



# Exploring Peritumoral White Matter Fibers for Neurosurgical Planning

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# Clinical Goal

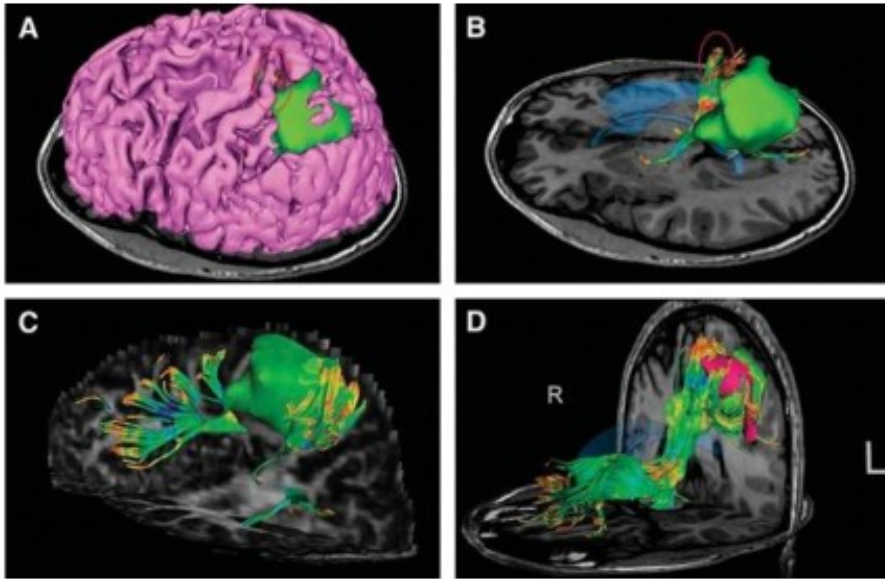
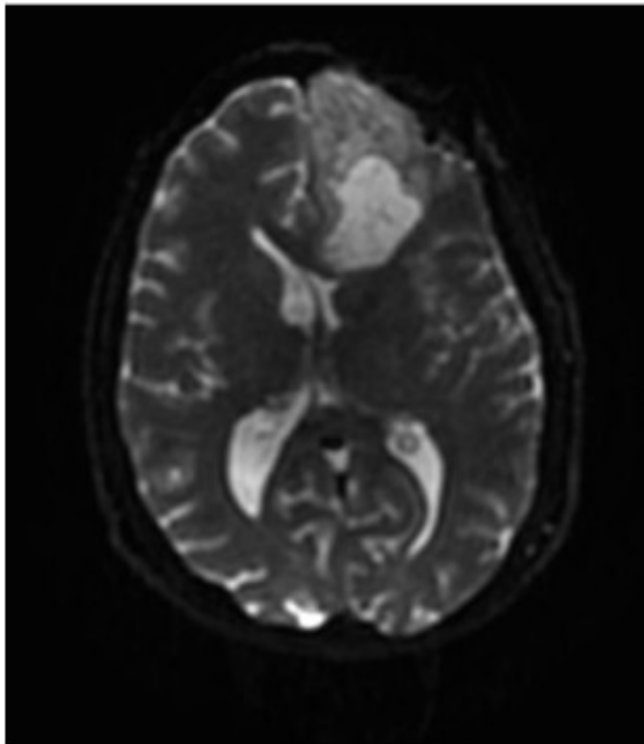


Image Courtesy of Dr. Alexandra Golby, Brigham and Women's Hospital, Boston, MA..

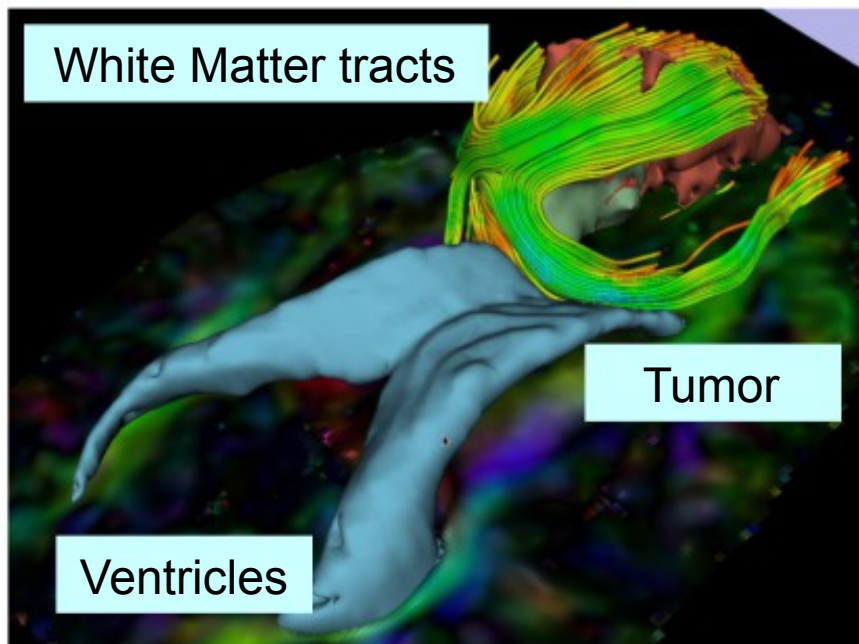
Diffusion Tensor Imaging (DTI) Tractography has the potential to bring valuable spatial information on tumor infiltration and tract displacement for neurosurgical planning of tumor resection.

# Clinical Case



- 35 year-old male diagnosed with Glioblastoma multiform (GBM)
- Diffusion Weighted Imaging (DWI) acquisition for neurosurgical planning

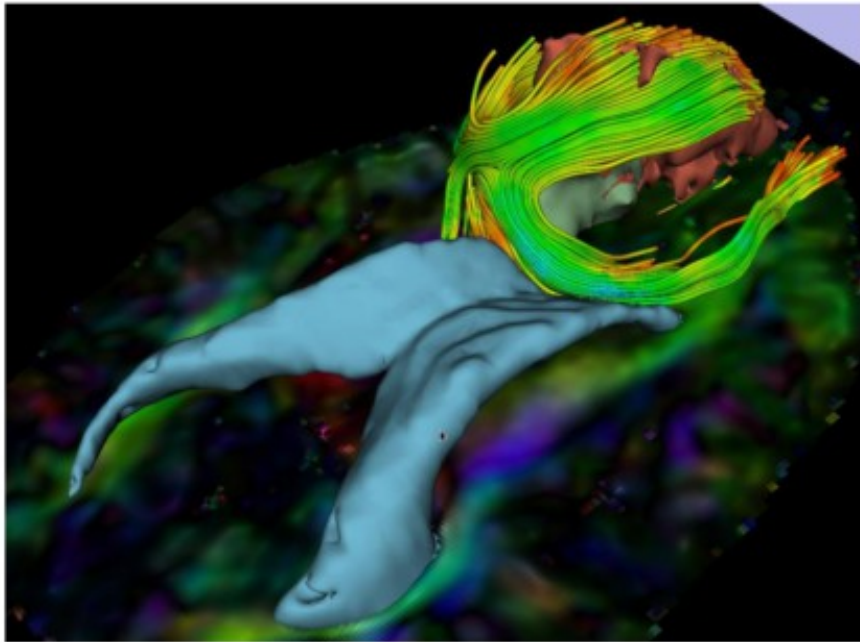
# Clinical Goal



The goal of this tutorial is to explore white matter fibers surrounding a tumor using Diffusion Tensor Imaging (DTI) Tractography.



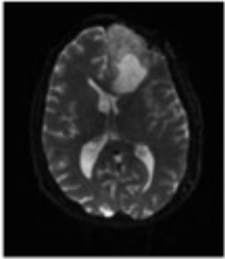
# Image Analysis Pipeline



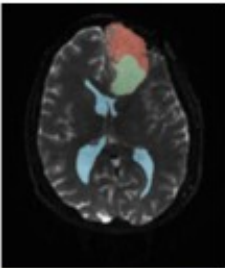
The image analysis pipeline described in this tutorial uses three different algorithms:

- 1) Grow Cut algorithm for segmentation of the tumor parts
- 2) Marching Cube algorithm for surface modeling
- 3) Single tensor streamline tractography algorithm for tract generation.

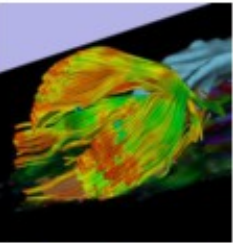
# Overview of the analysis pipeline



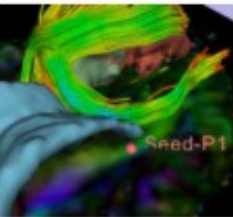
Part 1: Loading & Visualization of Diffusion Data



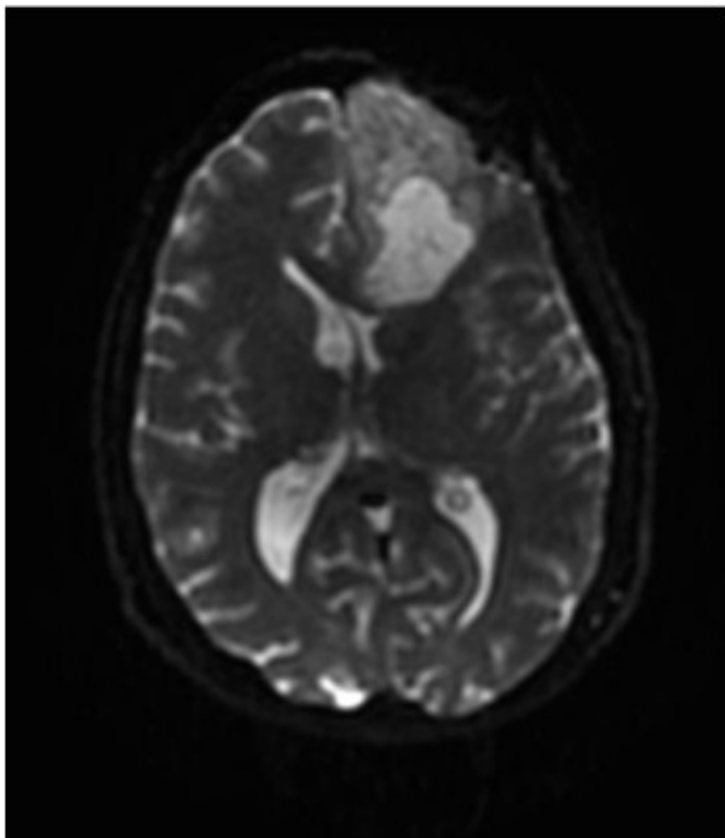
Part 2: Segmentation of lat. ventricles, and solid and cystic parts of the tumor



Part 3: Tractography reconstruction of white matter fibers in the peri-tumoral volume

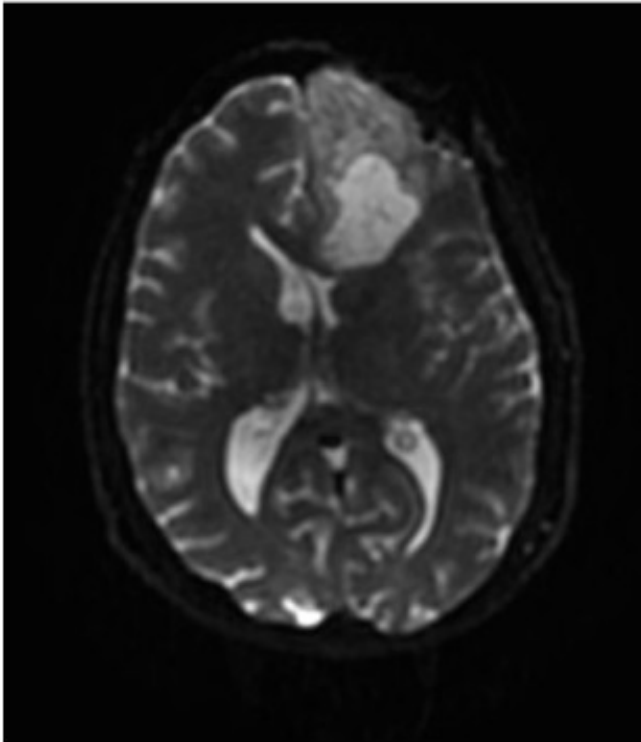


Part 4: Tractography exploration of the ipsilateral and contralateral side



# Part 1: Loading and Visualization of Diffusion Data

# Diffusion Tensor Imaging



$$S_i = S_0 e^{-b \hat{g}_i^T D \hat{g}_i}$$

(Stejskal and Tanner 1965, Basser 1994 )

$$\underline{\mathbf{D}} = \begin{bmatrix} D_{xx} & D_{xy} & D_{xz} \\ D_{yx} & D_{yy} & D_{yz} \\ D_{zx} & D_{zy} & D_{zz} \end{bmatrix}$$



# Loading DTI and Baseline Data

3D Slicer 4.4.0-2015-05-21

Modules: Welcome to Slicer

3DSlicer

## Welcome

**Load DICOM Data** **Load Data** **Customize Slicer** **Download Sample Data**

Feedback

Share your stories with us enabled your research.

We are always interested in improving our software. Please send us your feedback carefully read.

See more at [http://www.slicer.org](#)

About The Main Window Loading and Saving Display Mouse & Keyboard Data Probe

White Matter Exploration for Neurosurgical Planning

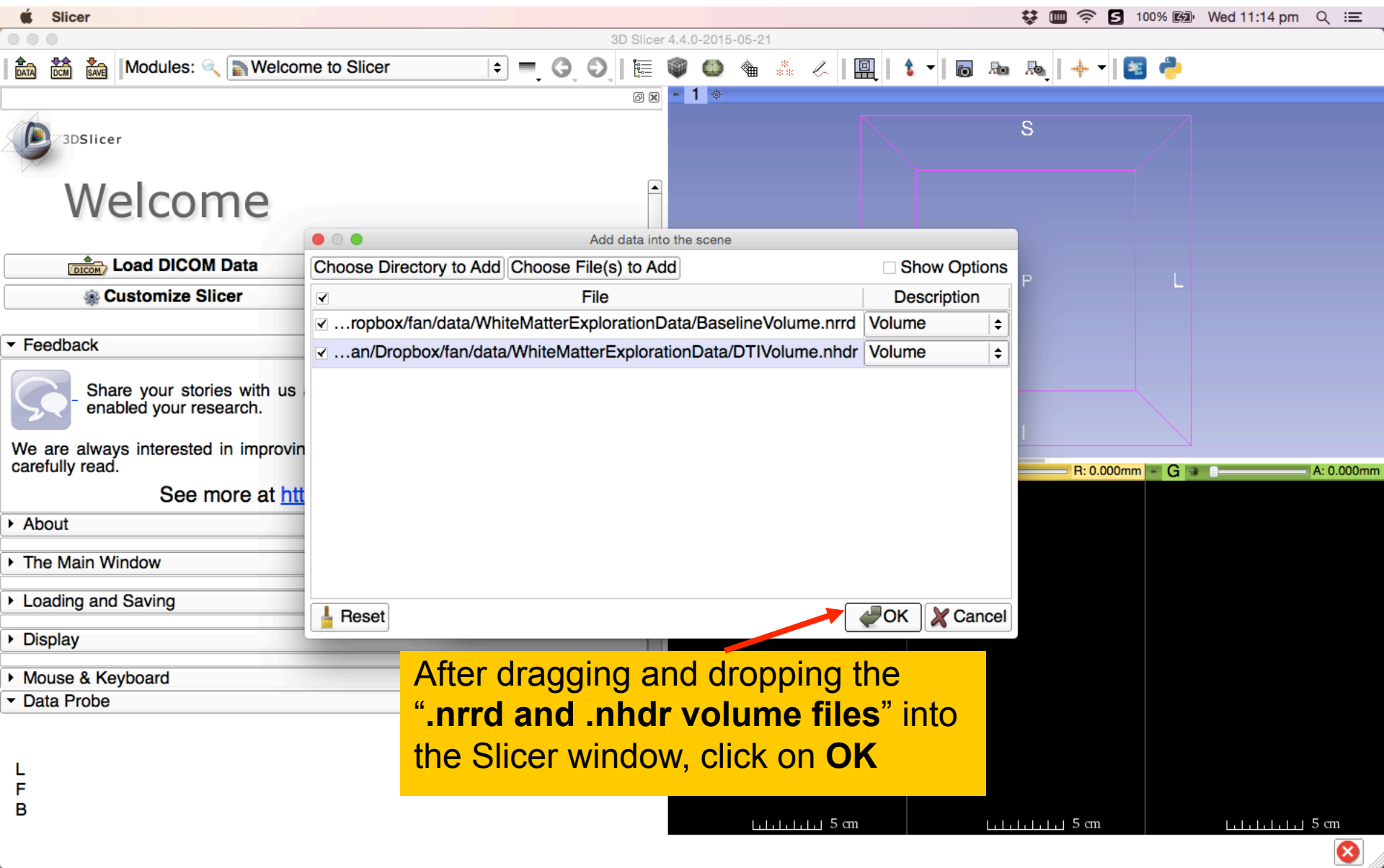
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Drag and drop both the **BaselineVolume.nrrd** and **DTIVolume.nhdr** files to the Slicer window

Name	Date Modified	Size	Kind
BaselineVolume.nrrd	29 Mar 2011 9:03 pm	2.8 MB	Unix E...le F
DTIVolume.nhdr	29 Mar 2011 9:03 pm	411 bytes	Unix E...le F
DTIVolume.raw.gz	29 Mar 2011 9:03 pm	16.1 MB	GZip archive

# Loading DTI and Baseline Data



# Loading DTI and Baseline Data

The screenshot shows the 3D Slicer 4.4.0-2015-05-21 interface. The top menu bar includes Apple, Slicer, File, Edit, View, and Help. The status bar shows 3D Slicer 4.4.0-2015-05-21, 100% zoom, and the date/time Wed 11:15 pm. The left sidebar contains the 'Welcome' section with buttons for 'Load DICOM Data', 'Load Data', 'Customize Slicer', and 'Download Sample Data'. Below this is a 'Feedback' section with a text input field and a 'Share your stories' button. The main 3D view area shows a blue background with a purple wireframe box labeled 'S', 'R', 'P', 'L', and 'I'. Below the 3D view are three panels showing brain slices: 'B: DTIVolume', 'B: DTIVolume', and 'B: DTIVolume'. Each panel has a 5 cm scale bar. The bottom of the interface shows the 'L', 'F', 'B' (Left, Front, Back) view controls.

3D Slicer 4.4.0-2015-05-21

Modules: Welcome to Slicer

3DSlicer

## Welcome

**Load DICOM Data** **Load Data** **Customize Slicer** **Download Sample Data**

Feedback

Share your stories with us and let us know about how 3D Slicer has enabled your research.

