Diffusion Tensor Analysis in Slicer3

Tutorial by:
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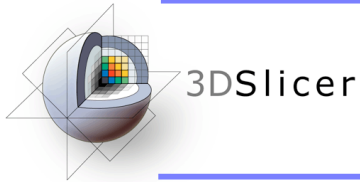
Acknowledgments

3DSlicer

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NIH R01MH074794

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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

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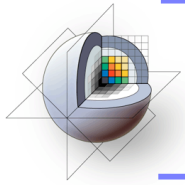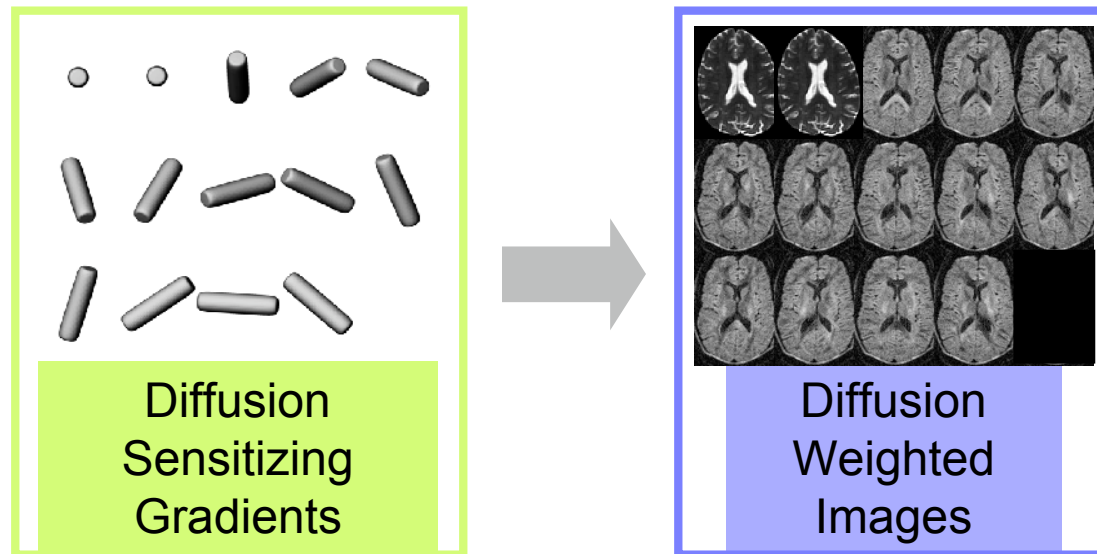
Outline

3DSlicer

- Introduction to DWI and DTI

- Introduction to Slicer3

- DTI-related functionalities

- Loading DWI and tensor data

- Estimating tensors from DWI

- Visualizing tensors
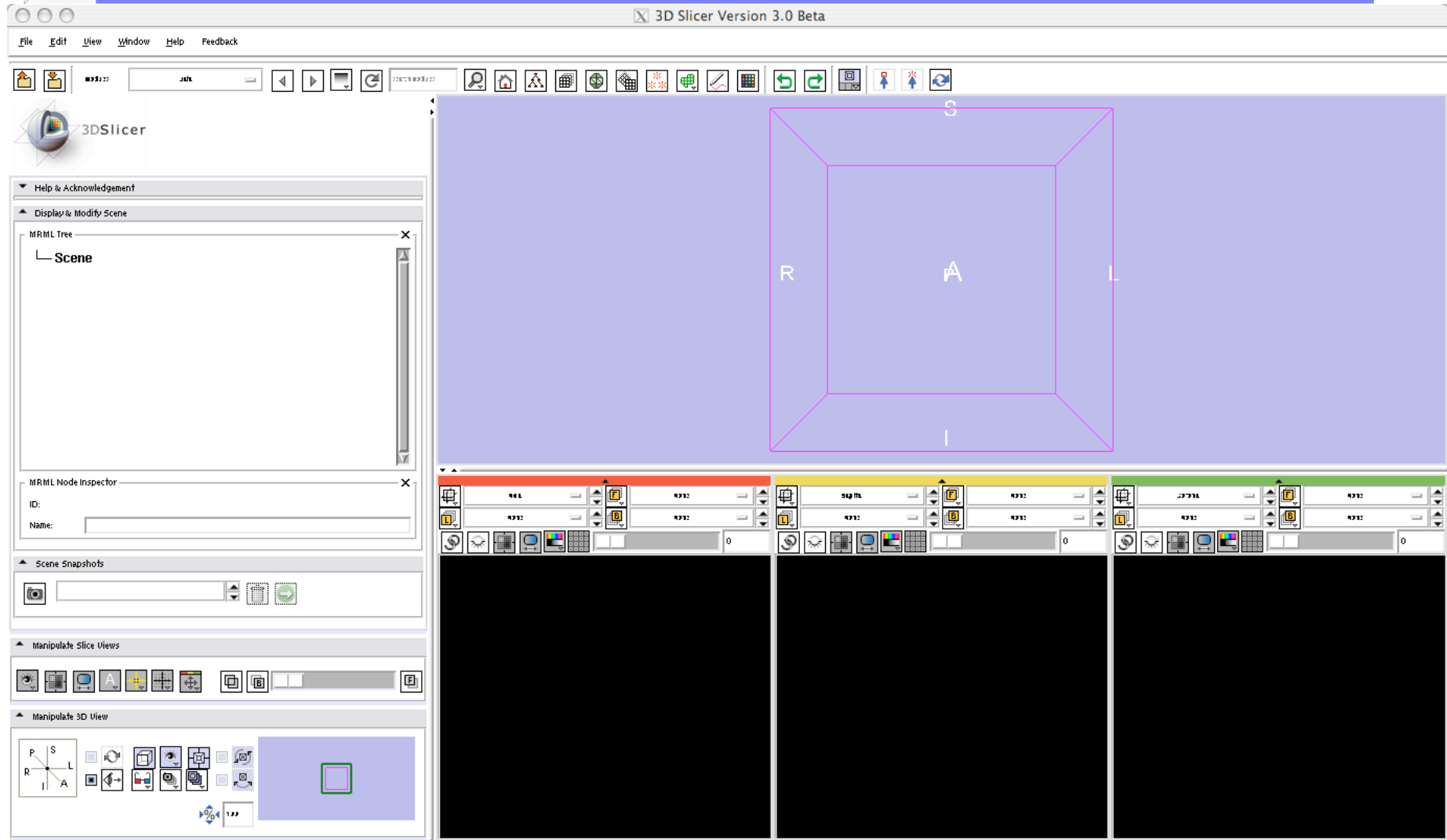
- DTI tensor resampling

- Tractography

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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.
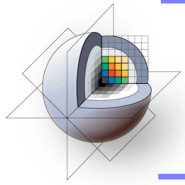

Diffusion
Sensitizing
Gradients

Diffusion
Weighted
Images

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Introduction to Slicer3

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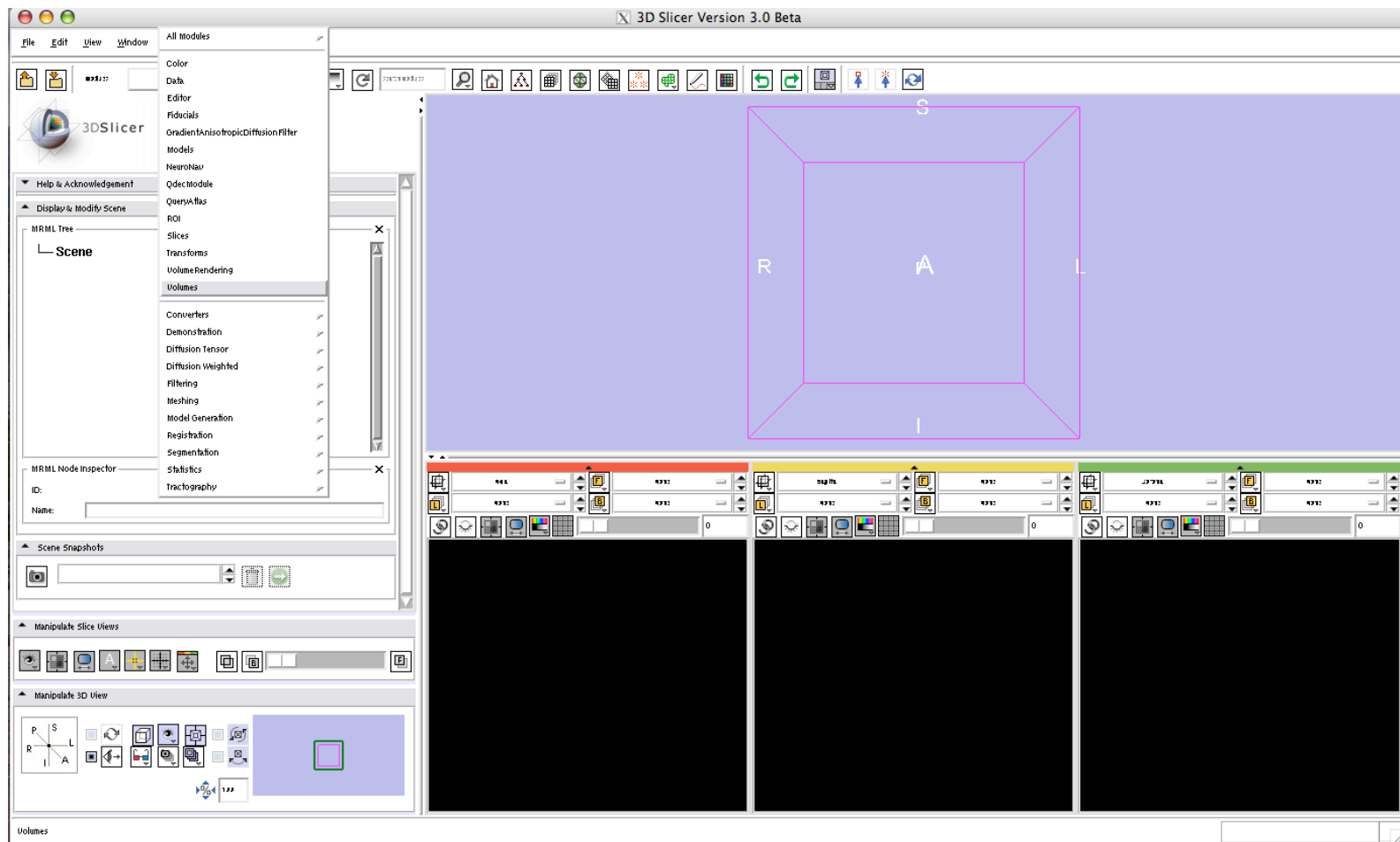http://www.slicer.org

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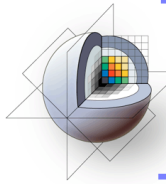
DTI-related functionalities

- 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)

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3DSlicer Loading Dataset 1 (DWI data)

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

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Loading Dataset 1 (DWI data)

A dialog window will appear for you to select the header file when you click "Select Volume File"
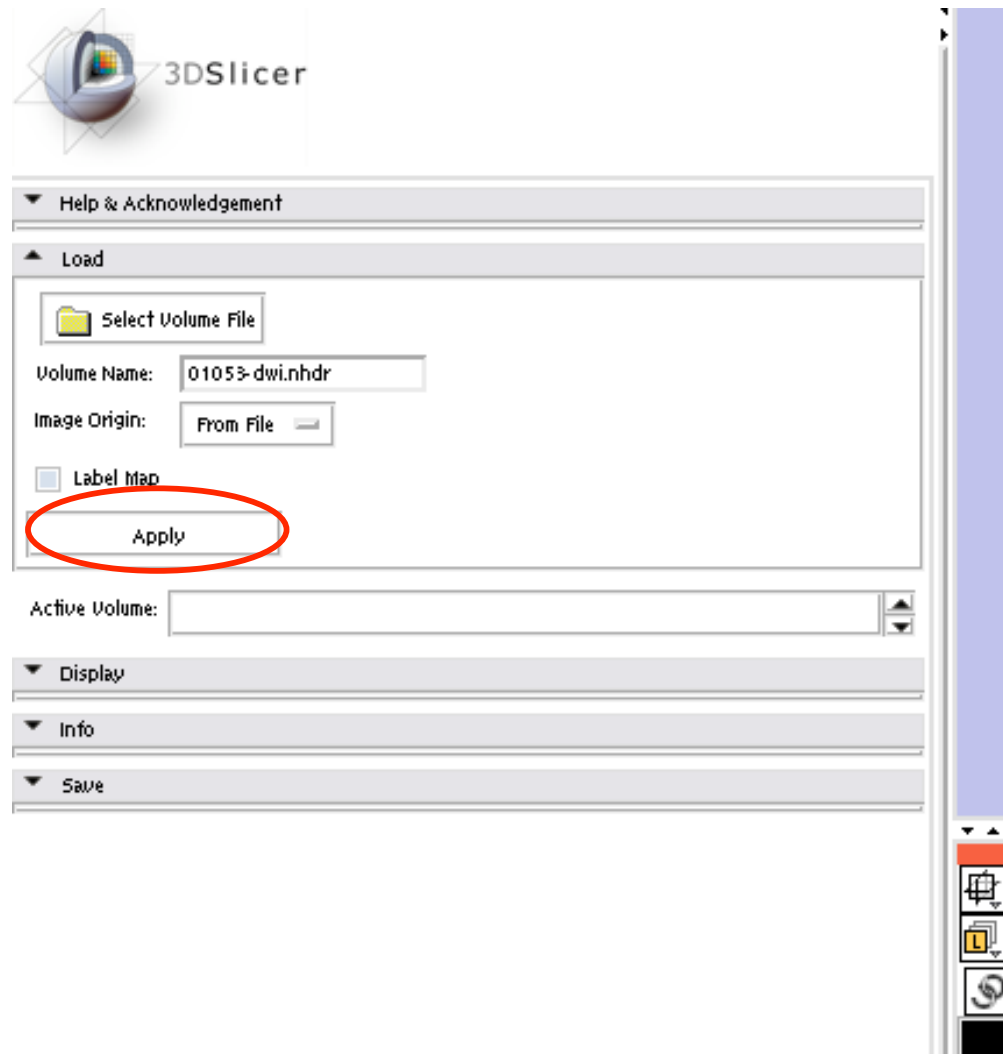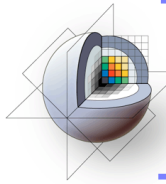
2- Select the file "01053-dwi.nhdr"

