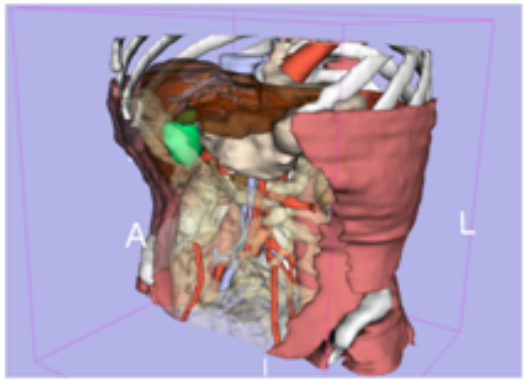
NIH Roadmap National Centers for Biomedical Computing
National Alliance for Medical Image Computing (NA-MIC)

3D Interactive Visualization of DICOM images



RSNA 2009 Quality Counts
November 29-December 4, 2009 McCormick Place, Chicago

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Brigham and Women's Hospital
Harvard Medical School

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Brigham and Women's Hospital
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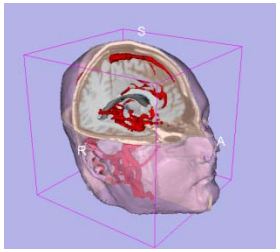
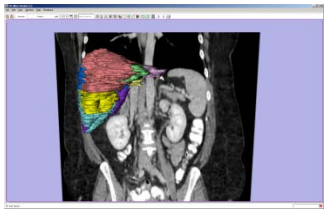
Overview

Part 1: Introduction to the 3D Slicer platform



Part 2: 3D Visualization of Dicom images and 3D models



Part 3: 3D exploration of liver segments using 3D Slicer

- Part 1 -

The 3D Slicer Platform

Sonia Pujol, Ph.D.

3D Slicer Course for Radiologists, November 30, 2009
RSNA 2009

3D Slicer

- Open-source application available for Windows, Linux and Mac

3D Slicer

- Open-source application available for Windows, Linux and Mac
- More than 2.8 million lines of code

3D Slicer

- Open-source application available for Windows, Linux and Mac
- More than 2.8 million lines of code
- Neuroscience and Image-Guided Therapy

3D Slicer History

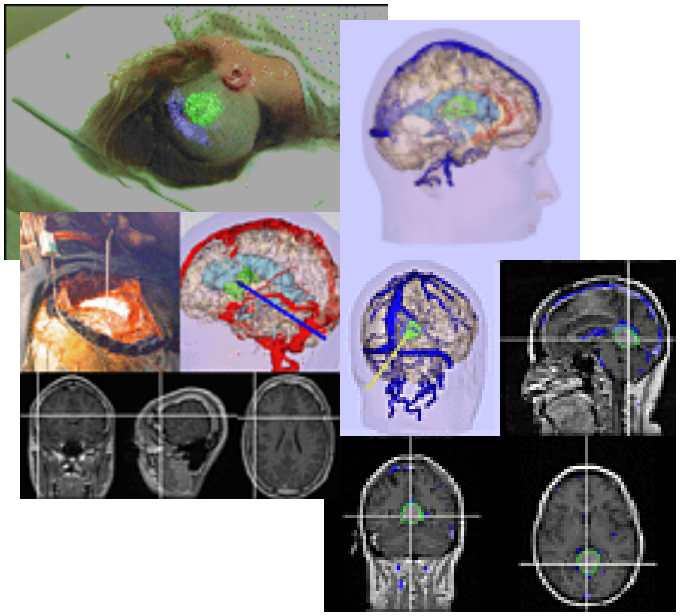
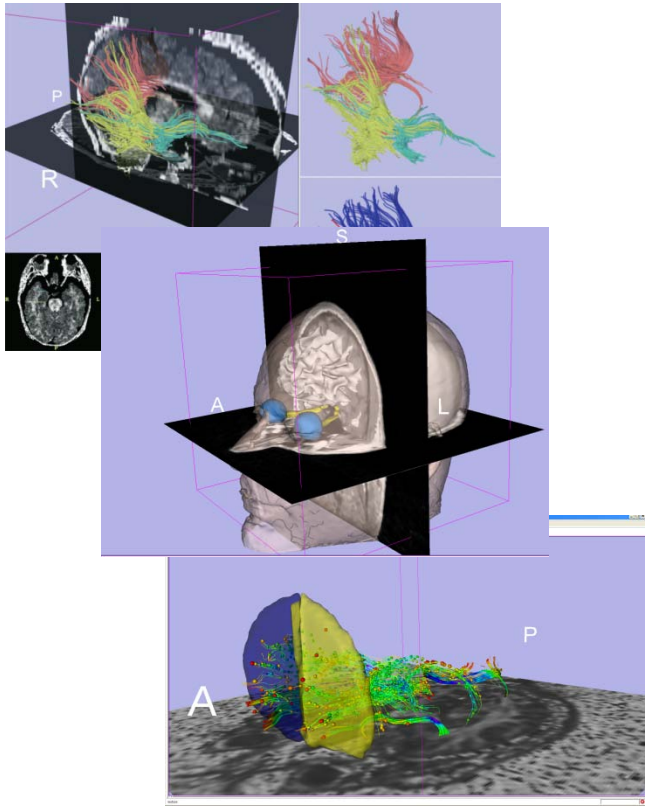


Image Courtesy of the CSAIL, MIT

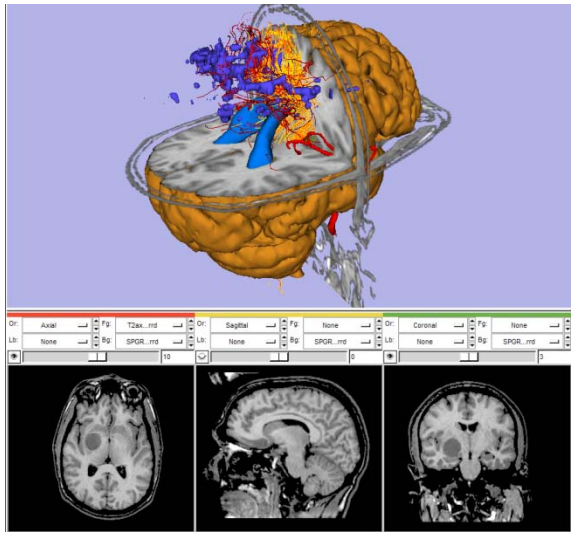
- Started in 1997 between the Surgical Planning Lab (Harvard) and the CSAIL (MIT)

3D Slicer History



- Started in 1997 between the Surgical Planning Lab (Harvard) and the (CSAIL) MIT
- 2009: Multi-institution effort to share the latest advances in image analysis with clinicians and scientists

3D Slicer



- **Open-source** platform supported by the **National Institutes of Health** consortia which include
  - National Alliance for Medical Image Computing (NA-MIC)
  - Neuroimage Analysis Center (NAC)

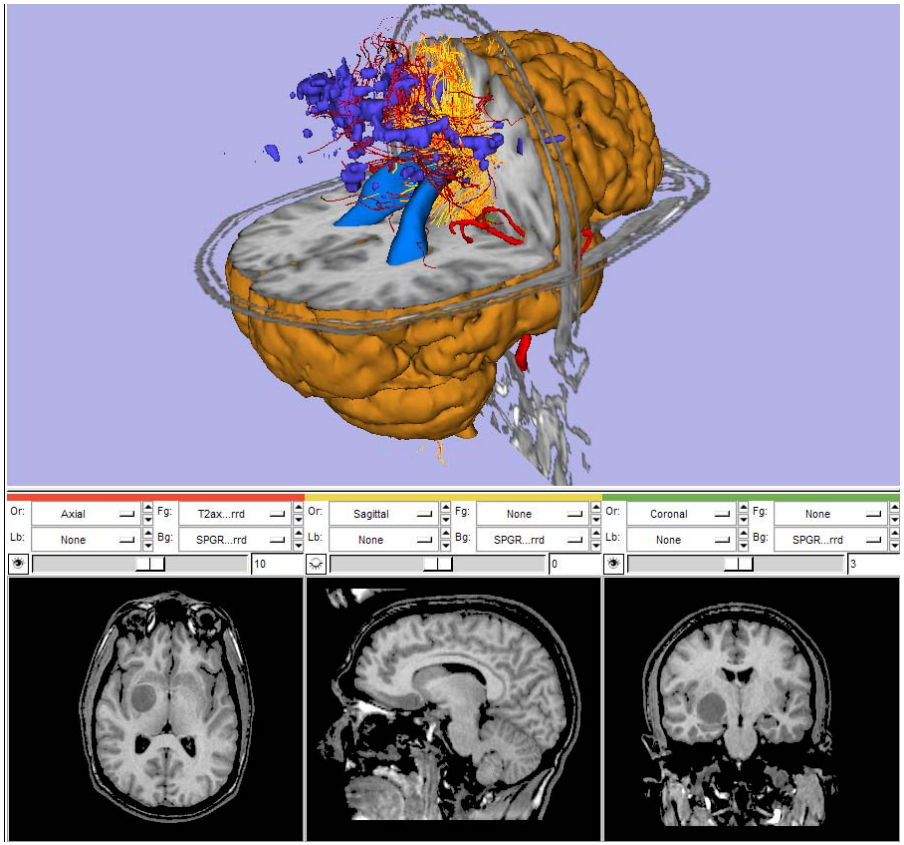
P.I. Prof. Ron Kikinis, MD,

Director of the Surgical Planning Lab,

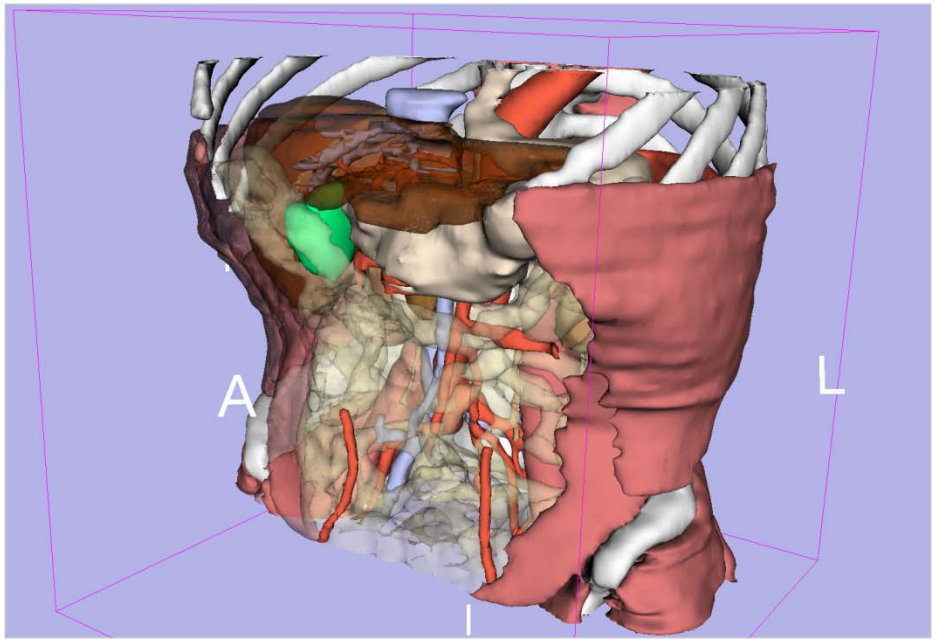
Brigham &Women's Hospital, Boston, MA

3DSlicer from three user perspectives

- Clinical researchers
- Biomedical engineers
- Algorithm developers

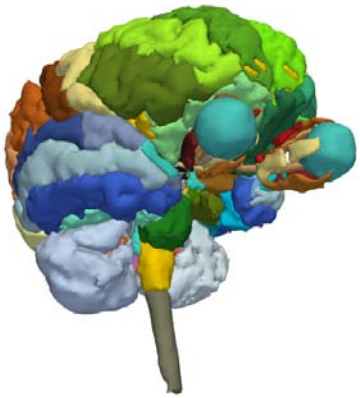


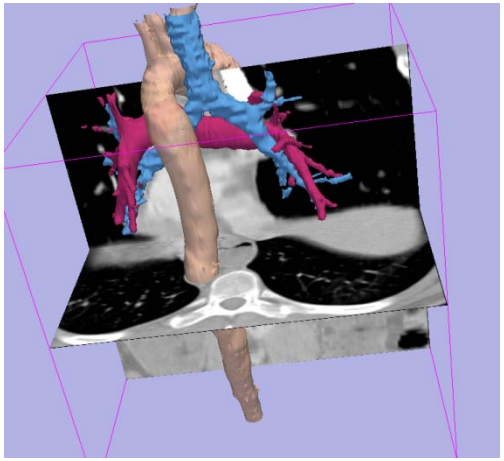
Clinical researchers

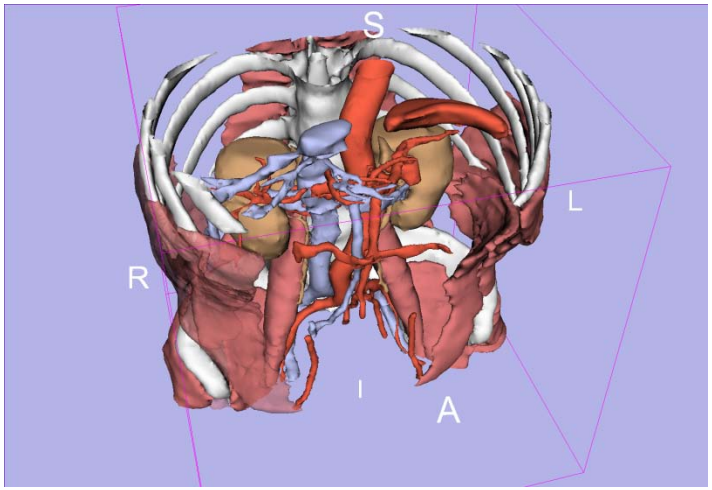


Interact in 3D to enhance data interpretation

Visualize

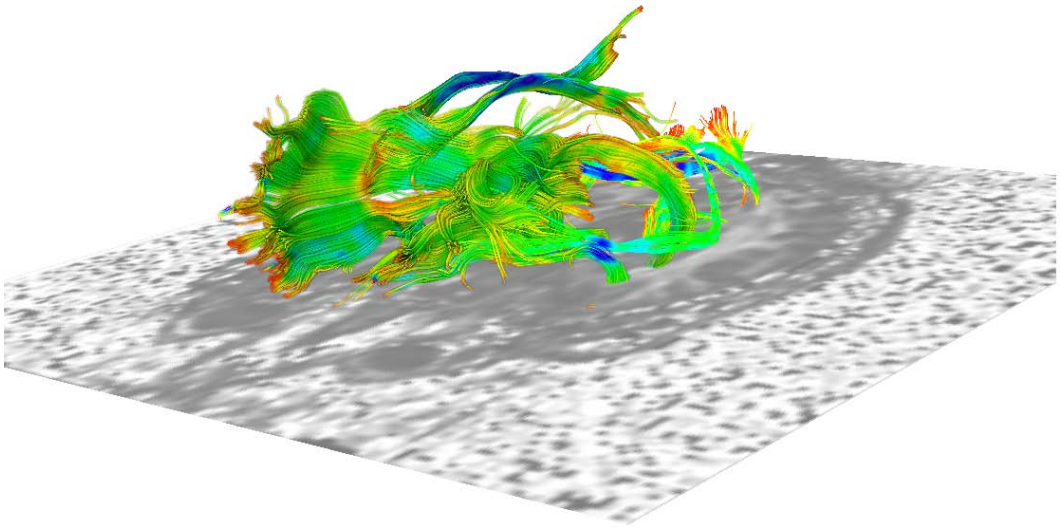






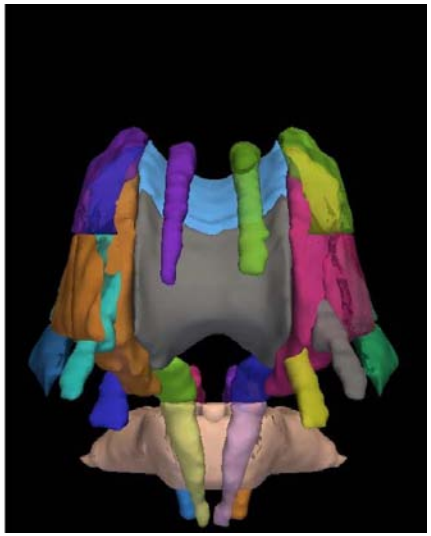
- User-driven views of anatomical structures
- Overlay between 2D grey-levels images and 3D anatomical structures
- Intuitive interaction with the 3D models

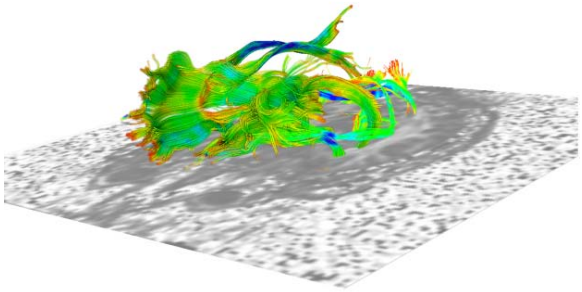
Biomedical Engineers

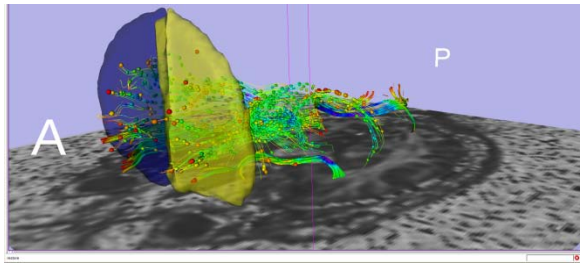


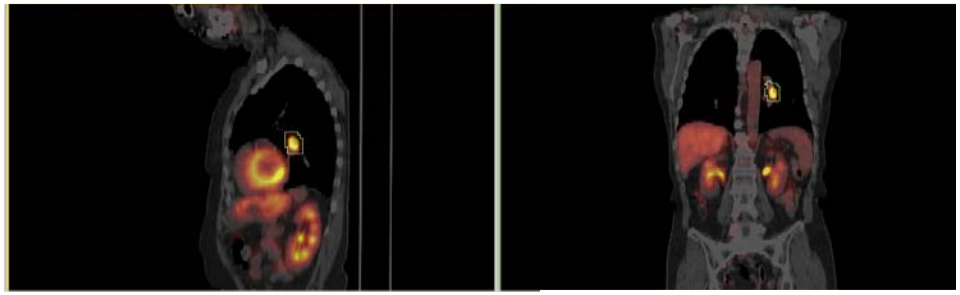
Extract relevant information from complex data

Analyze





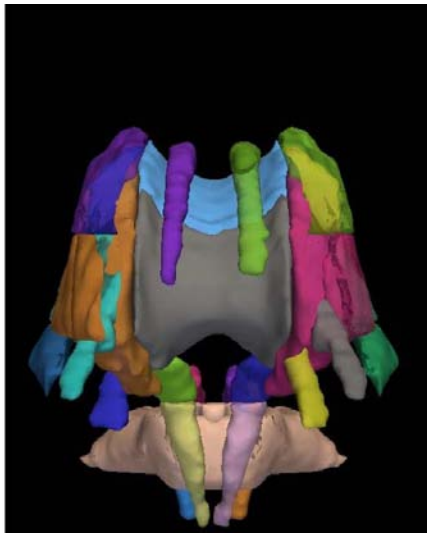


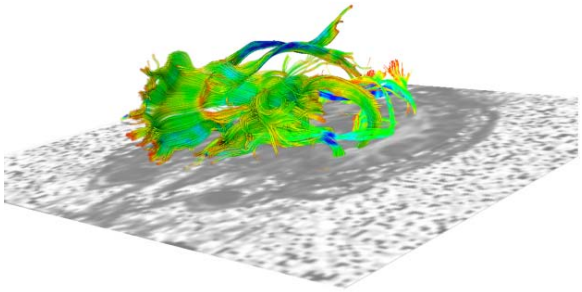


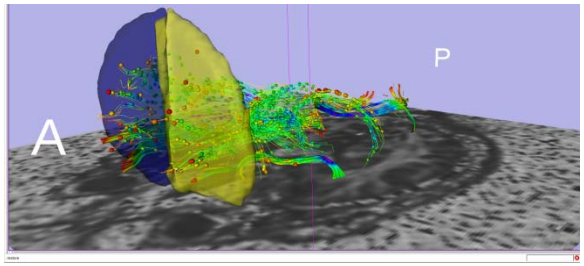
Courtesy of W. Plesniak, BWH

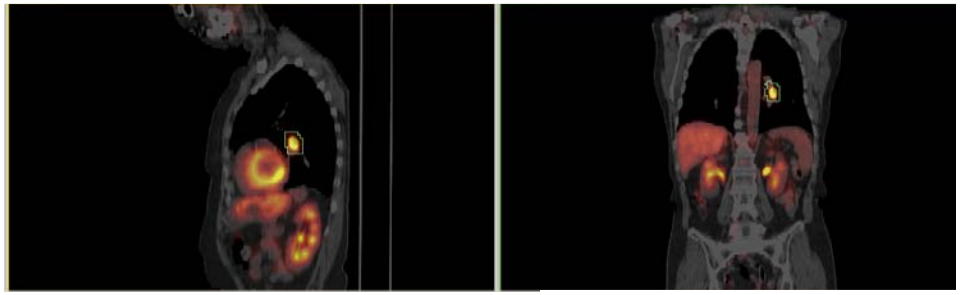
- Advanced analysis of complex data
- Multimodal data fusion
- Clinical parameters extraction

Analyze









Courtesy of W. Plesniak, BWH

- Advanced analysis of complex data
- Multimodal data fusion
- Clinical parameters extraction

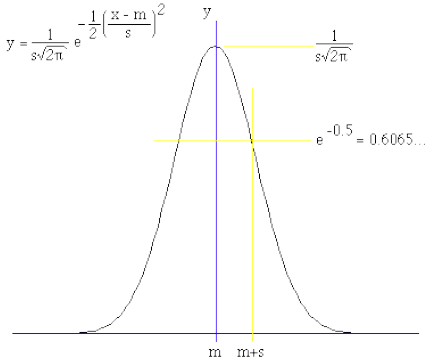
RSNA 2009 Course:

'Quantitative Medical Imaging for Clinical Research and Practice'

Tuesday, December 01
10:30-12:00 PM S401CD

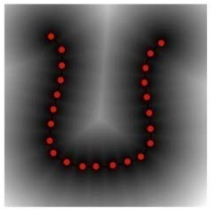
Algorithm Developers

$$\ln p(X \mid \pi, \mu, \Sigma) = \sum_{n=1}^{N} In \{ \sum_{k=1}^{K} \pi_k N\left(x_n \mid \mu_k, \Sigma_k\right) \}$$

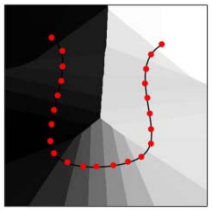


$$p_j^{(k)} = \frac{\sum_{i:D_{ij}=1} W_i^{(k-1)}}{\sum_i W_i^{(k-1)}}$$

$$q_j^{(k)} = \frac{\sum_{i:D_{ij}=0} \left(1 - W_i^{(k-1)}\right)}{\sum_i \left(1 - W_i^{(k-1)}\right)}.$$



(a)

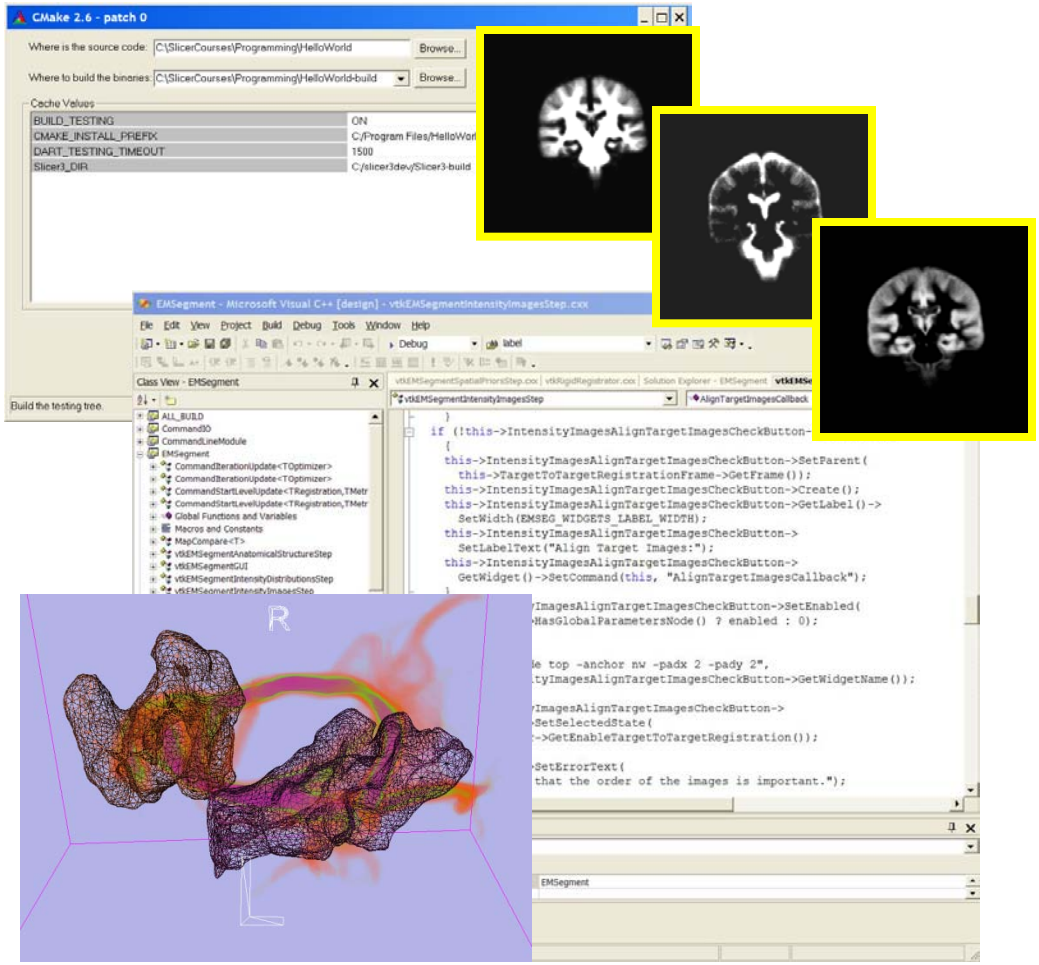


(b)

```
#include "itkDiscreteGaussianImageFilter.h"
int main ( int argc, char * argv[])
{
    PARSE_ARGS;
    typedef itk::Image< short, 3 >  ImageType;
    typedef itk::ImageFileReader< ImageType >  ReaderType;
    typedef itk::ImageFileWriter< ImageType >  WriterType;
    ReaderType::Pointer reader = ReaderType::New();
    WriterType::Pointer writer = WriterType::New();
    reader->SetFileName( FilterInputVolume.c_str() );
    writer->SetFileName(FilterOutputVolume.c_str());
    typedef itk::DiscreteGaussianImageFilter <ImageType, ImageType> FilterType;
    FilterType::Pointer filter = FilterType::New();
```

Develop plug-ins to extend image analysis capabilities

Create



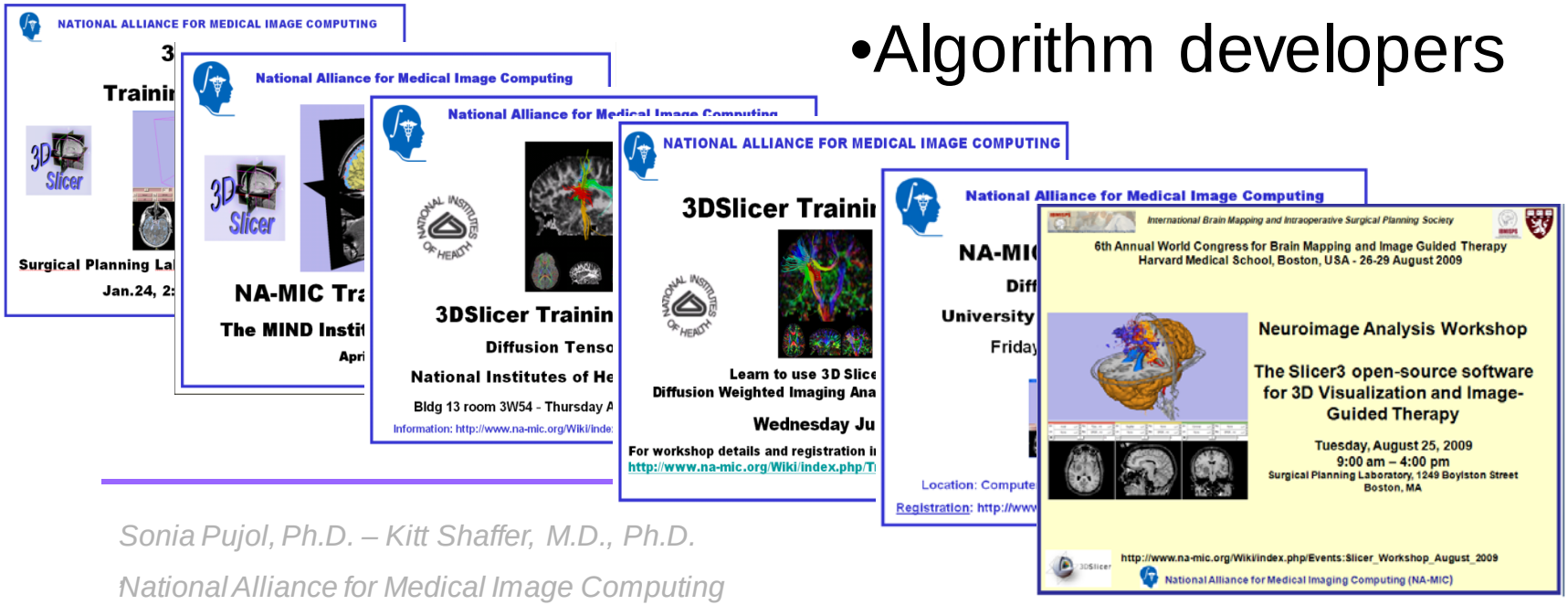
- Integrate external executables with the Slicer3 platform
- Develop plug-ins in C++, Tcl or Python
- Build upon the NA-MIC kit to meet your scientific goals

Clinical researchers
Biomedical engineers
Algorithm developers

Translate techniques into skills

Translate Techniques into Skills

- 3DSlicer hands-on workshops
- •Clinical researchers
- •Biomedical engineers
- •Algorithm developers



Leonardo da Vinci (1452-1519), Virgin and Child
Alte Pinakothek, München

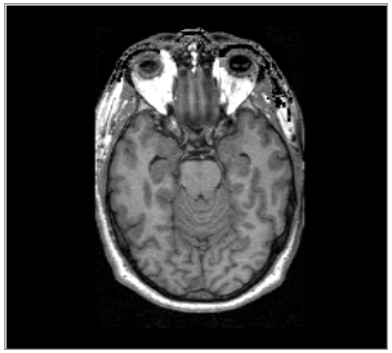
- Part 2 -

3D Visualization

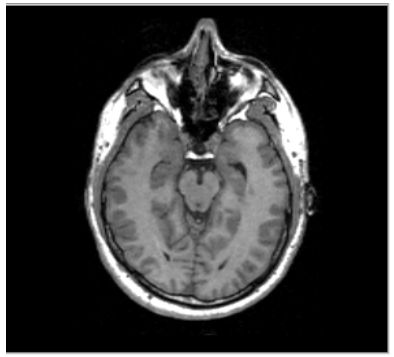
Sonia Pujol, Ph.D.

Data

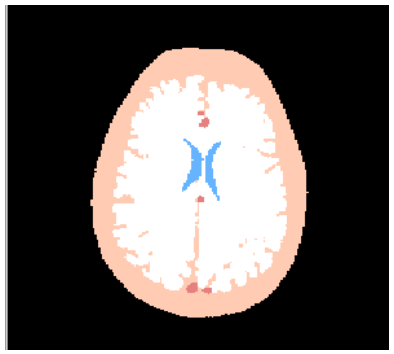
This course is built upon three datasets of a single healthy subject brain:



MR DICOM
GRASS



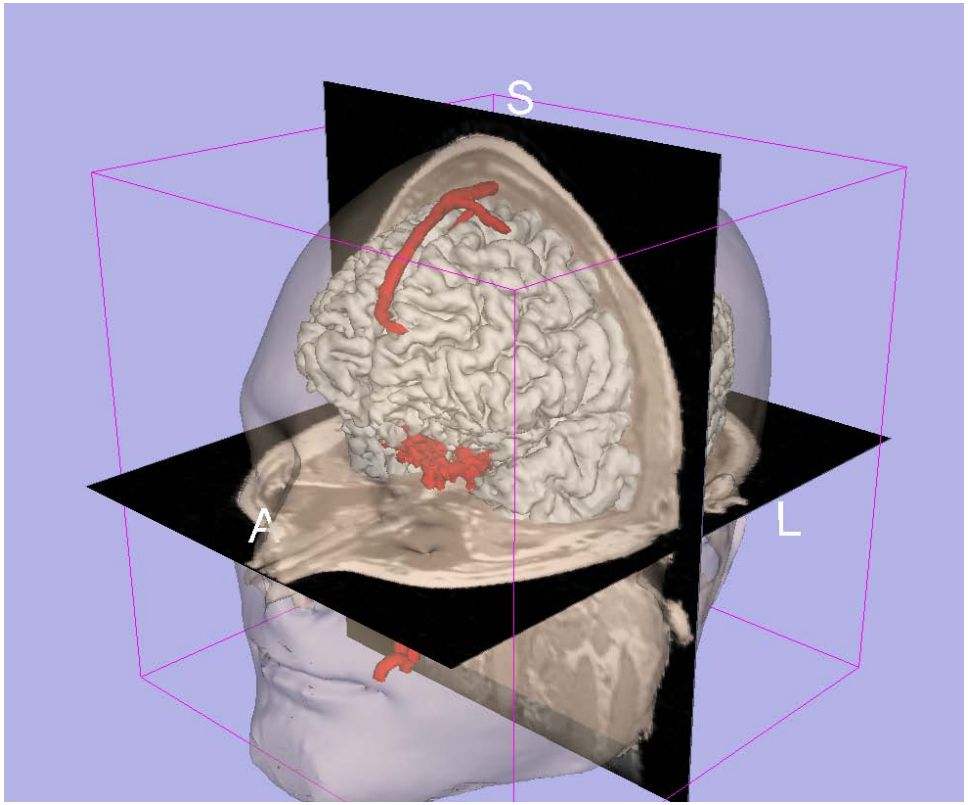
MR Nrrd
SPGR



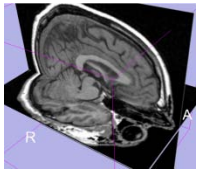
Pre-computed
Label Map

Learning objective

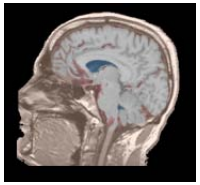
Following this tutorial, you'll be able to load and visualize volumes within Slicer3, and to interact in 3D with structural images and models.



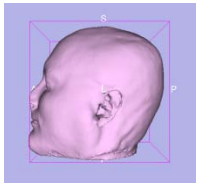
Overview



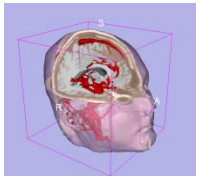
Loading and visualizing multiple volumes simultaneously



Loading and visualizing segmented structures overlaid on grayscale images



Loading and visualizing 3D models



Loading and saving a scene

Launch Slicer3

To launch Slicer3 on Windows:

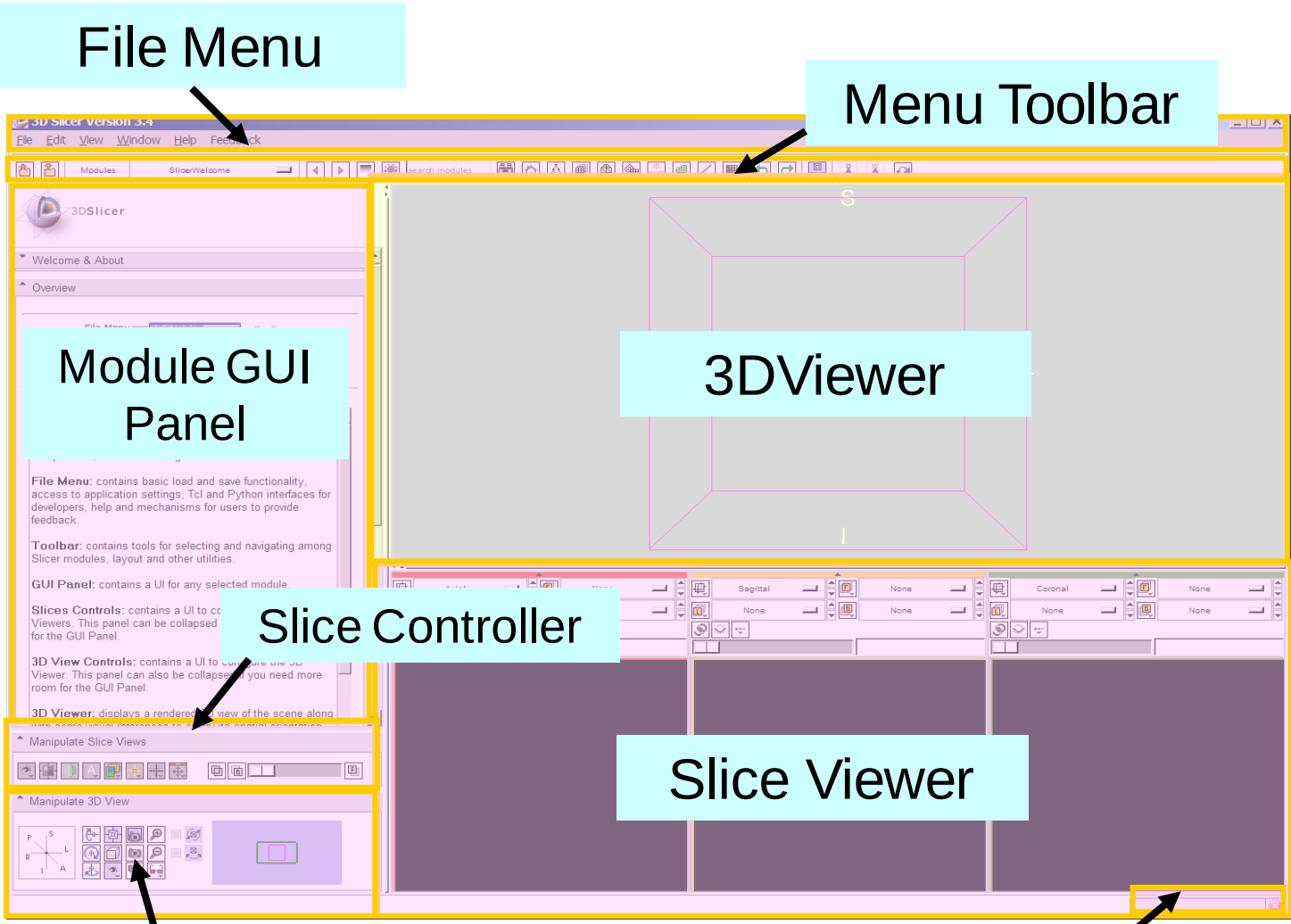
Select **Start → Programs → Slicer3 3.5.2009-11-06 →Slicer**

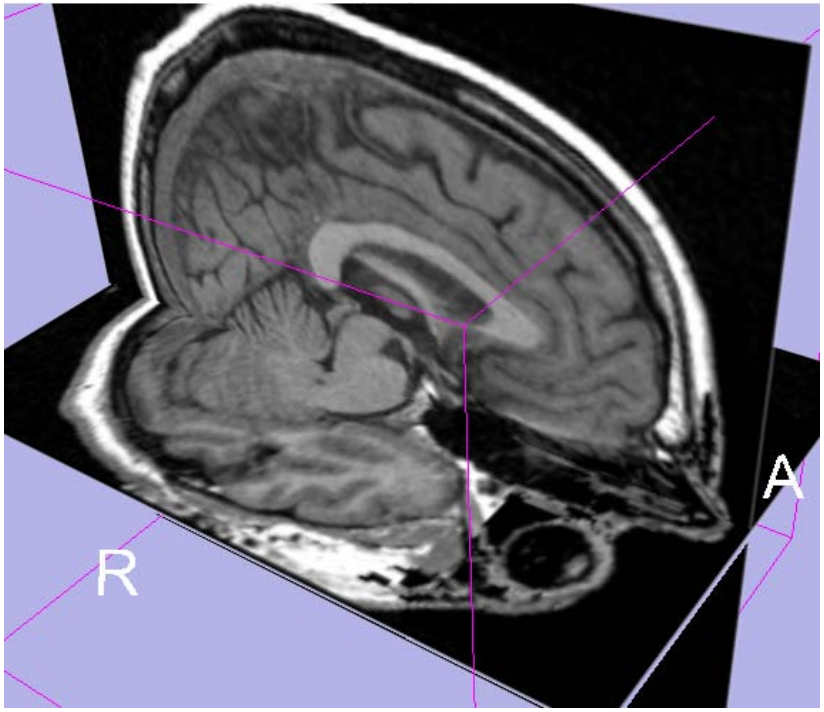
Disclaimer
It is the responsibility of the user of 3DSlicer to comply with both the terms of the license and with the applicable laws, regulations and rules.