We are always interested in improving 3D Slicer, and every submission will be carefully read.

Slicer has loaded the DTI volume and the baseline image.

3D View: S, R, P, L, I

DTI Volume: B: DTIVolume, 5 cm

DTI Volume: B: DTIVolume, 5 cm

DTI Volume: B: DTIVolume, 5 cm

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# Loading DTI and Baseline Data

The screenshot shows the 3D Slicer 4.4.0-2015-05-21 interface. The top menu bar includes File, Edit, View, and Help. The main window displays a 3D view of a brain slice with a purple wireframe box. The left sidebar contains a 'Modules' panel with 'Welcome to Slicer' selected, and a 'Data' panel with 'Load Data' and 'Load Sample Data' buttons. A yellow text box on the left provides instructions: 'Click on the pin icon to display the slice menu, then click on the link icon to link the 3 anatomical viewers. Then change the background so it is set to BaselineVolume'. A red arrow points from the 'Link' icon in the 'Data' panel to the 'BaselineVolume' option in the 'Volume' dropdown menu. The bottom of the interface shows three anatomical views (Axial, Coronal, and Sagittal) with a 5 cm scale bar. The status bar at the bottom indicates 'B: DTIVolume' and '5 cm'.

Click on the **pin icon** to display the slice menu, then click on the **link icon** to link the 3 anatomical viewers. Then change the background so it is set to **BaselineVolume**

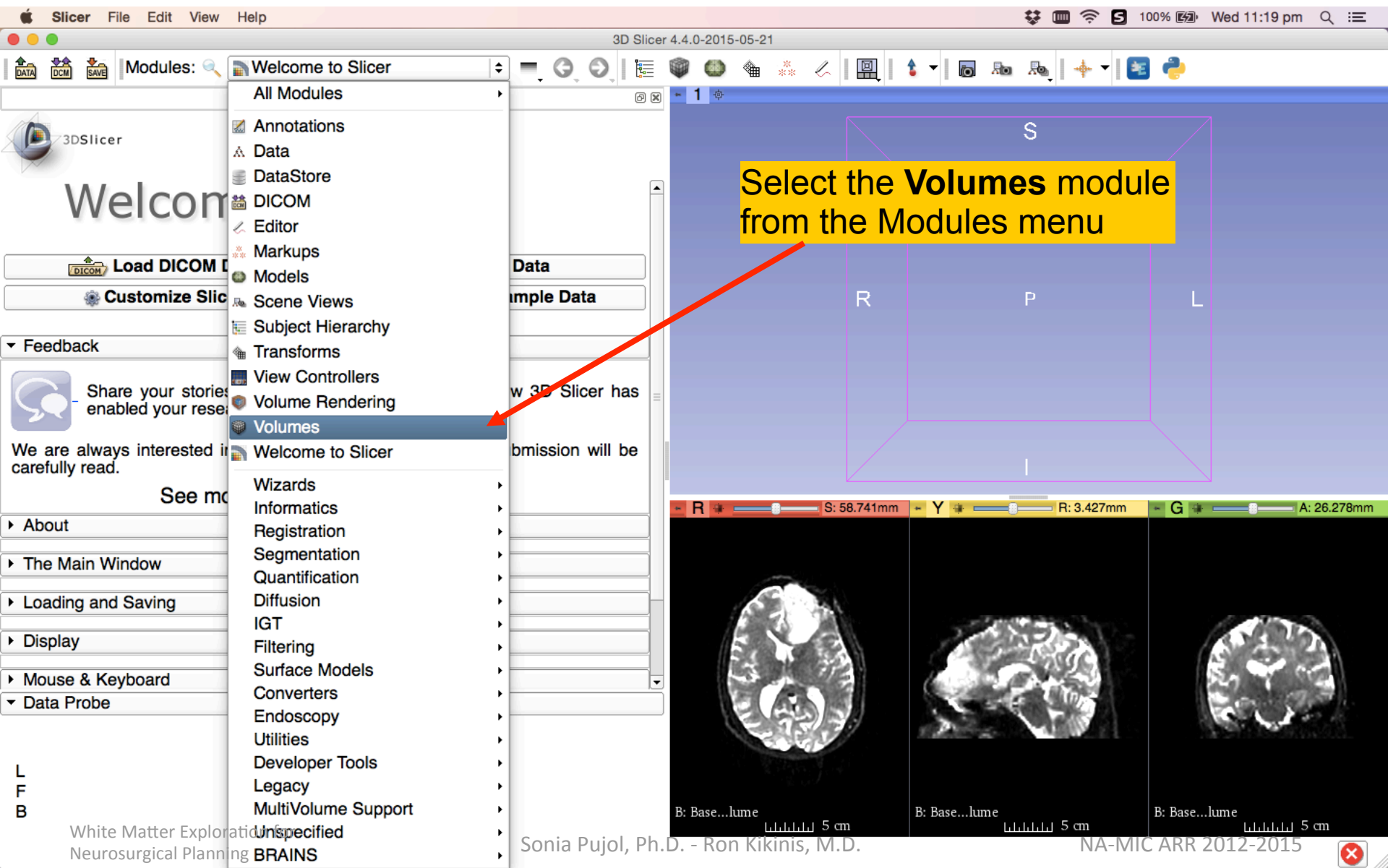
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# Loading DTI and Baseline Data



# Loading DTI and Baseline Data

The screenshot displays the 3D Slicer 4.4.0-2015-05-21 interface. The top menu bar includes File, Edit, View, and Help. The main toolbar shows various icons for data loading, saving, and viewing. The left sidebar contains the 'Modules' panel with 'Volumes' selected, and the 'Display' panel with 'Lookup Table: Grey' and 'Interpolate: [checked]'. The 'Window Level editor presets' section is highlighted with a red box, showing a 'Manual W/L' slider with 'W: 1946' and 'L: 880' values, and a 'Threshold: Manual' section with a range from -400 to 20017. The right panel shows a 3D view of a brain scan with a green box overlay containing the text: 'The user can manually adjust the **Window Level editor presets** with the **Volume** module menu'. Below the 3D view are three 2D viewports (axial, sagittal, and coronal) showing the brain scan. The bottom status bar displays coordinates (R: 58.741mm, Y: 3.427mm, G: 26.278mm) and a scale bar (5 cm).

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# Loading DTI and Baseline Data

The screenshot shows the 3D Slicer 4.4.0-2015-05-21 interface. The top menu bar includes File, Edit, View, and Help. The 'Modules' dropdown is set to 'Volumes'. A yellow callout box with the text 'Click on the Layout menu and select the layout Red Slice only' has a red arrow pointing to the 'Layout' menu. The 'Layout' menu is open, showing various display options. The 'Red slice only' option is highlighted. The left sidebar contains the 'Display' panel with a 'Lookup Table' set to 'Grey', 'Interpolate' checked, and 'Window Level editor presets' showing six thumbnails. Below these are sliders for 'W: 1946' and 'L: 880', and a 'Threshold' slider set to 'Manual' with values from -400 to 20017. The bottom of the interface shows three axial brain slices in the R, S, and G planes, each with a 5 cm scale bar. The status bar at the bottom indicates 'B: Base...lume' and '5 cm' for each slice.

Click on the **Layout** menu and select the layout **Red Slice only**

3D Slicer 4.4.0-2015-05-21

Modules: Volumes

Active Volume: BaselineVolume

Volume Information

Display

Lookup Table: Grey

Interpolate: ☒

Window Level editor presets:

W: 1946 Manual W/L L: 880

Threshold: Manual

-400 20017

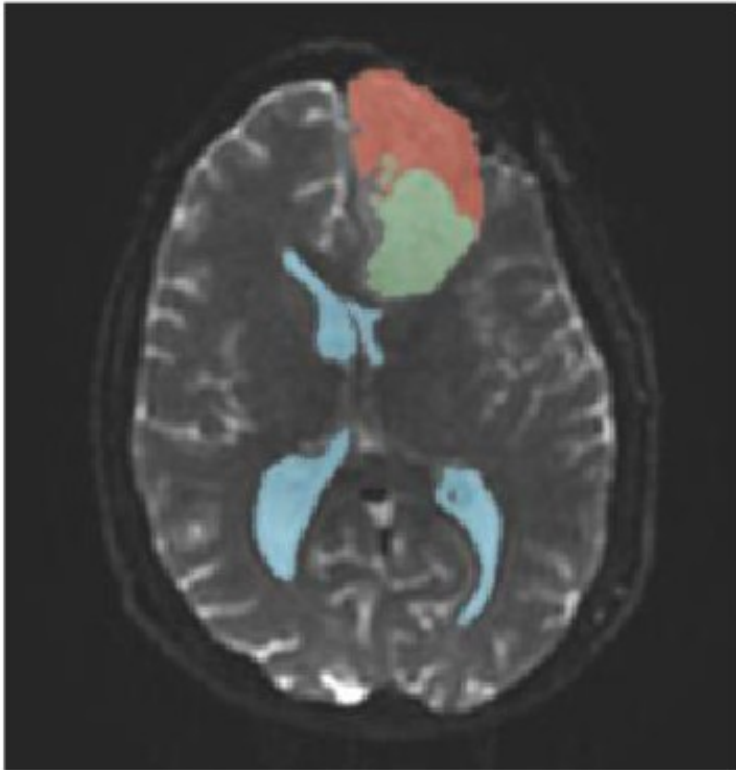
Histogram

Data Probe

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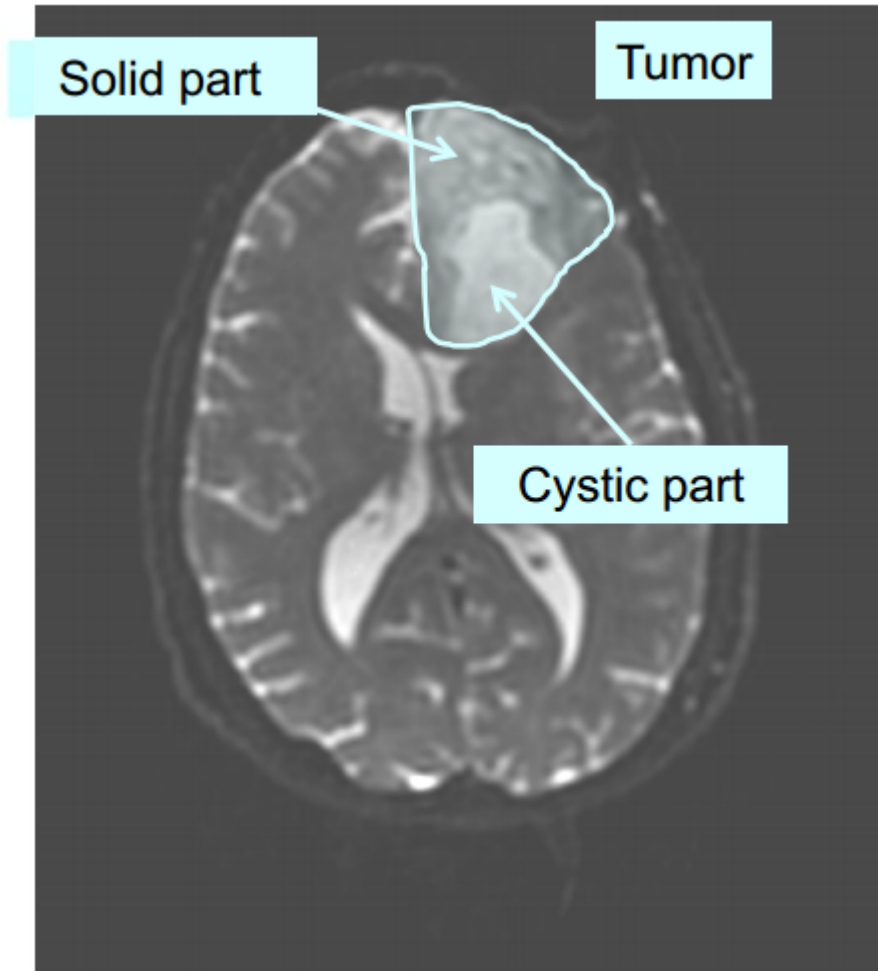
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# Part 1: Segmenting the tumor and ventricles

# Tumor Segmentation



The tumor in this clinical case is composed of two parts: a solid part, and a cystic part.

In this section, we will segment the different parts of the tumor using a Grow Cut Segmentation algorithm.

# Tumor Segmentation

3D Slicer 4.4.0-2015-05-21

Modules: Volumes

Active Volume: BaselineVolume

Volume Information

Display

Lookup Table: Grey

Interpolate: ☒

Window Level editor presets:

W: 3200 Manual W/L L: 1307

Threshold: Manual

-1280 20017

Histogram

Data Probe

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Slicer displays only the Axial anatomical slice in the Viewer

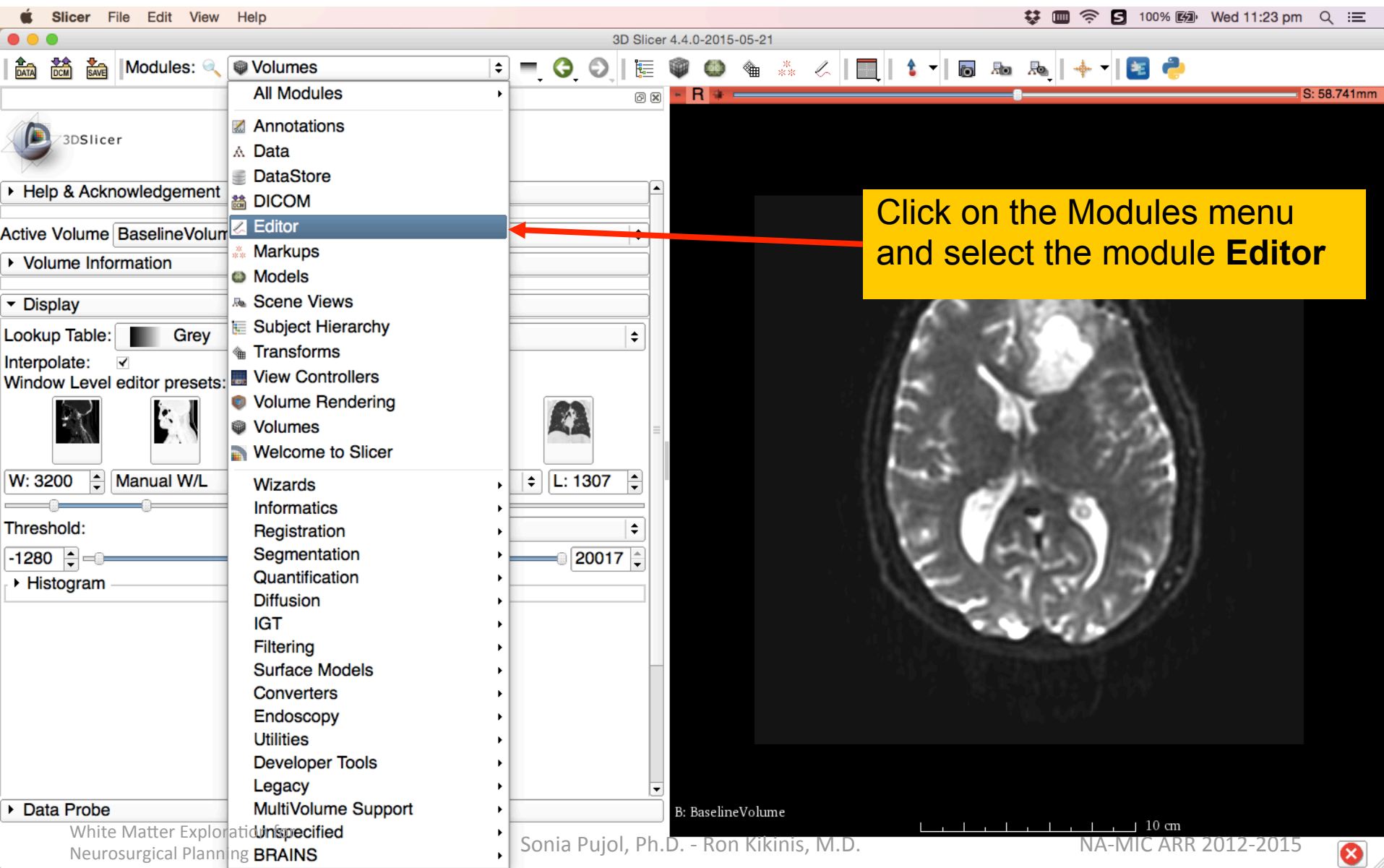
B: BaselineVolume

10 cm

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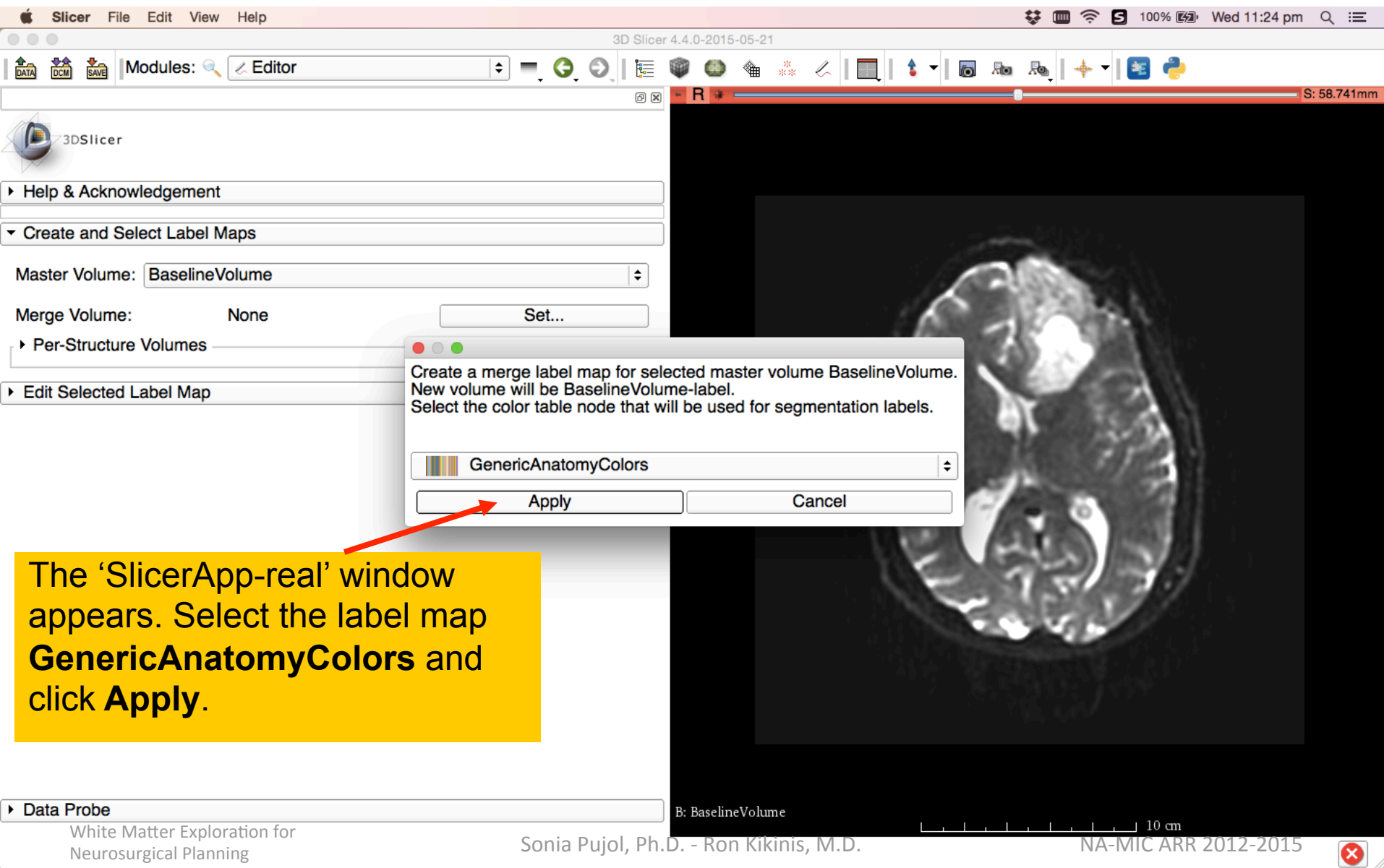
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# Tumor Segmentation





# Tumor Segmentation



3D Slicer 4.4.0-2015-05-21

Modules: Editor

Master Volume: BaselineVolume

Merge Volume: None

Set...