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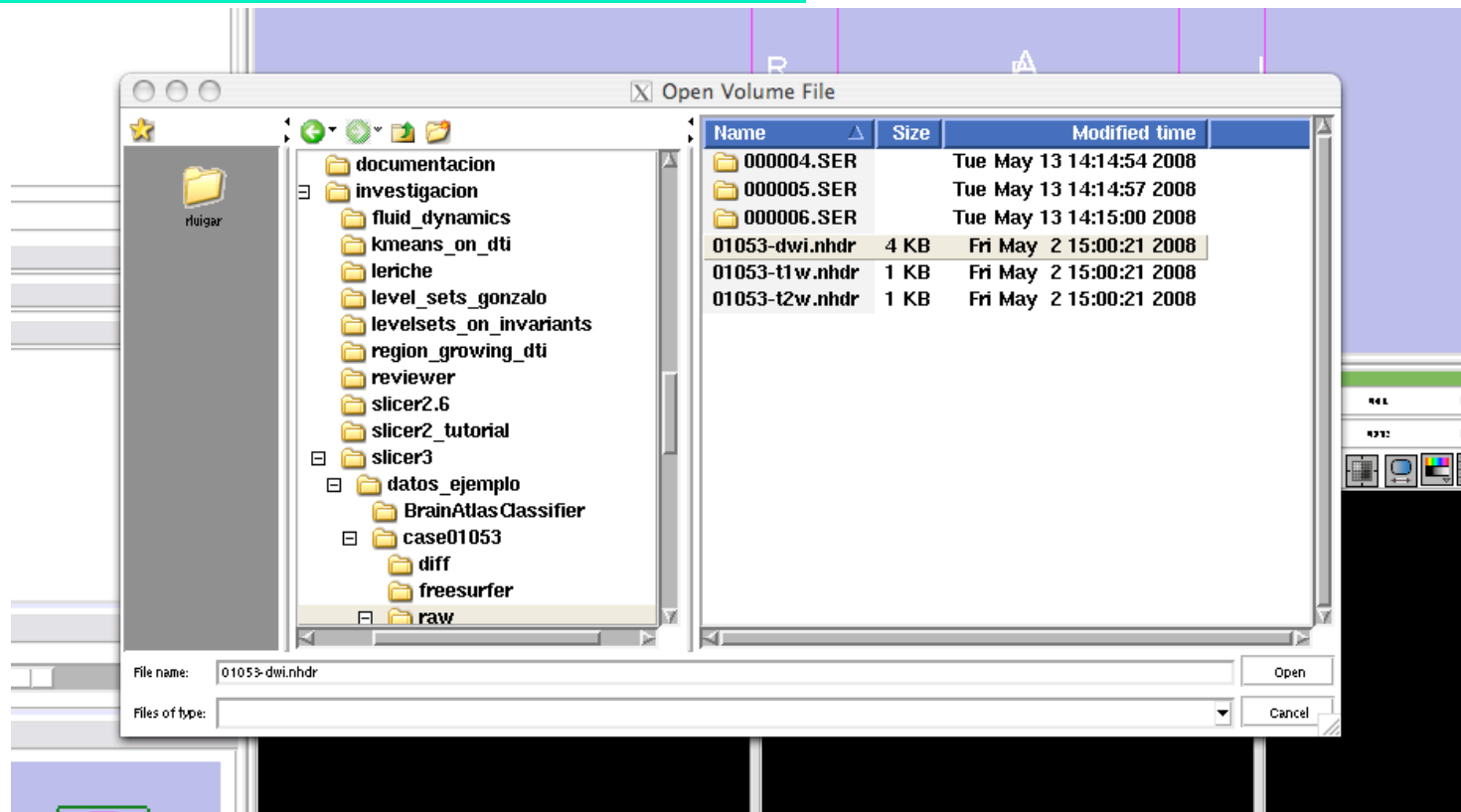
3DSlicer Loading Dataset 1 (DWI data)

The volume name will appear in the Load tag
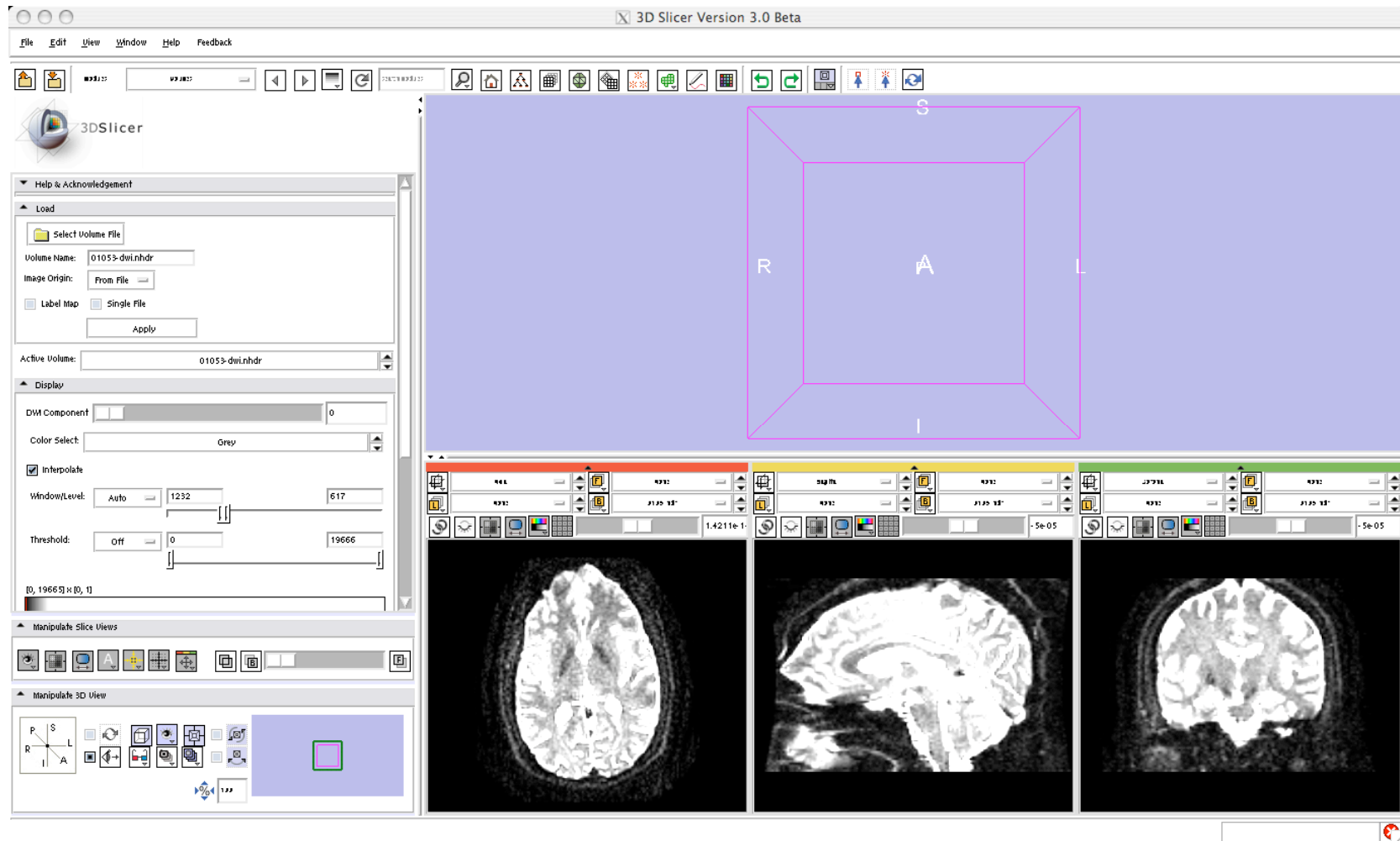
2- Select "Image Origin"--> "From File" and click "Apply"

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3DSlicer Loading Dataset 1 (DWI data)

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

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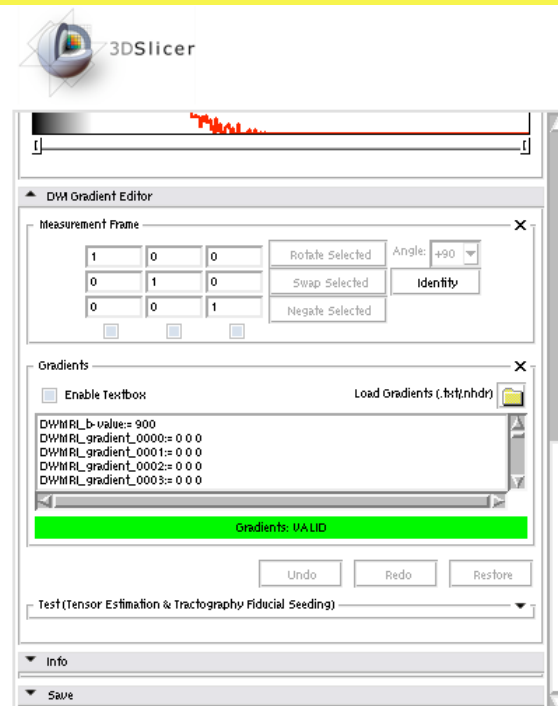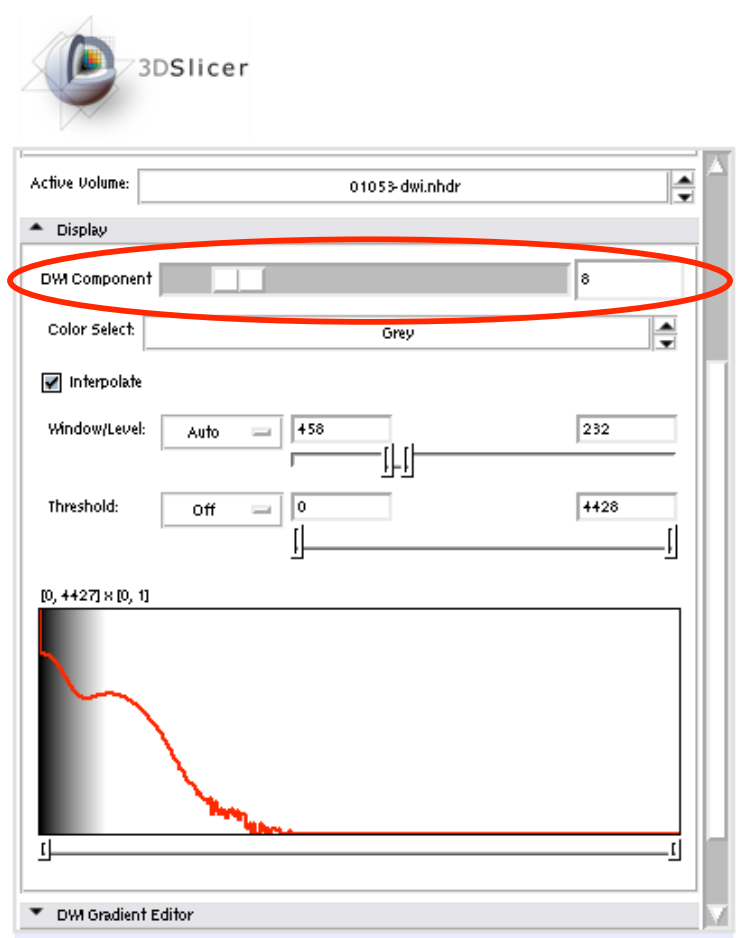http://www.slicer.org

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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.

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Loading Dataset 1 (DWI data)

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

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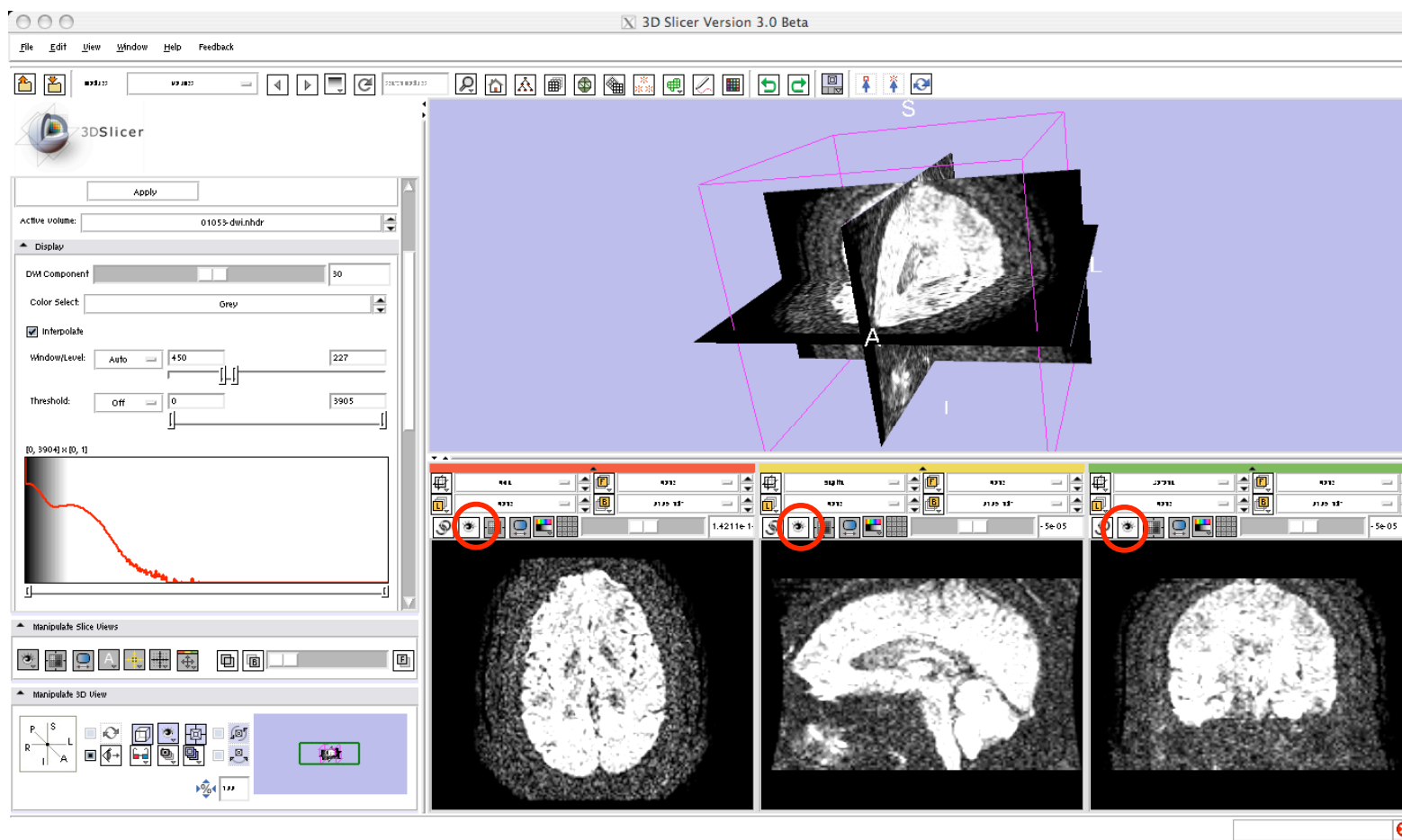
3DSlicer Converting from DWI to tensors

