Surgical Planning Laboratory
Brigham and Women's Hospital
Boston, Massachusetts USA

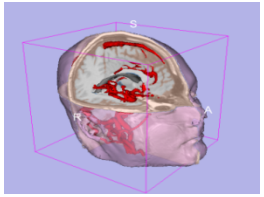
a teaching affiliate of
Harvard Medical School

3D VISUALIZATION OF DICOM IMAGES FOR RADIOLOGICAL APPLICATIONS

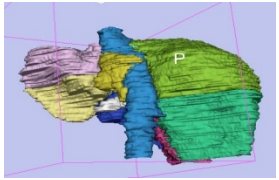
Sonia Pujol, Ph.D., Harvard Medical School
Director of Training, National Alliance for Medical Image Computing

Kitt Shaffer, M.D., Ph.D., Boston University
Vice-Chairman for Education, Boston University School of Medicine

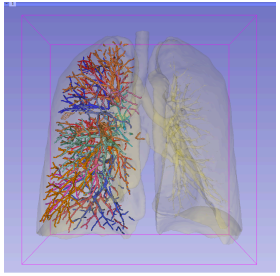
Overview



Part1: Introduction to data loading and 3D visualization of brain images



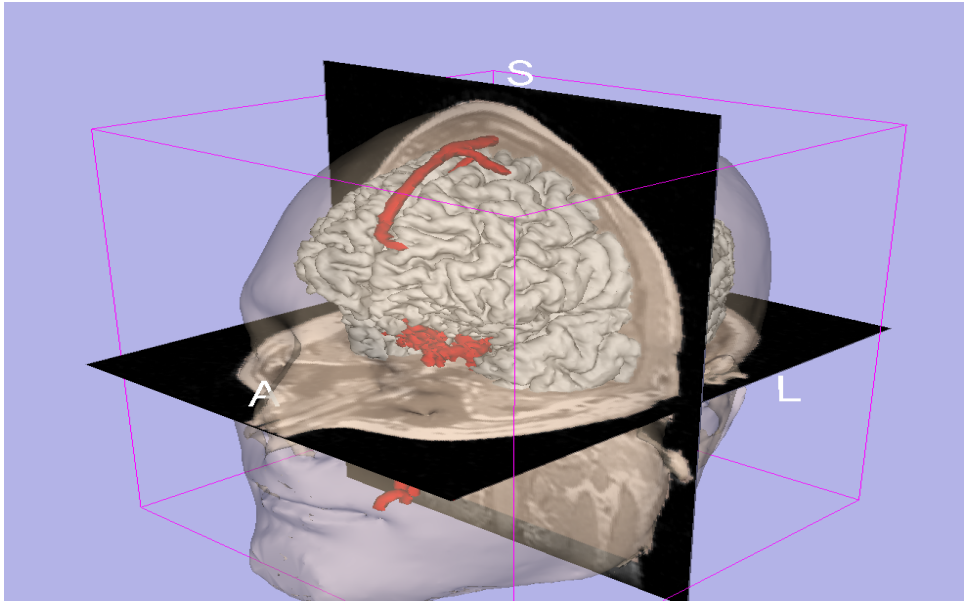
Part 2: 3D interactive exploration of the segments of the liver



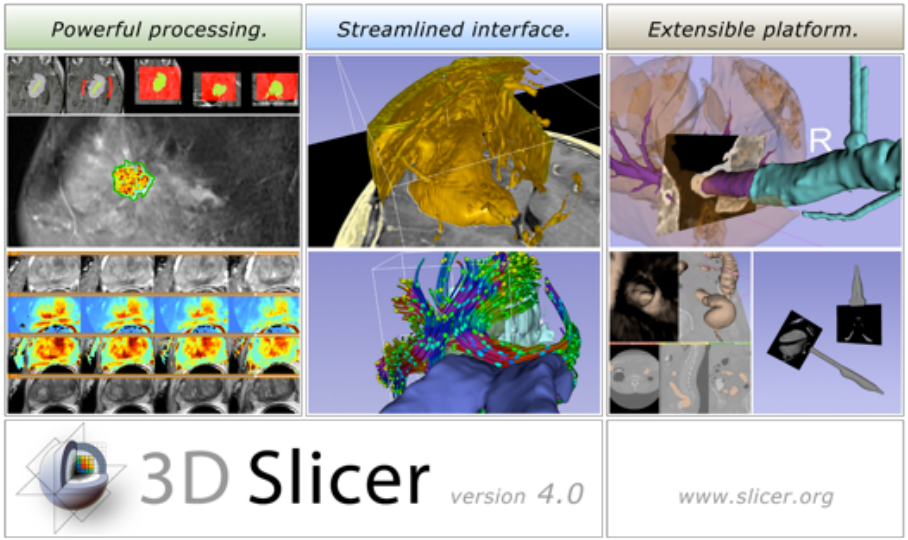
Part 3: 3D interactive exploration of the segments of the lung

3D Visualization of the Anatomy

Following this tutorial, you will be able to load and visualize volumes within Slicer4, and to interact in 3D with structural images and models of the anatomy.



3DSlicer

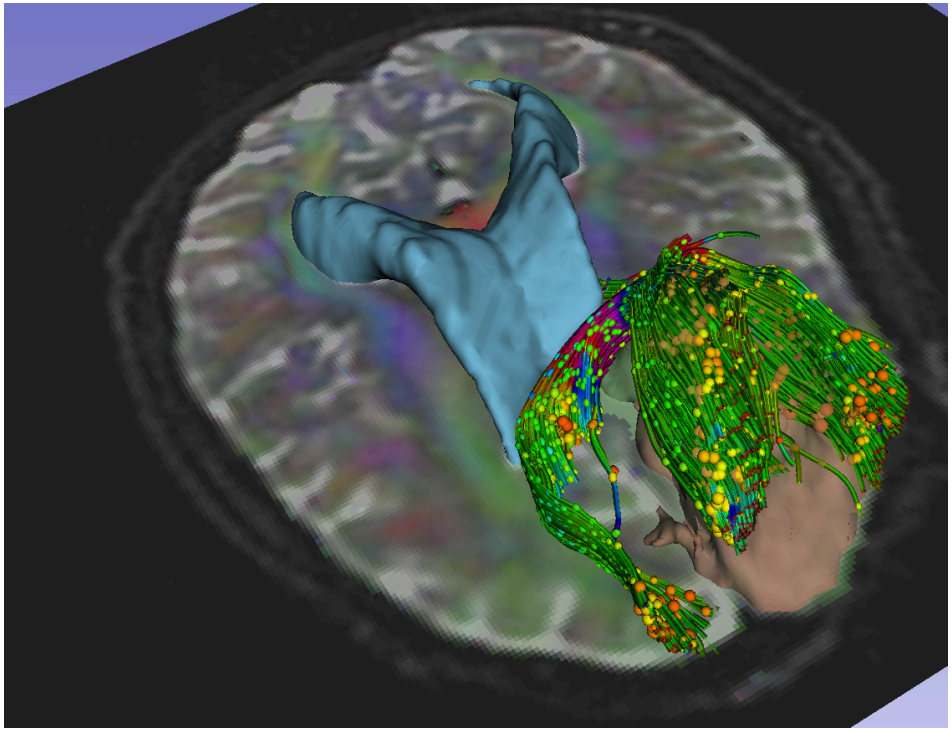


Slicer is a freely available open-source platform for segmentation, registration and 3D visualization of medical imaging data.

3DSlicer is a multi-institutional effort supported by the National Institute of Health.

3DSlicer

- An end-user application for image analysis
- An open-source environment for software development
- A software platform that is both easy to use for clinical researchers and easy to extend for programmers



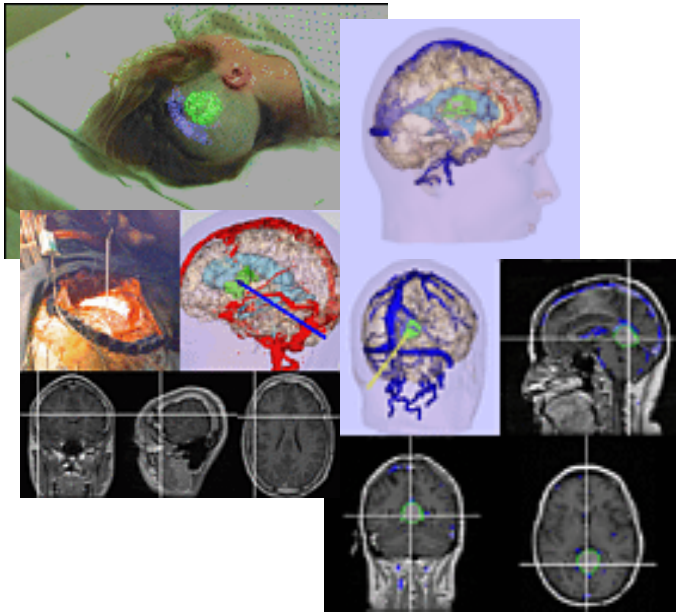
www.slicer.org

3DSlicer version 4 is a multi-platform software running on **Windows, Linux, and Mac OSX**.

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. **Slicer is a tool for research, and is not FDA approved.**

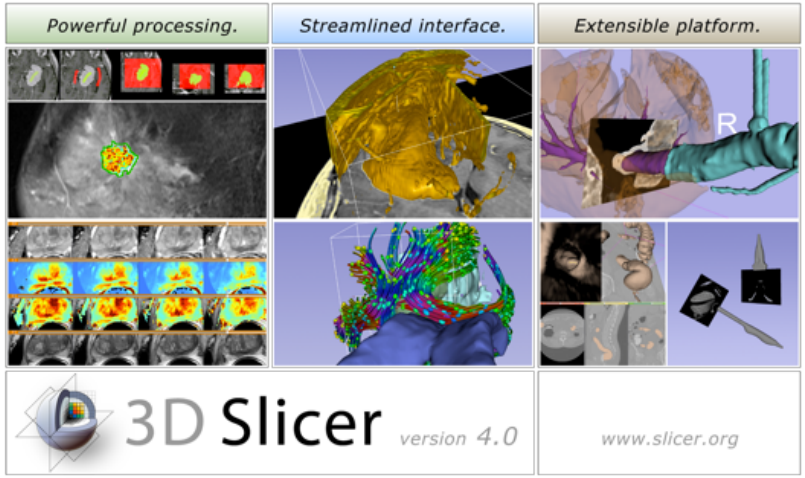
3DSlicer History



- 1997: Slicer started as a research project between the Surgical Planning Lab (Harvard) and the CSAIL (MIT)

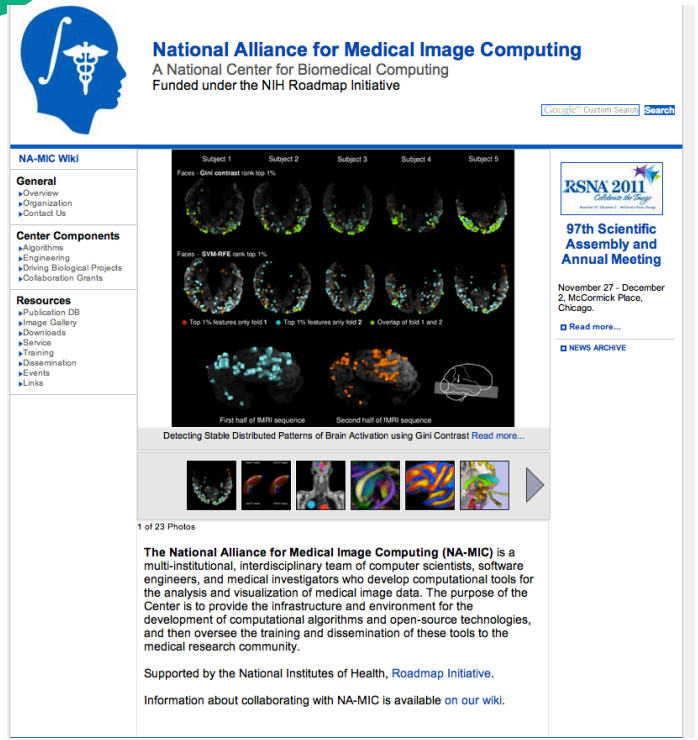
Image Courtesy of the CSAIL, MIT

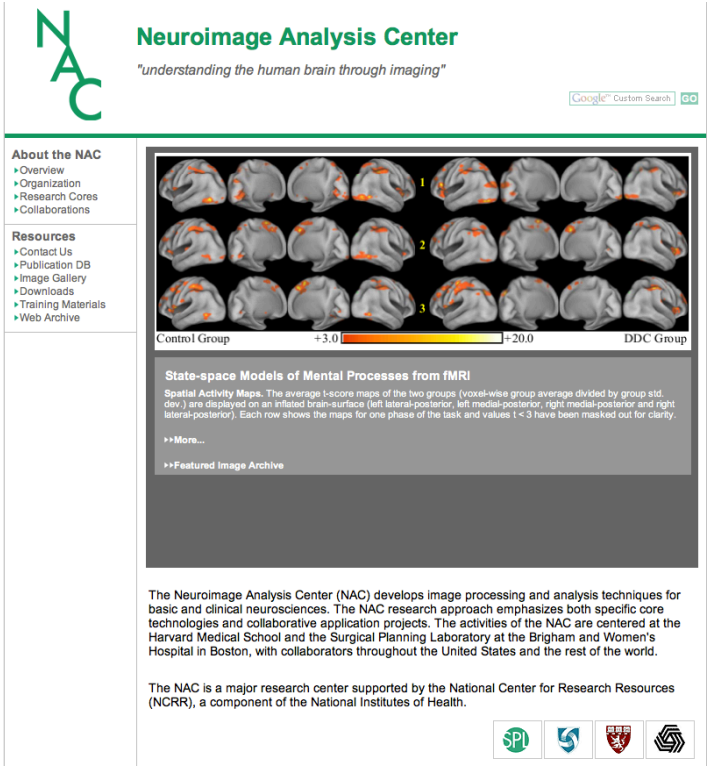
3DSlicer History



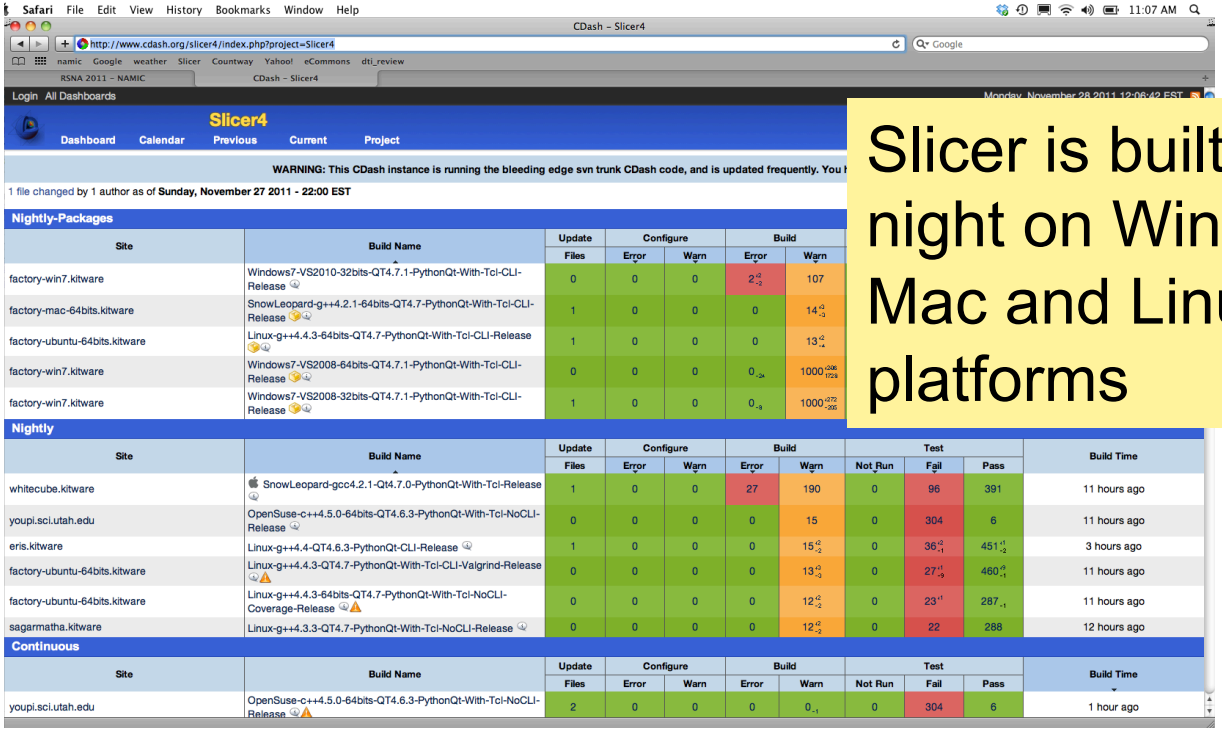
- 1997: Slicer started as a research project between the Surgical Planning Lab (Harvard) and the CSAIL (MIT)
- 2011: Multi-institution effort to share the latest advances in image analysis with clinicians and scientists

NA-MIC and NAC



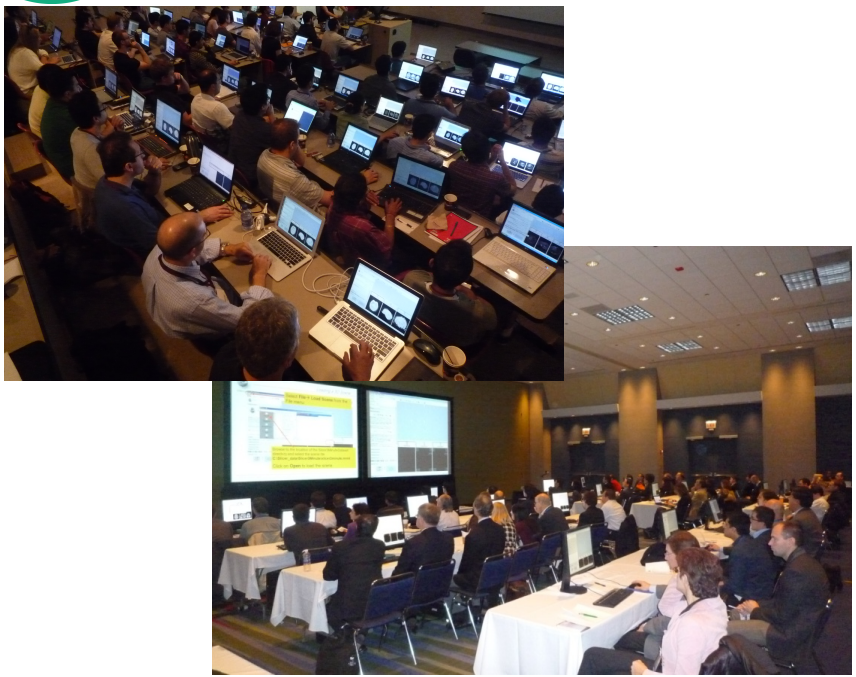


Slicer: Behind the scenes



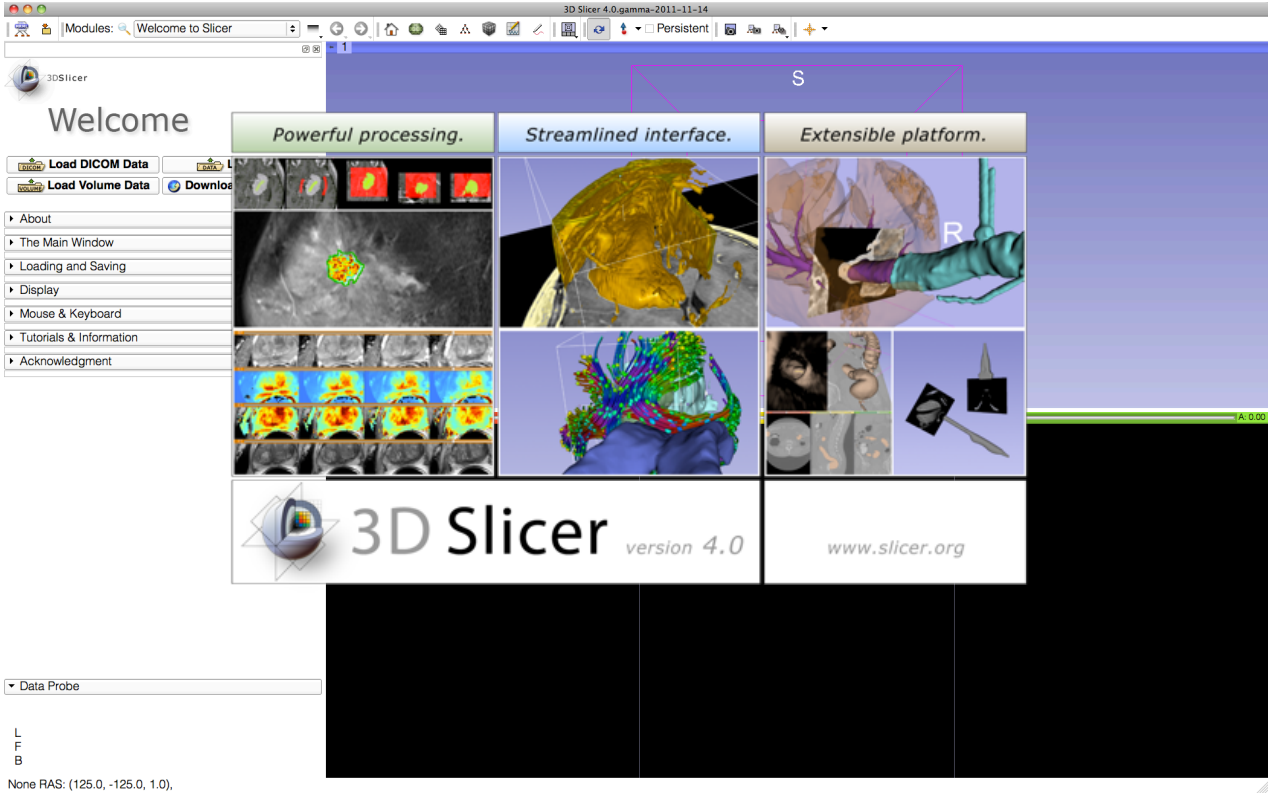
Slicer is built every night on Windows, Mac and Linux platforms

Slicer Training

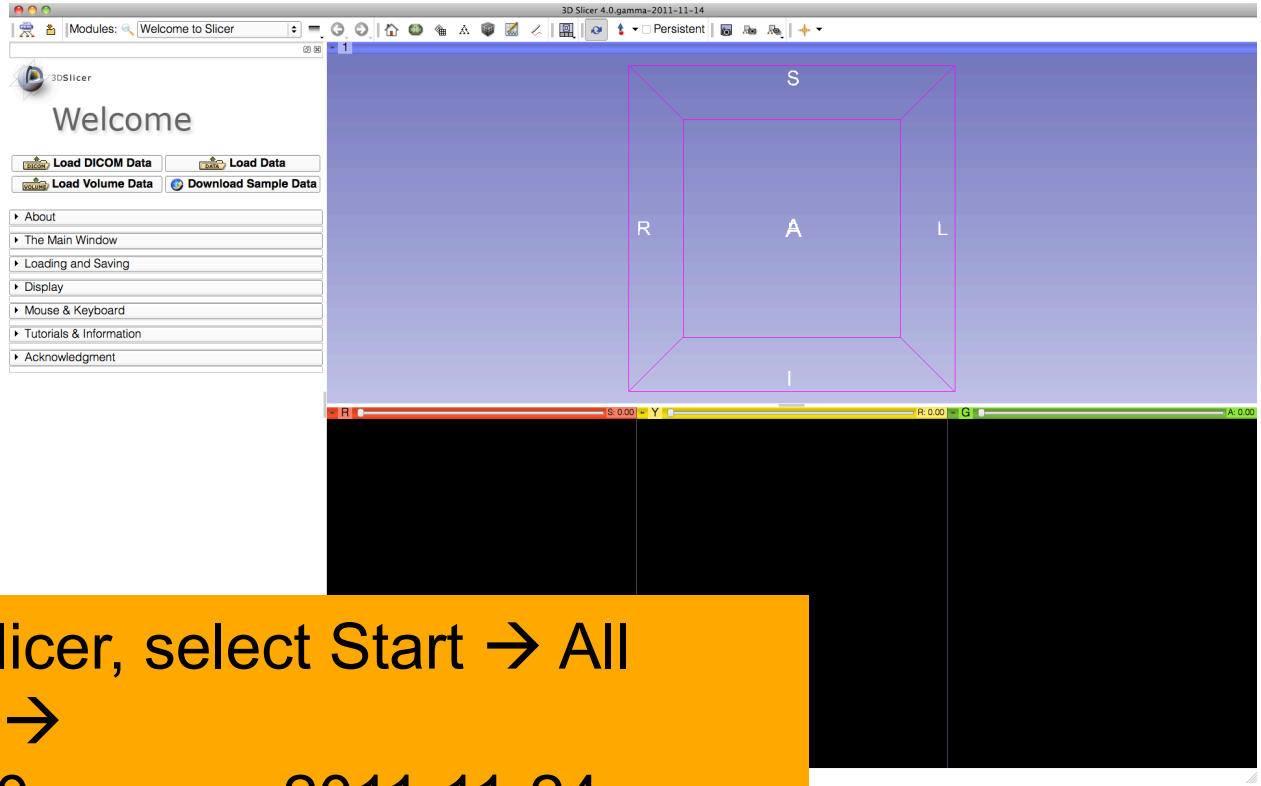


- Hands-on training workshops at national and international venues
- >1,700 clinicians, clinical researchers and scientists trained since 2005

3DSlicer version 4.0

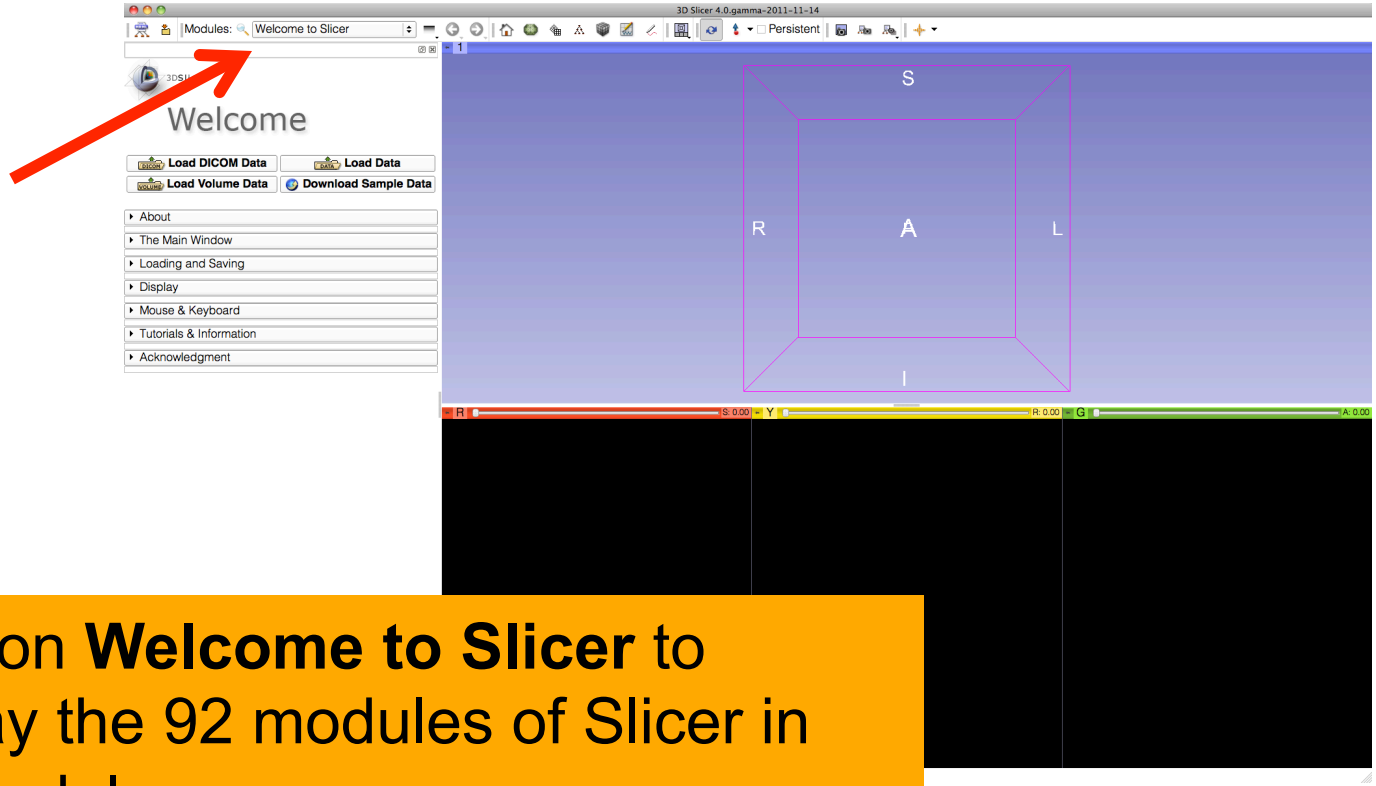


Welcome to Slicer4



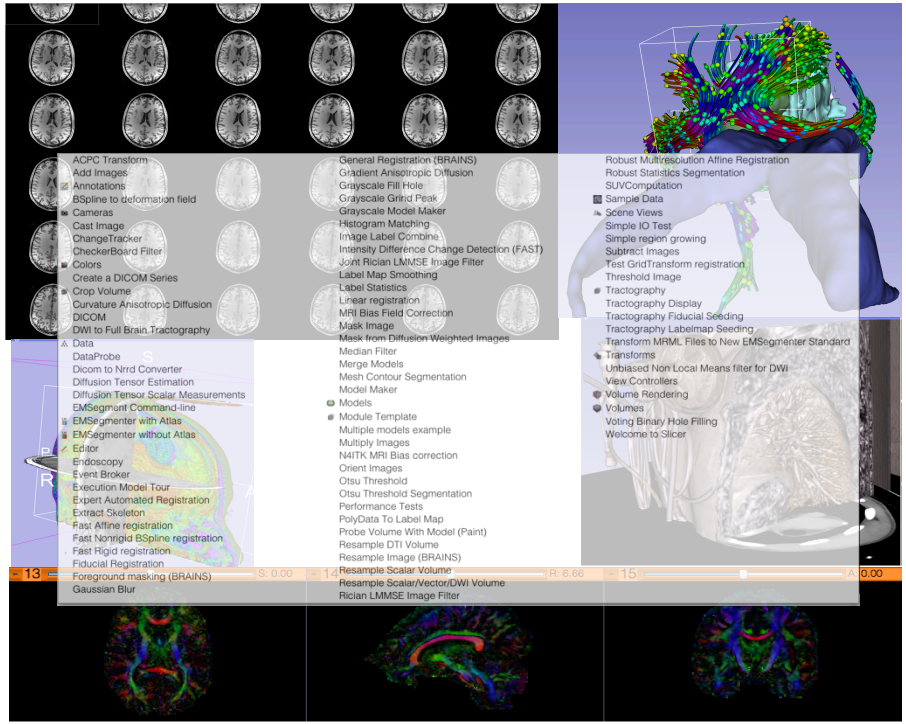
To start Slicer, select Start → All Programs→ Slicer4-4.0.gamma-2011-11-24

Welcome to Slicer4



Click on **Welcome to Slicer** to display the 92 modules of Slicer in the Modules menu

Welcome to Slicer4

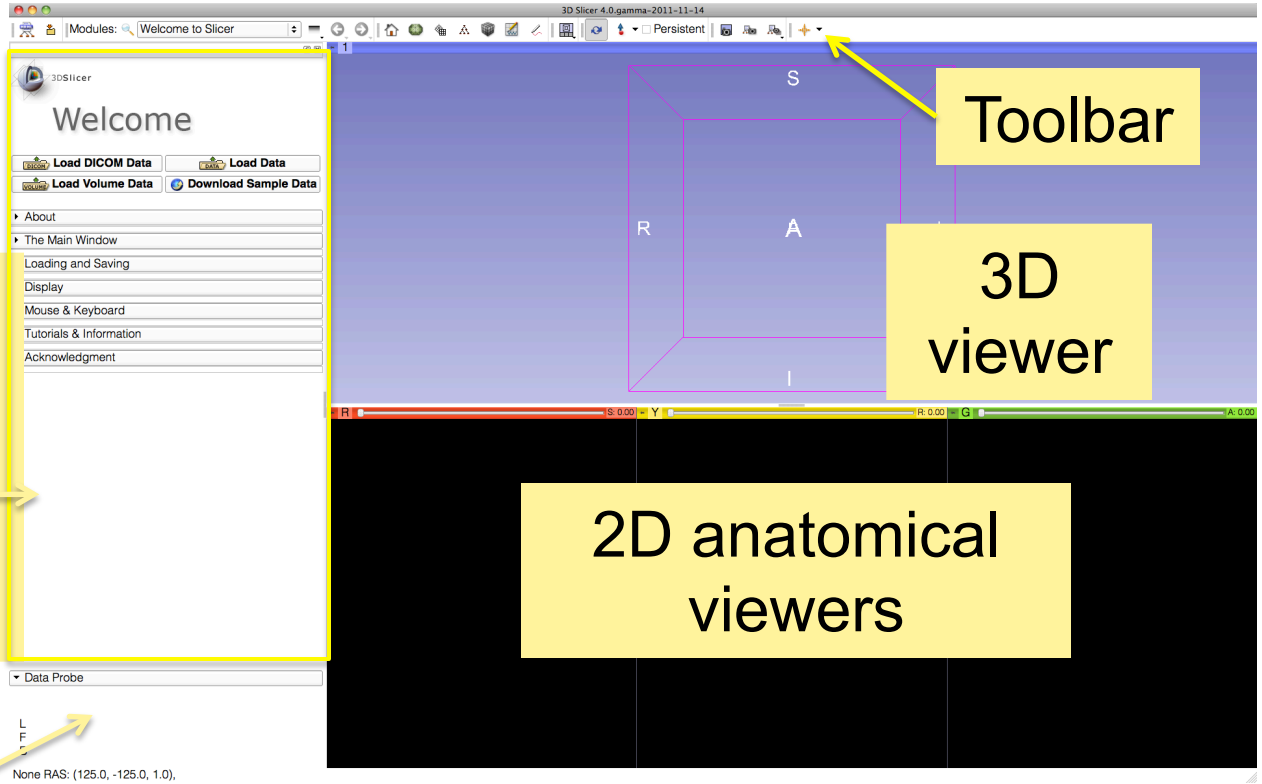


Slicer4 contains more than 90 modules for image segmentation, registration and 3D visualization of medical imaging data

Slicer User Interface

Main Menu

GUI panel of the Slicer Welcome Module



Data Probe

PART 1: LOADING A DICOM VOLUME

The DICOM 3.0 File Format

Radiological imaging equipment produce images in DICOM file format ('.dcm files')

