



# Slicer DICOM Tutorial

Sonia Pujol, Ph.D.

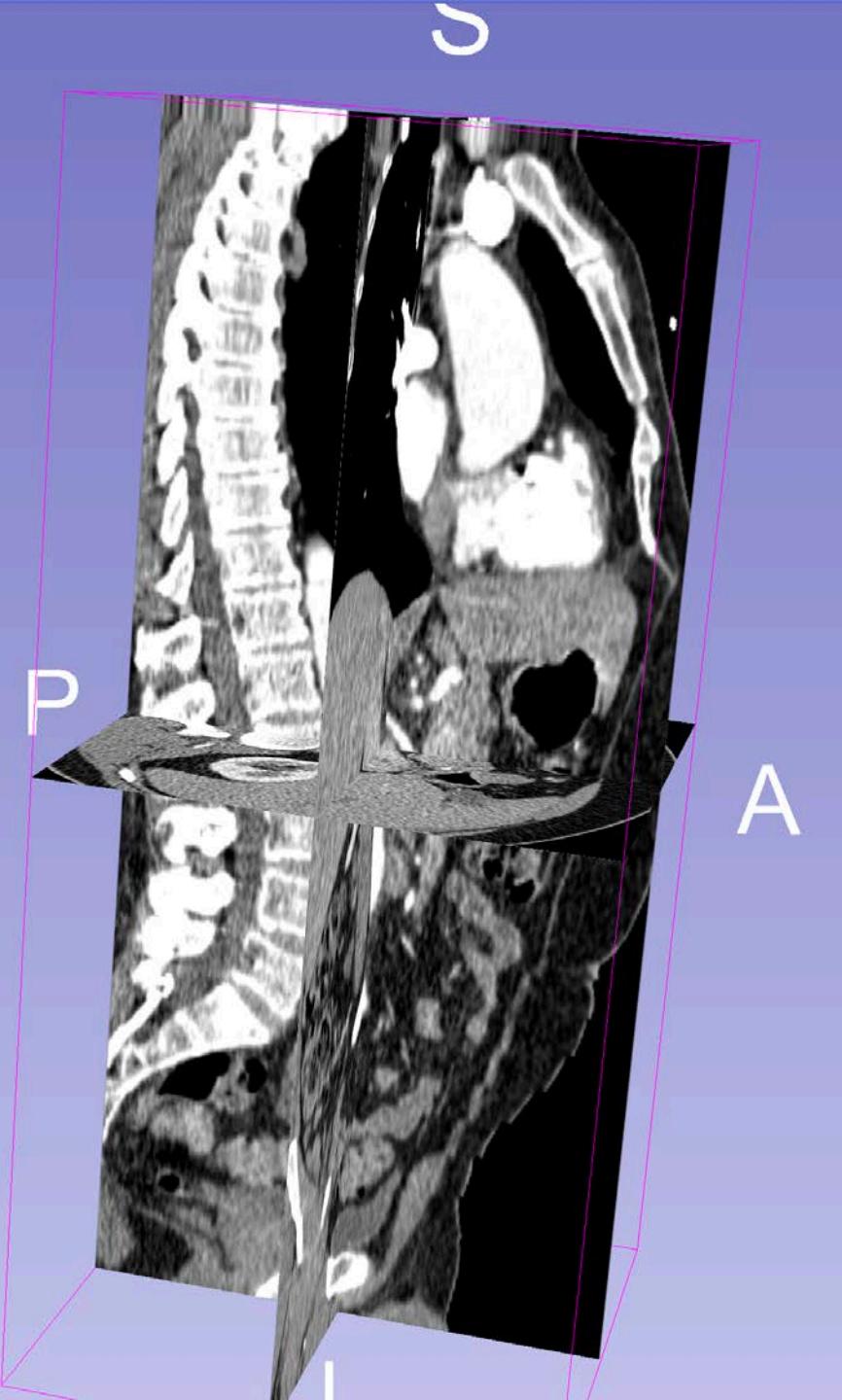
Assistant Professor of Radiology

Director of 3D Slicer Training & Education

Brigham and Women's Hospital

Harvard Medical School

[spujol@bwh.harvard.edu](mailto:spujol@bwh.harvard.edu)

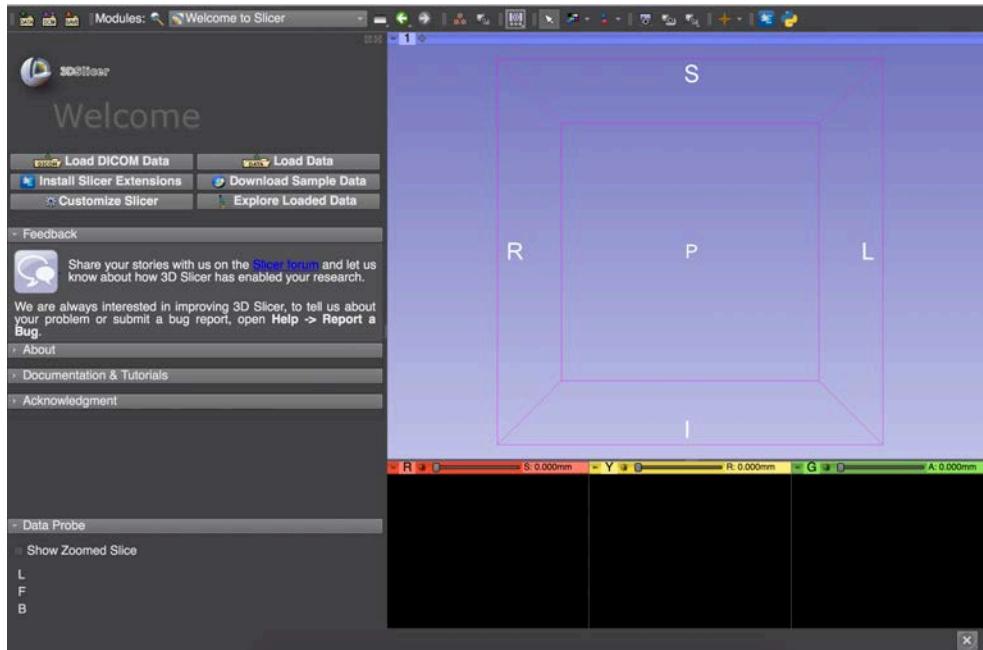


# Tutorial Objective

This tutorial provides a basic introduction to the DICOM standard, and shows how to visualize DICOM images in 3D Slicer version 5.0



# Tutorial materials



3D Slicer version 5.0



SlicerDICOMTutorialData:  
DICOM Torso CT



DICOM Breast MRI

# Disclaimer

- 3D Slicer is a free open source software application distributed under a BSD style license.
- The software is not FDA approved or CE-Marked, and is for research use only.

# Tutorial Outline



Part 1: Introduction to DICOM



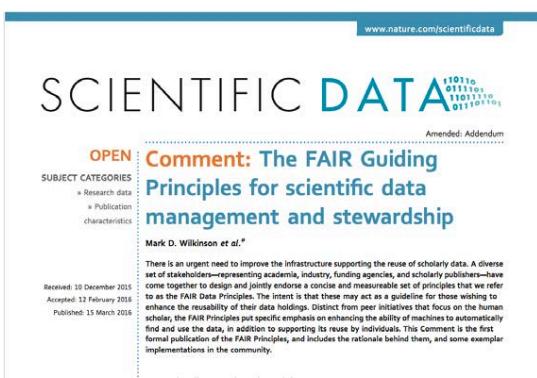
Part 2: Loading and Viewing DICOM data in  
Slicer 5



# Part1: Introduction to DICOM

# F.A.I.R. Principles

- **Findable:** Data are easily findable
- **Accessible:** Users know how to access the data can be accessed, possibly including authentication and authorization
- **Interoperable:** Data can be integrated with other data and can interoperate with applications for storage and analysis
- **Reusable:** Data can be replicated or combined for new research



*The FAIR Guiding Principles for scientific data management and stewardship. Wilkinson et al. Sci. Data 2016*  
<http://go-fair.org/fair-principles>

# The DICOM standard

- DICOM (Digital Imaging and Communications in Medicine) is the international standard for handling, storing, printing and transmitting medical imaging data.
- Clinical imaging equipment (CT scanners, MR scanners, X-Ray and ultrasound machines) generate DICOM files.



# DICOM History

- In 1982, the American College of Radiology (ACR) and the National Electrical Manufacturers Associations (NEMA) initiated standards for the interconnection of medical imaging devices
- In 1985, version 1.0 of the ACR-NEMA Digital Imaging and Communications Standards was published
- ACR-NEMA Standards version 2.0 was published in 1988
- In 1993, version 3.0 of the ACR-NEMA Standard also referred to as DICOM (Digital Imaging and Communication in Medicine) was published (living standard with multiple release per year)
- 2020/07/06, DICOM PS3 2020c ~ 4,000 pages

[dicomstandard.org/current](http://dicomstandard.org/current)

# FAIR Data and the DICOM Standard

www.nature.com/scientificdata

## SCIENTIFIC DATA

**OPEN**

**SUBJECT CATEGORIES**

- » Research data
- » Publication characteristics

Amended: Addendum

### Comment: The FAIR Guiding Principles for scientific data management and stewardship

Mark D. Wilkinson et al.\*

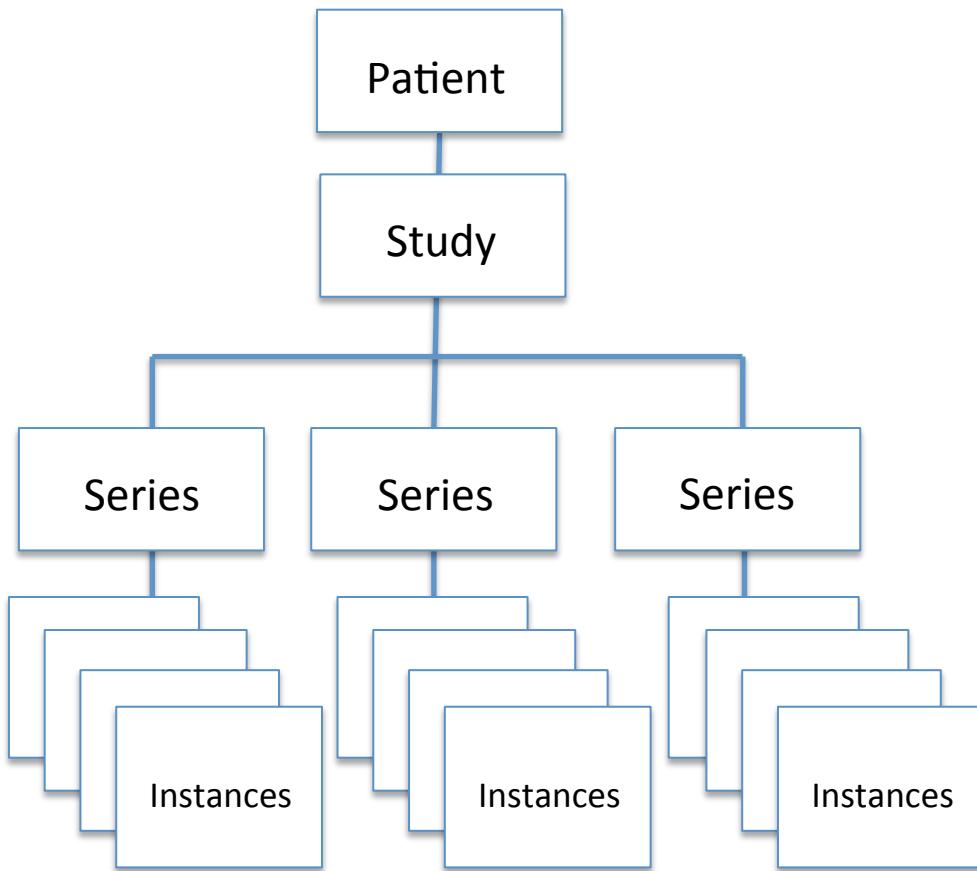
Received: 10 December 2015  
Accepted: 12 February 2016  
Published: 15 March 2016

There is an urgent need to improve the infrastructure supporting the reuse of scholarly data. A diverse set of stakeholders—representing academia, industry, funding agencies, and scholarly publishers—have come together to design and jointly endorse a concise and measurable set of principles that we refer to as the FAIR Data Principles. The intent is that these may act as a guideline for those wishing to enhance the reusability of their data holdings. Distinct from peer initiatives that focus on the human scholar, the FAIR Principles put specific emphasis on enhancing the ability of machines to automatically find and use the data, in addition to supporting its reuse by individuals. This Comment is the first formal publication of the FAIR Principles, and includes the rationale behind them, and some exemplar implementations in the community.



The DICOM Standard facilitates compliance of imaging data with FAIR principles

# DICOM Data Model



In the DICOM data model, a **DICOM Study** consists of several **DICOM Series**, and each DICOM Series contains **DICOM Instances**

Each of the DICOM Studies, Series and Instances are assigned a Unique Identifier (UID)

# DICOM MRI Image Data

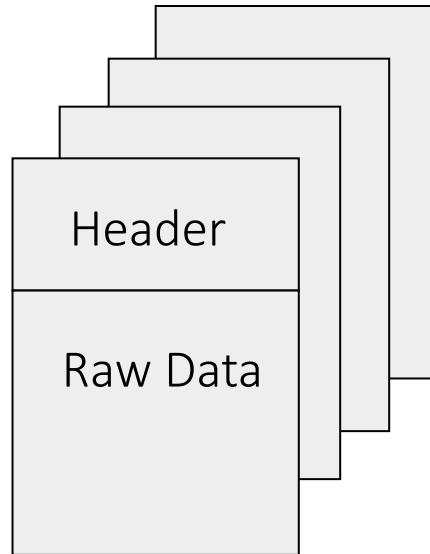
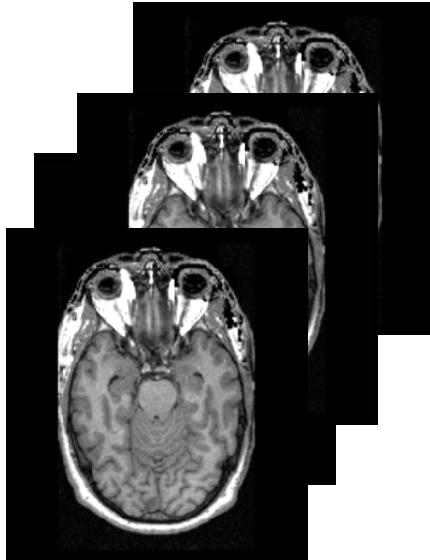


Image001.dcm

Image002.dcm

Image003.dcm

....

An MRI image is an example of DICOM Instance that consists of a **DICOM header** and an **image dataset**

```
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...  
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0008,0090,Referring Physician's Name=1852796513  
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0008,0201,?=0500  
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0008,103E,Series Description=anon  
0008,1040,Institutional Dept. Name=1852796513  
0008,1050,Performing Physician's Name=1852796513  
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0008,1070,Operator's Name=anon  
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0028,0103,Pixel Representation=1  
.....  
7FE0,0010,Pixel Data=131072
```

The DICOM header contains metadata information on the patient, study and imaging data.

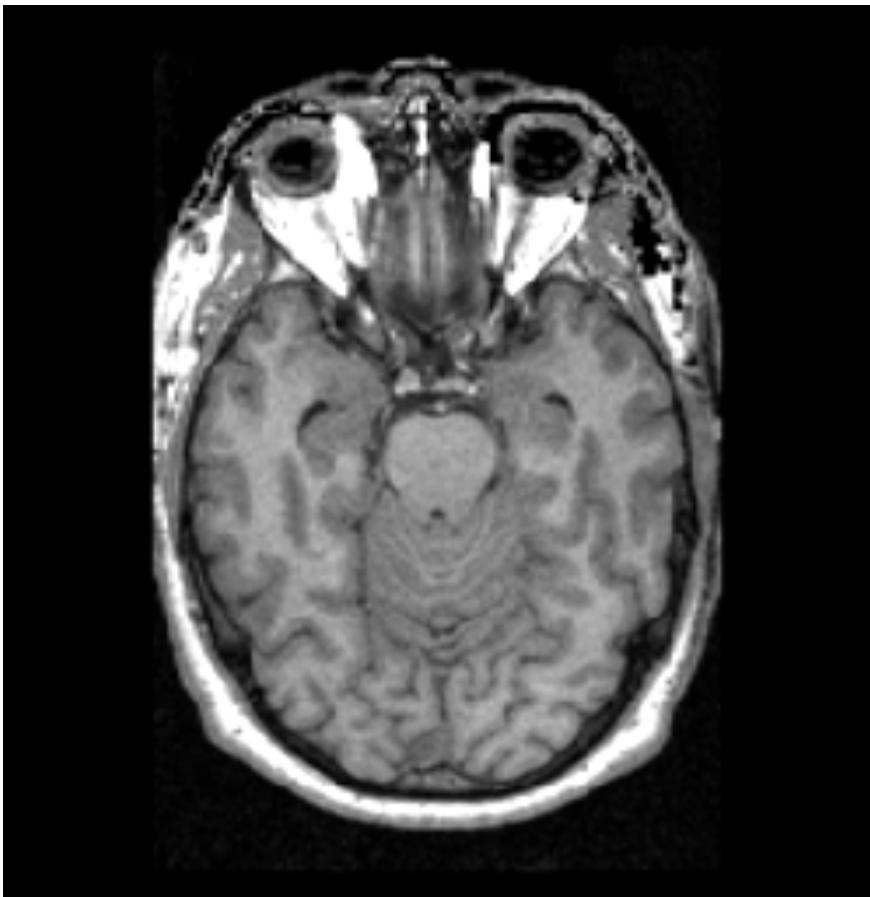
Original data from the scanner tell users important elements about the acquisition

The metadata information is accessible through DICOM tags

DICOM tags uniquely identify DICOM attributes

Example of DICOM header content

# DICOM Header Content



## Physician and Study information

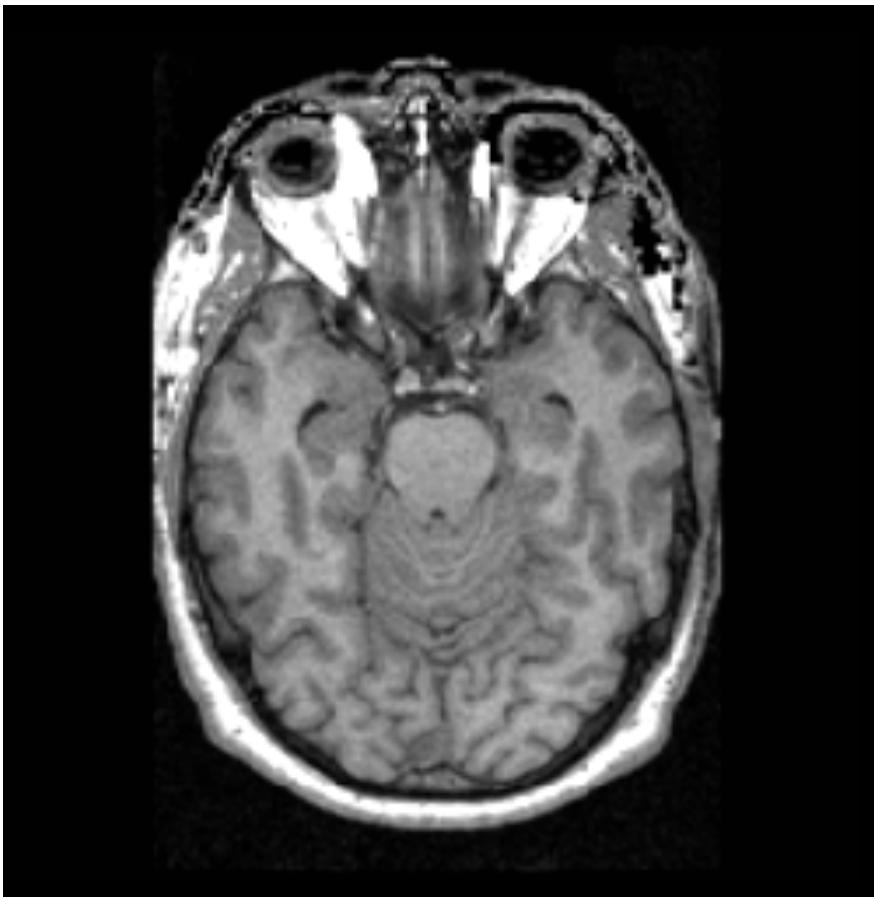
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0008,0201,?=0500  
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0008,1090,Manufacturer's Model Name=GENESIS.SIGMA .....