If a DWI volume is active, the "DWI Gradient Editor" tag is also active in the left panel.
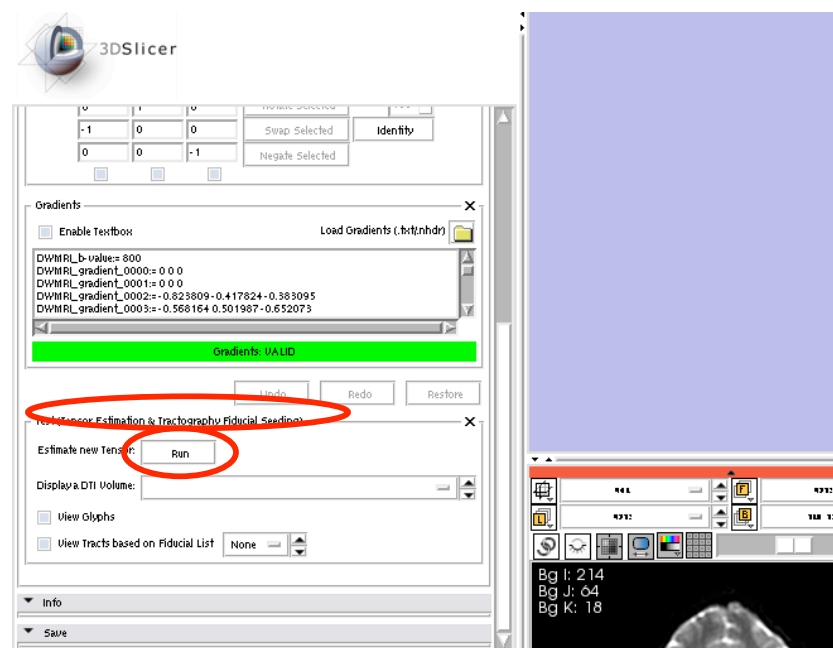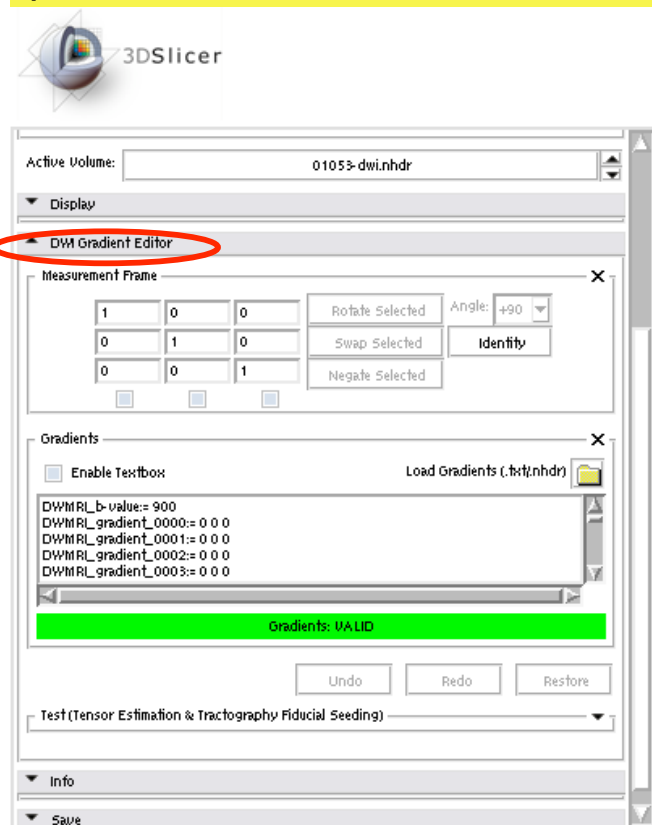
To estimate the tensors, first unfold the TEST (Tensor Estimation & Tractography Fiducial Seeding) and then click "Run" to Estimate New Tensor

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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.

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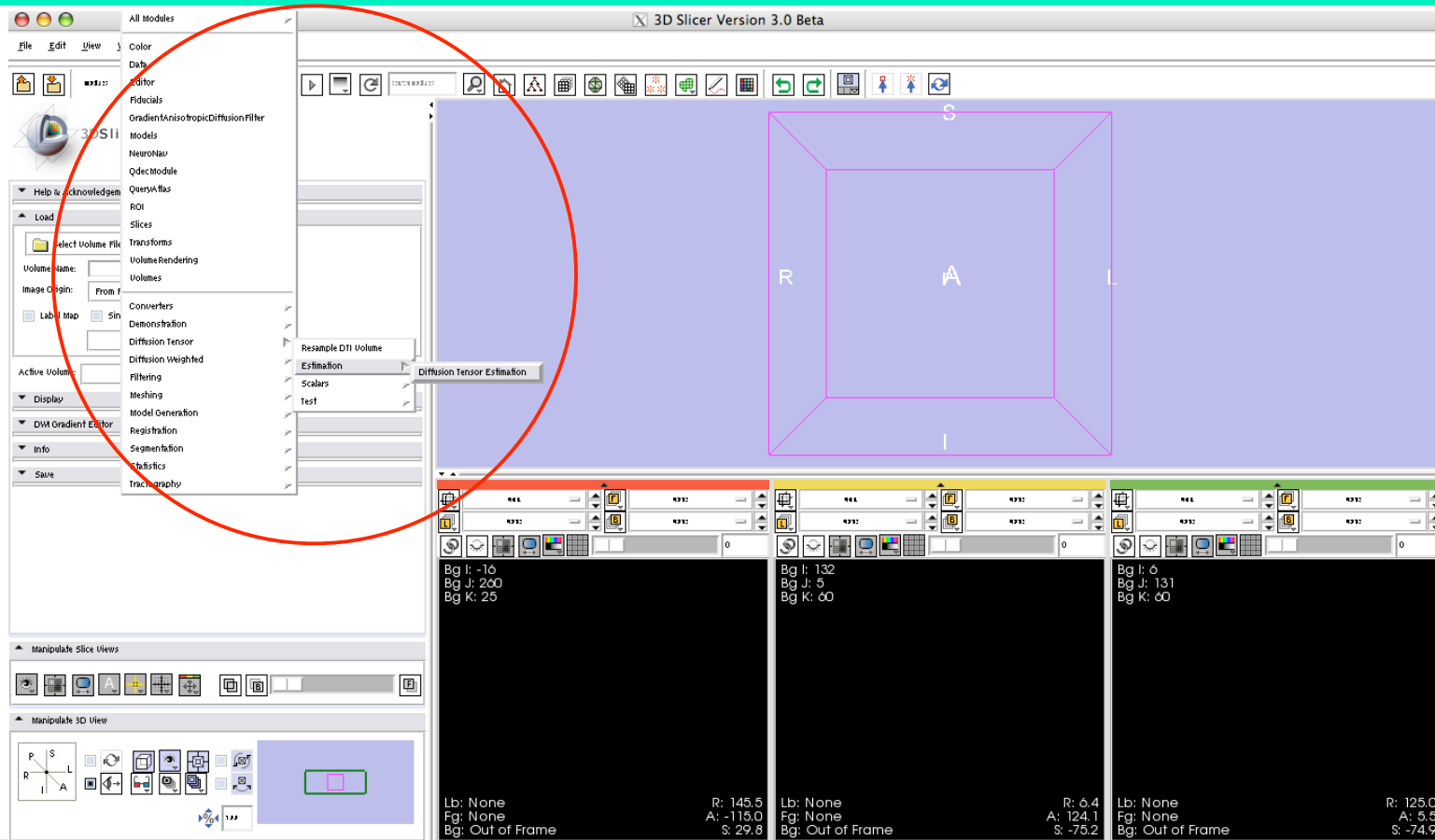*Brigham and Women's Hospital*
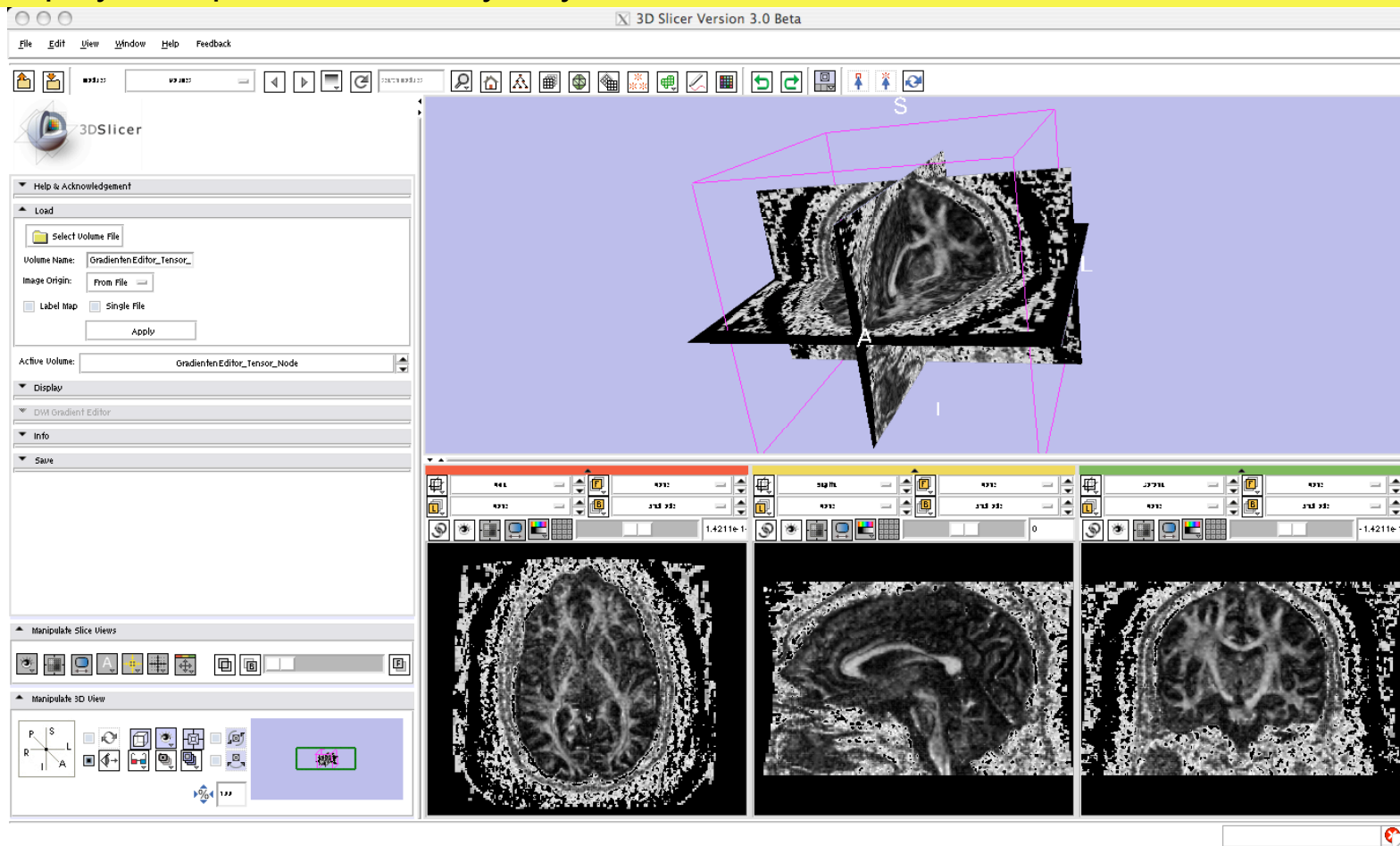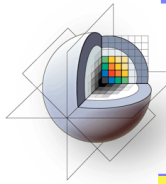
3DSlicer Converting from DWI to tensors

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

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Converting from DWI to tensors

2- Unfold the Diffusion Tensor Estimation tag, and select names for the output volumes that will be created
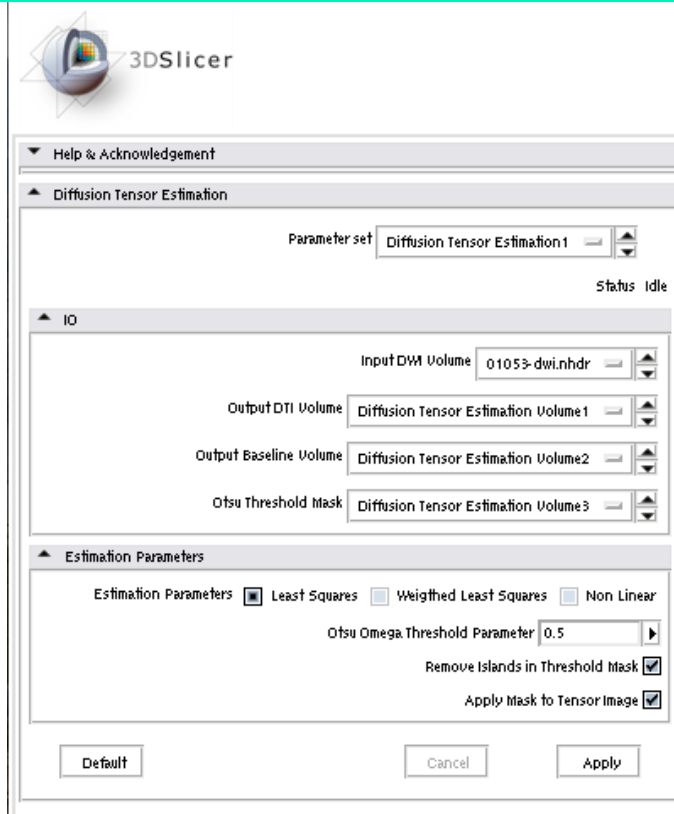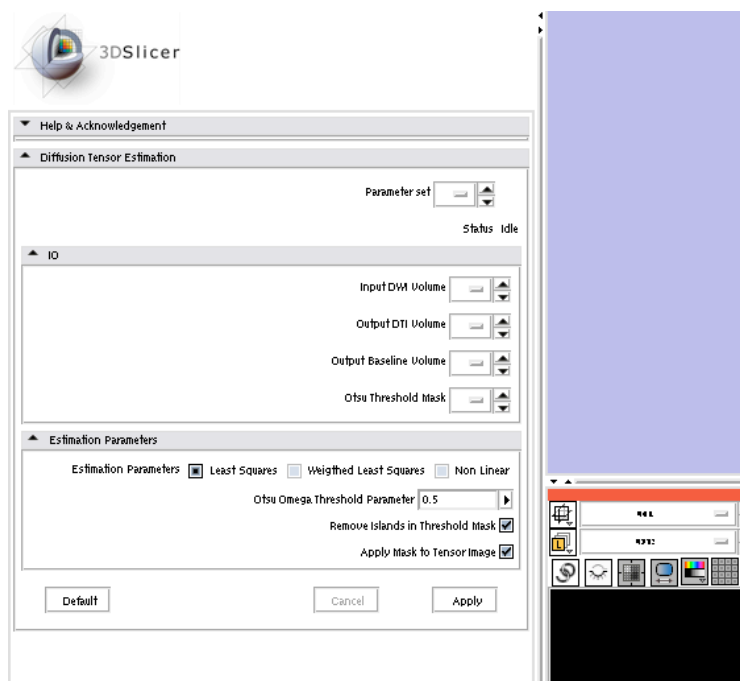
3- Select the desired options and click "Apply"

