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, PhD, Harvard Medical School
Surgical Planning Laboratory, Brigham and Women's Hospital

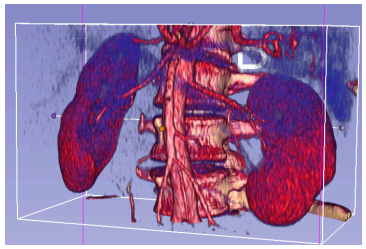
Nicholas Herlambang, PhD, AZE Research & Development
Project Manager, AZE R&D Boston

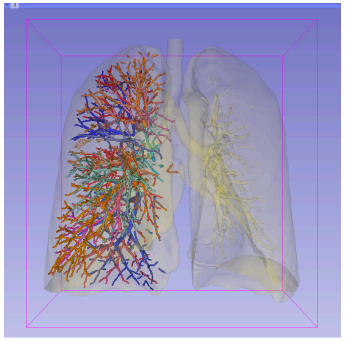
Kitt Shaffer, MD, PhD, Boston University
Vice-Chairman for Education, Boston University School of Medicine

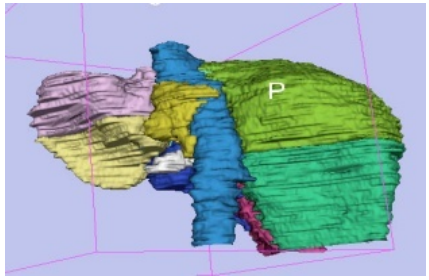
Ron Kikinis, MD, Harvard Medical School
Surgical Planning Laboratory, Brigham and Women's Hospital

3D Visualization of DICOM images for Radiological applications

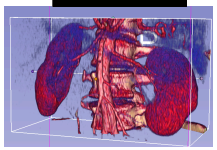
Following this tutorial, you will be able to load and visualize DICOM volumes with 3D Slicer, and to interact in 3D with structural images and models of the anatomy.





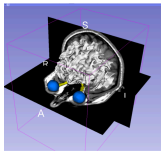


Overview



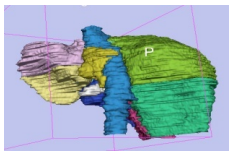
Part I: 3D Data Loading and visualization of DICOM images

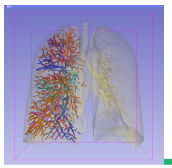
- Volume Rendering of thoraco-abdominal CT data



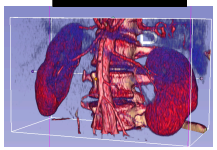
Part II: 3D interactive exploration of the anatomy

- Exploration of the Segments of the liver
- Exploration of the Segments of the lung



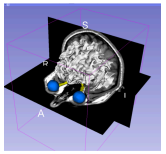


Overview



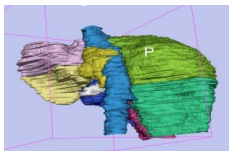
Part I: 3D Data Loading and visualization of DICOM images

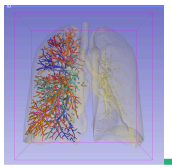
- Volume Rendering of thoraco-abdominal CT data



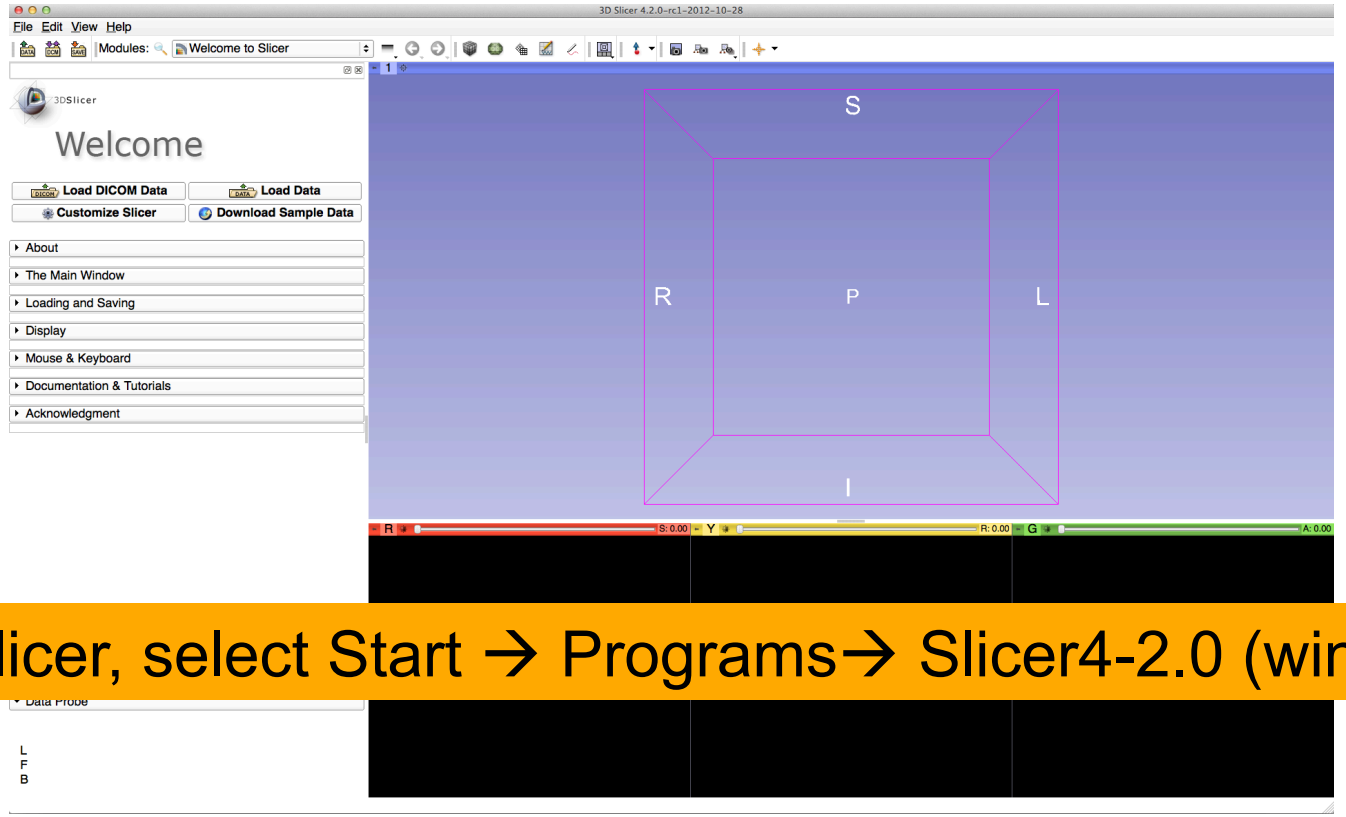
Part II: 3D interactive exploration of the anatomy

- Exploration of the Segments of the liver
- Exploration of the Segments of the lung





Welcome to Slicer4

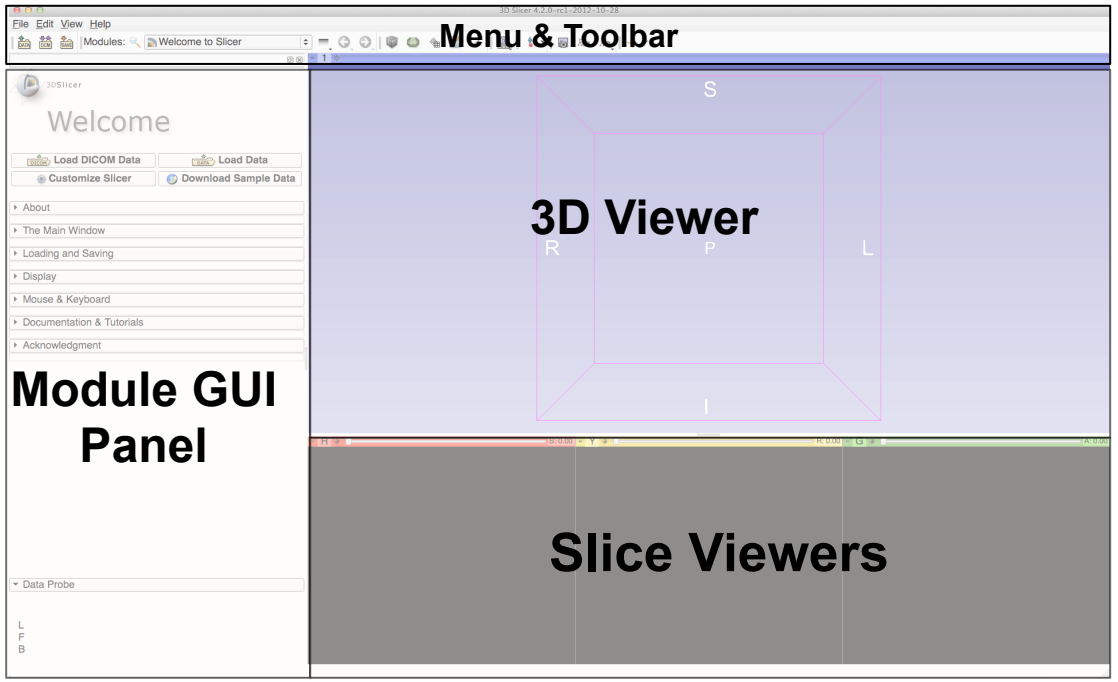


To start Slicer, select Start → Programs→ Slicer4-2.0 (win64)

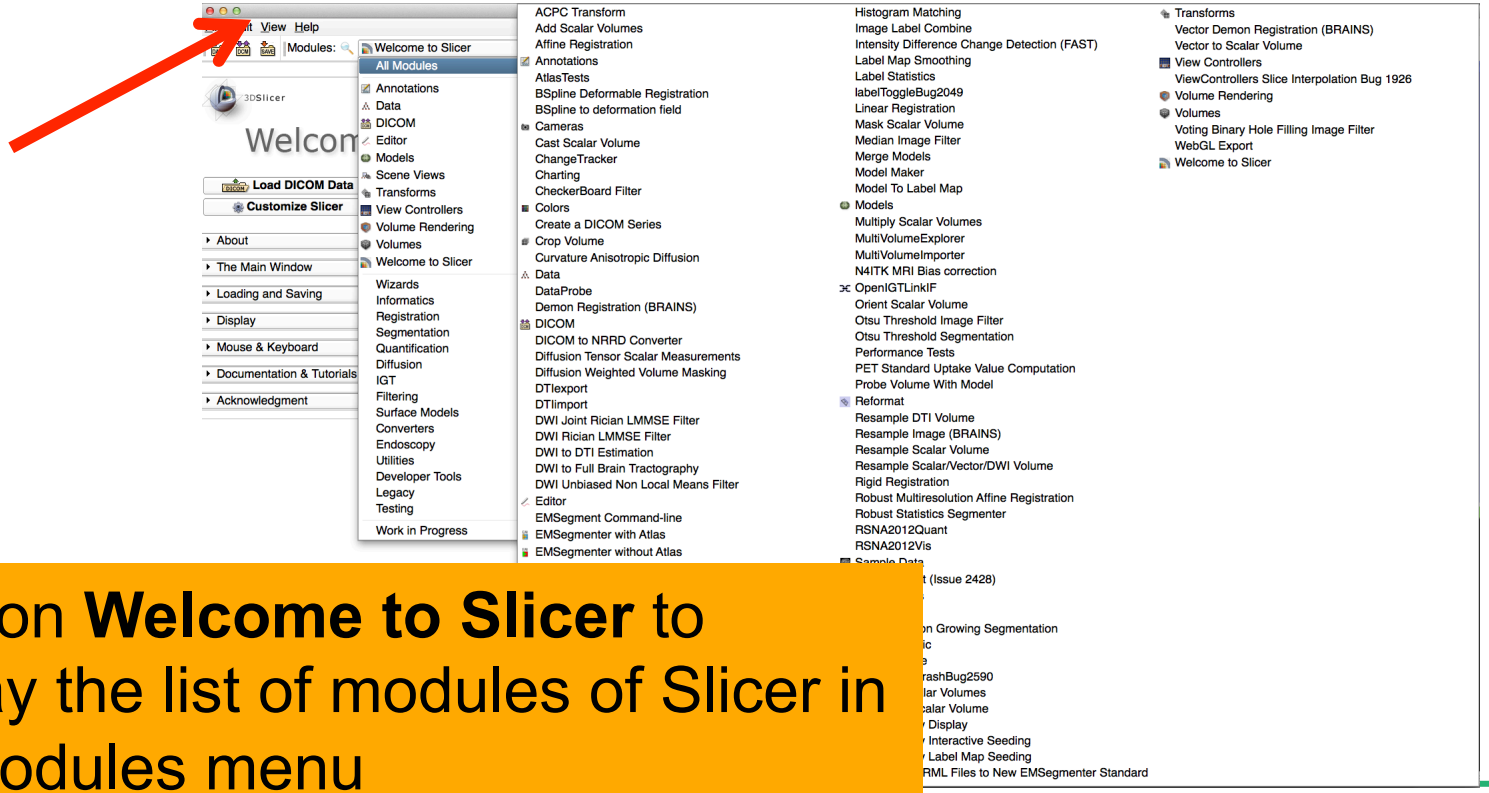
Navigating the Application GUI

The Graphic User Interface (GUI) of Slicer4 integrates **four components:**

- the Menu Toolbar
- the Module GUI Panel
- the 3D Viewer
- the Slice Viewer

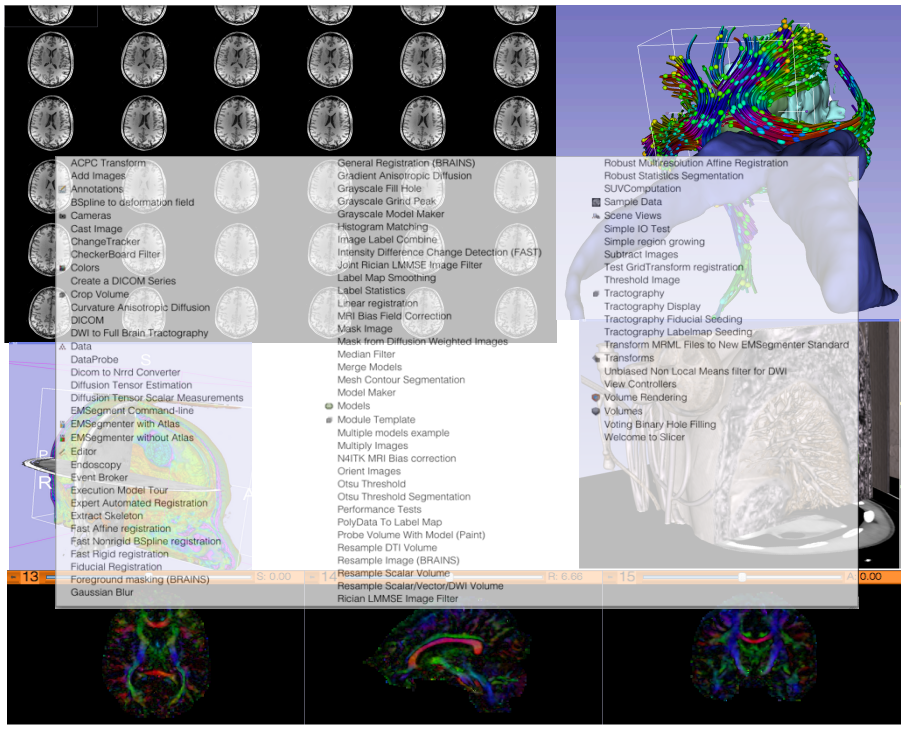


Welcome to Slicer4.2

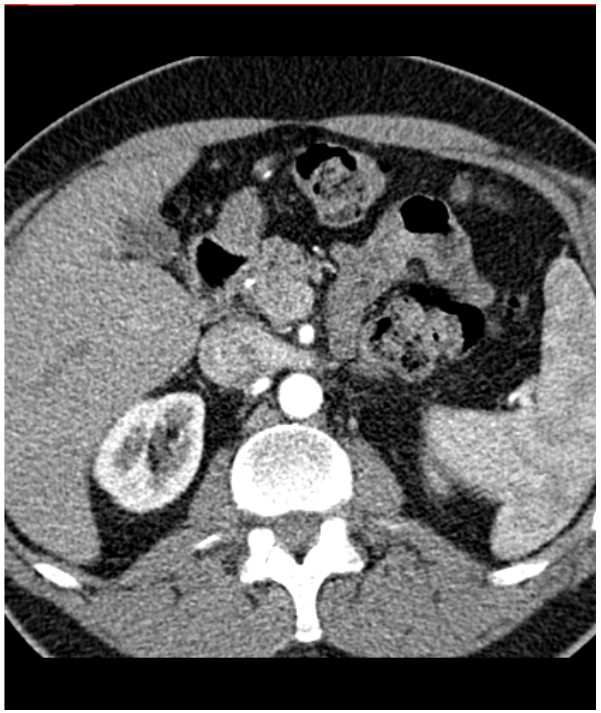


Click on **Welcome to Slicer** to display the list of modules of Slicer in the Modules menu

Welcome to Slicer4



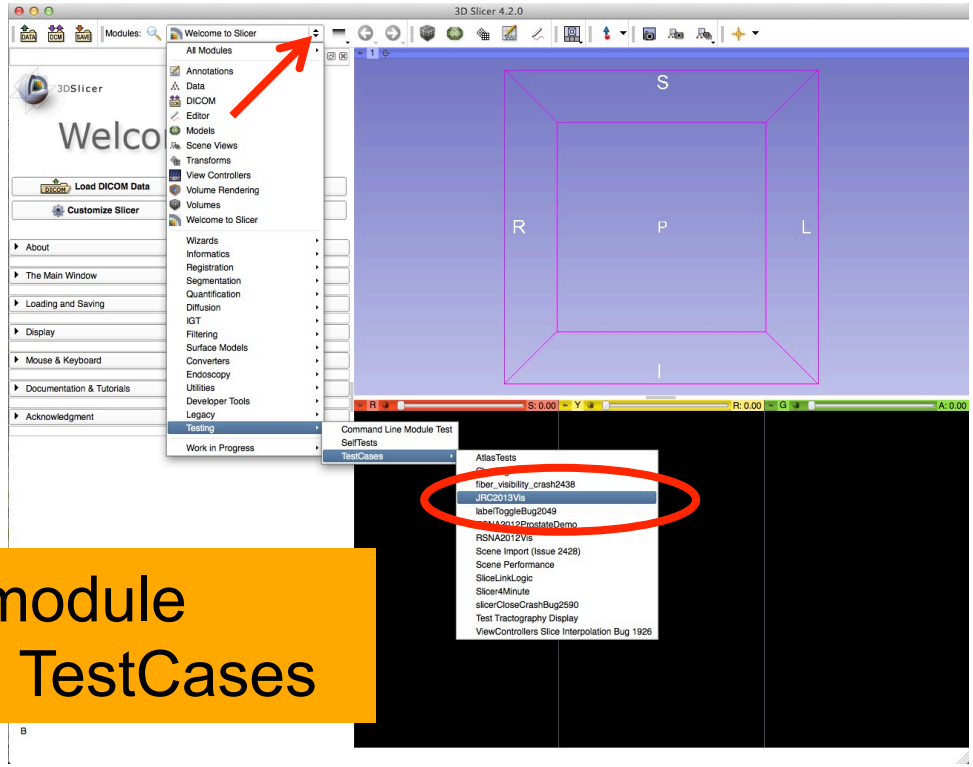
Slicer4.2 contains more than 100 modules for image segmentation, registration and 3D visualization of medical imaging data



Part 1:

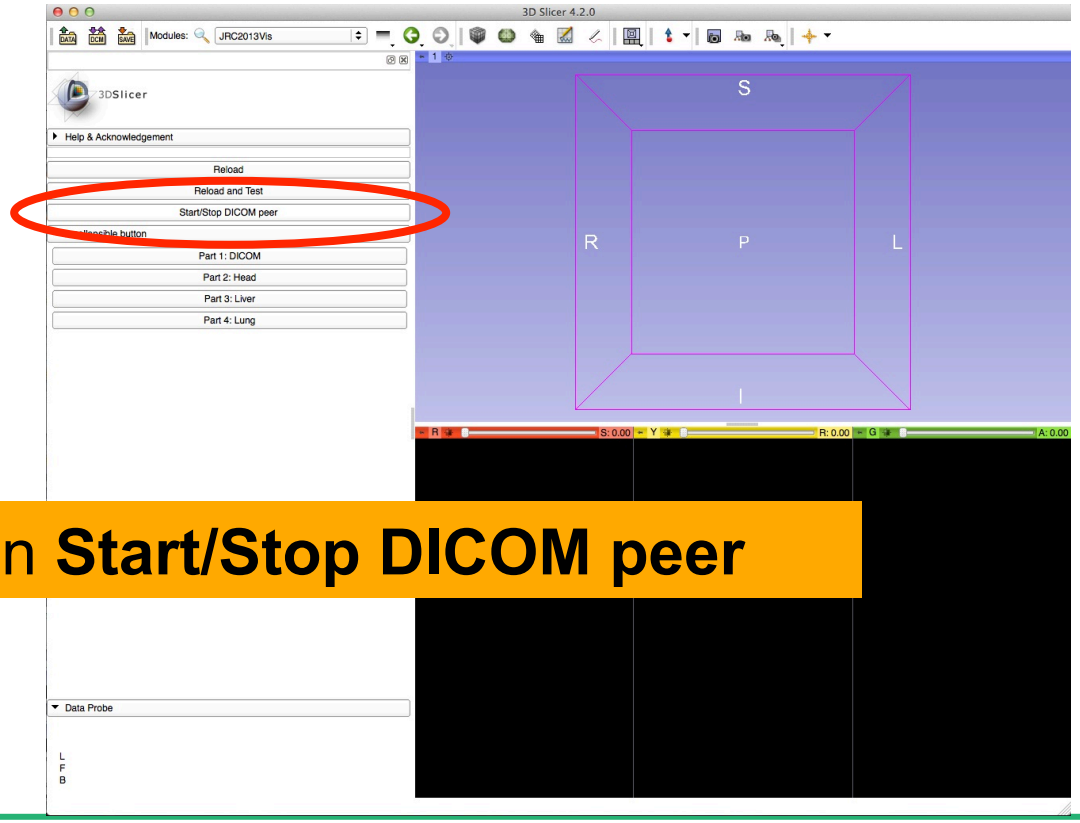
Retrieving a DICOM Volume from a DICOM Peer

Start a DICOM Peer Simulator



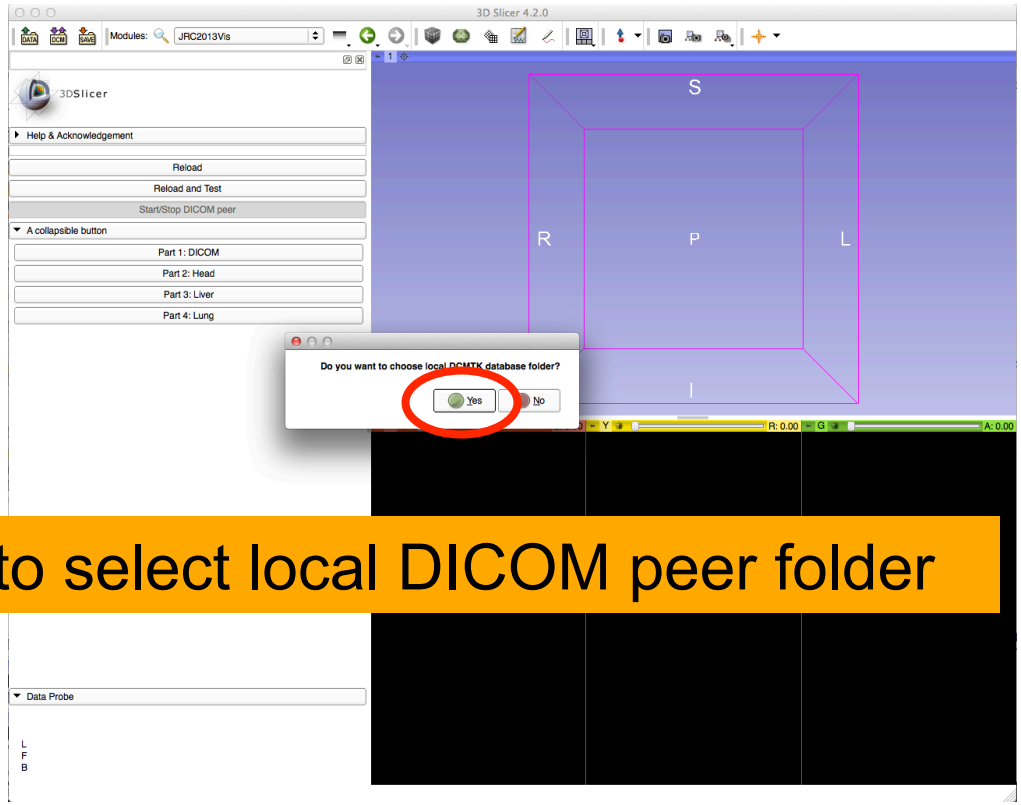
Go to **JRC2013Vis** module
Module -> Testing -> TestCases

Start a DICOM Peer Simulator



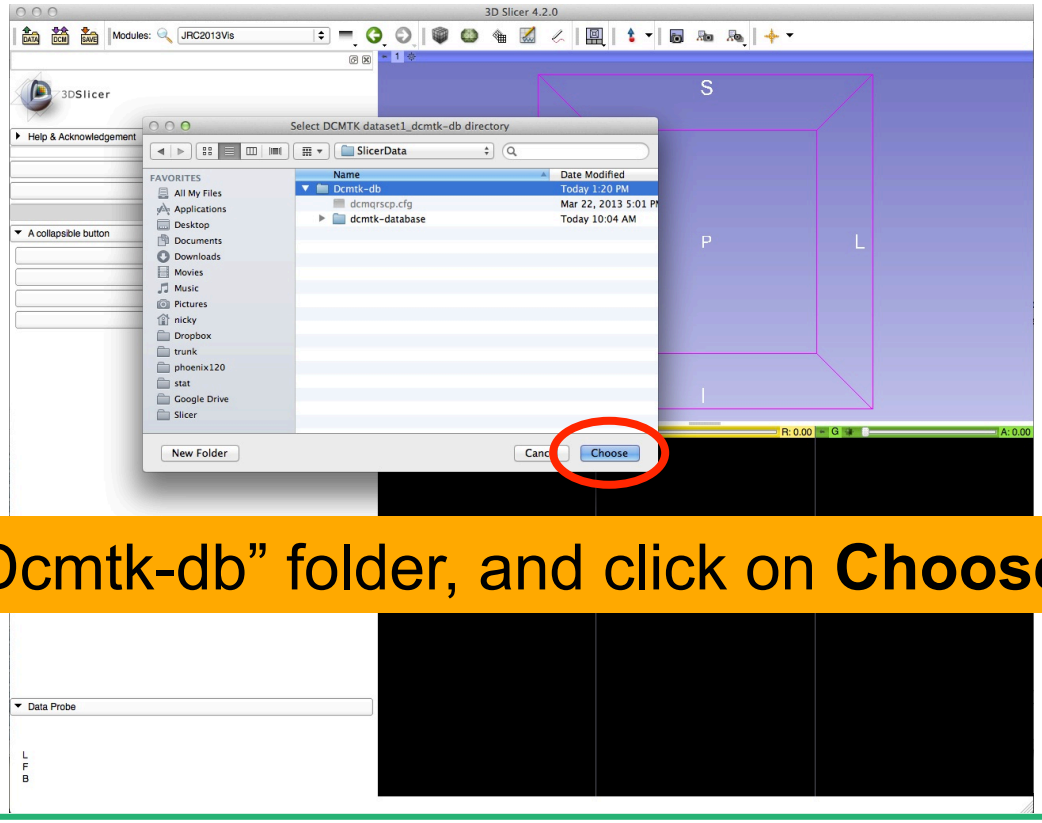
Click on **Start/Stop DICOM peer**

Start a DICOM Peer Simulator



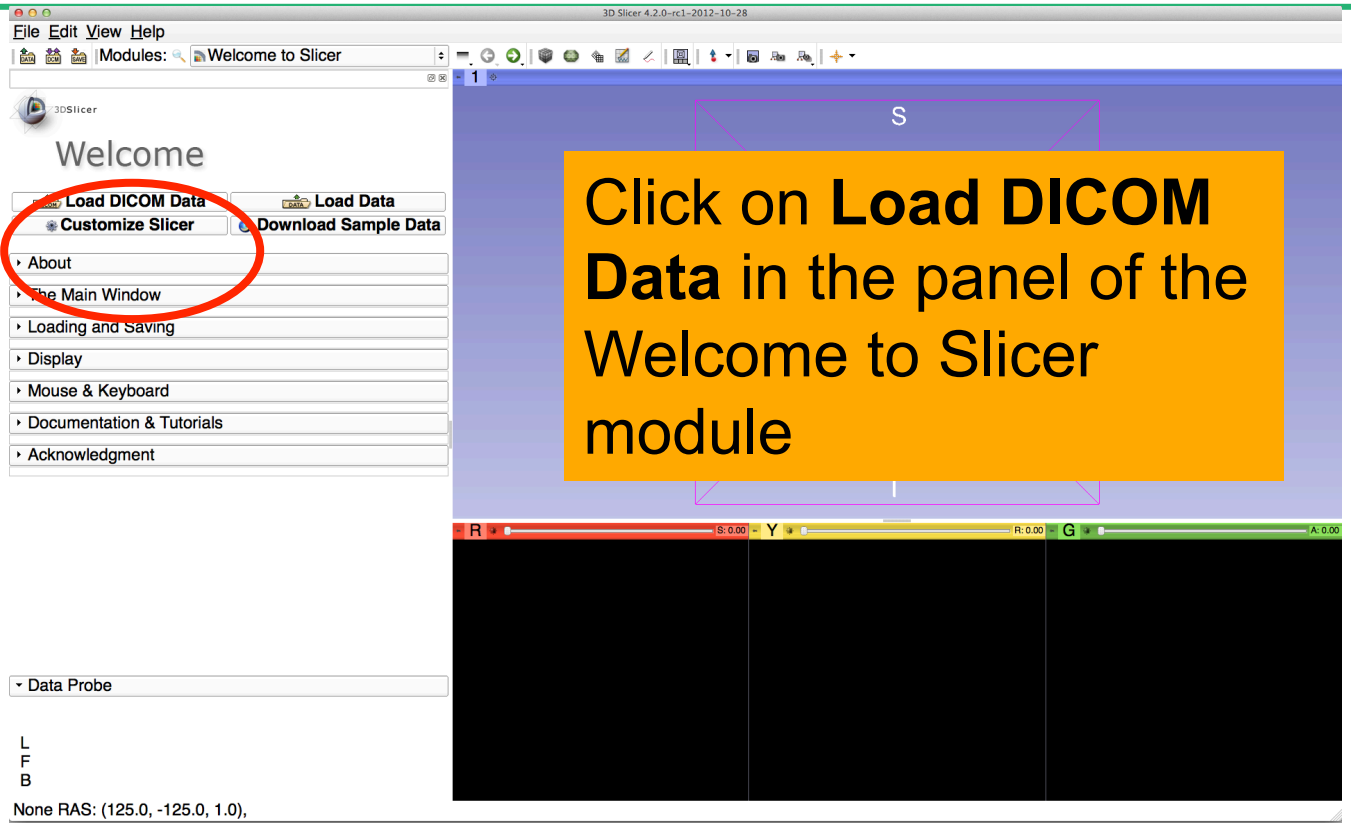
Click **Yes** to select local DICOM peer folder

