Slicer Developer Tutorial: Programming in Slicer

Sonia Pujol, Ph.D.
Assistant Professor of Radiology
Director of 3D Slicer Training & Education
Brigham and Women's Hospital
Harvard Medical School

Steve Pieper, Ph.D.
3D Slicer Chief Architect
Isomics Inc.

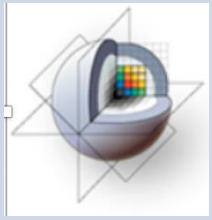
Goal of the tutorial


```
def threshold(t):
    n=getNode('T2')
    a=array('T2')
    a[a<t]=0
    arrayFromVolumeModified(n)
    print('Thresholding done')
```


```
b=qt.QPushButton('Toggle')
b.connect('clicked()',toggle)
b.styleSheet = "font-size: 24pt; color:
aqua; margin: 20px"
b.show()
```

This tutorial is an introduction to the Python interactor and the Qt widget toolkit in 3D Slicer release version 5

Tutorial Outline



Part 1: 3D Slicer Modules Overview

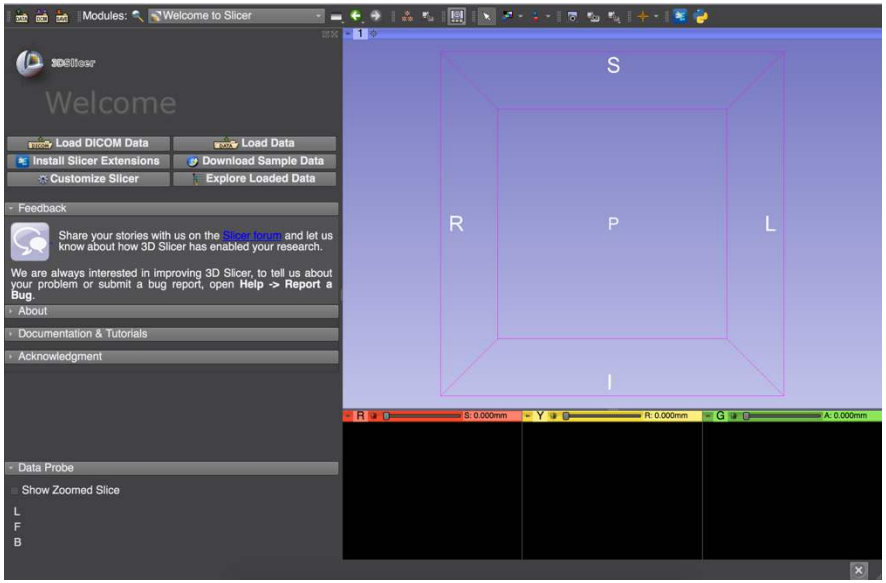
Part 2: Getting Familiar with the Python environment in 3D Slicer

Part 3: Getting Familiar with the Qt widget toolkit in 3D Slicer

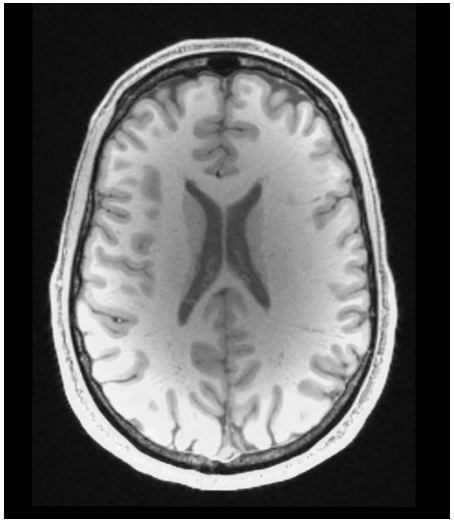
Disclaimer

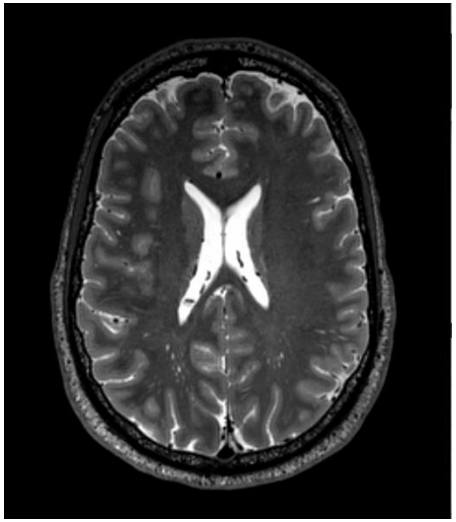
- 3D Slicer is a free open source software application distributed under a BSD style license.
- The software is not FDA approved or CE-Marked, and is for research use only.

Tutorial materials



3D Slicer version 5.10

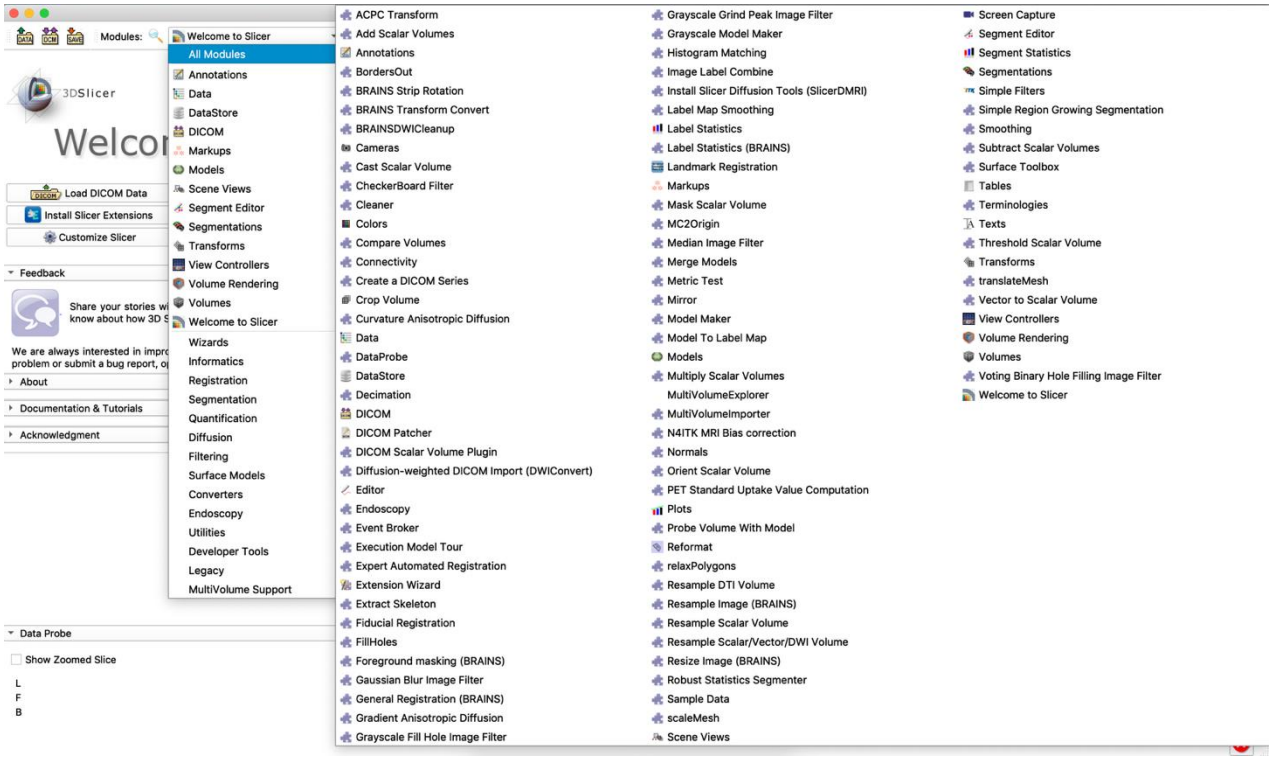




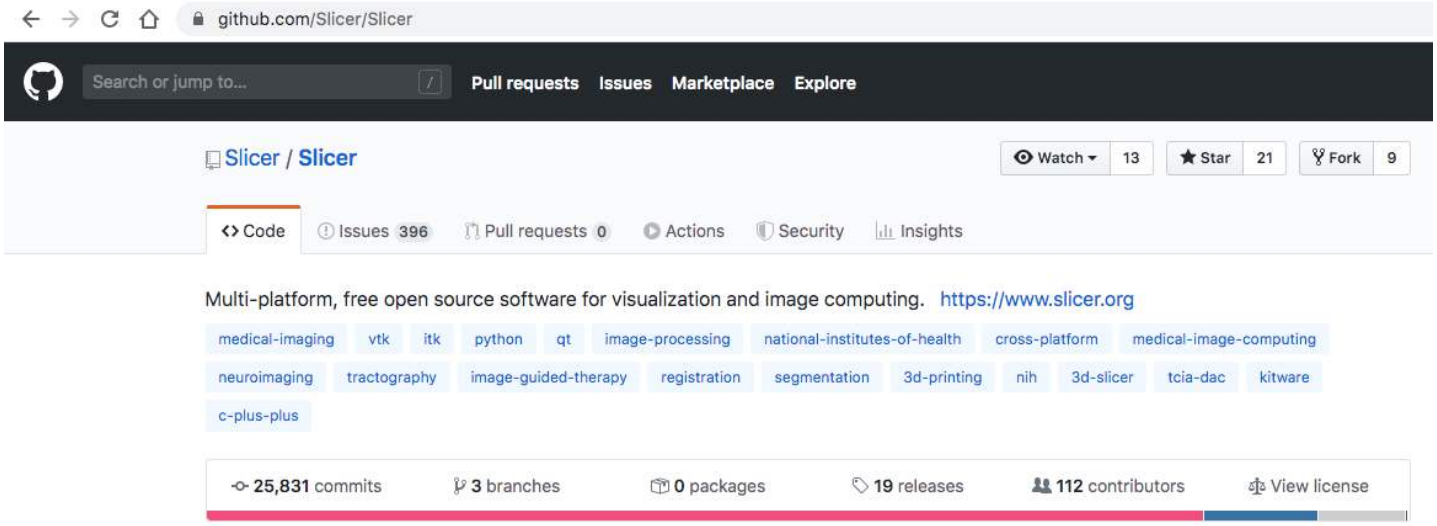
SlicerProgrammingTutorialData.zip

Part 1

Slicer Modules Overview



3D Slicer



- 3D Slicer is an open-source platform for the analysis and visualization of medical imaging data
- 3D Slicer is compiled and tested every day on Windows, Mac, and Linux platforms
- The source code is freely available on GitHub at http://github.com/Slicer/Slicer

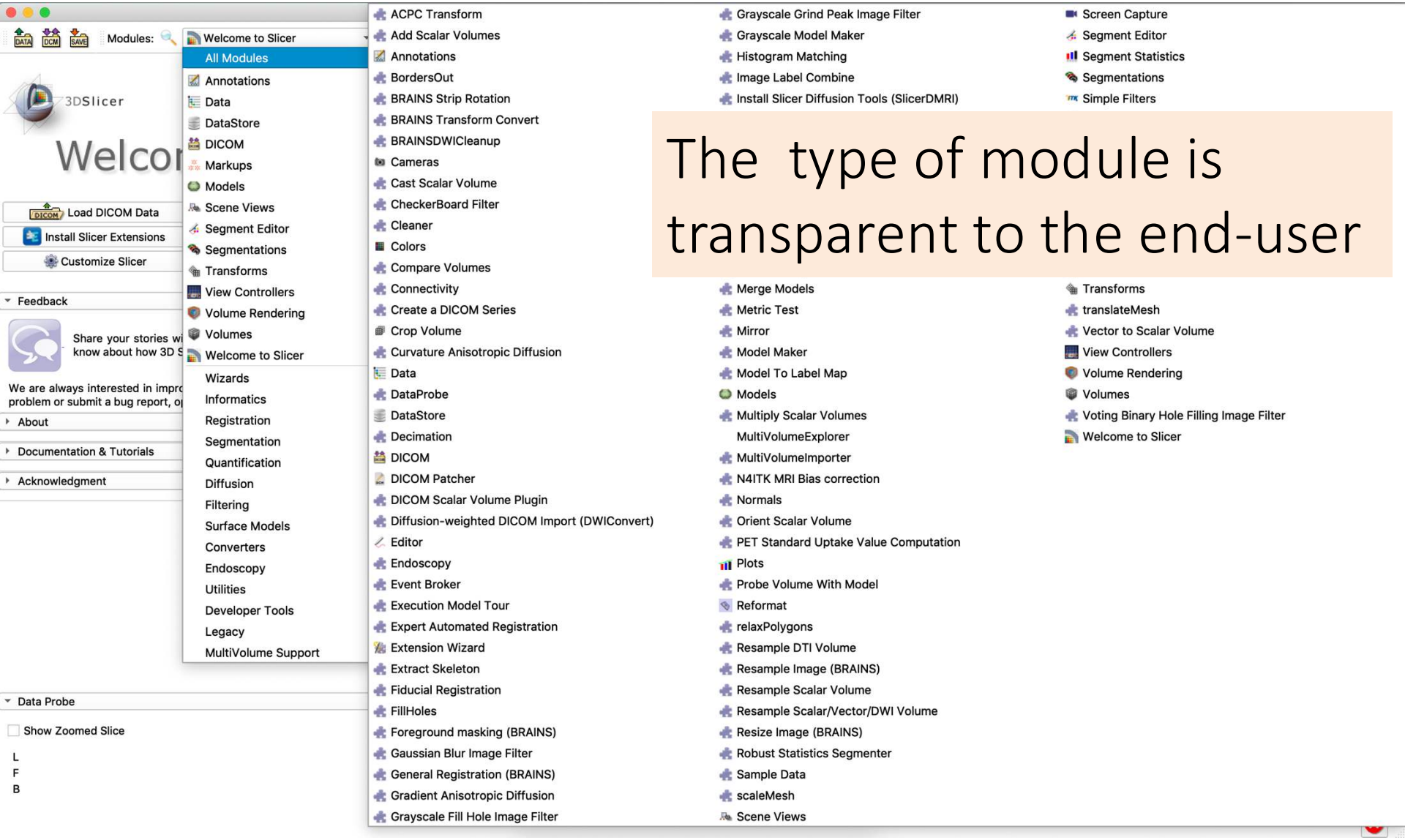
Slicer Modules

3D Slicer supports three types of modules:

- **Command Line Interface (CLI):** standalone executable with limited input/output arguments
- **Loadable Modules (C++ Plugins):** optimized for heavy computation
- **Scripted Modules (Python):** recommended for fast prototyping and workflow development