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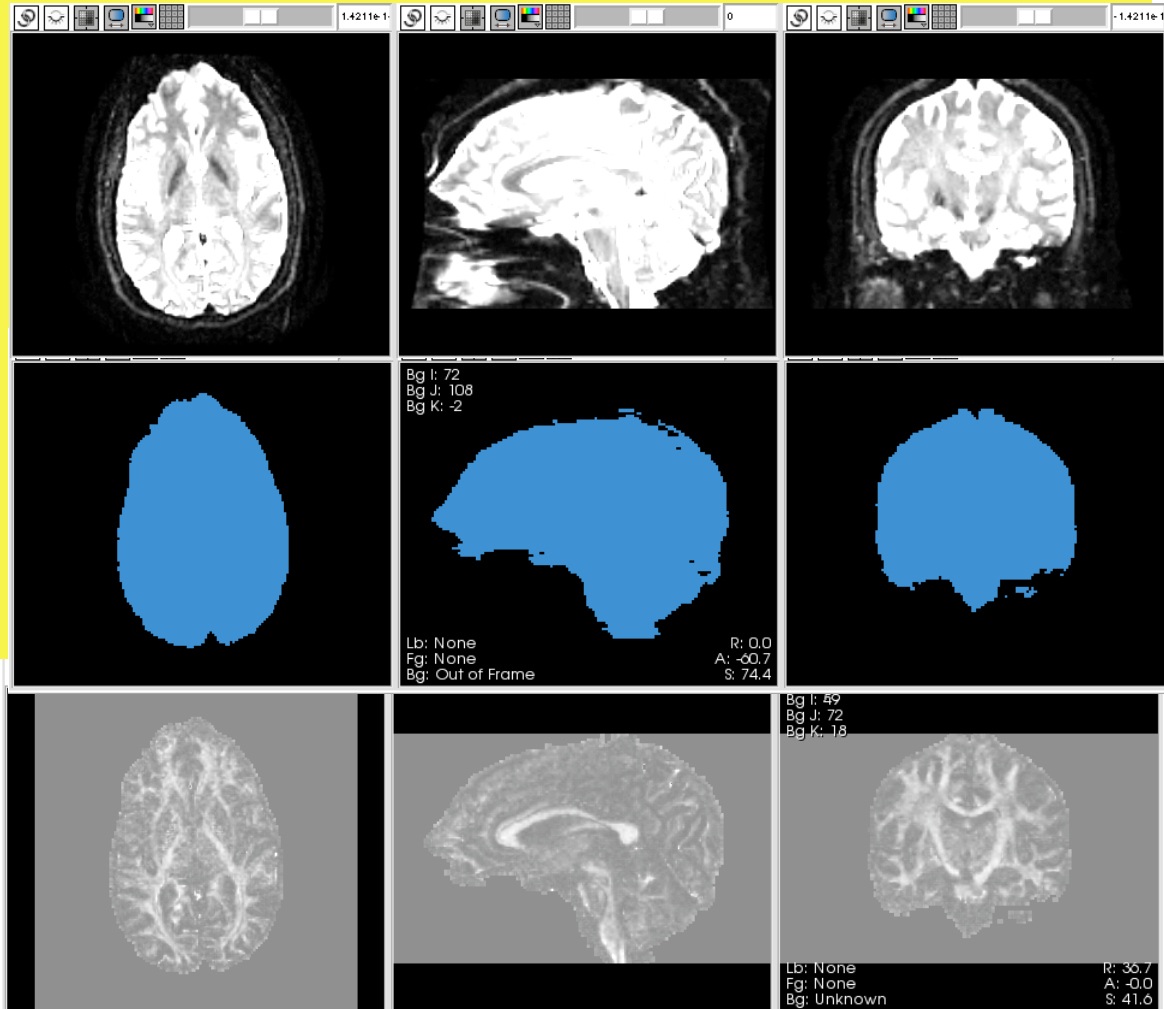http://www.slicer.org

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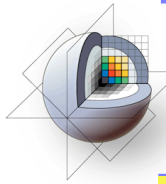
Converting from DWI to tensors

Once the tensor estimation has been performed, three volumes will become active:
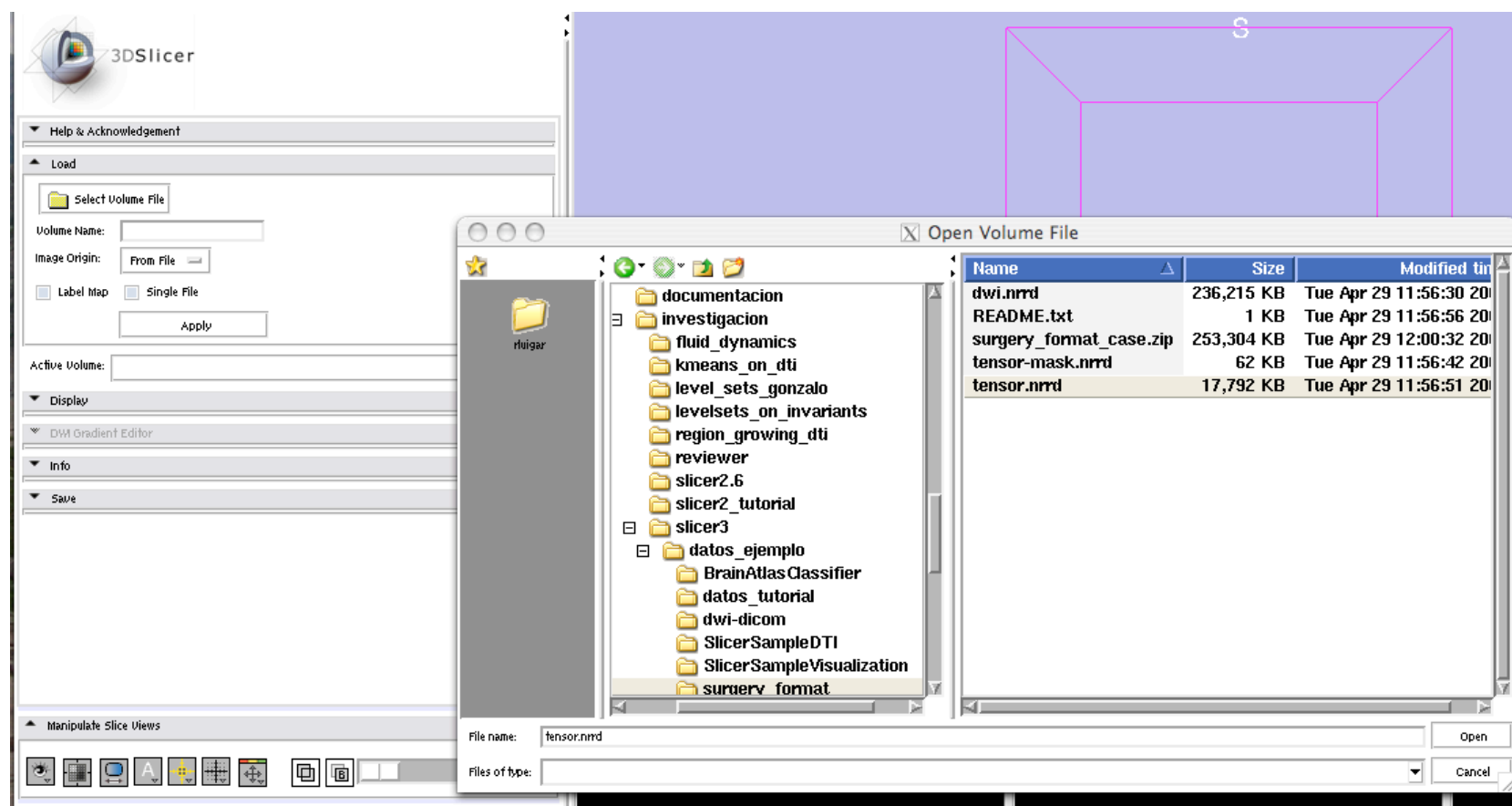
- Baseline

- Mask

- Tensors

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Visualizing tensors

1- Load the tensor volume "tensor.nrrd" using the "Volumes" module

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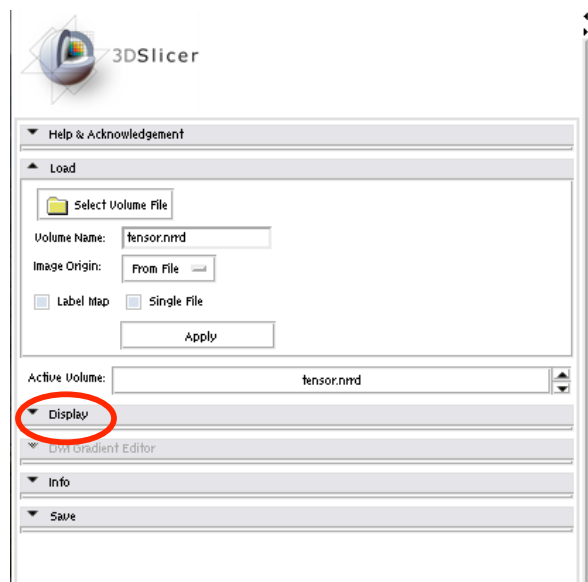
Visualizing tensors

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…)
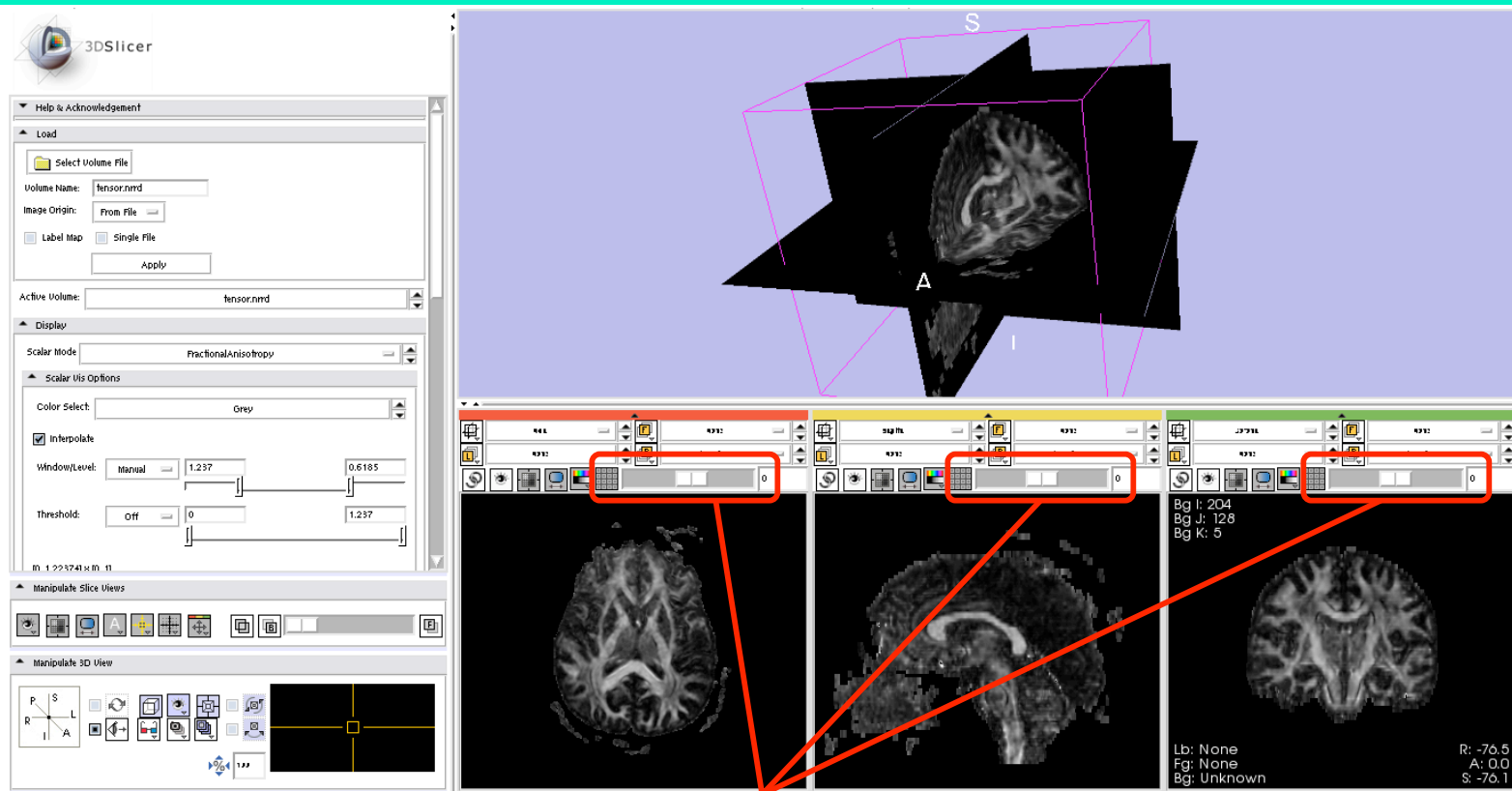- Glyphs

2- Unfold the "Display" menu

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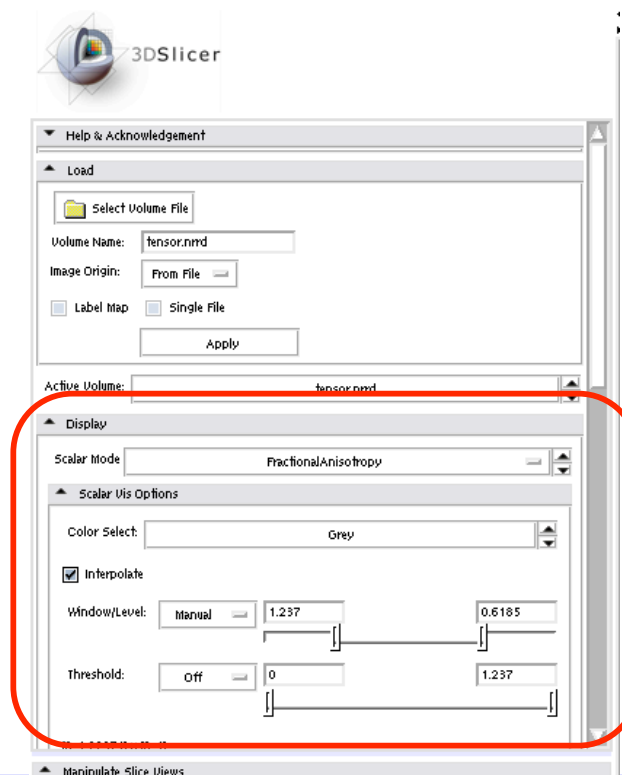
Visualizing tensors

