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

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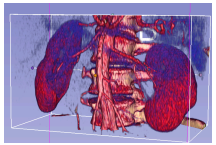
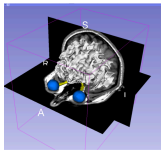
Vice-Chairman for Education, Boston University School of Medicine

Overview

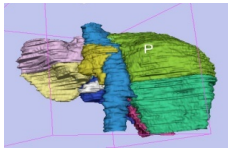
Part 1: DICOM data loading in 3DSlicer



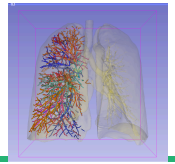
Part 2: 3D Interactive exploration of thoraco-abdominal CT data using Volume Rendering



Part 3: 3D Interactive exploration of MR head data using Surface Rendering



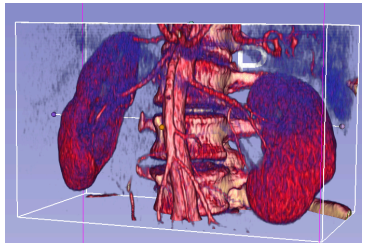
Part 4: 3D interactive exploration of the segments of the liver using Surface Rendering

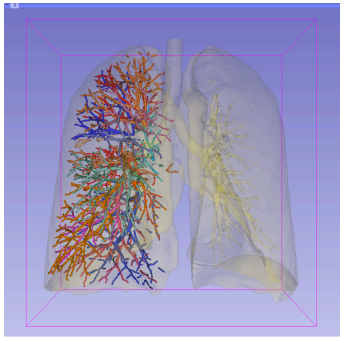


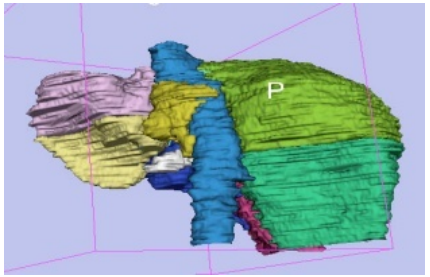
Part 5: 3D interactive exploration of the segments of the lung

3D Visualization of the Anatomy

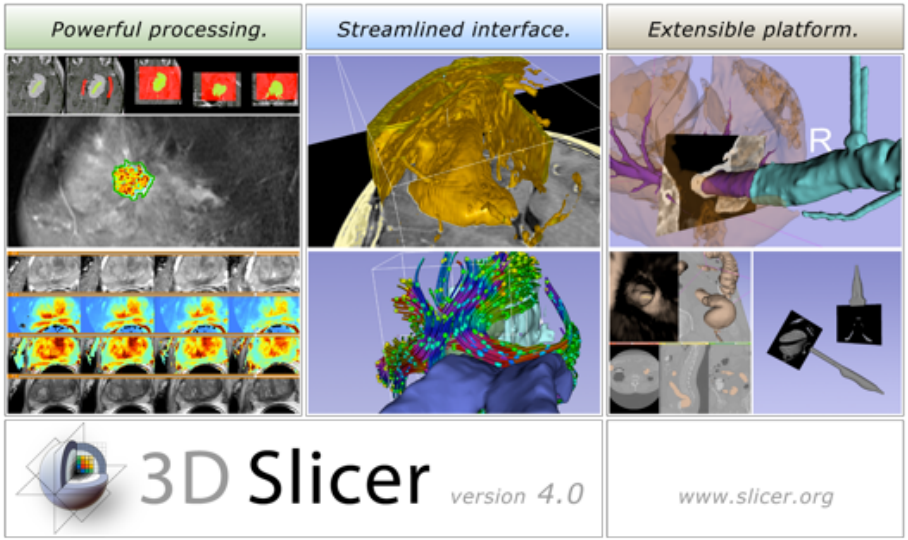
Following this tutorial, you will be able to load and visualize volumes within Slicer4.2, and to interact in 3D with structural images and models of the anatomy.







3DSlicer

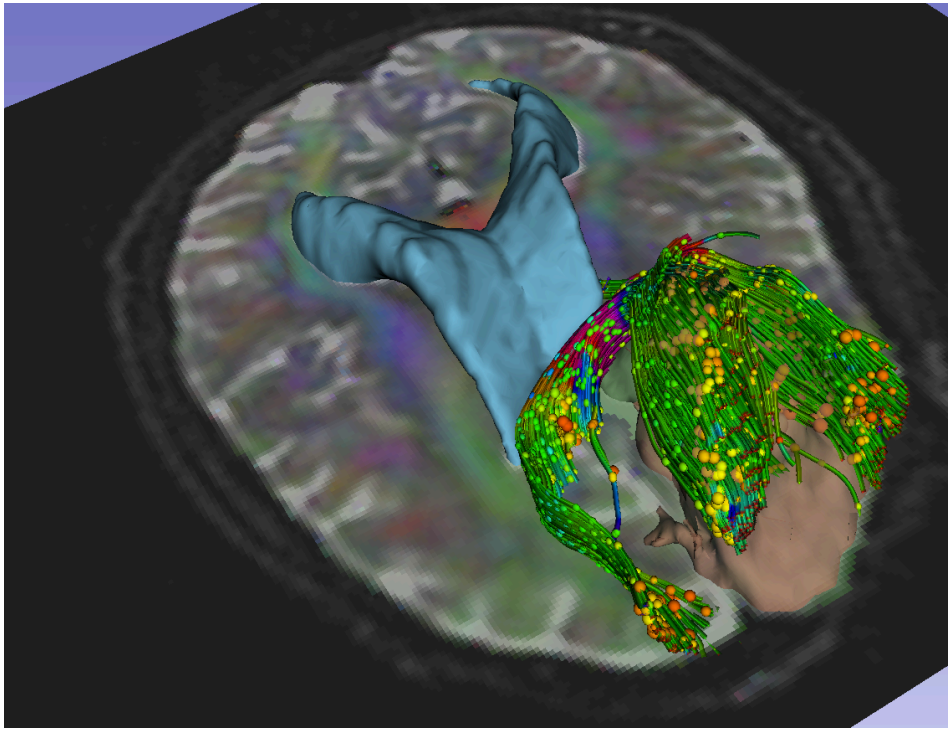


Slicer is a freely available open-source platform for segmentation, registration and 3D visualization of medical imaging data.

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



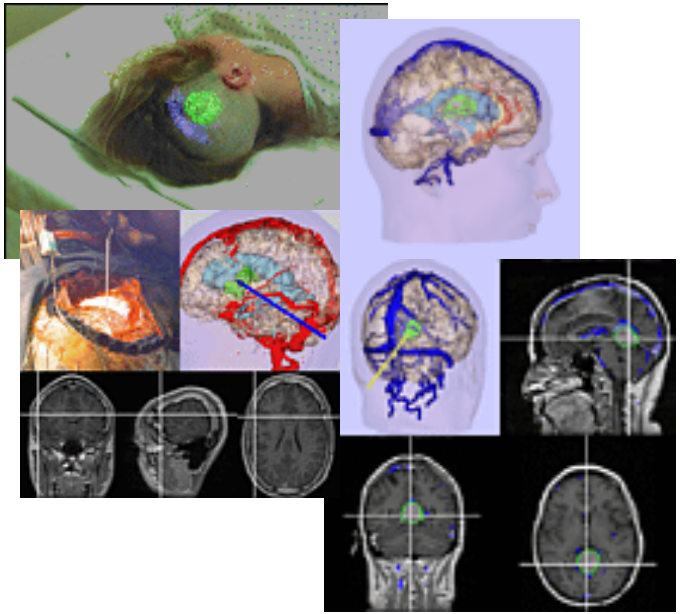
www.slicer.org

3DSlicer version 4.2 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.**

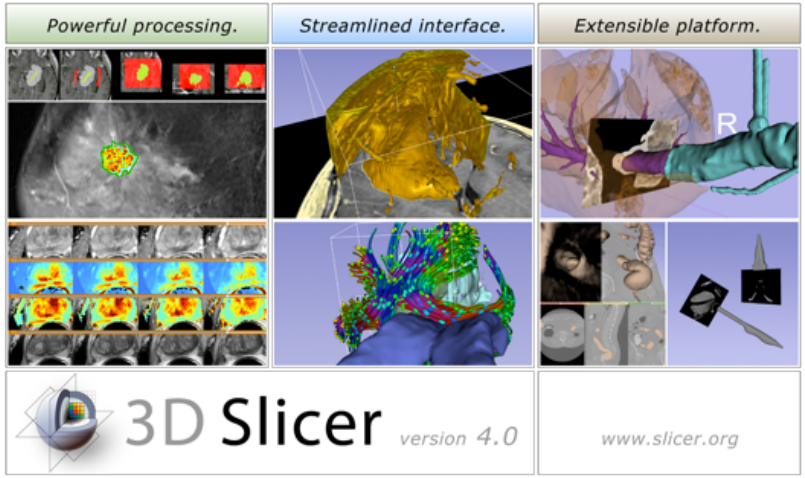
3DSlicer History



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

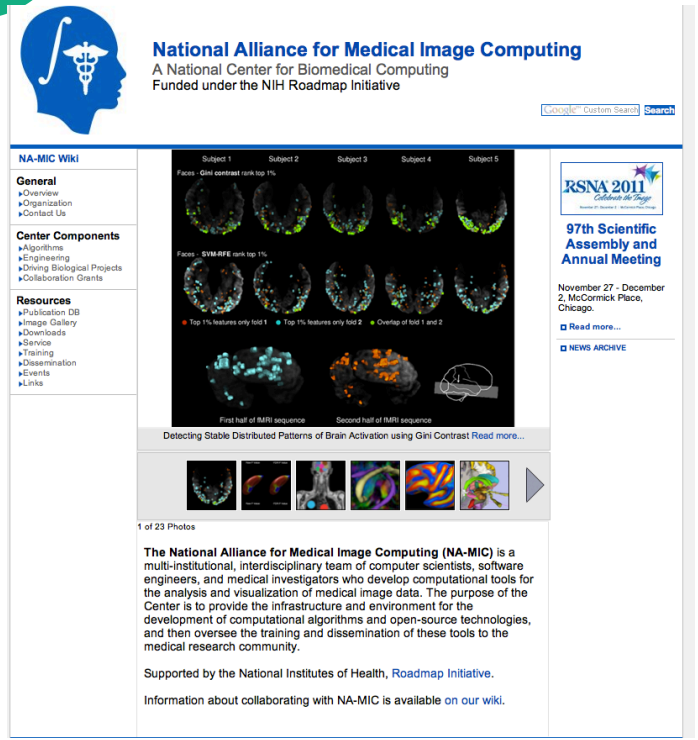
Image Courtesy of the CSAIL, MIT

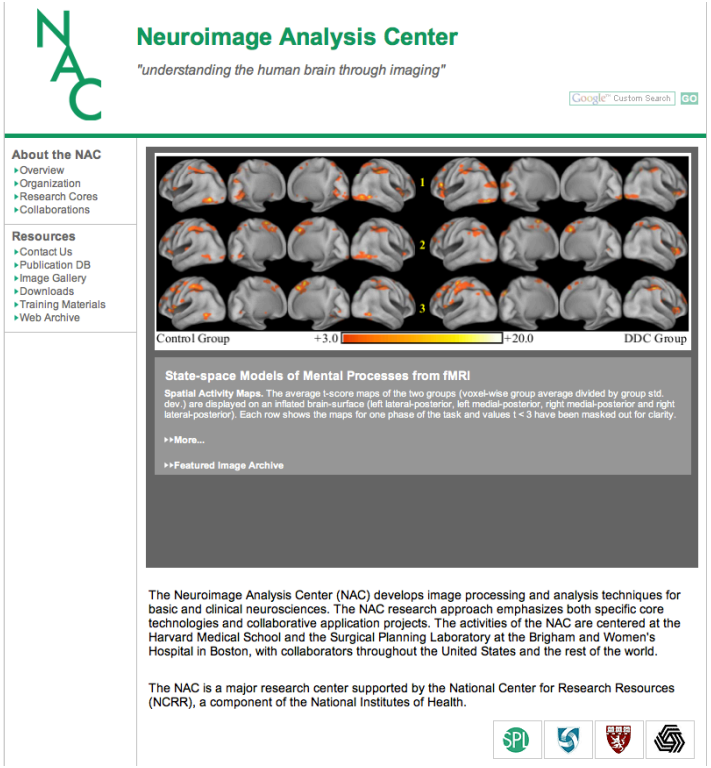
3DSlicer History



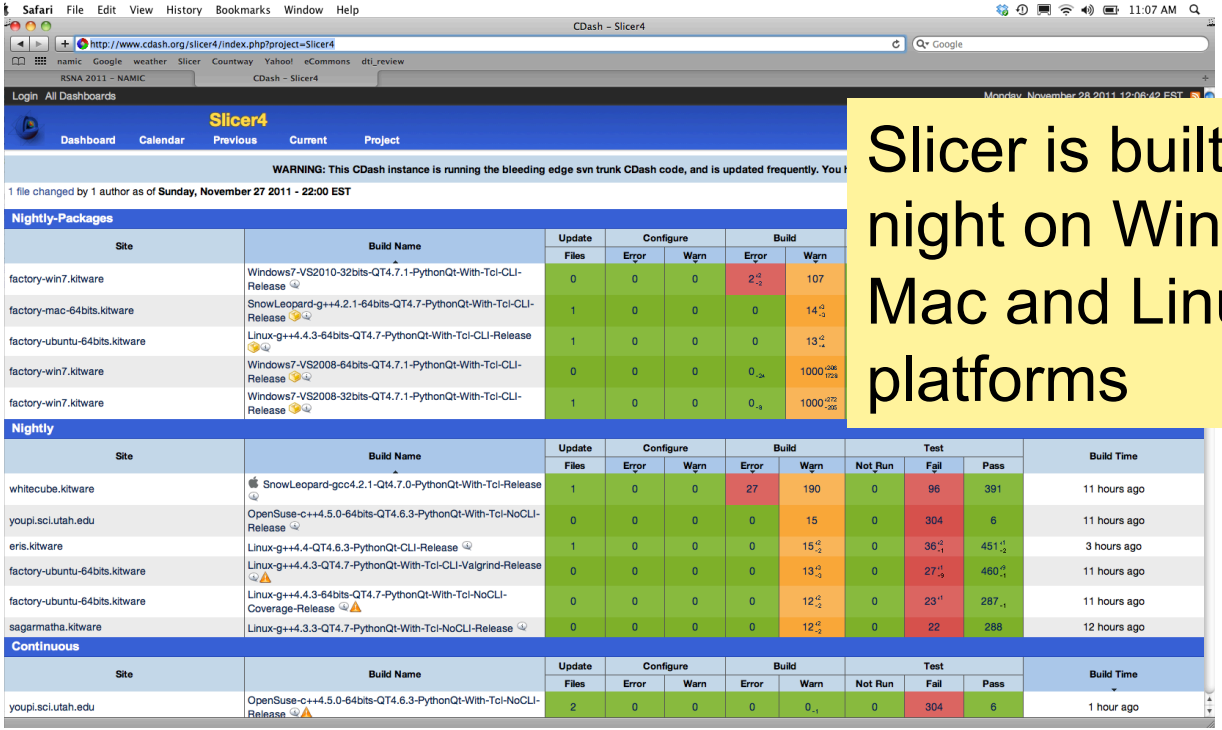
- 1997: Slicer started as a research project between the Surgical Planning Lab (Harvard) and the CSAIL (MIT)
- 2012: Multi-institution effort to share the latest advances in image analysis with clinicians and scientists

NA-MIC and NAC



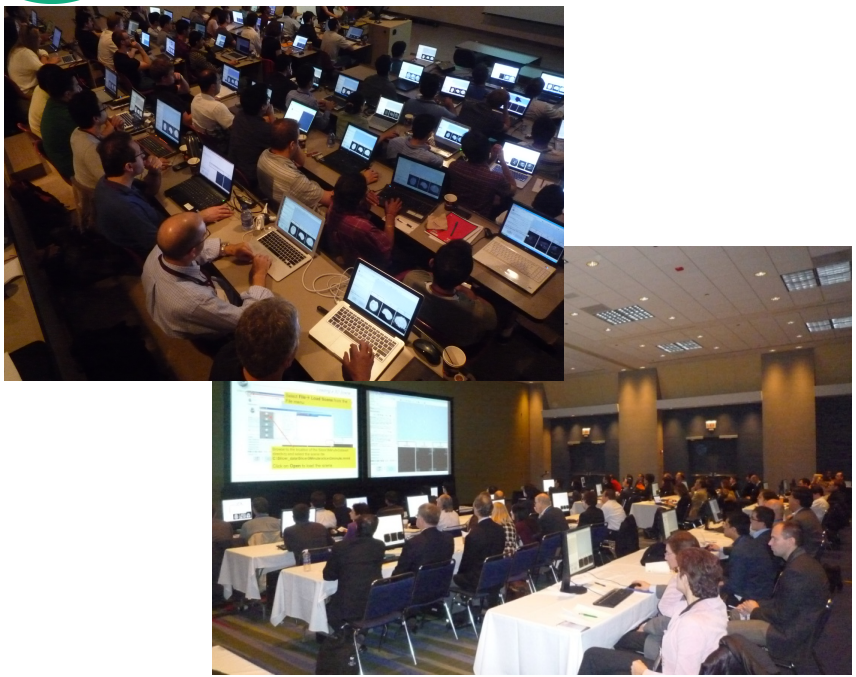


Slicer: Behind the scenes



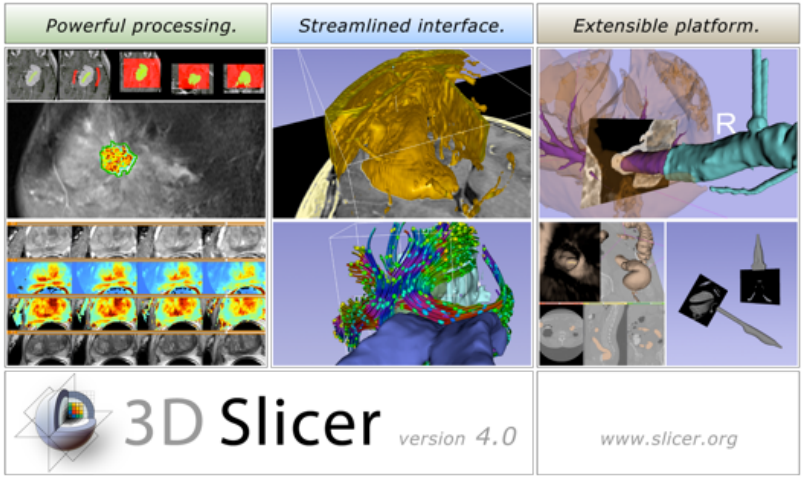
Slicer is built every night on Windows, Mac and Linux platforms

Slicer Training

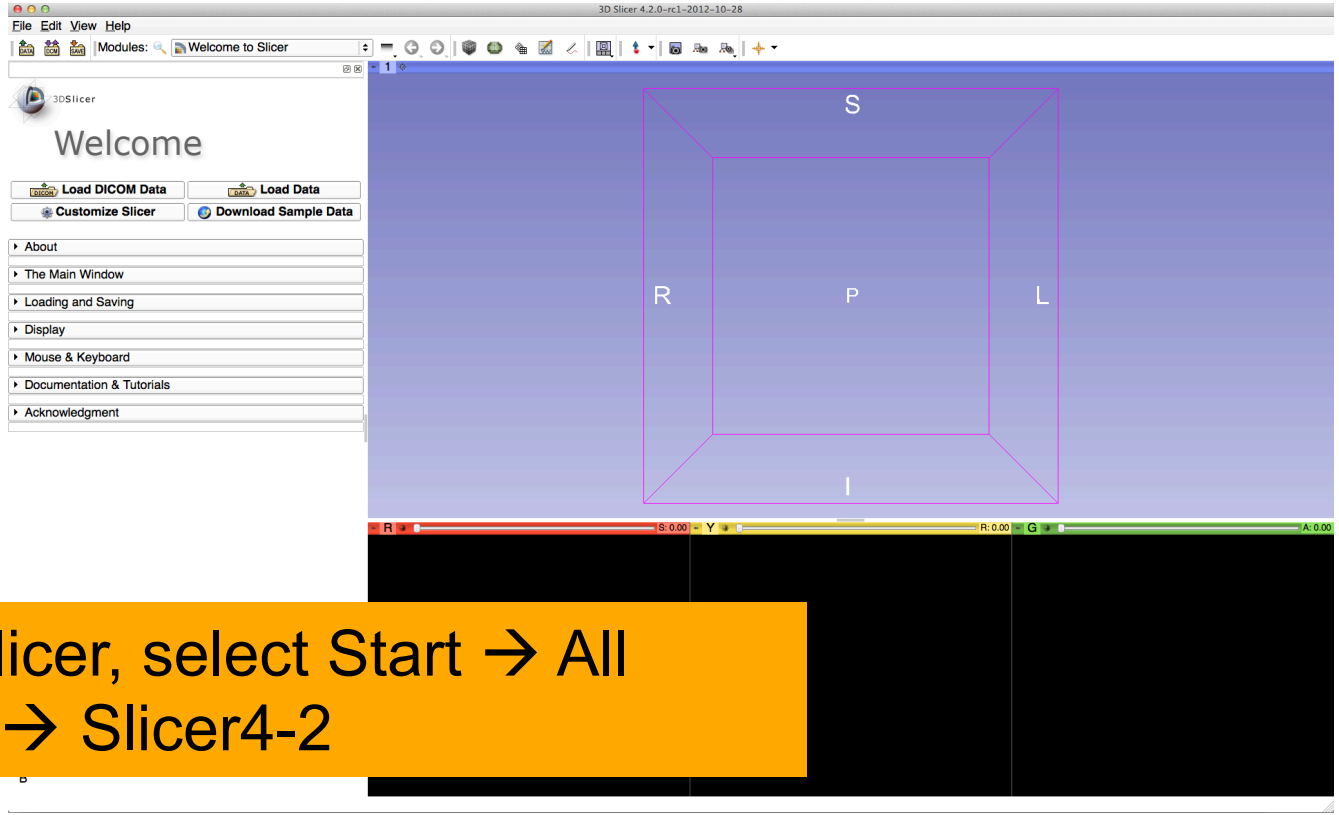


- Hands-on training workshops at national and international venues
- >2,000 clinicians, clinical researchers and scientists trained since 2005

3DSlicer version 4.2

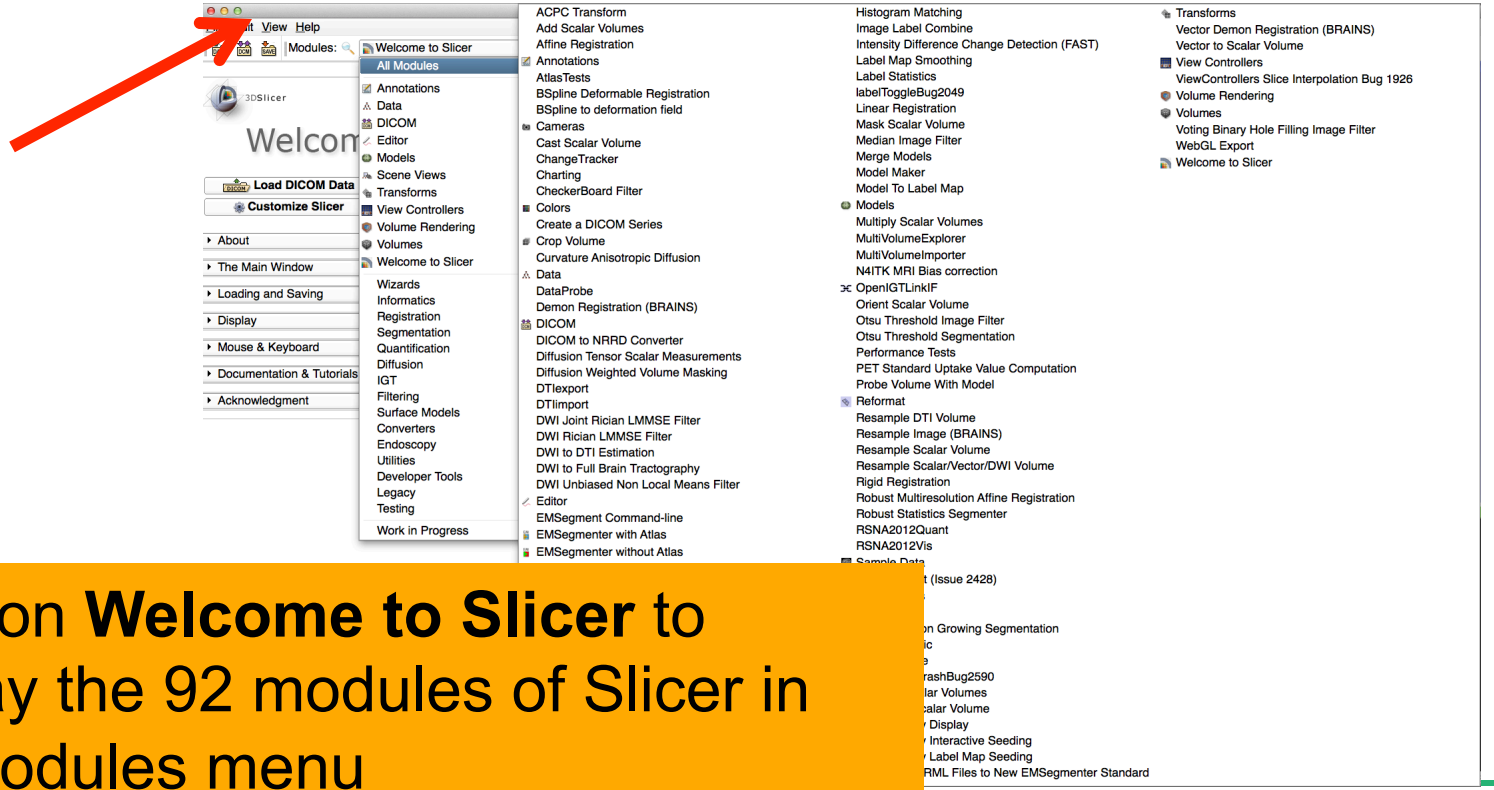


Welcome to Slicer4



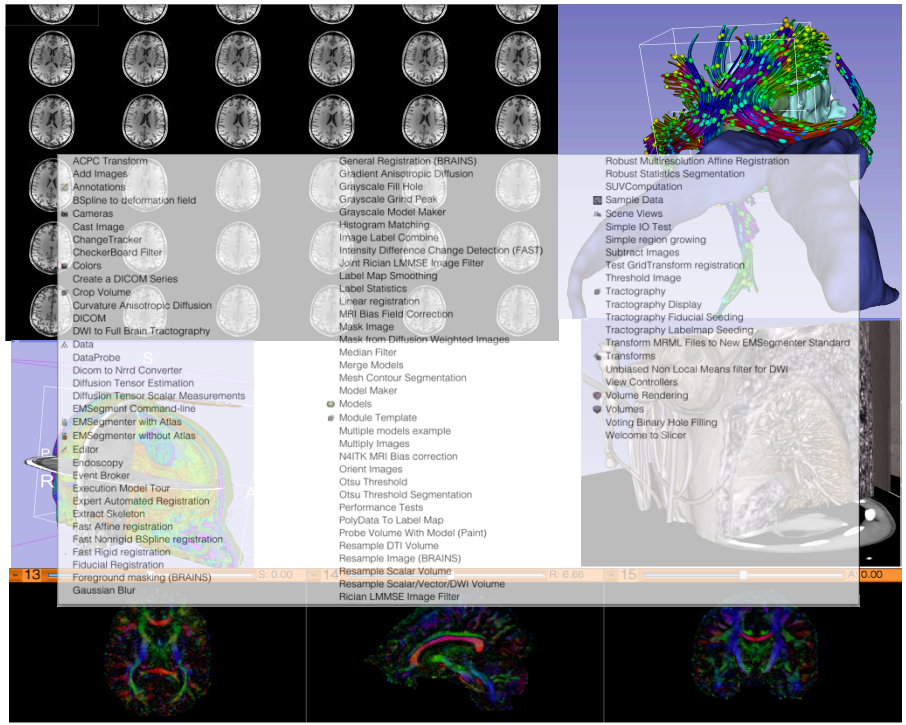
To start Slicer, select Start → All Programs→ Slicer4-2

Welcome to Slicer4.2

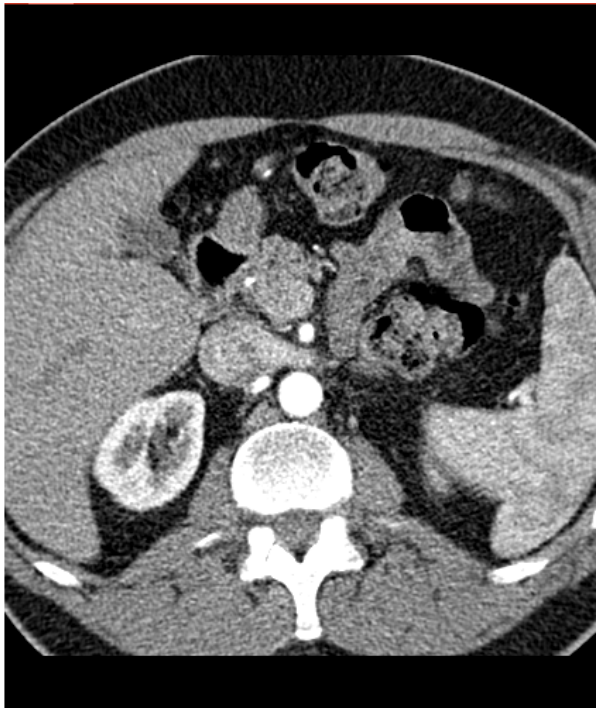


Click on **Welcome to Slicer** to display the 92 modules of Slicer in the Modules menu

Welcome to Slicer4



Slicer4.2 contains more than 90 modules for image segmentation, registration and 3D visualization of medical imaging data



Part 1:

Loading a DICOM Volume

The DICOM 3.0 File Format

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

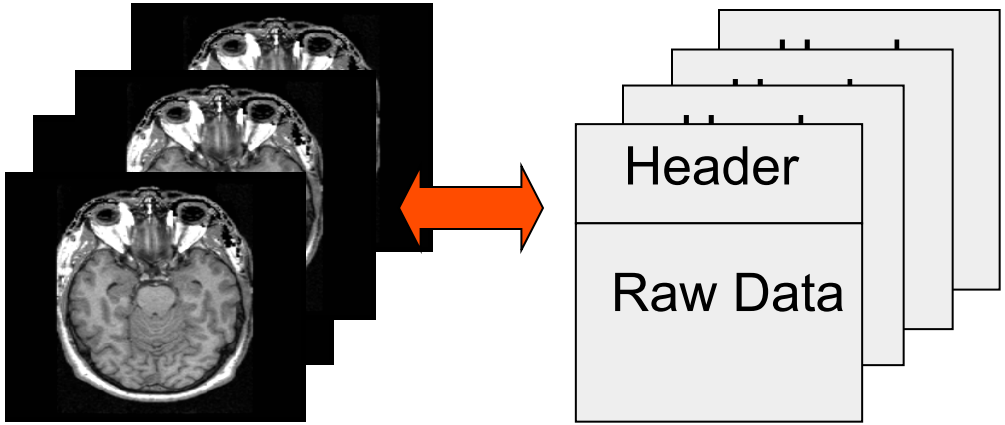


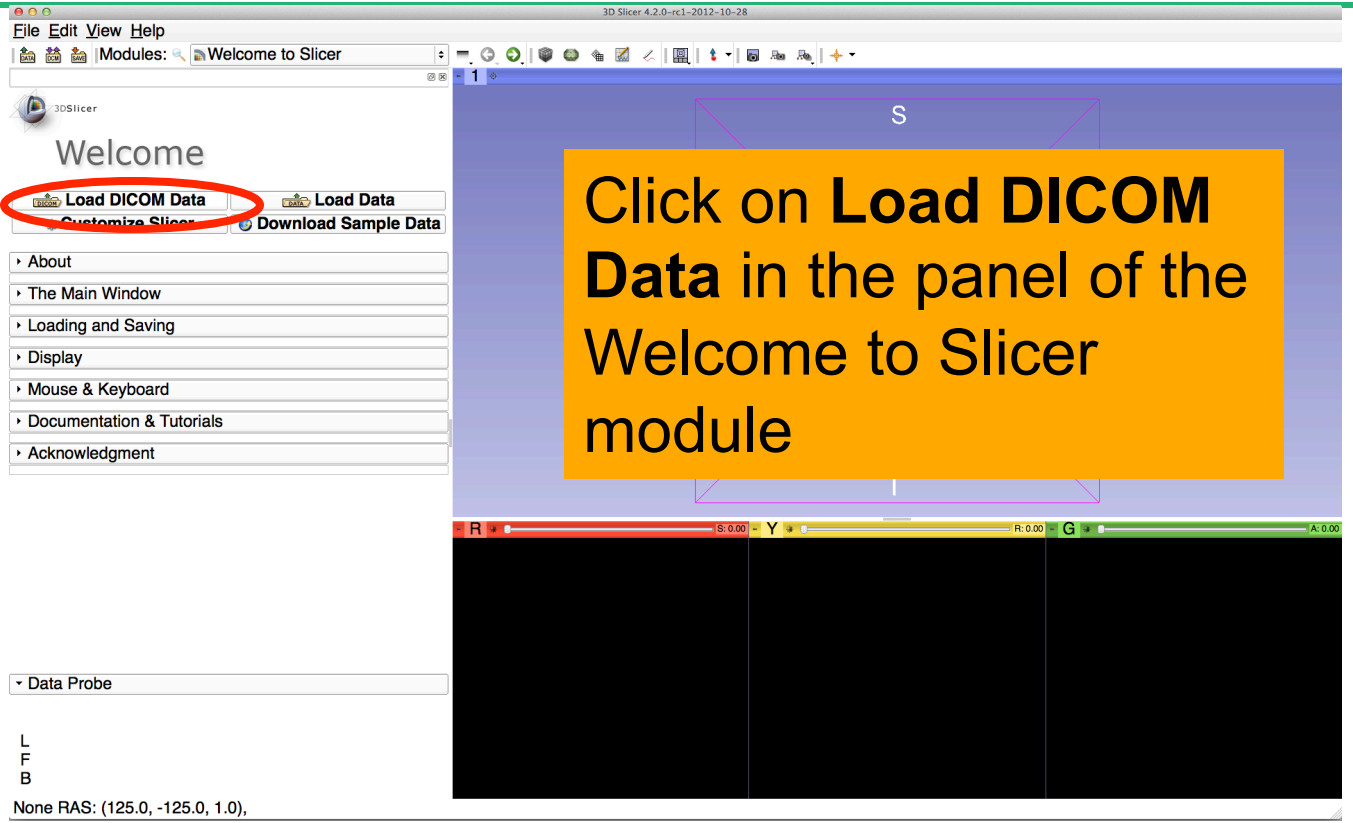
Image001.dcm

Image002.dcm

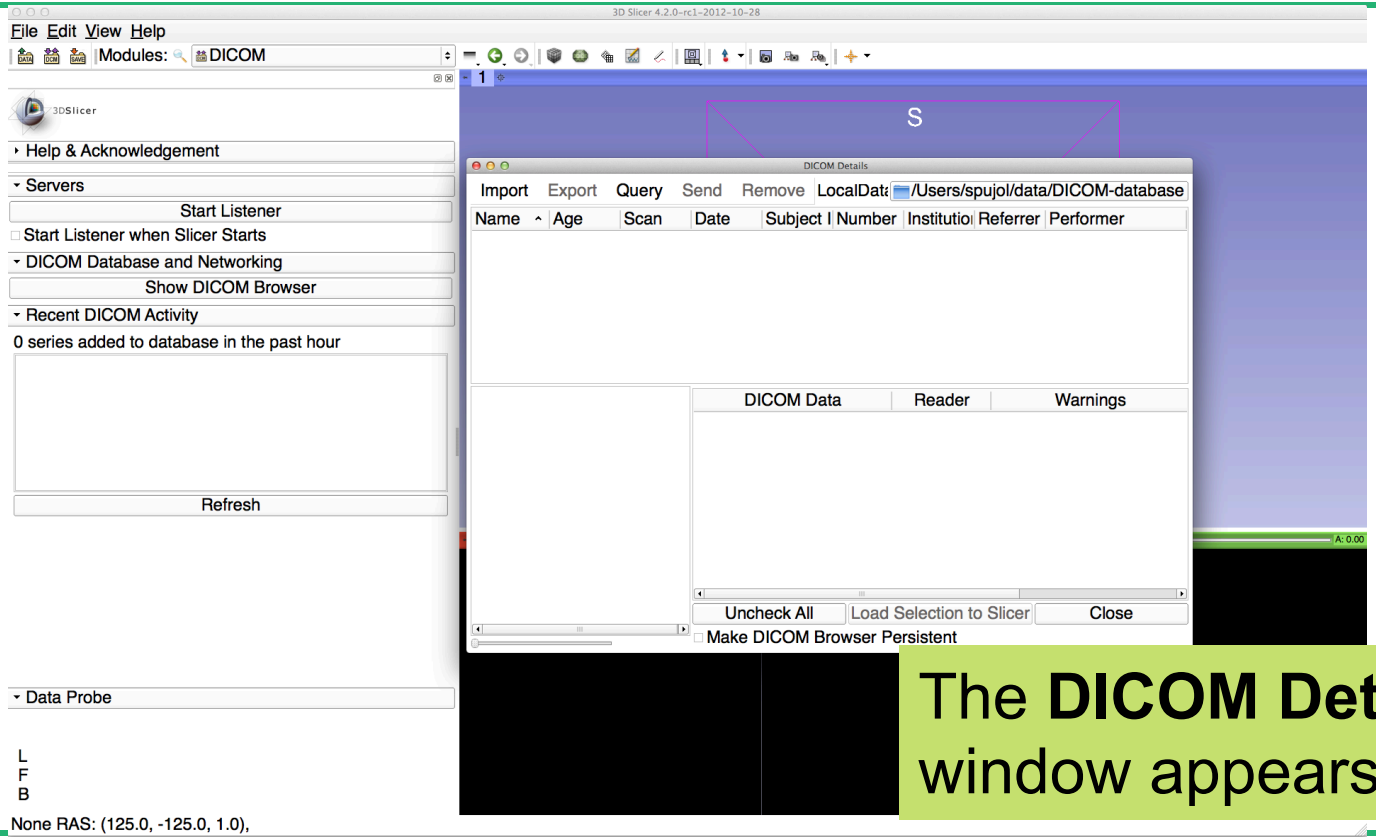
Image003.dcm

….

