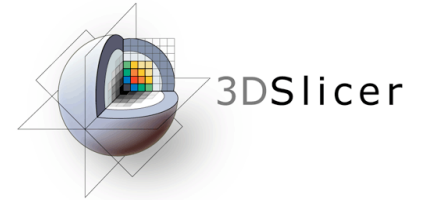




National Alliance for Medical Image Computing



Diffusion Tensor Analysis in Slicer3

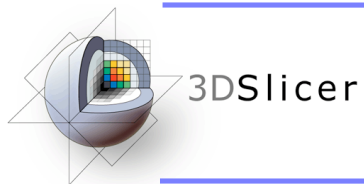
Tutorial by:
Rodrigo de Luis García, Ph.D.

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<http://www.slicer.org>

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Acknowledgments



National Alliance for Medical Image Computing

NIH U54EB005149



Neuroimage Analysis Center

NIH P41RR013218



**Laboratory of Mathematics in Imaging,
Brigham and Women's Hospital**

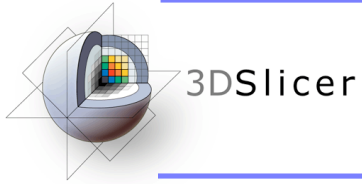
NIH R01MH074794



3DSlicer

Material

- 3D Slicer3 (Release 3.2)
http://www.slicer.org/slicerWiki/index.php/Main_Page
- DTI Sample Data Set
 - Dwi-dicom.zip 256x256x36, 14 gradient directions
 - Case 1 (01053): 144x144x83, 58 gradient directions
 - Surgery_format_case.zip 256x235x70, 59 gradient directions



Outline

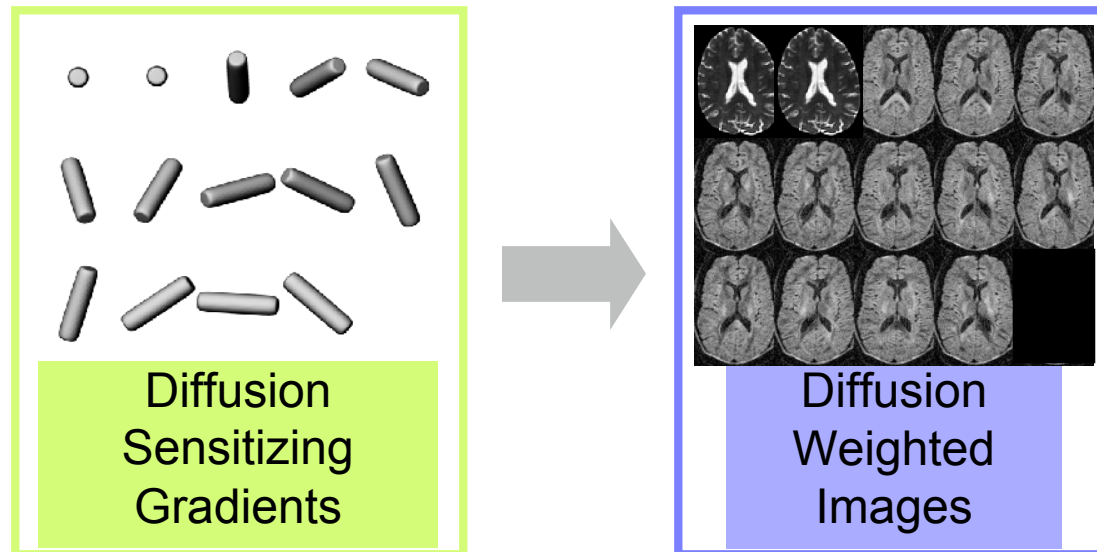
- Introduction to DWI and DTI
- Introduction to Slicer3
- DTI-related functionalities
- Loading DWI and tensor data
- Estimating tensors from DWI
- Visualizing tensors
- DTI tensor resampling
- Tractography



3DSlicer

Introduction to DWI and DTI

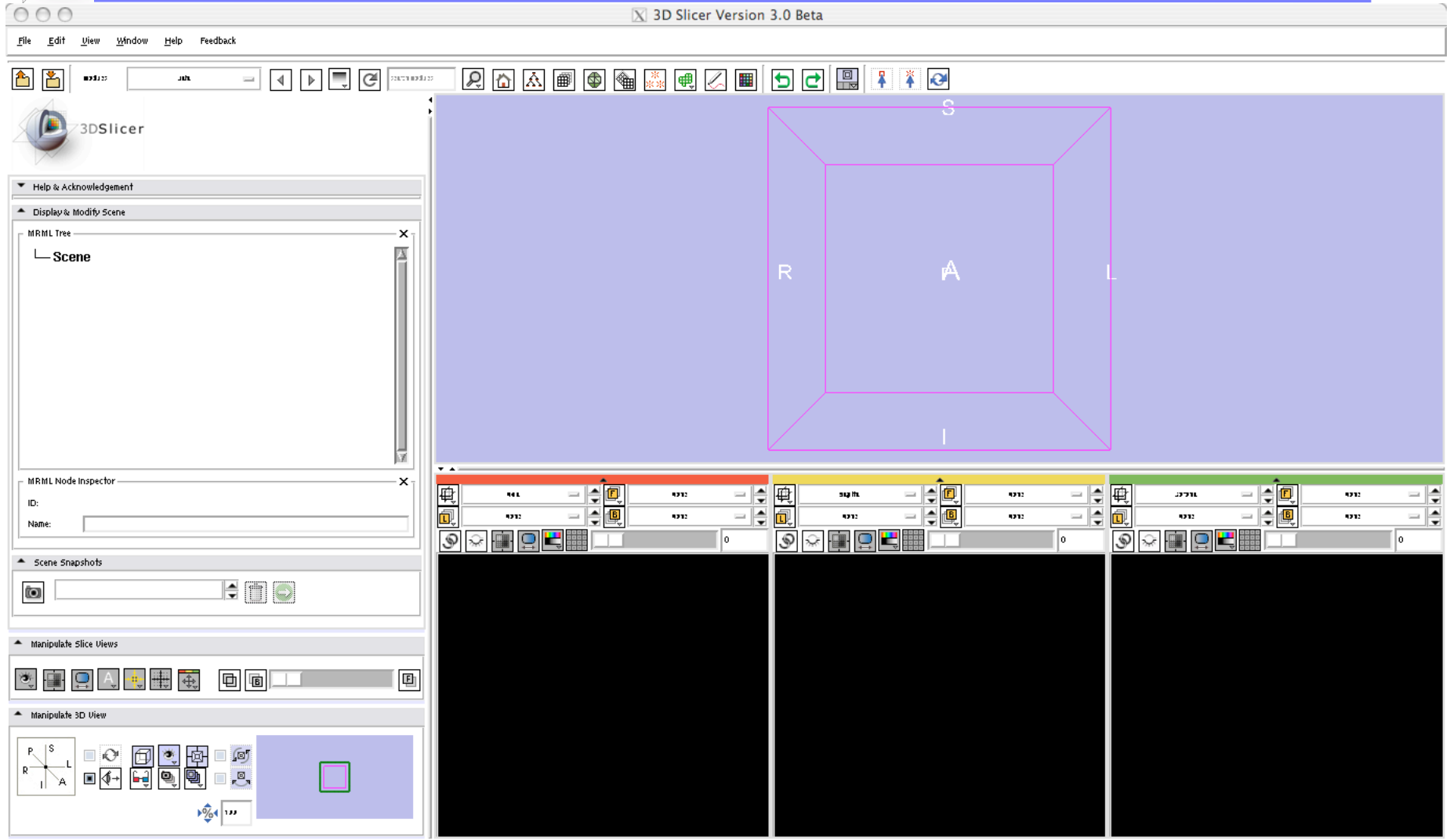
- DWI (Diffusion Weighted Imaging) is a MRI modality that produces images describing the diffusion of water molecules in tissues.
- The observed diffusion can vary with the orientation of the pulse gradient that is applied. This is due to anisotropy in water diffusion in tissues.
- Using different directions, different DWI images can be obtained. Each one describes diffusion in one direction.





3DSlicer

Introduction to Slicer3



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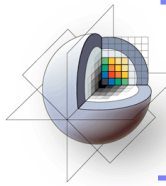
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3DSlicer

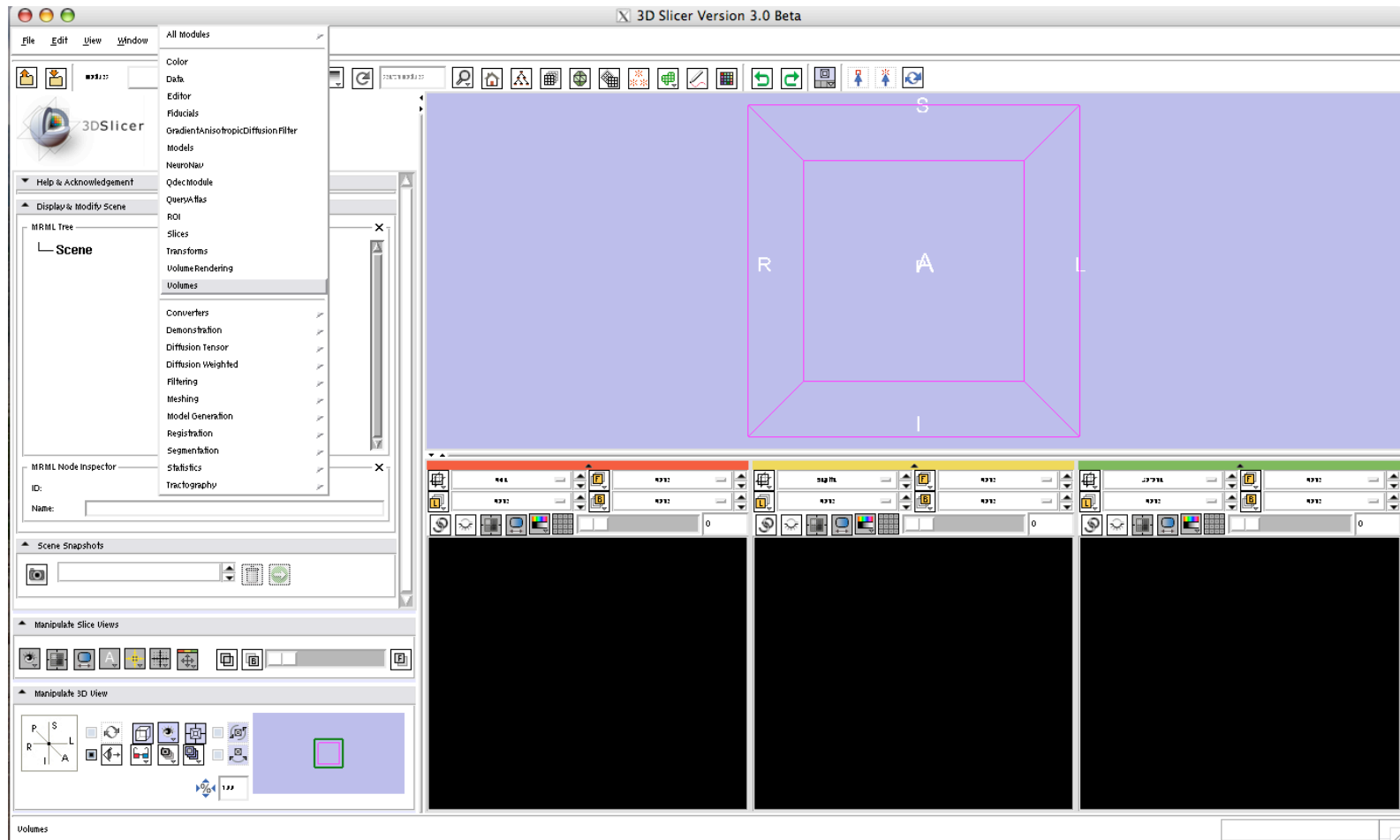
DTI-related functionalities

- Using Slicer3, you can:
 - Load DWI and tensor data. Load fiber tracts, and DTI-scenes
 - Estimate tensors from DWI data
 - Visualize tensors using scalar, color coding and glyphs (2D glyphs are new in Slicer3)
 - Resample DTI tensors
 - Perform tractography, using fiducials, label maps or stochastic tractography (new in Slicer3)



3DSlicer Loading Dataset 1 (DWI data)

1- Select the module "VOLUMES" in the Modules menu



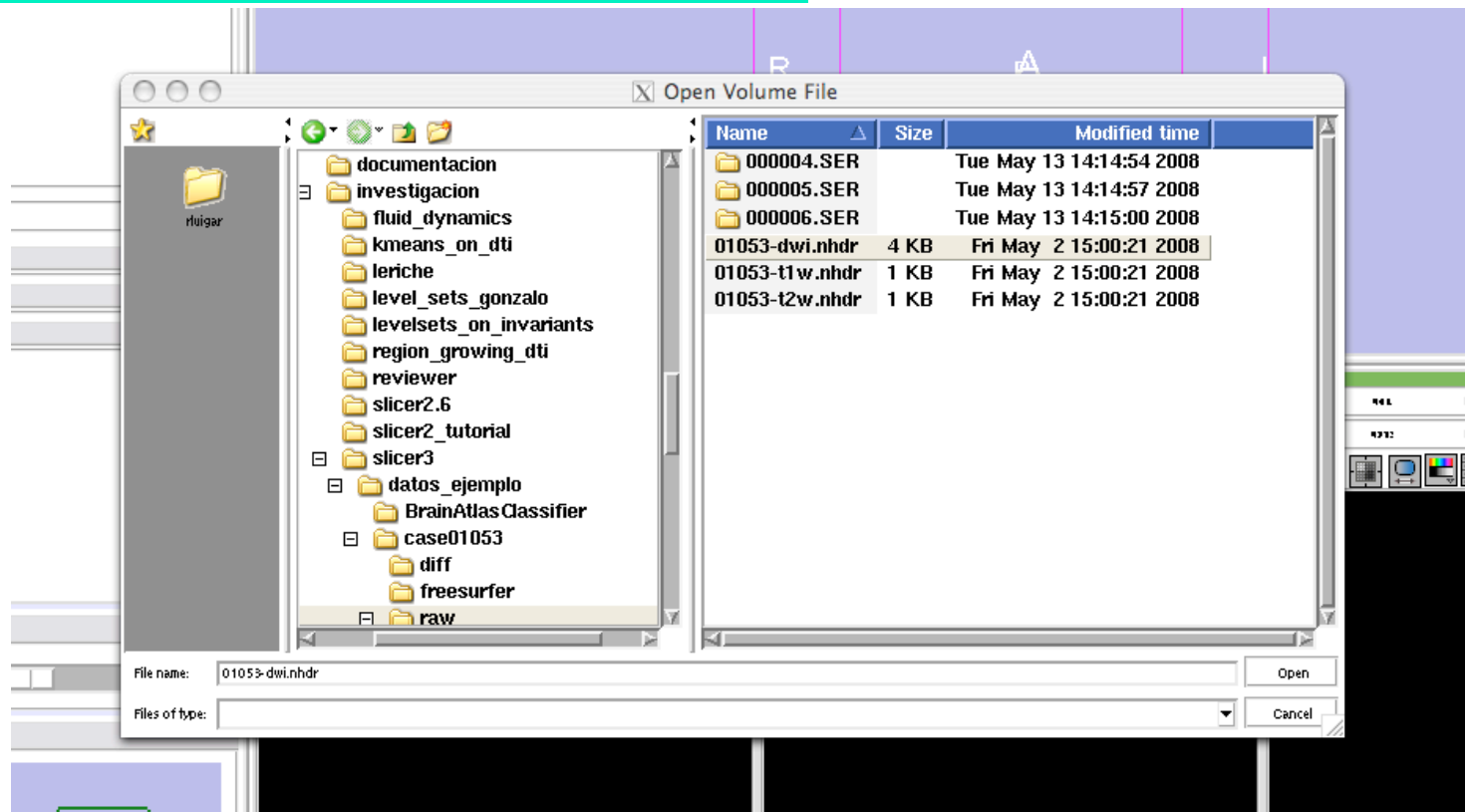


3DSlicer

Loading Dataset 1 (DWI data)

A dialog window will appear for you to select the header file when you click "Select Volume File"

2- Select the file "01053-dwi.nhdr"



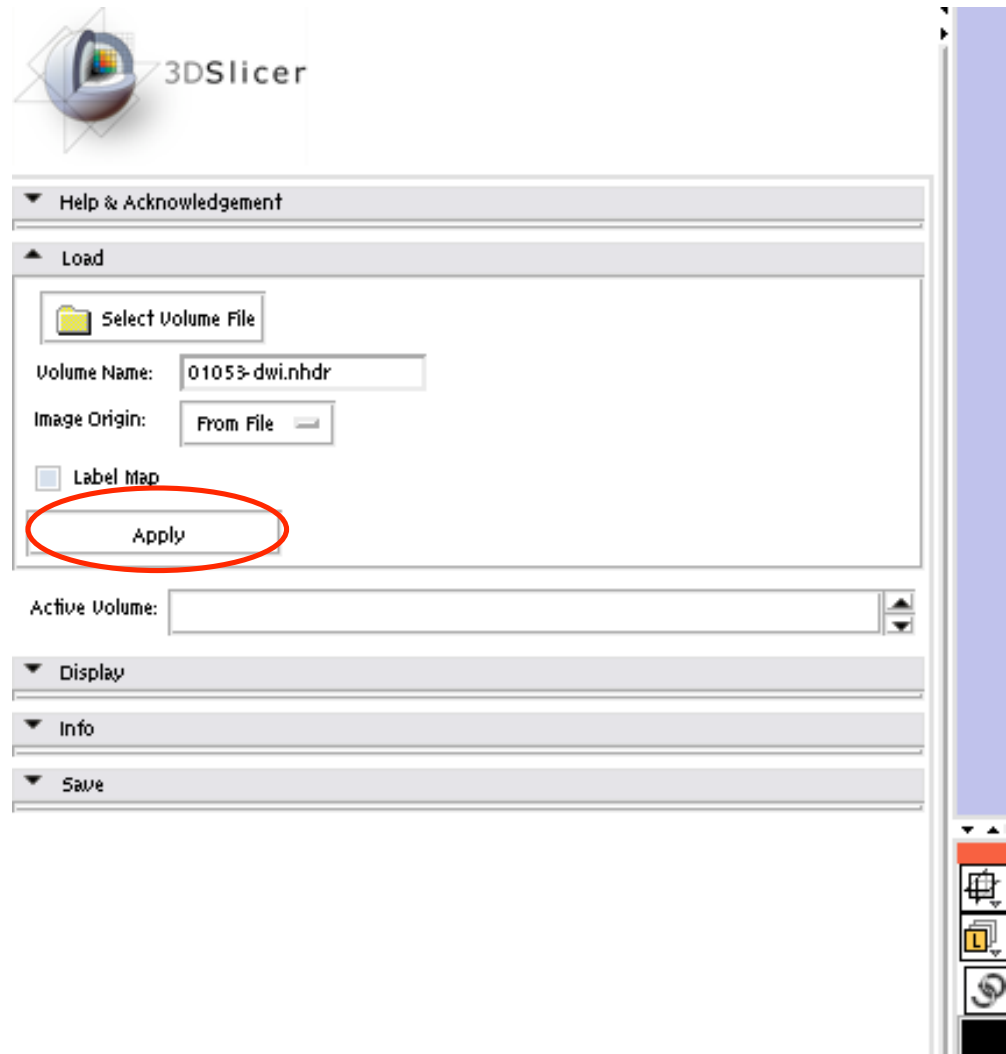


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Loading Dataset 1 (DWI data)

The volume name will appear in the Load tag

2- Select "Image Origin"--> "From File" and click "Apply"