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

You can navigate through the different slices using the slide bars

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Visualizing tensors

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

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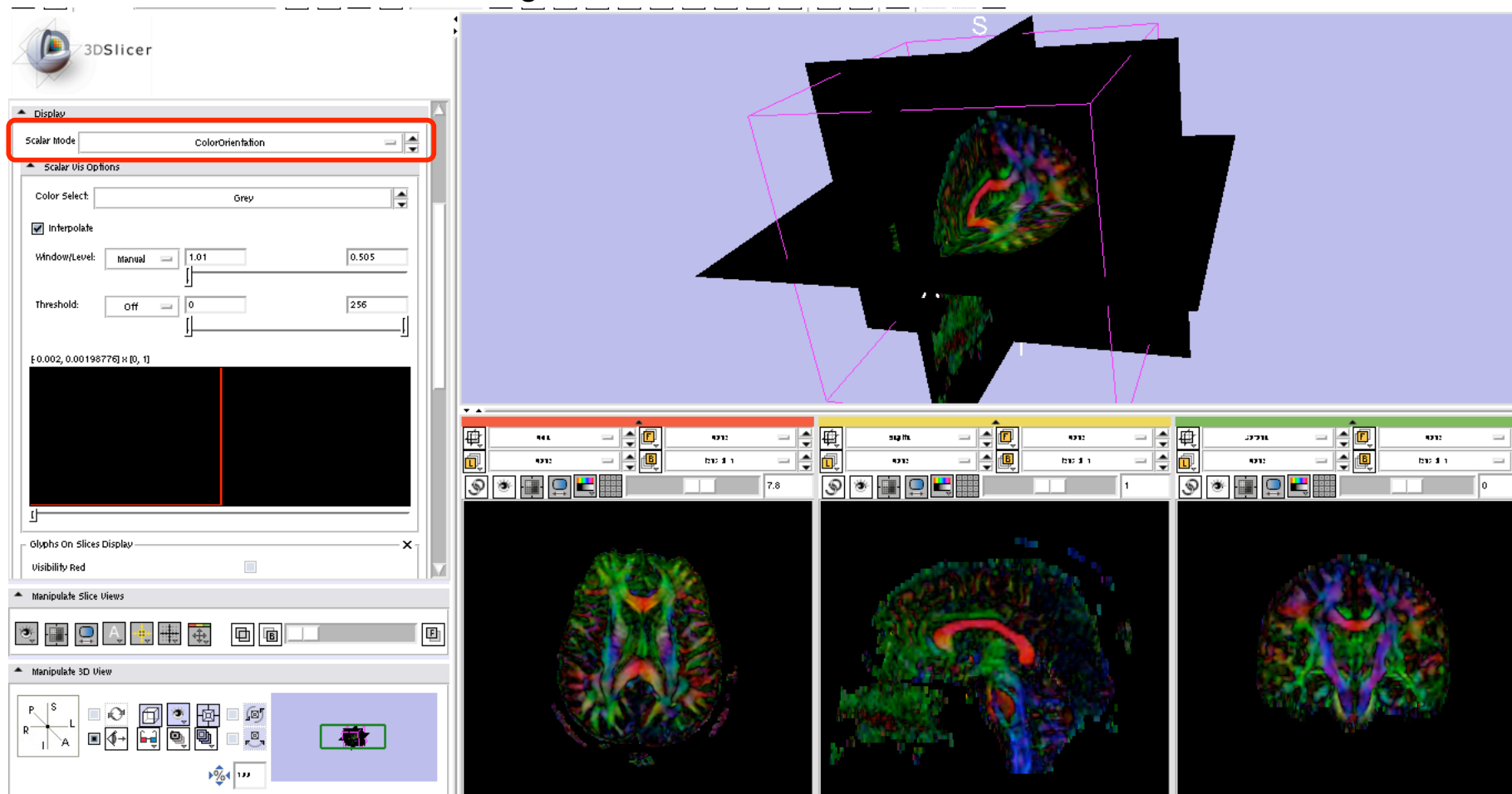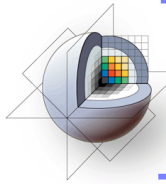http://www.slicer.org

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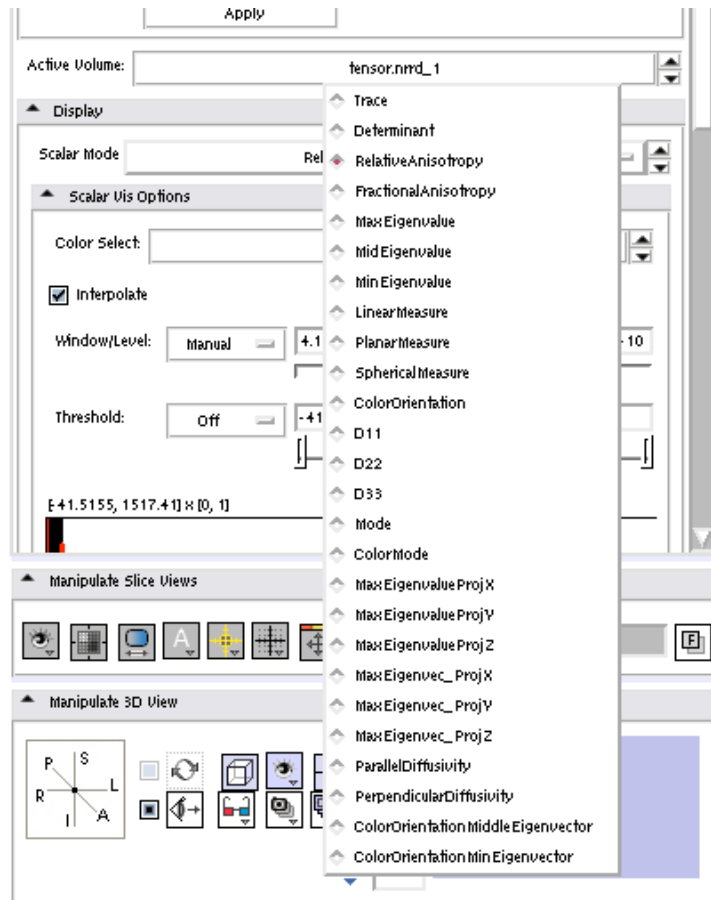
Visualizing tensors

5- Select "Color Orientation": This is a color measure that color-codes the orientation of the main eigenvector of the tensor
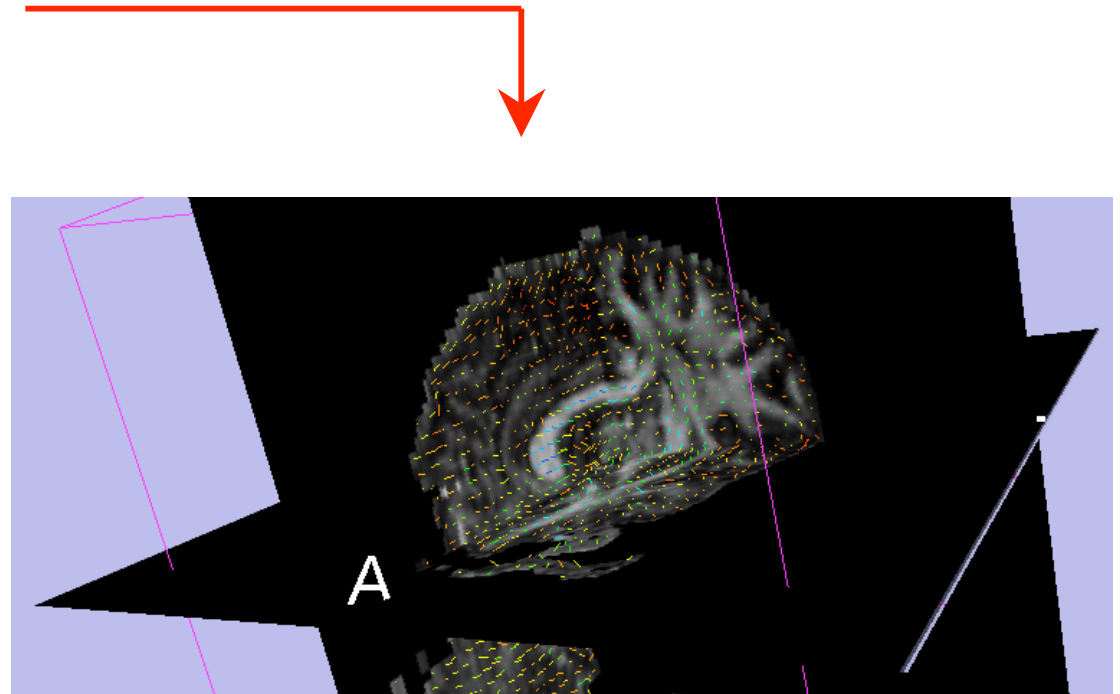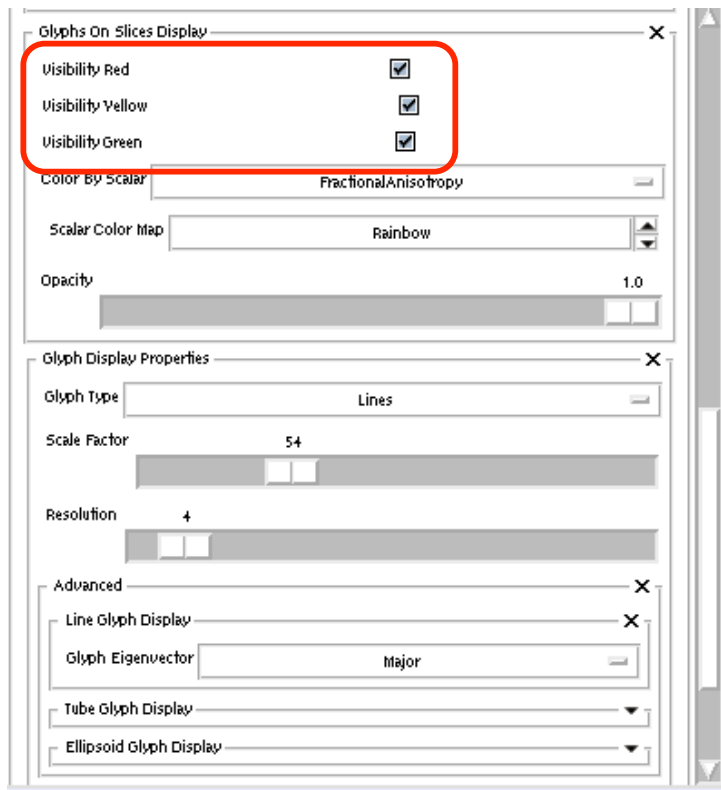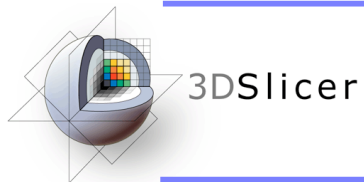
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Visualizing tensors

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

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Visualizing tensors

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

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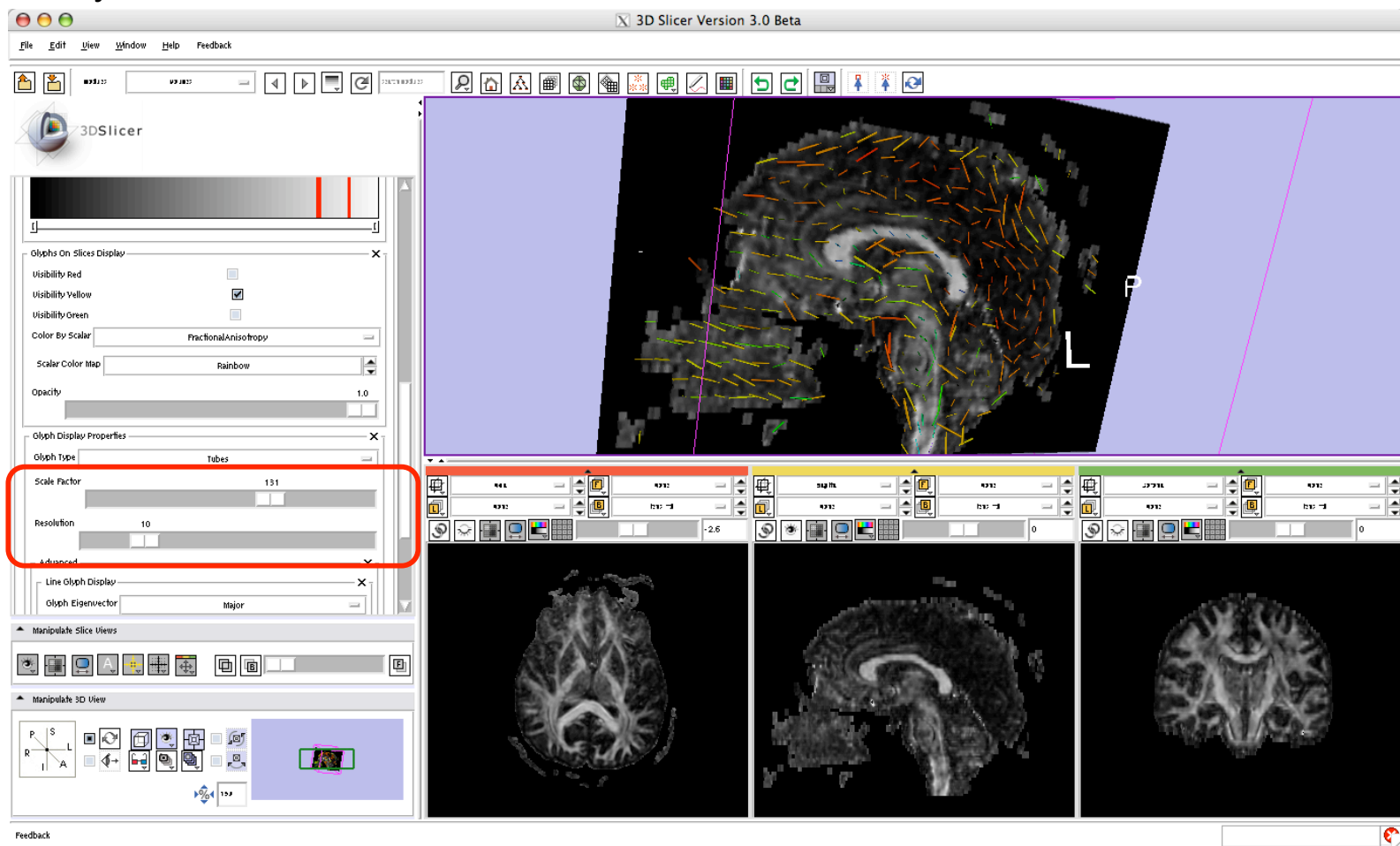http://www.slicer.org

