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# 3D VISUALIZATION OF DICOM IMAGES FOR RADIOLOGICAL APPLICATIONS

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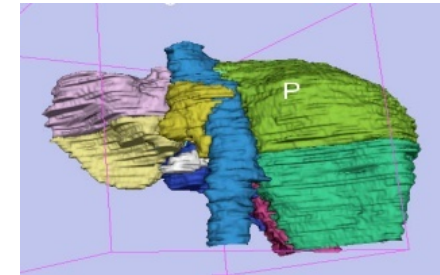
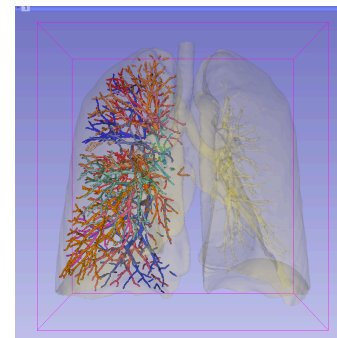
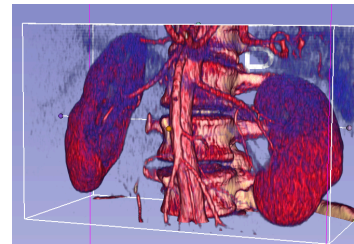
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## 3D Visualization of DICOM images for Radiological applications

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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.





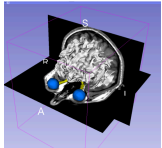
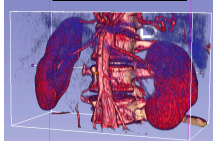


# Overview

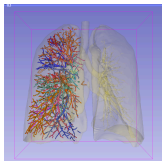
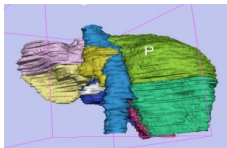
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- Part I:** 3D Data Loading and visualization of DICOM images
- Volume Rendering of thoraco-abdominal CT data



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



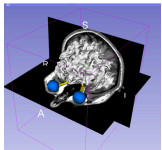
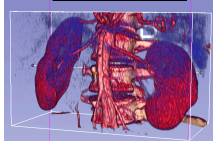


# Overview

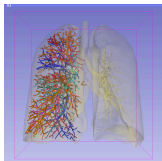
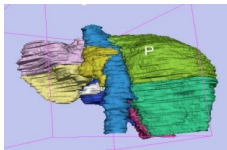
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- Part I: 3D Data Loading and visualization of DICOM images**
- Volume Rendering of thoraco-abdominal CT data

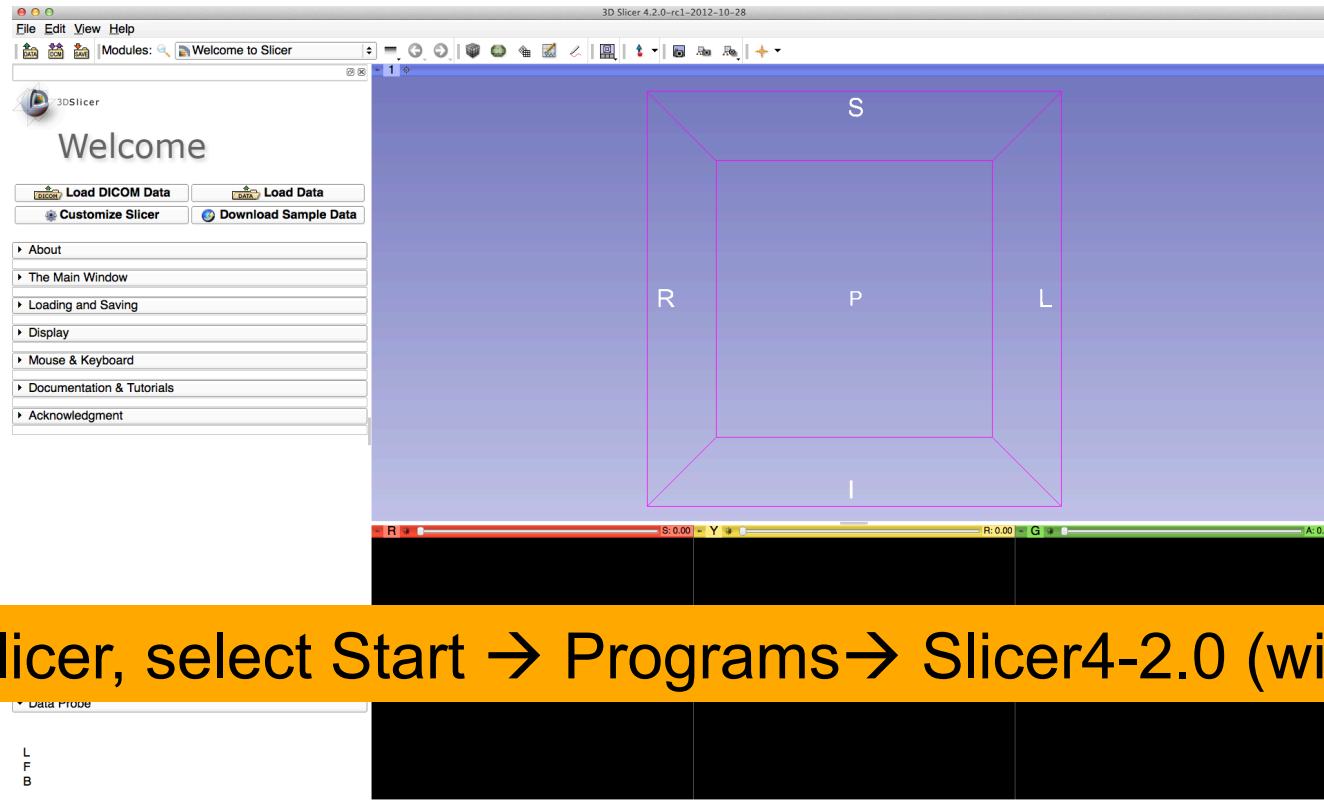


- Part II: 3D interactive exploration of the anatomy**
- Exploration of the Segments of the liver
  - Exploration of the Segments of the lung





# Welcome to Slicer4



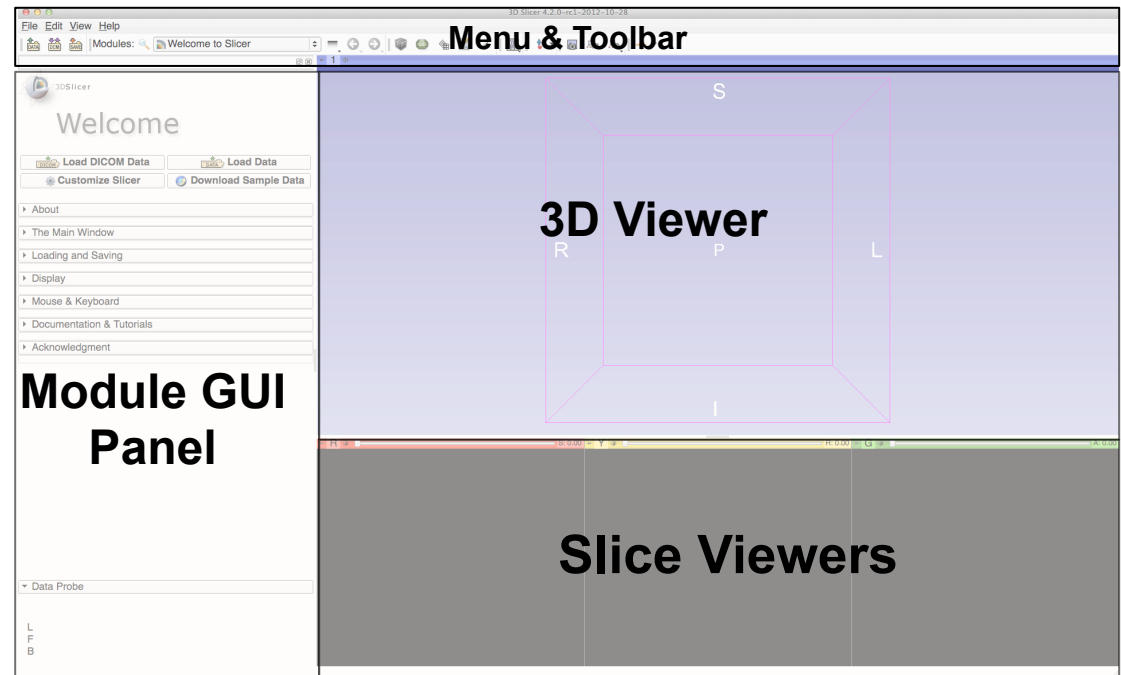
To start Slicer, select Start → Programs → Slicer4-2.0 (win64)



## Navigating the Application GUI

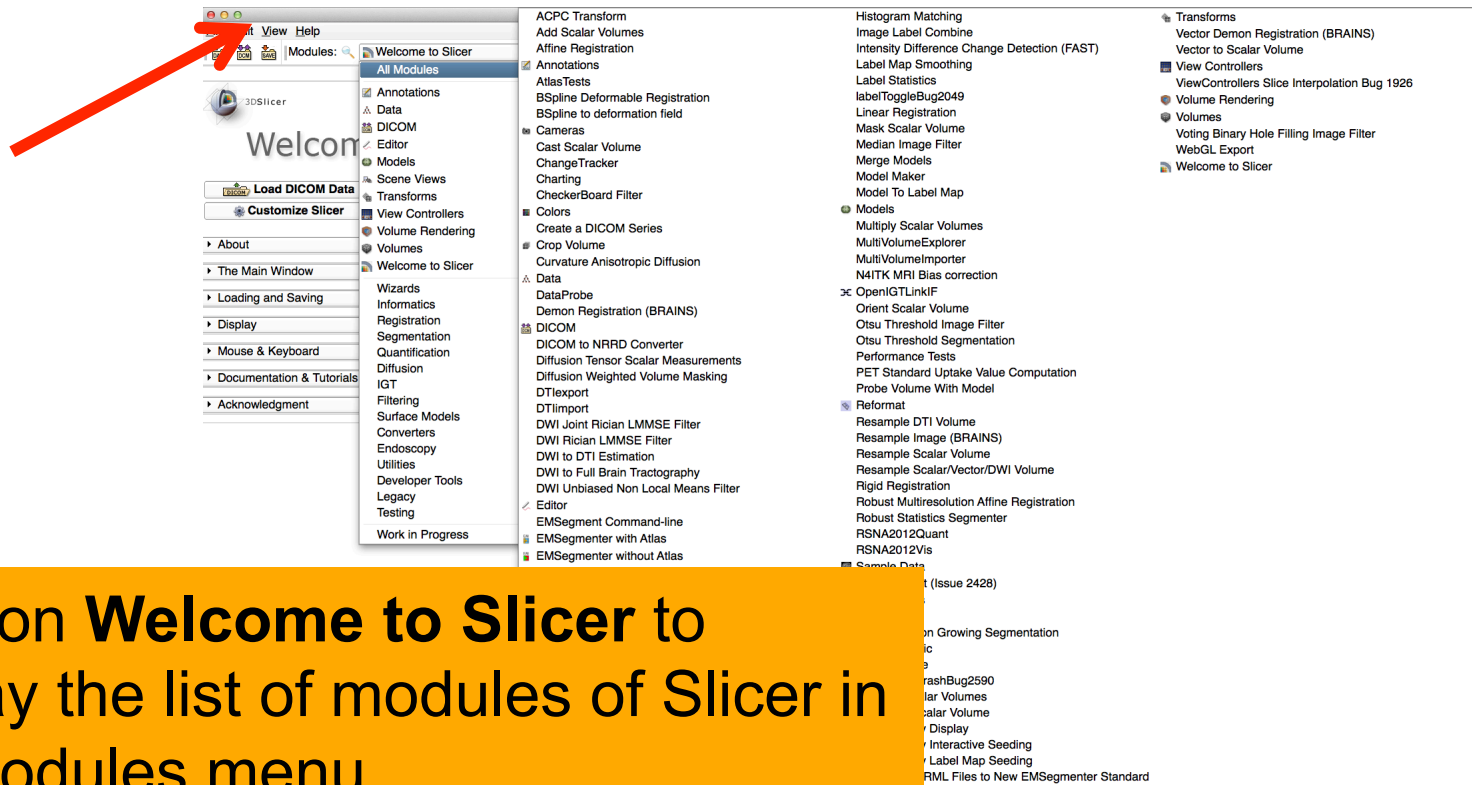
The Graphic User Interface (GUI) of Slicer4 integrates **four components**:

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





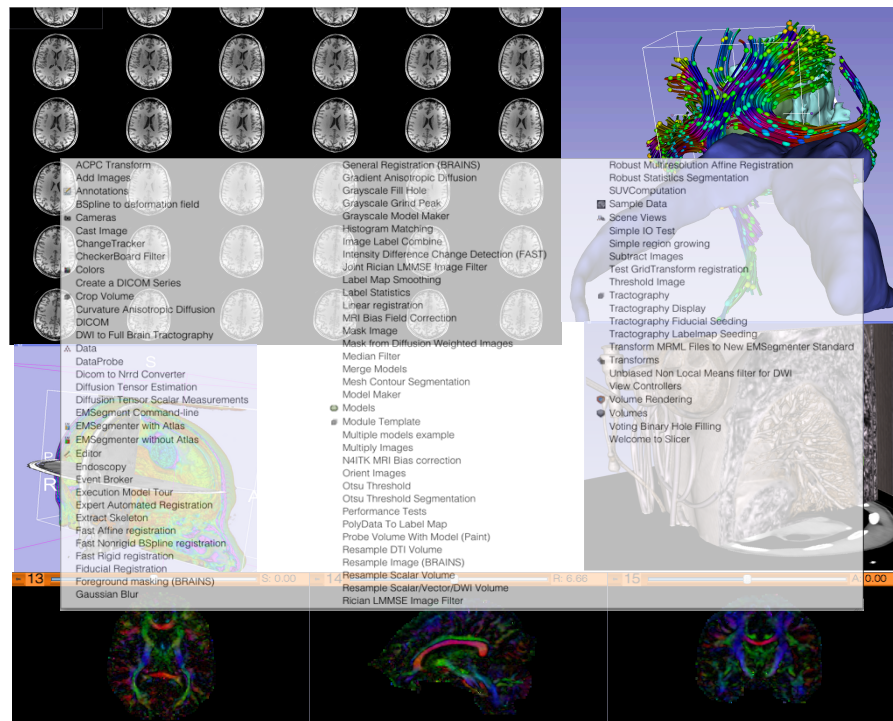
# Welcome to Slicer4.2



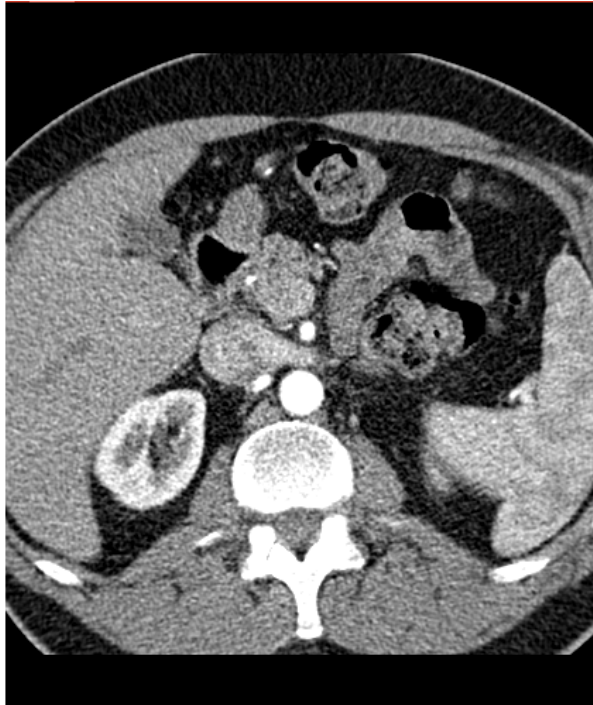
Click on **Welcome to Slicer** to display the list of modules of Slicer in the Modules menu



# Welcome to Slicer4



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

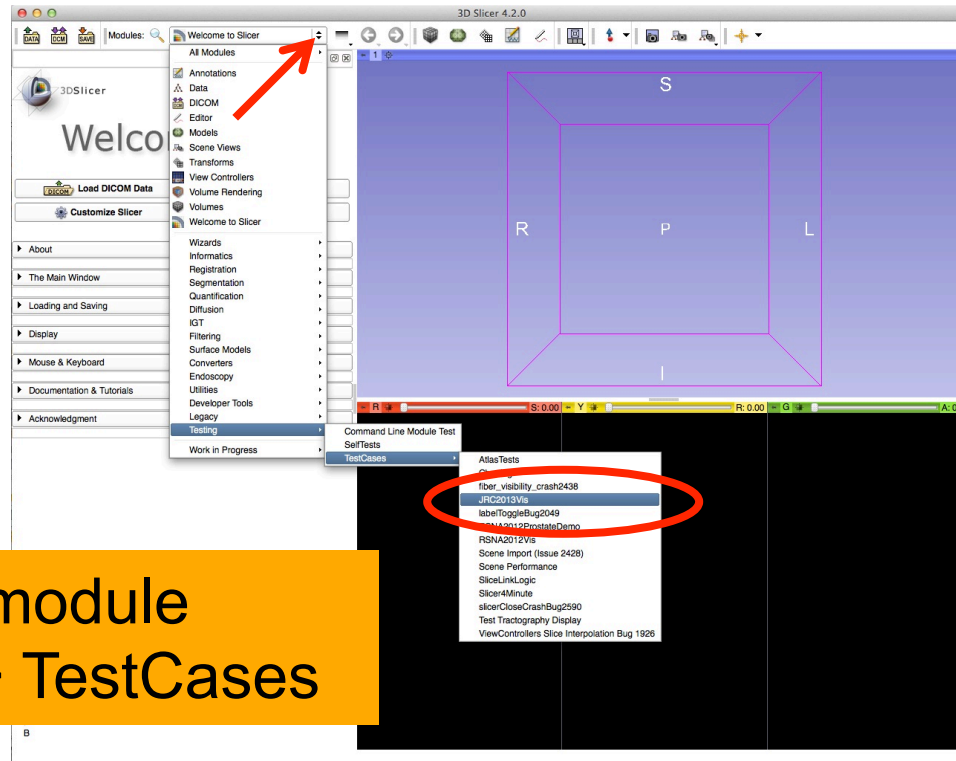


Part 1:

Retrieving a DICOM Volume  
from a DICOM Peer



# Start a DICOM Peer Simulator

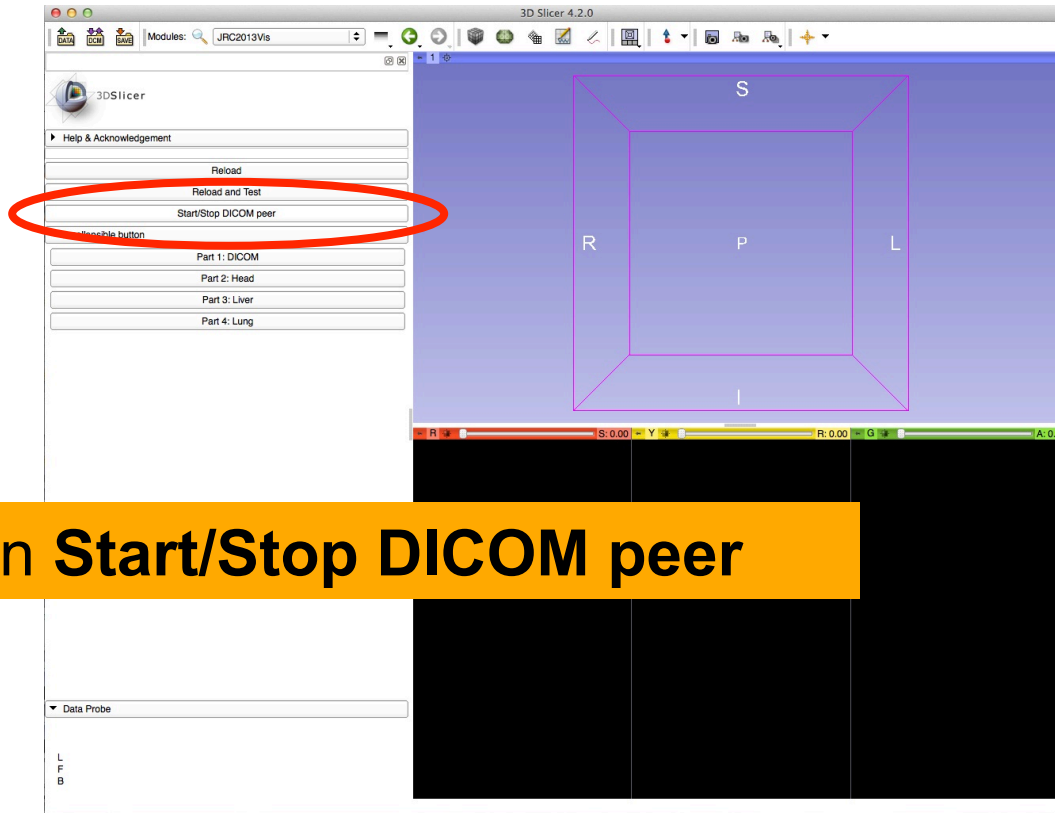


Go to **JRC2013Vis** module  
Module -> Testing -> TestCases





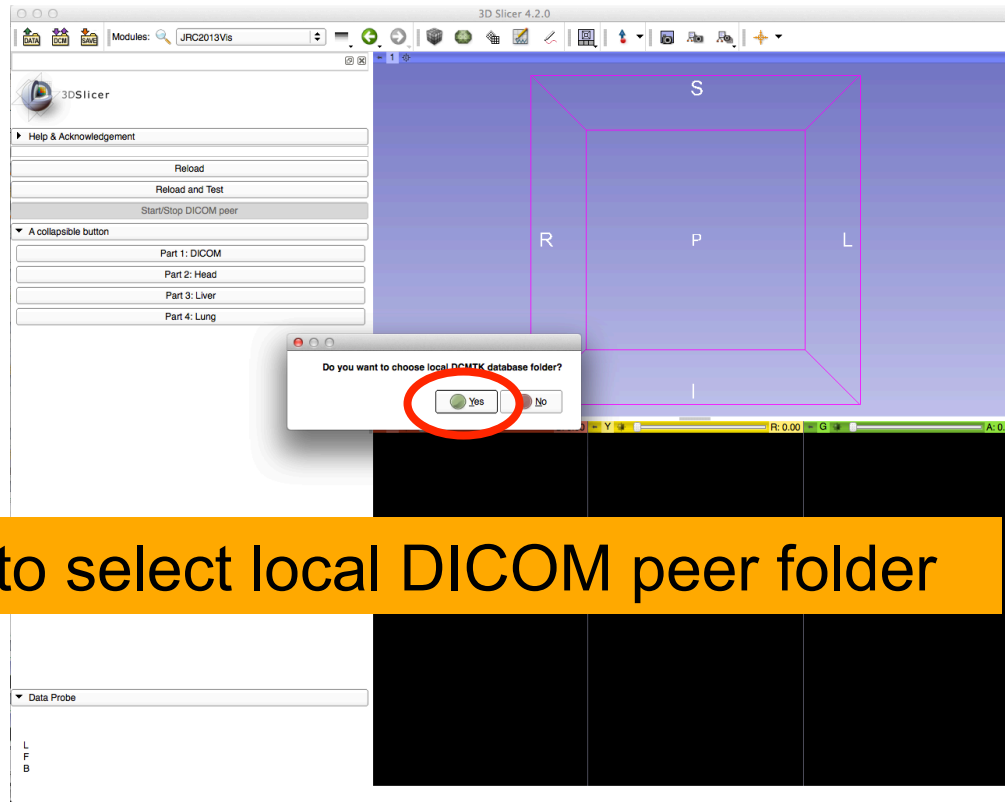
# Start a DICOM Peer Simulator



Click on **Start/Stop DICOM peer**



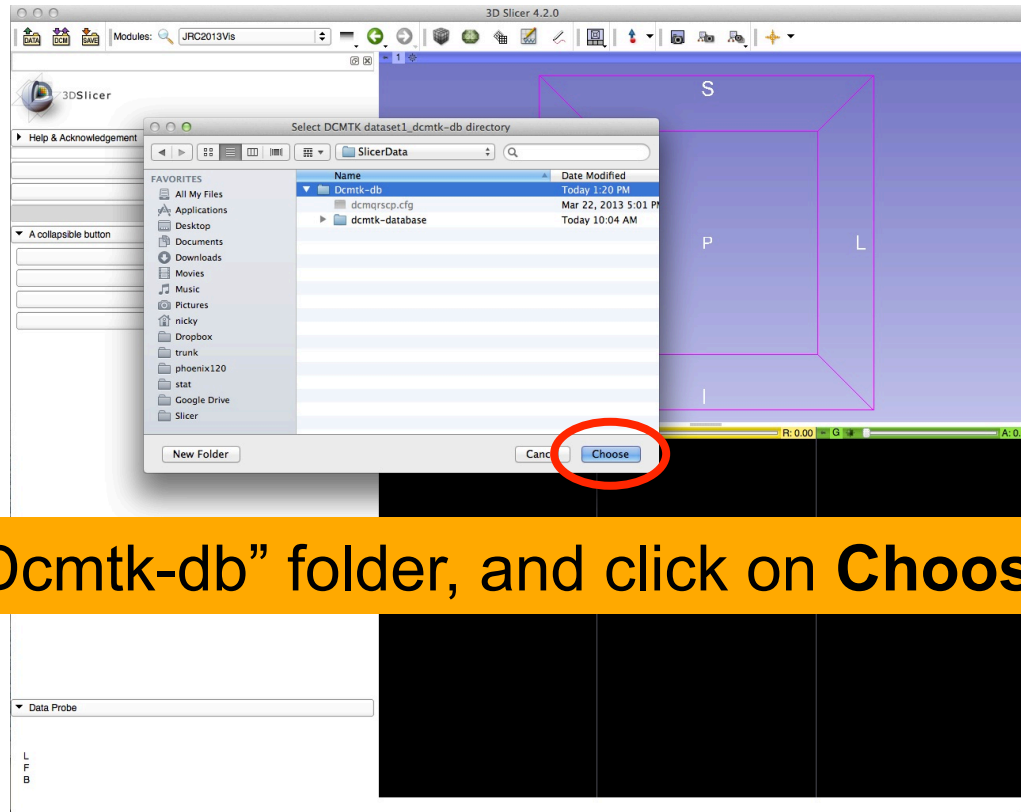
# Start a DICOM Peer Simulator



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



# Start a DICOM Peer Simulator



Select "Dcmk-db" folder, and click on **Choose**

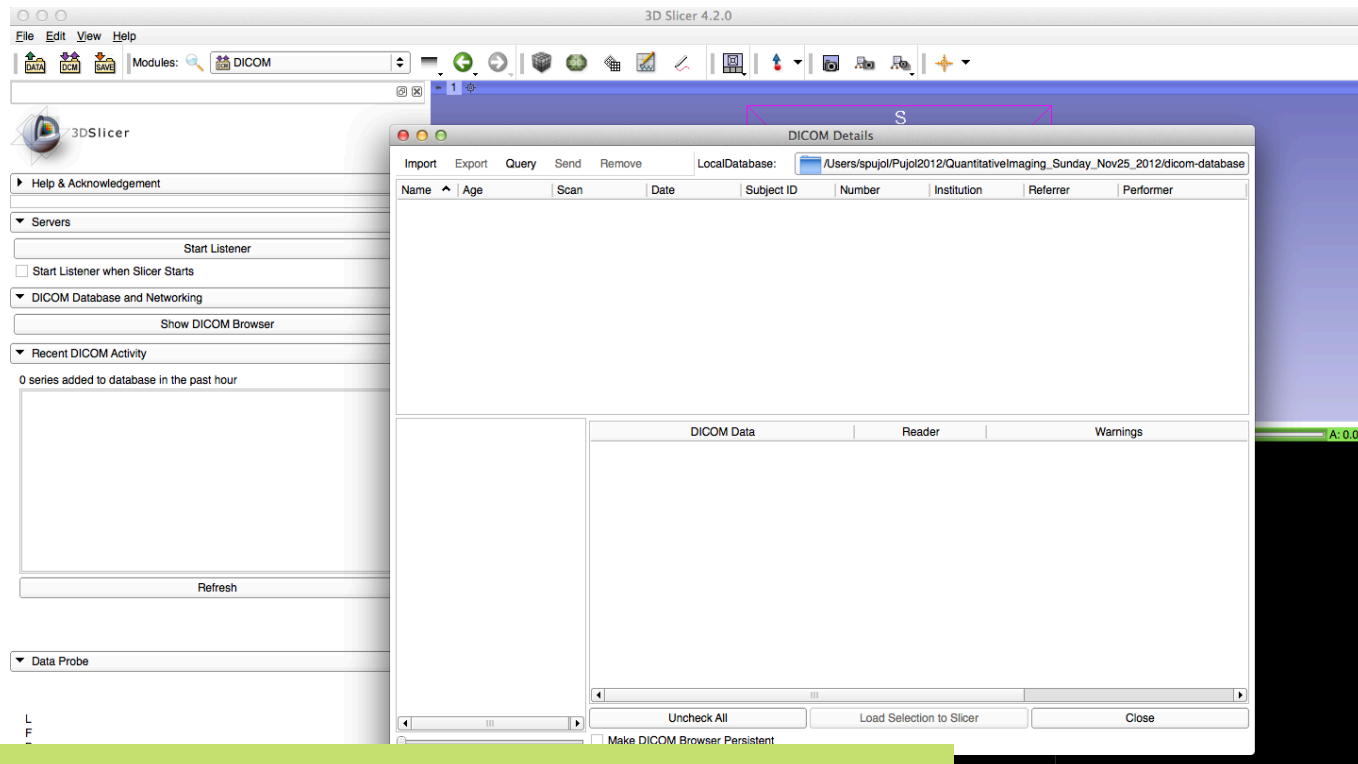


# Loading a DICOM volume

The screenshot shows the 3D Slicer software interface. The title bar reads "3D Slicer 4.2.0-rc1-2012-10-28". The menu bar includes "File", "Edit", "View", and "Help". The "Modules" dropdown is set to "Welcome to Slicer". The main window is titled "Welcome" and contains several buttons: "Load DICOM Data" (circled in red), "Load Data", "Customize Slicer", and "Download Sample Data". Below these are several expandable sections: "About", "The Main Window", "Loading and Saving", "Display", "Mouse & Keyboard", "Documentation & Tutorials", and "Acknowledgment". At the bottom left, there is a "Data Probe" section with "L", "F", "B" labels and the text "None RAS: (125.0, -125.0, 1.0)". The main 3D view area is currently empty, with a coordinate system (S, Y, R, G, A) visible at the top and bottom. A large yellow text box is overlaid on the 3D view area, containing the instruction: "Click on **Load DICOM Data** in the panel of the Welcome to Slicer module".