Slicer3 GUI

The Graphical User Interface (GUI) of Slicer3.5 integrates 8 main components:

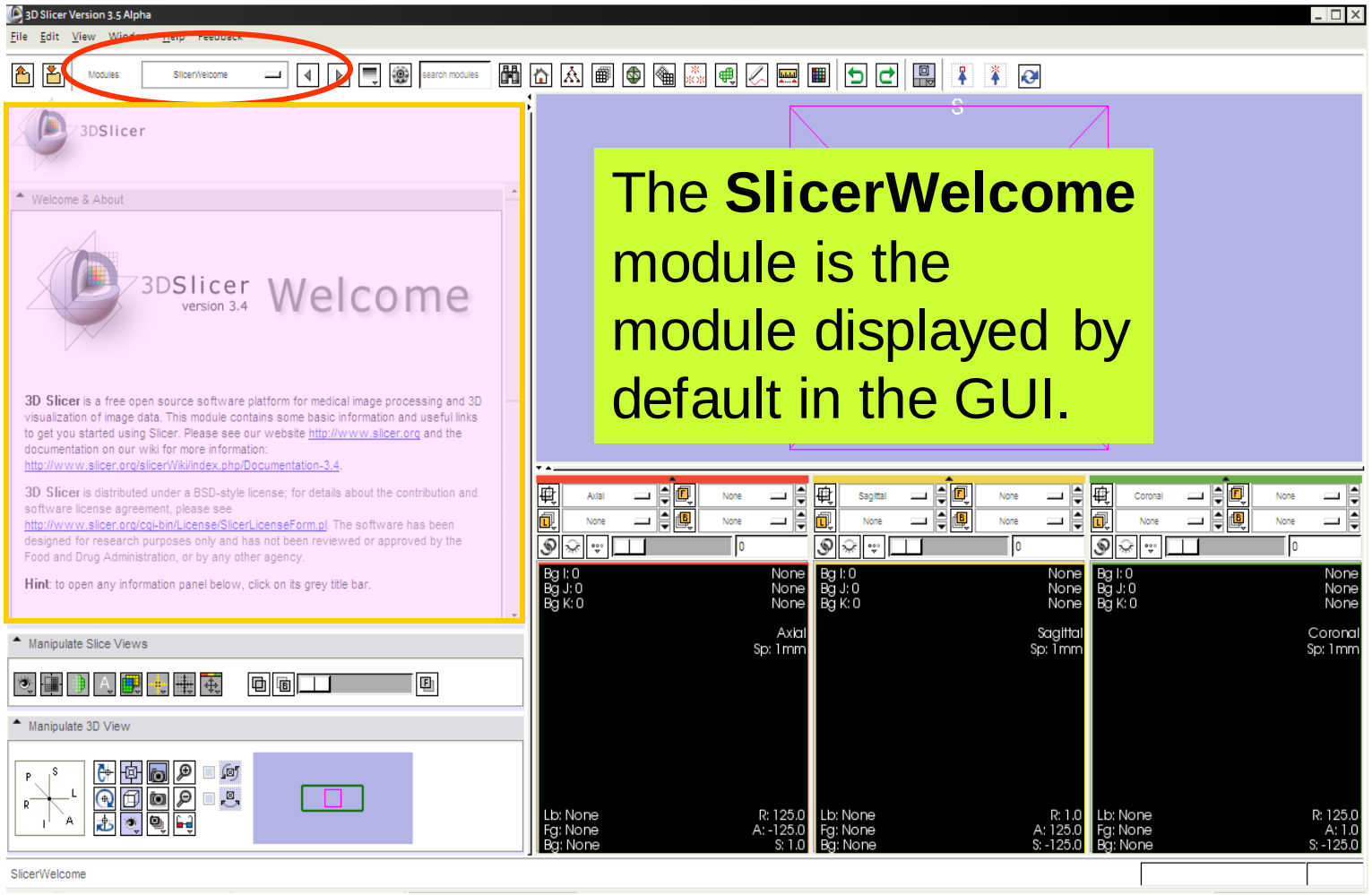
- the File Menu
- the Menu Toolbar
- the Module GUI Panel
- the 3D Viewer
- the Slice Viewer
- the Slice Controller
- the 3D View Controller



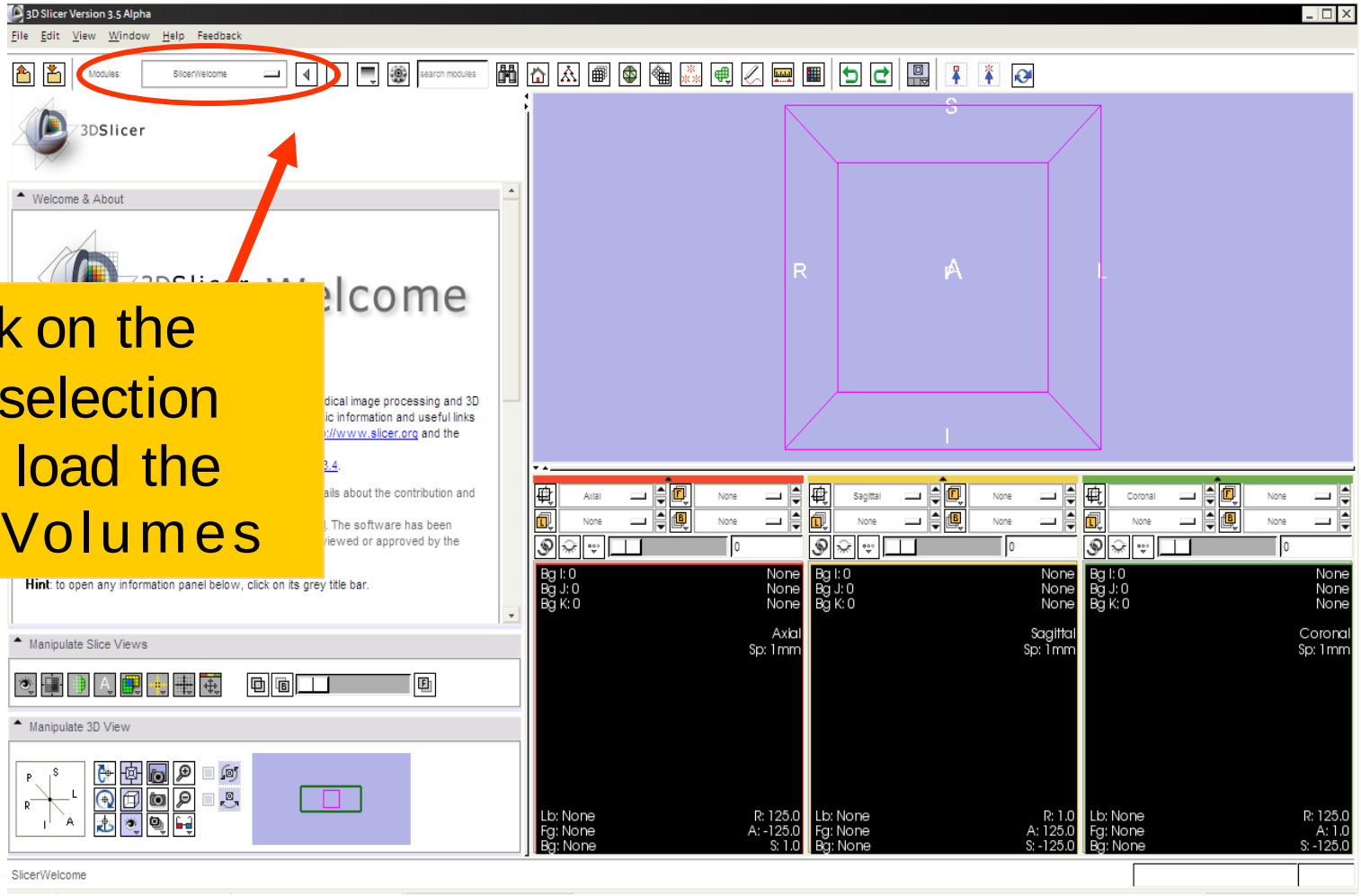


Part 1: Loading and visualizing multiple volumes simultaneously

Loading Volumes

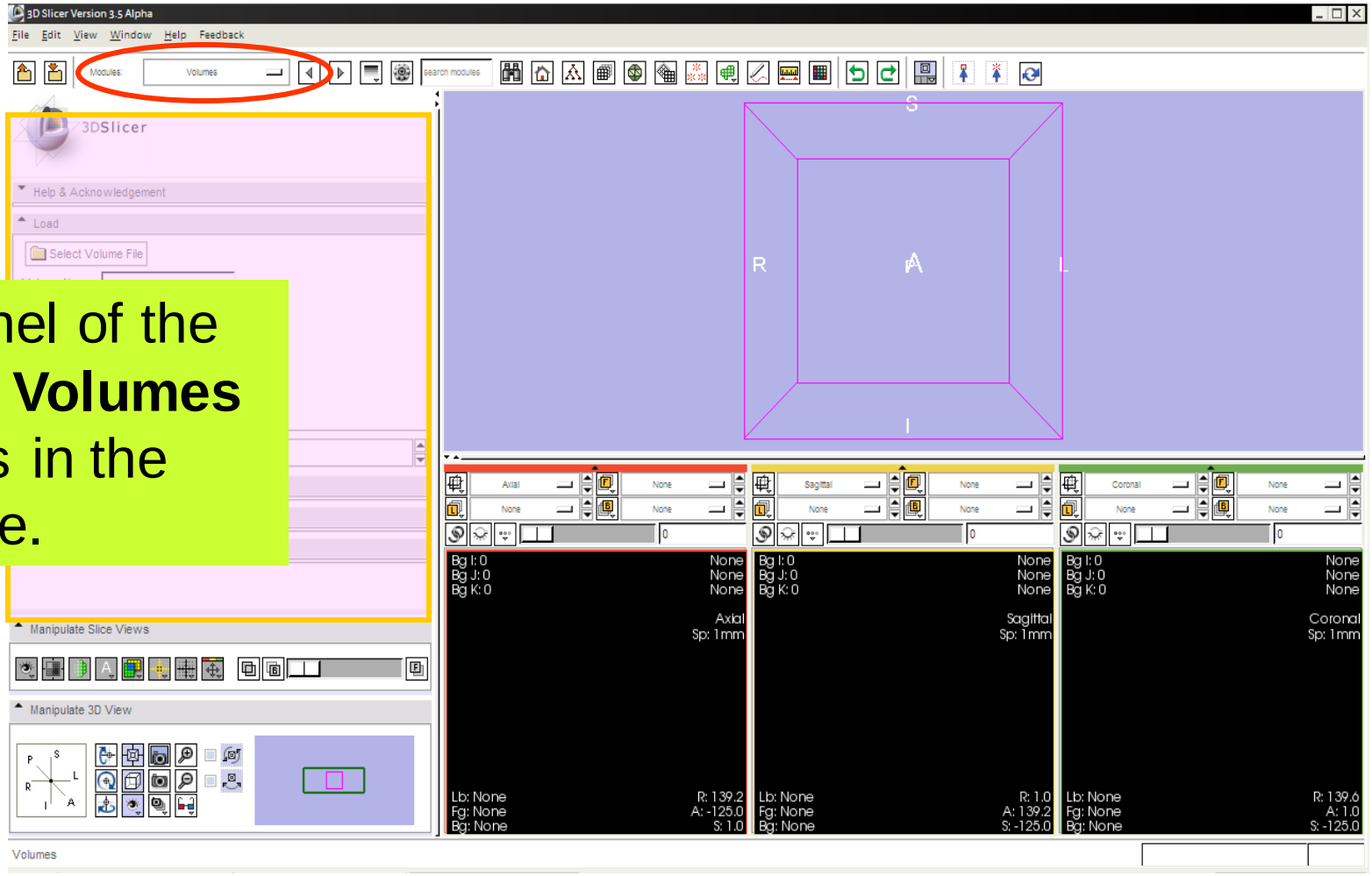


Loading Volumes



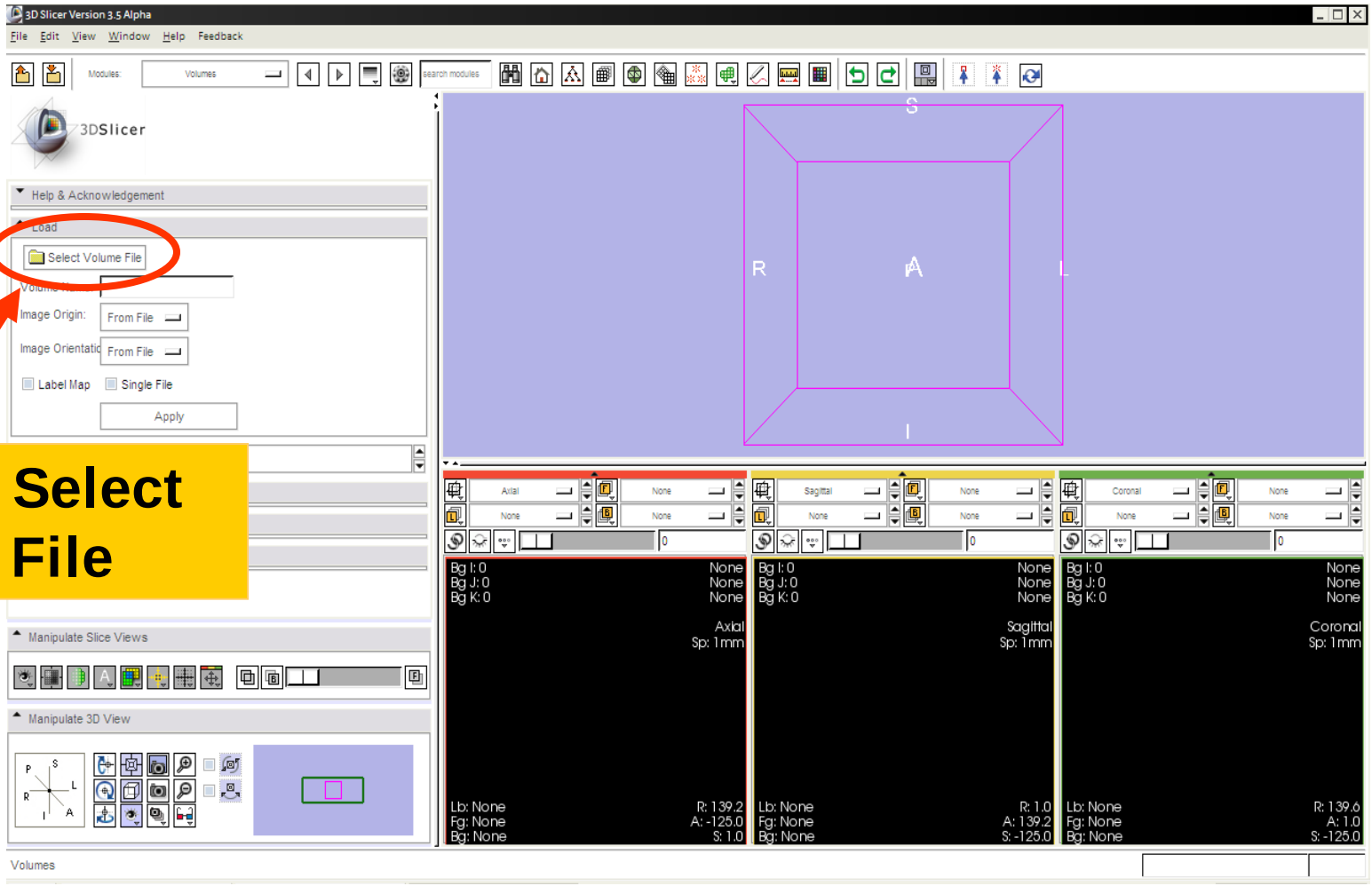
Left-click on the module selection menu to load the module Volumes

Loading Volumes



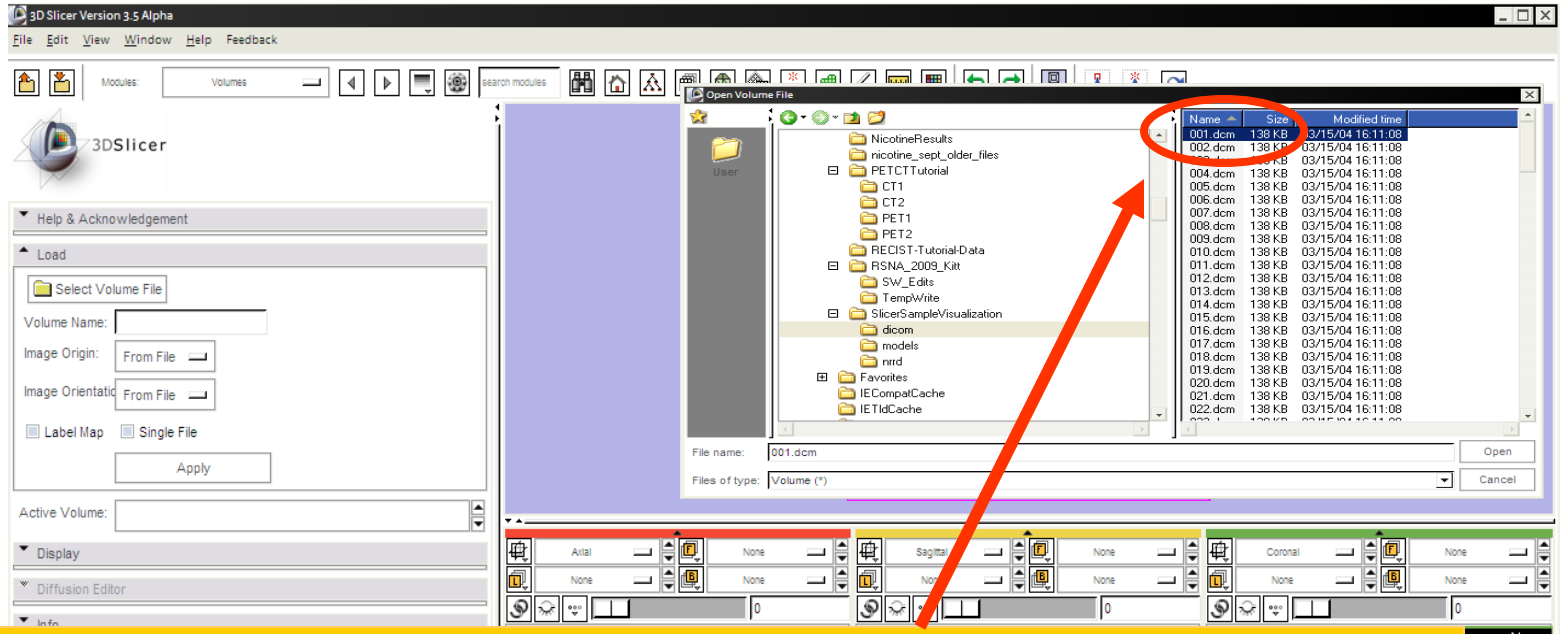
The panel of the module **Volumes** appears in the interface.

Loading Volumes



Click on **Select Volume File**

Loading Volumes

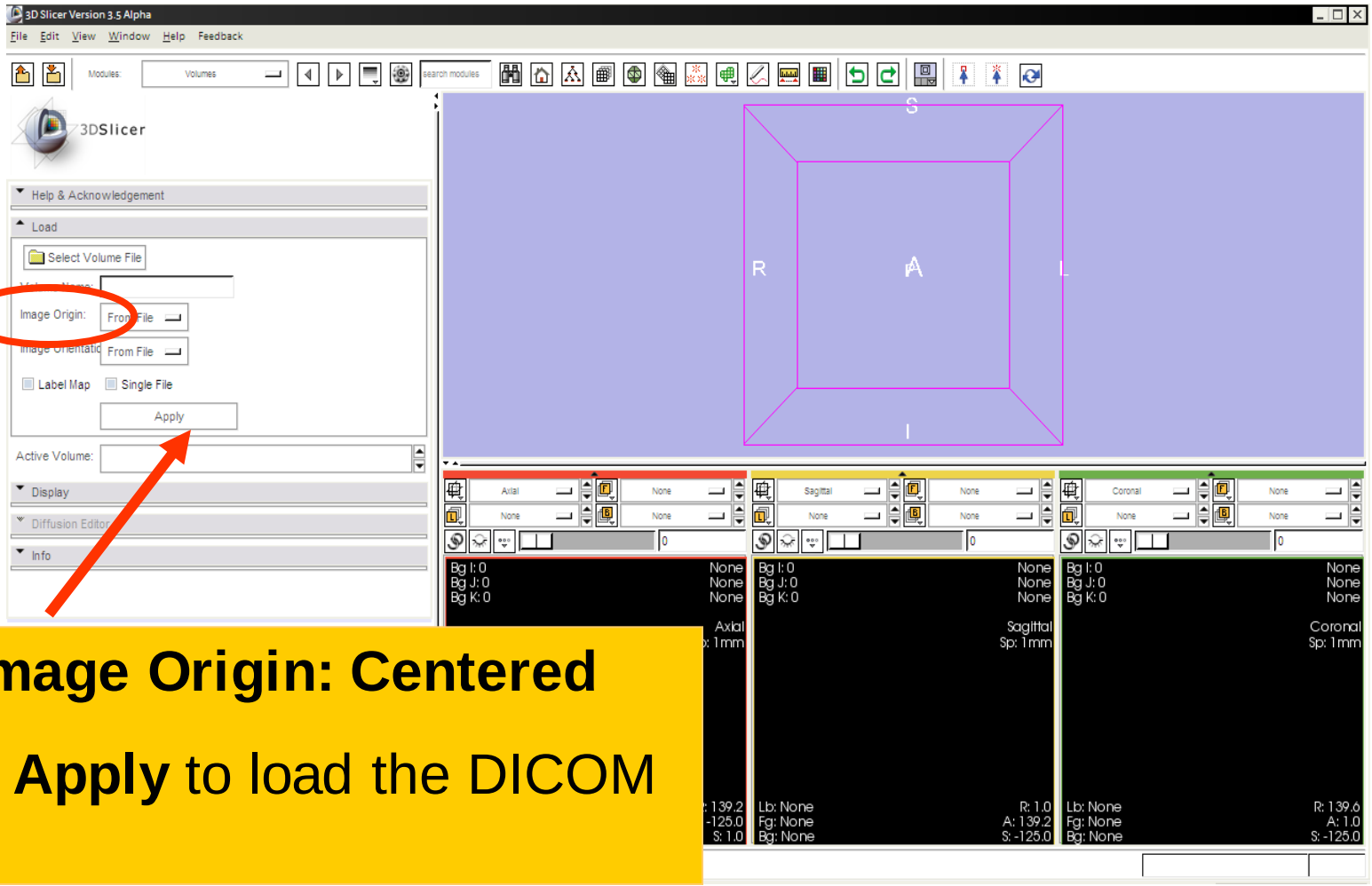


Browse to find the first image ***001.dcm*** of the dataset located in the directory

C:/slicer_data/Slicer3VizualizationDataset/dicom

and click on **Open**

Loading Volumes

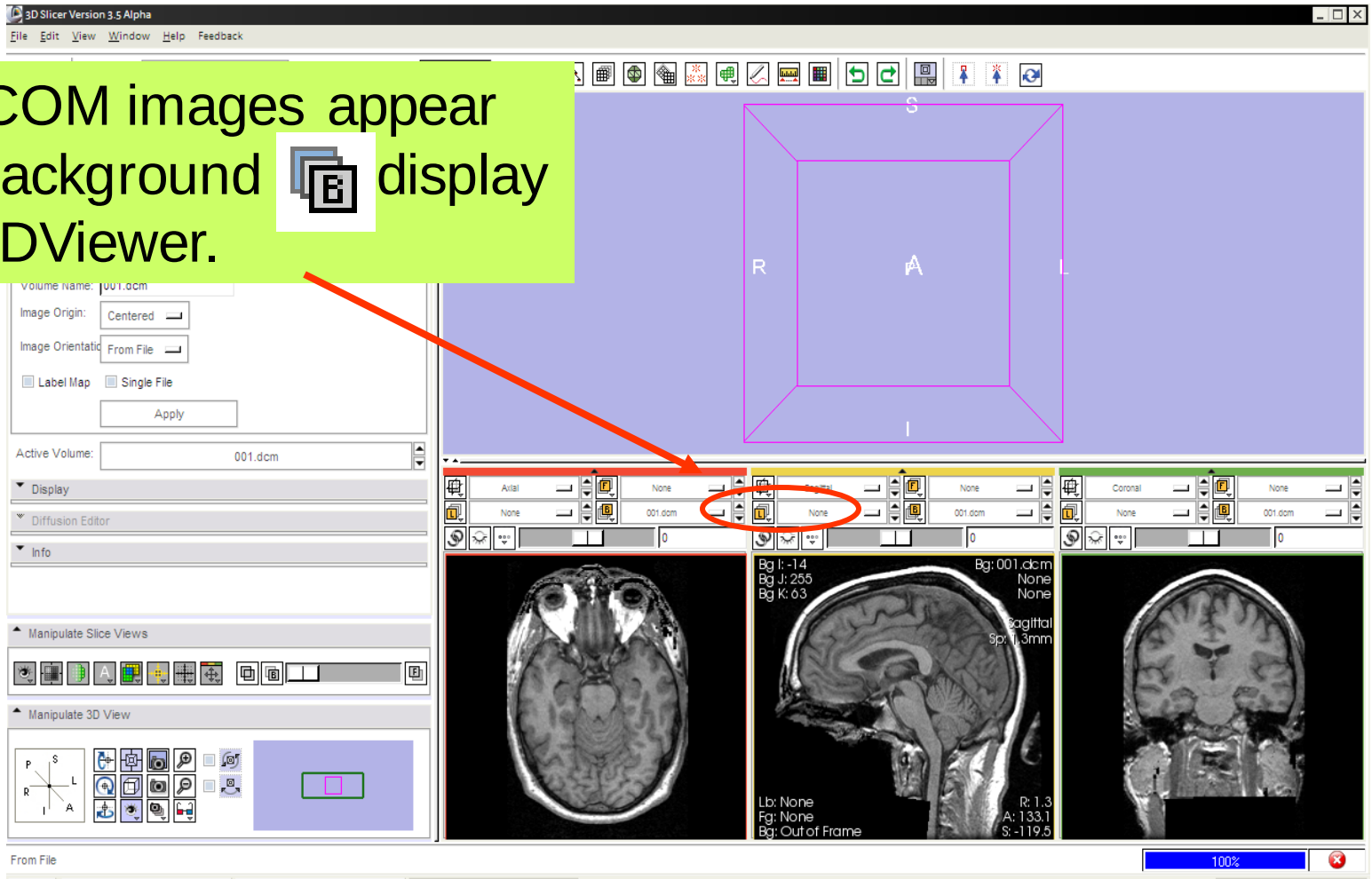


Select **Image Origin: Centered**

Click on **Apply** to load the DICOM dataset

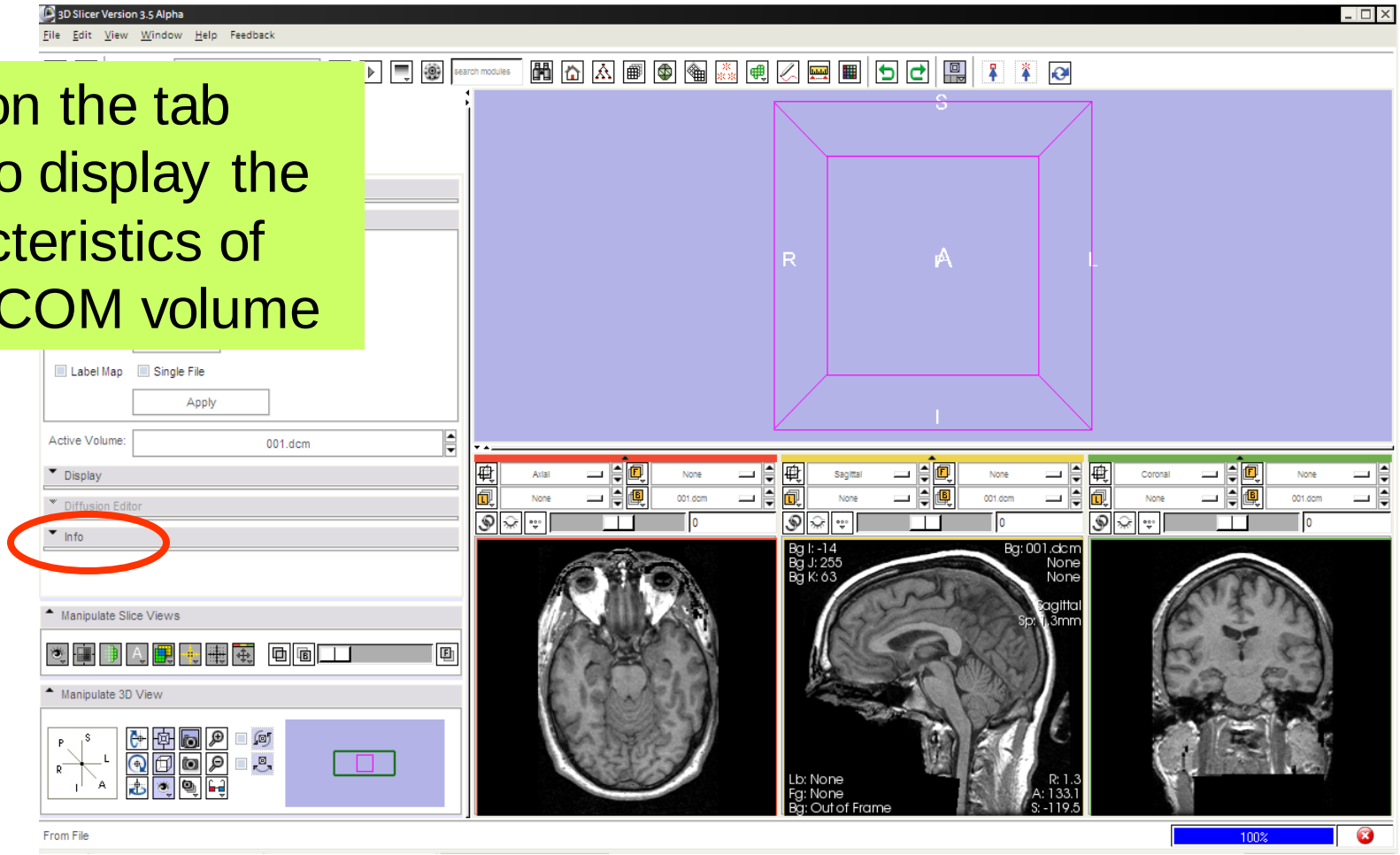
Loading Volumes

The DICOM images appear in the Background display of the 2DViewer.

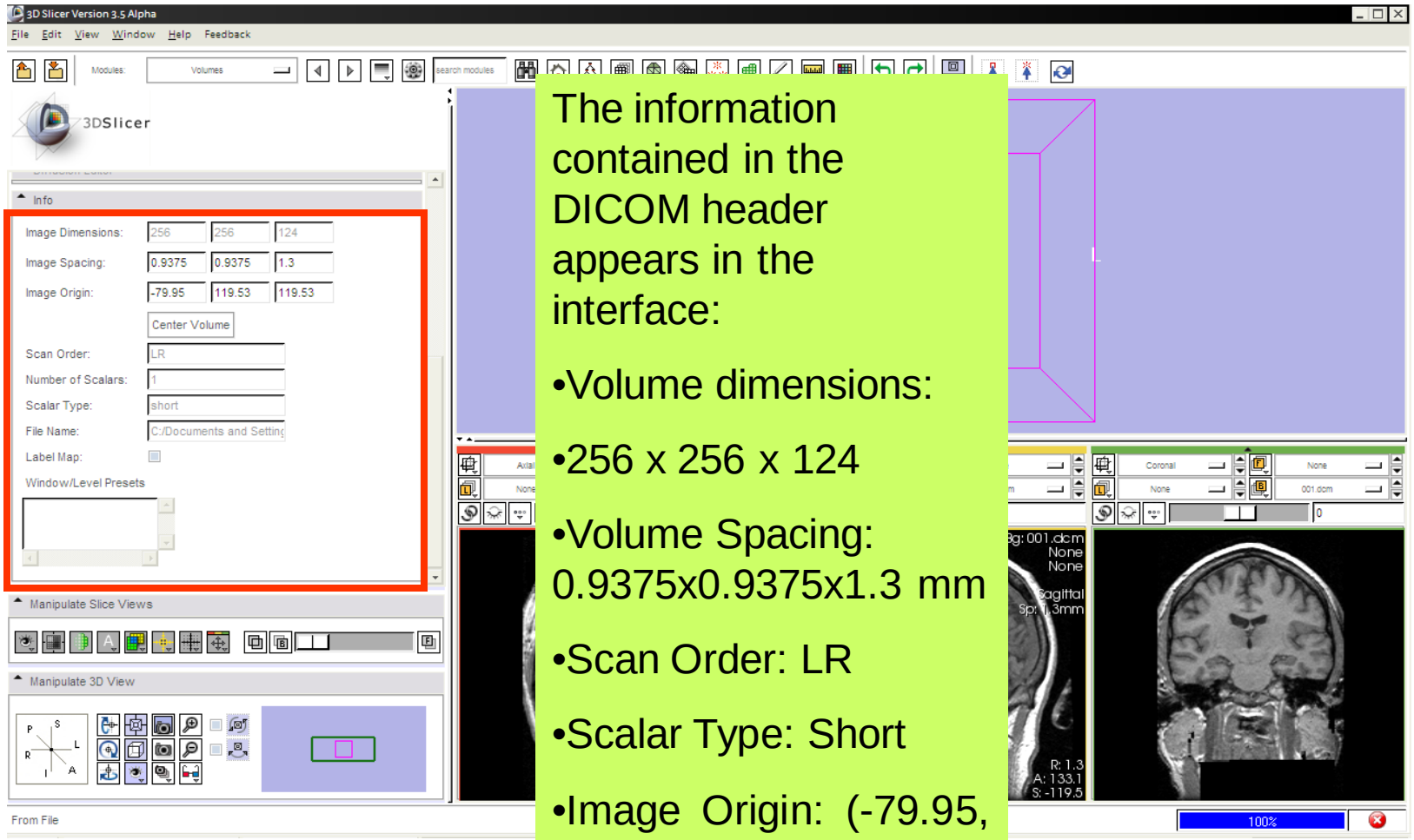


Loading Volumes

Click on the tab Info to display the characteristics of the DICOM volume



Viewing Volume Information

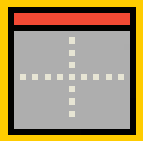


The information contained in the DICOM header appears in the interface:

- Volume dimensions:
- 256 x 256 x 124
- Volume Spacing: 0.9375x0.9375x1.3 mm
- Scan Order: LR
- Scalar Type: Short
- Image Origin: (-79.95, 119.53,119.53)

Exploring the data

Select the ***red slice only layout***



from the menu

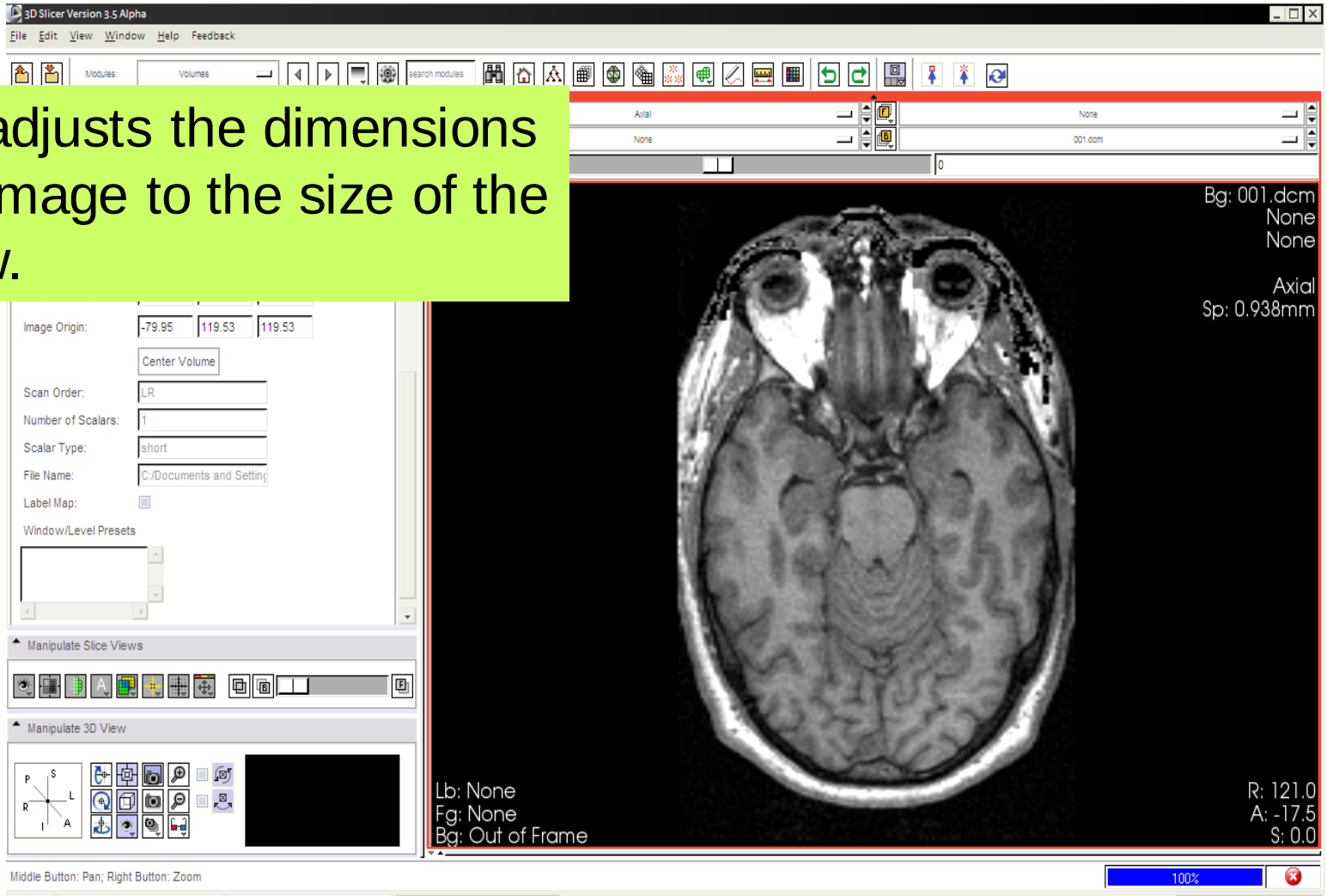
Exploring the data

The axial slices of the dicom volume appear in the 3D viewer

Click on the icon  to adjust the dimensions of the image to the size of the window.

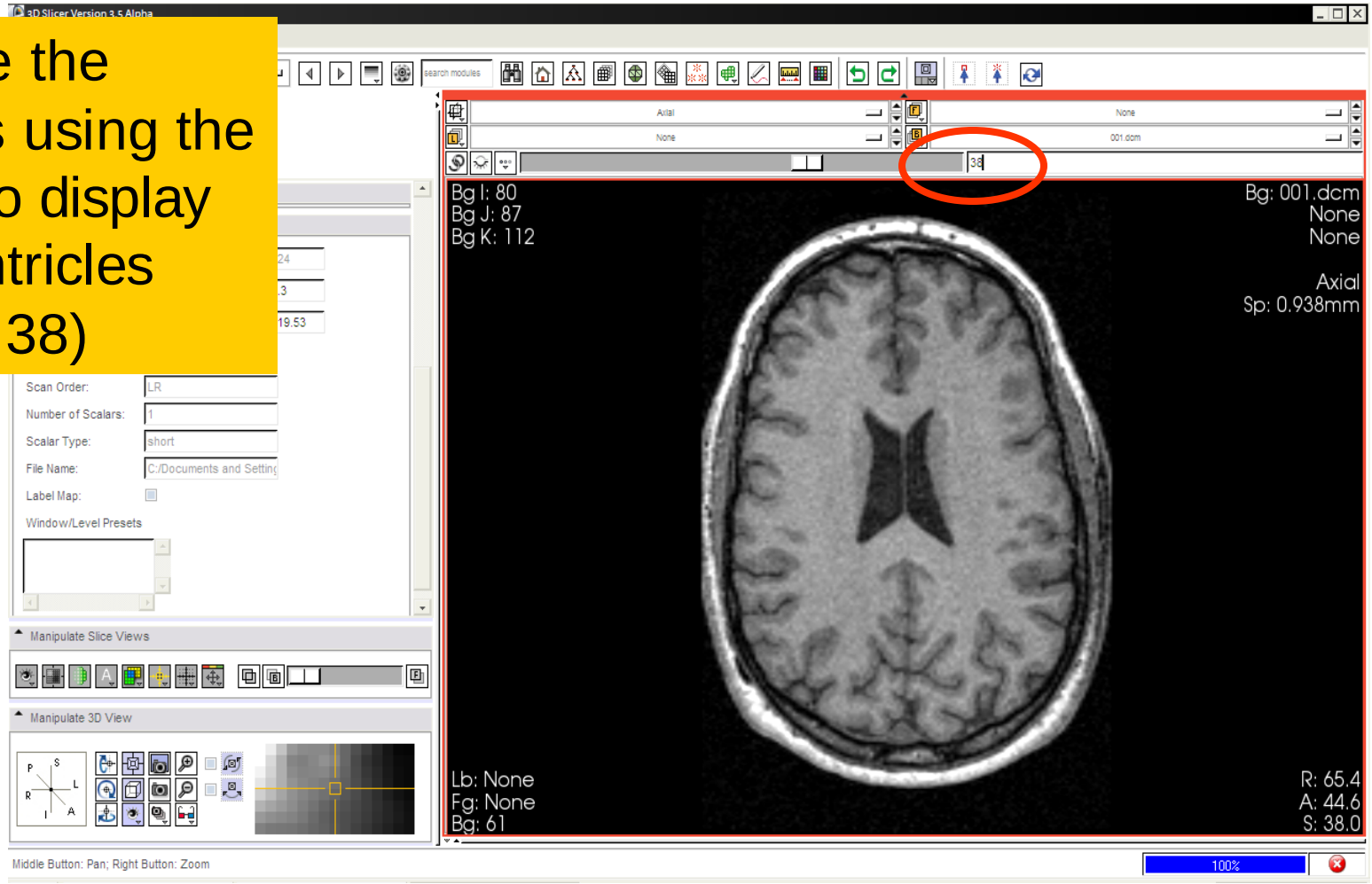
Exploring the data

Slicer adjusts the dimensions of the image to the size of the window.

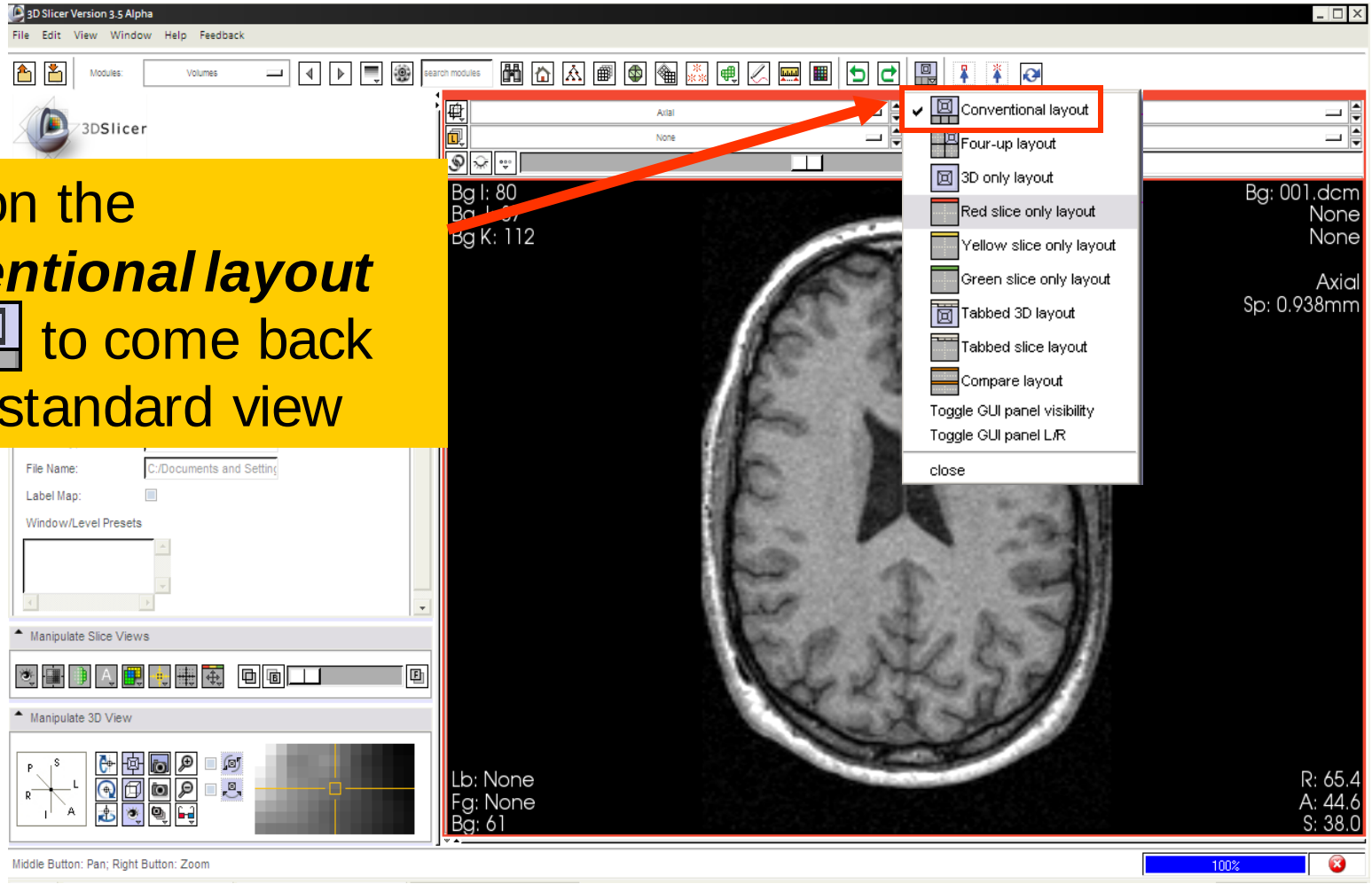


Exploring the data

Browse the images using the slider to display the ventricles (~slice 38)

