

PARTICLE THERAPY MASTERCLASS

**Planiranje radioterapijskih tretmana u
MatRadu**

1. Zadatak

- Korištenje TG119 fantoma
- Planiranje radioterapijskog tretmana pomoću fotona, protona i ugljikovih iona
- Analiza i poređenje dobivenih rezultata

1. Učitajte TG119 fantom pomoću opcije Load * .mat (TG119.mat)

The screenshot displays a software interface with a 'Workflow' panel on the left. The 'Load *.mat data' button is highlighted with a red arrow. A 'Select File to Open' dialog box is open, showing a file list with 'TG119' selected and highlighted by a red arrow. The dialog box shows the file name 'TG119' and the file type 'MAT-files (*.mat)'. The background interface includes various settings panels such as 'Plan', 'Objectives & constraints', and 'Visualization'. The 'Plan' panel shows settings for radiation mode (photons), machine (Generic), and iso-center (0 0 0). The 'Objectives & constraints' panel shows a table with columns for VOI name, VOI type, priority, and obj. / const. The 'Visualization' panel shows settings for slice, beam, and offset, along with plot options like 'plot CT', 'plot contour', and 'plot dose'. A graph is visible in the bottom right corner, showing a plot of dose or intensity over a range from 0 to 1.0.

VOI name	VOI type	priority	obj. / const.
1			
2			
3			
4			

File Name	Date modified	Type
standalone	6/19/2019 8:34 AM	File folder
tools	6/19/2019 8:34 AM	File folder
unitTest	6/19/2019 8:34 AM	File folder
vmc++	6/19/2019 8:34 AM	File folder
BOXPHANTOM	6/19/2019 8:33 AM	MAT File
carbon_Generic	6/19/2019 8:34 AM	MAT File
HEAD_AND_NECK	6/19/2019 8:33 AM	MAT File
LIVER	6/19/2019 8:33 AM	MAT File
photons_Generic	6/19/2019 8:34 AM	MAT File
PROSTATE	6/19/2019 8:33 AM	MAT File
protons_Generic	6/19/2019 8:34 AM	MAT File
TG119	6/19/2019 8:34 AM	MAT File

2. Odaberite fotone kao vrstu zračenja, te odredite jedan ugao snopa (gantry angle)

The screenshot displays the matRad software interface, which is part of the German Cancer Research Center (dkfz) in the Helmholtz Association. The interface is divided into several panels:

- Workflow:** Includes buttons for Refresh, Load *.mat data, Calc. influence Mx, Optimize, Save to GUI, Load DICOM, Recalc, Export, Import from Bin..., and Import Dose. The status is "ready for dose calculation".
- Plan:** Contains input fields for bixel width (10 mm), Gantry Angle (0°), Couch Angle (0°), Radiation Mode (photons), Machine (Generic), IsoCenter (251.3, 236.4, 162.6 mm), # Fractions (30), and Type of optimization (none). It also has radio buttons for "use MC (VMC++) dose calculations", "3D conformal", "Run Sequencing", "Stratification Levels" (7), and "Run Direct Aperture Optimizat...". Red arrows point to the Gantry Angle and Radiation Mode fields.
- Objectives & constraints:** A table with columns: VOI name, VOI type, priority, obj. / const., penalty, dose, EUD, volume, and ro. It lists three objectives: Core (priority 2, square overdosing, penalty 300, dose 25), OuterTarget (priority 1, square deviation, penalty 1000, dose 50), and BODY (priority 3, square overdosing, penalty 100, dose 30).
- Visualization:** Shows a viewing window with "axial plane z = 165 [mm]". The window displays a cross-section of a head and neck region with a yellow target area and a purple body area. A color scale on the right indicates Hounsfield Units from 0 to 60. The x and y axes range from 50 to 500 mm.
- Viewer Options:** Includes settings for CT (HU), Window (Custom), Window Center (0.85), Window Width (1.67), Range (0.02671, 1.692), bone, Dose opacity (1), and Structure Visibility (Core, OuterTarget, BODY).
- Info:** Shows version v3.0.0 and the GitHub repository link github.com/e0404/mat.

3. Pokrenite proračun doze pomoću opcije („Calc. Influence Mx“). Zatim započnite obrnutu optimizaciju klikom na („Optimize“)

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 'Refresh', 'Load *.mat data', 'Load DICOM', 'Import from Bin...', 'Calc. influence Mx', 'Optimize', 'Save to GUI', 'Export', and 'Import Dose'. Red arrows point to 'Calc. influence Mx' and 'Optimize'. The status below indicates 'ready for optimization'.
- Plan:** Includes input fields for 'bixel width in [mm]' (10), 'Gantry Angle in °' (0), 'Couch Angle in °' (0), 'Radiation Mode' (photons), 'Machine' (Generic), 'IsoCenter in [mm]' (251.3 236.4 162.6), '# Fractions' (30), and 'Type of optimization' (none). There are also radio buttons for 'use MC (VMC++) dose calculations', '3D conformal', 'Run Sequencing', and 'Run Direct Aperture Optimizat...'. A 'Stratification Levels' field is set to 7.
- Objectives & constraints:** A table with columns: VOI name, VOI type, priority, obj. / const., penalty, dose, EUD, volume, and ro.

	VOI name	VOI type	priority	obj. / const.	penalty	dose	EUD	volume	ro
1	Core	OAR	2	square overdosing	300	25	NaN	NaN	no
2	OuterTarget	TARGET	1	square deviation	1000	50	NaN	NaN	no
3	BODY	OAR	3	square overdosing	100	30	NaN	NaN	no
- Visualization:** Includes 'Slice', 'Beam', and 'Offset' controls. 'Type of plot' is set to 'inten...', 'Plane' is 'axial', and 'Dislay option' is 'no option avail...'. There are checkboxes for 'plot CT', 'plot contour', 'plot isolines', 'plot dose', 'plot isolines labels', 'plot iso center', and 'visualize plan / be...'. A 'GoTo' button is set to 'lateral' and 'Open 3D-View' is available.
- Viewing:** Shows an axial plane at z = 165 [mm]. The plot area displays a patient's head and neck with a yellow contour for the target and a purple contour for the body. A color scale on the right indicates Hounsfield Units from 10 to 60.
- Viewer Options:** Includes 'Set IsoDose Levels', 'Window: Breast', 'Window: Custom', 'Window Center: 0.85', 'Window Width: 1.67', 'Range: 0.02671 1.692', 'bone' structure selected, and 'Dose opacity: 1'. The 'Structure Visibility' list shows 'Core', 'OuterTarget', and 'BODY' are visible.
- Info:** Version v3.0.0, github.com/e0404/mat, and an 'About' button.

4. Analizirajte rezultujuću raspodjelu doze

Workflow

Refresh Load *.mat data Calc. influence Mx Optimize Save to GUI
 Load DICOM Recalc Export
 Import from Bin... Import Dose

Status: plan is optimized

Plan

bixel width in [mm] 10
 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
 Stratification Levels 7
 Run Direct Aperture Optimizat...

Objectives & constraints

	VOI name	VOI type	priority	obj. / const.	penalty	dose	EUD	volume	ro
1	Core	OAR	2	square overdosing	300	25	NaN	NaN	no
2	OuterTarget	TARGET	1	square deviation	1000	50	NaN	NaN	no
3	BODY	OAR	3	square overdosing	100	30	NaN	NaN	no

Visualization

Slice Type of plot inten... GoTo lateral
 Beam Plane axial Open 3D-View
 Dislay option physicalDose

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

matRad dkfz. GERMAN CANCER RESEARCH CENTER IN THE HELMHOLTZ ASSOCIATION

Viewing axial plane z = 165 [mm]

min max n 2.342

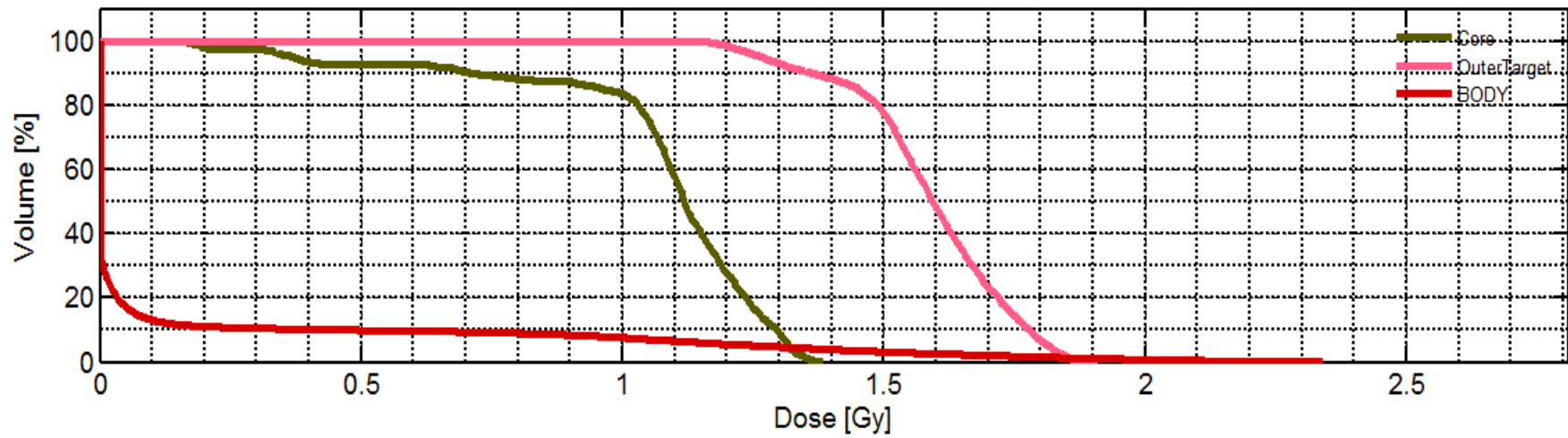
 Viewer Options
 Result (i.e. dose) Window Preset Custom
 Window Center: 1.17
 Window Width: 2.34
 Range: 0 2.342
 jet Dose opacity: 1
 Structure Visibility
 Core
 OuterTarget
 BODY
 Info
 v3.0.0
github.com/e0404/mat

5. Spremite rezultat optimizacije putem („Save to GUI“), te prikažite DVH pomoću („Show DVH/QI“).

The screenshot displays the matRad software interface. The top left contains a 'Workflow' section with buttons for 'Refresh', 'Load *.mat data', 'Calc. influence Mx', 'Optimize', 'Save to GUI', 'Load DICOM', 'Recalc', 'Export', and 'Import Dose'. A red arrow points to the 'Save to GUI' button. Below this is the 'Plan' section with various input fields and radio buttons for calculation methods and stratification levels. The 'Objectives & constraints' section features a table with columns for VOI name, type, priority, and various metrics.

