

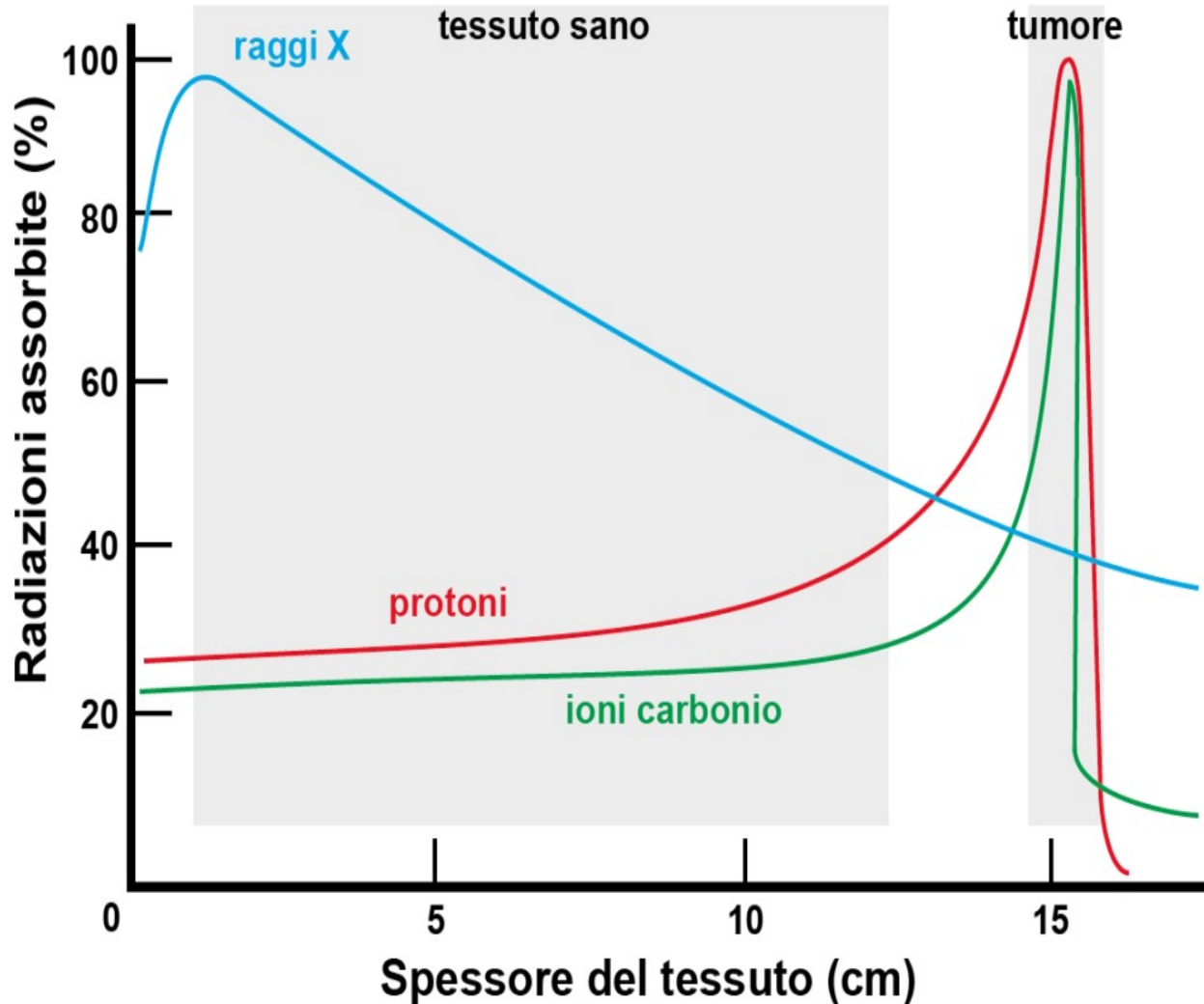
Particle Therapy MasterClass

matRad 

Preparazione all'analisi dati

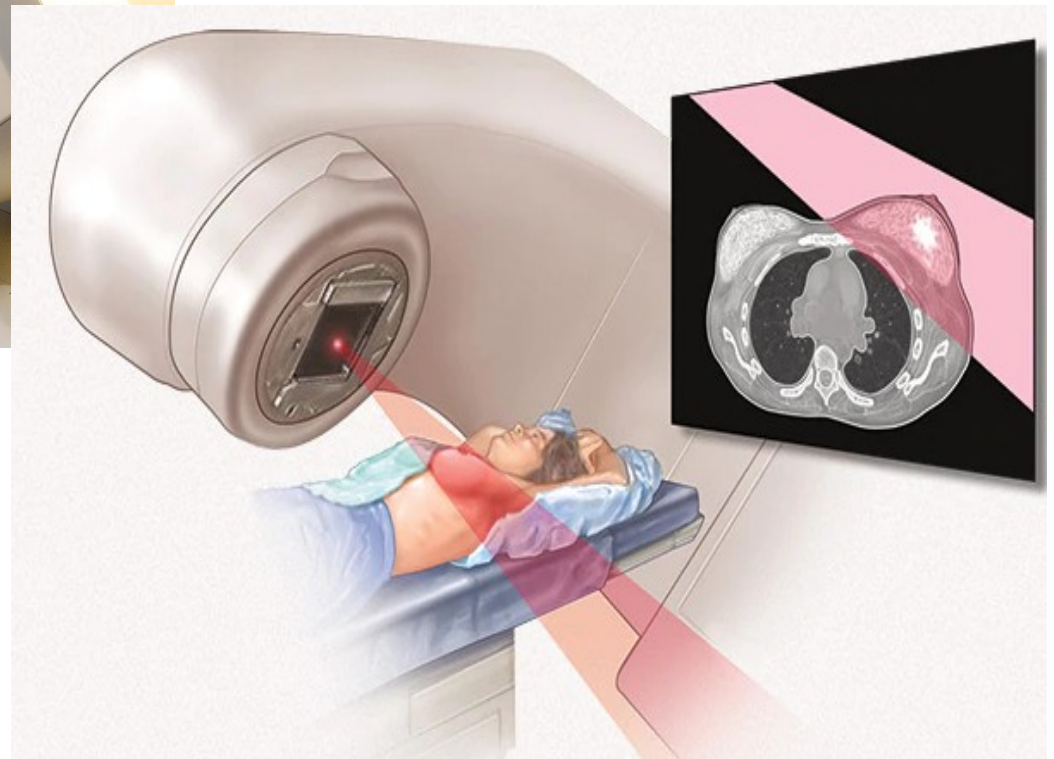
Antonietta Olivieri

Interazione radiazione - materia



- **Fotoni:** perdita di gran parte dell'energia in entrata (utile per tumori poco profondi)
- **Protoni:** picco pressoché stretto; caduta rapida di dose a valle del tumore
- **Ioni carbonio:** picco stretto e più selettivo; coda a valle del tumore

Radioterapia

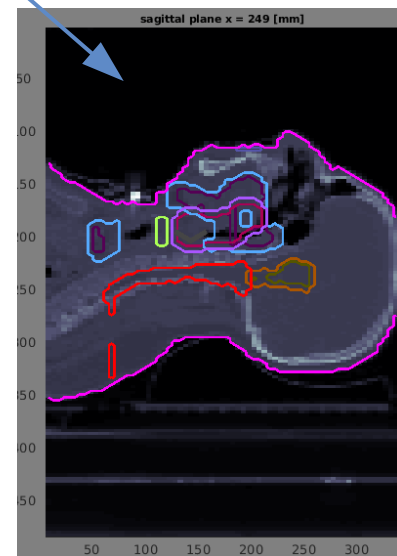
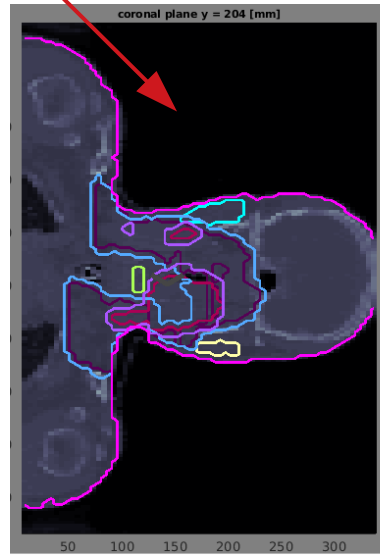
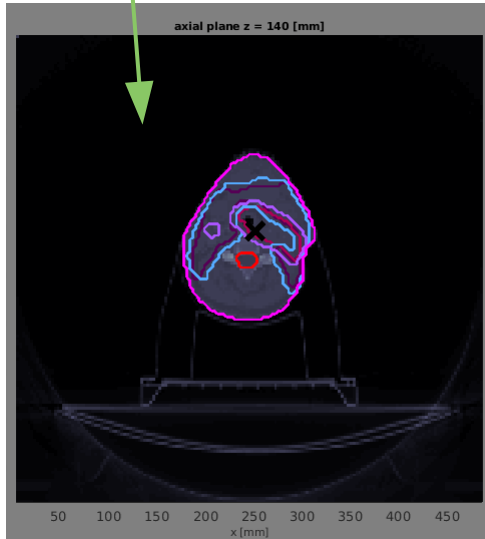
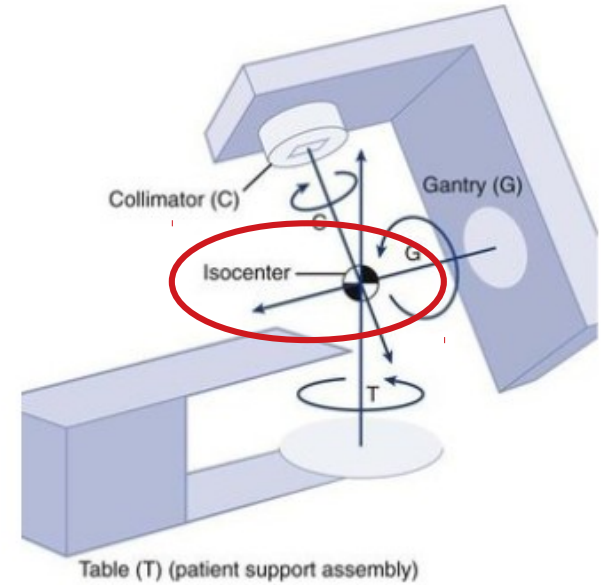
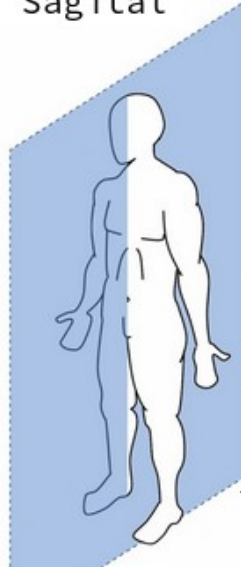
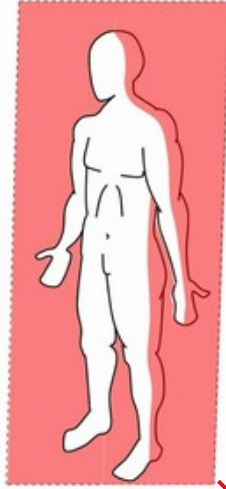
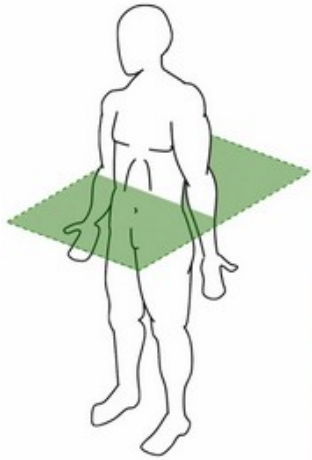


