



NA-MIC

National Alliance for Medical Image Computing

<http://www.na-mic.org>

SlicerRT Extension

Csaba Pinter¹, Andras Lasso¹, Kevin Wang²

¹Laboratory for Percutaneous Surgery, Queen's University, Canada

²University Health Network, Toronto, ON, Canada

`pinter@cs.queensu.ca`

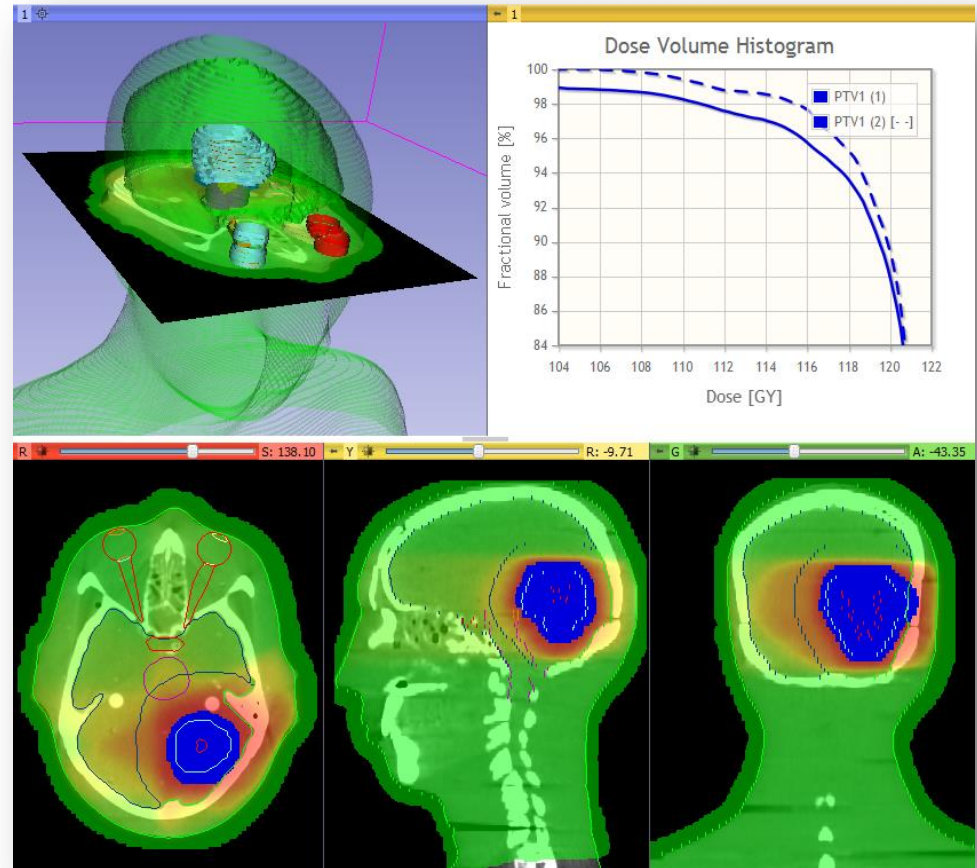
NA-MIC Tutorial Contest: Summer 2013



Learning Objective

This tutorial demonstrates how to perform a radiation therapy research workflow using the SlicerRT extension:

Evaluation of the isocenter shifting adaptation method





Pre-requisite

- Pre-requisite tutorial:
 - **Data Loading and Visualization**
 - Sonia Pujol, Ph.D.
 - http://www.slicer.org/slicerWiki/images/c/c7/DataLoadingAndVisualizationSlicer4.1_SoniaPujol.pdf



Material

This tutorial requires the installation of the most recent Slicer nightly release and the tutorial dataset. They are available at the following locations:

Slicer download page

<http://www.slicer.org/pages/Downloads/>

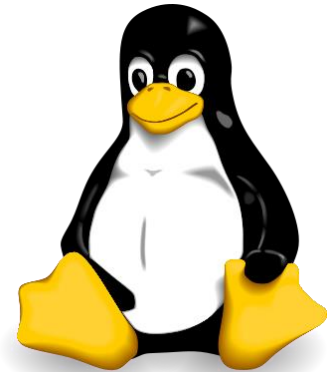
Tutorial dataset: SlicerRtTutorial_Namic2013June

http://slicer.kitware.com/midas3/download/folder/1345/SlicerRtTutorial_Namic2013June.zip