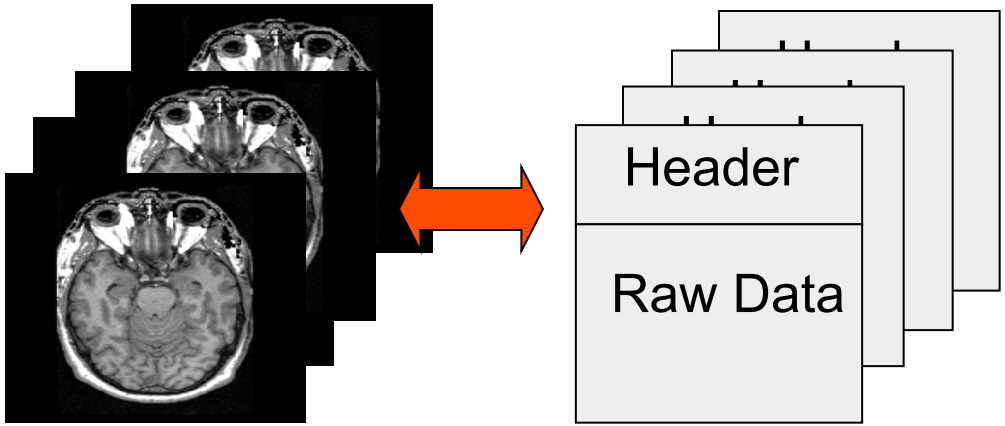


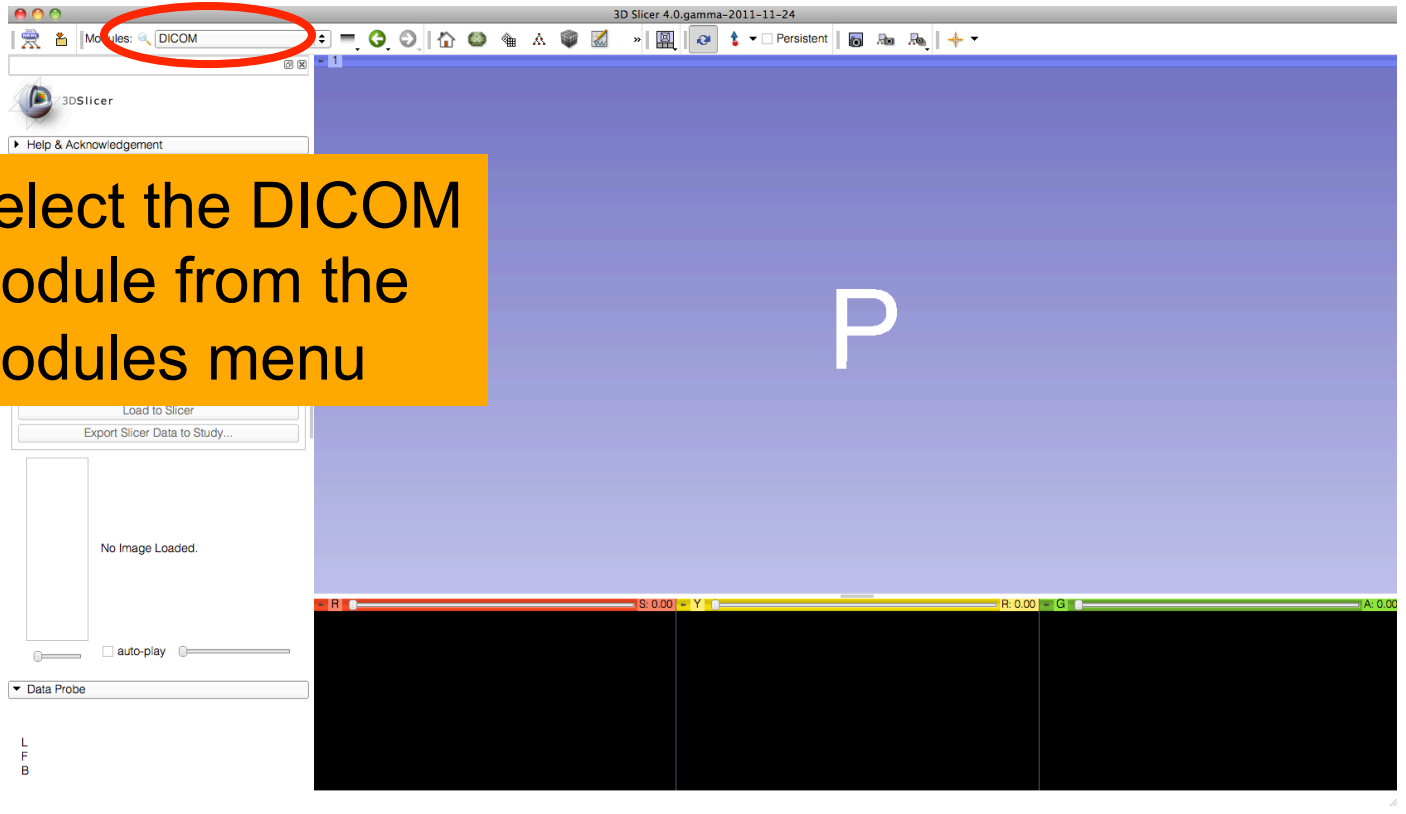
Image001.dcm

Image002.dcm

Image003.dcm

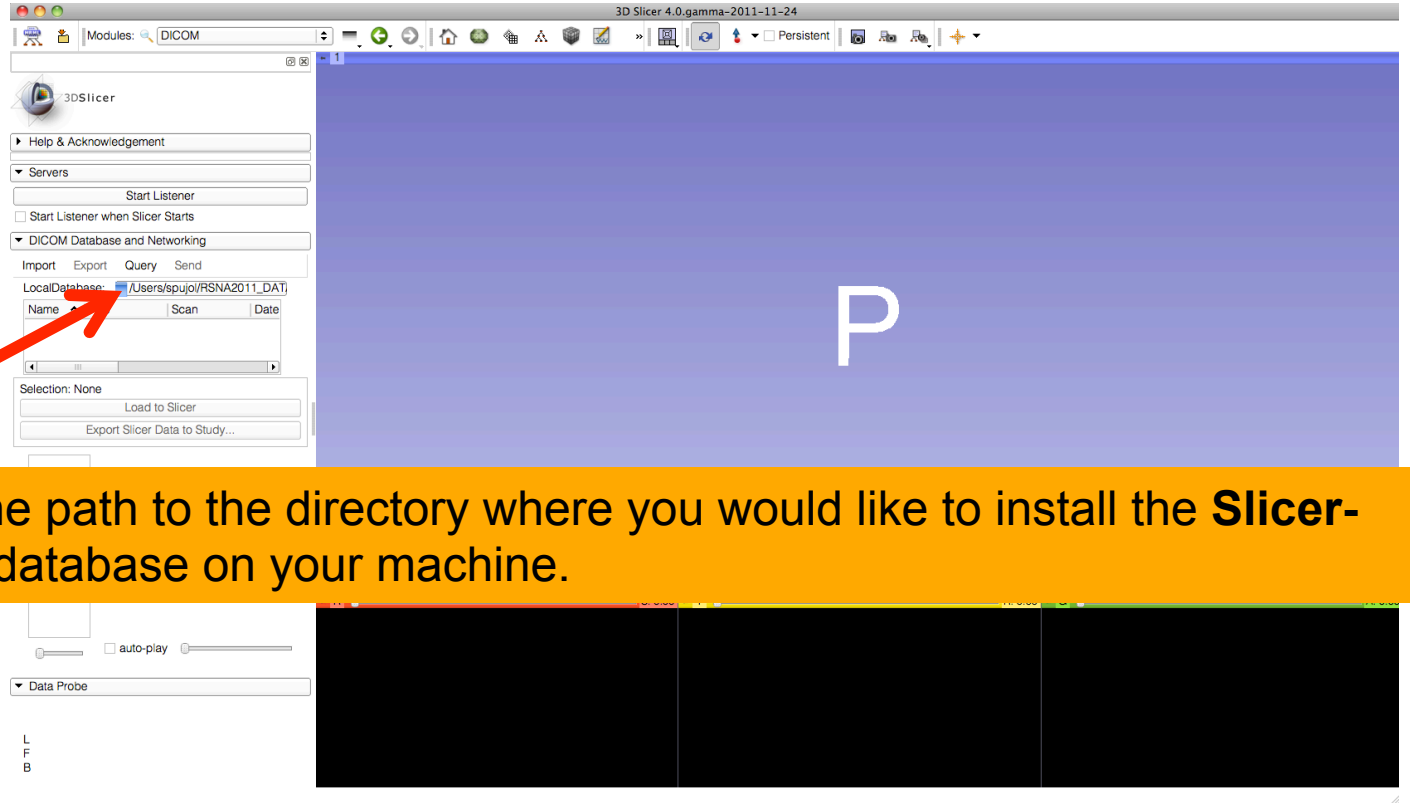
....

DICOM Module



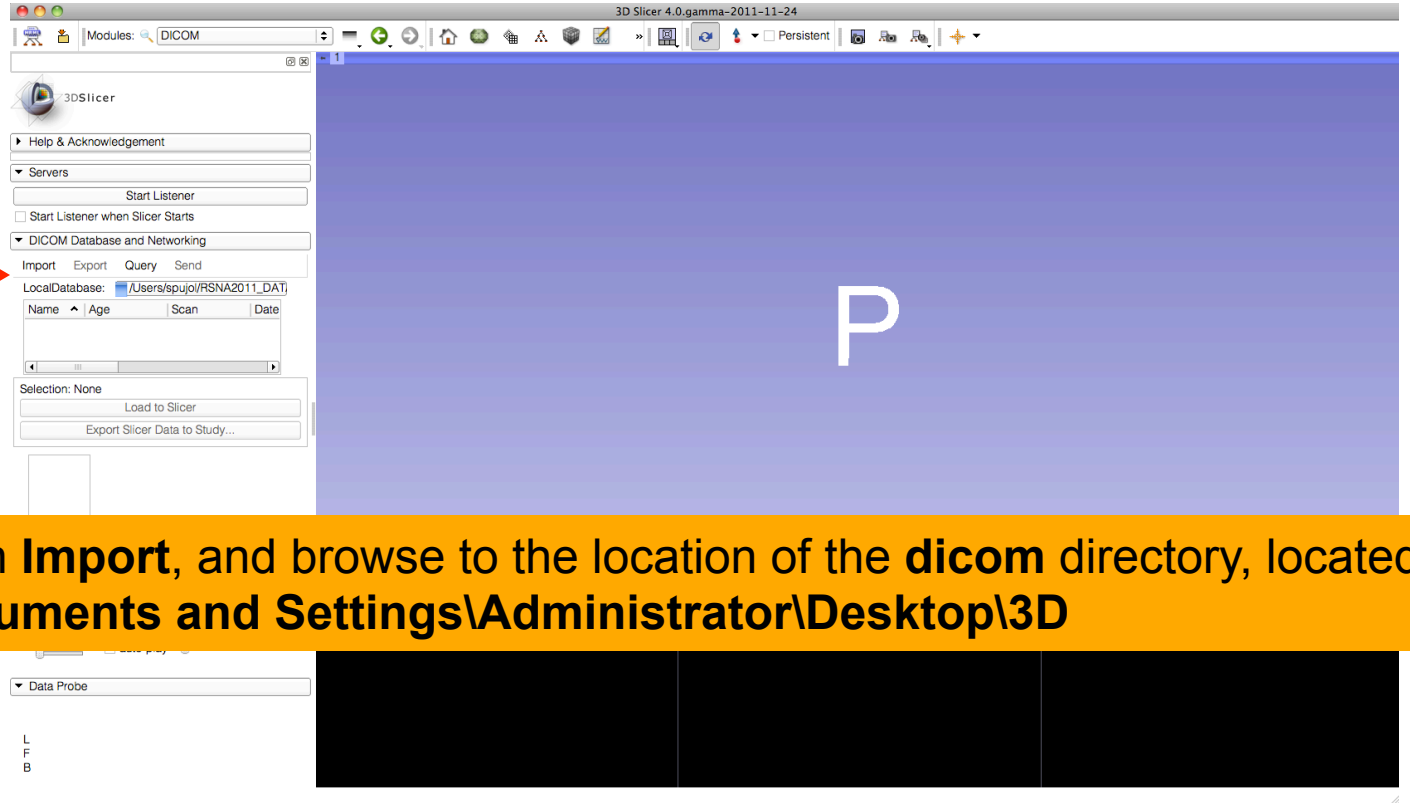
Select the DICOM module from the Modules menu

DICOM module



Enter the path to the directory where you would like to install the **Slicer-dicom** database on your machine.

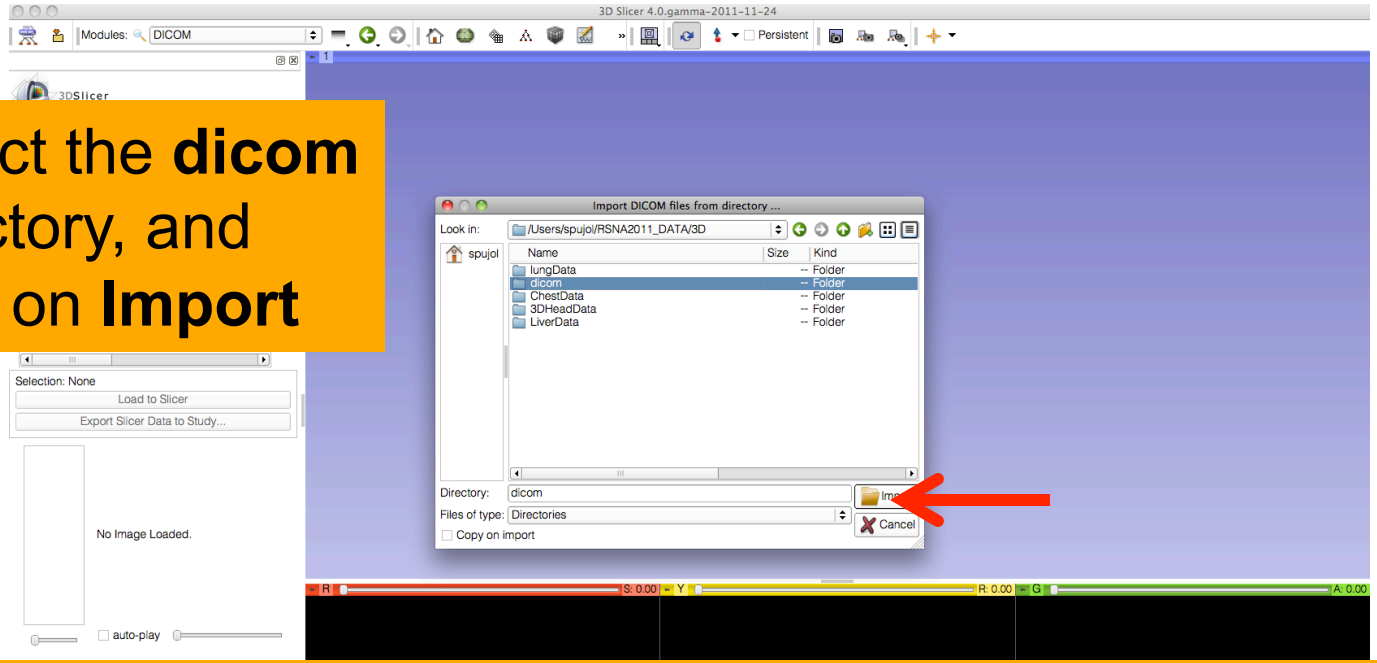
DICOM module



Click on **Import**, and browse to the location of the **dicom** directory, located in **C:\Documents and Settings\Administrator\Desktop\3D**

DICOM module

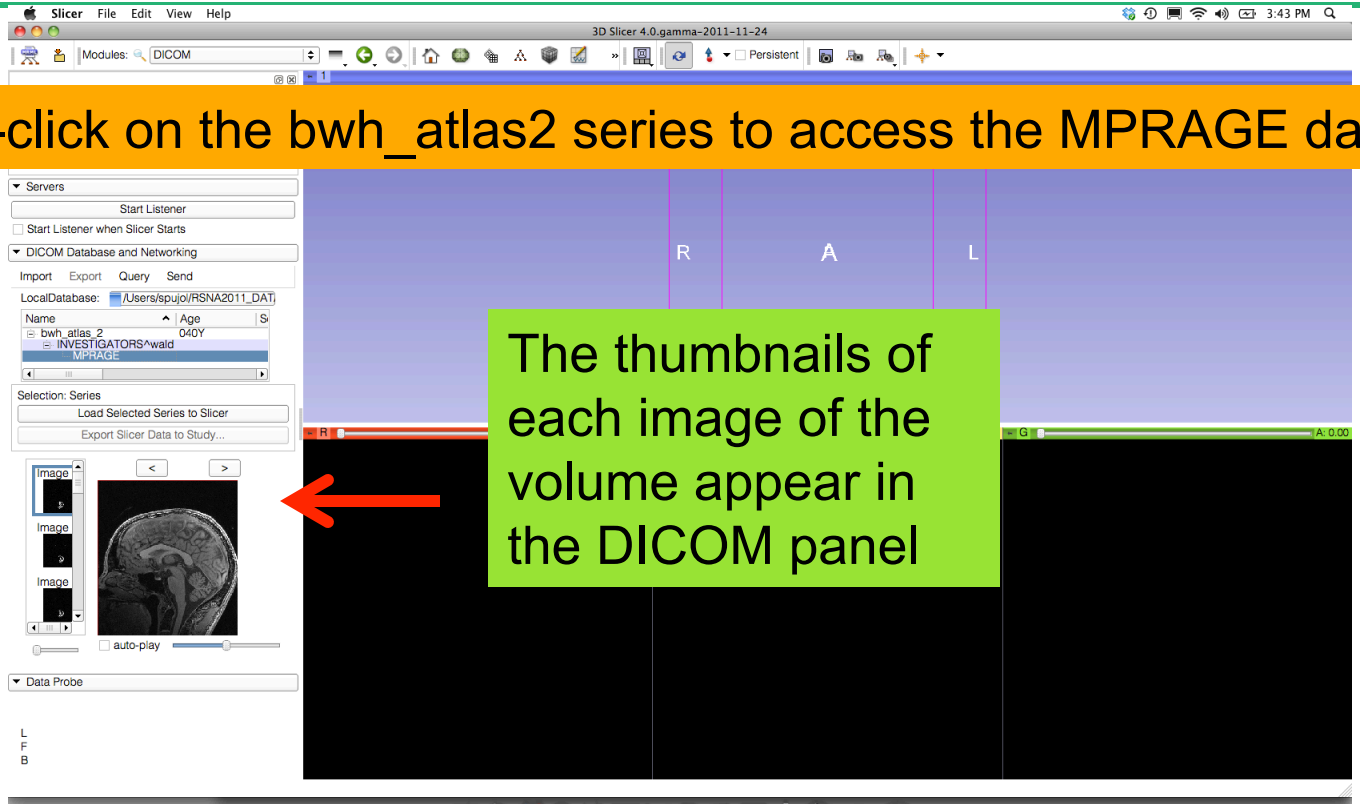
Select the **dicom** directory, and click on **Import**



Note: Loading the dicom dataset in the database may take a few minutes.

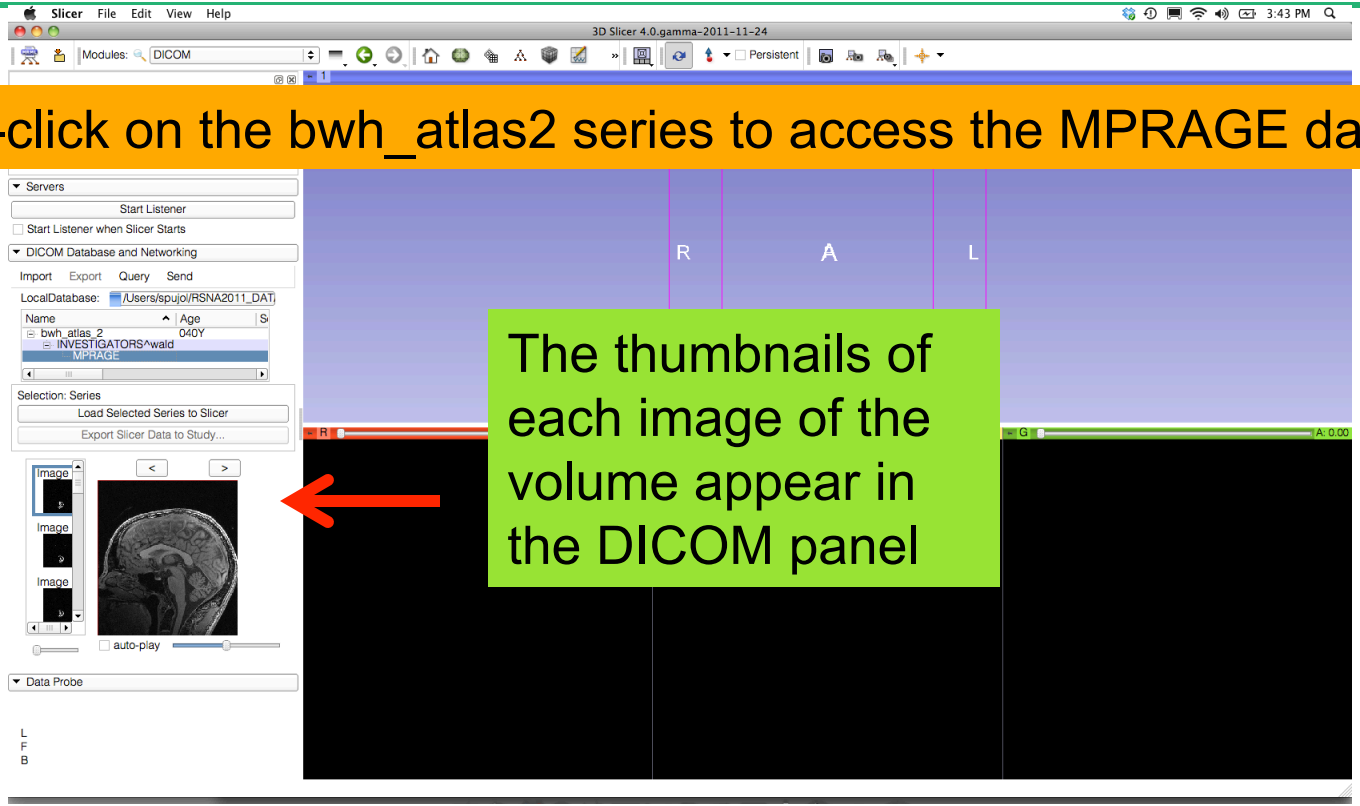
DICOM module

Double-click on the bwh_atlas2 series to access the MPRAGE dataset.

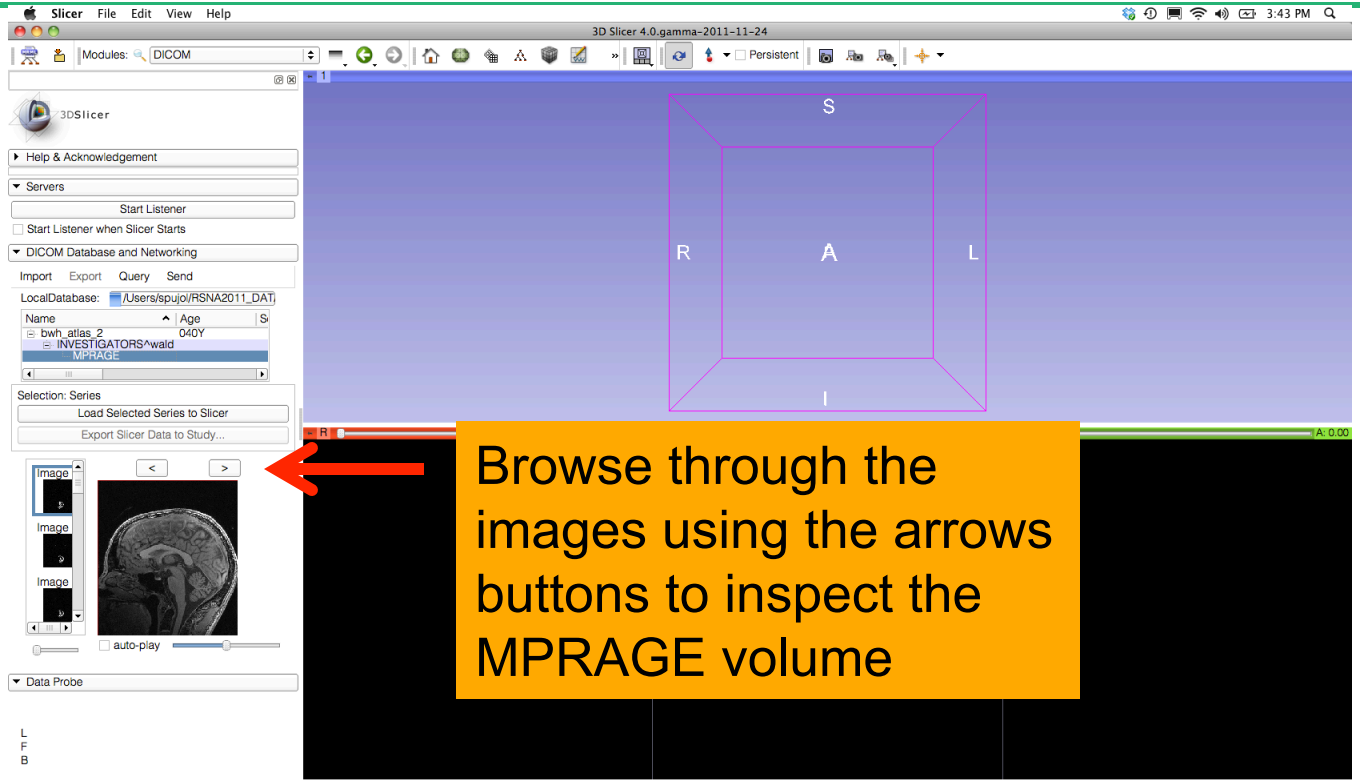


DICOM module

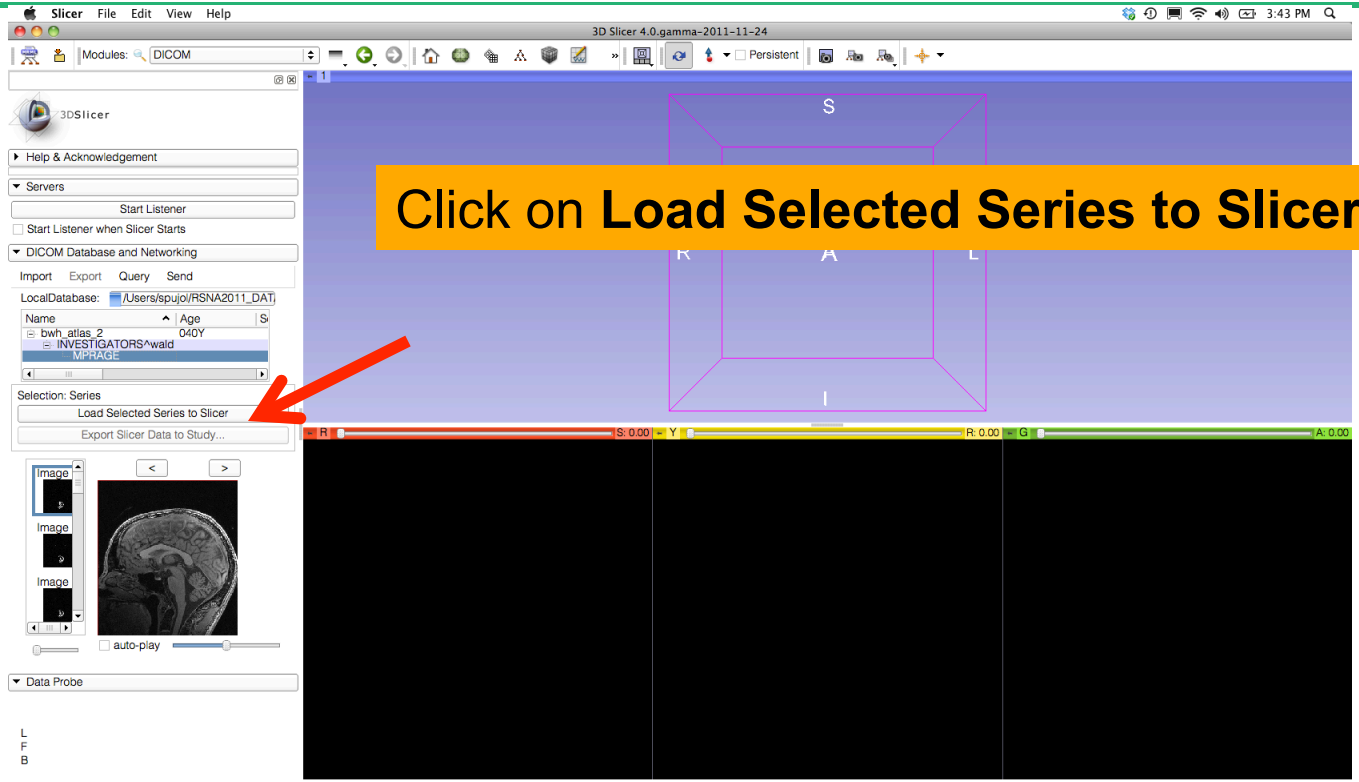
Double-click on the bwh_atlas2 series to access the MPRAGE dataset.



DICOM module

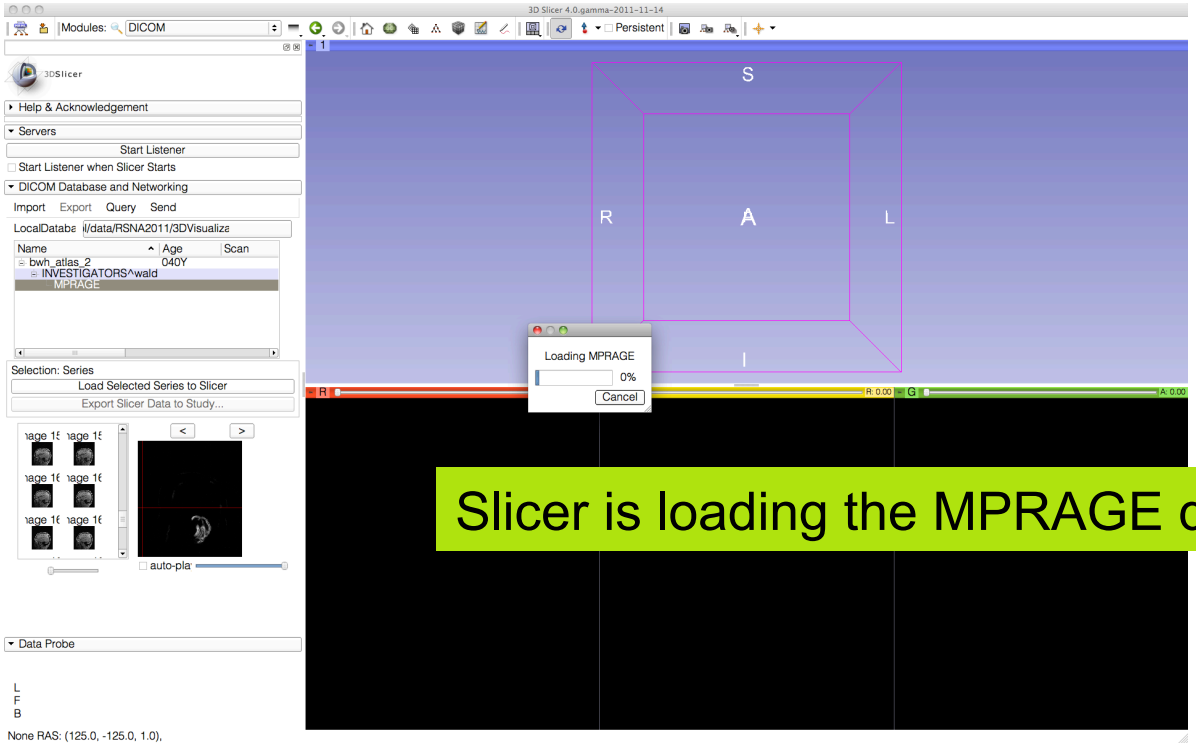


DICOM module



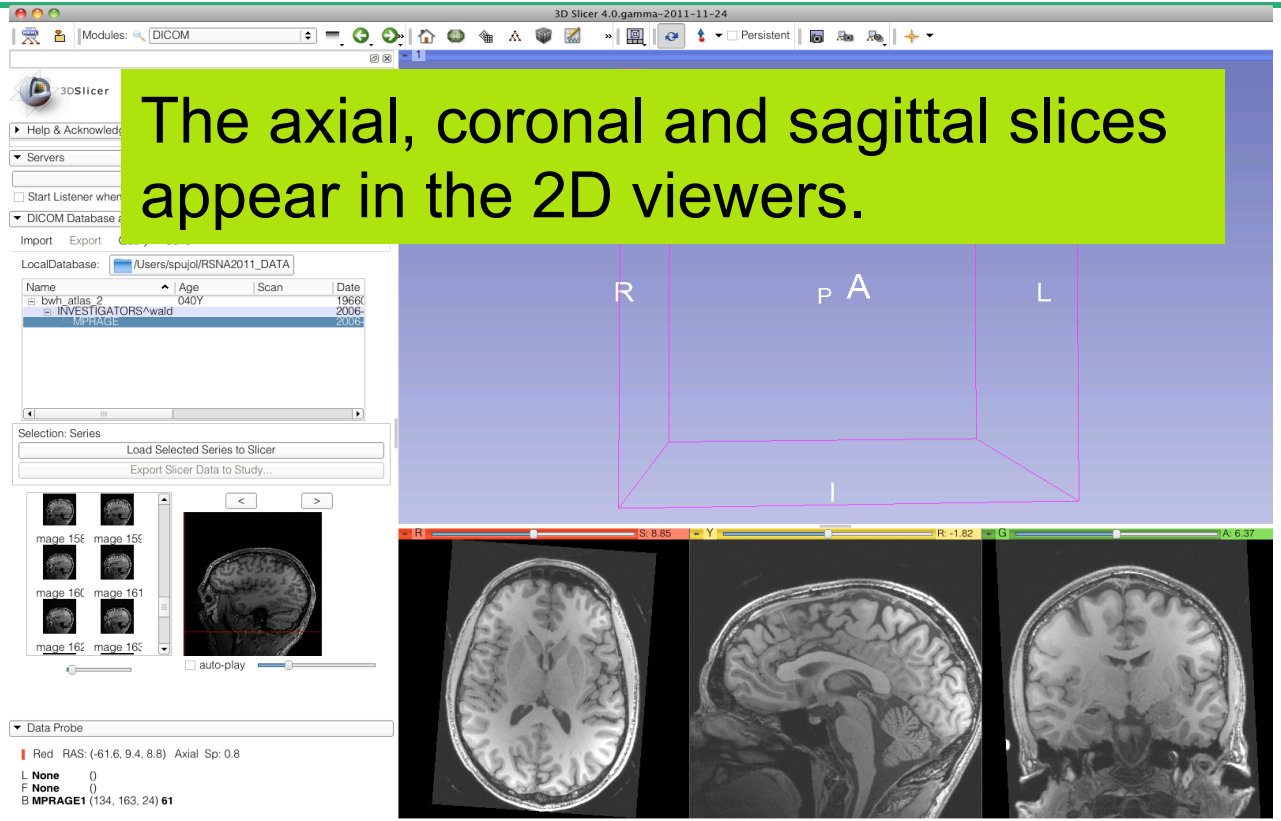
Click on **Load Selected Series to Slicer**

DICOM module



Slicer is loading the MPRAGE dataset

DICOM module



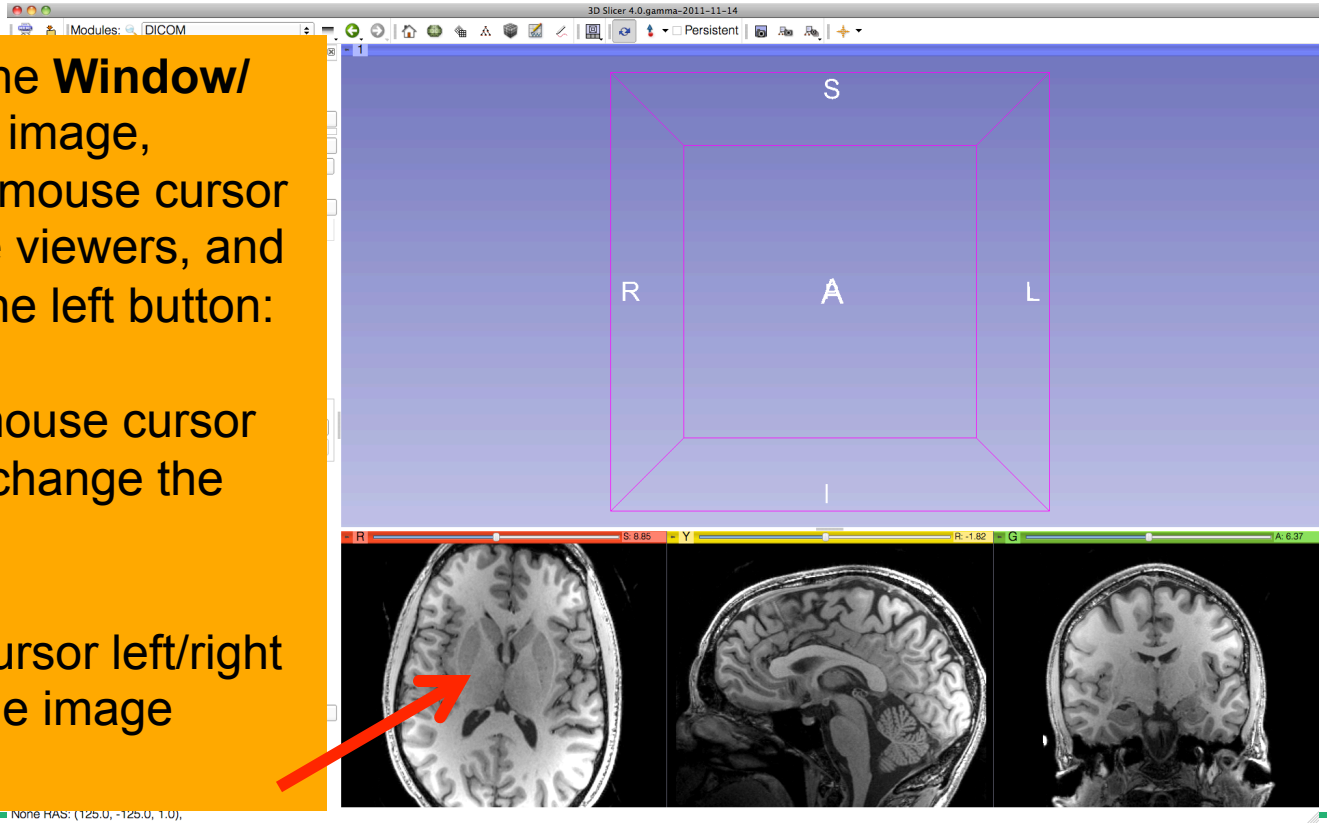
The axial, coronal and sagittal slices appear in the 2D viewers.

