

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

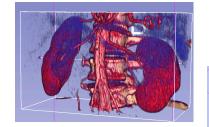
#### Kitt Shaffer, MD, PhD, Boston University Vice-Chairman for Education, Boston University School of Medicine

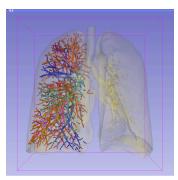
Ron Kikinis, MD, Harvard Medical School Surgical Planning Laboratory, Brigham and Women's Hospital

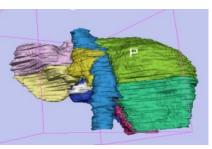


### **3D Visualization of DICOM images for Radiological applications**

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.





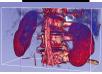




### **Overview**



Part I: Introduction to the 3DSlicer software



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

- Volume Rendering of thoraco-abdominal CT data
- Surface Rendering of MR head data



Part III: 3D interactive exploration of the anatomy

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





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# *Introduction to the 3DSlicer software*



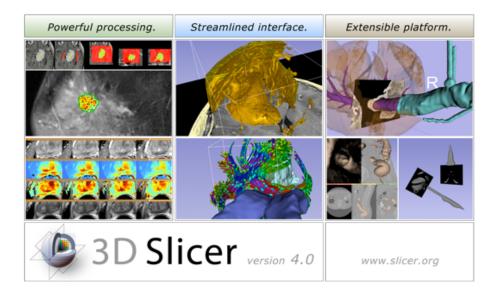




3DSlicer is a freely available opensource platform for segmentation, registration and 3D visualization of medical imaging data.

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





- 3DSlicer version 4.3 is a multiplatform software running on Windows, Linux, and Mac OSX
- Slicer is distributed under a BSD license with no restriction on use
- Slicer is a tool for research, and is not FDA approved

**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.

## An interdisciplinary platform



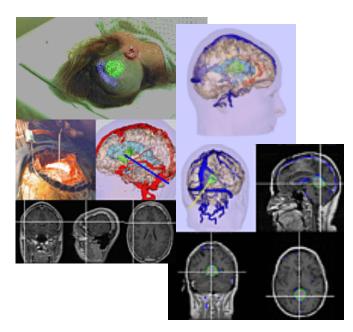


An open-source environment for software developers

An end-user application for clinical investigators and scientists

A software platform that is both easy to use for clinical researchers and easy to extend for programmers





 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**



Total matching downloads: 97702 Date range: forever ¢ Release type:

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Browser type: desktop

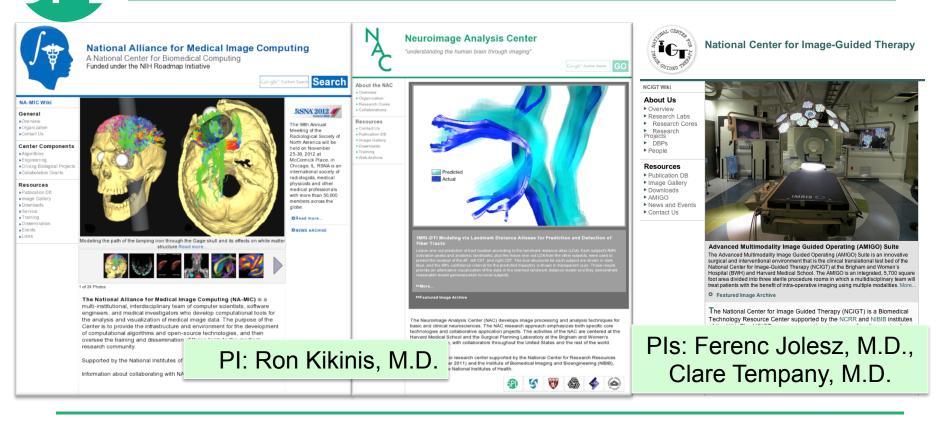
Update





- 1997: Slicer started as a research project between the Surgical Planning Lab (Harvard) and the CSAIL (MIT)
- 2013: Multi-institution effort to share the latest advances in image analysis with the clinical and scientific community

### A multi-institution: NA-MIC, NAC, NCIGT



### **Slicer: Behind the scenes**

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## **P** Slicer Training events



- Hands-on training workshops at national and international venues
- More than 2,700 clinicians, clinical researchers and scientists trained since 2005

# Slicer Training events



#### Major international conferences

- **RSNA** 2008, 2009, 2010, 2011, 2012,2013
- MICCAI 2008, 2009, 2011, 2012,2013
- **SfN** 2009, 2011
- **SPIE** 2012, 2013
- **CAOS** 2010
- **CARS** 2010, 2012, 2013



Hands-on refresher courses

- 3D Visualization of DICOM images for Radiology Applications
- Quantitative Imaging for Clinical Research and Practice

#### **Quantitative Imaging Reading Room Exhibit**

 3DSlicer: An Open Source Platform for Segmentation, Registration, Quantitative Imaging, and 3D Visualization of Multi-Modal Image Data.



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### Welcome to Slicer4

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Feedback						
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### To start Slicer, select Start $\rightarrow$ Programs $\rightarrow$ Slicer4-3.1-1 (win64)

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### **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

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Module GUI Panel	Slice Viewers

Welcome to Slicer4.3.1.1



ACPC Transform Add Scalar Volumes Affine Registration Annotations AtlasTests **BSpline Deformable Registration** BSpline to deformation field Cameras Cast Scalar Volume ChangeTracker Charting CheckerBoard Filter Colors Create a DICOM Series Crop Volume Curvature Anisotropic Diffusion Data DataProbe Demon Registration (BRAINS) 👪 DICOM DICOM to NBBD Converter Diffusion Tensor Scalar Measurements Diffusion Weighted Volume Masking DTlexport DTlimport DWI Joint Rician LMMSE Filter DWI Bician I MMSE Filter DWI to DTI Estimation DWI to Full Brain Tractography DWI Unbiased Non Local Means Filter Editor EMSegment Command-line EMSegmenter with Atlas EMSegmenter without Atlas

Histogram Matching Image Label Combine Intensity Difference Change Detection (FAST) Label Map Smoothing Label Statistics labelToggleBug2049 Linear Registration Mask Scalar Volume Median Image Filter Merge Models Model Maker Model To Label Map Models Multiply Scalar Volumes MultiVolumeExplorer MultiVolumeImporter N4ITK MRI Bias correction ℜ OpenIGTLinkIF **Orient Scalar Volume** Otsu Threshold Image Filter Otsu Threshold Segmentation Performance Tests PET Standard Uptake Value Computation Probe Volume With Model Reformat Resample DTI Volume Besample Image (BRAINS) Resample Scalar Volume Resample Scalar/Vector/DWI Volume **Rigid Registration** Robust Multiresolution Affine Registration Robust Statistics Segmenter RSNA2012Quant RSNA2012Vis Sample Data t (Issue 2428)

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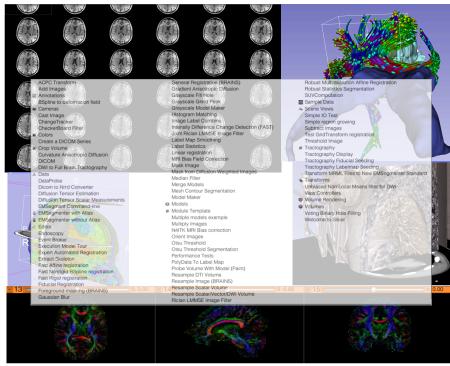
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Welcome to Slicer

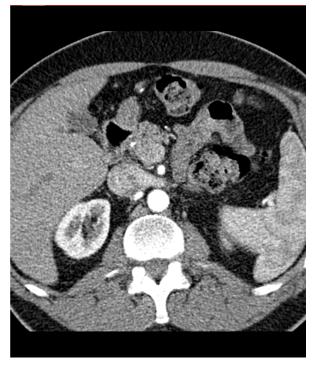
Click on **Welcome to Slicer** to display the list of modules of Slicer in the Modules menu SPI

### **Welcome to Slicer4**



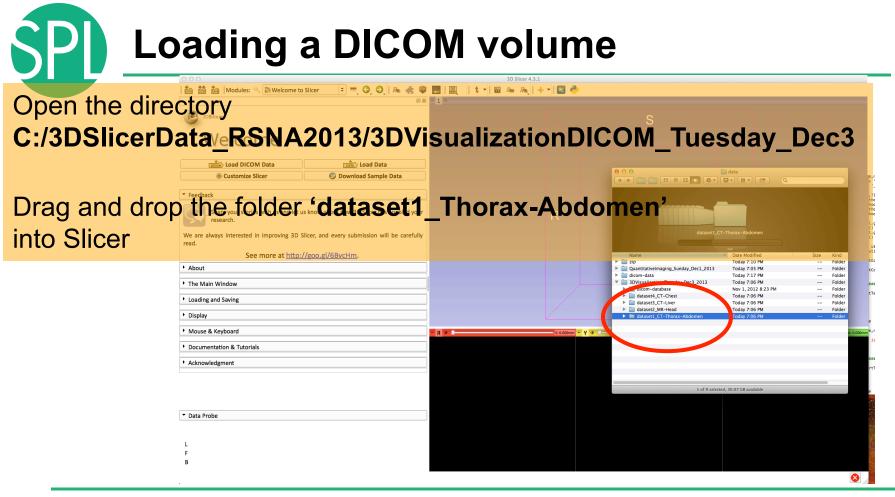
Slicer4.3.1 contains more than 100 modules for image segmentation, registration and 3D visualization of medical imaging data

