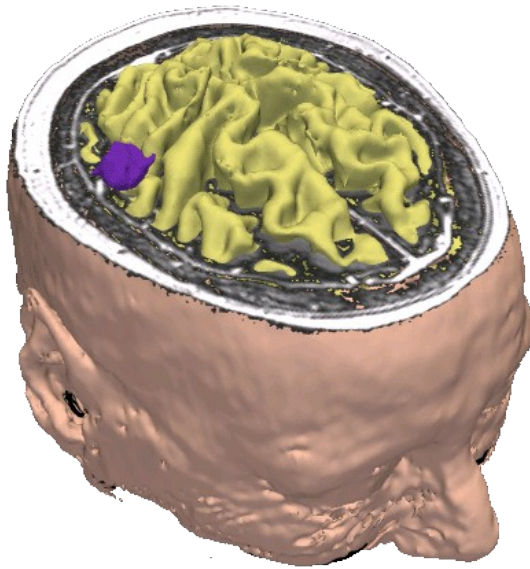


## Measuring Volume Change in Tumors



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Ender Konugolu, Ph.D.

Andriy Fedorov, Ph.D.

This course requires the following installation:

- 3DSlicer version 3.6 Software, which can be installed from:

<http://www.slicer.org/pages/Special:SlicerDownloads>

- A reliable internet connection for downloading the data

## Disclaimer

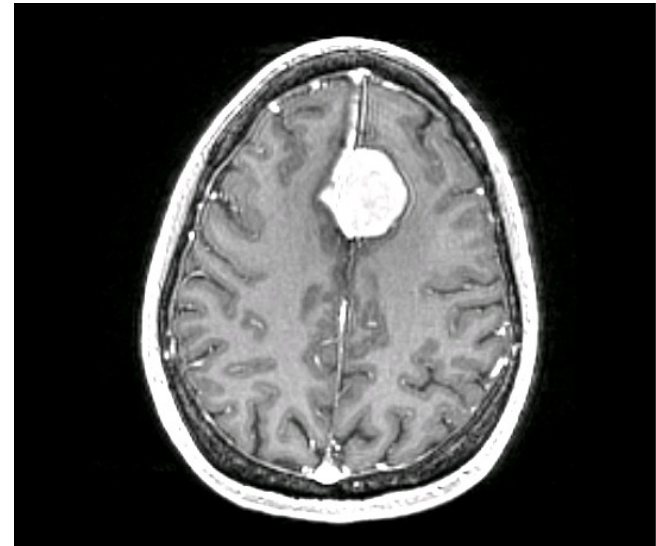
It is the responsibility of the user of 3DSlicer to comply with both the terms of the license and with the applicable laws, regulations and rules.

The module described in this tutorial was tested on Axial 3D SPGR T1 post Gadolinium scans (Voxel dimension: 0.94mm x 0.94mm x 1.20mm, FOV: 240mm, Matrix: 256 x 256)

This course is built upon two scans of a patient with meningioma:



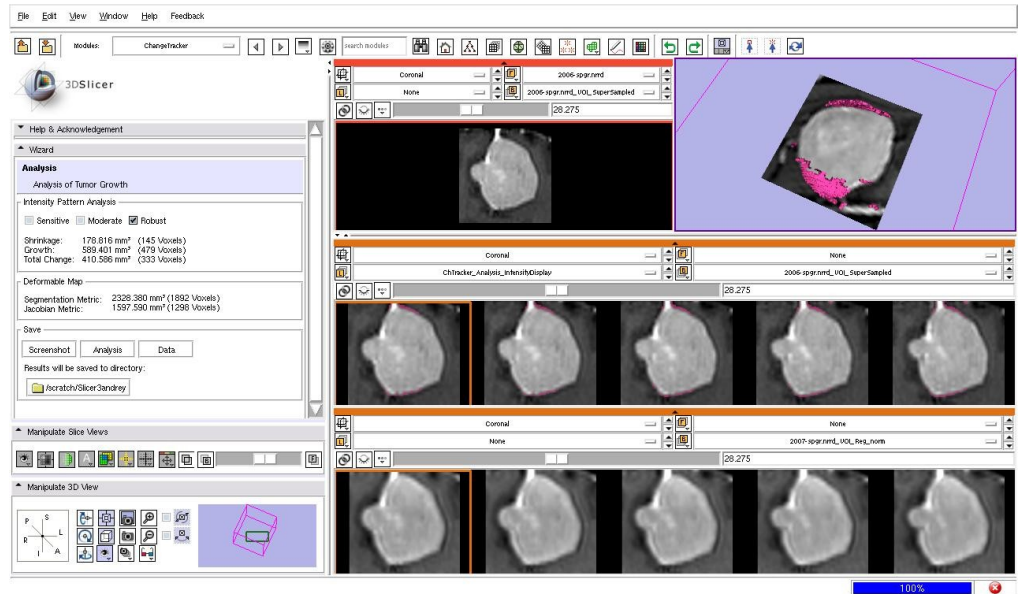
MR Scan 1

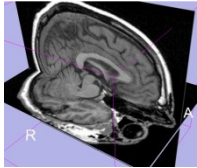


MR Scan 2

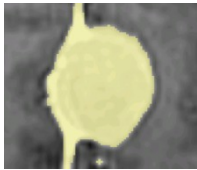
# Learning objective

Following this tutorial, you'll be able to **load two scans** into Slicer3, and **measure and visualize the change in volume** of the meningioma between the two scans.

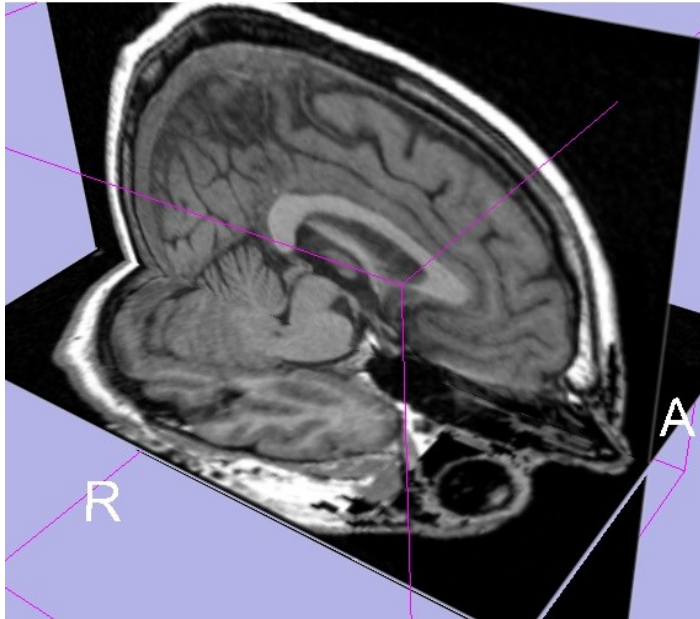




- Loading tutorial data



- Measuring volume change in tumors

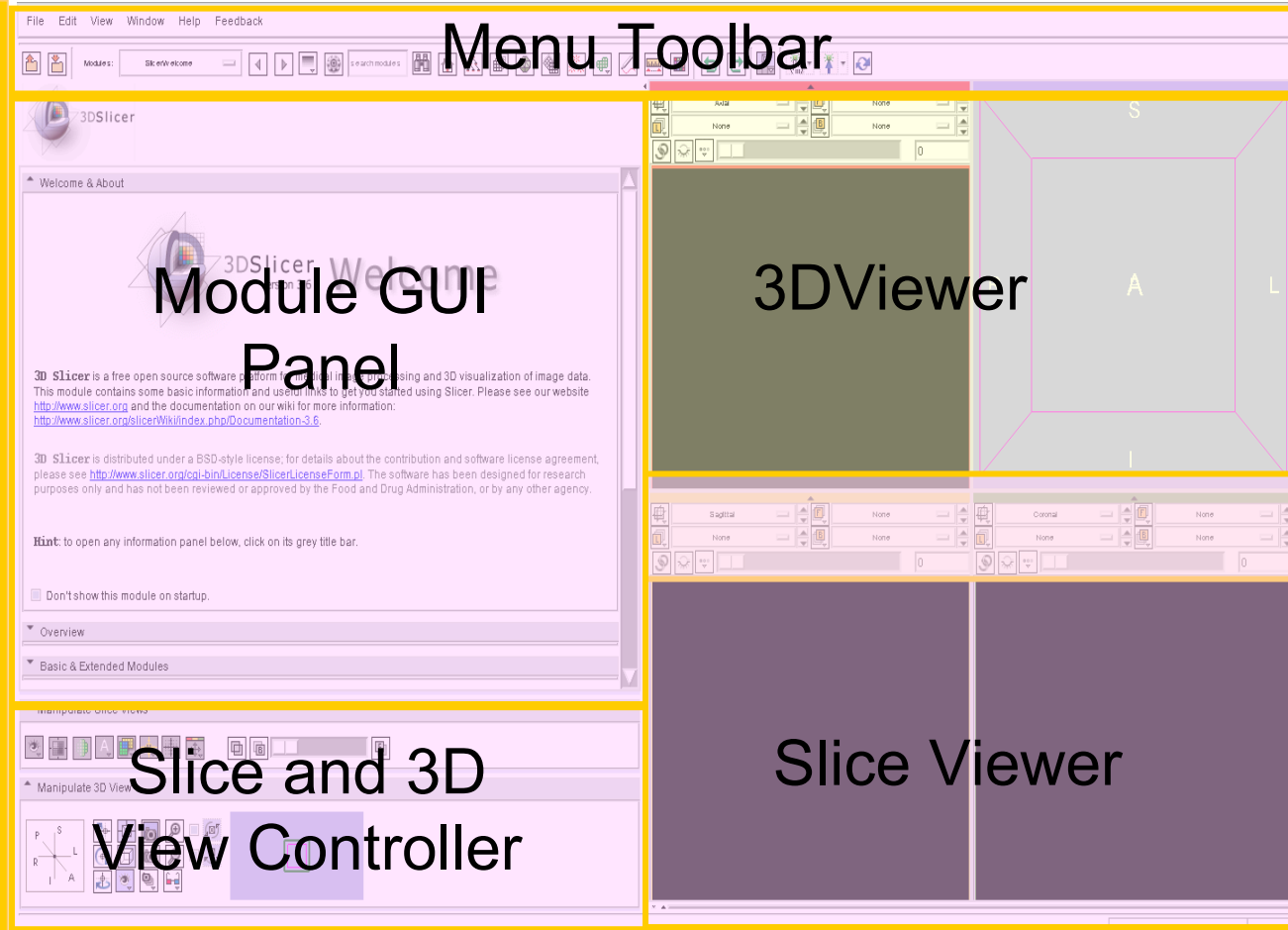


## Part 1: Loading the tutorial data

# Slicer3 GUI

The Graphical User Interface (GUI) of Slicer3 integrates five components:

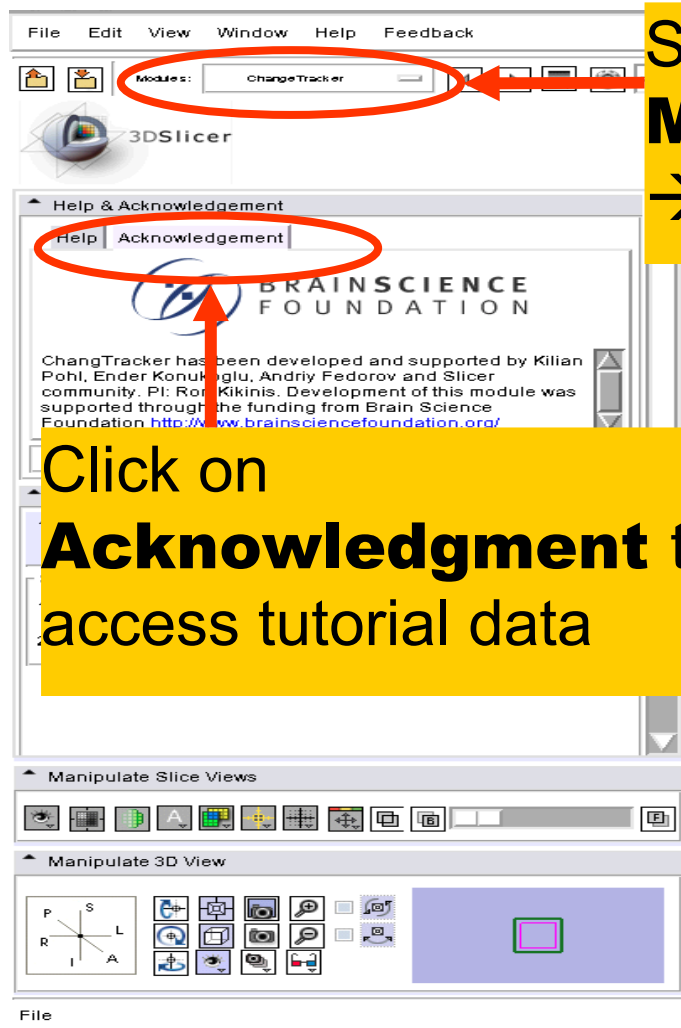
- the Menu Toolbar
- the Module GUI Panel
- the 3D Viewer
- the Slice Viewer
- the Slice and 3D View Controller



Slide courtesy of Sonia Pujol, Ph.D.



# Loading training dataset



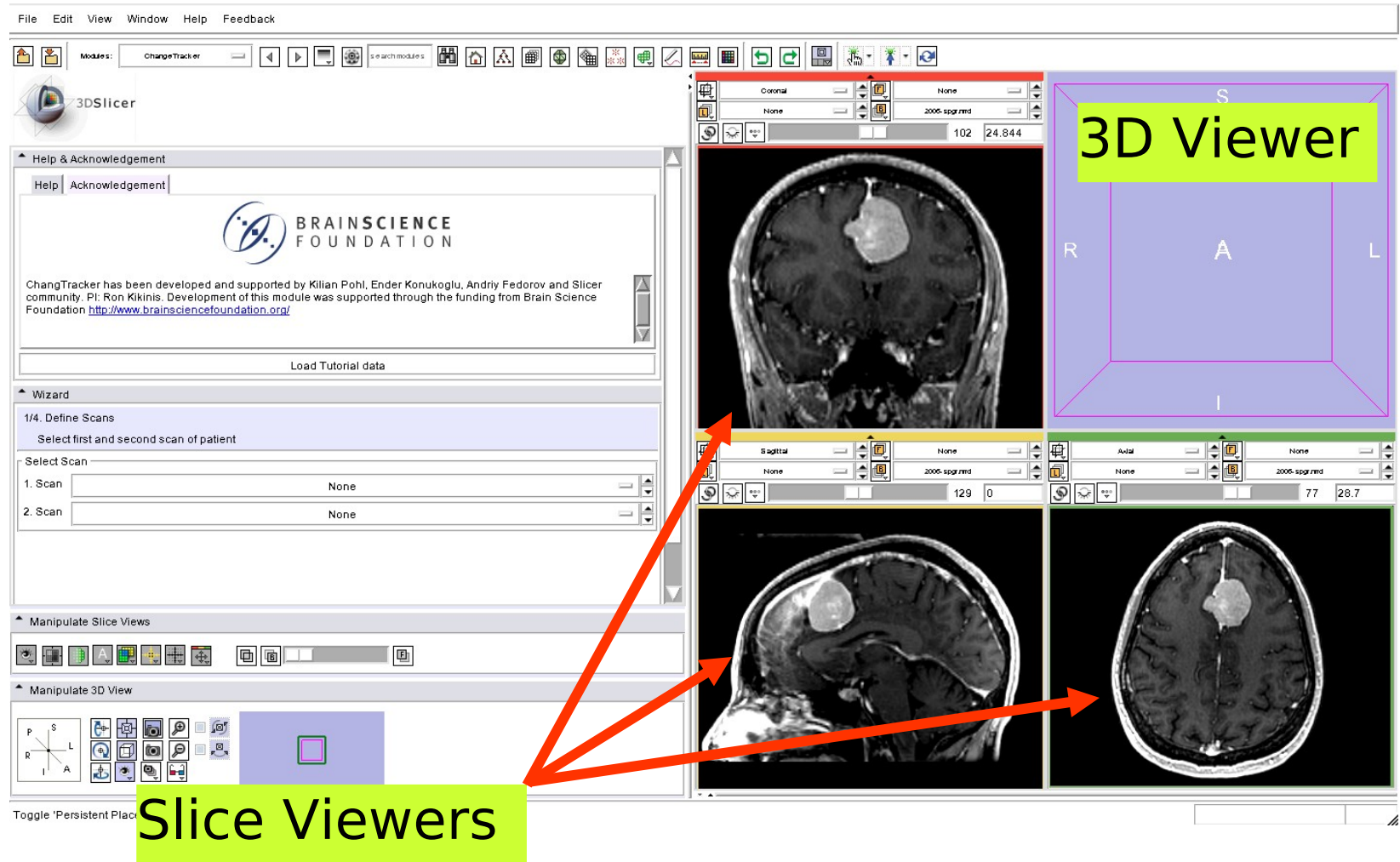
Select  
**Modules** → **Wizards**  
→ **ChangeTracker**

Click on  
**Acknowledgment** to  
access tutorial data

Press **Load Tutorial Data** button to load the training images



# New Layout of Viewer



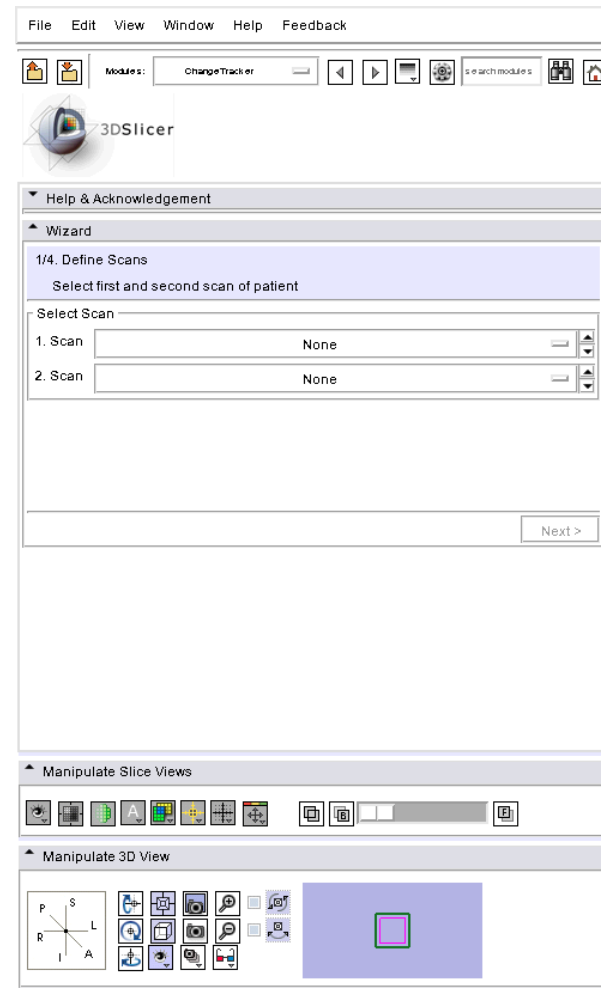


## Part 2: Measuring Volume Change

# Workflow Wizard

The Workflow Wizard of Slicer3 guides the user through a sequence of steps and is defined by the following components:

- the Step Panel
- the User Panel
- the Navigation Panel





Click Next

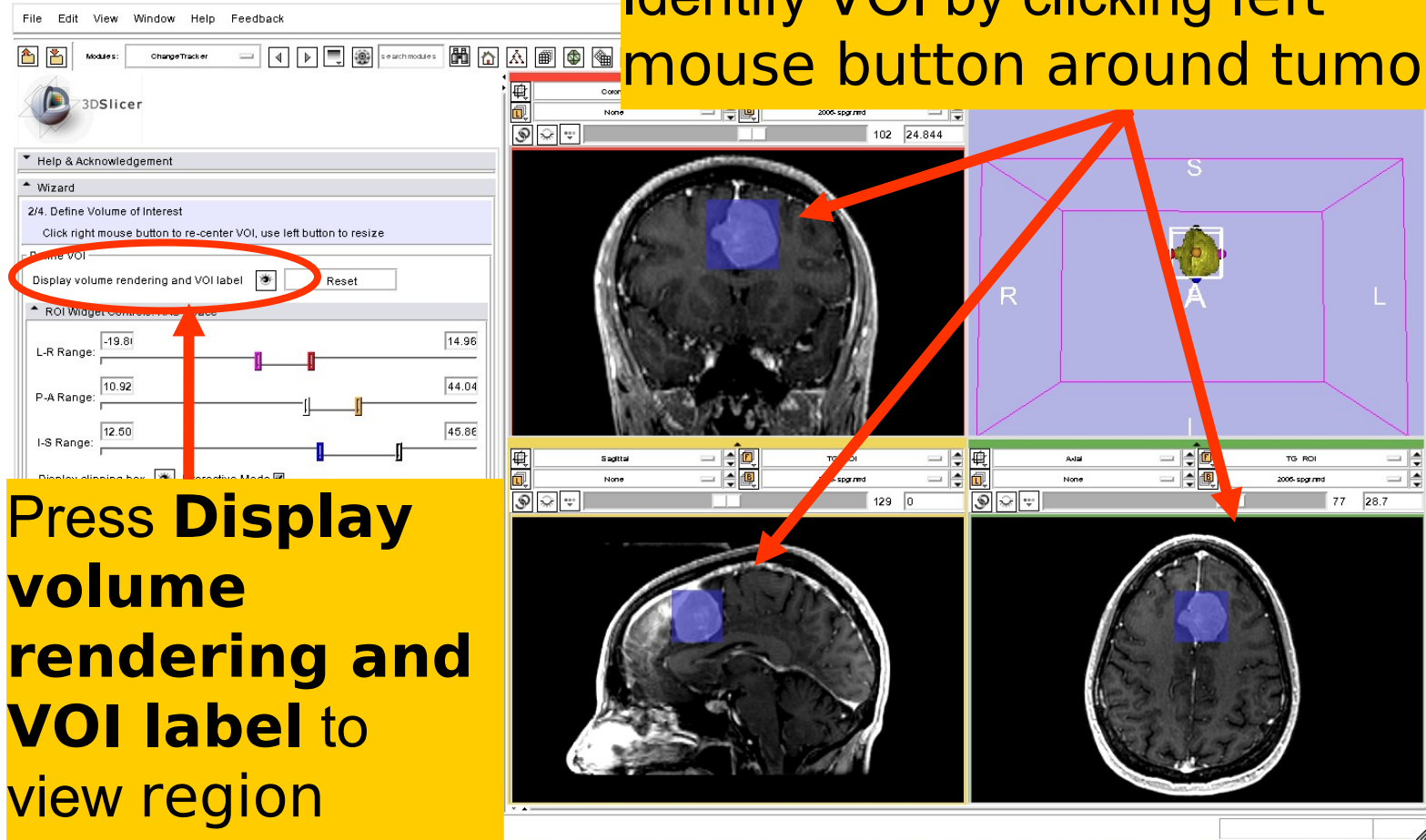


# Identify Volume of Interest



# Identify Volume of Interest

Identify VOI by clicking left mouse button around tumor

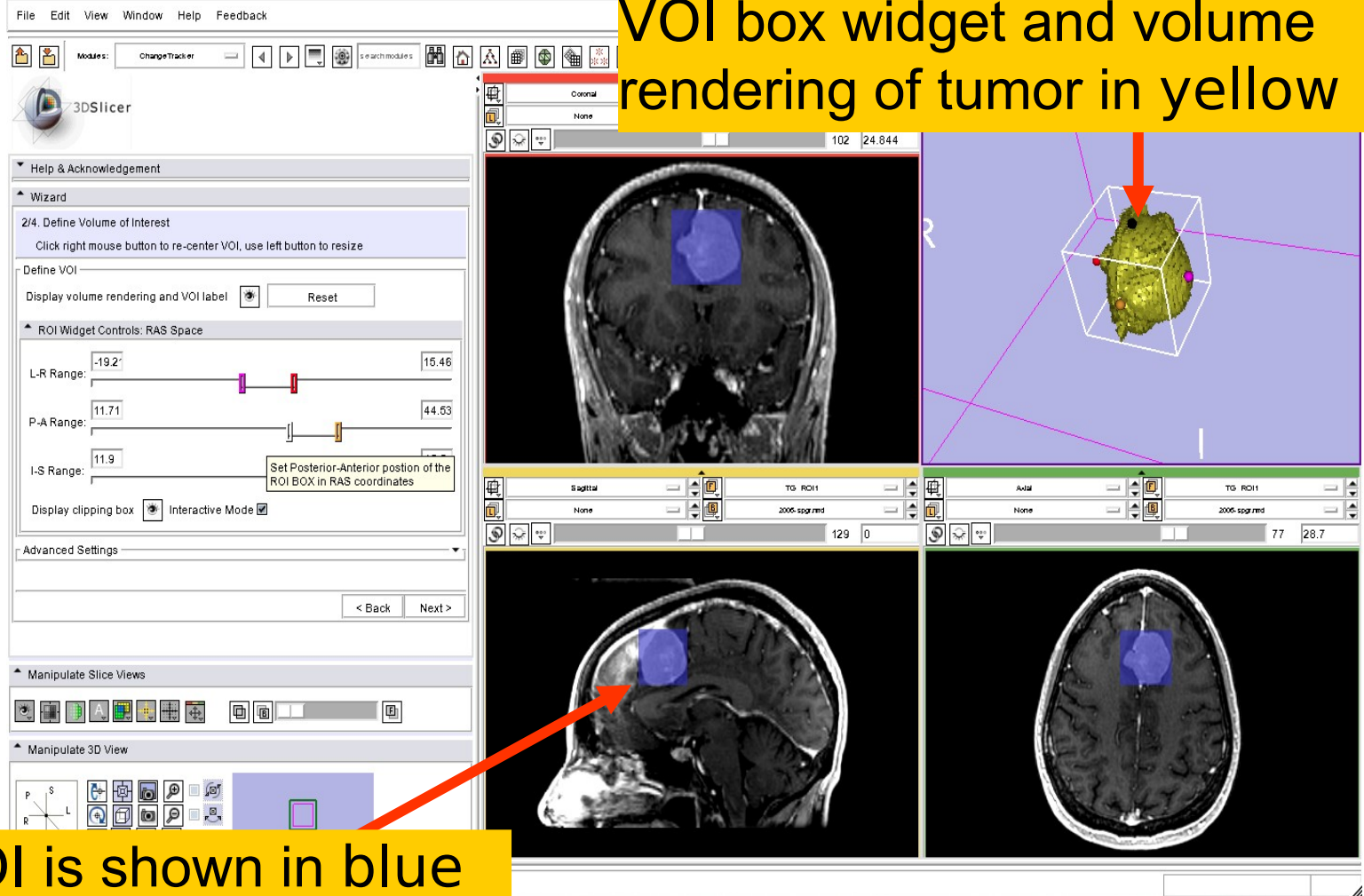


Press **Display volume rendering and VOI label** to view region



# Identify Volume of Interest

VOI box widget and volume rendering of tumor in yellow

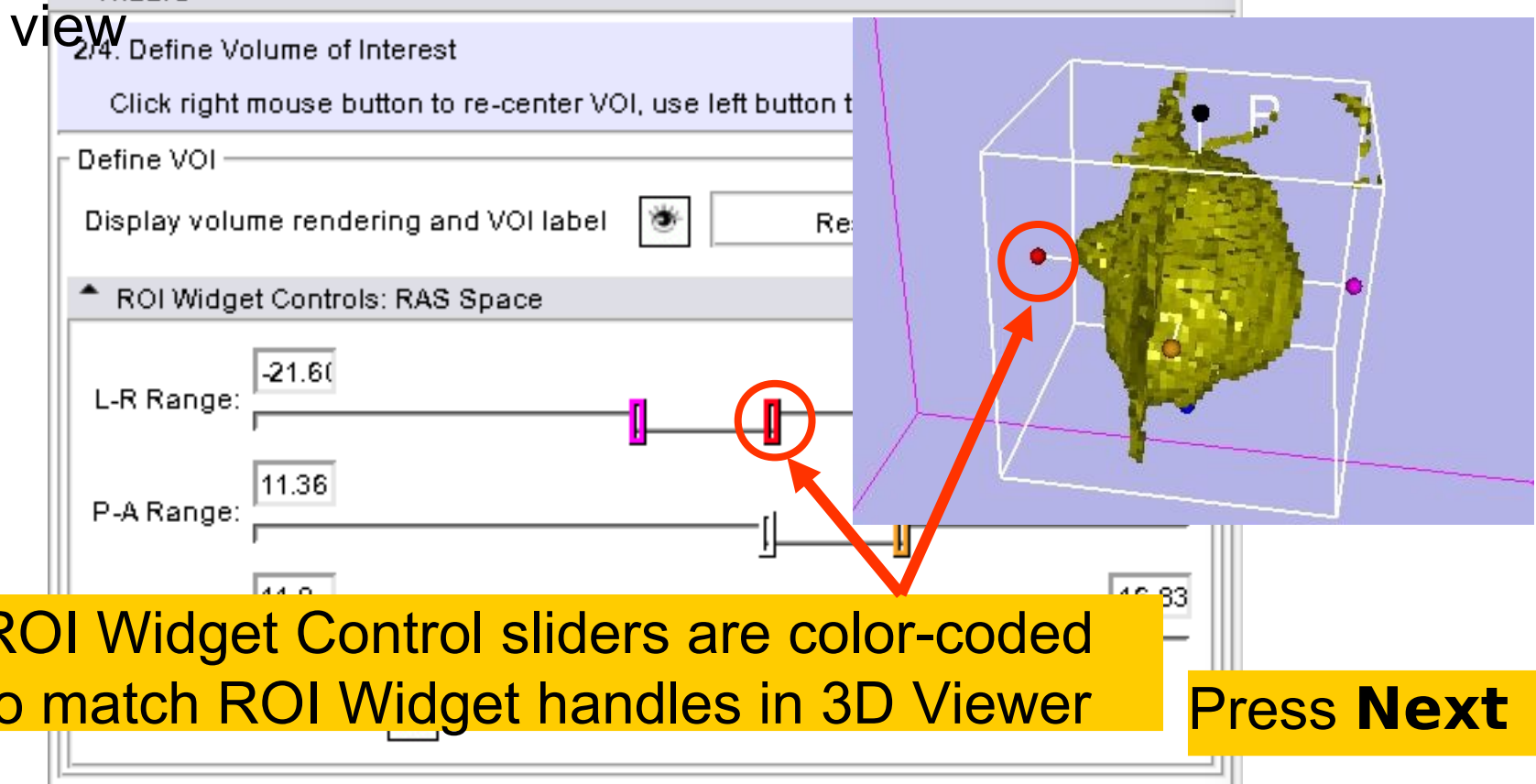


VOI is shown in blue



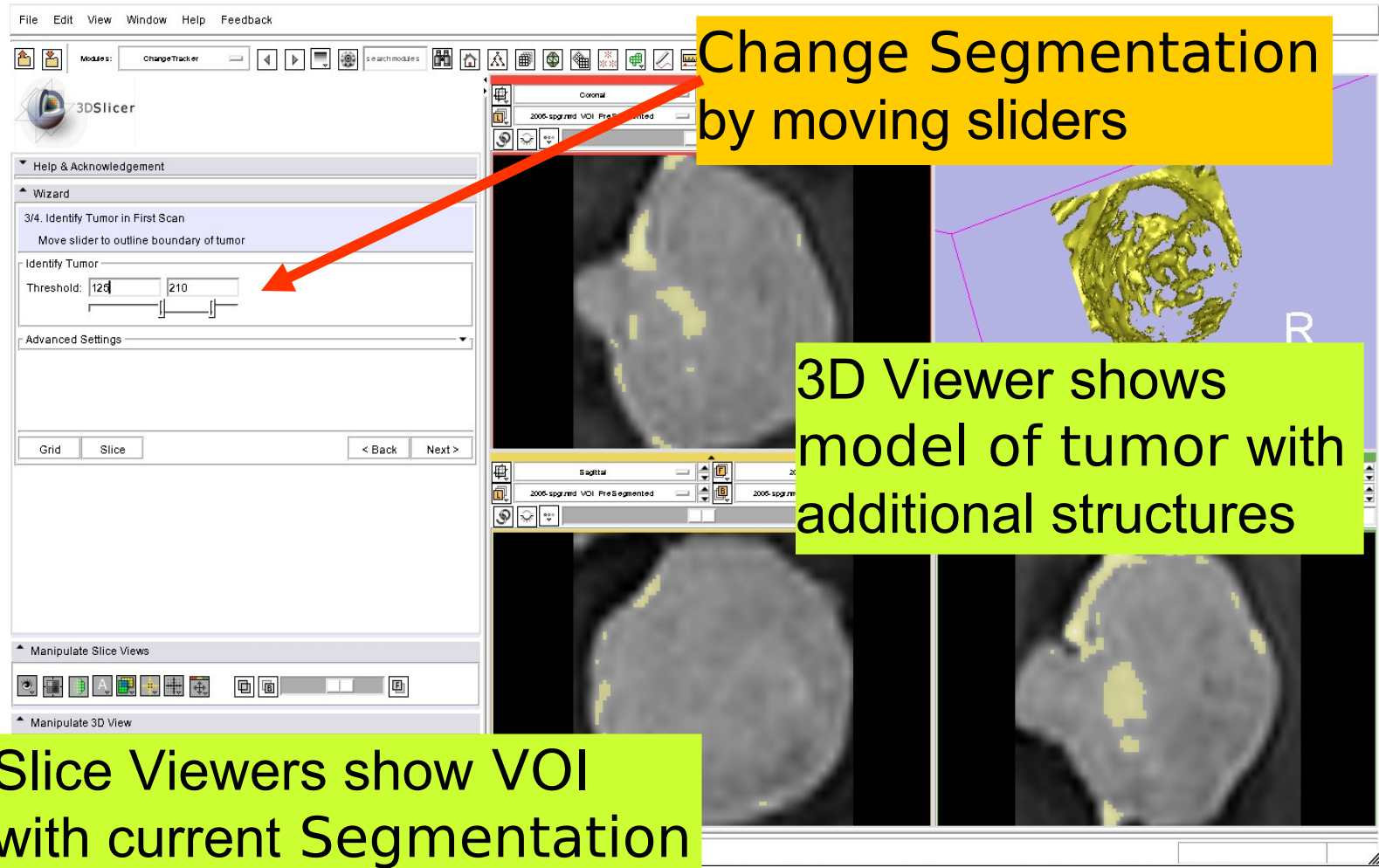
# Identify Volume of Interest

Adjust ROI by moving the **ROI Widget Control sliders** in the Step panel, or by moving the ROI Widget handles in 3D view





# Segment Tumor



The screenshot displays the 3DSlicer software interface. On the left, the 'Wizard' panel is active, showing the '3/4. Identify Tumor in First Scan' step. It includes a 