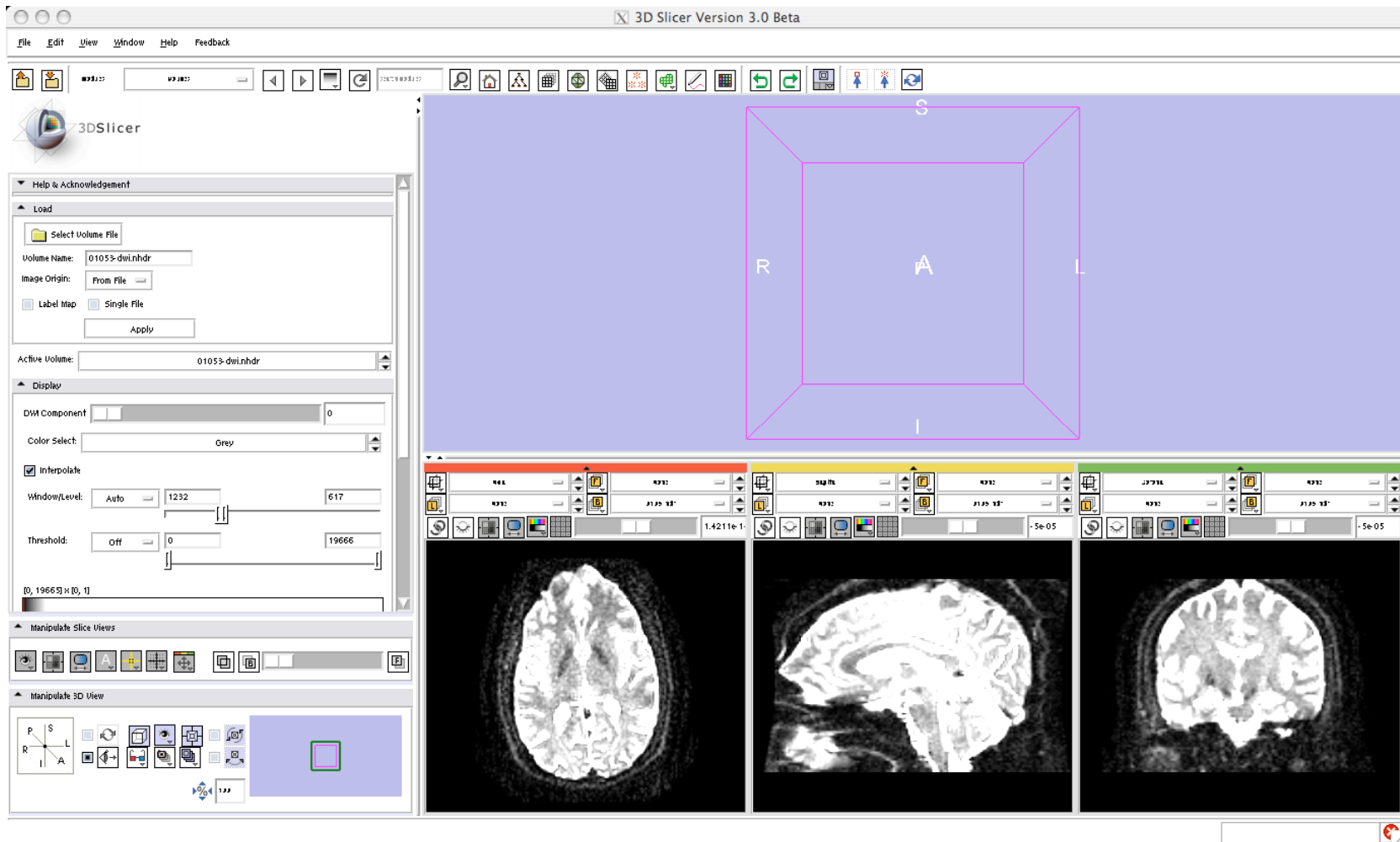




3DSlicer

Loading Dataset 1 (DWI data)

Once the dataset is loaded, three cuts will appear in the visualization area.



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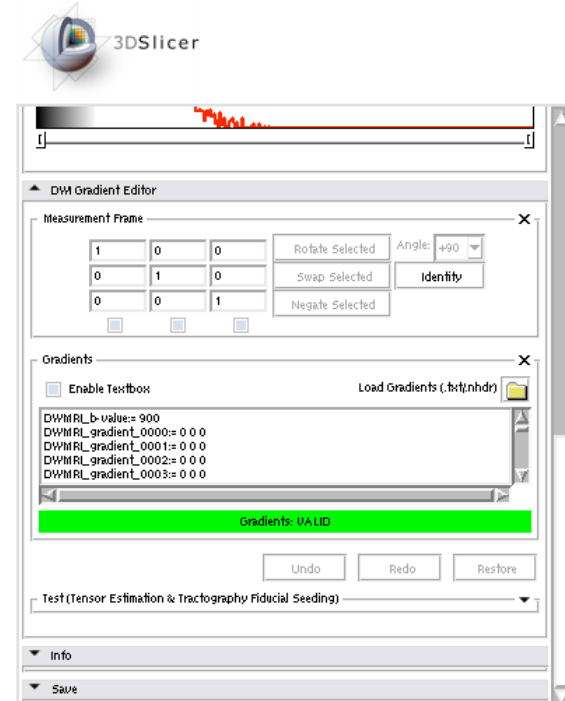
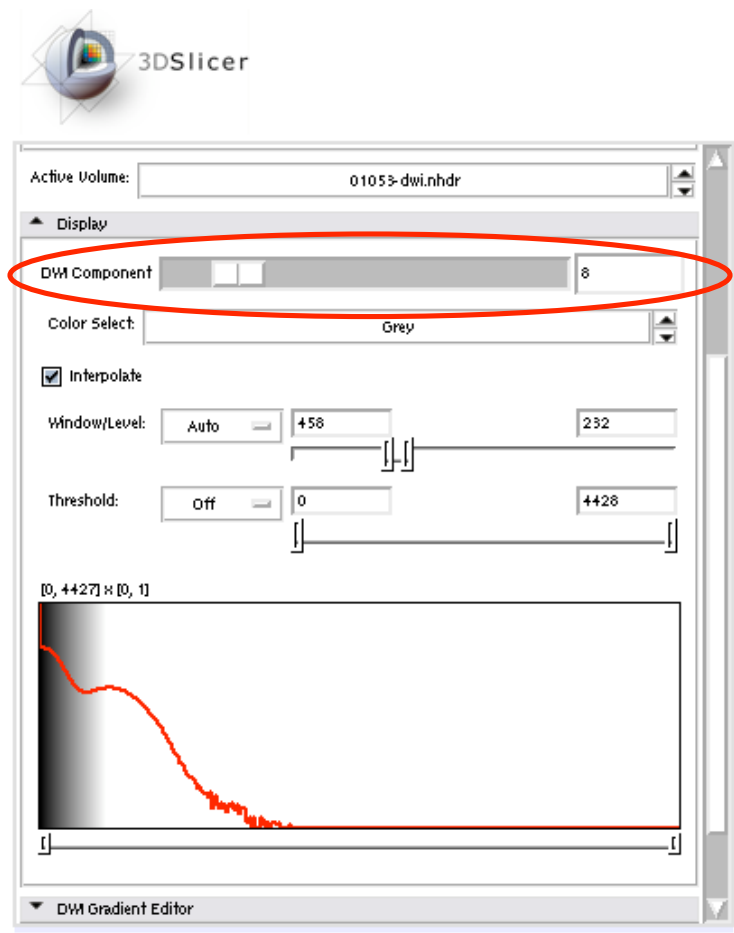
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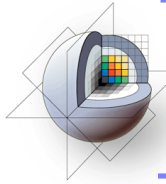
3DSlicer

Loading Dataset 1 (DWI data)

The Display area allows the selection of the volume you want to visualize. There are 59 volumes for this dataset.

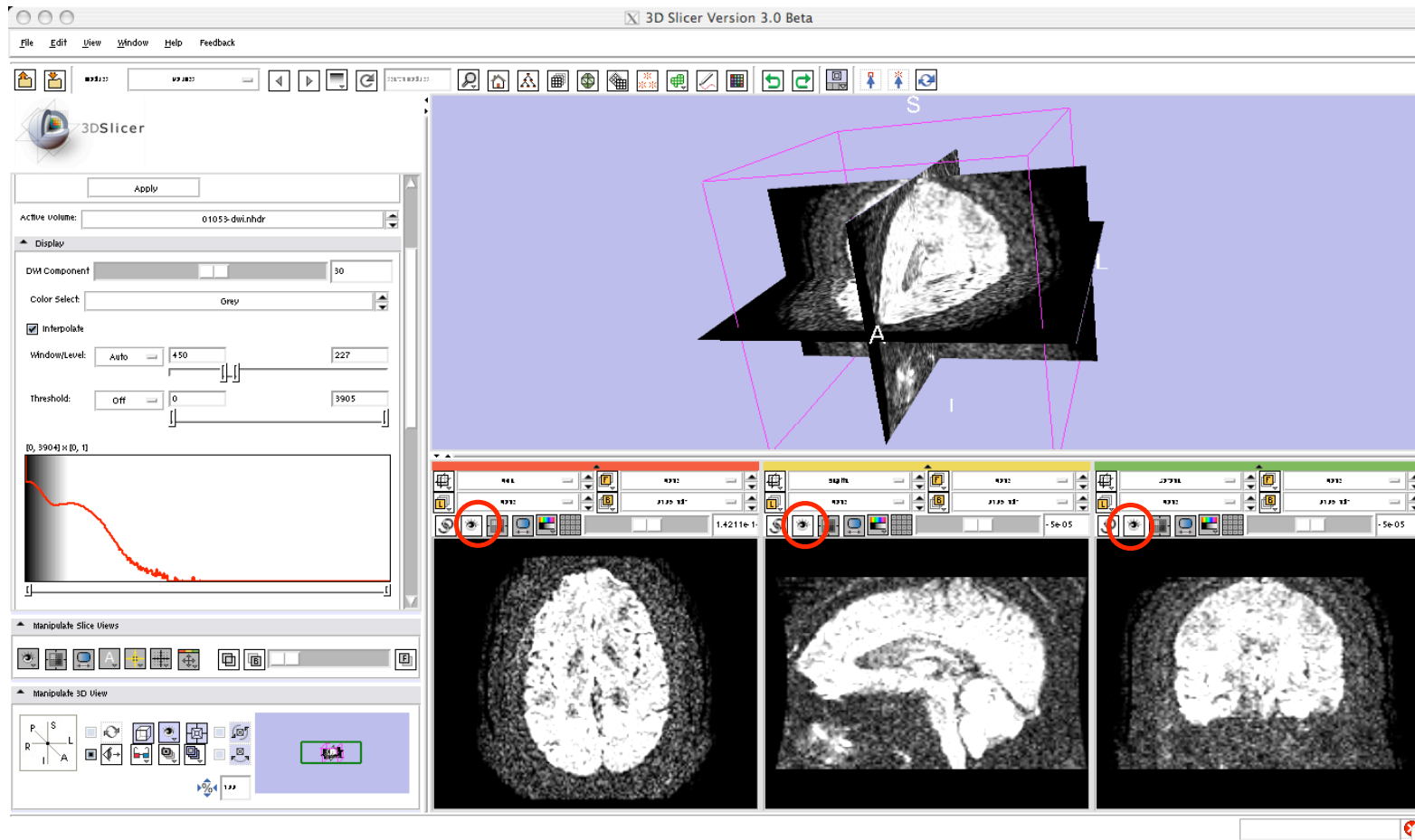


Also, when a DWI volume is loaded, the “DWI Gradient Editor” tag becomes active. This can be used for converting DWI to tensors.



3DSlicer Loading Dataset 1 (DWI data)

By activating the visibility button for each slice you can visualize slices in the main view.

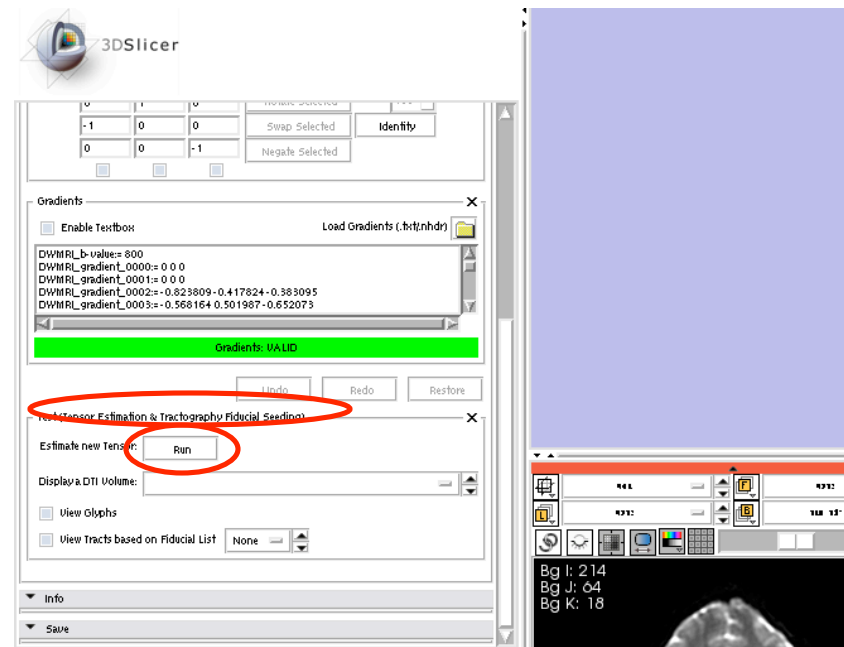
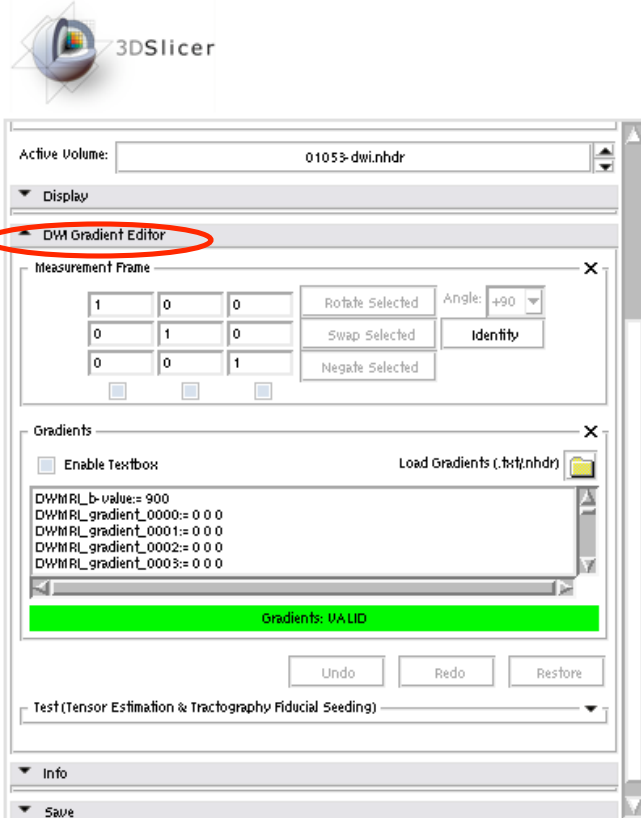




3DSlicer

Converting from DWI to tensors

If a DWI volume is active, the “DWI Gradient Editor” tag is also active in the left panel.

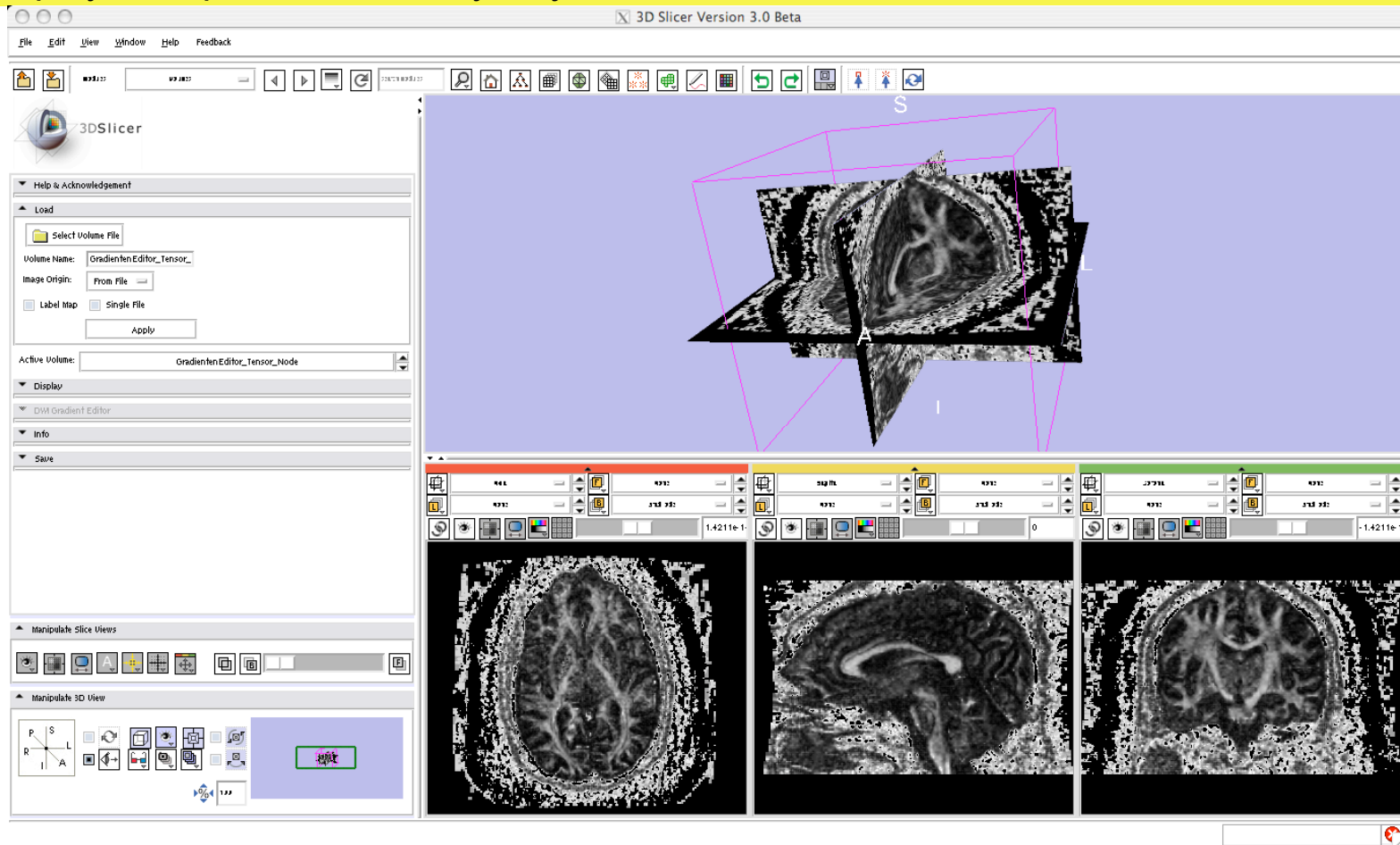


To estimate the tensors, first unfold the TEST (Tensor Estimation & Tractography Fiducial Seeding) and then click “Run” to Estimate New Tensor



3DSlicer Converting from DWI to tensors

Once the estimation is performed, the tensor volume becomes active, and it can be displayed or processed in any way.