Focus of this tutorial

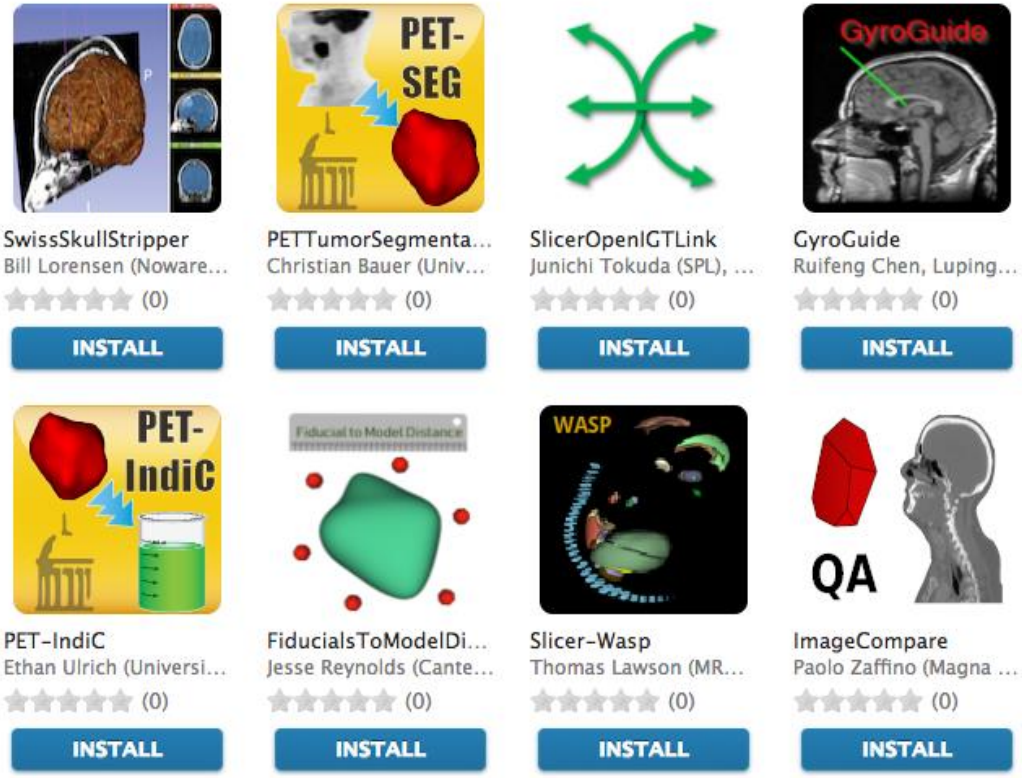
Slicer Modules



The type of module is transparent to the end-user

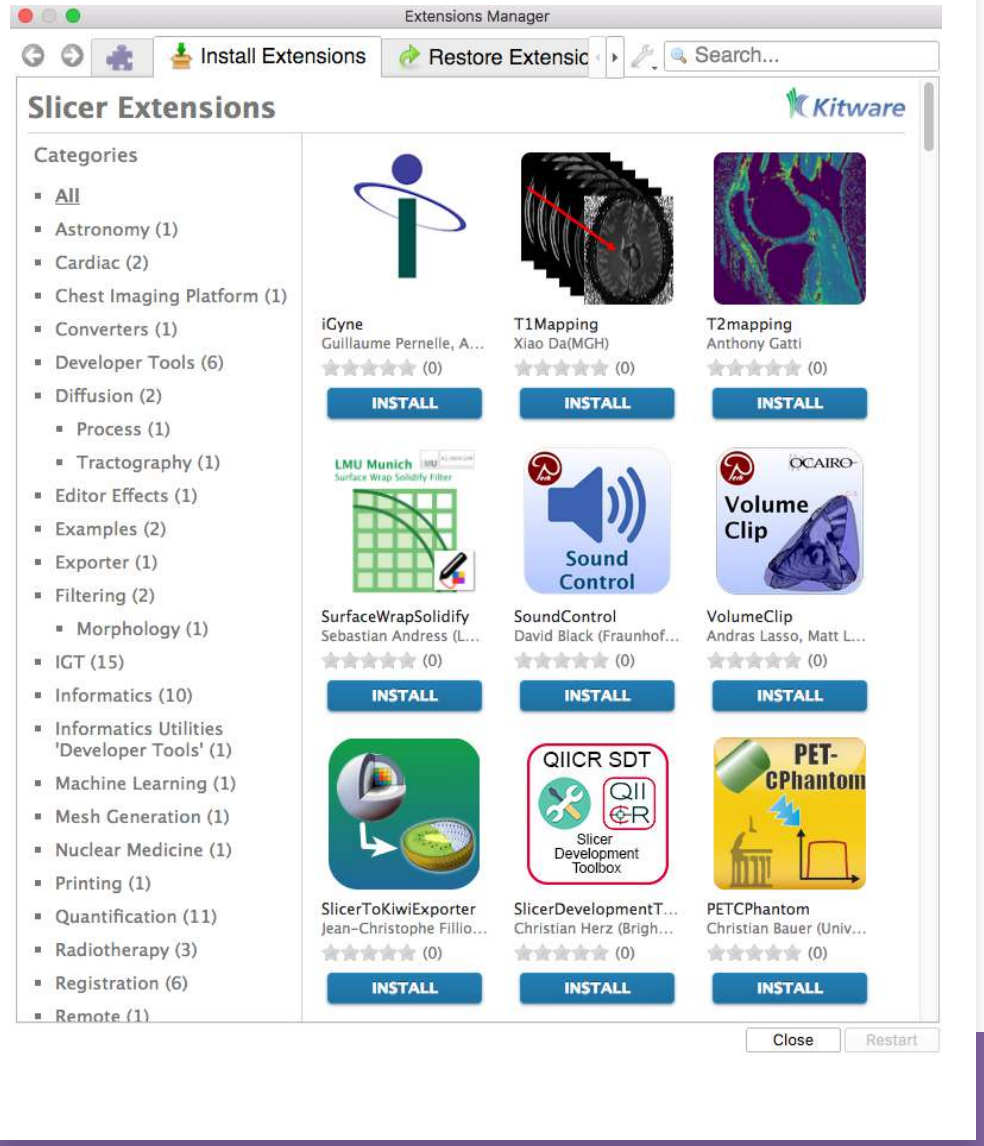
Slicer Extensions

A Slicer Extension is a delivery package bundling together one or more Slicer modules



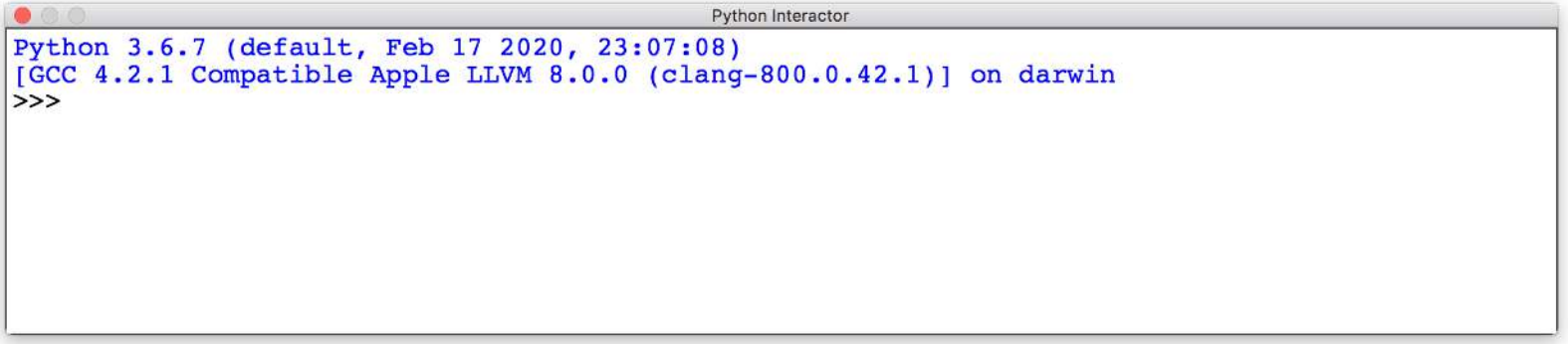
Slicer Extension Manager

- The Slicer Extension Manager provides an 'App store' platform for the 3D Slicer ecosystem
- The Extension Manager enables an easy creation and installation of Slicer extensions
- Slicer release version 5 includes over 130 extensions



Part 2

Getting Familiar with the Python environment in 3D Slicer



Python in Slicer

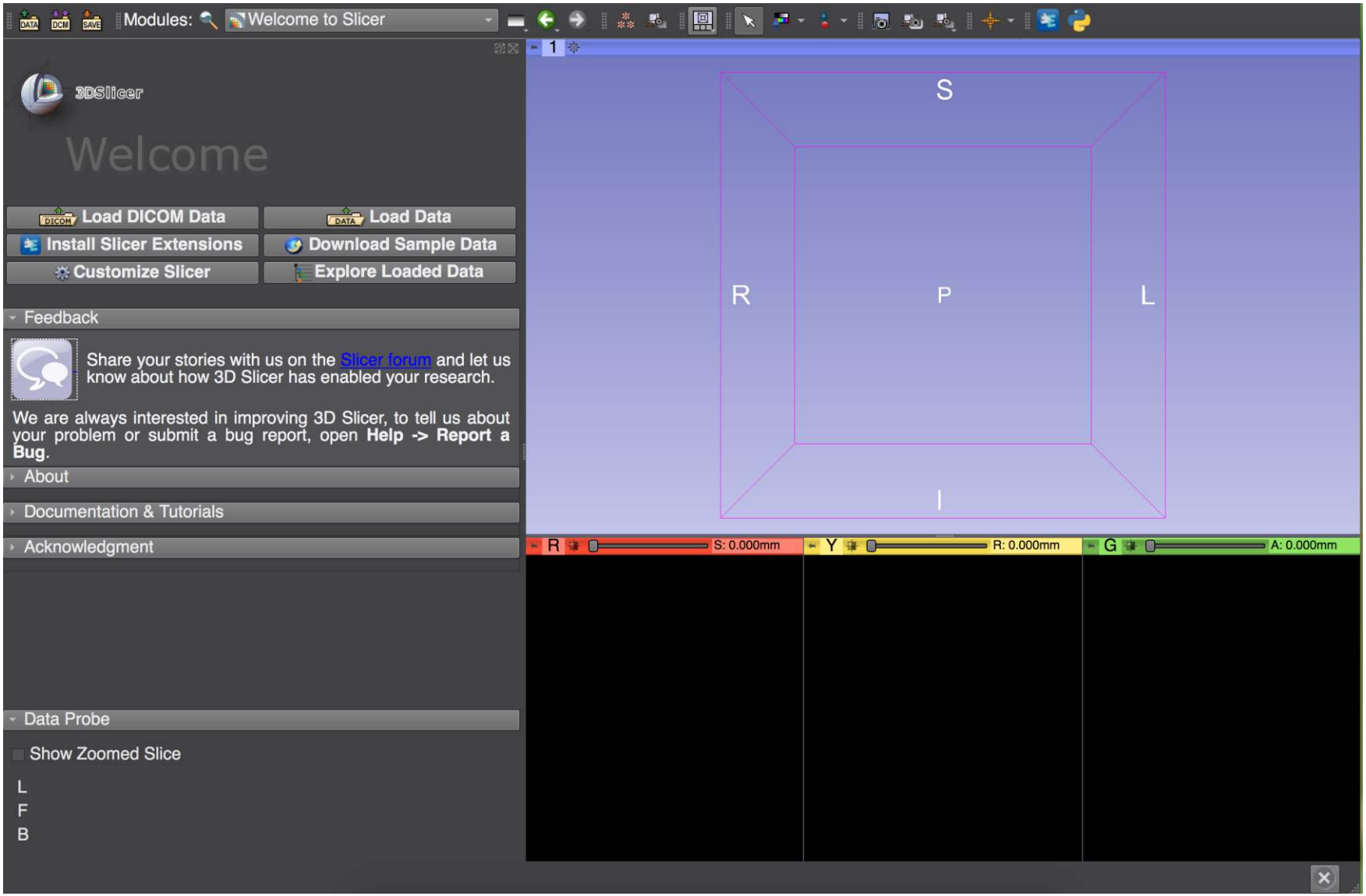
Slicer v5.10 works with **Python3** and a rich set of standard libraries

	NumPy is the fundamental package for scientific computing with Python.
	VTK is an open-source library for manipulating and displaying scientific data.
	ITK is an open-source library for image analysis.
	CTK is an open-source library for biomedical image computing.
	PythonQT is a Python binding for Qt.
	Qt is a cross-platform framework used as a graphical toolkit.

Python in Slicer

The **Python Package index (PyPi)** gives access to over 200,000 additional Python packages (http://pipy.org)

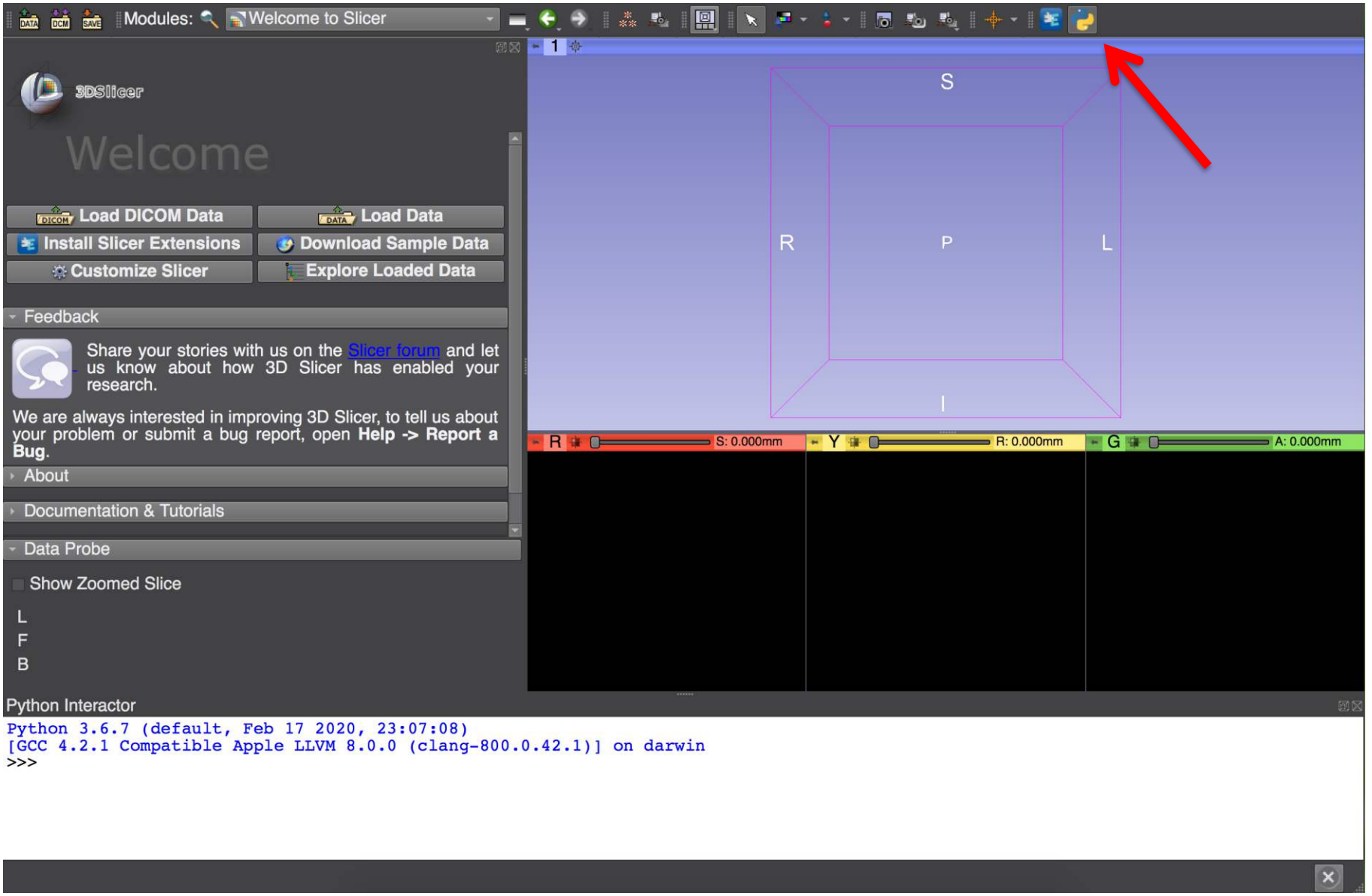
- The **pip install** command in Slicer enables developers to install most common scientific computing tools (e.g. TensorFlow, SciPy, PyTorch, Pandas, etc.)
- Slicer can be used as a **Jupyter notebook** kernel
- PyCharm and other Python development tools can be used with Slicer



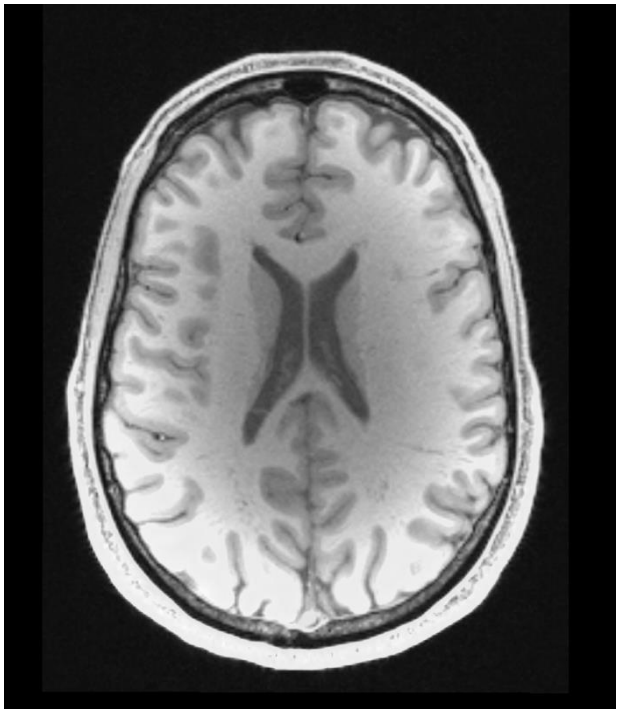
Slicer release version 5 integrates Python3, VTK5 and ITK5

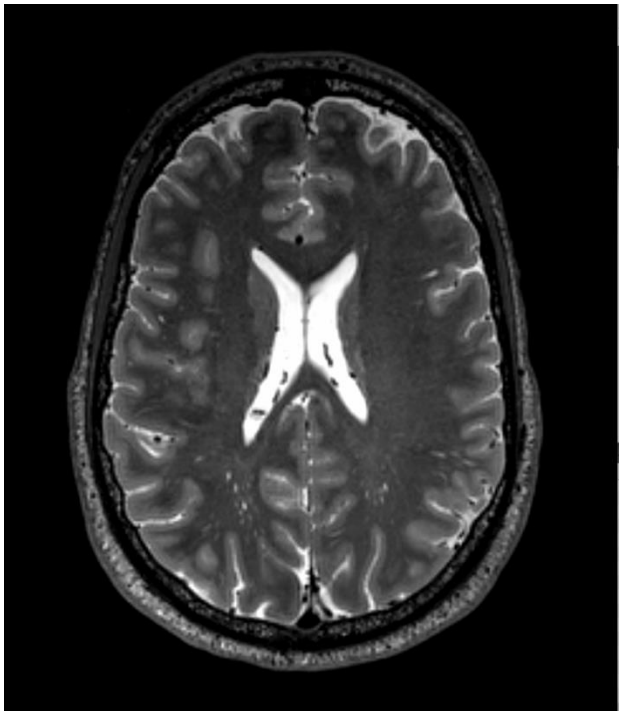
The Python Console in Slicer

The Python Interactor is a Qt-based console that enables direct access to Slicer MRML Nodes, libraries (NumPy, VTK, ITK, CTK) and Qt.