Window/Level

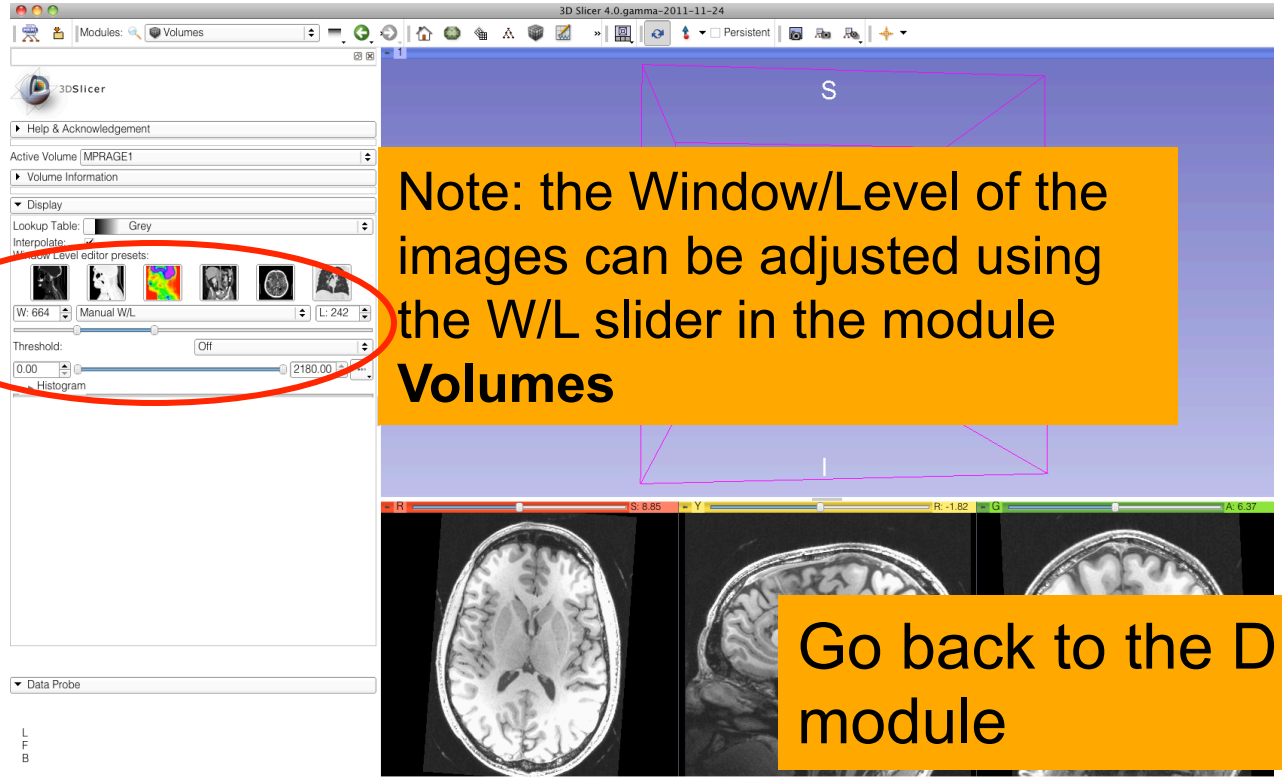
To change the **Window/ Level** of the image, position the mouse cursor in one of the viewers, and hold down the left button:

-Move the mouse cursor up/down to change the image level

-Move the cursor left/right to change the image window



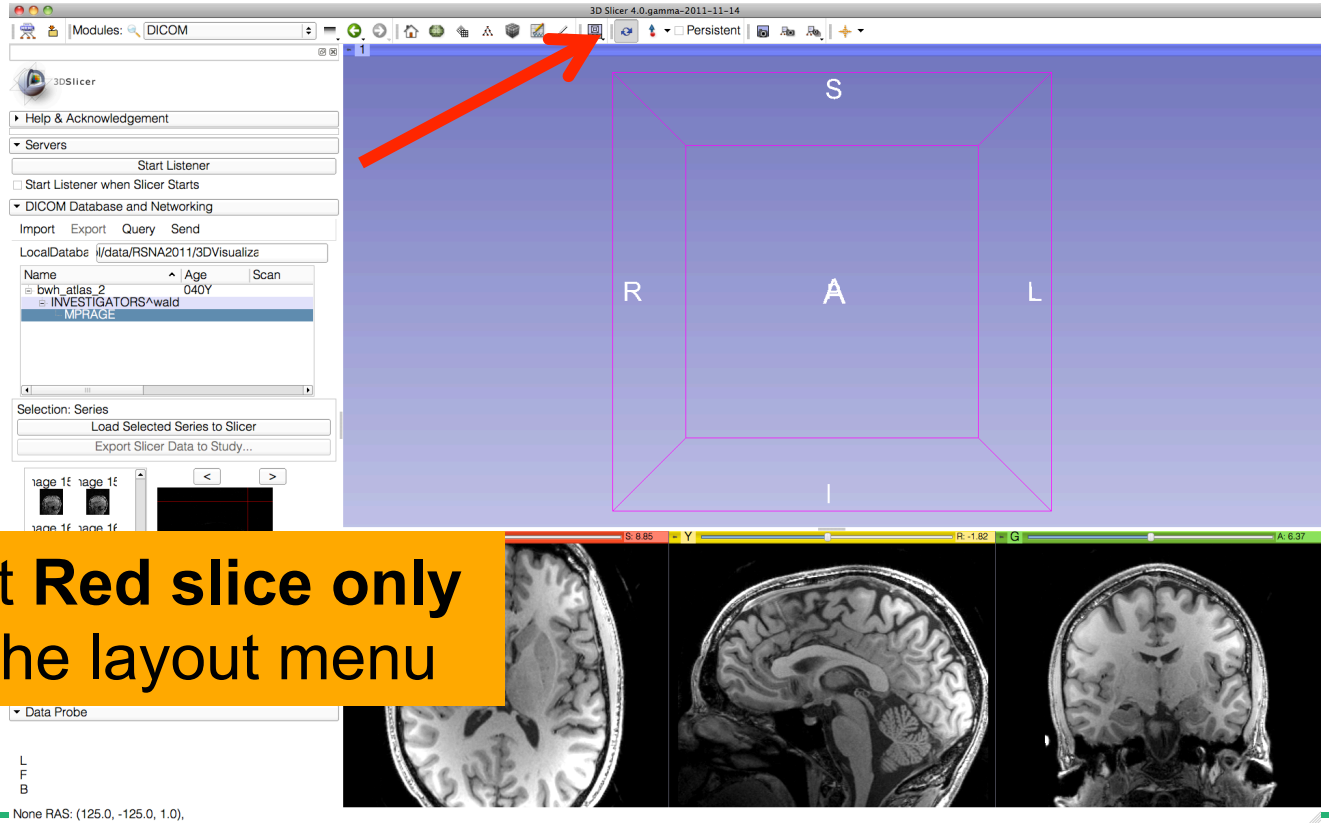
Window/Level



Note: the Window/Level of the images can be adjusted using the W/L slider in the module **Volumes**

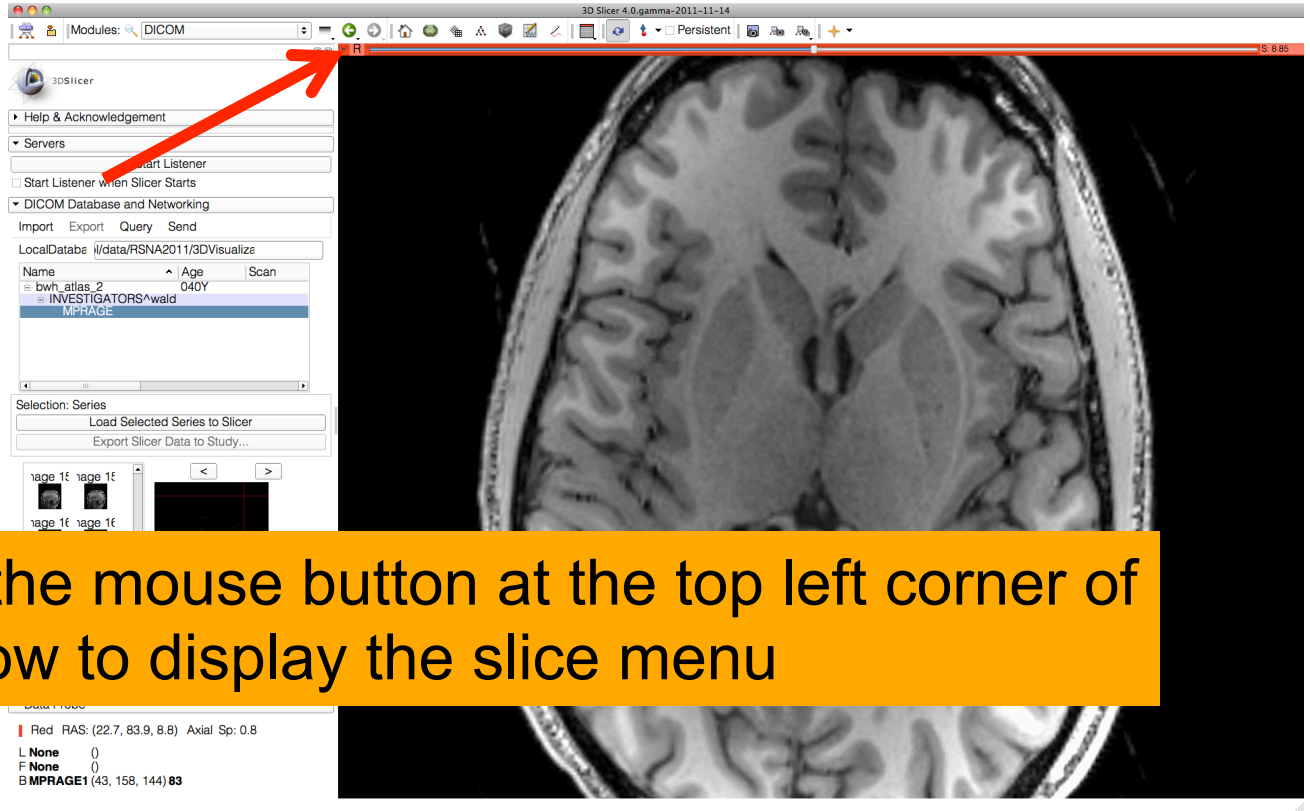
Go back to the DICOM module

DICOM module



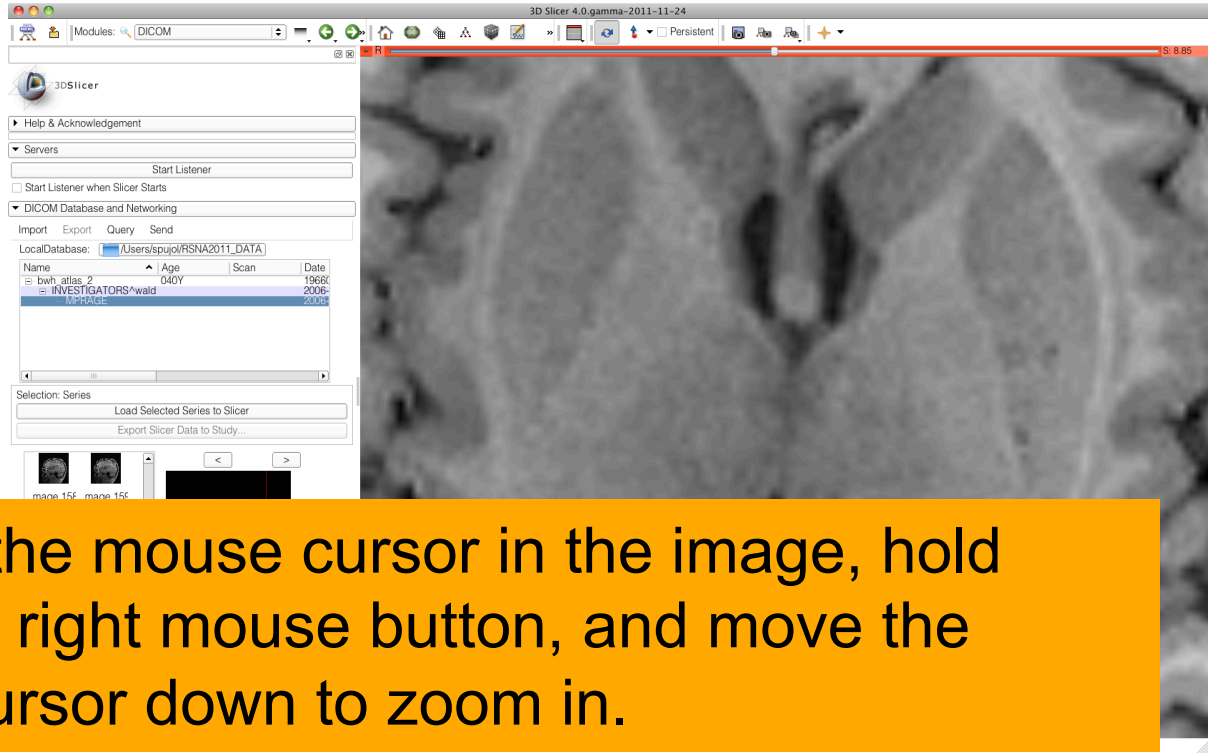
Select **Red slice only** from the layout menu

DICOM module



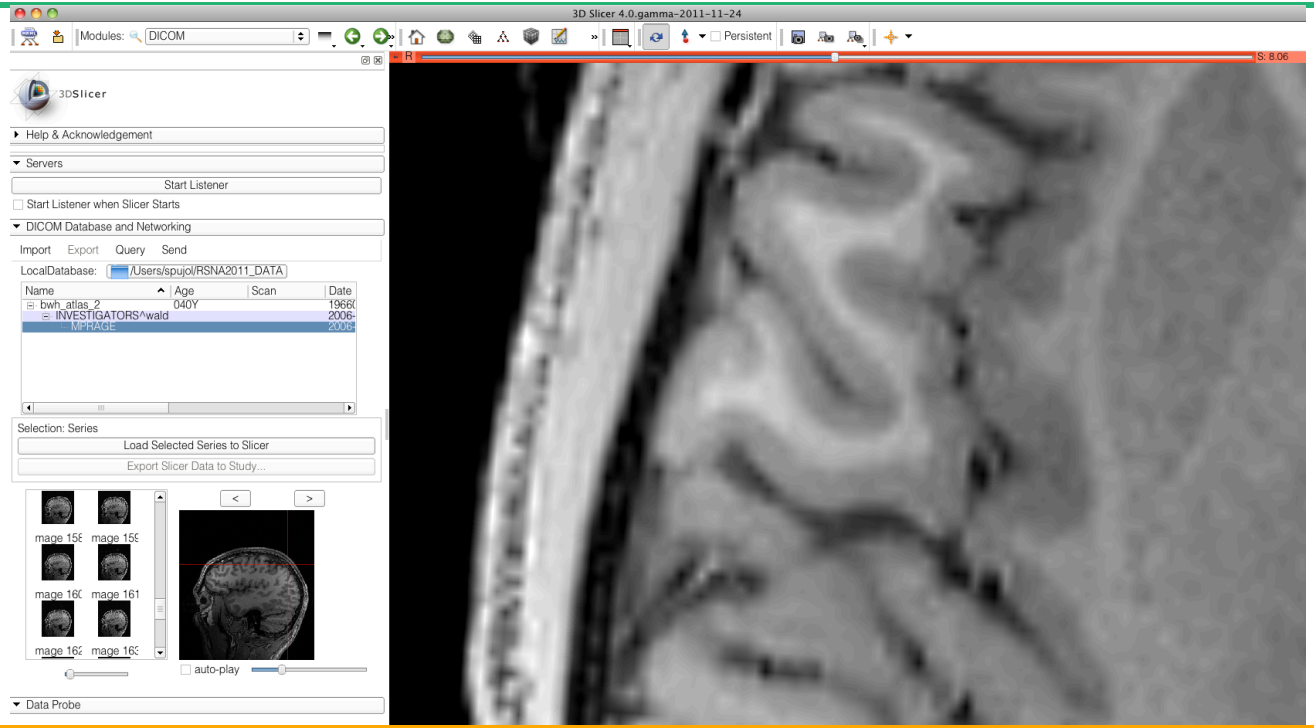
Position the mouse button at the top left corner of the window to display the slice menu

DICOM module



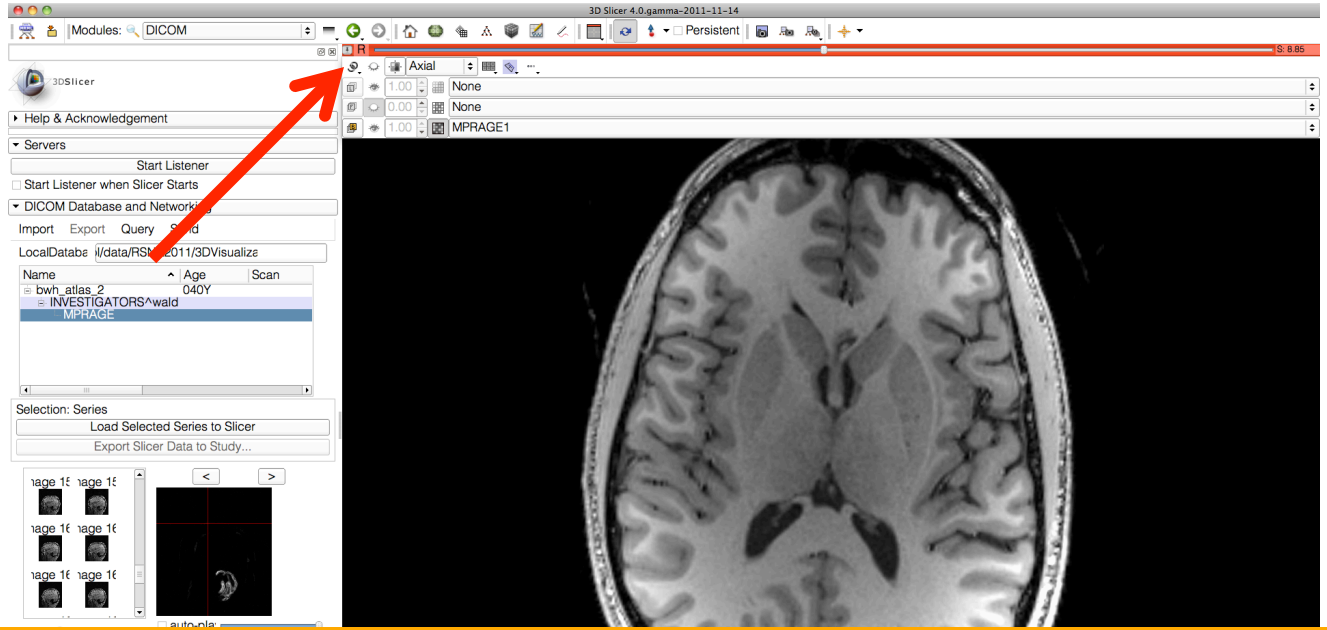
Position the mouse cursor in the image, hold down the right mouse button, and move the mouse cursor down to zoom in.

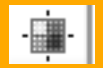
DICOM module



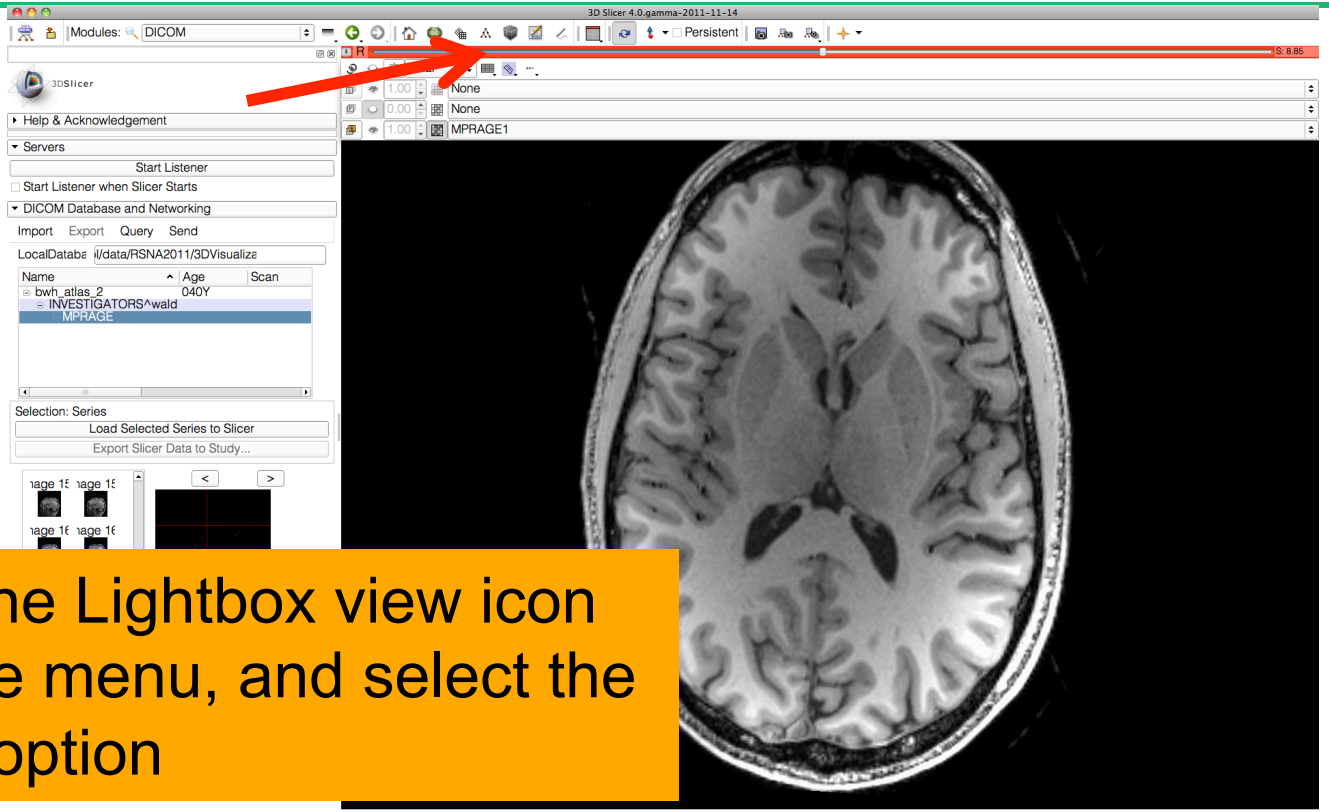
Hold down the middle mouse button and move the mouse cursor to explore a different part of the image.

DICOM module



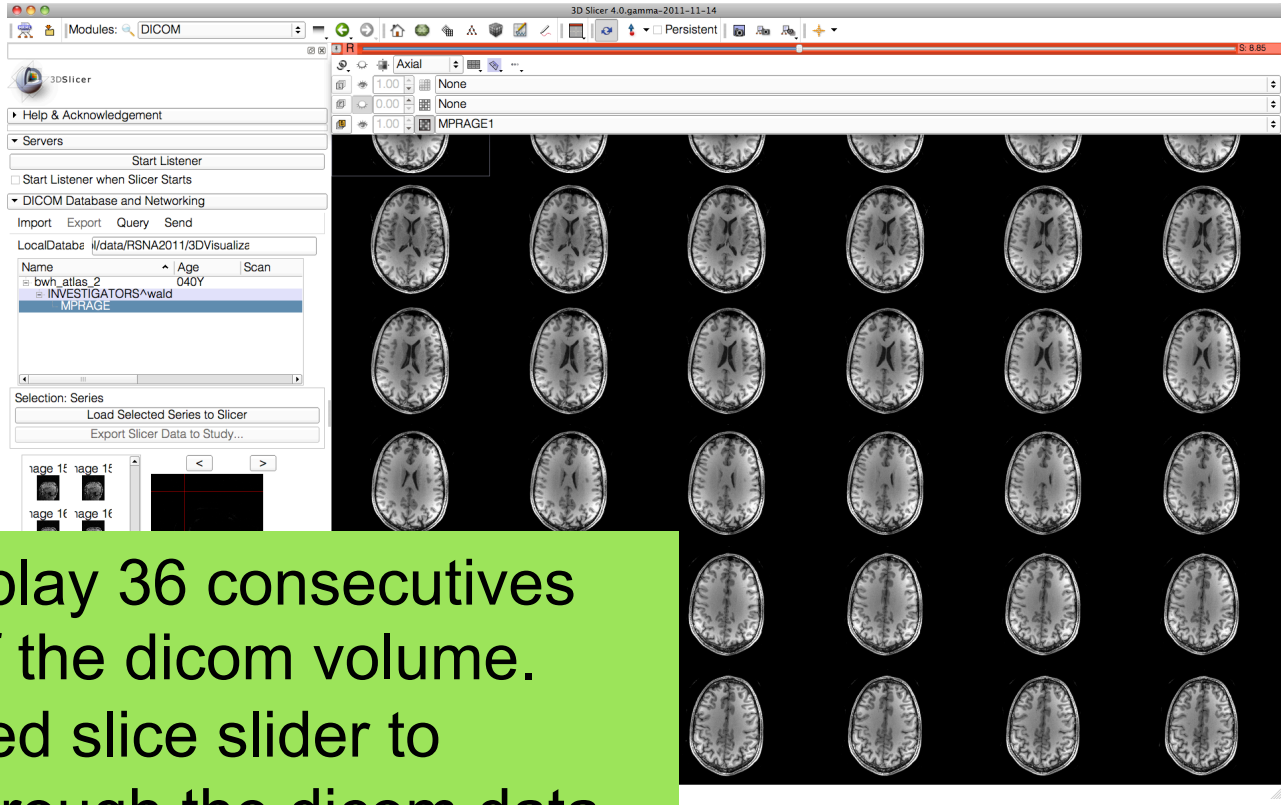
Position the mouse on the top left corner of the image to display the slide menu, and click on the  icon to re-center the image and adjust the view to the size of the window

DICOM module



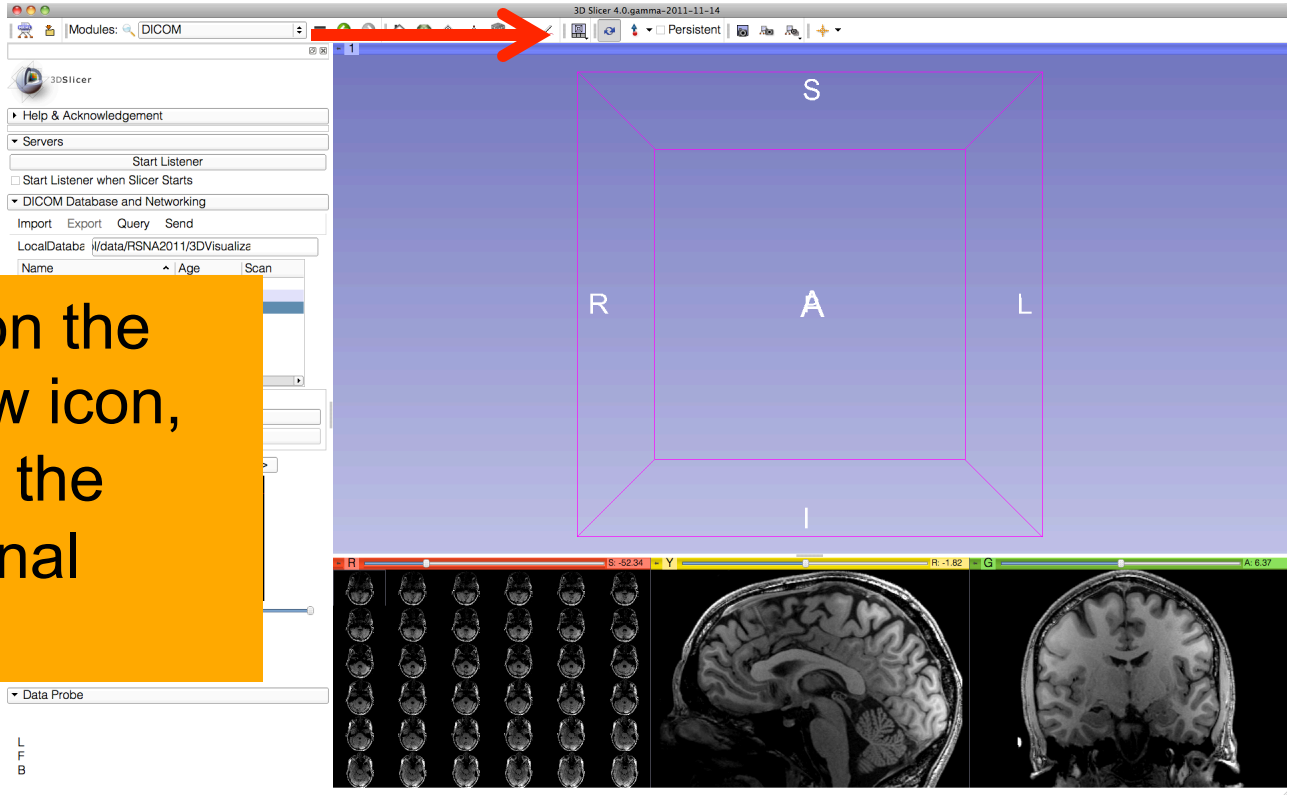
Click on the Lightbox view icon in the slice menu, and select the 6x6 view option

DICOM module



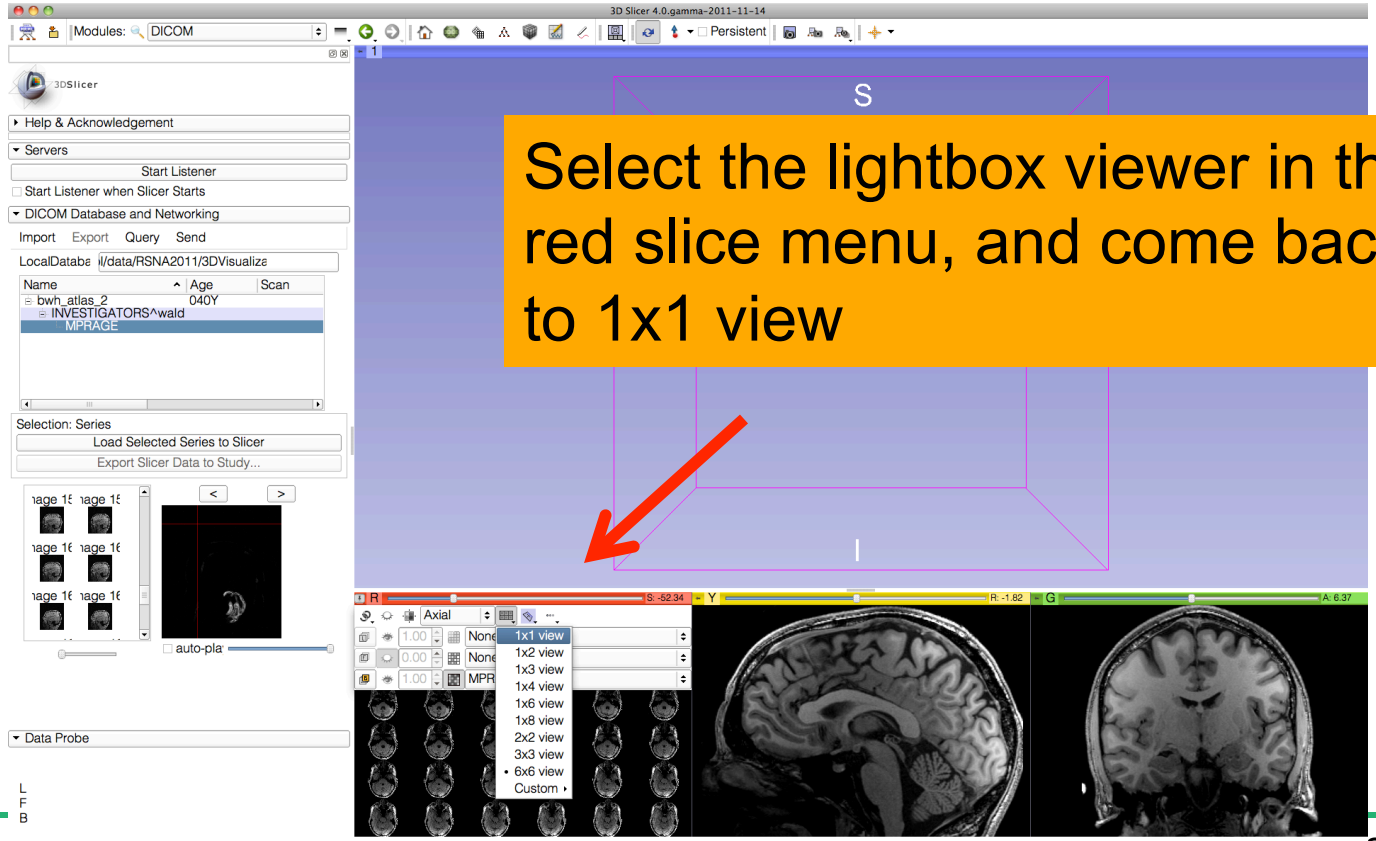
Slicer display 36 consecutives images of the dicom volume. Use the red slice slider to browse through the dicom data

DICOM module

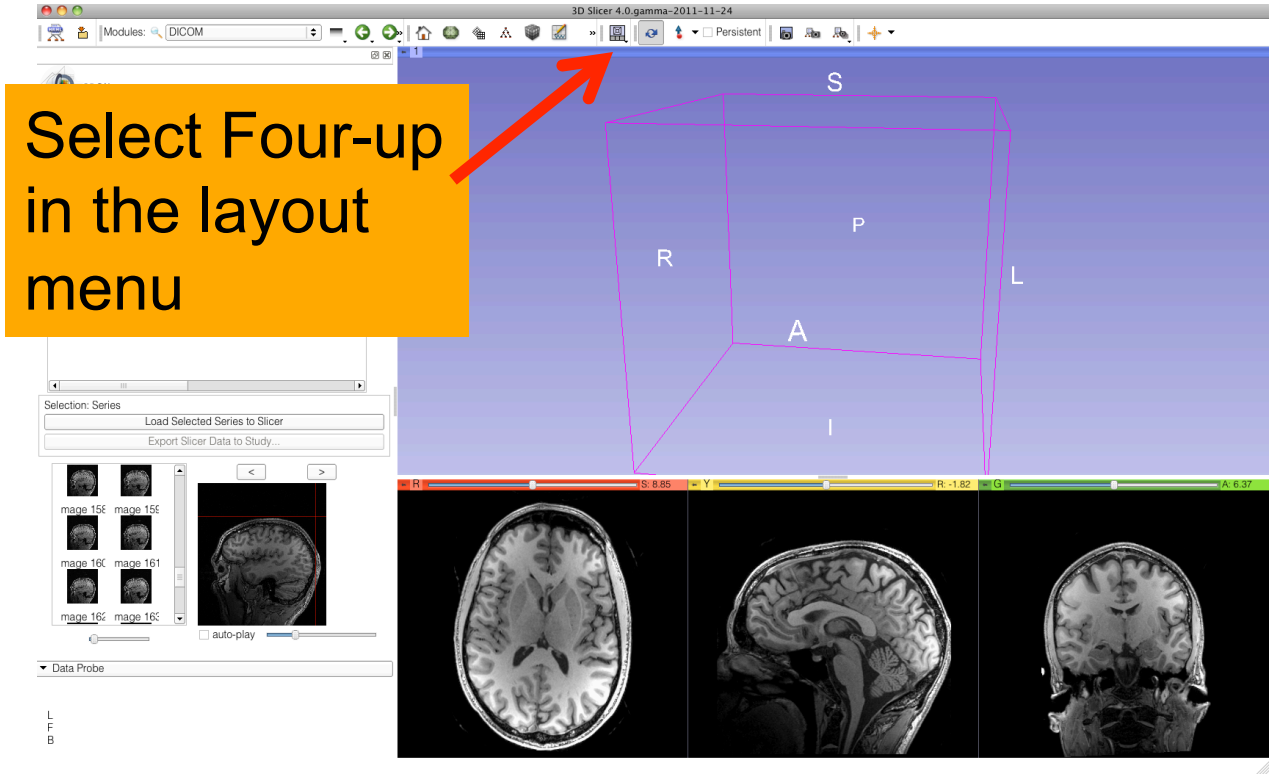


Left click on the red window icon, and select the Conventional layout

DICOM module

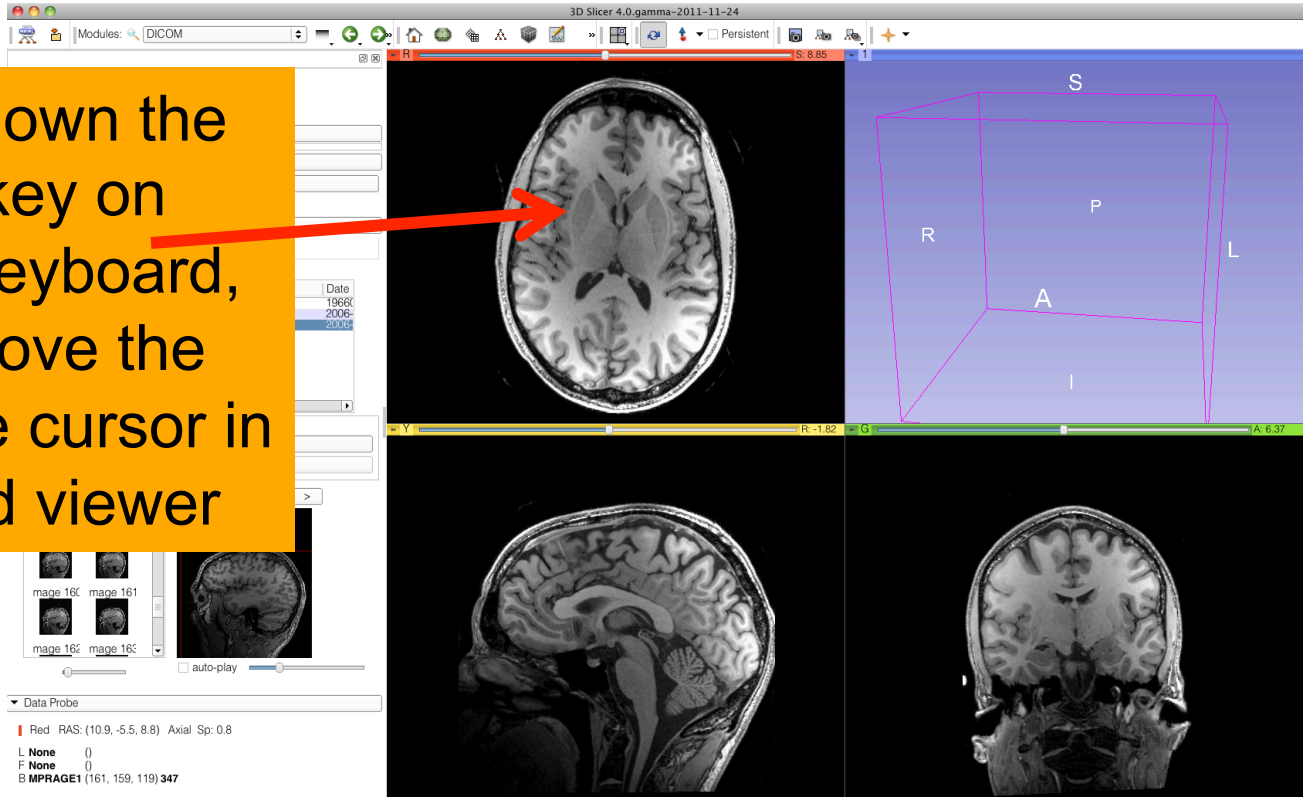


DICOM module



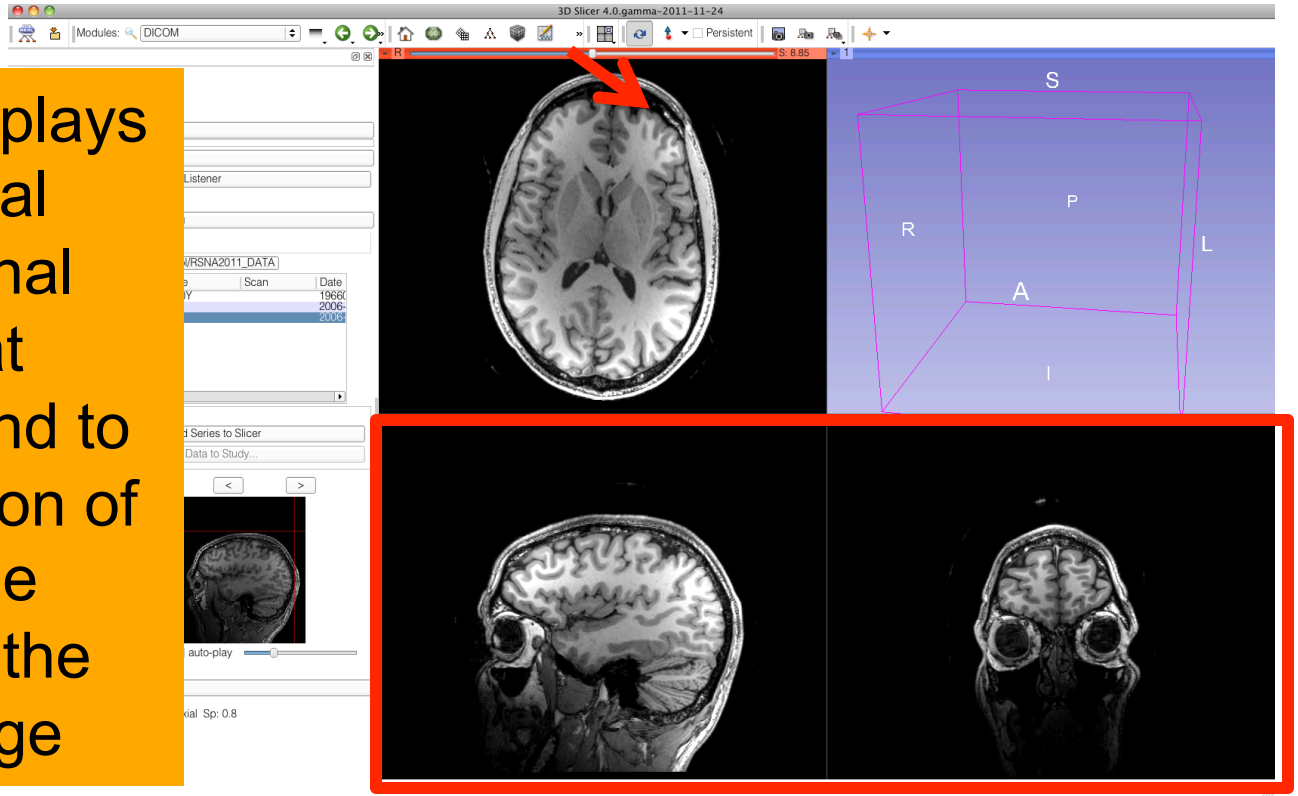
DICOM module

Hold down the **Shift** key on your keyboard, and move the mouse cursor in the red viewer