Start a DICOM Peer Simulator

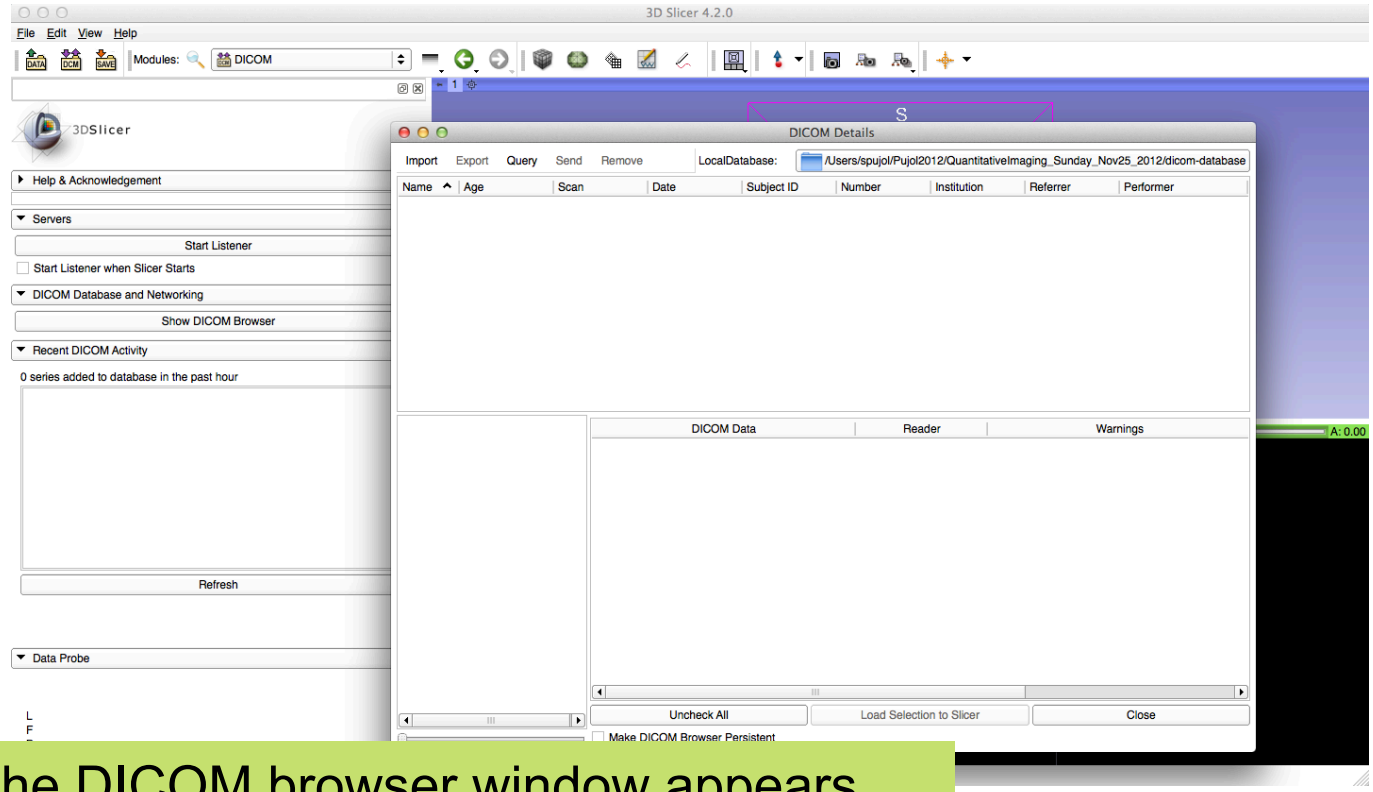


Select “Dcmtk-db” folder, and click on **Choose**

Loading a DICOM volume

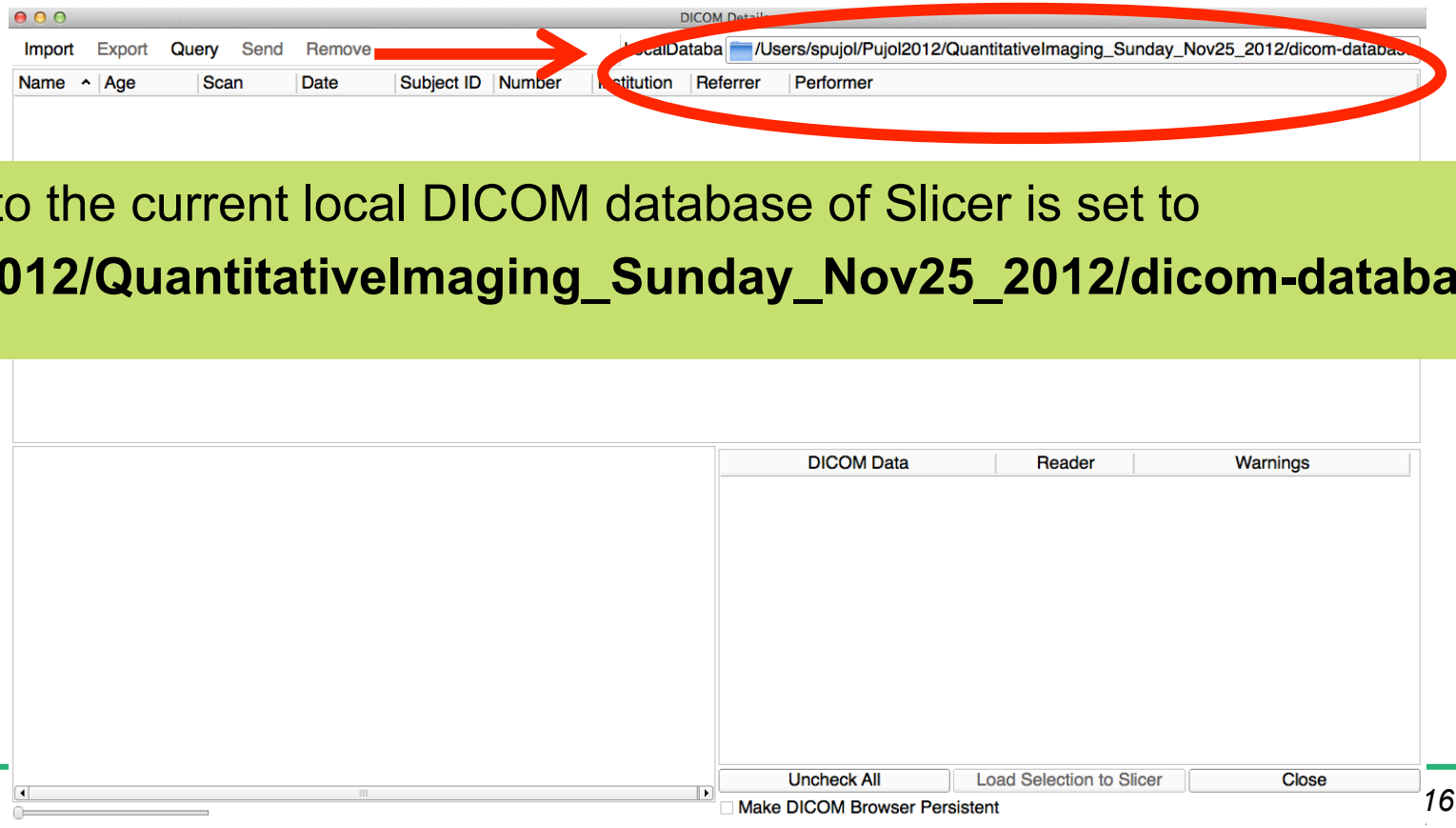


Select DICOM local database



The GUI of the DICOM browser window appears

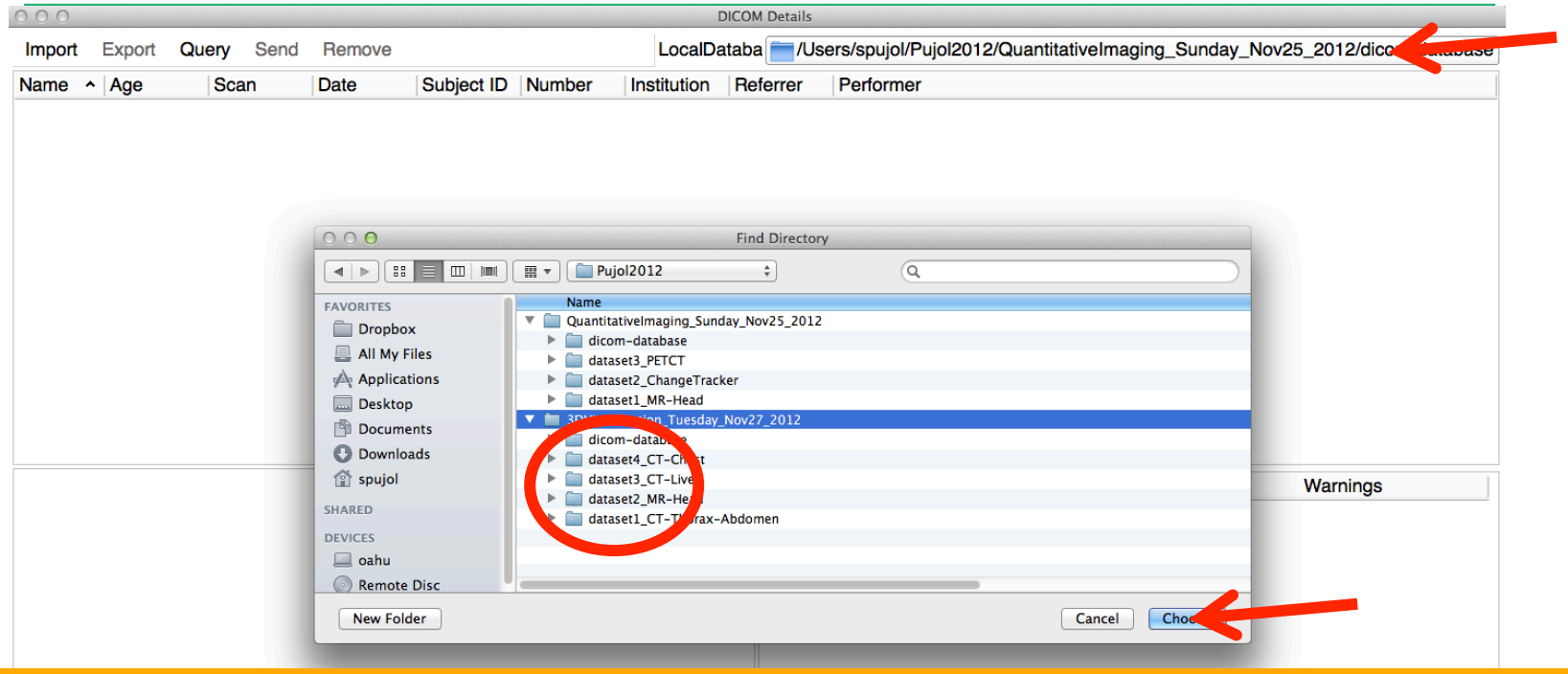
Select DICOM local database



The path to the current local DICOM database of Slicer is set to

C:/Pujol2012/QuantitativeImaging_Sunday_Nov25_2012/dicom-database

Select DICOM local database

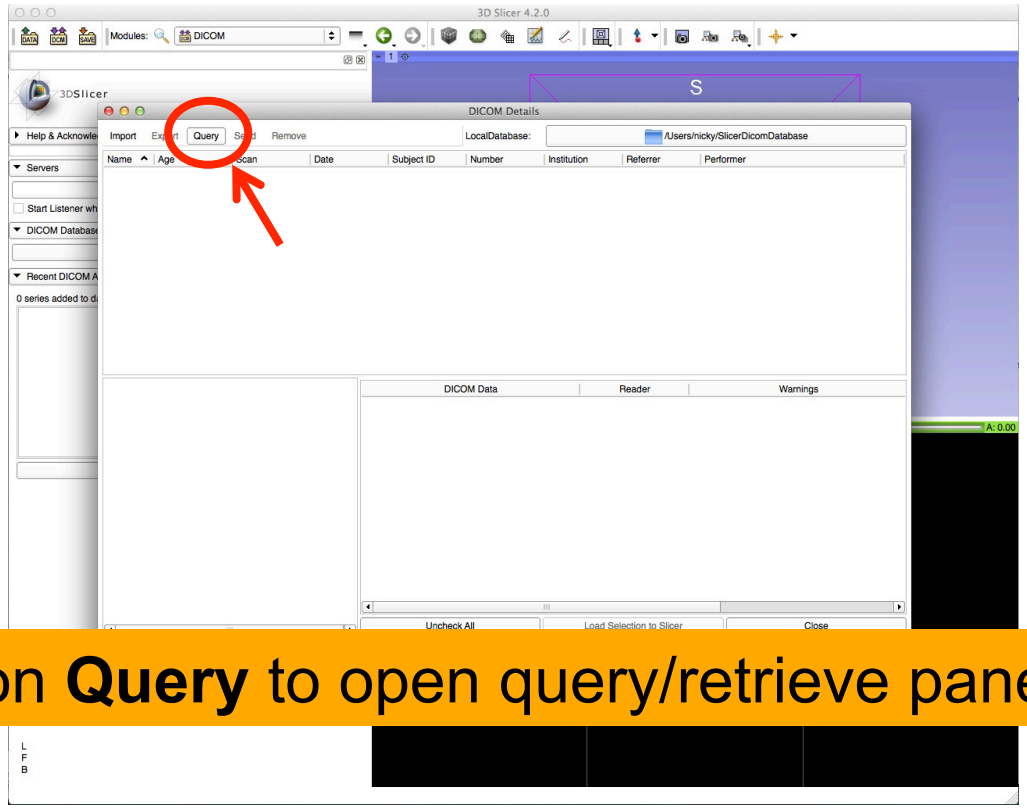


Click on this path name and change the local database directory to

C:/Pujol2012/3DVisualization_Tuesday_Nov27_2012/dicom-database

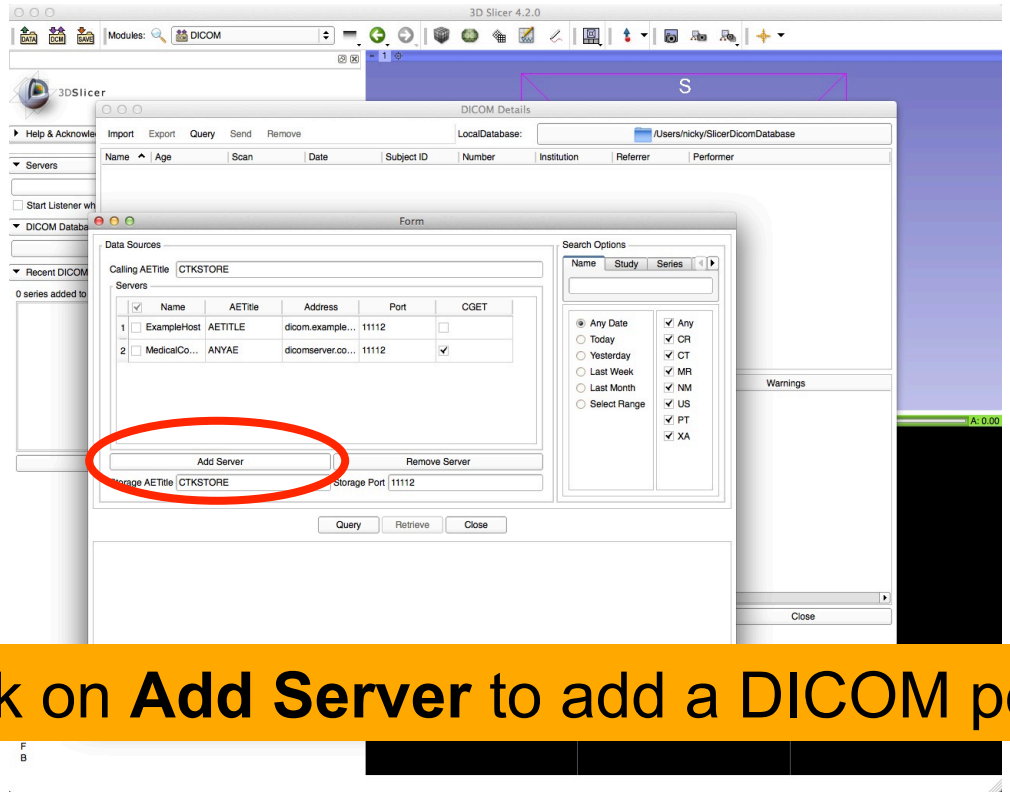
Click on Choose to set this directory as the local DICOM database of Slicer

Show query/retrieve panel



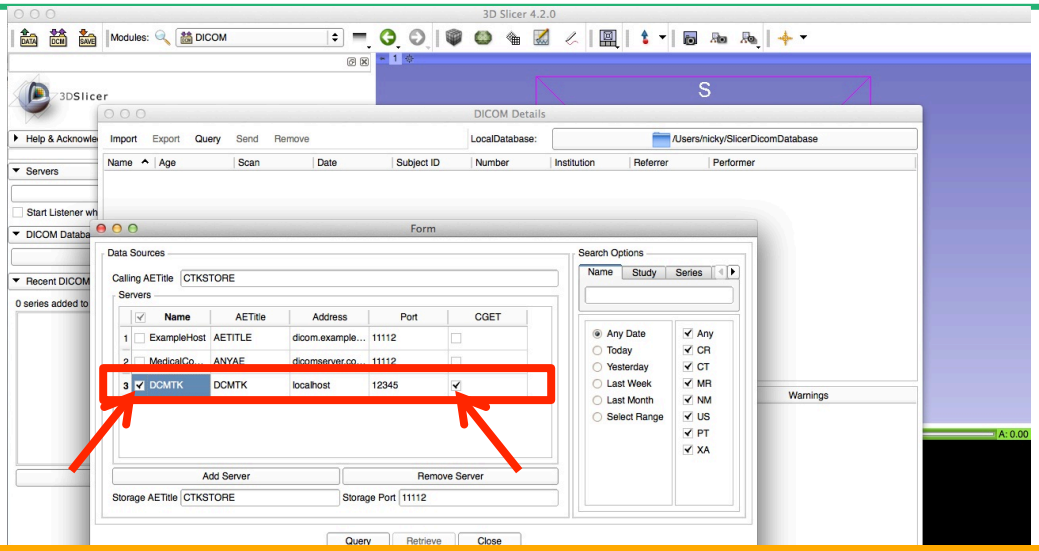
Click on **Query** to open query/retrieve panel

Add a DICOM peer



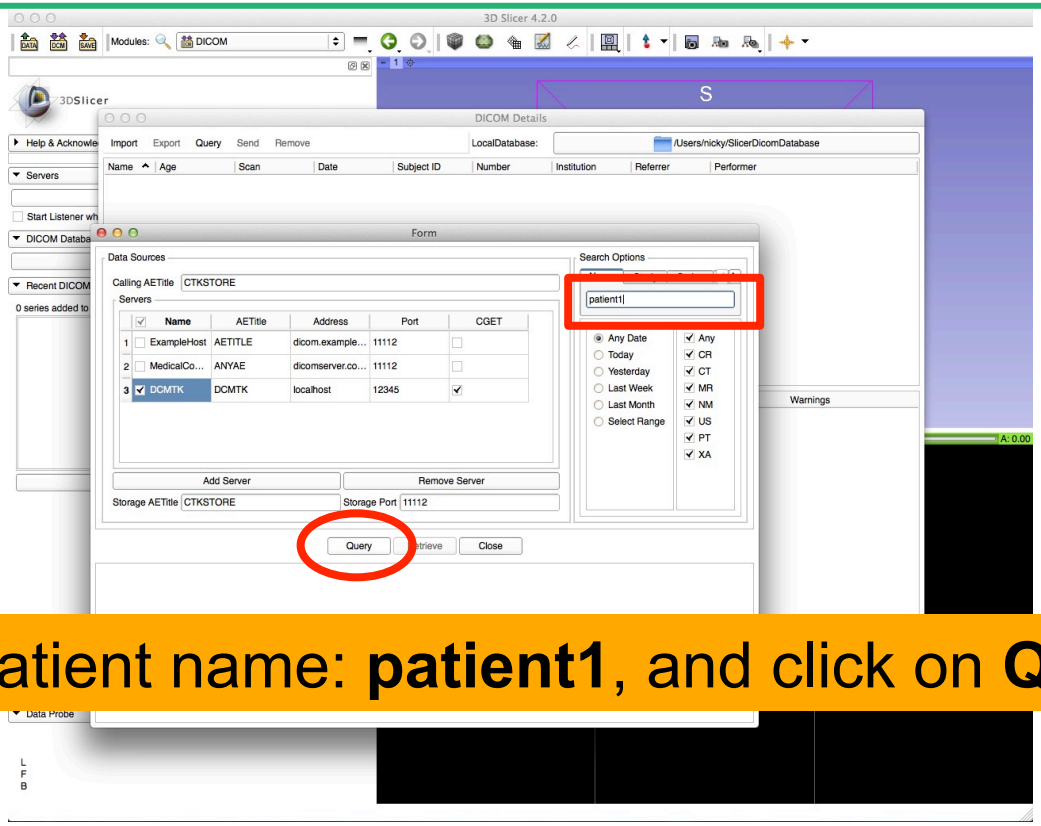
Click on **Add Server** to add a DICOM peer

Add a DICOM peer



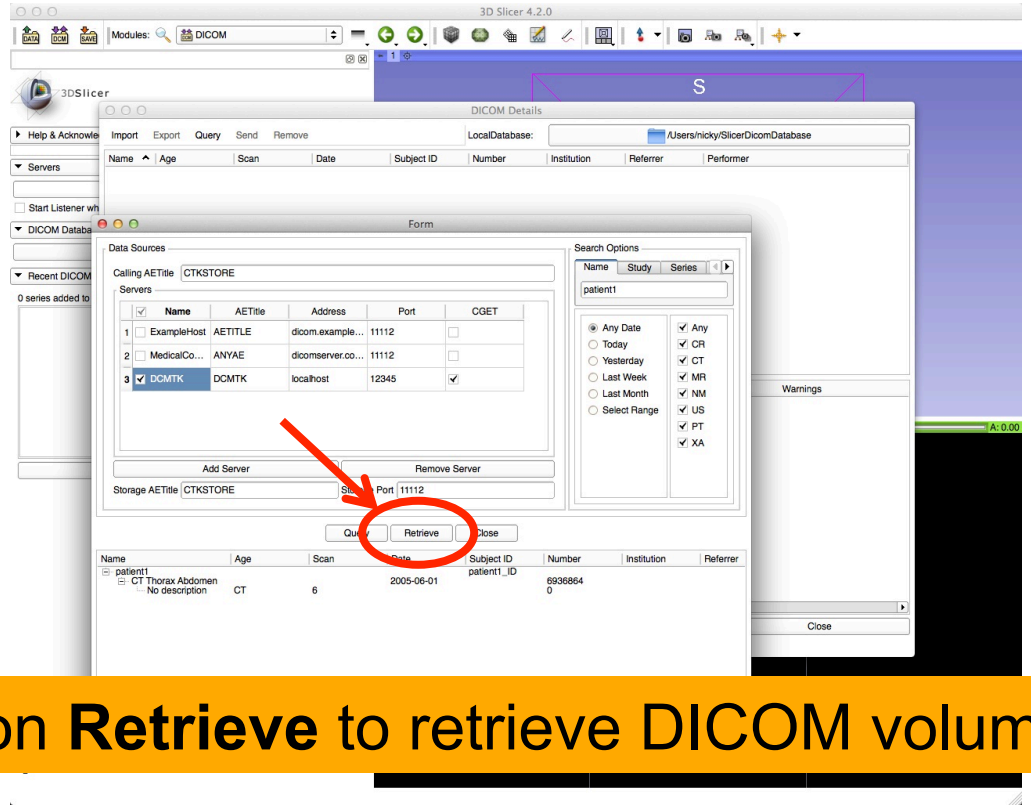
Fill DICOM peer info:
Name: **DCMTK**, AETitle: **DCMTK**, Address: **12345**
Check to **enable CGET**
Check to **activate**

Query DICOM volumes



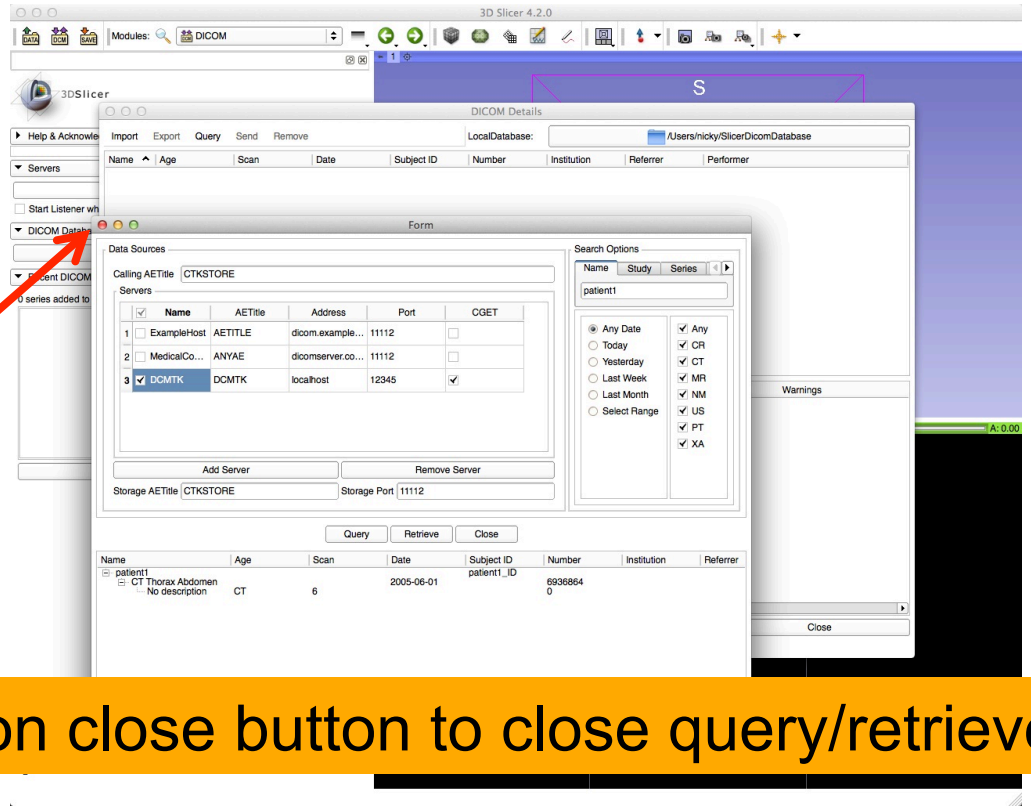
Type patient name: **patient1**, and click on **Query**

Retrieve DICOM volumes



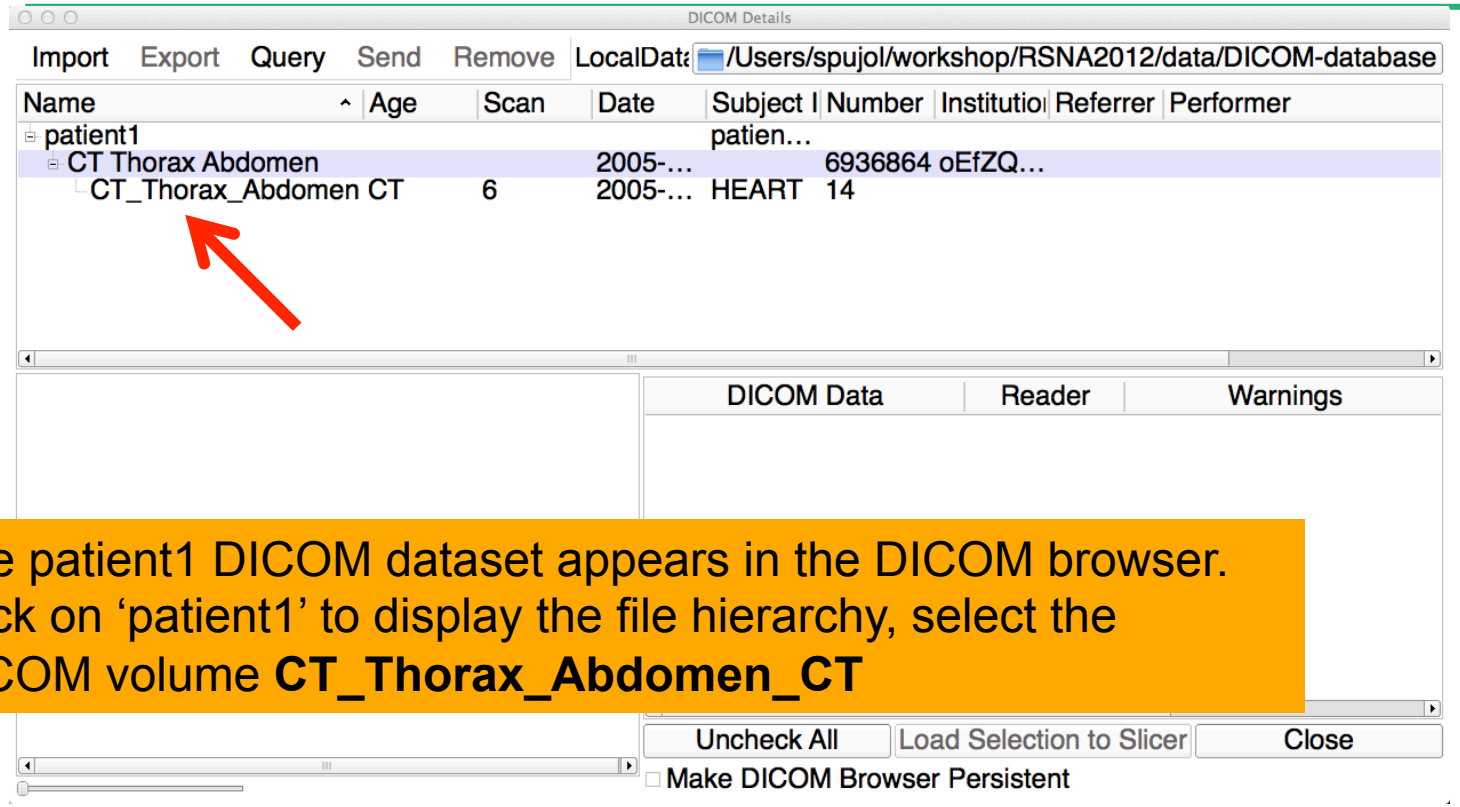
Click on **Retrieve** to retrieve DICOM volume

Close query/retrieve panel



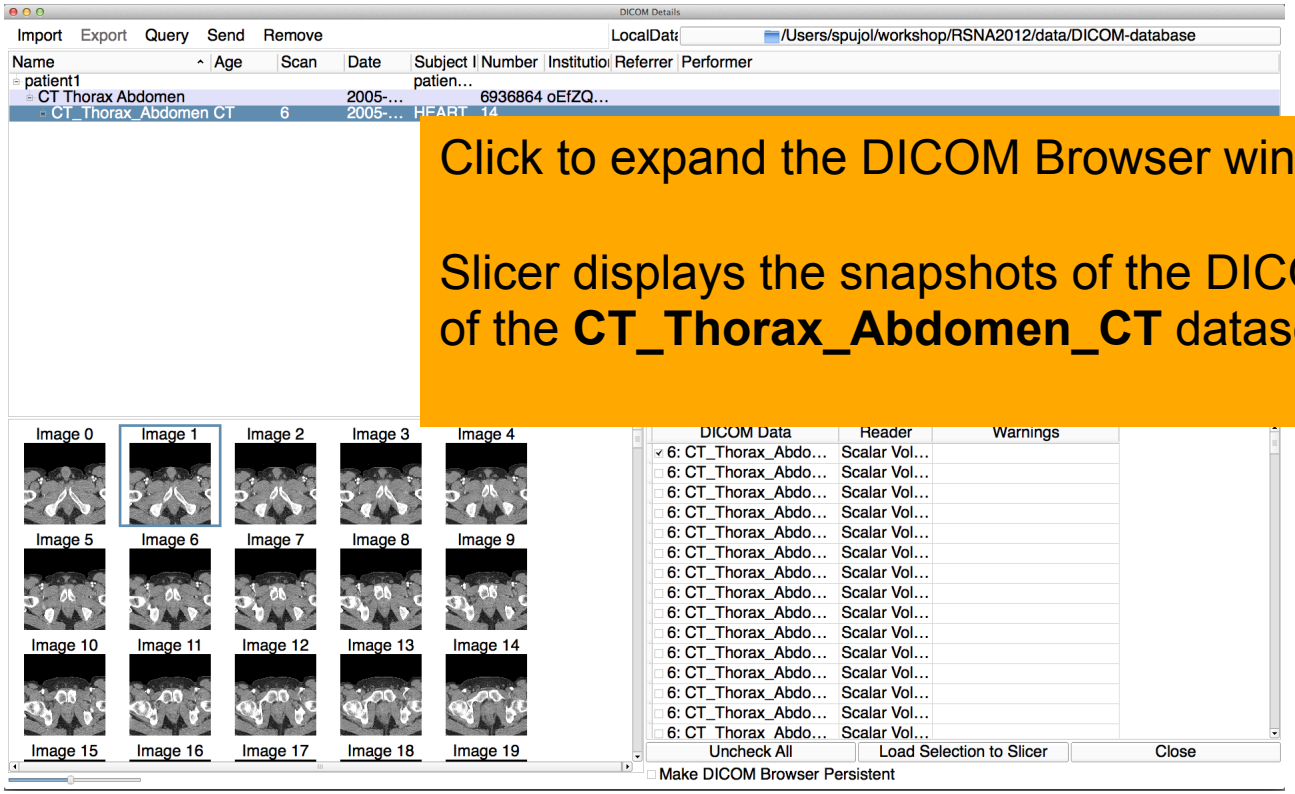
Click on close button to close query/retrieve panel

Loading a DICOM volume



The patient1 DICOM dataset appears in the DICOM browser. Click on 'patient1' to display the file hierarchy, select the DICOM volume **CT_Thorax_Abdomen_CT**

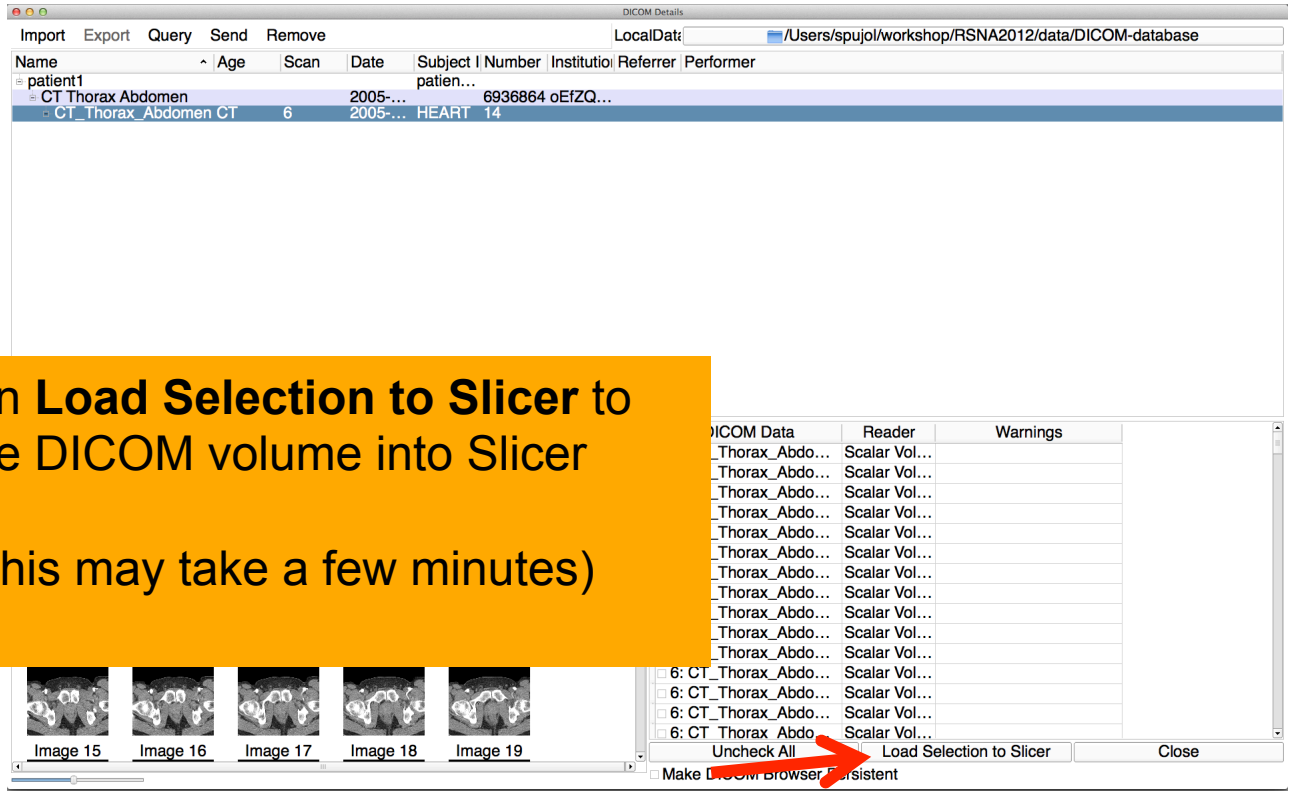
Loading a DICOM volume



Click to expand the DICOM Browser window.

