



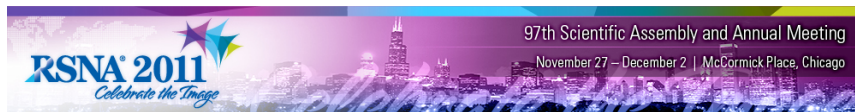
Surgical Planning Laboratory
Brigham and Women's Hospital
Boston, Massachusetts USA

a teaching affiliate of
Harvard Medical School

3D VISUALIZATION OF DICOM IMAGES FOR RADIOLOGICAL APPLICATIONS

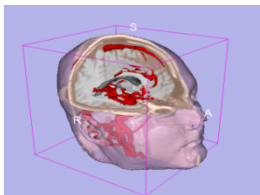
Sonia Pujol, Ph.D., Harvard Medical School
Director of Training, National Alliance for Medical Image Computing

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

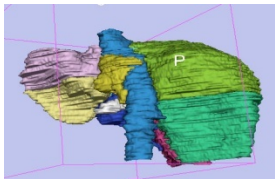




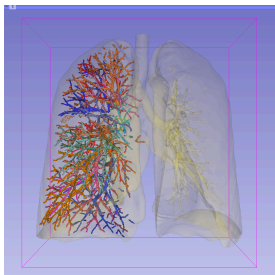
Overview



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



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

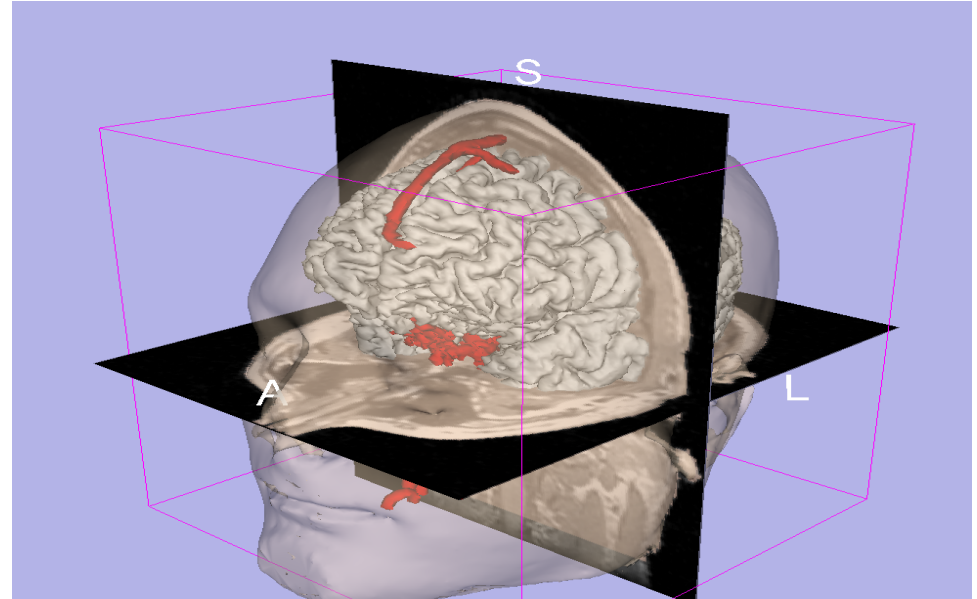


Part 3: 3D interactive exploration of the segments of the lung



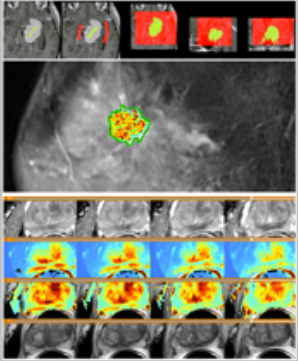
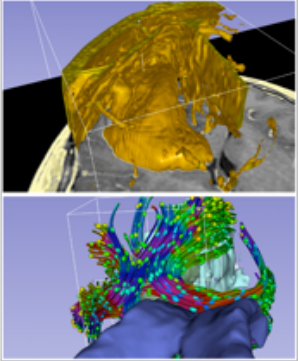
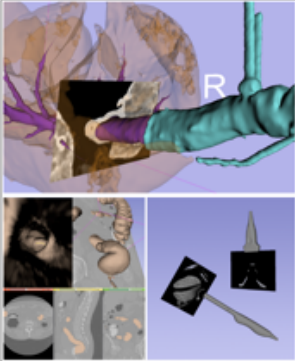

3D Visualization of the Anatomy

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

Powerful processing.	Streamlined interface.	Extensible platform.
		
 3D Slicer <i>version 4.0</i>		www.slicer.org

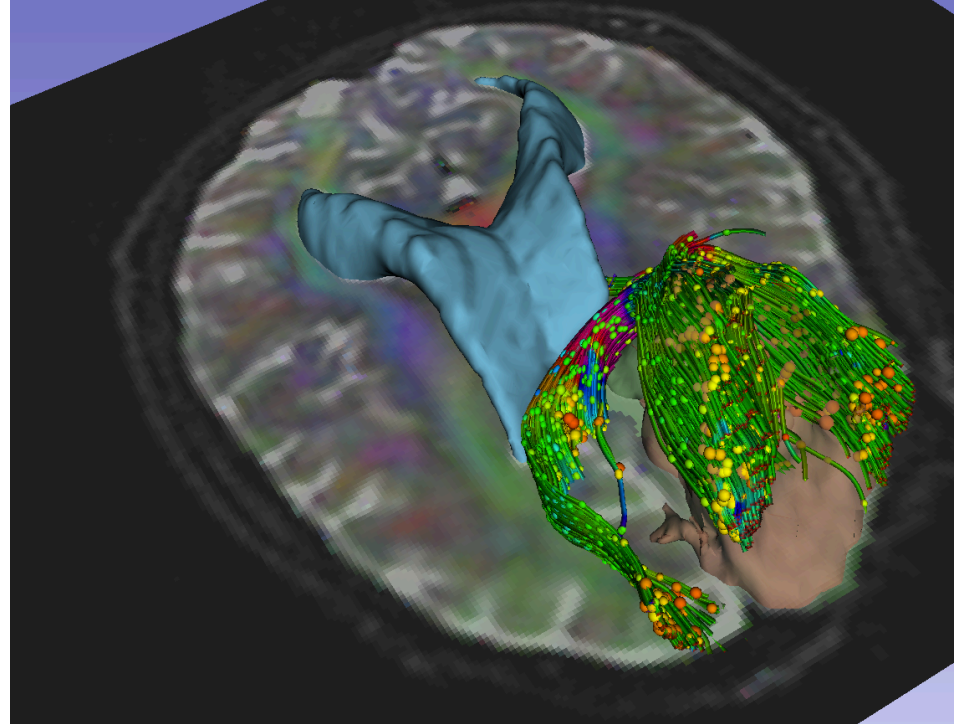
Slicer is a freely available **open-source** platform for segmentation, registration and 3D visualization of medical imaging data.

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)

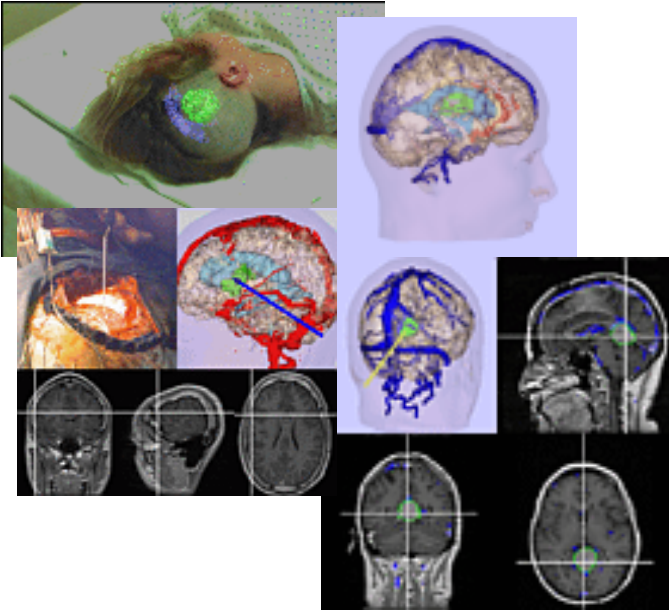
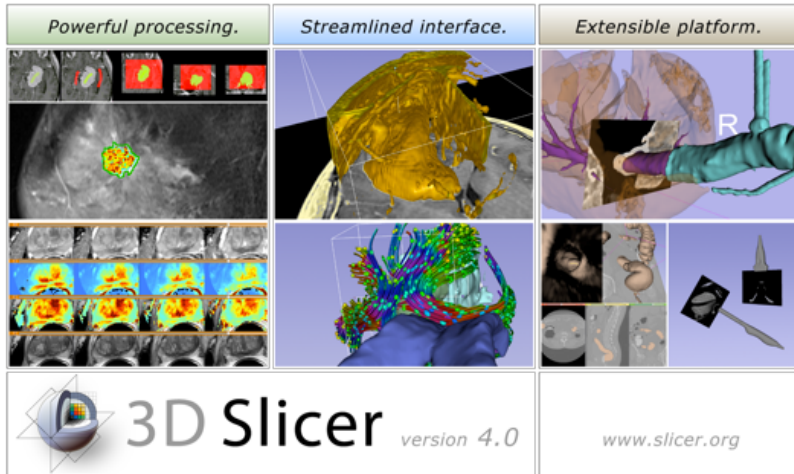


Image Courtesy of the CSAIL, MIT



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



National Alliance for Medical Image Computing

A National Center for Biomedical Computing
Funded under the NIH Roadmap Initiative

Meqool Custom Search Search

NA-MIC Wiki

General

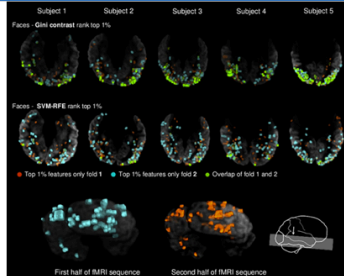
- Overview
- Organization
- Contact Us

Center Components

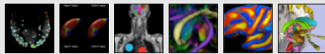
- Algorithms
- Engineering
- Dividing Biological Projects
- Collaboration Grants

Resources

- Publication DB
- Image Gallery
- Downloads
- Service
- Training
- Dissemination
- Events
- Links



Detecting Stable Distributed Patterns of Brain Activation using Gini Contrast [Read more...](#)



1 of 23 Photos

The National Alliance for Medical Image Computing (NA-MIC) is a multi-institutional, interdisciplinary team of computer scientists, software engineers, and medical investigators who develop computational tools for the analysis and visualization of medical image data. The purpose of the Center is to provide the infrastructure and environment for the development of computational algorithms and open-source technologies, and then oversee the training and dissemination of these tools to the medical research community.

Supported by the National Institutes of Health, [Roadmap Initiative](#).

Information about collaborating with NA-MIC is available [on our wiki](#).



97th Scientific Assembly and Annual Meeting

November 27 - December 2, McCormick Place, Chicago.

[Read more...](#)

[NEWS ARCHIVE](#)



Neuroimage Analysis Center

"understanding the human brain through imaging"

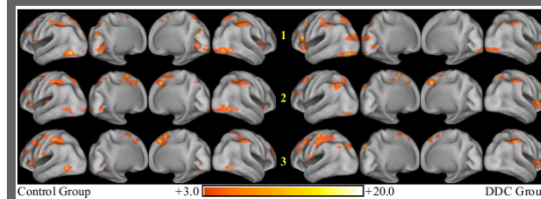
Google Custom Search

About the NAC

- Overview
- Organization
- Research Cores
- Collaborations

Resources

- Contact Us
- Publication DB
- Image Gallery
- Downloads
- Training Materials
- Web Archive



State-space Models of Mental Processes from fMRI

Spatial Activity Maps. The average t-score maps of the two groups (voxel-wise group average divided by group std. dev.) are displayed on an inflated brain-surface (left lateral-posterior, left medial-posterior, right medial-posterior and right lateral-posterior). Each row shows the maps for one phase of the task and values ≤ -3 have been masked out for clarity.

[More...](#)

[Featured Image Archive](#)

The Neuroimage Analysis Center (NAC) develops image processing and analysis techniques for basic and clinical neurosciences. The NAC research approach emphasizes both specific core technologies and collaborative application projects. The activities of the NAC are centered at the Harvard Medical School and the Surgical Planning Laboratory at the Brigham and Women's Hospital in Boston, with collaborators throughout the United States and the rest of the world.

The NAC is a major research center supported by the National Center for Research Resources (NCRR), a component of the National Institutes of Health.



P.I. Ron Kikinis, M.D.



Slicer: Behind the scenes

CDash - Slicer4

WARNING: This CDash instance is running the bleeding edge svn trunk CDash code, and is updated frequently. You

1 file changed by 1 author as of Sunday, November 27 2011 - 22:00 EST

Nightly-Packages

Site	Build Name	Update			Configure			Build		
		Files	Error	Warn	Error	Warn	Error	Warn	Pass	
factory-win7.kitware	Windows7-VS2010-32bits-QT4.7.1-PythonQt-With-Tcl-CLI-Release	0	0	0	2 ⁰	0	2 ⁰	107		
factory-mac-64bits.kitware	SnowLeopard-g++4.2.1-64bits-QT4.7-PythonQt-With-Tcl-CLI-Release	1	0	0	0	0	14 ⁰	3		
factory-ubuntu-64bits.kitware	Linux-g++4.4.3-64bits-QT4.7-PythonQt-With-Tcl-CLI-Release	1	0	0	0	0	13 ⁰	3		
factory-win7.kitware	Windows7-VS2008-64bits-QT4.7.1-PythonQt-With-Tcl-CLI-Release	0	0	0	0	0	1000 ⁰	223		
factory-win7.kitware	Windows7-VS2008-32bits-QT4.7.1-PythonQt-With-Tcl-CLI-Release	1	0	0	0	0	1000 ⁰	223		

Nightly

Site	Build Name	Update			Configure			Build			Test			Build Time
		Files	Error	Warn	Error	Warn	Error	Warn	Not Run	Fail	Pass			
whitecube.kitware	SnowLeopard-gcc4.2.1-QT4.7.0-PythonQt-With-Tcl-Release	1	0	0	27	0	190	0	96	391		11 hours ago		
youpi.sci.utah.edu	OpenSuse-c++4.5.0-64bits-QT4.6.3-PythonQt-With-Tcl-NoCLI-Release	0	0	0	0	0	15	0	304	6		11 hours ago		
eris.kitware	Linux-g++4.4-QT4.6.3-PythonQt-CLI-Release	1	0	0	0	0	15 ⁰	2	36 ⁰	451 ⁰		3 hours ago		
factory-ubuntu-64bits.kitware	Linux-g++4.4.3-QT4.7-PythonQt-With-Tcl-CLI-Valgrind-Release	0	0	0	0	0	13 ⁰	3	27 ⁰	460 ⁰		11 hours ago		
factory-ubuntu-64bits.kitware	Linux-g++4.4.3-64bits-QT4.7-PythonQt-With-Tcl-NoCLI-Coverage-Release	0	0	0	0	0	12 ⁰	3	23 ⁰	287 ⁰		11 hours ago		
sagarmatha.kitware	Linux-g++4.4.3-QT4.7-PythonQt-With-Tcl-NoCLI-Release	0	0	0	0	0	12 ⁰	3	22	288		12 hours ago		

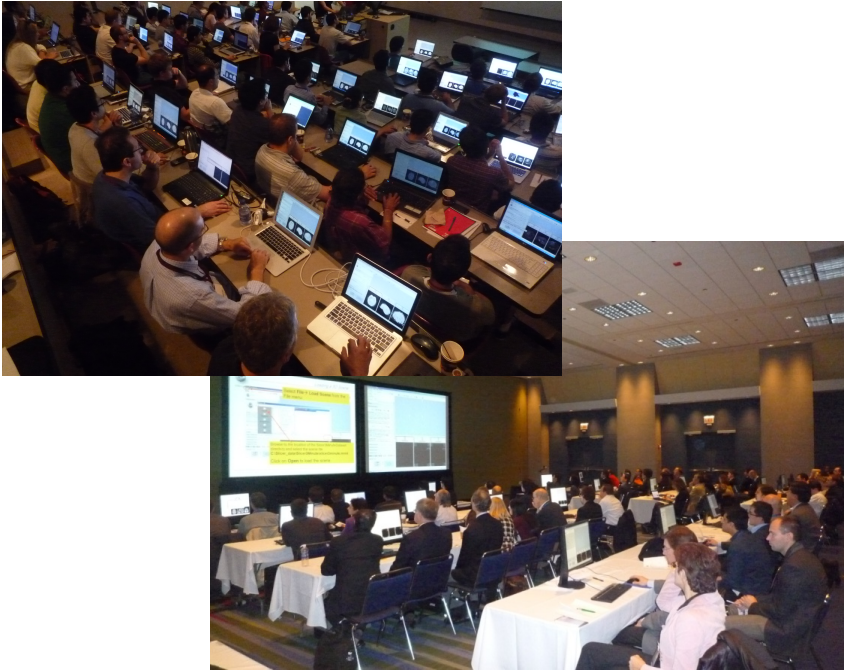
Continuous

Site	Build Name	Update			Configure			Build			Test			Build Time
		Files	Error	Warn	Error	Warn	Error	Warn	Not Run	Fail	Pass			
youpi.sci.utah.edu	OpenSuse-c++4.5.0-64bits-QT4.6.3-PythonQt-With-Tcl-NoCLI-Release	2	0	0	0	0	0	0	304	6		1 hour ago		

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



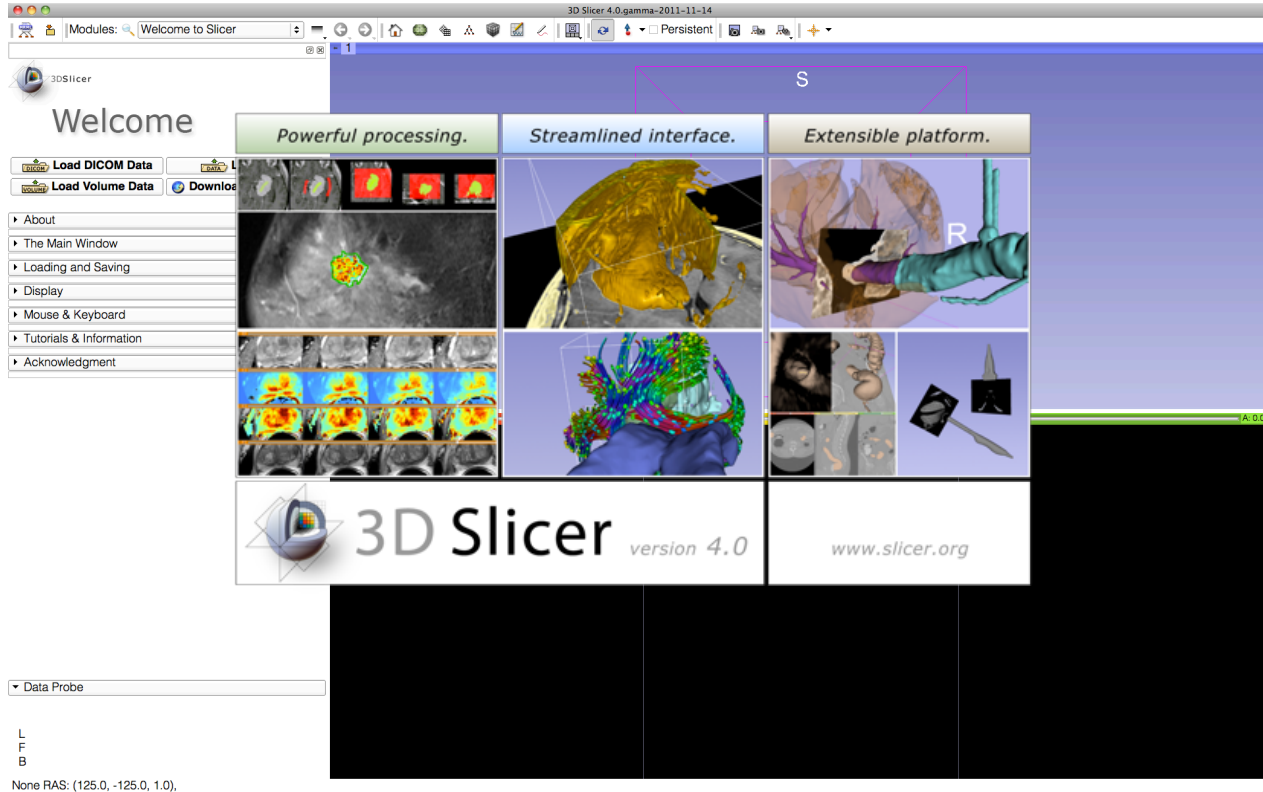
Slicer Training



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

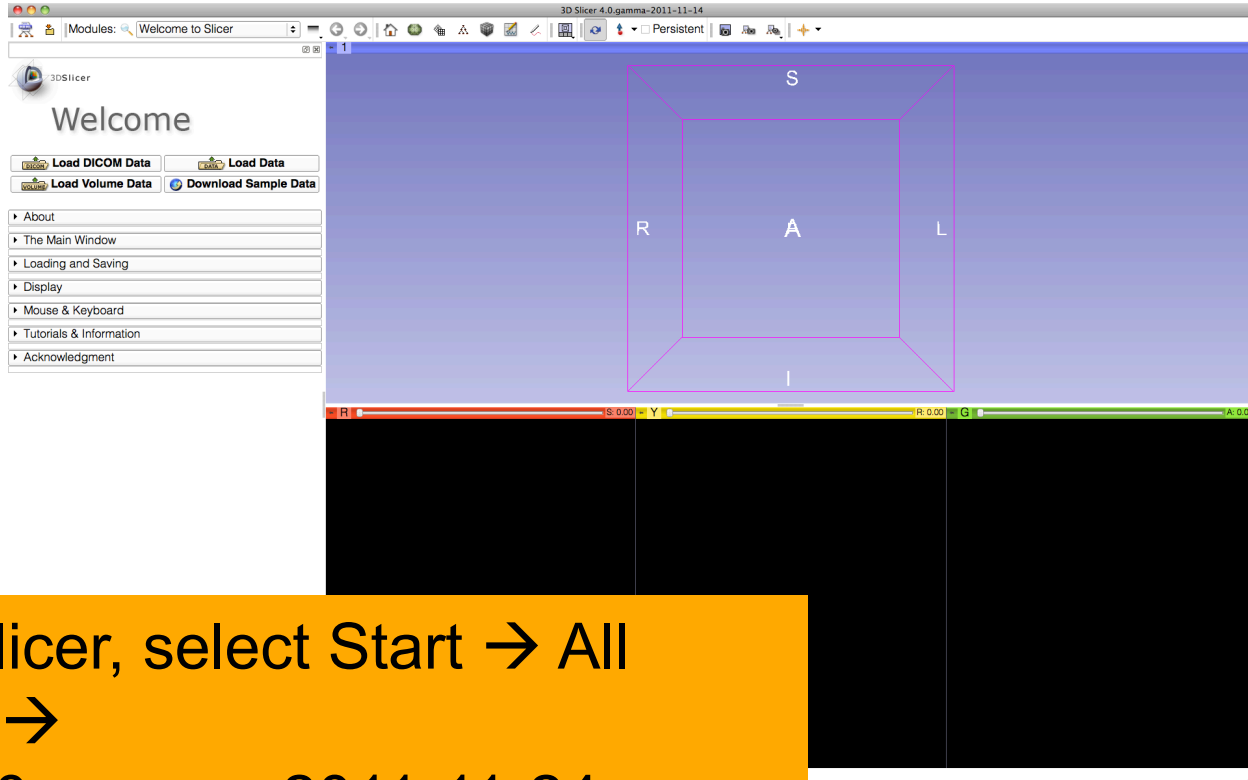


3DSlicer version 4.0





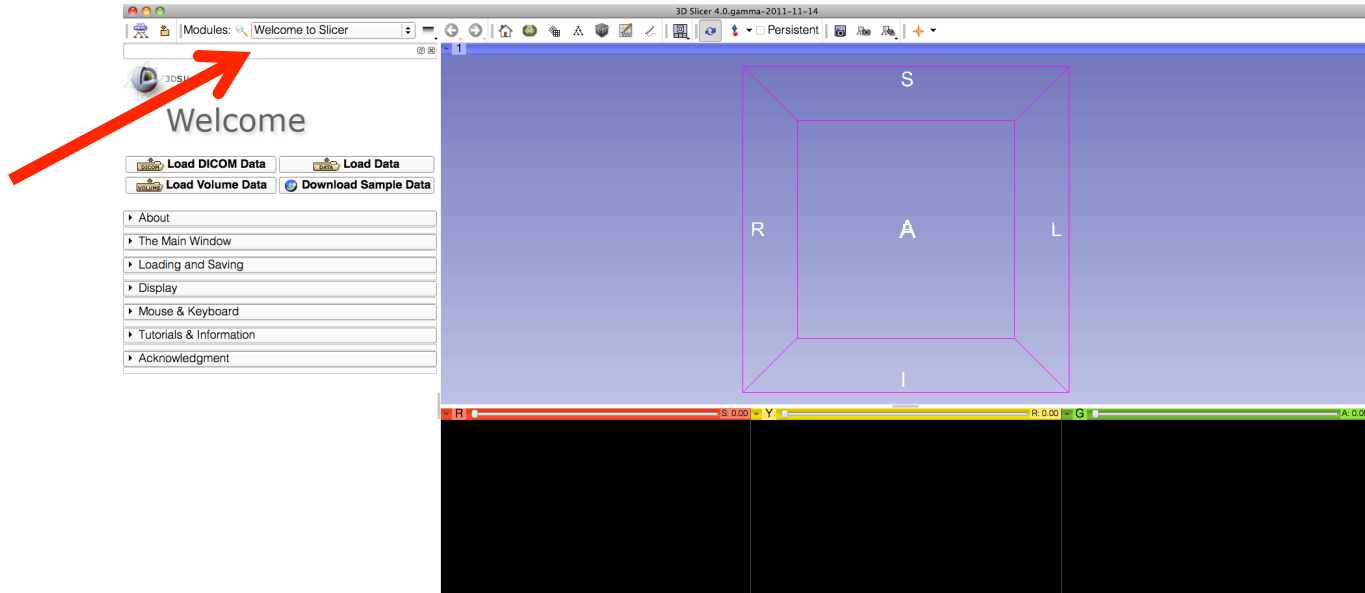
Welcome to Slicer4



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



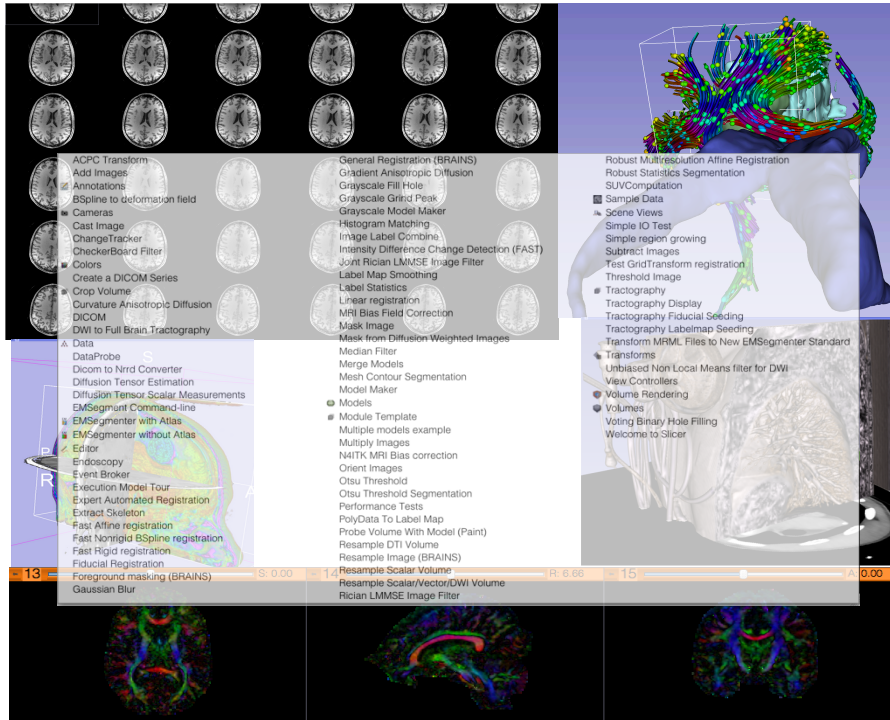
Welcome to Slicer4



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

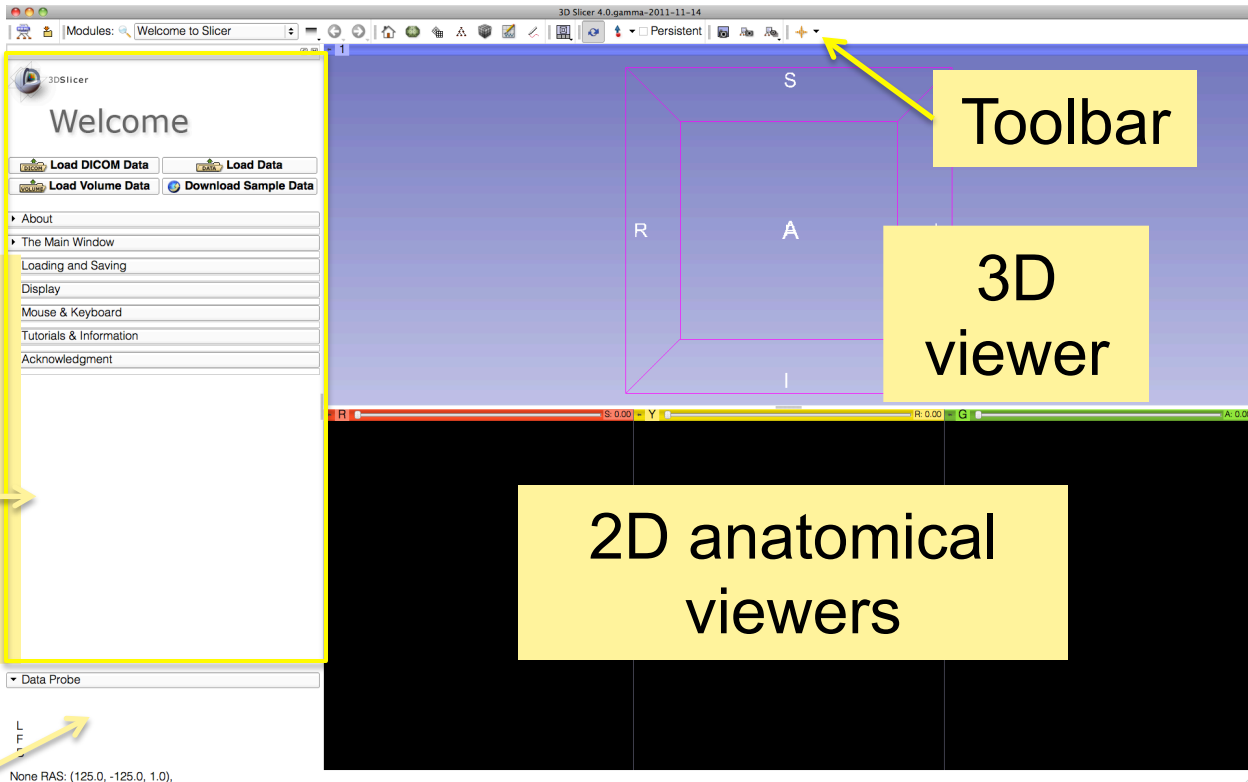


Slicer User Interface

Main Menu

GUI panel of the Slicer Welcome Module

Data Probe



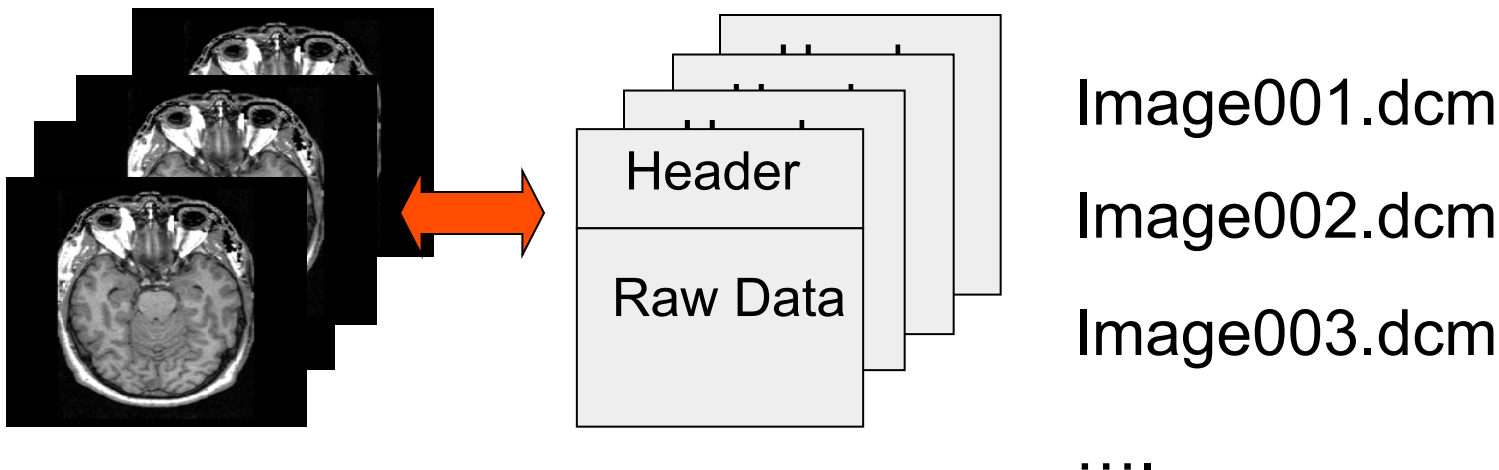


PART 1: LOADING A DICOM VOLUME



The DICOM 3.0 File Format

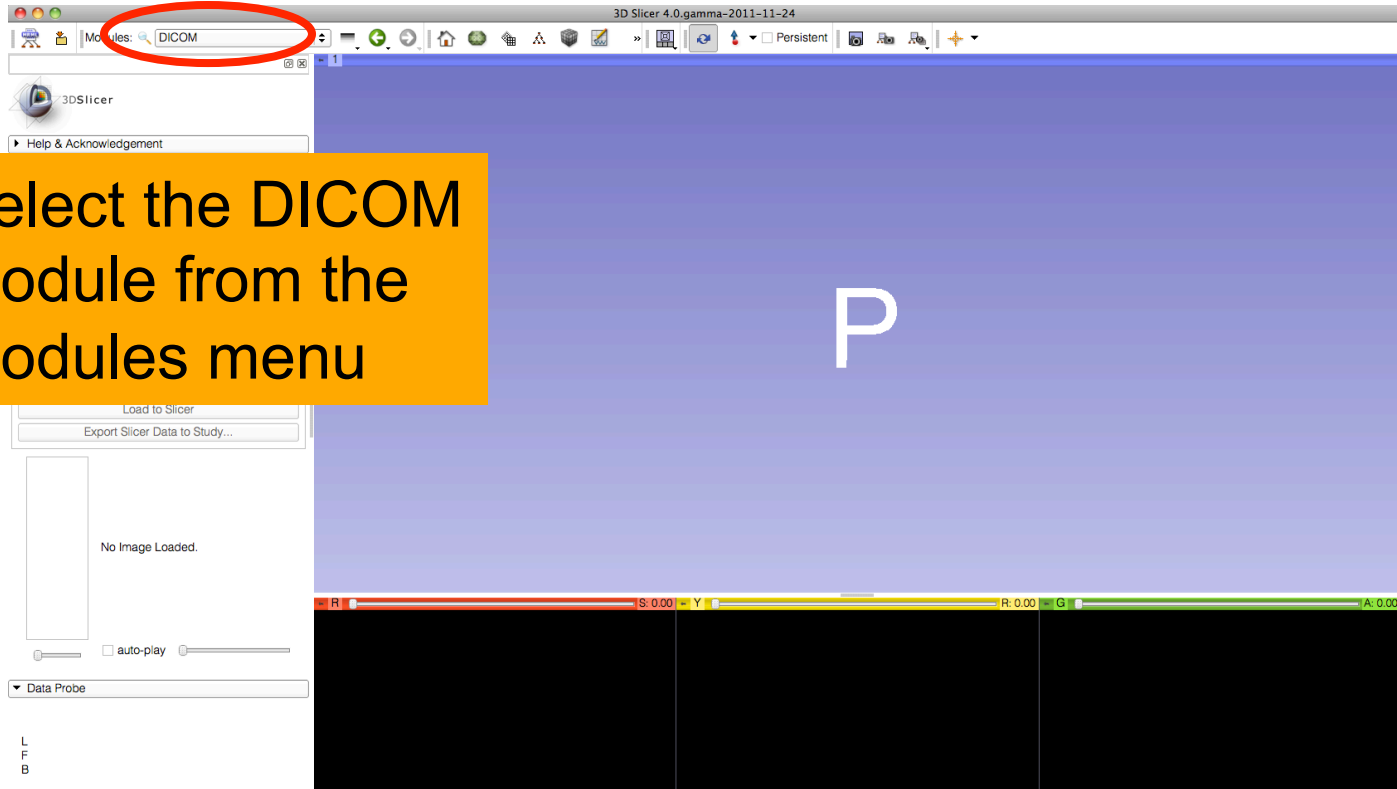
Radiological imaging equipment produce images in DICOM file format (‘.dcm files’)





