

PARTICLE THERAPY MASTERCLASS

Hands-On Treatment Planning with matRad

Workflow step by step instructions

1st Exercise

- First steps on the TG119 phantom
- Radiotherapy treatment - photons vs. protons vs. carbon ions
- Analysing and comparing results

1. Load the TG119 phantom via the Load *.mat button (TG119.mat).

The screenshot shows a software interface with a file selection dialog box open. The dialog box is titled "Select File to Open" and displays a list of files and folders. The file "TG119" is selected, and a red arrow points to it. The background shows the software's main interface with various settings and a plot area.

Workflow

Refresh Load *.mat data Load *.COM Import Bin...

Status: no data loaded

Plan

bixel width in [mm] 5
Gantry Angle in ° 0
Couch Angle in ° 0
Radiation Mode photons
Machine Generic
IsoCenter in [mm] 0 0 0 Auto.
Fractions 30
Type of optimization none Set Tissue

Objectives & constraints

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

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...

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: TG119 MAT-files (*.mat)

Open Cancel

min max

Set IsoDose Levels

Viewer Options

None No available

Window Center: 0.5
Window Width: 1.0
Range: 0 1

bone Dose opacity: 0 1

Structure Visibility

no data loaded

Info

v3.0.0
github.com/e0404/mat
About

2. Set radiation modality to Photons and define one beam angle (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]

Gantry Angle in ° ➡

Couch Angle in °

Radiation Mode **photons** ➡

Machine

IsoCenter in [mm] Auto.

Fractions

Type of optimization

use MC (VMC++) dose calculations

3D conformal

Run Sequencing

Stratification Levels

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 GoTo

Beam Plane

Offset Dislay option

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



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min 1000 max 1040.

Viewer Options

CT (HU)

Window:

Window Center: Window Width:

Range:

Dose opacity:

Structure Visibility

- Core
- OuterTarget
- BODY

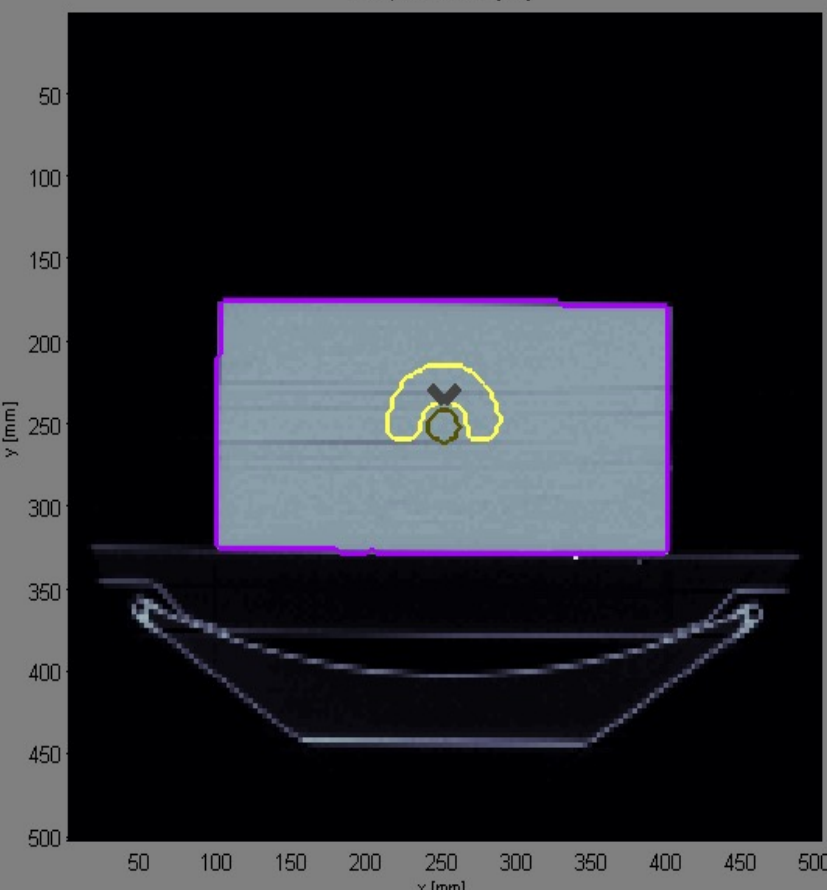
Info

v3.0.0

github.com/e0404/mat

Viewing

axial plane z = 165 [mm]