Definizioni: piani

Axial

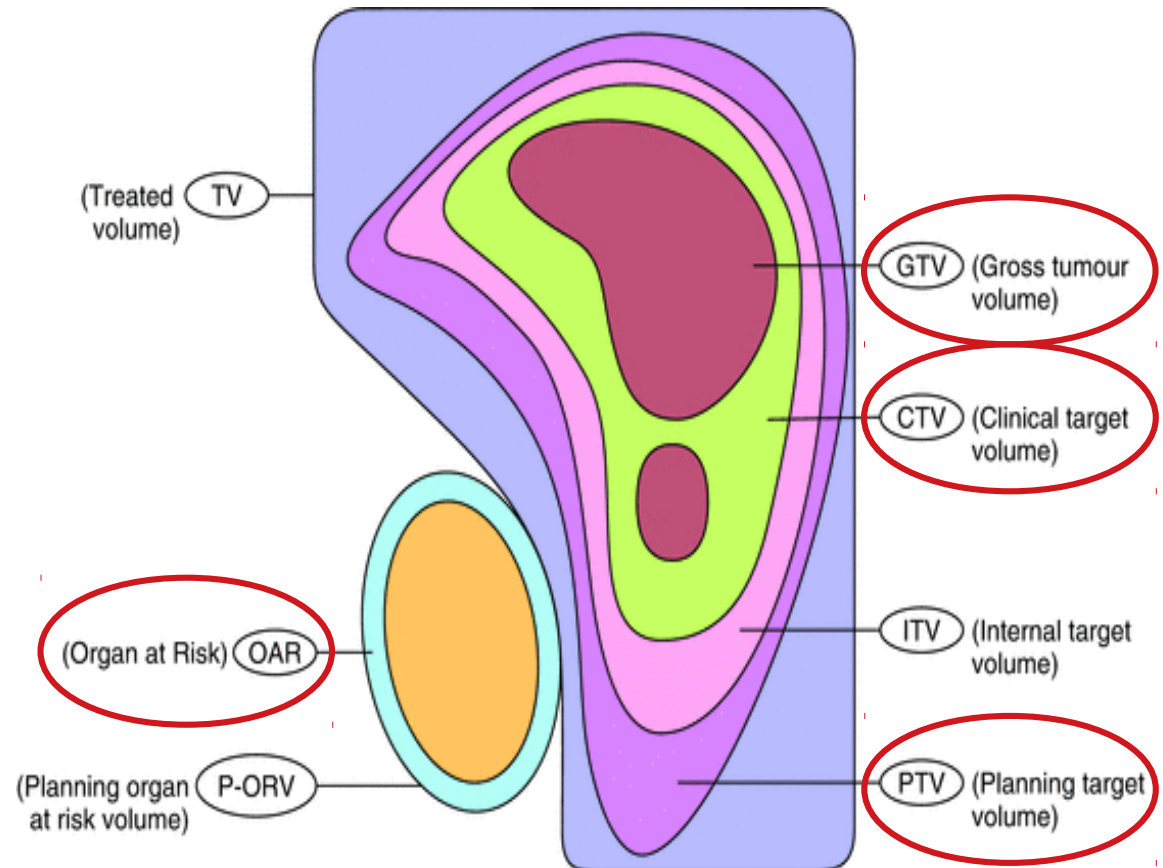
Coronal

Sagittal



Definizioni: volumi

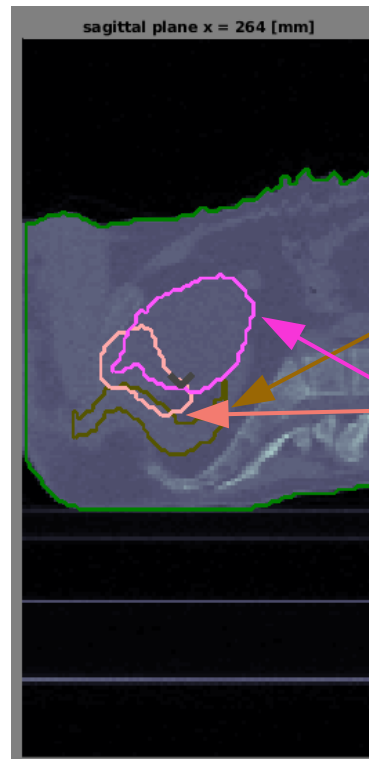
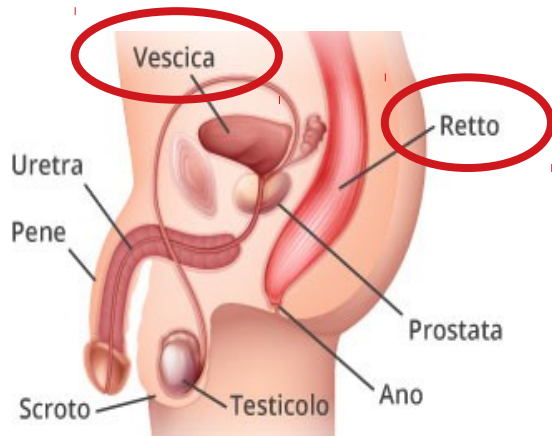
- **GTV**
Volume del tumore da trattare
- **CTV**
Margine all'interno del quale è contenuta l'area da trattare o ogni altro tessuto che si presume tumorale
- **PTV**
area da irradiare tenendo conto dei possibili movimenti del paziente
- **OAR**
organi sani a rischio irradiazione



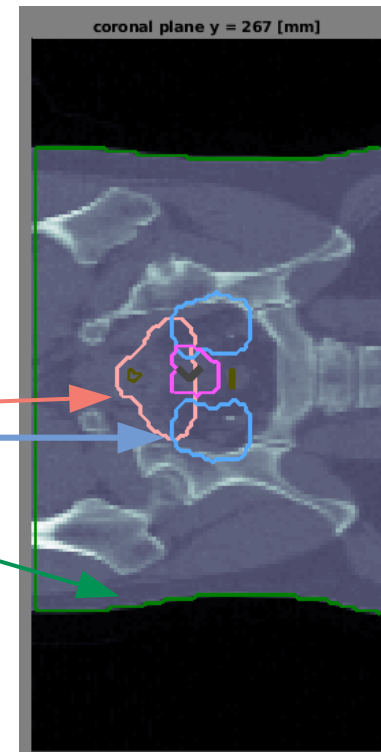
Organi a rischio: il caso della prostata

La prostata è una ghiandola che fa parte dell'apparato genitale maschile dei mammiferi

OAR: vescica e retto sono tra gli organi a rischio facilmente danneggiabili



Structure Visibility	
<input checked="" type="checkbox"/>	Rectum
<input checked="" type="checkbox"/>	Penile_bulb
<input checked="" type="checkbox"/>	Lymph_Nodes
<input checked="" type="checkbox"/>	Rt femoral he
<input checked="" type="checkbox"/>	prostate_bed
<input checked="" type="checkbox"/>	PTV_68
<input checked="" type="checkbox"/>	PTV_56
<input checked="" type="checkbox"/>	Bladder
<input checked="" type="checkbox"/>	BODY

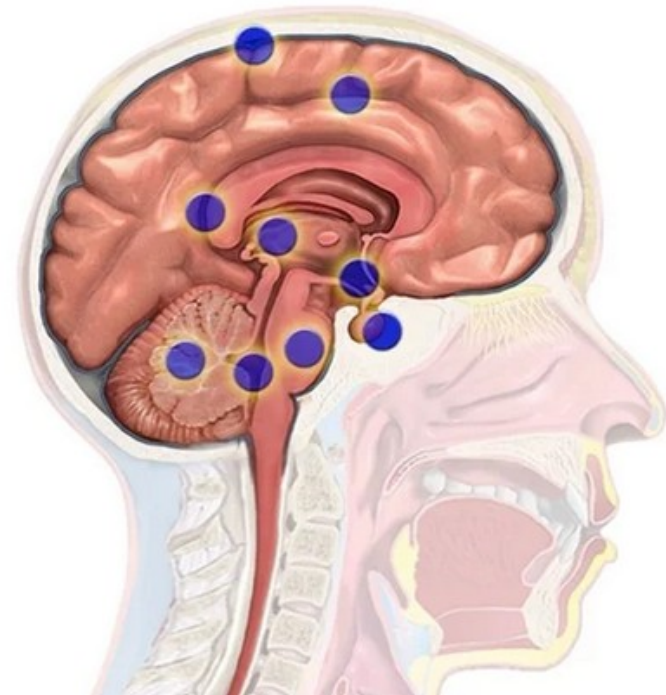
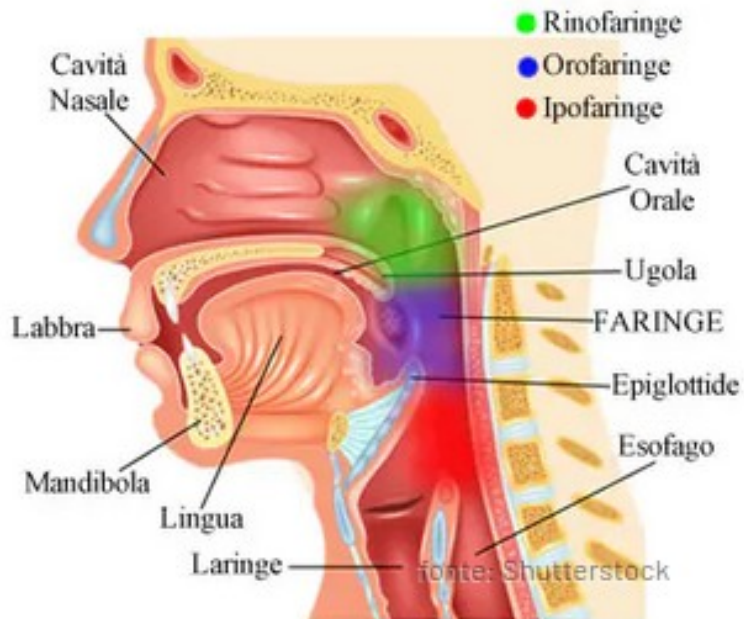


L'importanza di diversi punti di vista...