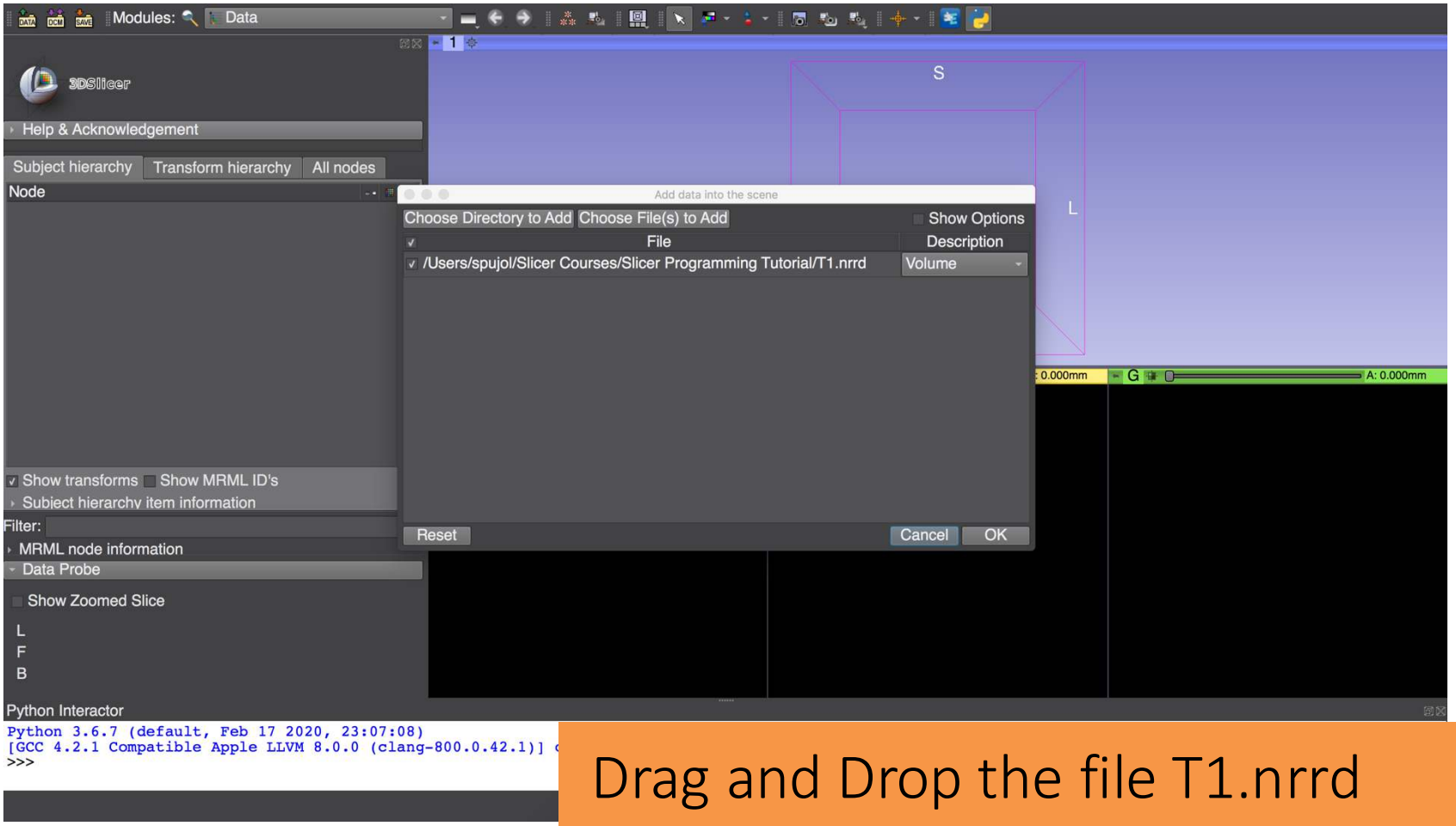
To access the Python Interactor, click on the Python icon in the top bar menu of Slicer





The Slicer Programming tutorial dataset includes a T1-weighted and a T2-weighted MRI scan of a healthy subject

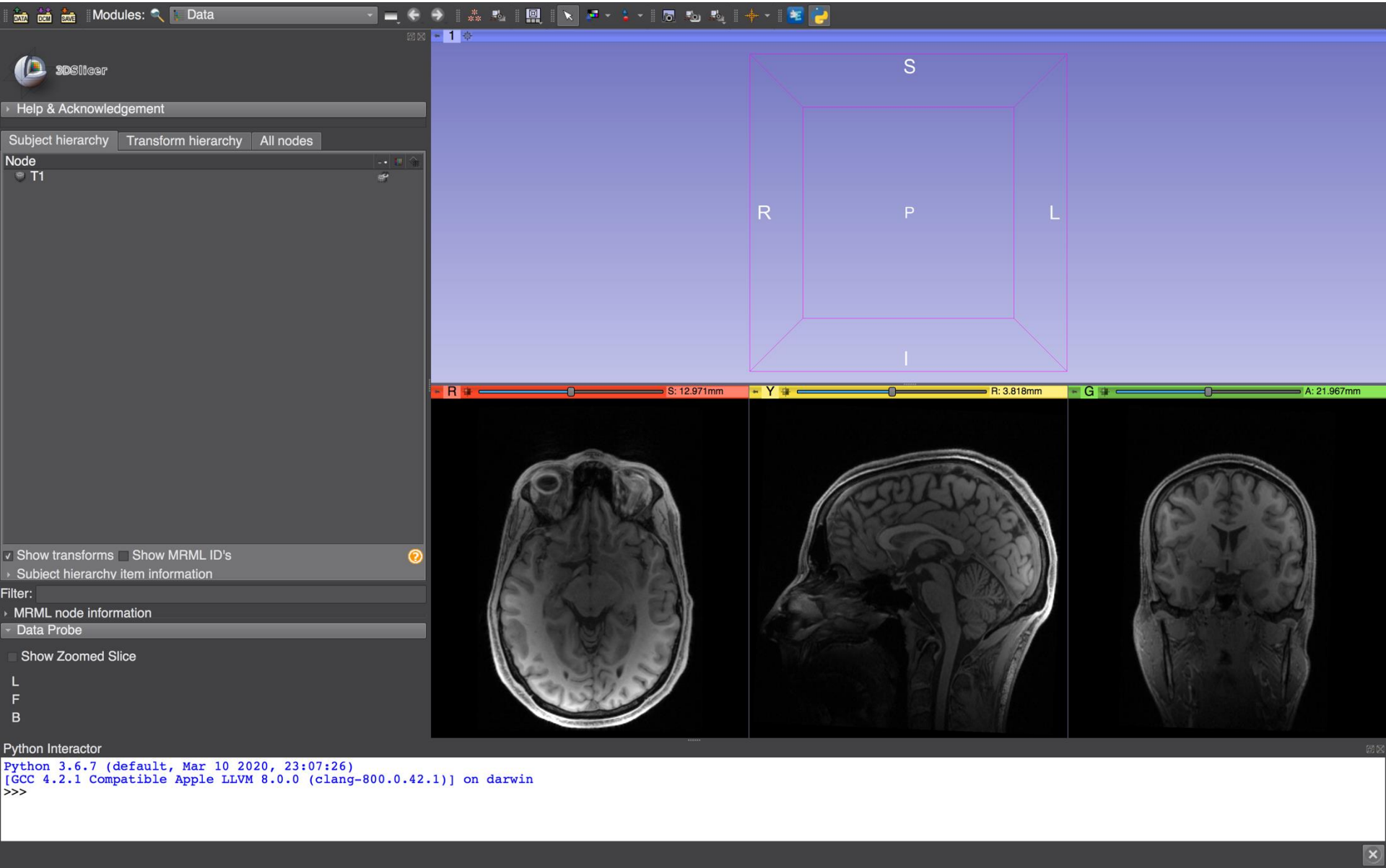
Tutorial dataset



Drag and Drop the file T1.nrrd

Click on OK to load the file in Slicer

Tutorial dataset



Big Picture

- Slicer is free and open-source software

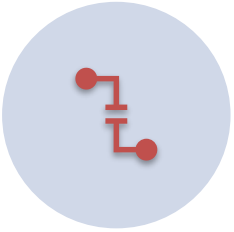
- There are thousands of sophisticated medical images available on the Internet that you could visualize and analyze with 3D Slicer

Slicer Data Model

The **Slicer Data Model** is based on the Slicer Scene Data Structure

A **Slicer scene** is a collection of images, annotations, 3D models, spatial transforms, fiducials and cameras

The **Medical Reality Markup Language (MRML)** is an XML-based language used to serialize the content of Slicer scene on disk (scene.mrml)



Each element a scene is called a **MRML node**

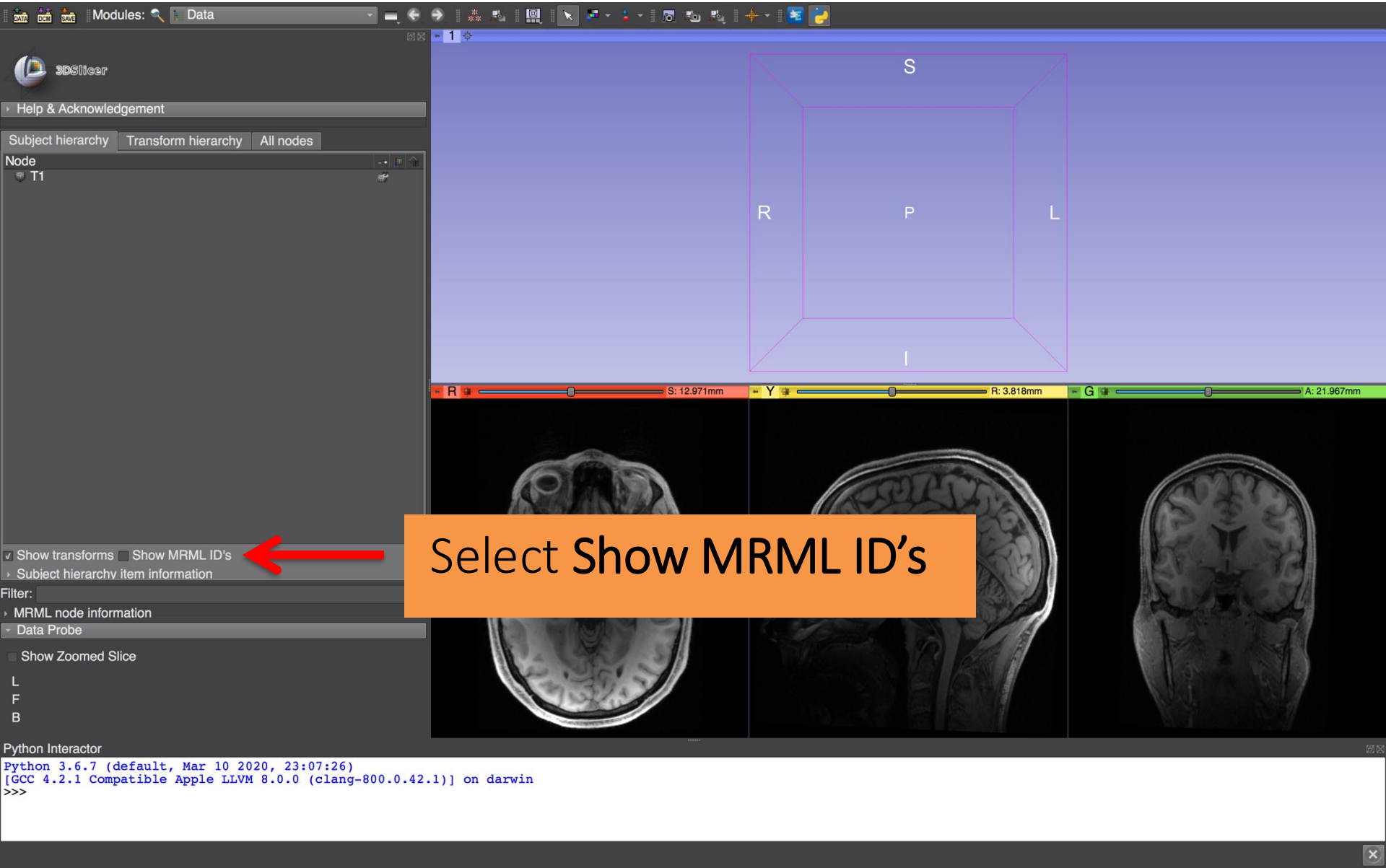
Slicer MRML Nodes: Basic Types

Data Node: Stores the raw data

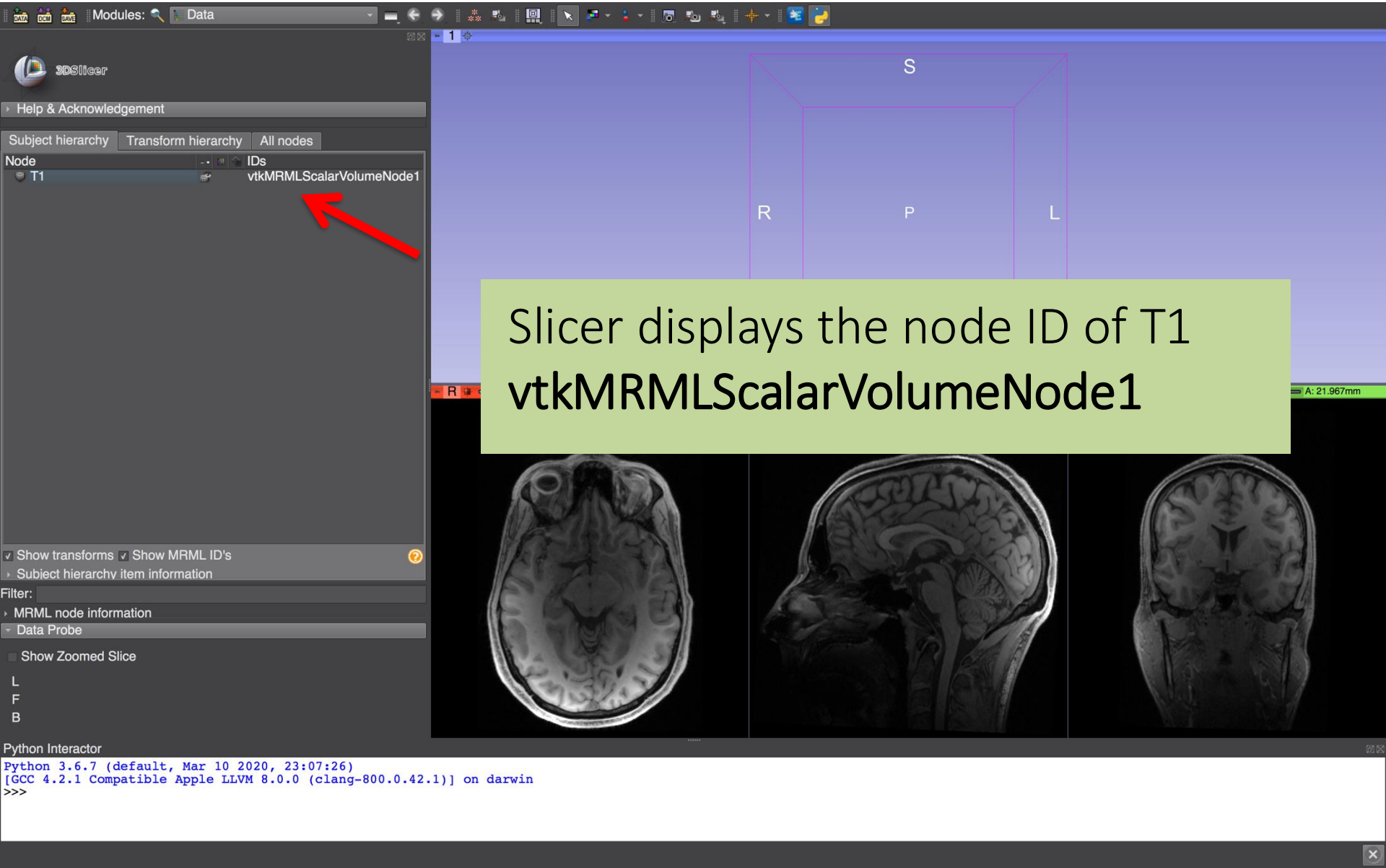
Display Node: Describes how the data should be visualized