Y [mm] 50 100 150 200 250 300 350 400 450 500

X [mm] 50 100 150 200 250 300 350 400 450 500

Hounsfield Units 60 50 40 30 20 10

3. Trigger dose calculation via button („Calc. Influence Mx“) and start inverse optimization by clicking on („Optimize“).

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', '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:** 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). It also features radio buttons for 'use MC (VMC++) dose calculations', '3D conformal', 'Run Sequencing', and 'Run Direct Aperture Optimizat...', along with a 'Stratification Levels' field set to 7.
- Objectives & constraints:** A table listing VOI names, types, priorities, and 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:** Includes 'Slice' and 'Beam' selection, 'Type of plot' (intensity), 'Plane' (axial), and 'Dislay option' (no option avail...). It also has 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:** A central window showing an axial plane at z = 165 [mm]. The plot shows a cross-section of a head with a yellow target area and a purple body area. The axes are labeled 'x [mm]' and 'y [mm]'. A color scale on the right indicates 'Hounsfield Units' from 0 to 60.
- Viewer Options:** Includes 'Set IsoDose Levels', 'Window Center' (0.85), 'Window Width' (1.67), 'Range' (0.02671 - 1.692), and 'Structure Visibility' (Core, OuterTarget, BODY).
- Info:** Shows the version 'v3.0.0' and the GitHub repository 'github.com/e0404/mat'.

4. Analyze the resulting dose distribution.

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
 Offset Dislay 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 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. Save the optimization result via („Save to GUI“). Next, show the DVH by („Show DVH/QI“).

The screenshot displays the matRad software interface. The top left contains a 'Workflow' panel 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 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 'GoTo'. 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 x and y axes range from 50 to 500 mm. A color scale on the right indicates 'physicalDose [Gy]' from 0 to 60. The top right corner features the 'matRad' and 'dkfz. GERMAN CANCER RESEARCH CENTER IN THE HELMHOLTZ ASSOCIATION' logos. The bottom right corner includes 'Viewer Options' (Result, Window, Range, Dose opacity) and 'Structure Visibility' (Core, OuterTarget, BODY) sections.

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 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
 Selection Dislay option physicalDose plot isolines
 Offset plot isolines labels
 Show DVH/QI plot iso center
 visualize plan / be...

Viewing
 axial plane z = 165 [mm]