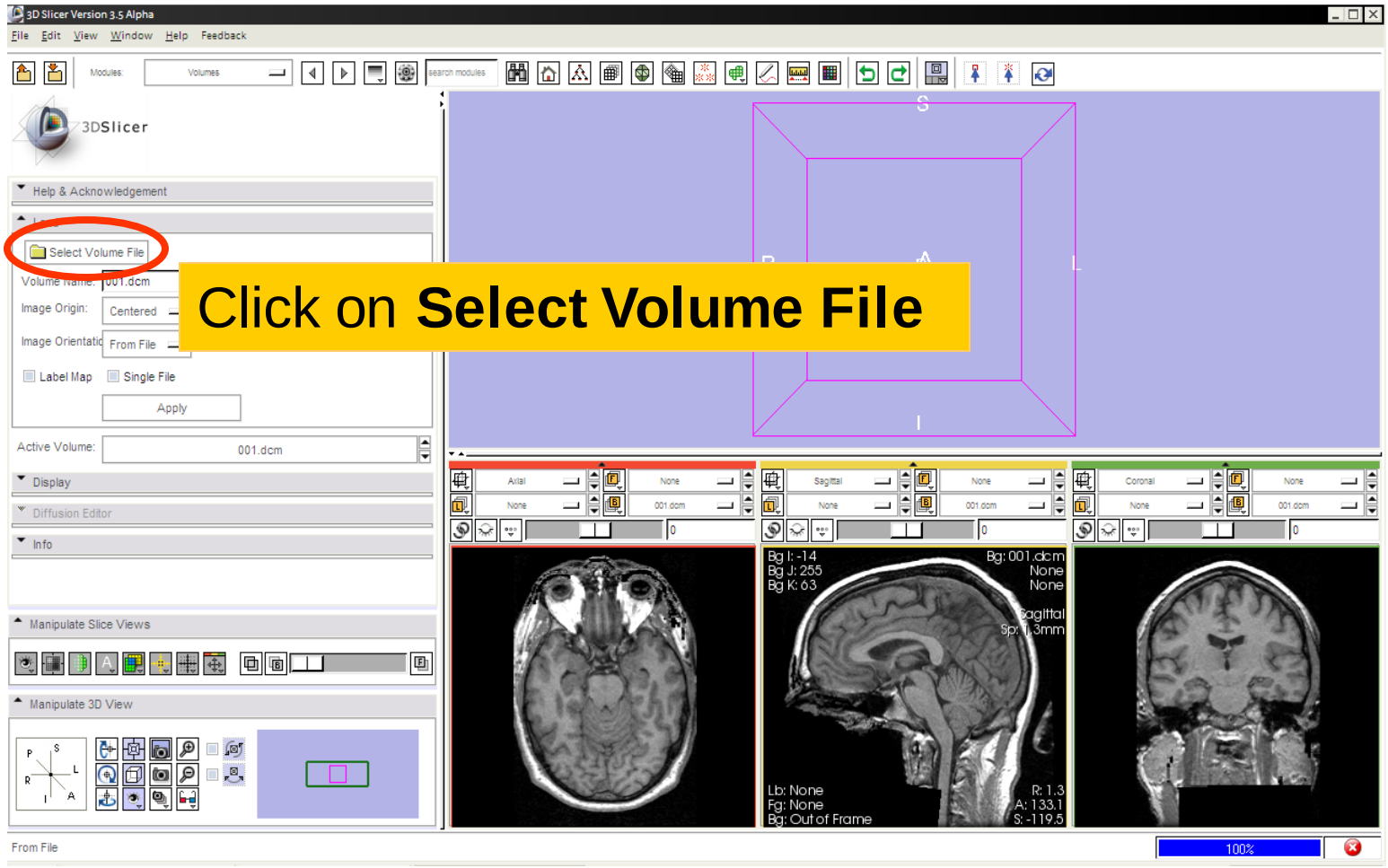


Exploring the data

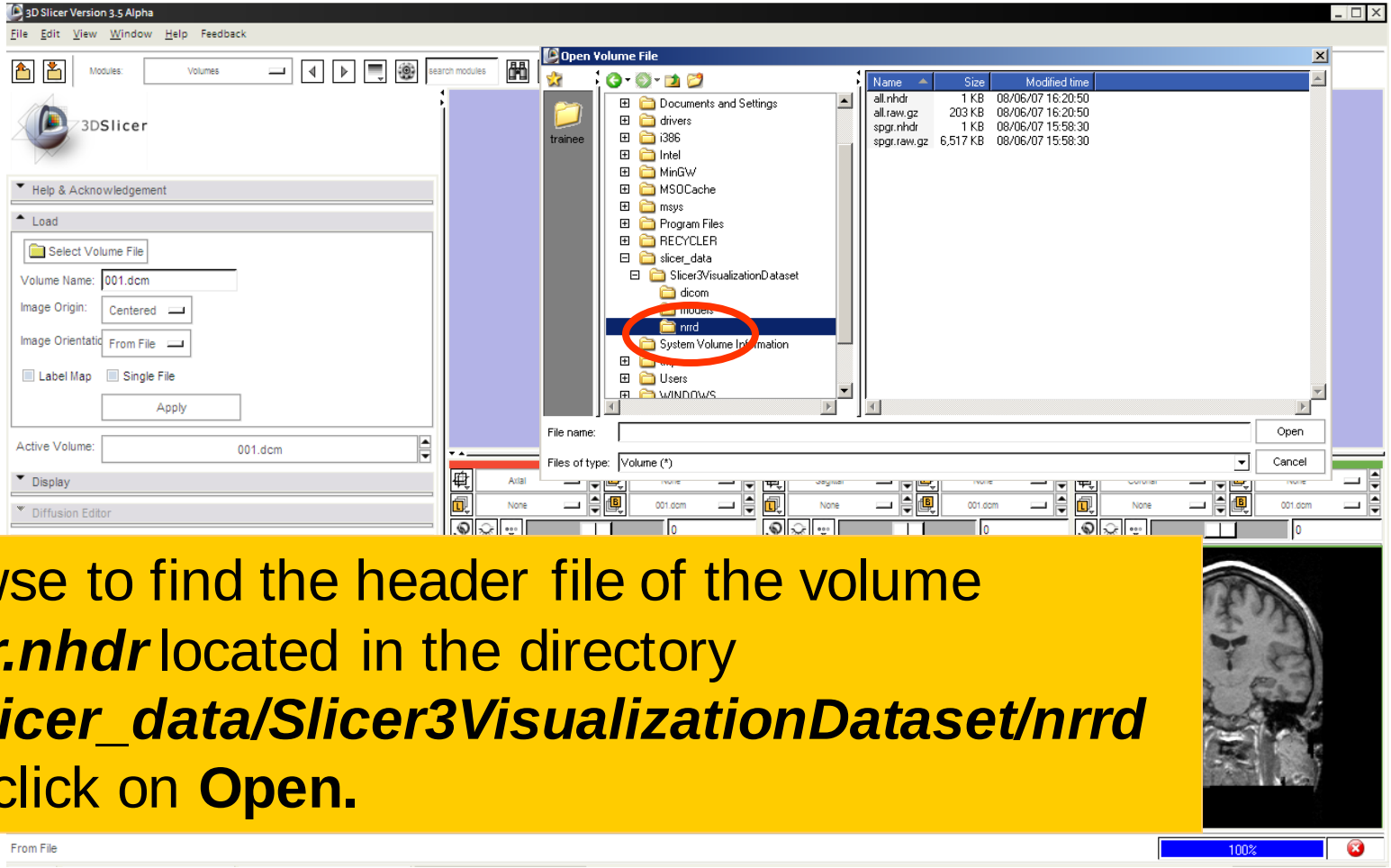


Click on the ***conventional layout*** *icon* to come back to the standard view

Loading Volumes

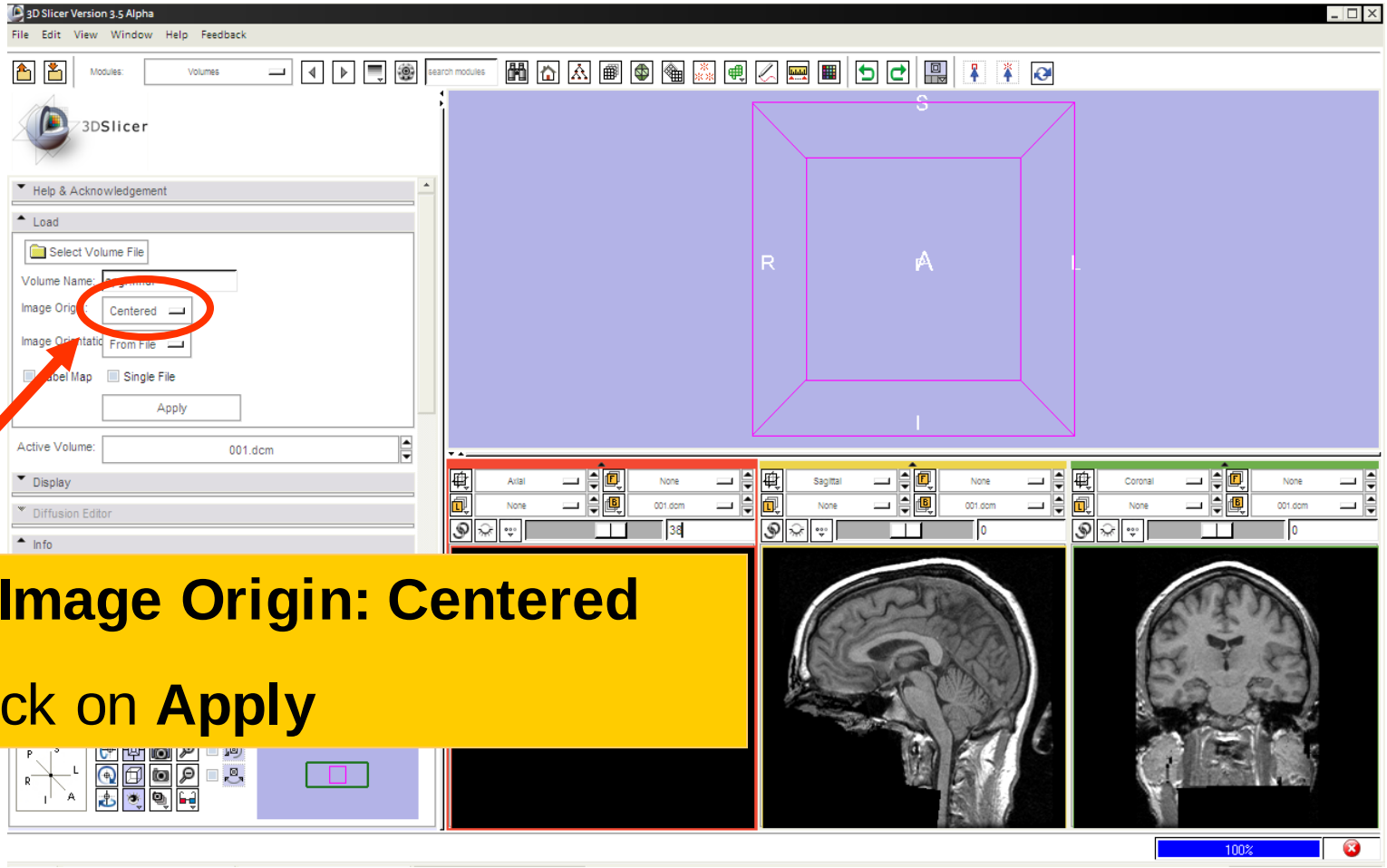


Loading Volumes



Browse to find the header file of the volume ***spgr.nhdr*** located in the directory ***c:/slicer_data/Slicer3VisualizationDataset/nrrd*** and click on **Open.**

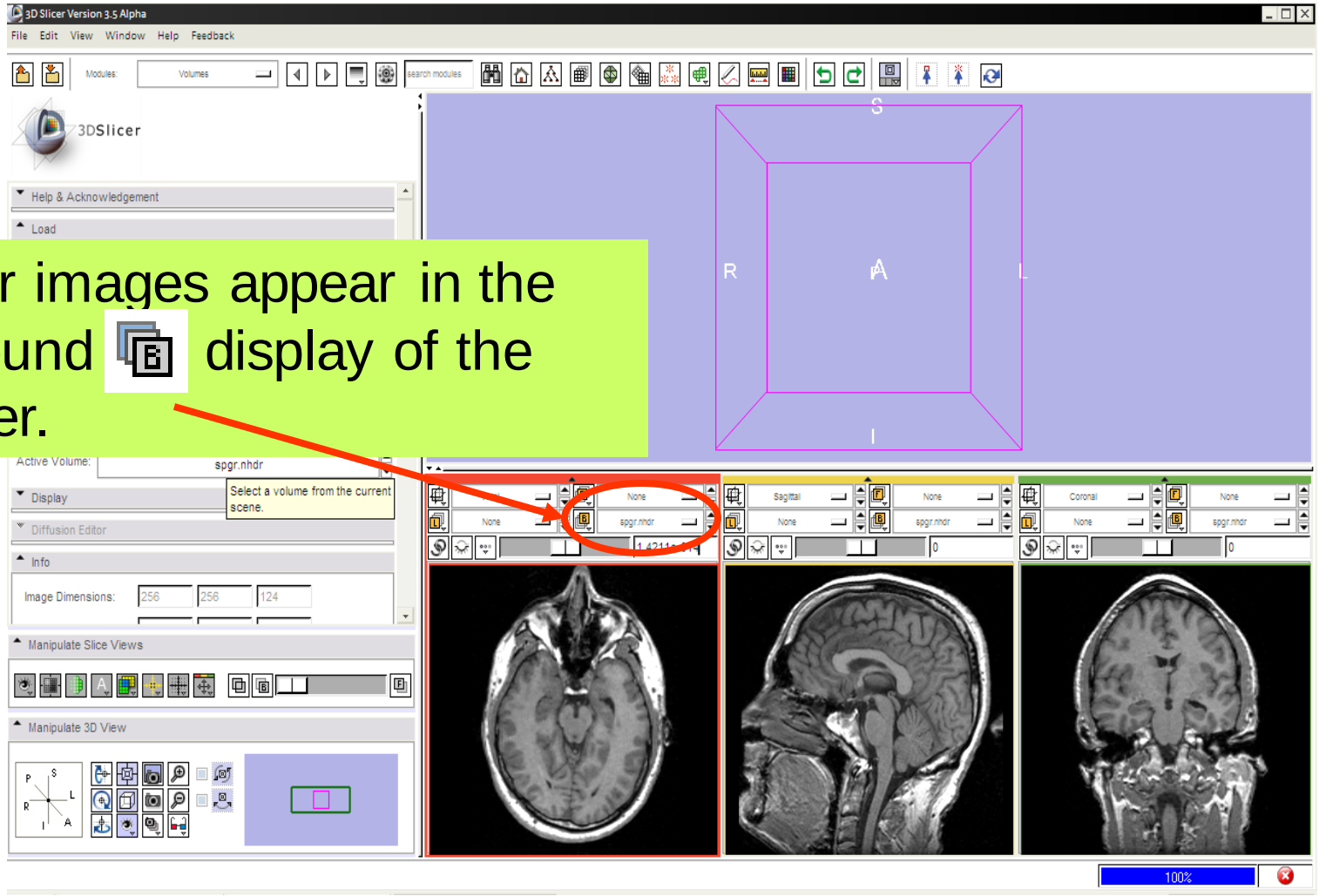
Loading Volumes



Select **Image Origin: Centered**

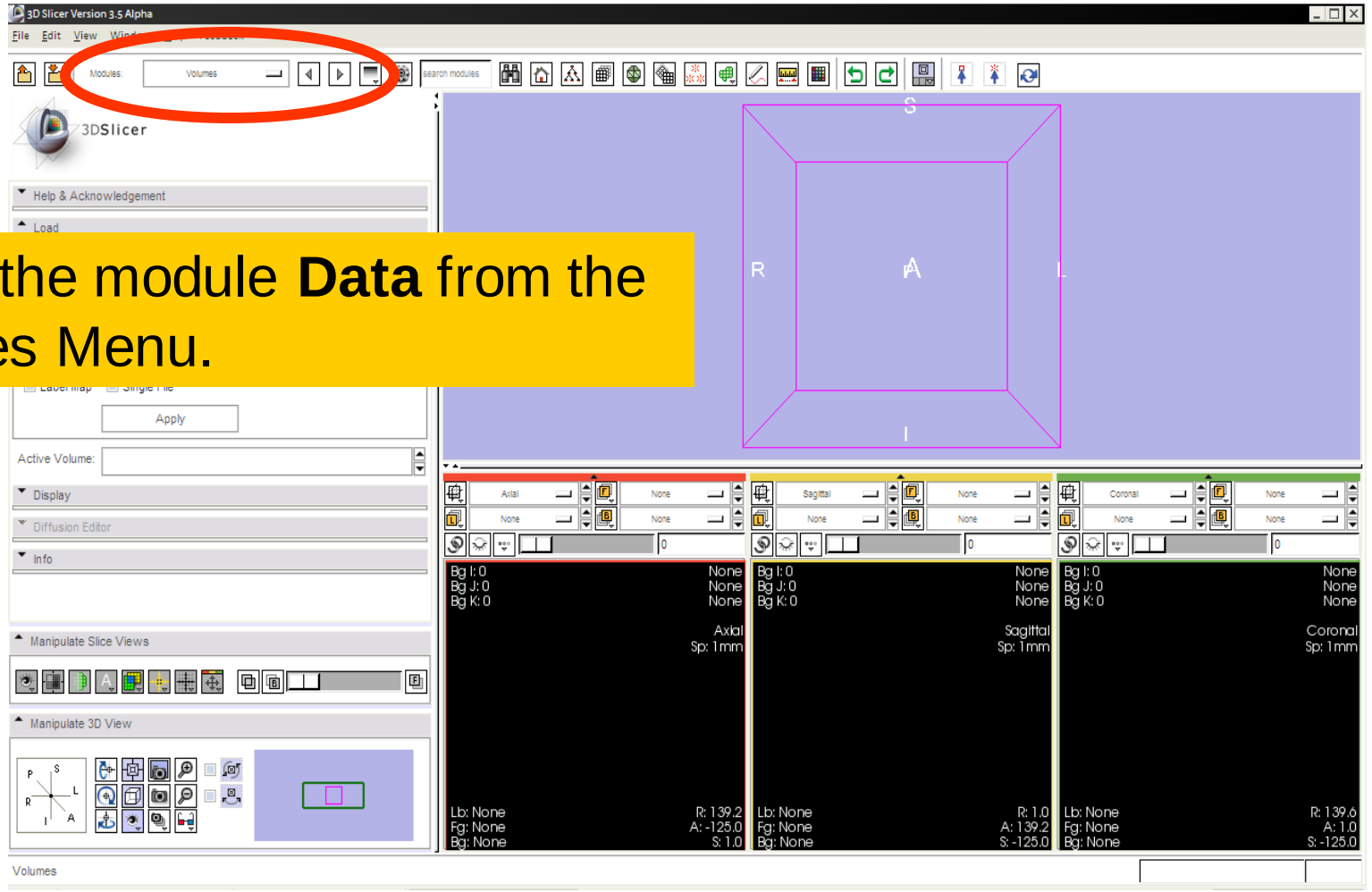
and Click on **Apply**

Loading Volumes



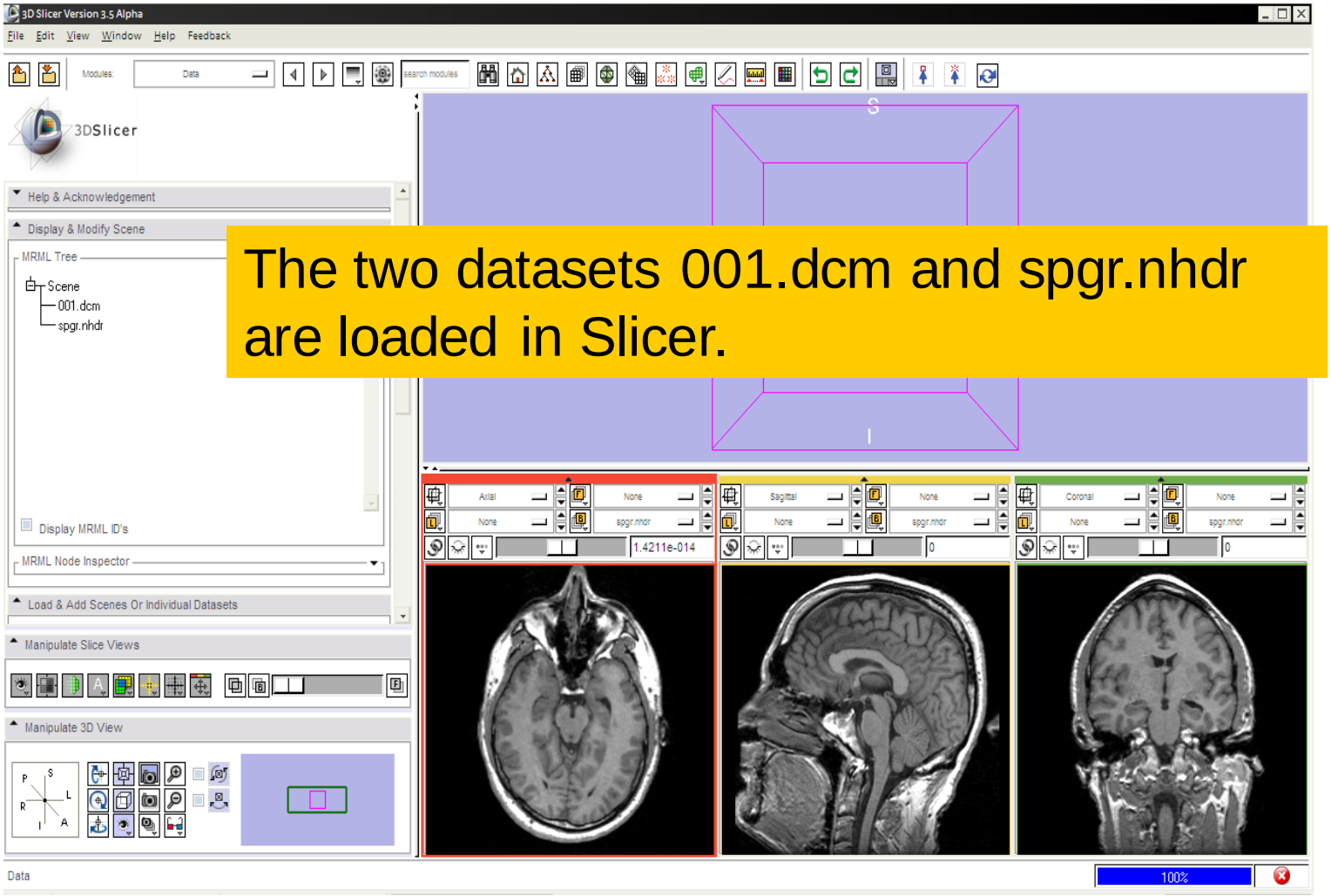
The spgr images appear in the Background display of the 2DViewer.

Loading Volumes



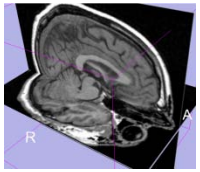
Select the module **Data** from the Modules Menu.

Loading Volumes

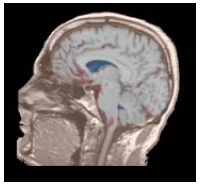


The two datasets 001.dcm and spgr.nhdr are loaded in Slicer.

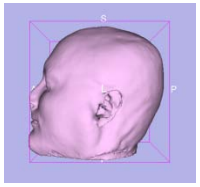
Overview



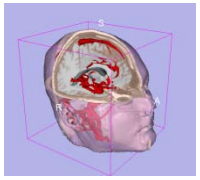
Loading and visualizing multiple volumes simultaneously



Loading and visualizing segmented structures overlaid on grayscale images



Loading and visualizing 3D models



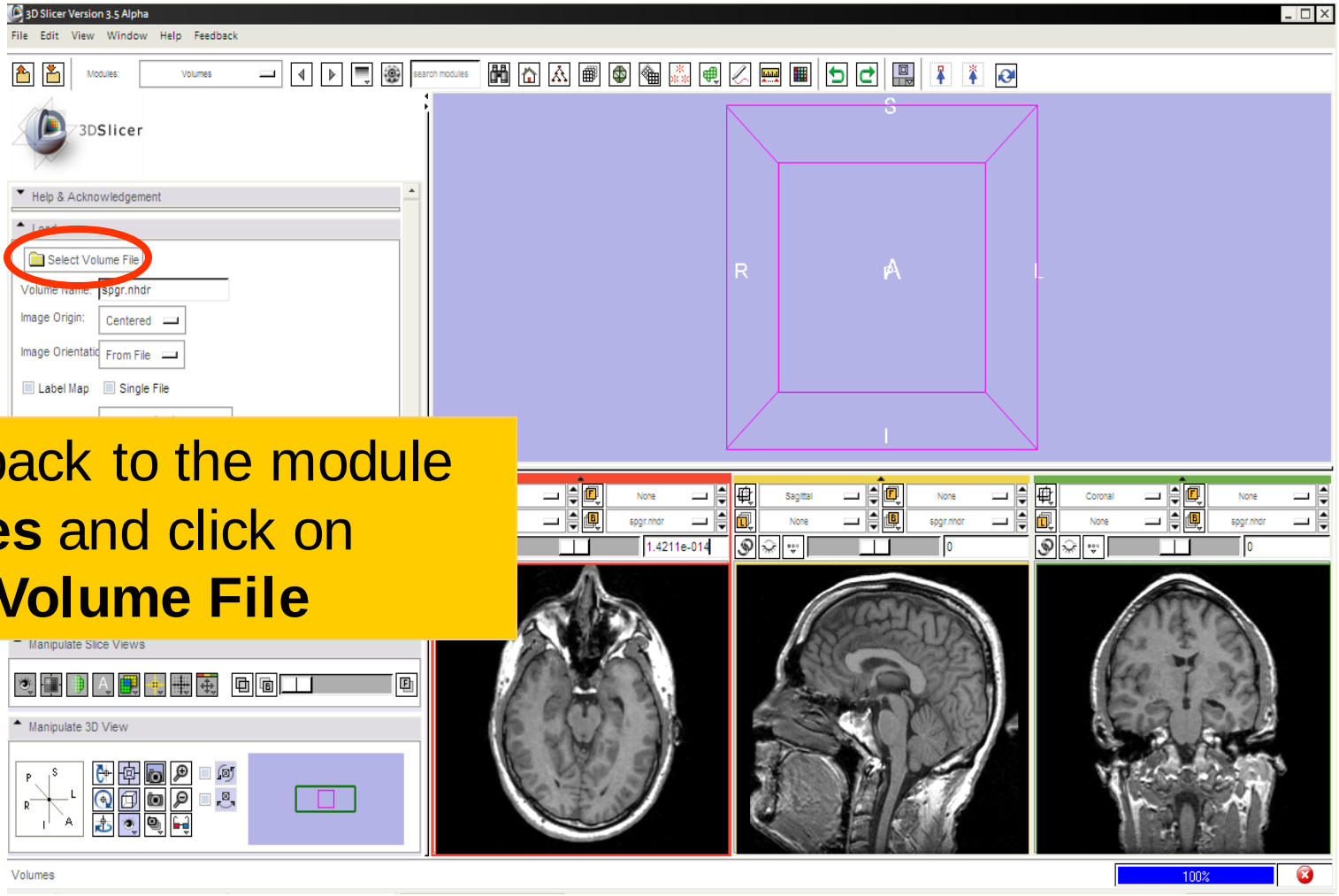
Loading and saving a scene

Part 2: Loading and visualizing segmented structures overlaid on grayscale images

Label map

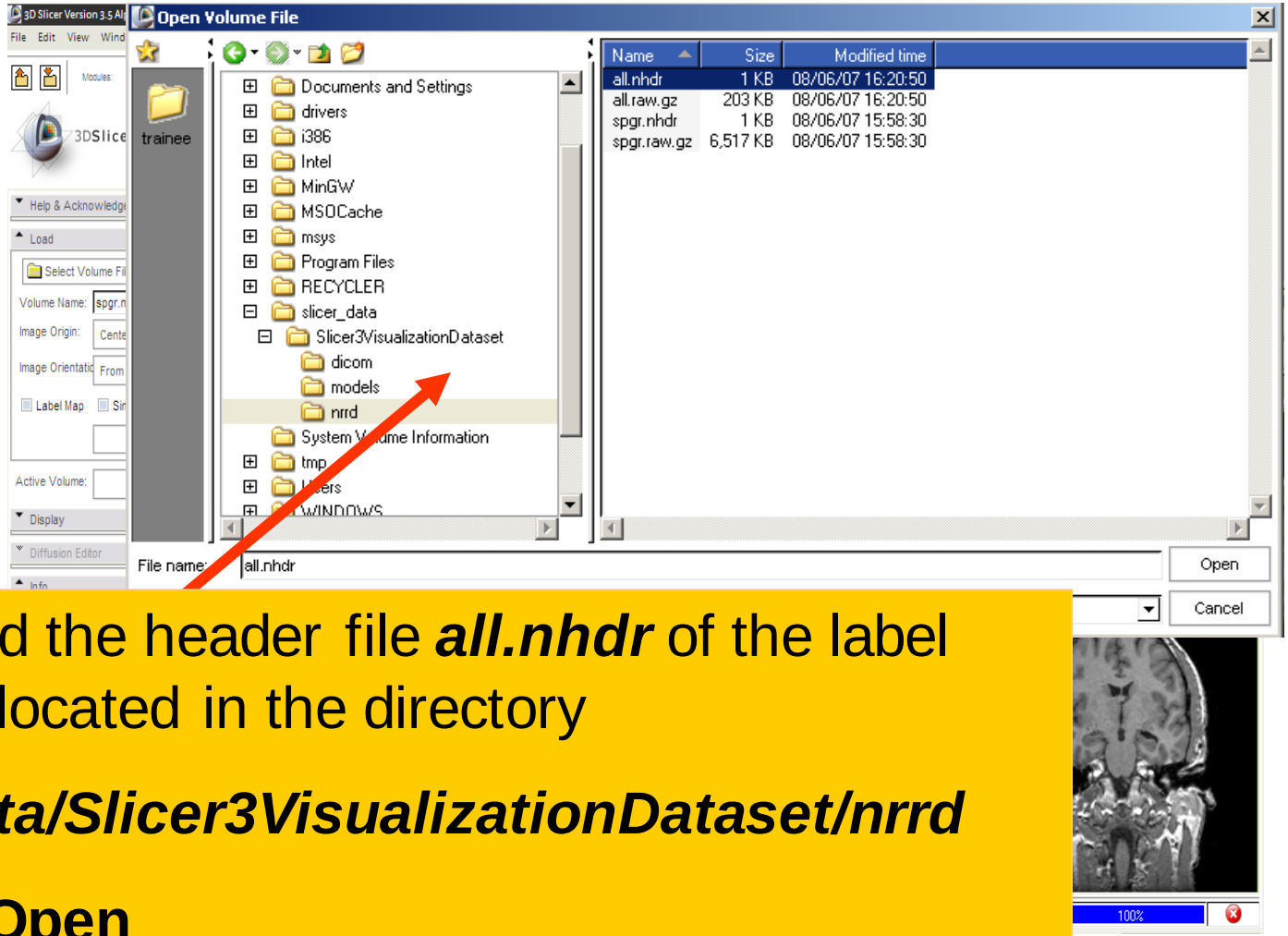
- Image segmentation is the extraction of structural information of particular interest from surrounding image.
- Each pixel is assigned a specific label value which corresponds to the anatomical structure that it belongs to.
- The three-dimensional result of the segmentation is a binary array called a label map.

Loading a label map



Come back to the module **Volumes** and click on **Select Volume File**

Loading a label map

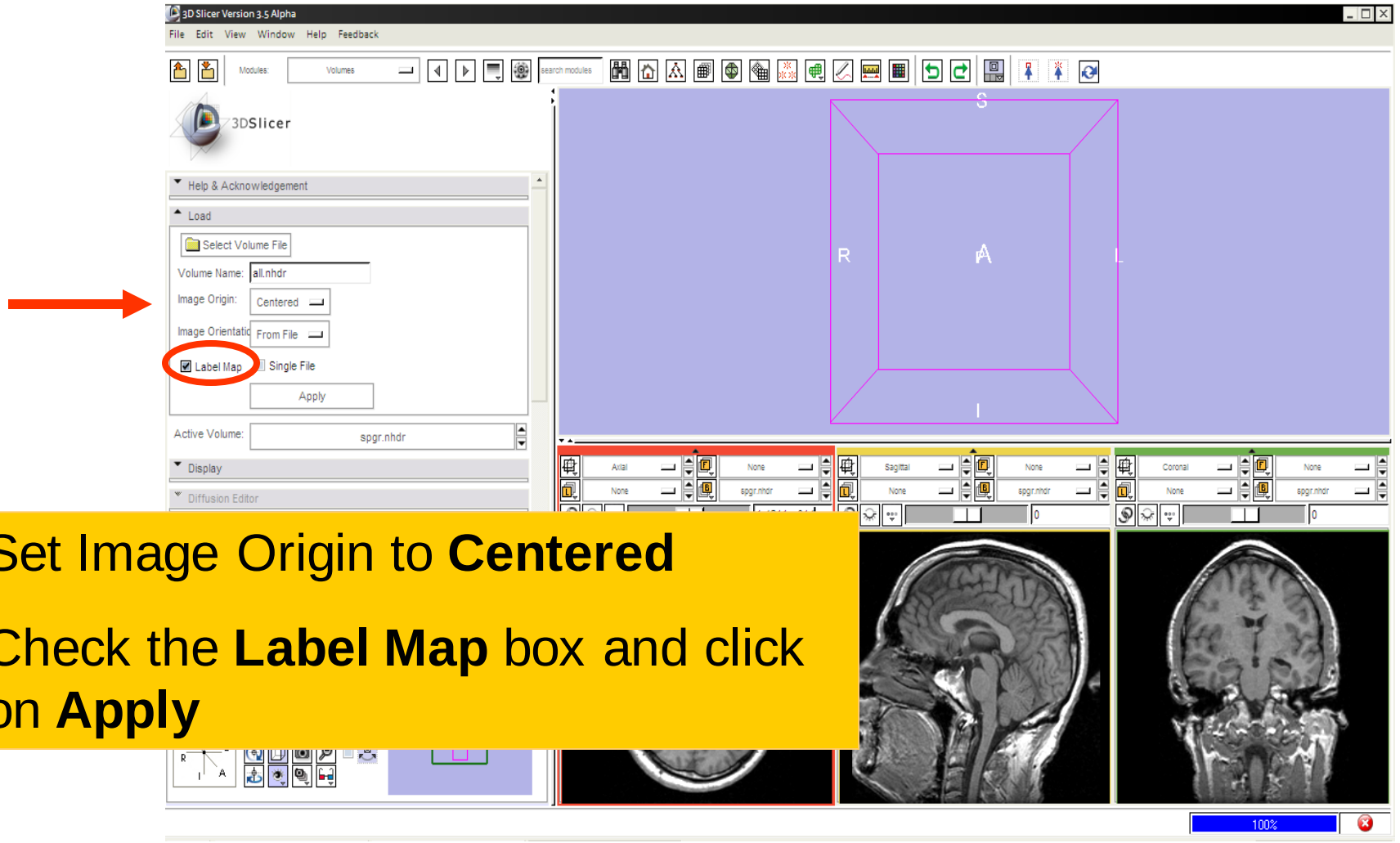


Browse to find the header file ***all.nhdr*** of the label map dataset located in the directory

C:/slicer_data/Slicer3VisualizationDataset/nrrd

and click on **Open**

Visualizing a label map



Set Image Origin to **Centered**

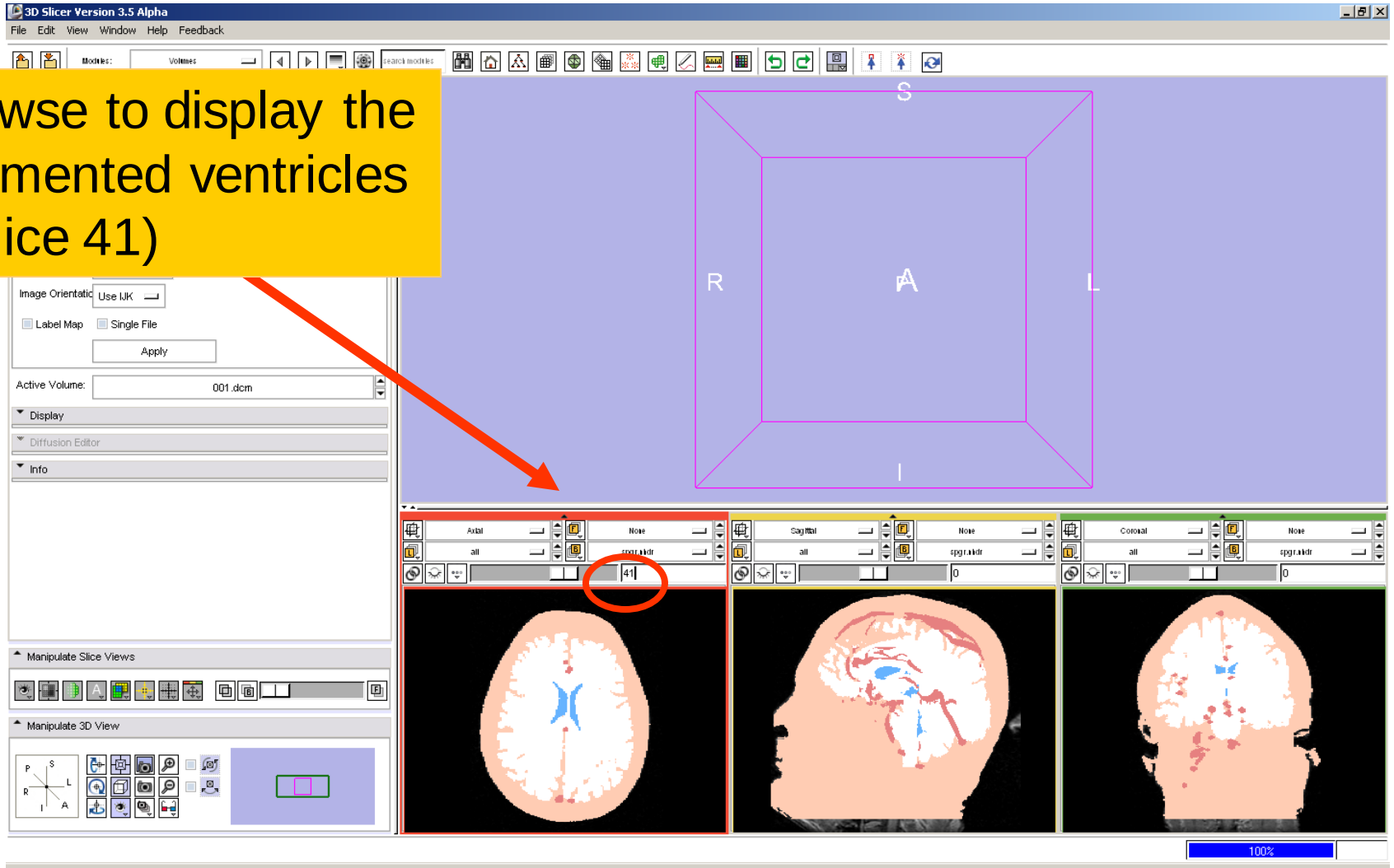
Check the **Label Map** box and click on **Apply**

Visualizing a label map

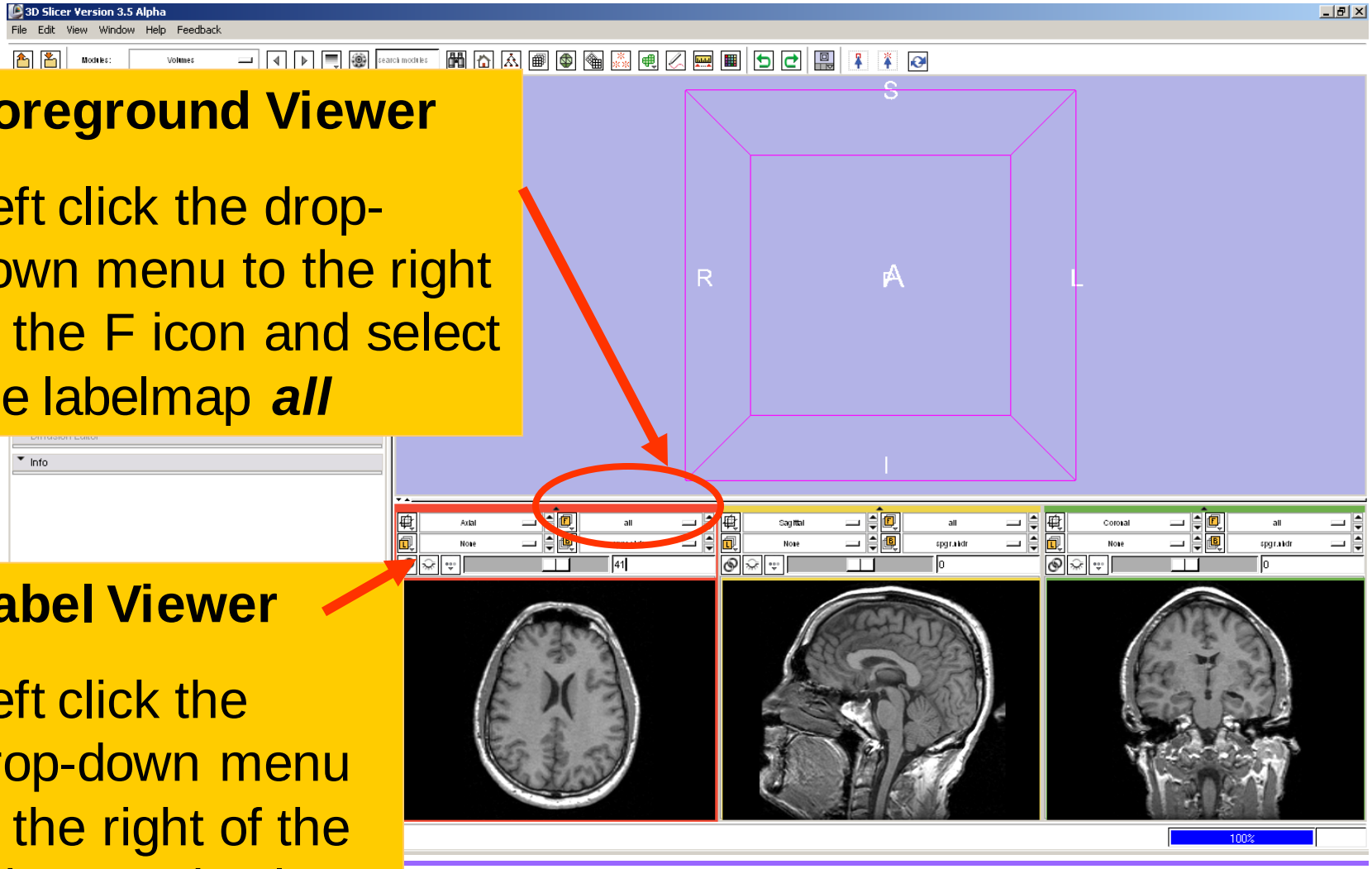
Slicer displays the label map ***all*** in the **Label layer**

Click on the ***links*** icon.

