

MASTERCLASS ZA HADRONSKU TERAPIJU

**Planiranje radioterapijskih tretmana u
MatRadu**

Instrukcije

Amila Avdić

1. Zadatak

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

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 several panels and a central file selection dialog.

Workflow Panel: Contains buttons for 'Refresh', 'Load *.mat data' (highlighted with a red arrow), 'Load *.COM', and 'Import from Bin...'. The status indicates 'no data loaded'.

Plan Panel: Includes settings for 'bixel width in [mm]' (5), 'Gantry Angle in °' (0), 'Couch Angle in °' (0), 'Radiation Mode' (photons), 'Machine' (Generic), 'IsoCenter in [mm]' (0 0 0), '# Fractions' (30), and 'Type of optimization' (none).

Objectives & constraints Panel: Features a table with columns 'VOI name', 'VOI type', 'priority', and 'obj. / const.'. The table is currently empty.

Visualization Panel: Includes 'Slice' and 'Beam' controls, 'Type of plot' (intensity), 'Plane' (axial), and 'Dislay option' (no option avail...). It also has a 'Show DVH/QI' button and a list of plot options: plot CT, plot contour, plot isolines, plot dose, plot isolines labels, plot iso center, and visualize plan / be...

Select File to Open Dialog: Shows the file path 'e0404-matRad-2.1... > e0404-matRad-2957fcc'. The file list includes folders like 'standalone', 'tools', 'unitTest', 'vmc++' and MAT files such as 'BOXPHANTOM', 'carbon_Generic', 'HEAD_AND_NECK', 'LIVER', 'photons_Generic', 'PROSTATE', 'protons_Generic', and 'TG119' (highlighted with a red arrow). The file name field contains 'TG119' and the file type is 'MAT-files (*.mat)'. The 'Open' button is visible.

Right Panel: Contains 'min max' settings, 'Set IsoDose Levels', 'Viewer Options' (None), 'Window Center' (0.5), 'Window Width' (1.0), 'Range' (0 1), 'bone' material, 'Dose opacity' (0 1), 'Structure Visibility' (no data loaded), and 'Info' (v3.0.0, github.com/e0404/mat, About button).

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

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
 Couch Angle in ° 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	priority	obj. / const.	penalty	dose	EUD	volume	ro
1	Core	OAR	2	square overdosing	300	25	NaN	NaN	+
2	OuterTarget	TARGET	1	square deviation	1000	50	NaN	NaN	no
3	BODY	OAR	3	square overdosing	100	30	NaN	NaN	no

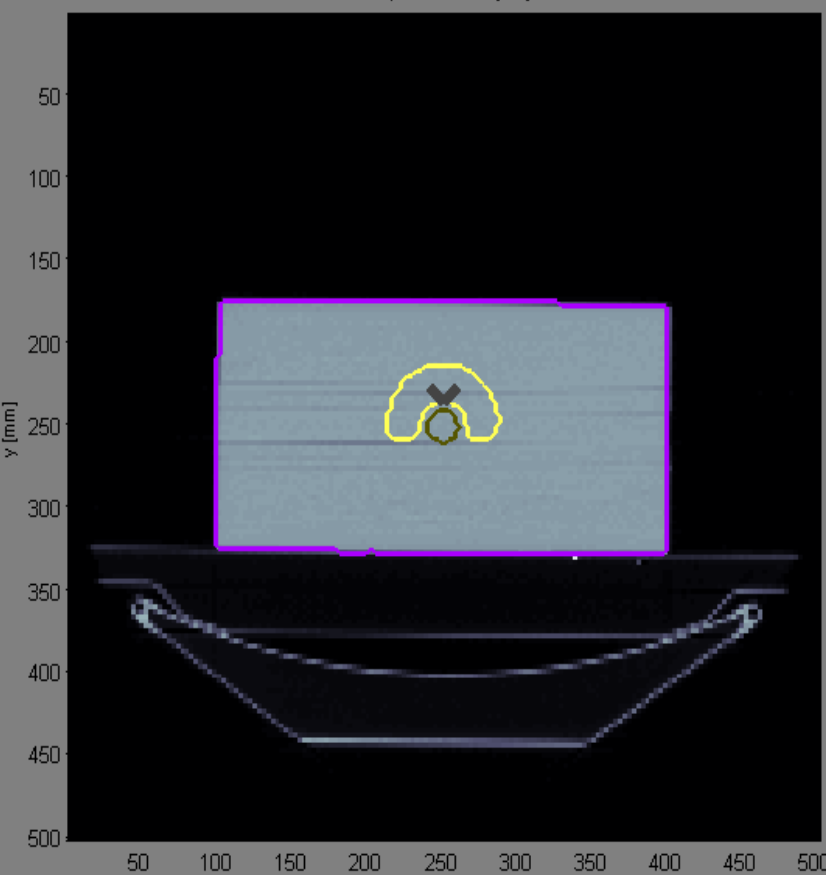
Visualization

Slice Type of plot inten... GoTo lateral
 Beam Plane axial Open 3D-View
 Offset Dislay option no option avail...

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



axial plane z = 165 [mm]



min 1000
max 1040.

Set IsoDose Levels

Viewer Options

CT (HU)
 Window: Default
 Custom
 Window Center: 0.851
 Window Width: 1.67
 Range: 0.02671 1.692
 bone
 Dose opacity: 1

Structure Visibility

Core
 OuterTarget
 BODY

Info

v3.0.0
 github.com/e0404/mat
 About



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 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 the 'Calc. influence Mx' and 'Optimize' buttons. The status below these buttons reads 'Status: ready for optimization'.
- Plan Panel:** 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), and '# Fractions' (30). It also has 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 Panel:** Contains a table with columns for '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 Panel:** Includes 'Slice', 'Beam', and 'Offset' controls, 'Type of plot' (intensity), 'Plane' (axial), and 'Dislay option' (no option avail...). It also has 'GoTo lateral' and 'Open 3D-View' buttons. A 'Show DVH/QI' button is at the bottom.
- Viewing Panel:** Shows a 3D visualization of a patient's head and neck in an axial plane at z = 165 [mm]. The x and y axes range from 50 to 500 mm. A color scale on the right indicates Hounsfield Units from 10 to 60. The target volume is outlined in yellow, and the organs at risk (Core, OuterTarget, BODY) are outlined in purple.
- Viewer Options Panel:** Includes 'Set IsoDose Levels', 'Viewer Options' (CT (HU), Window, Custom), 'Window Center' (0.85), 'Window Width' (1.67), 'Range' (0.02671 - 1.692), 'bone' structure, 'Dose opacity' (0), and 'Structure Visibility' (Core, OuterTarget, BODY).
- Info Panel:** Shows the version 'v3.0.0' and the GitHub repository 'github.com/e0404/mat'.

4. Analizirajte rezultujuću raspodjelu doze

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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 ° 0 3D conformal

Couch Angle in ° 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

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 plot CT

Beam Plane axial plot contour

Offset Dislay option physicalDose plot isolines

plot dose

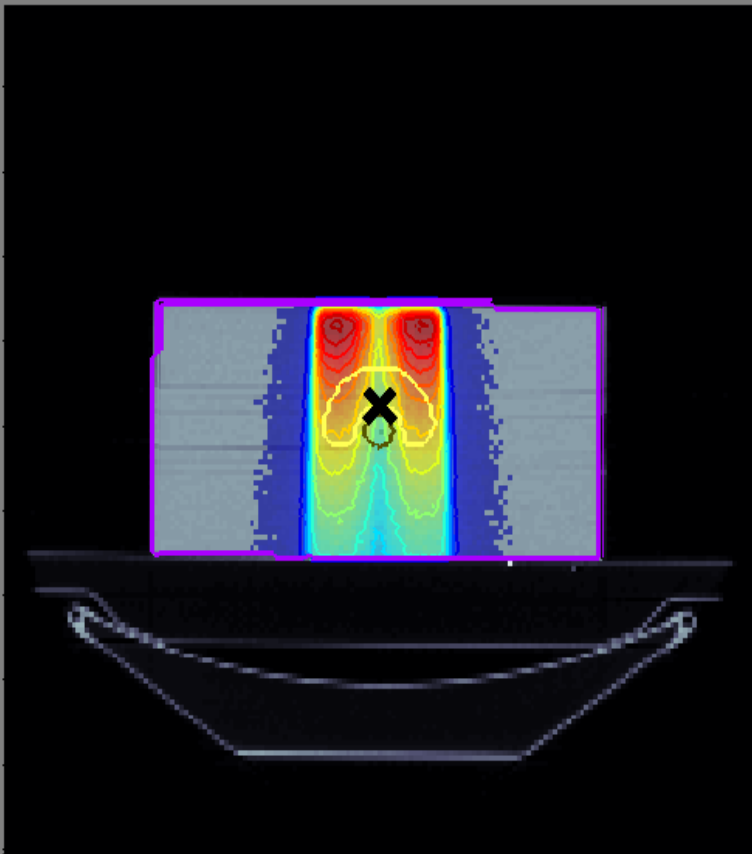
plot isolines labels

plot iso center

visualize plan / be...