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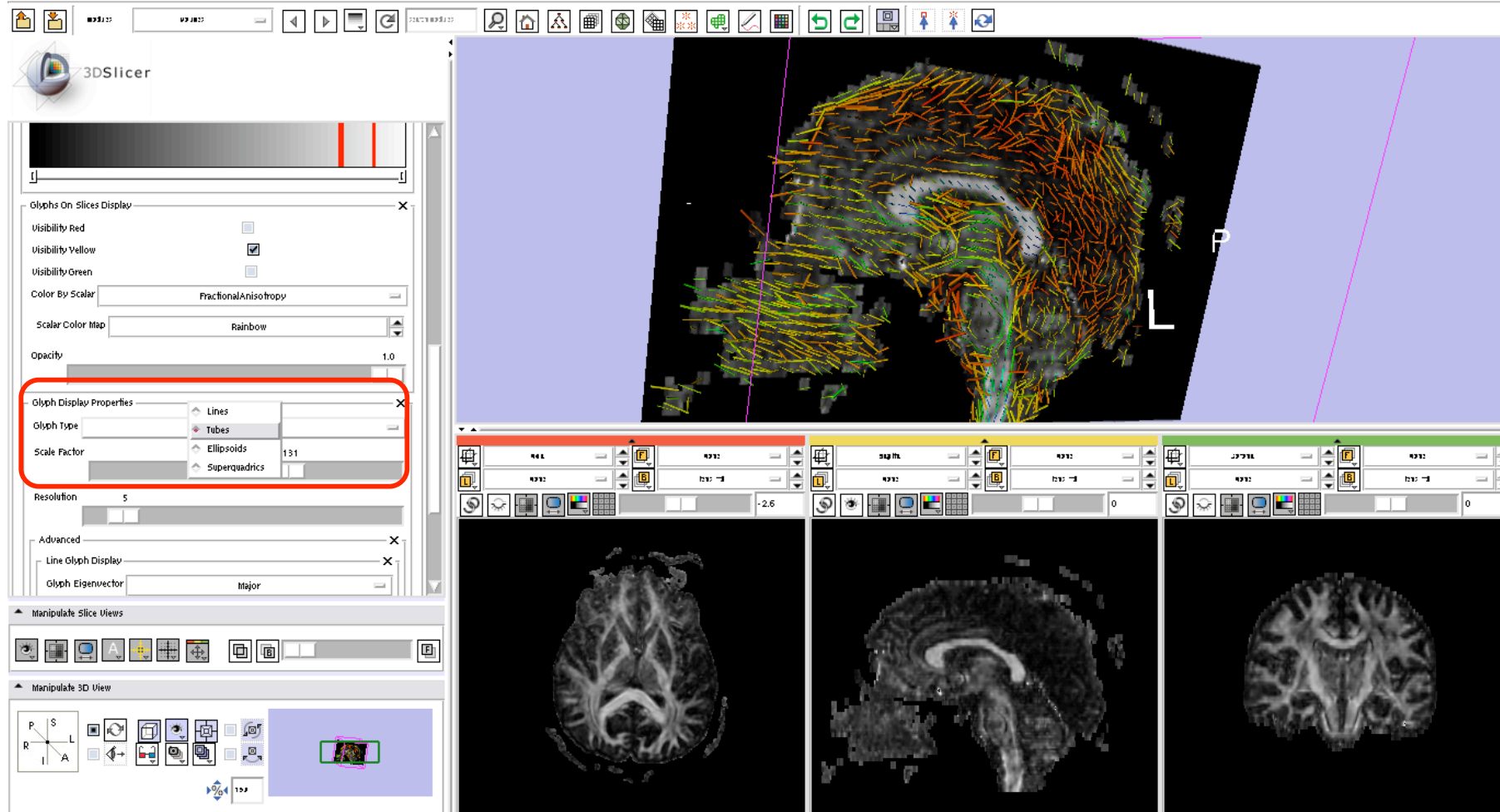
Visualizing tensors

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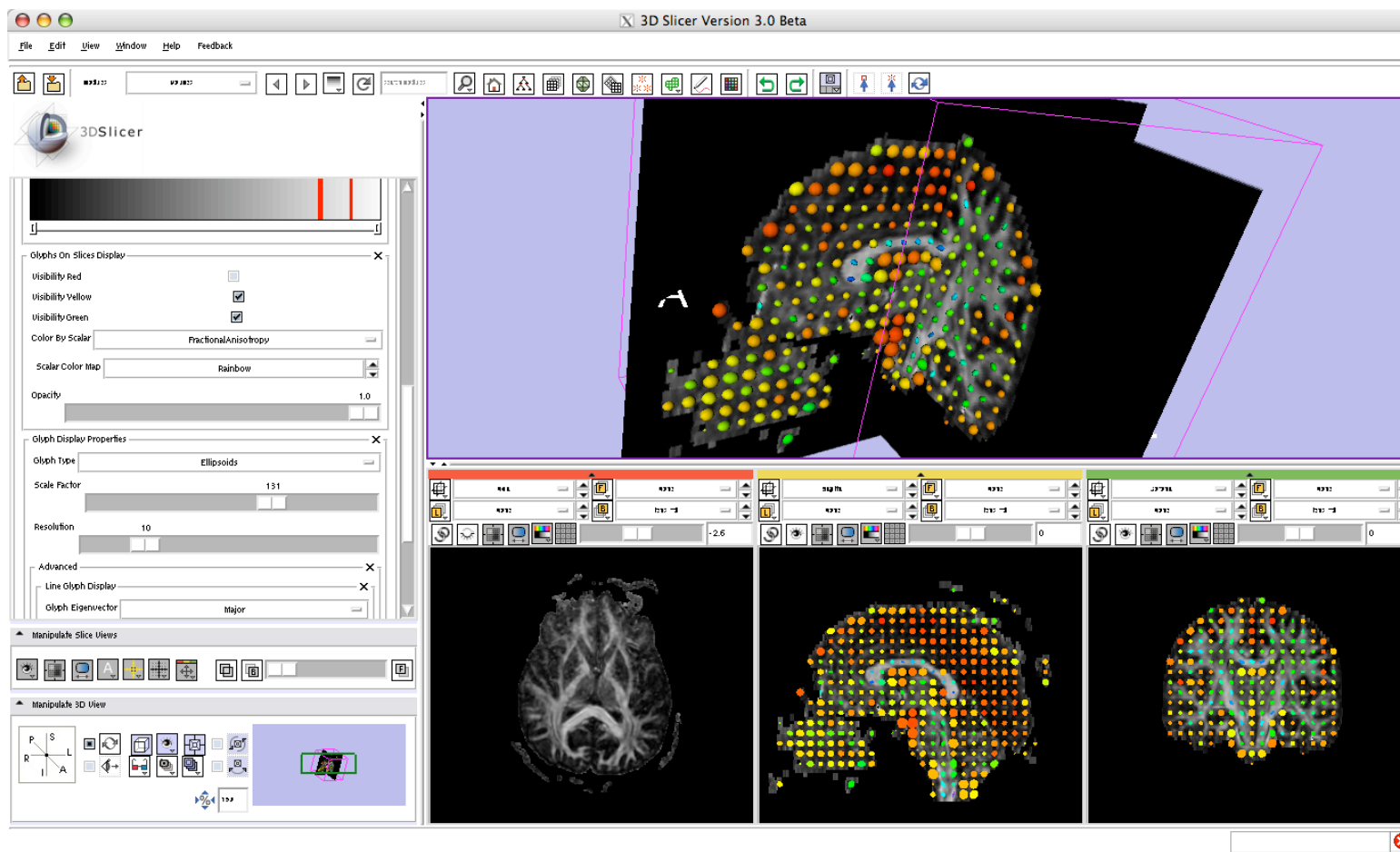
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Visualizing tensors

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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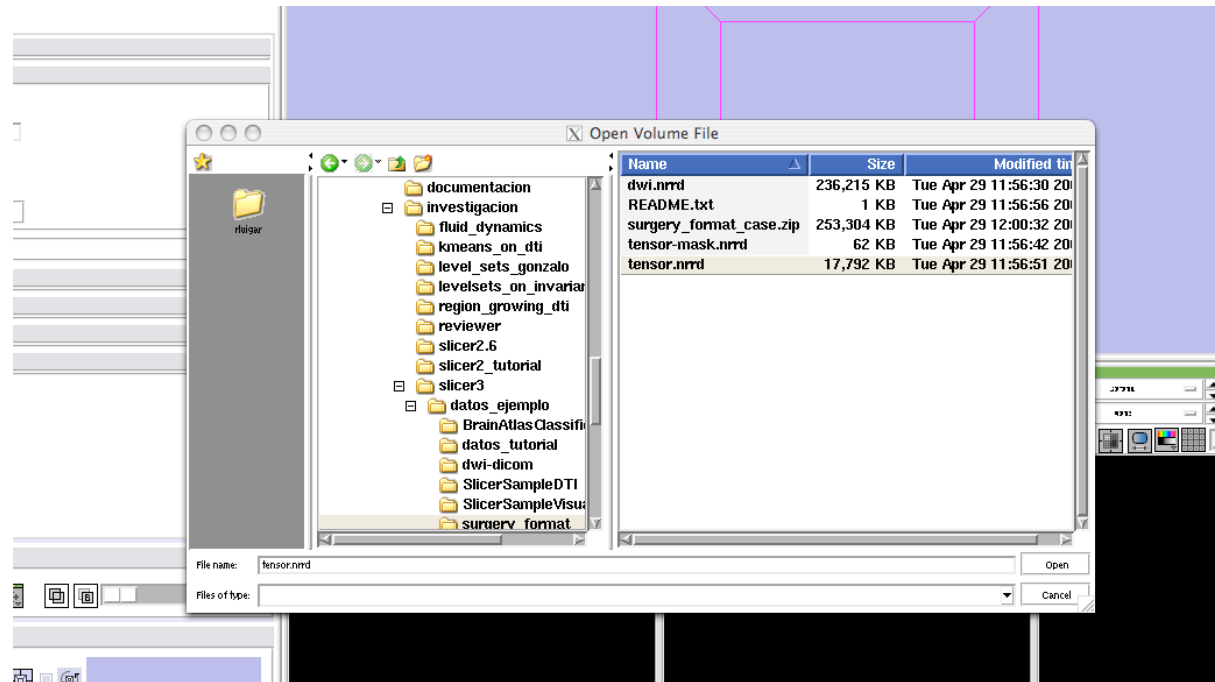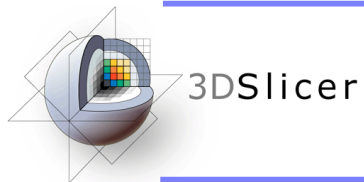http://www.slicer.org

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DTI tensor resampling

With slicer3, you can apply transforms to a tensor volume:
- Rotations, translations.
- Rigid or affine transforms
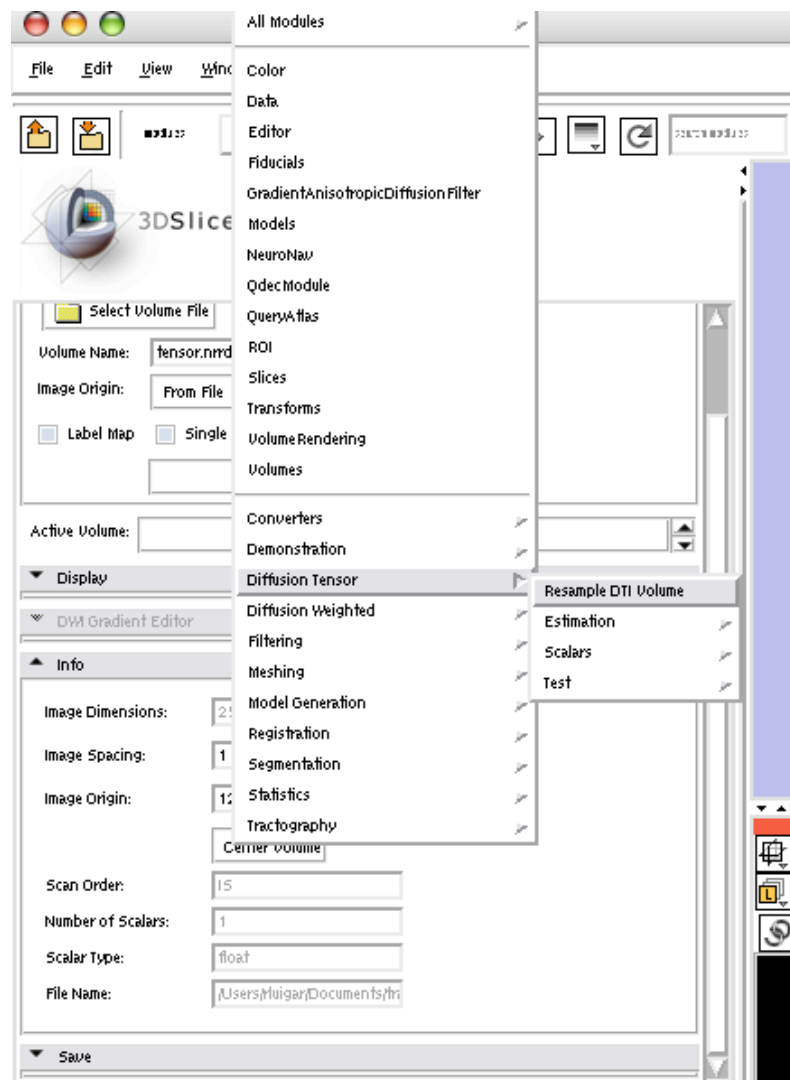- Linear interpolation, nearest neighbor, b-splines