Slicer displays the snapshots of the DICOM images of the **CT_Thorax_Abdomen_CT** dataset

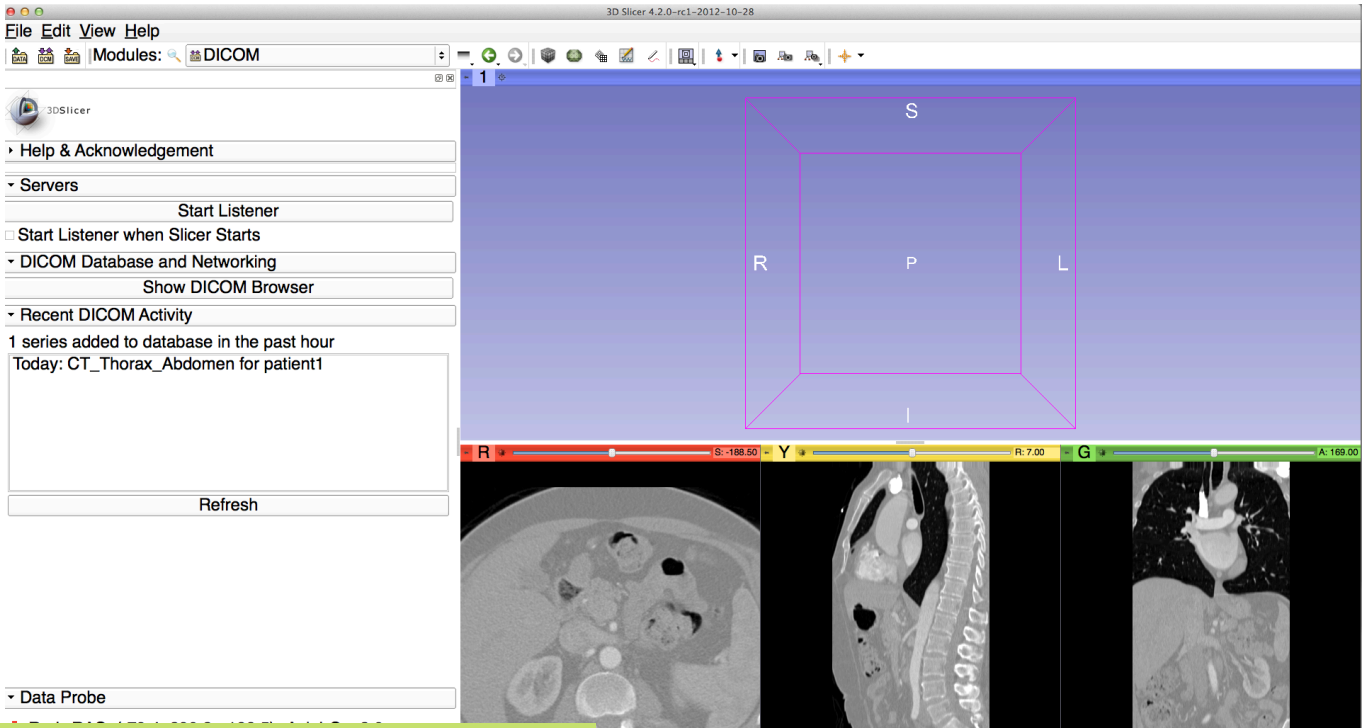
Loading a DICOM volume



Click on **Load Selection to Slicer** to load the DICOM volume into Slicer

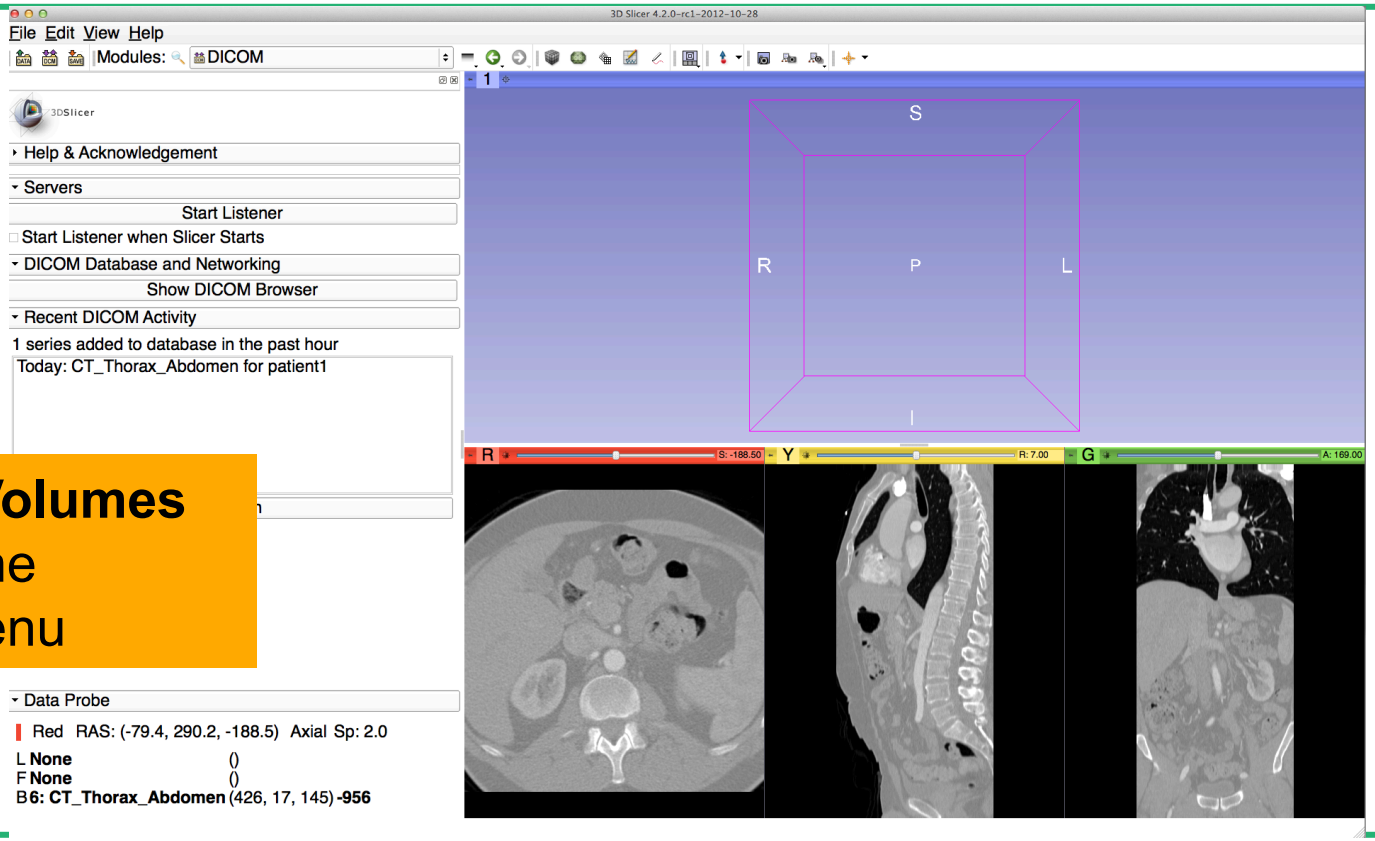
(note: this may take a few minutes)

Loading a DICOM volume



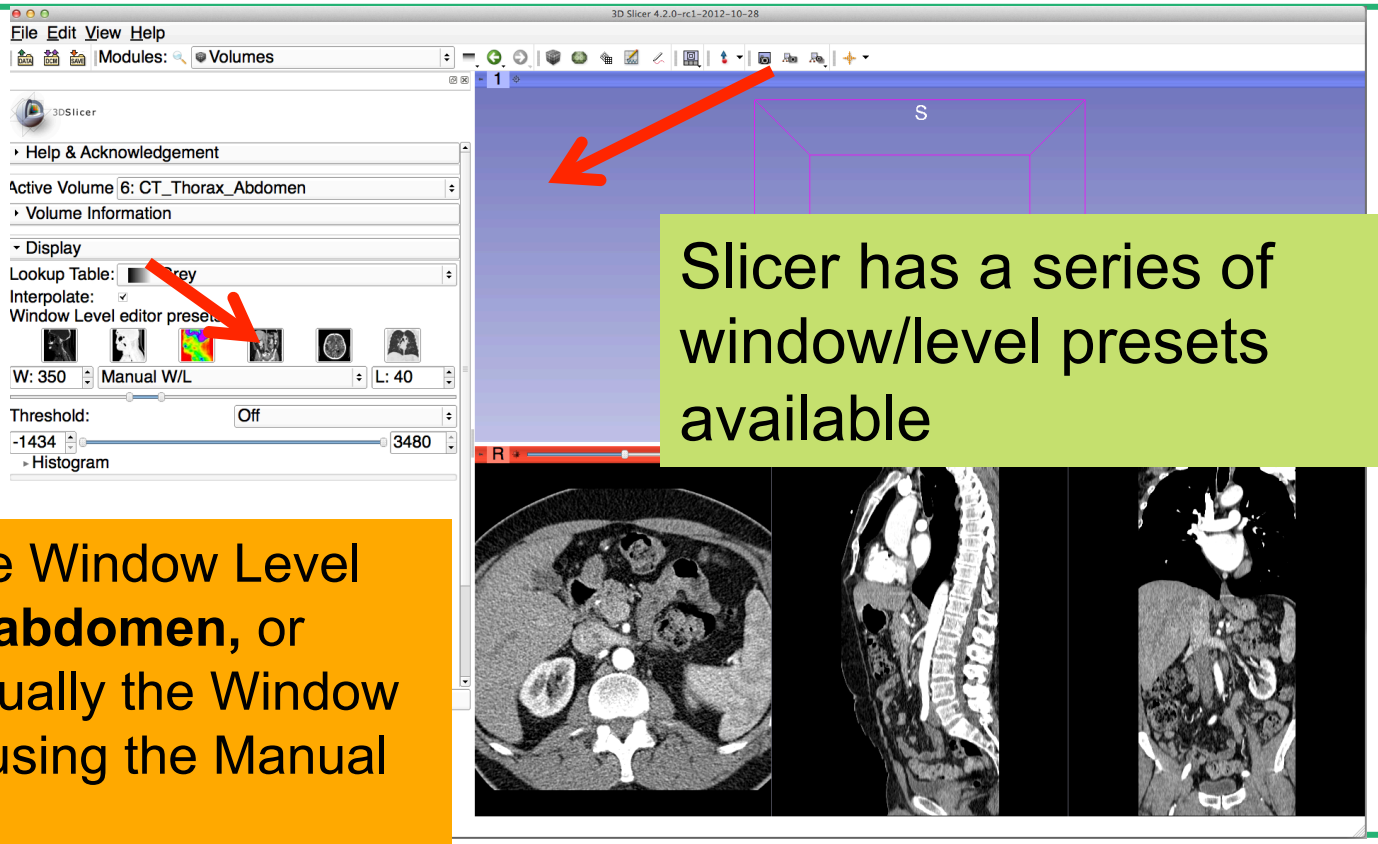
Slicer displays the axial, coronal and sagittal slices of the DICOM dataset

Loading a DICOM volume



Select the **Volumes** module in the modules menu

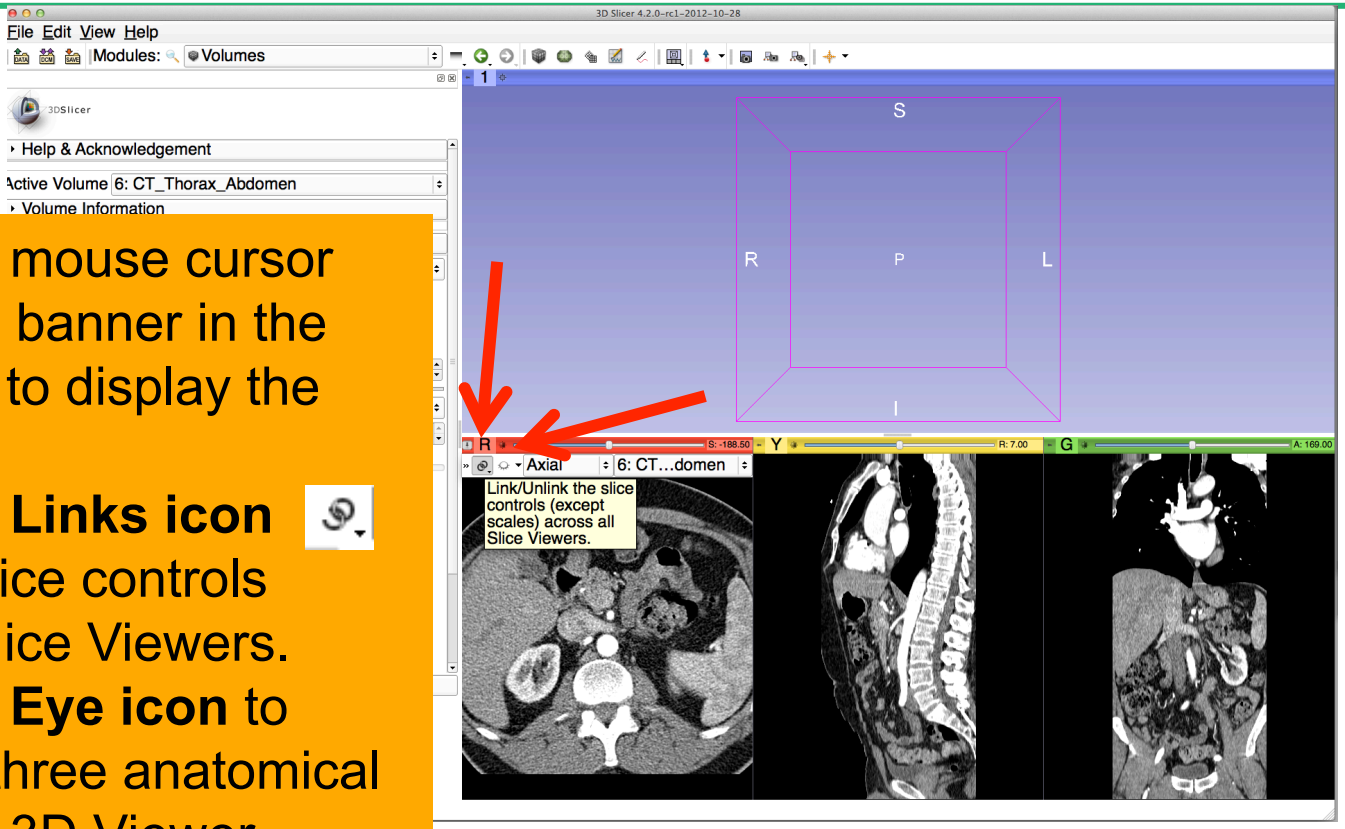
Loading a DICOM volume



Slicer has a series of window/level presets available

Click on the Window Level Preset **CT-abdomen,** or adjust manually the Window and Level using the Manual W/L slider

Loading a DICOM volume

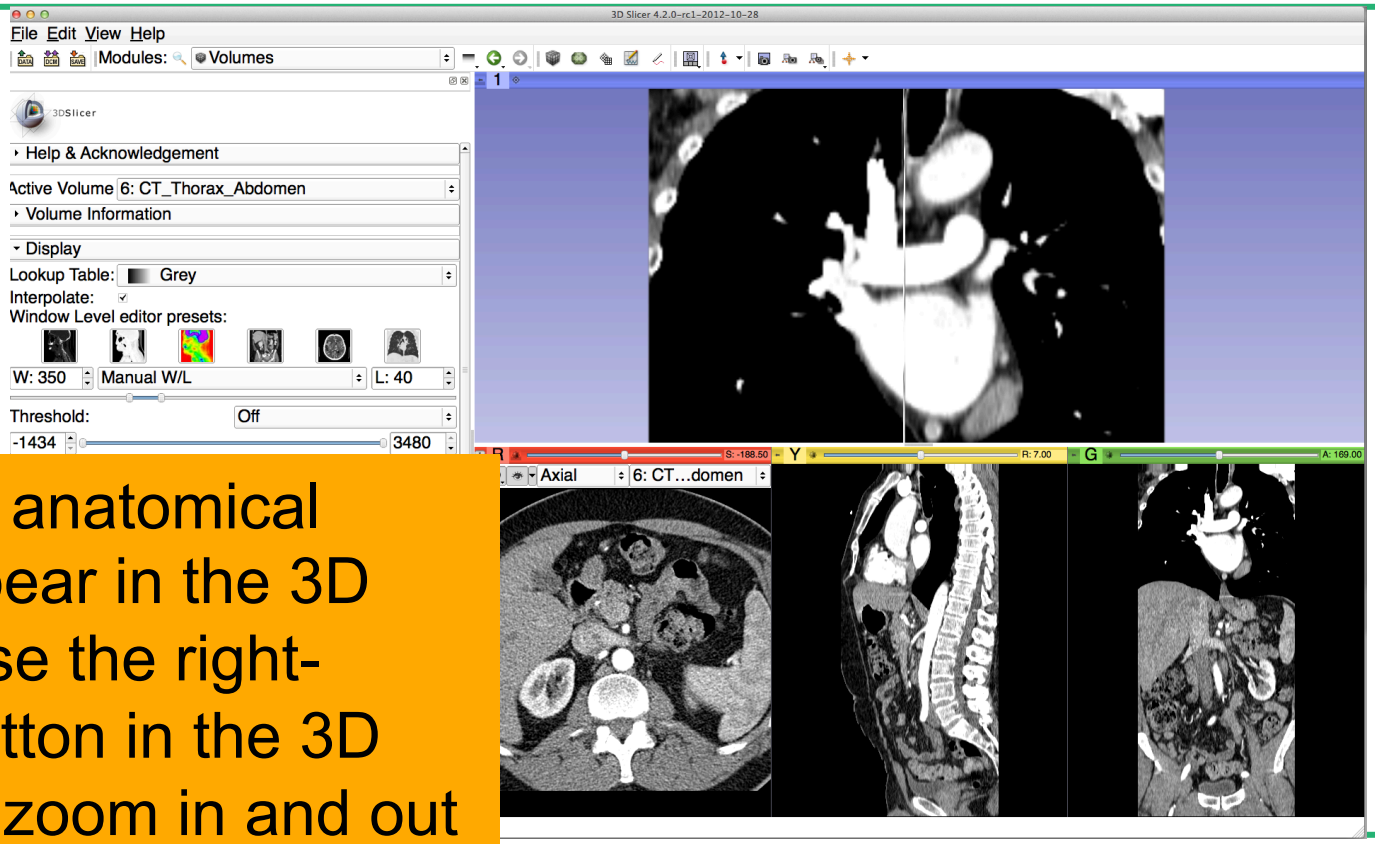


Position the mouse cursor over the red banner in the Red Viewer to display the slice menu.

Click on the **Links icon** to link the slice controls across all Slice Viewers.

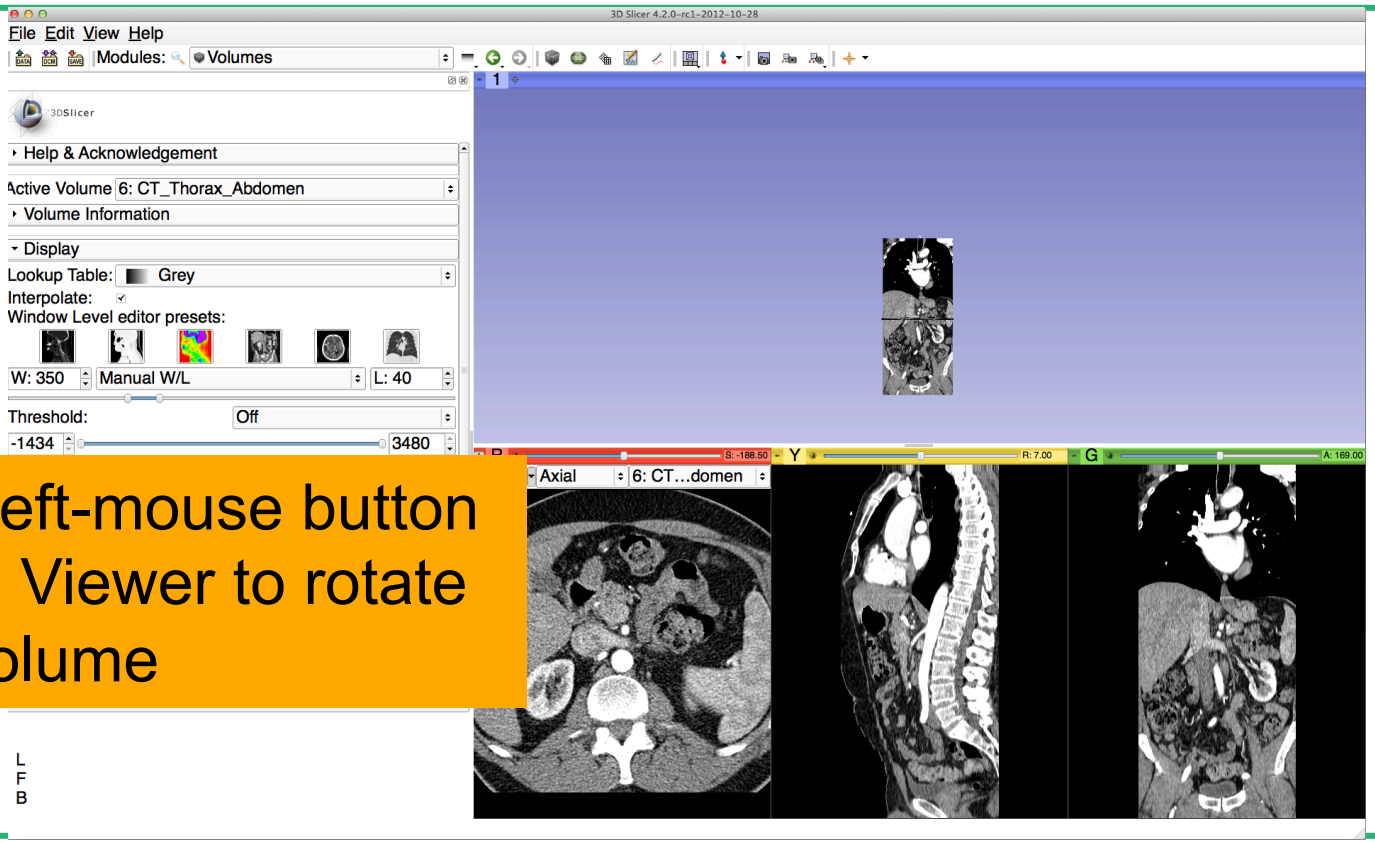
Click on the **Eye icon** to display the three anatomical slices in the 3D Viewer

Loading a DICOM volume



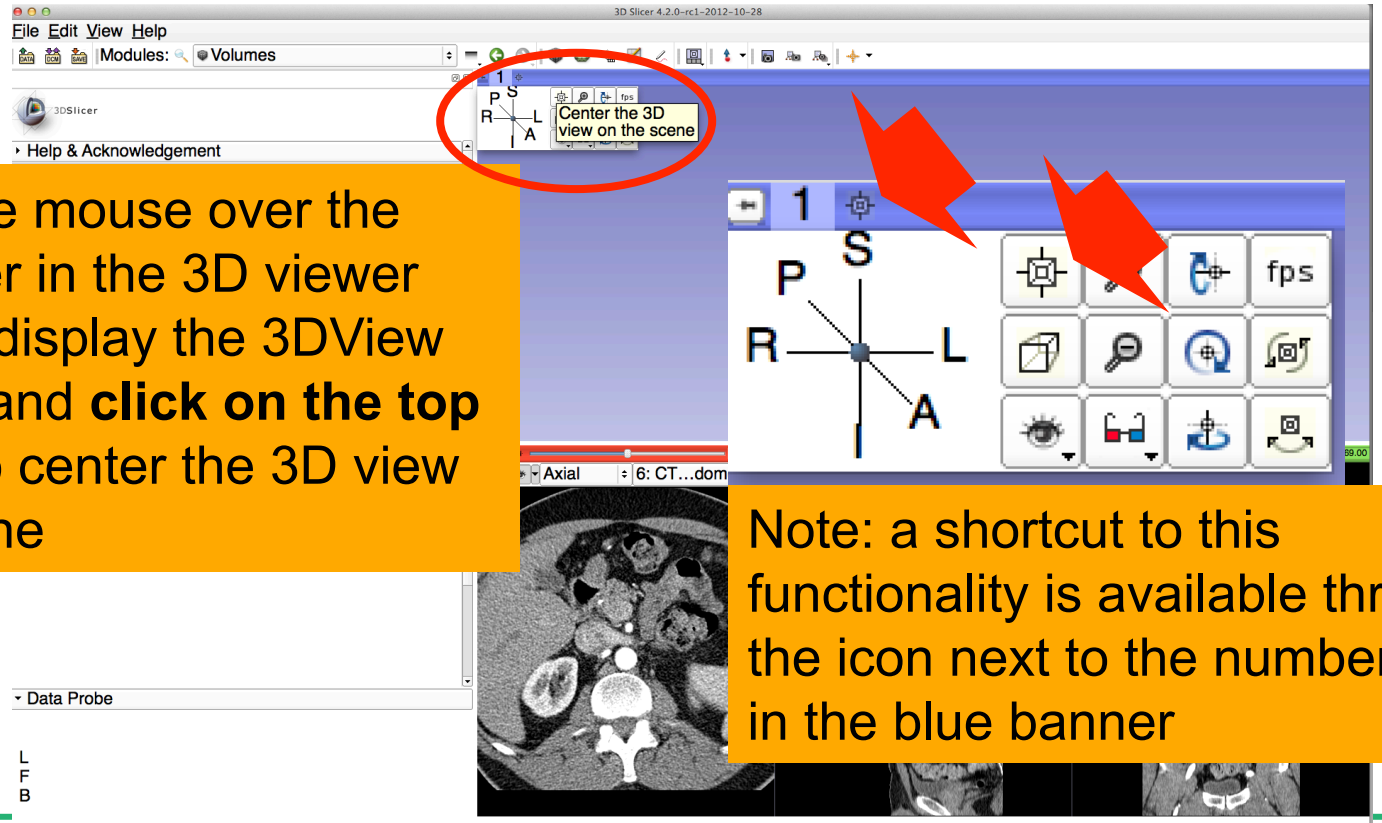
The three anatomical slices appear in the 3D viewer. Use the right-mouse button in the 3D Viewer to zoom in and out

Loading a DICOM volume



Use the left-mouse button in the 3D Viewer to rotate the 3D volume

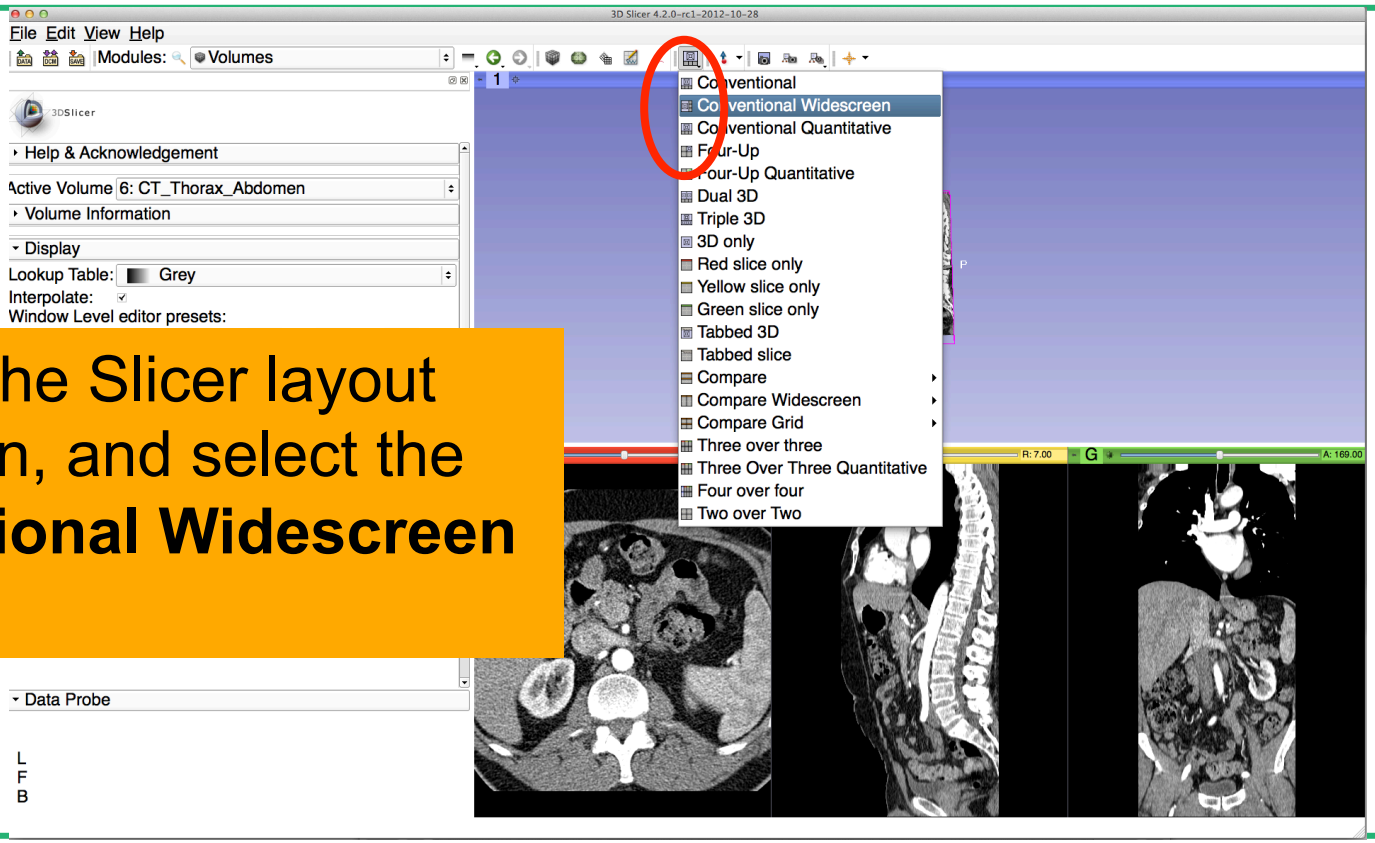
Loading a DICOM volume



Position the mouse over the blue banner in the 3D viewer window to display the 3DView controller, and **click on the top left icon** to center the 3D view on the scene

Note: a shortcut to this functionality is available through the icon next to the number ‘1’ in the blue banner

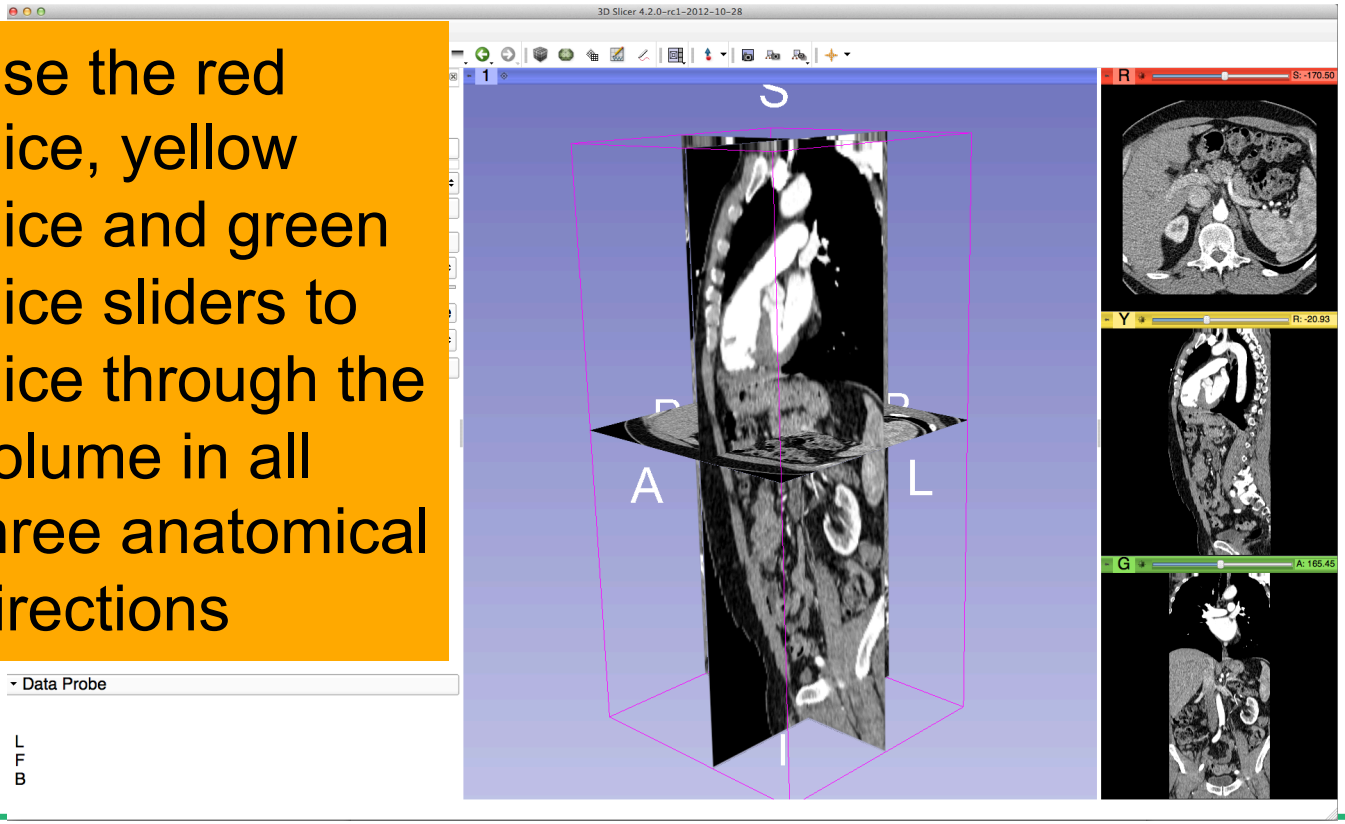
Loading a DICOM volume

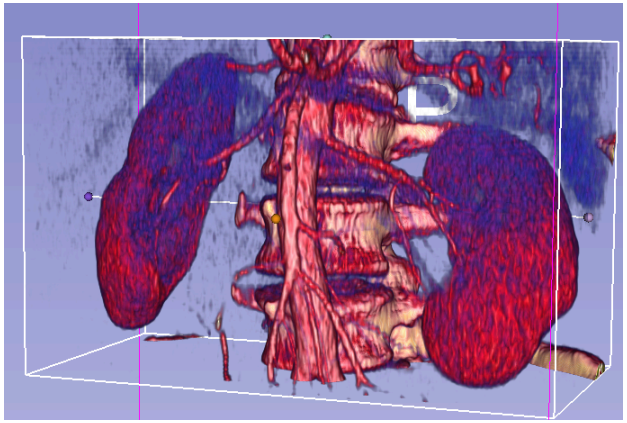


Click on the Slicer layout menu icon, and select the **Conventional Widescreen** layout

Loading a DICOM volume

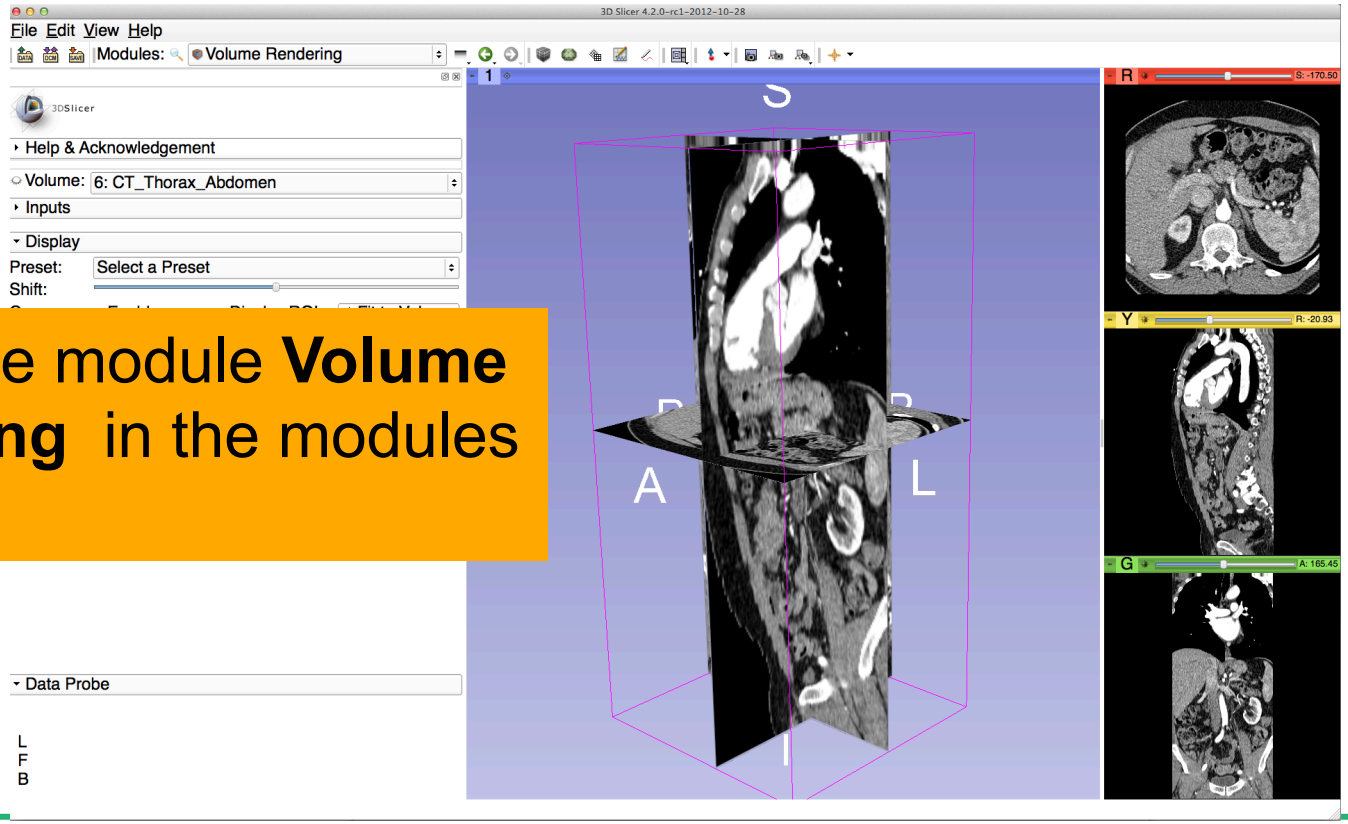
Use the red slice, yellow slice and green slice sliders to slice through the volume in all three anatomical directions