Per-Structure Volumes

Edit Selected Label Map

Create a merge label map for selected master volume BaselineVolume.  
New volume will be BaselineVolume-label.  
Select the color table node that will be used for segmentation labels.

GenericAnatomyColors

Apply Cancel

The 'SlicerApp-real' window appears. Select the label map **GenericAnatomyColors** and click **Apply**.

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10 cm



# Tumor Segmentation

The screenshot displays the 3D Slicer 4.4.0-2015-05-21 interface. The top menu bar includes Apple logo, Slicer, File, Edit, View, and Help. The status bar at the top right shows system icons, 100% zoom, and the date/time: Wed 11:25 pm. The main toolbar contains icons for Data, DCM, SAVE, and various editing tools. The left sidebar shows the 'Modules' panel with 'Editor' selected. The 'Edit Selected Label Map' section is active, showing a grid of icons. A red arrow points from a yellow text box 'Select the PaintEffect' to the 'Paint' icon (a green square with a white brushstroke). Below the icons are 'Undo/Redo' buttons, an 'Active Tool' dropdown set to 'DefaultTool', and a 'Label' dropdown set to 'tissue' with a value of '1' and a green progress bar. The main 3D view shows an axial MRI slice of a brain with a white tumor region. A legend at the bottom left of the 3D view indicates 'L: BaselineVolume-label (100%)' and 'B: BaselineVolume'. A scale bar at the bottom right of the 3D view shows '10 cm'. The bottom status bar includes the text 'White Matter Exploration for Neurosurgical Planning', 'Sonia Pujol, Ph.D. - Ron Kikinis, M.D.', and 'NA-MIC ARR 2012-2015'.

3D Slicer 4.4.0-2015-05-21

Modules: Editor

3DSlicer

► Help & Acknowledgement

▼ Create and Select Label Maps

Master Volume: BaselineVolume

Merge Volume: BaselineVolume-label Set...

► Per-Structure Volumes

▼ Edit Selected Label Map

Undo/Redo: [Undo] [Redo]

Active Tool: DefaultTool

Label: tissue 1

► Data Probe

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Select the PaintEffect

L: BaselineVolume-label (100%)  
B: BaselineVolume

10 cm

# Tumor Segmentation

3D Slicer 4.4.0-2015-05-21

Modules: Editor

Merge Volume: BaselineVolume-label Set...

Per-Structure Volumes

Edit Selected Label Map

Undo/Redo: [Undo] [Redo]

Active Tool: PaintEffect

Label: region 1 293

☒ Paint Over  
☐ Threshold Paint

Radius: 4.000mm px: 2 3 4 5 10 20

☐ Sphere  
☐ Smudge  
☐ Pixel Mode  
?

Data Probe

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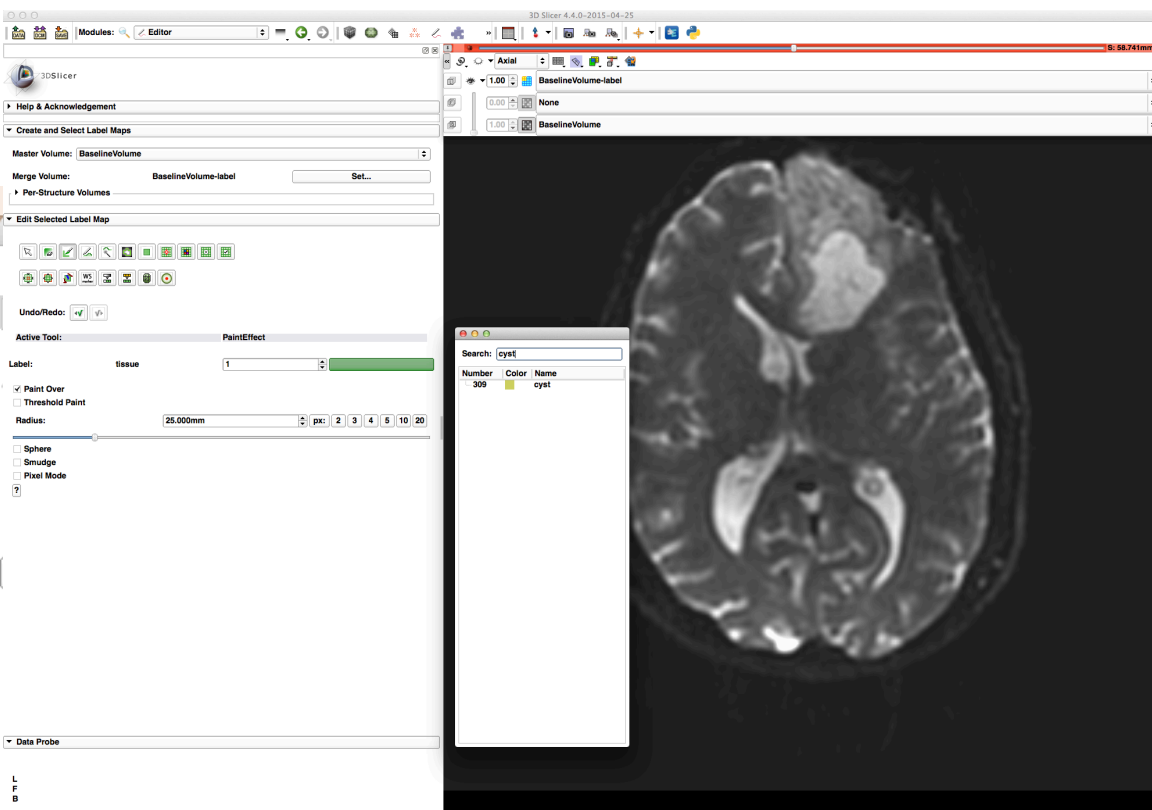
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L: BaselineVolume-label (100%)  
B: BaselineVolume

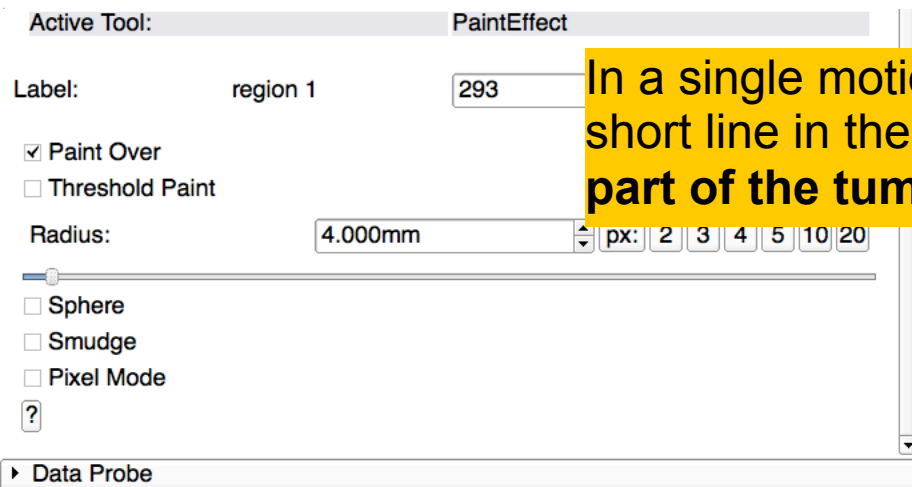
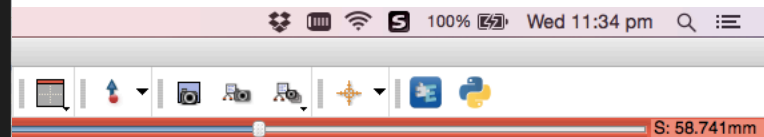
10 cm

S: 58.741mm

Scroll down the **Editor** module.  
Set **color #293** and **radius 4** for the  
region 1 label.



# ntation

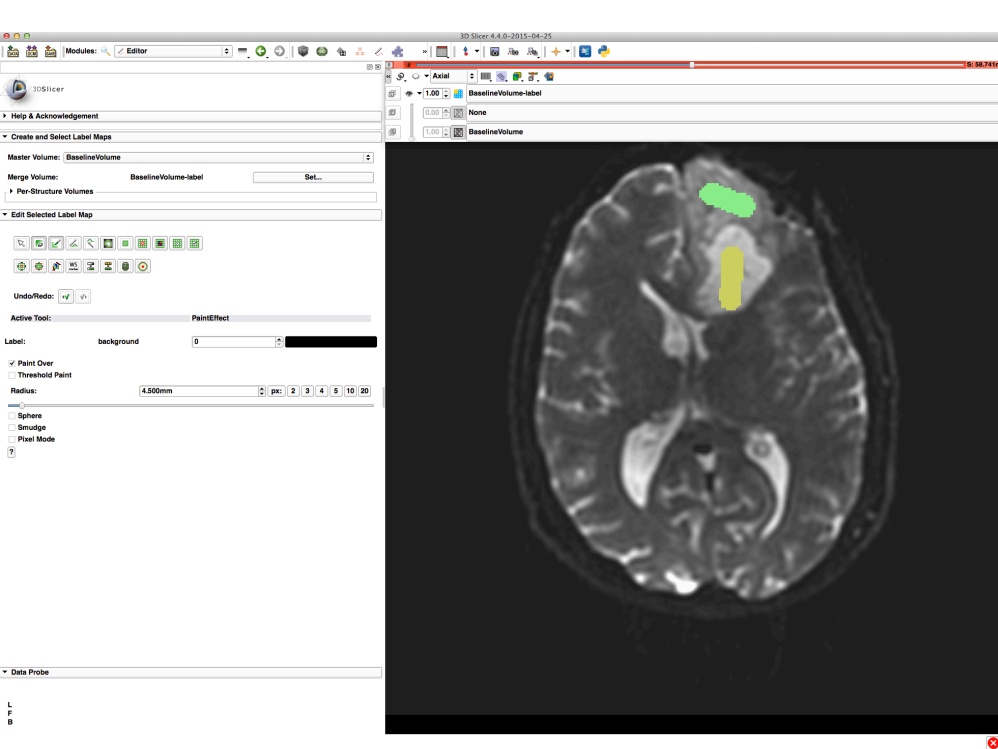


**In a single motion, draw a short line in the cystic part of the tumor.**

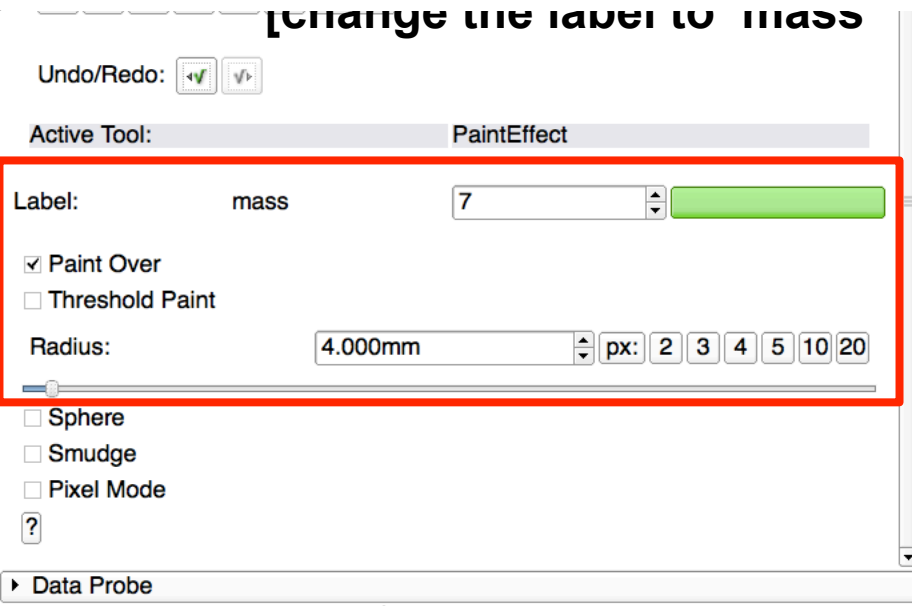
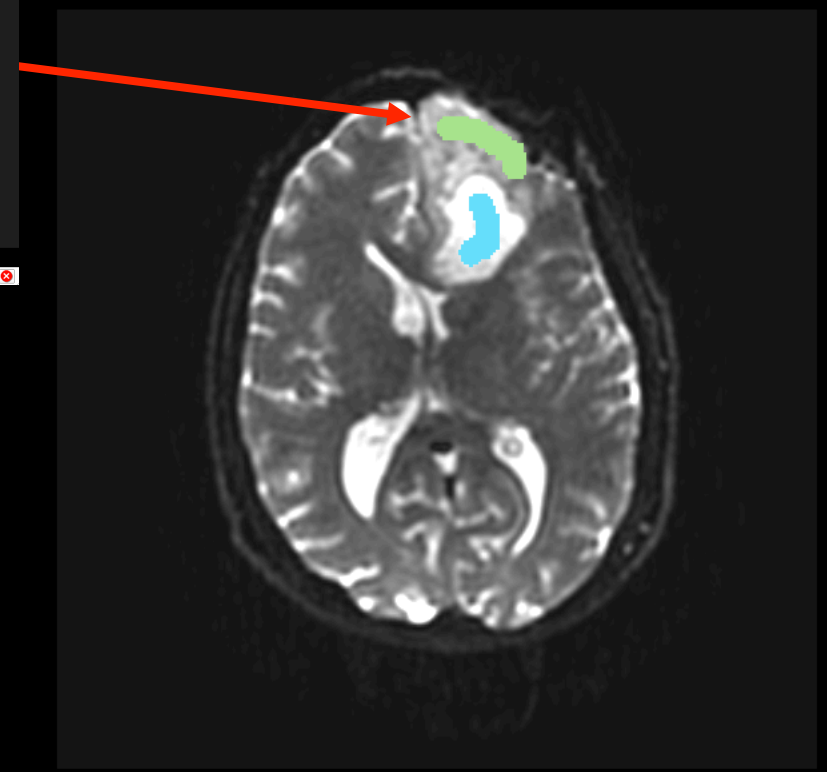