Viewing

axial plane z = 165 [mm]



min max n
2.342

Viewer Options

Result (i.e. dose)

Window:

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

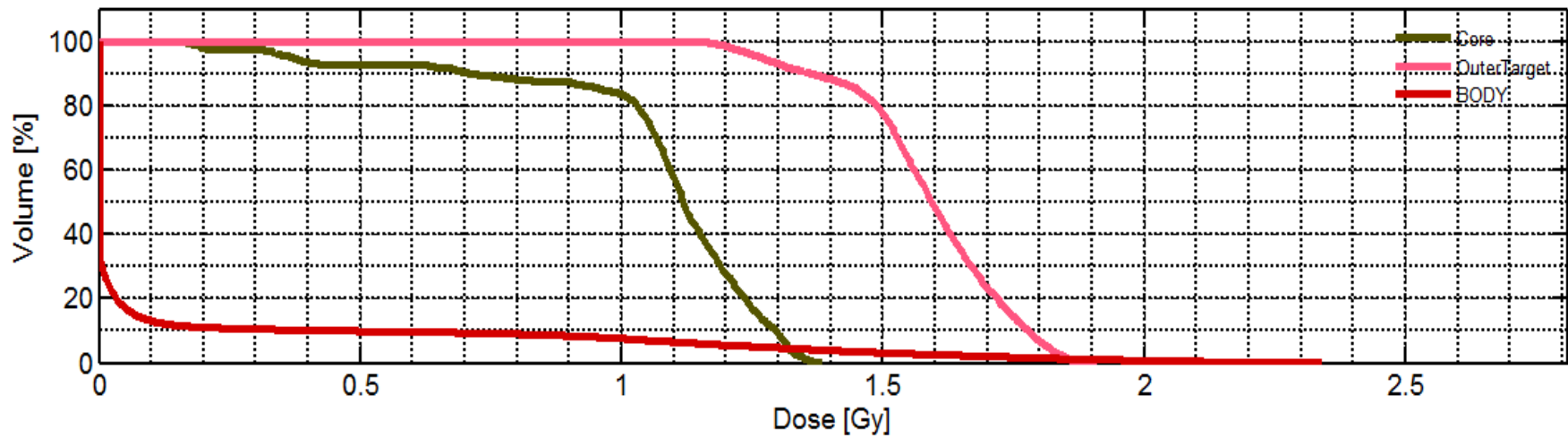
5. Spremite rezultat optimizacije putem („Save to GUI“), te prikažite DVH pomoću („Show DVH/QI“).

The screenshot displays the matRad software interface, which is used for radiation 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 points to the "Save to GUI" button. The status below indicates "plan is optimized".
- Plan:** Contains various parameters for optimization, including 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). There are also radio buttons for "use MC (VMC++) dose calculations", "3D conformal", "Run Sequencing", "Stratification Levels" (7), and "Run Direct Aperture Optimizat...".
- Objectives & constraints:** A table listing three VOI (Volume of Interest) entries:

	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:** Contains settings for Slice, Beam, and Offset. It also has dropdowns for "Type of plot" (intentional), "Plane" (axial), and "Display option" (physicalDose). There are buttons for "GoTo lateral" and "Open 3D-View". A red arrow points to the "Show DVH/QI" button.
- Viewing:** Shows a dose distribution plot in the axial plane at z = 165 mm. The plot displays the physical dose in Gy, with a color scale from 0 to 60 Gy. The plot shows the target (Core) and organs at risk (OAR) regions. The axes are labeled x [mm] and y [mm].
- Viewer Options:** Contains settings for "Result (i.e. dose)", "Window Preset" (Custom), "Window Center" (1.17), "Window Width" (2.34), "Range" (0 to 2.342), "jet" color map, and "Dose opacity" (1).
- Structure Visibility:** A list of structures with checkboxes: Core (checked), OuterTarget (checked), and BODY (checked).
- Info:** Displays the version number (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_0.4Gy	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

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

Show DVH/QI

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axial plane z = 165 [mm]

min 0
max 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

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

Workflow

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

Status: 1 ready for optimization 2

Plan

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 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	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...

Show DVH/QI

matRad dkfz. GERMAN CANCER RESEARCH CENTER IN THE HELMHOLTZ ASSOCIATION

Viewing axial plane z = 165 [mm]

min max n 2.342

Set IsoDose Levels

Viewer Options

Result (i.e. dose) Window Presest Custom
 Window Center: Window Width: 1.17
 Range: 0 2.342
 jet Dose opacity: 1
 Structure Visibility
 Core
 OuterTarget
 BODY

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

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

The screenshot displays the matRad software interface. The top left shows the workflow area with 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. Below this is the 'Plan' section with various 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 contains a table with columns for 'VOI name', 'VOI type', 'priority', 'obj. / const.', 'penalty', 'dose', 'EUD', 'volume', and 'ro'. The 'Visualization' section at the bottom left has options for 'Slice', 'Beam', 'Offset', 'Type of plot', 'Plane', 'Dislay option', and 'Show DVH/QI', with a red arrow labeled '2' pointing 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 plot shows a central target area (red/yellow) surrounded by organs at risk (blue/green). A color scale on the right indicates RBE x Dose [Gy(RBE)] from 0 to 60. The bottom right panel shows 'Viewer Options' and 'Structure Visibility' settings.

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 ° 0 3D conformal
Couch Angle in ° 0 Run Sequencing
Radiation Mode protons Stratification Levels 7
Machine Generic Run Direct Aperture Optimizat...
IsoCenter in [mm] 251.3 236.4 162.6 Auto.
Fractions 30
Type of optimization const_RBExD Set Tissue

Objectives & constraints

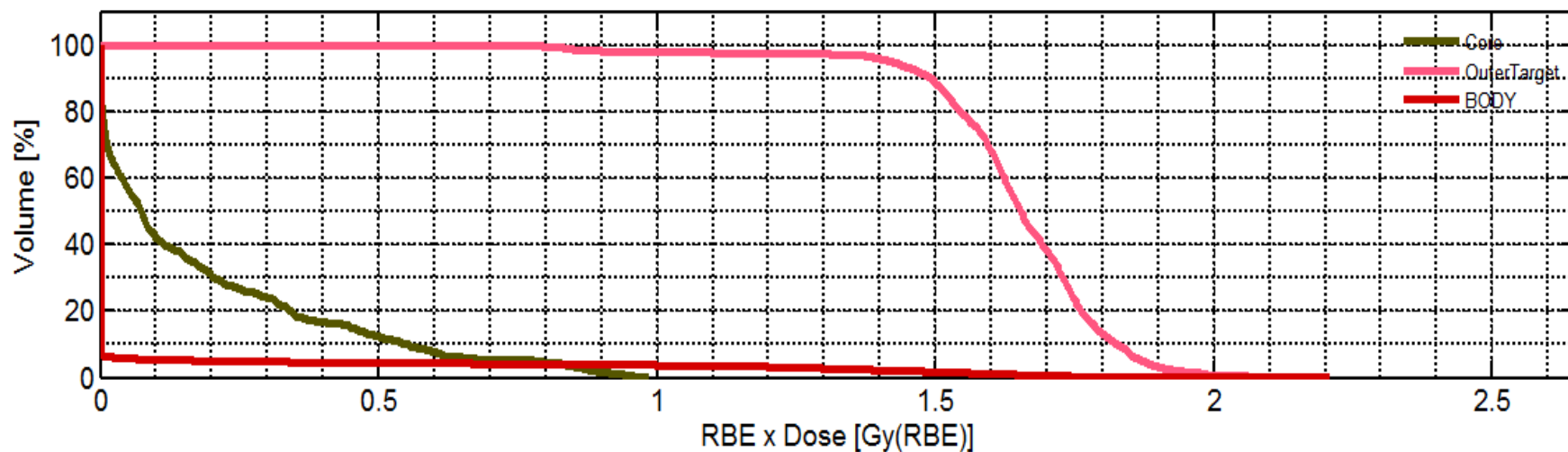
	VOI name	VOI type	priority	obj. / const.	penalty	dose	EUD	volume	ro	
1	Core	OAR	2	square overdosing	300	25	NaN	NaN	no	+
2	OuterTarget	TARGET	1	square deviation	1000	50	NaN	NaN	no	-
3	BODY	OAR	3	square overdosing	100	30	NaN	NaN	no	