	VOI name	VOI type	priority	obj. / const.	penalty	dose	EUD	volume	ro
1	Core	OAR	2	square overdosing	300	25	NaN	NaN	no
2	OuterTarget	TARGET	1	square deviation	1000	50	NaN	NaN	no
3	BODY	OAR	3	square overdosing	100	30	NaN	NaN	no

The 'Visualization' section at the bottom left includes options for 'Slice', 'Beam', 'Offset', 'Type of plot', 'Plane', and 'Dislay option'. A red arrow points to the 'Show DVH/QI' button. The main viewing area shows a color-coded dose distribution on an axial plane at z = 165 mm, with a color scale from 0 to 60 Gy. The right side contains 'Viewer Options' for windowing and visibility, and an 'Info' section at the bottom right.



	mean	std	max	min	D_2	D_5	D_50	D_95	D_98	V_0Gy	V_0.4Gy	V_0.9Gy	V_1.4Gy	V_1.9Gy
Core	1.0665	0.2554	1.3860	0.1329	1.3434	1.3187	1.1183	0.3706	0.1988	1	0.9341	0.8727	0	0
OuterTarget	1.5852	0.1536	1.9115	1.0935	1.8453	1.8153	1.5941	1.2663	1.2077	1	1	1	0.8824	0
BODY	0.1443	0.4168	2.3420	0	1.7203	1.2694	0	0	0	1	0.1019	0.0846	0.0393	0

6. Promijenite vrstu zračenja u Proton i ostavite uglove snopa nepromijenjenim

Workflow

Refresh Load *.mat data Calc. influence Mx Optimize Save to GUI
 Load DICOM Recalc Export
 Import from Bin... Import Dose

Status: plan is optimized

Plan

bixel width in [mm] 10
 Gantry Angle in ° 0
 Couch Angle in ° 0
 Radiation Mode photons
 Machine photons
 IsoCenter in [mm] protons **←**
 # Fractions carbon
 Type of optimization none Set Tissue

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

Objectives & constraints

	VOI name	VOI type	priority	obj. / const.	penalty	dose	EUD	volume	ro
1	Core	OAR	2	square overdosing	300	25	NaN	NaN	no
2	OuterTarget	TARGET	1	square deviation	1000	50	NaN	NaN	no
3	BODY	OAR	3	square overdosing	100	30	NaN	NaN	no

save

Visualization

Slice Type of plot inten... GoTo lateral
 Beam Plane axial Open 3D-View
 Offset Dislay option physicalDose
 Show DVH/QI

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

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axial plane z = 165 [mm]

min max 0 2.342

Set IsoDose Levels

Viewer Options

Result (i.e. dose) Window Doseat Custom
 Window Center: 1.17
 Window Width: 2.34
 Range: 0 2.342
 jet Dose opacity: 1

Structure Visibility

- Core
- OuterTarget
- BODY

Info

v3.0.0
github.com/e0404/mat
 About

7. Pokrenite proračun doze pomoću opcije („Calc. Influence Mx“) i započnite obrnutu optimizaciju klikom na („Optimize“)

The screenshot displays the matRad software interface, which is used for proton therapy dose calculation and optimization. The interface is divided into several panels:

- Workflow:** Contains buttons for 'Refresh', 'Load *.mat data', 'Calc. influence Mx' (indicated by a red arrow and the number 1), 'Optimize' (indicated by a red arrow and the number 2), 'Save to GUI', 'Load DICOM', 'Finalize', 'Export', 'Import from Bin...', and 'Import Dose'. The status below these buttons reads 'Status: 1 ready for optimization 2'.
- Plan:** A configuration panel with various parameters:
 - bixel width in [mm]: 10
 - Gantry Angle in °: 0
 - Couch Angle in °: 0
 - Radiation Mode: protons
 - Machine: Generic
 - IsoCenter in [mm]: 251.3 236.4 162.6 (with 'Auto.' checked)
 - # Fractions: 30
 - Type of optimization: const_RBExD
 - Options: 'use MC (VMC++) dose calculations', '3D conformal', 'Run Sequencing', 'Stratification Levels: 7', and 'Run Direct Aperture Optimizat...'
- Objectives & constraints:** A table defining the optimization goals:

	VOI name	VOI type	priority	obj. / const.	penalty	dose	EUD	volume	ro
1	Core	OAR	2	square overdosing	300	25	NaN	NaN	no
2	OuterTarget	TARGET	1	square deviation	1000	50	NaN	NaN	no
3	BODY	OAR	3	square overdosing	100	30	NaN	NaN	no
- Visualization:** Controls for the plot, including 'Slice', 'Beam', 'Offset', 'Type of plot' (set to 'inten...'), 'Plane' (set to 'axial'), and 'Dislay option' (set to 'physicalDose'). There are also checkboxes for 'plot CT', 'plot contour', 'plot isolines', 'plot dose', 'plot isolines labels', 'plot iso center', and 'visualize plan / be...'. A 'Show DVH/QI' button is also present.
- Viewing:** Shows a dose distribution plot for an axial plane at z = 165 [mm]. The plot displays a color-coded dose distribution with a central target area marked by a black 'X'. The axes are labeled 'x [mm]' and 'y [mm]'. A color scale on the right indicates 'physicalDose [Gy]' ranging from 0 to 60.
- Right Panel:** Contains 'min max' values (0, 2.342), 'Set IsoDose Levels', 'Viewer Options' (including 'Result (i.e. dose)', 'Window: Precept', 'Custom', 'Window Center', 'Window Width', 'Range', 'jet' color map, and 'Dose opacity'), 'Structure Visibility' (with 'Core', 'OuterTarget', and 'BODY' checked), and 'Info' (version v3.0.0 and GitHub link).

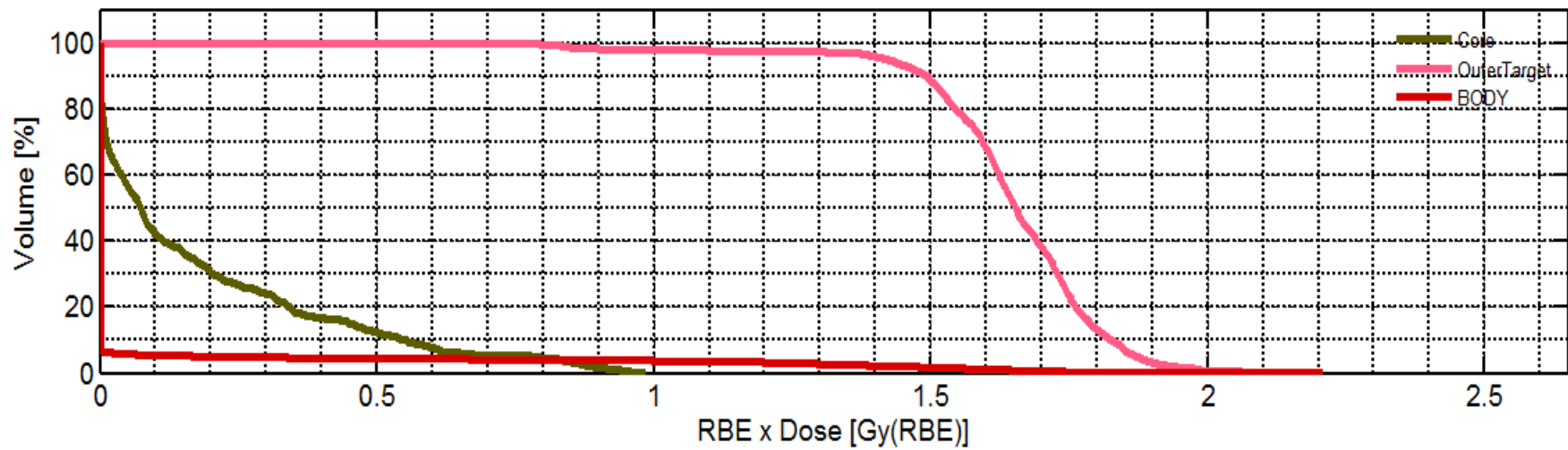
8. Spremite rezultat optimizacije putem („Save to GUI“) i prikažite DVH pomoću („Show DVH/QI“)

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

- Workflow:** Contains buttons for Refresh, Load *.mat data, Calc. influence Mx, Optimize, Save to GUI, Load DICOM, Recalc, Export, and Import Dose. A red arrow labeled '1' points to the 'Save to GUI' button. The status below indicates 'plan is optimized'.
- Plan:** Includes parameters for bixel width (10 mm), Gantry Angle (0°), Couch Angle (0°), Radiation Mode (protons), Machine (Generic), IsoCenter (251.3, 236.4, 162.6 mm), # Fractions (30), and Type of optimization (const_RBExD). It also has checkboxes for 'use MC (VMC++) dose calculations', '3D conformal', 'Run Sequencing', 'Stratification Levels' (7), and 'Run Direct Aperture Optimizat...'. A 'Set Tissue' button is also present.
- Objectives & constraints:** A table with columns for VOI name, VOI type, priority, obj./const., penalty, dose, EUD, volume, and ro. The table lists three VOIs: Core, OuterTarget, and BODY.
- Visualization:** Includes controls for Slice, Beam Selection, and Offset. It has dropdowns for 'Type of plot' (intentional), 'Plane' (axial), and 'Dislay option' (RBExDose). Buttons for 'GoTo lateral', 'Open 3D-View', and 'Show DVH/QI' are visible. A red arrow labeled '2' points to the 'Show DVH/QI' button.

The central 'Viewing' panel shows an axial plane at z = 165 mm. It displays a color-coded dose distribution (RBExDose) over a cross-section of the patient's anatomy. A color scale on the right ranges from 0 to 60 Gy(RBE). The 'min' is 0 and the 'max' is 2.21. The 'Viewer Options' panel on the right allows for adjusting the 'Result (i.e. dose)', 'Window Center', 'Window Width', 'Range', and 'Dose opacity'. The 'Structure Visibility' panel shows 'Core', 'OuterTarget', and 'BODY' are visible. The 'Info' panel at the bottom right indicates the version is v3.0.0 and provides a GitHub link.

VOI name	VOI type	priority	obj. / const.	penalty	dose	EUD	volume	ro
1 Core	OAR	2	square overdosing	300	25	NaN	NaN	no
2 OuterTarget	TARGET	1	square deviation	1000	50	NaN	NaN	no
3 BODY	OAR	3	square overdosing	100	30	NaN	NaN	no



	mean	std	max	min	D_2	D_5	D_50	D_95	D_98	V_0Gy	V_0.4Gy	V_0.8Gy	V_1.3Gy	V_...
Core	0.1815	0.2396	0.9866	2.0386e-09	0.8909	0.7849	0.0744	2.4933e-05	6.0723e-07	1	0.1682	0.0470	0	
OuterTarget	1.6449	0.1770	2.1789	0.7475	1.9408	1.8726	1.6533	1.4205	0.9187	1	1	0.9949	0.9722	
BODY	0.0640	0.2912	2.2101	0	1.4572	0.2364	0	0	0	1	0.0462	0.0405	0.0282	

Rezultati

- Srednje doze po regionima (Gy):

Region/Zračenje	Fotoni	Protoni
Osjetljivi region	1.0665	0.1815
Vanjska meta	1.5852	1.6449
Tijelo	0.1443	0.0640

- Fotoni daju najveću dozu na površini
- Protoni daju najveću dozu na meti (tumoru) uz maksimalnu zaštitu osjetljivih regiona

9. Pokušajte definisati bolji plan tretmana fotonima pomoću većeg broja uglova snopa (npr. ekvivalentni razmak [0, 72, 144, 216, 288]. Pokrenite proračun doze i započnite obrnutu optimizaciju.

Workflow

Refresh Load *.mat data Calc. influence Mx Optimize Save to GUI
 Load DICOM ReCalc Export
 Import from Bin... Import Dose

Status: ready for dose calculation

Plan

bixel width in [mm] 10
 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 Auto.
 # Fractions 30
 Type of optimization none Set Tissue

Objectives & constraints

	VOI name	VOI type	priority	obj. / const.	penalty	dose	EUD	volume	ro
1	Core	OAR	2	square overdosing	300	25	NaN	NaN	no
2	OuterTarget	TARGET	1	square deviation	1000	50	NaN	NaN	no
3	BODY	OAR	3	square overdosing	100	30	NaN	NaN	no

Visualization

Slice Type of plot inten... GoTo lateral
 Beam Plane axial Open 3D-View
 Offset Disolv option physicalDose

plot CT
 plot contour
 plot isolines
 plot dose
 plot isolines labels
 plot iso center
 visualize plan / be...

