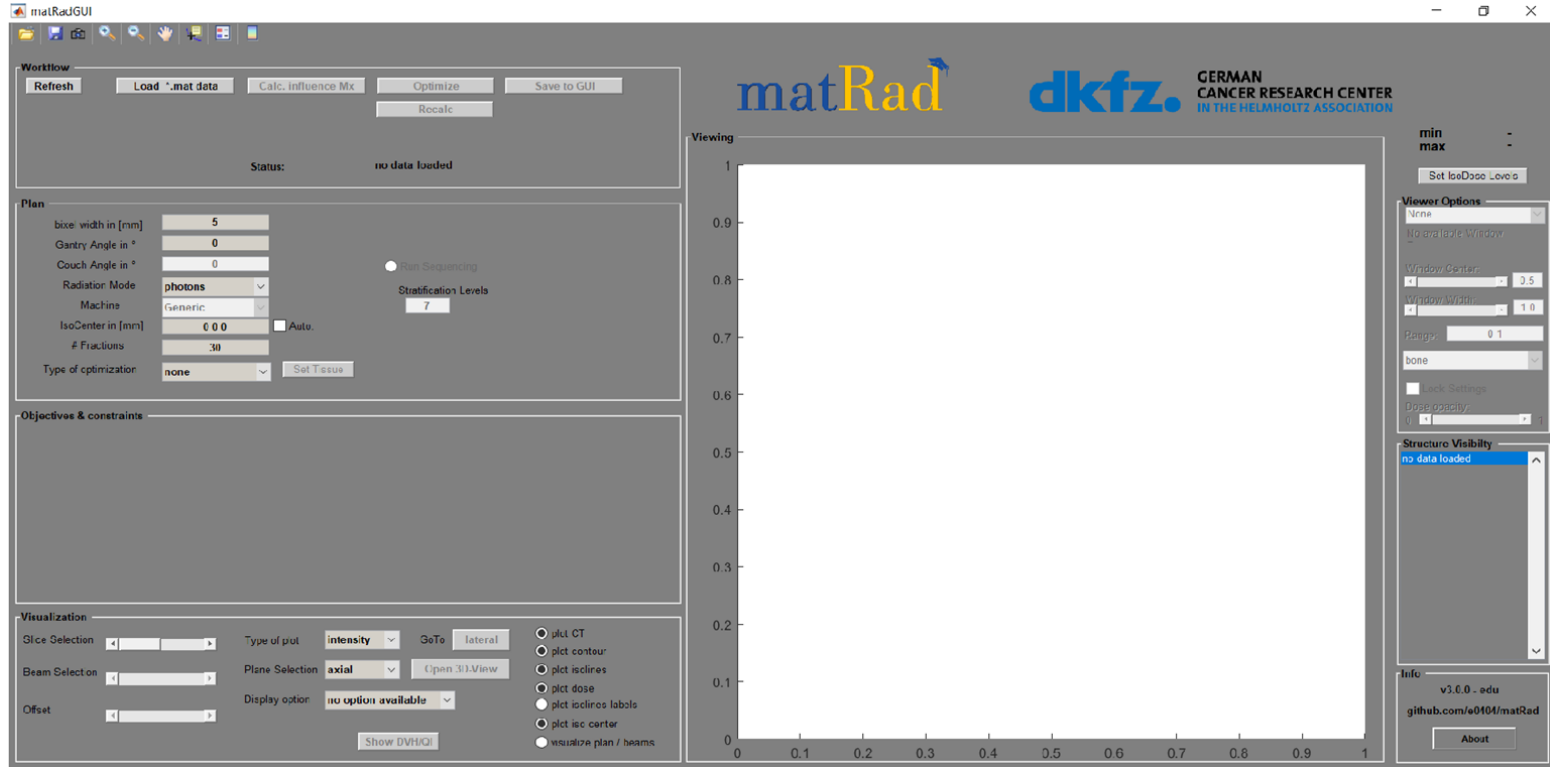
VOI name	VOI type	prio...	obj. / const.	penalty	dose	EUD	vol.
1 Dose	DAI	2	square overloading	300	28	NaN	
2 OvaryTarget	TARGET	1	square deviation	1000	50	NaN	
3 BODY	DAI	3	square overloading	100	30	NaN	