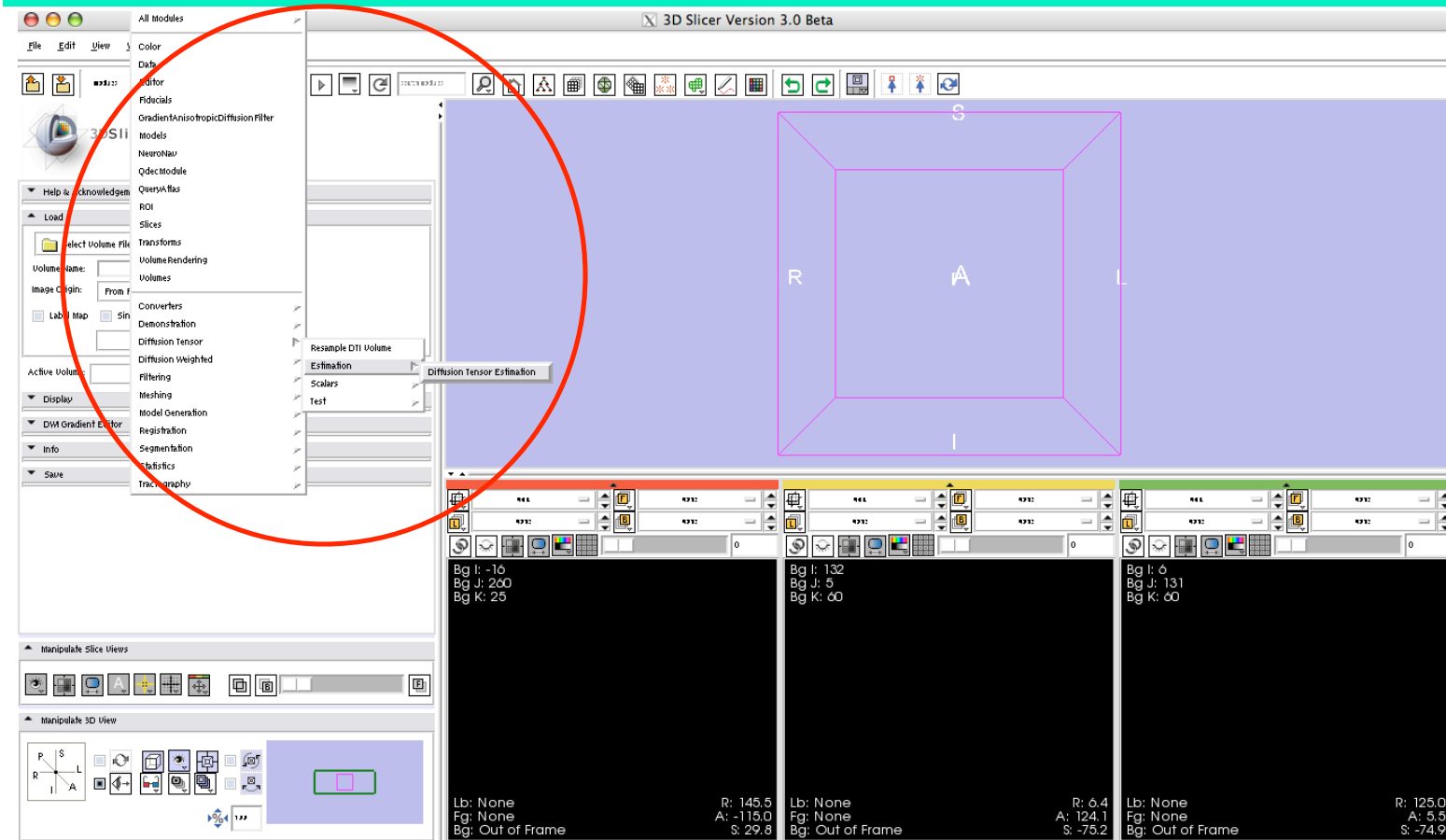




3DSlicer **Converting from DWI to tensors**

Tensor estimation can also be performed from the DT-MRI module (you need to have an active DWI volume)

1- Select DIFFUSION TENSOR --> ESTIMATION --> DIFFUSION TENSOR ESTIMATION

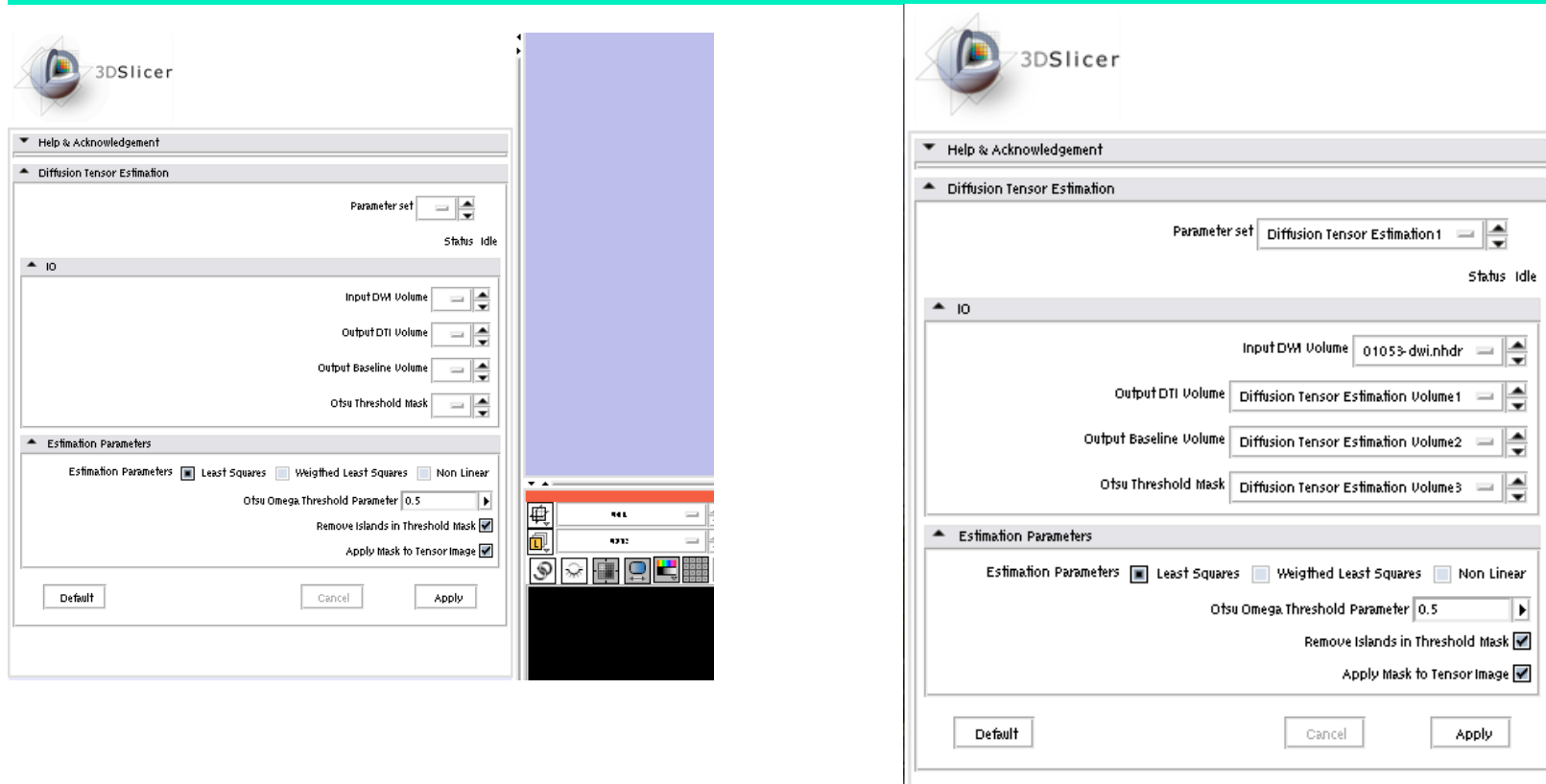




3DSlicer

Converting from DWI to tensors

2- Unfold the Diffusion Tensor Estimation tag, and select names for the output volumes that will be created



3- Select the desired options and click “Apply”



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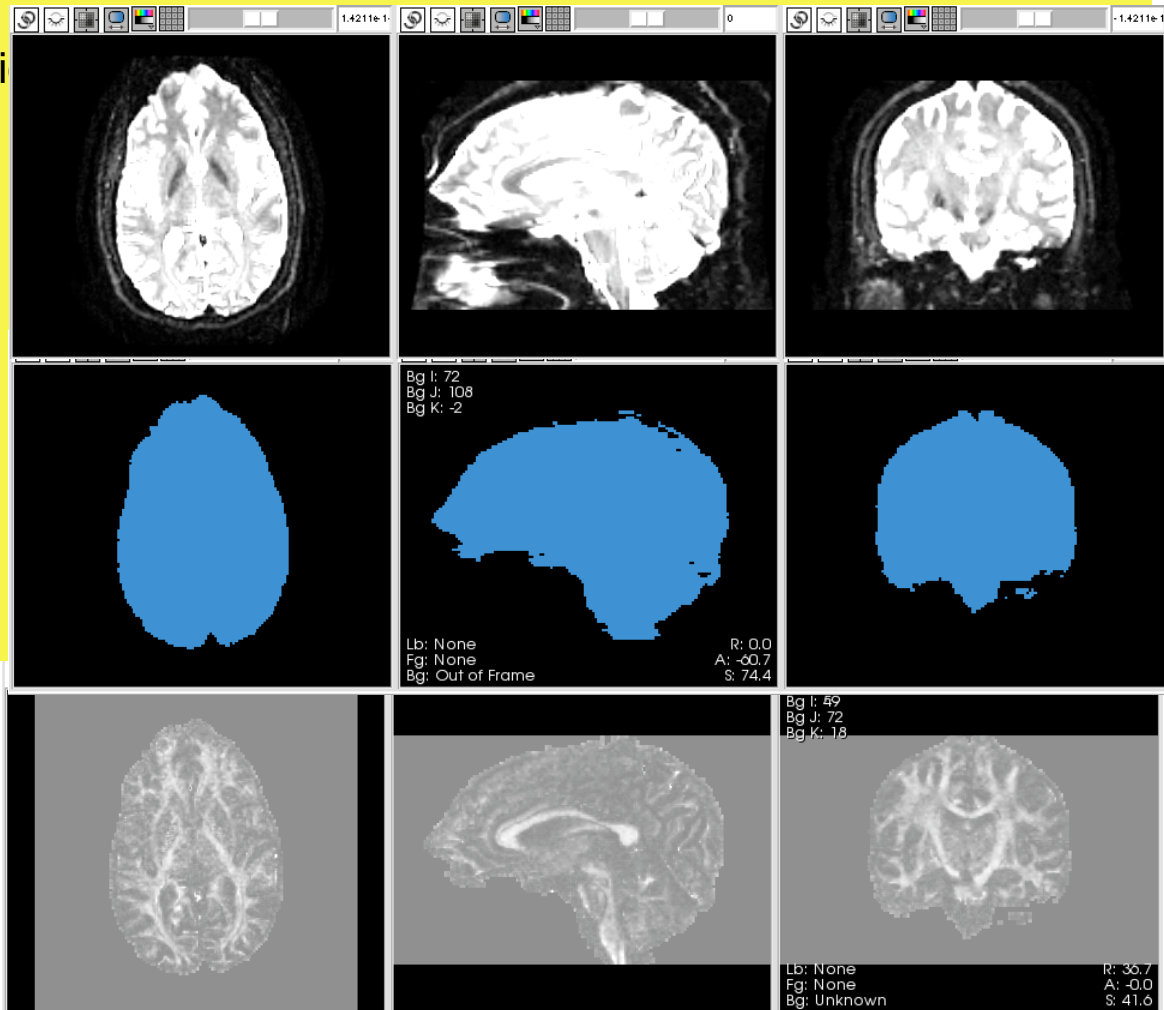
Converting from DWI to tensors

Once the tensor estimati

- Baseline

- Mask

- Tensors

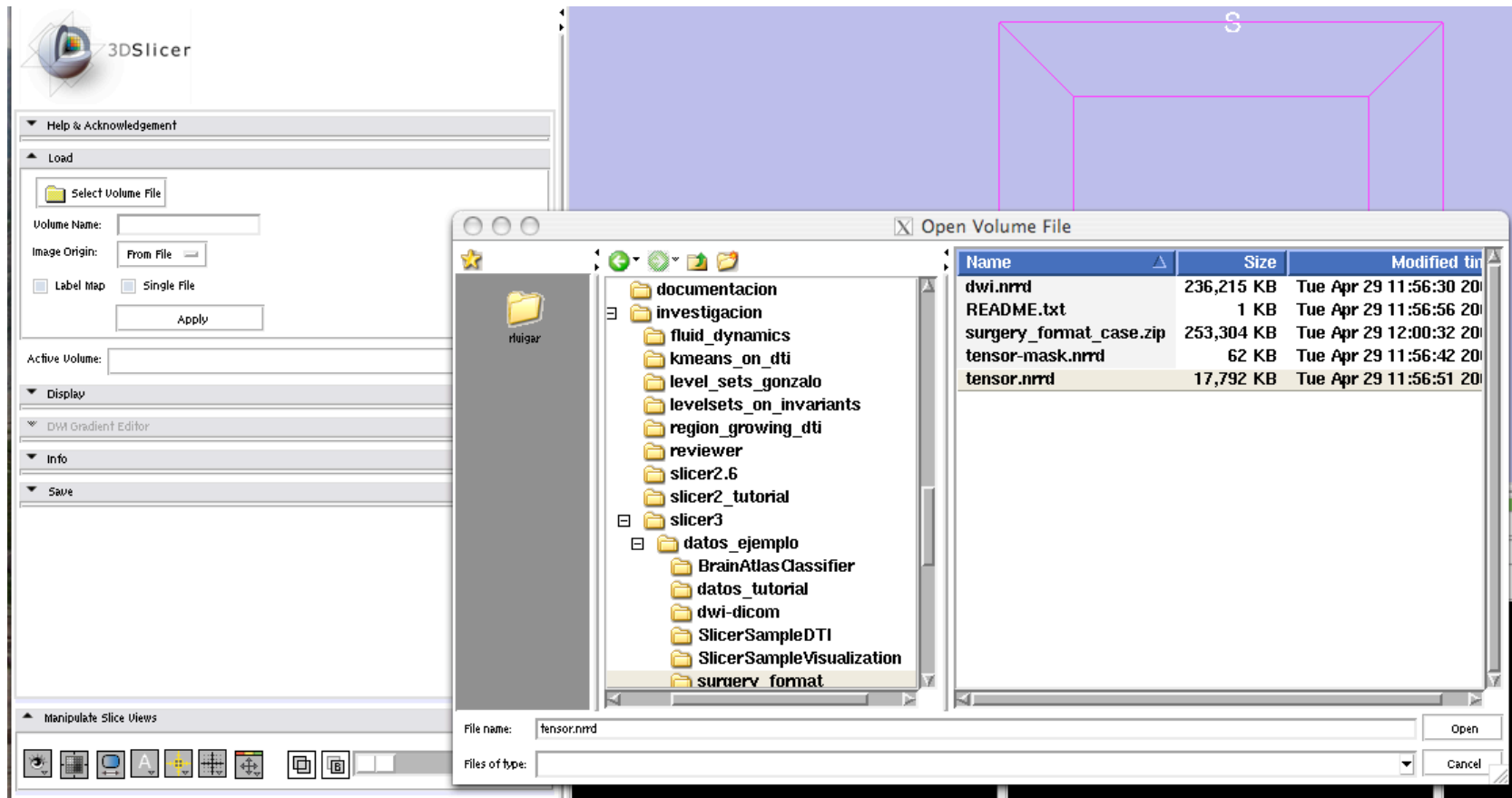




3DSlicer

Visualizing tensors

1- Load the tensor volume “tensor.nrrd” using the “Volumes” module





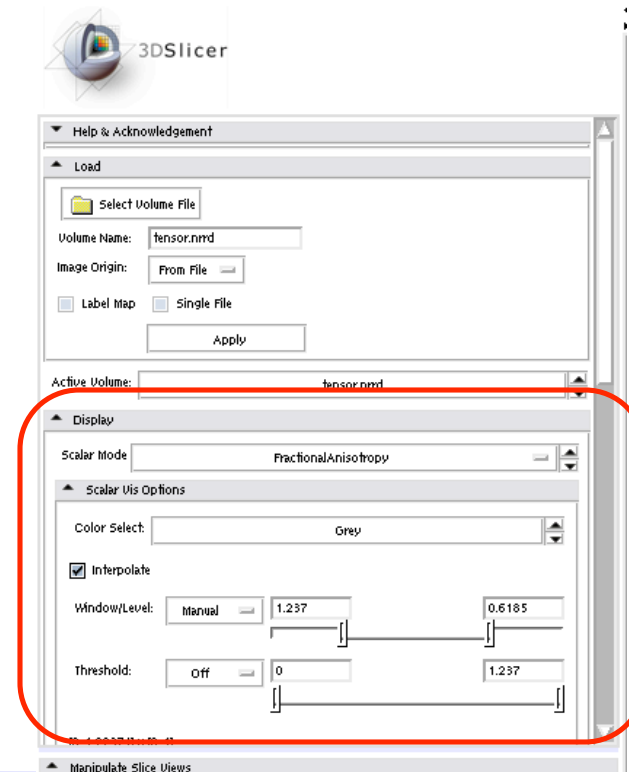
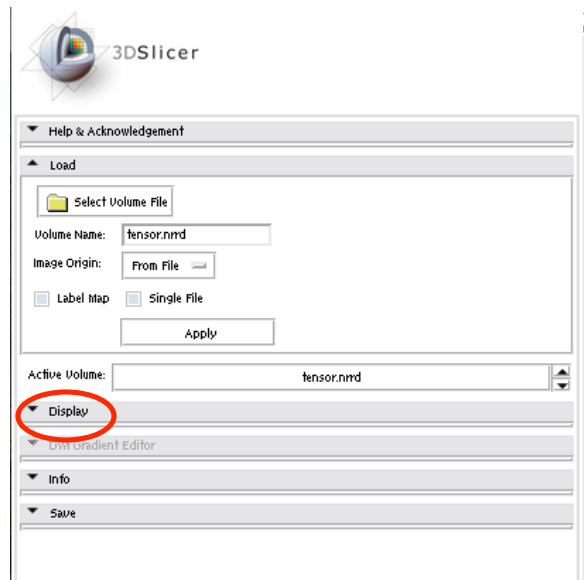
3DSlicer

Visualizing tensors

Once the tensor volume has been loaded, the “Display” tag will become active, offering different visualization options:

- Scalar measures (norm, trace, fractional anisotropy...)
- Color measures (orientation of the main eigenvector...)
- Glyphs

2- Unfold the “Display” menu

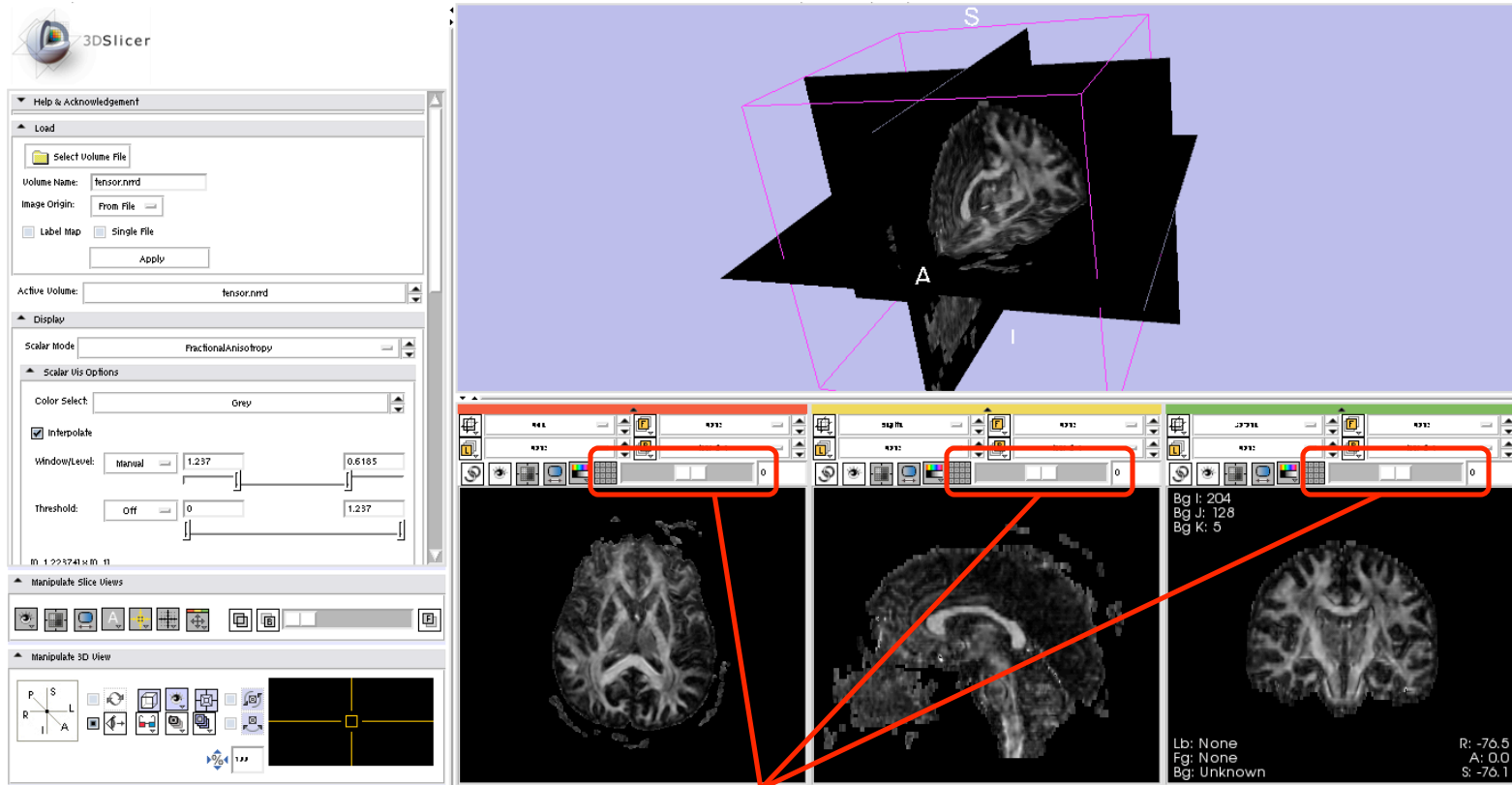




3DSlicer

Visualizing tensors

3- Select "Scalar Mode"--> Fractional Anisotropy



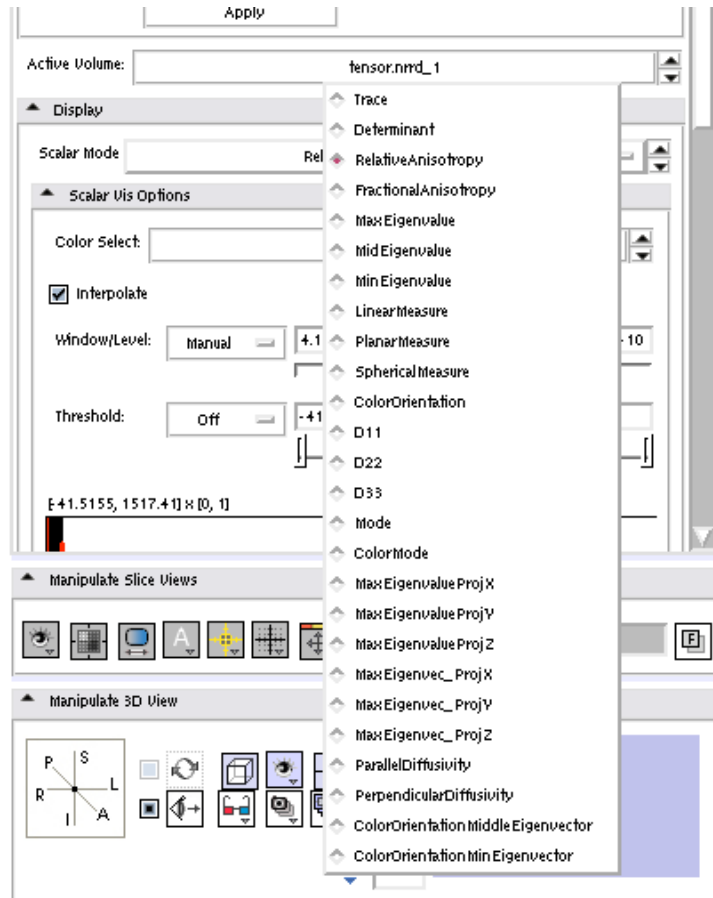
You can navigate through the different slices using the slide bars