Platforms

- All major desktop platforms are supported



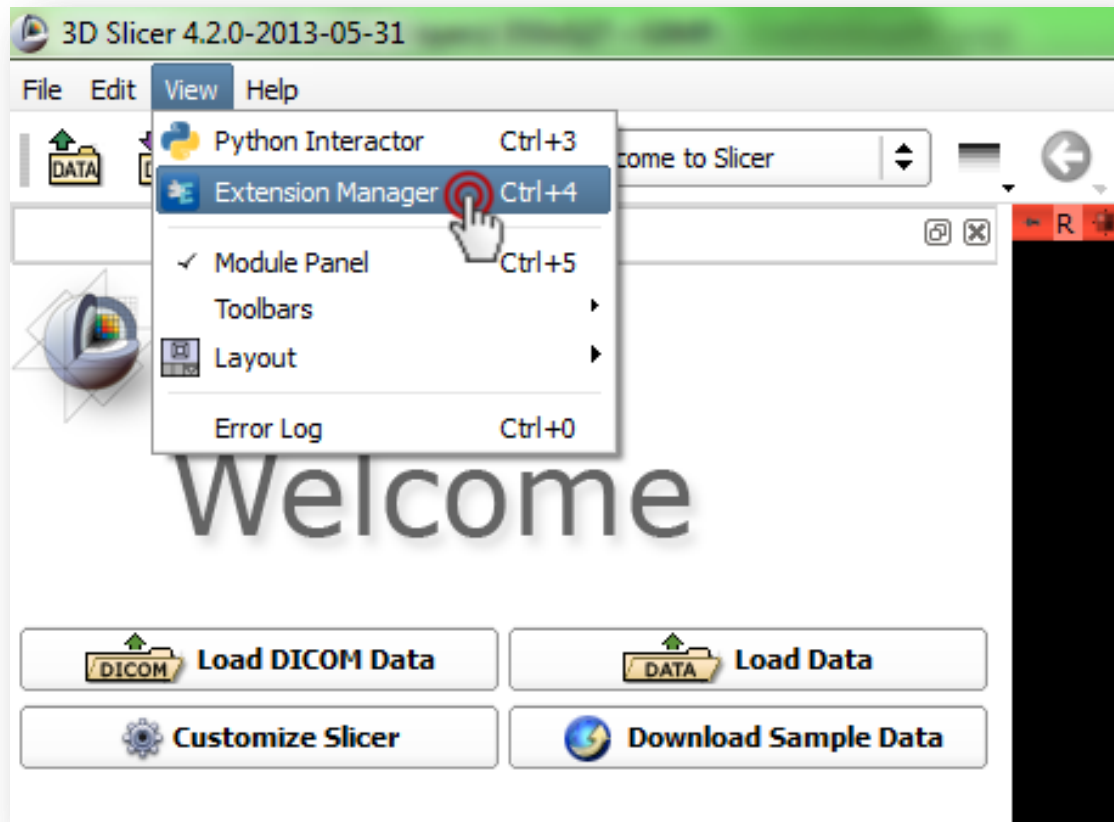


Overview

1. Install SlicerRT extension
 2. Load data from DICOM and nrrd
 3. Create isodose lines and surfaces
 4. Perform rigid registration on CT images
 5. Resample day 2 dose volume
 6. Compare dose distributions
 7. Accumulate dose distributions
 8. Compute dose volume histogram
-

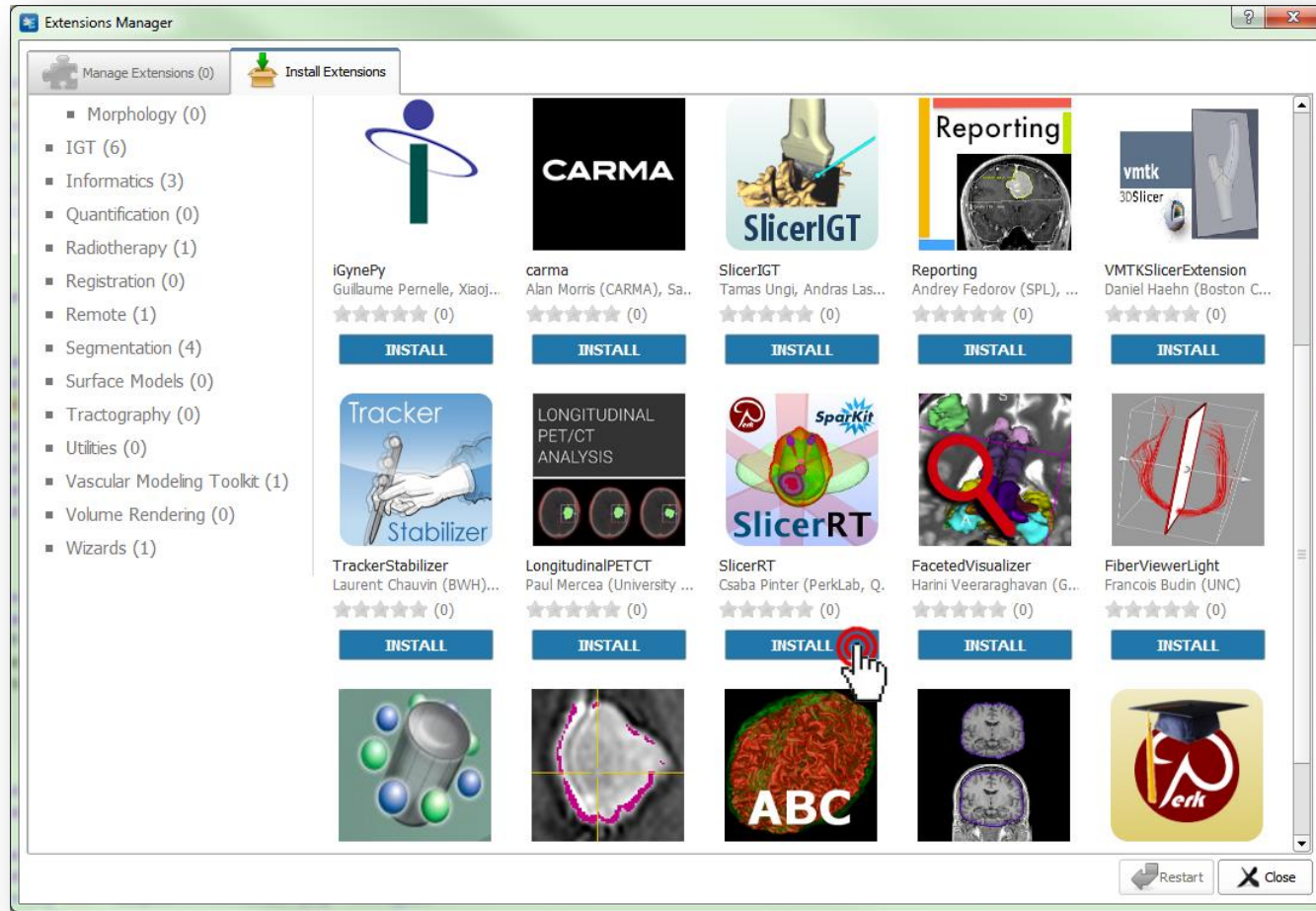


1/1. Install SlicerRT extension



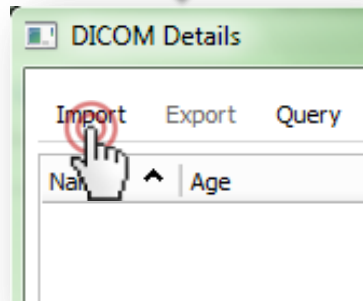
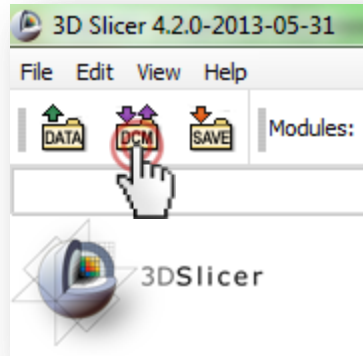


1/2. Install SlicerRT extension

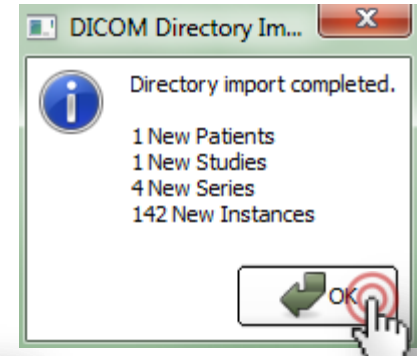
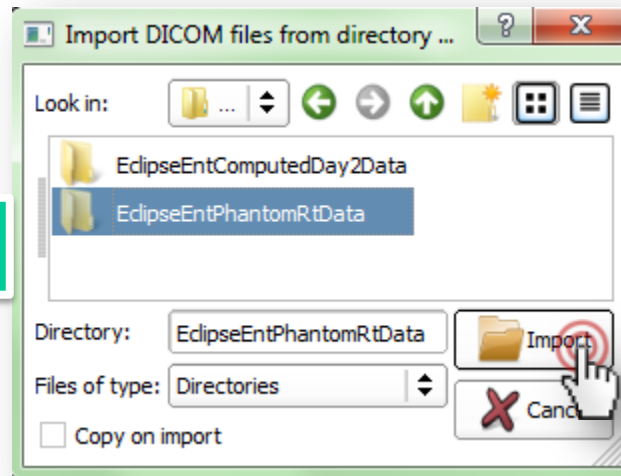