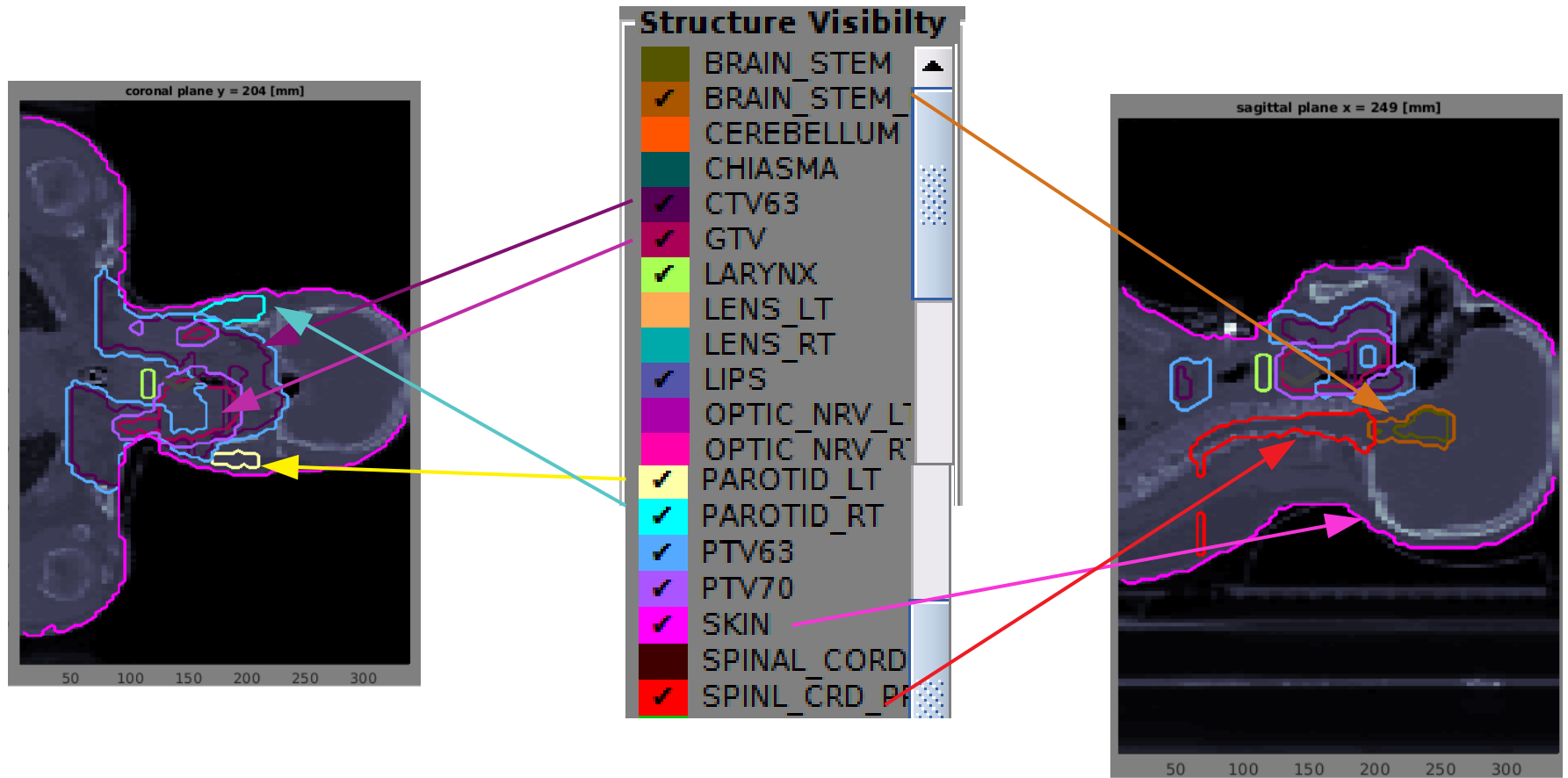
Organi a rischio: il caso della regione testa-collo

I tumori della testa e del collo possono svilupparsi in alcune aree specifiche, cioè bocca, gola, naso, seni paranasali, laringe (corde vocali), faringe, linfonodi del collo, ghiandole salivari e tiroide.

O nella parte superiore, come tumori al cervello o melanomi oculari



Organi a rischio: il caso della regione testa-collo



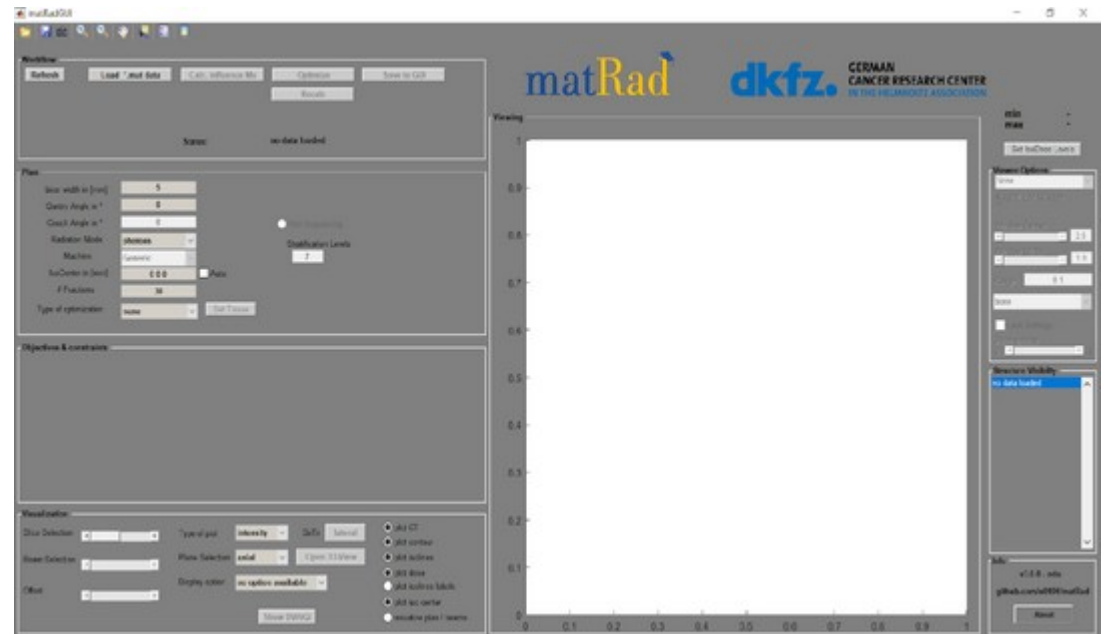
Organi a rischio: il caso della regione testa-collo

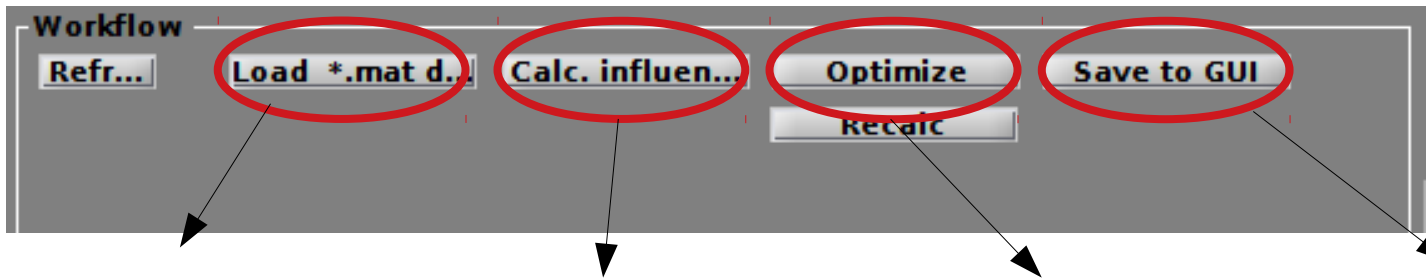


matRad

È un software che permette di ottimizzare i piani di trattamento con fotoni, protoni e ioni carbonio

È stato sviluppato dal **German Cancer Research Center** per gestire la pianificazione di un piano di trattamento in modo semplice





Load *.mat data:
carica il file selezionato

Calc. Influence Mx:
viene calcolato il rilascio di dose

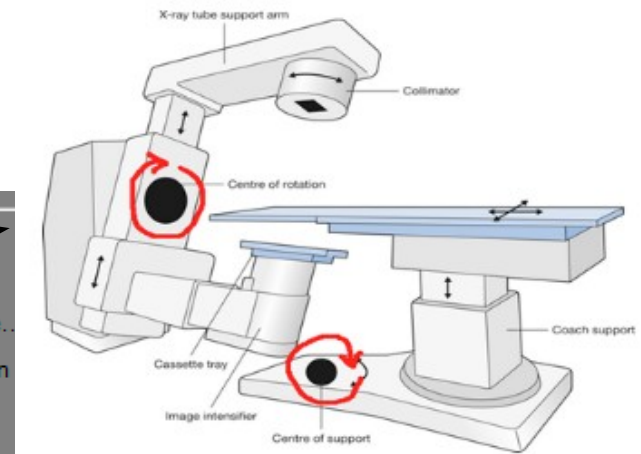
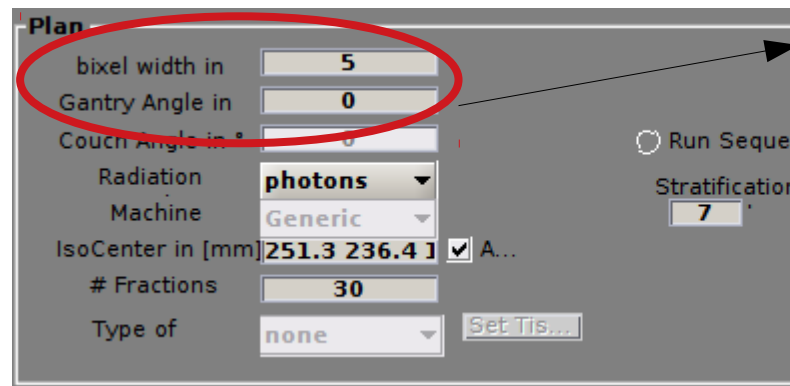
Optimize:
ottimizza la distribuzione di dose rispetto al target e agli OAR