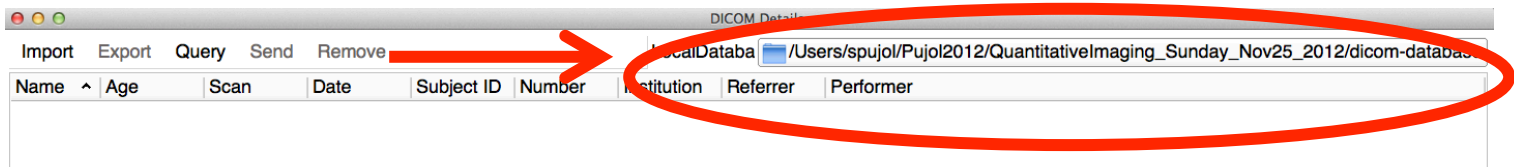
# Select DICOM local database



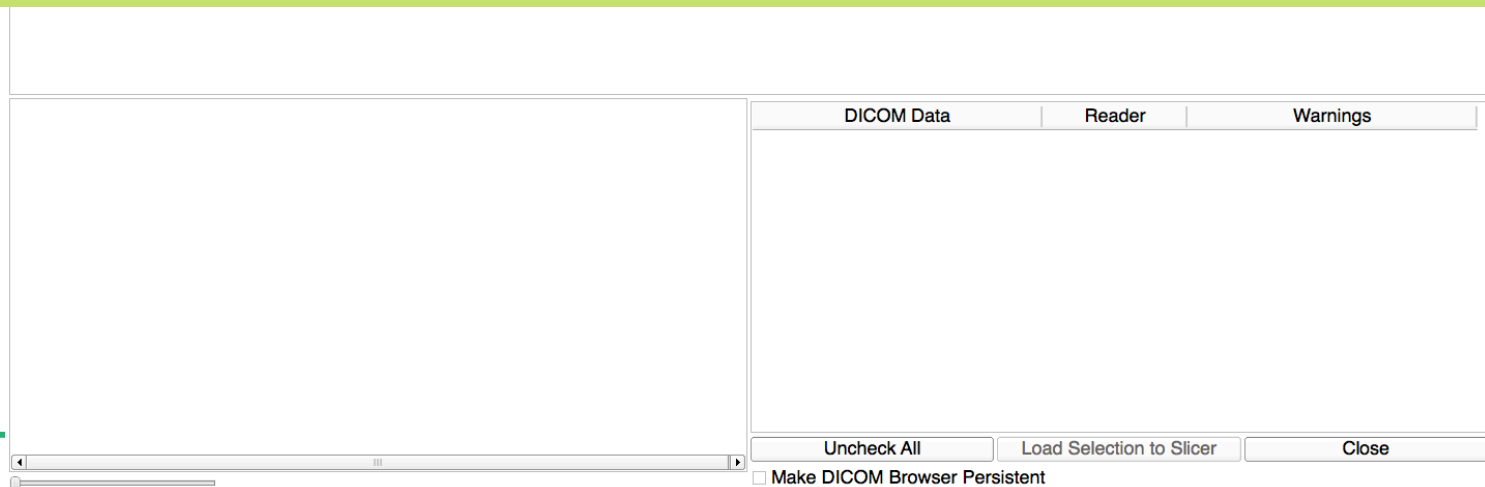
The GUI of the DICOM browser window appears



# Select DICOM local database

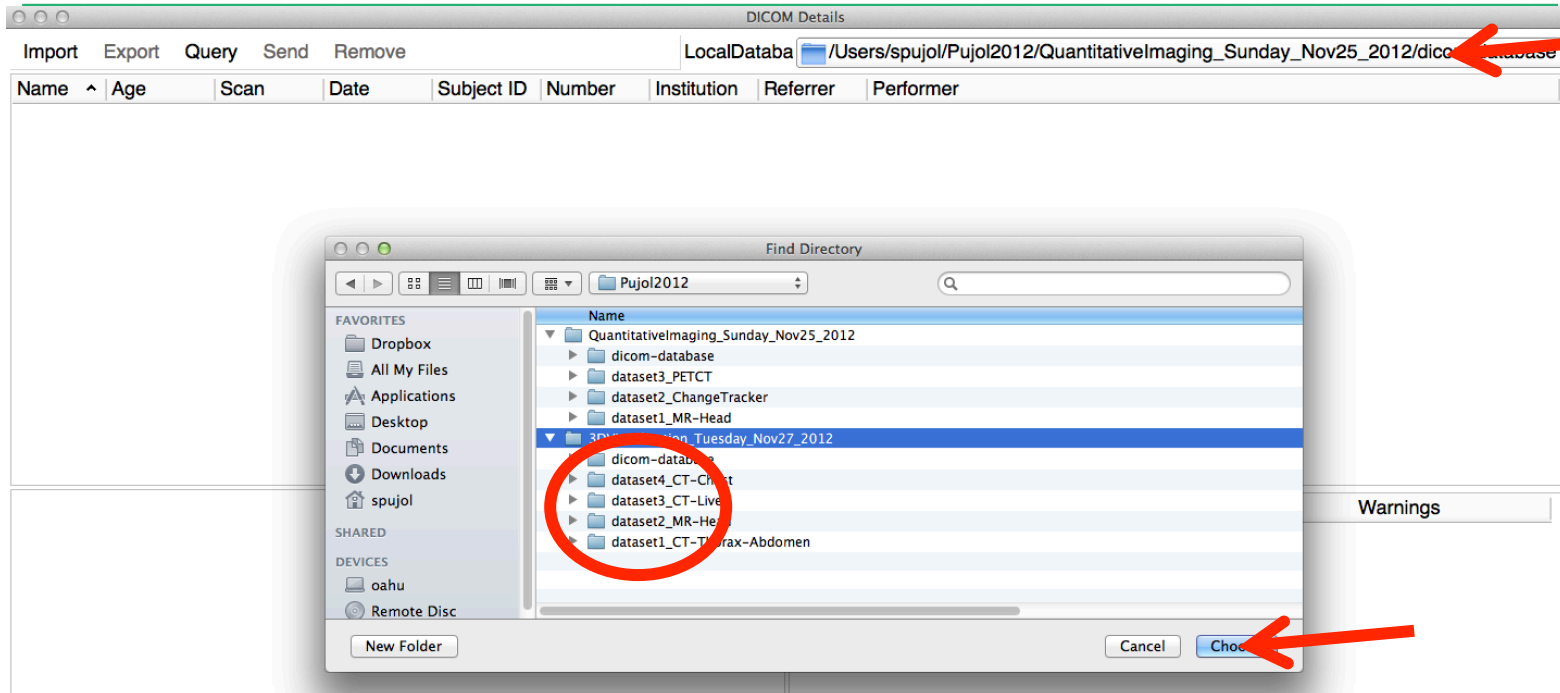


The path to the current local DICOM database of Slicer is set to **C:/Pujol2012/QuantitativeImaging\_Sunday\_Nov25\_2012/dicom-database**





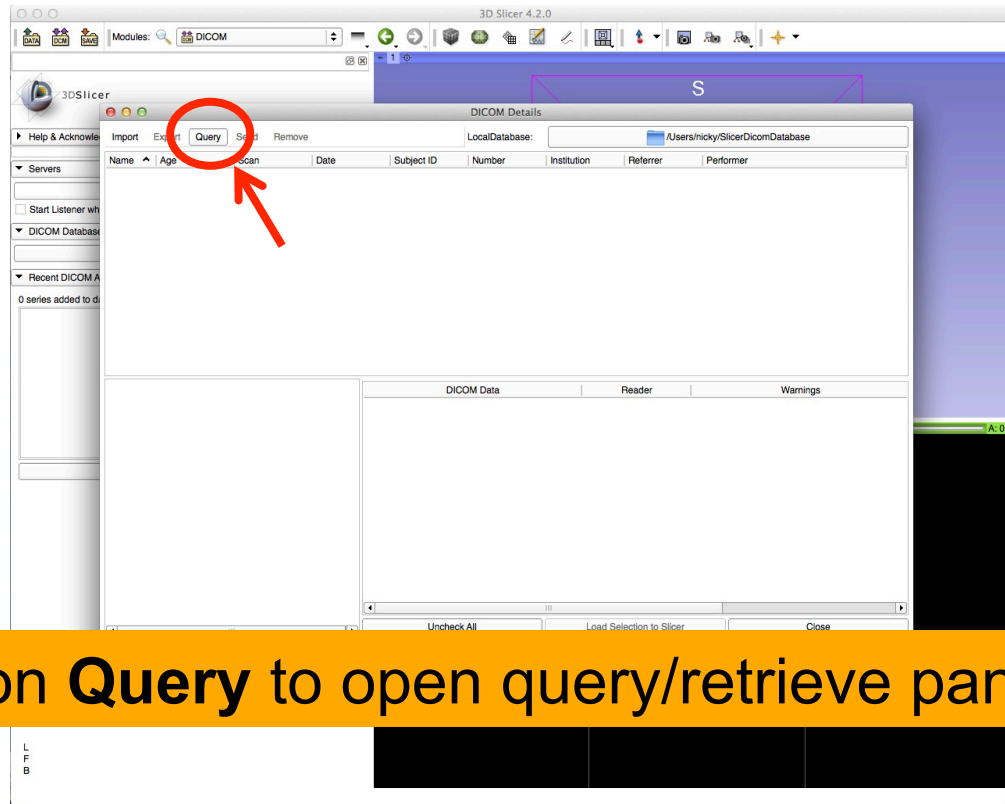
# Select DICOM local database



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

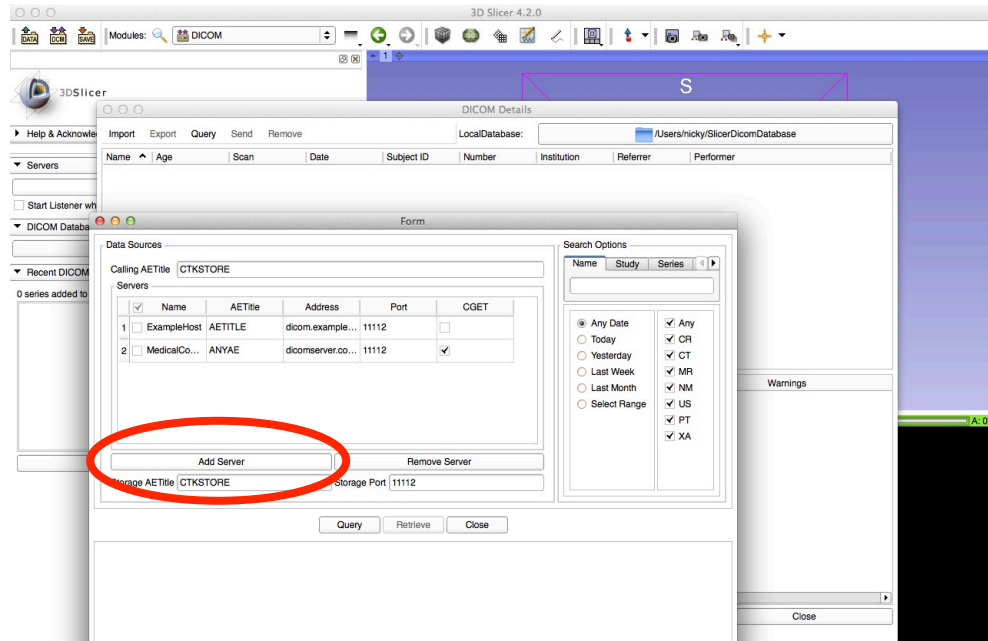


Click on **Query** to open query/retrieve panel





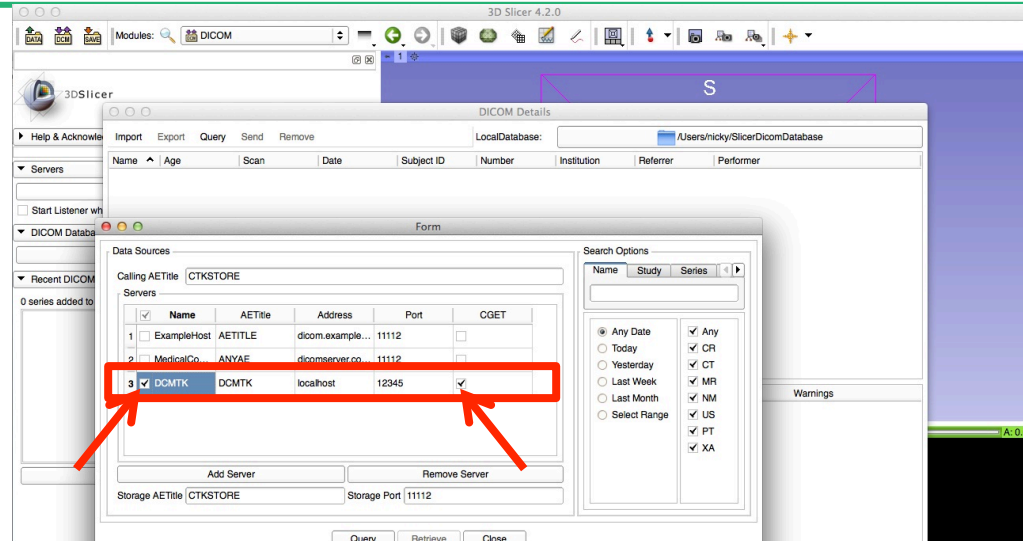
# Add a DICOM peer



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



# Add a DICOM peer



Fill DICOM peer info:

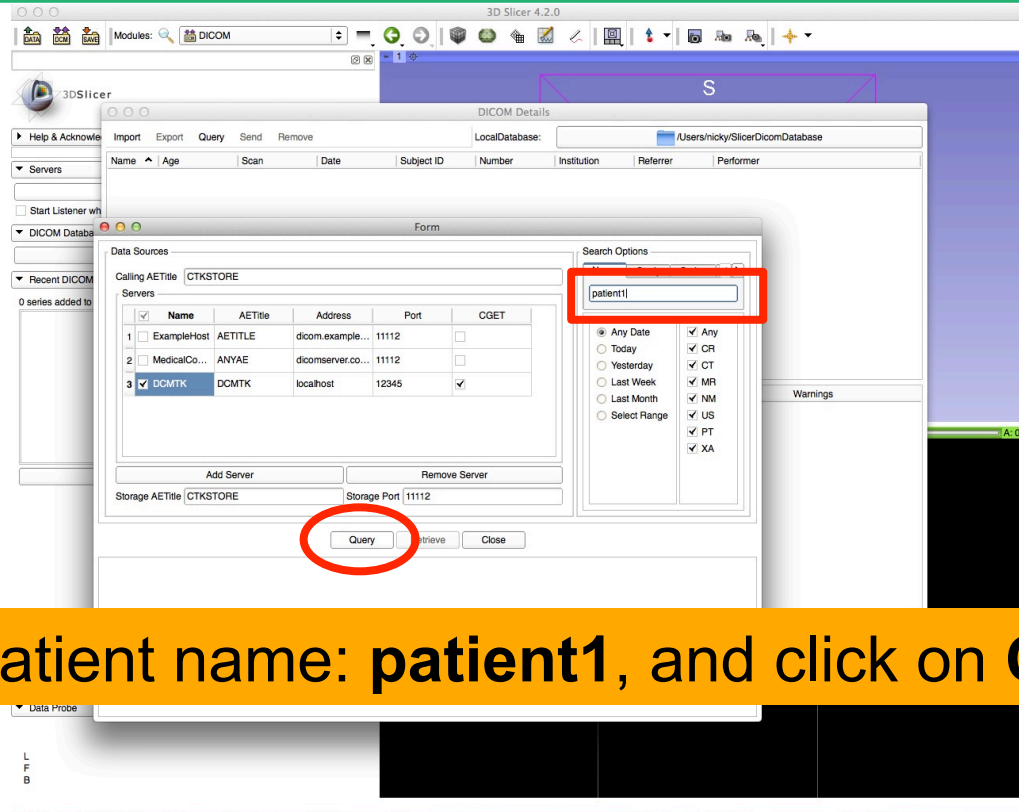
Name: **DCMTK**, AETitle: **DCMTK**, Address: **12345**

Check to **enable CGET**

Check to **activate**



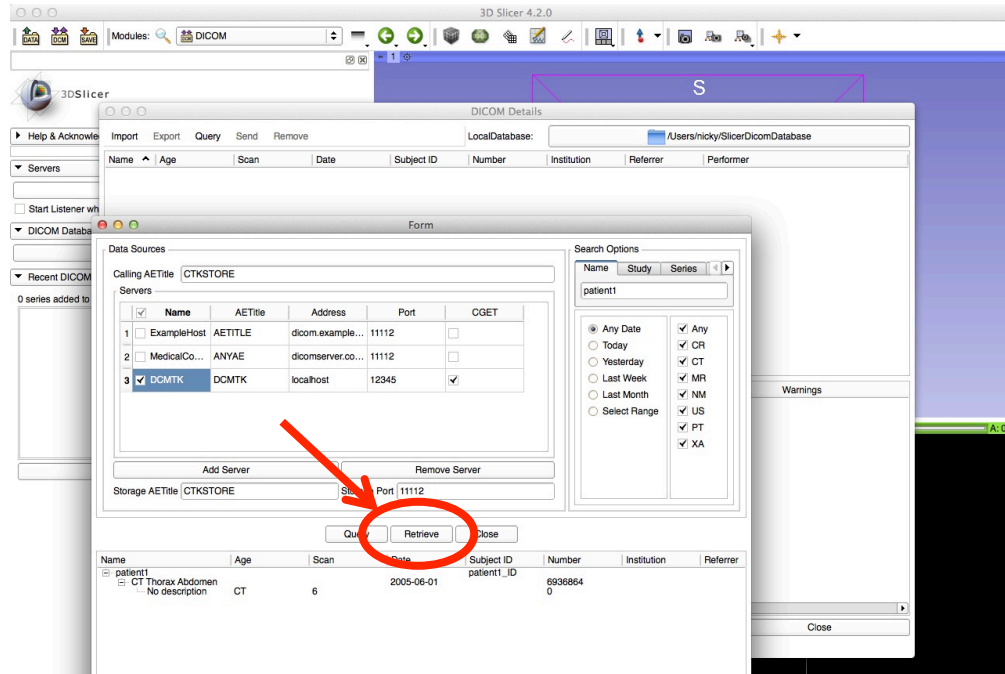
# Query DICOM volumes



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



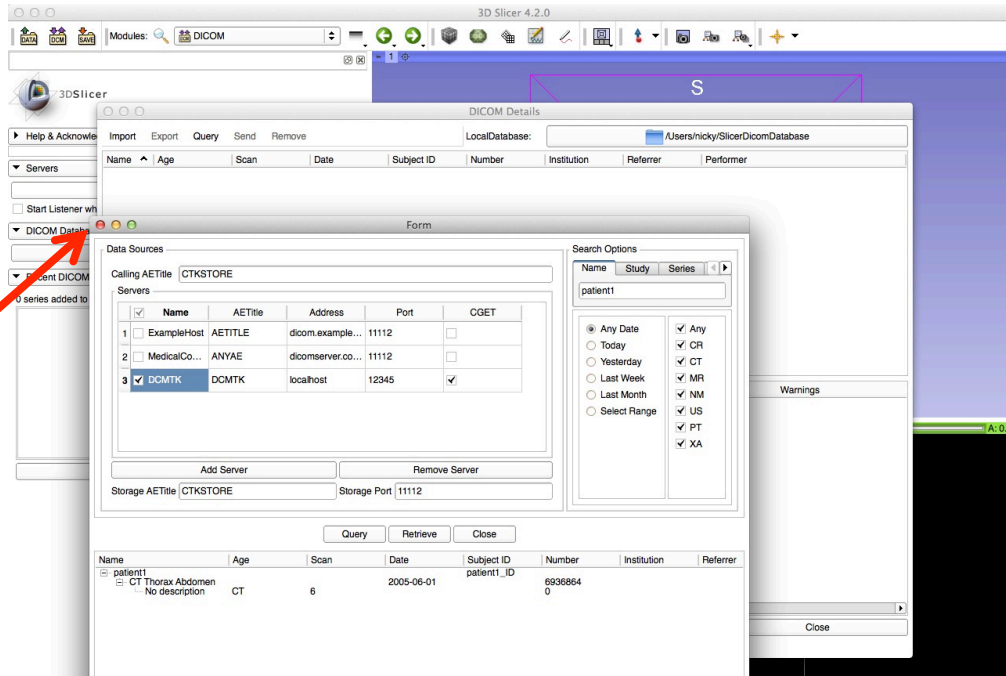
# Retrieve DICOM volumes



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 screenshot shows a DICOM browser window titled "DICOM Details" with a local data path of "/Users/spujol/workshop/RSNA2012/data/DICOM-database". The interface includes a menu bar (Import, Export, Query, Send, Remove) and a table of DICOM datasets. The table has columns for Name, Age, Scan, Date, Subject ID, Number, Institution, Referrer, and Performer. The "patient1" dataset is expanded, showing a sub-entry "CT Thorax Abdomen" which is further expanded to show "CT\_Thorax\_Abdomen CT" selected. A red arrow points to this selected entry. Below the table, there are tabs for "DICOM Data", "Reader", and "Warnings". At the bottom, there are buttons for "Uncheck All", "Load Selection to Slicer", and "Close", along with a checkbox for "Make DICOM Browser Persistent".

Name	Age	Scan	Date	Subject ID	Number	Institution	Referrer	Performer
patient1				patien...				
CT Thorax Abdomen			2005-...		6936864	oEfZQ...		
CT_Thorax_Abdomen CT		6	2005-...	HEART	14			

**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

The screenshot shows the Slicer DICOM browser interface. At the top, there is a menu bar with 'Import', 'Export', 'Query', 'Send', and 'Remove'. Below the menu is a table with columns: Name, Age, Scan, Date, Subject I Number, Institution, Referrer, and Performer. The table contains one main entry: 'patient1' with a sub-entry 'CT\_Thorax\_Abdomen CT'. The 'CT\_Thorax\_Abdomen CT' entry is selected and highlighted in blue. Below the table is a large empty space. At the bottom of the window, there is a grid of 20 image thumbnails labeled 'Image 0' through 'Image 19'. A red arrow points from the left towards the grid. To the right of the grid is a 'DICOM Data' panel with columns 'DICOM Data', 'Header', and 'Warnings'. The 'DICOM Data' column contains multiple entries for '6: CT\_Thorax\_Abdo...' with 'Scalar Vol...' in the 'Header' column. At the bottom of the DICOM Data panel are buttons: 'Uncheck All', 'Load Selection to Slicer', and 'Close'. Below the DICOM Data panel is a checkbox labeled 'Make DICOM Browser Persistent'.

Name	Age	Scan	Date	Subject I Number	Institution	Referrer	Performer
patient1				patien...			
CT_Thorax_Abdomen			2005-...	6936864 oEFZQ...			
CT_Thorax_Abdomen CT		6	2005-...	HEART 14			

DICOM Data	Header	Warnings
6: CT_Thorax_Abdo...	Scalar Vol...	
6: CT_Thorax_Abdo...	Scalar Vol...	
6: CT_Thorax_Abdo...	Scalar Vol...	
6: CT_Thorax_Abdo...	Scalar Vol...	
6: CT_Thorax_Abdo...	Scalar Vol...	
6: CT_Thorax_Abdo...	Scalar Vol...	
6: CT_Thorax_Abdo...	Scalar Vol...	
6: CT_Thorax_Abdo...	Scalar Vol...	
6: CT_Thorax_Abdo...	Scalar Vol...	
6: CT_Thorax_Abdo...	Scalar Vol...	
6: CT_Thorax_Abdo...	Scalar Vol...	
6: CT_Thorax_Abdo...	Scalar Vol...	
6: CT_Thorax_Abdo...	Scalar Vol...	
6: CT_Thorax_Abdo...	Scalar Vol...	
6: CT_Thorax_Abdo...	Scalar Vol...	
6: CT_Thorax_Abdo...	Scalar Vol...	
6: CT_Thorax_Abdo...	Scalar Vol...	
6: CT_Thorax_Abdo...	Scalar Vol...	
6: CT_Thorax_Abdo...	Scalar Vol...	
6: CT_Thorax_Abdo...	Scalar Vol...	
6: CT_Thorax_Abdo...	Scalar Vol...	

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

The screenshot shows a 'DICOM Details' window with a table of scan data. The table has columns for Name, Age, Scan, Date, Subject I Number, Institution, Referrer, and Performer. The selected row is 'CT\_Thorax\_Abdomen CT' with a scan number of 6 and a date of 2005-... HEART 14. Below the table, there are five image thumbnails labeled 'Image 15' through 'Image 19'. At the bottom right of the window, there is a 'Load Selection to Slicer' button, which is highlighted with a red arrow. Other buttons include 'Uncheck All' and 'Close'. A 'Warnings' panel is also visible on the right side of the window.

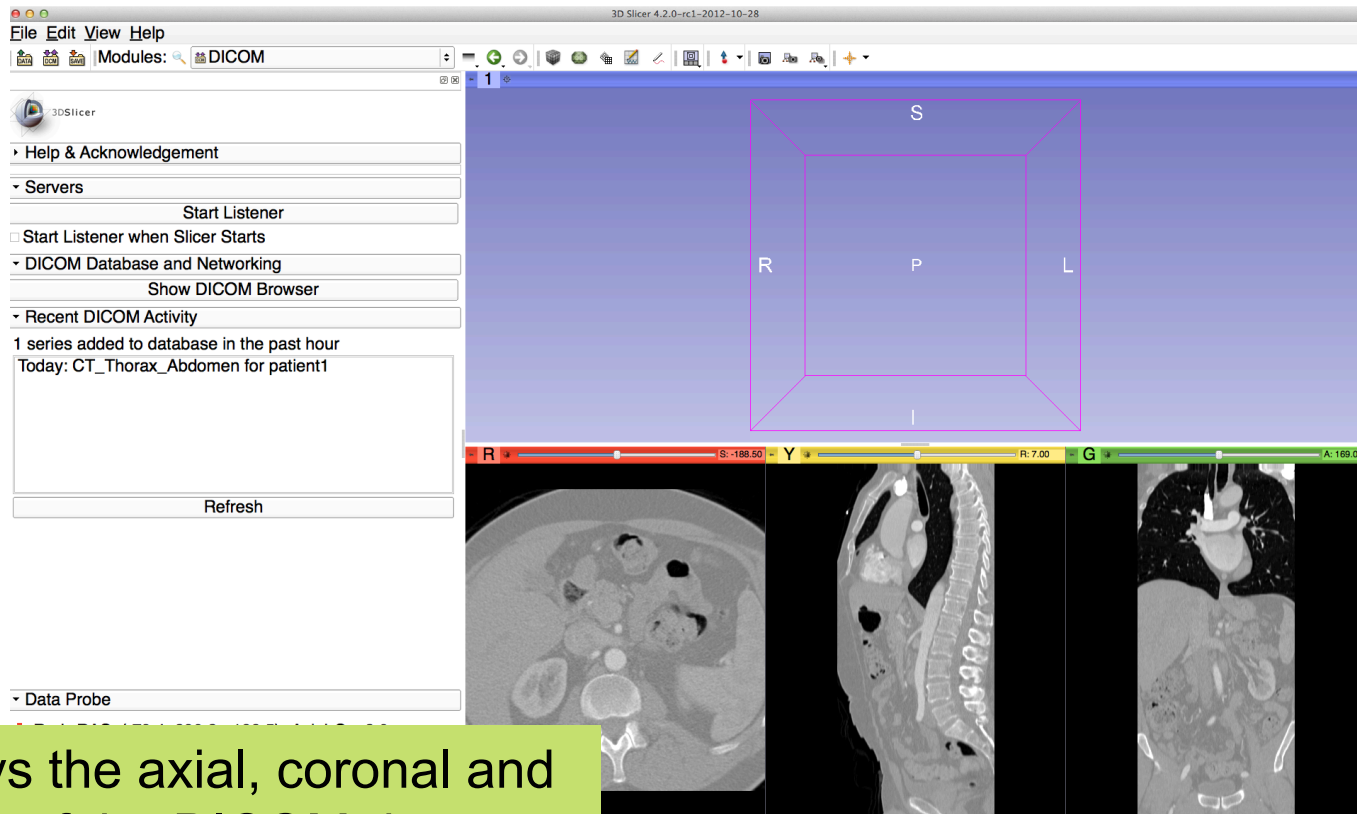
Name	Age	Scan	Date	Subject I Number	Institution	Referrer	Performer
patient1				patien...			
CT_Thorax_Abdomen			2005-...	6936864 oEfZQ...			
CT_Thorax_Abdomen CT		6	2005-...	HEART 14			

Click on **Load Selection to Slicer** to load the DICOM volume into Slicer  
  
(note: this may take a few minutes)