'Threshold' slider set between 125 and 210. A red arrow points from a yellow text box to this slider. Below the threshold, there are 'Grid' and 'Slice' buttons, and '< Back' and 'Next >' navigation buttons. The main 3D viewer on the right shows a coronal slice of a brain with a yellow segmented tumor. A yellow text box points to this 3D view. Below the 3D view, two slice viewers (axial and sagittal) show the same tumor segmentation. A yellow text box points to these slice viewers. The top of the interface shows a menu bar (File, Edit, View, Window, Help, Feedback) and a toolbar with various icons.

Change Segmentation by moving sliders

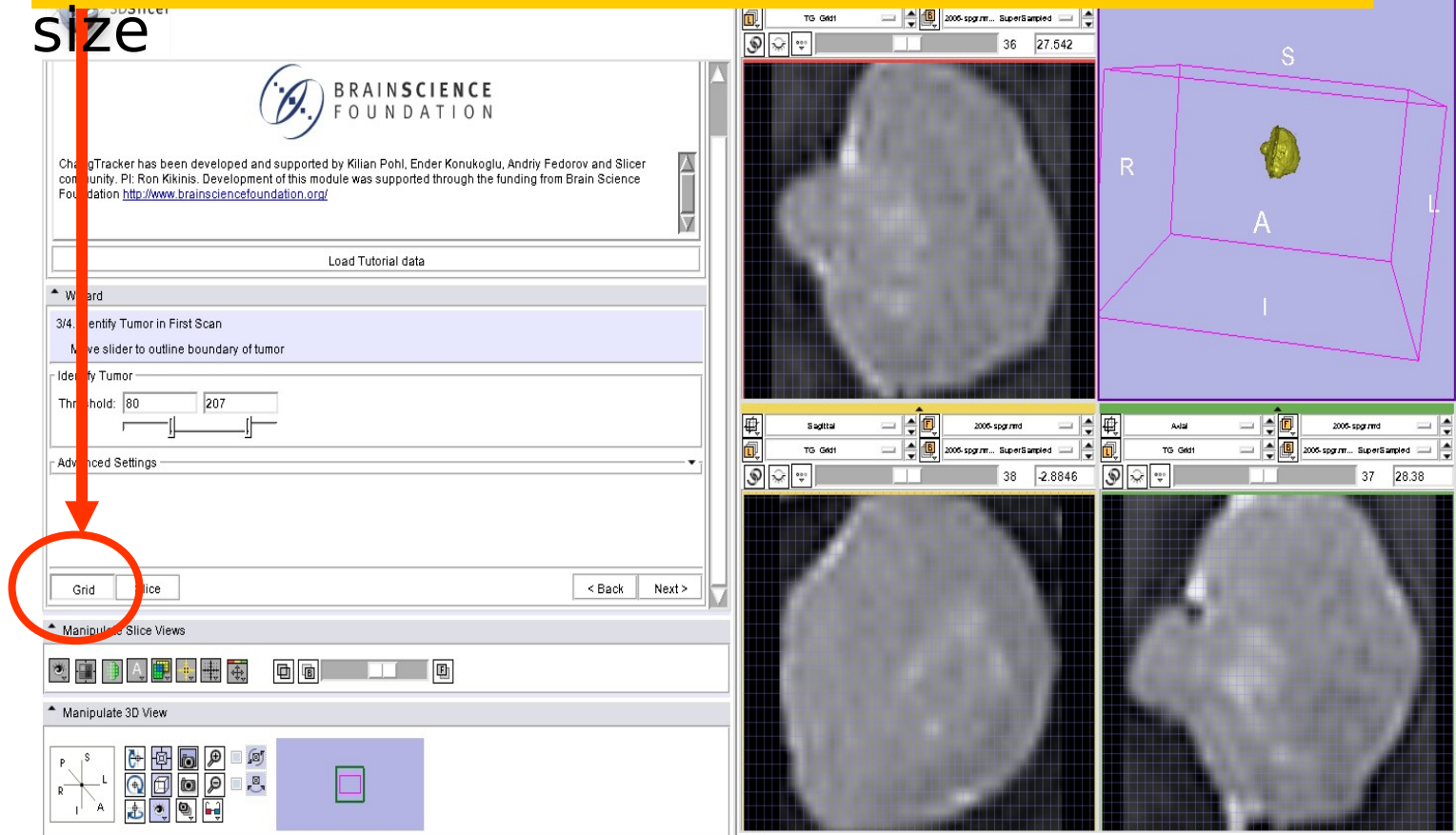
3D Viewer shows model of tumor with additional structures

Slice Viewers show VOI with current Segmentation

# Segment Tumor

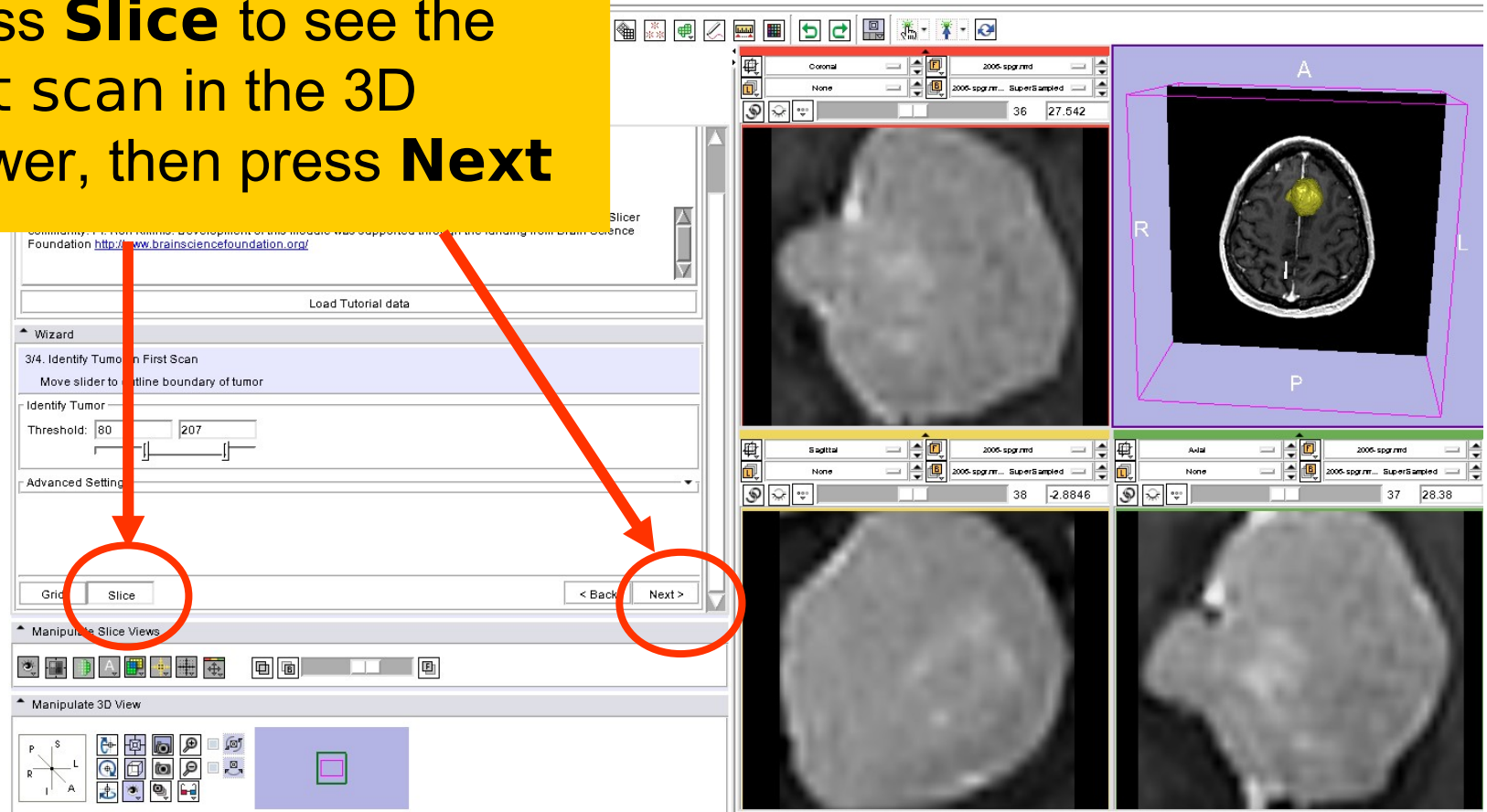
Press **Grid** to view grid with original voxel