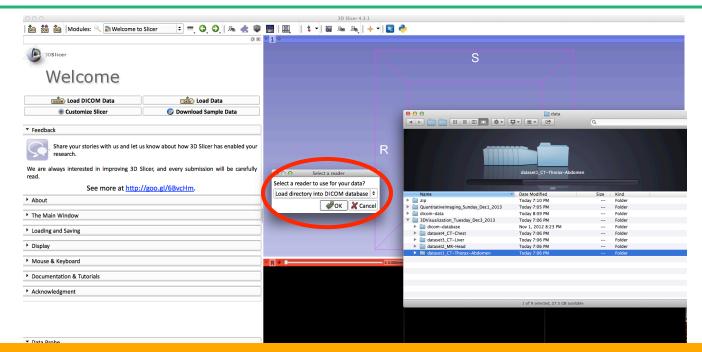




### Part 1:

### Loading a DICOM Volume





### A pop-up window appears: Select Load directory into DICOM database and click on OK

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Image 5	Image 11	Image 12	Image 13	Image 14	6: CT_Thorax_Abdo			

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Import Export Query Send Remove Name ^ Age Scan Date Subject I Num e patient1	Click on Load Selection to Slicer to load the DICOM volume into Slicer (note: this may take a few minutes)
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Slicer displays the axial, coronal and sagittal slices of the DICOM dataset

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

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Histogram



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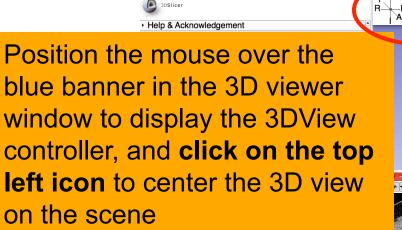
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The three anatomical slices appear in the 3D viewer. Use the rightmouse button in the 3D Viewer to zoom in and out



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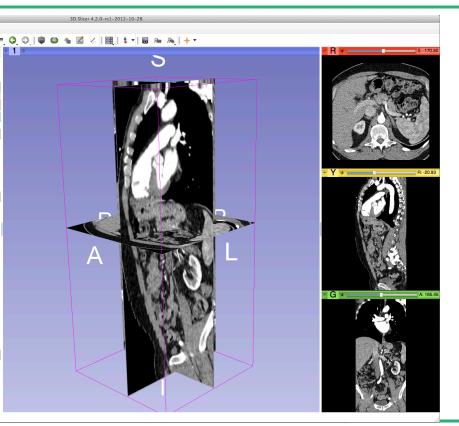
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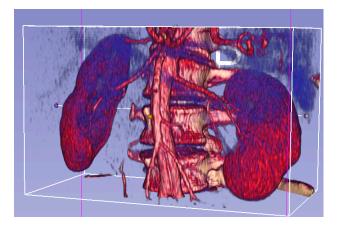
### Loading a DICOM volume

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

Data Probe





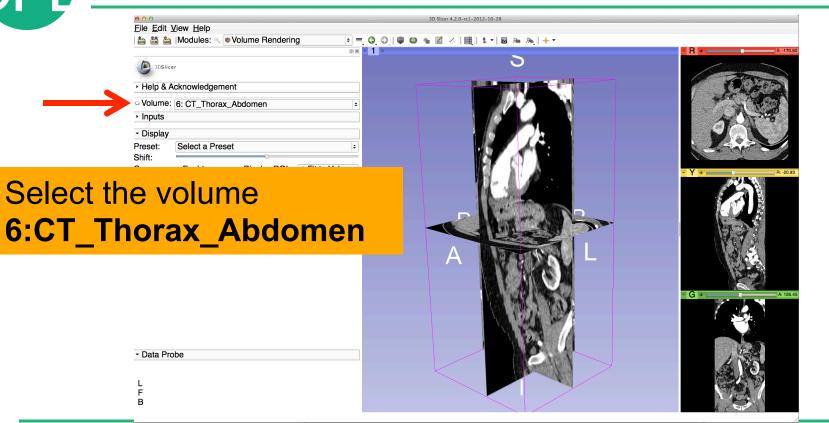


3D Interactive exploration of thoraco-abdominal CT data using Volume Rendering

SPL

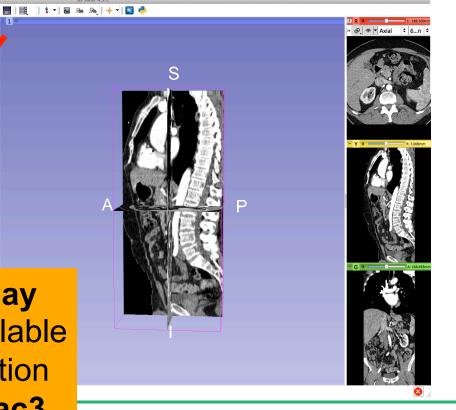
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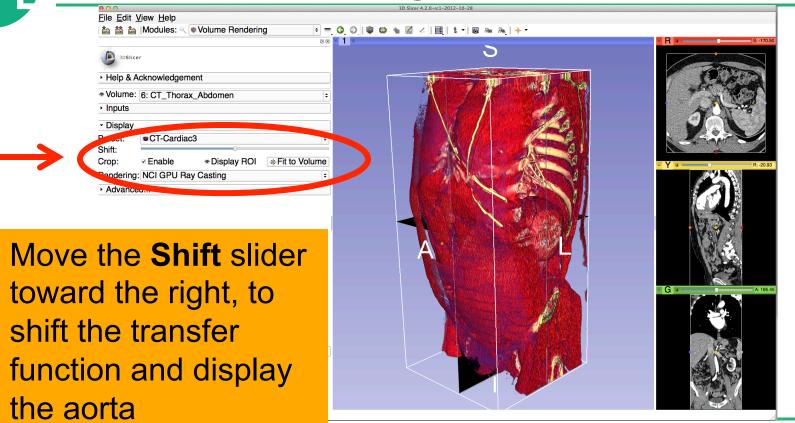
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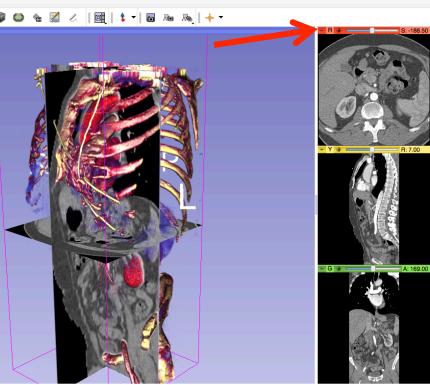


3D Slicer 4.2.0

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

Data Probe

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### **Volume Rendering**

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

3DSlicer



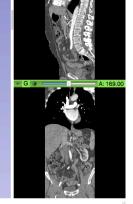


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Click on **Display ROI** to display a region of interest that we will use for cropping the dataset, and check the option **Enabled** 



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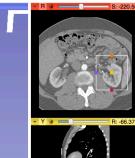
#### **Volume Rendering**

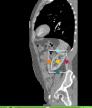
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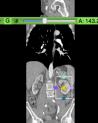
BD Slicer 4.2.0

- Volume: 6: CT\_Thorax\_Abdomen Turn on the visibility of the grayscale images in to the 3D Viewer, and position the ROI around the left and right kidneys using the ROI controls in the 2D anatomical views and in the **3D** viewer

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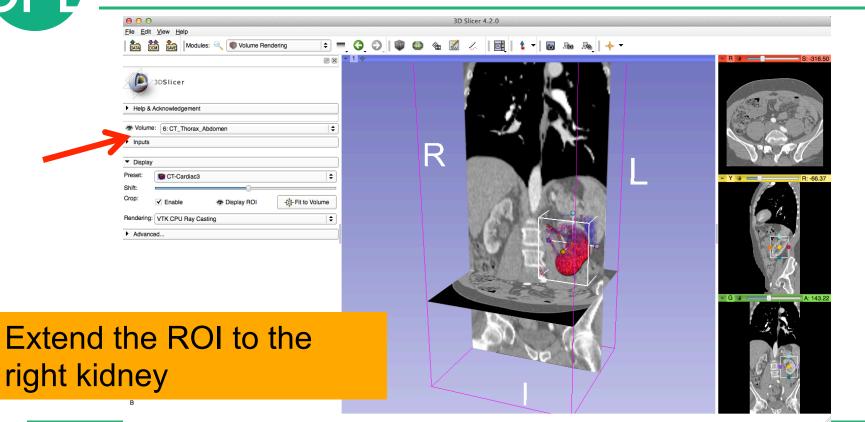




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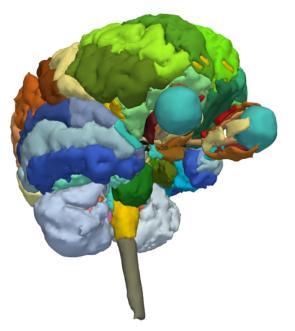
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Slicer displays the cropped volume rendered images showing the left and right kidney