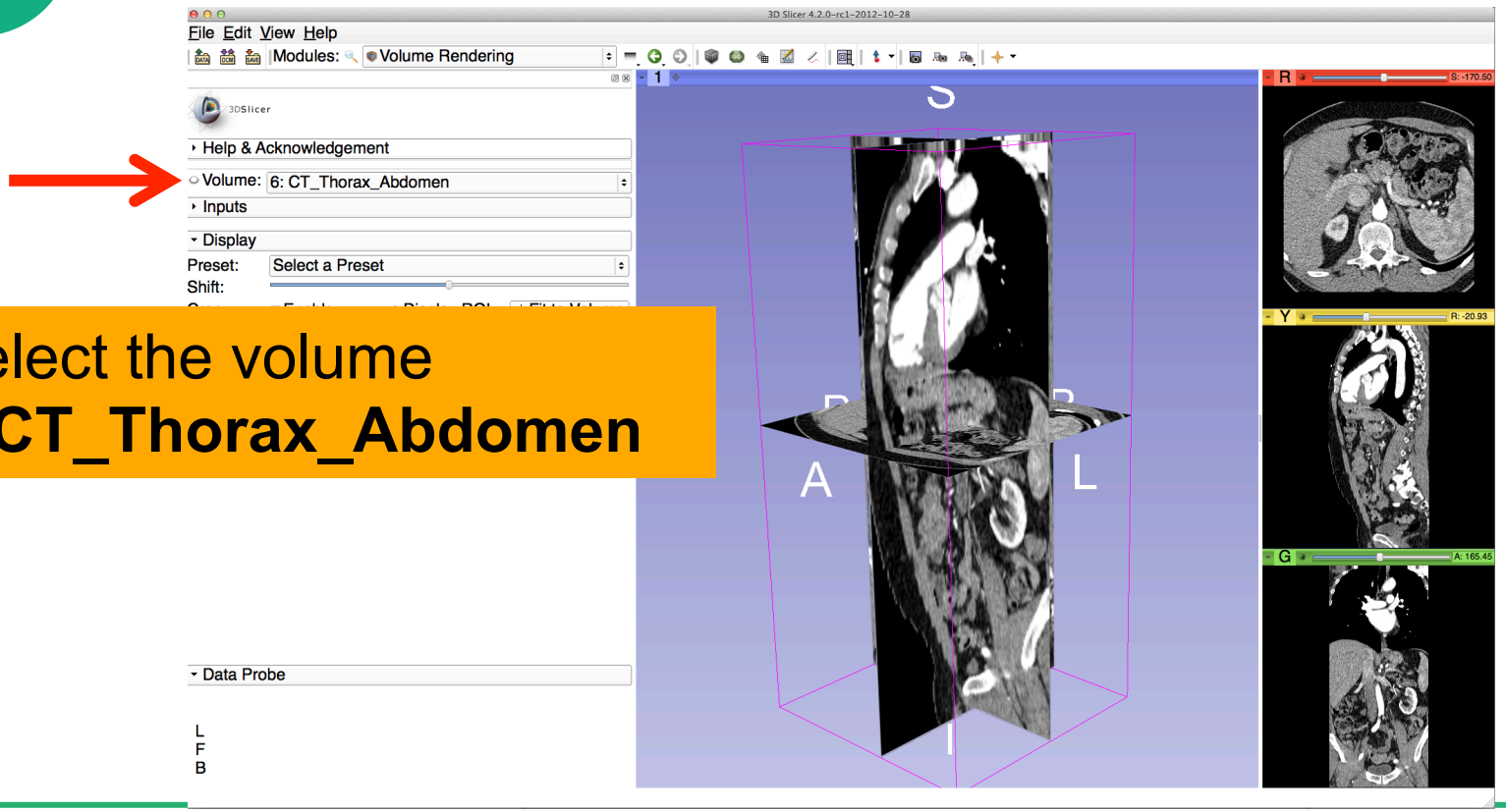
3D Interactive exploration of thoraco-abdominal CT data using Volume Rendering

Volume Rendering



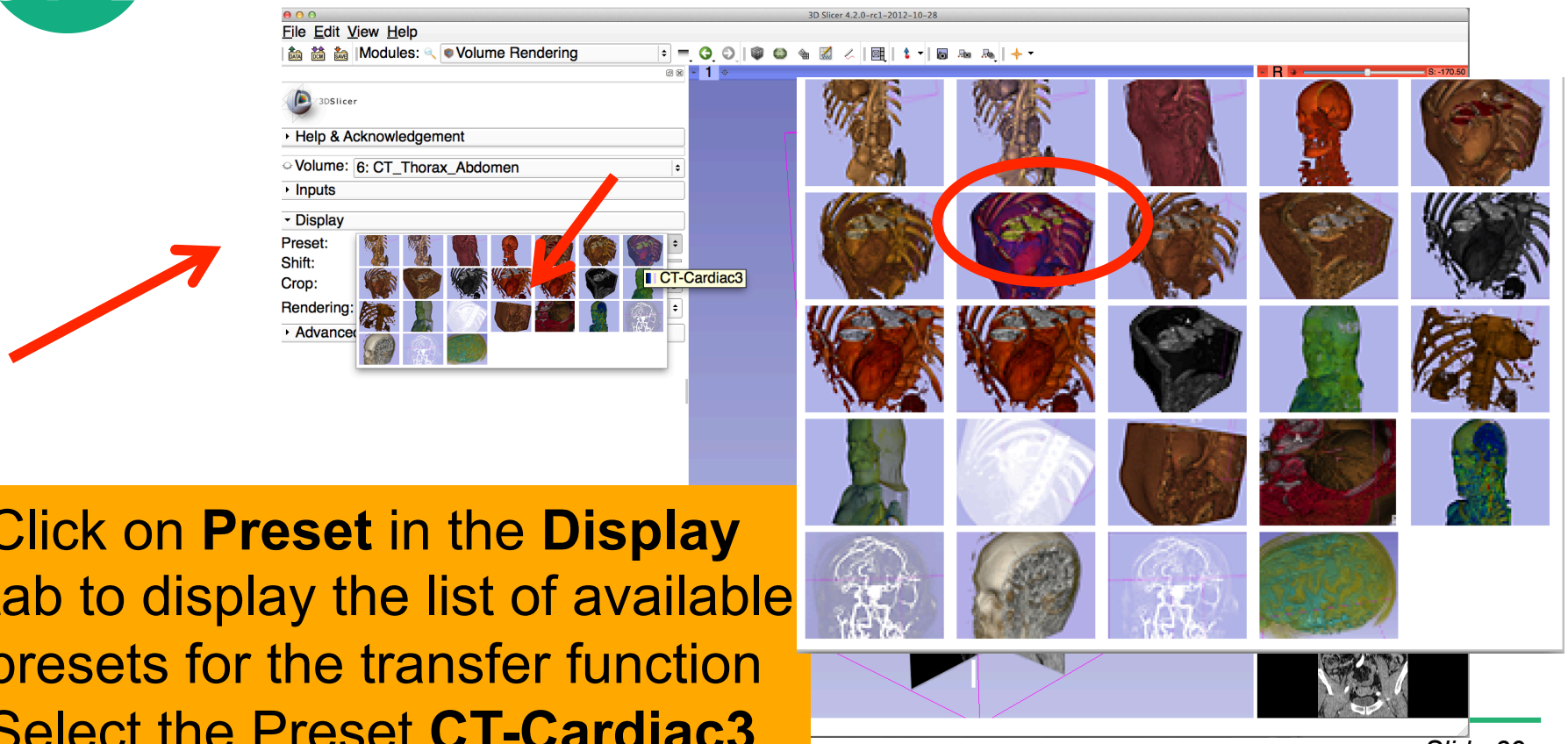
Select the module **Volume Rendering** in the modules menu

Volume Rendering



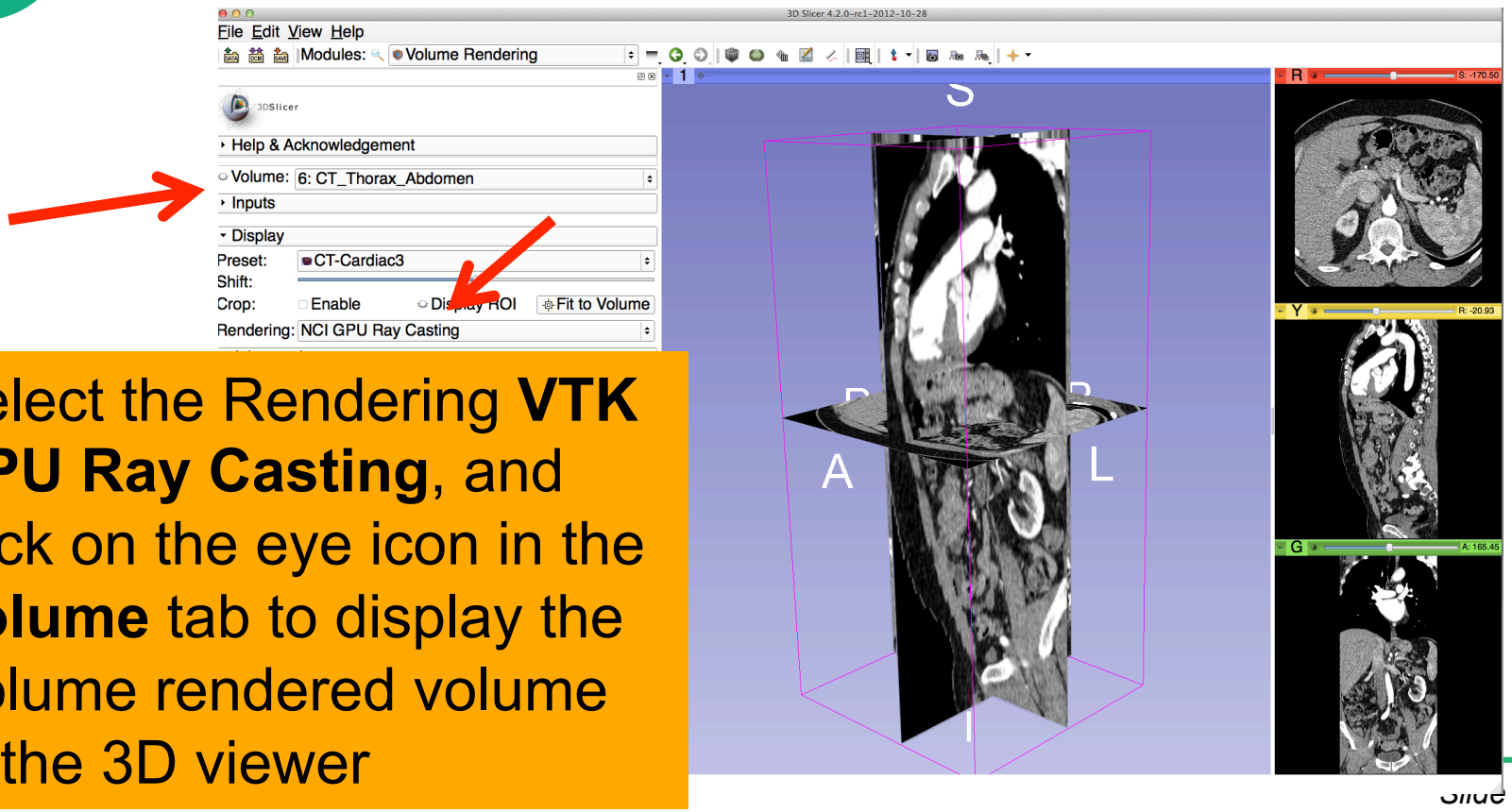
Select the volume
6:CT_Thorax_Abdomen

Volume Rendering



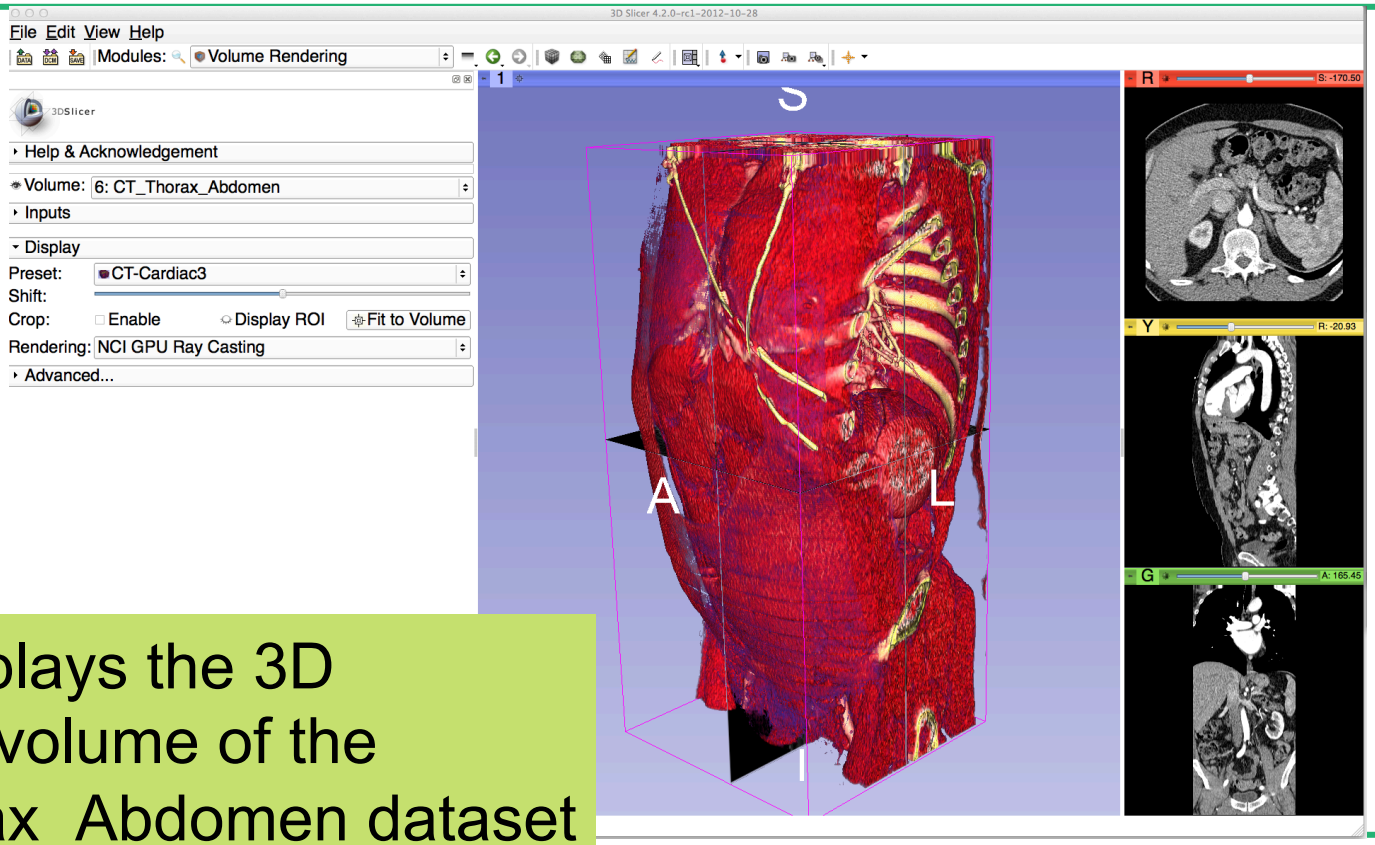
Click on **Preset** in the **Display** tab to display the list of available presets for the transfer function
Select the Preset **CT-Cardiac3**

Volume Rendering



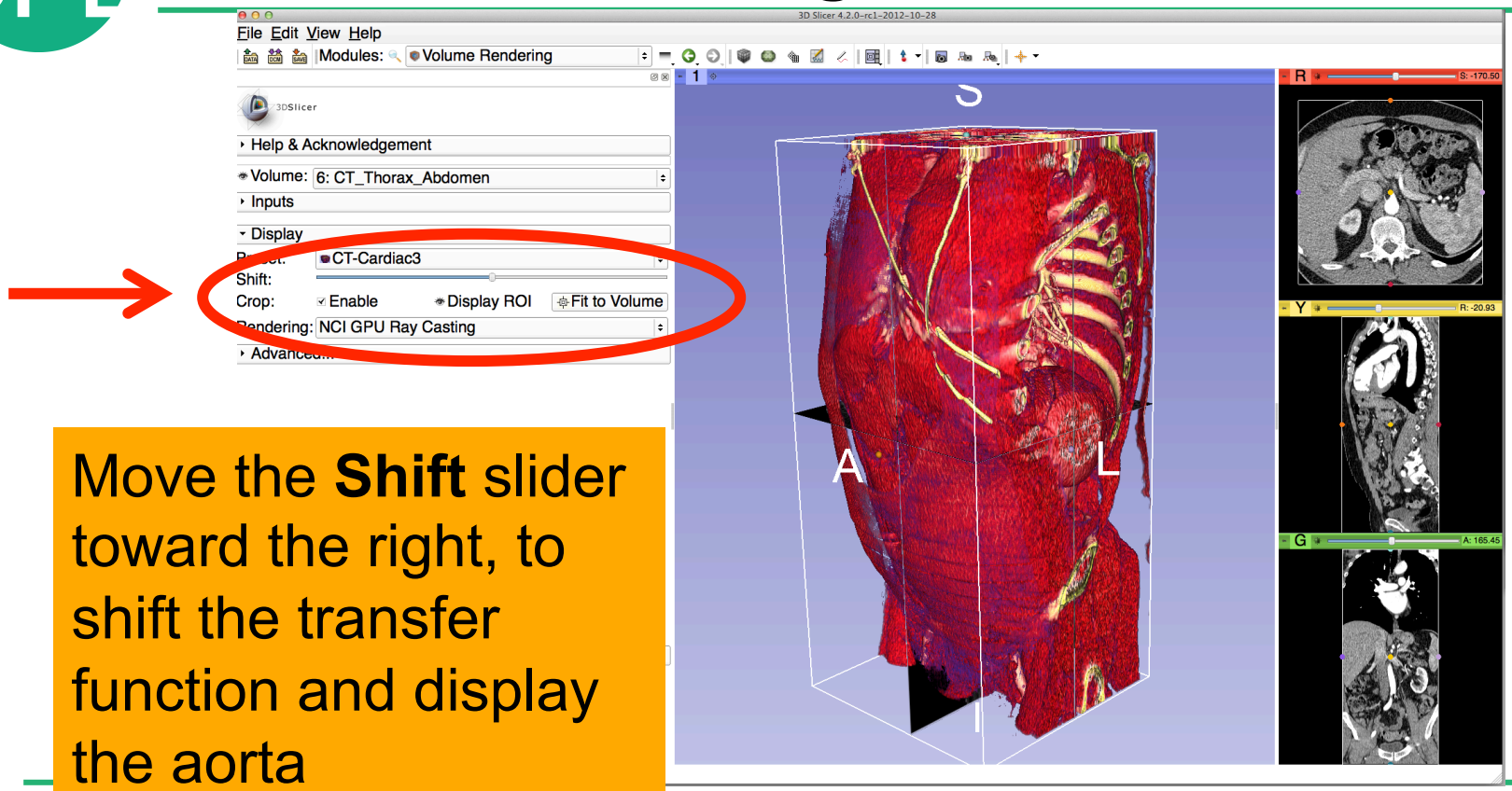
Select the Rendering **VTK CPU Ray Casting**, and click on the eye icon in the **Volume** tab to display the Volume rendered volume in the 3D viewer

Volume Rendering



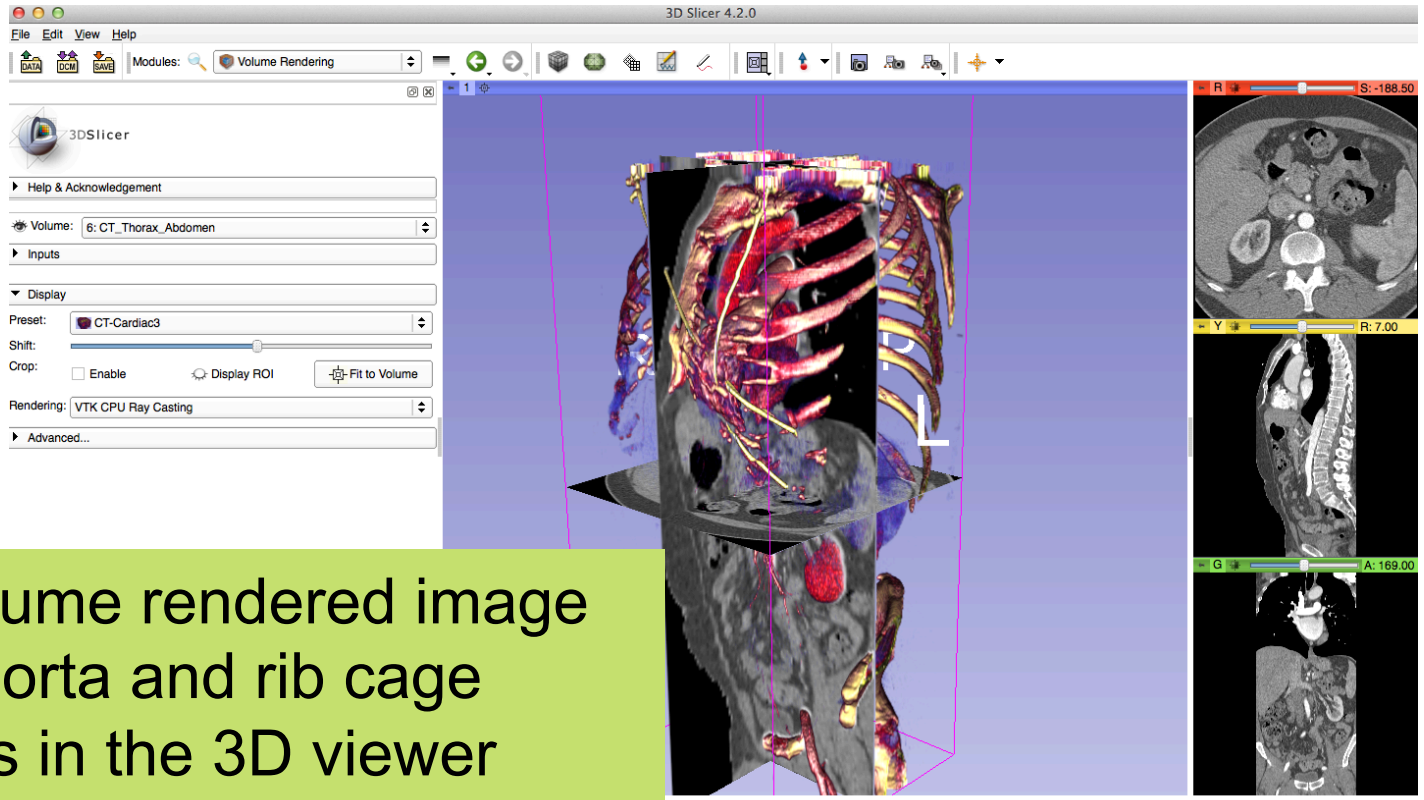
Slicer displays the 3D rendered volume of the CT_Thorax_Abdomen dataset

Volume Rendering



Move the **Shift** slider toward the right, to shift the transfer function and display the aorta

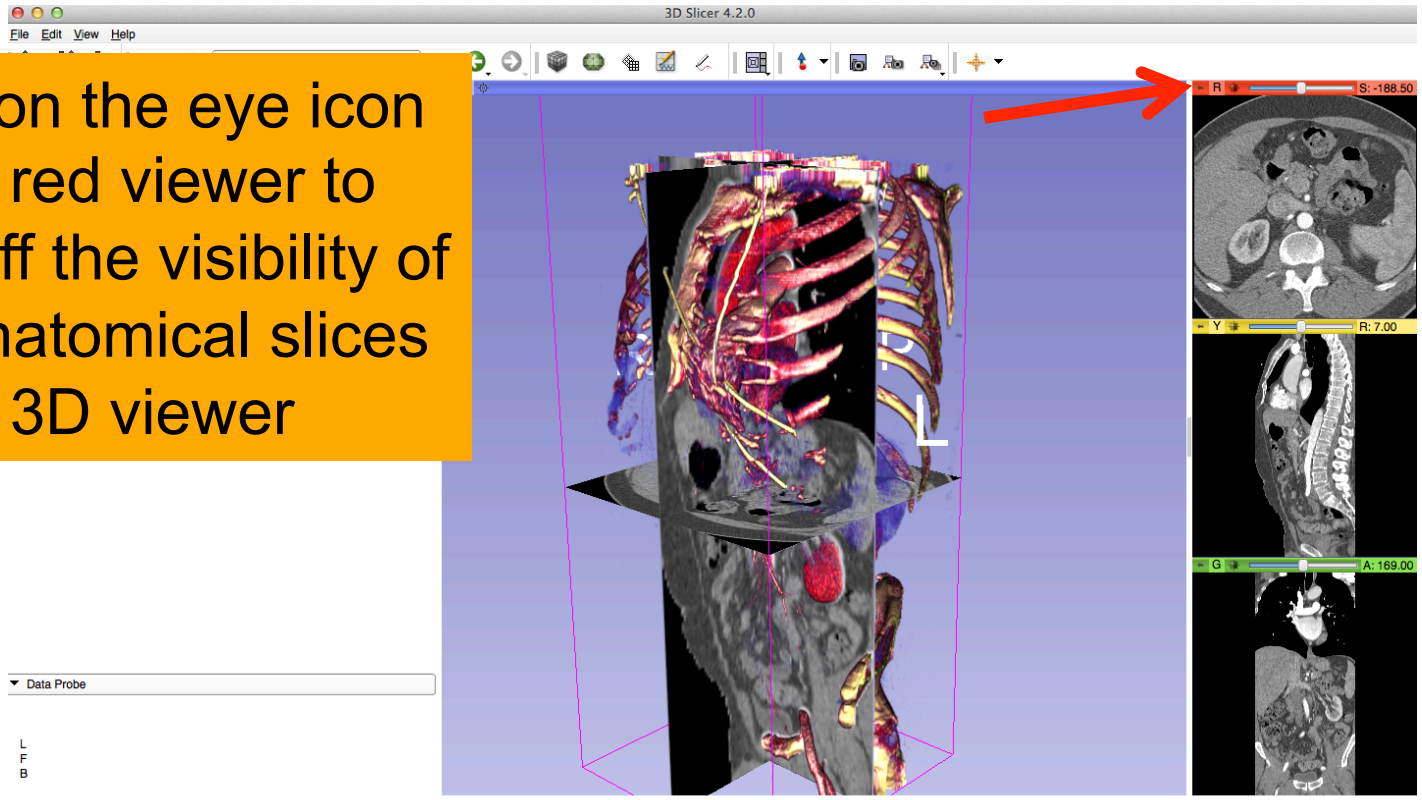
Volume Rendering



The volume rendered image of the aorta and rib cage appears in the 3D viewer

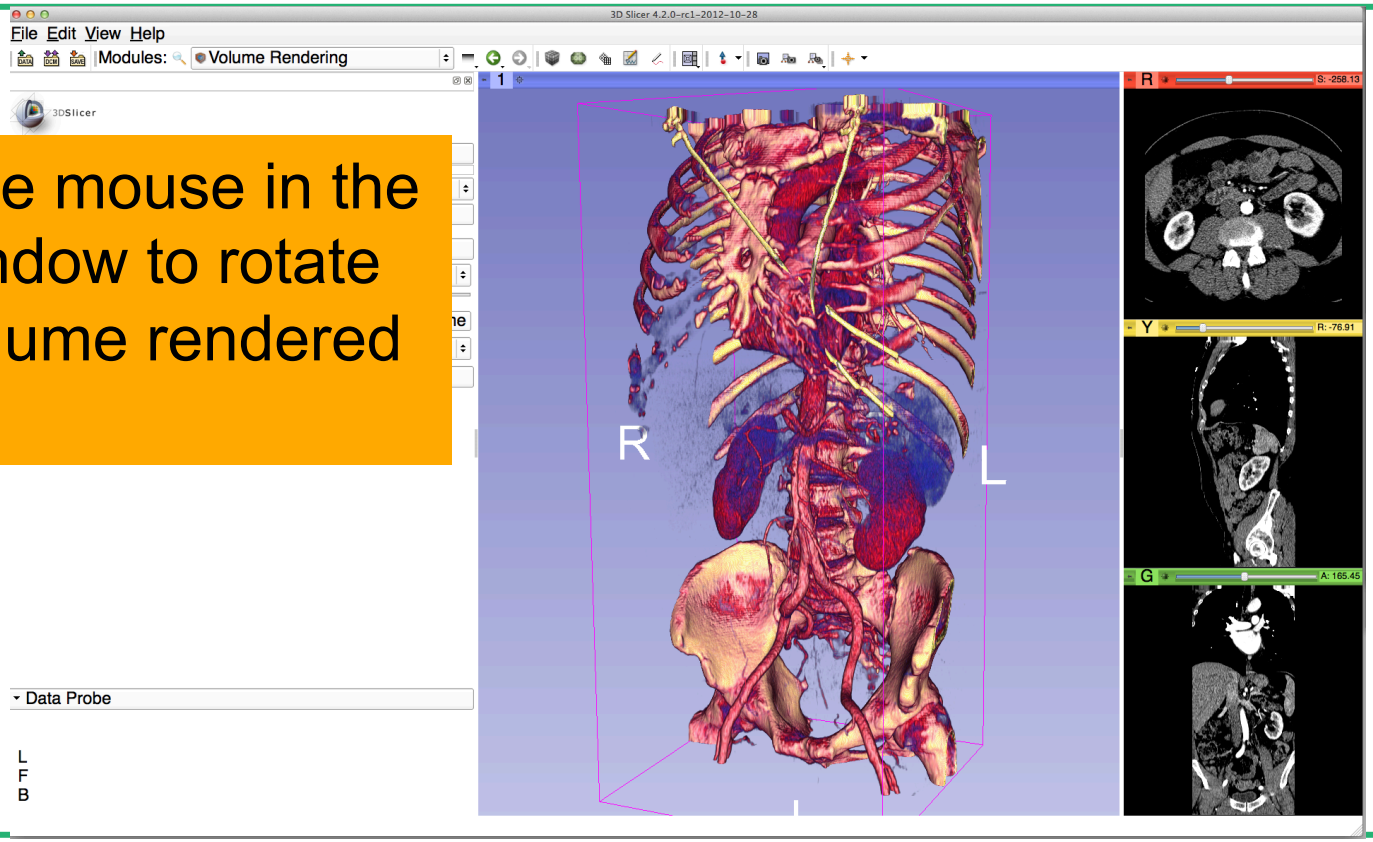
Volume Rendering

Click on the eye icon in the red viewer to turn off the visibility of the anatomical slices in the 3D viewer