Visualizing a label map



Visualizing Multiple Volumes



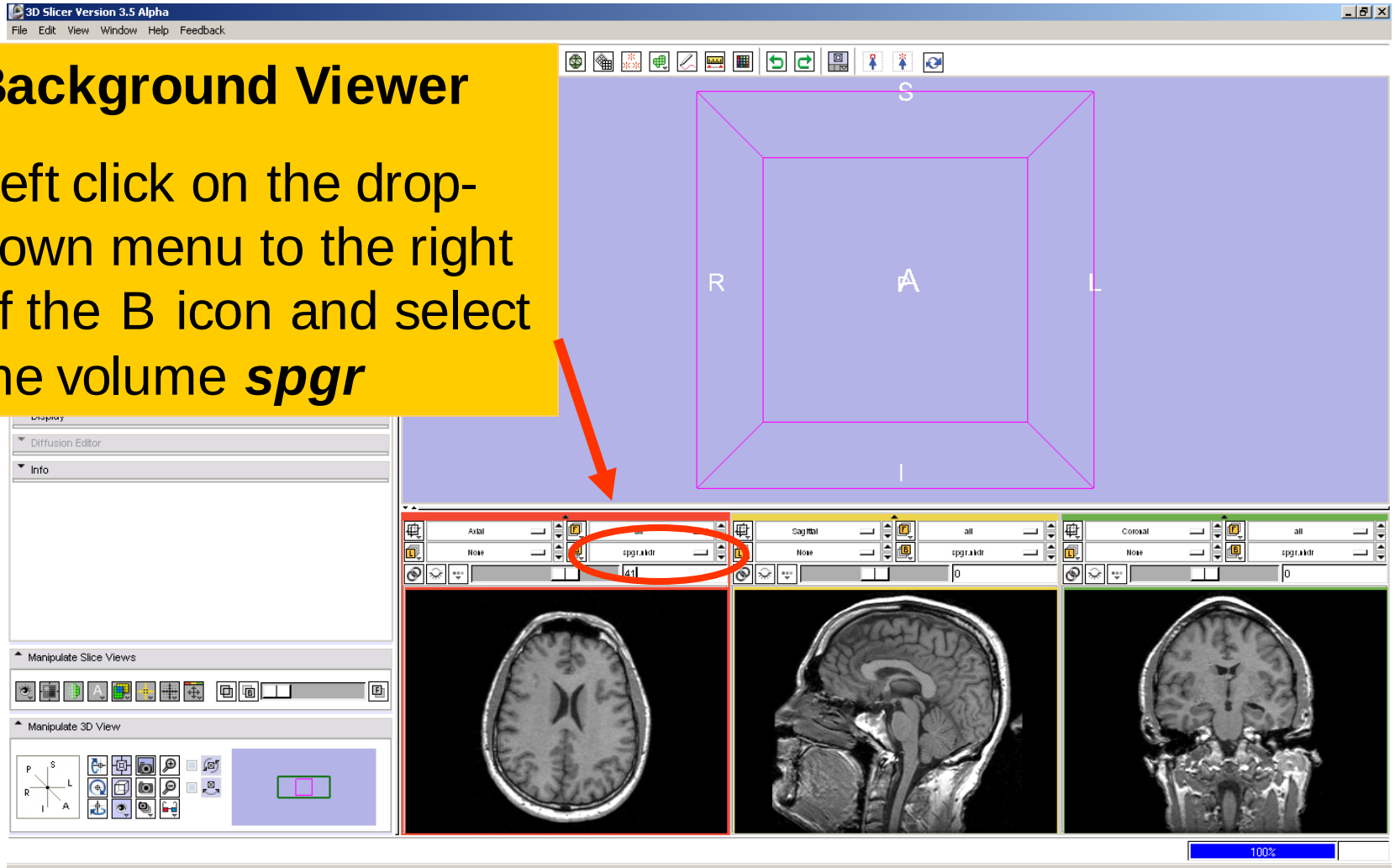
Foreground Viewer

Left click the drop-down menu to the right of the F icon and select the labelmap ***all***

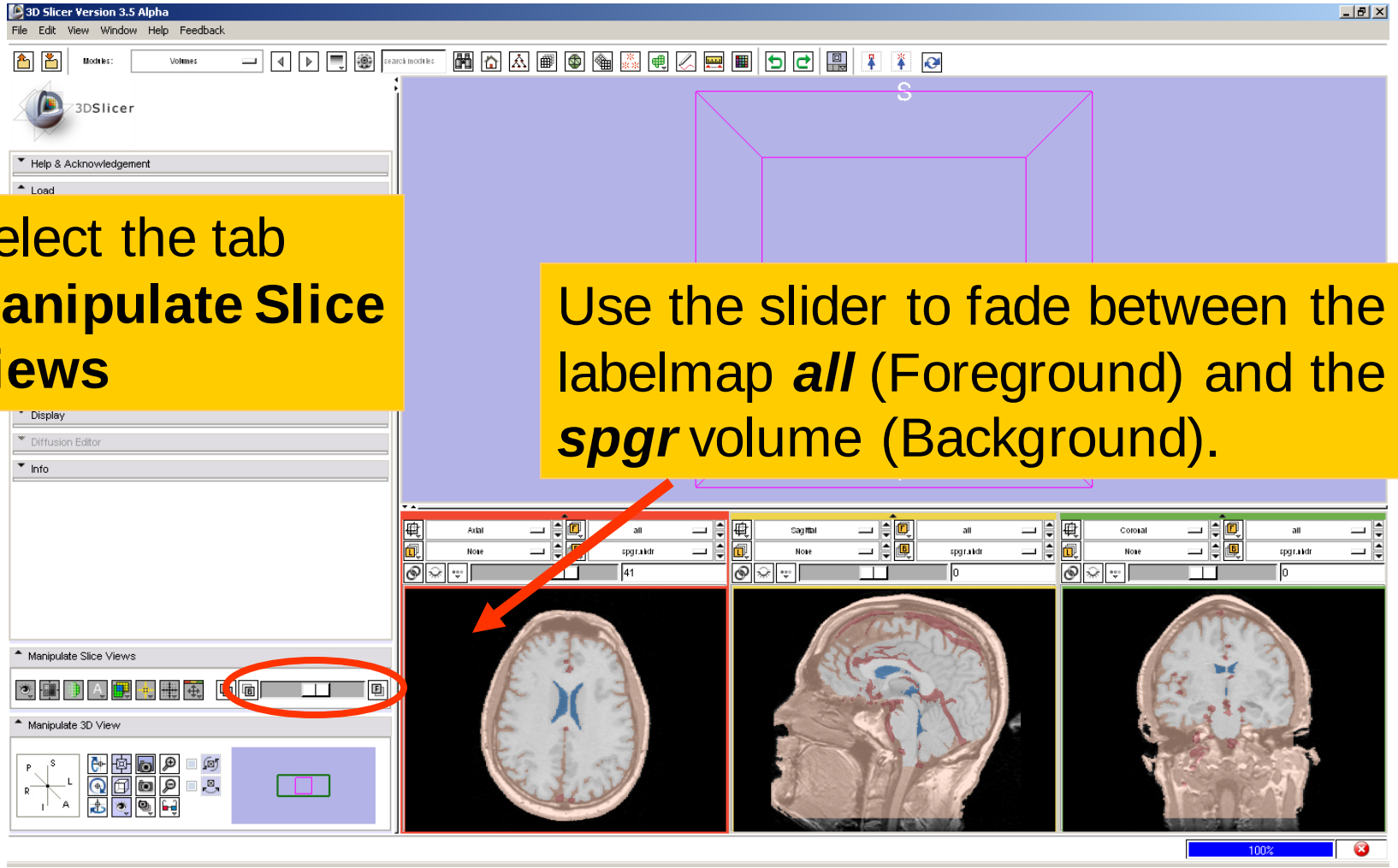
Label Viewer

Left click the drop-down menu to the right of the L icon and select ***None***

Visualizing Multiple Volumes



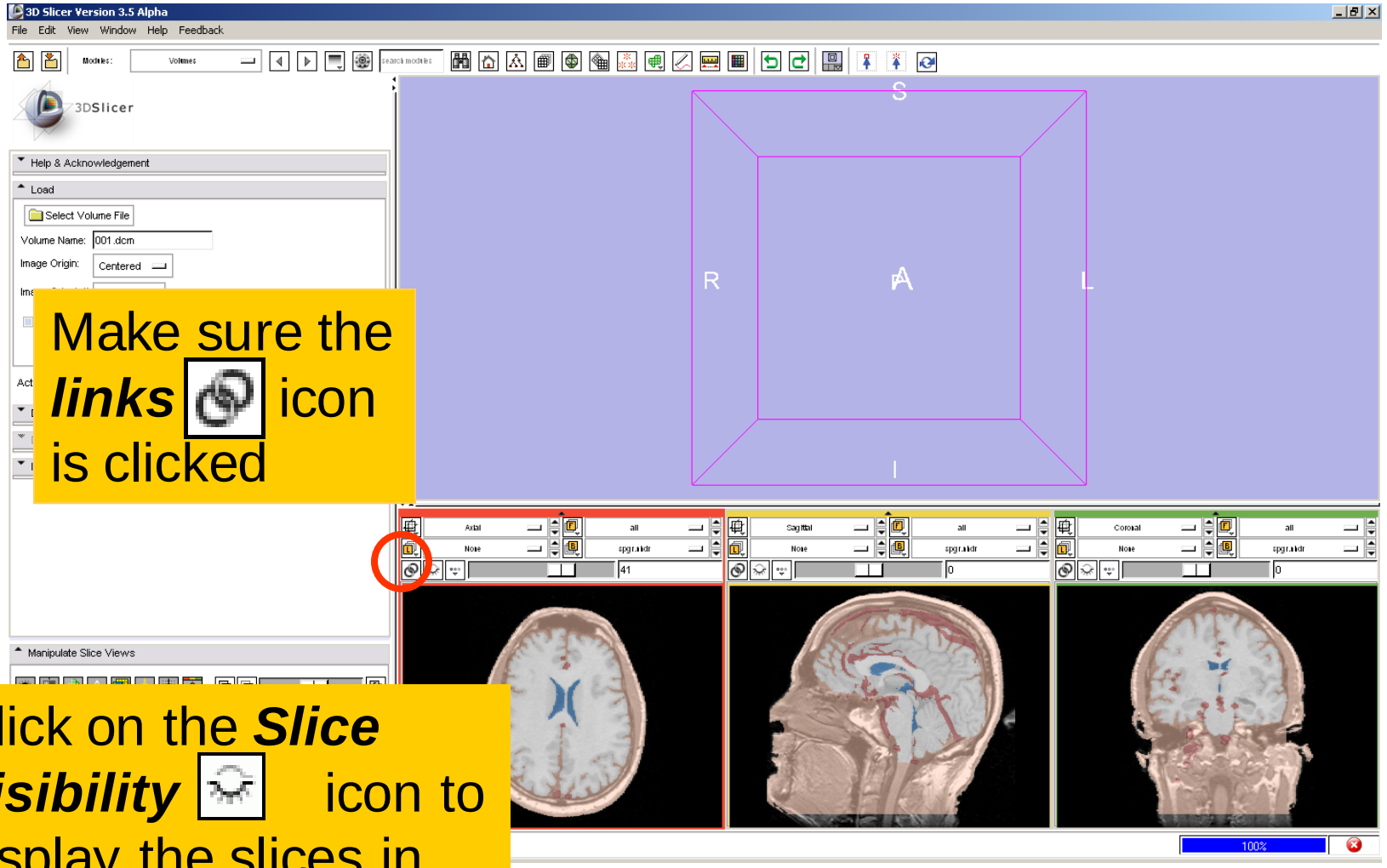
Visualizing Multiple Volumes



Select the tab **Manipulate Slice Views**

Use the slider to fade between the labelmap ***all*** (Foreground) and the ***spgr*** volume (Background).

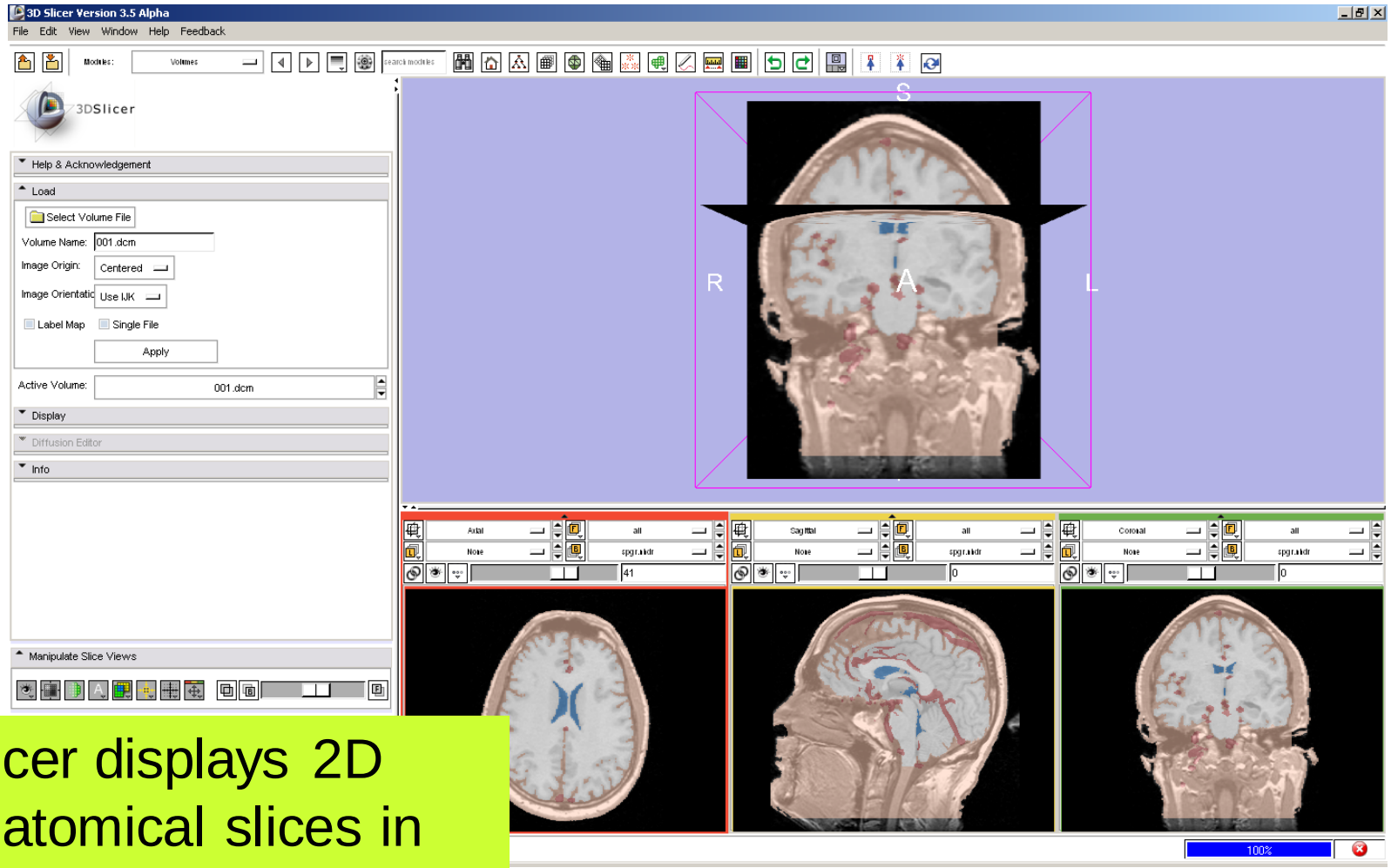
Visualizing Multiple Volumes



Make sure the ***links*** icon is clicked

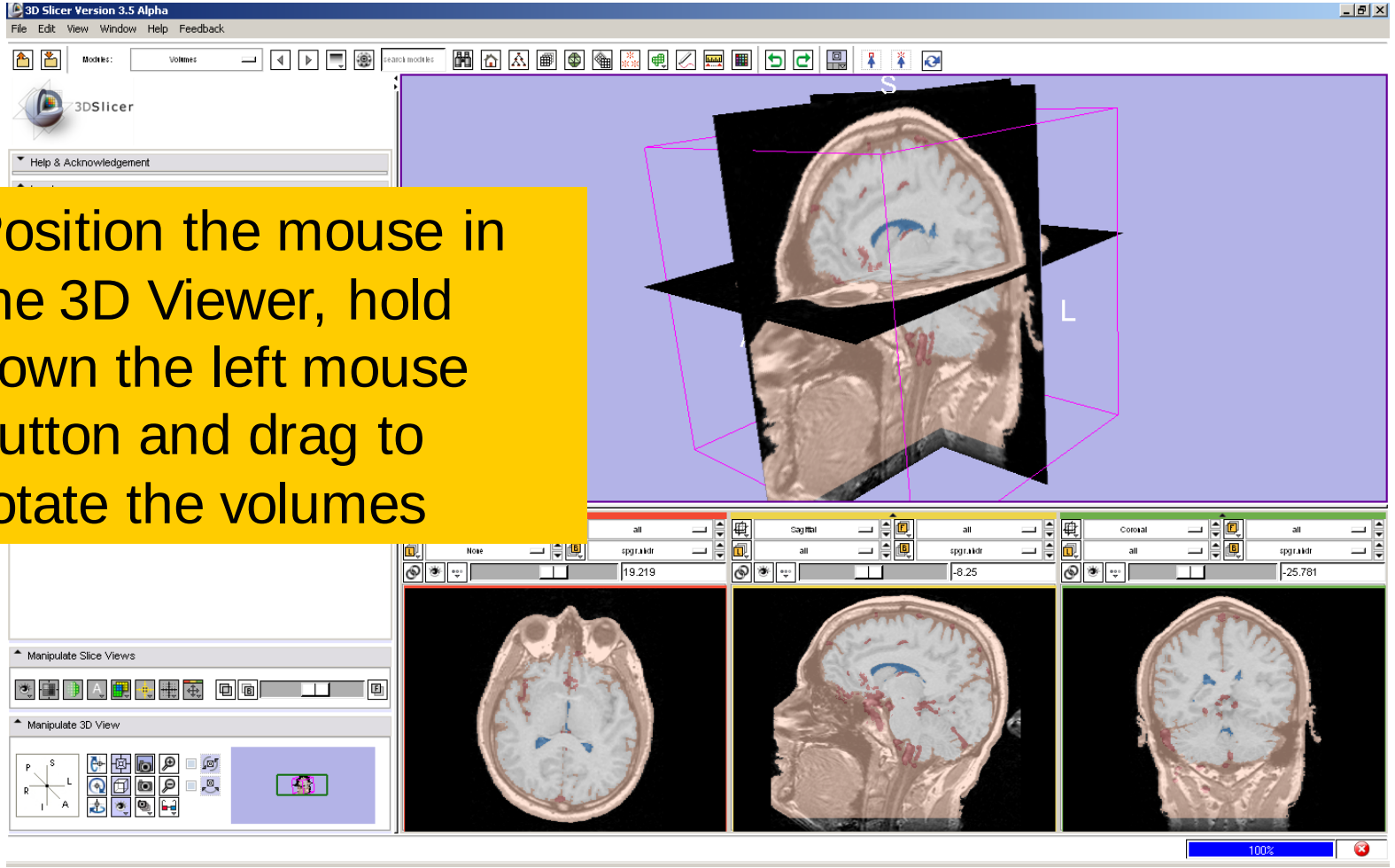
Click on the ***Slice Visibility*** icon to display the slices in the 3D Viewer

Visualizing Multiple Volumes



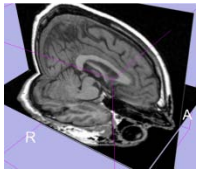
Slicer displays 2D anatomical slices in the 3D viewer

3D Visualization

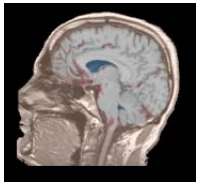


Position the mouse in the 3D Viewer, hold down the left mouse button and drag to rotate the volumes

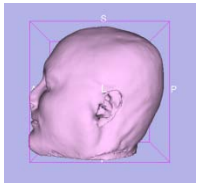
Overview



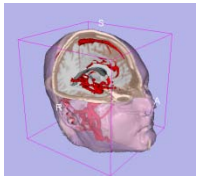
Loading and visualizing multiple volumes simultaneously



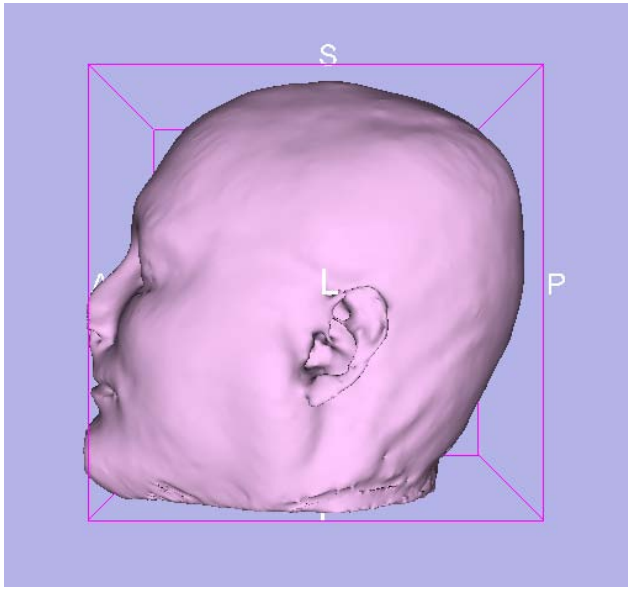
Loading and visualizing segmented structures overlaid on grayscale images



Loading and visualizing 3D models

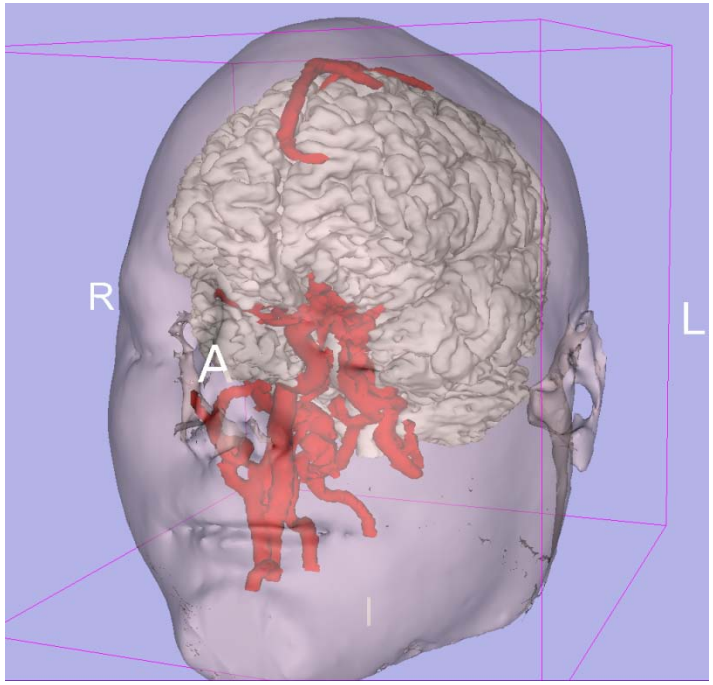


Loading and saving a scene



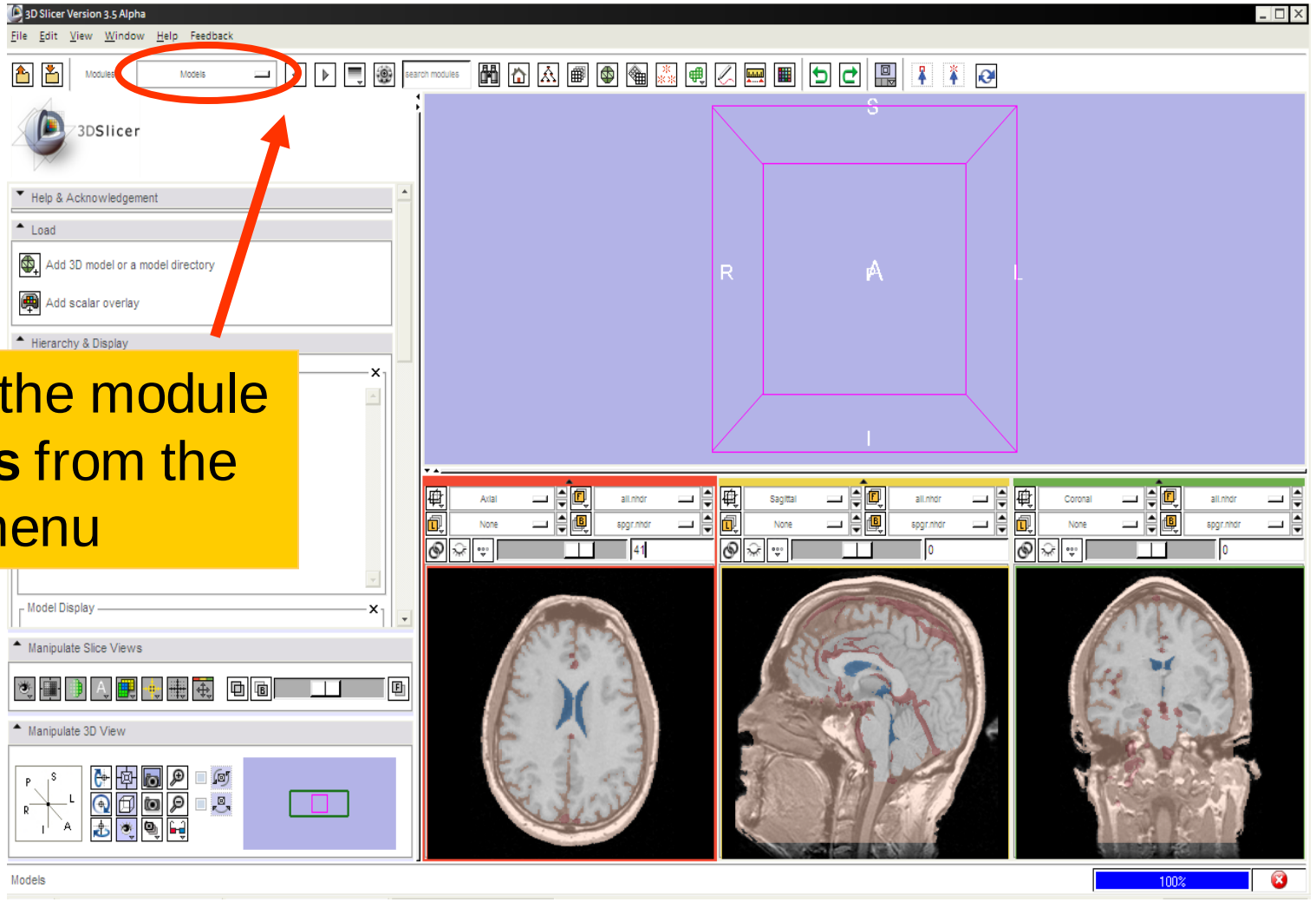
Part 3: Loading and visualizing 3D models

3D models



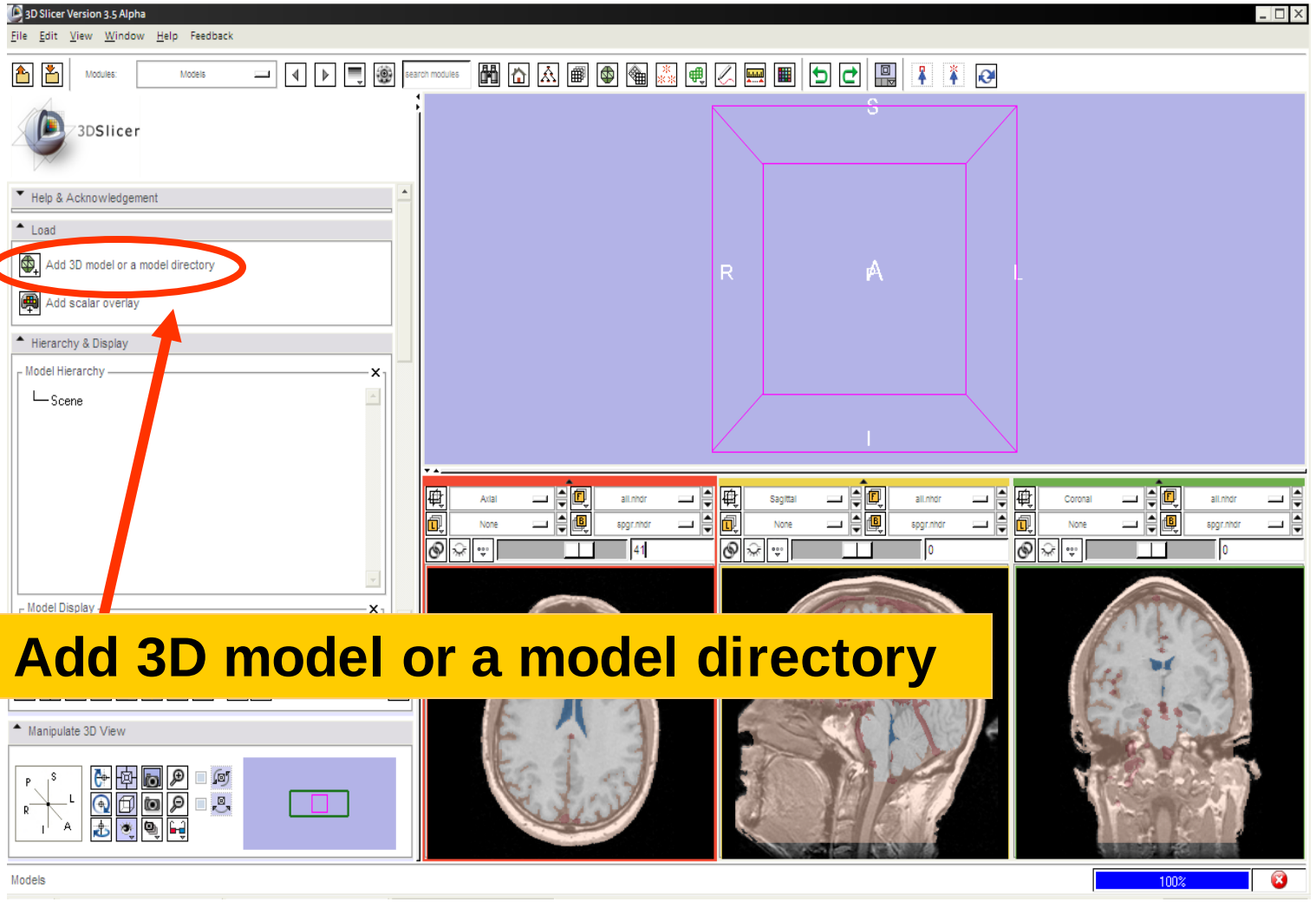
- A 3D model is a surface reconstruction of an anatomical structure.
- The model is a triangular mesh that approximates a surface from a 3D label map.
- The scalar values for surface models are integers which correspond to the label that had been assigned in the segmentation process.

Loading a 3D model



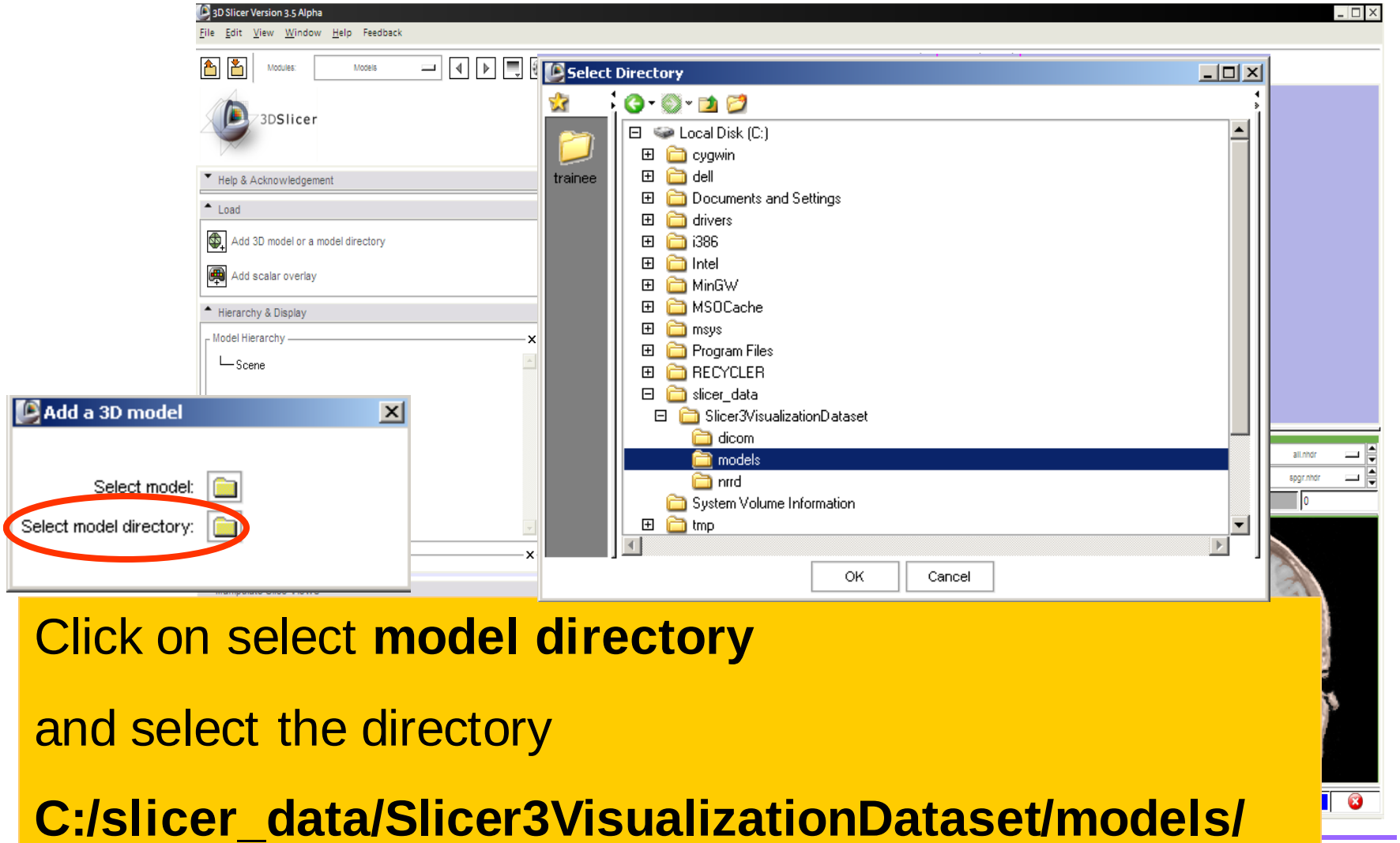
Select the module **Models** from the main menu

Loading a 3D model



Click on **Add 3D model or a model directory**

Loading a 3D model

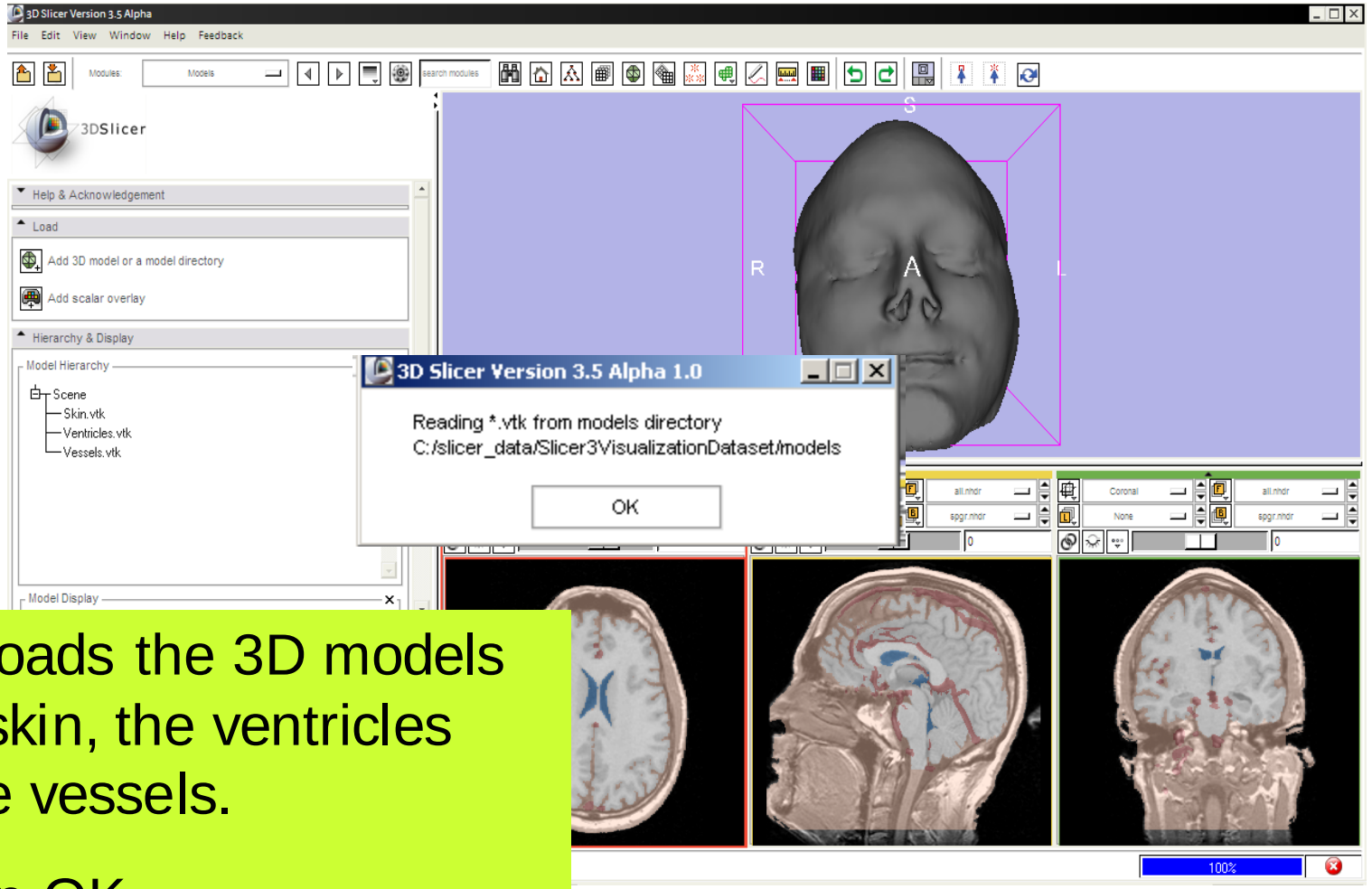


Click on select **model directory**

and select the directory

C:/slicer_data/Slicer3VisualizationDataset/models/

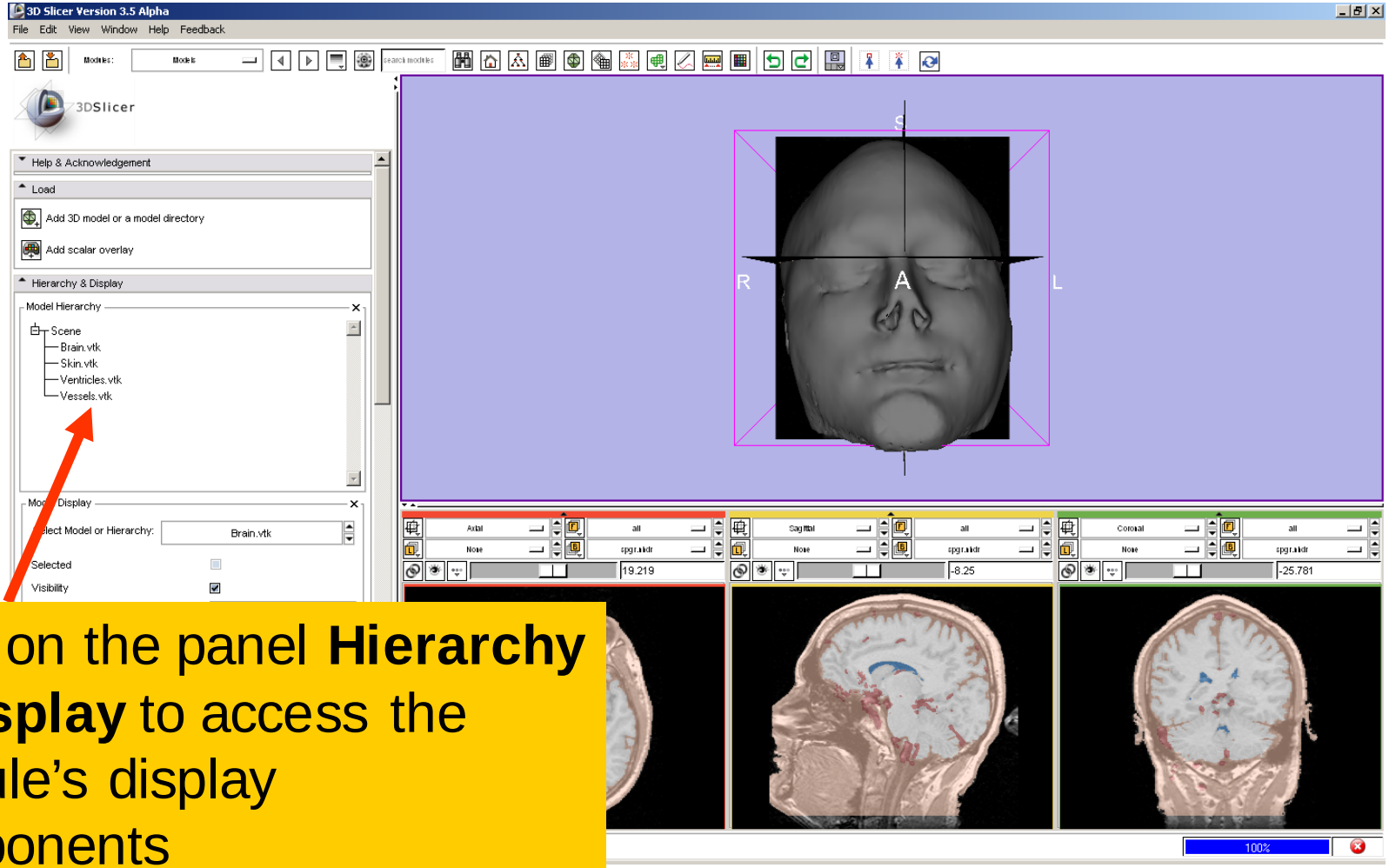
Loading a 3D model



Slicer loads the 3D models of the skin, the ventricles and the vessels.

Click on OK.

Loading a 3D model

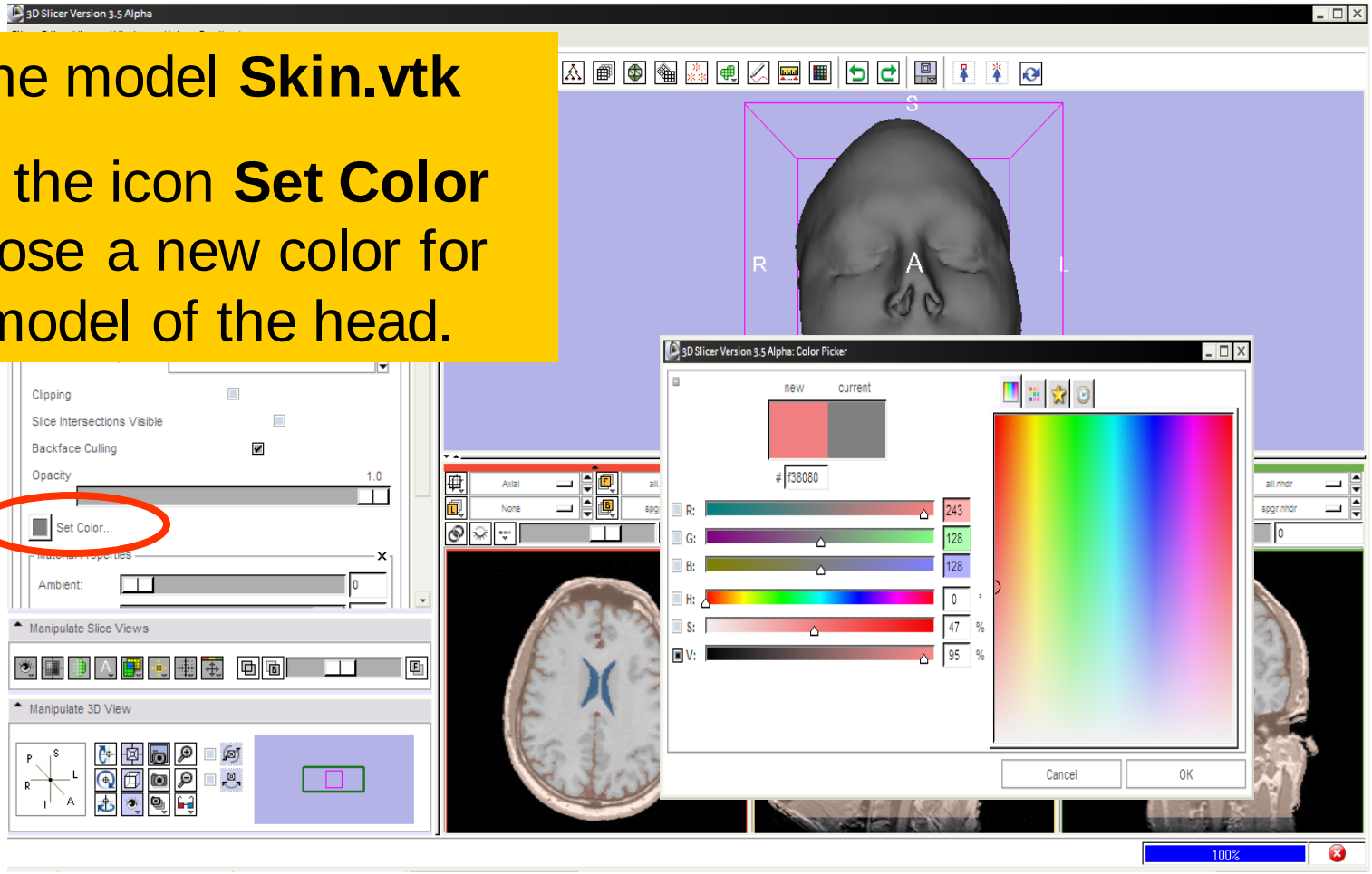


Click on the panel **Hierarchy & Display** to access the module's display components

Visualizing a 3D model

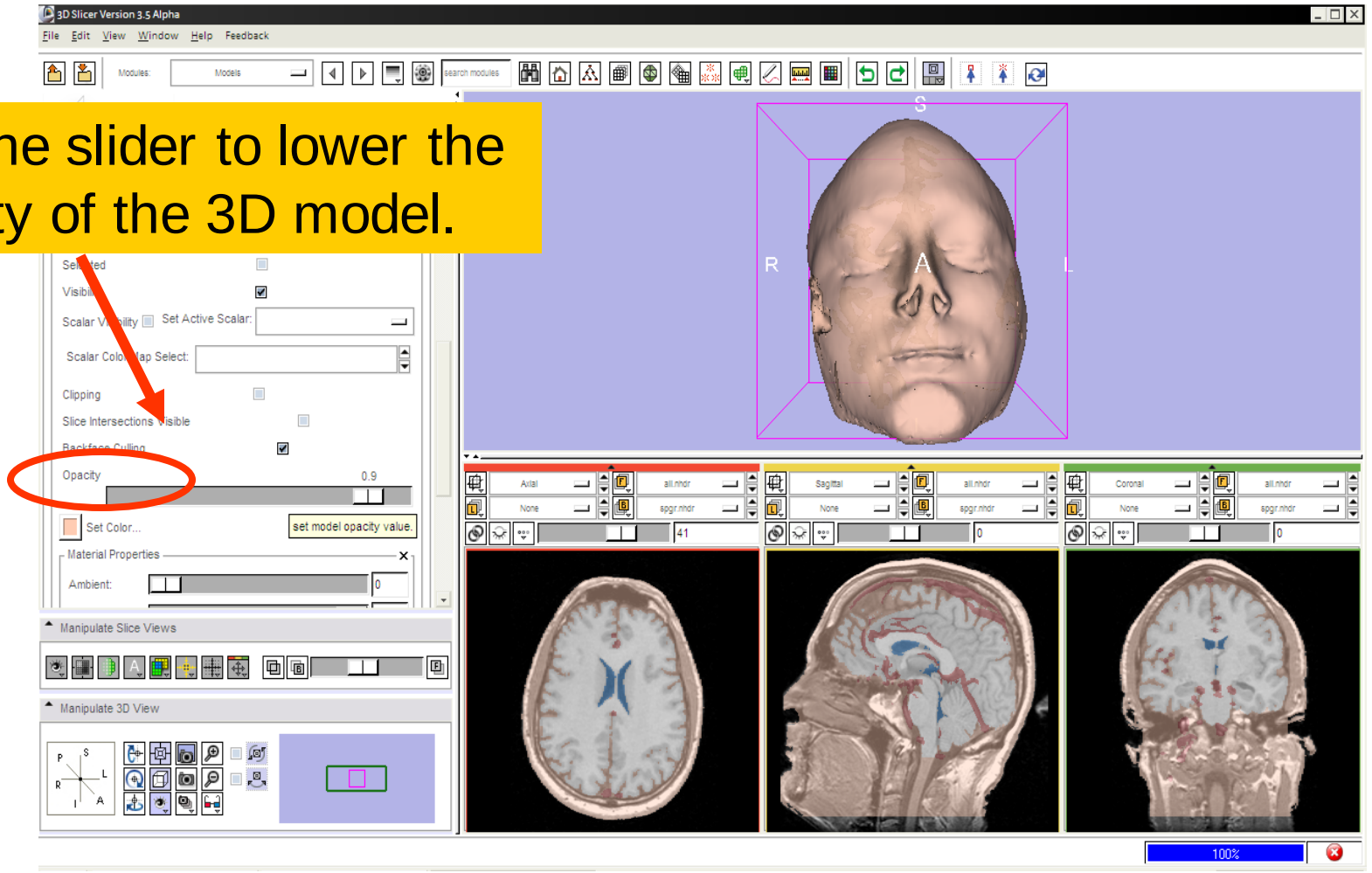
Select the model **Skin.vtk**

Click on the icon **Set Color** and choose a new color for the 3D model of the head.