L: BaselineVolume-label (100%)  
B: BaselineVolume





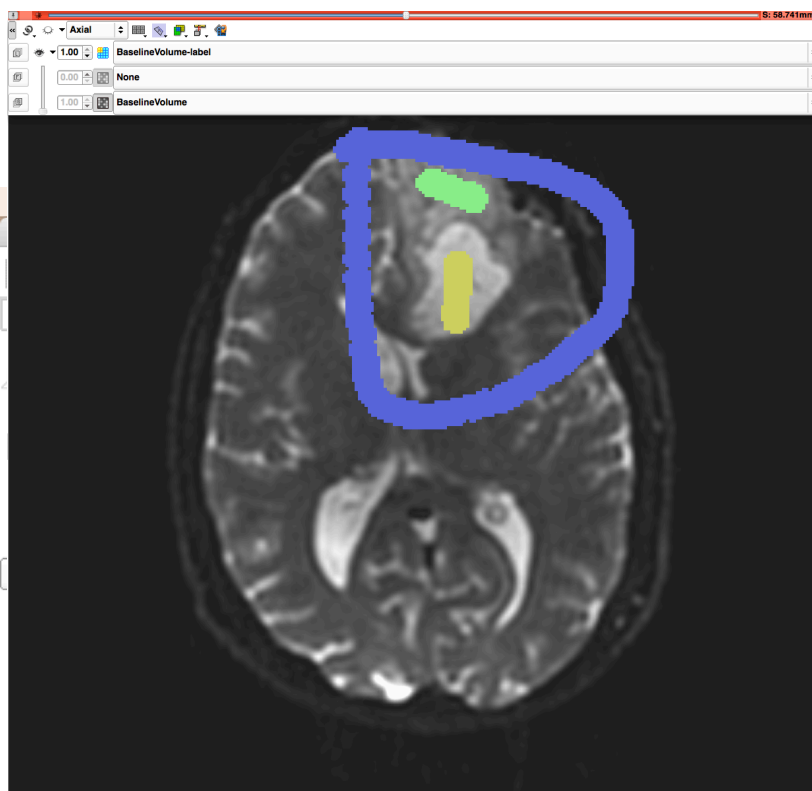
# mentation



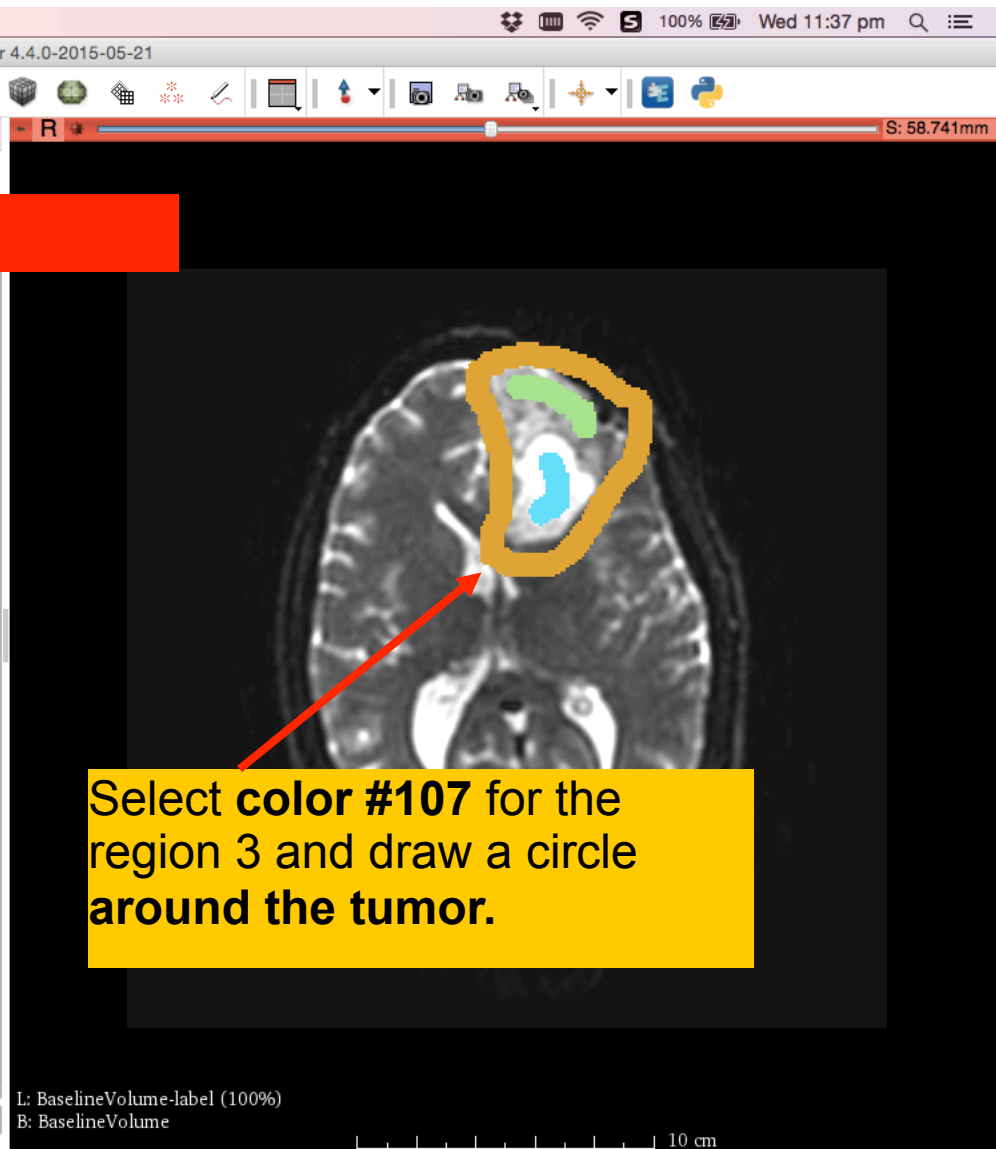
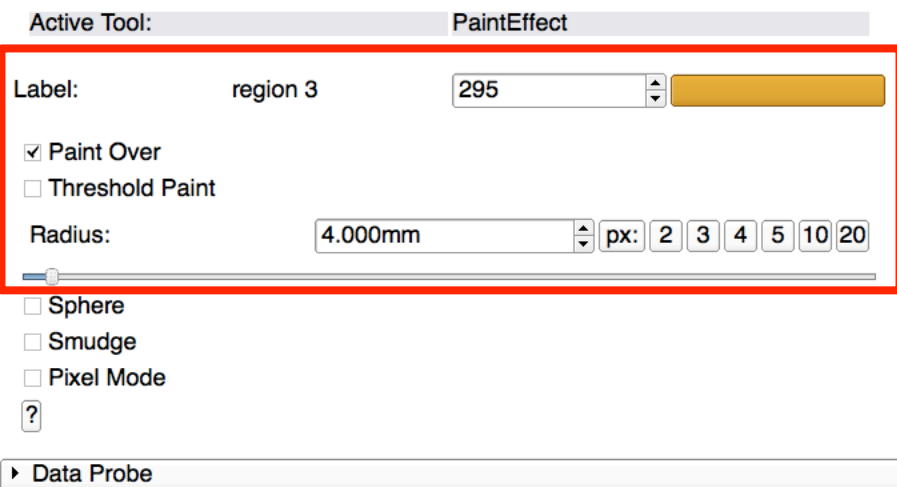
L: BaselineVolume-label (100%)  
B: BaselineVolume



# Segmentation



slide



Select **color #107** for the region 3 and draw a circle around the tumor.

# Tumor Segmentation

3D Slicer 4.4.0-2015-05-21

Modules: Editor

Select the **GrowCutEffect** tool.

Edit Selected Label Map

GrowCutEffect

Active Tool: GrowCutEffect

Label: region 3 295

Run the GrowCut segmentation on the current label map.  
This will use your current segmentation as an example  
to fill in the rest of the volume.

Apply

Data Probe

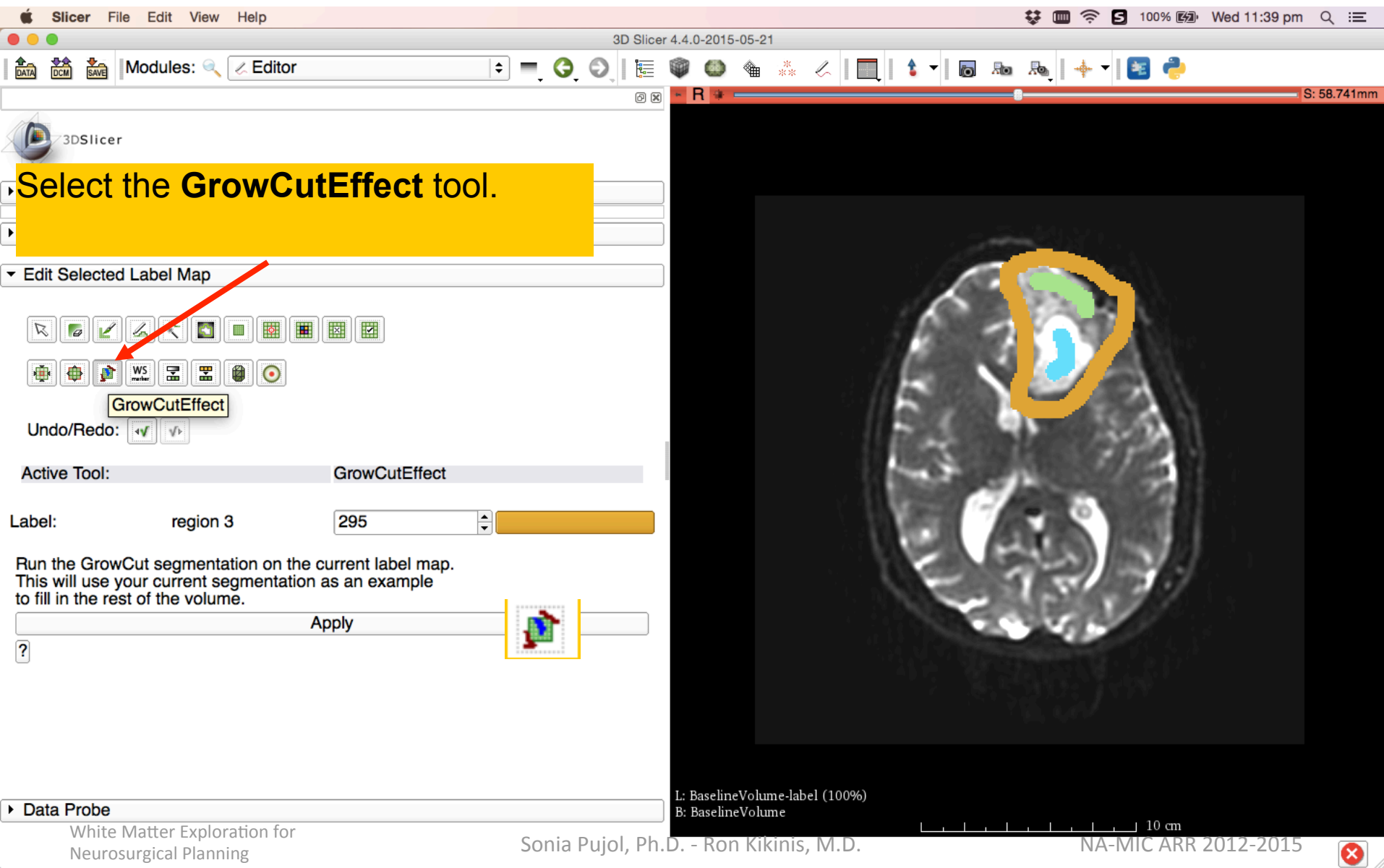
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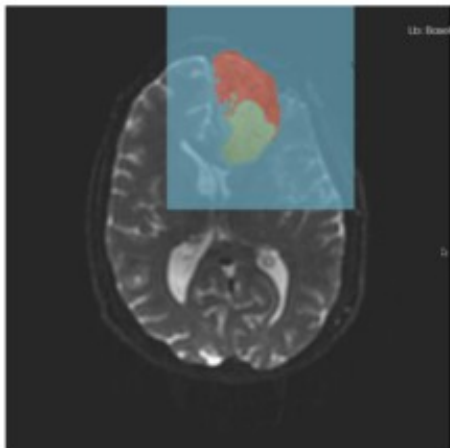
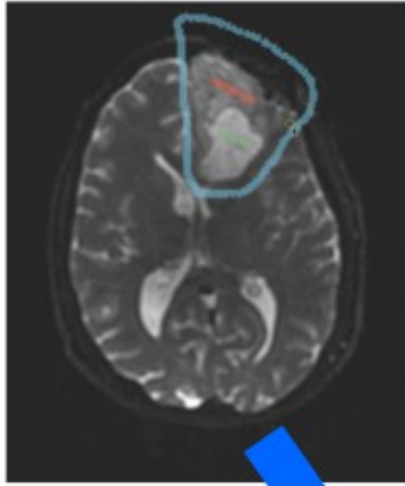
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L: BaselineVolume-label (100%)  
B: BaselineVolume

10 cm



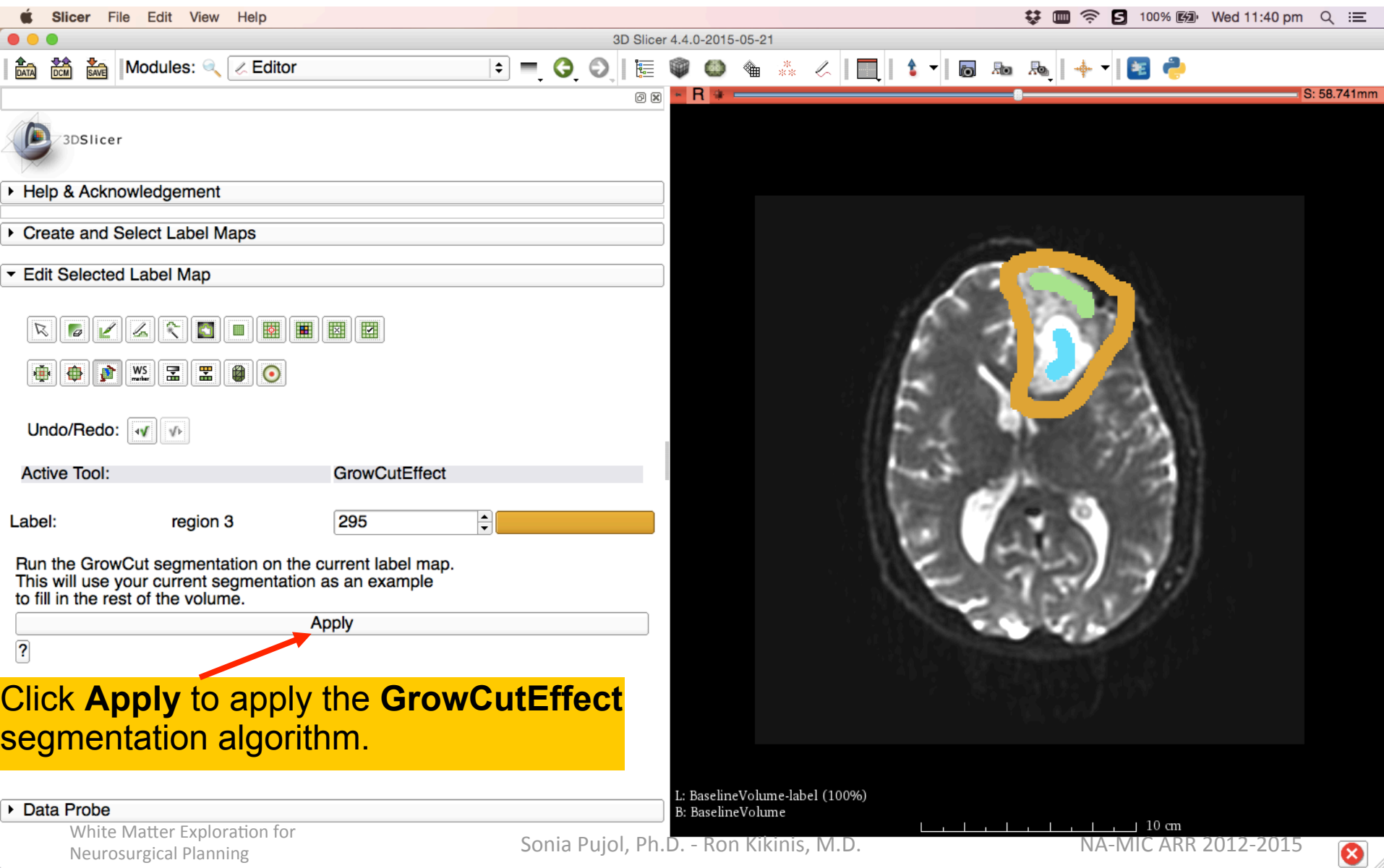
# Grow Cut Segmentation



- The Grow Cut Segmentation method is a competitive region growing algorithm using Cellular Automata.
- The algorithm performs multi-label image segmentation using a set of user input scribbles.
- V. Vezhnevets, V. Konouchine. "Grow-Cut" - Interactive Multi-Label N-D Image Segmentation". Proc. Graphicon. 2005 . pp. 150-156.



# Tumor Segmentation



3D Slicer 4.4.0-2015-05-21

Modules: Editor

3DSlicer

- Help & Acknowledgement
- Create and Select Label Maps
- Edit Selected Label Map

Undo/Redo: [Undo] [Redo]

Active Tool: GrowCutEffect

Label: region 3 295

Run the GrowCut segmentation on the current label map. This will use your current segmentation as an example to fill in the rest of the volume.

Apply

Click **Apply** to apply the **GrowCutEffect** segmentation algorithm.

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L: BaselineVolume-label (100%)  
B: BaselineVolume

10 cm



# Tumor Segmentation

Slicer displays the results from the segmentation

Solid part

Cystic part

Active Tool: GrowCutEffect

Label: region 3 295

Run the GrowCut segmentation on the current label map. This will use your current segmentation as an example to fill in the rest of the volume.

Apply

L: BaselineVolume-label (100%)  
B: BaselineVolume

10 cm

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# Tumor Segmentation

3D Slicer 4.4.0-2015-05-21

File Edit View Help

100% Wed 11:42 pm

S: 58.741mm

Scroll up the **Editor** menu and select the tab **Per-Structure Volumes**. Then click **Split Merge Volume**.

Master Volume: BaselineVolume

Merge Volume: BaselineVolume-label Set...