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Viewing axial plane z = 165 [mm]

min max 1.902

Set IsoDose Levels

Viewer Options

Result (i.e. dose)
 Window: Breast
 Custom
 Window Center:
 Window Width: 0.95
 Range: 0 1.903
 jet
 Dose opacity: 0 1

Structure Visibility

- Core
- OuterTarget
- BODY

Info v3.0.0
 github.com/e0404/mat
 About

10. Spremite rezultat optimizacije putem („Save to GUI“) i prikažite DVH pomoću („Show DVH/QI“)

The screenshot displays the matRad software interface. The top left contains a 'Workflow' section with buttons for 'Refresh', 'Load *.mat data', 'Calc. influence Mx', 'Optimize', 'Save to GUI', 'Load DICOM', 'Recalc', 'Export', and 'Import Dose'. A red arrow points to the 'Save to GUI' button. Below this is a 'Plan' section with various input fields for parameters like 'bixel width in [mm]', 'Gantry Angle in °', 'Couch Angle in °', 'Radiation Mode', 'Machine', 'IsoCenter in [mm]', '# Fractions', and 'Type of optimization'. The 'Objectives & constraints' section features a table with columns for 'VOI name', 'VOI type', 'priority', 'obj. / const.', 'penalty', 'dose', 'EUD', and 'volume'. The 'Visualization' section at the bottom left includes 'Slice', 'Beam', and 'Offset' controls, along with 'Type of plot', 'Plane', and 'Dislay option' settings. A red arrow points to the 'Show DVH/QI' button. The main viewing area shows an axial plane at z = 165 [mm] with a color-coded dose distribution plot. The y-axis is labeled 'y [mm]' and the x-axis is 'x [mm]'. A color scale on the right indicates 'physicalDose [Gy]' from 0 to 60. The top right corner displays 'min max' values and 'n' (1.789). The 'Viewer Options' section on the right includes 'Result (i.e. dose)', 'Window Dreset', 'Custom', 'Window Center', 'Window Width', 'Range', and 'Dose opacity'. The 'Structure Visibility' section shows 'Core', 'OuterTarget', and 'BODY' as visible. The bottom right corner shows 'Info' with version 'v3.0.0' and the GitHub link 'github.com/e0404/matRad'.

Workflow

Refresh Load *.mat data Calc. influence Mx Optimize Save to GUI
Load DICOM Recalc Export
Import from Bin... Import Dose

Status: plan is optimized

Plan

bixel width in [mm] 10
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 Auto.
Fractions 30
Type of optimization none Set Tissue

Objectives & constraints

	VOI name	VOI type	priority	obj. / const.	penalty	dose	EUD	volume	ro
1	Core	OAR	2	square overdosing	300	25	NaN	NaN	no
2	OuterTarget	TARGET	1	square deviation	1000	50	NaN	NaN	no
3	BODY	OAR	3	square overdosing	100	30	NaN	NaN	no

Visualization

Slice Type of plot inten... GoTo lateral
Beam Plane axial Open 3D-View
Offset Dislay option physicalDose

plot CT
plot contour
plot isolines
plot dose
plot isolines labels
plot iso center
visualize plan / be...

min max n 1.789

Set IsoDose Levels

Viewer Options

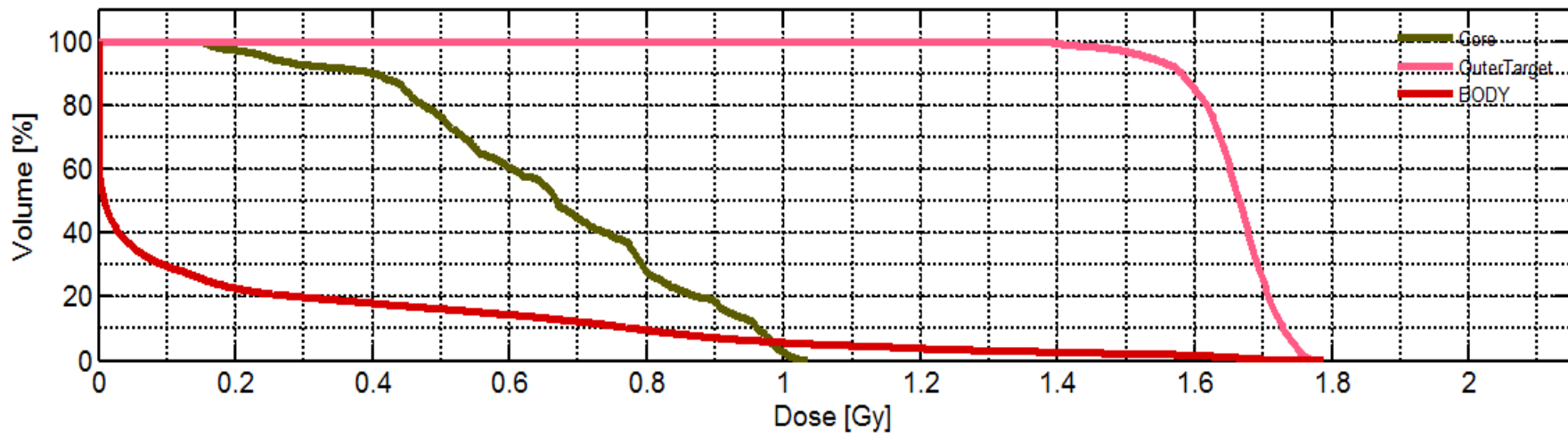
Result (i.e. dose)
Window Dreset
Custom
Window Center: 0.89
Window Width: 1.79
Range: 0 1.79
jet
Dose opacity: 1

Structure Visibility

Core
 OuterTarget
 BODY

Info

v3.0.0
github.com/e0404/matRad
About



	mean	std	max	min	D_2	D_5	D_50	D_95	D_98	V_0Gy	V_0.3Gy	V_0.7Gy	V_1Gy	V_1.5Gy
Core	0.6625	0.2176	1.0370	0.1450	1.0030	0.9853	0.6686	0.2460	0.1755	1	0.9265	0.4477	0.0250	0.0000
OuterTarget	1.6563	0.0659	1.7897	1.2866	1.7566	1.7450	1.6652	1.5323	1.4636	1	1	1	1	0.0000
BODY	0.1968	0.3777	1.7897	0	1.5510	1.0629	0.0091	0	0	1	0.1986	0.1230	0.0568	0.0000

Rezultati

- Srednje doze po regionima (Gy):

Region/Zračenje(uglovi)	Fotoni(0)	Protoni(0)	Fotoni (0,72,144,216,288)
Osjetljivi region	1.0665	0.1815	0.6625
Vanjska meta	1.5852	1.6449	1.6563
Tijelo	0.1443	0.0640	0.1968

- Plan tretmana sa više snopova fotona daje bolje rezultate nego sa jednim snopom fotona.
- Najbolji rezultati su dobiveni korištenjem protona.

11. Promijenite cilj optimizacije za poboljšanje plana liječenja protonima. Koristite tabelu („Objectives & constraints“) i dodajte ograničenje (npr. maksimalna doza u meti ili minimalna doza u vanjskoj ciljnoj strukturi).

Workflow

Refresh Load *.mat data Calc. influence Mx Optimize Save to GUI
 Load DICOM Recalc Export
 Import from Bin... Import Dose

Status: ready for optimization

Plan

bixel width in [mm] 10 use MC (VMC++) dose calculations
 Gantry Angle in ° 0 72 144 216 288 3D conformal
 Couch Angle in ° 0 0 0 0 Run Sequencing
 Radiation Mode photons Stratification Levels 7
 Machine Generic Run Direct Aperture Optimizat...
 IsoCenter in [mm] 251.3 236.4 162.6 Auto.
 # Fractions 30
 Type of optimization none Set Tissue

Objectives & constraints

	VOI name	VOI type	priority	obj. / const.	penalty	dose	EUD	volume	ro
1	Core	OAR	2	max dose constraint	5	5	NaN	NaN	no +
2	OuterTarget	TARGET	1	min dose constraint	0	0	NaN	NaN	no -
3	BODY	OAR	3	square overdosing	100	30	NaN	NaN	no

save

Visualization

Slice Type of plot inten... GoTo lateral
 Beam Plane axial Open 3D-View
 Offset Dislay option physicalDose Show DVH/QI
 plot CT plot contour plot isolines plot dose plot isolines labels plot iso center visualize plan / be...

matRad dkfz. GERMAN CANCER RESEARCH CENTER IN THE HELMHOLTZ ASSOCIATION

axial plane z = 165 [mm]

min max n 1.789

Set IsoDose Levels

Viewer Options

Result (i.e. dose) Window: Breast Custom Window Center: 0.89 Window Width: 1.79 Range: 0 1.79 jet Dose opacity: 1

Structure Visibility

- Core
- OuterTarget
- BODY

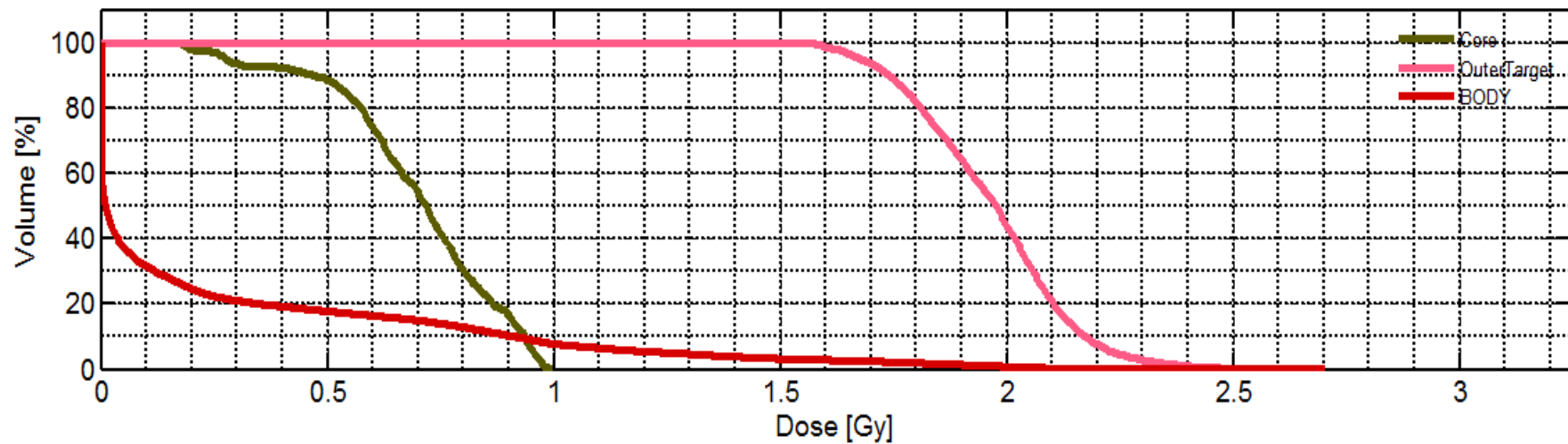
Info v3.0.0 qithub.com/e0404/mat About

12. Pokrenite proračun doze pomoću opcije („Calc. Influence Mx“) i započnite obrnutu optimizaciju klikom na („Optimize“). Zatim spremite rezultat optimizacije putem („Save to GUI“) i prikažite DVH pomoću („Show DVH/QI“)

The screenshot displays the matRad software interface, which is part of the German Cancer Research Center (dkfz) in the Helmholtz Association. The interface is divided into several sections:

- Workflow:** Contains buttons for 'Refresh', 'Load *.mat data', 'Load DICOM', 'Import from Bin...', 'Calc. influence Mx', 'Optimize', 'Save to GUI', 'Recalc', 'Export', and 'Import dose'. Red arrows point to 'Calc. influence Mx', 'Optimize', and 'Save to GUI'. The status bar indicates 'plan is optimized'.
- Plan:** Includes parameters for 'bixel width in [mm]' (10), '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), and 'Type of optimization' (none). It also has radio buttons for 'use MC (VMC++) dose calculations', '3D conformal', 'Run Sequencing', and 'Run Direct Aperture Optimizat...'. A 'Stratification Levels' dropdown is set to '7'.
- Objectives & constraints:** A table with columns: VOI name, VOI type, priority, obj. / const., penalty, dose, EUD, volume, and ro.