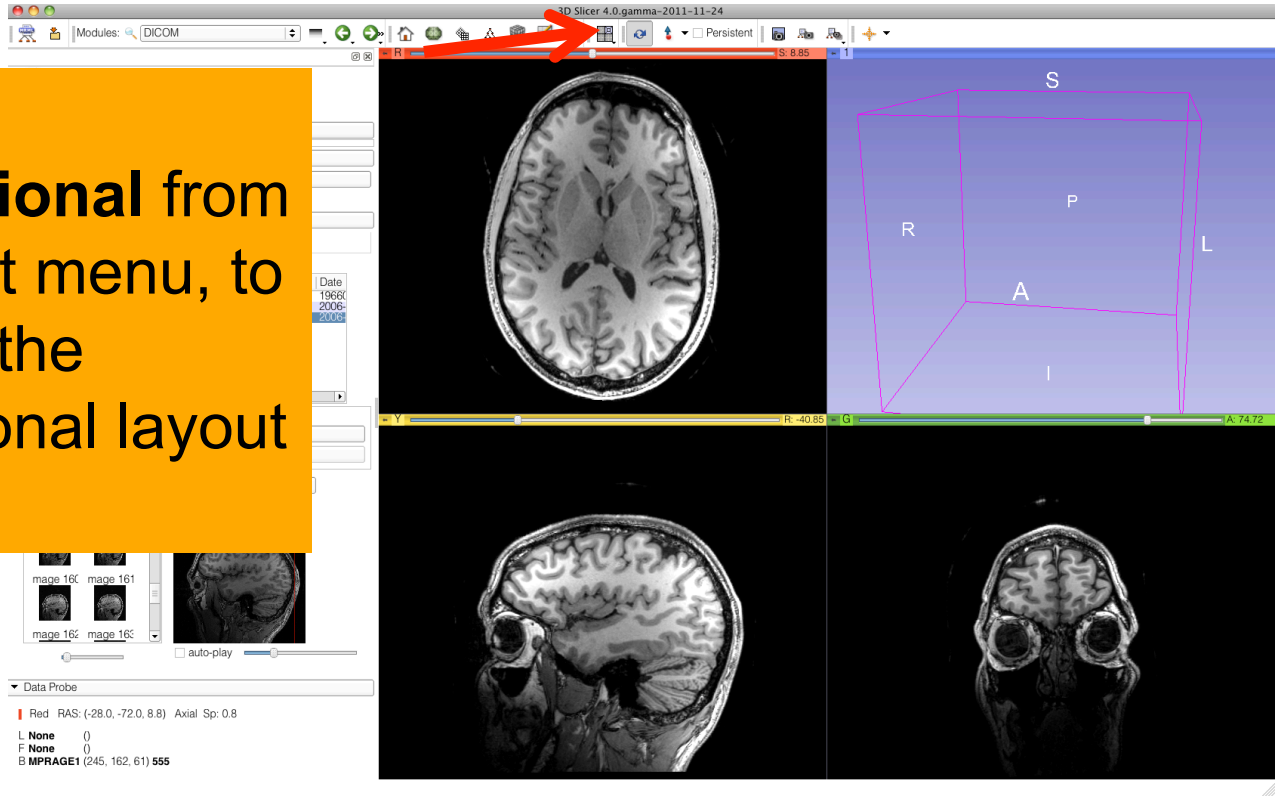
DICOM module

Slicer displays the sagittal and coronal slices that correspond to the location of the mouse cursor in the axial image

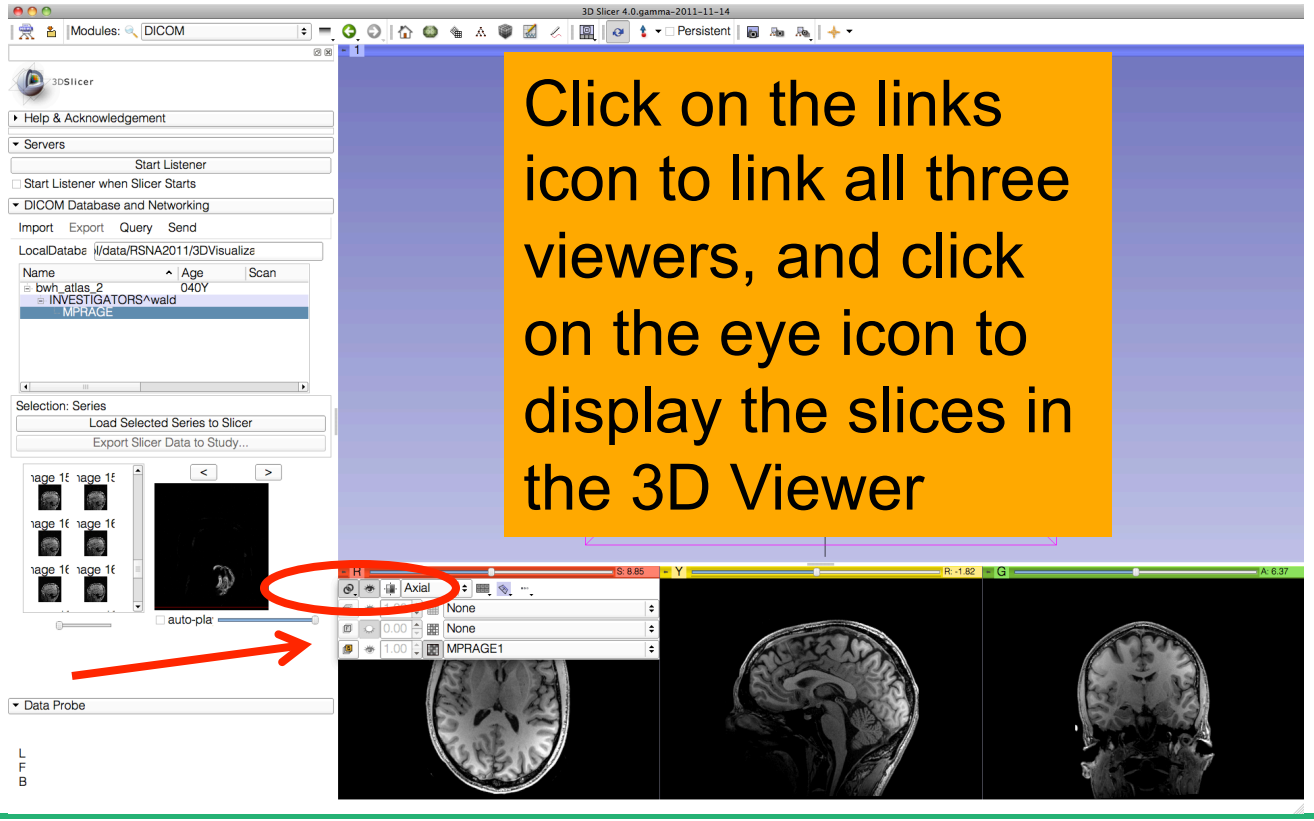


DICOM module

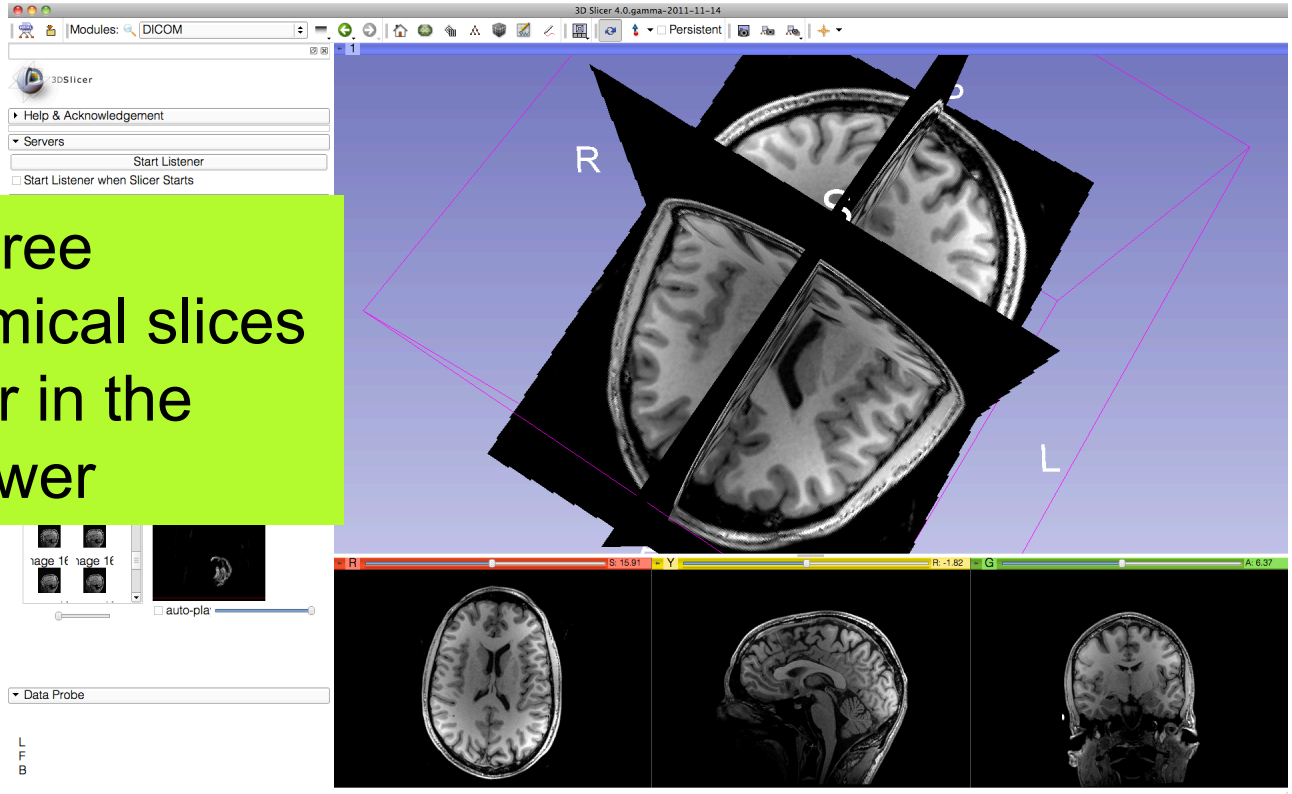
Select **Conventional** from the layout menu, to return to the conventional layout of Slicer.



DICOM module



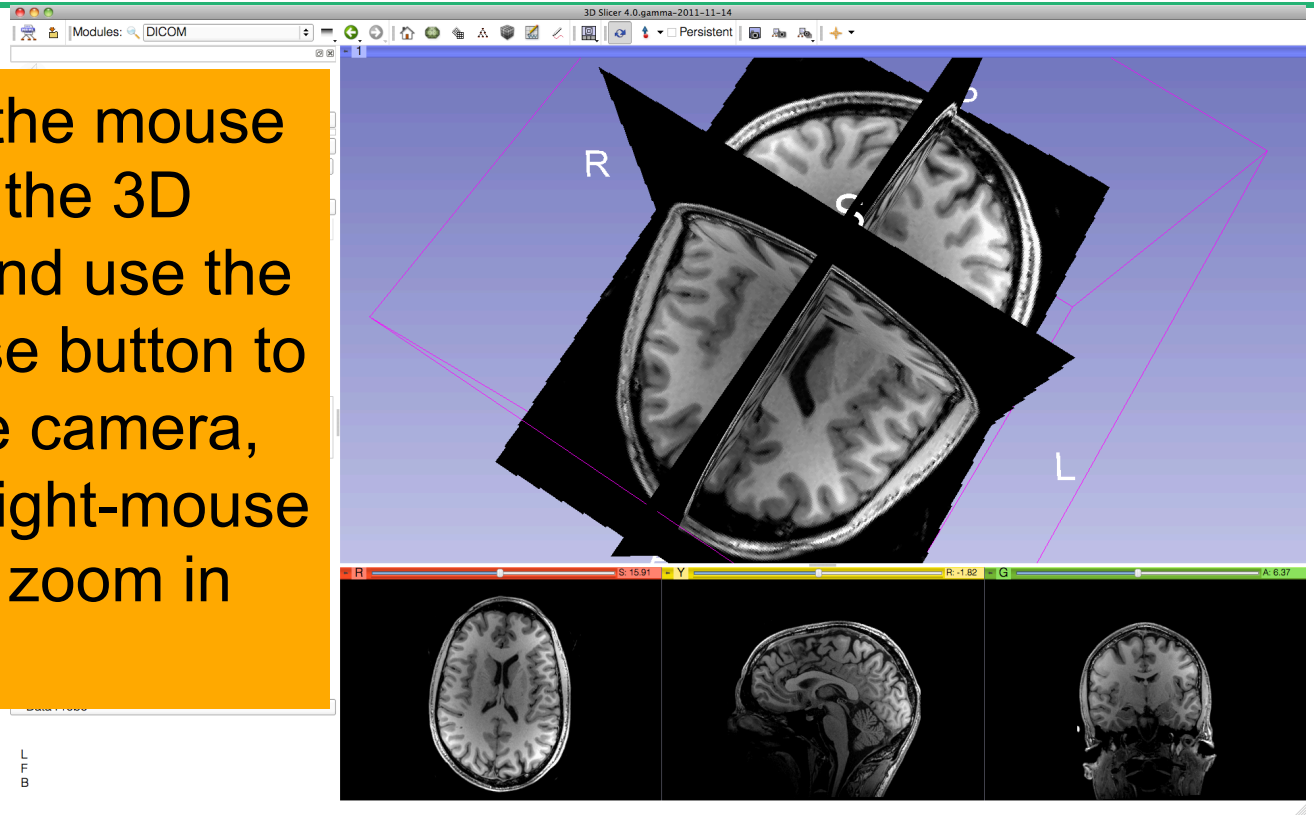
DICOM module



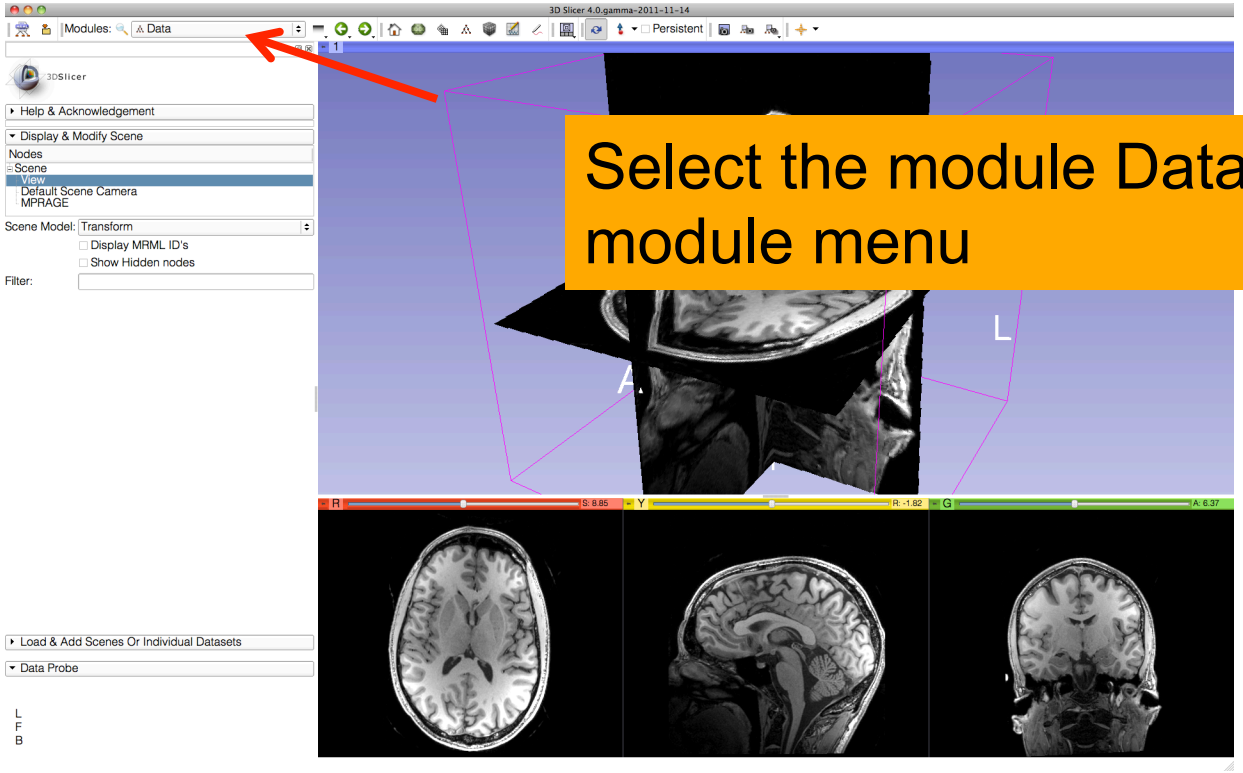
The three anatomical slices appear in the 3DViewer

DICOM module

Position the mouse cursor in the 3D viewer, and use the left-mouse button to rotate the camera, and the right-mouse button to zoom in and out

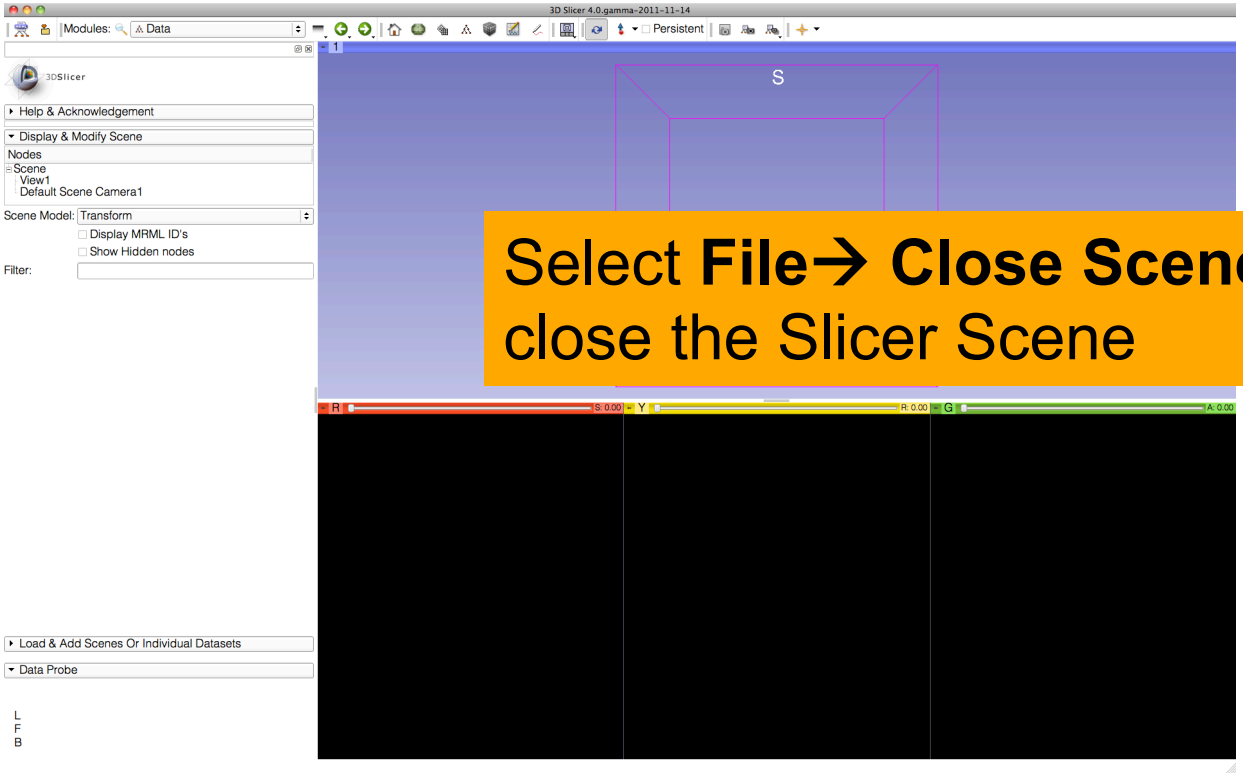


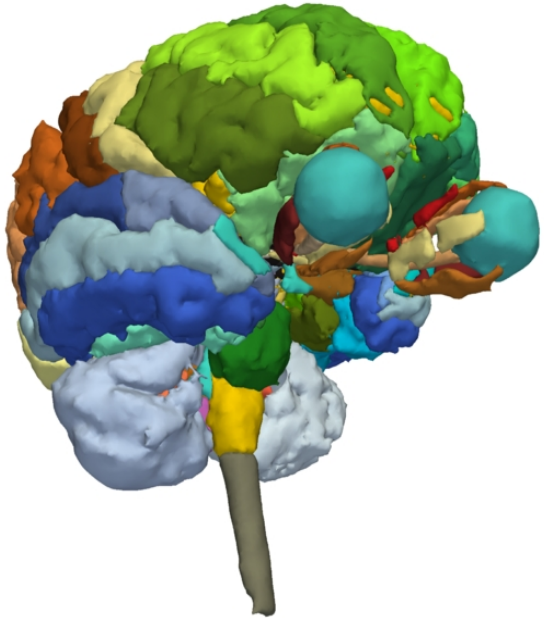
DICOM module



Select the module Data from the module menu

Close the Scene

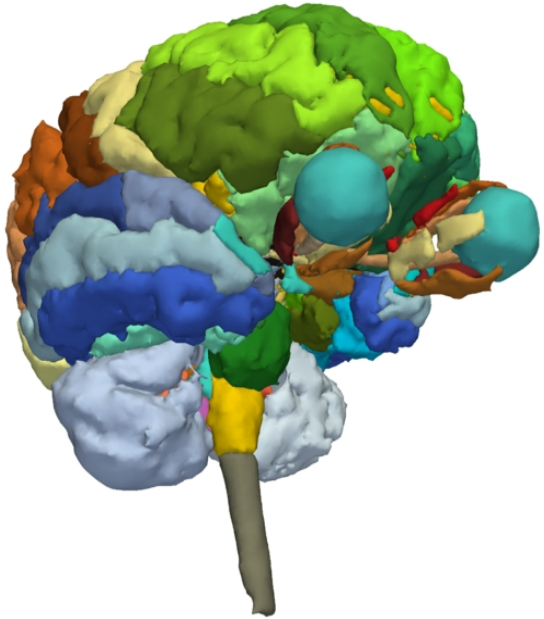




Part 2:

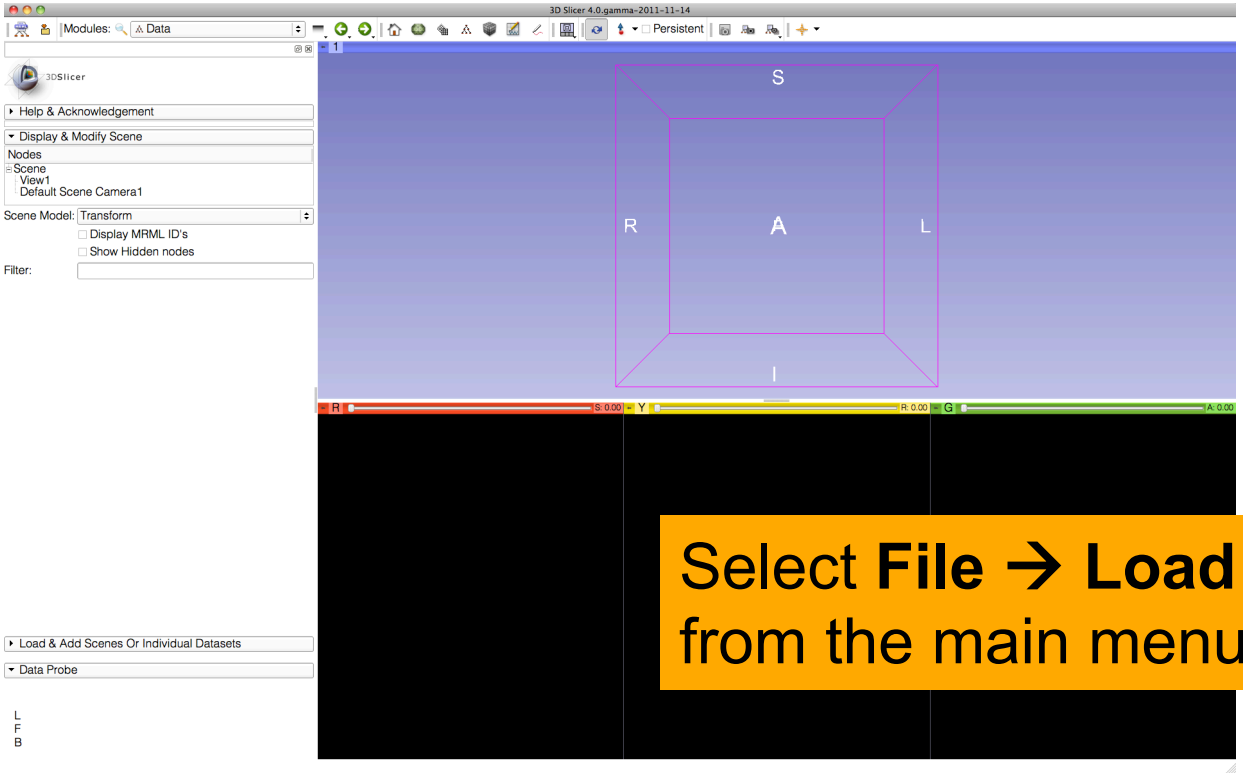
3D visualization of surface models of the brain

3D Slicer Scene

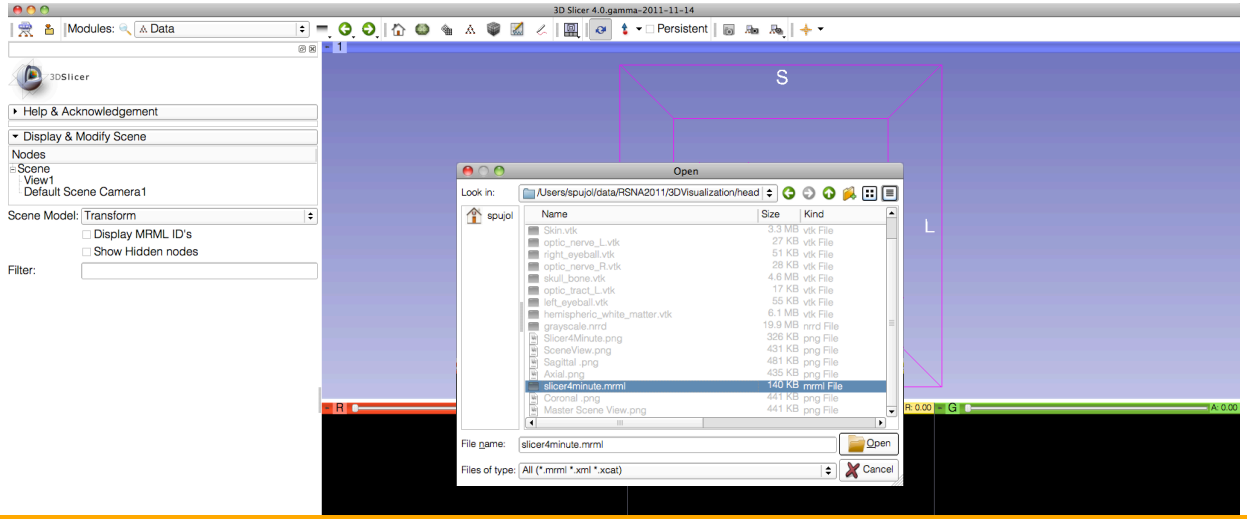


- A Slicer scene is a MRML file which contains a list of elements loaded into Slicer (volumes, models, fiducials…)
- The tutorial scene contains an MR scan of the brain and 3D surface models of anatomical structures.

Loading a Scene



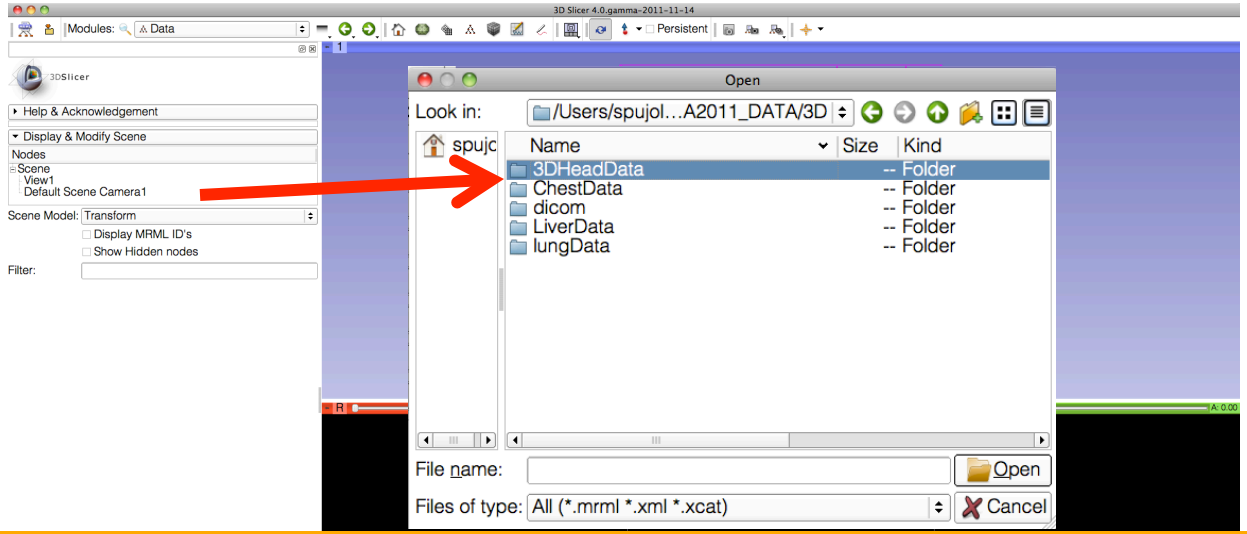
Loading a Scene



Browse to the directory **3D**, located on the Desktop:

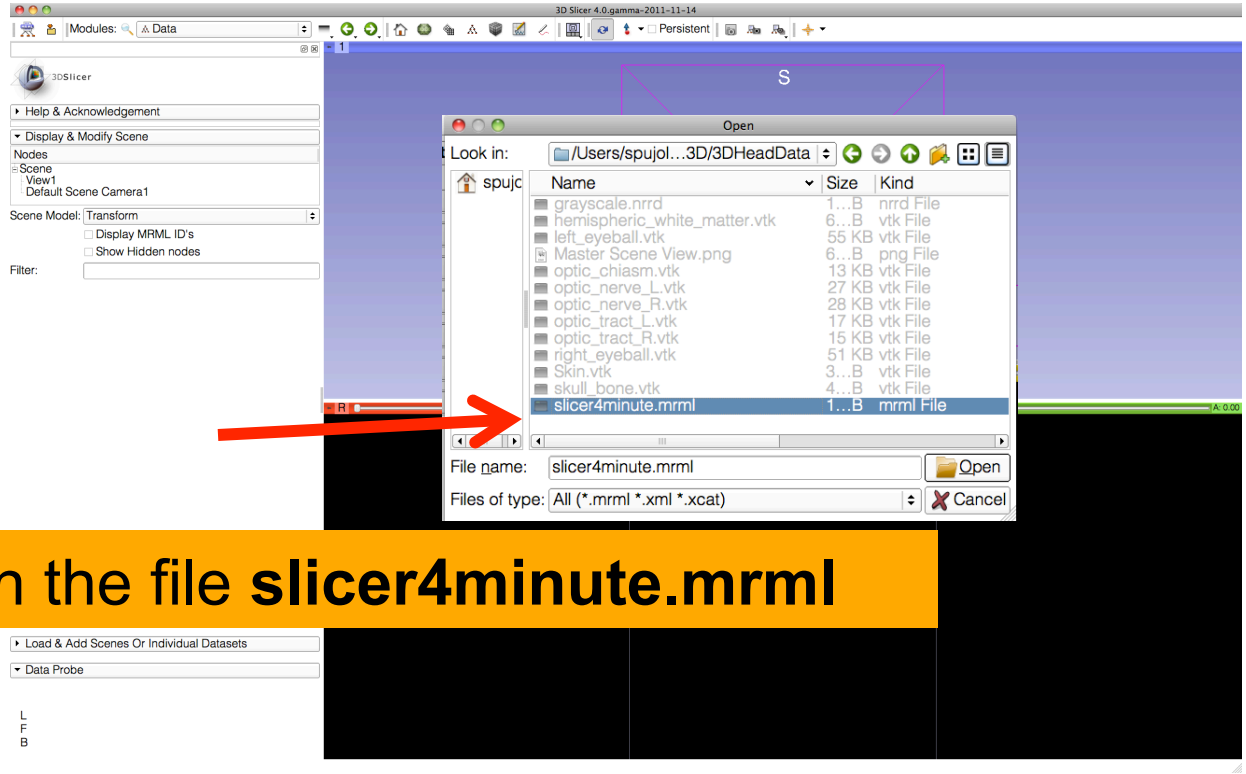
C:\Documents and Settings\Administrator\Desktop\3D