min max n
 2.342

Set IsoDose Levels

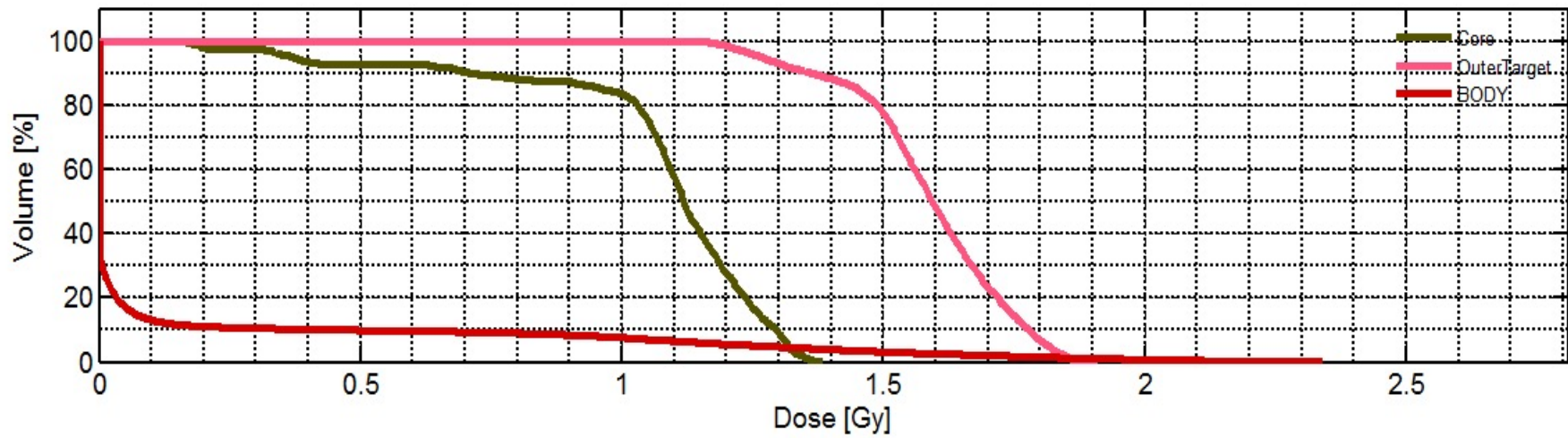
Viewer Options

Result (i.e. dose)
 Window: 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



	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. Change the radiation modality to: Protons and leave the beam angles unchanged.

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



use MC (VMC++) dose calculations

3D conformal

Run Sequencing

Stratification Levels 7

Run Direct Aperture Optimizat...

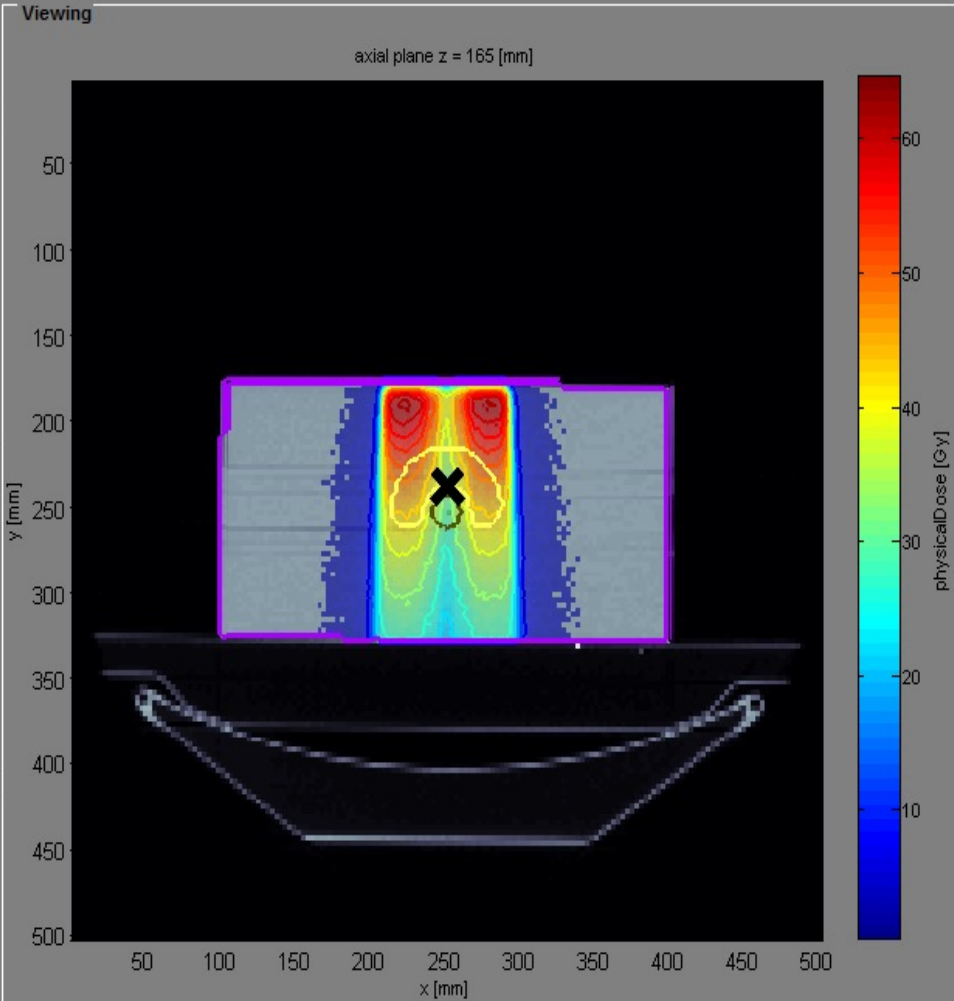
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Objectives & constraints