VOI name	VOI type	priority	obj. / const.	penalty	dose	EUD	volume	ro
1 Core	OAR	2	max dose constraint	NaN	25	NaN	NaN	no
2 OuterTarget	TARGET	1	min dose constraint	NaN	50	NaN	NaN	no
3 BODY	OAR	3	square overdosing	100	30	NaN	NaN	no
- Visualization:** Includes 'Slice' and 'Beam' selection, 'Type of plot' (intensity), 'Plane' (axial), and 'Dislay option' (physicalDose). A 'Show DVH/QI' button is highlighted with a red arrow. There are also checkboxes for 'plot CT', 'plot contour', 'plot isolines', 'plot dose', 'plot isolines labels', 'plot iso center', and 'visualize plan / be...'. A 'GoTo' dropdown is set to 'lateral' and 'Open 3D-View' is available.
- Viewing:** Shows an axial plane at z = 165 [mm]. The plot displays a color-coded dose distribution with a central target area (yellow/red) and surrounding organs at risk (blue). A color scale on the right indicates 'physicalDose [Gy]' from 0 to 60. The axes are labeled 'x [mm]' and 'y [mm]'.
- Viewer Options:** Includes 'Result (i.e. dose)', 'Window Preset' (Custom), 'Window Center' (1.35), 'Window Width' (2.71), 'Range' (0 to 2.705), 'jet' color map, and 'Dose opacity' (1).
- Structure Visibility:** A list of structures with checkboxes: 'Core' (checked), 'OuterTarget' (checked), and 'BODY' (checked).
- Info:** Shows version 'v3.0.0' and the GitHub repository 'github.com/e0404/mat'.



	mean	std	max	min	D_2	D_5	D_50	D_95	D_98	V_0Gy	V_0.5Gy	V_1Gy	V_1.6Gy	V_...
Core	0.6974	0.1876	0.9986	0.1704	0.9743	0.9563	0.7189	0.2781	0.1981	1	0.8848	0	0	
OuterTarget	1.9652	0.1732	2.7054	1.5511	2.3409	2.2397	1.9766	1.6761	1.6190	1	1	1	0.9857	
BODY	0.2343	0.4481	2.7054	0	1.7993	1.2658	0.0110	0	0	1	0.1780	0.0784	0.0288	

Rezultati

- Srednje doze po regionima (Gy) dobivene pomoću 5 snopova fotona sa i bez ograničenja:

Region/Zračenje	Bez ograničenja	Sa ograničenjima
Osjetljivi region	0.6625	0.6974
Vanjska meta	1.6563	1.9652
Tijelo	0.1968	0.2343

2. Zadatak

- Plan liječenja bolesti jetre ugljikovim ionima
- Definisanje vlastitog plana liječenja fotonima i protonima
- Analiza i poređenje različitih planova liječenja

1. Učitajte jetru pacijenta pomoću opcije Load *.mat (LIVER.mat)

The screenshot displays the matRad software interface. The top navigation bar includes the matRad logo and the DKFZ logo (GERMAN CANCER RESEARCH CENTER IN THE HELMHOLTZ ASSOCIATION). The main interface is divided into several sections:

- Workflow:** Contains buttons for Refresh, Load *.mat data (highlighted with a red arrow), Load *.COM, Import Bin..., Calc. influence Mx, Recalc, Optimize, Save to GUI, Export, and Import Dose.
- Plan:** Includes settings for biixel width (20), Gantry Angle (0 72 144 216 288), Couch Angle (0 0 0 0), Radiation Mode (protons), Machine (Generic), IsoCenter (251.3 236.4 162.6), # Fractions (30), and Type of optimization (const_RBExD).
- Objectives & constraints:** A table listing VOI names, types, priorities, and constraints.
- Visualization:** Includes settings for Slice, Beam, Offset, Type of plot, Plane, and Displav option.

The 'Select File to Open' dialog box is open, showing a file list with the following columns: Name, Date modified, and Type. The file 'LIVER' is selected and highlighted with a red arrow. The file list includes folders like standalone, tools, unitTest, vmc++ and files like BOXPHANTOM, carbon_Generic, HEAD_AND_NECK, LIVER, photons_Generic, PROSTATE, protons_Generic, and TG119.

VOI name	VOI type	priority	obj. / const.	penalty	dose	EUD	volume
1 Core	OAR	2	max dose constraint	NaN	25	NaN	NaN
2 OuterTarget	TARGET	1	min dose constraint	NaN	50	NaN	NaN
3 BODY	OAR	3	square overdosing	100	30	NaN	NaN

Name	Date modified	Type
standalone	6/19/2019 8:34 AM	File folder
tools	6/19/2019 8:34 AM	File folder
unitTest	6/19/2019 8:34 AM	File folder
vmc++	6/19/2019 8:34 AM	File folder
BOXPHANTOM	6/19/2019 8:33 AM	MAT File
carbon_Generic	6/19/2019 8:34 AM	MAT File
HEAD_AND_NECK	6/19/2019 8:33 AM	MAT File
LIVER	6/19/2019 8:33 AM	MAT File
photons_Generic	6/19/2019 8:34 AM	MAT File
PROSTATE	6/19/2019 8:33 AM	MAT File
protons_Generic	6/19/2019 8:34 AM	MAT File
TG119	6/19/2019 8:34 AM	MAT File

2. Definišite vlastiti plan liječenja fotonima sa 4-5 uglova snopa

Workflow

Refresh Load *.mat data Calc. influence Mx Optimize Save to GUI
Load DICOM Recalc Export
Import from Bin... Import Dose

Status: ready for optimization

Plan

bixel width in [mm] 10
Gantry Angle in ° 0 180 225 270 315
Couch Angle in ° 0 0 0 0
Radiation Mode photons
Machine Generic
IsoCenter in [mm] 265.8 296.7 316.4 Auto.
Fractions 30
Type of optimization none Set Tissue

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

Objectives & constraints

	VOI name	VOI type	priority	obj. / const.	penalty	dose	EUD	volume	ro	
1	Skin	OAR	2	square overdosing	300	25	NaN	NaN	no	+
2	PTV	TARGET	1	square deviation	1000	45	NaN	NaN	no	-

save

Visualization

Slice Type of plot inten... GoTo lateral
Beam Plane axial Open 3D-View
Offset Dislay option physicalDose

plot CT
plot contour
plot isolines
plot dose
plot isolines labels
plot iso center
visualize plan / be...

Show DVH/QI

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min 0 max 3.706
Set IsoDose Levels

Viewer Options

Result (i.e. dose) Window Doseat Custom
Window Center: Window Width: 1.85 Range: 0 3.71
jet Dose opacity: 0 1

Structure Visibility

- GTV
- Kidney_R
- Kidney_L
- Stomach
- SmallBowel
- LargeBowel
- Celiac
- SMA_SMV
- Liver
- Heart
- SpinalCord
- DoseFalloff

Info

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About

axial plane z = 317.5 [mm]

3. Pokrenite proračun doze pomoću opcije („Calc. Influence Mx“) i započnite obrnutu optimizaciju klikom na („Optimize“)

The screenshot displays the matRad software interface, which is part of the German Cancer Research Center (dkfz) in the Helmholtz Association. The interface is divided into several panels:

- Workflow Panel:** Contains buttons for 'Refresh', 'Load *.mat data', 'Load DICOM', 'Import from Bin...', 'Calc. influence Mx', 'Optimize', 'Save to GUI', 'Export', and 'Import Dose'. Red arrows point to 'Calc. influence Mx' (labeled '1') and 'Optimize' (labeled '2'). The status below indicates 'ready for optimization'.
- Plan Panel:** Includes settings for 'bixel width in [mm]' (10), 'Gantry Angle in °' (0 180 225 270 315), 'Couch Angle in °' (0 0 0 0), 'Radiation Mode' (photons), 'Machine' (Generic), 'IsoCenter in [mm]' (265.8 296.7 316.4), '# Fractions' (30), and 'Type of optimization' (none). It also has options for 'use MC (VMC++) dose calculations', '3D conformal', 'Run Sequencing', 'Stratification Levels' (7), and 'Run Direct Aperture Optimizat...'. A 'Set Tissue' button is also present.
- Objectives & constraints Panel:** Contains a table with the following data:

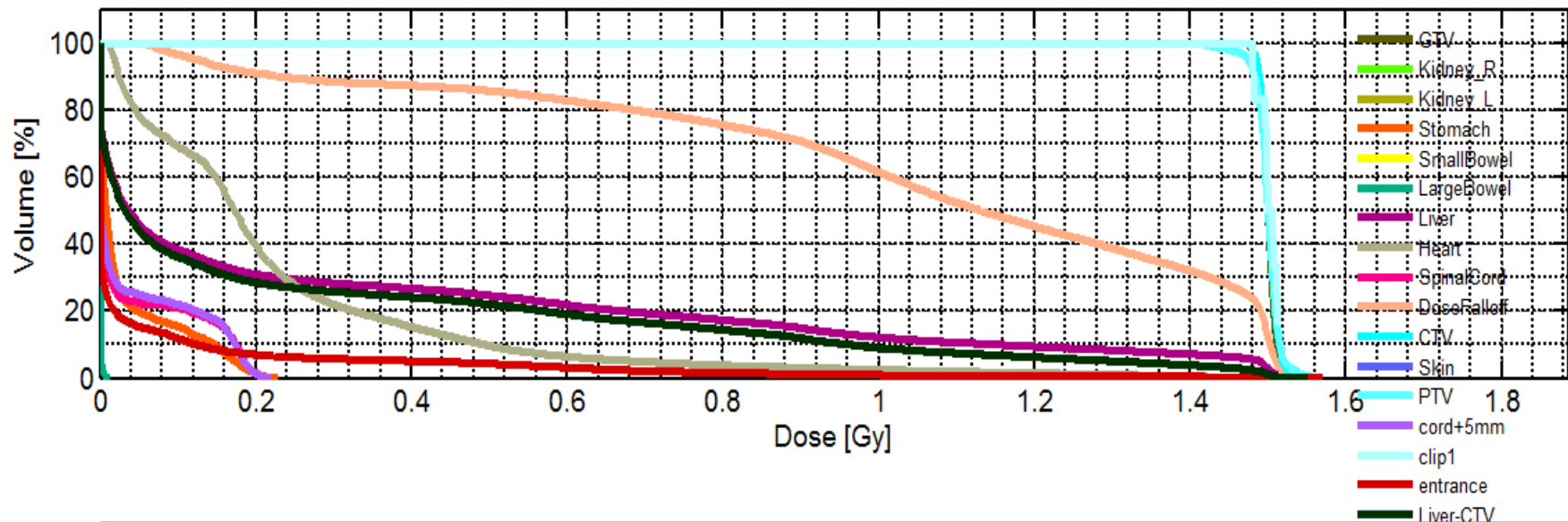
	VOI name	VOI type	priority	obj. / const.	penalty	dose	EUD	volume	ro
1	Skin	OAR	2	square overdosing	300	25	NaN	NaN	no
2	PTV	TARGET	1	square deviation	1000	45	NaN	NaN	no
- Visualization Panel:** Shows 'Slice' and 'Beam' settings, 'Type of plot' (intensity), 'Plane' (axial), and 'Dislay option' (physicalDose). It includes a 'GoTo' button set to 'lateral' and an 'Open 3D-View' button. A 'Show DVH/QI' button is at the bottom.
- Viewing Panel:** Displays an axial CT scan of a patient's head and neck at 'axial plane z = 317.5 [mm]'. The image shows various anatomical structures with colored contours (blue, pink, yellow, green) representing different dose levels. A color scale on the right indicates 'physicalDose [Gy]' from 0 to 60.
- Viewer Options Panel:** Includes 'Set IsoDose Levels', 'Result (i.e. dose)' dropdown, 'Window Center' (1.85), 'Window Width' (3.71), 'Range' (0 to 3.706), 'Dose opacity' (1), and 'Structure Visibility' list with checkboxes for GTV, Kidney_R, Kidney_L, Stomach, SmallBowel, LargeBowel, Celiac, SMA_SMV, Liver, Heart, SpinalCord, and DoseFalloff.
- Info Panel:** Shows 'v3.0.0' and 'github.com/e0404/mat' with an 'About' button.