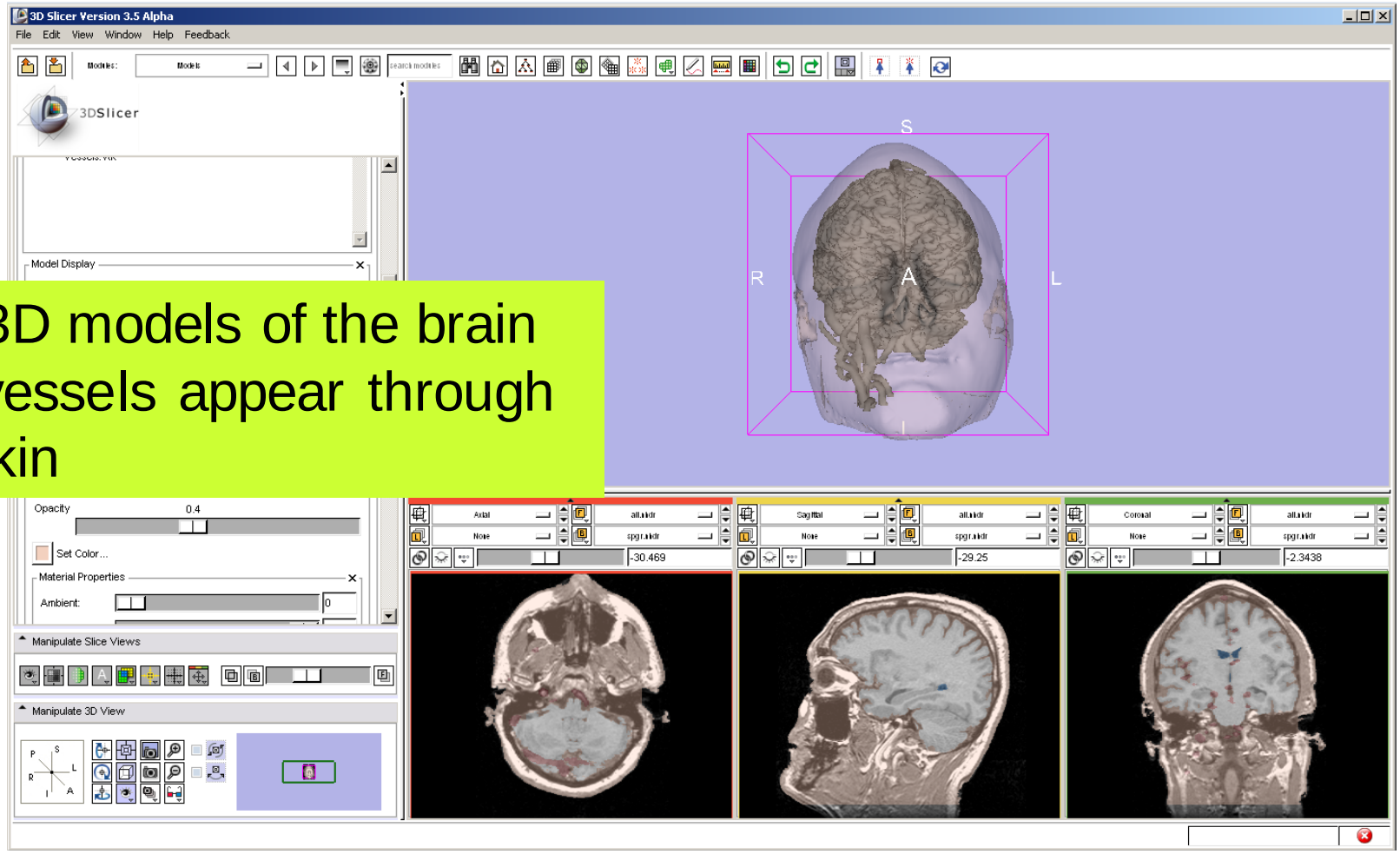


Visualizing a 3D model

Use the slider to lower the opacity of the 3D model.



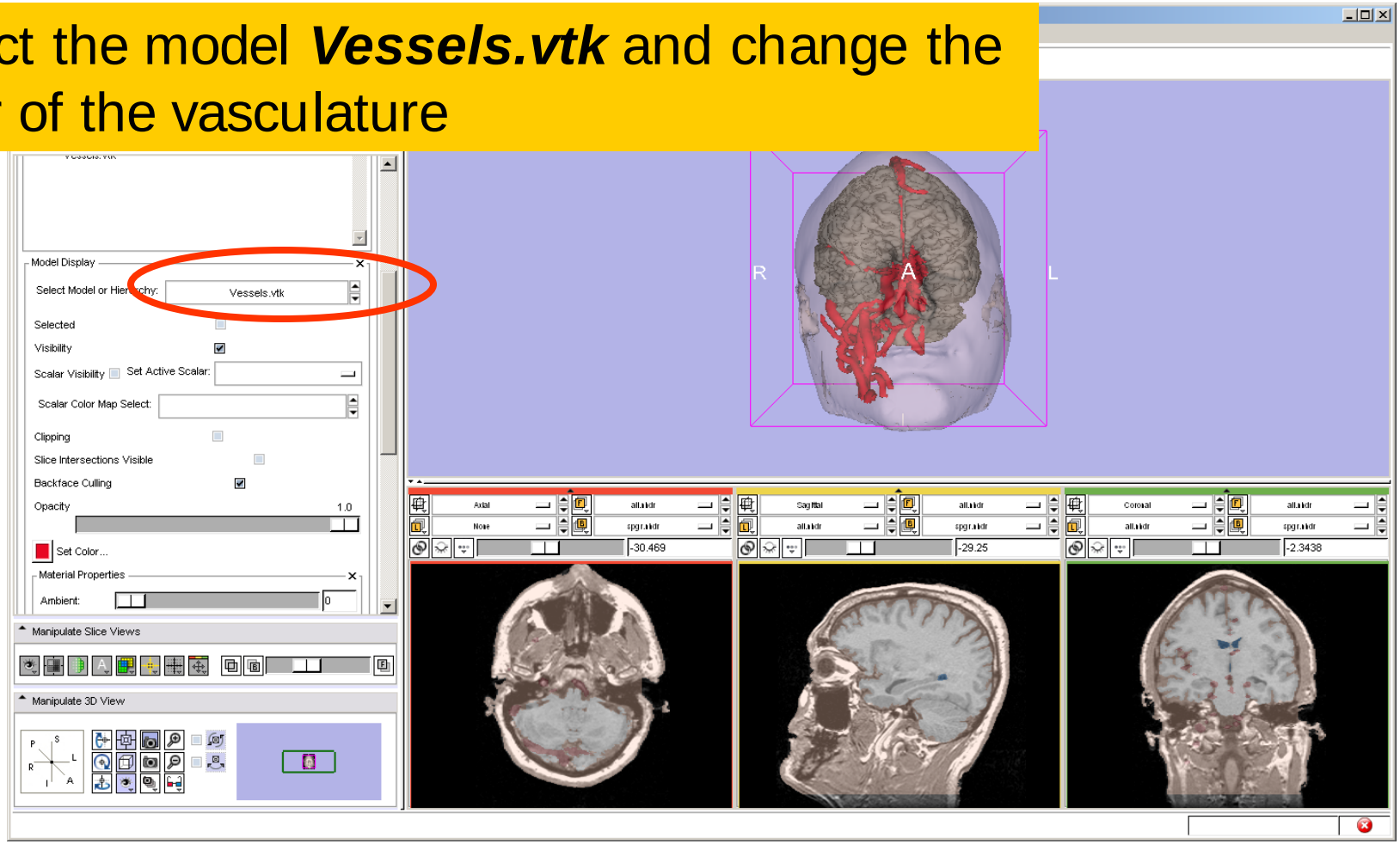
Visualizing a 3D model



The 3D models of the brain and vessels appear through the skin

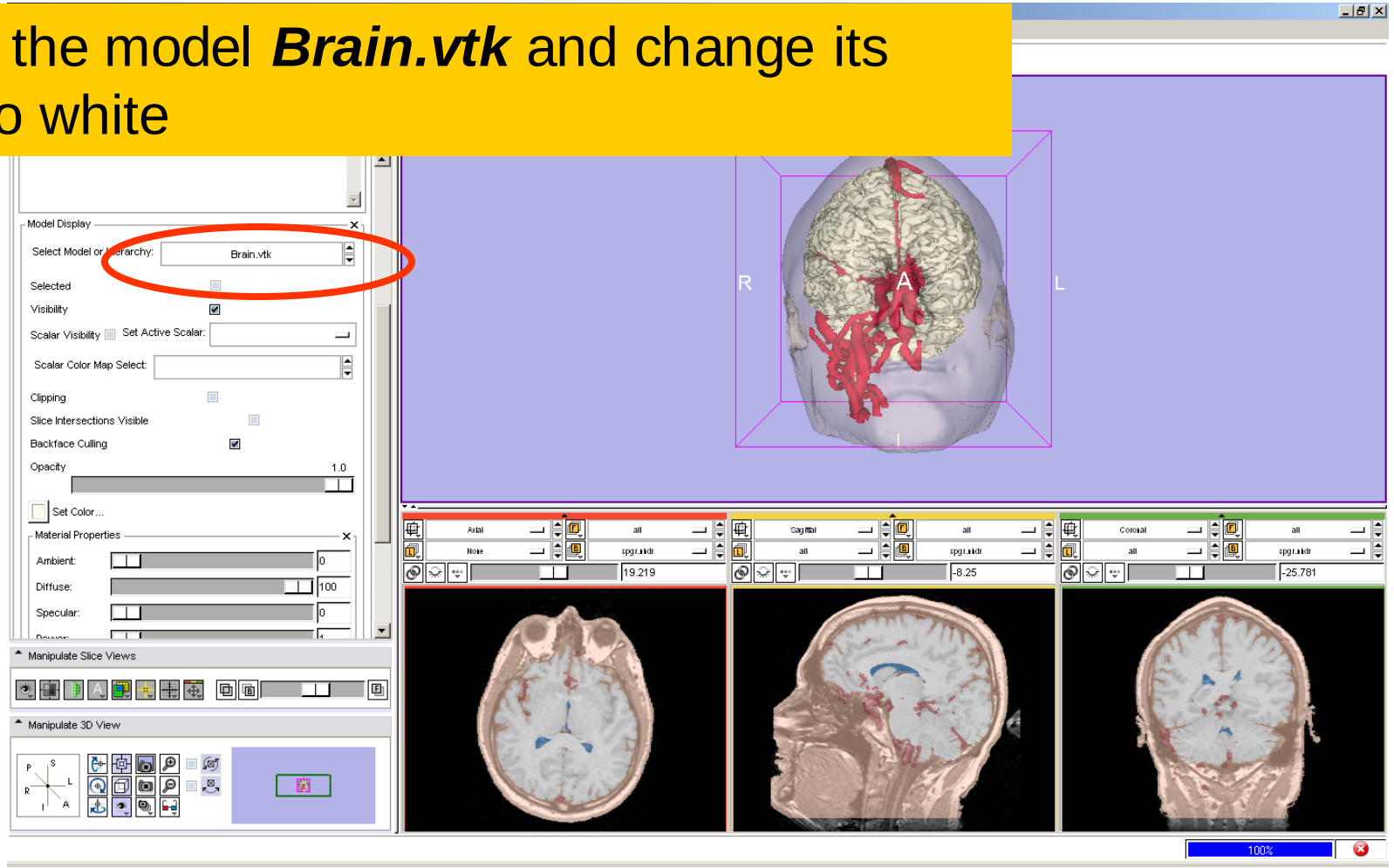
Visualizing a 3D model

Select the model ***Vessels.vtk*** and change the color of the vasculature

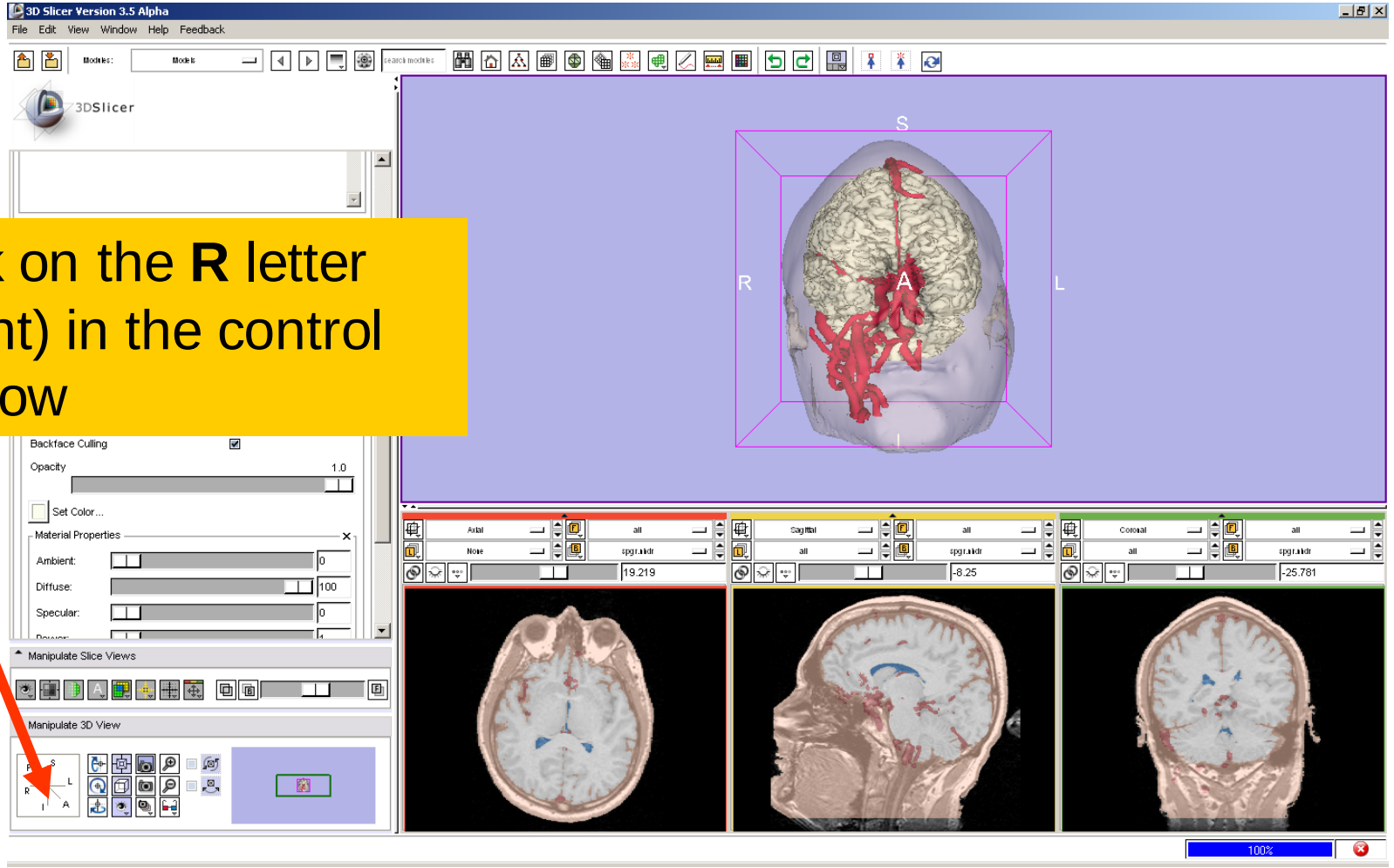


Visualizing a 3D model

Select the model ***Brain.vtk*** and change its color to white

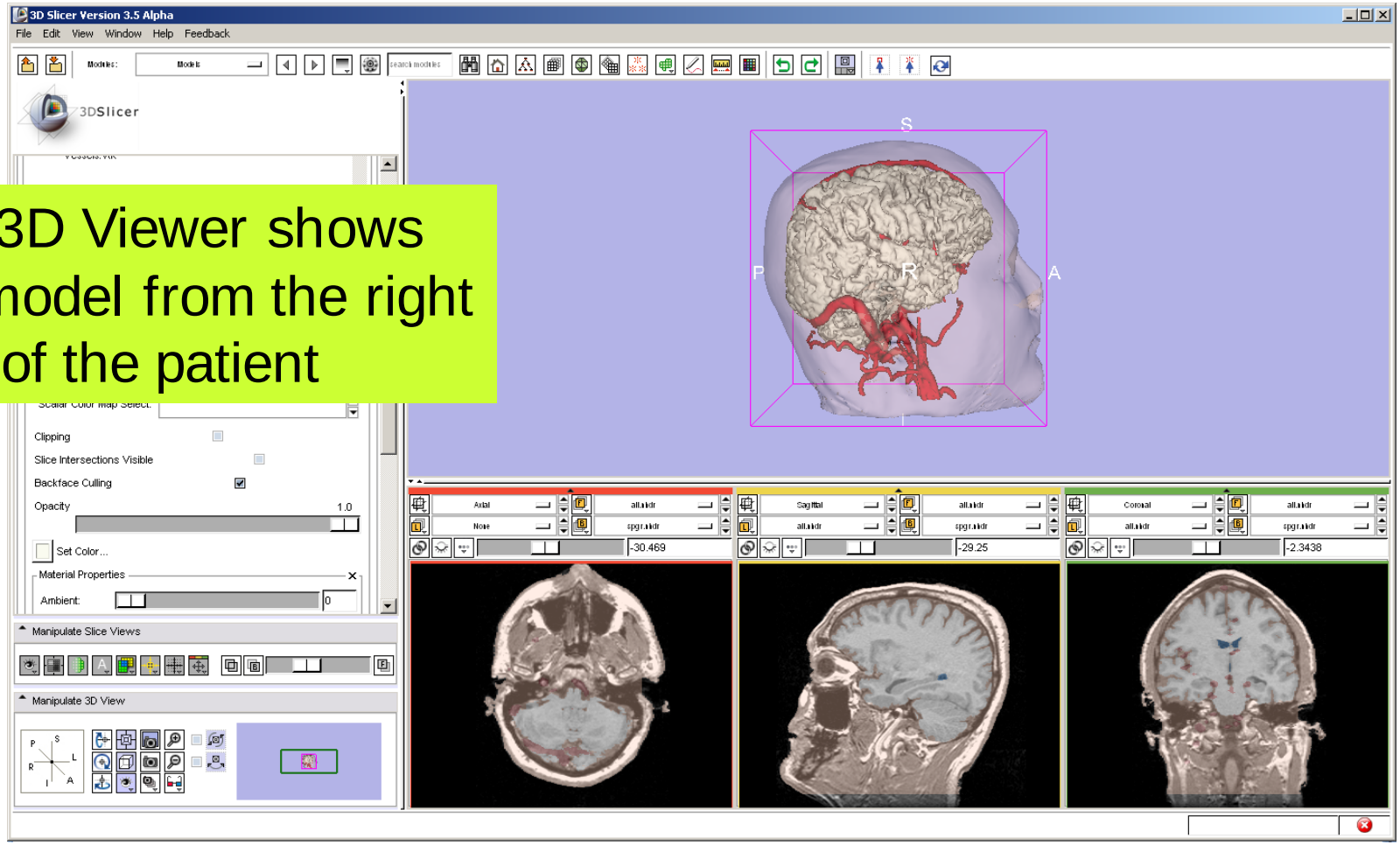


Visualizing a 3D model



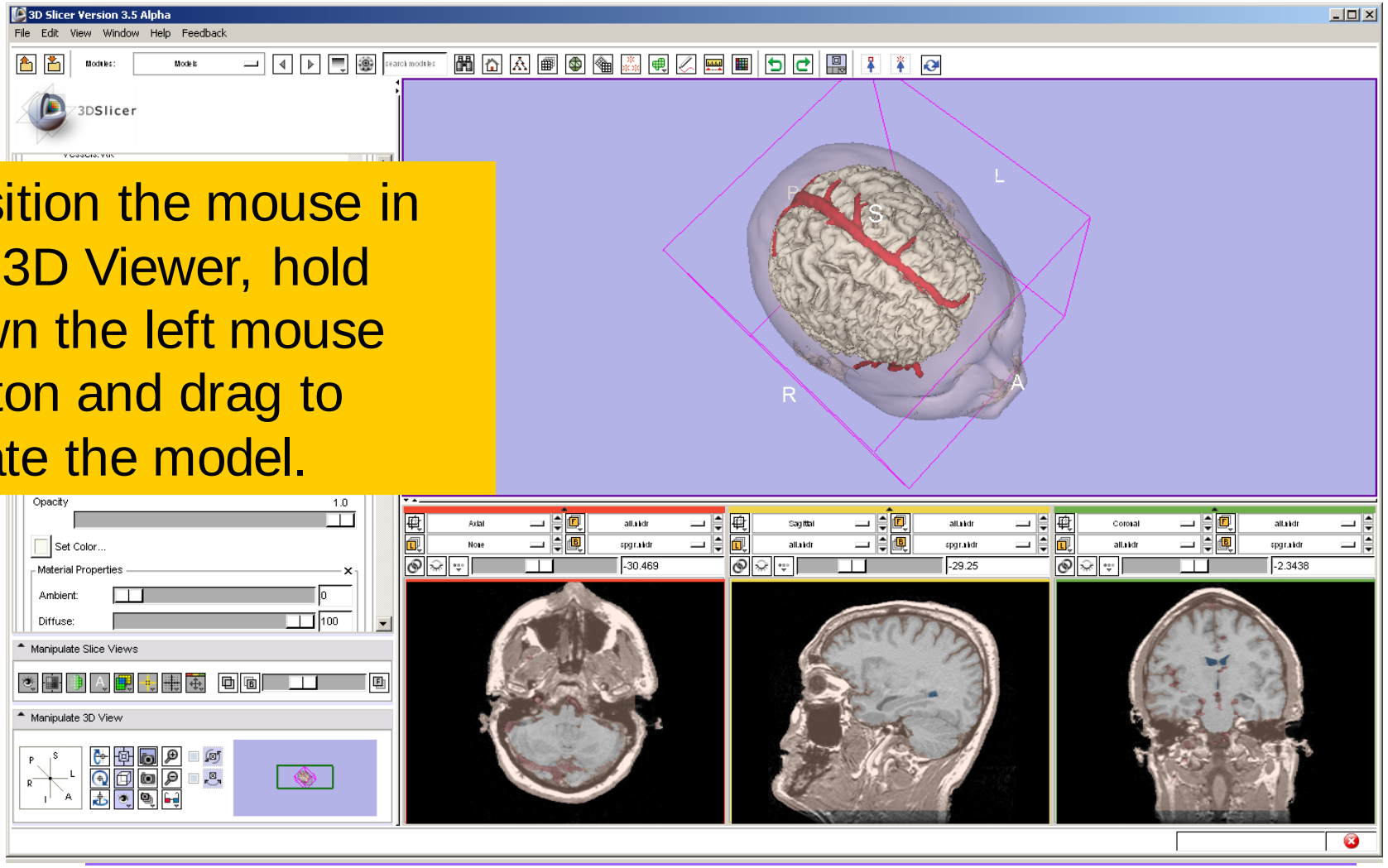
Click on the **R** letter (Right) in the control window

Manipulating a 3D model



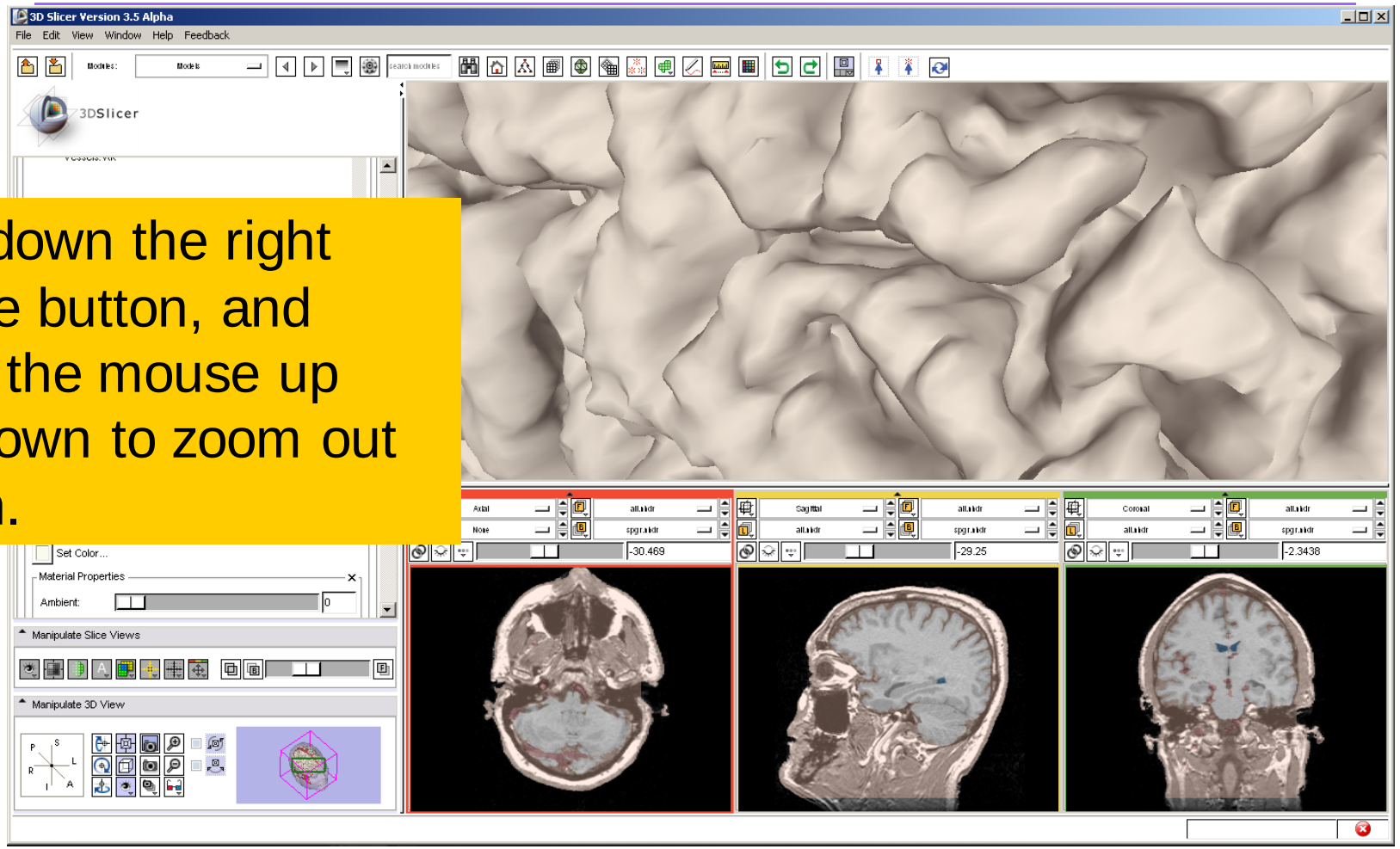
The 3D Viewer shows the model from the right side of the patient

Manipulating a 3D model



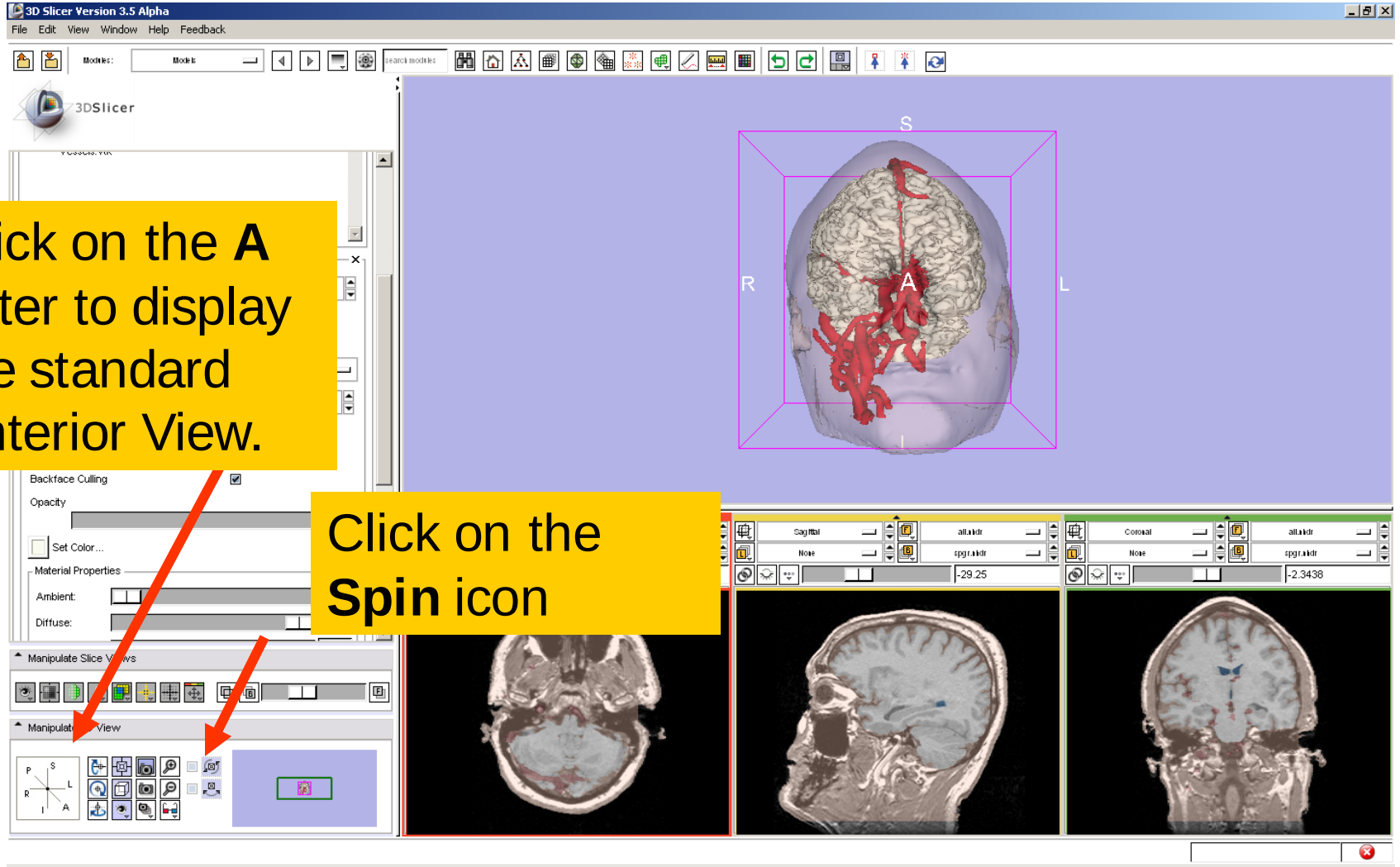
Position the mouse in the 3D Viewer, hold down the left mouse button and drag to rotate the model.

Manipulating a 3D model



Hold down the right mouse button, and move the mouse up and down to zoom out and in.

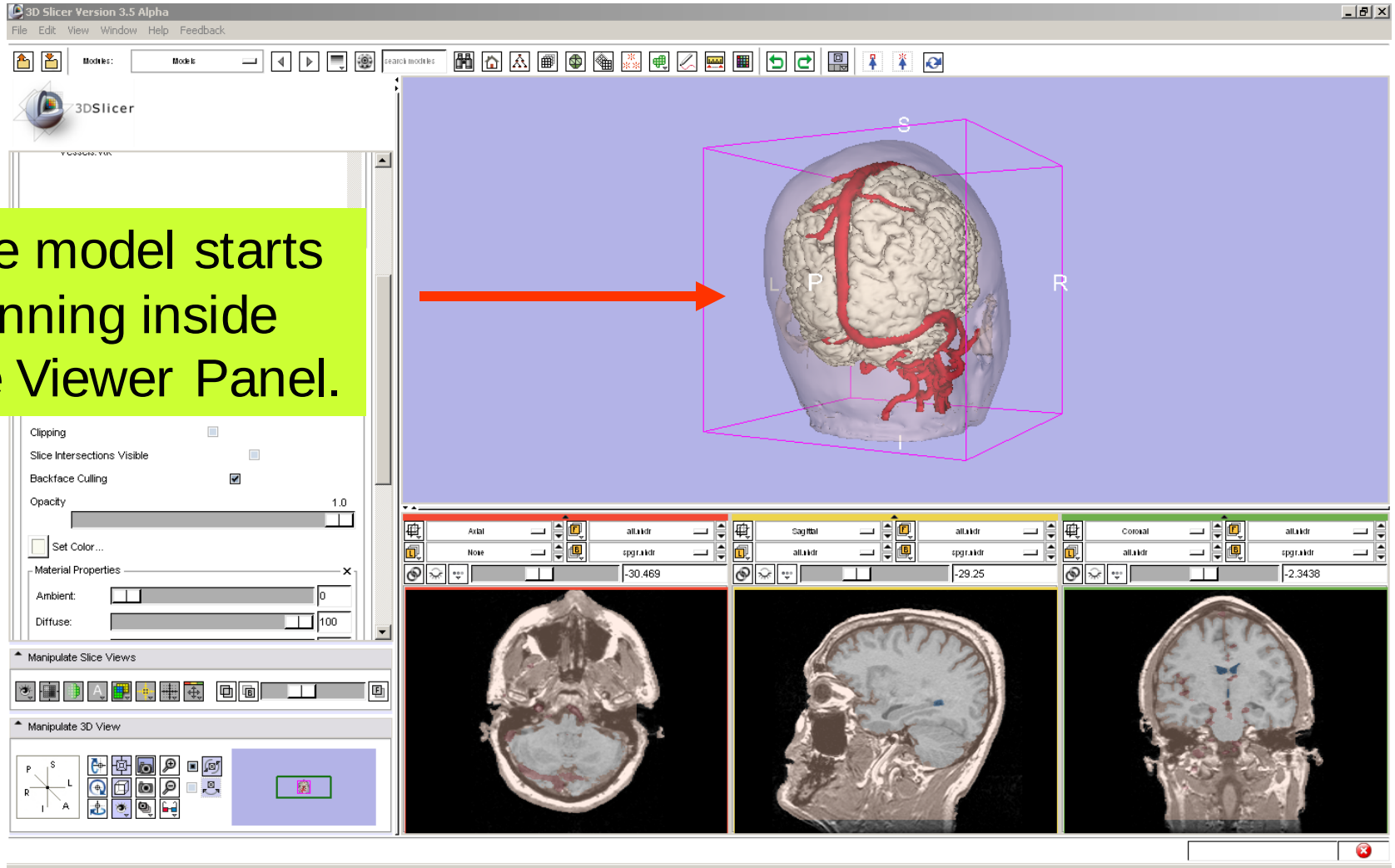
Manipulating a 3D model



Click on the **A** letter to display the standard Anterior View.

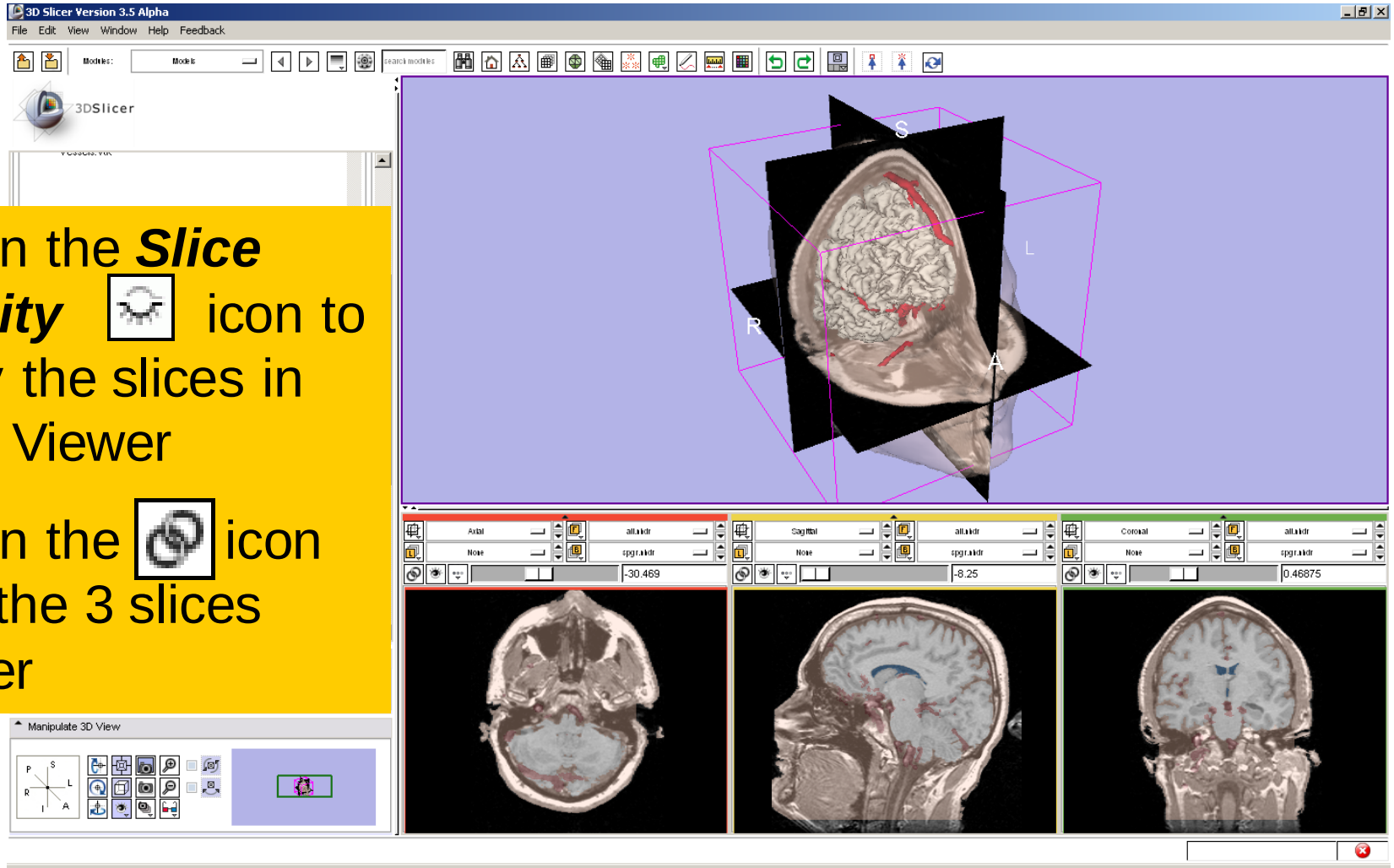
Click on the **Spin** icon

Manipulating a 3D model



The model starts spinning inside the Viewer Panel.

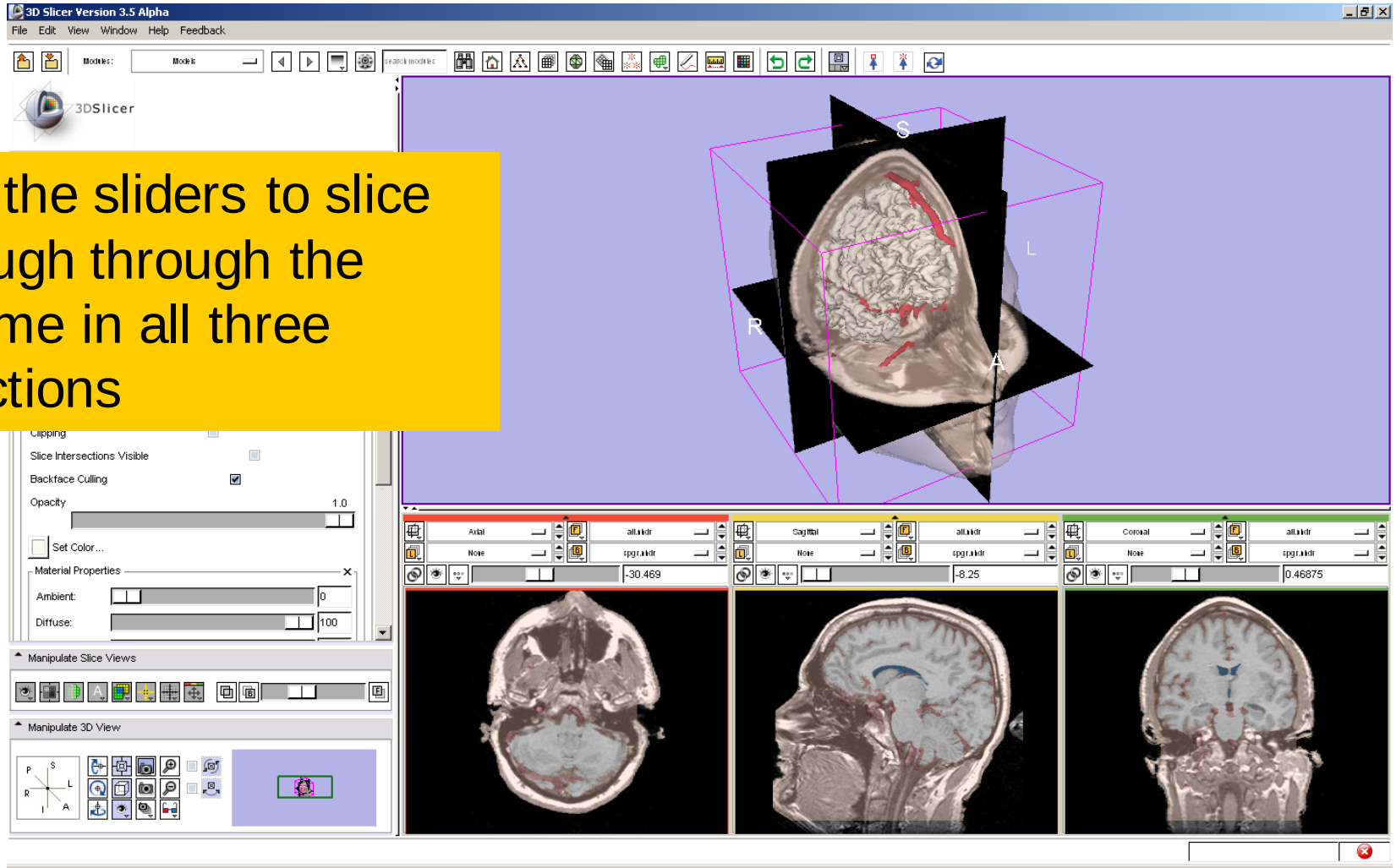
Manipulating a 3D model



Click on the ***Slice Visibility*** icon to display the slices in the 3D Viewer

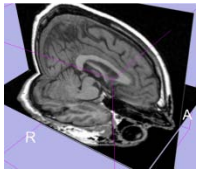
Click on the icon to link the 3 slices together

Manipulating the images

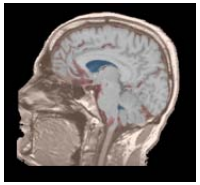


Use the sliders to slice through through the volume in all three directions

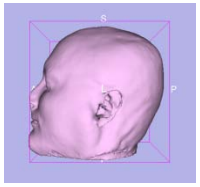
Overview



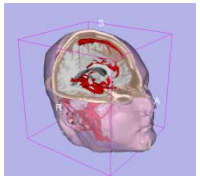
Loading and visualizing multiple volumes simultaneously



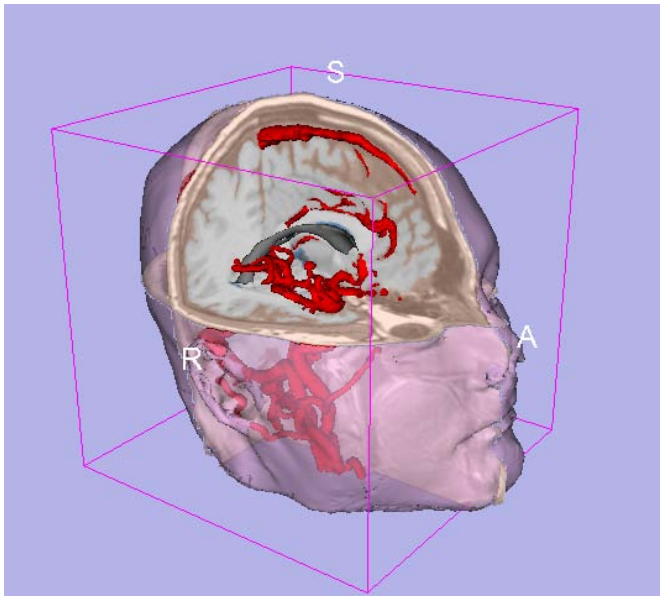
Loading and visualizing segmented structures overlaid on grayscale images