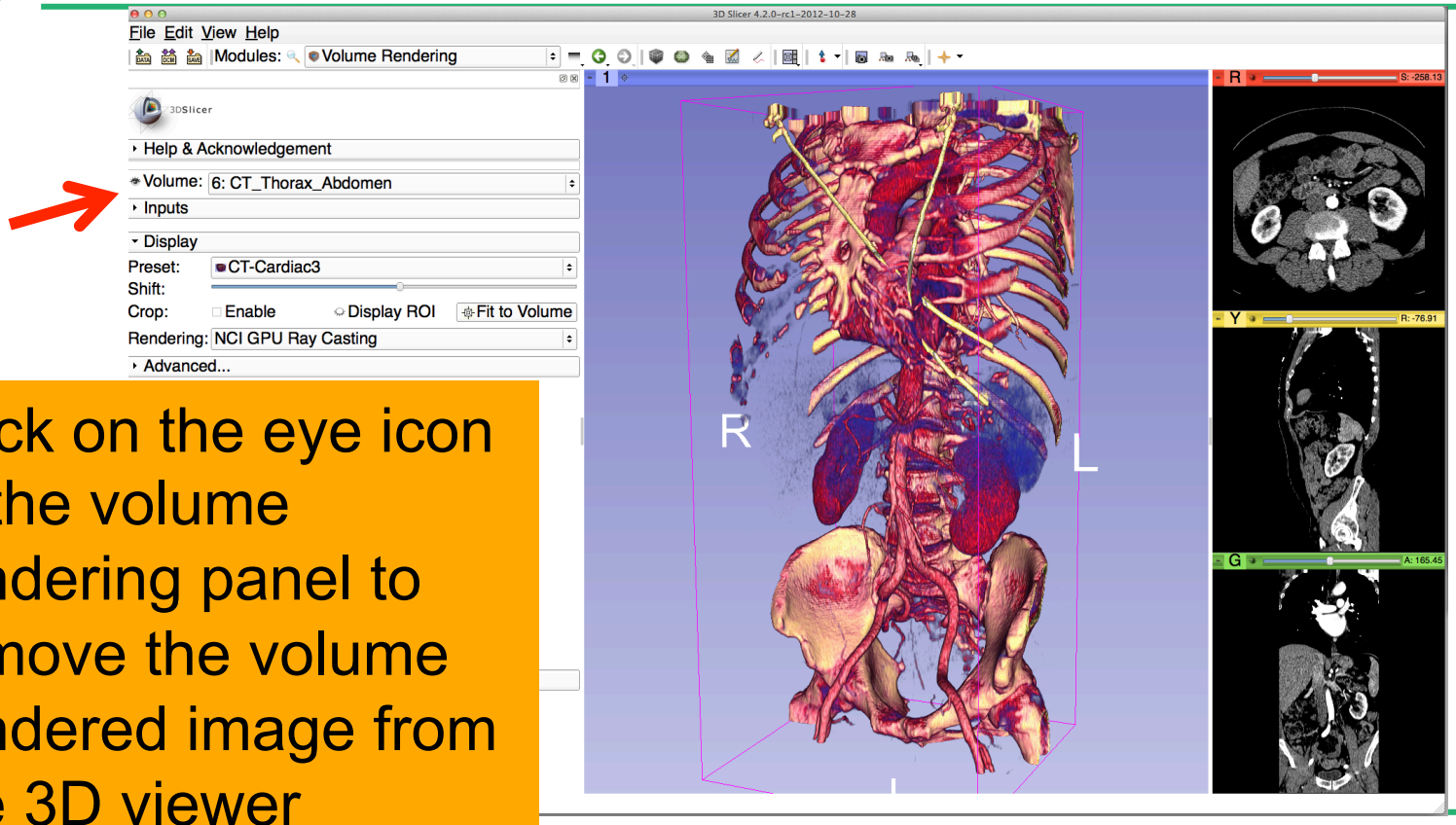


Volume Rendering

Use the mouse in the 3D window to rotate the volume rendered image

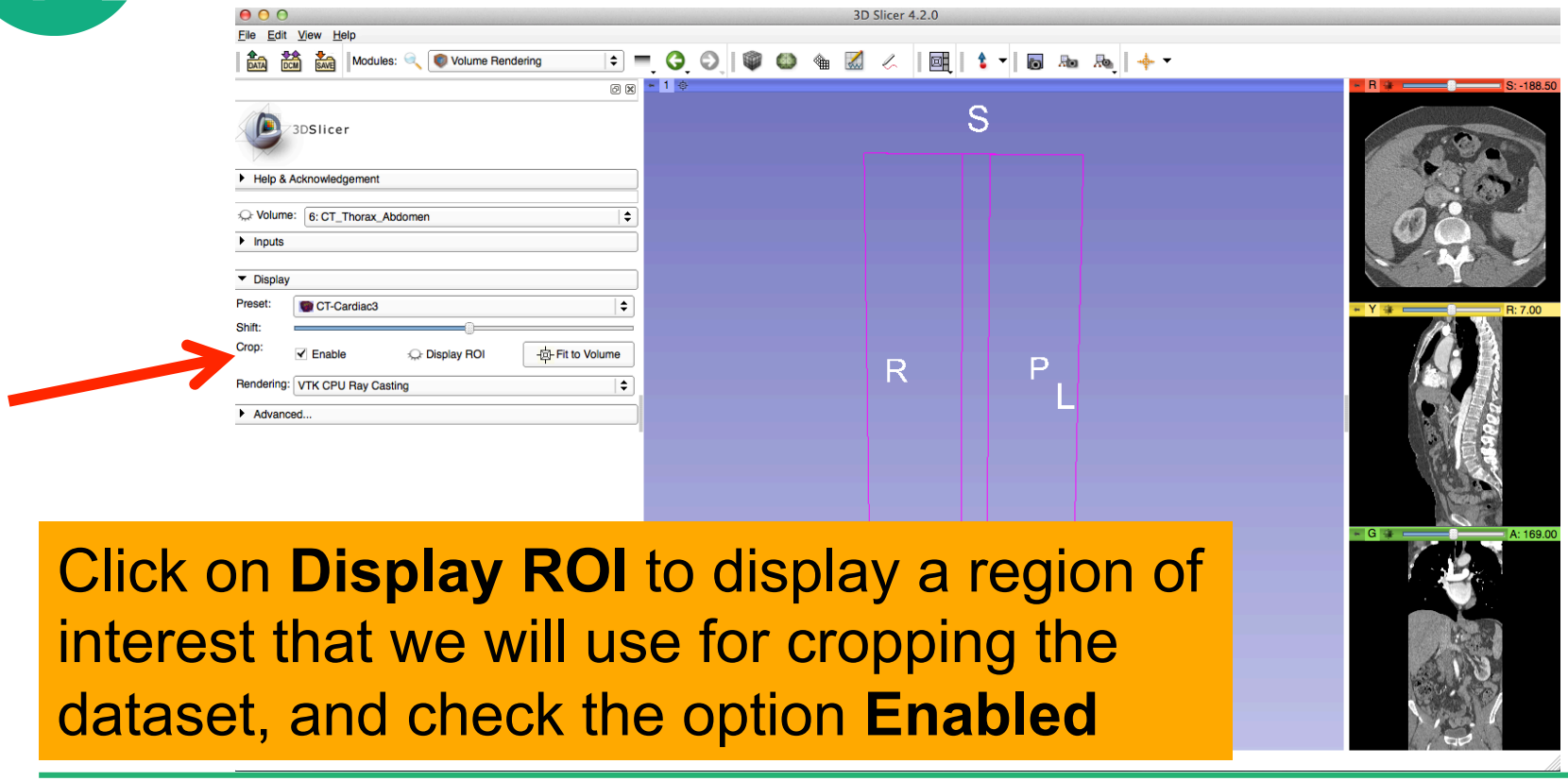


Volume Rendering



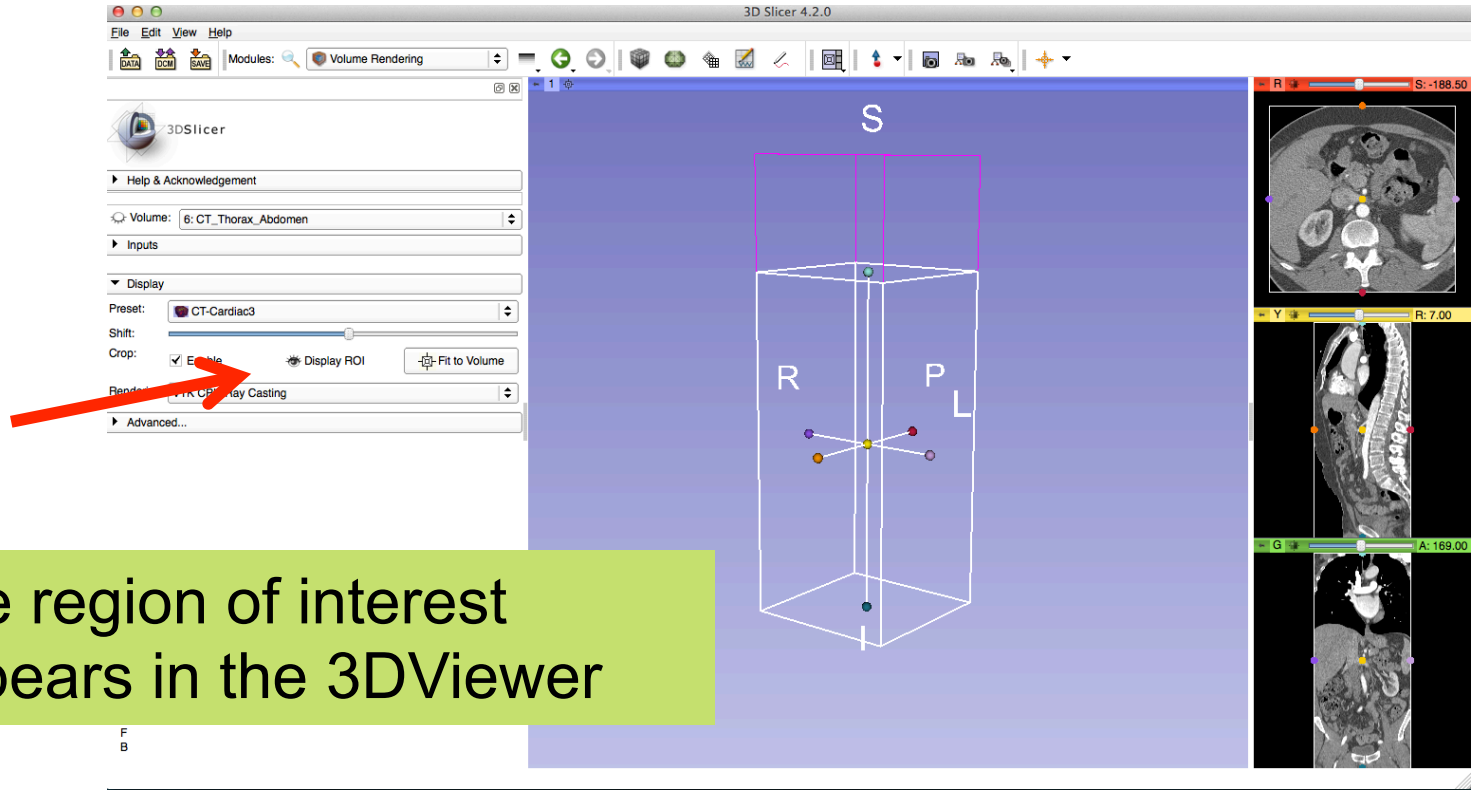
Click on the eye icon in the volume rendering panel to remove the volume rendered image from the 3D viewer

Volume Rendering



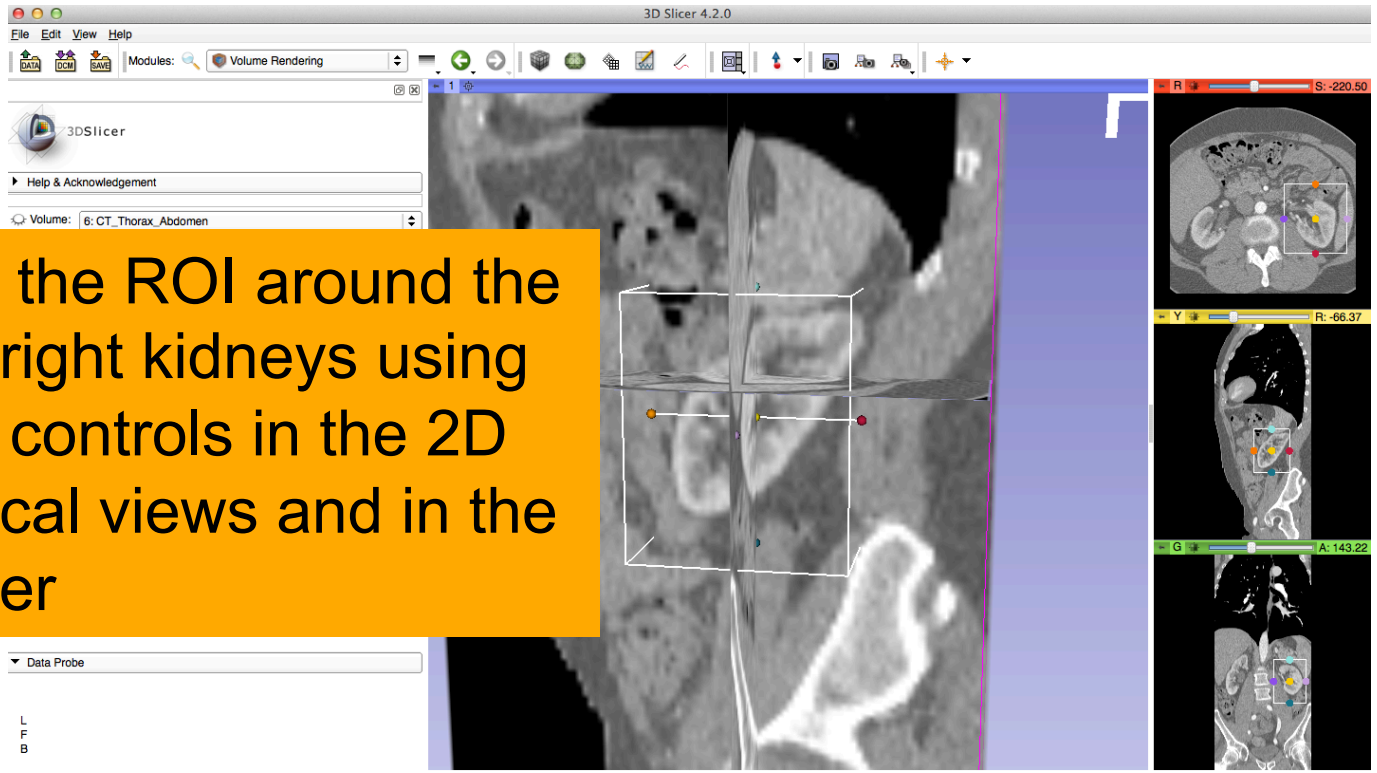
Click on **Display ROI** to display a region of interest that we will use for cropping the dataset, and check the option **Enabled**

Volume Rendering



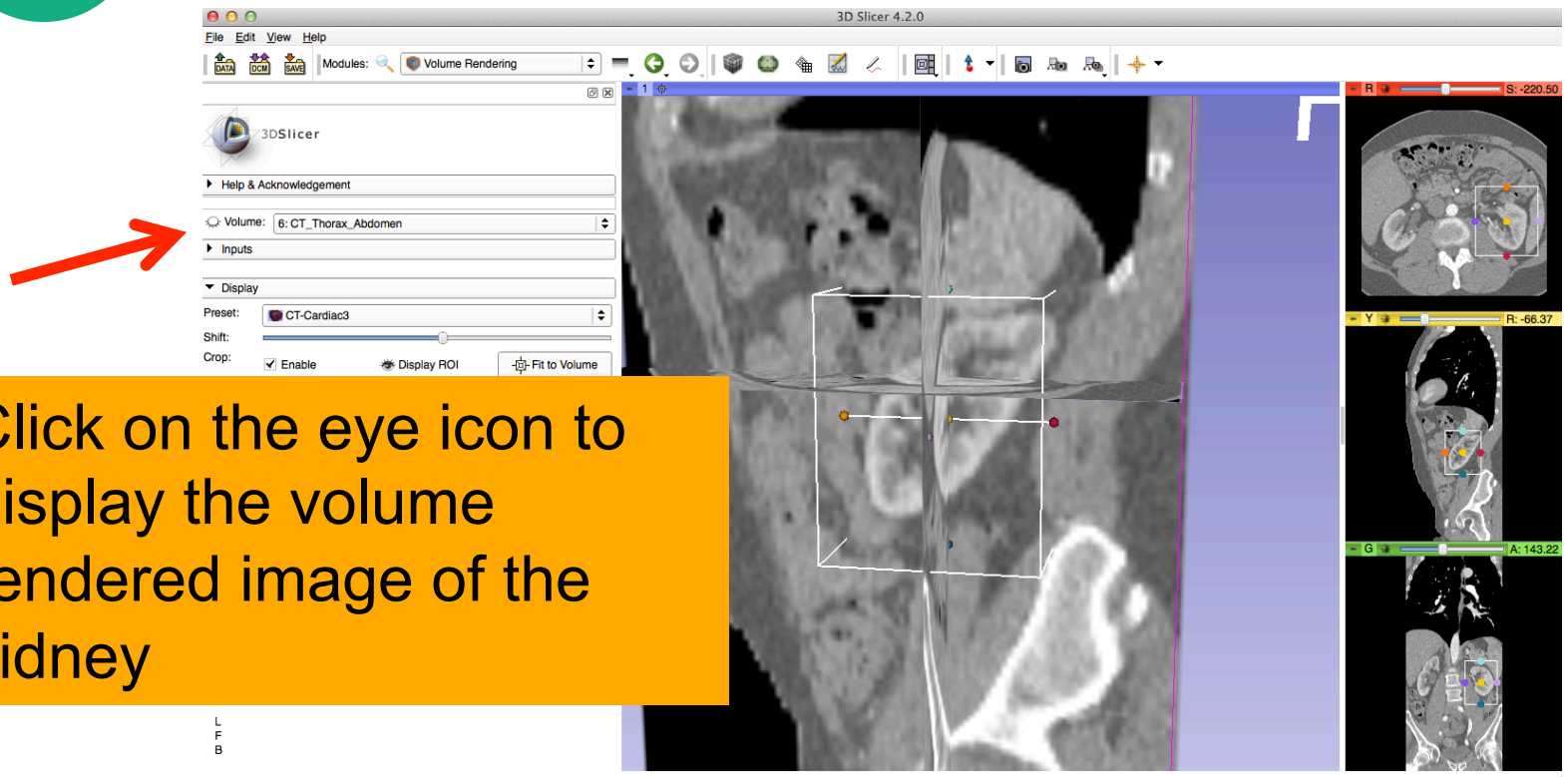
The region of interest appears in the 3DViewer

Volume Rendering



Position the ROI around the left and right kidneys using the ROI controls in the 2D anatomical views and in the 3D viewer

Volume Rendering

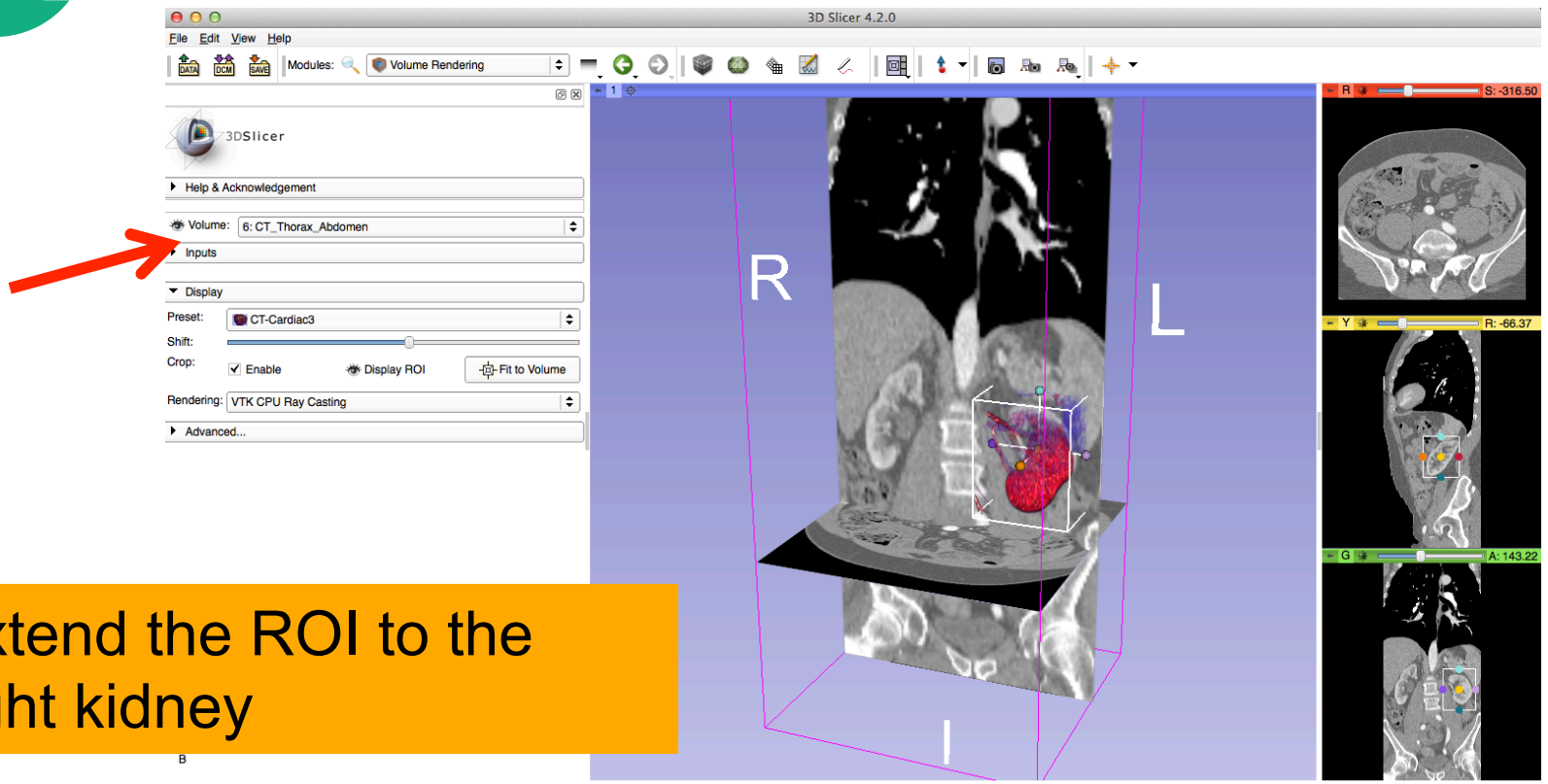


Click on the eye icon to display the volume rendered image of the kidney

Volume Rendering

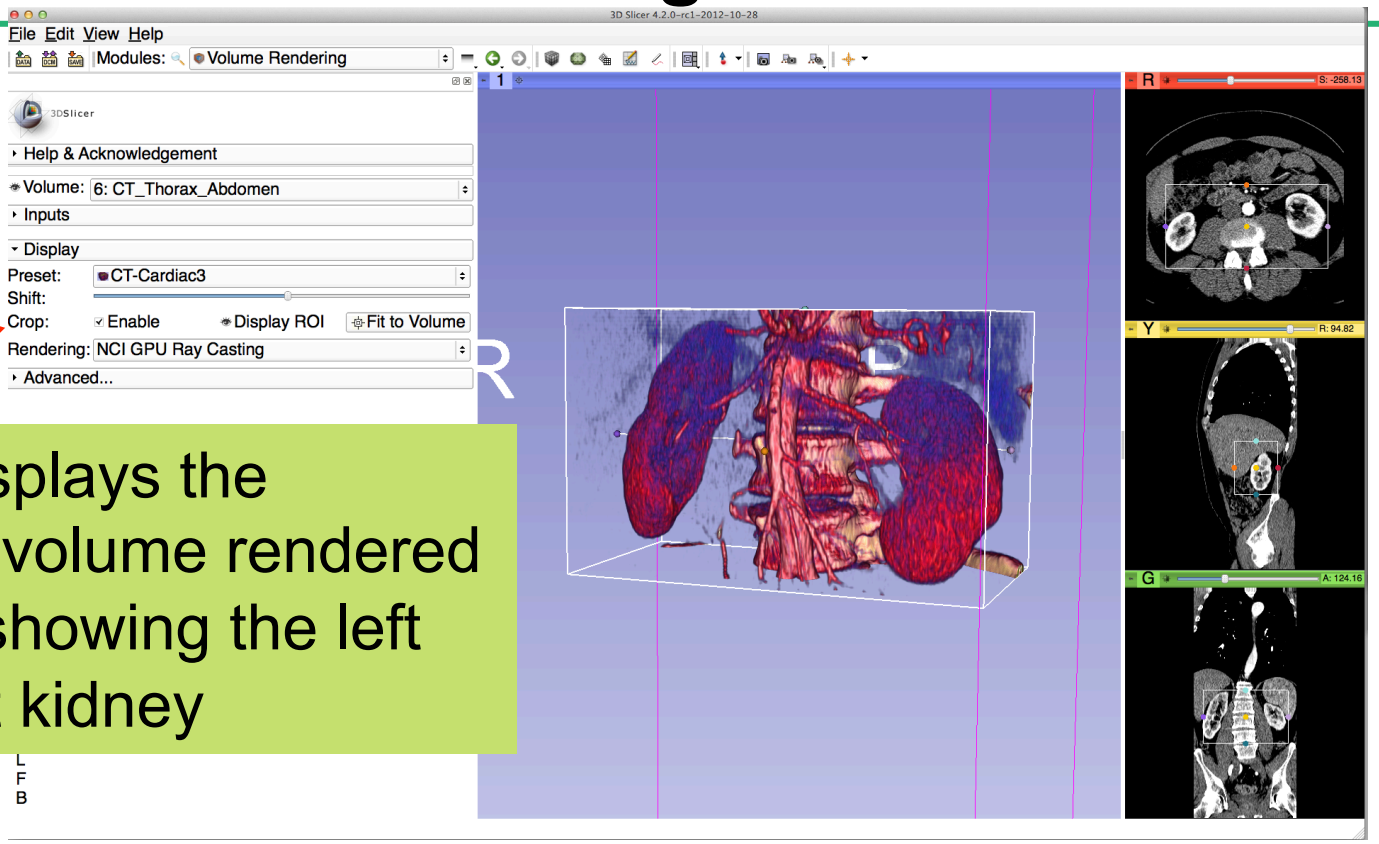
Slicer displays the volume rendered image of the left kidney

Volume Rendering



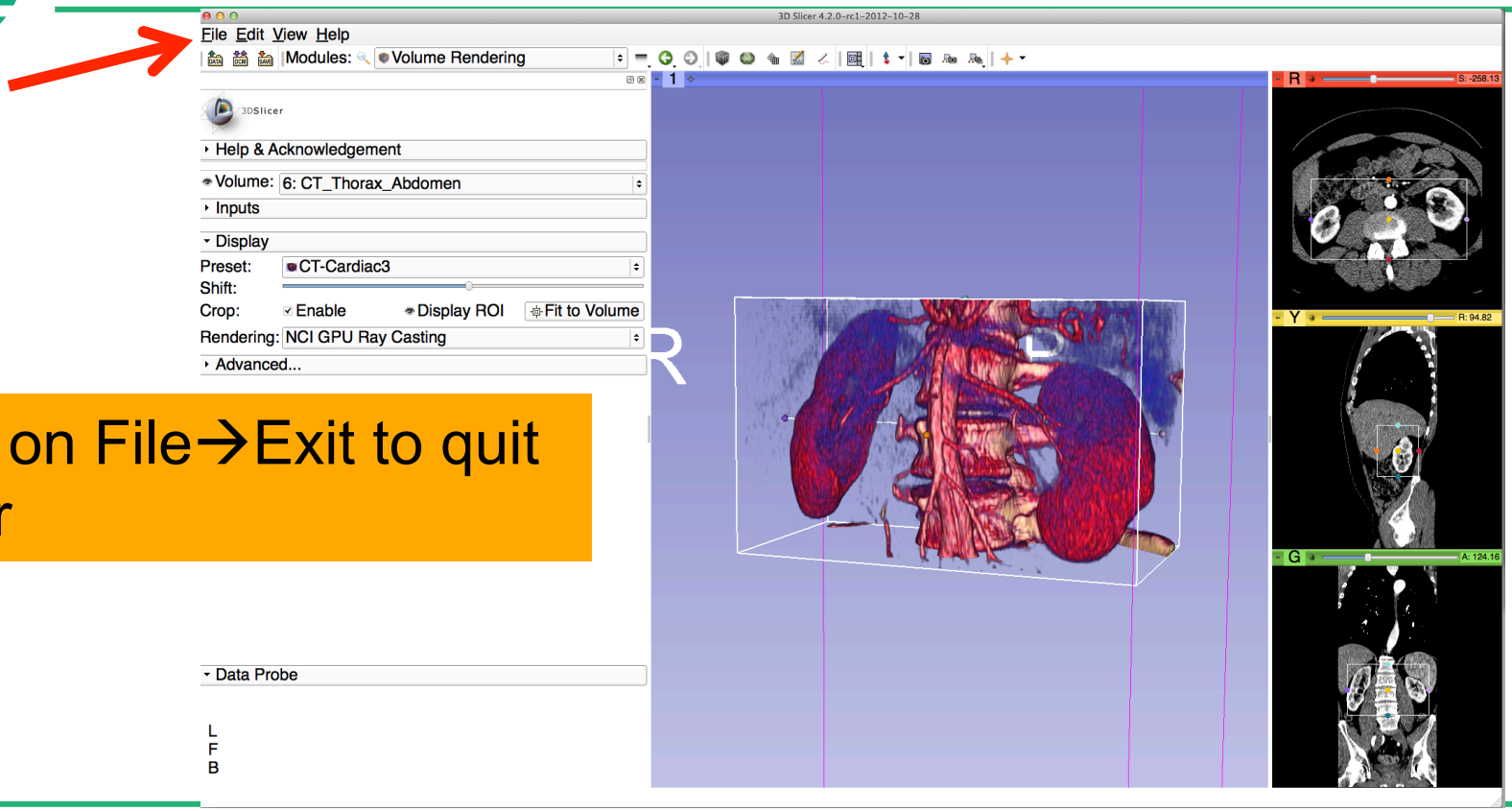
Extend the ROI to the right kidney

Volume Rendering



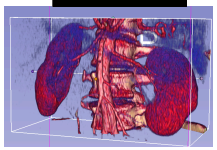
Slicer displays the cropped volume rendered images showing the left and right kidney

Volume Rendering

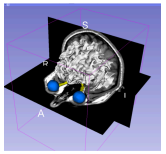


Click on File→Exit to quit Slicer

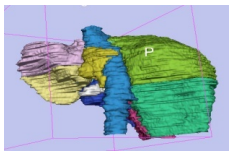
Overview

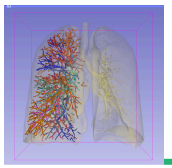


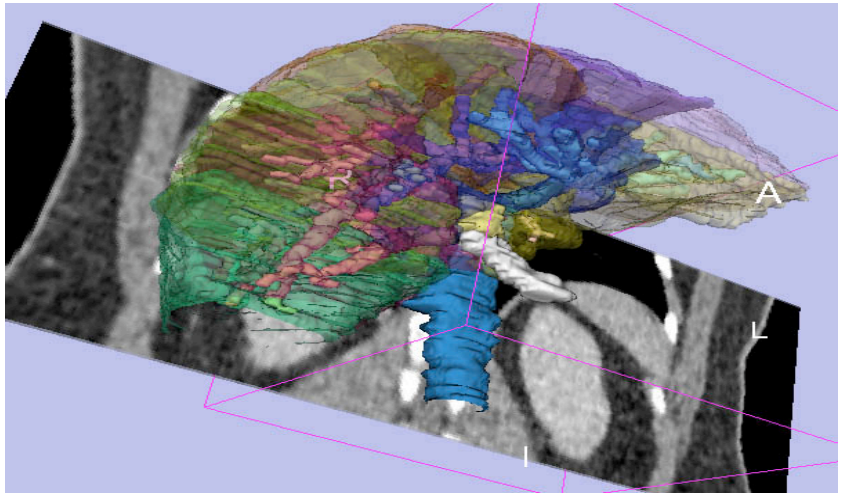
Part I: 3D Data Loading and visualization of DICOM images
- Volume Rendering of thoraco-abdominal CT data



Part II: 3D interactive exploration of the anatomy
- Exploration of the Segments of the liver
- Exploration of the Segments of the lung



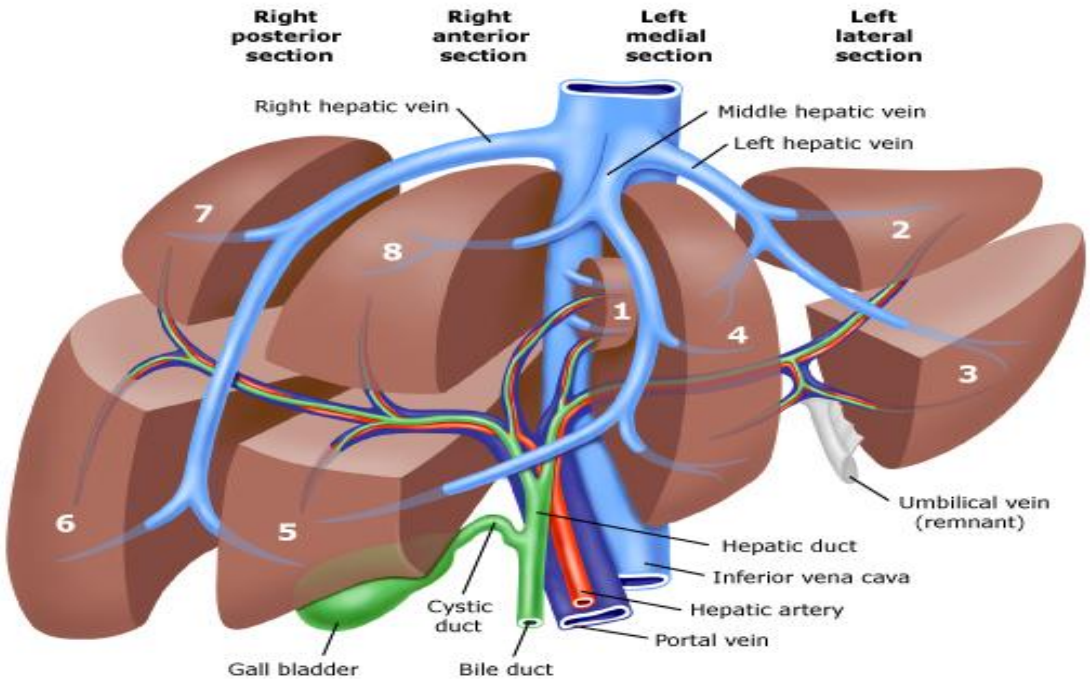




Part II:

Interactive 3D Visualization of the segments of the liver

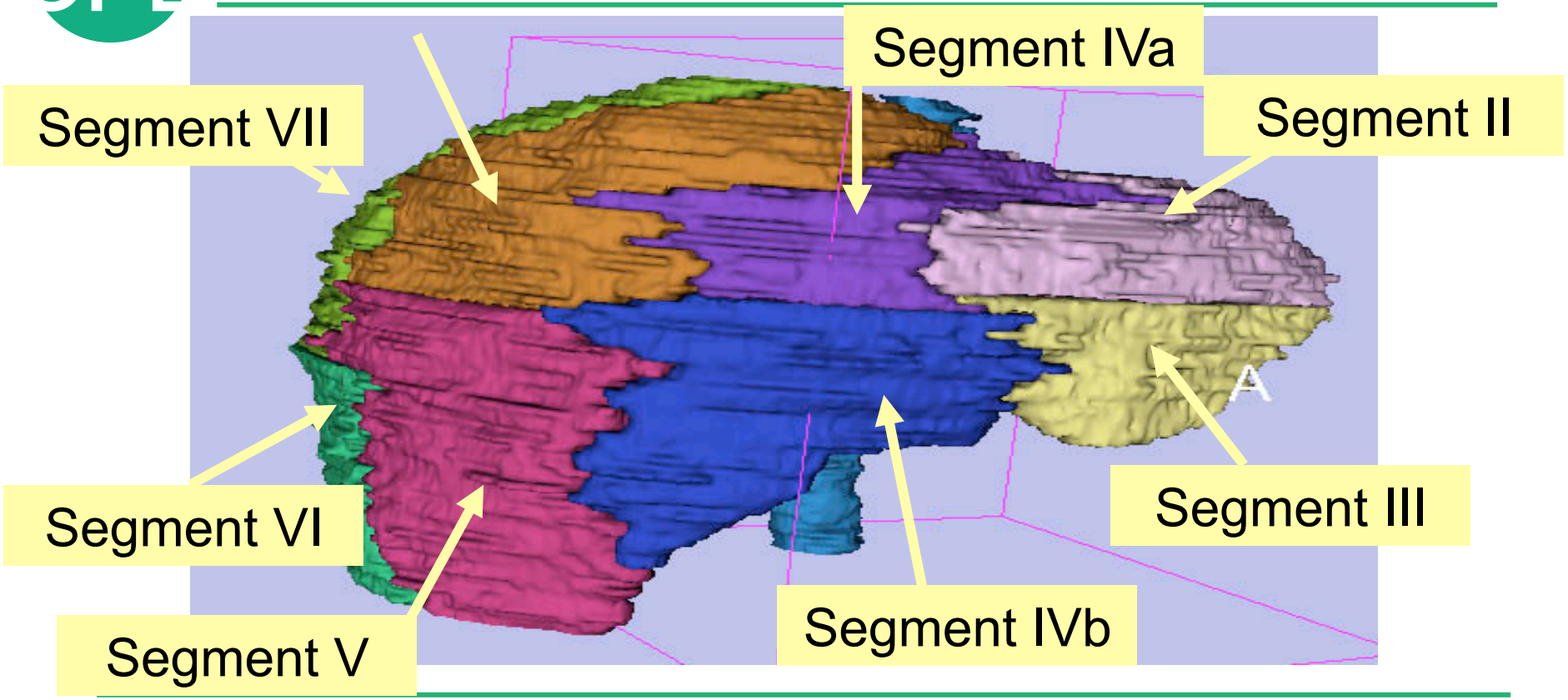
Anatomy of the liver



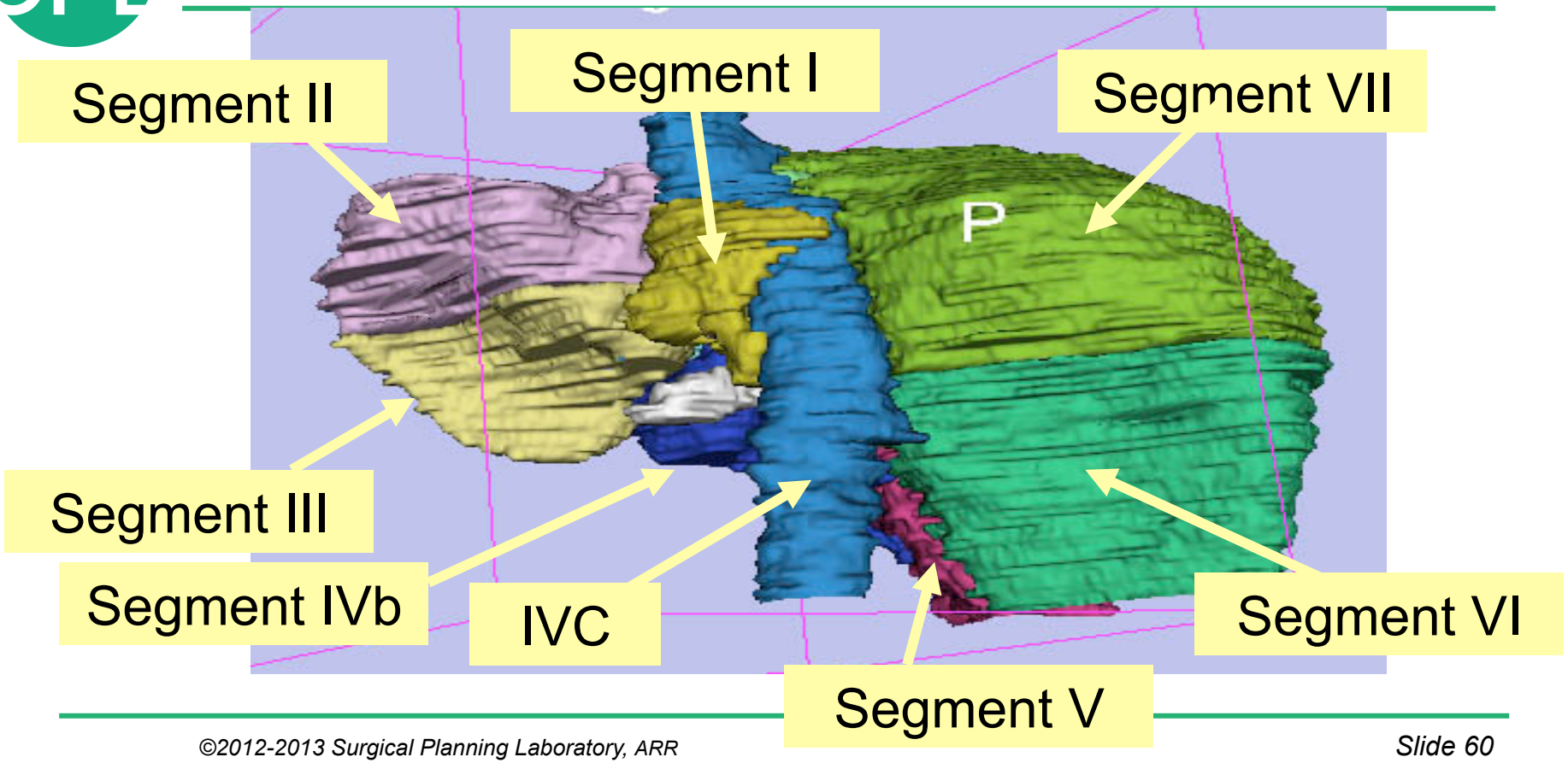
Liver dataset

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

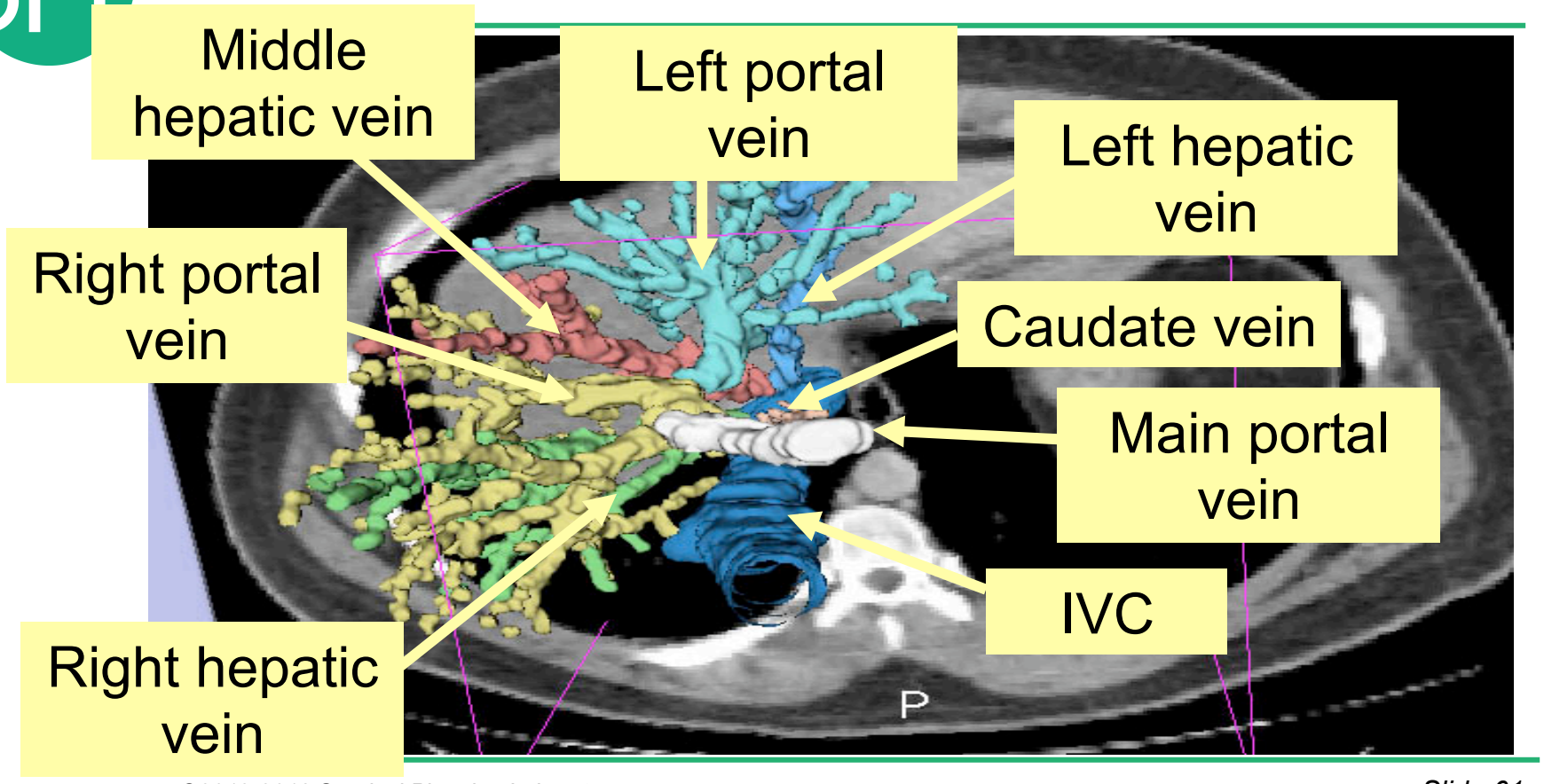
3D segments of the liver



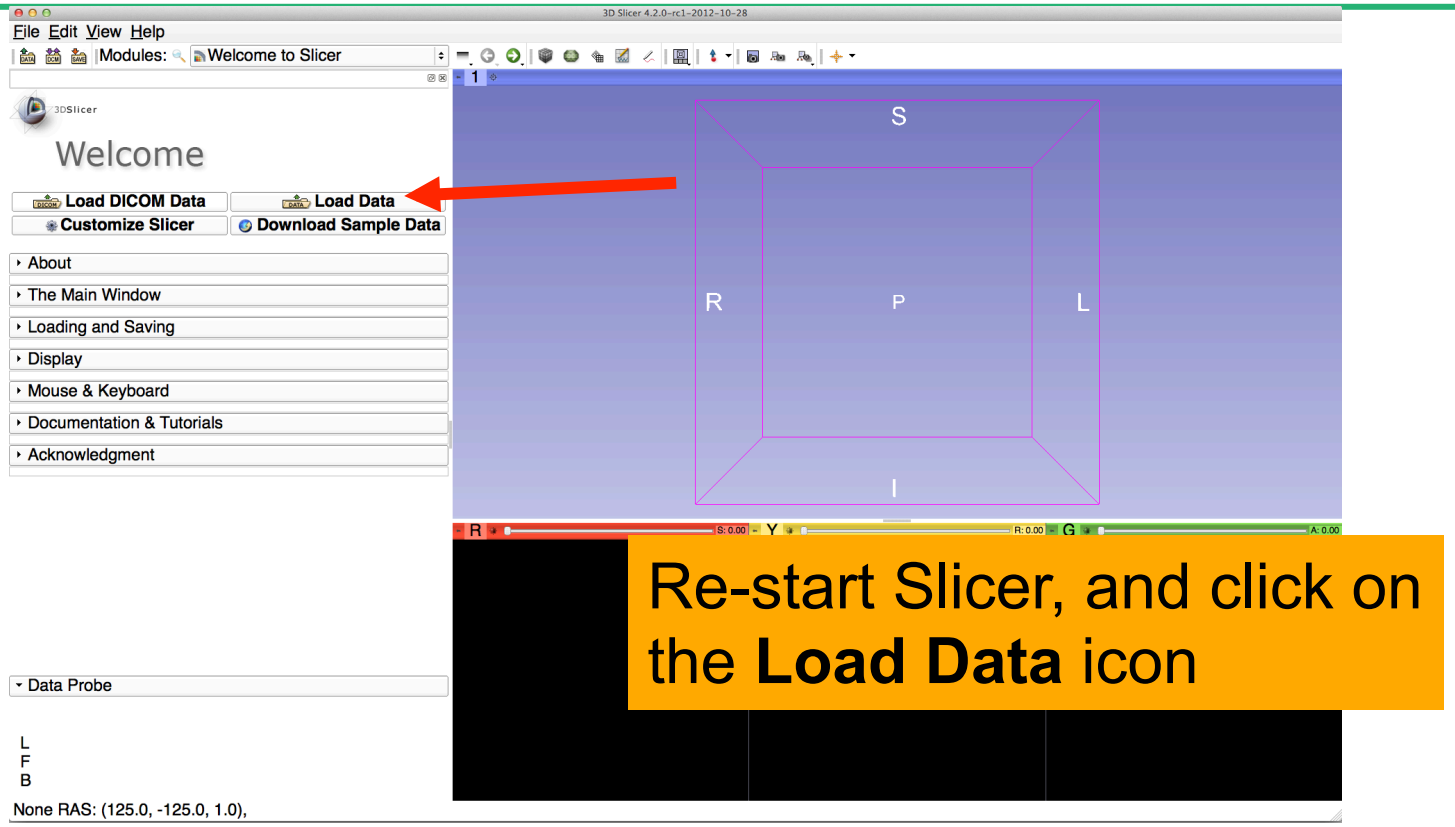
3D segments of the liver



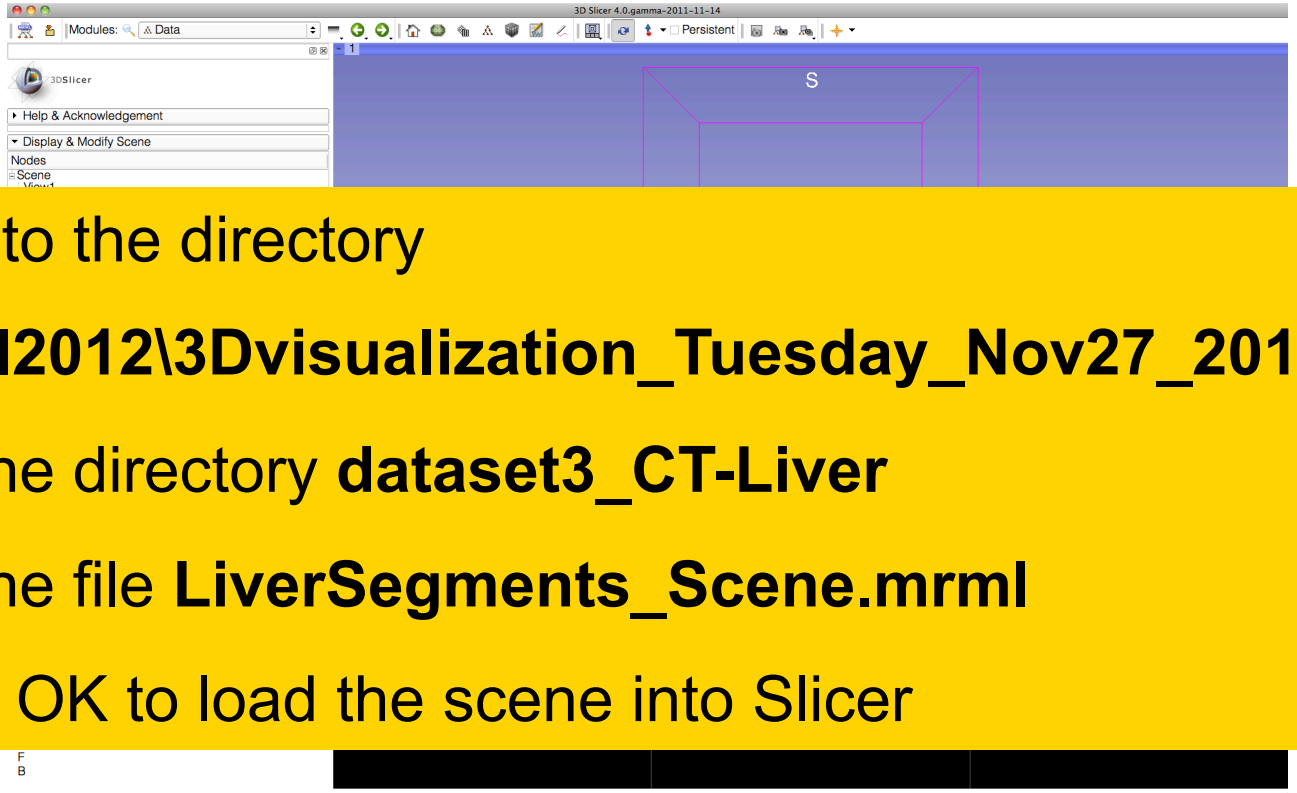
Liver vasculature



Loading the Liver Data Scene



Loading the Liver Scene



Browse to the directory

C:\Pujol2012\3Dvisualization_Tuesday_Nov27_2012

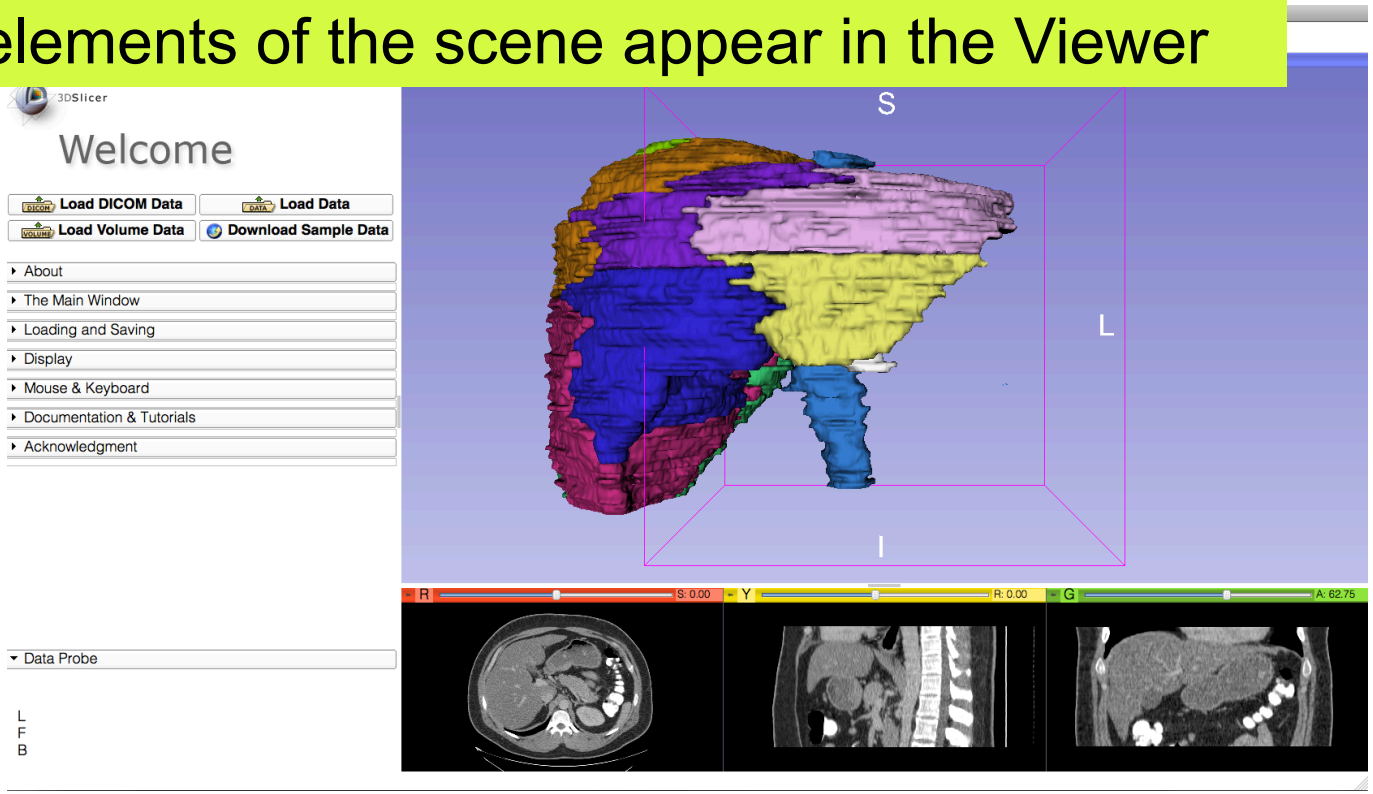
Select the directory **dataset3_CT-Liver**

Select the file **LiverSegments_Scene.mrml**

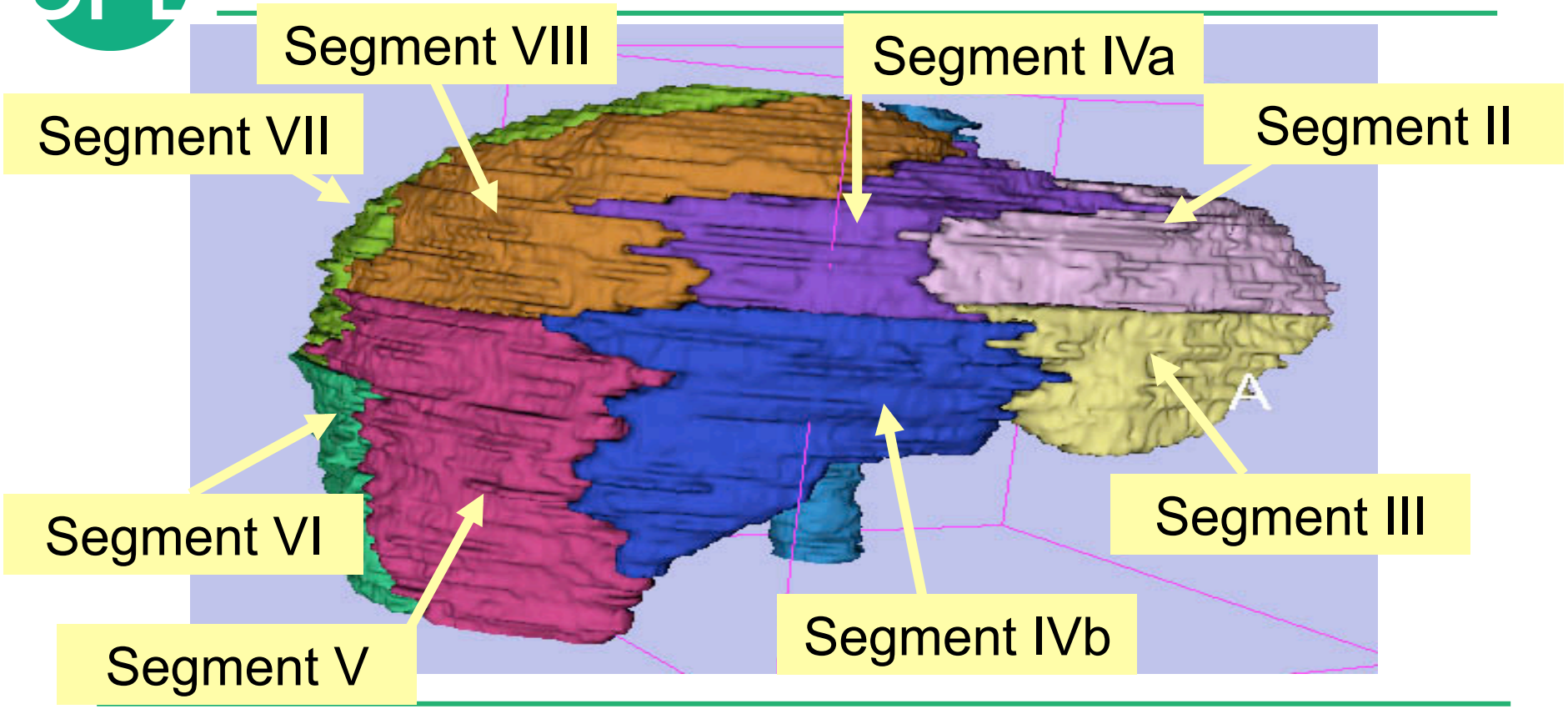
Click on OK to load the scene into Slicer

Liver Segments Scene

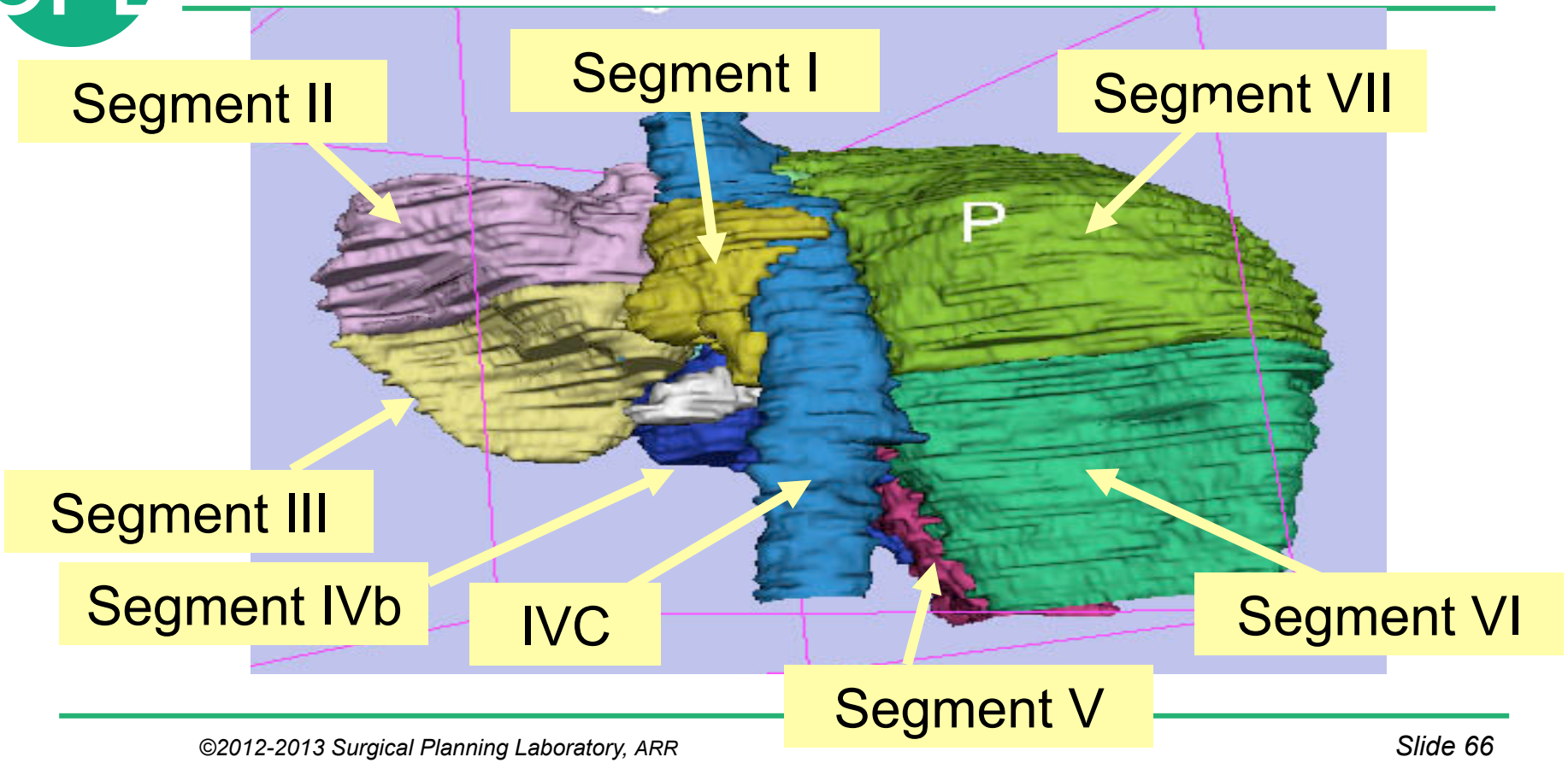
The elements of the scene appear in the Viewer



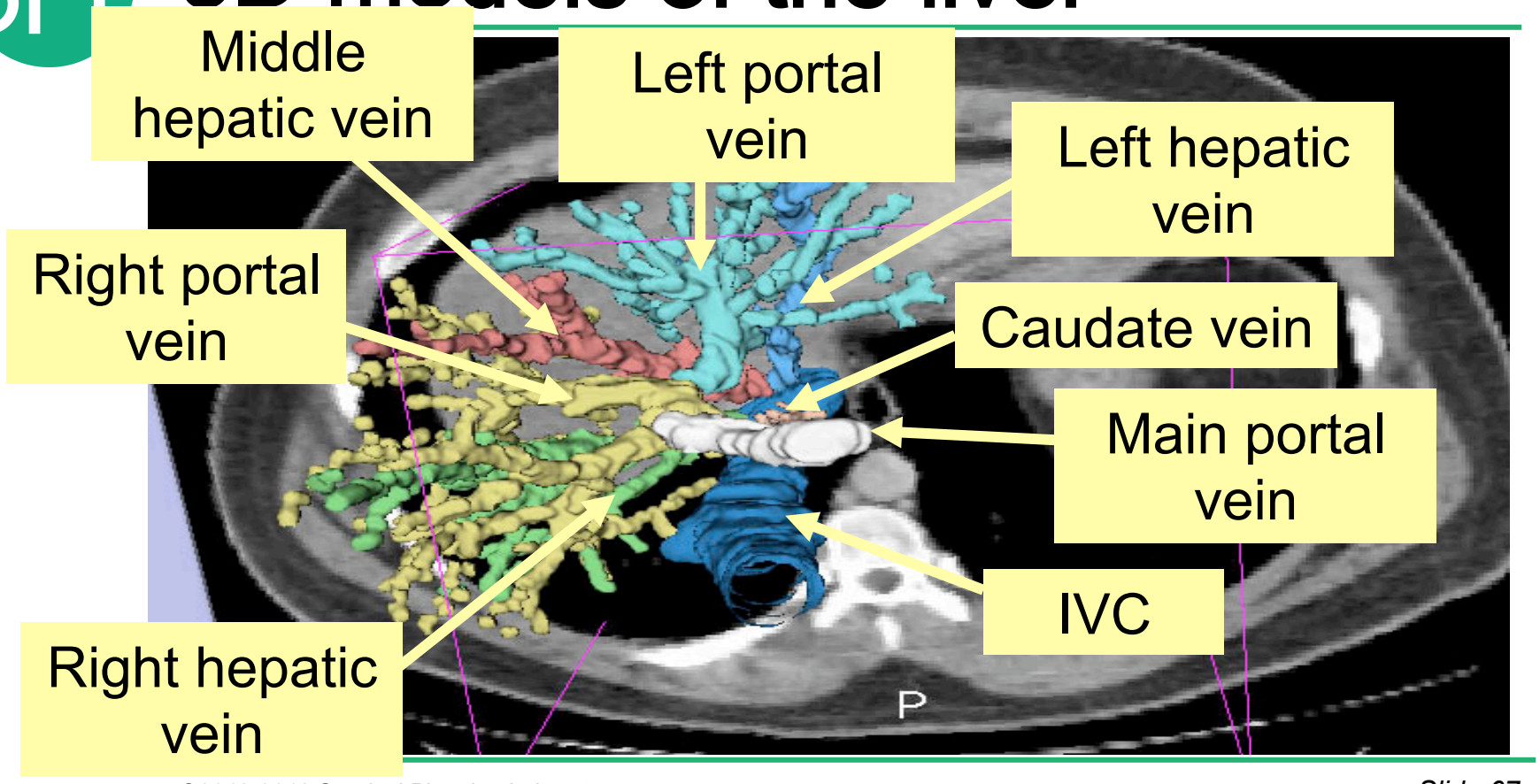
3D models of the liver



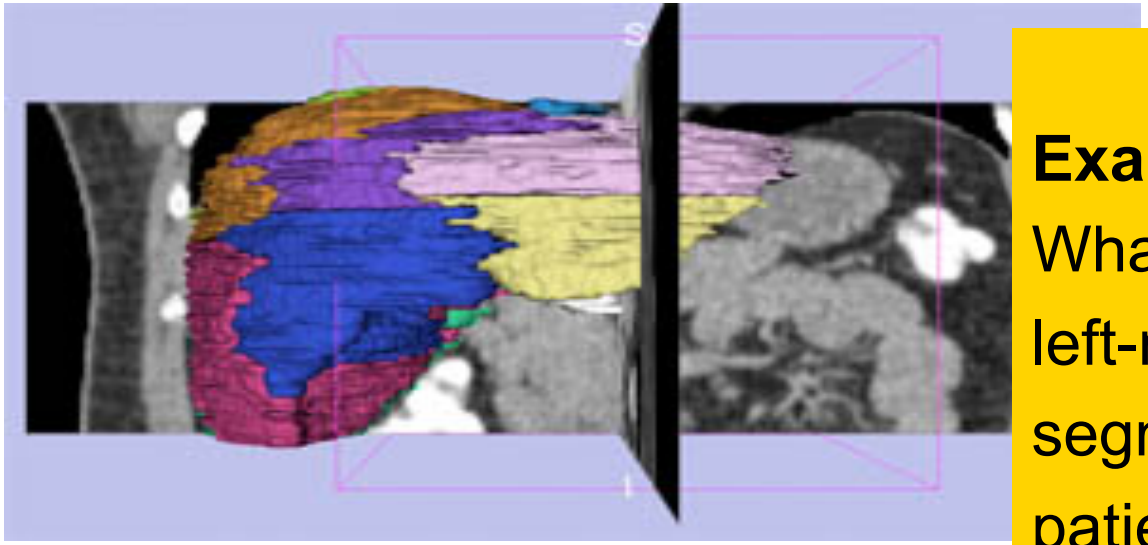
3D models of the liver



3D models of the liver



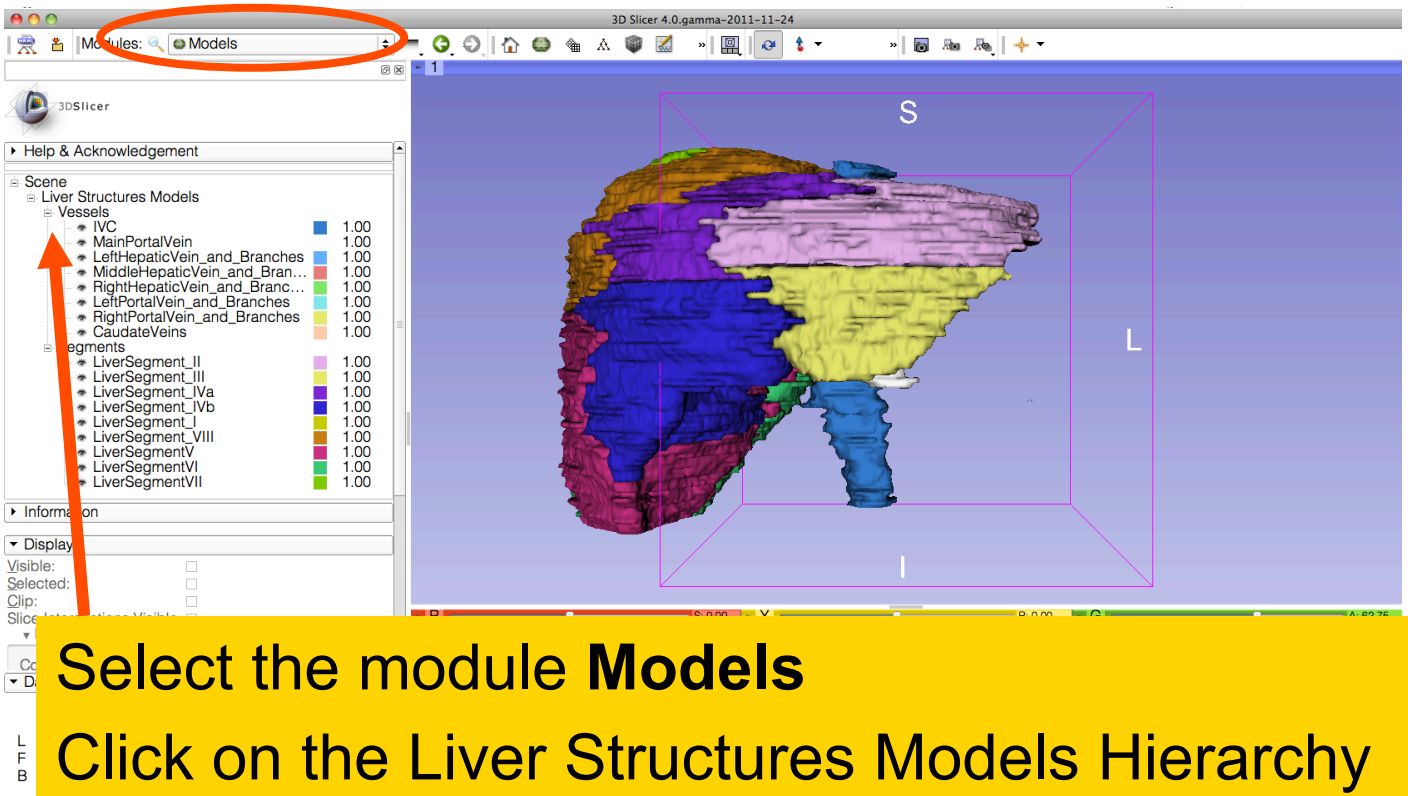
3D Exploration of Liver Segments



Example:

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

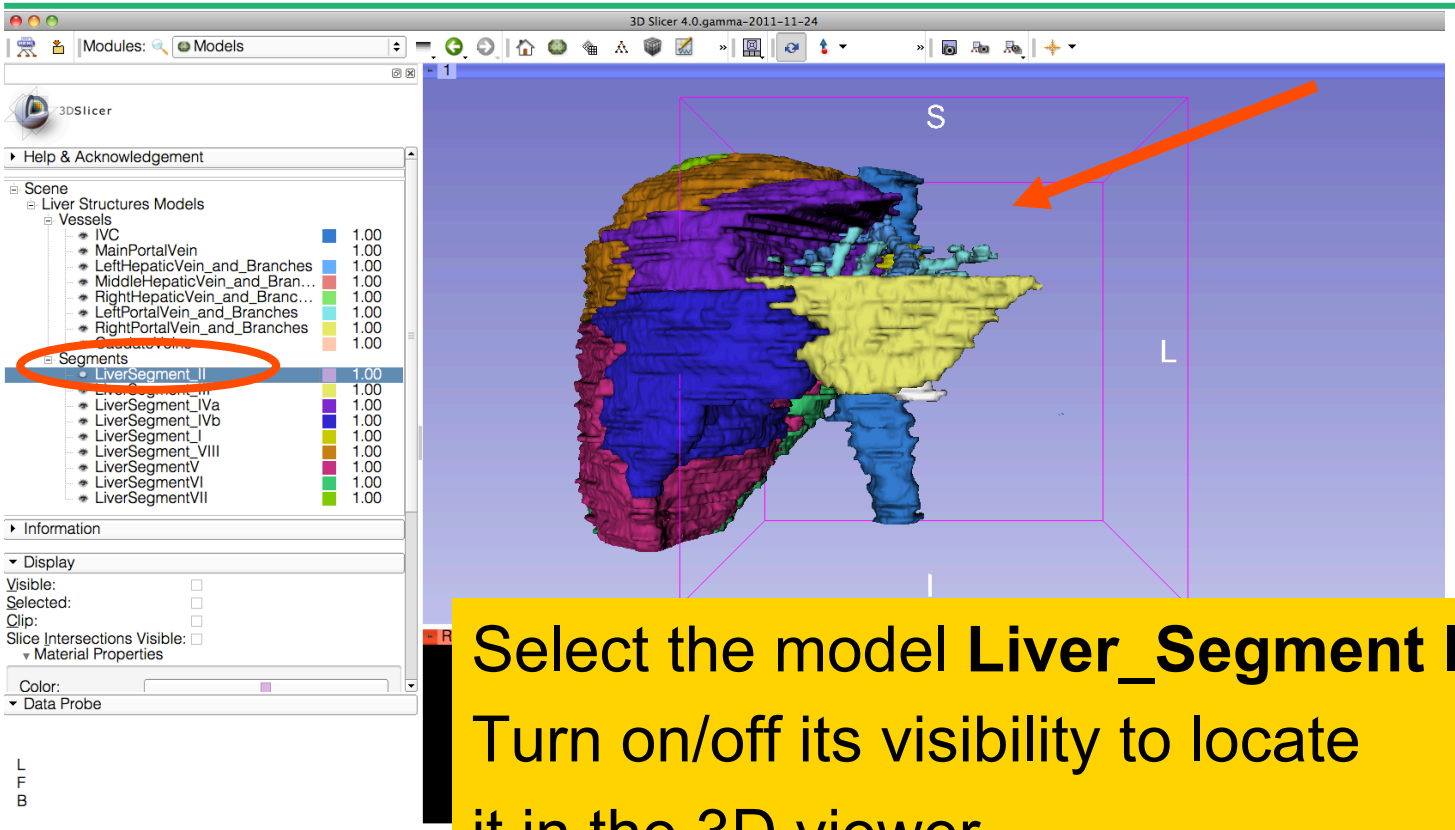
3D Exploration of Liver Segments



Select the module **Models**

Click on the Liver Structures Models Hierarchy

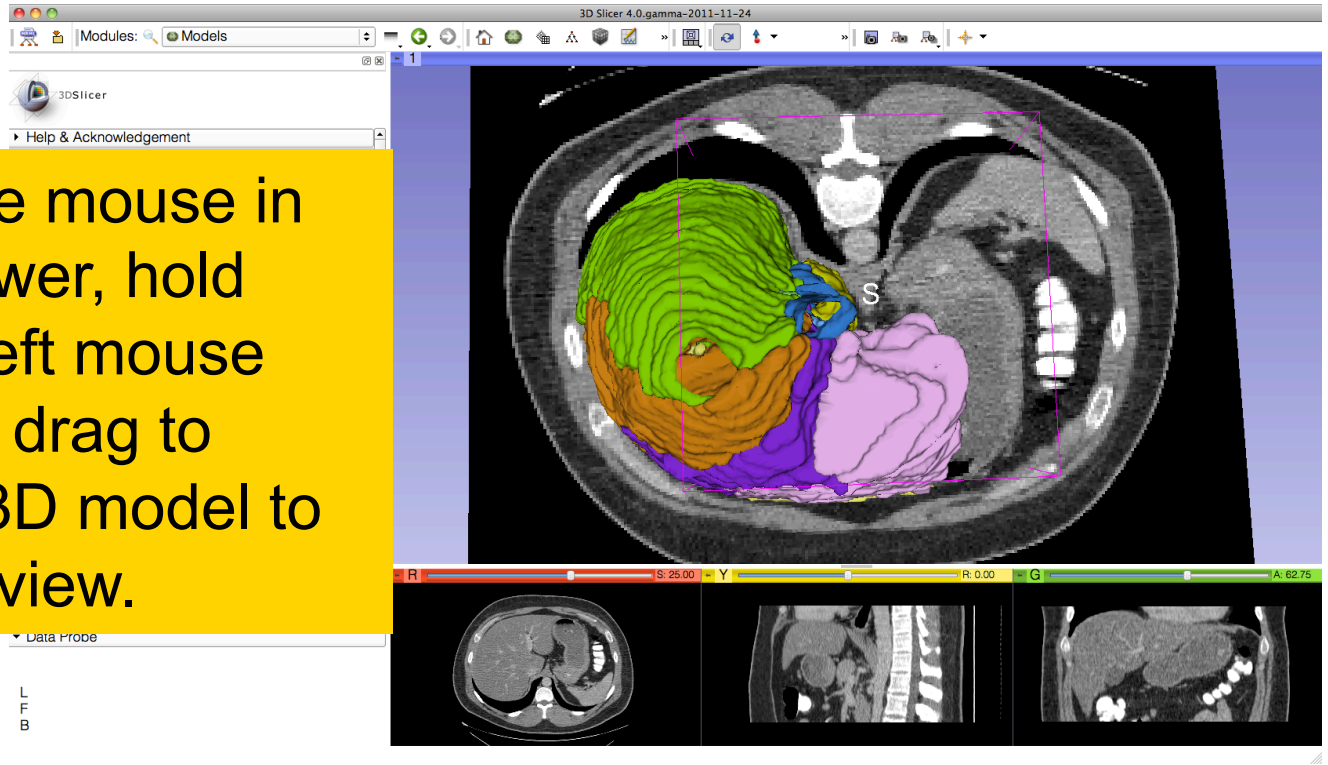
3D Exploration of Liver Segments



Select the model **Liver_Segment II**

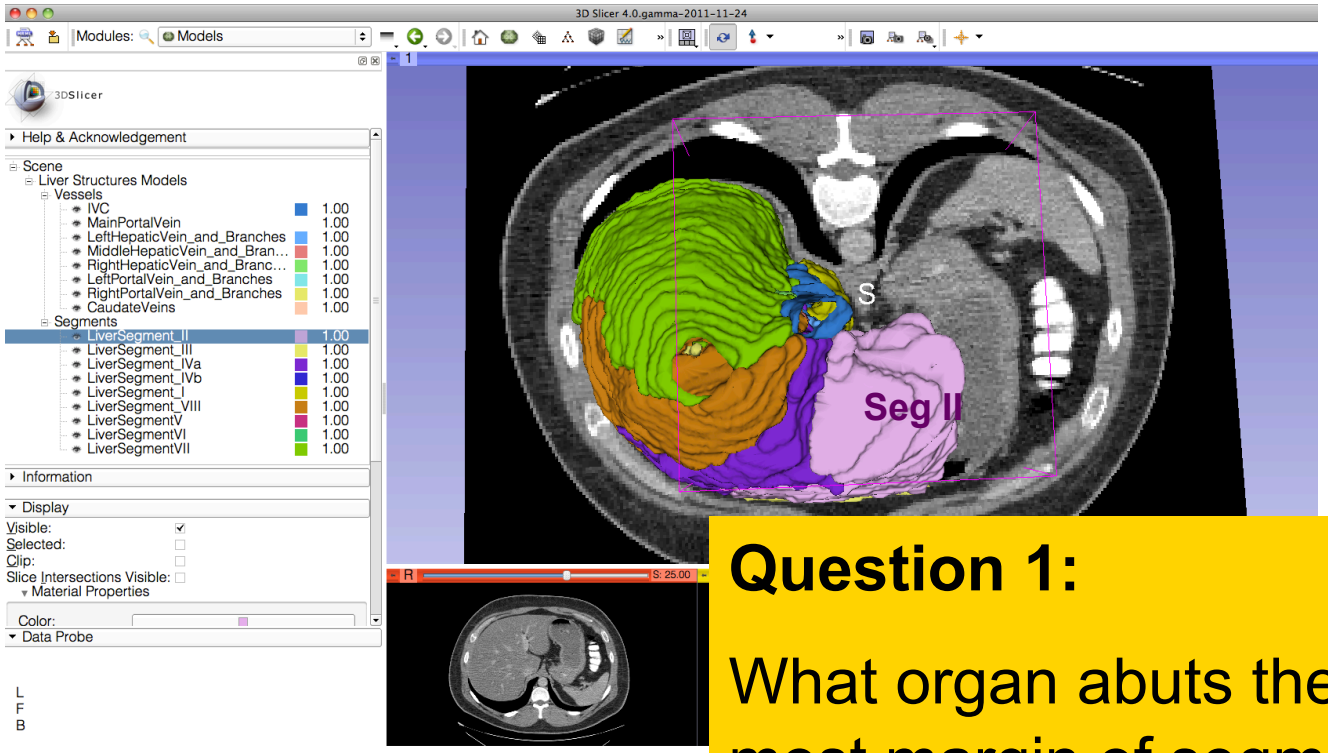
Turn on/off its visibility to locate it in the 3D viewer.

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:

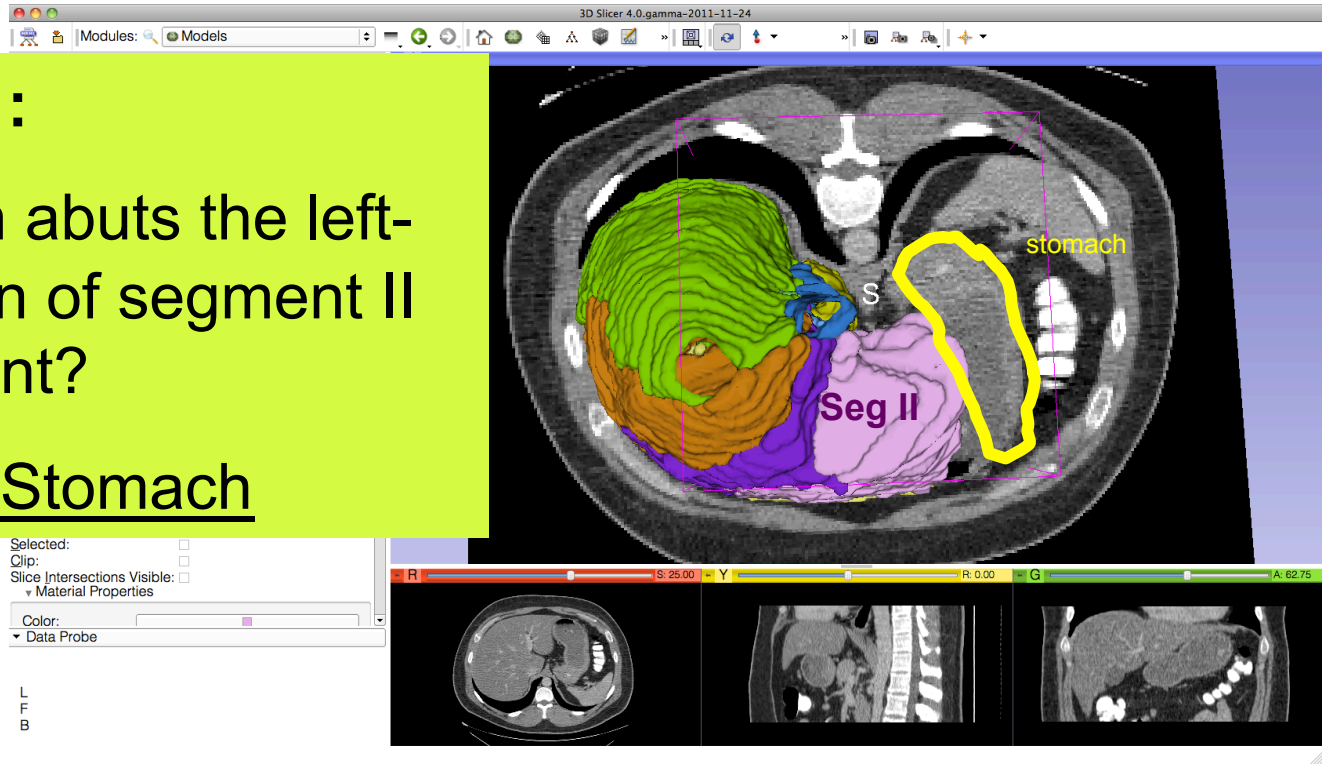
What organ abuts the left-most margin of segment II in Patient 1?

3D Exploration of Liver Segments

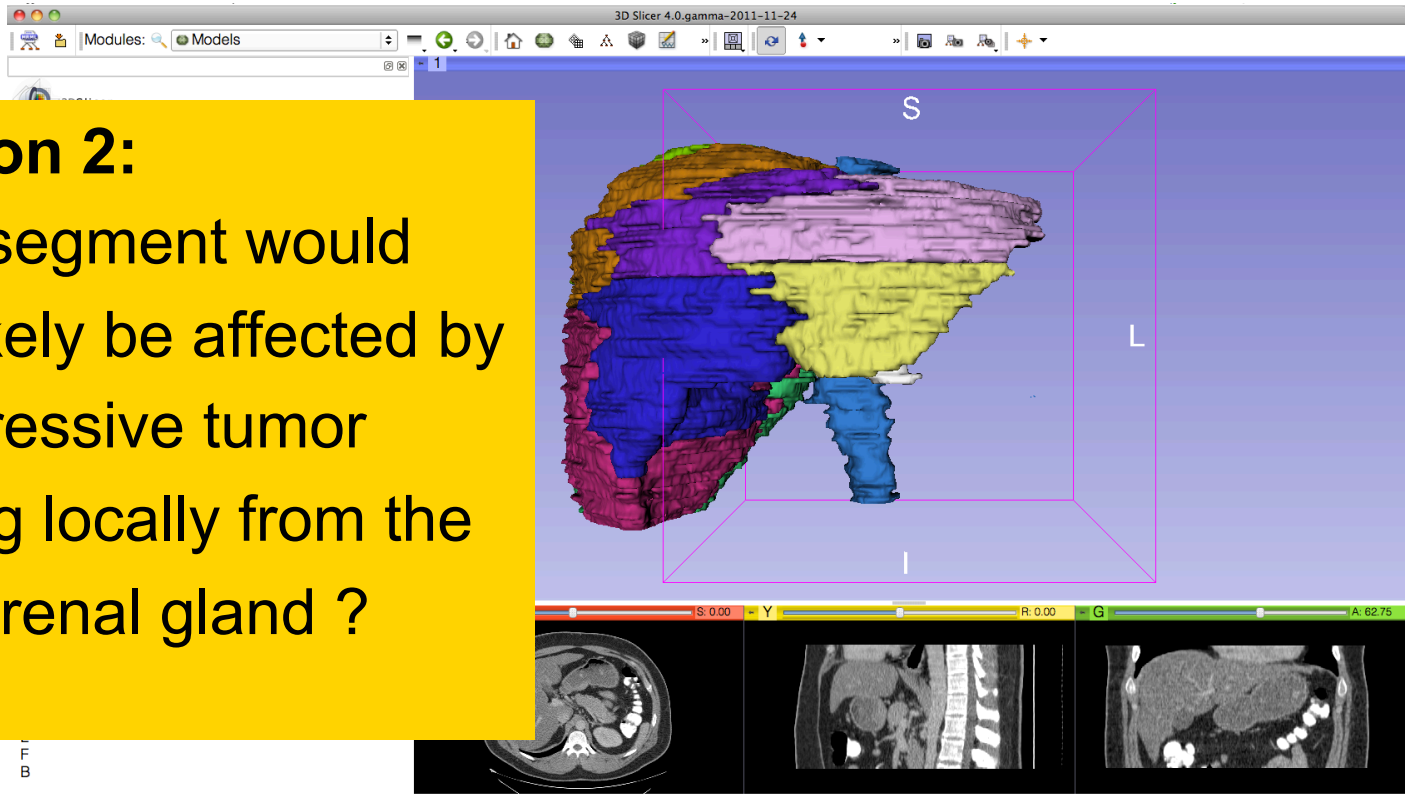
Question 1:

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

Answer 1: Stomach



3D Exploration of Liver Segments



Question 2:

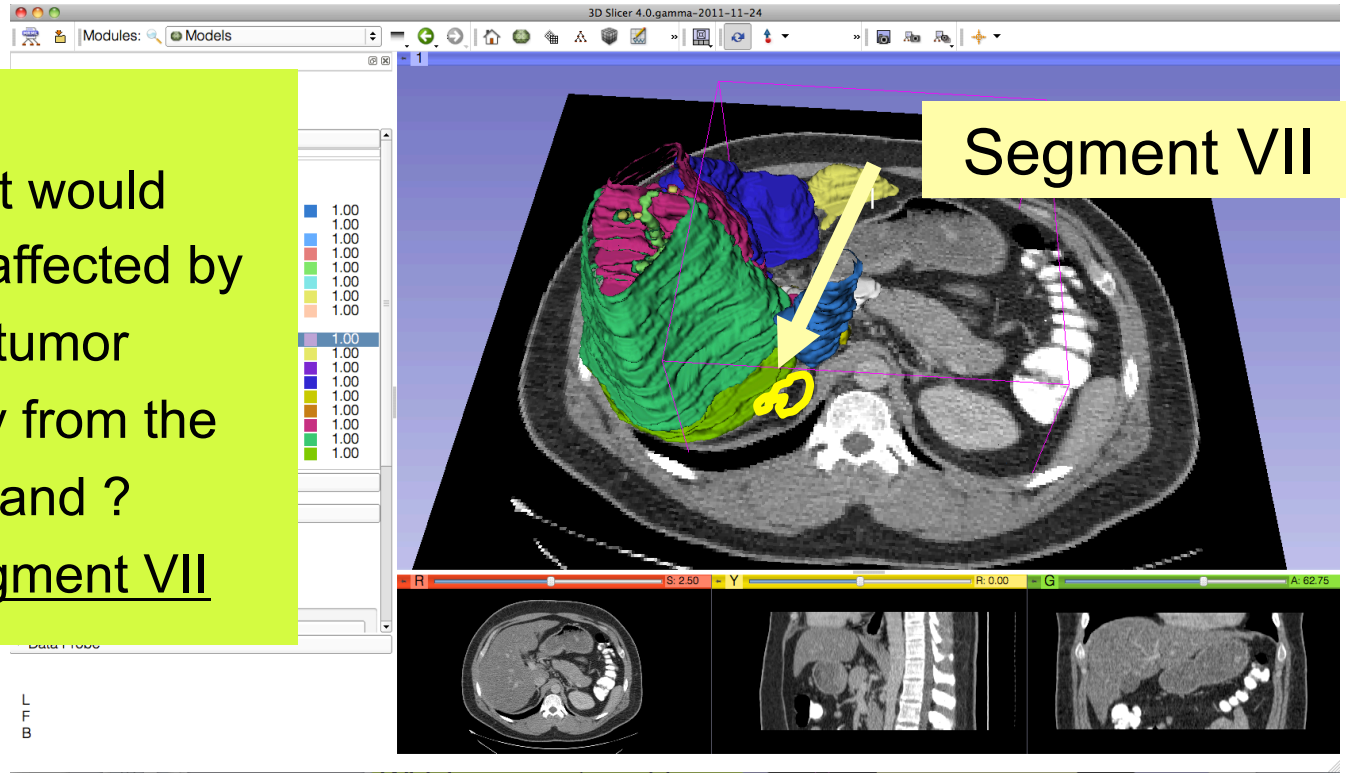
Which segment would most likely be affected by an aggressive tumor invading locally from the right adrenal gland ?

3D Exploration of Liver Segments

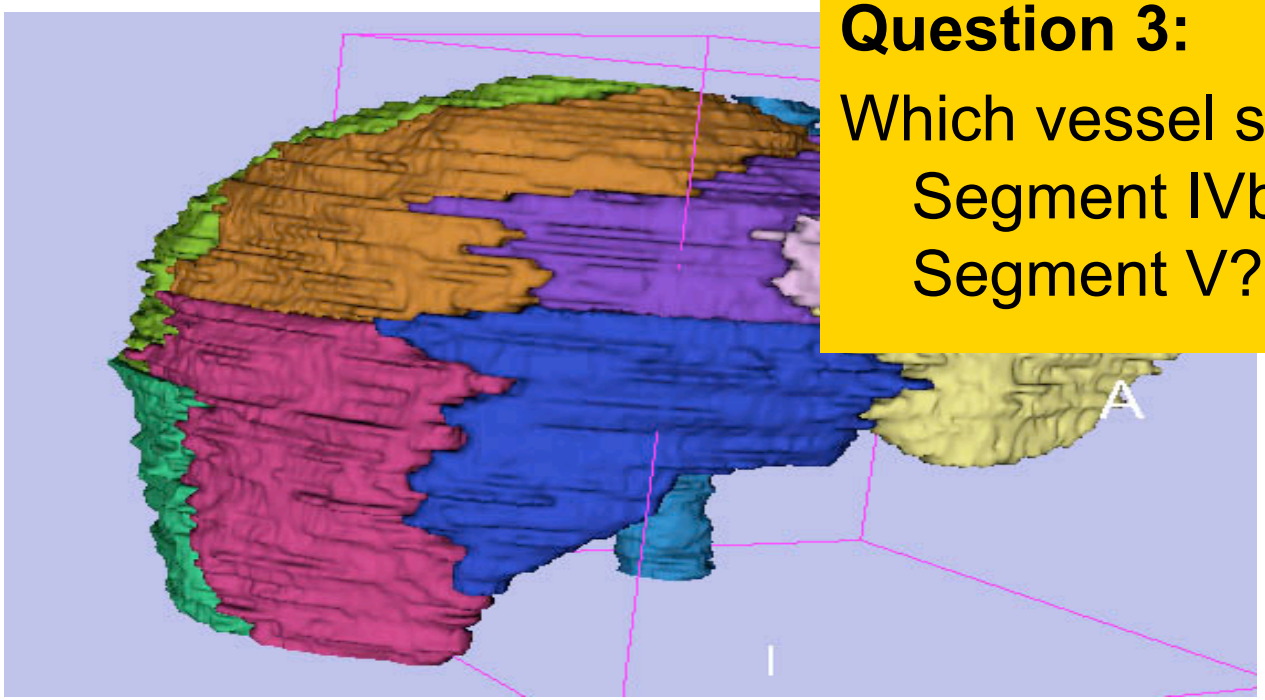
Question 2:

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

Answer 2: Segment VII



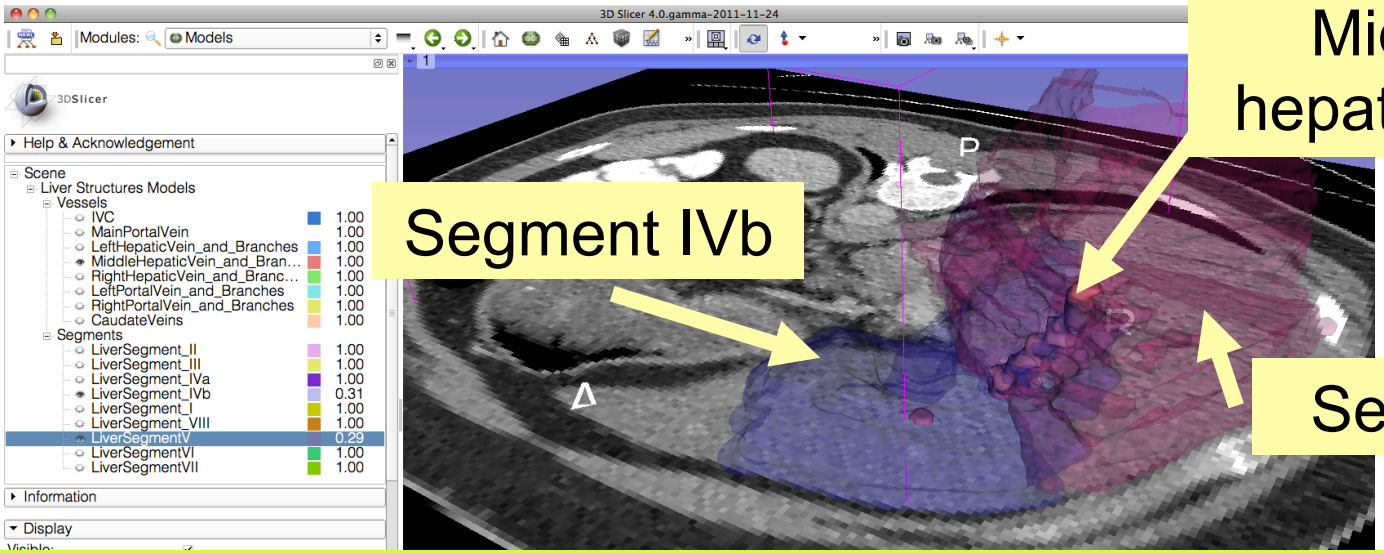
3D Exploration of Liver Segments



Question 3:

Which vessel separates Segment IVb and Segment V?

Middle Hepatic Vein



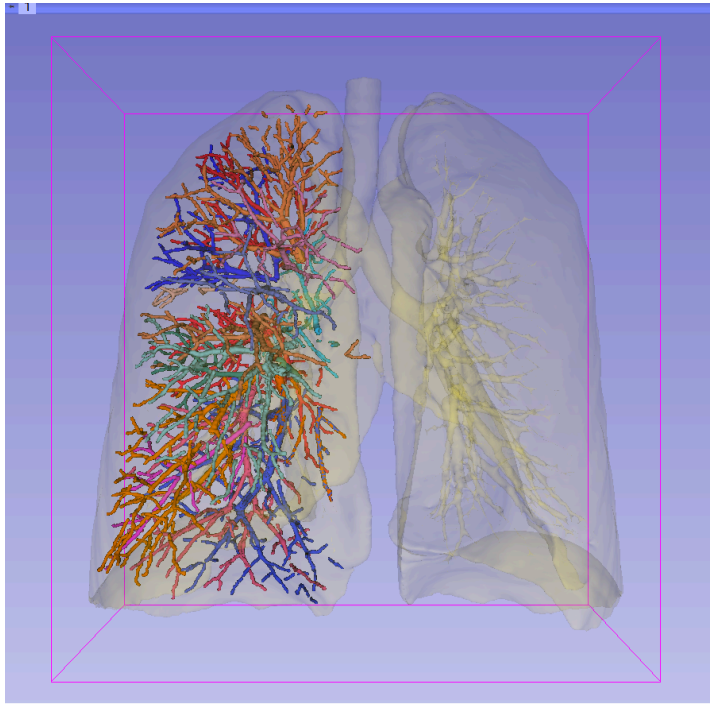
Question 3:

Which vessel separates Segment IVb and Segment V?

Answer 3: The middle hepatic vein

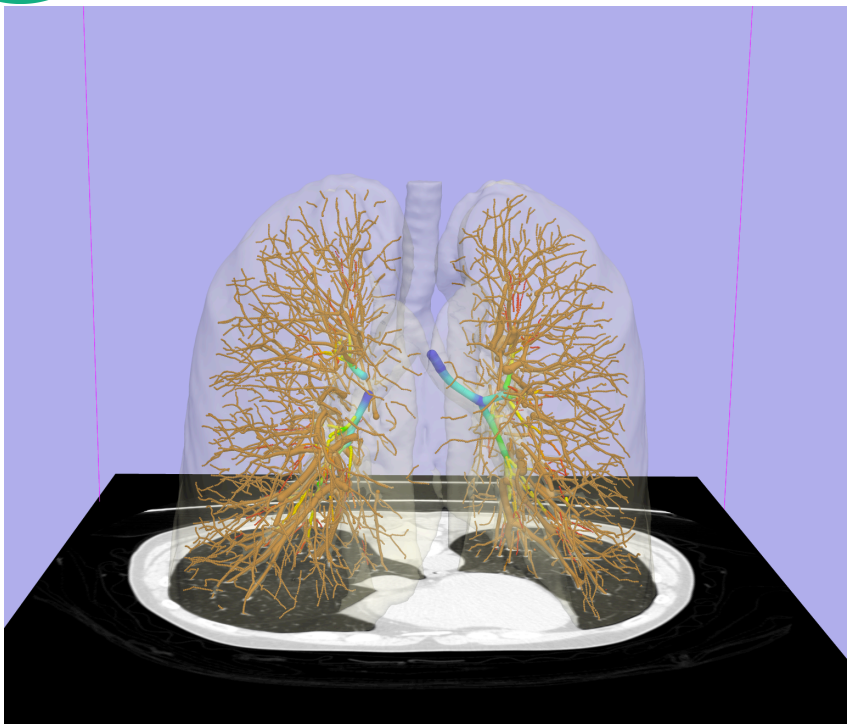
Closing the Liver Scene

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



Interactive 3D Visualization of the segments of the lungs

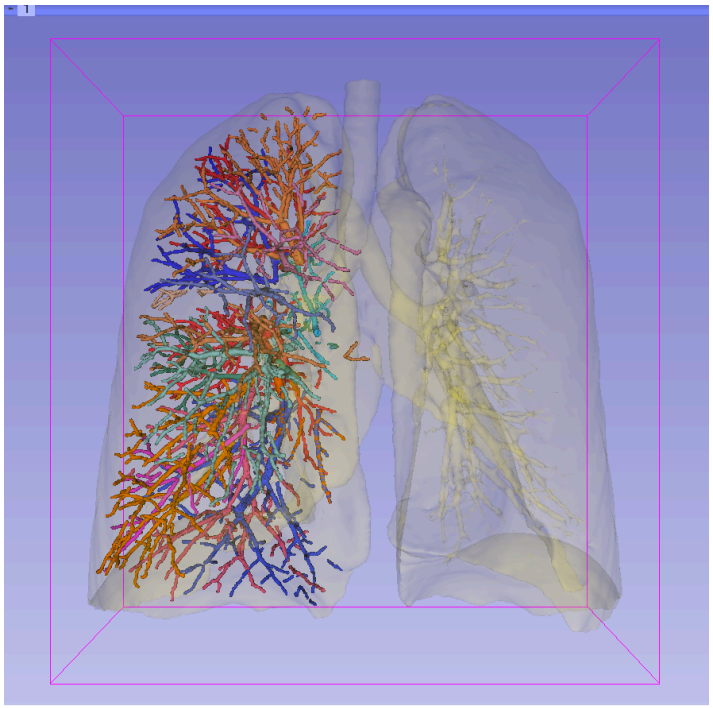
Segments of the lung



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 (K25 HL104085) and COPDGene (01 HL089897 and U01 HL089856)

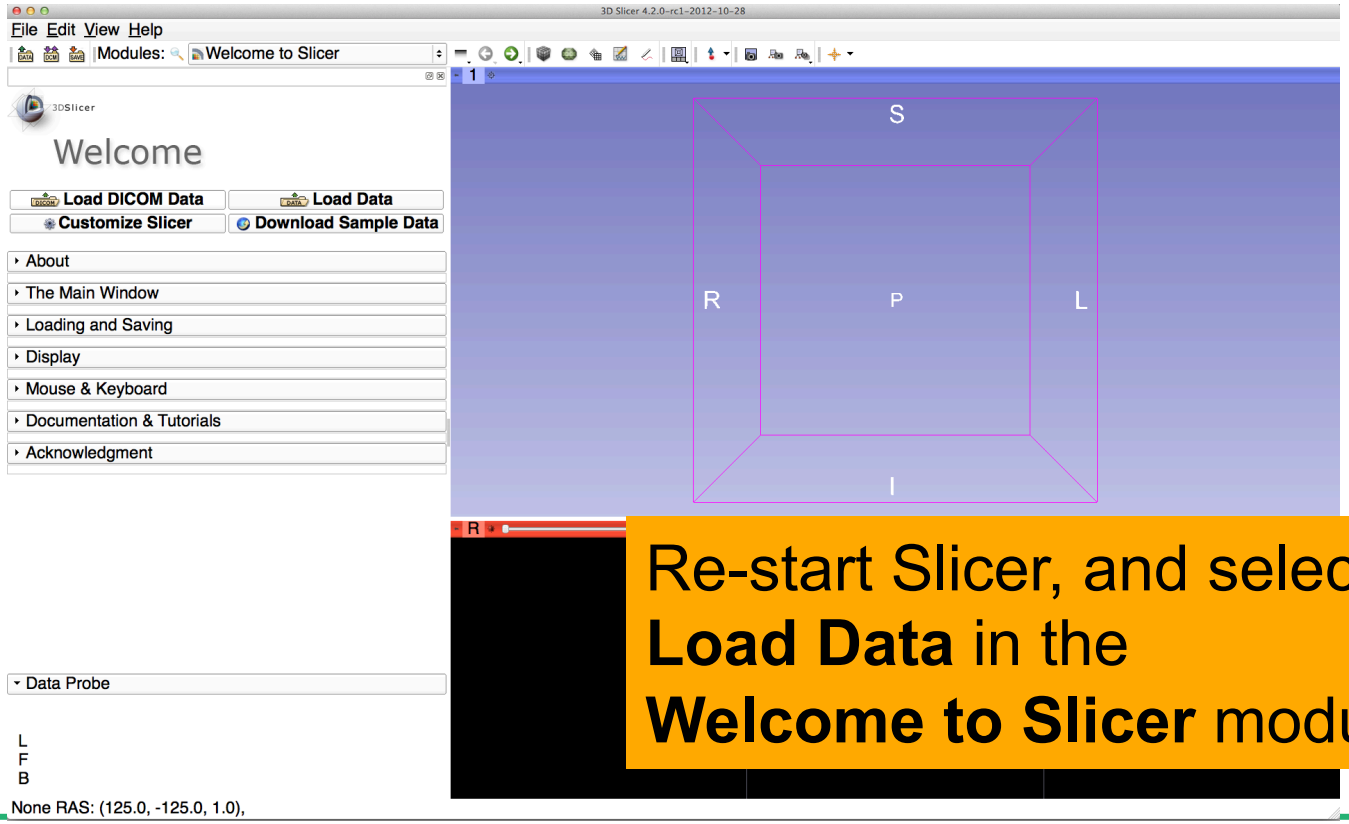
Segments of the lung



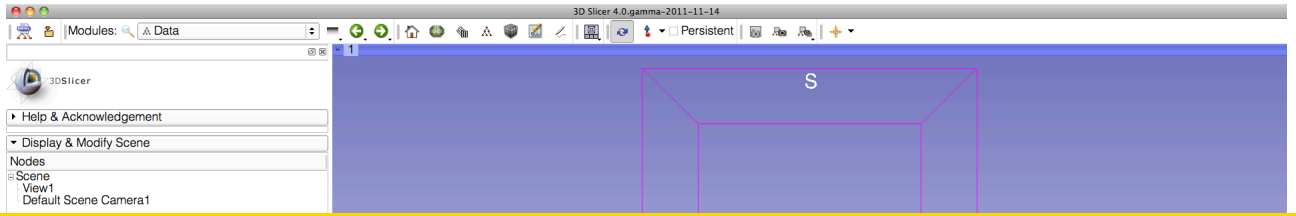
3D parcellation of arteries and veins from original model of pulmonary vessels
(Kitt Shaffer, M.D., Ph.D. - Sonia Pujol, Ph.D.)