Per-Structure Volumes

Add Structure Split Merge Volume

Delete All Delete Selected Merge All Merge And Build

☒ Replace Models

Edit Selected Label Map

Data Probe

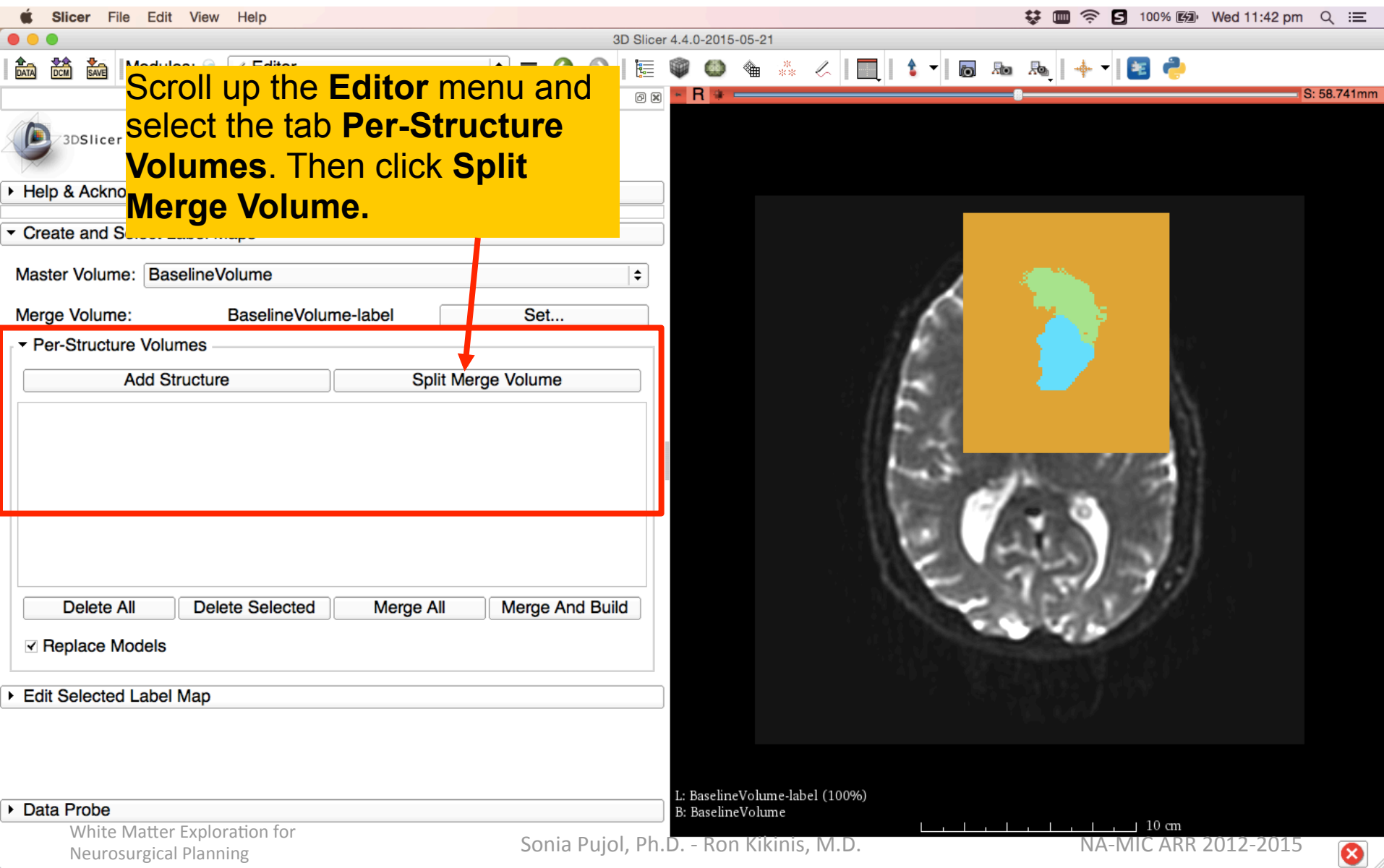
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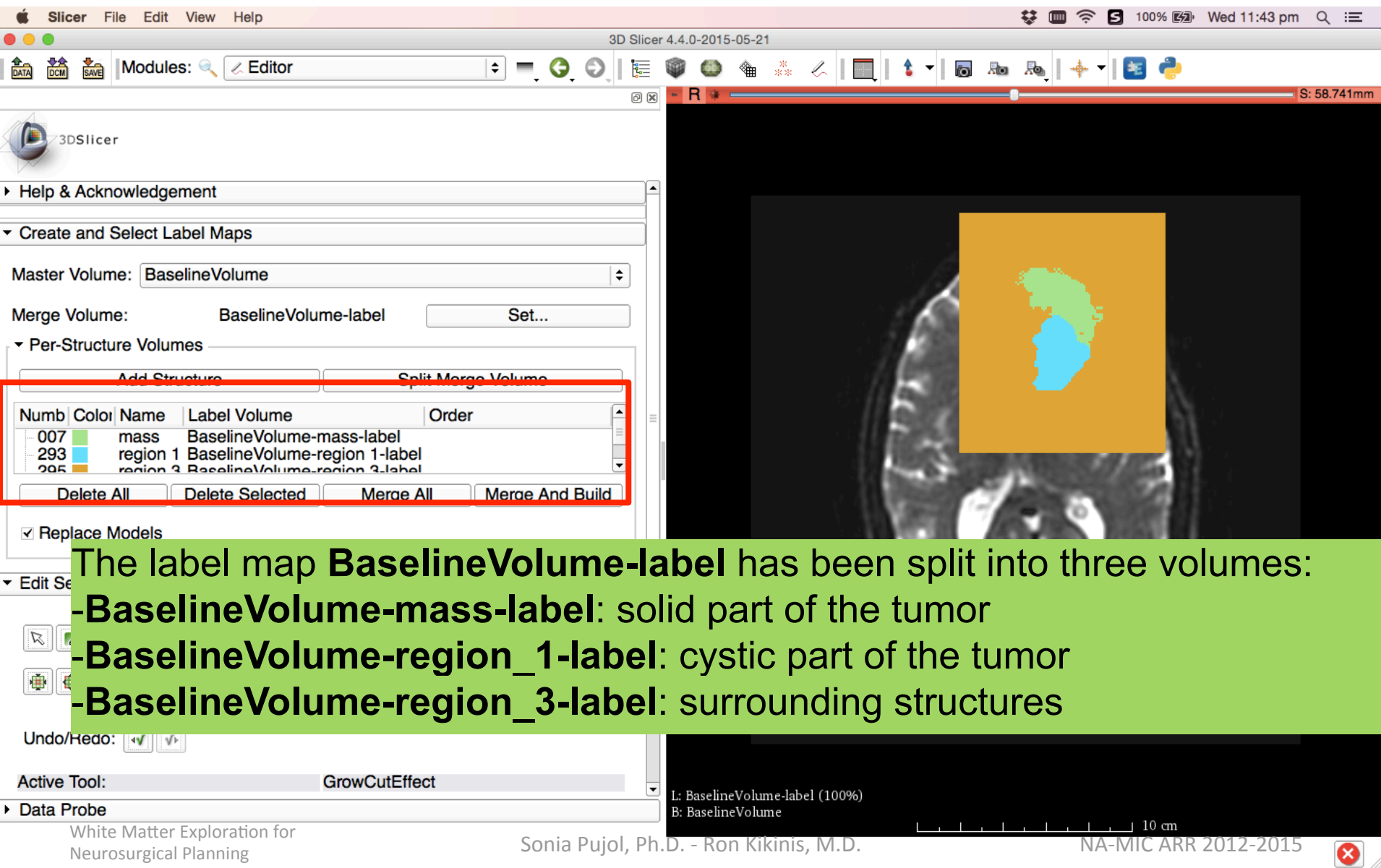
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L: BaselineVolume-label (100%)  
B: BaselineVolume

10 cm



# Tumor Segmentation



3D Slicer 4.4.0-2015-05-21

Modules: Editor

Master Volume: BaselineVolume

Merge Volume: BaselineVolume-label Set...

Per-Structure Volumes

Numb	Color	Name	Label Volume	Order
007	Green	mass	BaselineVolume-mass-label	
293	Blue	region 1	BaselineVolume-region 1-label	
295	Orange	region 3	BaselineVolume-region 3-label	

Delete All Delete Selected Merge All Merge And Build

Replace Models

Active Tool: GrowCutEffect

Data Probe

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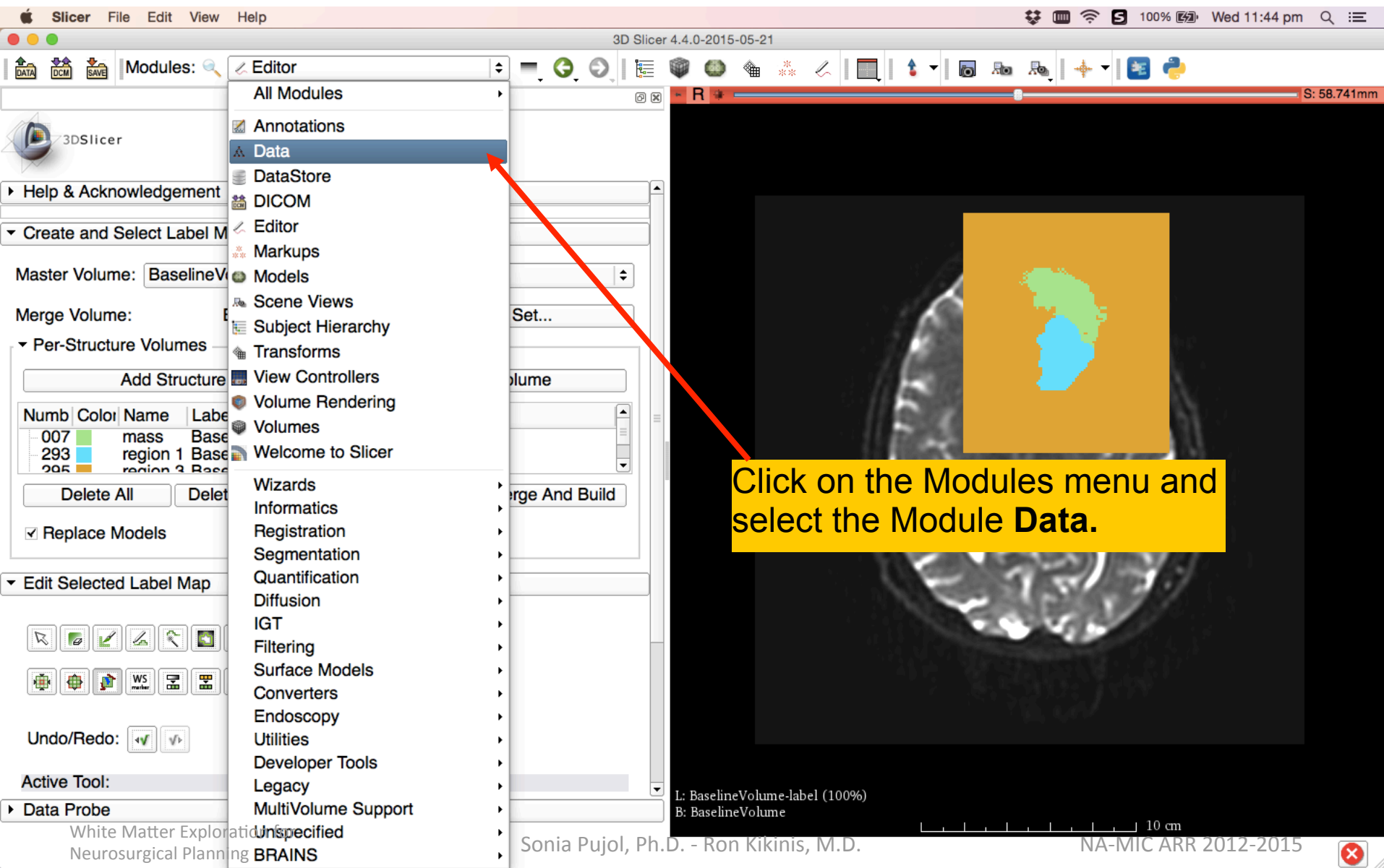
The label map **BaselineVolume-label** has been split into three volumes:

- **BaselineVolume-mass-label**: solid part of the tumor
- **BaselineVolume-region\_1-label**: cystic part of the tumor
- **BaselineVolume-region\_3-label**: surrounding structures

L: BaselineVolume-label (100%)  
B: BaselineVolume

10 cm

# Tumor Segmentation



3D Slicer 4.4.0-2015-05-21

Modules: Editor

- All Modules
- Annotations
- Data**
- DataStore
- DICOM
- Editor
- Markups
- Models
- Scene Views
- Subject Hierarchy
- Transforms
- View Controllers
- Volume Rendering
- Volumes
- Welcome to Slicer
- Wizards
- Informatics
- Registration
- Segmentation
- Quantification
- Diffusion
- IGT
- Filtering
- Surface Models
- Converters
- Endoscopy
- Utilities
- Developer Tools
- Legacy
- MultiVolume Support
- Unspecified
- BRAINS

Click on the Modules menu and select the Module **Data**.

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# Tumor Segmentation

3D Slicer 4.4.0-2015-05-21

Modules: Data

Nodes

- Scene
- View1
- Red
- Yellow
- Green
- Default Scene Camera
- BaselineVolume
- DTIVolume
- BaselineVolume-label
- BaselineVolume-mass-label
- BaselineVolume-region 1-label
- BaselineVolume-region 3-label

The different label maps have been generated.

MRML Node Inspector

Data Probe

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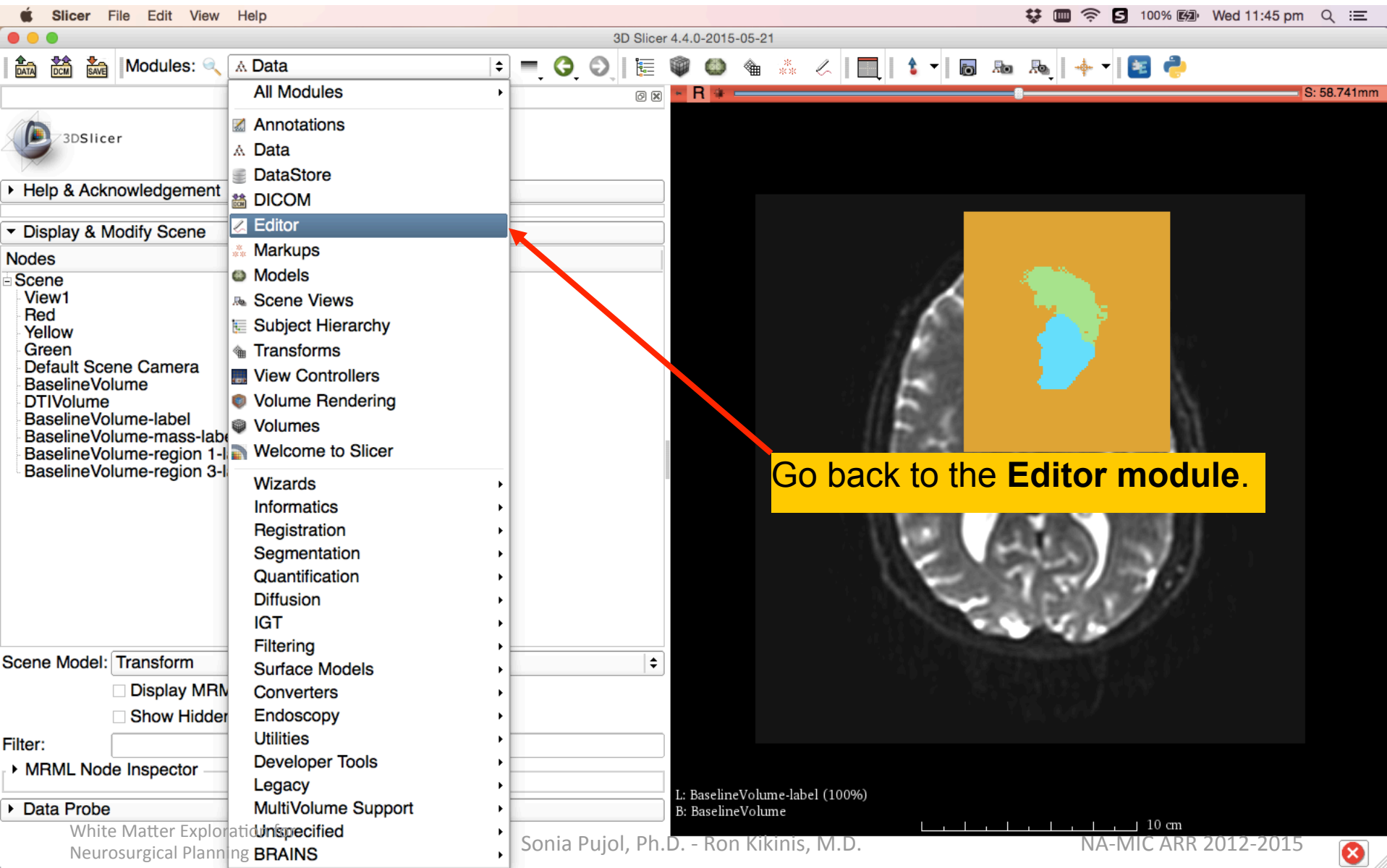
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NA-MIC ARR 2012-2015

L: BaselineVolume-label (100%)  
B: BaselineVolume

10 cm

# Ventricles Segmentation



# Ventricles Segmentation

3D Slicer 4.4.0-2015-05-21

Modules: Editor

Help & Acknowledgement

Create and Select Label Maps

Master Volume: BaselineVolume

Merge Volume: BaselineVolume-label Set...

Per-Structure Volumes

Numb	Color	Name	Label Volume	Order
290		region 1 BaselineVolume-region 1-label		
295		region 3 BaselineVolume-region 3-label		

Delete All Delete Selected Merge All Merge And Build

Replace Models

Edit Selected Label Map

Active Tool: DefaultTool

Data Probe

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L: BaselineVolume-region 3-label (100%)  
B: BaselineVolume

10 cm

S: 58.741mm

Select the volume **BaselineVolume-region\_3-label** so that it is highlighted and that the yellow region is visible in the viewer



# Ventricles Segmentation

3D Slicer 4.4.0-2015-05-21

Modules: Editor

3DSlicer

Help & Acknowledgement

Create and Select Label Maps

Master Volume: BaselineVolume

Merge Volume: BaselineVolume-label Set...

Per-Structure Volumes

Add Structure Split Merge Volume

Numb	Color	Name	Label Volume	Order
293		region 1	BaselineVolume-region 1-label	
295		region 3	BaselineVolume-region 3-label	

Delete All Delete Selected

Replace Models

Edit Selected Label Map

ThresholdEffect

Active Tool: DefaultTool

Data Probe

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L: BaselineVolume-region 3-label (100%)  
B: BaselineVolume

10 cm



# Ventricles Segmentation

3D Slicer 4.4.0-2015-05-21

Modules: Editor

Num	Color	Name	Label volume	Order
293		region 1	BaselineVolume-region 1-label	
295		region 3	BaselineVolume-region 3-label	

Delete All Delete Selected Merge All Merge And Build

☒ Replace Models

▼ Edit Selected Label Map

Undo/Redo:

Active Tool: ThresholdEffect

Label: region 3 295

Threshold Range: 1700.00

Use For Paint

Apply

▼ Data Probe

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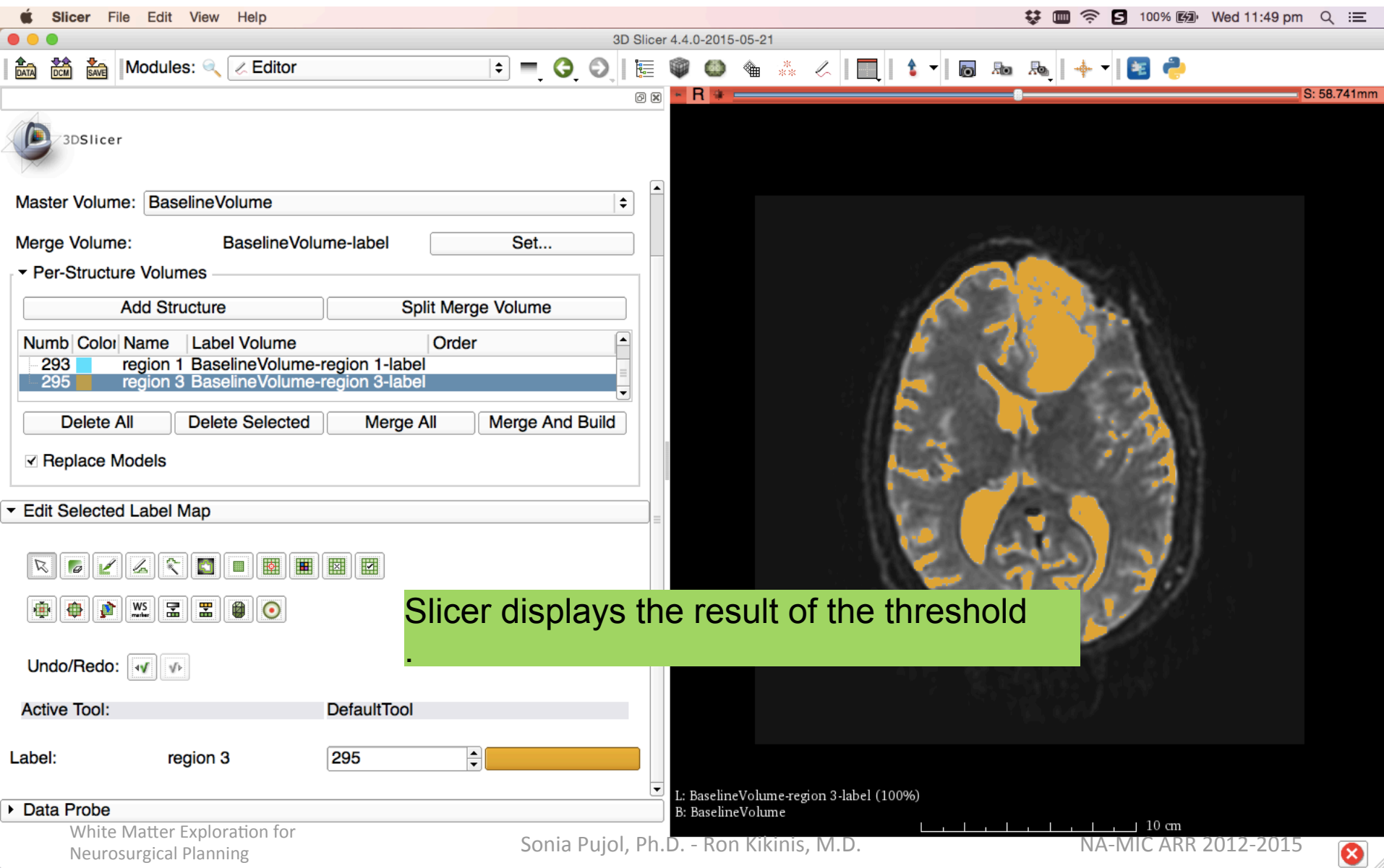
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L: BaselineVolume-region 3-label (100%)  
B: BaselineVolume

10 cm

# Ventricles Segmentation



3D Slicer 4.4.0-2015-05-21

Master Volume: BaselineVolume

Merge Volume: BaselineVolume-label Set...