Visualization

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

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

min max 0 2.710
Set IsoDose Levels
Viewer Options
Result (i.e. dose) Custom
Window Center: 1.11
Window Width: 2.21
Range: 0 2.21
jet Dose opacity: 1
Structure Visibility
Core OuterTarget BODY
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_1.3Gy	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

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
 Offset Disolv 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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Viewing axial plane z = 165 [mm]

min max 1.902

Set IsoDose Levels

Viewer Options

Result (i.e. dose)
 Window: Breast
 Custom
 Window Center: 0.95
 Window Width: 1.9
 Range: 0 1.903
 jet
 Dose opacity: 1

Structure Visibility

- Core
- OuterTarget
- BODY

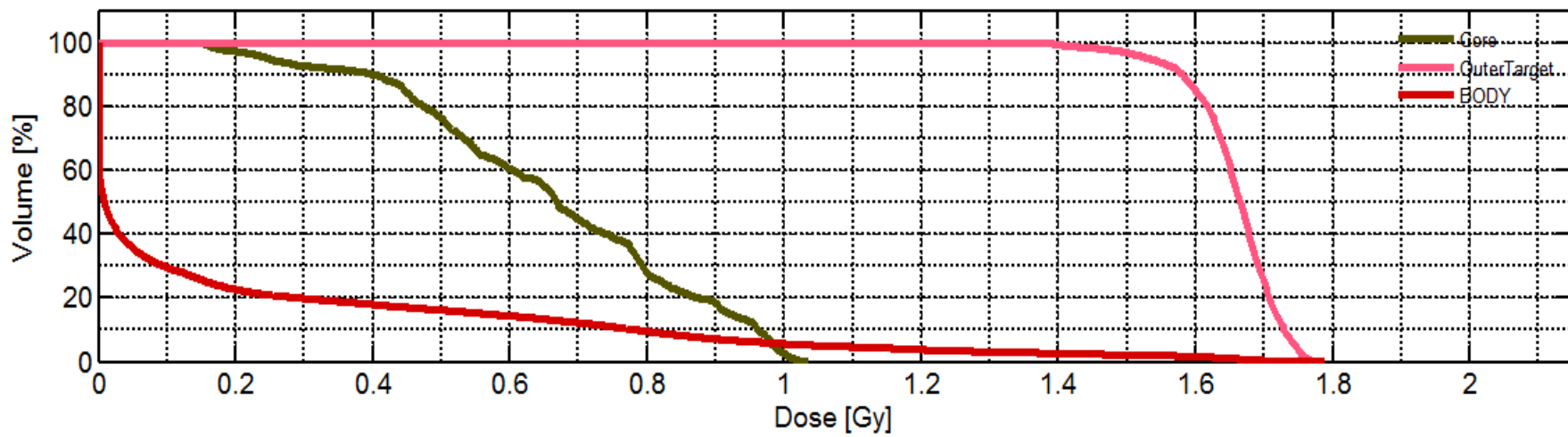
Info v3.0.0
 github.com/e0404/mat
 About

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

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

- 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 points to the 'Save to GUI' button. The status below indicates 'plan is optimized'.
- Plan:** Includes input fields for bixel width (10), Gantry Angle (0 72 144 216 288), Couch Angle (0 0 0 0), Radiation Mode (photons), Machine (Generic), IsoCenter (251.3 236.4 162.6), # Fractions (30), and Type of optimization (none). It also has radio buttons for MC dose calculations, 3D conformal, Run Sequencing, and Run Direct Aperture Optimization, along with a Stratification Levels field set to 7.
- Objectives & constraints:** A table listing three objectives:

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:** Features a 'Show DVH/QI' button with a red arrow pointing to it. Other options include plot CT, contour, isolines, dose, and iso center.
- Viewer:** Shows an axial plane at z = 165 [mm] with a color-coded dose distribution. The x and y axes range from 50 to 500 mm. A color scale on the right indicates physical dose from 0 to 60 Gy.
- Viewer Options:** Includes 'Set IsoDose Levels', 'Result (i.e. dose)', 'Window Center' (0.89), 'Window Width' (1.79), 'Range' (0 to 1.79), and 'Structure Visibility' (Core, OuterTarget, BODY).



	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
OuterTarget	1.6563	0.0659	1.7897	1.2866	1.7566	1.7450	1.6652	1.5323	1.4636	1	1	1	1	0
BODY	0.1968	0.3777	1.7897	0	1.5510	1.0629	0.0091	0	0	1	0.1986	0.1230	0.0568	0

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	NaN	NaN	no	+
2	OuterTarget	TARGET	1	min dose constraint	5	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

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

Show DVH/QI

matRad dkfz. GERMAN CANCER RESEARCH CENTER IN THE HELMHOLTZ ASSOCIATION

axial plane z = 165 [mm]

min max n
 max 1.789

Set IsoDose Levels

Viewer Options

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

Structure Visibility

Core
 OuterTarget
 BODY

Info

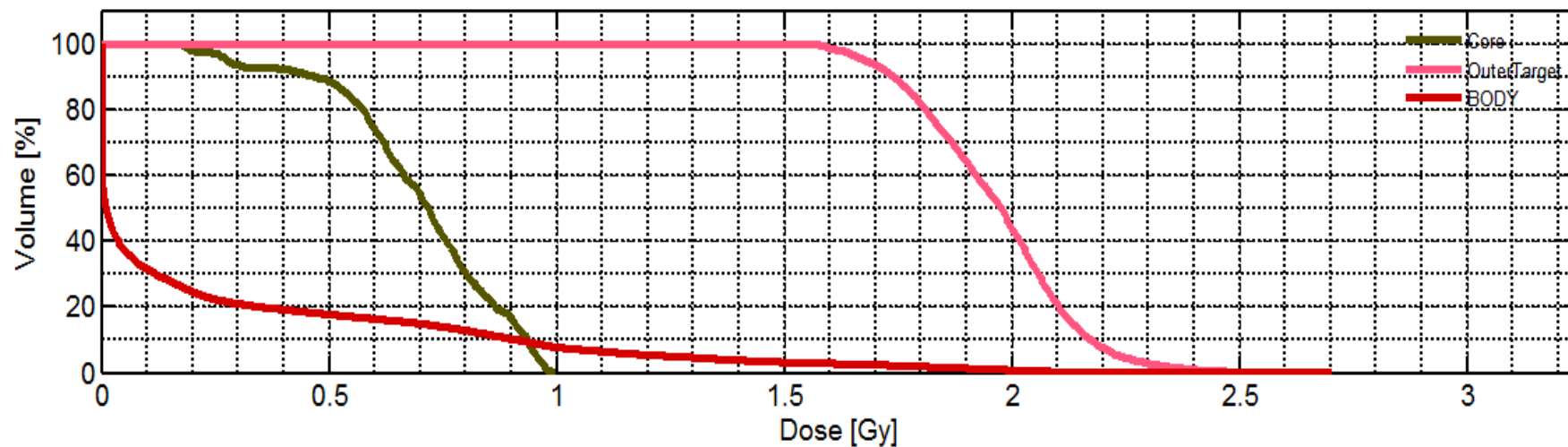
v3.0.0
 github.com/e0404/mat
 About

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', 'Calc. influence Mx', 'Optimize', 'Save to GUI', 'Load DICOM', 'Replc', 'Export', and 'Import dose'. Red arrows point to 'Calc. influence Mx', 'Optimize', and 'Save to GUI'. The status below reads 'Status: 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...', and a 'Stratification Levels' dropdown set to '7'.
- Objectives & constraints:** A table with columns for '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', 'Beam', and 'Offset' controls, 'Type of plot' (intensity), 'Plane' (axial), and 'Dislay option' (physicalDose). A 'Show DVH/QI' button is highlighted with a red arrow.
- Viewing:** Shows an axial plane at z = 165 [mm]. The plot displays a dose distribution with a color scale from 0 to 60 Gy. The axes are labeled 'x [mm]' and 'y [mm]'. A 'Structure Visibility' panel on the right shows 'Core', 'OuterTarget', and 'BODY' are visible.
- Info:** Displays 'v3.0.0' and 'qithub.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 German Cancer Research Center logo. The main interface is divided into several panels:

- Workflow:** Contains buttons for 'Refresh', 'Load *.mat data' (highlighted with a red arrow), 'Load *.COM', 'Import Plan Bin...', 'Calc. influence Mx', 'Optimize', 'Save to GUI', 'Recalc', and 'Export'.
- Plan:** Includes input fields for 'bixel width in [mm]' (20), 'Gantry Angle in °' (0 72 144 216 288), 'Couch Angle in °' (0 0 0 0), 'Radiation Mode' (protons), 'Machine' (Generic), 'IsoCenter in [mm]' (251.3 236.4 162.6), '# Fractions' (30), and 'Type of optimization' (const_RBExD).
- Objectives & constraints:** A table with columns for VOI name, VOI type, priority, obj. / const., penalty, dose, EUD, and volume.
- Visualization:** Includes 'Slice' and 'Beam' controls, 'Type of plot' (intensity), 'Plane' (axial), and 'Displacement option' (RBExDose).