Mund të përdoret me Matlab ose me matRad GUI

- Paketa e instalimit të programit vjen bashkë me 3 raste studimi:
  - TG 119 ose fantoma C
  - Liver
  - Head & Neck (H&N)



# Nisja e programit



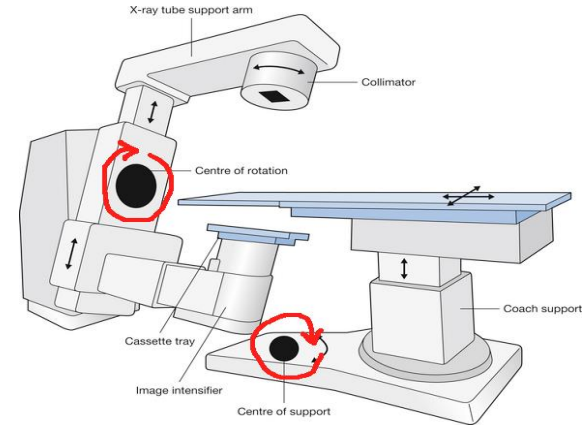
The screenshot displays the matRad GUI interface, which is used for configuring and visualizing radiation therapy plans. The interface is divided into several functional areas:

- Workflow:** Contains buttons for Refresh, Load \*.mat data, Calc. influence Mx, Optimize, Save to GUI, and Recalc.
- Status:** Displays the current state, which is "no data loaded".
- Plan:** A configuration panel with various parameters:
  - bice width in [mm]: 5
  - Gantry Angle in °: 0
  - Couch Angle in °: 0
  - Radiation Mode: photons
  - Machins: Generic
  - IsoCenter in [mm]: 0 0 0 (with an Auto checkbox)
  - # Fractions: 30
  - Type of optimization: none (with a Set Tissue button)
  - Run Sequencing:  (selected)
  - Stratification Levels: 7
- Objectives & constraints:** An empty section for defining optimization goals.
- Visualization:** Controls for how the data is displayed:
  - Slice Selection:
  - Beam Selection:
  - Offset:
  - Type of plot: intensity
  - Plane Selection: axial
  - Display option: no option available
  - GoTo: lateral
  - Open 3D View:
  - Show DVH/QI:
  - Radio buttons for visualization:  plot CT,  plot contour,  plot isodines,  plot dose,  plot isodines labels,  plot iso center,  visualize plan / beams
- Viewing:** A central plot area with axes ranging from 0 to 1. It is currently empty.
- min max:** A section for setting the range of the plot, with a Set IsoDose Level button.
- Viewer Options:** A panel for adjusting the view:
  - View: none
  - Window Center: 3.5
  - Window Width: 1.0
  - Range: 0.1
  - bone:
  - Dark Settings:
  - Display opacity: 1
- Structure Visibility:** A list showing "no data loaded".
- Info:** Displays version information: v3.0.0 - edu, github.com/e0104/matRad, and an About button.



## 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 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

GERMAN  
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

**Objectives & 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 CT  
plot contour  
plot isolines  
plot dose  
plot isolines 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

