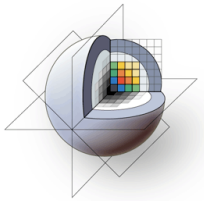

Diffusion Tensor Analysis in Slicer3

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

Acknowledgments

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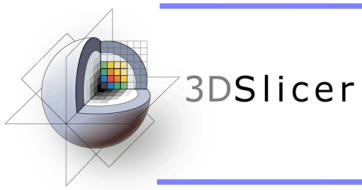
Laboratory of Mathematics in Imaging,
Brigham and Women's Hospital
NIH R01MH074794

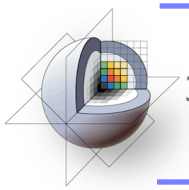
Material

- 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



Material

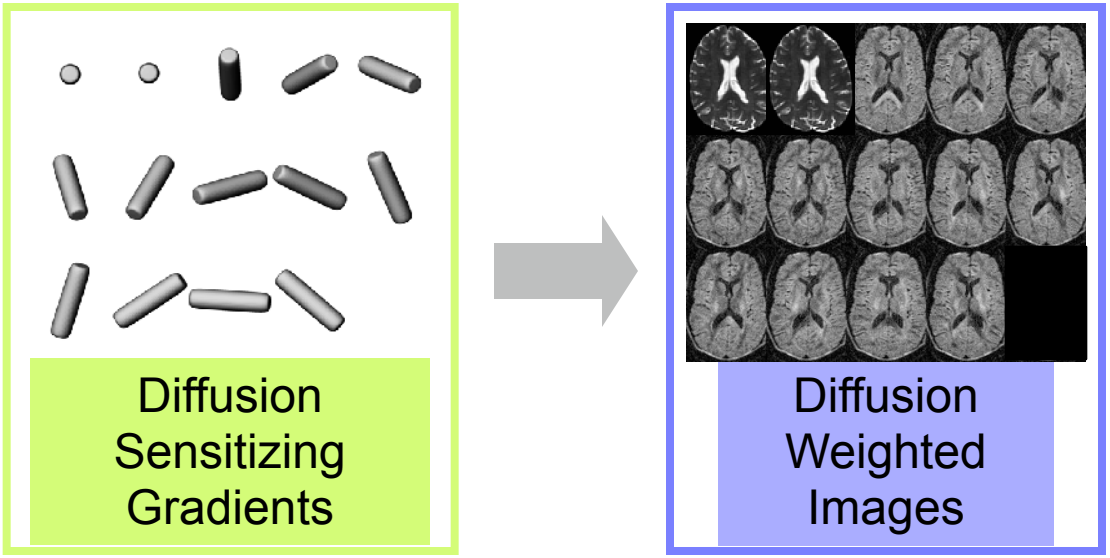


Outline

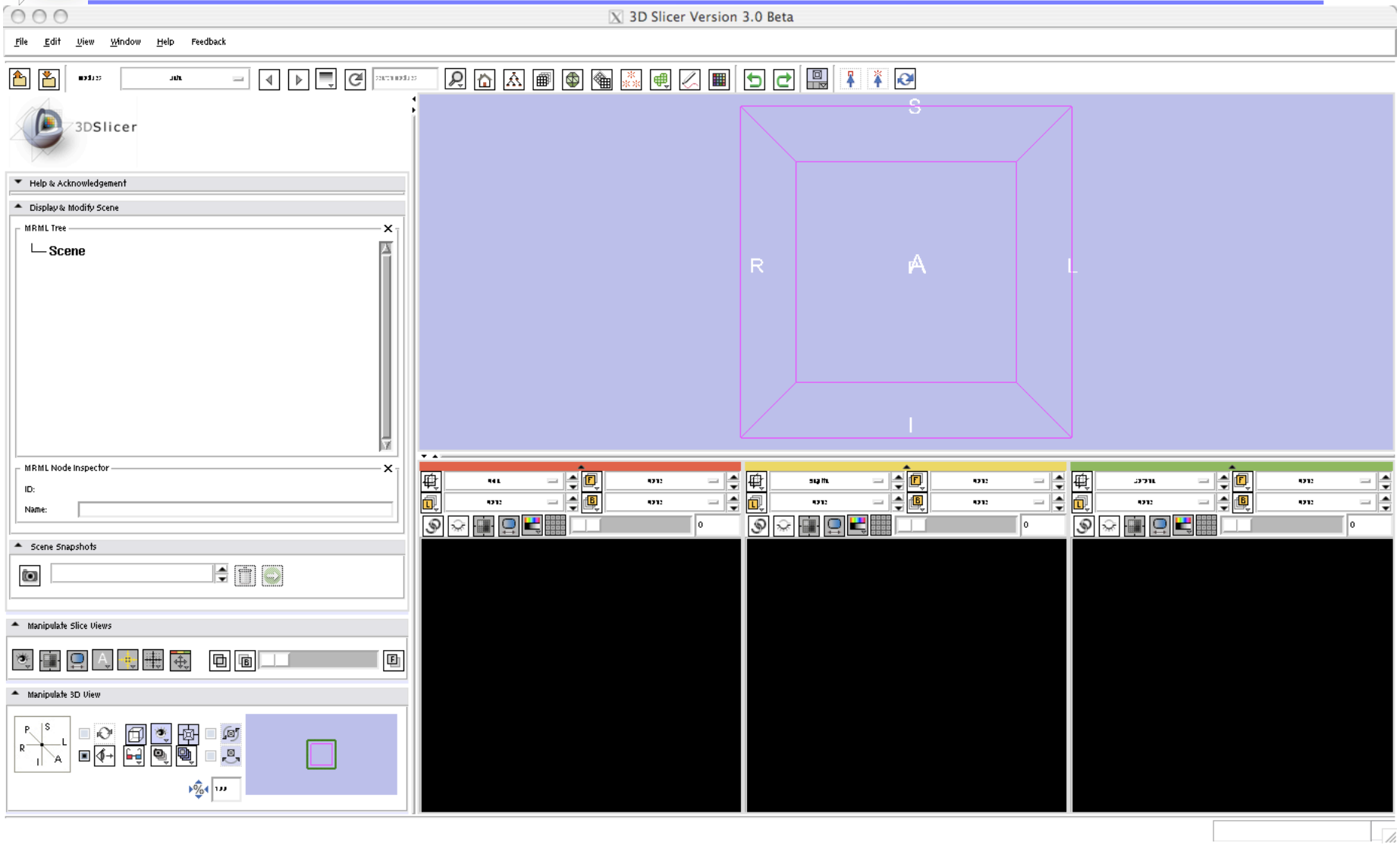
- Introduction to DWI and DTI
- Introduction to Slicer3
- DTI-related functionalities
- Loading DWI and tensor data
- Estimating tensors from DWI
- Visualizing tensors
- DTI tensor resampling
- Tractography

Introduction to DWI and DTI

- DWI (Diffusion Weighted Imaging) is a MRI modality that produces images describing the diffusion of water mollecules 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.



Introduction to Slicer3



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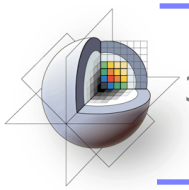
Surgical Planning Laboratory

http://www.slicer.org

Brigham and Women's Hospital

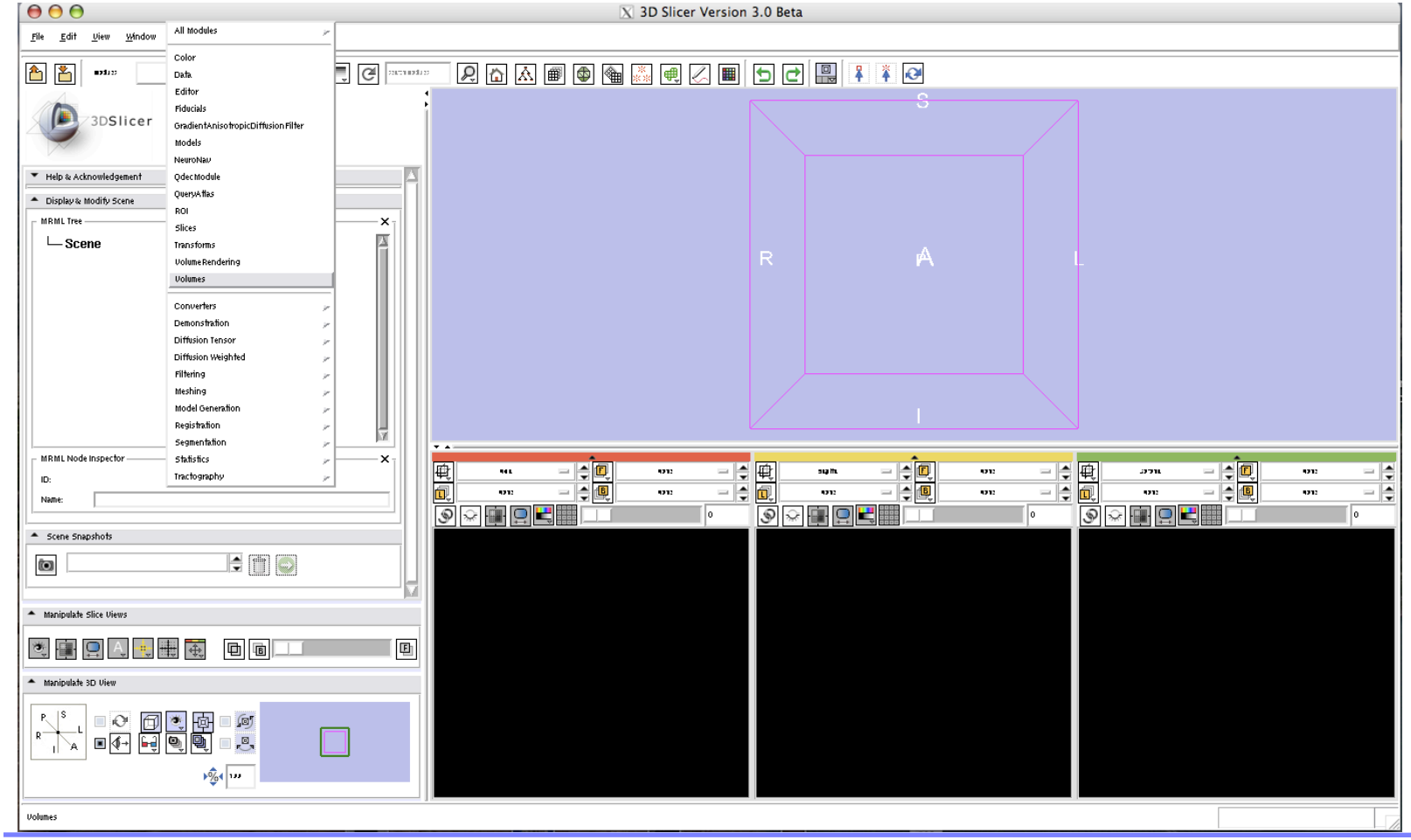


DTI-related functionalities

- 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)

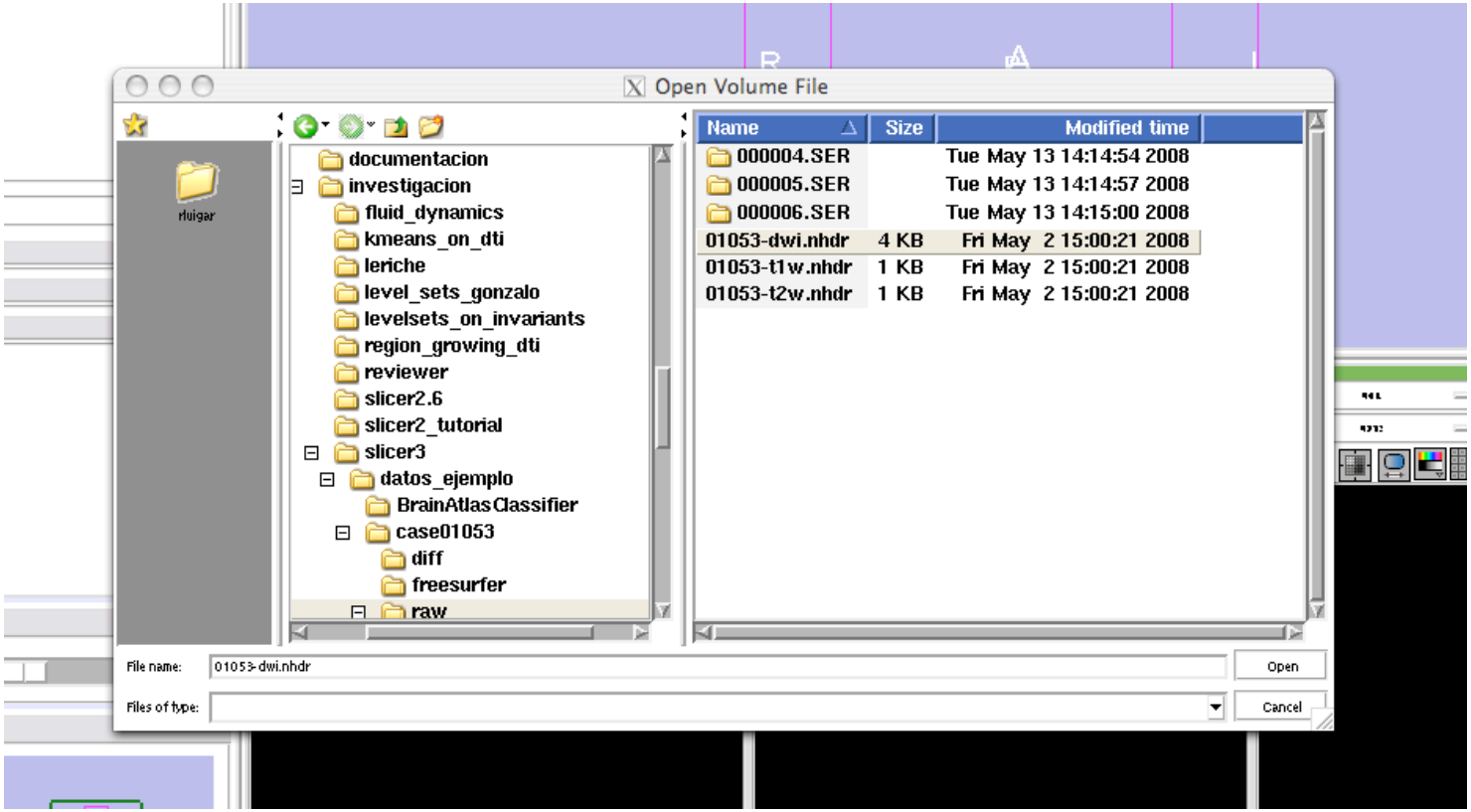
1- Select the module “VOLUMES” in the Modules menu



3DSlicer Loading Dataset 1 (DWI data)

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

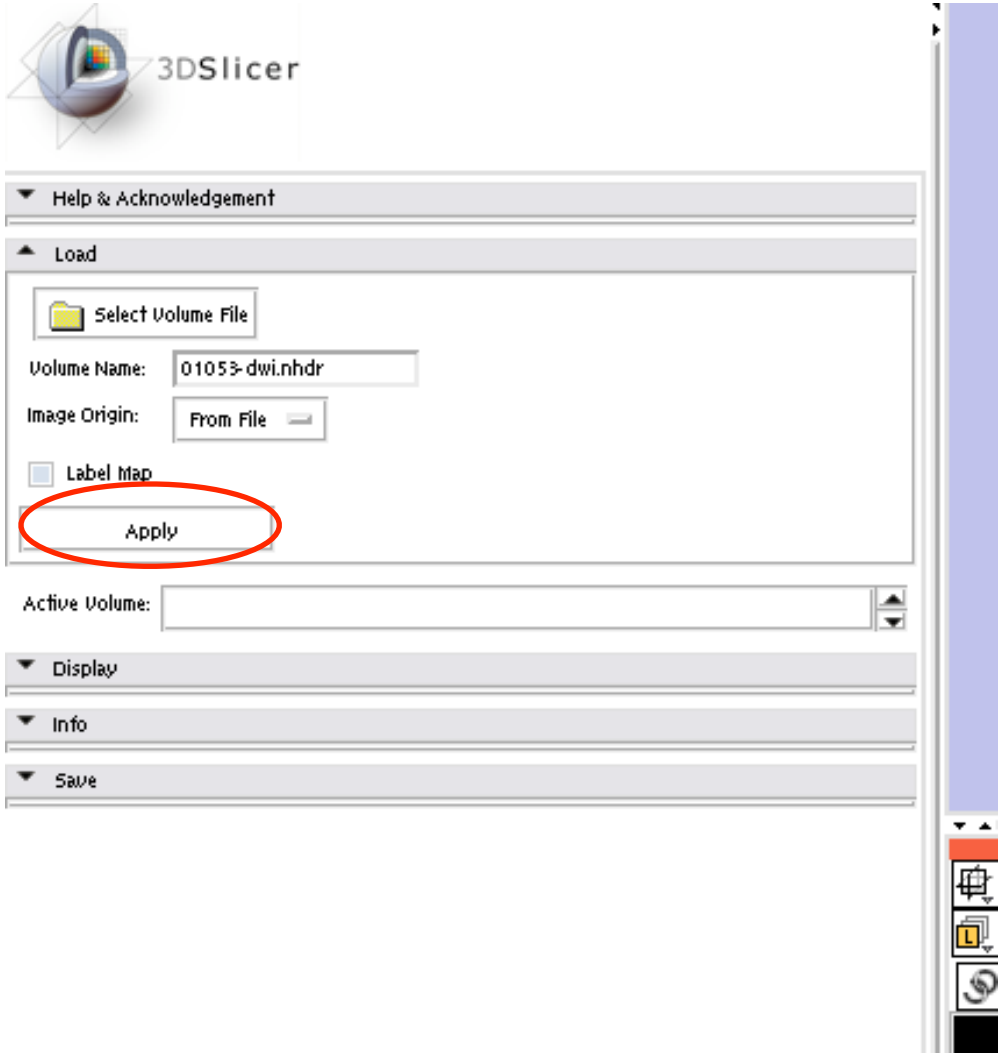
2- Select the file “01053-dwi.nhdr”



3DSlicer Loading Dataset 1 (DWI data)