2/1. Import planning data



Browse





2/2. Load planning data

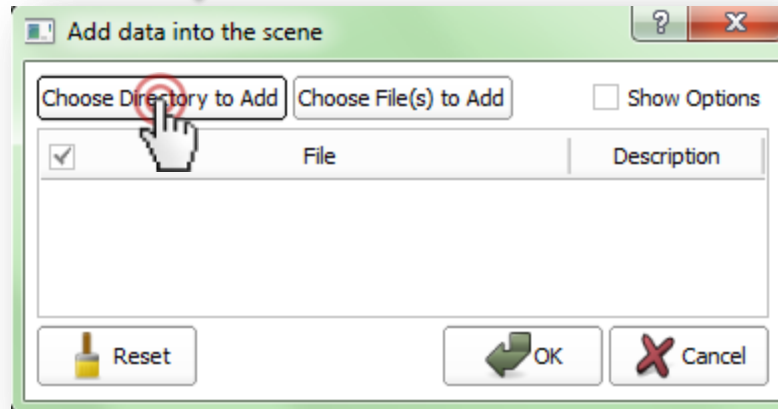
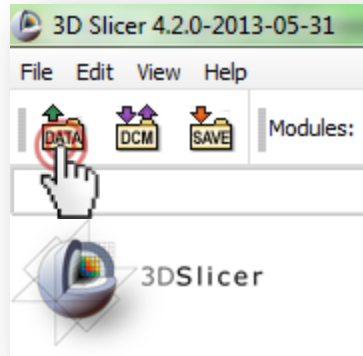
The screenshot shows the 'DICOM Details' application window. At the top, there are menu options: Import, Export, Query, Send, Remove. Below that is a 'LocalDatabase:' field with a folder icon and the path 'C:/Slicer_ctkDICOM-Database'. A table lists patient information with columns: Name, Age, Scan, Date, Subject ID, Number, Institution, Referrer, and Performer. The first row is highlighted in blue and has a mouse cursor pointing to it. Below the table, there are three green callout boxes with white text: '1. Click patient 'RANDO, ENT'', '2. The loadables appear in the bottom', and '3. Click 'Load Selection to Slicer''. The bottom part of the window shows a 'DICOM Data' table with columns: DICOM Data, Reader, and Warnings. The table contains several rows with checkboxes, some of which are checked. At the bottom of the window, there are three buttons: 'Uncheck All', 'Load Selection to Slicer', and 'Close'. A mouse cursor is pointing to the 'Load Selection to Slicer' button.

Name	Age	Scan	Date	Subject ID	Number	Institution	Referrer	Performer
RANDO, ENT				TEST PHYS ENT				
No description			2011-09-20					
ENT IMRT CT		2	2011-09-20		1			
No description RTDOSE		5			0			
No description RTPLAN		4			0			
No description RTSTRUCT		3			0			

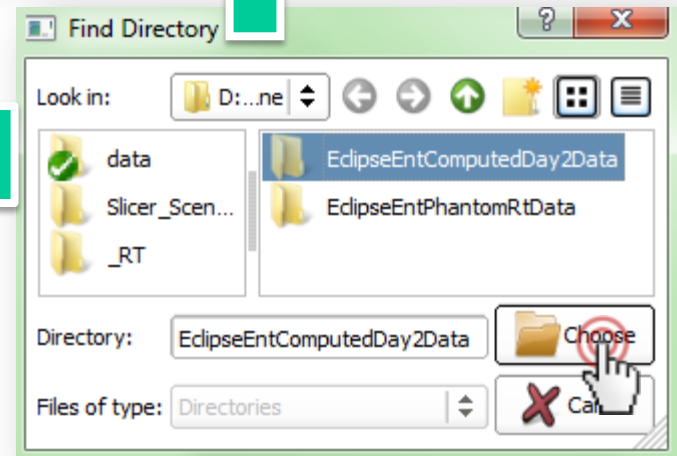
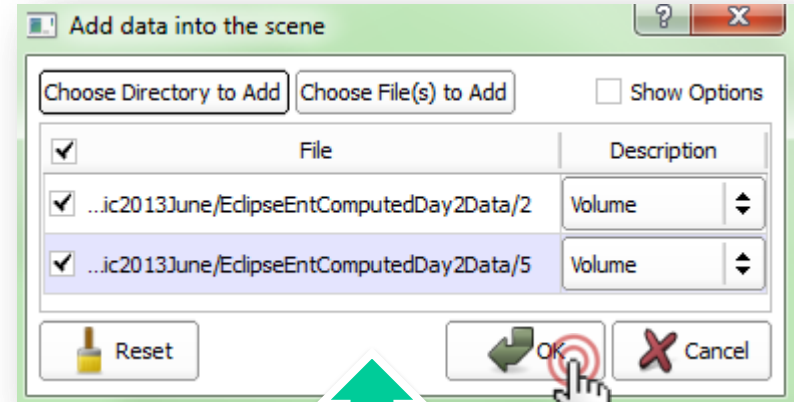
DICOM Data	Reader	Warnings
<input checked="" type="checkbox"/> 5: RTDOSE: BRAI1	RT	
<input checked="" type="checkbox"/> 4: RTPLAN: BRAI1	RT	
<input checked="" type="checkbox"/> 3: RTSTRUCT: ENT	RT	
<input checked="" type="checkbox"/> 2: ENT IMRT		
<input type="checkbox"/> 2: ENT IMRT for contentTime of 085833	Scalar Volume	spacings was detected). Slicer will load this series as
<input type="checkbox"/> 2: ENT IMRT for contentTime of 085845	Scalar Volume	Images are not equally spaced (a difference of 10 in spacings was detected). Slicer will load this series as
<input type="checkbox"/> 2: ENT IMRT for contentTime of 085846	Scalar Volume	Images are not equally spaced (a difference of 17.5 spacings was detected). Slicer will load this series as
<input type="checkbox"/> 2: ENT IMRT for contentTime of 085847	Scalar Volume	Images are not equally spaced (a difference of 15 in spacings was detected). Slicer will load this series as