3DSlicer

Visualizing tensors

4- Using the same procedure, you can choose many other scalar measures to visualize



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3DSlicer

Visualizing tensors

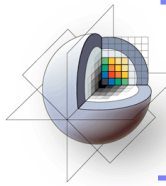
5- Select “Color Orientation”: This is a color measure that color-codes the orientation of the main eigenvector of the tensor

The screenshot displays the 3DSlicer software interface. On the left, the 'Display' panel is open, with the 'Scalar Mode' dropdown menu highlighted by a red box and set to 'ColorOrientation'. Below it, the 'Scalar Vis Options' panel shows 'Color Select' set to 'Grey', 'Interpolate' checked, and 'Window/Level' and 'Threshold' sliders. The 'Manipulate Slice Views' and 'Manipulate 3D View' panels are also visible. The main 3D view shows a brain slice with a tensor visualization, where the main eigenvector is color-coded. The 2D slice views at the bottom show the same tensor visualization from different perspectives.

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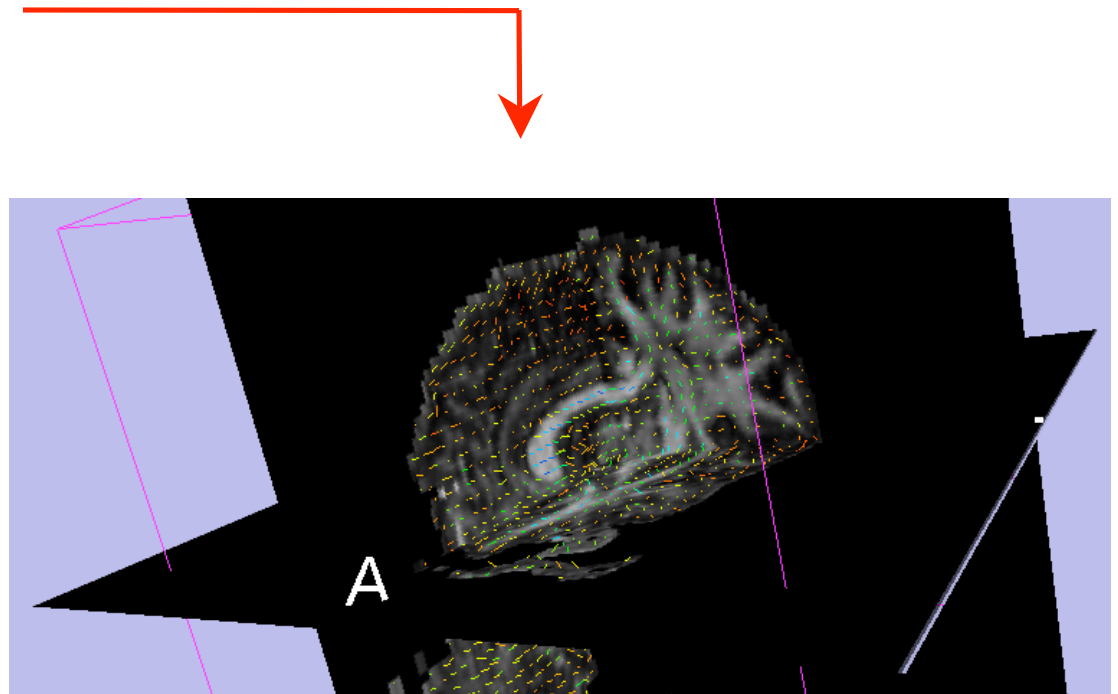
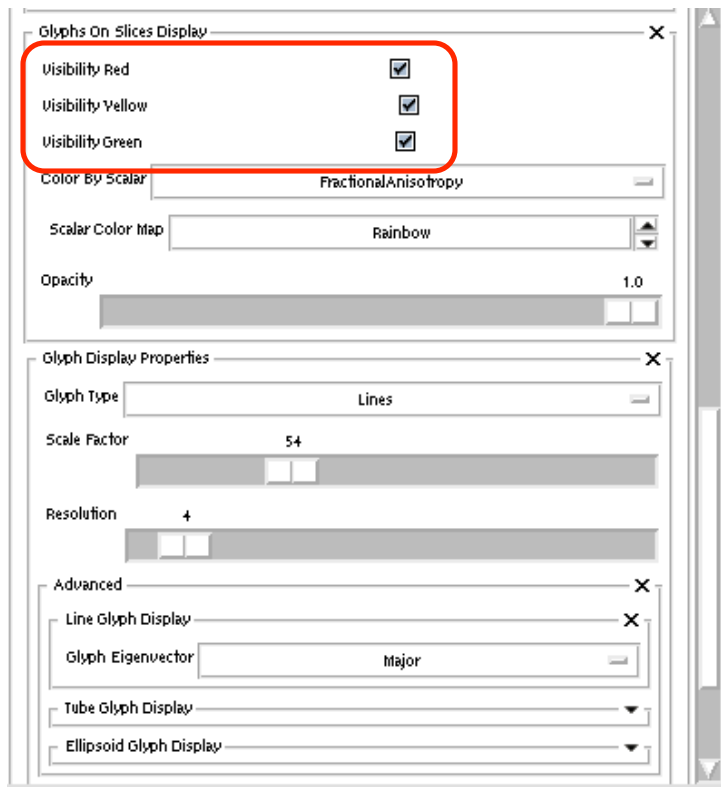
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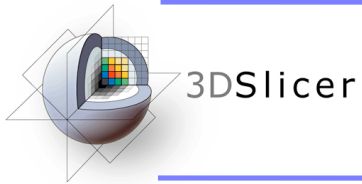


3DSlicer

Visualizing tensors

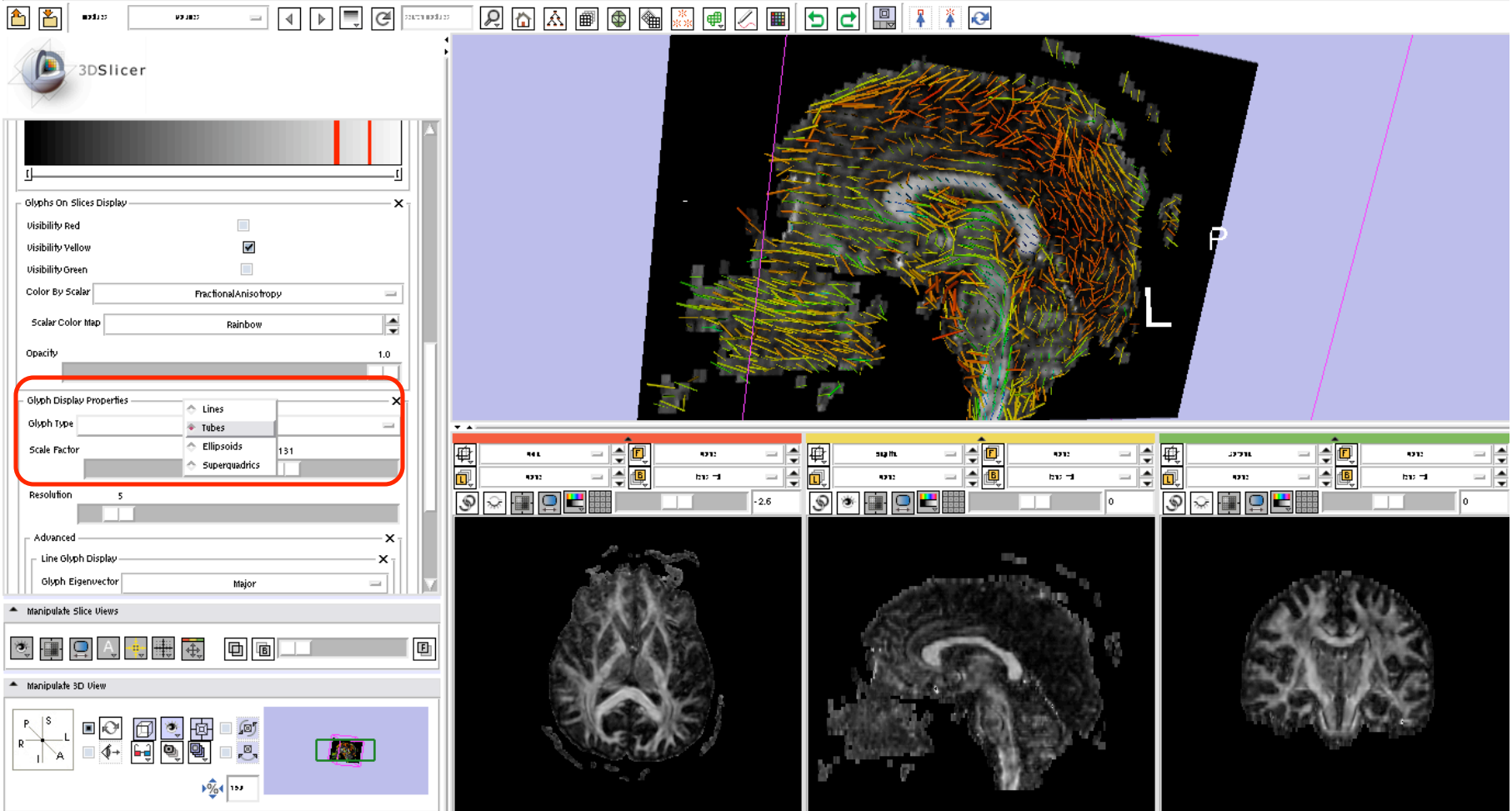
6- To visualize glyphs, activate the corresponding tags in the display menu





Visualizing tensors

7- Use the Glyph Type menu to choose the glyph type (lines, tubes, ellipsoids, superquadrics)

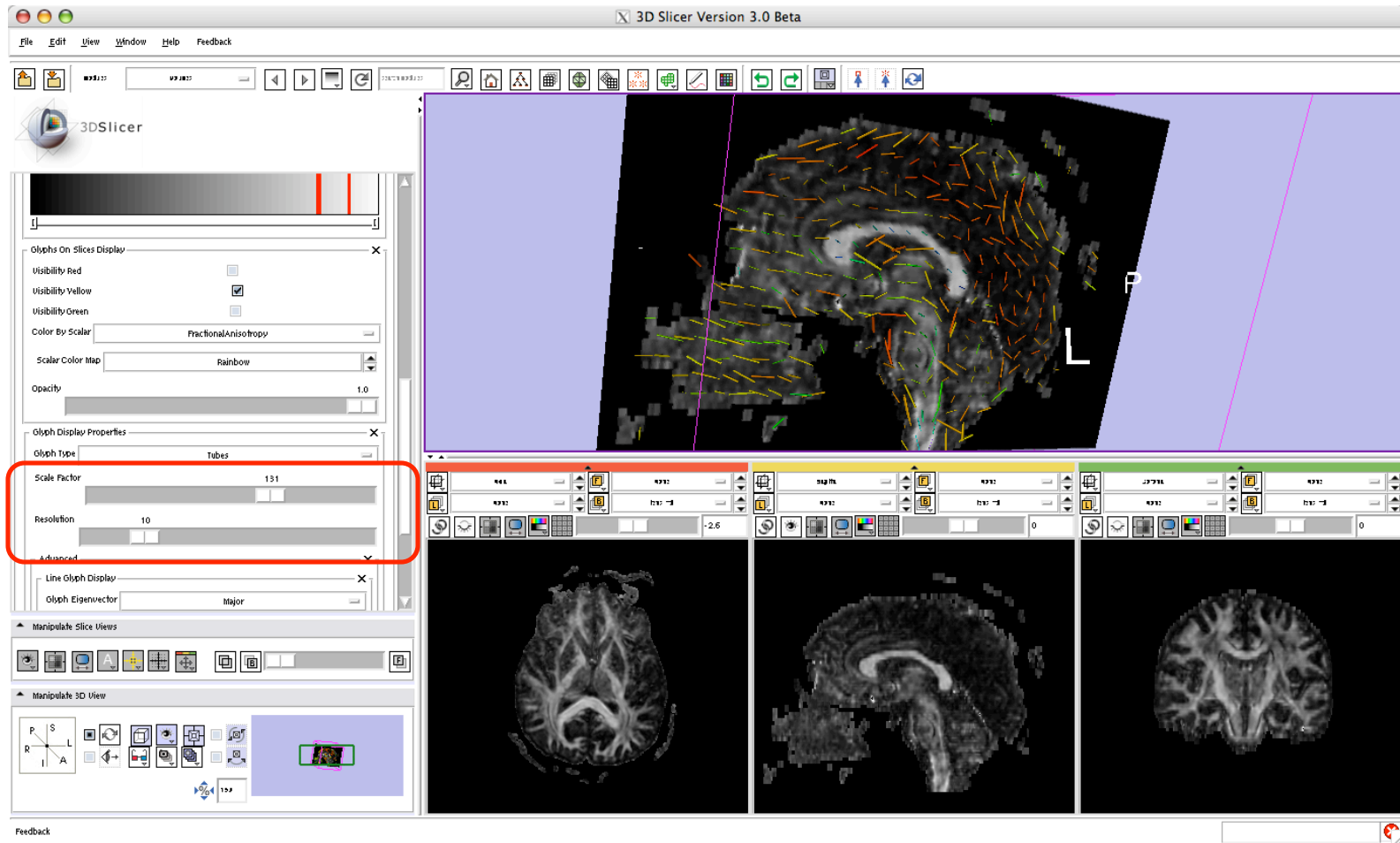




3DSlicer

Visualizing tensors

8- Use the Scale Factor and the Resolution controls to change the size and the density of Glyphs in your visualization.



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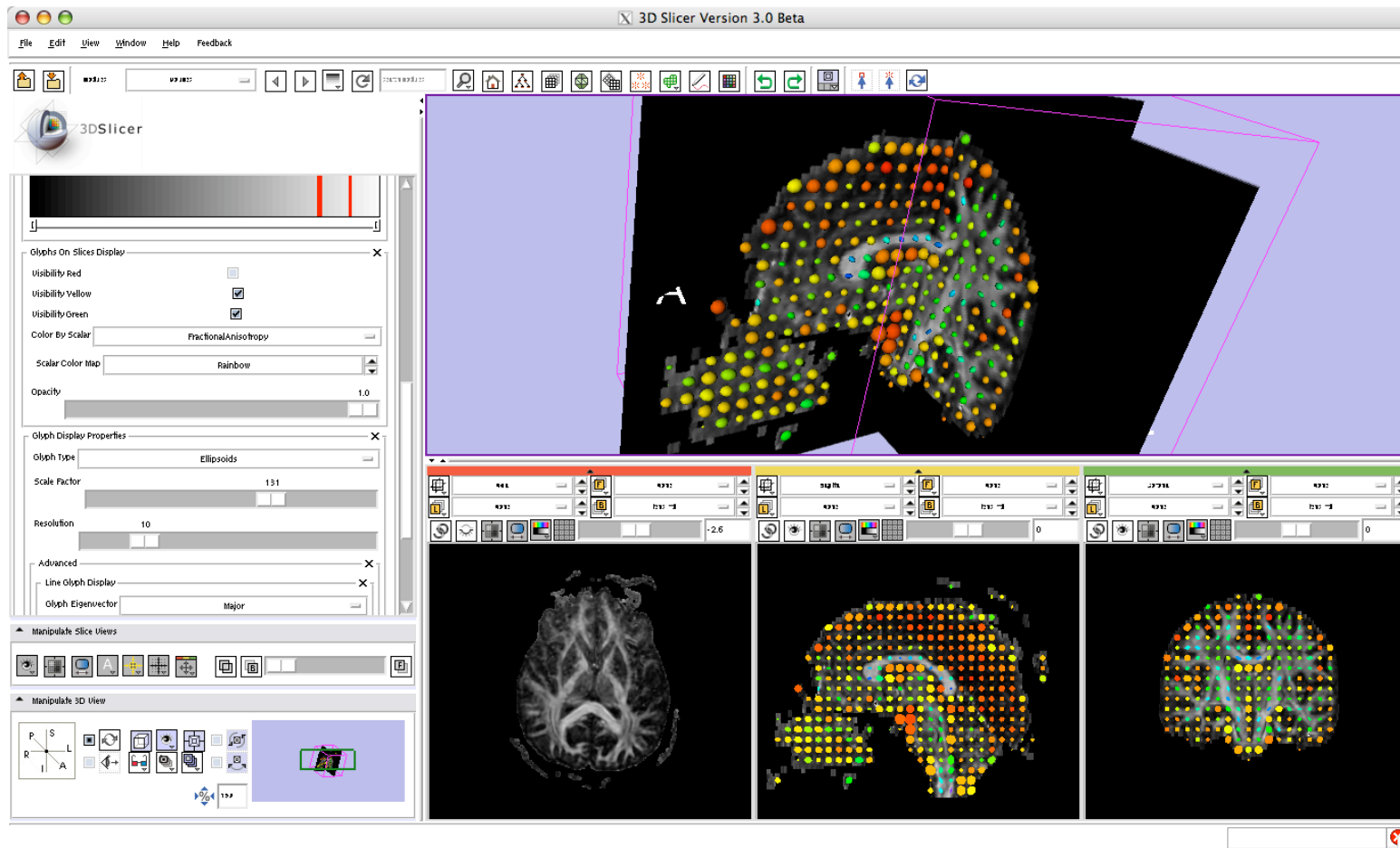
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3DSlicer

Visualizing tensors

9- You can select to view glyphs in all three or only some of the slices, both in 2D views and the 3D view.