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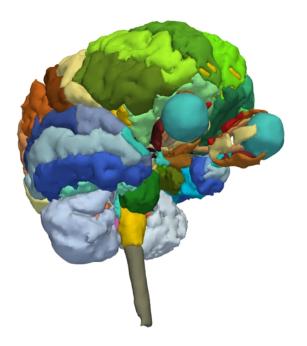
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# 3D visualization of surface models of the brain

## **3D** Data Loading and Visualization



- This tutorial is a short introduction to the advanced 3D visualization capabilities Slicer
- The Slicer4 Minute dataset is composed of an MR scan of the brain and 3D surface reconstructions of anatomical structures.
- The data are part of the SPL-PNL Brain Atlas developed by Talos, Jakab, Kikinis *et al.* The atlas is available at:

http://www.spl.harvard.edu/publications/item/view/2037

### Welcome to Slicer4

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We are always interested in improving 3D Slicer, and every s See more at <u>http://</u>						
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#### To start Slicer, select Start $\rightarrow$ Programs $\rightarrow$ Slicer4-3.1 (win64)

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#### **Slicer4 Minute Tutorial: Viewing the Scene**

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Open the directory dataset2\_Head located in C:/3DSlicerData\_RSNA2013/3DVisualizationDICOM\_Tuesday\_Dec3 Drag and drop the file Head\_Scene.mrb into Slicer

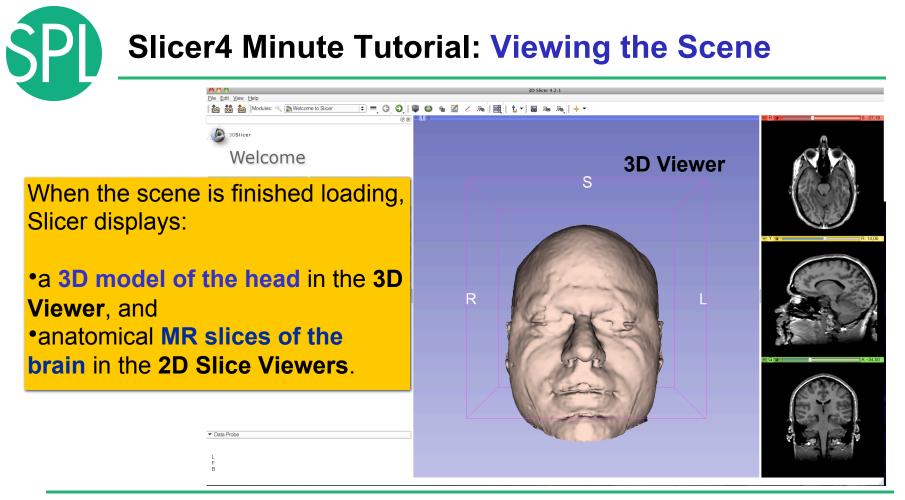


#### **Slicer4 Minute Tutorial: Viewing the Scene**

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#### Click on **OK** to load the file **MRHead\_Scene.mrb** into Slicer

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©2012-2013 Surgical Planning Laboratory, ARR

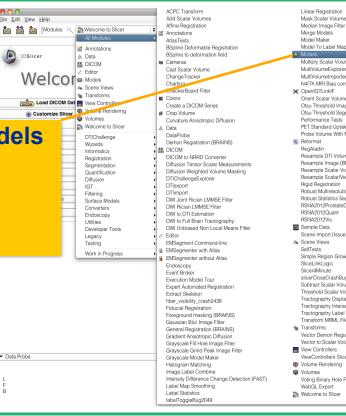
#### Slicer4 Minute Tutorial: Exploring Slicer's functionality

To access the **Models** module, browse through the list of modules.

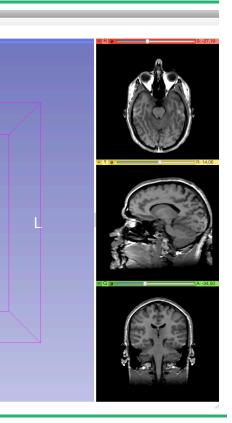
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3DSlicer



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Data Probe

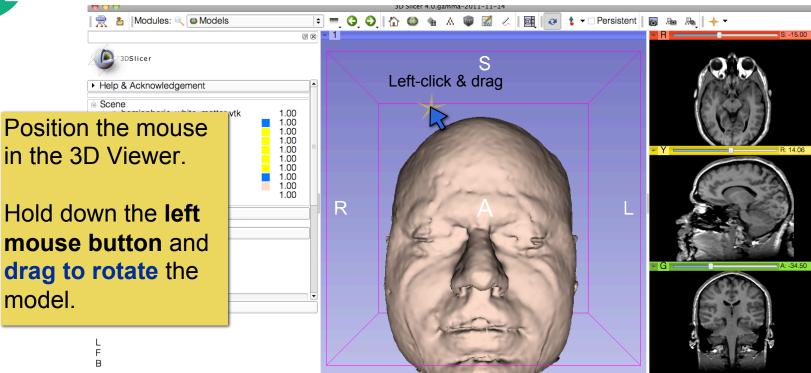


#### **Slicer4 Minute Tutorial: Switching to the Models Module**

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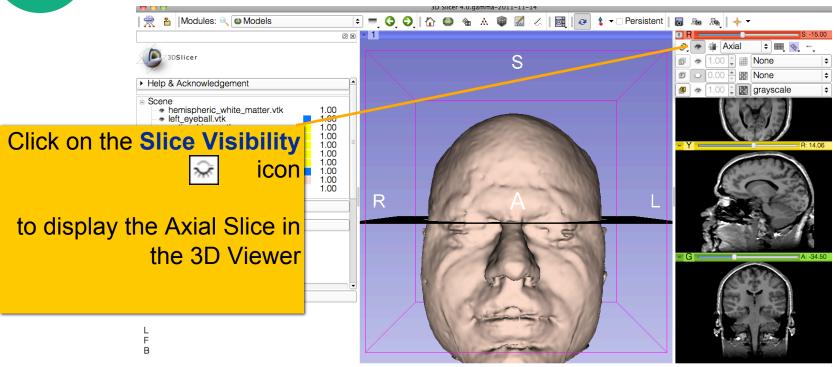


#### **Slicer4 Minute Tutorial: Basic 3D Interaction**





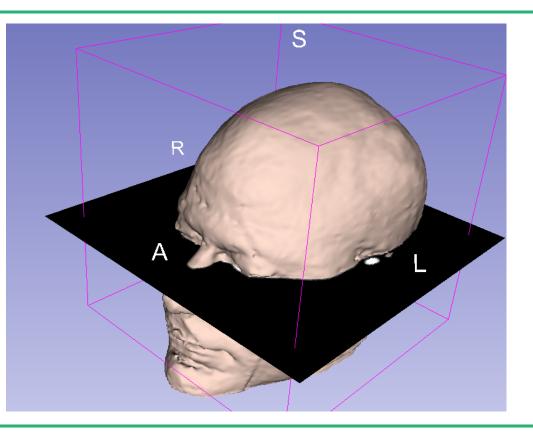
#### **Slicer4 Minute Tutorial: Viewing Slices in the 3D Viewer**





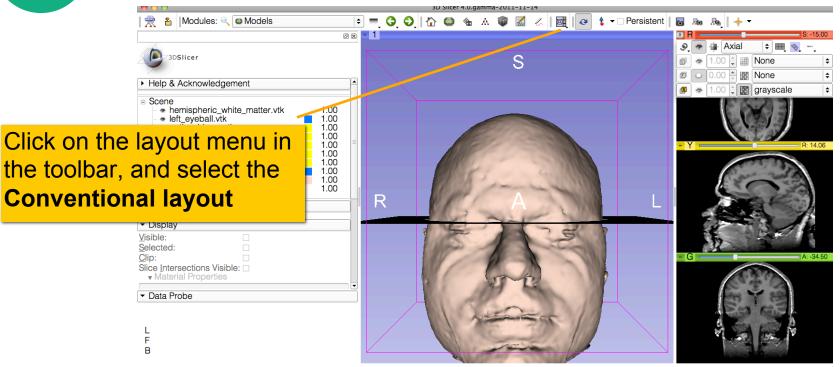
#### Slicer4 Minute Tutorial: 3D Visualization

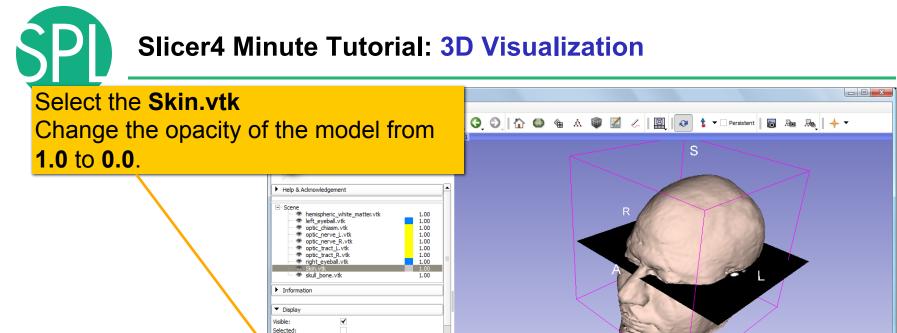
Slicer adds a view of the **Axial slice** in the 3D View.