2/3. Load day 2 data



Browse





2/4. Add day 2 non-DICOM data to patient hierarchy

1. Right-click the patient

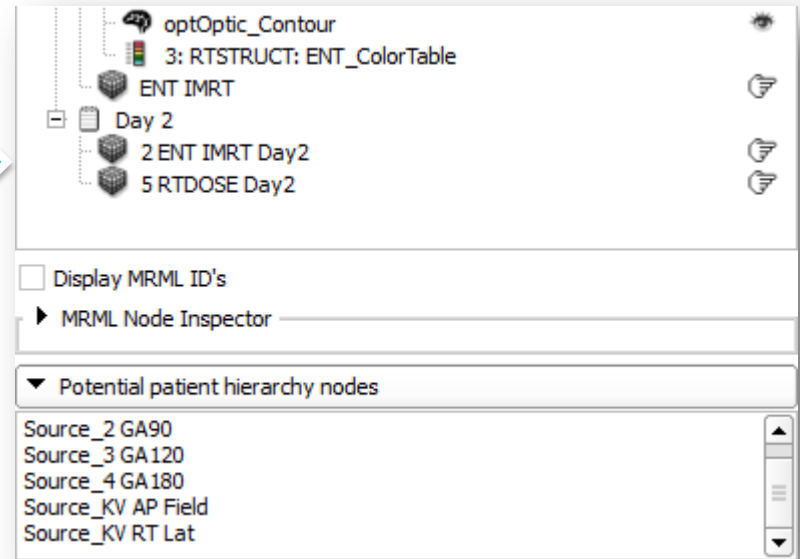
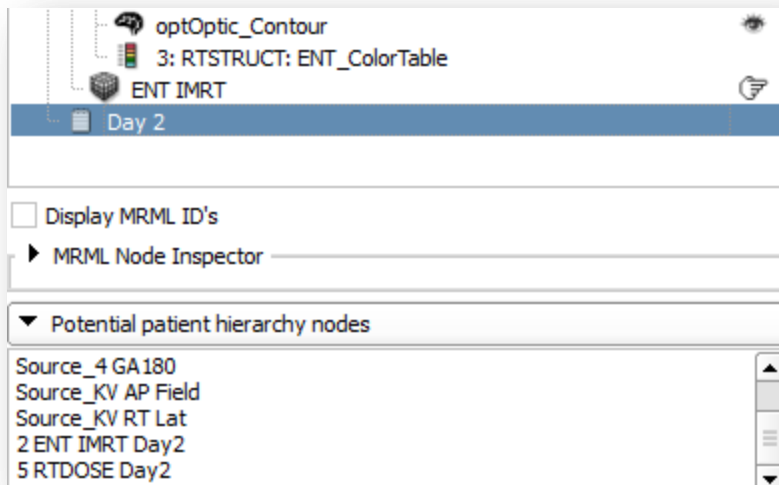
2. Choose 'Create child node'

3. Right-click the new node

4. Rename to 'Day 2'



2/5. Add day 2 non-DICOM data to patient hierarchy

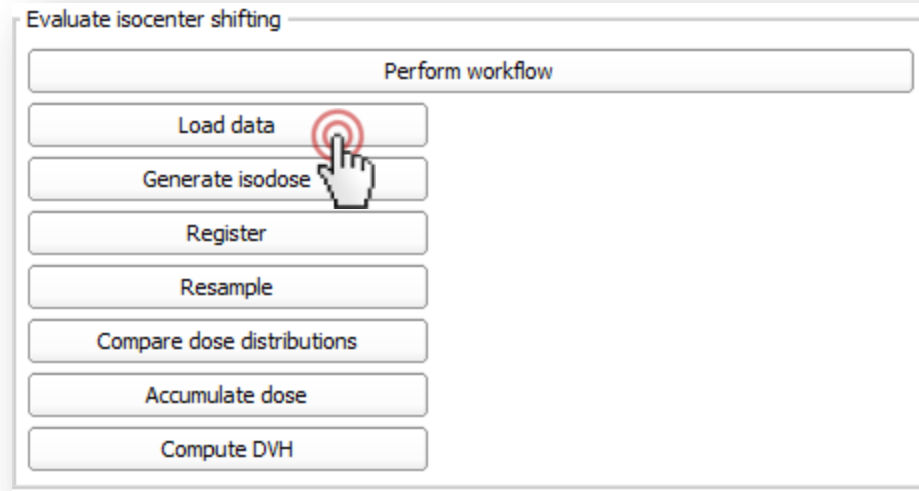


1. Drag&drop 'ENT IMRT Day2' on the study 'Day 2'

2. Do the same with '5 RTDOSE Day2'



Note: Automatic loading



Test data can be automatically downloaded, imported and loaded using the self test module:
Testing / SlicerRT Tests / SlicerRT NA-MIC Tutorial
2013June Self Test