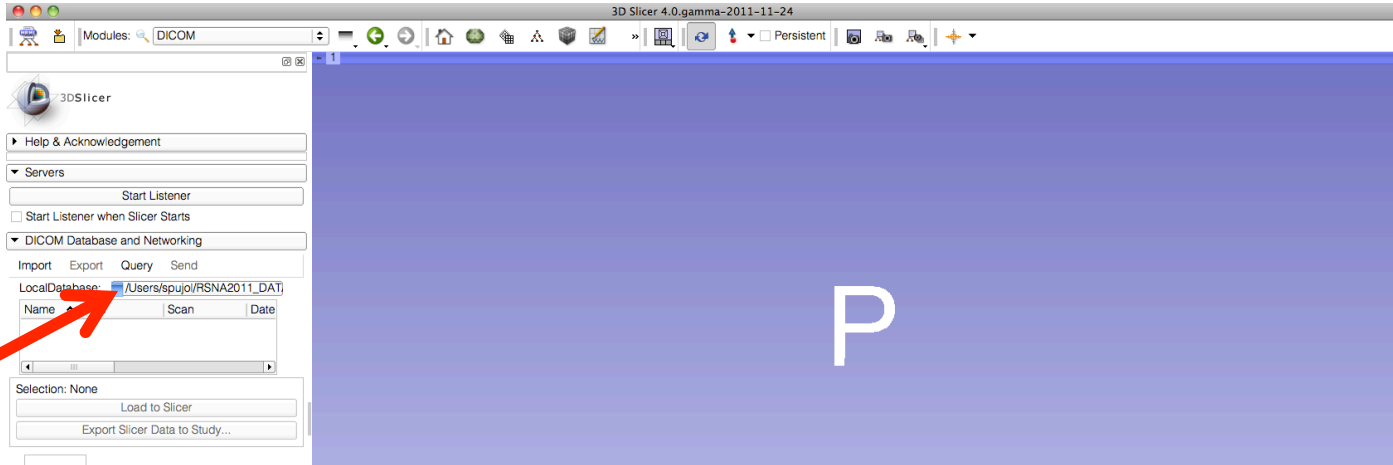
DICOM Module

Select the DICOM module from the Modules menu

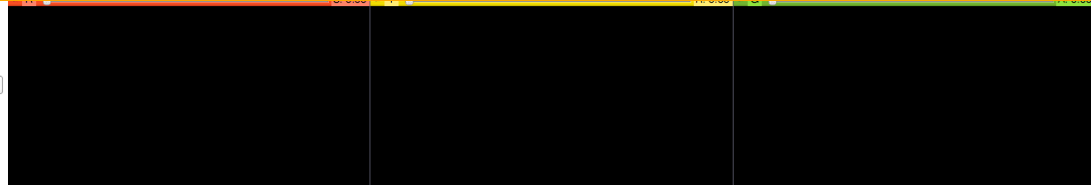
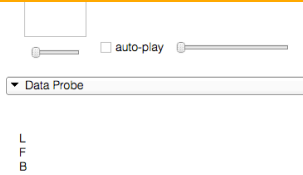




DICOM module

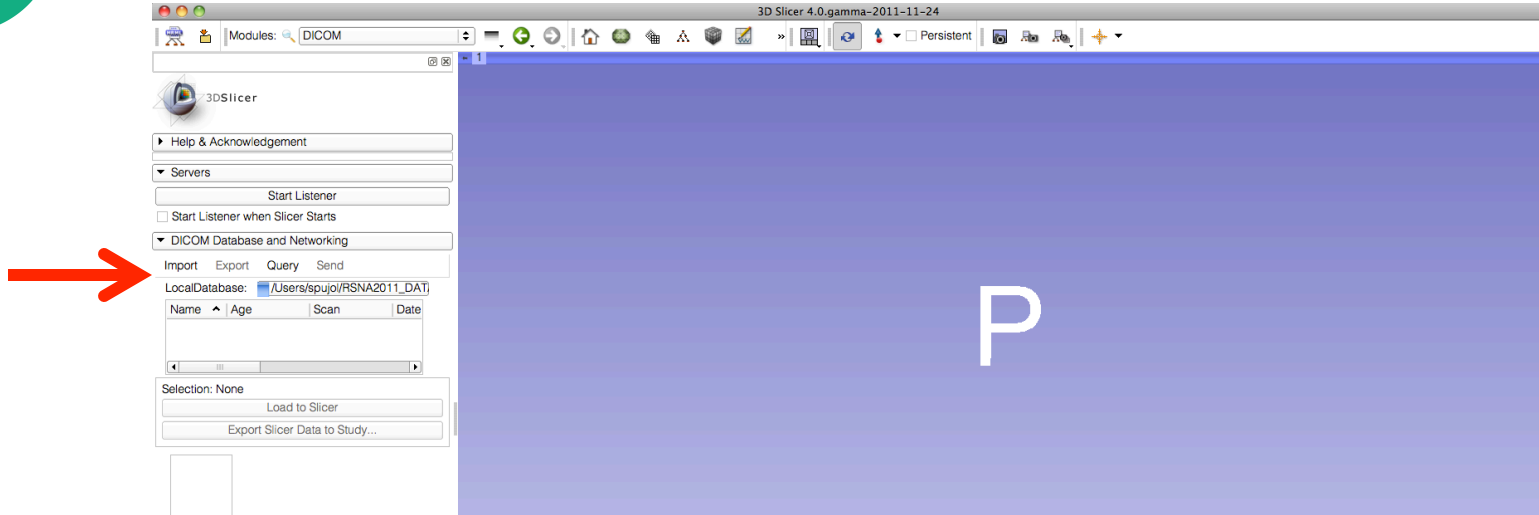


Enter the path to the directory where you would like to install the **Slicer-dicom** database on your machine.





DICOM module

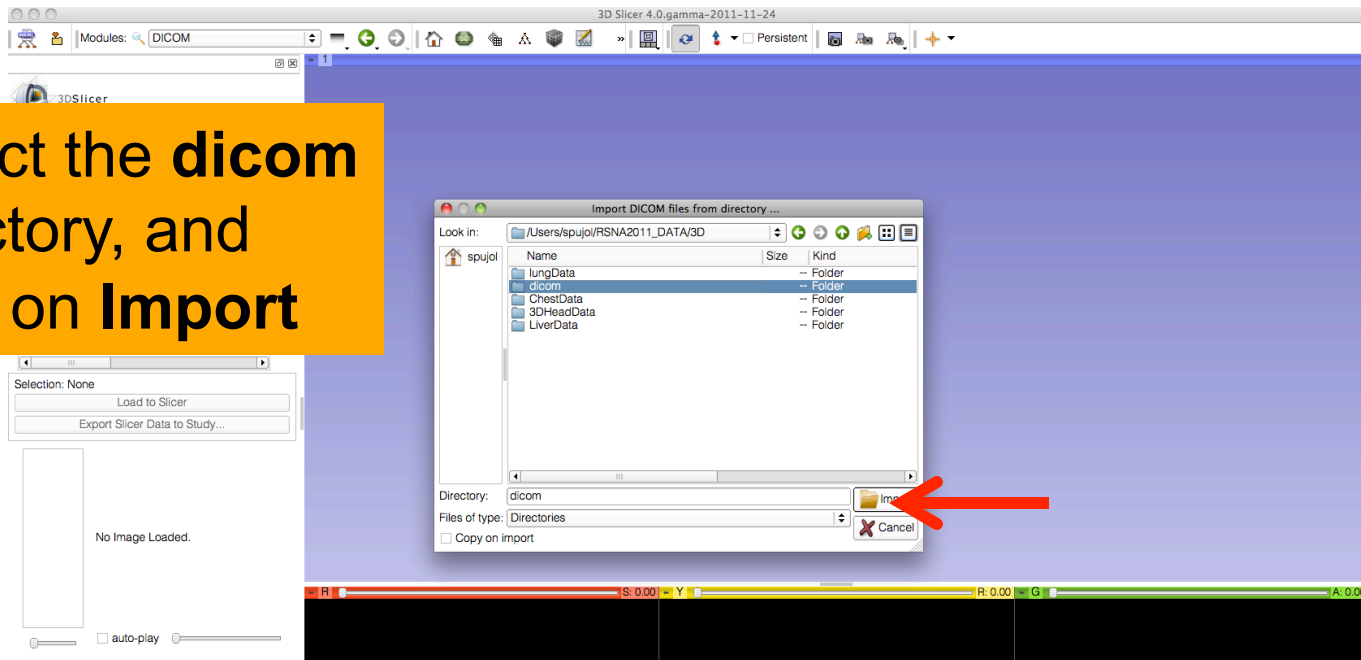


Click on **Import**, and browse to the location of the **dicom** directory, located in **C:\Documents and Settings\Administrator\Desktop\3D**



DICOM module

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

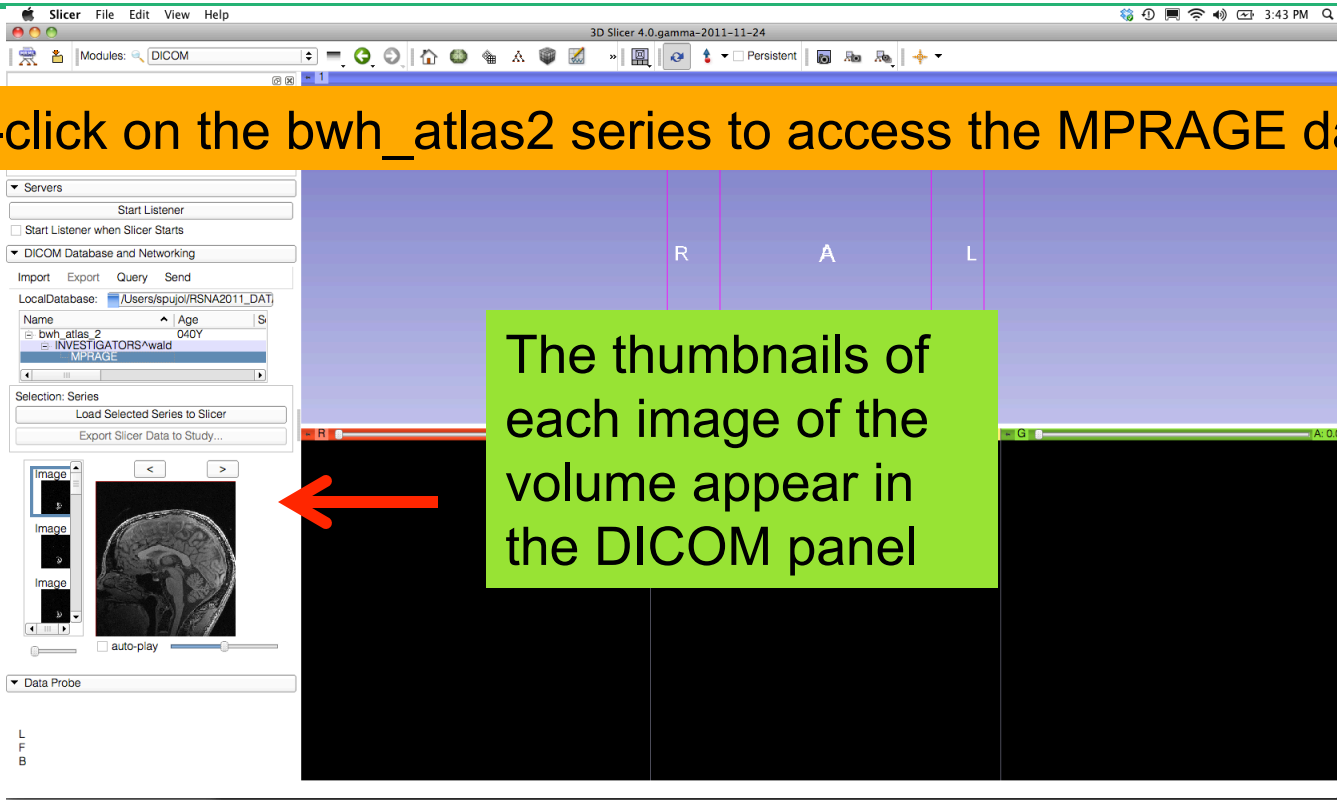


Note: Loading the dicom dataset in the database may take a few minutes.