Loading and visualizing 3D models

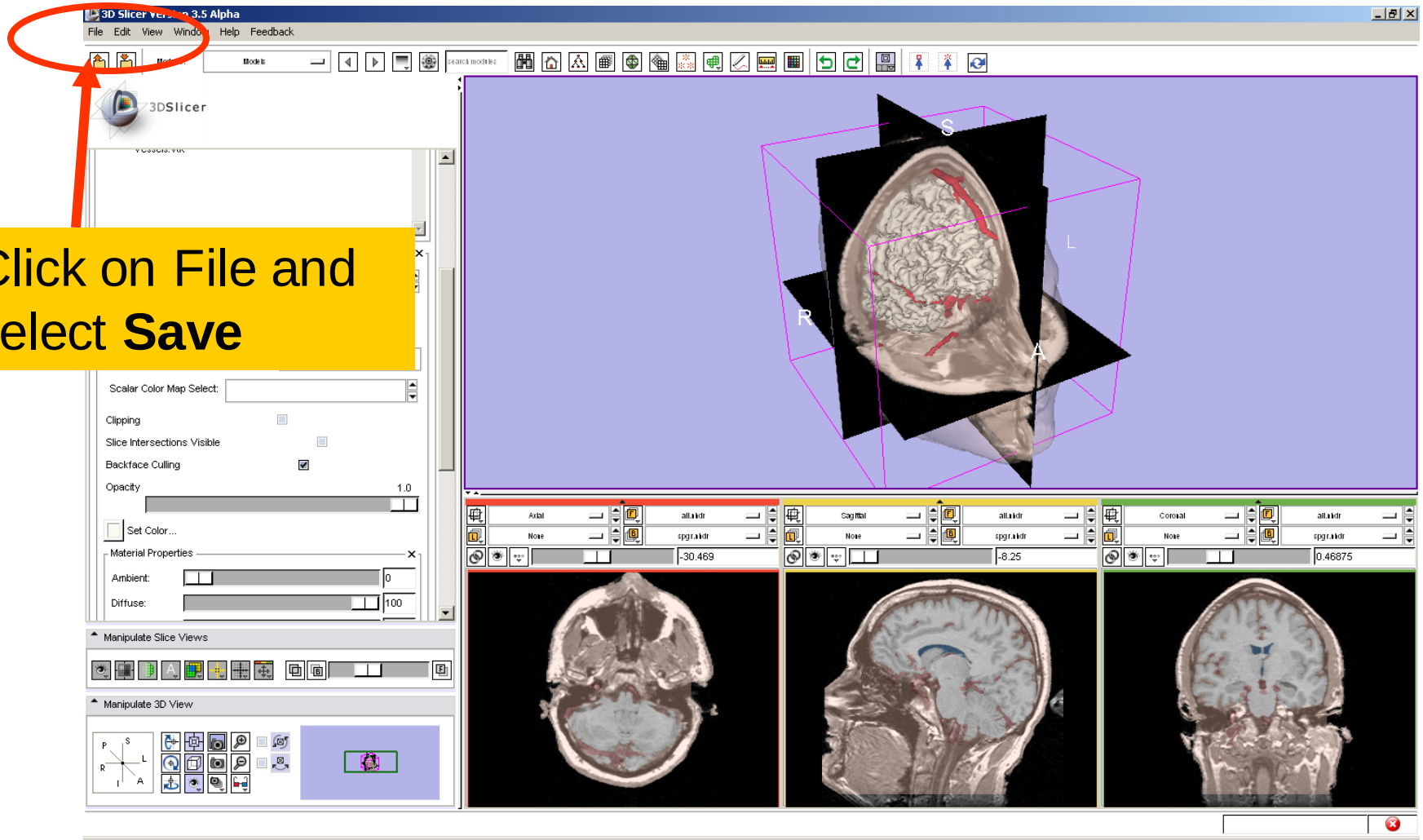


Loading and saving a scene



Part 4: Loading and saving a Scene

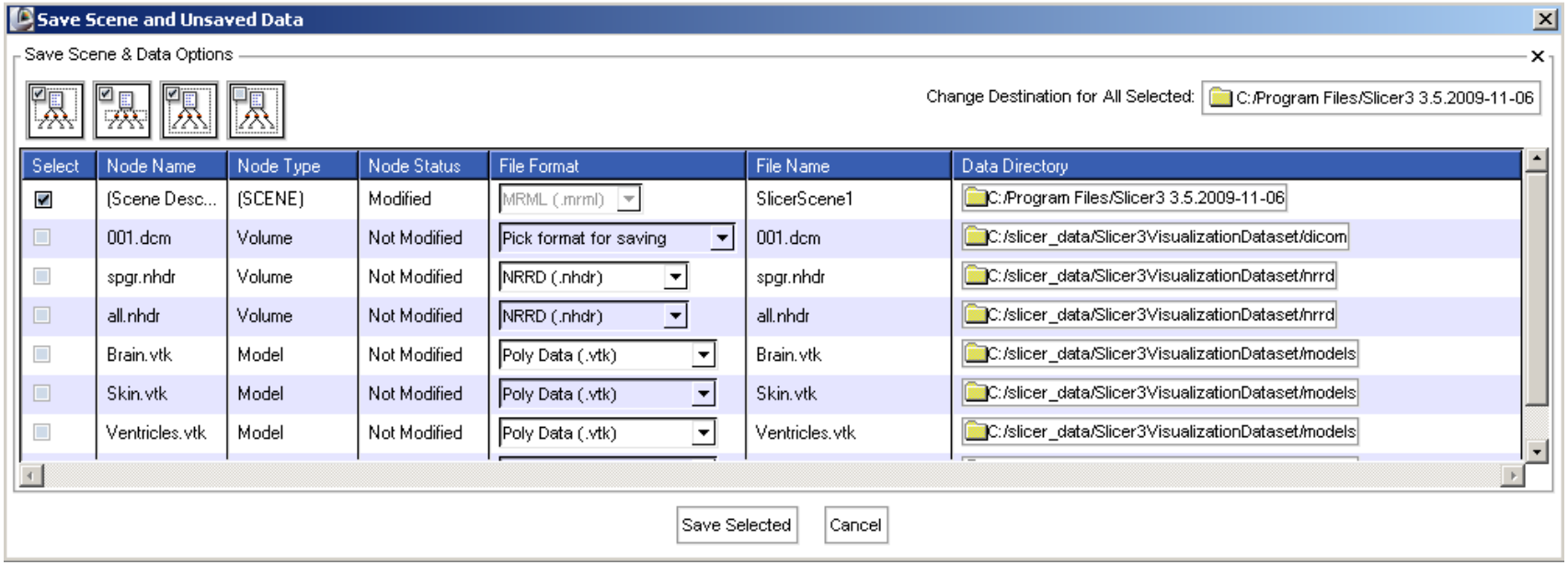
Saving Data



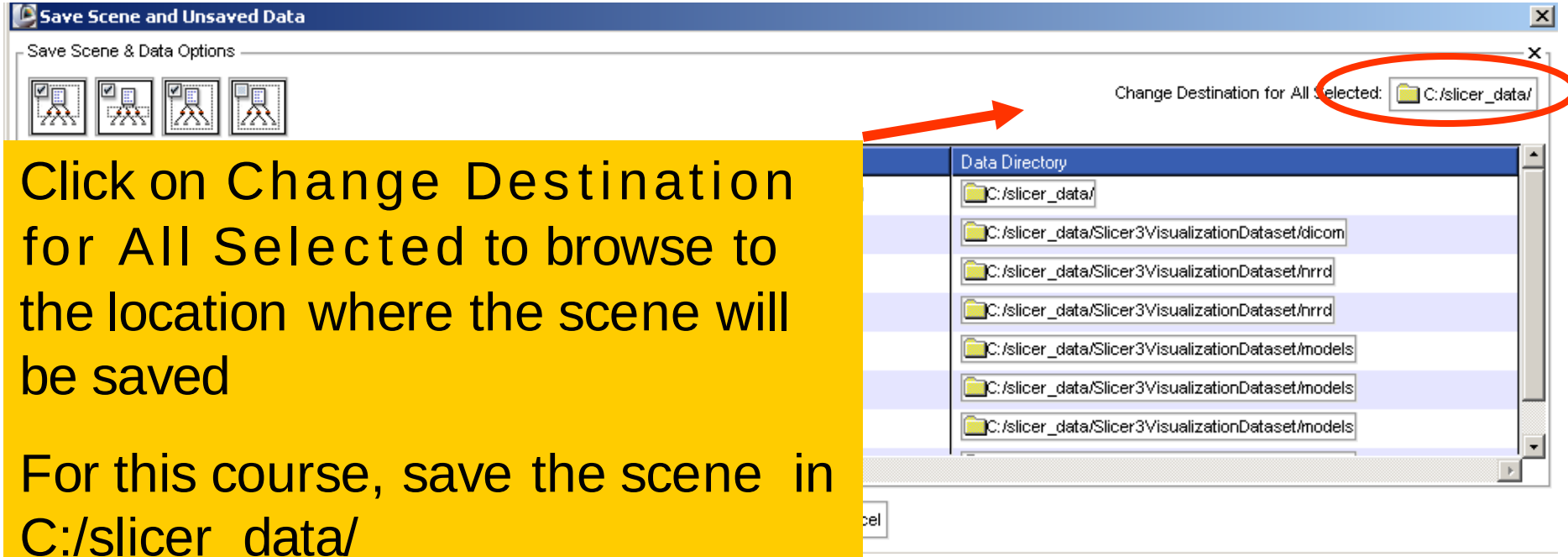
Click on File and select **Save**

Saving Data

The list of elements currently loaded into Slicer3 appears.



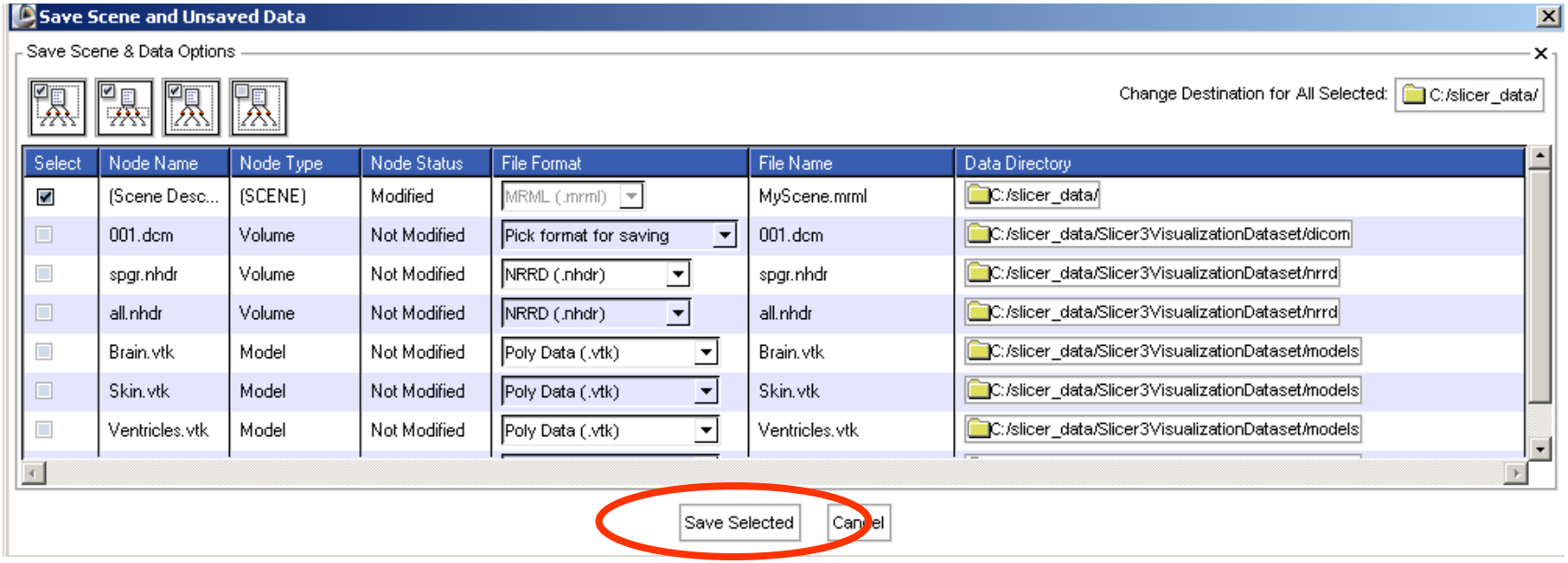
Saving Data



Click on Change Destination for All Selected to browse to the location where the scene will be saved

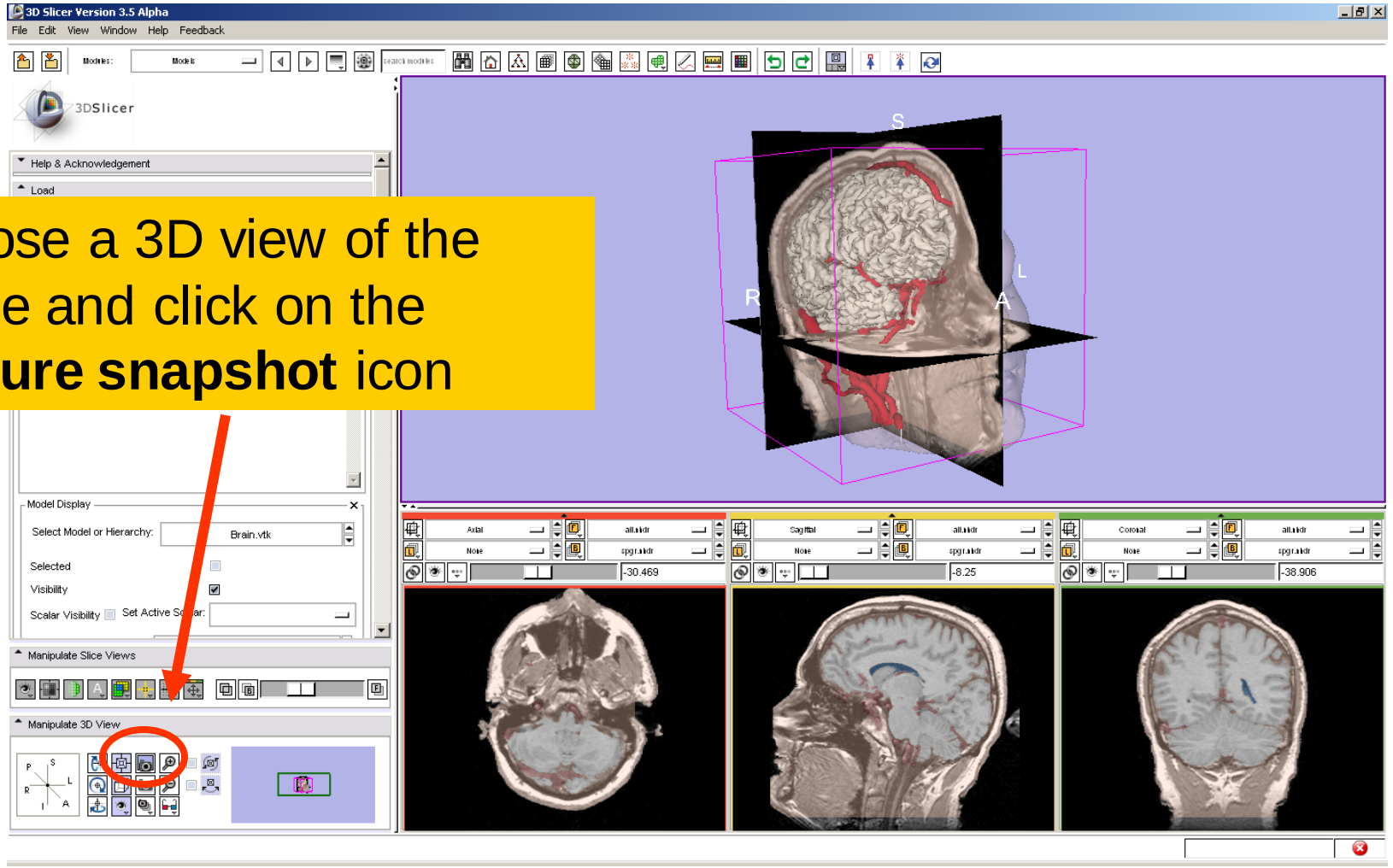
For this course, save the scene in C:/slicer_data/

Saving Data



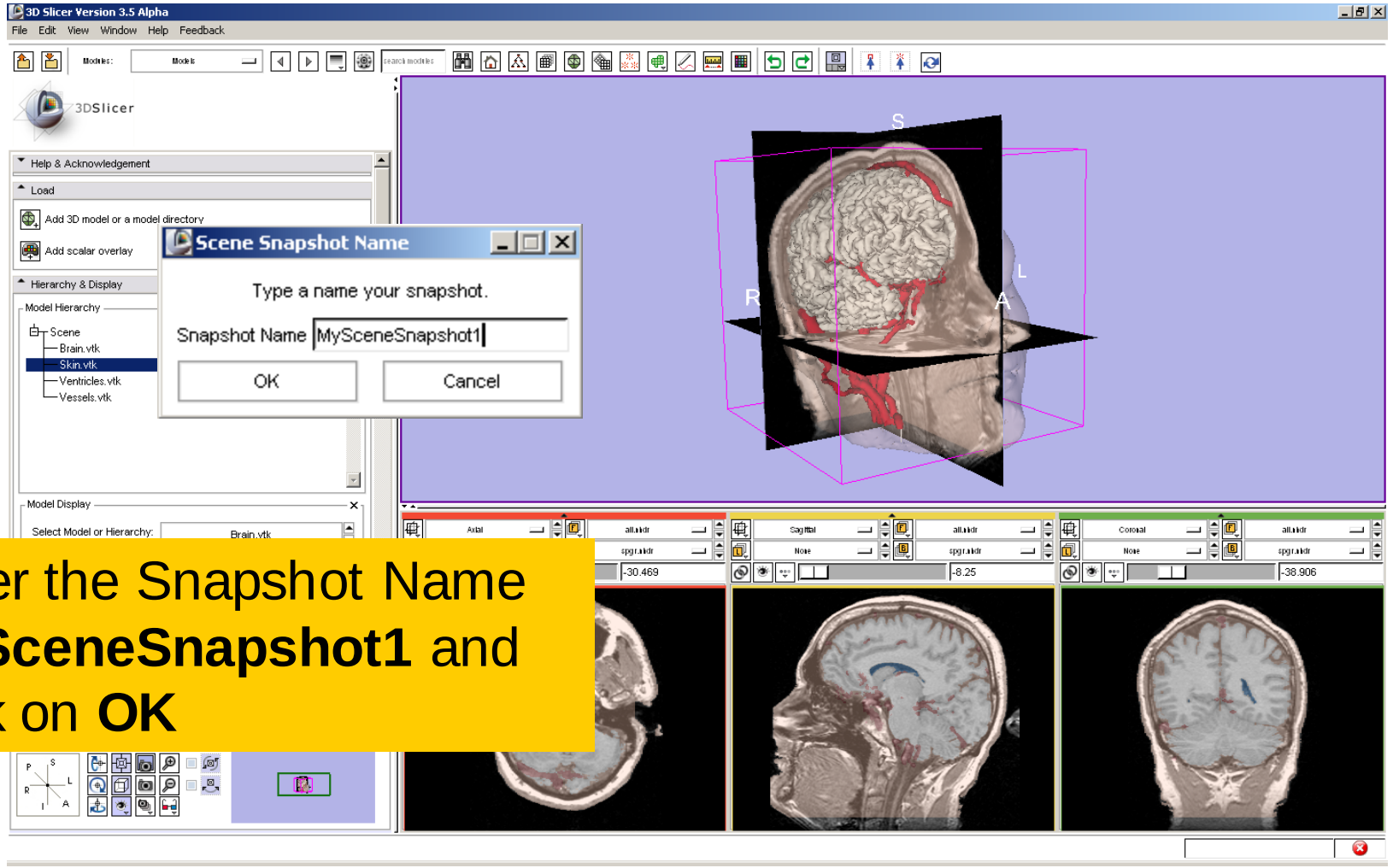
Enter the name **MyScene.mrml,** and click on **Save Selected.**

Creating Scene Snapshots



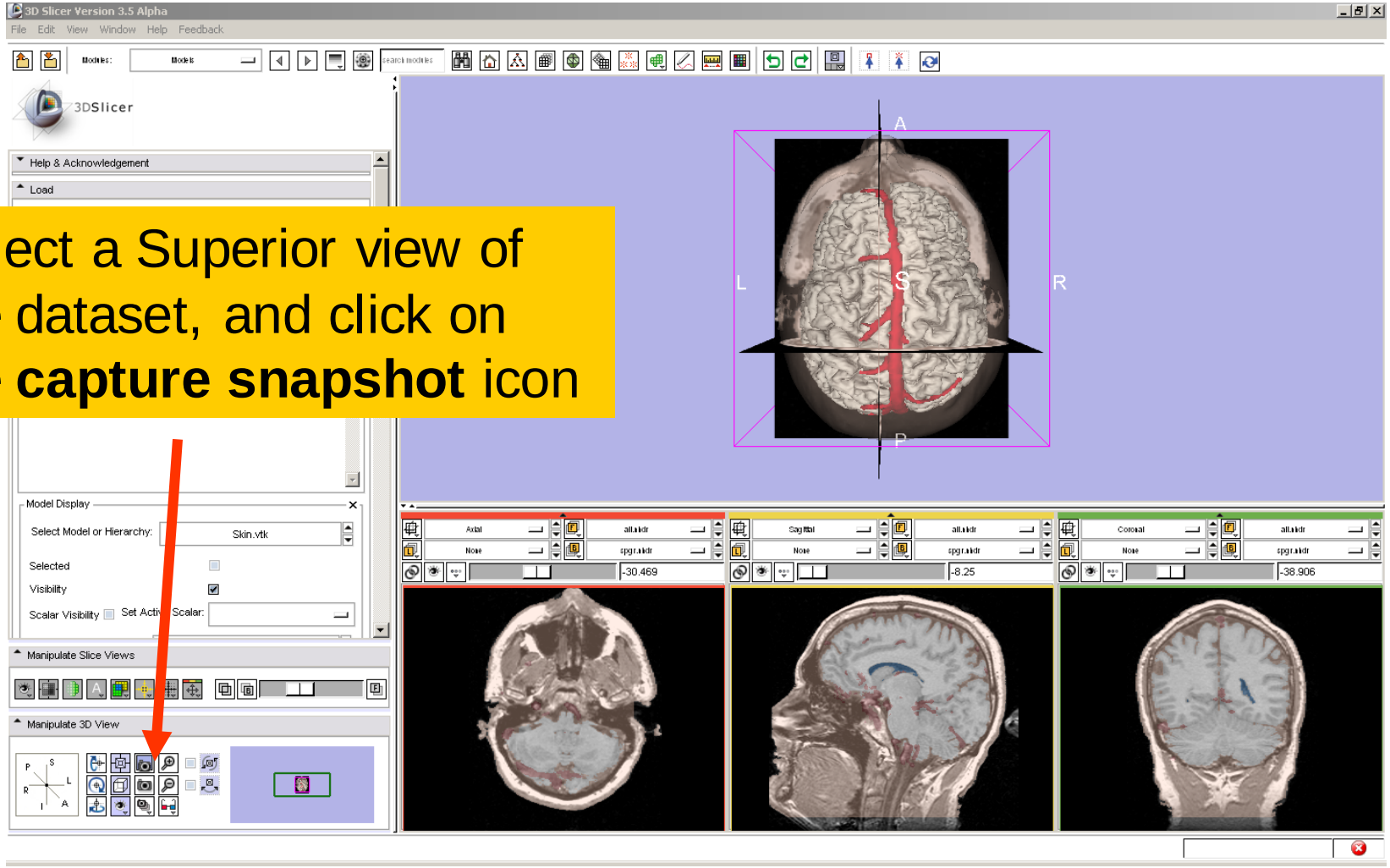
Choose a 3D view of the scene and click on the **capture snapshot** icon

Creating Scene Snapshots



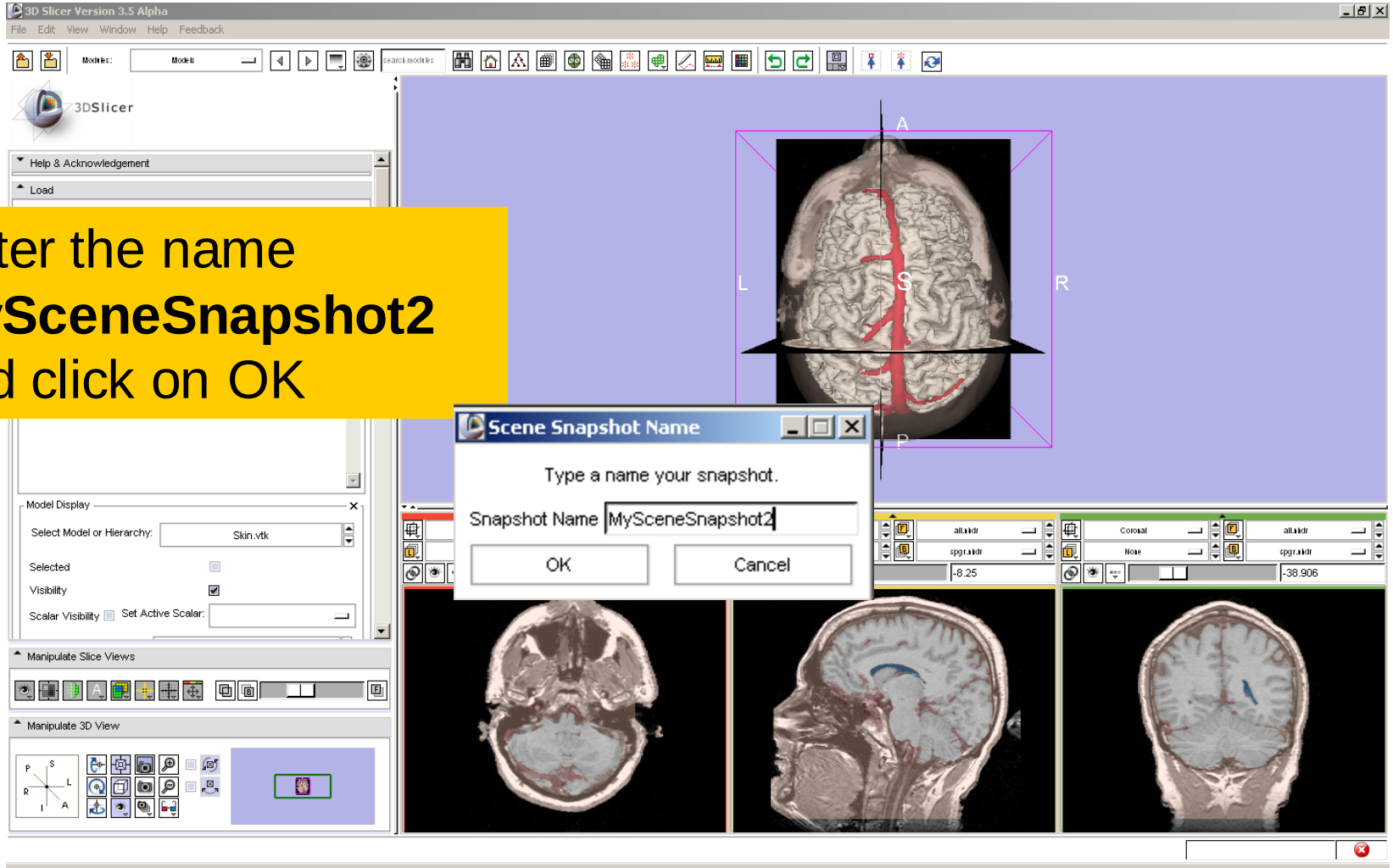
Enter the Snapshot Name **MySceneSnapshot1** and click on **OK**

Creating Scene Snapshots



Select a Superior view of the dataset, and click on the **capture snapshot** icon

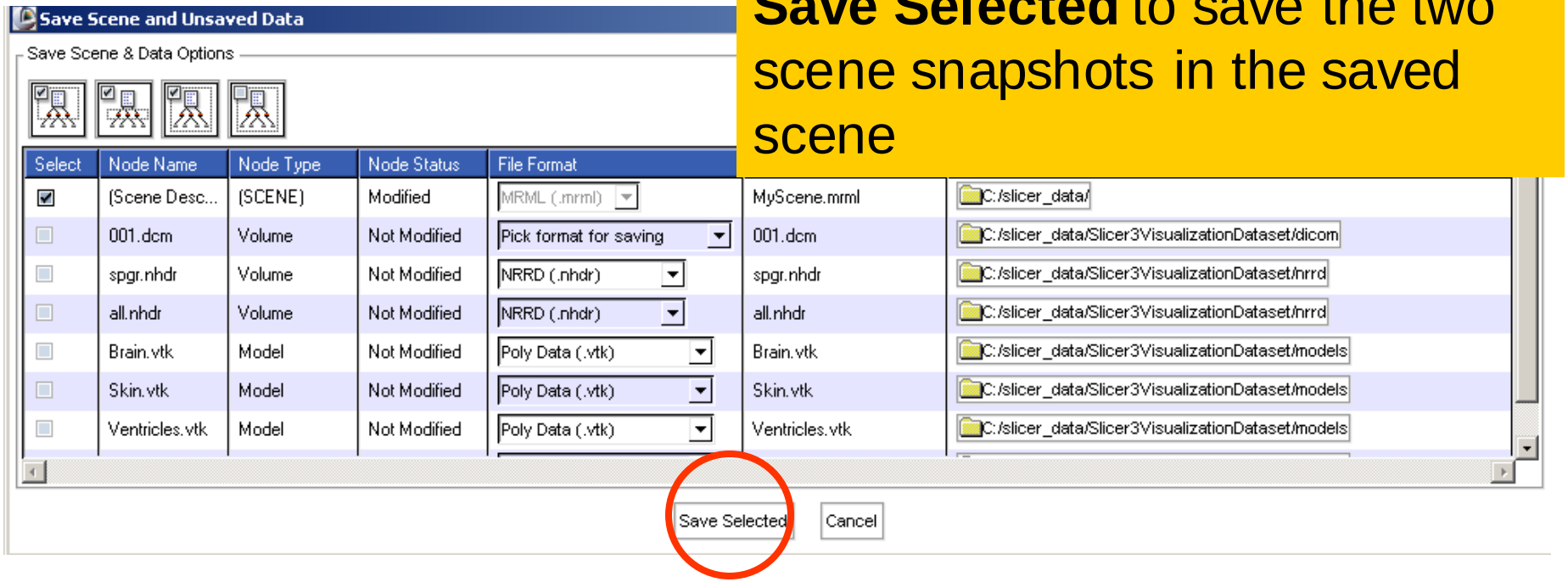
Creating Scene Snapshots



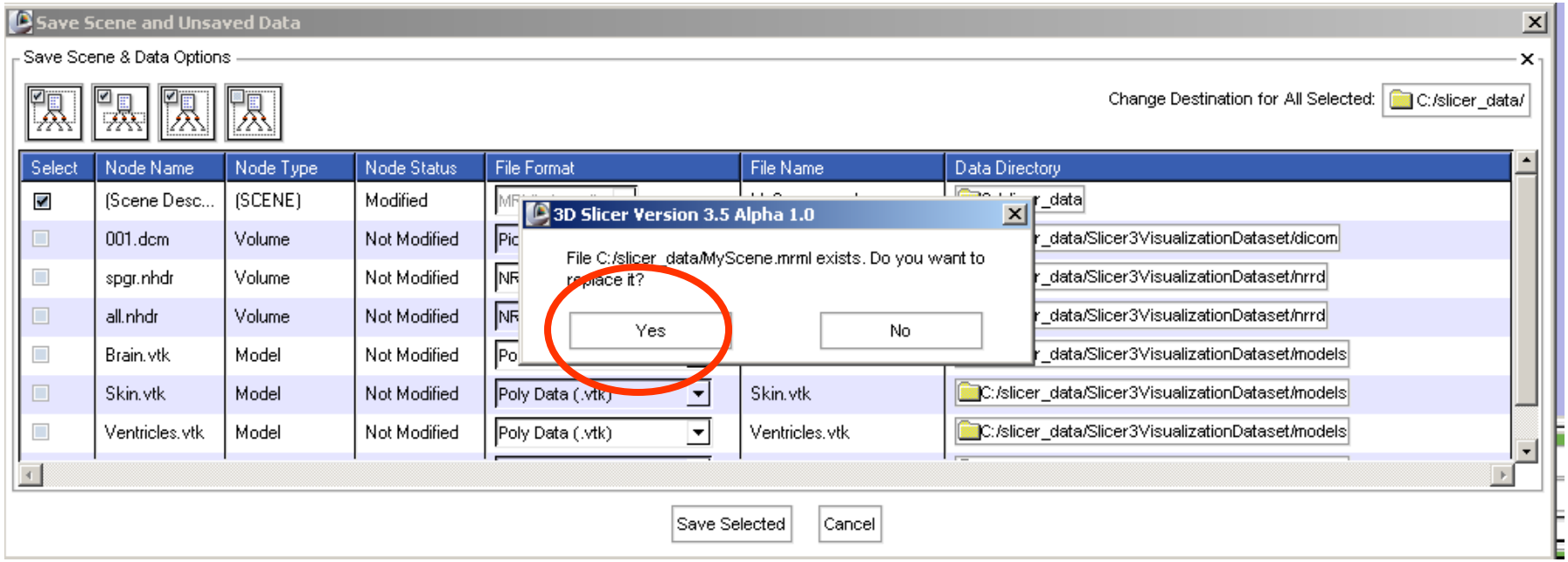
Enter the name **MySceneSnapshot2** and click on OK

Creating Scene Snapshots

Select File→Save and click on **Save Selected** to save the two scene snapshots in the saved scene

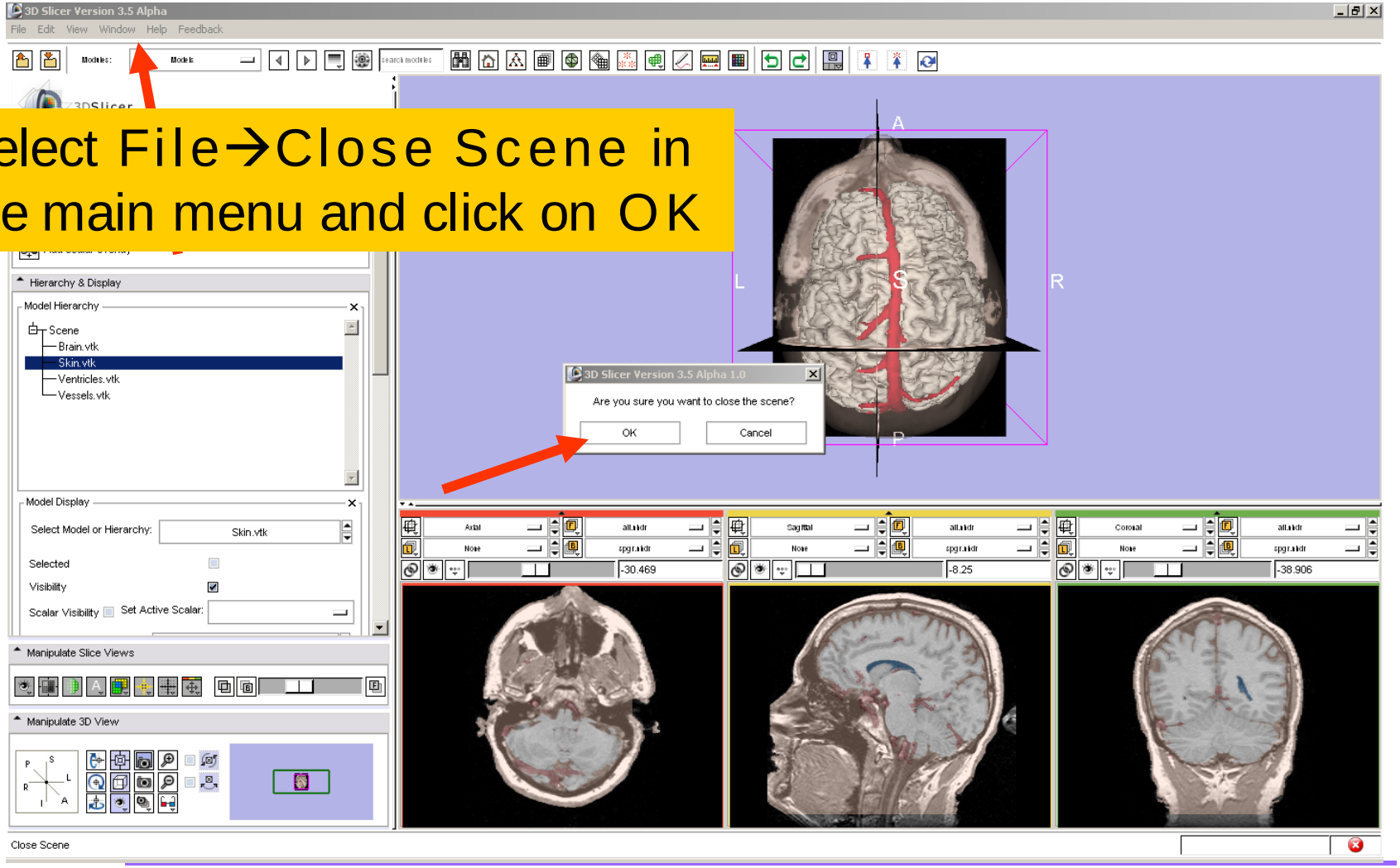


Creating Scene Snapshots

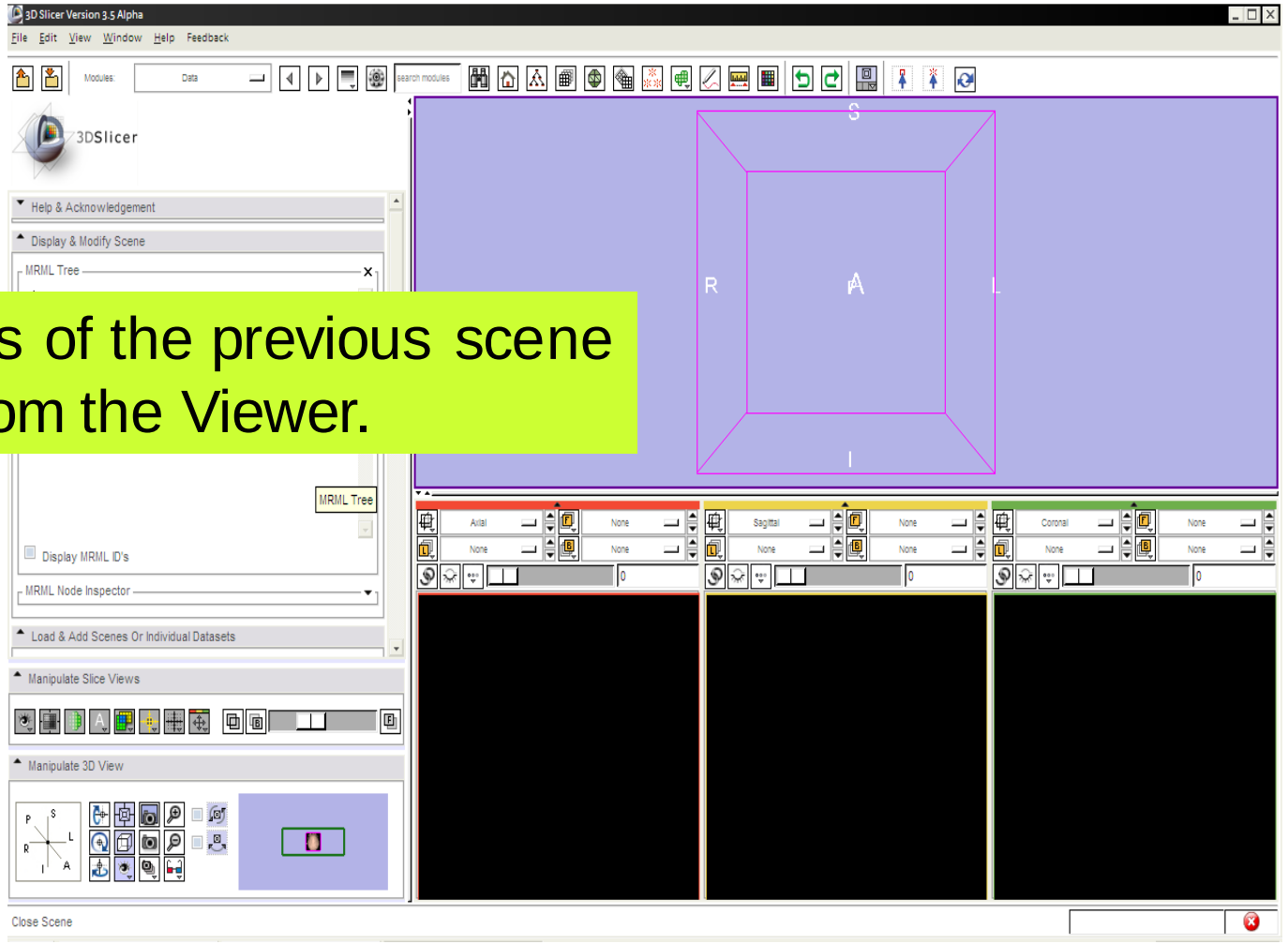


Click on **Yes** to save the scene

Saving Data

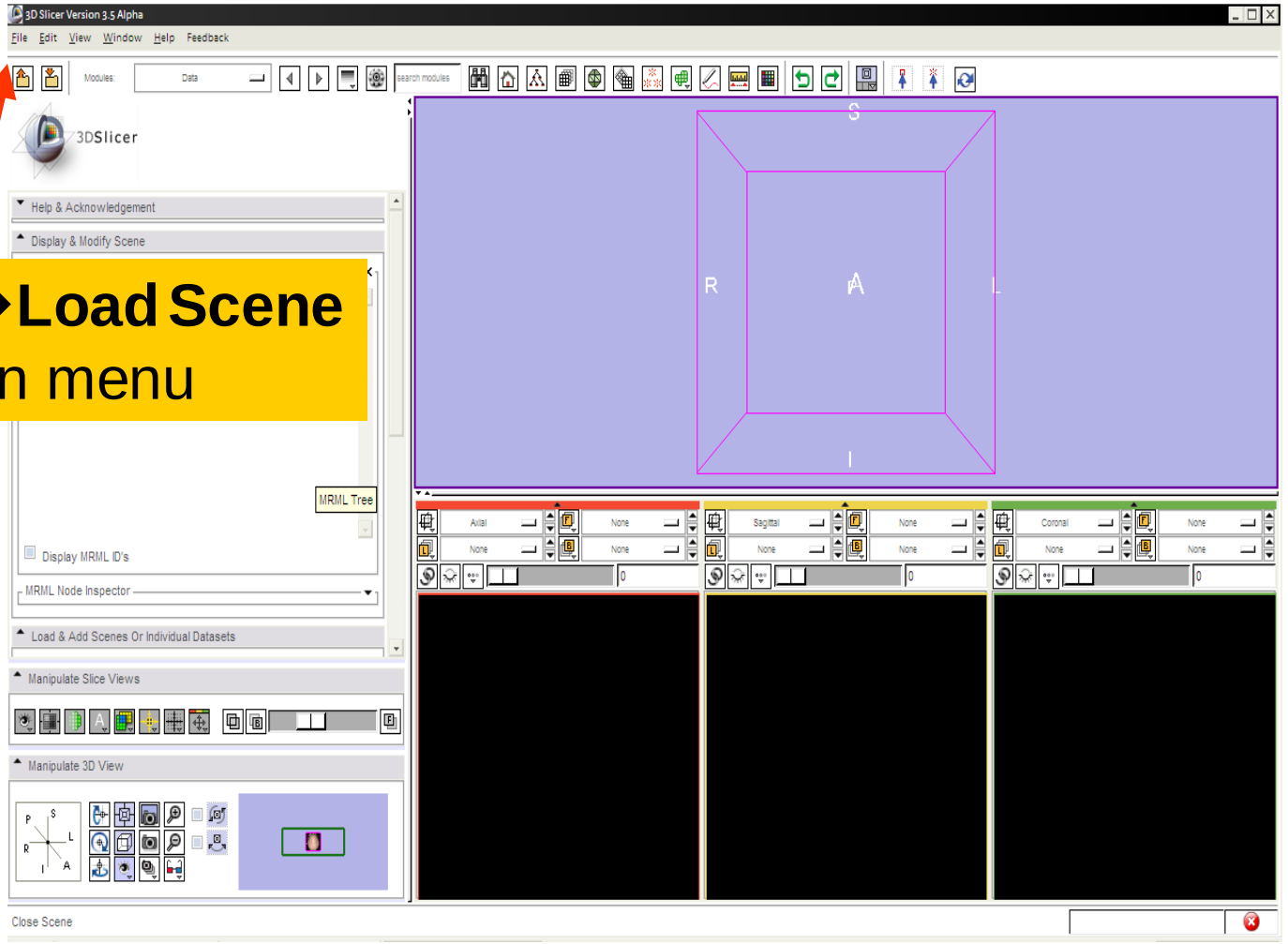

3D Slicer Version 3.5 Alpha
File Edit View Window Help Feedback
Select File→Close Scene in the main menu and click on OK
Hierarchy & Display
Model Hierarchy
Scene
Brain.vtk
Skin.vtk
Ventricles.vtk
Vessels.vtk
Model Display
Select Model or Hierarchy:
Skin.vtk
Selected
Visibility
Scalar Visibility
Set Active Scalar:
Manipulate Slice Views
Manipulate 3D View
3D Slicer Version 3.5 Alpha 1.0
Are you sure you want to close the scene?
OK
Cancel
A
L
S
R
P
Axial
Sagittal
Coronal
-30.469
-8.25
-38.906
Close Scene

Saving Data



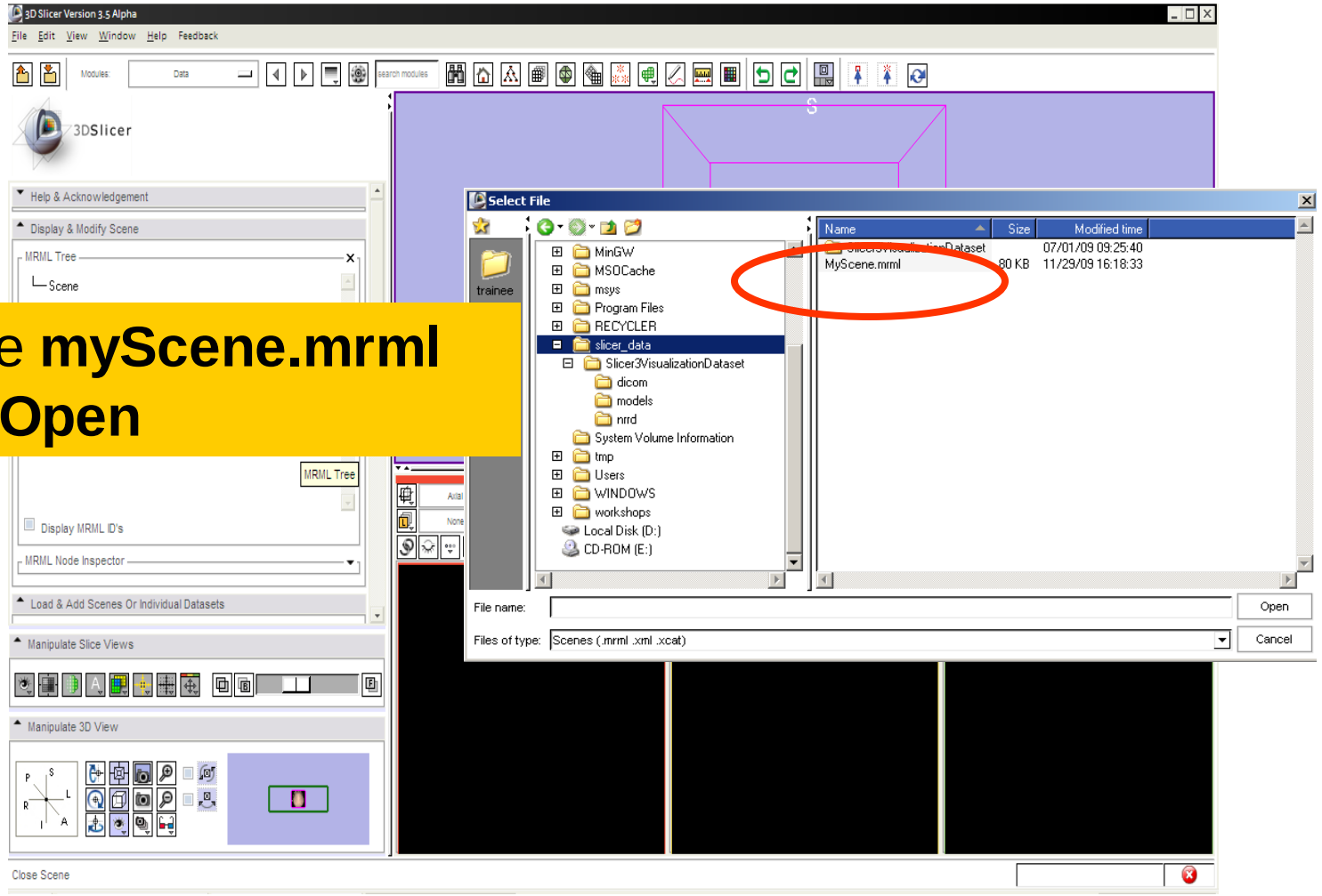
The elements of the previous scene disappear from the Viewer.