Save:
salva il piano di trattamento

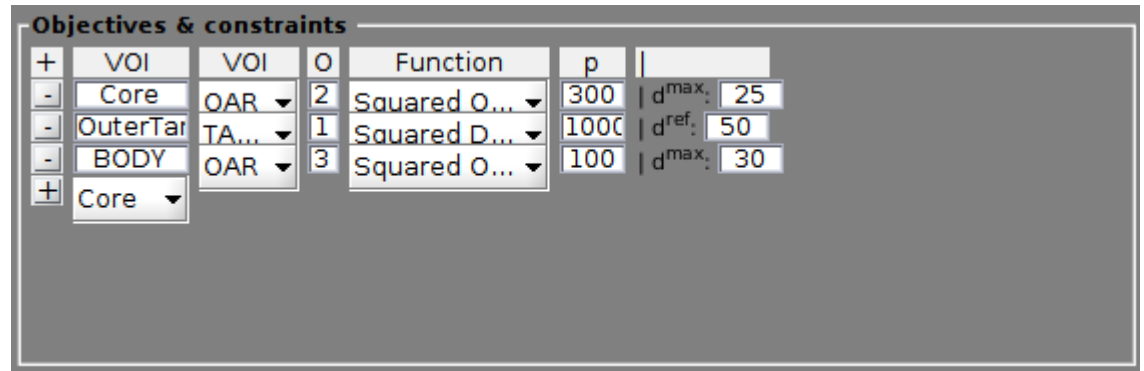
Gantry angles: valori di angoli per il fascio di particelle. Valori da 0° a 359°;

Radiation: tipi di particelle da scegliere;

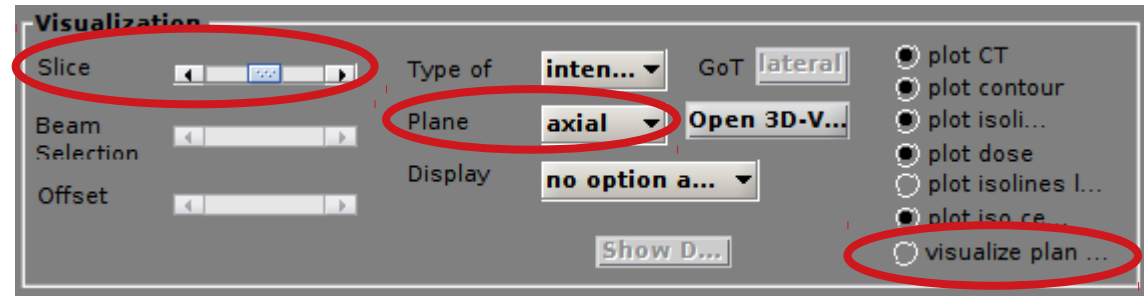
Isocenter: punto all'interno del tumore (automatico);



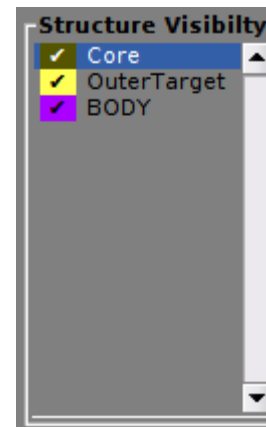
In questo panel è possibile scegliere e definire i ruoli di ogni volume



In **Visualization** ci sono le opzioni per le immagini

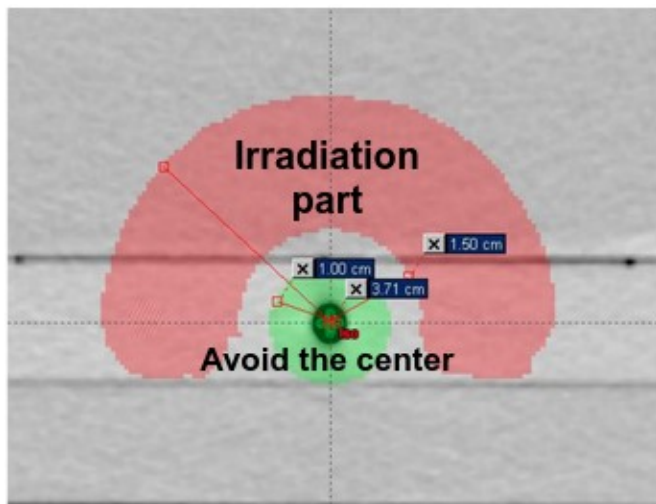


In **Structure visibility** è possibile visualizzare (selezionare/deselezionare) tutti gli organi/tessuti in gioco (sia organi a rischio che interni all'area tumorale da trattare)

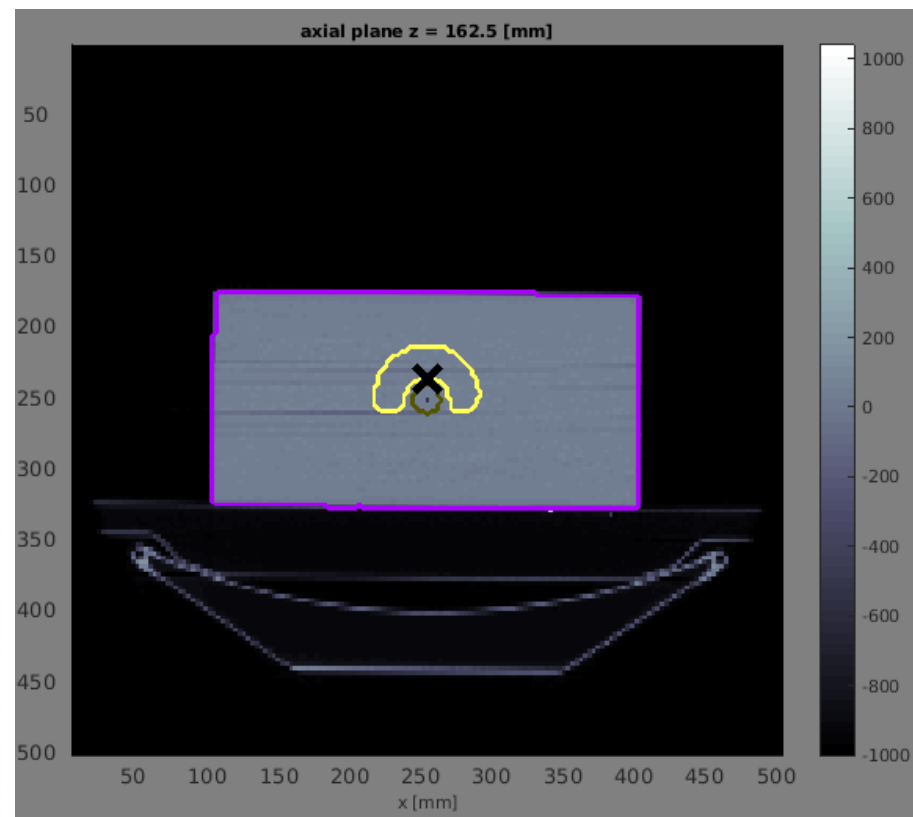
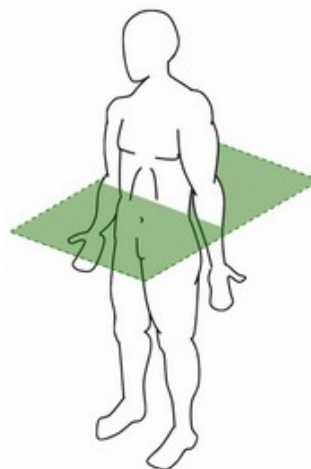


MatRad mostra
GTV, CTV, PTV

TG119 è un fantoccio in plastica che simula il corpo umano; viene usato per testare i parametri del fascio



Axial



TG119 con fotoni

The screenshot displays the matRad software interface, which is used for radiation therapy planning. The interface is divided into several panels:

- Workflow:** Contains buttons for 'Refr...', 'Load *.mat d...' (highlighted with a red circle), 'Calc. influen...', 'Optimize', 'Save to GUI', and 'Recalc'. The status below indicates 'no data loaded'.
- Plan:** Includes input fields for 'bixel width in' (5), 'Gantry Angle in' (0), 'Couch Angle in °' (0), 'Radiation' (photons), 'Machine' (Generic), 'IsoCenter in [mm]' (0 0 0), '# Fractions' (30), and 'Type of' (none). There are also radio buttons for 'Run Seque...' and 'Stratification' (7).
- Objectives & constraints:** This panel is currently empty.
- Visualization:** Features 'Slice' and 'Beam Selection' sliders, 'Type of' (intentional), 'Plane' (axial), and 'Display' (no option a...). It includes a 'Show D...' button and a list of visualization options: plot CT, plot contour, plot isoli..., plot dose, plot isolines l..., plot iso ce..., and visualize plan ...
- Viewing:** A large central plot area with axes ranging from 0 to 1. The plot is currently blank.
- Viewer Options:** Includes a 'Set IsoDose ...' button, a 'Viewer Options' dropdown (None), 'Window' (0.5), 'Window Width' (1.0), 'Range' (0 1), and 'bone' selection.
- Structure Visibility:** Shows 'no data loaded'.
- Info:** Displays 'v3.0.0 - github.com/e0404' and an 'About' button.

Logos for 'matRad' and 'dkfz. GERMAN CANCER RESEARCH CENTER IN THE HELMHOLTZ ASSOCIATION' are visible at the top right of the interface.

TG119 con fotoni

The screenshot displays the matRad software interface, which is used for radiation therapy planning. The interface is divided into several panels:

- Workflow:** Contains buttons for 'Refr...', 'Load *.mat d...', 'Calc. influen...', 'Optimize', 'Save to GUI', and 'Recalc'. The 'Calc. influen...' button is circled in red. The status below reads 'Status: ready for dose calculation'.
- Plan:** Contains input fields for 'bixel width in' (5), 'Gantry Angle in' (0), 'Couch Angle in °' (0), 'Radiation' (photons), 'Machine' (Generic), 'IsoCenter in [mm]' (251.2 226.4 1), '# Fractions' (30), and 'Type of' (none). The 'Radiation' dropdown is circled in red. There are also radio buttons for 'Run Seque...' and 'Stratification' (7).
- Objectives & constraints:** A table with columns for '+', 'VOI', 'VOI', 'O', 'Function', and 'p'.