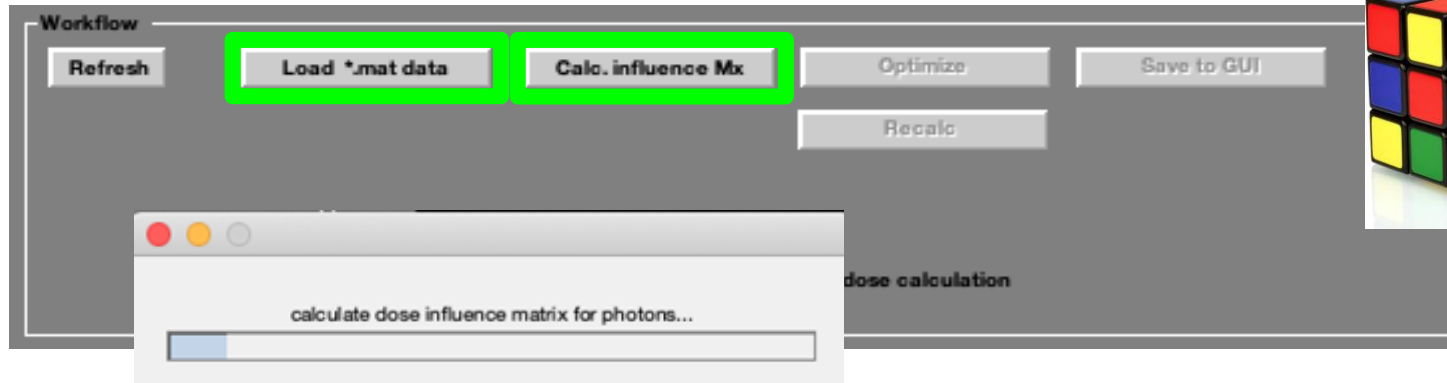
**Structure Visibility**

Core  
OuterTarget  
BODY

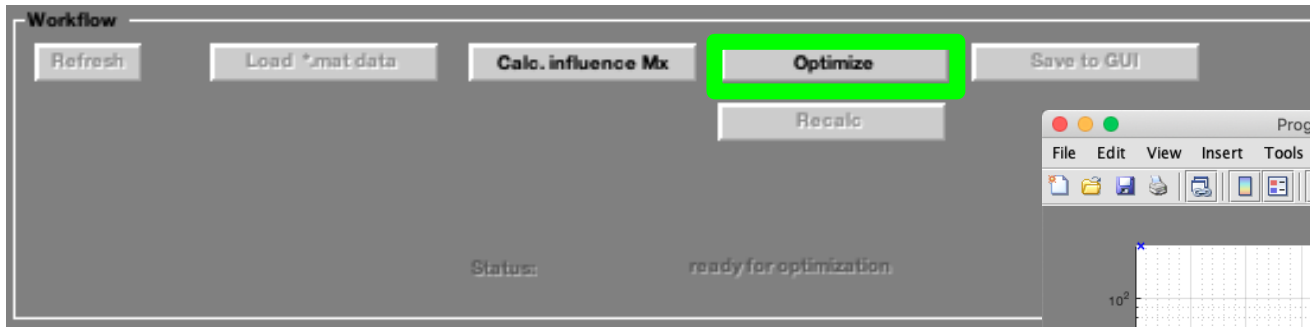
Info

v3.0.0 - edu  
github.com/e040/matRad

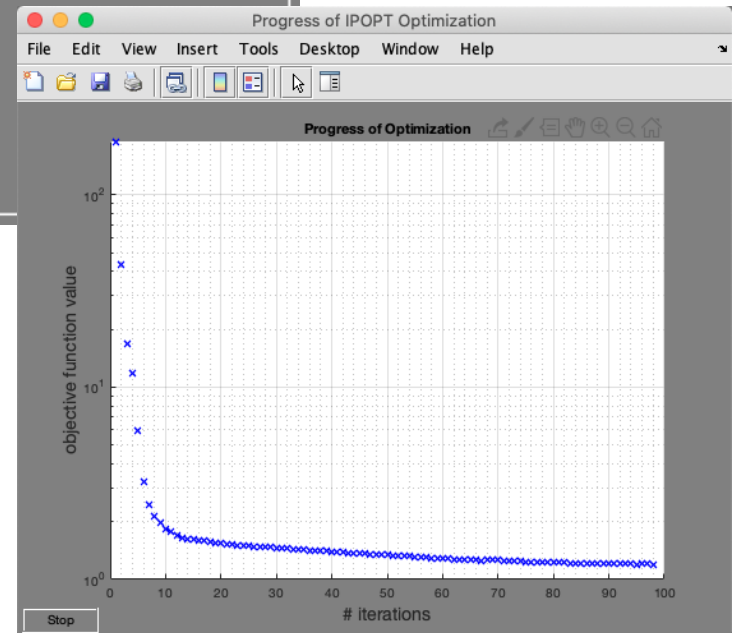
About

A screenshot of a software interface titled "Workflow". It contains several buttons: "Refresh", "Load \*.mat data", "Calc. influence Mx", "Optimize", "Recalc", and "Save to GUI". The "Load \*.mat data" and "Calc. influence Mx" buttons are highlighted with a green border. Below the buttons is a progress bar window with the text "calculate dose influence matrix for photons..." and a partially filled blue progress bar. The text "dose calculation" is visible to the right of the progress bar. To the right of the main interface is a 3D rendering of a Rubik's cube.