Loading a DICOM volume

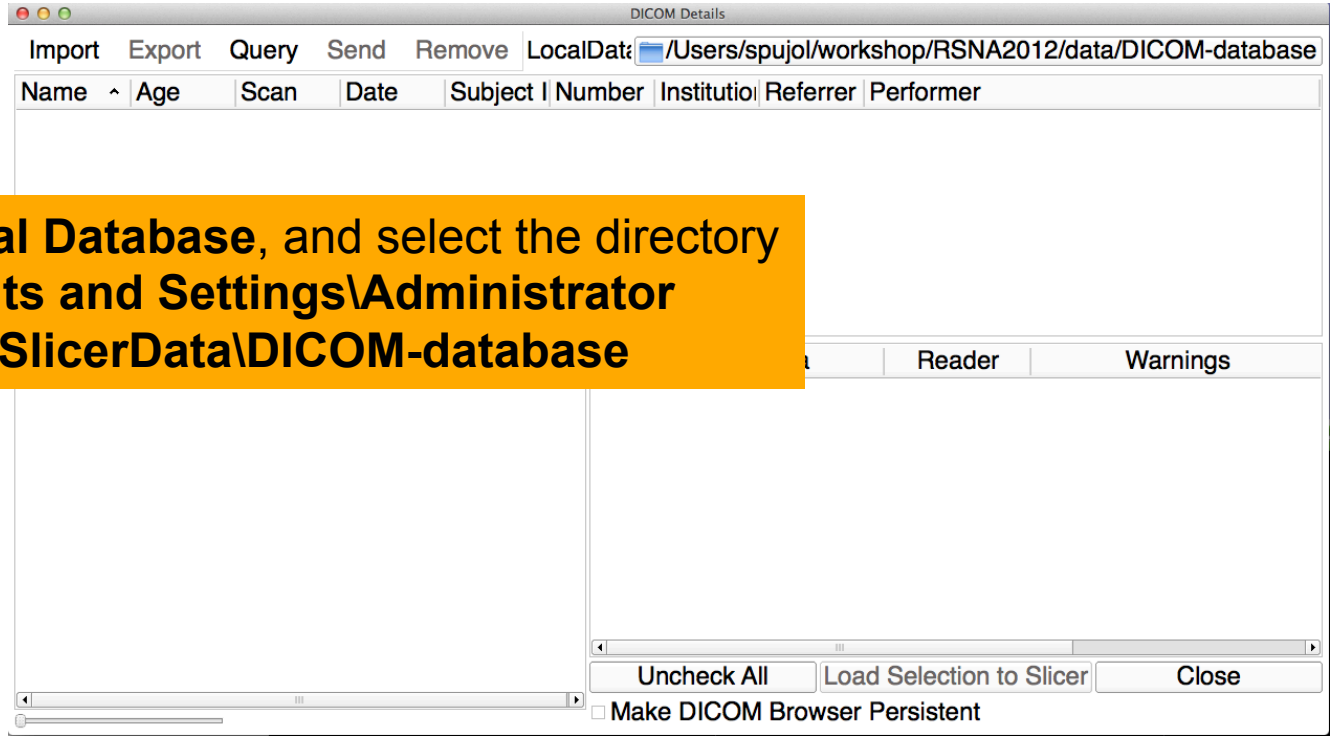


Loading a DICOM volume



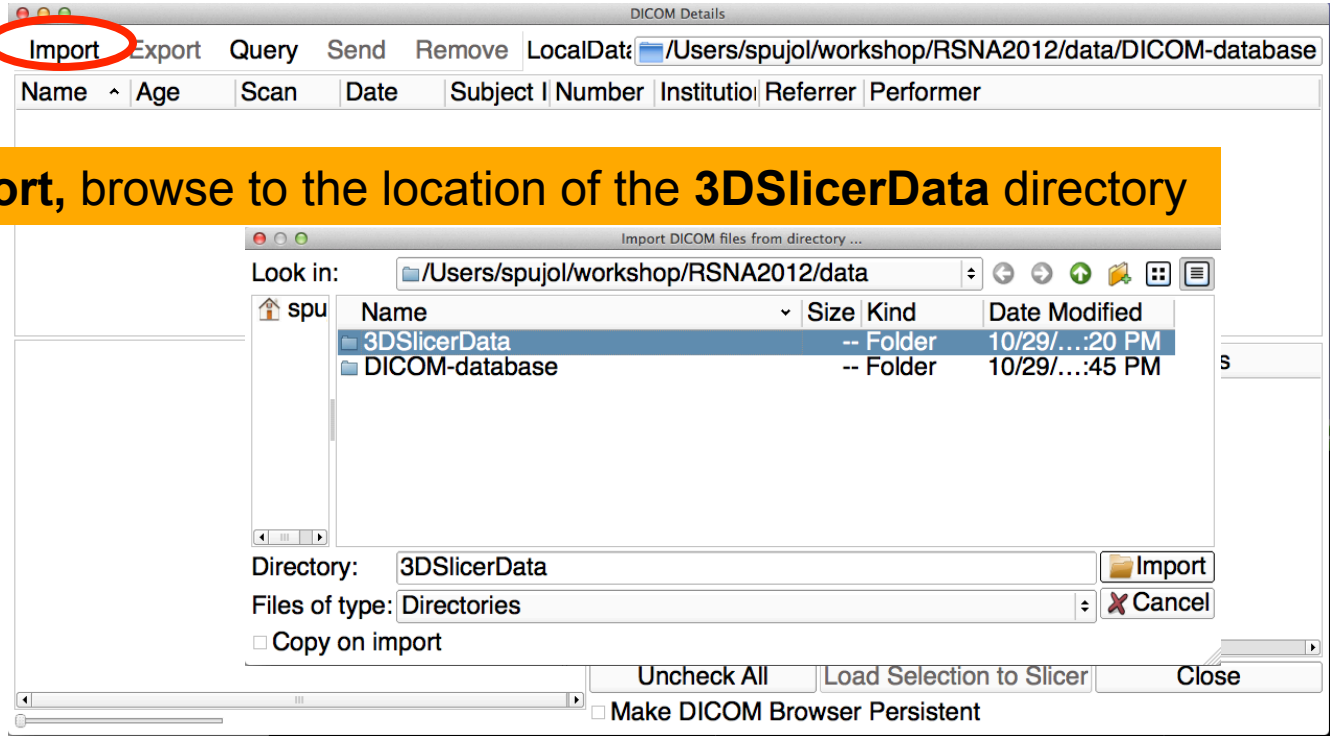
The **DICOM Details** window appears

Loading a DICOM volume



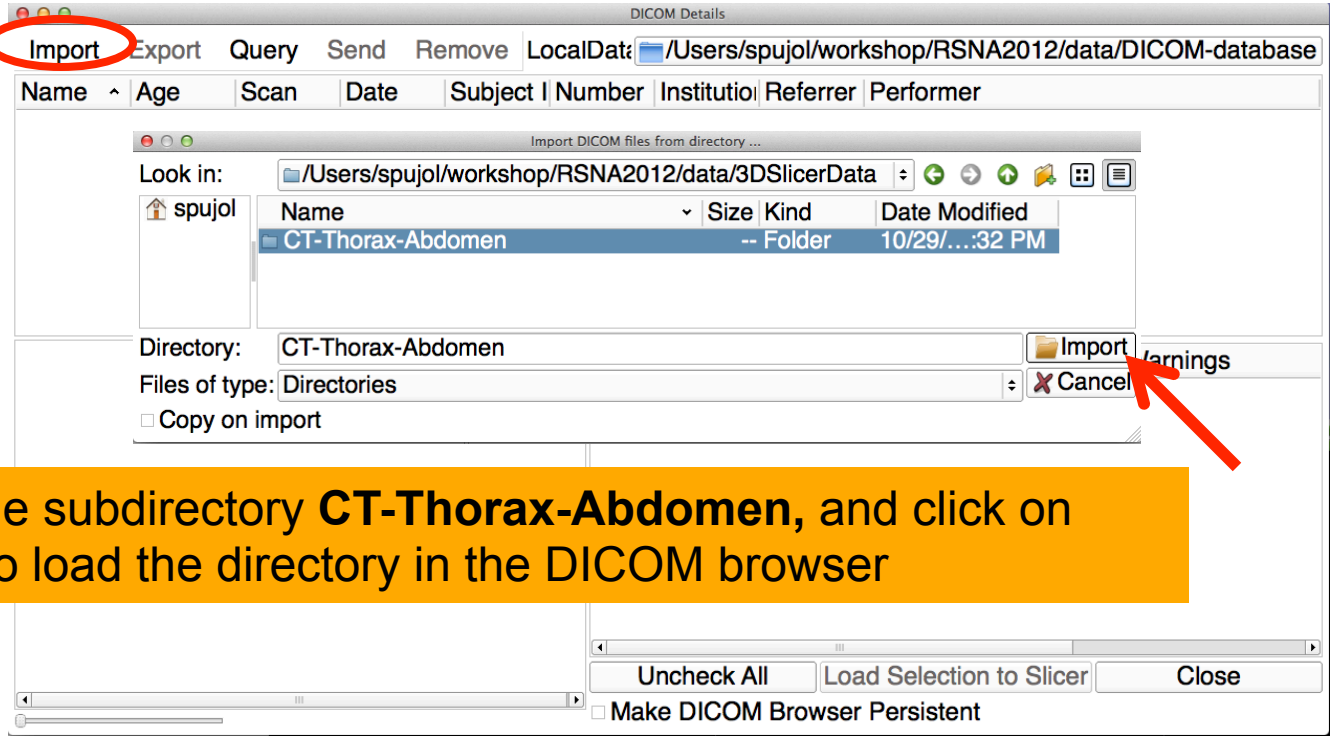
Click on **Local Database**, and select the directory **C:\Documents and Settings\Administrator\Desktop\3DSlicerData\DICOM-database**

Loading a DICOM volume



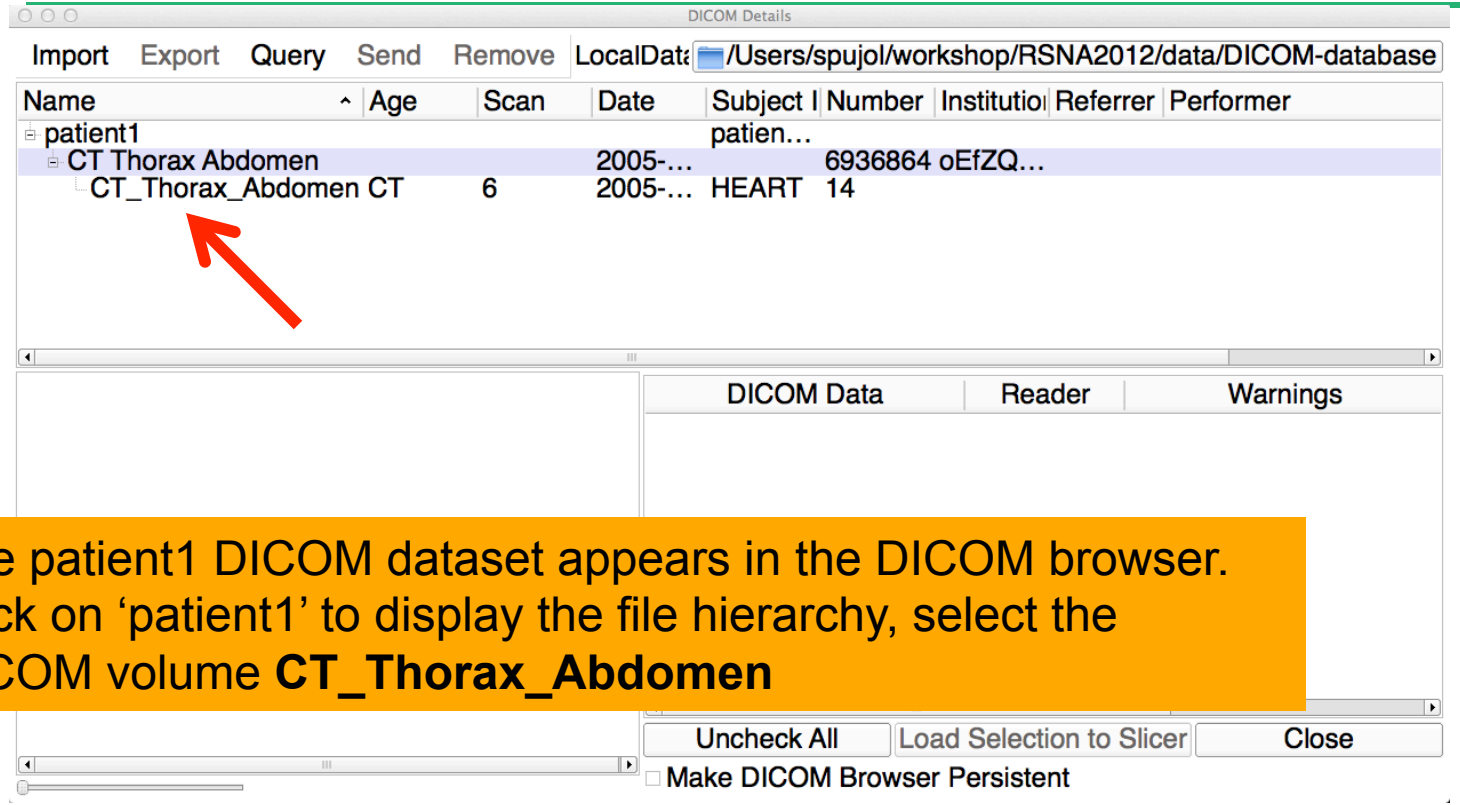
Click on **Import,** browse to the location of the **3DSlicerData** directory

Loading a DICOM volume



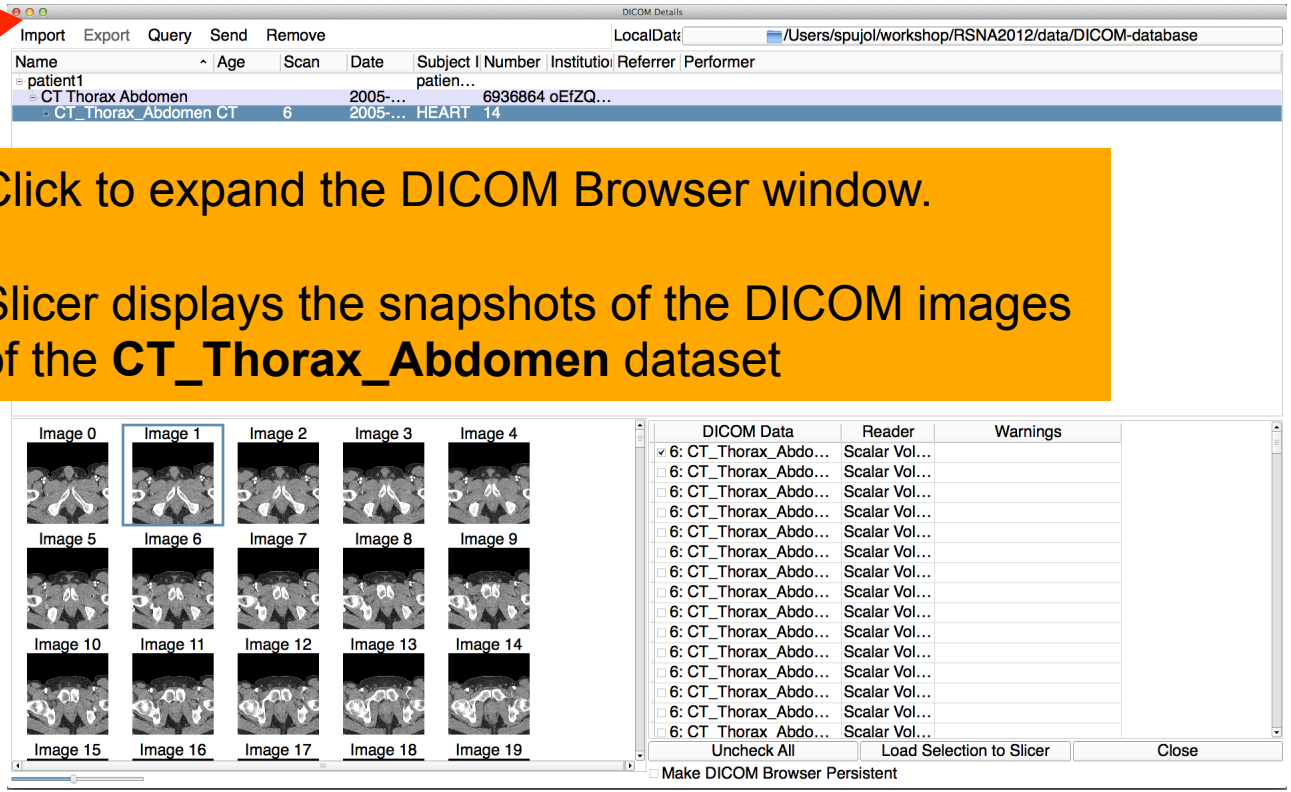
Select the subdirectory **CT-Thorax-Abdomen,** and click on **Import** to load the directory in the DICOM browser

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**

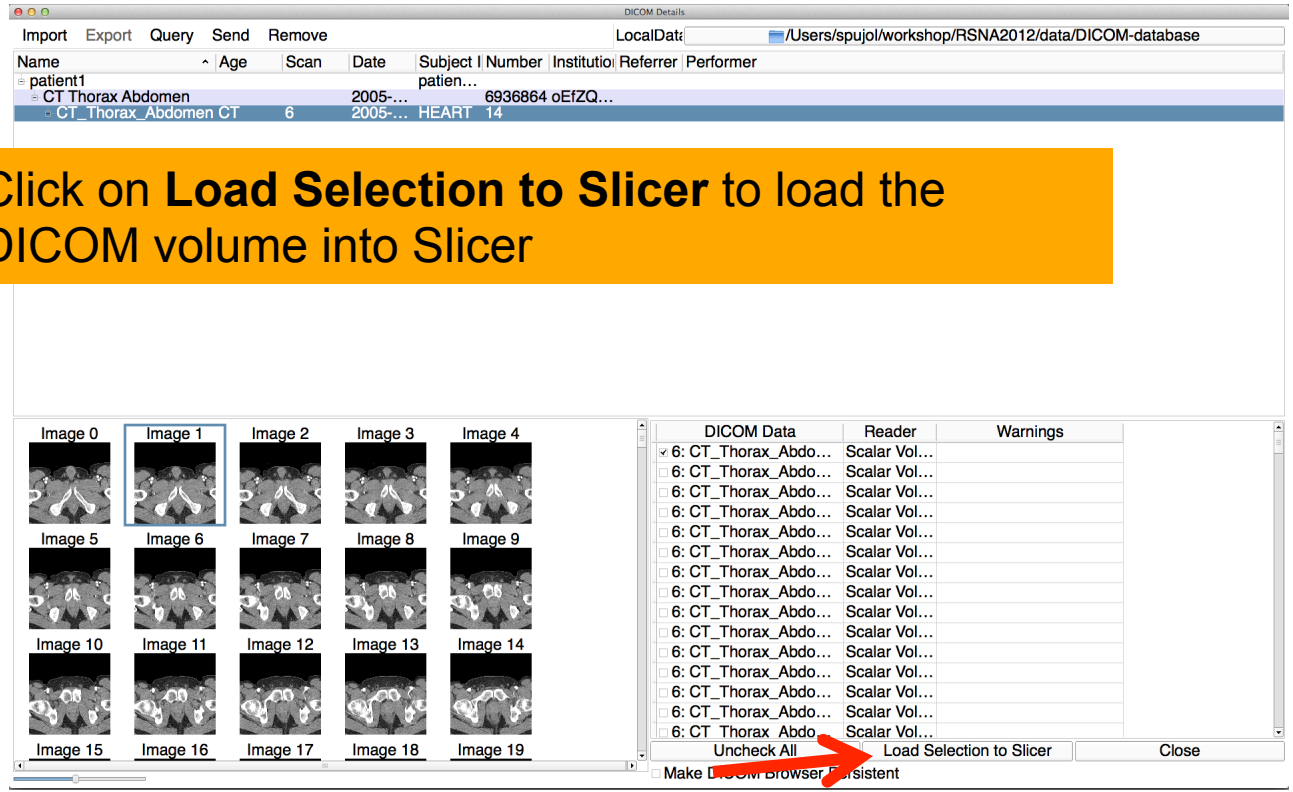
Loading a DICOM volume



Click to expand the DICOM Browser window.

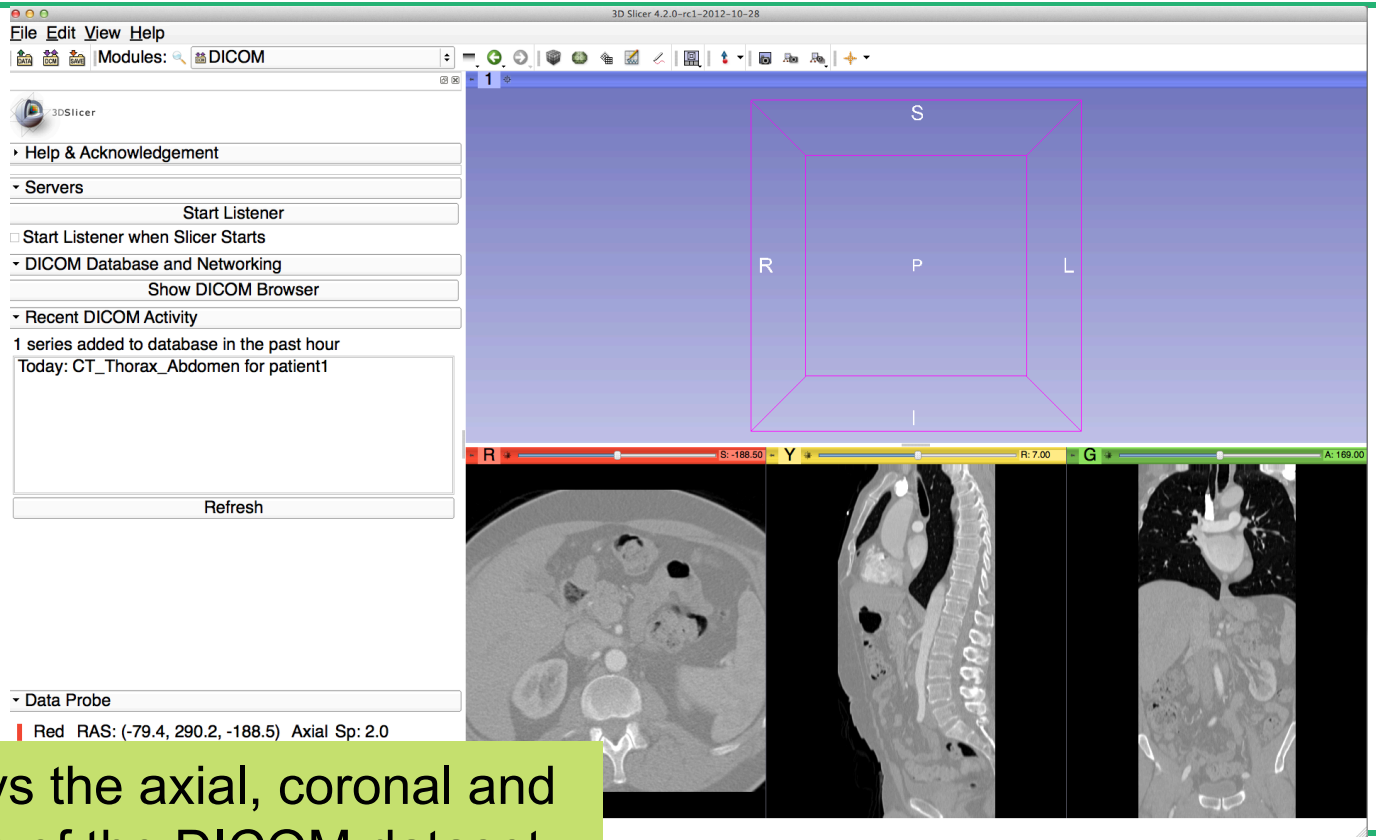
Slicer displays the snapshots of the DICOM images of the **CT_Thorax_Abdomen** dataset

Loading a DICOM volume



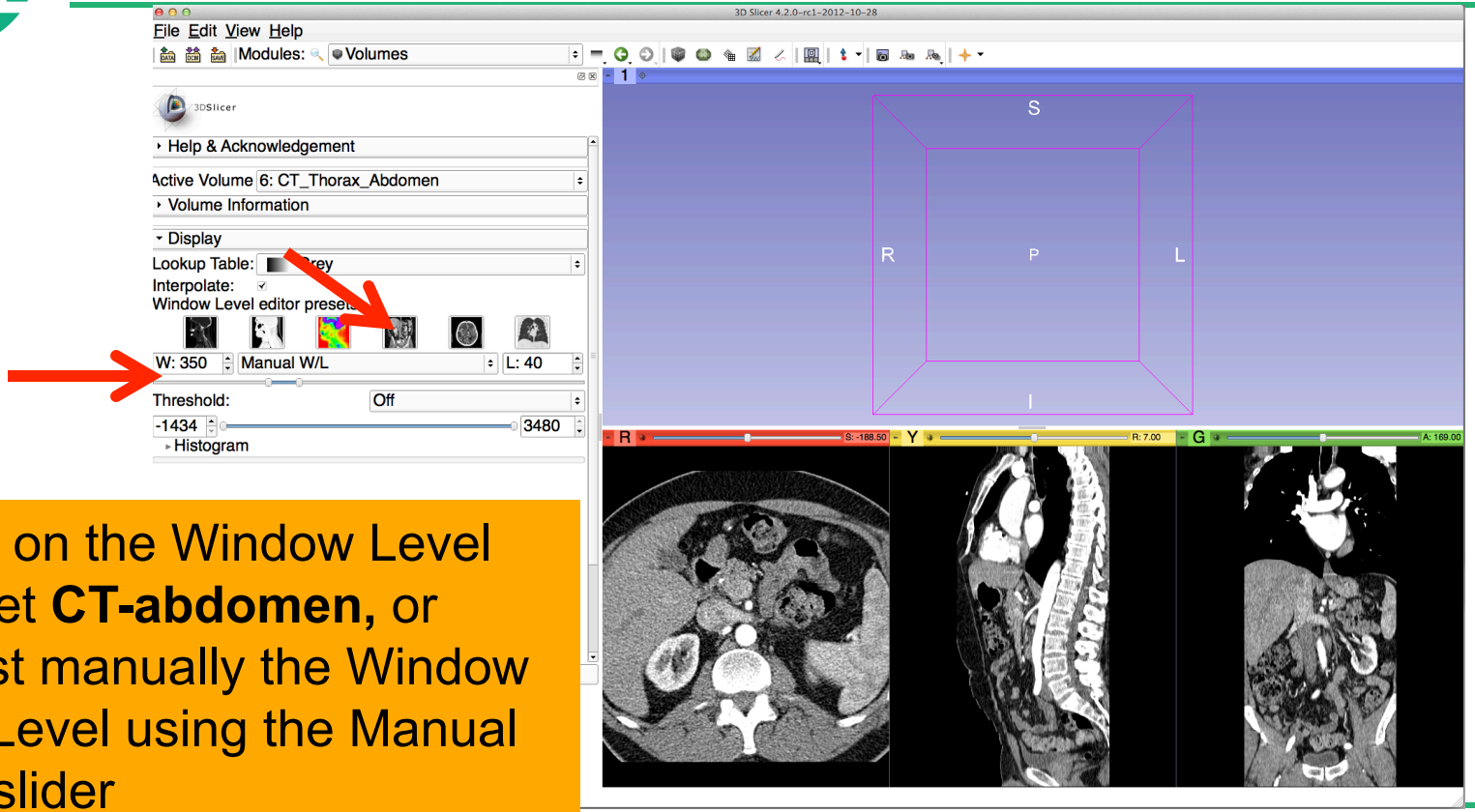
Click on **Load Selection to Slicer** to load the DICOM volume into Slicer

Loading a DICOM volume



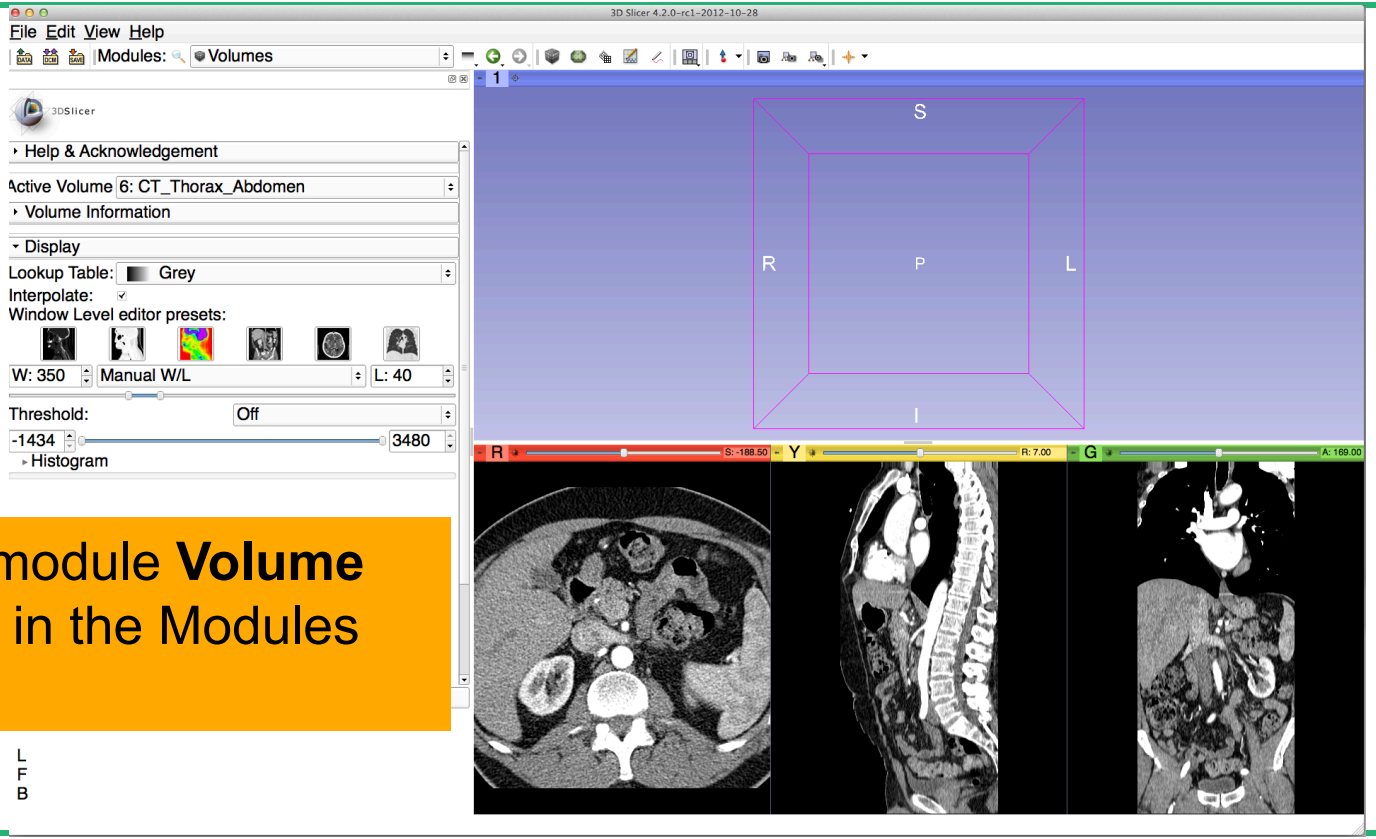
Slicer displays the axial, coronal and sagittal slices of the DICOM dataset

Loading a DICOM volume



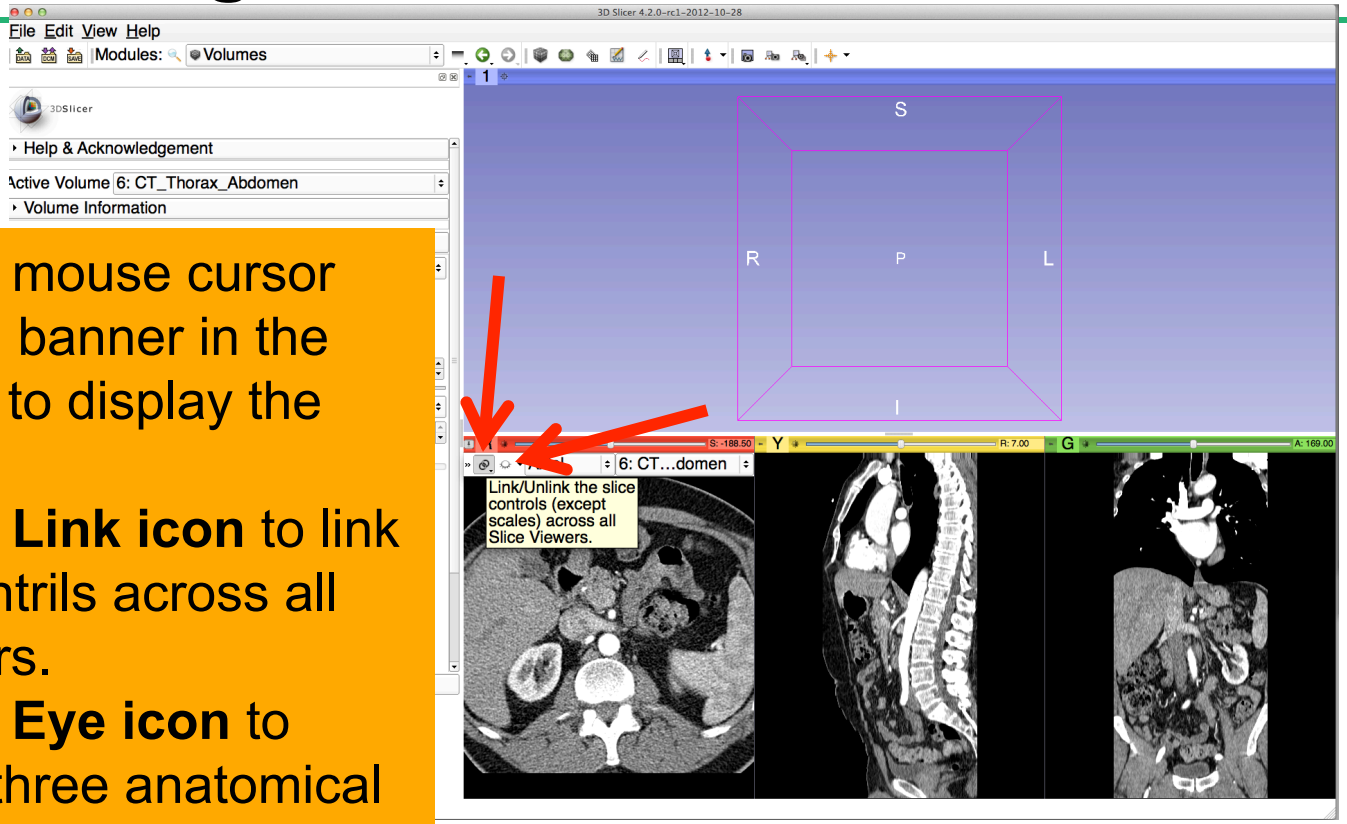
Click on the Window Level Preset **CT-abdomen,** or adjust manually the Window and Level using the Manual W/L slider

Loading a DICOM volume



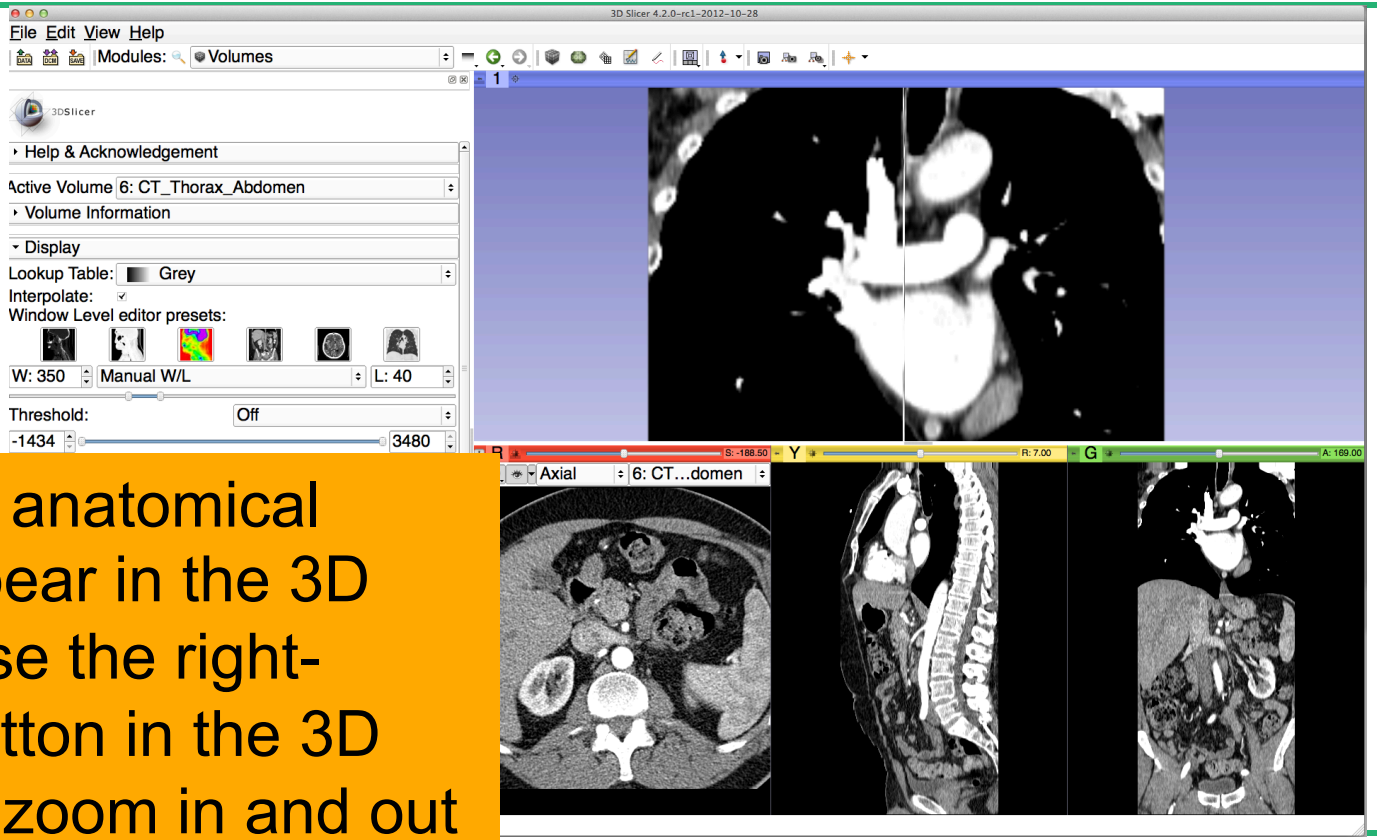
Select the module **Volume Rendering** in the Modules Menu