4. Spremite rezultat optimizacije putem („Save to GUI“) i prikažite DVH pomoću („Show DVH/QI“)

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

- Workflow Panel:** Contains buttons for Refresh, Load *.mat data, Calc. influence Mx, Optimize, Save to GUI, Load DICOM, Recalc, Export, and Import dose. A red arrow points to the "Save to GUI" button, labeled with a "1".
- Status:** Indicates "plan is optimized".
- Plan Panel:** Shows various optimization parameters:
 - bixel width in [mm]: 10
 - Gantry Angle in °: 0 180 225 270 315
 - Couch Angle in °: 0 0 0 0
 - Radiation Mode: photons
 - Machine: Generic
 - IsoCenter in [mm]: 265.8 296.7 316.4 (with "Auto" checked)
 - # Fractions: 30
 - Type of optimization: none
 - Stratification Levels: 7
 - Options: use MC (VMC++) dose calculations, 3D conformal, Run Sequencing, Run Direct Aperture Optimizat...
- Objectives & constraints Panel:** Contains a table of objectives and constraints:

	VOI name	VOI type	priority	obj. / const.	penalty	dose	EUD	volume	ro
1	Skin	OAR	2	square overdosing	300	25	NaN	NaN	no
2	PTV	TARGET	1	square deviation	1000	45	NaN	NaN	no
- Visualization Panel:** Shows settings for the visualization:
 - Slice: [input field]
 - Beam: [input field]
 - Offset: [input field]
 - Type of plot: inten...
 - Plane: axial
 - Display option: physicalDose
 - Buttons: GoTo lateral, Open 3D-View
 - Options: plot CT, plot contour, plot isolines, plot dose, plot isolines labels, plot iso center, Visualize plan / be...
 - A red arrow points to the "Show DVH/QI" button, labeled with a "2".
- Viewing Panel:** Shows a 3D visualization of the dose distribution in an axial plane at z = 317.5 [mm]. The color scale represents physical dose in Gy, ranging from 0 to 60. The visualization shows a target volume (PTV) and organs at risk (OAR) with dose contours.
- Right Panel:** Contains viewer options:
 - min: 0, max: 1.572
 - Set IsoDose Levels
 - Viewer Options: Result (i.e. dose), Window: Default, Custom, Window Center: 0.781, Window Width: 1.57, Range: 0 1.572, jet, Dose opacity: 1
 - Structure Visibility: GTV, Kidney_R, Kidney_L, Stomach, SmallBowel, LargeBowel, Celiac, SMA_SMV, Liver, Heart, SpinalCord, DoseFalloff
 - Info: v3.0.0, github.com/e0404/mat, About



	mean	std	max	min	D_2	D_5	D_50	D_95	D_98	V_0Gy	V_0.3Gy	V_0.6Gy	V_0.9Gy
GTV	1.5000	0.0090	1.5281	1.4727	1.5188	1.5148	1.5002	1.4851	1.4796	1	1	1	
Kidney_R	0	0	0	0	0	0	0	0	0	1	0	0	
Kidney_L	0	0	0	0	0	0	0	0	0	1	0	0	
Stomach	0.0342	0.0566	0.2310	0	0.1940	0.1736	0.0082	0	0	1	0	0	
SmallBowel	0	0	0	0	0	0	0	0	0	1	0	0	
LargeBowel	2.6018e-04	0.0012	0.0147	0	0.0047	0.0019	0	0	0	1	0	0	
Celiac	0	0	0	0	0	0	0	0	0	1	0	0	
SMA_SMV	0	0	0	0	0	0	0	0	0	1	0	0	
Liver	0.3033	0.4713	1.5526	0	1.5042	1.4889	0.0367	0	0	1	0.2838	0.2190	0
Heart	0.2296	0.2426	1.5232	0.0066	1.1065	0.6913	0.1728	0.0182	0.0141	1	0.2202	0.0650	0
SpinalCord	0.0391	0.0686	0.2167	0	0.1969	0.1856	0	0	0	1	0	0	

5. Definišite vlastiti plan liječenja protonima s jednim snopom, npr. 315 °, te pokrenite proračun doze pomoću opcije („Calc. Influence Mx“) i obrnutu optimizaciju klikom na („Optimize“)

Workflow

Refresh Load *.mat data **Calc. influence Mx** Optimize Save to GUI
 Load DICOM Re Export
 Import from Bin... Import Dose

Status: ready for dose calculation

Plan

bixel width in [mm] 10
 Gantry Angle in ° 315
 Couch Angle in ° 0
 Radiation Mode protons
 Machine Generic
 IsoCenter in [mm] 265.8 296.7 316.4 Auto.
 # Fractions 30
 Type of optimization const_RBExD Set Tissue

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

Objectives & constraints

	VOI name	VOI type	priority	obj. / const.	penalty	dose	EUD	volume	ro
1	Skin	OAR	2	square overdosing	300	25	NaN	NaN	no
2	PTV	TARGET	1	square deviation	1000	45	NaN	NaN	no

Visualization

Slice Type of plot inten... GoTo lateral
 Beam Plane axial Open 3D-View
 Offset Display option physicalDose

plot CT
 plot contour
 plot isolines
 plot dose
 plot isolines labels
 plot iso center
 visualize plan / be...

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axial plane z = 317.5 [mm]

min max n
 0 1.572 1.572

Set IsoDose Levels

Viewer Options

Result (i.e. dose) Window Doseat Custom
 Window Center: 0.784
 Window Width: 1.57
 Range: 0 1.572
 jet
 Dose opacity: 1

Structure Visibility

- GTV
- Kidney_R
- Kidney_L
- Stomach
- SmallBowel
- LargeBowel
- Celiac
- SMA_SMV
- Liver
- Heart
- SpinalCord
- DoseFalloff

Info

v3.0.0
 github.com/e0404/mat
 About

6. Spremite rezultat optimizacije putem („Save to GUI“) i prikažite DVH pomoću („Show DVH/QI“)

Workflow

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

Load DICOM Recalc

Import from Bin...

Status: plan is optimized 1

Plan

bixel width in [mm] 10

Gantry Angle in ° 315

Couch Angle in ° 0

Radiation Mode protons

Machine Generic

IsoCenter in [mm] 265.8 296.7 316.4 Auto.

Fractions 30

Type of optimization const_RBExD

use MC (VMC++) dose calculations

3D conformal

Run Sequencing

Stratification Levels 7

Run Direct Aperture Optimizat...

Objectives & constraints

	VOI name	VOI type	priority	obj. / const.	penalty	dose	EUD	volume	ro
1	Skin	OAR	2	square overdosing	300	25	NaN	NaN	no
2	PTV	TARGET	1	square deviation	1000	45	NaN	NaN	no

Visualization

Slice

Beam

Offset

Type of plot inten...

Plane axial

Dislay option RBExDose 2

plot CT

plot contour

plot isolines

plot dose

plot isolines labels

plot iso center

visualize plan / be...

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

Viewing axial plane z = 317.5 [mm]

min max n 2.501

Viewer Options

Result (i.e. dose)

Window Prea... Custom

Window Center:

Window Width: 1.25

Window Height: 2.5

Range: 0 2.501

jet

Dose opacity:

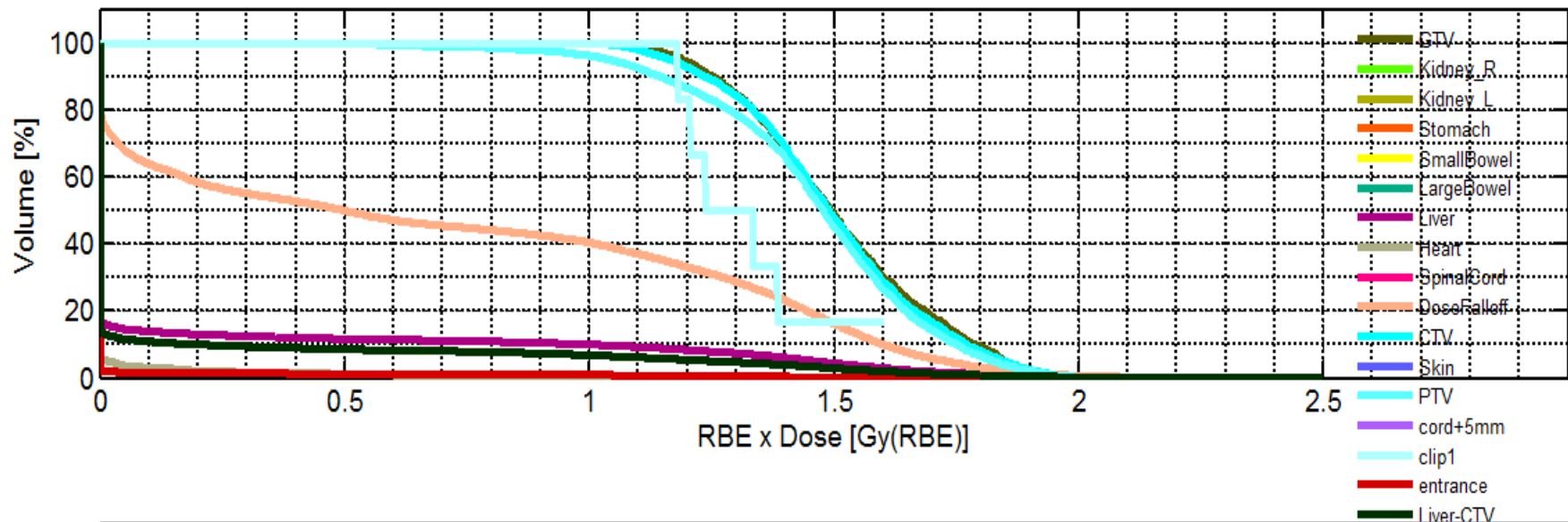
Structure Visibility

- GTV
- Kidney_R
- Kidney_L
- Stomach
- SmallBowel
- LargeBowel
- Celiac
- SMA_SMV
- Liver
- Heart
- SpinalCord
- DoseFalloff

Info

v3.0.0

github.com/e0404/mat



	mean	std	max	min	D_2	D_5	D_50	D_95	D_98	V_0Gy	V_0.5Gy	V_1Gy	V_1.5Gy
GTV	1.5053	0.1981	2.0110	1.0341	1.8973	1.8506	1.4947	1.1921	1.1231	1	1	1	0
Kidney_R	0	0	0	0	0	0	0	0	0	1	0	0	0
Kidney_L	0	0	0	0	0	0	0	0	0	1	0	0	0
Stomach	0	0	0	0	0	0	0	0	0	1	0	0	0
SmallBowel	0	0	0	0	0	0	0	0	0	1	0	0	0
LargeBowel	0	0	0	0	0	0	0	0	0	1	0	0	0
Celiac	0	0	0	0	0	0	0	0	0	1	0	0	0
SMA_SMV	0	0	0	0	0	0	0	0	0	1	0	0	0
Liver	0.1694	0.4605	2.5011	0	1.6940	1.4688	0	0	0	1	0.1177	0.1008	0
Heart	0.0172	0.1143	1.8597	0	0.2483	0.0195	0	0	0	1	0.0127	0.0050	0
SpinalCord	0	0	0	0	0	0	0	0	0	1	0	0	0

7. Napravite tretman ugljikovim jonima sa tačno istim postavkama kao za plan protonskog tretmana

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

- Workflow:** Contains buttons for 'Refresh', 'Load *.mat data', 'Load DICOM', 'Import from Bin...', 'Calc. influence Mx', 'Optimize', 'Save to GUI', 'Export', and 'Import Dose'. Red arrows point to 'Calc. influence Mx' (labeled '2') and 'Optimize' (labeled '3'). The status below indicates 'ready for dose calculation'.
- Plan:** Contains input fields for 'bixel width in [mm]' (10), 'Gantry Angle in °' (315), 'Couch Angle in °' (0), 'Radiation Mode' (carbon), 'Machine' (photons), 'IsoCenter in [mm]', '# Fractions', and 'Type of optimization' (LEMIV_RBExD). A red arrow points to the 'carbon' option in the 'Radiation Mode' dropdown (labeled '1'). Other options include 'use MC (VMC++) dose calculations', '3D conformal', 'Run Sequencing', 'Stratification Levels' (7), and 'Run Direct Aperture Optimizat...'. There is also a 'Set Tissue' button.
- Objectives & constraints:** A table with columns: 'VOI name', 'VOI type', 'priority', 'obj. / const.', 'penalty', 'dose', 'EUD', 'volume', and 'ro'.