DICOM module

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

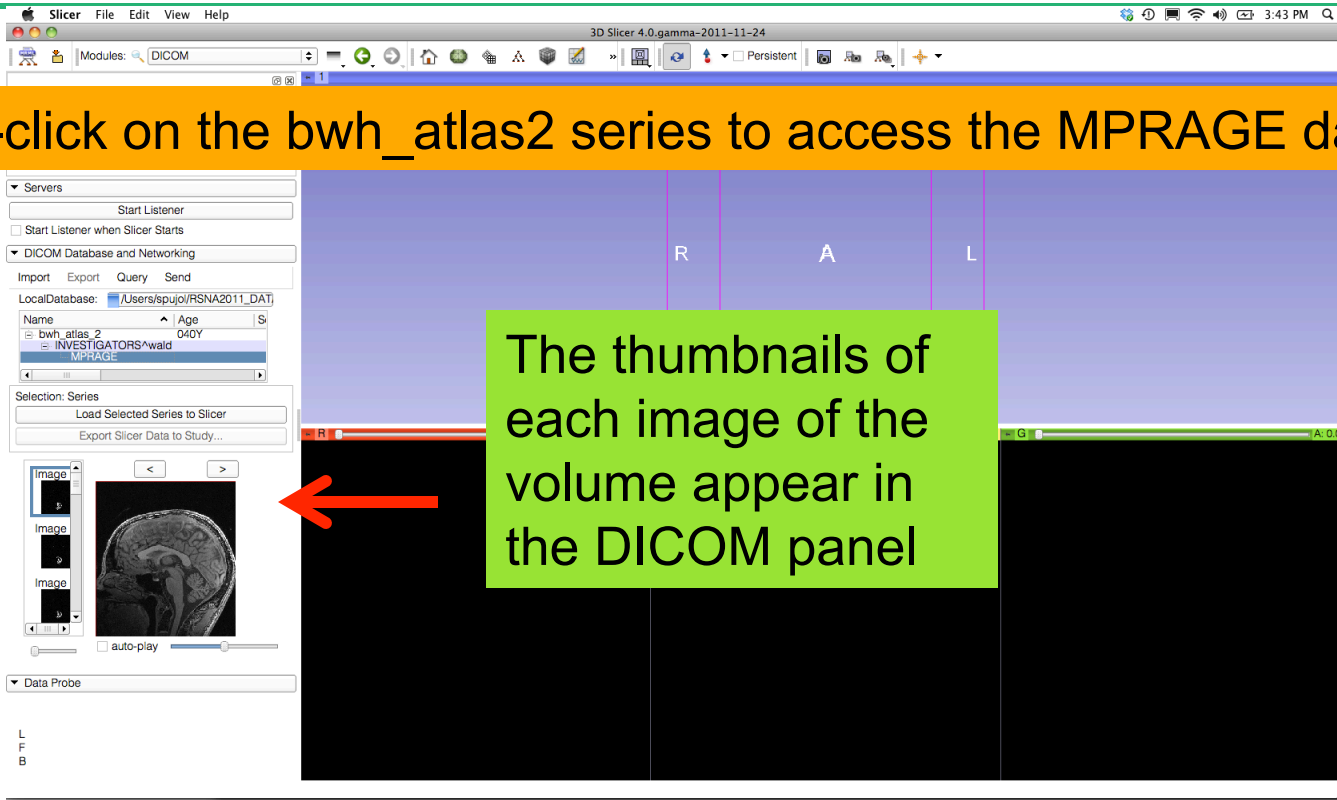


The thumbnails of each image of the volume appear in the DICOM panel



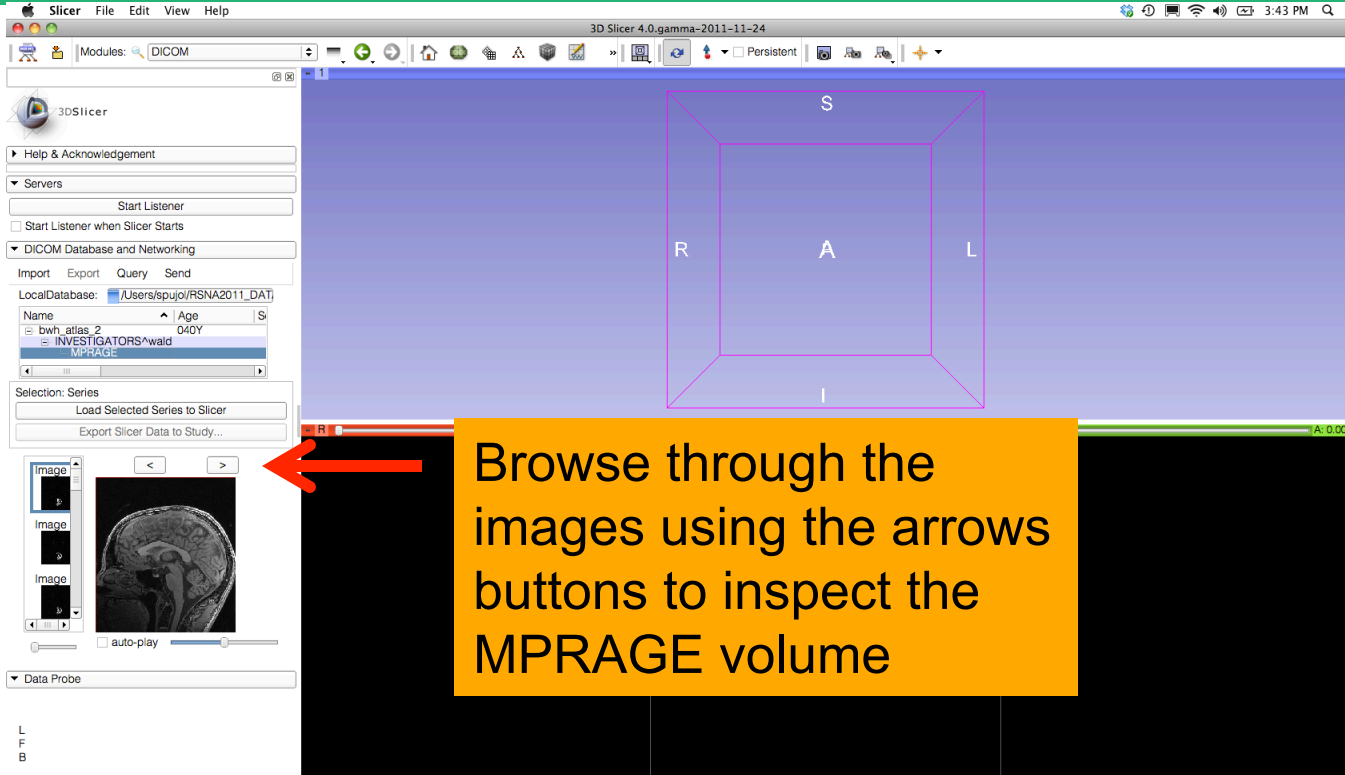
DICOM module

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



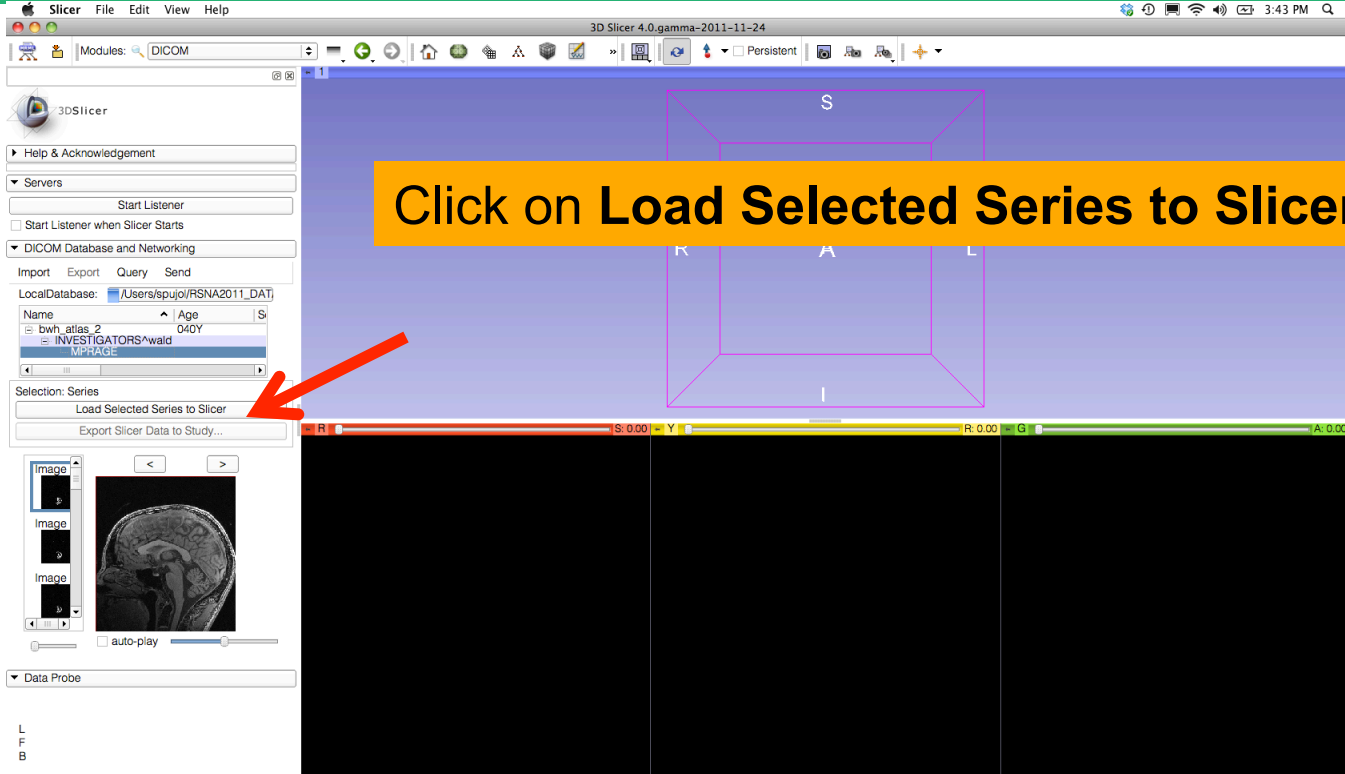


DICOM module



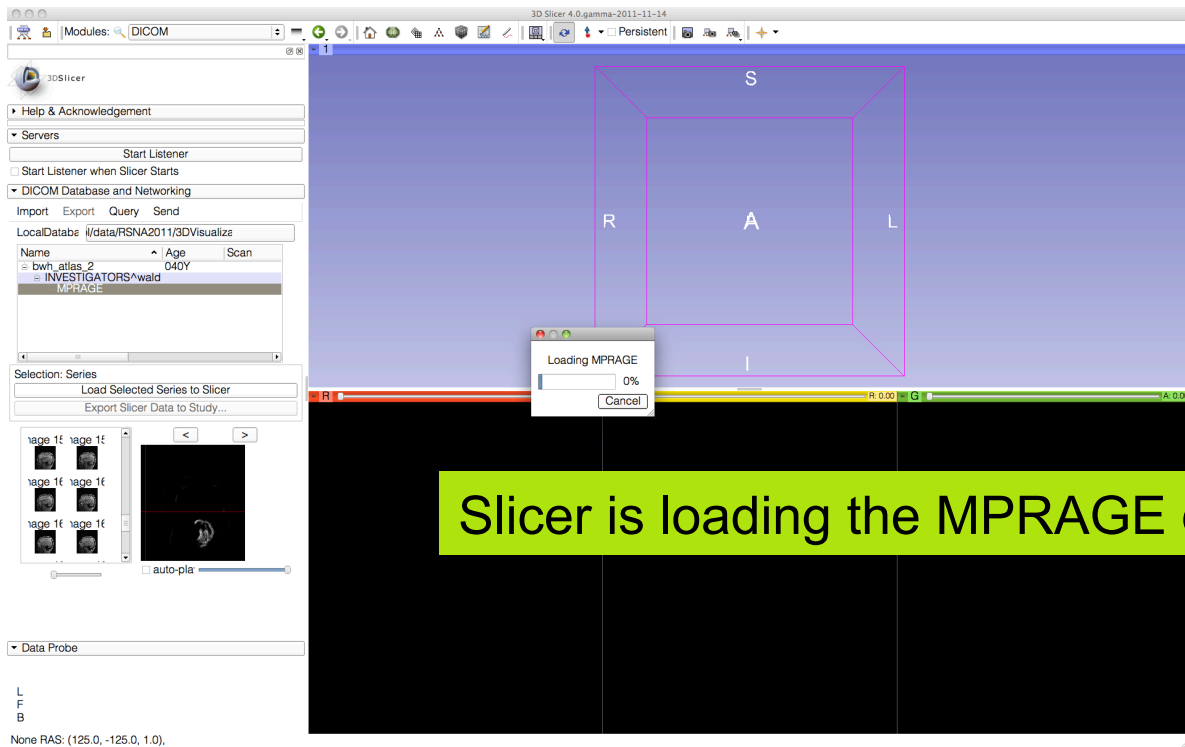


DICOM module





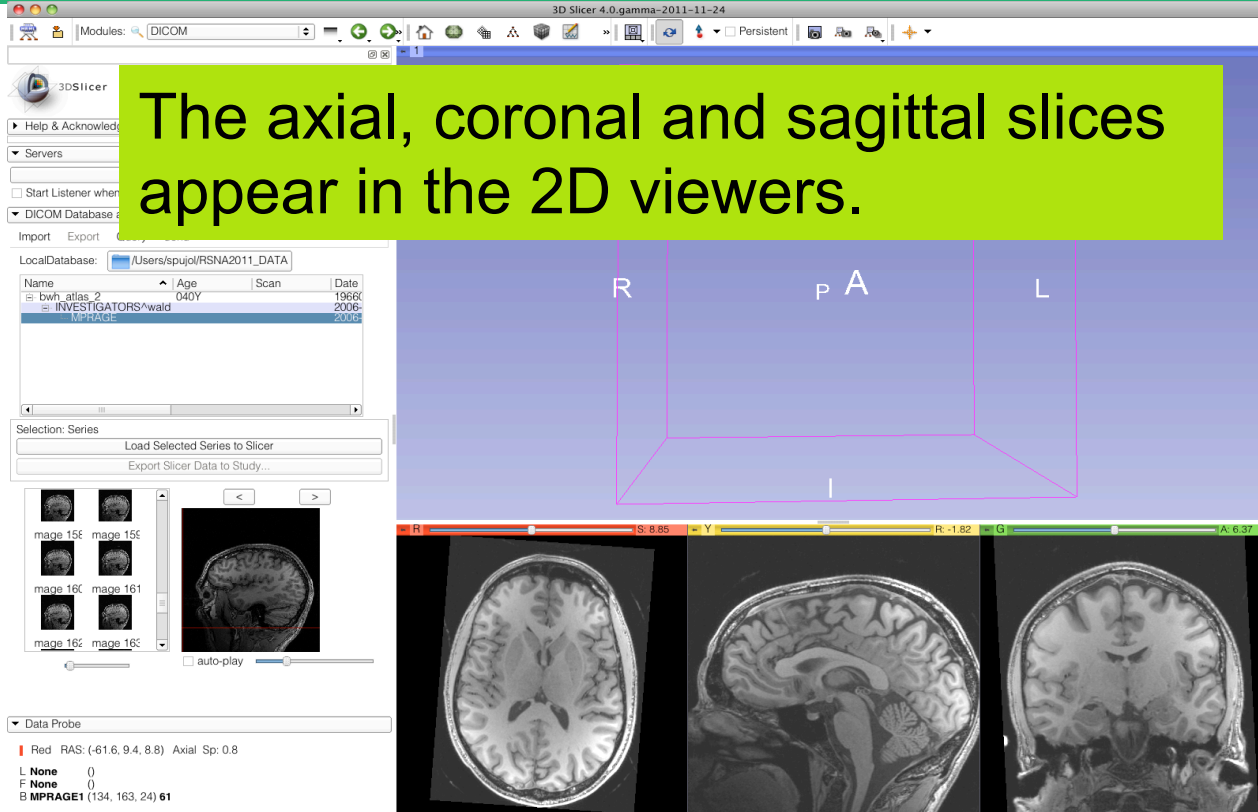
DICOM module



Slicer is loading the MPRAGE dataset



DICOM module



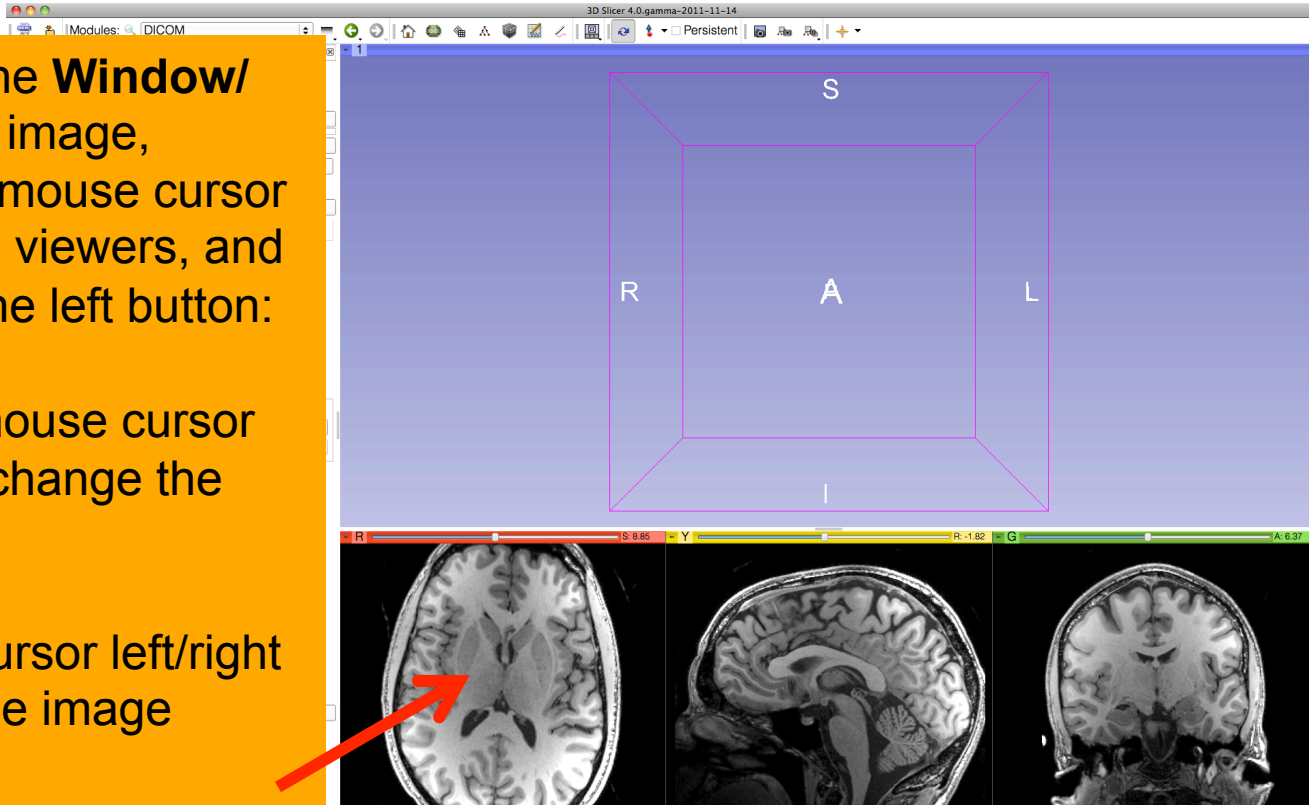


Window/Level

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



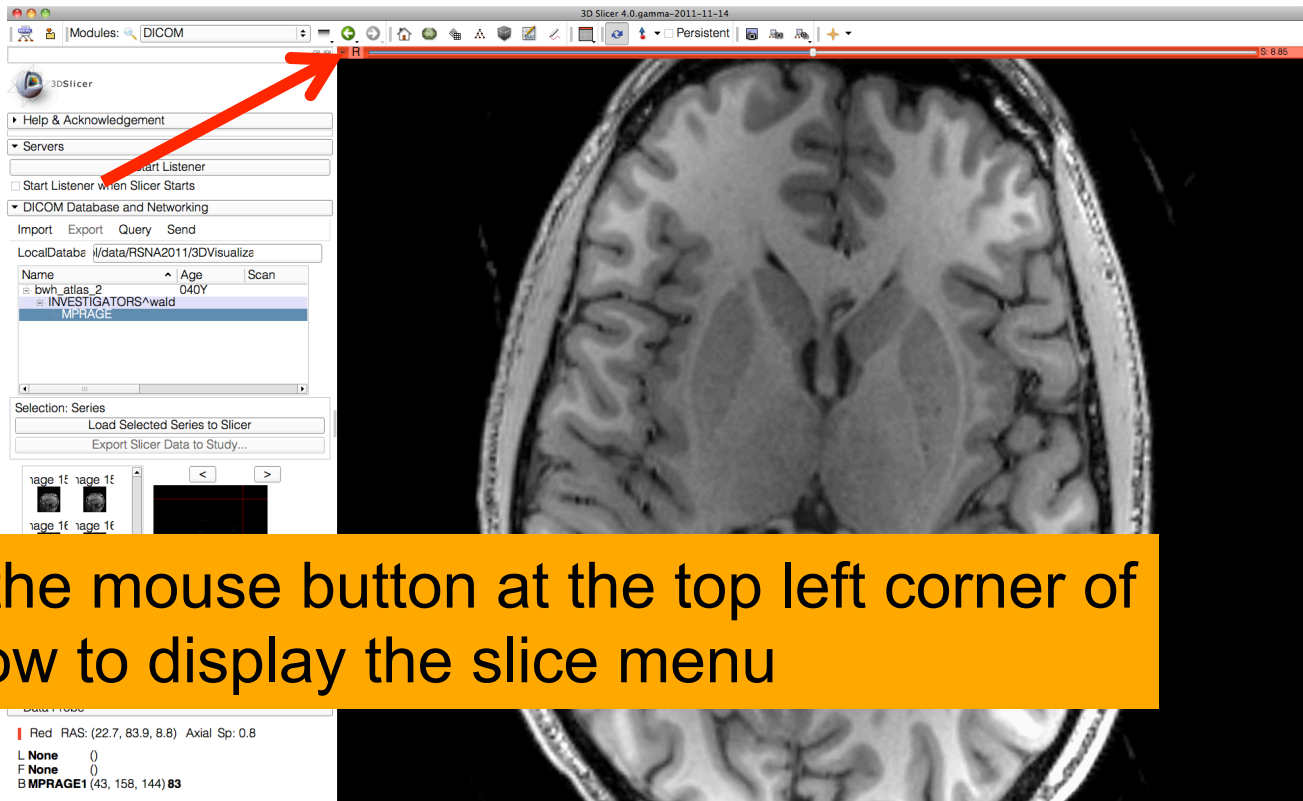
DICOM module



Select Red slice only from the layout menu



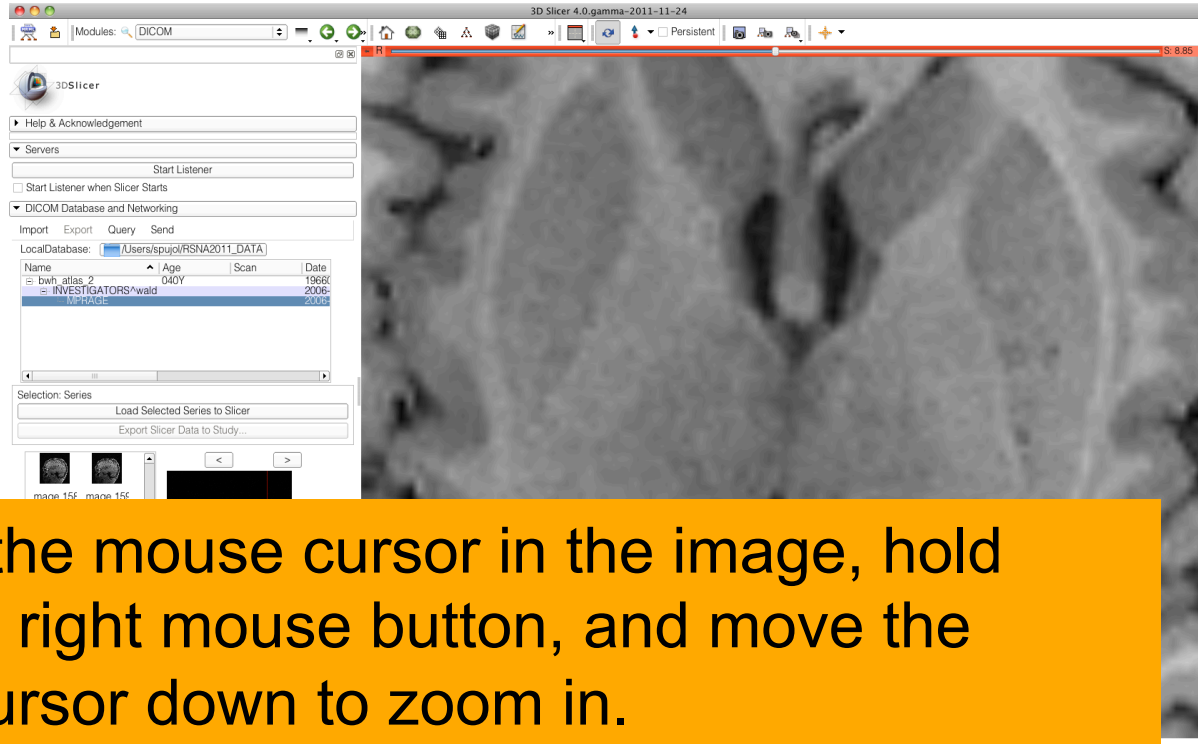
DICOM module



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



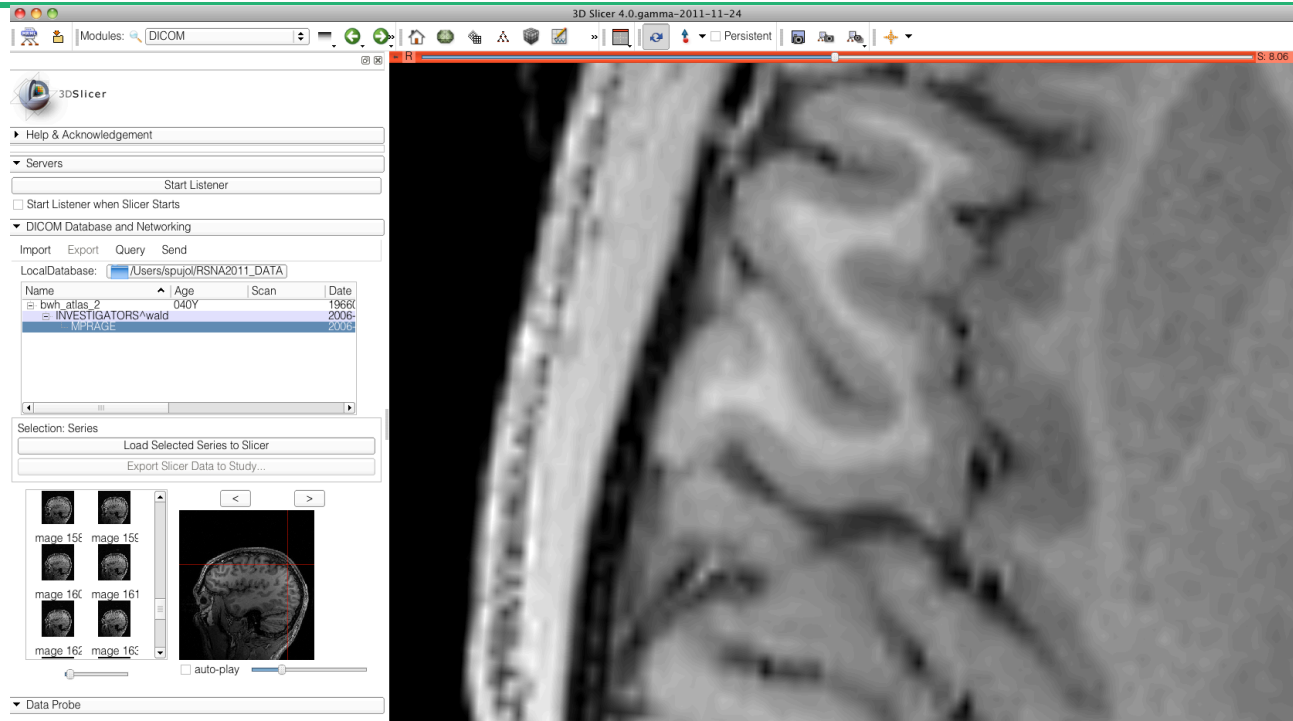
DICOM module



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



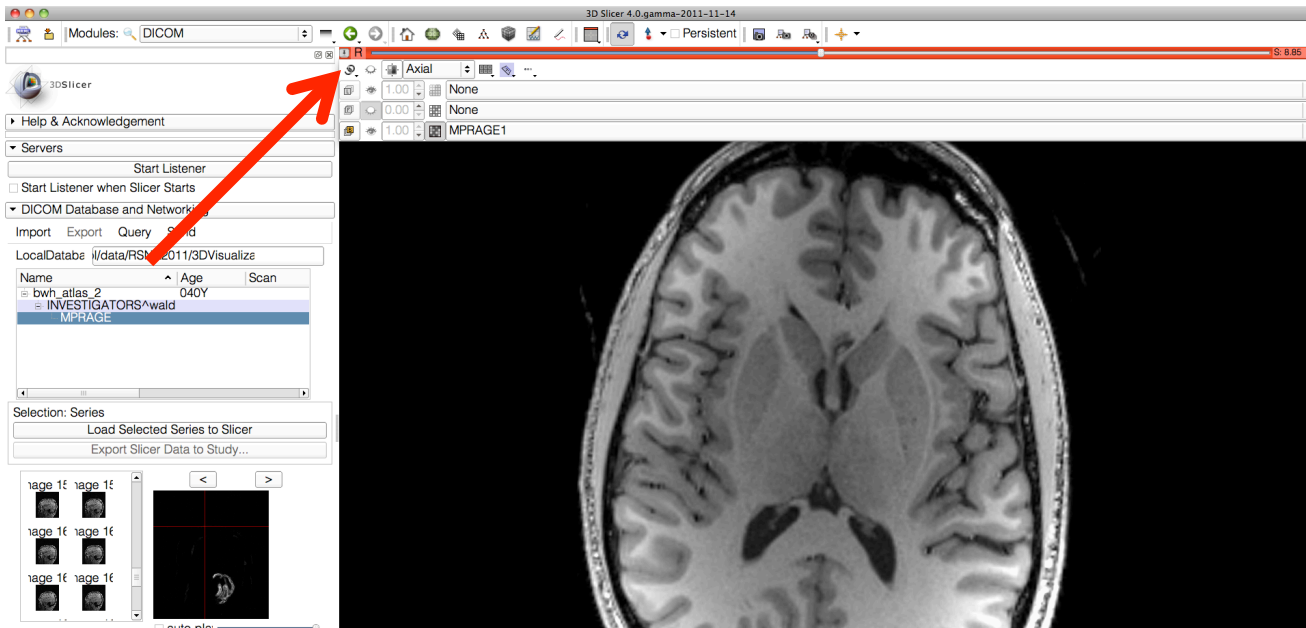
DICOM module




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



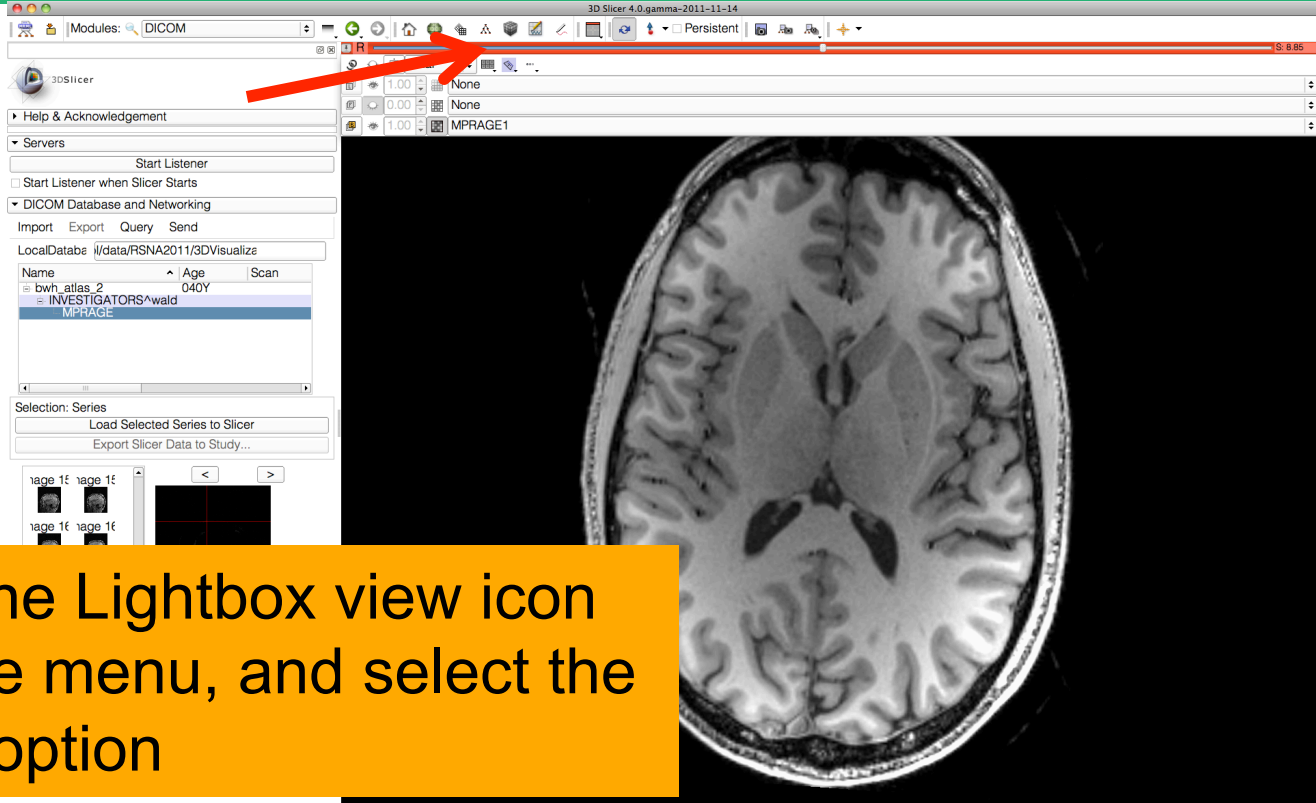
DICOM module



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



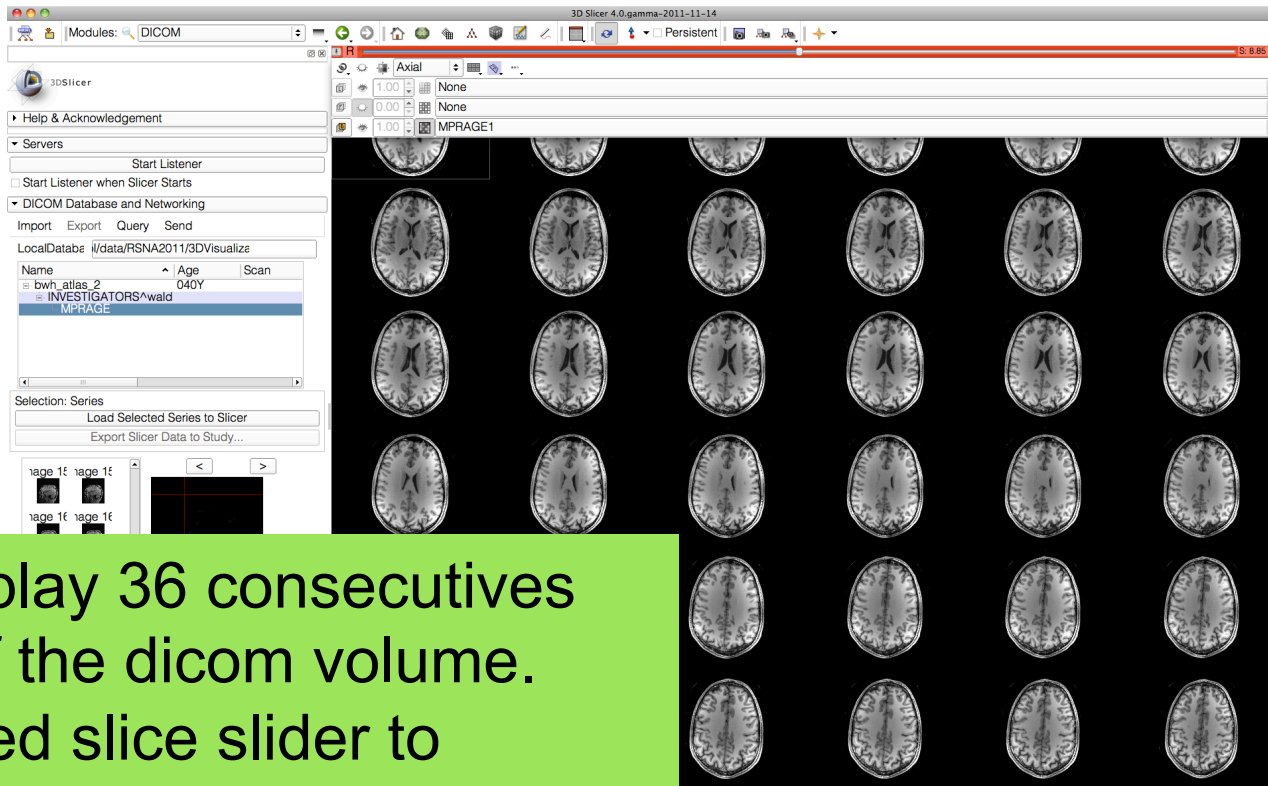
DICOM module



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



DICOM module

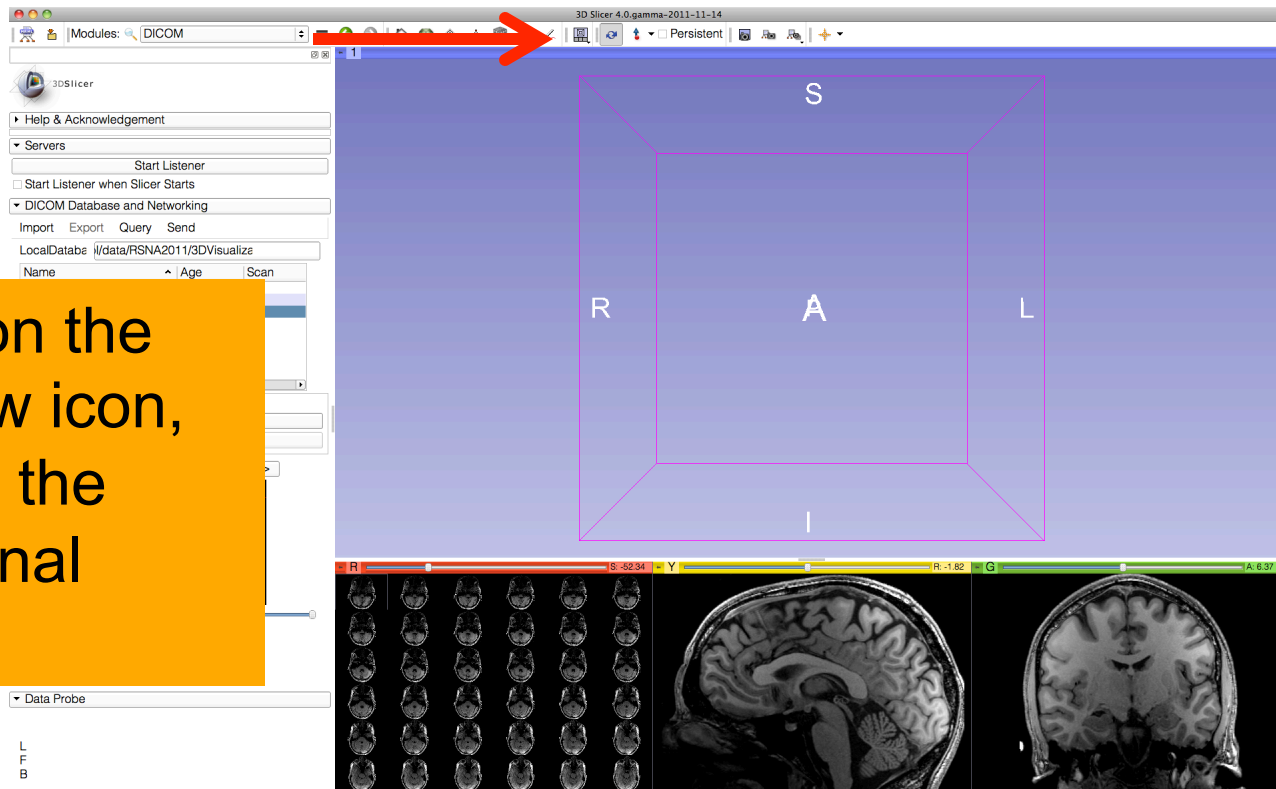


Slicer display 36 consecutives images of the dicom volume.
Use the red slice slider to browse through the dicom data



DICOM module

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





DICOM module

Select the lightbox viewer in the red slice menu, and come back to 1x1 view

3D Slicer 4.0.gamma-2011-11-14

Modules: DICOM

3DSlicer

Help & Acknowledgement

Servers

Start Listener

Start Listener when Slicer Starts

DICOM Database and Networking

Import Export Query Send

LocalDatabase: //data/RSNA2011/3DVisualize

Name	Age	Scan
bw_h_atlas_2	040Y	
= INVESTIGATORS^wald		
= MPRAGE		

Selection: Series

Load Selected Series to Slicer

Export Slicer Data to Study...

age 1f age 1f

age 1f age 1f

age 1f age 1f

auto-pla

Data Probe

L
F
B

View: 1x1 view

1x2 view

1x3 view

1x4 view

1x6 view

1x8 view

2x2 view

3x3 view

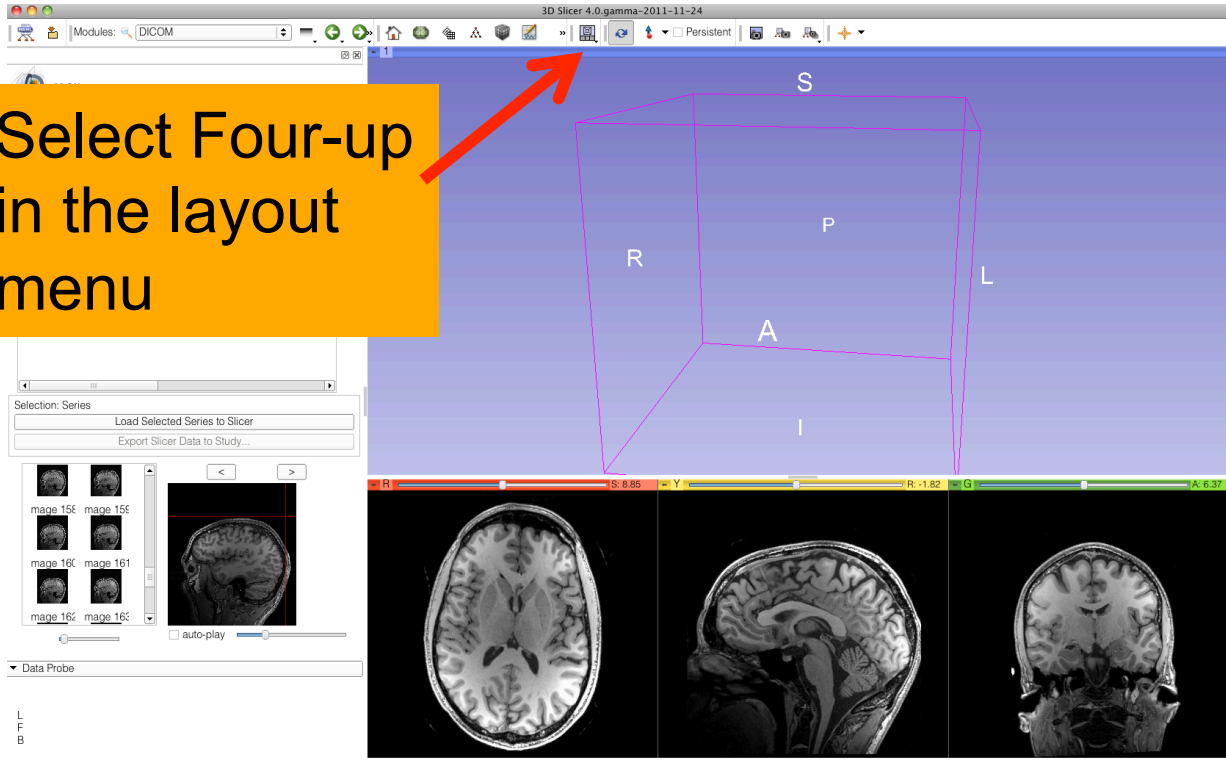
6x6 view

Custom



DICOM module

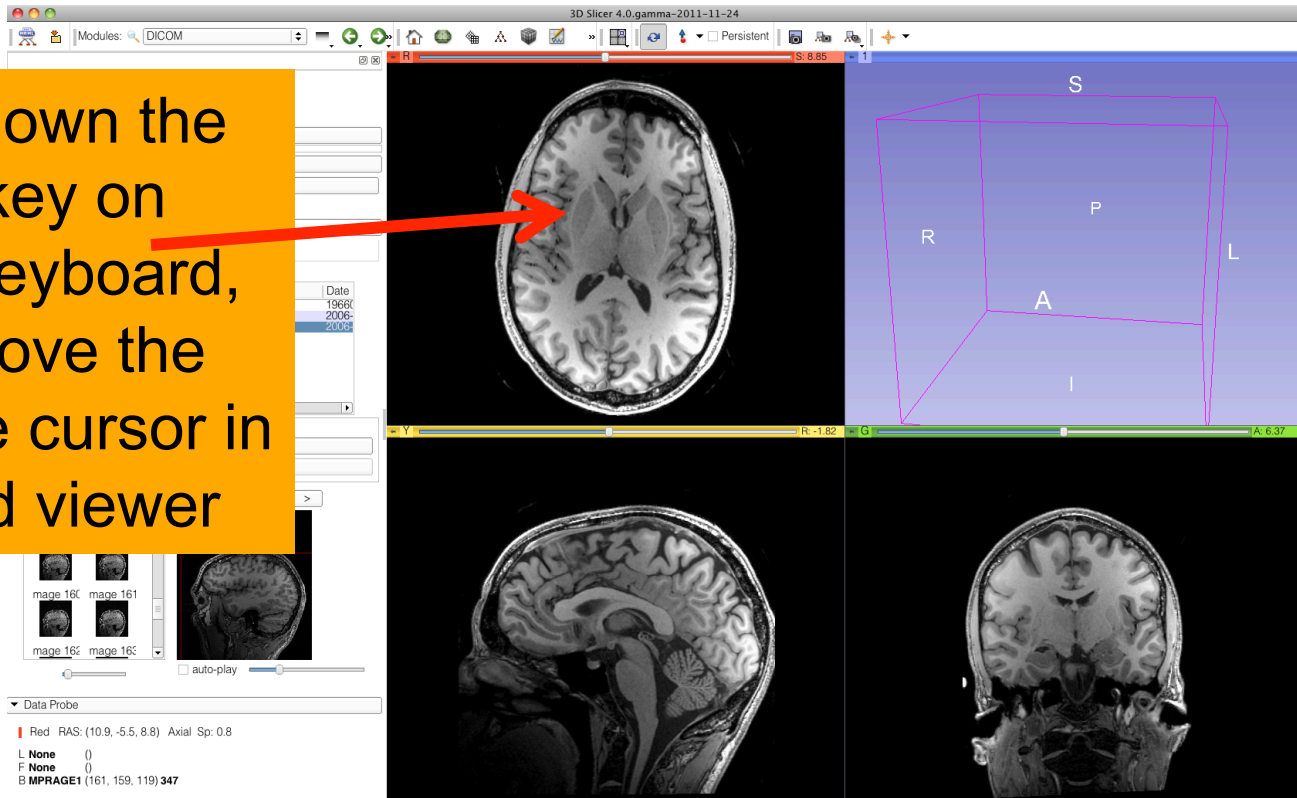
Select Four-up
in the layout
menu





DICOM module

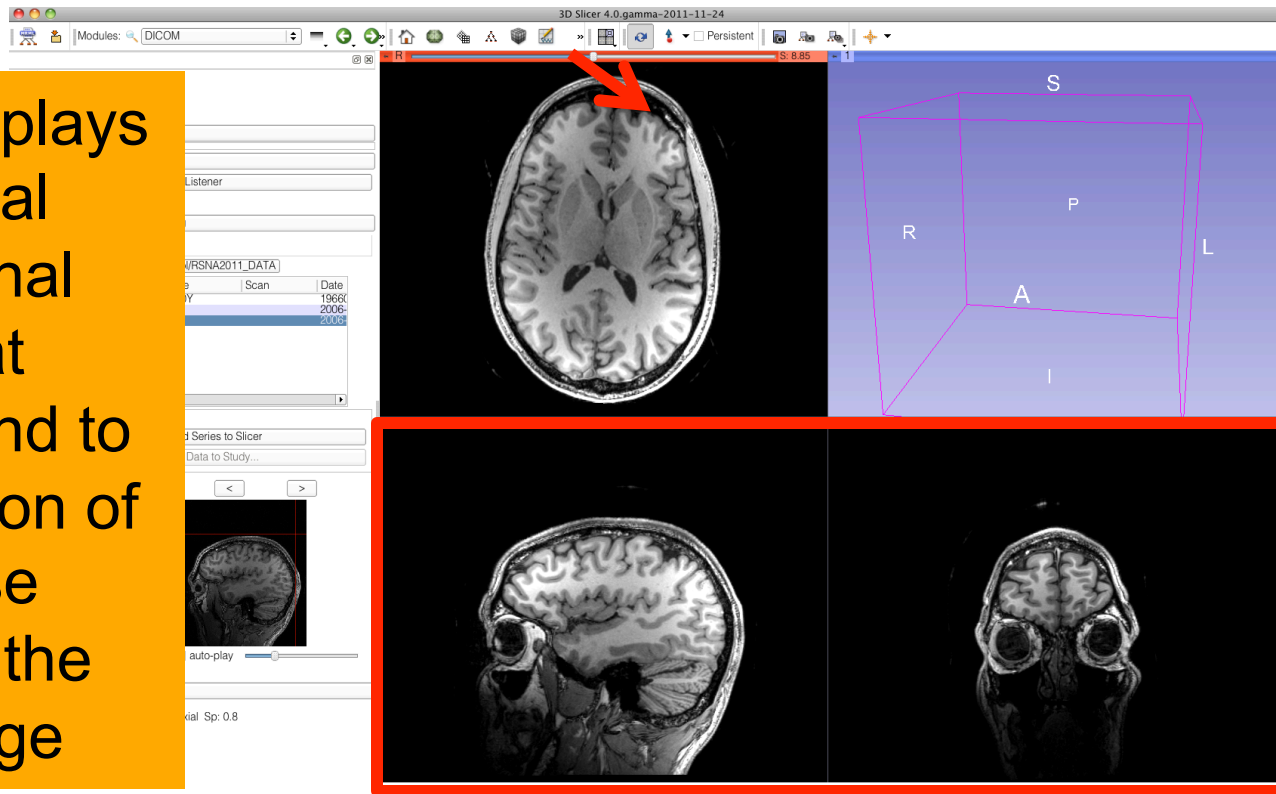
Hold down the **Shift** key on your keyboard, and move the mouse cursor in the red viewer





DICOM module

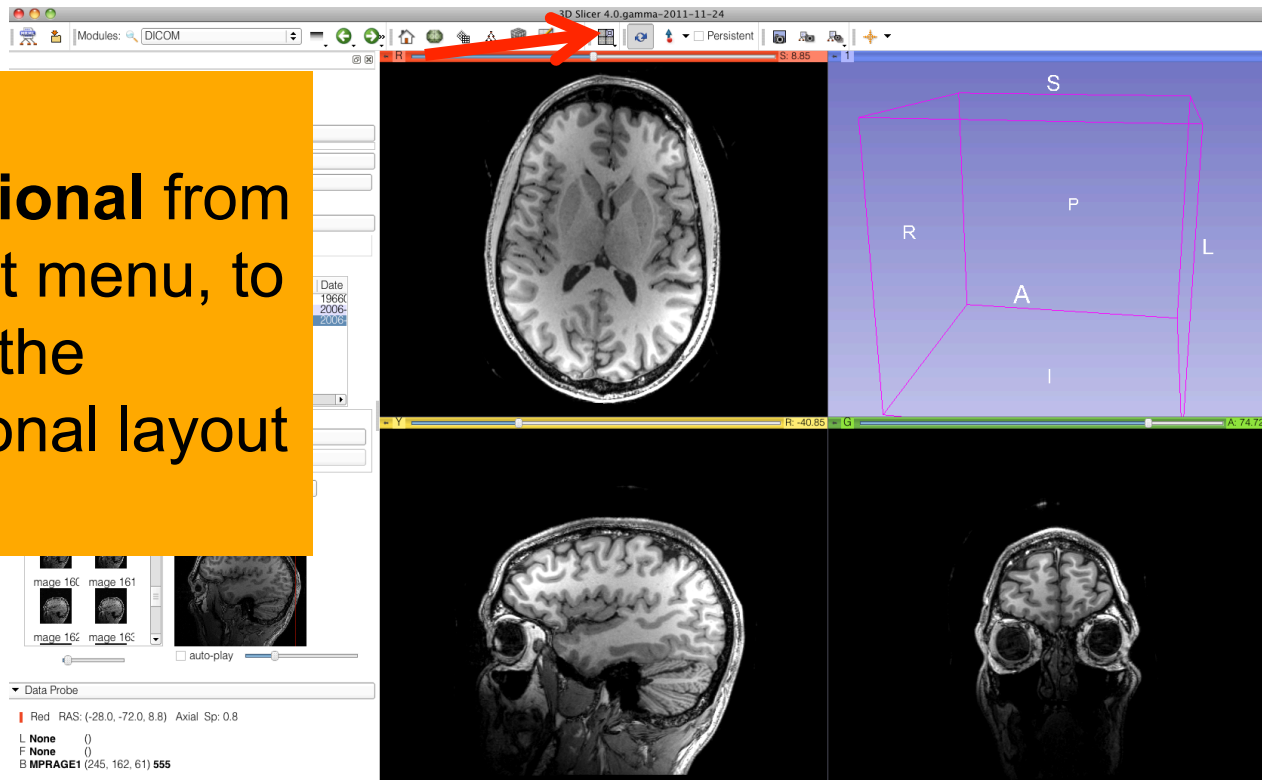
Slicer displays the sagittal and coronal slices that correspond to the location of the mouse cursor in the axial image





DICOM module

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





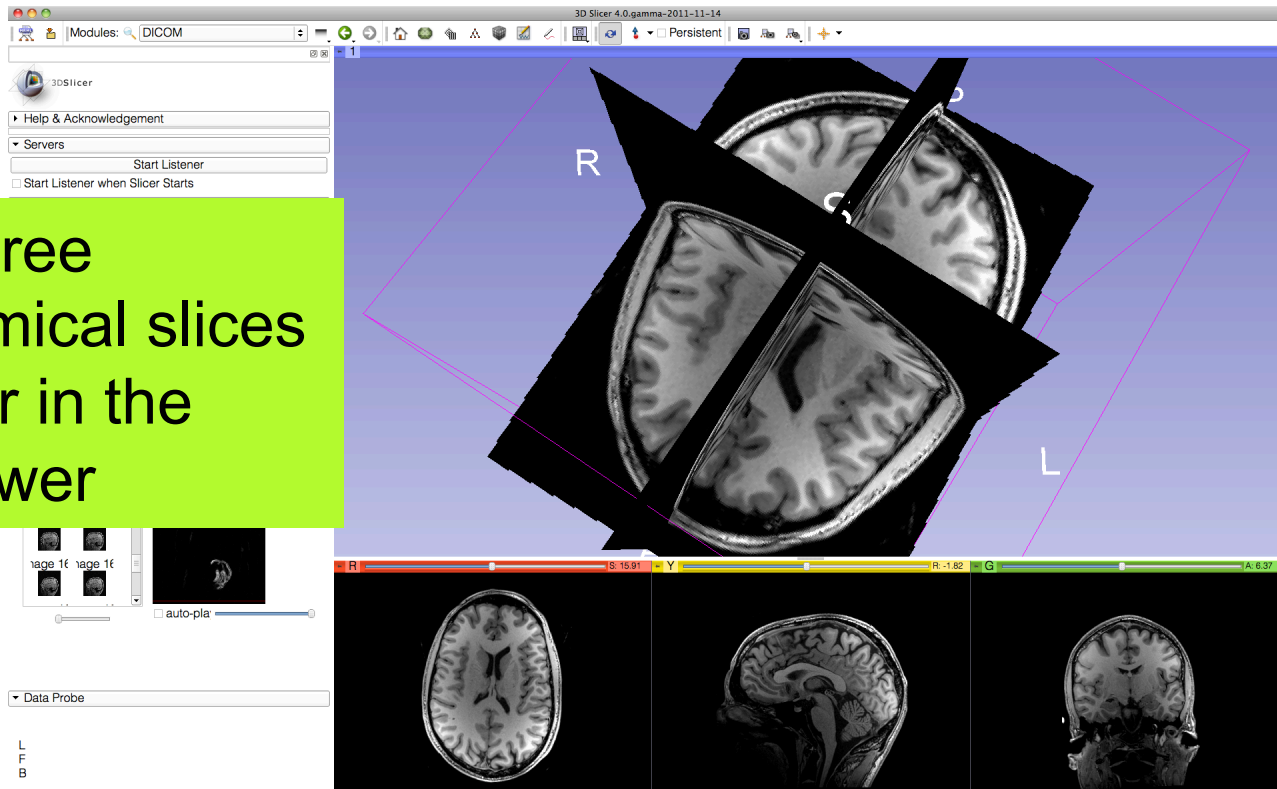
DICOM module

The screenshot shows the 3D Slicer DICOM module interface. A yellow callout box with black text reads: "Click on the links icon to link all three viewers, and click on the eye icon to display the slices in the 3D Viewer". A red circle highlights the 'links' icon in the viewer toolbar, and a red arrow points from the 'Data Probe' section to the 'eye' icon in the same toolbar. The interface includes a 'LocalDatabase' table with columns 'Name', 'Age', and 'Scan', containing entries like 'bwh_atlas_2' and 'INVESTIGATORS^wald'. The '3D Viewer' at the bottom shows three orthogonal views of a brain MRI slice.