Per-Structure Volumes

Add Structure Split Merge Volume

Numb	Color	Name	Label Volume	Order
293		region 1	BaselineVolume-region 1-label	
295		region 3	BaselineVolume-region 3-label	

Delete All Delete Selected Merge All Merge And Build

☒ Replace Models

Edit Selected Label Map

Undo/Redo: [Undo] [Redo]

Active Tool: DefaultTool

Label: region 3 295

Data Probe

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Slicer displays the result of the threshold

L: BaselineVolume-region 3-label (100%)  
B: BaselineVolume

10 cm

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# Ventricles Segmentation

3D Slicer 4.4.0-2015-05-21

Modules: Editor

Master Volume: BaselineVolume

Merge Volume: BaselineVolume-label Set...

Per-Structure Volumes

Add Structure Split Merge Volume

Numb	Color	Name	Label Volume	Order
293		region 1	BaselineVolume-region 1-label	
295		region 3	BaselineVolume-region 3-label	

Delete All Delete Selected Merge All

☒ Replace Models

Edit Selected Label Map

SaveIslandEffect

Undo/Redo: [Undo] [Redo]

Active Tool: DefaultTool

Label: region 3 295

Data Probe

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L: BaselineVolume-region 3-label (100%)  
B: BaselineVolume

10 cm

# Ventricles Segmentation

3D Slicer 4.4.0-2015-05-21

Master Volume: BaselineVolume

Merge Volume: BaselineVolume-label Set...

Per-Structure Volumes

Add Structure Split Merge Volume

Numb	Color	Name	Label Volume	Order
293		region 1	BaselineVolume-region 1-label	
295		region 3	BaselineVolume-region 3-label	

Delete All Delete Selected Merge All Merge And Build

☒ Replace Models

Edit Selected Label Map

With the **SavelslandEffect** tool equipped, click in the occipital horn of the ventricle .

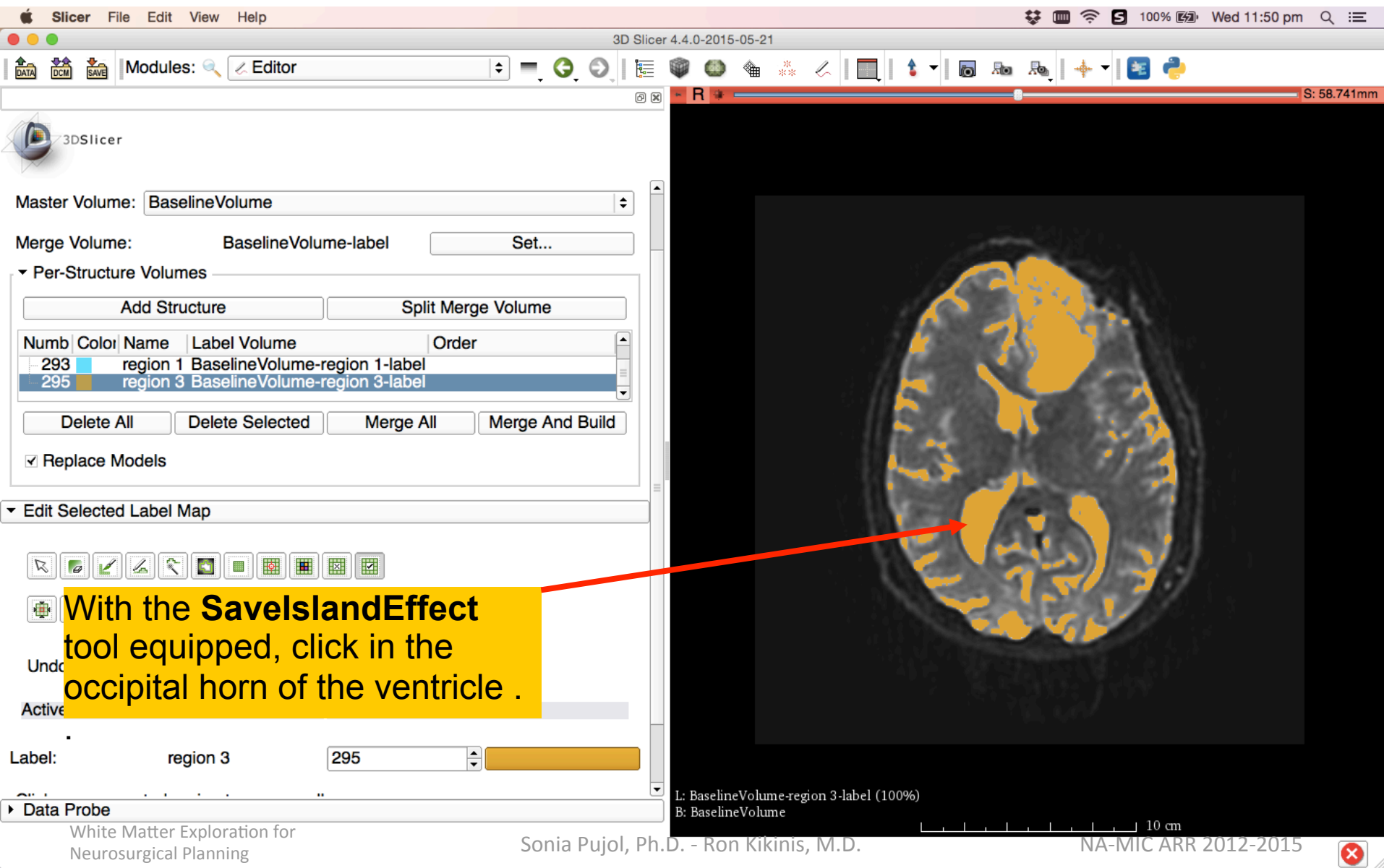
Label: region 3 295

Data Probe

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L: BaselineVolume-region 3-label (100%)  
B: BaselineVolume

10 cm

# Final Result of Segmentation

3D Slicer 4.4.0-2015-05-21

Modules: Editor

Master Volume: BaselineVolume

Merge Volume: BaselineVolume-label Set...

Per-Structure Volumes

Add Structure Split Merge Volume

Numb	Color	Name
293	Blue	region 3
295	Orange	region 3

Delete All Delete Selected Merge All Merge And Build

☒ Replace Models

Edit Selected Label Map

Undo/Redo: [Undo] [Redo]

Active Tool: SavelslandEffect

Label: region 3 295

Data Probe

White Matter Exploration for Neurosurgical Planning

Slicer displays the results of the segmentation of the ventricle.

L: BaselineVolume-region 3-label (100%)  
B: BaselineVolume

10 cm

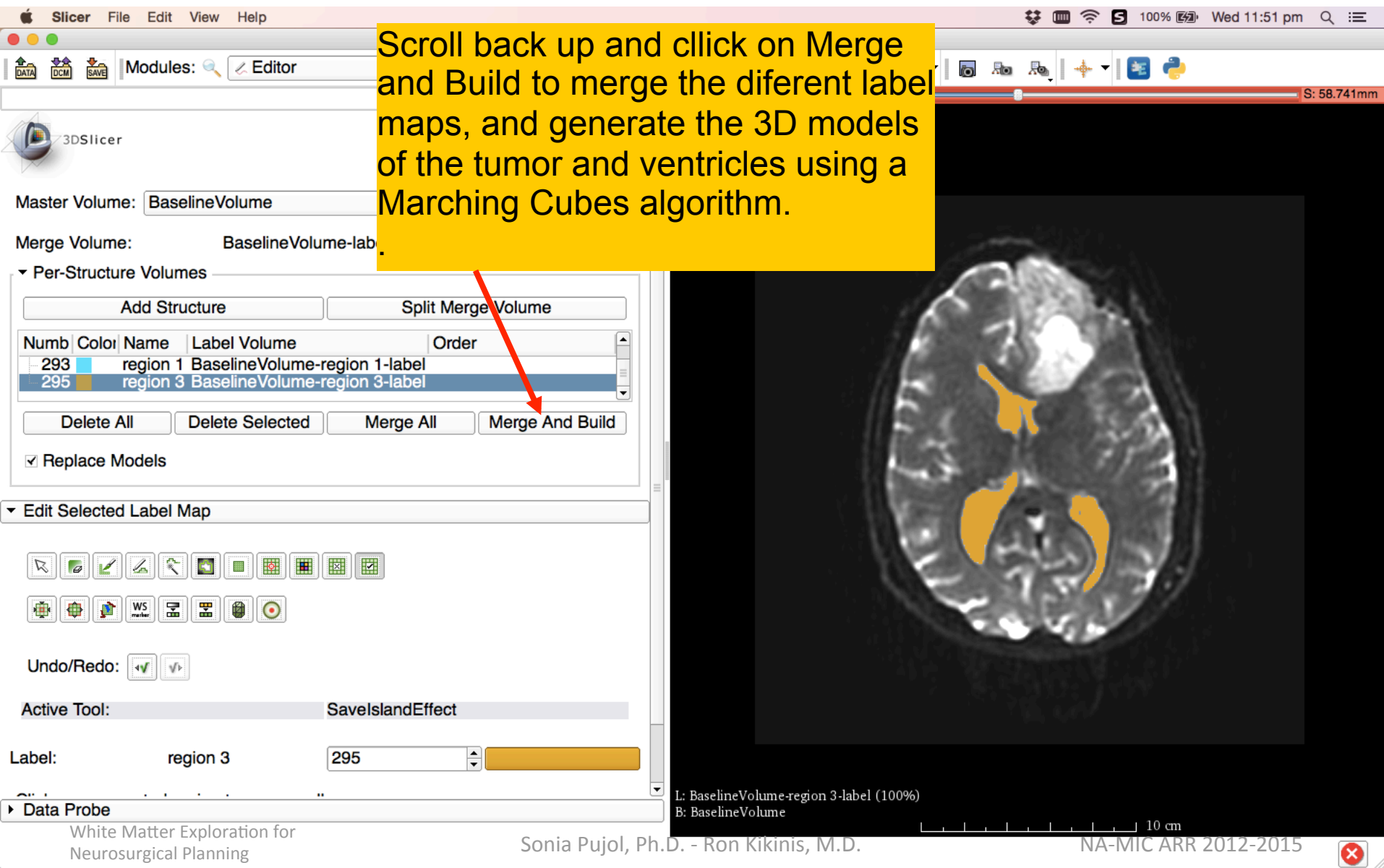
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S: 58.741mm

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# Final Result of Segmentation

Scroll back up and click on Merge and Build to merge the different label maps, and generate the 3D models of the tumor and ventricles using a Marching Cubes algorithm.



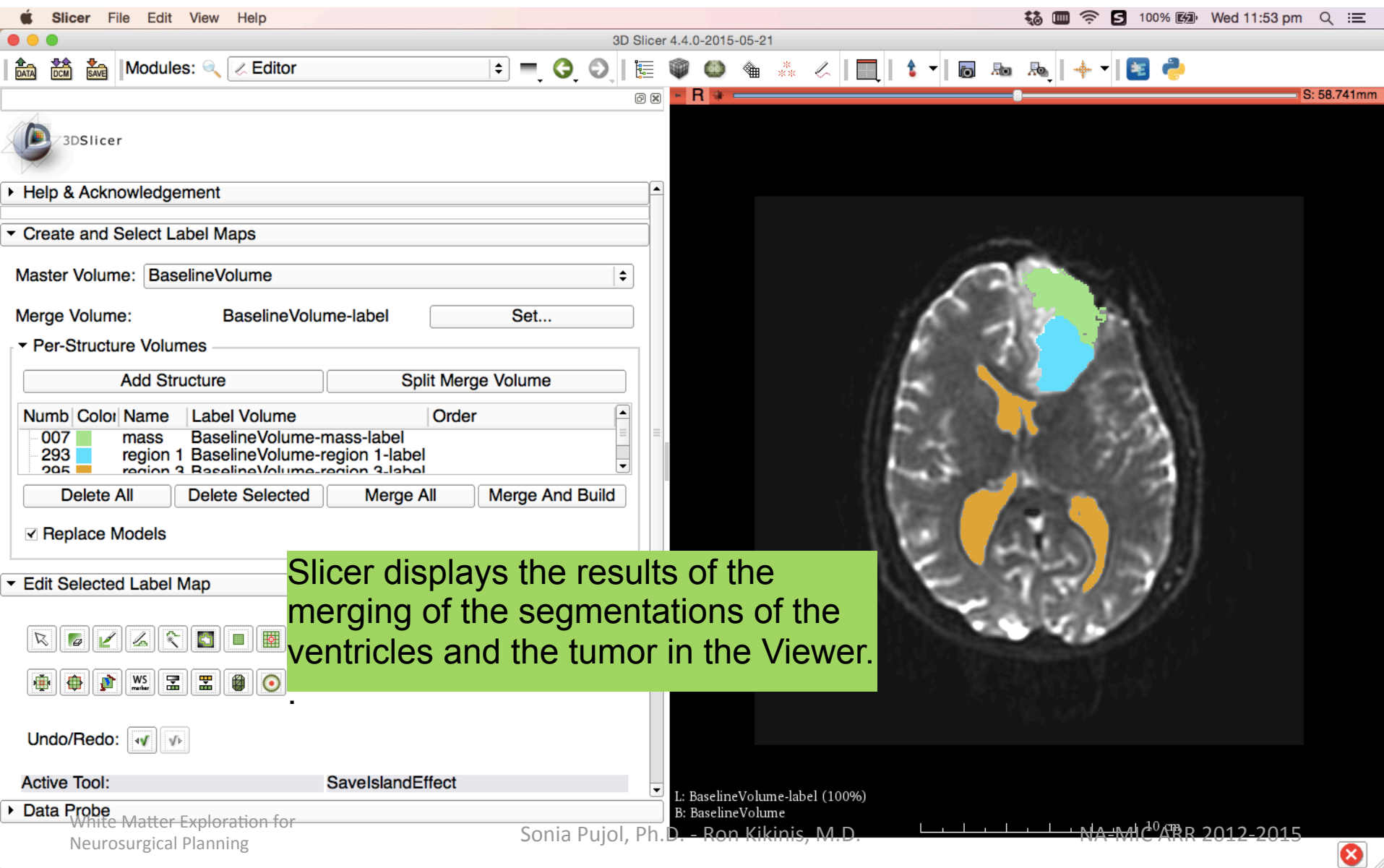
The screenshot displays the 3D Slicer software interface. The left sidebar shows the 'Modules' panel with 'Editor' selected. The 'Master Volume' is 'BaselineVolume'. The 'Merge Volume' is 'BaselineVolume-label'. The 'Per-Structure Volumes' section shows a table with two entries: 'region 1' (BaselineVolume-region 1-label) and 'region 3' (BaselineVolume-region 3-label). The 'Merge And Build' button is highlighted with a red arrow. The 'Edit Selected Label Map' section shows various tools and the 'Active Tool' is 'SavelslandEffect'. The 'Label' is 'region 3' with value '295'. The main window shows an axial MRI brain scan with segmented tumor and ventricles. The bottom status bar shows 'L: BaselineVolume-region 3-label (100%)' and 'B: BaselineVolume'.

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# Final Result of Segmentation





# Final Result of Segmentation

The screenshot displays the 3D Slicer 4.4.0-2015-05-21 interface. The top menu bar includes 'Slicer', 'File', 'Edit', 'View', and 'Help'. The 'Modules' dropdown is set to 'Editor'. The left sidebar contains sections for 'Help & Acknowledgement', 'Create and Select Label Maps', and 'Edit Selected Label Map'. The 'Create and Select Label Maps' section shows 'Master Volume: BaselineVolume' and 'Merge Volume: BaselineVolume-label'. Below this is a table of 'Per-Structure Volumes' with columns 'Numb' and 'Co'. The table lists three volumes: 007 (green), 293 (blue), and 295 (orange), all associated with 'region 3 BaselineVolume-region 3-label'. Buttons for 'Delete All', 'Delete Selected', 'Merge All', and 'Merge And Build' are present, along with a checked 'Replace Models' checkbox. The 'Edit Selected Label Map' section shows various tool icons. The 'Active Tool' is 'SavelslandEffect'. The 'Data Probe' section shows 'White Matter Exploration for Neurosurgical Planning'. The main 3D view area shows a sagittal slice of a brain. A red arrow points from the 'Layout' menu icon in the top toolbar to the 'Conventional' option in the layout menu. A yellow text box with the instruction 'Click on the Layout menu and select Conventional.' is overlaid on the left sidebar. The layout menu is open, showing options like 'Conventional', 'Conventional Widescreen', 'Conventional Quantitative', 'Four-Up', 'Four-Up Quantitative', 'Dual 3D', 'Triple 3D', '3D only', 'One-Up Quantitative', 'Red slice only', 'Yellow slice only', 'Green slice only', 'Tabbed 3D', 'Tabbed slice', 'Compare', 'Compare Widescreen', 'Compare Grid', 'Three over three', 'Three Over Three Quantitative', 'Four over four', 'Two over Two', 'Side by side', 'Four by three slice', 'Four by two slice', and 'Three by three slice'. The status bar at the bottom indicates 'L: BaselineVolume-label (100%)' and 'B: BaselineVolume'.