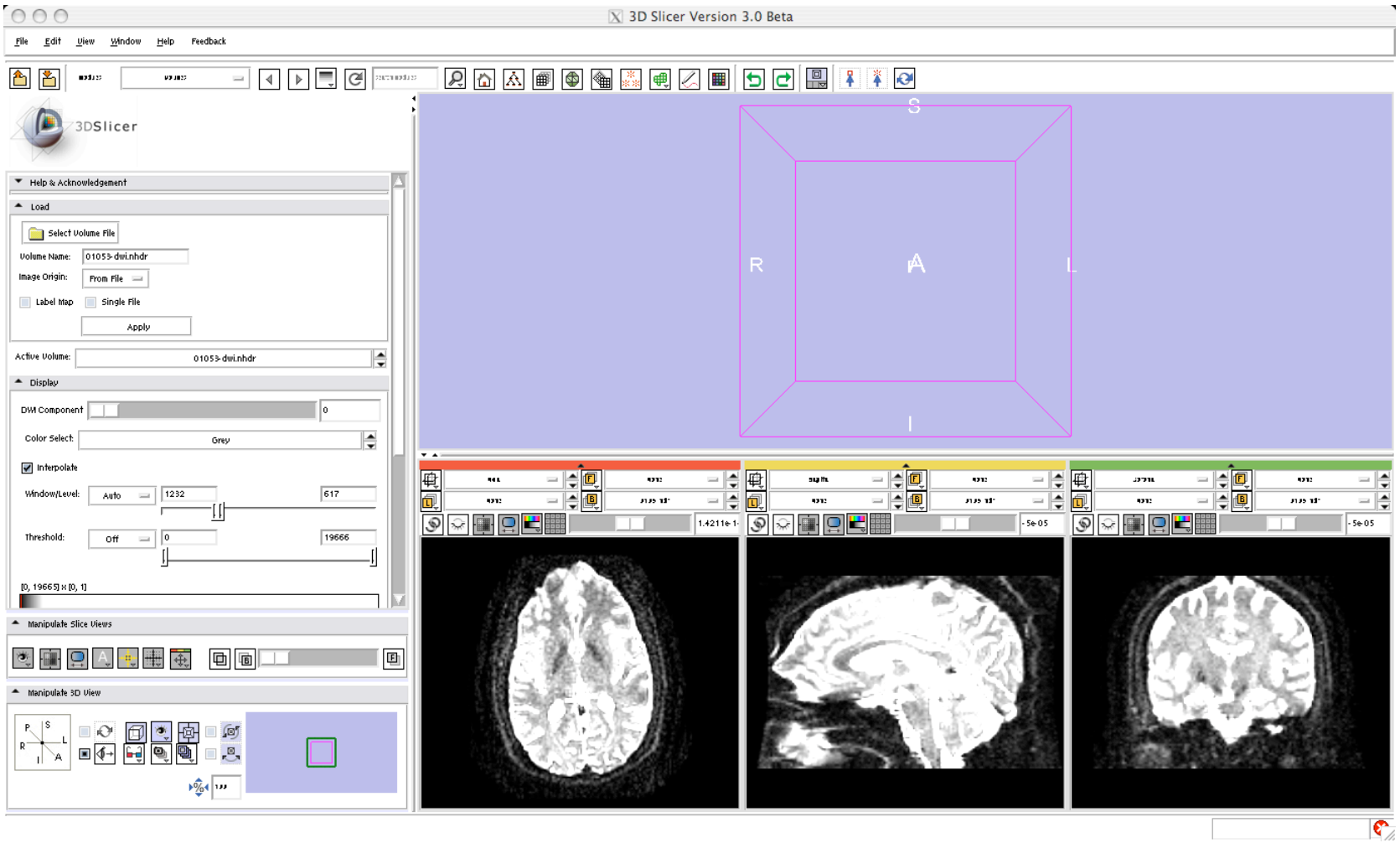
The volume name will appear in the Load tag

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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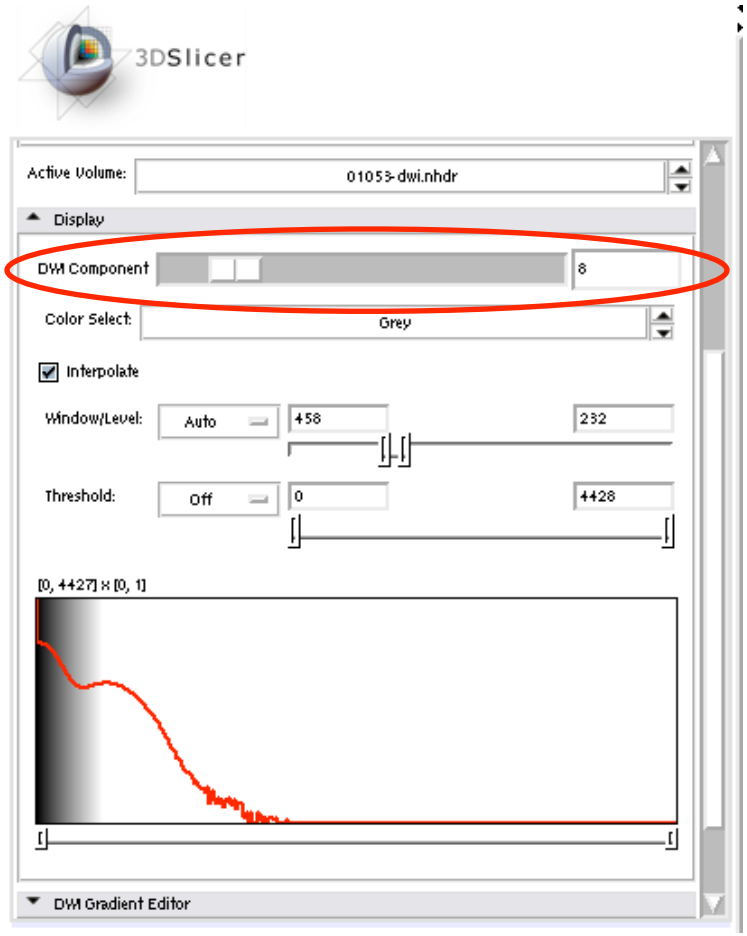
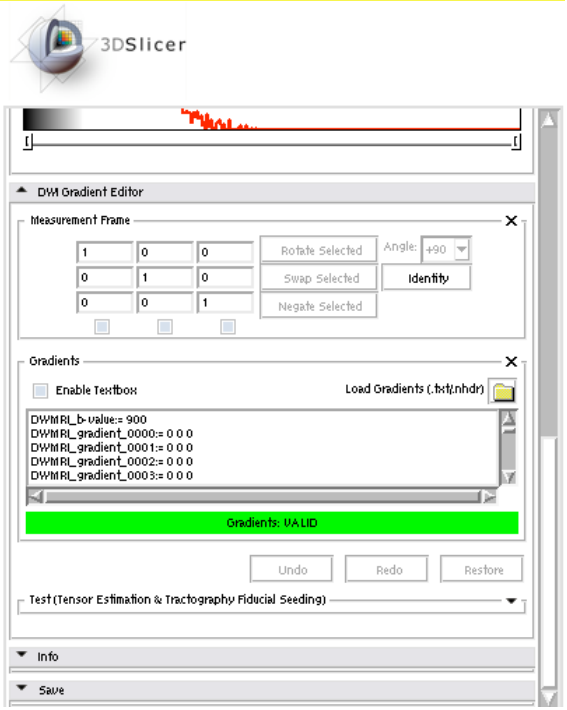
3DSlicer Loading Dataset 1 (DWI data)

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

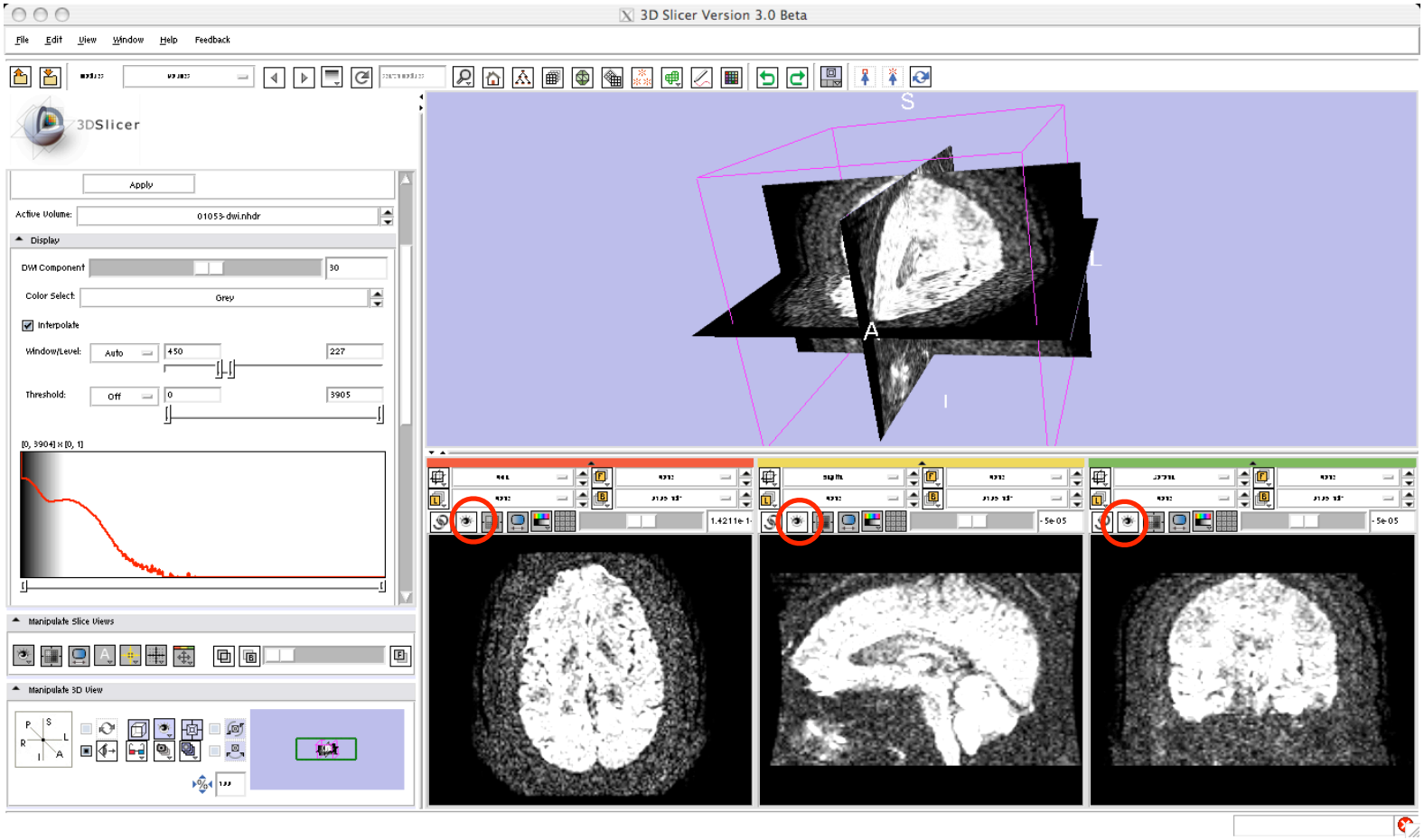




Also, when a DWI volume is loaded, the “DWI Gradient Editor” tag becomes active. This can be used for converting DWI to tensors.

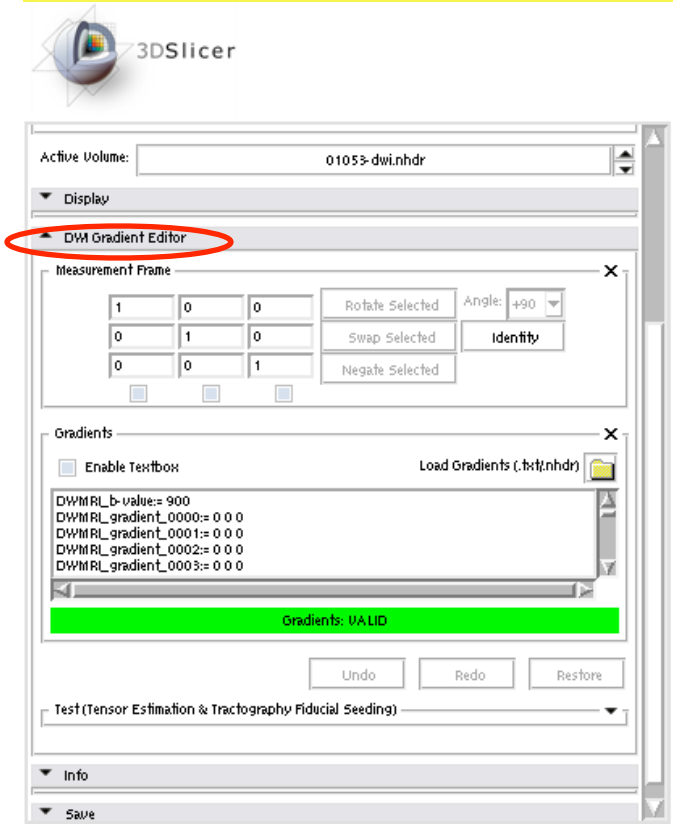
3DSlicer Loading Dataset 1 (DWI data)

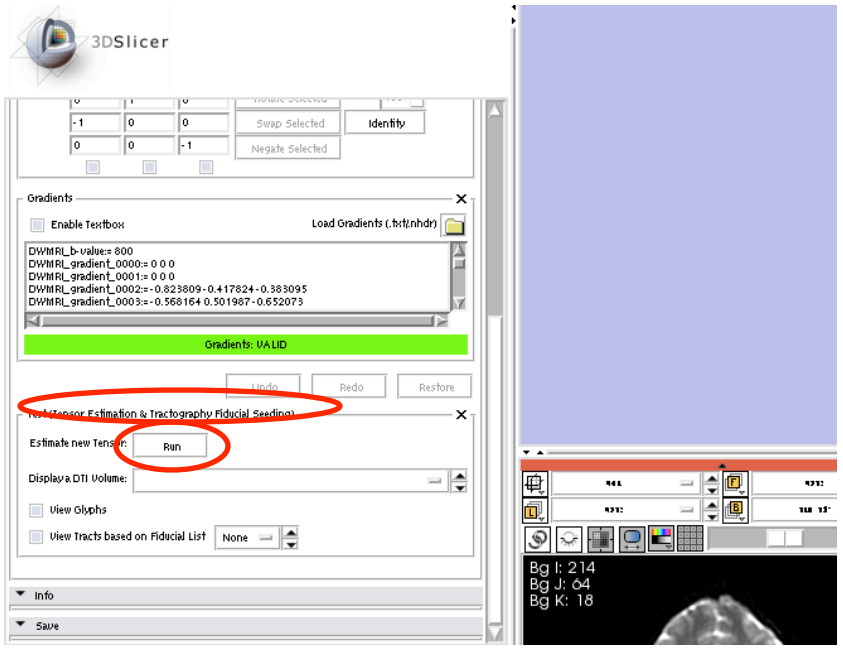
By activating the visibility button for each slice you can visualize slices in the main view.



3DSlicer Converting from DWI to tensors

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

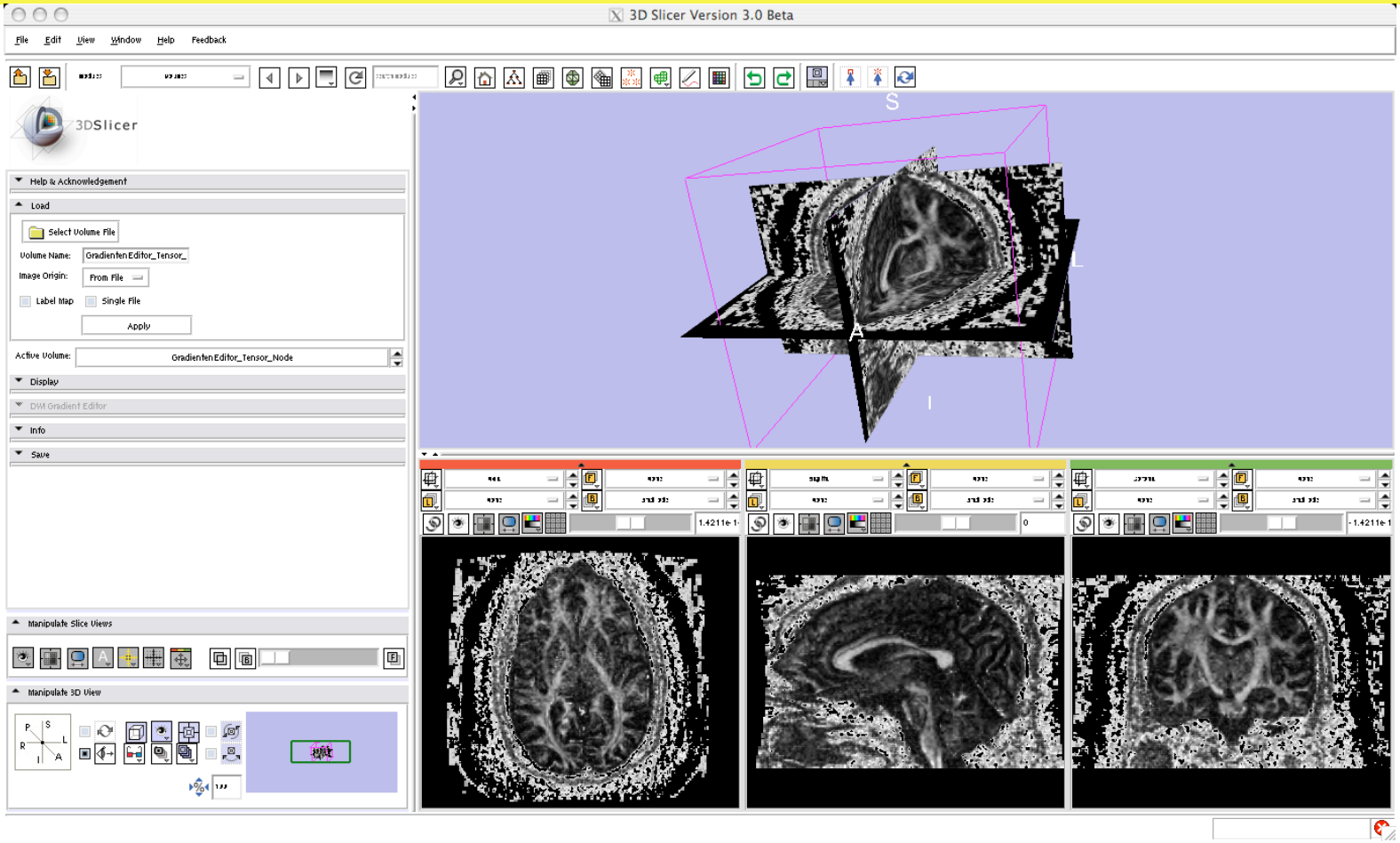




To estimate the tensors, first unfold the TEST (Tensor Estimation & Tractography Fiducial Seeding) and then click “Run” to Estimate New Tensor

3DSlicer Converting from DWI to tensors

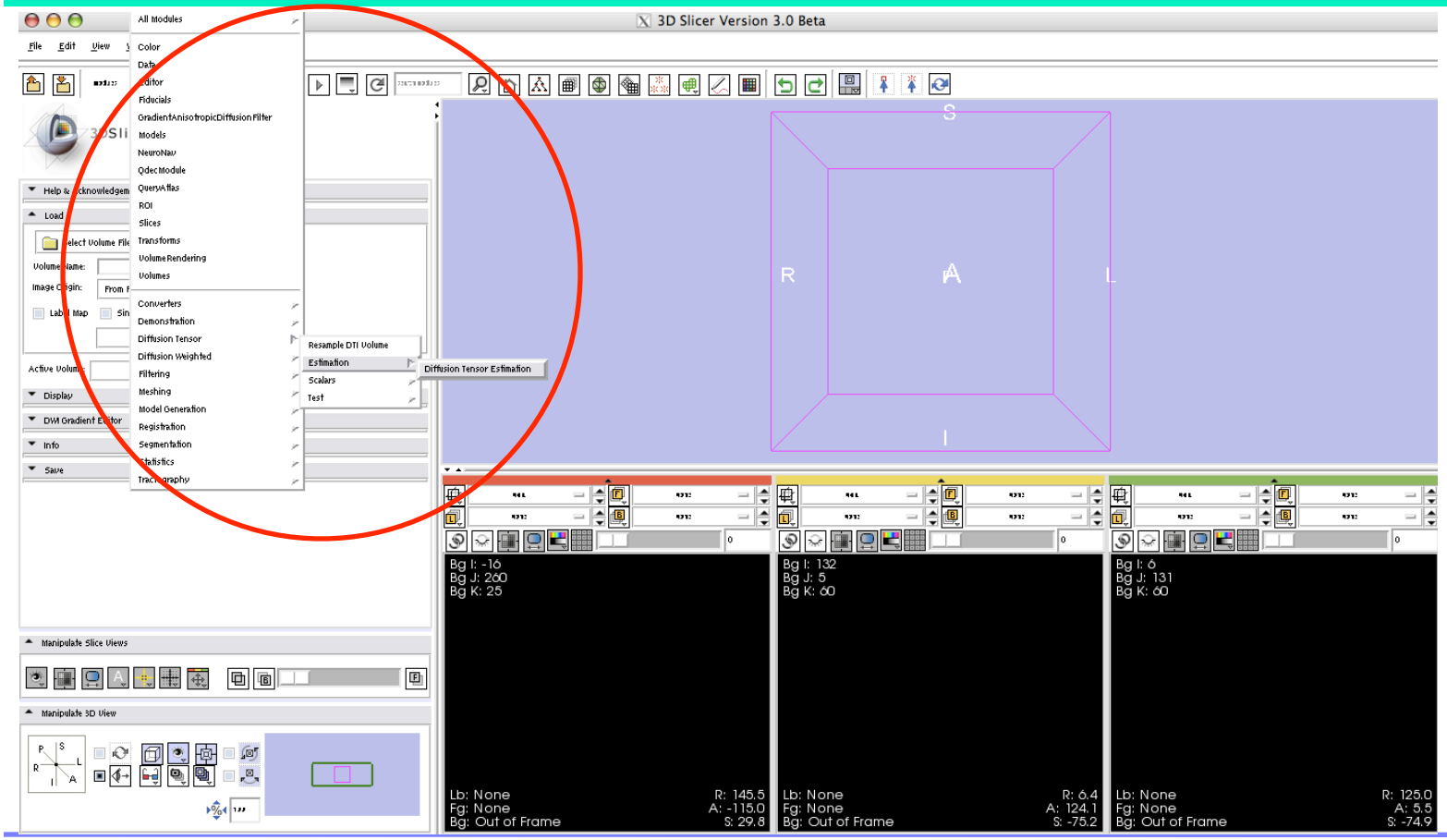
Once the estimation is performed, the tensor volume becomes active, and it can be displayed or processed in any way.