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0010,0030,Patient Date of Birth=00000000  
0010,0032,Patient Birth Time=000000  
0010,0040,Patient Sex=O  
0010,1010,Patient Age=000Y  
.....

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.....  
, FE0,0010,Pixel Data=131072

# DICOM Header Content



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```

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0008,1070,Operator's Name=anon  
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```
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```

```
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0028,0101,Bits Stored=16  
^028,0102,High Bit=15  
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.....  
. FE0,0010,Pixel Data=131072
```

Patient information



# HIPPA Patient privacy

The Health Insurance Portability and Accountability Act of 1996 (HIPAA) protects the privacy and security of certain health information

<http://www.hhs.gov/hipaa/index.html>

0002,0000,File Meta Elements Group Len=148  
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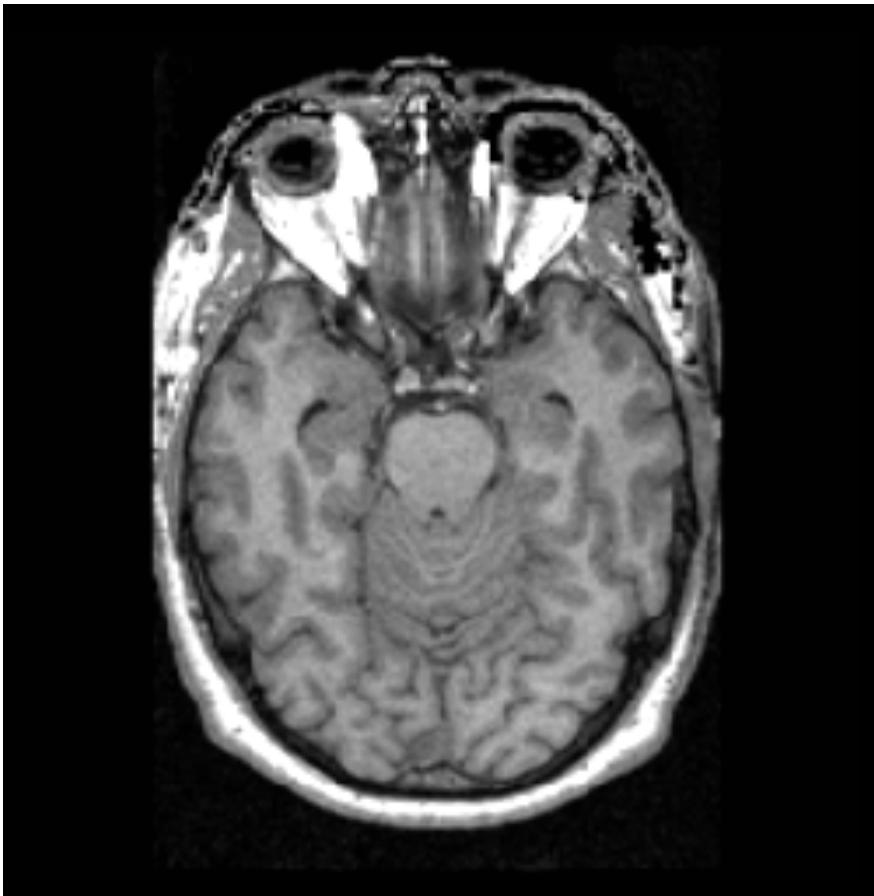
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.....  
7FE0,0010,Pixel Data=131072

Anonymized patient information



# DICOM Header Content



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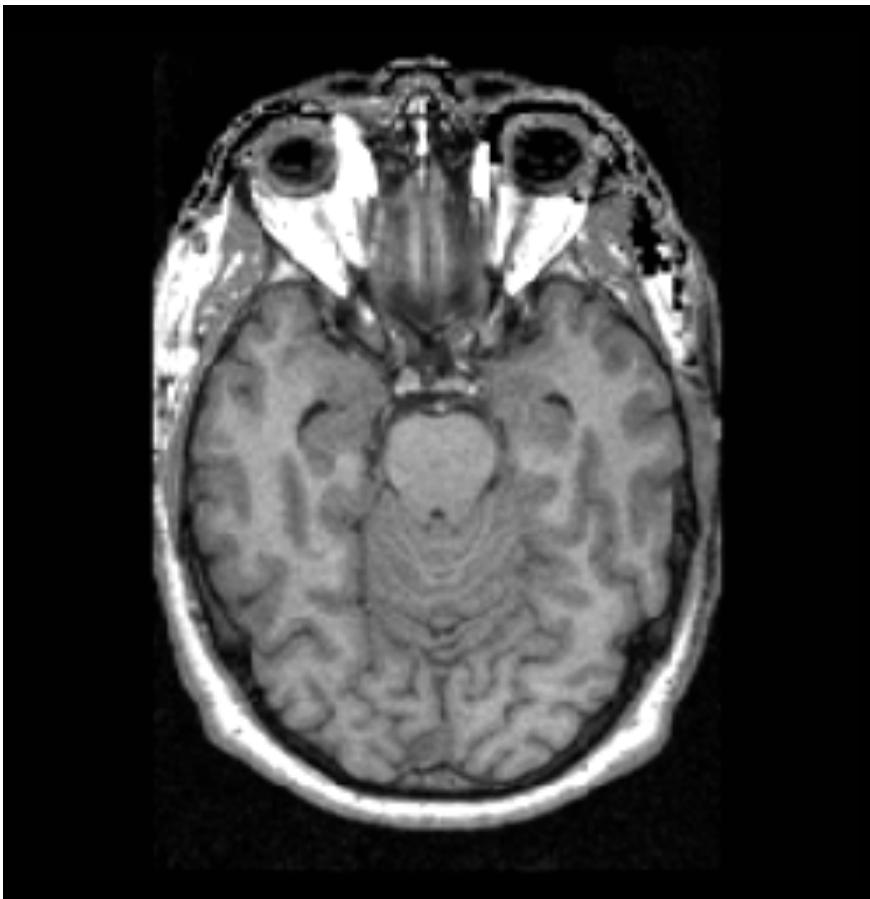
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**Image information**

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.....  
7FE0,0010,Pixel Data=131072

# DICOM Header Content



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```

```
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0008,1010,Station Name=1852796513  
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```

**Pixel Data**

```
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```

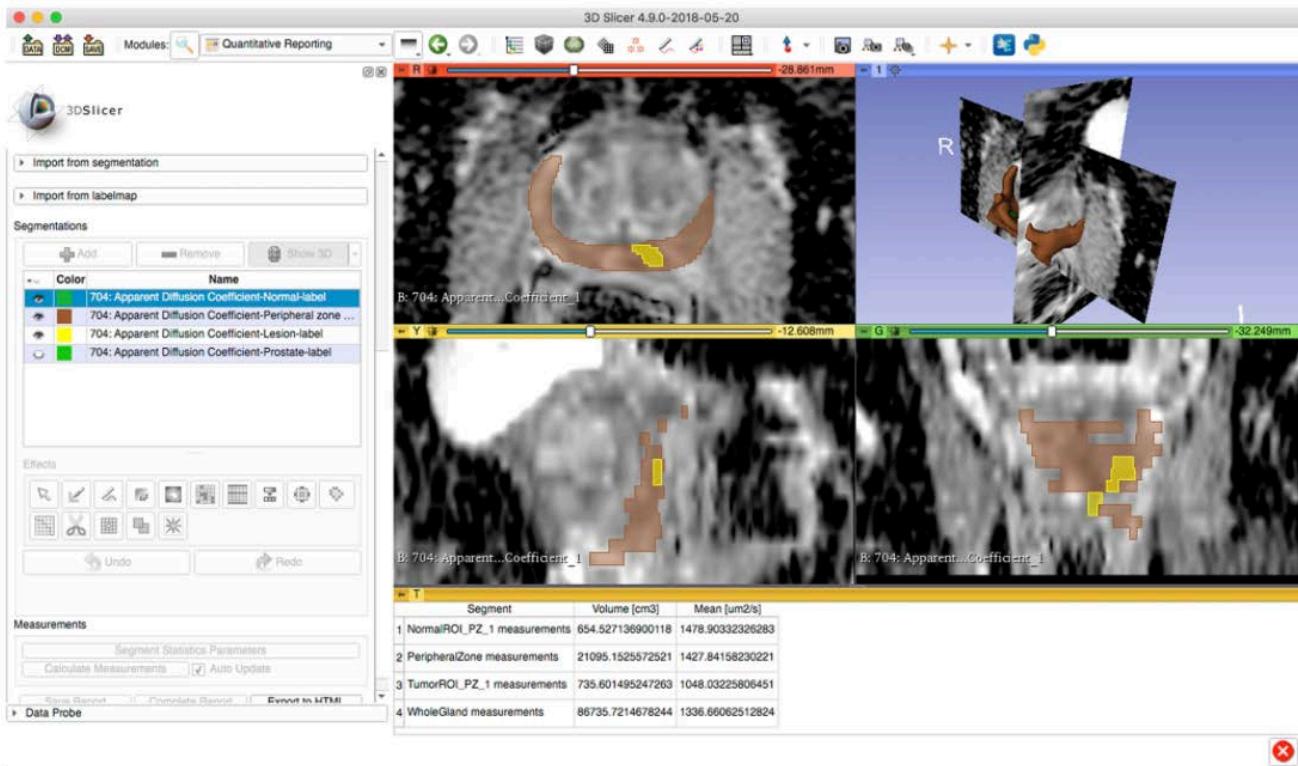


# Standard DICOM Instances

Standard DICOM Instances can consist of:

- **images** produced by the imaging equipment:  
DICOM MRI or DICOM CT images
- **voxels labeled** in regions of interest:  
DICOM Segmentation Image (SEG)
- **measurements** derived from the segmented  
ROIs: DICOM Structure Report (SR)

# Examples of Standard DICOM Instances



Images:

DICOM Prostate MRI data

## Segmented Structures

Segmented structure	SegmentedPropertyCategoryCodeSequence	SegmentedPropertyTypeCodeSequence	AnatomicRegionSequence
Prostate gland	(“T-D000A”, “SRT”, “Anatomical Structure”)	(“T-9200B”, “SRT”, “Prostate”)	NA
Peripheral zone of the prostate gland	(“T-D000A”, “SRT”, “Anatomical Structure”)	(“T-D05E4”, “SRT”, “Peripheral zone of the prostate”)	NA
Lesion in the peripheral zone of the prostate gland	(“M-0100”, “SRT”, “Morphologically Altered Structure”)	(“M-0110”, “SRT”, “Lesion”)	(“T-D05E4”, “SRT”, “Peripheral zone of the prostate”)
Normal tissue in the peripheral zone of the prostate gland	(“T-D0050”, “SRT”, “Tissue”)	(“G-A460”, “SRT”, “Normal”)	(“T-D05E4”, “SRT”, “Peripheral zone of the prostate”)

Measured structure	Finding	Finding Site
Prostate gland *	(T-F6078, SRT, “Entire Gland”)	(“T-9200B”, “SRT”, “Prostate”)
Peripheral zone of the prostate gland	(R-404A4, SRT, “Entire”)	(“T-D05E4”, “SRT”, “Peripheral zone of the prostate”)
Lesion in the peripheral zone of the prostate gland	(R-42037, SRT, “Abnormal”)	(“T-D05E4”, “SRT”, “Peripheral zone of the prostate”)
Normal tissue of peripheral zone of the prostate gland	(“G-A460”, “SRT”, “Normal”)	(“T-D05E4”, “SRT”, “Peripheral zone of the prostate”)

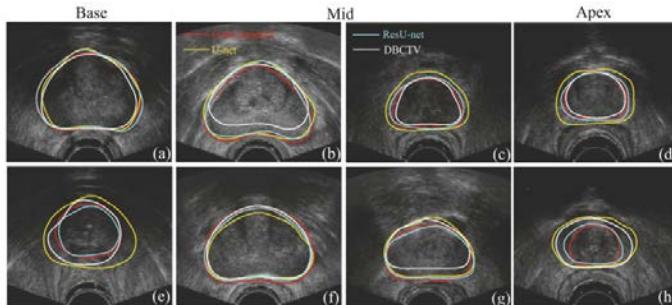
## Measurements

Volumes of prostate Gland, Peripheral Zone, Lesion, Normal Tissue

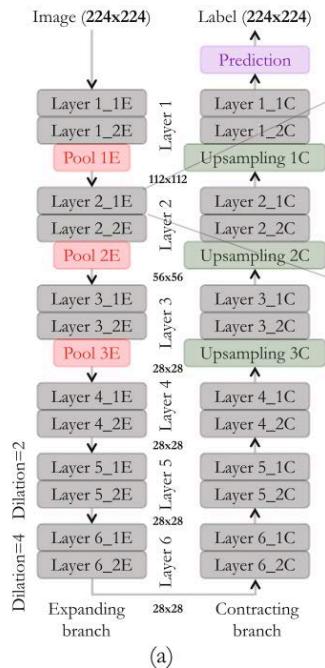
# DICOM Terminology

- DICOM provides support for annotation and segmentation objects
- DICOM Structured Reports enable provenance tracking
- DICOM derived data can be stored on a DICOM server or on other archive (e.g. TCIA) with permission and is compliant with FAIR principles

# DICOM for AI studies



DICOM defines **syntax rules** and **vocabularies** that enable easy extraction of knowledge from the data

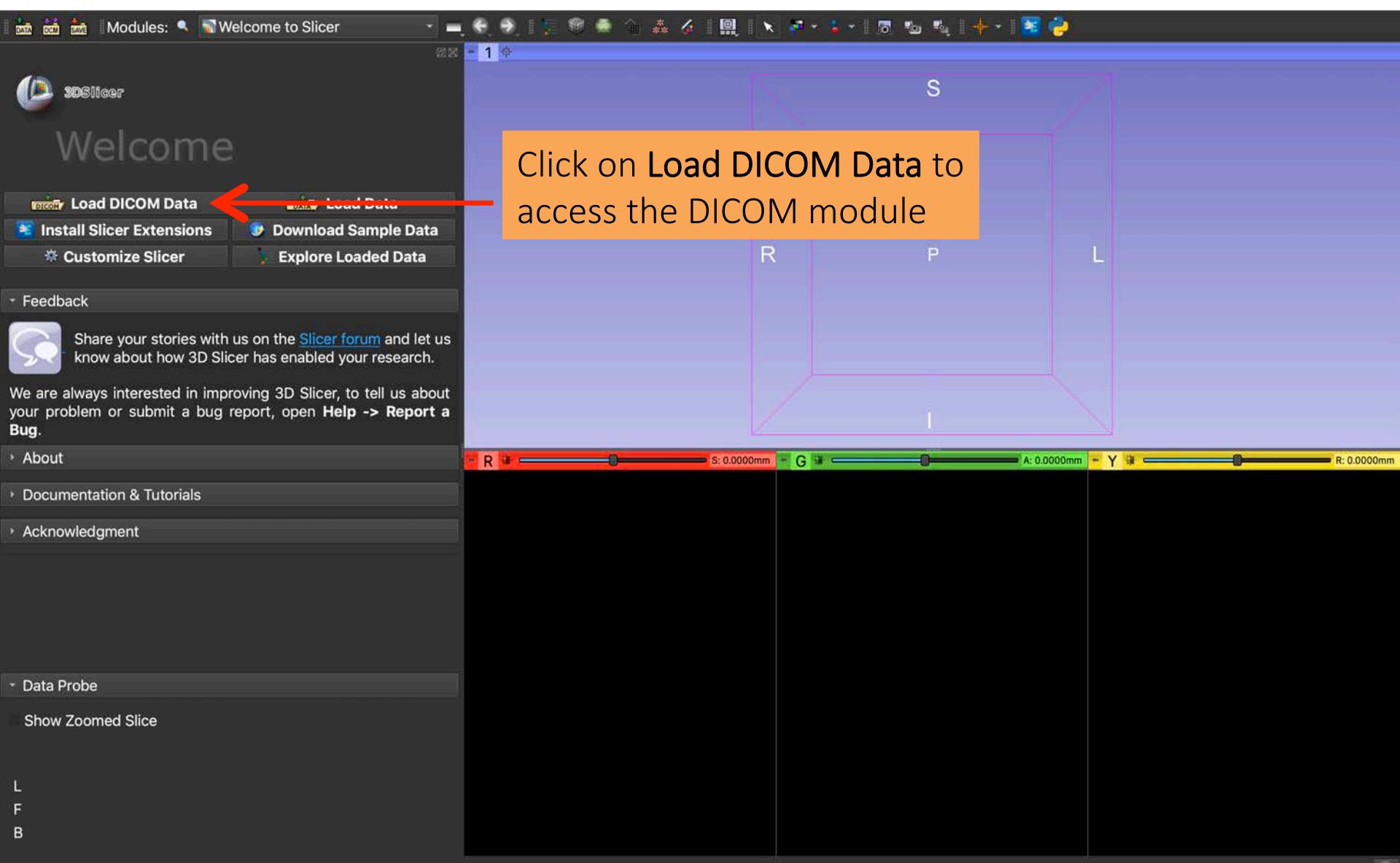


The DICOM framework for medical imaging data management enables the automation of cohort formation and maximizes the interoperability of the data for AI studies