	VOI name	VOI type	priority	obj. / const.	penalty	dose	EUD	volume	ro
1	Skin	OAR	2	square overdosing	300	25	NaN	NaN	no
2	PTV	TARGET	1	square deviation	1000	45	NaN	NaN	no
- Visualization:** Contains settings for 'Slice', 'Beam', 'Offset', 'Type of plot' (inten...), 'GoTo' (lateral), 'Plane' (axial), 'Dislay option' (RBExDose), and 'Show DVH/QI'. There are also checkboxes for 'plot CT', 'plot contour', 'plot isolines', 'plot dose', 'plot isolines labels', 'plot iso center', and 'visualize plan / be...'. A 'Show DVH/QI' button is at the bottom.
- Viewing:** Shows a 3D visualization of the treatment plan. The title is 'axial plane z = 317.5 [mm]'. The y-axis is labeled 'y [mm]' and ranges from 50 to 650. The x-axis is labeled 'x [mm]' and ranges from 50 to 650. A color scale on the right indicates 'RBExDose [Gy(RBE)]' from 0 to 60. The visualization shows a cross-section of a head and neck with a tumor (PTV) and surrounding organs at risk (OAR) outlined. A color-coded dose distribution is overlaid on the tumor, showing a high-dose region (red/yellow) and a lower-dose region (blue).
- Right Panel:** Contains 'min max' (0, 2.501), 'Set IsoDose Levels', 'Viewer Options' (Result (i.e. dose), Window, Window Center, Window Width, Range, jet, Dose opacity), 'Structure Visibility' (GTV, Kidney_R, Kidney_L, Stomach, SmallBowel, LargeBowel, Celiac, SMA_SMV, Liver, Heart, SpinalCord, DoseFalloff), and 'Info' (v3.0.0, github.com/e0404/mat, About).

8. Spremite rezultat optimizacije putem („Save to GUI“) i prikažite DVH pomoću („Show DVH/QI“)

Workflow

Refresh Load *.mat data Calc. influence Mx Optimize **Save to GUI** Export Import dose

Load DICOM Recalc

Import from Bin...

Status: plan is optimized

1

Plan

bixel width in [mm] 10 use MC (VMC++) dose calculations

Gantry Angle in ° 315 3D conformal

Couch Angle in ° 0 Run Sequencing

Radiation Mode carbon Stratification Levels 7

Machine Generic Run Direct Aperture Optimizat...

IsoCenter in [mm] 265.8 296.7 316.4 Auto.

Fractions 30

Type of optimization LEMIV_RBExD Set Tissue

Objectives & constraints

	VOI name	VOI type	priority	obj. / const.	penalty	dose	EUD	volume	ro
1	Skin	OAR	2	square overdosing	300	25	NaN	NaN	no
2	PTV	TARGET	1	square deviation	1000	45	NaN	NaN	no

Visualization

Slice Type of plot inten... GoTo lateral plot CT

Beam Plane axial Open 3D-View plot contour

Offset Dislay option RBExDose plot isolines

2

plot dose

plot isolines labels

plot iso center

visualize plan / be...

Show DVH/QI

3

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axial plane z = 317.5 [mm]

min 0 max 2.122

Set IsoDose Levels

Viewer Options

Result (i.e. dose) Window Default Custom

Window Center: 1.06

Window Width: 2.12

Range: 0 2.123

jet Dose opacity: 1

Structure Visibility

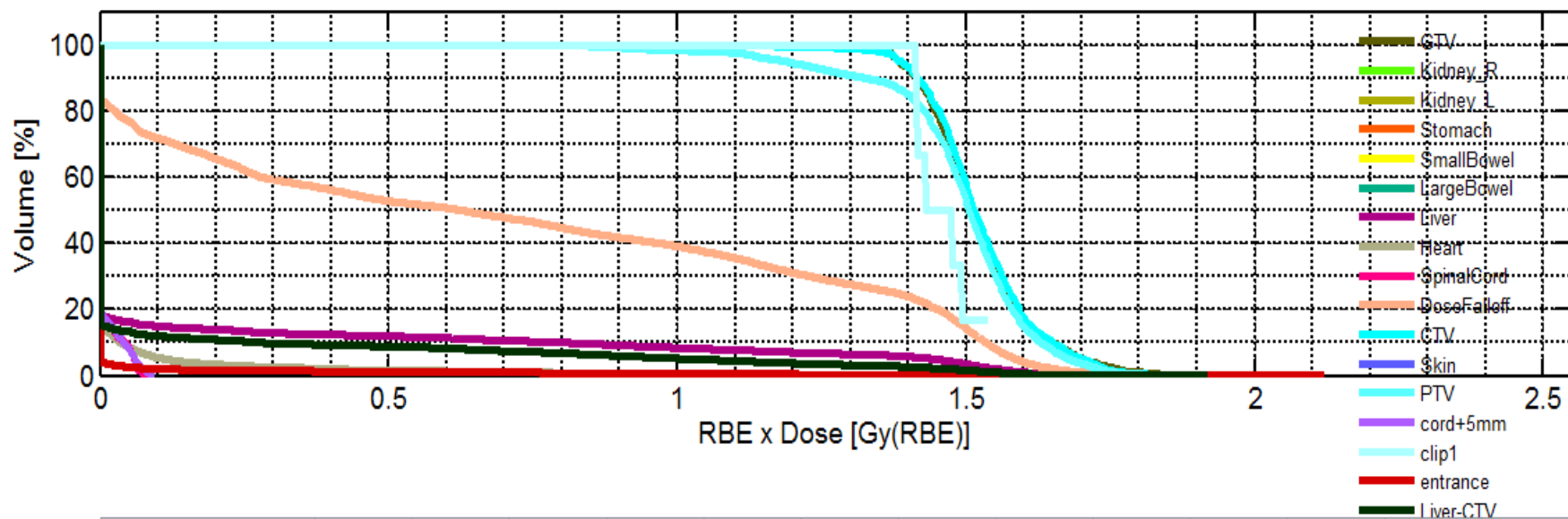
- GTV
- Kidney_R
- Kidney_L
- Stomach
- SmallBowel
- LargeBowel
- Cellac
- SMA_SMV
- Liver
- Heart
- SpinalCord
- DoseFalloff

Info

v3.0.0

github.com/e0404/mat

About



	mean	std	max	min	D_2	D_5	D_50	D_95	D_98	V_0Gy	V_0.4Gy	V_0.8Gy	V_1.2Gy
GTV	1.5212	0.0930	1.8920	1.2809	1.7595	1.7032	1.5090	1.3845	1.3641	1	1	1	
Kidney_R	0	0	0	0	0	0	0	0	0	1	0	0	
Kidney_L	0	0	0	0	0	0	0	0	0	1	0	0	
Stomach	0	0	0	0	0	0	0	0	0	1	0	0	
SmallBowel	0	0	0	0	0	0	0	0	0	1	0	0	
LargeBowel	0	0	0	0	0	0	0	0	0	1	0	0	
Celiac	0	0	0	0	0	0	0	0	0	1	0	0	
SMA_SMV	0	0	0	0	0	0	0	0	0	1	0	0	
Liver	0.1570	0.4178	1.9880	0	1.5533	1.4456	0	0	0	1	0.1243	0.1004	0.0000
Heart	0.0277	0.1314	1.8137	0	0.4139	0.1145	0	0	0	1	0.0212	0.0088	0.0000
SpinalCord	0.0077	0.0187	0.0855	0	0.0659	0.0582	0	0	0	1	0	0	

Rezultati

- Srednje doze po regionima (Gy) dobivene pomoću 5 snopova fotona, jednog snopa protona i iona karbona:

Region/Zračenje(uglovi)	Fotoni(0,180,225,270,315)	Protoni(315)	Karbon(315)
GTV	1.5	1.5053	1.5212
Bubrezi	0	0	0
Stomak	0.0342	0	0
Jetra	0.3033	0.1694	0.1570
Srce	0.2296	0.0172	0.0277
Kičmena moždina	0.0391	0	0.0077
CTV	1.5015	1.4981	1.5236
PTV	1.4991	1.4595	1.4868
Koža	0.0568	0.0179	0.0162

3. Zadatak

- Neizvjesnosti u planiranju liječenja
- Planiranje protonske terapije za glavu pacijenta
- Simuliranje greške u postavljanju pacijenta
- Analiza i upoređivanje rezultujućih raspodjela doze

1. Učitajte glavu pacijenta pomoću opcije Load * .mat (HEAD_AND_NECK or ALDERSON.mat)

The screenshot displays the matRad software interface, which is part of the German Cancer Research Center (dkfz) in the Helmholtz Association. The main window shows a workflow panel on the left with buttons for 'Refresh', 'Load *.mat data', 'Load *.COM', 'Import Bin...', 'Calc. influence Mx', 'Optimize', 'Save to GUI', 'Recalc', 'Export', and 'Import Dose'. A red arrow points to the 'Load *.mat data' button. The status bar indicates 'plan is optimized'. The main viewing area shows an axial plane at z = 317.5 [mm]. A 'Select File to Open' dialog box is open, showing a file list with 'HEAD_AND_NECK' selected, indicated by a red arrow. The file list includes folders like 'standalone', 'tools', 'unitTest', 'vmc++' and files like 'BOXPHANTOM', 'carbon_Generic', 'HEAD_AND_NECK', 'LIVER', 'photons_Generic', 'PROSTATE', 'protons_Generic', and 'TG119'. The 'File name' field contains 'HEAD_AND_NECK' and the file type is set to 'MAT-files (*.mat)'. The 'Open' button is highlighted.