3DSlicer Converting from DWI to tensors

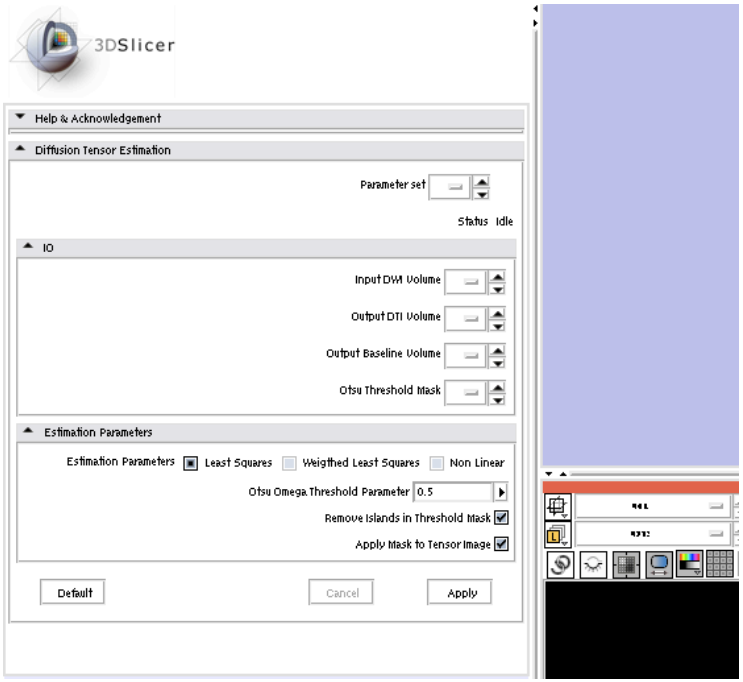
Tensor estimation can also be performed from the DT-MRI module (you need to have an active DWI volume)

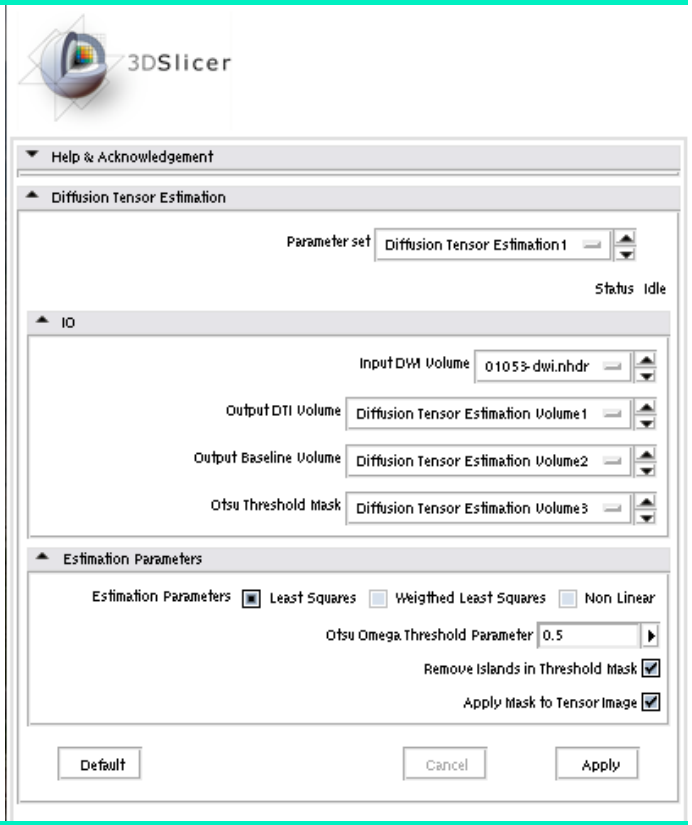
1- Select DIFFUSION TENSOR --> ESTIMATION --> DIFFUSION TENSOR ESTIMATION



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”

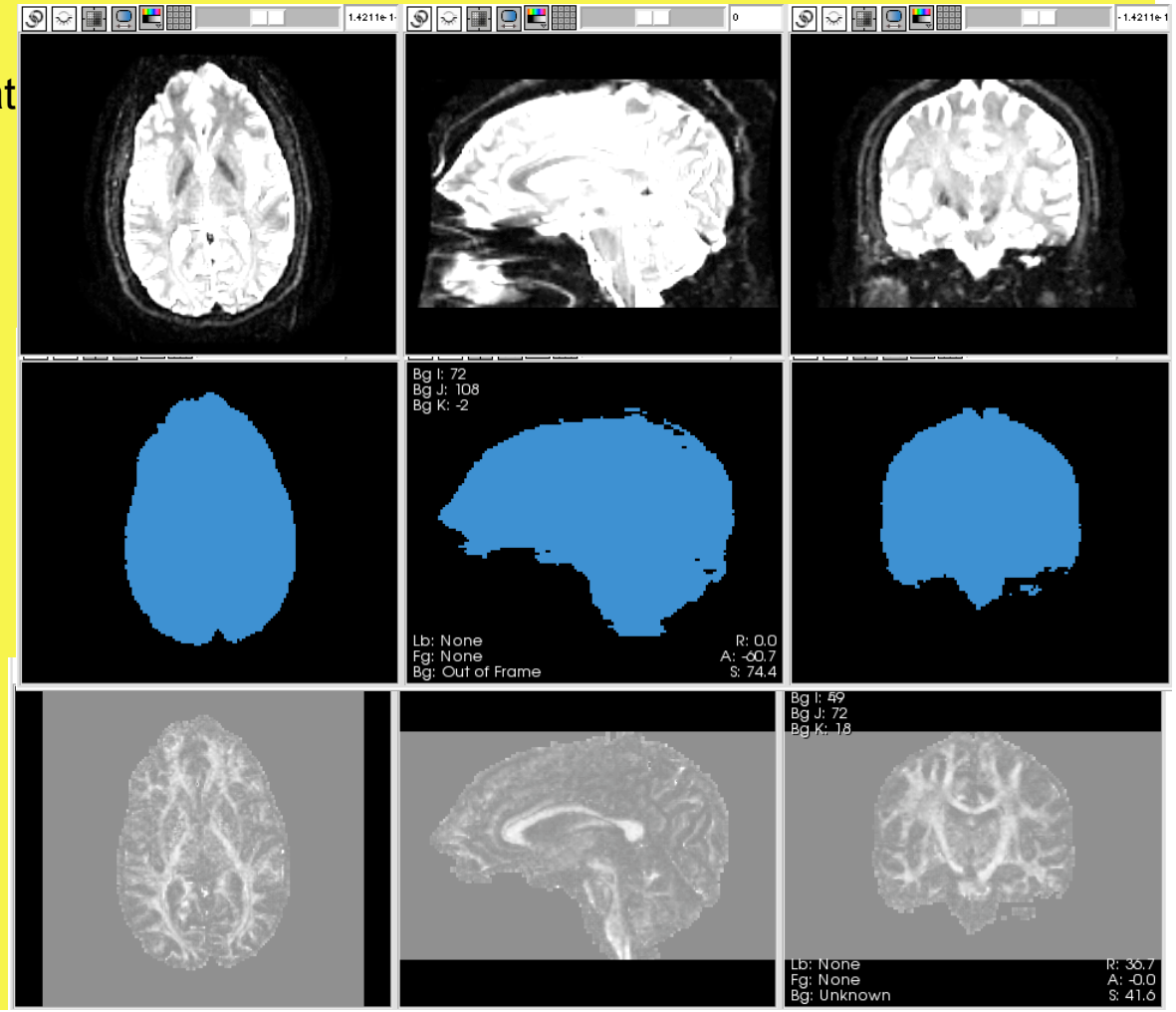
3DSlicer Converting from DWI to tensors

Once the tensor estimat

- Baseline

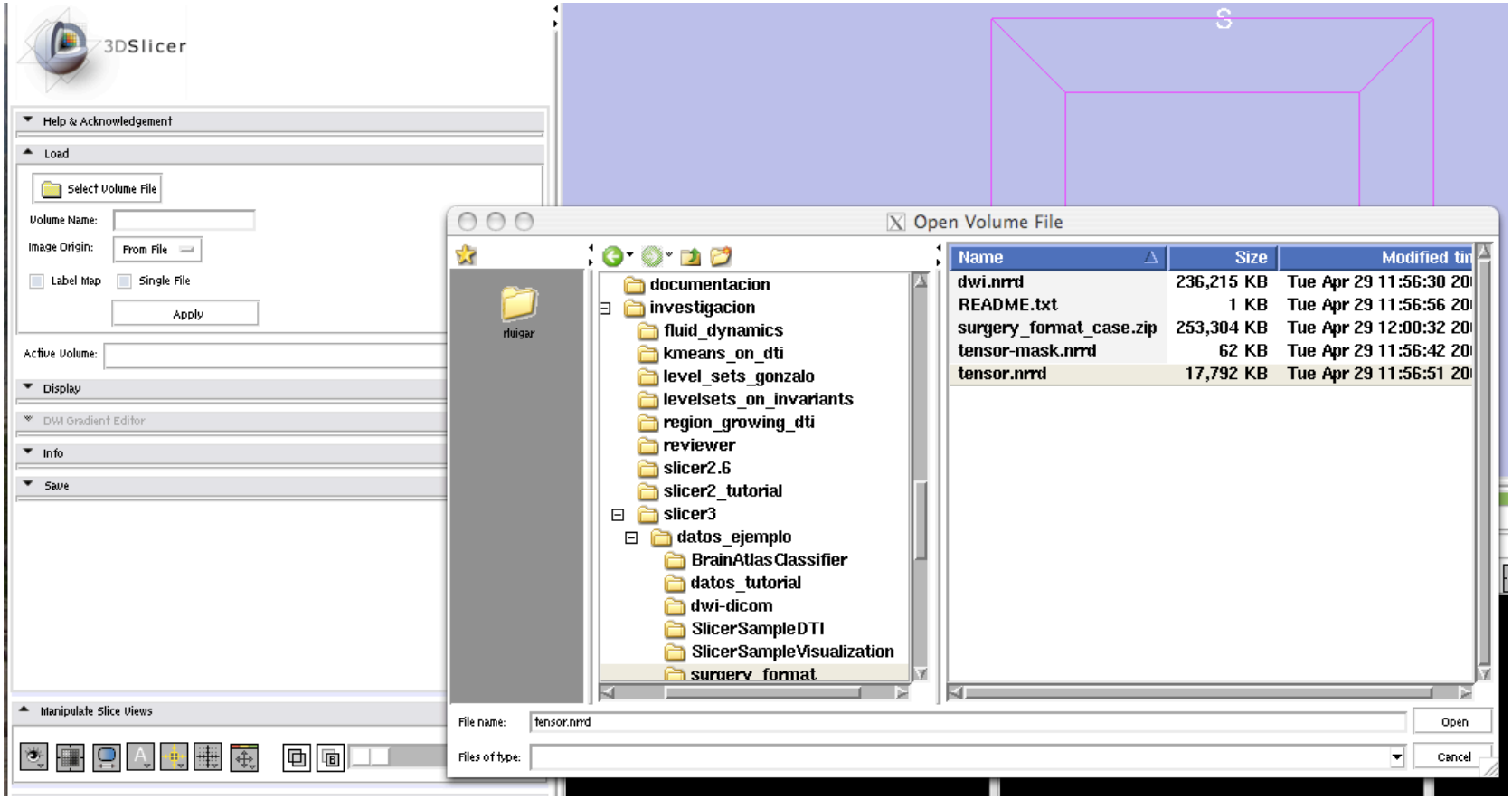
- Mask

- Tensors



Visualizing tensors

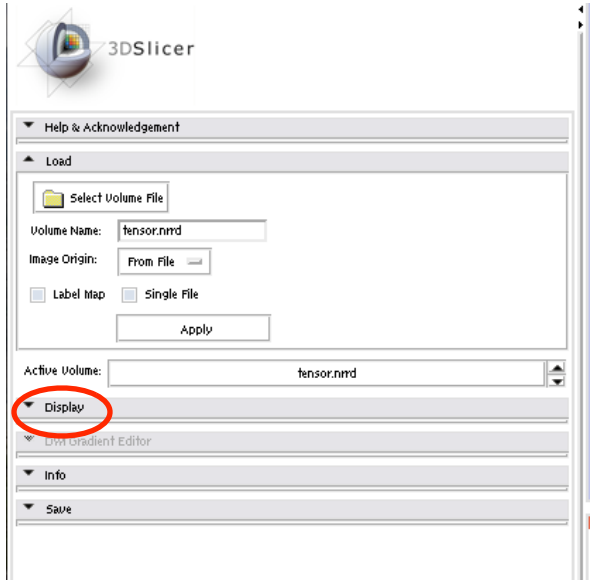
1- Load the tensor volume “tensor.nrrd” using the “Volumes” module

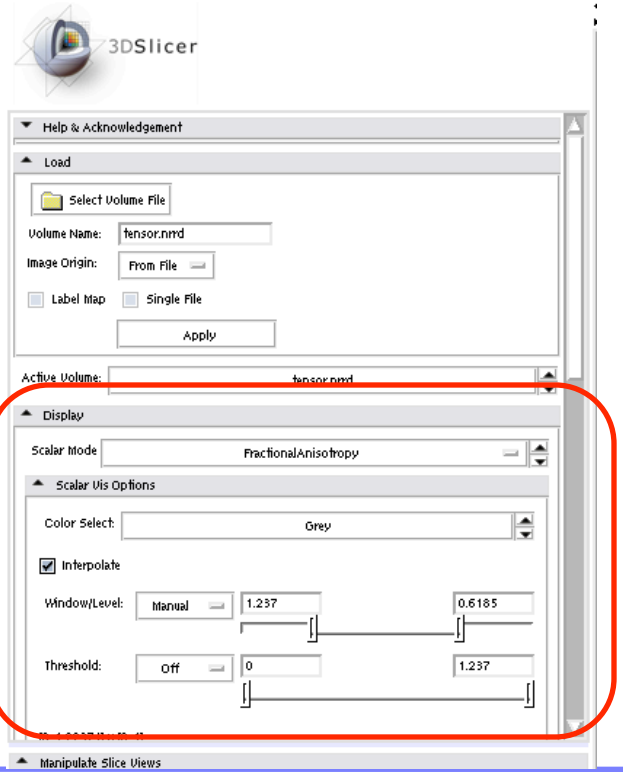


Visualizing tensors

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

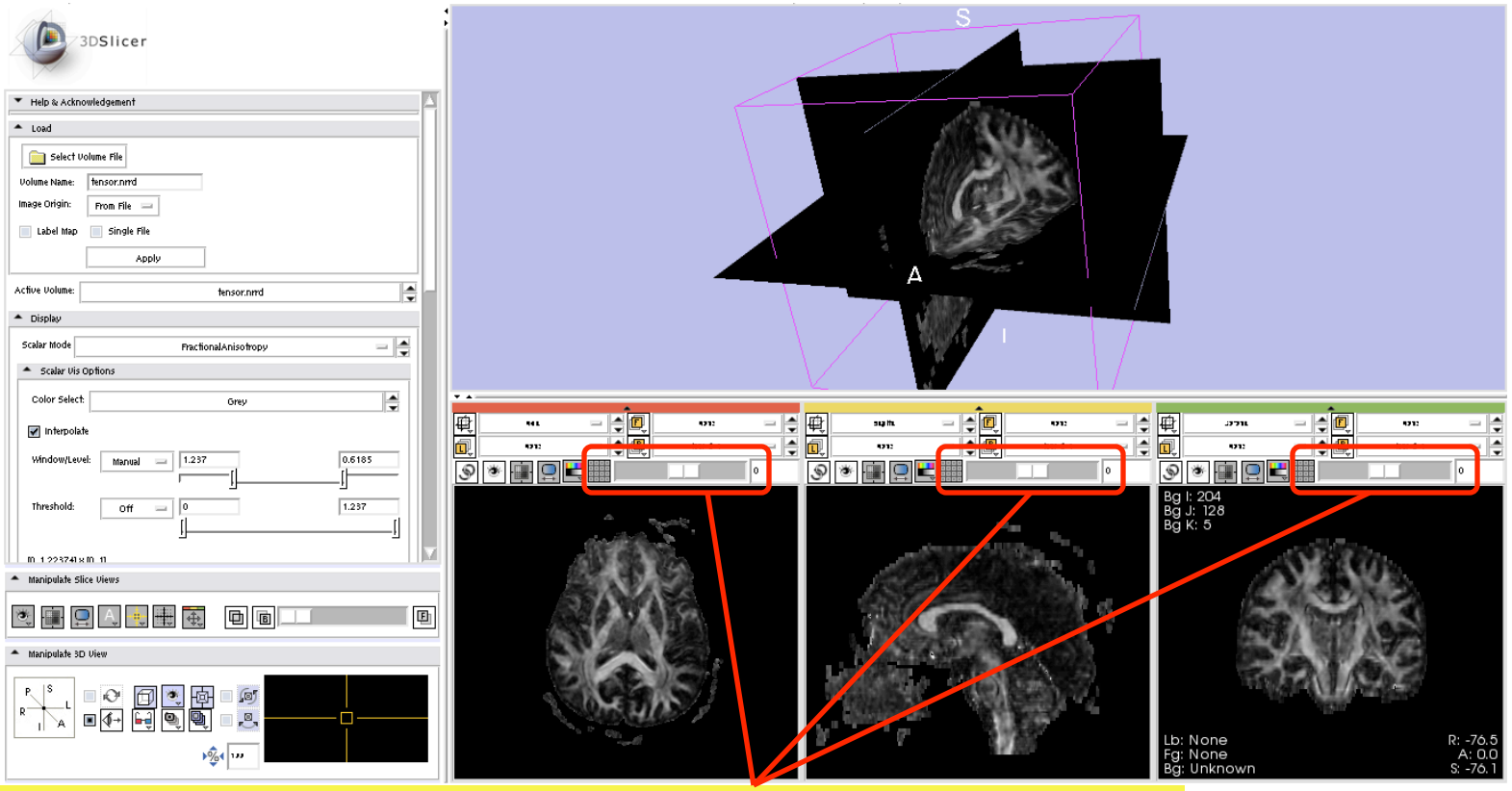
2- Unfold the “Display” menu





Visualizing tensors

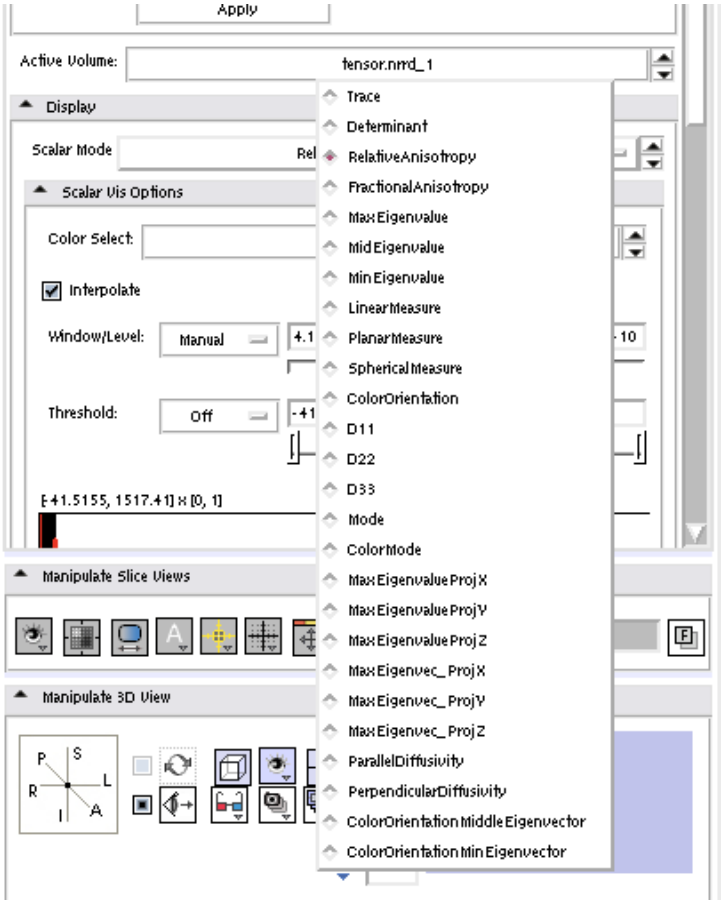
3- Select “Scalar Mode”--> Fractional Anisotropy