Storage Node: Describes how the data should be stored on disk

Tutorial dataset



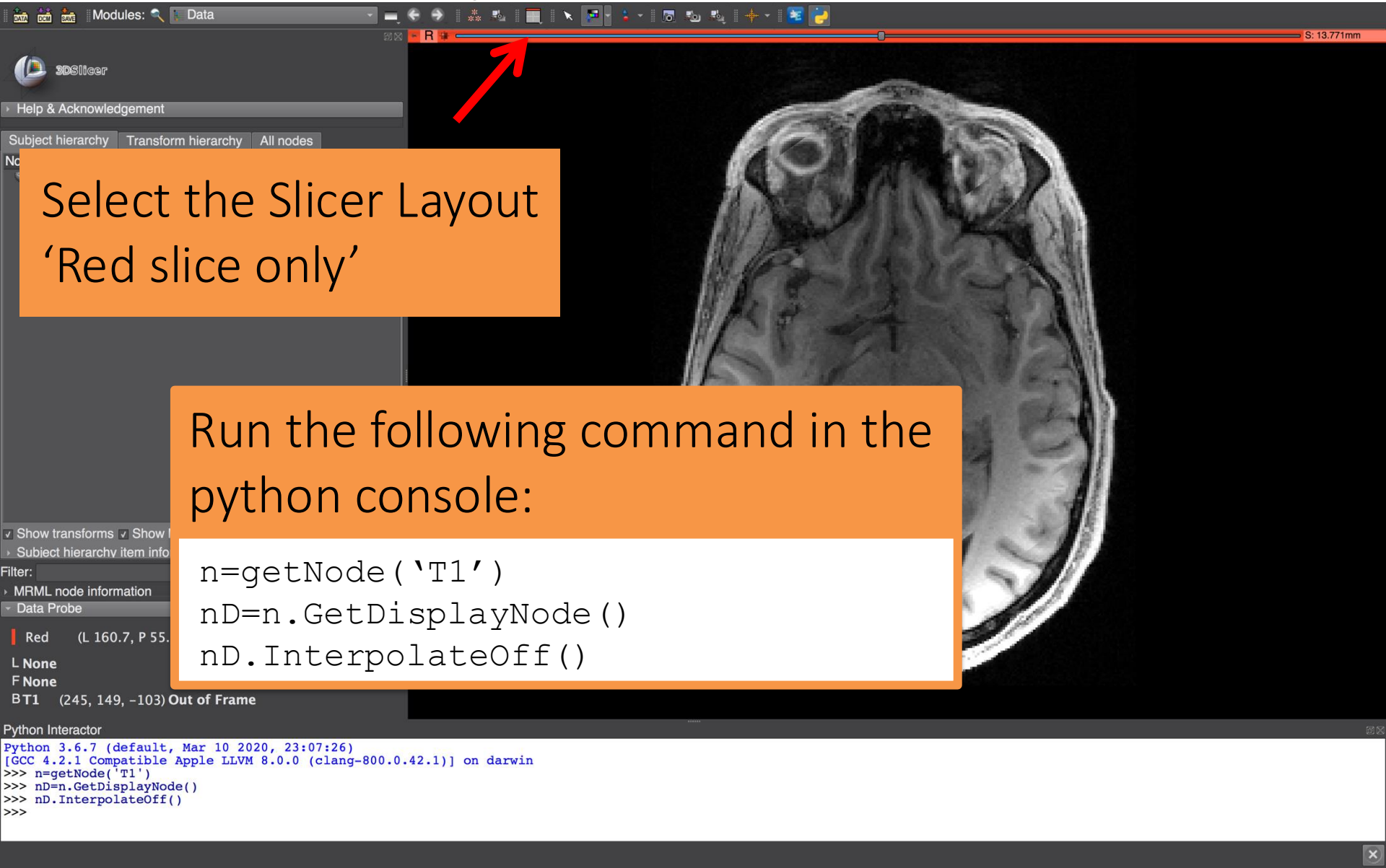
Slicer Data Model



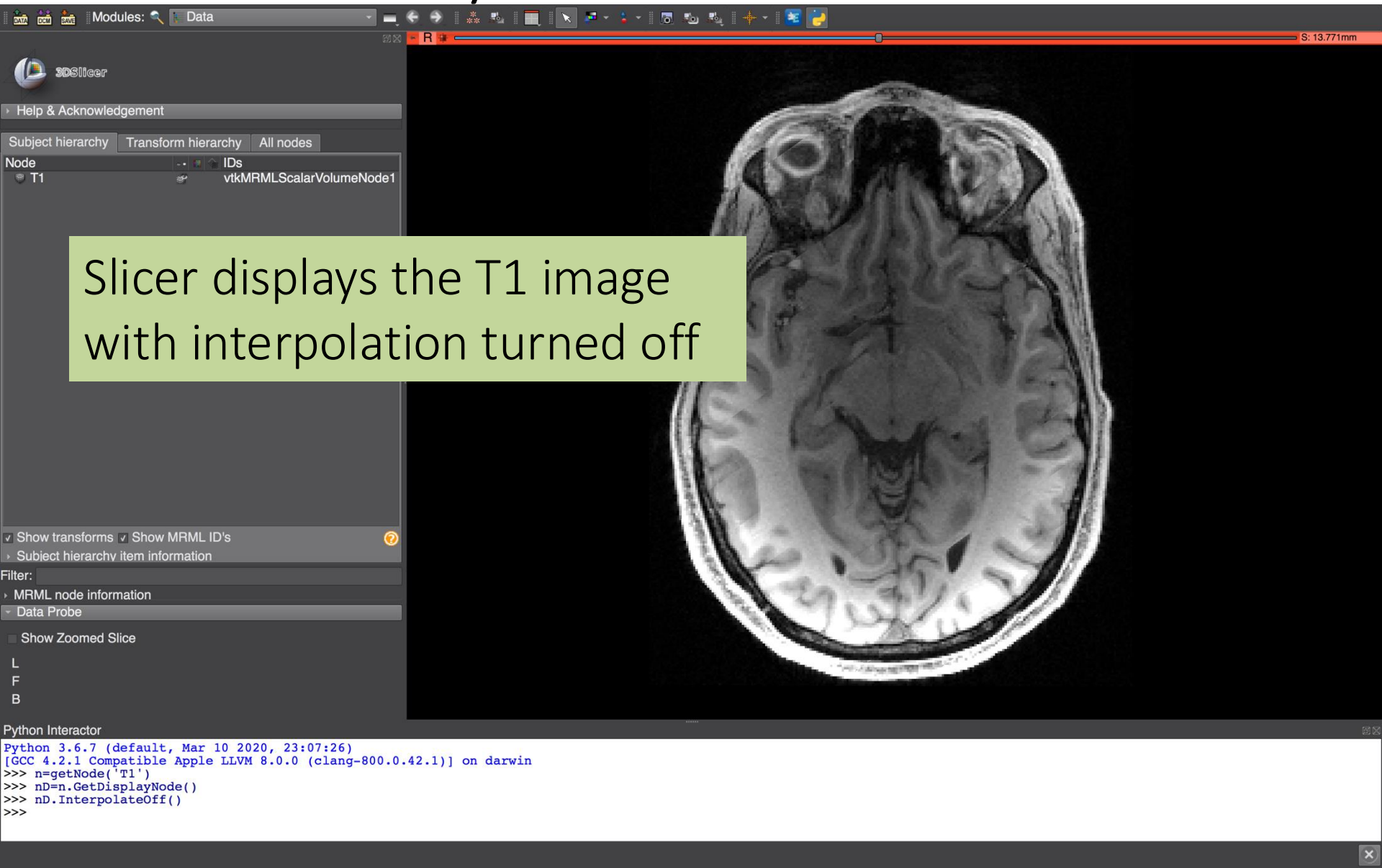
Slicer displays the node ID of T1

vtkMRMLScalarVolumeNode1

Accessing MRML nodes from the Python interactor

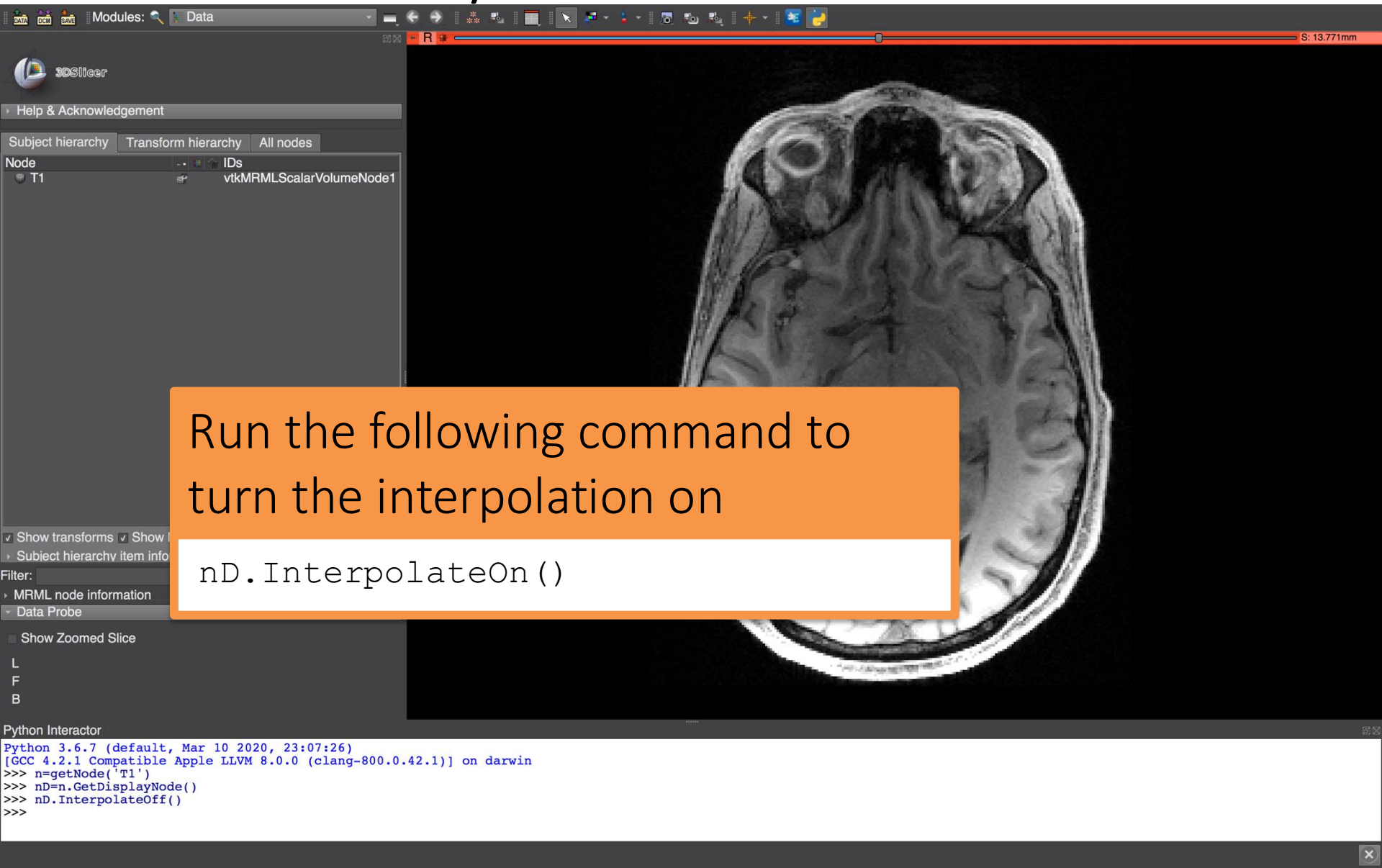


Accessing MRML nodes from the Python interactor



Slicer displays the T1 image with interpolation turned off

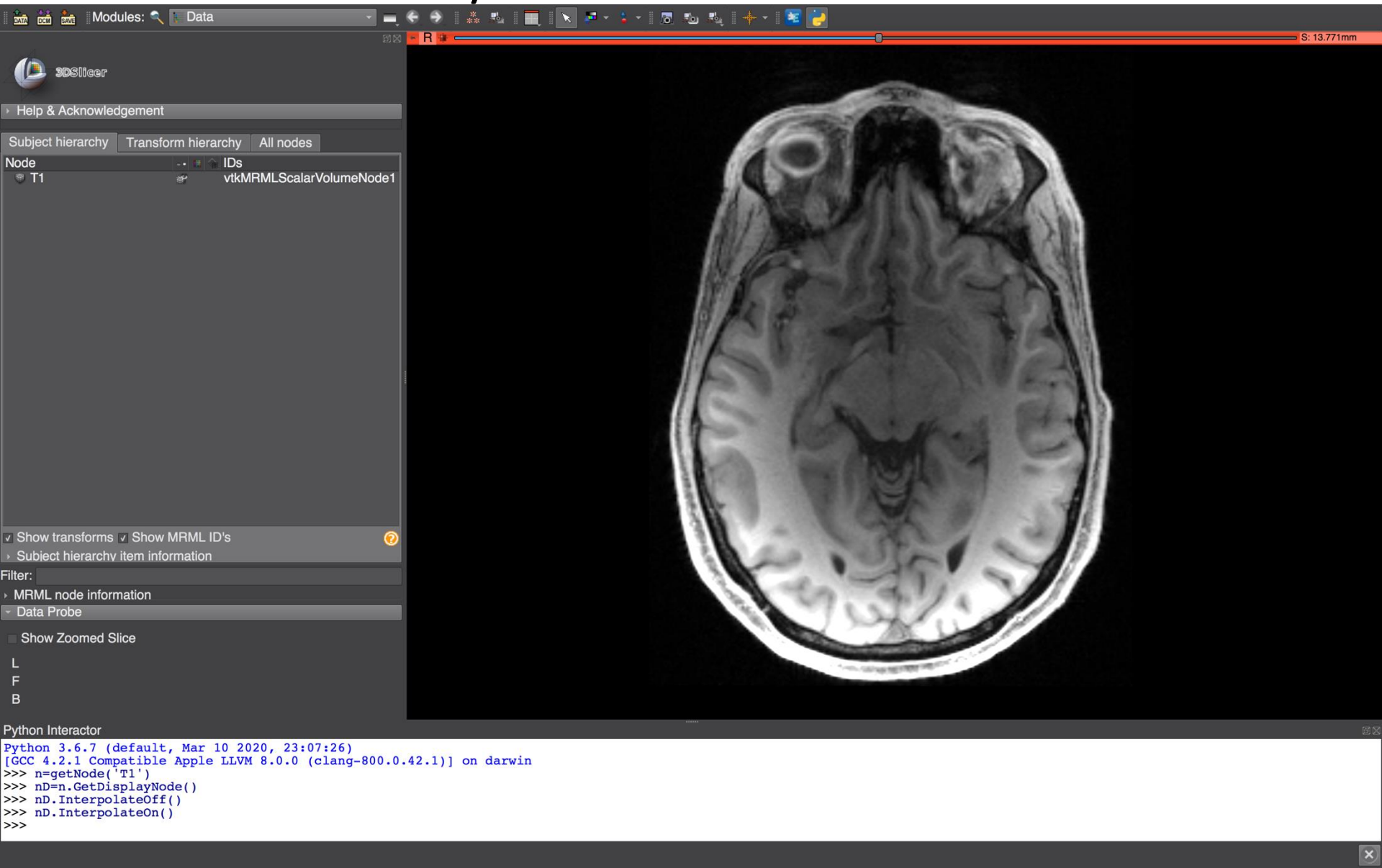
Accessing MRML nodes from the Python interactor



Run the following command to turn the interpolation on

```
nD.InterpolateOn()
```