## Part 2: Loading and Viewing DICOM data in Slicer 5

# DICOM Module



# DICOM Module

The DICOM database follows the DICOM model hierarchy organized in patients, studies and series

**Patients**

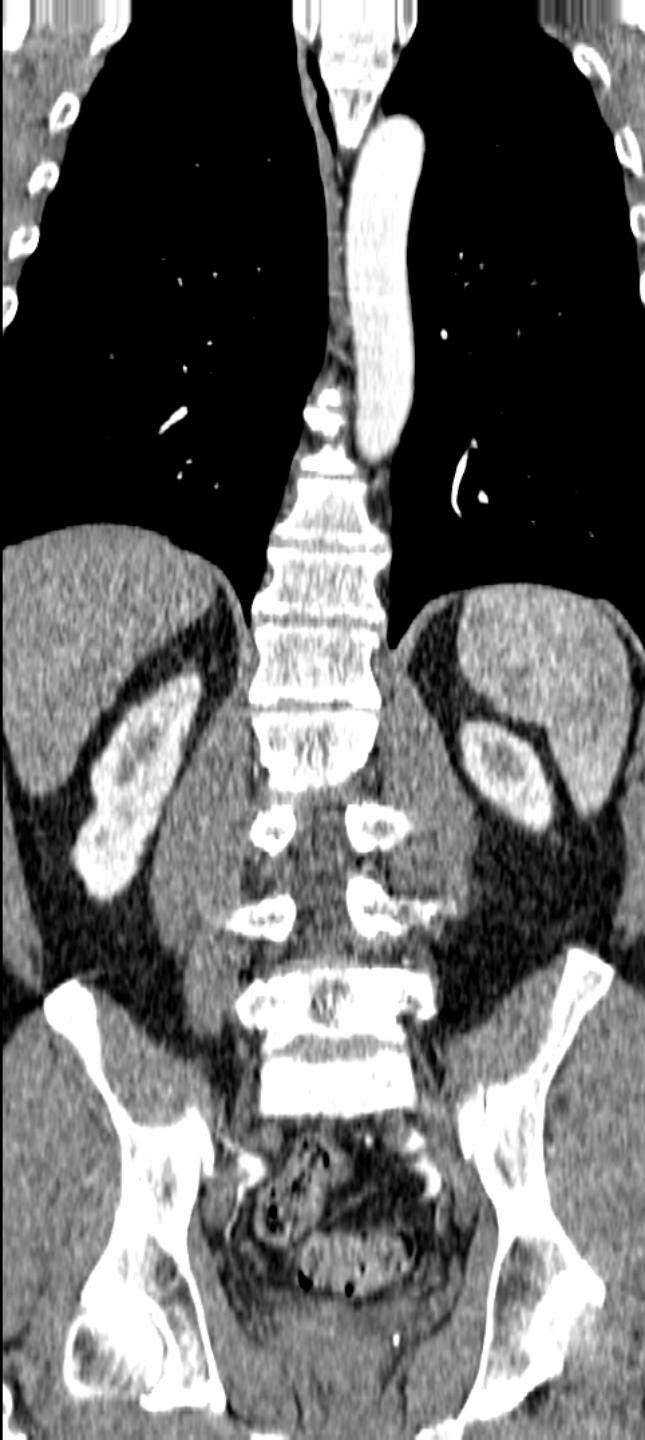
**Studies**

**Series**

DICOM Data Reader      Warnings

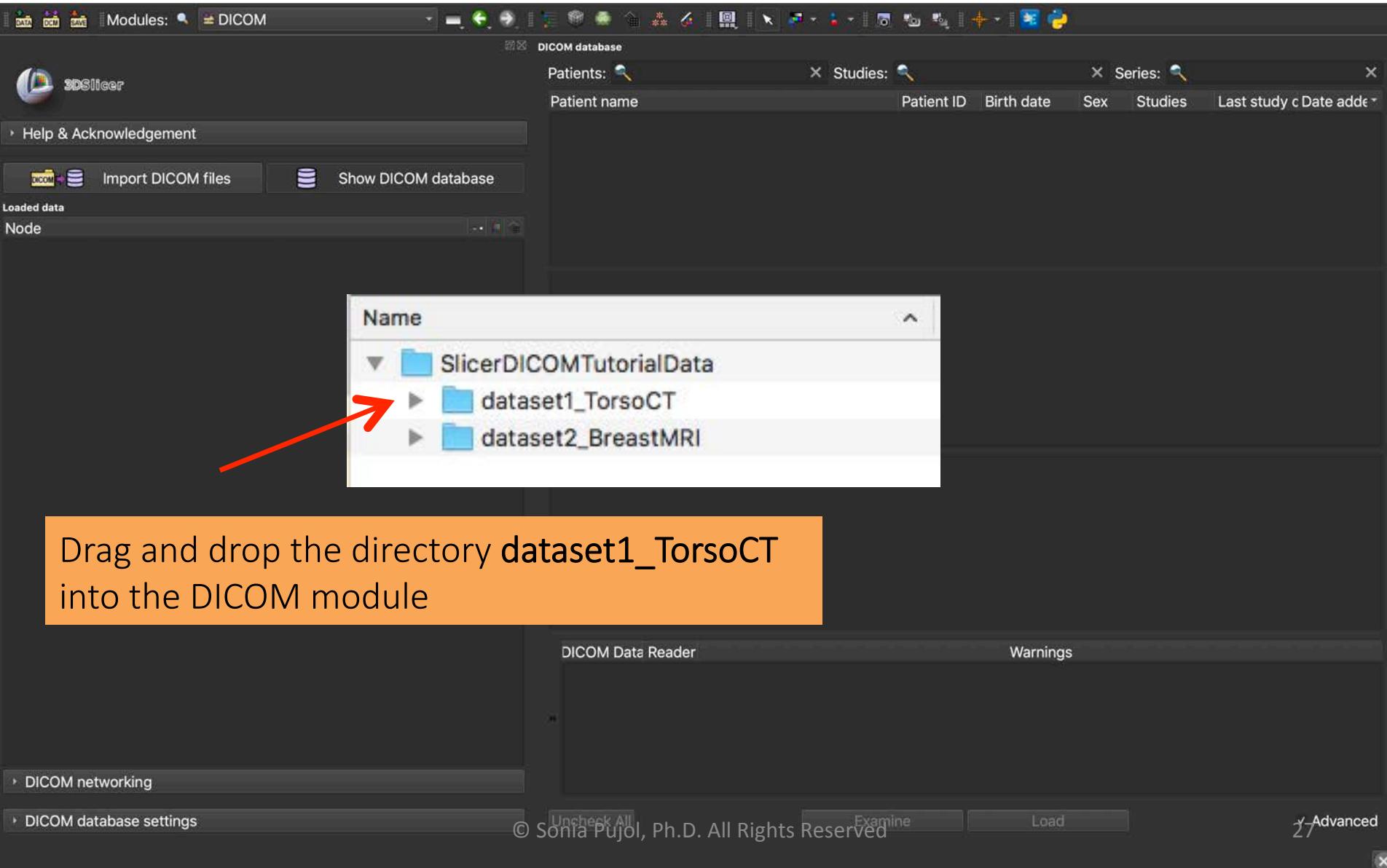
Uncheck All      Examine      Load

Advanced



Dataset #1  
Torso CT

# Loading a DICOM volume



# Loading a DICOM volume

Click on patient1 in the list of patients

Slicer displays the corresponding study and series

DICOM database

Patient name	Patient ID	Birth date	Sex	Studies	Last study	Date added
patient1	patient1_ID			1	Wed Jun 1 2005	2020...953

Study date	Study ID	Study description	Series	Date added
20050601	6936864	CT Thorax Abdomen	1	2020...953

Series #	Series description	Modality	Size	Count	Date added
6	CT_Thorax_Abdomen	CT	512x512	291	2020...953

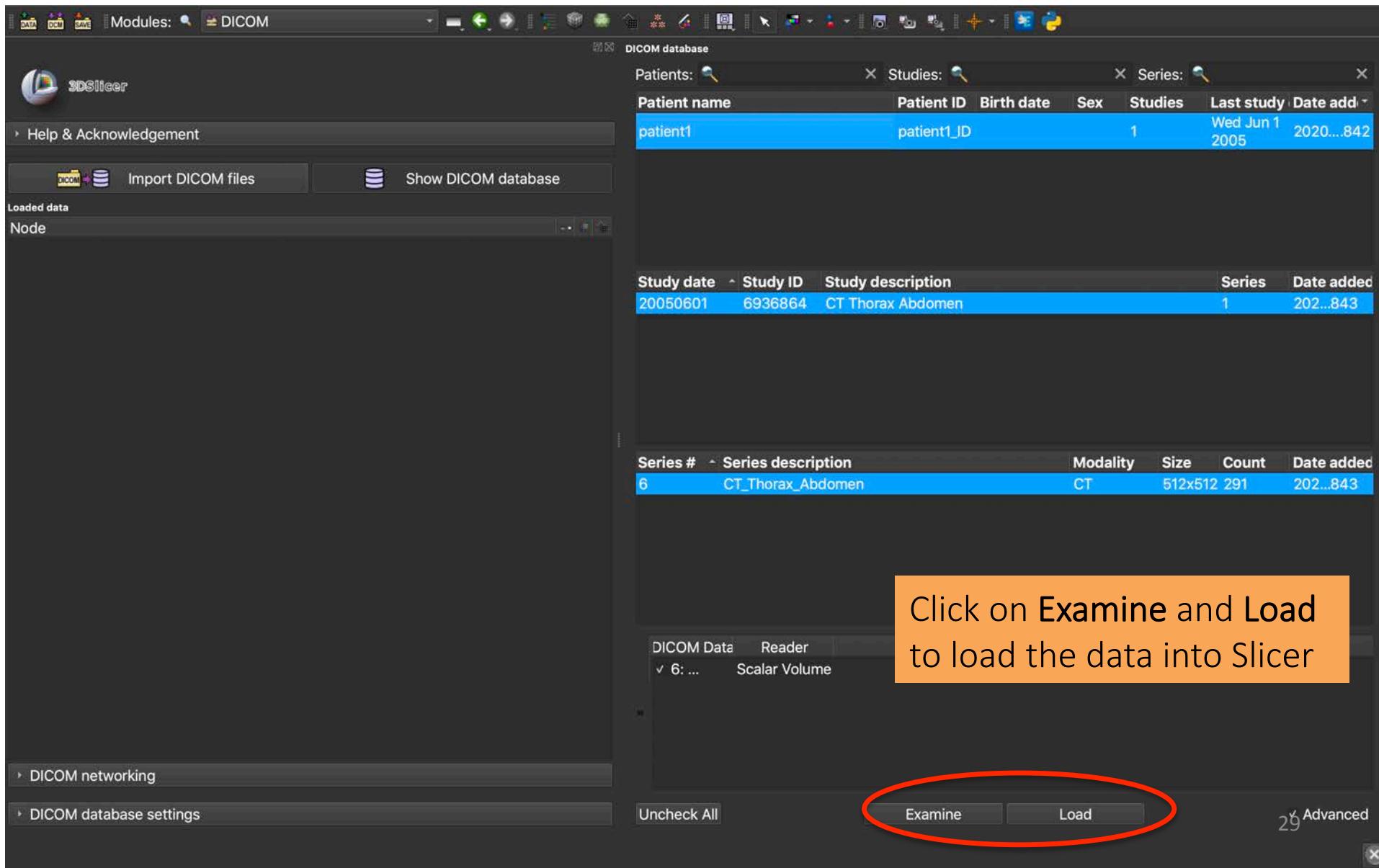
DICOM networking

DICOM database settings

Load

Advanced

# Loading a DICOM volume



# Loading a DICOM volume

The screenshot shows the 3DSlicer application interface with the DICOM module selected. The main window displays a DICOM database with one patient entry:

Patient name	Patient ID	Birth date	Sex	Studies	Last study	Date added
patient1	patient1_ID			1	Wed Jun 1 2020...842	2005

Below the database, two tables show study and series details:

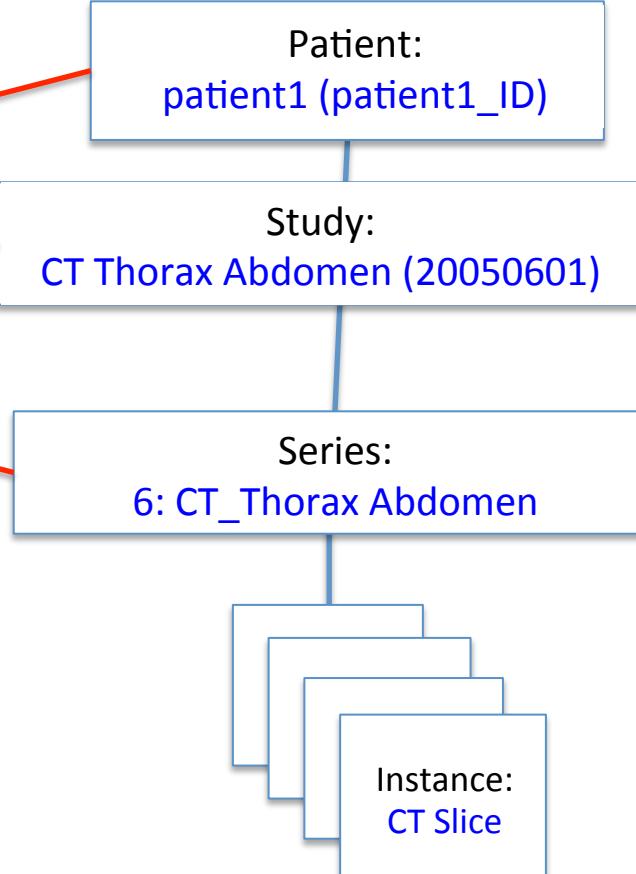
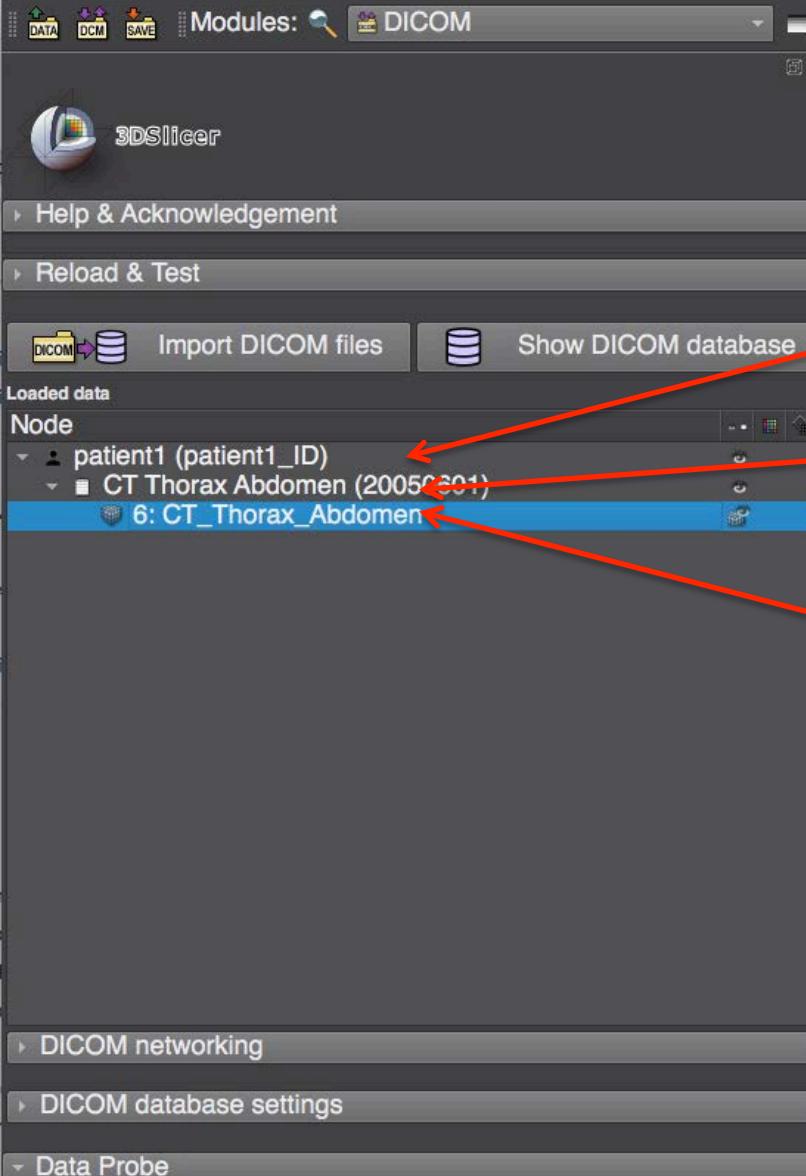
Study date	Study ID	Study description	Series	Date added
20050601	6936864	CT Thorax Abdomen	1	202..843

Series #	Series description	Modality	Size	Count	Date added
6	CT_Thorax_Abdomen	CT	512x512	291	202..843

A callout box highlights the following text:

Slicer displays the axial, coronal and sagittal images of the Torso CT dataset

At the bottom of the interface, there are tabs for DICOM Data, Reader, and Warnings, along with buttons for Examine, Load, and Advanced.