You can navigate through the different slices using the slide bars

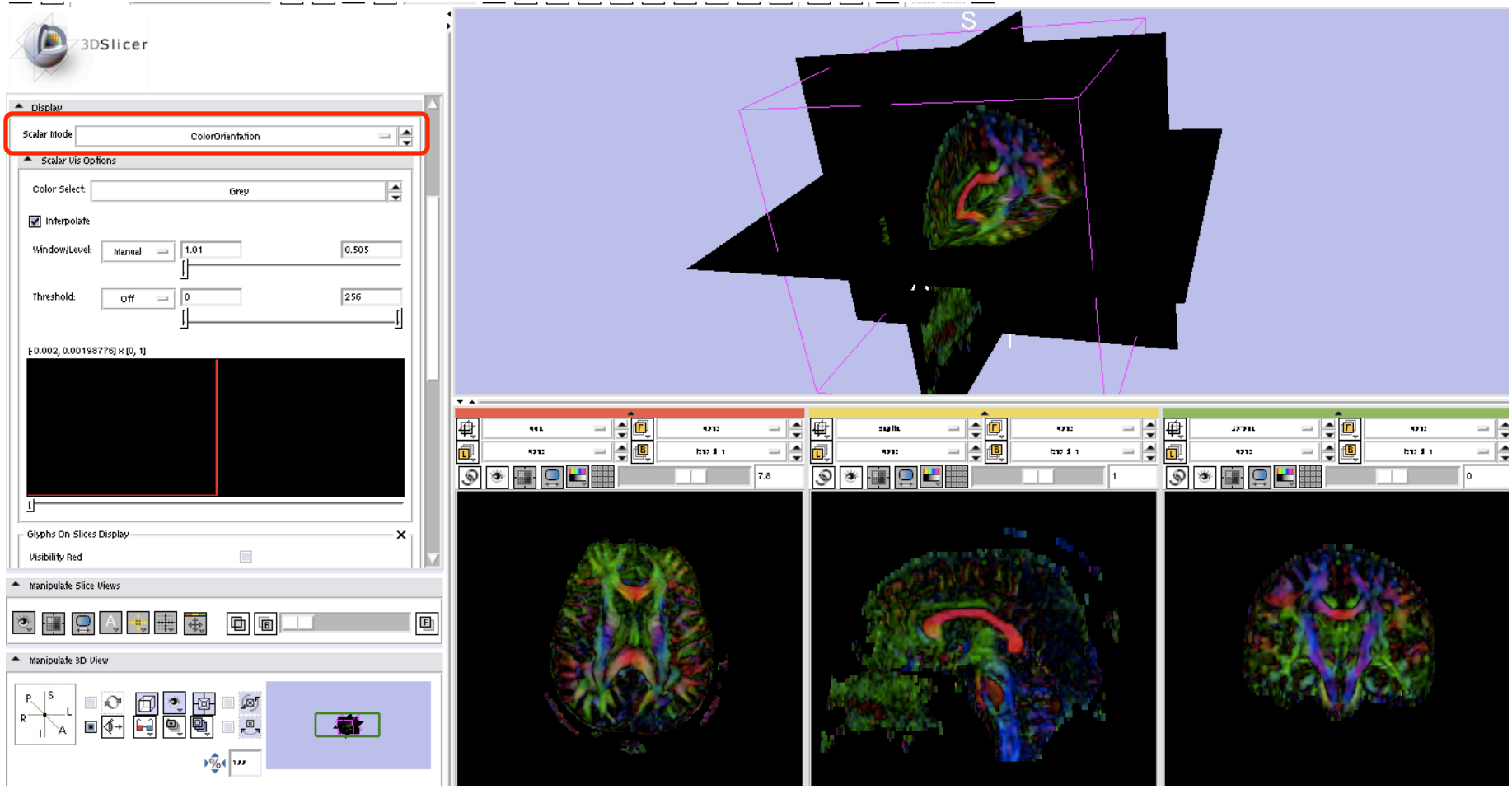
Visualizing tensors

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



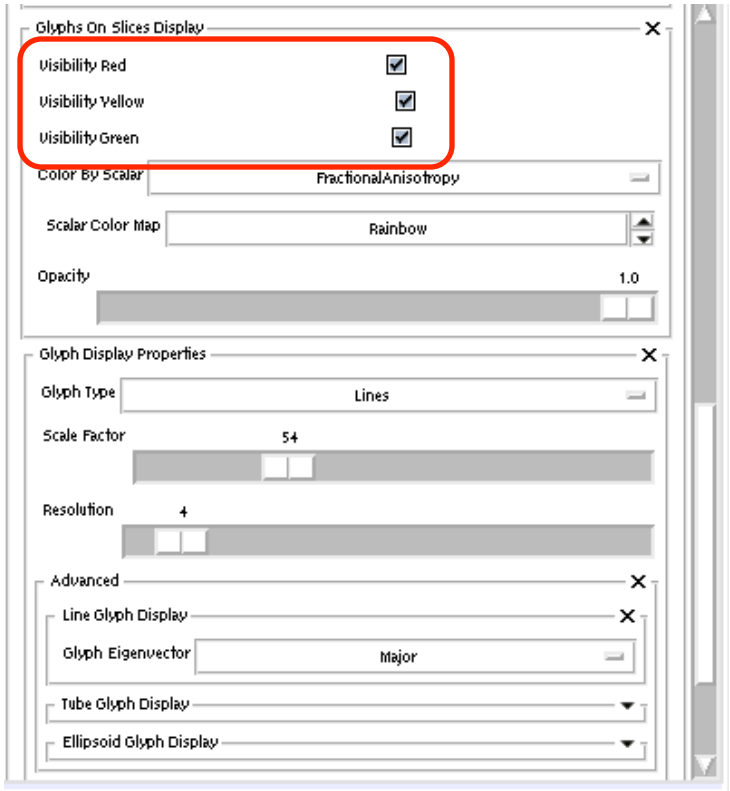
Visualizing tensors

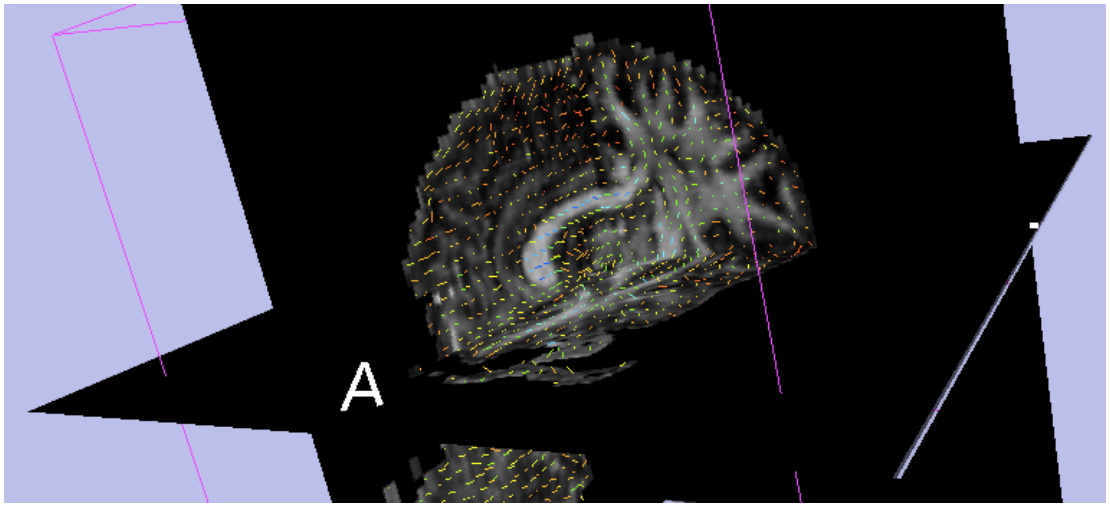
5- Select “Color Orientation”: This is a color measure that color-codes the orientation of the main eigenvector of the tensor



Visualizing tensors

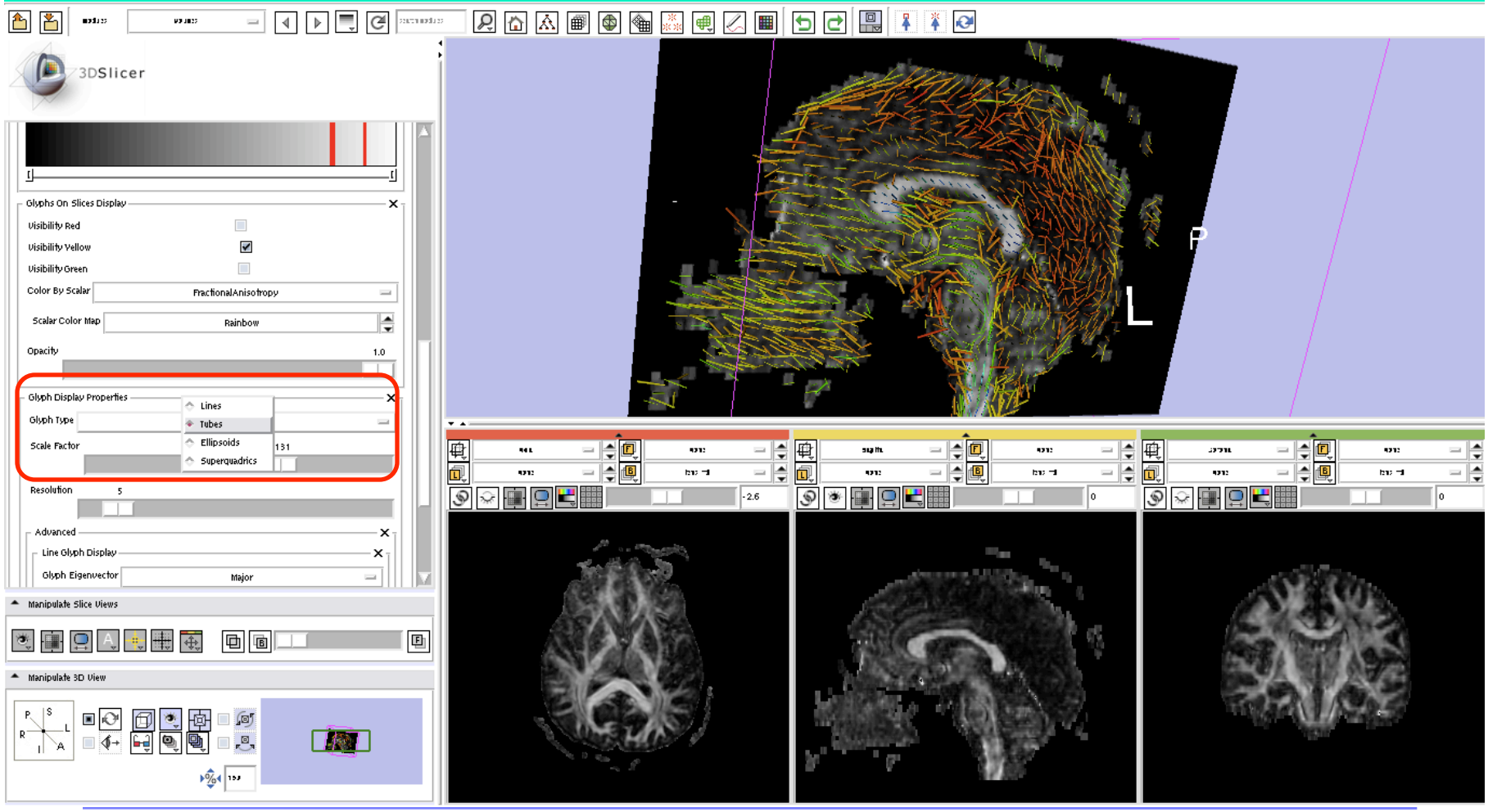
6- To visualize glyphs, activate the corresponding tags in the display menu





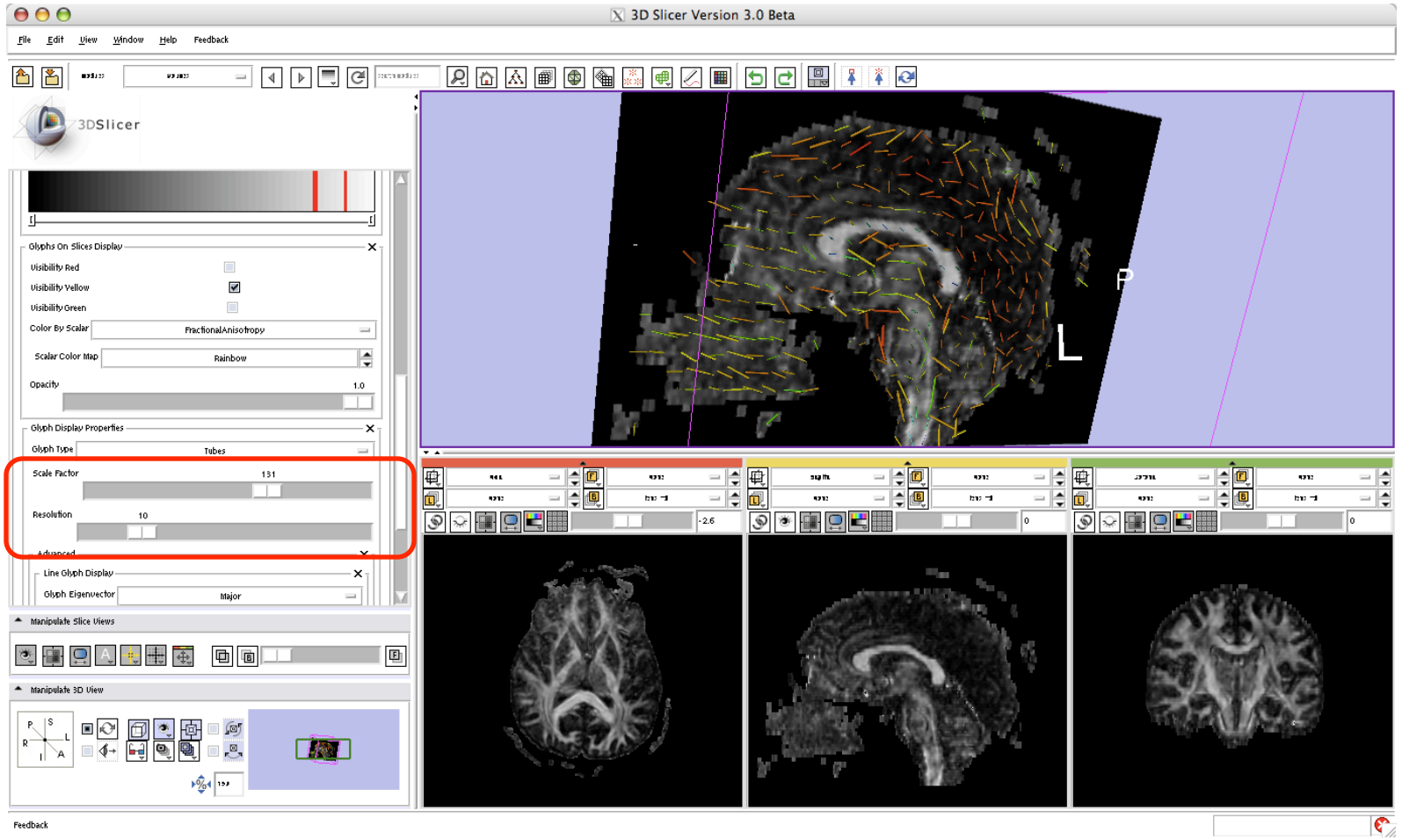
Visualizing tensors

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



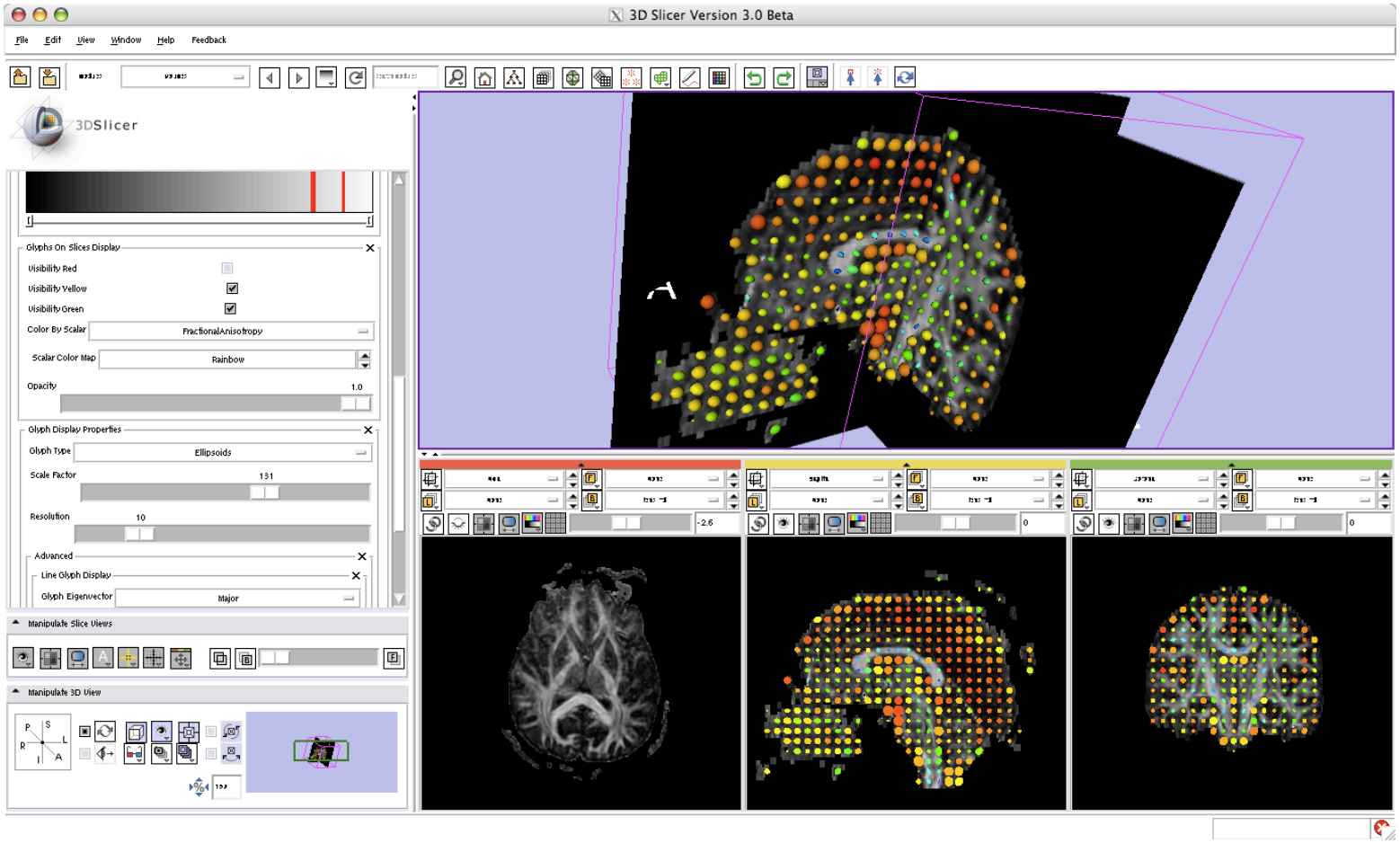
Visualizing tensors

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



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.