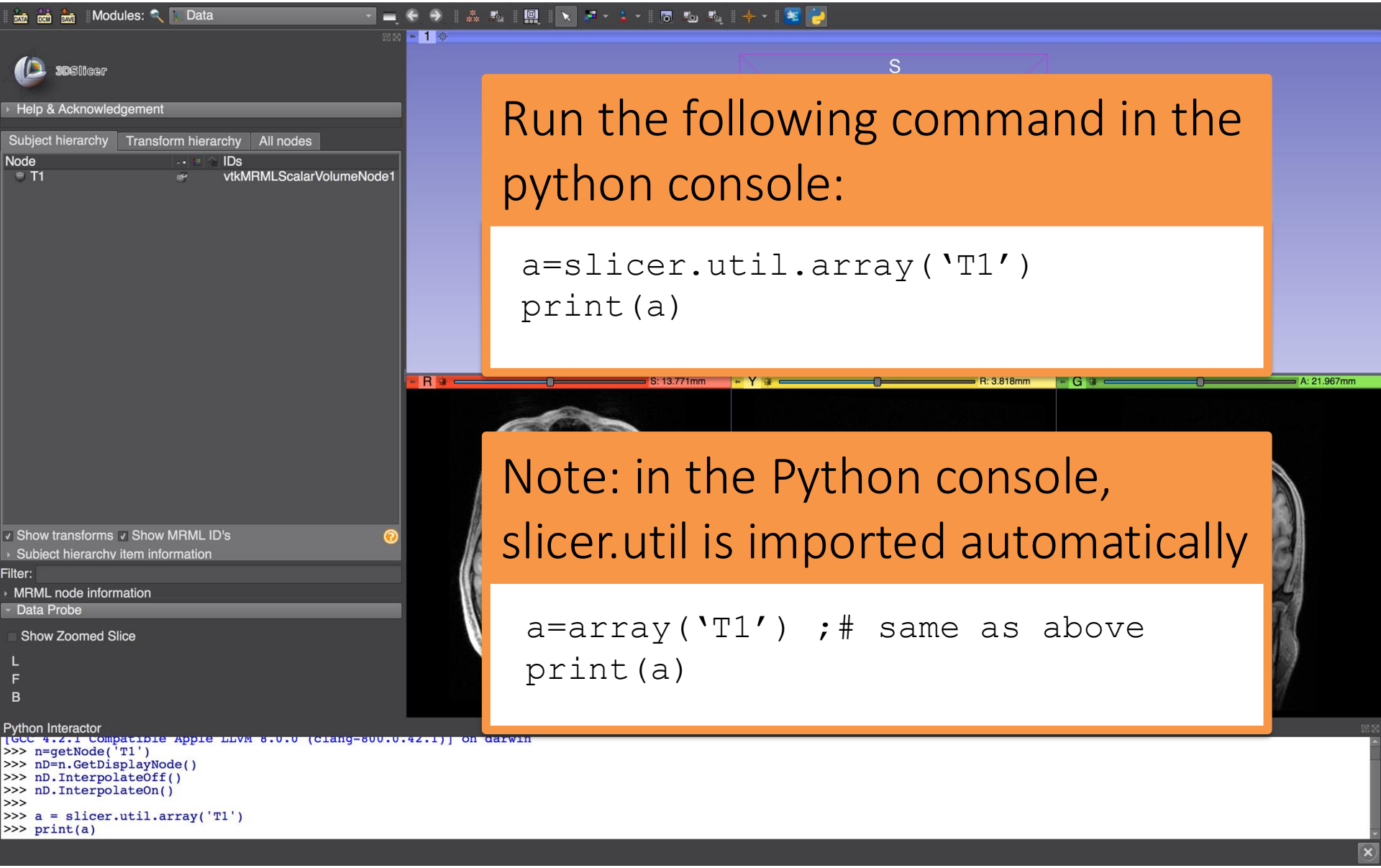
Accessing MRML nodes from the Python interactor



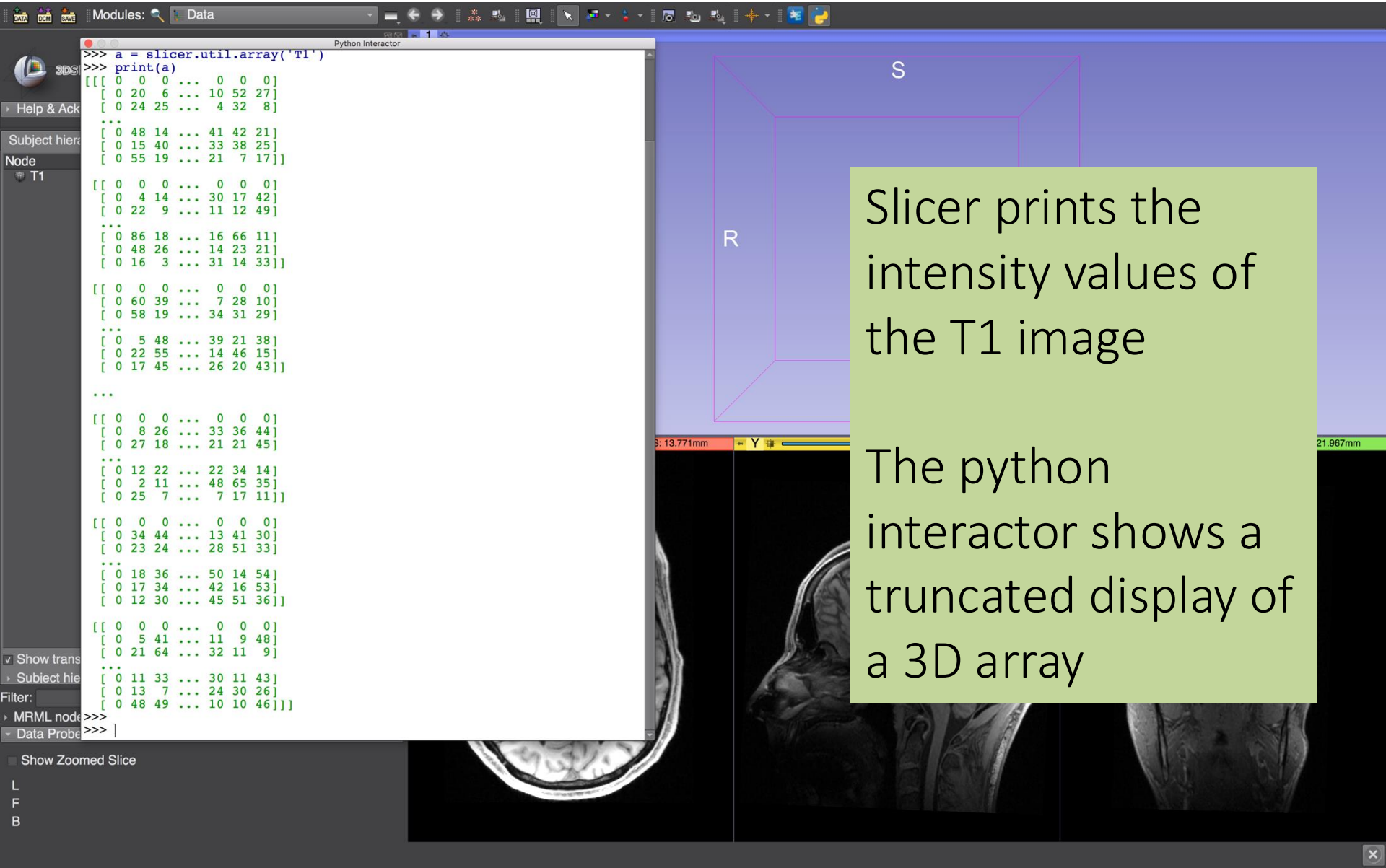
Accessing voxels in a volume

- The `slicer.util` package gives access to volumes as NumPy multidimensional **arrays**
- Volumes can be modified using standard NumPy methods

Accessing voxels in a volume



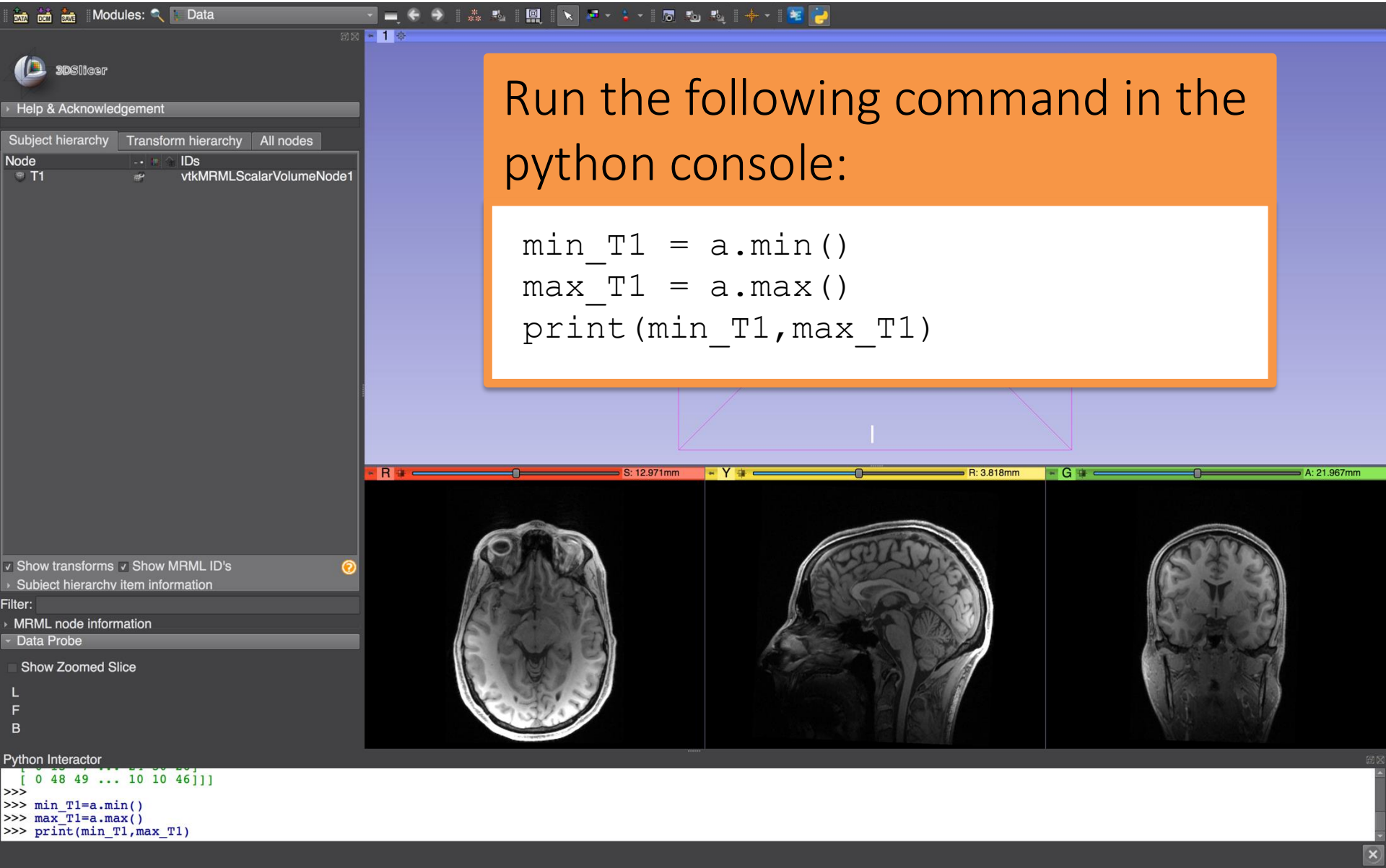
Accessing voxels in a volume



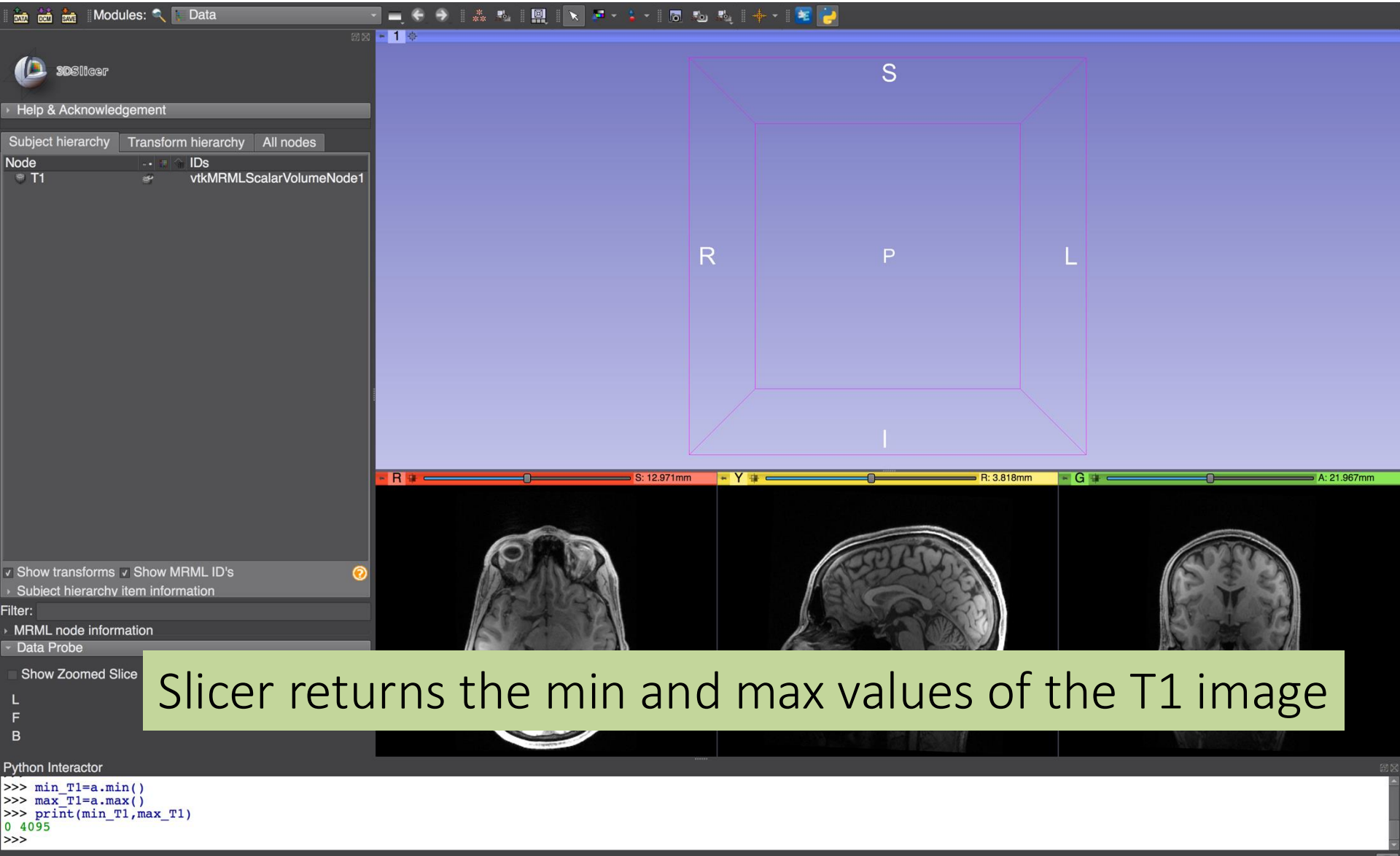
Slicer prints the intensity values of the T1 image