#### **Slicer4 Minute Tutorial: Viewing Slices in the 3D Viewer**





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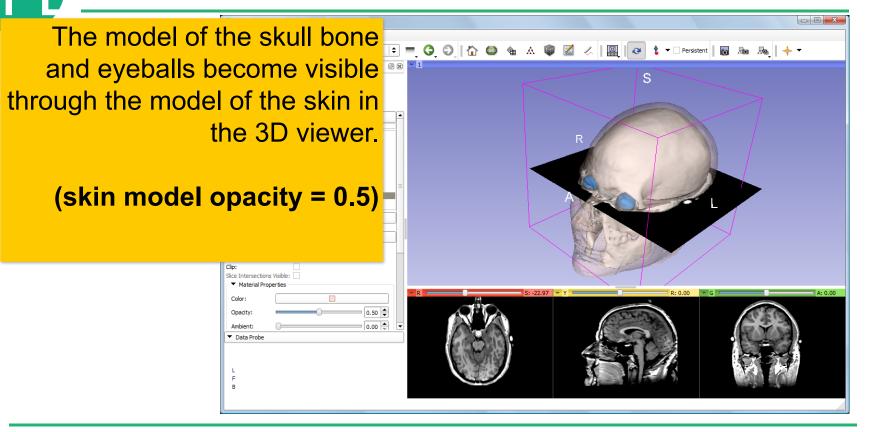
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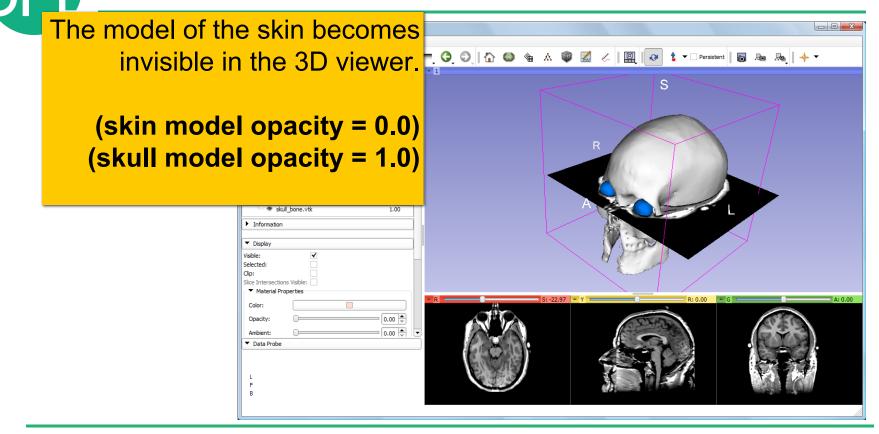
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#### Slicer4 Minute Tutorial: 3D Visualization



#### **Slicer4 Minute Tutorial: 3D Visualization**





Click on the Slice Visibility icon in the Green Slice Viewer to display the Coronal Slice in the 3D Viewer.

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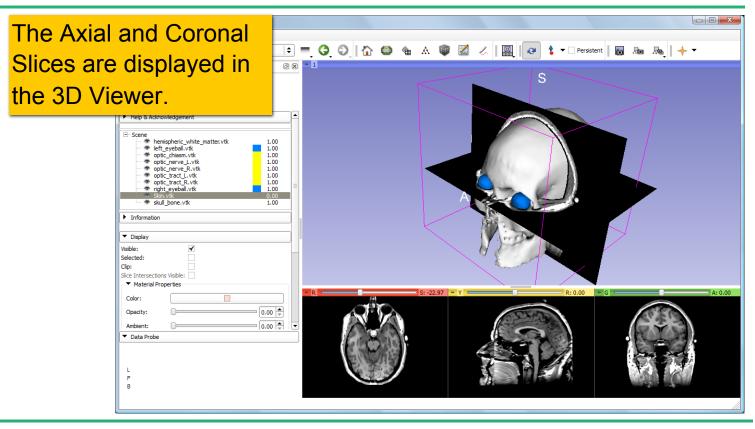
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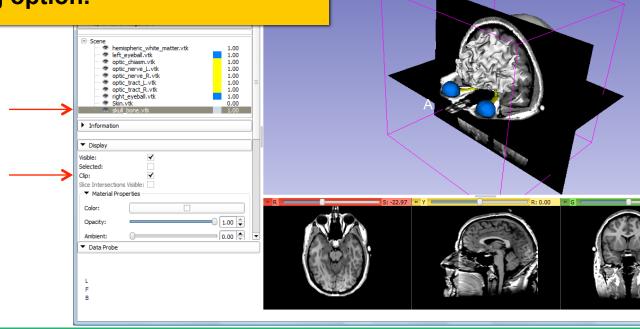
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# Select the 3D model **skull\_bone.vtk** in the Model Hierarchy and turn on the **Clipping option.**



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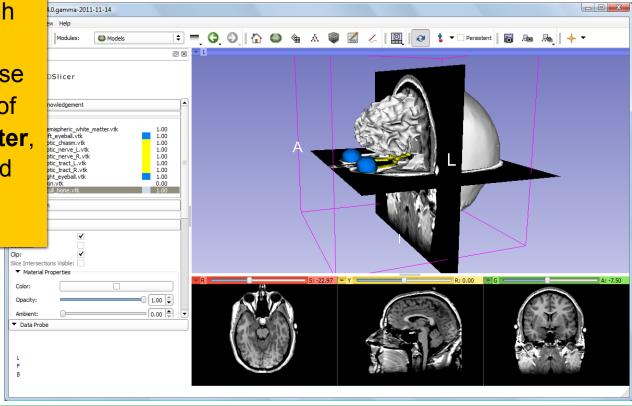
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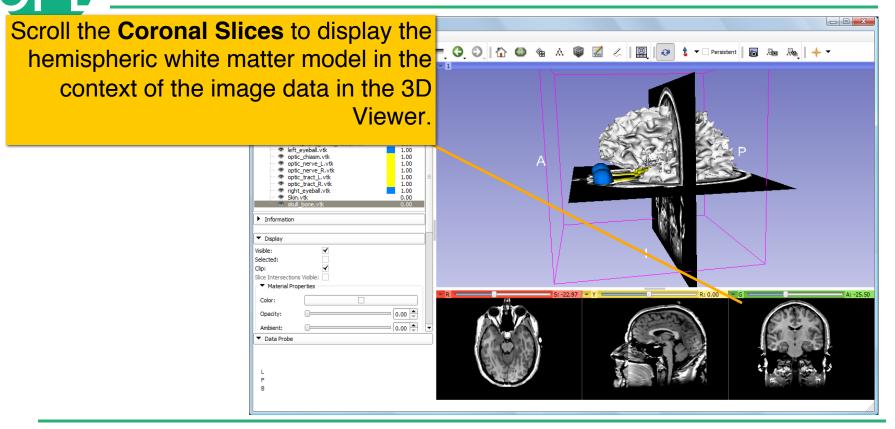
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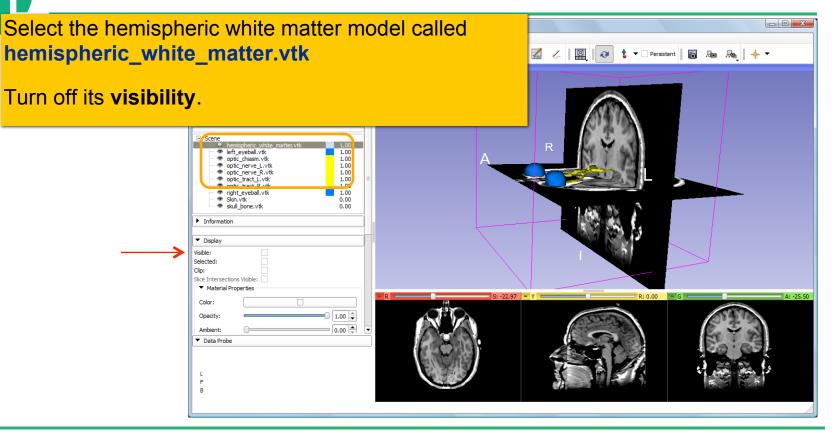
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Browse through the coronal slices to expose the 3D model of the white matter, and the left and right optic nerves.



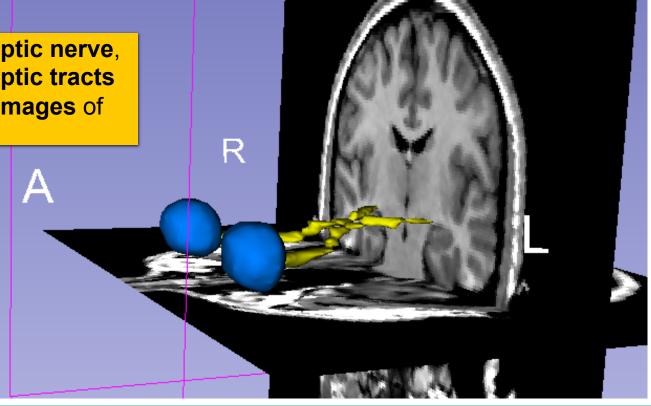
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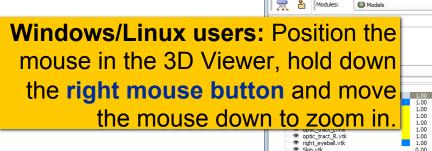
Slicer displays the **optic nerve**, **optic chiasm** and **optic tracts** overlaid on the **MR images** of the brain.