size



# Segment Tumor

Press **Slice** to see the first scan in the 3D Viewer, then press **Next**

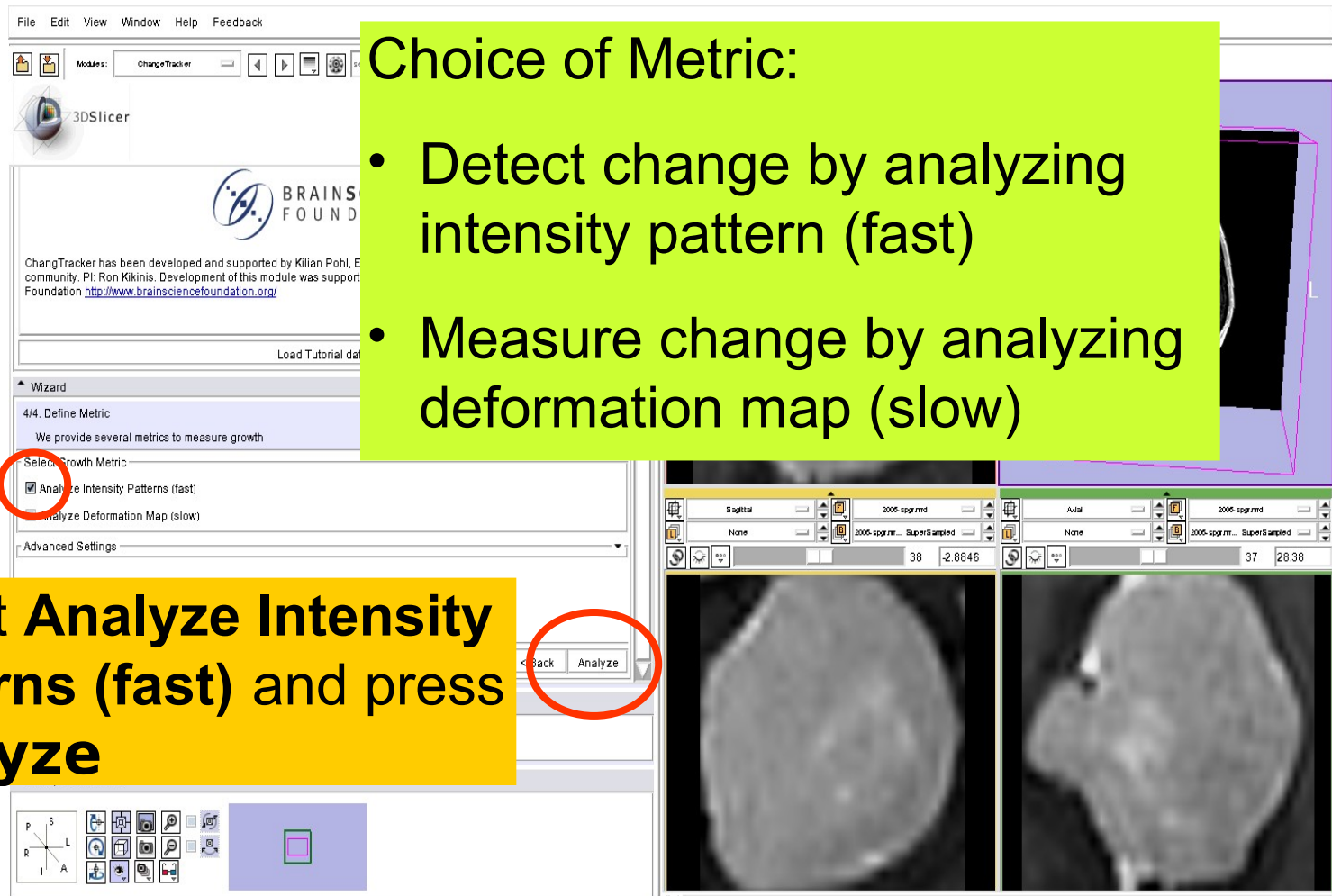


# Choose Metric Type

## Choice of Metric:

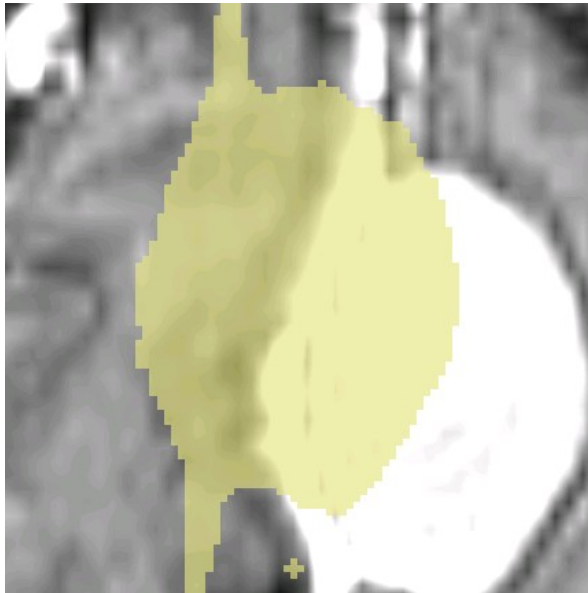
- Detect change by analyzing intensity pattern (fast)
- Measure change by analyzing deformation map (slow)

**Select Analyze Intensity Patterns (fast) and press Analyze**

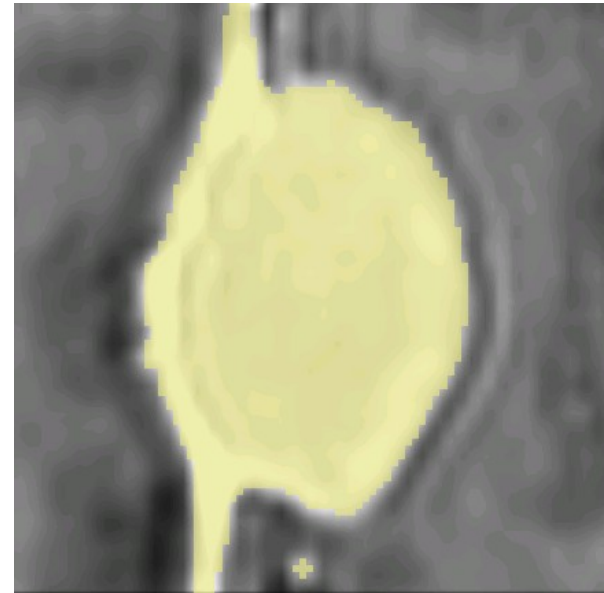


# Analysis I: Volume Preserving Registration

---



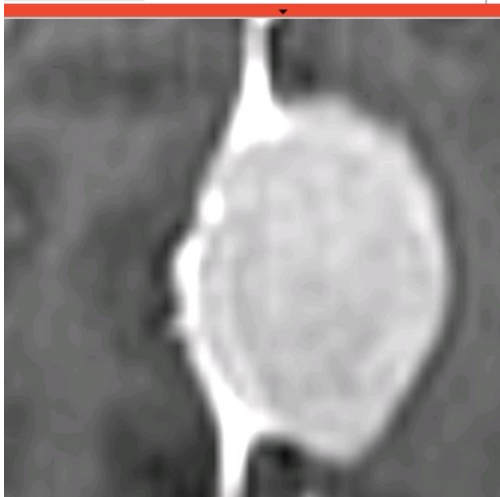
Before



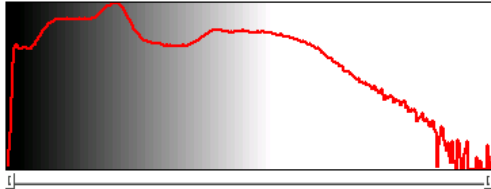
After

# Analysis II: Normalize Intensities

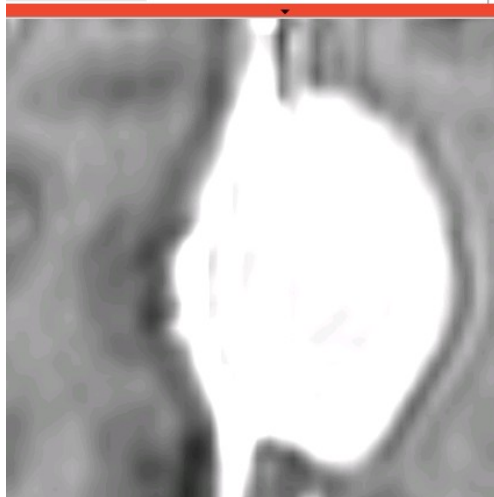
Scan 1



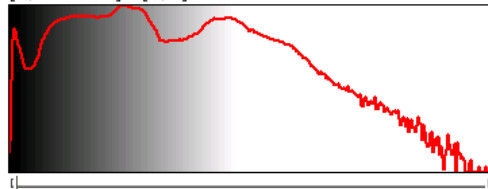
[2, 440.999] x [0, 1]



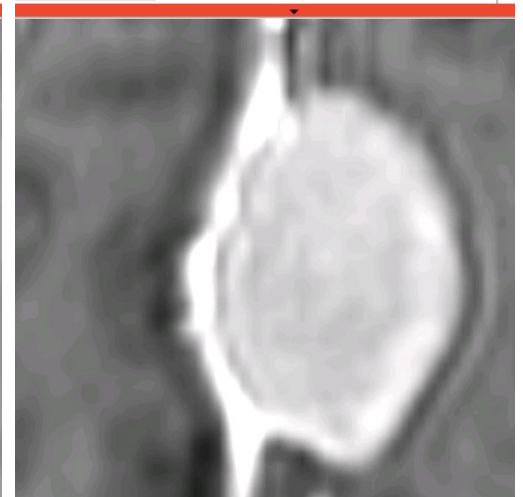
Scan 2



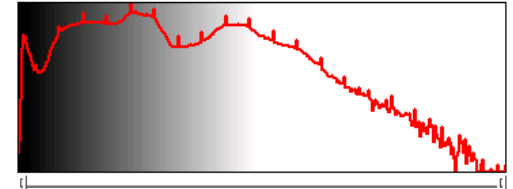
[6, 508.999] x [0, 1]