Loading a Scene



Select the directory **3DHeadData**, and open the file **slicer4minute.mrml**

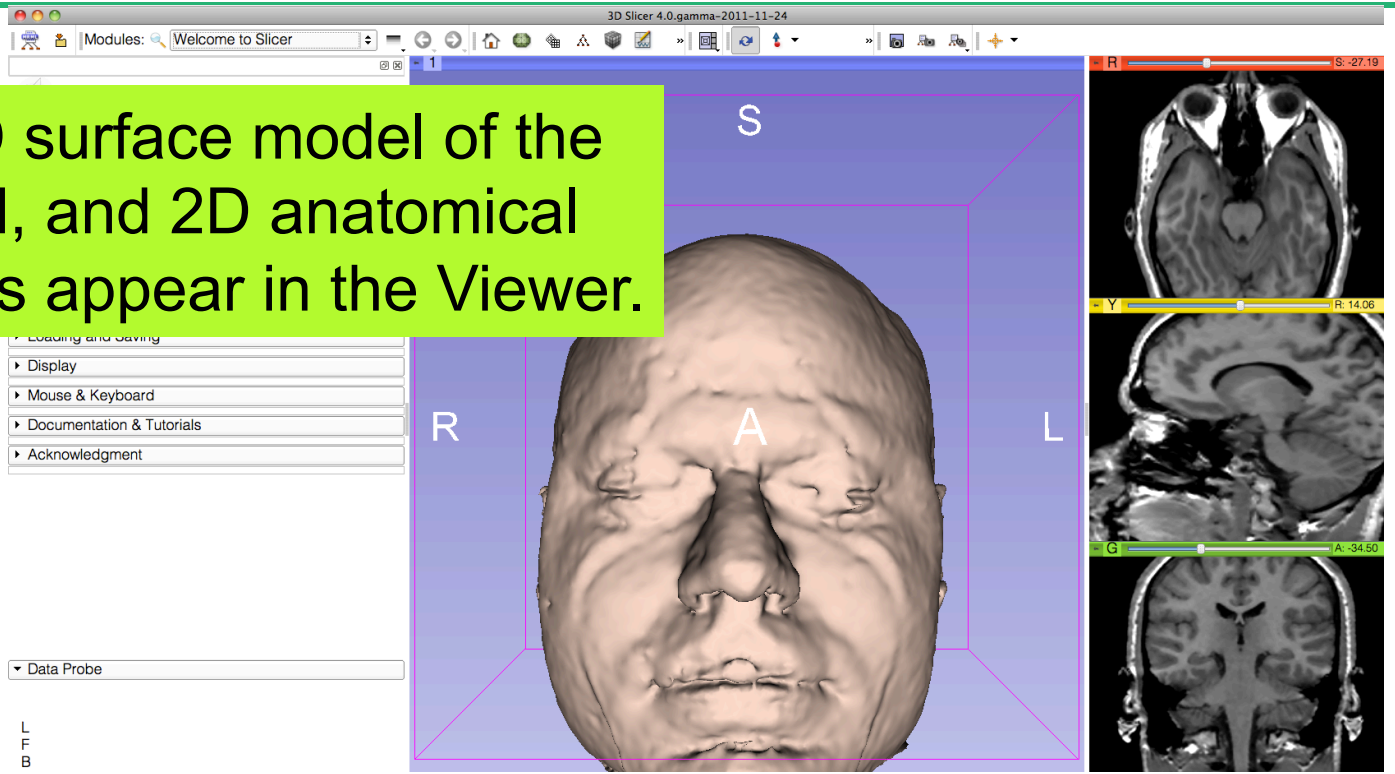
Loading a Scene



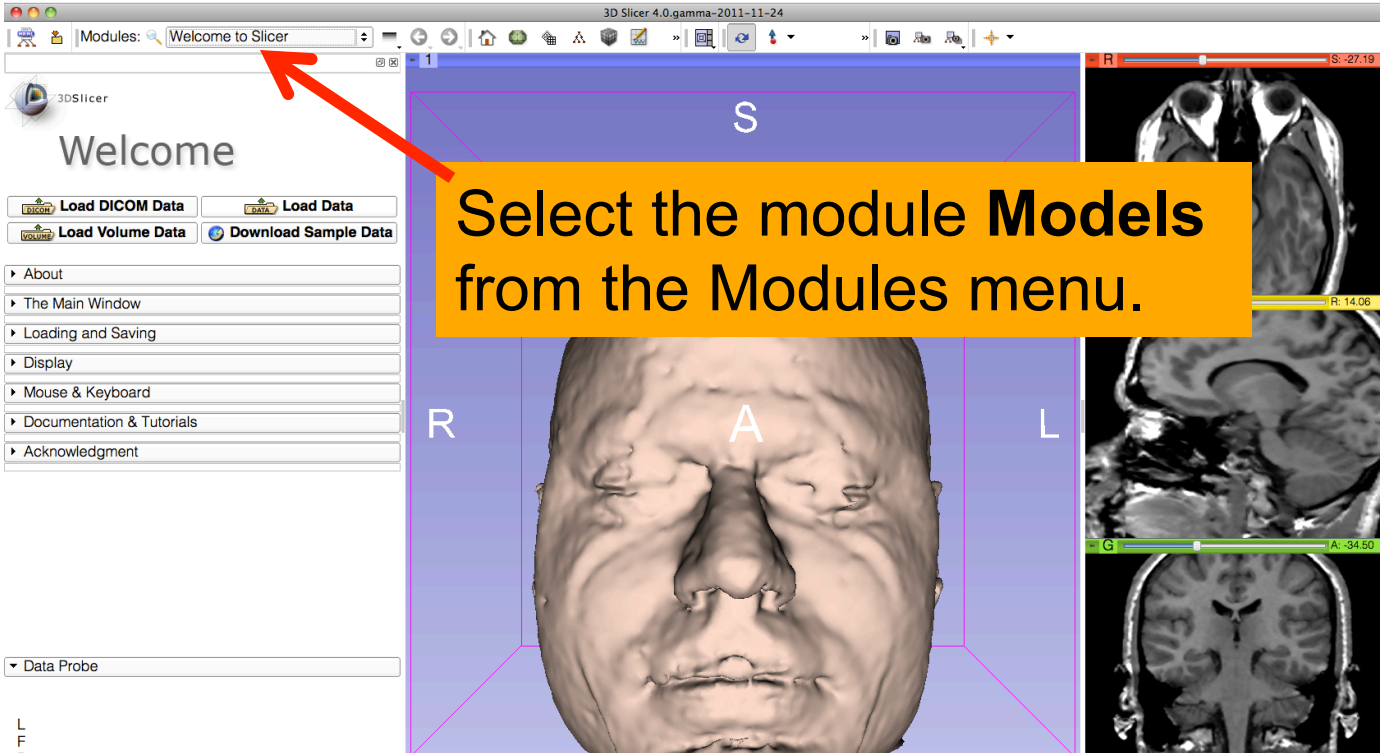
Open the file **slicer4minute.mrml**

Loading the Slicer Scene

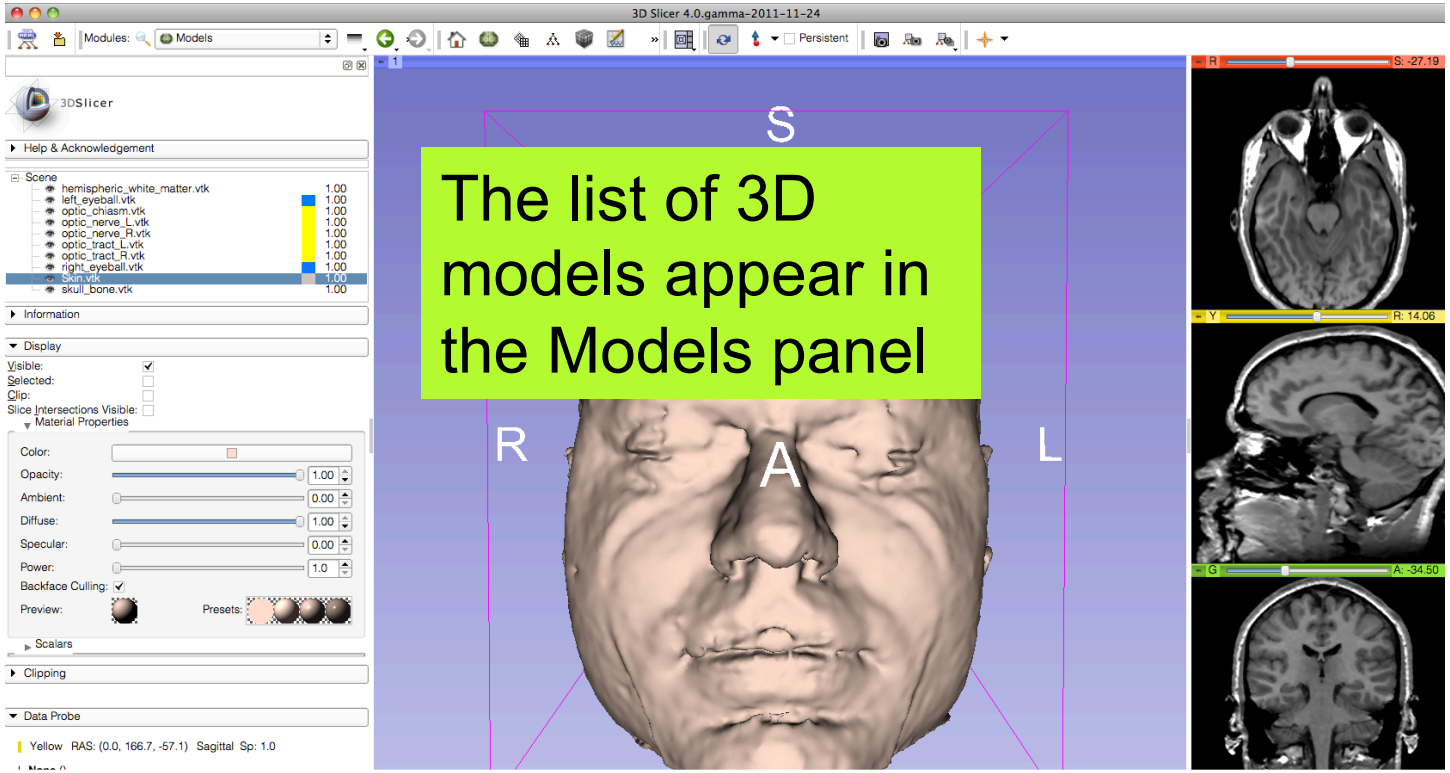
A 3D surface model of the head, and 2D anatomical slices appear in the Viewer.



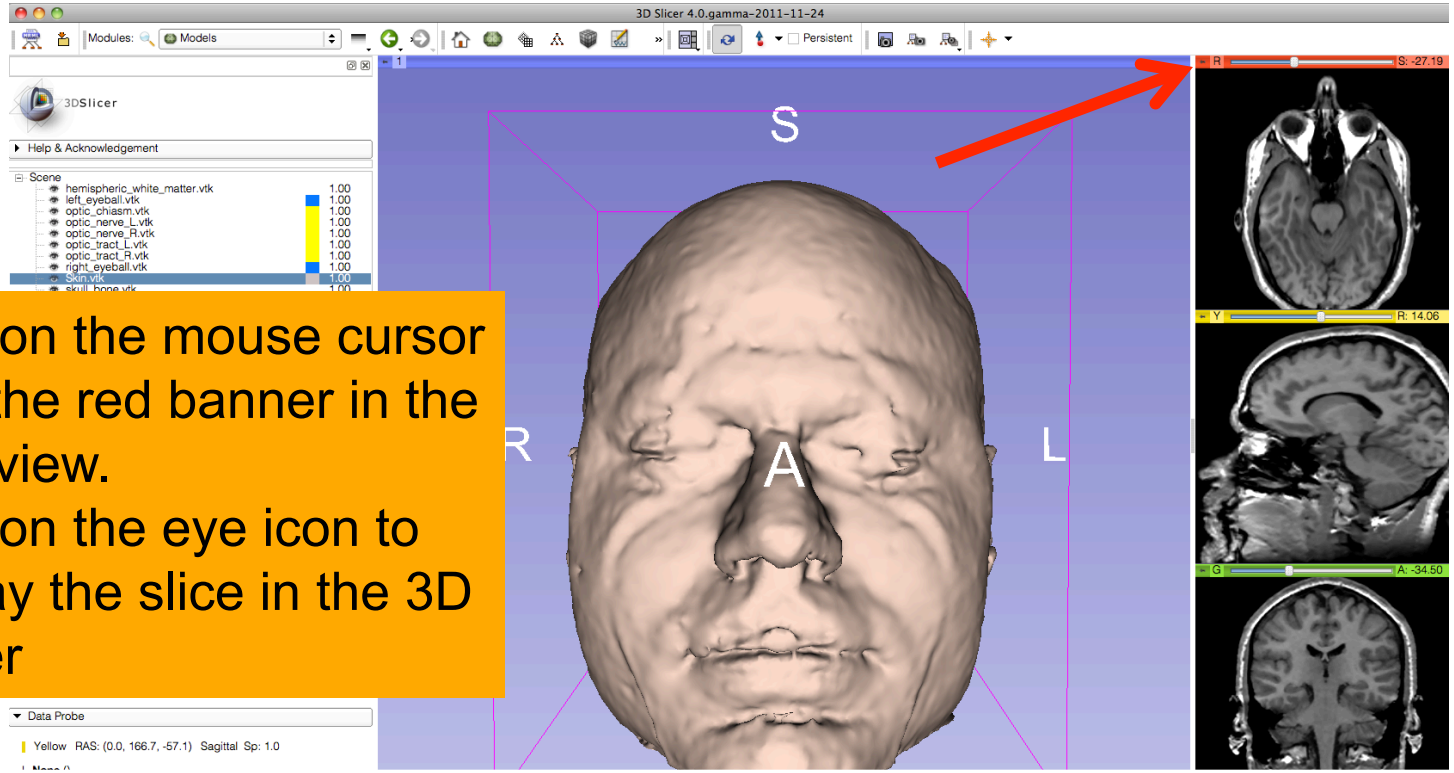
Loading the Slicer Scene



Models module

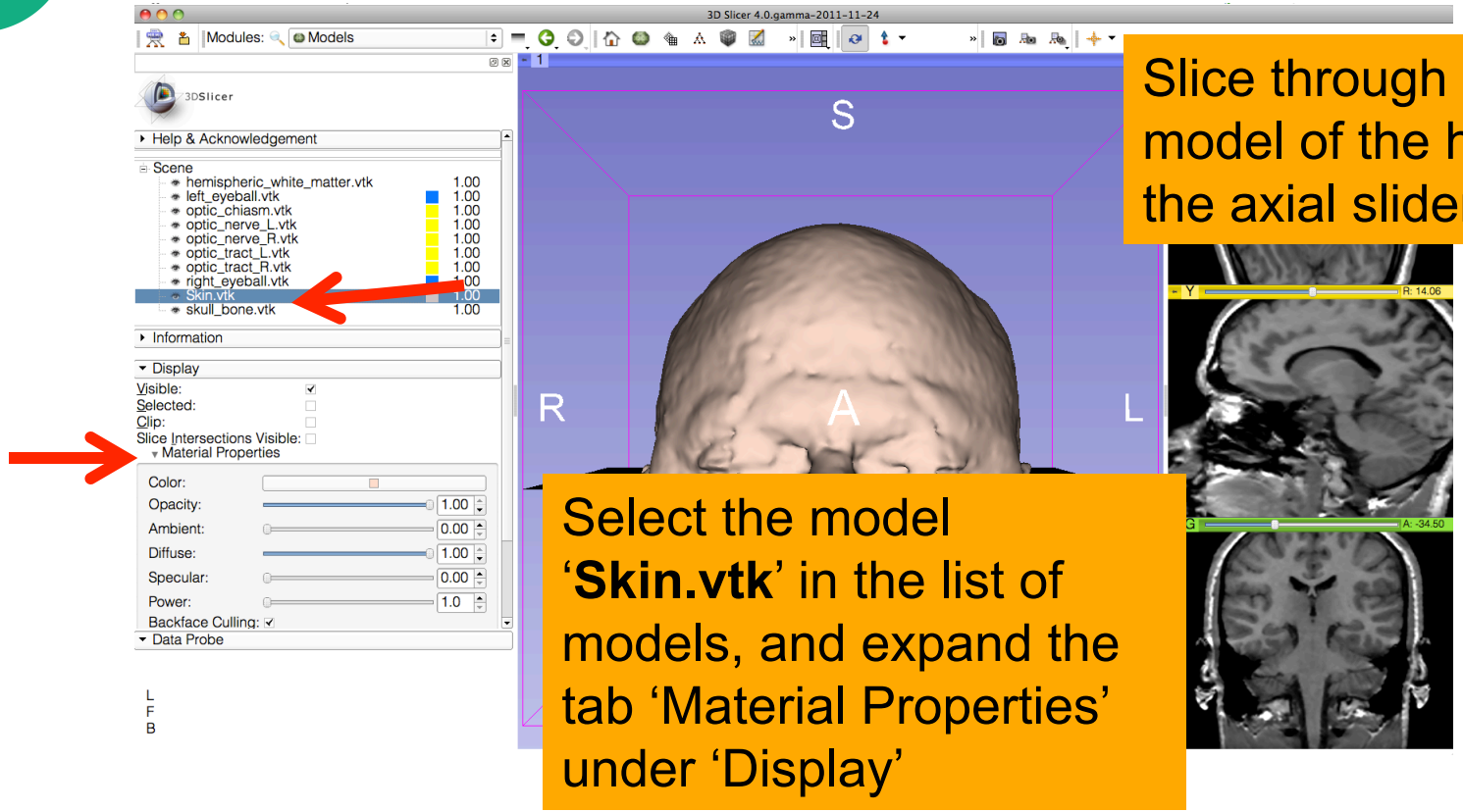


3D Visualization



Position the mouse cursor over the red banner in the axial view.
Click on the eye icon to display the slice in the 3D viewer

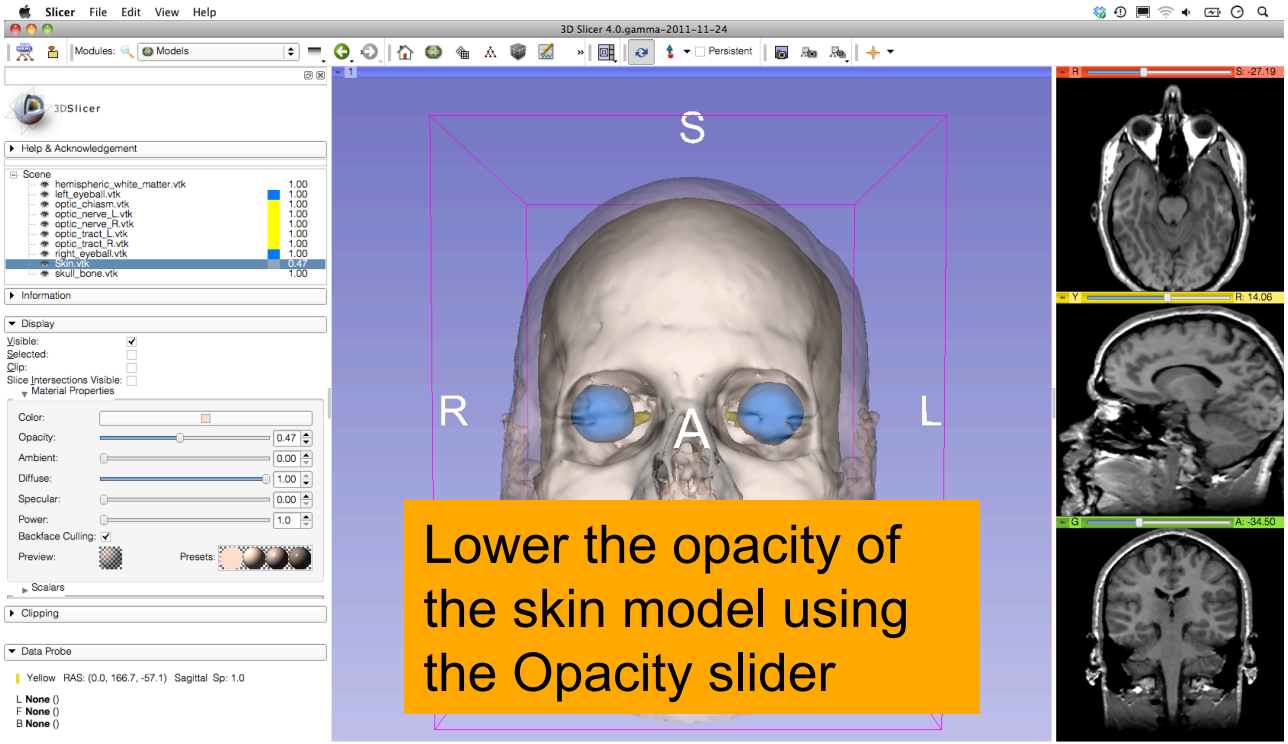
3D Visualization



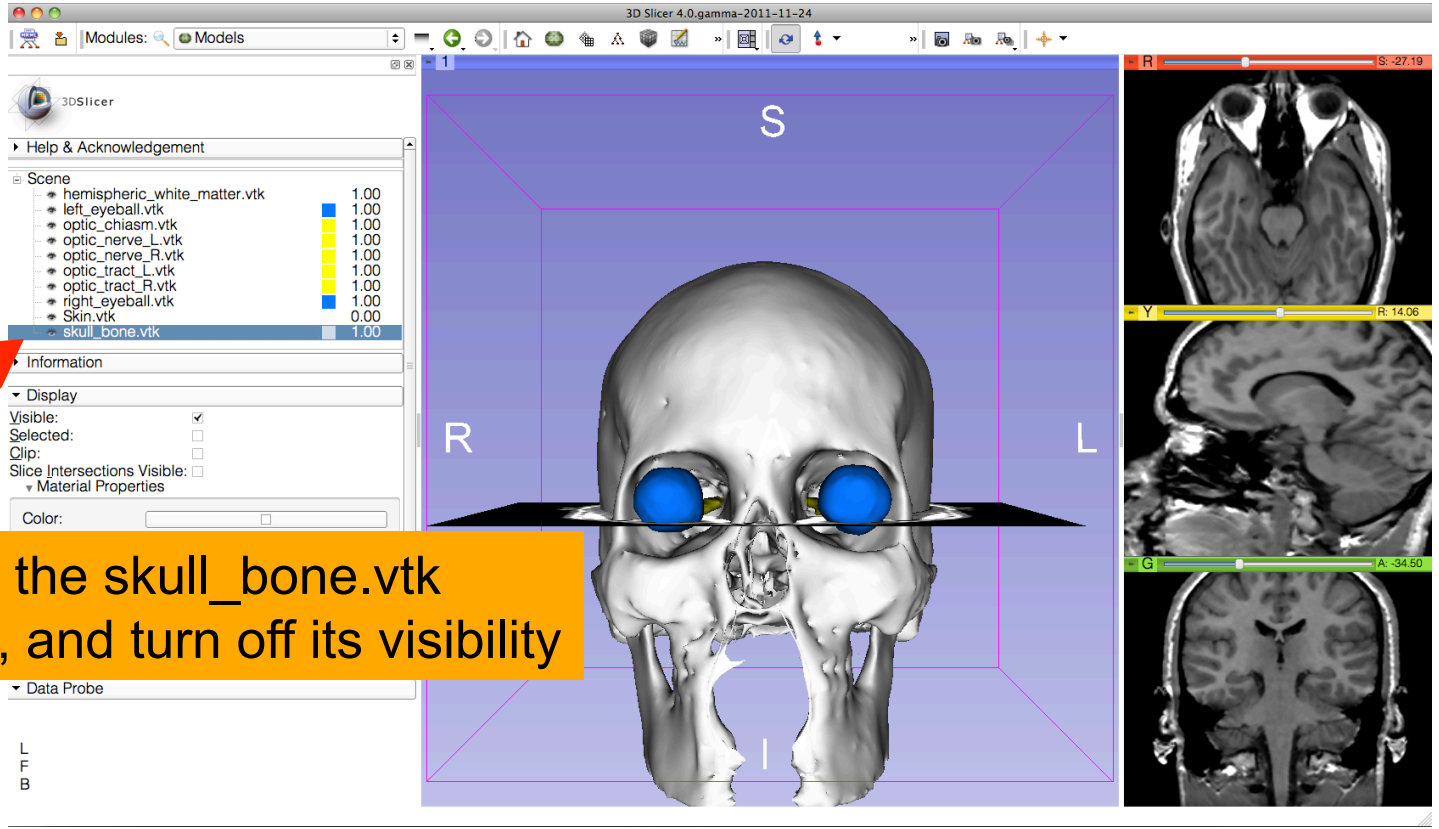
Slice through the 3D model of the head using the axial slider

Select the model '**Skin.vtk**' in the list of models, and expand the tab 'Material Properties' under 'Display'

3D Visualization

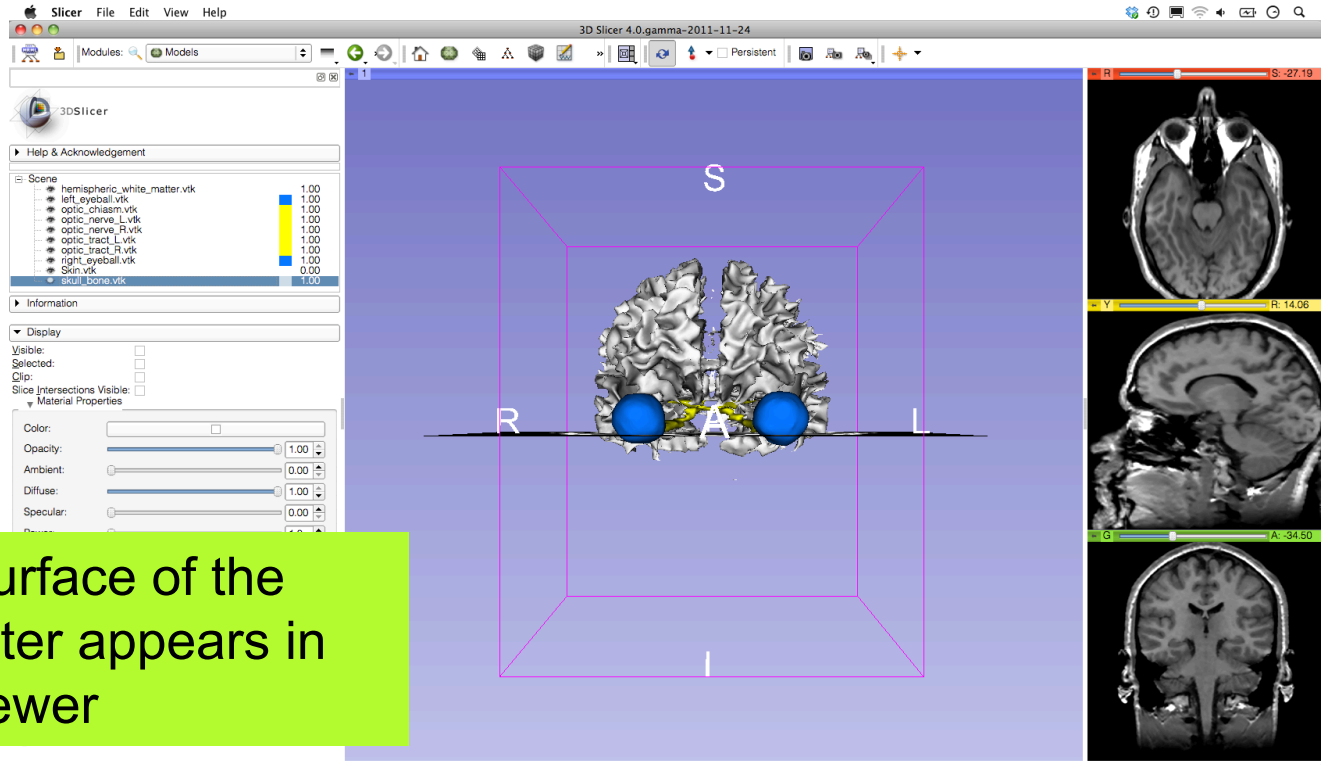


3D Visualization



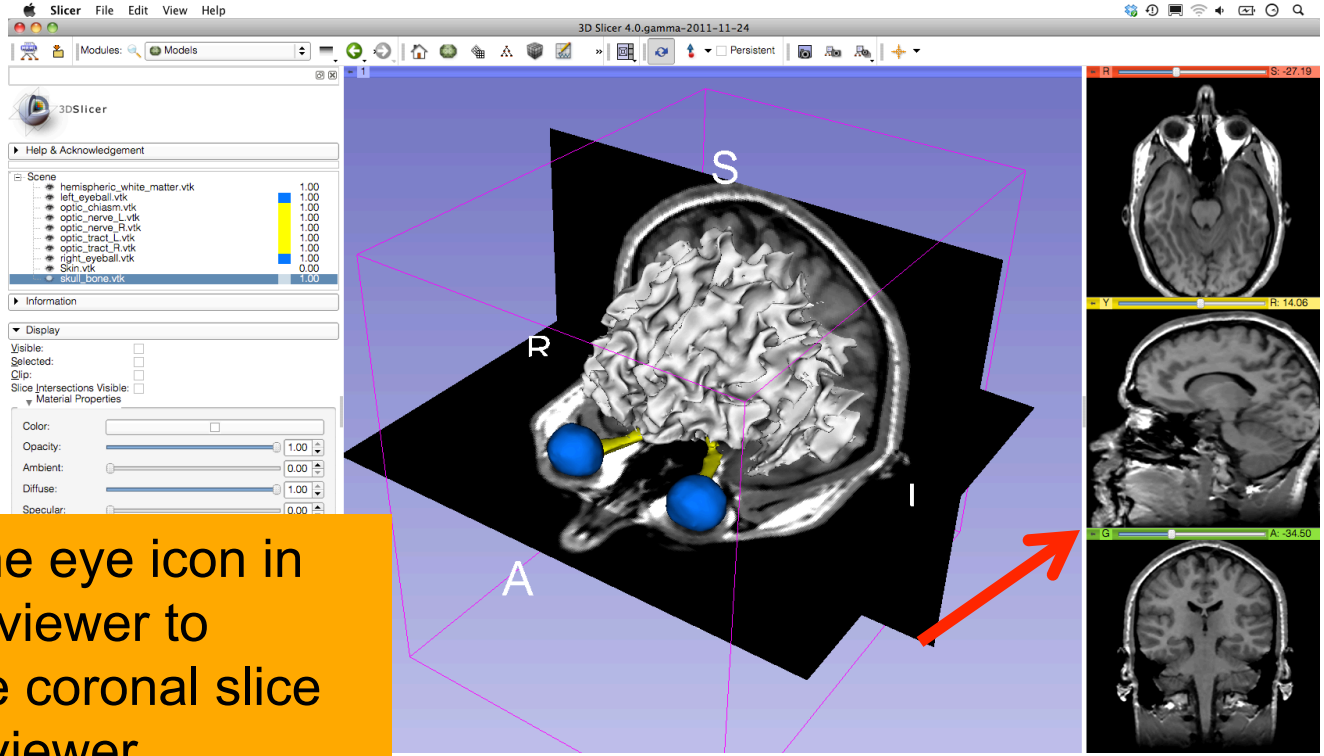
Select the skull_bone.vtk model, and turn off its visibility

3D Visualization



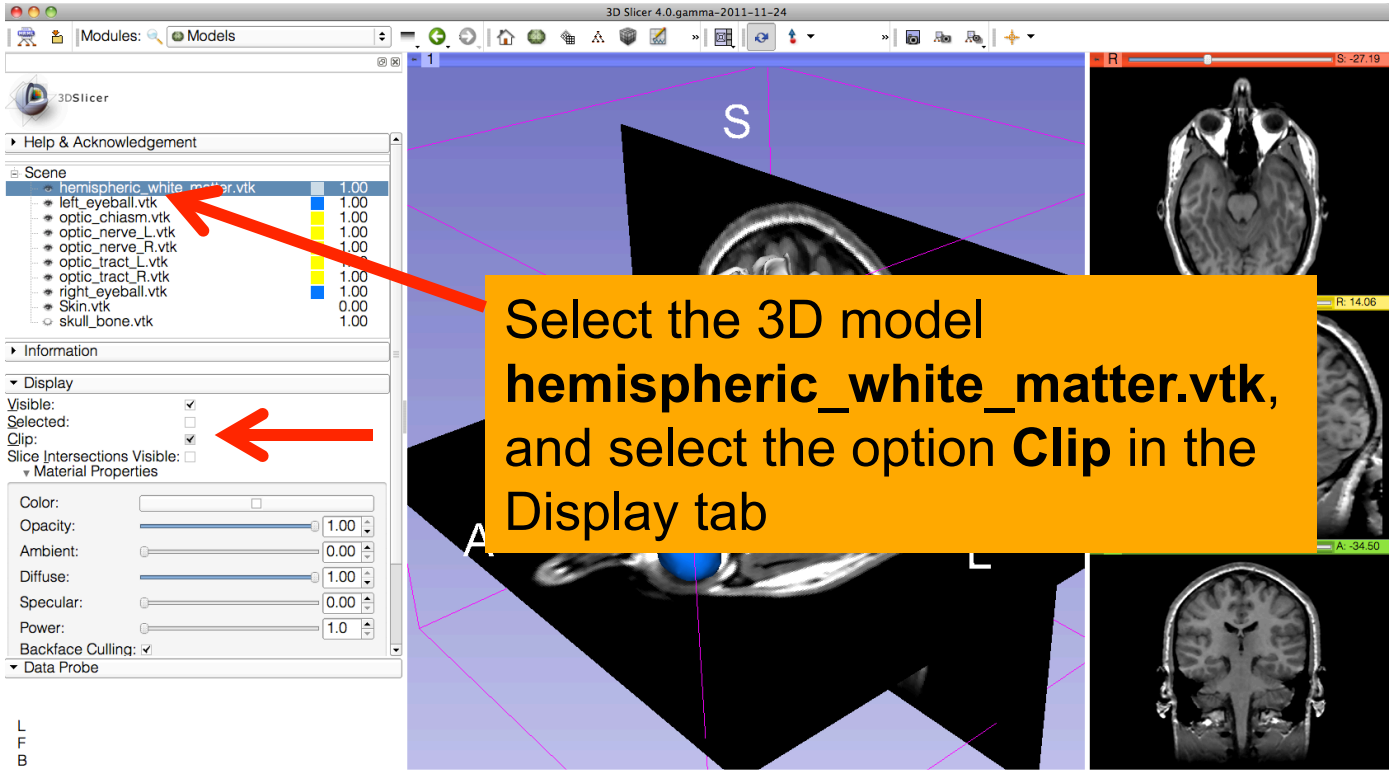
The 3D surface of the white matter appears in the 3D viewer

3D Visualization

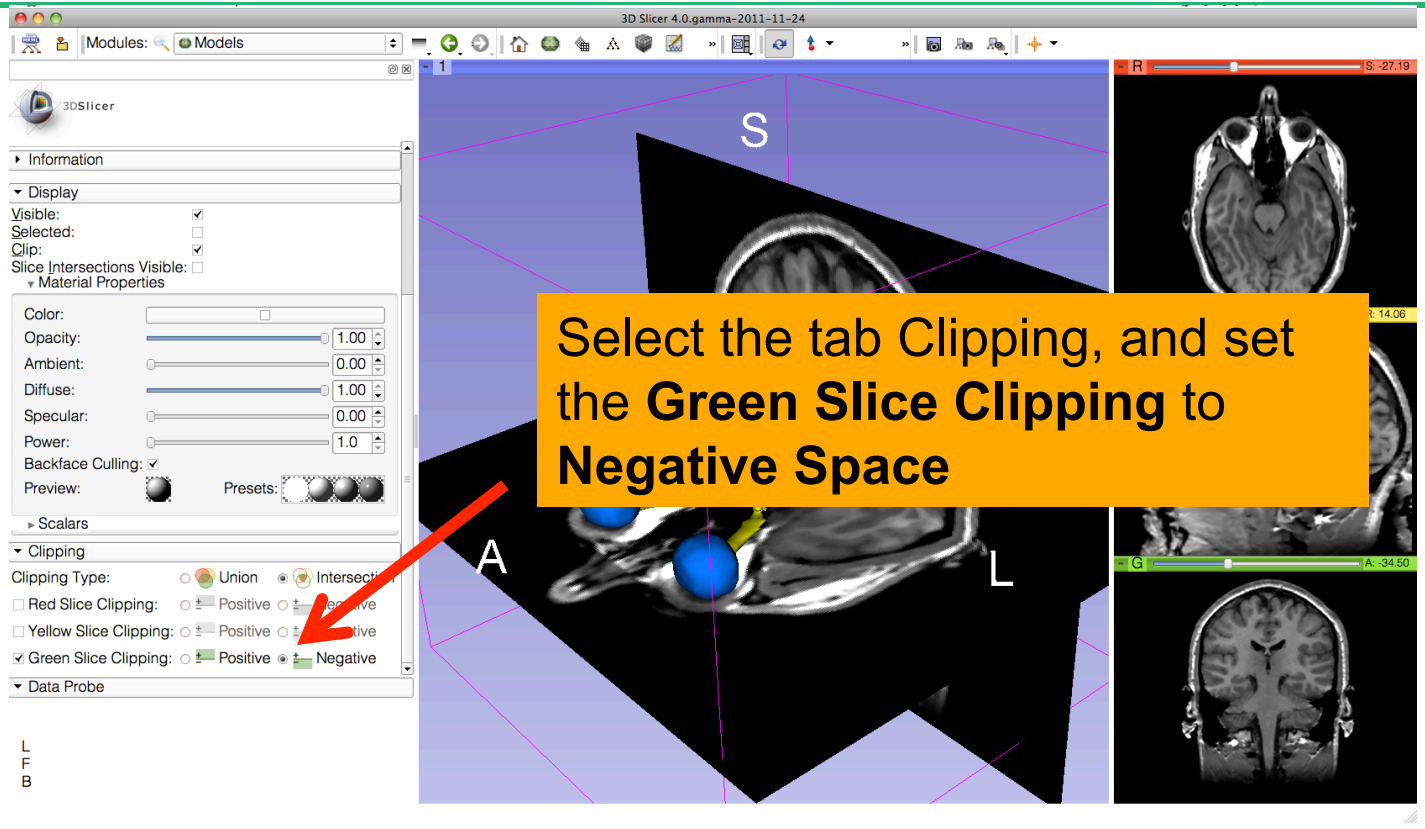


Click on the eye icon in the green viewer to display the coronal slice in the 3D viewer