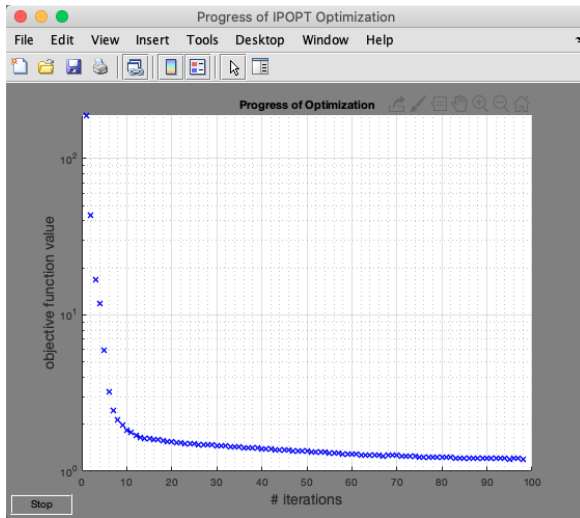
## Paneli: Workflow



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



# Workflow – exponential distribution



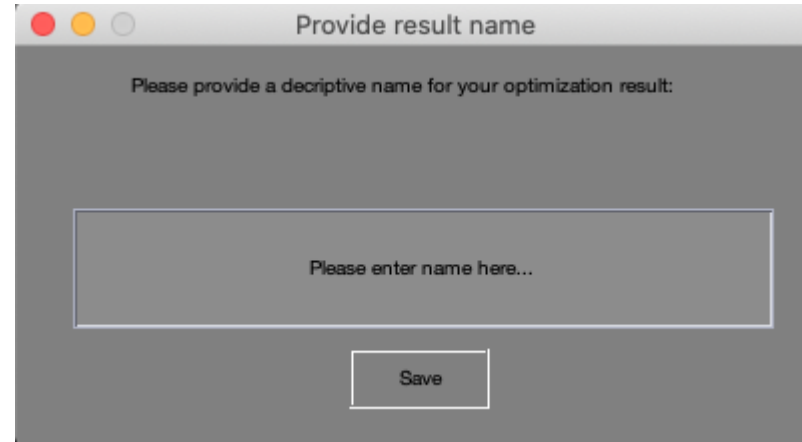
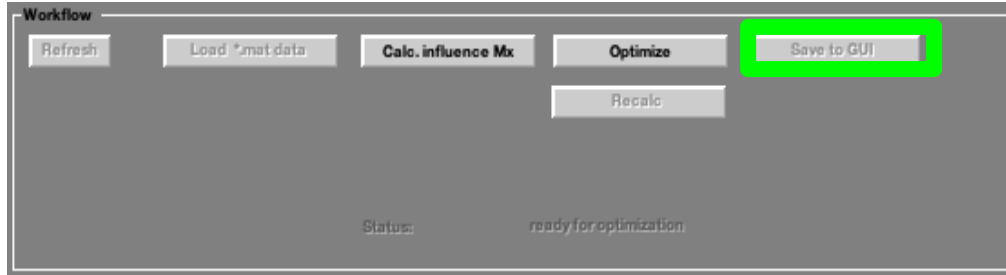
- The optimizer optimizes a non-linear constrained optimization problem with an interior-point algorithm. The objective function and constraint functions are built from the specific objectives one can set in the table.

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. Ky hap është i rëndësishëm për shfaqjen e DVH.