DICOM data are loaded into Slicer as a patient-study-series DICOM hierarchy

# Loading a DICOM volume

Click on the Slicer GUI icon to display list of Slicer layouts and select Conventional

DICOM database

patients: patient1

Patient name: patient1

Study date: 20050601

Series #:

6

DICOM

Modality: CT

Size: 512x512

Count: 291

Date added: 2020...273

Warnings

Examine Load

DATA DCM GAME Modules: DICOM

3DSlicer

Help & Acknowledgement

Import DICOM files Show DICOM database

Loaded data

Node

- patient1 (patient1)

- CT Thorax A

- 6: CT\_Tho

DICOM networking

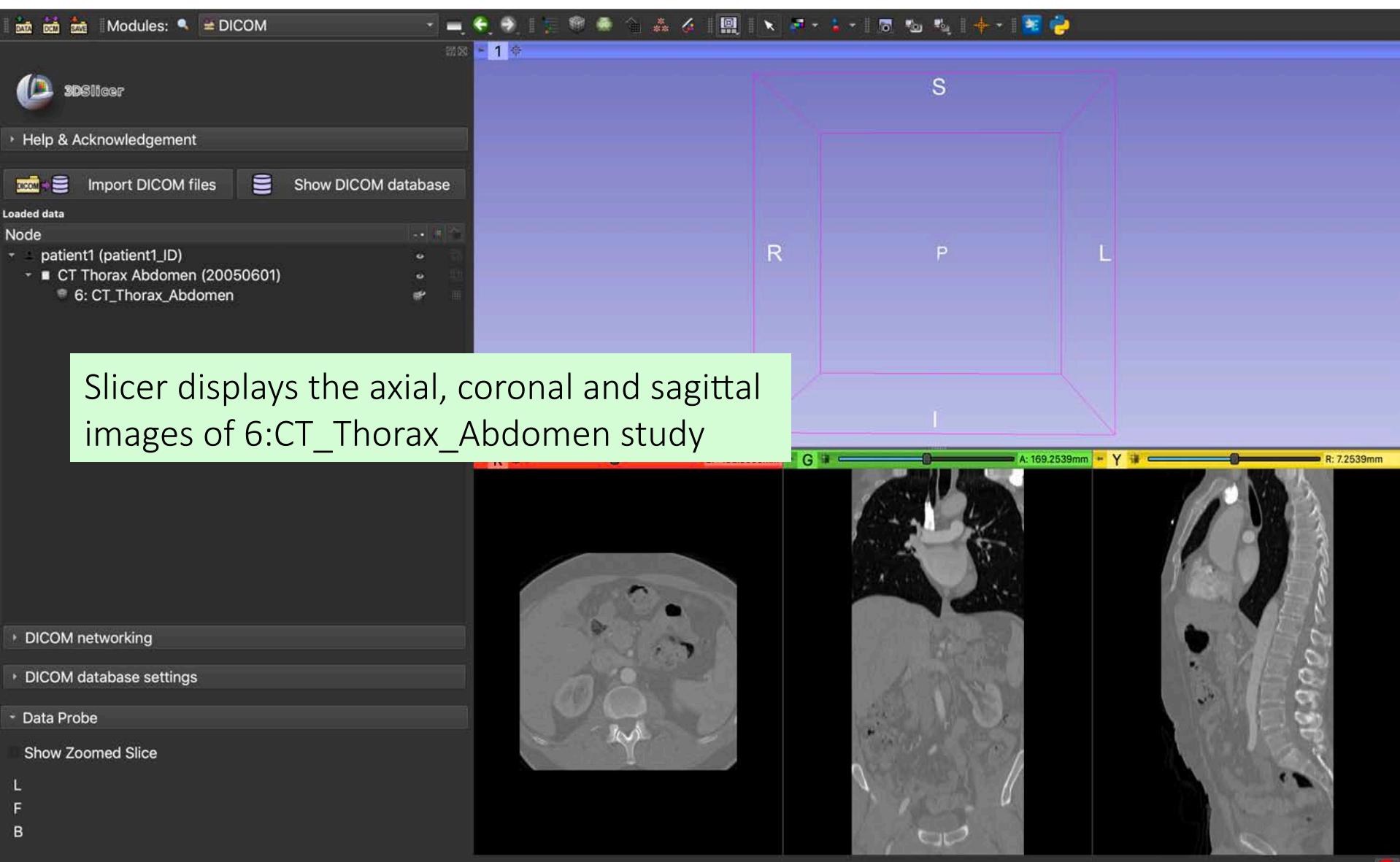
DICOM database settings

© Sonia Pujol, Ph.D. All Rights Reserved

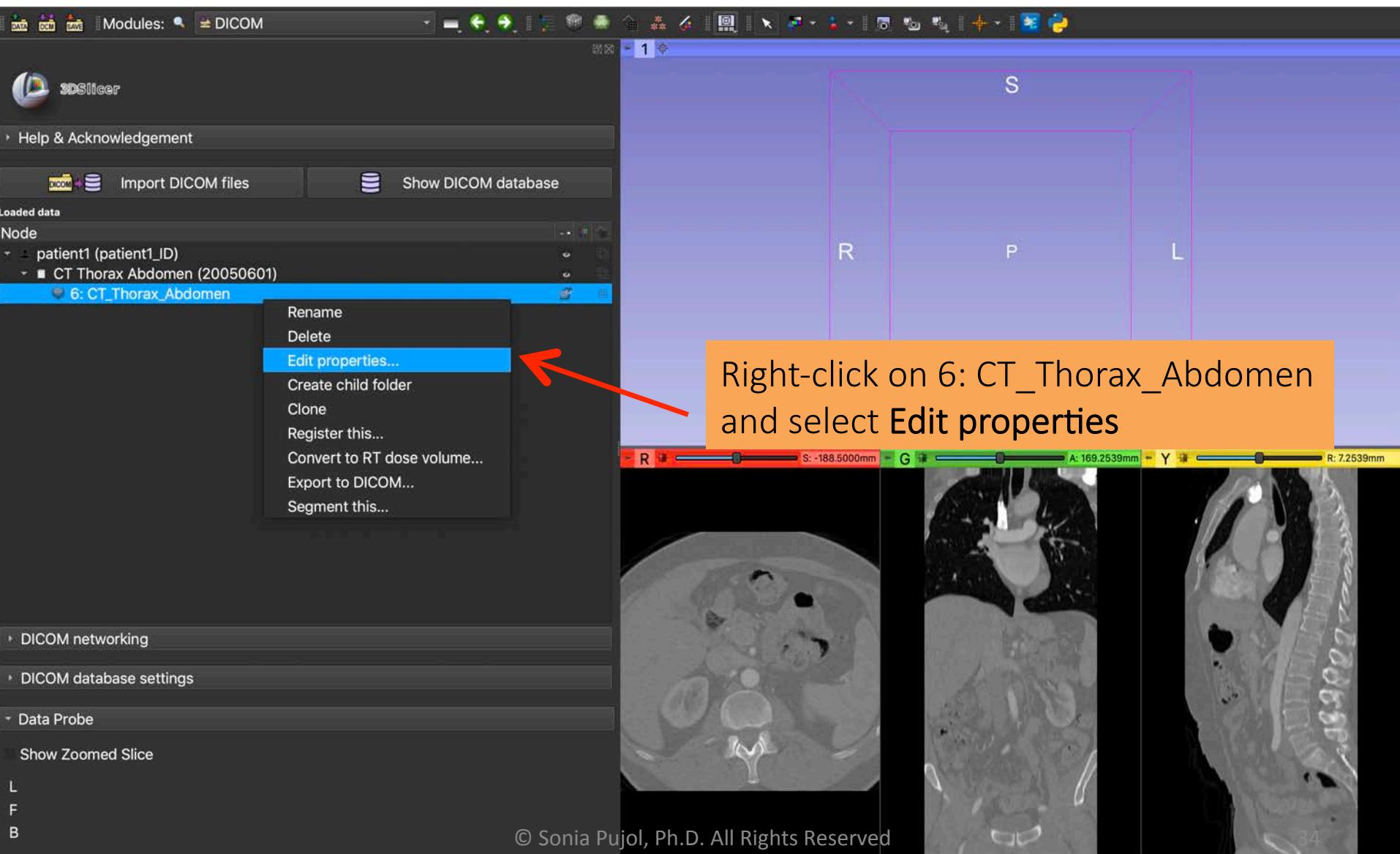
Uncheck All

32 Advanced

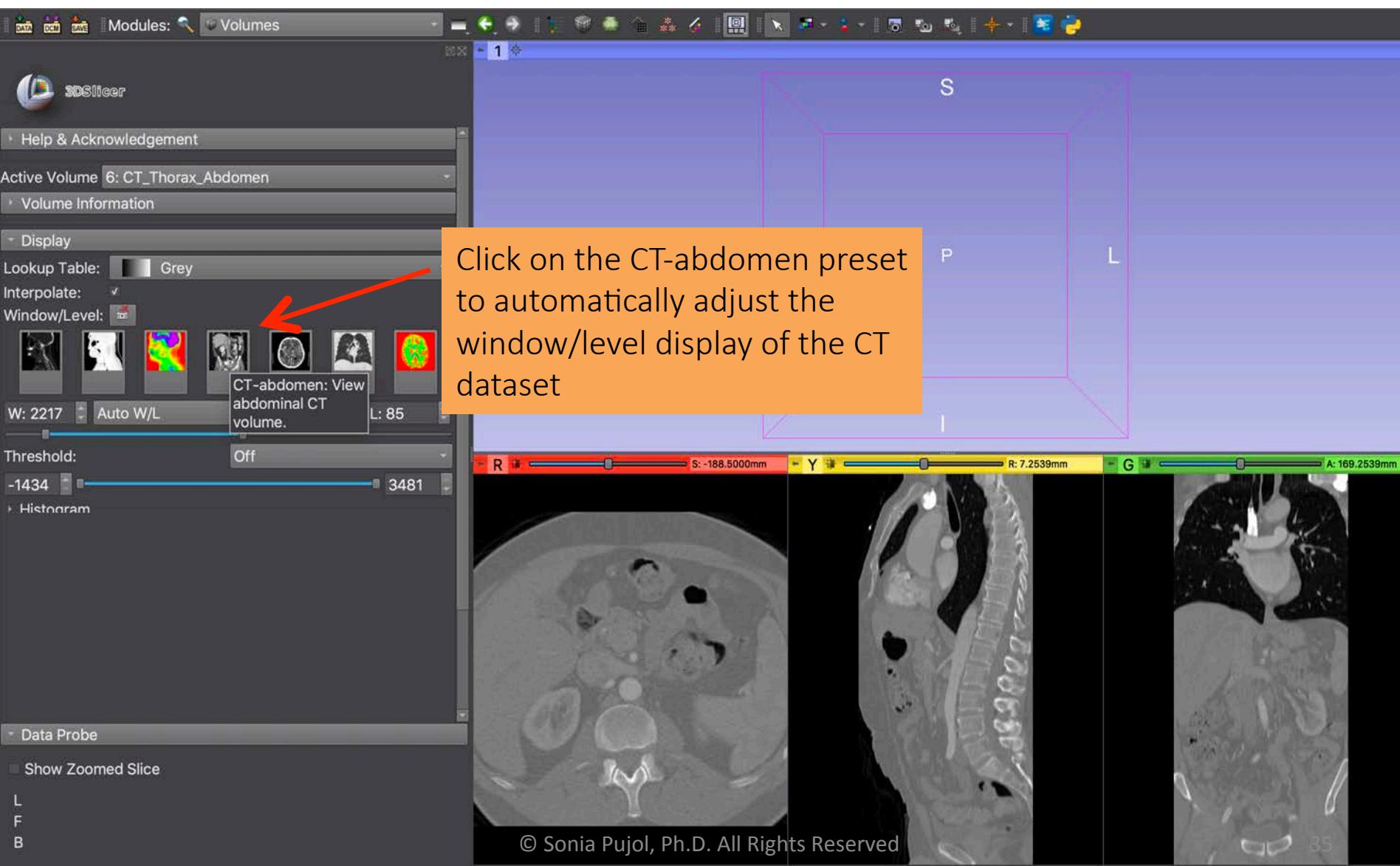