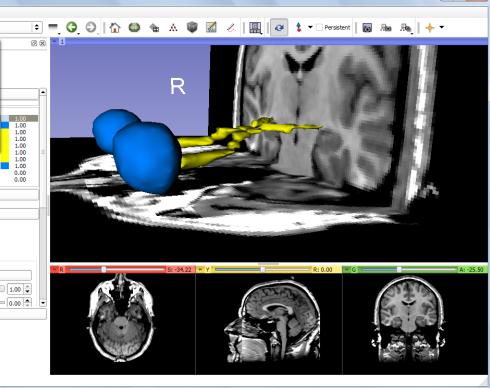
#### Slicer4 Minute Tutorial: 3D Visualization: Zoom the view

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

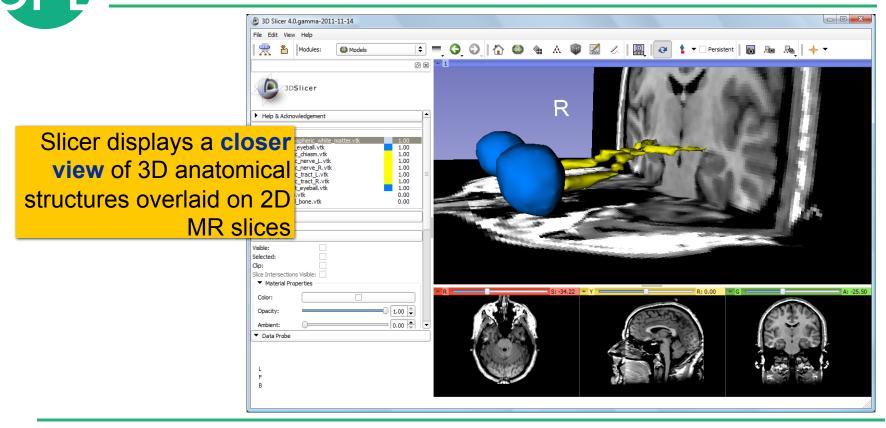
Mac users: Position the mouse in the 3D Viewer, hold down the apple button and the mouse button and move the mouse down to zoom in (or use two fingers on the touch pad)



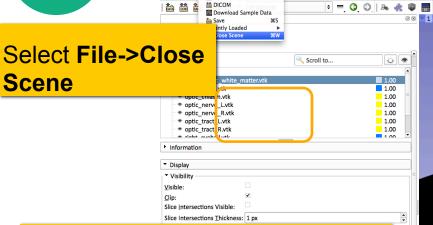
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#### **Slicer4 Minute Tutorial: 3D Visualization: Zoom the view**



### Close the existing scene and all its data

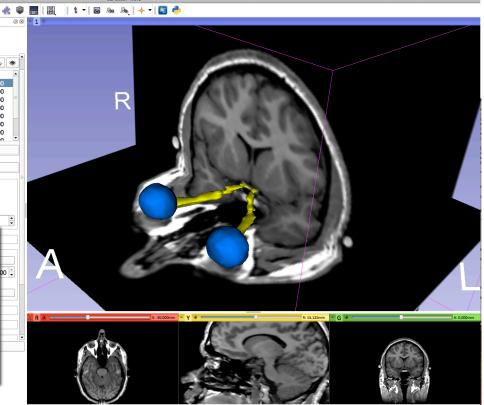


a Add Data

This removes any dataset previously loaded into Slicer.

Select Slicer→Quit to exit the software

в



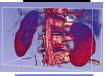




### **Overview**

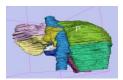


Part I: Introduction to the 3DSlicer software



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

- Volume Rendering of thoraco-abdominal CT data
- Surface Rendering of MR head data

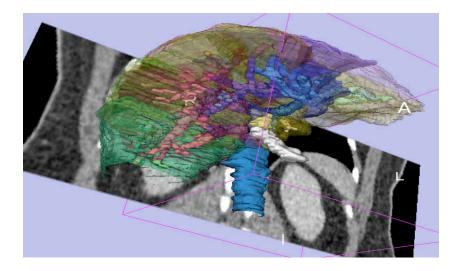


Part III: 3D interactive exploration of the anatomy

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





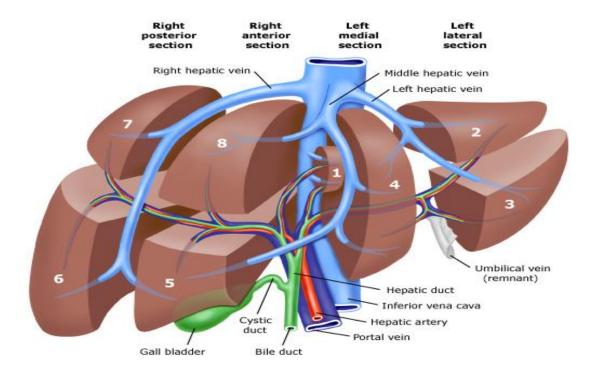


### Part II:

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



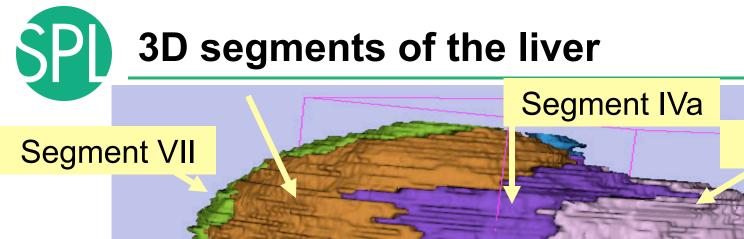
### Anatomy of the liver







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



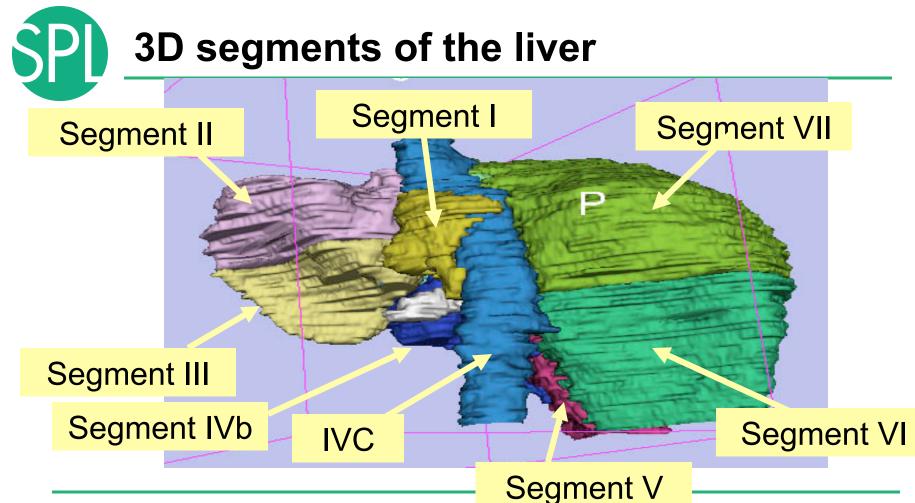


### Segment IVb

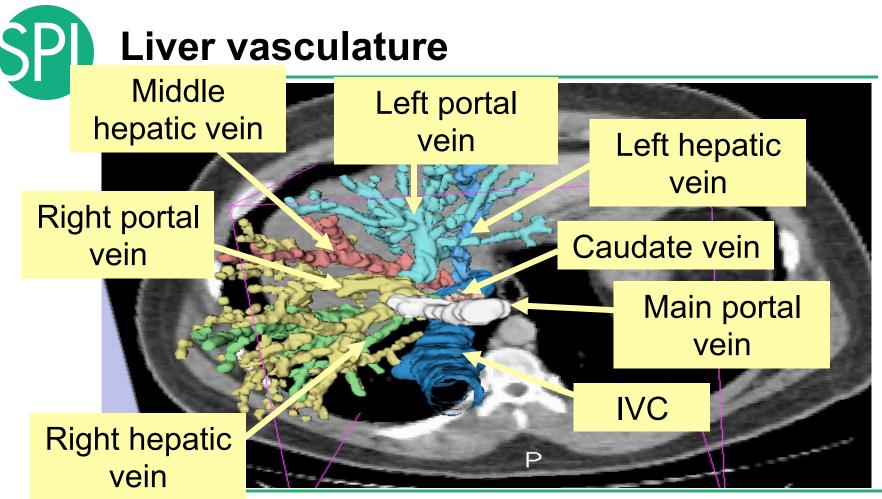
Segment V

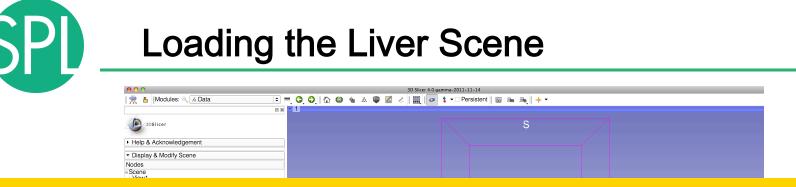
Segment II

Segment III



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### Browse to the directory

- C:\3DSlicerData\_RSNA2013\3DVisualizationDICOM\_Tuesday\_Dec3
- Select the directory dataset3\_Liver

