

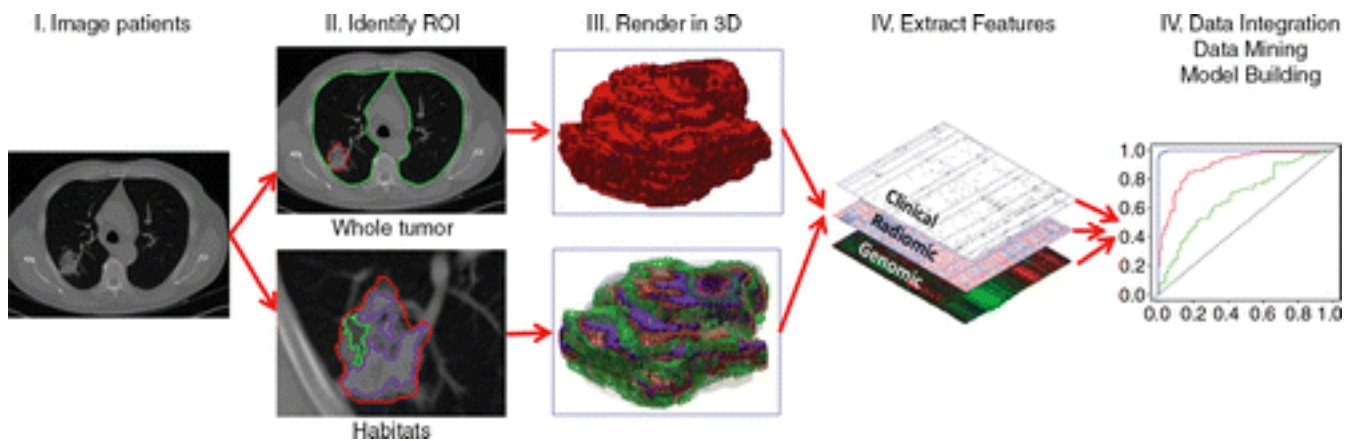
# An Introduction to Image Phenotyping

Sonia Pujol, Ph.D.

Director of Training and Education, 3D Slicer  
Assistant Professor of Radiology  
Brigham and Women's Hospital  
Harvard Medical School

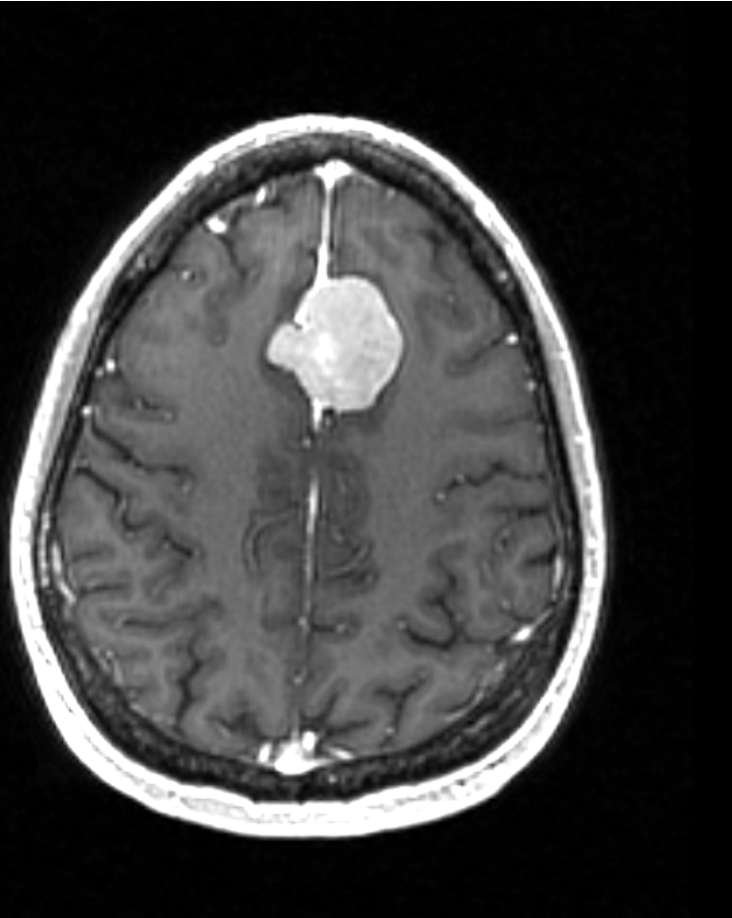
# Imaging Phenotypes

- Imaging phenotypes describe features of disease that can be detected through medical imaging combined with feature detection, machine learning and statistical analysis, and correlated with other indicators of disease.



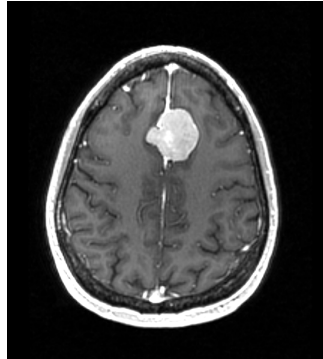
Gillies et al. Radiology 2015

# Clinical Case: Meningioma

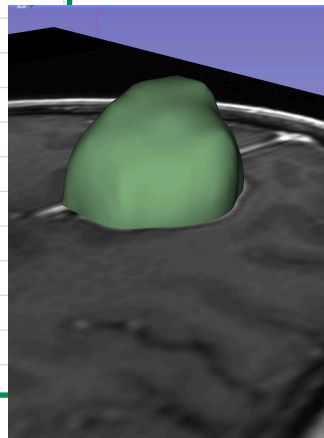


- Meningiomas are slow-growing extra axial brain tumor arising from arachnoidal cells
- Treatment options include observation, surgery and radiation therapy
- Image-based predictors of tumor grades have the potential to enhance clinical decision-making

# Overall Goal

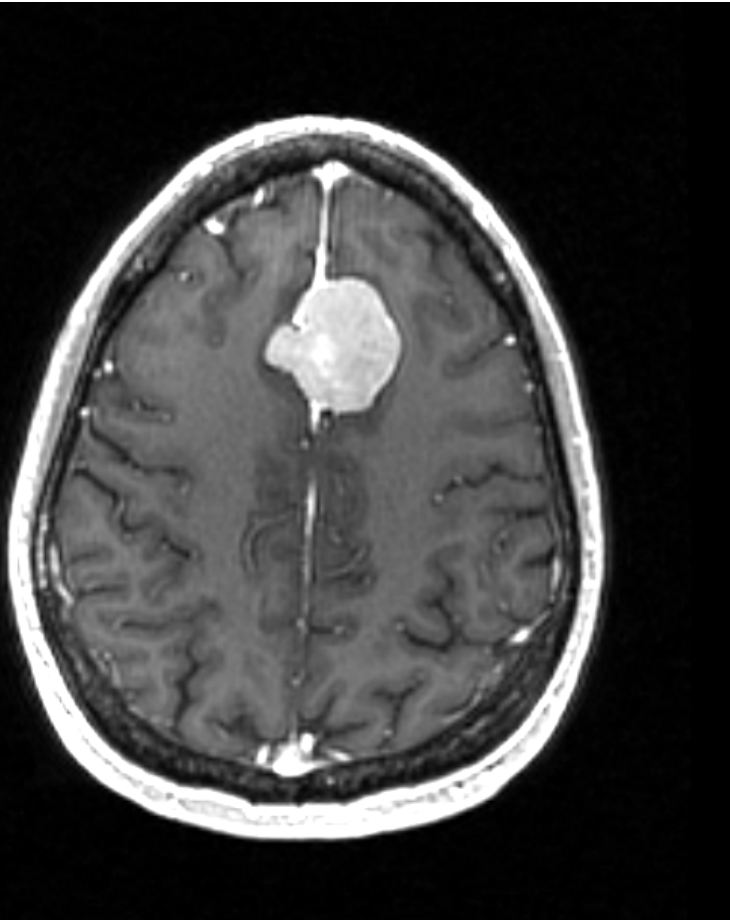


Kurtosis	12.4315749384
Mean	179.297568367
GrayLevelVariance	1.00567651545
HighGrayLevelEmphasis	45.873151021
DependenceEntropy	6.16459662954
DependenceNonUniformity	548.562883325
GrayLevelNonUniformity	4972.61959737
SmallDependenceEmphasis	0.0389261318031
SmallDependenceHighGrayLe...	1.92568883112
DependenceNonUniformityNor...	0.0395817074338
LargeDependenceEmphasis	237.650263367
LargeDependenceLowGrayLev...	5.58612453125
DependenceVariance	51.1747739691



This tutorial is an introduction to the basics of image phenotyping for tumor characterization using the 3D Slicer platform.

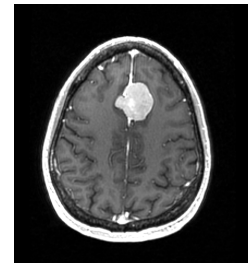
# Imaging Features



Quantitative features derived from imaging data have the potential to provide clinically relevant information for predicting tumor grade and evaluating response treatment

# Tutorial materials

- 3D Slicer release version 4.10.1
- Slicer Radiomics Extension
- Meningioma dataset



# 3D Slicer installation

- To install and start the 3D Slicer software on your computer, follow the instructions of the **Quick Start Guide tutorial** available at <https://www.slicer.org/wiki/Documentation/4.10/Training>

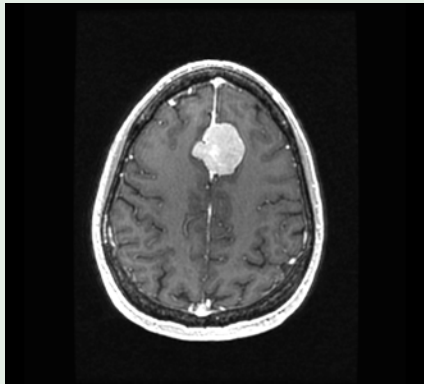
	Windows	Mac OS X	Linux
Stable Release <i>older releases</i>	<b>version 4.10.1</b> revision 27931 built 2019-01-16	<b>version 4.10.1</b> revision 27931 built 2019-01-18	<b>version 4.10.1</b> revision 27931 built 2019-01-16
Nightly Build	<b>version 4.11.0</b> revision 28040 built 2019-03-18	<b>version 4.11.0</b> revision 28040 built 2019-03-18	<b>version 4.11.0</b> revision 28040 built 2019-03-18

# Disclaimer

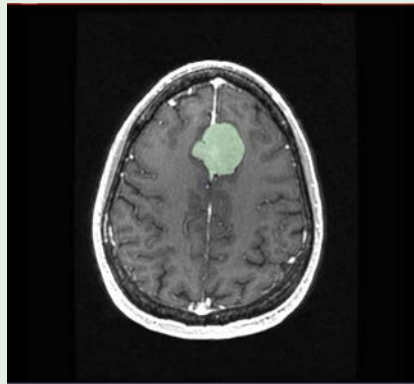
- 3D Slicer is a free open source software for medical image computing research distributed under a BDS style license.
- The software is not FDA approved or CE-Marked, and is for research use only.