# Visualizing DICOM images



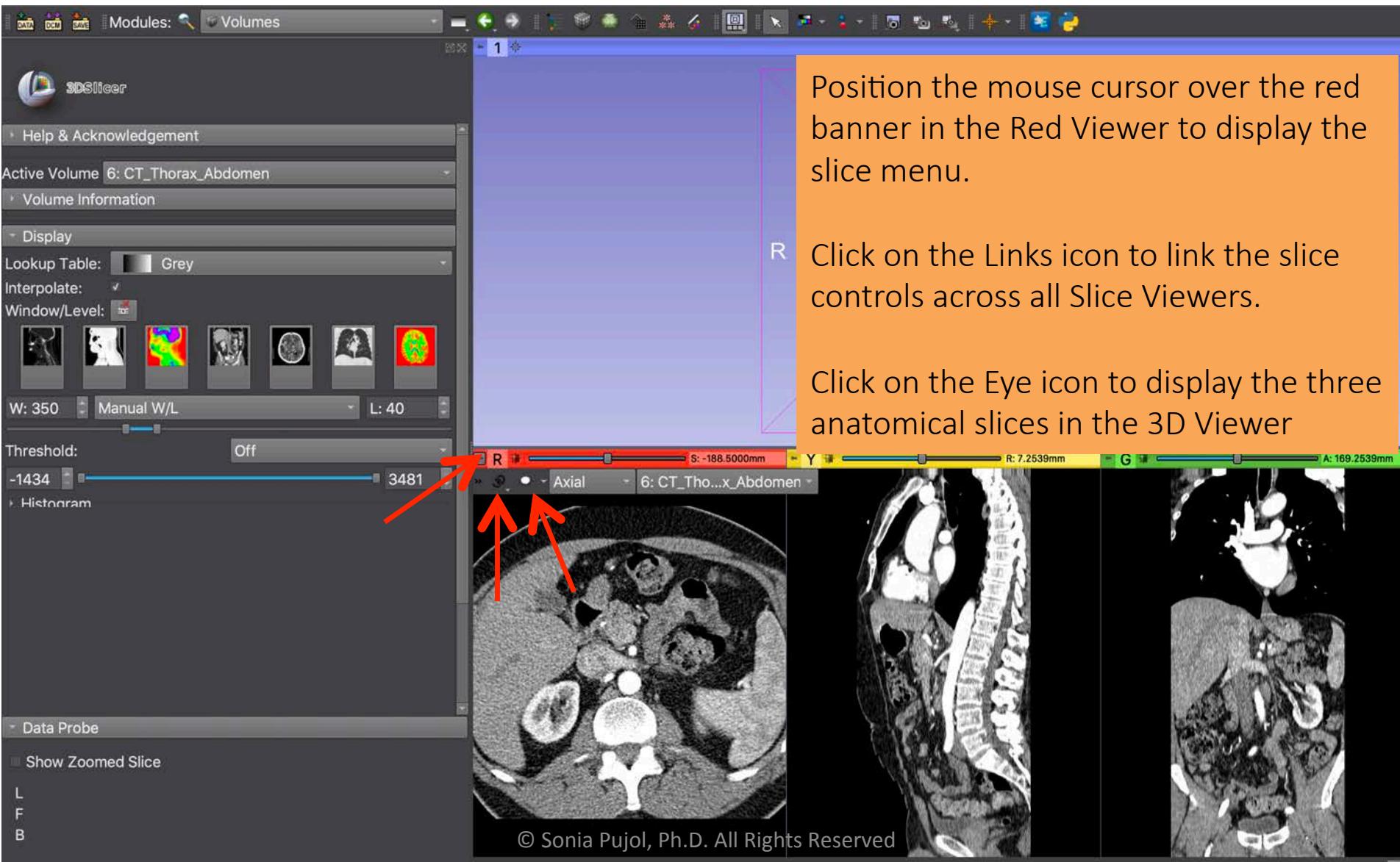
# Visualizing DICOM images



# Visualizing DICOM images



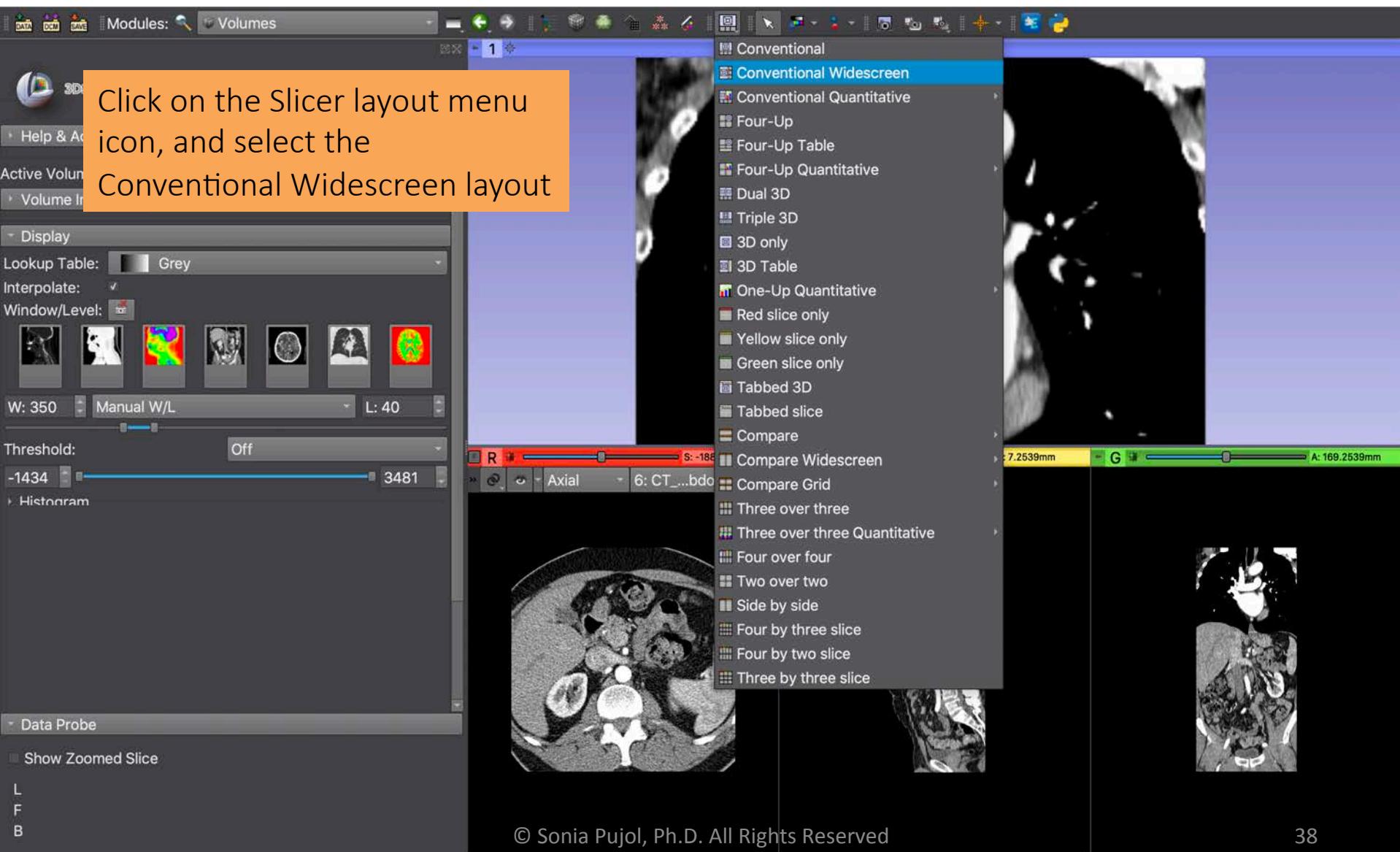
# Visualizing DICOM images



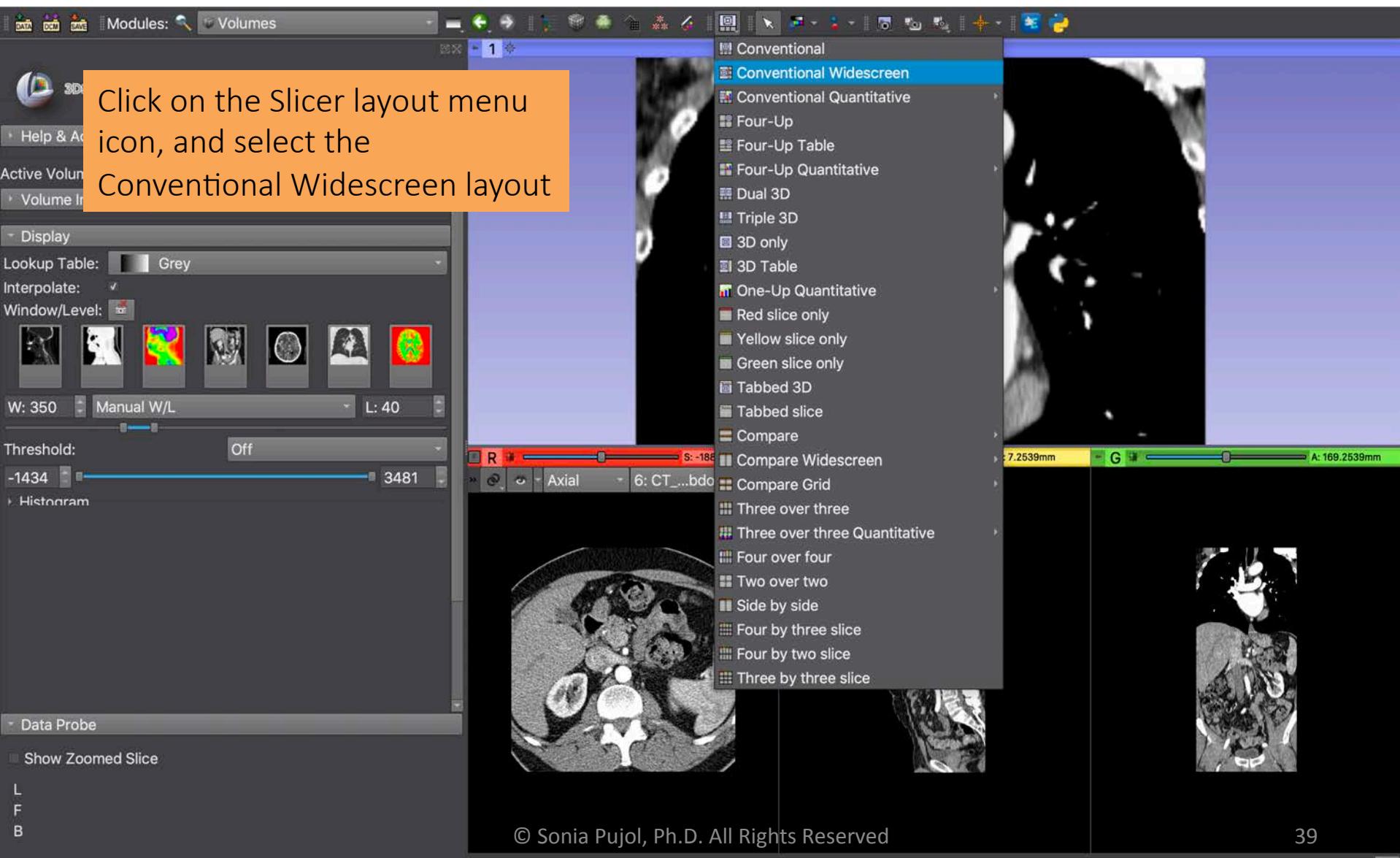
# Visualizing DICOM images



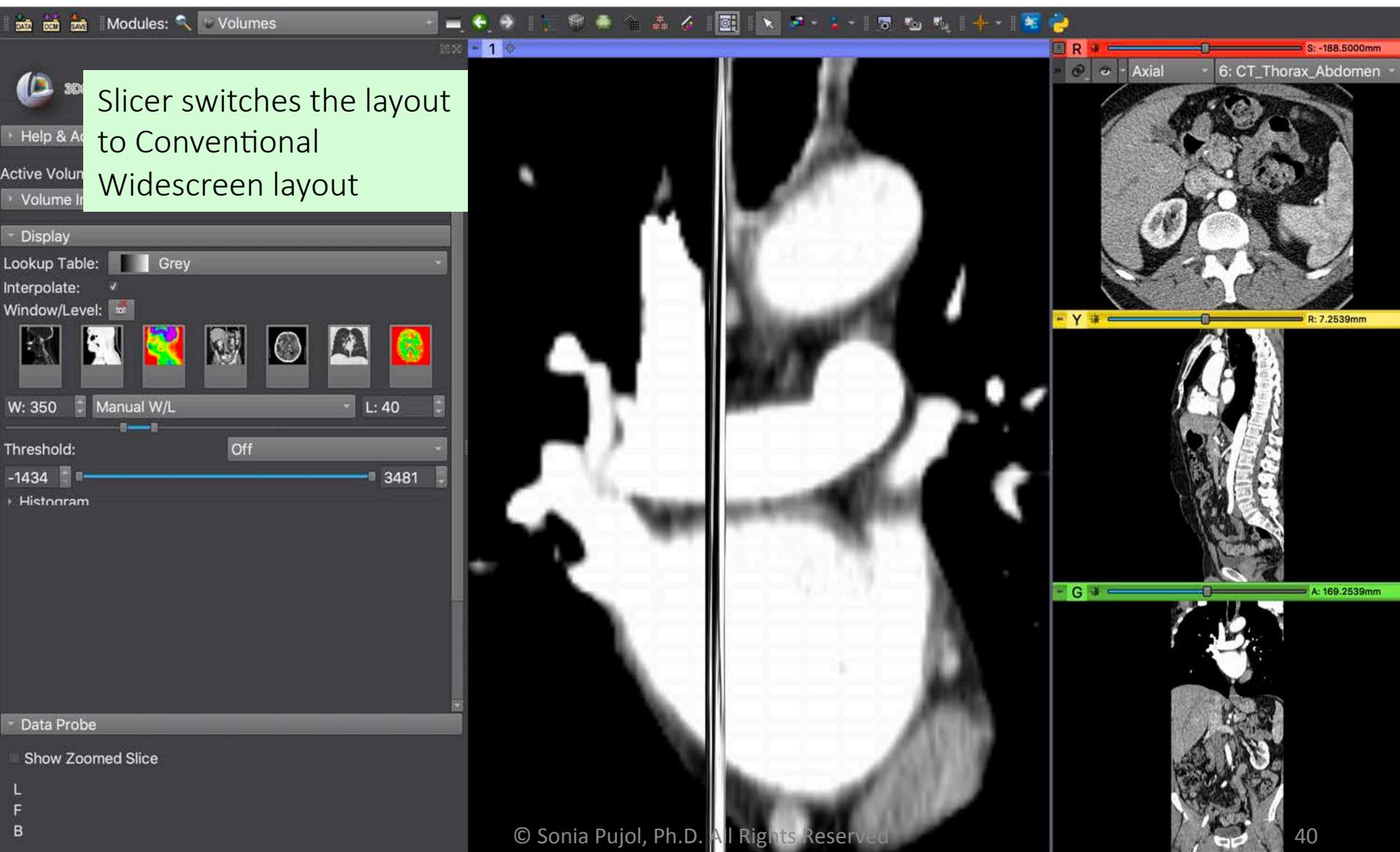
# Visualizing DICOM images



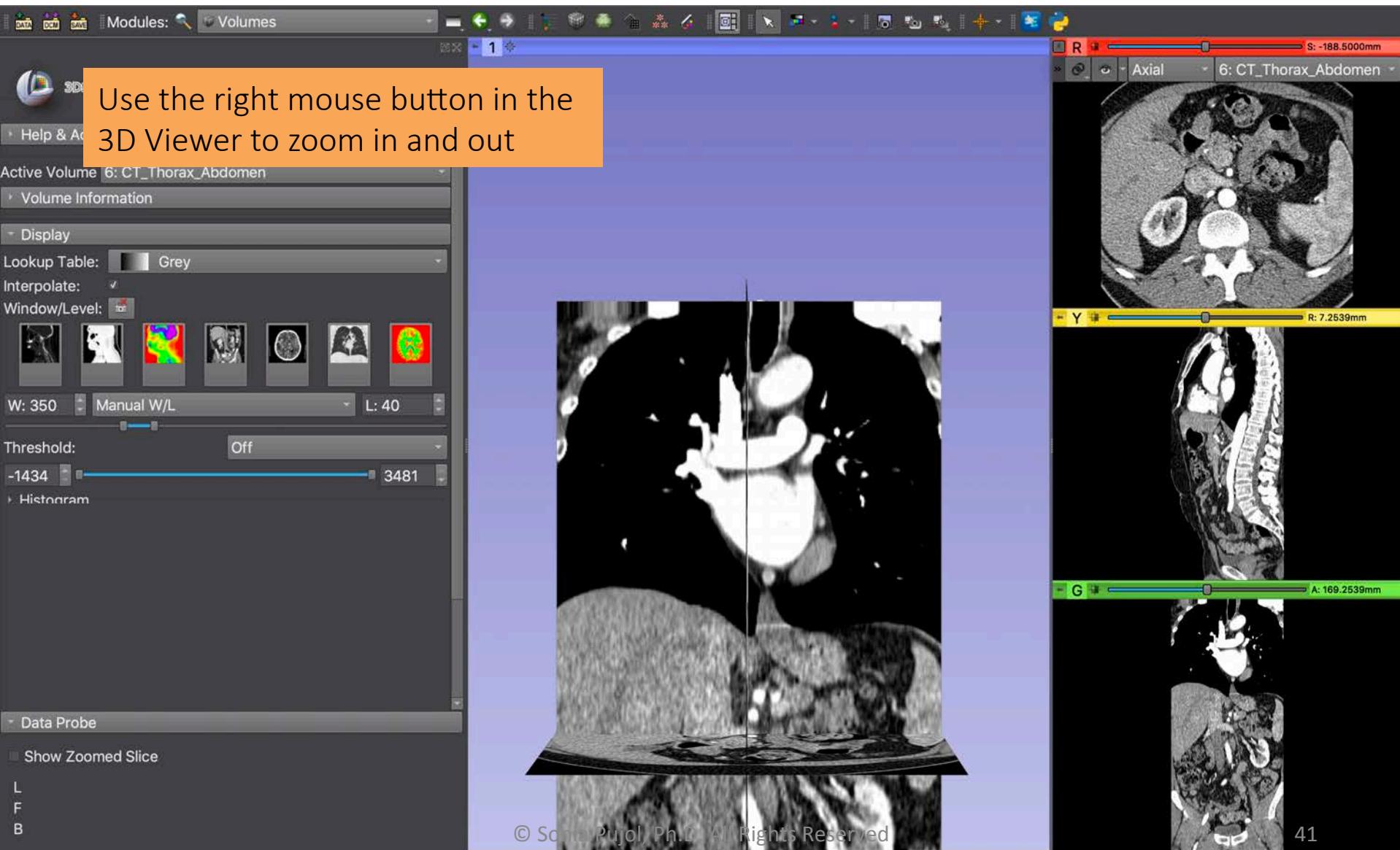
# Visualizing DICOM images



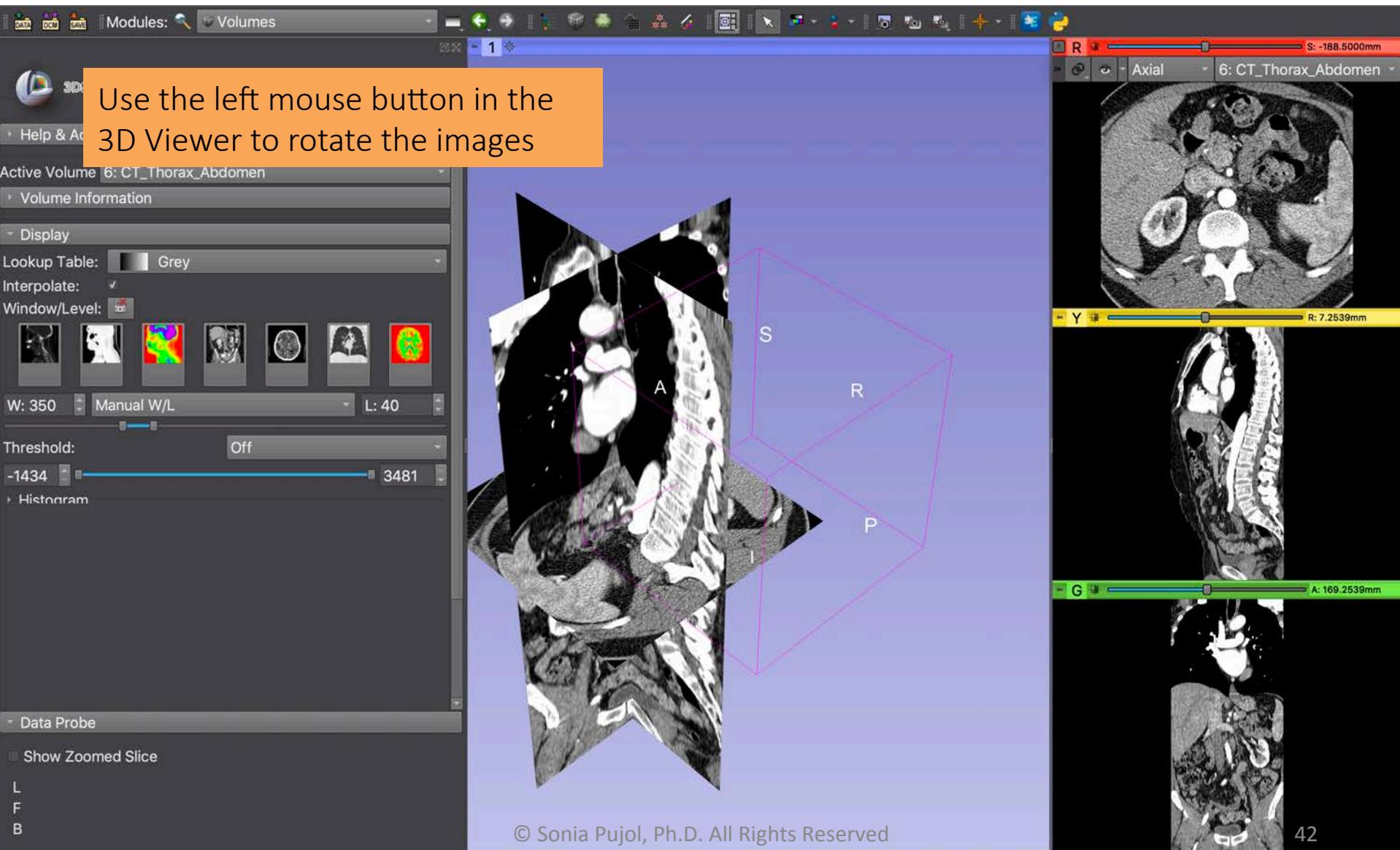
# Visualizing DICOM images



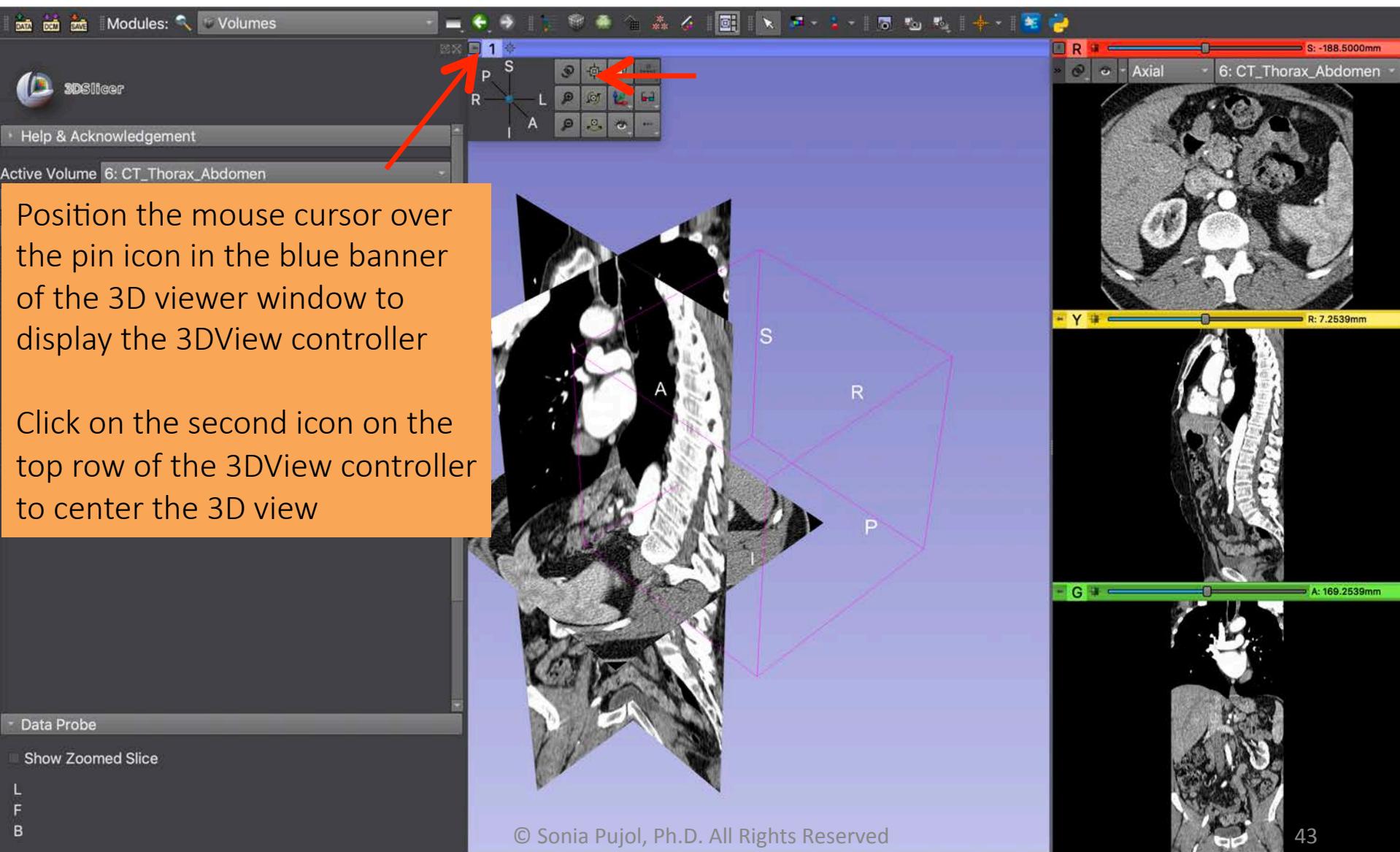
# Visualizing DICOM images



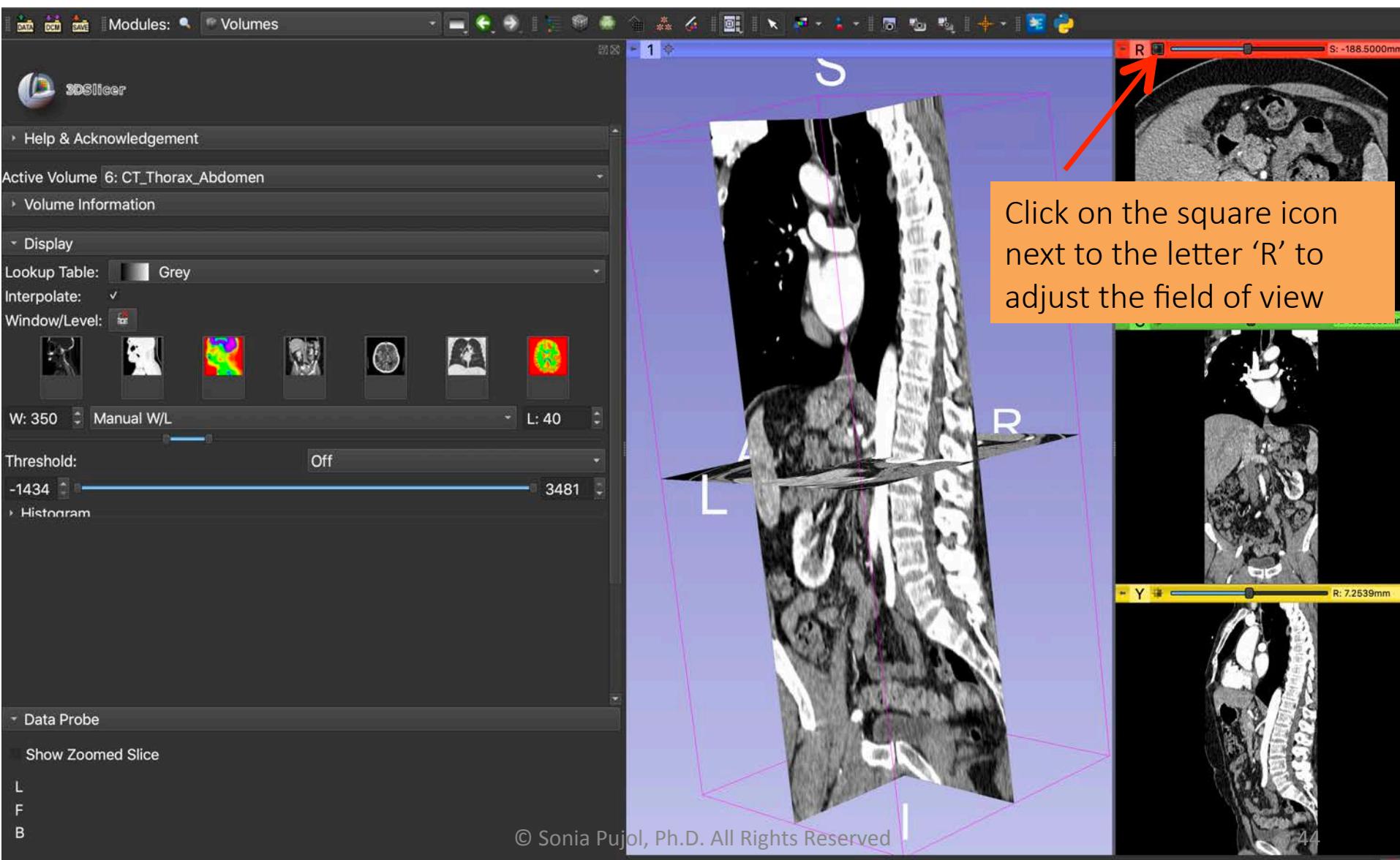
# Visualizing DICOM images



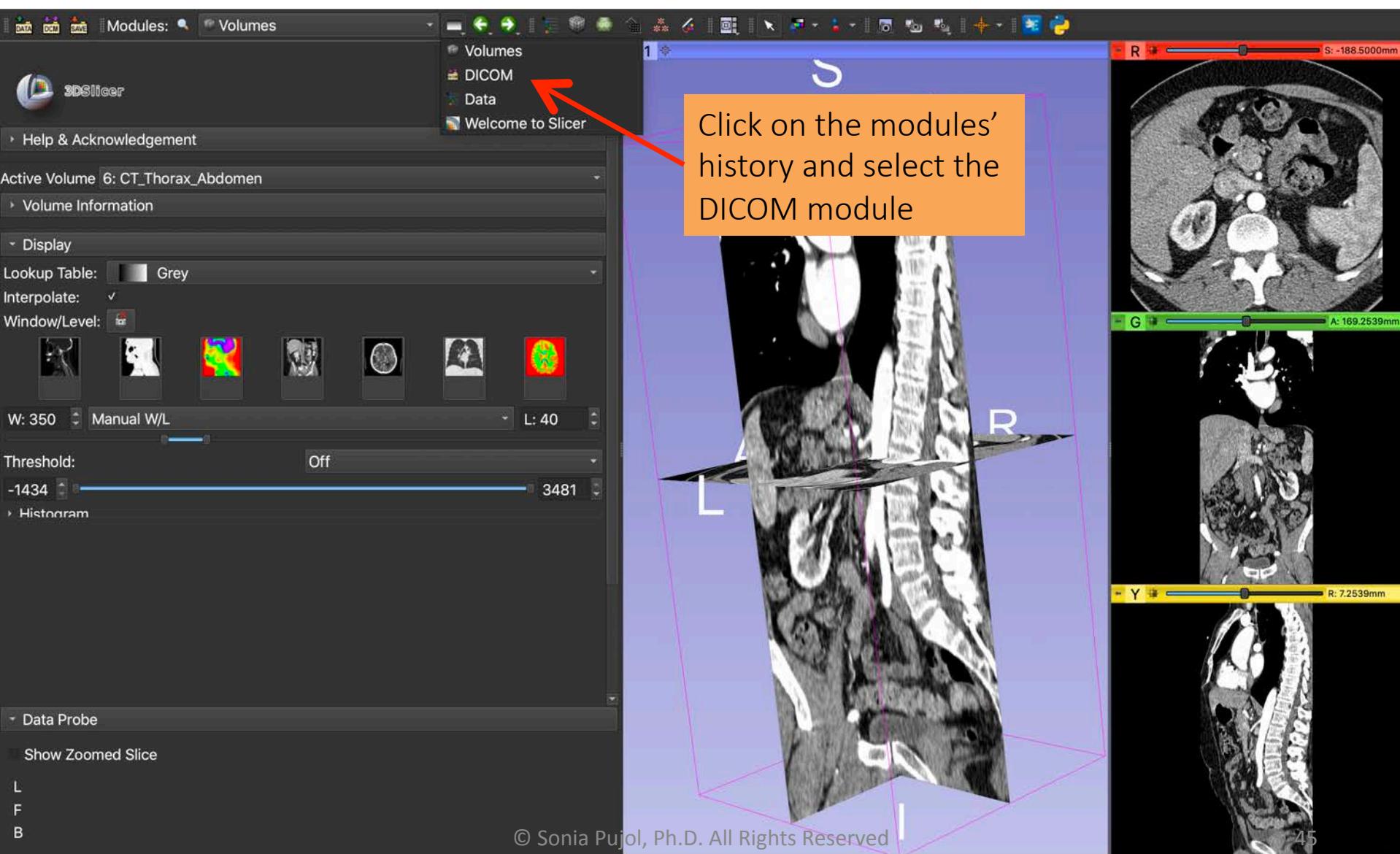
# 3D Viewer Controller

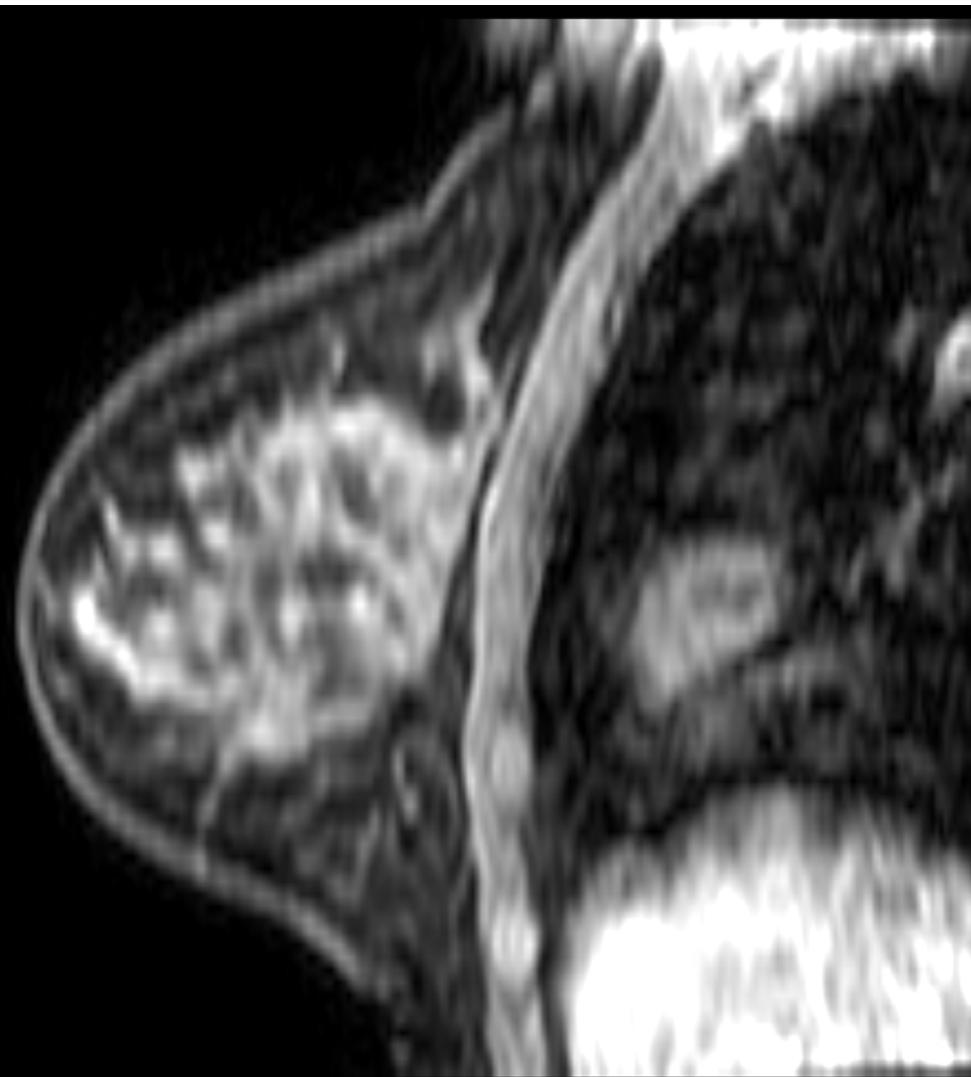


# Visualizing DICOM images



# Visualizing DICOM images





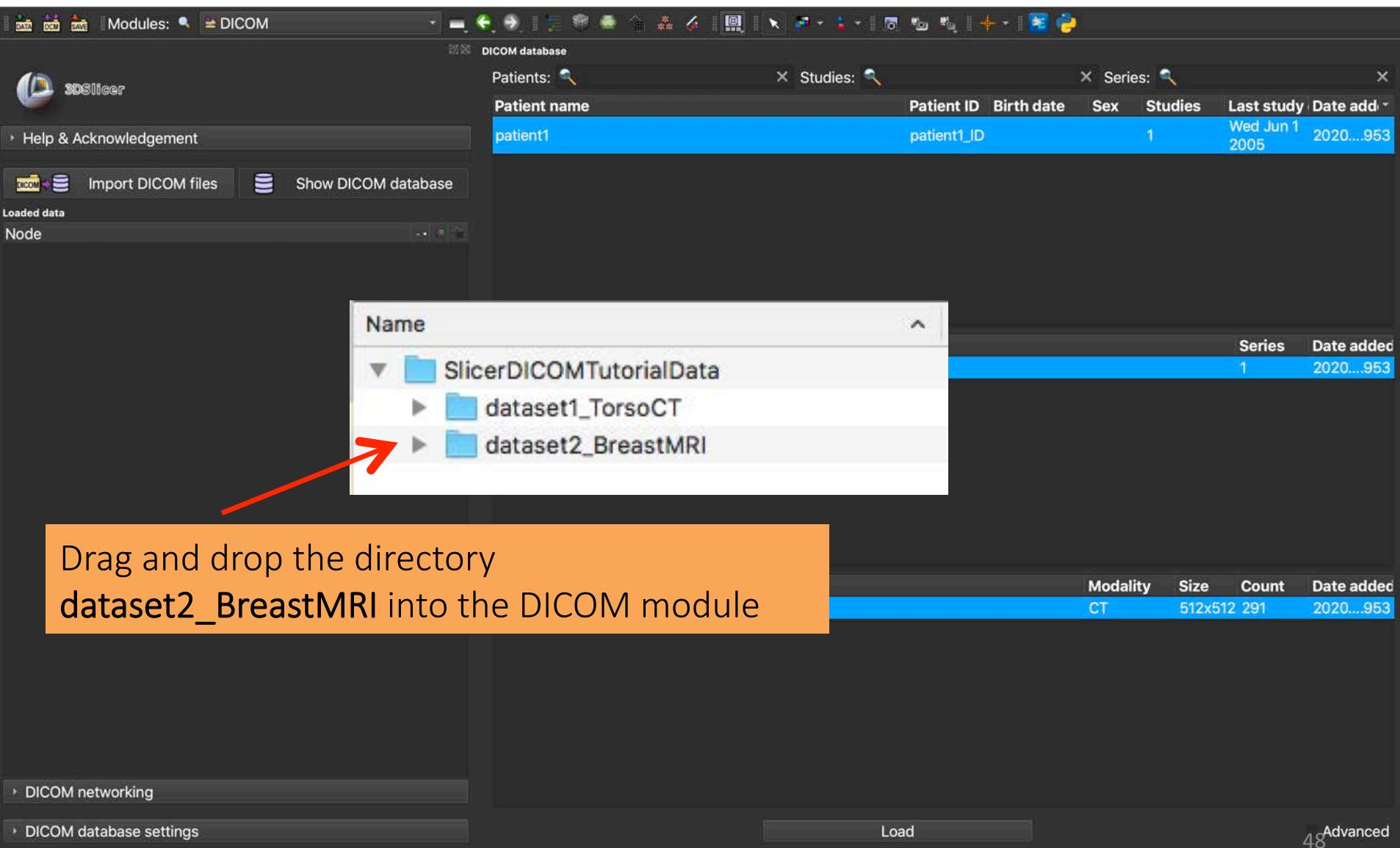
Dataset #2  
Breast MRI

# Breast MRI Dataset

- The Breast MRI dataset is part of the BREAST-DIAGNOSIS collection of the The Cancer Imaging Archive (TCIA) of the National Cancer Institute.
- The dataset was acquired on patient with right breast infiltrating ductal carcinoma
- The DICOM images consist of one study and three series: T2, STIR and BLISS

Bloch, B. Nicolas, Jain, Ashali, & Jaffe, C. Carl. (2015). Data From BREAST-DIAGNOSIS. The Cancer Imaging Archive. <http://doi.org/10.7937/K9/TCIA.2015.SDNRQXXR>

# Loading a DICOM volume



# Loading a DICOM volume

Slicer imports the `dataset2_BreastMRI` directory into the DICOM database

The directory contains 1 patient, 1 study and 3 series

Import completed: added 1 patients, 1 studies, 3 series, 1008 instances.