Drag and drop the file LiverSegments\_Scene.mrb into Slicer

Click on OK to load the scene into Slicer

### Loading the Liver Scene

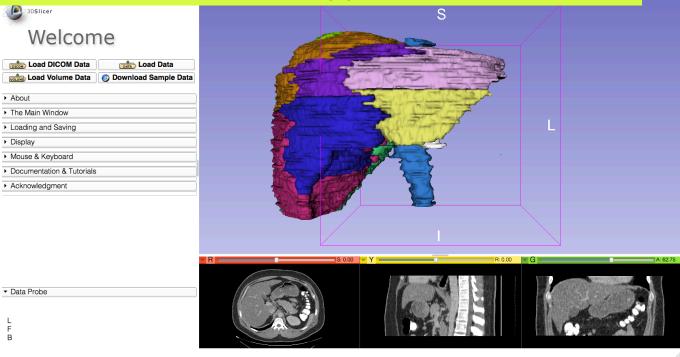
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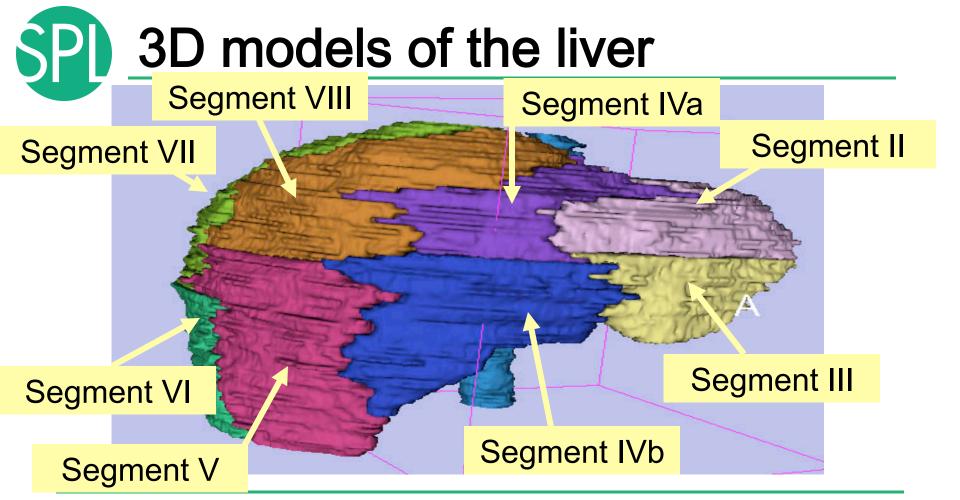
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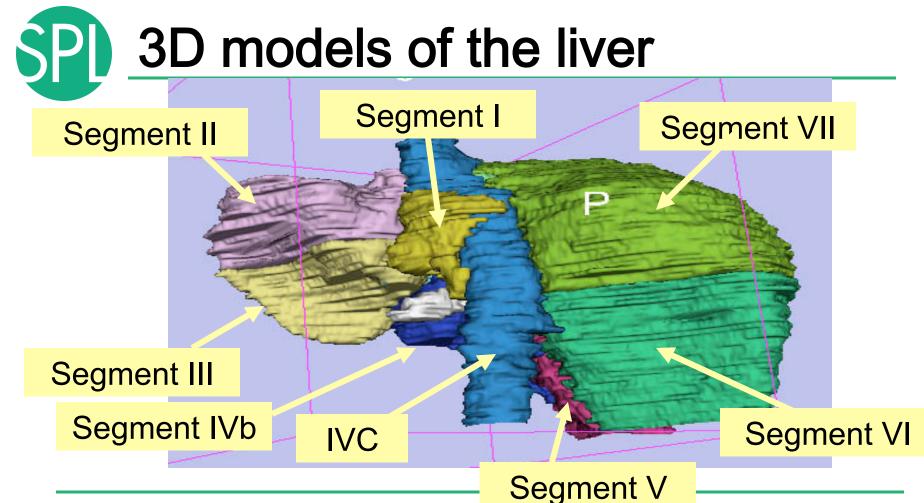
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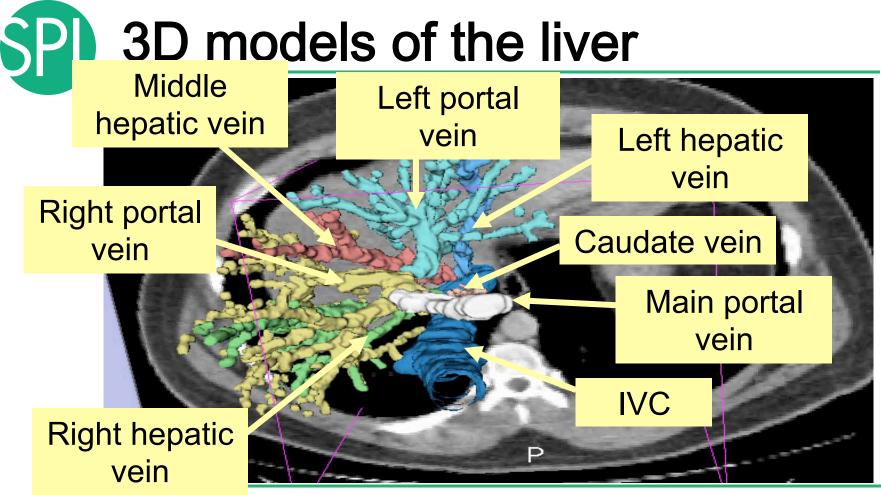
### **Liver Segments Scene**

#### The elements of the scene appear in the Viewer

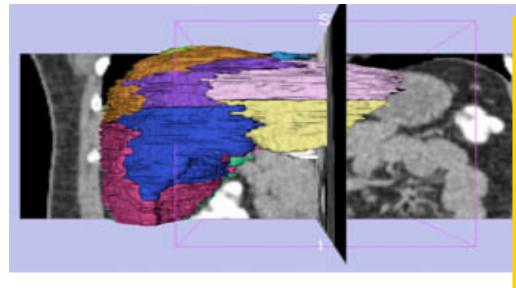




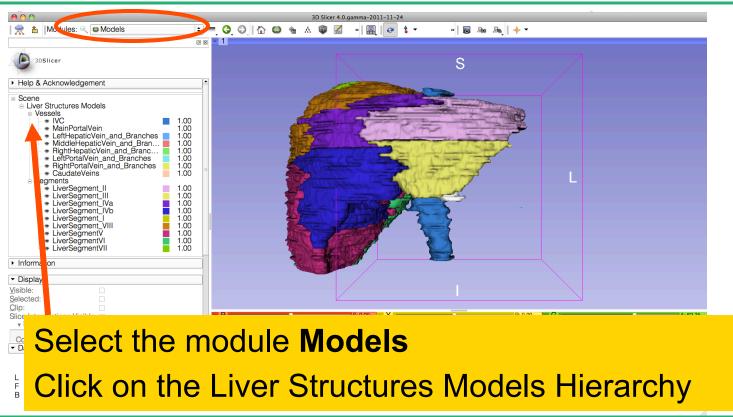


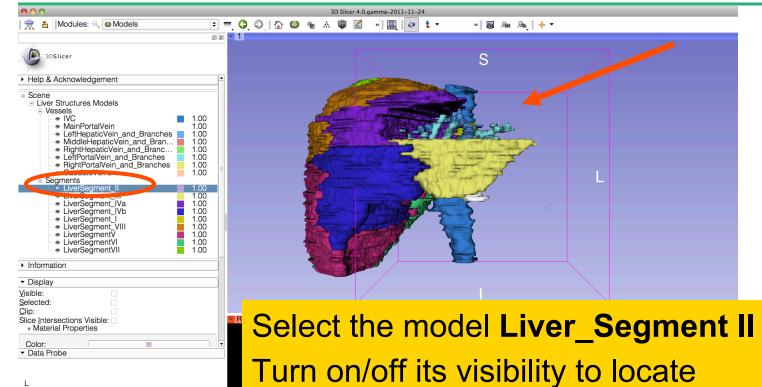






Example: What organ abuts the left-most margin of segment II in this patient ?





it in the 3D viewer.

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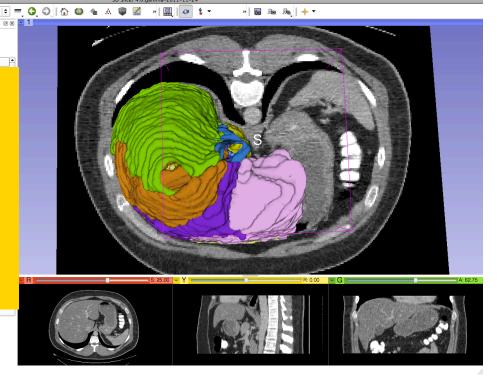
F B

Position the mouse in the 3D Viewer, hold down the left mouse button and drag to orient the 3D model to a superior view.

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Models



National Alliance for Medical Image Computing Slide 10 http://na-mic.org © 2010, ARR

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### **Question 1:**

What organ abuts the leftmost margin of segment II in this patient?