+	VOI	VOI	O	Function	p
-	Core	OAR	2	Squared O...	300
-	OuterTar	TA...	1	Squared D...	1000
-	BODY	OAR	3	Squared O...	100
+	Core				
- Visualization:** Contains controls for 'Slice' (100), 'Beam Selection', 'Offset', 'Type of' (inten...), 'Plane' (axial), 'Display' (no option a...), and 'GoT' (lateral). There are also checkboxes for 'plot CT', 'plot contour', 'plot iso...', 'plot dose', 'plot isolines l...', 'plot iso ce...', and 'visualize plan ...'. A 'Show D...' button is also present.
- Viewing:** The main display area shows an axial CT scan slice at 'axial plane z = 162.5 [mm]'. The x and y axes range from 50 to 500 mm. A red circle highlights a target area, and a yellow circle highlights a core area. A color scale on the right ranges from -1000 to 1000 HU.
- Viewer Options:** Contains settings for 'CT (HU)', 'Window Preset' (Custom), 'Window' (20.0), 'Window Width' (2.0), 'Rang' (-1000, 104), and 'bone'. There are also checkboxes for 'Lock Settings' and 'Dose opacity' (0 to 1).
- Structure Visibility:** A list of structures with checkboxes: 'Core' (checked), 'OuterTarget' (checked), and 'BODY' (checked).
- Info:** Displays the version 'v3.0.0 - github.com/e0404' and an 'About' button.

TG119 con fotoni

Workflow

Refr... Load *.mat d... Calc. influ n... **Optimize** Save to GUI
Recalc

Status: ready for optimization

Plan

bixel width in 5
Gantry Angle in 0
Couch Angle in ° 0 Run Seque...
Radiation photons Stratification 7
Machine Generic
IsoCenter in [mm] 251.3 236.4 1 A...
Fractions 30
Type of none

Objectives & constraints

	VOI	VOI	O	Function	p	
-	Core	OAR	2	Squared O...	300	d ^{max} : 25
-	OuterTar	TA...	1	Squared D...	1000	d ^{ref} : 50
-	BODY	OAR	3	Squared O...	100	d ^{max} : 30
+	Core					

Visualization

Slice Type of inten... GoT lateral plot CT
Beam Plane axial plot contour
Selection Display no option a... plot isoli...
Offset plot dose
 plot isolines I...
 plot iso ce...
 visualize plan ...

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Viewing

axial plane z = 162.5 [mm]

min max -100 104
Set IsoDose ...

Viewer Options

CT (HU)
Window Preset Custom
Window
Window Width:
Rang -1000 104
bone
 Lock Settings
Dose opacity:

Structure Visibility

- Core
- OuterTarget
- BODY

Info

v3.0.0 - github.com/e0404

TG119 con fotoni

Workflow

Refr... Load *.mat d... Calc. influen... Optimize Save to GUI

Recalc

Status: plan is optimized

Plan

bixel width in
 Gantry Angle in
 Couch Angle in ° Run Seque...
 Radiation **photons** Stratification
 Machine **Generic**
 IsoCenter in [mm] **251.3 236.4 1** A...
 # Fractions
 Type of **none**

Objectives & constraints

+	VOI	VOI	O	Function	p	
-	Core	OAR	2	Squared O...	300	d ^{max} : 25
-	OuterTar	TA...	1	Squared D...	1000	d ^{ref} : 50
-	BODY	OAR	3	Squared O...	100	d ^{max} : 30
+	Core					

Visualization

Slice Type of **inten...** GoT **lateral** plot CT
 Beam Plane **axial** plot contour
 Selection Display **physicalDose** plot isoli...
 Offset plot dose
 plot isolines l...
 plot iso ce...
 visualize plan ...

matRad **dkfz.** GERMAN CANCER RESEARCH CENTER IN THE HELMHOLTZ ASSOCIATION

Viewing

axial plane z = 165 [mm]

min max n
2.39

Viewer Options

Result (i.e. dose)
 Window Preset **Custom**
 Window
 Window Width
 Rang
 jet
 Lock Settings
 Dose opacity:

Structure Visibility

- Core
- OuterTarget
- BODY

Info

v3.0.0 - github.com/e0404

TG119 con fotoni

The screenshot displays the matRad software interface. The top left contains workflow buttons: Refr..., Load *.mat d..., Calc. influen..., Optimiz (circled in red), and Save to GUI (circled in red). Below these is a Recalc button. The status bar indicates "plan is optimized".

The Plan section includes parameters for bixel width (5), Gantry Angle (0), Couch Angle (0), Radiation type (photons), Machine (Generic), IsoCenter (251.3, 236.4, 1), # Fractions (30), and Type of (none). A "Run Sequ..." button and a Stratification value of 7 are also present.

The Objectives & constraints table is as follows:

	VOI	VOI	O	Function	p	
+	Core	OAR	2	Squared O...	300	d ^{max} : 25
-	OuterTar	TA...	1	Squared D...	1000	d ^{ref} : 50
-	BODY	OAR	3	Squared O...	100	d ^{max} : 30

The Visualization section shows Slice, Beam Selection, and Offset controls.

The central Viewing area shows an axial plane at z = 165 [mm] with a dose distribution plot. A red circle highlights the target area. The plot includes a color scale for physical dose in Gy, ranging from 0 to 2.397.

The right sidebar contains Viewer Options (Result (i.e. dose), Window Preset: Custom, Window: 1.2, Window Width: 2.4, Rang: 0 - 2.397, jet), Structure Visibility (Core, OuterTarget, BODY), and Info (v3.0.0 - github.com/e0404).

A dialog box titled "Provide result name" is open, asking for a descriptive name for the optimization result. The text "TG119_fotoni1_GruppoX" is entered in the text field (circled in red), and a "Save" button is at the bottom.

TG119 con fotoni

Workflow
Refr... Load *.mat d... Calc. influen... Optimize Save to GUI
Recalc

Status: plan is optimized

Plan
bixel width in 5
Gantry Angle in 0
Couch Angle in ° 0
Radiation photons
Machine Generic
IsoCenter in [mm] 251.3 236.4 1
Fractions 30
Type of none

Objectives & constraints

+	VOI	VOI	O	Function	p	
-	Core	OAR	2	Squared O...	300	d ^{max} : 25
-	OuterTar	TA...	1	Squared D...	1000	d ^{ref} : 50
-	BODY	OAR	3	Squared O...	100	d ^{max} : 30

Visualization
Slice 500 Type of inten... GoT lateral
Beam Plane axial Open 3D-V...
Selection
Offset
Display physicalDose
Show D...

matRad **dkfz.** GERMAN CANCER RESEARCH CENTER IN THE HELMHOLTZ ASSOCIATION

Viewing
axial plane z = 165 [mm]

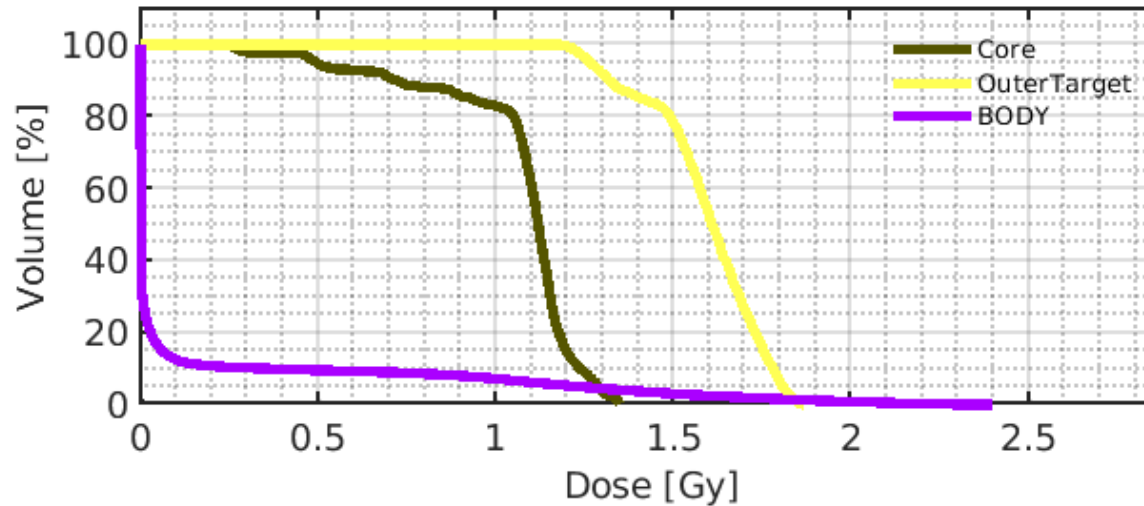
min max n 2.39
Set IsoDose ...

Viewer Options
Result (i.e. dose) Window Preset Custom Window 1.2 Window Width 2.4 Rang 0 2.397 jet Lock Settings Dose opacity 1

Structure Visibility
Core OuterTarget BODY

Info
v3.0.0 - github.com/e0404 About

Istogramma Dose-Volume (DVH)



	max	min	mean	std
Core	1.3525	0.2364	1.0615	0.2183
OuterTarget	1.8672	1.0975	1.5905	0.1581
BODY	2.3969	0	0.1373	0.4068

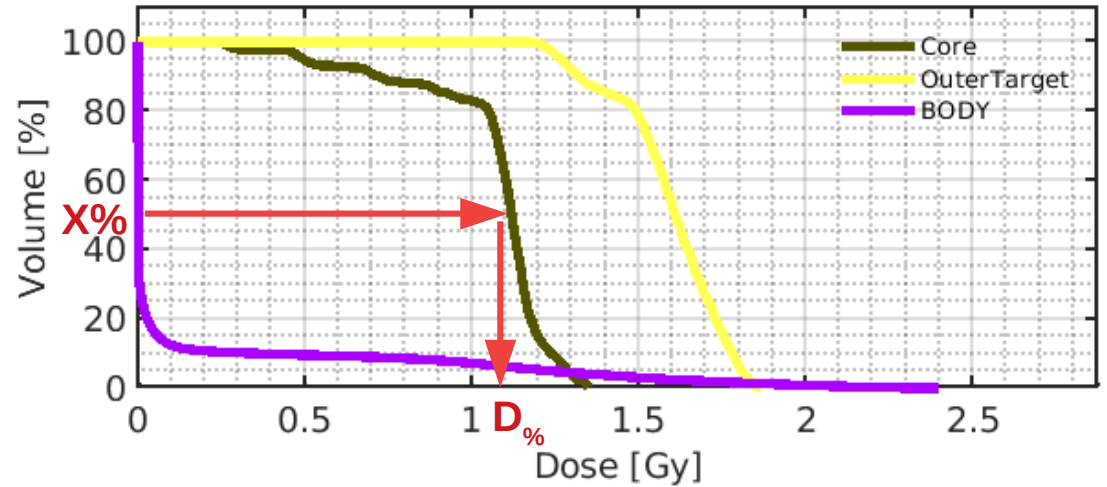
Grafico della dose ricevuta da ciascun organo