DICOM Data Reader Warnings

✓ 6: ... Scalar Volume

OK

DATA DICOM SAVE Modules: DICOM DICOM database Patients: Studies: Series: Patient name Patient ID Birth date Sex Studies Last study c Date added Bre...005 F 1 Tue Nov 11 2008 2020....583 patient1 patient1\_ID 1 Wed Jun 1 2005 2020....273

SDSlicer Help & Acknowledgement Import DICOM files Show DICOM database

Loaded data Node patient1 (patient1\_ID) CT Thorax Abdomen (20050601) 6: CT\_Thorax\_Abdomen

DICOM networking DICOM database settings Uncheck All Examine Load Advanced 49

# Loading a DICOM volume

The screenshot shows the 3DSlicer interface with the DICOM module selected. On the left, a tree view shows a node for 'patient1 (patient1\_ID)' under 'Node'. In the center, a 'DICOM database' window displays a table of patients. A red arrow points to the 'Patient name' column for the first row, which contains 'BreastDx-01-0005'. Below this, a table shows studies for this patient, with one study highlighted: '20081111 MRI BREAST, BILATERAL WITH T WITHOUT CONTRAST'. At the bottom, a table lists three series: '301 T2W\_TSE SENSE', '401 STIR SENSE', and '801 AX BLISS\_AUTO SENSE'. A large orange callout box on the left contains the following text:

Click on the PatientID  
**BreastDx-01-0005** to display  
the study and the three T2W,  
STIR and BLISS series

Click on Examine

Navigation bar at the bottom includes: DICOM networking, DICOM database settings, Uncheck All, Examine, Load, Advanced, and a page number '50'.

Patient name	Patient ID	Birth date	Sex	Studies	Last study	Date added
patient1	BreastDx-01-0005		F	1	Tue Nov 11 2008	2020...583
	patient1_ID			1	Wed Jun 1 2005	2020...273

Study date	Study ID	Study description	Series	Date added
20081111		MRI BREAST, BILATERAL WITH T WITHOUT CONTRAST	3	2020...583

Series #	Series description	Modality	Size	Count	Date added
301	T2W_TSE SENSE	MR	528x528	84	2020...583
401	STIR SENSE	MR	528x528	84	2020...221
801	AX BLISS_AUTO SENSE	MR	528x528	840	202...646

# Loading a DICOM volume

The screenshot shows the 3DSlicer interface with the DICOM module active. The top menu bar includes 'DATA', 'DICOM', 'SAVE', 'Modules: DICOM', and various tool icons. The left sidebar displays 'SDSlicer' branding and navigation links like 'Help & Acknowledgement', 'Import DICOM files', and 'Show DICOM database'. The main area is titled 'DICOM database' and contains three tables: 'Patients', 'Studies', and 'Series'. A red arrow points from the 'Patient name' column in the 'Patients' table to the 'Patient ID' column in the 'Studies' table, which is highlighted in blue. Another red arrow points from the 'Series #' column in the 'Studies' table to the 'Series description' column in the 'Series' table, also highlighted in blue. An orange callout box on the left says 'Click on the double arrow to display the list of DICOM readers' with an arrow pointing to the double arrow icon in the 'Studies' table header. An orange callout box on the right says 'Slicer displays the readers used for each series' with an arrow pointing to the 'Reader' column in the 'Series' table.

SDSlicer

Modules: DICOM

DICOM database

Patients: Studies: Series:

Patient name	Patient ID	Birth date	Sex	Studies	Last study	Date added
BreastDx-01-0005			F	1	Tue Nov 11 2008	2020...583
patient1	patient1_ID			1	Wed Jun 1 2005	2020...273

Study date	Study ID	Study description	Series	Date added
20081111		MRI BREAST, BILATERAL WITH T WITHOUT CONTRAST	3	2020...583

Series #	Series description	Modality	Size	Count	Date added
301	T2W_TSE SENSE	MR	528x528 84	2020...583	2020...221
401	STIR SENSE	MR	528x528 84	2020...221	46
801	AX BLISS_AUTO SENSE				

Node

- patient1 (patient1\_ID)
- CT Thorax Abdomen (20050601)
  - 6: CT\_Thorax\_Abdomen

Loaded data

Click on the double arrow to display the list of DICOM readers

Slicer displays the readers used for each series

DICOM Data Reader Warnings

DICOM Data	Reader	Warnings
✓ 301: T2W_TSE SENSE	Scalar Volume	
✓ 401: STIR SENSE	Scalar Volume	
✓ AX BLISS_AUTO SENSE ...	MultiVolume	
801: AX BLISS_AUTO ...	Scalar Volume	Images are not equally spaced (a difference of 2 vs 0 in spacings ...)
AX BLISS_AUTO SENSE ...	MultiVolume	

DICOM networking

DICOM database settings

Uncheck All Examine Load Advanced

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# Loading a DICOM volume

The screenshot shows the 3DSlicer application interface. On the left, there's a sidebar with a tree view under 'Node' showing 'patient1 (patient1\_ID)' and 'CT Thorax Abdomen (20050601)'. Below that is a section for 'DICOM networking' and 'DICOM database settings'. The main area is titled 'DICOM database' and contains three tables:

- Patients:** Shows a list of patients. A red arrow points to the row for 'patient1'.

Patient name	Patient ID	Birth date	Sex	Studies	Last study date	Date added
BreastDx-01-0005	F	1	Tue Nov 11 2008	1	2020-0...28.583	
patient1	patient1_ID			1	Wed Jun 1 2005	2020-0...43.273
- Studies:** Shows a list of studies for the selected patient.

Study date	Study ID	Study description	Series	Date added
20081111	MRI BREAST, BILATERAL WITH T WITHOUT CONTRAST	3	2020-0...28.583	
- Series:** Shows a list of series for the selected study.

Series #	Series description	Modality	Size	Count	Date added
301	T2W_TSE SENSE	MR	528x528	84	2020-0...28.583
401	STIR SENSE	MR	528x528	84	2020-0...29.221
801	AX BLISS_AUTO SENSE	MR	528x528	840	2020-0...28.646

At the bottom, there's a table for 'DICOM Data' with columns for 'DICOM Data', 'Reader', and 'Warnings'. The first row is highlighted.

**The list of DICOM plugins appear**

A red arrow points from the text 'The list of DICOM plugins appear' to the list of DICOM plugins on the right.

- DICOMPETSVPlugin
- DICOPParametricMapPlugin
- DICOMRWVMPPlugin
- DICOMScalarVolumePlugin
- DICOMSegmentationPlugin
- DICOMSlicerDataBundlePlugin
- DICOMTID1500Plugin
- DICOMVolumeSequencePlugin
- DicomRtImportExportPlugin
- DicomSrlImportExportPlugin
- MultiVolumeImporterPlugin

DICOM Data Reader Warnings

DICOM Data	Reader	Warnings
301: T2W_TSE SENSE	Scalar Volume	
401: STIR SENSE	Scalar Volume	
801: AX BLISS_AUTO SENSE	Scalar Volume	Images are not equally spaced (a difference of 2 vs 0 in spacing...)
AX BLISS_AUTO SENSE - as a 10 ...	MultiVolume	
AX BLISS_AUTO SENSE - as a 10 ...	MultiVolume	
AX BLISS_AUTO SENSE - as a 10 ...	MultiVolume	



# Slicer DICOM Plugins

- ✓ DICOMPETSUVPlugin
- ✓ DICOMParametricMapPlugin
- ✓ DICOMRWVMPlugin
- ✓ DICOMScalarVolumePlugin
- ✓ DICOMSegmentationPlugin
- ✓ DICOMSlicerDataBundlePlugin
- ✓ DICOMTID1500Plugin
- ✓ DICOMVolumeSequencePlugin
- ✓ DicomRtImportExportPlugin
- ✓ DicomSrolImportExportPlugin
- ✓ MultiVolumeImporterPlugin

- Slicer implements a list of DICOM plugins to handle a diverse set of DICOM data objects
- These plugins need to be enabled in order to read specific DICOM data objects such DICOM RT data or DICOM DWI data

# Visualizing DICOM volumes

The screenshot shows the 3DSlicer interface with the DICOM module selected. The left sidebar displays the loaded data for patient1, including a node for CT Thorax Abdomen. The main area contains three tables:

- DICOM database (Patients):**

Patient name	Patient ID	Birth date	Sex	Studies	Last study date	Date added
BreastDx-01-0005	F	1	Tue Nov 11 2008	2020-0...28.583		
patient1	patient1_ID			1	Wed Jun 1 2005	2020-0...43.273
- DICOM database (Studies):**

Study date	Study ID	Study description	Series	Date added
20081111	MRI BREAST, BILATERAL WITH T WITHOUT CONTRAST		3	2020-0...28.583
- DICOM database (Series):**

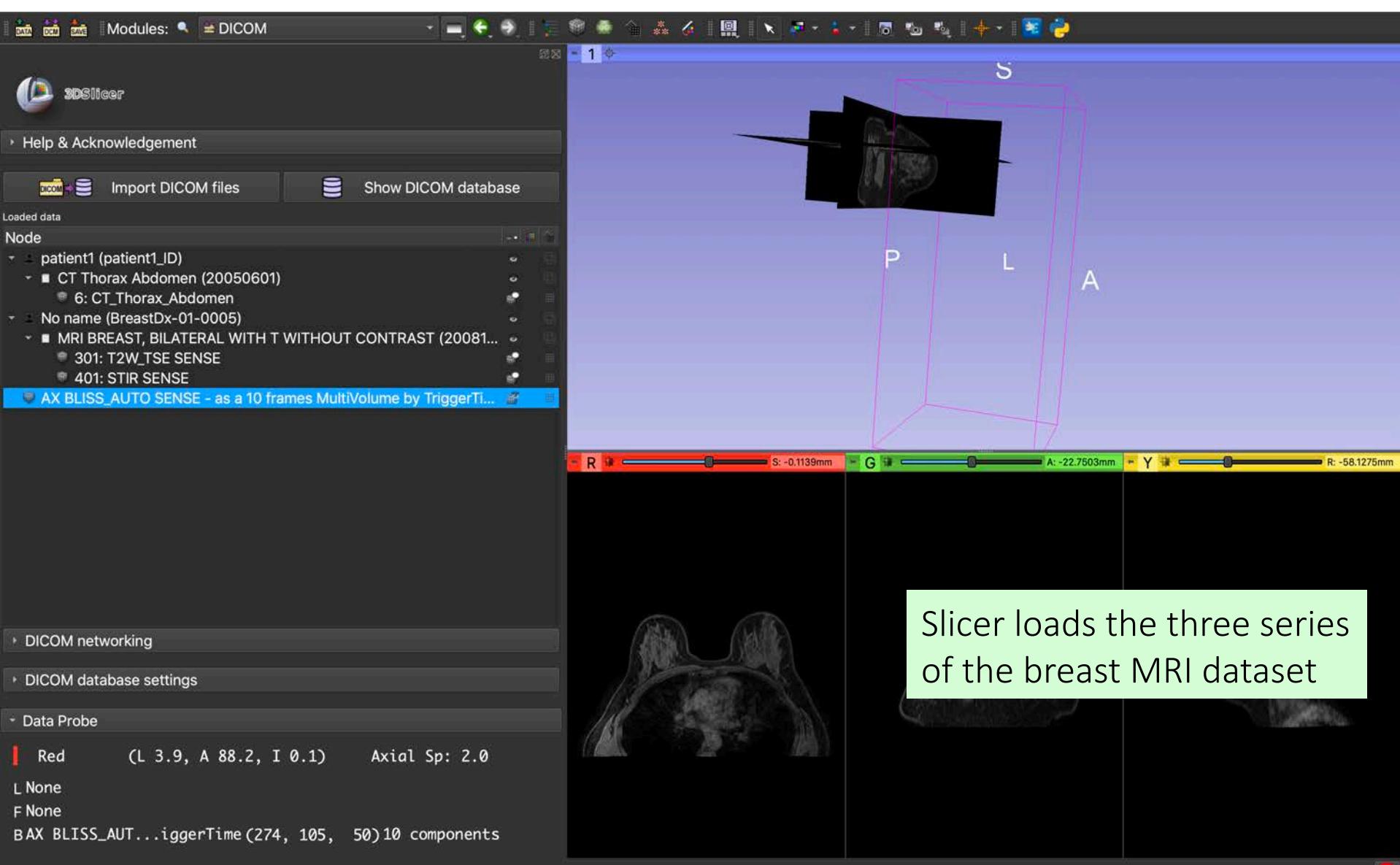
Series #	Series description	Modality	Size	Count	Date added
301	T2W_TSE SENSE	MR	528x528	84	2020-0...28.583
401	STIR SENSE	MR	528x528	84	2020-0...29.221
801	AX BLISS_AUTO SENSE	MR	528x528	840	2020-0...28.646

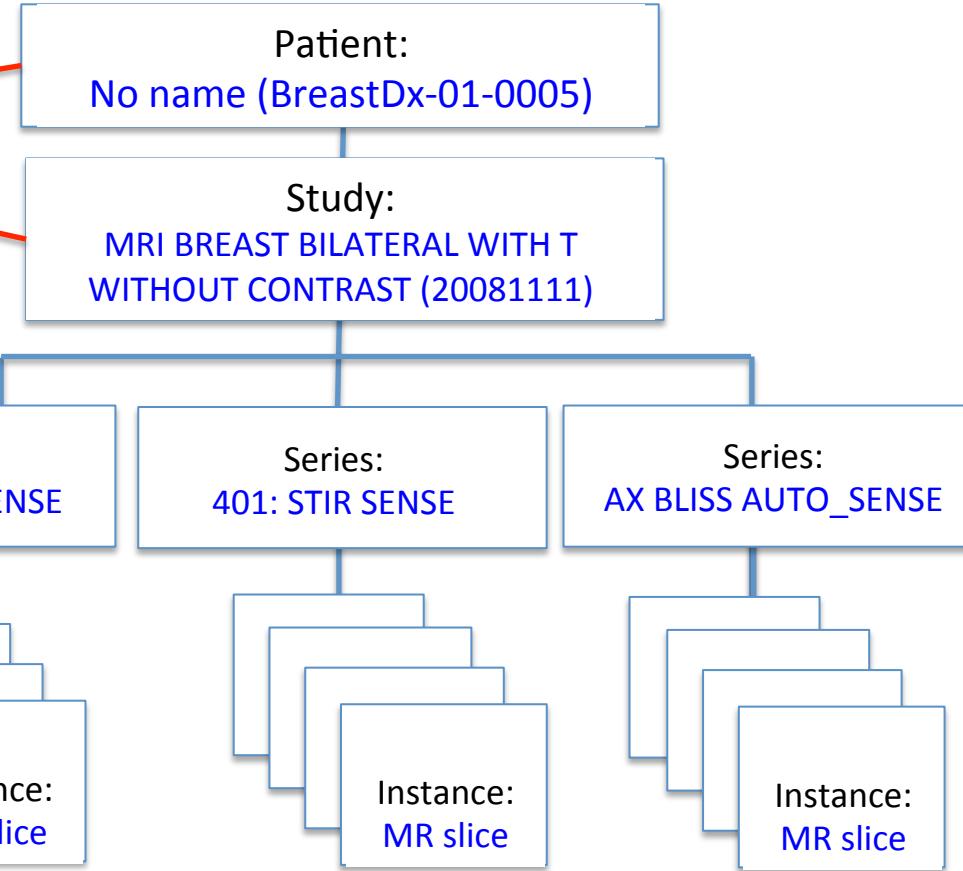
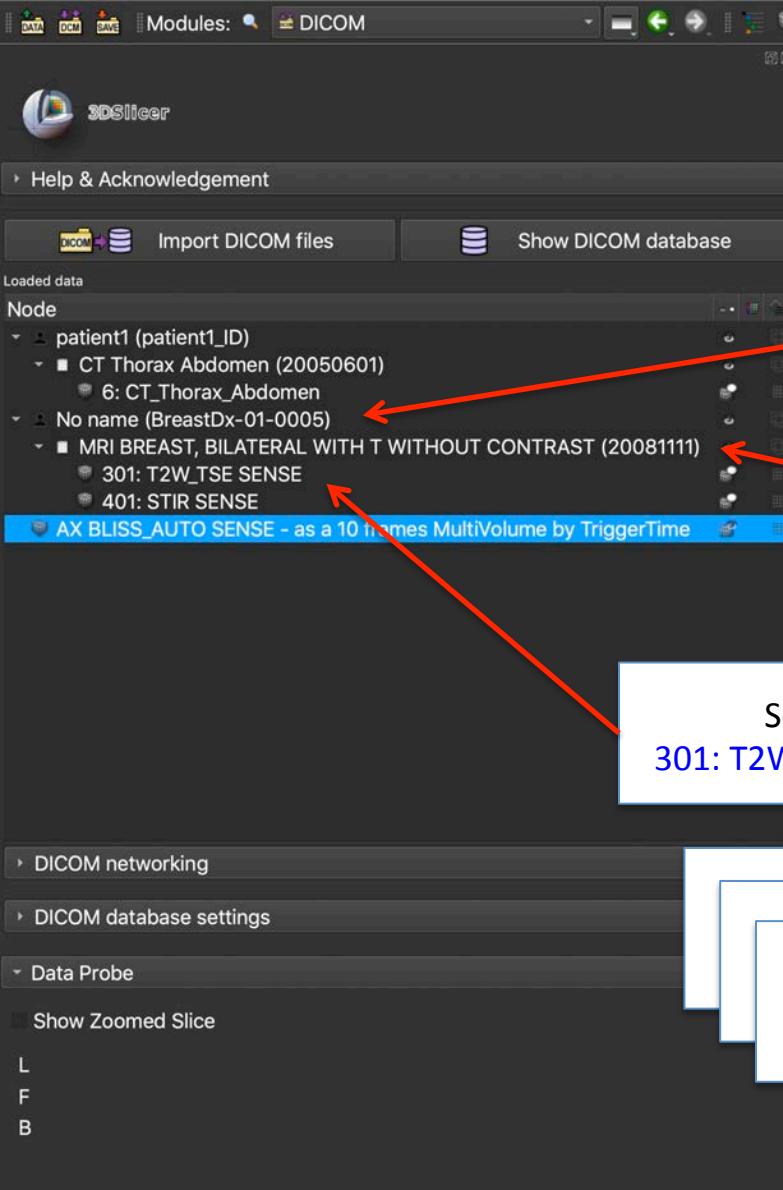
A callout box with the text "Click on Load to load the data into Slicer" points to the "Load" button at the bottom right of the series list table.