3/1. Create isodose lines

Parameter set: IsodoseParameterSet_5: RTDOSE: BRAI1

Input

Dose volume: 5: RTDOSE: BRAI1

Number of iso levels: 6

	Label	Opacity
1	5	0.20
2	10	0.20
3	15	0.20
4	20	0.20
5	25	0.20
6	30	0.20

Display options

Show isodose surfaces

Show isodose lines

Scalar bar

Show scalar bar in 3D viewer

Show scalar bar in 2D viewer

Apply

1. Choose Radiotherapy / Isodose module

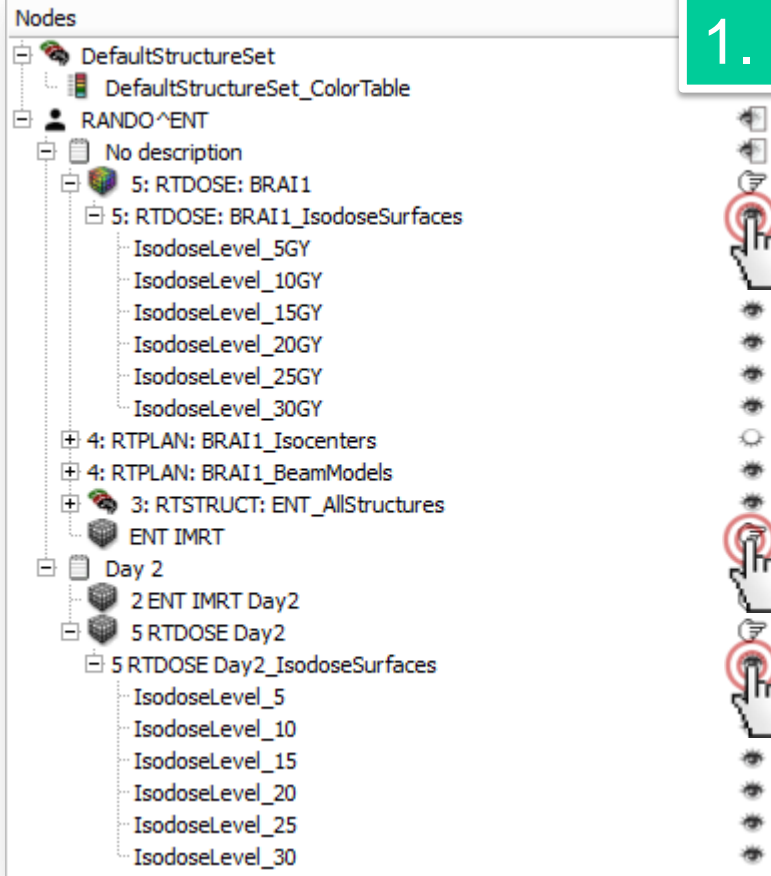
2. Click Apply

3. Choose '5 RTDOSE Day2' volume as Dose volume

4. Click Apply



3/2. Visualize isodose lines



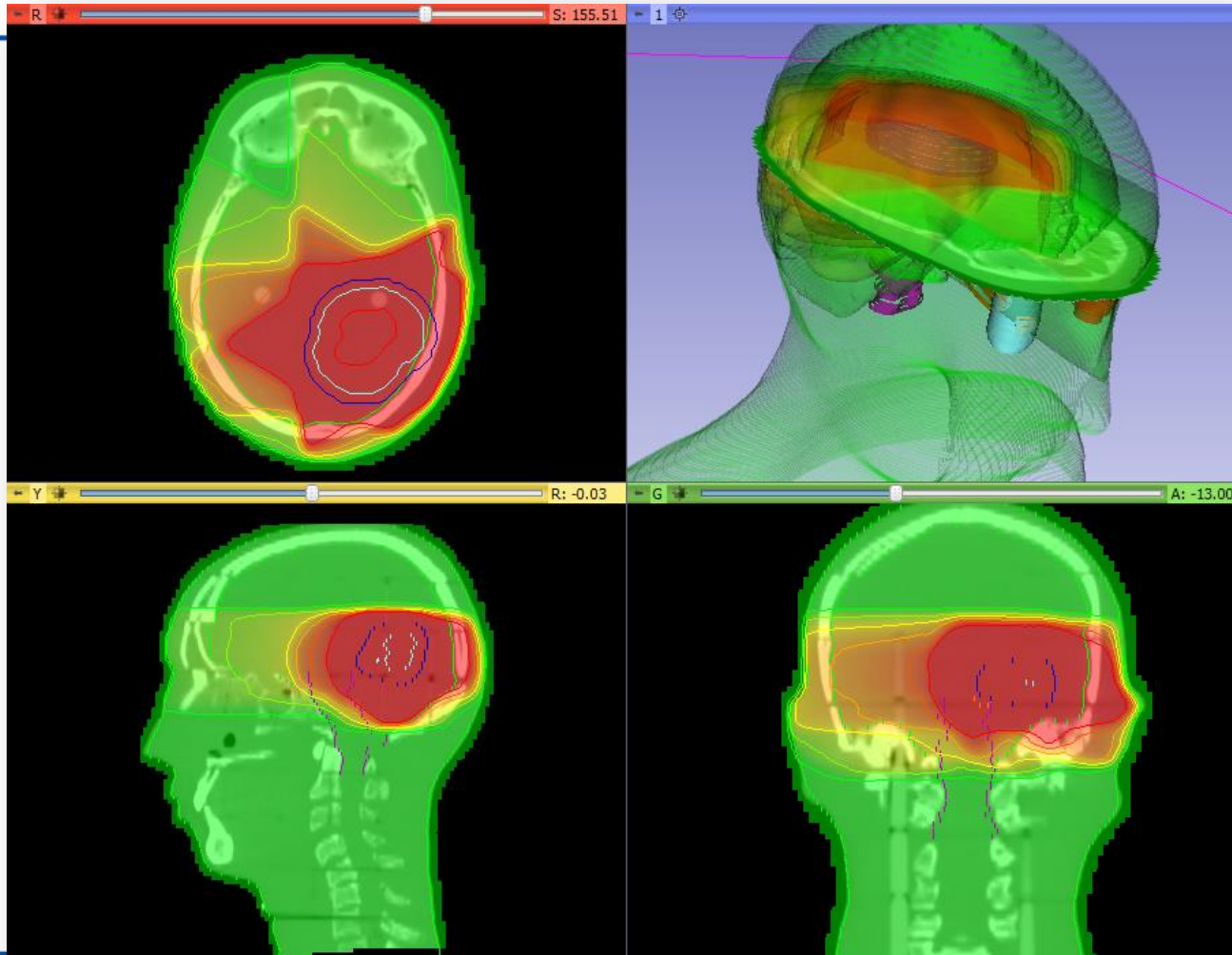
1. Switch back to Patient Hierarchy

2. Turn on and off visualization of isodose line and surface groups by clicking the eye icon next to the parent node

3. Display volumes in the 2D viewers by clicking the hand icon next to the volumes



3/3. Relevant data showed





4. Register CT volumes

▼ General Registration (BRAINS)

Parameter set: General Registration (BRAINS)

▼ Input Images

Fixed Image Volume 2: ENT IMRT

Moving Image Volume 2 ENT IMRT Day2

▼ Output Settings (At least one output must be specified.)