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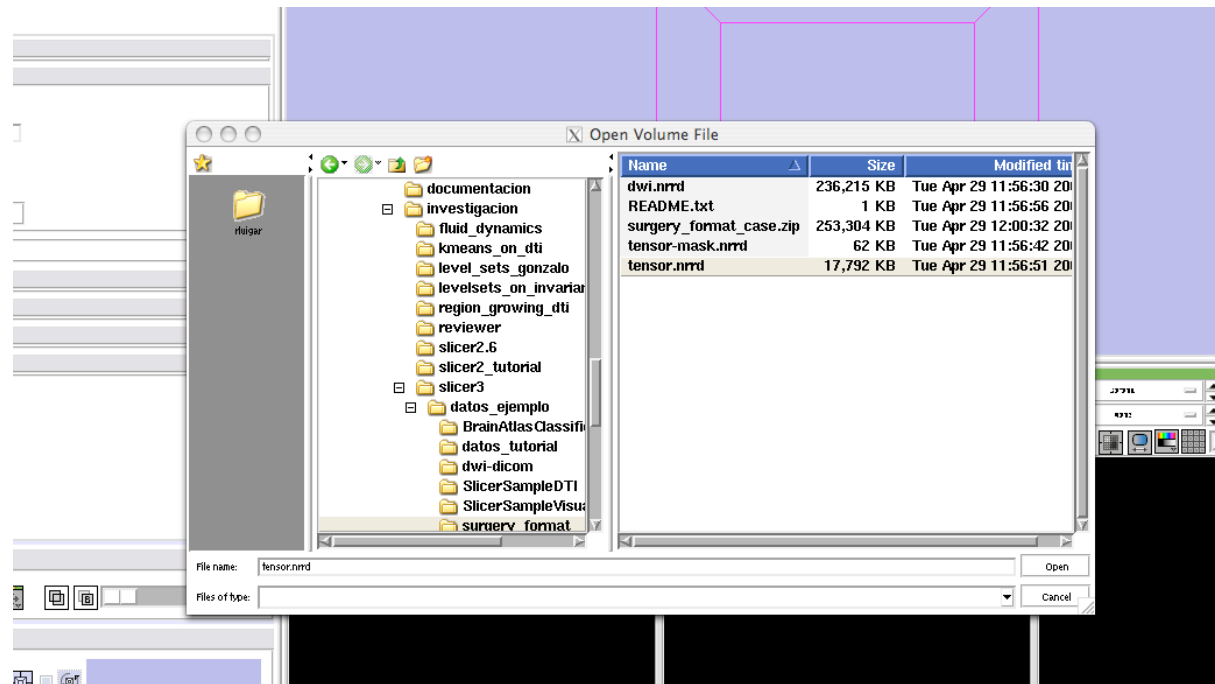
3DSlicer

DTI tensor resampling

With slicer3, you can apply transforms to a tensor volume:

- Rotations, translations.
- Rigid or affine transforms
- Linear interpolation, nearest neighbor, b-splines

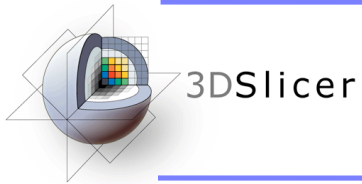
1- Load a tensor volume to begin the process



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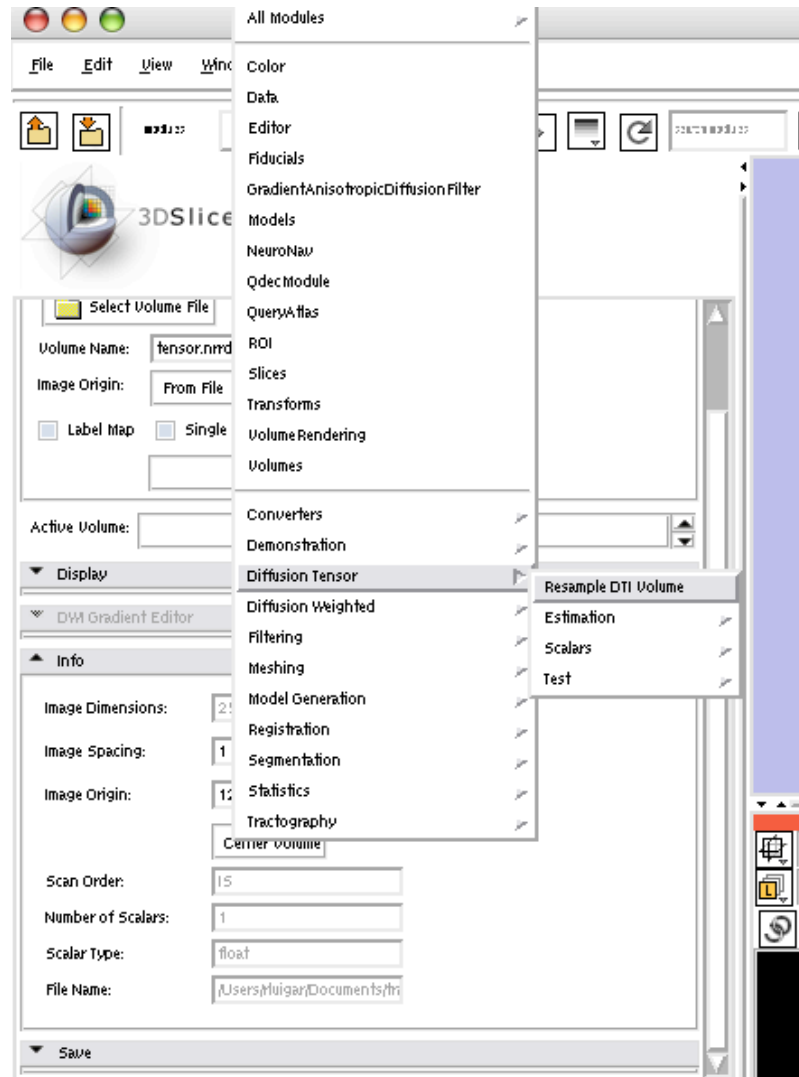
<http://www.slicer.org>

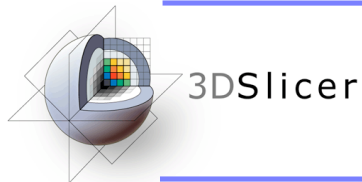
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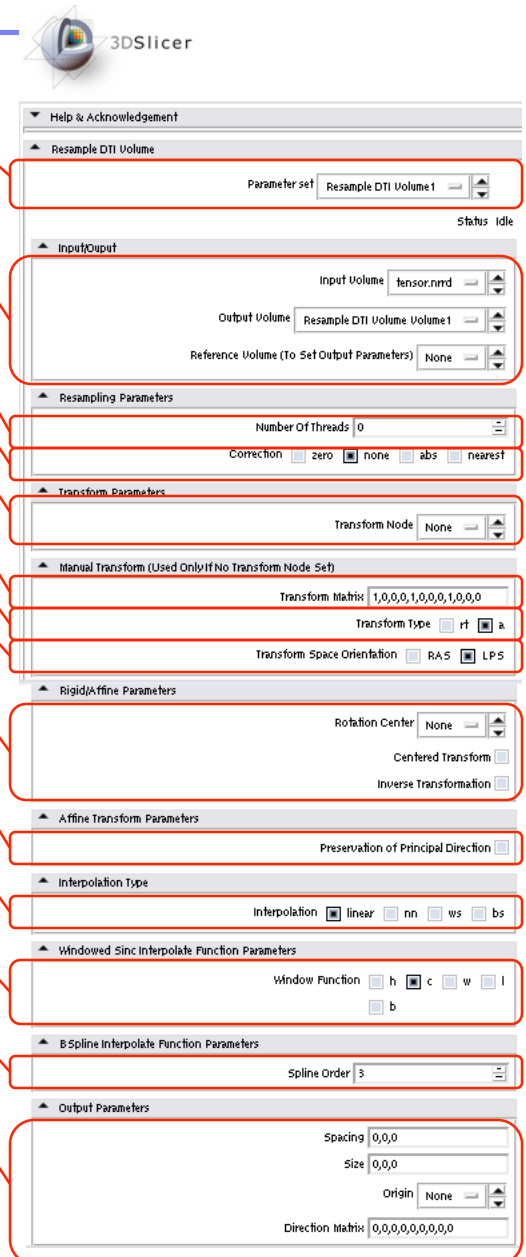
DTI tensor resampling

2- Select "Diffusion Tensor--> Resample DTI volume"





DTI tensor resampling



- 3- Load a pre-stored parameter set for the tensor resampling
- 4- Select the input tensor volume (the active one) and an output volume
- 5- Number of threads for the computation of the tensors
- 6- Type of correction if a computed tensor is not SPD
- 7- Select slicer transform
- 8- Transformation matrix (rotation and translation)
- 9- Transformation type (rigid/affine)
- 10- If the transform is in RAS (slicer), or LPS(itk) coordinate system
- 11- Define center of transformation (fiducial or volume center)
- 12- Define if you want finite strain or PPD for tensor reorientation technique
- 11- Type of interpolation performed (linear, nearest neighbor, windowed sinc, B splines)
- 12- Window function for the windowed sinc interpolation (Hamming, cosine, Welch, Lanczos, Blackman)
- 13- Spline order for the B splines interpolation
- 14- General parameters of the output volume

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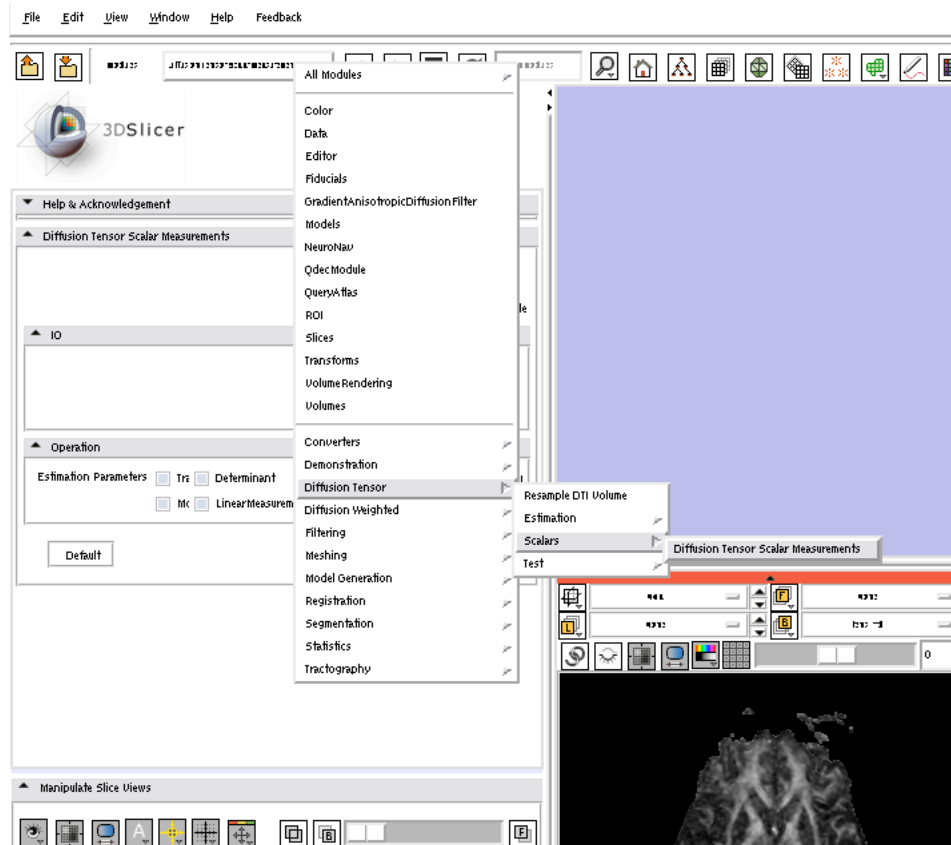
<http://www.slicer.org>



3DSlicer

DTI scalar measurements

1- Select the module “Diffusion Tensor Scalar Measurements”

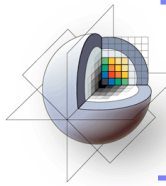


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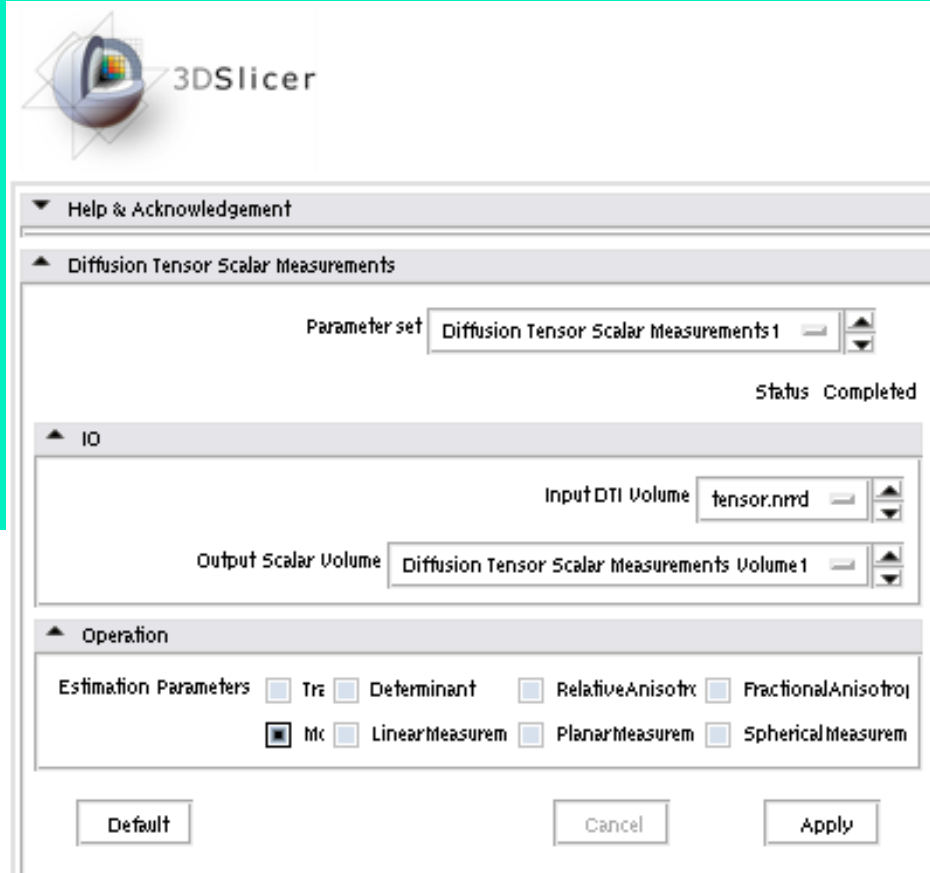


3DSlicer

DTI scalar measurements

2- Select the options:

- Input DTI volume: tensor.nrrd
- Output Scalar volume: new volume
- Estimation parameters:
 - Trace
 - Determinant
 - Relative Anisotropy
 - Fractional Anisotropy
 - Mo....
 - Linear Measurement
 - Planar Measurement
 - Spherical Measurement
- Click Apply

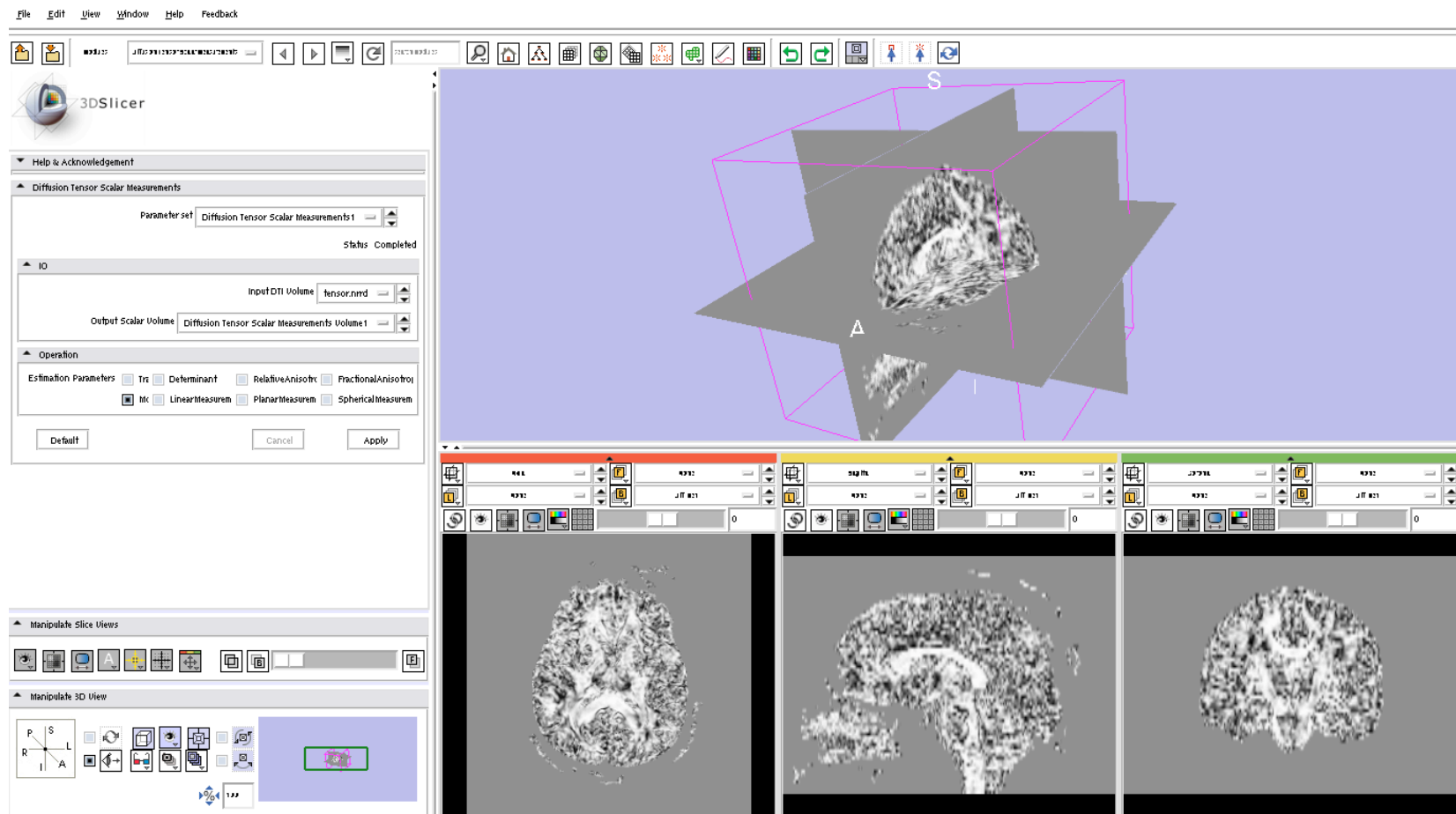




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DTI scalar measurements

The resulting scalar volume can be displayed, stored, further processed...