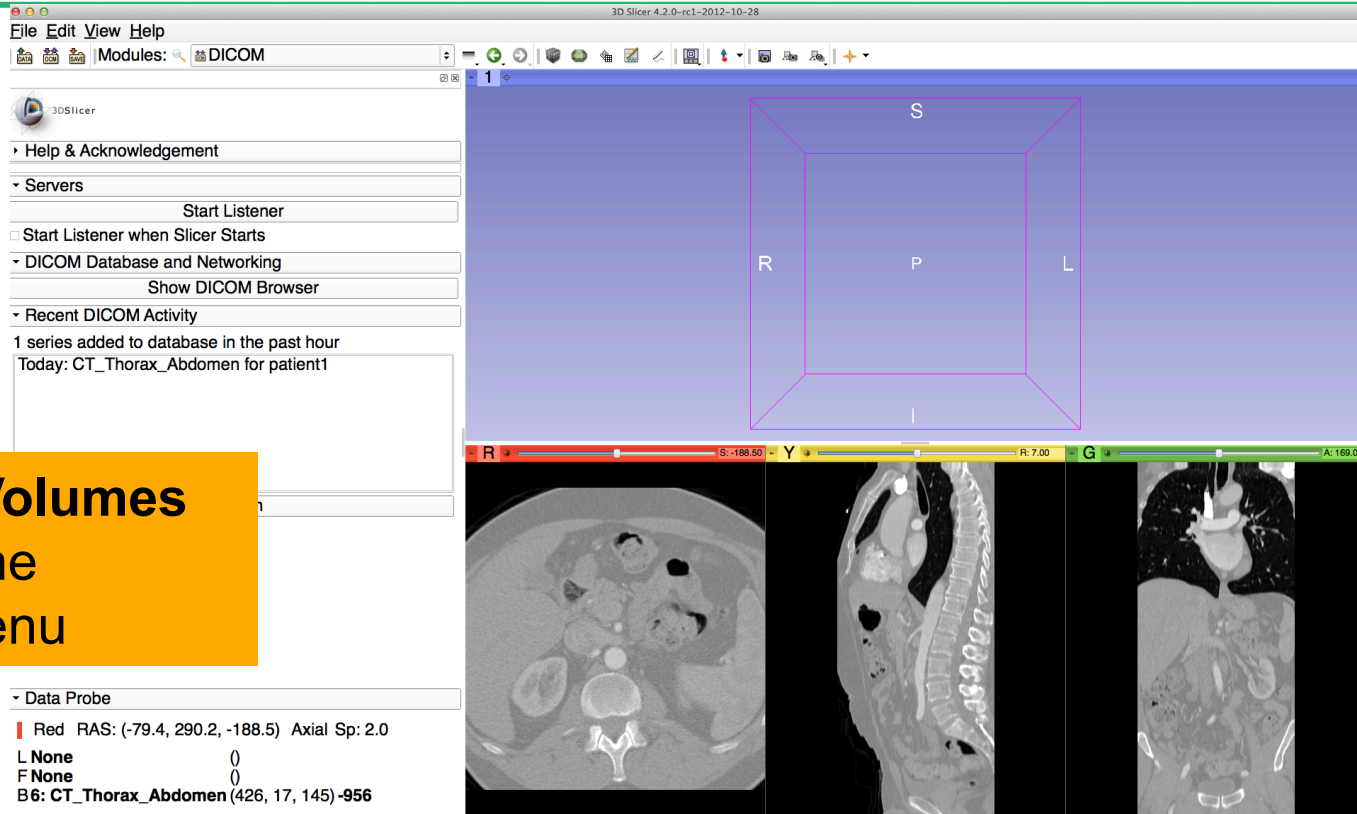
# Loading a DICOM volume



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



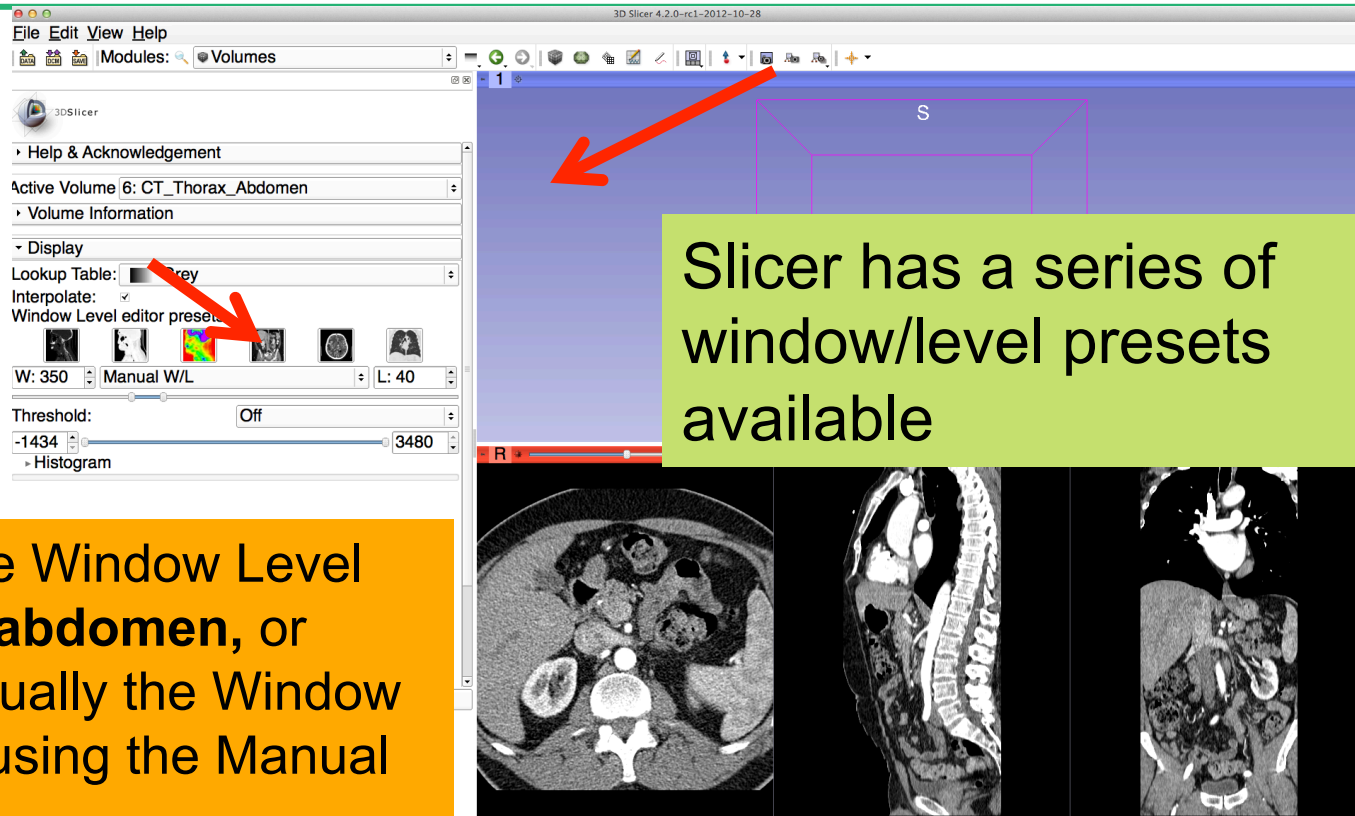
# Loading a DICOM volume



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

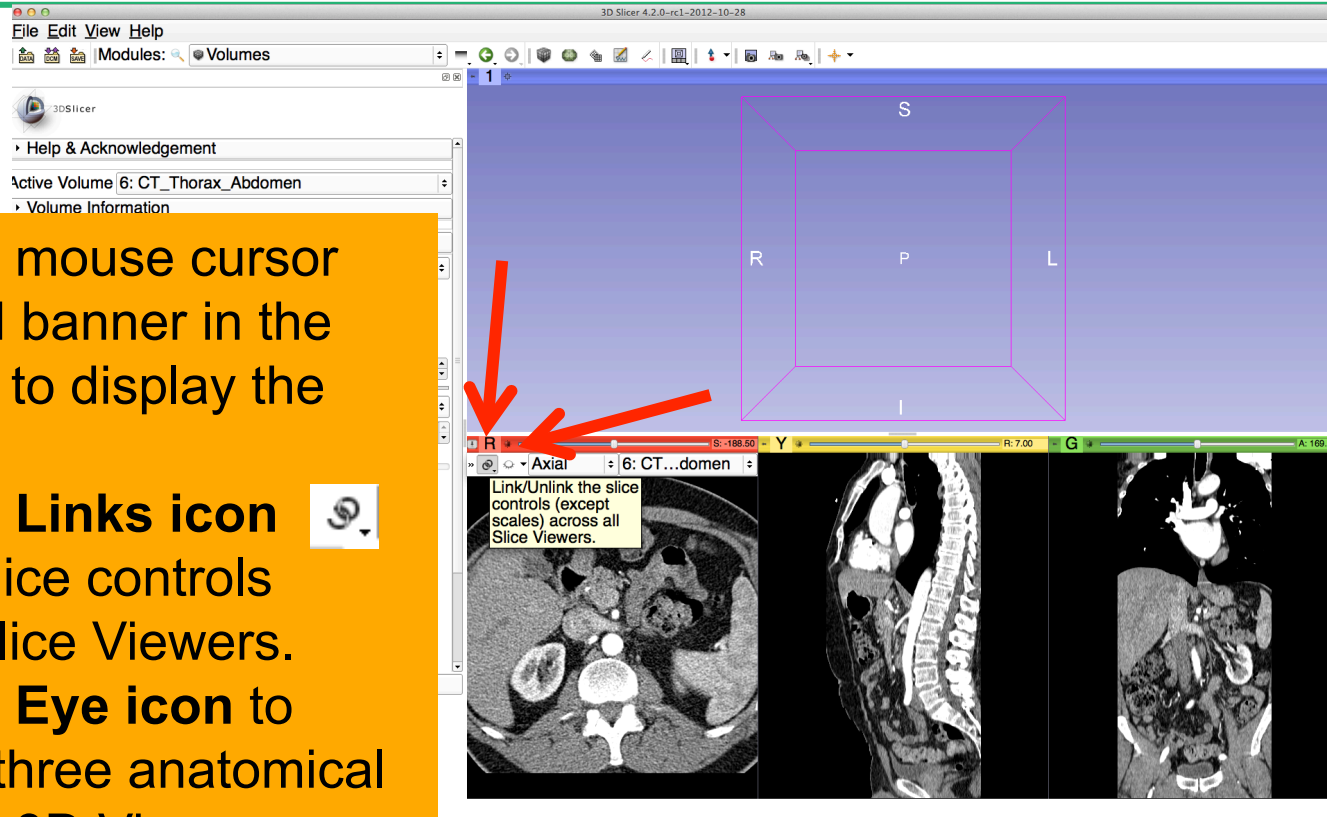


# Loading a DICOM volume

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

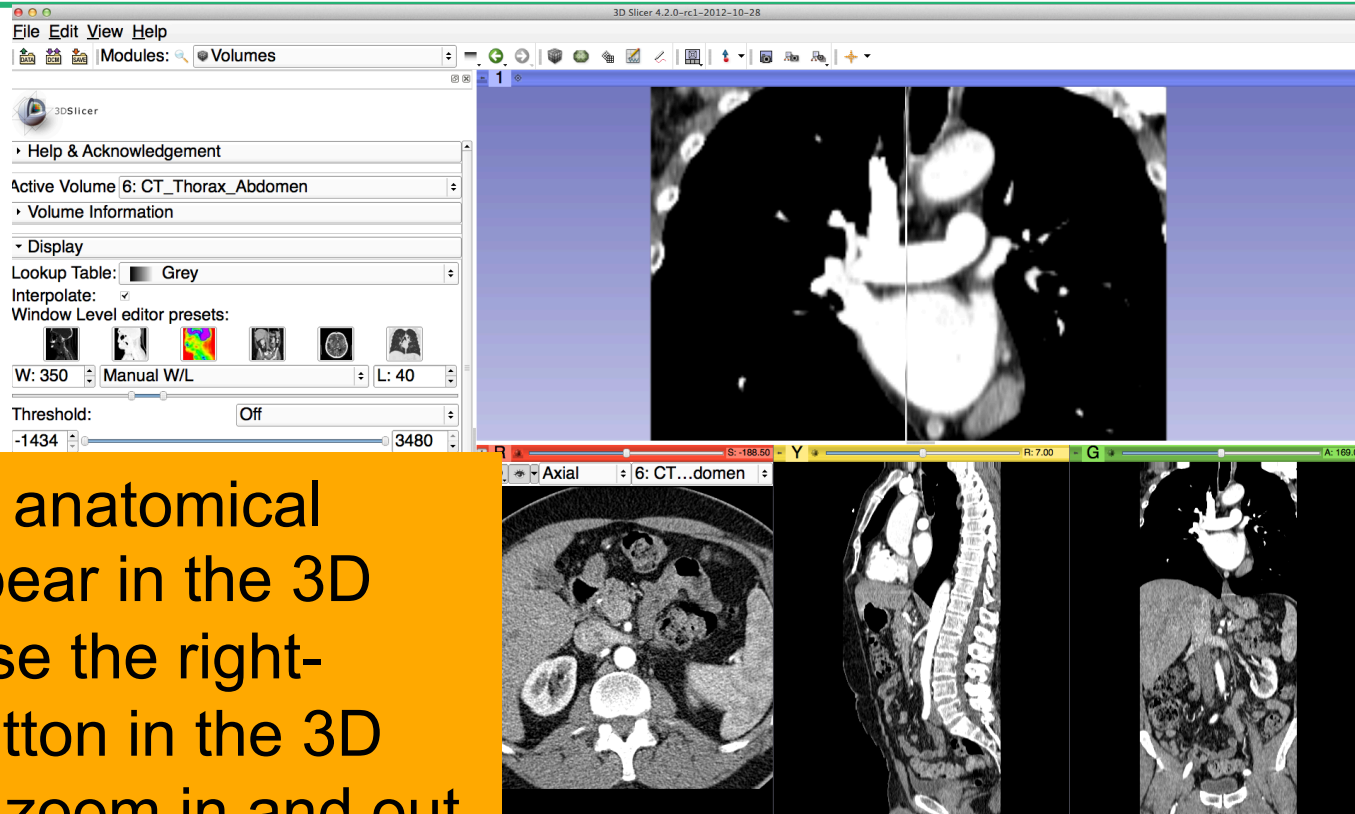
Click on the **Links icon**  to link the slice controls across all Slice Viewers.

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





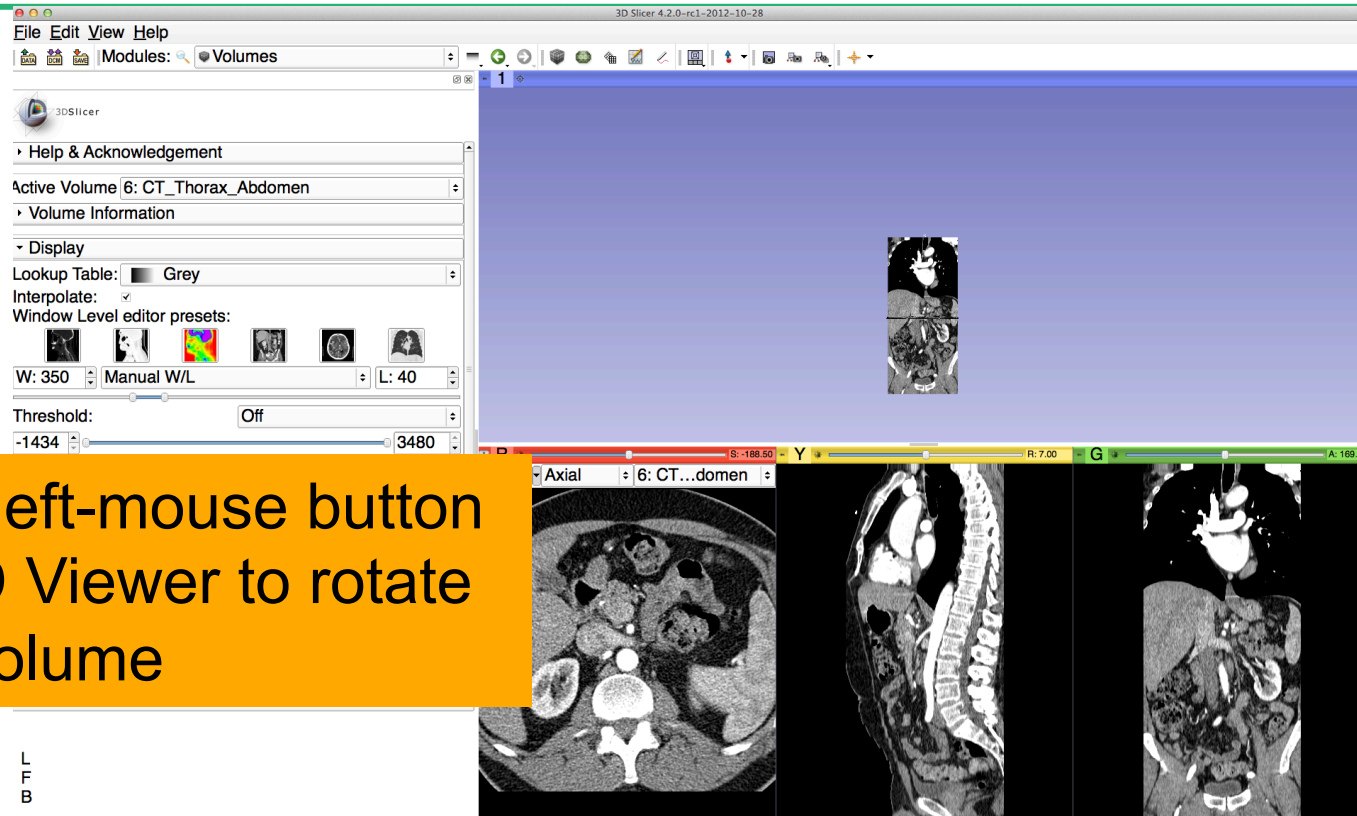
# Loading a DICOM volume



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

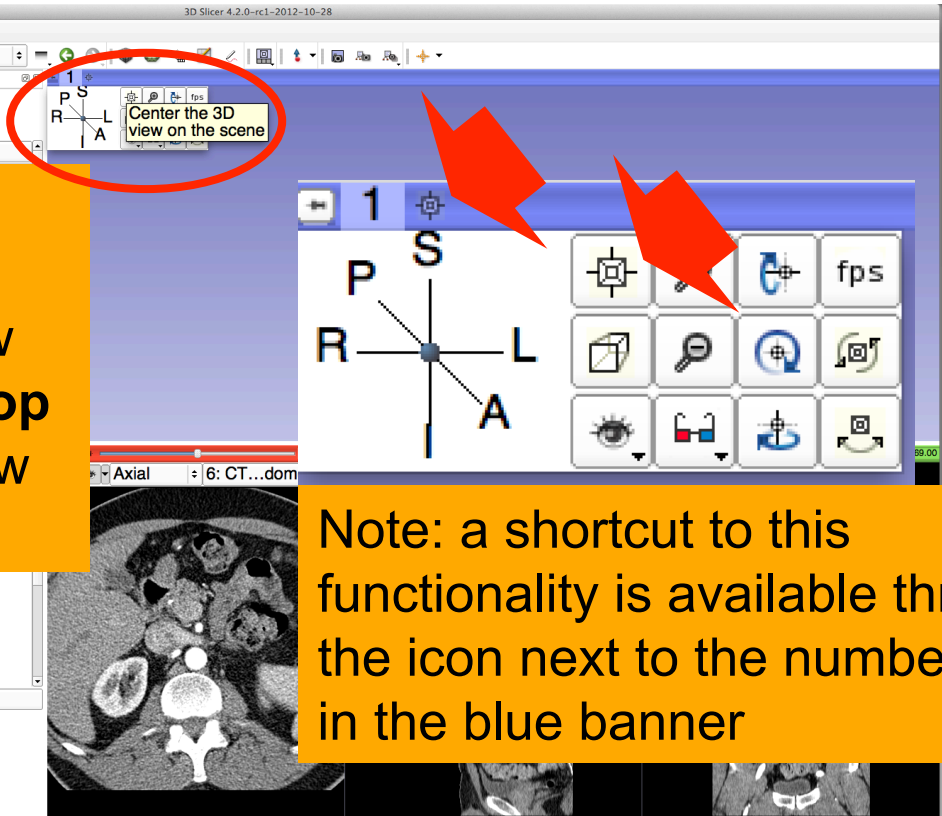


Use the left-mouse button in the 3D Viewer to rotate the 3D volume



# 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

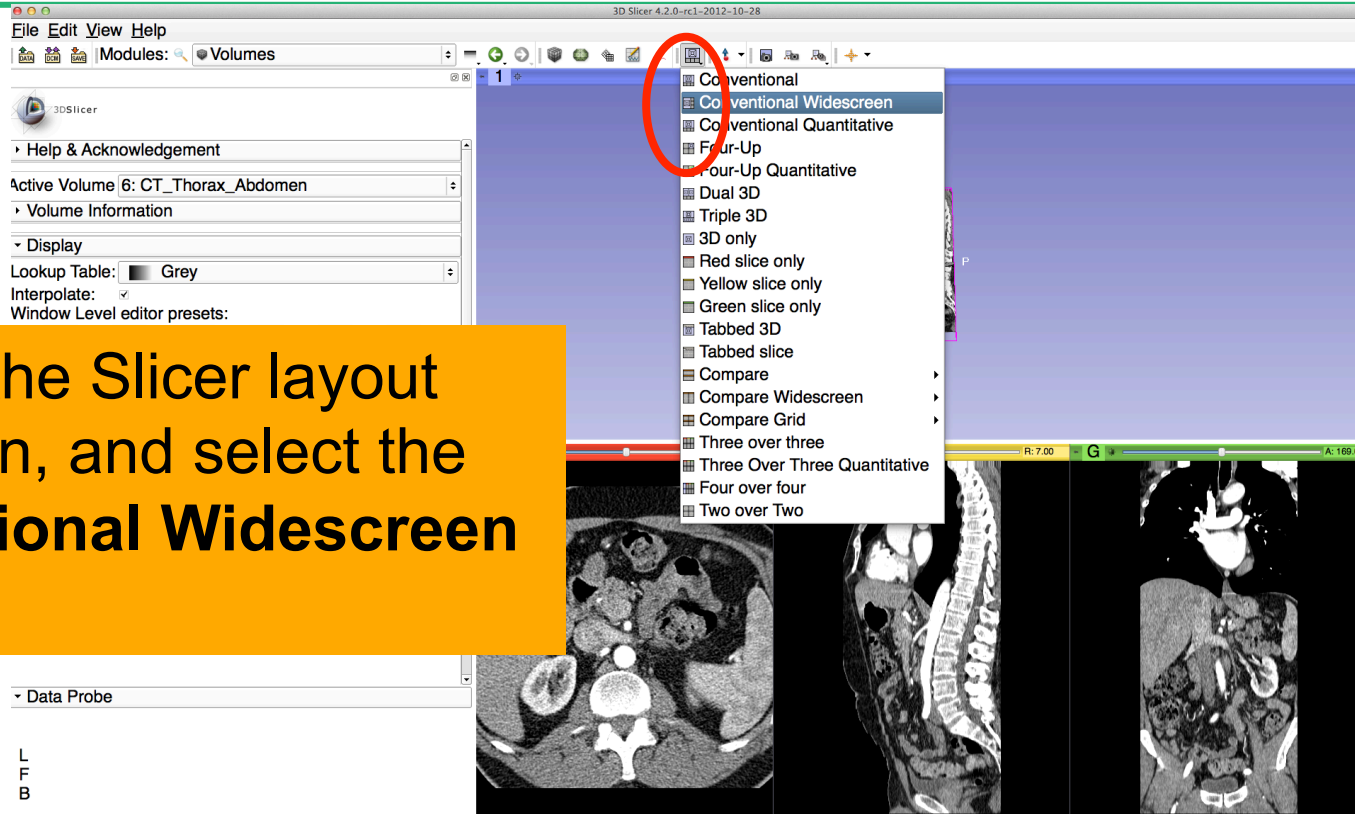


Note: a shortcut to this functionality is available through the icon next to the number '1' in the blue banner





# Loading a DICOM volume



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



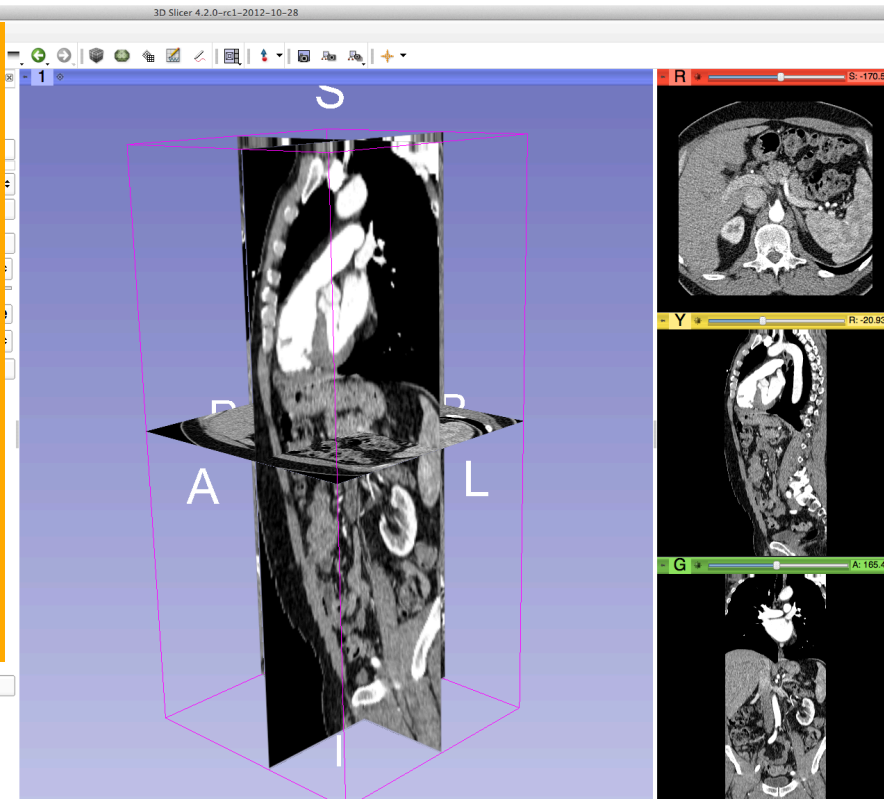


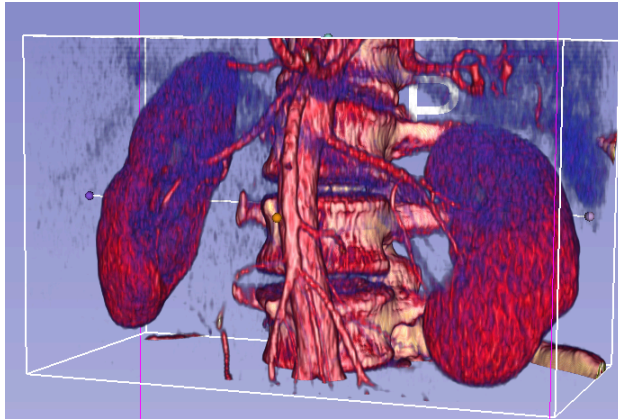
# Loading a DICOM volume

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

Data Probe

L  
F  
B



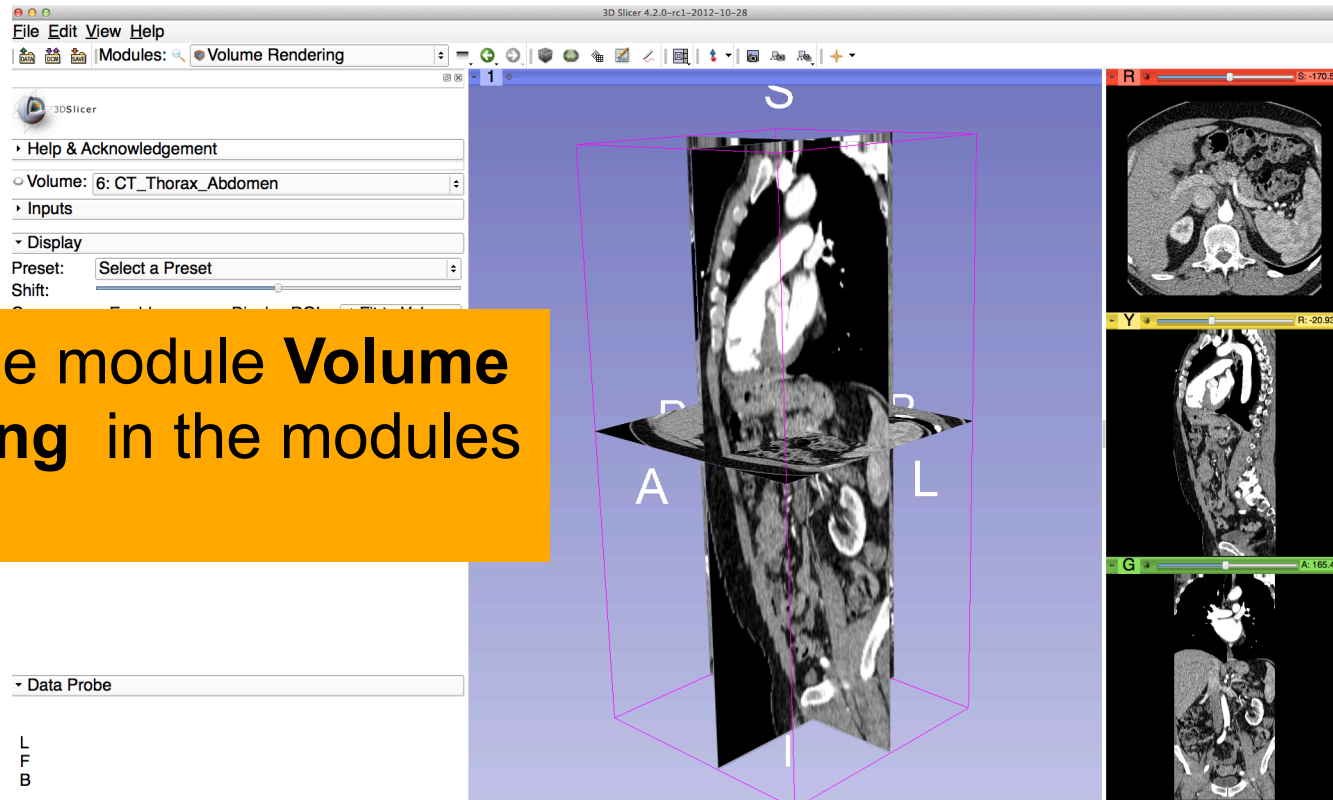


3D Interactive exploration of  
thoraco-abdominal CT data  
using Volume Rendering