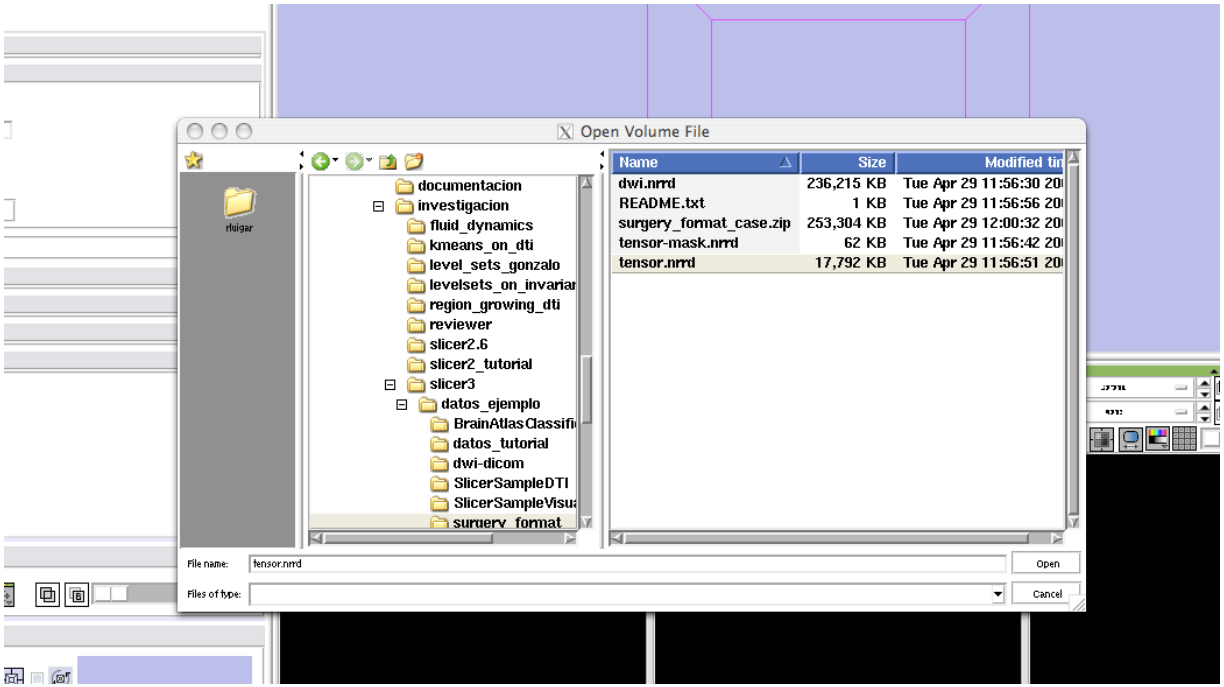


DTI tensor resampling

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

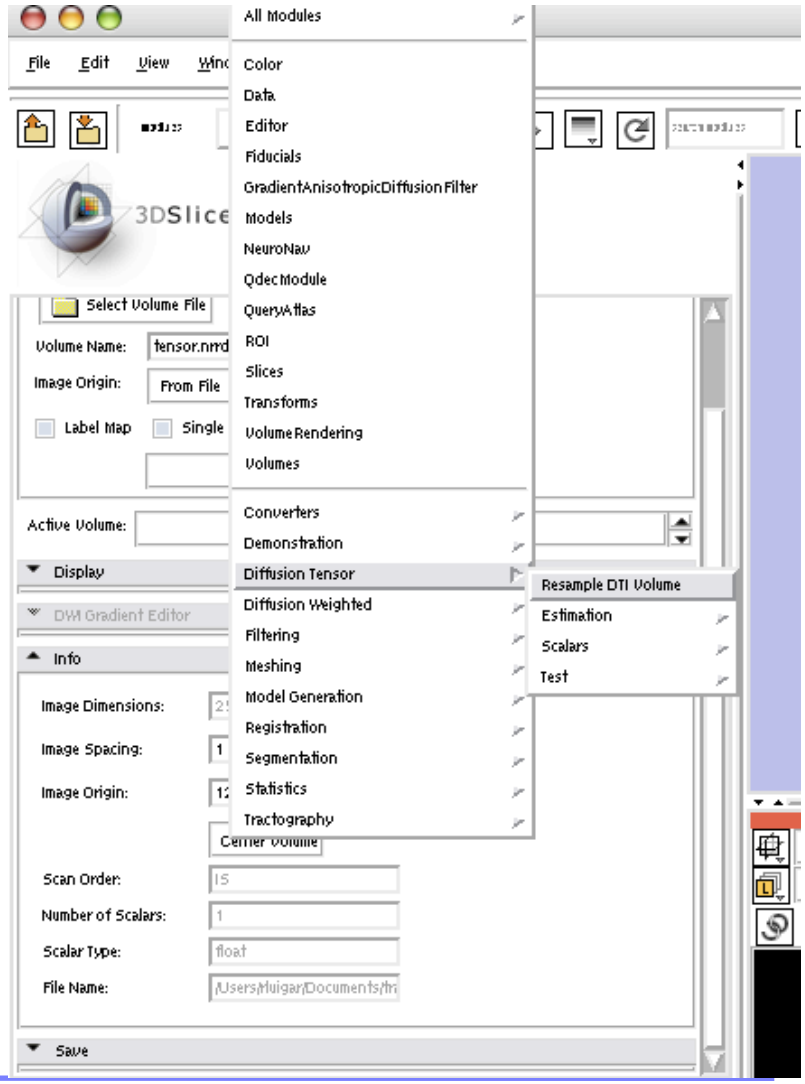
- Rotations, translations.
- Rigid or affine transforms
- Linear interpolation, nearest neighbor, b-splines

1- Load a tensor volume to begin the process



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)

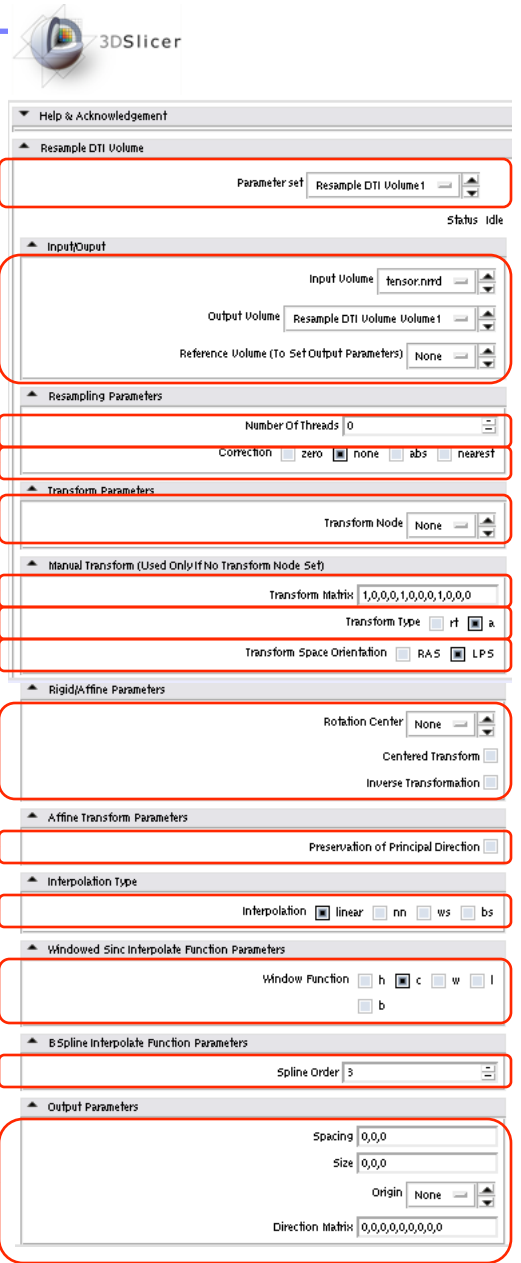
12- Define if you want finit strain or PPD for tensor reorientation teqnique

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)

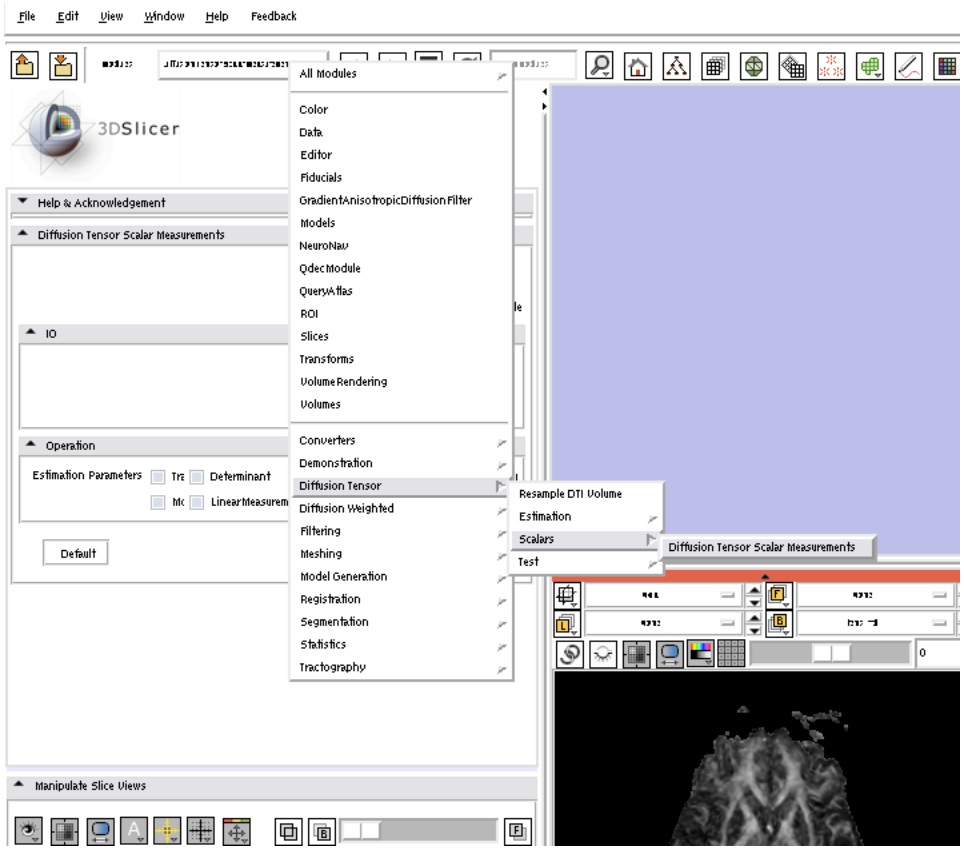
13- Spline order for the B splines interpolation

14- General parameters of the output volume



DTI scalar measurements

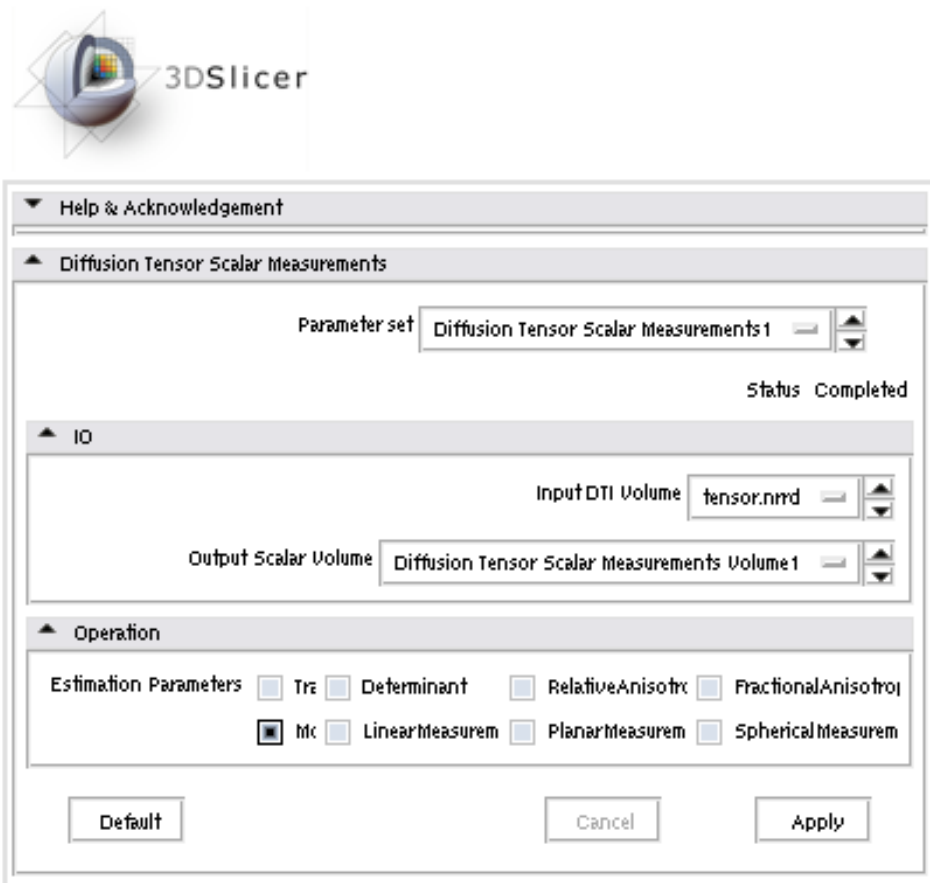
1- Select the module “Diffusion Tensor Scalar Measurements”



DTI scalar measurements

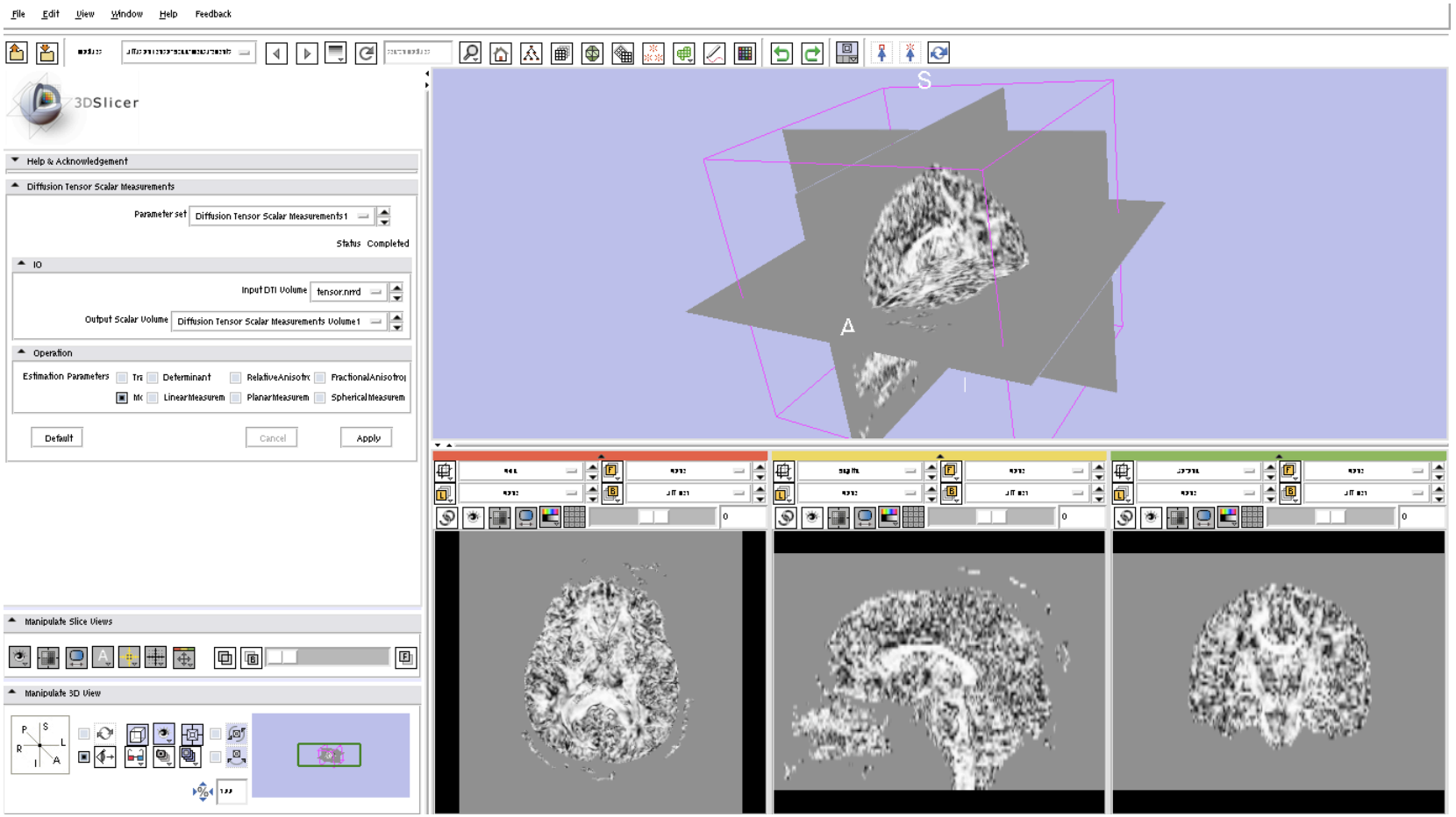
2- Select the options:
-Input DTI volume: tensor.nrrd
-Output Scalar volume: new volume
-Estimation parameters:
- Trace
- Determinant
- Relative Anisotropy
- Fractional Anisotropy
- Mo….
- Linear Measurement
- Planar Measurement
- Spherical Measurement