Slicer BSpline Transform None

Slicer Linear Transform None

Output Image Volume

Rename current LinearTransform

Create new LinearTransform

Create and rename new LinearTransform

Delete current LinearTransform

▼ Initialization of regis

Initialization transform

Initialize Transform Mode

Off useMomentsAlign

useCenterOfHeadAlign useGeometryAlign

useCenterOfROIAlign

▼ Registration Phases (Check one or more, executed in order listed)

Rigid (6 DOF)

Rigid+Scale(7 DOF)

Rigid+Scale+Skew(10 DOF)

Affine(12 DOF)

BSpline (>27 DOF)

SyN

Composite (many DOF)

1. Go to module Registration / General Registration (BRAINS)

Set up parameters as shown:

2. Choose planning CT as fixed image

3. Choose day 2 CT as moving image

4. Create transform and rename it to Transform_Day2ToDay1_Rigid

5. Choose 'Rigid (6 DOF)'

6. Click 'Apply'



5. Resample day 2 dose

▼ Resample Image (BRAINS)

Parameter set: Resample Image (BRAINS)

▼ Inputs

Image To Warp 5 RTDOSE Day2

Reference Image 5: RTDOSE: BRAI1

▼ Outputs

Output Image 5_RTDOSE_Day2Registered_Rigid

Pixel Type float short ushort int uint uc

▼ Warping Parameters

Displacement Field (deprecated) None

Transform file Transform_Day2ToDay1_Rigid

Interpolation Mode NearestNeighbor Linear

1. Go to module Registration / Resample Image (BRAINS)

2. Set parameters as indicated (output image needs to be created and renamed)

3. Click 'Apply'



6/1. Compare dose volumes

Parameter set: DoseComparison

▼ Input

Reference dose volume: 5: RTDOSE: BRAI1

Compare dose volume: 5_RTDOSE_Day2Registered_Rigid

DTA distance tolerance (mm): 3.00

Dose difference tolerance (%): 3.00

Reference dose: Use maximum dose Use custom value (Gy): 50.00

Maximum gamma: 2.00

▼ Output

Gamma volume: 5: RTDOSE: BRAI1
2: ENT IMRT
2 ENT IMRT Day2
5 RTDOSE Day2
5_RTDOSE_Day2Registered_Rigid

Rename current Volume
Create new Volume
Create and rename new Volume
Delete current Volume

1. Go to module Radiotherapy / Dose Comparison

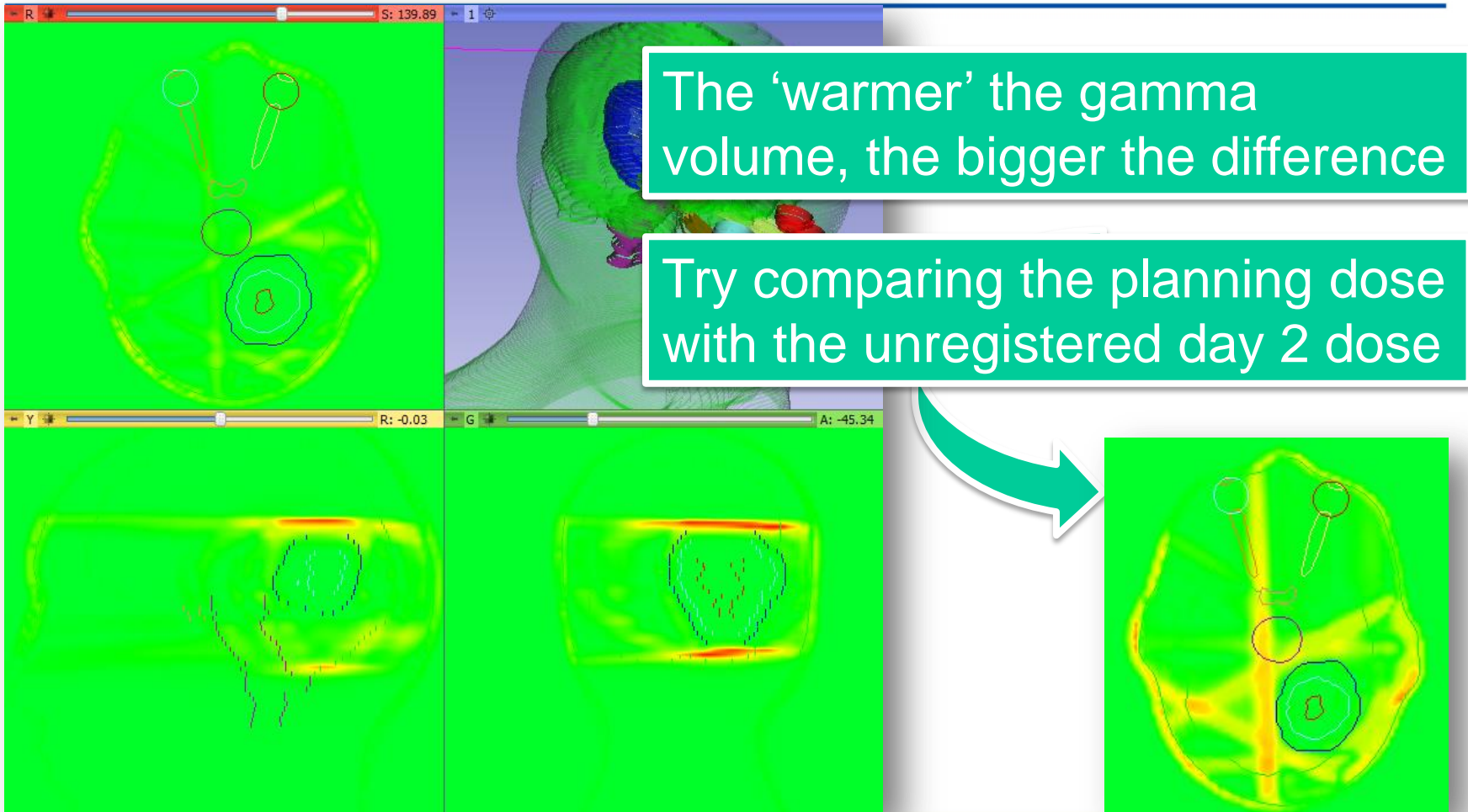
2. Set input volumes:
Reference: Planning dose
Compare: Registered day 2 dose

3. Create output
(no rename necessary)

4. Click 'Apply'



6/2. Verify registration





7/1. Accumulate doses unregistered = no adaptation

Reference dose volume: 5: RTDOSE: BRAI1

Show dose volumes only

	Dose Volume	Weighting Factor
<input type="checkbox"/>	2: ENT IMRT	1.00
<input checked="" type="checkbox"/>	5: RTDOSE: BRAI1	1.00
<input type="checkbox"/>	2_ENT_IMRT_Day2	1.00
<input checked="" type="checkbox"/>	5_RTDOSE_Day2	1.00
<input type="checkbox"/>	5_RTDOSE_Day2Registered_Rigid	1.00