A 'Select File to Open' dialog box is open, showing a file explorer view of the directory 'e0404-matRad-2.1... \ e0404-matRad-2957fcc'. The file 'LIVER' (MAT File) is selected and highlighted with a red arrow. The file name field at the bottom of the dialog shows 'LIVER' and the file type is set to 'MAT-files (*.mat)'. The 'Open' button is visible.

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

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 1

Gantry Angle in ° 0 180 225 270 315 2

Couch Angle in ° 0 0 0 0 2

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

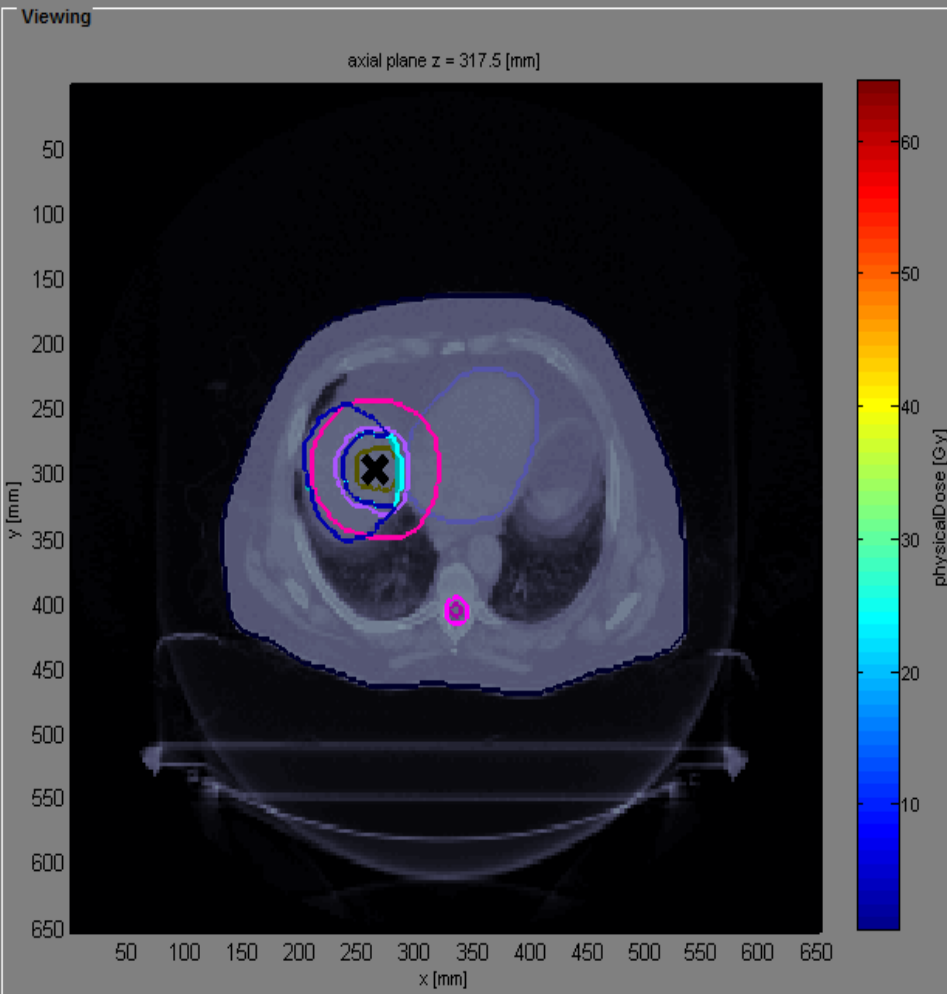
Show DVH/QI

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

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axial plane z = 317.5 [mm]



min 0
max 3.706

Set IsoDose Levels

Viewer Options

Result (i.e. dose) Window Doseat Custom
 Window Center: 1.85
 Window Width: 3.71
 Range: 0 3.706
 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

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 functional areas:

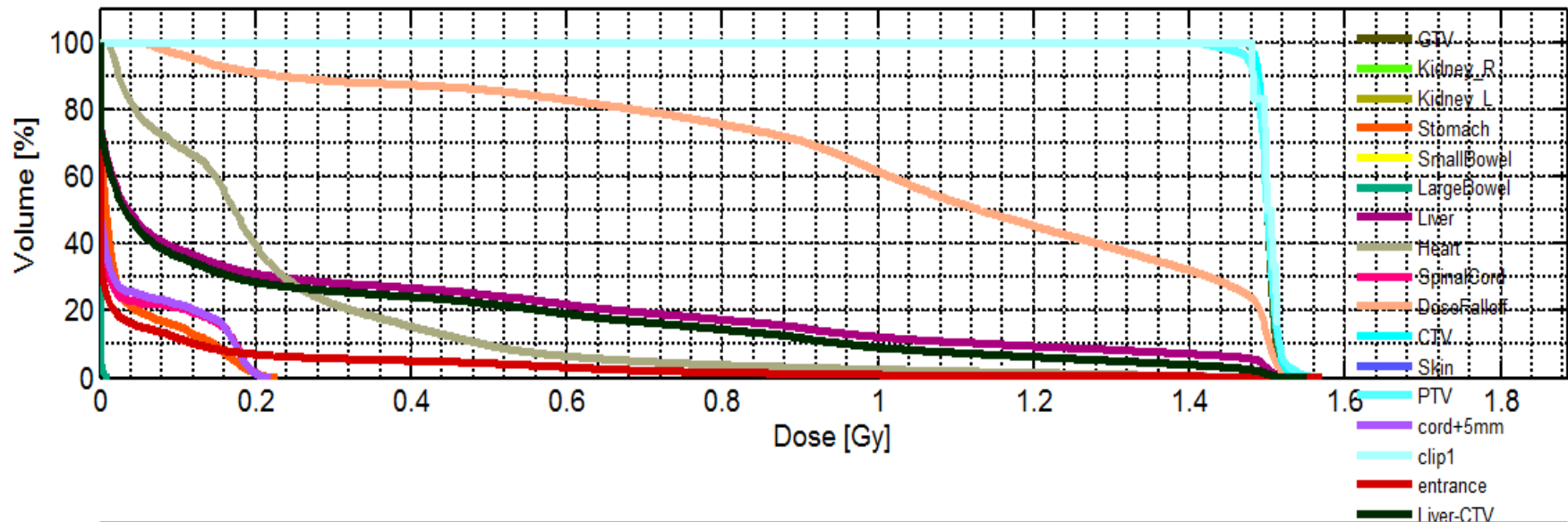
- Workflow:** Contains buttons for 'Refresh', 'Load *.mat data', 'Load DICOM', 'Import from Bin...', 'Calc. influence Mx' (indicated by a red arrow and '1'), 'Optimize' (indicated by a red arrow and '2'), 'Save to GUI', 'Export', and 'Import Dose'. The status below these buttons reads 'ready for optimization'.
- Plan:** Includes parameters 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) with an 'Auto.' checkbox, '# 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:** A table listing objectives and constraints for VOI (Volume of Interest).
- Visualization:** 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 legend on the right lists various structures like GTV, Kidney_R, Kidney_L, Stomach, SmallBowel, LargeBowel, Cellac, SMA_SMV, Liver, Heart, SpinalCord, and DoseFalloff.
- 3D Visualization:** A central window shows an axial CT scan of a patient's head and neck at z = 317.5 [mm]. The image is overlaid with various colored contours representing different anatomical structures and dose levels. A color scale on the right indicates 'physicalDose [Gy]' ranging from 0 to 60.
- Right Panel:** Shows 'min' (0) and 'max' (3.706) dose values, a 'Set IsoDose Levels' button, 'Viewer Options' (Result (i.e. dose), Window, Custom), 'Window Center' (1.85), 'Window Width' (3.71), 'Range' (0 to 3.706), 'jet' color map, and 'Dose opacity' (1). It also includes a 'Structure Visibility' list and an 'Info' section with version 'v3.0.0' and a link to 'github.com/e0404/mat'.