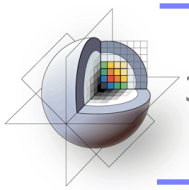
- Click Apply



DTI scalar measurements

The resulting scalar volume can be displayed, stored, futher processed…



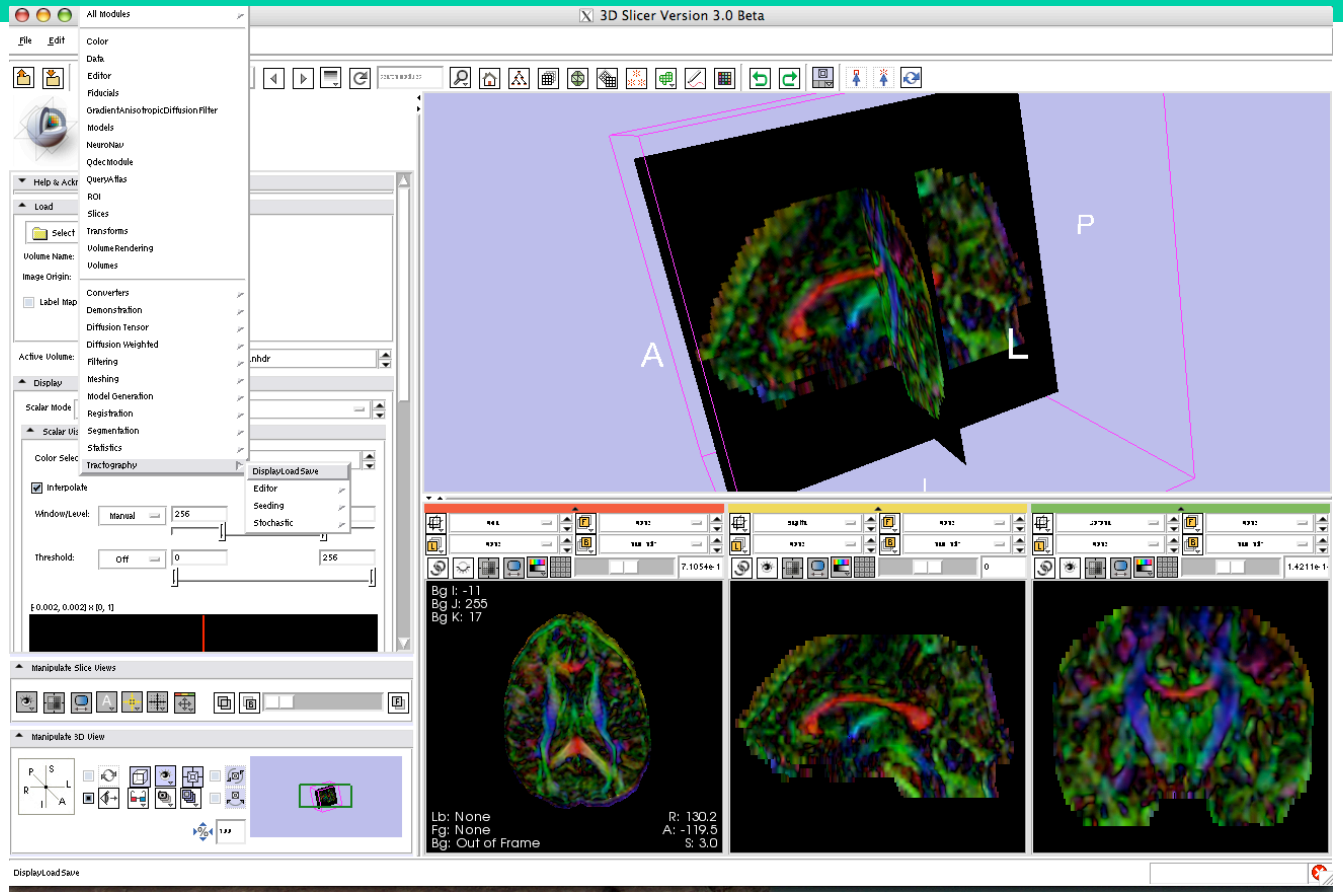


Tractography

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

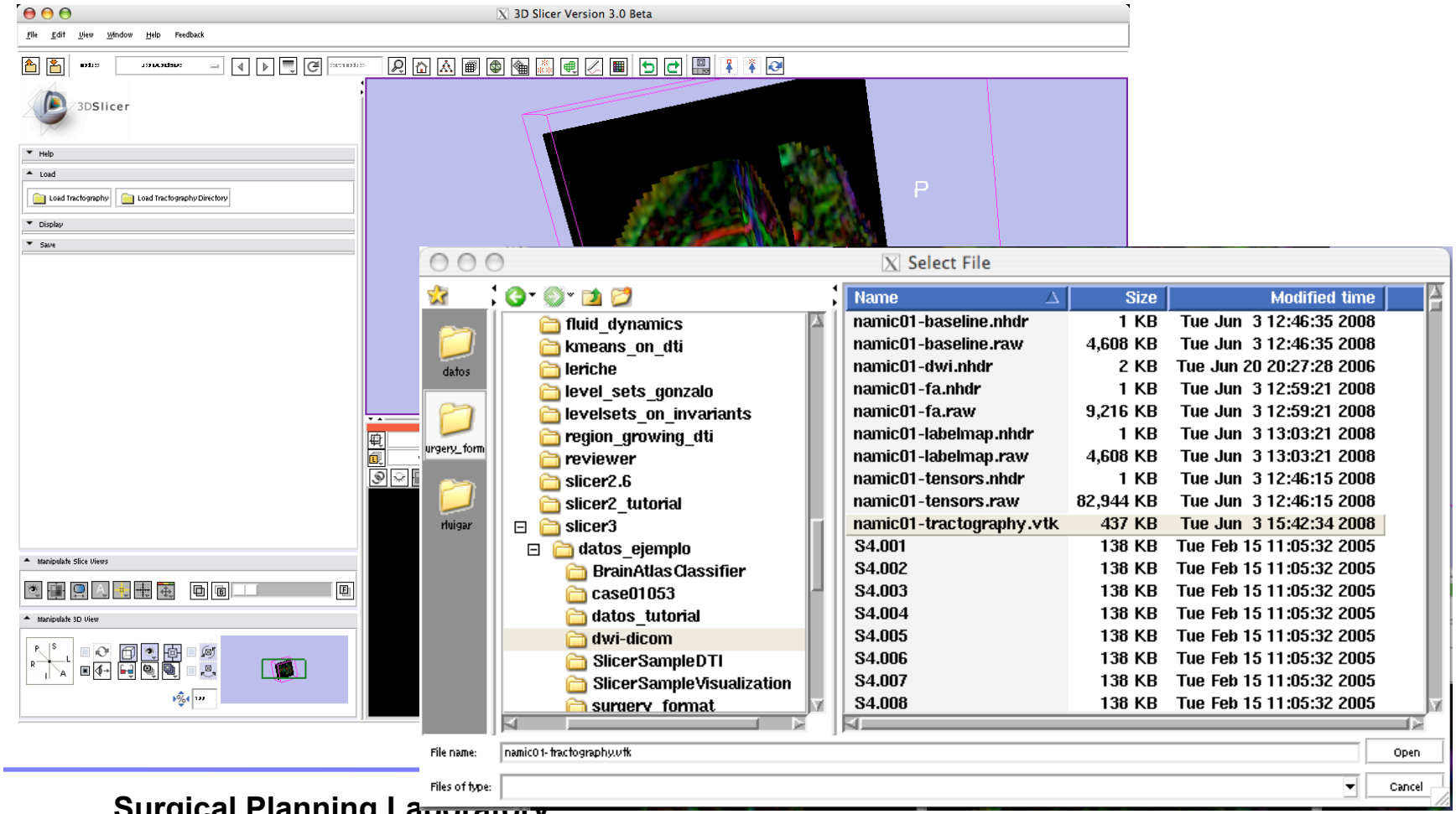
Loading and displaying tracts

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



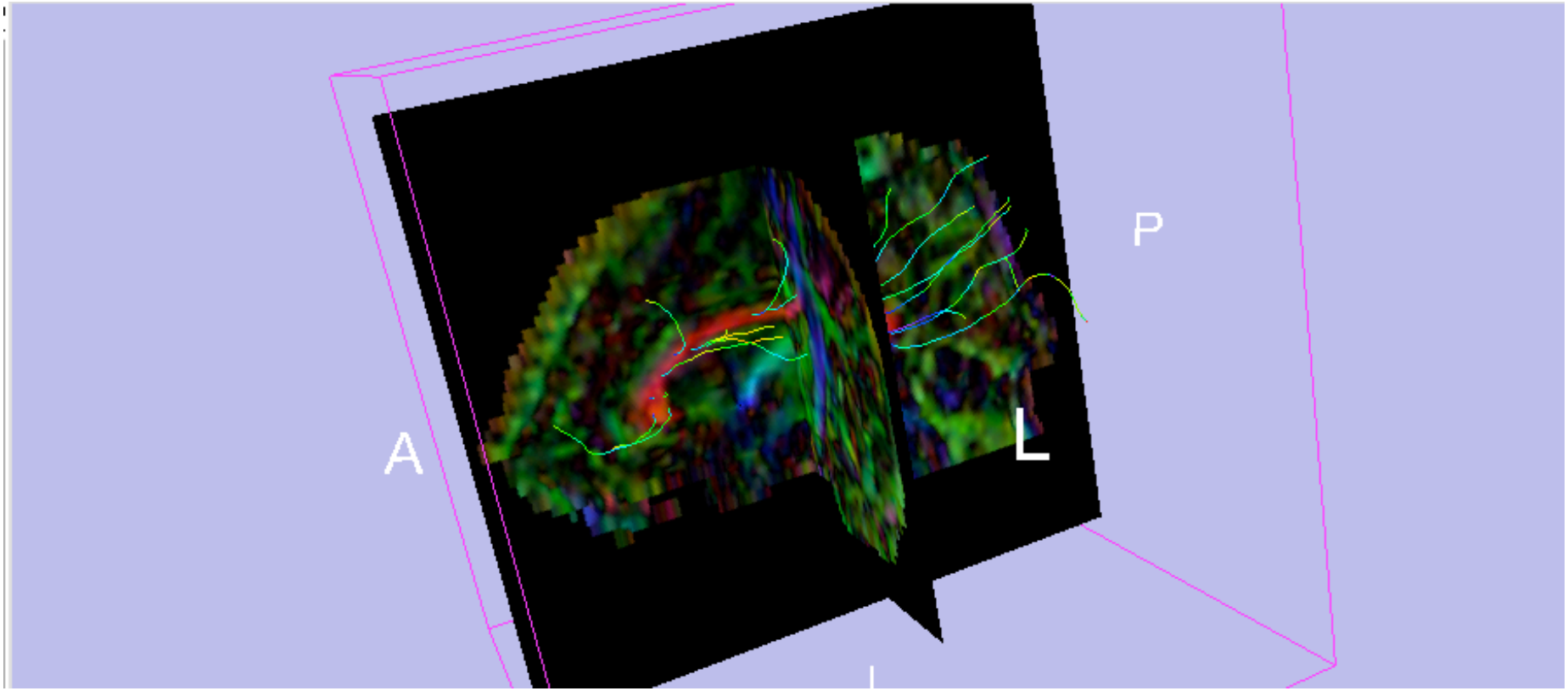
Loading and displaying tracts

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



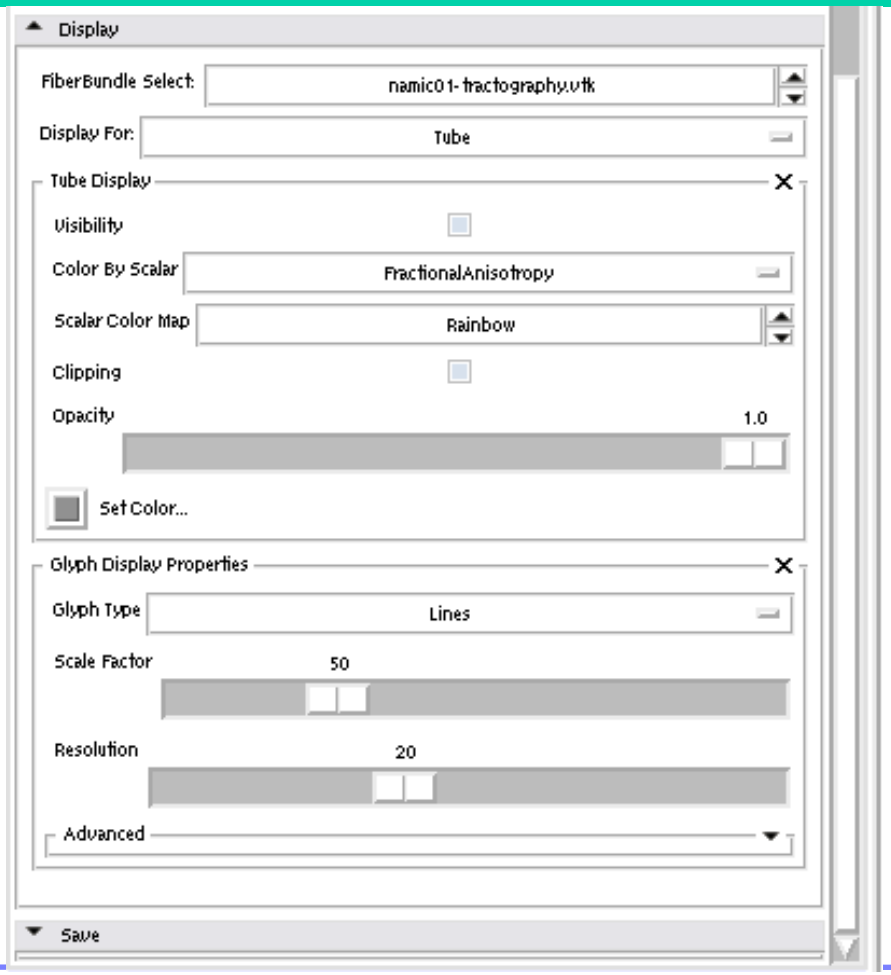
Loading and displaying tracts

The loaded tracts will appear in the 3D view



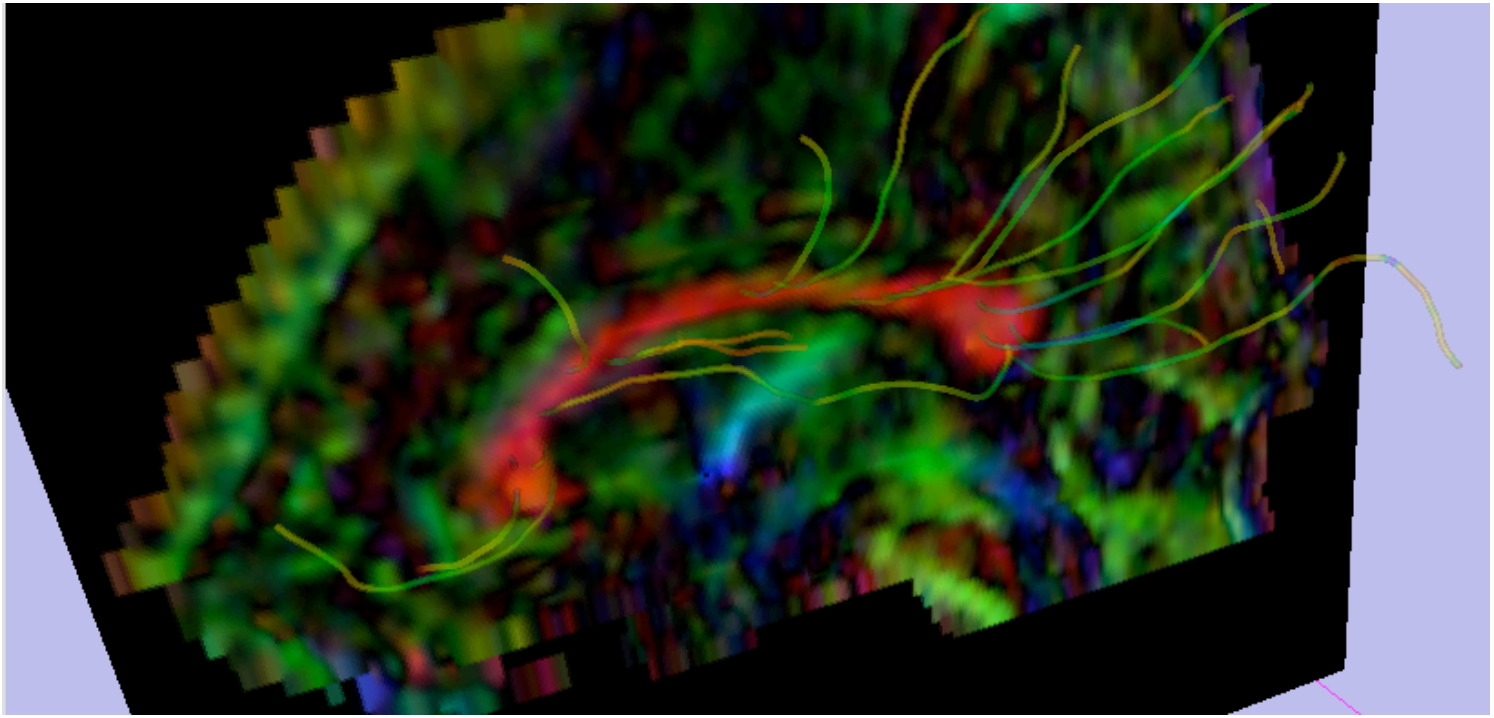
Loading and displaying tracts

Unfold the Display tag from the tractography module

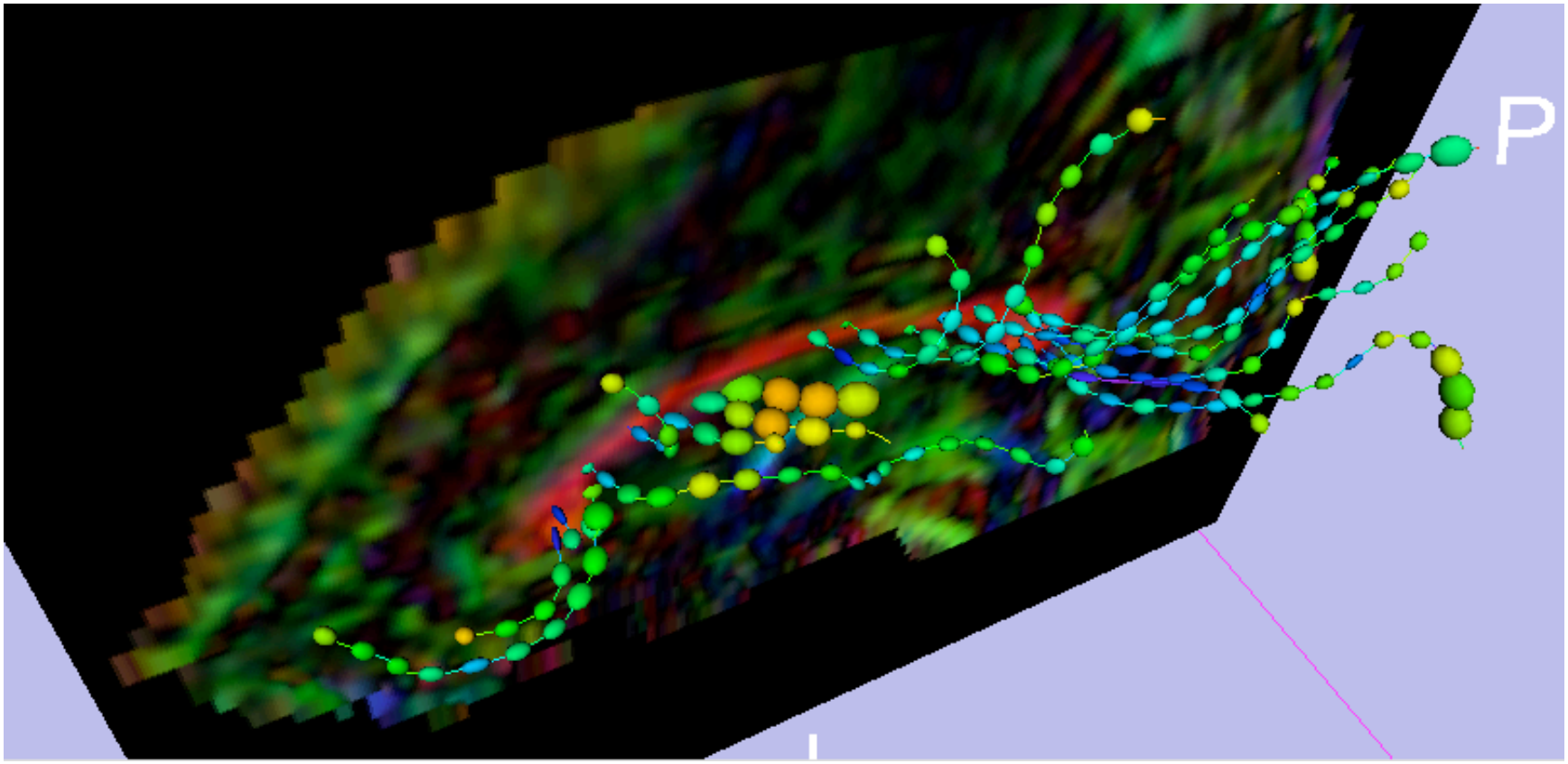


Loading and displaying tracts