Saving Data



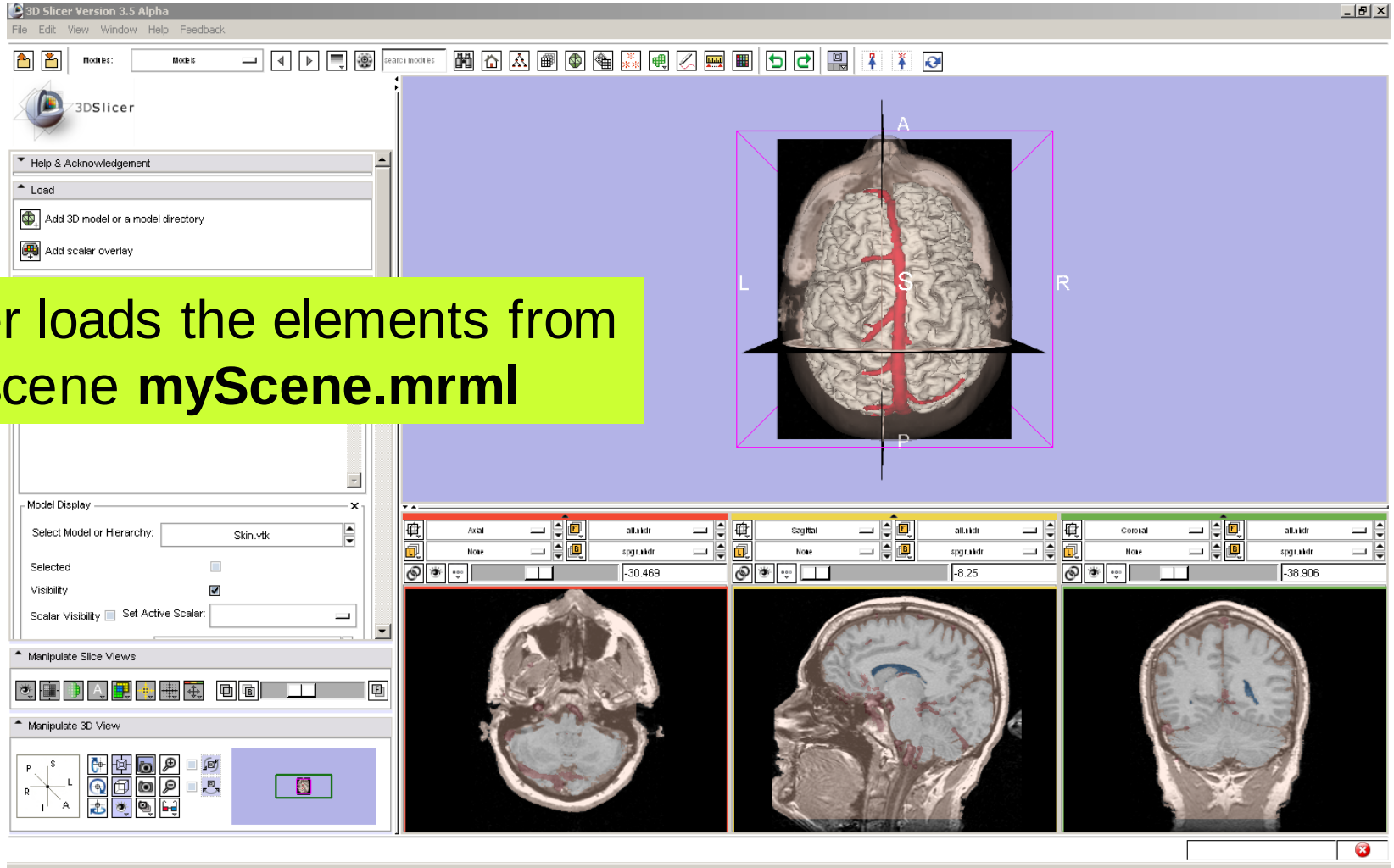
Select **File→Load Scene** from the main menu

Saving Data



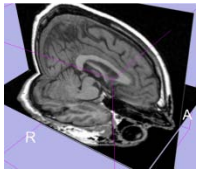
Select the file **myScene.mrml** and click on **Open**

Loading a Scene

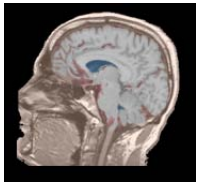


Slicer loads the elements from the scene **myScene.mrml**

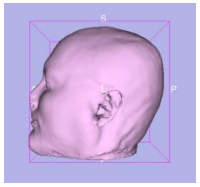
Overview



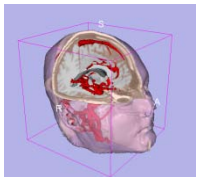
Loading and visualizing multiple volumes simultaneously



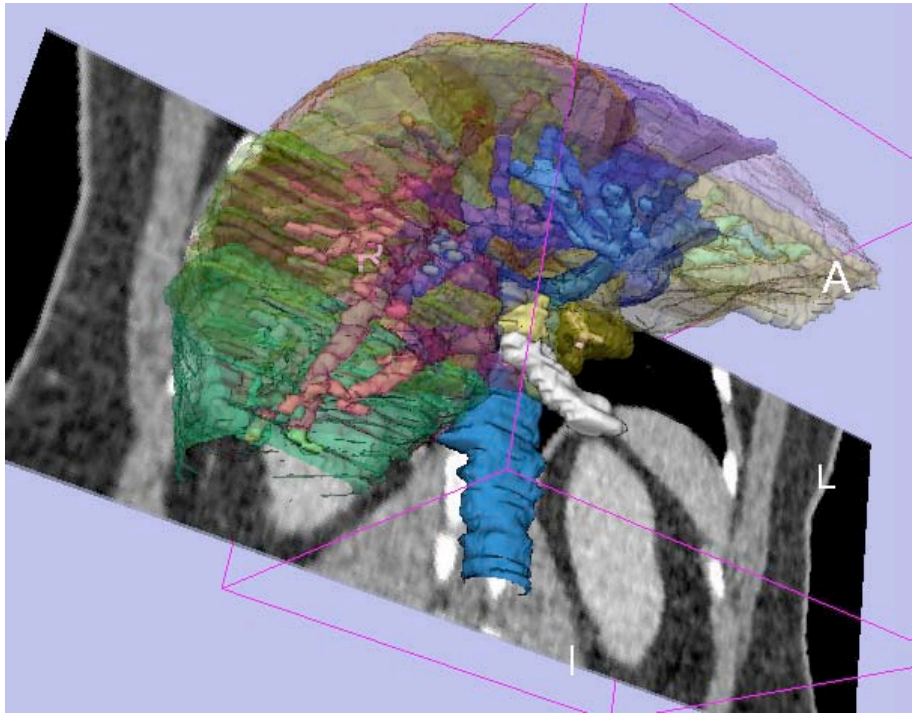
Loading and visualizing segmented structures overlaid on grayscale images



Loading and visualizing 3D models



Loading and saving a scene



- Part 3 -

Exploring liver segments using 3DSlicer

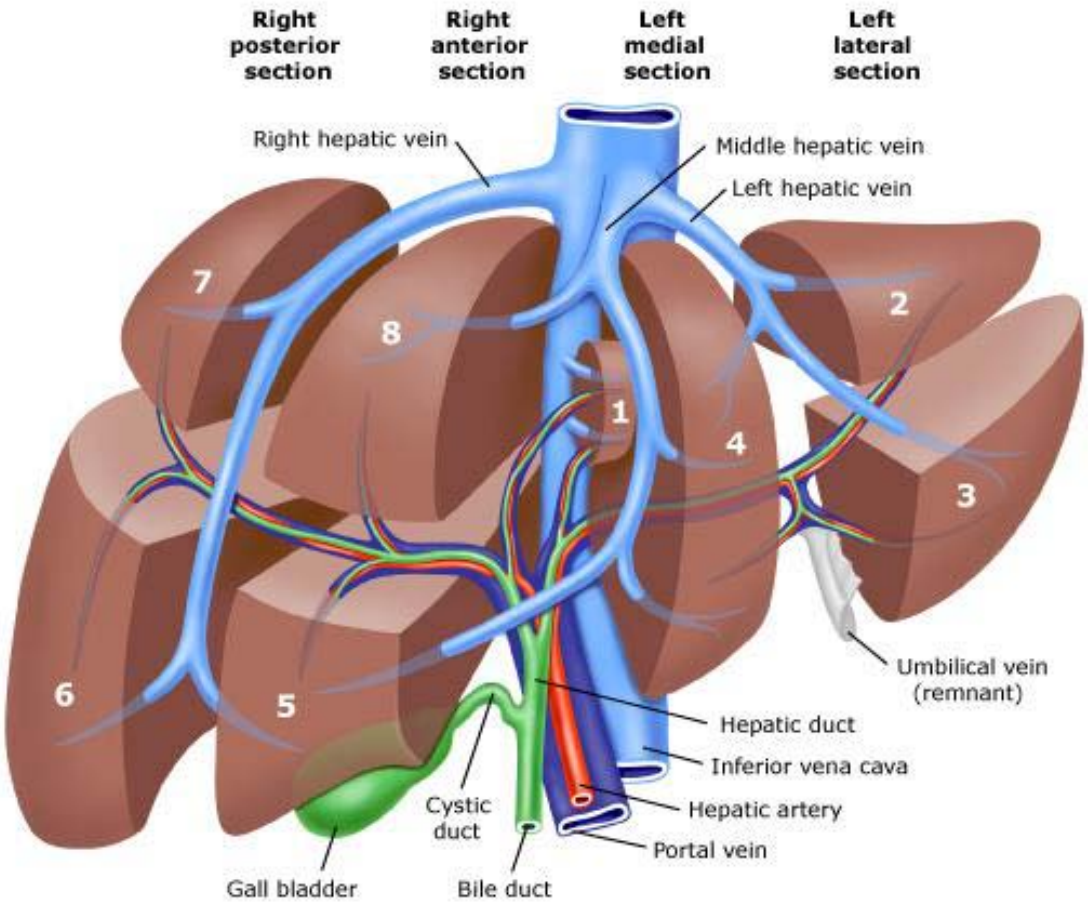
Sonia Pujol, PhD - Kitt Shaffer, MD, PhD

3D Slicer Course for Radiologists, November 30, 2009
RSNA 2009

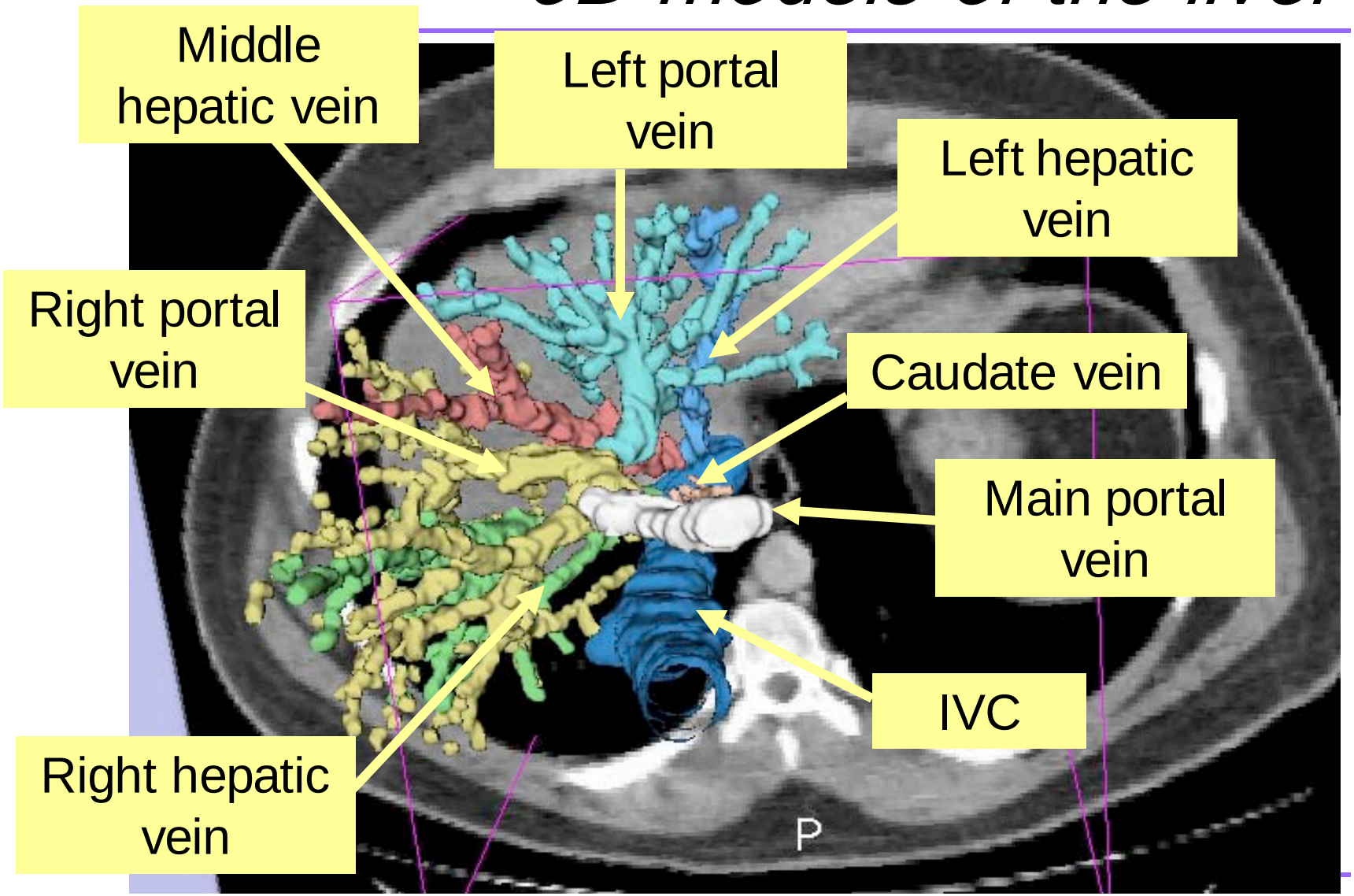
Dataset

The patient1 dataset is a contrast-enhanced CT abdominal scan of a healthy 36 year old male.

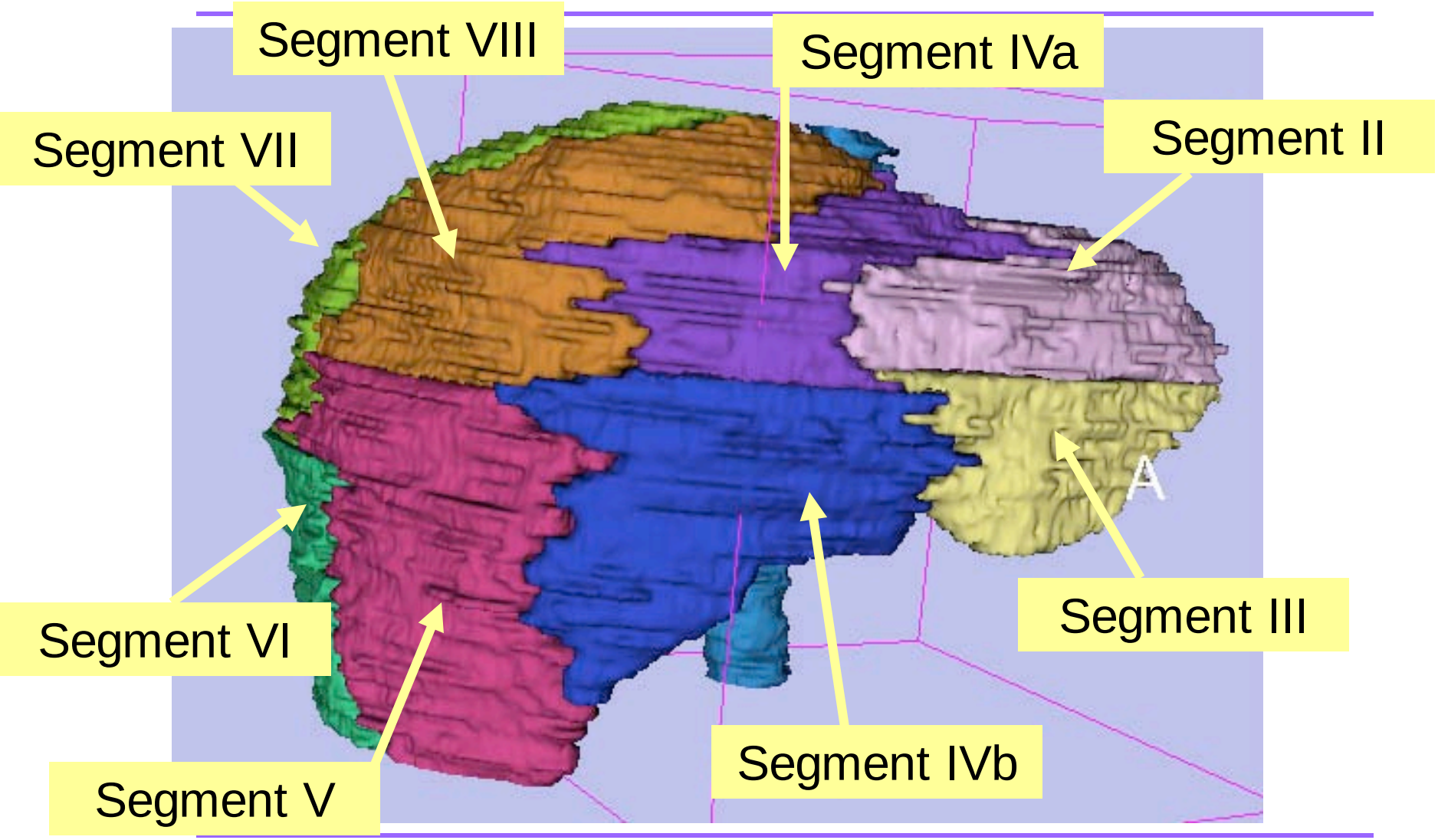
Anatomy of the liver



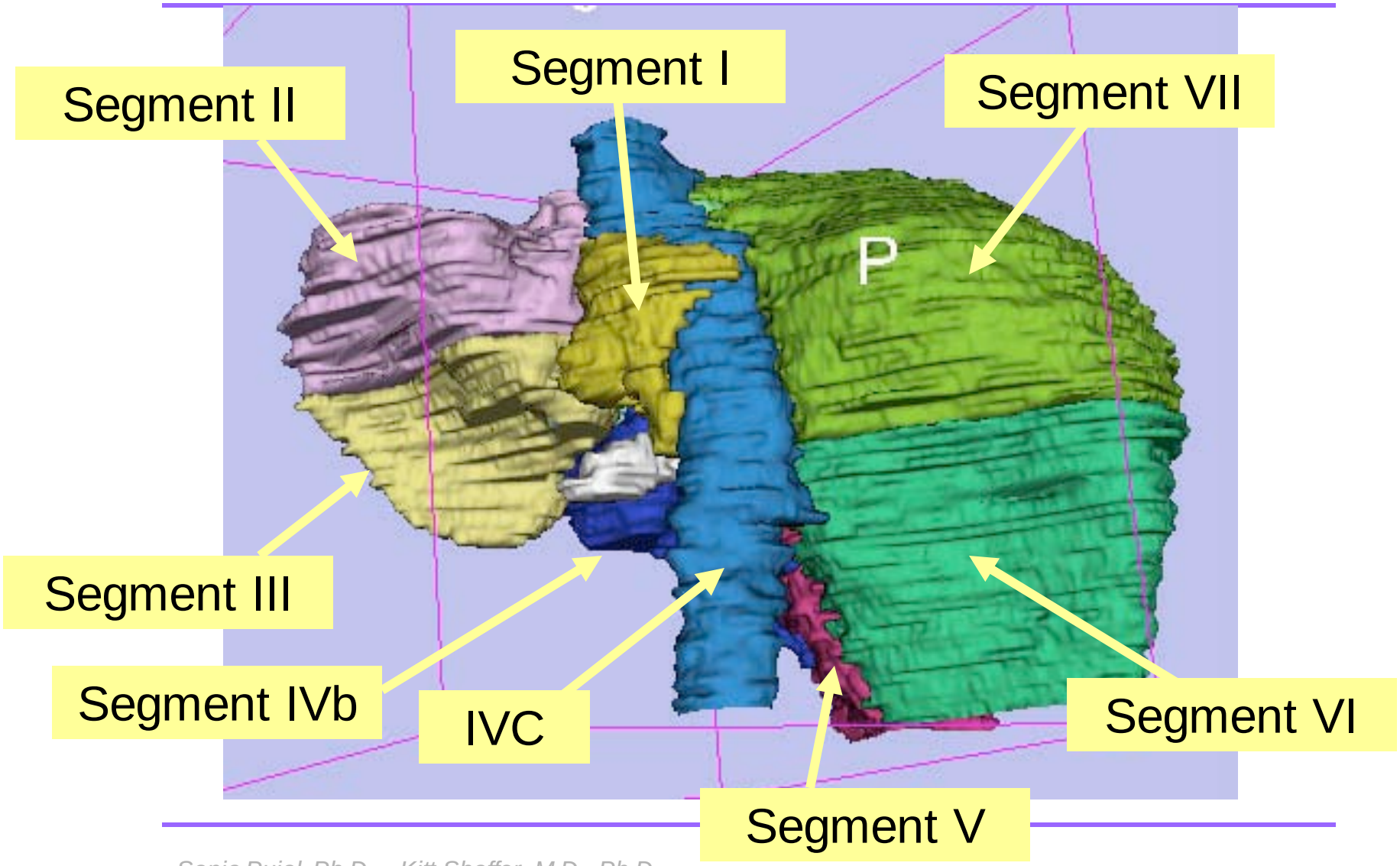
3D models of the liver



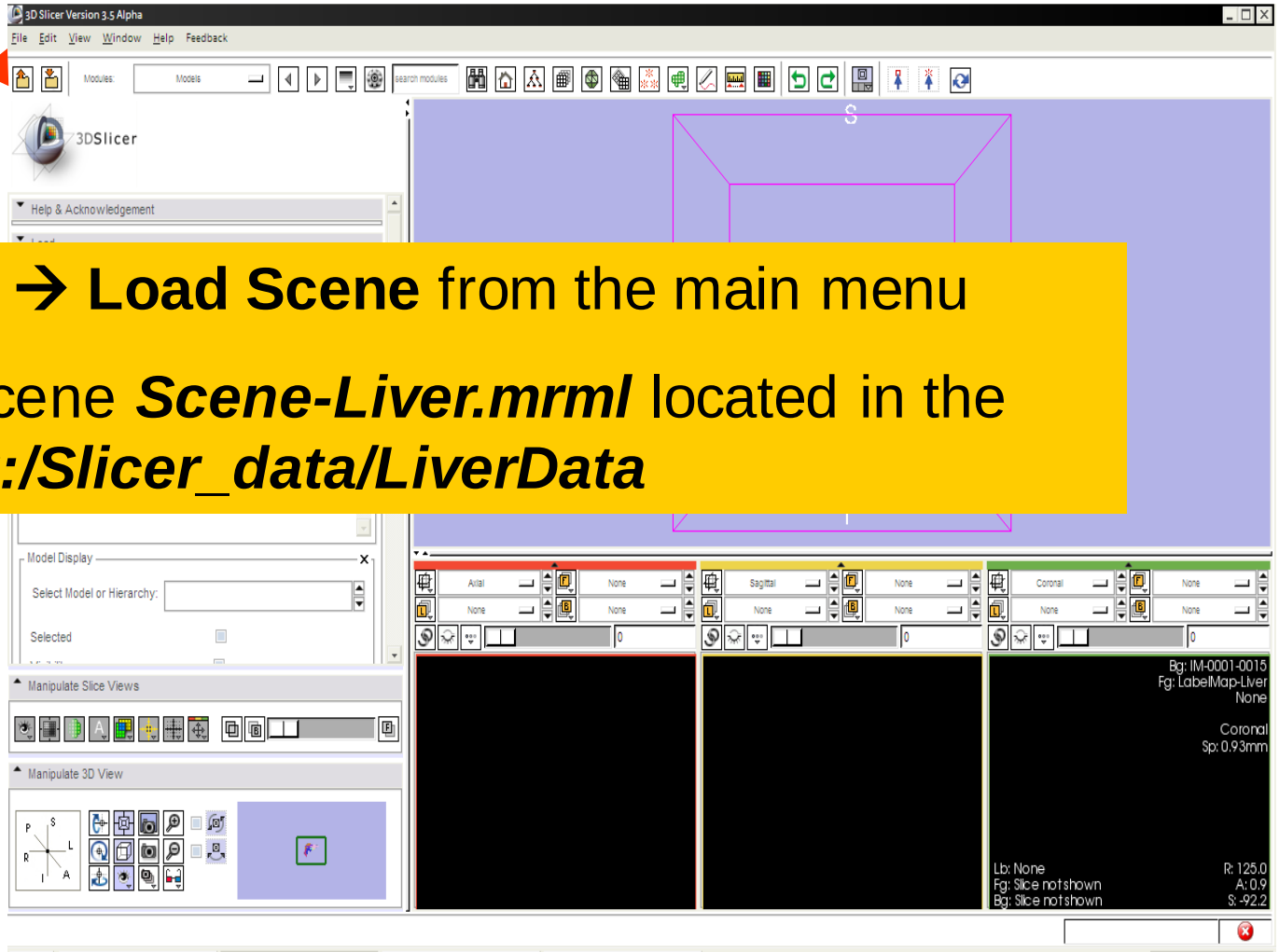
3D models of the liver



3D models of the liver



Loading the Liver Scene



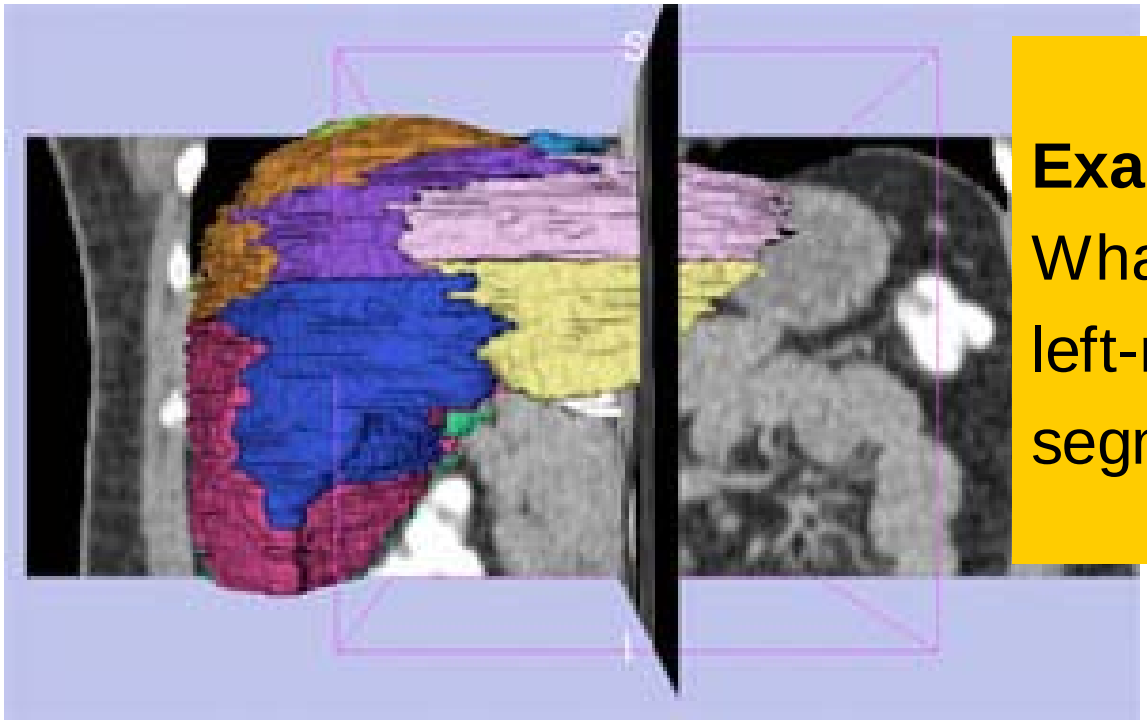
Select **File → Load Scene** from the main menu

Load the scene ***Scene-Liver.mrml*** located in the directory ***C:/Slicer_data/LiverData***

Liver Segments Scene

The elements of the scene appear in the Viewer

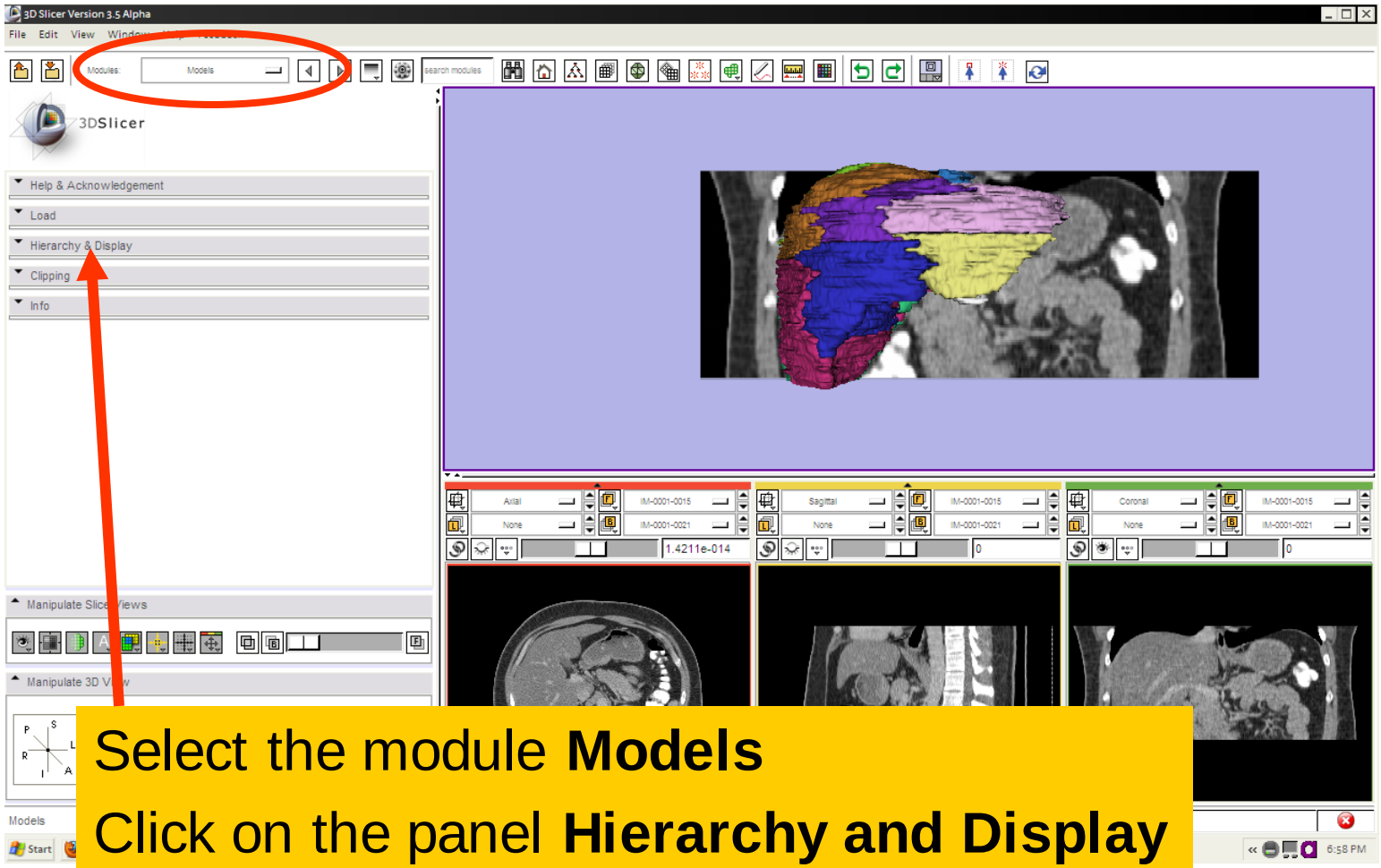
3D Exploration of Liver Segments



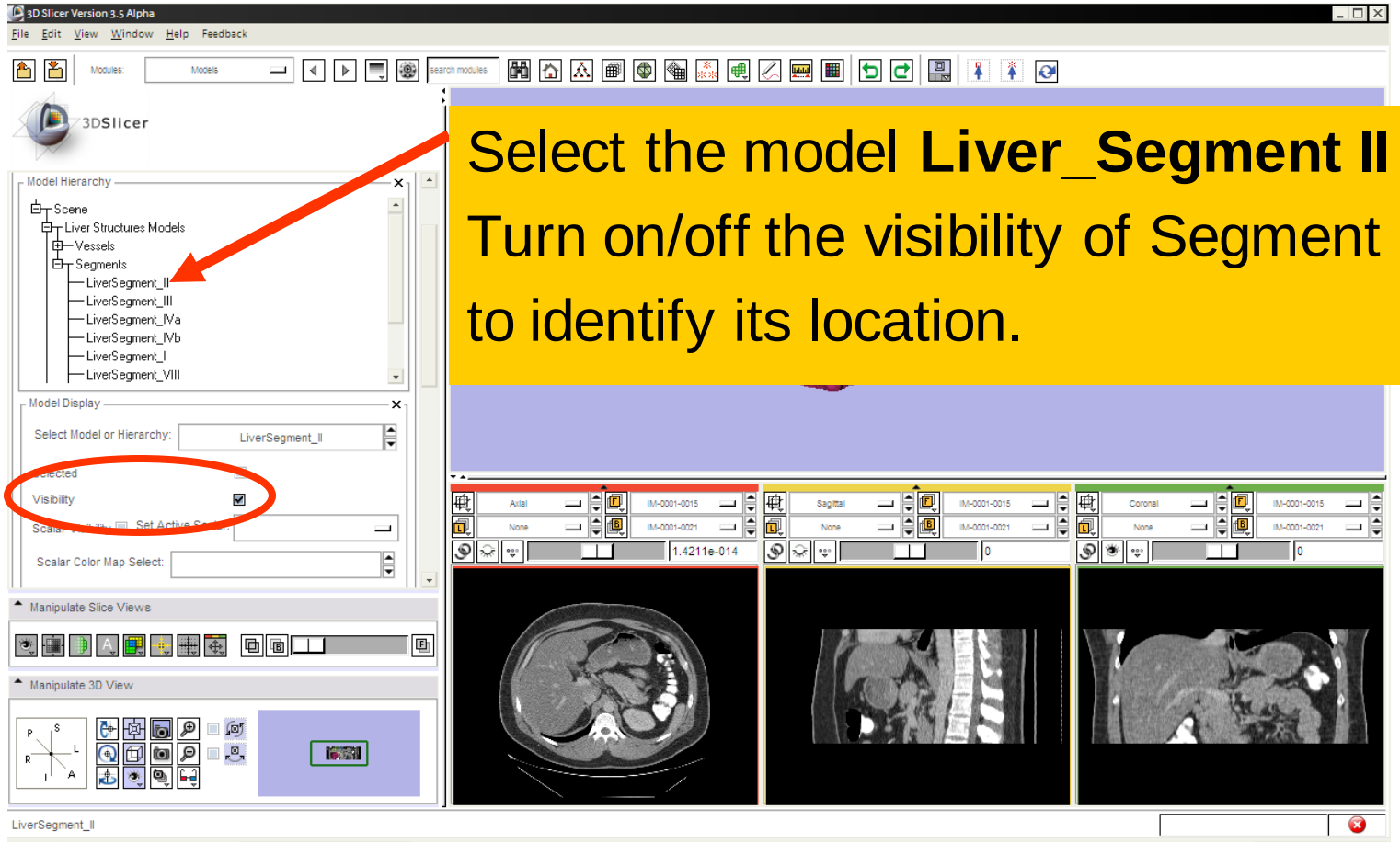
Example:

What organ abuts the left-most margin of segment II in Patient 1?

3D Exploration of Liver Segments



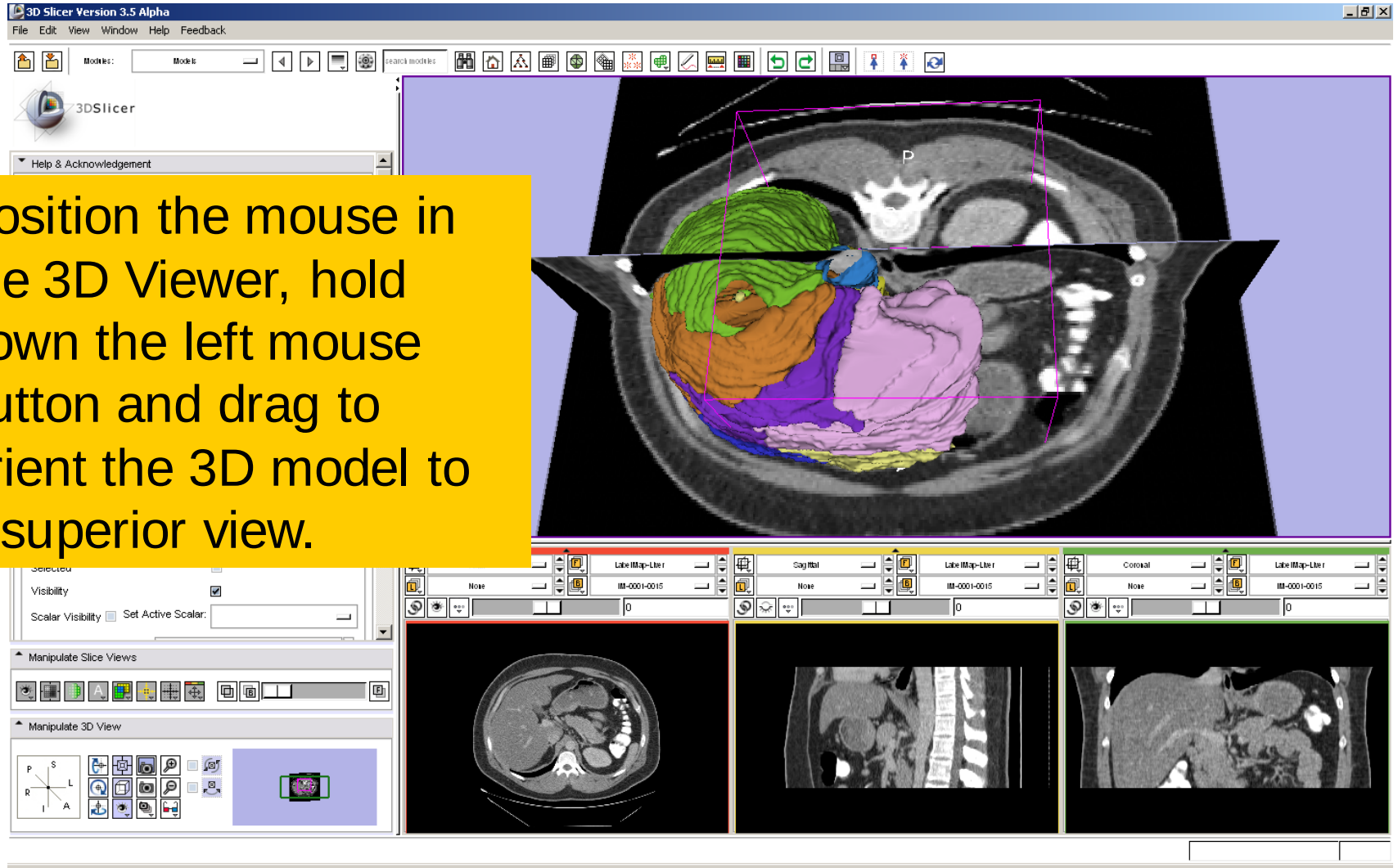
3D Exploration of Liver Segments



Select the model **Liver_Segment II**

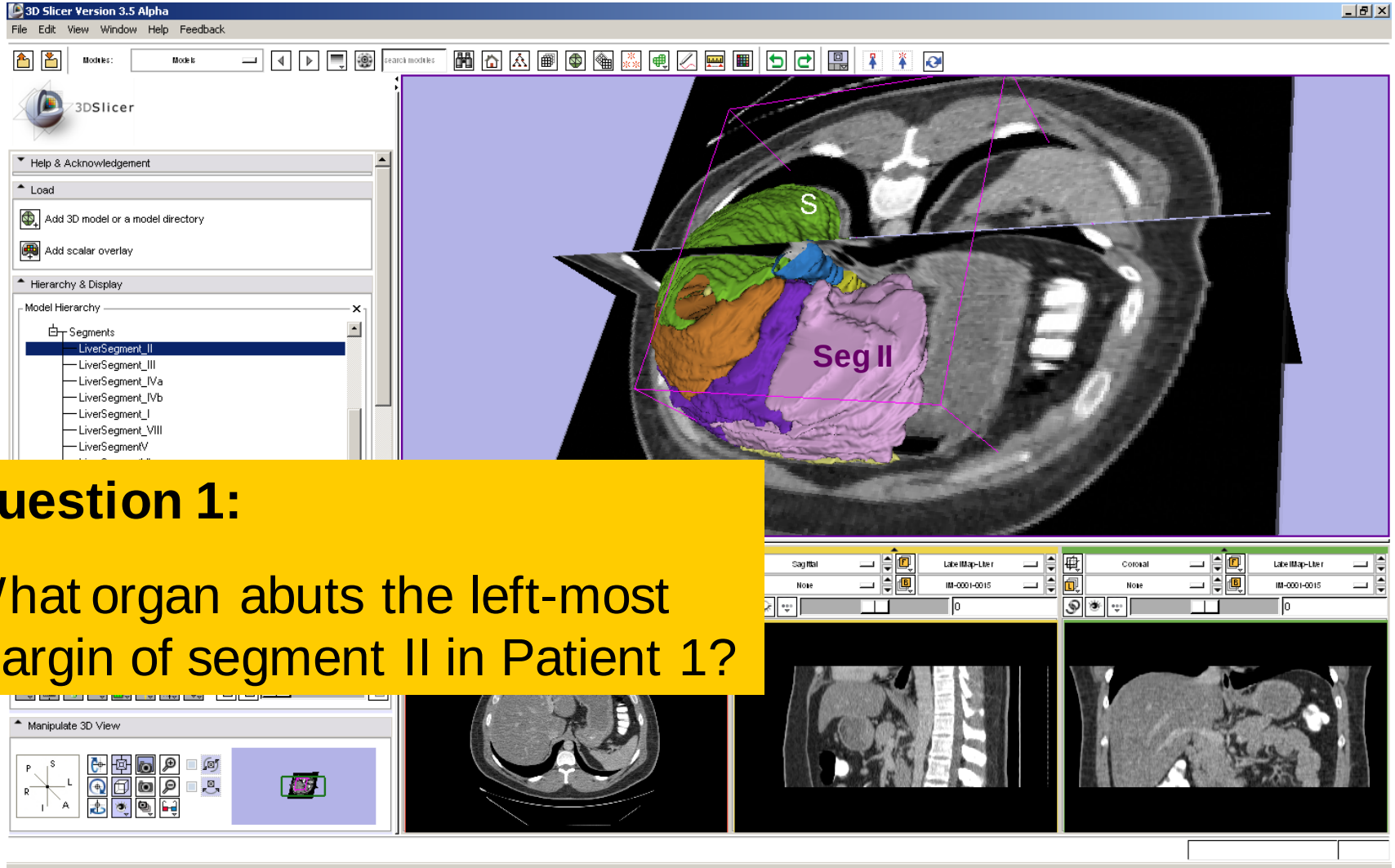
Turn on/off the visibility of Segment II to identify its location.

