

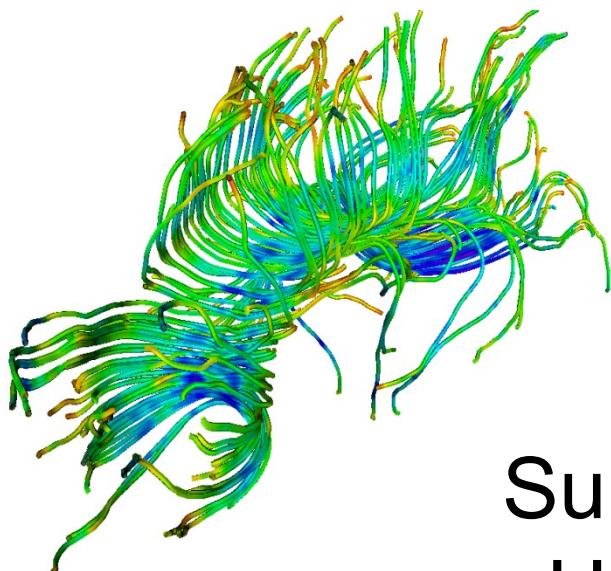


NA-MIC

National Alliance for Medical Image Computing

<http://www.na-mic.org>

Diffusion Tensor Imaging Tutorial



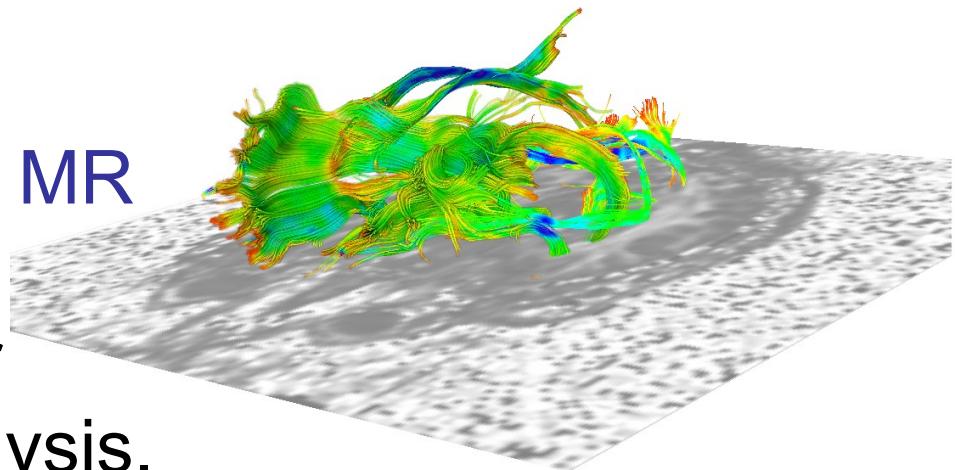
Sonia Pujol, Ph.D.

Surgical Planning Laboratory
Harvard Medical School



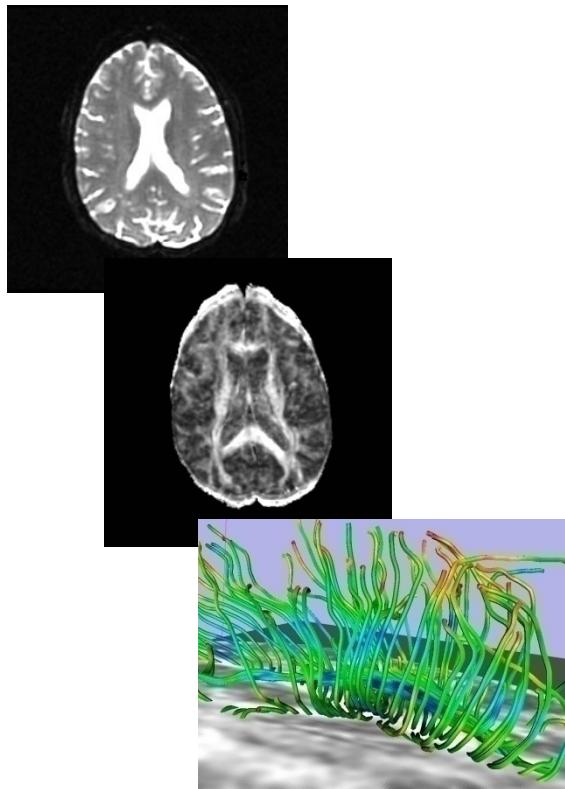
DTI tutorial

This tutorial is an introduction to the advanced **Diffusion MR** capabilities of the **Slicer3** software for medical image analysis.





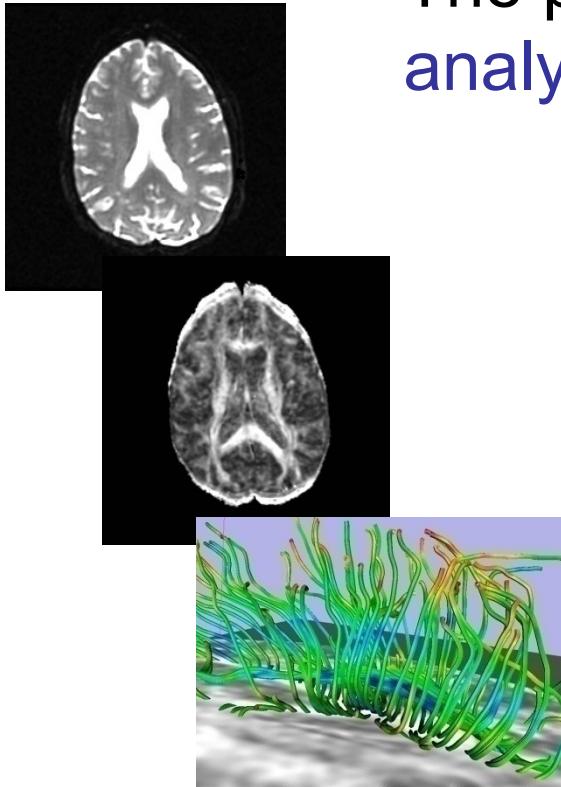
Outline



This tutorial guides you through the process of **loading diffusion MR data**, **estimating diffusion tensors**, and **performing tractography** of white matter bundles.



Outline



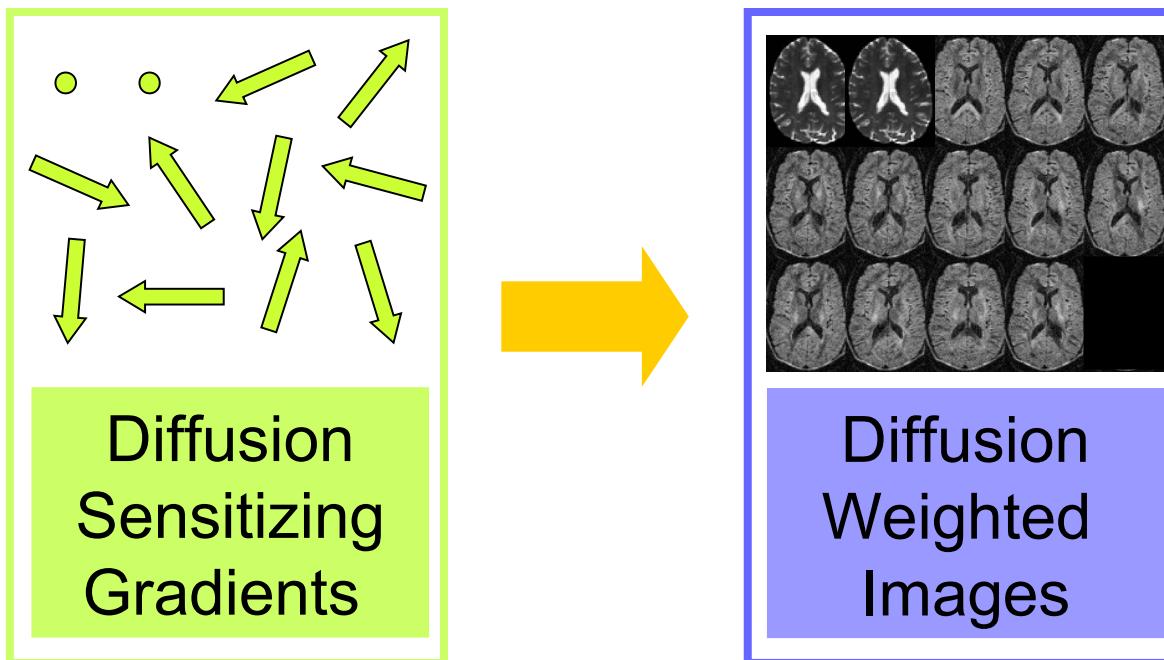
The processing pipeline uses **9 image analysis modules** of Slicer3.6

1. Data
2. Volumes
3. Diffusion Tensor Estimation
4. Diffusion Tensor Scalar Measurements
5. Editor
6. LabelMap Seeding
7. Fiber Bundles
8. Fiducials
9. Fiducial Seeding



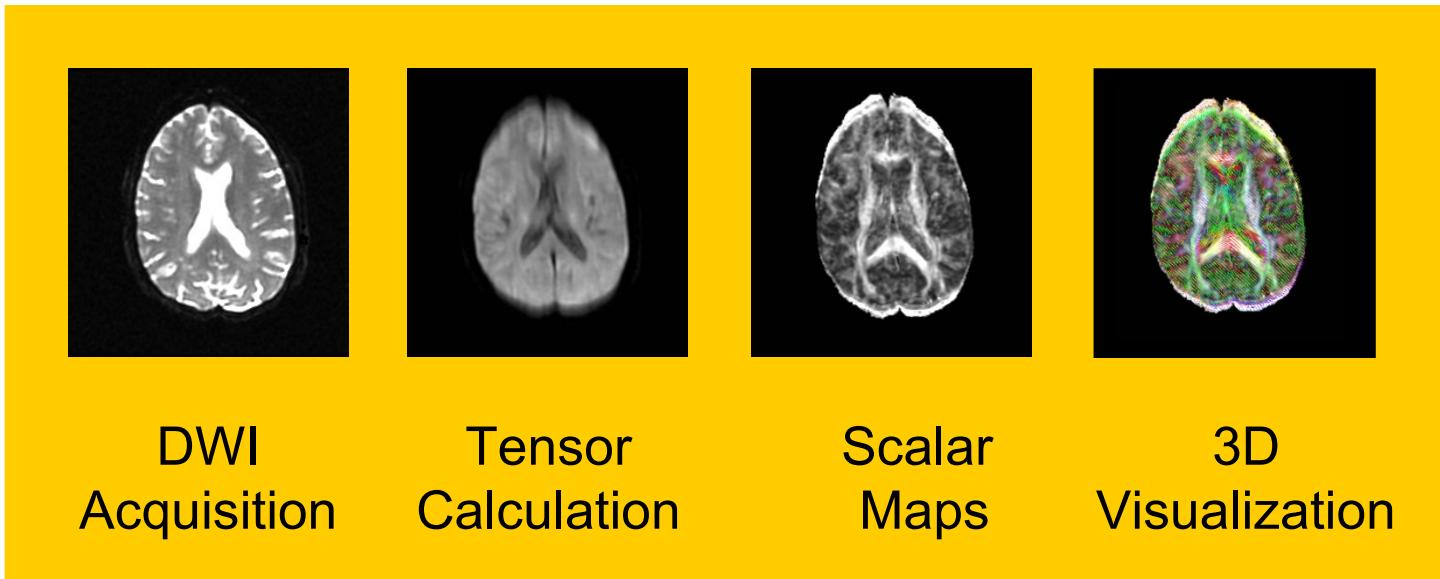
Tutorial Dataset

The Diffusion MR tutorial dataset is composed of a **Diffusion Weighted MR scan** of the brain acquired with 12 gradient directions and 2 baseline.





DTI Processing Pipeline





Start Slicer3



Linux/Mac users

Launch the Slicer3 executable located in the Slicer3.6 directory

Windows users

Select

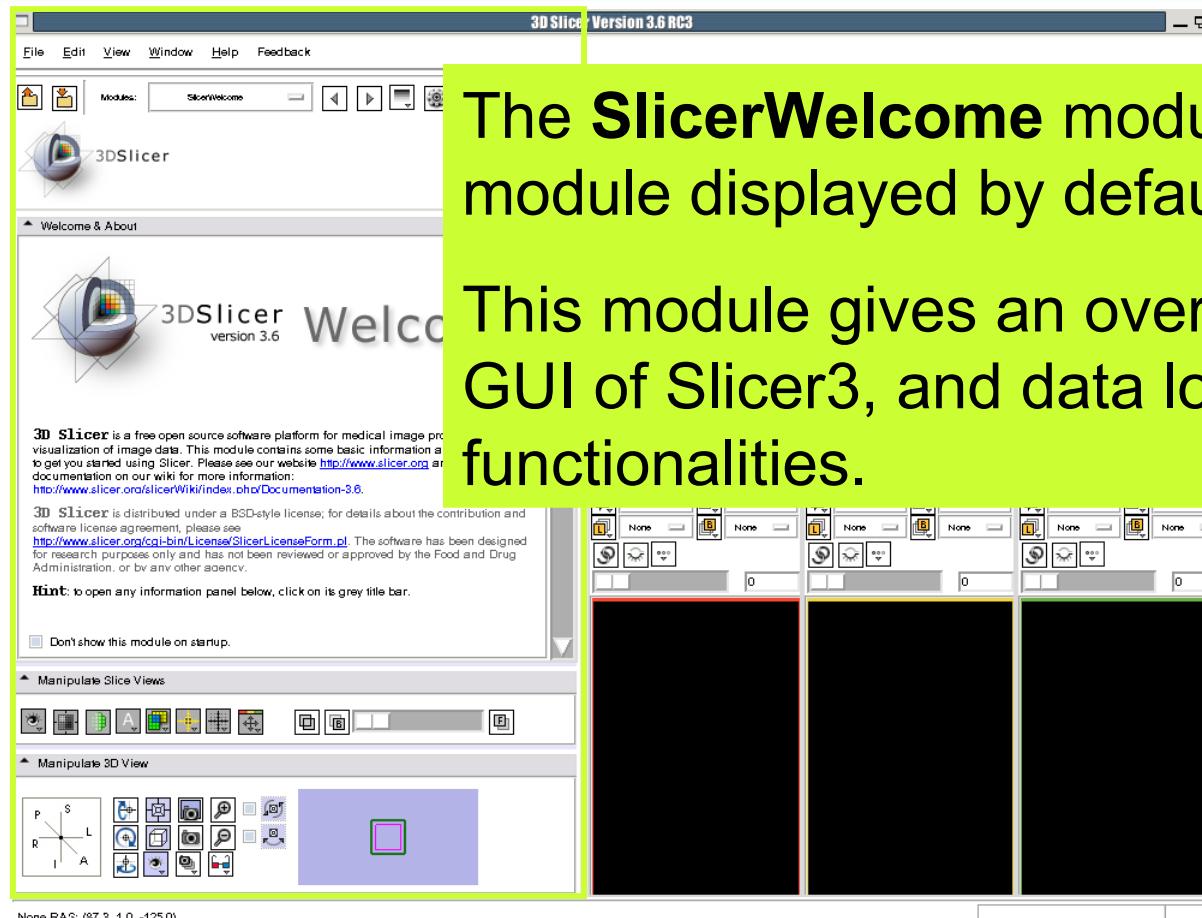
Start → All Programs

→ Slicer3-3.6-RC3-2010-06-04

→ Slicer3



Slicer Welcome

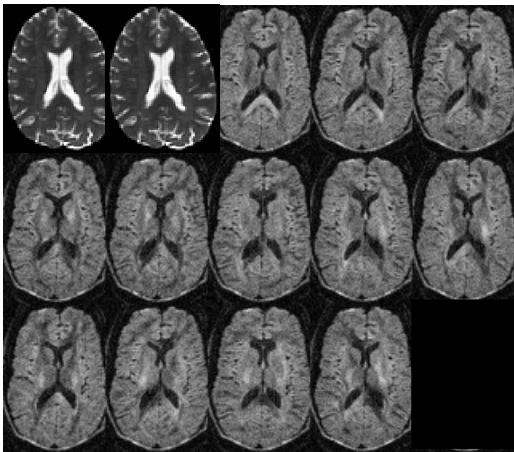


The **SlicerWelcome** module is the module displayed by default.

This module gives an overview of the GUI of Slicer3, and data loading & saving functionalities.



Part 1:

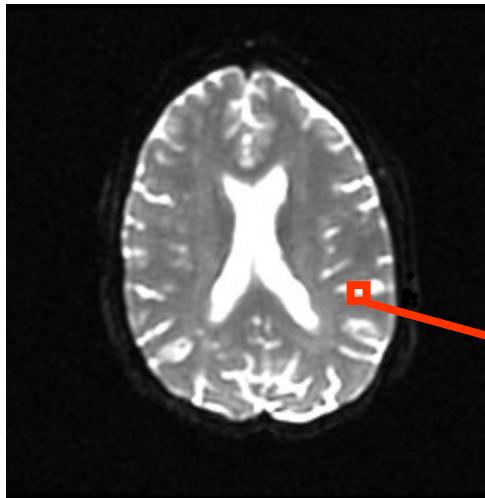


Diffusion data loading and tensor estimation



Diffusion Tensor

Stejskal-Tanner



$$S_i = S_0 e^{-b\hat{g}^T \underline{D} \hat{g}_i}$$

$$\underline{\mathbf{D}} = \begin{bmatrix} D_{xx} & D_{xy} & D_{xz} \\ D_{yx} & D_{yy} & D_{yz} \\ D_{zx} & D_{zy} & D_{zz} \end{bmatrix}$$



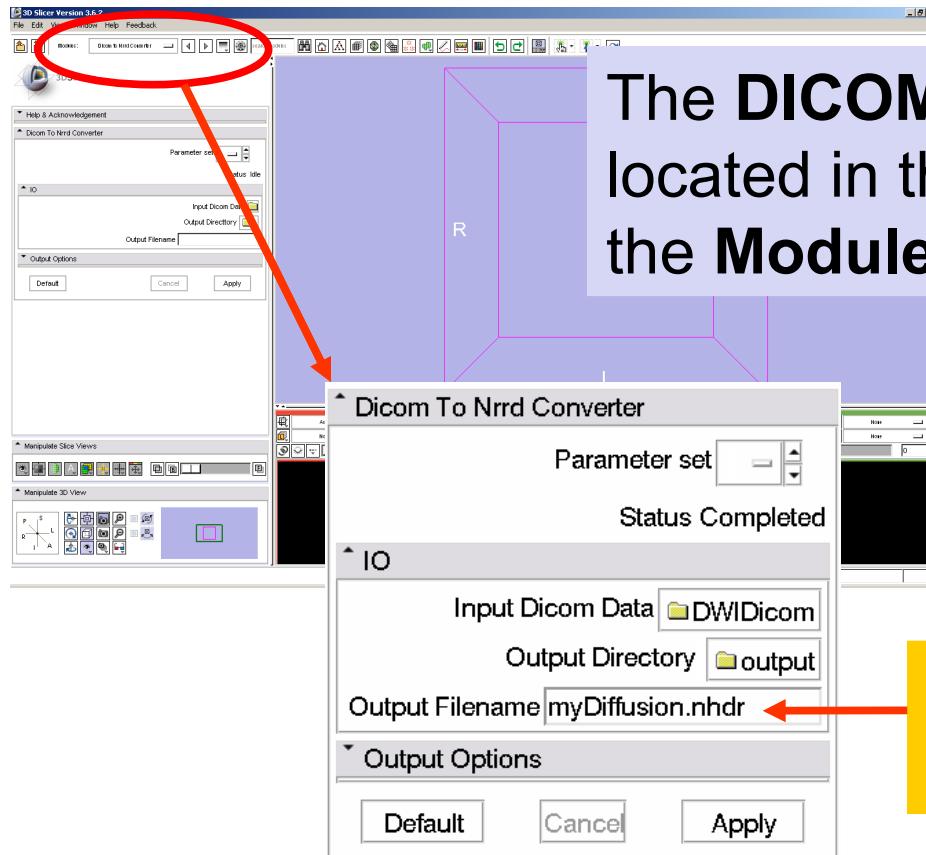
Tutorial Dataset

The dataset used in this tutorial is in **the Nrrd file format**, which is part of the NA-MIC kit.

To convert your own Dicom data to Nrrd, use the **DicomToNrrdConverter** module in Slicer.



DicomToNrrd converter



The **DICOMToNrrdConverter** is located in the **Converters** category in the **Modules** menu

Use .nhdr for **Output
Filename** extension



DicomToNrrd converter



search
Google Custom Search
GO
navigation
■ Slicer website
■ Wiki Home
■ Slicer Downloads
■ Training
■ Documentation
■ Users
■ Developers
■ FAQ
■ Acknowledgements
■ Links
■ Recent Changes

toolbox
■ What links here
■ Related changes
■ Special pages
■ Printable version
■ Permanent link

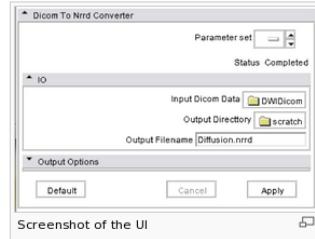
[page](#) [discussion](#) [view source](#) [history](#)

Modules:DicomToNRRD-3.6

[Return to Slicer 3.6 Documentation](#)

Module Name

DWI Dicom To NRRD



GENERAL INFORMATION

Module Type & Category

Type: Command line module

Category: Converters

Authors, Collaborators & Contact

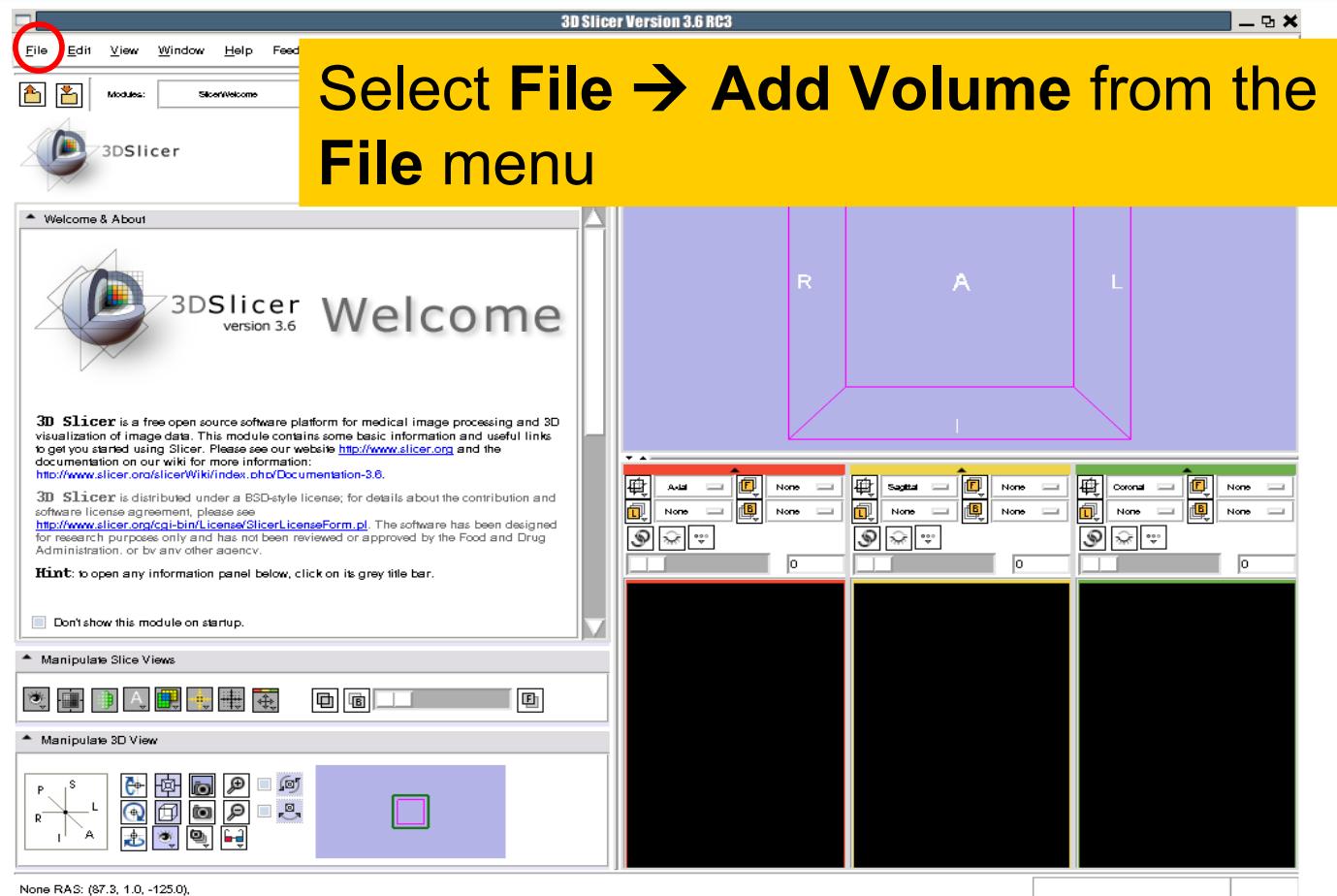
■ Author: Xiaodong Tao (with contribution from Vince Magnotta and Hans Johnson)

A list of supported DWI formats can be found on the documentation page of the **DicomToNrrdconverter**:

<http://www.slicer.org/slicerWiki/index.php/Modules:DicomToNRRD-3.6>

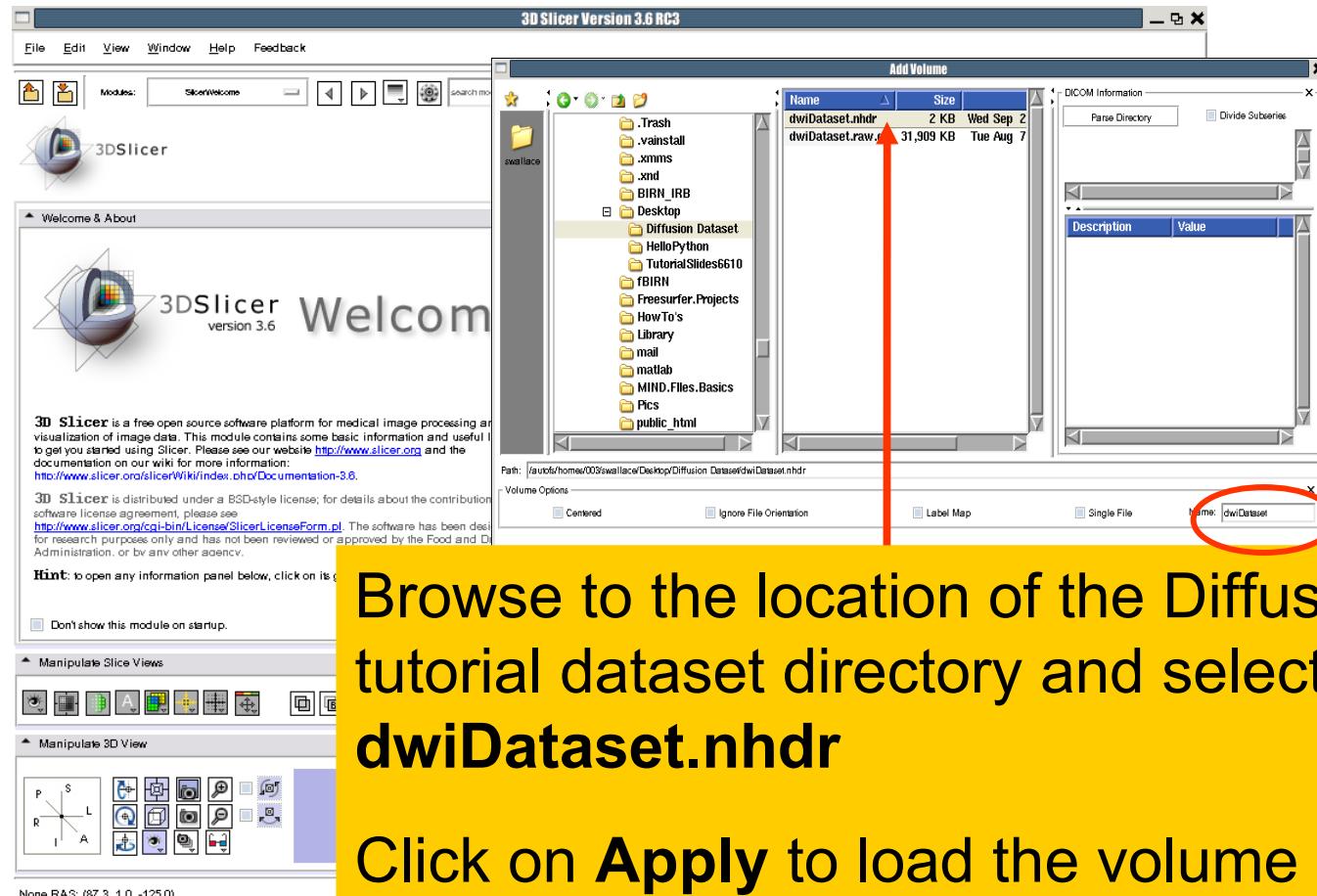


Loading the DWI Volume



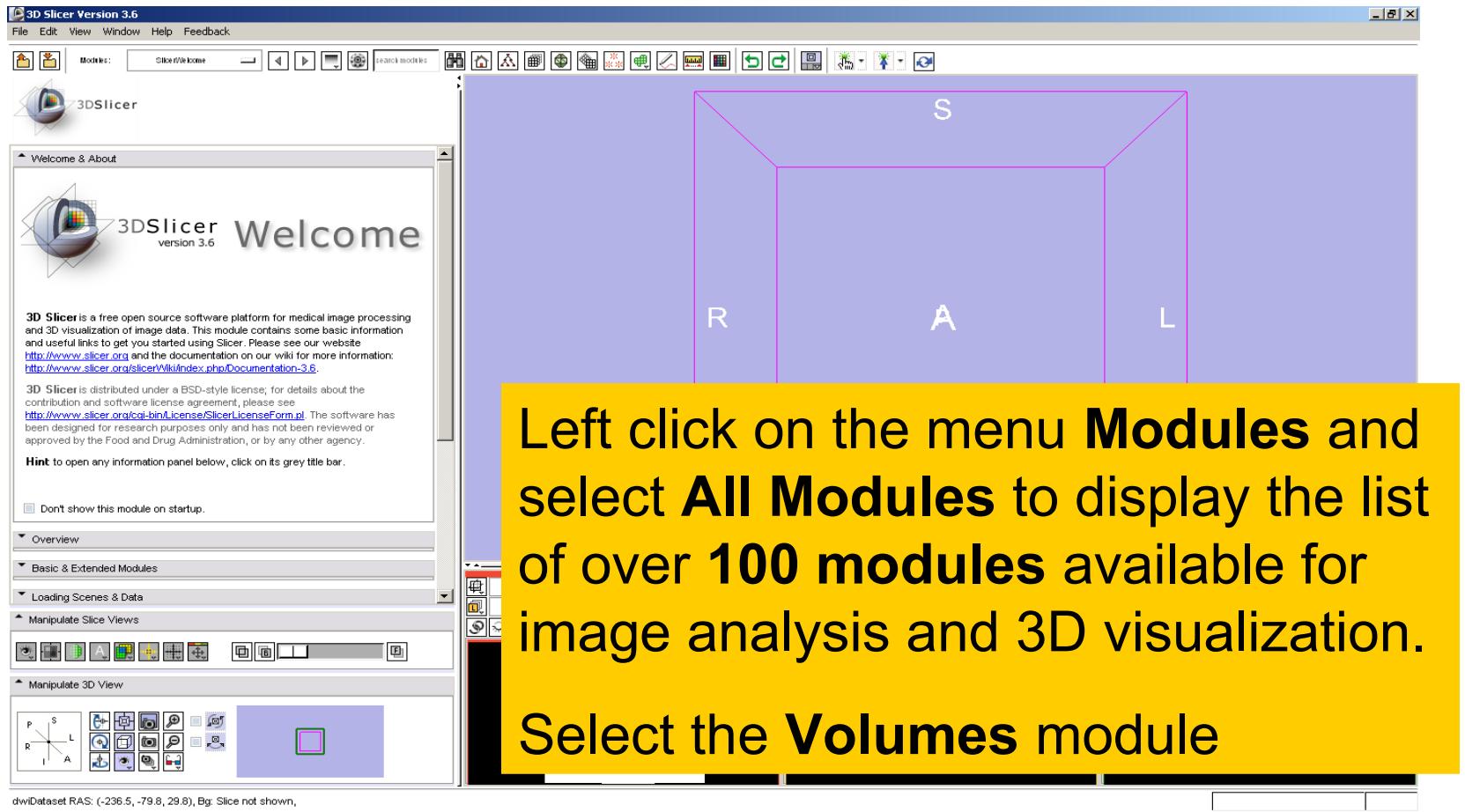


Loading the DWI Volume



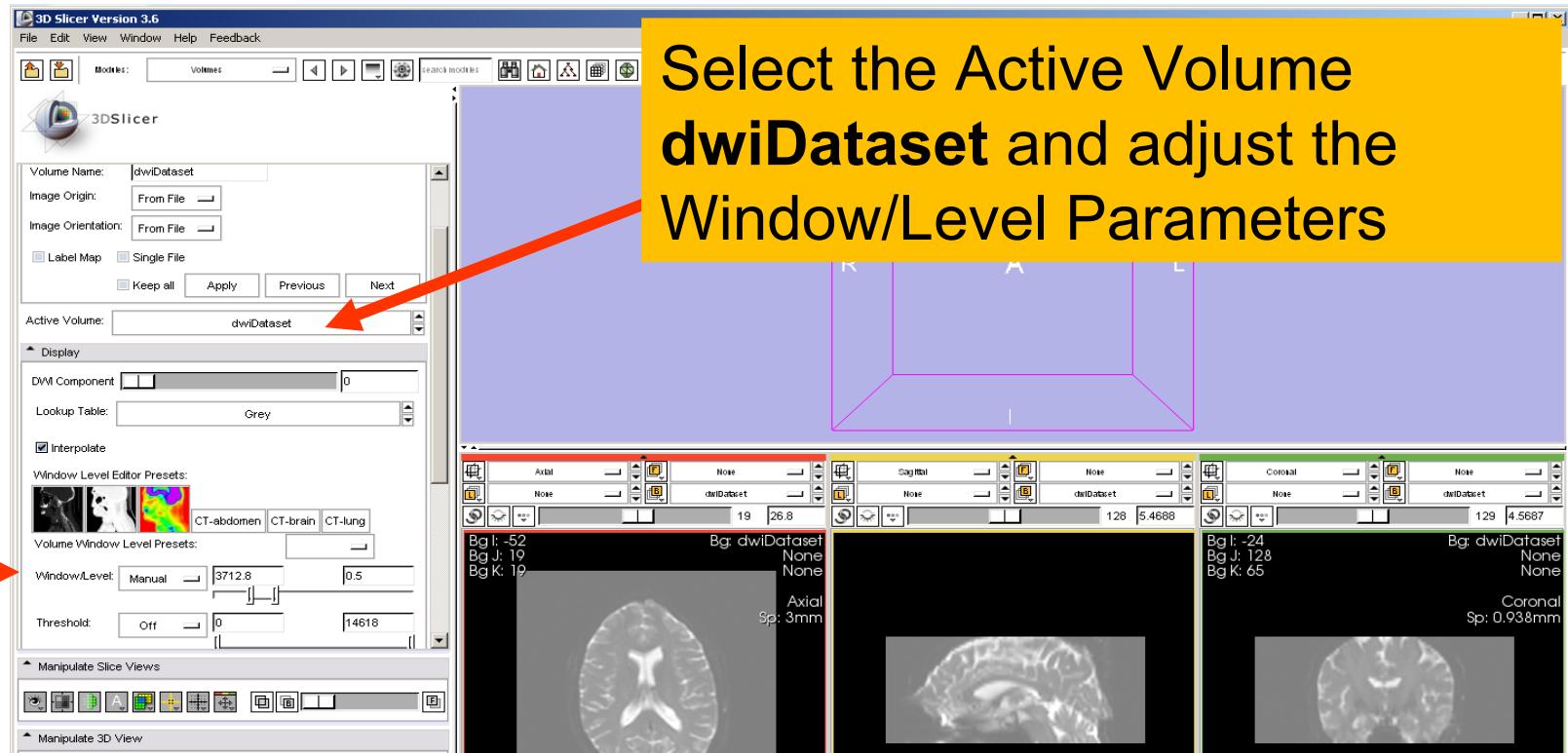


Loading the DWI Volume





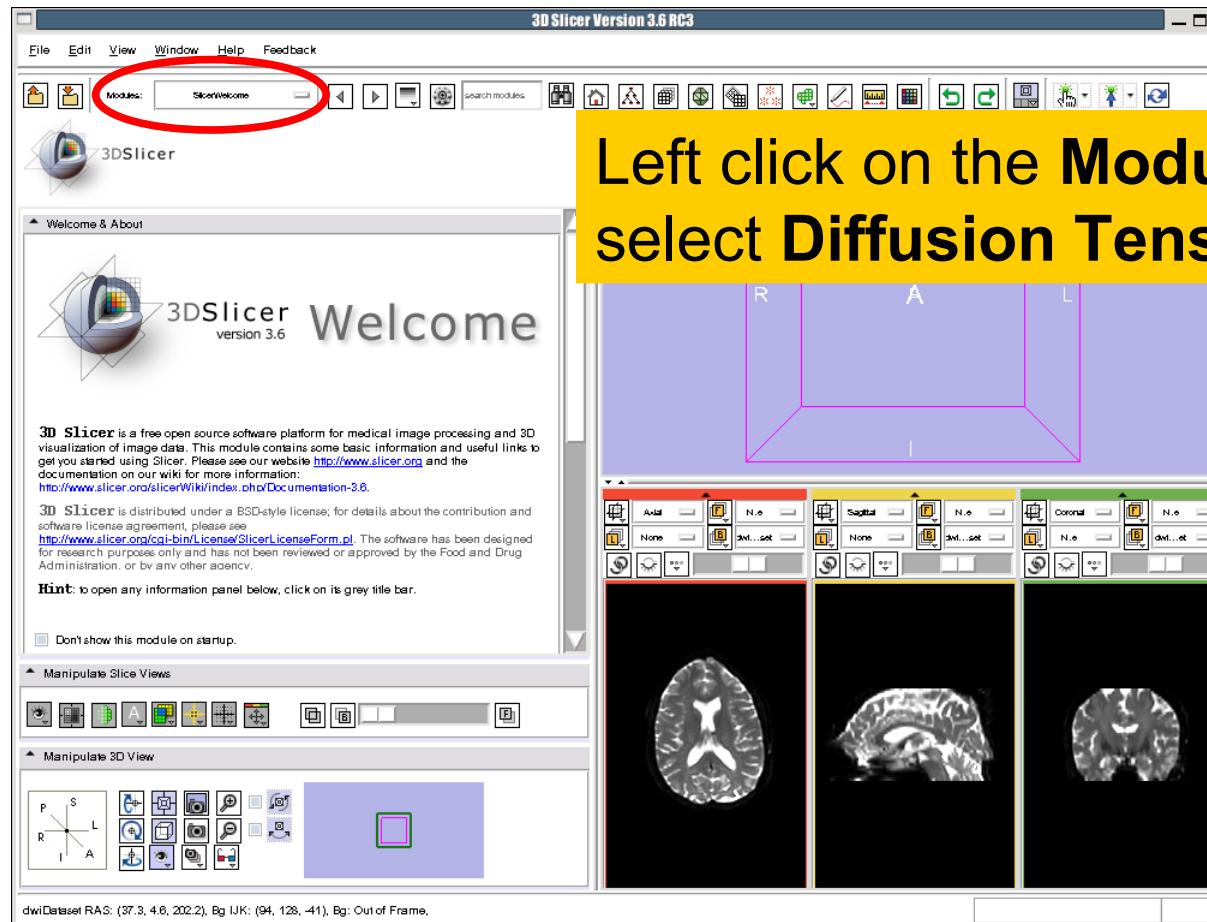
Loading the DWI Volume



Slicer displays the anatomical views of the baseline volume of the diffusion dataset in the 2D Slice Viewer.



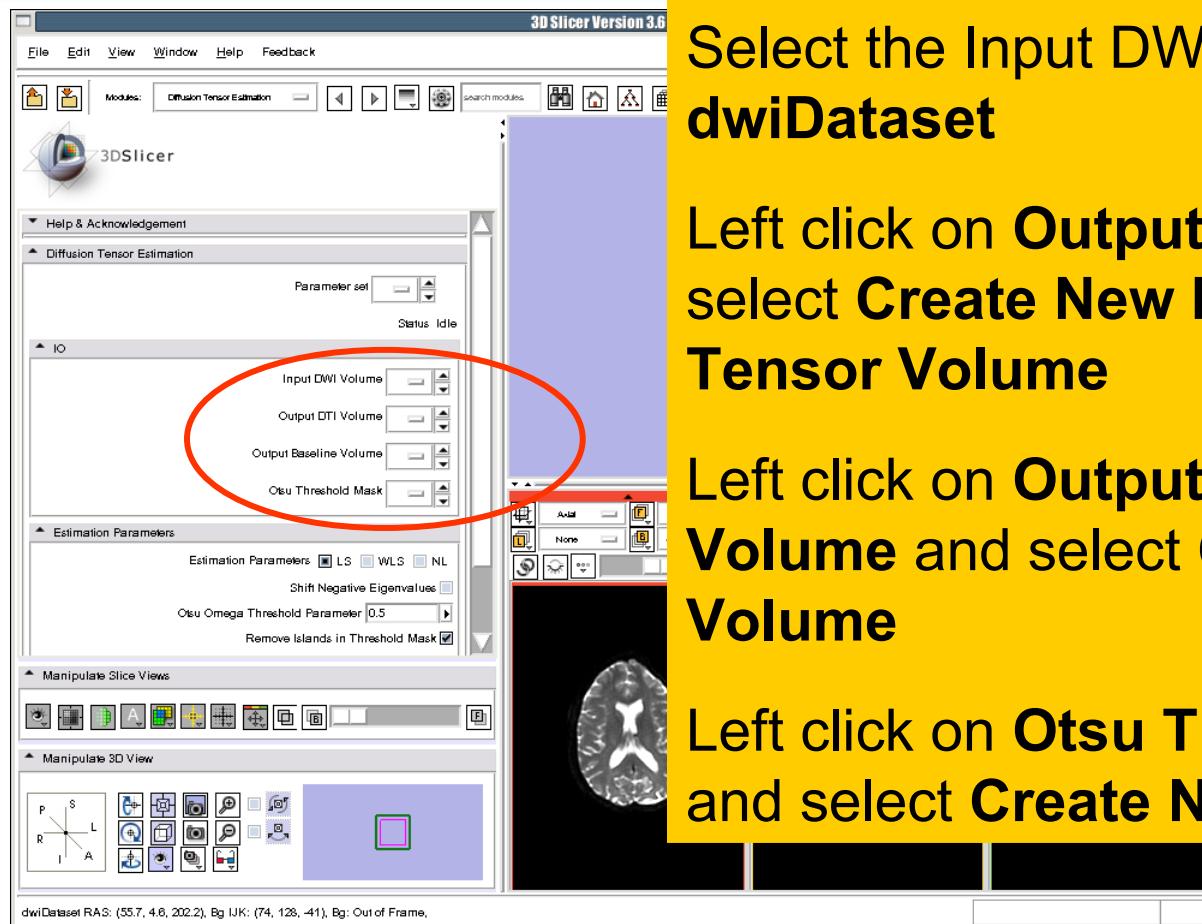
Tensor Estimation



Left click on the **Modules** menu and select **Diffusion Tensor Estimation**.



Tensor Estimation



Select the Input DWI Volume
dwiDataset

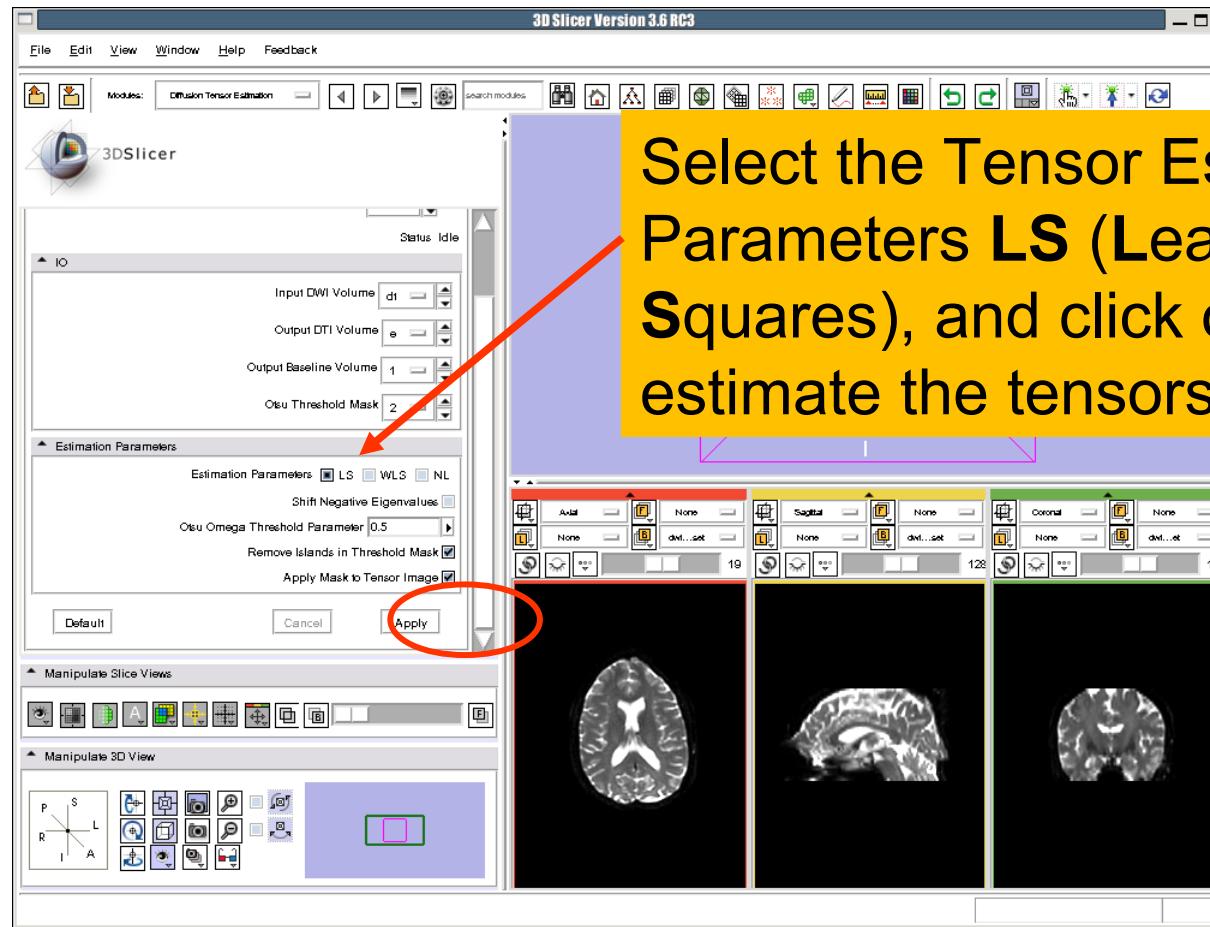
Left click on **OutputDTIVolume** and
select **Create New Diffusion
Tensor Volume**