Loading a DICOM volume



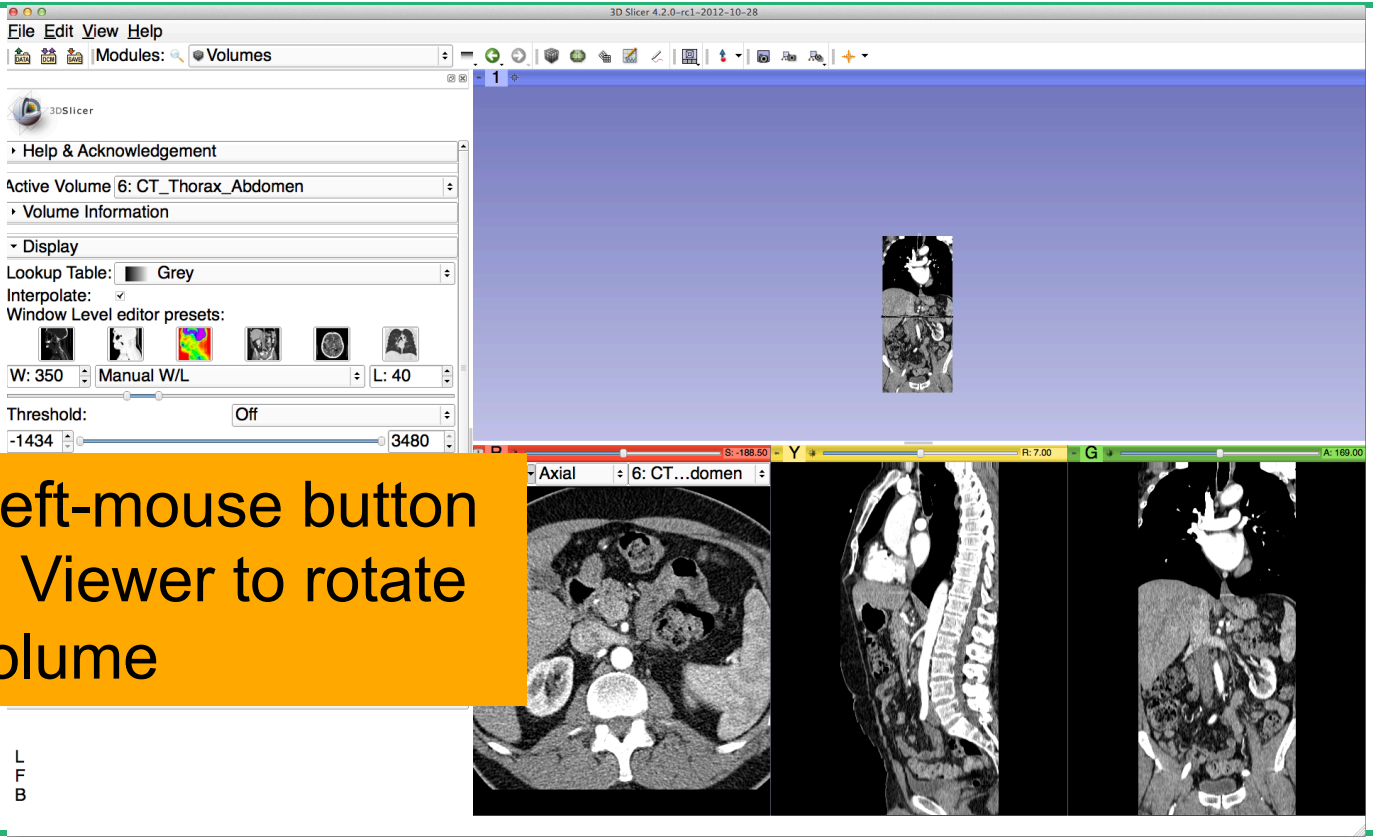
Position the mouse cursor over the red banner in the Red Viewer to display the slice menu.
Click on the **Link icon** to link the slice contrils across all Slice Viewers.
Click on the **Eye icon** to display the three anatomical slices in the 3D Viewer

Loading a DICOM volume



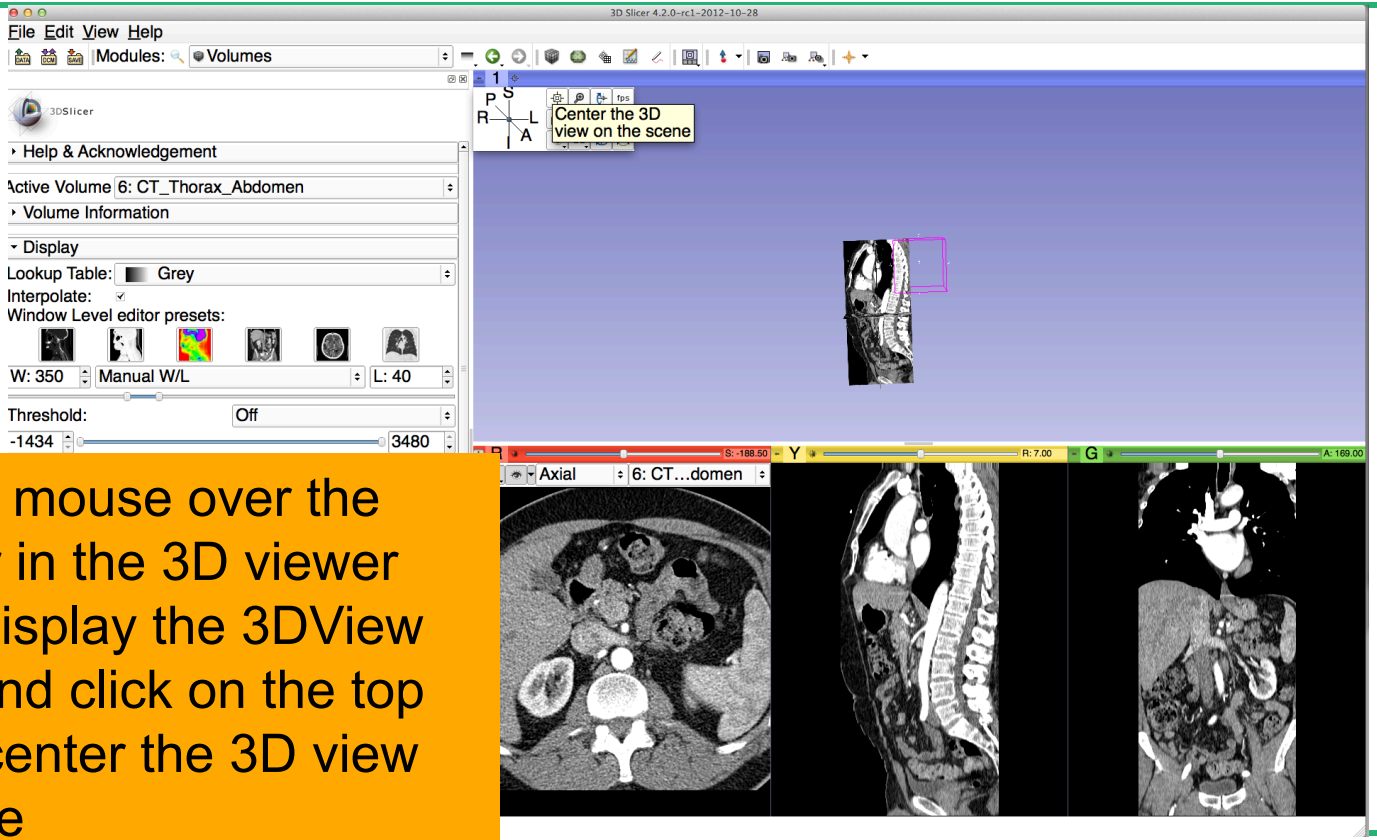
The three anatomical slices appear in the 3D viewer. Use the right-mouse button in the 3D Viewer to zoom in and out

Loading a DICOM volume



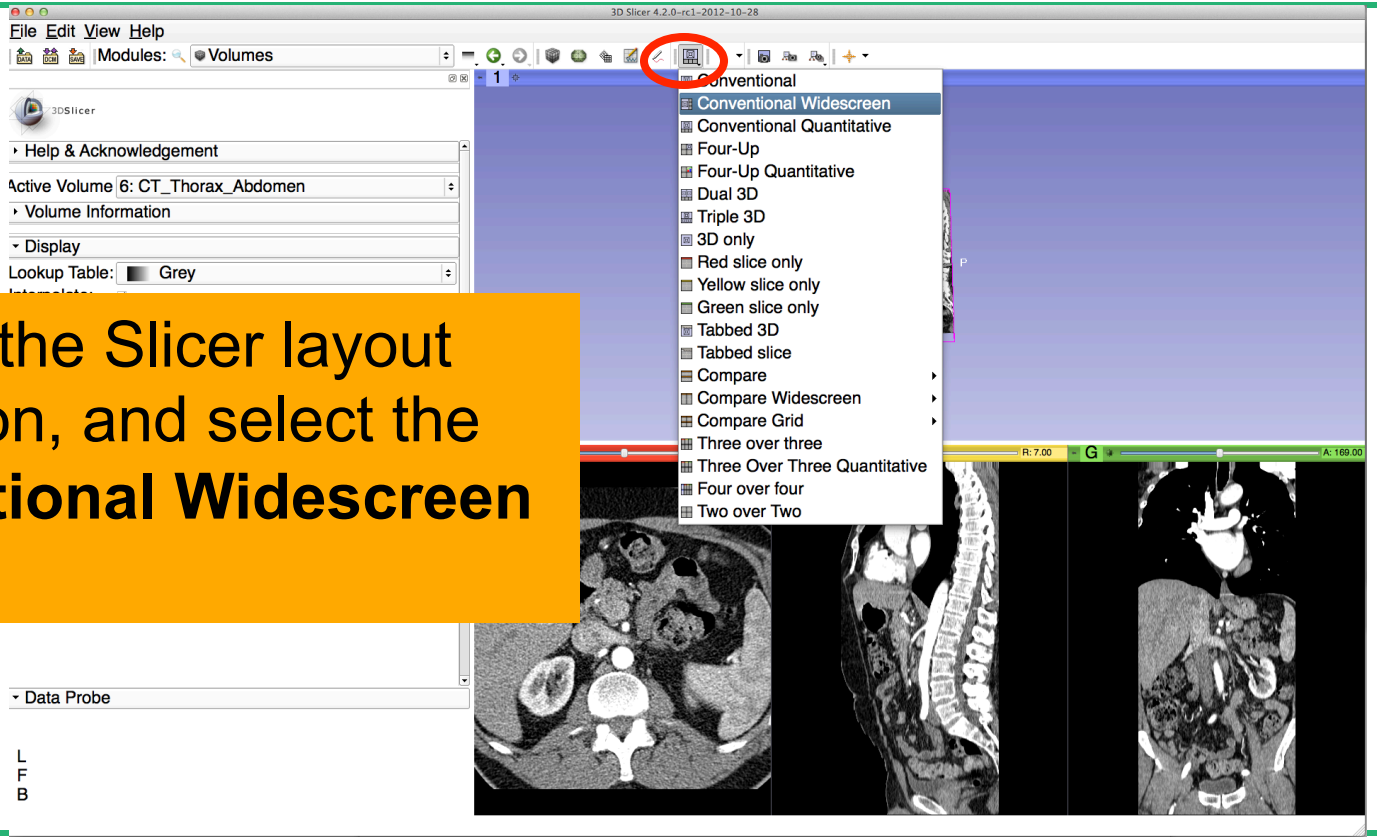
Use the left-mouse button in the 3D Viewer to rotate the 3D volume

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

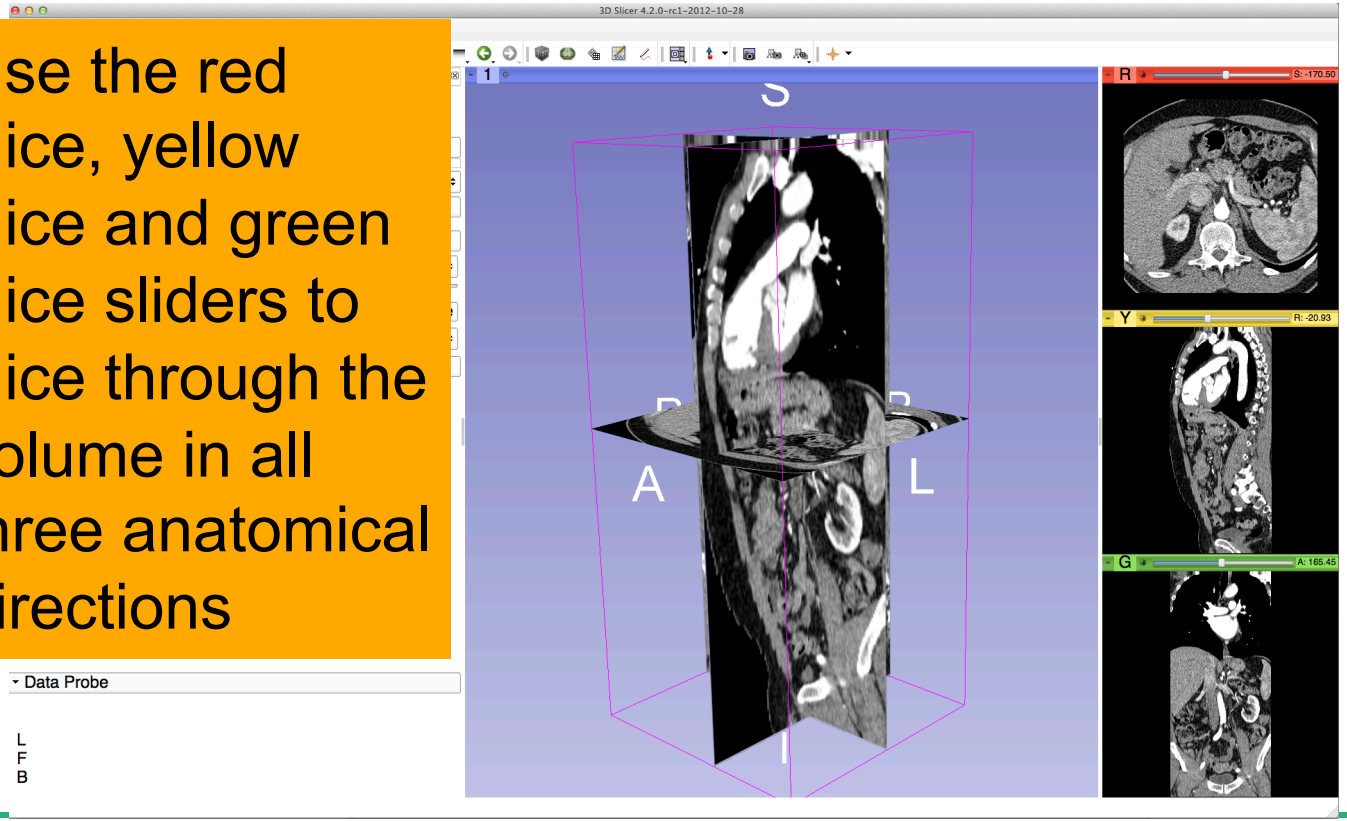
Loading a DICOM volume

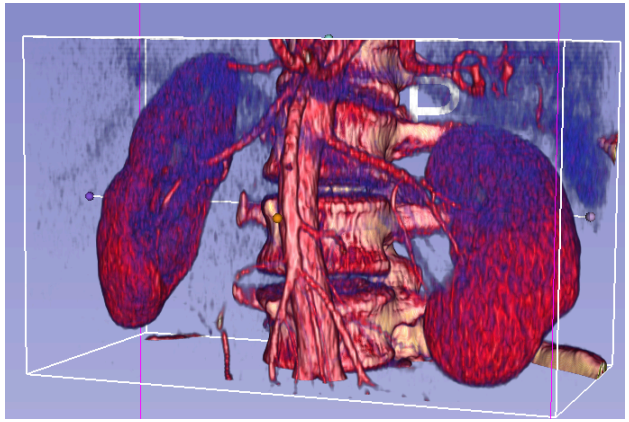


Click on the Slicer layout menu icon, and select the **Conventional Widescreen** layout

Loading a DICOM volume

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

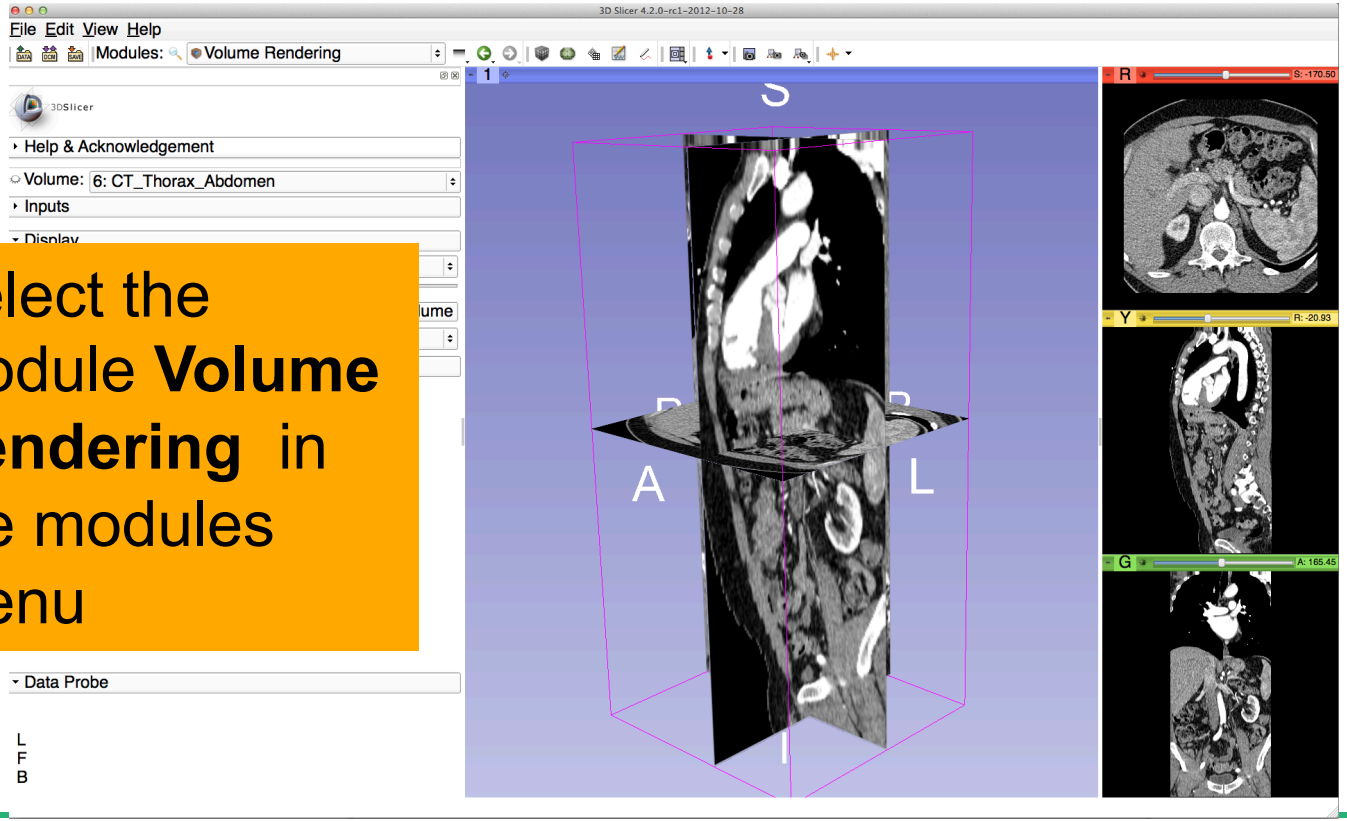




Part 2:

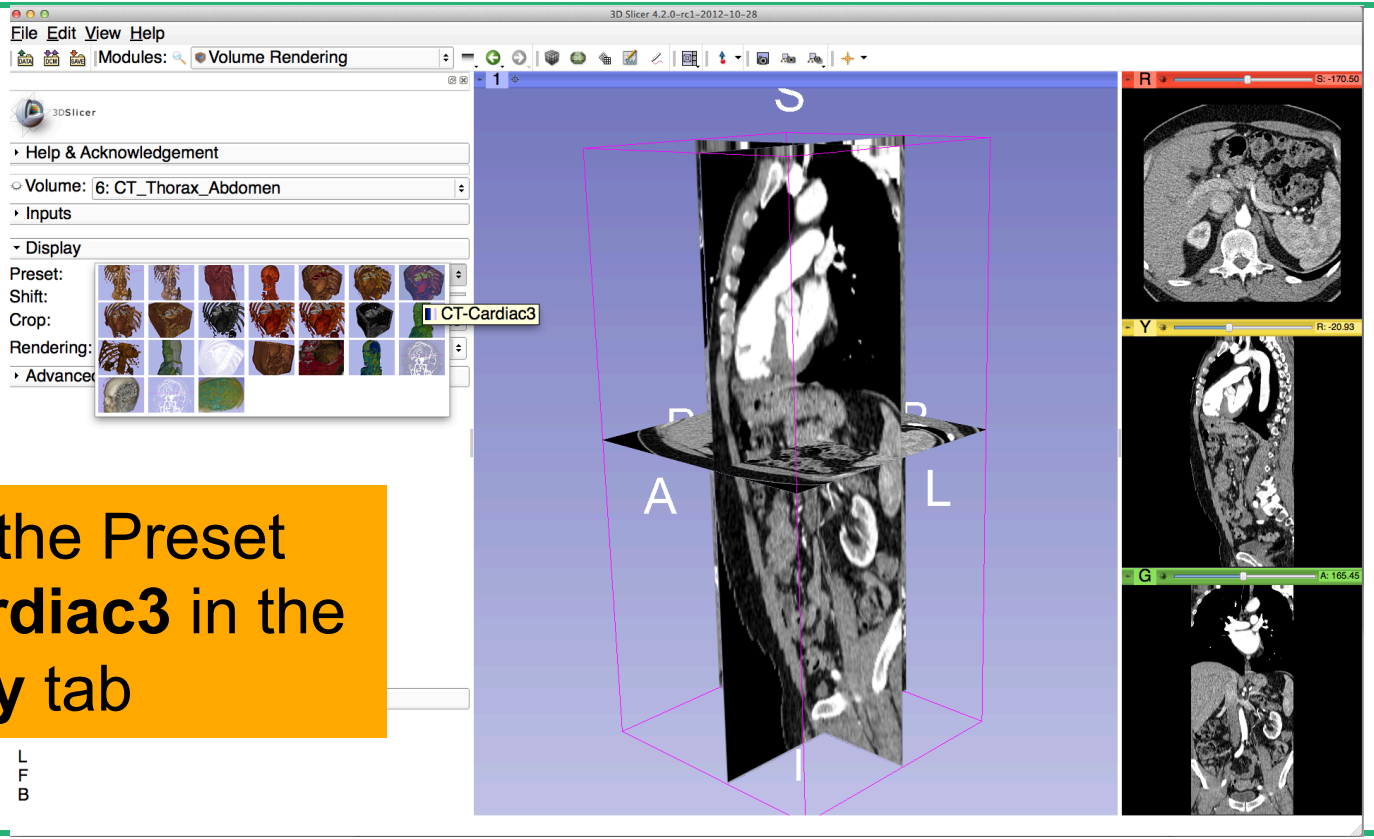
3D Interactive exploration of thoraco-abdominal CT data using Volume Rendering

Loading a DICOM volume



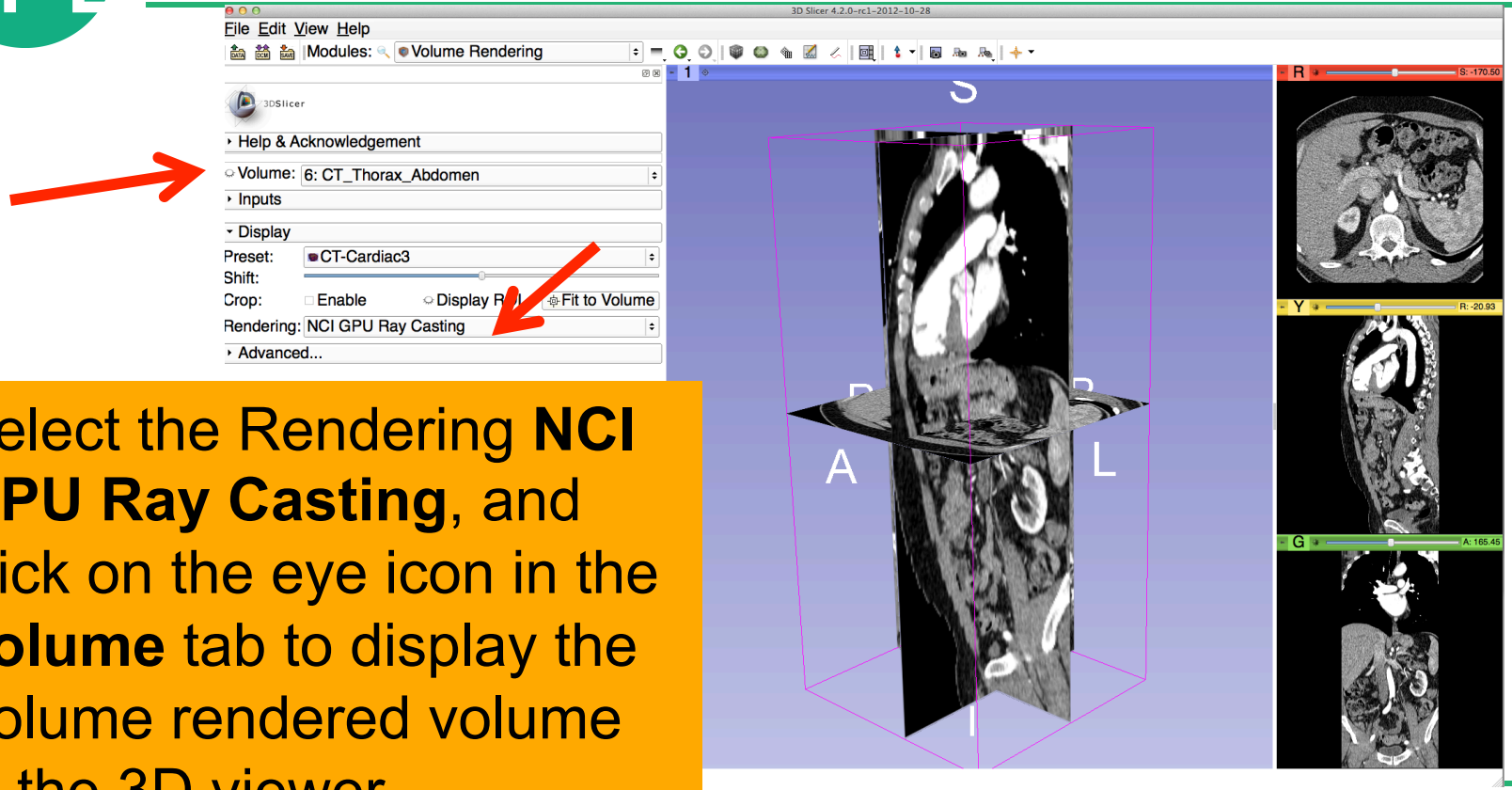
Select the module **Volume Rendering** in the modules menu

Loading a DICOM volume



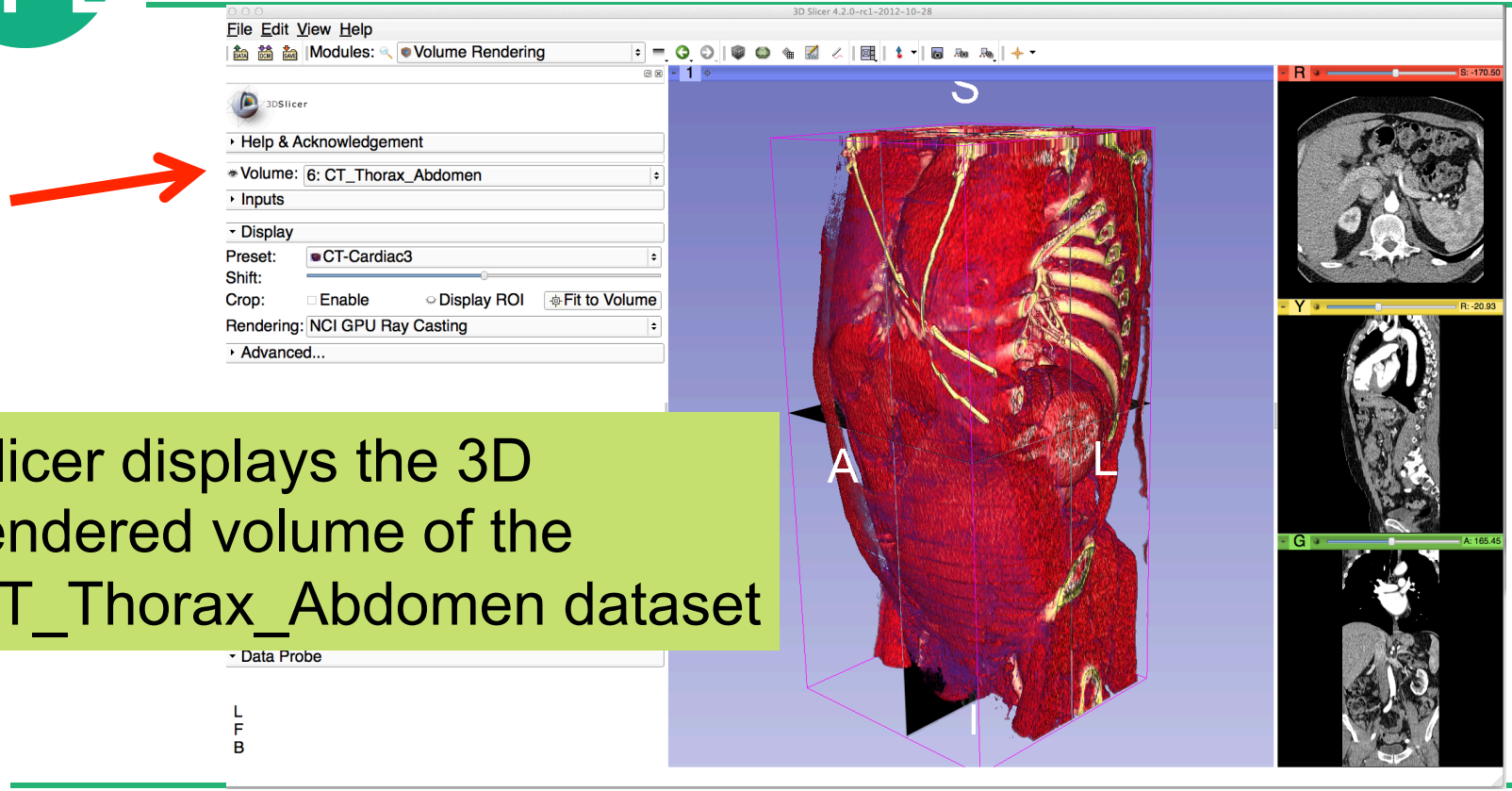
Select the Preset **CT-Cardiac3** in the **Display** tab

Loading a DICOM volume



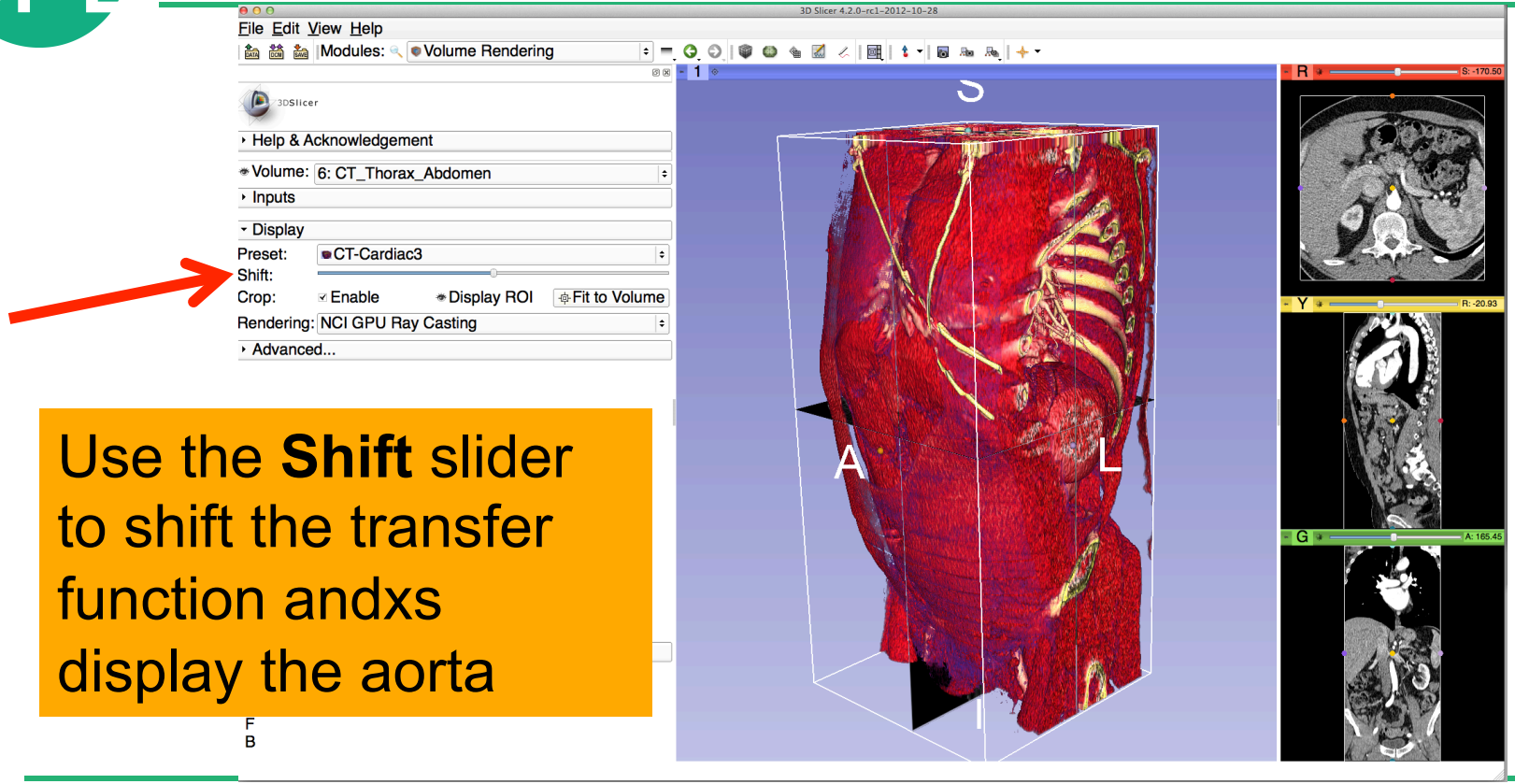
Select the Rendering **NCI GPU Ray Casting**, and click on the eye icon in the **Volume** tab to display the Volume rendered volume in the 3D viewer

GPU Volume Rendering



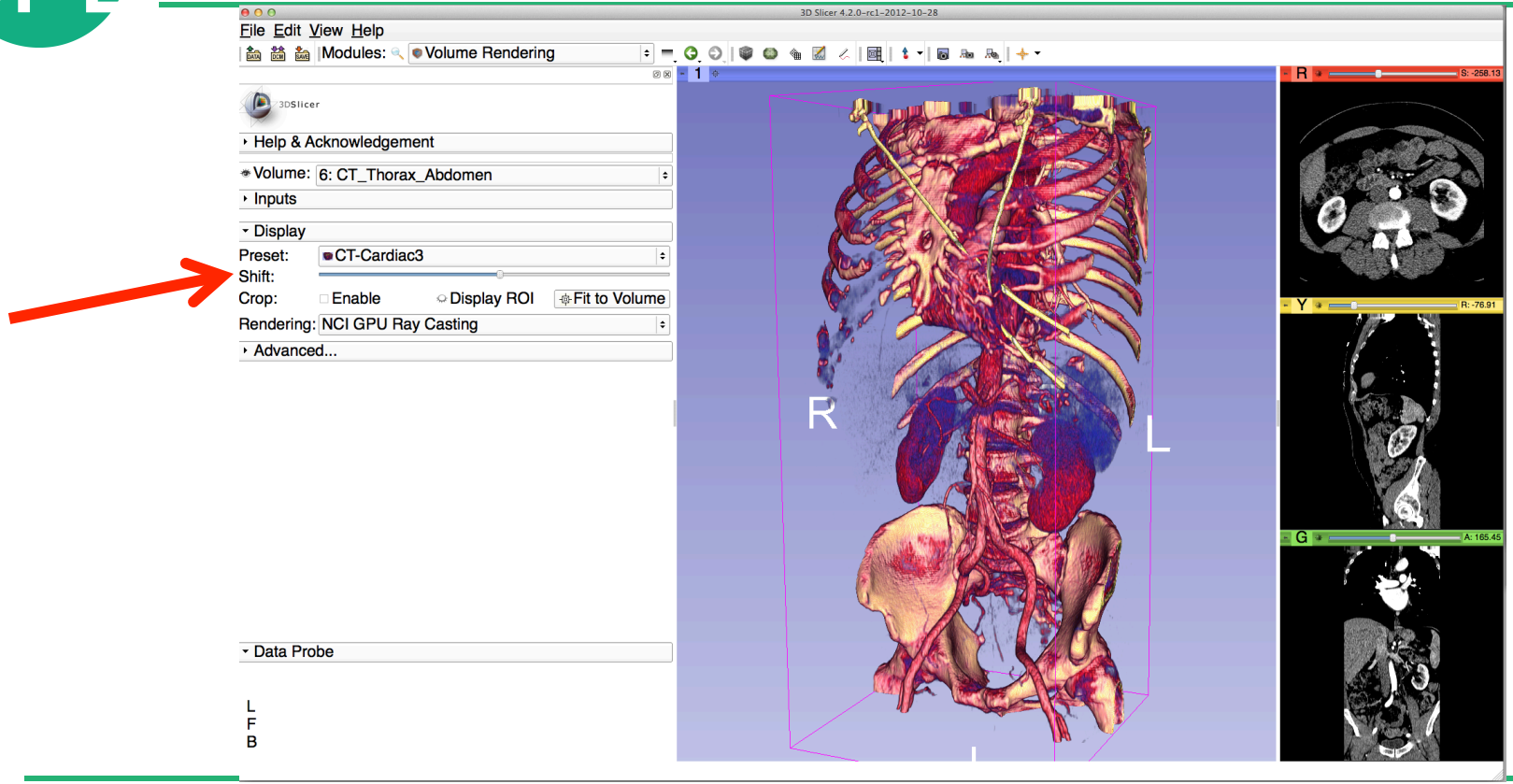
Slicer displays the 3D rendered volume of the CT_Thorax_Abdomen dataset