The python interactor shows a truncated display of a 3D array

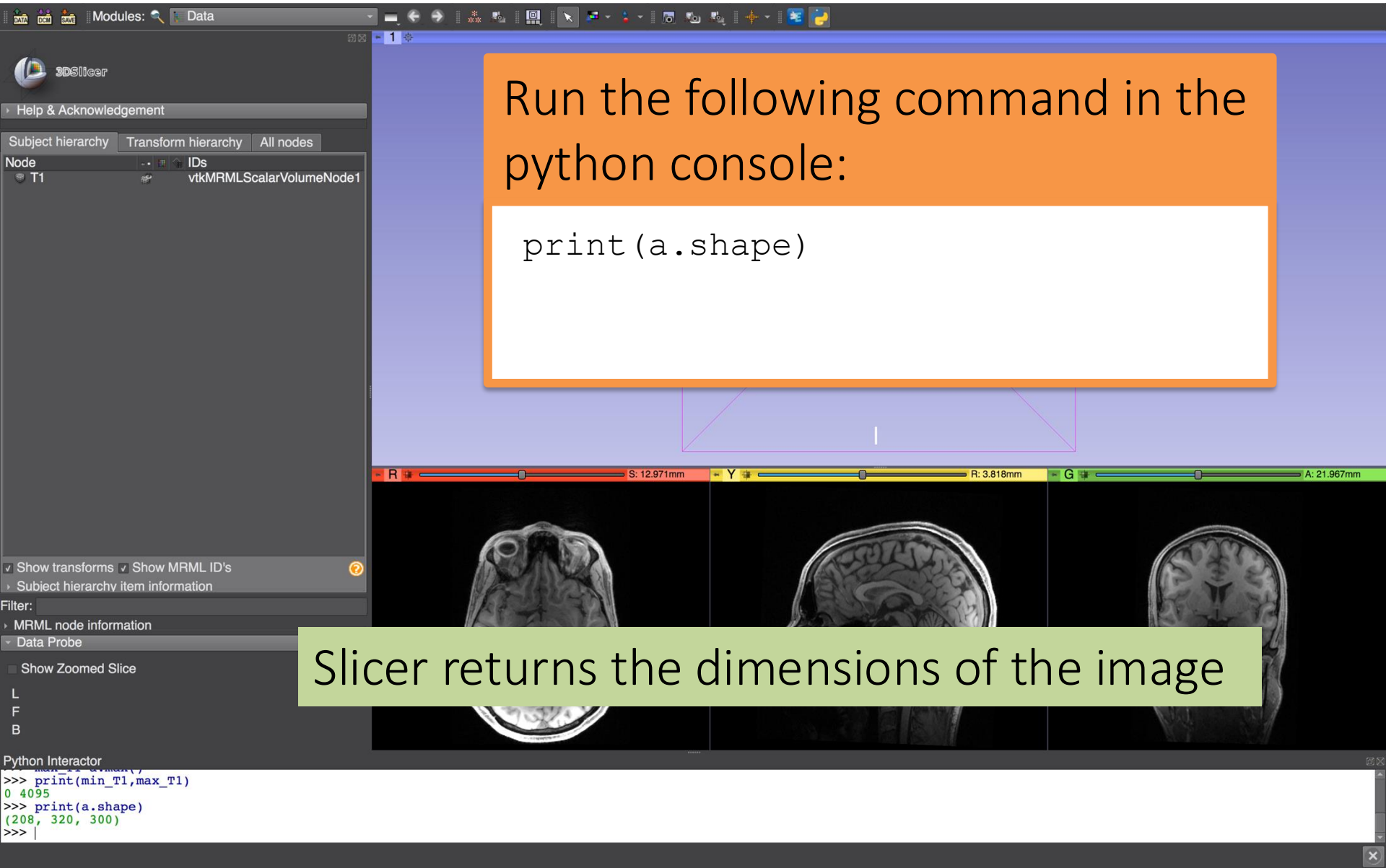
Accessing voxels in a volume



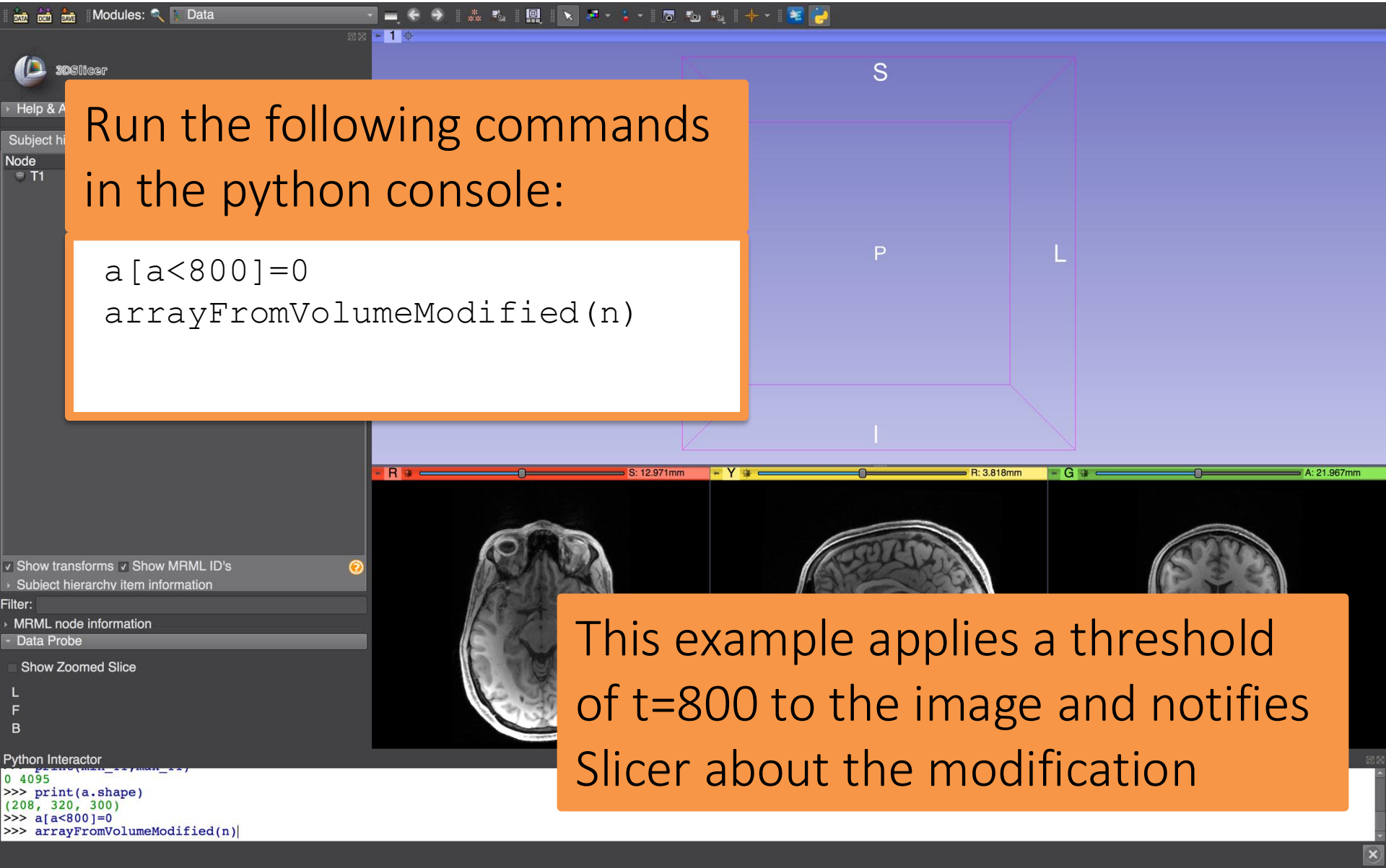
Accessing voxels in a volume



Modifying voxels in a volume



Modifying voxels in a volume

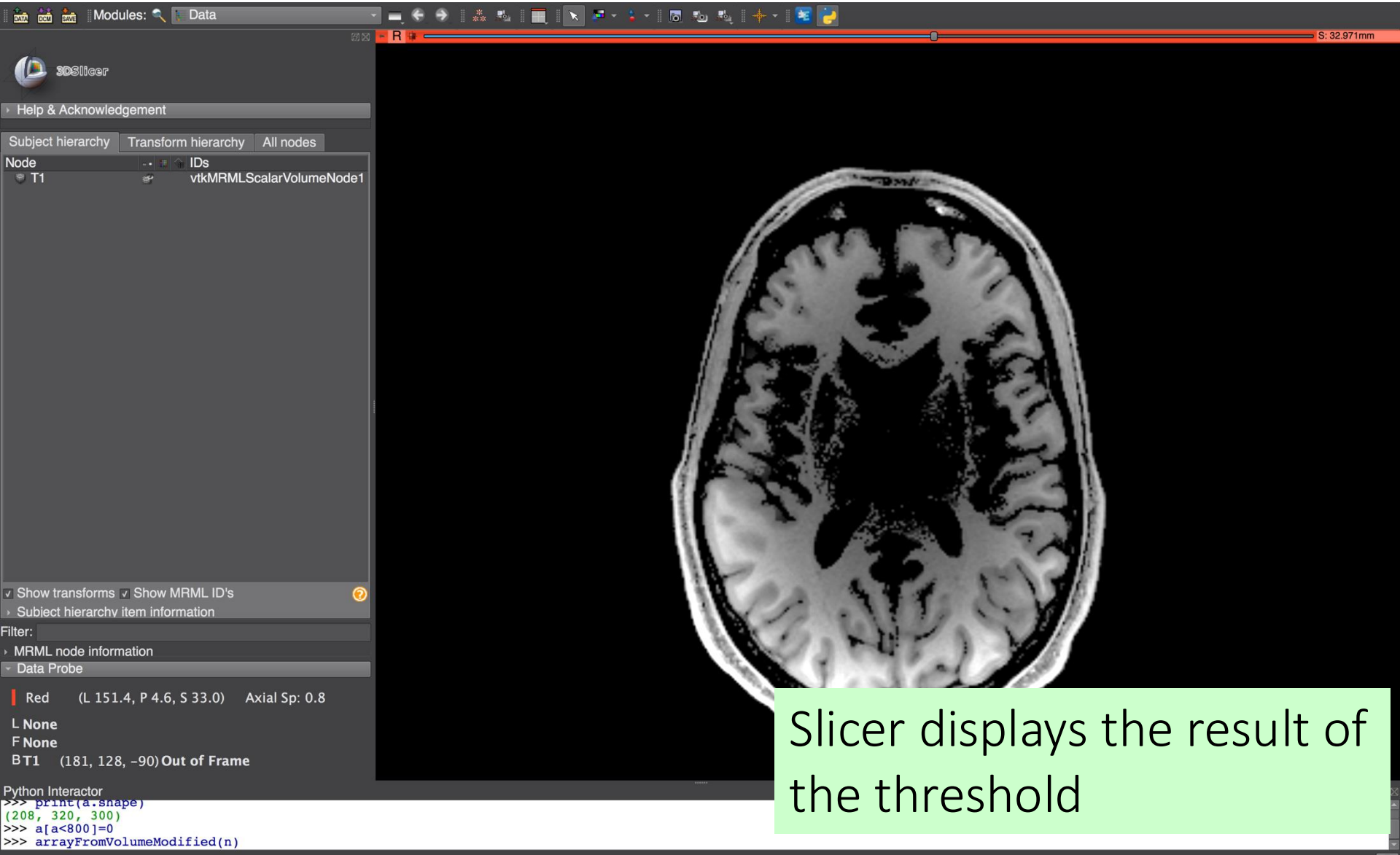


Run the following commands in the python console:

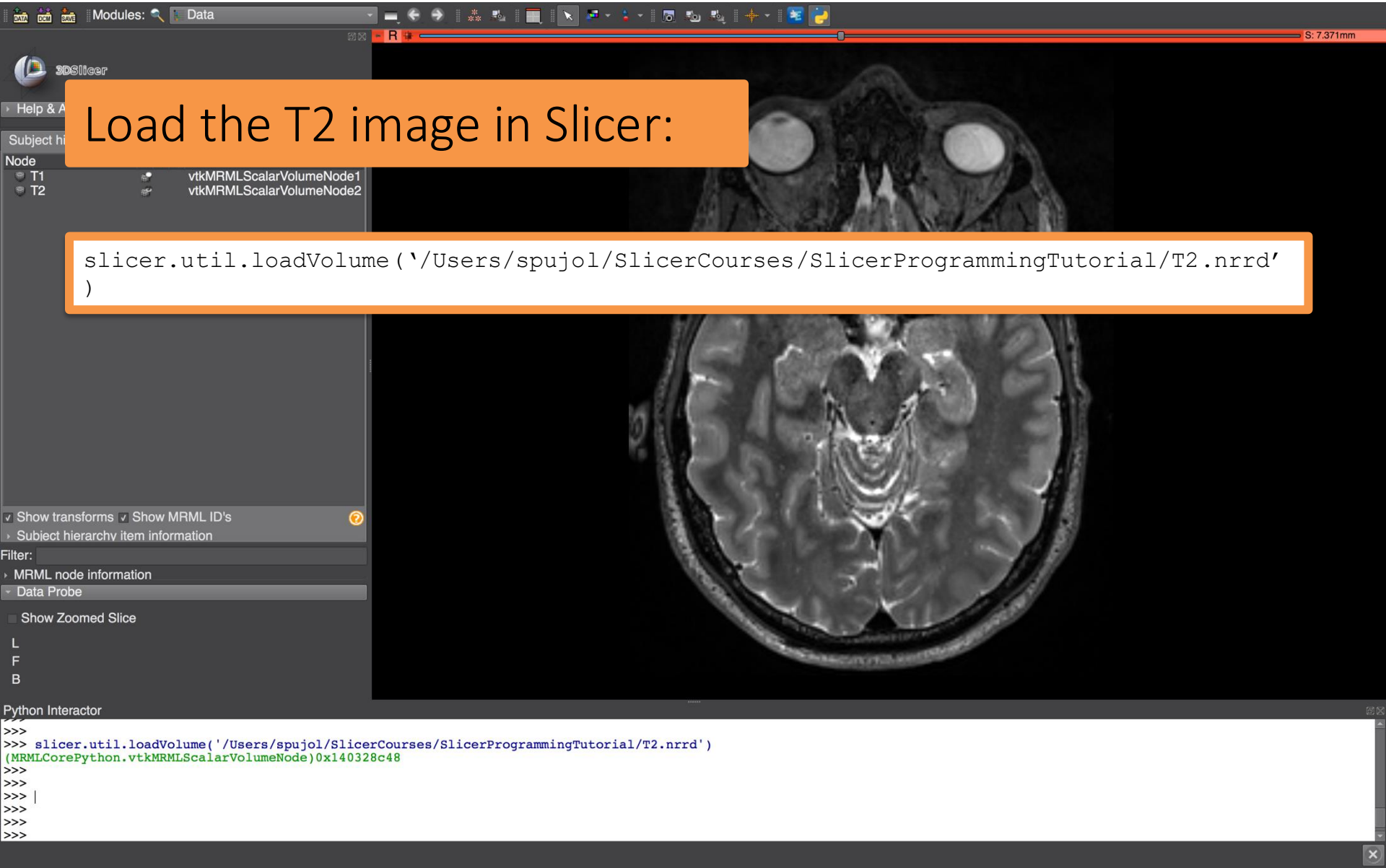
```
a[a<800]=0
arrayFromVolumeModified(n)
```

This example applies a threshold of t=800 to the image and notifies Slicer about the modification