Left click on **Output Baseline
Volume** and select **Create New
Volume**

Left click on **Otsu Threshold Mask**
and select **Create New Volume**

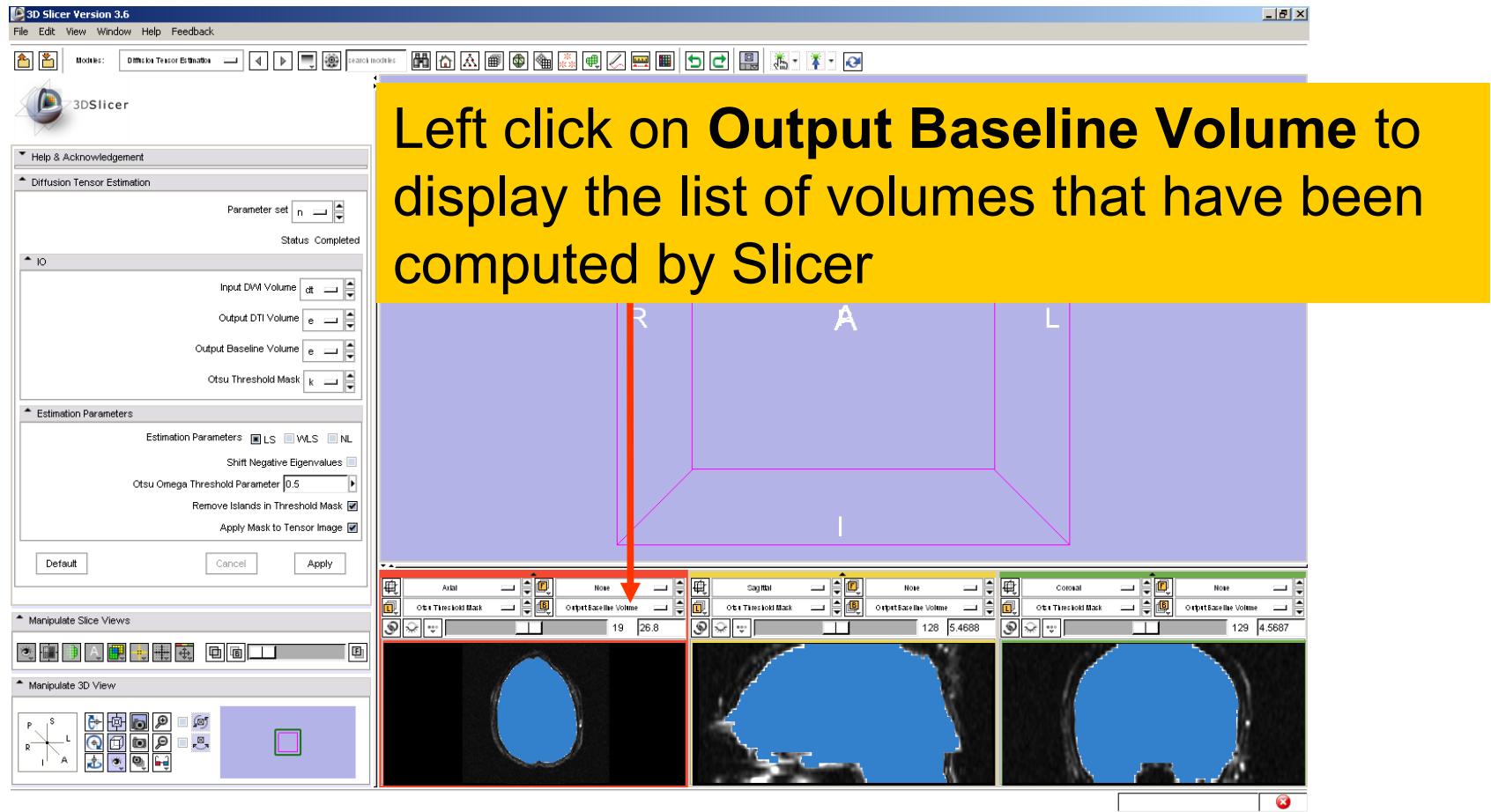


Tensor Estimation





Tensor Estimation



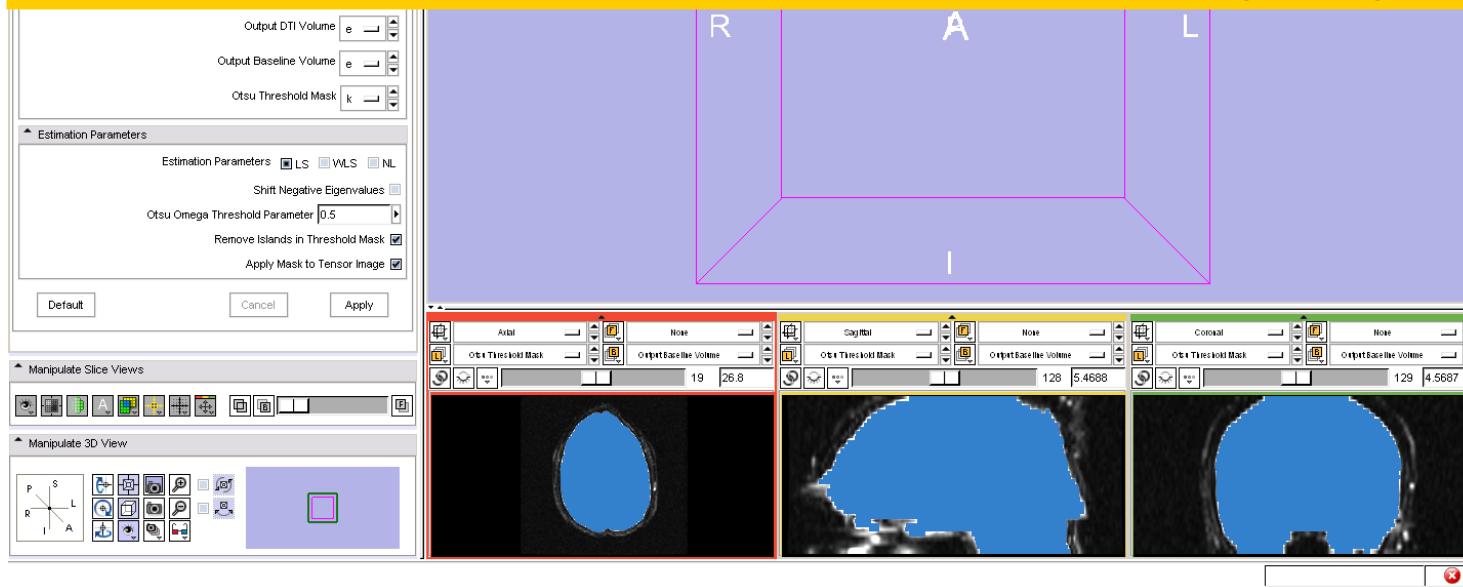


Tensor Estimation

Output DTI Volume is the volume of estimated tensors

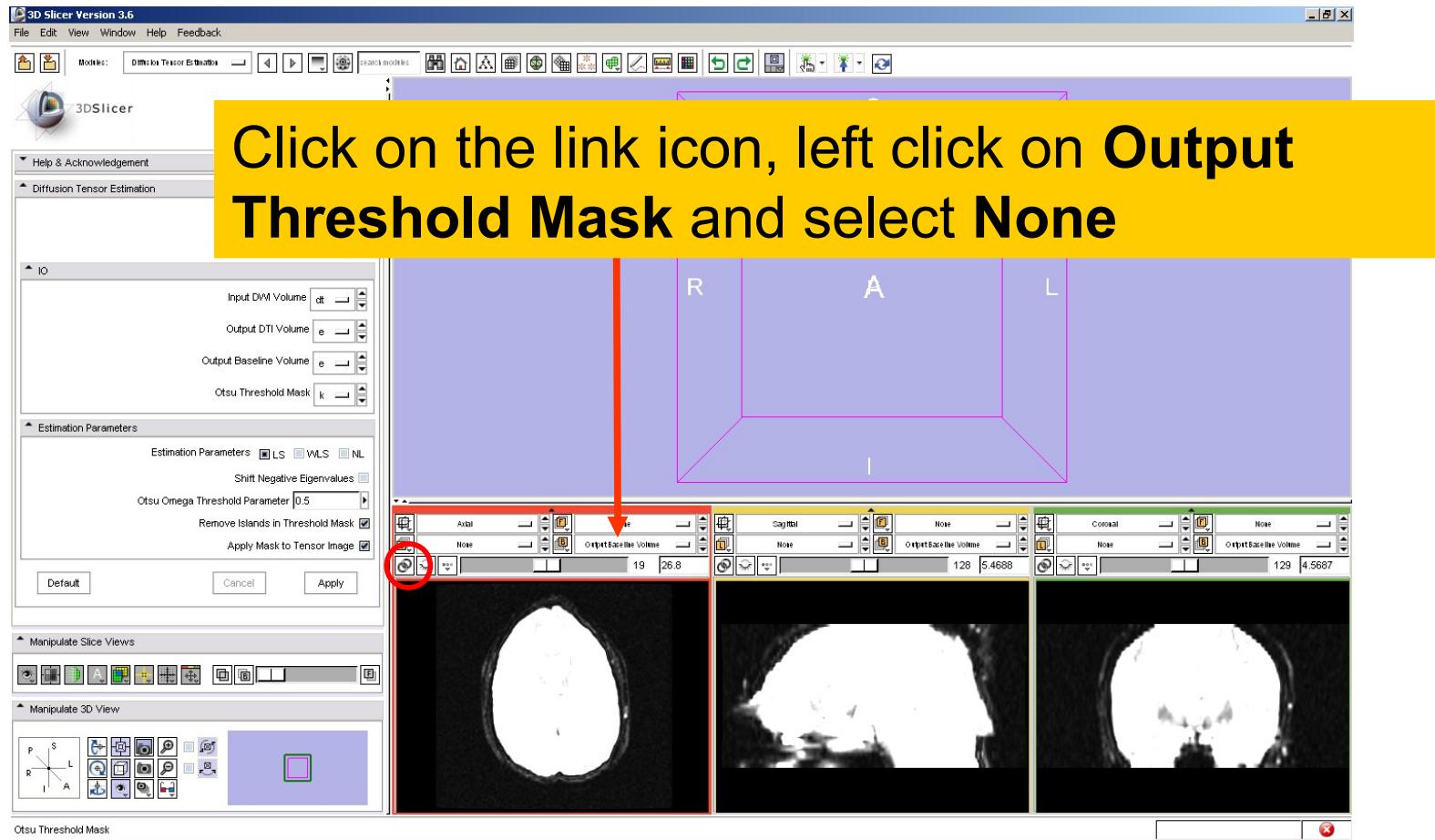
Output Baseline Volume is the Baseline volume

Otsu Threshold Mask is the tensor mask (blue)