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

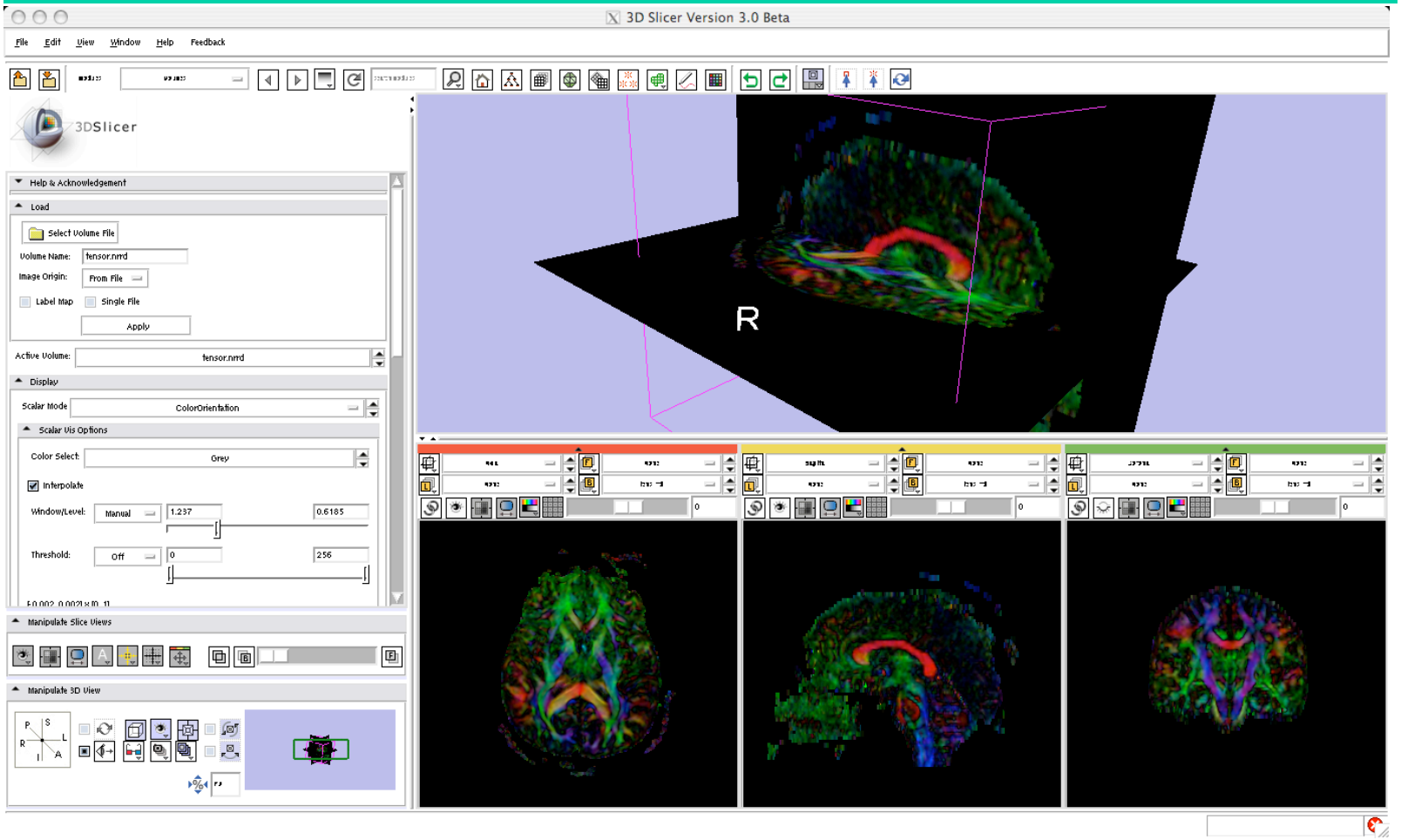


Loading and displaying tracts



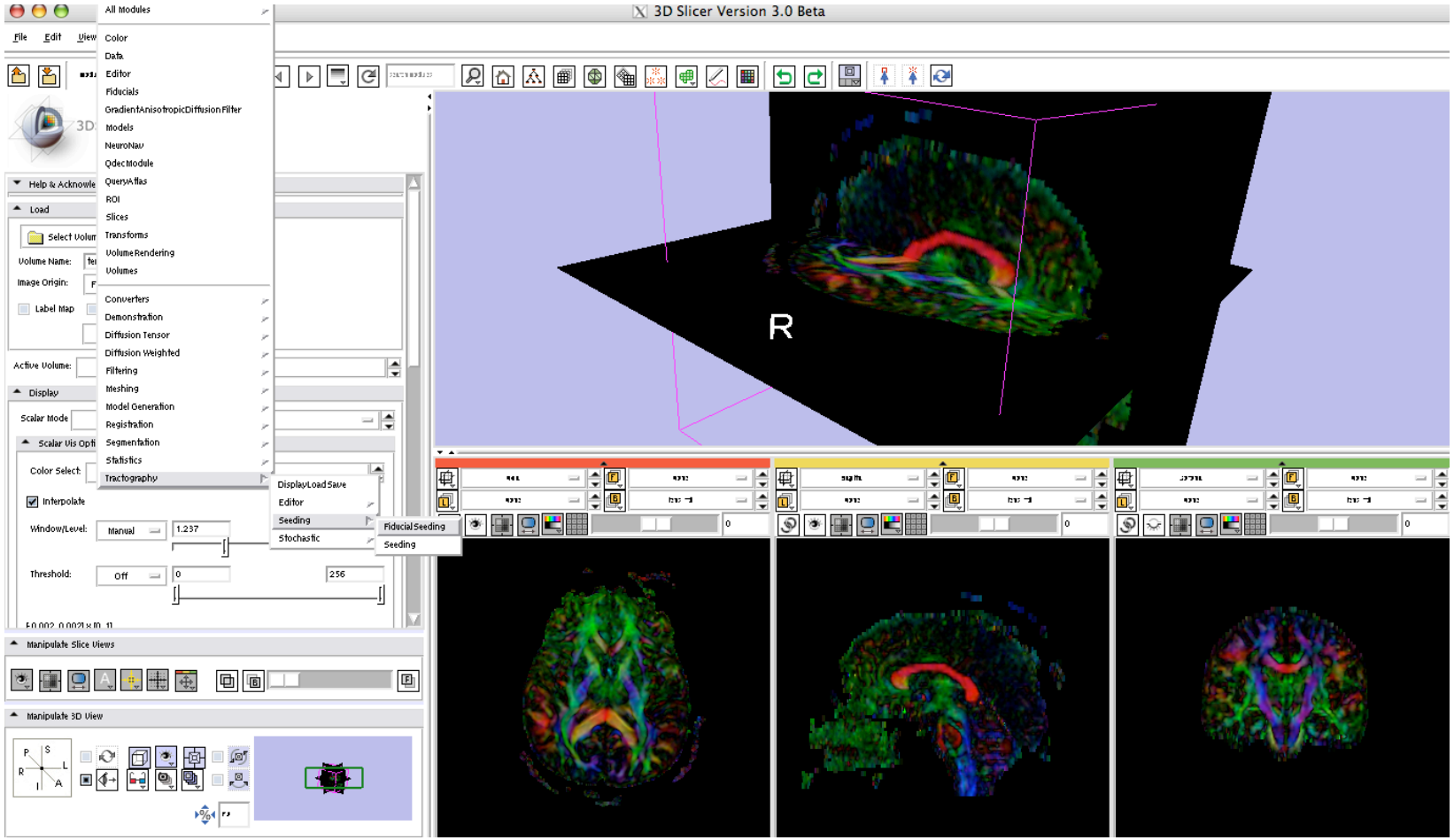
Performing tractography with fiducial seedings

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



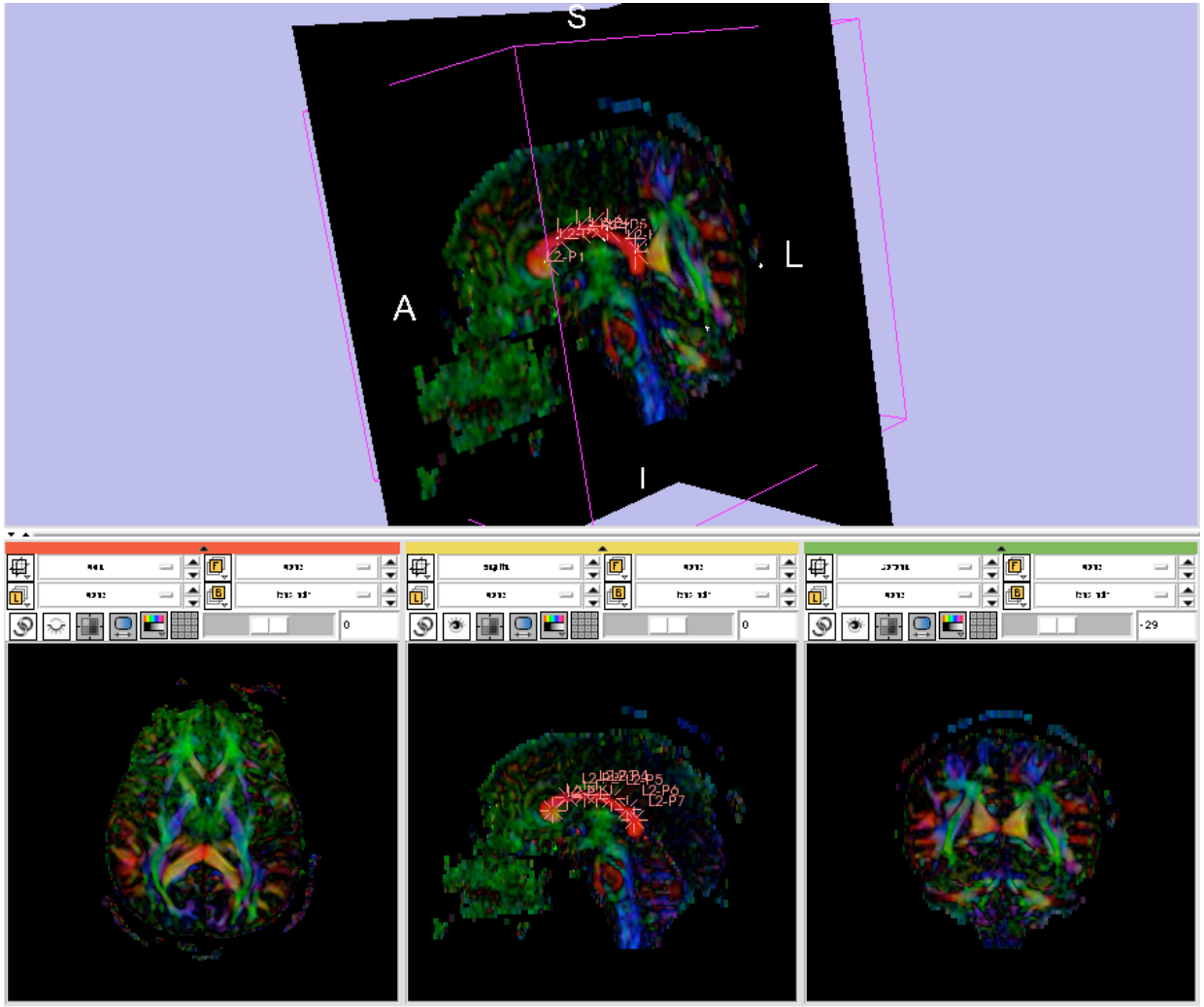
Performing tractography with fiducial seedings

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



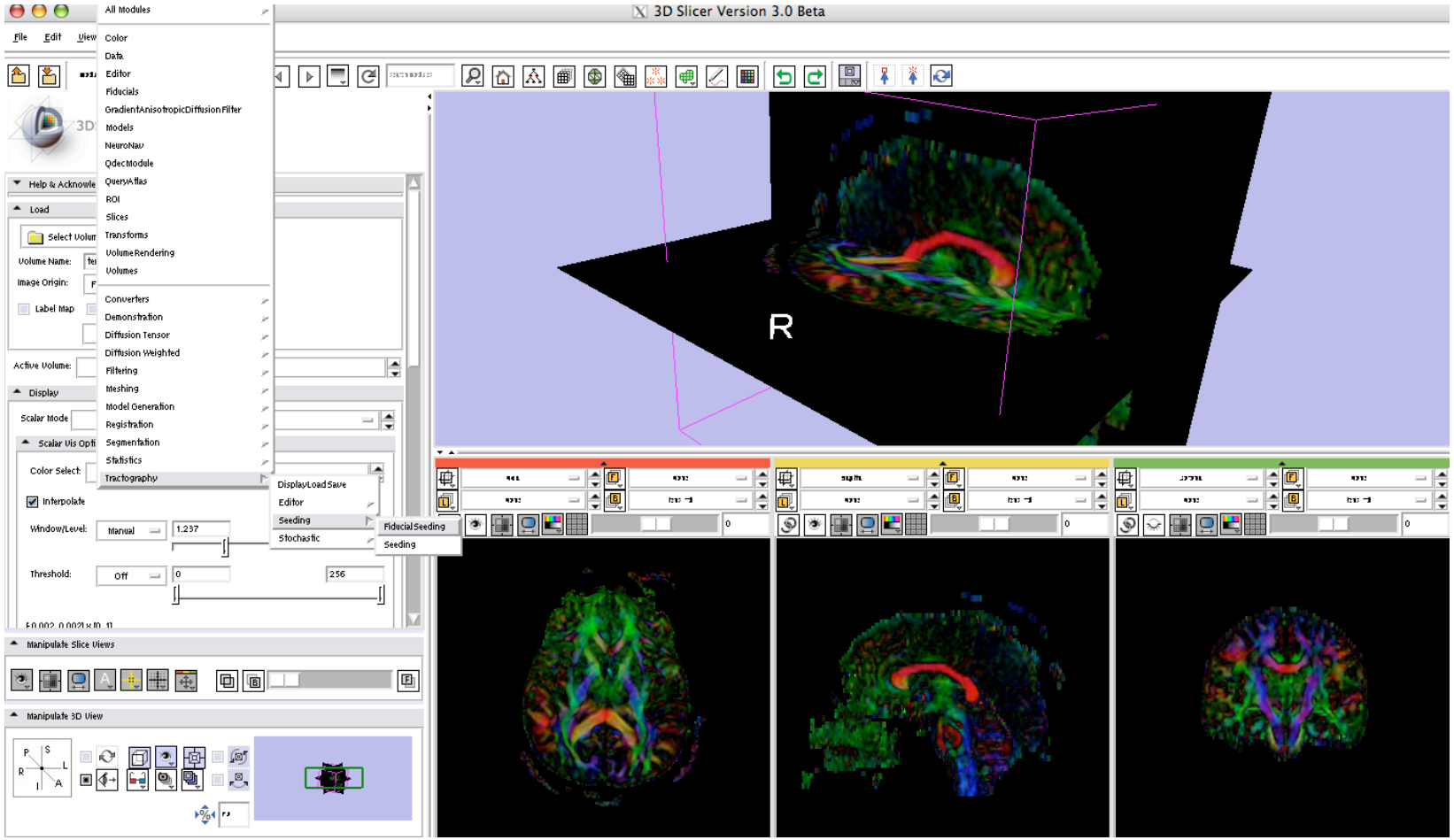
Performing tractography with fiducial seedings

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)



Performing tractography with fiducial seedings

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



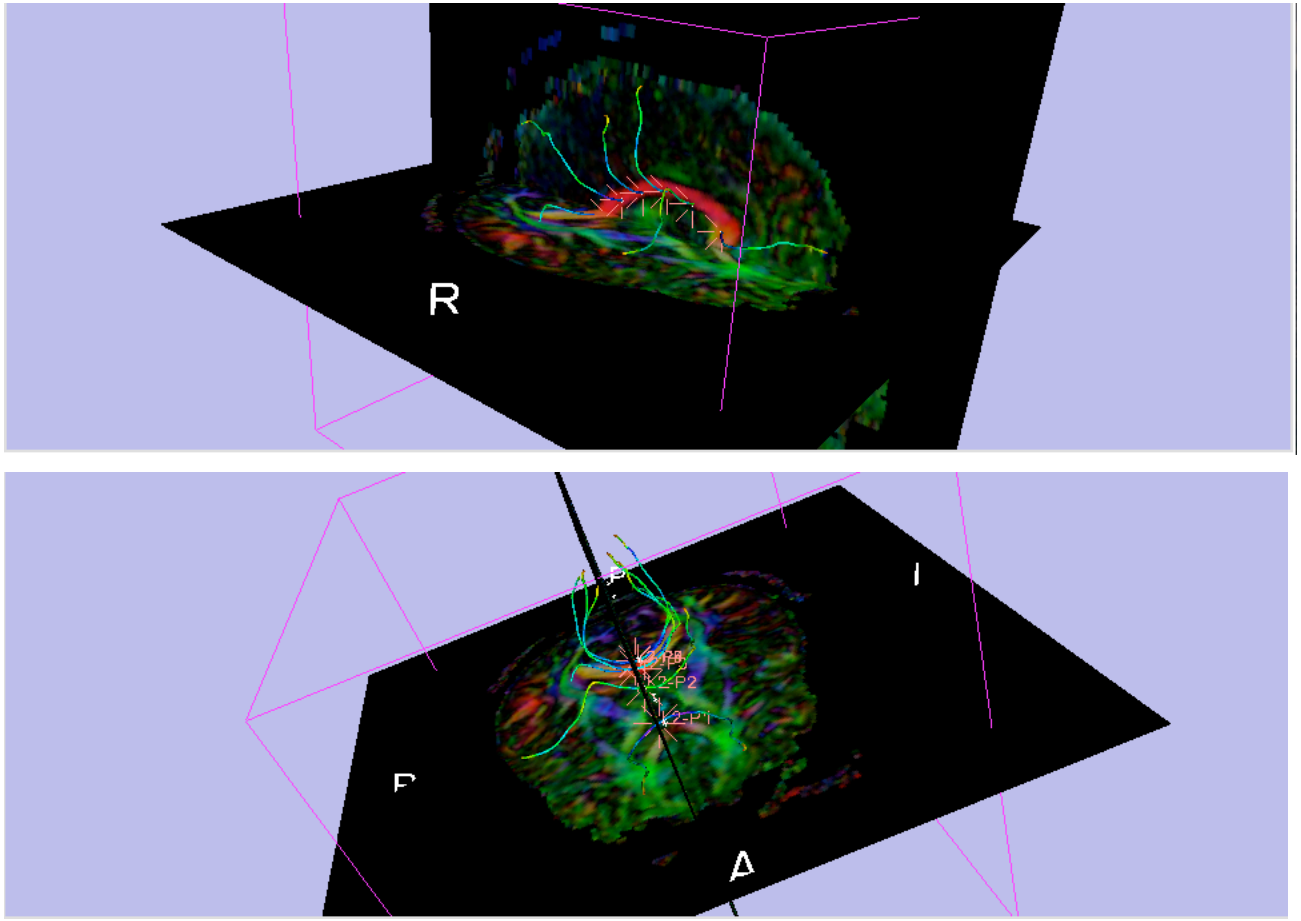
Performing tractography with fiducial seedings

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.