3D Visualization

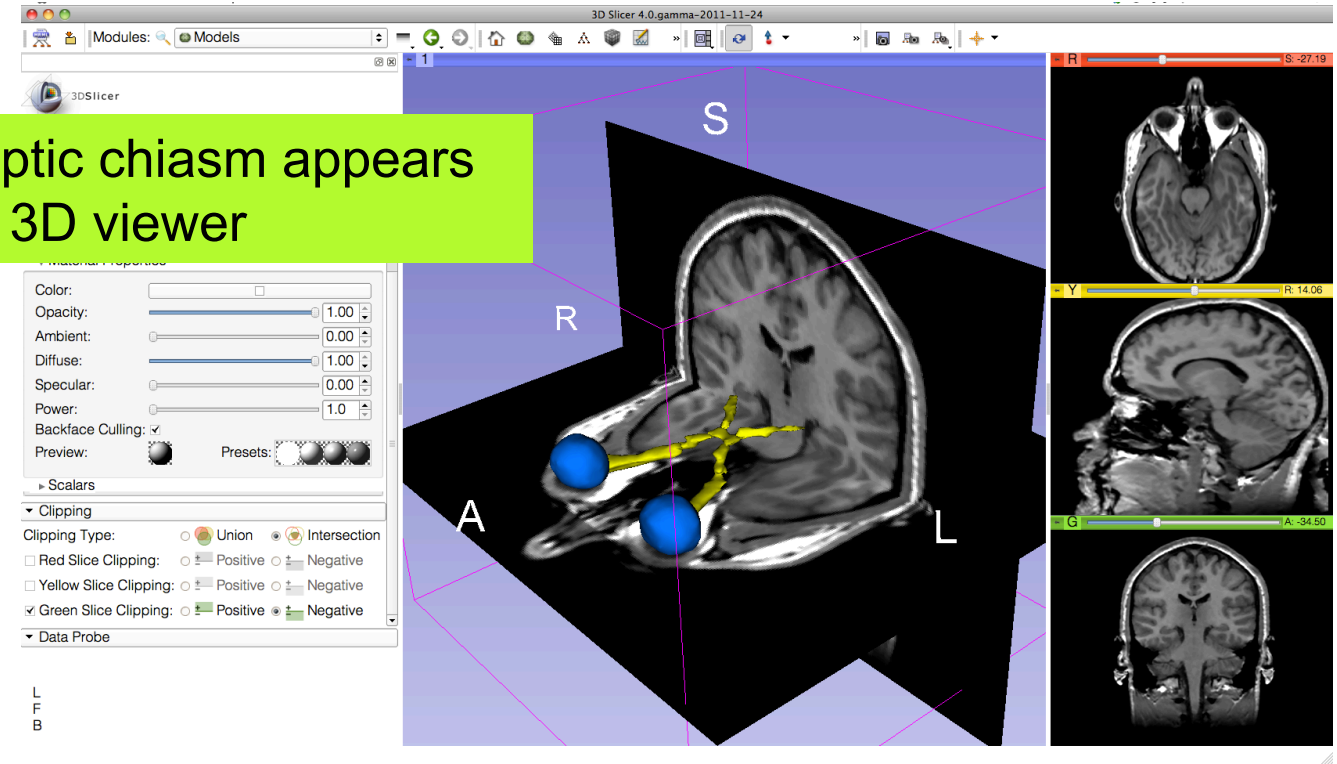


3D Visualization

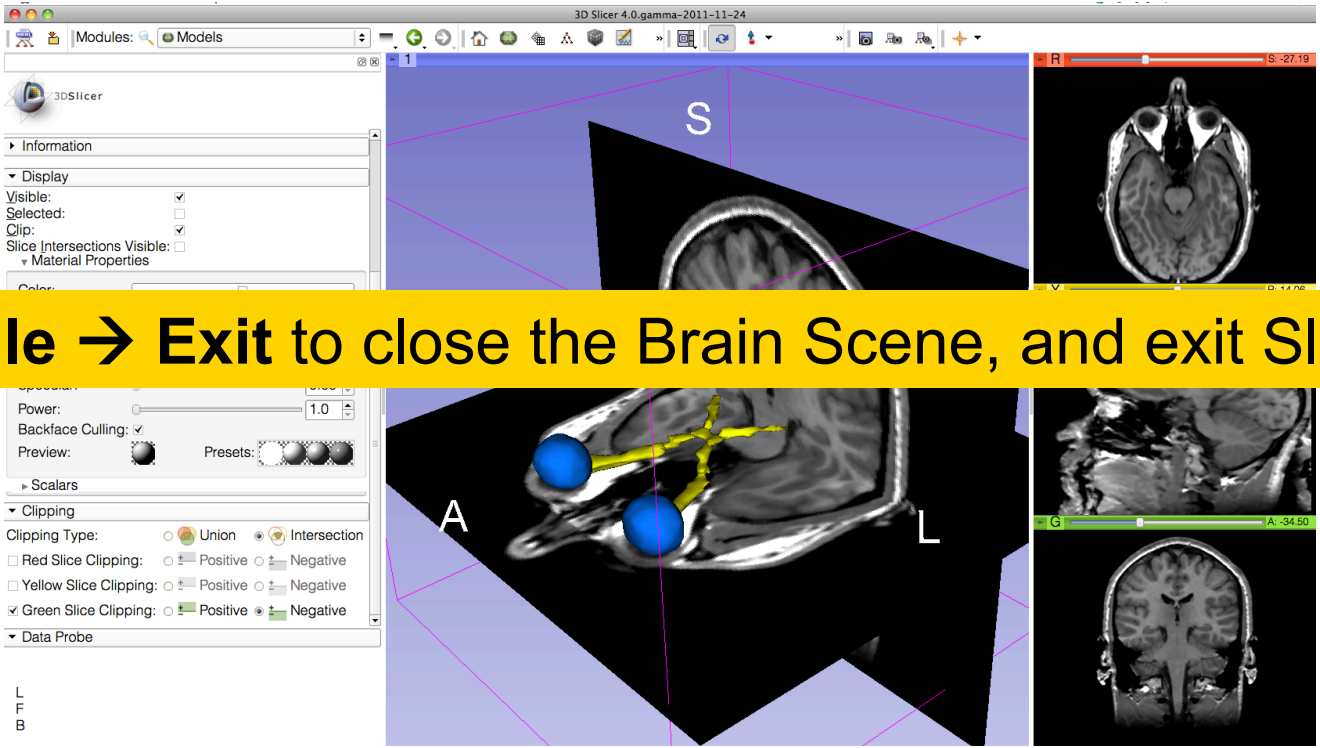


3D Visualization

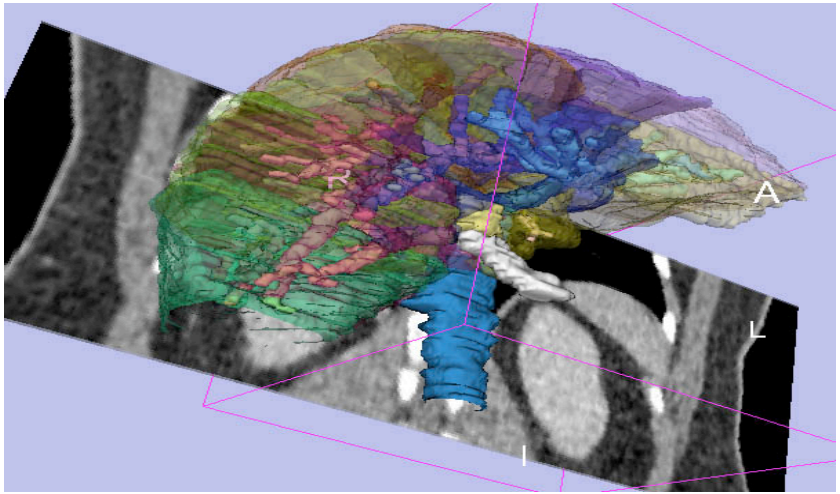
The optic chiasm appears in the 3D viewer



3D Visualization



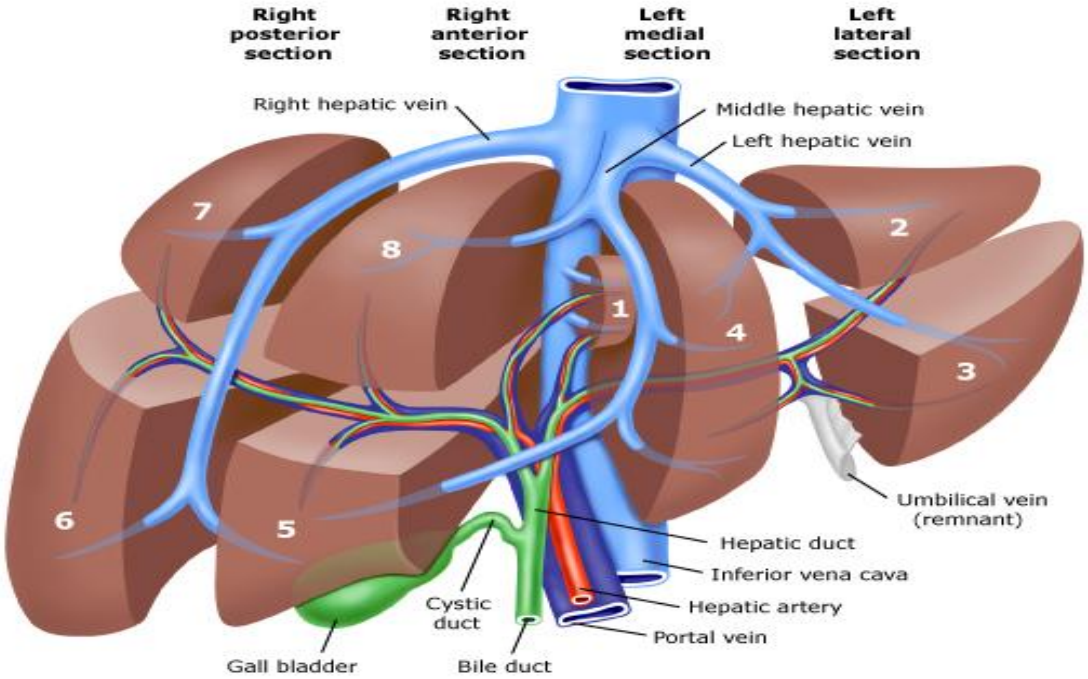
Select **File → Exit** to close the Brain Scene, and exit Slicer



Part 3:

Interactive 3D Visualization of the segments of the liver

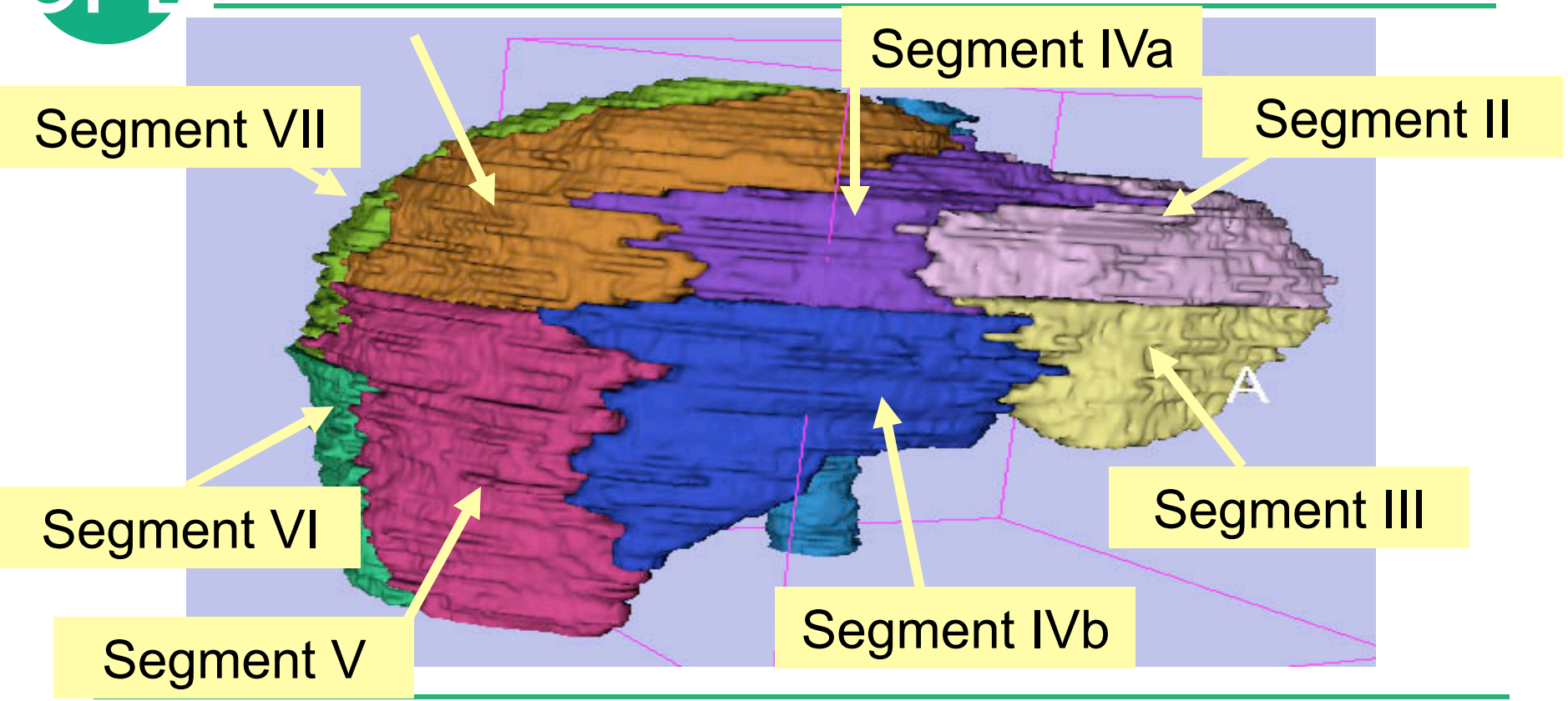
Anatomy of the liver



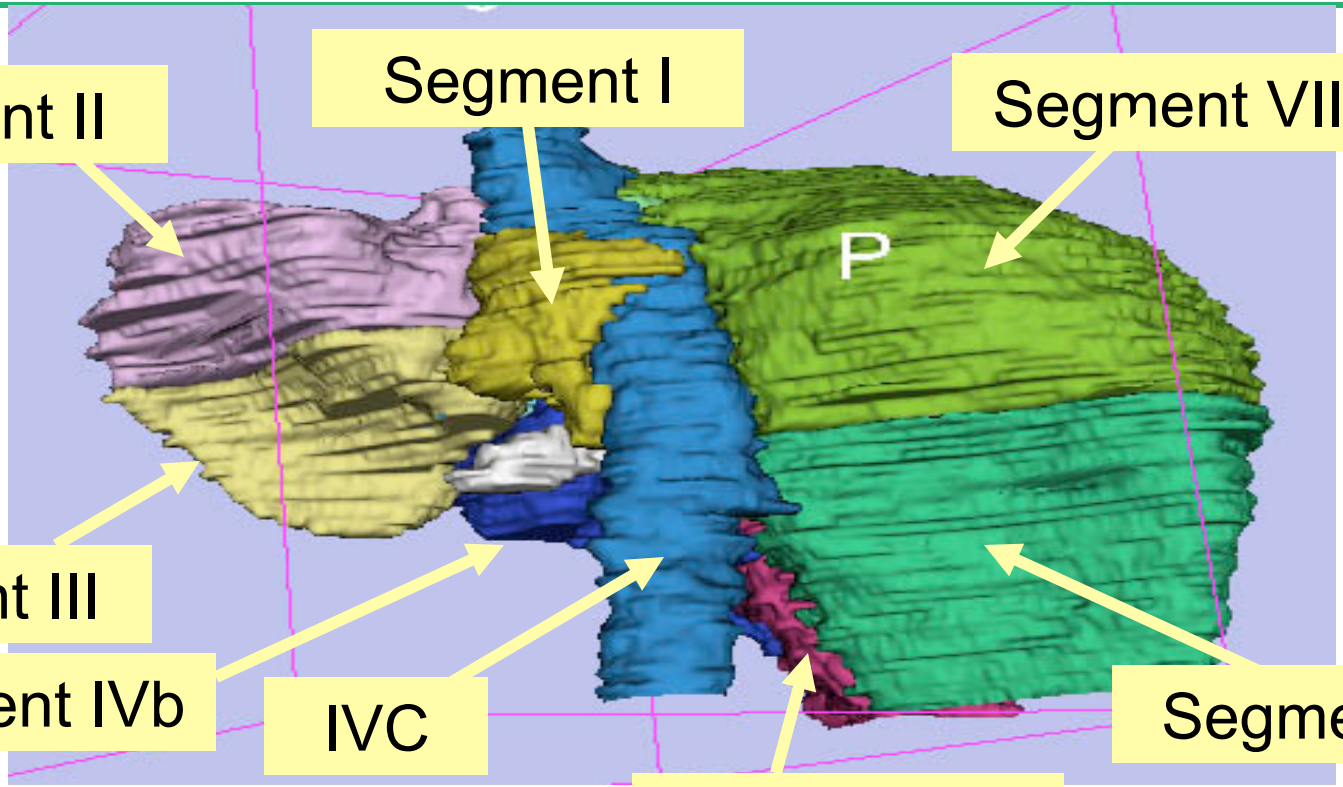
Liver dataset

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

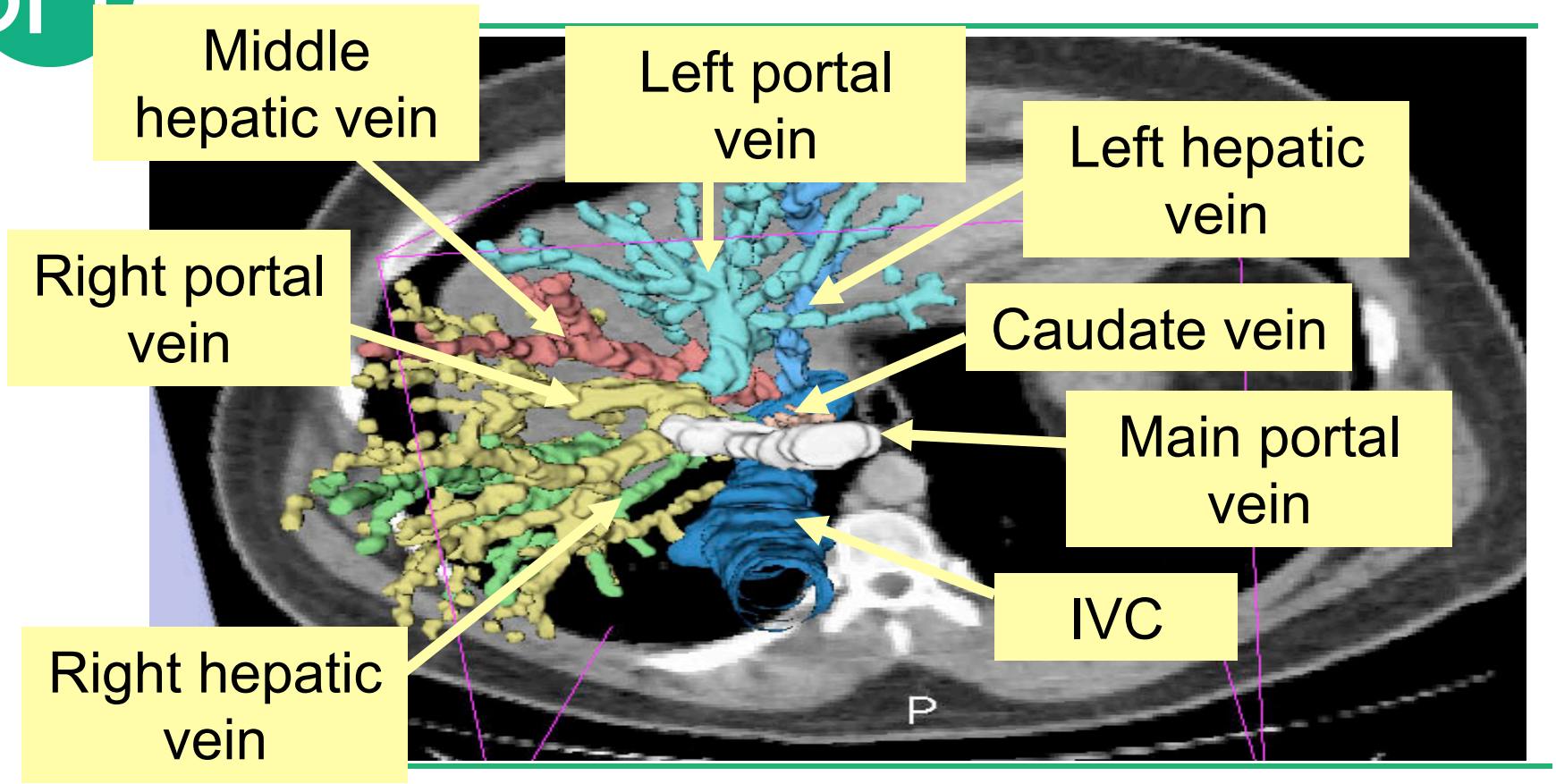
3D segments of the liver



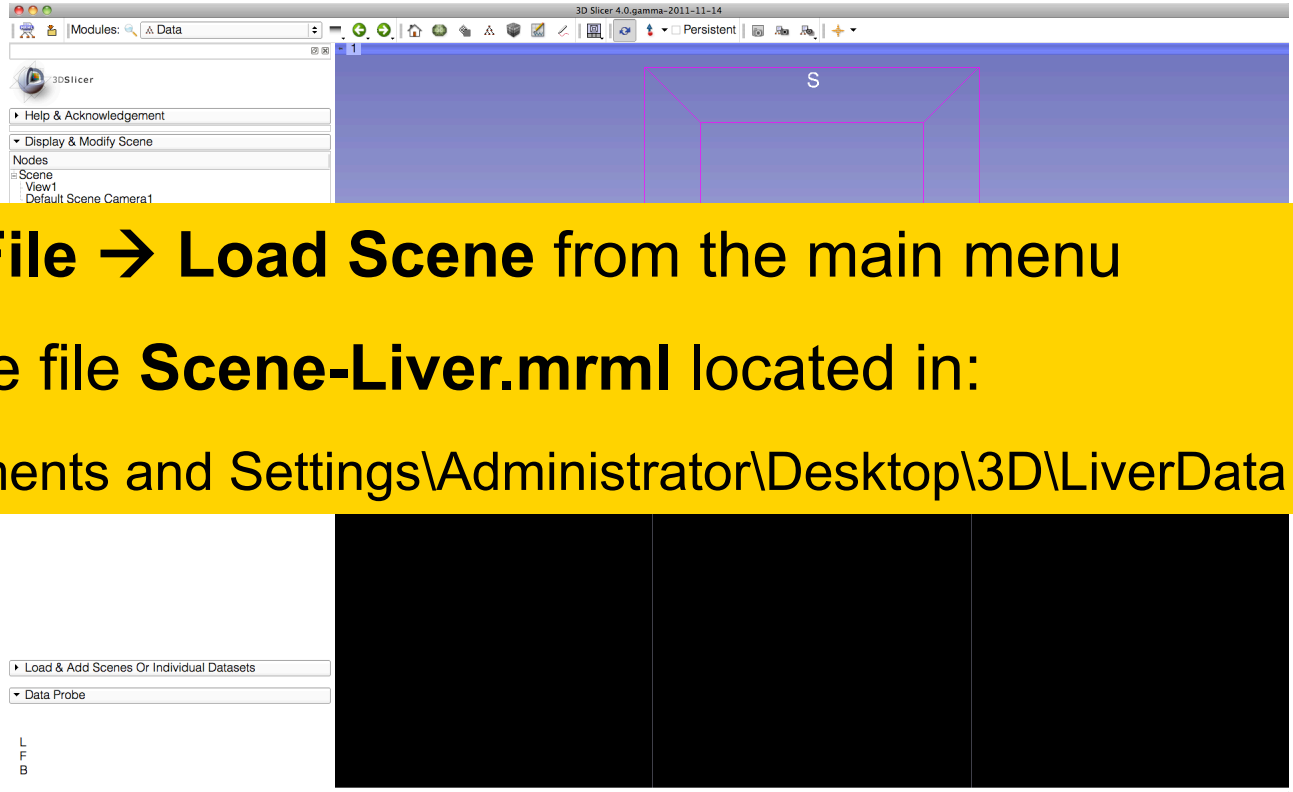
3D segments of the liver



Liver vasculature



Loading the Liver Scene



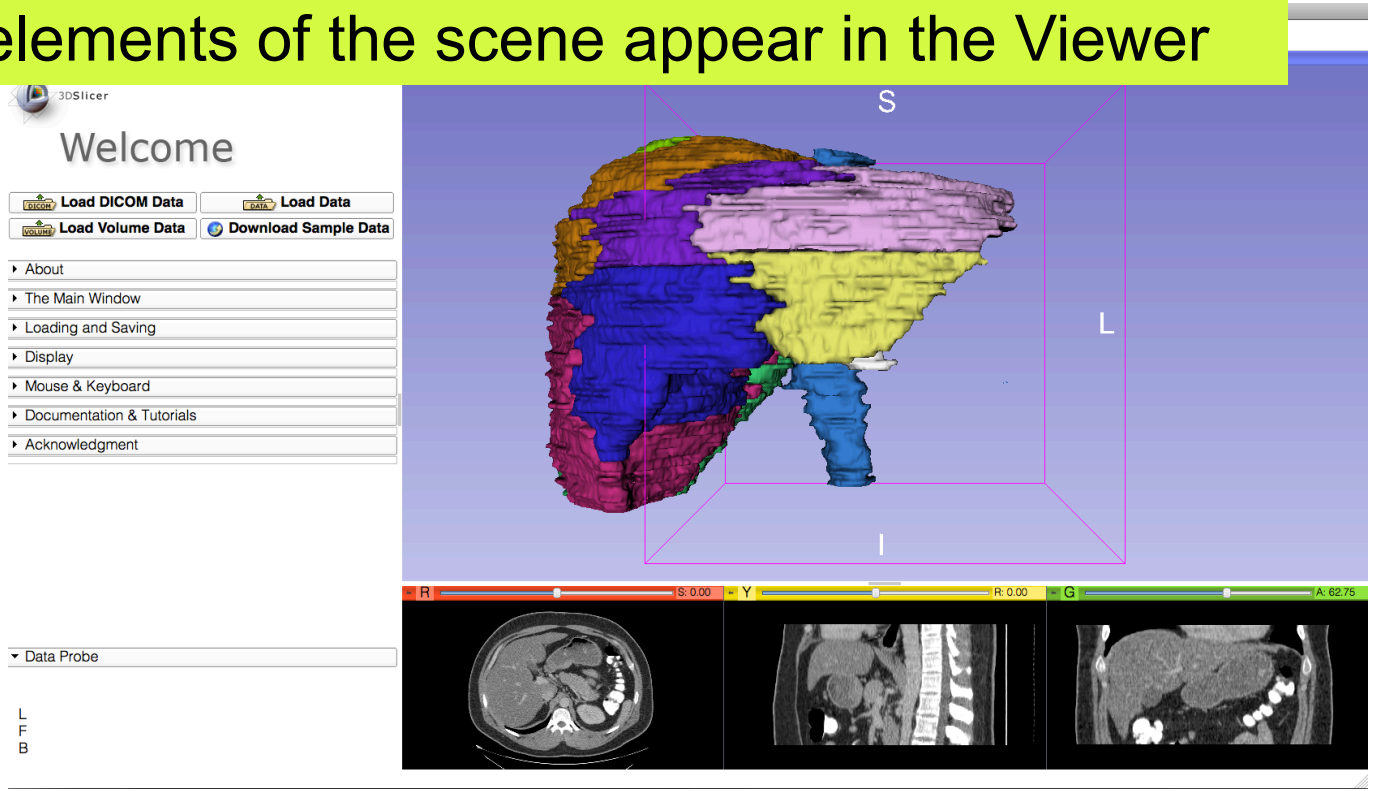
Select **File → Load Scene** from the main menu

Load the file **Scene-Liver.mrml** located in:

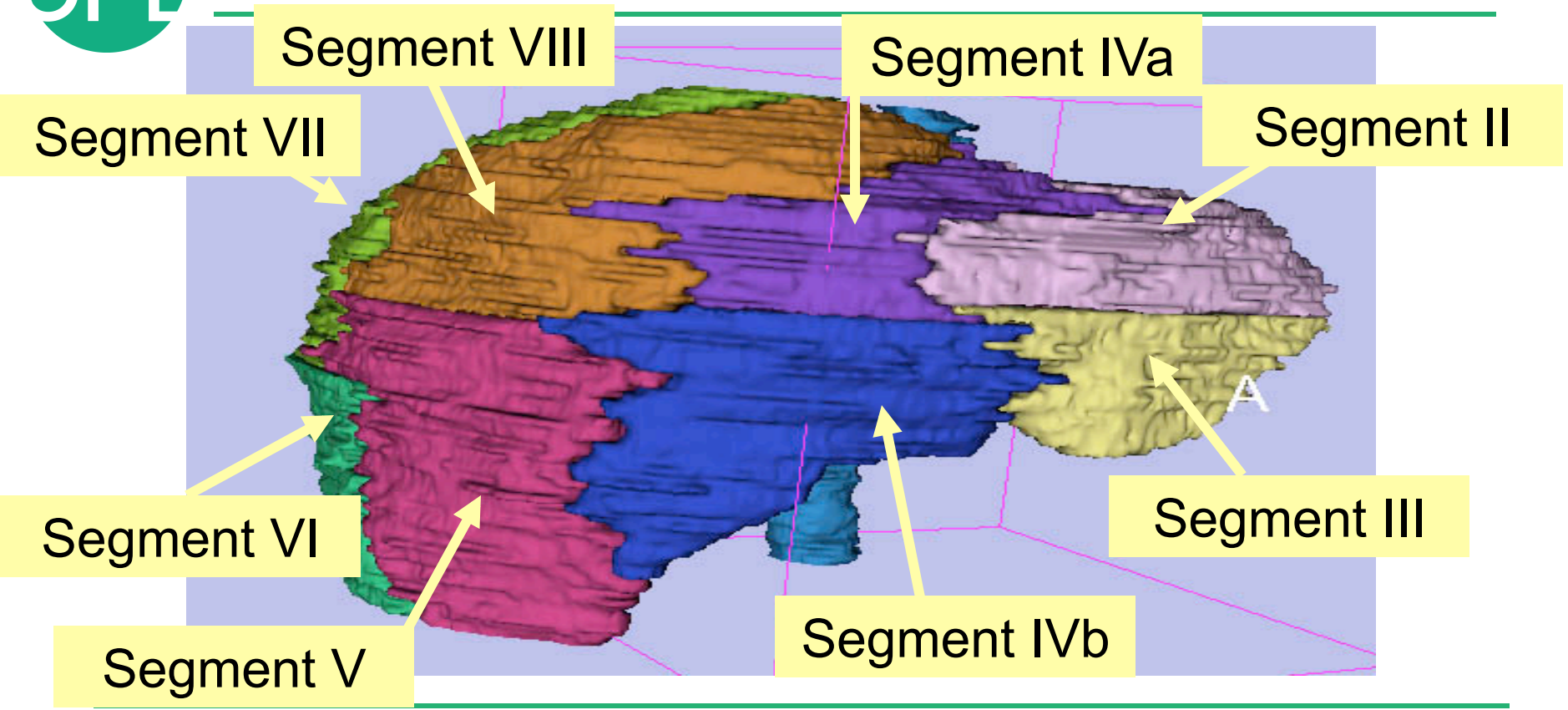
C:\Documents and Settings\Administrator\Desktop\3D\LiverData

Liver Segments Scene

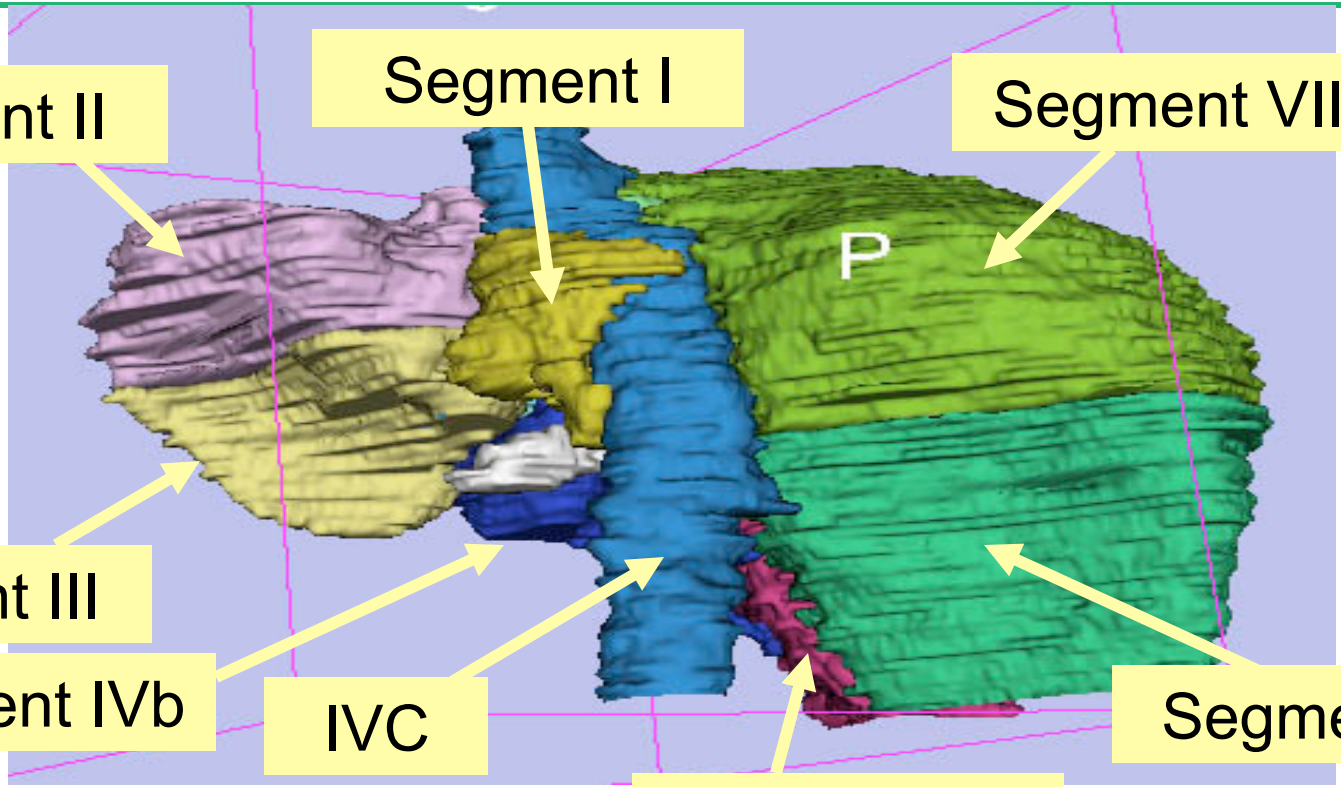
The elements of the scene appear in the Viewer