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

Visualization

Slice Selection: [Slider]

Beam Selection: [Slider]

Offset: [Slider]

Type of plot: intensity

Plane Selection: axial

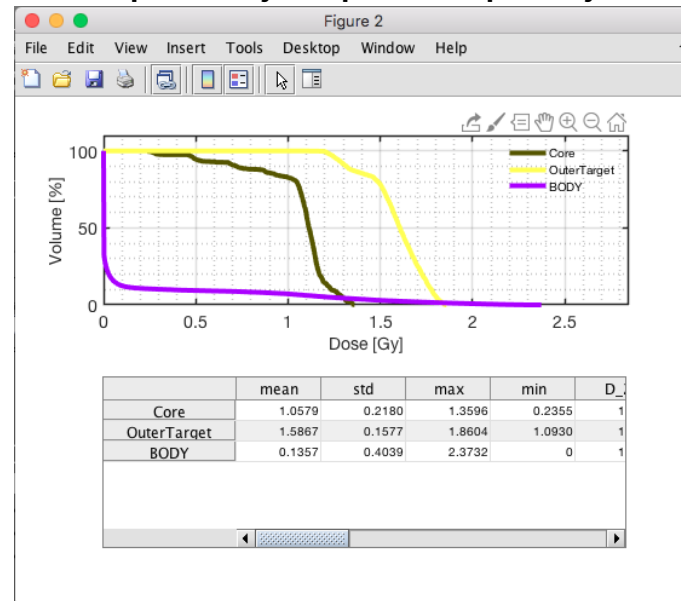
Display option: physicalDose

GoTo: lateral

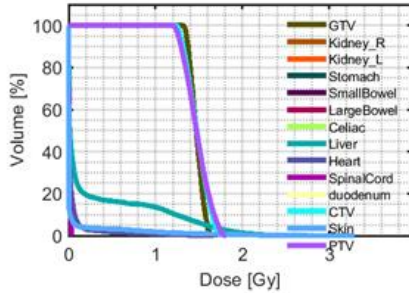
Open 3D-View

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

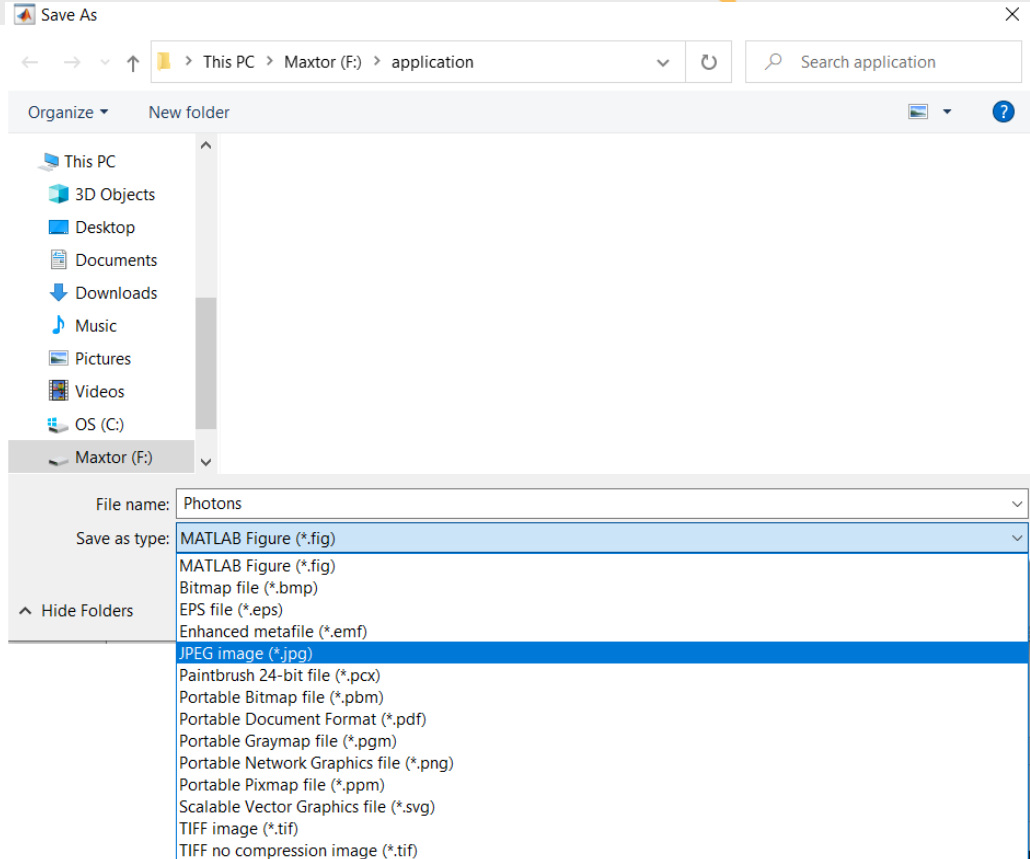