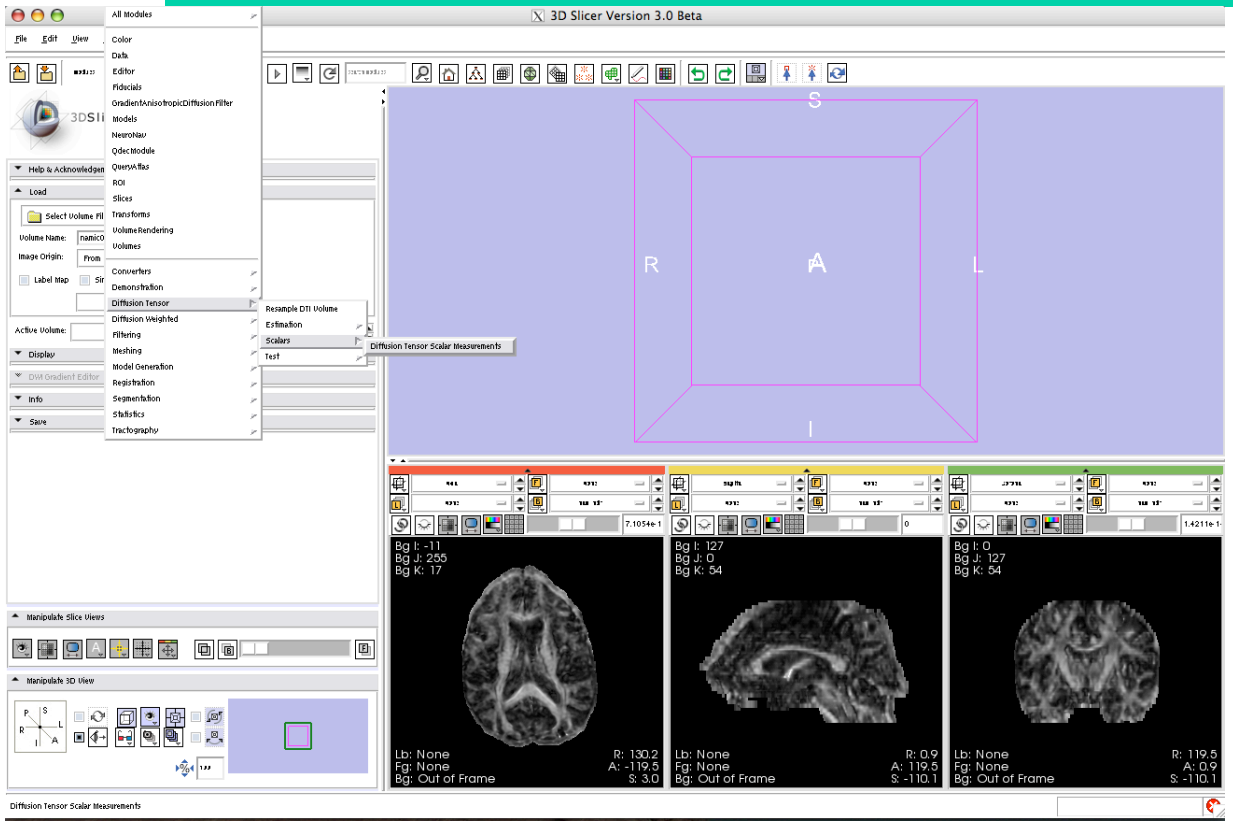
Performing tractography with fiducial seedings

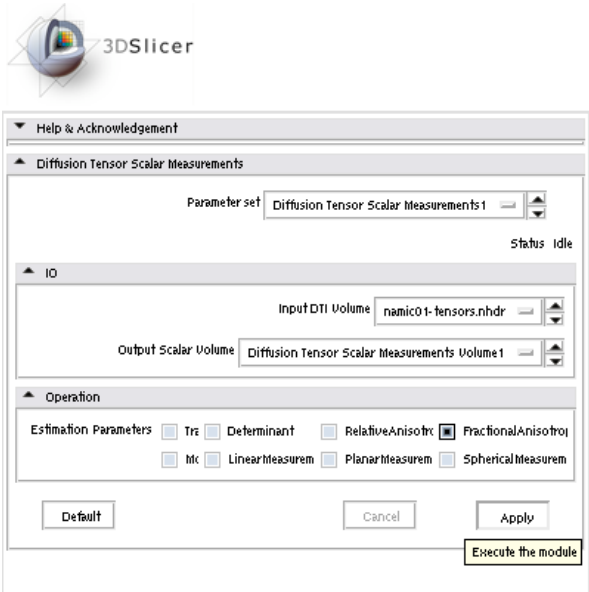
The obtained fibers will appear in the 3D view, toghether with the fiducial seeds.



Performing tractography with ROI seeding

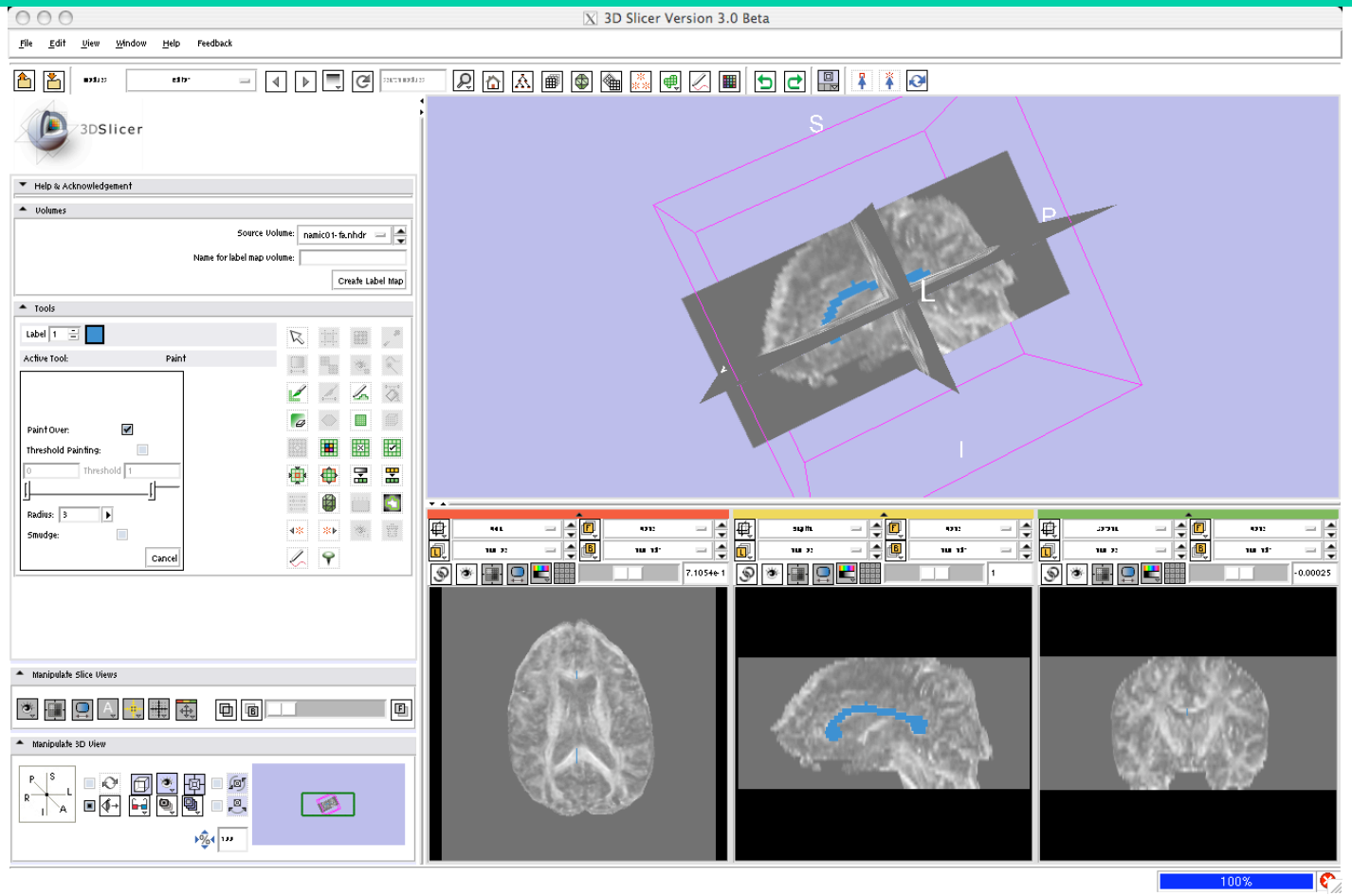
1.- Load a tensor volume: dwi-dicom
2.- Obtain an appropriate scalar measure for the delineation of the ROI (fractional anisotropy, for instance).





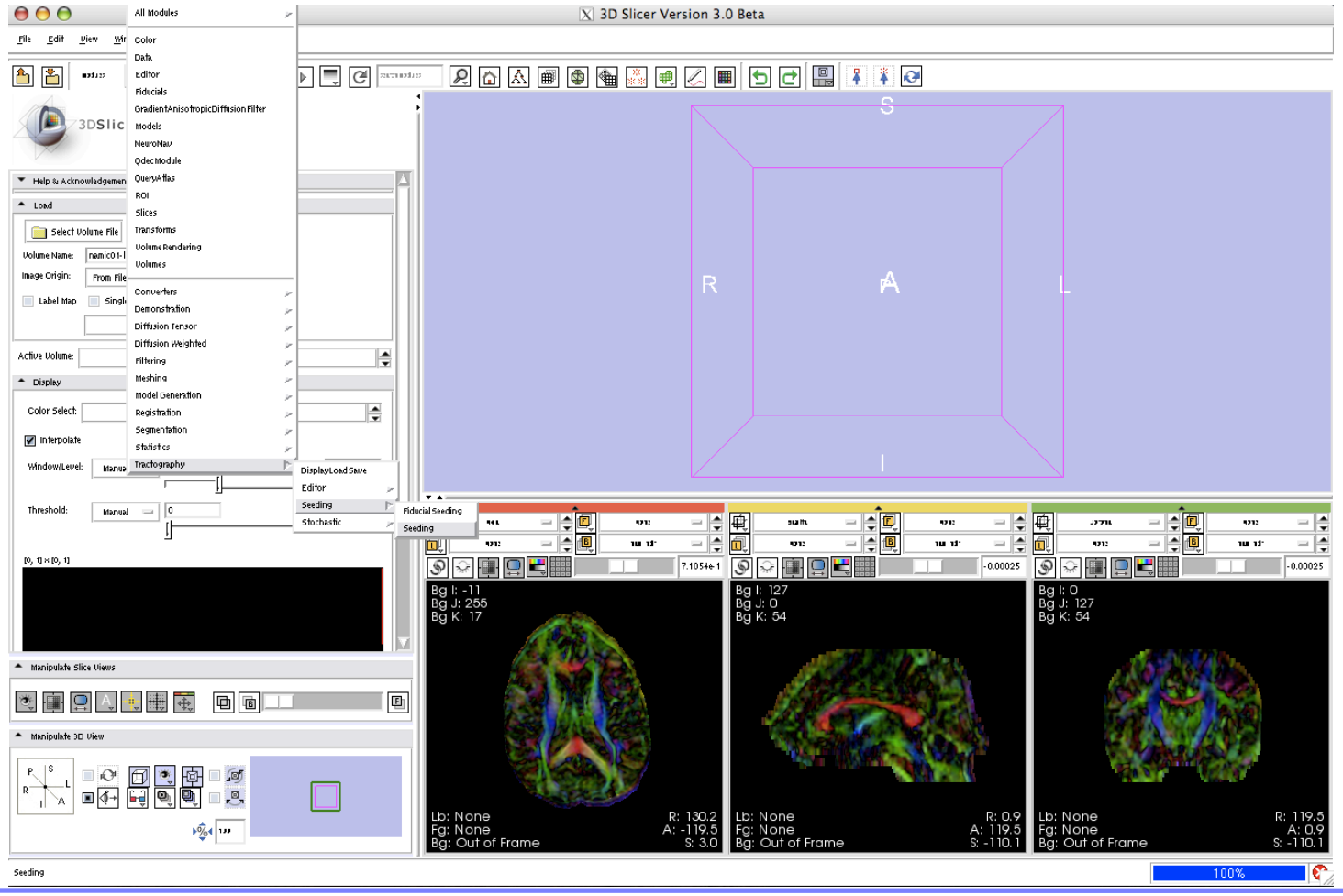
Performing tractography with ROI seeding

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



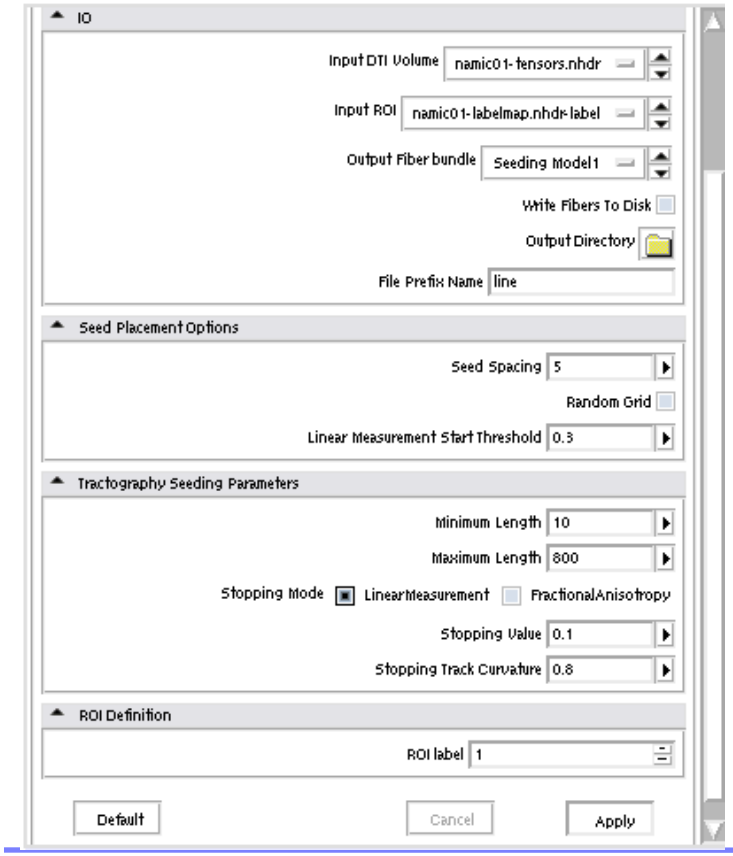
Performing tractography with ROI seeding

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



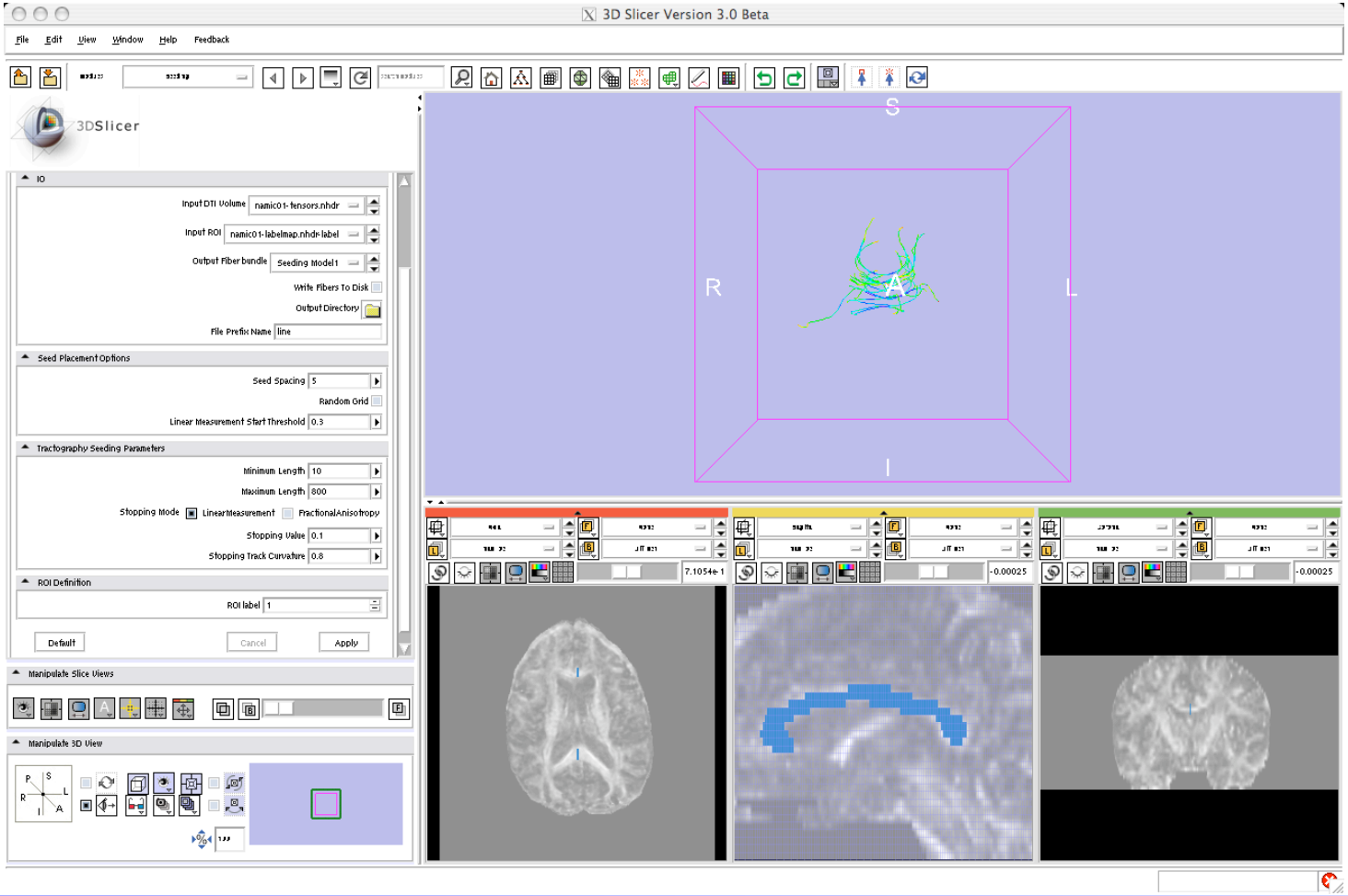
Performing tractography with ROI seeding

5.- Select the parameters, and click Apply



Performing tractography with ROI seeding

The obtained tracts will appear in the 3D view.



Performing tractography with ROI seeding

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