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'.
- Plan Panel:** Shows various optimization parameters such as '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), and '# Fractions' (30). It also includes options for 'use MC (VMC++) dose calculations', '3D conformal', 'Run Sequencing', and 'Stratification Levels' (7).
- Objectives & constraints Panel:** A table listing VOI names, types, priorities, 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:** Includes 'Slice', 'Beam', and 'Offset' controls. It also has 'Type of plot' (intensity), 'Plane' (axial), and 'Dislay option' (physicalDose). A red arrow points to the 'Show DVH/QI' button, labeled with a '2'.
- Viewing Panel:** Shows a 3D visualization of the patient's head and neck. The axial plane is at z = 317.5 [mm]. A color scale on the right indicates 'physicalDose [Gy]' from 0 to 60. The visualization shows the target (PTV) and organs at risk (OAR) with corresponding dose distributions.
- Right Panel:** Contains 'Viewer Options' (Result (i.e. dose), Window, Window Center, Window Width, Range, Dose opacity) and 'Structure Visibility' (GTV, Kidney_R, Kidney_L, Stomach, SmallBowel, LargeBowel, Celiac, SMA_SMV, Liver, Heart, SpinalCord, DoseFalloff).



	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	0
Kidney_L	0	0	0	0	0	0	0	0	0	1	0	0	0
Stomach	0.0342	0.0566	0.2310	0	0.1940	0.1736	0.0082	0	0	1	0	0	0
SmallBowel	0	0	0	0	0	0	0	0	0	1	0	0	0
LargeBowel	2.6018e-04	0.0012	0.0147	0	0.0047	0.0019	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	0.3033	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	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 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
 # 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 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...

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

axial plane z = 317.5 [mm]

physicalDose [Gy]

min max n
 max 1.572

Set IsoDose Levels

Viewer Options

Result (i.e. dose)
 Window Dose
 Custom
 Window Center:
 Window Width: 0.784
 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“)

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min max n
2.501

Set IsoDose Levels

Viewer Options

Result (i.e. dose)
 Window: Prezent
 Custom

Window Center:
 1.25

Window Width:
 2.5

Range: 0 2.501

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

Workflow

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

Load DICOM Recalc Export

Import from Bin... Import

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 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 RBExDose 2

plot CT

plot contour

plot isolines

plot dose

plot isolines labels

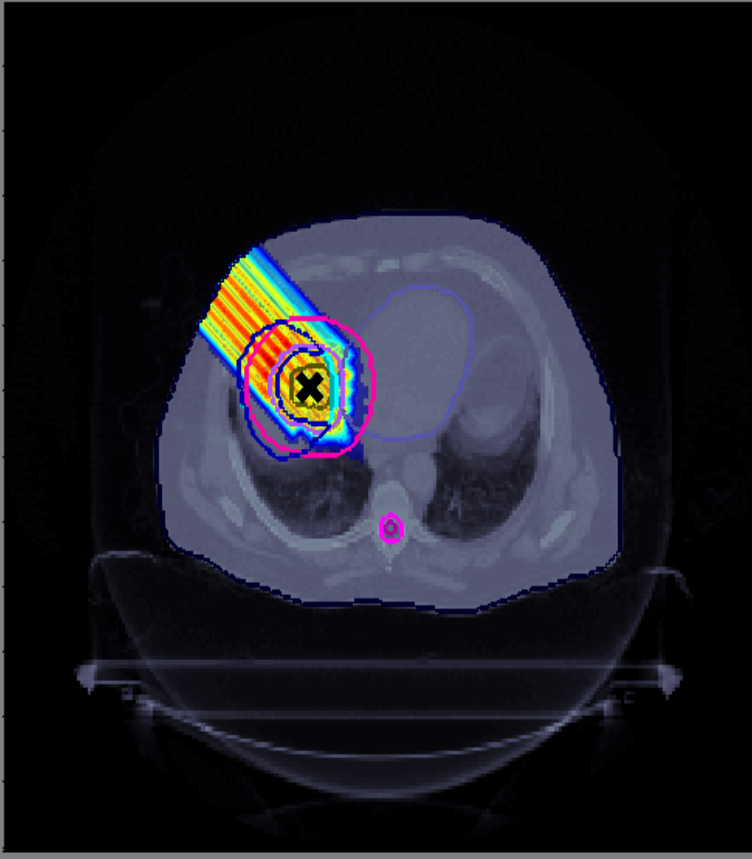
plot iso center

visualize plan / be...

Show DVH/QI

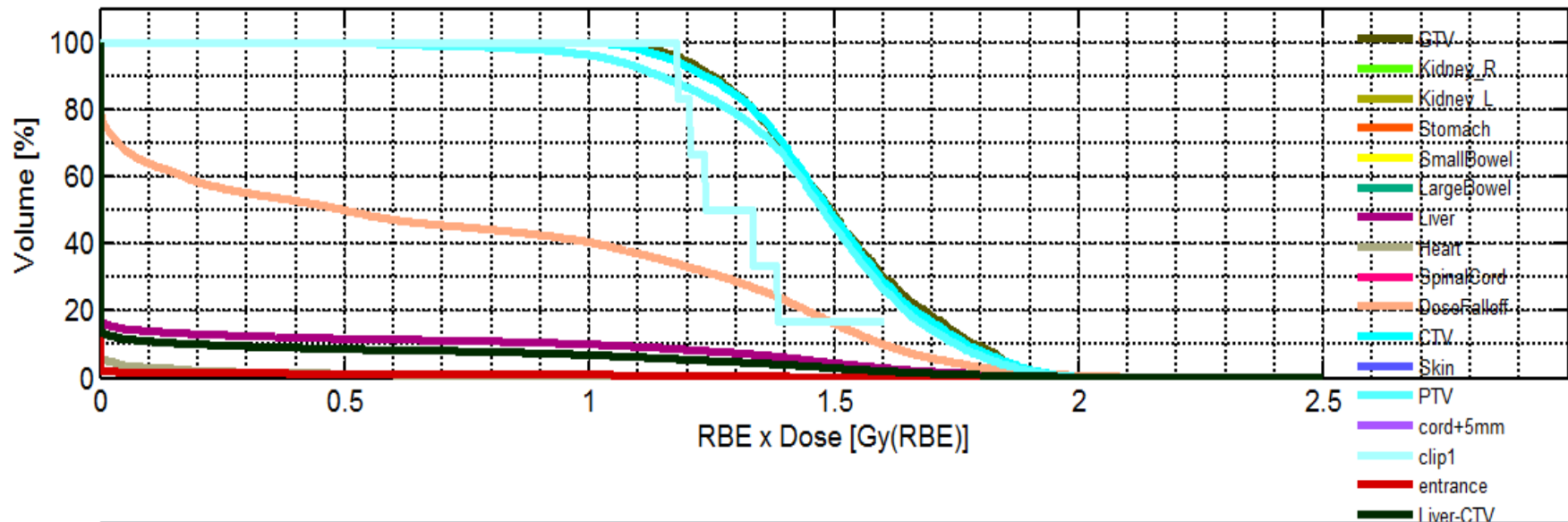
Viewing

axial plane z = 317.5 [mm]



y [mm]

x [mm]



	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

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 use MC (VMC++) dose calculations
 Gantry Angle in °: 315 3D conformal
 Couch Angle in °: 0 Run Sequencing
 Radiation Mode: carbon Stratification Levels: 7
 Machine: photons Auto. Run Direct Aperture Optimizat...
 IsoCenter in [mm]: # Fractions: carbon Type of optimization: LEMIV_RBExD