	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

axial plane z = 165 [mm]



physicalDose [Gy]

min 0

max 2.342

Set IsoDose Levels

Viewer Options

Result (i.e. dose) 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

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...

7. Trigger dose calculation via button („Calc. InfluenceMx“) and start inverse optimization by clicking on („Optimize“).

Workflow

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

Status: 1 ready for optimization 2

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
 Machine Generic Stratification Levels 7
 IsoCenter in [mm] 251.3 236.4 162.6 Auto. Run Direct Aperture Optimizat...
 # 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
 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...

Show DVH/QI

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Viewing axial plane z = 165 [mm]

min max n 2.342

Set IsoDose Levels

Viewer Options

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

Structure Visibility

- Core
- OuterTarget
- BODY

Info

v3.0.0
 github.com/e0404/mat
 About

8. Save the optimization result via („Save to GUI“). Next, show the DVH by („Show DVH/QI“). Analyze the dose distribution.

The screenshot displays the matRad software interface. The top left shows the '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 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'. A red arrow labeled '2' 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 labeled 'x [mm]'. A color scale on the right indicates 'RBExDose [Gy(RBE)]' from 0 to 60. The right sidebar contains 'min max' values, 'Set IsoDose Levels', 'Viewer Options', 'Structure Visibility', and 'Info'.

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

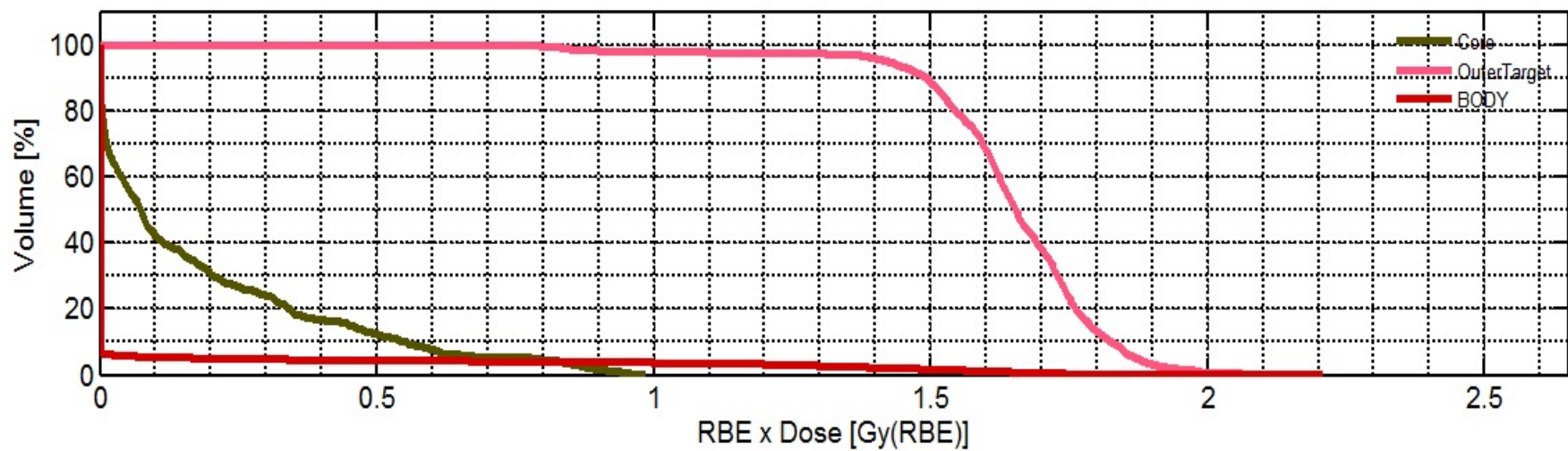
Objectives & constraints

	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 dose
 plot isolines labels
 plot iso center

min max 0 2.710
 Set IsoDose Levels
 Viewer Options
 Result (i.e. dose) Window Breast 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	