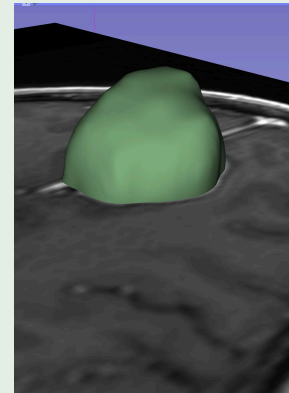
# Workflow Overview



Step 1: Data Loading



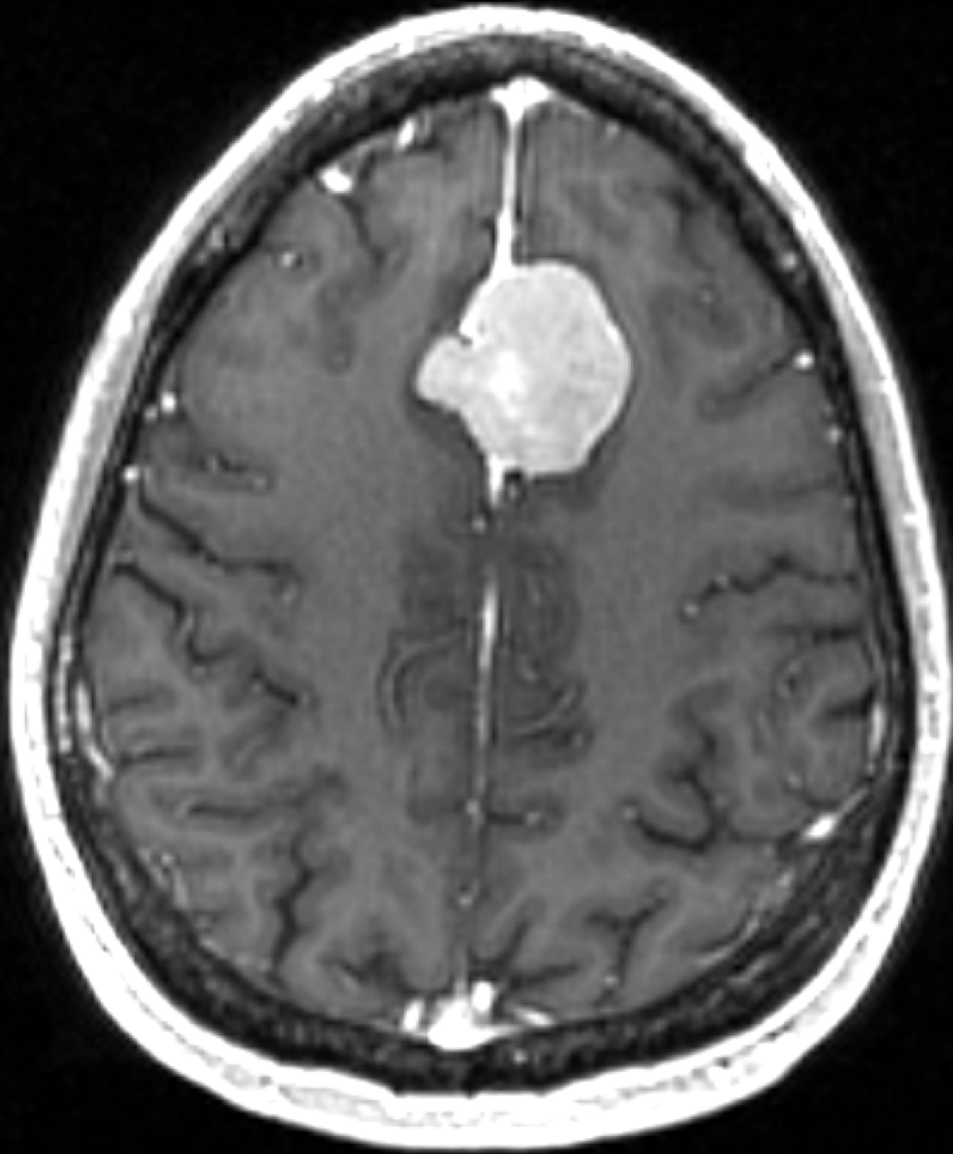
Step 2: Tumor Segmentation



Step 3: Tumor Volume Calculation

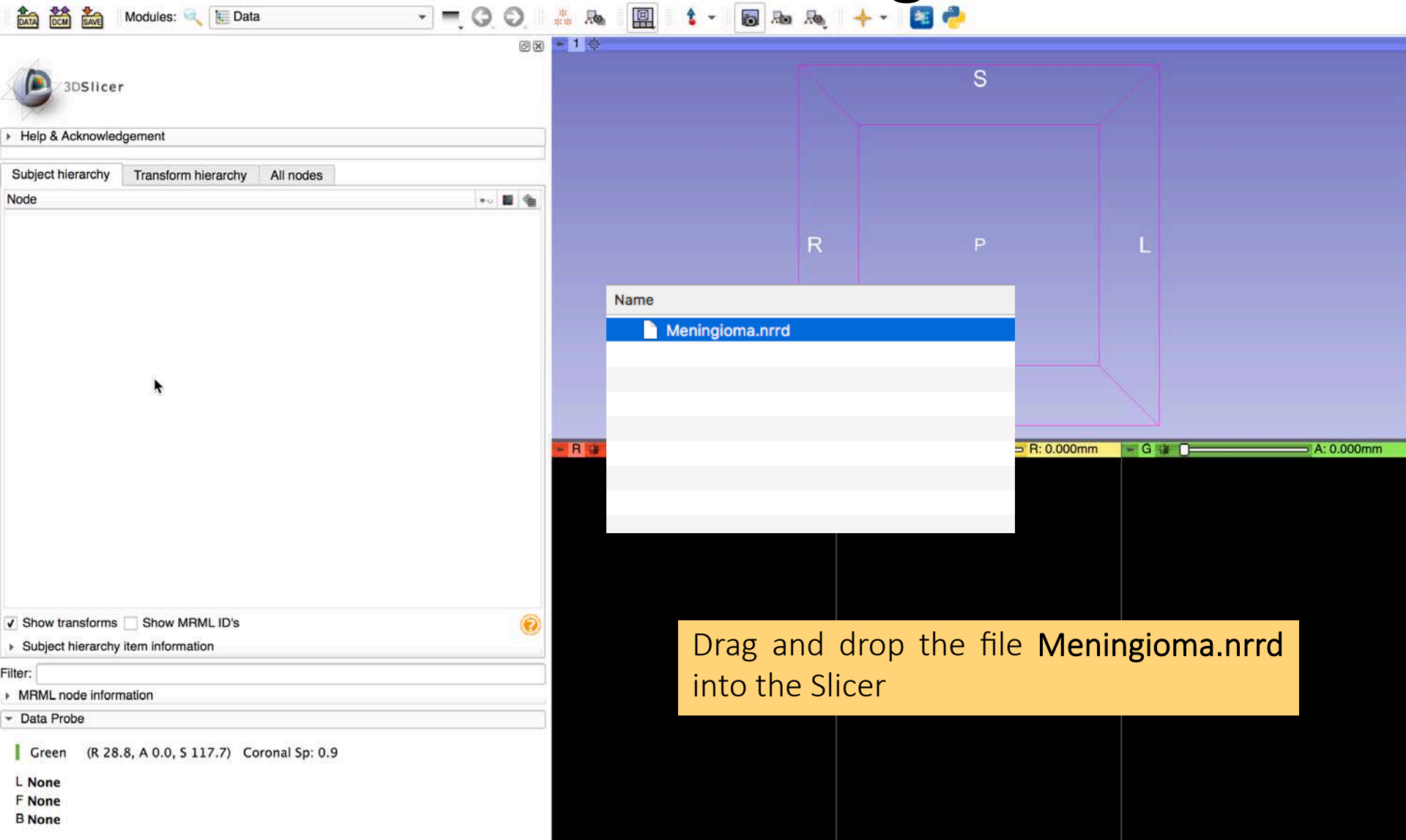
Kurtosis	12.4315749384
Mean	179.297568367
GrayLevelVariance	1.00567651545
HighGrayLevelEmphasis	45.873151021
DependenceEntropy	6.16459662954
DependenceNonUniformity	548.562883325
GrayLevelNonUniformity	4972.61959737
SmallDependenceEmphasis	0.0389261318031
SmallDependenceHighGrayLe...	1.92568883112
DependenceNonUniformityNor...	0.0395817074338
LargeDependenceEmphasis	237.650263367
LargeDependenceLowGrayLev...	5.58612453125
DependenceVariance	51.1747739691

Step 4: Imaging Features Extraction



Part 1: Data  
Loading and tumor  
diameter  
measurements

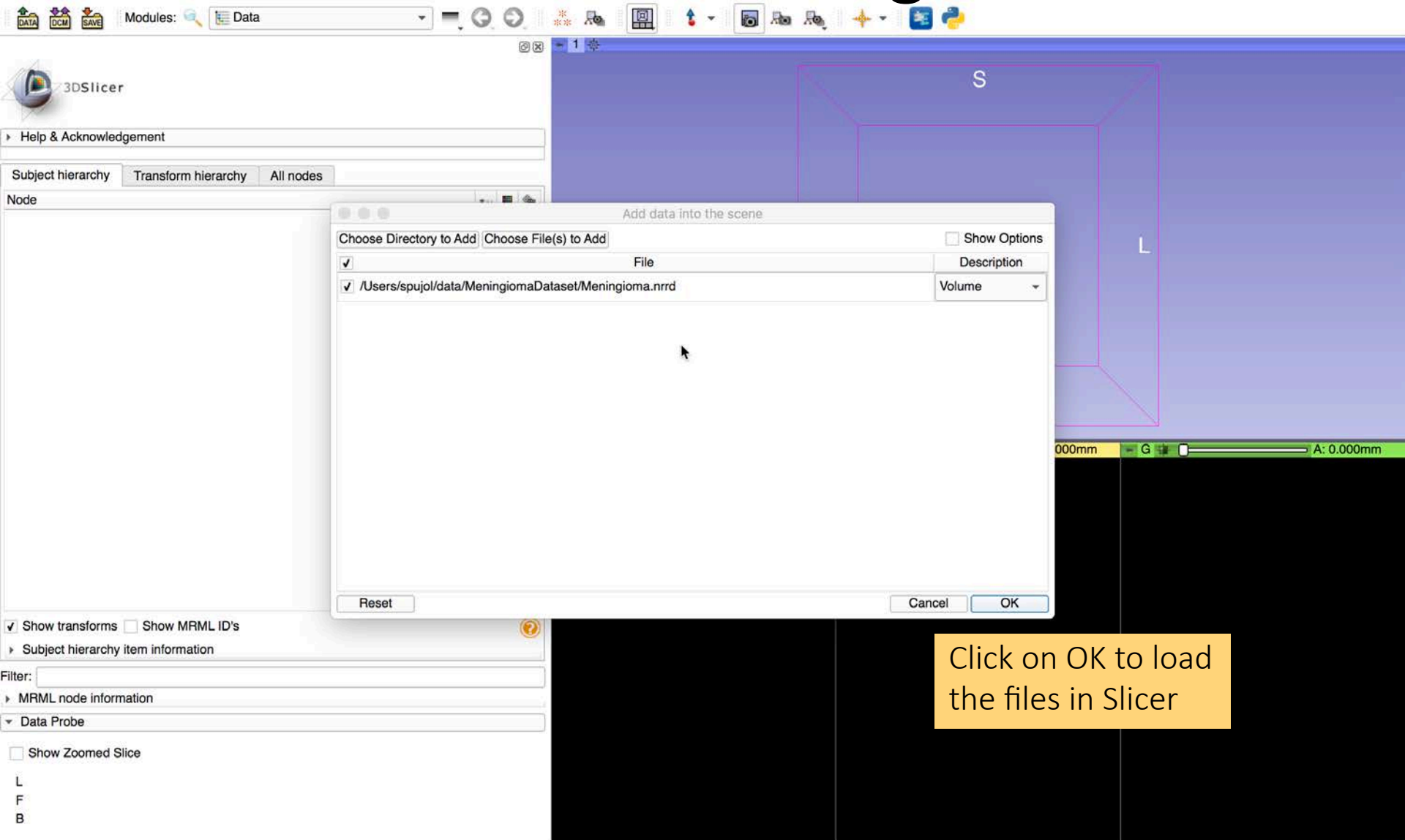
# Data Loading



Drag and drop the file **Meningioma.nrrd** into the Slicer



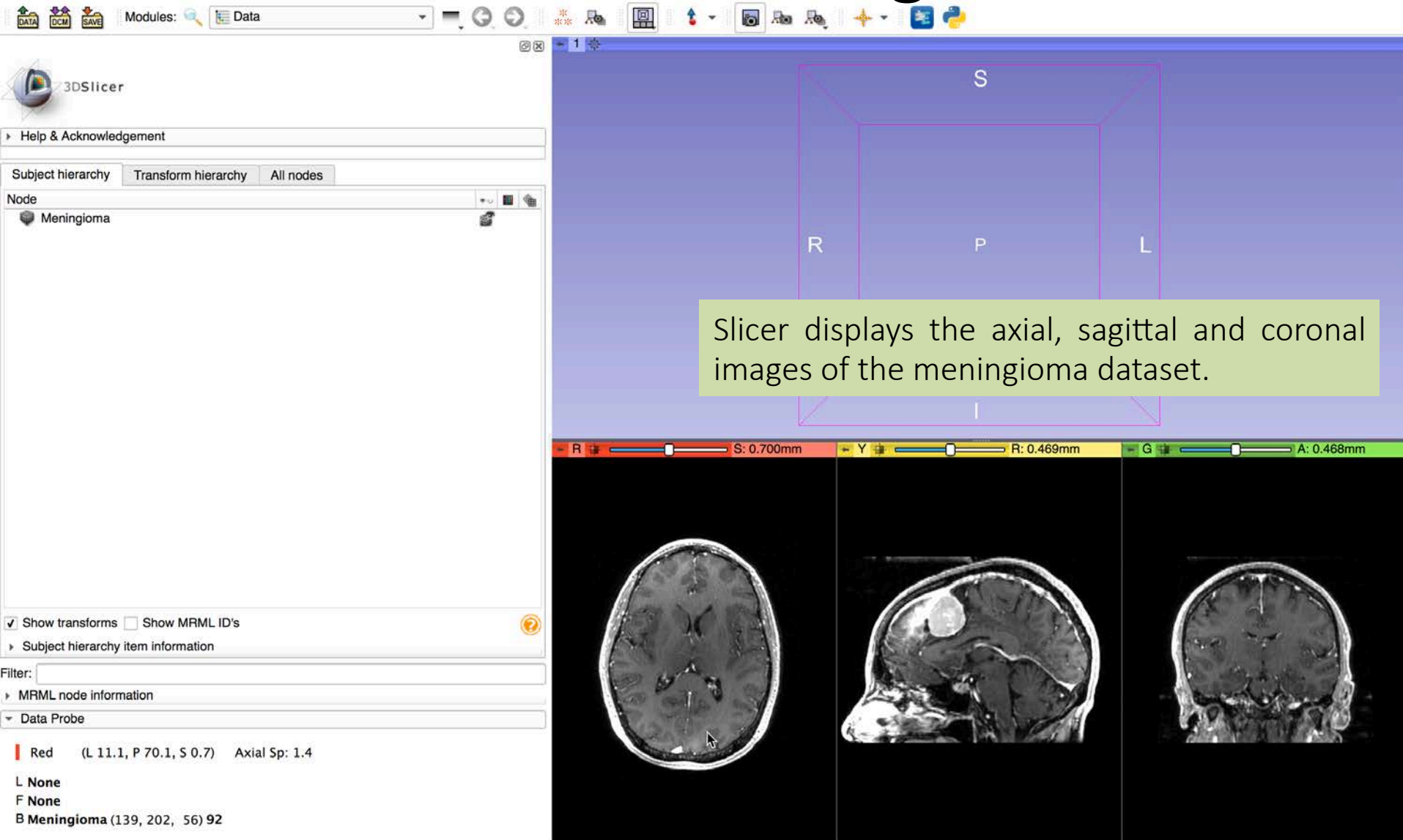
# Data Loading



Click on OK to load the files in Slicer



# Data Loading



# Data Loading

The screenshot displays the 3D Slicer software interface. On the left, the 'Subject hierarchy' panel shows a 'Meningioma' node. The 'Layout Menu' is open, listing various display configurations such as 'Conventional', 'Four-Up', and 'Red slice only'. The 'Red slice only' option is highlighted. The main 3D view shows a brain slice with a purple bounding box and axes labeled 'S', 'P', and 'L'. Below the 3D view, three 2D MRI slices are visible: axial, sagittal, and coronal. The status bar at the bottom indicates 'R: 0.469mm' and 'A: 0.468mm'. An orange text box at the bottom center contains the instruction: 'Select the Red Slicer Only Layout from the Layout Menu'.