# Volume Rendering

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

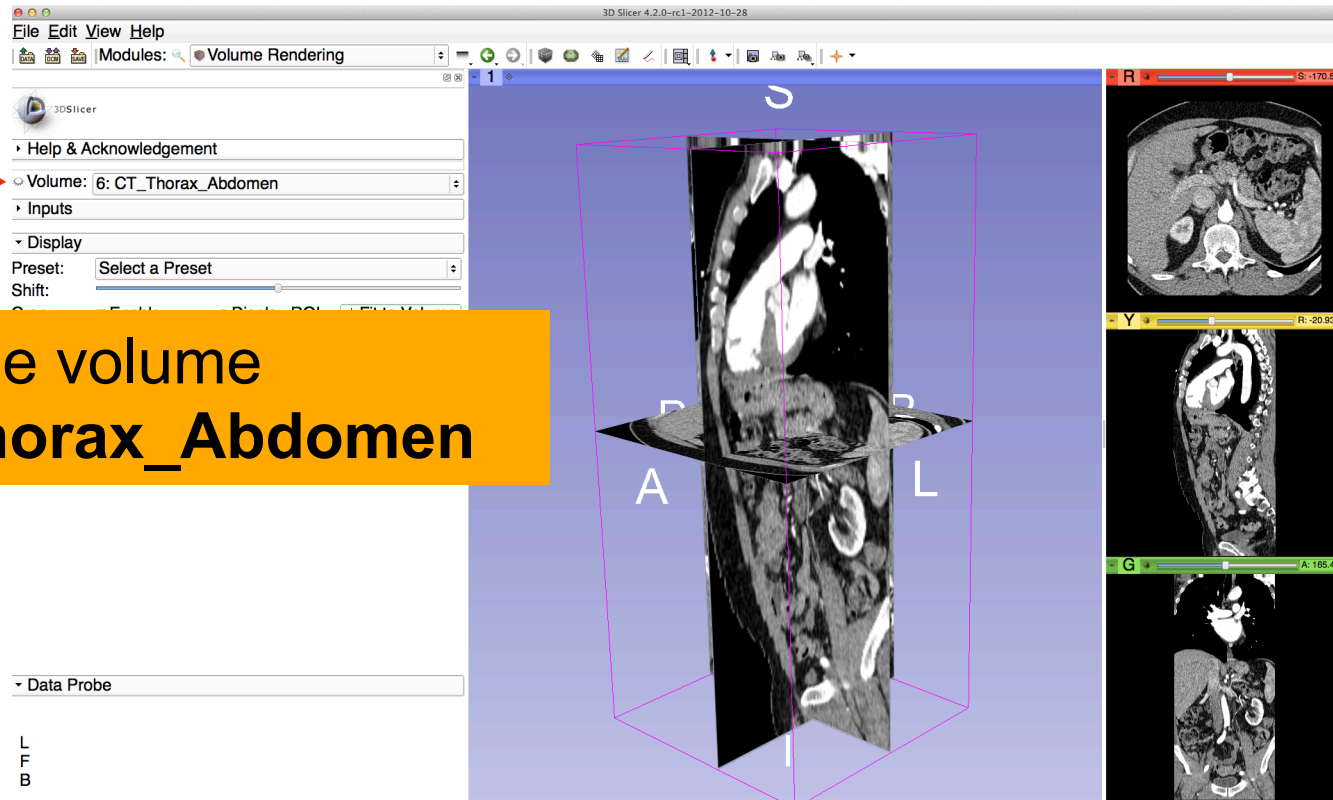




# Volume Rendering

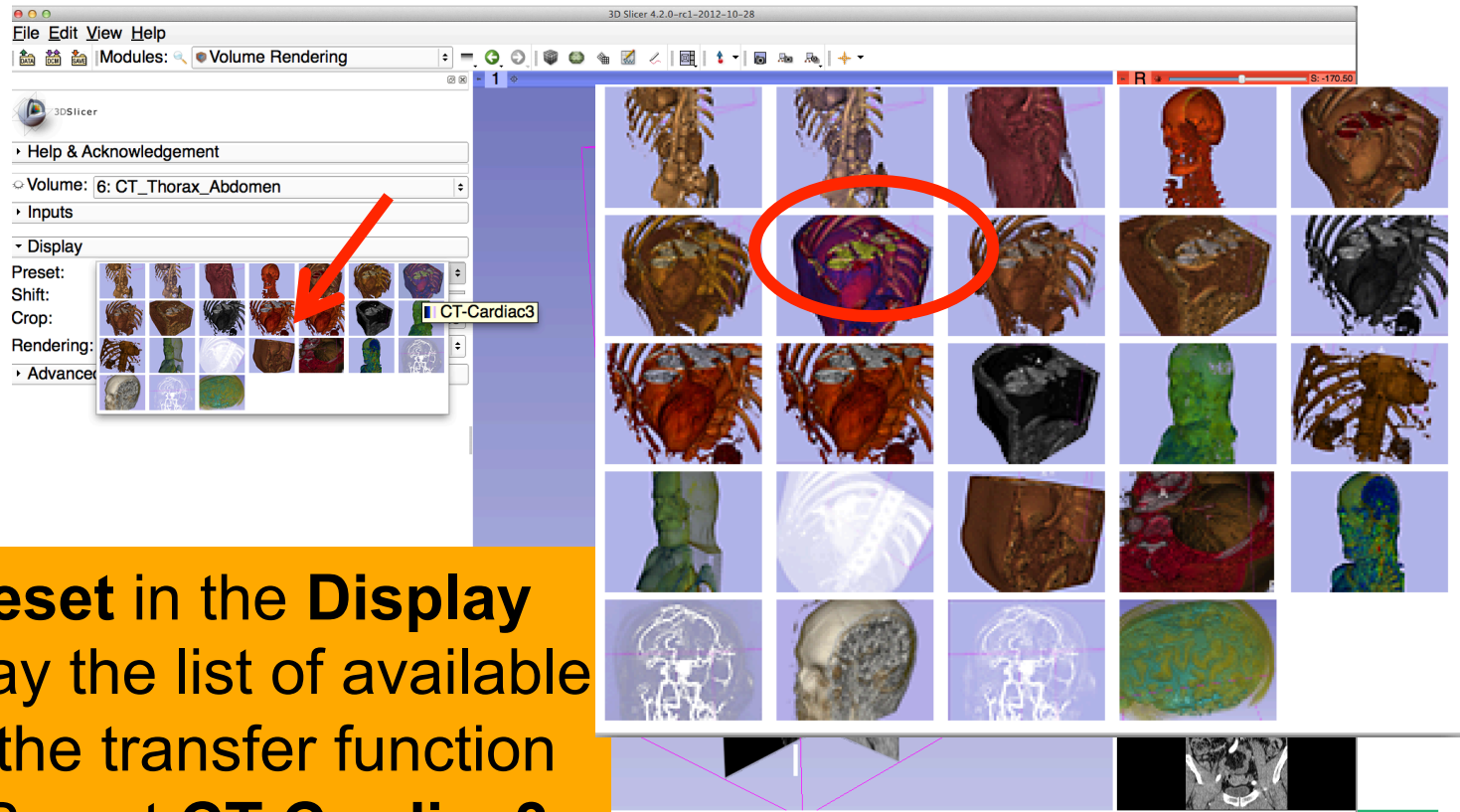


Select the volume  
6:CT\_Thorax\_Abdomen





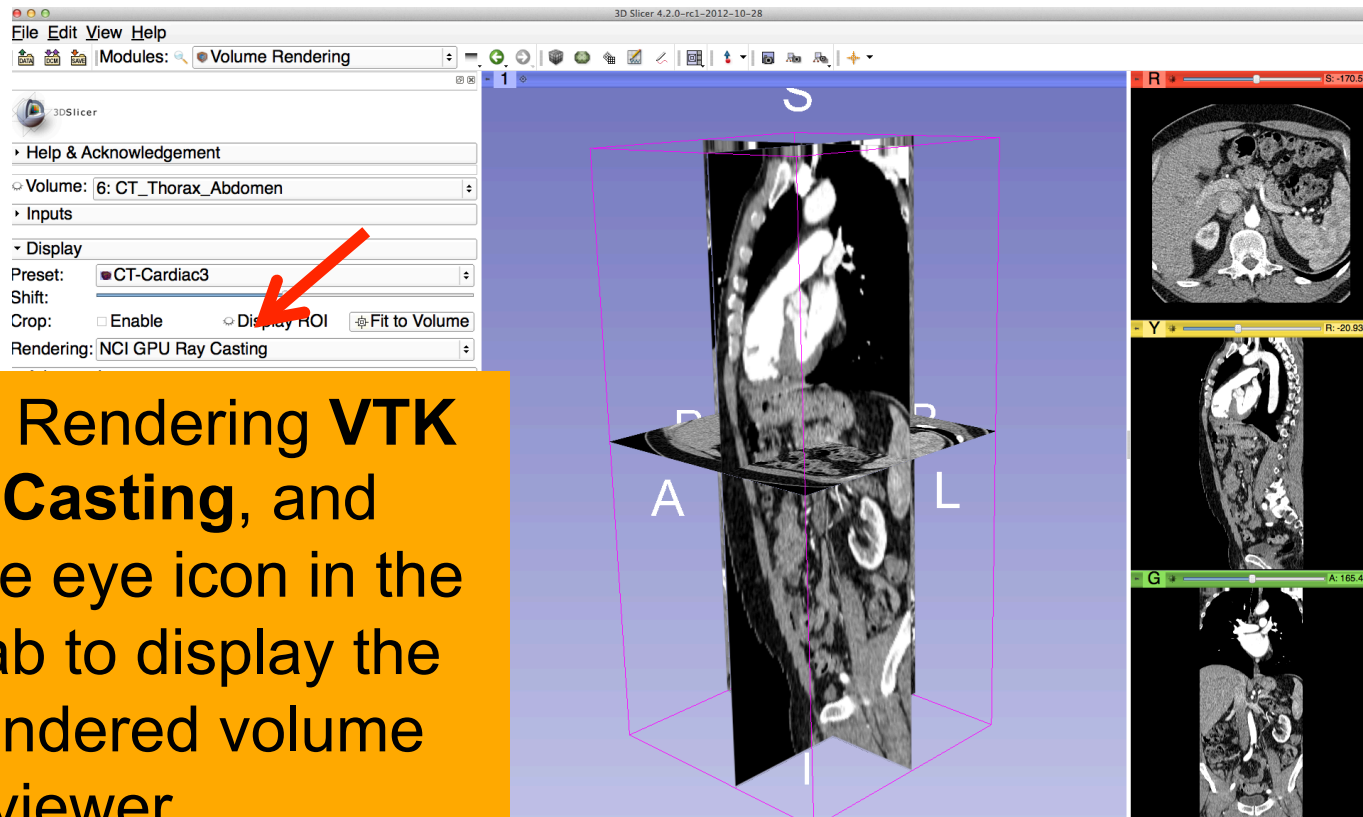
# Volume Rendering



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



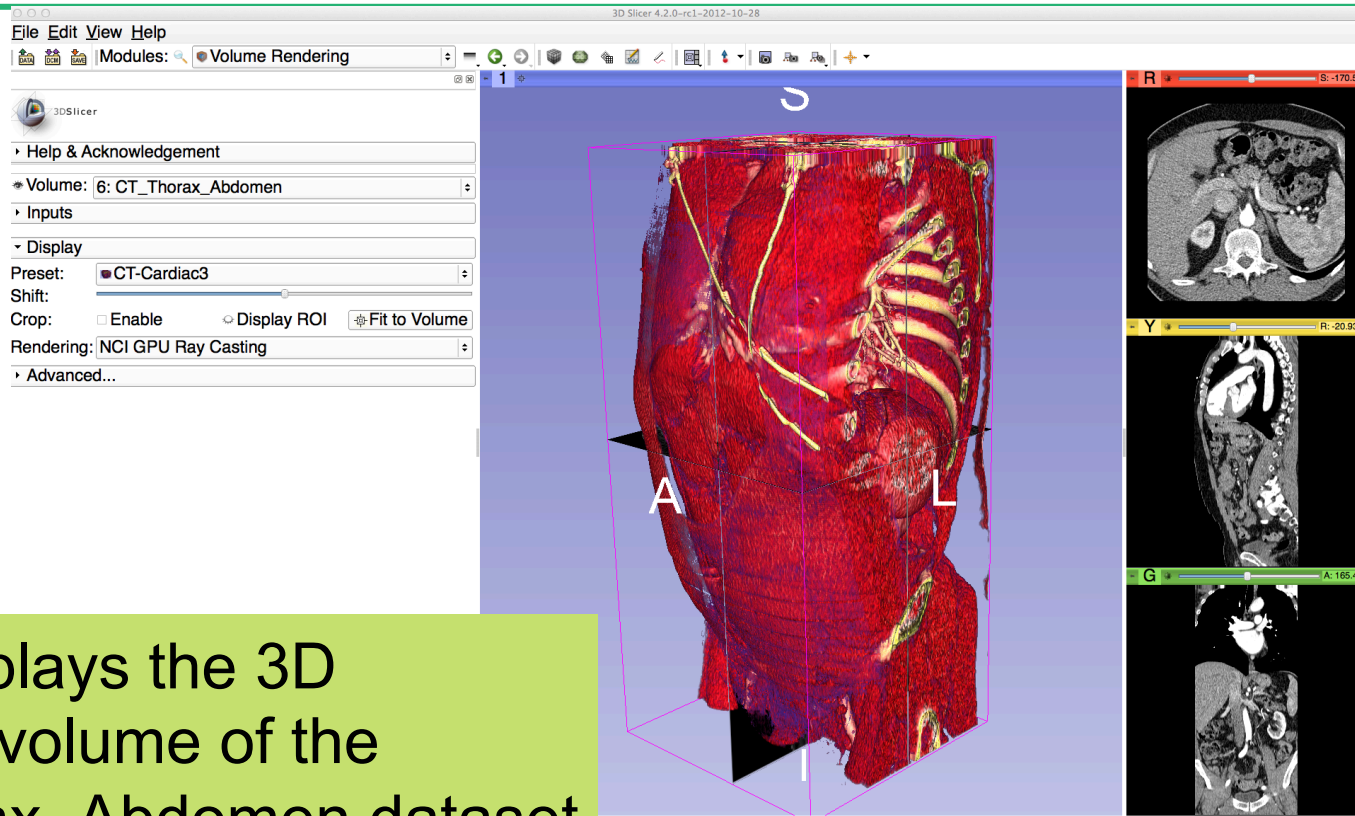
# Volume Rendering



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

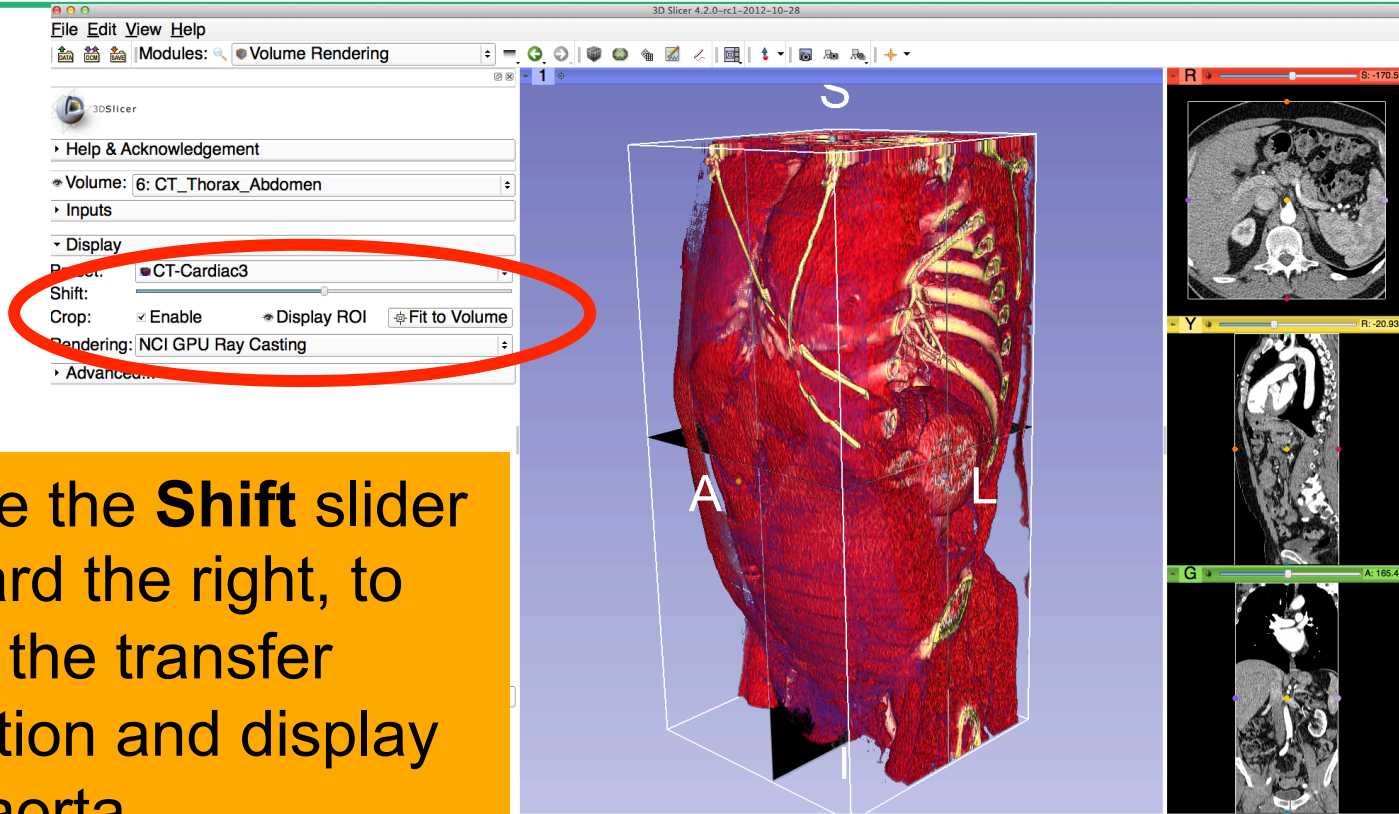


Slicer displays the 3D rendered volume of the CT\_Thorax\_Abdomen dataset





# Volume Rendering

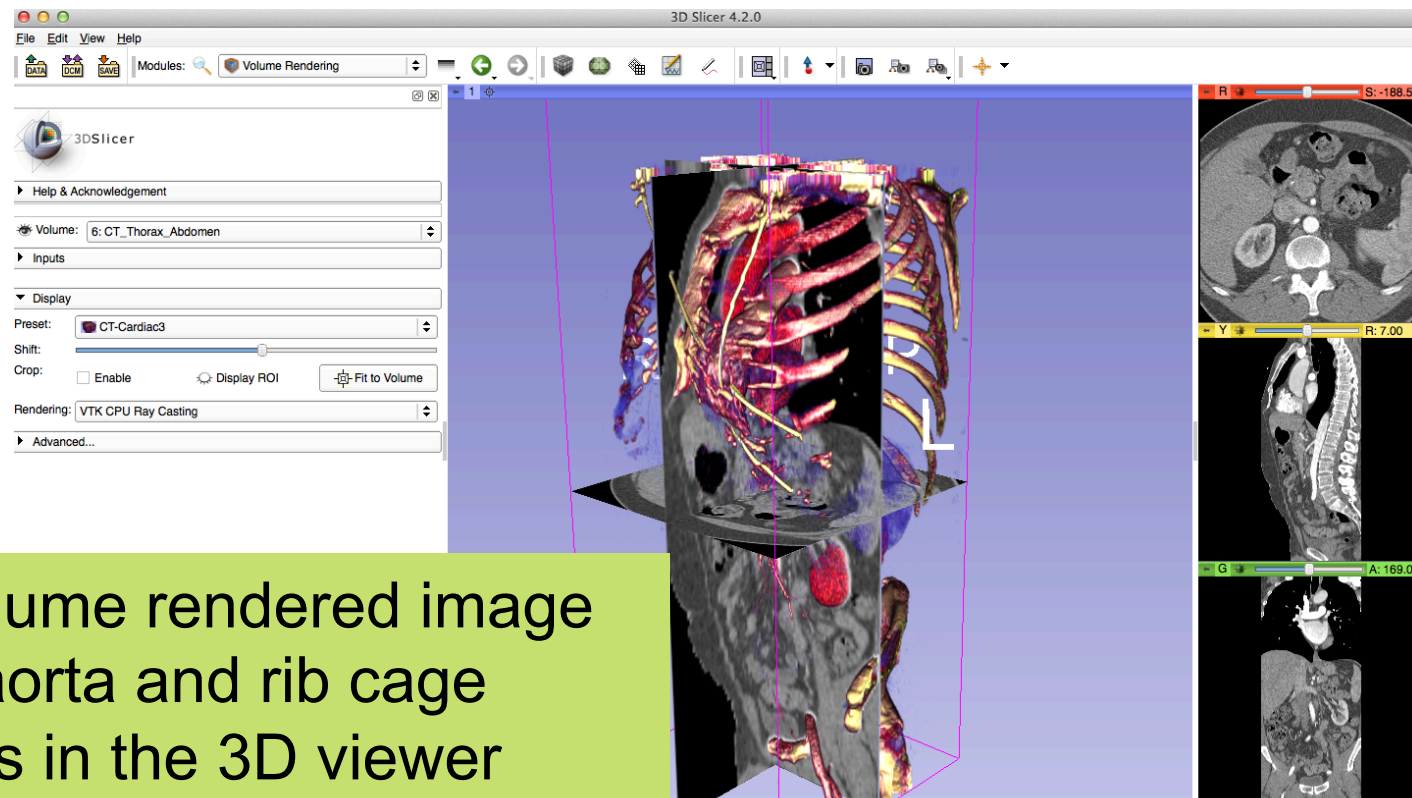


Move the **Shift** slider toward the right, to shift the transfer function and display the aorta





# Volume Rendering

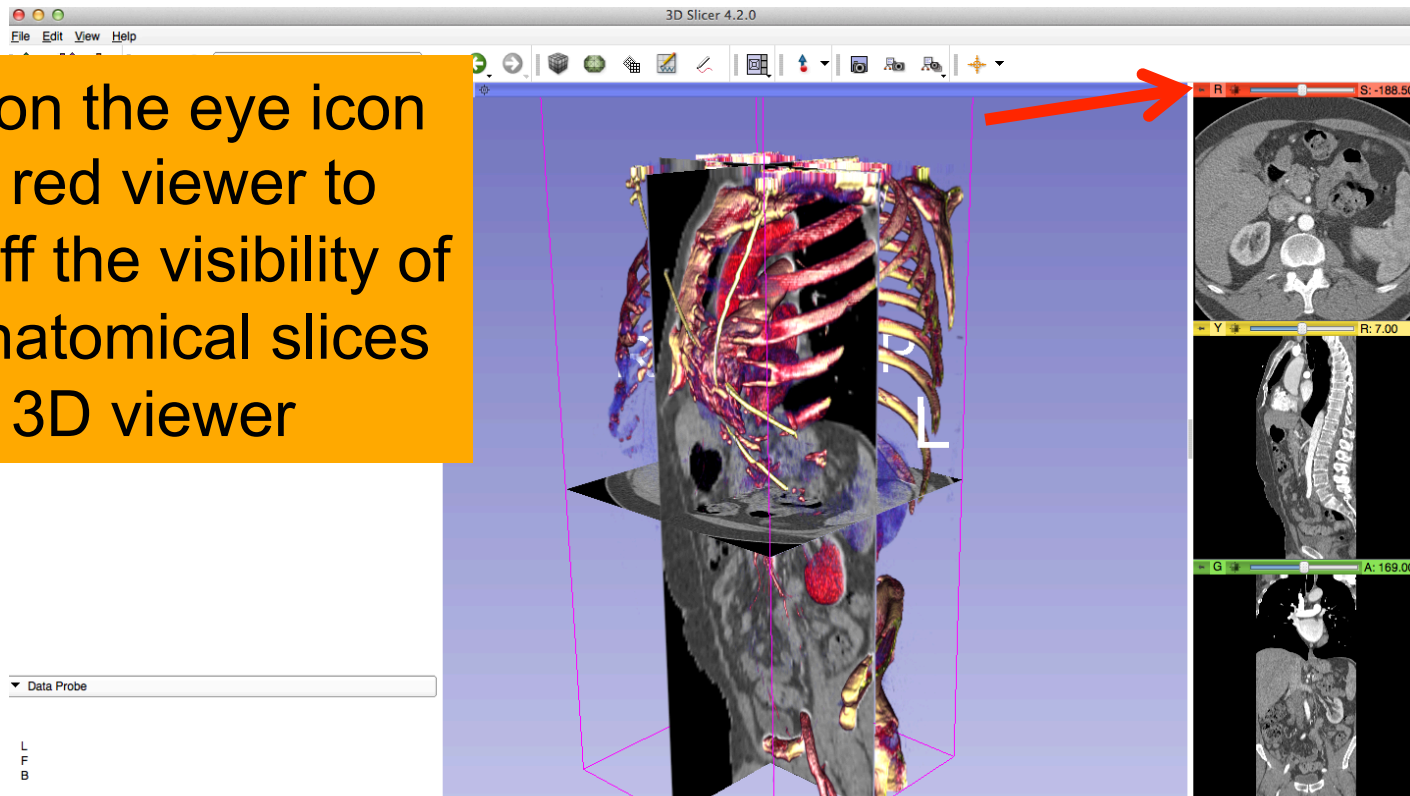


The volume rendered image of the aorta and rib cage appears in the 3D viewer



# Volume Rendering

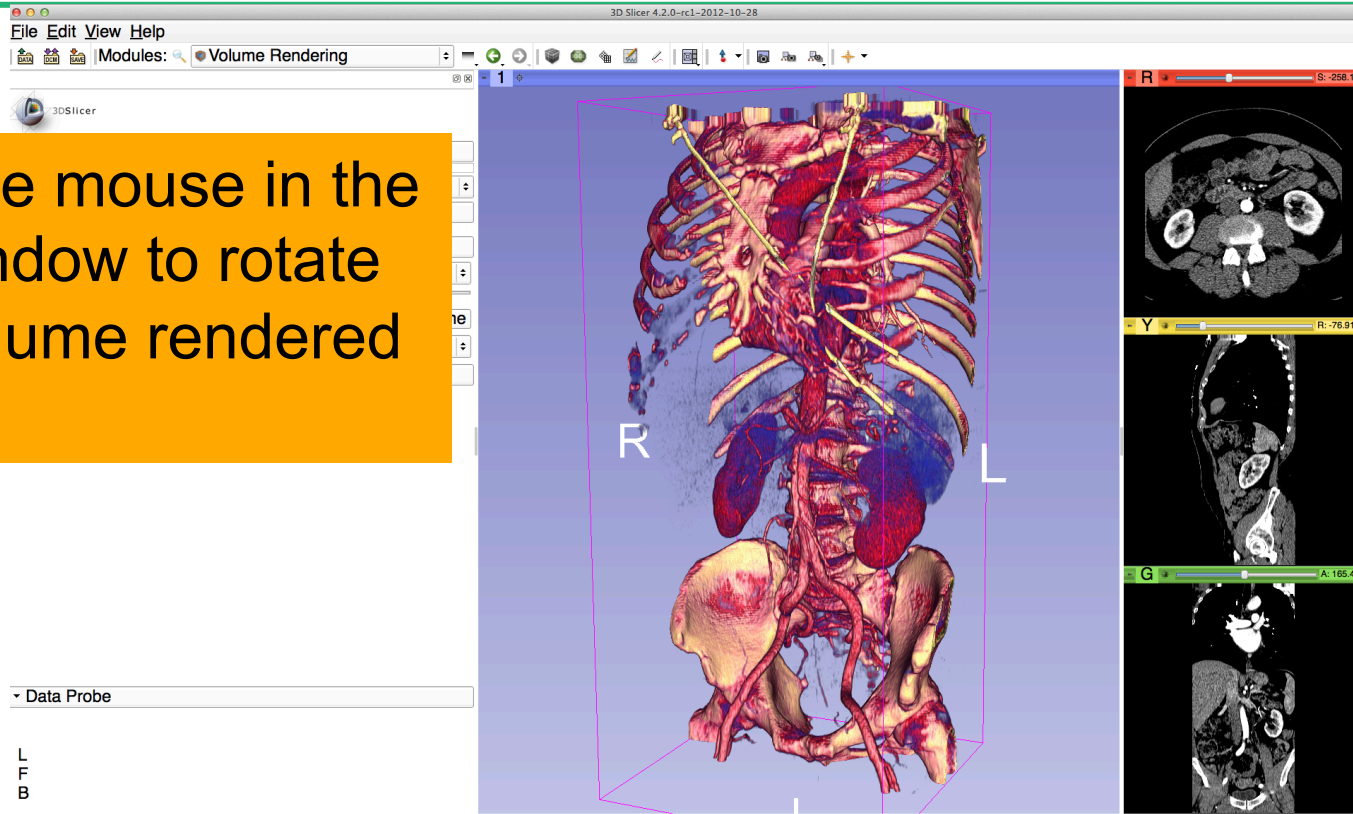
Click on the eye icon in the red viewer to turn off the visibility of the anatomical slices in the 3D viewer