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3DSlicer

Tractography

With slicer3, you can:

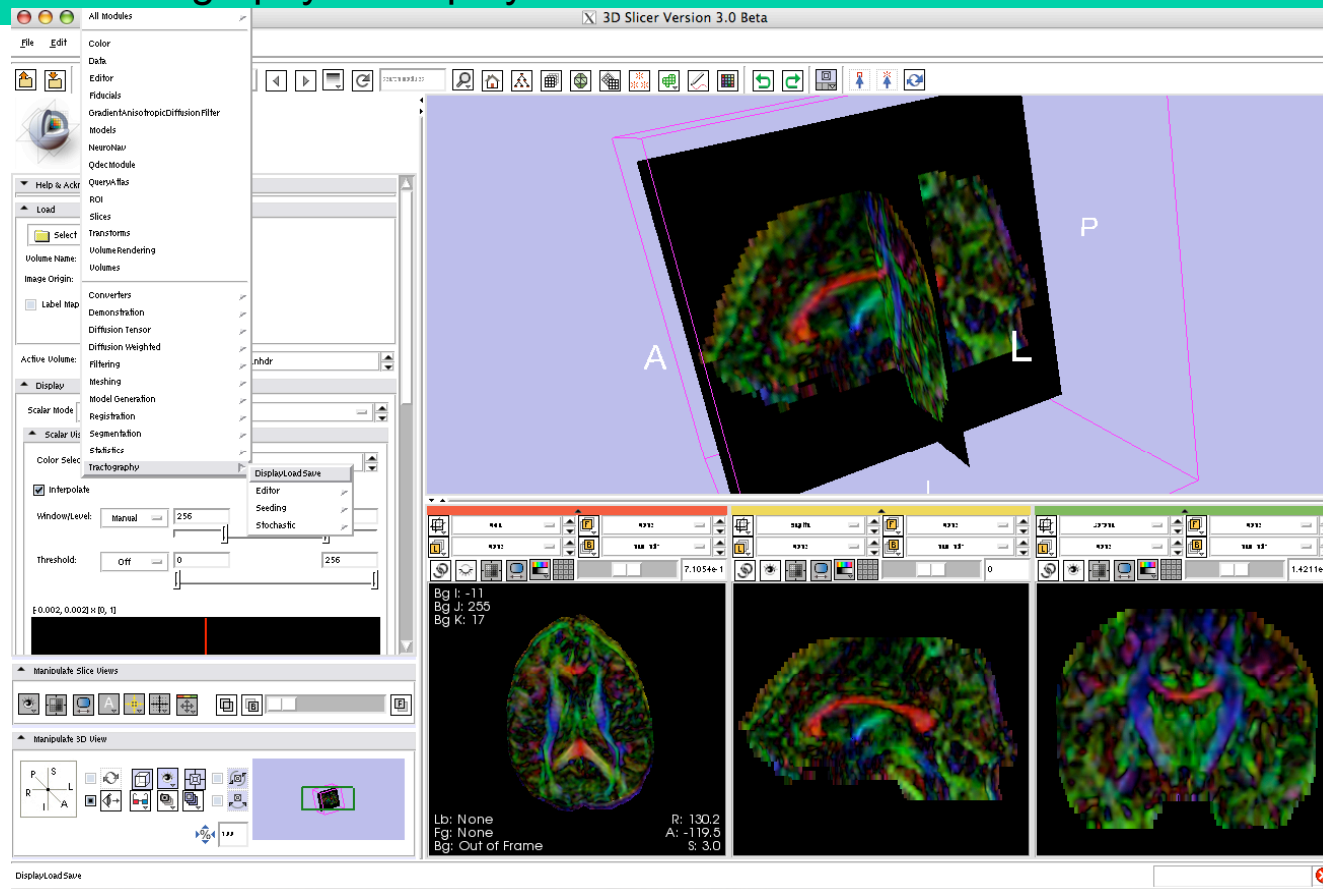
- Load and display previously obtained tracts.
- Create new tracts, using:
 - Fiducial seedings
 - ROIs
 - Stochastic Tractography
- Save the tracts you have obtained



3DSlicer

Loading and displaying tracts

- 1.- Load the tensor volume dwi-dicom.
- 2.- Visualize the tensors in your preferred way (color orientation, for instance).
- 3.- Go to Tractography -> DisplayLoadSave



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3DSlicer

Loading and displaying tracts

- 4.- Click on “Load Tractography”
- 5.- Load the file namic01-tractography.vtk

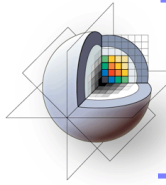
The screenshot shows the 3DSlicer software interface. A file selection dialog box is open, displaying a list of files and folders. The file 'namic01-tractography.vtk' is selected. The background shows the 3DSlicer interface with a 3D view of brain tracts.

Name	Size	Modified time
namic01-baseline.nhdr	1 KB	Tue Jun 3 12:46:35 2008
namic01-baseline.raw	4,608 KB	Tue Jun 3 12:46:35 2008
namic01-dwi.nhdr	2 KB	Tue Jun 20 20:27:28 2006
namic01-fa.nhdr	1 KB	Tue Jun 3 12:59:21 2008
namic01-fa.raw	9,216 KB	Tue Jun 3 12:59:21 2008
namic01-labelmap.nhdr	1 KB	Tue Jun 3 13:03:21 2008
namic01-labelmap.raw	4,608 KB	Tue Jun 3 13:03:21 2008
namic01-tensors.nhdr	1 KB	Tue Jun 3 12:46:15 2008
namic01-tensors.raw	82,944 KB	Tue Jun 3 12:46:15 2008
namic01-tractography.vtk	437 KB	Tue Jun 3 15:42:34 2008
S4.001	138 KB	Tue Feb 15 11:05:32 2005
S4.002	138 KB	Tue Feb 15 11:05:32 2005
S4.003	138 KB	Tue Feb 15 11:05:32 2005
S4.004	138 KB	Tue Feb 15 11:05:32 2005
S4.005	138 KB	Tue Feb 15 11:05:32 2005
S4.006	138 KB	Tue Feb 15 11:05:32 2005
S4.007	138 KB	Tue Feb 15 11:05:32 2005
S4.008	138 KB	Tue Feb 15 11:05:32 2005

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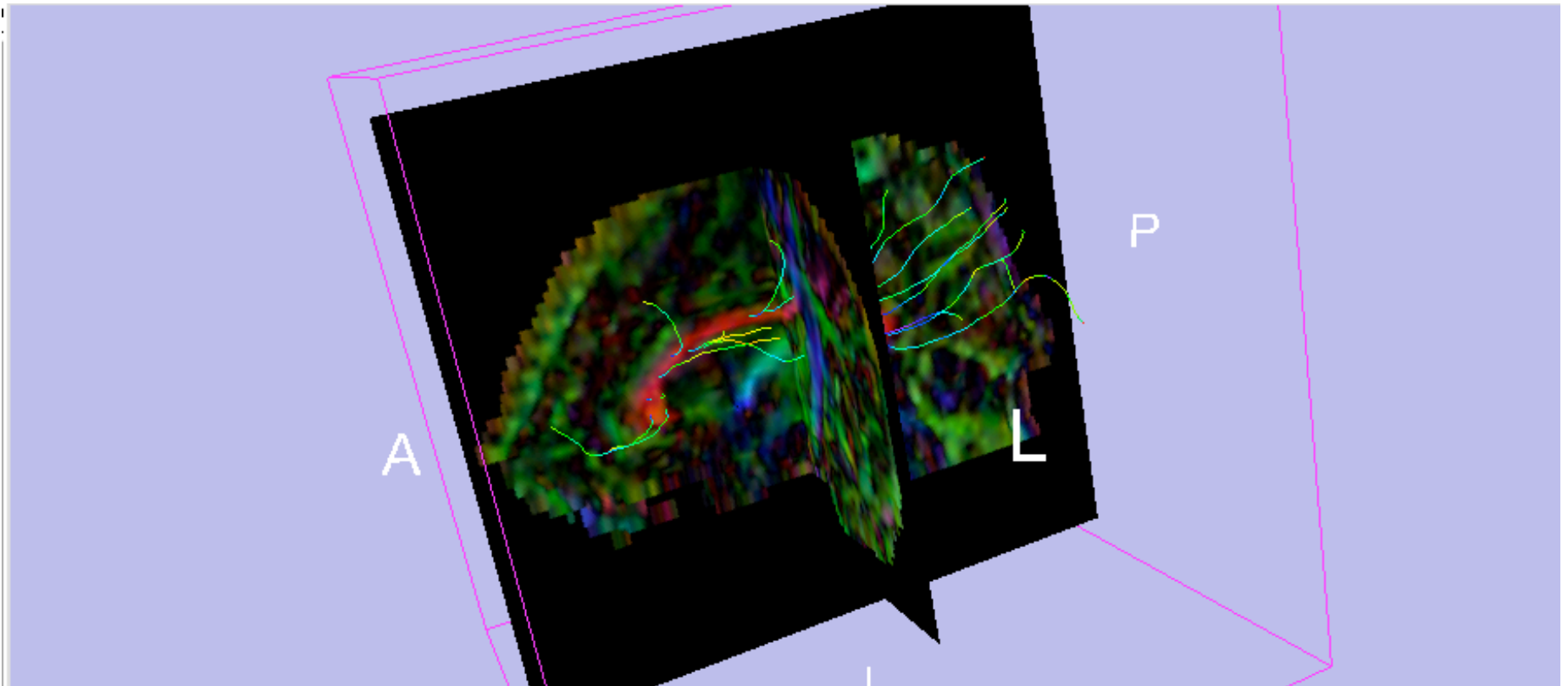
<http://www.slicer.org>



3DSlicer

Loading and displaying tracts

The loaded tracts will appear in the 3D view

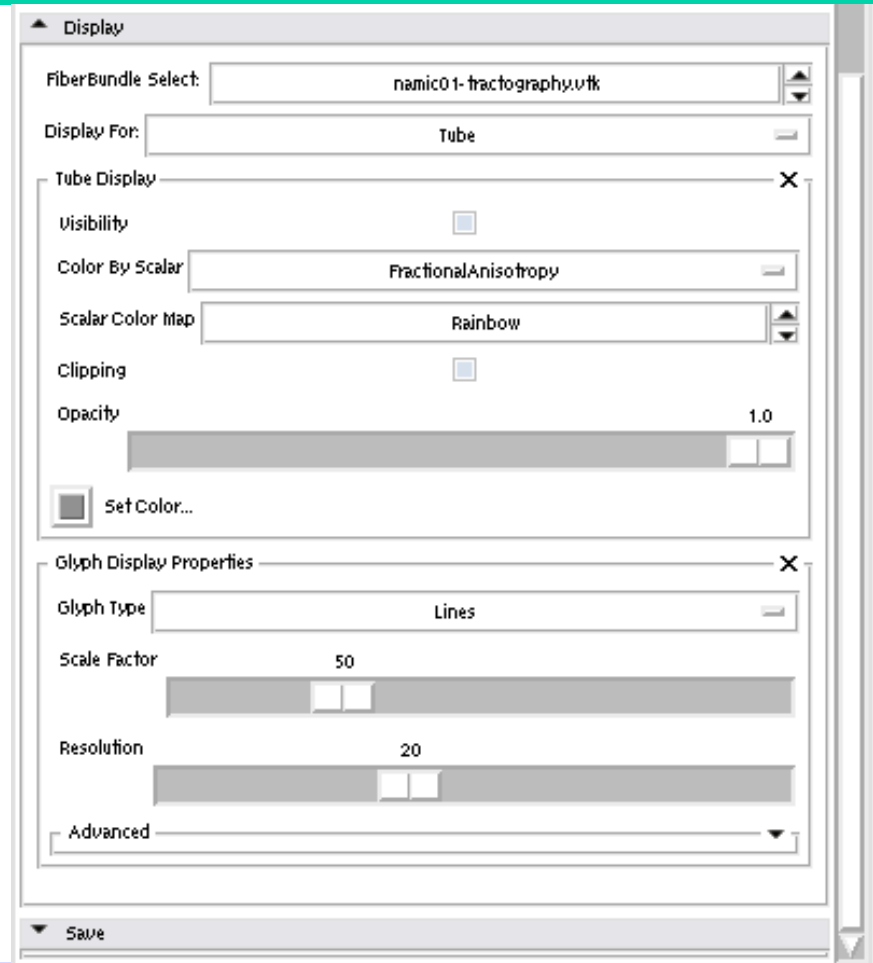




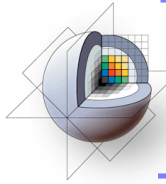
3DSlicer

Loading and displaying tracts

Unfold the Display tag from the tractography module



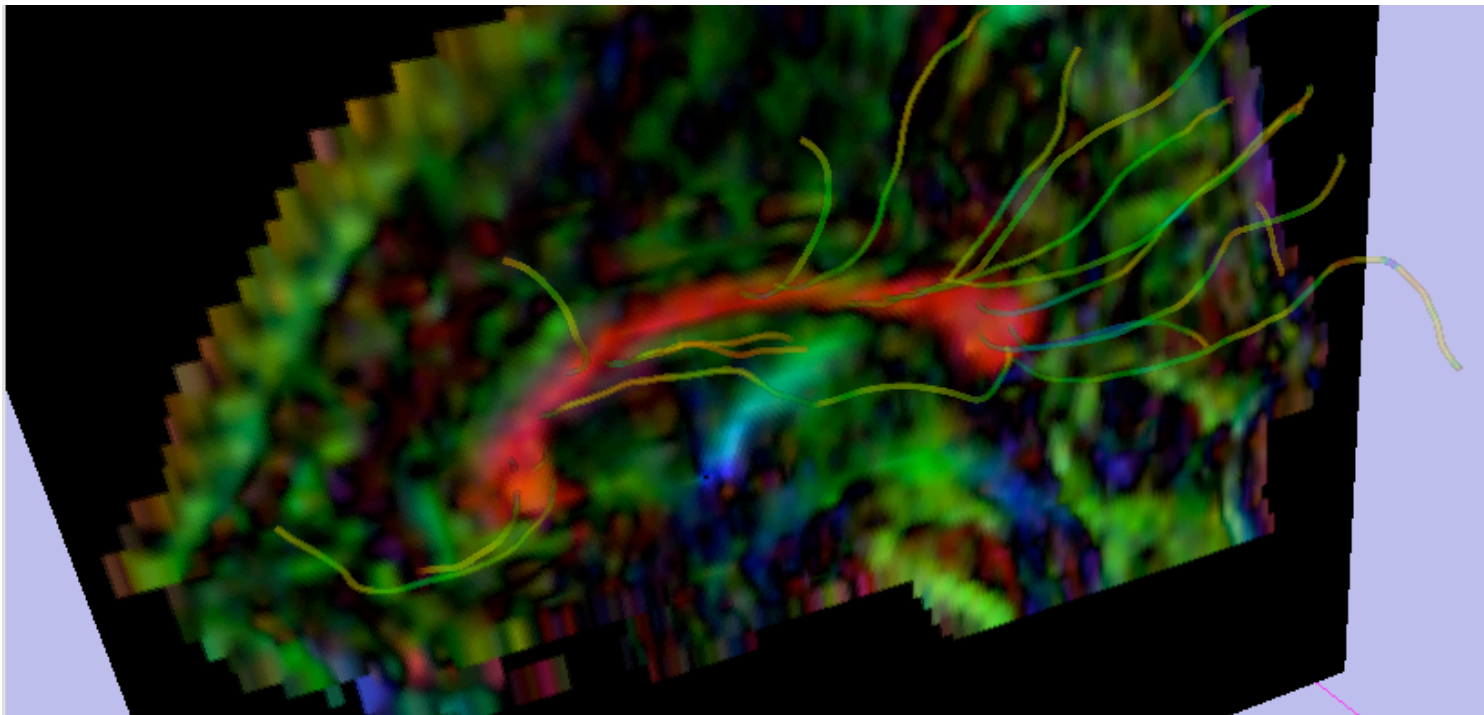
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3DSlicer

Loading and displaying tracts

Using the controls, you can display Tubes, Lines and Glyphs, and can control the Appearance of each of them (scale, color, opacity...)

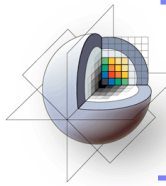


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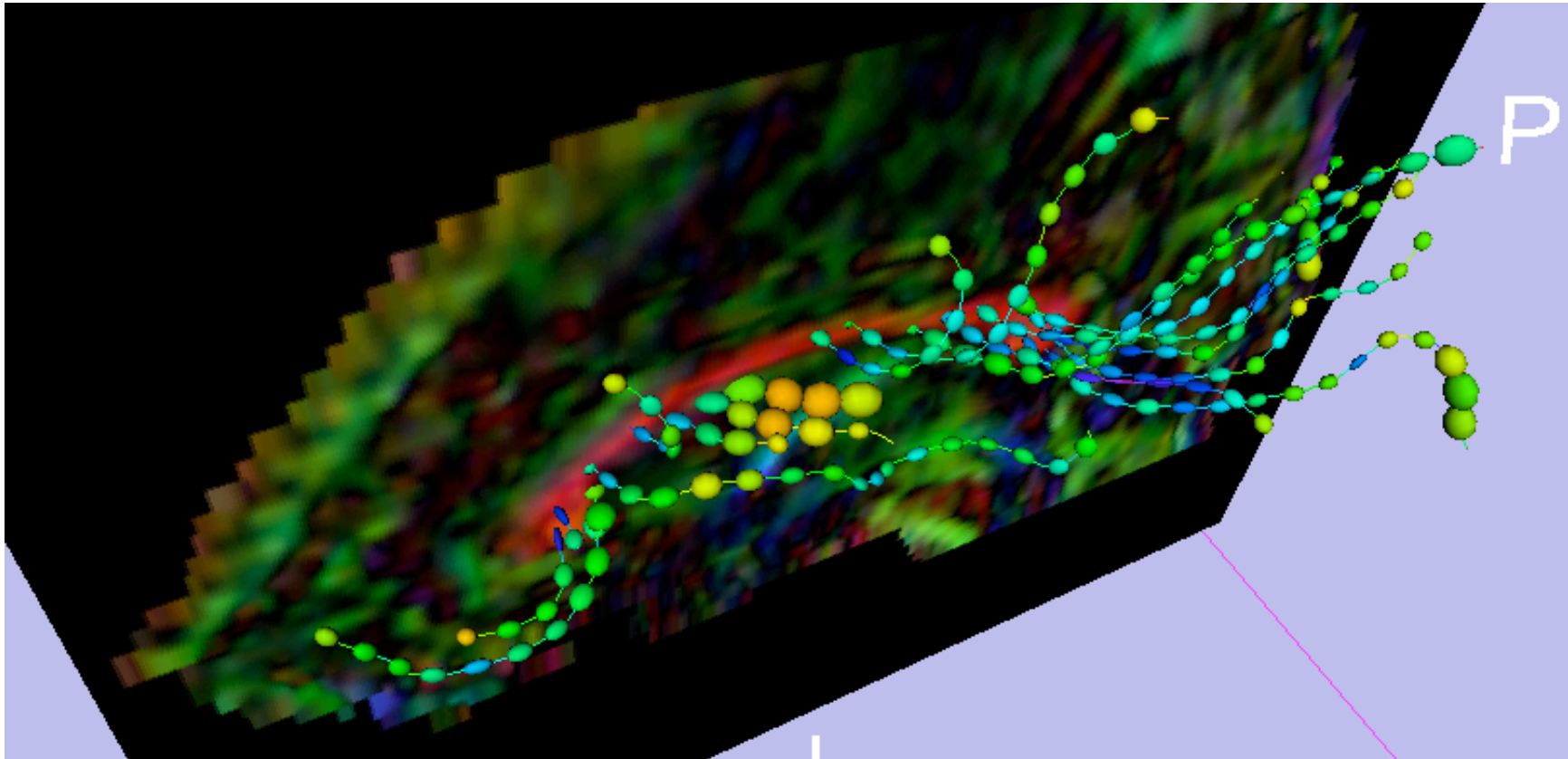
<http://www.slicer.org>

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3DSlicer

Loading and displaying tracts



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<http://www.slicer.org>

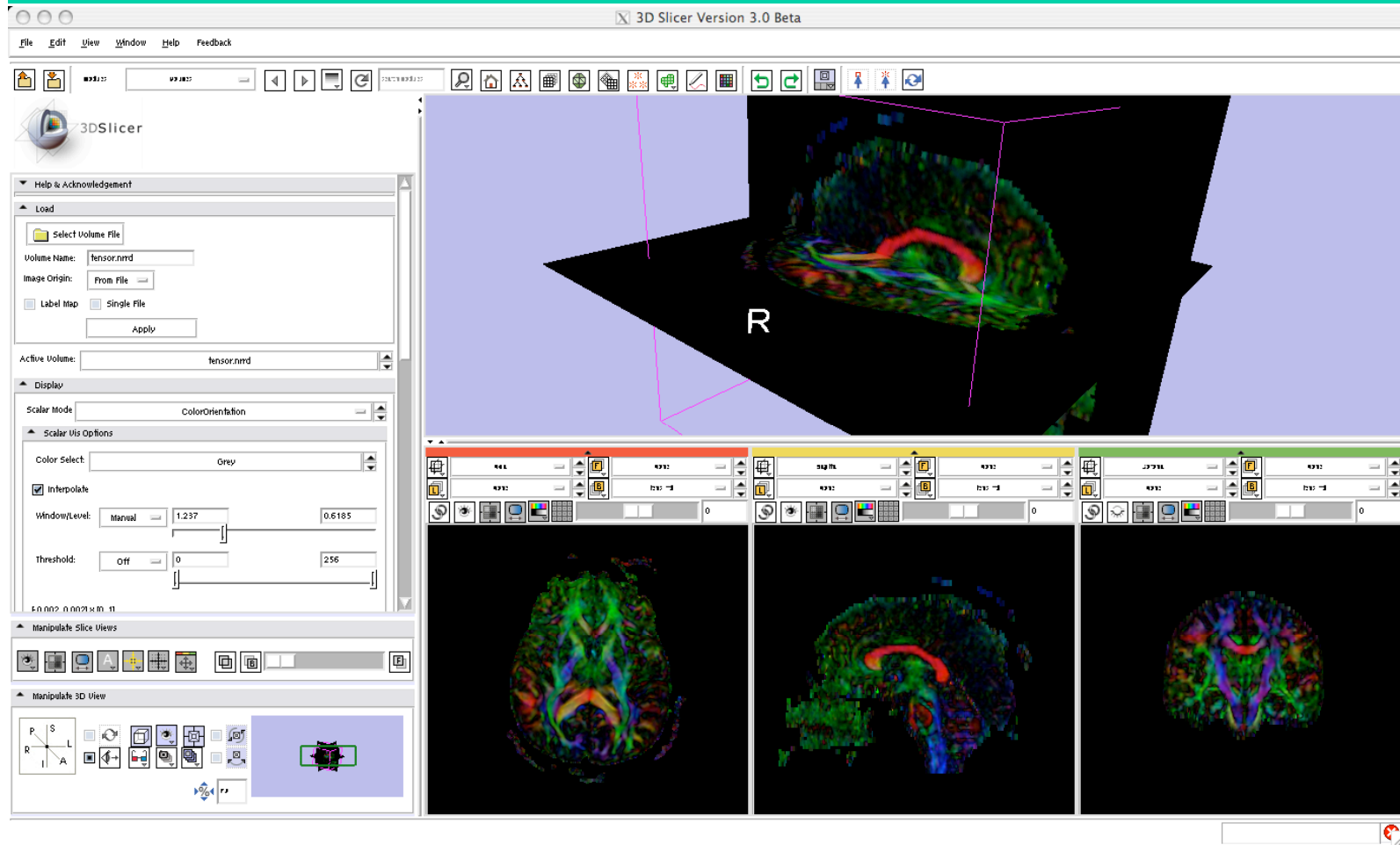
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3DSlicer