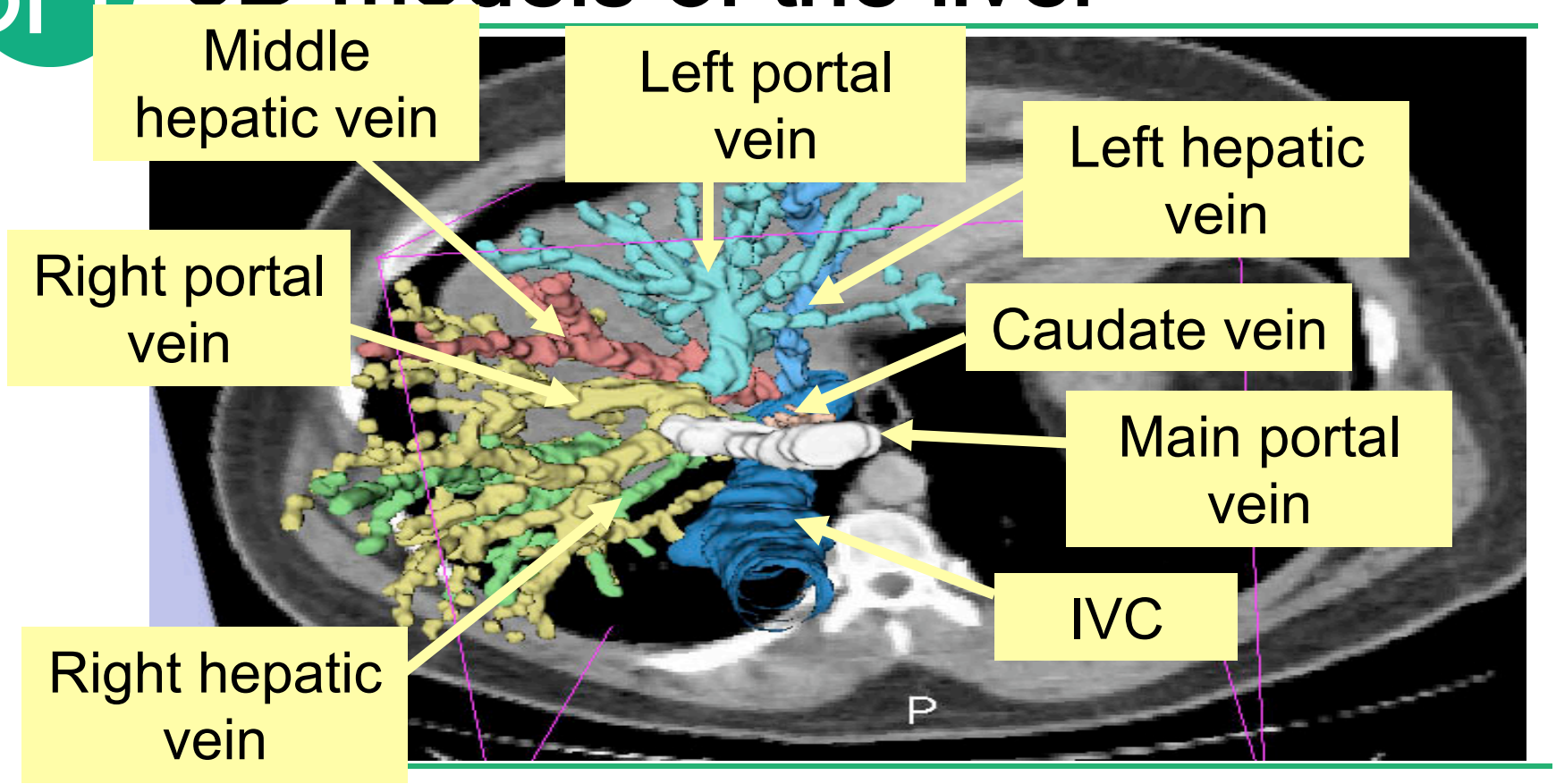
3D models of the liver



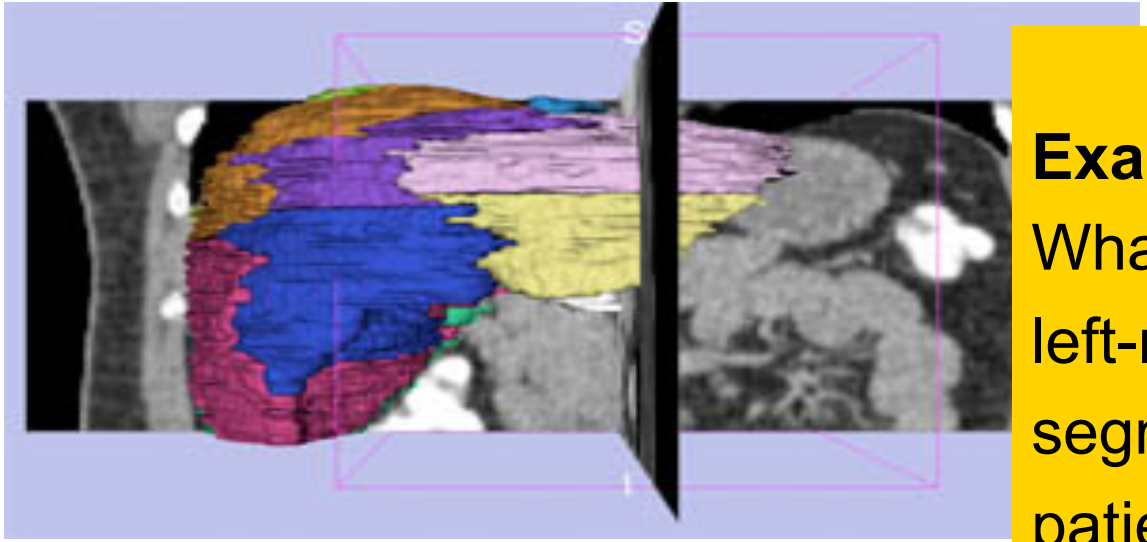
3D models of the liver



3D models of the liver



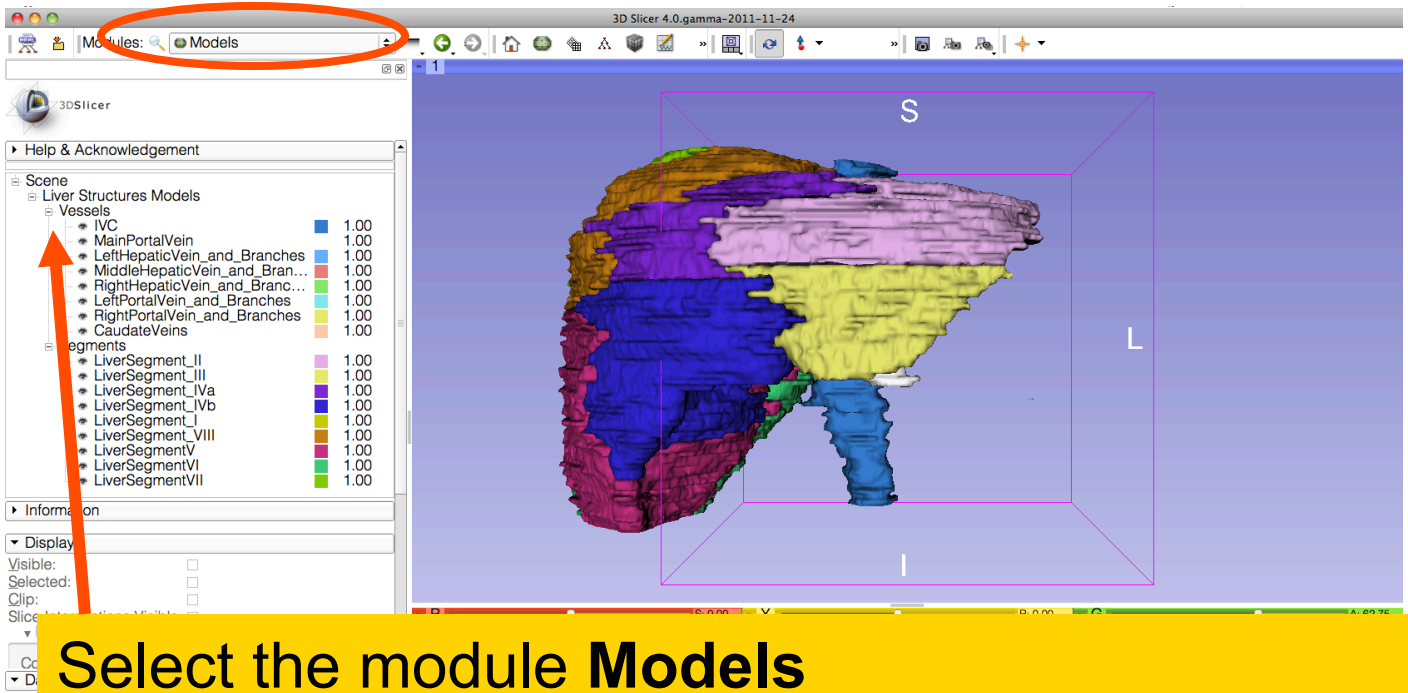
3D Exploration of Liver Segments



Example:

What organ abuts the left-most margin of segment II in this patient ?

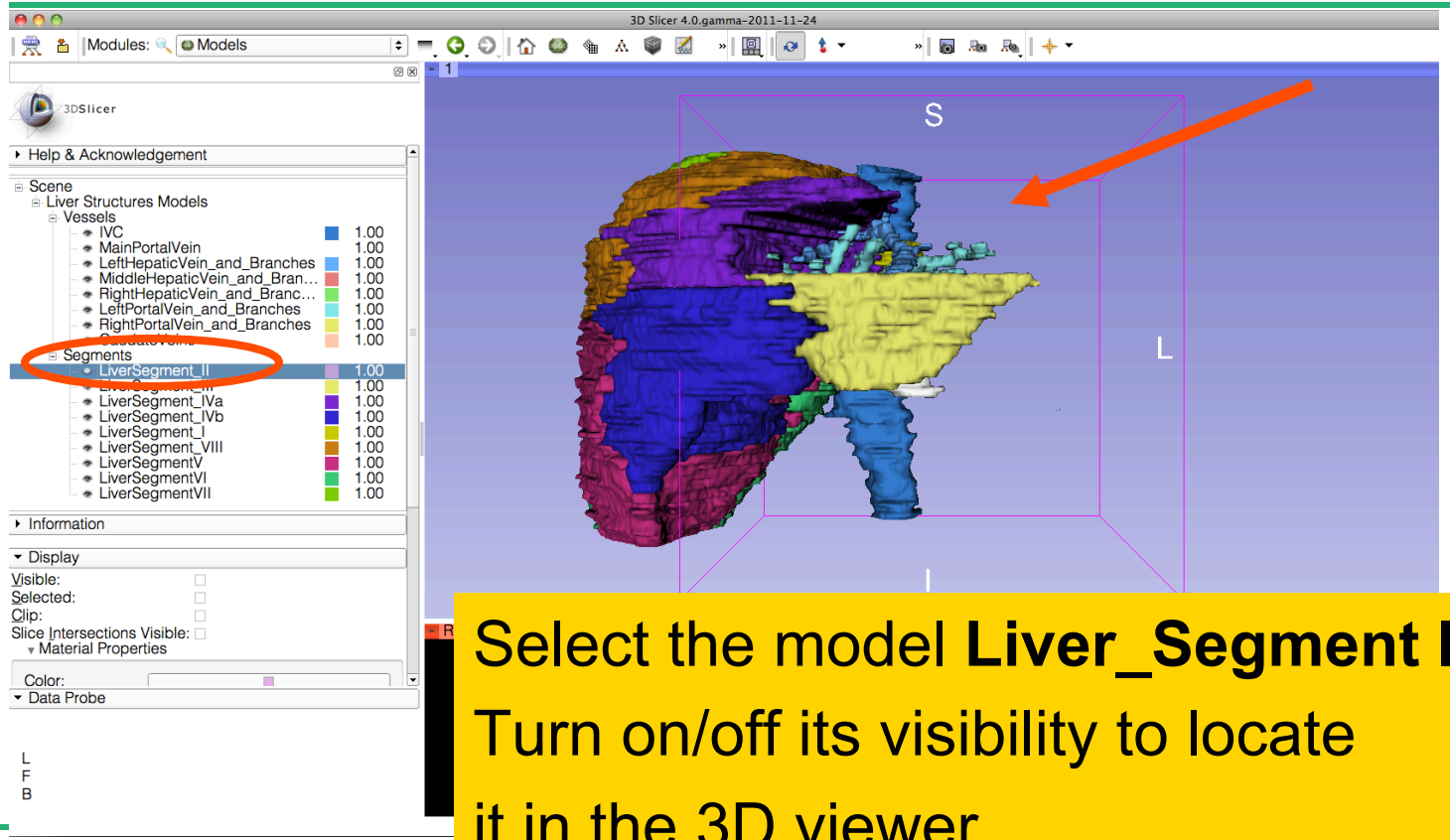
3D Exploration of Liver Segments



Select the module **Models**

Click on the Liver Structures Models Hierarchy

3D Exploration of Liver Segments

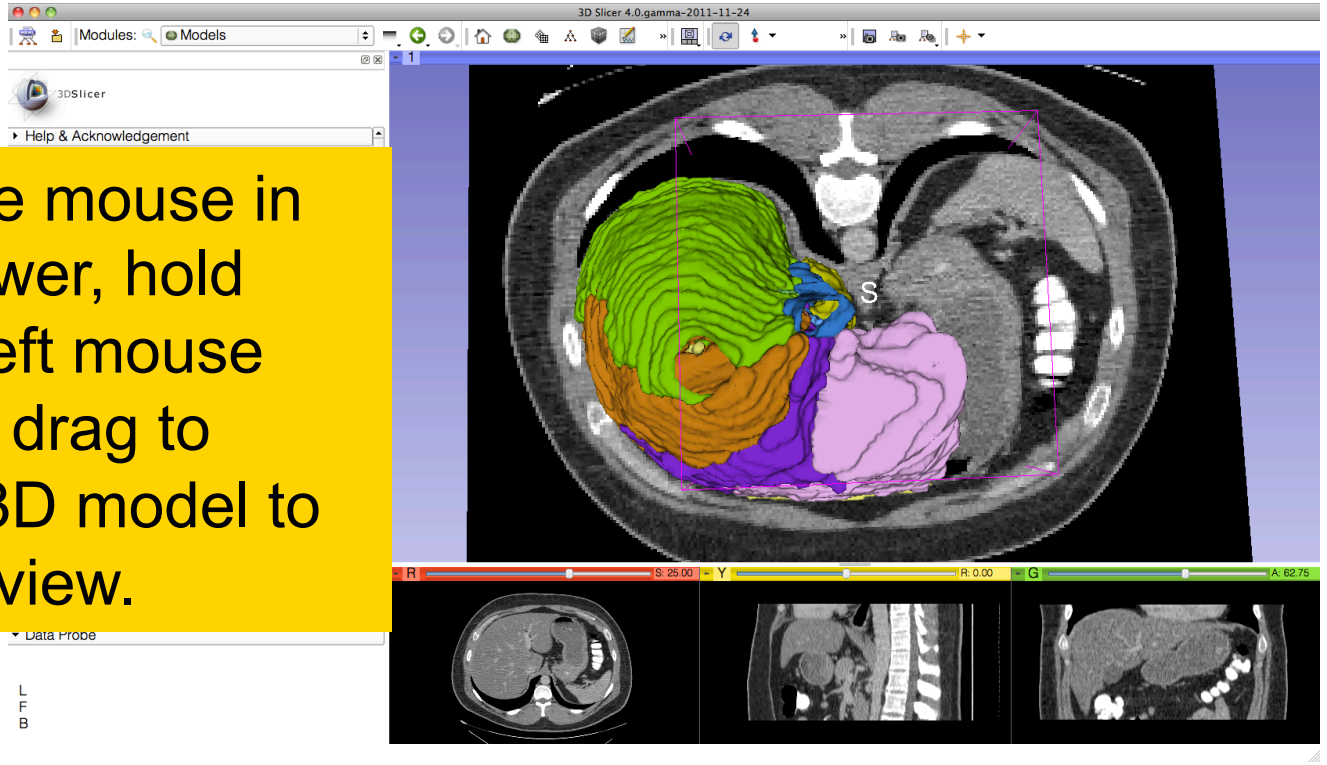


Select the model **Liver_Segment II**

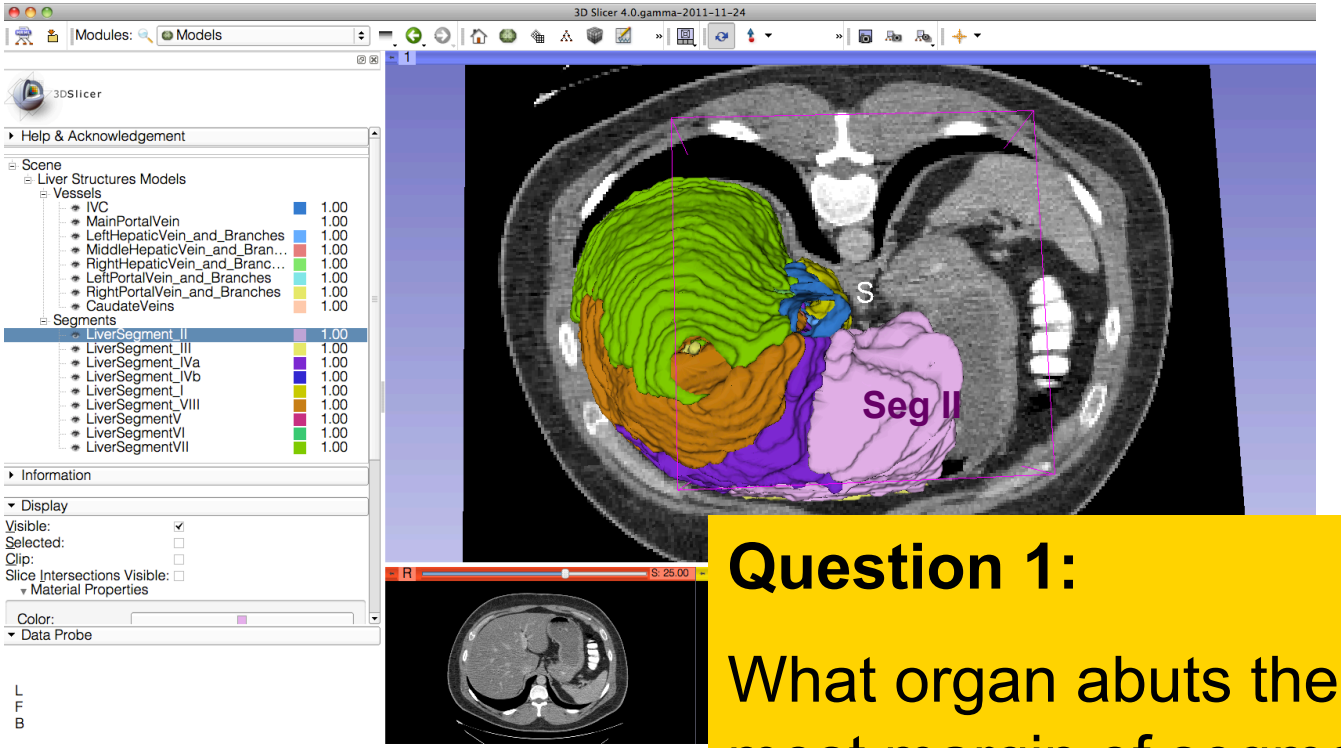
Turn on/off its visibility to locate it in the 3D viewer.

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:

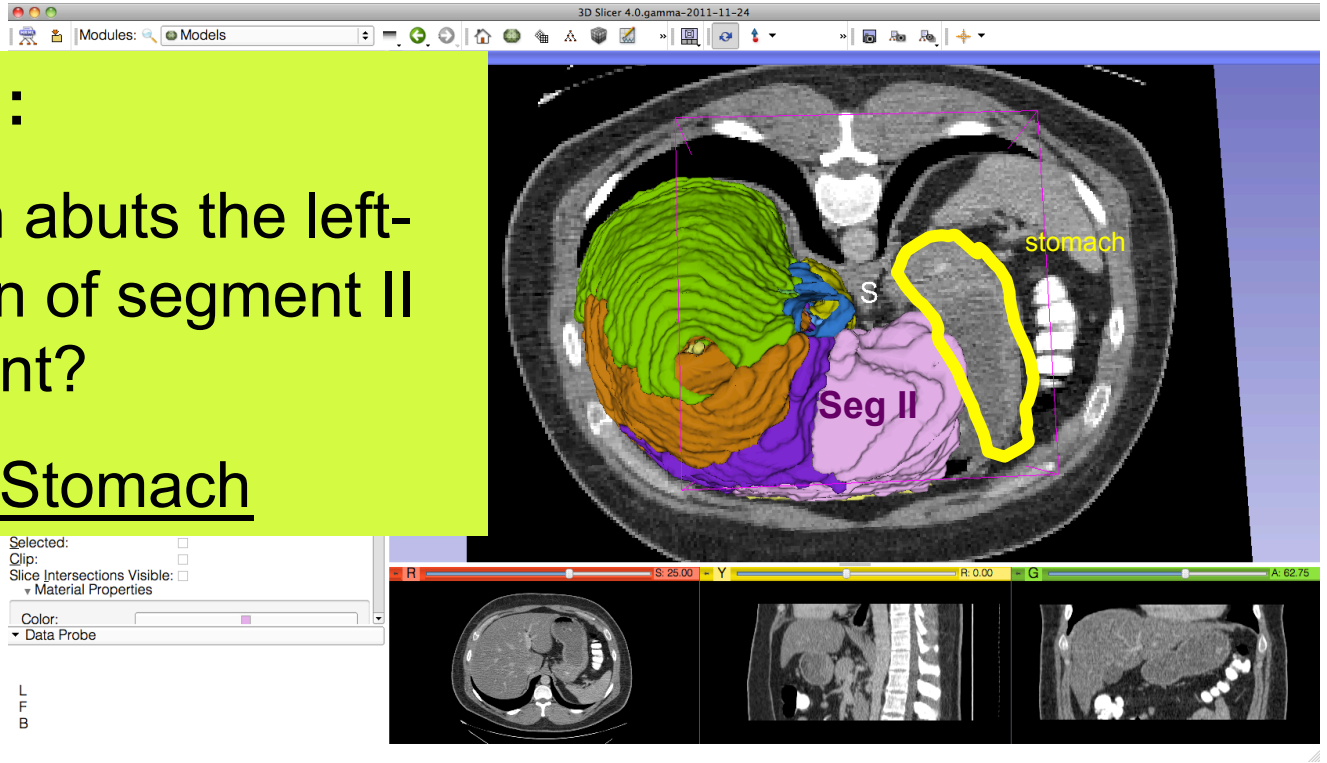
What organ abuts the left-most margin of segment II in Patient 1?

3D Exploration of Liver Segments

Question 1:

What organ abuts the left-most margin of segment II in this patient?

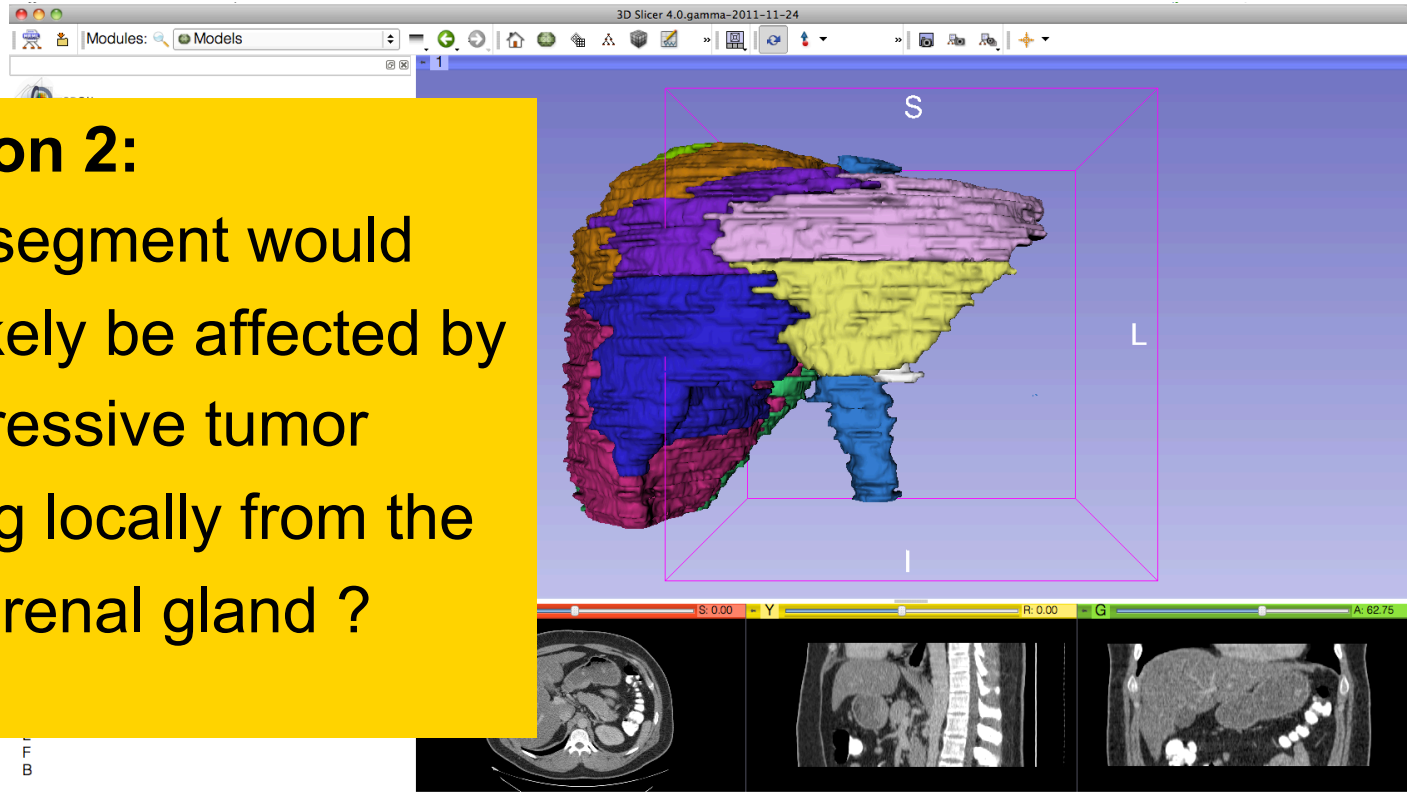
Answer 1: Stomach



3D Exploration of Liver Segments

Question 2:

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



3D Exploration of Liver Segments

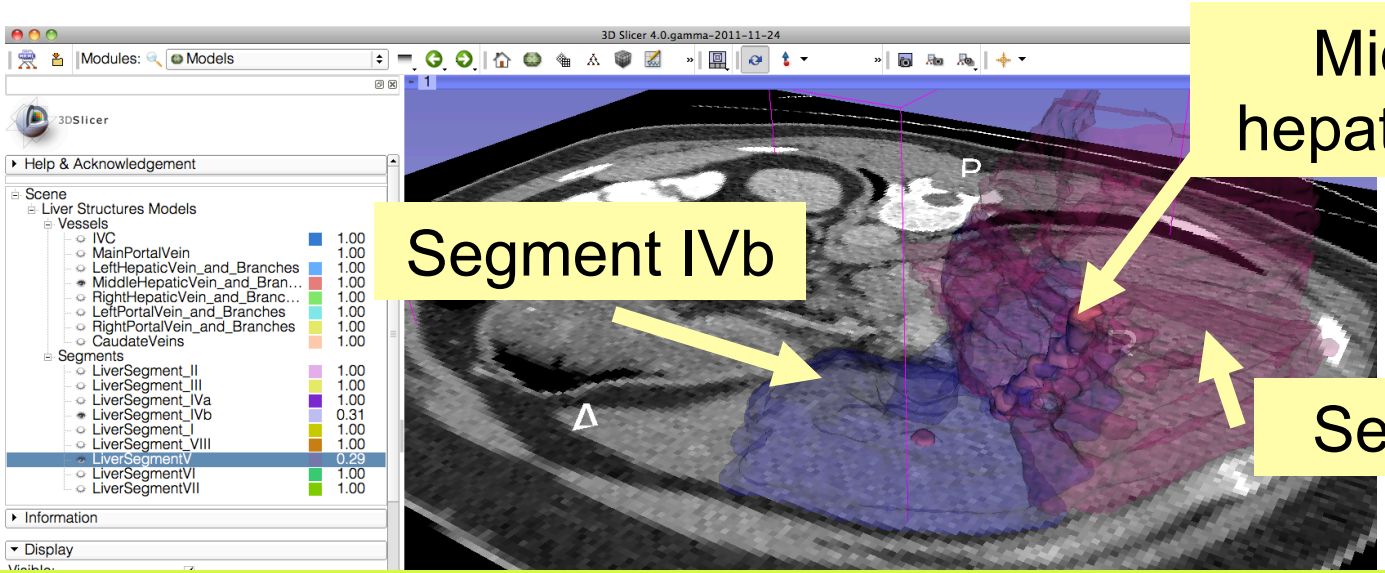
Question 2:
Which segment would most likely be affected by an aggressive tumor invading locally from the right adrenal gland ?
Answer 2: Segment VII

3D Exploration of Liver Segments

Question 3:

Which vessel separates Segment IVb and Segment V?

Middle Hepatic Vein



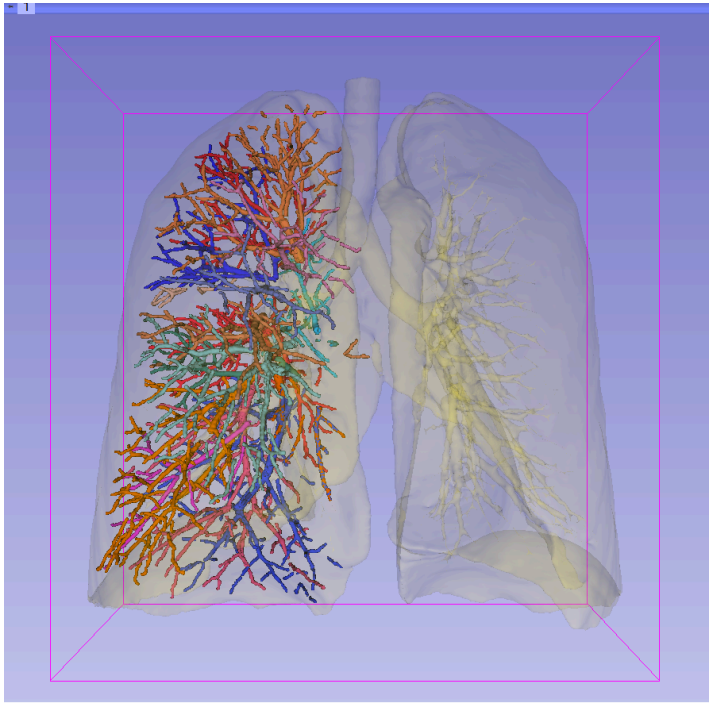
Question 3:

Which vessel separates Segment IVb and Segment V?

Answer 3: The middle hepatic vein

Closing the Liver Scene

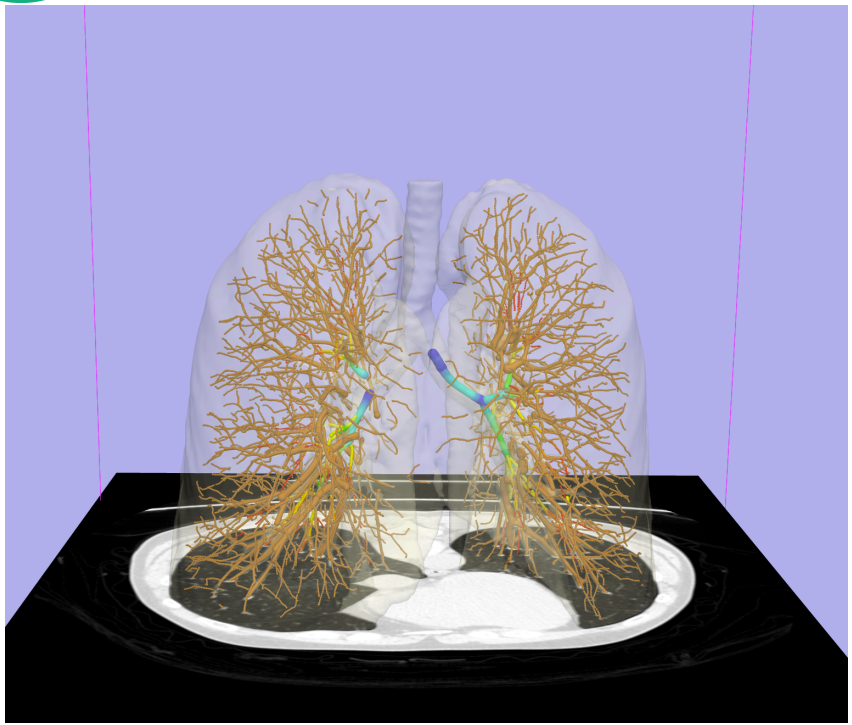
Select **File → Exit** to close the Liver Scene and exit Slicer



Part 4:

Interactive 3D Visualization of the segments of the lungs

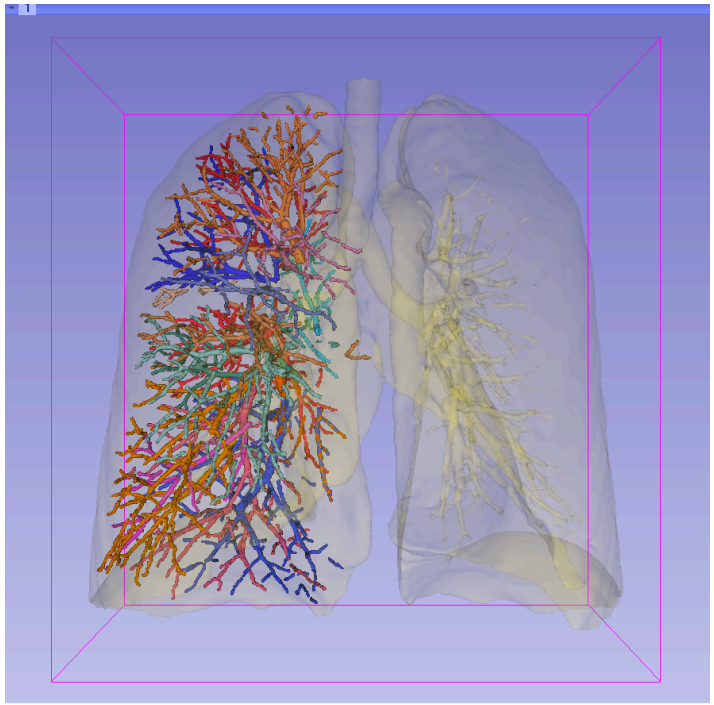
Segments of the lung



Segmentation and 3D surface reconstruction of the lung and pulmonary vessels

Acknowledgment:
Segmentation of the lung surface and vasculature: Raul San Jose Estepar, Ph.D., George Washko, M.D., Ed Silverman, M.D. and James Ross, MSc. Brigham and Women's Hospital, Boston, MA

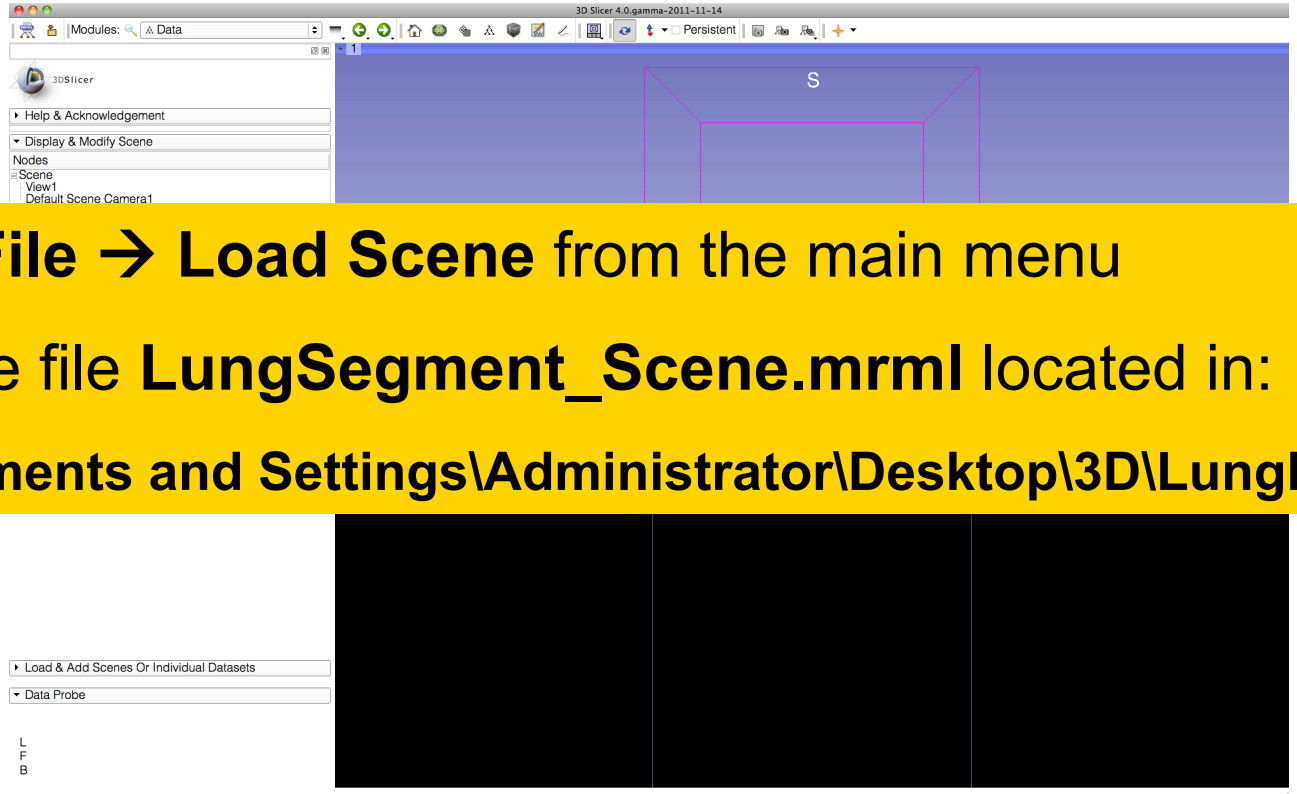
Segments of the lung



3D parcellation of arteries and veins from original model of pulmonary vessels
(Kitt Shaffer, M.D., Ph.D. - Sonia Pujol, Ph.D.)