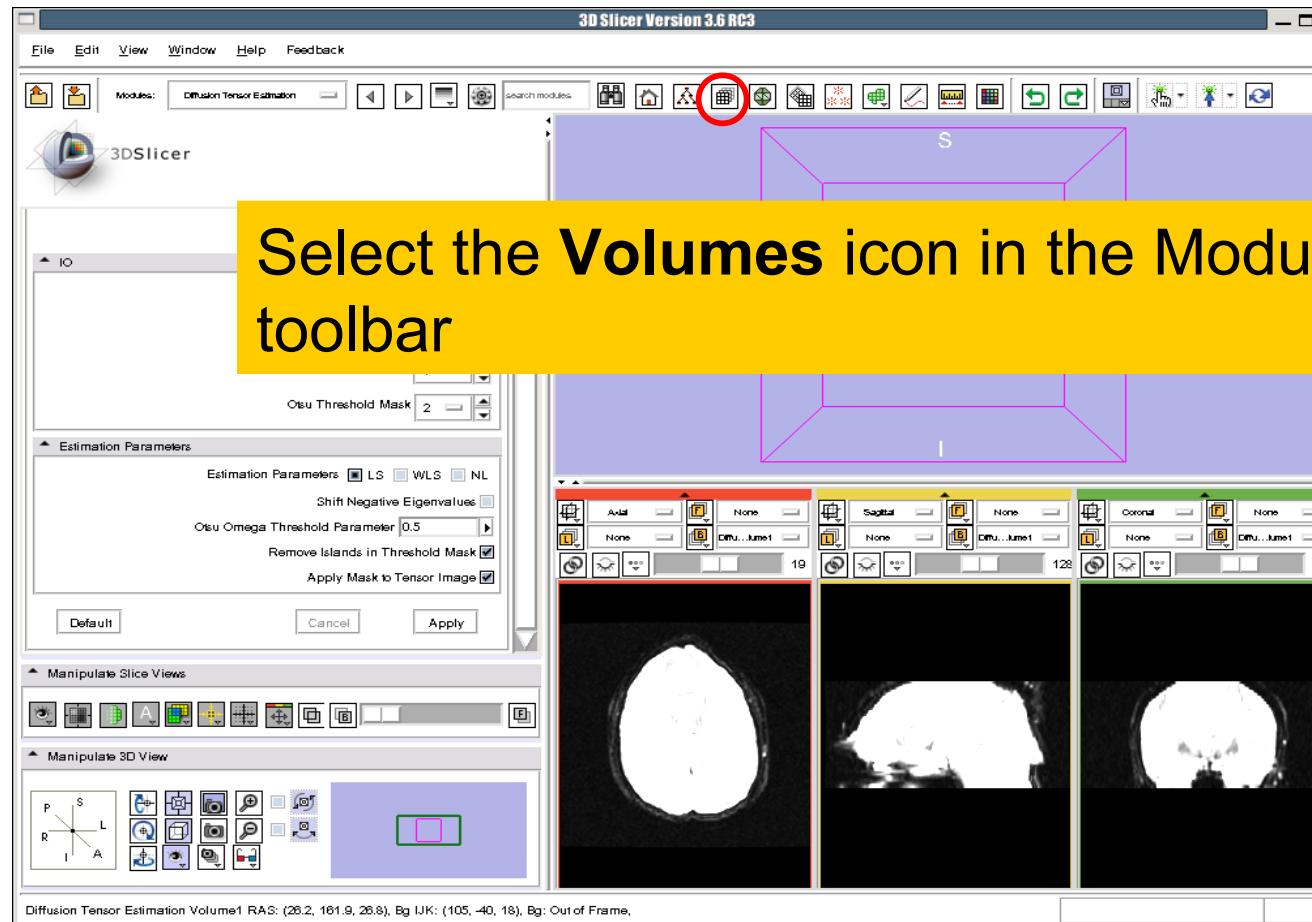


Tensor Estimation



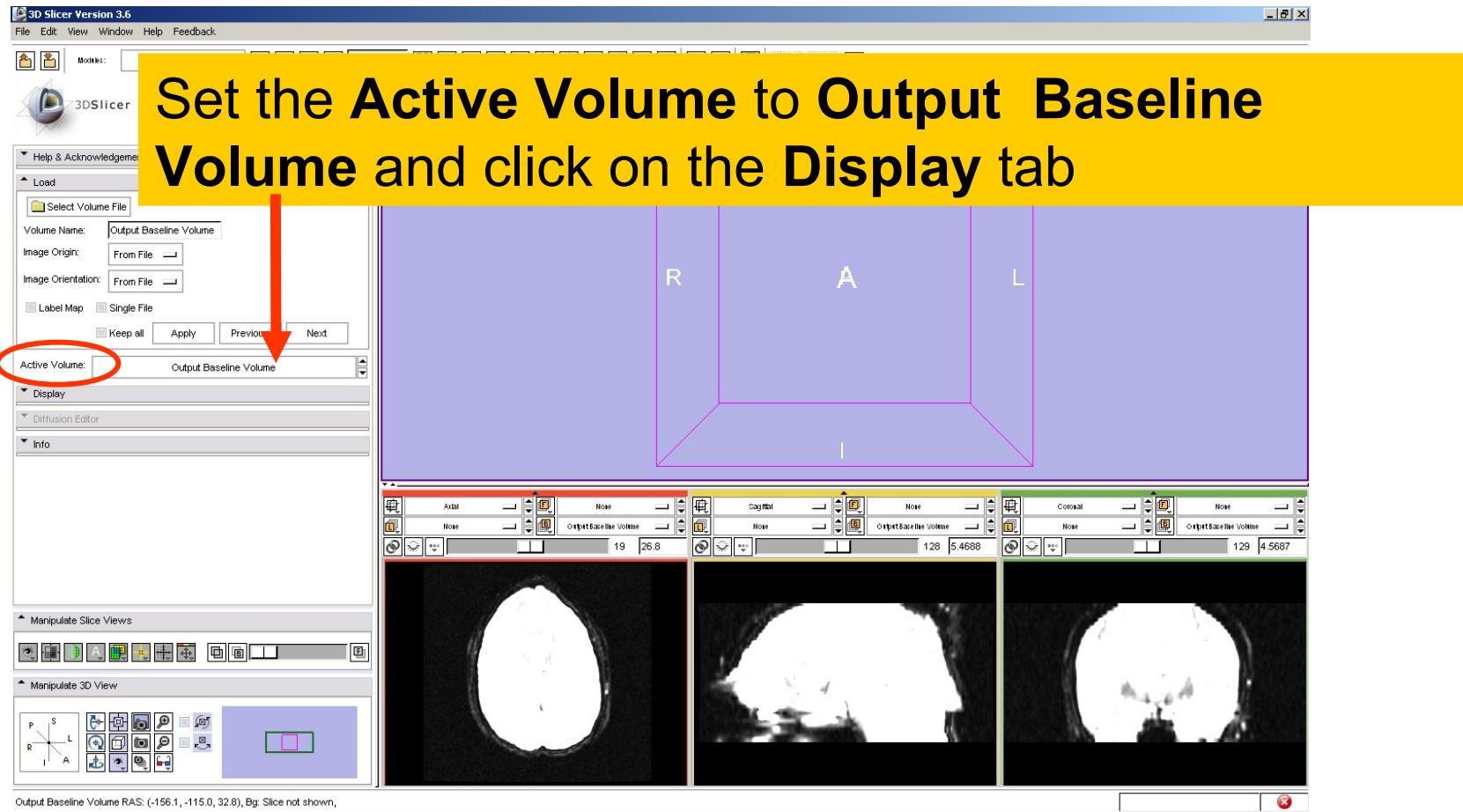


Tensor Estimation



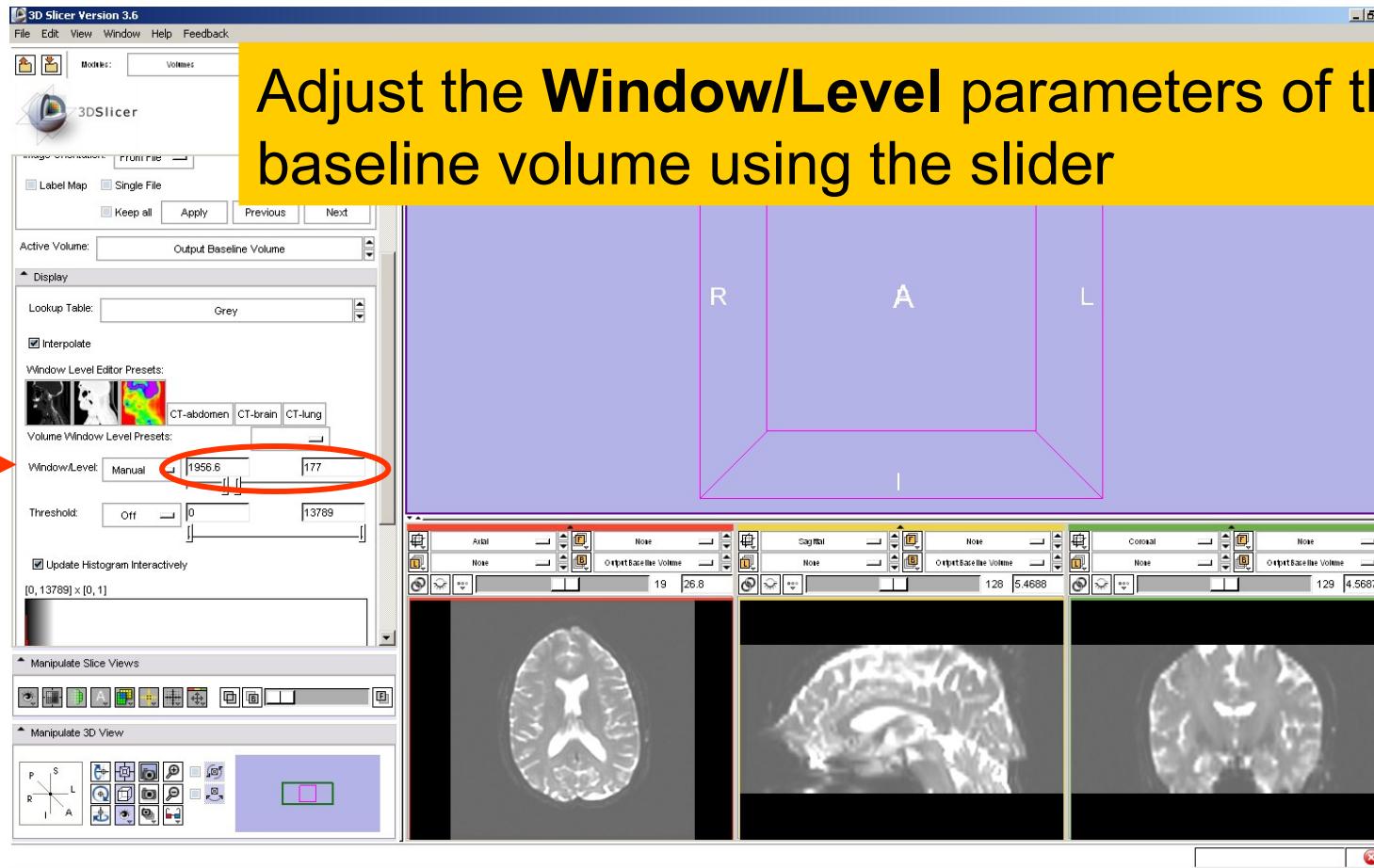


Tensor Estimation





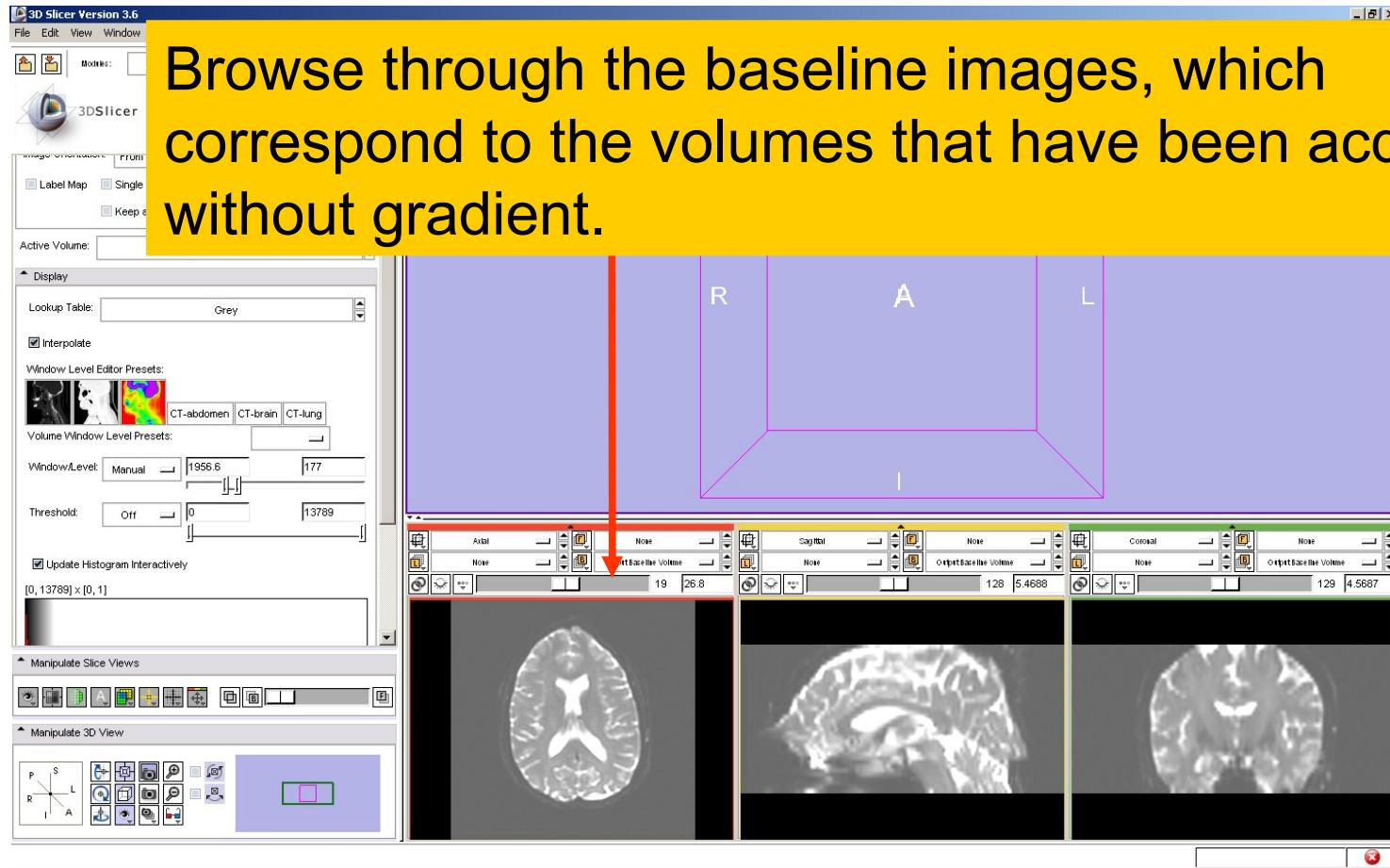
Tensor Estimation

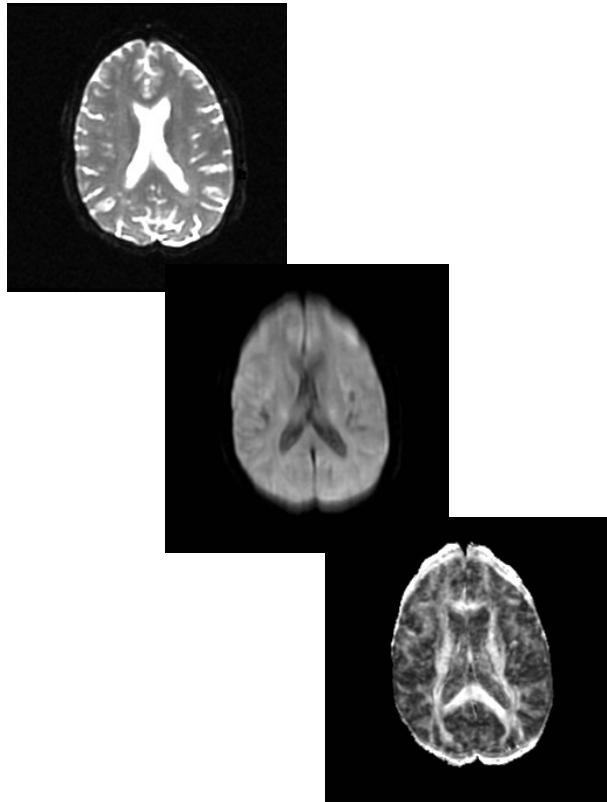


Adjust the **Window/Level** parameters of the baseline volume using the slider



Tensor Estimation

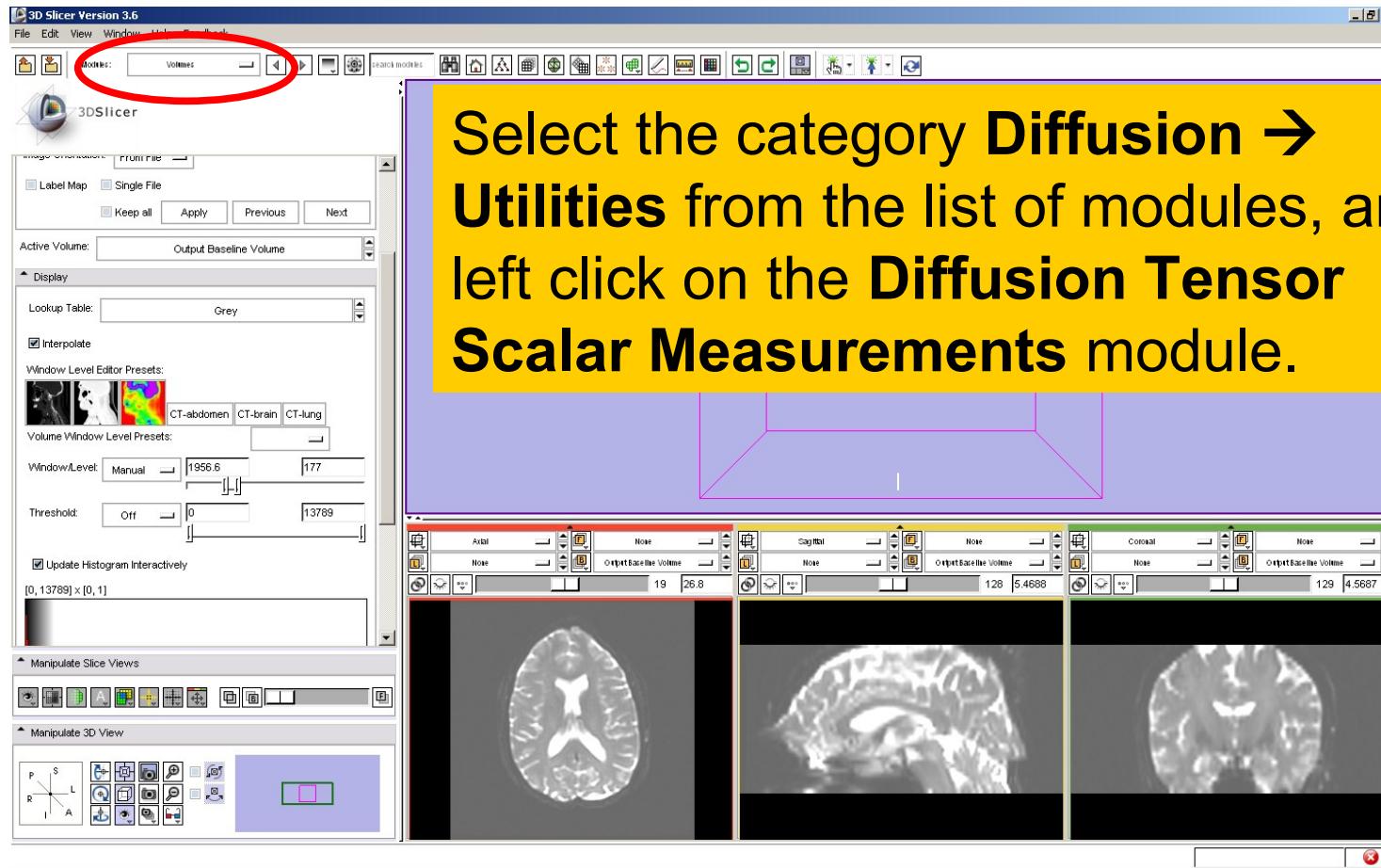




Part 2: Scalar Measurements

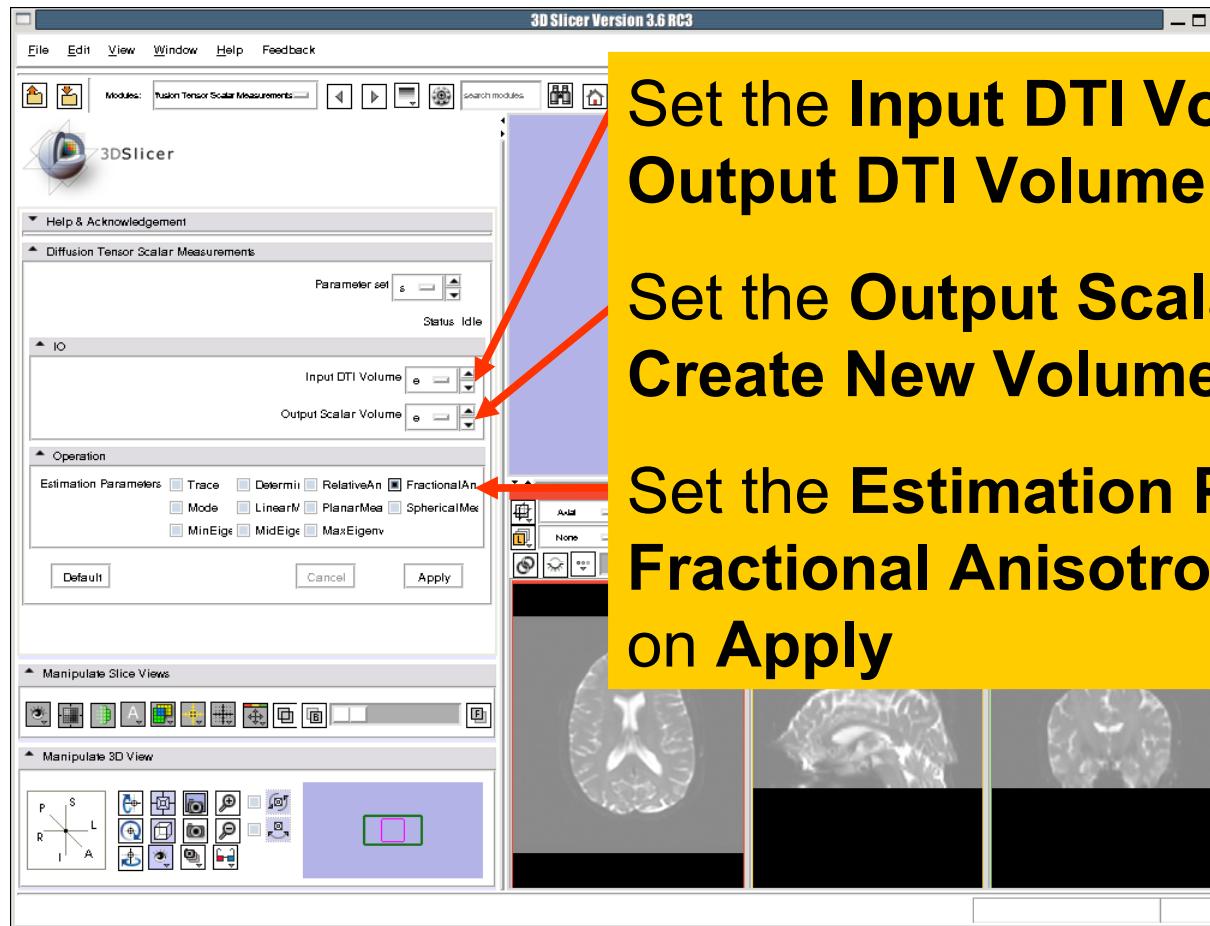


Scalar Measurements





Scalar Measurements



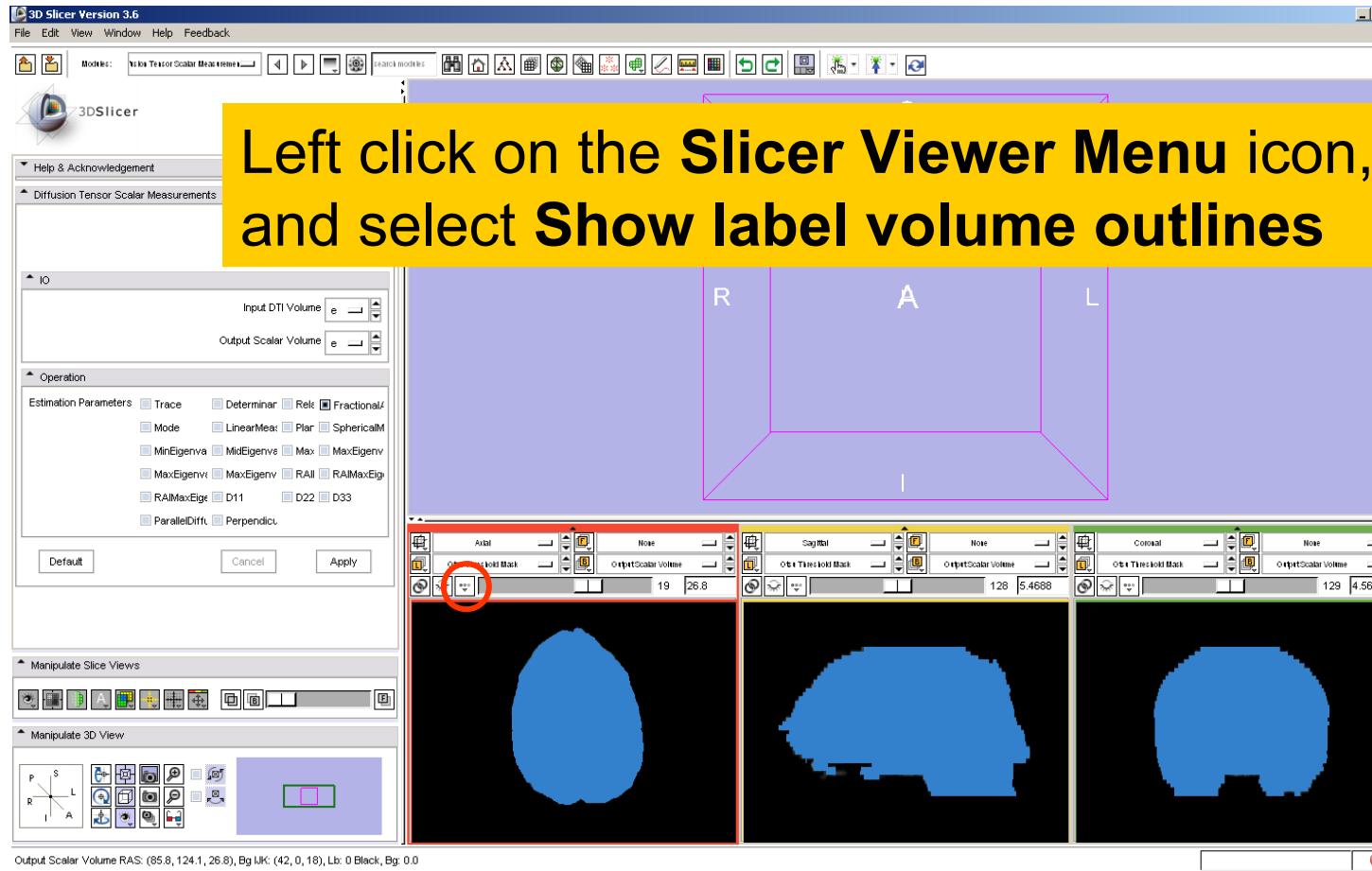
Set the Input DTI Volume to Output DTI Volume

Set the Output Scalar Volume to Create New Volume

Set the Estimation Parameters to Fractional Anisotropy, and click on Apply

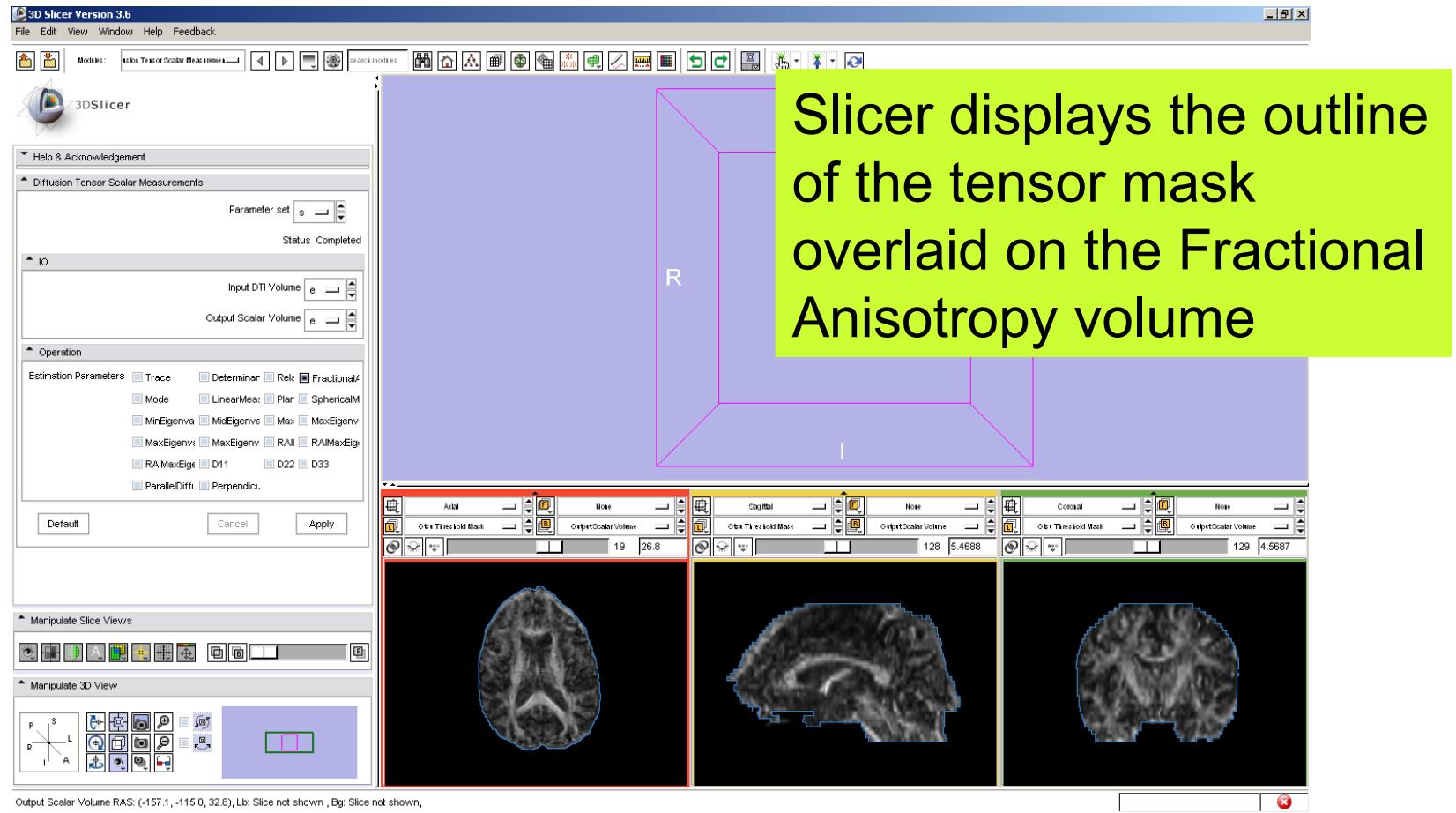


Fractional Anisotropy Volume



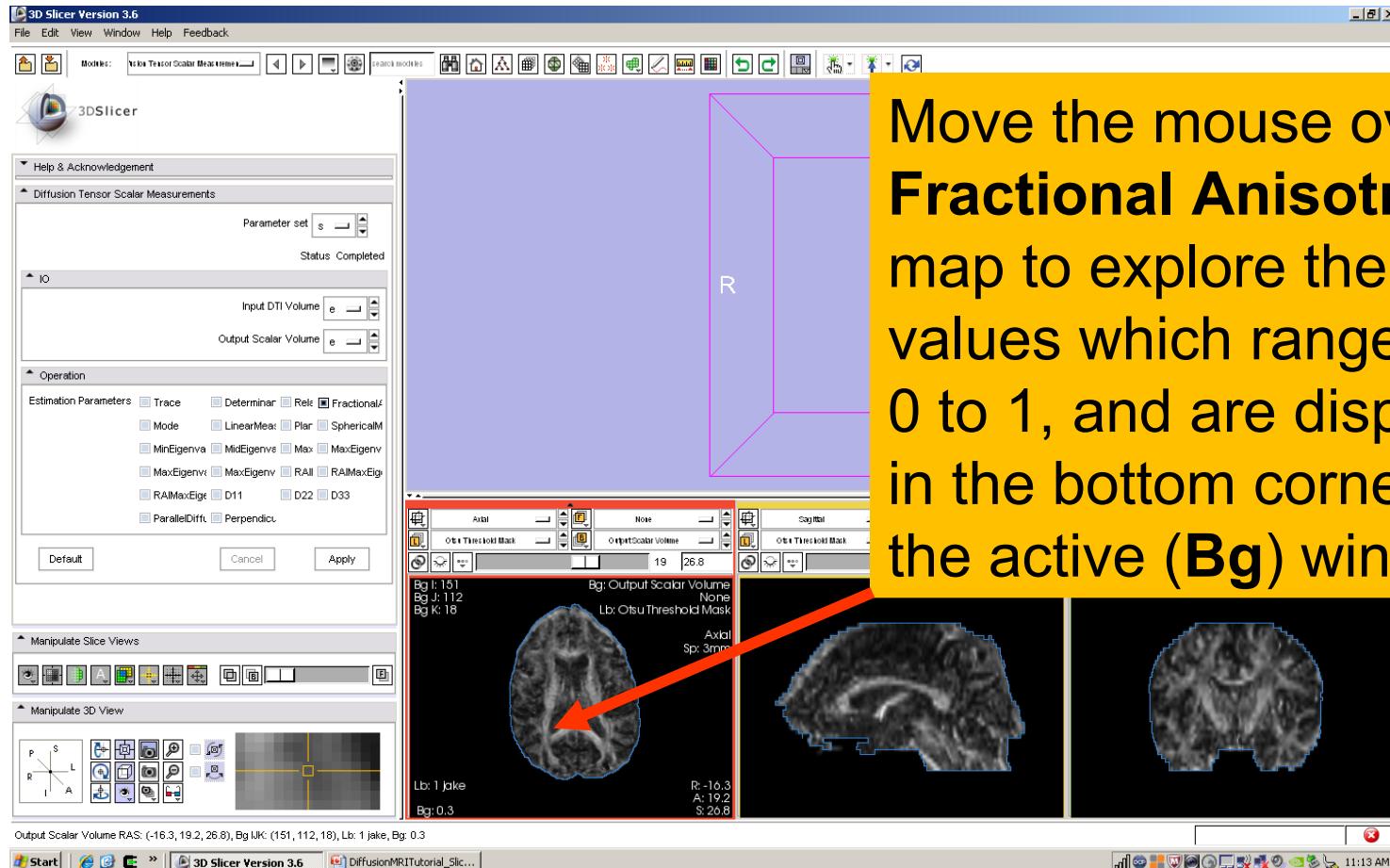


Fractional Anisotropy Volume





Fractional Anisotropy Volume





Part 3:

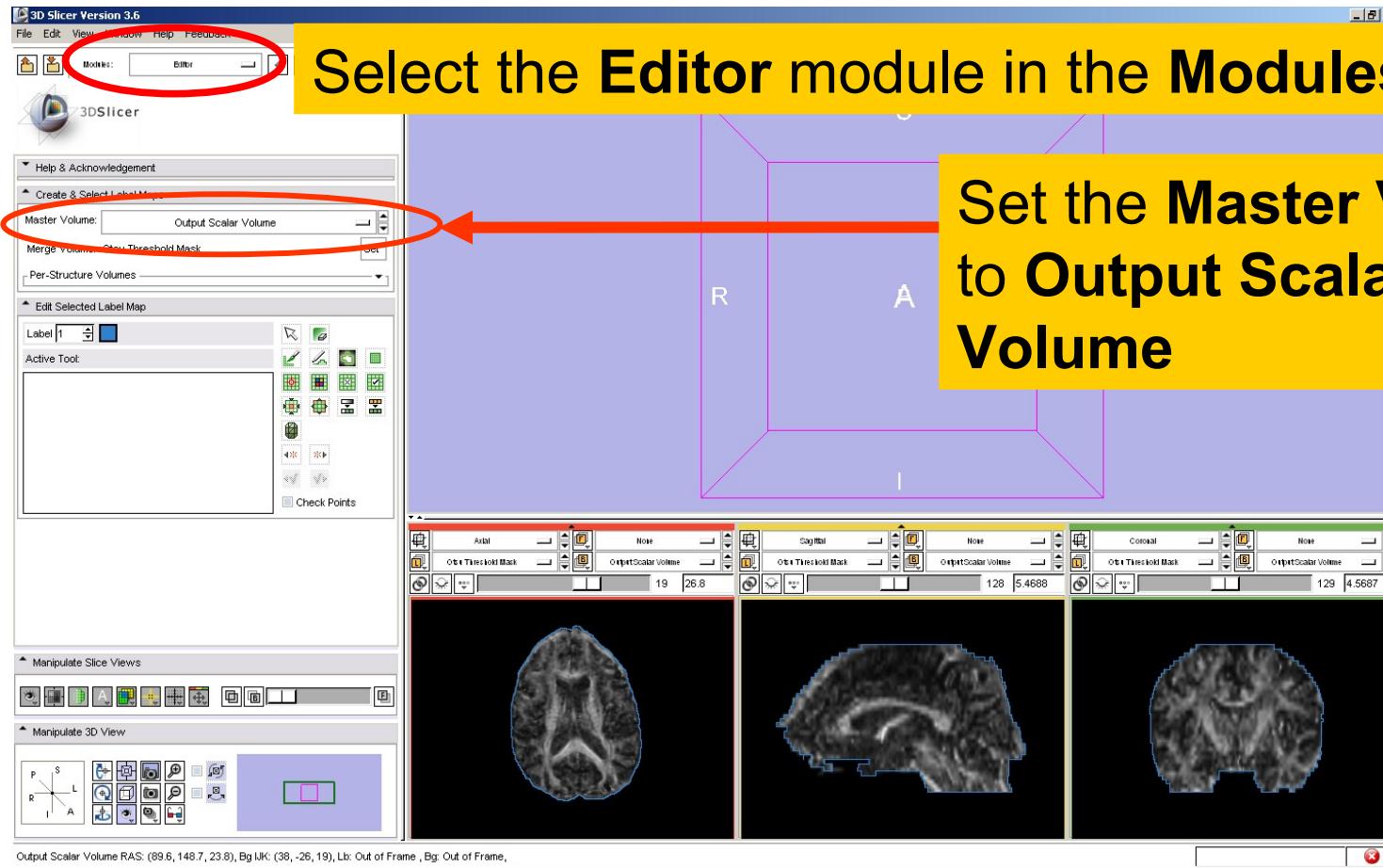
Region of

Interest Based

Tractography

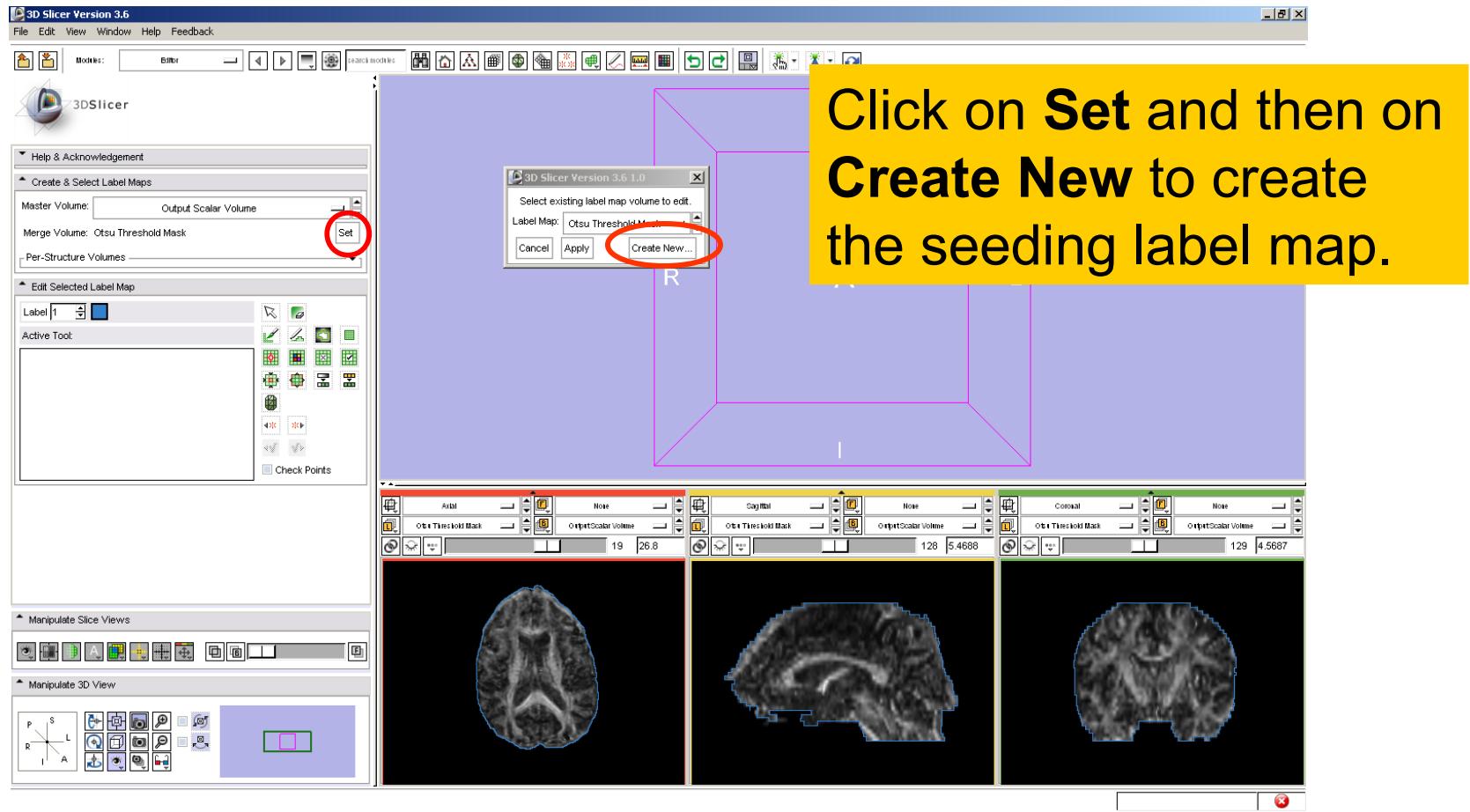


LabelMap Generation



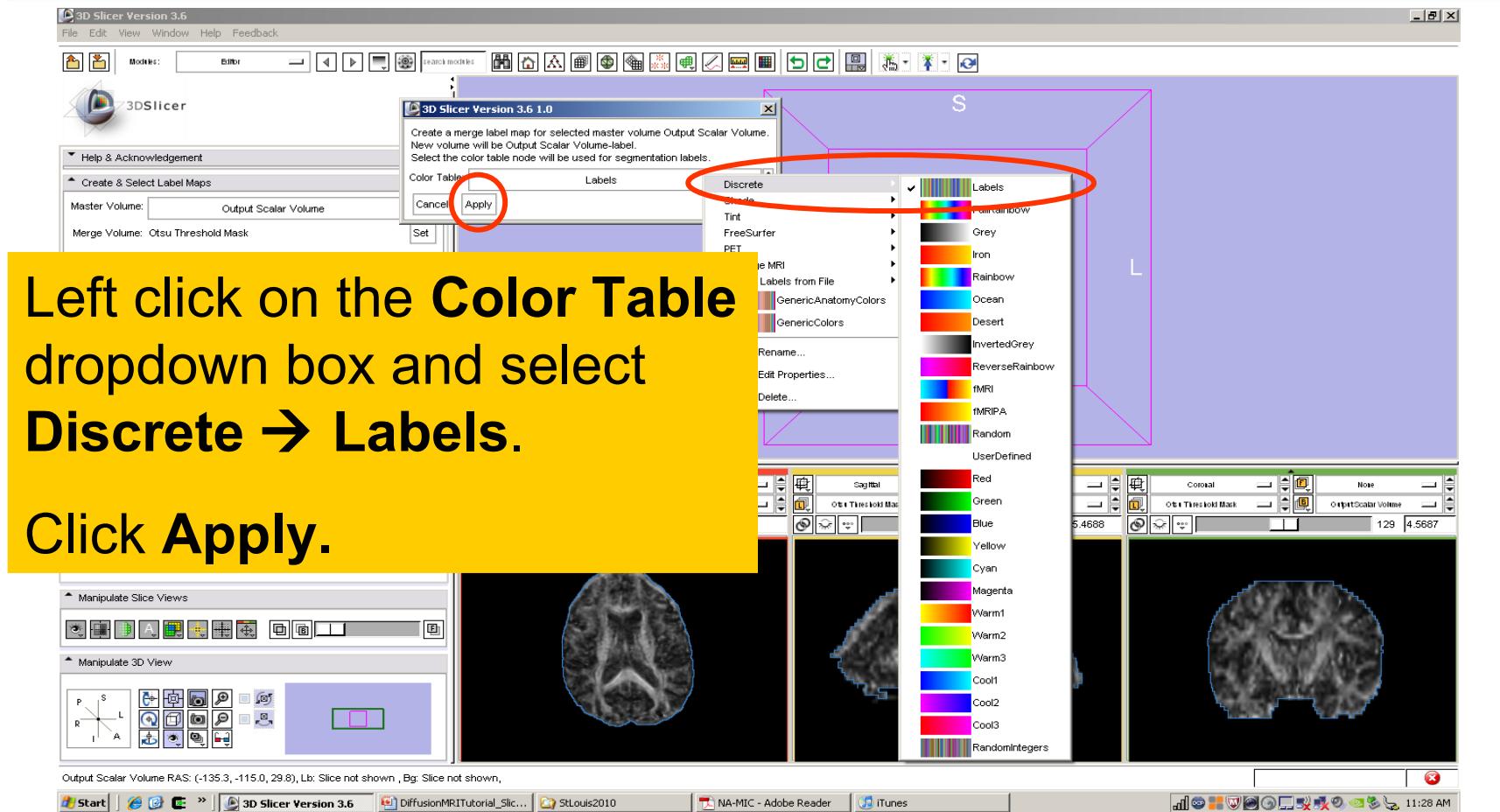


LabelMap Generation



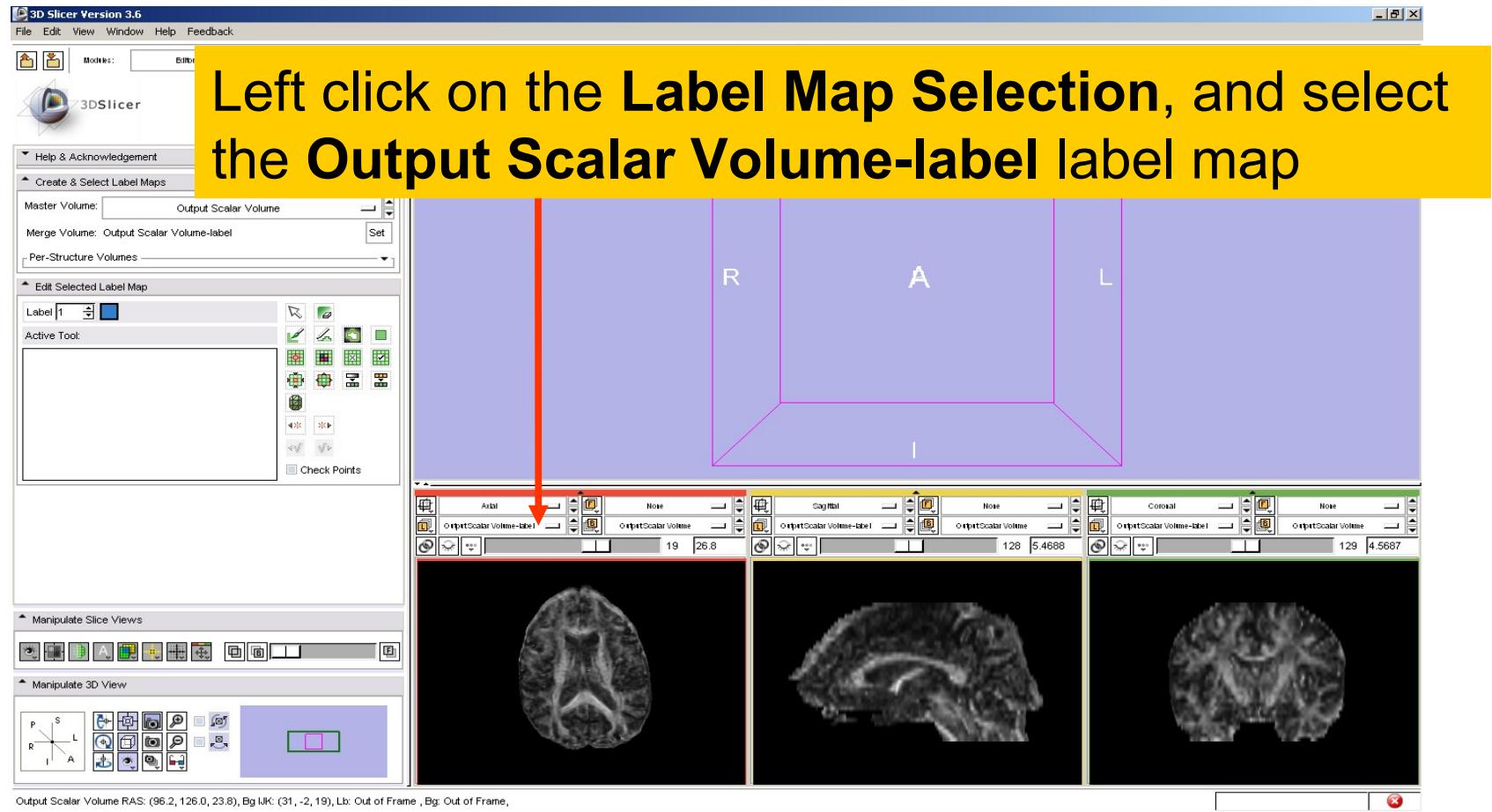


LabelMap Generation



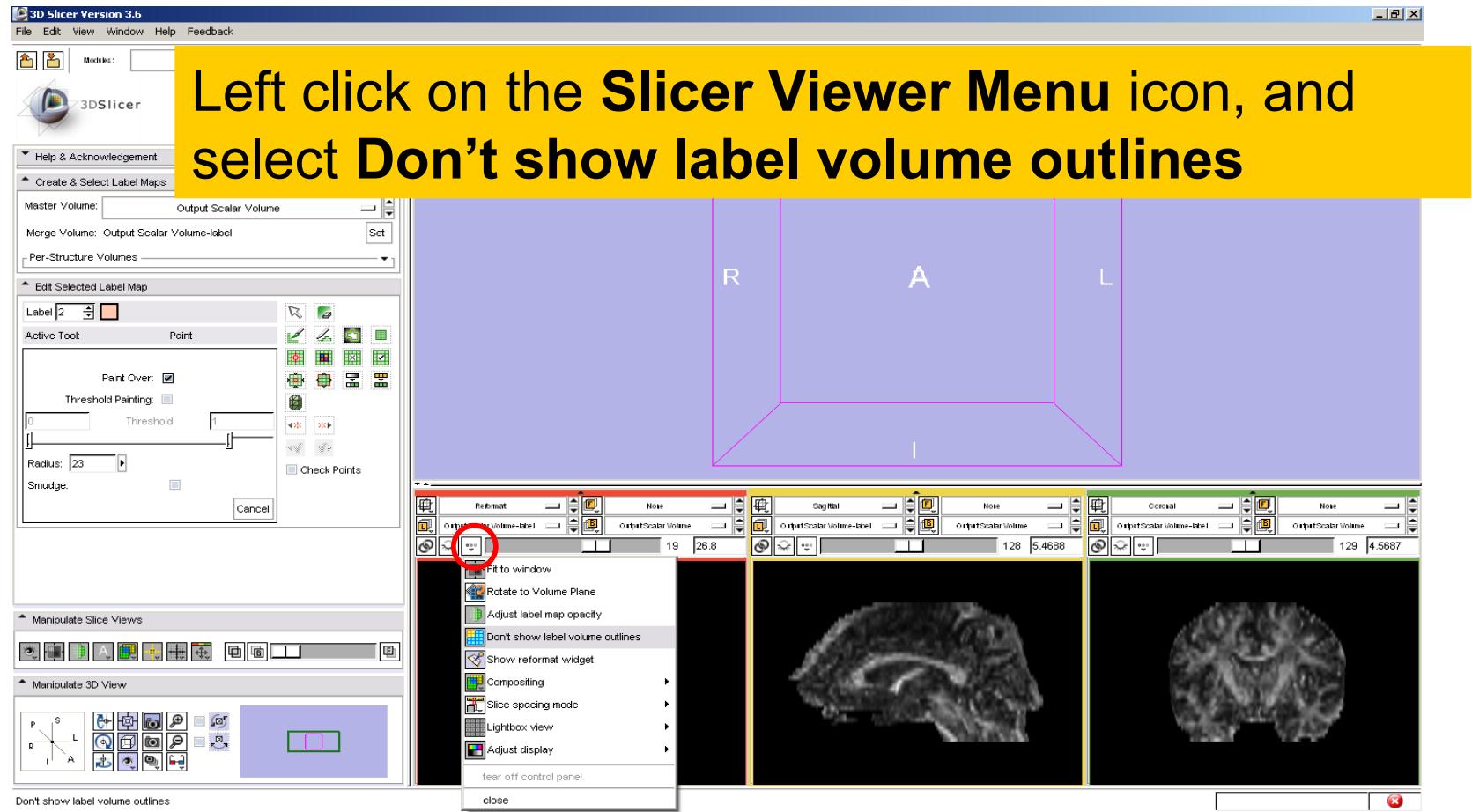


LabelMap Generation





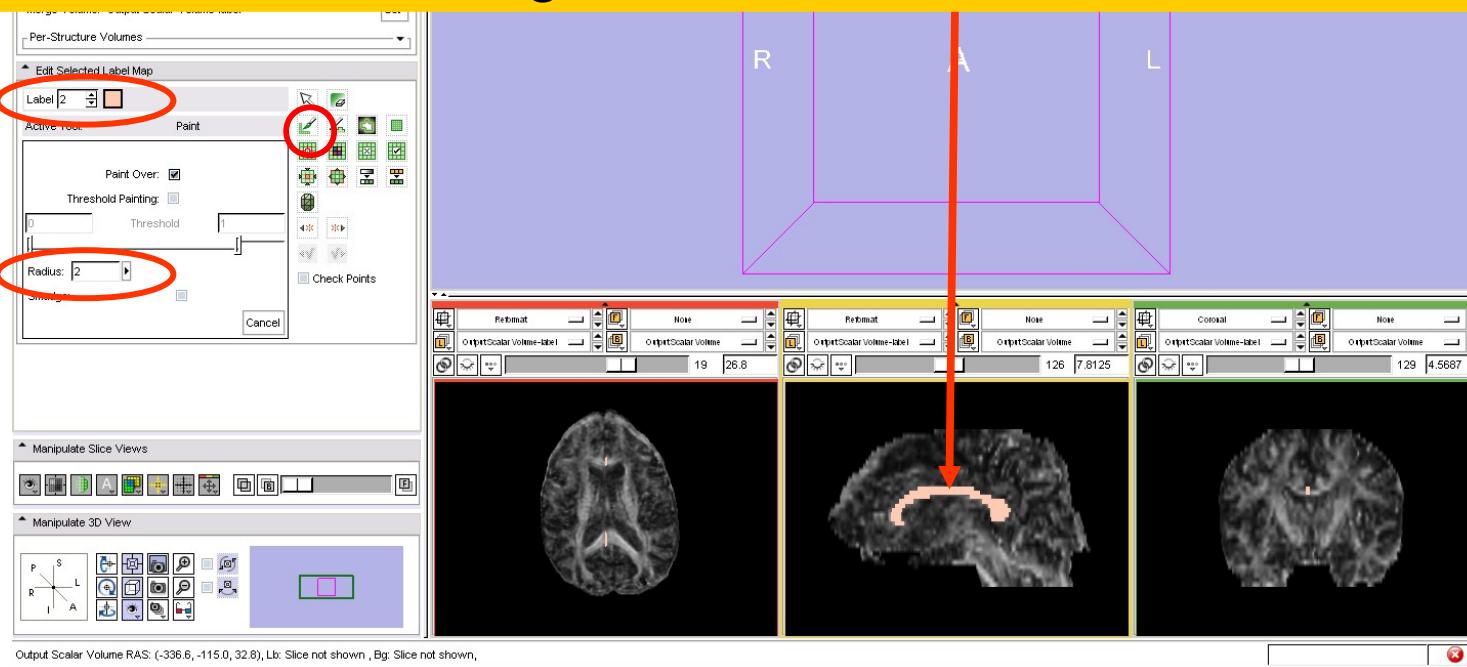
LabelMap Generation





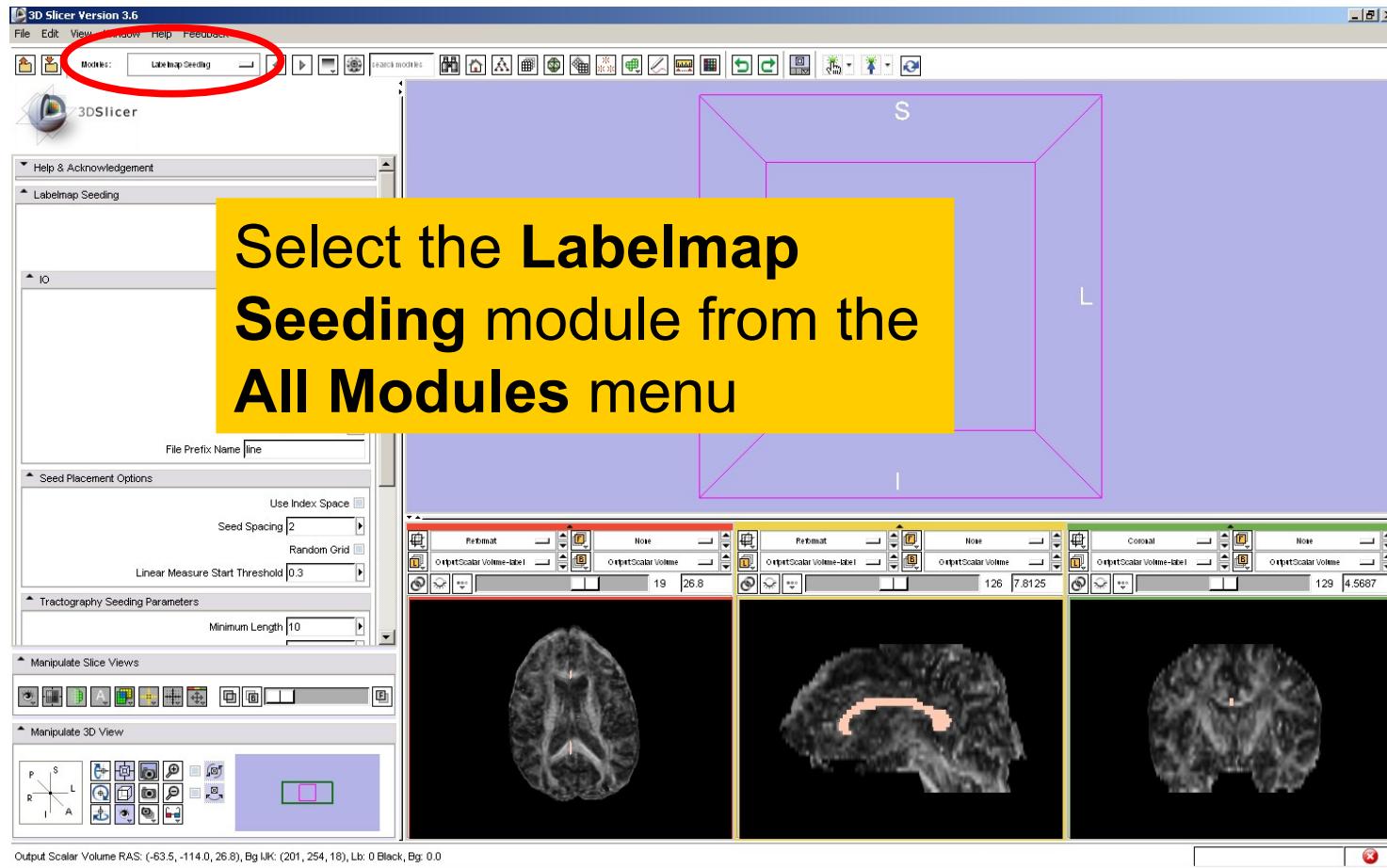
LabelMap Generation

Select the label 2 (pink), click on the **Paint** icon, set the radius to **2** and draw a region of interest within the corpus callosum in the sagittal view on a set of 2 or 3 slices



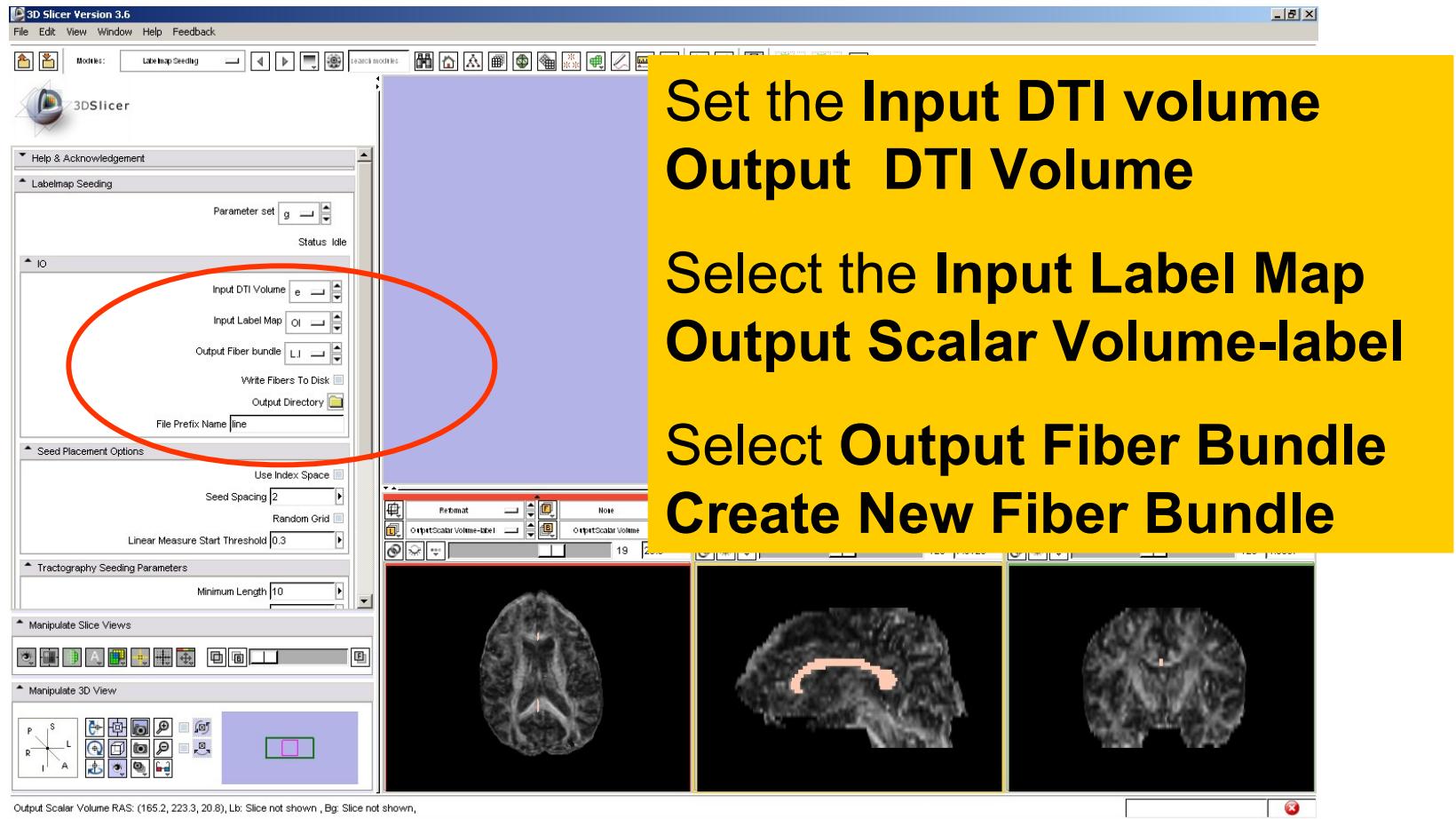


LabelMap Seeding



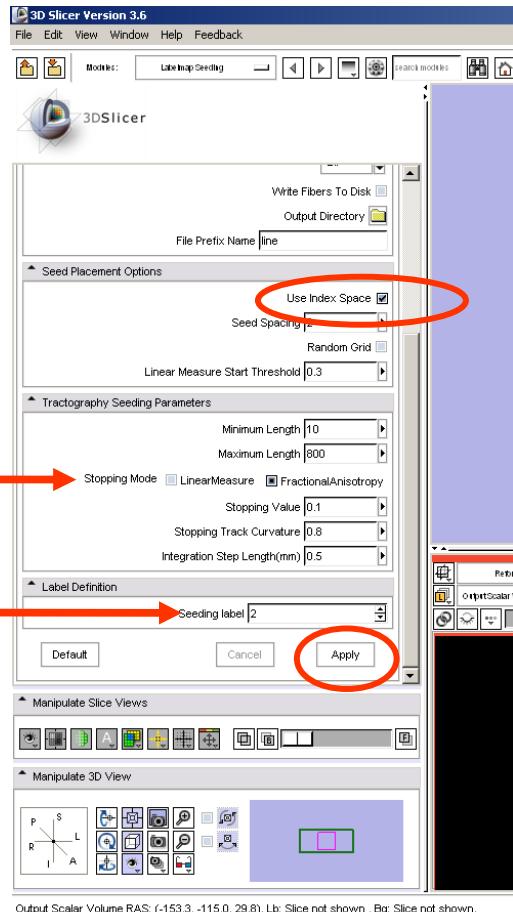


LabelMap Seeding





LabelMap Seeding



In the **Seed Placement Options** tab, check mark **Use Index Space**.

In the **Tractography Seeding Parameters** tab, set the **Stopping Mode** to **Fractional Anisotropy**, and use the default parameters for the Minimum and Maximum Length, Stopping Value, Stopping Track Curvature and Integration Step Length.

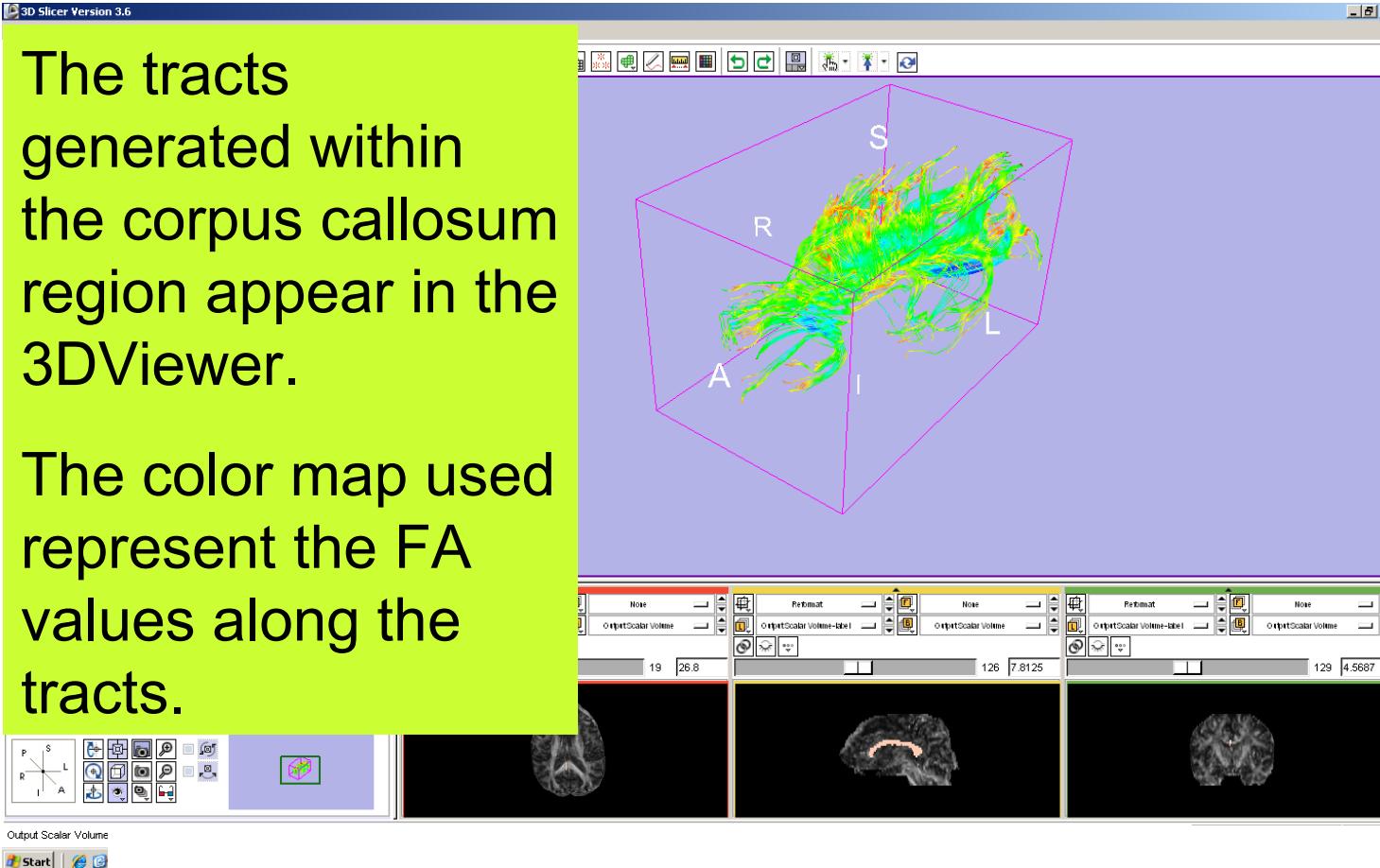
In the **Label Definition** tab, set Seeding label to label 2, and click on **Apply**.



LabelMap Seeding

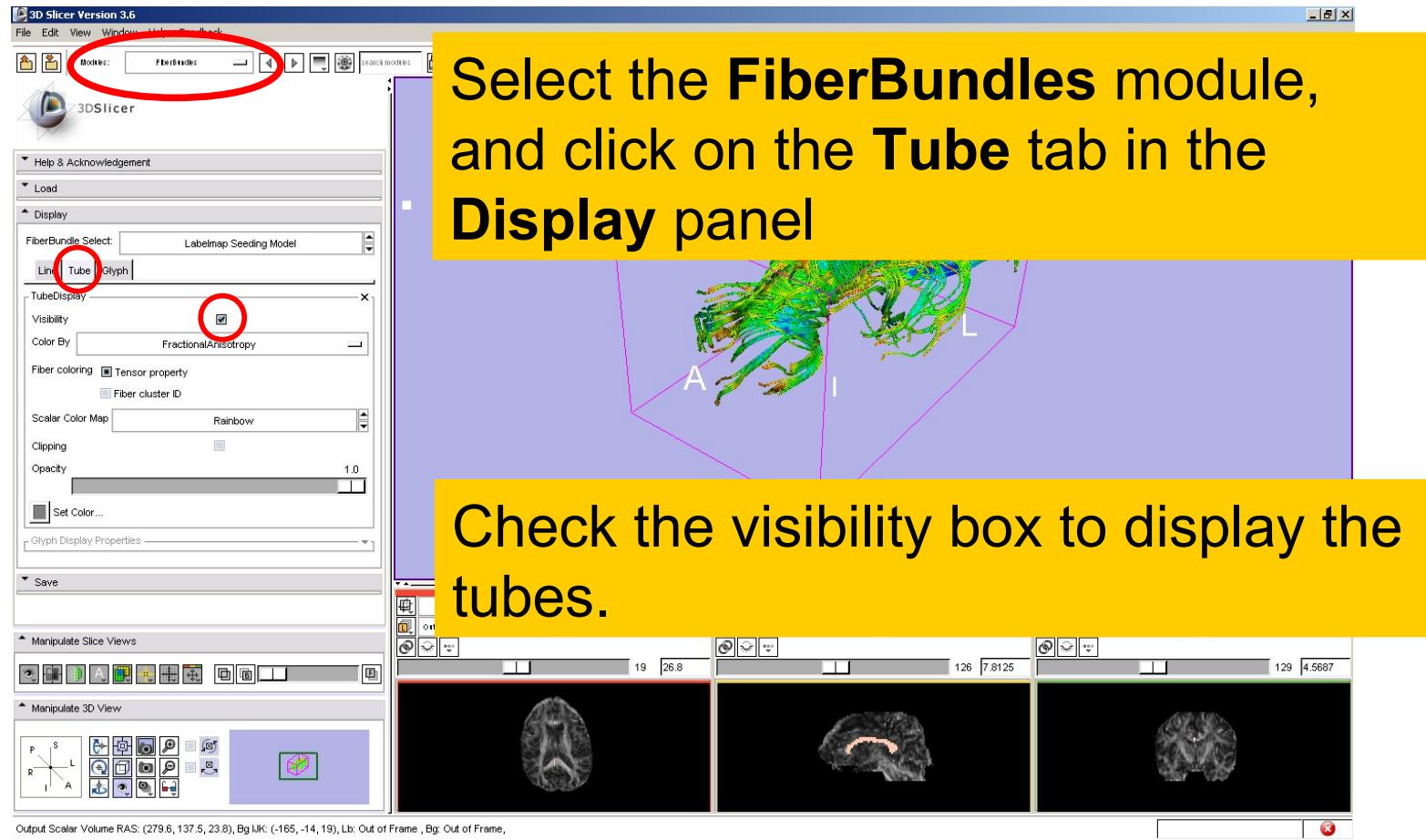
The tracts generated within the corpus callosum region appear in the 3DViewer.