Performing tractography with fiducial seedings

1.- Visualize the tensor volume in the most appropriate way to select fiducials



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<http://www.slicer.org>

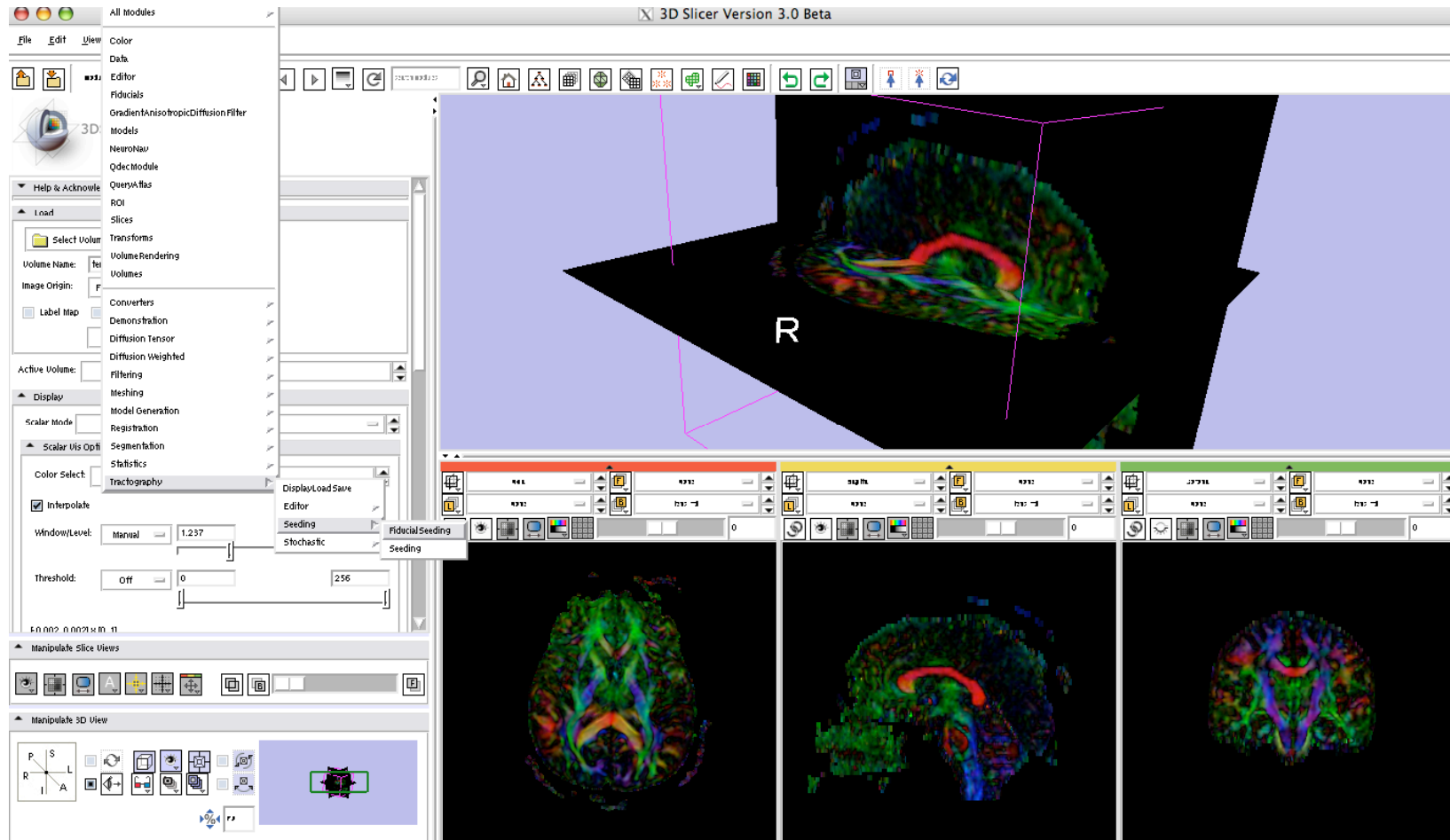
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3DSlicer

Performing tractography with fiducial seedings

2.-Select the module Tractography --> Seeding --> Fiducial Seeding



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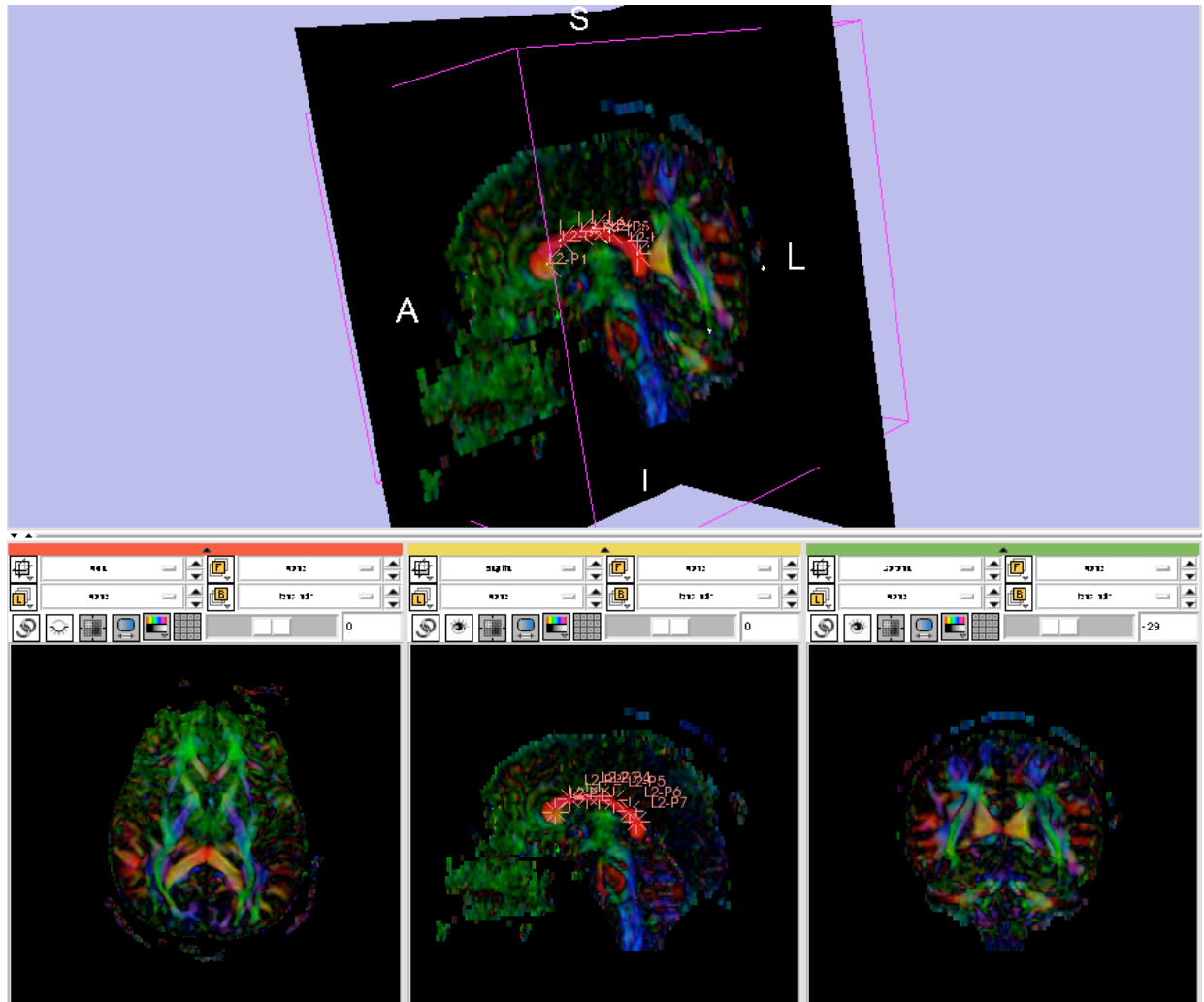
<http://www.slicer.org>



3DSlicer

Performing tractography with fiducial seedings

2.-Select as many fiducials as you want by clicking with the mouse and pressing "P" (both in the 2D views or in the 3D view)



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<http://www.slicer.org>

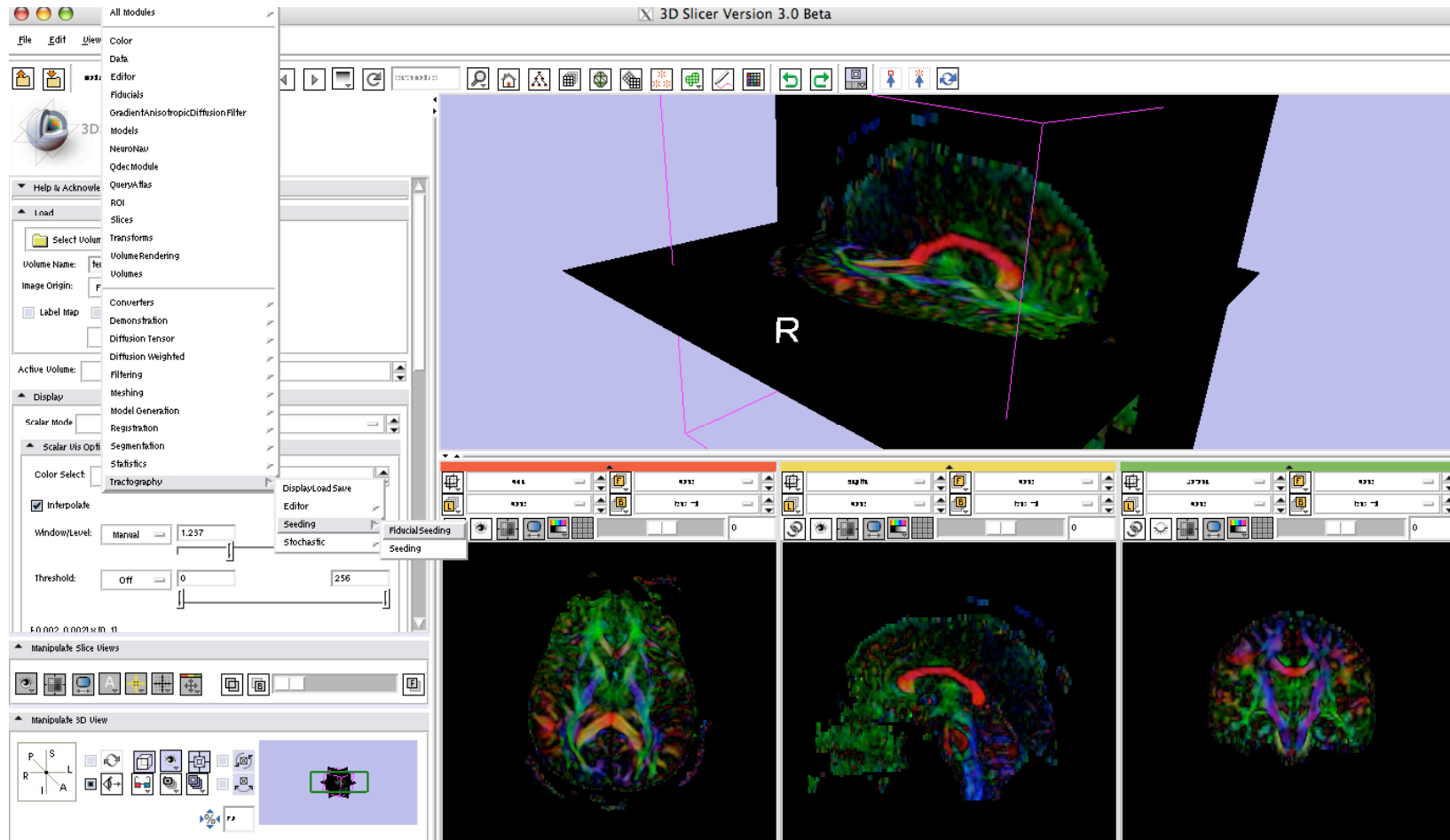
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3DSlicer

Performing tractography with fiducial seedings

3.-Select the module Tractography --> Seeding --> Fiducial Seeding



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<http://www.slicer.org>



3DSlicer

Performing tractography with fiducial seedings

3.-Select the tensor volume on which tractography will be performed.

Select the fiducial list, and the name of the Output Fiber Bundle.

Other parameters can be adjusted and readjusted interactively.



▼ Help & Acknowledgement

▲ Tractography Seeding From Fiducial

Select DTI Volume:

Select Fiducial List:

Output FiberBundleNode:

Stopping Mode:

Stopping Value: 0.3

Stopping Track Curvature: 0.8

Integration Step Length (mm): 0.6

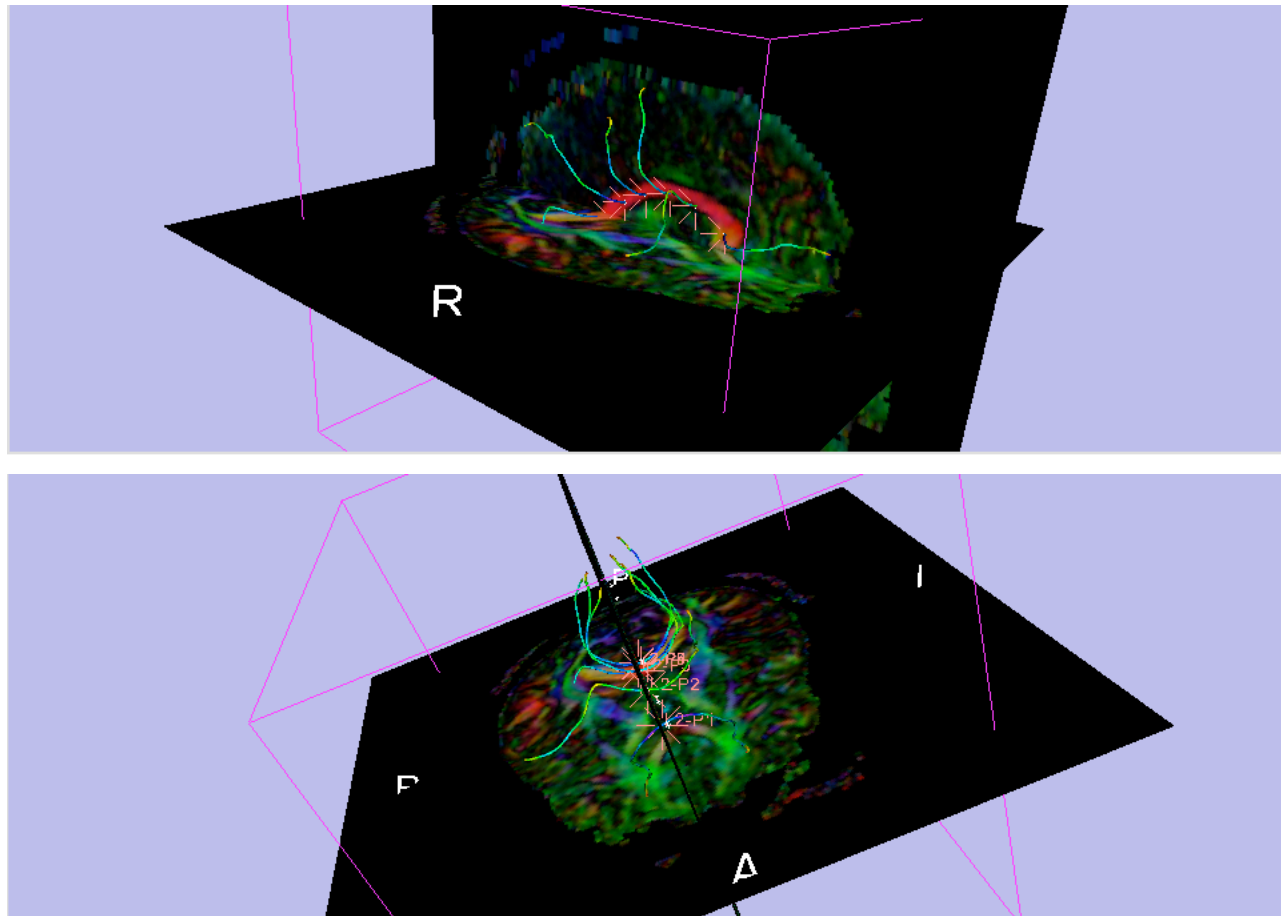
Seed Tracts



3DSlicer

Performing tractography with fiducial seedings

The obtained fibers will appear in the 3D view, together with the fiducial seeds.