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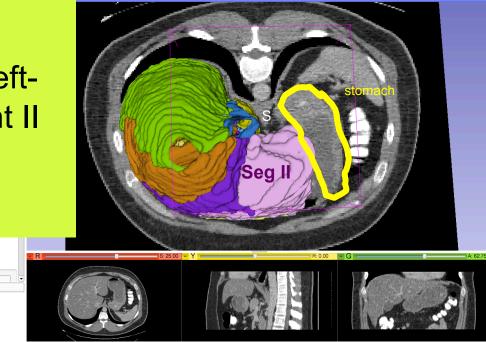
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### Answer 1: Stomach



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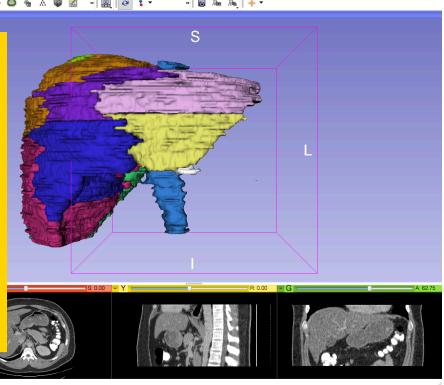
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### **Question 2:**

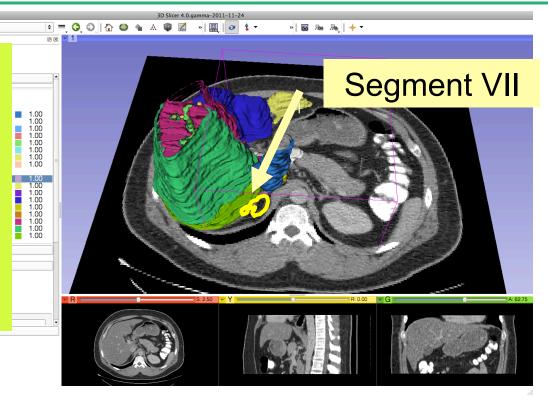
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Which segment would most likely be affected by an aggressive tumor invading locally from the right adrenal gland ?



#### **Question 2:**

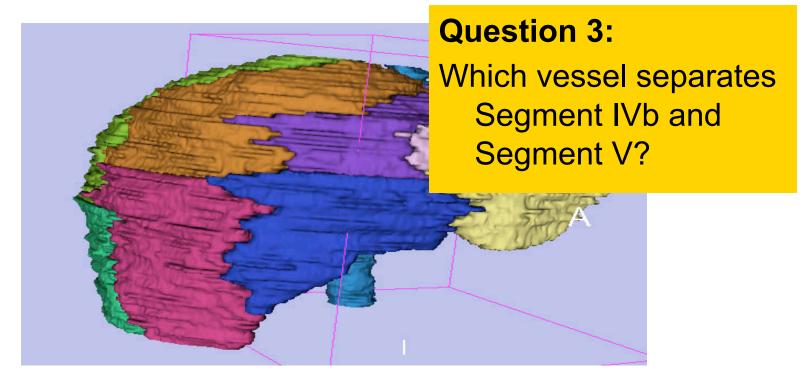
Which segment would most likely be affected by an aggressive tumor invading locally from the right adrenal gland ? Answer 2: <u>Segment VII</u>



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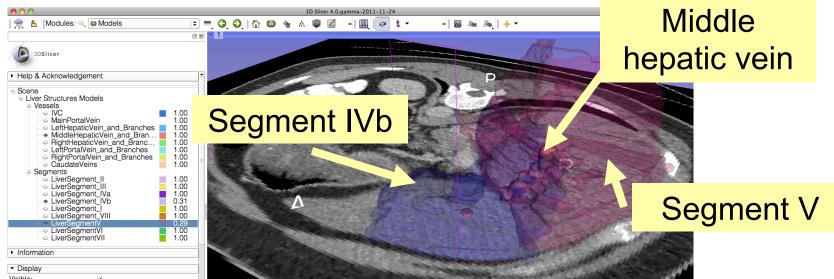
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### **Middle Hepatic Vein**



### **Question 3:**

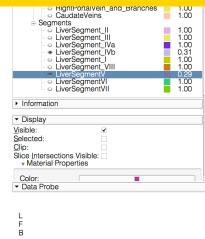
Which vessel separates Segment IVb and Segment V? Answer 3: <u>The middle hepatic vein</u>

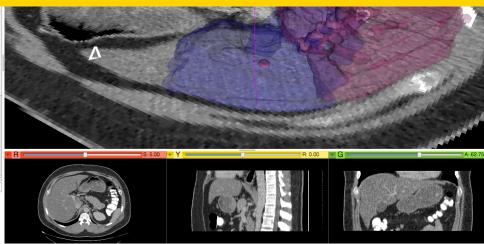


### **Closing the Liver Scene**

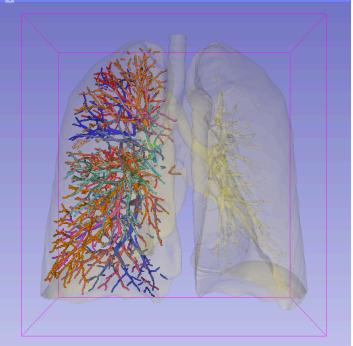


#### Select **Slicer** → **Exit** to close the Liver Scene and exit Slicer



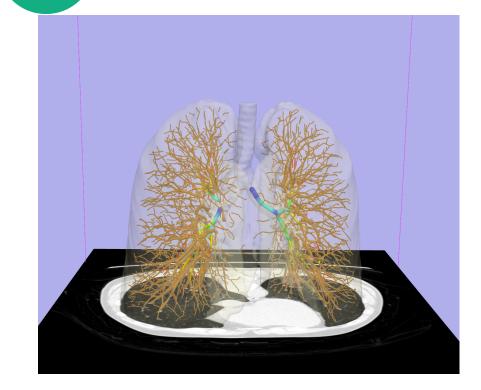






## Interactive 3D Visualization of the segments of the lungs

### Segments of the lung

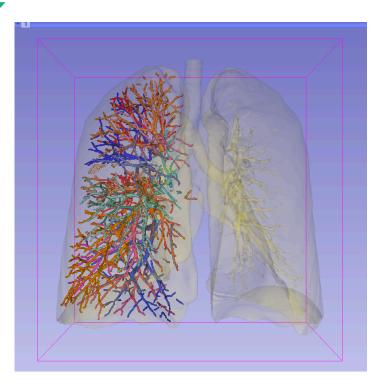


Segmentation and 3D surface reconstruction of the lung and pulmonary vessels

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

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Select the subdirectory dataset4\_Chest

Drag and drop the file LungSegments\_Scene.mrb into Slicer

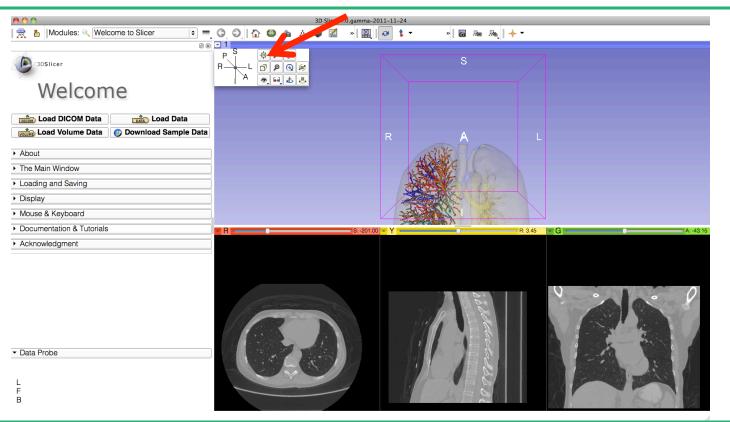
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#### Loading the Lung Scene



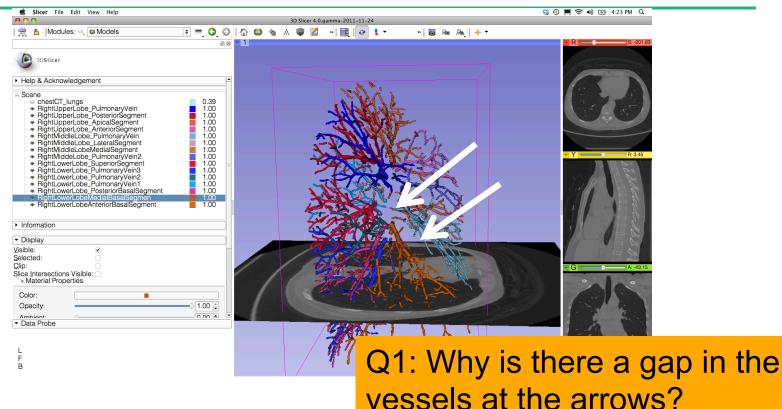
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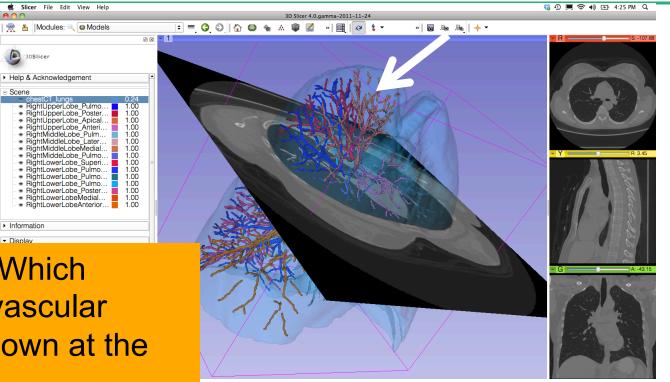