Results

- Mean doses for different regions (Gy):

Region/Radiation	Photons	Protons
Core	1.0665	0.1815
Outer Target	1.5852	1.6449
Body	0.1443	0.0640

- Photons deliver highest dose at the surface
- Protons deliver highest dose at the target (tumor) and protect sensitive organs

9. Try to define a better photon treatment plan by defining more beam angles (e.g. [0, 72, 144, 216, 288]). Trigger dose calculation („Calc. Influence Mx“) and start inverse optimization („Optimize“).

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 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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Viewing axial plane z = 165 [mm]

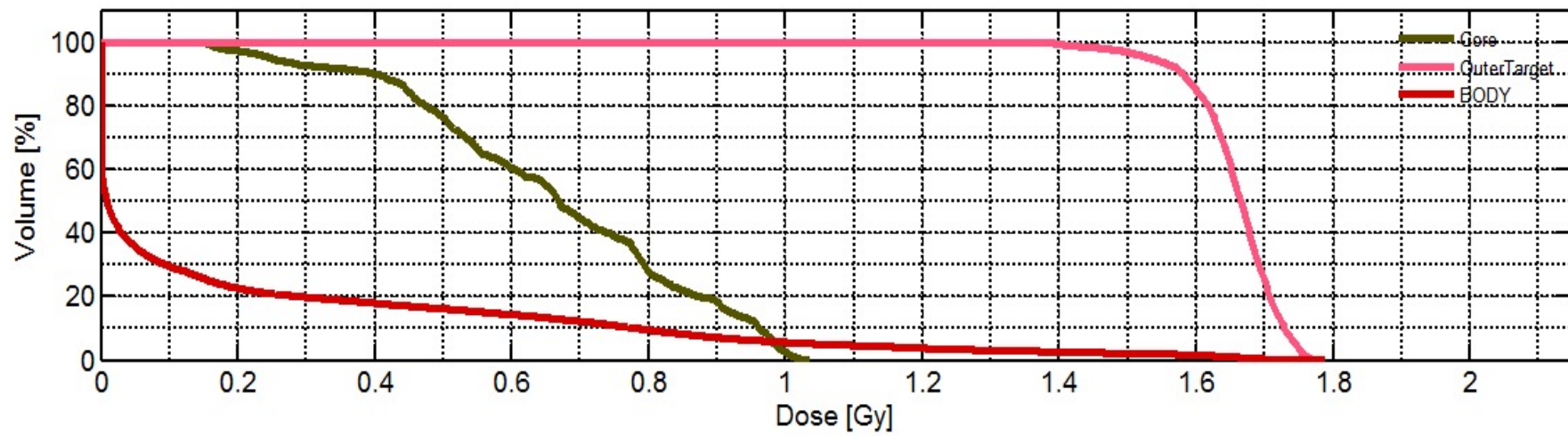
min max 1.902
 Set IsoDose Levels
 Viewer Options
 Result (i.e. dose)
 Window: Breast Custom
 Window Center: 0.95
 Window Width: 1.9
 Range: 0 1.903
 jet
 Dose opacity: 1
 Structure Visibility
 Core
 OuterTarget
 BODY
 Info
 v3.0.0
 github.com/e0404/mat
 About

10. Save the optimization result via („Save to GUI“). Show the DVH by („Show DVH/QI“). Analyze resulting dose distribution.