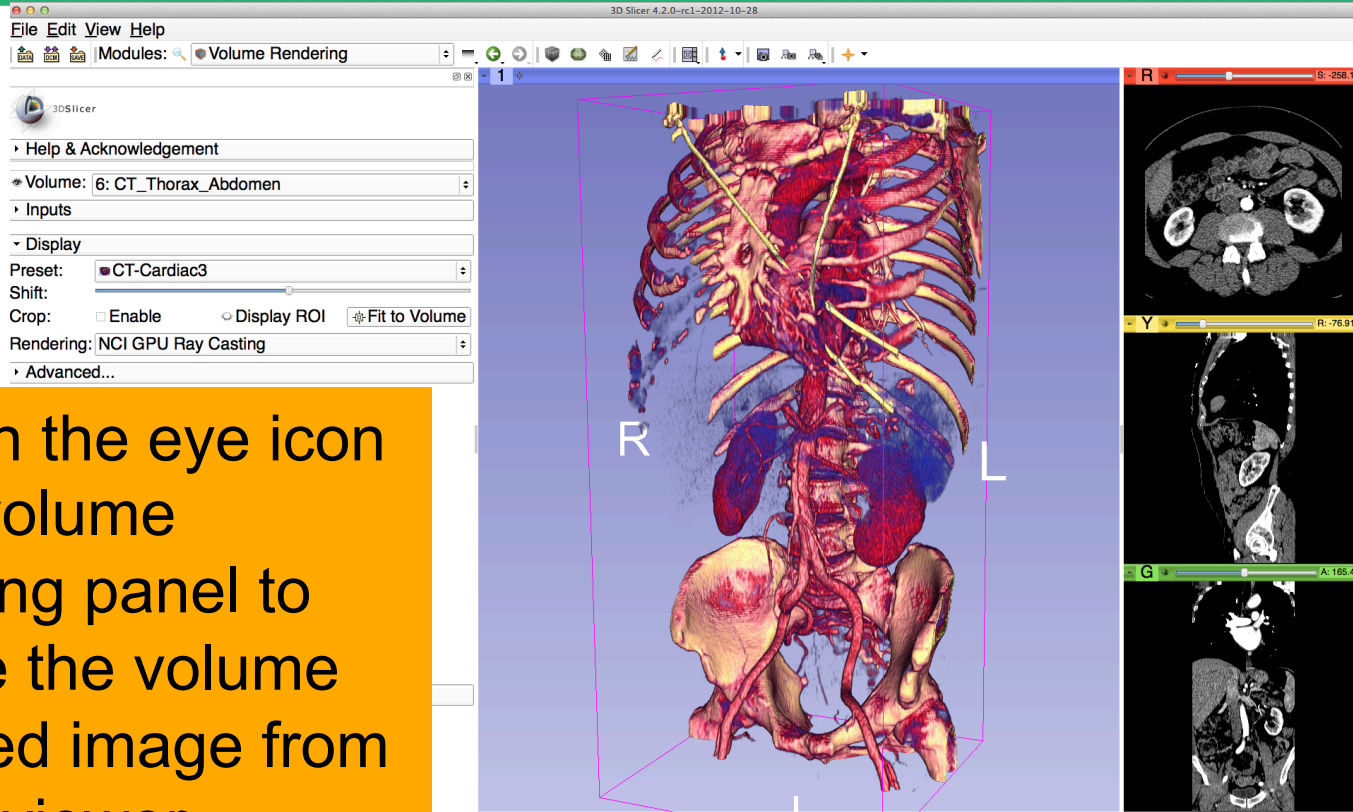
# Volume Rendering

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





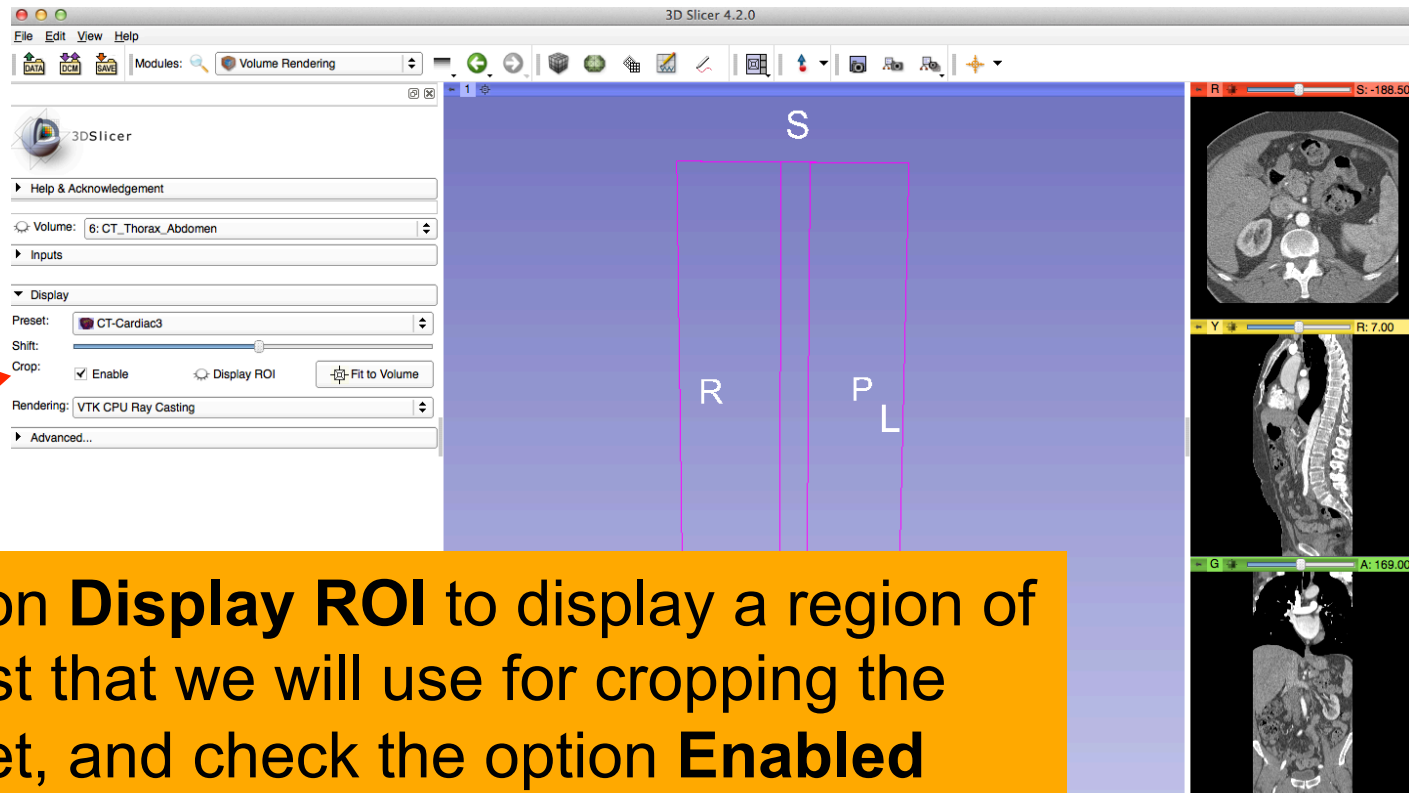
# Volume Rendering



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



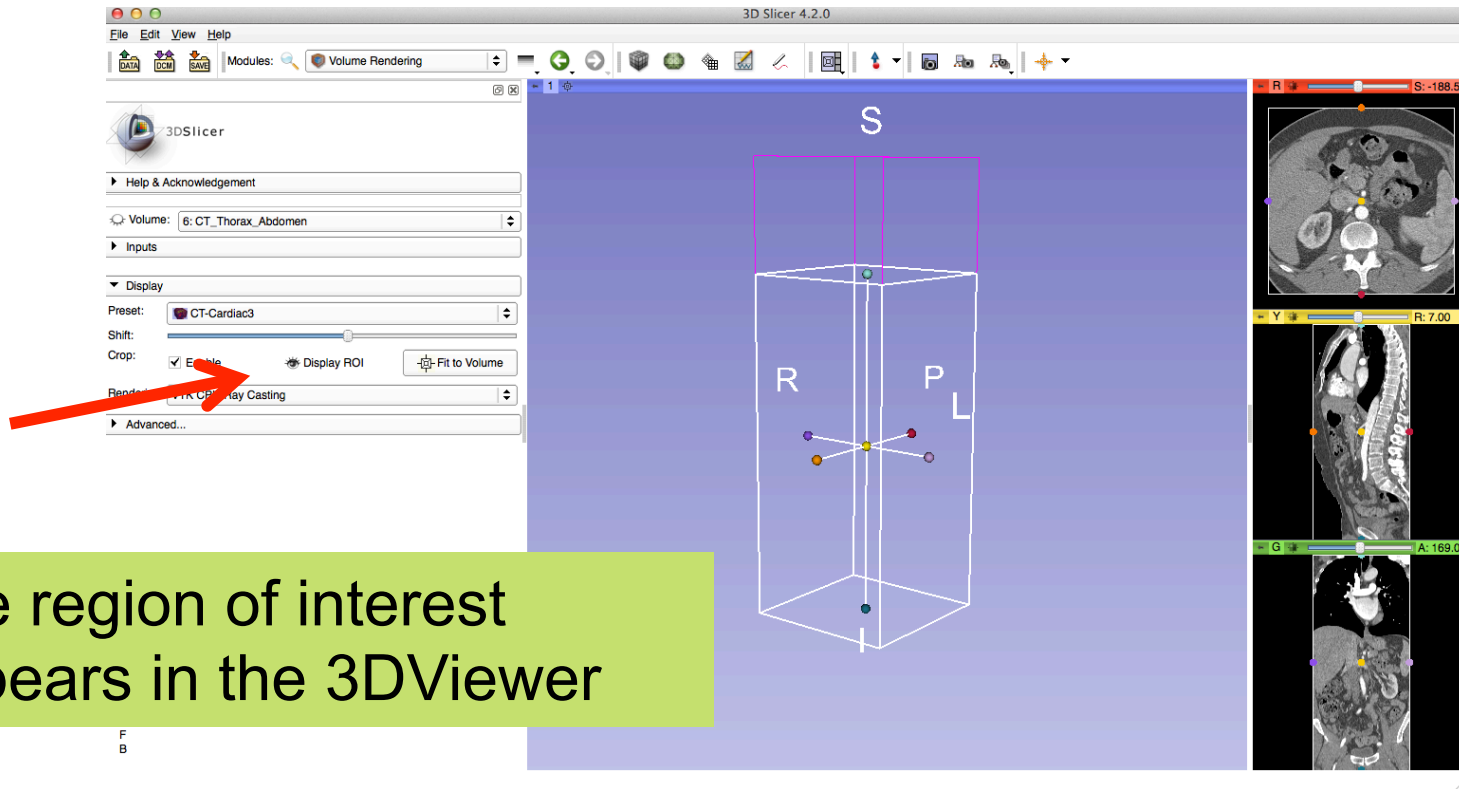
# Volume Rendering



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

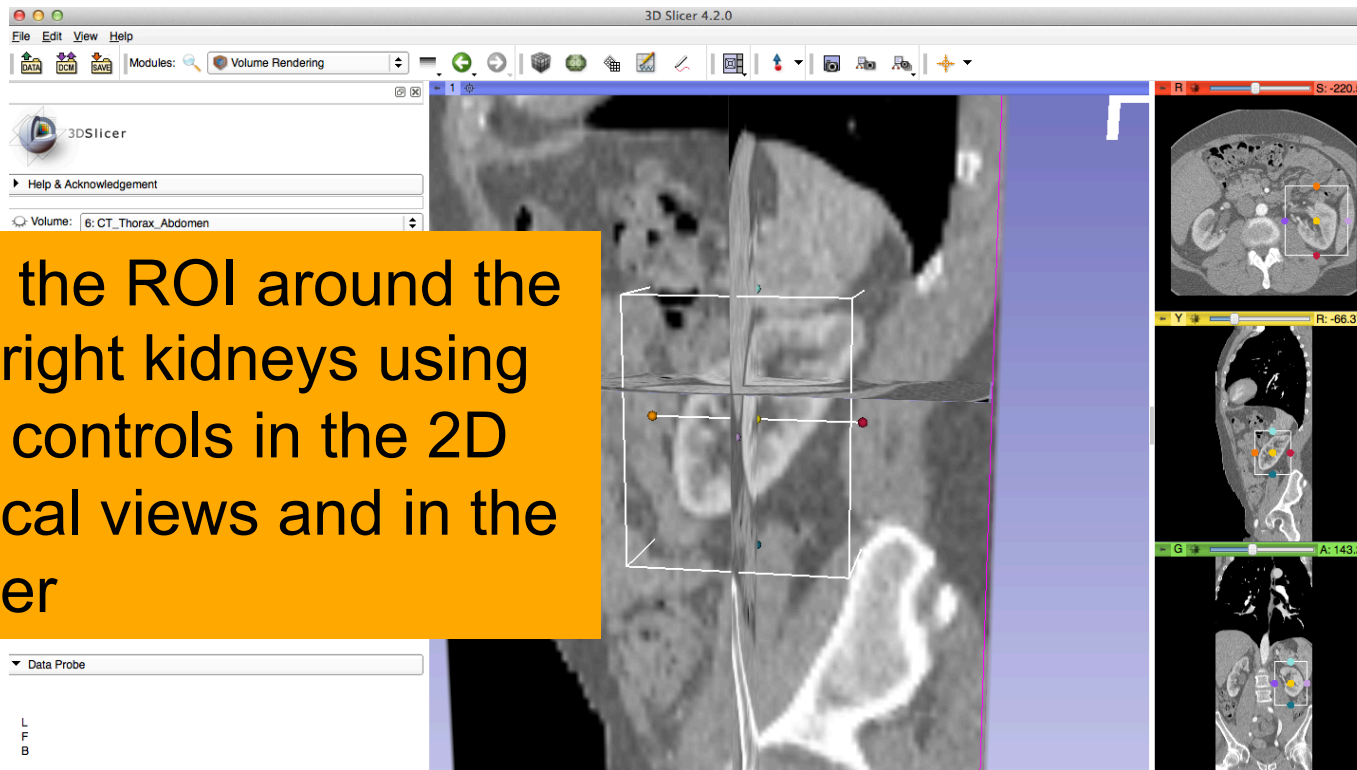


The region of interest appears in the 3DViewer



# Volume Rendering

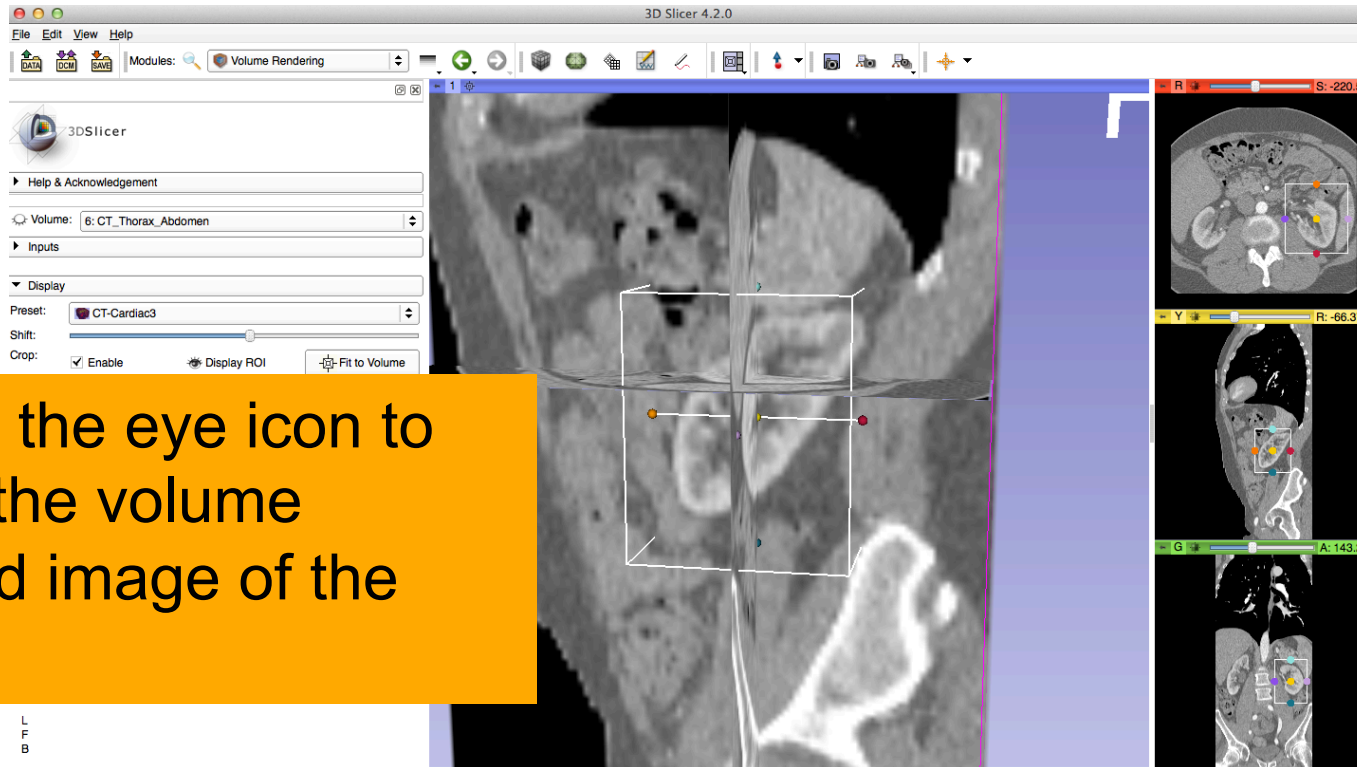
Position the ROI around the left and right kidneys using the ROI controls in the 2D anatomical views and in the 3D viewer







# Volume Rendering

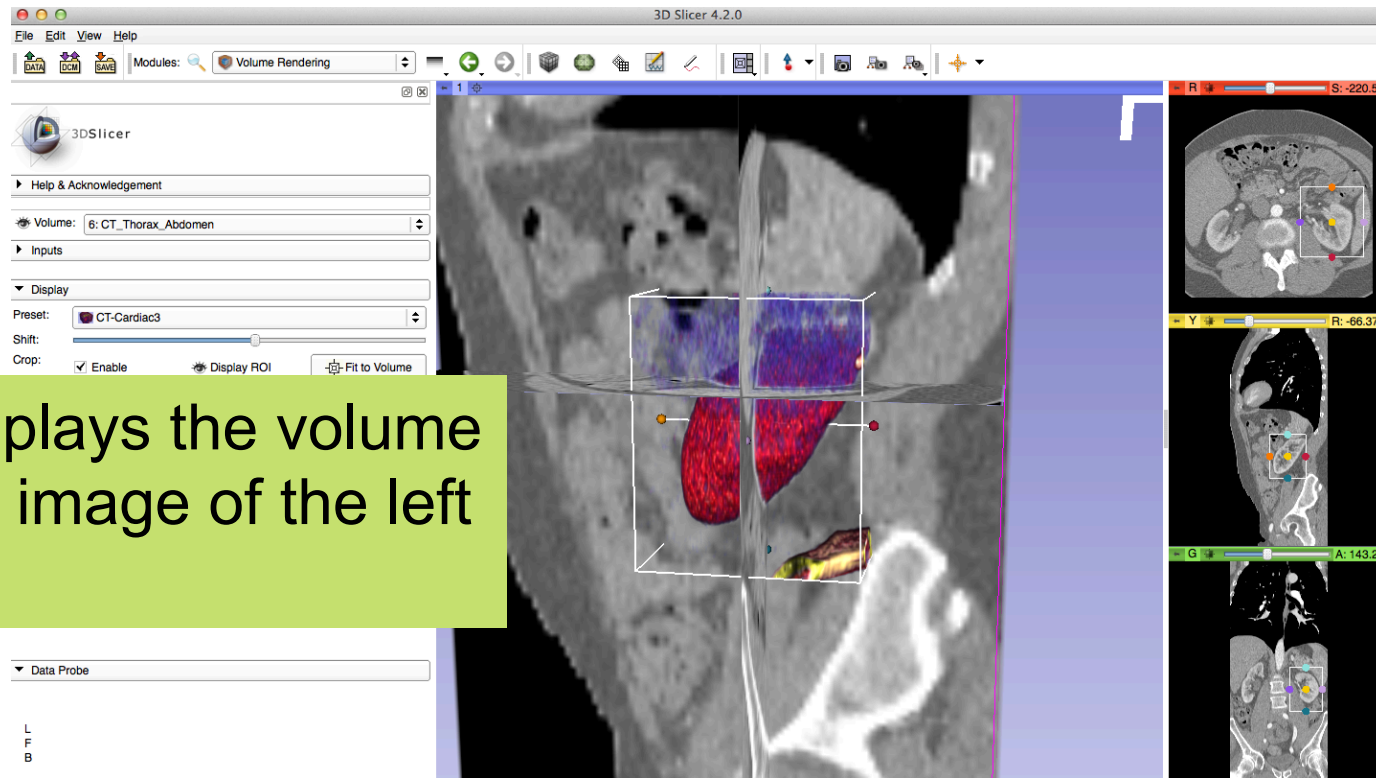


Click on the eye icon to display the volume rendered image of the kidney





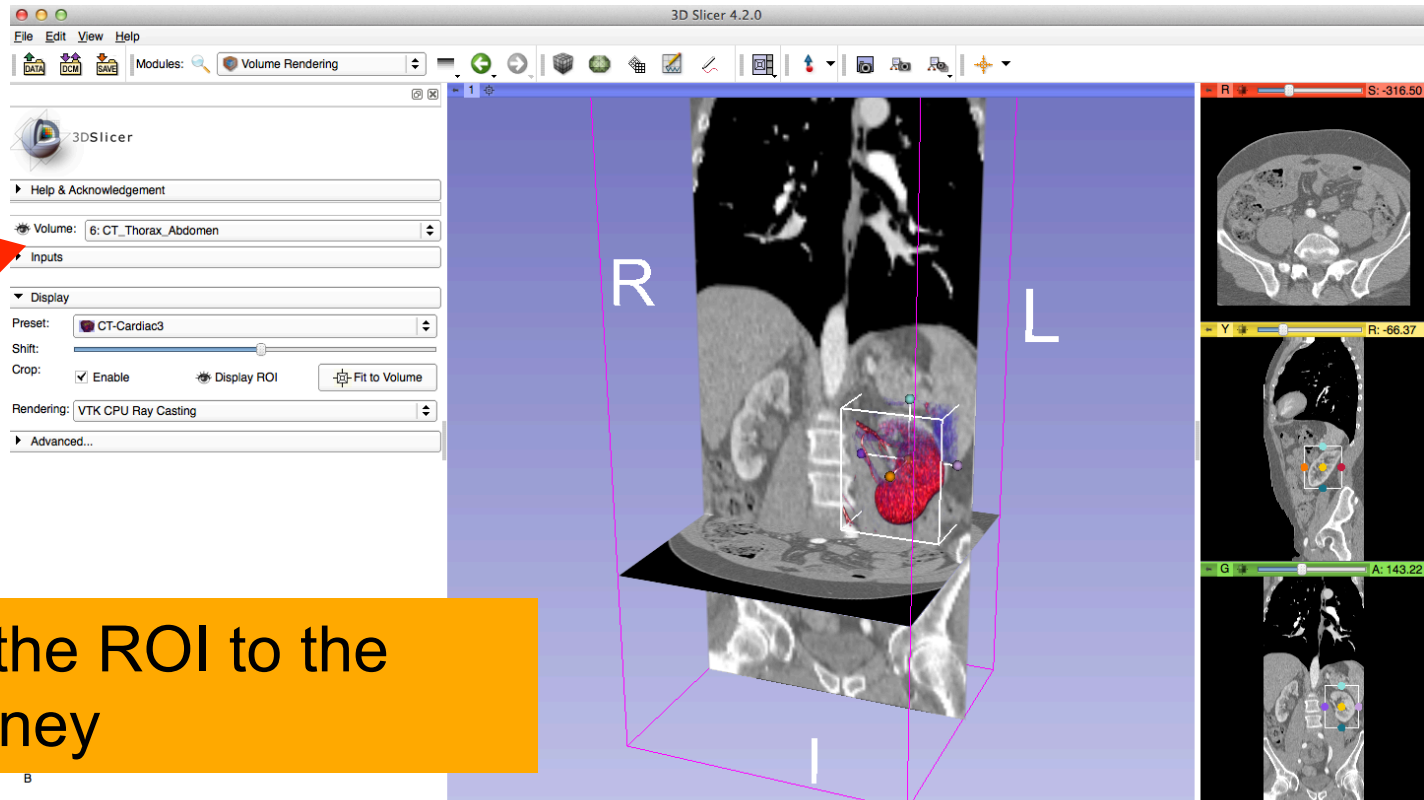
# Volume Rendering



Slicer displays the volume rendered image of the left kidney



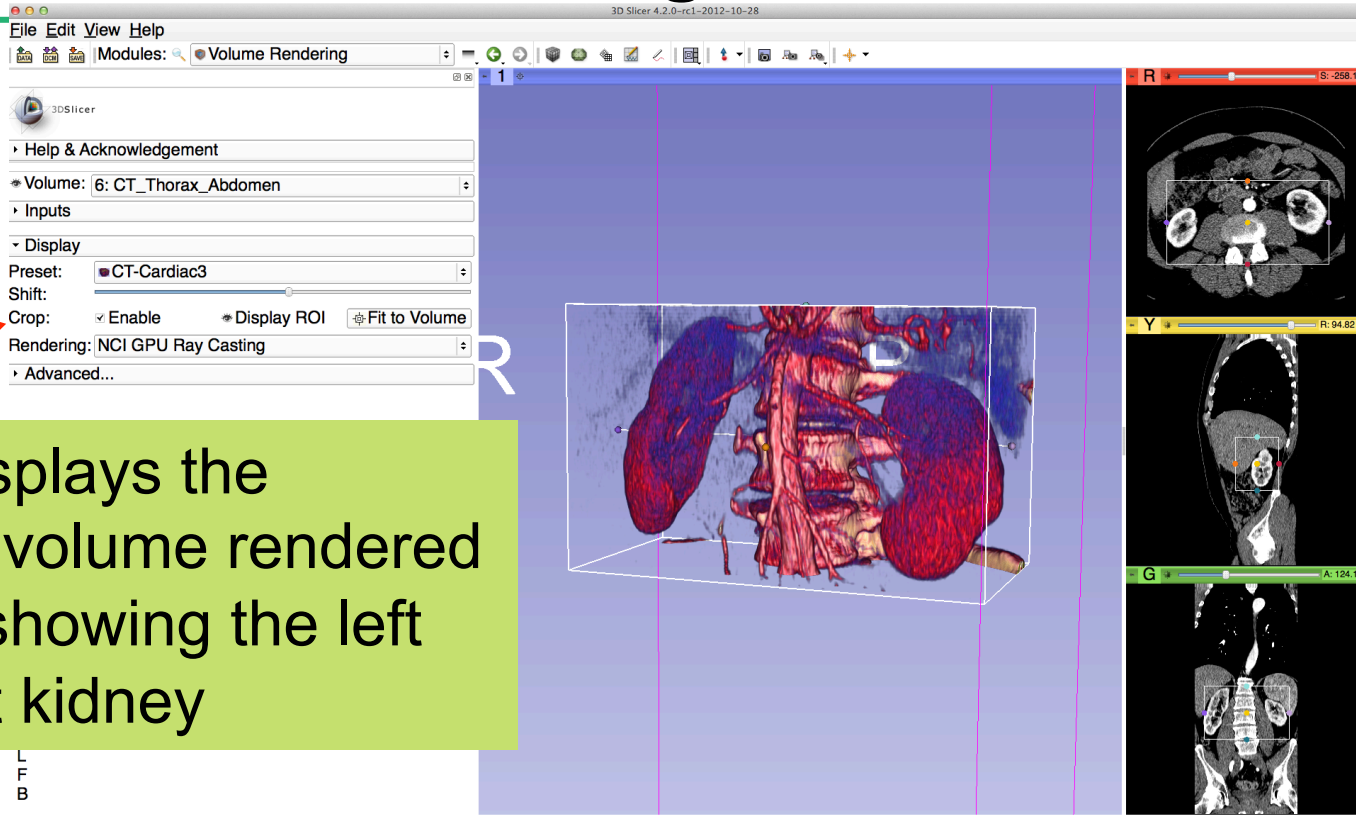
# Volume Rendering



Extend the ROI to the right kidney



# Volume Rendering



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



# Volume Rendering

File Edit View Help  
Modules: Volume Rendering

3DSlicer

- Help & Acknowledgement
- Volume: 6: CT\_Thorax\_Abdomen
- Inputs
- Display
  - Preset: CT-Cardiac3
  - Shift: [slider]
  - Crop:  Enable  Display ROI  Fit to Volume
  - Rendering: NCI GPU Ray Casting
  - Advanced...
- Data Probe

L  
F  
B

R

R S: -258.13  
Y R: 94.82  
G A: 124.16

Click on File → Exit to quit Slicer

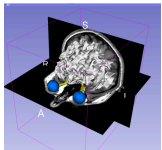
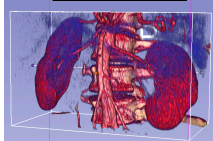


# Overview

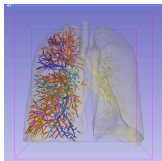
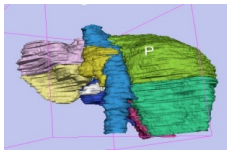
---

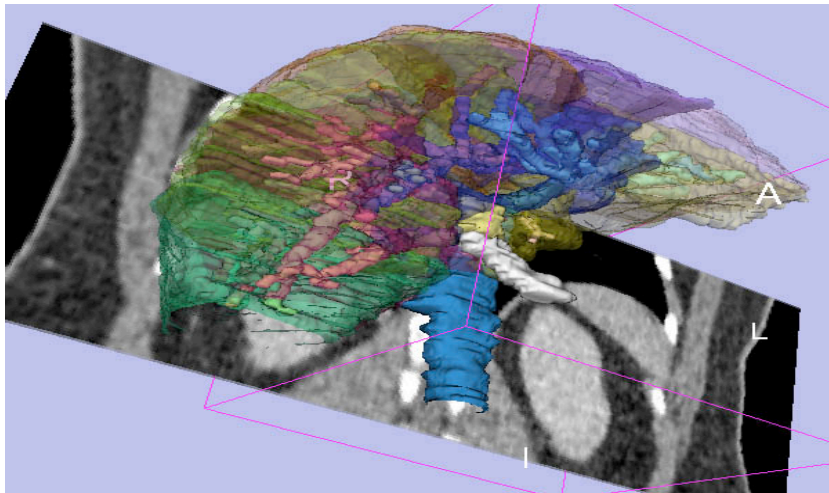


**Part I:** 3D Data Loading and visualization of DICOM images  
- Volume Rendering of thoraco-abdominal CT data



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



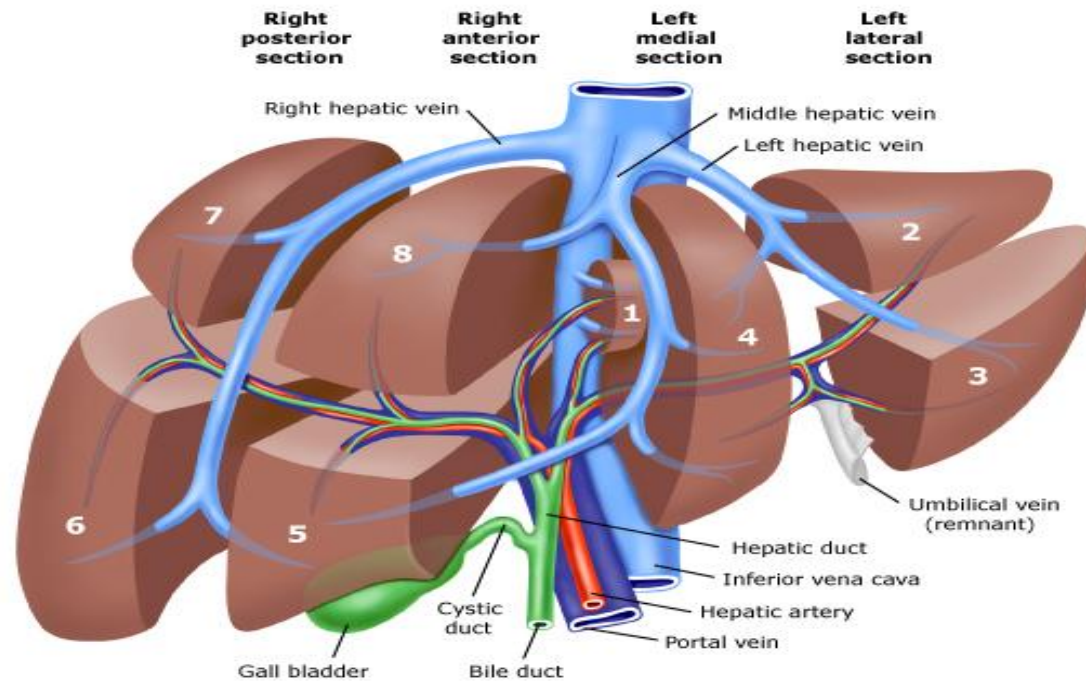


Part II:

Interactive 3D Visualization  
of the segments of the liver



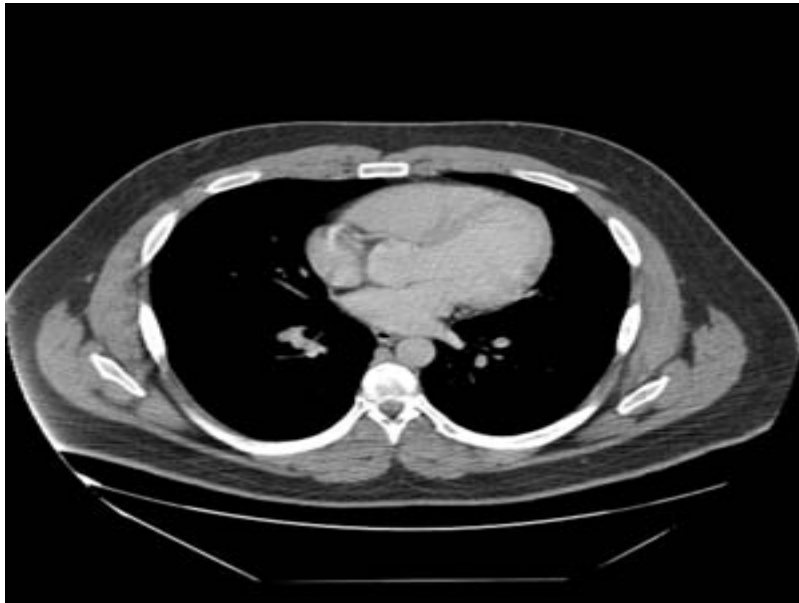
# Anatomy of the liver





## Liver dataset

---

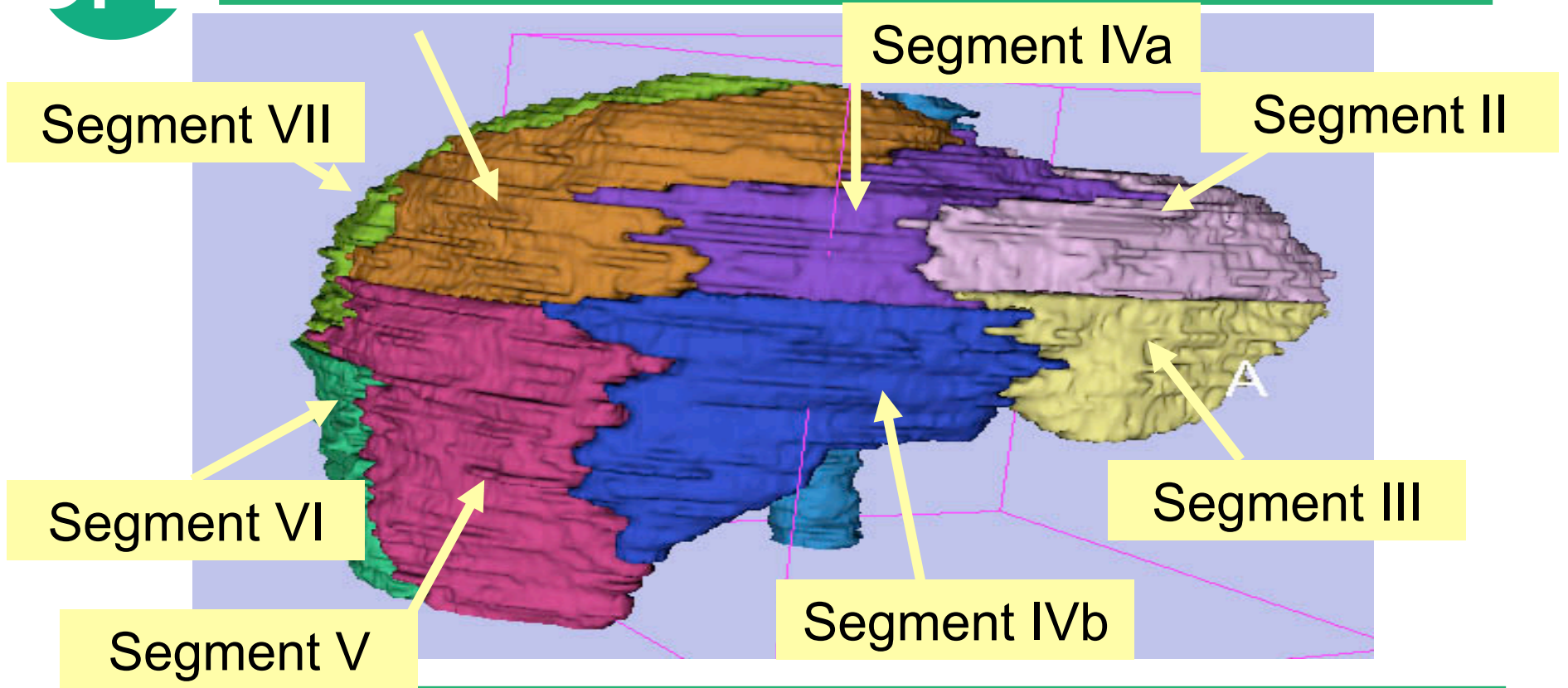


The liver dataset is a contrast-enhanced CT abdominal scan of a healthy 36 year-old male.