- 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 Chest Data Scene



Loading the Lung Scene



Click on Choose Files and browse to the directory

C:\PujolI2012\3DVisualization_Tuesday_Nov27_2012

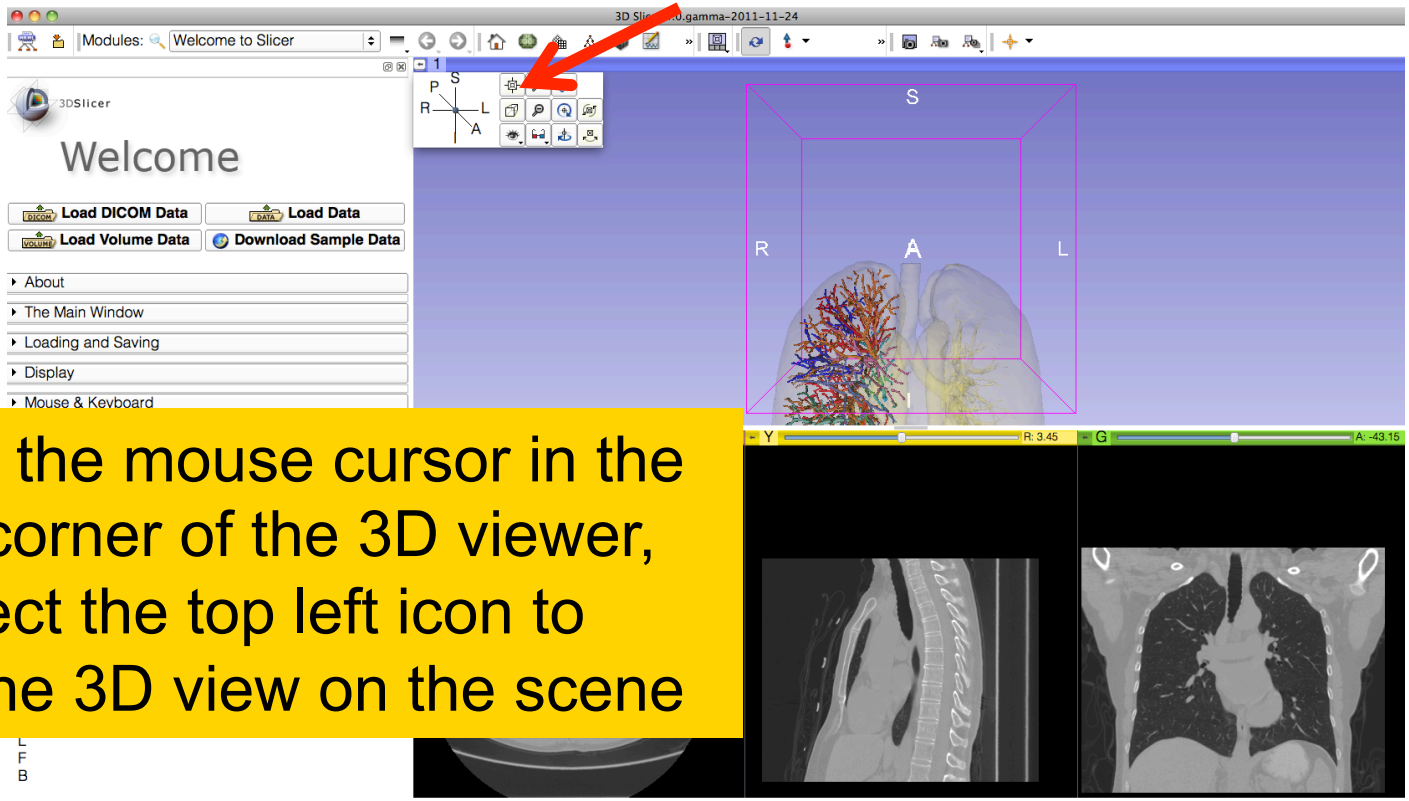
Select the subdirectory dataset4_CT-Chest

Select the file **LungSegment_Scene.mrml**

Click on Open

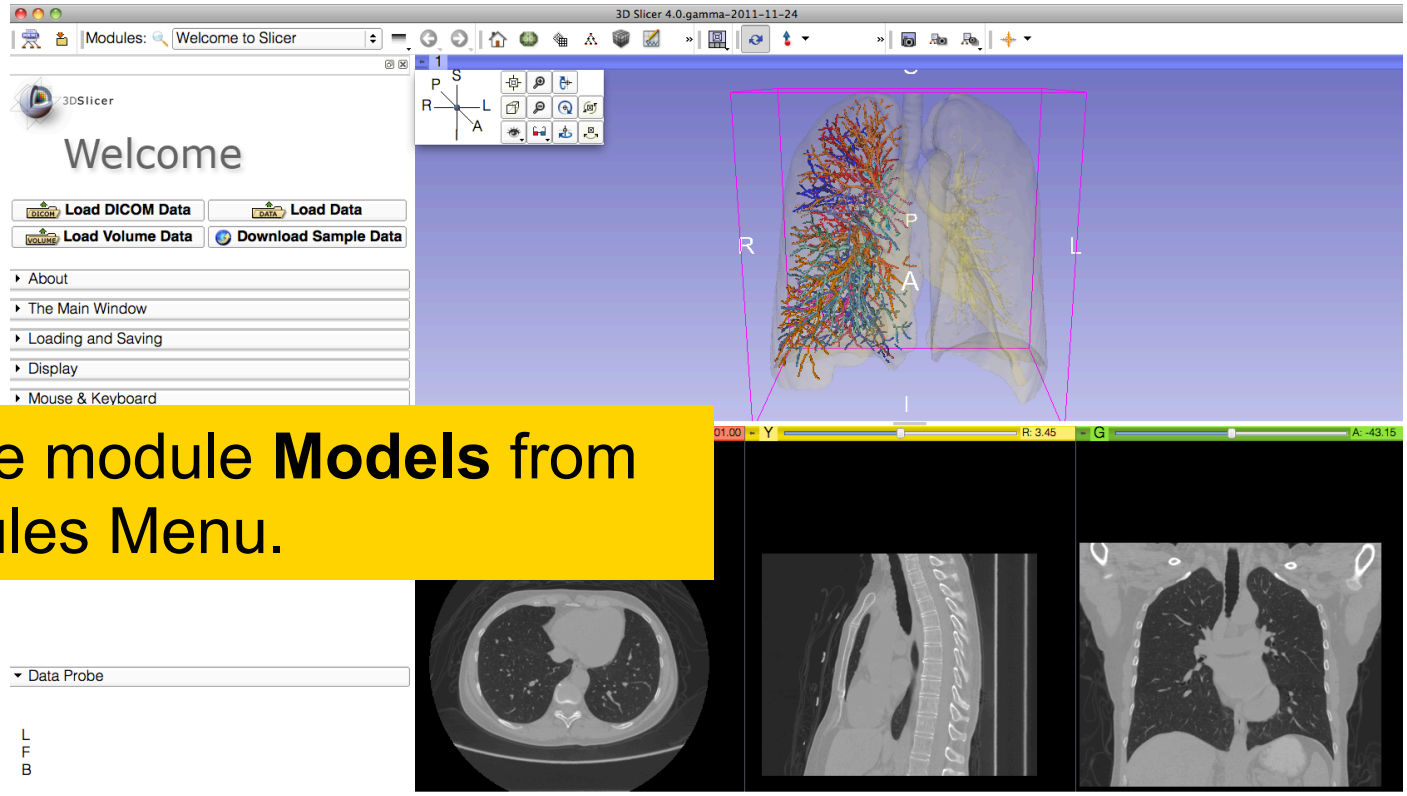
Click on OK to load the scene in Slicer

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

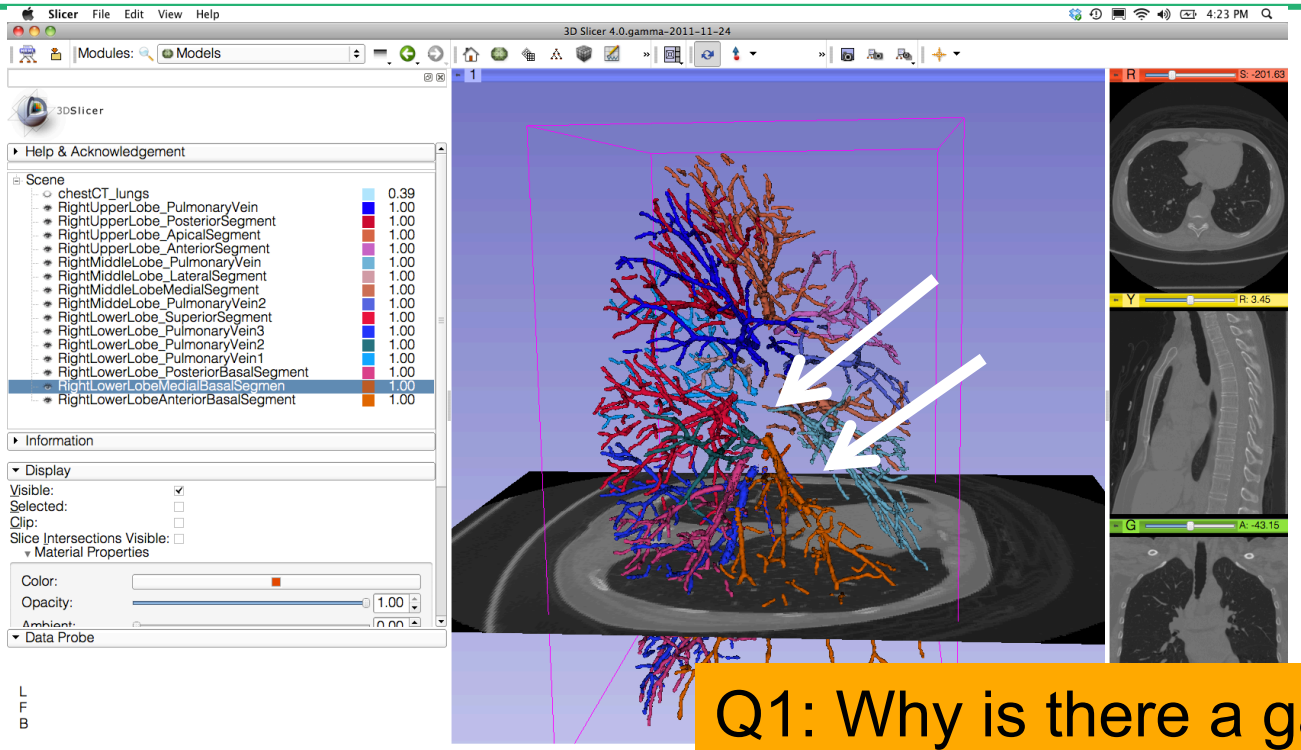


Select the module **Models** from the modules Menu.

Lung Segments

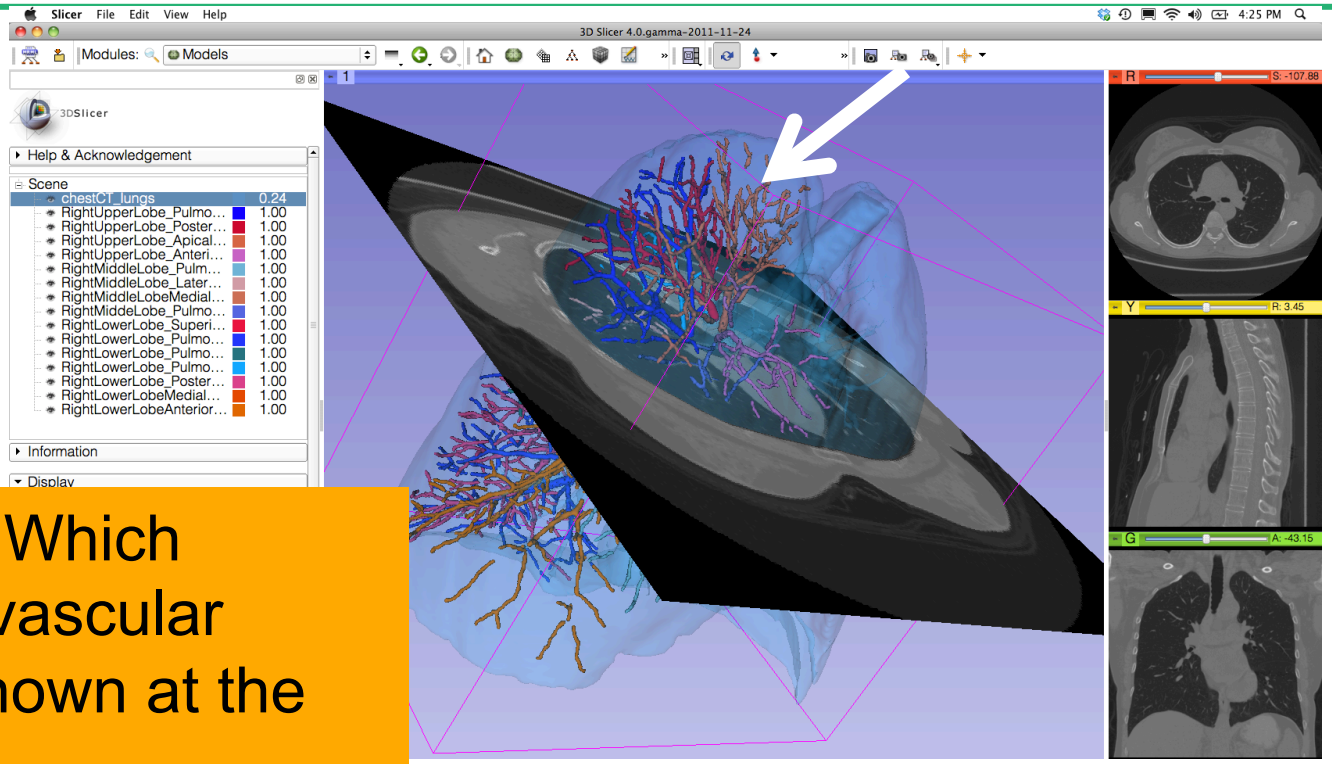
Slicer displays the list of 15 surface models of pulmonary structures.

Lung Segments – Question 1



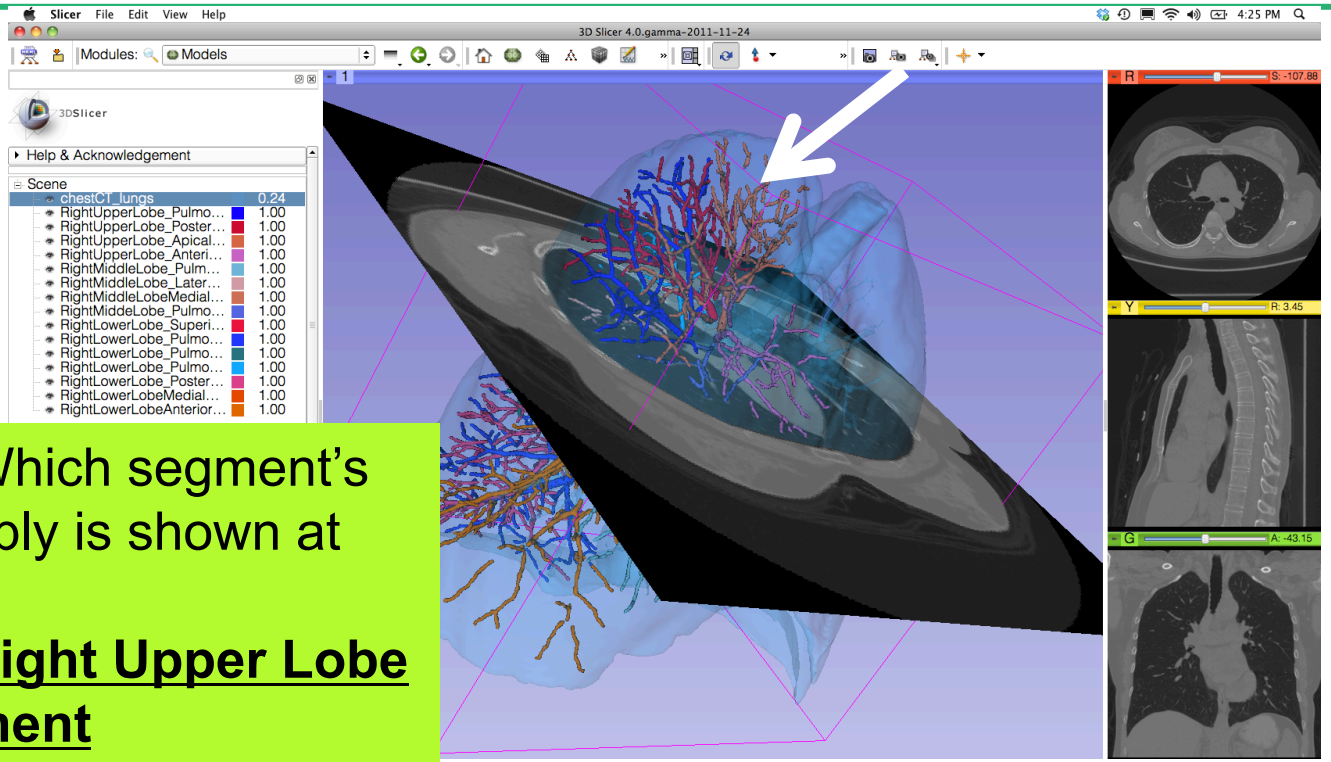
Q1: Why is there a gap in the vessels at the arrows?

Lung Segments – Question 2



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

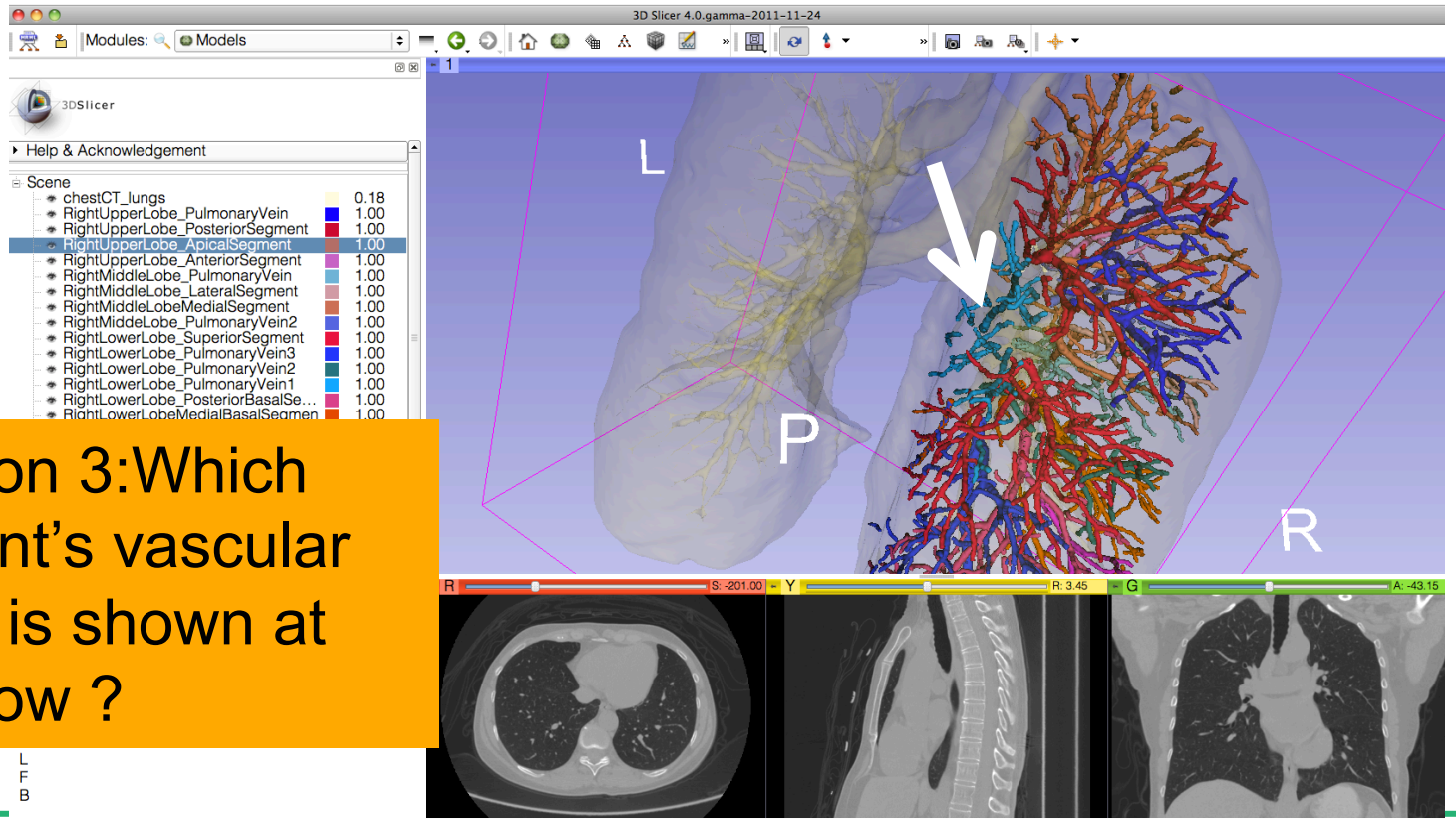
Lung Segments – Question 2



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

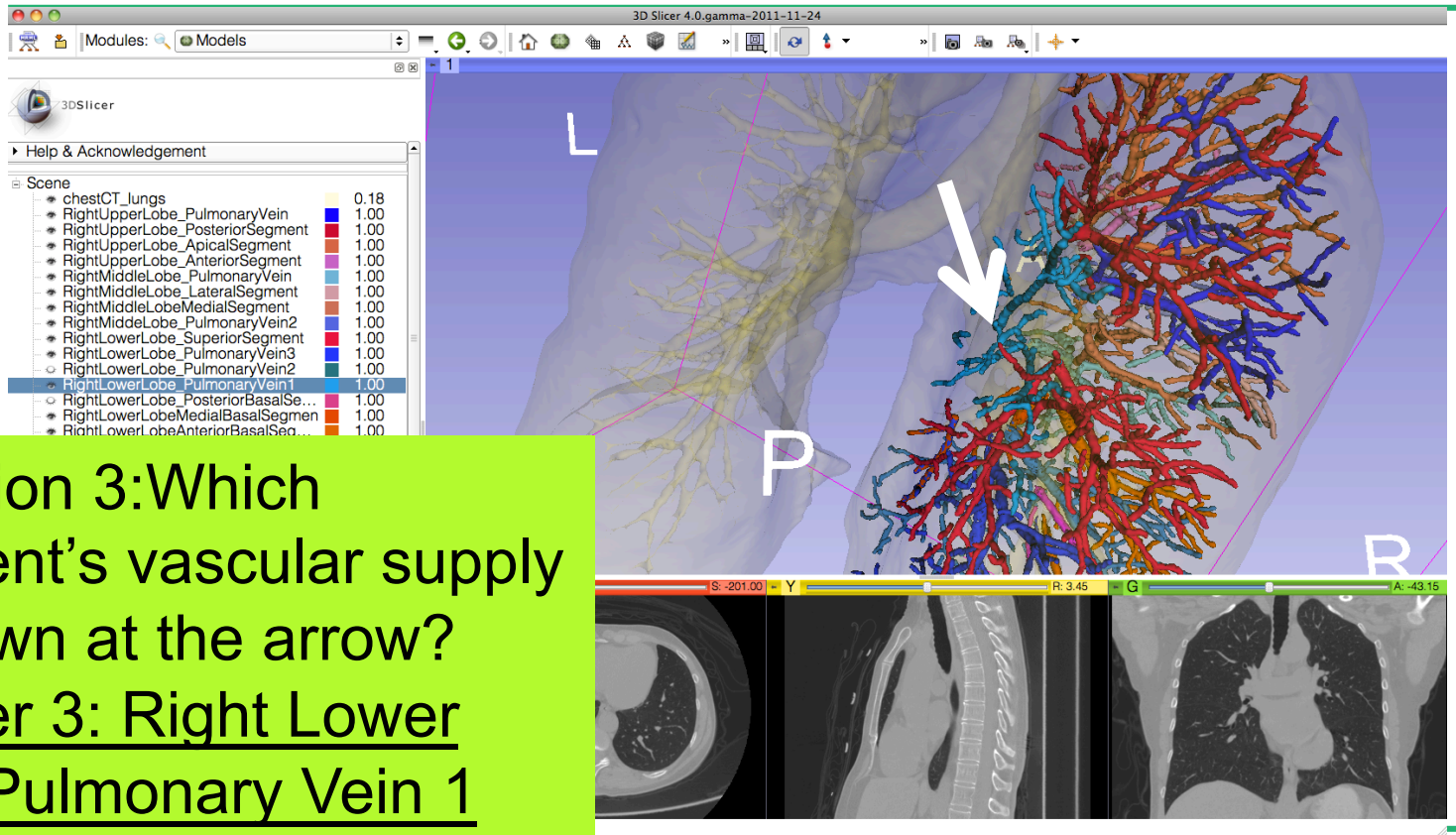
Answer 2: Right Upper Lobe Apical Segment

Lung Segments – Question 3



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

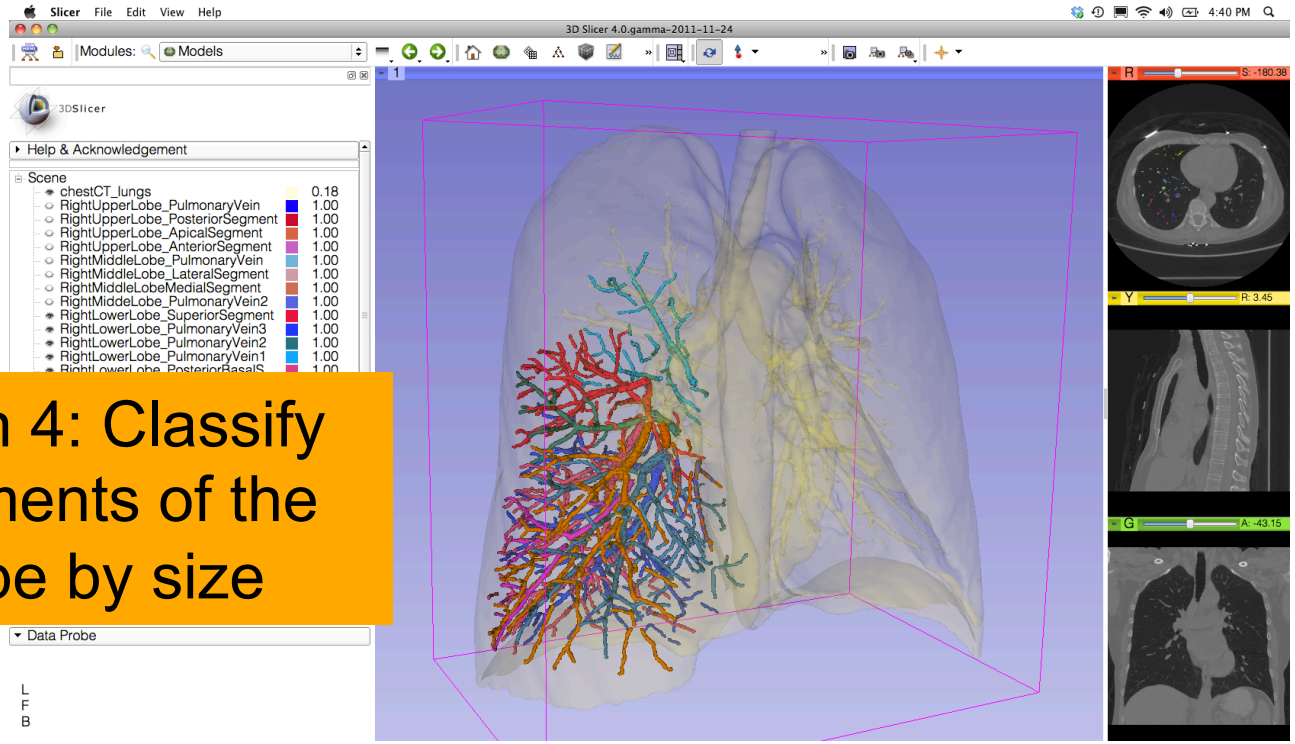
Lung Segments – Question 3



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

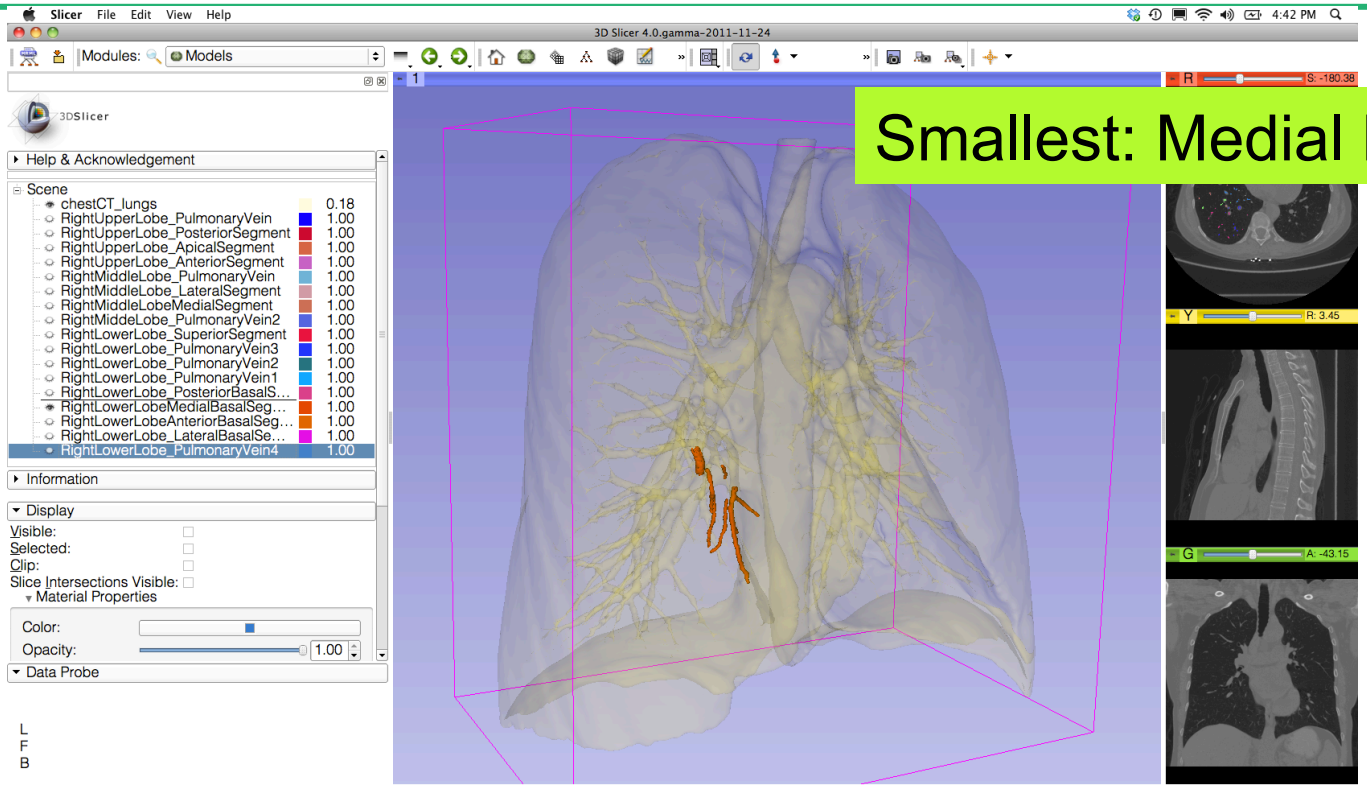
Answer 3: Right Lower Lobe Pulmonary Vein 1

Lung Segments – Question 4



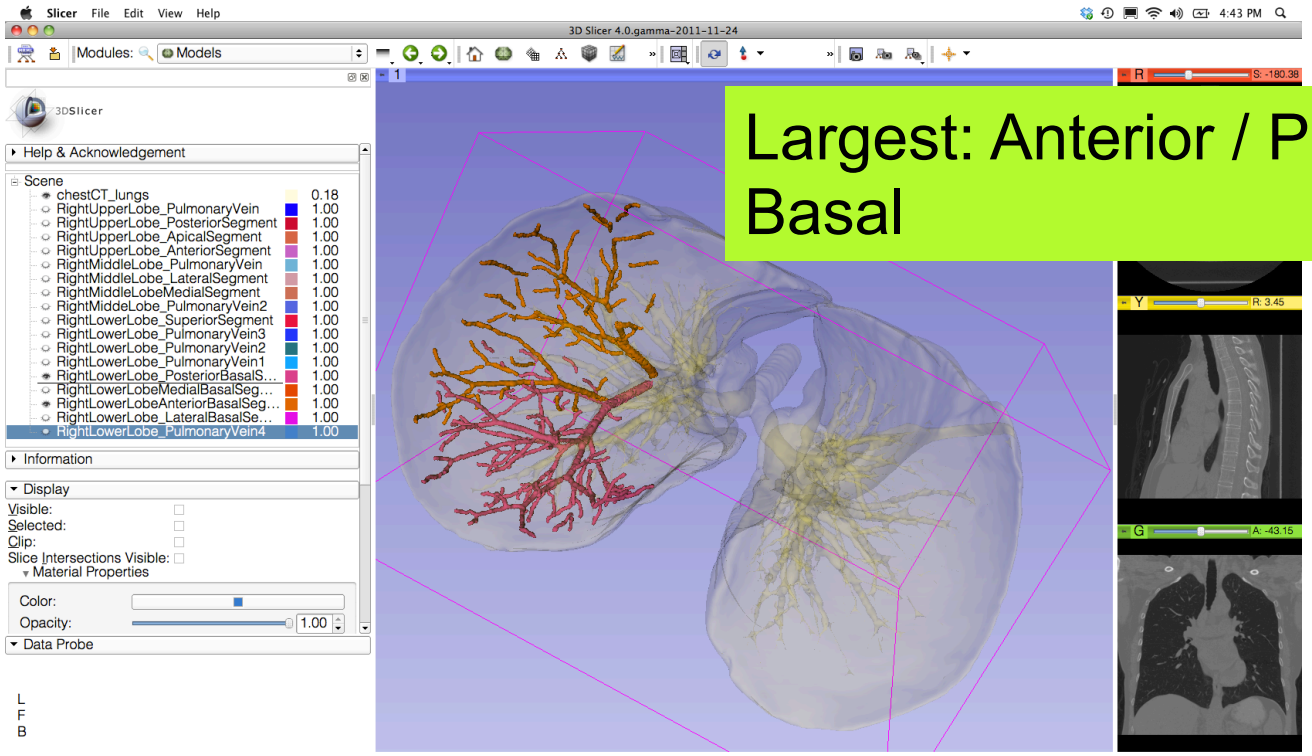
Question 4: Classify the segments of the lower lobe by size

Lung Segments – Question 4



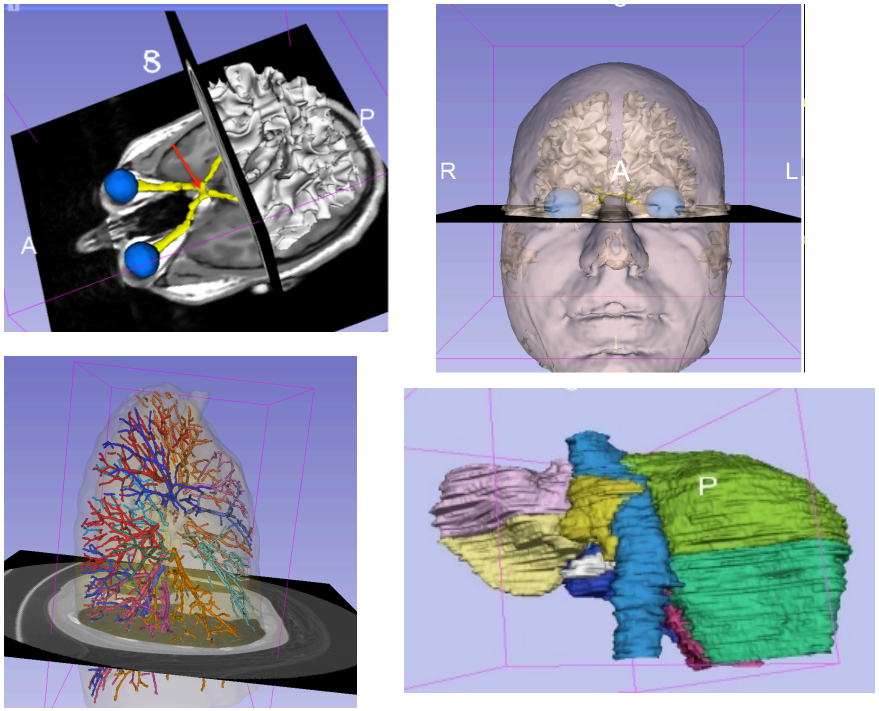
Smallest: Medial Basal

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

Acknowledgments

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

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

Marianna Jakab, Surgical Planning Laboratory, Brigham and Women's Hospital

3DSlicer website