Bottom navigation buttons: Uncheck All, Examine, Load, Advanced.

Page number: 54

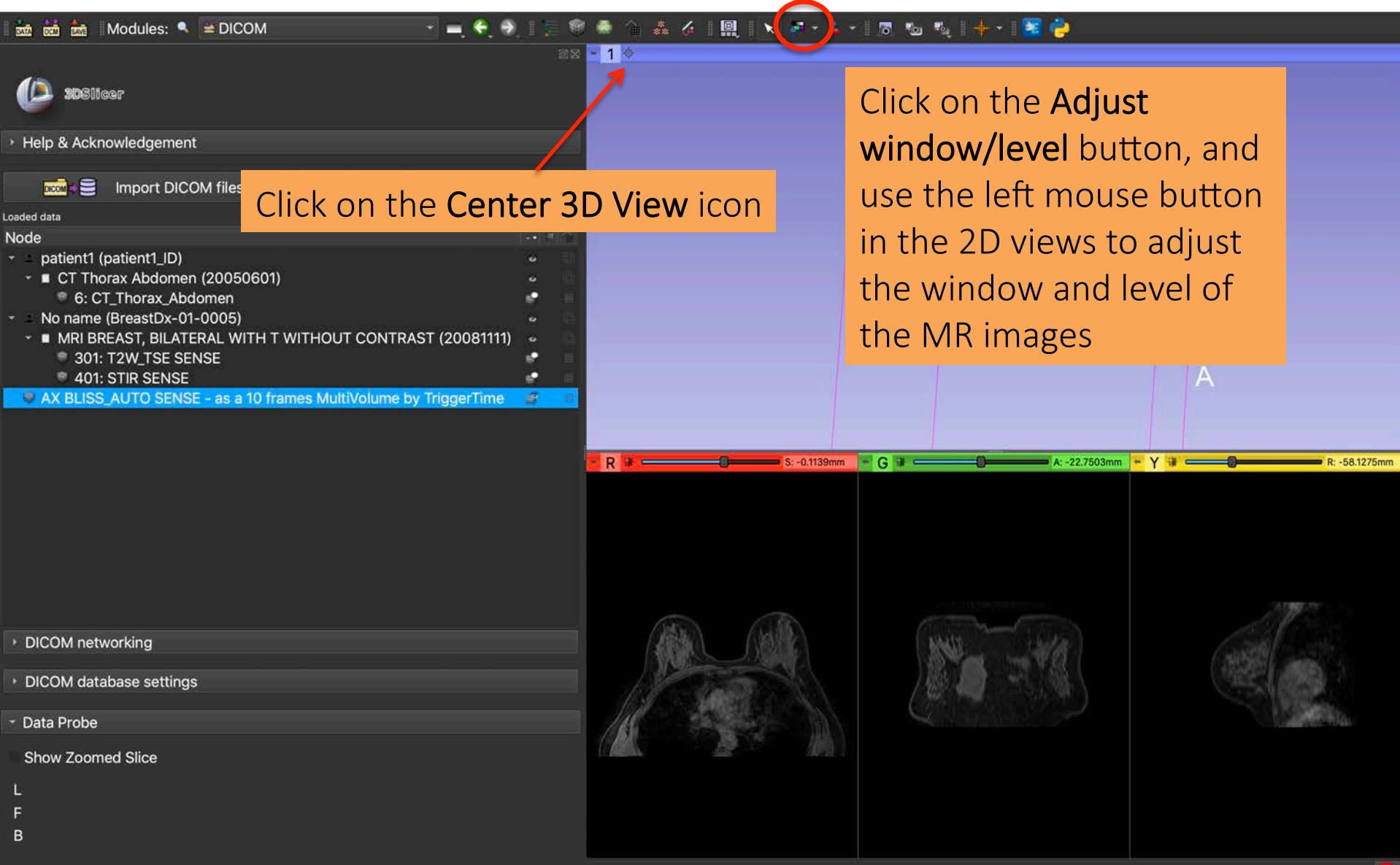
# Visualizing DICOM volumes



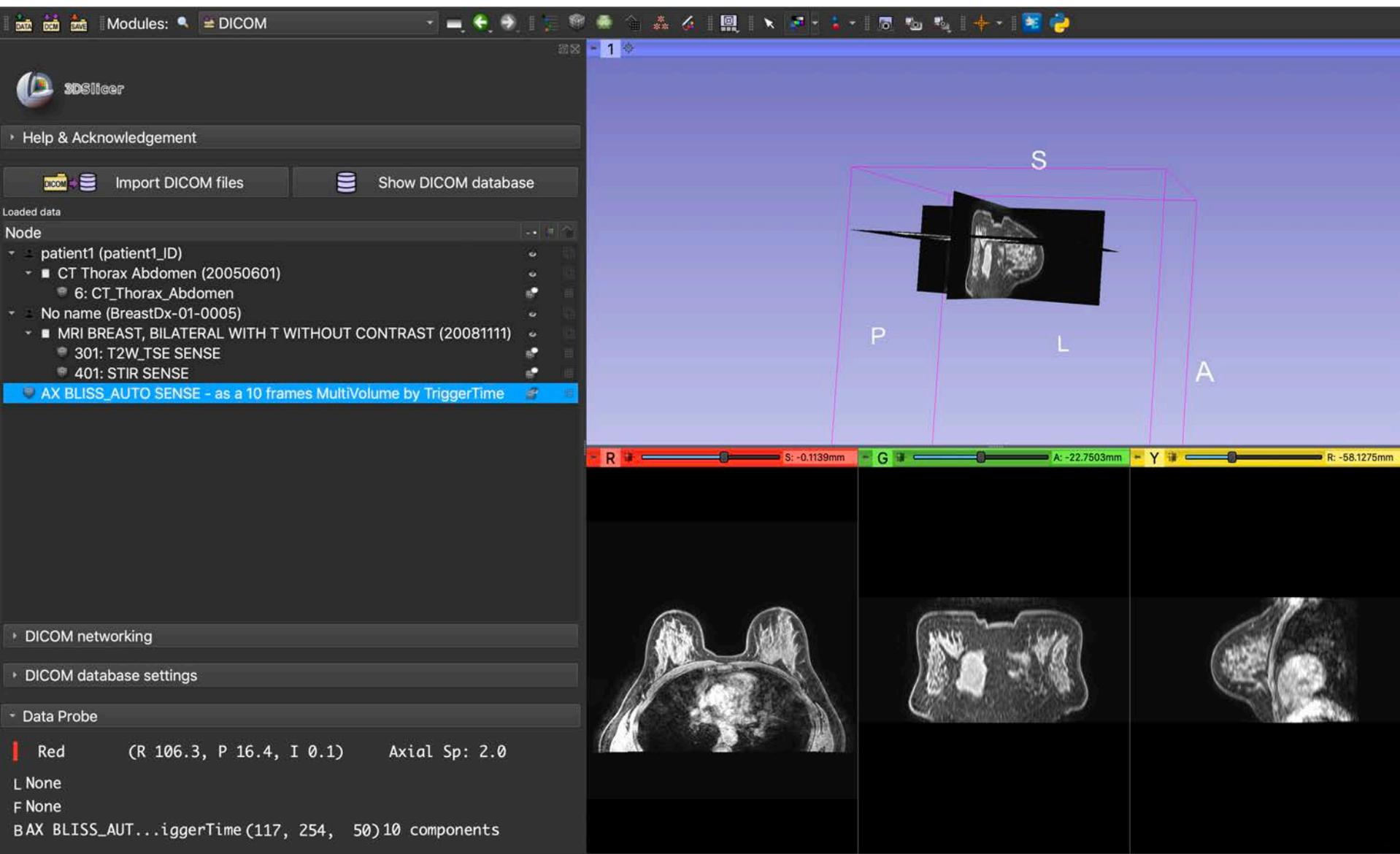


DICOM data are loaded into Slicer as a patient-study-series hierarchy

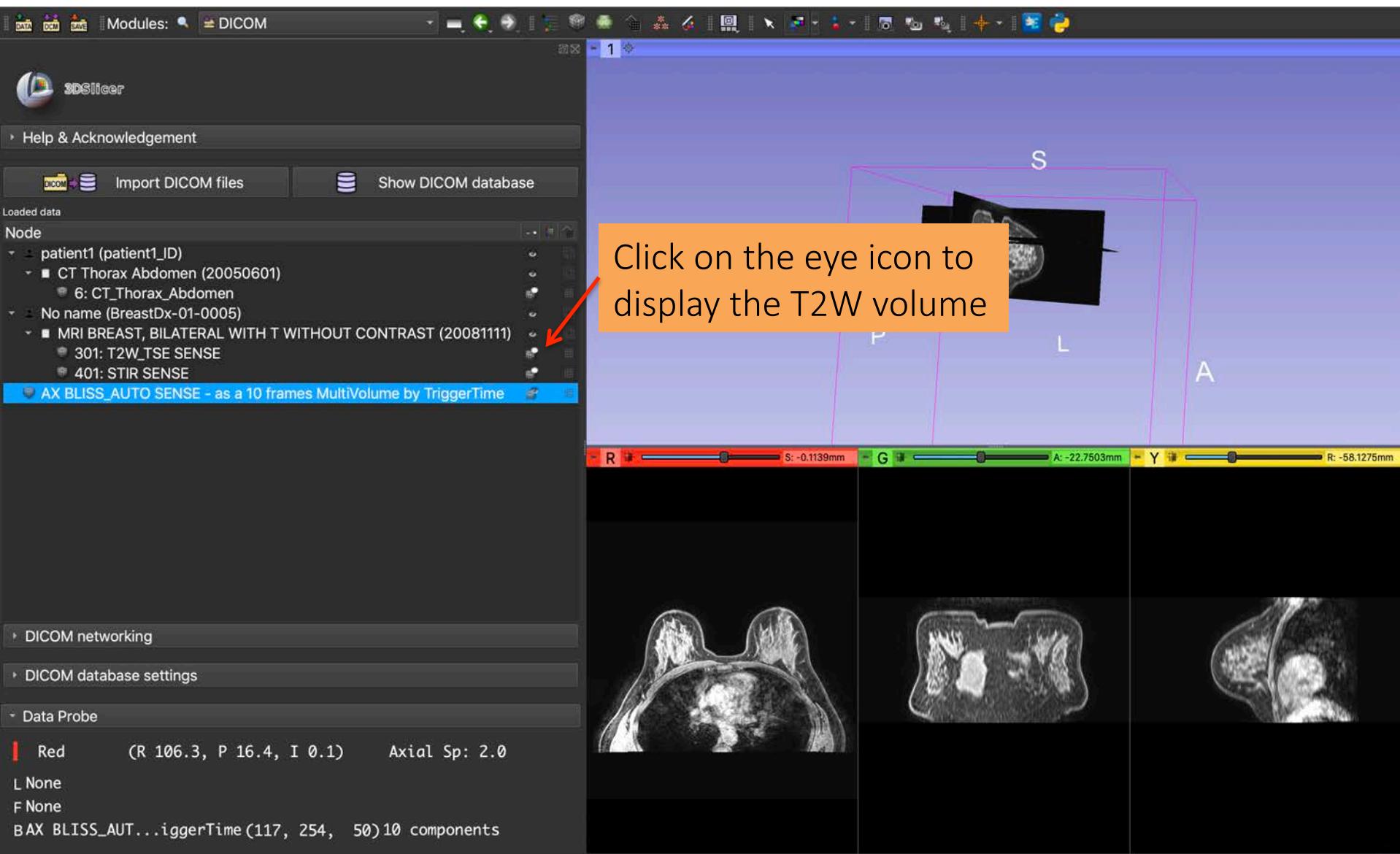
# Visualizing DICOM volumes



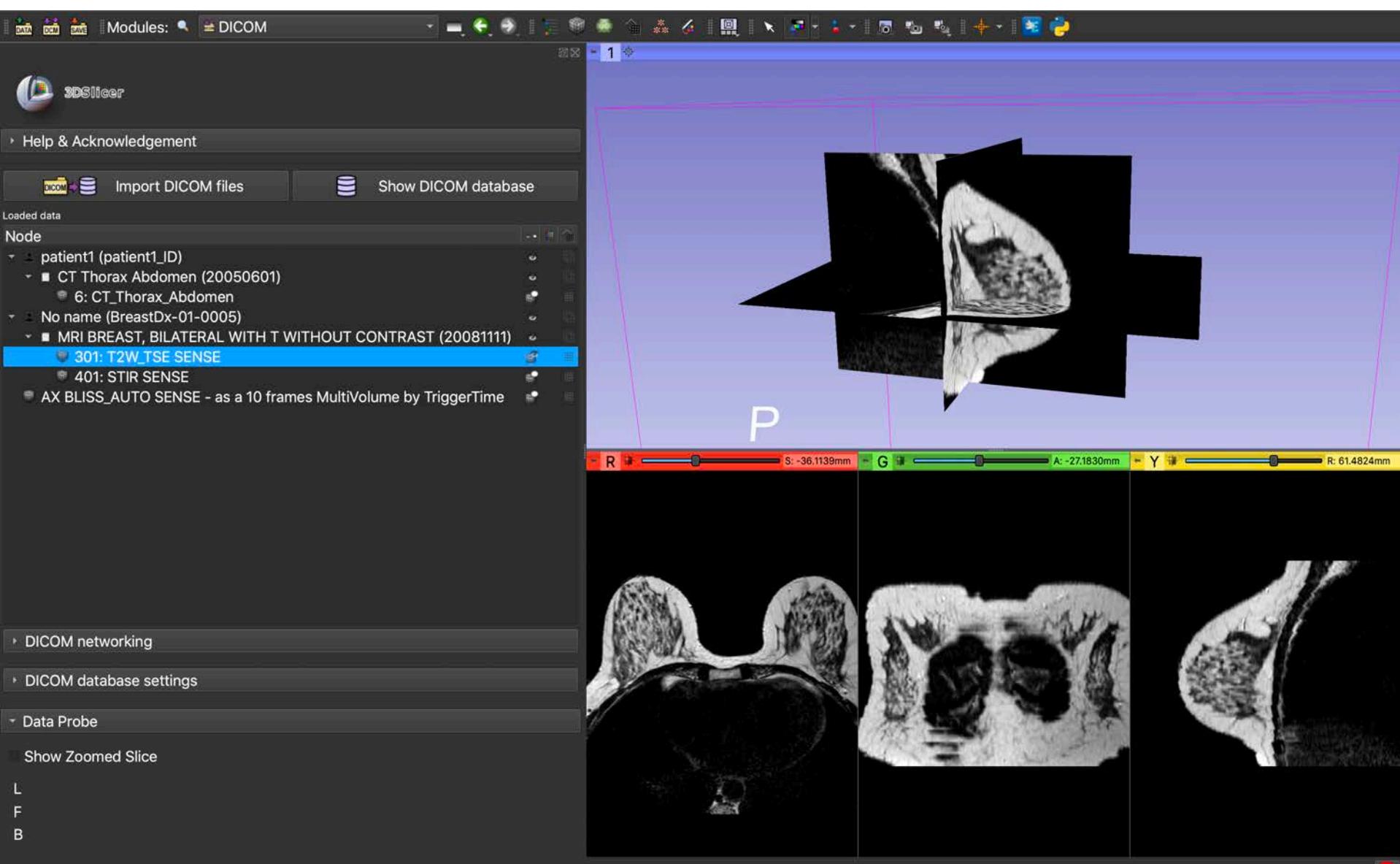
# Visualizing DICOM volumes



# Visualizing DICOM volumes



# Visualizing DICOM volumes



# Acknowledgments

 Neuroimage Analysis Center  
(NIBIB P41 EB015902)

# Conclusion

- The DICOM standard enables compliance with the FAIR principles for biomedical research
- This dataset provided step-by-step guidance on how to load and visualize DICOM images in 3D Slicer version 5.0