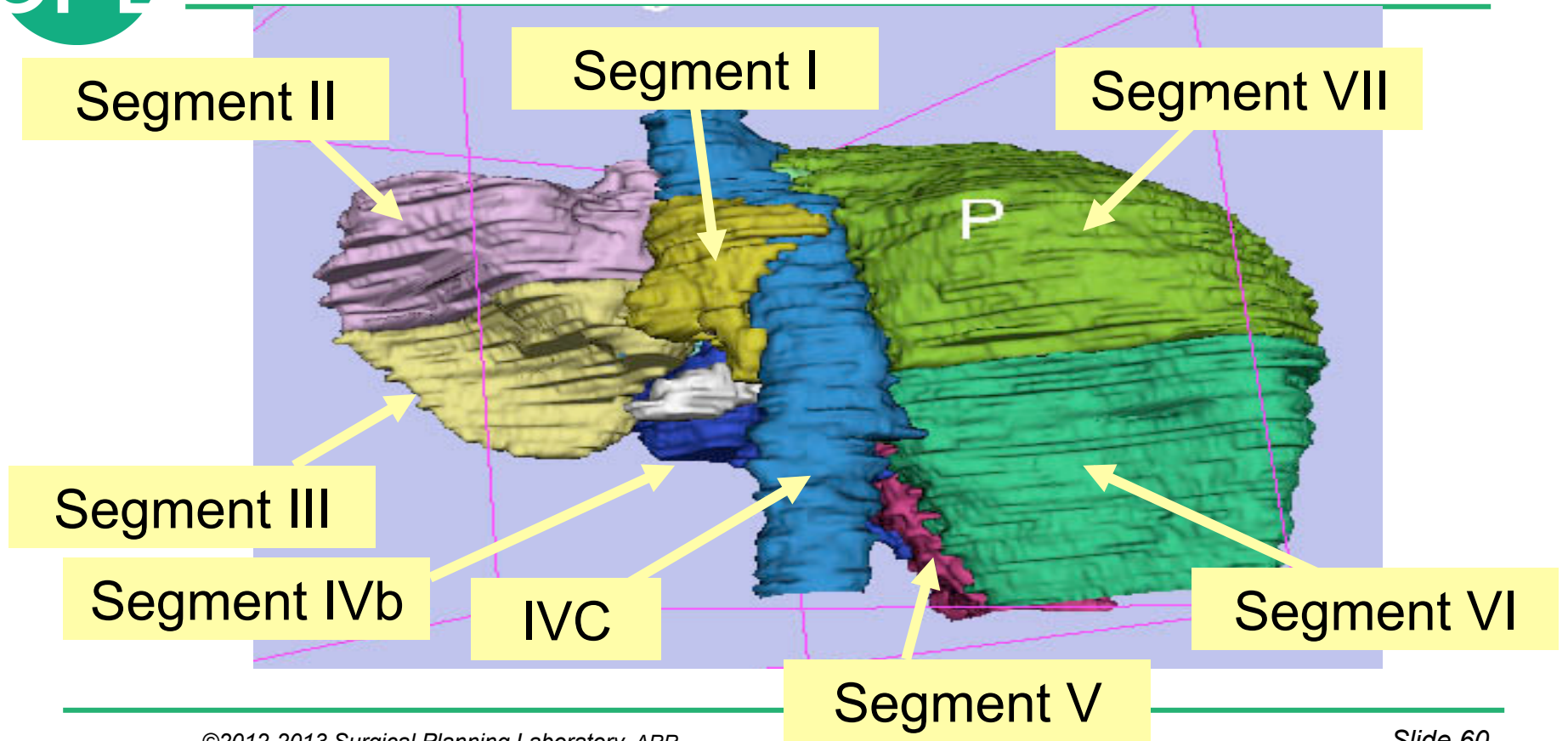


# 3D segments of the liver



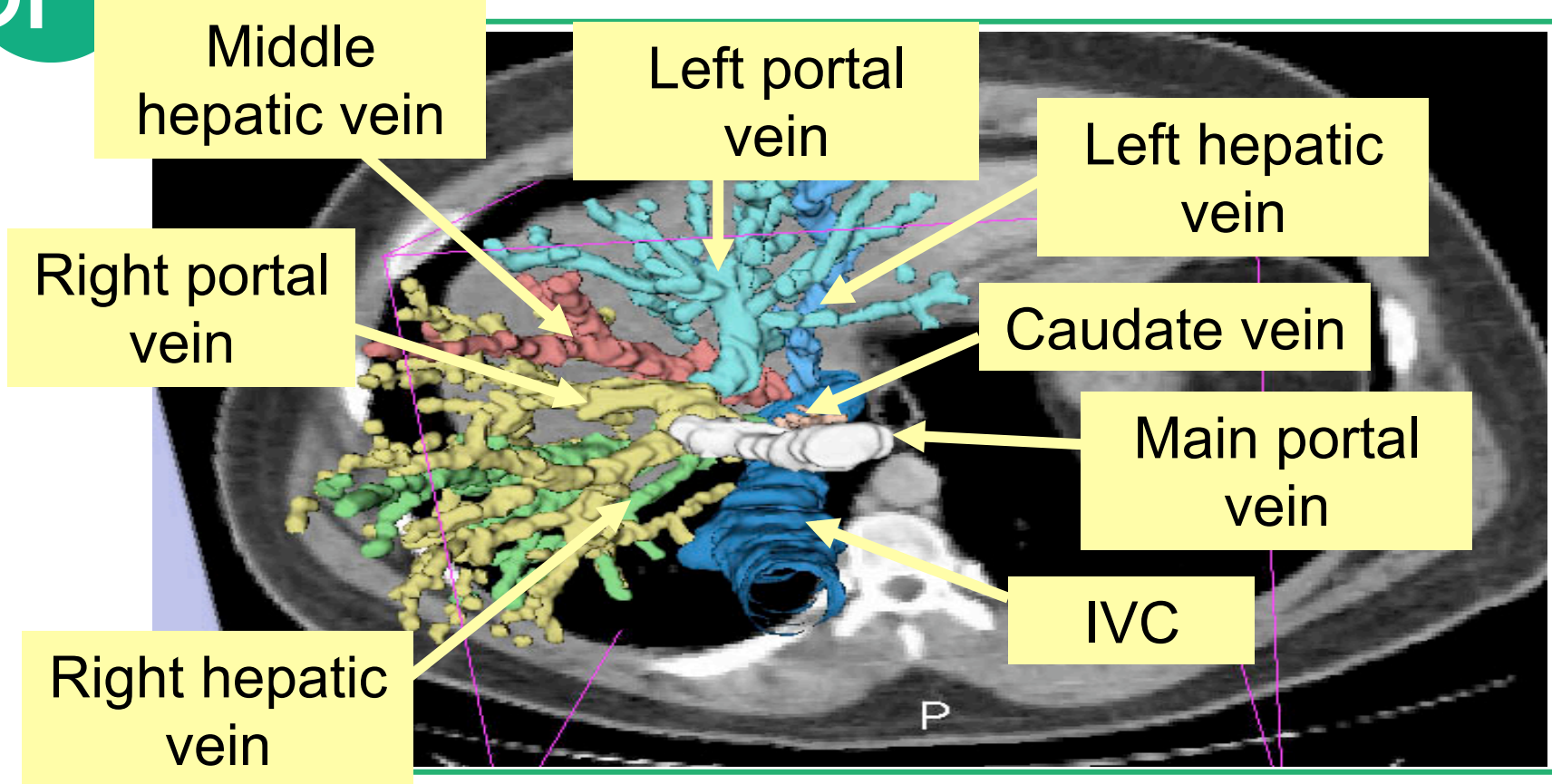


# 3D segments of the liver



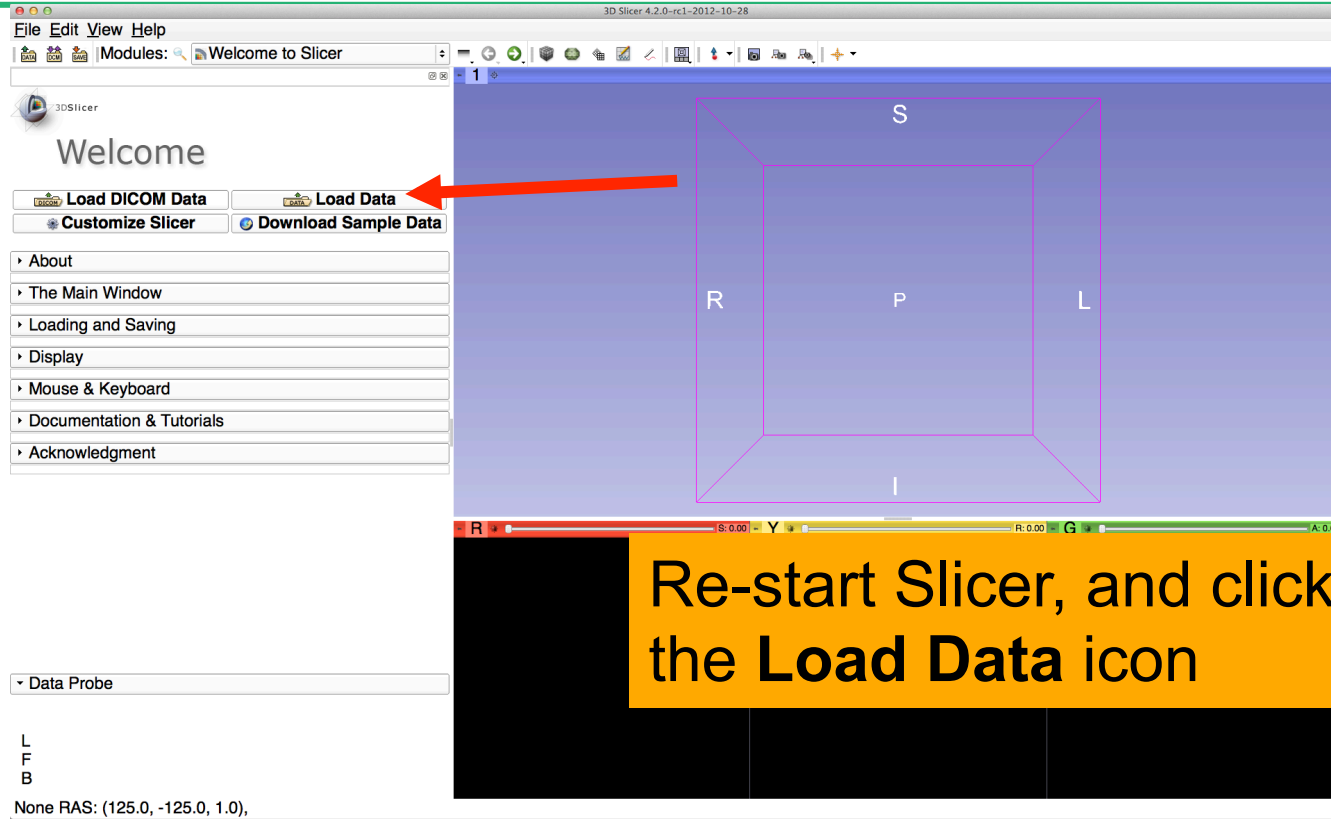


# Liver vasculature



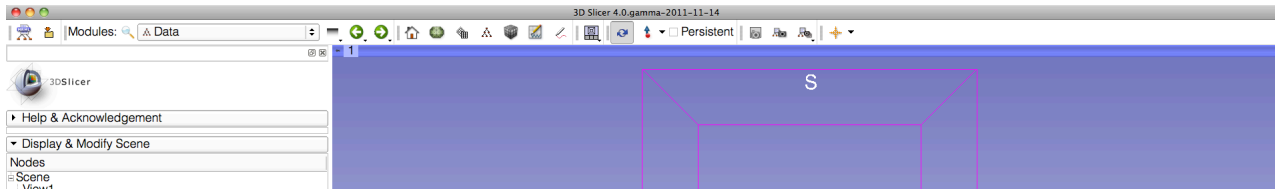


# Loading the Liver Data Scene





## Loading the Liver Scene



Browse to the directory

**C:\Pujol2012\3Dvisualization\_Tuesday\_Nov27\_2012**

Select the directory **dataset3\_CT-Liver**

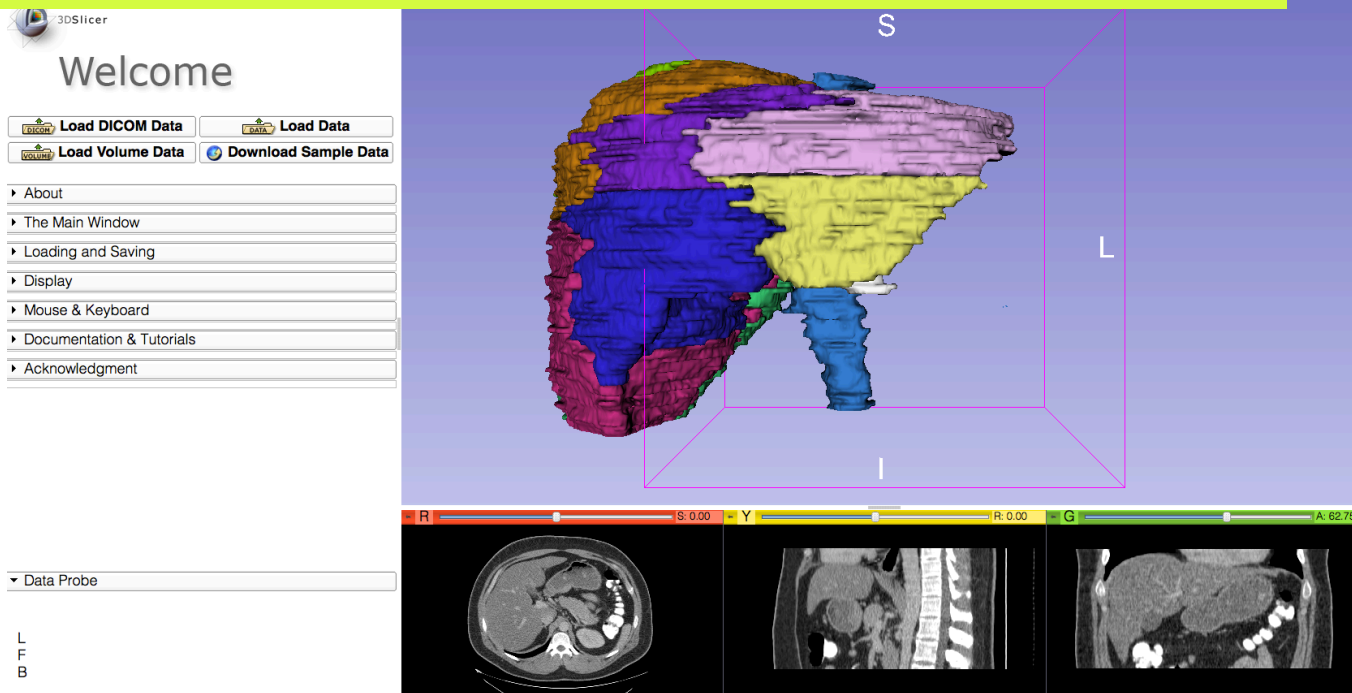
Select the file **LiverSegments\_Scene.mrml**

Click on OK to load the scene into Slicer



# Liver Segments Scene

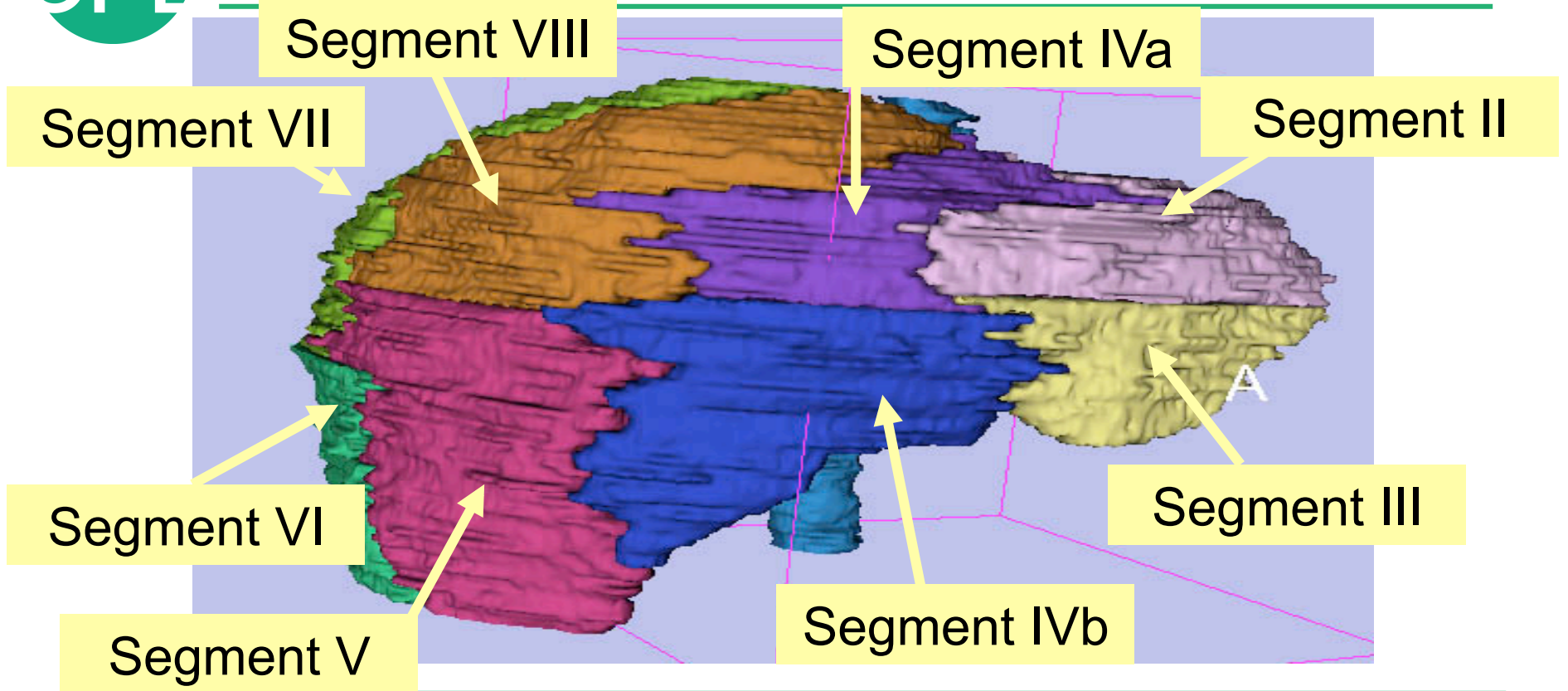
The elements of the scene appear in the Viewer