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 (VMC++) dose calculations, 3D conformal, Run Sequencing, and Run Direct Aperture Optimizat..., and 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:** Includes controls for Slice, Beam, and Offset, as well as Type of plot (intentional), Plane (axial), and Dislay option (physicalDose). 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 = 165 [mm]. The main window displays a color-coded dose distribution map with a central target area (red/yellow) and surrounding organs at risk (blue/green). 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 "Set IsoDose Levels" (min 0, max 1.79), "Result (i.e. dose)", "Window Center" (0.89), "Window Width" (1.79), "Range" (0 to 1.79), "jet" color map, and "Dose opacity" (1).
- Structure Visibility:** Shows checkboxes for Core, OuterTarget, and BODY, all of which are checked.
- Info:** Displays version v3.0.0 and the GitHub repository path qithub.com/e0404/mat.



	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

Results

- Mean doses for different regions (Gy):

Region/Radiation(angles)	Photons(0)	Protons(0)	Photons (0,72,144,216,288)
Core	1.0665	0.1815	0.6625
Outer Target	1.5852	1.6449	1.6563
Body	0.1443	0.0640	0.1968

- Treatment plan using multiple photon beams gives better results than single photon beam.
- Best results are obtained using protons.

11. Change optimization objective to improve the photon treatment plan. Use Table („Objectives & constraints“) and add for e.g. maximal dose for the core or minimal dose for the outer target.

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] 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	ro
1	Core	OAR	2	max dose constraint	5	NaN	NaN	no	+
2	OuterTarget	TARGET	1	min dose constraint	0	NaN	NaN	no	-
3	BODY	OAR	3	square overdosing	100	30	NaN	NaN	no

Visualization



Slice Type of plot GoTo plot CT

Beam Plane plot contour

Offset Display option plot isolines

plot dose plot isolines labels

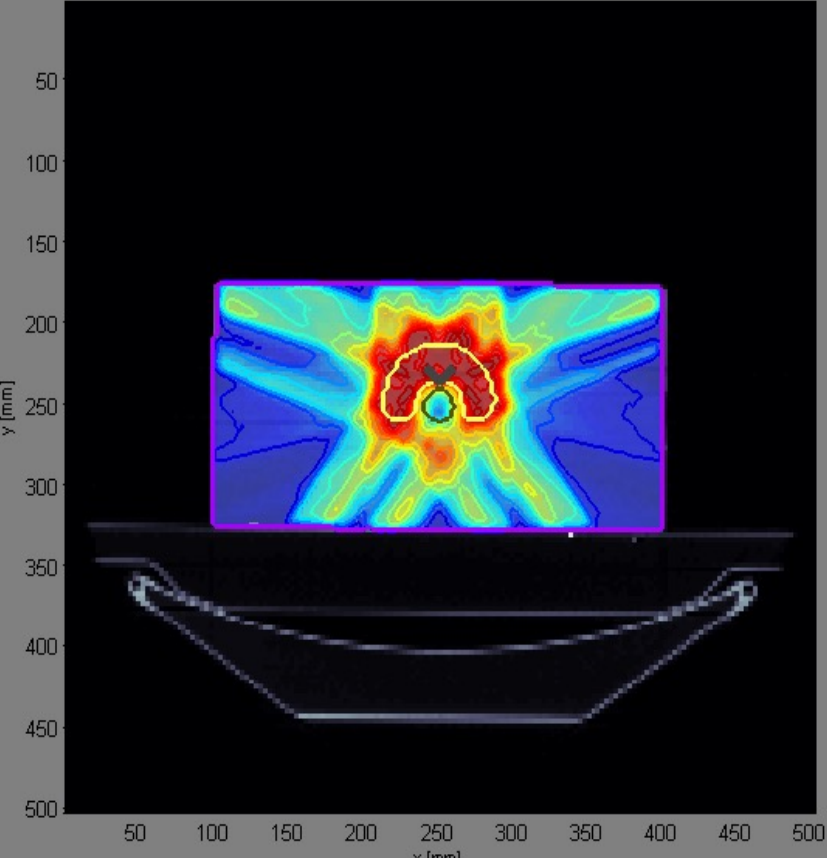
plot iso center visualize plan / be...