Conventional  
Conventional Widescreen  
Conventional Quantitative  
Four-Up  
Four-Up Table  
Four-Up Quantitative  
Dual 3D  
Triple 3D  
3D only  
3D Table  
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  
Three by three slice

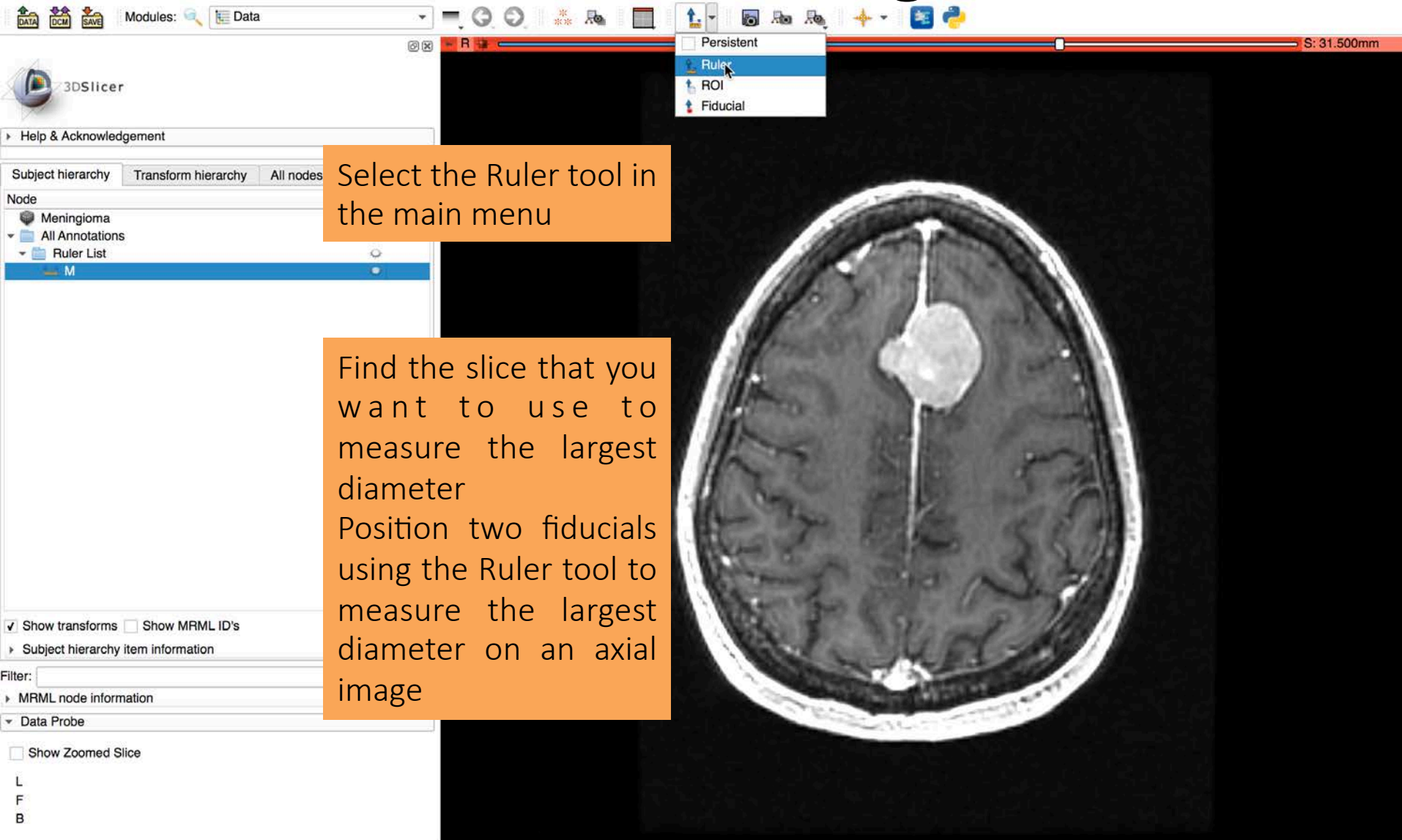
Red (L 11.1, P 70.1, S 0.7)  
L None  
F None  
B Meningioma (139, 202, 56)

Select the Red Slicer Only Layout from the Layout Menu





# Data Loading



The screenshot displays the 3D Slicer software interface. The top toolbar contains various icons, and a dropdown menu is open, showing options: Persistent, Ruler, ROI, and Fiducial. The 'Ruler' option is highlighted. On the left, the 'Node' panel shows a hierarchy: Meningioma, All Annotations, Ruler List, and M. An orange callout box points to the 'Ruler' option in the menu. Another orange callout box points to the 'M' node in the 'Node' panel. The main view shows an axial MRI slice of a brain with a central lesion. The bottom status bar shows 'S: 31.500mm'.

Select the Ruler tool in the main menu

Find the slice that you want to use to measure the largest diameter

Position two fiducials using the Ruler tool to measure the largest diameter on an axial image



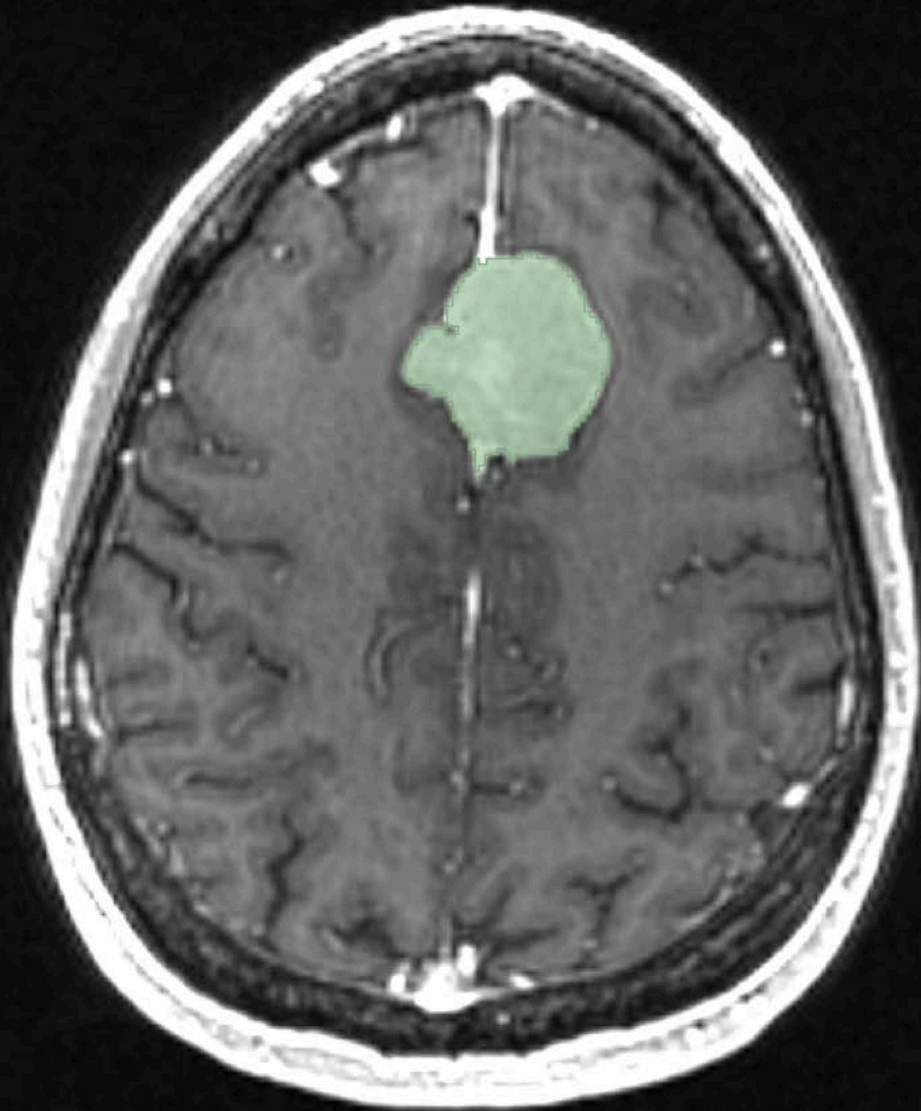
# Data Loading

Slicer displays the value of the tumor diameter as measured on an axial slice

Red (R 63.6, A 26.4, S 31.5) Axial Sp: 1.4  
L None  
F None  
B Meningioma ( 60, 99, 78) 214







Part  
Seg

## Part 2: Tumor Segmentation

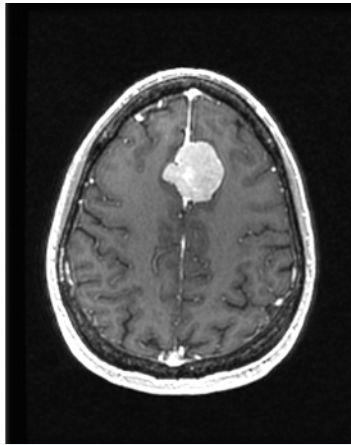
# Image Segmentation

- Image Segmentation is the process of identifying the contours of structures of interest in imaging data
- Image Segmentation can be performed by manual contouring or by using automated segmentation algorithms

# Image Segmentation

- The Segment Editor module of 3D Slicer provides powerful tools for manual and semi-automated segmentation
- The module takes a reference image (**Master Volume**) as input and produces a segmented image (**Segmentation**) in output