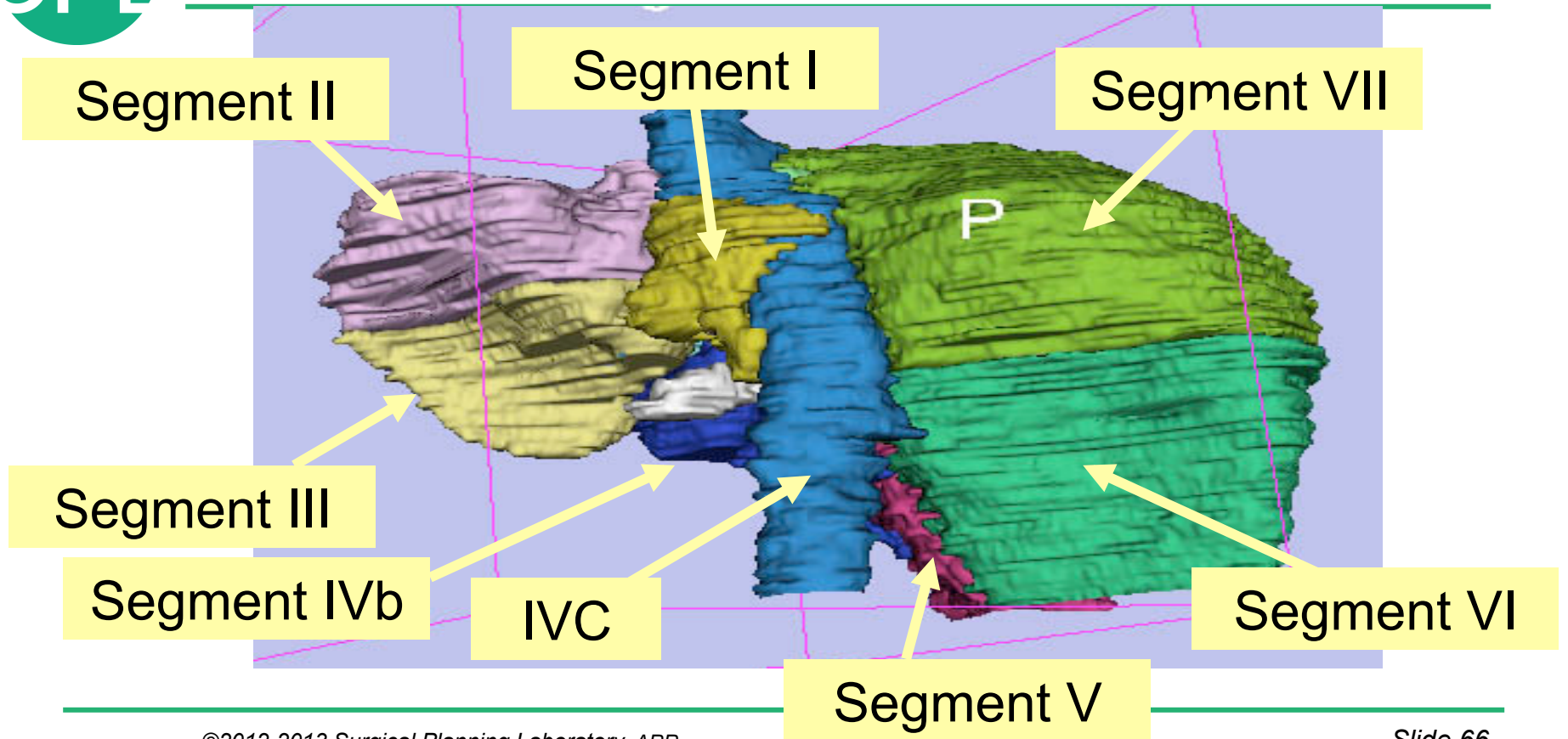


# 3D models of the liver





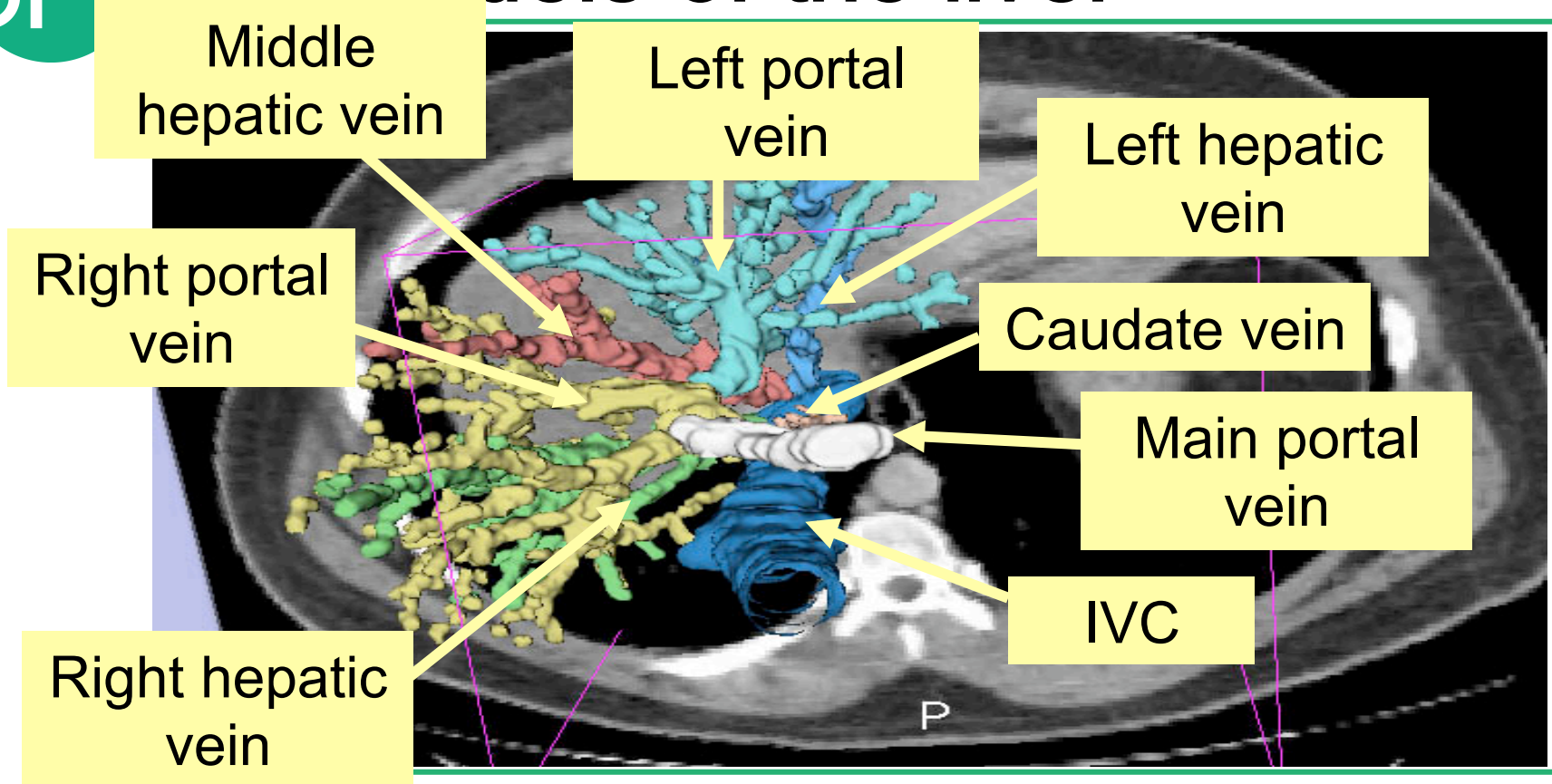
# 3D models of the liver







# 3D models of the liver



Middle hepatic vein

Left portal vein

Left hepatic vein

Right portal vein

Caudate vein

Main portal vein

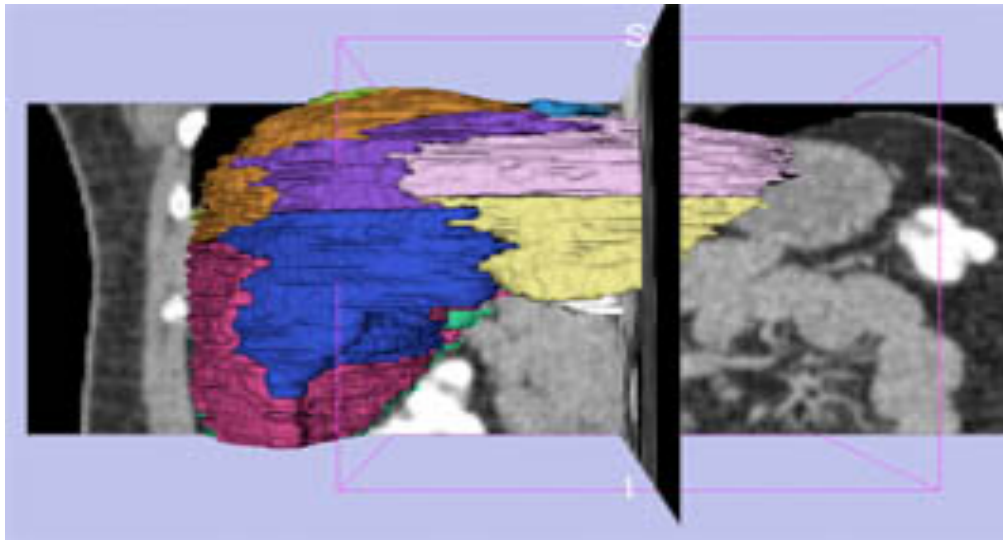
Right hepatic vein

IVC



## 3D Exploration of Liver Segments

---

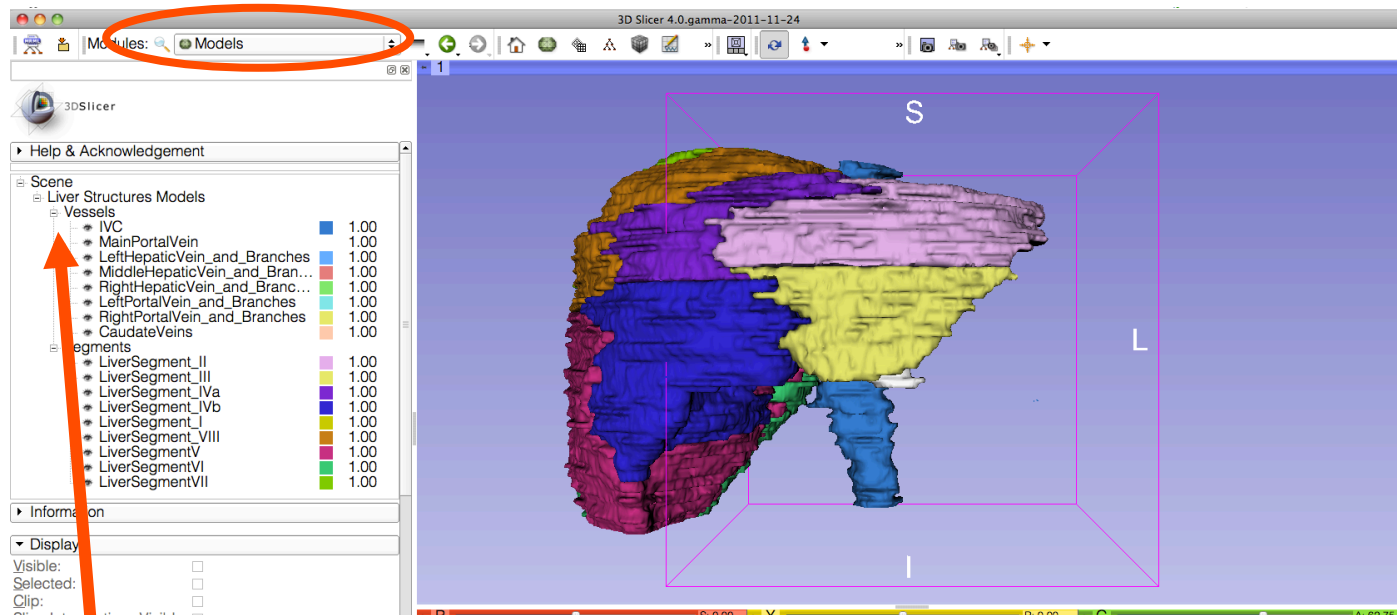


### **Example:**

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



# 3D Exploration of Liver Segments

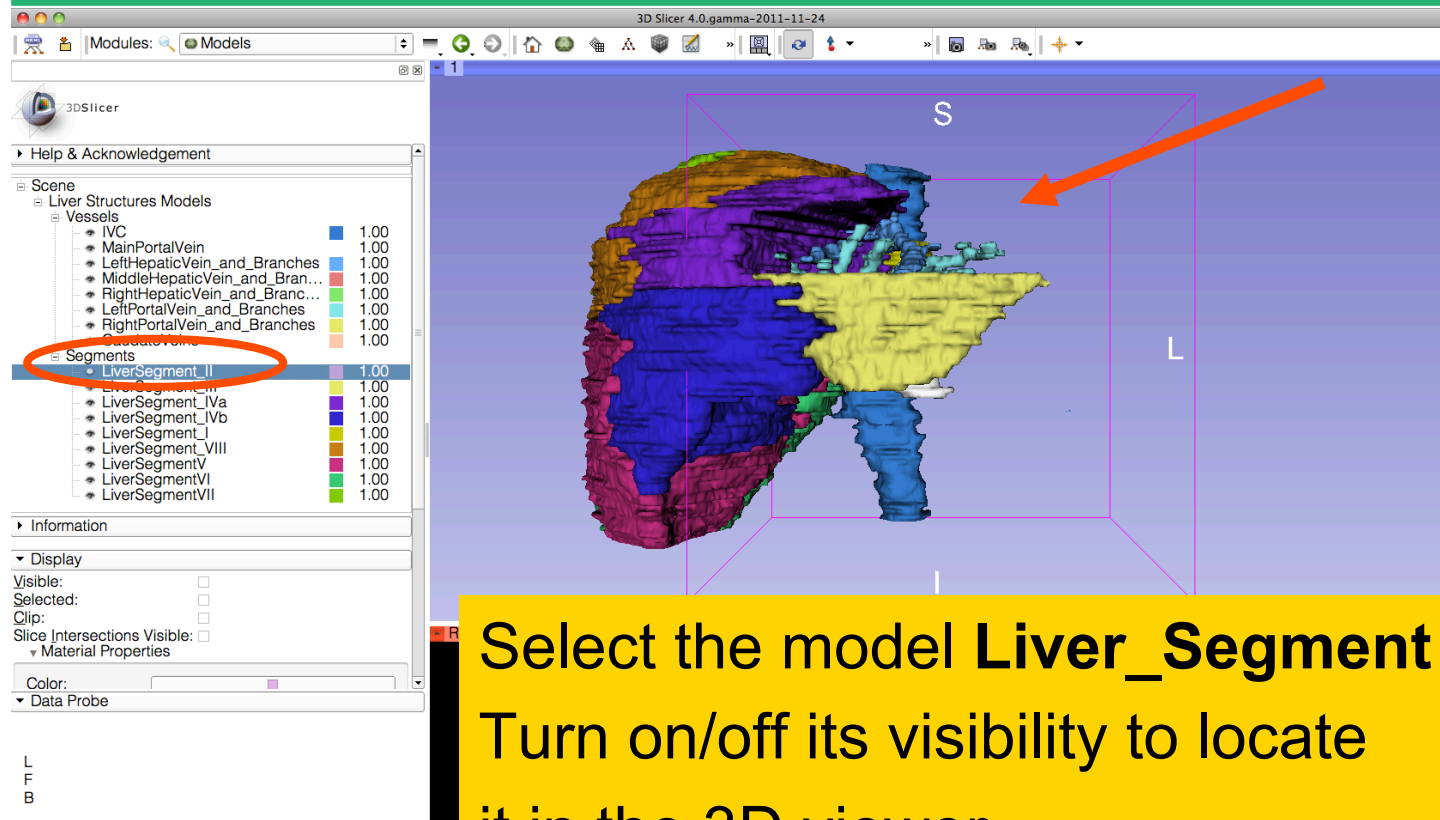


Select the module **Models**

Click on the Liver Structures Models Hierarchy



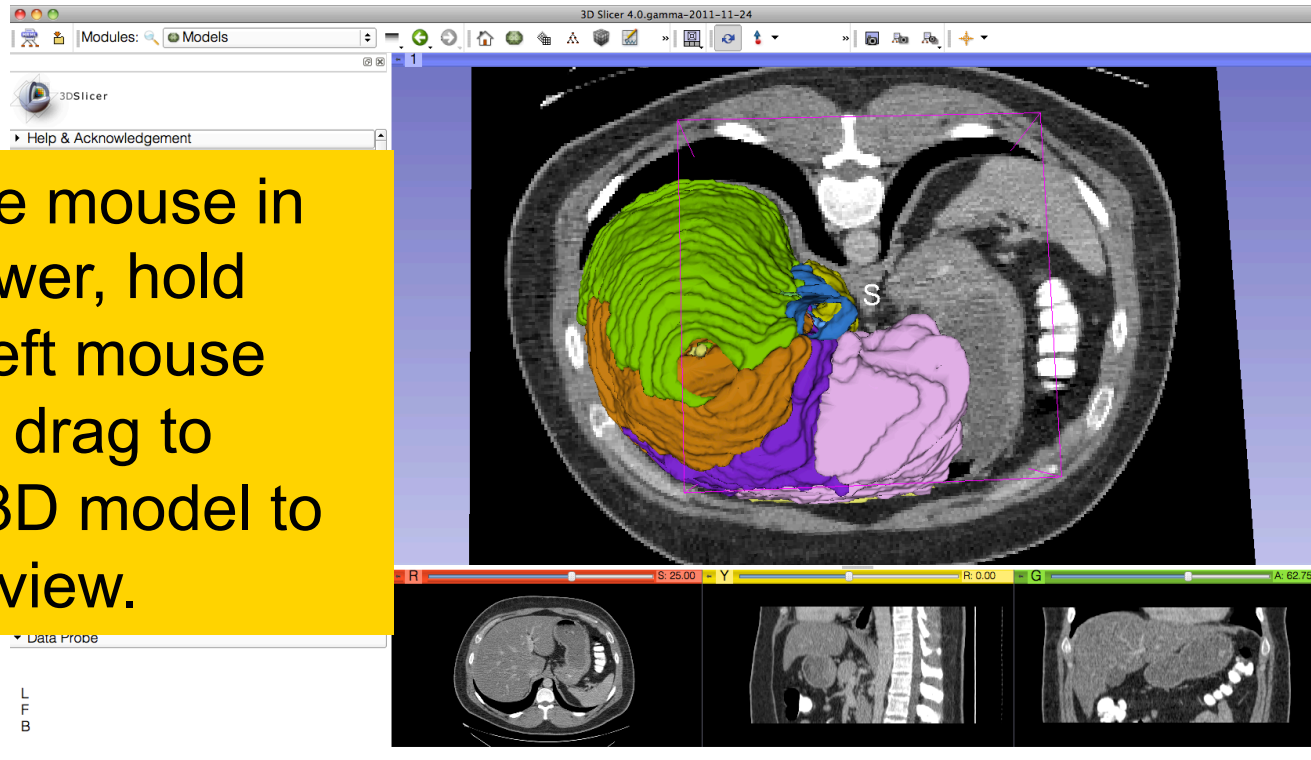
# 3D Exploration of Liver Segments





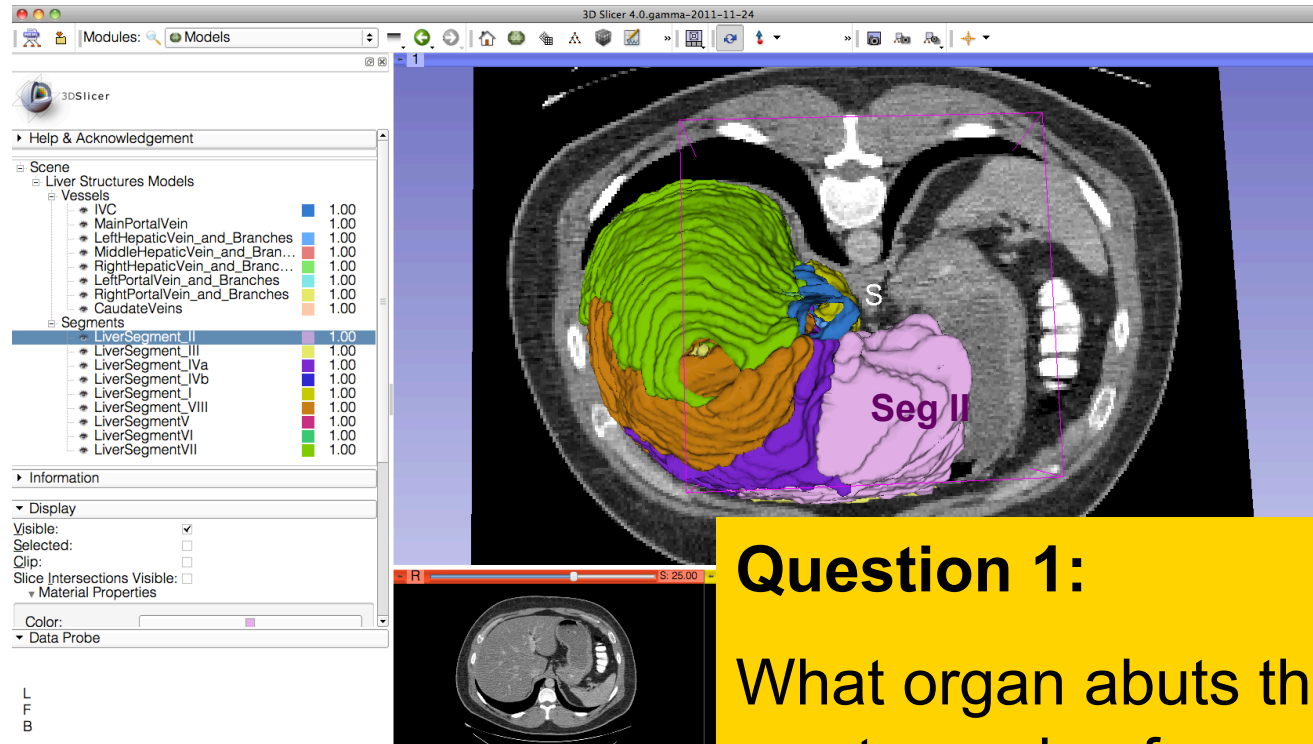
# 3D Exploration of Liver Segments

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



## Question 1:

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



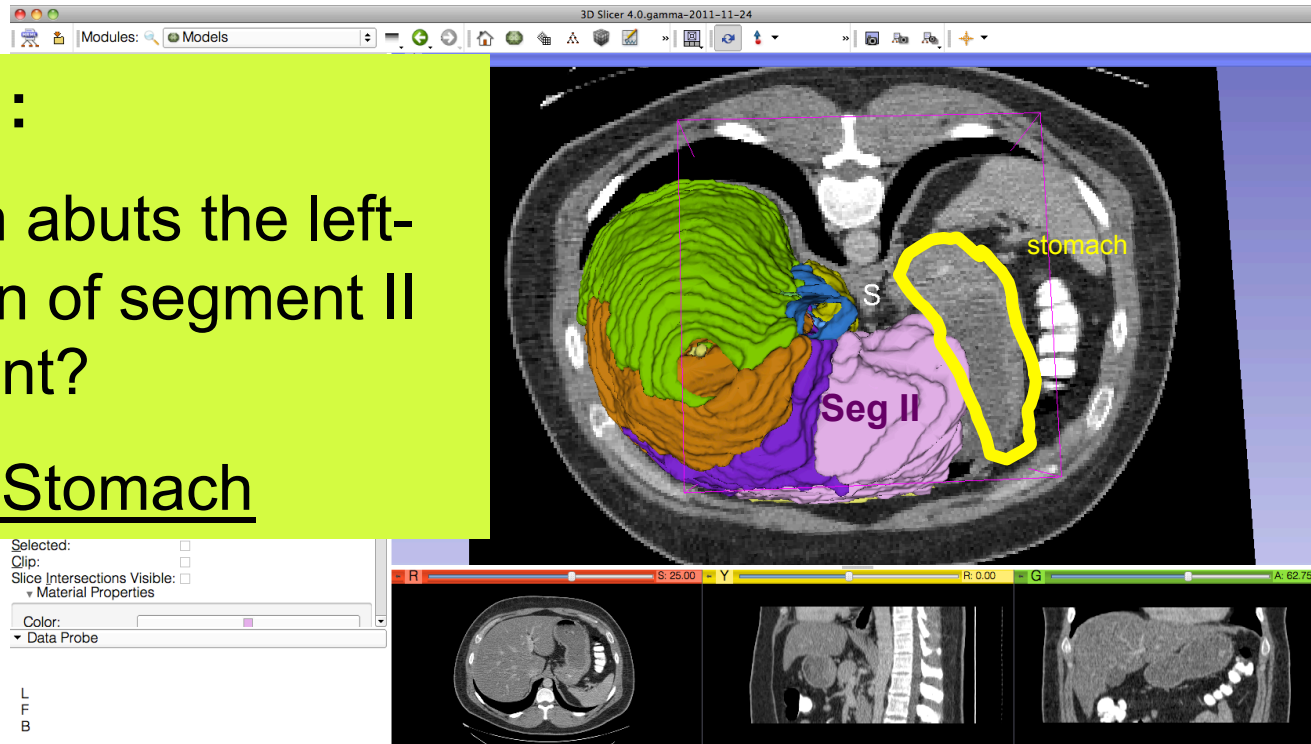


# 3D Exploration of Liver Segments

## Question 1:

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

**Answer 1: Stomach**

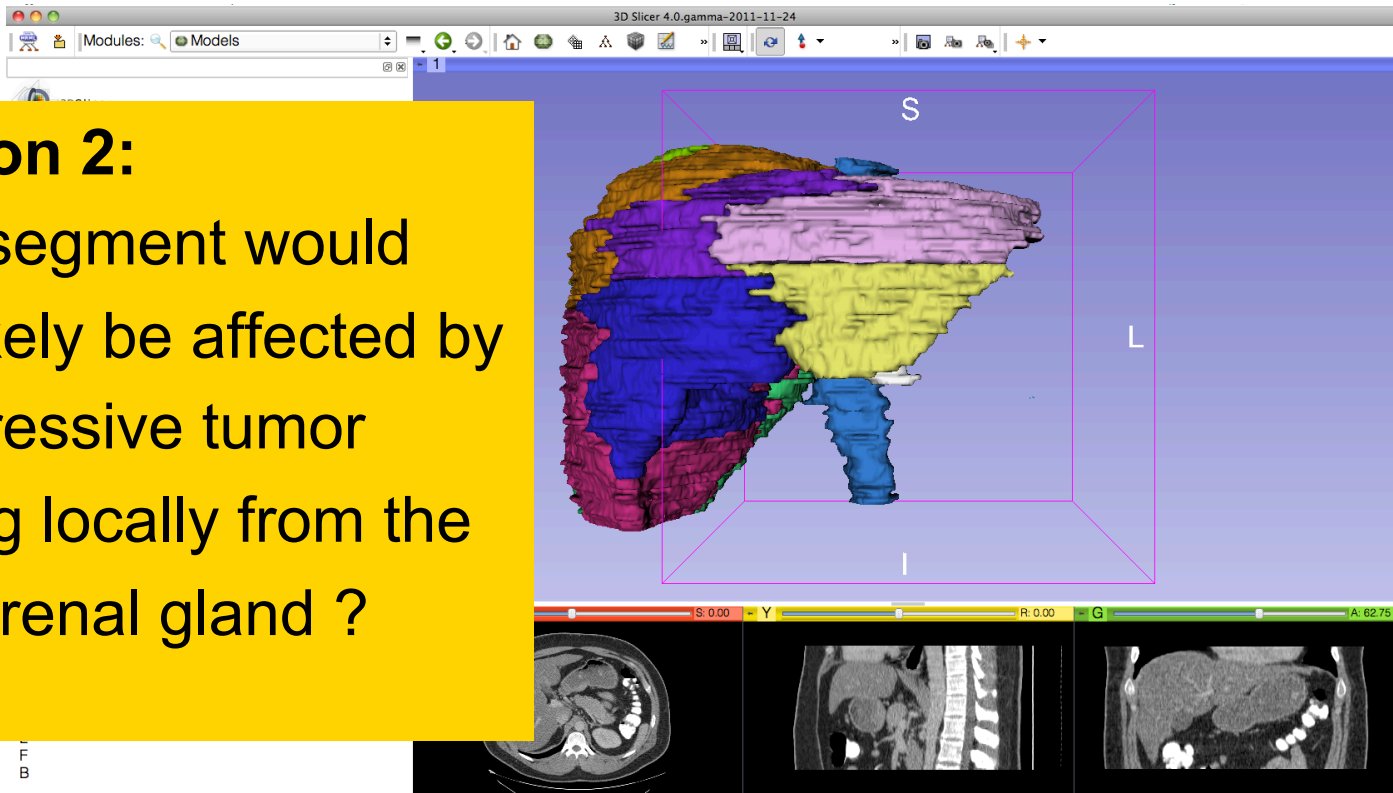




# 3D Exploration of Liver Segments

## Question 2:

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





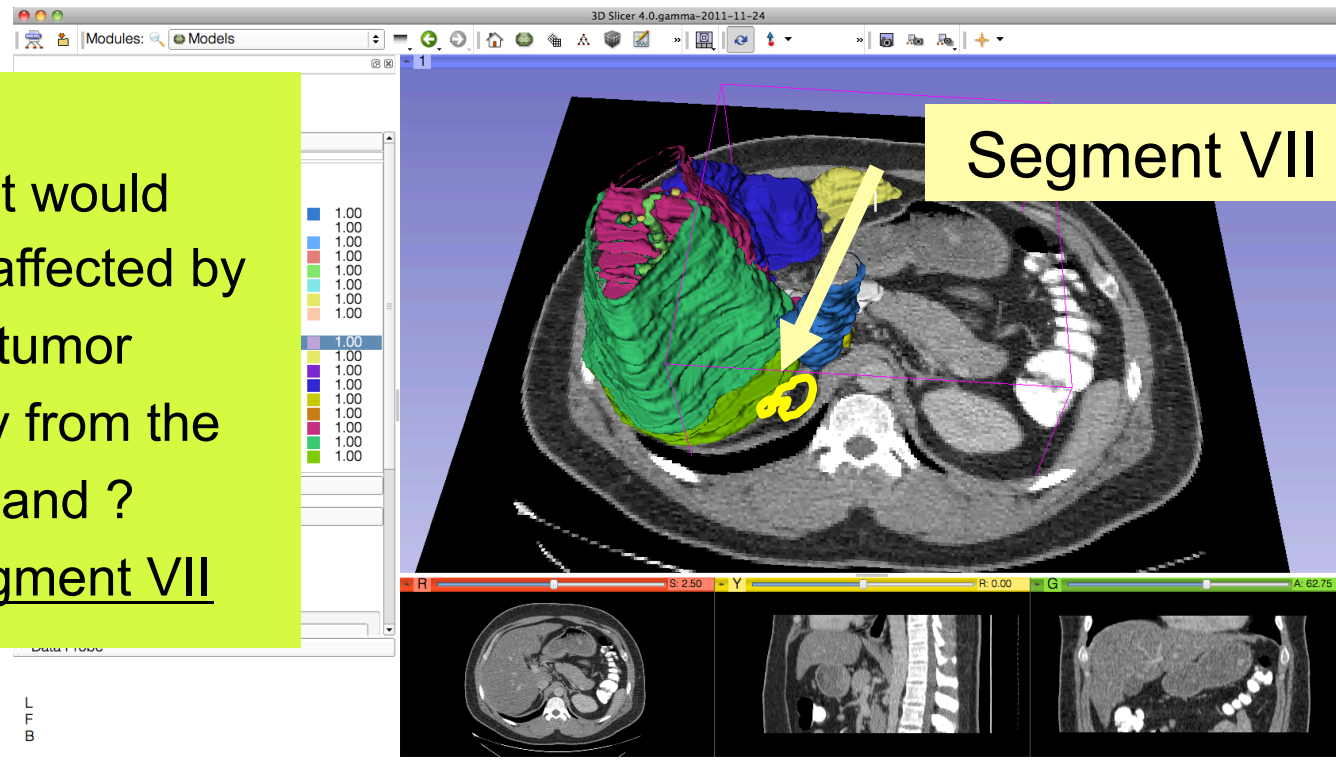


# 3D Exploration of Liver Segments

## Question 2:

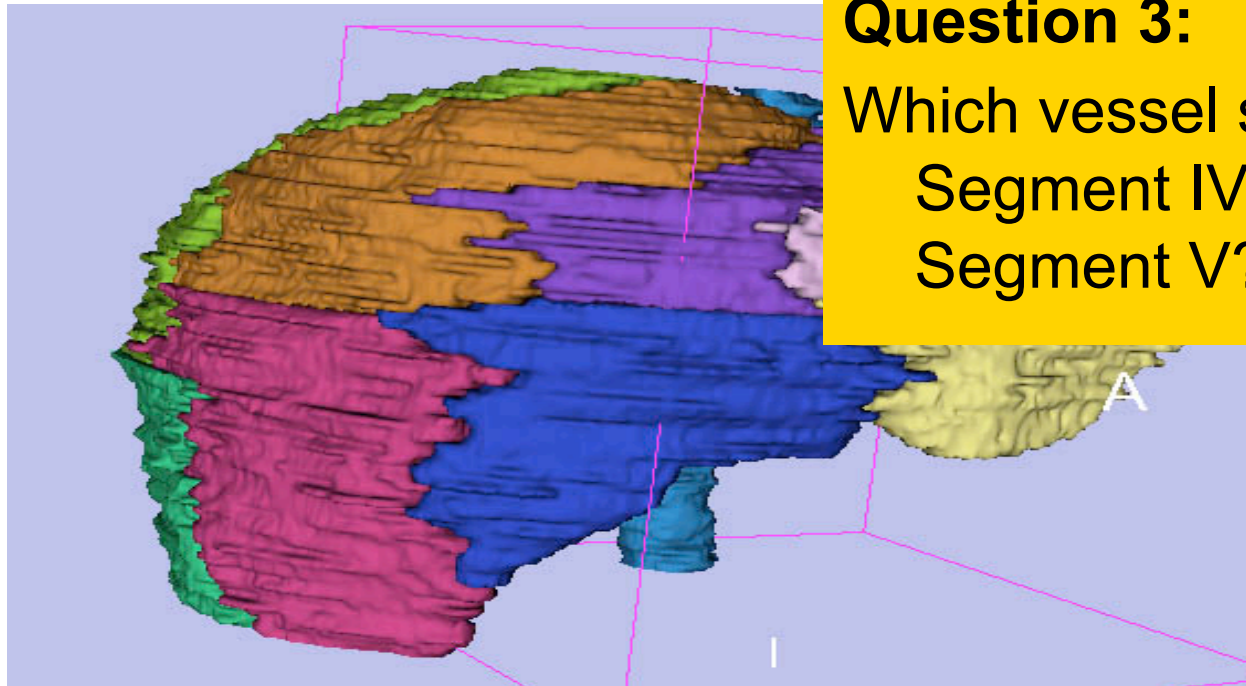
Which segment would most likely be affected by an aggressive tumor invading locally from the right adrenal gland ?

**Answer 2: Segment VII**





## 3D Exploration of Liver Segments

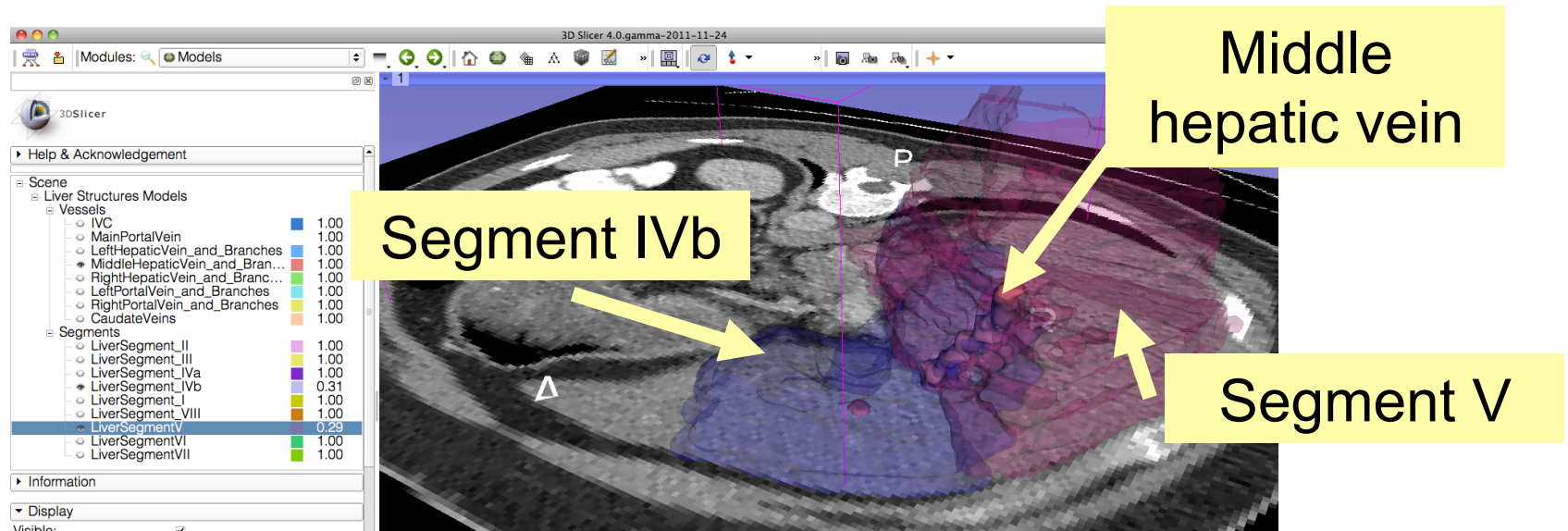


### Question 3:

Which vessel separates Segment IVb and Segment V?



# Middle Hepatic Vein



## Question 3:

Which vessel separates Segment IVb and Segment V?

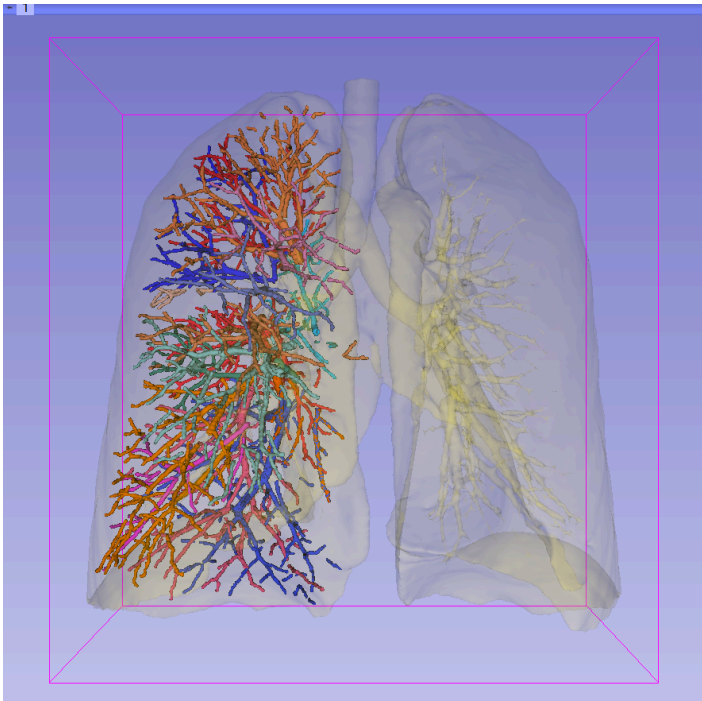
**Answer 3:** The middle hepatic vein



# Closing the Liver Scene

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



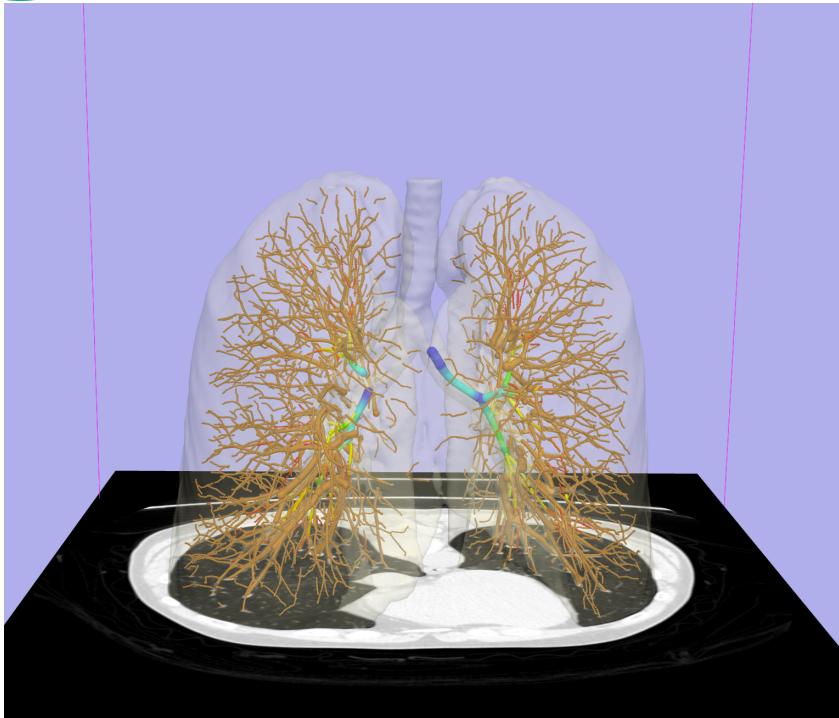


## Interactive 3D Visualization of the segments of the lungs



# Segments of the lung

---



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

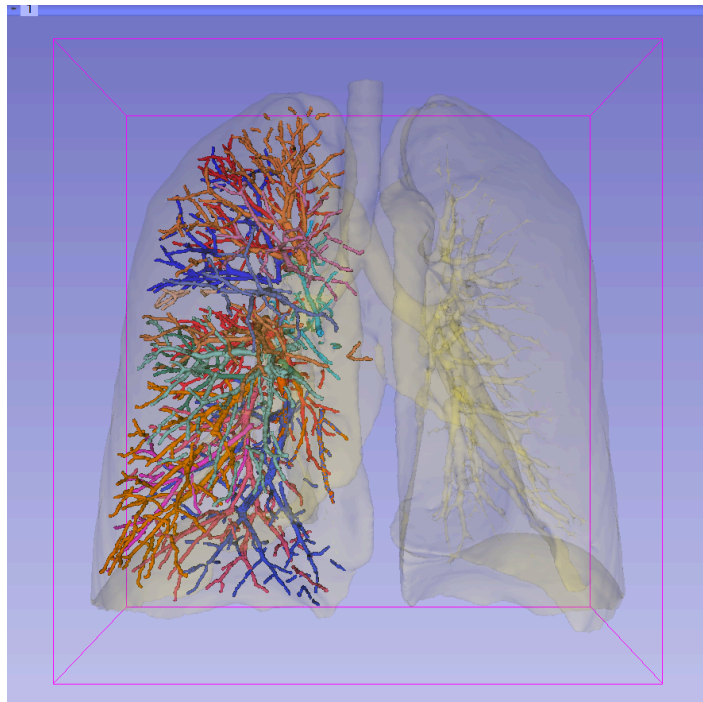
Acknowledgment:

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

3D Slicer 4.2.0-rc1-2012-10-28

File Edit View Help

Modules: Welcome to Slicer

3DSlicer

Welcome

Load DICOM Data Load Data

Customize Slicer Download Sample Data

- About
- The Main Window
- Loading and Saving
- Display
- Mouse & Keyboard
- Documentation & Tutorials
- Acknowledgment

Data Probe

L  
F  
B

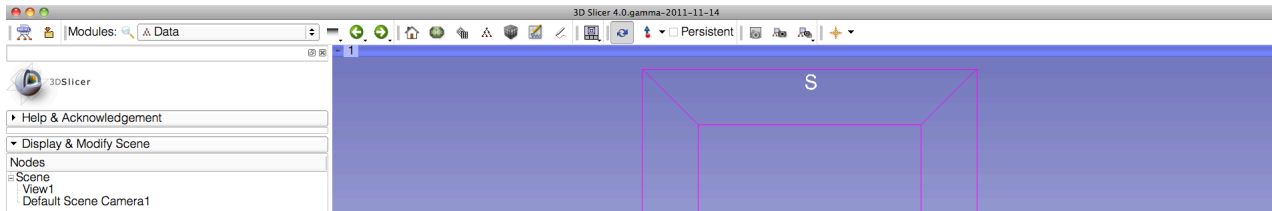
None RAS: (125.0, -125.0, 1.0),

**Re-start Slicer, and select Load Data in the Welcome to Slicer module**





## Loading the Lung Scene



Click on Choose Files and browse to the directory

**C:\Pujol2012\3DVisualization\_Tuesday\_Nov27\_2012**

Select the subdirectory dataset4\_CT-Chest

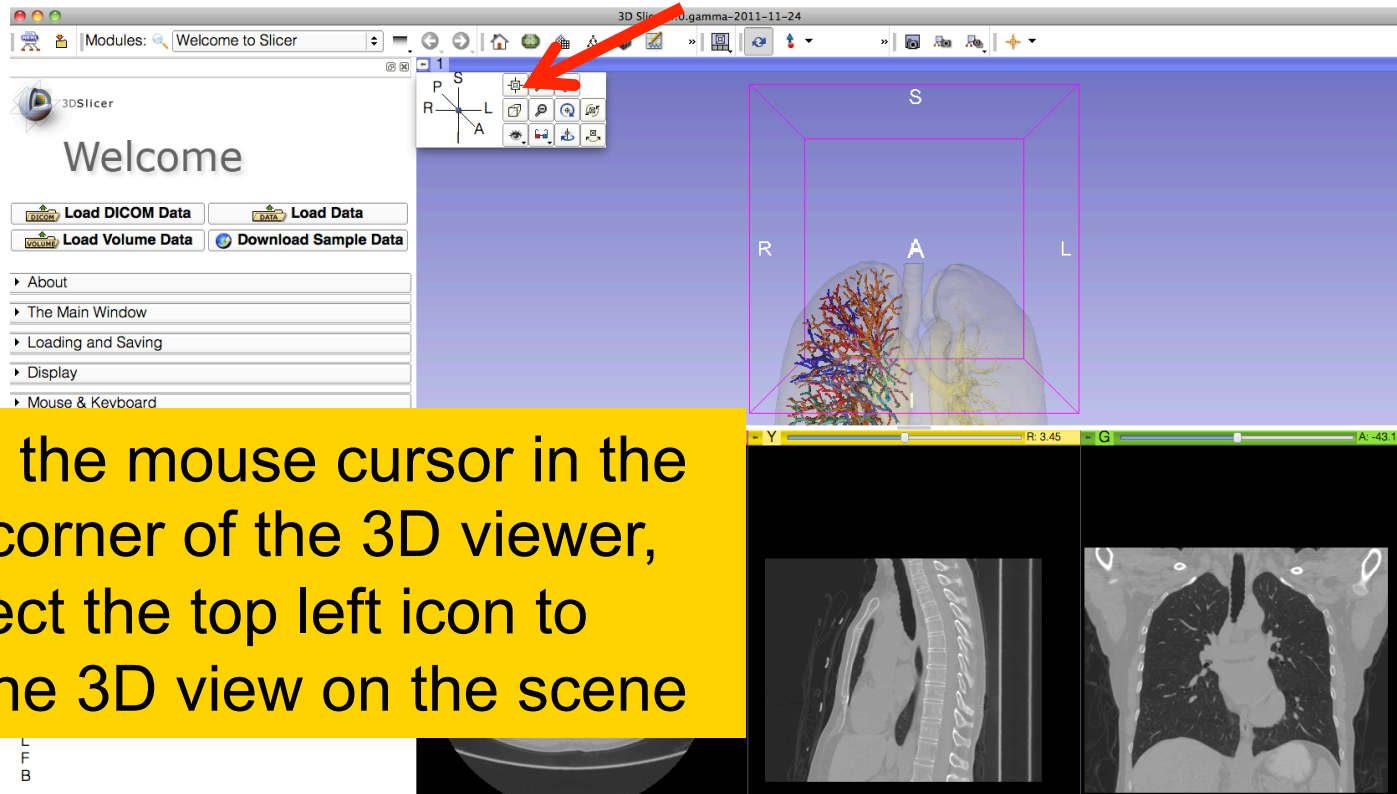
Select the file **LungSegment\_Scene.mrml**

Click on Open

Click on OK to load the scene in Slicer



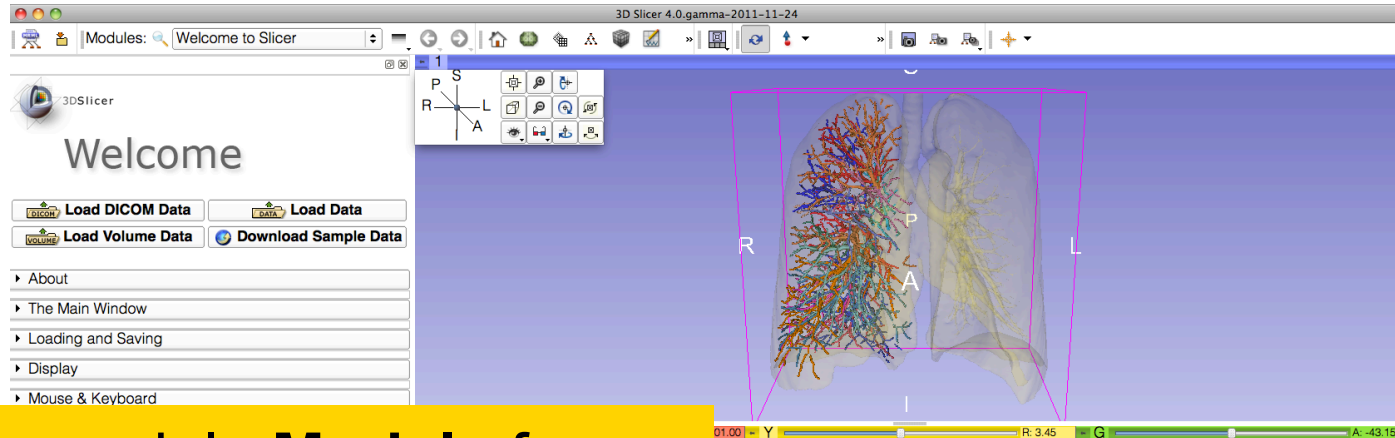
# Loading the Lung Scene



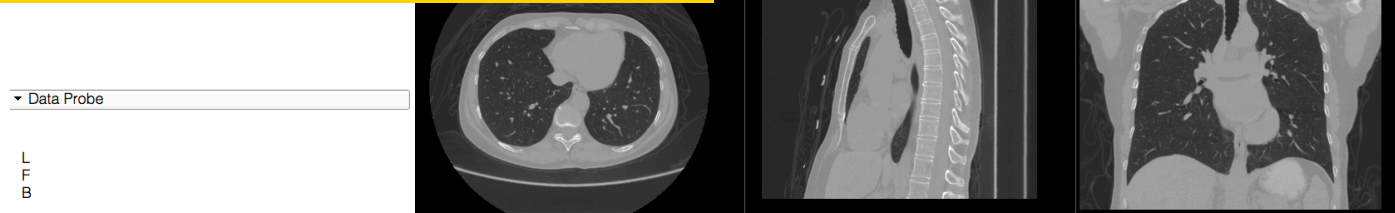
Position the mouse cursor in the top left corner of the 3D viewer, and select the top left icon to center the 3D view on the scene



# Loading the Lung Scene

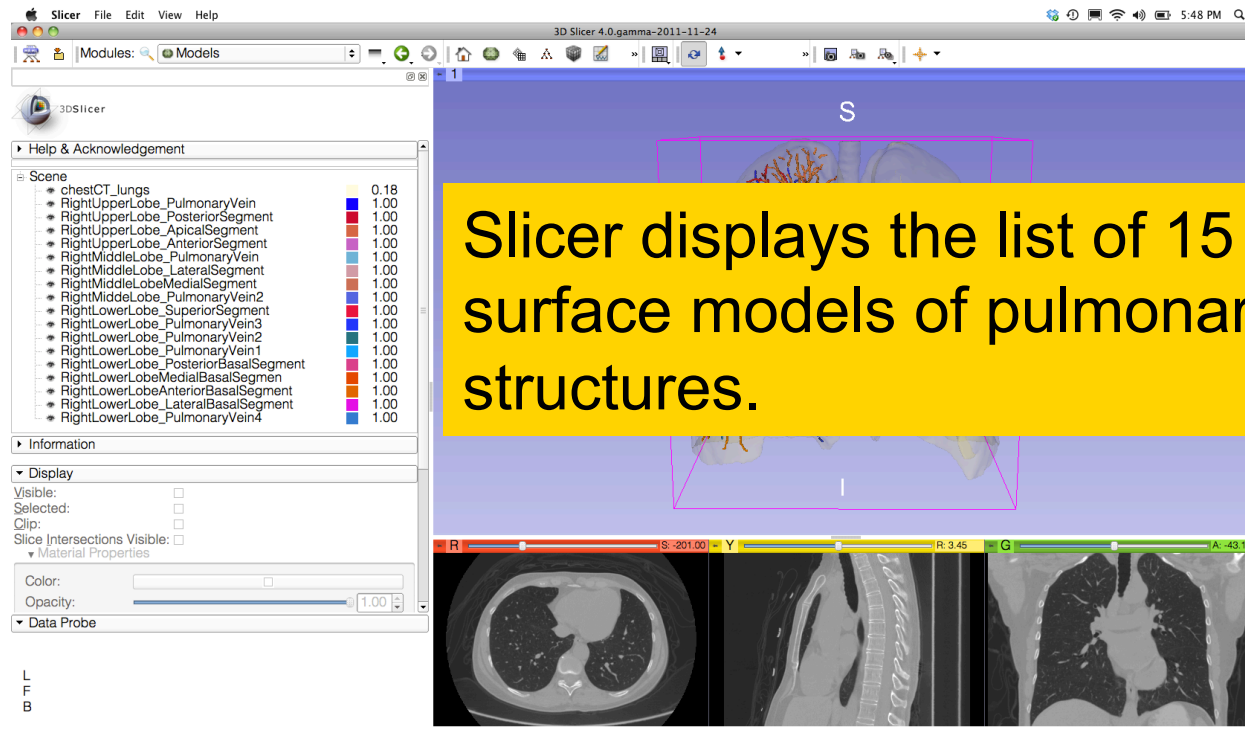


Select the module **Models** from the modules Menu.