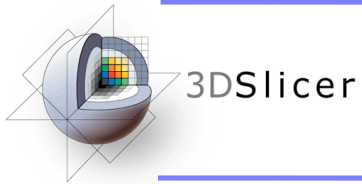


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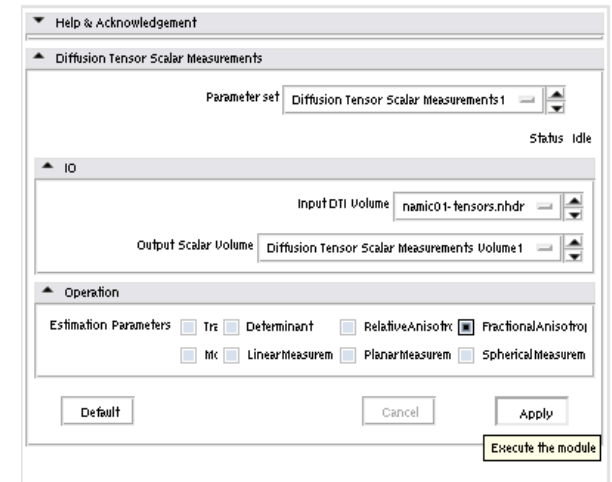
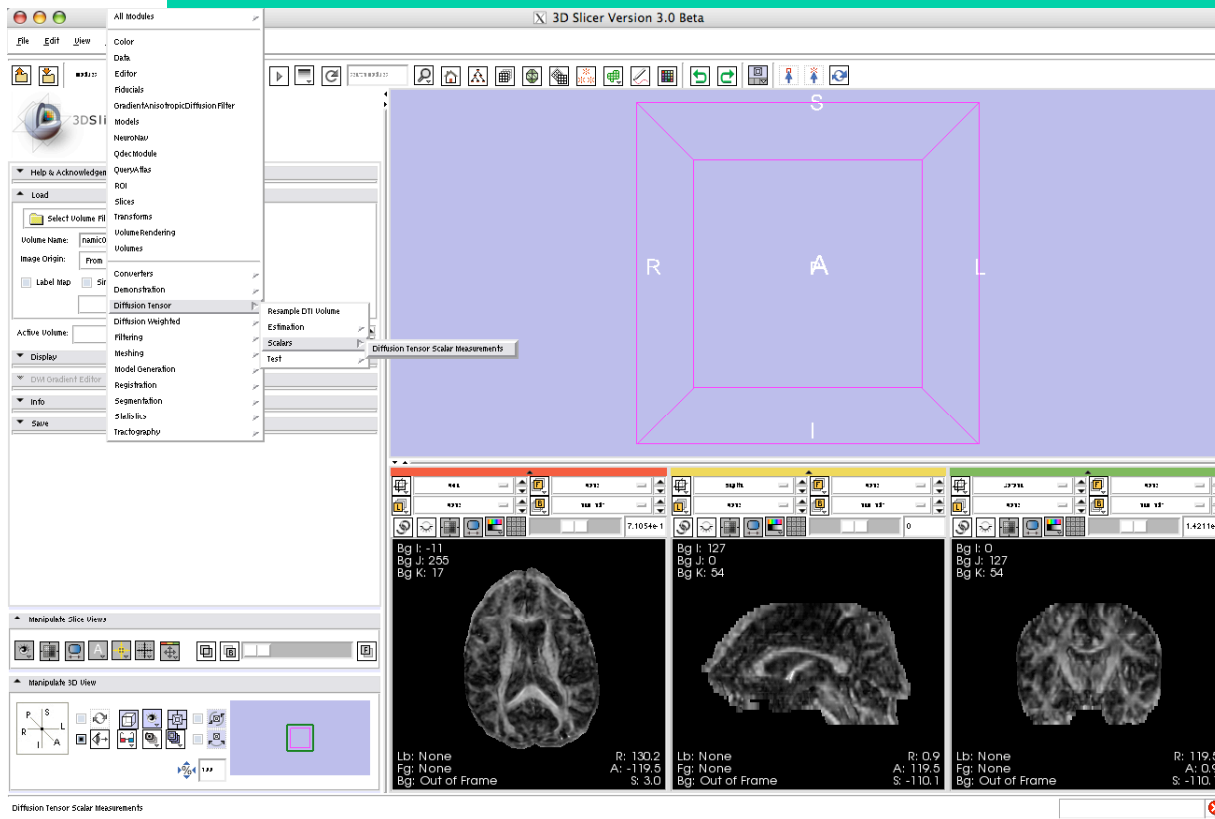
<http://www.slicer.org>

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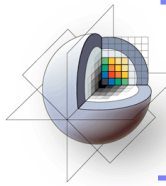


Performing tractography with ROI seeding

- 1.- Load a tensor volume: dwi-dicom
- 2.- Obtain an appropriate scalar measure for the delineation of the ROI (fractional anisotropy, for instance).



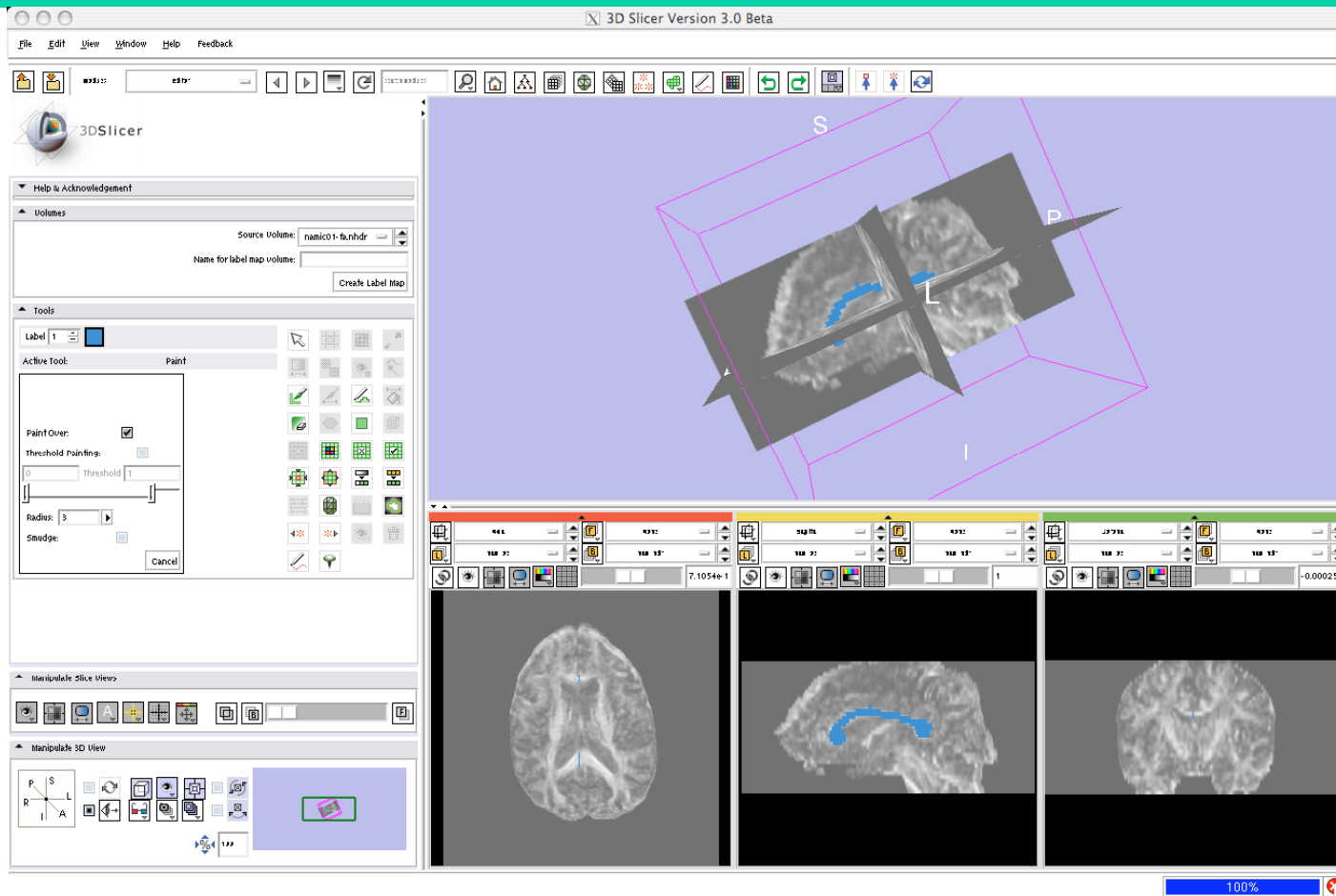
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3DSlicer

Performing tractography with ROI seeding

3.- On the scalar measure, use the Editor module to create a label map delineating the ROI. Save it.



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<http://www.slicer.org>

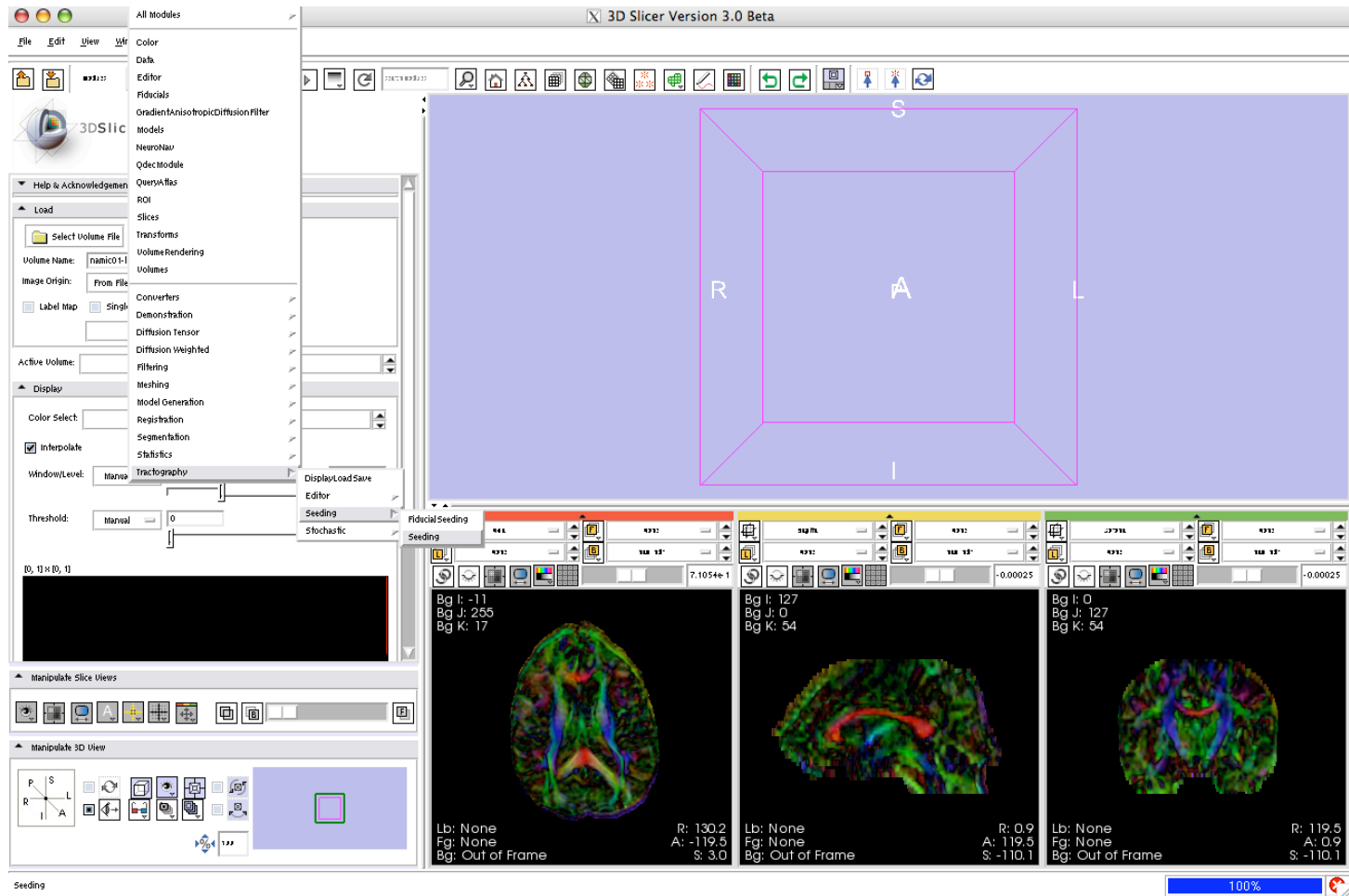
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3DSlicer

Performing tractography with ROI seeding

4.- Select the module Tractography -> Seeding -> Seeding



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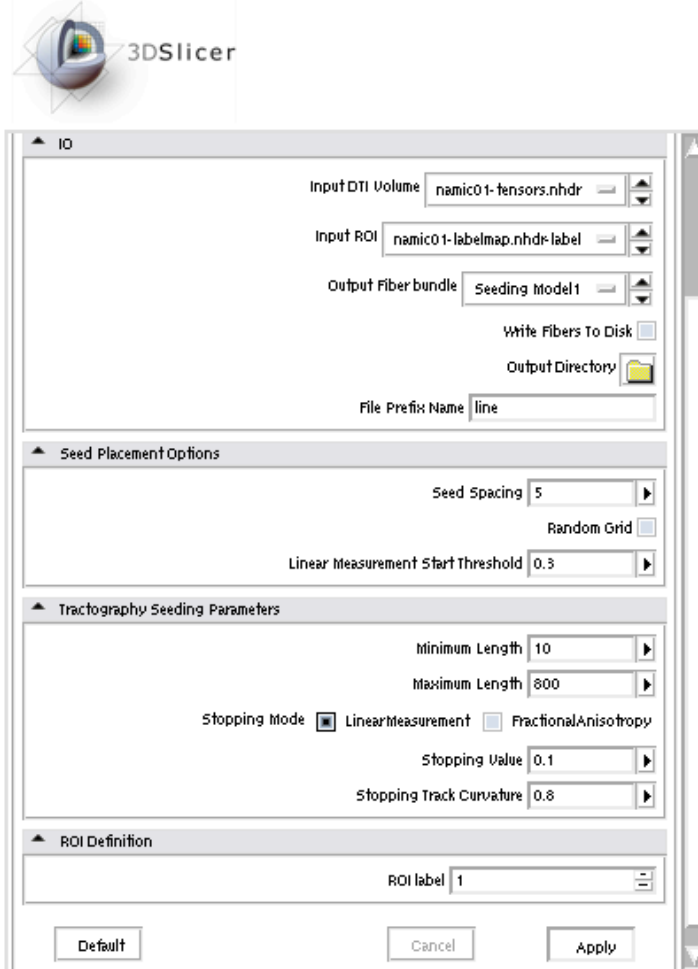
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3DSlicer

Performing tractography with ROI seeding

5.- Select the parameters, and click Apply



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<http://www.slicer.org>

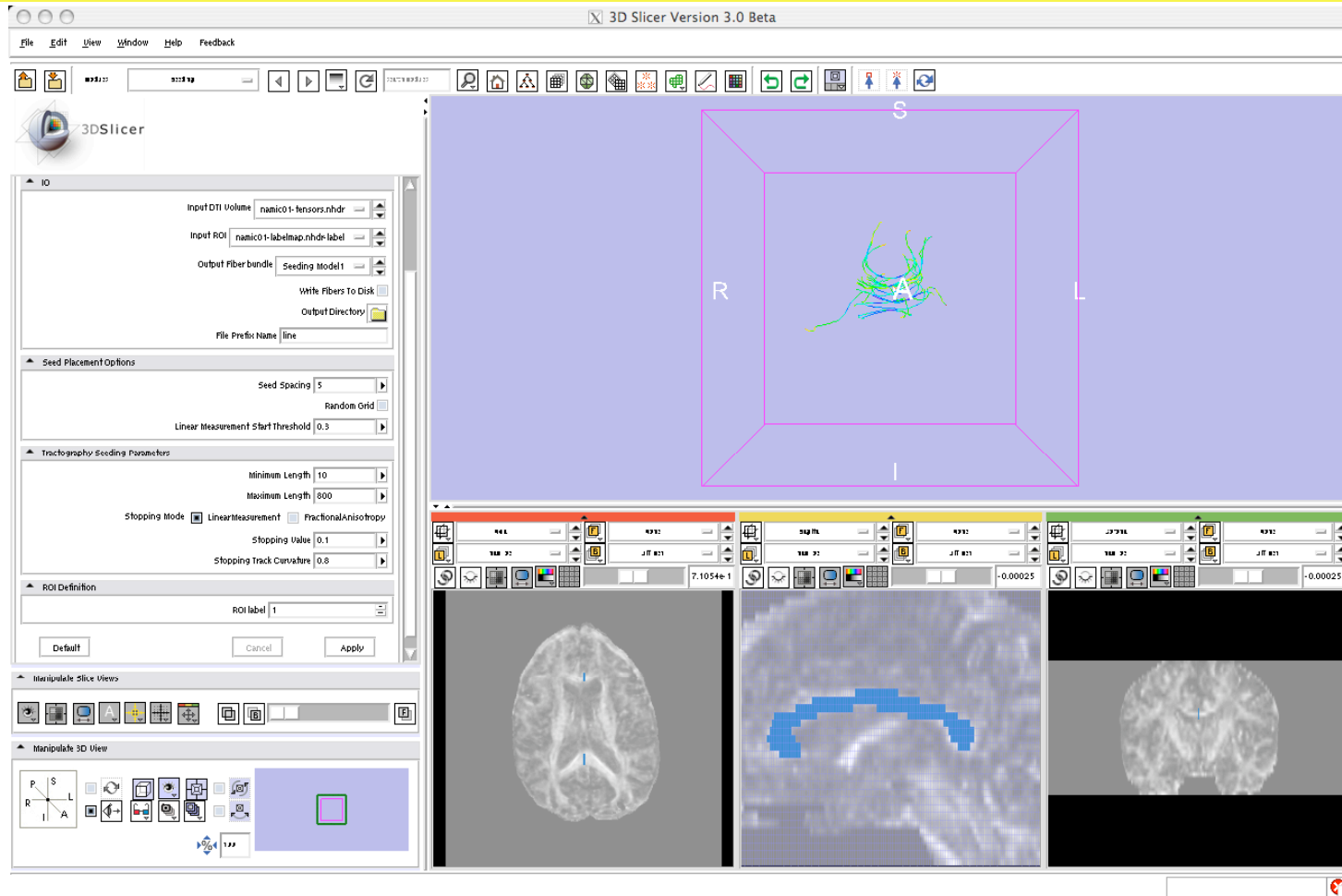
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3DSlicer

Performing tractography with ROI seeding

The obtained tracts will appear in the 3D view.



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<http://www.slicer.org>

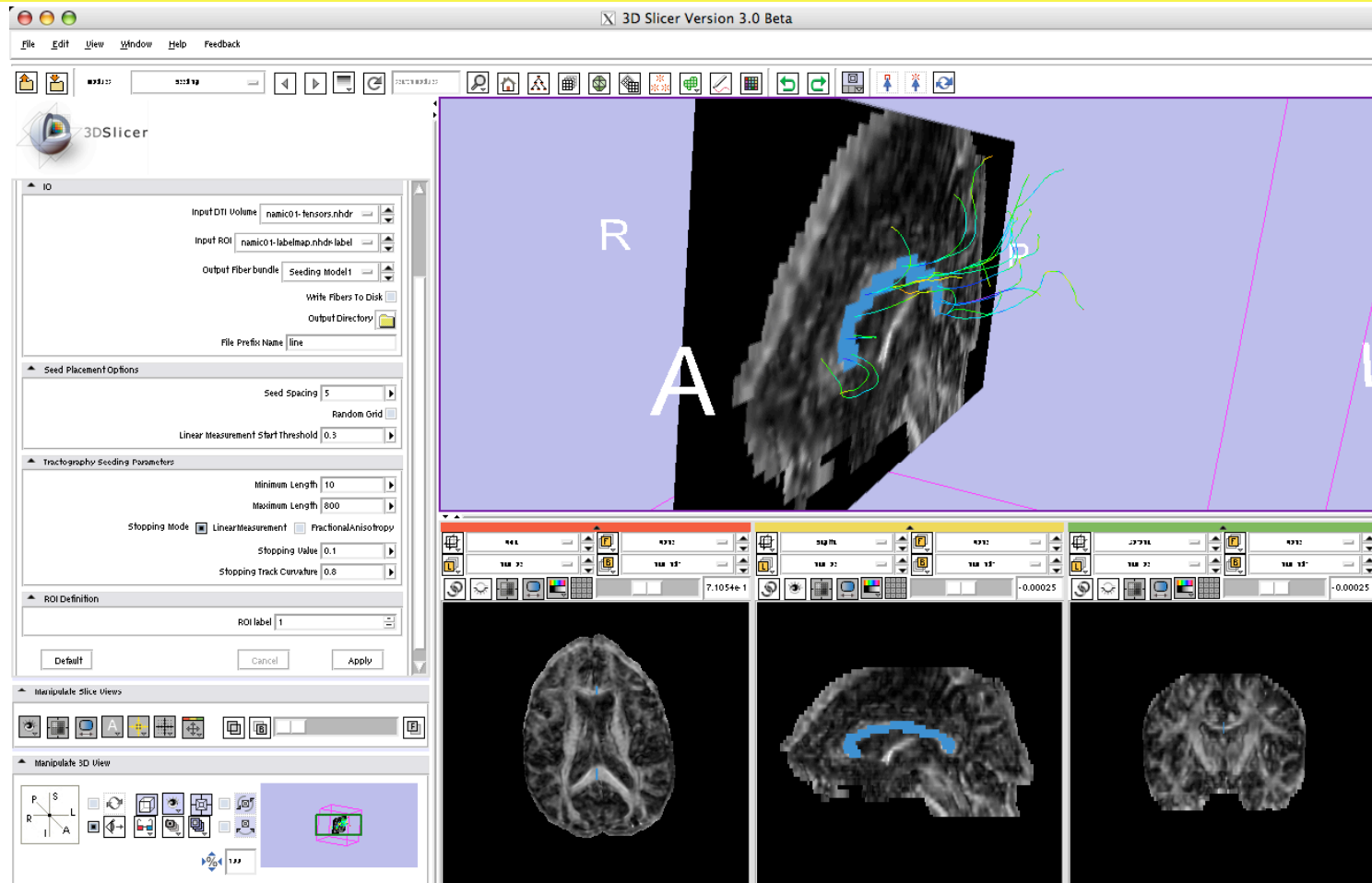
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3DSlicer

Performing tractography with ROI seeding

You can visualize the tracts together with the tensor volume, the label map...



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