DICOM module

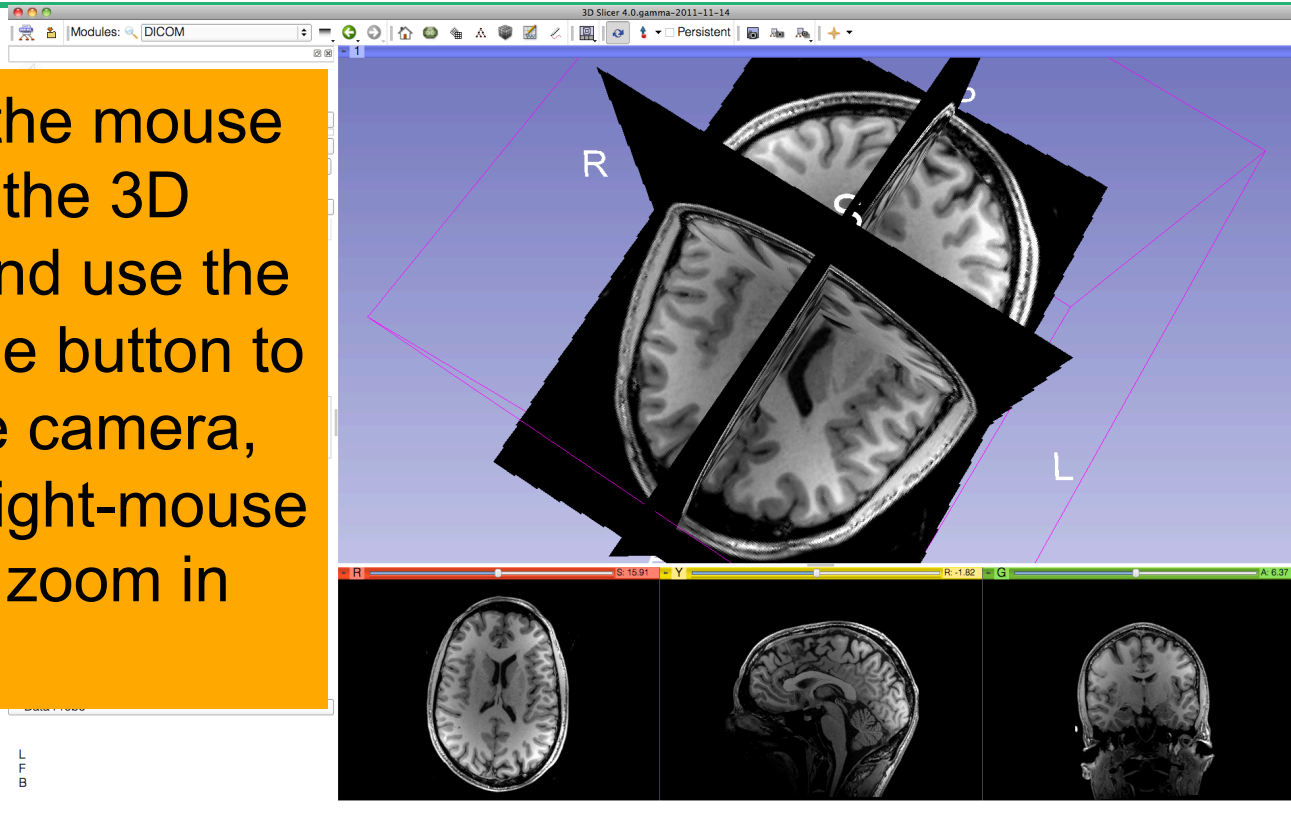
The three anatomical slices appear in the 3DViewer





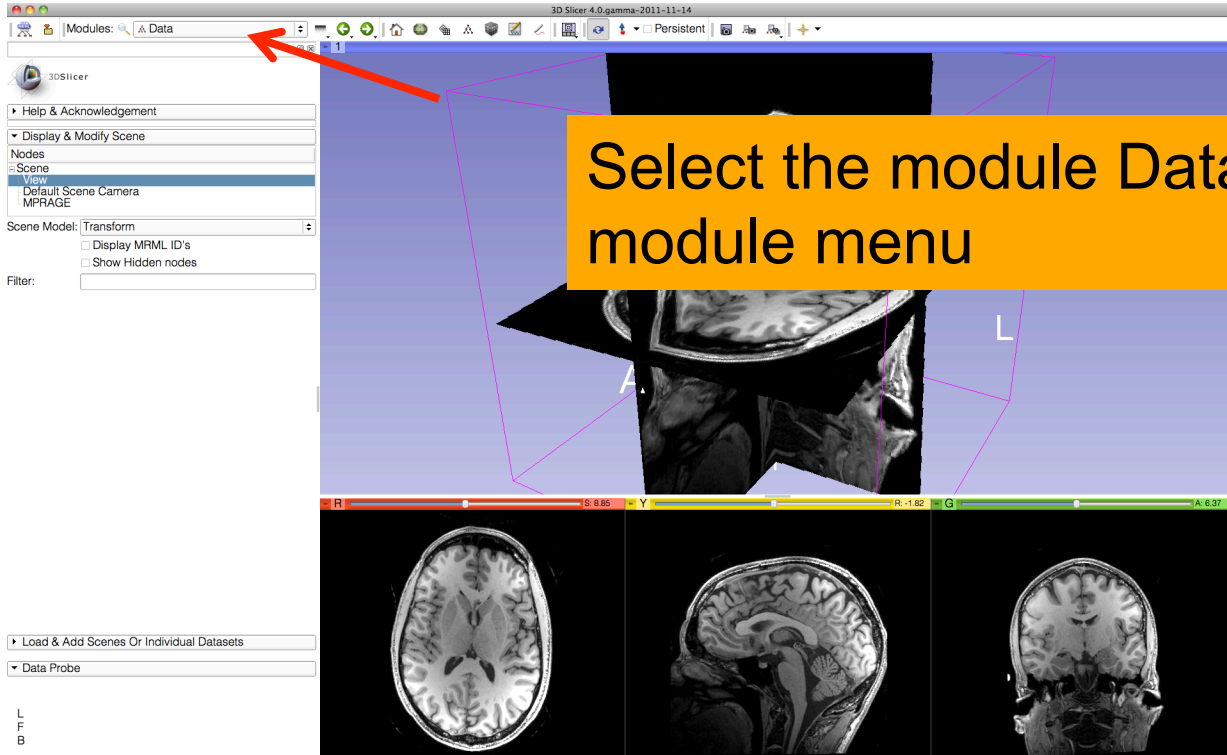
DICOM module

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



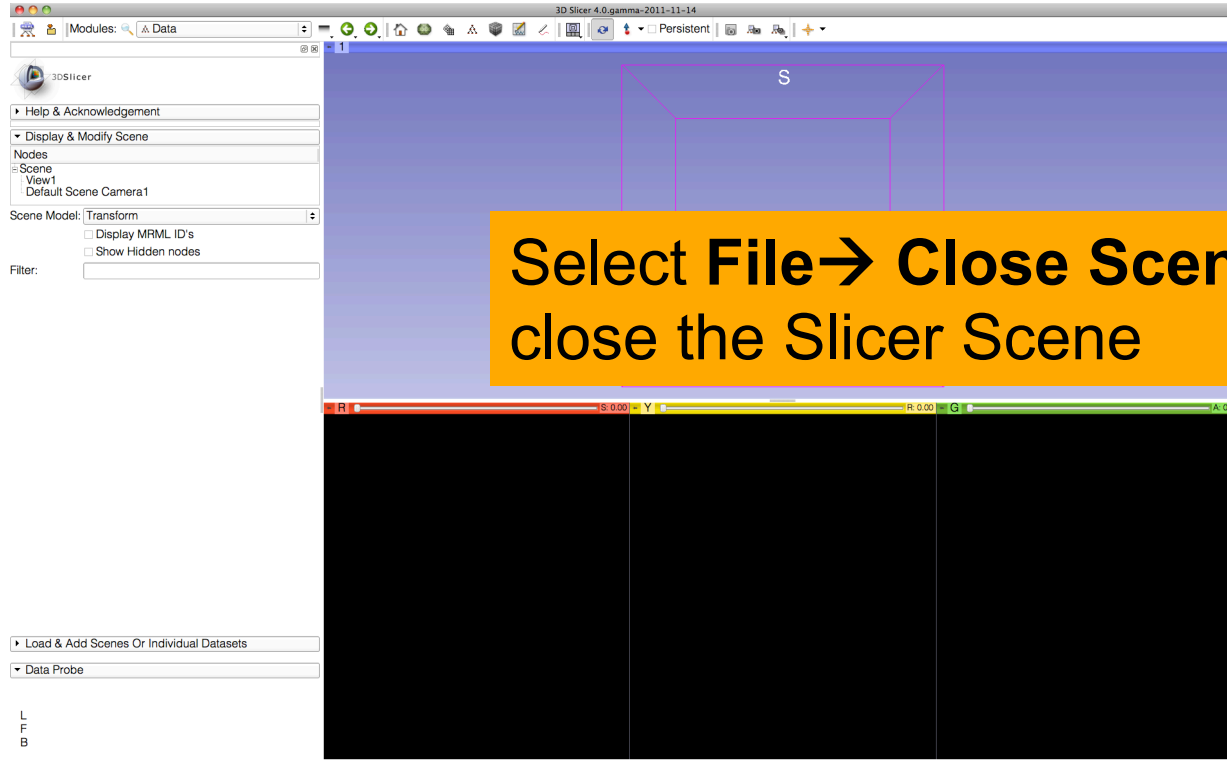


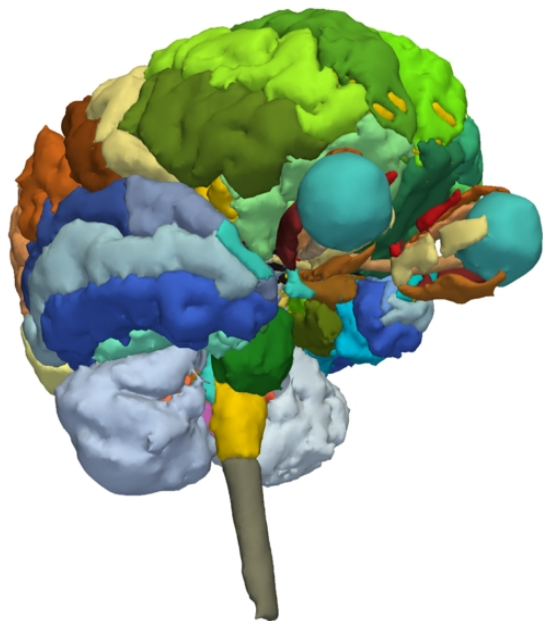
DICOM module





Close the Scene



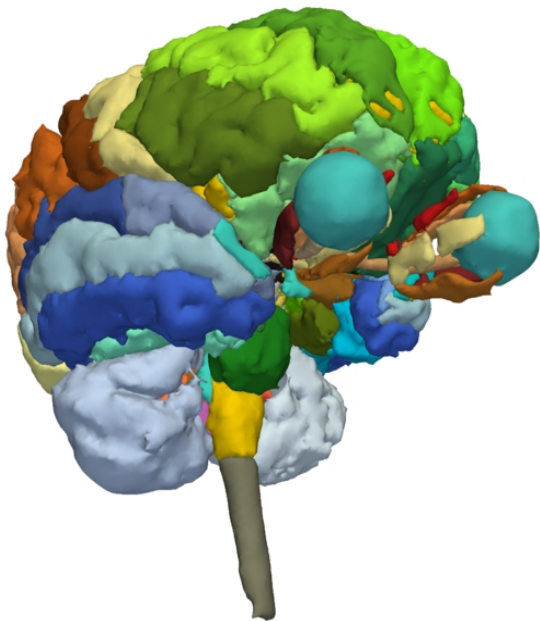


Part 2:

3D visualization of surface models of the brain



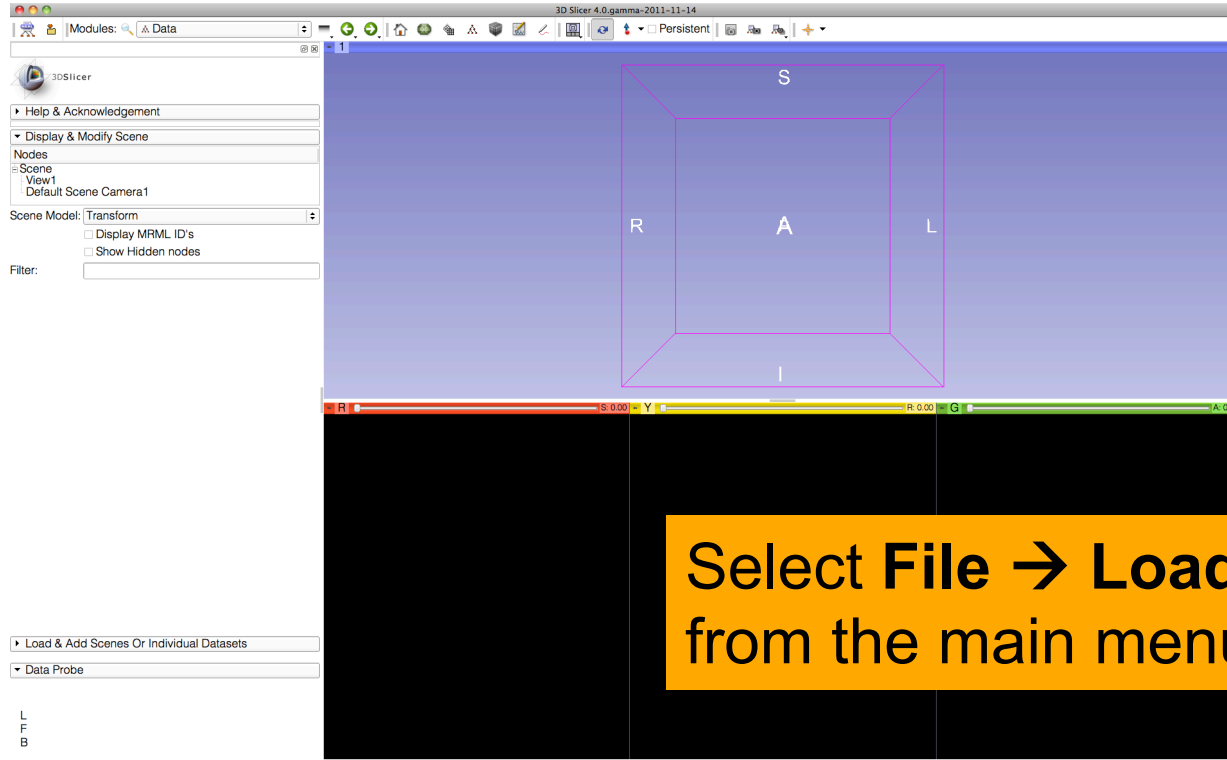
3D Slicer Scene



- 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.



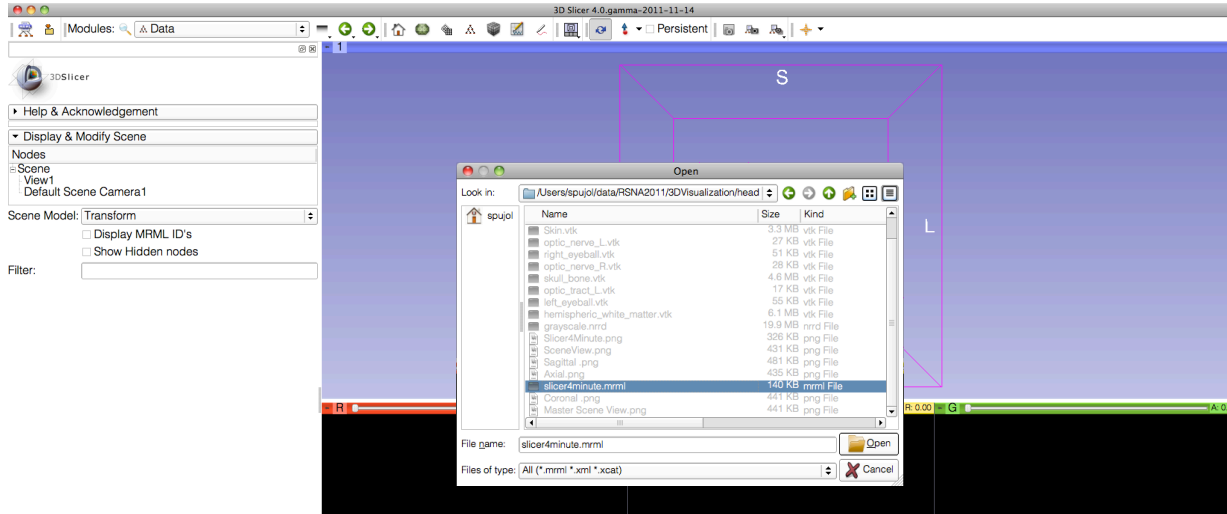
Loading a Scene



Select File → Load Scene from the main menu



Loading a Scene

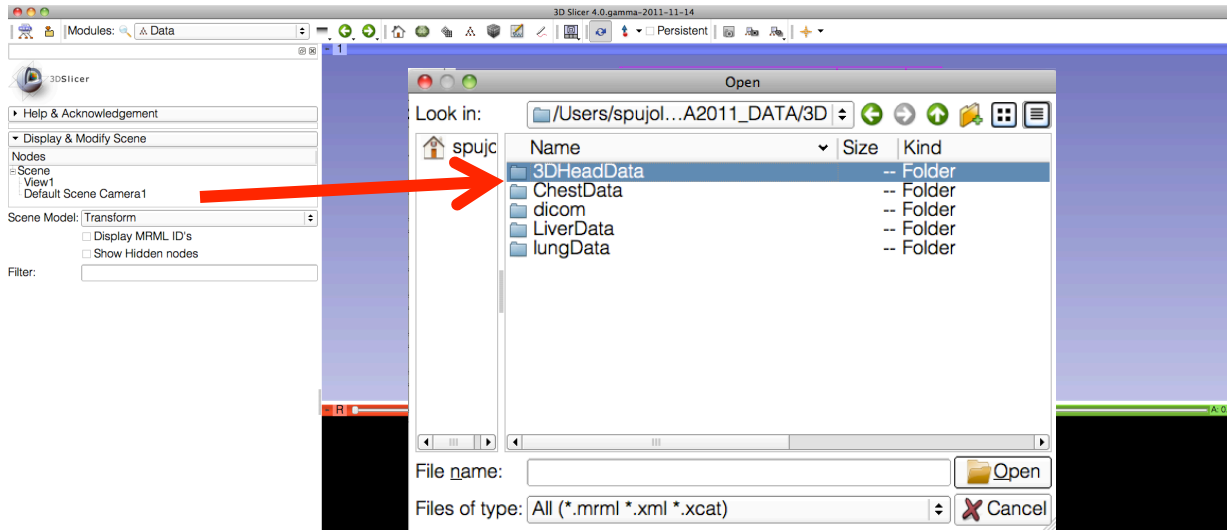


Browse to the directory **3D**, located on the Desktop:

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



Loading a Scene

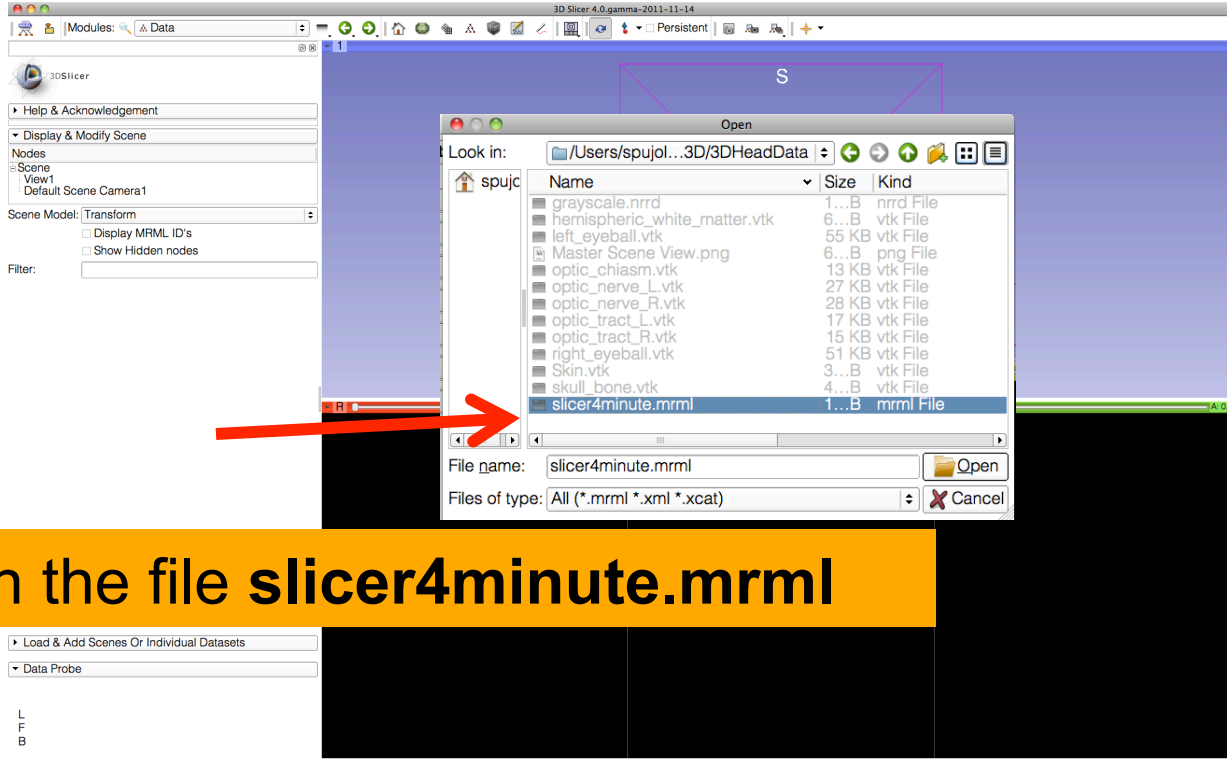


Select the directory **3DHeadData**, and open the file **slicer4minute.mrml**

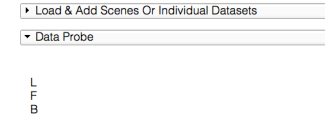
L
F
B



Loading a Scene



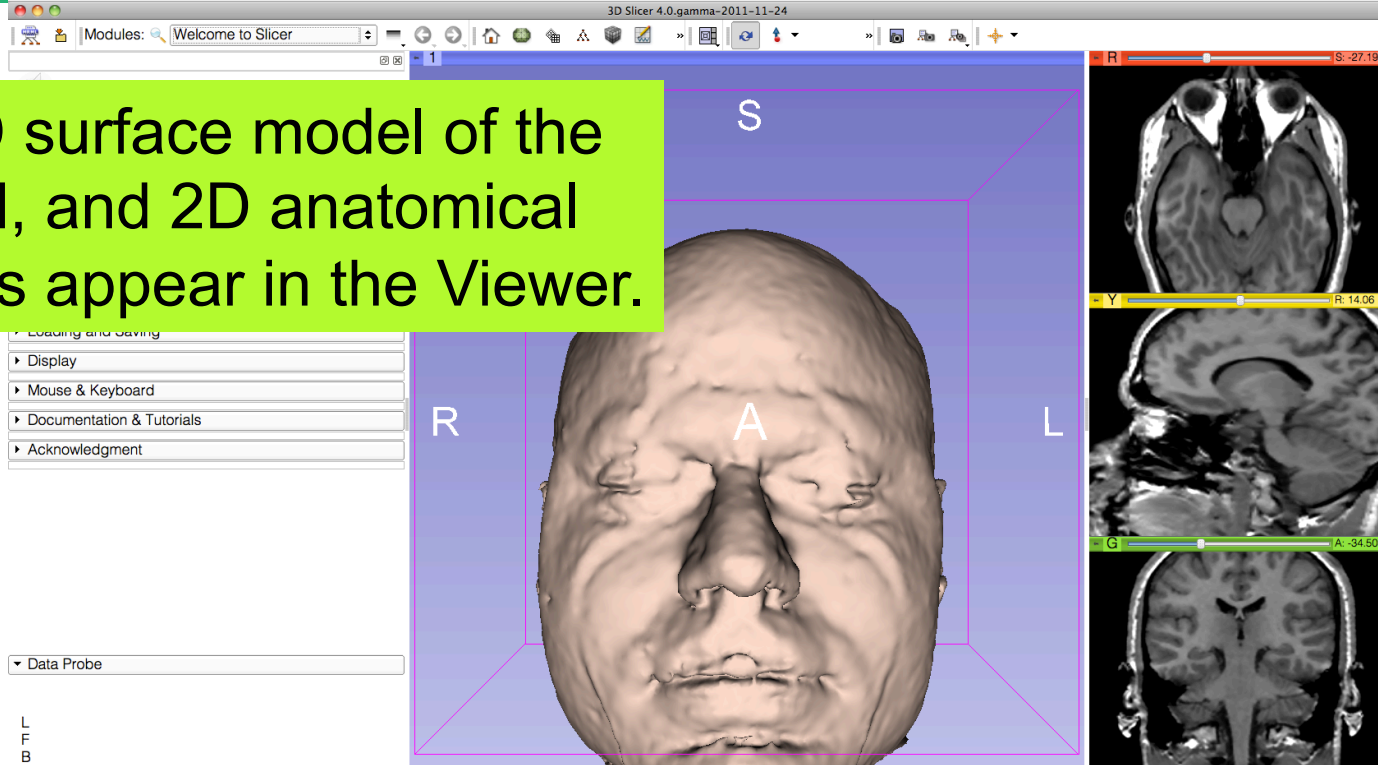
Open the file **slicer4minute.mrml**





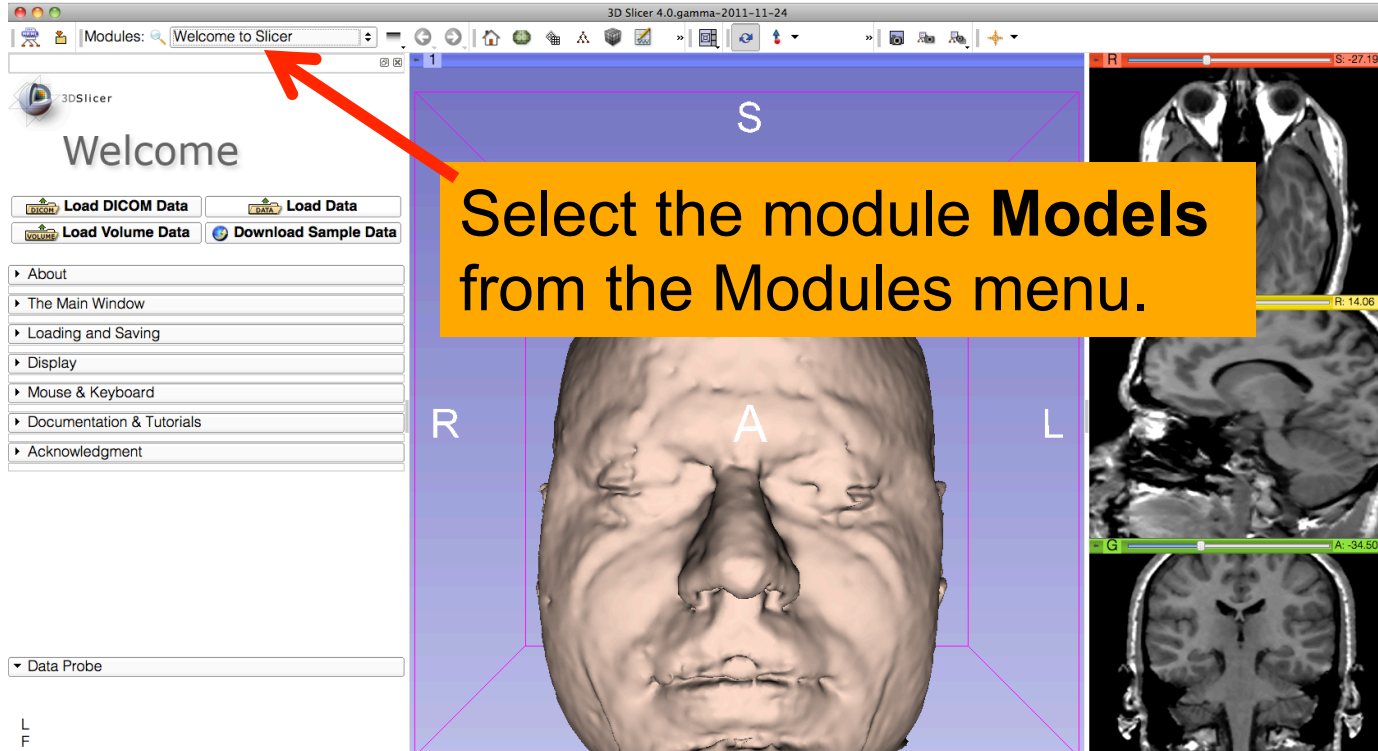
Loading the Slicer Scene

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



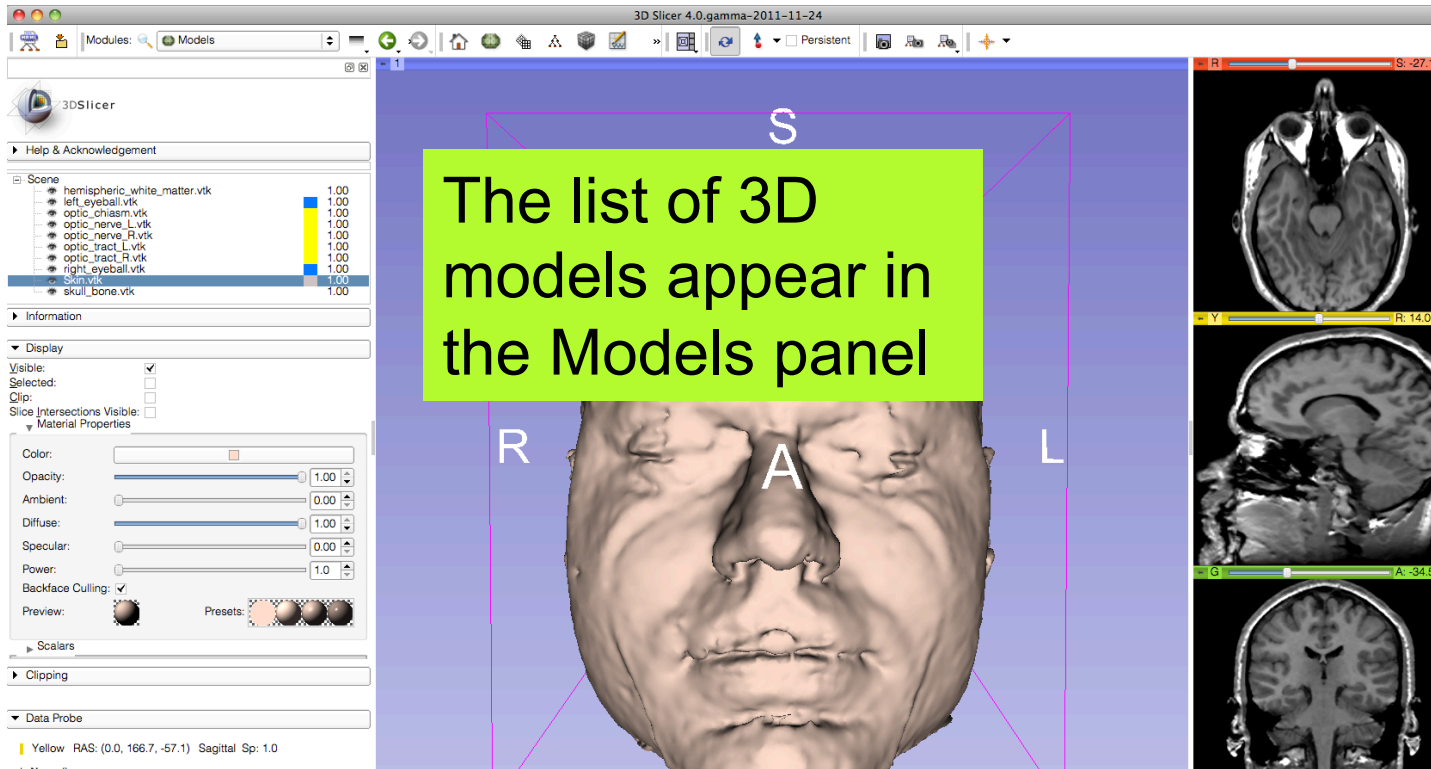


Loading the Slicer Scene



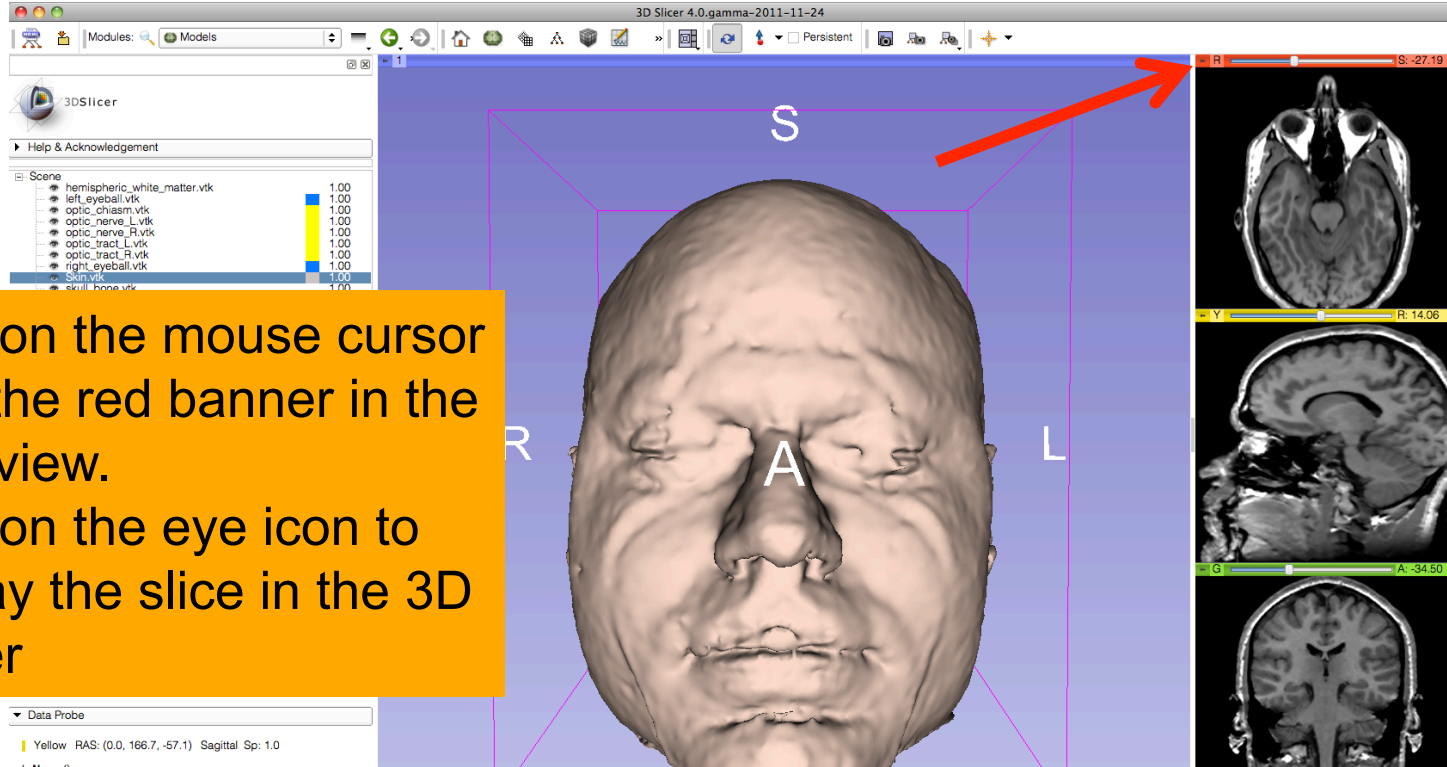


Models module



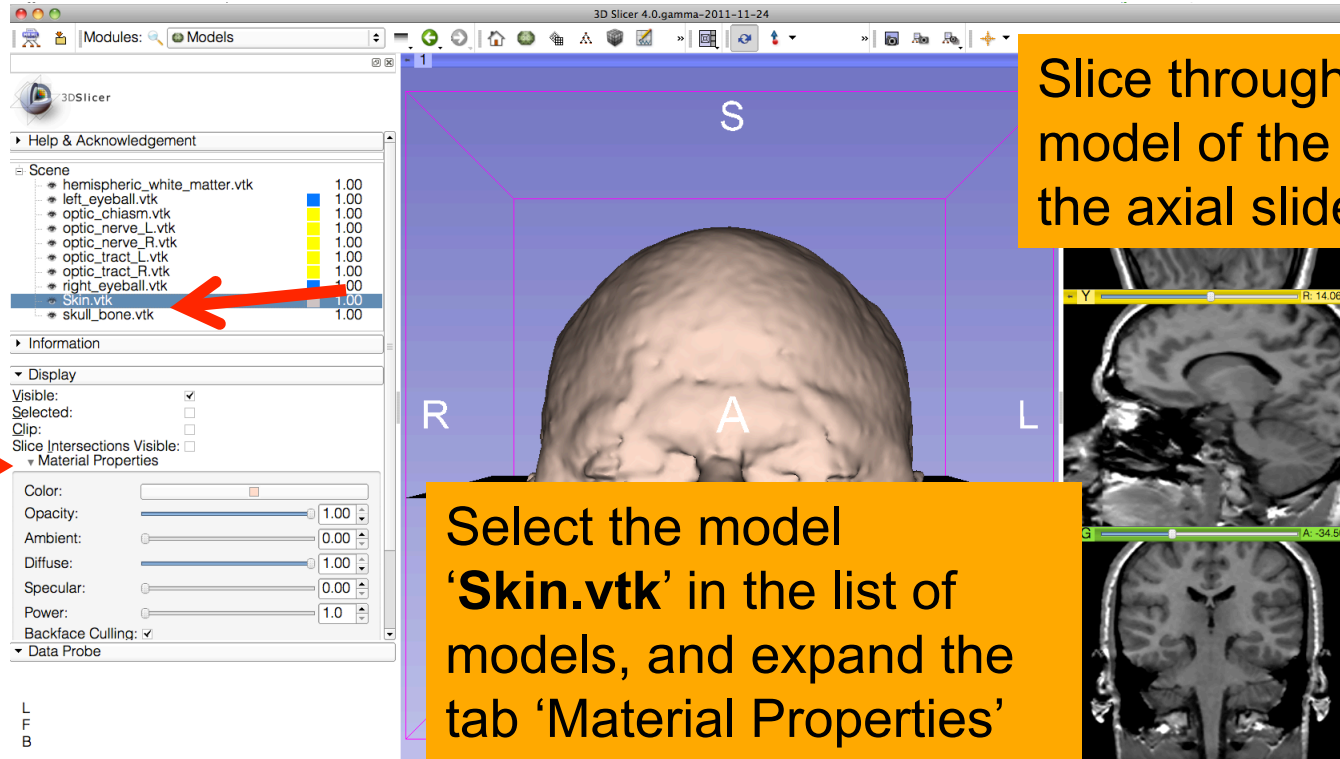


3D Visualization





3D Visualization

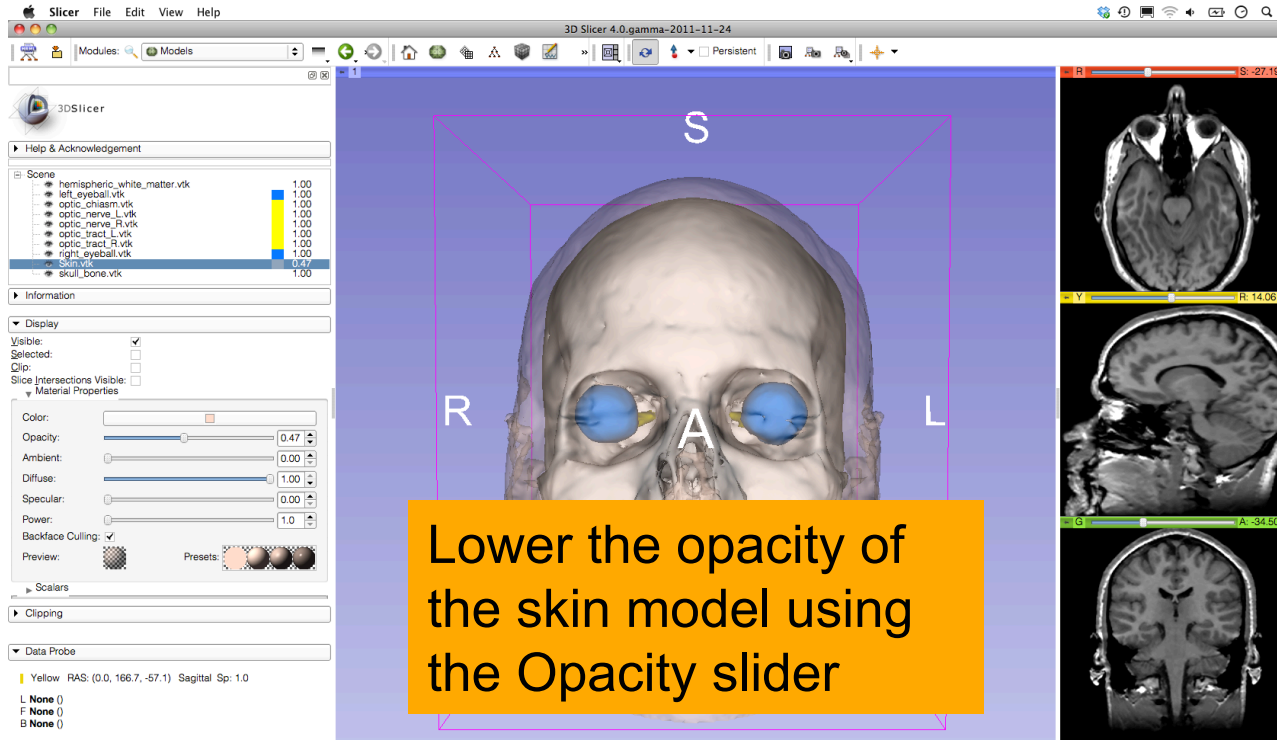


Slice through the 3D model of the head using the axial slider

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

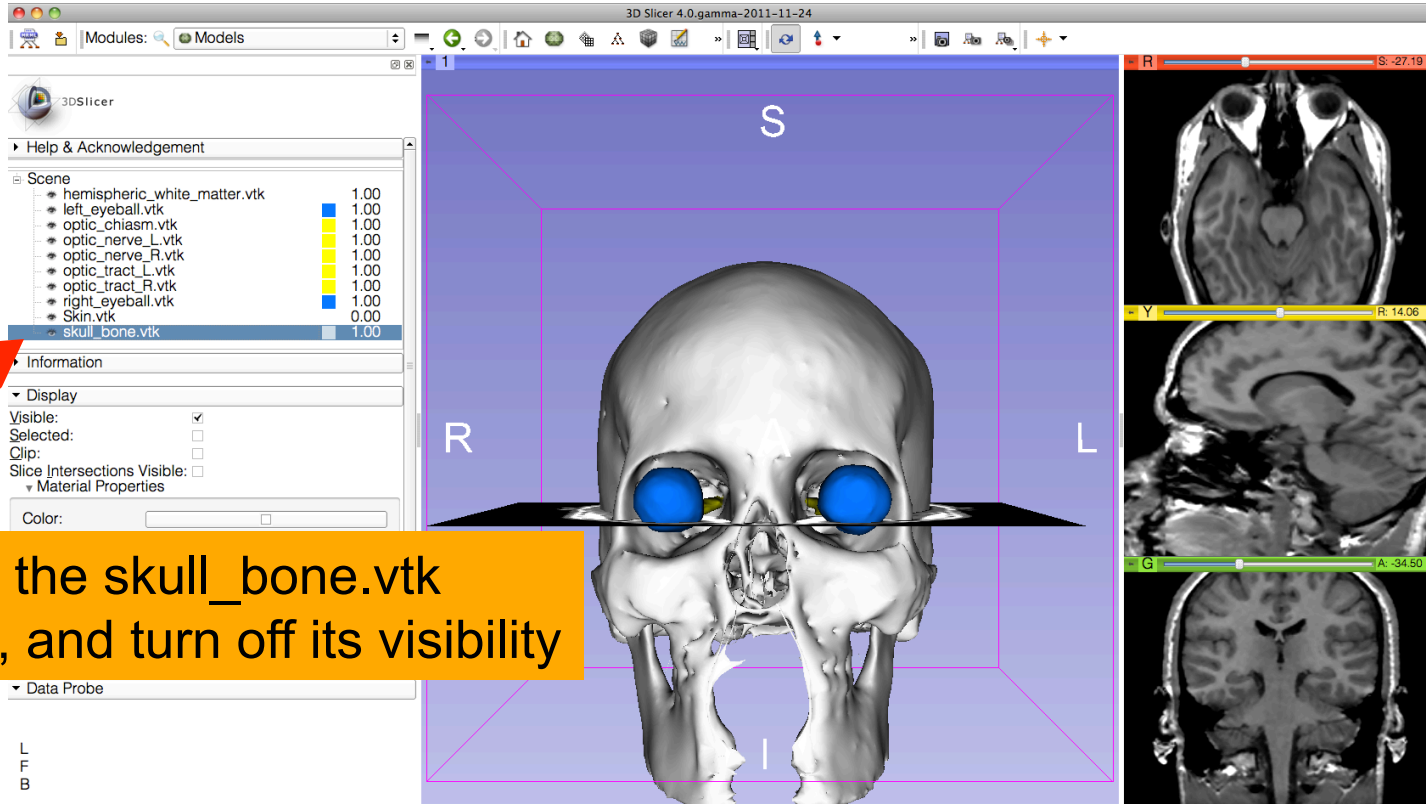


3D Visualization





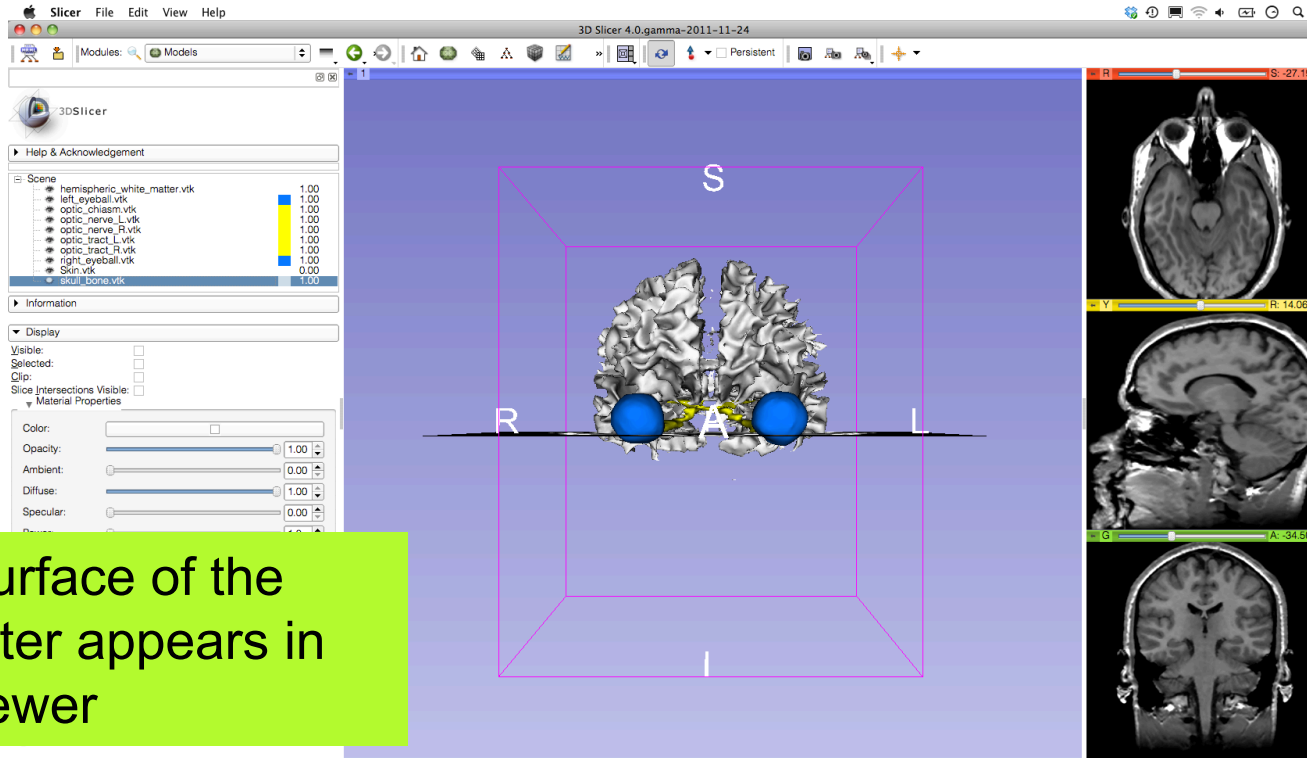
3D Visualization



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



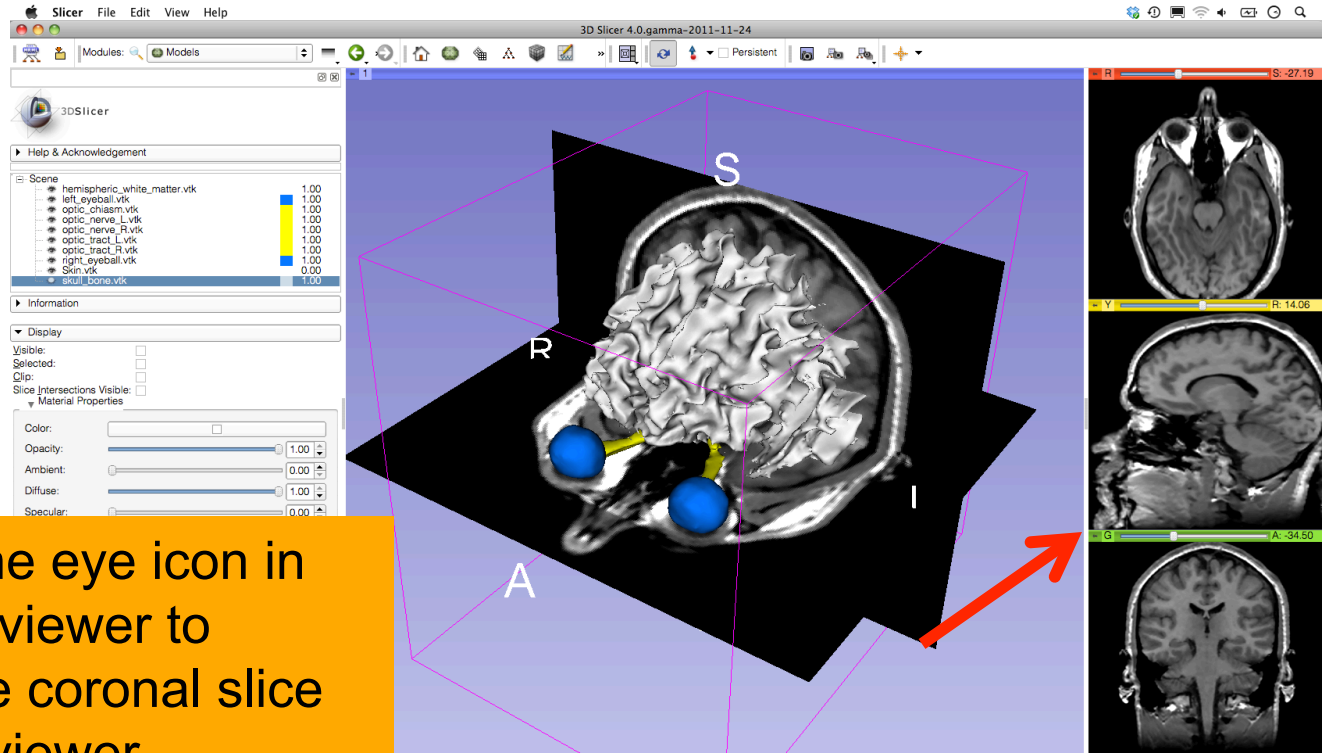
3D Visualization



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 Slicer 4.0.gamma-2011-11-24

Modules: Models

3DSlicer

Help & Acknowledgement

Scene

- hemispheric_white_matter.vtk 1.00
- left_eyeball.vtk 1.00
- optic_chiasm.vtk 1.00
- optic_nerve_L.vtk 1.00
- optic_nerve_R.vtk 1.00
- optic_tract_L.vtk 1.00
- optic_tract_R.vtk 1.00
- right_eyeball.vtk 1.00
- Skin.vtk 0.00
- skull_bone.vtk 1.00

Information

Display

Visible:

Selected:

Clip:

Slice Intersections Visible:

Material Properties

Color:

Opacity: 1.00

Ambient: 0.00

Diffuse: 1.00

Specular: 0.00

Power: 1.0

Backface Culling:

Data Probe

L
F
B

S

R -27.19

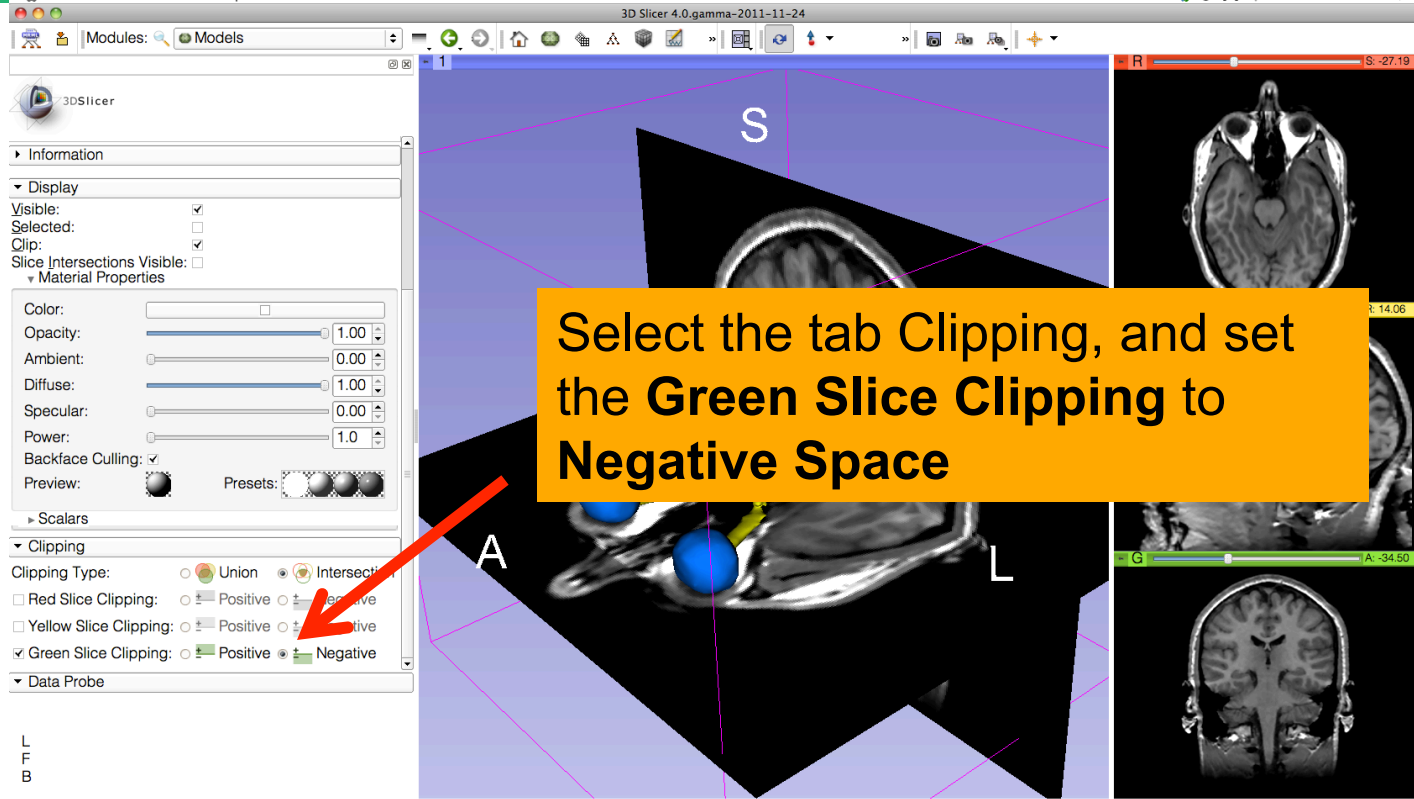
R 14.06

A -34.50

Select the 3D model **hemispheric_white_matter.vtk**, and select the option **Clip** in the Display tab



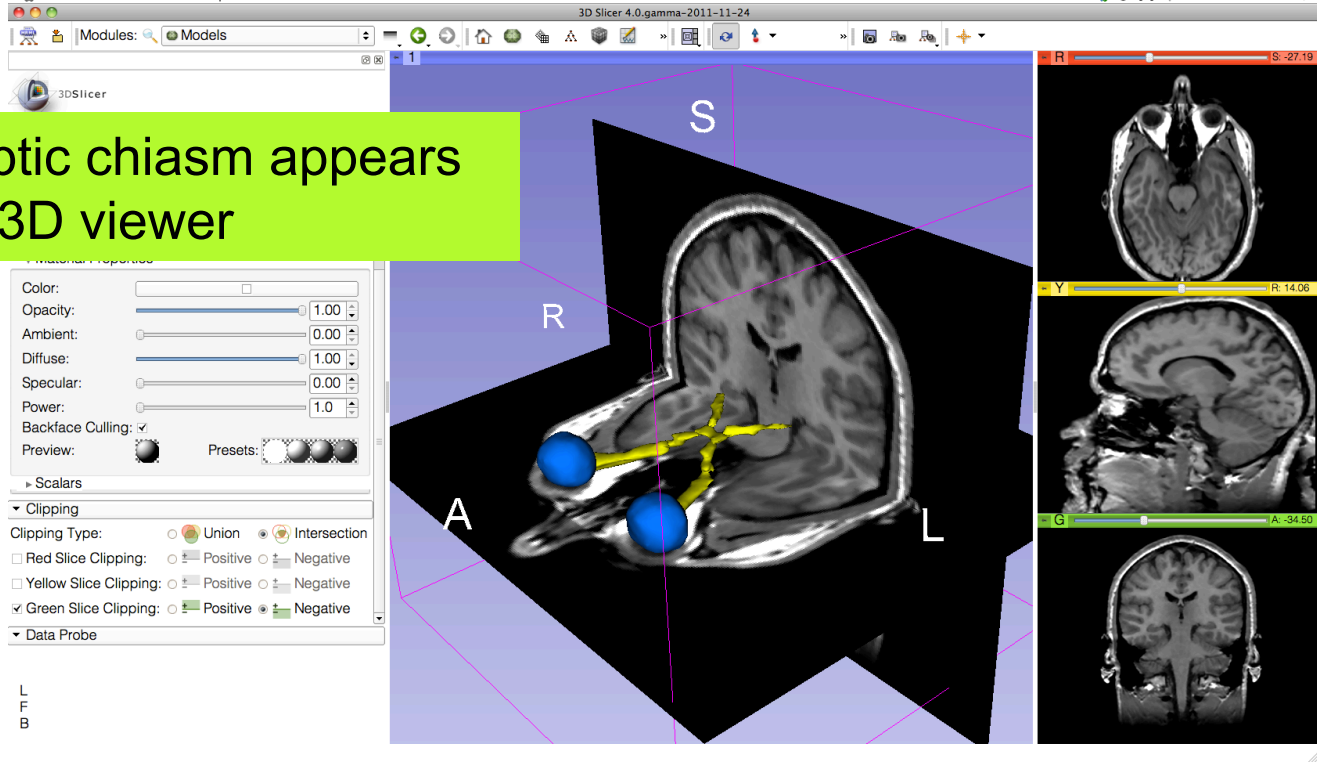
3D Visualization





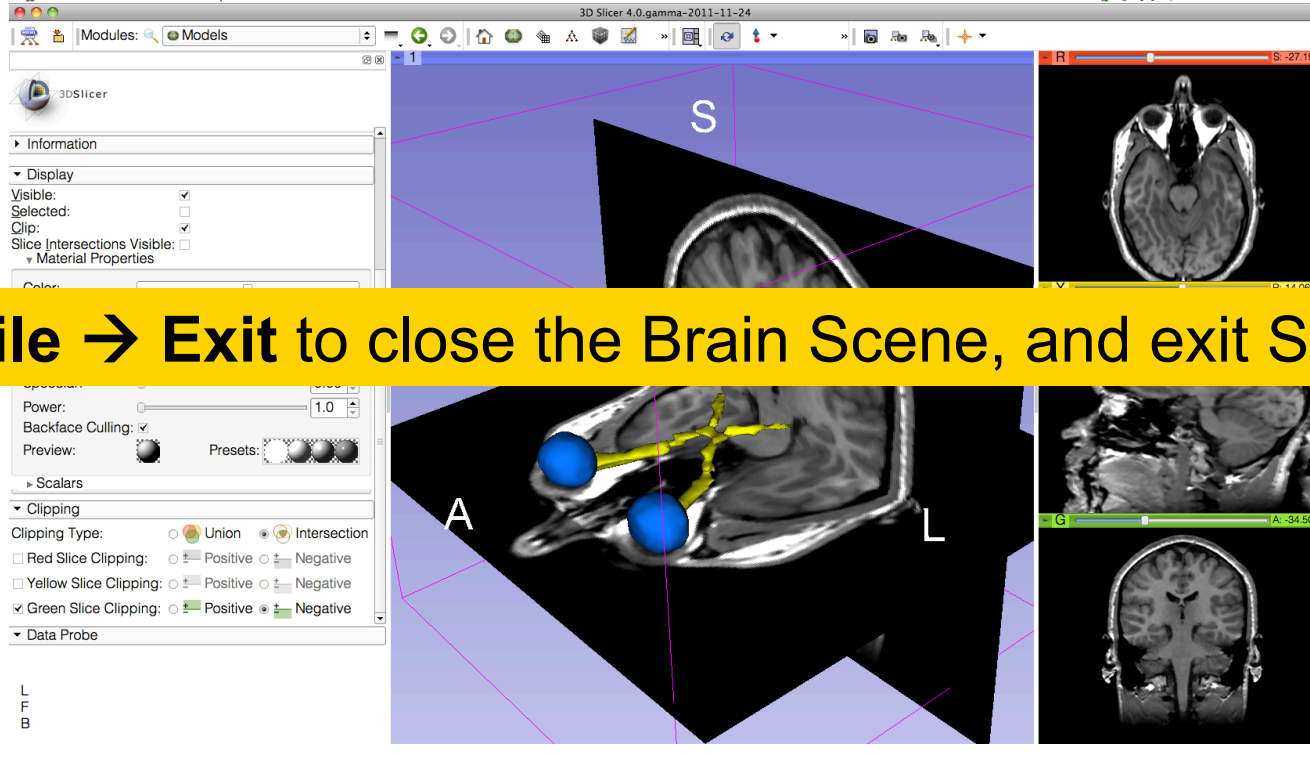
3D Visualization

The optic chiasm appears in the 3D viewer

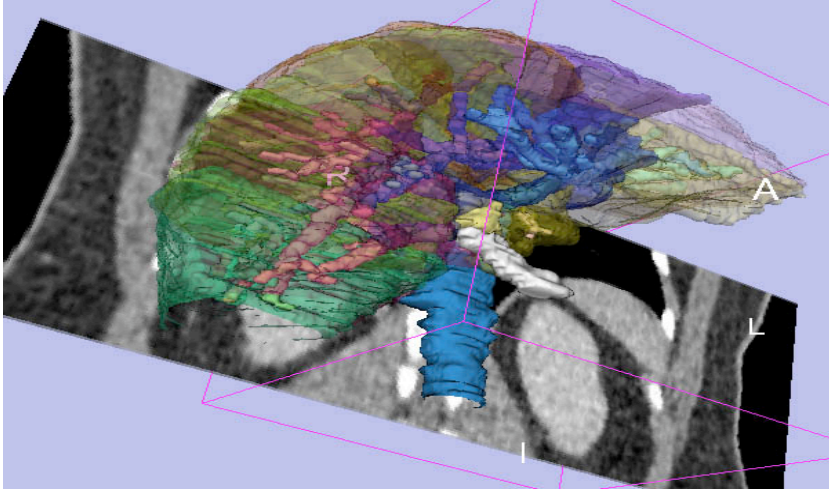




3D Visualization



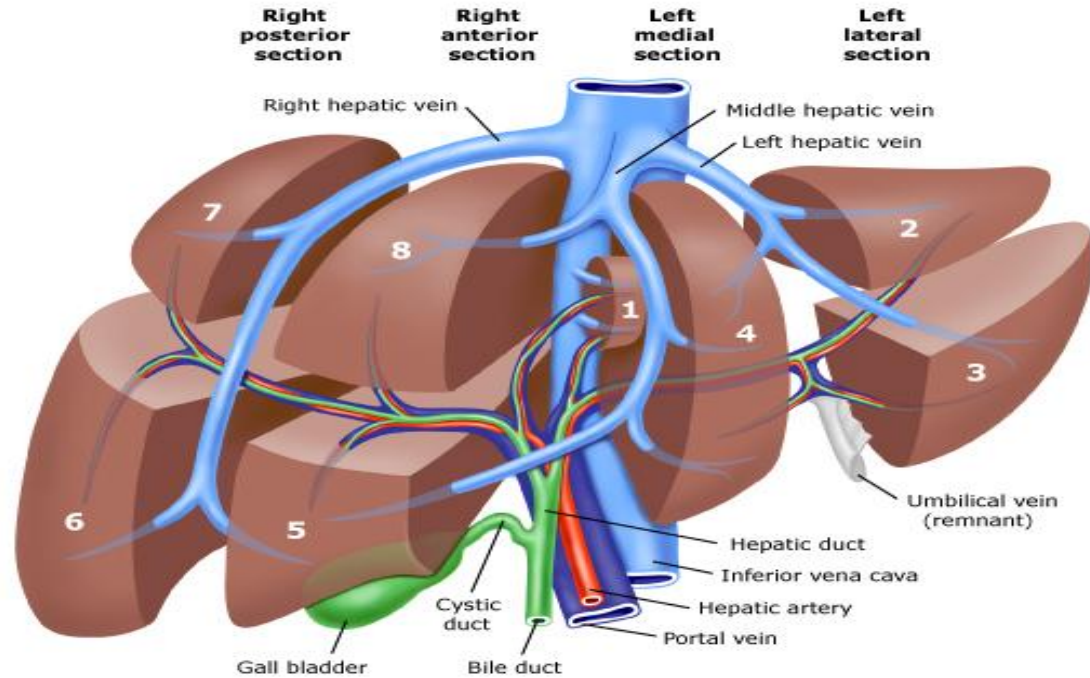
Select **File** → **Exit** to close the Brain Scene, and exit Slicer