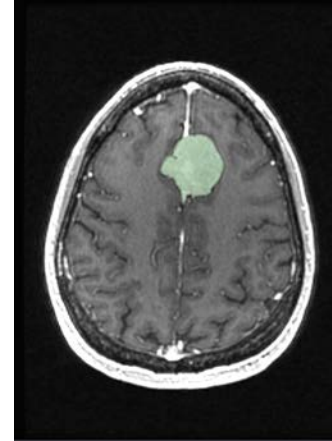
# Terminology



Master Volume



Segmentation

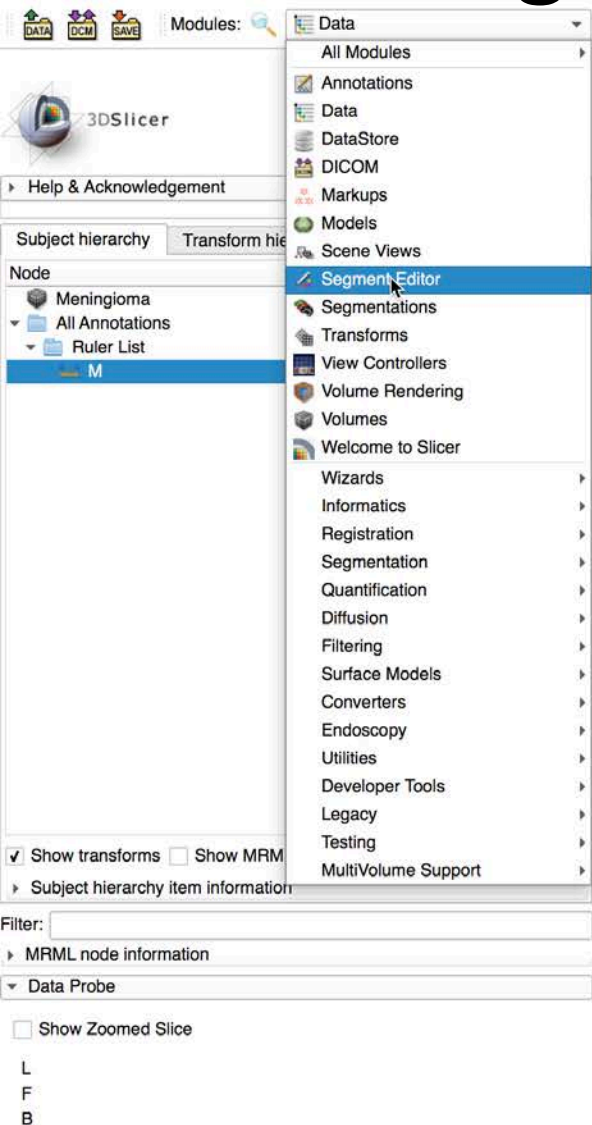


Master Volume  
&  
Segmentation

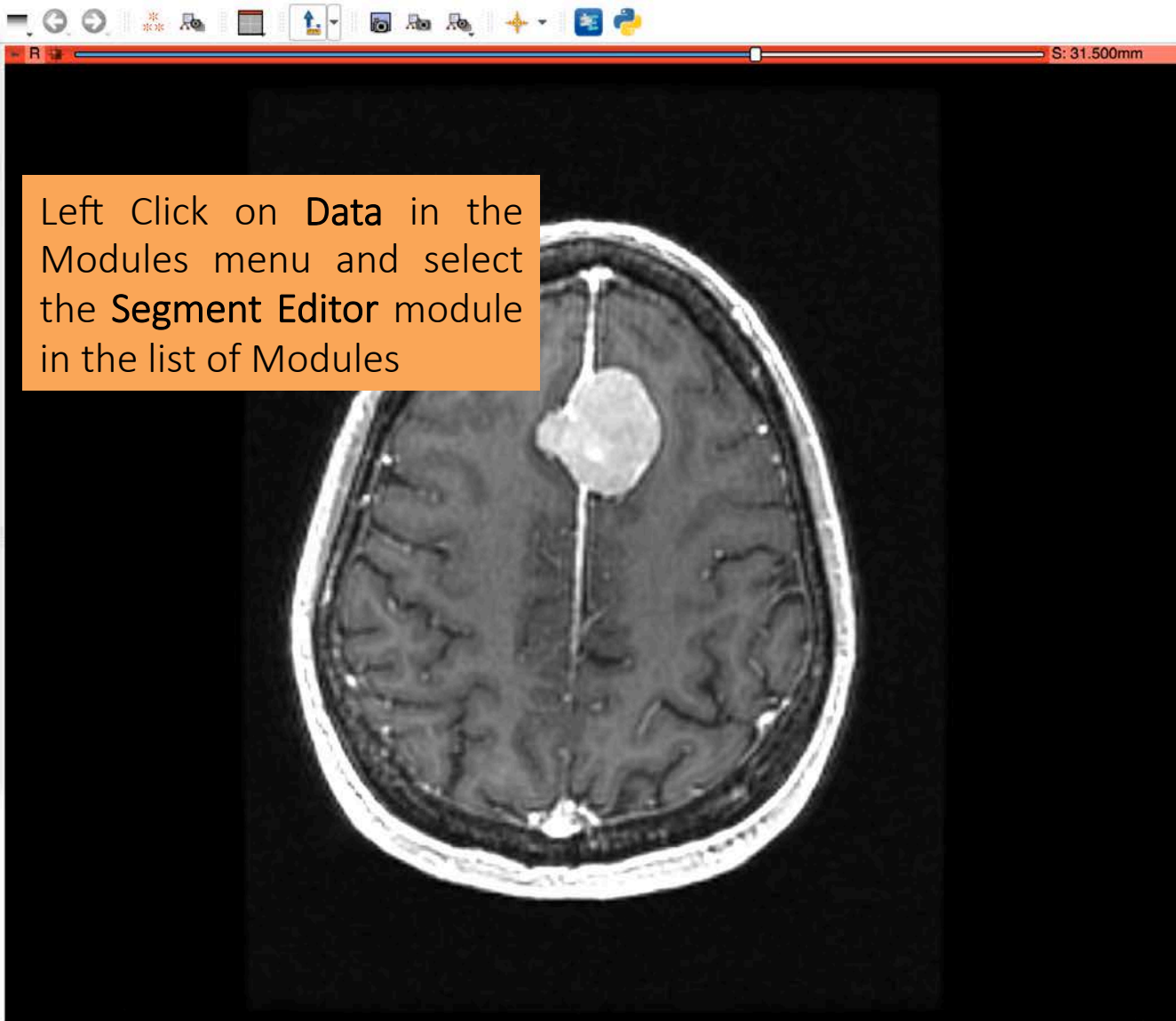
In this tutorial,

- The Master Volume **Meningioma** is the initial brain MRI dataset
- The Segmentation Volume **Segmentation** is a segmentation object with the same dimensions and origin as the Master Volume

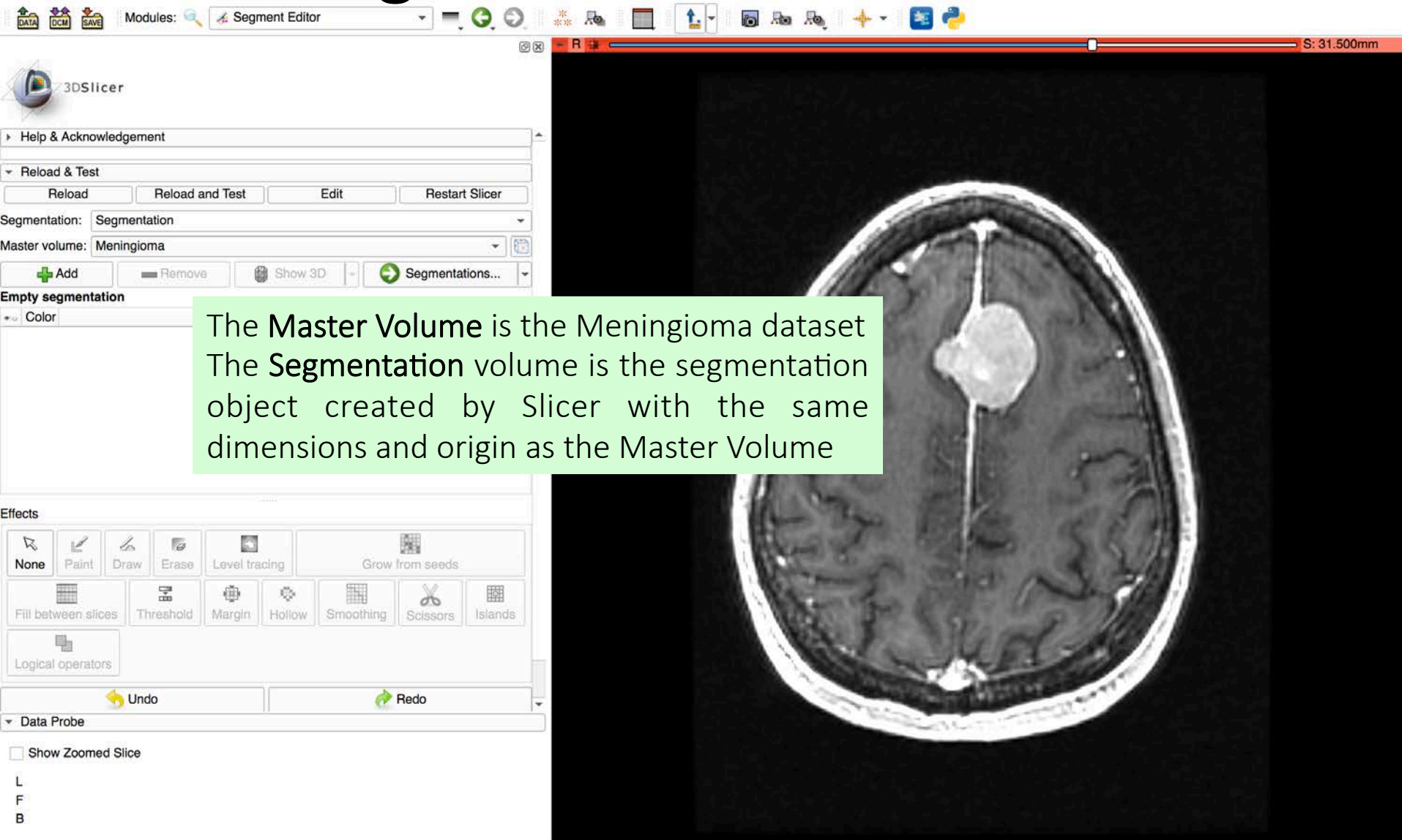
# Segment Editor Module



Left Click on **Data** in the Modules menu and select the **Segment Editor** module in the list of Modules



# Segment Editor Module



# Segment Editor Module

The screenshot displays the 3D Slicer software interface, specifically the Segment Editor module. The main window shows an axial MRI slice of a brain with a central enhancing lesion. The left sidebar contains the following panels:

- Help & Acknowledgement**
- Reload & Test**: Includes buttons for Reload, Reload and Test, Edit, and Restart Slicer.
- Segmentation**: Set to 'Segmentation'.
- Master volume**: Set to 'Meningioma'.
- Actions**: Includes Add, Remove, Show 3D, and Segmentations... buttons.
- Color**: A table with columns for Color and Name. One entry is visible: a blue square next to the name 'Tumor'.
- Effects**: A toolbar with icons for None, Paint, Draw, Erase, Level tracing, Grow from seeds, Fill between slices, Threshold, Margin, Hollow, Smoothing, Scissors, Islands, and Logical operators.
- Undo** and **Redo** buttons.
- Data Probe**: Includes a checkbox for 'Show Zoomed Slice'.
- Orientation**: L, F, B indicators.

A yellow callout box is overlaid on the 'Add' button, containing the text: "Click on Add to add a segment to the Segmentation and rename it Tumor".





# Segment Editor Module

3DSlicer

Modules: Segment Editor

Help & Acknowledgement

Reload & Test

Reload Reload and Test Edit Restart Slicer

Segmentation: Segmentation

Master volume: Meningioma

Add Remove Show 3D Segmentations...

Color	Name
	Tumor

Effects

None Paint Draw Erase Level tracing Grow from seeds

Fill between slices Threshold Margin Hollow Smoothing Scissors Islands

Logical operators

Paint

Data Probe

Red (L 6.5, A 24.3, S 28.7) Axial Sp: 1.4

L None

F None

B Meningioma (134, 102, 76) 173

S Segmentation: Tumor

S: 28.700mm

Select the Paint tool and draw a small mark inside the tumor on 2-3 consecutive slices





# Segment Editor Module

The screenshot displays the 3D Slicer software interface. At the top, the 'Segment Editor' module is selected. The main window shows an axial MRI slice of a brain with a green segment. A yellow callout box with the text 'Click on Add to add a new segment and rename it Background' is overlaid on the image. The left sidebar contains several panels: 'Help & Acknowledgement', 'Reload & Test' (with buttons for Reload, Reload and Test, Edit, and Restart Slicer), 'Segmentation' (set to Segmentation), 'Master volume' (set to Meningioma), 'Add' and 'Remove' buttons, 'Show 3D' dropdown, and 'Segmentations...' dropdown. Below these is a 'Color' table with columns for 'Color' and 'Name'. The table has two rows: 'Tumor' with a green color swatch and 'Background' with a blue color swatch. The 'Background' row is selected. Below the color table is the 'Effects' panel with various tools like None, Paint, Draw, Erase, Level tracing, Grow from seeds, Fill between slices, Threshold, Margin, Hollow, Smoothing, Scissors, Islands, and Logical operators. The 'Paint' panel is also visible. At the bottom, the status bar shows 'Red (R 114.6, A 35.2, S 28.7) Axial Sp: 1.4', 'L None', 'F None', and 'B Meningioma ( 5, 90, 76) 0'.

Click on **Add** to add a new segment and rename it **Background**



# Segment Editor Module

The screenshot displays the 3D Slicer software interface. The main window shows an axial MRI slice of a brain with a central tumor highlighted in green. A yellow circle is drawn around the tumor, indicating the use of the Paint tool. The left sidebar contains several panels: 'Help & Acknowledgement', 'Reload & Test' (with buttons for Reload, Reload and Test, Edit, and Restart Slicer), 'Segmentation' (set to Segmentation), 'Master volume' (set to Meningioma), 'Color' (with Tumor in green and Background in blue), 'Effects' (with tools like None, Paint, Draw, Erase, Level tracing, Grow from seeds, Fill between slices, Threshold, Margin, Hollow, Smoothing, Scissors, Islands, and Logical operators), and 'Paint' (with 'Paint with a round brush...' and 'Data Probe'). The bottom status bar shows 'Red (L 19.2, A 58.1, S 28.7) Axial Sp: 1.4', 'L None', 'F None', and 'B Meningioma (148, 65, 76) 95'. The top toolbar includes icons for DATA, DCM, SAVE, and various editing tools. The top right corner shows 'S: 28.700mm'.

Select the Paint Tool and draw a circle around the tumor



# Segment Editor Module

The screenshot displays the 3DSlicer Segment Editor interface. The top toolbar includes icons for DATA, DCM, SAVE, and a Modules dropdown menu set to Segment Editor. The main window shows an axial MRI slice of a brain with a green segmented tumor and a yellow outline. A context menu is open over the slice, listing various layout options such as Conventional, Four-Up, and Three over three. A yellow callout box points to the 'Four-Up' option with the text 'Select the Four-Up slice layout'. The left sidebar contains panels for Help & Acknowledgement, Reload & Test, Segmentation (Master volume: Meningioma), Color (Tumor, Background), Effects (Paint, Draw, Erase, Level tracing, Grow from seeds, Fill between slices, Threshold, Margin, Hollow, Smoothing, Scissors, Islands, Logical operators), Paint, and Data Probe. The bottom status bar shows: Red (L 19.2, A 58.1, S 28.7) Axial Sp: 1.4, L None, F None, B Meningioma (148, 65, 76) 95.

Select the Four-Up slice layout

- Conventional
- Conventional Widescreen
- Conventional Quantitative
- Four-Up
- Four-Up Table
- Four-Up Quantitative
- Dual 3D
- Triple 3D
- 3D only
- 3D Table
- 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
- Three by three slice

Red (L 19.2, A 58.1, S 28.7) Axial Sp: 1.4  
L None  
F None  
B Meningioma (148, 65, 76) 95



# Segment Editor Module

The screenshot displays the 3DSlicer Segment Editor interface. The top toolbar includes icons for DATA, DCM, SAVE, and various editing tools. The main window shows three views of a brain MRI: an axial view at the top, a sagittal view at the bottom left, and a coronal view at the bottom right. A tumor is segmented in green, and a yellow circle is drawn around it in all three views. The interface includes a left sidebar with a 'Color' panel showing 'Tumor' (green) and 'Background' (blue), and an 'Effects' panel with tools like 'Paint', 'Draw', and 'Erase'. The 'Paint' tool is selected, and its settings are visible, including a 'Diameter' of 3%.