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Viewing

axial plane z = 165 [mm]



min max n
1.789

Viewer Options

Result (i.e. dose)

Window Center:

Window Width:

Range:

Structure Visibility

Core

OuterTarget

BODY

Info

v3.0.0

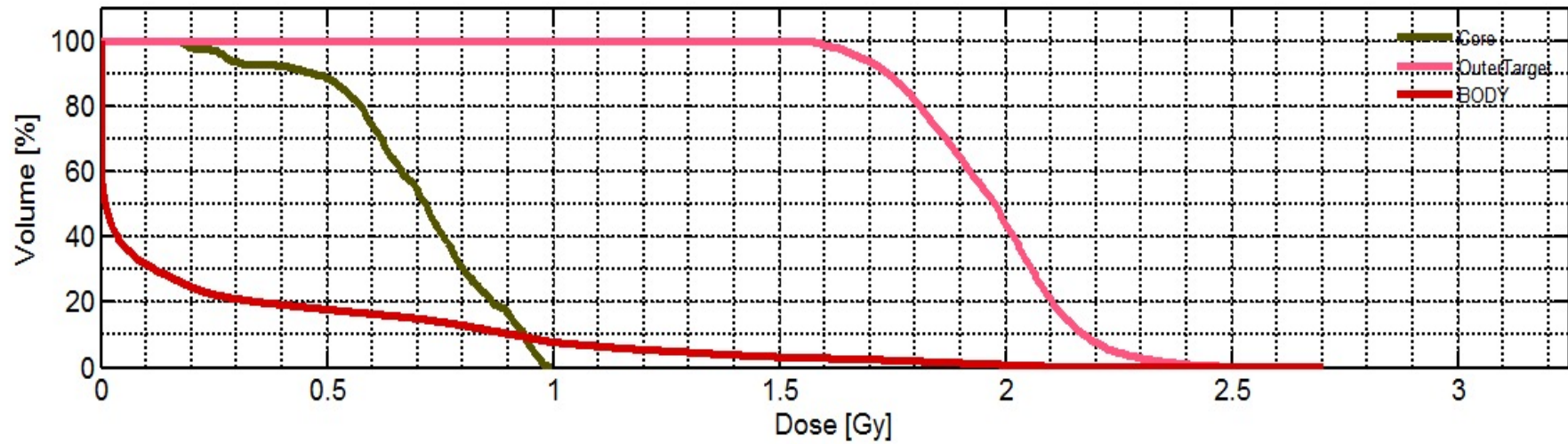
github.com/e0404/mat

12. Trigger dose calculation („Calc. Influence Mx“) and start inverse optimization („Optimize“). Save the optimization result via („Save to GUI“). Next, show the DVH by („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', '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 'Status: plan is optimized'.
- Plan:** A configuration panel with various parameters:
 - 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 (with 'Auto.' checked)
 - # Fractions: 30
 - Type of optimization: none
 - 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	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:** A panel for rendering the dose distribution. It includes 'Slice' and 'Beam' selection, 'Type of plot' (set to 'intentional'), 'Plane' (set to 'axial'), and 'Dislay option' (set to 'physicalDose'). A 'Show DVH/QI' button with a red arrow is located at the bottom. Checkboxes for 'plot CT', 'plot contour', 'plot isolines', 'plot dose', 'plot isolines labels', 'plot iso center', and 'visualize plan / be...' are also present.
- Viewing:** The main visualization area shows an axial plane at z = 165 [mm]. It features a color-coded dose distribution map with a central target area (Core) and surrounding organs at risk (OAR). A color scale on the right indicates 'physicalDose [Gy]' from 0 to 60. The axes are labeled 'x [mm]' and 'y [mm]'. A 'Viewer Options' panel on the right allows for adjusting 'Result (i.e. dose)', 'Window Center', 'Window Width', 'Range', and 'Dose opacity'.



	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	

Results

- Mean doses for different regions (Gy) using 5 beams with and without constraints:

Region/Radiation	With constraints	Without constraints
Core	0.6625	0.6974
Outer Target	1.6563	1.9652
Body	0.1968	0.2343