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

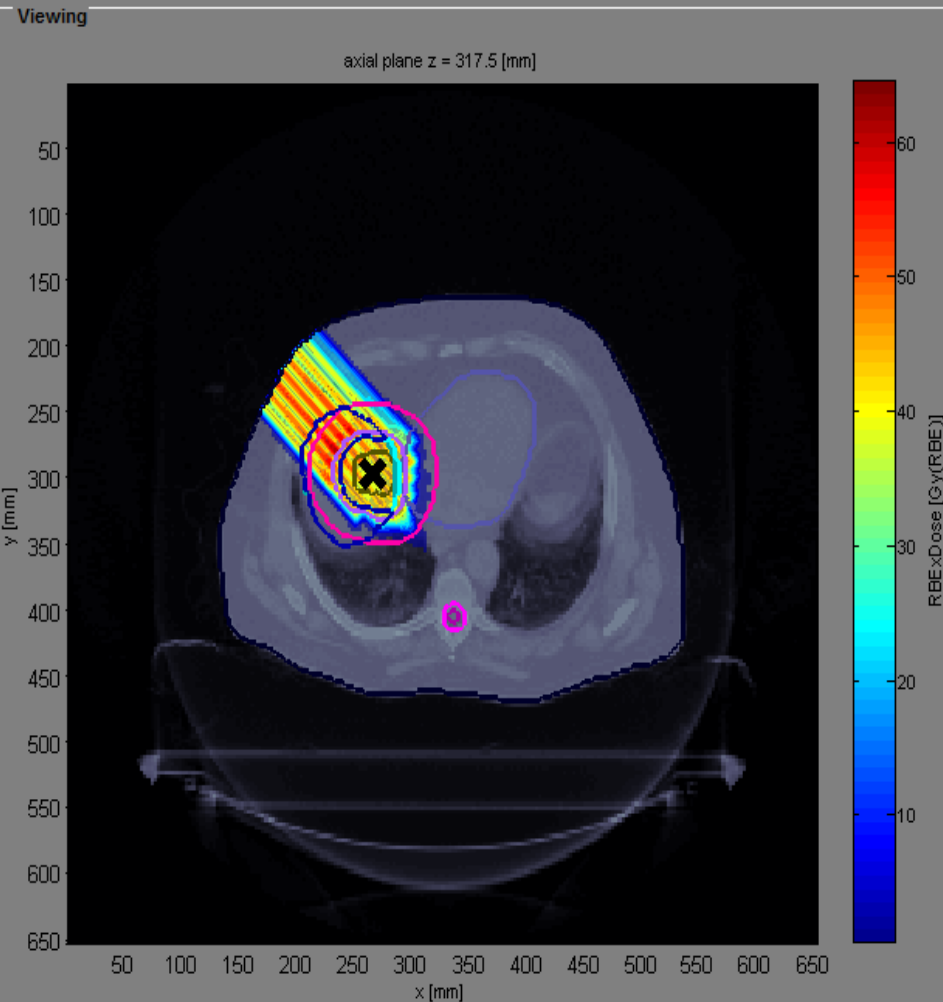
Visualization

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

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



axial plane z = 317.5 [mm]



min 0
max 2.501

Set IsoDose Levels

Viewer Options

Result (i.e. dose):
 Window: Default
 Custom
 Window Center: 1.25
 Window Width: 2.5
 Range: 0 2.501
 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

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

plot dose

plot isolines labels

plot iso center

visualize plan / be...

Show DVH/QI

2

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axial plane z = 317.5 [mm]

min 0 max 2.123

Set IsoDose Levels

Viewer Options

Result (i.e. dose) Window Dose Custom

Window Center: 1.06

Window Width: 2.12

Range: 0 2.123

jet Dose opacity: 1

Structure Visibility

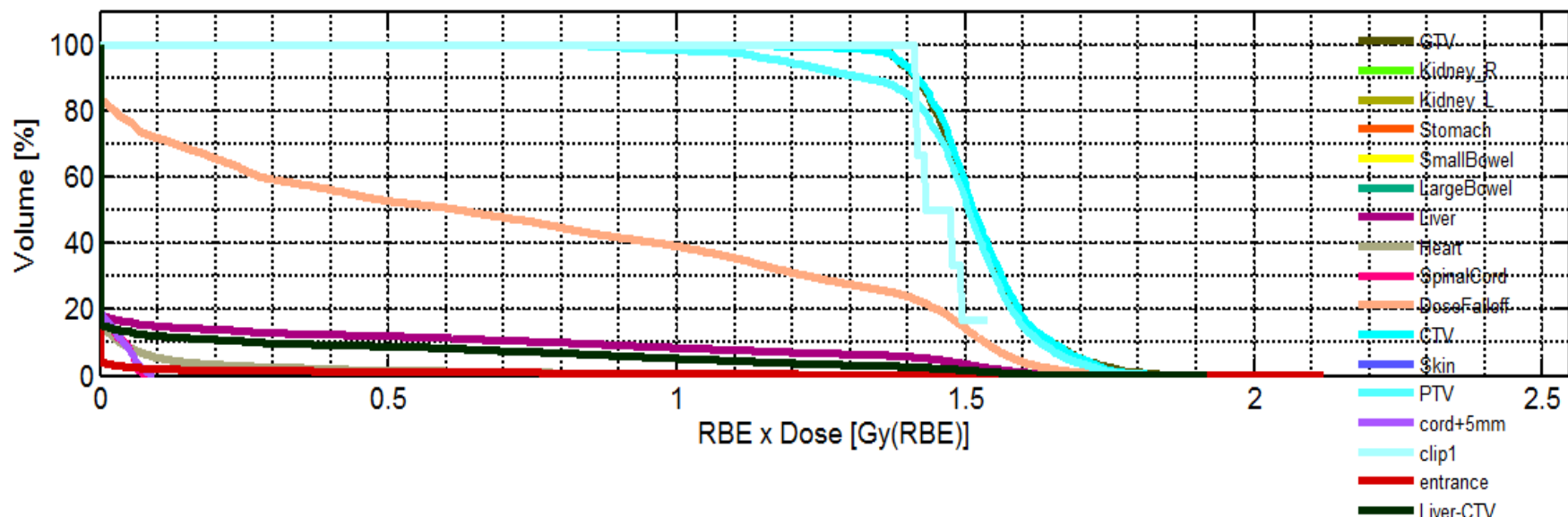
- GTV
- Kidney_R
- Kidney_L
- Stomach
- SmallBowel
- LargeBowel
- Celiac
- SMA_SMV
- Liver
- Heart
- SpinalCord
- DoseFalloff

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_0.4Gy	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. The main window shows the 'Workflow' section with buttons for 'Refresh', 'Load *.mat data', 'Calc. influence Mx', 'Optimize', 'Save to GUI', 'Load COM', 'Recalc', 'Export', 'Import Dose', and 'Import Bin...'. A red arrow points to the 'Load *.mat data' button. The 'Plan' section shows various 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 contains a table with columns for 'VOI name', 'VOI type', 'priority', 'obj. / const.', 'penalty', 'dose', 'EUD', and 'volume'. The 'Visualization' section includes 'Slice', 'Beam', 'Offset', 'Type of plot', 'Plane', 'Disolav option', and 'Show DVH/QI'. A file selection dialog box is open, showing the path 'e0404-matRad-2.1... > e0404-matRad-2957fcc' and a list of files. A red arrow points to the 'HEAD_AND_NECK' file in the list. The 'File name' field in the dialog is set to 'HEAD_AND_NECK' and the file type is 'MAT-files (*.mat)'. The 'Open' button is highlighted.

Workflow

Refresh Load *.mat data Calc. influence Mx Optimize Save to GUI
Load COM Recalc Export
Import Bin... 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 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 Disolav option RBExDose Show DVH/QI

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Select File to Open

Organize New folder

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

File name: HEAD_AND_NECK MAT-files (*.mat)

Open Cancel

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 with the following components:

- Workflow:** Buttons for Refresh, Load *.mat data, Load DICOM, Import from Bin..., Calc. influence Mx (marked with a red arrow and '2'), Optimize (marked with a red arrow and '3'), Save to GUI, Export, and Import Dose. Status: ready for dose calculation.
- Plan:**
 - bixel width in [mm]: 10
 - Gantry Angle in °: 90 180 270 (marked with red arrows and '1')
 - Couch Angle in °: 0 0 0 (marked with red arrows and '1')
 - Radiation Mode: protons (marked with a red arrow and '1')
 - Machine: Generic
 - IsoCenter in [mm]: 250.4 205.3 138.5 (checked Auto)
 - # Fractions: 30
 - Type of optimization: const_RBExD
 - Options: use MC (VMC++) dose calculations, 3D conformal, Run Sequencing, Stratification Levels: 7, Run Direct Aperture Optimizat...
- Objectives & constraints:**