Show DVH/QI



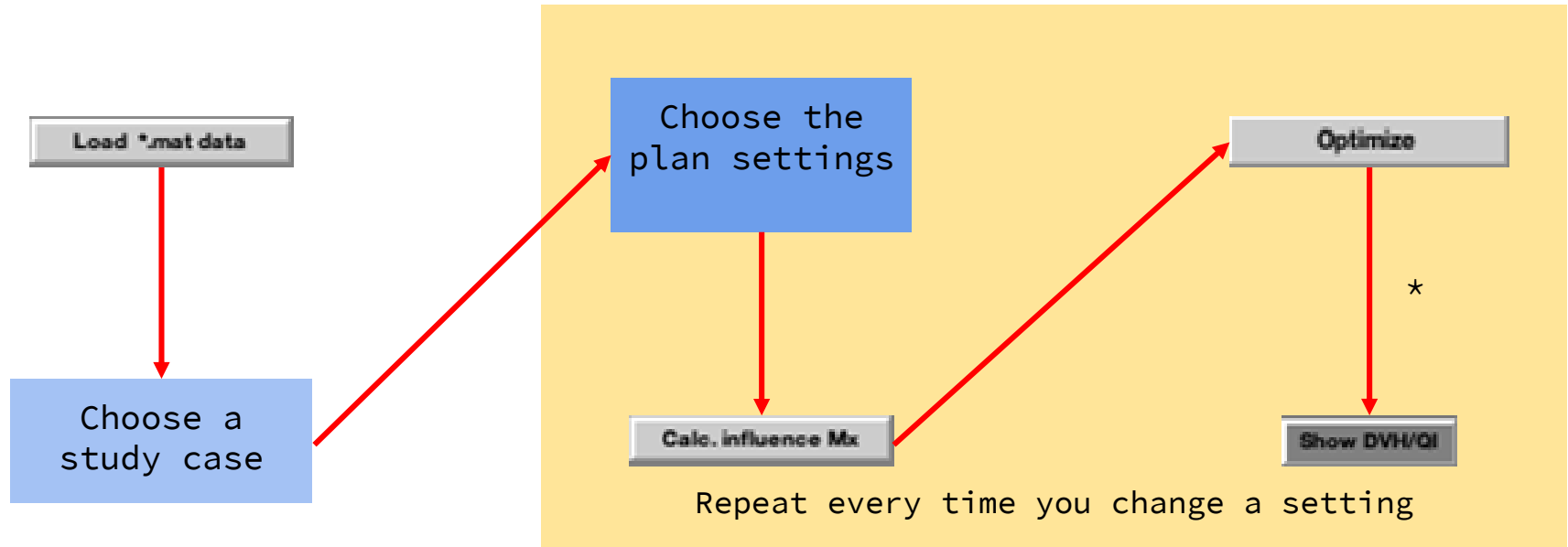
# DVH për çdo rast studimi



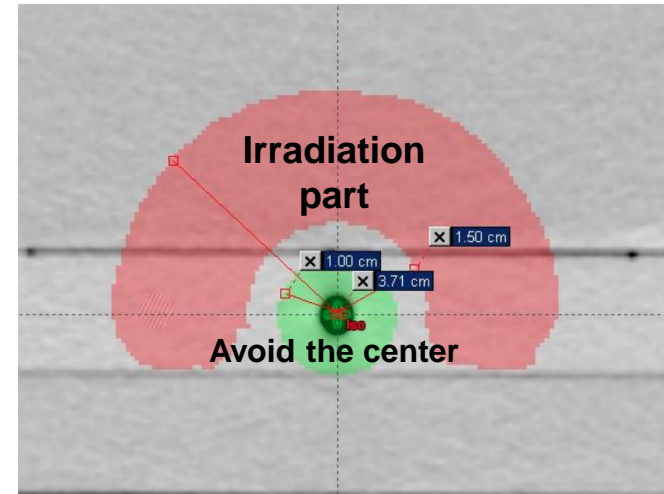
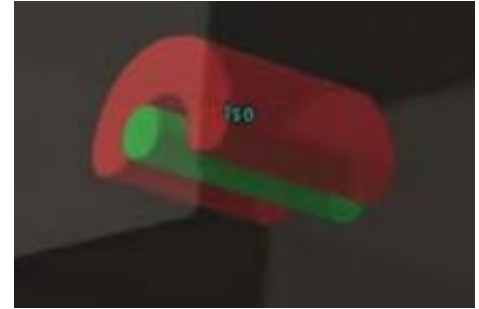
	max	min	mean
GTV	1.6394	1.3173	1.4714
Kidney_R	0	0	0
Kidney_L	0	0	0
Stomach	0	0	0
SmallBowel	0	0	0
LargeBowel	0	0	0
Celiac	0	0	0
Liver	2.6394	0	0.2547
Heart	1.6706	0	0.0370
SpinalCord	0.0383	0	0.0053
duodenum	0	0	0