- Sull'asse delle ascisse troviamo i **valori di dose**
- Sull'asse delle ordinate troviamo la **percentuale di volume** che ha ricevuto tale dose

Istogramma Dose-Volume (DVH)

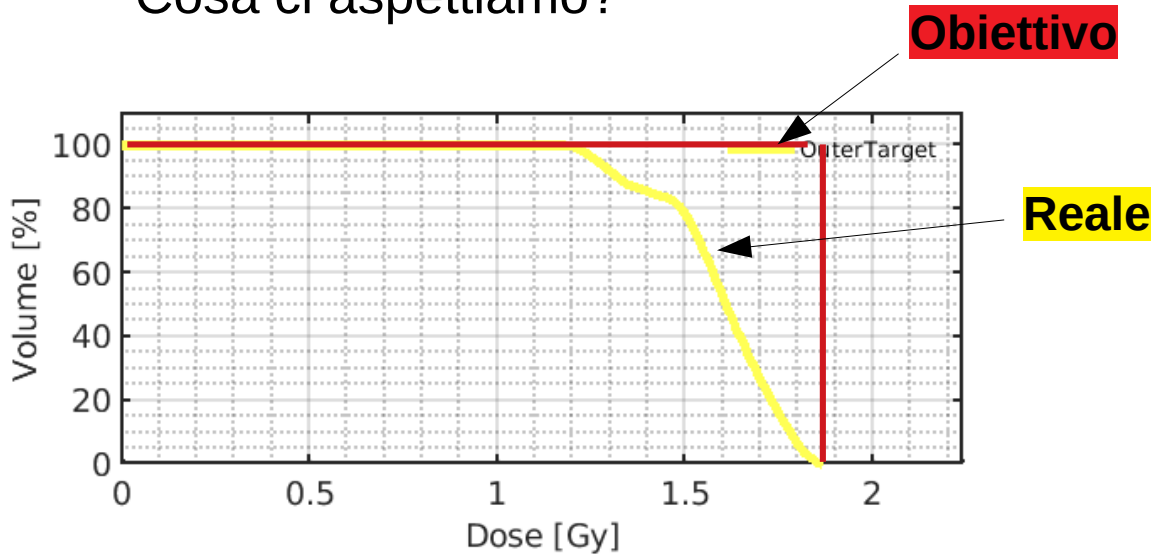
Ogni "pixel" riceve energia e quindi una certa quantità di dose (Gy)

$D_{\%}$: dose ricevuta da X% del volume



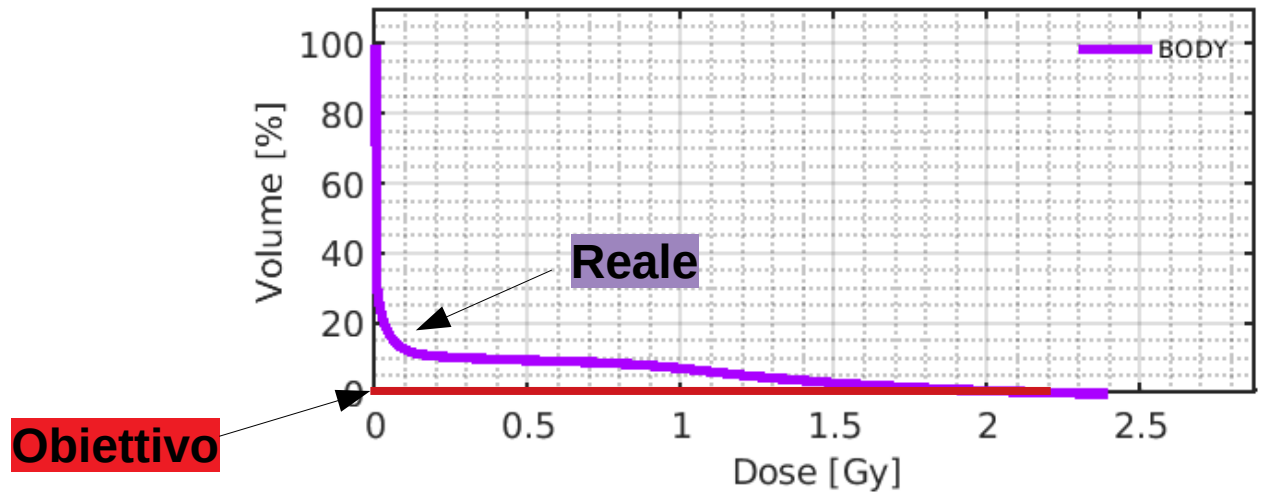
Istogramma Dose-Volume (DVH)

Cosa ci aspettiamo?

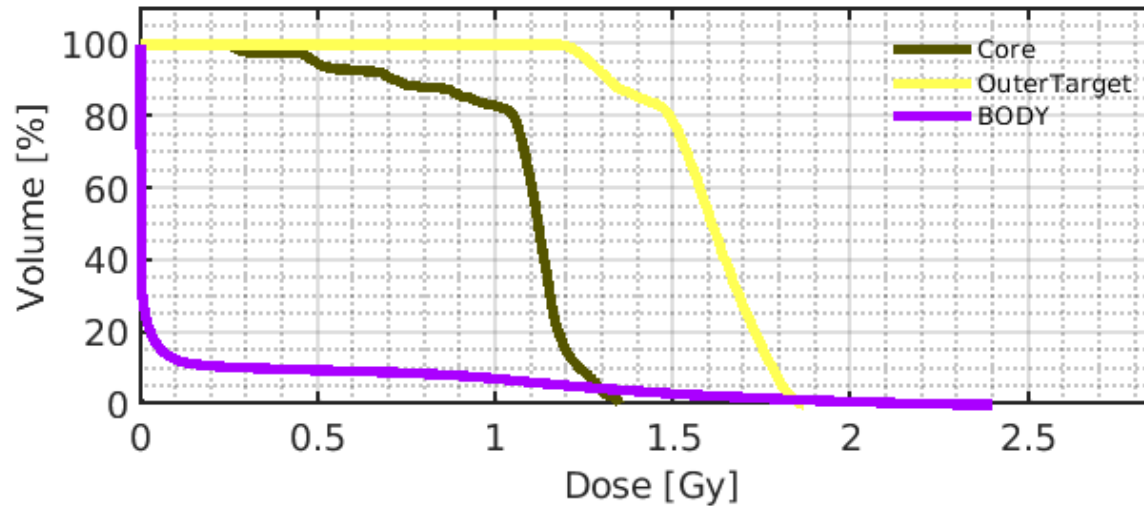


Target

OAR



Istogramma Dose-Volume (DVH)



	max	min	mean	std
Core	1.3525	0.2264	1.0615	0.2183
OuterTarget	1.8672	1.0975	1.5905	0.1581
BODY	2.3969	0	0.1373	0.4068

Più alto valore di dose osservato nel volume

Più basso valore di dose osservato nel volume

Valore medio di dose nel volume

Deviazione standard dei valori osservati

TG119 con fotoni – 5 angoli

Workflow
Refr... Load *.mat d... Calc. influen... Optimize Save to GUI
Recalc

Status: ready for optimization

Plan
Voxel width in [mm] 5
Gantry Angle in [deg] 144 216 288
Couch Angle in [deg] 0 0 0
Radiation photons
Machine Generic
IsoCenter in [mm] 251.3 236.4 1
Fractions 30
Type of none

Objectives & constraints

	VOI	VOI	O	Function	p	
-	Core	OAR	2	Squared O...	300	d ^{max} : 25
-	OuterTar	TA...	1	Squared D...	1000	d ^{ref} : 50
-	BODY	OAR	3	Squared O...	100	d ^{max} : 30
+	Core					

Visualization
Slice [mm] Type of inten... GoT lateral
Beam Selection Plane axial Open 3D-V...
Offset Display physicalDose Show D...
plot CT
plot contour
plot isoli...
plot dose
plot isolines l...
plot iso ce...
visualize plan ...

matRad **dkfz.** GERMAN CANCER RESEARCH CENTER IN THE HELMHOLTZ ASSOCIATION

Viewing
axial plane z = 165 [mm]

min max n
0 2.39

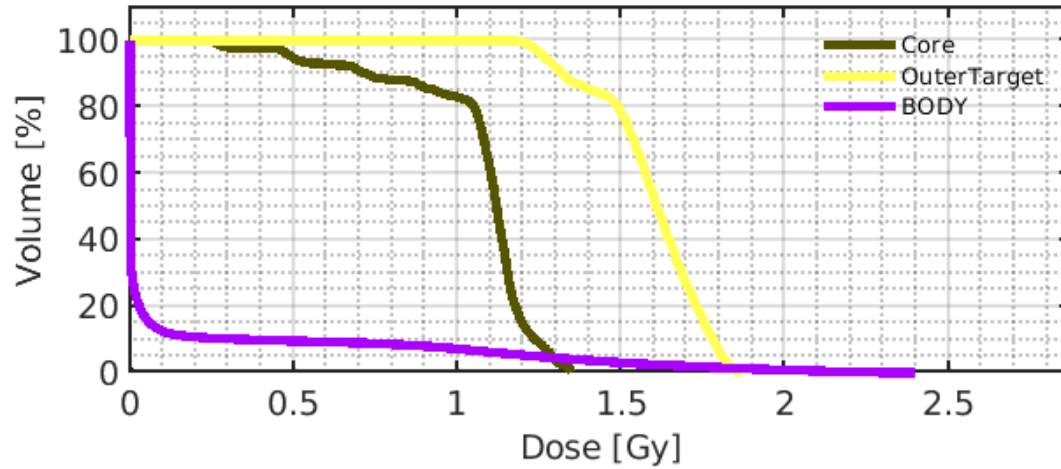
Set IsoDose ...