Scan 2 - Norm

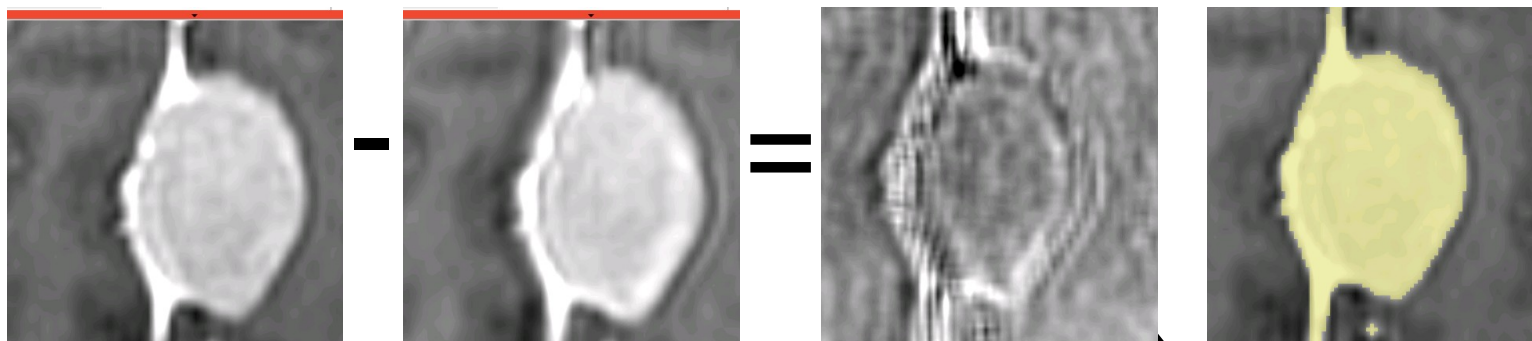


[5, 487.999] x [0, 1]

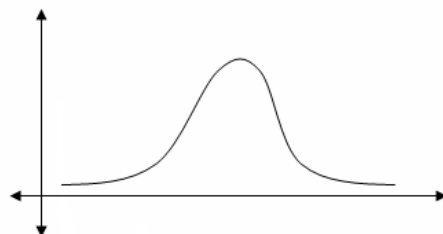




# Analysis III: Detect Change – Intensity Based



PDF of Dormant Tissue



Compute statistics of static tissue

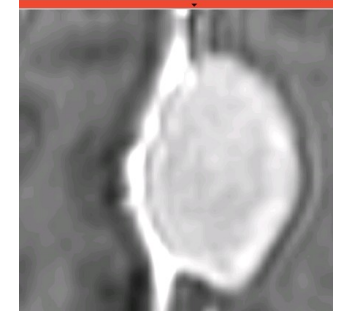
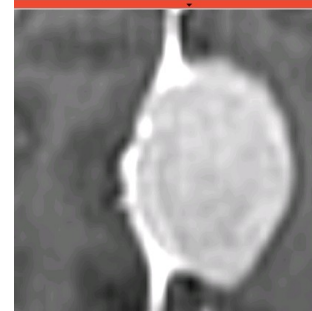
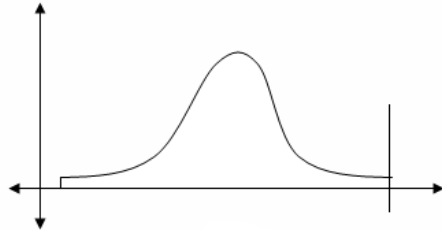
Subtract Scan2 from Scan1

Define region of static tissue

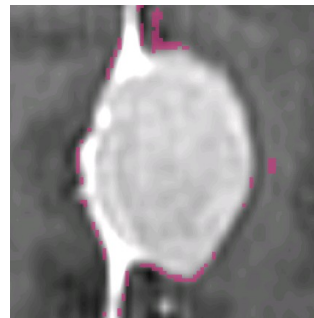
Determine probability density function

# Analysis III: Detect Change – Intensity Based

Data



Analysis

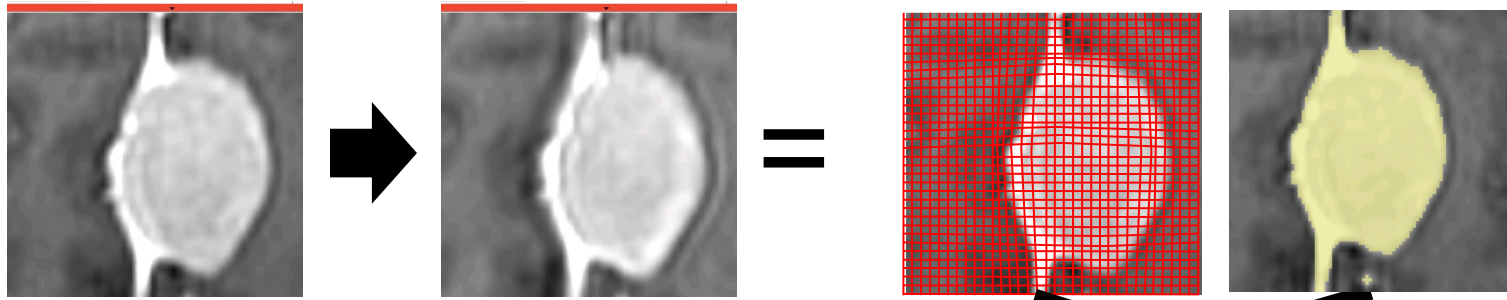


Mode :	Sensitive	Moderate	Robust
False Positive Risk:	High	Medium	Low
Growth (mm <sup>3</sup> ) :	1301	547	100
Growth (voxel):	1057	444	81

Konukoglu et al. , “Monitoring Slowly Evolving Tumors”, ISBI, 2008



# Analysis III: Detect Change–Deformation Map



Mode : Segmentation  
 Growth (mm<sup>3</sup>) : 1386  
 Growth (voxels): 1126



Mode : Jaccobian  
 Growth (mm<sup>3</sup>) : 1291  
 Growth (voxels): 1049

Determine change  
via mapping:

Compute diffeomorphic  
mapping between scans

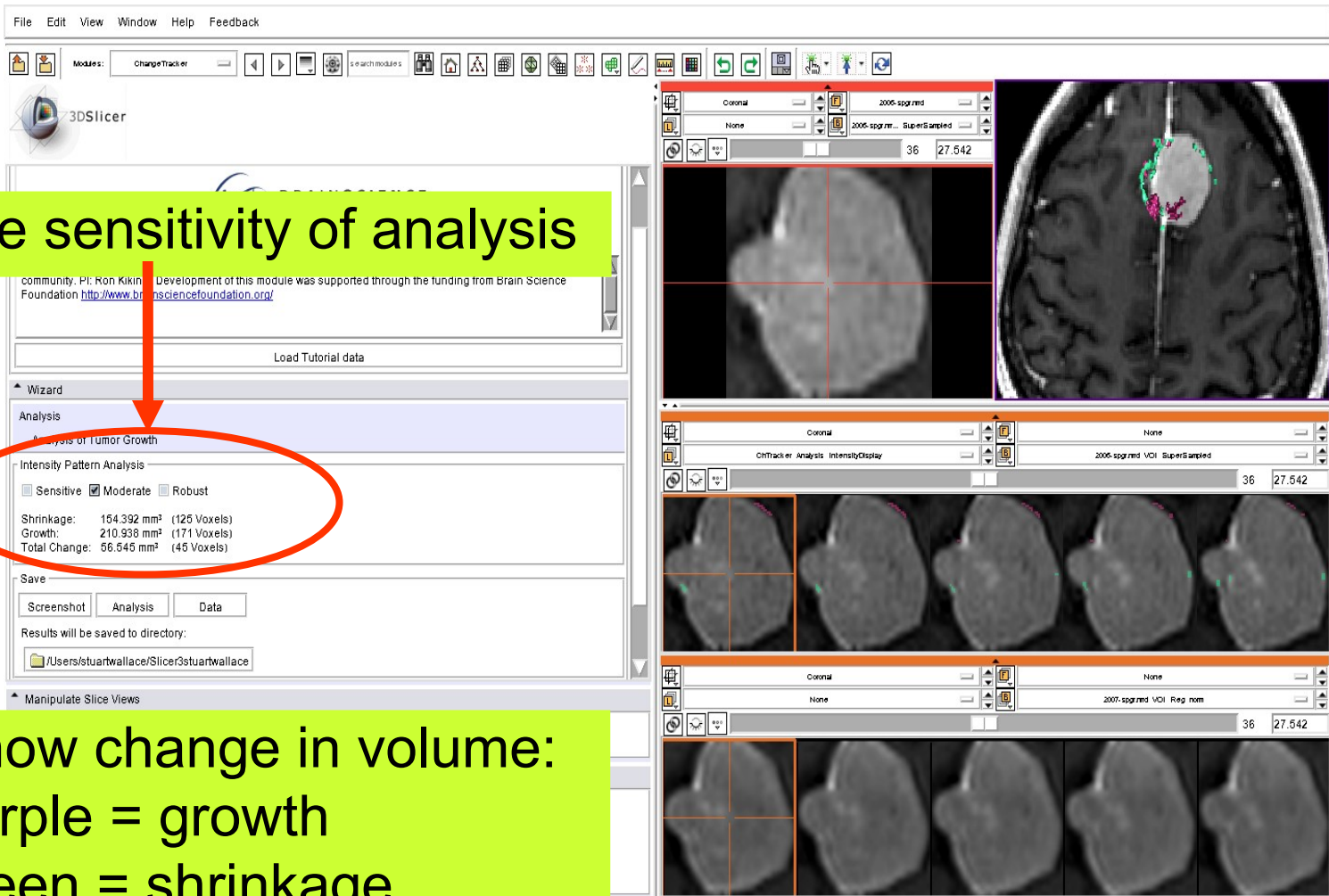
Compute  
Jacobian

or

Apply mapping to  
segmentation

# Show Change in Pathology

Define sensitivity of analysis




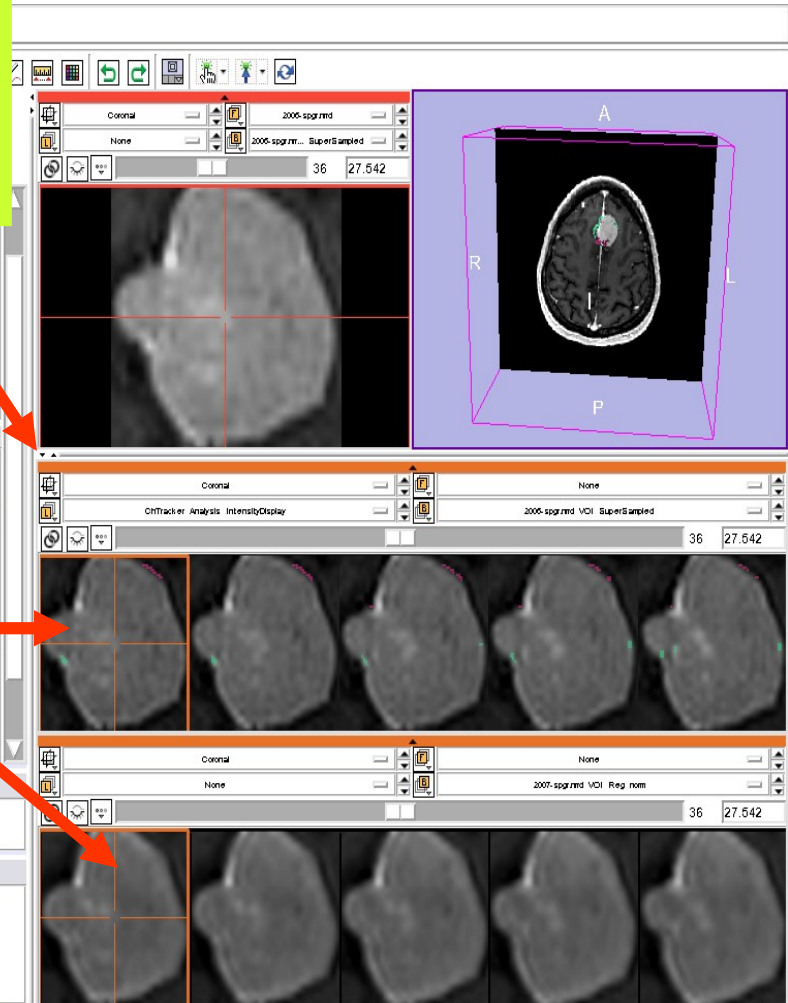
Show change in volume:  
purple = growth  
green = shrinkage