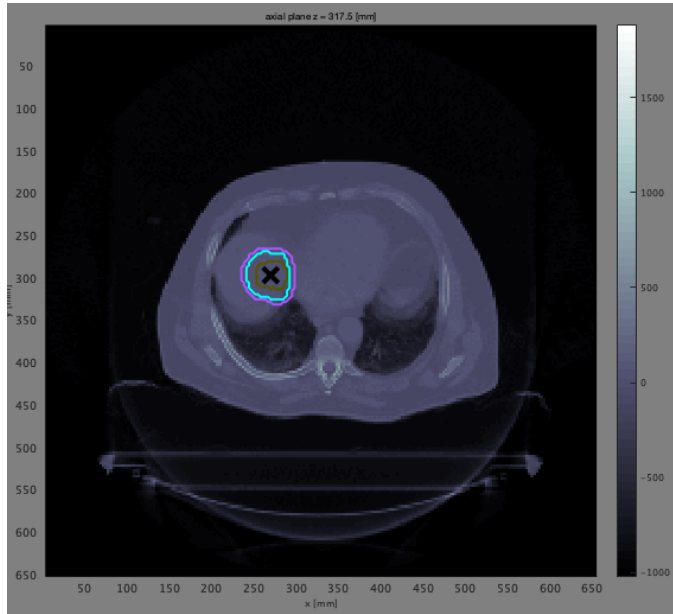




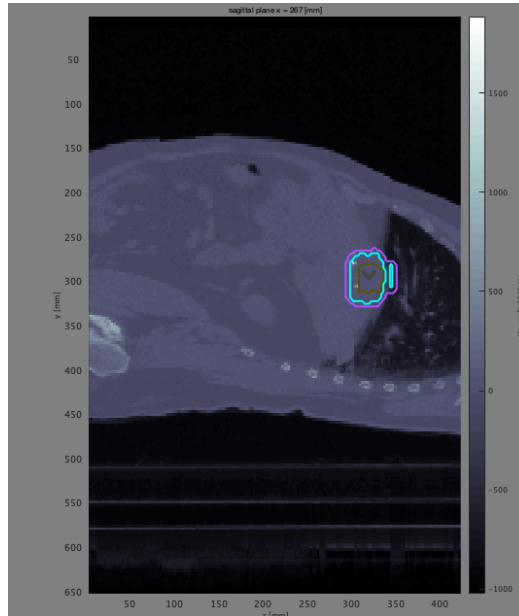
- Fantoma TG119 apo fantoma C përdoret nga profesionistë për të verifikuar të paisjet funksionojnë siç duhet. Kanë formë dhe dimensione standarte.
- Qëllimi i përdorimit është rrezatimi i zonës në formë “C” dhe evitimi i zones qendrore