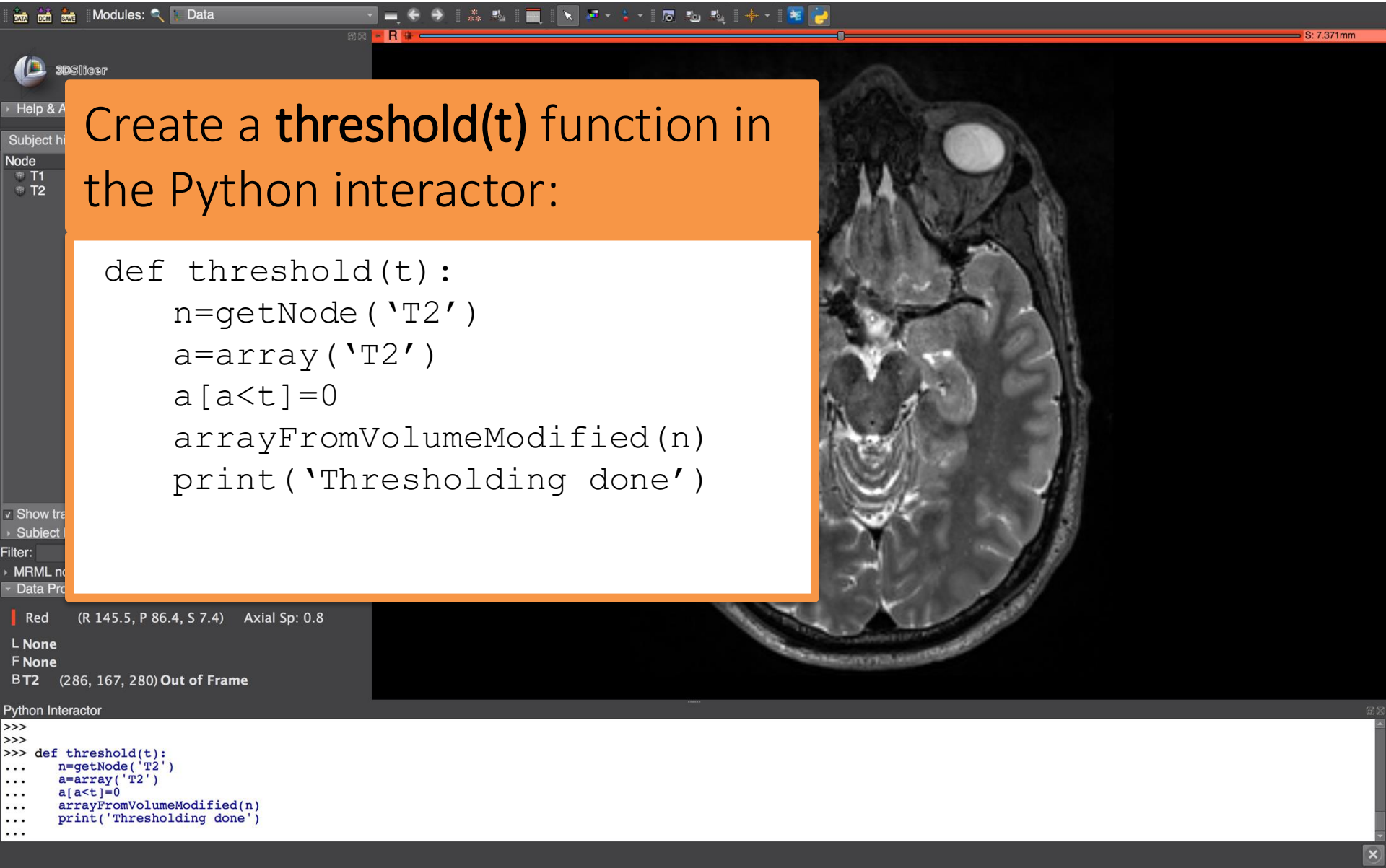
Modifying voxels in a volume



Loading the T2 volume



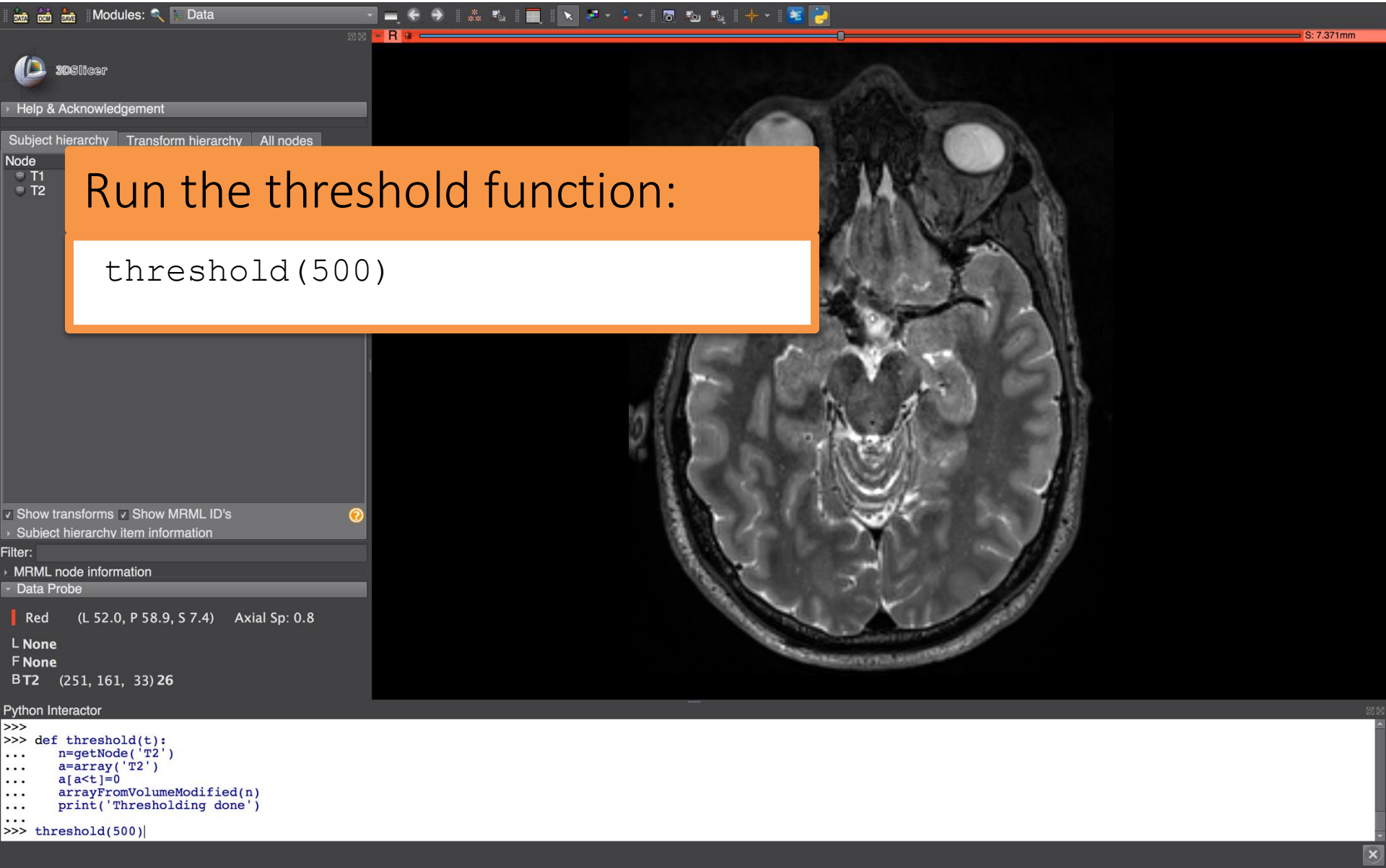
Python function: threshold



Create a **threshold(t)** function in the Python interactor:

```
def threshold(t):
    n=getNode('T2')
    a=array('T2')
    a[a<t]=0
    arrayFromVolumeModified(n)
    print('Thresholding done')
```

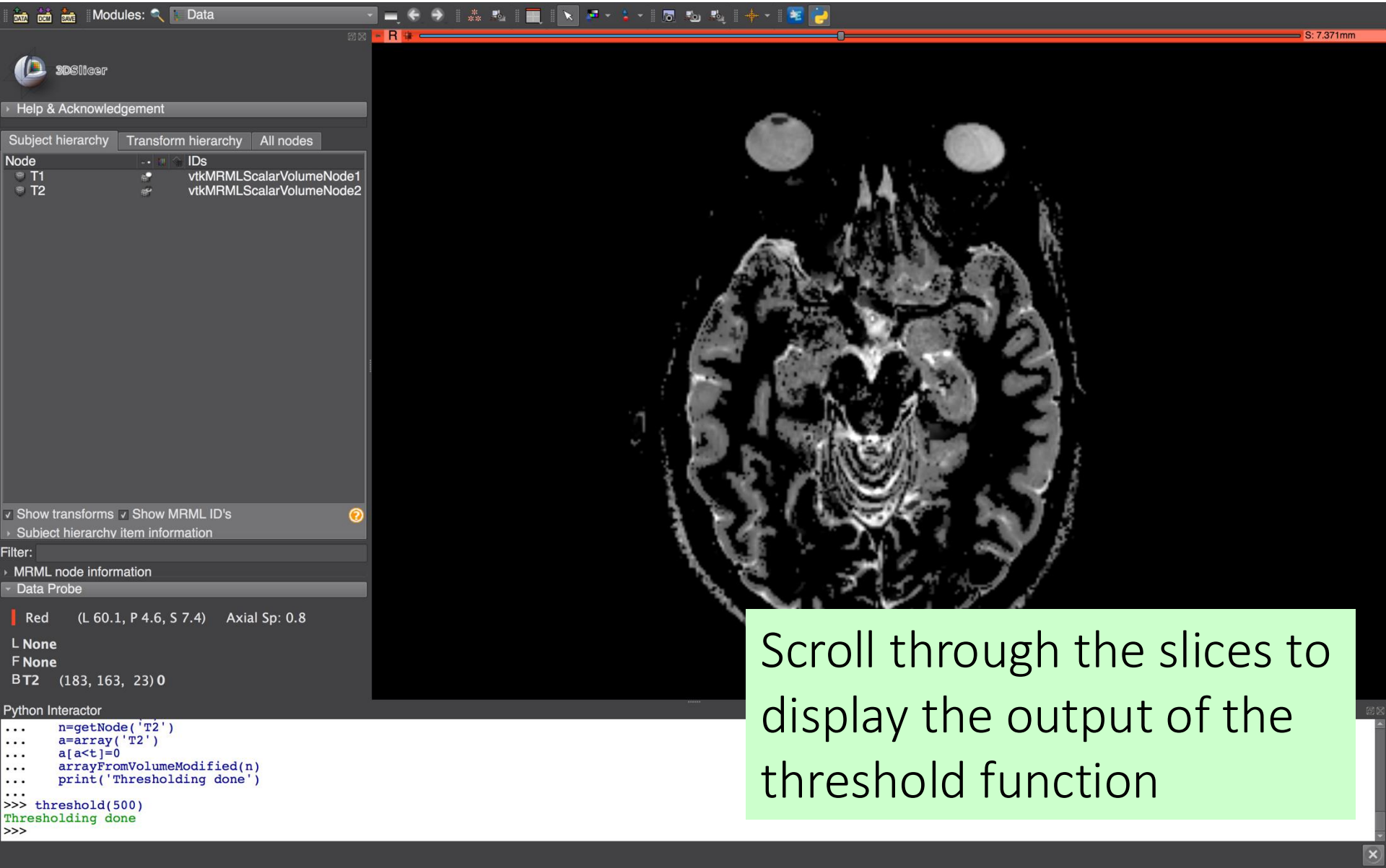
Python function: threshold



Run the threshold function:

```
threshold(500)
```

Python function: threshold



Big Picture

- Slicer provides easy access to analyze and modify complex data types
- Slicer is compatible with a wide range of Python scientific computing packages
- Slicer is a research environment for performing medical imaging experiments

Part 3

Getting familiar with Qt in Slicer

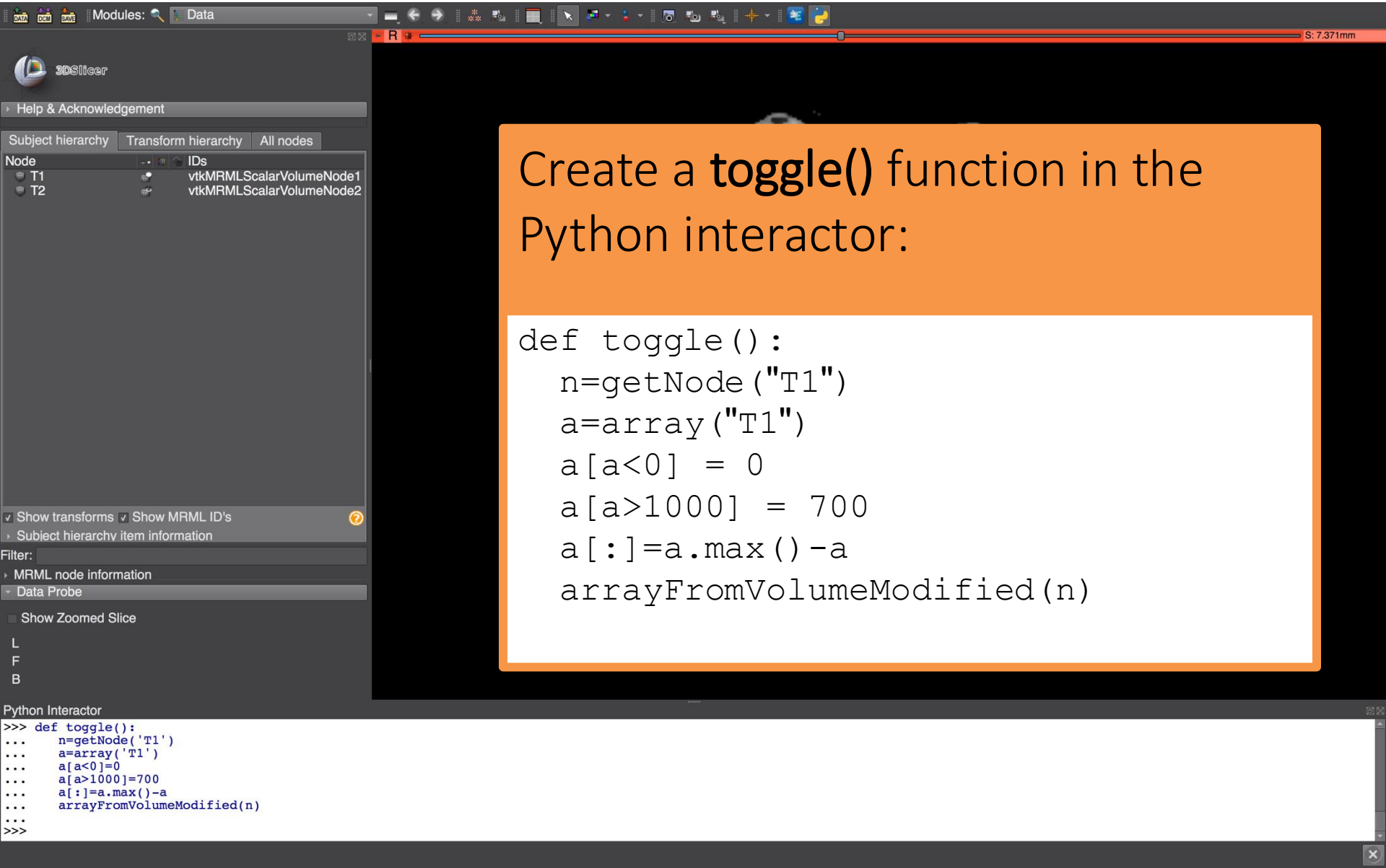
Qt & PythonQt

- **Qt** is the main tool in Slicer to create widgets, dialogs, text entries, etc.

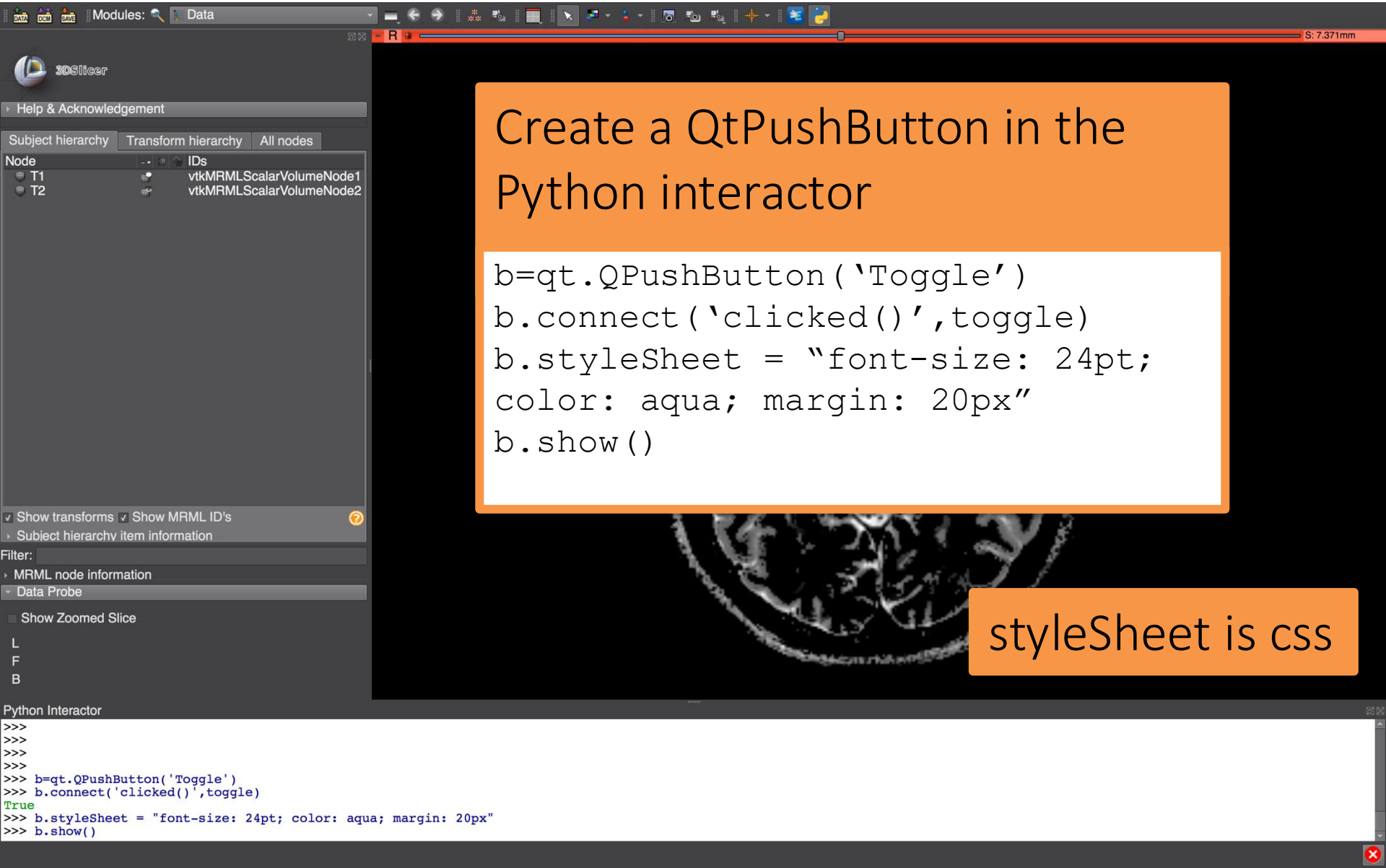
- **PythonQt** exposes most Qt functionalities and is accessible through the Python interactor in Slicer