# Lung Segments

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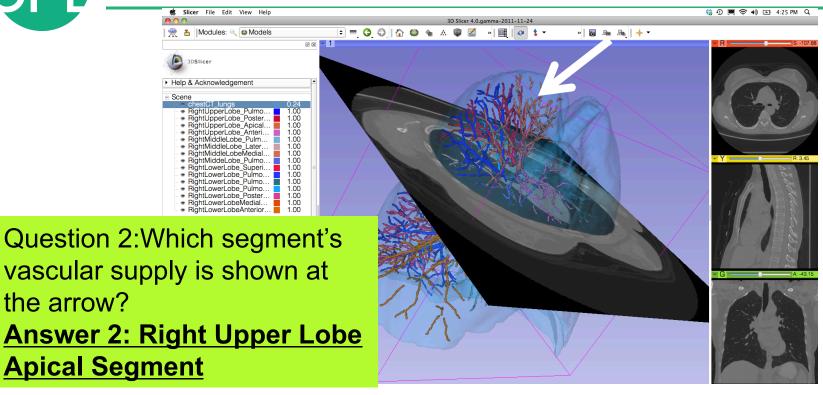


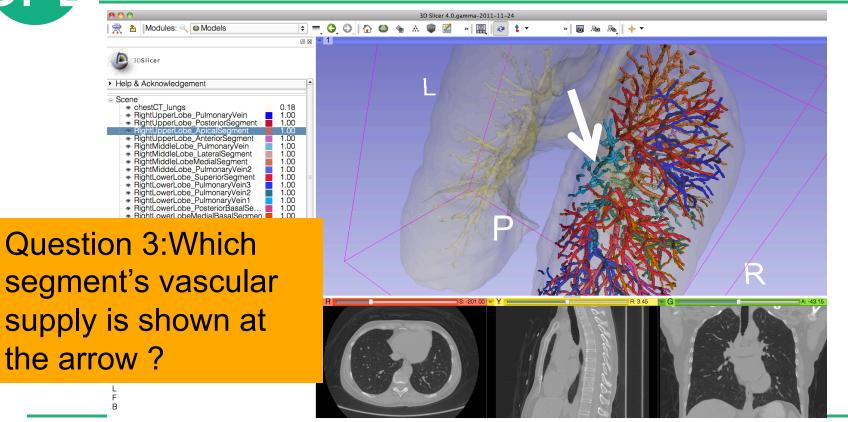
Slide 116



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

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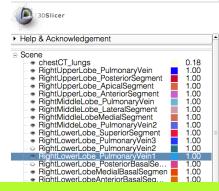
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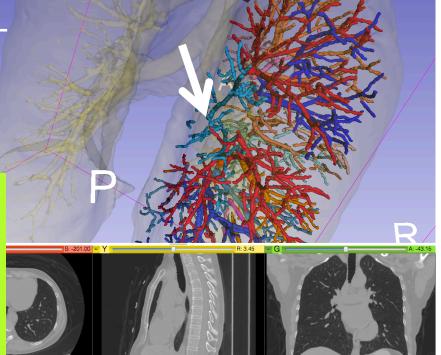


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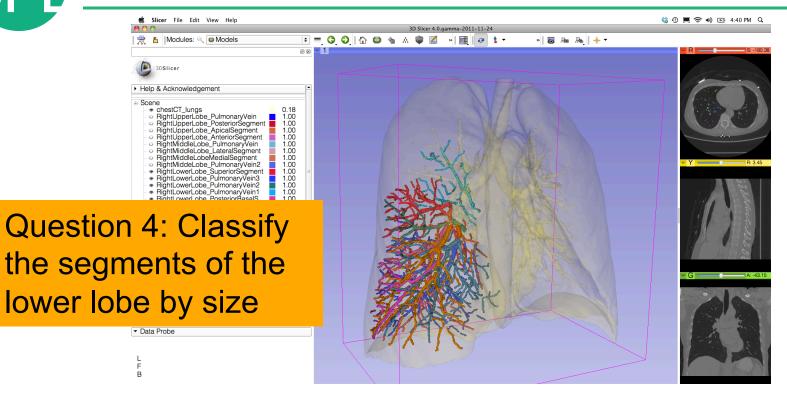
👷 皆 Modules: 🔍 🚳 Models

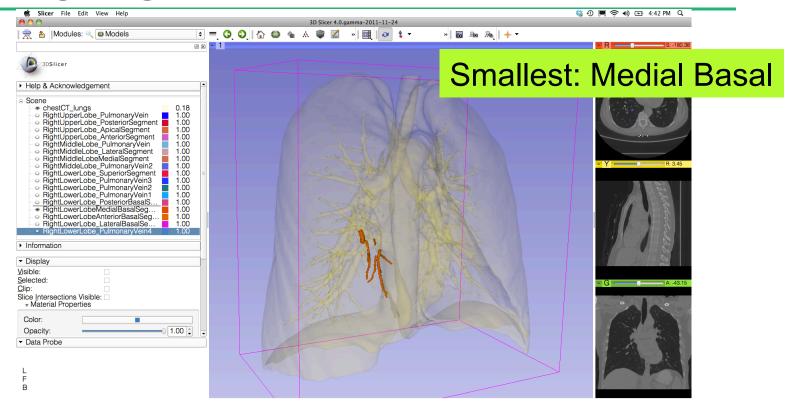


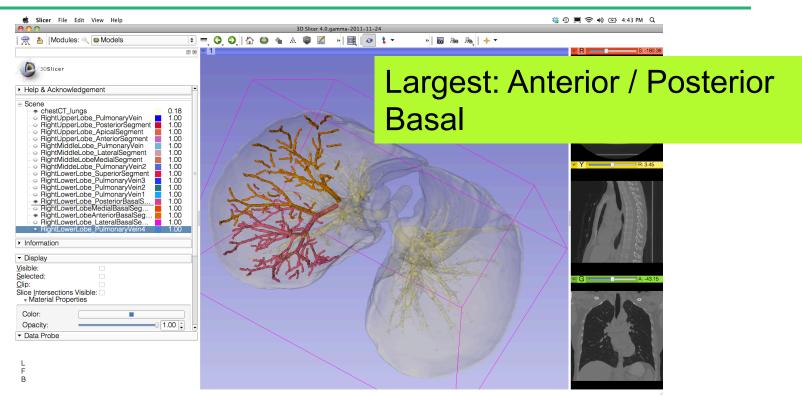
Question 3:Which segment's vascular supply is shown at the arrow? <u>Answer 3: Right Lower</u> Lobe Pulmonary Vein 1



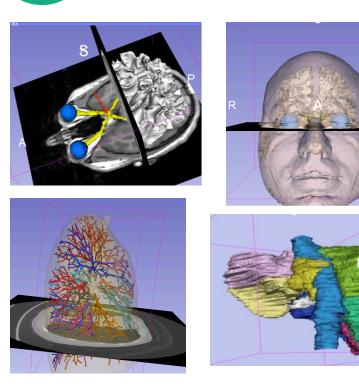
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## **3D Visualization of DICOM images**



- 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

#### **3DSlicer website**



## 3DSlicer at RSNA 2013

#### **Quantitative Imaging Reading Room Exhibit QIRR 1028**

- Sun. Dec.1-Fri. Dec.6, 8:00-6:00
- 3DSlicer: An Open Source Platform for Segmentation, Registration, Quantitative Imaging, and 3D Visualization of Multi-Modal Image Data.
- Sonia Pujol, PhD, Steve Pieper, PhD, Andriy Fedorov, PhD, Ron Kikinis, MD,



#### **Additional Related Hands-on courses**

All courses are in this Advanced Imaging Classroom: S401CD (except Monday when it is in S401AB)

Sunday 11:00 am – Quantitative Imaging for Medical Research and Practice

**Sunday 4:00 pm** – Structured Annotation and Image Markup (AIM) Template and Toolsets (ICIW12)

Monday 4:30 pm – Clinical Trials Software for Clinical Trials and Research (ICIW24)

Wed 10:30 am – Open Access Imaging Data Resources: NIH Cancer Imaging Archive (ICIA41)

Wed 12:30 pm – Correlating Imaging with Human Genomics (ICIA42)



#### **3DSlicer at RSNA**

#### Questions: spujol@bwh.harvard.edu



#### Acknowledgments

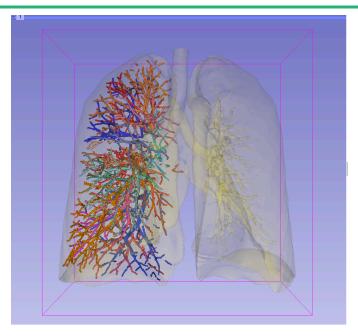
National Alliance for Medical Image Computing (NA-MIC) (NIH Grant U54EB005149)



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

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





www.slicer.org www.na-mic.org

Questions and comments: spujol@bwh.harvard.edu