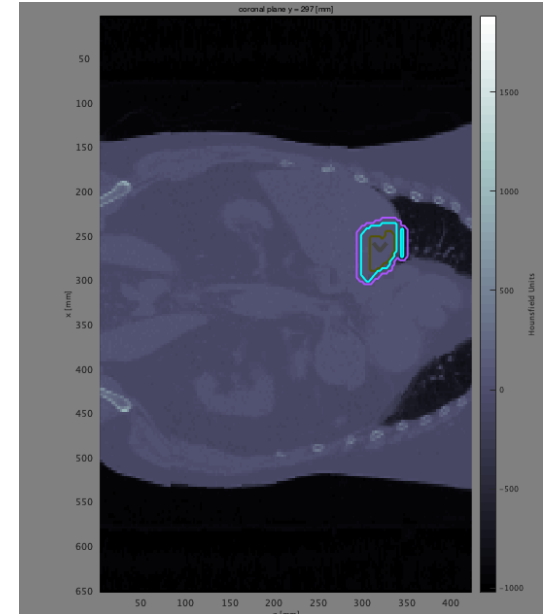
# Liver case



Axial  
view

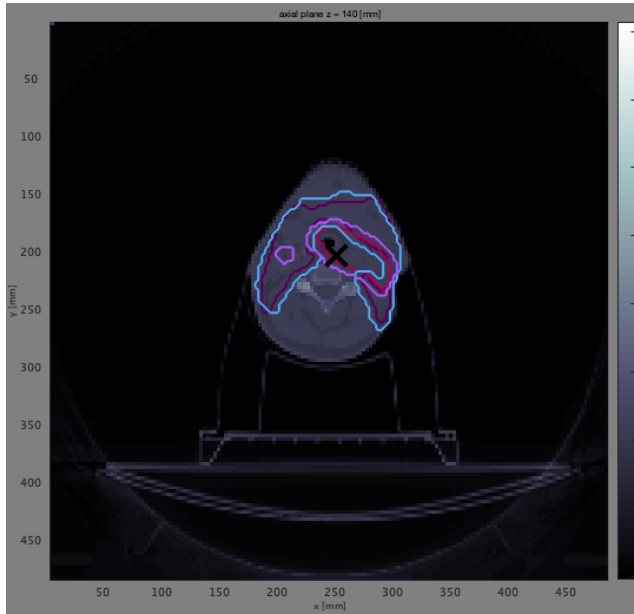


Sagittal  
view

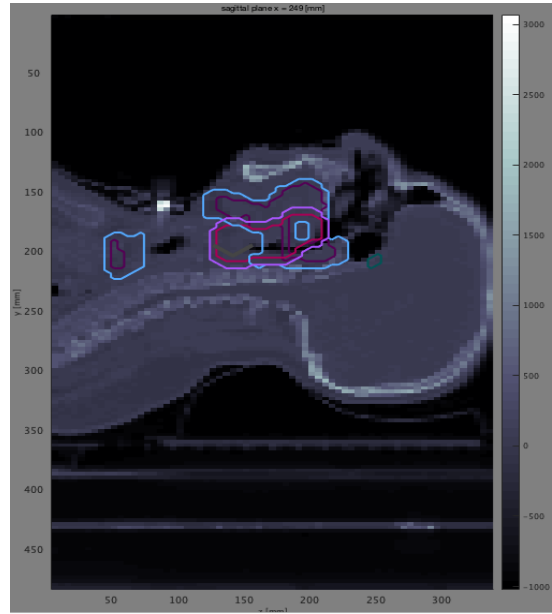


Coronal  
view

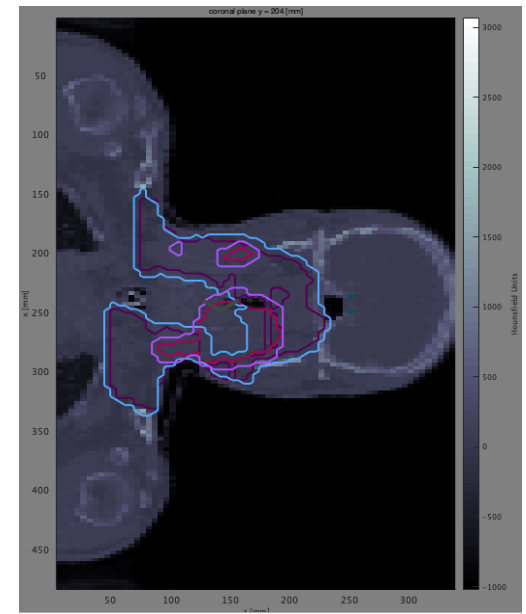
# Head & Neck case



Axial  
view



Sagittal  
view



Coronal  
view