# Show Change in Pathology

You can hide slice controls to have more screen space for viewing the images

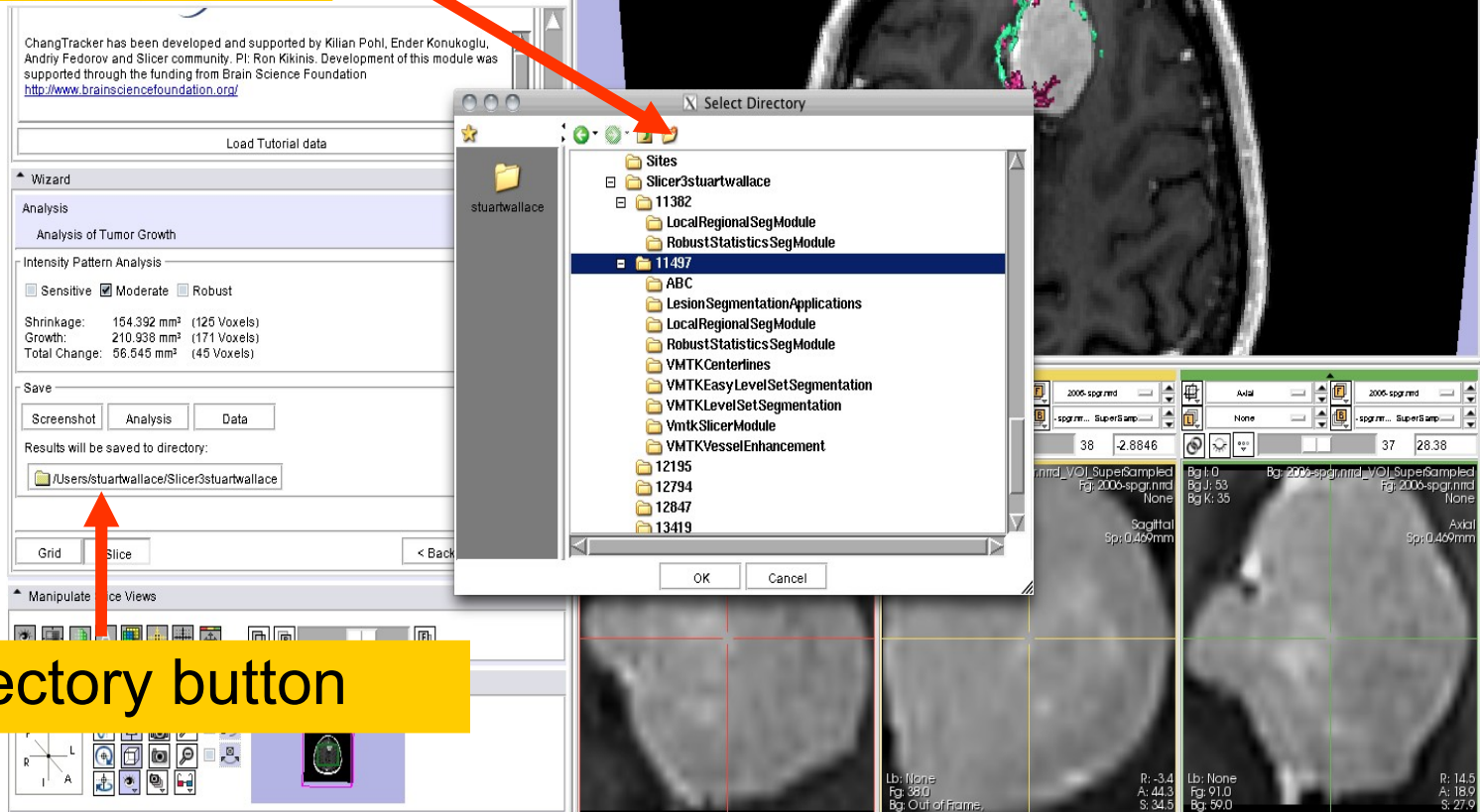
Lightbox View shows 5 consecutive slices for the ROI in the first scan (top), and in the second scan (bottom)

You can switch to  Four-up layout or other layout at any time.