Workflow

Refresh Load *.mat data Load *.COM Import Bin... Calc. influence Mx Optimize Save to GUI Recalc Export Import Dose

Status: plan is optimized

Plan

bixel width in [mm] 10
Gantry Angle in ° 315
Couch Angle in ° 0
Radiation Mode carbon
Machine Generic
IsoCenter in [mm] 265.8 296.7 316.4 [x] [y] [z] Auto.
Fractions 30
Type of optimization LEMIV_RBExD Set Tissue

Objectives & constraints

	VOI name	VOI type	priority	obj. / const.	penalty	dose	EUD	volume
1	Skin	OAR	2	square overdosing	300	25	NaN	NaN
2	PTV	TARGET	1	square deviation	1000	45	NaN	NaN

Visualization

Slice Type of plot inten... GoTo lateral
Beam Plane axial Open 3D-View
Offset Disolv option RBExDose

plot CT
plot contour
plot isolines
plot dose
plot isolines labels
plot iso center
visualize plan / be...

min max 0 2.122
Set IsoDose Levels
Viewer Options
Result (i.e. dose)
Custom
Window Center: 1.06
Window Width: 2.12
Range: 0 2.123
jet
Dose opacity: 0 1
Structure Visibility
GTV
Kidney_R
Kidney_L
Stomach
SmallBowel
LargeBowel
Celiac
SMA_SMV
Liver
Heart
SpinalCord
DoseFalloff
Info
v3.0.0
github.com/e0404/mat
About

2. Dodajte tri ugla za protonske snopove po vašoj želji. Izračunajte i optimizirajte dozu („Calc. Influence Mx“ & „Optimize“).

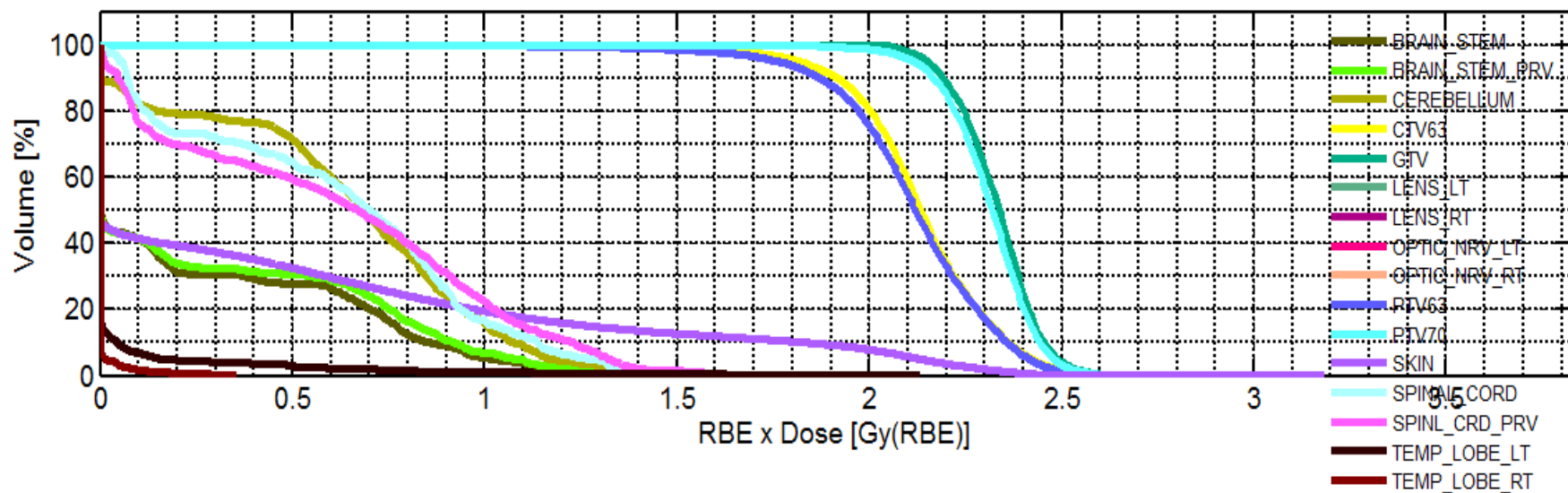
The screenshot displays the matRad software interface, which is used for proton therapy planning. The interface is divided into several panels:

- Workflow:** Contains buttons for 'Refresh', 'Load *.mat data', 'Load DICOM', 'Import from Bin...', 'Calc. influence Mx', 'Optimize', 'Save to GUI', 'Export', and 'Import Dose'. Red arrows point to 'Calc. influence Mx' (labeled '2') and 'Optimize' (labeled '3'). The status below indicates 'ready for dose calculation'.
- Plan:** Contains input fields for 'bixel width in [mm]' (10), 'Gantry Angle in °' (90 180 270), 'Couch Angle in °' (0 0 0), 'Radiation Mode' (protons), 'Machine' (Generic), 'IsoCenter in [mm]' (250.4 205.3 138.5), '# Fractions' (30), and 'Type of optimization' (const_RBExD). Red arrows point to the Gantry Angle, Couch Angle, and Radiation Mode fields (labeled '1'). There are also radio buttons for 'use MC (VMC++) dose calculations', '3D conformal', 'Run Sequencing', and 'Run Direct Aperture Optimizat...'. A 'Stratification Levels' field is set to 7.
- Objectives & constraints:** A table with columns: VOI name, VOI type, priority, obj. / const., penalty, dose, EUD, volume. It lists four objectives for parotid glands and two target volumes (PTV63, PTV70).
- Visualization:** Contains settings for 'Slice', 'Beam', 'Offset', 'Type of plot' (intensity), 'Plane' (axial), and 'Dislay option'. There are checkboxes for 'plot CT', 'plot contour', 'plot isolines', 'plot dose', 'plot isolines labels', 'plot iso center', and 'visualize plan / be...'. A 'GoTo' dropdown is set to 'lateral' and 'Open 3D-View' is available.
- Viewing:** Shows an axial CT scan at z = 140 [mm]. The x and y axes range from 50 to 450 mm. A color scale on the right indicates Hounsfield Units from 0 to 60. A target volume is outlined in red, and organs at risk are outlined in blue and green.
- Right Panel:** Contains 'min max' values (1024, 3071), 'Set IsoDose Levels', 'Viewer Options' (CT (HU), Window, Custom), 'Window Center' (1.27), 'Window Width' (2.53), 'Range' (0.00324, 2.531), 'bone' structure, 'Dose opacity' (1), and 'Structure Visibility' (BRAIN_STEM, BRAIN_STEM_PR, CEREBELLUM, CHIASSMA, CTV63, GTV, LARYNX, LENS_LT, LENS_RT, LIPS, OPTIC_NRV_LT, OPTIC_NRV_RT).

3. Analizirajte rezultat (doza i DVH) i sačuvajte („Save to GUI“)

The screenshot displays the matRad software 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, and Import case. A red arrow points to the "Save to GUI" button. The status below indicates "plan is optimized".
- Plan:** Includes input fields for biixel width (10 mm), Gantry Angle (90, 180, 270), Couch Angle (0, 0, 0), Radiation Mode (protons), Machine (Generic), IsoCenter (250.4, 205.3, 138.5), # Fractions (30), and Type of optimization (const_RBExD). There are also radio buttons for "use MC (VMC++) dose calculations", "3D conformal", "Run Sequencing", and "Run Direct Aperture Optimizat...".
- Objectives & constraints:** A table listing VOI names, types, priorities, and constraints.
- Visualization:** Includes controls for Slice, Beam, Offset, Type of plot (intensity), Plane (axial), and Dislay option (RBExDose). A red arrow points to the "Show DVH/QI" button. There are also checkboxes for "plot CT", "plot contour", "plot isolines", "plot dose", "plot isolines labels", "plot iso center", and "visualize plan / be...".
- Viewing:** Shows an axial plane at z = 140 [mm]. The visualization includes a color scale for RBExDose [Gy(RBE)] ranging from 0 to 60. The x and y axes are labeled in mm.
- Viewer Options:** Includes "Result (i.e. dose)", "Window Center" (1.59), "Window Width" (3.19), "Range" (0 to 3.186), "jet" color map, and "Dose opacity" (1).
- Structure Visibility:** A list of structures with checkboxes: BRAIN_STEM, BRAIN_STEM_PR, CEREBELLUM, CHIASMA, CTV63, GTV, LARYNX, LENS_LT, LENS_RT, LIPS, OPTIC_NRV_LT, and OPTIC_NRV_RT.
- Info:** Shows version v3.0.0 and the GitHub repository link github.com/e0404/mat.



	mean	std	max	min	D_2	D_5	D_50	D_95	D_98	V_0Gy	V_0.6Gy	V_1.2Gy	V_1.9Gy
BRAIN_STEM	0.2645	0.3831	1.5408	0	1.1597	1.0153	0.0030	0	0	1	0.2649	0.0167	
BRAIN_STEM_PRV	0.2906	0.4099	1.5754	0	1.2980	1.0952	0.0016	0	0	1	0.2896	0.0251	
CEREBELLUM	0.6355	0.3774	2.0785	0	1.3512	1.1661	0.6933	0	0	1	0.5998	0.0469	7.3233
CHIASMA	0	0	0	0	0	0	0	0	0	1	0	0	
CTV63	2.1304	0.1945	3.1861	0.9407	2.4868	2.4230	2.1346	1.8175	1.6587	1	1	0.9973	0.0000
GTV	2.3305	0.1036	2.7047	1.9940	2.5353	2.4898	2.3381	2.1496	2.0935	1	1	1	
LARYNX	0.9230	0.4283	1.9861	0.2391	1.8607	1.7473	0.8058	0.3375	0.2819	1	0.7891	0.2585	0.0000
LENS_LT	0	0	0	0	0	0	0	0	0	1	0	0	
LENS_RT	0	0	0	0	0	0	0	0	0	1	0	0	
LIPS	0.0157	0.0412	0.2352	1.1603e-35	0.1705	0.1231	5.8836e-06	4.7064e-25	6.6316e-30	1	0	0	
OPTIC_NRV_LT	0	0	0	0	0	0	0	0	0	1	0	0	

4. Simulirajte grešku u postavljanju pacijenta: Uklonite kvakicu u checkboxa za auto-izocentar i odredite novi izo-centar. Preračunajte dozu klikom na dugme („Recalc“)

Workflow

Refresh Load *.mat data Calc. influence Mx Optimize Save to GUI
 Load DICOM Recalc Export
 Import from Bin... Import Dose

Status: ready for dose calculation

Plan

bixel width in [mm] 10
 Gantry Angle in ° 90 180 270
 Couch Angle in ° 0 0 0
 Radiation Mode protons
 Machine Generic
 IsoCenter in [mm] 260 220 150 Auto
 # Fractions 30
 Type of optimization const_RBExD Set Tissue

use MC (VMC++) dose calculations
 3D conformal
 Run Sequencing
 Stratification Levels 7

Objectives & constraints

	VOI name	VOI type	priority	obj. / const.	penalty	dose	EUD	volume
1	PAROTID_LT	OAR	1	square overdosing	100	25	NaN	NaN
2	PAROTID_RT	OAR	1	square overdosing	100	25	NaN	NaN
3	PTV63	TARGET	2	square deviation	1000	63	NaN	NaN
4	PTV70	TARGET	1	square deviation	1000	70	NaN	NaN

Visualization

Slice Type of plot inten... GoTo lateral
 Beam Plane axial Open 3D-View
 Offset Dislay option RBExDose

plot CT
 plot contour
 plot isolines
 plot dose
 plot isolines labels
 plot iso center
 visualize plan / be...

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

axial plane z = 140 [mm]

min 0
 max 3.186

Set IsoDose Levels

Viewer Options

Result (i.e. dose)
 Window Doseat
 Custom
 Window Center:
 Window Width: 1.59
 3.19
 Range: 0 3.186
 jet
 Dose opacity: 1
 0

Structure Visibility

- BRAIN_STEM
- BRAIN_STEM_PR
- CEREBELLUM
- CHIASSMA
- CTV63
- GTV
- LARYNX
- LENS_LT
- LENS_RT
- LIPS
- OPTIC_NRV_LT
- OPTIC_NRV_RT

Info

v3.0.0
 github.com/e0404/mat
 About



Workflow

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

Load DICOM Recalc Export

Import from Bin... Import Dose

Status: plan is optimized

Plan

bixel width in [mm] use MC (VMC++) dose calculations

Gantry Angle in ° 3D conformal

Couch Angle in ° Run Sequencing

Radiation Mode Stratification Levels

Machine Run Direct Aperture Optimizat...