Viewer Options
Result (i.e. dose)
Window Preset Custom
Window [mm] 1.2
Window Width [mm] 2.4
Rang 0 2.397
jet
Lock Settings
Dose opacity: 0 1

Structure Visibility
Core
OuterTarget
BODY

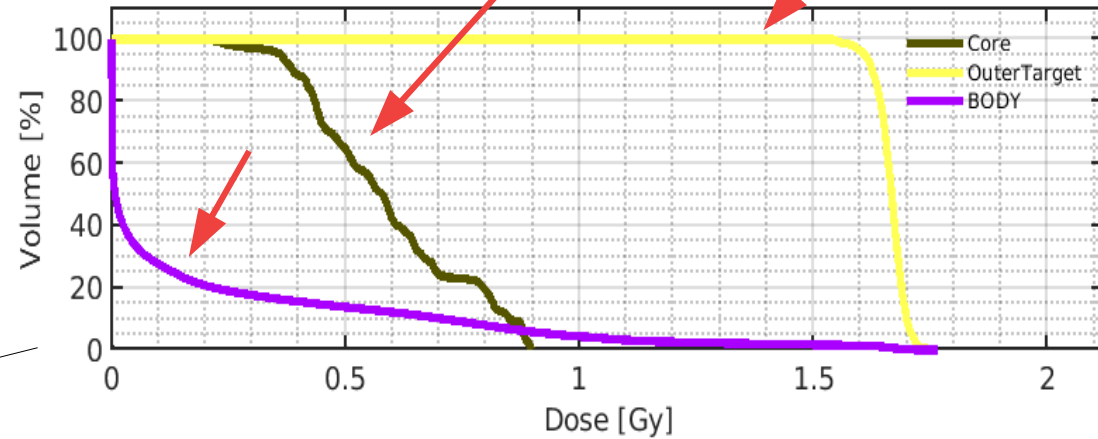
Info
v3.0.0 - github.com/e0404
About

TG119 con fotoni – comparazione



1 solo angolo

	max	min	mean	std
Core	1.3525	0.2364	1.0615	0.2183
OuterTarget	1.8672	1.0975	1.5905	0.1581
BODY	2.3969	0	0.1373	0.4068



5 angoli

	max	min	mean	std
Core	0.8992	0.1999	0.5892	0.1710
OuterTarget	1.7683	1.5206	1.6645	0.0313
BODY	1.7683	0	0.1705	0.3423

TG119 con protoni

Workflow
Refr... Load *.mat d... Calc. influen... Optimize Save to GUI
Recalc

Status: plan is optimized

Plan
bixel width in 5
Gantry Angle in 0
Couch Angle in 0
Radiation **protons**
Machine Generic
IsoCenter in [mm] 251.3 236.4 1
Fractions 30
Type of const_RB...
Run Seque...
Stratification 7

Objectives & constraints

	VOI	VOI	O	Function	p	
+	Core	OAR	2	Squared O...	300	d^{max} : 25
-	OuterTar	TA...	1	Squared D...	1000	d^{ref} : 50
-	BODY	OAR	3	Squared O...	100	d^{max} : 30
+	Core					

Visualization
Slice Type of inten... GoT lateral
Beam Selection Plane axial Open 3D-V...
Offset Display RBExDose
Show D...
 plot CT
 plot contour
 plot isoli...
 plot dose
 plot isolines l...
 plot iso ce...
 visualize plan ...

matRad **dkfz.** GERMAN CANCER RESEARCH CENTER IN THE HELMHOLTZ ASSOCIATION

min max n 1.76

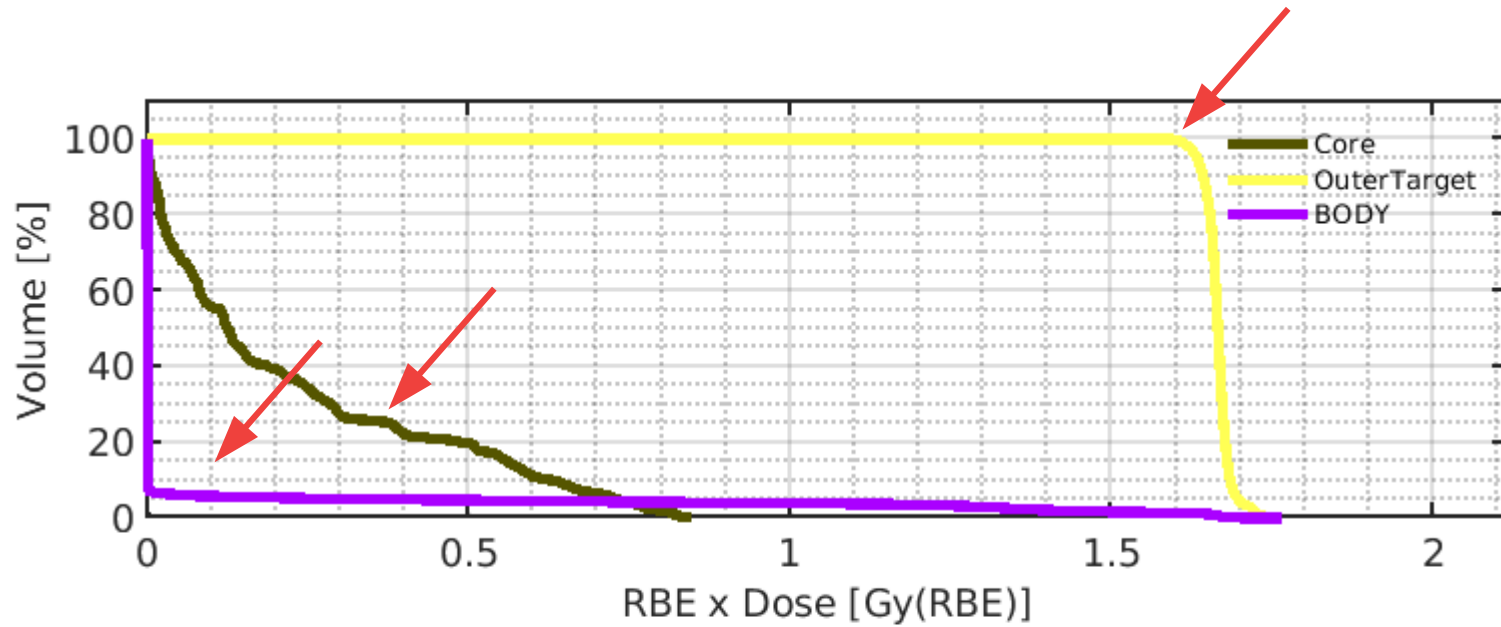
axial plane z = 165 [mm]

Viewer Options
Result (i.e. dose) Window Preset Custom
Window 0.88
Window Width: 1.76
Rang 0 1.764
jet
 Lock Settings
Dose opacity: 1

Structure Visibility
 Core
 OuterTarget
 BODY

Info
v3.0.0 - github.com/e0404
About

TG119 con protoni



	max	min	mean	std
Core	0.8461	0	0.2259	0.2391
OuterTarget	1.7643	1.5599	1.6652	0.0201
BODY	1.7643	0	0.0652	0.2890

TG119 con ioni carbonio

Workflow
Refr... Load *.mat d... Calc. influen... Optimize Save to GUI
Recalc

Status: plan is optimized

Plan
bixel width in 5
Gantry Angle in 0
Couch Angle in * 0
Radiation carbon
Machine Generic
IsoCenter in [mm] 251.3 236.4 1
Fractions 30
Type of LEMIV_RB...
Run Sequ...
Stratification 7

Objectives & constraints

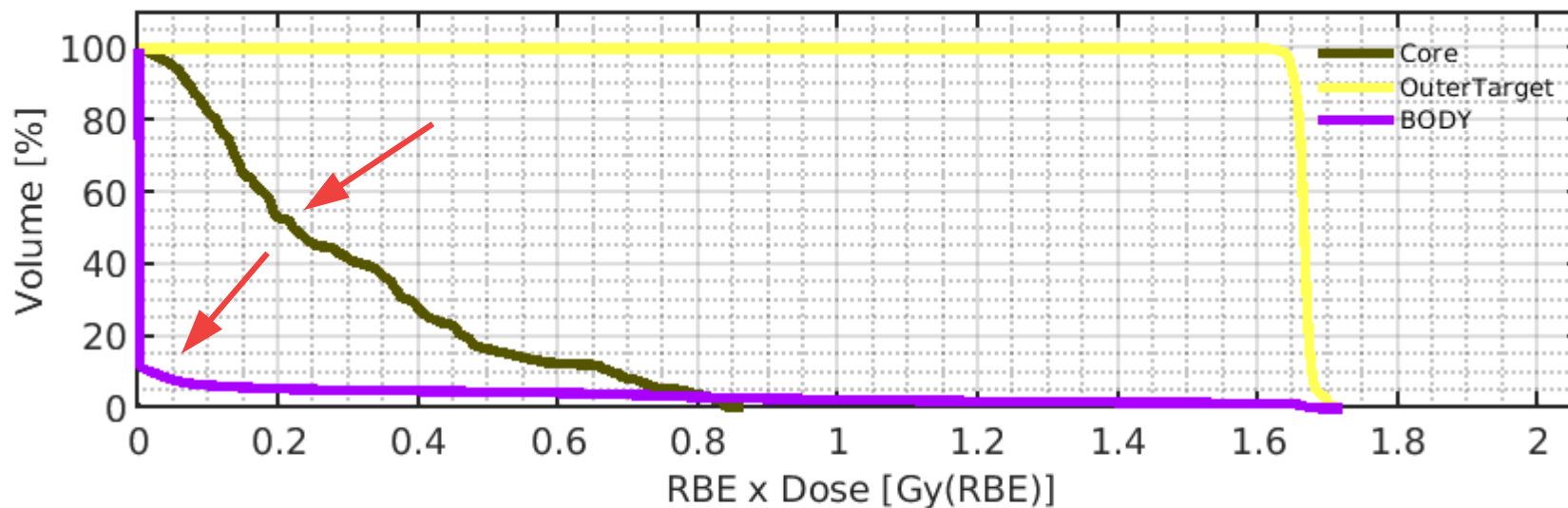
	VOI	VOI	O	Function	p	
-	Core	OAR	2	Squared O...	300	d^{max} : 25
-	OuterTar	TA...	1	Squared D...	1000	d^{ref} : 50
-	BODY	OAR	3	Squared O...	100	d^{max} : 30

Visualization
Slice 150 Type of inten... GoT lateral
Beam Selection Plane axial Open 3D-V...
Offset Display RBExDose
Show D...
plot CT
plot contour
plot isoli...
plot dose
plot isolines l...
plot iso ce...
visualize plan ...