GPU Volume Rendering

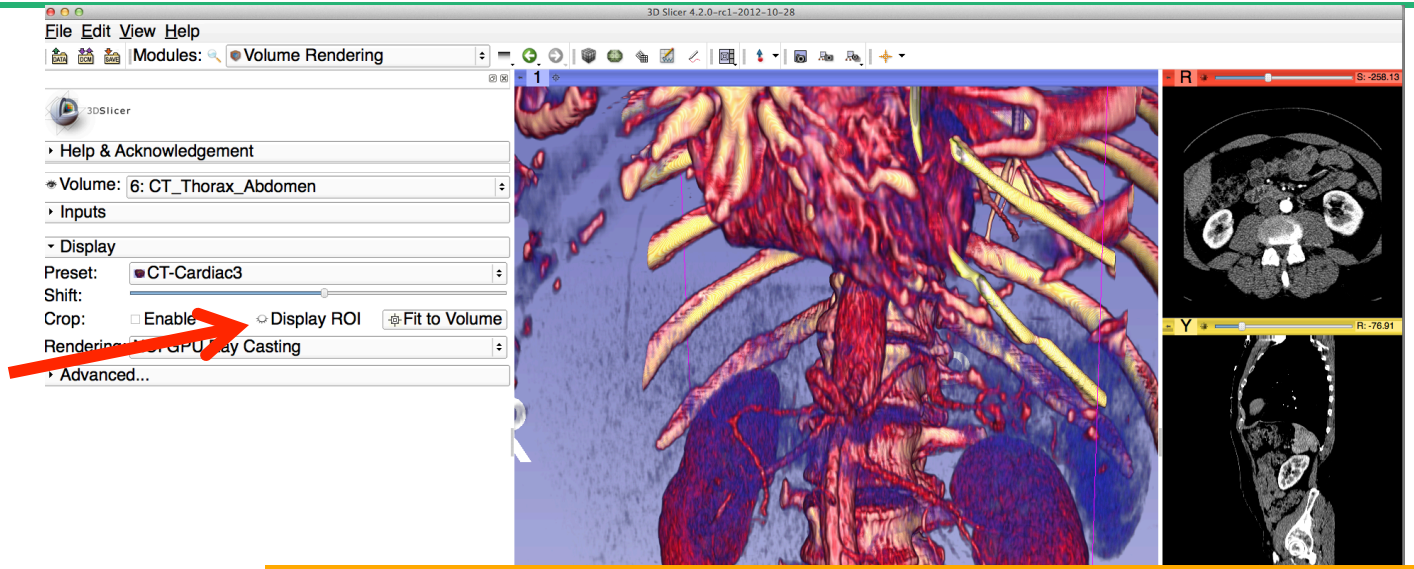


Use the **Shift** slider to shift the transfer function andxs display the aorta

GPU Volume Rendering

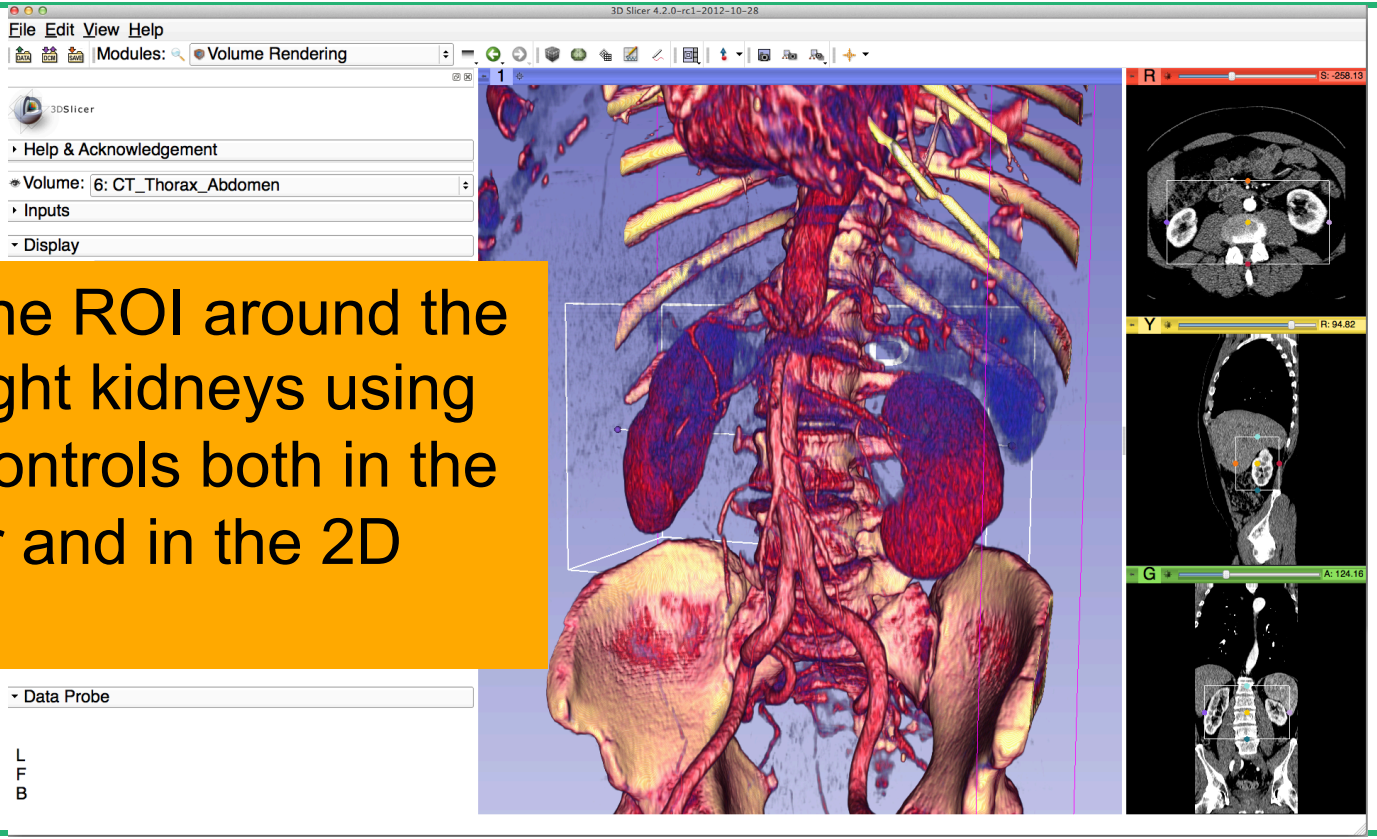


GPU Volume Rendering



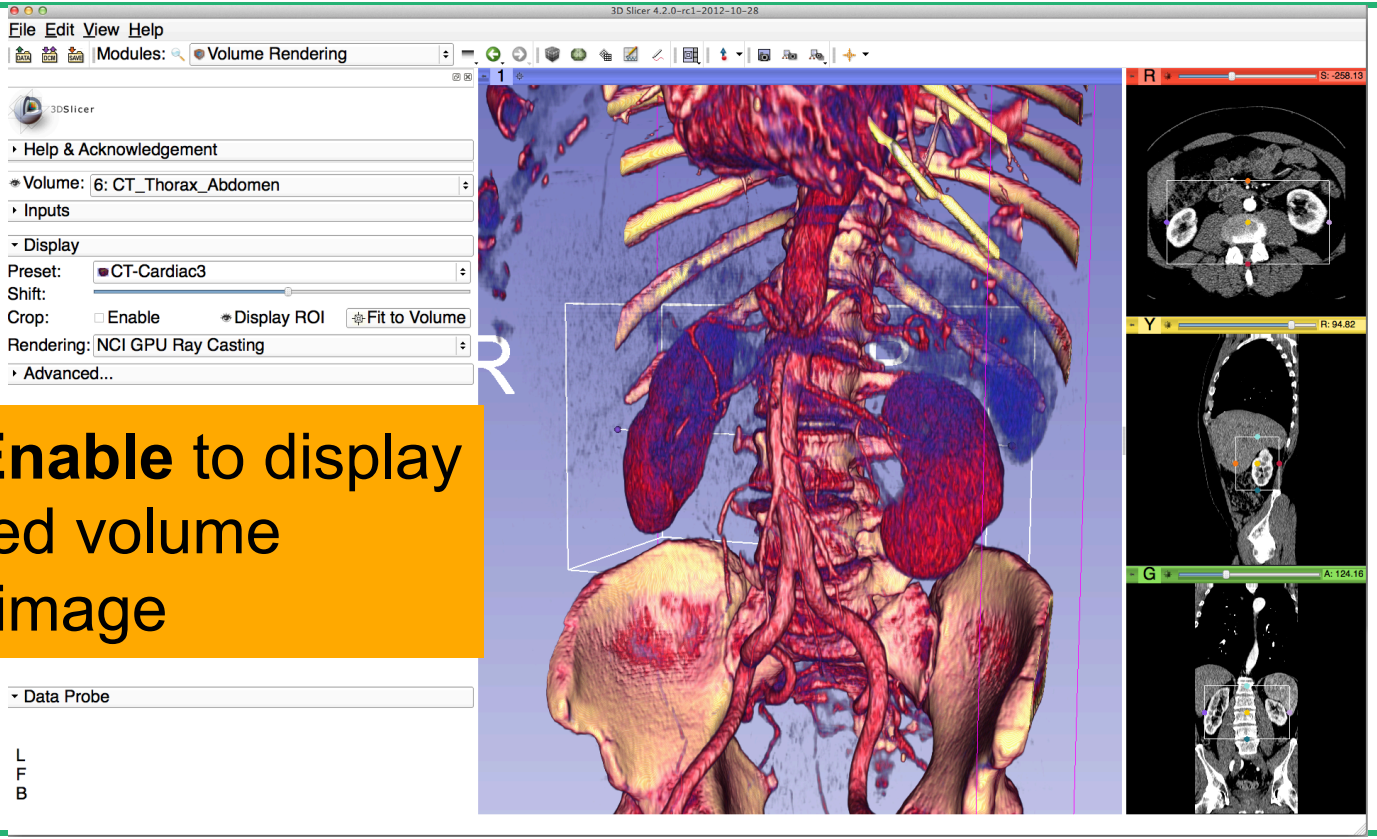
Use the right-mouse button to zoom in. Click on **Display ROI** to display a region of interest that we will use for cropping the dataset.

GPU Volume Rendering



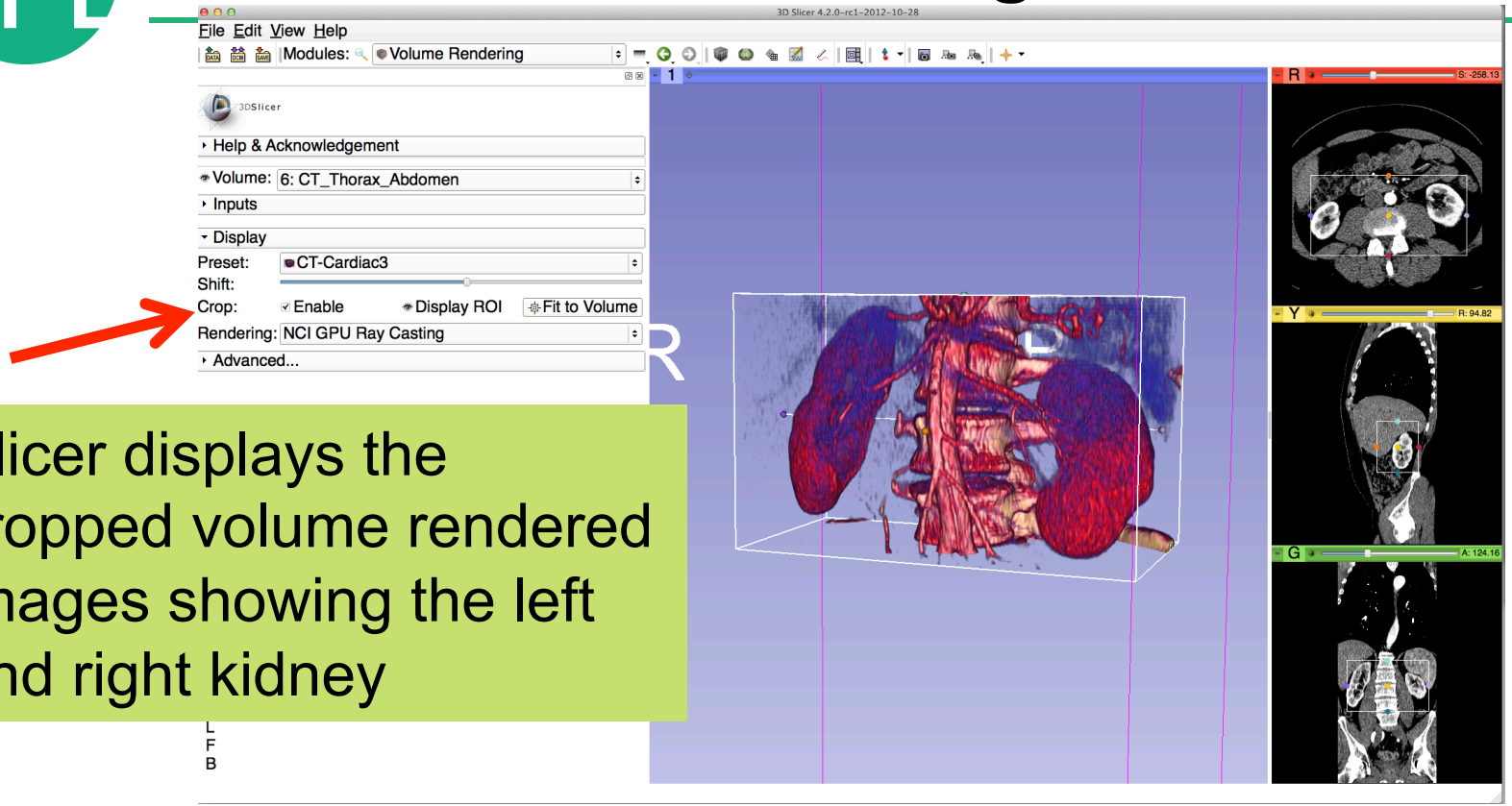
Position the ROI around the left and right kidneys using the ROI controls both in the 3D viewer and in the 2D views

GPU Volume Rendering



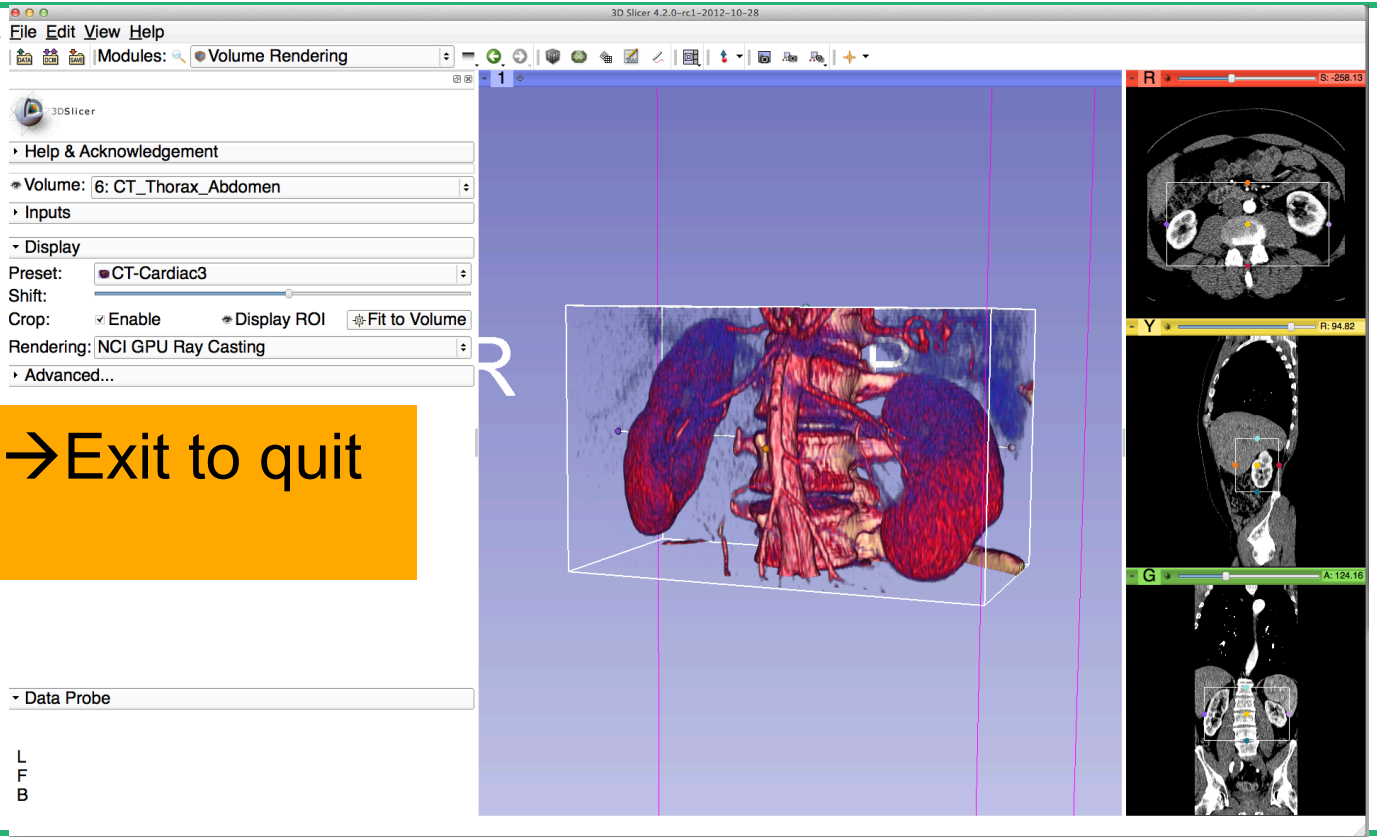
Click on **Enable** to display the cropped volume rendered image

GPU Volume Rendering

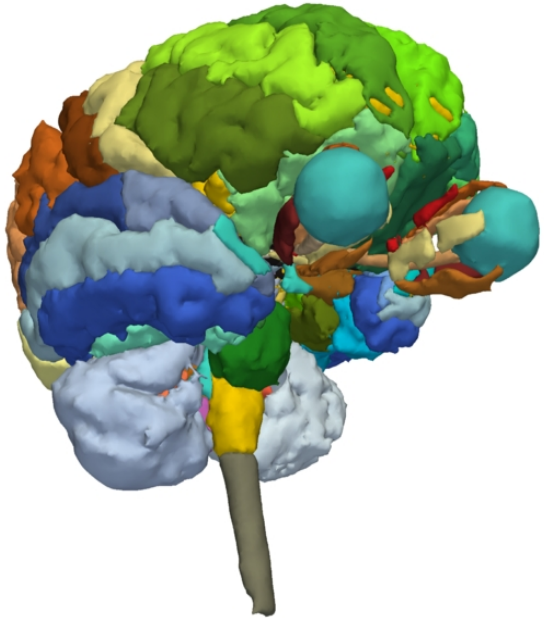


Slicer displays the cropped volume rendered images showing the left and right kidney

GPU Volume Rendering



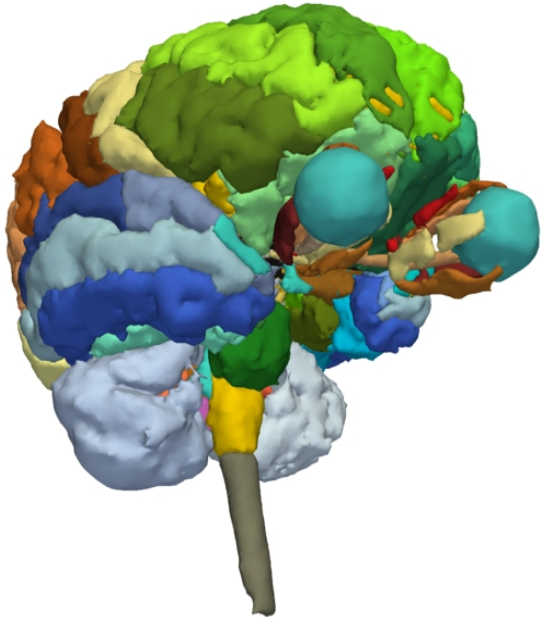
Click on File→Exit to quit Slicer



Part 2:

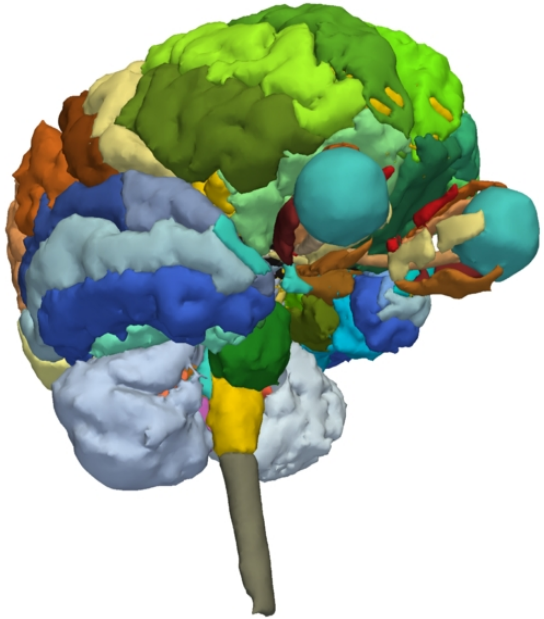
3D visualization of surface models of the brain

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.

3D models of the brain



- The tutorial data are part of the SPL-PNL Brain Atlas developed by Thalos et al

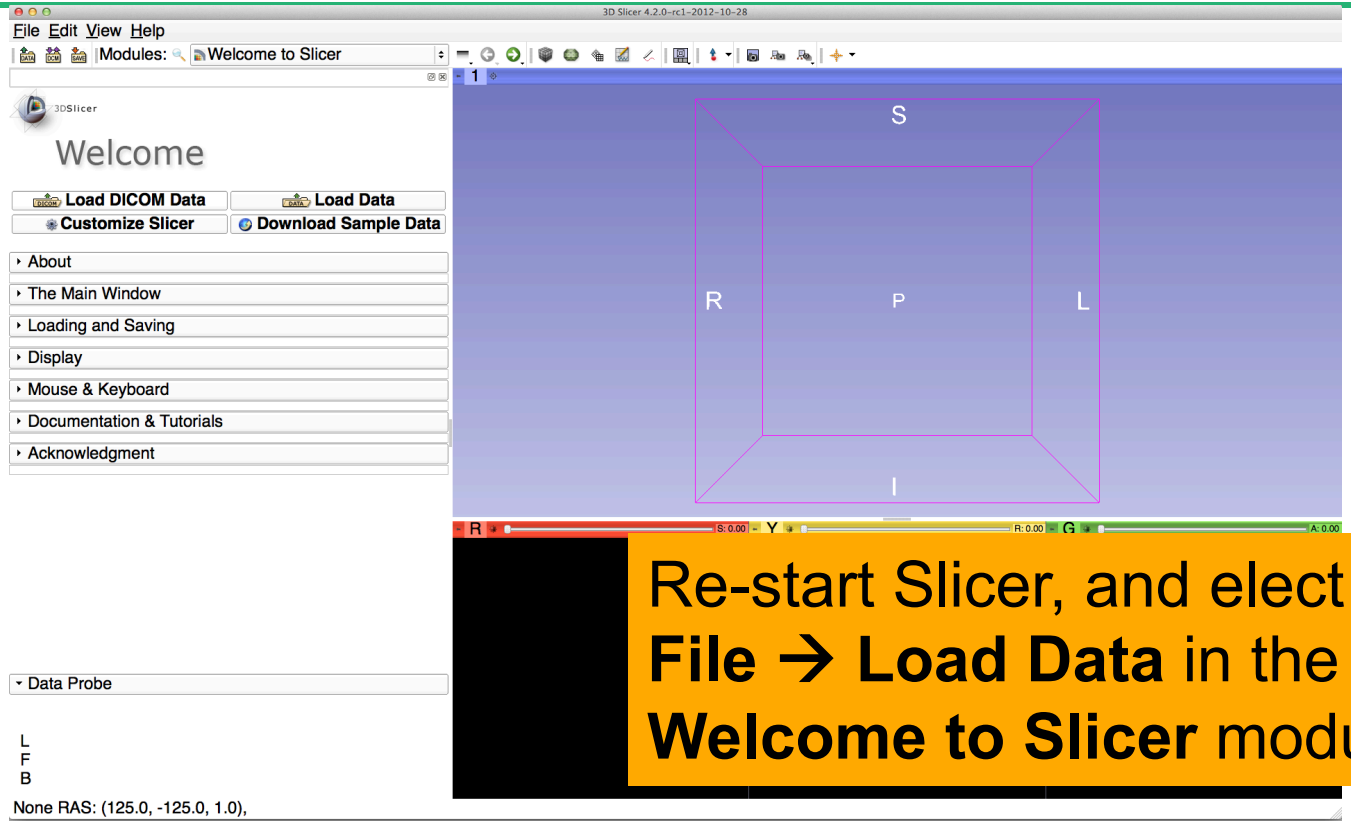
- **RSNA 2011 Presentation:**

Publicly available RaxLex-linked Anatomy Atlases for Image Analysis Informatics and Education. Michael Halle, Samira Farough, Marianna Jakab, Ron Kikinis

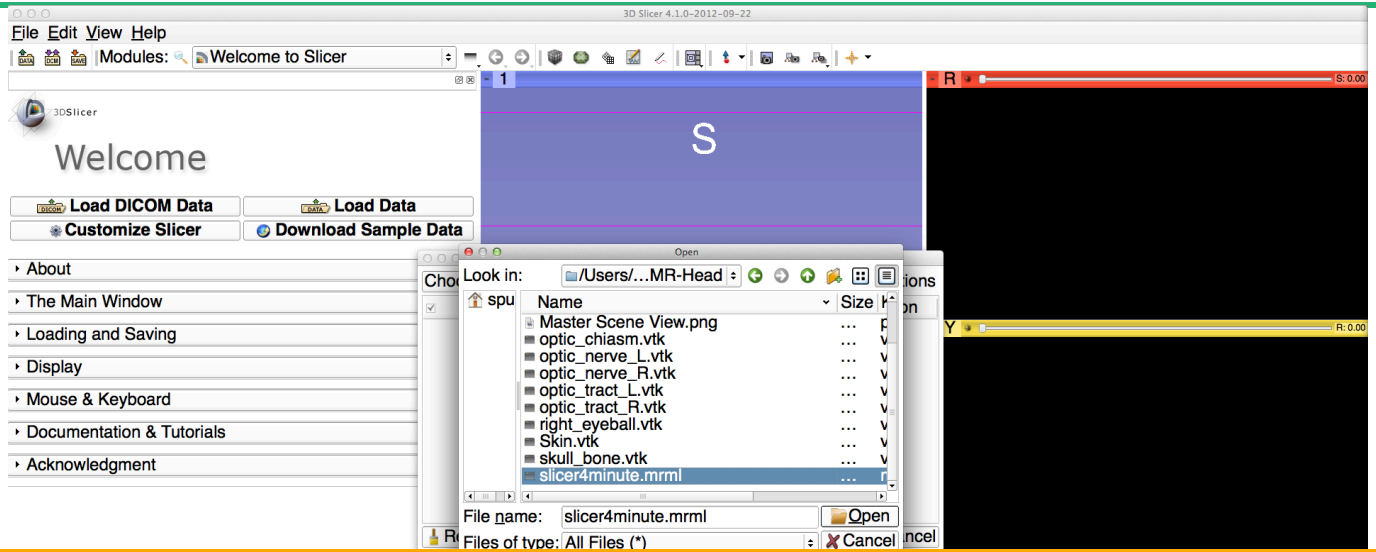
Thurs. Dec.1st, 11:10-11:20 am

Room S402AB

Loading a Scene

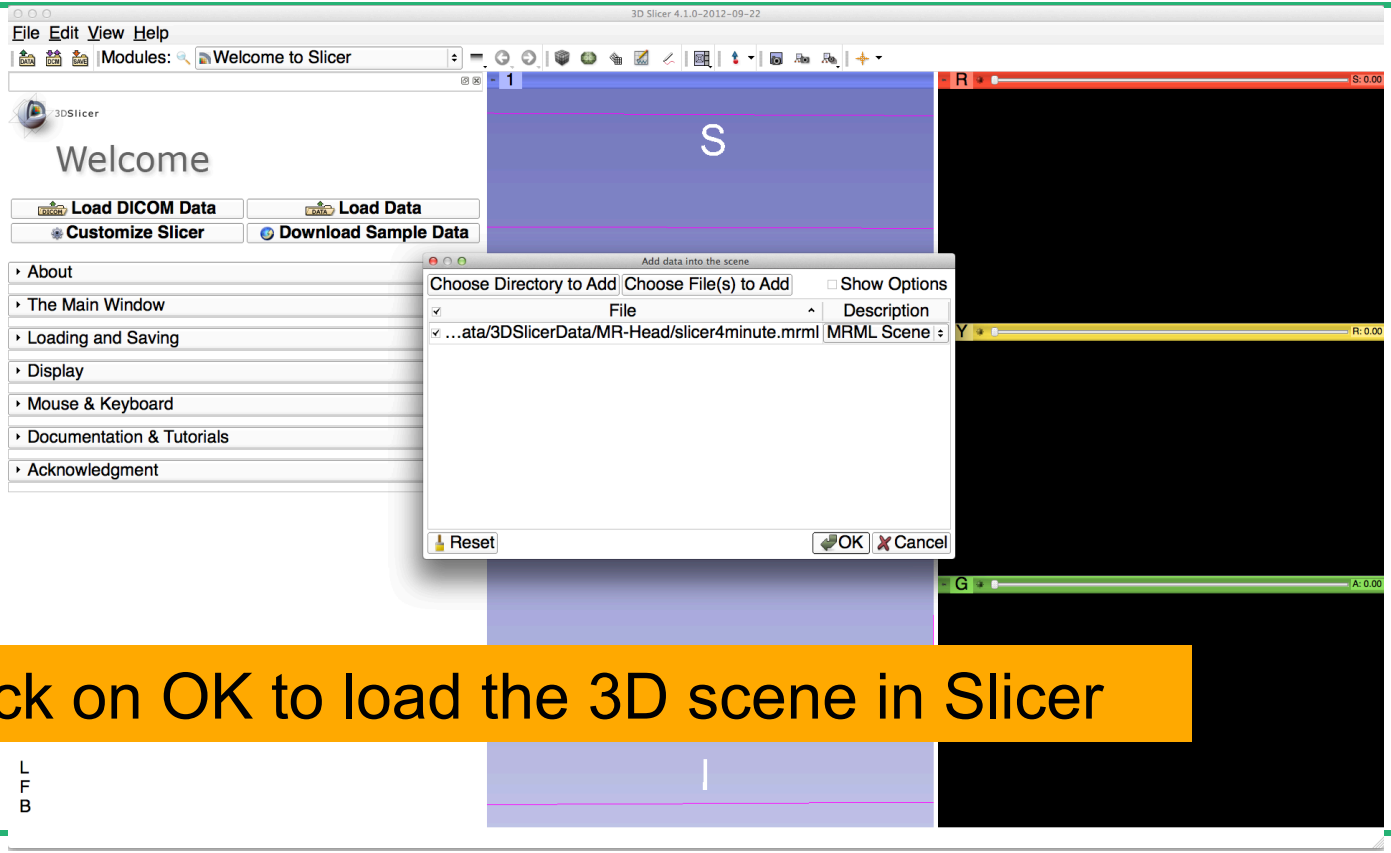


Loading a Scene



Browse to the directory **MR-Head**, located on the Desktop:
C:\Documents and Settings\Administrator\Desktop\3DSlicerData
Select the file **slicer4minute.mrml**, and click on **Open**

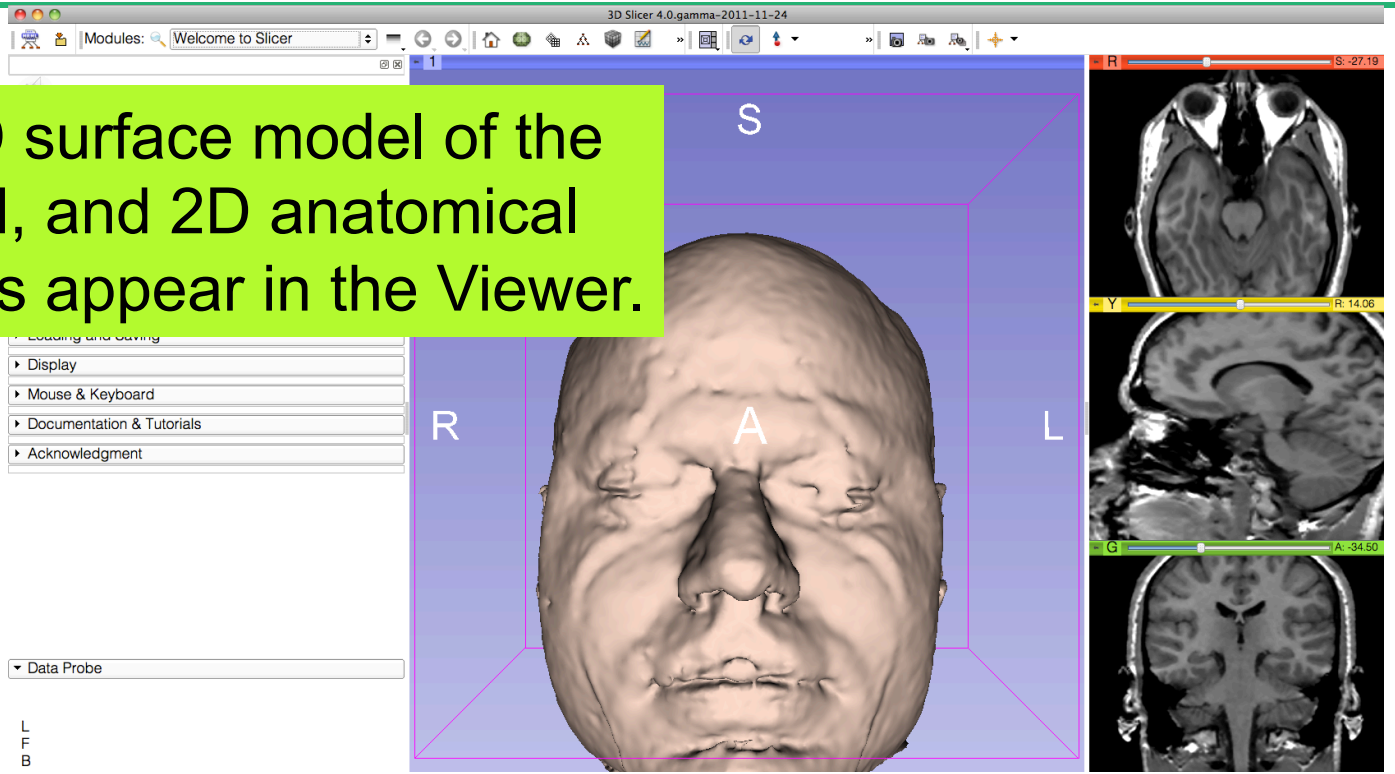
Loading a Scene



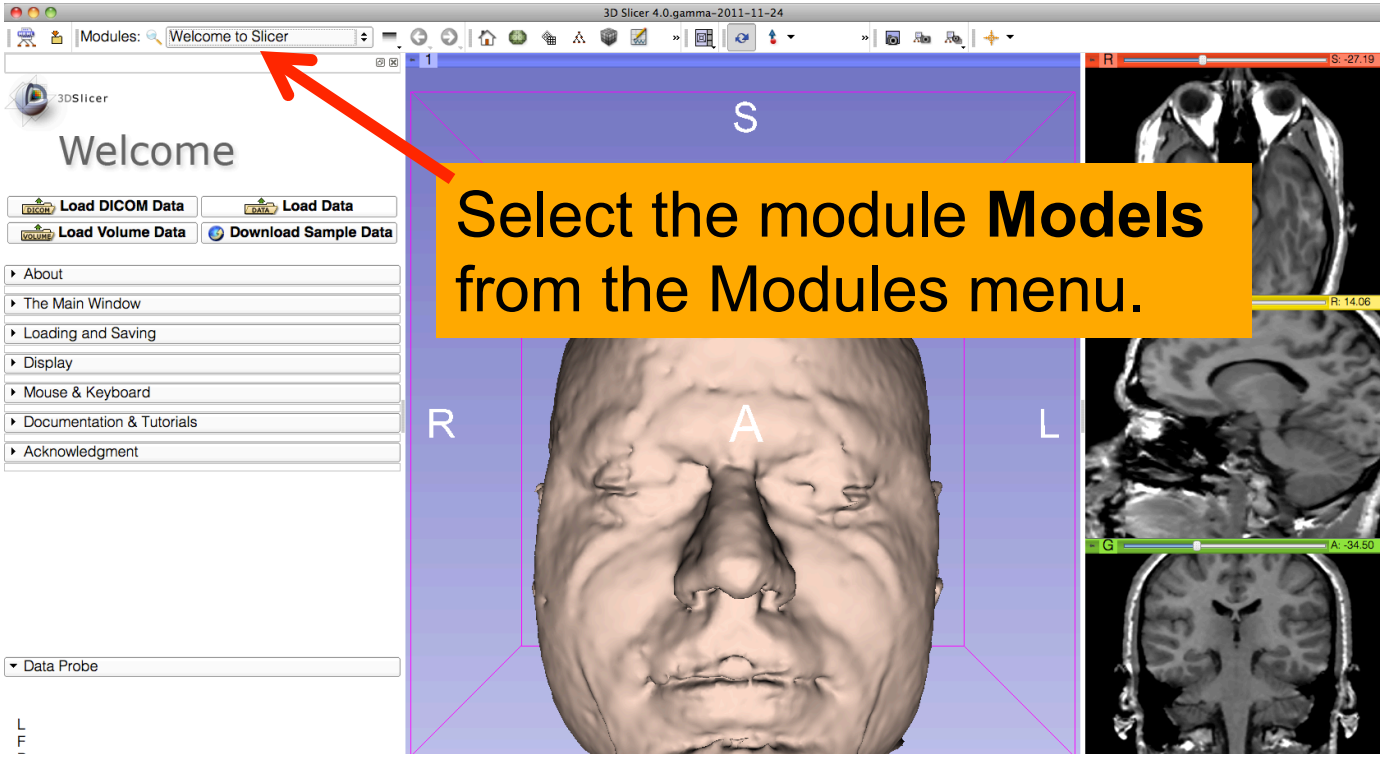
Click on OK to load the 3D scene in Slicer

Loading the Slicer Scene

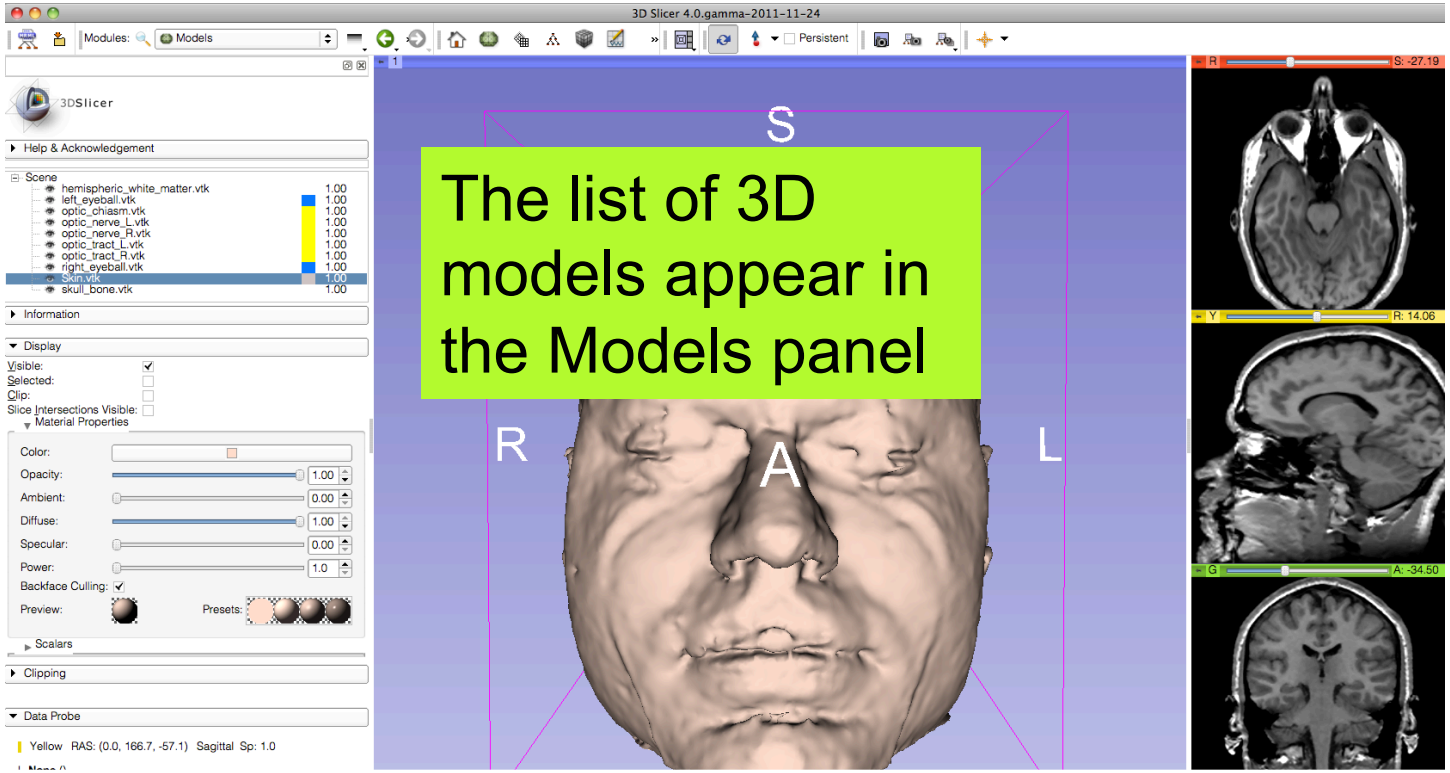
A 3D surface model of the head, and 2D anatomical slices appear in the Viewer.