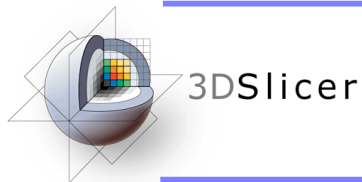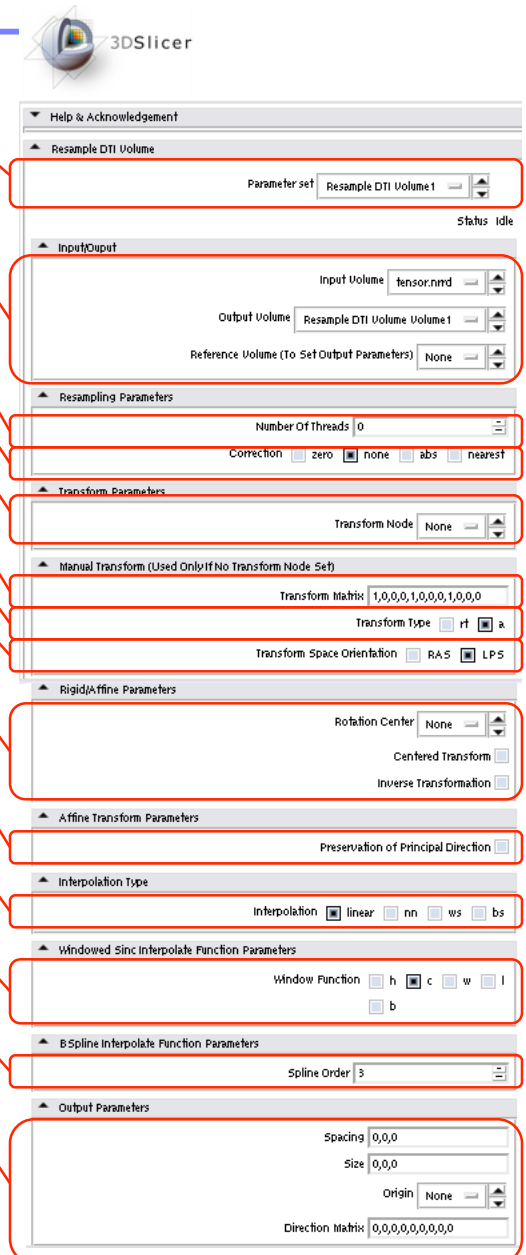1- Load a tensor volume to begin the process

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DTI tensor resampling

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

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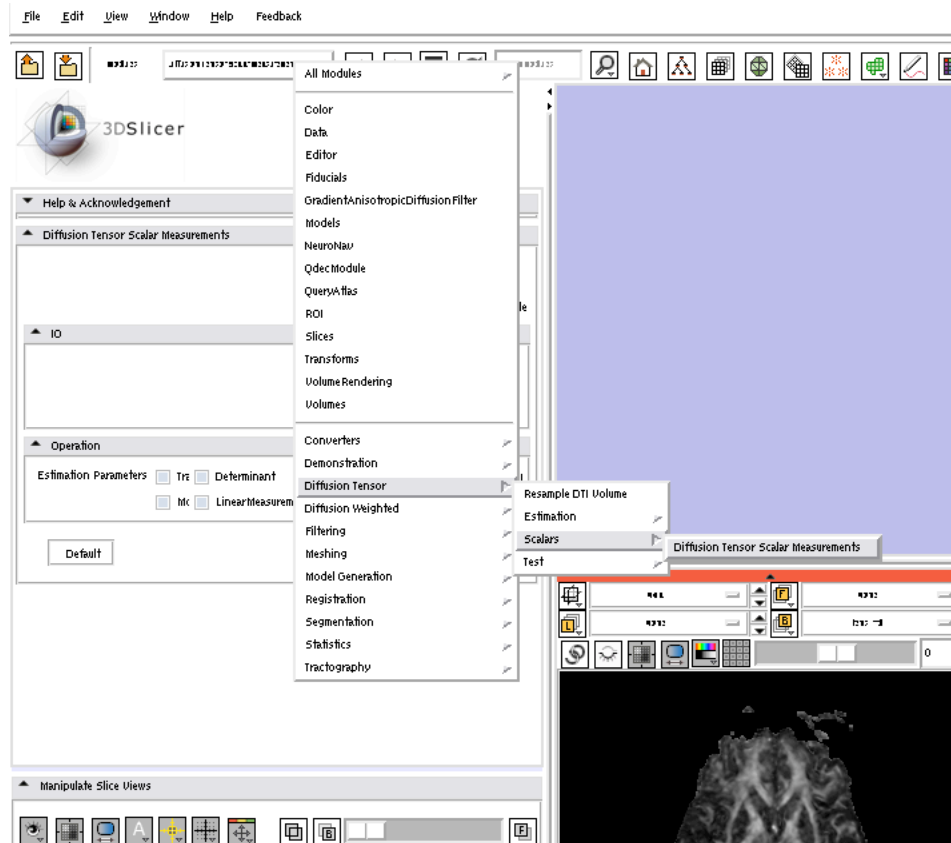*Brigham and Women's Hospital*

DTI tensor resampling

3DSlicer

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

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DTI scalar measurements

1- Select the module "Diffusion Tensor Scalar Measurements"

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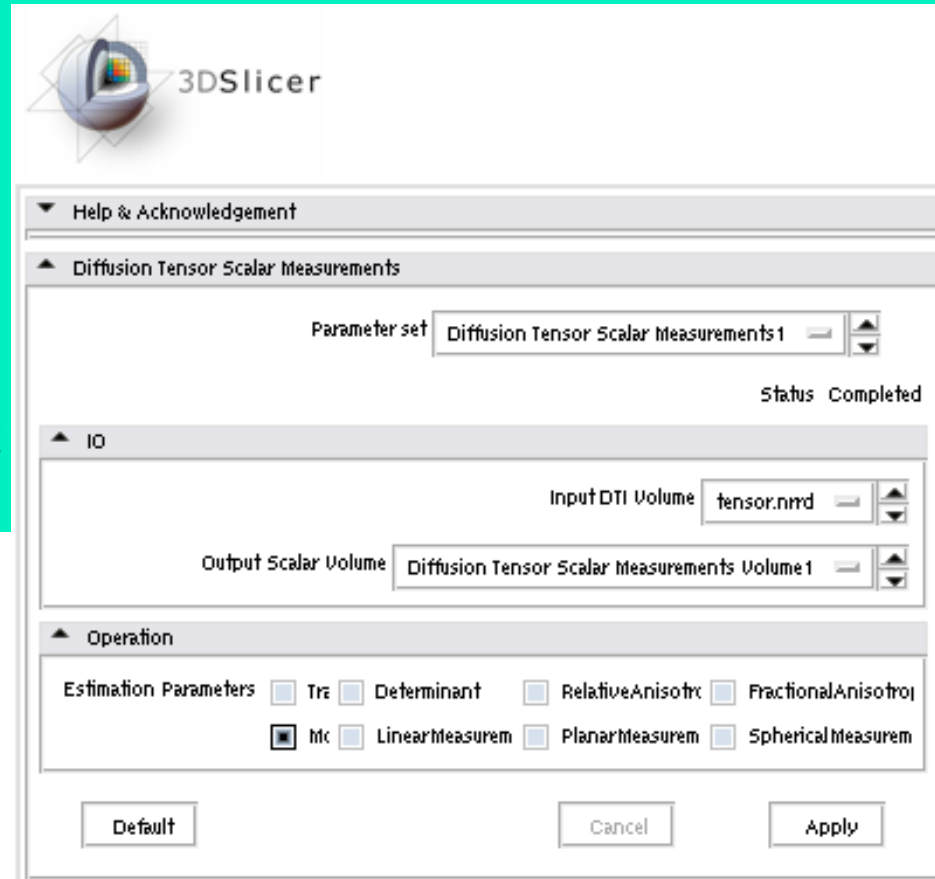http://www.slicer.org

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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
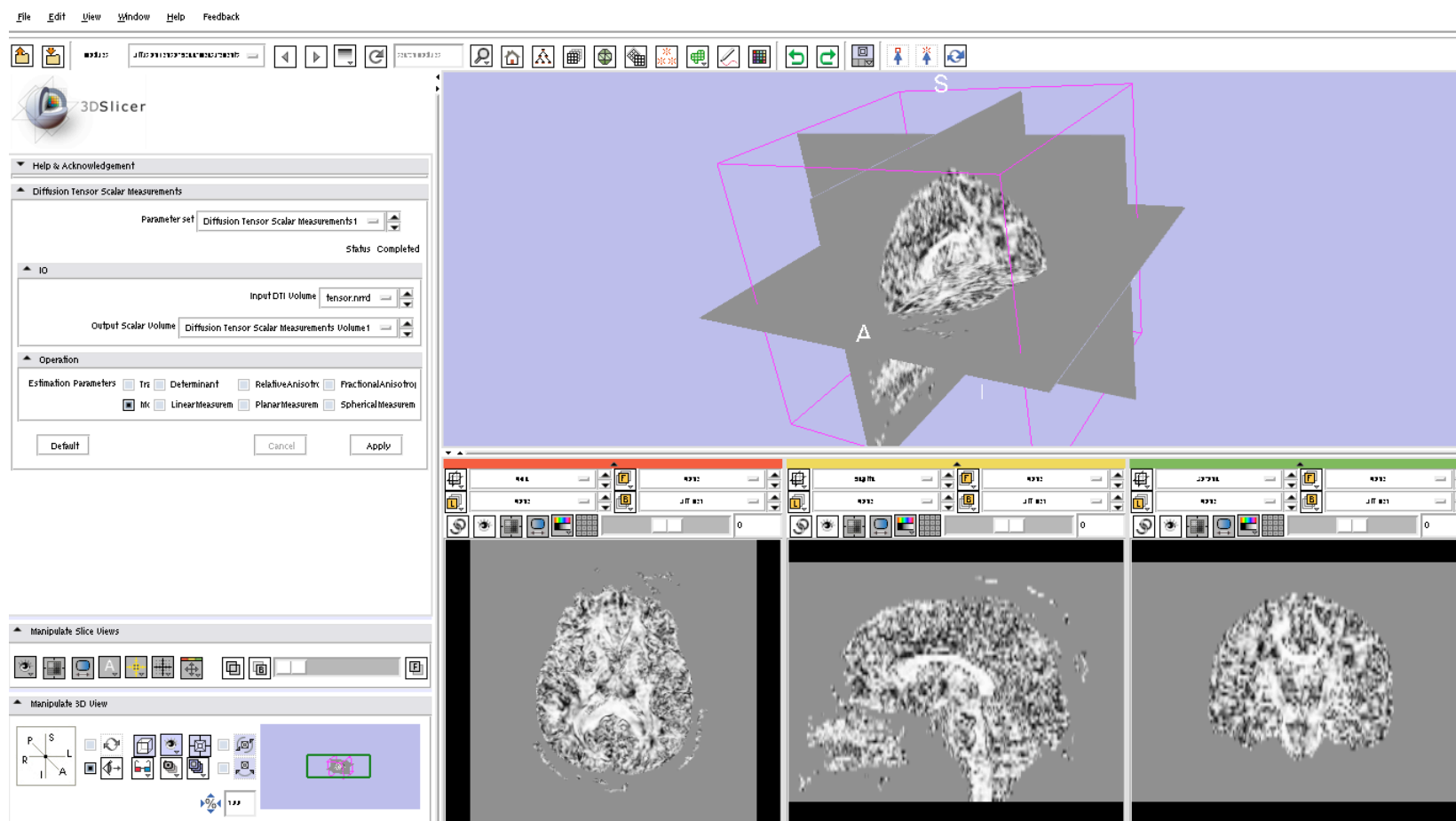- Planar Measurement
- Spherical Measurement

- Click Apply

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DTI scalar measurements

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

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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

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Loading and displaying tracts

3DSlicer

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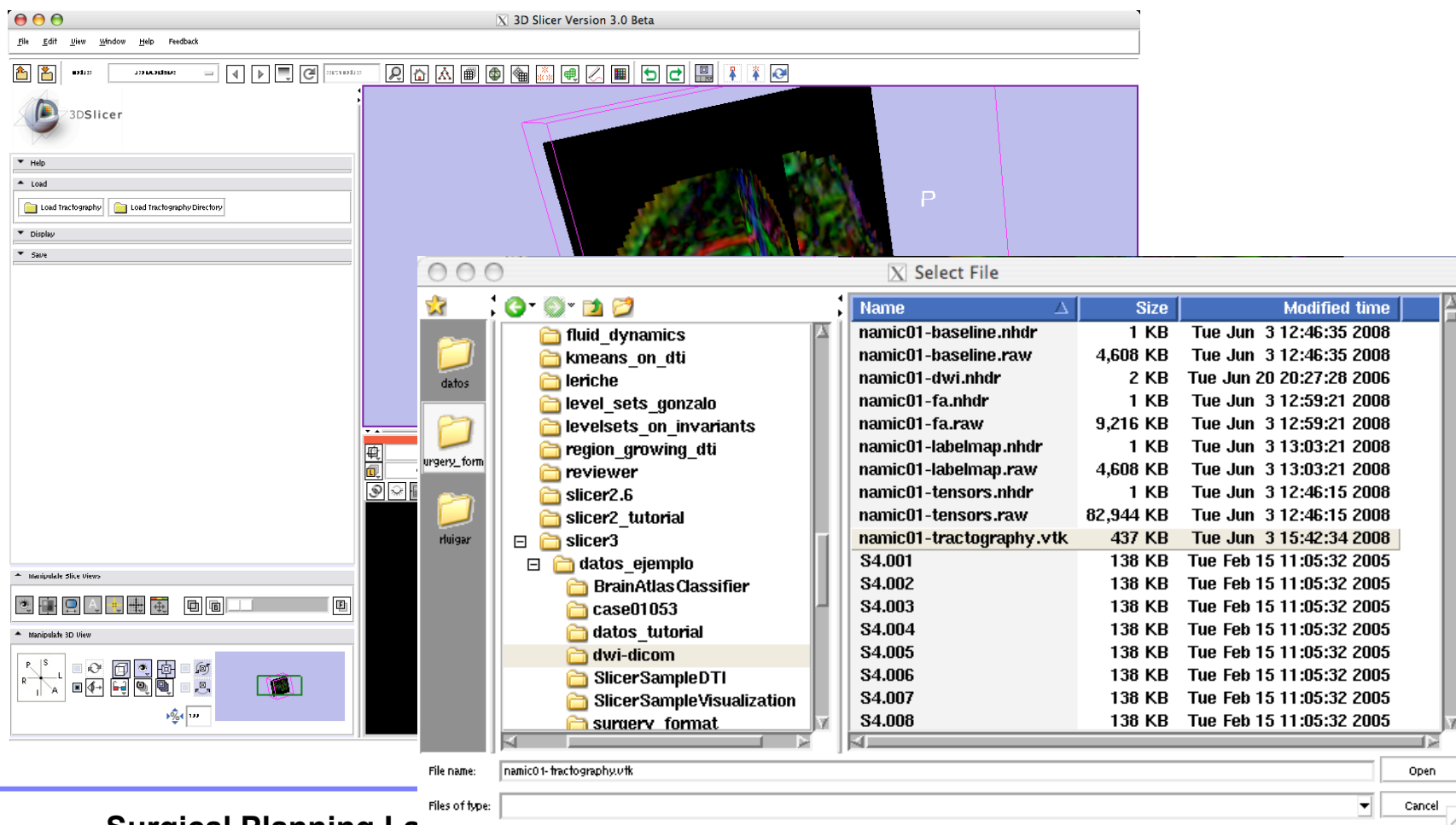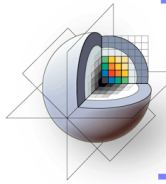3.- Go to Tractography -> DisplayLoadSave