Select the Paint Tool and draw a circle around the tumor in the sagittal and coronal slices





# Segment Editor Module

The image displays the 3DSlicer Segment Editor module interface. On the left, the 'Effects' panel shows the 'Grow from seeds' tool circled in red. Below it, the 'Grow from seeds' dialog box is also circled in red, with the 'Initialize' button highlighted. The main window shows three MRI slices: an axial slice at the top, a sagittal slice at the bottom left, and a coronal slice at the bottom right. A yellow dashed circle highlights a tumor region in each slice. A yellow callout box over the axial slice says 'Select the Grow from seeds tool'. Another yellow callout box over the sagittal slice says 'Click on Initialize'. The top right of the interface shows a 3D view of the tumor with axes labeled S (Superior), R (Right), L (Left), and P (Posterior). The bottom status bar shows coordinates: R: -6.953mm and A: 27.207mm.



# Segment Editor Module

The screenshot displays the 3DSlicer Segment Editor module interface. The top toolbar includes icons for DATA, DCM, SAVE, and various editing tools. The main window shows three views of a brain MRI slice: an axial view at the top, a sagittal view at the bottom left, and a coronal view at the bottom right. A central green box highlights the segmentation result in the axial view. The right panel shows a preview of the segmentation result with a green box containing the text "Slicer shows a preview of the segmentation result". The left panel contains the Effects toolbar with options like None, Paint, Draw, Erase, Level tracing, and Grow from seeds. Below the toolbar are controls for the "Grow from seeds" effect, including a preview checkbox, auto-update, and display options. The bottom left corner shows the "Masking" section with "Editable area" set to "Everywhere" and "Overwrite other segments" set to "All segments". The bottom right corner shows the "Data Probe" section with "Show Zoomed Slice" checked.

3DSlicer

Modules: Segment Editor

Effects

None Paint Draw Erase Level tracing Grow from seeds

Fill between slices Threshold Margin Hollow Smoothing Scissors Islands

Logical operators

Grow from seeds

Growing segments to create complete segmentation... [Show details.](#)

Preview:  Auto-update  Update

Display: inputs  results  Show 3D

Cancel Apply

Undo Redo

Masking

Editable area: Everywhere

Editable intensity range:

Overwrite other segments: All segments

Data Probe

Show Zoomed Slice

L  
F  
B

Slicer shows a preview of the segmentation result

R S: 28.700mm

Y R: -6.953mm G A: 27.207mm



# Segment Editor Module

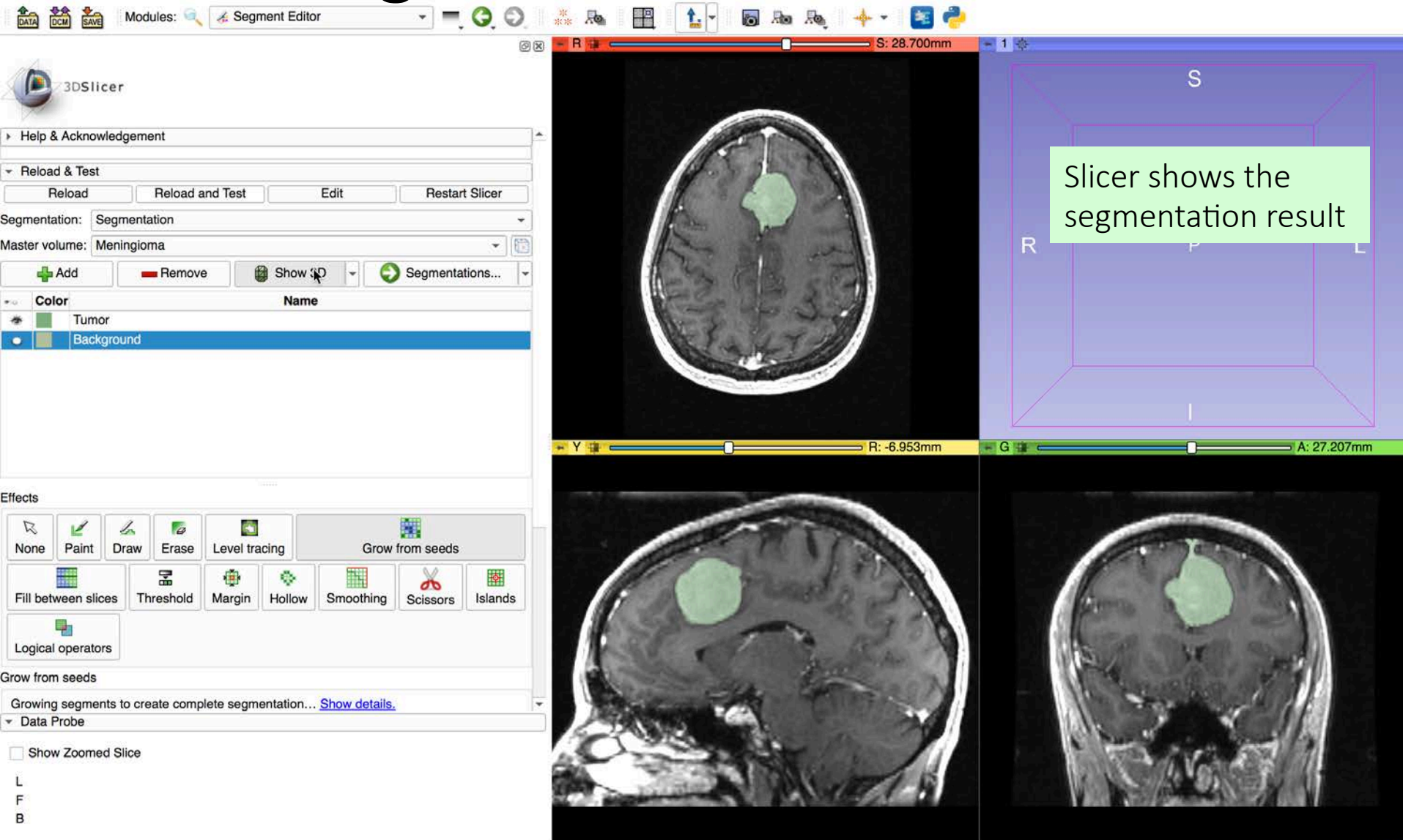
The screenshot displays the 3DSlicer Segment Editor interface. The top toolbar includes icons for DATA, DCM, SAVE, and various editing tools. The main window shows a brain MRI slice with a segmented tumor (green) and a 3D view of the segmentation (purple). The 3D view is labeled with 'S' (Superior), 'R' (Right), 'P' (Posterior), 'L' (Left), and 'I' (Inferior). The interface includes a 'Grow from seeds' panel with options like 'None', 'Paint', 'Draw', 'Erase', 'Level tracing', 'Fill between slices', 'Threshold', 'Margin', 'Hollow', 'Smoothing', 'Scissors', 'Islands', and 'Logical operators'. The 'Grow from seeds' panel is highlighted with a red circle, and the 'Apply' button is circled in red. A yellow callout box points to the 'Apply' button with the text 'Click on Apply to accept the result'. The interface also shows a 'Masking' section with 'Editable area: Everywhere' and 'Overwrite other segments: All segments'. The 'Data Probe' section is visible at the bottom left.

Click on Apply to accept the result





# Segment Editor Module





# Segment Editor Module

The screenshot displays the 3DSlicer Segment Editor Module interface. The top toolbar includes icons for DATA, DCM, SAVE, and various editing tools. The main window is divided into four panels: a top-left panel with a list of segmentation objects (Tumor, Background), a top-right panel showing a 3D view of the brain with a green tumor segmentation, a bottom-left panel showing a sagittal view of the brain with the tumor, and a bottom-right panel showing a coronal view of the brain with the tumor. A red circle highlights the 'Show 3D' button in the segmentation list. A yellow box with the text 'Click on Show 3D' is overlaid on the interface. The status bar at the top indicates the current slice position: S: 28.700mm, R: -6.953mm, A: 27.207mm.

3DSlicer

Help & Acknowledgement

Reload & Test

Reload Reload and Test Edit Restart Slicer

Segmentation: Segmentation

Master volume: Meningioma

+ Add - Remove Show 3D Segmentations...

Color

Name

Tumor

Background

Effects

None Paint Draw Erase Level tracing Grow from seeds

Fill between slices Threshold Margin Hollow Smoothing Scissors Islands

Logical operators

Grow from seeds

Growing segments to create complete segmentation... [Show details.](#)