- User interfaces can be created on the fly for rapid prototyping and debugging

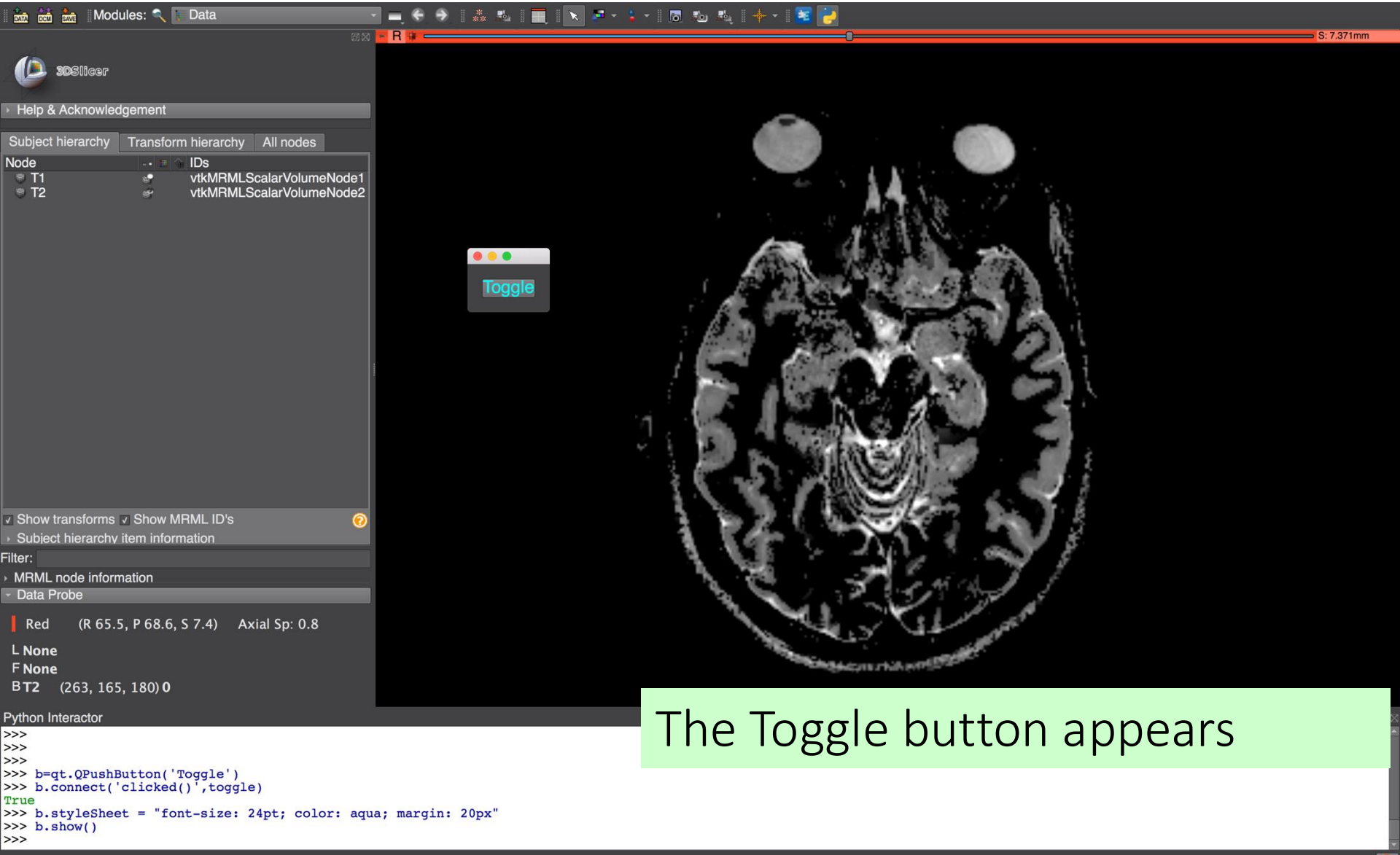
Python function: toggle



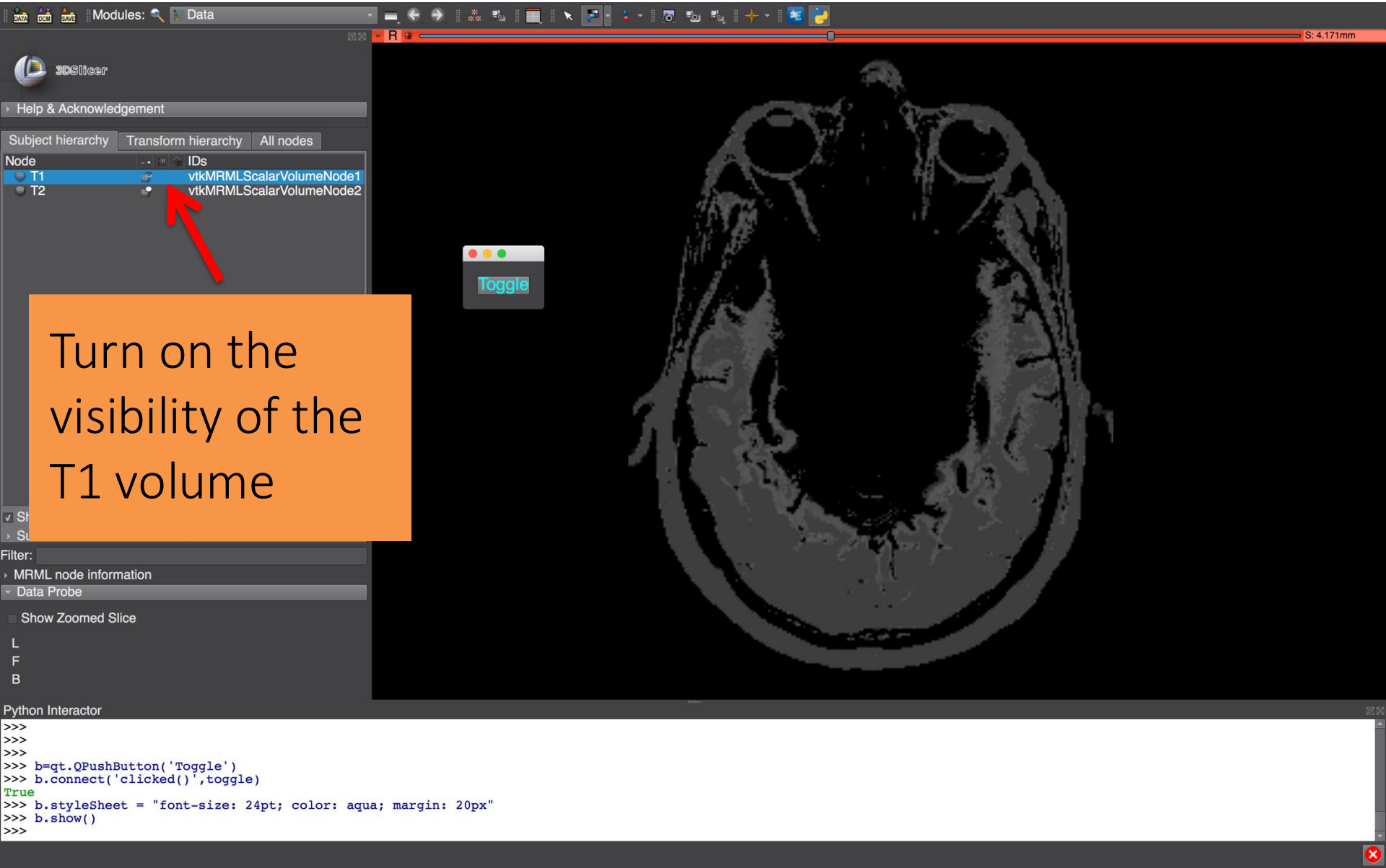
Creating a Qt Push Button



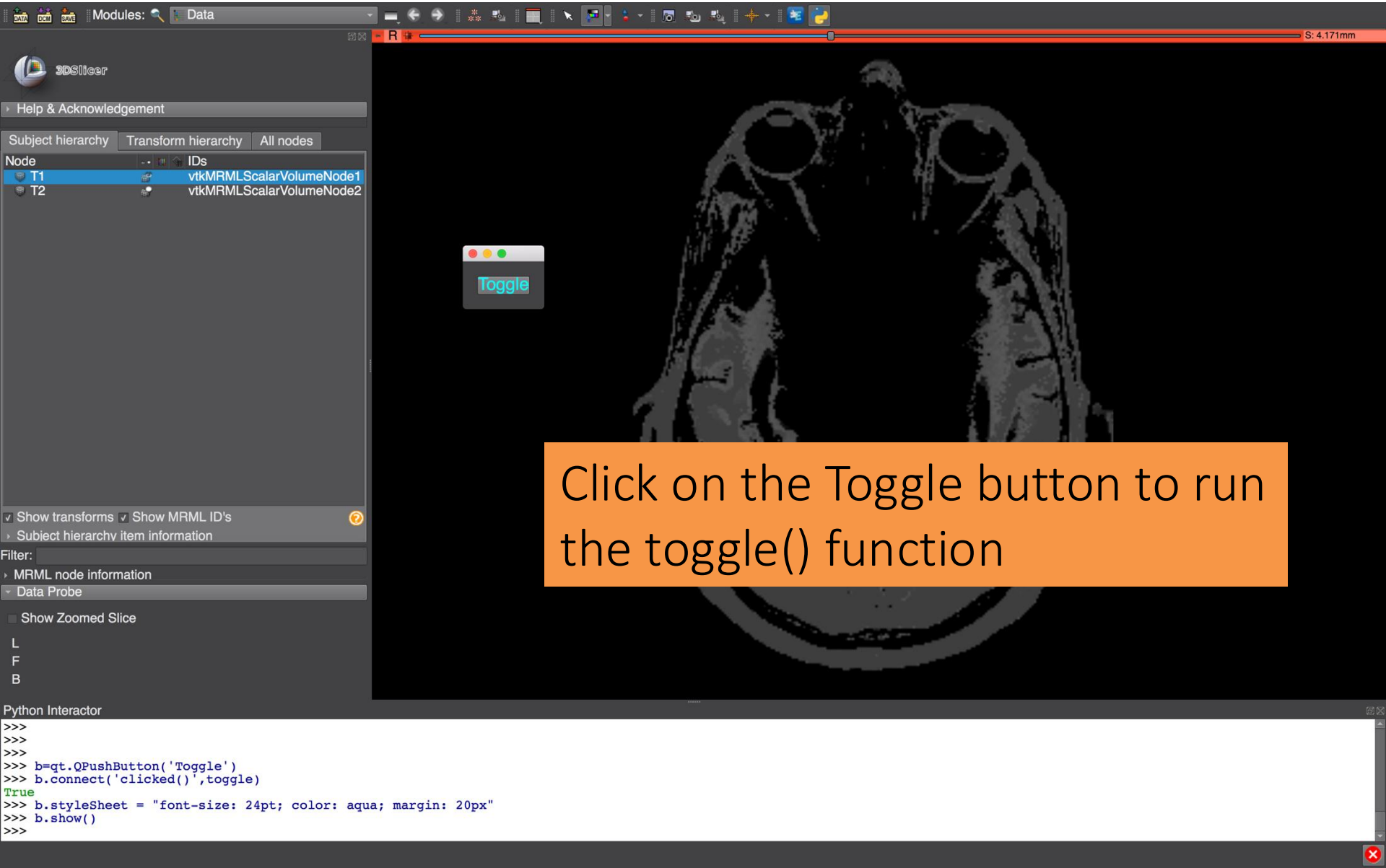
Creating a Qt Push Button



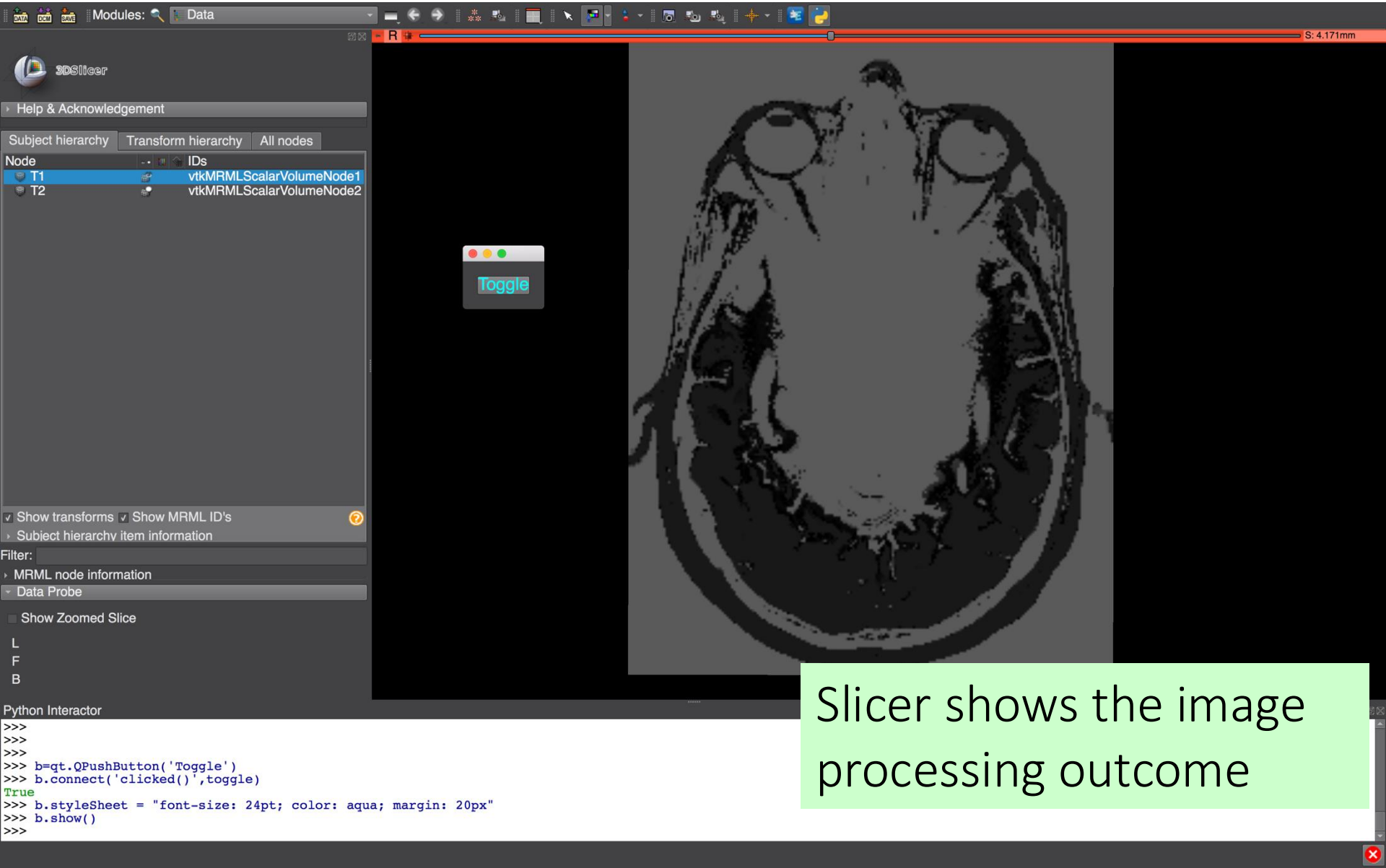
Creating a Qt Push Button



Creating a Qt Push Button



Creating a Qt Push Button



Examples of scripted modules

- The tutorial demonstrates how to create a simple interface in Python

- Slicer integrates many sophisticated scripted module such as Segment Statistics, Sample Data, Endoscopy module, etc.

- For further reading, please look at the Slicer Script Repository:

https://slicer.readthedocs.io/en/latest/developer_guide/script_repository.html

Conclusion

- Slicer enables developees to create complex interfaces that are streamlined for target users
- The software platform provides unlimited customization possibilities
- Slicer gives access to advanced underlying libraries through a cross-platform package that is easy to deploy to end-users

Acknowledgments

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(NIBIB P41 EB015902)