IsoCenter in [mm] Auto.

Fractions

Type of optimization

Objectives & constraints

	VOI name	VOI type	priority	obj. / const.	penalty	dose	EUD	volume
1	PAROTID_LT	OAR	1	square overdosing	100	25	NaN	NaN
2	PAROTID_RT	OAR	1	square overdosing	100	25	NaN	NaN
3	PTV63	TARGET	2	square deviation	1000	63	NaN	NaN
4	PTV70	TARGET	1	square deviation	1000	70	NaN	NaN

Visualization

Slice Type of plot GoTo plot CT

Beam Plane plot contour

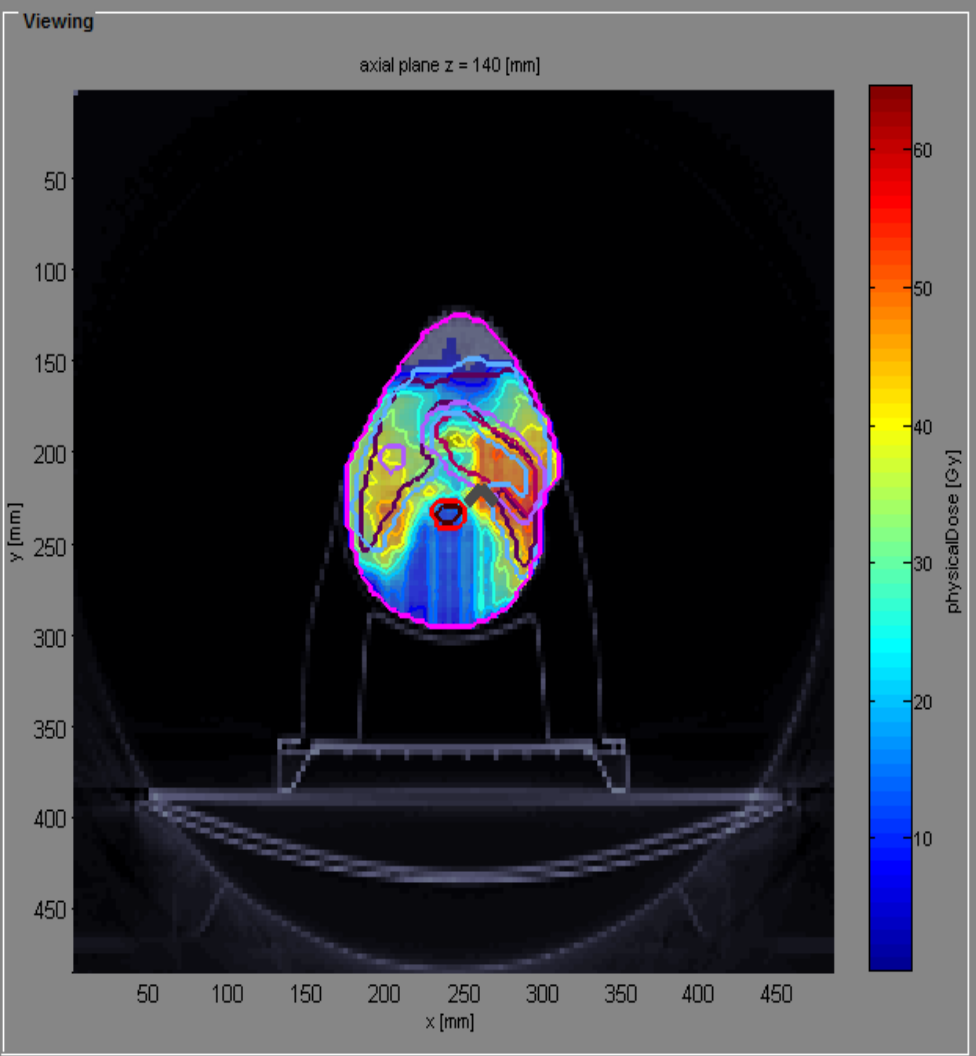
Offset Disolv option plot isolines

plot dose

plot isolines labels

plot iso center

visualize plan / be...



min n
max 3.186

Viewer Options

Result (i.e. dose)
 Window Center:
 Window Width:
 Range:
 jet
 Dose opacity:

Structure Visibility

- BRAIN_STEM
- BRAIN_STEM_PR
- CEREBELLUM
- CHIASMA
- CTV63
- GTV
- LARYNX
- LENS_LT
- LENS_RT
- LIPS
- OPTIC_NRV_LT
- OPTIC_NRV_RT

Info

v3.0.0
 github.com/e0404/mat

5. Podešavanjem opcije “Slice” pronađite izocentar te analizirajte i uporedite rezultirajuću raspodjelu doze (doza i DVH)

Workflow

Refresh Load *.mat data Calc. influence Mx Optimize Save to GUI
 Load DICOM Recalc Export
 Import from Bin... Import Dose

Status: plan is optimized

Plan

bixel width in [mm] 10 use MC (VMC++) dose calculations
 Gantry Angle in ° 90 180 270 3D conformal
 Couch Angle in ° 0 0 0 Run Sequencing
 Radiation Mode protons Stratification Levels 7
 Machine Generic Run Direct Aperture Optimizat...
 IsoCenter in [mm] 260 220 150 Auto.
 # Fractions 30
 Type of optimization const_RBExD Set Tissue

Objectives & constraints

	VOI name	VOI type	priority	obj. / const.	penalty	dose	EUD	volume
1	PAROTID_LT	OAR	1	square overdosing	100	25	NaN	NaN
2	PAROTID_RT	OAR	1	square overdosing	100	25	NaN	NaN
3	PTV63	TARGET	2	square deviation	1000	63	NaN	NaN
4	PTV70	TARGET	1	square deviation	1000	70	NaN	NaN

Visualization

Slice inten... GoTo lateral plot CT
 Beam Plane 1 axial Open 3D-View plot contour
 Offset Dislay option physicalDose 2 plot isolines
 Show DVH/QI plot dose
 plot isolines labels
 plot iso center
 visualize plan / be...

matRad dkfz. GERMAN CANCER RESEARCH CENTER IN THE HELMHOLTZ ASSOCIATION

Viewing axial plane z = 150 [mm]

min 0 max 3.186

Set IsoDose Levels

Viewer Options

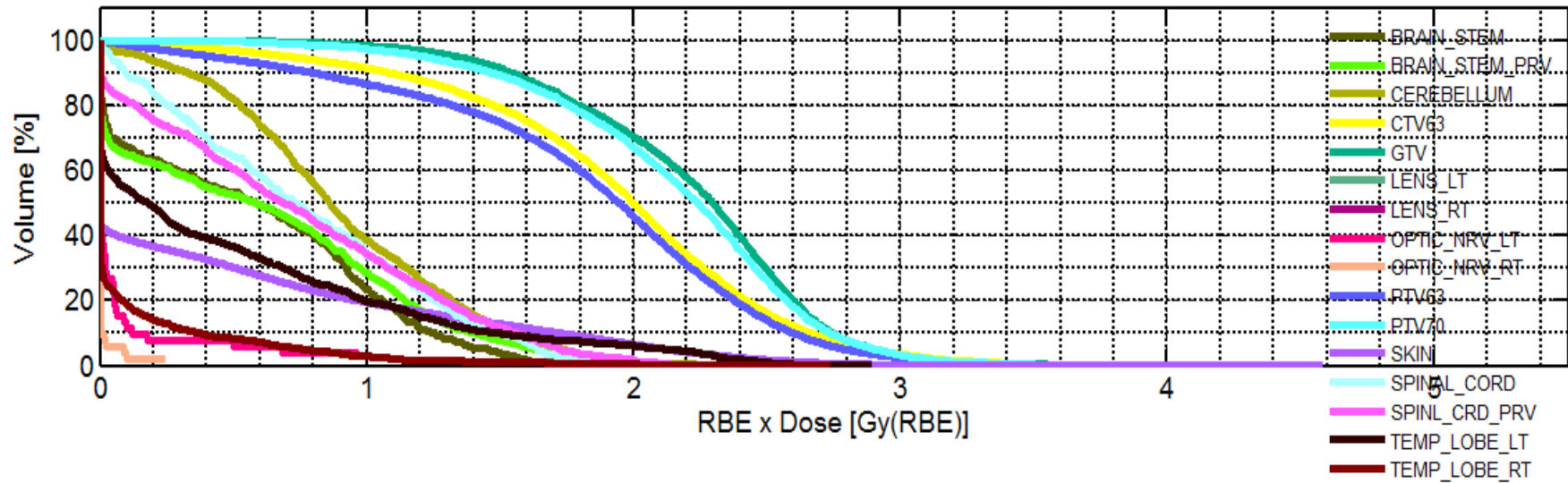
Result (i.e. dose) Window Doseat Custom
 Window Center: 1.59 Window Width: 3.19
 Range: 0 3.186
 jet Dose opacity: 1

Structure Visibility

- BRAIN_STEM
- BRAIN_STEM_PR
- CEREBELLUM
- CHIASMA
- CTV63
- GTV
- LARYNX
- LENS_LT
- LENS_RT
- LIPS
- OPTIC_NRV_LT
- OPTIC_NRV_RT

Info

v3.0.0
 github.com/e0404/mat
 About



	mean	std	max	min	D_2	D_5	D_50	D_95	D_98	V_0Gy	V_0.9Gy	V_1.8Gy	V_2.7Gy
BRAIN_STEM	0.5784	0.5092	1.8823	0	1.5814	1.4499	0.5847	0	0	1	0.3294	0.0048	
BRAIN_STEM_PRV	0.6153	0.5759	2.3528	0	1.8157	1.6326	0.5786	0	0	1	0.3519	0.0240	
CEREBELLUM	0.9112	0.4681	2.5823	0	1.9049	1.7408	0.8620	0.1636	0.0032	1	0.4588	0.0373	
CHIASMA	0.2487	0.2353	0.8091	0.0071	0.7505	0.6536	0.2672	0.0169	0.0118	1	0	0	
CTV63	1.9376	0.6348	4.0525	0.0093	3.1482	2.8966	1.9997	0.7051	0.3469	1	0.9282	0.6441	0
GTV	2.2150	0.4918	3.9825	0.4100	3.1008	2.8992	2.2980	1.3330	1.0648	1	0.9886	0.7991	0
LARYNX	0.5702	0.3493	1.7209	0.0422	1.5158	1.2552	0.4717	0.1262	0.1006	1	0.1769	0	
LENS_LT	0	0	0	0	0	0	0	0	0	1	0	0	
LENS_RT	0	0	0	0	0	0	0	0	0	1	0	0	
LIPS	0.0064	0.0261	0.2268	0	0.0963	0.0371	8.7893e-18	0	0	1	0	0	
OPTIC_NRV_LT	0.0775	0.2143	0.9674	0	0.9571	0.5805	7.5343e-04	0	0	1	0.0385	0	

Rezultati

- Srednje doze po regionima (Gy) dobivene pomoću tri snopa protona, sa I bez pomijeranja:

Region/Izocentar	Bez pomijeranja	Sa pomijeranjem
Moždano stablo	0.2645	0.5784
Mali mozak	0.6355	0.9112
CTV63	2.1304	1.9376
GTV	2.3305	2.2150
Leće (L,D)	0,0	0,0
Koža	0.4682	0.4555
Optički nerv (L,D)	0,0	0.0775, 0.0092
Kičmena moždina	0.6268	0.7466
PTV63	2.1092	1.8369
PTV70	2.3102	2.1671

Hvala na pažnji :)