Data Probe

Show Zoomed Slice

L

F

B

Click on Show 3D

S: 28.700mm

R: -6.953mm

A: 27.207mm

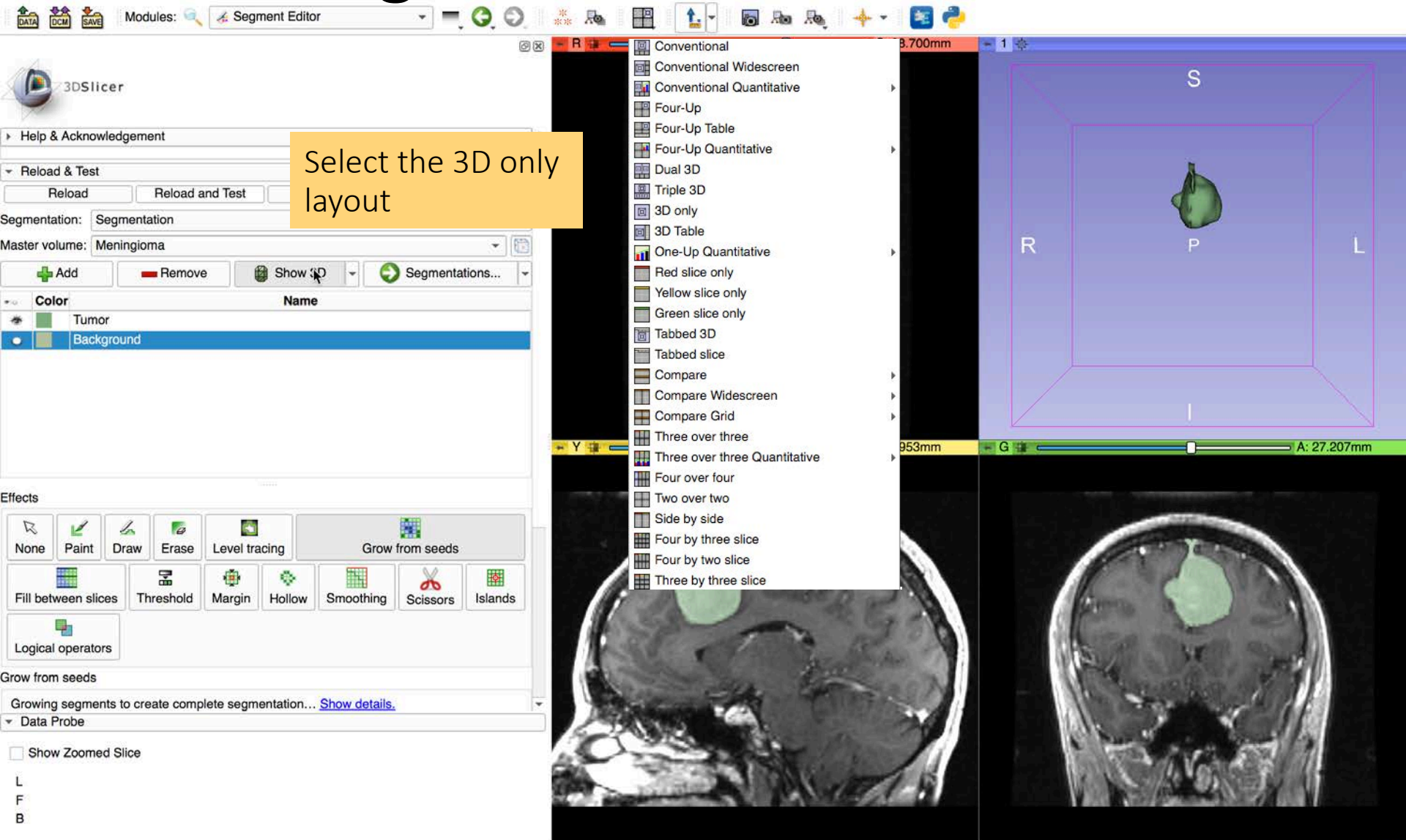


# Segment Editor Module

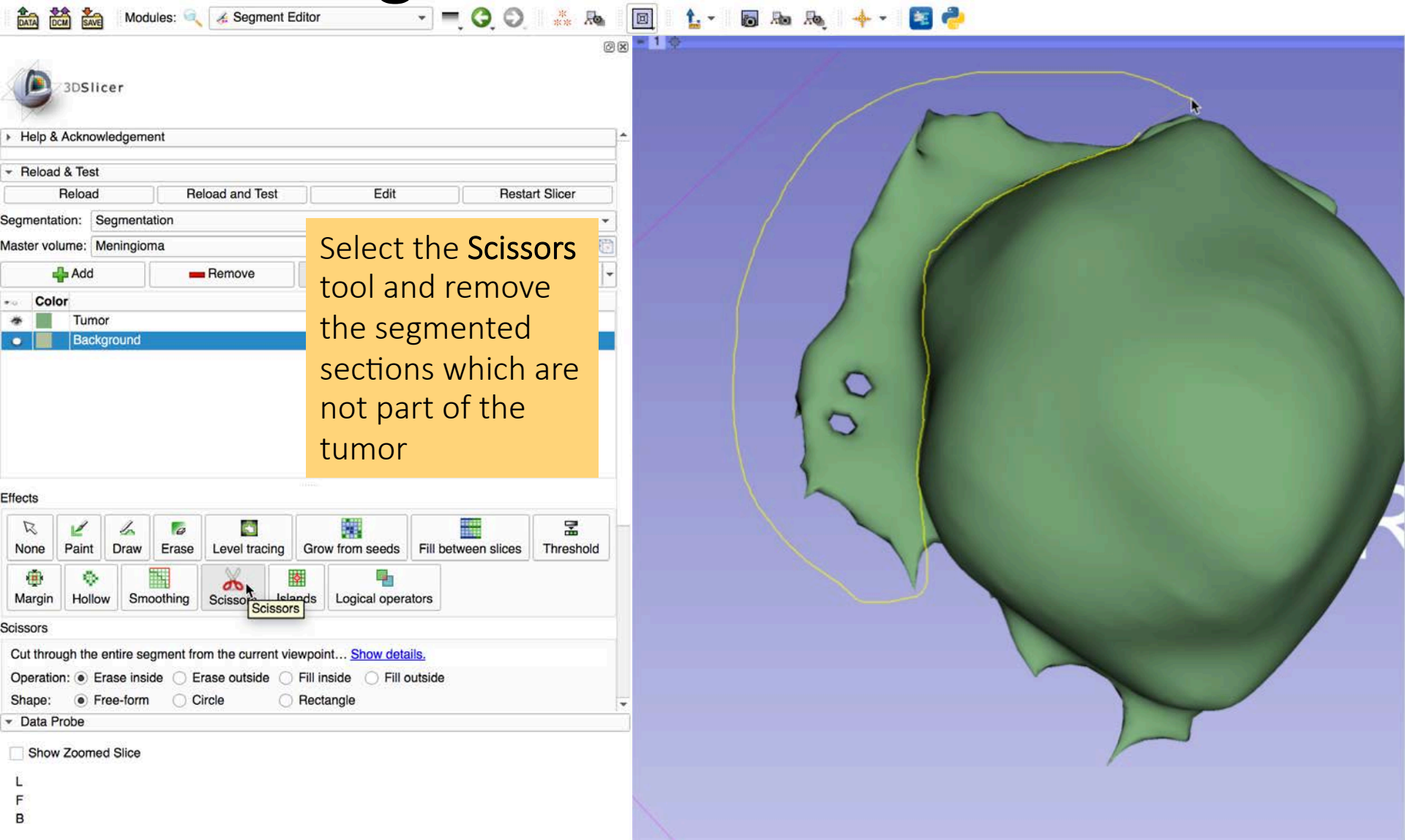
The screenshot displays the 3D Slicer Segment Editor module interface. On the left, the software's logo and a sidebar menu are visible, including sections for 'Help & Acknowledgement', 'Reload & Test' (with buttons for Reload, Reload and Test, Edit, and Restart Slicer), 'Segmentation' (set to Segmentation), and 'Master volume' (set to Meningioma). Below these are controls for adding and removing segments, a 'Show 3D' button, and a color selection table with 'Tumor' (green) and 'Background' (blue) options. The 'Effects' panel at the bottom left contains various tools like 'None', 'Paint', 'Draw', 'Erase', 'Level tracing', 'Grow from seeds', 'Fill between slices', 'Threshold', 'Margin', 'Hollow', 'Smoothing', 'Scissors', 'Islands', and 'Logical operators'. The main workspace is divided into three views: an axial view at the top, a sagittal view at the bottom left, and a coronal view at the bottom right. A 3D visualization of the segmented tumor is shown in the top right corner, with a light green box overlaid on it containing the text 'Slicer shows the segmentation result in 3D'. The top status bar shows the current slice position as S: 28.700mm, and the bottom status bar shows R: -6.953mm and A: 27.207mm.