- Right Upper Lobe (RUL)
  - RUL Pulmonary Vein
  - RUL Anterior Segment
  - RUL Apical Segment
  - RUL Posterior Segment
- Right Middle Lobe (RML)
  - RML Pulmonary Vein 1 & 2
  - RML Lateral Segment
  - RML Medial Segment
- Right Lower Lobe (RLL)
  - RLL Pulmonary Vein 1,2,3
  - RLL Anterior Basal Segment
  - RLL Medial Basal Segment
  - RLL Lateral Basal Segment
  - RLL Posterior Basal Segment

Loading the Lung Scene

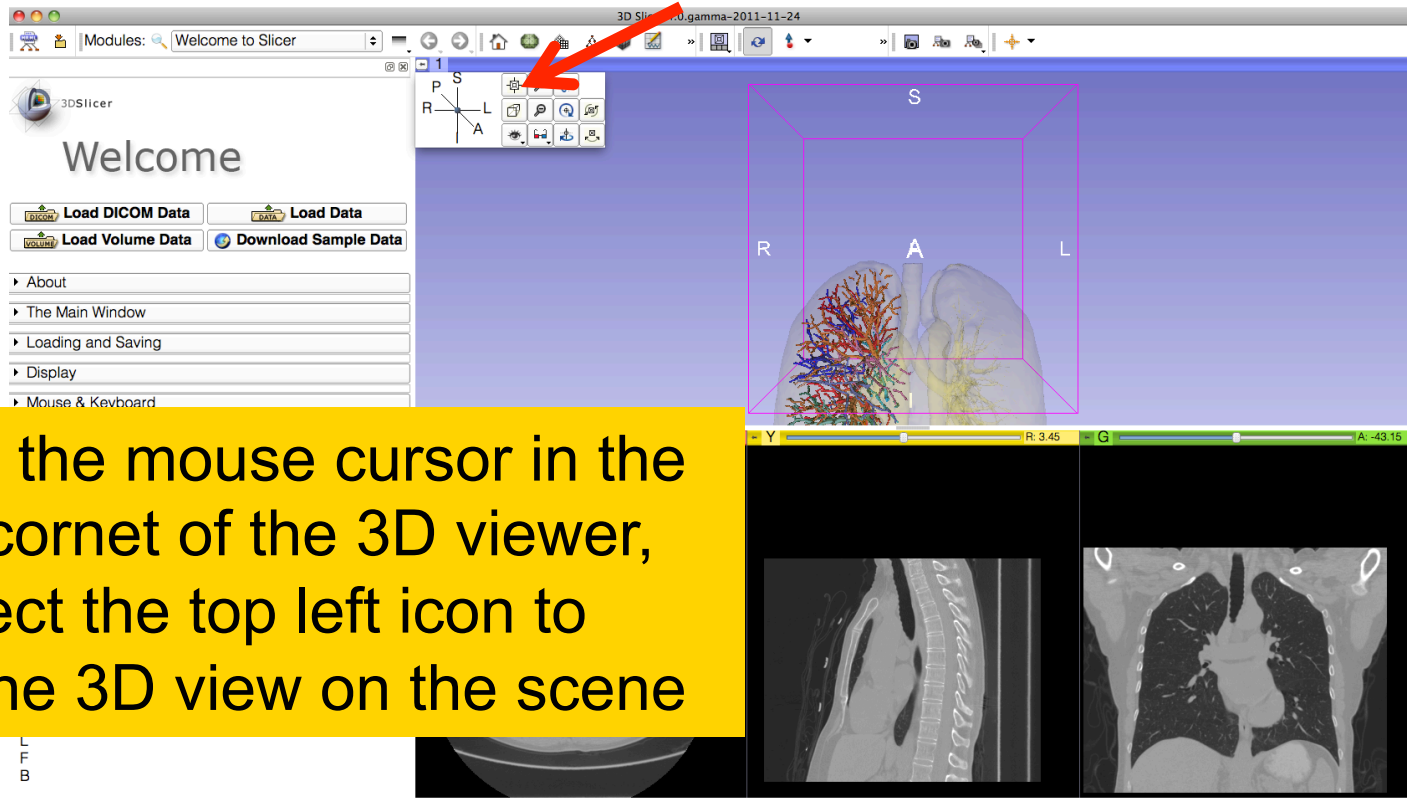


Select **File → Load Scene** from the main menu

Load the file **LungSegment_Scene.mrml** located in:

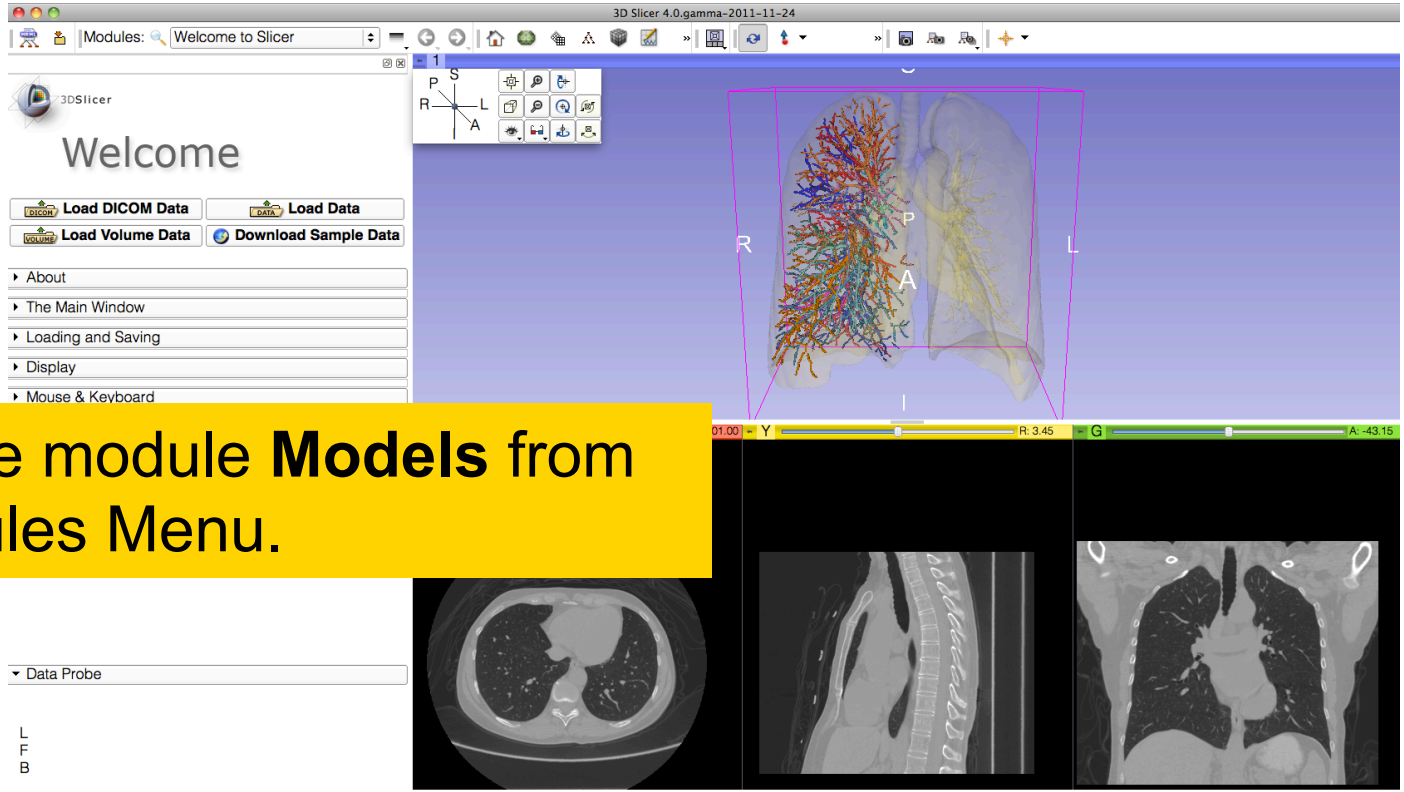
C:\Documents and Settings\Administrator\Desktop\3D\LungData

Loading the Lung Scene



Position the mouse cursor in the top left cornet of the 3D viewer, and select the top left icon to center the 3D view on the scene

Loading the Lung Scene

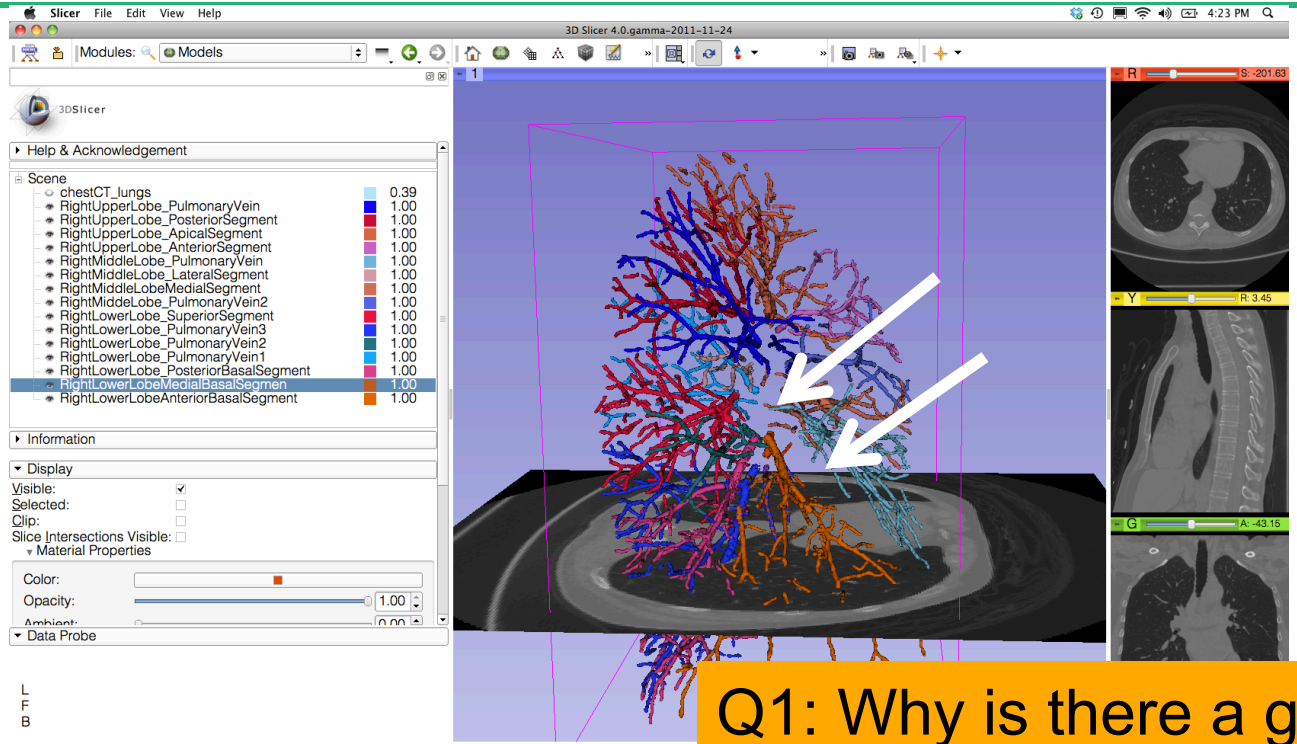


Select the module **Models** from the modules Menu.

Lung Segments

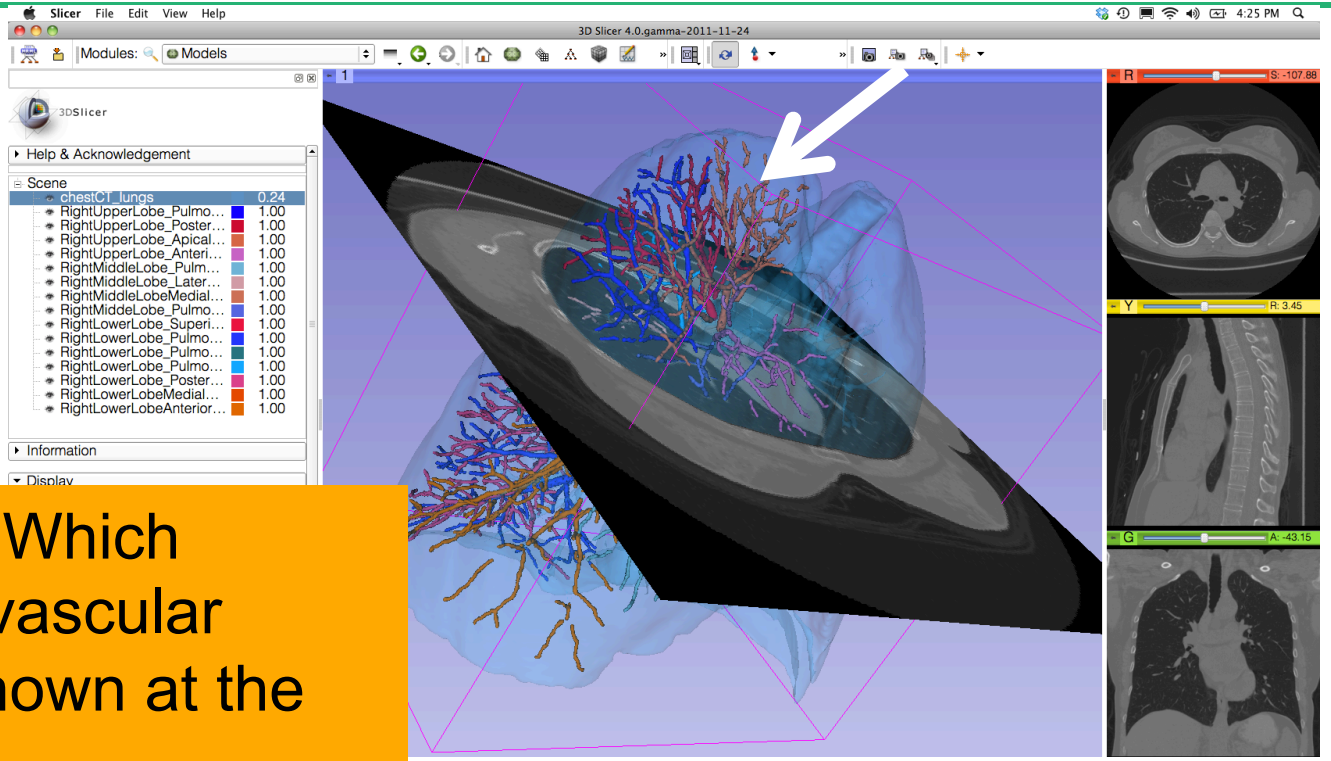
Slicer displays the list of 15 surface models of pulmonary structures.

Lung Segments – Question 1



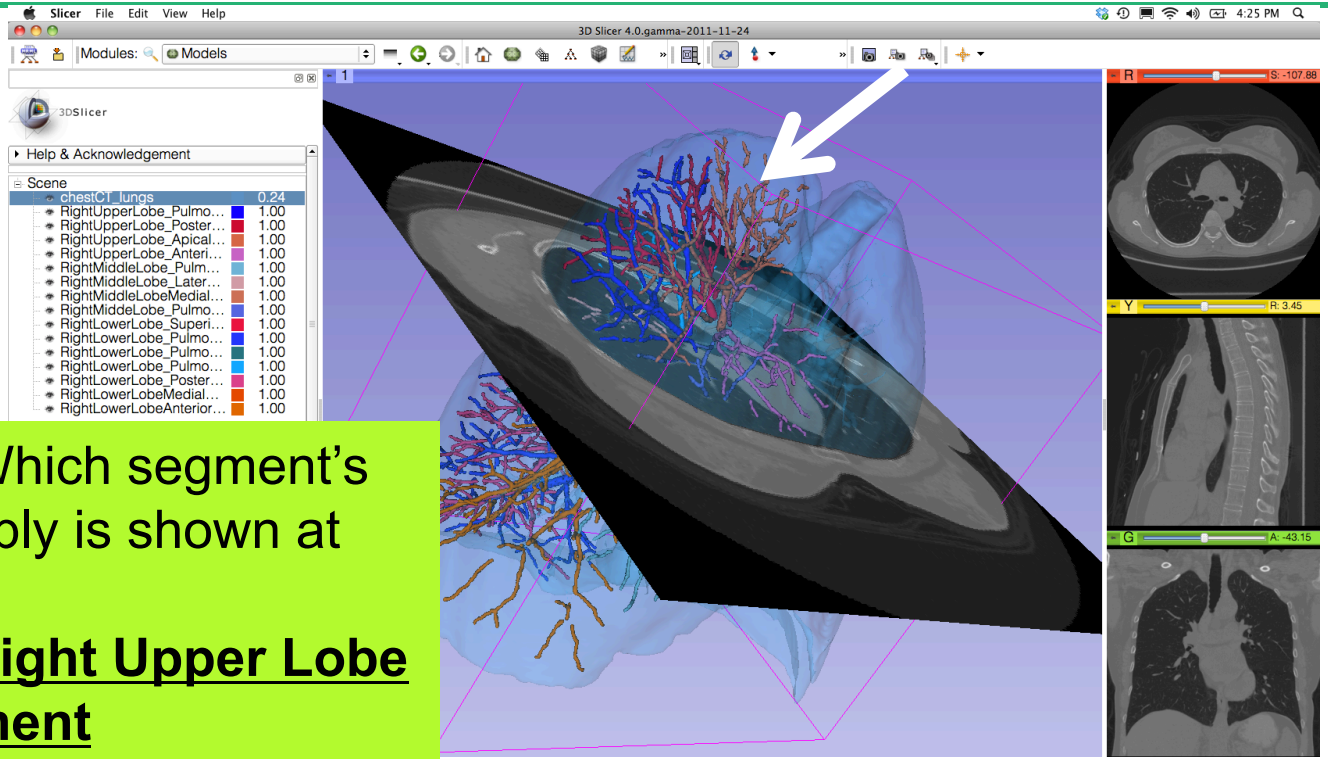
Q1: Why is there a gap in the vessels at the arrows?

Lung Segments – Question 2



Question 2:Which segment's vascular supply is shown at the arrow?

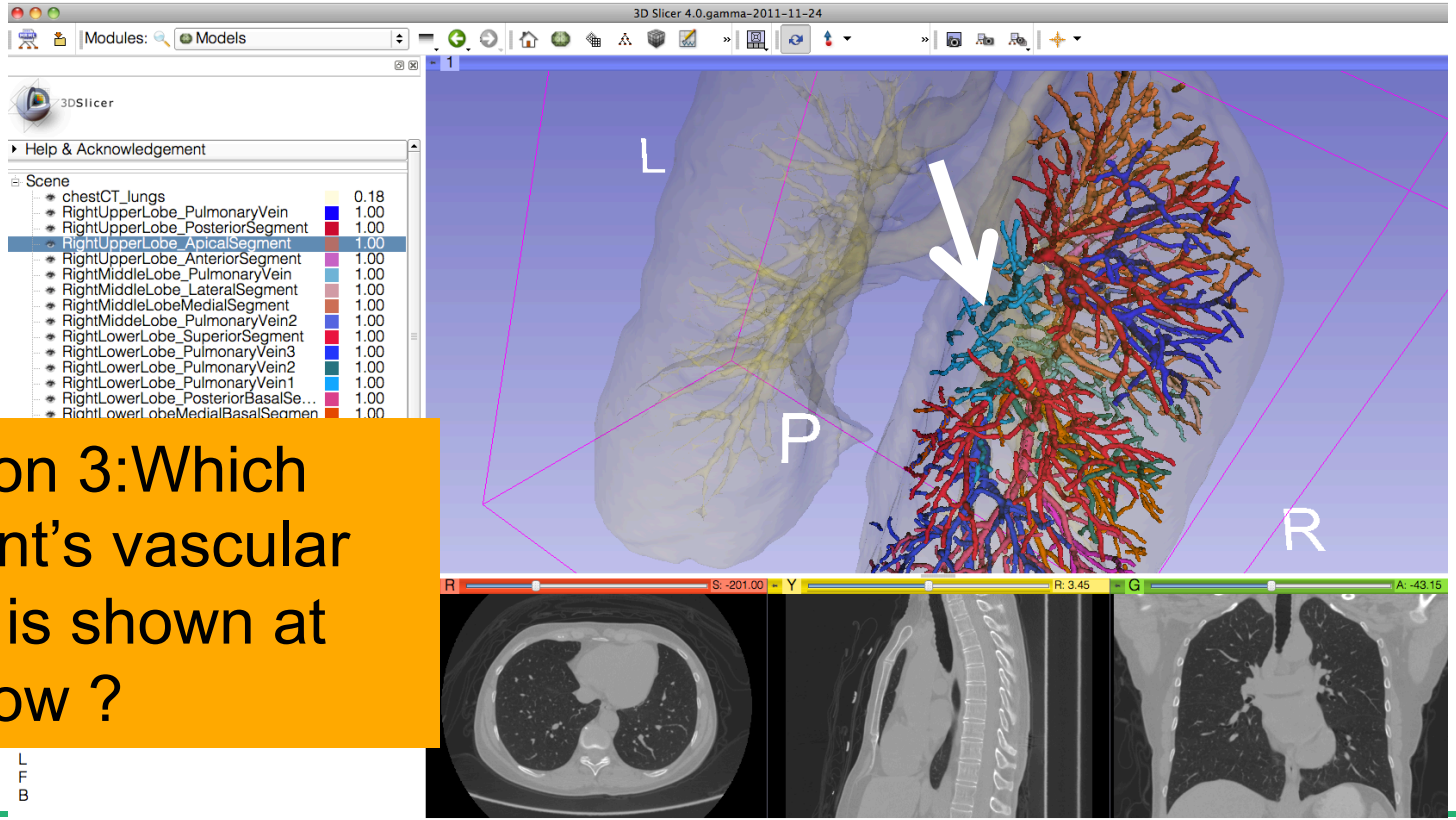
Lung Segments – Question 2



Question 2:Which segment's vascular supply is shown at the arrow?

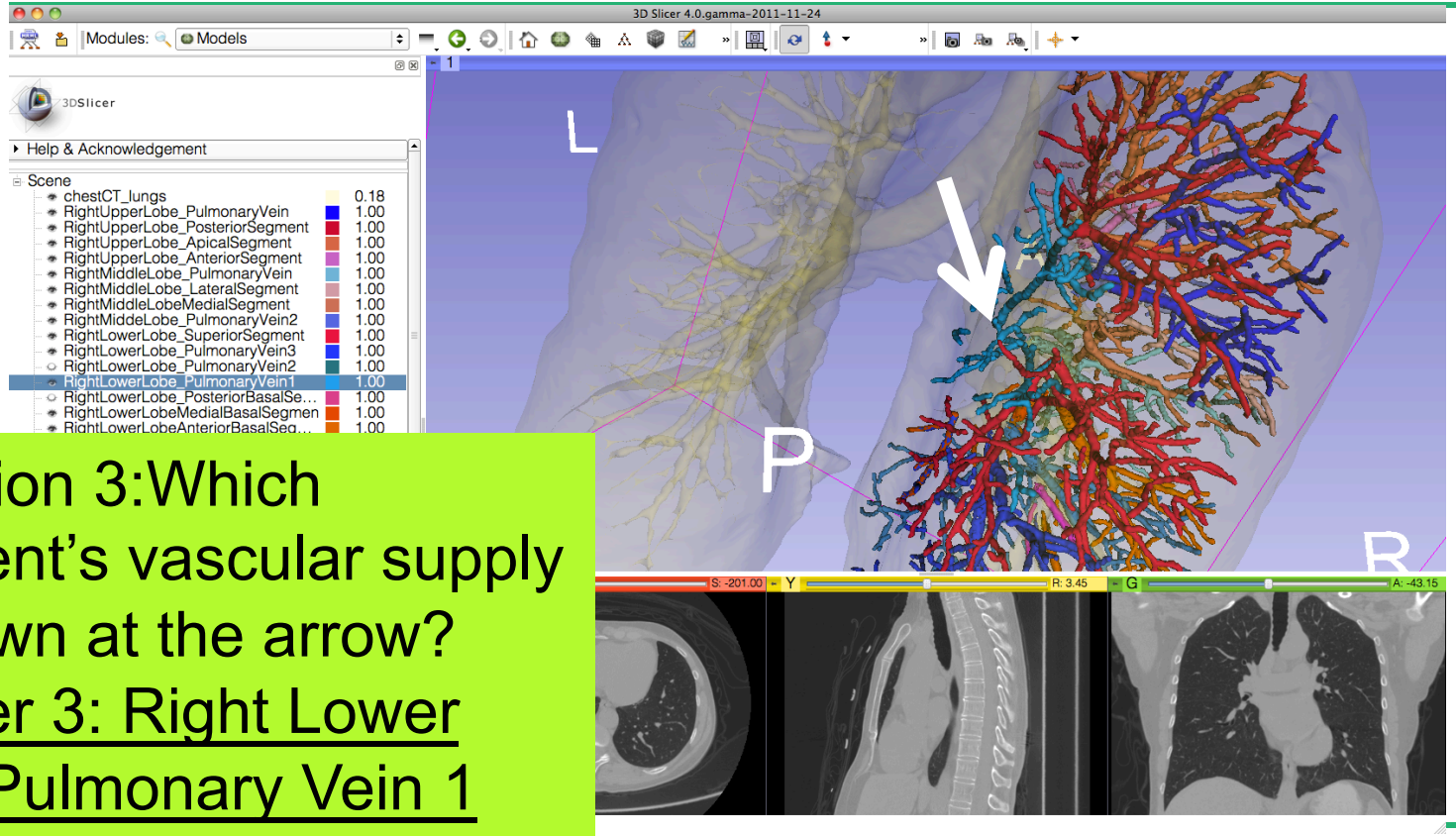
Answer 2: Right Upper Lobe Apical Segment

Lung Segments – Question 3



Question 3:Which segment's vascular supply is shown at the arrow ?

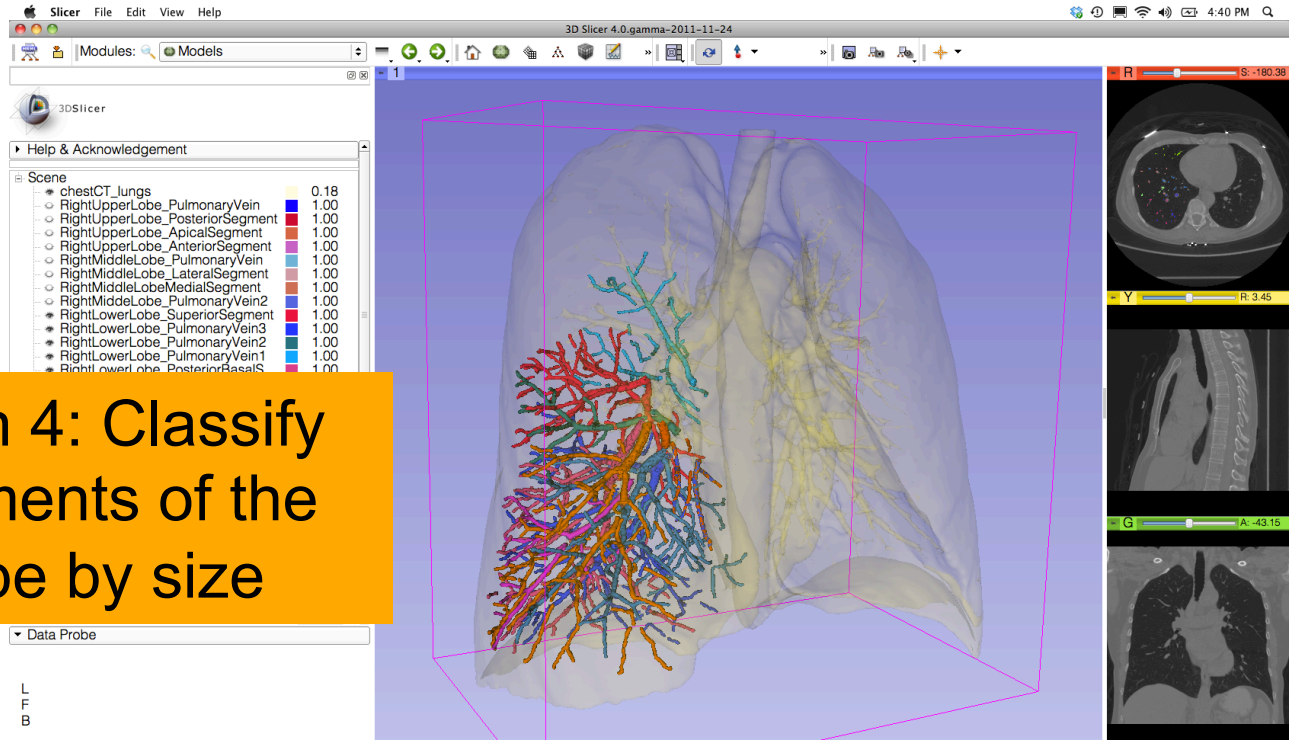
Lung Segments – Question 3



Question 3:Which segment's vascular supply is shown at the arrow?

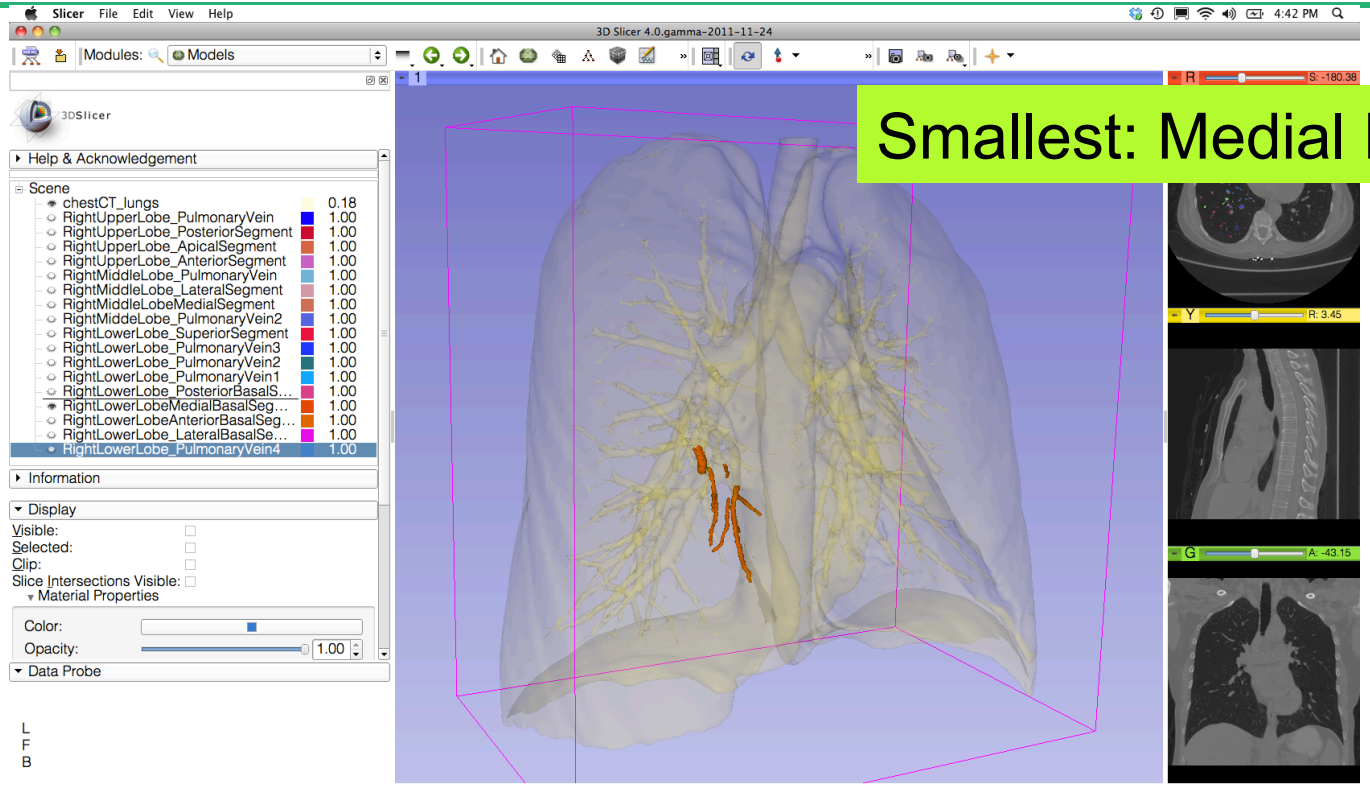
Answer 3: Right Lower Lobe Pulmonary Vein 1

Lung Segments – Question 4



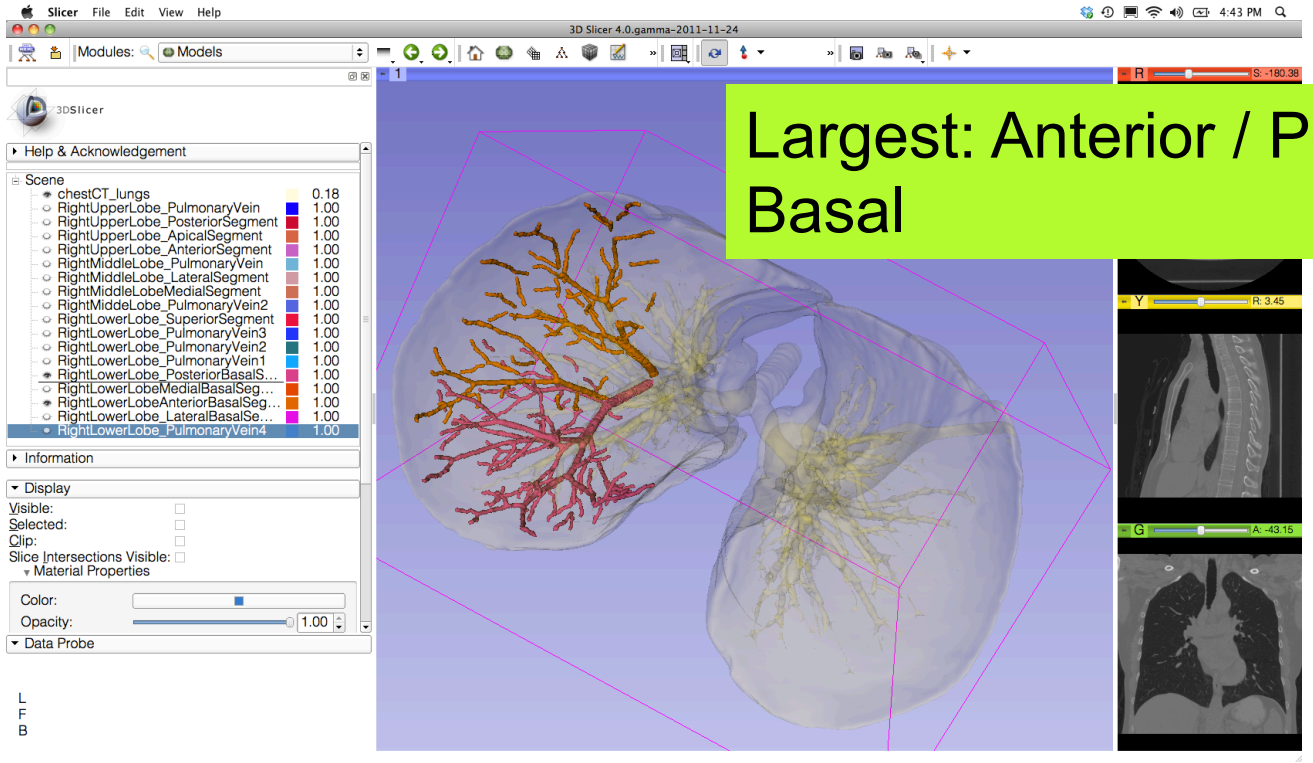
Question 4: Classify the segments of the lower lobe by size

Lung Segments – Question 4



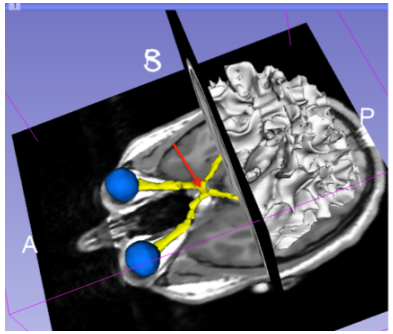
Smallest: Medial Basal

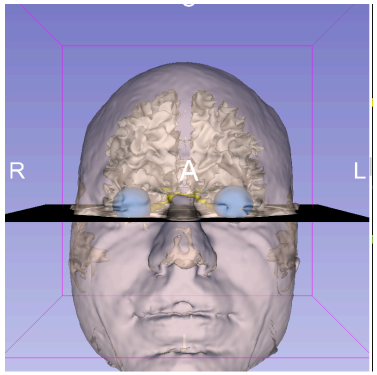
Lung Segments – Question 4

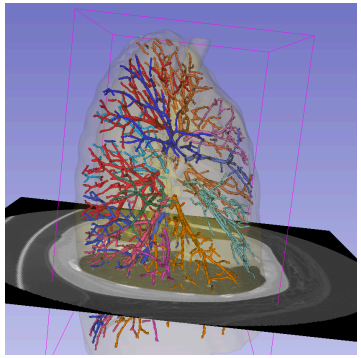


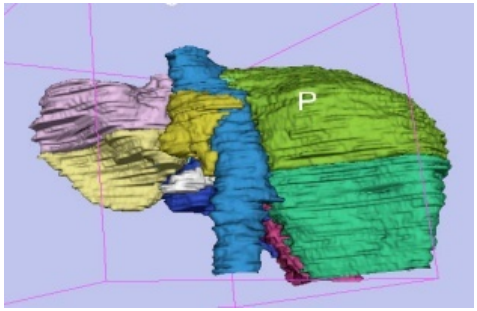
Largest: Anterior / Posterior Basal

3D Visualization of DICOM images









- Interactive user-interface to load and manipulate greyscale volumes, labelmaps and 3D models.
- User-defined 3D view of the anatomy
- 3D Open-source platform for Linux, Mac and Windows

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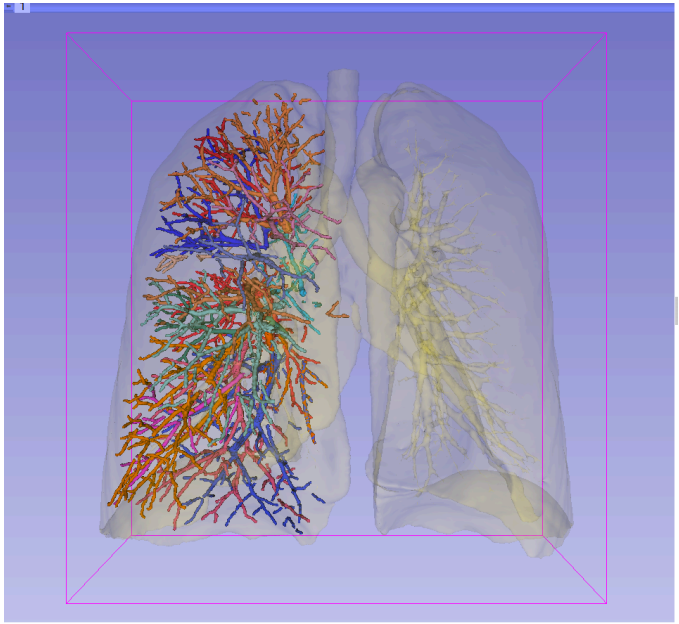
Neuroimage Analysis Center (NAC)
(NIH Grant P41 RR013218)



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Questions and comments: spujol@bwh.harvard.edu