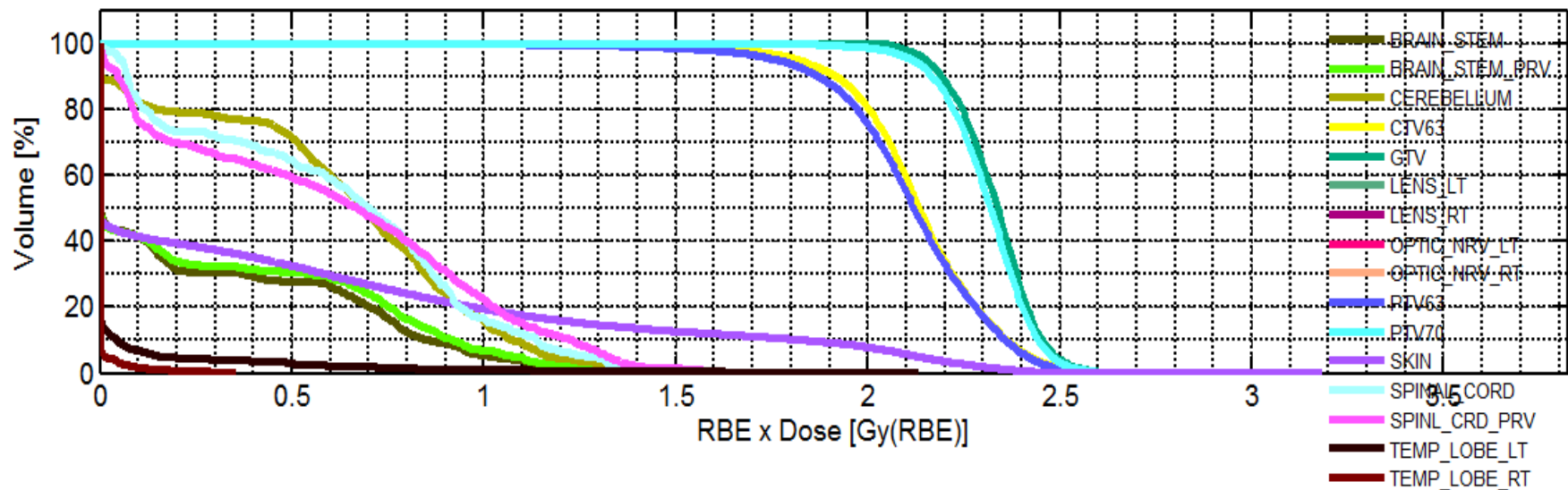
	VOI name	VOI type	priority	obj. / const.	penalty	dose	EUD	volume
1	PAROTID_LT	OAR	1	square overdosing	100	25	NaN	NaN
2	PAROTID_RT	OAR	1	square overdosing	100	25	NaN	NaN
3	PTV63	TARGET	2	square deviation	1000	63	NaN	NaN
4	PTV70	TARGET	1	square deviation	1000	70	NaN	NaN
- Visualization:**
 - Slice: [Slider]
 - Beam: [Slider]
 - Offset: [Slider]
 - Type of plot: inten...
 - Plane: axial
 - Dislay option: [Slider]
 - Options: plot CT, plot contour, plot isolines, plot dose, plot isolines labels, plot iso center, visualize plan / be...
 - Buttons: GoTo lateral, Open 3D-View, Show DVH/Q
- Viewing:**
 - axial plane z = 140 [mm]
 - Central image showing a cross-section of a head with colored contours (red, yellow, green, blue, magenta) and a black 'X' mark.
 - Color scale: Hounsfield Units (0 to 60).
 - min: 1024, max: 3071
 - Buttons: Set IsoDose Levels, Viewer Options (CT (HU), Window: Breast, Custom, Window Center: 1.27, Window Width: 2.53, Range: 0.00324 - 2.531, bone, Dose opacity: 1), 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)

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 (highlighted with a red arrow), Load DICOM, Recalc, Export, and Import dose. The status indicates "plan is optimized".
- Plan:** Includes parameters 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). It also has options for MC dose calculations, 3D conformal, Run Sequencing, Stratification Levels (7), and Run Direct Aperture Optimizat...
- Objectives & constraints:** A table listing VOI names, types, priorities, and 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:** Includes controls for Slice, Beam, Offset, Type of plot (intensity), Plane (axial), Dislay option (RBExDose), and a "Show DVH/QI" button (highlighted with a red arrow). It also has 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 displays a color-coded dose distribution (RBExDose) over a cross-section of a head. A color scale on the right ranges from 0 to 60 Gy(RBE). The x and y axes are labeled in mm, ranging from 50 to 450.
- Right Panel:** Contains "min max" values (0, 3.186), "Set IsoDose Levels", "Viewer Options" (Result: dose, Window: Dose, Custom), "Window Center" (1.59), "Window Width" (3.19), "Range" (0, 3.186), "jet" color map, "Dose opacity" (1), "Structure Visibility" (listing various anatomical structures like BRAIN_STEM, CHIASMA, etc.), and "Info" (v3.0.0, github.com/e0404/mat).



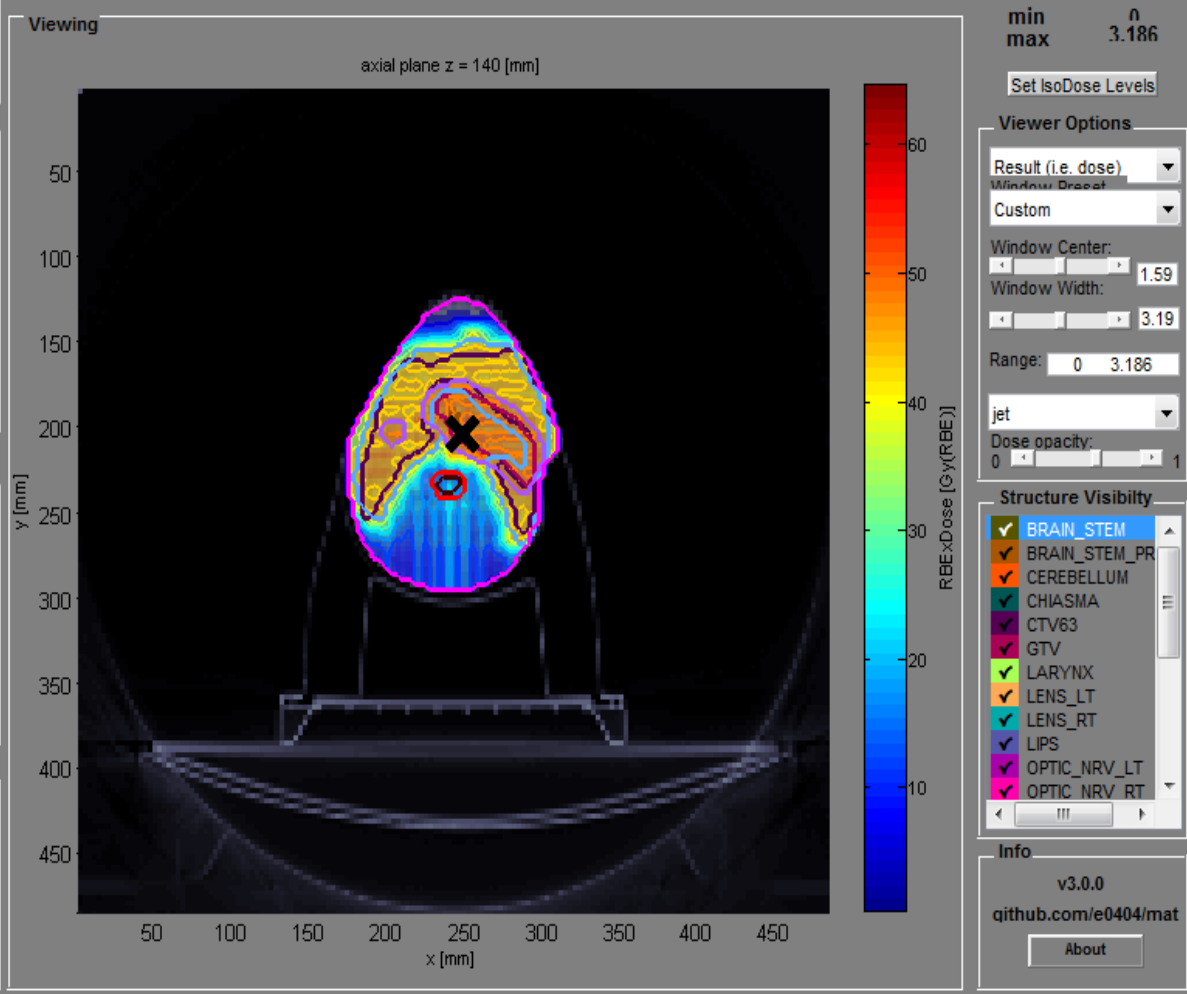
	mean	std	max	min	D_2	D_5	D_50	D_95	D_98	V_0Gy	V_0.6Gy	V_1.2Gy	V_1.9Gy
BRAIN_STEM	0.2645	0.3831	1.5408	0	1.1597	1.0153	0.0030	0	0	1	0.2649	0.0167	
BRAIN_STEM_PRV	0.2906	0.4099	1.5754	0	1.2980	1.0952	0.0016	0	0	1	0.2896	0.0251	
CEREBELLUM	0.6355	0.3774	2.0785	0	1.3512	1.1661	0.6933	0	0	1	0.5998	0.0469	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	0.9973
GTV	2.3305	0.1036	2.7047	1.9940	2.5353	2.4898	2.3381	2.1496	2.0935	1	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	0.2585
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 izocentar. Preračunajte dozu klikom na dugme („Recalc“)