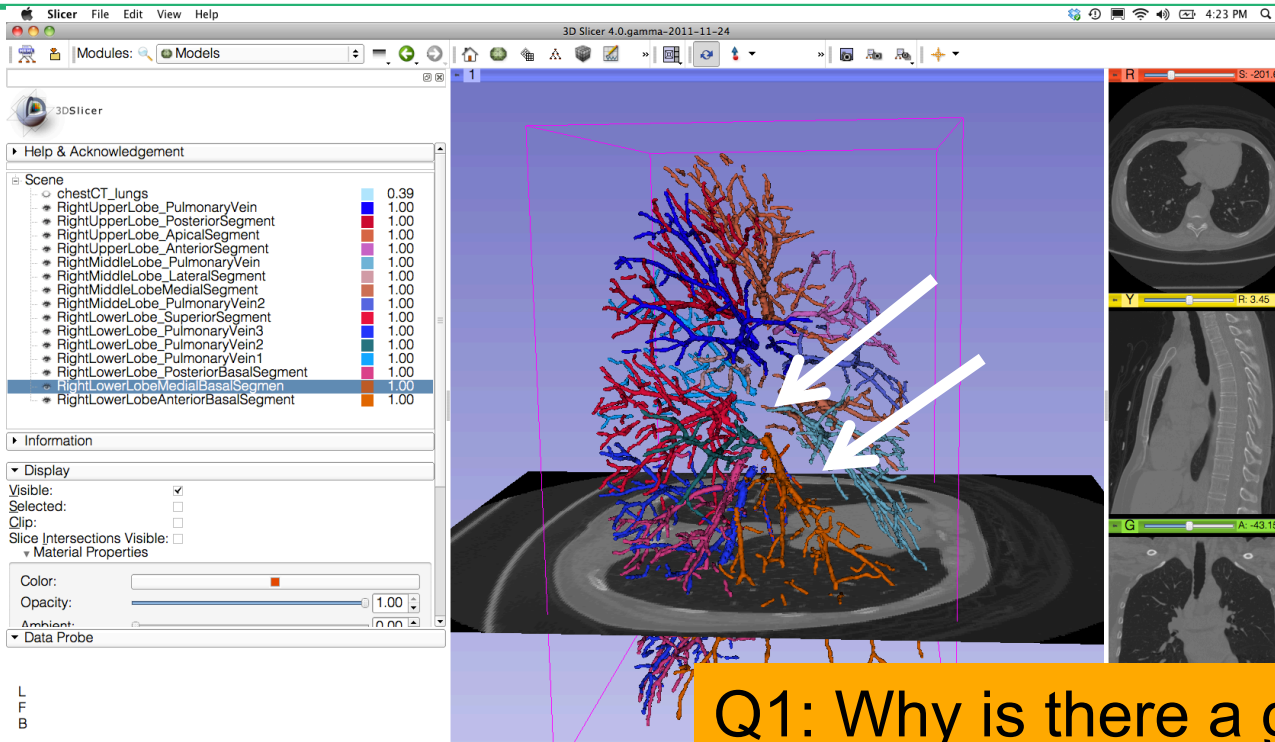


# Lung Segments





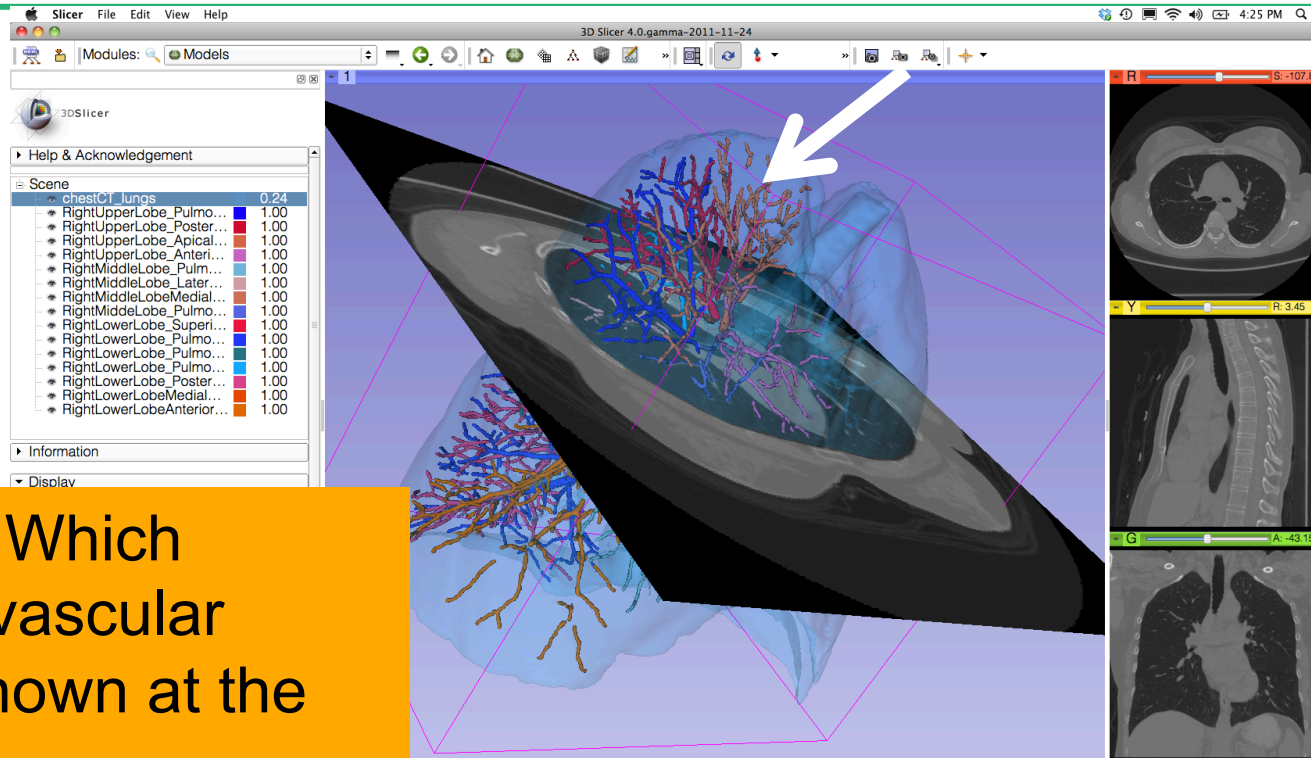
# Lung Segments – Question 1



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



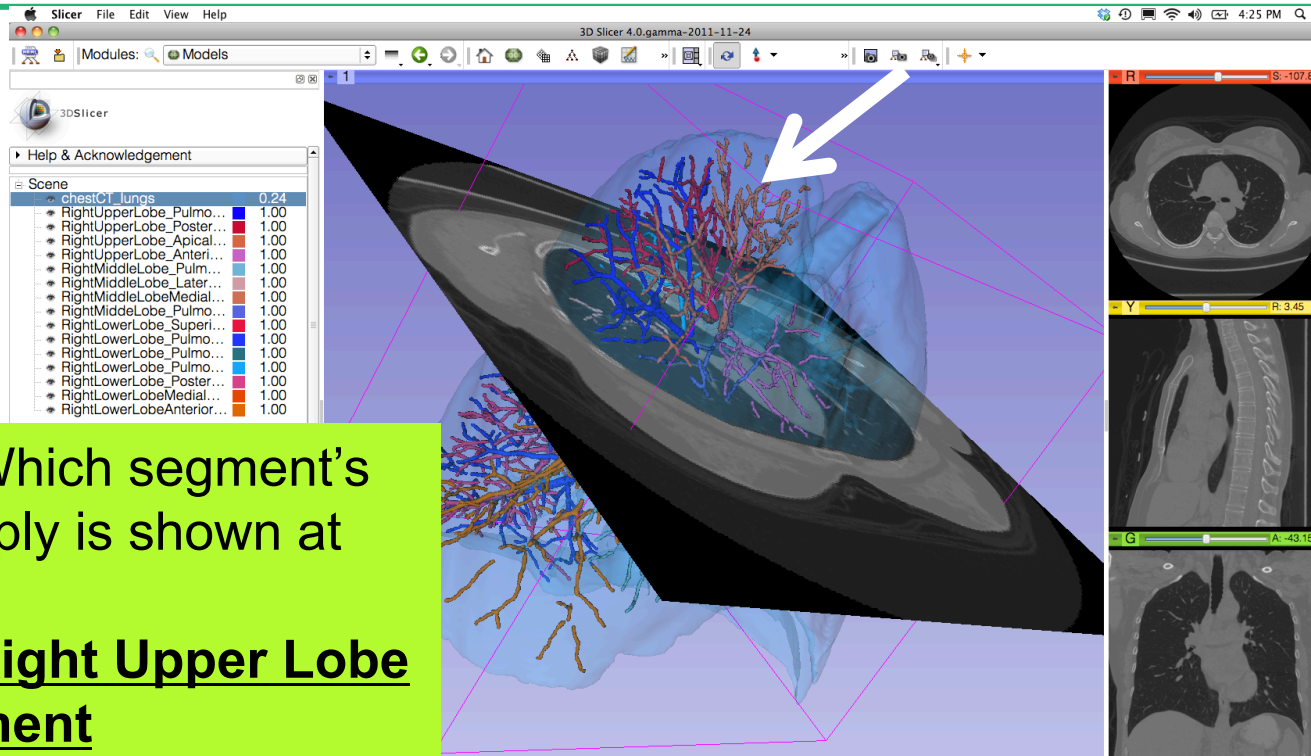
# Lung Segments – Question 2



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



# Lung Segments – Question 2



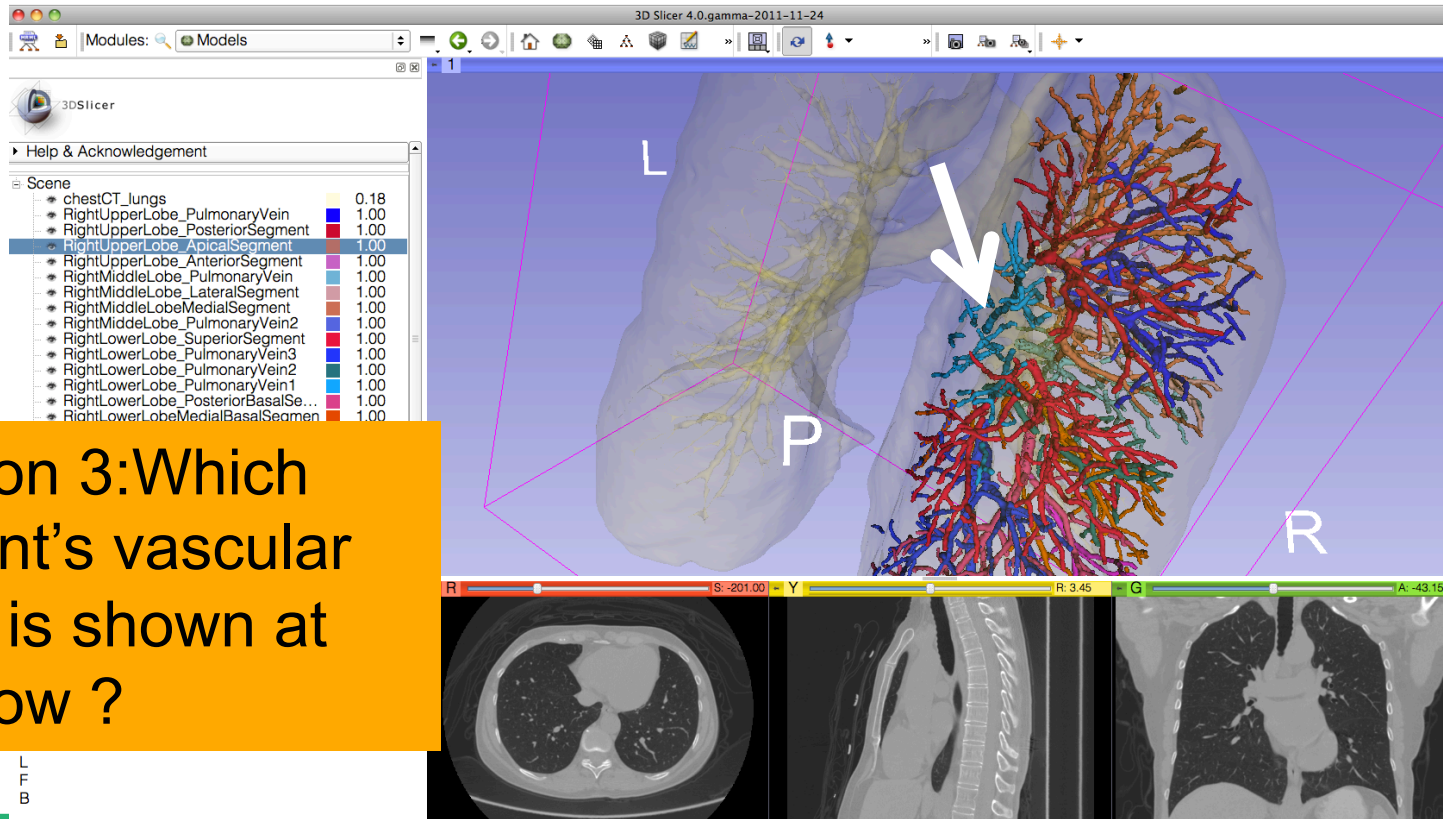
Question 2: Which segment's vascular supply is shown at the arrow?

**Answer 2: Right Upper Lobe Apical Segment**





# Lung Segments – Question 3



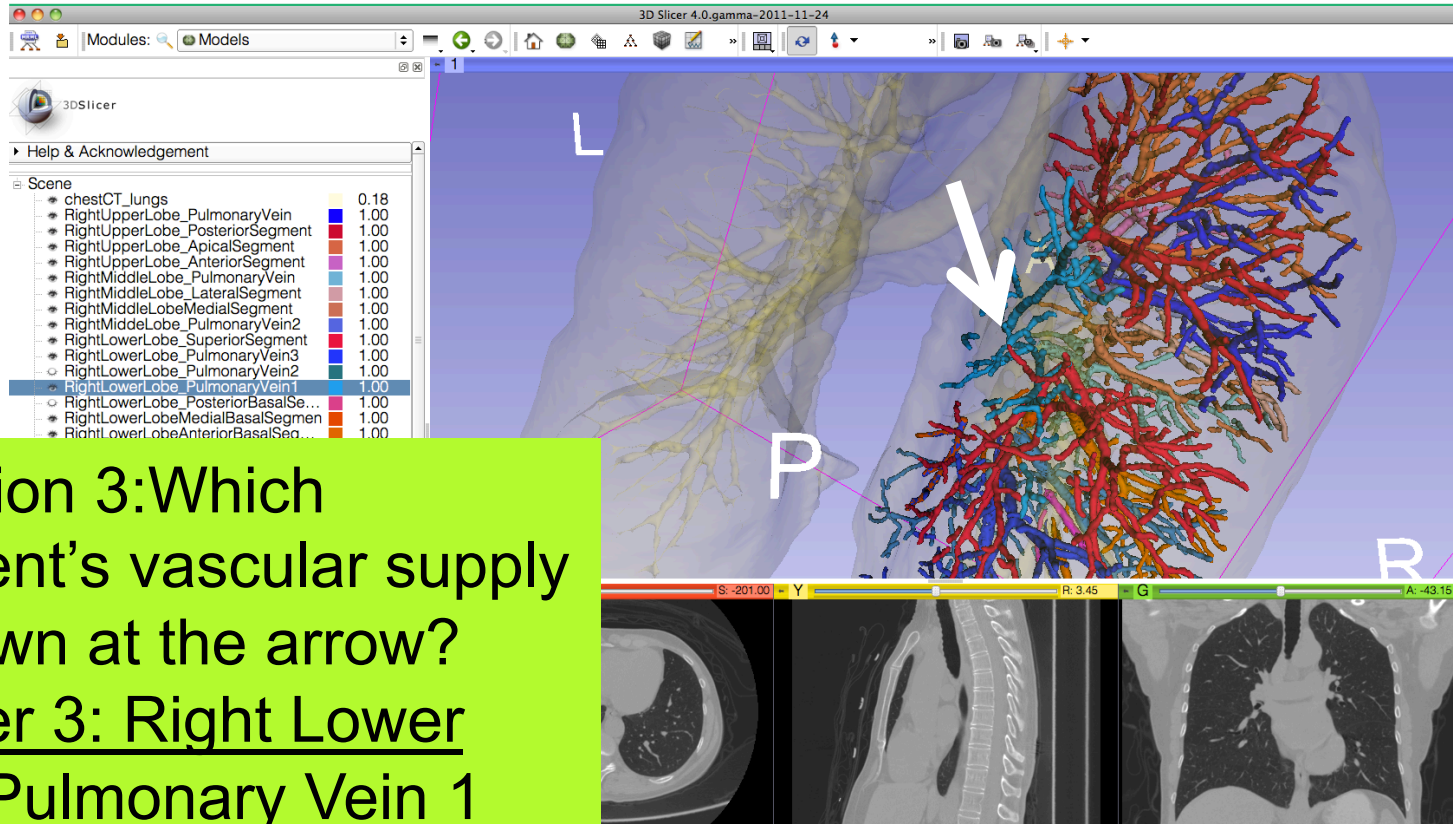
Question 3: Which segment's vascular supply is shown at the arrow ?

L  
F  
B





# Lung Segments – Question 3

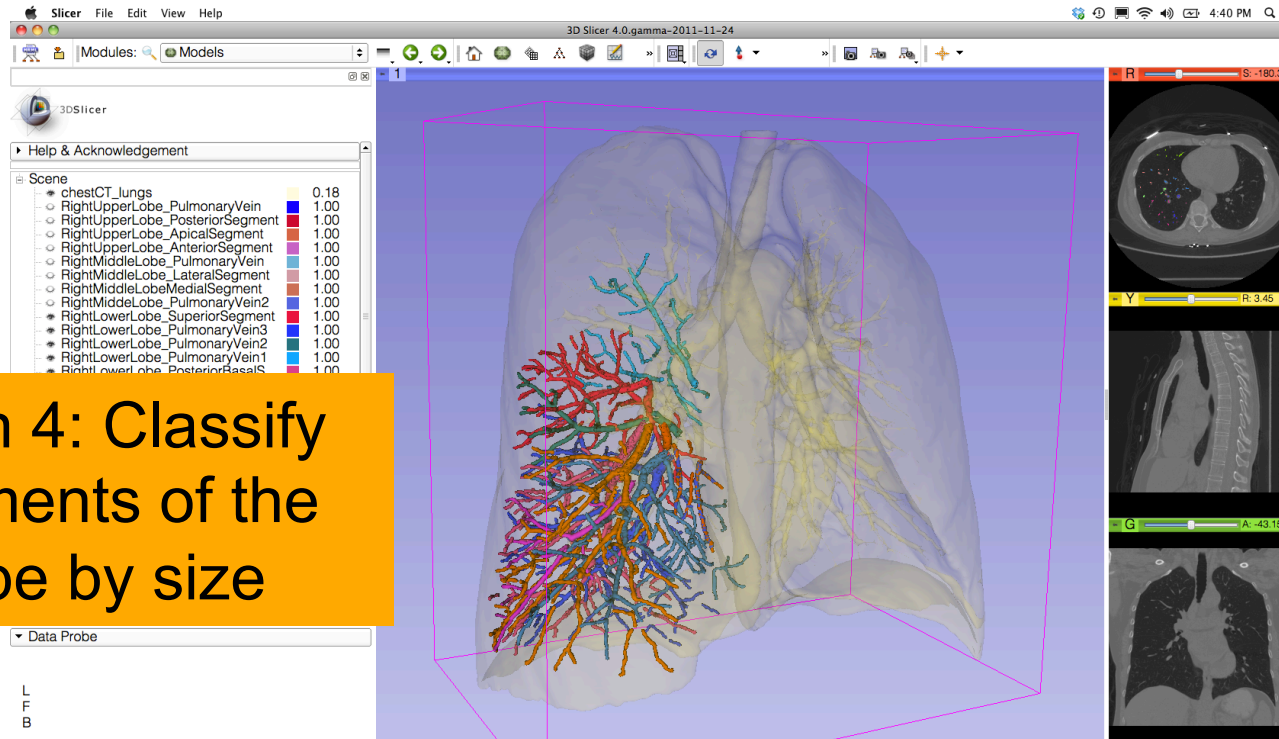


Question 3: Which segment's vascular supply is shown at the arrow?  
Answer 3: Right Lower Lobe Pulmonary Vein 1



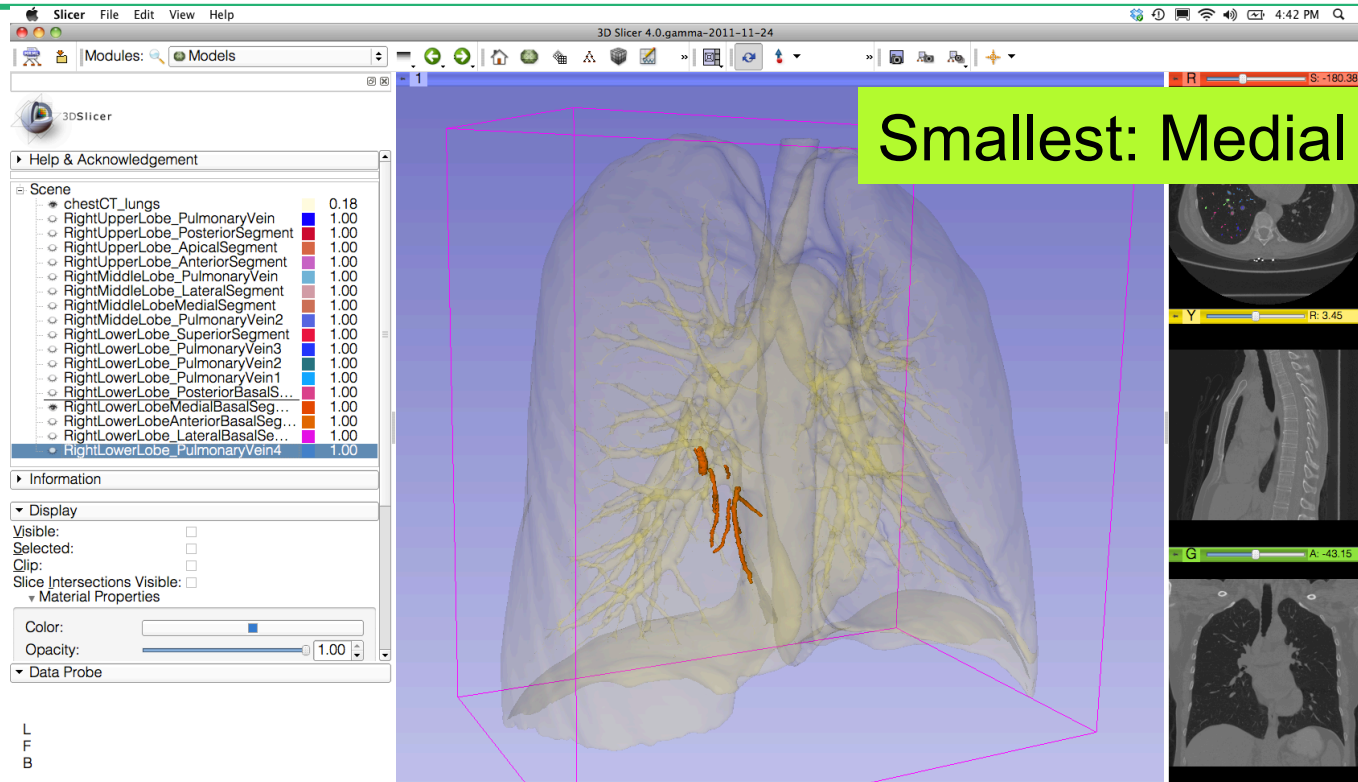
# Lung Segments – Question 4

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



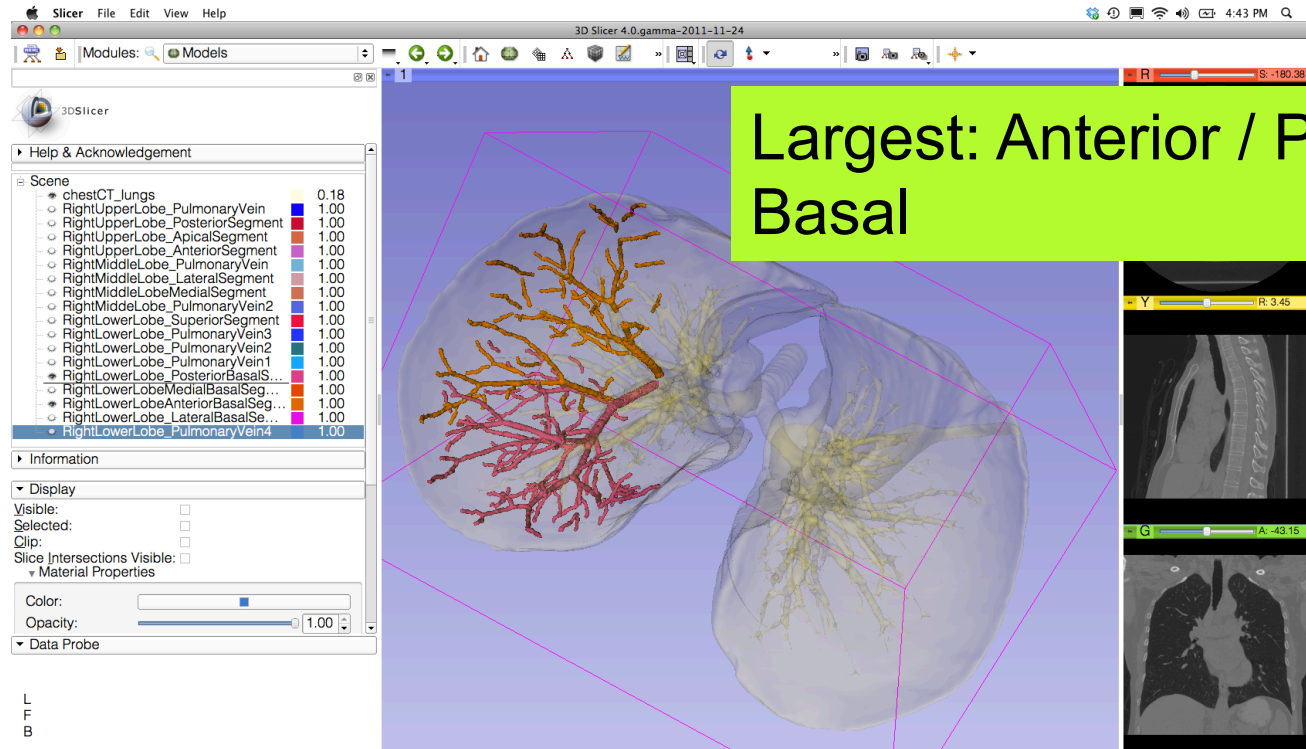


# Lung Segments – Question 4





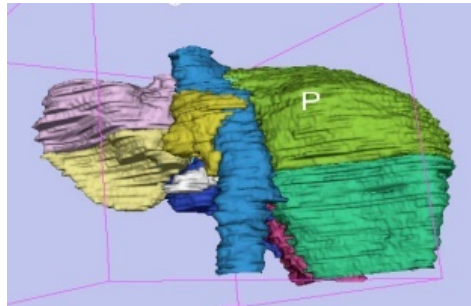
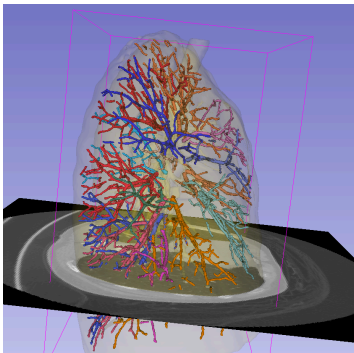
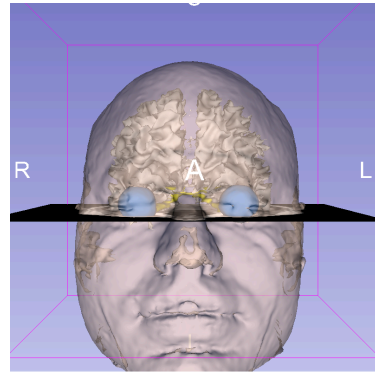
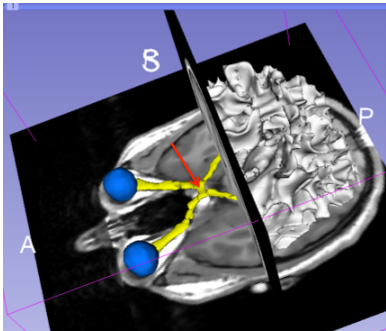
# Lung Segments – Question 4





## 3D Visualization of DICOM images

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- 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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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

The screenshot shows the 3DSlicer website homepage. At the top left is the 3DSlicer logo, a stylized sphere with a grid. To its right is the text "3DSlicer" and a tagline: "A multi-platform, free and open source software package for visualization and medical image computing". Below the tagline are four buttons: "Download", "Tutorial", "Feedback", and "Documentation". A search bar is located in the top right corner.

On the left side, there is a "Slicer Wiki" section with a sidebar menu containing "About Slicer" (with sub-links for Introduction, Acknowledgments, and Contact Us) and "Resources" (with a "Download" button and sub-links for For Users, For Developers, Commercial Use, NCIA, Publication DB, Image Gallery, Slicer Community, Source Code, Licensing, Mailing Lists, and Web Archive).

The main content area features three columns of images illustrating the software's capabilities:

- Powerful processing.** Shows a series of medical images with a heatmap overlay.
- Streamlined interface.** Shows a 3D model of a brain with a yellow overlay.
- Extensible platform.** Shows a 3D model of a hand with a purple overlay.

Below these images is a large banner for "3D Slicer version 4" with the website URL "www.slicer.org".

At the bottom, there is a news item: "The community of Slicer developers is proud to announce the release of Slicer 4.2. Find out more..." and a link to a "Webinar: Introduction to Slicer 4.1".

Footnote text at the very bottom: "Content of this site is Copyright 2012 BWH and 3D Slicer contributors, unless otherwise noted. Contact [webmaster@bwh.harvard.edu](mailto:webmaster@bwh.harvard.edu) for questions about the use of this site's content. See [here](#) for more information about the web infrastructure."