matRad **dkfz.** GERMAN CANCER RESEARCH CENTER IN THE HELMHOLTZ ASSOCIATION

Viewing
axial plane z = 165 [mm]
min 1.72
max 0
Set IsoDose ...
Viewer Options
Result (i.e. dose)
Window Preset Custom
Window 0.80
Window Width 1.72
Rang 0 1.722
jet
Lock Settings
Dose opacity: 1
Structure Visibility
Core
OuterTarget
BODY
Info
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TG119 con ioni carbonio

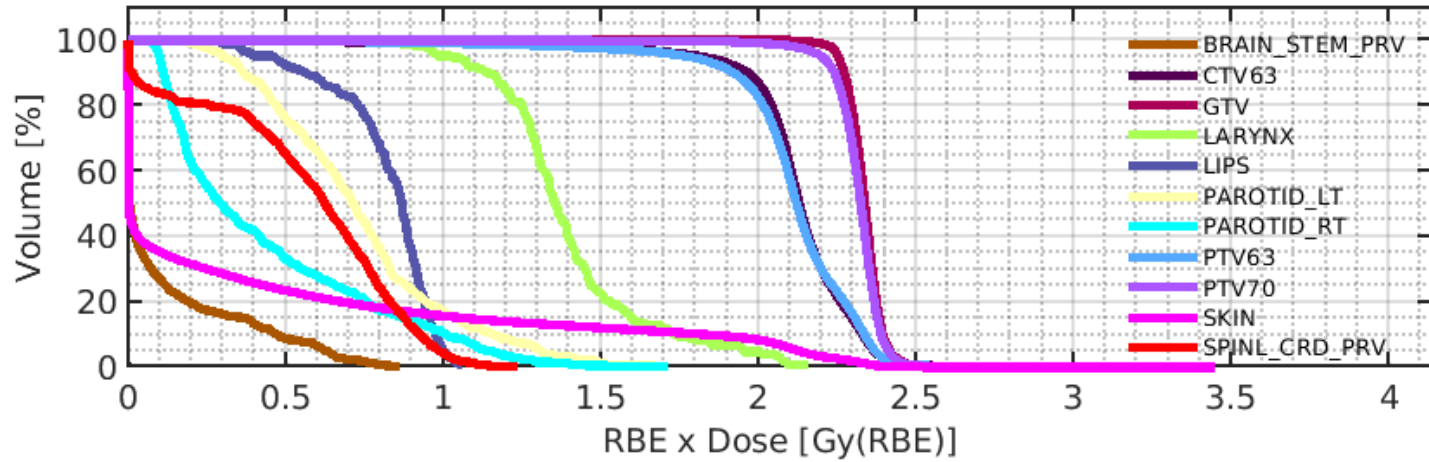


	max	min	mean	std
Core	0.8668	0.0056	0.2975	0.2199
OuterTarget	1.7224	1.5684	1.6659	0.0117
BODY	1.7224	0	0.0582	0.2550

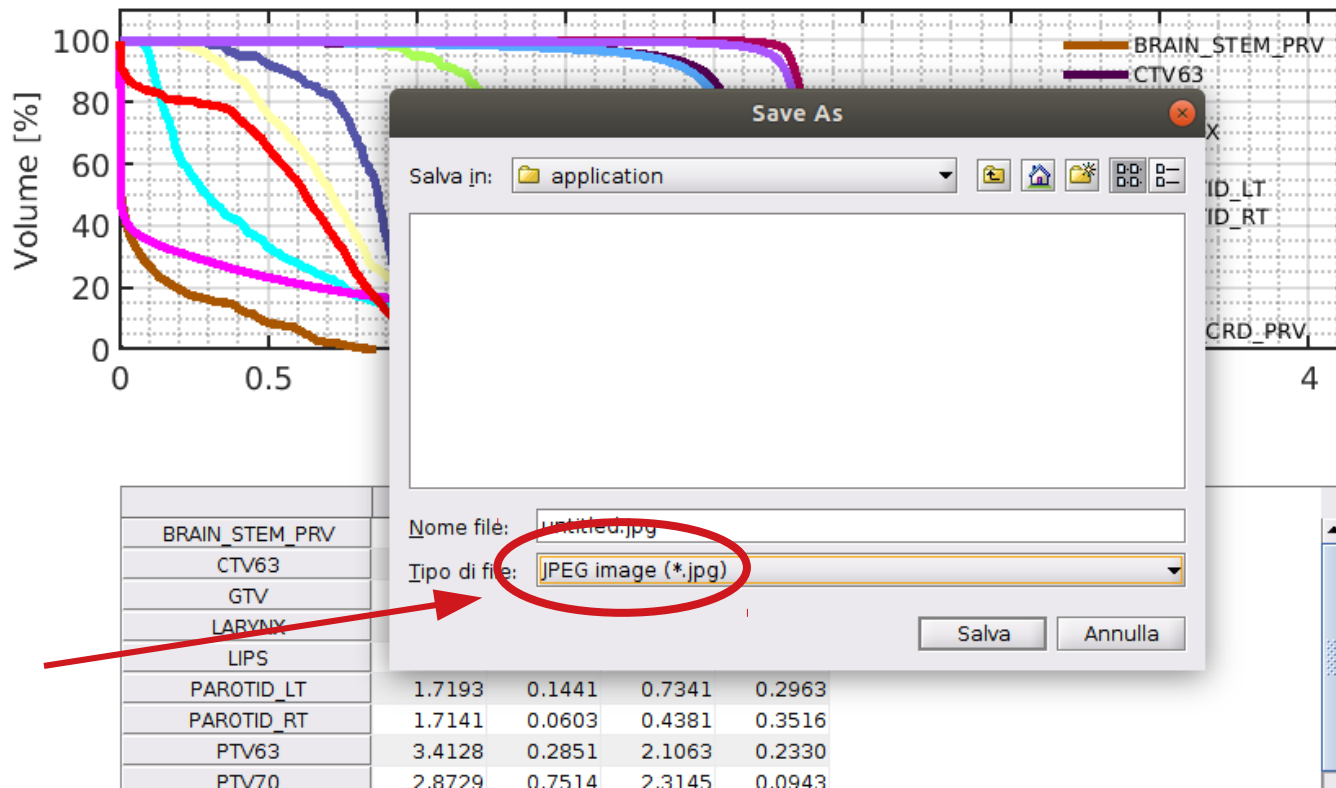
Figure 1



Save Figure



	max	min	mean	std
BRAIN_STEM_PRV	0.8645	0	0.1161	0.2061
CTV63	3.4128	0.3848	2.1169	0.2263
GTV	2.7977	2.0873	2.3360	0.0543



Organo

Particella

Angoli usati

Gruppo assegnato

Esempio nome file: Fegato_fotoni_45_90_Gruppo2

Buon divertimento!

The image shows the matRad software interface. At the top, there are logos for 'matRad' and 'dkfz. GERMAN CANCER RESEARCH CENTER IN THE HELMHOLTZ ASSOCIATION'. The 'Workflow' section contains buttons for 'Load *.mat d...', 'Calc influen...', 'Optimize', 'Save to GUI', and 'Recalc'. A red circle highlights the 'Load *.mat d...' button, with an arrow pointing to a central text box. The 'Plan' section includes fields for 'bixel width in' (5), 'Gantry Angle in' (0), 'Couch Angle in °' (0), 'Radiation' (photons), 'Machine' (Generic), 'IsoCenter in [mm]' (0 0 0), '# Fractions' (30), and 'Type of' (none). The 'Objectives & constraints' section is currently empty. The 'Visualization' section has 'Slice' (axial), 'Type of' (intentional), 'Plane' (axial), and 'Display' (no option available). A list of visualization options includes 'plot CT', 'plot contour', 'plot isol...', 'plot dose', 'plot isolines I...', 'plot iso ce...', and 'visualize plan ...'. A central text box contains the instruction: 'Caricate nel software il file corrispondente all'organo che vi è stato assegnato'. The right side of the interface shows 'Viewer Options' (Window, Window Width, Rang, bone) and 'Structure Visibility' (no data loaded). The bottom right corner displays 'Info v3.0.0 - github.com/e0404' and an 'About' button.

Caricate nel software il file corrispondente all'organo che vi è stato assegnato

Buon divertimento!

- Sofia Chiappetta - Andrea Sammarro: **Gruppo 6**
- Lorenza Donato - Francescamaria Filice: **Gruppo 7**
- Martina ed Elena Mastroianni: **Gruppo 8**
- Anna Gaia Lillo Odoardi - Francesca Maria Pia Nicoletti: **Gruppo 9**

- Martina Monaco – Francesca De Luca: **Gruppo 10**
- Chiara Iazzolino - Rosaria Serra: **Gruppo 11**

Esempio nome file: Fegato_fotoni_45_90_Gruppo2

Per ogni punto dell'esercizio (a, b, c) dovete salvare:

1) il grafico

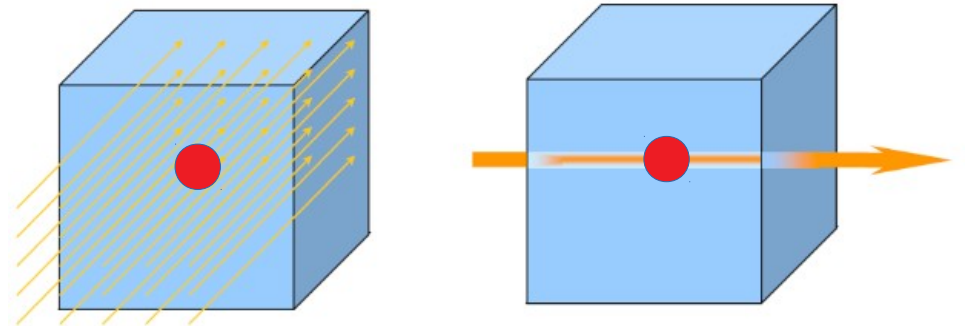
*2) uno screen dell'immagine CT **dopo** aver ottimizzato*

Definizioni: RBE

RBE (relative biological effectiveness) è un fattore di qualità che quantifica il danno causato da un tipo di radiazione rispetto ad un altro

$$RBE = \frac{D_x}{D_r}$$

Una radiazione ad elevato rilascio di energia per unità di tempo causa più danni biologici in un'area rispetto ad una radiazione a basso rilascio. Questo tipo di radiazione ha una maggiore efficacia biologica (RBE) perché per causare lo stesso effetto è necessaria una dose minore.



Organi a rischio: il caso del **fegato**

Il fegato alloggia nella parte superiore dell'addome; protetto dalla gabbia toracica, risiede appena più in basso del diaframma e poco al di sopra dello stomaco, del rene destro e del colon trasverso.

Sono organi a rischio (OAR): midollo spinale, polmoni, esofago, cuore, parete toracica, trachea e bronchi principali, ...