Part 3:

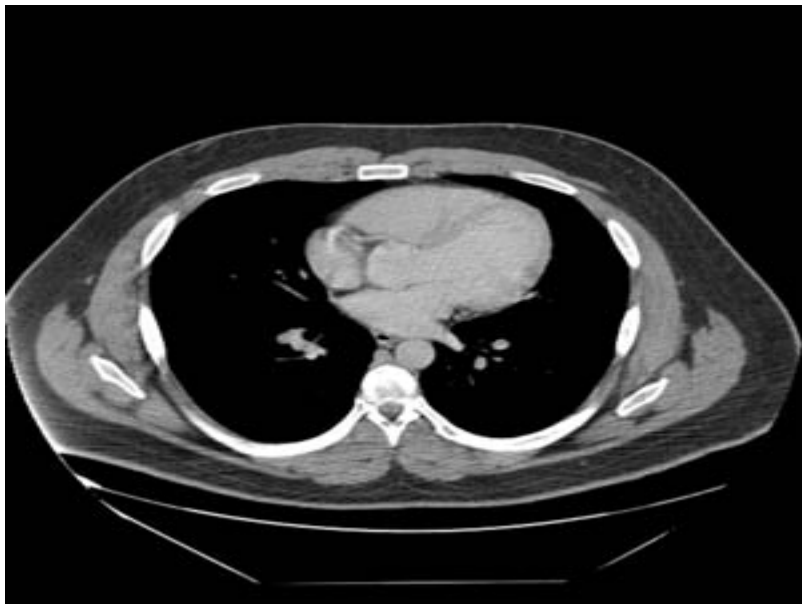
Interactive 3D Visualization
of the segments of the liver

Anatomy of the liver





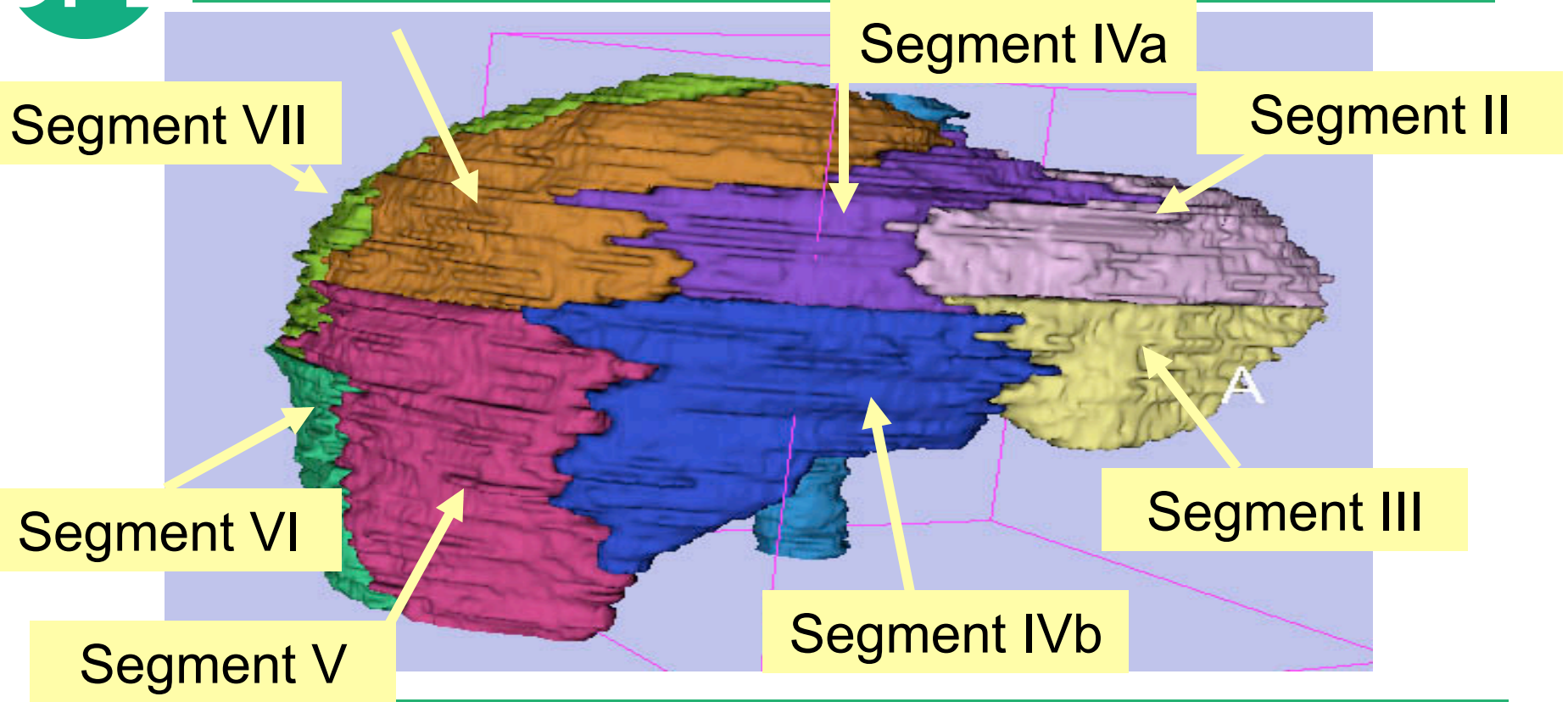
Liver dataset



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

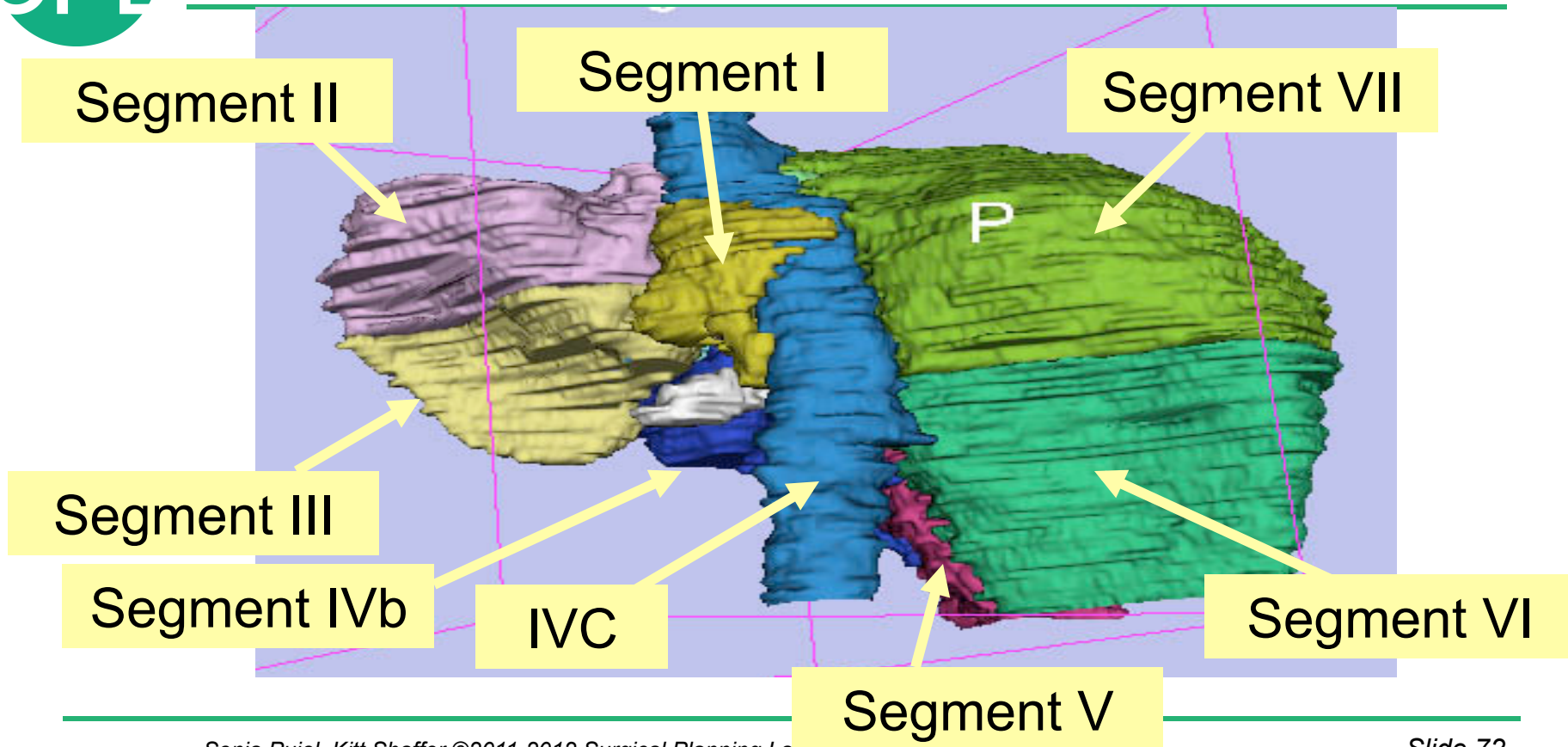


3D segments of the liver



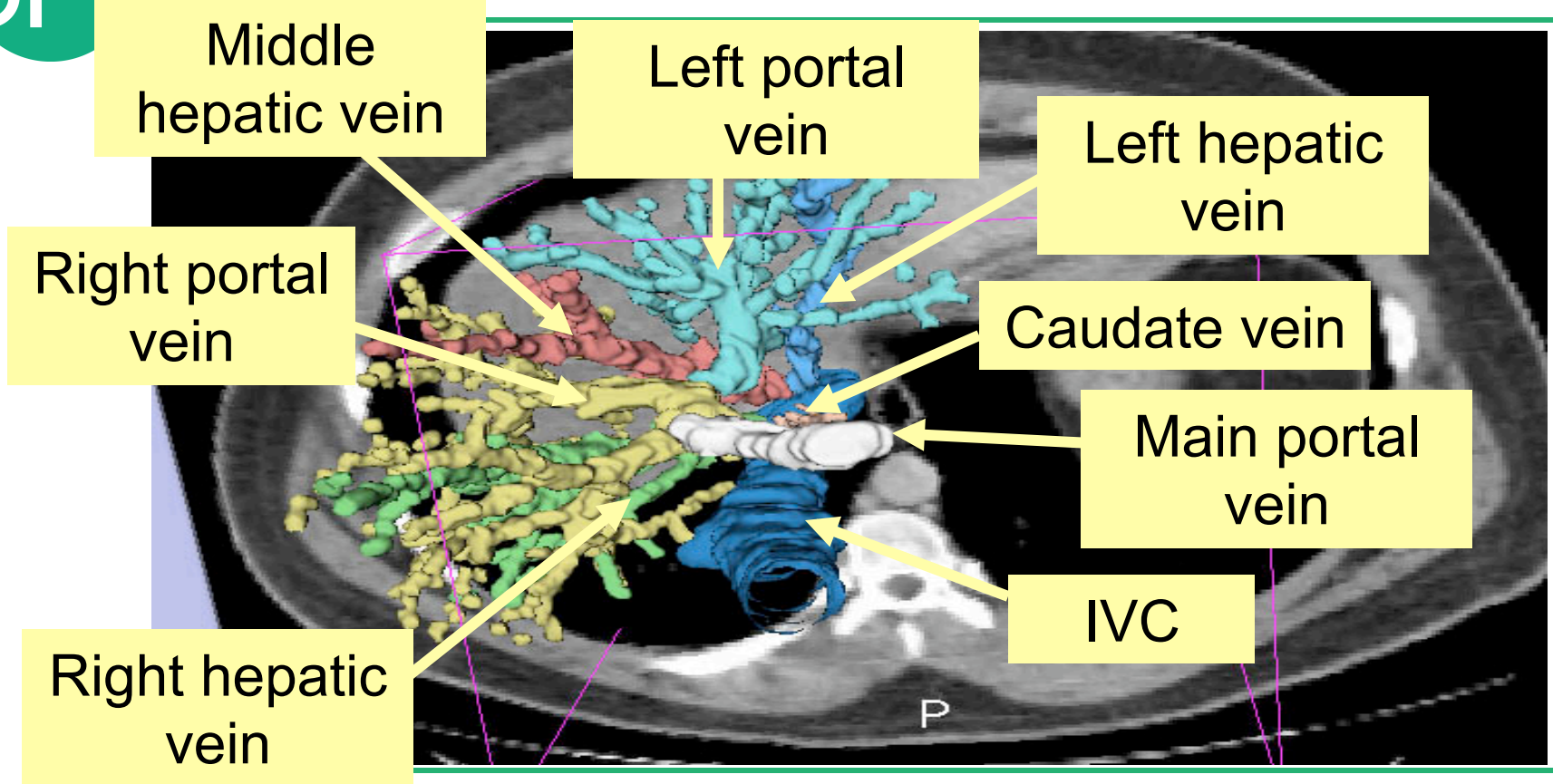


3D segments of the liver



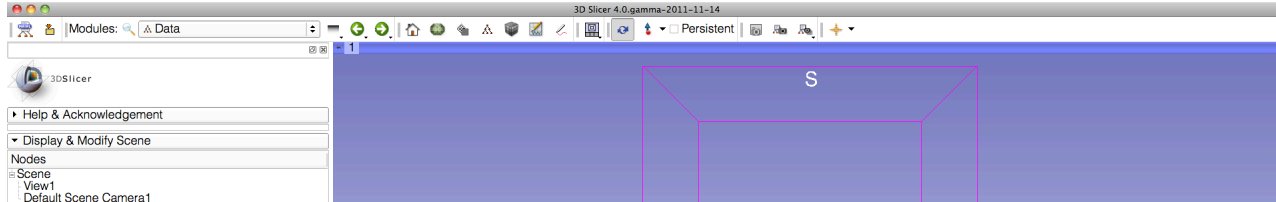


Liver vasculature





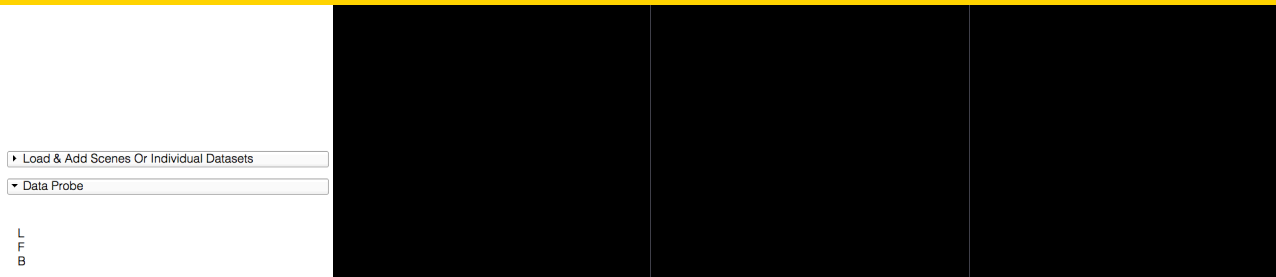
Loading the Liver Scene



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

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

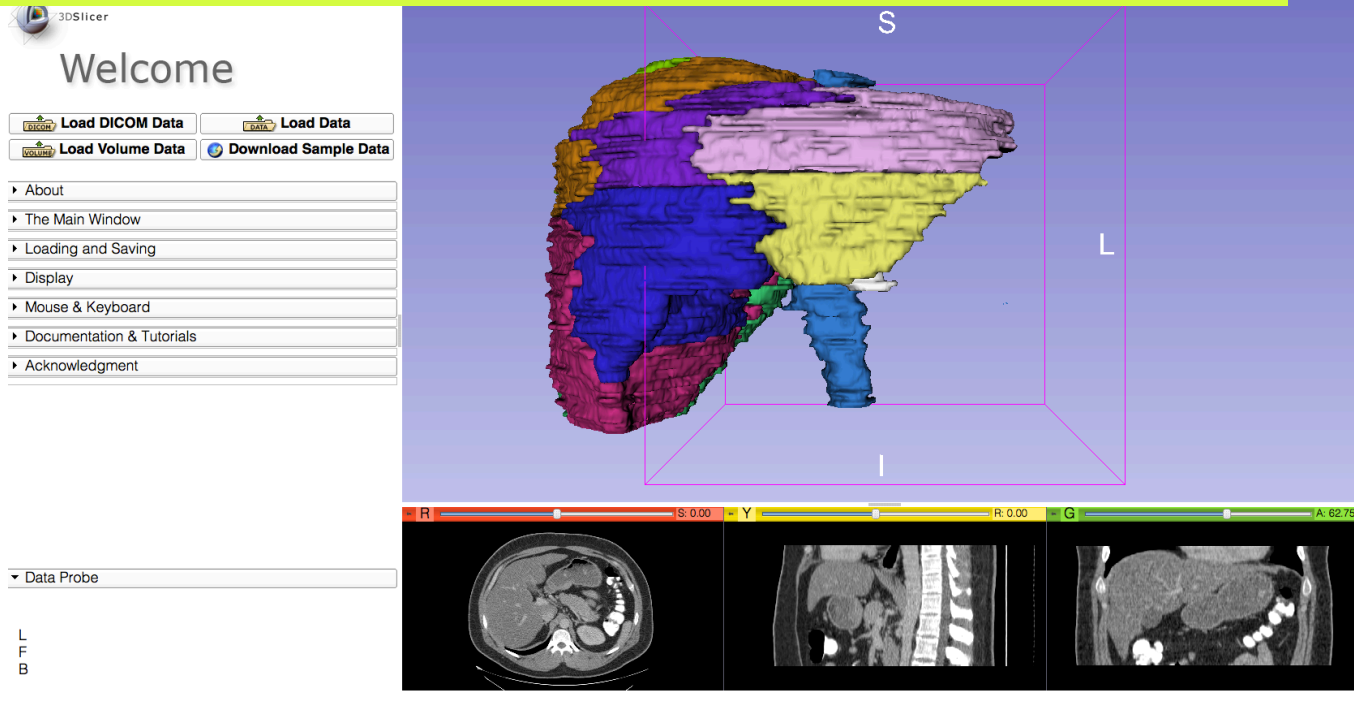
C:\Documents and Settings\Administrator\Desktop\3D\LiverData





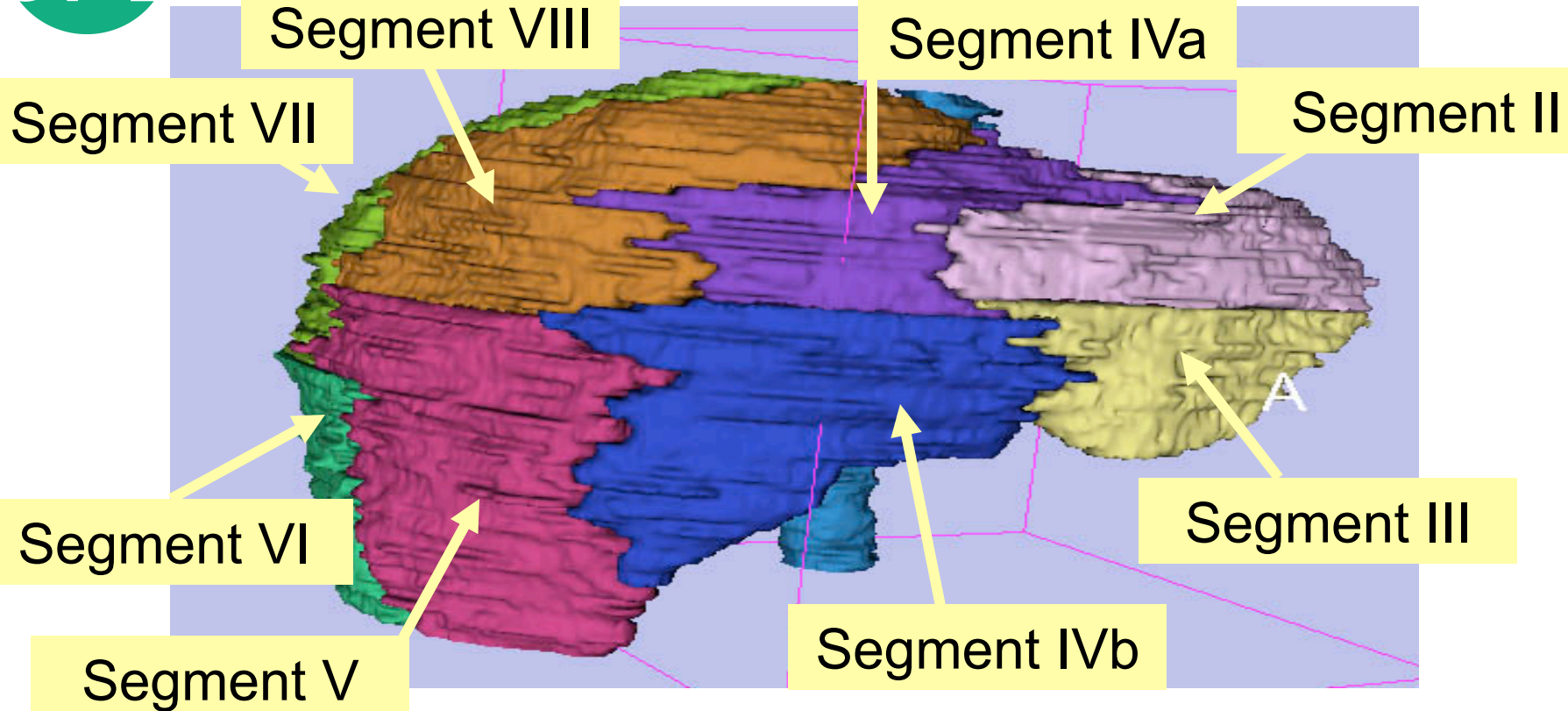
Liver Segments Scene

The elements of the scene appear in the Viewer



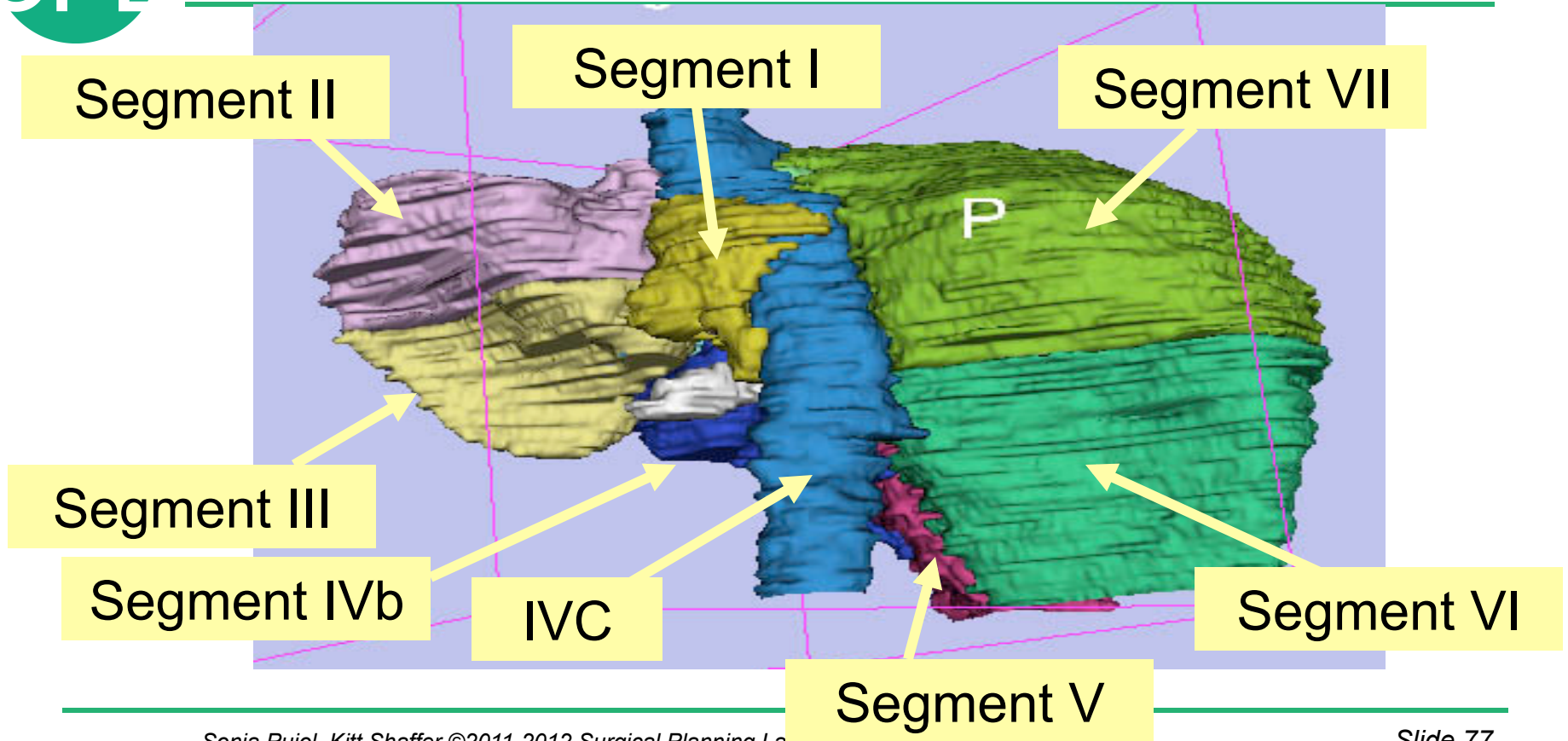


3D models of the liver



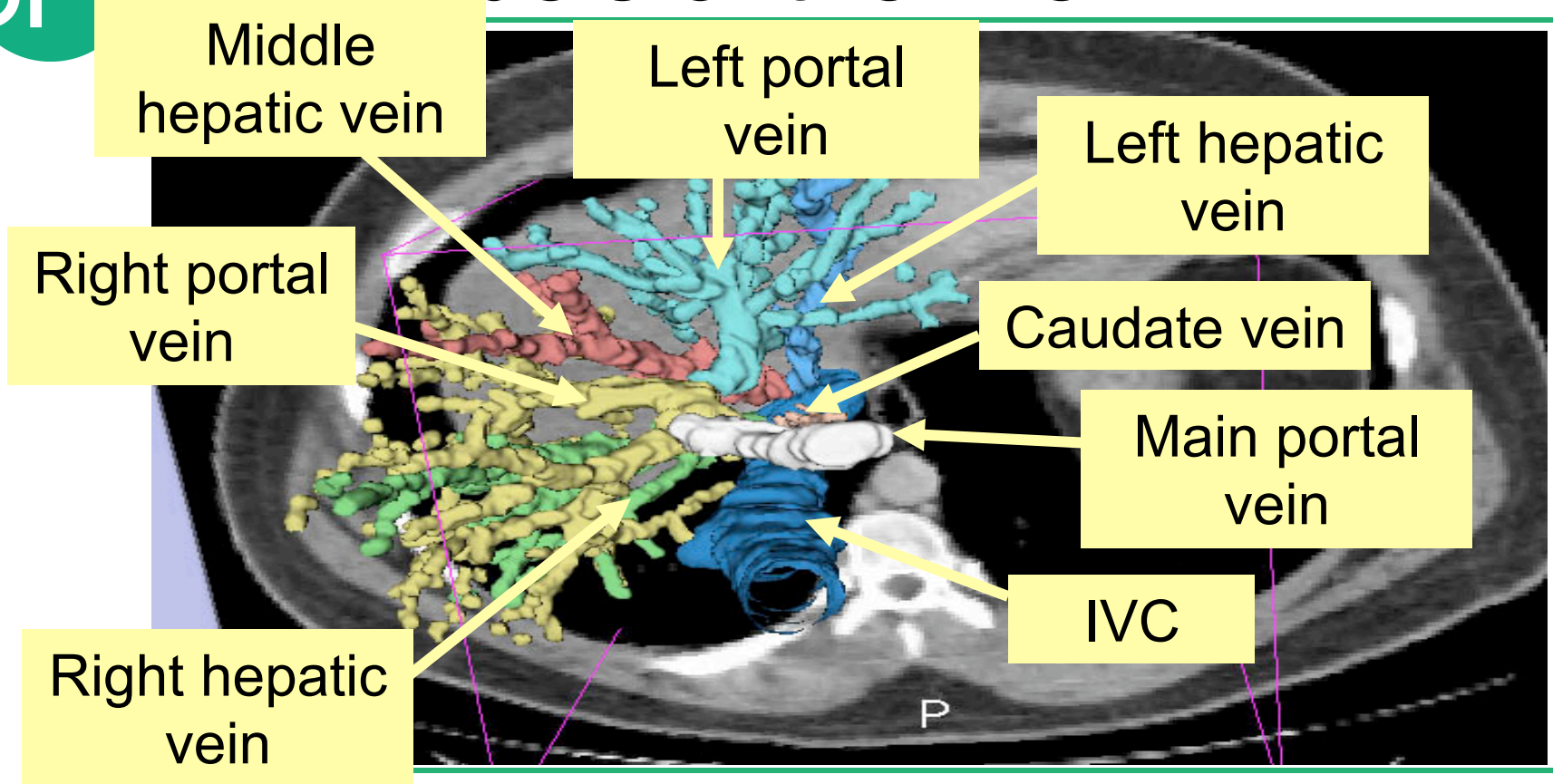


3D models of the liver



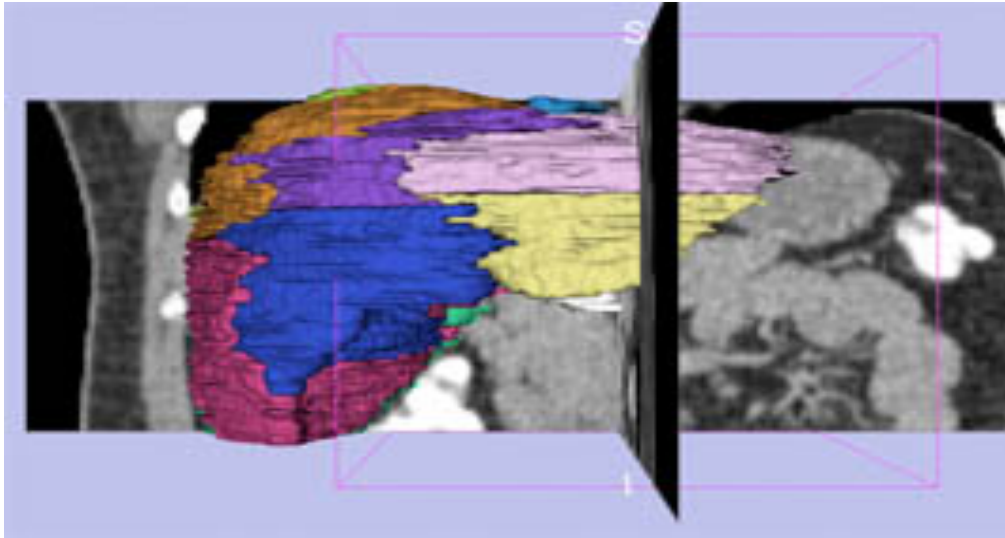


3D models of the liver





3D Exploration of Liver Segments

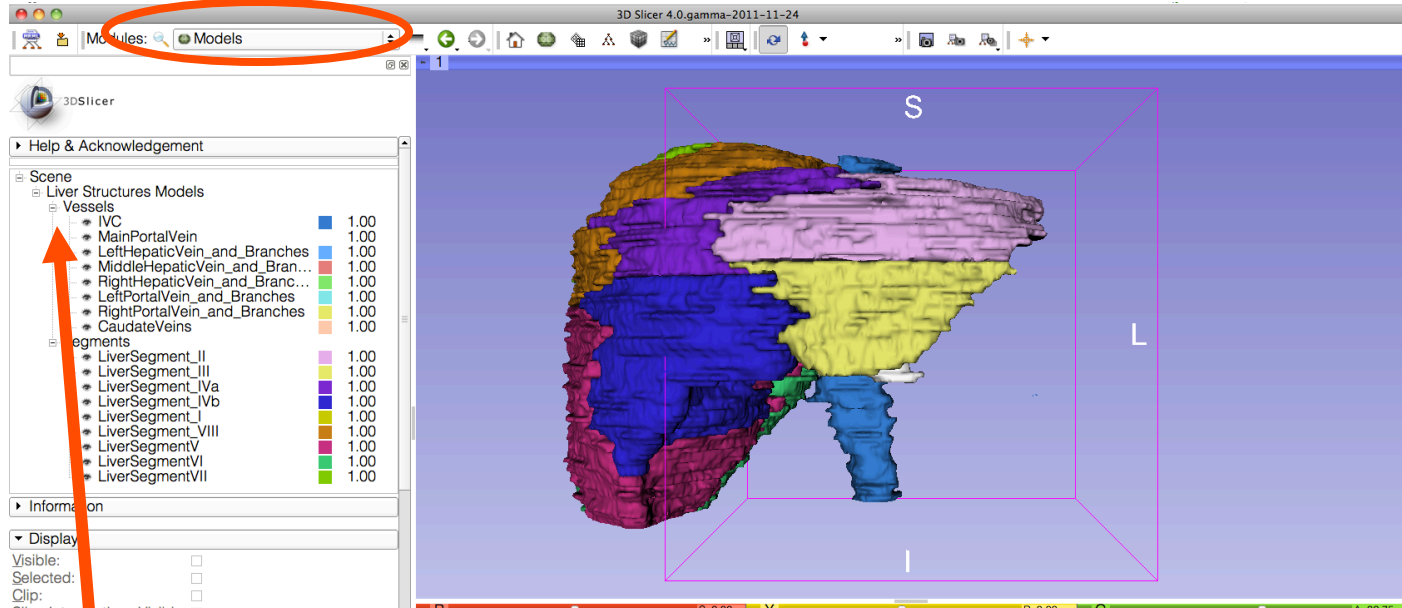


Example:

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



3D Exploration of Liver Segments

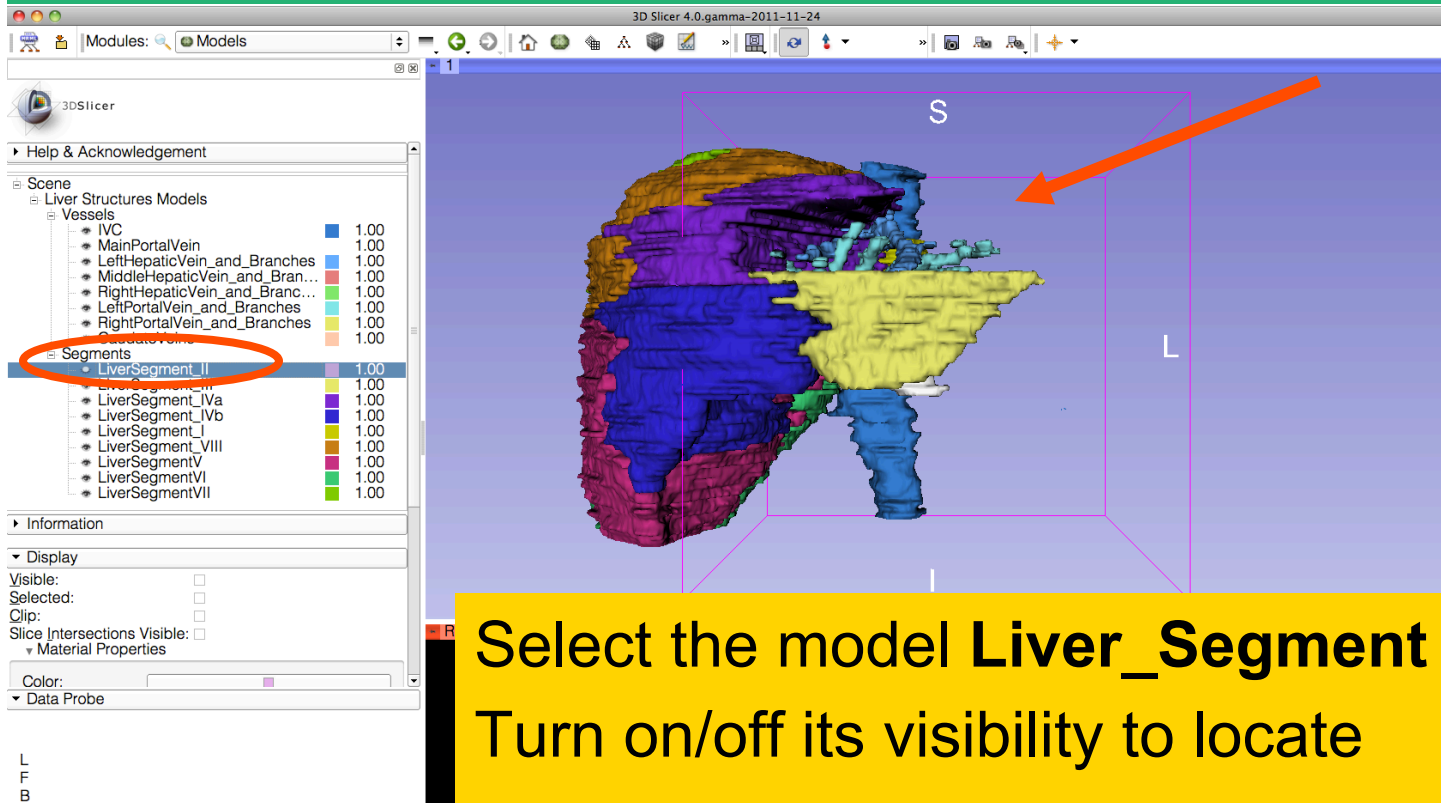


Select the module **Models**

Click on the Liver Structures Models Hierarchy



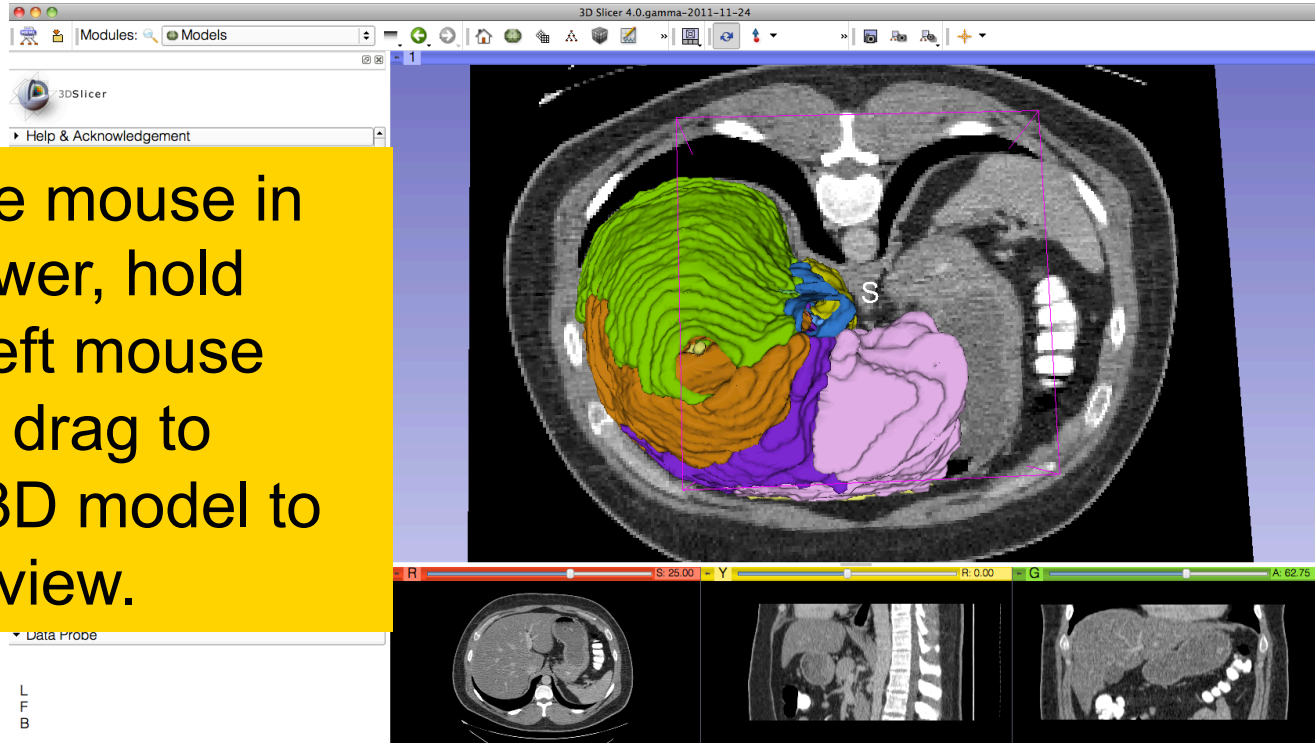
3D Exploration of Liver Segments





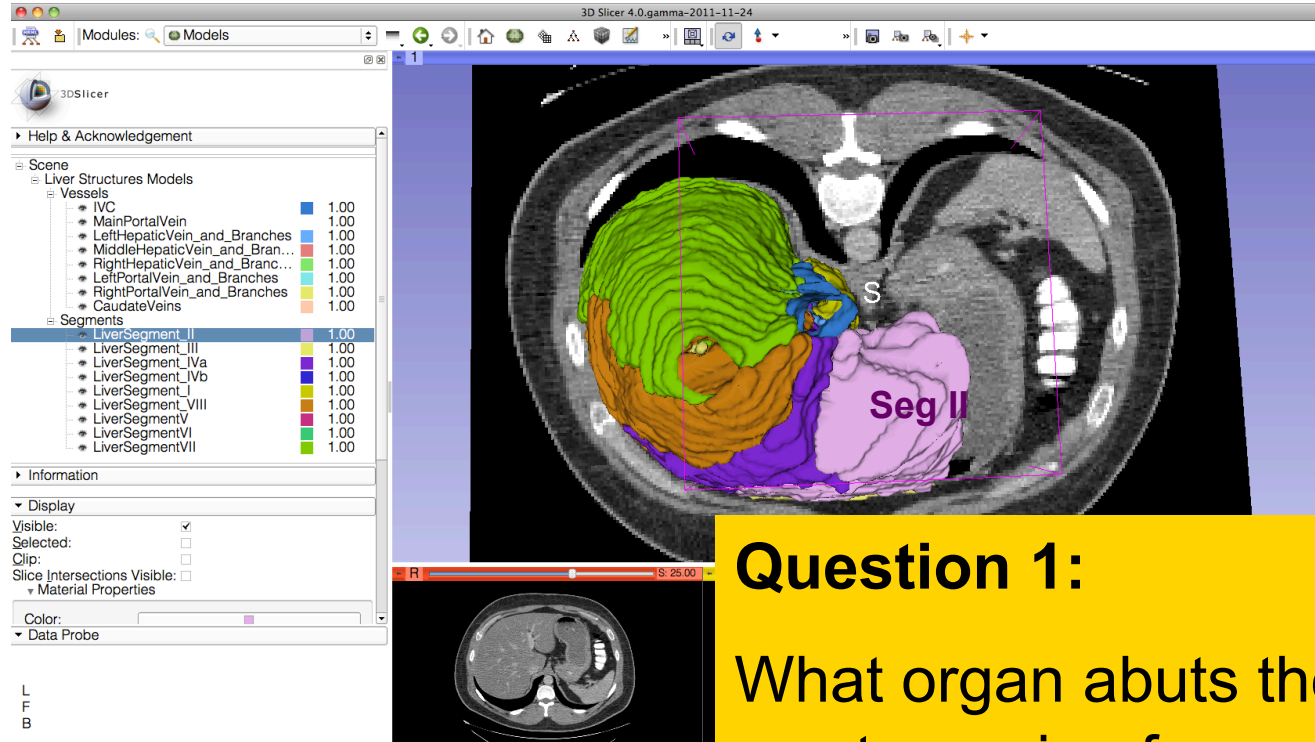
3D Exploration of Liver Segments

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



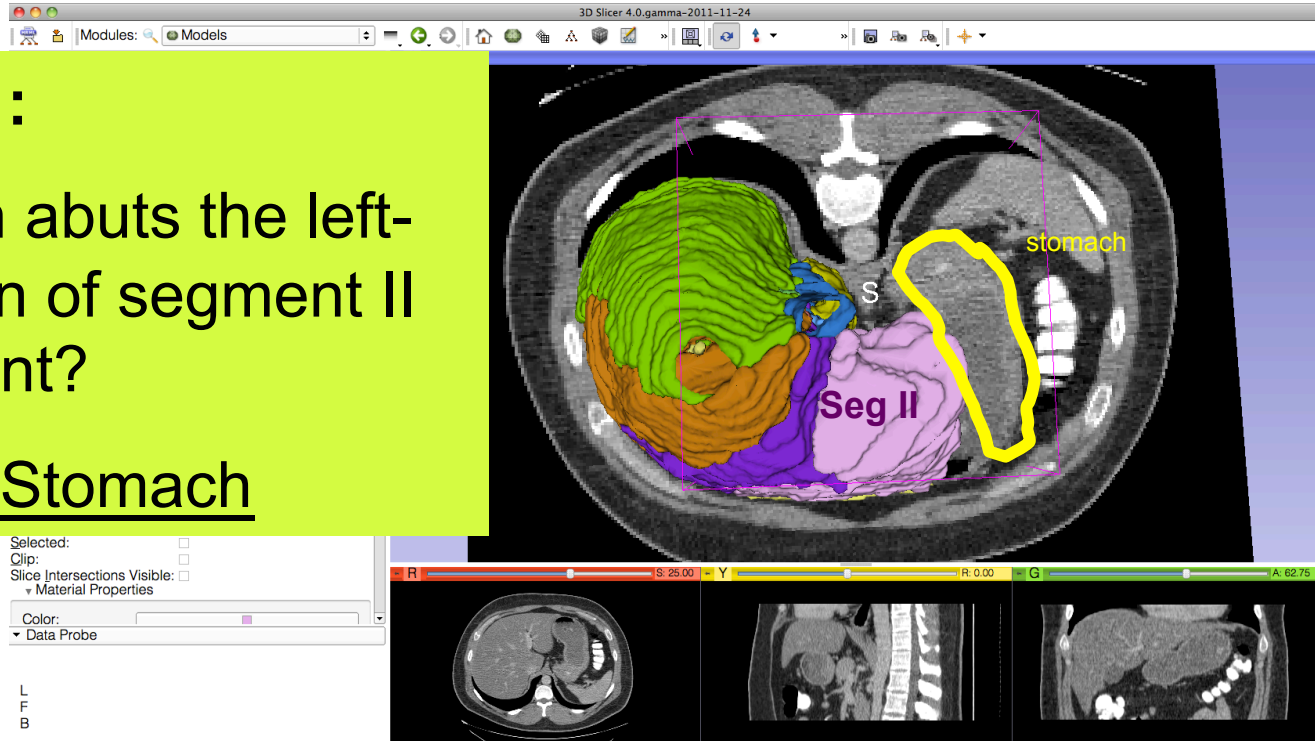


3D Exploration of Liver Segments

Question 1:

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

Answer 1: Stomach

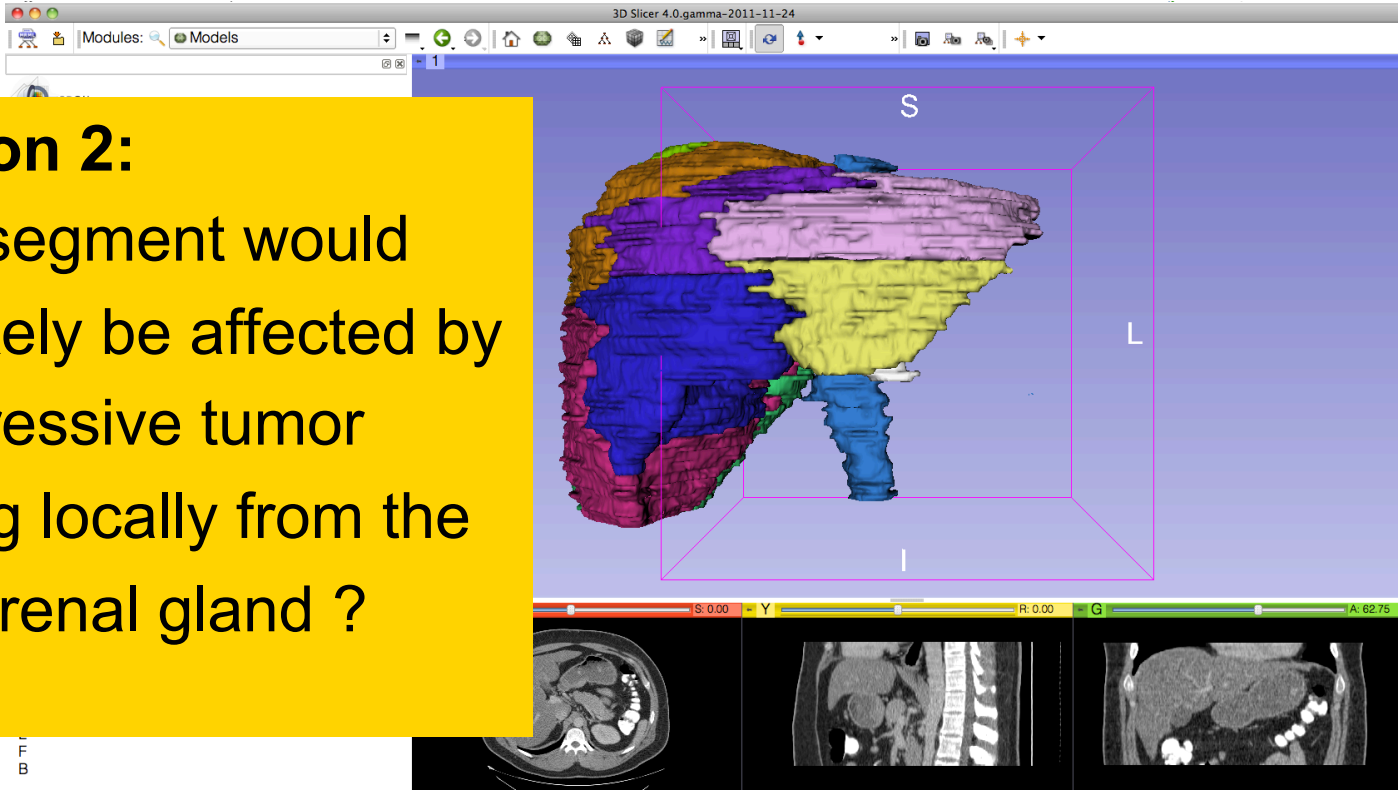




3D Exploration of Liver Segments

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

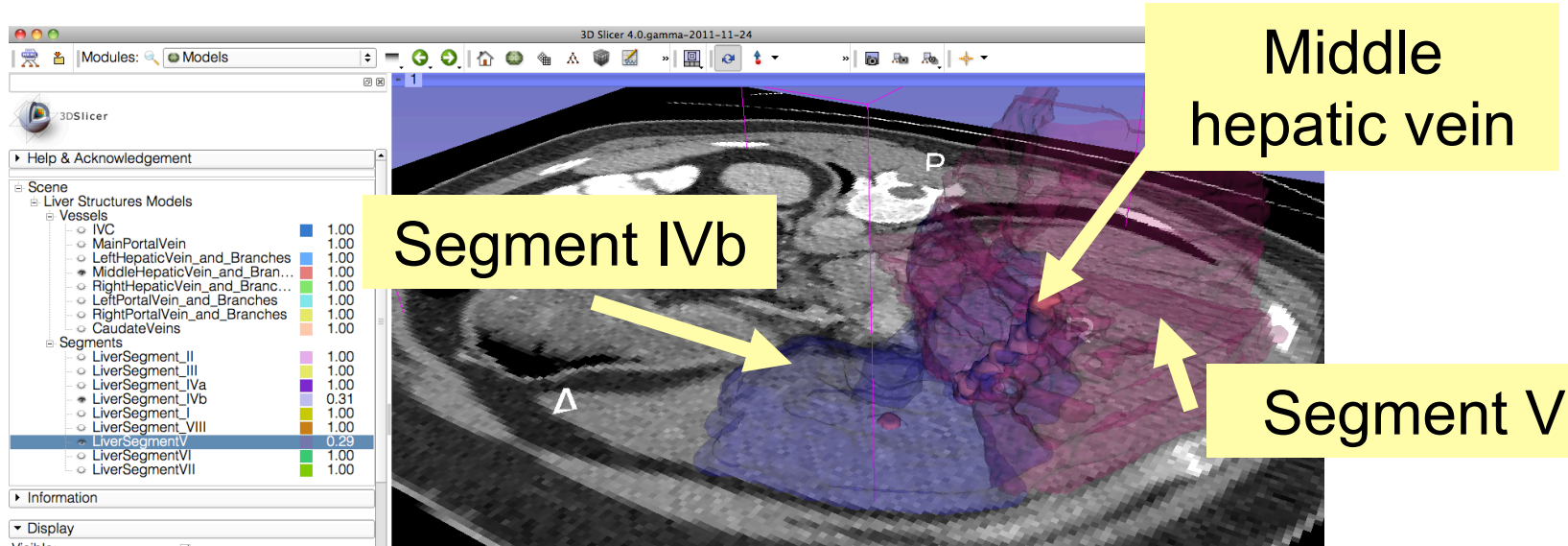


Question 3:

Which vessel separates Segment IVb and Segment V?



Middle Hepatic Vein



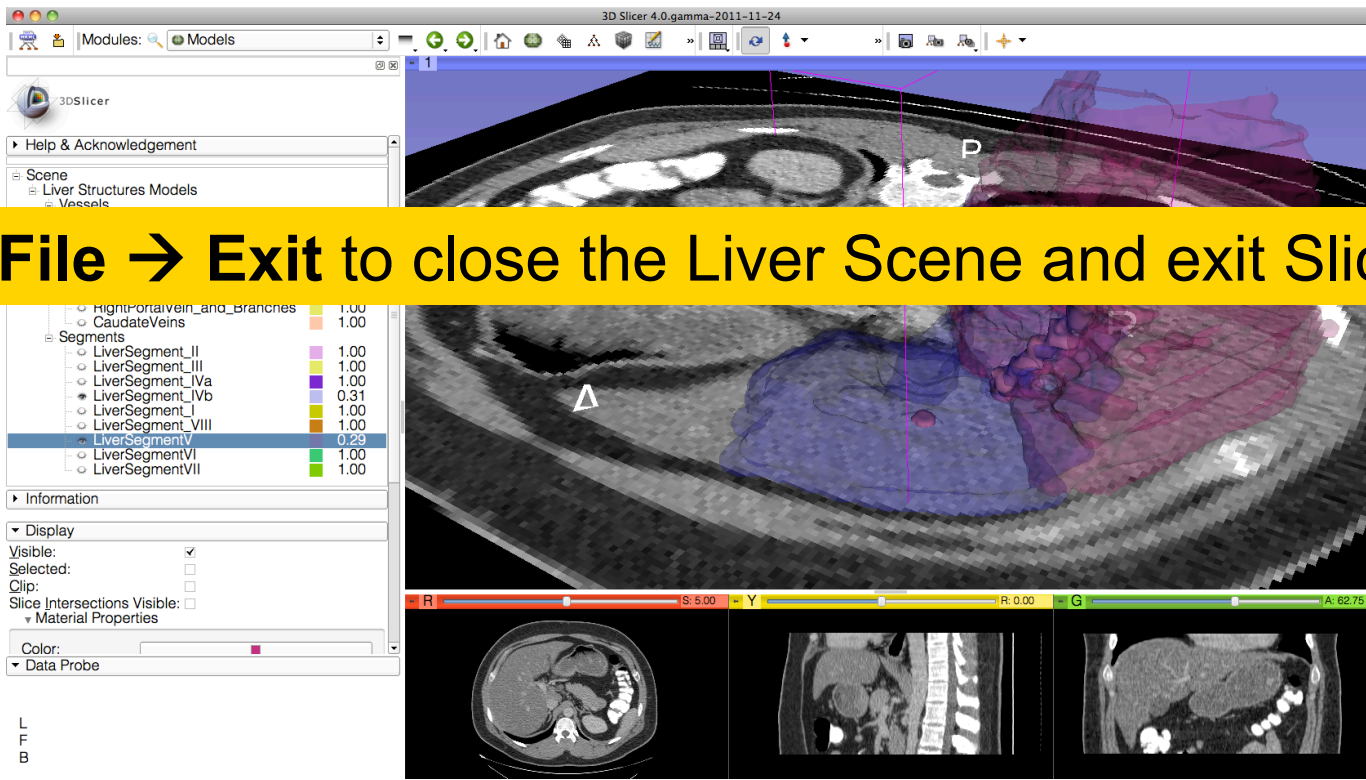
Question 3:

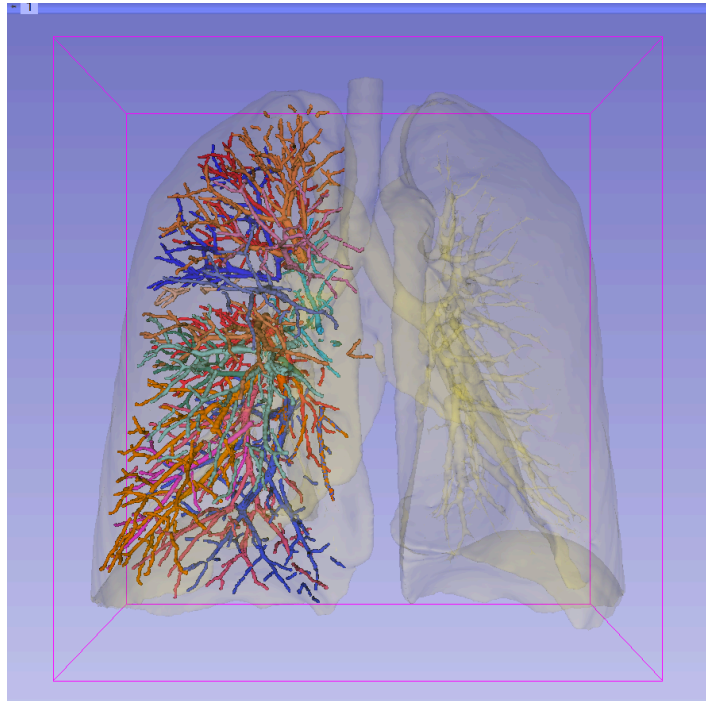
Which vessel separates Segment IVb and Segment V?

Answer 3: The middle hepatic vein



Closing the Liver Scene



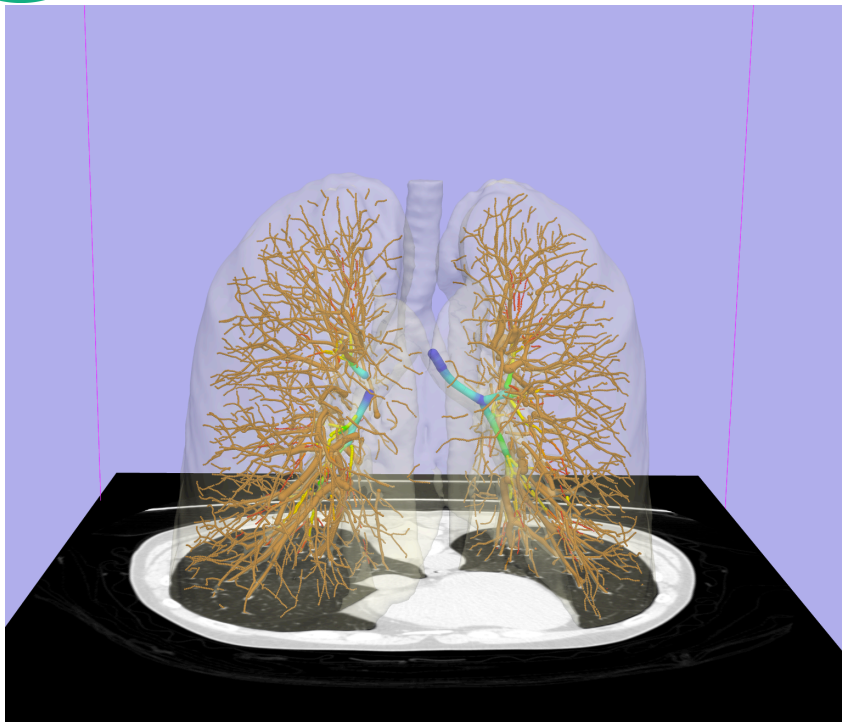


Part 4:

Interactive 3D Visualization
of the segments of the lungs



Segments of the lung



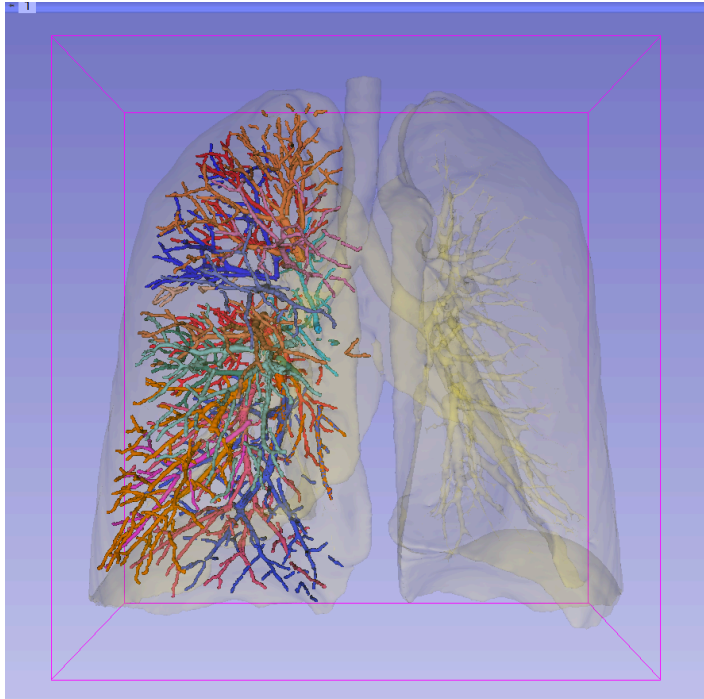
Segmentation and 3D surface reconstruction of the lung and pulmonary vessels

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

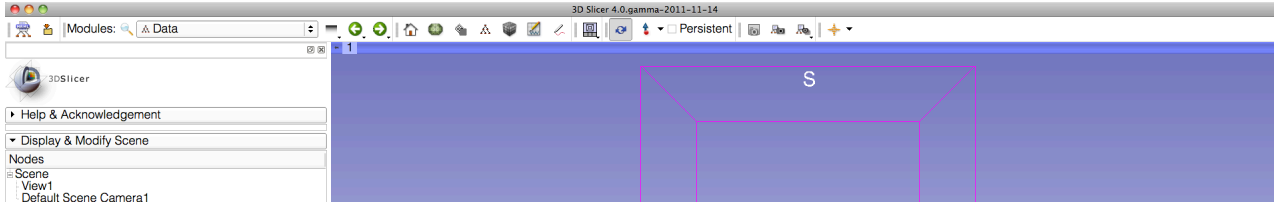


3D parcellation of arteries and veins from original model of pulmonary vessels
(Kitt Shaffer, M.D., Ph.D. - Sonia Pujol, Ph.D.)

- 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



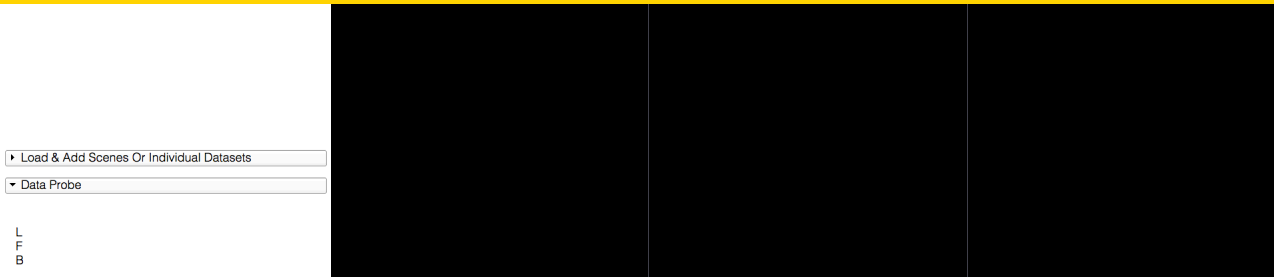
Loading the Lung Scene



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

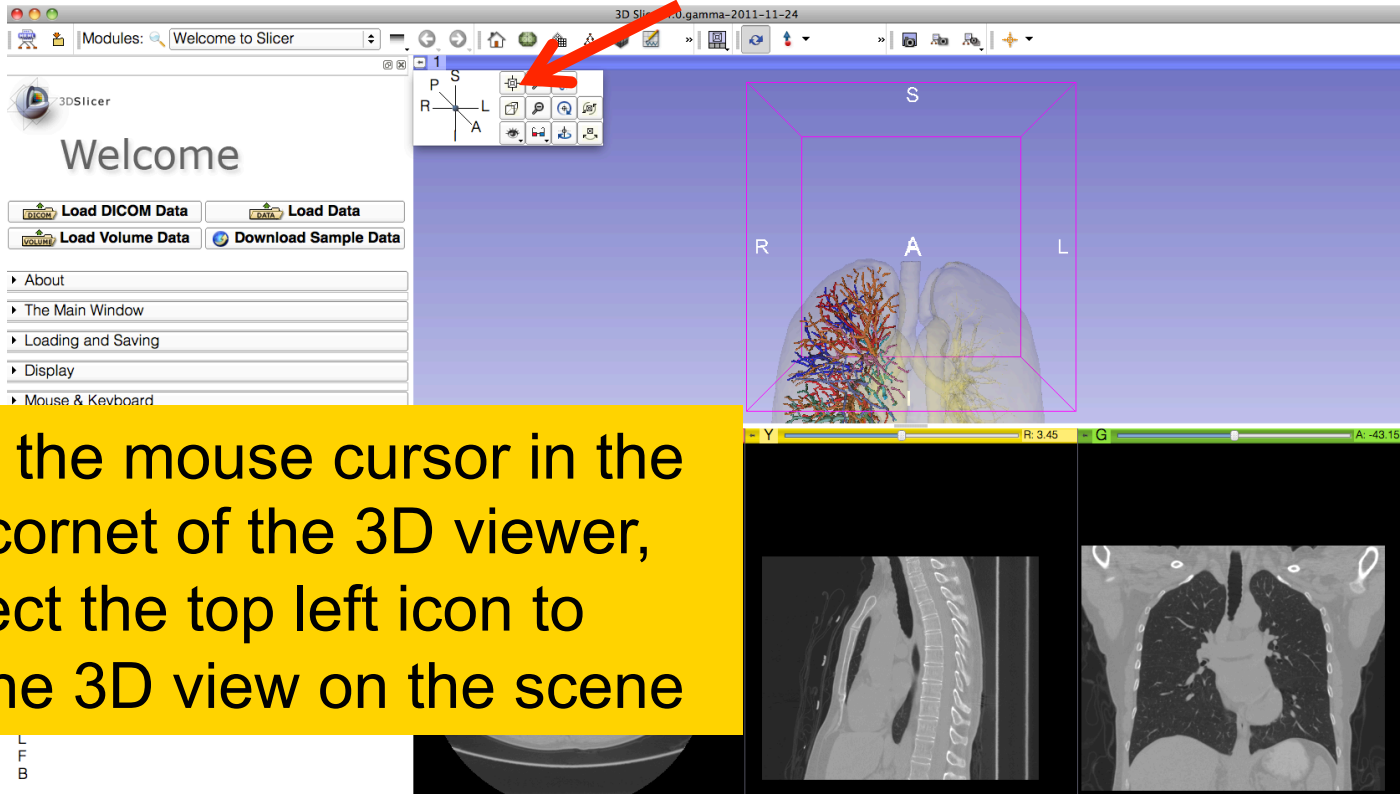
Load the file **LungSegment_Scene.mrml** located in:

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





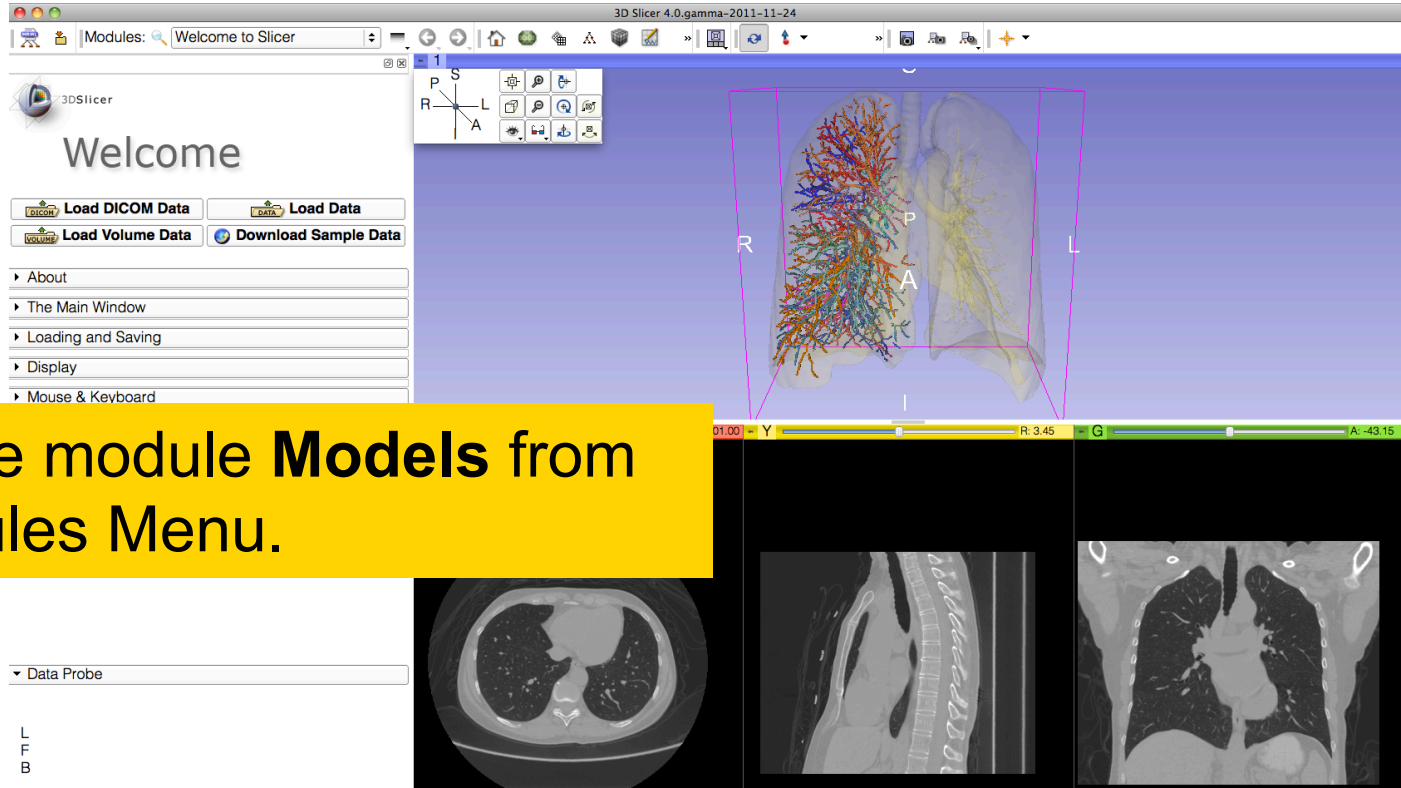
Loading the Lung Scene



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

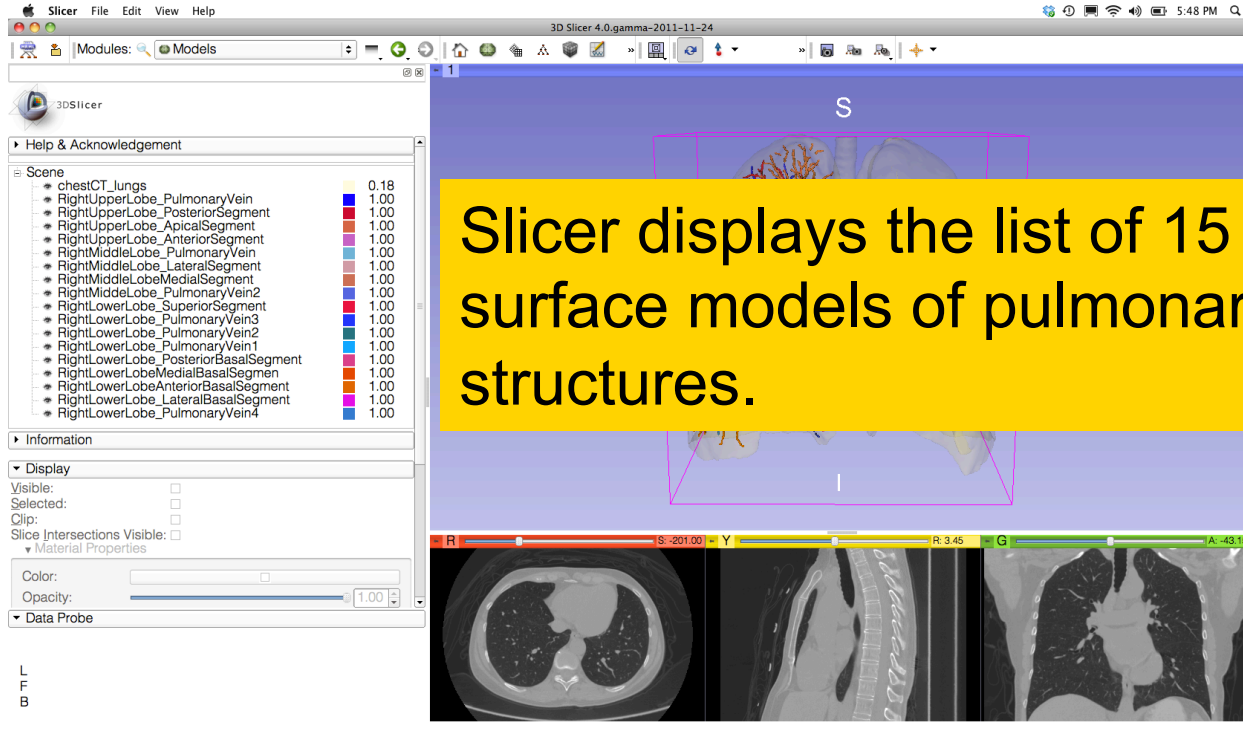


Loading the Lung Scene





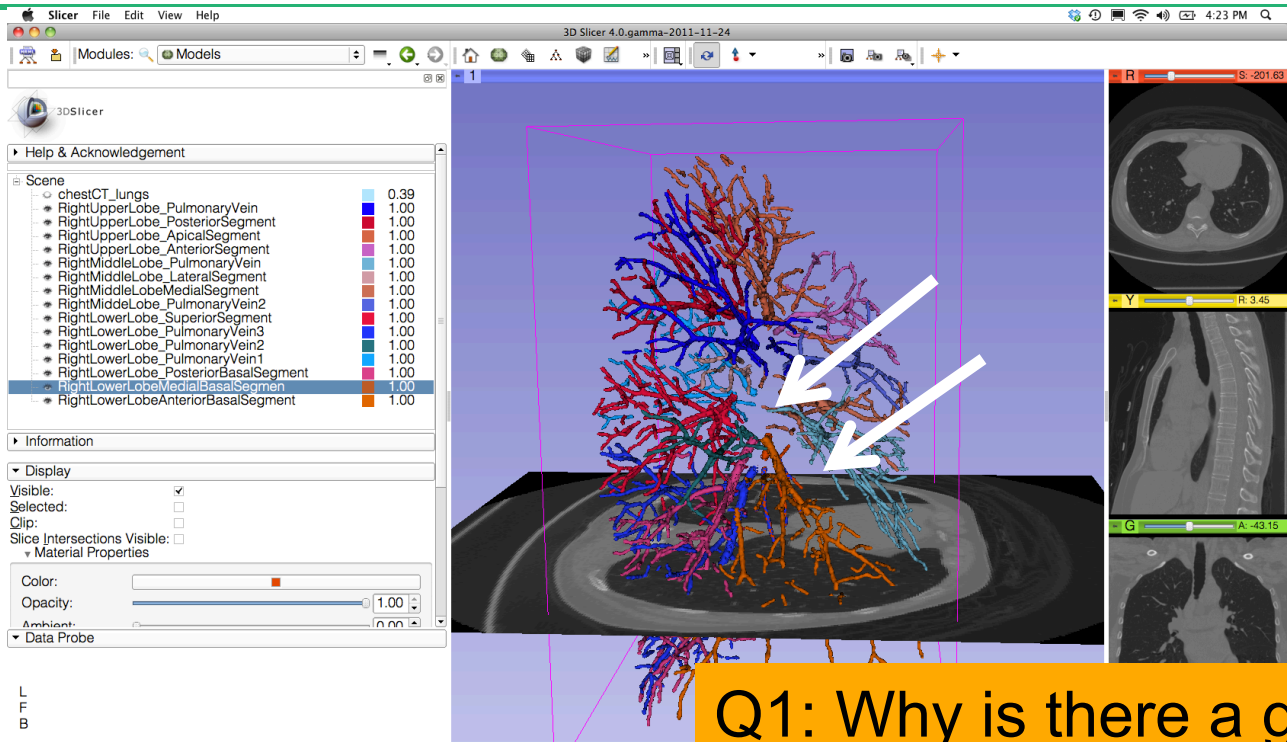
Lung Segments



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



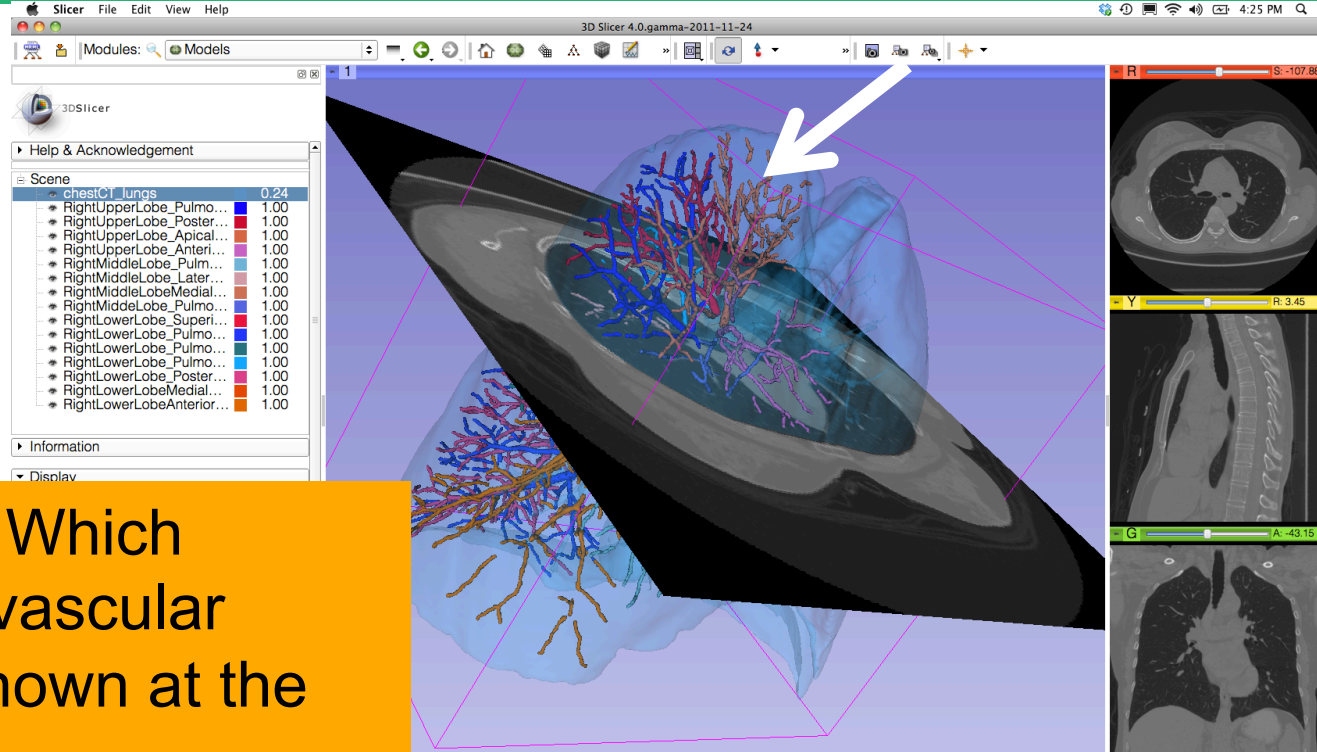
Lung Segments – Question 1



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



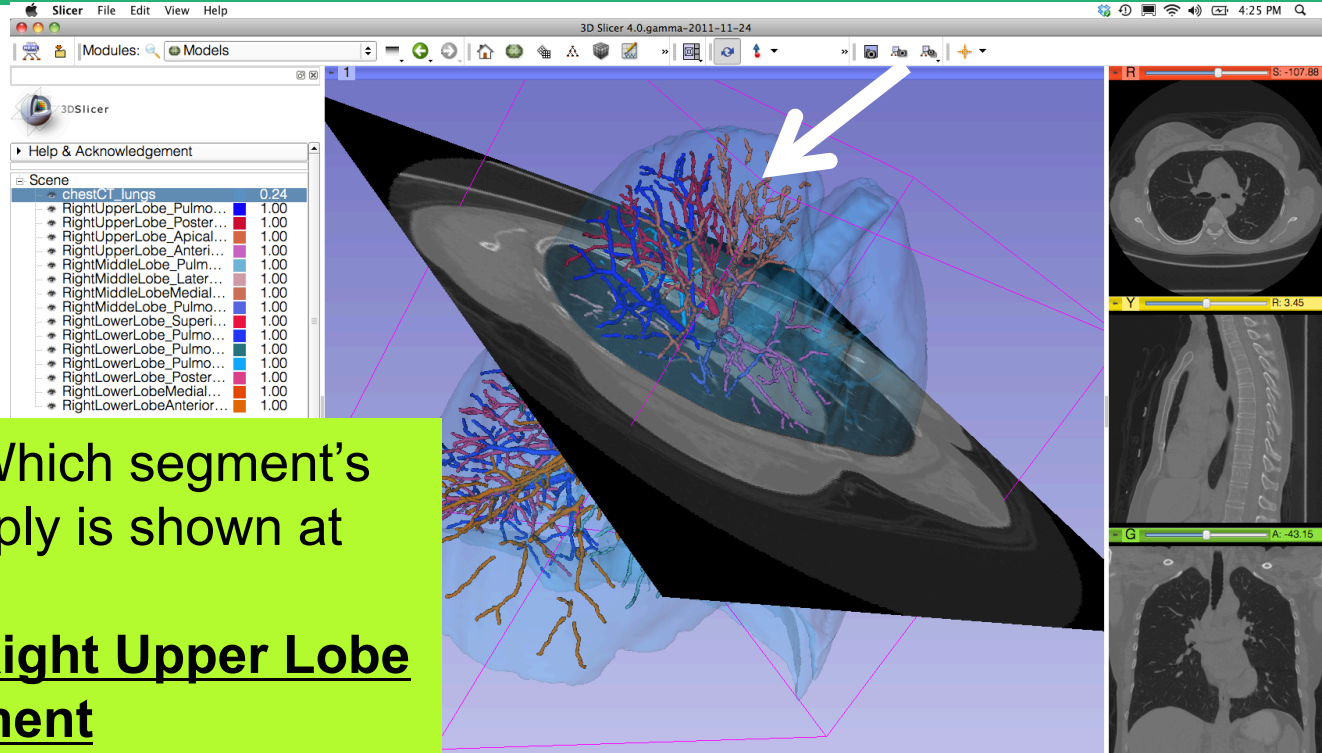
Lung Segments – Question 2



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



Lung Segments – Question 2

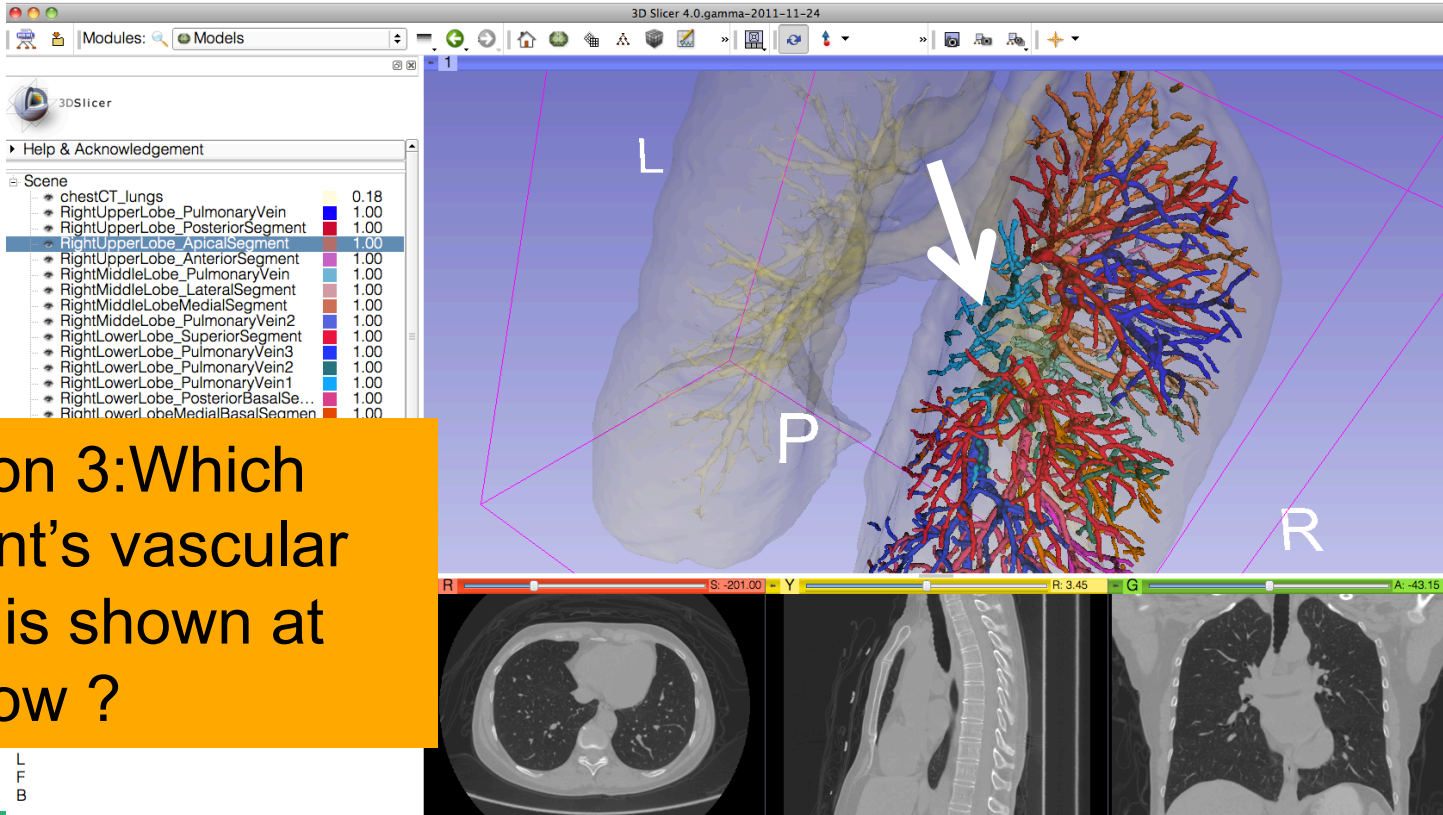


Question 2: Which segment's vascular supply is shown at the arrow?

Answer 2: Right Upper Lobe Apical Segment



Lung Segments – Question 3

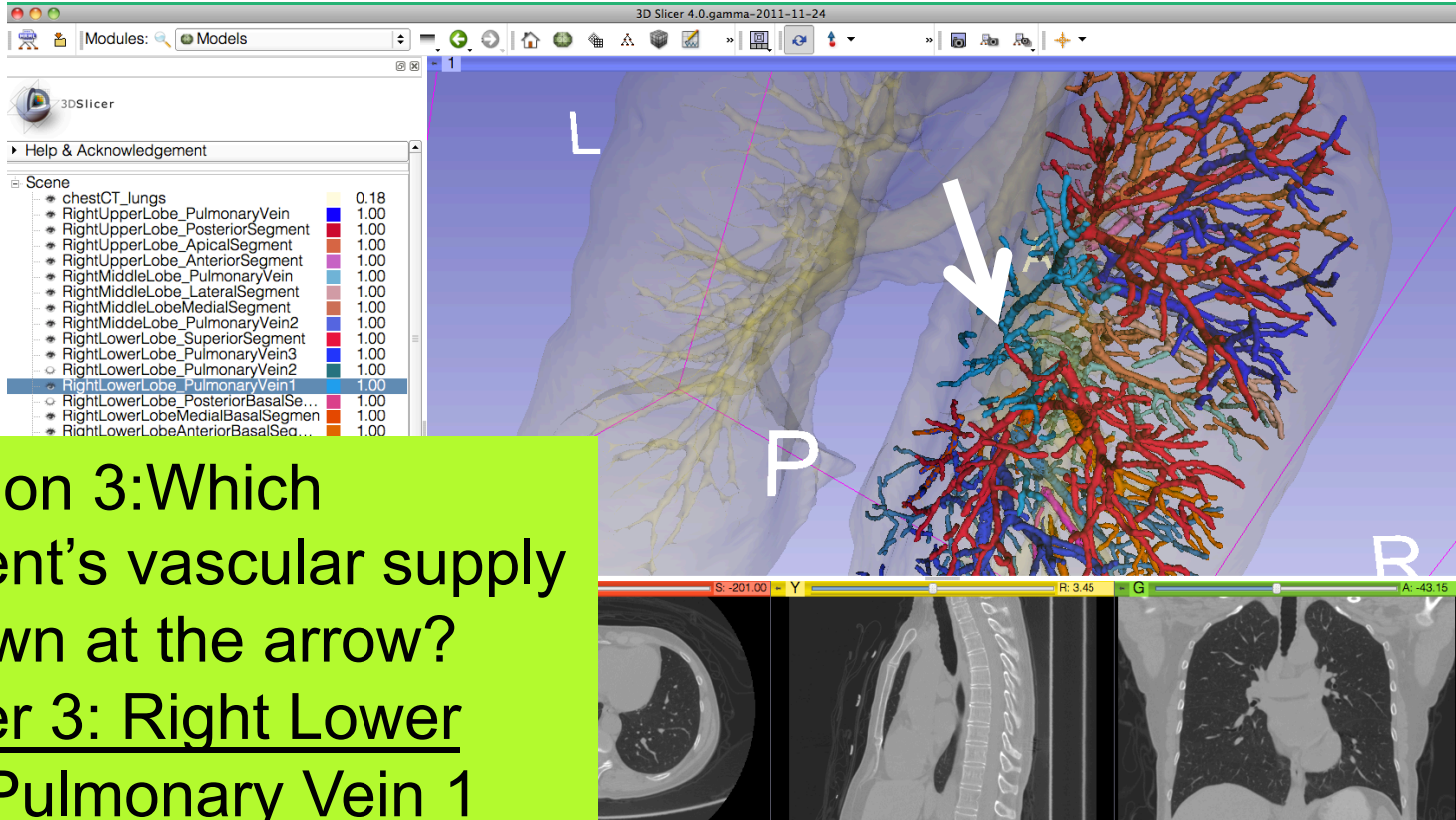


Question 3: Which segment's vascular supply is shown at the arrow ?

L
F
B



Lung Segments – Question 3



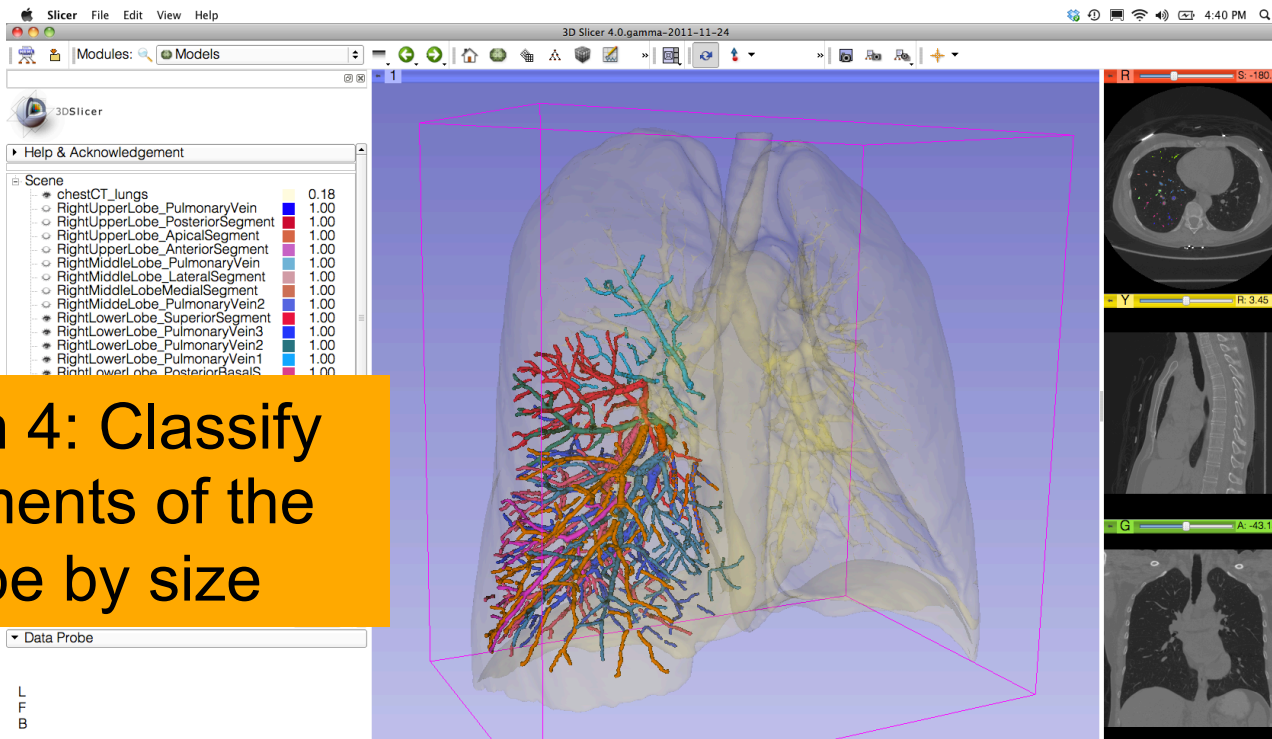
Question 3: Which segment's vascular supply is shown at the arrow?

Answer 3: Right Lower Lobe Pulmonary Vein 1



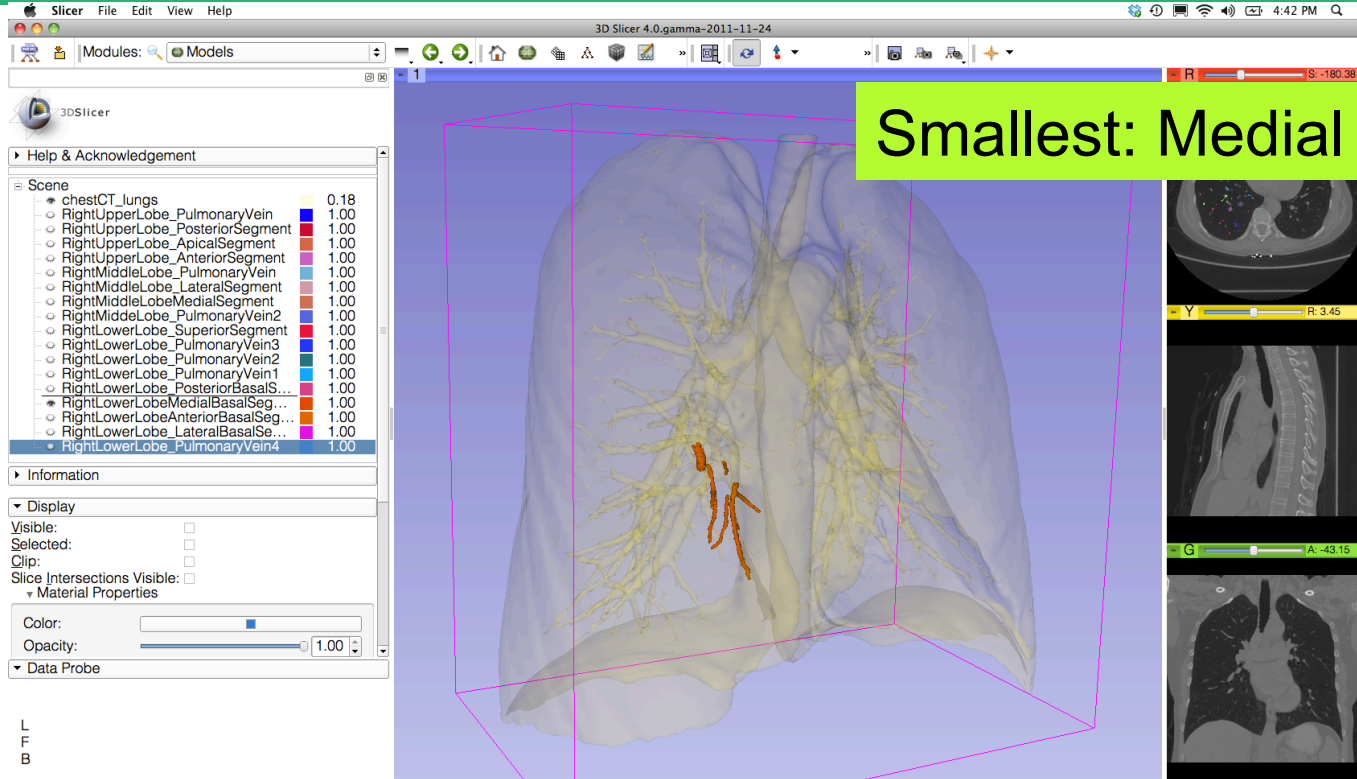
Lung Segments – Question 4

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



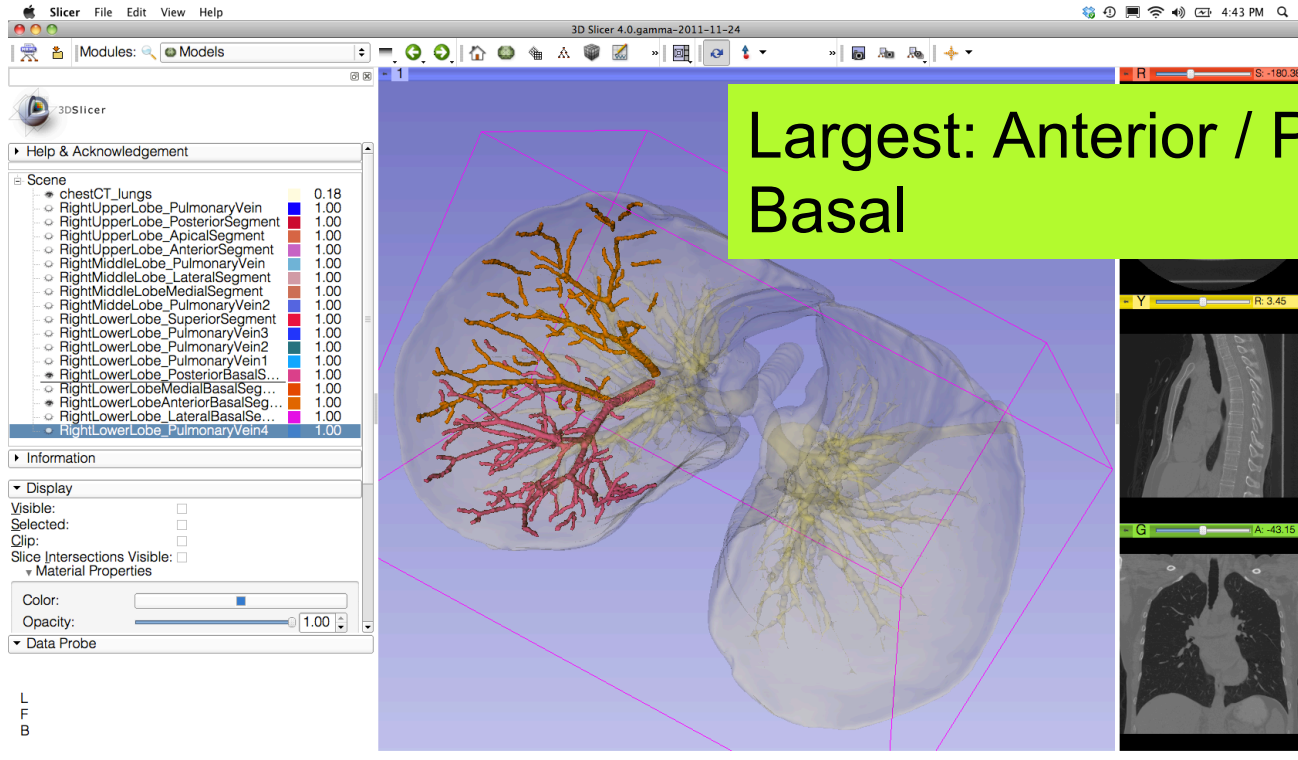


Lung Segments – Question 4



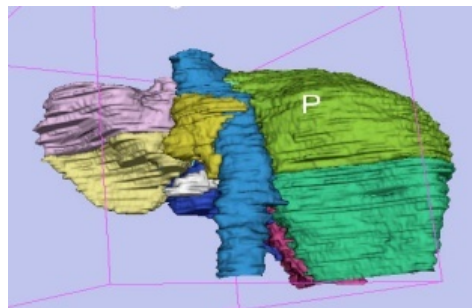
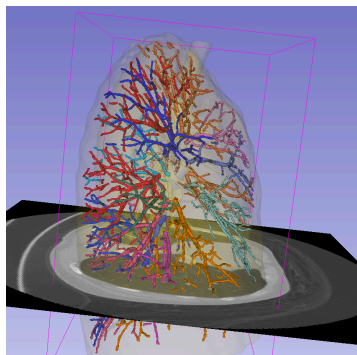
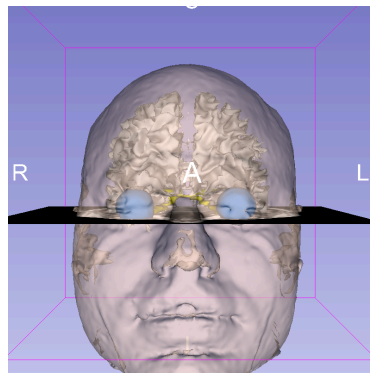
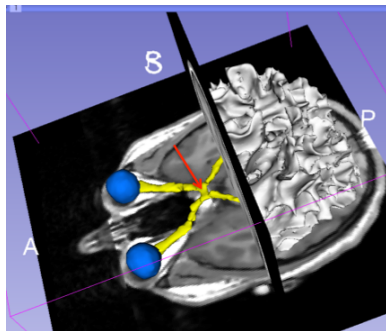


Lung Segments – Question 4





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



Acknowledgments



National Alliance for Medical Image Computing (NA-MIC)
(NIH Grant U54EB005149)



Lung Data: Estepar, Washko, Silverman, Ross - Brigham and Women's Hospital. K25 HL104085, COPDGene 01 HL089897 and U01 HL089856

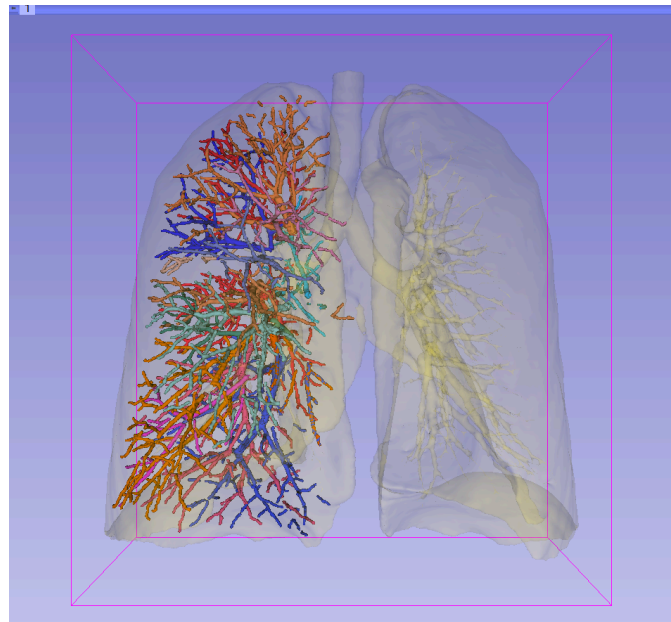


Neuroimage Analysis Center (NAC)
(NIH Grant P41 RR013218)



www.slicer.org

www.na-mic.org



Questions and comments: spujol@bwh.harvard.edu