Click on the **Layout** menu and select **Conventional**.

Active Tool: SavelslandEffect

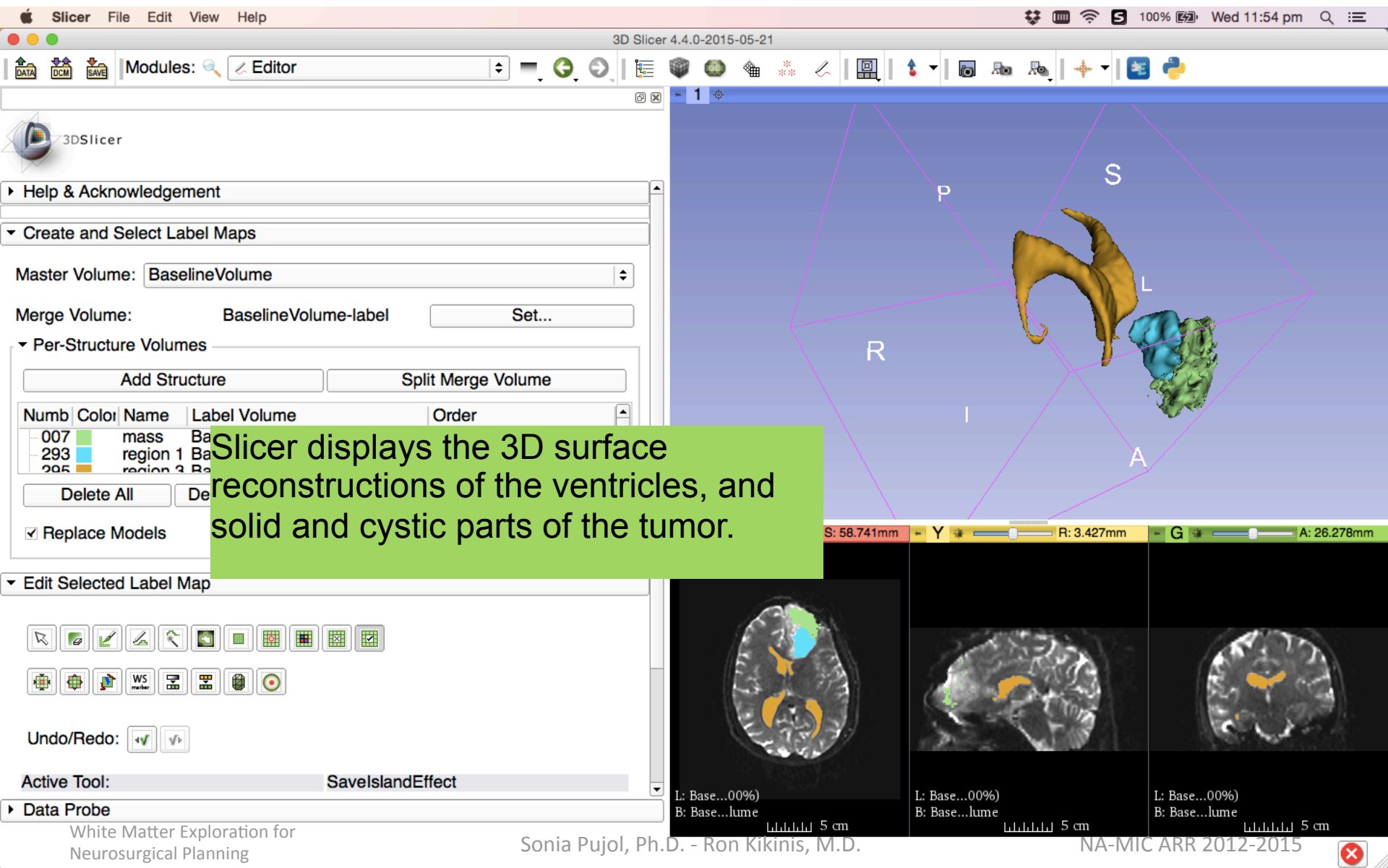
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# Final Result of Segmentation



# Definition of peri-tumoral volume

3D Slicer 4.4.0-2015-05-21

Modules: Editor

Position the mouse over the **pin icon**, **deselect the link icon**, and select the **eye icon** to view just the axial slice in the 3D viewer.

Master Volume: BaselineVolume-mass-label

Merge Volume:

Per-Structure Volume

Numb	Color	Name	Label Volume	Order
007	Green	mass	BaselineVolume-mass-label	
293	Blue	region 1	BaselineVolume-region 1-label	
295	Orange	region 3	BaselineVolume-region 3-label	

Delete All Delete Selected Merge All Merge And Build

☒ Replace Models

Edit Selected Label Map

Undo/Redo: [Undo] [Redo]

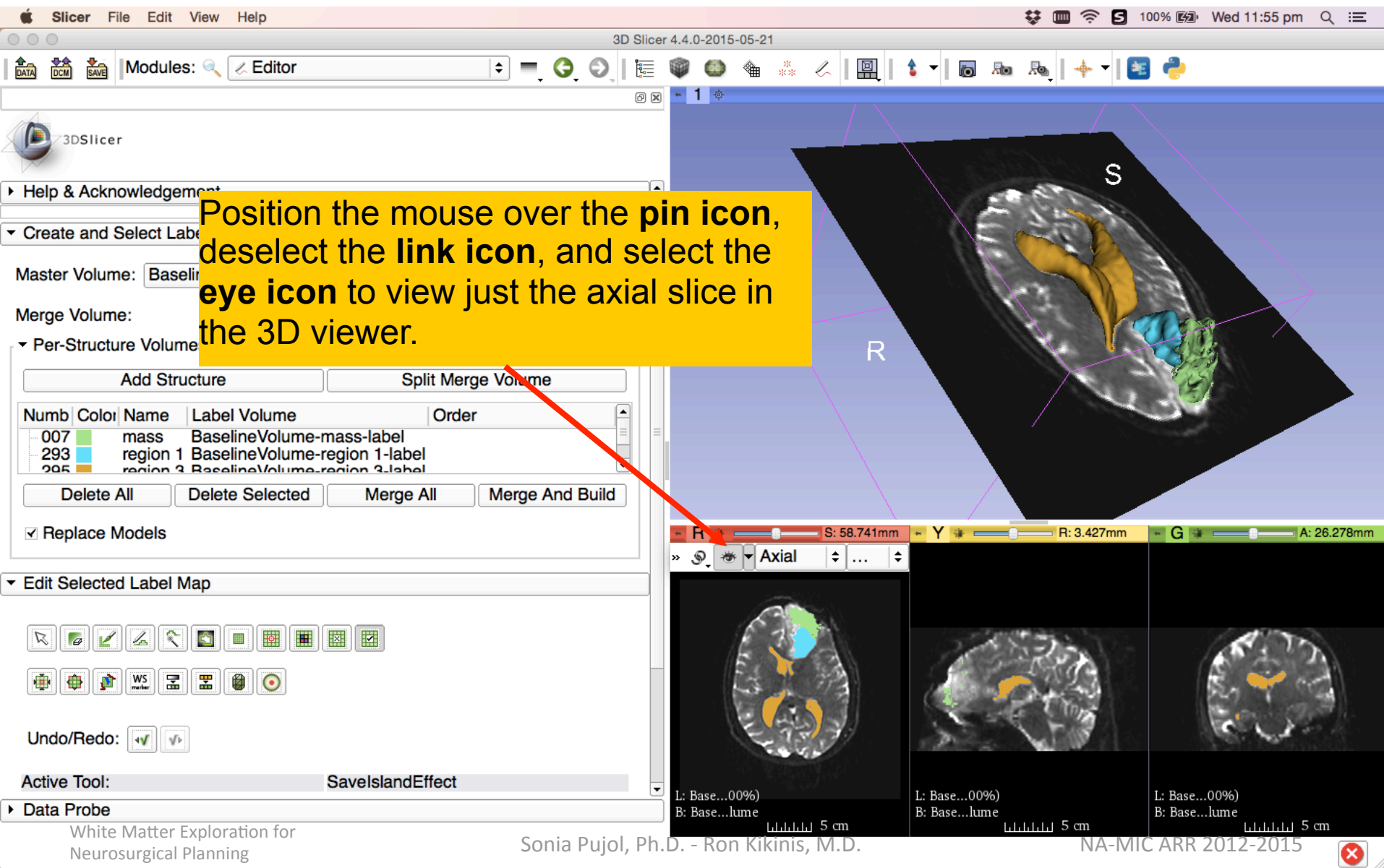
Active Tool: SavelslandEffect

Data Probe

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3D Slicer 4.4.0-2015-05-21

Modules: Editor

Position the mouse over the **pin icon**, **deselect the link icon**, and select the **eye icon** to view just the axial slice in the 3D viewer.

Master Volume: BaselineVolume-mass-label

Merge Volume:

Per-Structure Volume

Numb	Color	Name	Label Volume	Order
007	Green	mass	BaselineVolume-mass-label	
293	Blue	region 1	BaselineVolume-region 1-label	
295	Orange	region 3	BaselineVolume-region 3-label	

Delete All Delete Selected Merge All Merge And Build

☒ Replace Models

Edit Selected Label Map

Undo/Redo: [Undo] [Redo]

Active Tool: SavelslandEffect

Data Probe

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# Definition of peri-tumoral volume

3D Slicer 4.4.0-2015-05-21

Master Volume: BaselineVolume

Merge Volume: BaselineVolume-label

Per-Structure Volumes

Numb	Color	Name	Label Volume	Order
007		mass	BaselineVolume-mass-label	
293		region 1	BaselineVolume-region 1-label	
005		region 2	BaselineVolume-region 2-label	

Buttons: Add Structure, Split Merge Volume, Delete All, Delete Selected, Merge All, Merge And Build

☒ Replace Models

Edit Selected Label Map

Tools: DilateEffect

Undo/Redo:

Active Tool: SavelslandEffect

Label: region 1 293

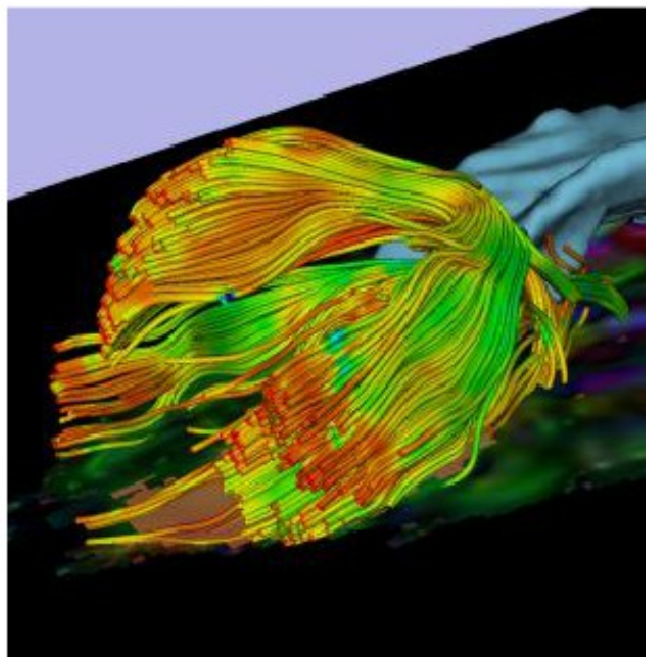
Data Probe

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Select the label map **BaselineVolume-region\_1** label (blue) and select the **DilateEffect** tool.



## Part 2: Tractography exploration of peri- tumoral white matter fibers

# Definition of peri-tumoral volume

With the **DilateEffect** tool equipped, click on the cystic part of the tumor in the axial slice viewer once, then select **Apply** 3 times to generate the peritumoral volume

3D Slicer 4.4.0-2015-05-21

Modules: Editor

Add Structure

Numb	Color	Name
007		mass
293		region 1
295		region 2

Delete All Delete Selected Merge All Merge And Build

☒ Replace Models

▼ Edit Selected Label Map

Undo/Redo: ☒ ☒

Active Tool: DilateEffect

Label: region 1 293

☐ Eight Neighbors

☒ Four Neighbors

Apply

► Data Probe

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3D Slicer 4.4.0-2015-05-21

100% Wed 11:59 pm

S: 58.741mm R: 3.427mm A: 26.278mm

L: Base...00%) B: Base...lume 5 cm

L: Base...00%) B: Base...lume 5 cm

L: Base...00%) B: Base...lume 5 cm

# Definition of peritumoral volume

3D Slicer 4.4.0-2015-05-21

Modules: Editor

Add Structure Split Merge Volume

Numb	Color	Name	Label Volume	Order
007		mass	BaselineVolume-mass-label	
293		region 1	BaselineVolume-region 1-label	
295		region 3	BaselineVolume-region 3-label	

Delete All Delete Selected Merge All Merge And Build

Note the dilation of the cystic part of the tumor in the 3D Viewer.

Undo/Redo: [Undo] [Redo]

Active Tool: DilateEffect

Label: region 1 293

☐ Eight Neighbors  
☒ Four Neighbors

Apply

3D Viewer

3D Slicer interface showing a 3D volume rendering of a brain tumor. The tumor is segmented into regions: mass (yellow), region 1 (blue), and region 3 (green). The 3D viewer shows the tumor in a sagittal view, with axes labeled R (Right), S (Superior), and A (Anterior). A red arrow points to the cystic part of the tumor, indicating dilation. The 3D viewer also displays a 2D axial slice of the tumor, showing the mass and region 1. The 2D slice is labeled with 'L: Base...00%)' and 'B: Base...lume'.

2D Viewer

2D Slicer interface showing three 2D axial slices of the brain. The slices are labeled with 'L: Base...00%)' and 'B: Base...lume'. The slices are displayed in a 2x2 grid, with the bottom-right slice being a zoomed-in view of the tumor. The slices are labeled with 'L: Base...00%)' and 'B: Base...lume'.

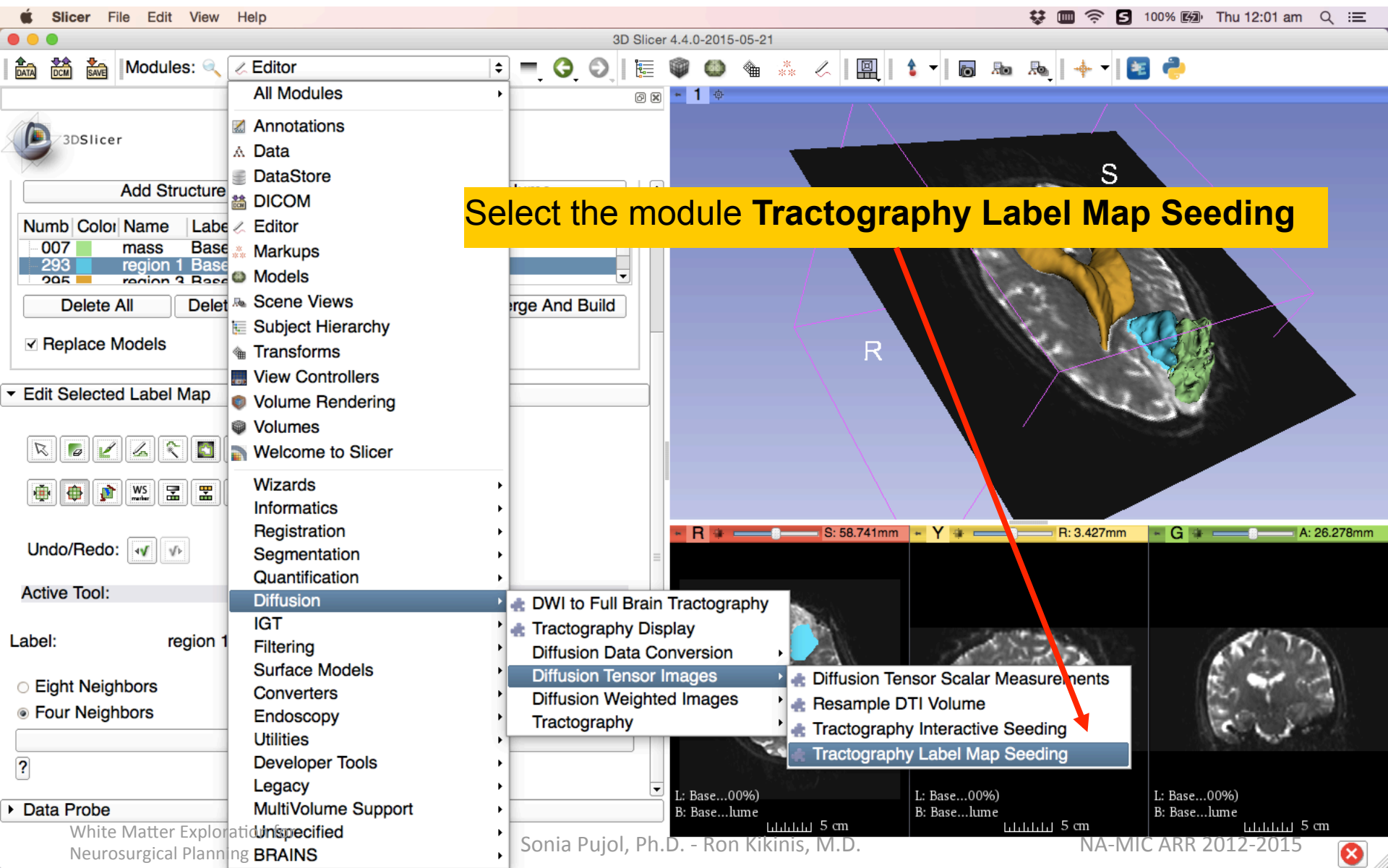
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# Final Result of Segmentation



# Final Result of Segmentation

**3D Slicer 4.4.0-2015-05-21**

Modules: Tractography Label Map Seeding

**I/O**

Input DTI Volume: DTIVolume  
Input Label Map: BaselineVolume-region\_1-label  
Output Fiber Bundle: newFiberBundle

**Seed Placement Options**

Use Index Space: ☐  
Seed Spacing: 2.00  
Random Grid: ☐  
Linear Measure Start Threshold: 0.3

**Tractography Seeding Parameters**

Minimum Path Length: 20.00  
Maximum Length: 800.00  
Stopping Criteria: ☐ LinearMeasure ☒ FractionalAnisotropy  
Stopping Value: 0.25  
Stopping Track Curvature: 0.7  
Integration Step Length(mm): 0.5

**Label definition**

Restore Defaults AutoRun

Status: Idle

Cancel Apply

**Data Probe**

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**I/O: Set the following input and output volume:**