The color map used represent the FA values along the tracts.



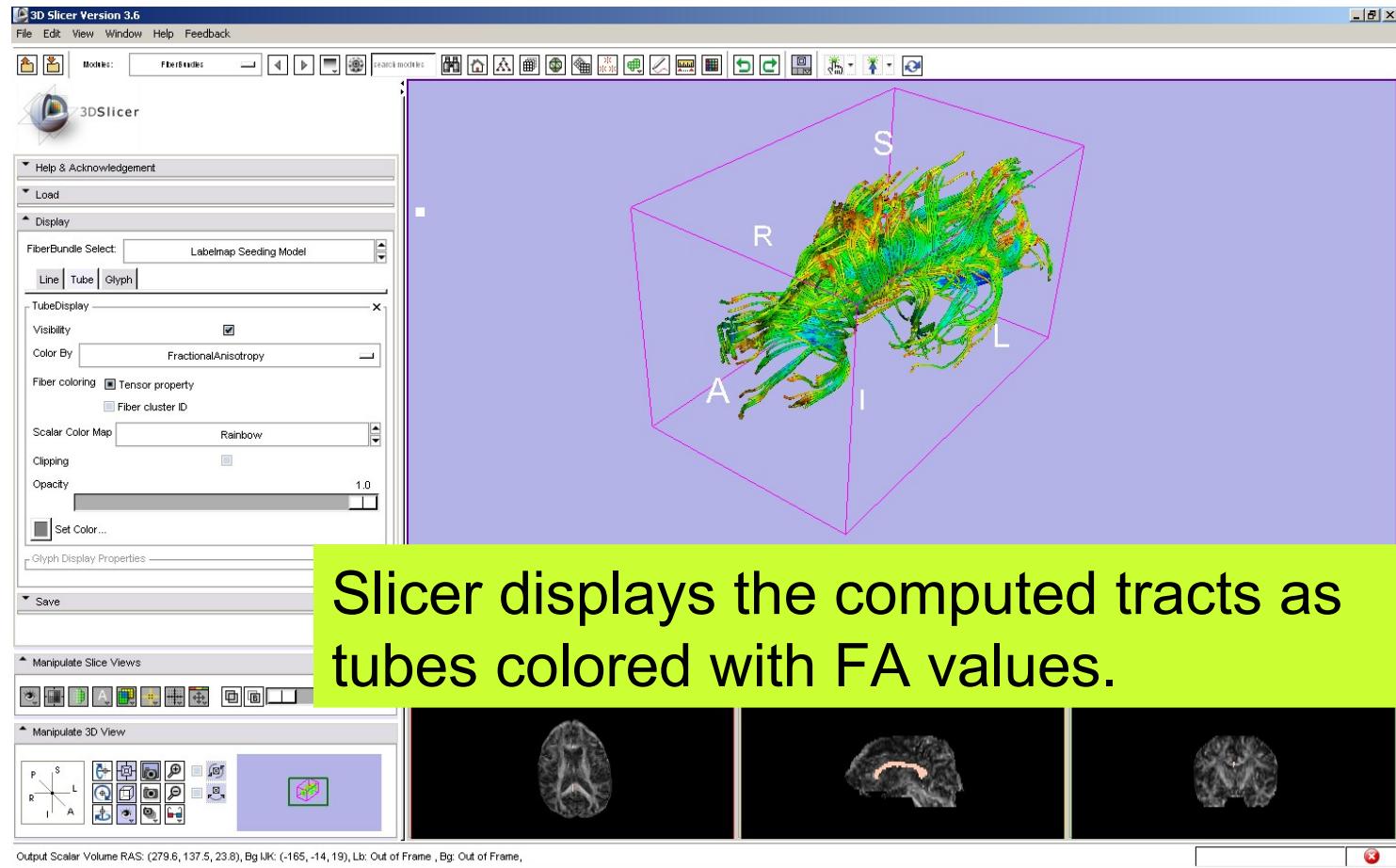


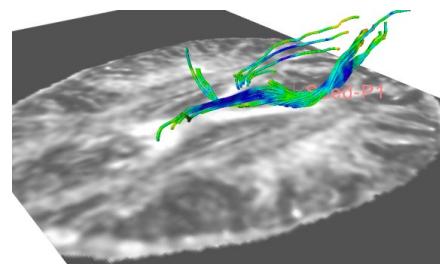
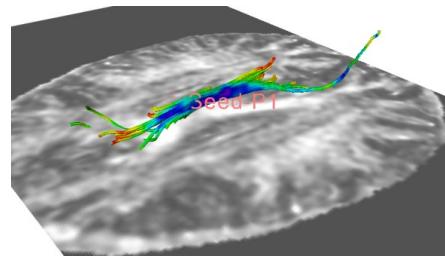
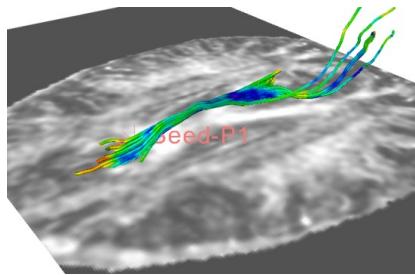
LabelMap Seeding





LabelMap Seeding



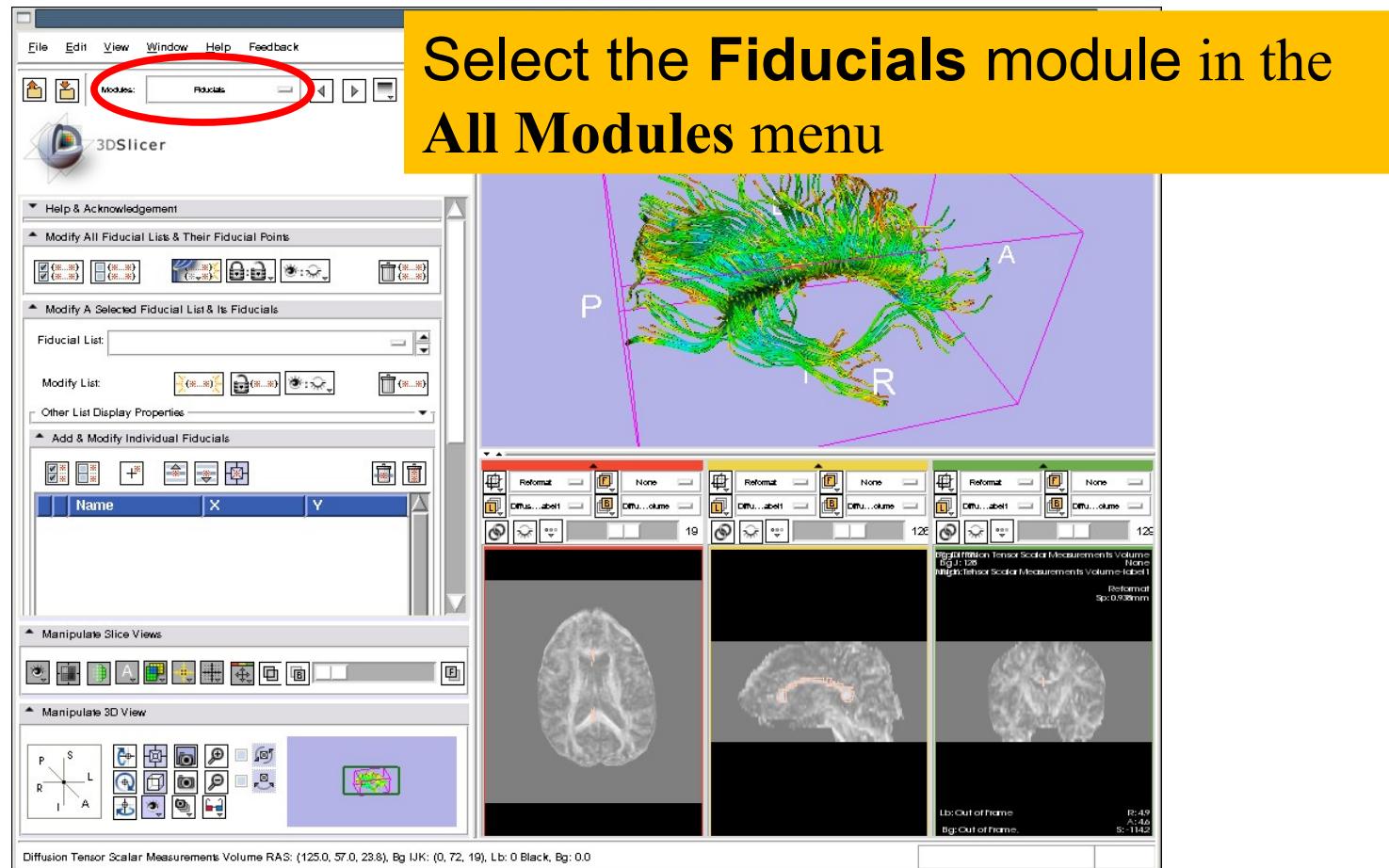


Part 4:

Tractography on-the-fly

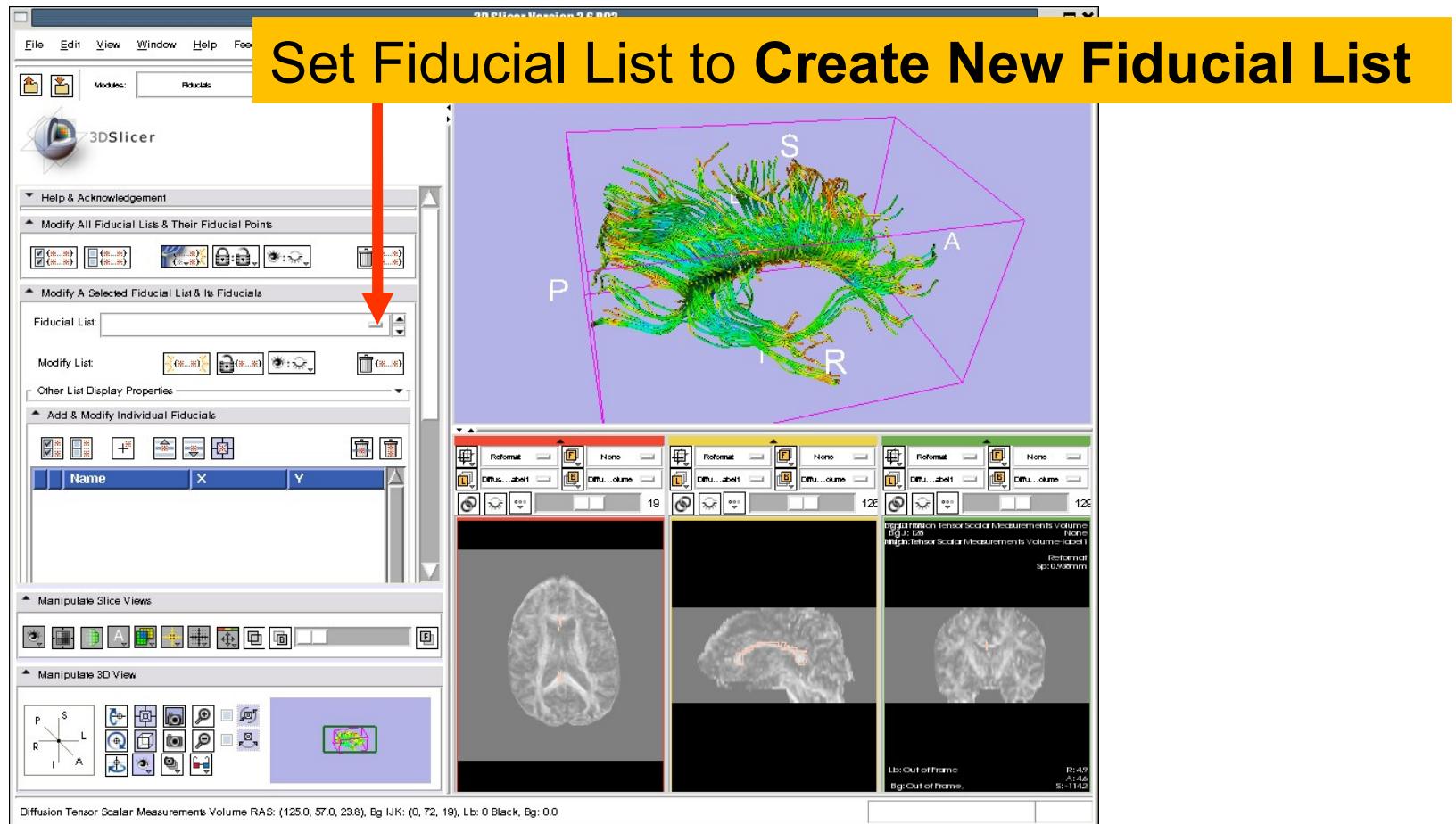


Fiducial Seeding



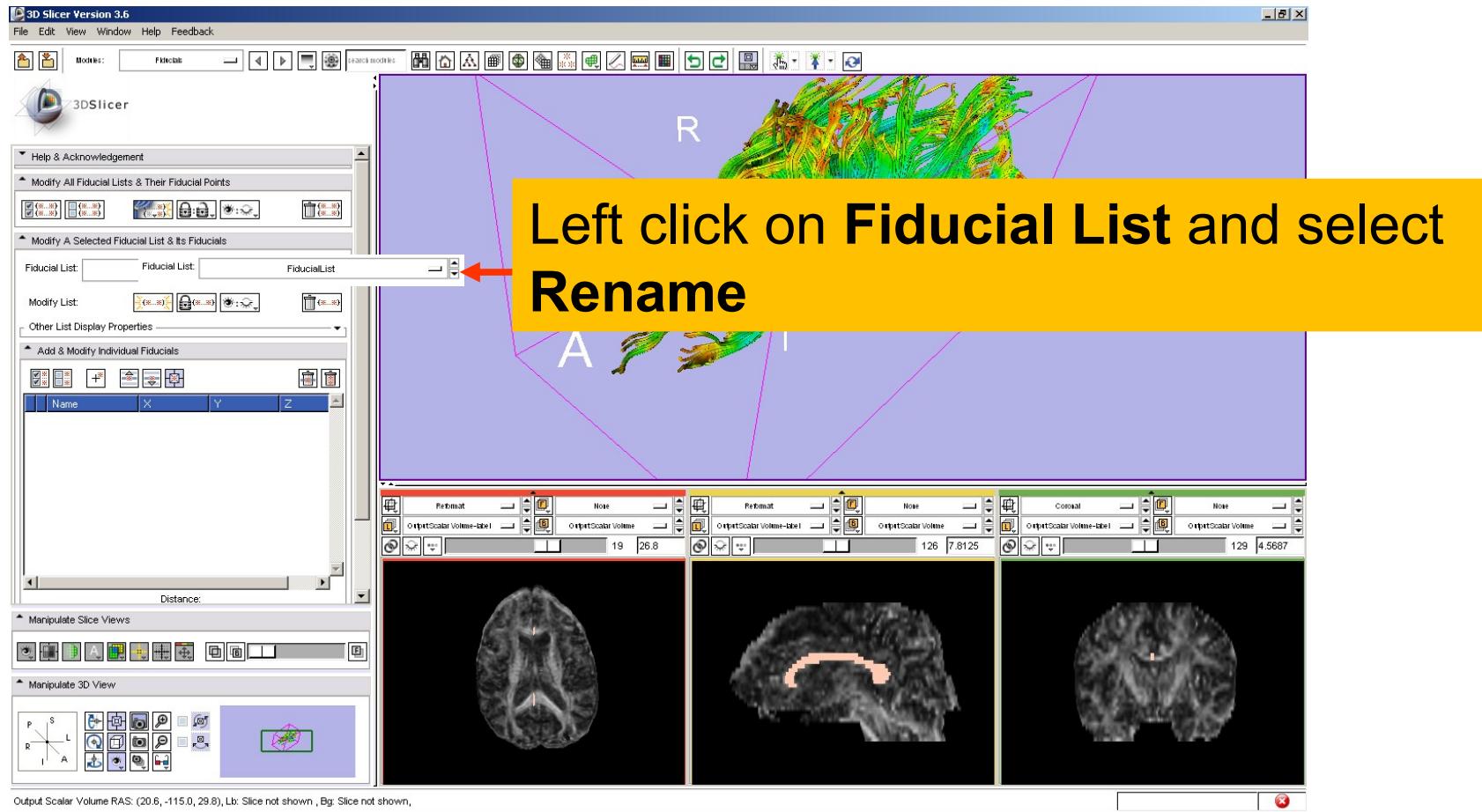


Fiducial Seeding



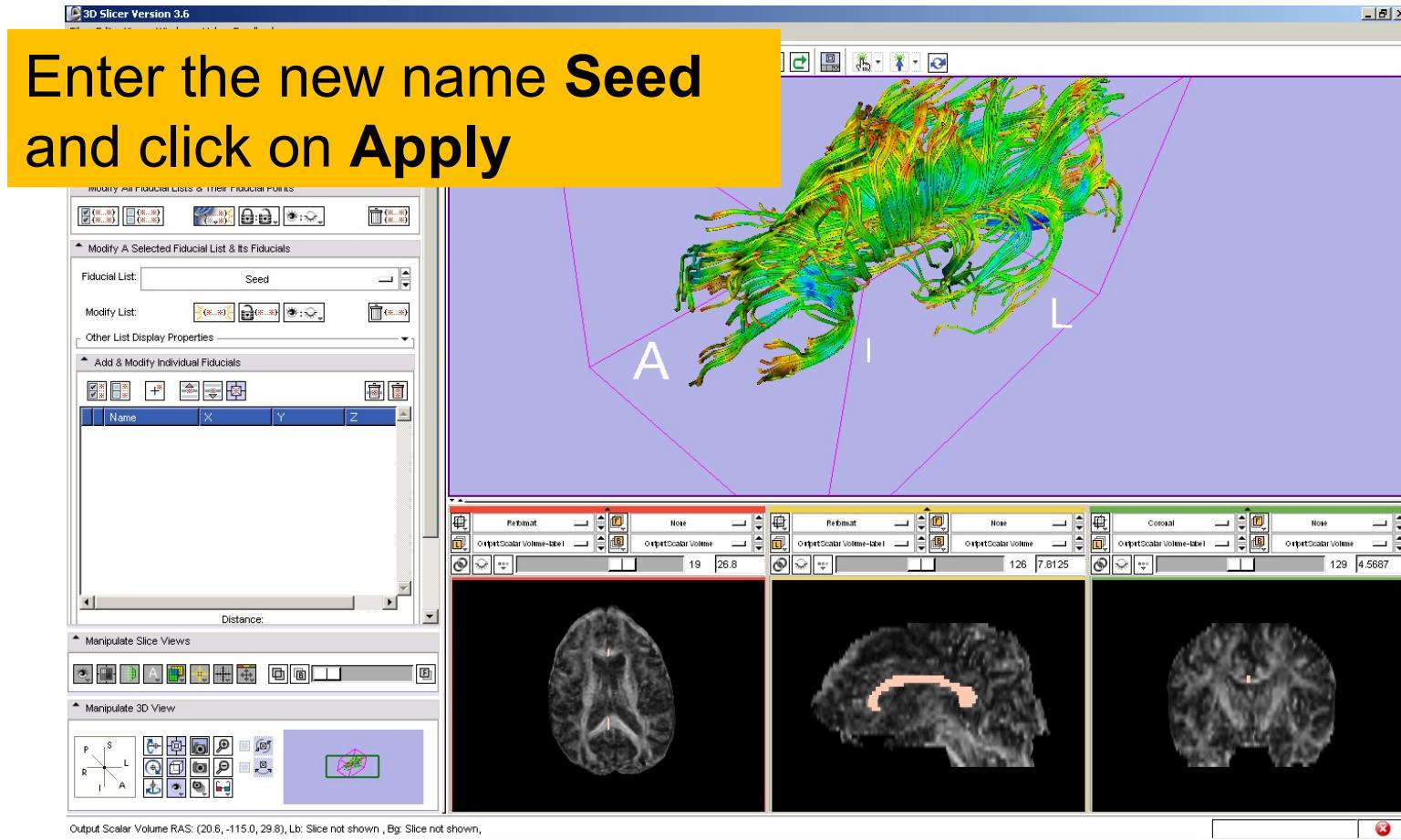


Fiducial Seeding



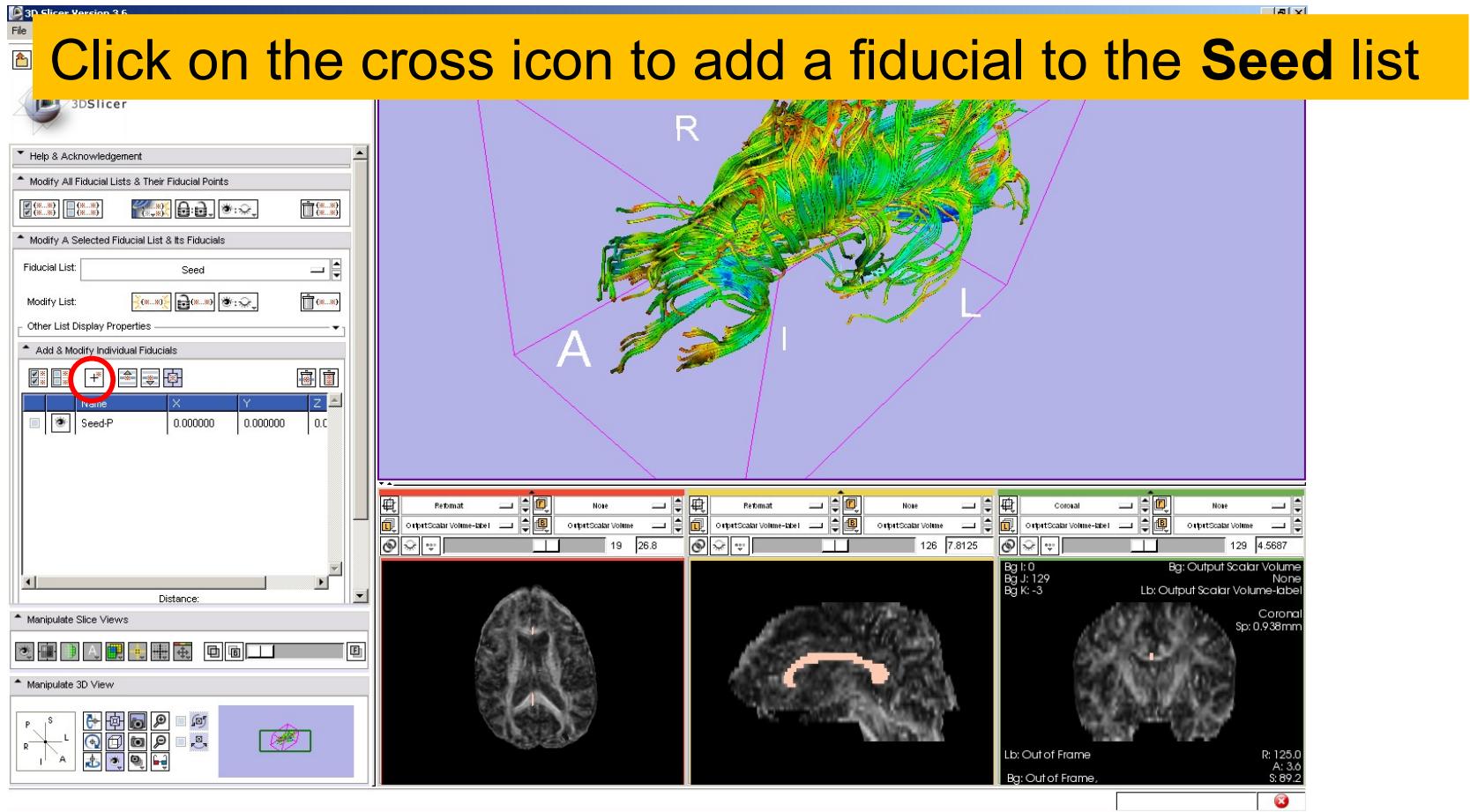


Fiducial Seeding





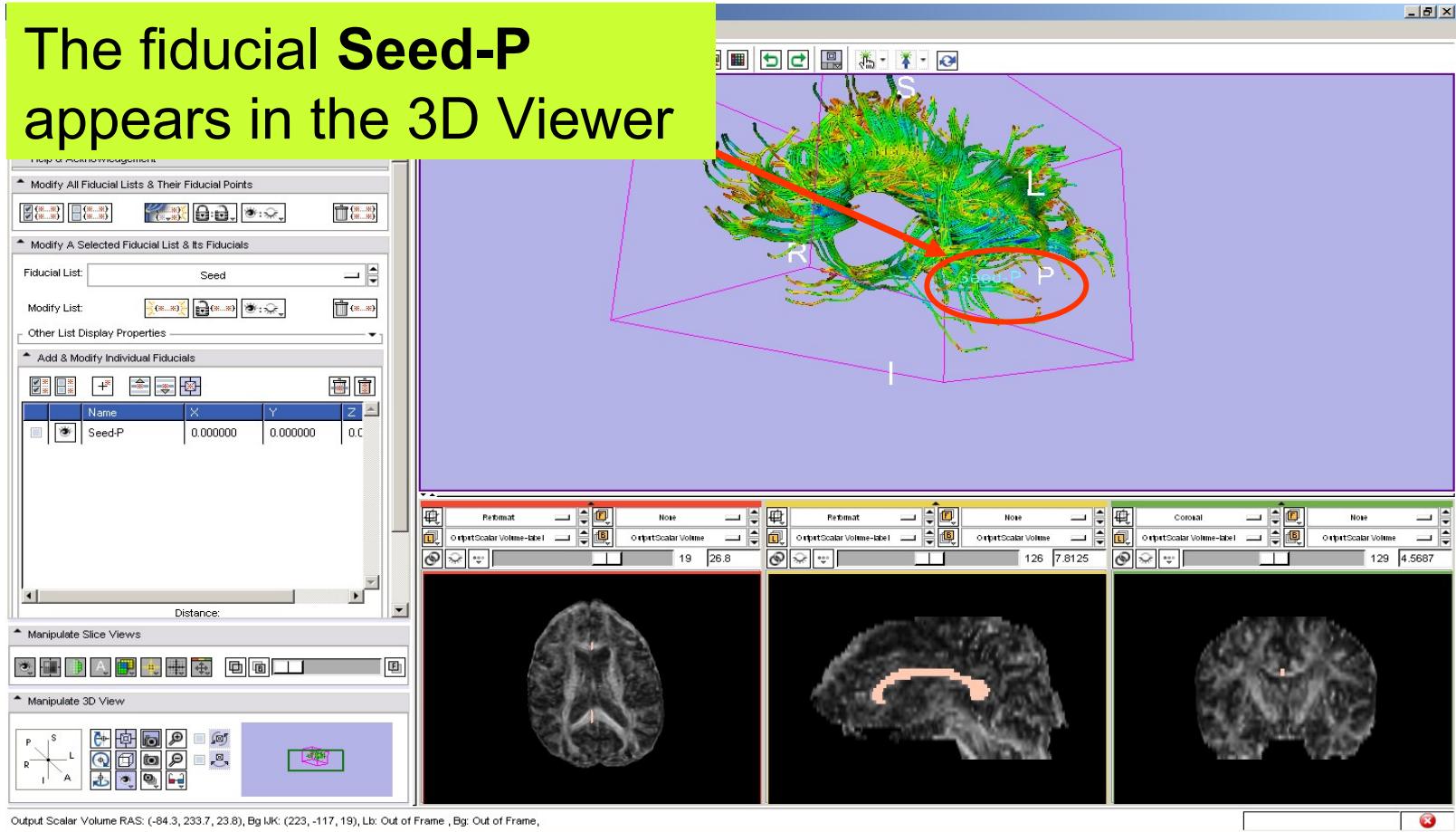
Fiducial Seeding





Fiducial Seeding

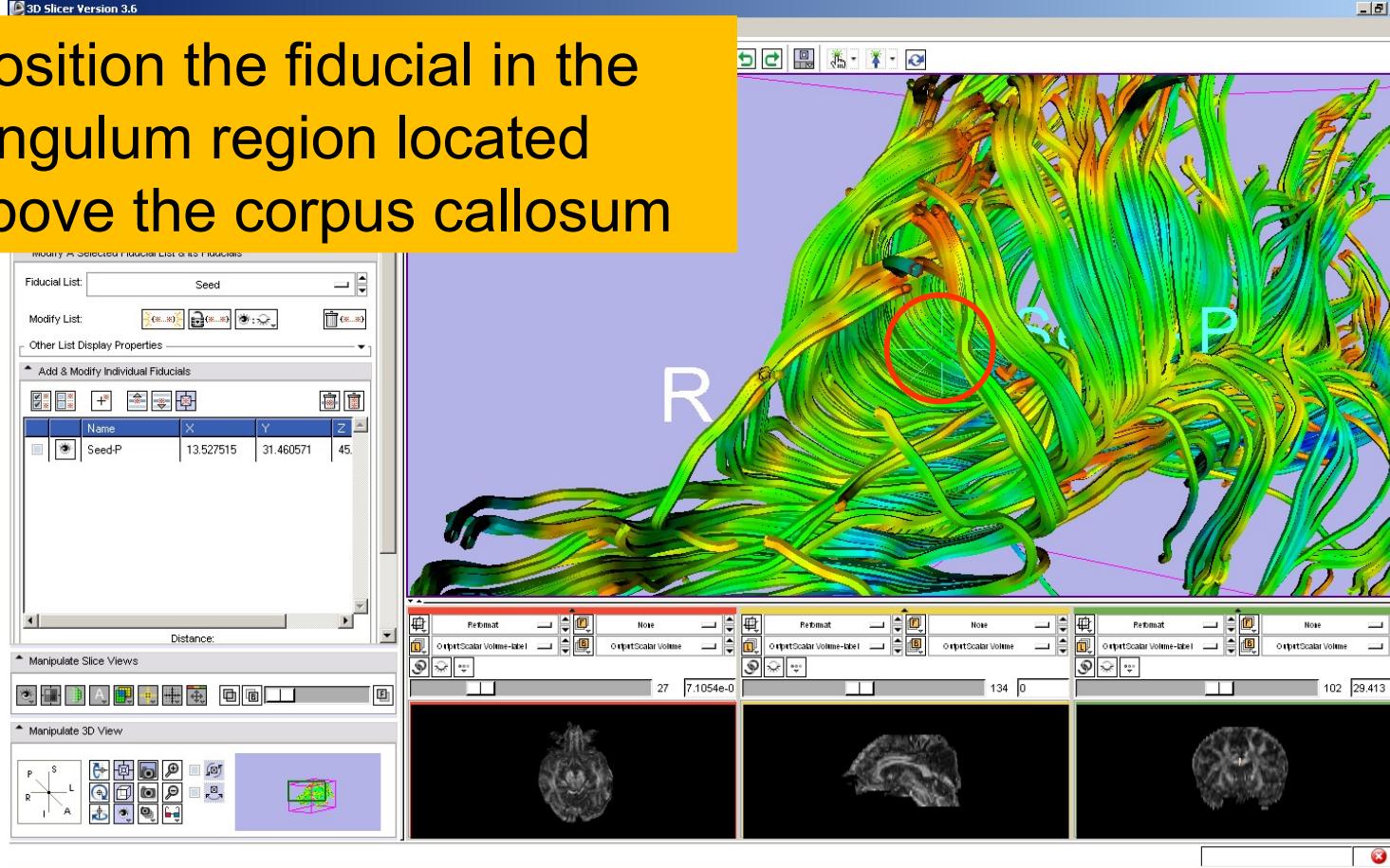
The fiducial **Seed-P** appears in the 3D Viewer





Fiducial Seeding

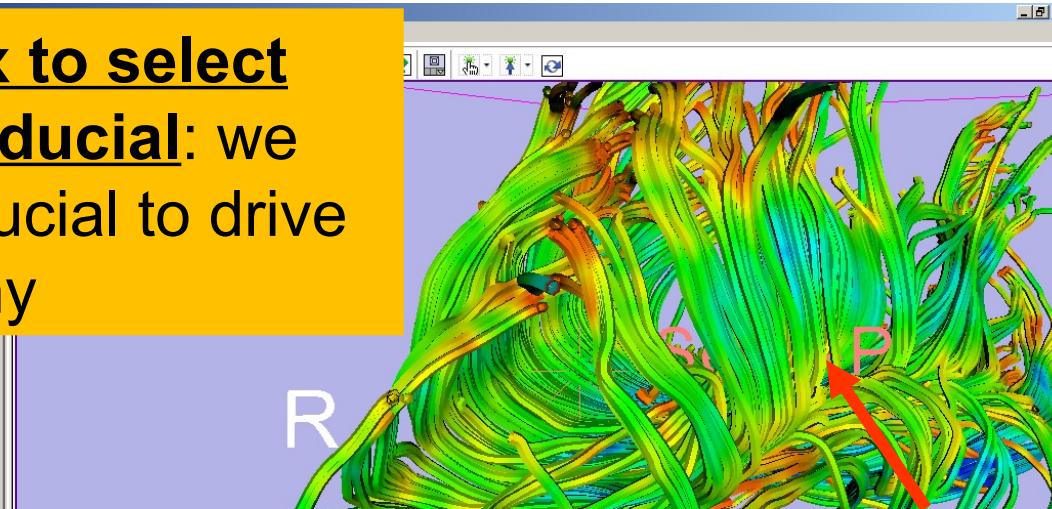
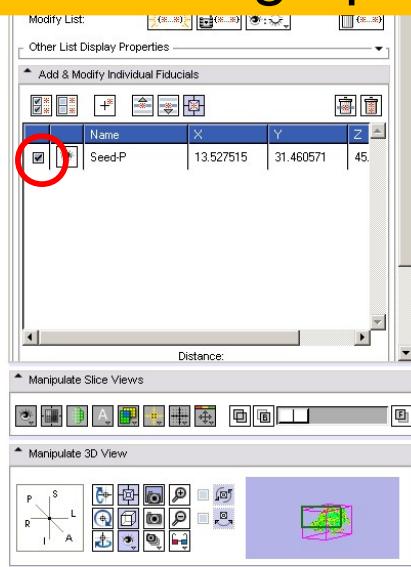
Position the fiducial in the cingulum region located above the corpus callosum





Fiducial Seeding

Check the box to select the ‘Seed-P’ fiducial: we will use this fiducial to drive the tractography

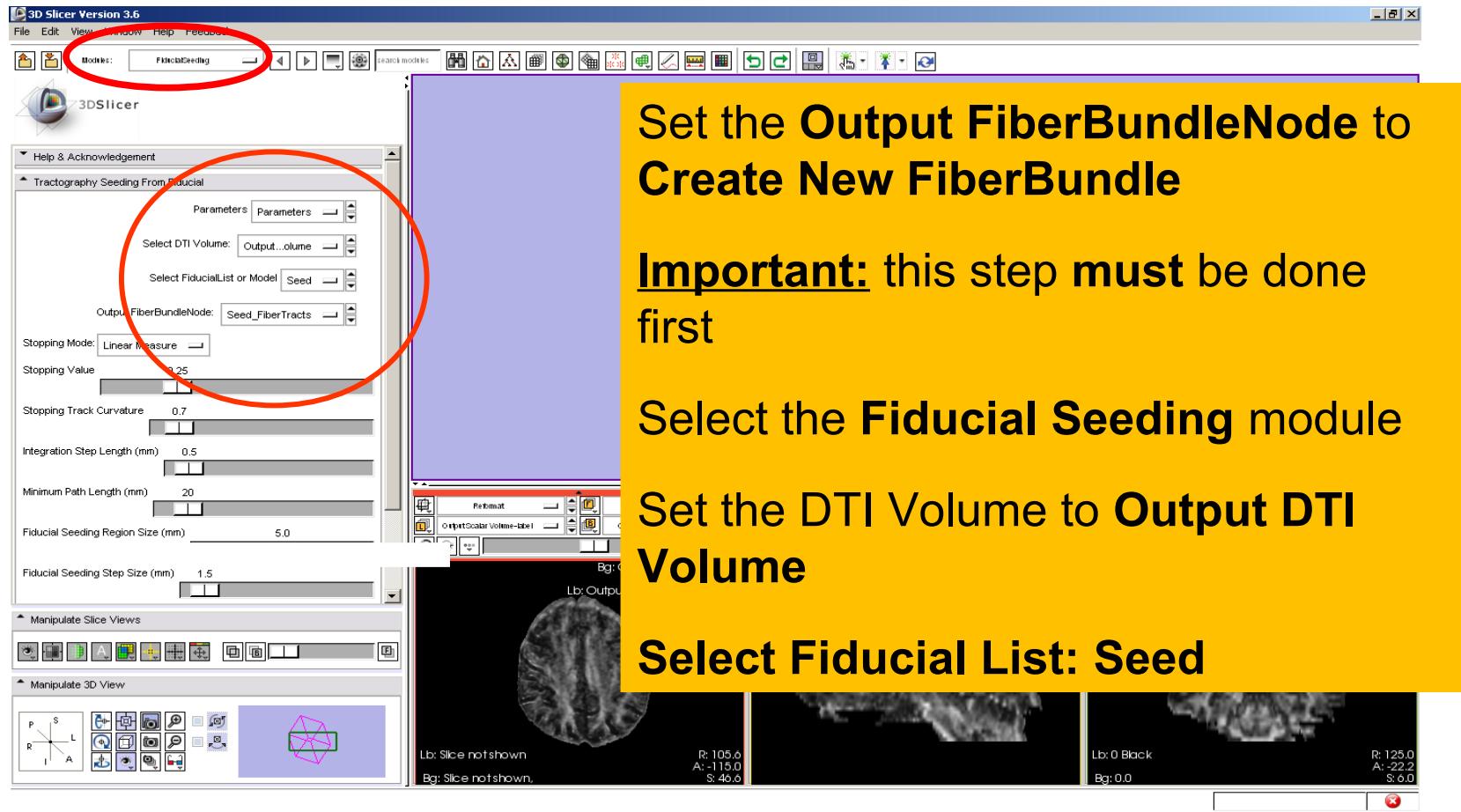


Once selected, the fiducial Seed-P is displayed in pink letters in the 3D viewer.





Fiducial Seeding





Fiducial Seeding

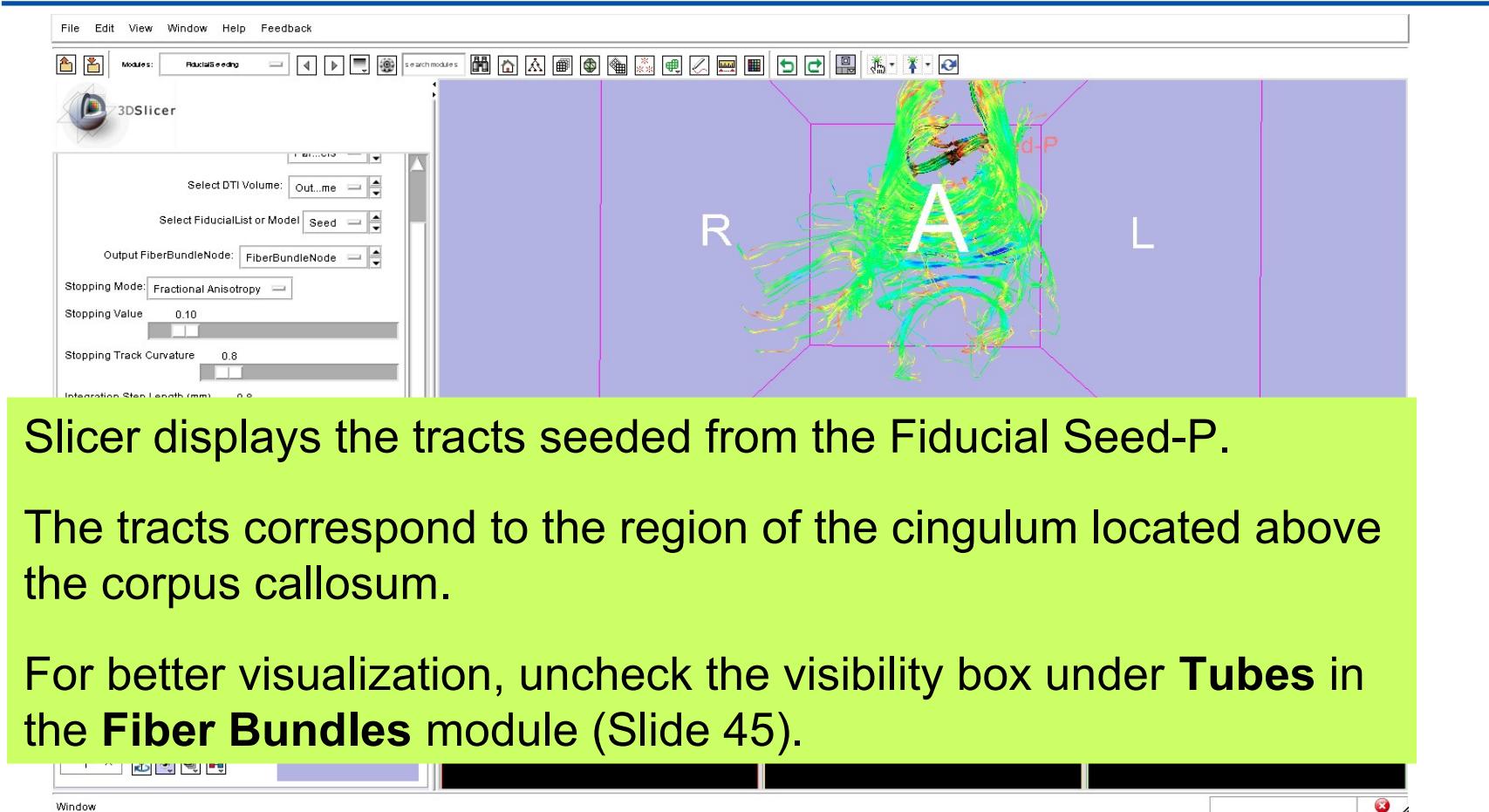
The screenshot shows the 3D Slicer Version 3.6 RC3 interface. The main window title is "3D Slicer Version 3.6 RC3". The menu bar includes File, Edit, View, Window, Help, and Feedback. The toolbar has icons for file operations and search. The central panel displays the "Fiducial Seeding" module settings. The "Stopping Mod" is set to "Fractional Anisotropy". Other parameters are: Stopping Value (0.10), Stopping Track Curvature (0.8), Integration Step Length (mm) (0.8), Minimum Path Length (mm) (10), Fiducial Seeding Region Size (mm) (5.0), and Fiducial Seeding Step Size (mm) (1.5). A checked checkbox says "Seed Selected Fiducials". Below the settings are sections for "Manipulate Slice Views" and "Manipulate 3D View" with various icons. At the bottom, a status bar reads: "Diffusion Tensor Scalar Measurements Volume RAS: (-105.5, 4.6, -113.6), Bg IJK: (248, 128, 64), Lb: Out of Frame , Bg: Out of Frame," and a red "X" button.

Set the Stopping Mode to Fractional Anisotropy and set the tractography parameters to the values that we used for the corpus callosum:

Stopping Value: 0.1
Stopping Track Curvature: 0.8
Integration Step Length: 0.8 mm
Minimum Path Length: 10 mm
Fiducial Seeding Region Size: 5 mm
Fiducial Seeding Step Size: 1.5 mm



Fiducial Seeding



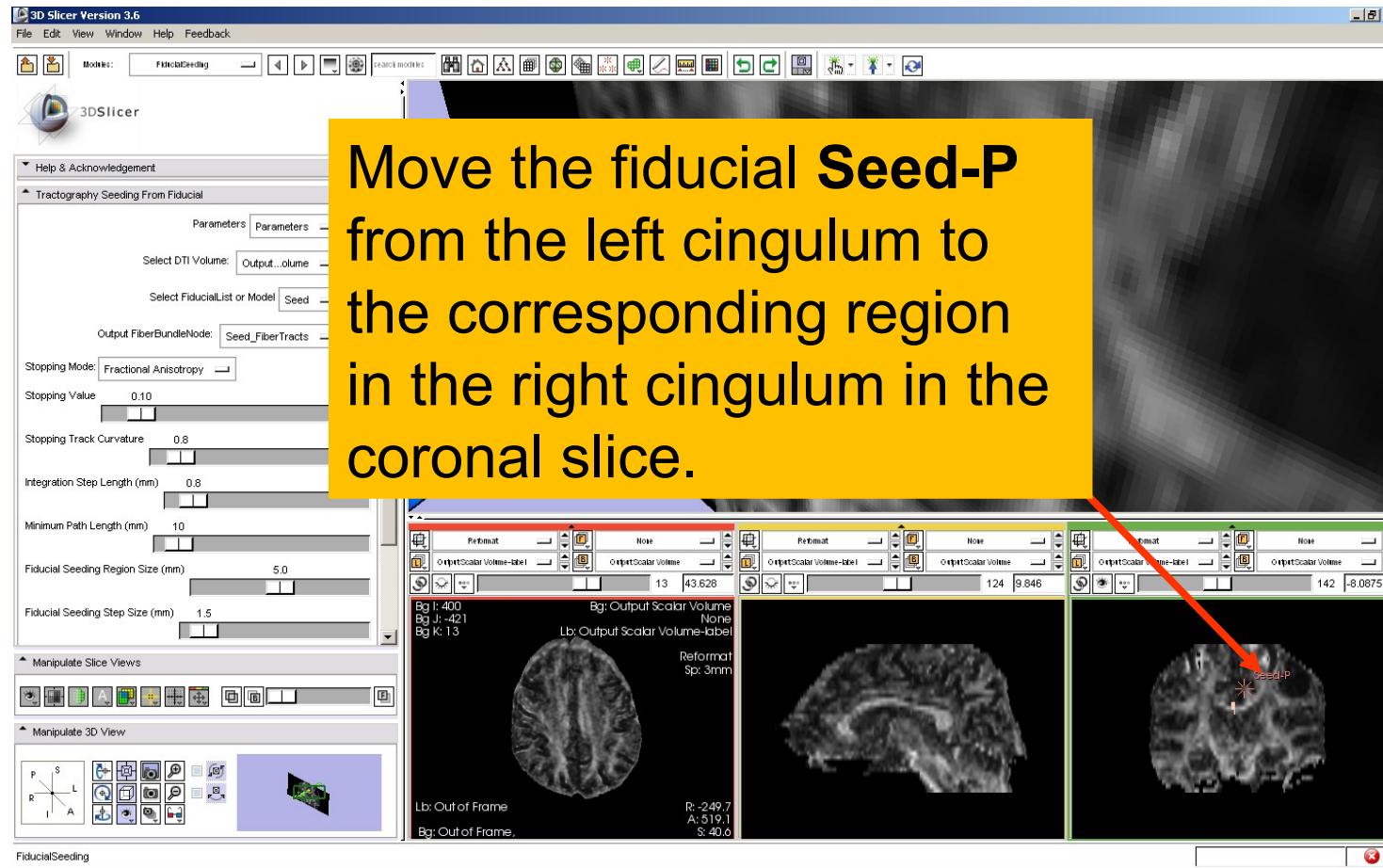
Slicer displays the tracts seeded from the Fiducial Seed-P.

The tracts correspond to the region of the cingulum located above the corpus callosum.

For better visualization, uncheck the visibility box under **Tubes** in the **Fiber Bundles** module (Slide 45).