# Segment Editor Module

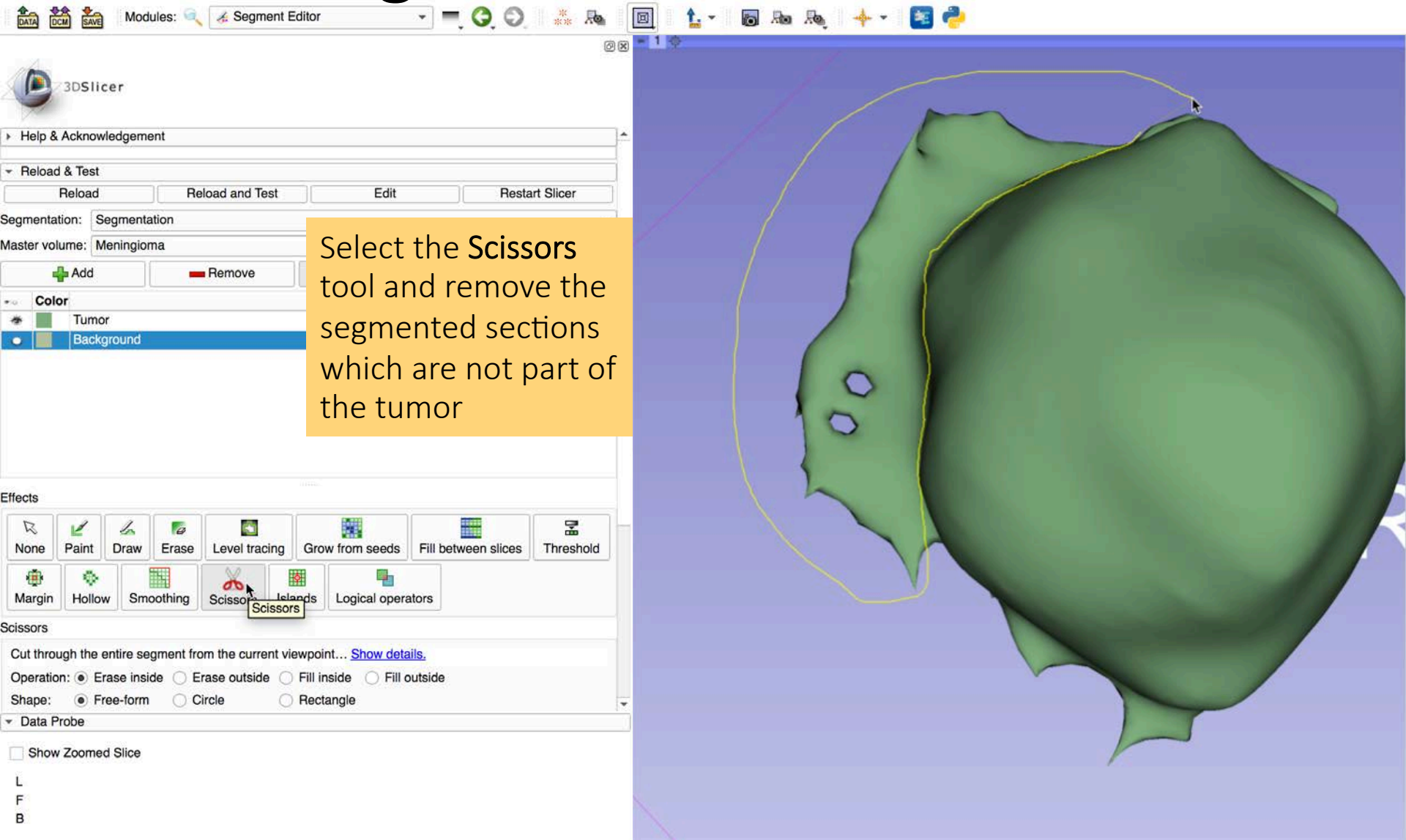


# Segment Editor Module





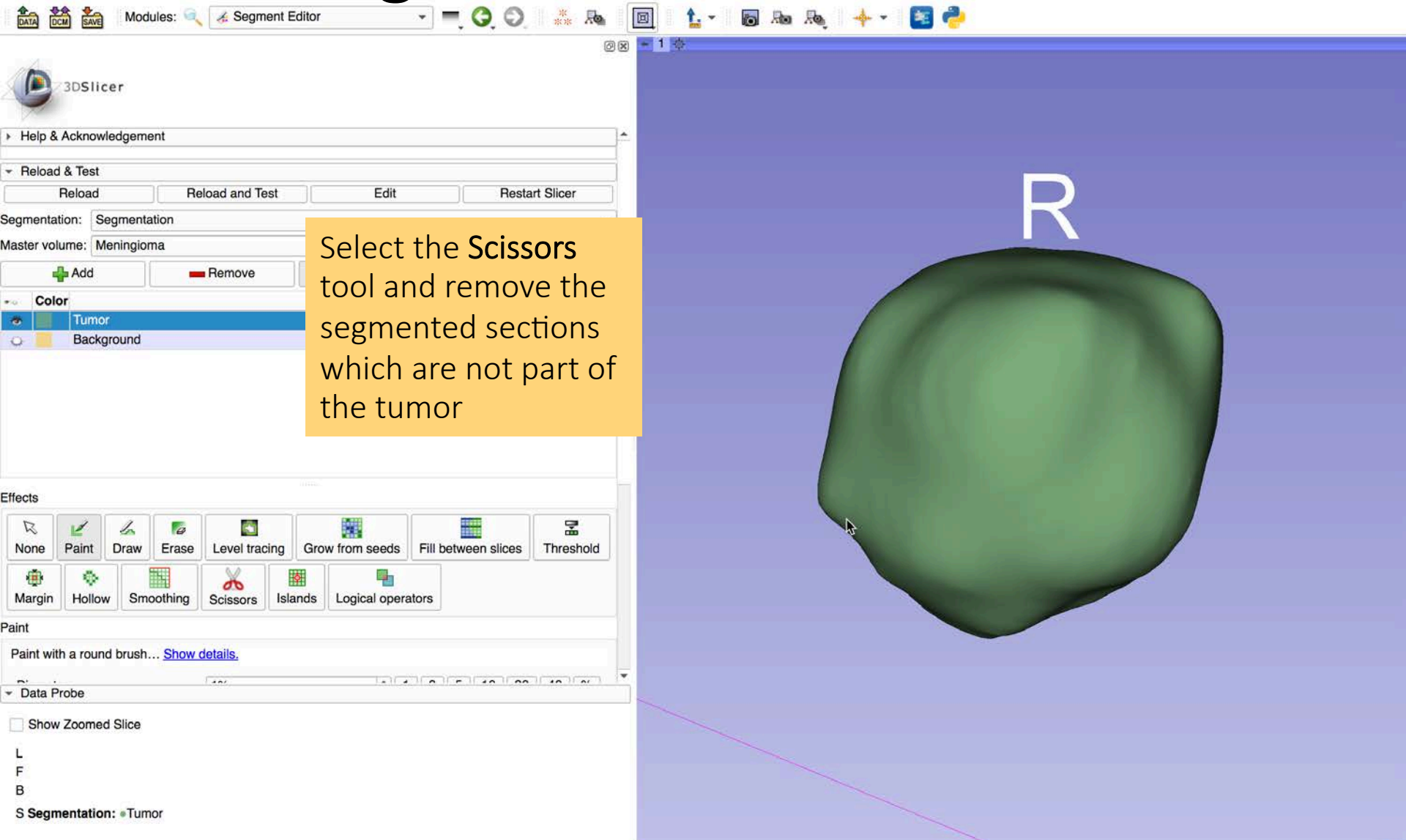
# Segment Editor Module

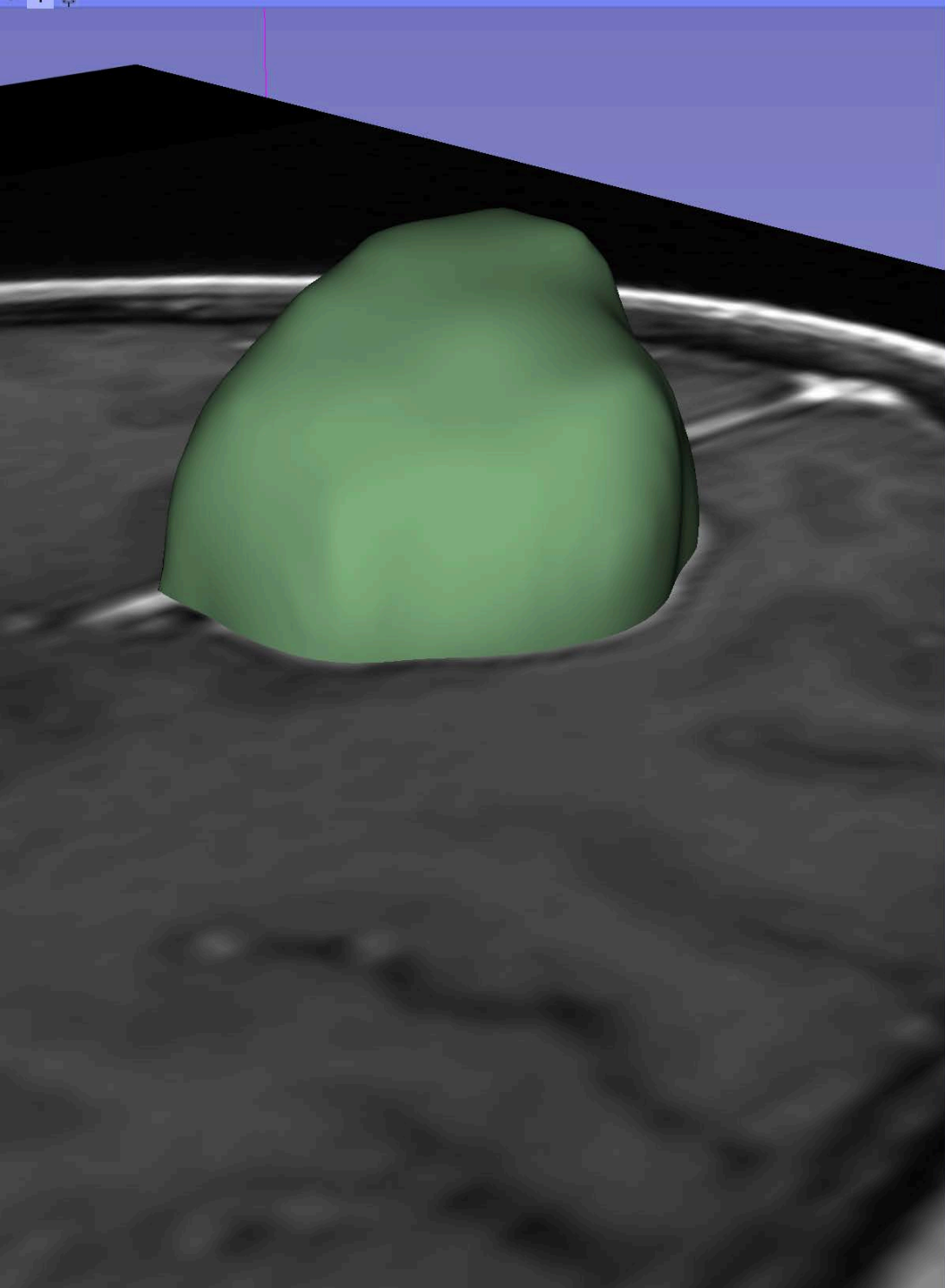


Select the Scissors tool and remove the segmented sections which are not part of the tumor



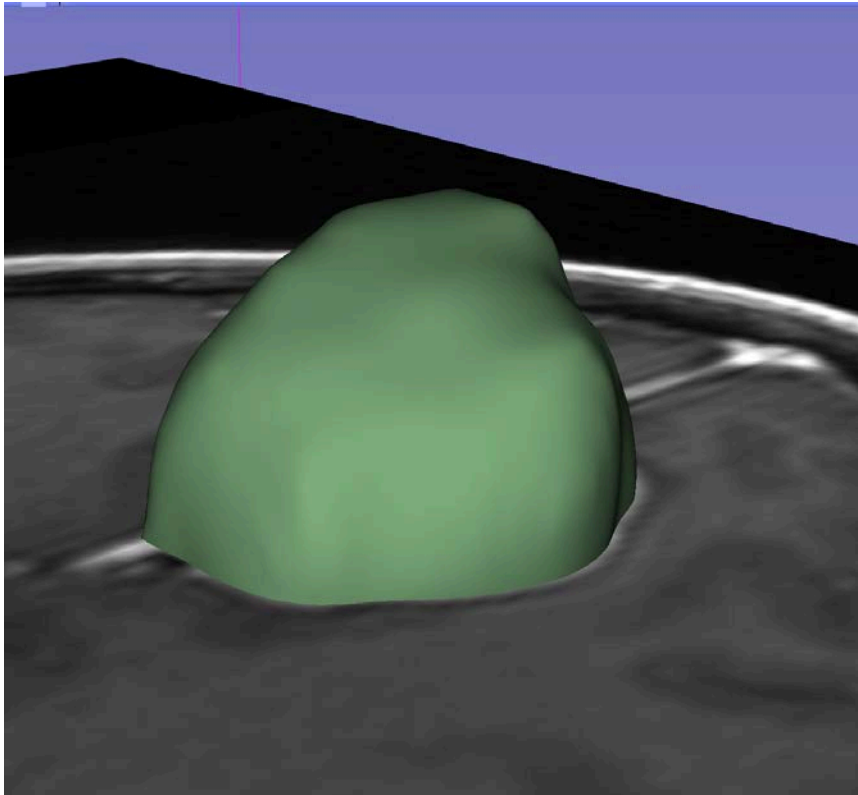
# Segment Editor Module





## Part 3: Tumor Volume Calculation

# 3D Measurements



This section shows how to compute the volume of the segmented tumor using the Segment Statistics module



# Tumor Measurements

The image shows the 3DSlicer software interface. On the left, the 'Modules' panel is open, showing a list of modules. The 'Quantification' category is expanded, and 'Segment Statistics' is highlighted. A yellow callout box points to this selection with the text: 'Select the Segment Statistics module in the Quantification category'. In the center, a 3D model of a brain slice is shown with a green tumor region. A large white letter 'R' is positioned above the tumor. At the bottom left, the 'Data Probe' panel is visible, showing 'Show Zoomed Slice' checked and 'Segmentation: Tumor' selected.

Select the **Segment Statistics** module in the **Quantification** category

R

None Paint Draw Erase  
Margin Hollow Smoothing

Segmentation: Tumor



# Tumor Measurements

DATA DCM SAVE Modules: Segment Statistics

3DSlicer

Help & Acknowledgement

Reload & Test

Reload Reload and Test Edit

SegmentStatistics

Inputs

Segmentation: Segmentation

Scalar volume: Meningioma

Output

Output table: Create new table

Advanced

Apply

Calculate Statistics.

Data Probe

Show Zoomed Slice

L

F

B

S Segmentation: Tumor

Select the Segmentation Segmentation

Select the Scalar Volume Meningioma



# Tumor Measurements

The screenshot displays the 3DSlicer software interface. The top toolbar includes icons for DATA, DCM, SAVE, and a Modules dropdown menu. The Segment Statistics module is active, showing a list of layout options. A red arrow points to the 'Conventional' layout option. The 'Apply' button is circled in red. The main 3D view shows a green tumor model with a white 'R' label. Below the 3D view are three 2D slice views (axial, sagittal, and coronal) and a color scale for Y, R, G, and A. The R value is 0.469mm and the A value is 27.481mm. The bottom left shows the Data Probe section with 'Show Zoomed Slice' checked and 'L', 'F', 'B' labels.

Modules: Segment Statistics

3DSlicer

Help & Acknowledgement

Reload & Test

Reload Reload and Test Edit Restart Slicer

SegmentStatistics

Inputs

Segmentation: Segmentation

Scalar volume: Meningioma

Output

Output table: Table

Advanced

Apply

Conventional

Conventional Widescreen

Conventional Quantitative

Four-Up

Four-Up Table

Four-Up Quantitative

Dual 3D

Triple 3D

3D only

3D Table

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

Three by three slice

R

Y R: 0.469mm G A: 27.481mm

Data Probe

Show Zoomed Slice

L

F

B

Select the  
Conventional layout  
and click on Apply



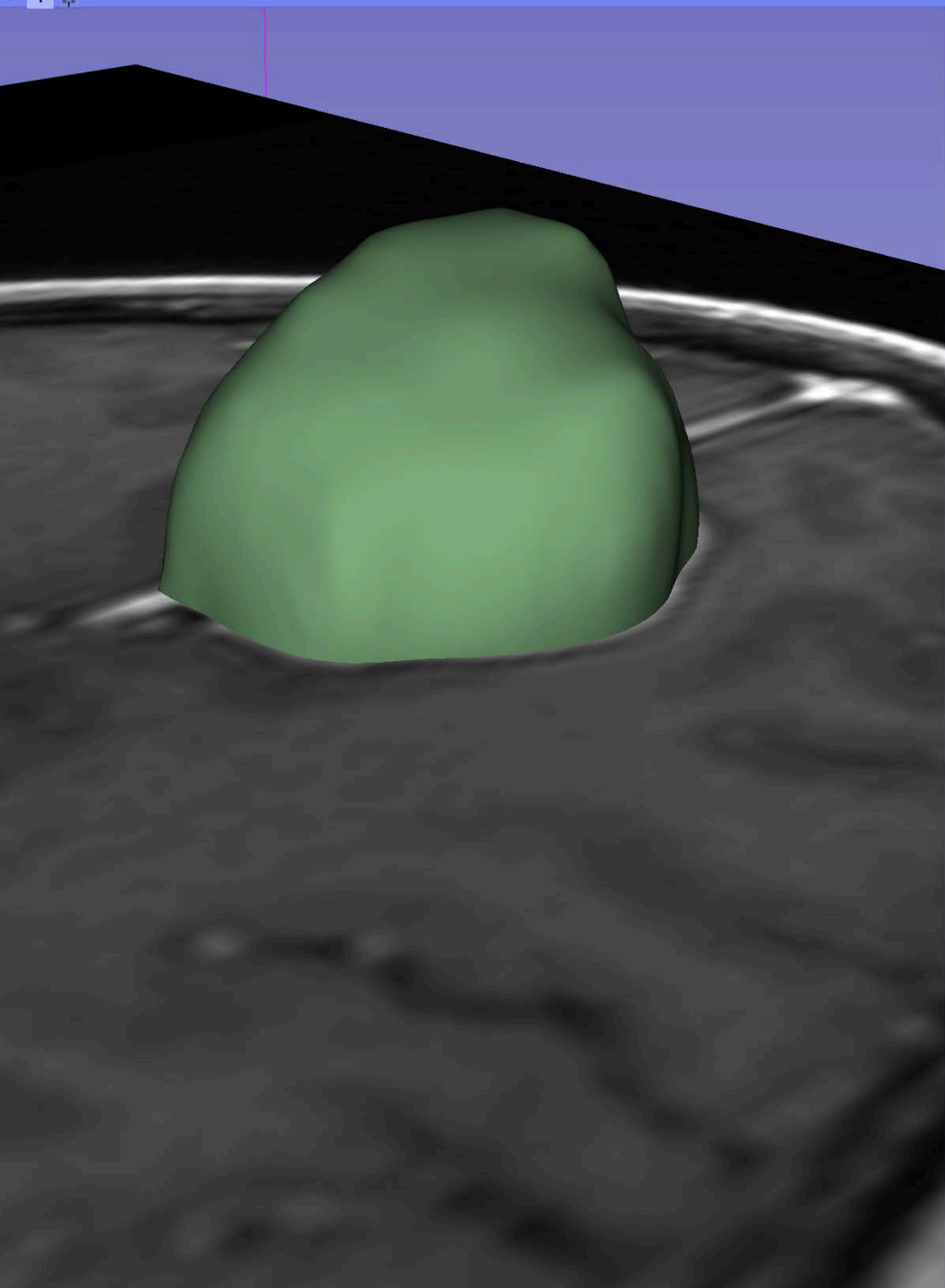
# Tumor Measurements

The screenshot displays the 3D Slicer interface with a brain MRI scan. A tumor is segmented in green. The software shows three orthogonal views: axial, sagittal, and coronal. The axial view includes a 3D model of the tumor. The sagittal view shows a yellow line indicating a measurement of 0.469mm. The coronal view shows a green line indicating a measurement of 27.481mm. The Segment Statistics panel on the left shows the segmentation type as 'Segmentation' and the scalar volume as 'Meningioma'. The 'Apply' button is visible. A table at the bottom right provides detailed statistics for the tumor segment.