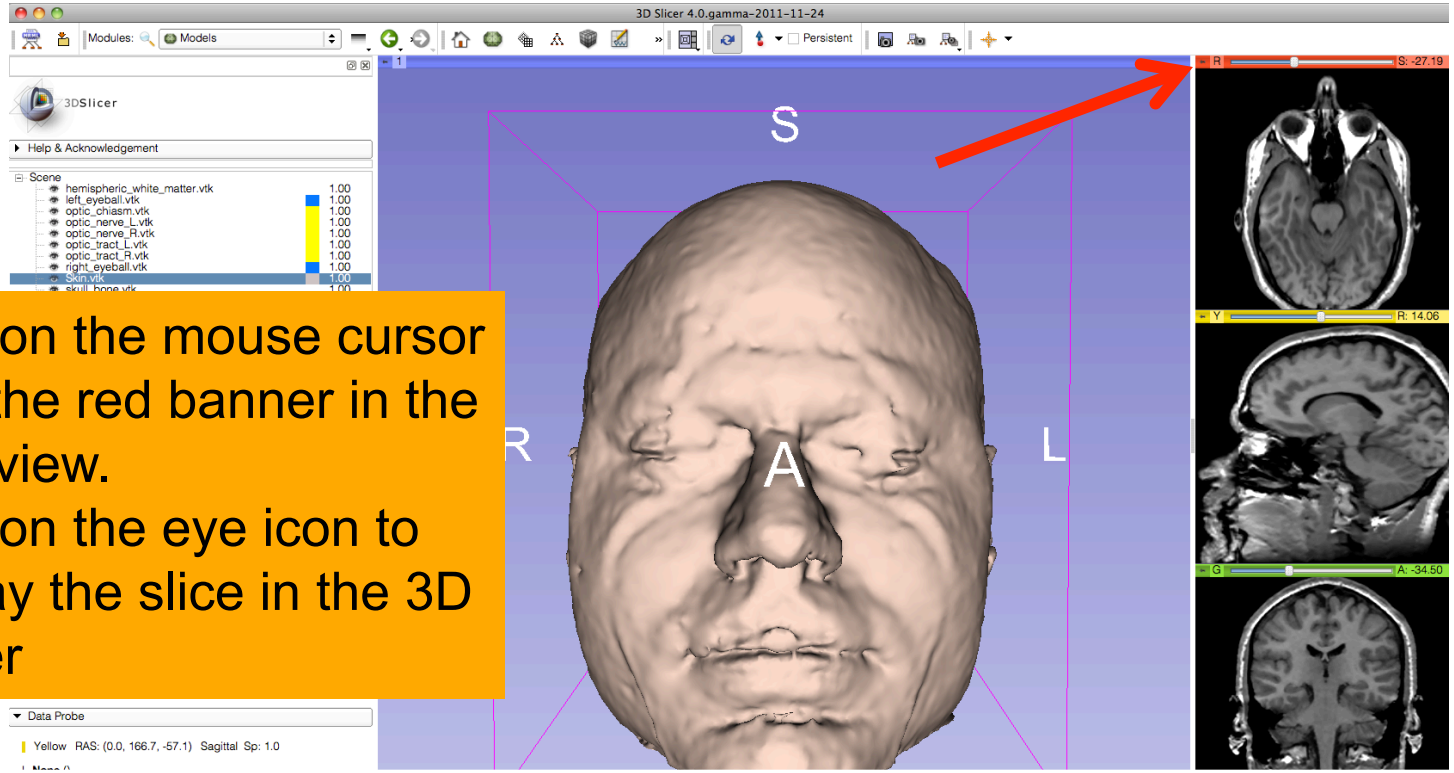
Loading the Slicer Scene



Models module

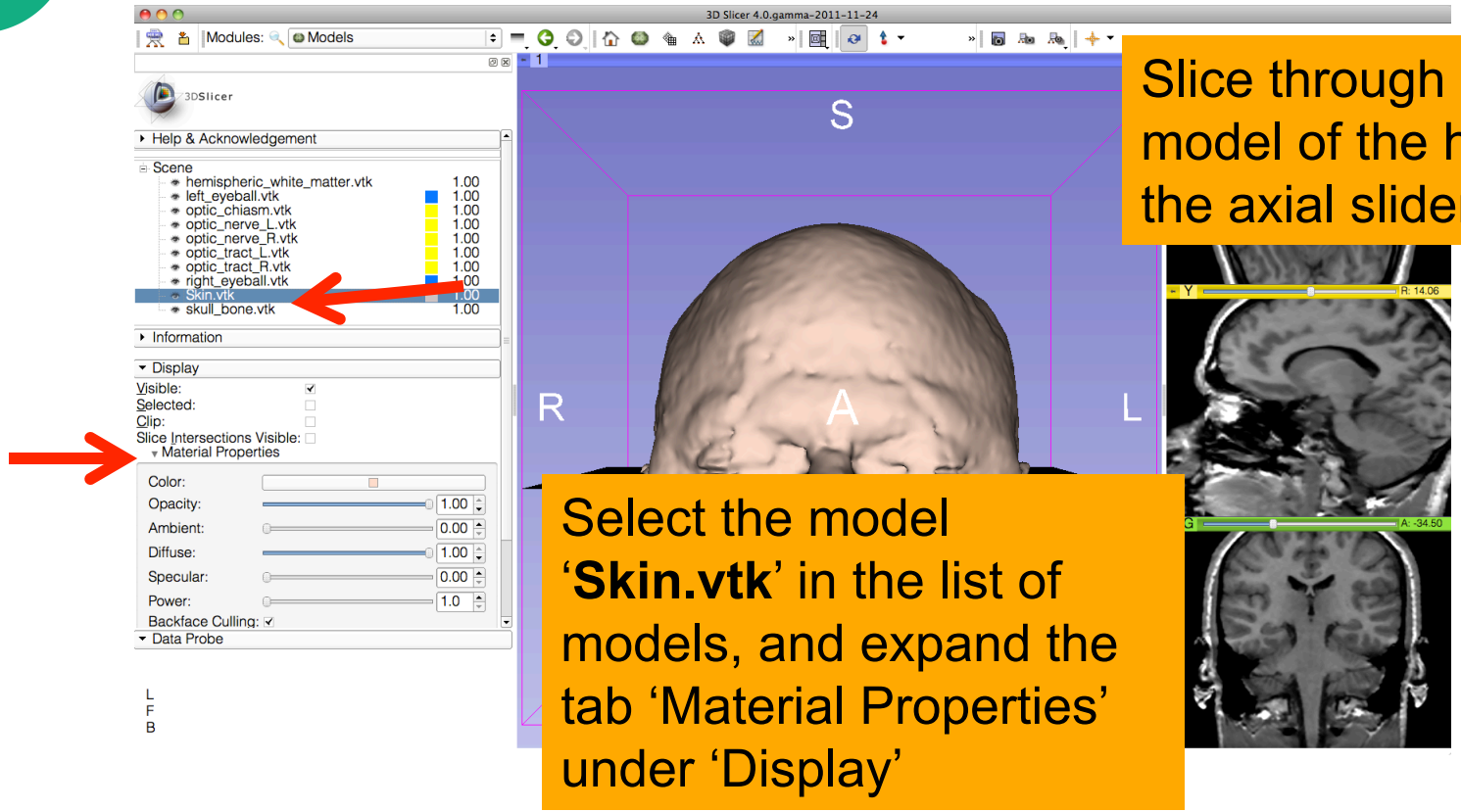


3D Visualization



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

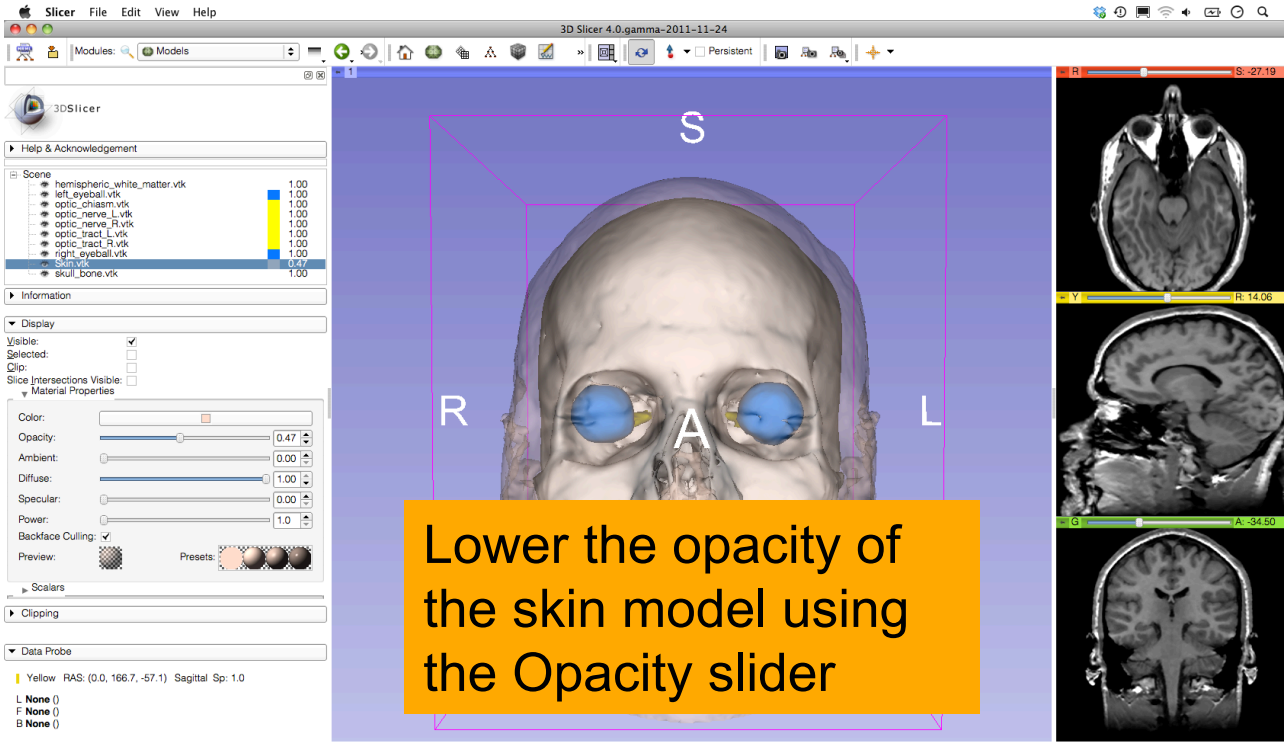
3D Visualization



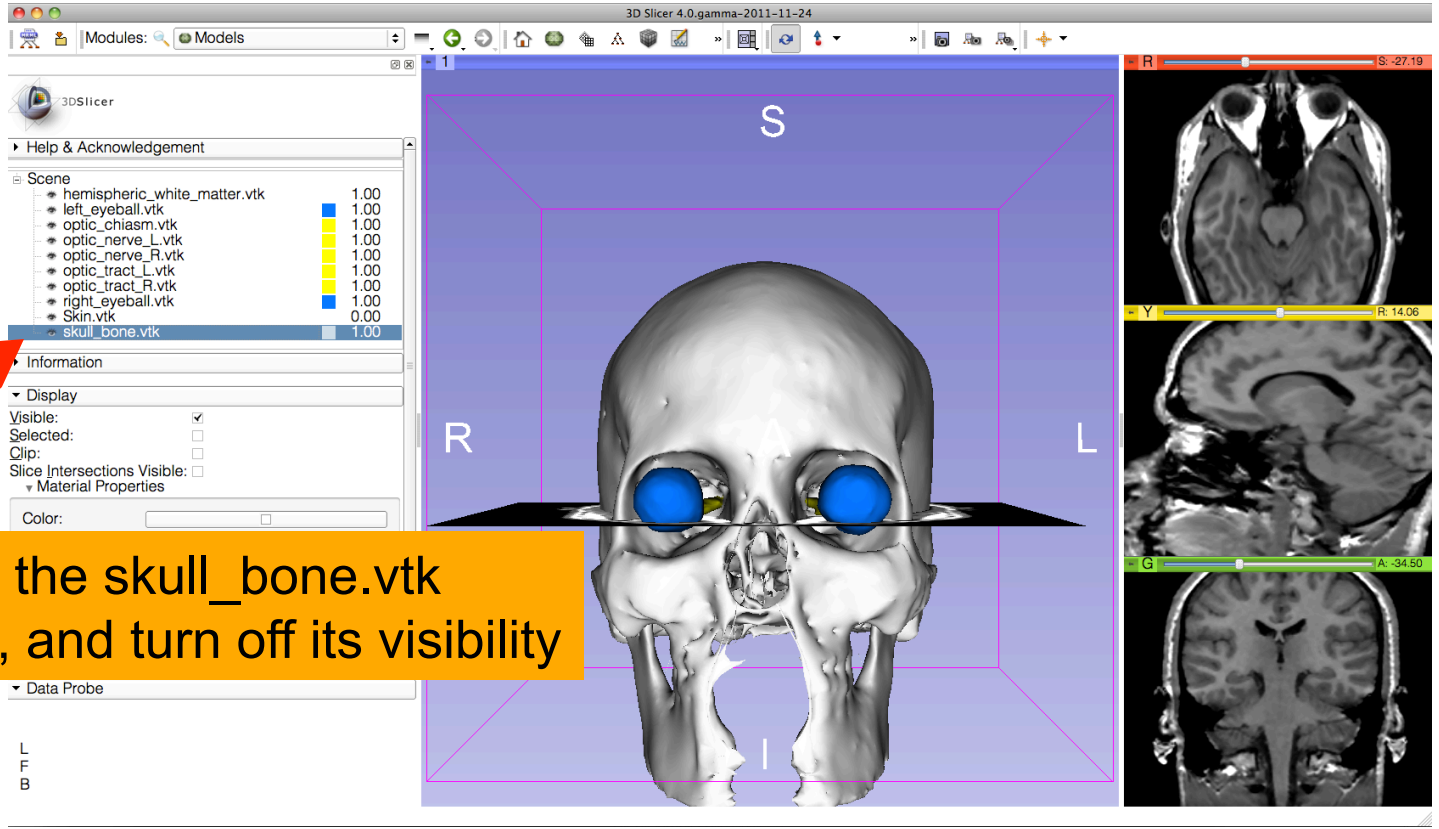
Slice through the 3D model of the head using the axial slider

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

3D Visualization

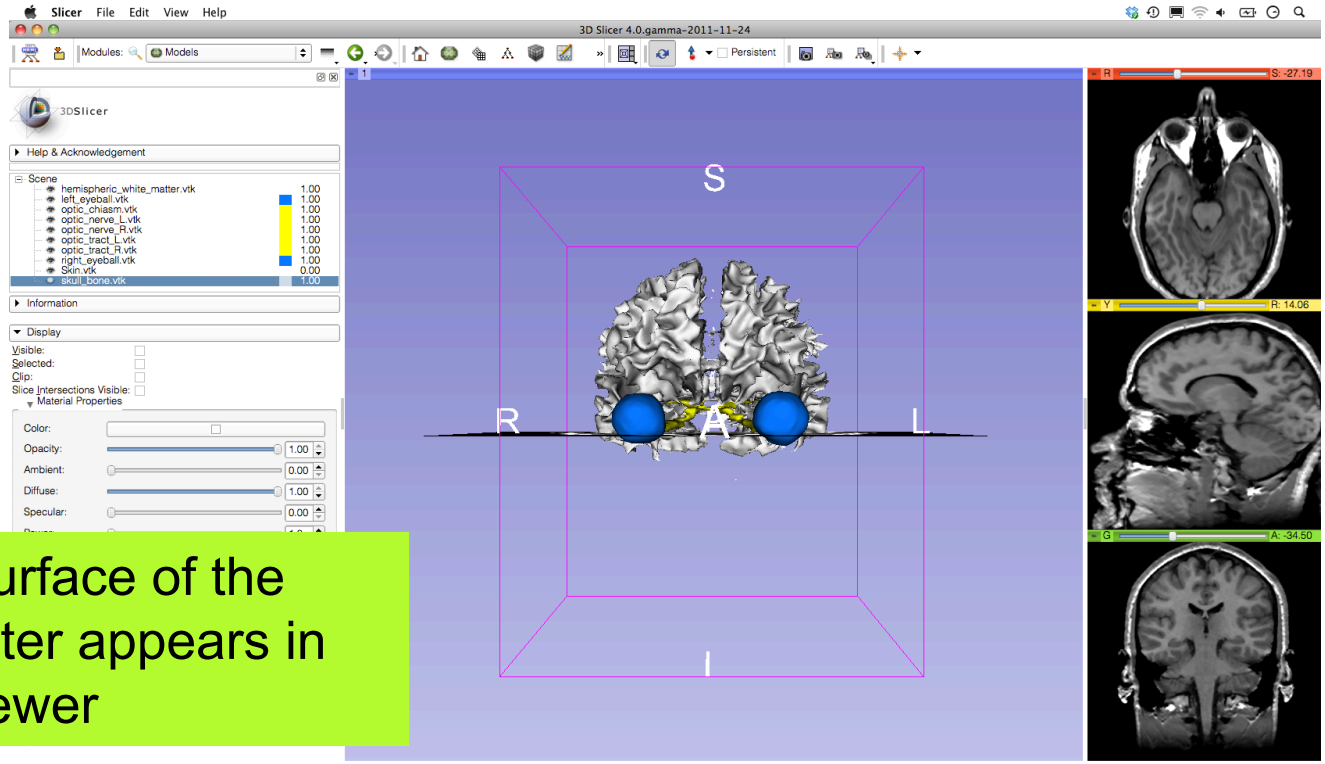


3D Visualization



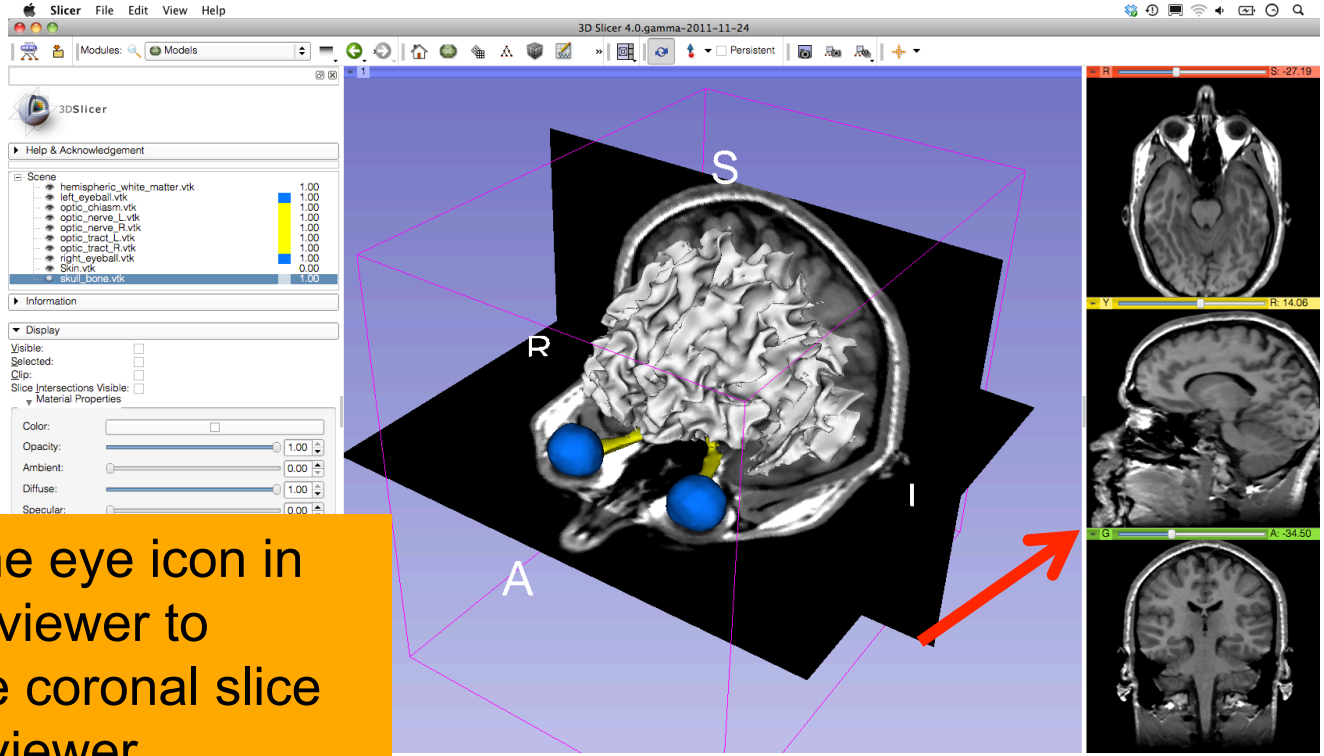
Select the skull_bone.vtk model, and turn off its visibility

3D Visualization



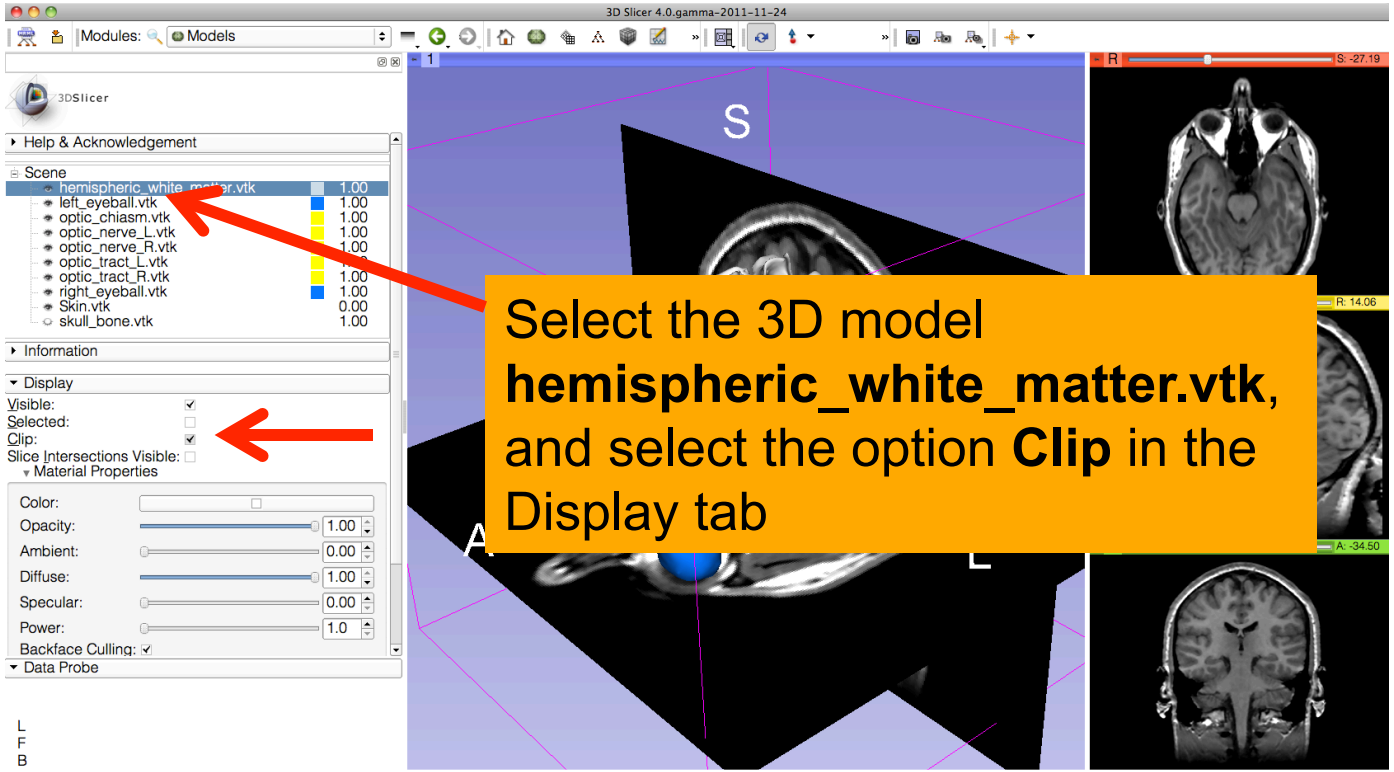
The 3D surface of the white matter appears in the 3D viewer

3D Visualization

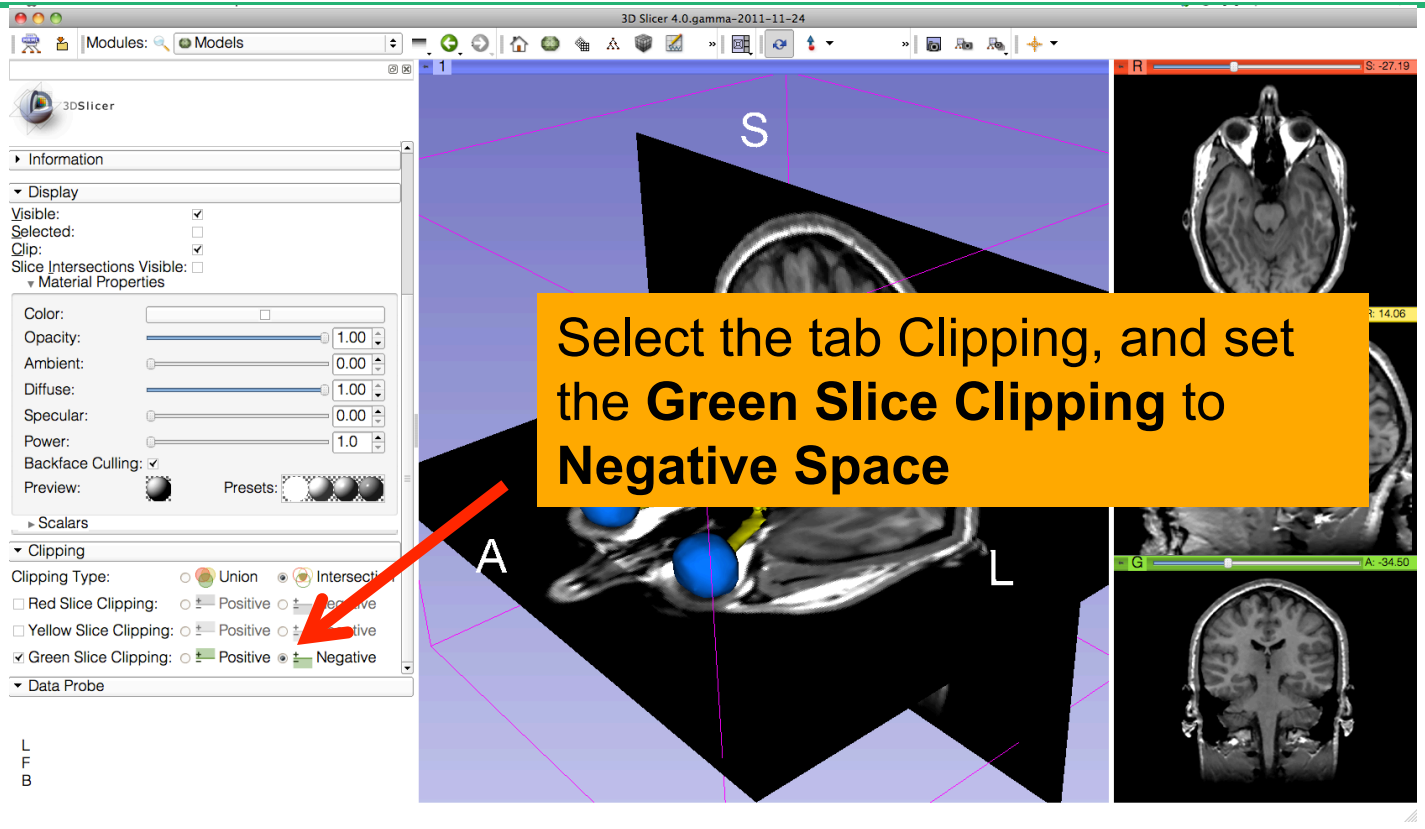


Click on the eye icon in the green viewer to display the coronal slice in the 3D viewer

3D Visualization

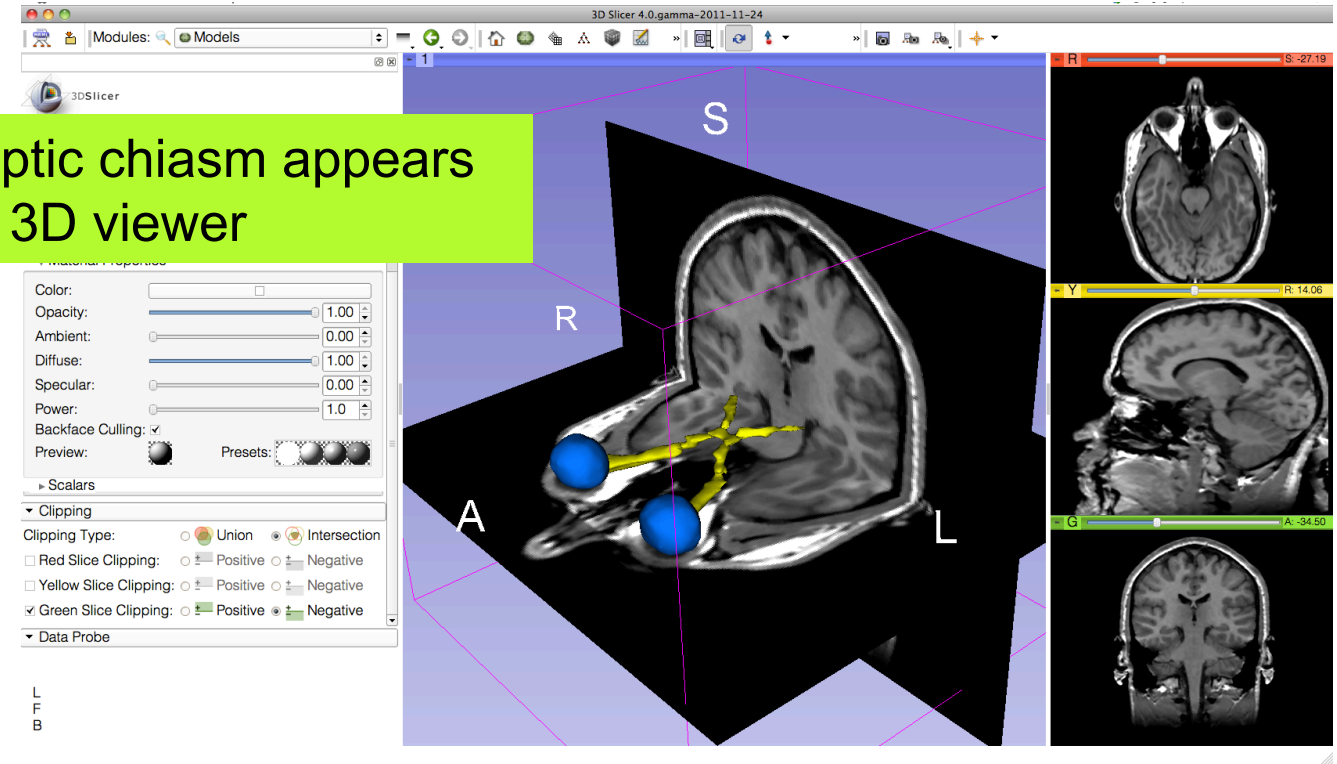


3D Visualization

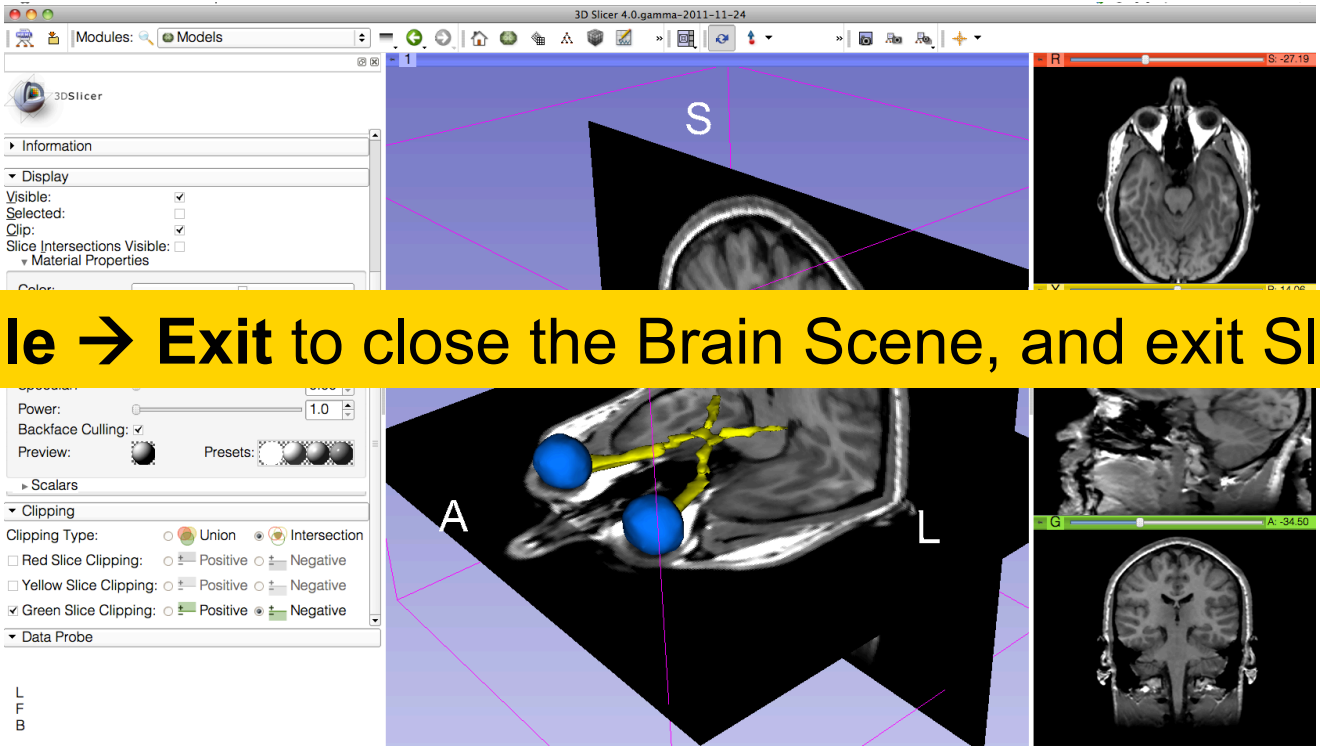


3D Visualization

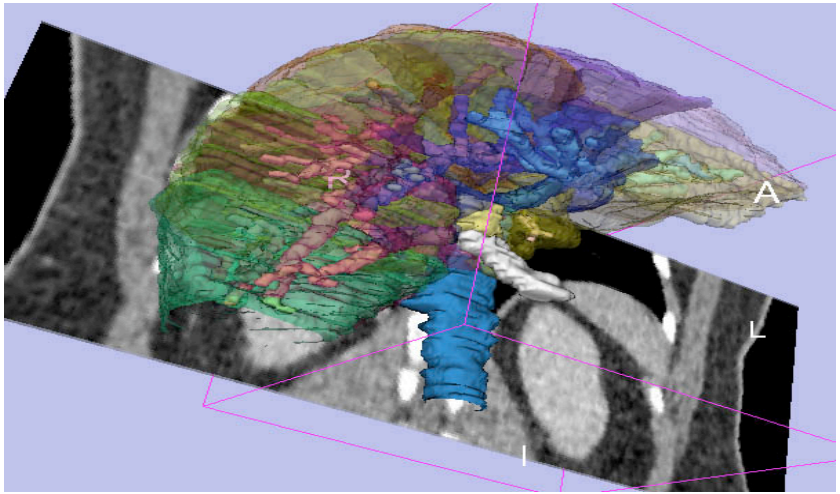
The optic chiasm appears in the 3D viewer