# Define Working Directory

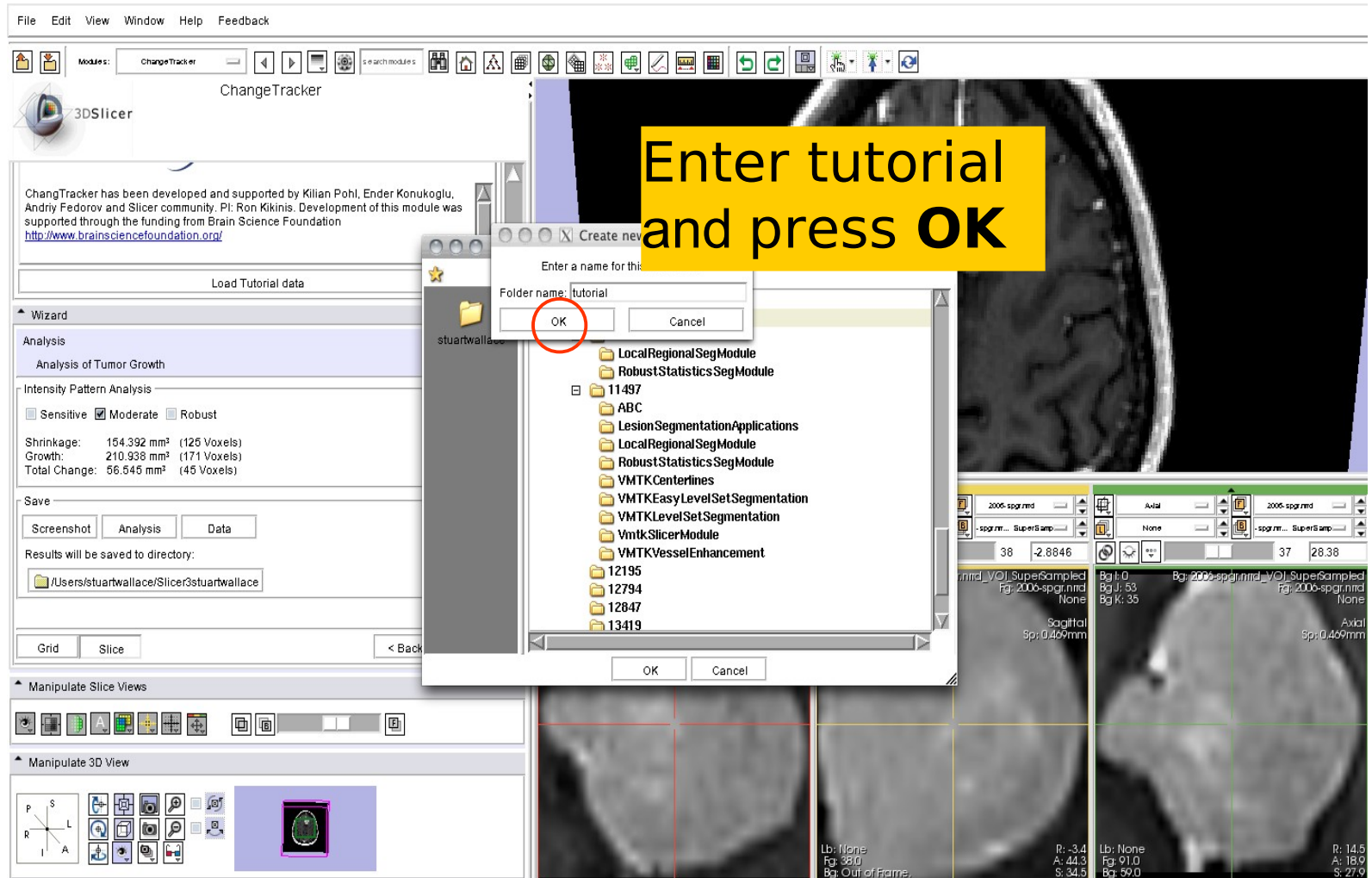
Select  to create directory



Press directory button



# Define Working Directory



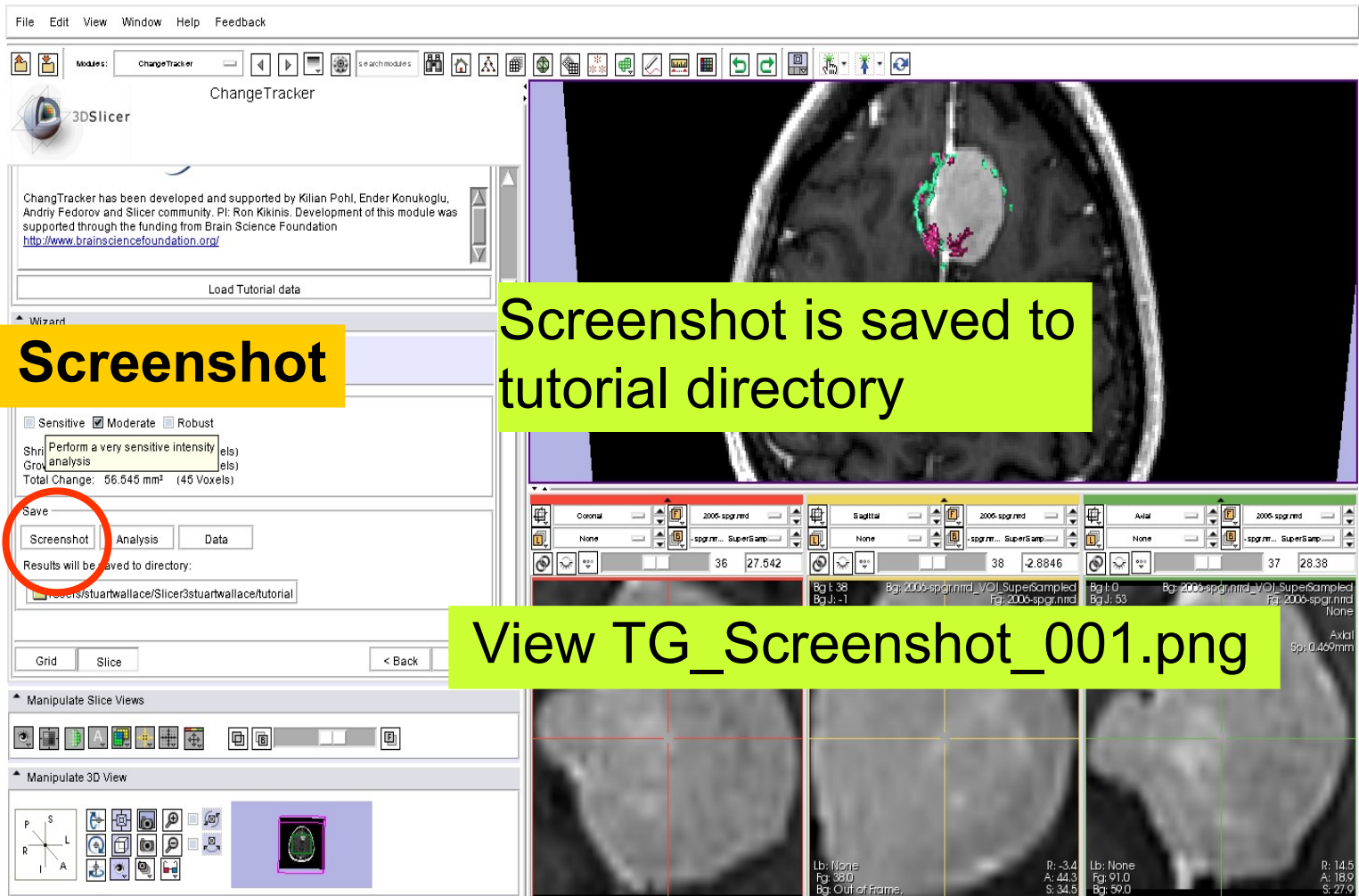


# Save Screenshot

Press **Screenshot**

Screenshot is saved to tutorial directory

View TG\_Screenshot\_001.png





# Save Analysis Result

Press Analysis

Outcome of analysis is saved to tutorial directory

The screenshot shows the 3DSlicer interface with the 'Analysis' button circled in red in the 'Save' section of the 'Analysis of Tumor Growth' wizard. An 'AnalysisOutcome.log' window is open, displaying the following text:

```
AnalysisOutcome.log
Show Log List Move to Trash Clear Display Insert Marker Reload
This file was generated by vtkMrmChangeTrackerNode
Date: Wed Jun 9 18:41:25 PDT 2010
Scan1_Ref: /Users/stuartwallace/Slicer3stuartwallace/2006-spgr.nrrd
Scan2_Ref: /Users/stuartwallace/Slicer3stuartwallace/2007-spgr.nrrd
ROI:
Min: 112 80 63
Max: 149 116 87
Threshold: [80, 207]
Analysis based on Intensity Pattern
Sensitivity: 0.96
Intensity Metric:
Shrinkage: 154.392mm (125.474 Voxels)
Growth: 210.937mm (171.429 Voxels)
Total Change: 56.545mm (45.954 Voxels)
```

At the bottom of the log window, there is a table of statistics:

Label	Value	Label	Value
R: 3.4		L: None	
A: 44.3		F: 38.0	
S: 34.5		B: 59.0	

View AnalysisOutcome.log

# Save Intermediate Results



File Edit View Window Help Feedback

Modules: ChangeTracker

ChangeTracker

ChangeTracker has been developed and supported by Kilian Pohl, Ender Konukoglu, Andriy Fedorov and Slicer community. PI: Ron Kikinis. Development of this module was supported through the funding from Brain Science Foundation <http://www.brainsciencefoundation.org/>

Load Tutorial data

Wizard

Press Data

Sensitive Moderate Robust

Shrink analysis (els)

Grow analysis (els)

Total Change: 56.545 mm<sup>3</sup> (45 Voxels)

Save

Screenshot Analysis Data

Results will be saved to directory

/Users/stuartwallace/Slicer3stuartwallace/tutorial

Grid Slice

< Back OK

Manipulate Slice Views

Manipulate 3D View

Save Scene and Unsaved Data

Change Destination for All Selected: /Users/stuartwallace/Slicer3stuartwallace/tutorial

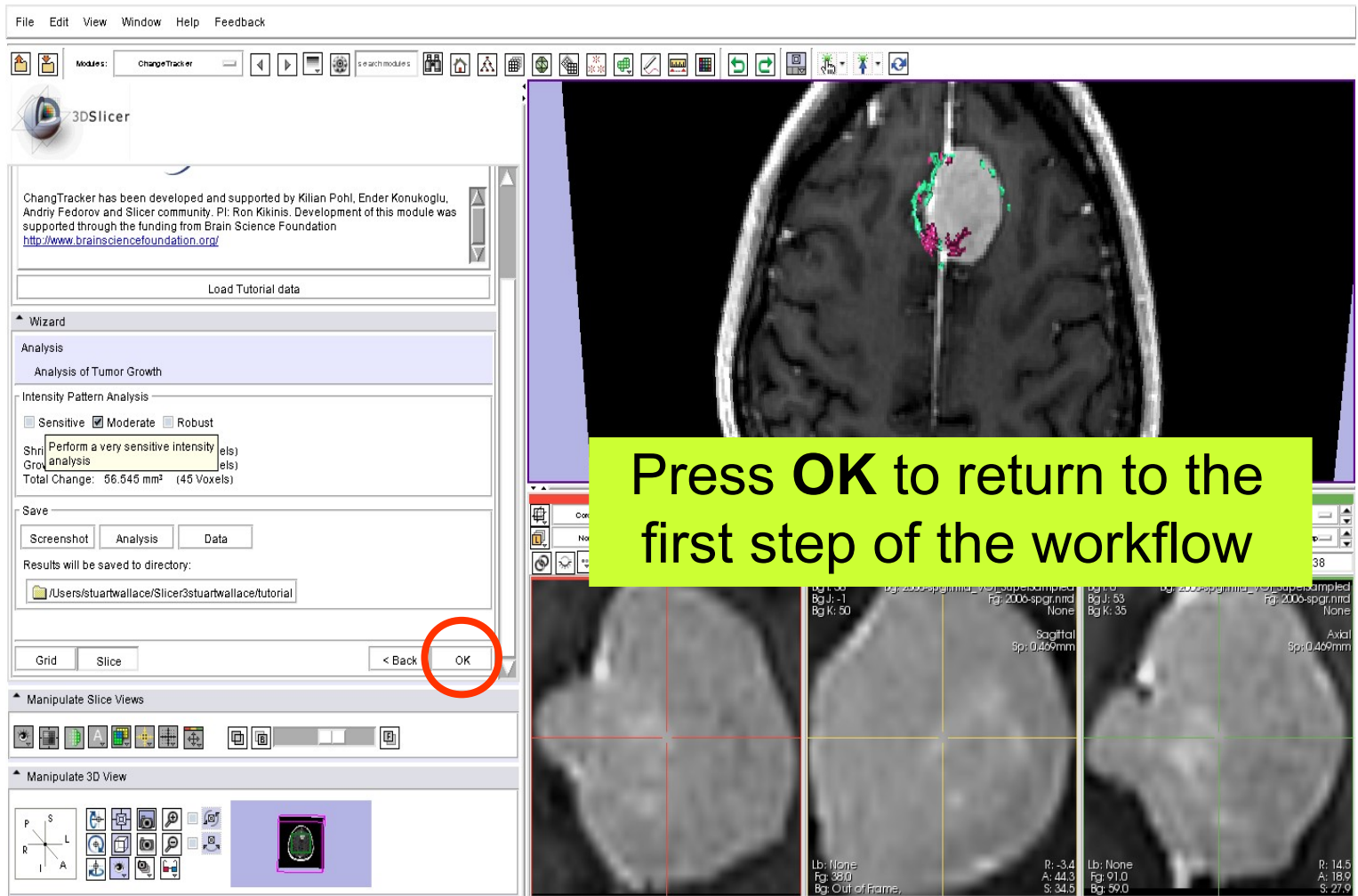
Select	Node Name	Node Type	Node Status	File Format	File Name	Data Directory
<input checked="" type="checkbox"/>	(Scene Des...	(SCENE)	Modified	MRML (.mrm)	Data.mrm	/Users/stuartwallace/Slicer3stuartwallace/tutorial
<input checked="" type="checkbox"/>	2007-spgr.n...	Volume	Modified	NRRD (.nrrd)	2007-spgr.nrrd	/Users/stuartwallace/Slicer3stuartwallace/tutorial
<input checked="" type="checkbox"/>	2006-spgr.n...	Volume	Modified	NRRD (.nrrd)	2006-spgr.nrrd	/Users/stuartwallace/Slicer3stuartwallace/tutorial
<input checked="" type="checkbox"/>	2006-spgr.n...	Volume	Modified	NRRD (.nrrd)	2006-spgr.nrrd_VOI...	/Users/stuartwallace/Slicer3stuartwallace/tutorial
<input checked="" type="checkbox"/>	2006-spgr.n...	Volume	Modified	NRRD (.nrrd)	2006-spgr.nrrd_VOI...	/Users/stuartwallace/Slicer3stuartwallace/tutorial
<input checked="" type="checkbox"/>	2007-spgr.n...	Volume	Modified	NRRD (.nrrd)	2007-spgr.nrrd_Globa...	/Users/stuartwallace/Slicer3stuartwallace/tutorial
<input checked="" type="checkbox"/>	Global_LR.T...	LinearTrans...	Modified	Transform (.tfm)	Global_LRTransform....	/Users/stuartwallace/Slicer3stuartwallace/tutorial
<input checked="" type="checkbox"/>	2007-spgr.n...	Volume	Modified	NRRD (.nrrd)	2007-spgr.nrrd_VOI...	/Users/stuartwallace/Slicer3stuartwallace/tutorial

Save Selected Cancel

Press Select All and Save Selected

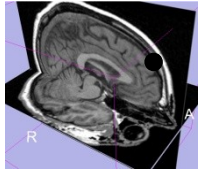


# Finish Workflow

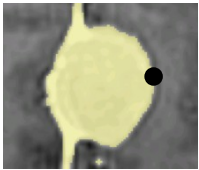


# Overview

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Loading a scene



- Measuring volume change in tumors

- We tested the tool on Axial 3D SPGR T1 post Gadolinium scans  
(Voxel dimension: 0.94mm x 0.94mm x 1.20mm, FOV: 240mm, Matrix: 256 x 256)
- We expect the tool to work also on set of scans that fulfill the following requirements:
  - same patient was scanned
  - scans were acquired with the same acquisition protocol
  - scans have isotropic resolution
  - pathology appearance is hyper-intense

# Acknowledgments

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National Alliance for Medical  
Image Computing  
NIH U54EB005149



Brain Science Foundation



INRIA, France