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 functional areas:

- Workflow:** Contains buttons for 'Refresh', 'Load *.mat data', 'Calc. influence Mx', 'Optimize', 'Save to GUI', 'Load DICOM', 'Recalc', 'Export', 'Import from Bin...', and 'Import Dose'. A red arrow labeled '2' points to the 'Recalc' button.
- Plan:** Includes 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]' (260 220 150), and '# Fractions' (30). There are also radio buttons for 'use MC (VMC++) dose calculations', '3D conformal', and 'Run Sequencing'. A checkbox labeled 'Auto' is checked, with a red arrow labeled '1' pointing to it. A 'Stratification Levels' field is set to 7.
- Objectives & constraints:** A table listing various objectives and constraints for the treatment plan.
- Visualization:** Controls for 'Slice', 'Beam', and 'Offset' are shown. The 'Type of plot' is set to 'inten...', and the 'Plane' is 'axial'. A 'GoTo' field is set to 'lateral'. There are 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 an axial dose distribution plot at 'axial plane z = 140 [mm]'. The plot displays a color-coded dose distribution over a patient's head and neck region. A color scale on the right indicates 'RBExDose [Gy(RBE)]' ranging from 0 to 60. The plot axes are labeled 'x [mm]' and 'y [mm]'.
- Right Panel:** Contains 'min' (0) and 'max' (3.186) values, a 'Set IsoDose Levels' button, 'Viewer Options' (Result, Window, Window Center, Window Width, Range, jet color map, Dose opacity), and 'Structure Visibility' (listing various anatomical structures like BRAIN_STEM, CEREBELLUM, etc.).

	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	save





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

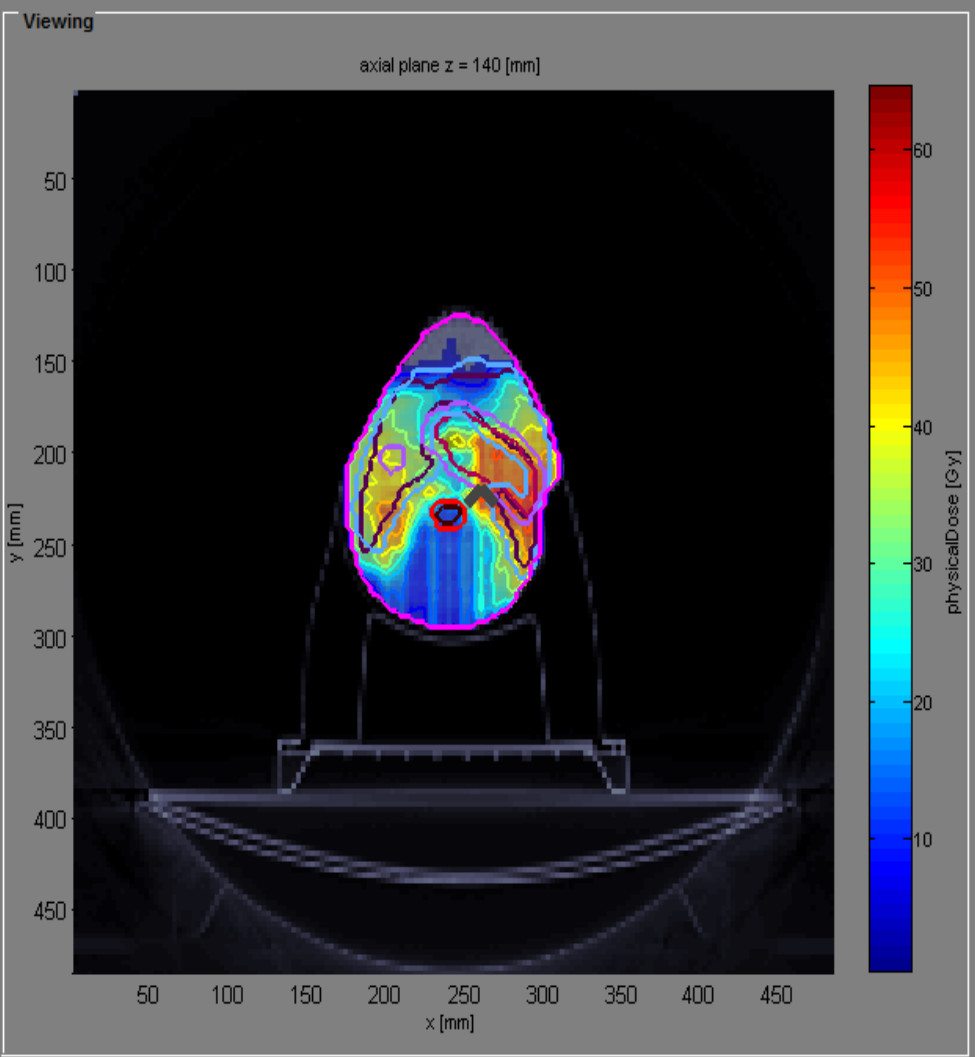
Visualization

Slice Type of plot GoTo

Beam Plane

Offset Disolv option

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



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 plot isolines
 plot dose
 plot isolines labels
 plot iso center
 visualize plan / be...
 Show DVH/QI

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axial plane z = 150 [mm]

physicalDose [Gy]

min 0 max 3.186

Set IsoDose Levels

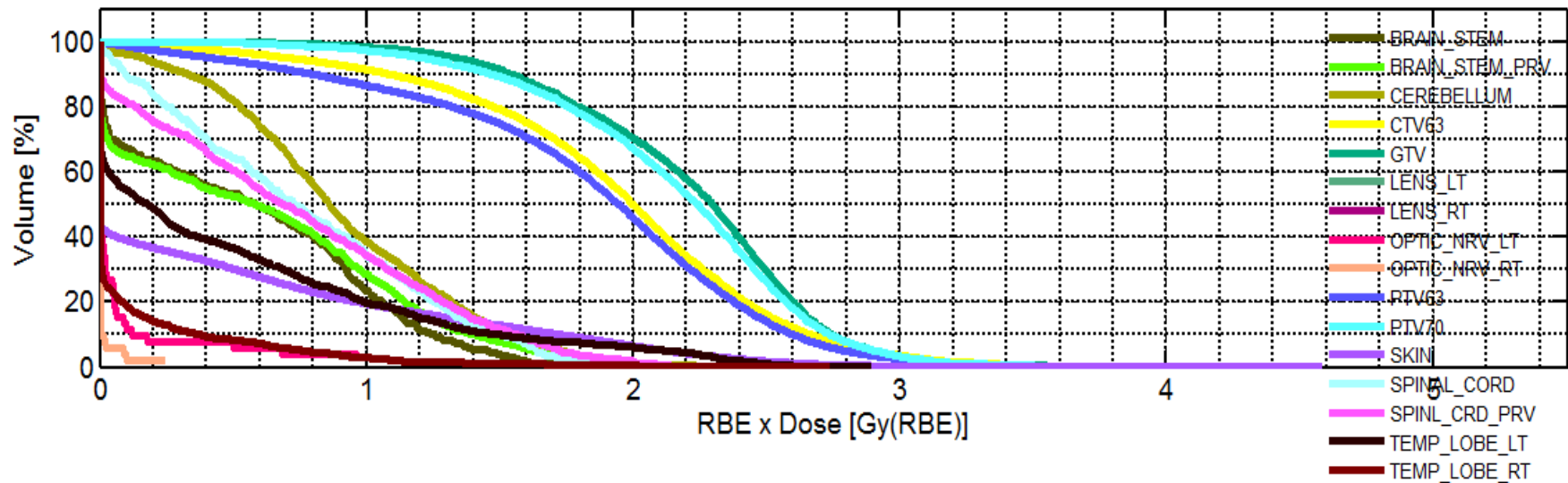
Viewer Options

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 :)