**Input DTI Volume:** DTIVolume  
**Input Label Map:** BaselineVolume-region\_1-label  
**Output Fiber Bundle:** Create and rename newFiberBundle

R S: 58.741mm Y R: 3.427mm G A: 26.278mm

L: Base...00%)  
B: Base...lume

5 cm

L: Base...00%)  
B: Base...lume

5 cm

L: Base...00%)  
B: Base...lume

5 cm

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# Final Result of Segmentation

3D Slicer 4.4.0-2015-05-21

Modules: Tractography Label Map Seeding

3DSlicer

Help & Acknowledgement

Tractography Label Map Seeding

Parameter set: Tractography Label Map Seeding

IO

Input DTI Volume: DTIVolume

Input Label Map: BaselineVolume-region 1-label

Output Fiber Bundle: newFiberBundle

Seed Placement Options

Use Index Space ☒

Seed Spacing: 2.00

Random Grid ☐

Linear Measure Start Threshold: 0.3

Tractography Seeding Parameters

Minimum Path Length: 20.00

Maximum Length: 800.00

Stopping Criteria: ☐ LinearMeasure ☒ FractionalAnisotropy

Stopping Value: 0.25

Stopping Track Curvature: 0.7

Integration Step Length(mm): 0.5

Label definition

Status: Idle

Restore Defaults AutoRun

Cancel Apply

Data Probe

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Scroll down and set the following values:

- Seed Placement Options: Check Use Index Space

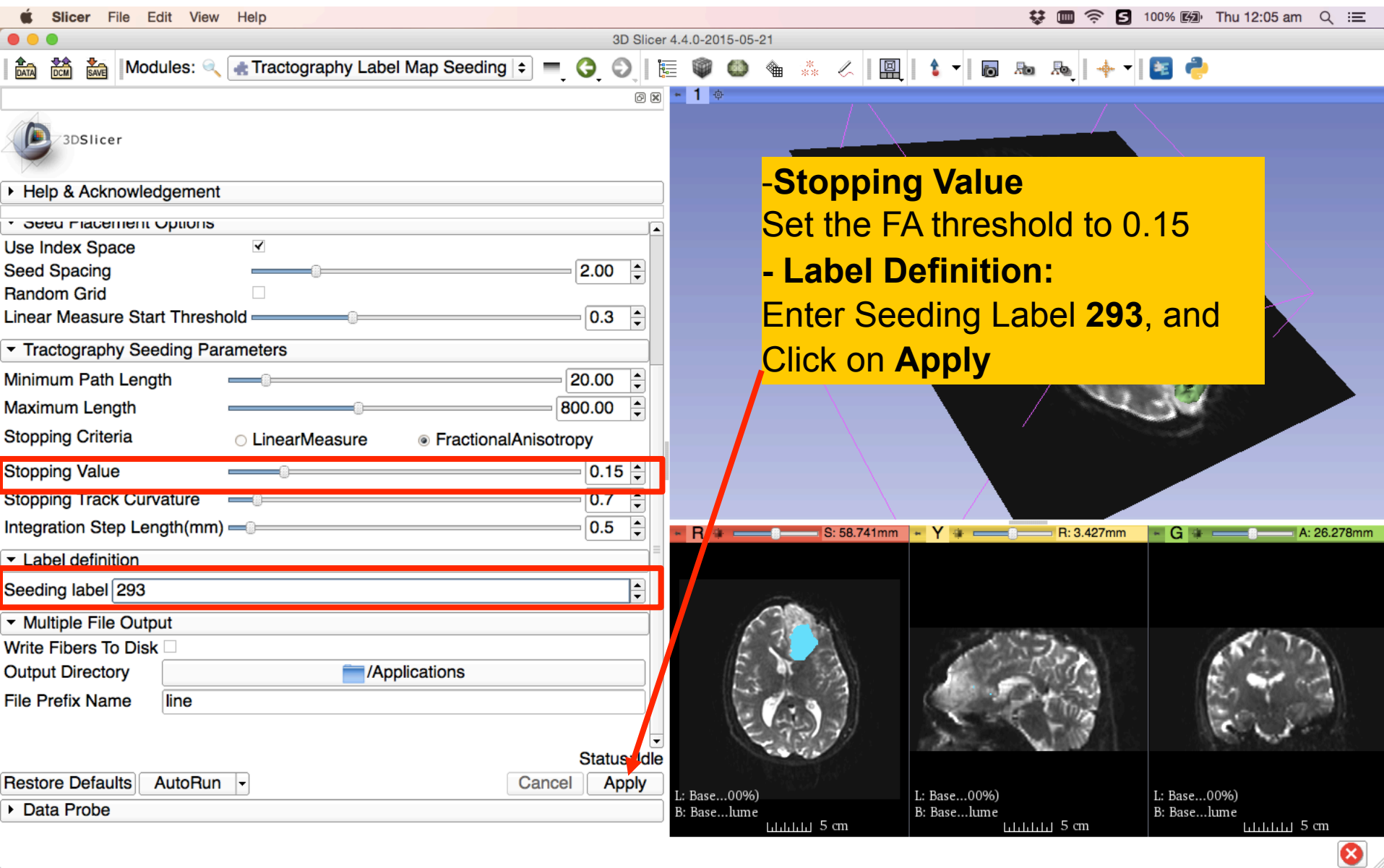
R S: 58.741mm Y R: 3.427mm G A: 26.278mm

L: Base...00%) B: Base...lume 5 cm

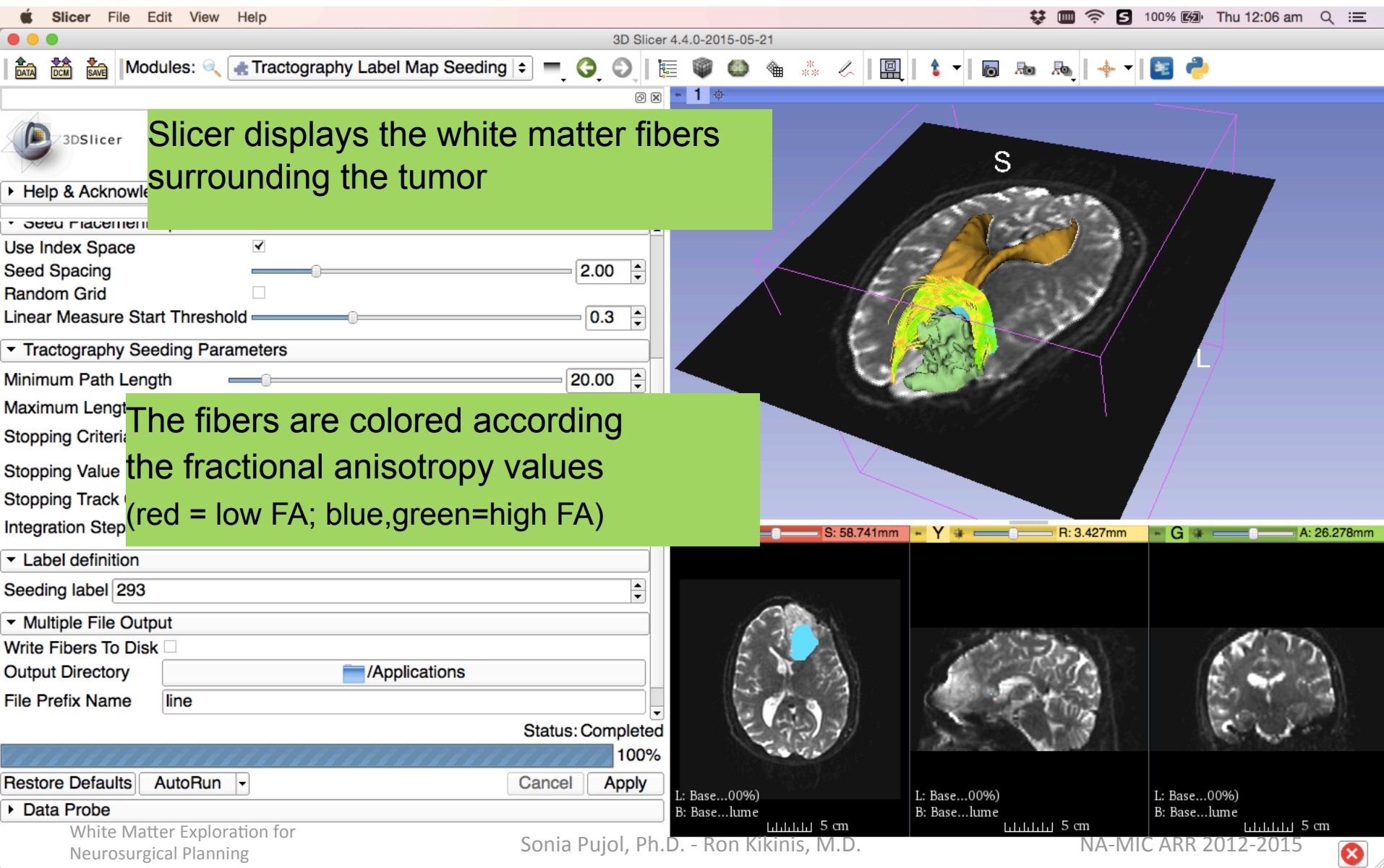
L: Base...00%) B: Base...lume 5 cm

L: Base...00%) B: Base...lume 5 cm

# Final Result of Segmentation



# Final Result of Segmentation



**Slicer displays the white matter fibers surrounding the tumor**

**The fibers are colored according to the fractional anisotropy values (red = low FA; blue, green = high FA)**

**Tractography Label Map Seeding Parameters:**

- Use Index Space: ☒
- Seed Spacing: 2.00
- Random Grid: ☐
- Linear Measure Start Threshold: 0.3
- Tractography Seeding Parameters
  - Minimum Path Length: 20.00
  - Maximum Length: [slider]
  - Stopping Criteria: [slider]
  - Stopping Value: [slider]
  - Stopping Track: [slider]
  - Integration Step: [slider]
- Label definition
  - Seeding label: 293
- Multiple File Output
  - Write Fibers To Disk: ☐
  - Output Directory: /Applications
  - File Prefix Name: line

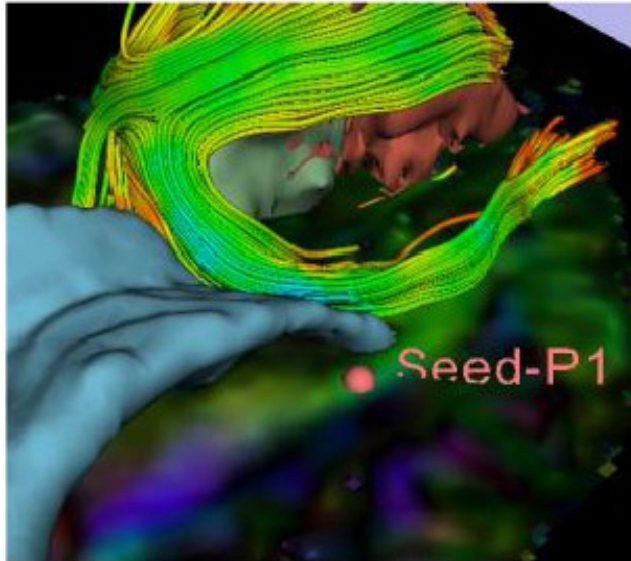
Status: Completed 100%

Restore Defaults AutoRun Cancel Apply

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## Part 4: Tractography exploration of the ipsilateral and contralateral side

# Tractography on-the-fly

The screenshot displays the 3D Slicer 4.4.0-2015-05-21 interface. The 'Modules' menu is open, showing a list of modules. The 'Diffusion' module is selected, and its sub-menu is also open, showing 'Tractography Interactive Seeding' as the selected option. A red arrow points from the 'Tractography Interactive Seeding' option in the sub-menu to the 'Tractography Label Map Seeding' module in the main menu. The main menu also shows 'Tractography Display' and 'Tractography Label Map Seeding' as available modules. The background shows a 3D rendering of a brain with a green and yellow tractography visualization. The interface includes a top menu bar (File, Edit, View, Help), a toolbar, and a bottom status bar with coordinates and a 5 cm scale bar.

Click on the **Modules** menu and select the module **Tractography Interactive Seeding**

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# Tractography on-the-fly

Position the mouse over the **pin icon** in the axial slice viewer and change the volume to **DTIVolume**

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# Tractography on-the-fly

3D Slicer 4.4.0-2015-05-21

Modules: Tractography Interactive Seeding

Select the **Fiducial** icon, and position it next to the cystic part of the tumor by clicking near it in the 3D viewer

Input DTI Volume: DTIVolume

Input Fiducials, Model or Label Map: Select a MarkupsFiducial

Output Fiber Bundle: Select a FiberBundle

Enable Seeding Tracts: ☒

Seed Placement Options

Fiducial Region Size: 2.50mm

Fiducial Seeding Step Size: 1.00mm

Seed Selected Fiducials: ☐

Max Number of Seeds: 100

Tractography Seeding Parameters

Minimum Path Length: 20.000mm

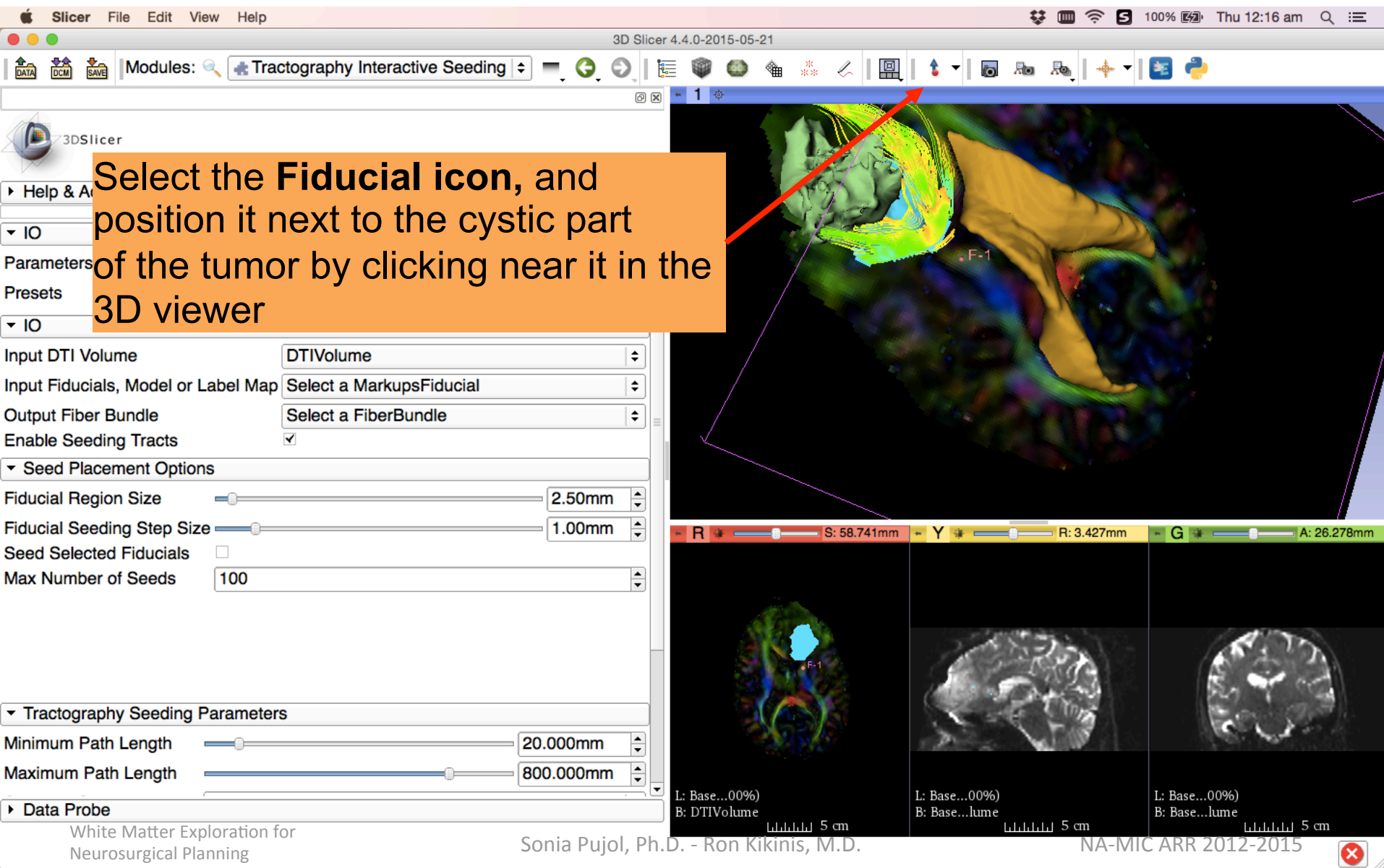
Maximum Path Length: 800.000mm

Data Probe

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# Tractography on-the-fly

3D Slicer 4.4.0-2015-05-21

Modules: Tractography Interactive Seeding

IO

Parameters: FiducialSeedingParameters

Presets: Slicer4 Interactive Seeding Defaults

Input DTI Volume: DTIVolume

Input Fiducials, Model or Label Map: F

Output Fiber Bundle: FiberBundle\_F

Enable Seeding Tracts: ☒

Seed Placement Options

Fiducial Region Size: 2.50mm

Fiducial Seeding Step Size: 1.00mm

Seed Selected Fiducials: ☐

Max Number of Seeds: 100

Tractography Seeding Parameters

Minimum Path Length: 20.000mm

Maximum Path Length: 800.000mm

Data Probe

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Set Input DTI Volume to **DTIVolume**  
Set Fiducial List or Model to **F**  
Set Output Fiber Bundle to **Create new Fiber Bundle**



# Tractography on-the-fly

3D Slicer 4.4.0-2015-05-21

Modules: Tractography Interactive Seeding

Input DTI Volume: DTI Volume

Input Fiducials, Model or Label Map: F

Output Fiber Bundle: FiberBundle\_F

Enable Seeding Tracts: ☒

Seed Placement Options

Fiducial Region Size: 2.50mm

Fiducial Seeding Step Size: 1.00mm

Seed Selected Fiducials: ☐

Max Number of Seeds: 100

Tractography Seeding Parameters

Minimum Path Length: 10.000mm

Maximum Path Length: 800.000mm

Stopping Criteria: Fractional Anisotropy

Stopping Value: 0.15

Stopping Track Curvature: 0.70

Integration Step Length: 0.500mm

Enabling Options

Create Tracts Initially As: Tubes

Data Probe

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Scroll down the module and set the **Minimum Path Length** to 10.0 mm and the **FA Stopping Value** at 0.15

L: Base...00%)  
B: DTIVolume  
5 cm

L: Base...00%)  
B: Base...lume  
5 cm

L: Base...00%)  
B: Base...lume  
5 cm

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