▼ Output

Accumulated dose volume: None

2: ENT IMRT

5: RTDOSE: BRAI1

▼ Data Probe

2_ENT_IMRT_Day2

5_RTDOSE_Day2

5_RTDOSE_Day2Registered_Rigid

L

F

B

Rename current Volume

Create new Volume

Create and rename new Volume

Delete current Volume

1. Go to module Radiotherapy / Dose Accumulation

2. Uncheck 'Show dose volumes only' (dose attributes are not yet automatically added to the nodes)

3. Choose reference, then planning and day 2 dose volumes

4. Create output volume

5. Click 'Apply'



7/2. Accumulate doses registered = isocenter shift

Reference dose volume: 5: RTDOSE: BRAI1

Show dose volumes only

	Dose Volume	Weighting Factor
<input type="checkbox"/>	2: ENT IMRT	1.00
<input checked="" type="checkbox"/>	5: RTDOSE: BRAI1	1.00
<input type="checkbox"/>	2_ENT_IMRT_Day2	1.00
<input type="checkbox"/>	5_RTDOSE_Day2	1.00
<input checked="" type="checkbox"/>	5_RTDOSE_Day2Registered_Rigid	1.00

Accumulated_5_RTDOSE_Day25: RTDOSE: BRAI1

Output

Accumulated dose volume

Data Probe

- None
- 2: ENT IMRT
- 5: RTDOSE: BRAI1
- 2_ENT_IMRT_Day2
- 5_RTDOSE_Day2
- 5_RTDOSE_Day2Registered_Rigid
- Accumulated_5_RTDOSE_Day25: RTDOSE: BRAI1
- Rename current Volume
- Create new Volume
- Create and rename new Volume
- Delete current Volume

1. Uncheck day 2 dose volume

2. Select registered day 2 dose

3. Create output volume

4. Click 'Apply'



8/1. Compute dose volume histogram for unregistered

▼ Input

Dose volume: Accumulated_5 RTDOSE Day25: RTDOSE: BRAI1

Structure set: 3: RTSTRUCT: ENT_AllStructures_PatientHierarchy

Show dose volumes only

Compute DVH

1. Go to module Radiotherapy / Dose Volume Histogram

2. Choose unregistered accumulated dose

3. Uncheck 'Show dose volumes only'

4. Choose
'3: RTSTRUCT: ENT_AllStructures_PatientHierarchy'

5. Click 'Compute DVH'



8/2. Compute dose volume histogram for registered

▼ Input

Dose volume: Accumulated_5: RTDOSE: BRAI15_RTDOSE_Day2Registered_Rigid

Structure set: 3: RTSTRUCT: ENT_AllStructures_PatientHierarch

Show dose volumes only

Compute DVH

▼ Output

Chart: Chart

Show/hide all

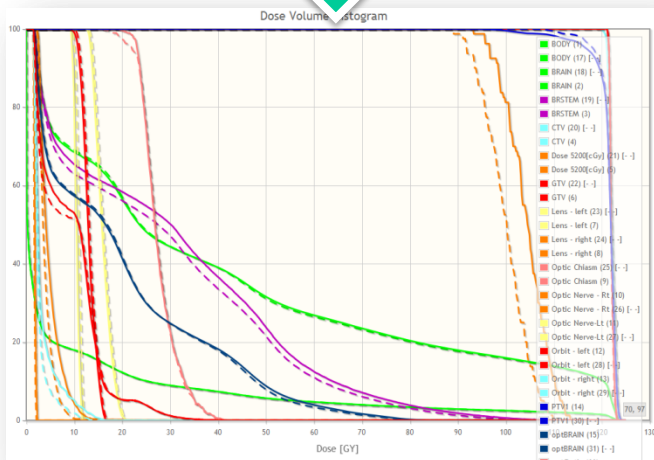
1. Choose registered accumulated dose

2. Click 'Compute DVH'

3. Create chart

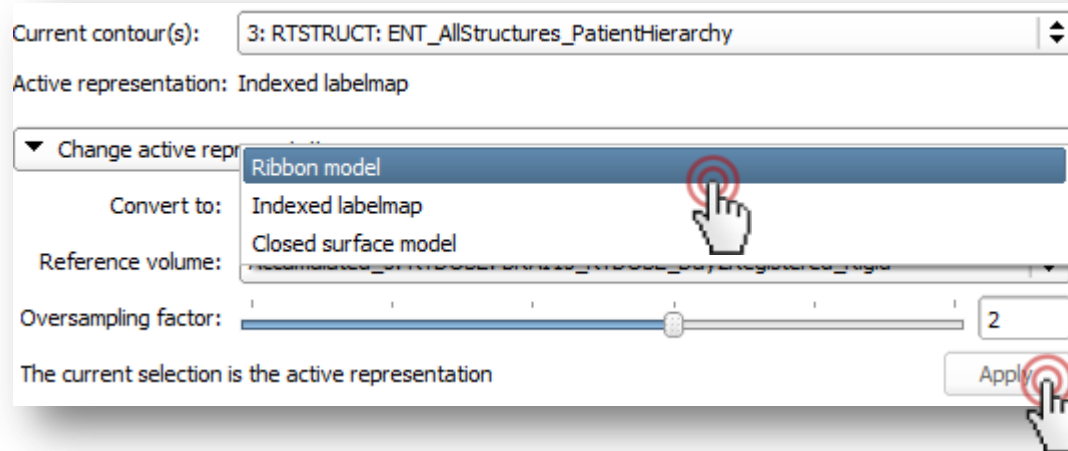
4. Click 'Show/hide all'

5. DVH curves appear







Note: Structures have been rasterized



Structures are automatically rasterized during DVH computation. In this state, they can be seen as labelmaps over the volumes in the 2D viewers. To show the models again, convert back in the Radiotherapy / Contours module.





8/3. Quantify improvement

Chart: Chart Show/hide all  

	Structure	Volume name	Volume (cc)	Mean dose (GY)	Min dose (GY)	Max dose (GY)	V50 (%)	D99% (Gy)
1	<input checked="" type="checkbox"/>	BODY	Accumulated_5 RTDOSE Day25: RTDOSE: BRAI1 8054	8.76107	0	124.52	5.64	0.00
2	<input checked="" type="checkbox"/>	BRAIN	Accumulated_5 RTDOSE Day25: RTDOSE: BRAI1 1114.79	41.1543	1.27333	124.52	31.57	1.58
3	<input checked="" type="checkbox"/>	BRSTEM	Accumulated_5 RTDOSE Day25: RTDOSE: BRAI1 31.5742	30.5489	1.69507	113.388	23.69	1.79
4	<input checked="" type="checkbox"/>	CTV	Accumulated_5 RTDOSE Day25: RTDOSE: BRAI1 70.1289	122.158	119.76	124.176	100.00	120.54
5	<input checked="" type="checkbox"/>	Dose 5200[cGy]	Accumulated_5 RTDOSE Day25: RTDOSE: BRAI1 0.15625	104.27	93.2519	113.388	100.00	93.26
6	<input checked="" type="checkbox"/>	GTV	Accumulated_5 RTDOSE Day25: RTDOSE: BRAI1 8.49219	122.051	121.093	123.294	100.00	121.26
7	<input checked="" type="checkbox"/>	Lens - left	Accumulated_5 RTDOSE Day25: RTDOSE: BRAI1 0.128906	10.4467	9.39761	11.5707	0.00	9.34