	A	B	C	D	E	F
1 Segment	Number of voxels [voxels] (1)	Volume [mm3] (1)	Volume [cm3] (1)	Number of voxels [voxels] (2)	Volume [mm3] (2)	
2 Tumor	13859	17053.1	17.0531	13859	17053.1	

Slicer displays the computed tumor volume: 17.053 cm<sup>3</sup>





## Part 4: Quantitative Imaging features computation



# PyRadiomics package

- **Pyradiomics** is an open source python package that enables the automated extraction of over 1,500 quantitative features from medical imaging data.
- The package includes tools for image pre-processing and filtering based on SimpleITK
- Pyradiomics command line tools enable batchprocessing

<https://pyradiomics.readthedocs.io>

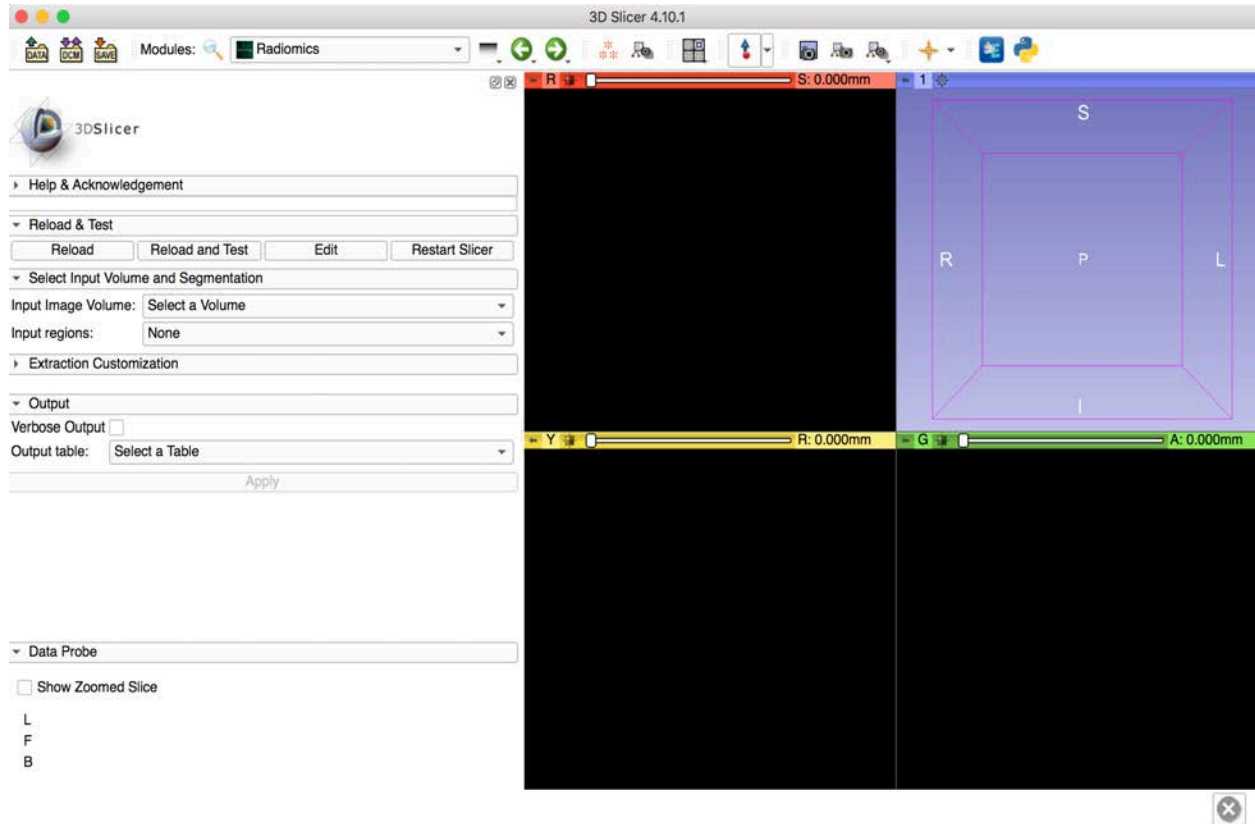
<http://www.radiomics.io/>

*van Griethuysen, J. J. M., Fedorov, A., Parmar, C., Hosny, A., Aucoin, N., Narayan, V., Beets-Tan, R. G. H., Fillon-Robin, J. C., Pieper, S., Aerts, H. J. W. L. (2017). Computational Radiomics System to Decode the Radiographic Phenotype. Cancer Research, 77(21), e104–e107.*





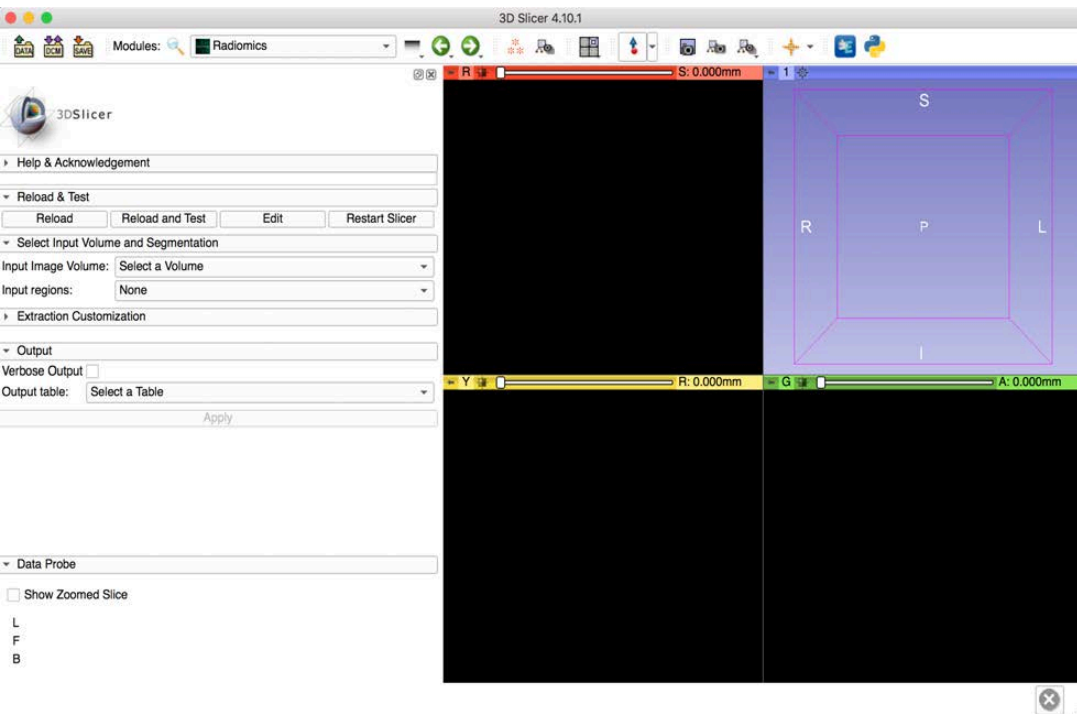
# Slicer Radiomics



The **Slicer Radiomics** extension provides a graphical user interface to the pyradiomics library



# Slicer Radiomics



The Slicer Radiomics Extension enables interactive imaging features exploration and configuration of extraction parameters

# Radiomics Module

Left click on the module **Data** to display the list of modules

3DSlicer

Modules: Data

Help & Acknowledgement

Subject hierarchy Transform hierarchy All nodes

Node

Show transforms  Show MRML ID's

Subject hierarchy item information

Filter:

MRML node information

Data Probe

Green (L 32.0, A 0.0, S 15.7) Coronal Sp: 1.0

L None

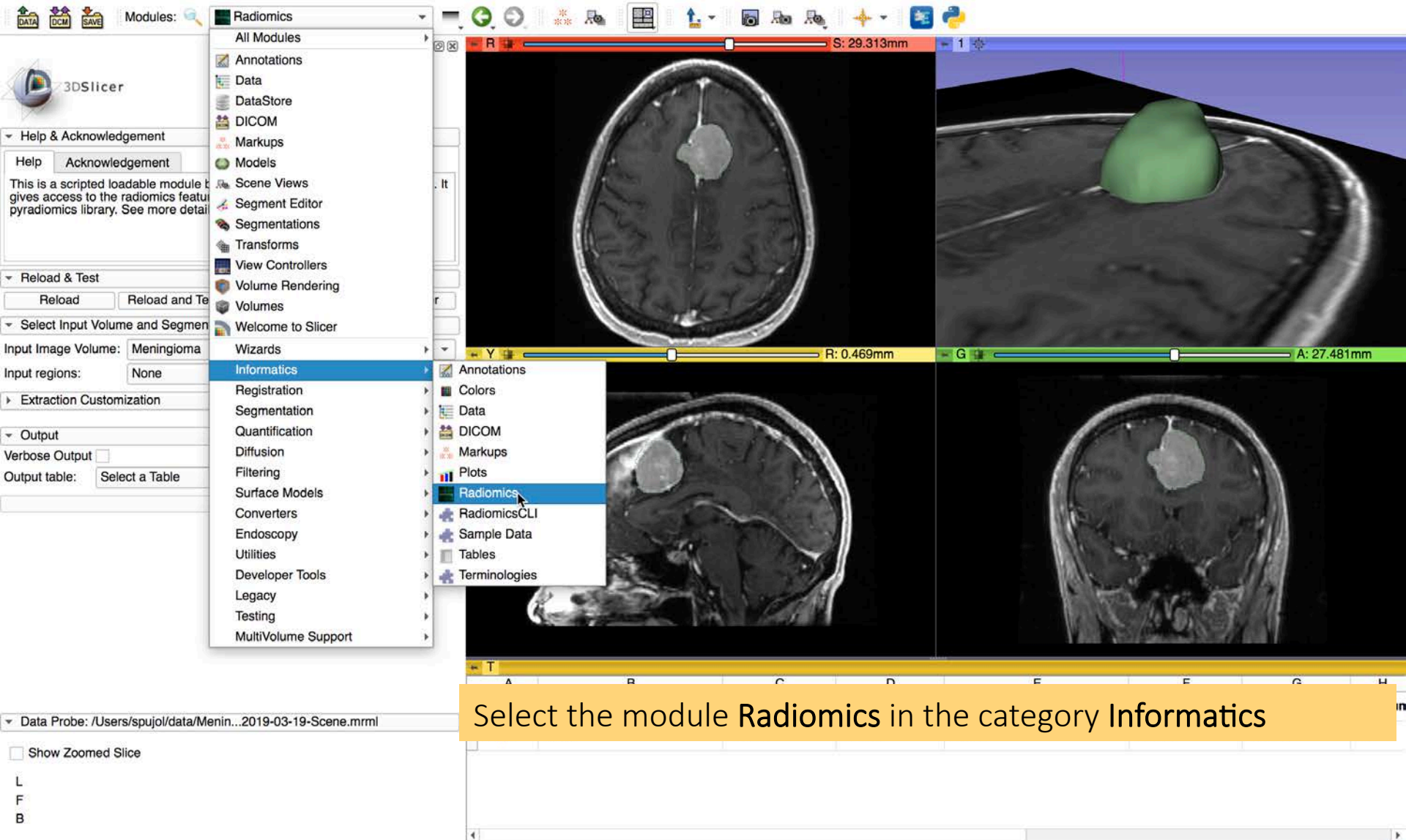
F None

B None

R S: 0.000mm Y R: 0.000mm G A: 0.000mm



# Radiomics Module Installation



# Radiomics Module Installation

The screenshot shows the 3DSlicer Radiomics module interface. The top toolbar includes icons for DATA, DCM, SAVE, and a Modules dropdown menu with 'Radiomics' selected. The main window is divided into three panes: a central axial MRI slice, a right-side 3D visualization of a green meningioma with an 'R' label, and a bottom row of two sagittal MRI slices. The left sidebar contains the Radiomics configuration panel with sections for 'Help & Acknowledgement', 'Reload & Test', 'Select Input Volume and Segmentation', 'Extraction Customization', 'Resampling and Filtering', 'Settings', and 'Output'. A yellow callout box is overlaid on the 'Select Input Volume and Segmentation' section, and another is overlaid on the 'Extraction Customization' section. A third yellow callout box is overlaid on the 'Output' section.

Select the Image Volume Meningioma  
Select the Input Regions Segmentation

Select the feature class First Order and glcm

Select Output Table → Create New and click on Apply





# Features Computation

3DSlicer

Modules: Radiomics

Input Image Volume: Meningioma  
Input regions: Segmentation

Extraction Customization

Manual Customization

Feature Classes

Features:  gldm  shape2D  glcm  shape  firstorder  glrlm  glszm

Toggle Features:

Resampling and Filtering

Resampled voxel size:

LoG kernel sizes:

Wavelet-based features:

Settings

Bin Width:

Enforce Symmetrical GLCM:

Output

Verbose Output:

Output table:

Apply

Data Probe: /Users/spujol/data/Menin...2019-03-19-Scene.mrml

Show Zoomed Slice:

L  
F  
B

Slicer displays the result of the features computation

	A	B	C	D	E
1	Image type	Feature Class	Feature Name	Segmentation_segment_Tu...	Segmentation_segme
2	diagnostics	Versions	PyRadiomics	2.1.2.post58+g6d385a1	2.1.2.post58+g6d385a
3	diagnostics	Versions	Numpy	1.13.1	1.13.1
4	diagnostics	Versions	SimpleITK	1.1.0	1.1.0
5	diagnostics	Versions	PyWavelet	1.0.0	1.0.0
6	diagnostics	Versions	Python	2.7.13	2.7.13
7	diagnostics	Configuration	Settings	{'distances': [1], 'additionalInfo': True, 'force2D': False, 'interpol...	{'distances': [1], 'additio... True, 'force2D': False, '...
8	diagnostics	Configuration	EnabledImageTypes	{'u'Original': {}}	{'u'Original': {}}
9	diagnostics	Image-original	Hash	d96124aaa2dcfd45fa2b4b80f6...	d96124aaa2dcfd45fa2...



# Features Computation

Slicer displays the values of the 18 features for the **FirstOrder** class

34	original	firstorder	InterquartileRange	20.0
35	original	firstorder	Skewness	1.99316623652
36	original	firstorder	Uniformity	0.358800750225
37	original	firstorder	Median	177.0
38	original	firstorder	Energy	453513881.0
39	original	firstorder	RobustMeanAbsoluteDeviation	9.02739158026
40	original	firstorder	MeanAbsoluteDeviation	15.6561086211
41	original	firstorder	TotalEnergy	558034658.262
42	original	firstorder	Maximum	370.0
43	original	firstorder	RootMeanSquared	180.8961587
44	original	firstorder	90Percentile	202.0
45	original	firstorder	Minimum	36.0
46	original	firstorder	Entropy	1.83048891173
47	original	firstorder	Range	334.0
48	original	firstorder	Variance	575.802209976
49	original	firstorder	10Percentile	156.0
50	original	firstorder	Kurtosis	12.4315749384
51	original	firstorder	Mean	179.297568367

# Conclusion

- This tutorial provides a basic introduction to image phenotyping using the Slicer Radiomics extension.
- The extension enables the computation of feature classes implemented in pyradiomics
- The description of each class is available at <https://pyradiomics.readthedocs.io/>

# Acknowledgments: Neuroimaging Analysis Center



The mission of the Neuroimage Analysis Center (NAC) (NIH P41 EB015902)

is to advance the role of neuroimaging in health care.