3D Visualization



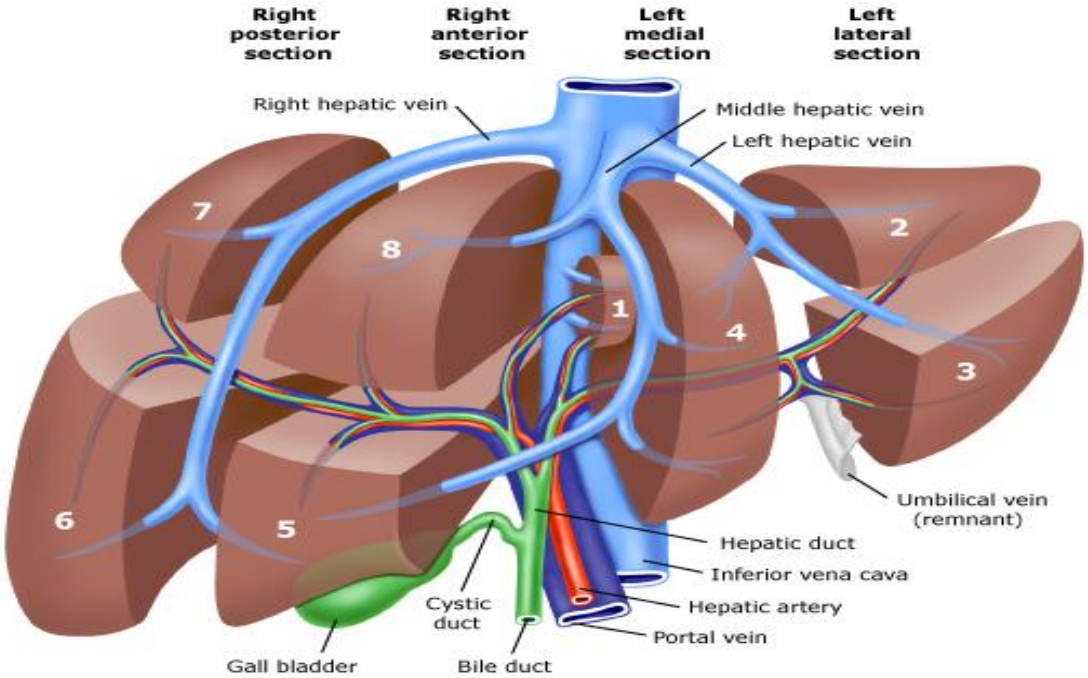
Select **File → Exit** to close the Brain Scene, and exit Slicer



Part 4:

Interactive 3D Visualization of the segments of the liver

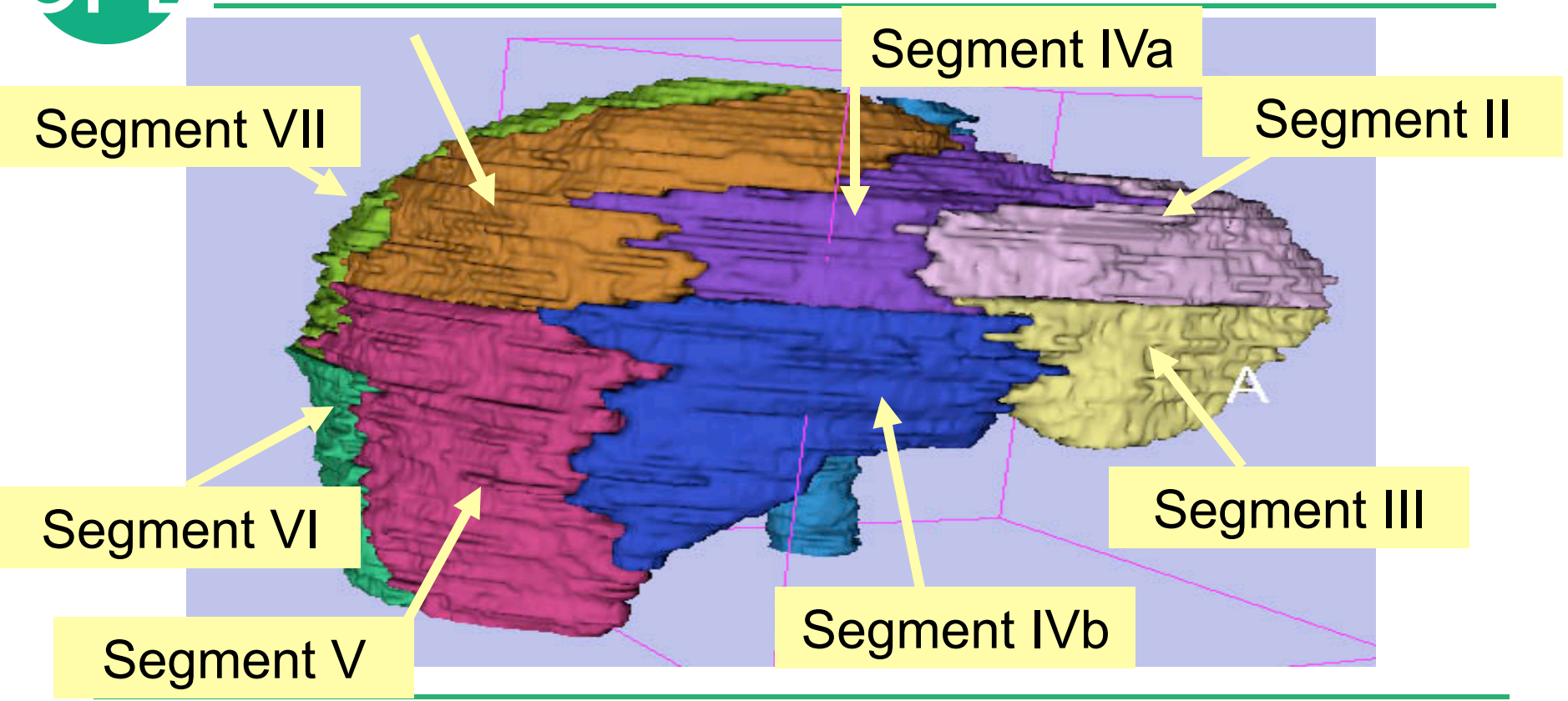
Anatomy of the liver



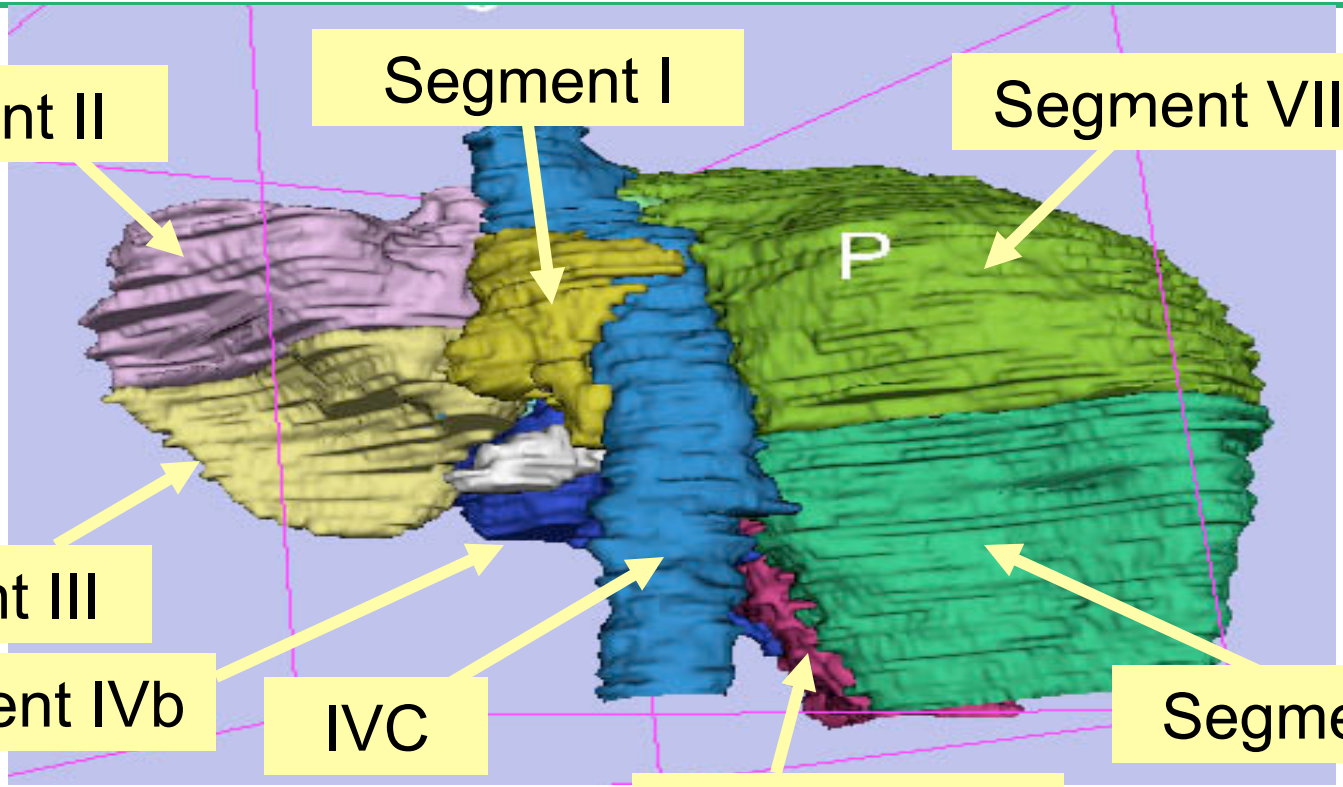
Liver dataset

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

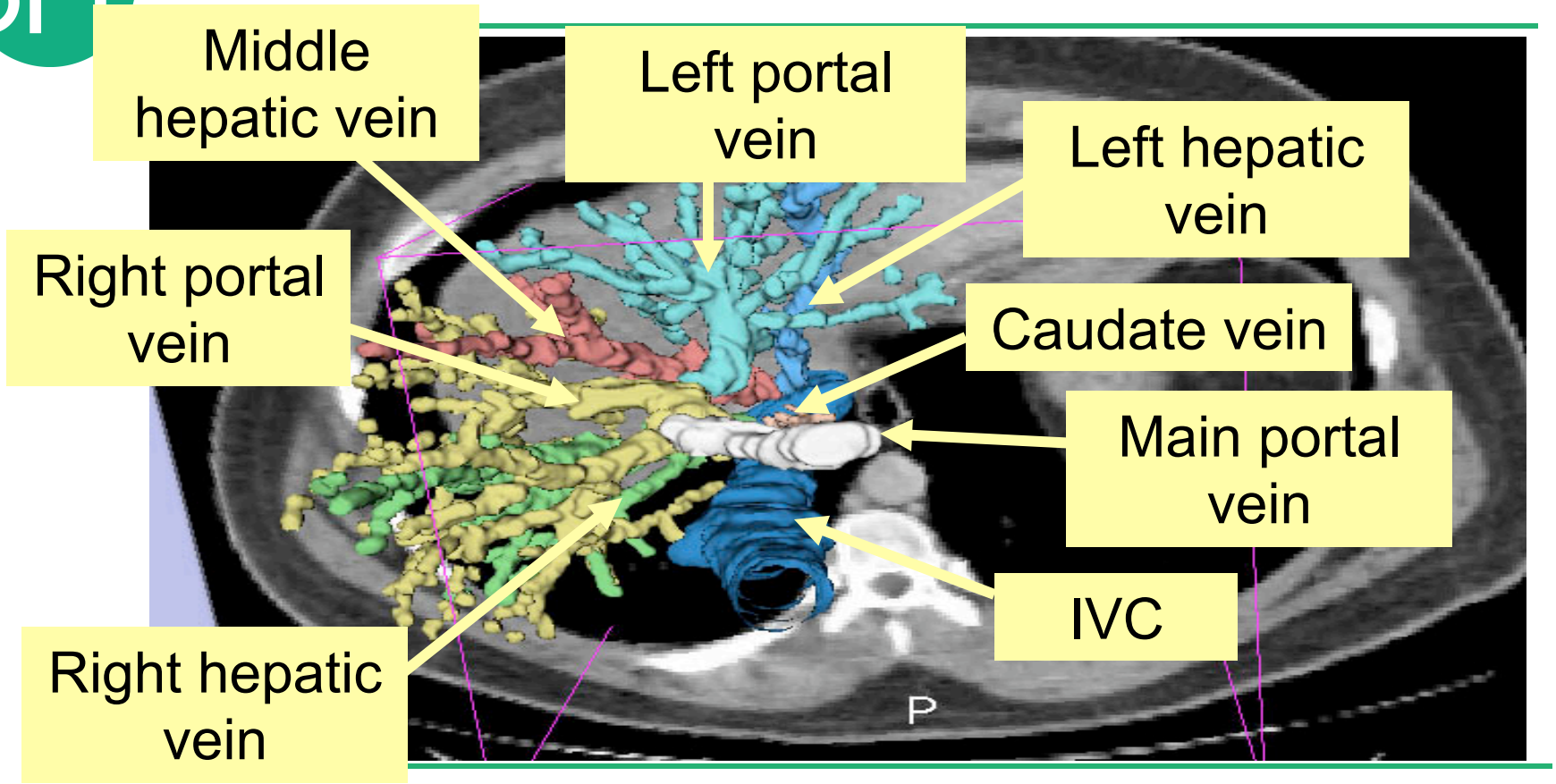
3D segments of the liver



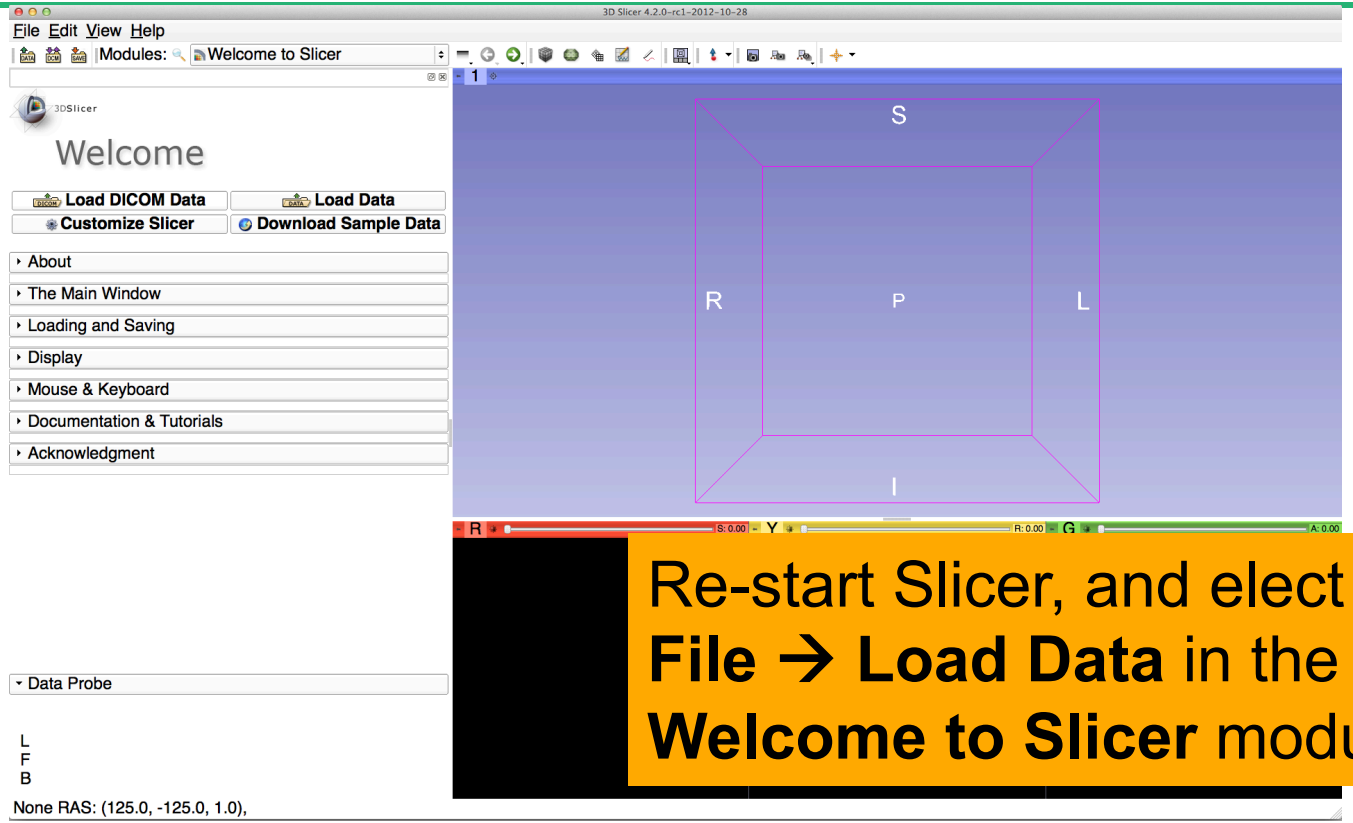
3D segments of the liver



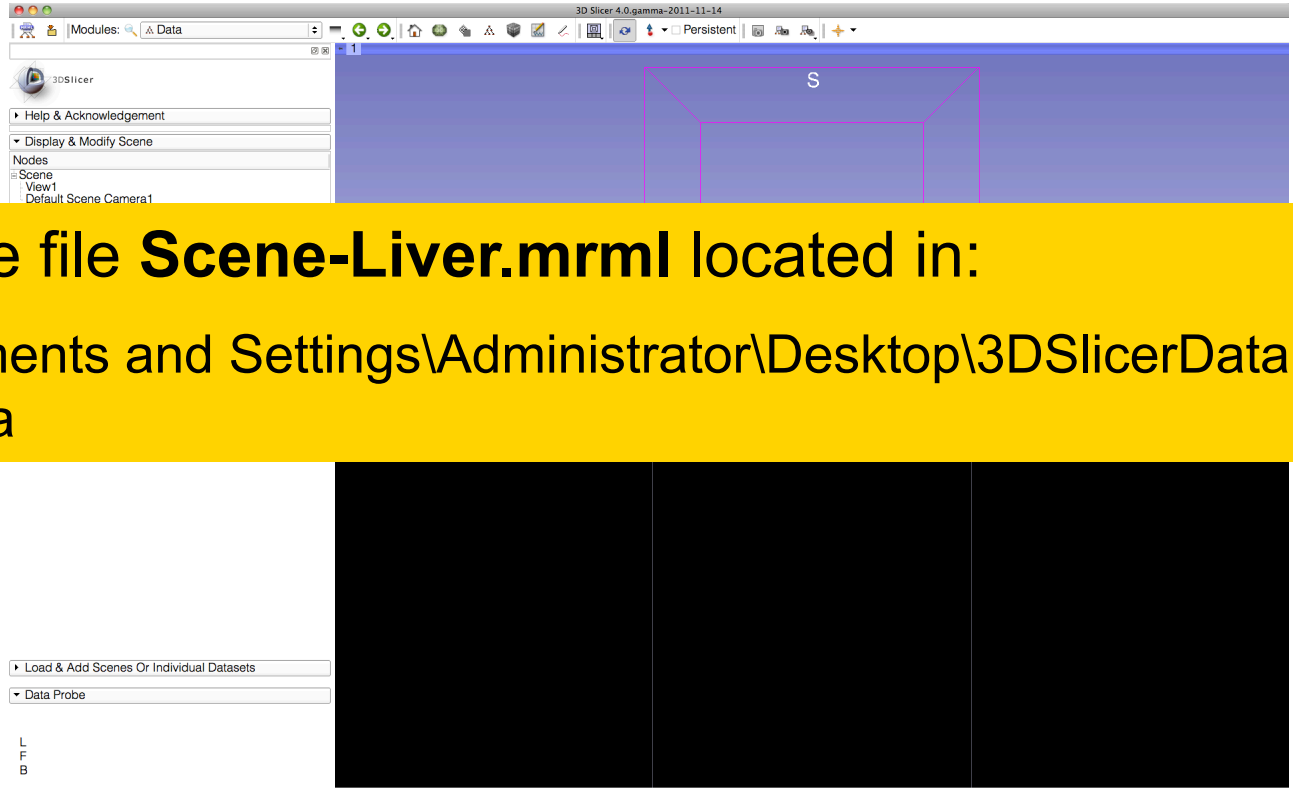
Liver vasculature



Loading the Liver Data Scene



Loading the Liver Scene

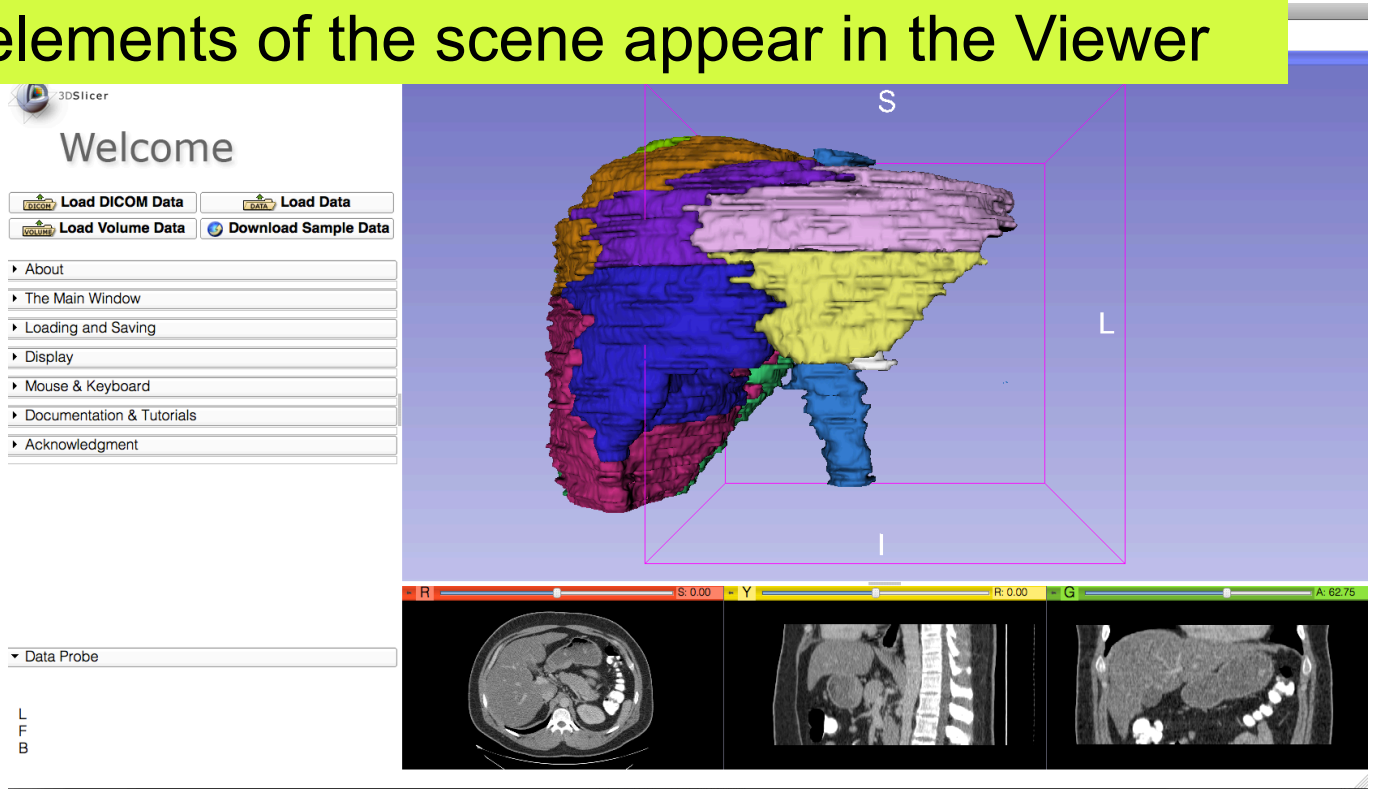


Load the file **Scene-Liver.mrml** located in:

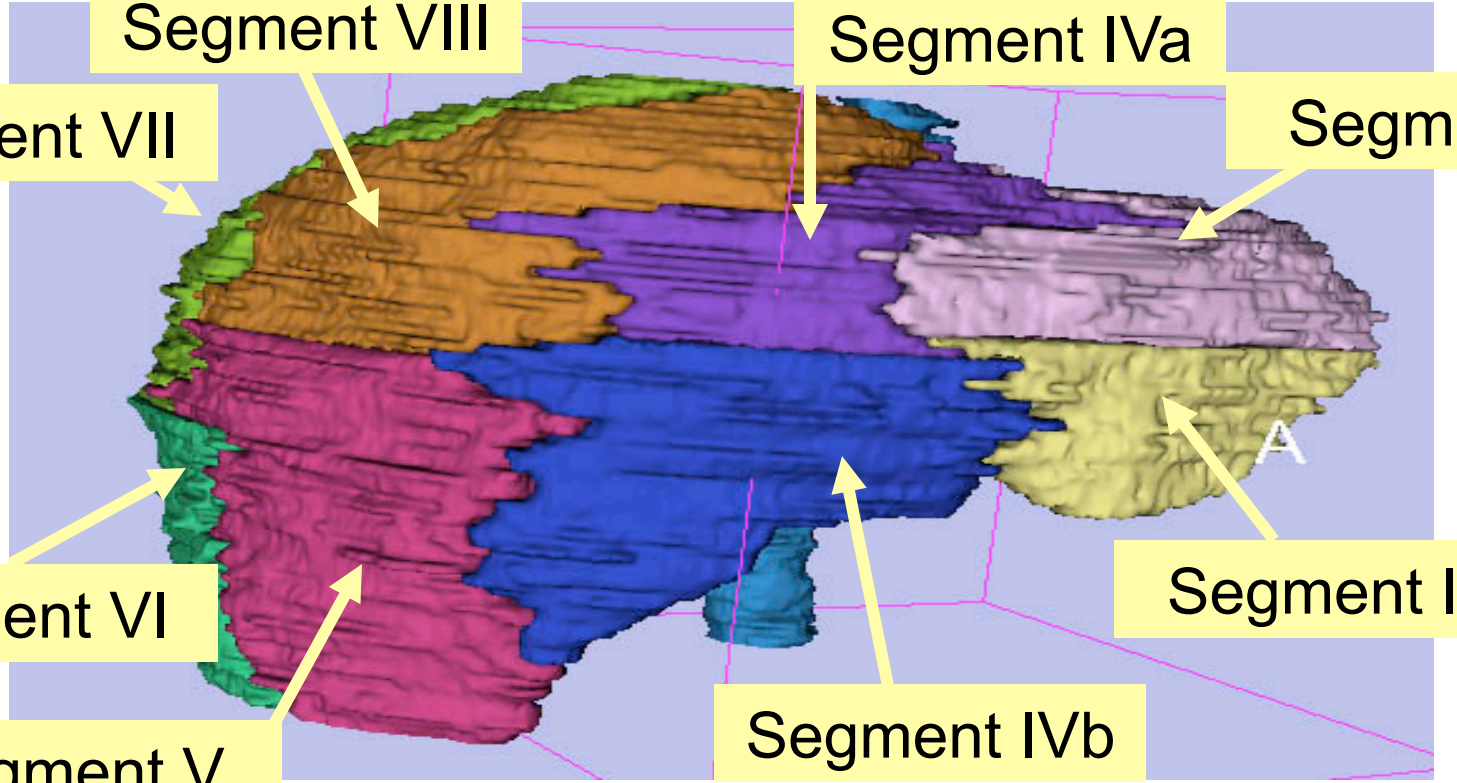
C:\Documents and Settings\Administrator\Desktop\3DSlicerData\LiverData

Liver Segments Scene

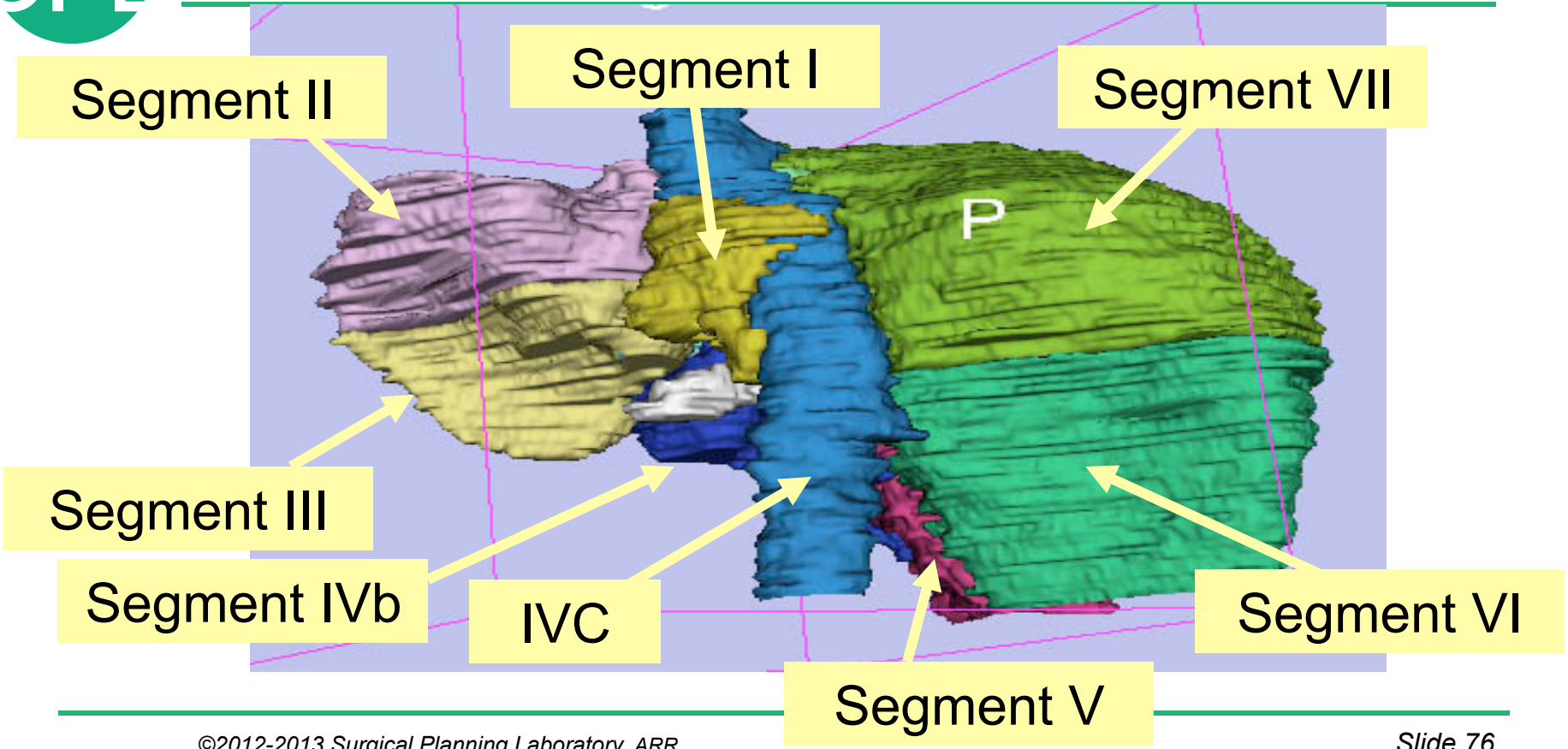
The elements of the scene appear in the Viewer



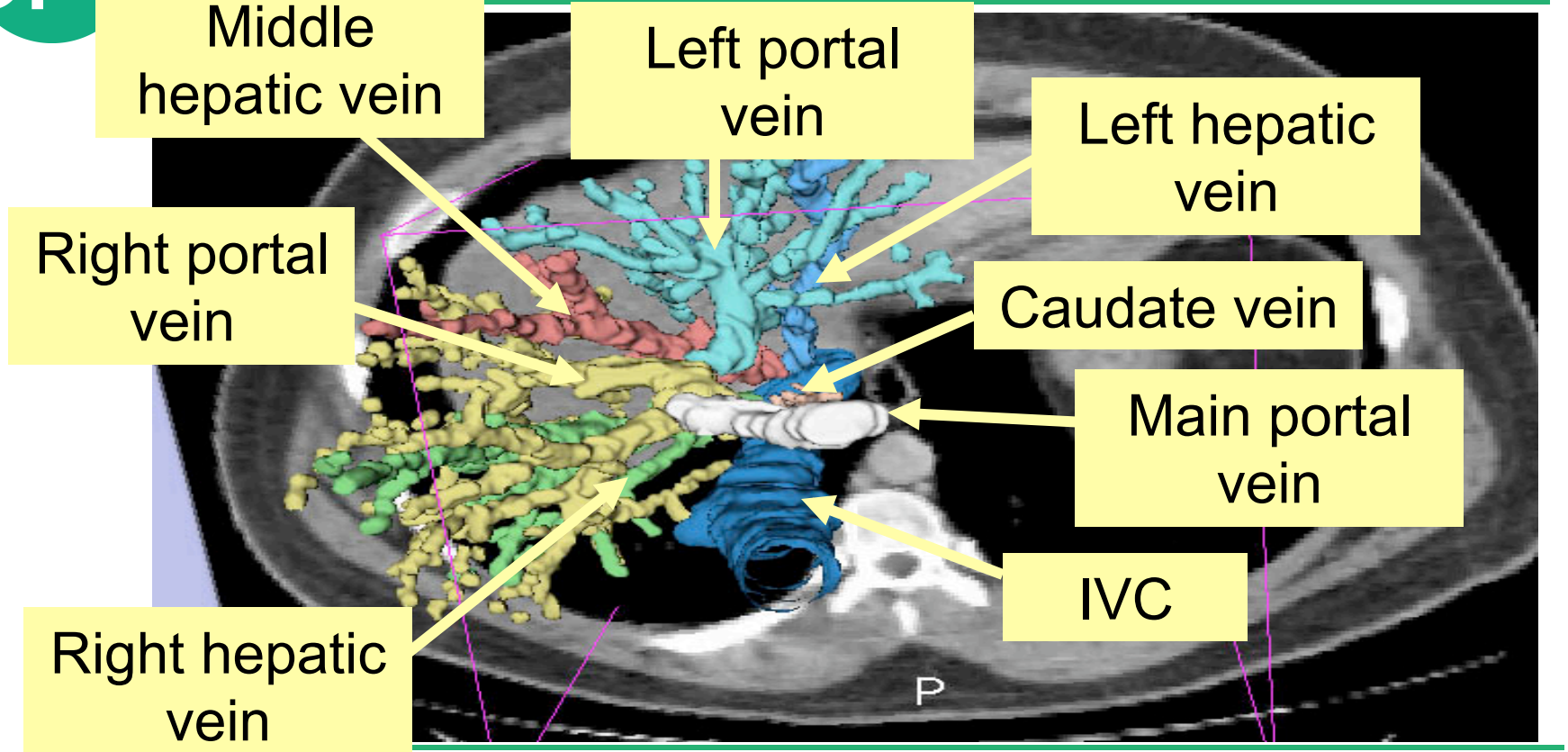
3D models of the liver



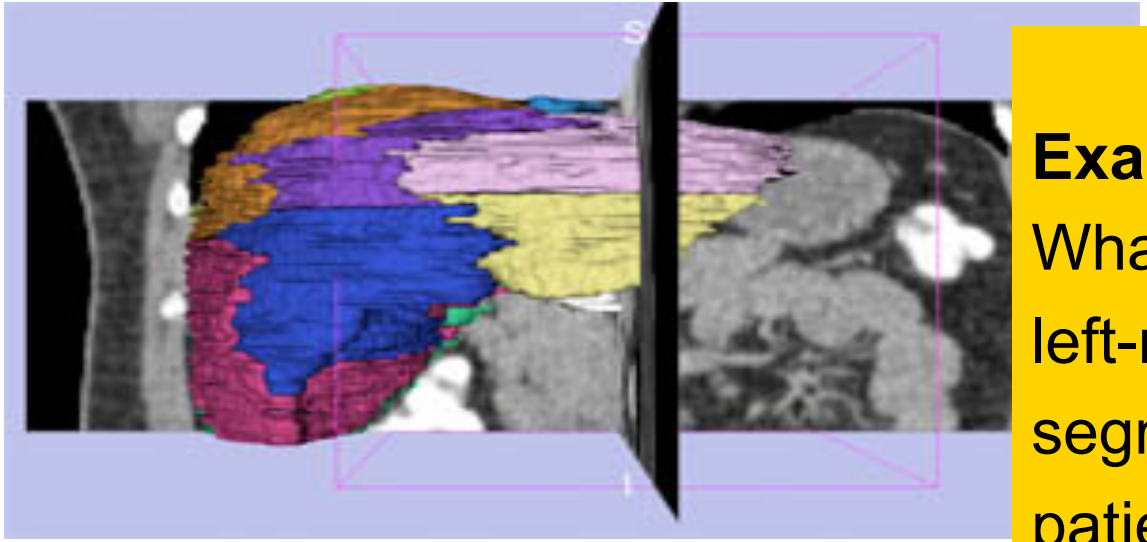
3D models of the liver



3D models of the liver



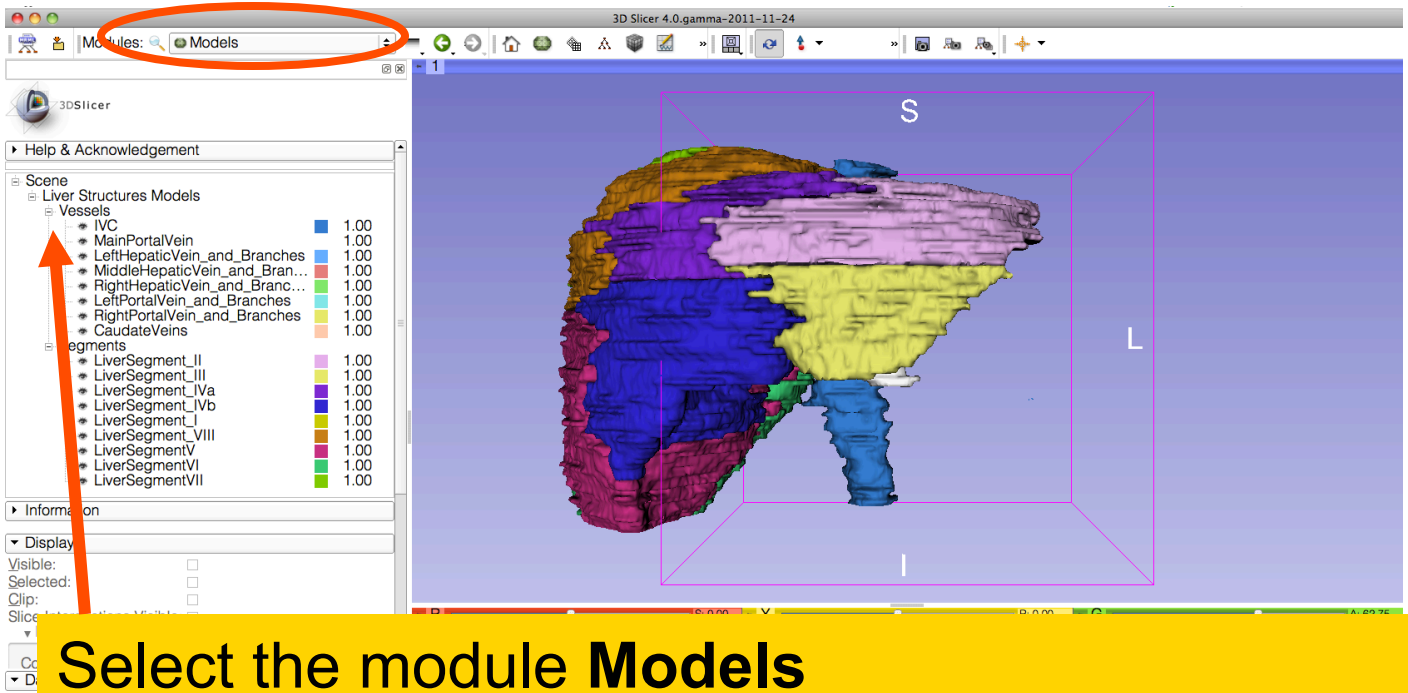
3D Exploration of Liver Segments



Example:

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

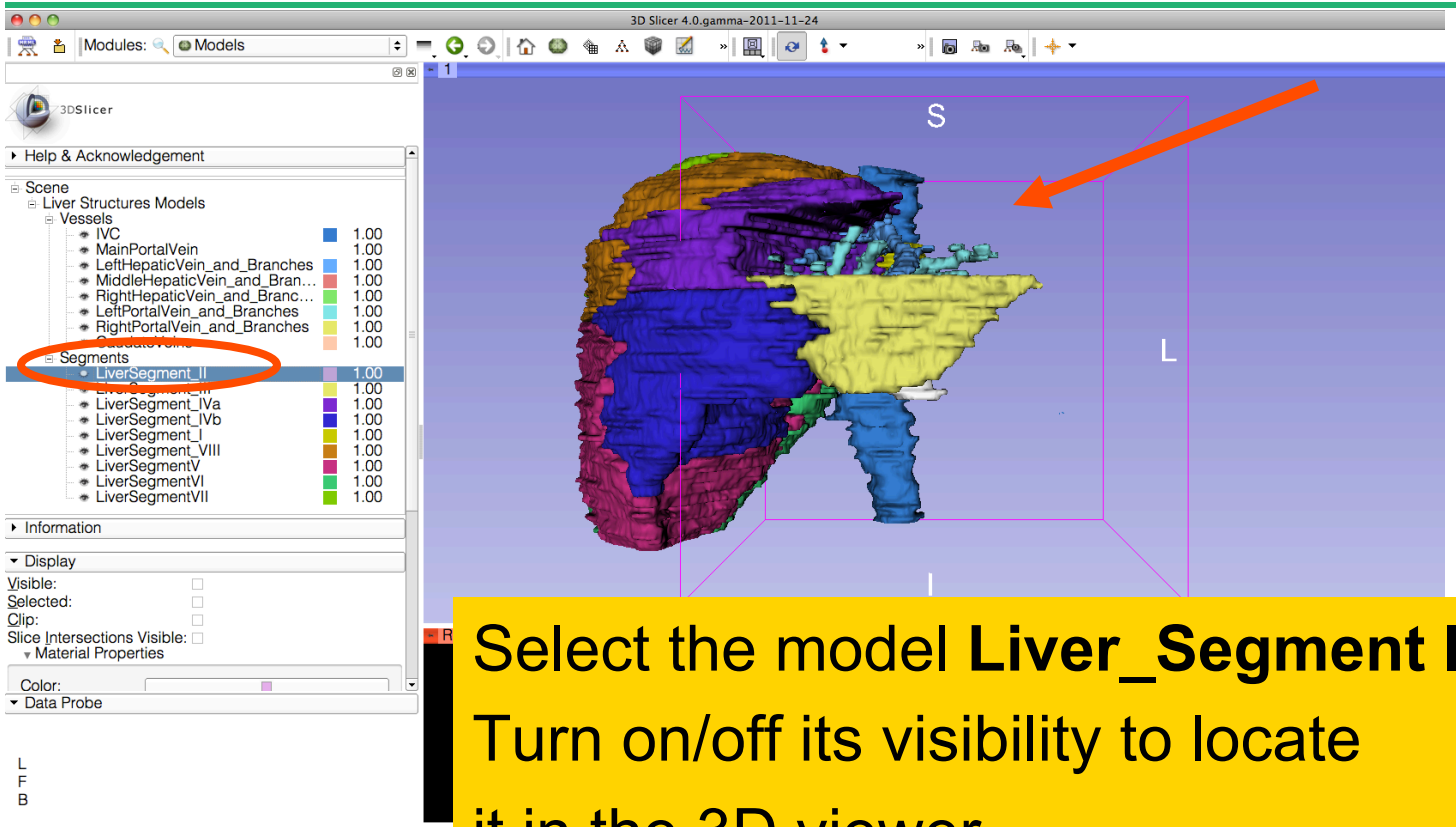
3D Exploration of Liver Segments



Select the module **Models**

Click on the Liver Structures Models Hierarchy

3D Exploration of Liver Segments

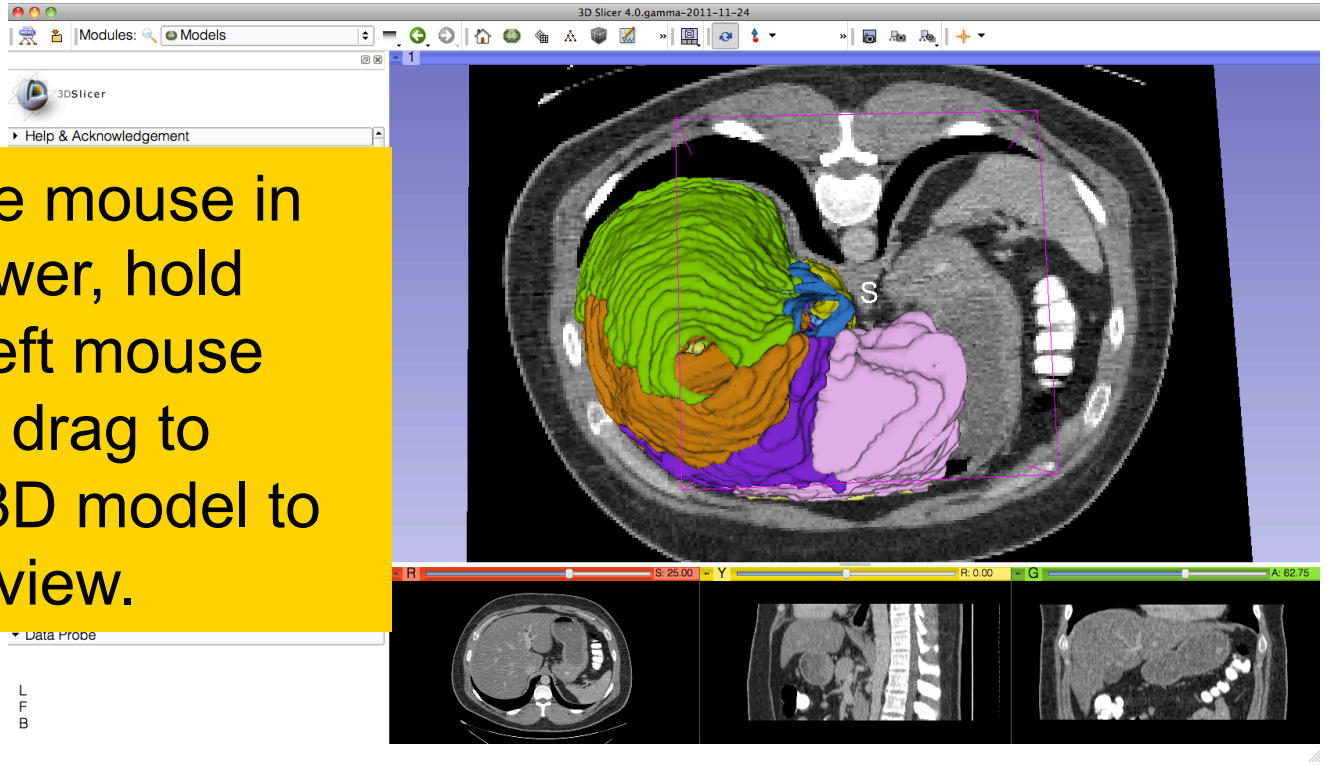


Select the model **Liver_Segment II**

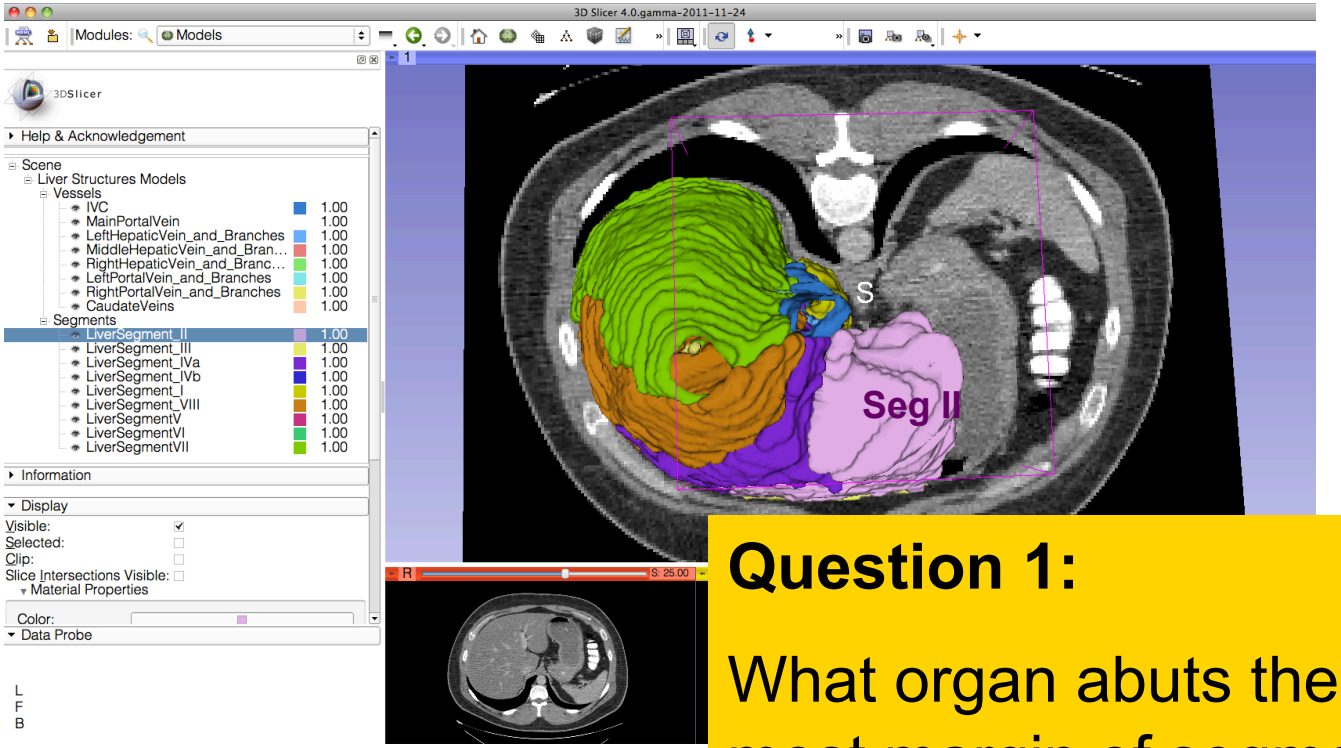
Turn on/off its visibility to locate it in the 3D viewer.

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:

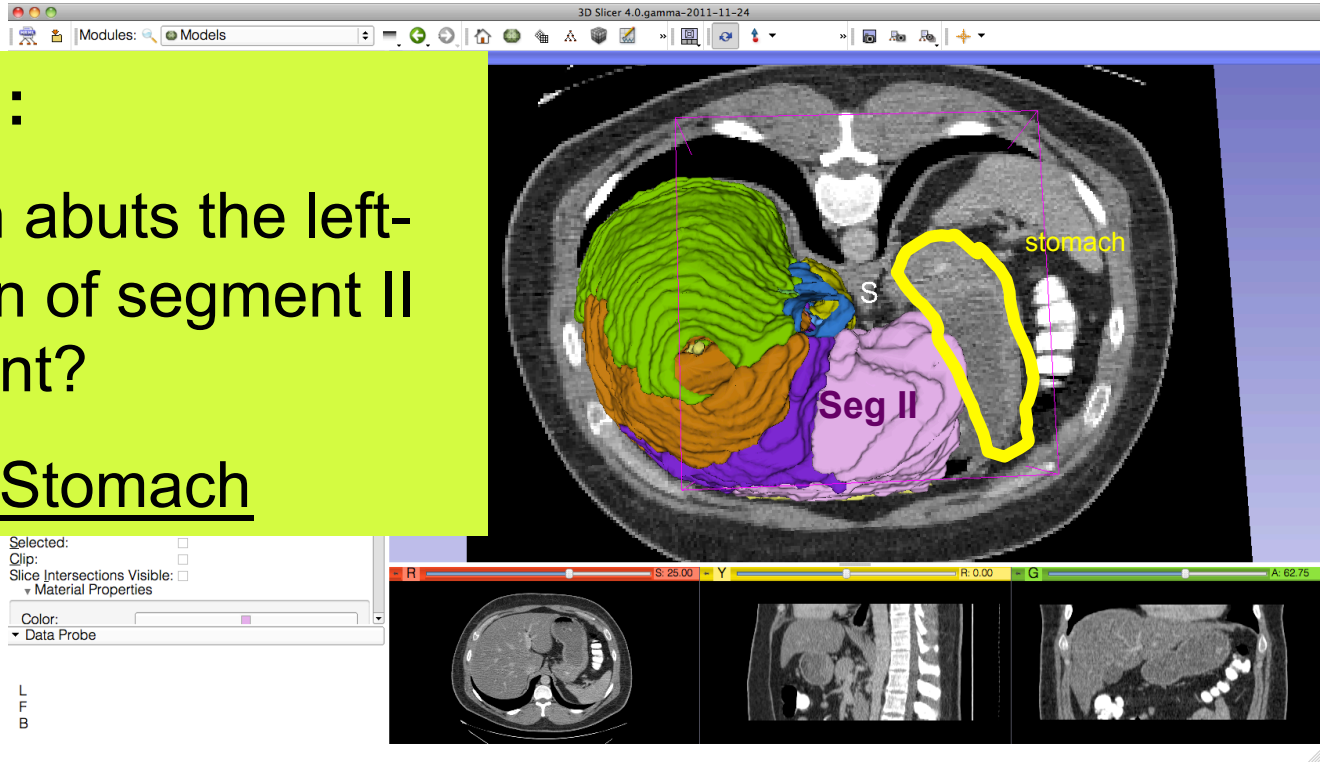
What organ abuts the left-most margin of segment II in Patient 1?

3D Exploration of Liver Segments

Question 1:

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

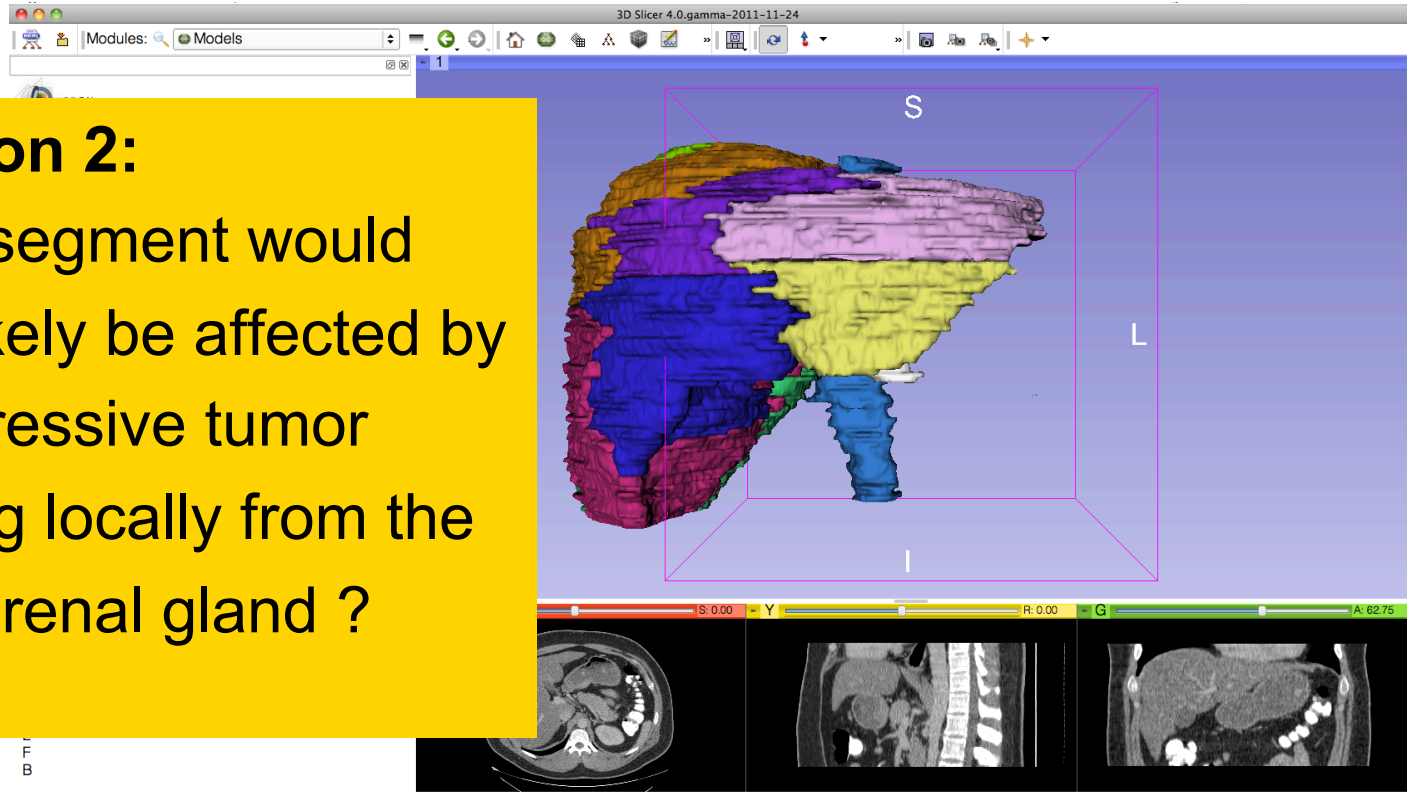
Answer 1: Stomach



3D Exploration of Liver Segments

Question 2:

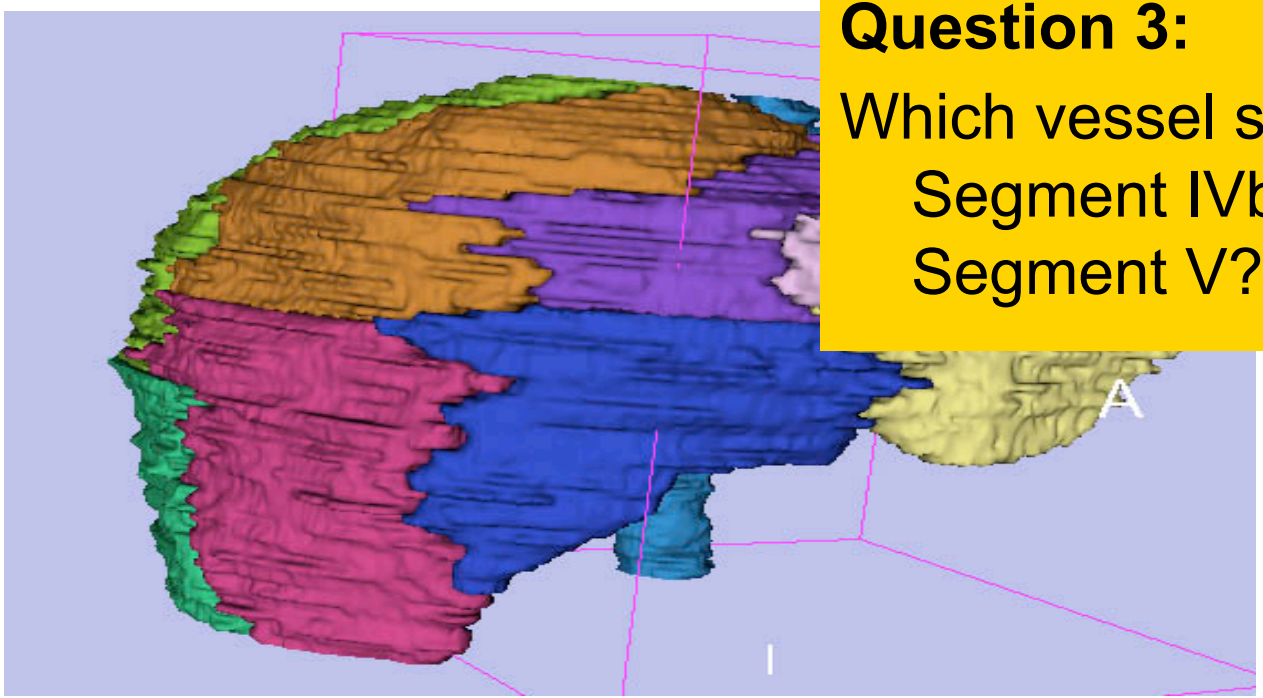
Which segment would most likely be affected by an aggressive tumor invading locally from the right adrenal gland ?



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

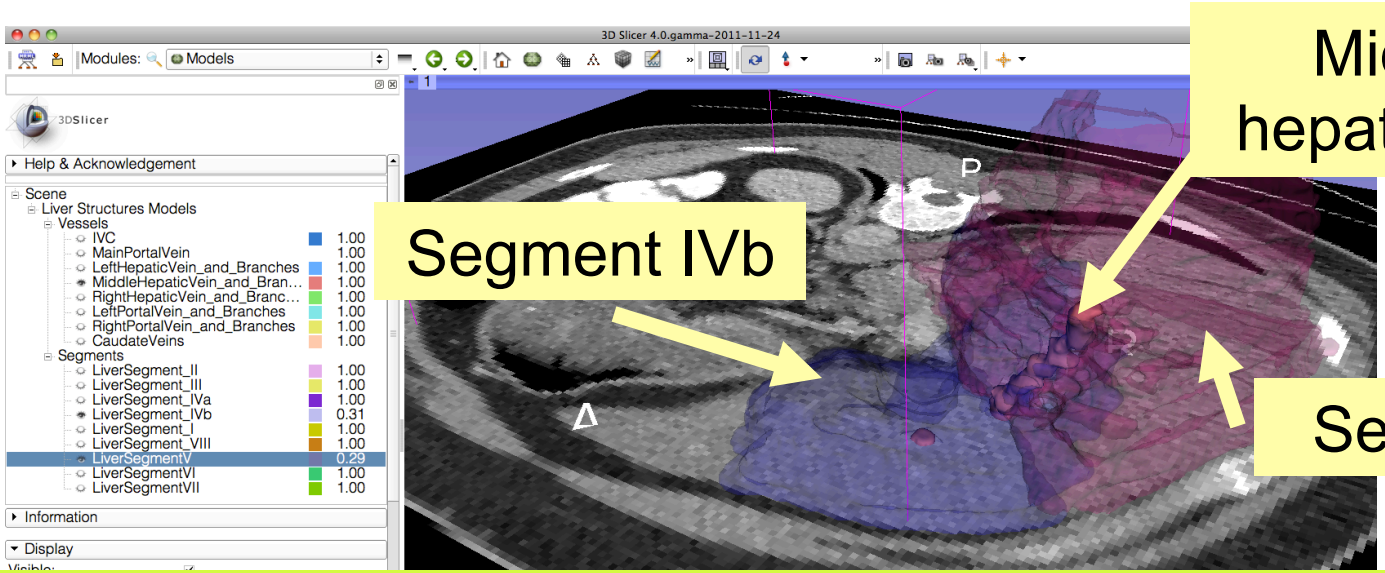
3D Exploration of Liver Segments



Question 3:

Which vessel separates Segment IVb and Segment V?

Middle Hepatic Vein



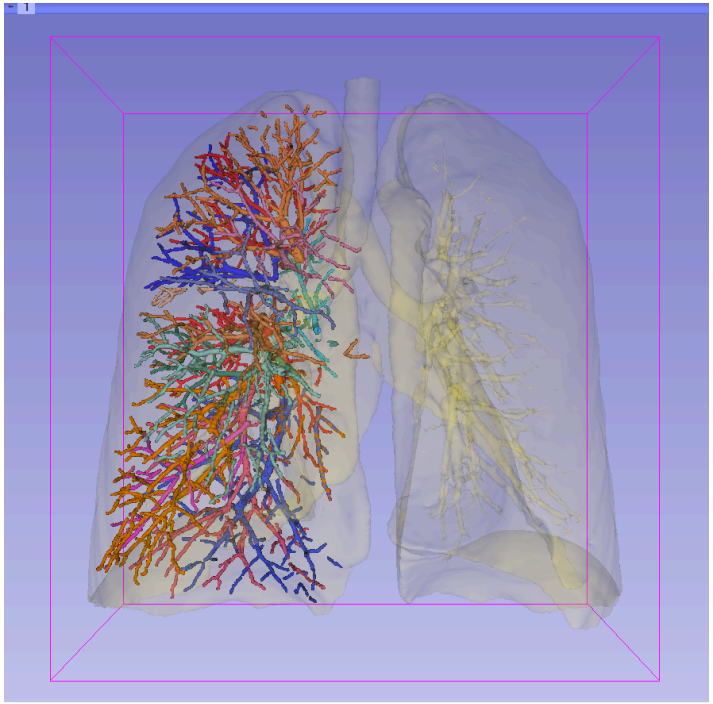
Question 3:

Which vessel separates Segment IVb and Segment V?

Answer 3: The middle hepatic vein

Closing the Liver Scene

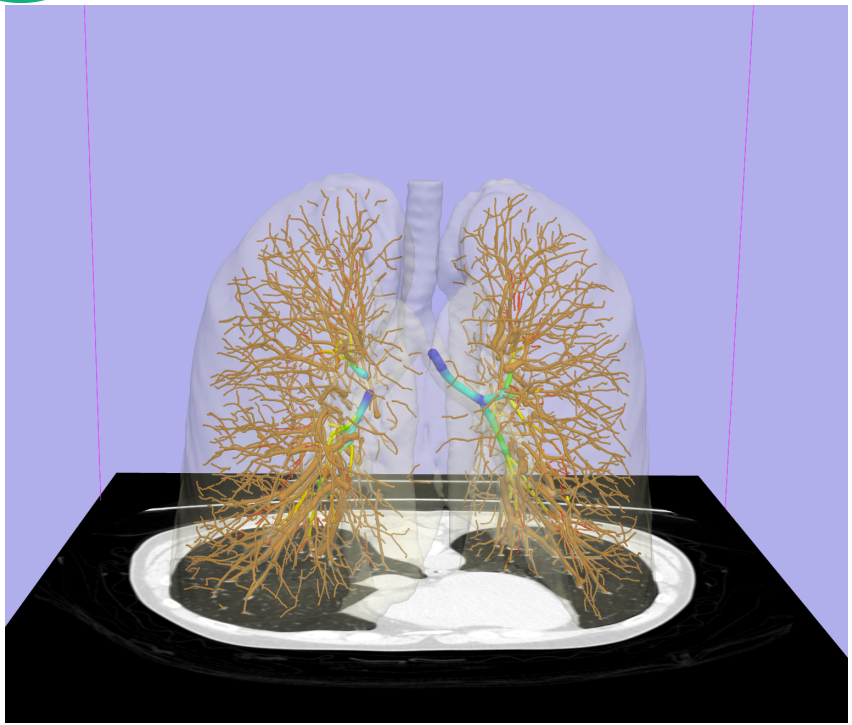
Select **File → Exit** to close the Liver Scene and exit Slicer



Part 4:

Interactive 3D Visualization of the segments of the lungs

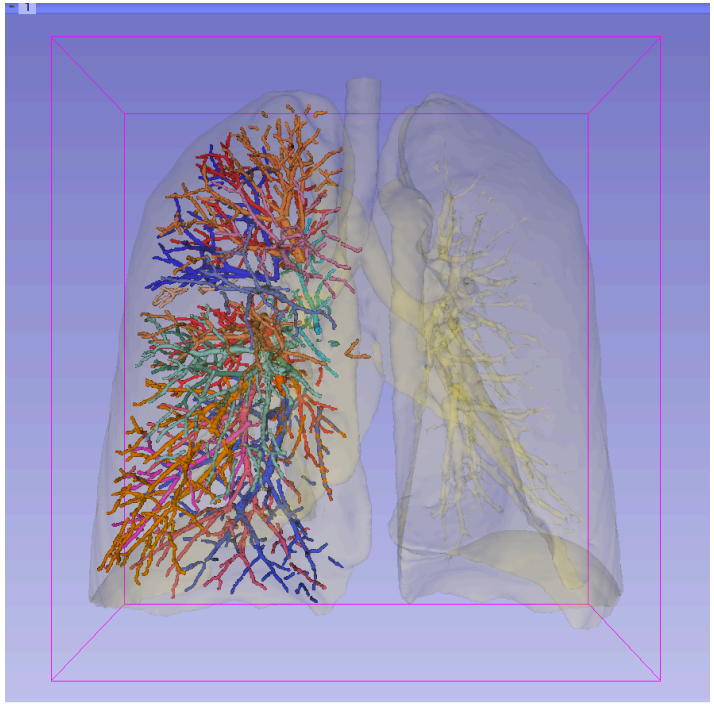
Segments of the lung



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

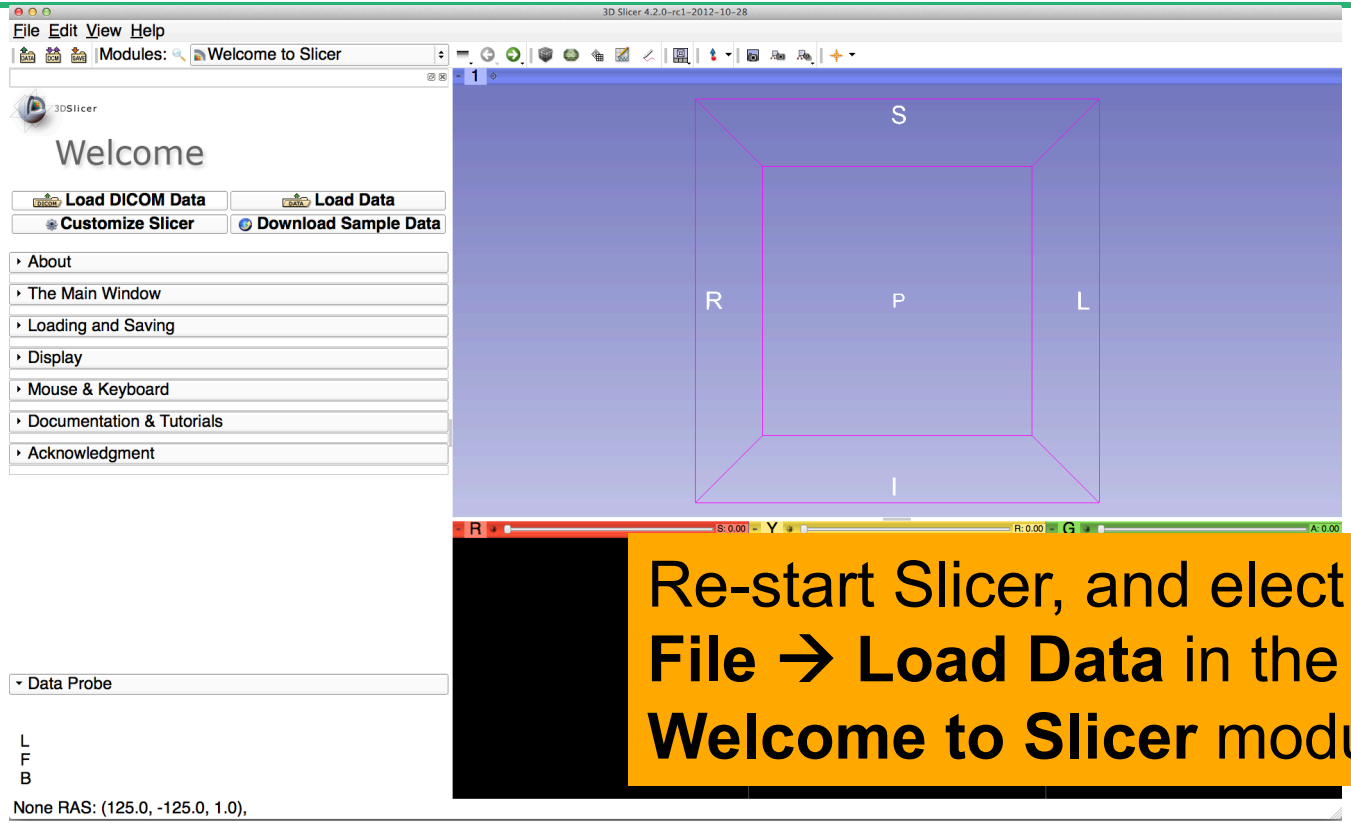
Segments of the lung



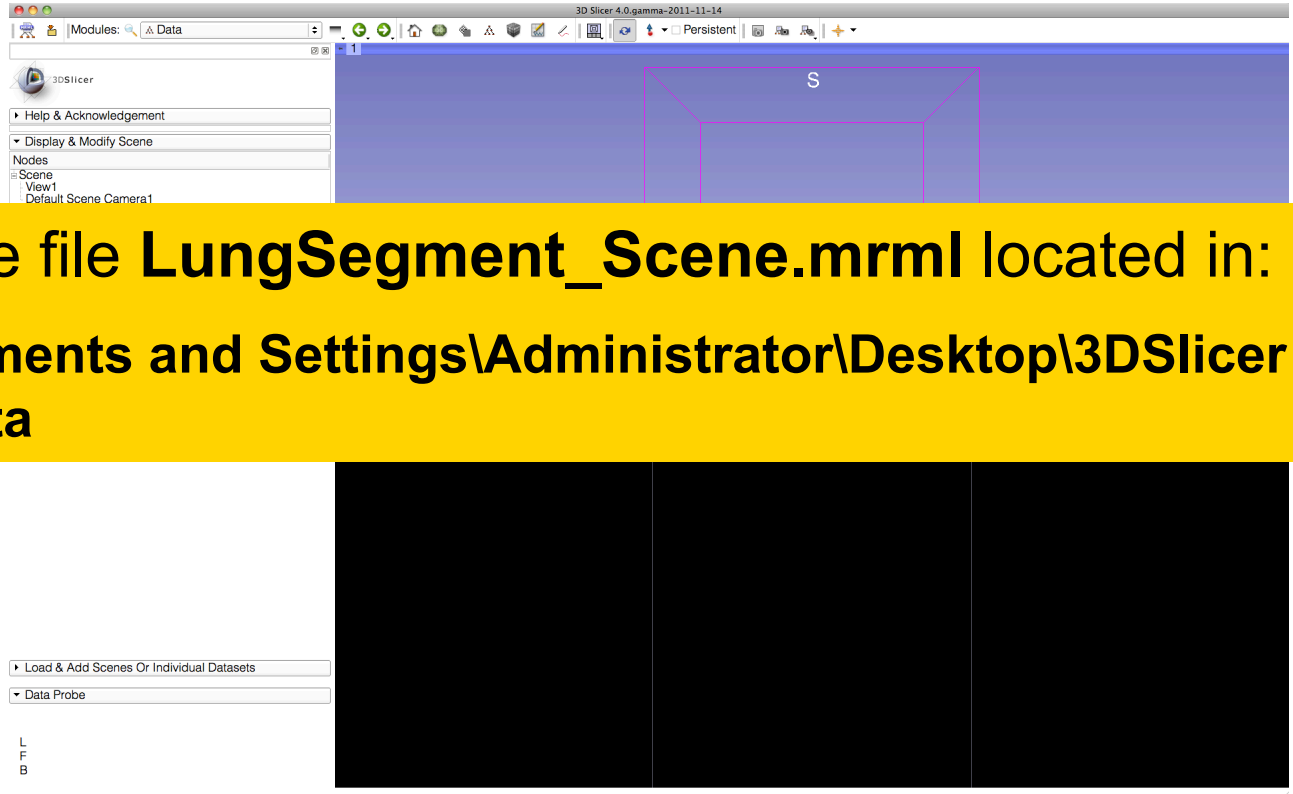
3D parcellation of arteries and veins from original model of pulmonary vessels
(Kitt Shaffer, M.D., Ph.D. - Sonia Pujol, Ph.D.)