3D Exploration of Liver Segments



Position the mouse in the 3D Viewer, hold down the left mouse button and drag to orient the 3D model to a superior view.

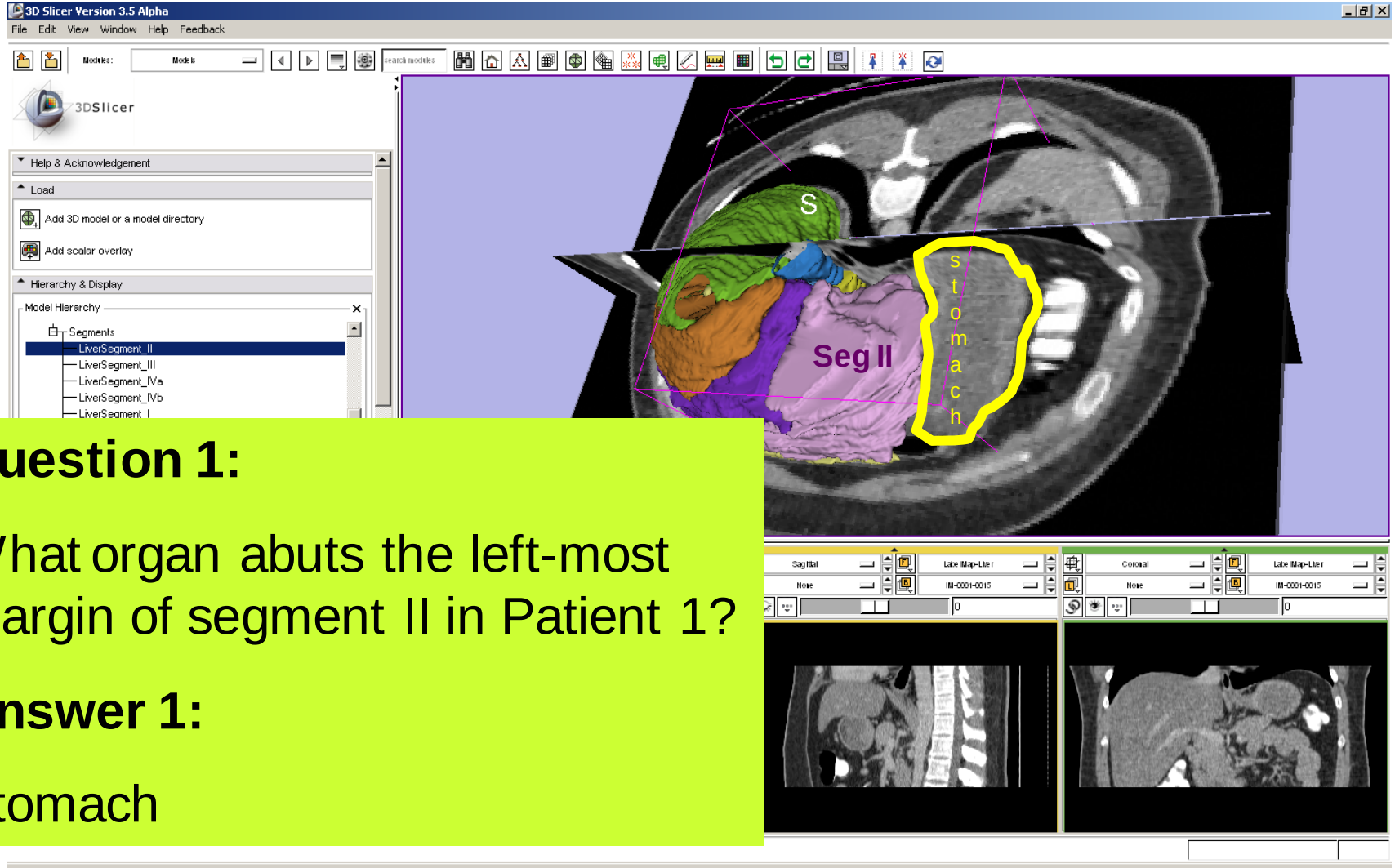
3D Exploration of Liver Segments



Question 1:

What organ abuts the left-most margin of segment II in Patient 1?

3D Exploration of Liver Segments



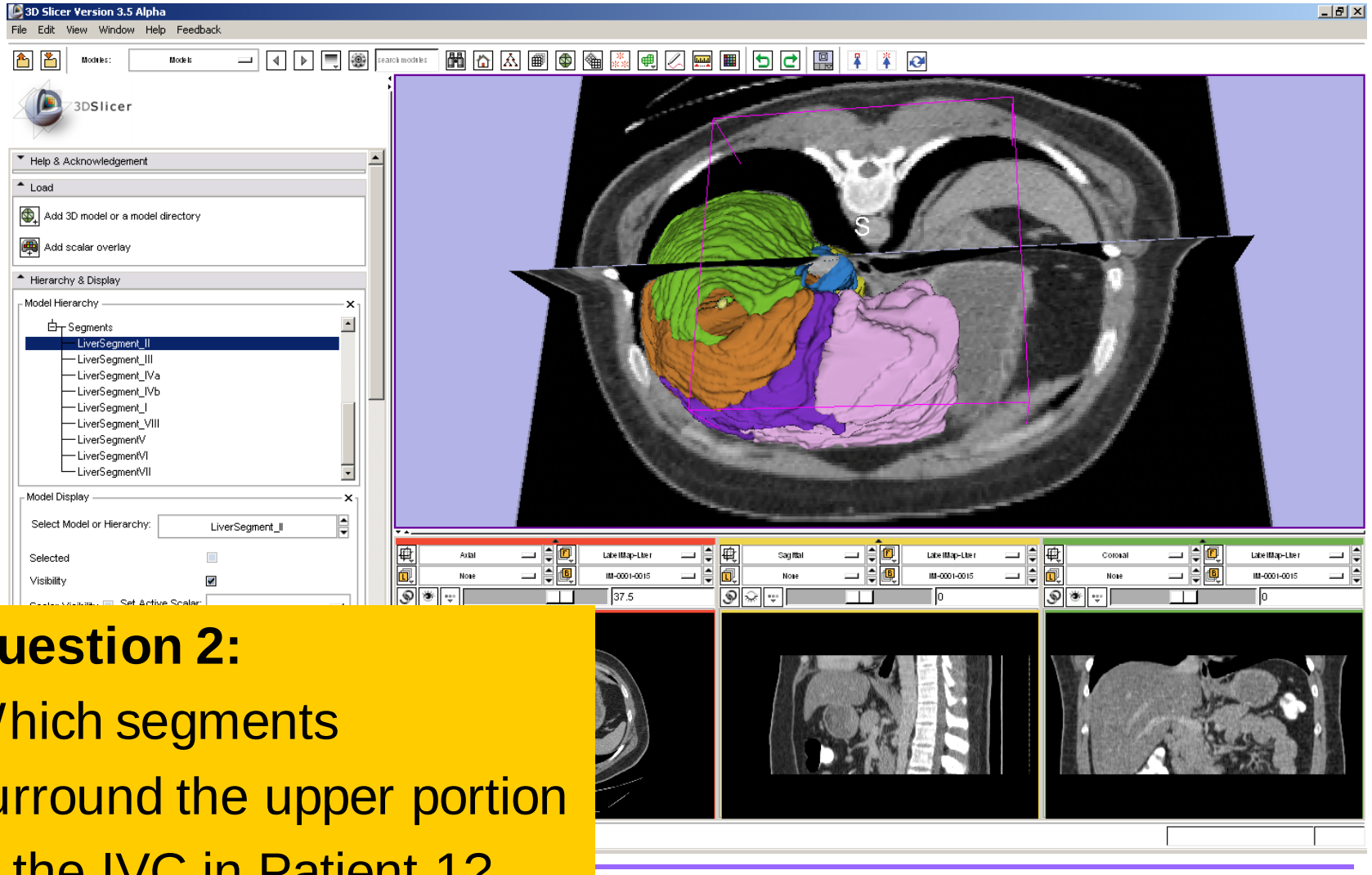
Question 1:

What organ abuts the left-most margin of segment II in Patient 1?

Answer 1:

Stomach

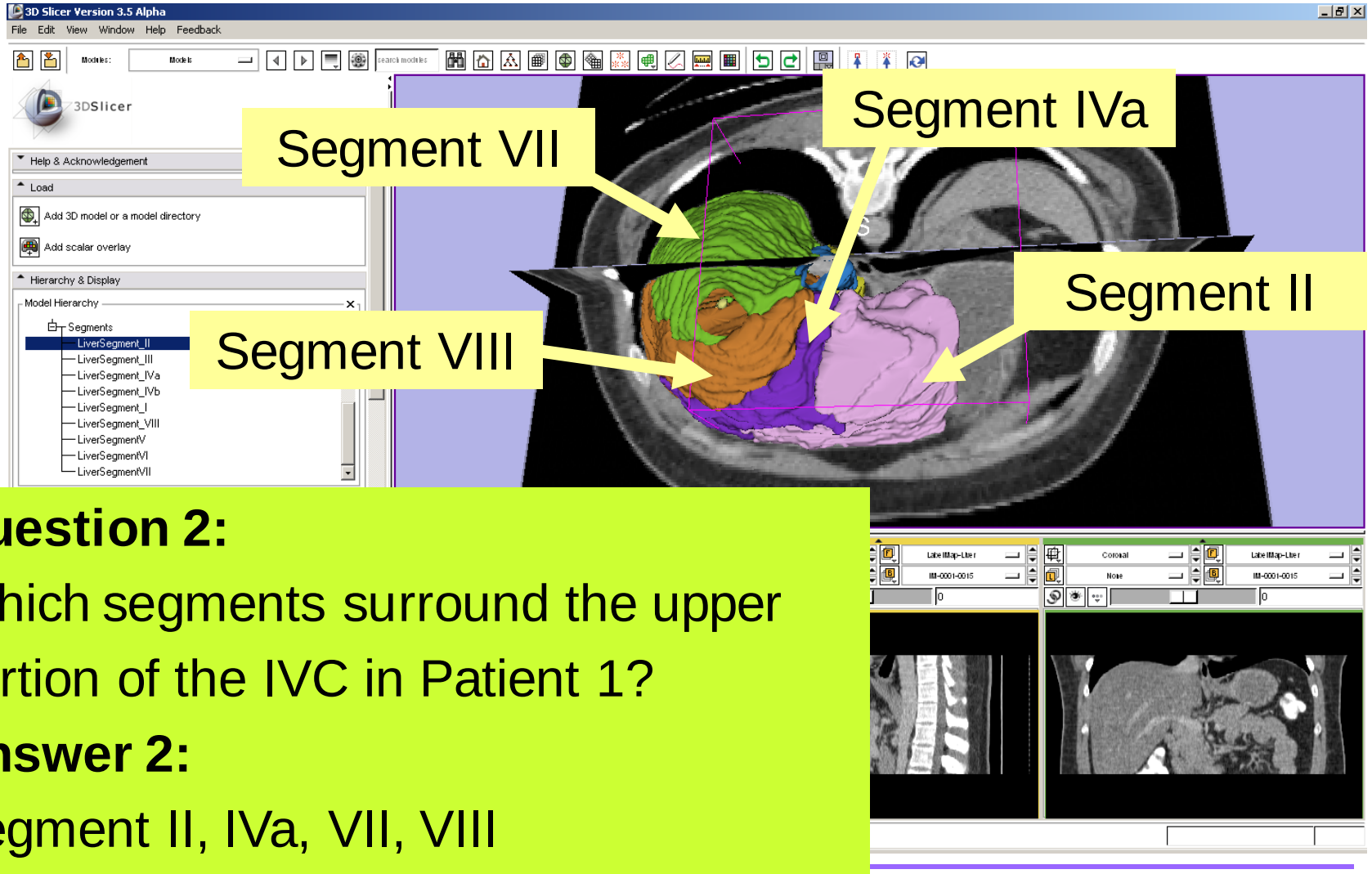
3D Exploration of Liver Segments



Question 2:

Which segments surround the upper portion of the IVC in Patient 1?

3D Exploration of Liver Segments



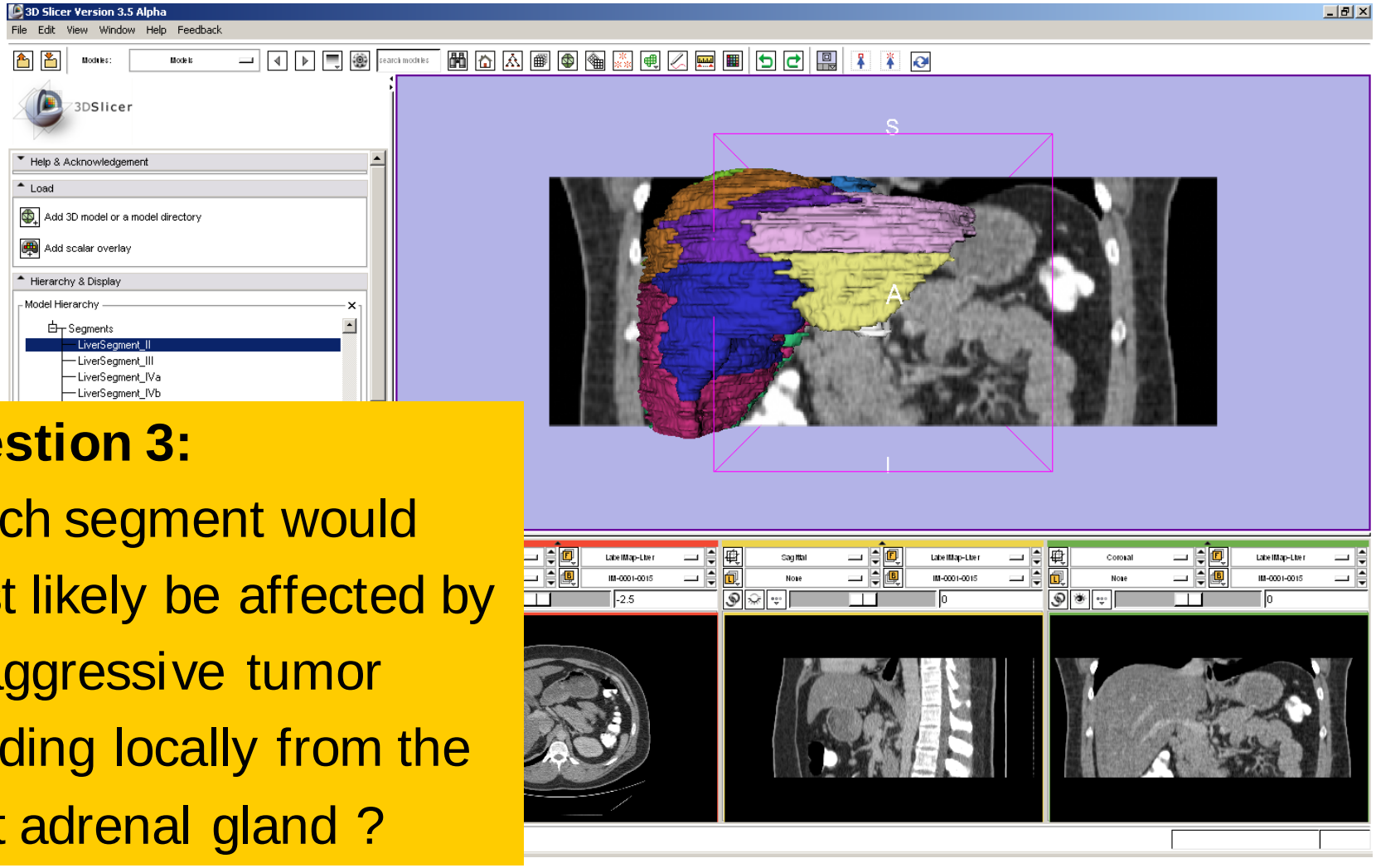
Question 2:

Which segments surround the upper portion of the IVC in Patient 1?

Answer 2:

Segment II, IVa, VII, VIII

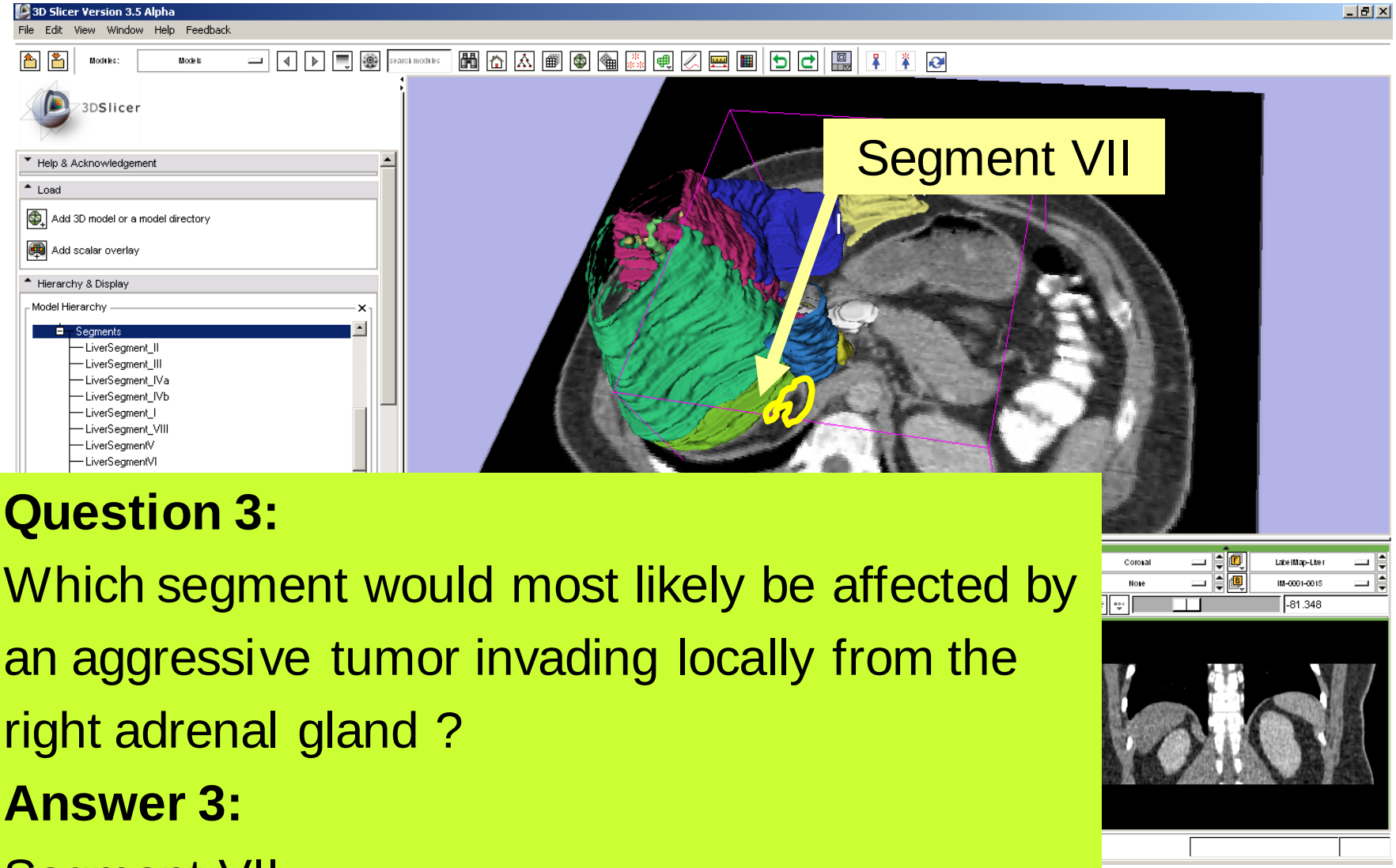
3D Exploration of Liver Segments



Question 3:

Which segment would most likely be affected by an aggressive tumor invading locally from the right adrenal gland ?

Segment VII



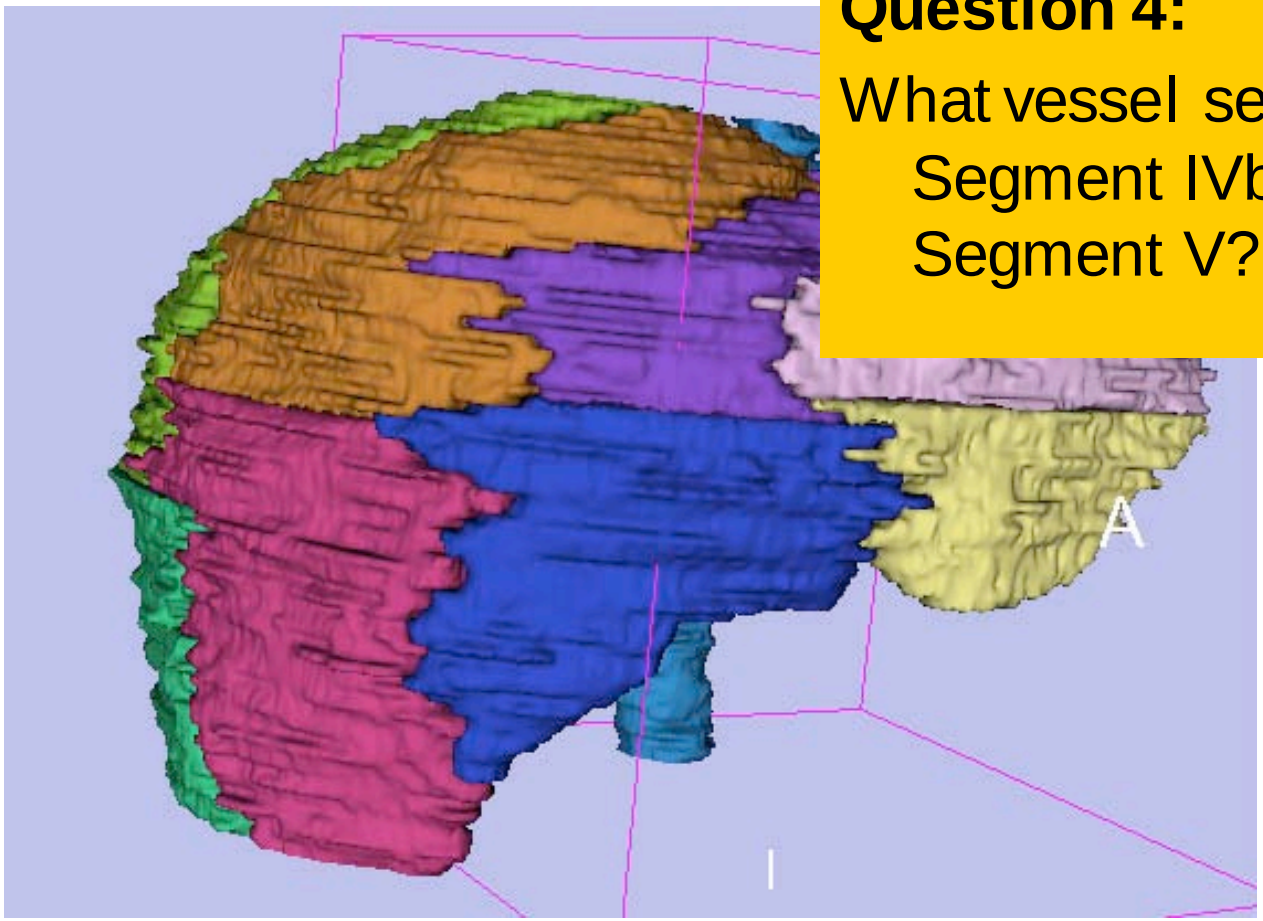
Question 3:

Which segment would most likely be affected by an aggressive tumor invading locally from the right adrenal gland ?

Answer 3:

Segment VII

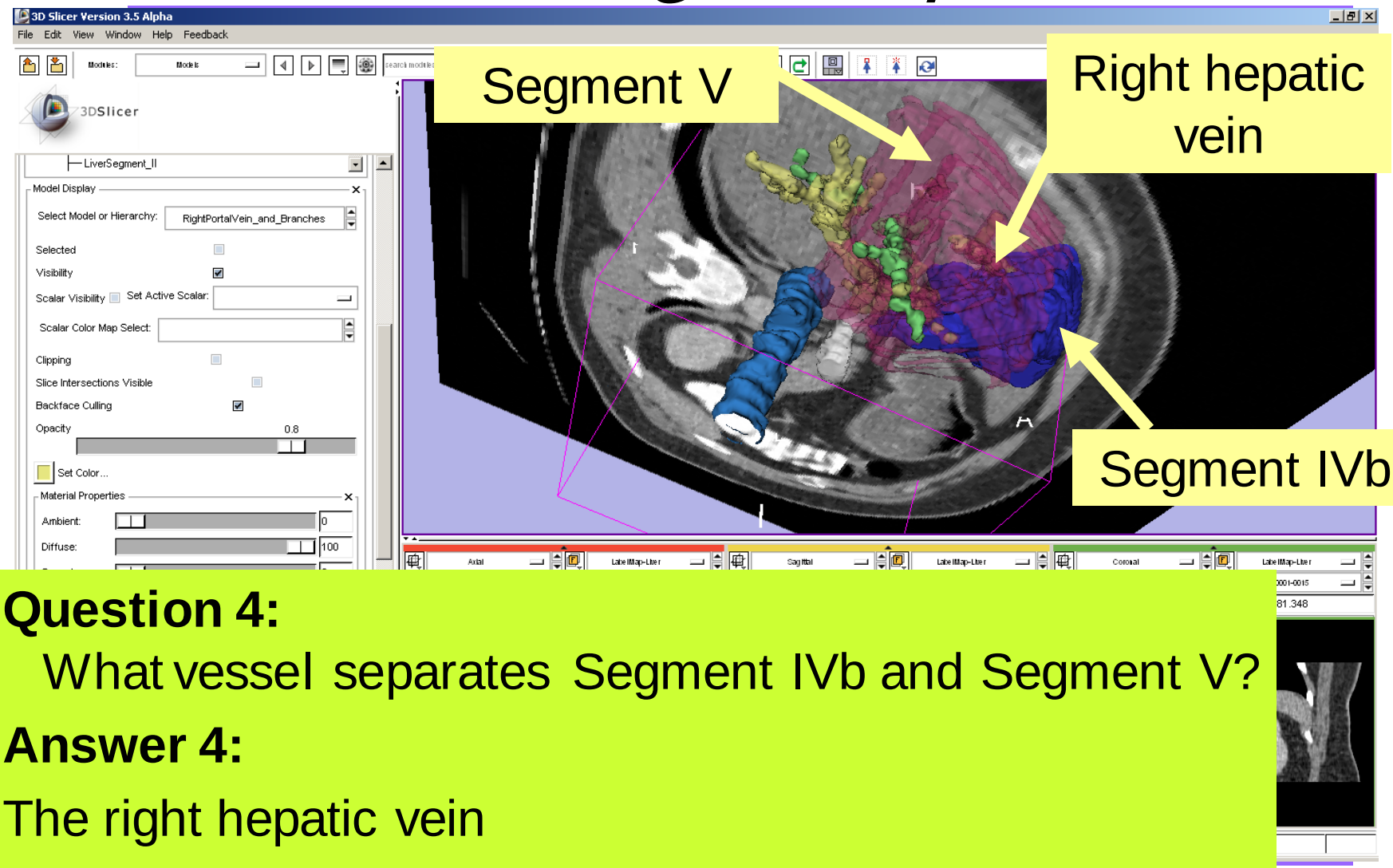
3D Exploration of Liver Segments



Question 4:

What vessel separates Segment IVb and Segment V?

Right Hepatic Vein



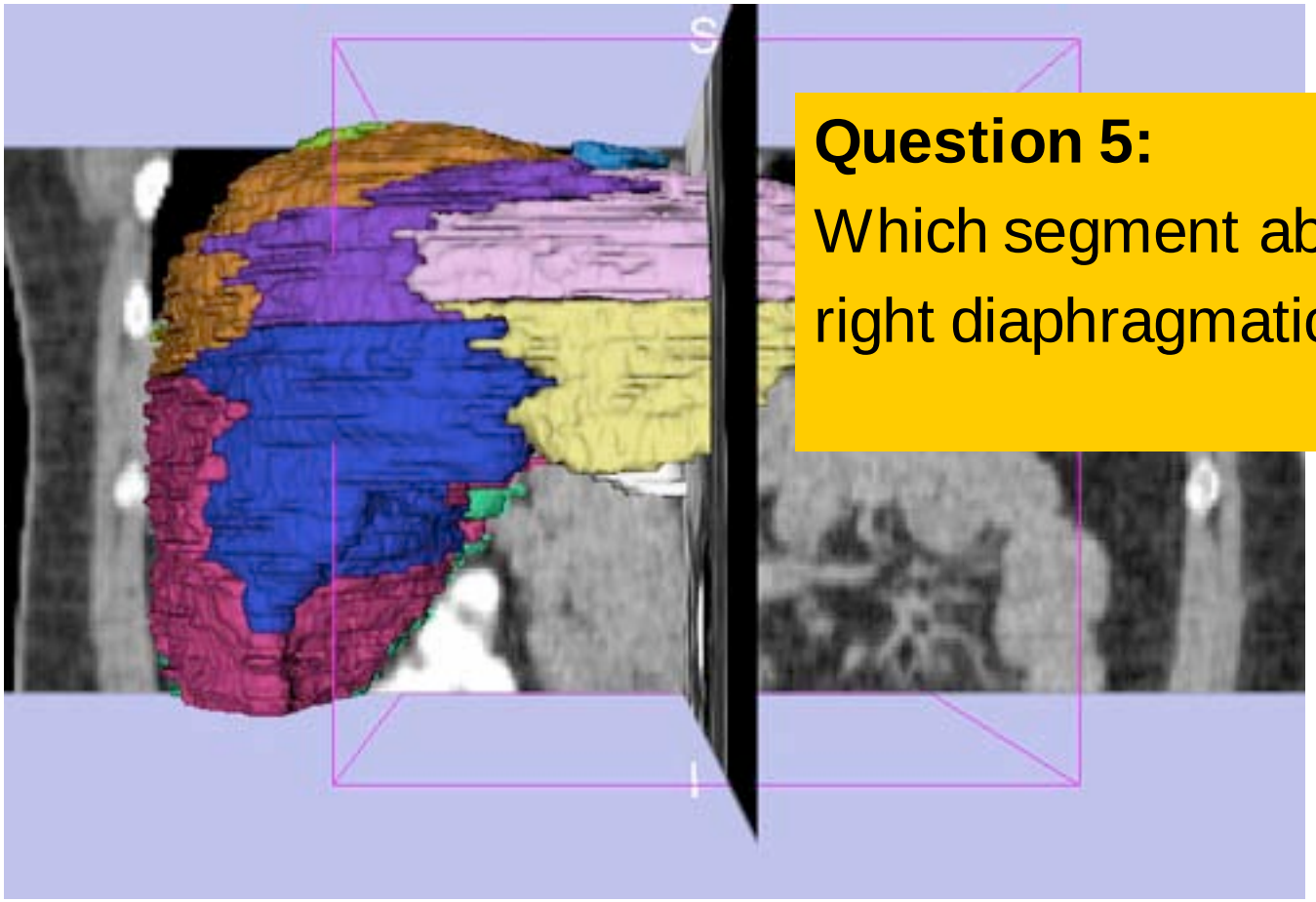
Question 4:

What vessel separates Segment IVb and Segment V?

Answer 4:

The right hepatic vein

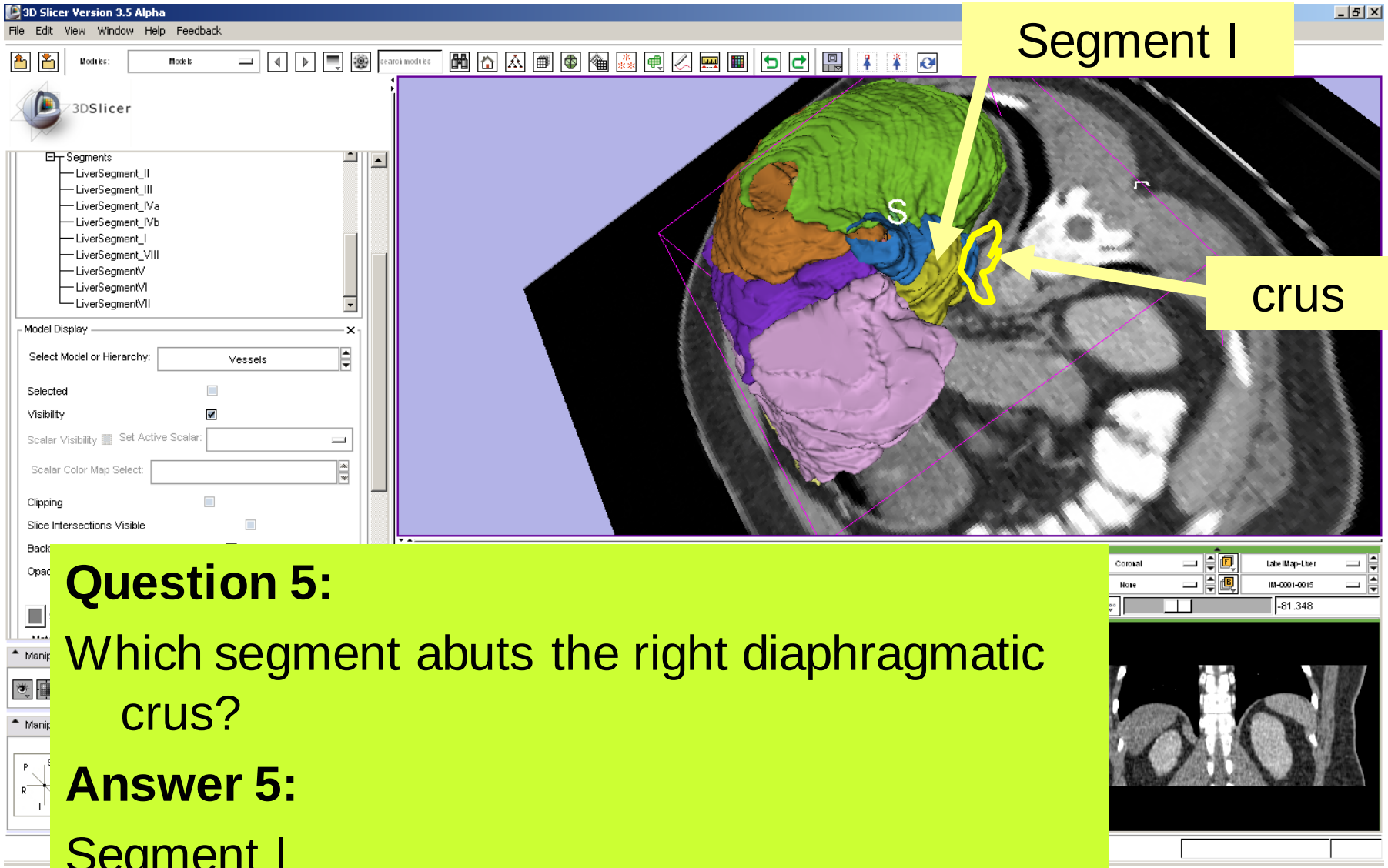
3D Exploration of Liver Segments



Question 5:

Which segment abuts the right diaphragmatic crus?

3D Exploration of Liver Segments



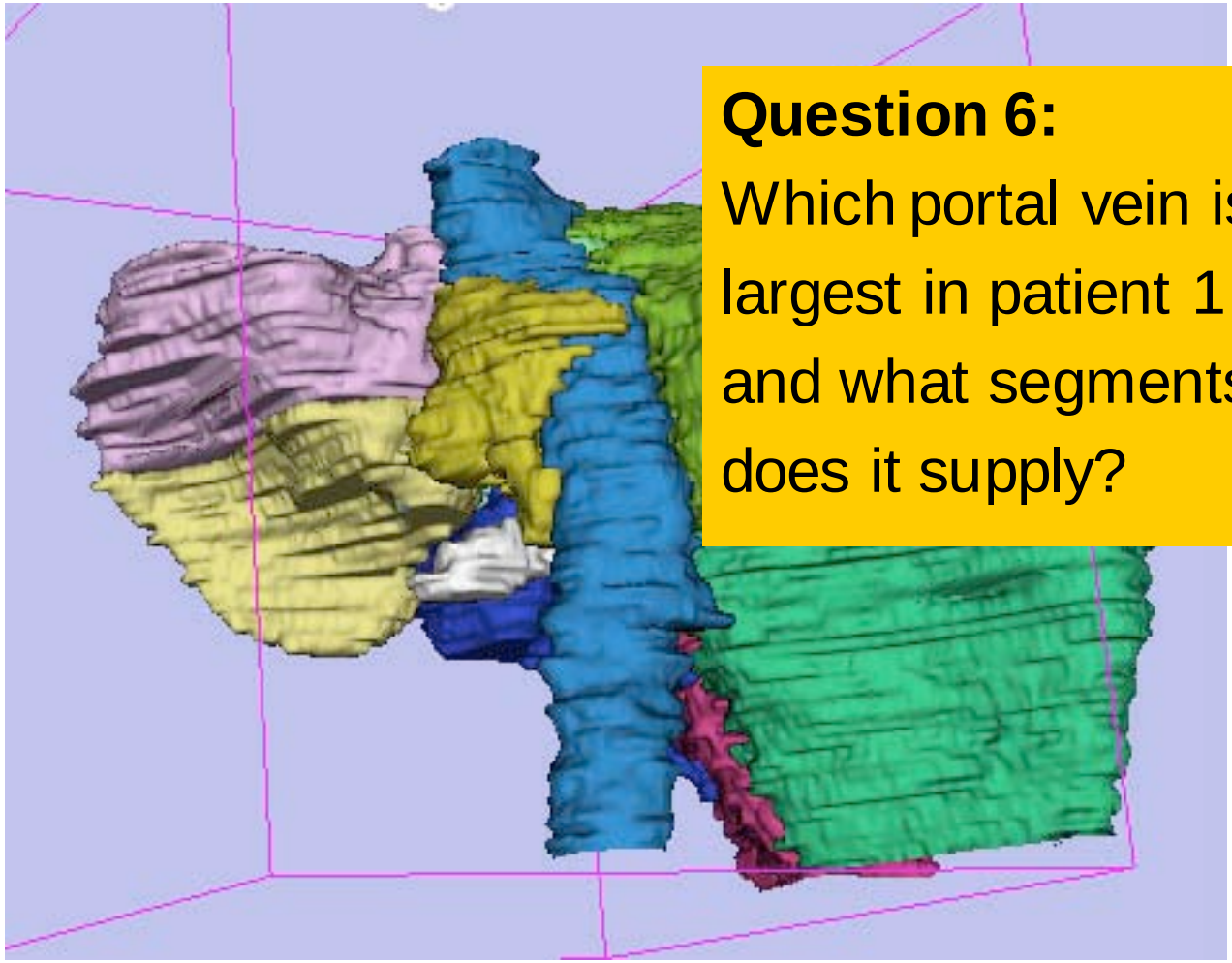
Question 5:

Which segment abuts the right diaphragmatic crus?

Answer 5:

Segment I

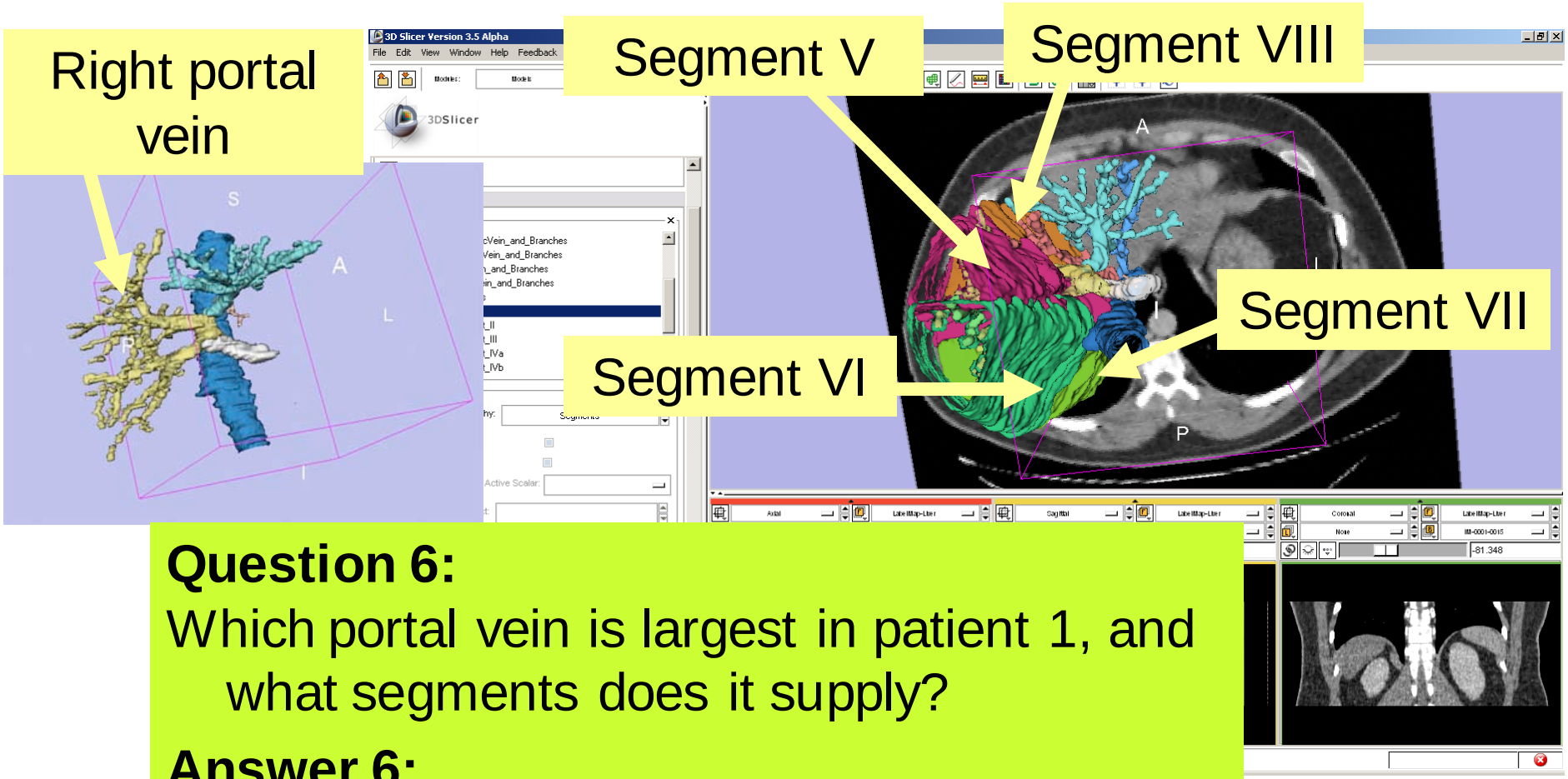
3D Exploration of Liver Segments



Question 6:

Which portal vein is largest in patient 1, and what segments does it supply?

3D Exploration of Liver Segments



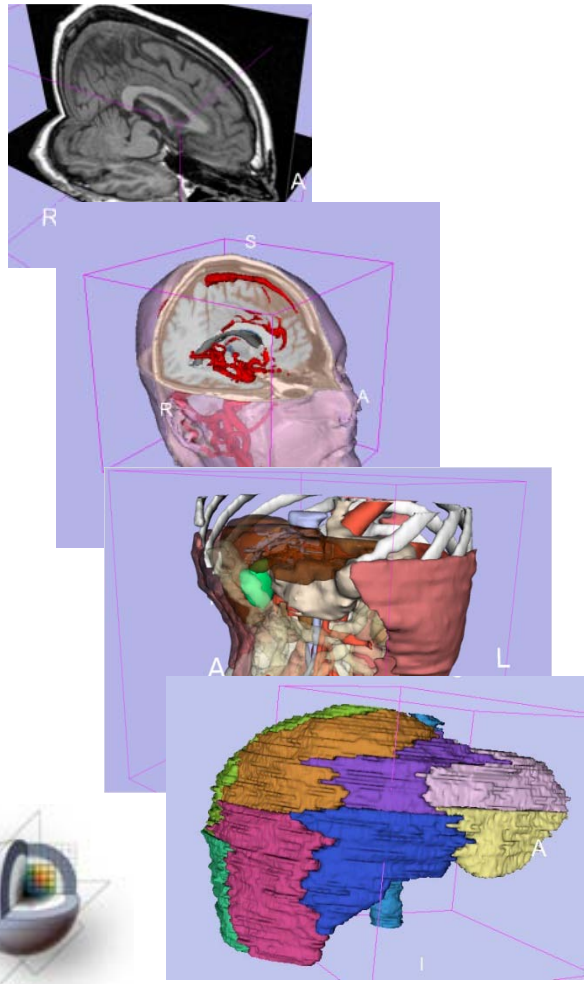
Question 6:

Which portal vein is largest in patient 1, and what segments does it supply?

Answer 6:

The Right portal vein, supplying Segments V, VI, VII and VIII

Conclusion



- Interactive interface to load and manipulate greyscale volumes, labelmaps and 3D models.
- 3D interaction with anatomical views
- Open-source platform for Linux, Mac and Windows

Acknowledgments

National Alliance for Medical Image Computing

NIH U54EB005149

Neuroimage Analysis Center

NIH P41RR013218