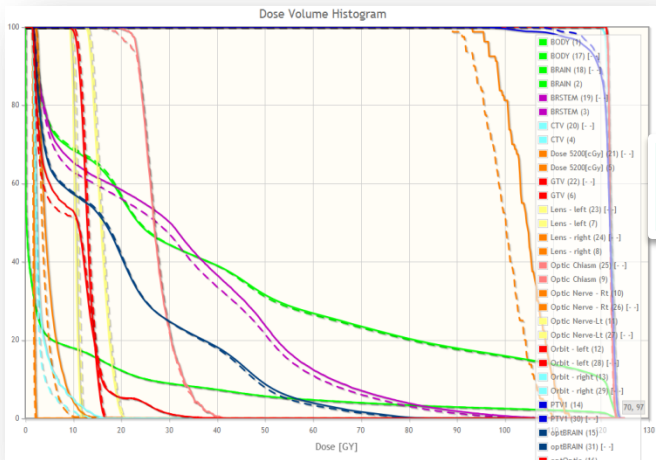
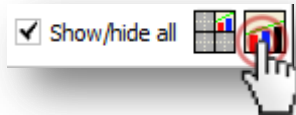
▼ Advanced Options

V metric for dose values: 50 Gy - cc % 

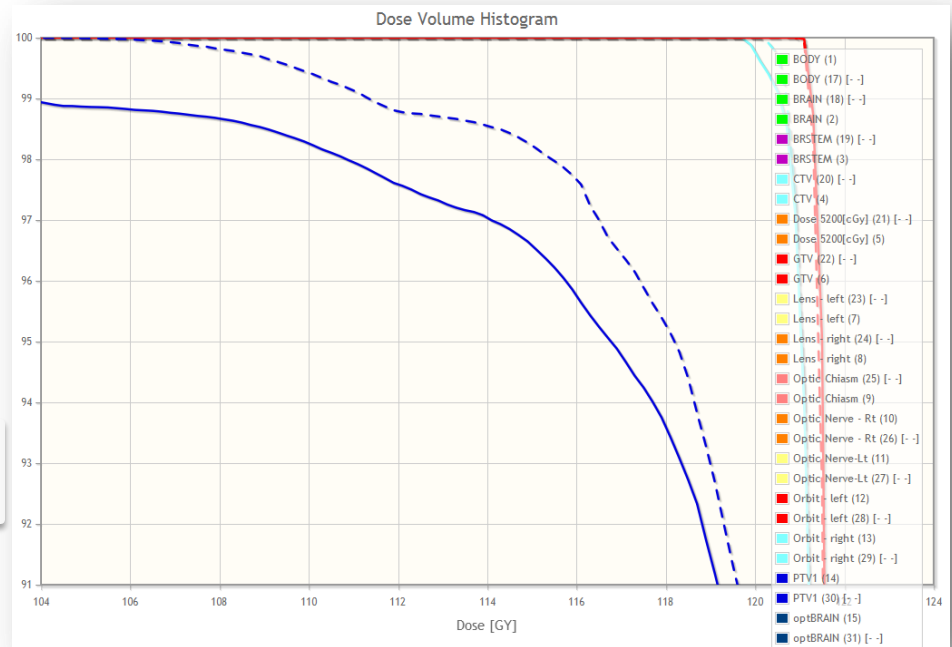
D metric for volumes: cc - Gy % 



8/4. Visualize improvement



Zoom



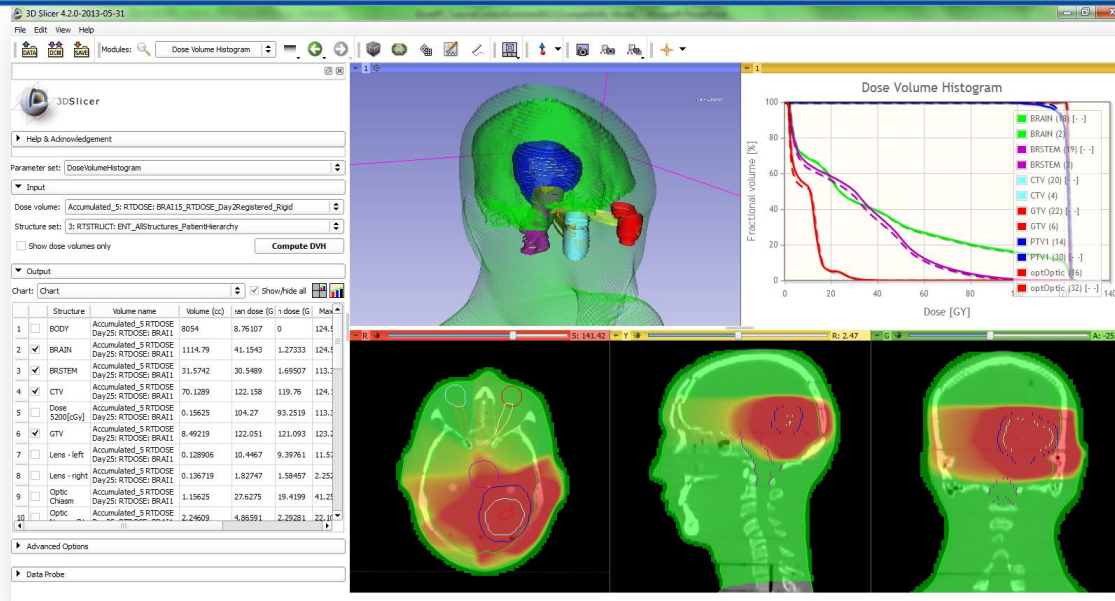


Conclusion

Creating and performing radiation therapy research workflows are easy using the BRAINS registration tools along with the numerous SlicerRT modules



Reference and webpage



- Overview paper: Csaba Pinter, Andras Lasso, An Wang, David Jaffray, and Gabor Fichtinger, “SlicerRT: Radiation therapy research toolkit for 3D Slicer”, Med. Phys. 39 (10), October 2012
- Project homepage: <http://www.SlicerRT.org/>



Acknowledgments



**National Alliance for Medical
Image Computing**

NIH U54EB005149



Cancer Care Ontario



SparKit
(Software Platform and Adaptive
Radiotherapy Kit)