- 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



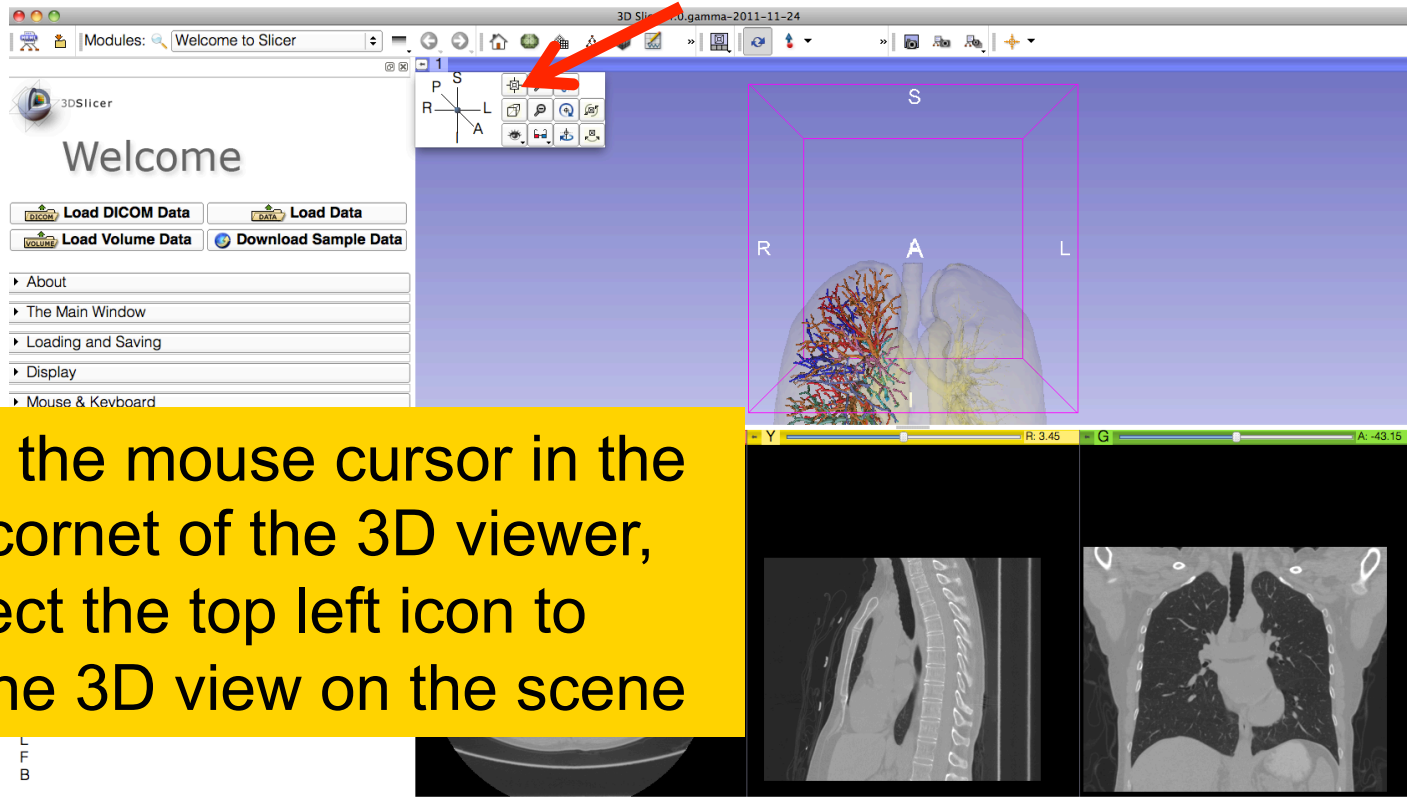
Loading the Lung Scene



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

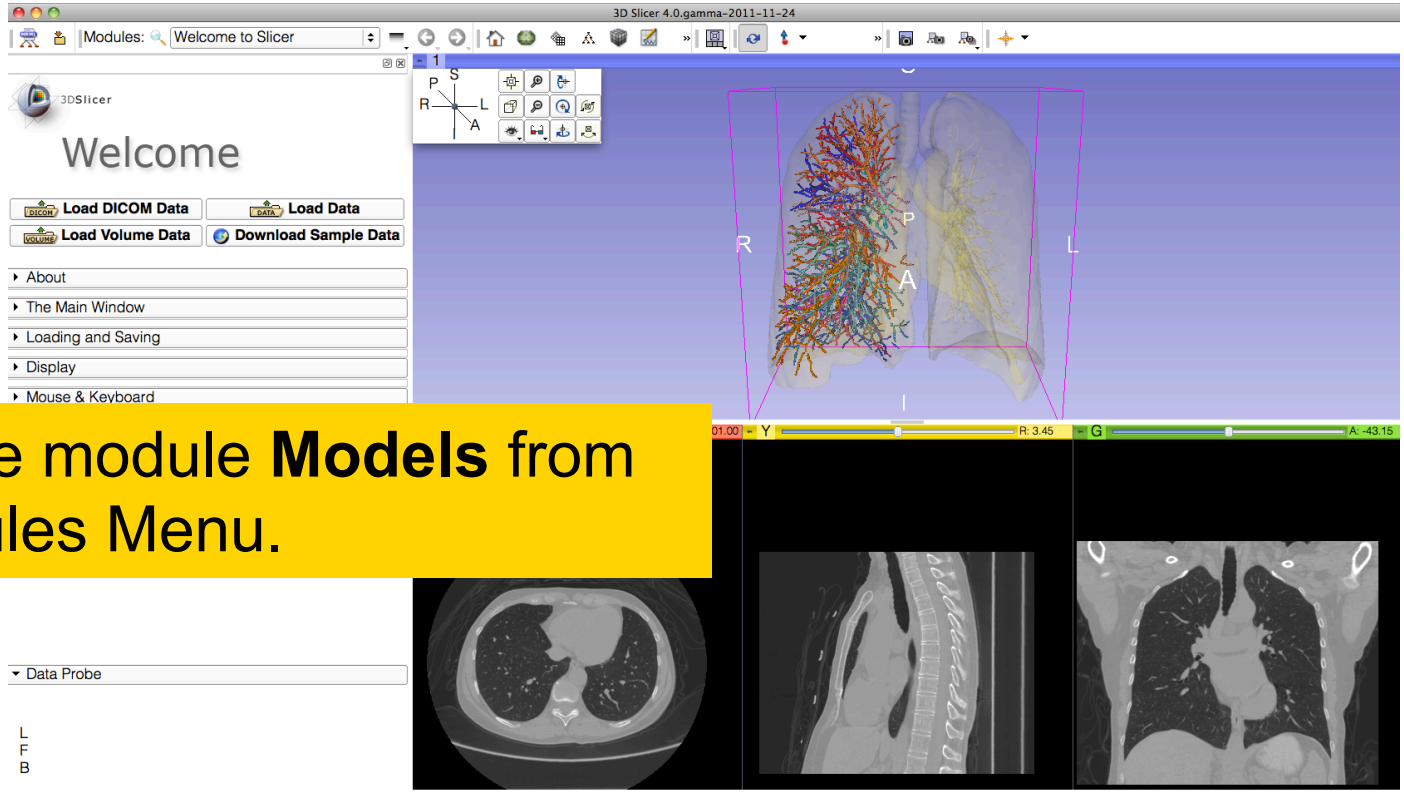
C:\Documents and Settings\Administrator\Desktop\3DSlicer \LungData

Loading the Lung Scene



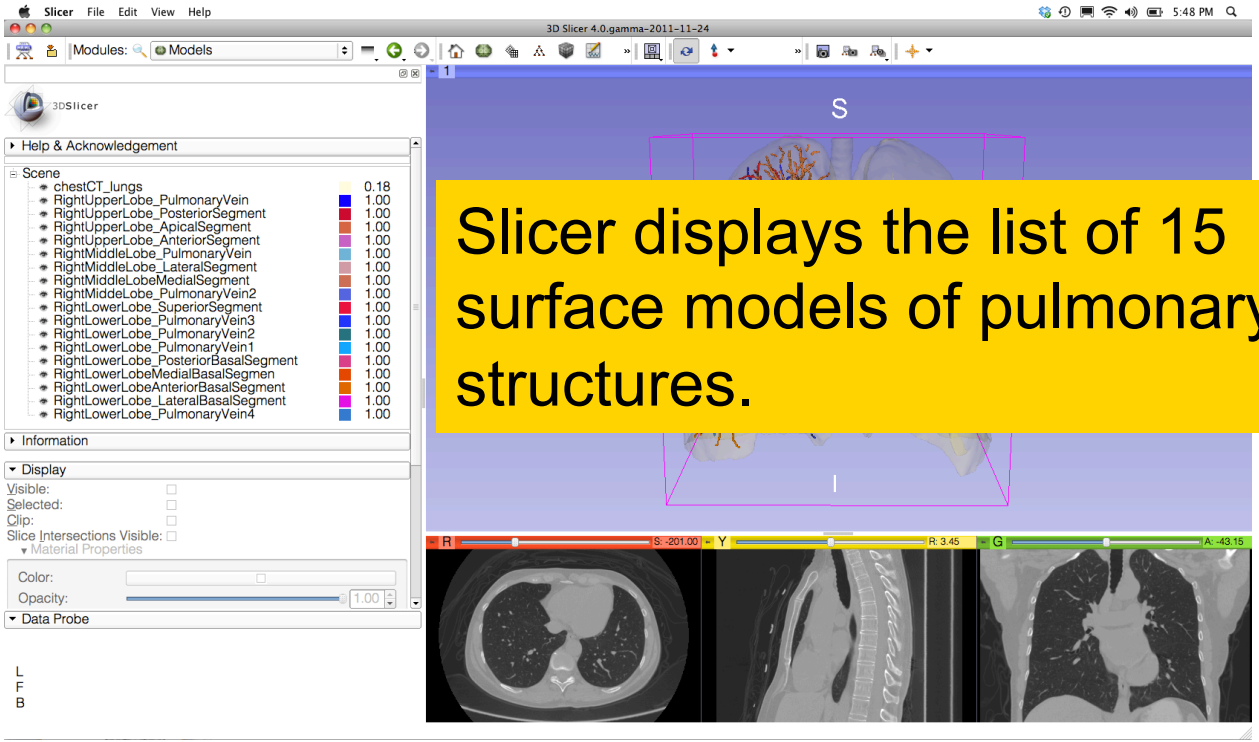
Position the mouse cursor in the top left cornet of the 3D viewer, and select the top left icon to center the 3D view on the scene

Loading the Lung Scene



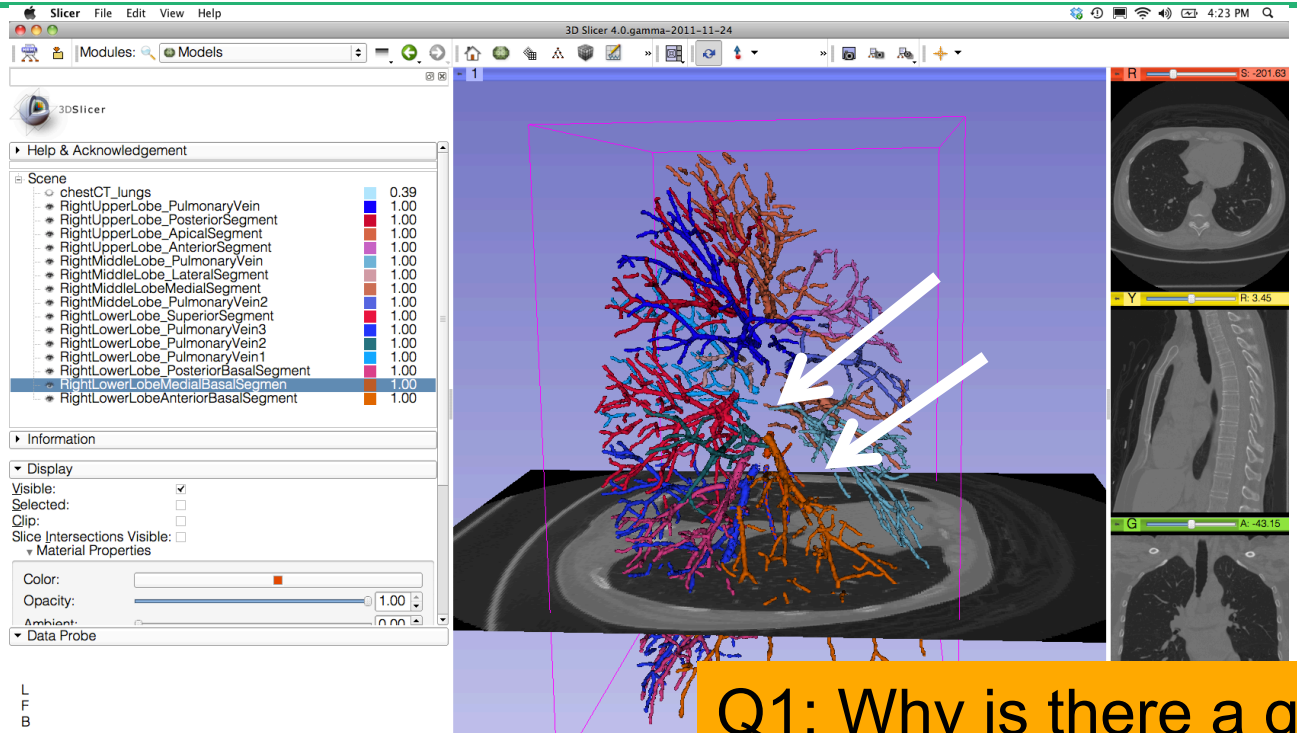
Select the module **Models** from the modules Menu.

Lung Segments



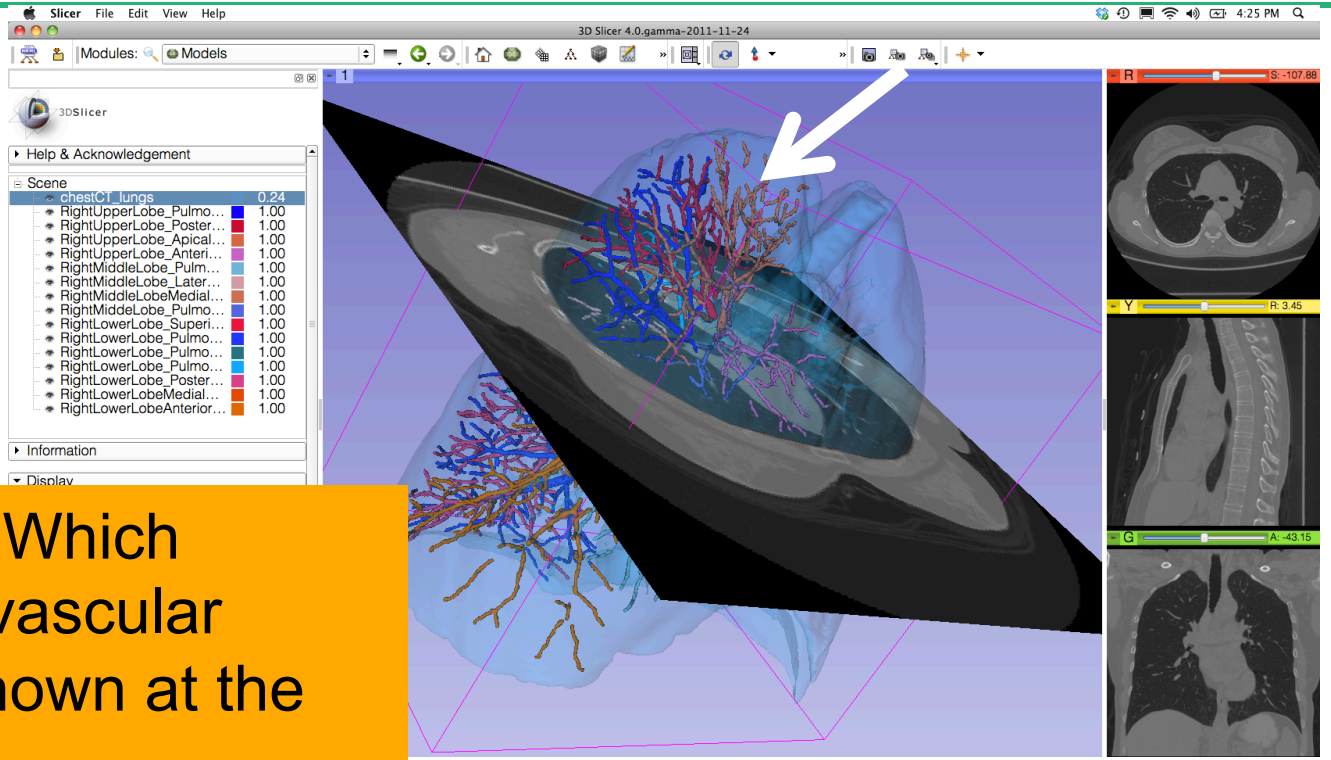
Slicer displays the list of 15 surface models of pulmonary structures.

Lung Segments – Question 1



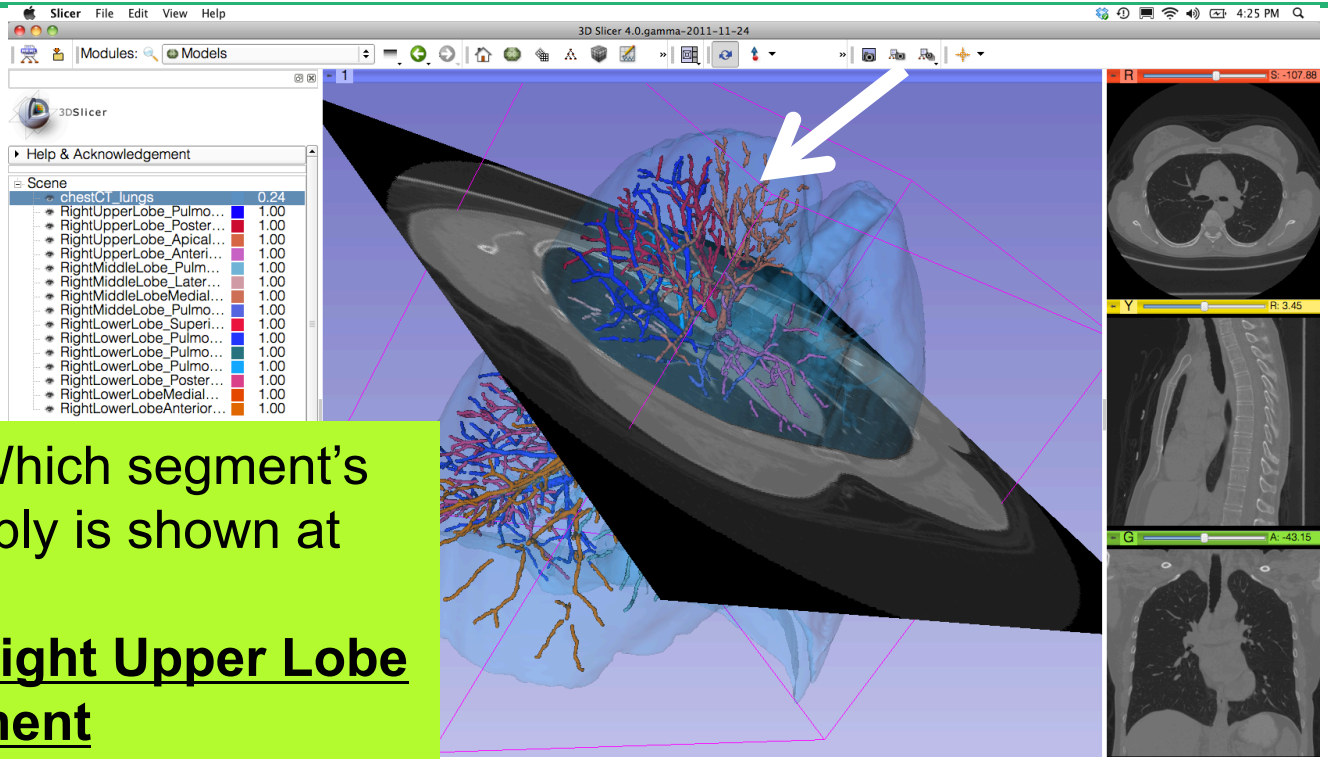
Q1: Why is there a gap in the vessels at the arrows?

Lung Segments – Question 2



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

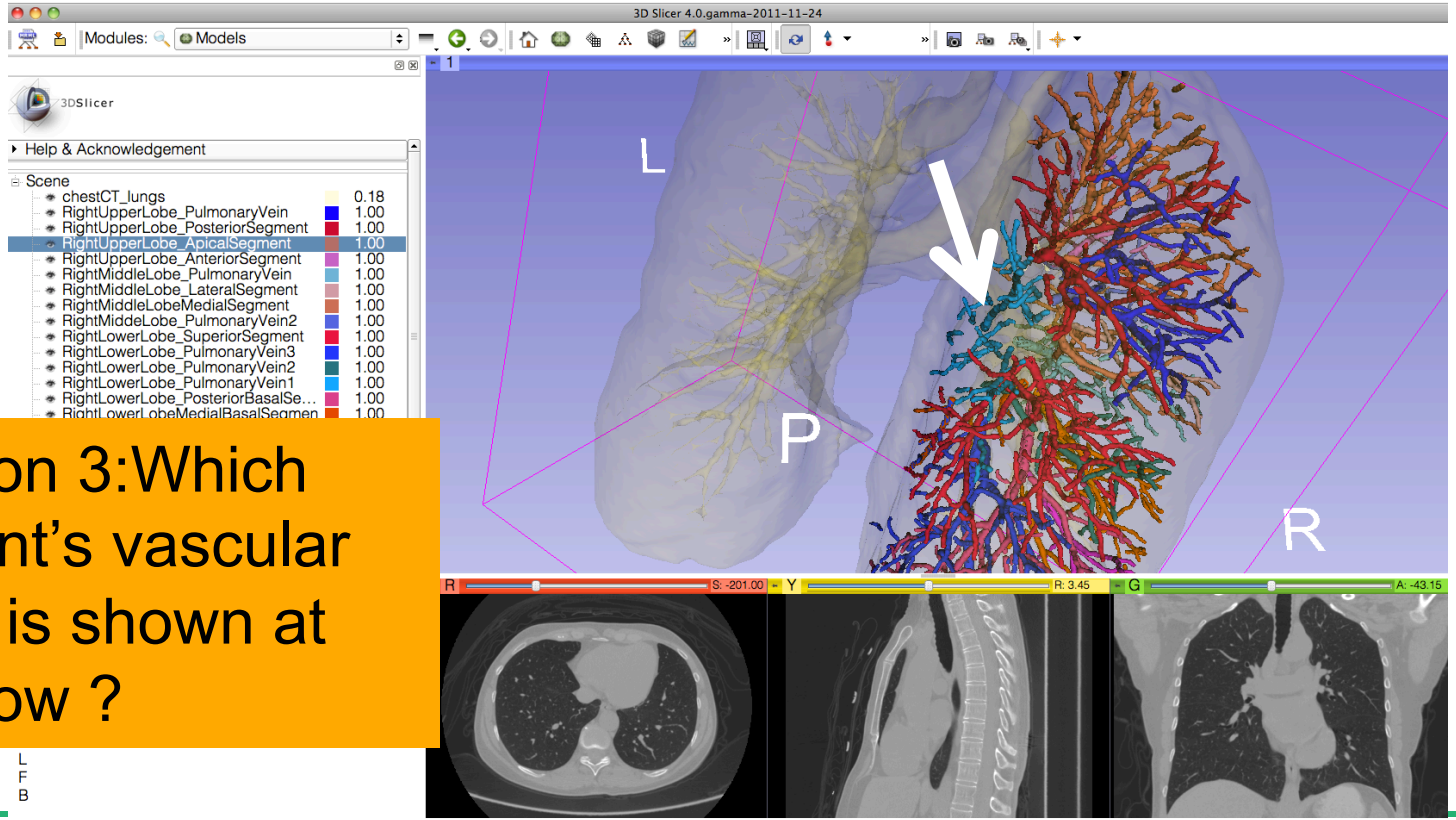
Lung Segments – Question 2



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

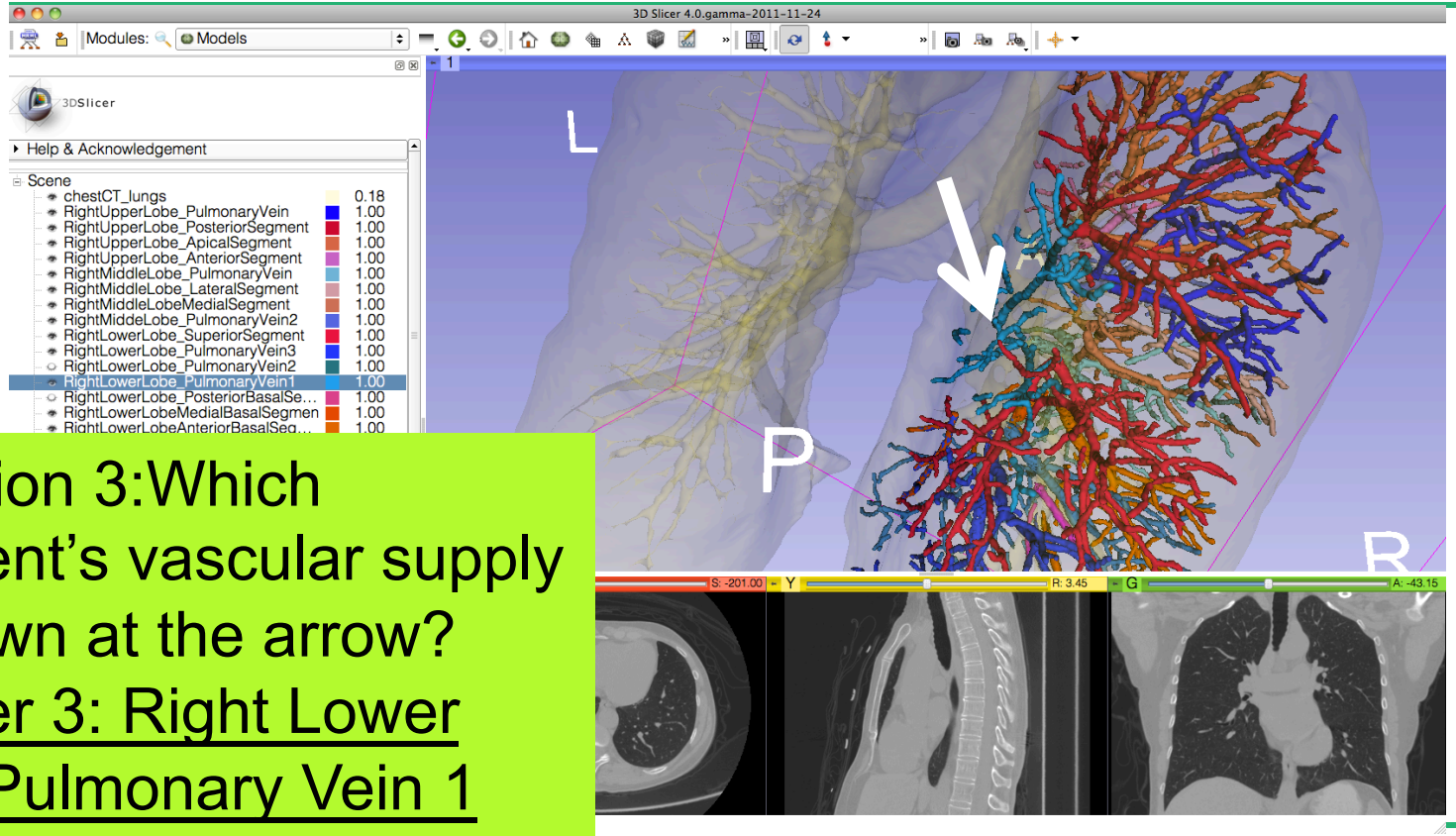
Answer 2: Right Upper Lobe Apical Segment

Lung Segments – Question 3



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

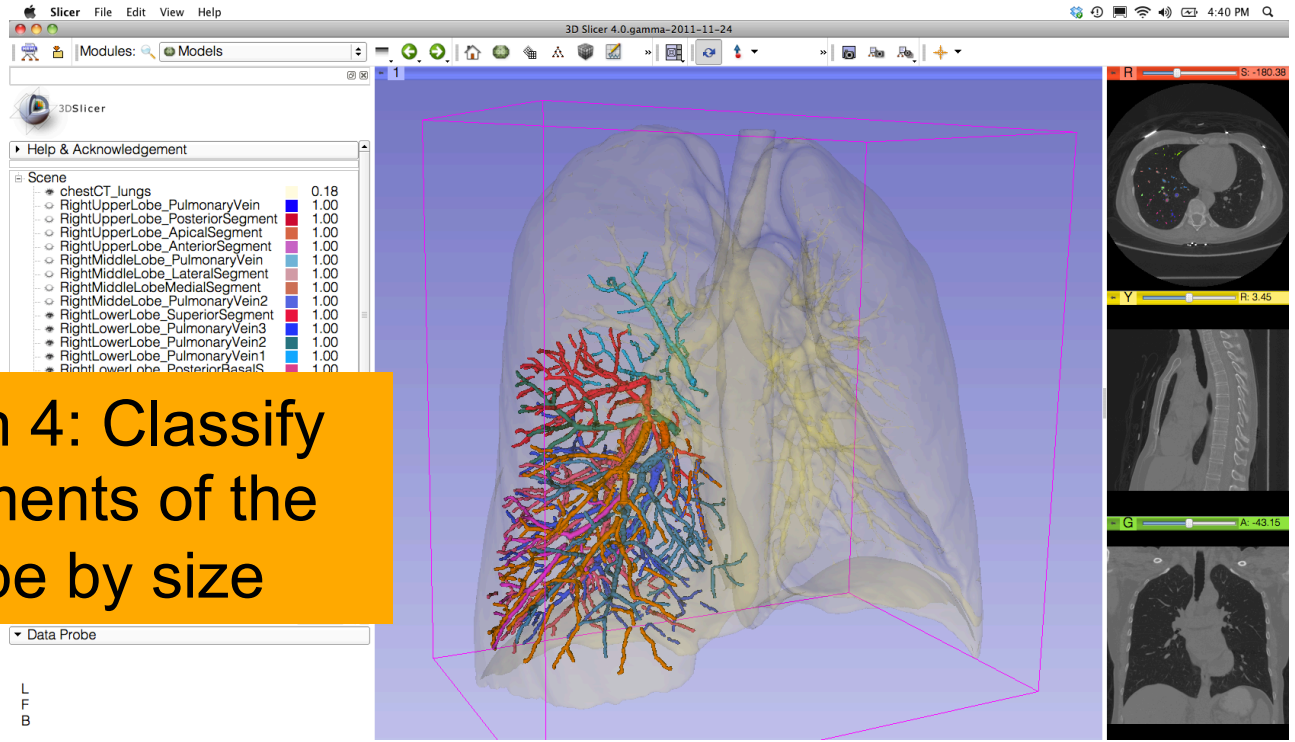
Lung Segments – Question 3



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

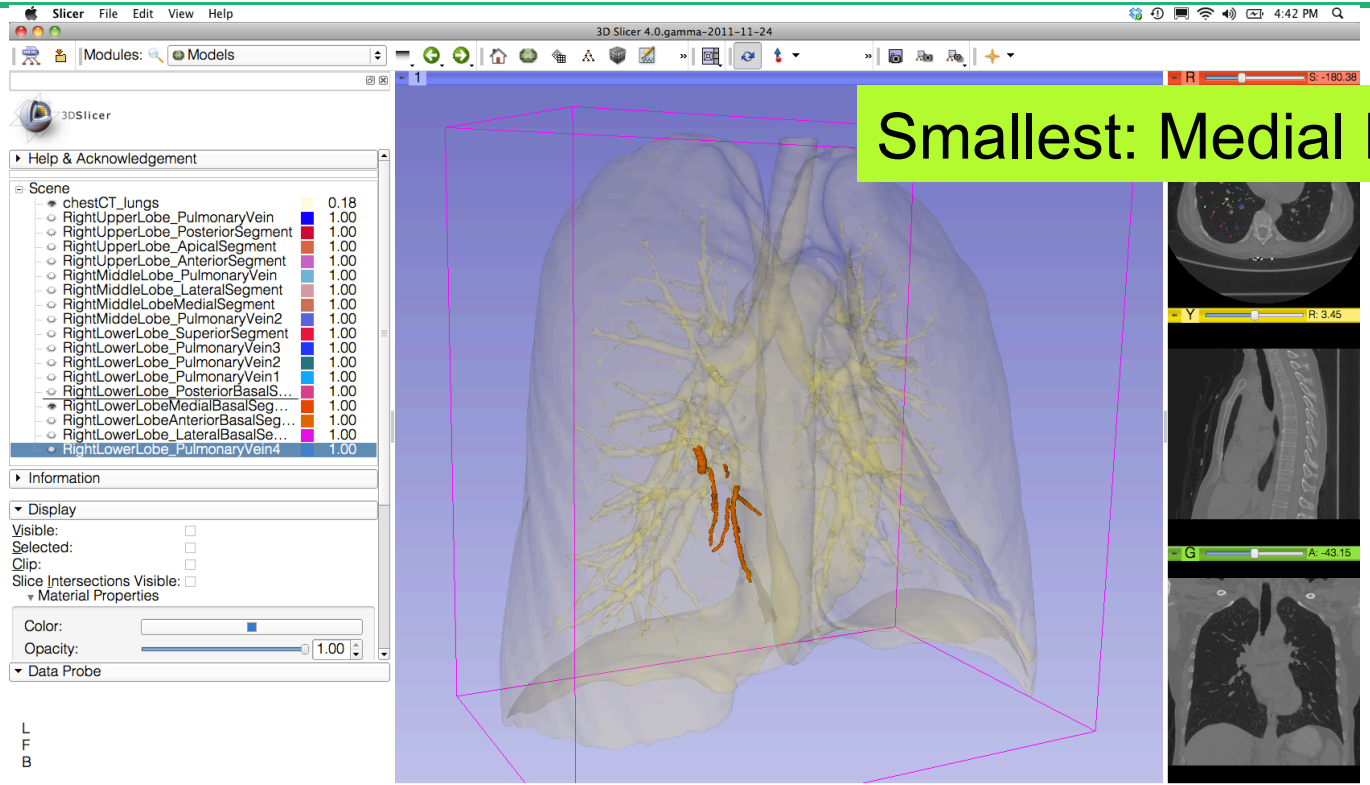
Answer 3: Right Lower Lobe Pulmonary Vein 1

Lung Segments – Question 4



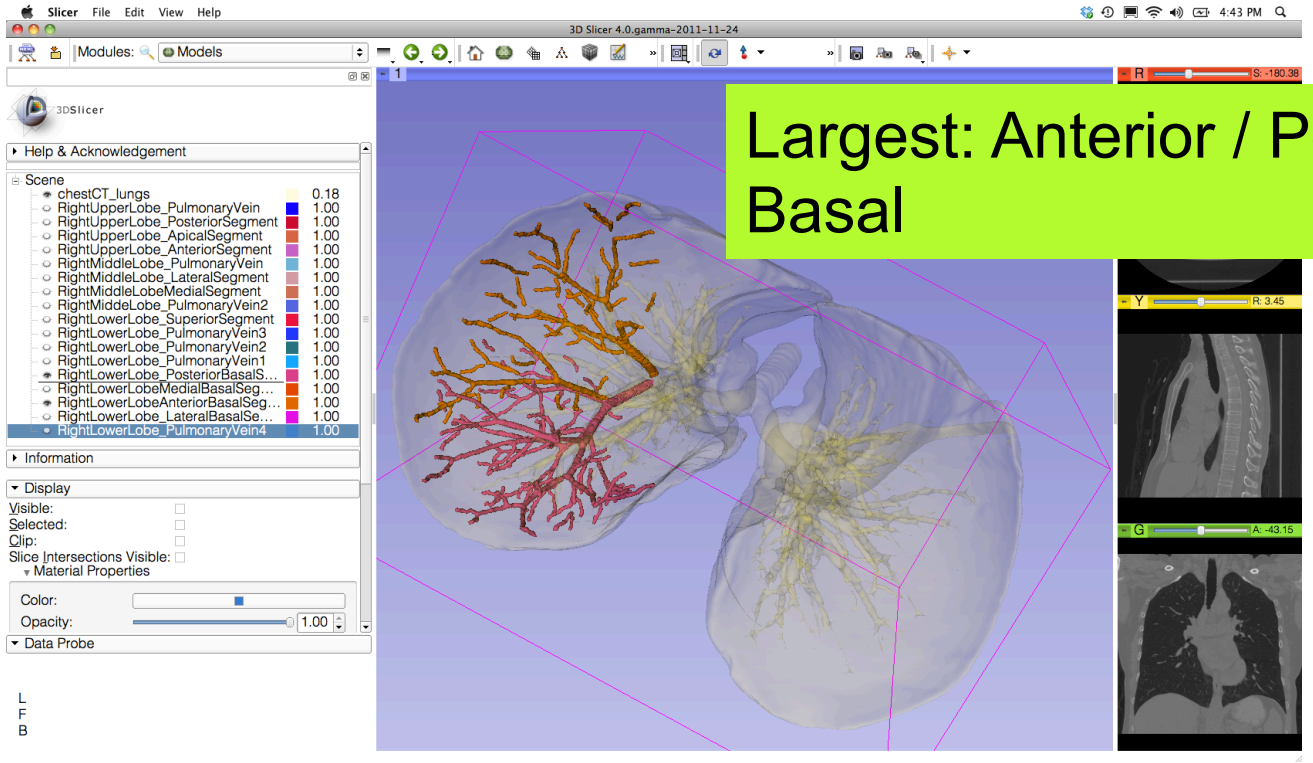
Question 4: Classify the segments of the lower lobe by size

Lung Segments – Question 4

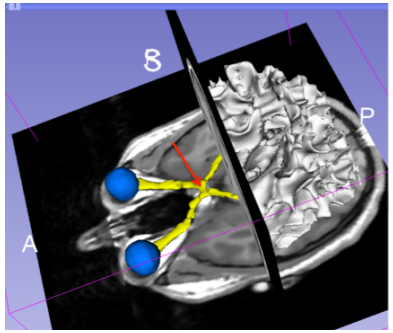


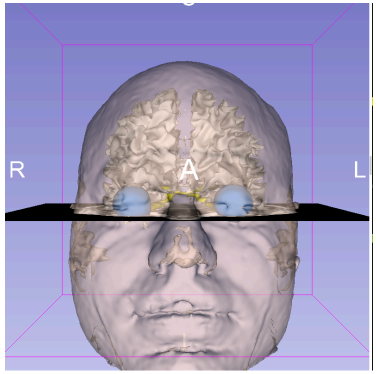
Smallest: Medial Basal

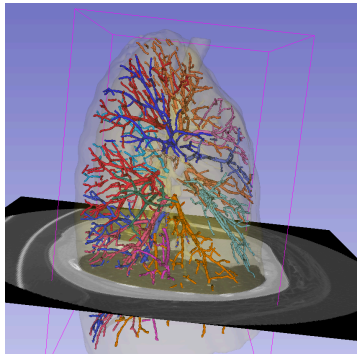
Lung Segments – Question 4

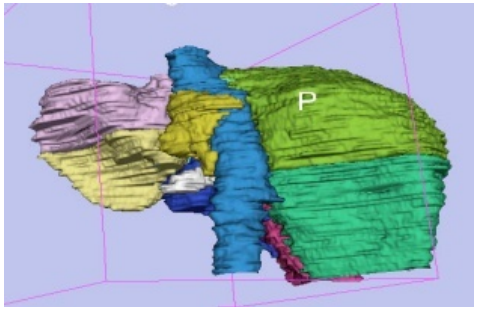


3D Visualization of DICOM images









- 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

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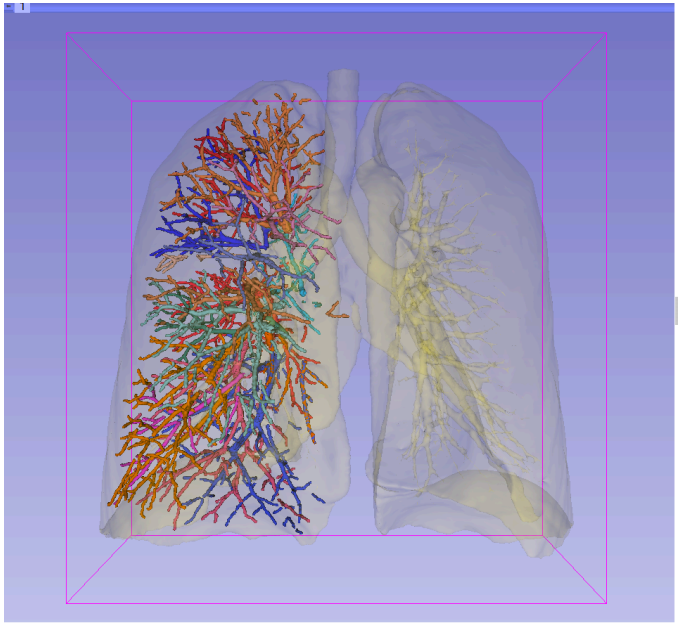

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