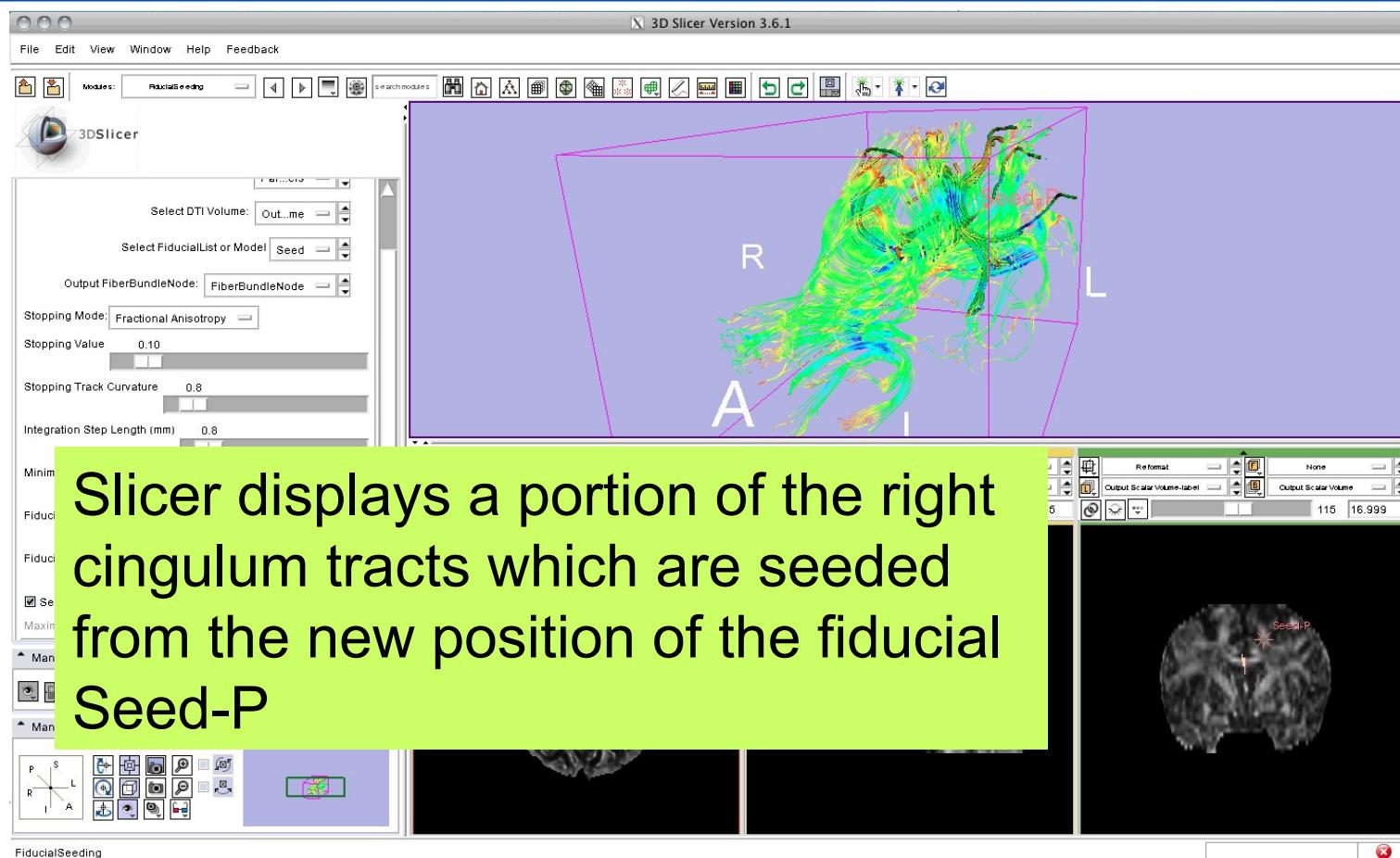


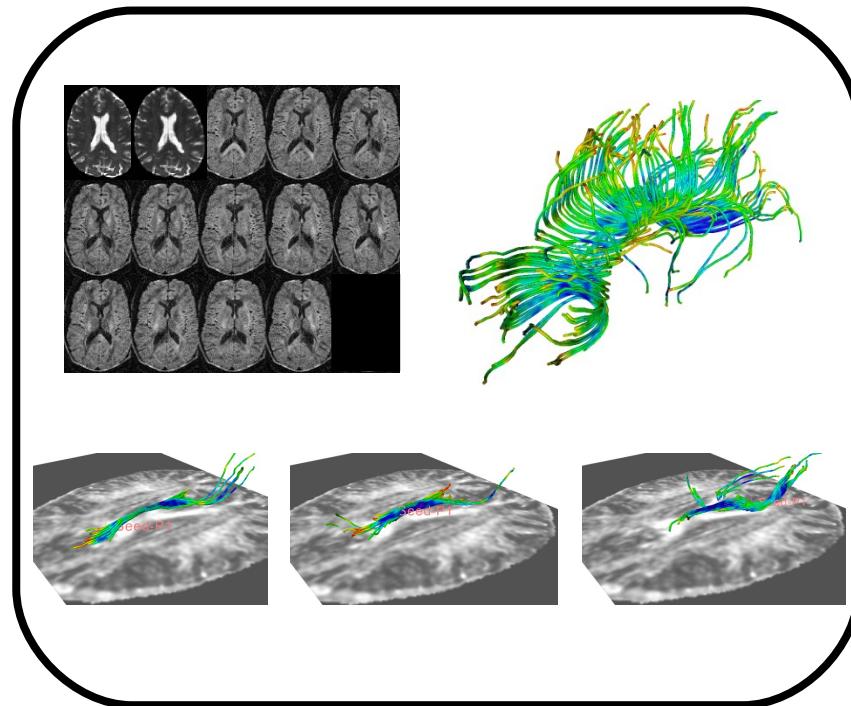
Fiducial Seeding





Fiducial Seeding



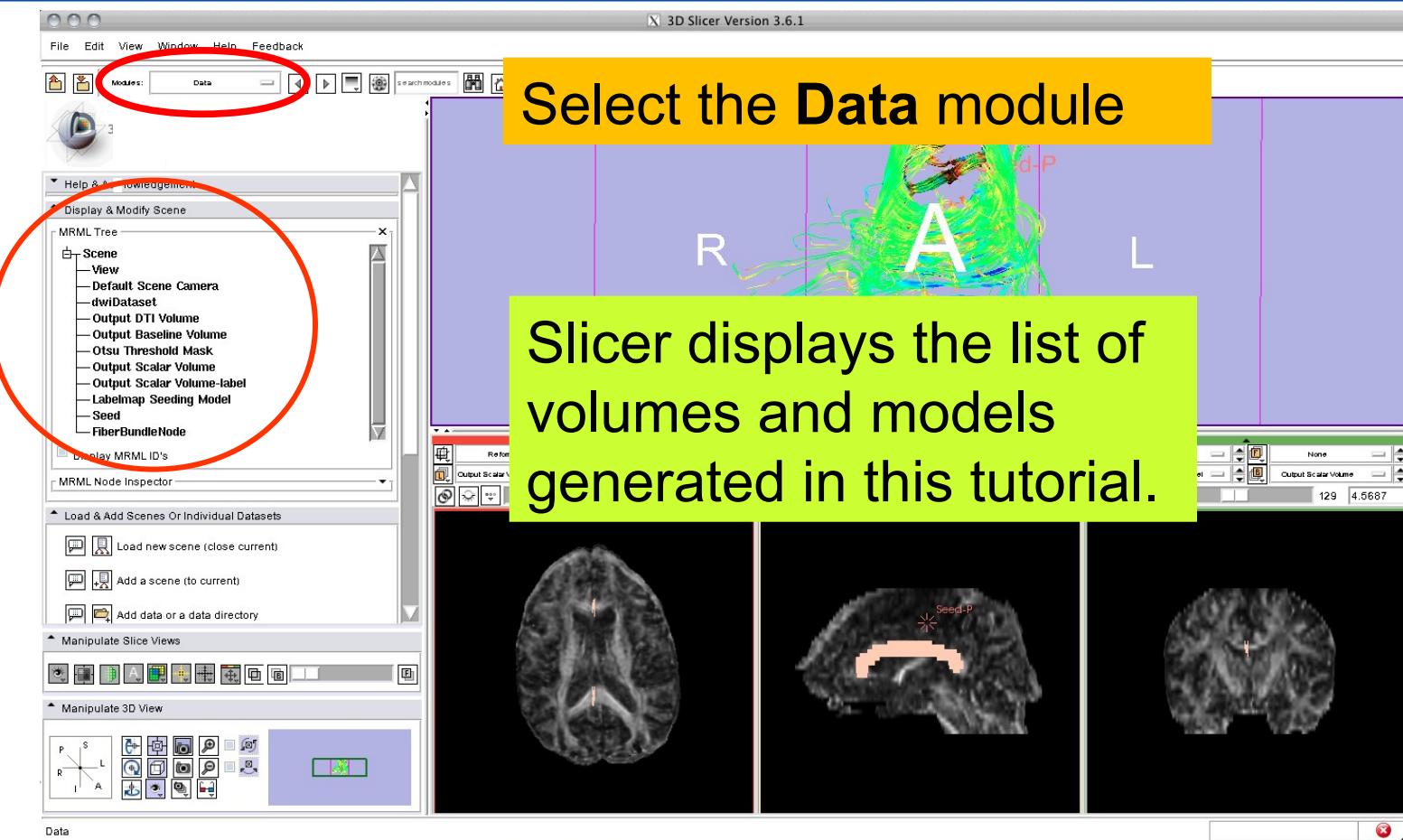


Part 5:

Saving a DTI Scene



DTI Scene





Saving a DTI Scene





Saving a DTI Scene

Browse to a directory where you would like to save the data.
Once you have selected a directory, select all the files that have
been created during this tutorial and click on **Save Selected**

Save Scene & Data Options

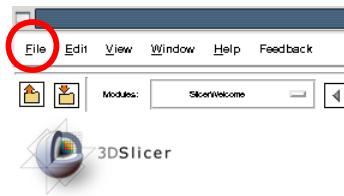
Change Destination for A Selected:

Select	Node Name	Node Type	Node Status	File Format	File Name	Data Directory
<input checked="" type="checkbox"/>	(Scene Description)	(SCENE)	Modified	MRML (.mrml)	SlicerScene1	D:/SlicerData/DiffusionDataset/
<input type="checkbox"/>	dwiDataset	DiffusionWei...	Not Modified	NRRD (.nhdr)	dwiDataset.nhdr	D:/SlicerData/DiffusionDataset/
<input checked="" type="checkbox"/>	Output DTI Volume	DiffusionTen...	Not Modified	NRRD (.nhdr)	Output DTI Volume.nhdr	D:/SlicerData/DiffusionDataset/
<input checked="" type="checkbox"/>	Output Baseline Volume	Volume	Modified	NRRD (.nrrd)	Output Baseline Volum...	D:/SlicerData/DiffusionDataset/
<input checked="" type="checkbox"/>	Otsu Threshold Mask	Volume	Modified	NRRD (.nrrd)	Otsu Threshold Mask.n...	D:/SlicerData/DiffusionDataset/
<input checked="" type="checkbox"/>	Output Scalar Volume	Volume	Modified	NRRD (.nrrd)	Output Scalar Volume....	D:/SlicerData/DiffusionDataset/
<input checked="" type="checkbox"/>	Output Scalar Volume-label	Volume	Modified	NRRD (.nrrd)	Output Scalar Volume-...	D:/SlicerData/DiffusionDataset/
<input checked="" type="checkbox"/>	Labelmap Seeding Model	FiberBundle	Modified	Poly Data (.vtk)	Labelmap Seeding Mo...	D:/SlicerData/DiffusionDataset/
<input checked="" type="checkbox"/>	Seed	FiducialList	Modified	Fiducial List CSV (.fcsv)	Seed.fcsv	D:/SlicerData/DiffusionDataset/
<input checked="" type="checkbox"/>	Seed_FiberTracts	FiberBundle	Modified	Poly Data (.vtk)	Seed_FiberTracts.vtk	D:/SlicerData/DiffusionDataset/

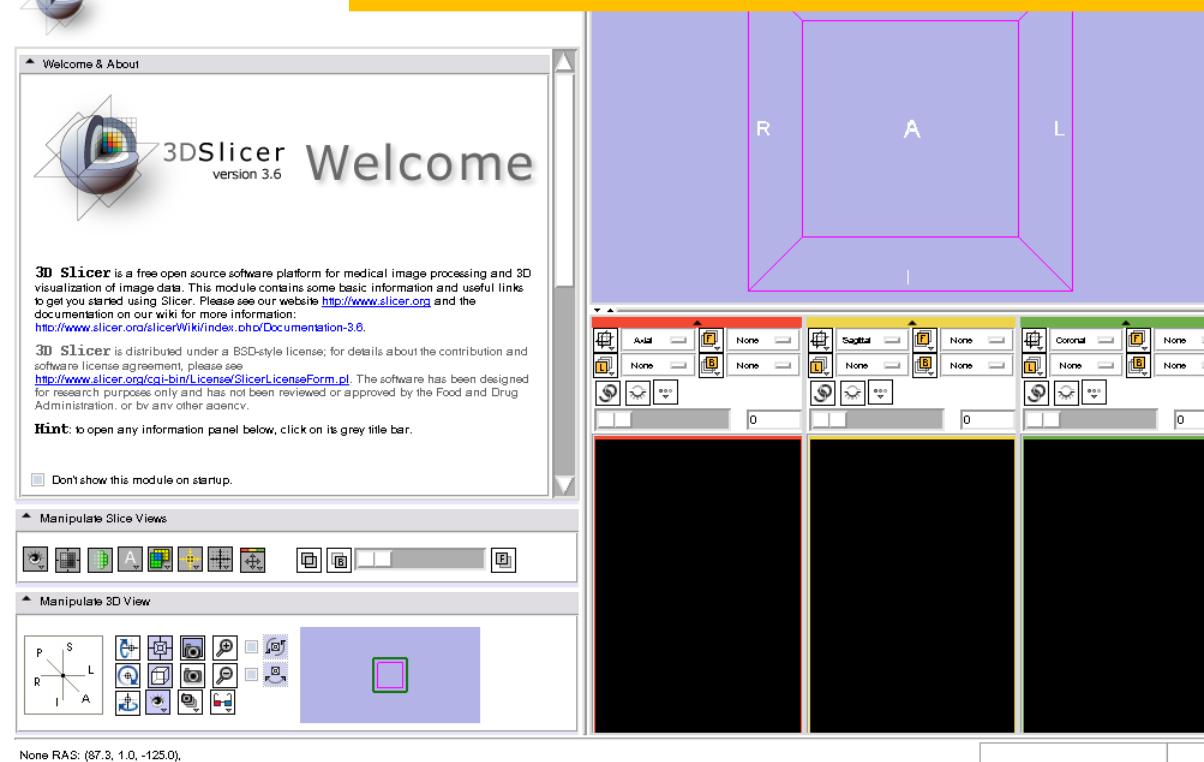
 Save Selected Cancel



Saving a DTI Scene

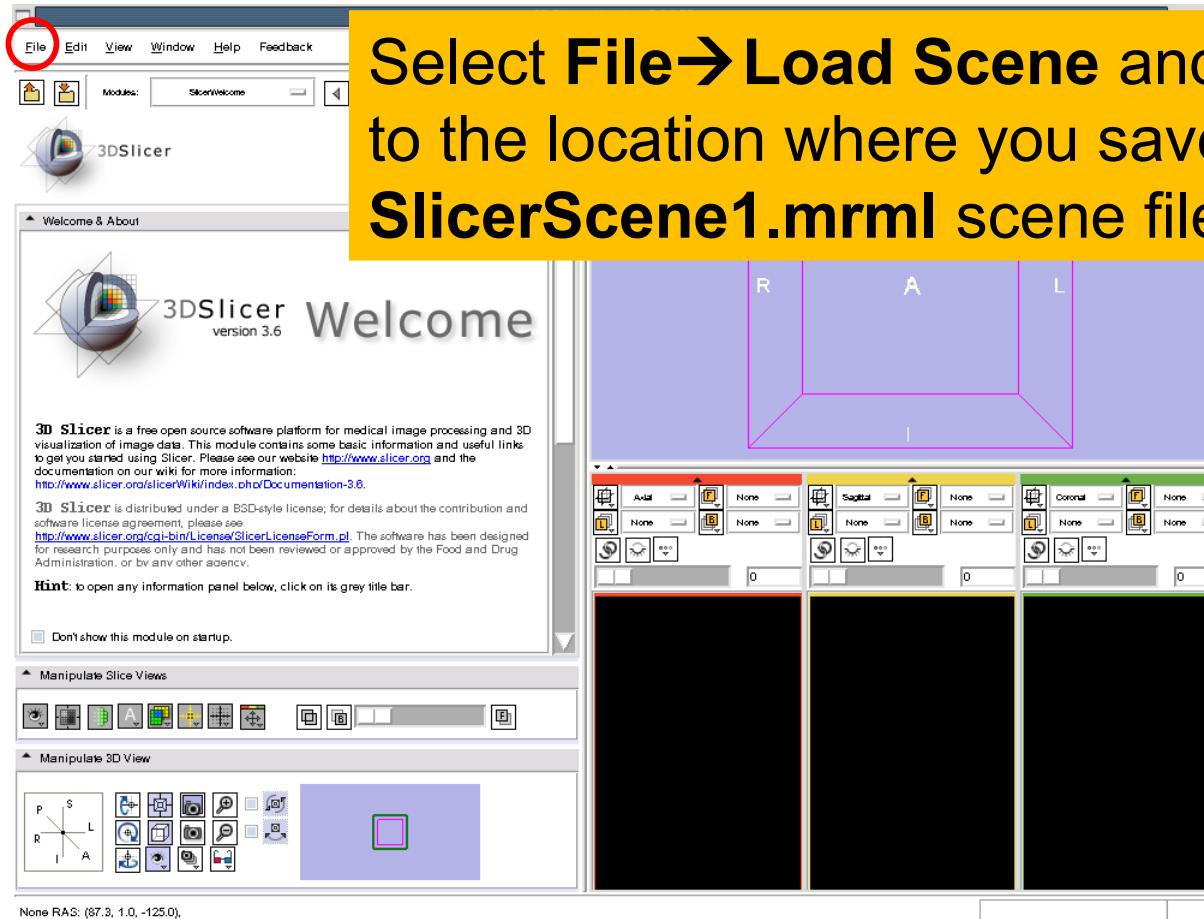


Select **File** → **Close Scene** to close the current DTI Scene



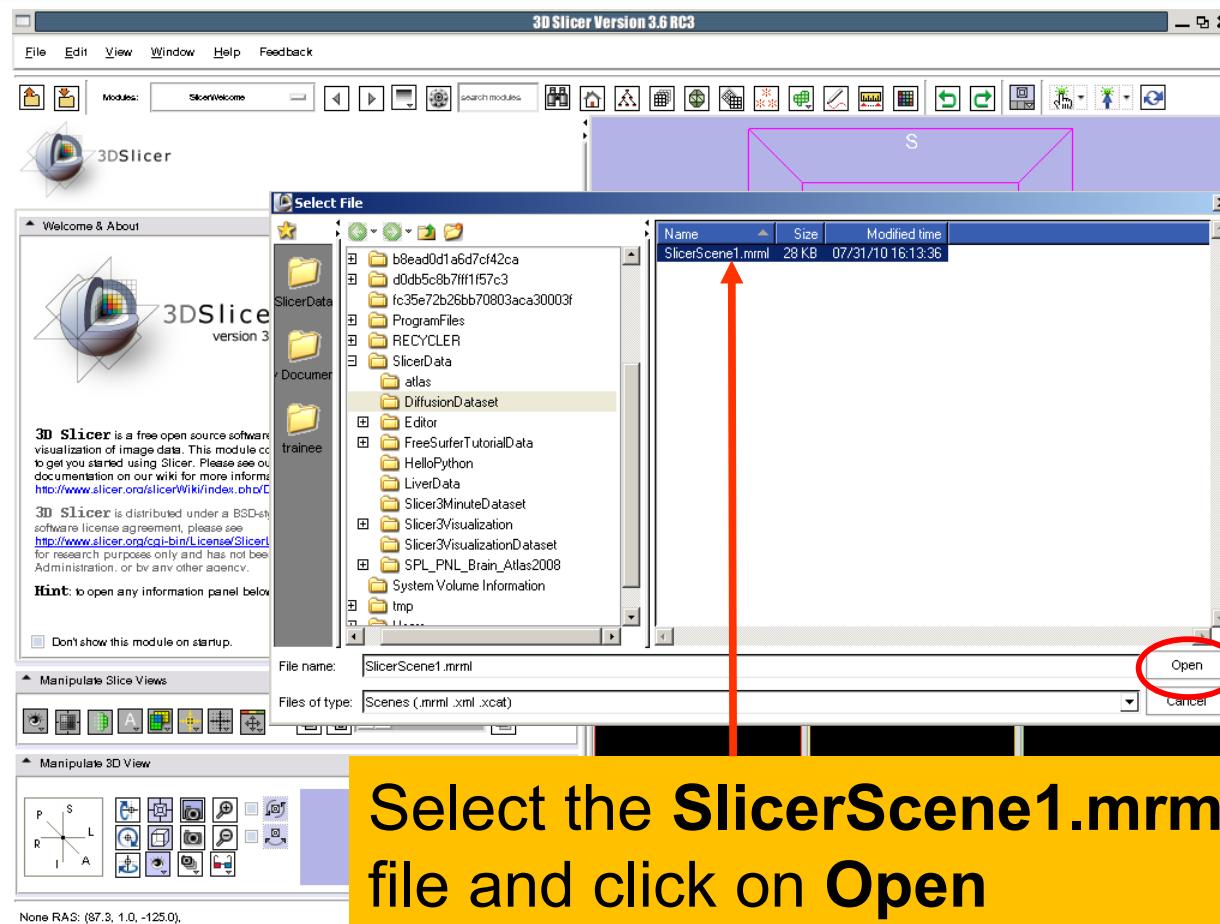


Loading a DTI Scene



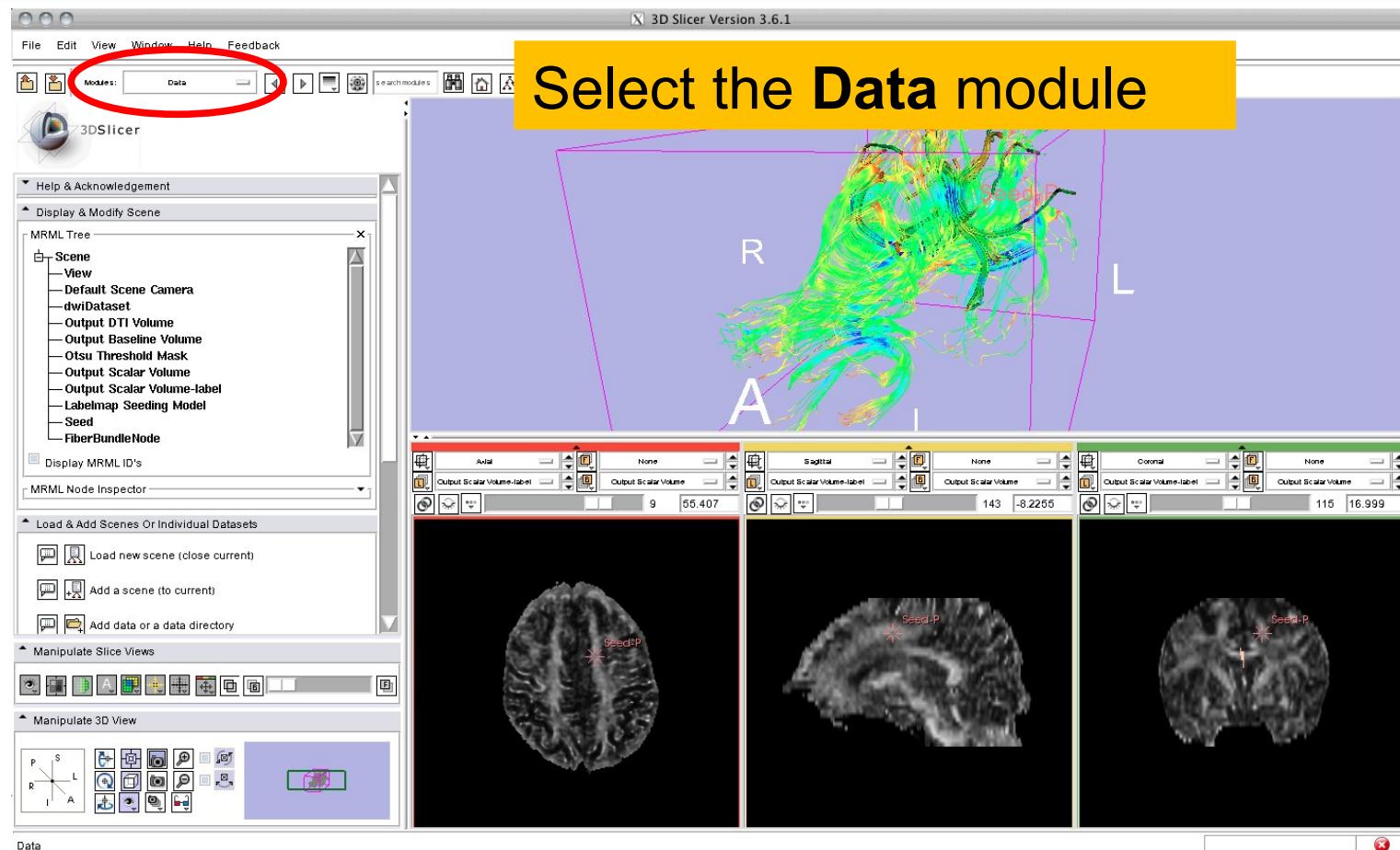


Loading a DTI Scene



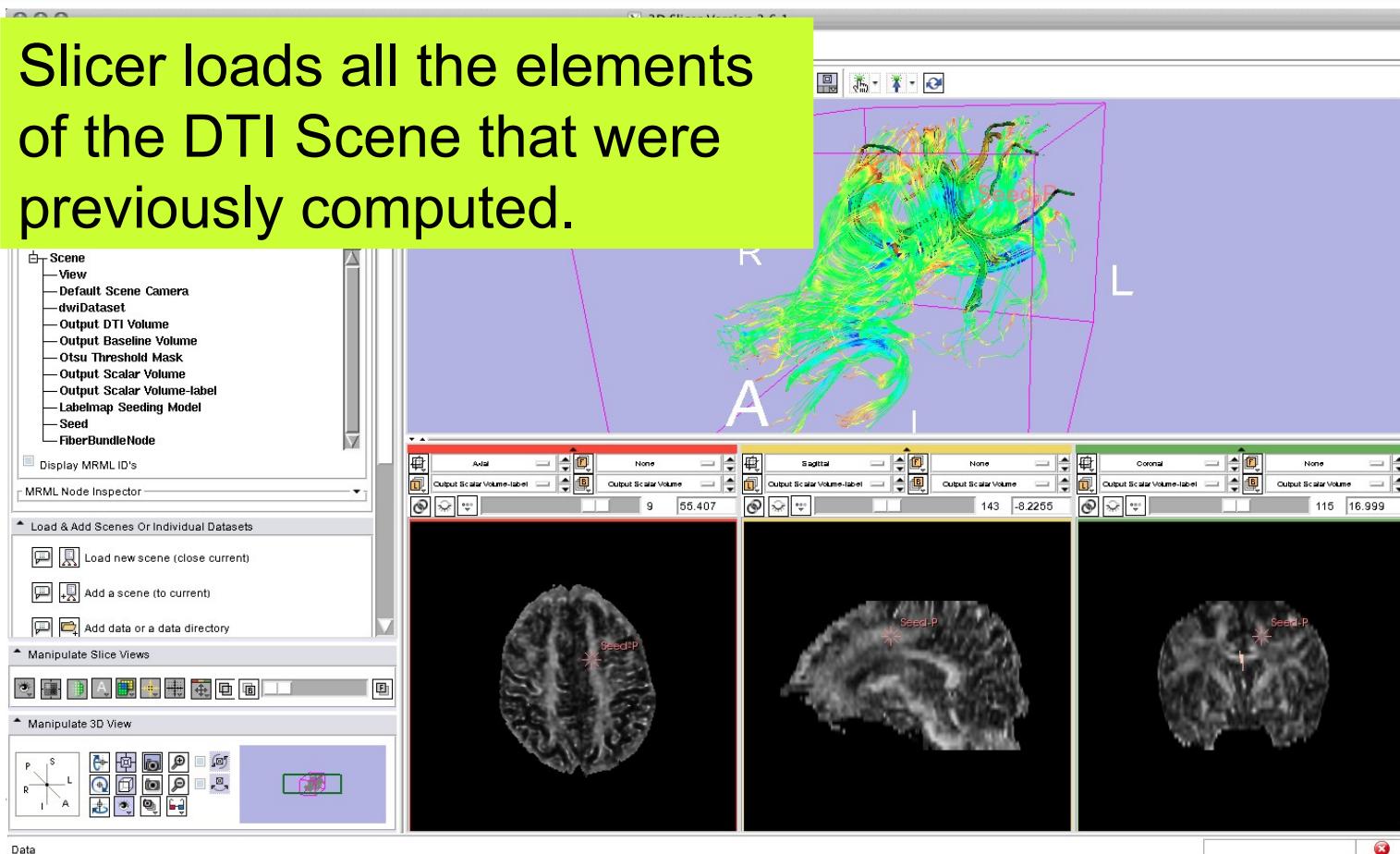


Loading a DTI Scene



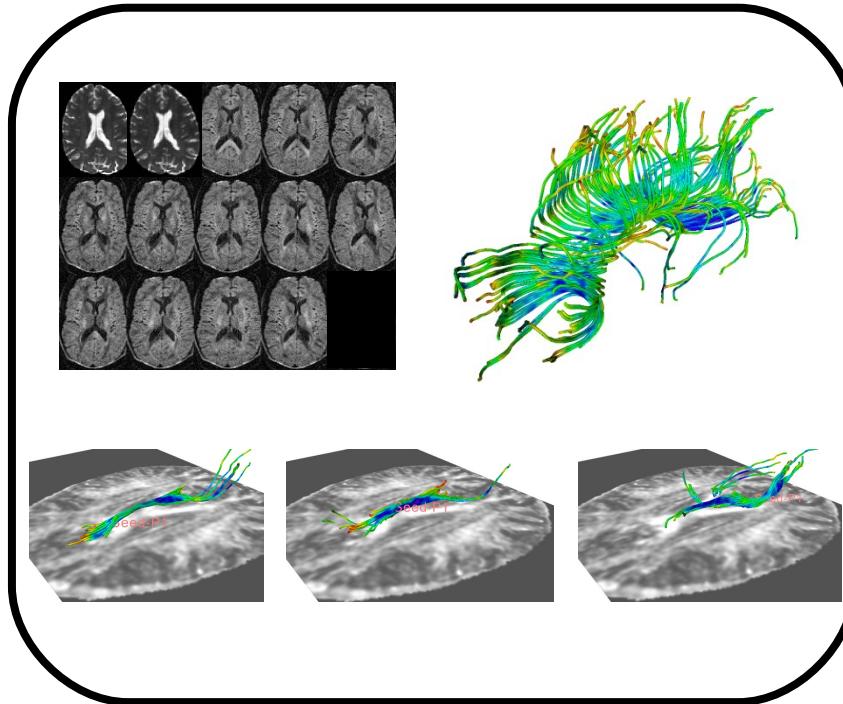


Loading a DTI Scene





Conclusion



This tutorial guided you through some of the **Diffusion MR** capabilities of the **Slicer3** software for studying the brain white matter pathways.

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