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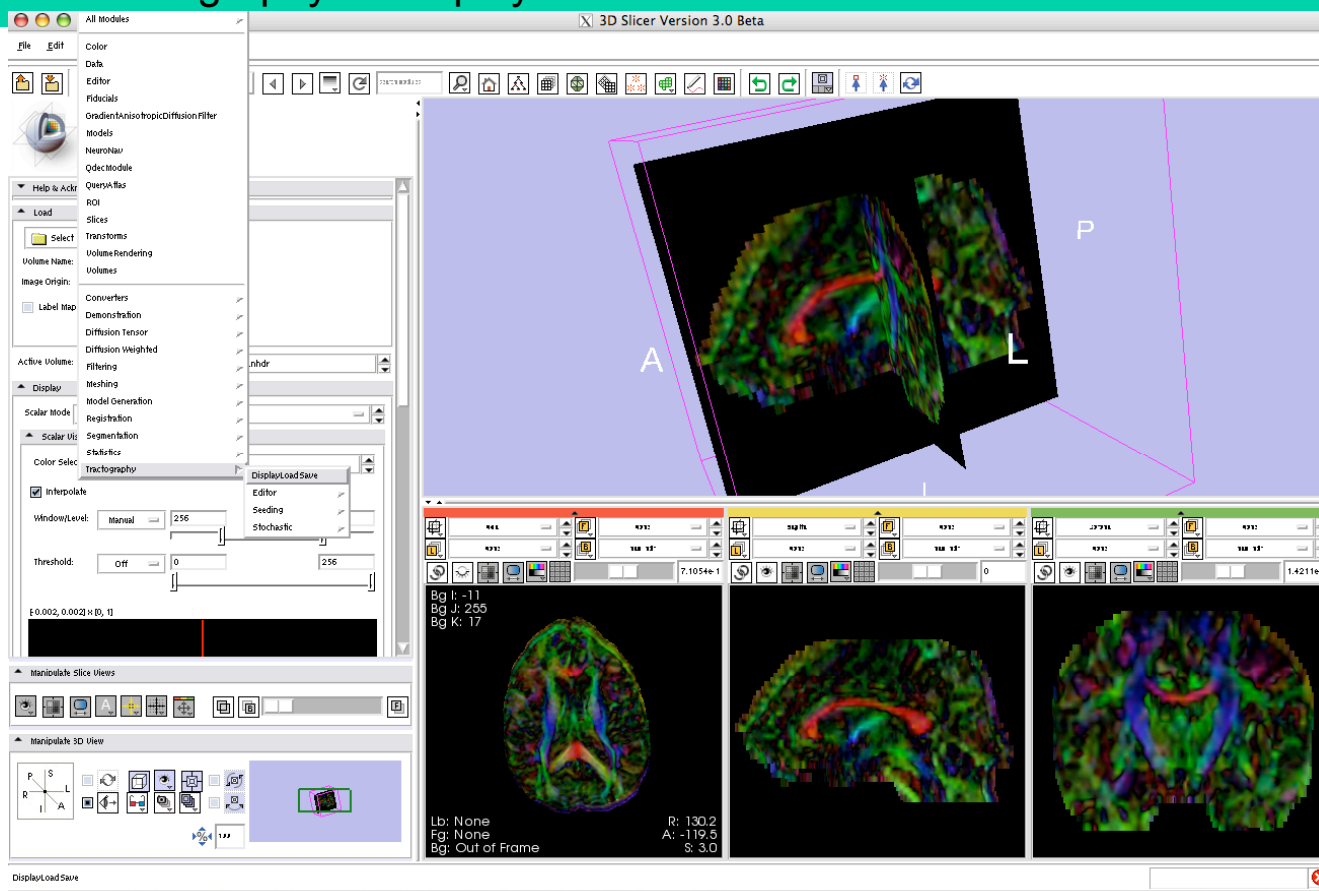
Loading and displaying tracts

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

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Loading and displaying tracts

The loaded tracts will appear in the 3D view

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Loading and displaying tracts

3DSlicer

Unfold the Display tag from the tractography module

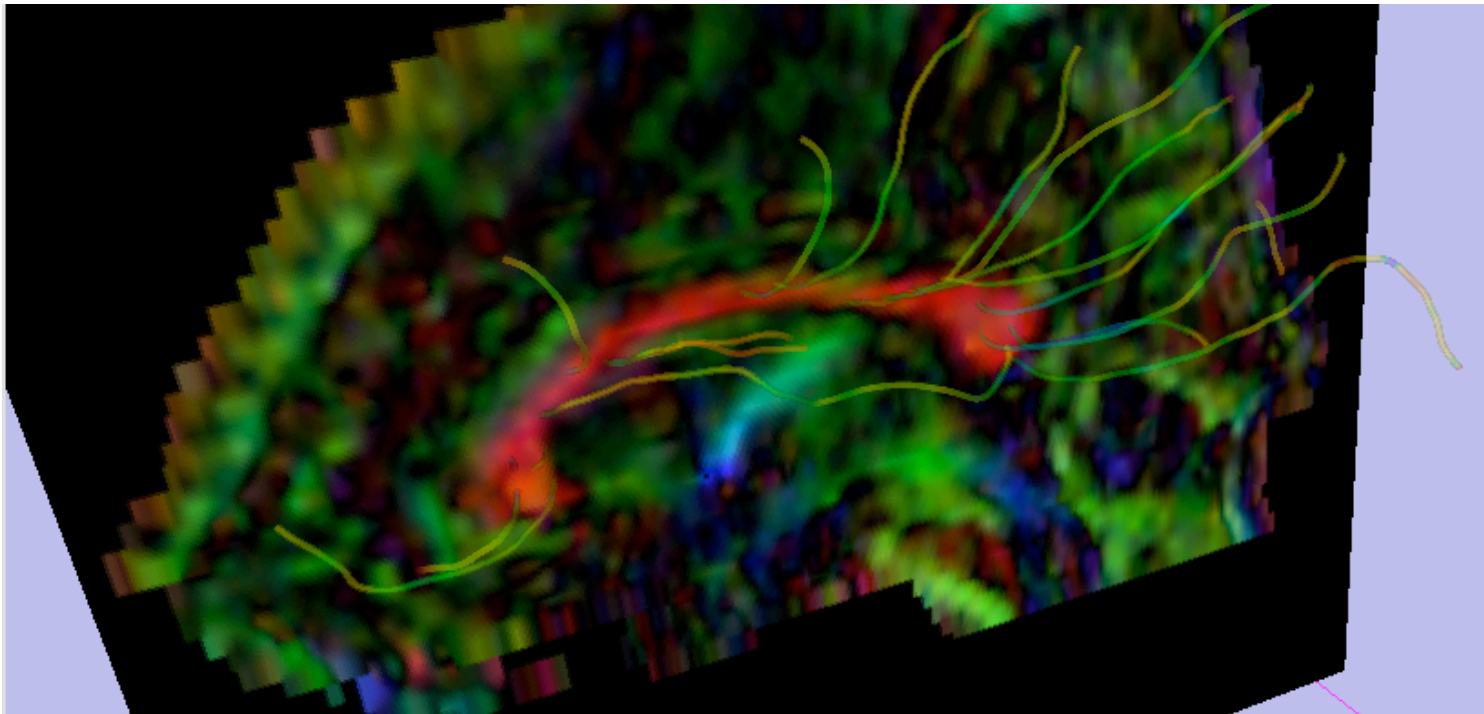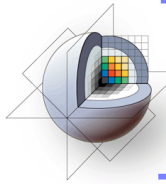**Surgical Planning Laboratory**
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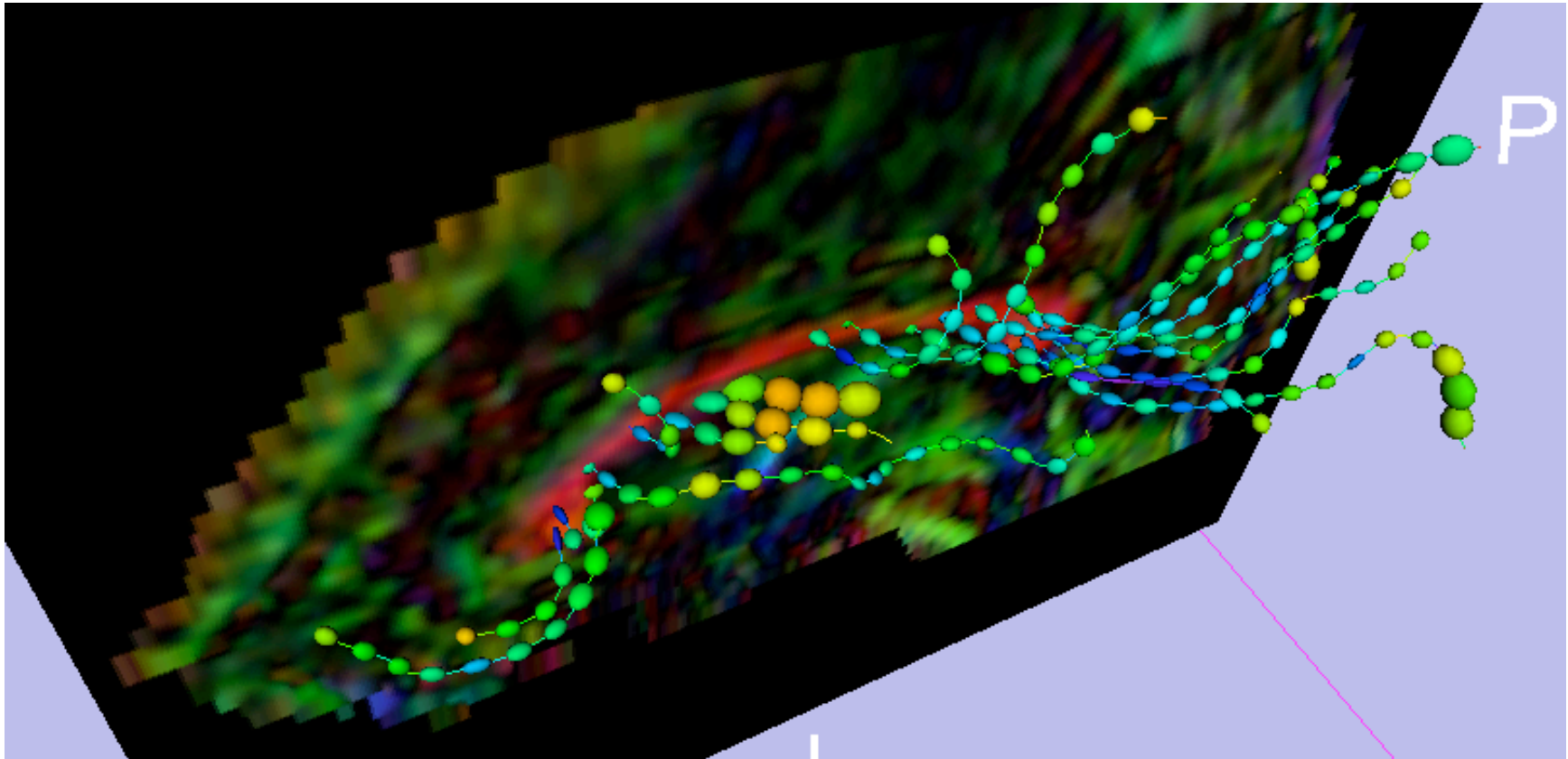*Brigham and Women's Hospital*
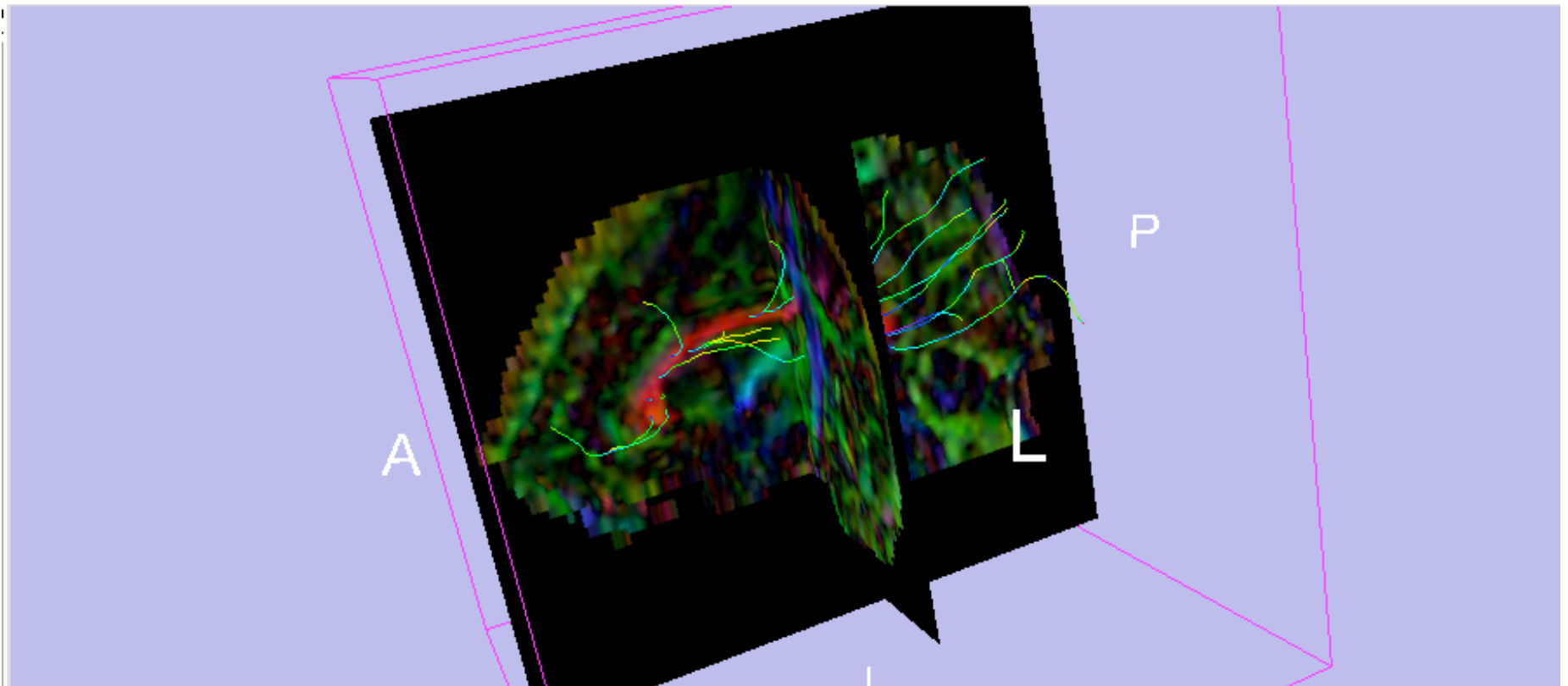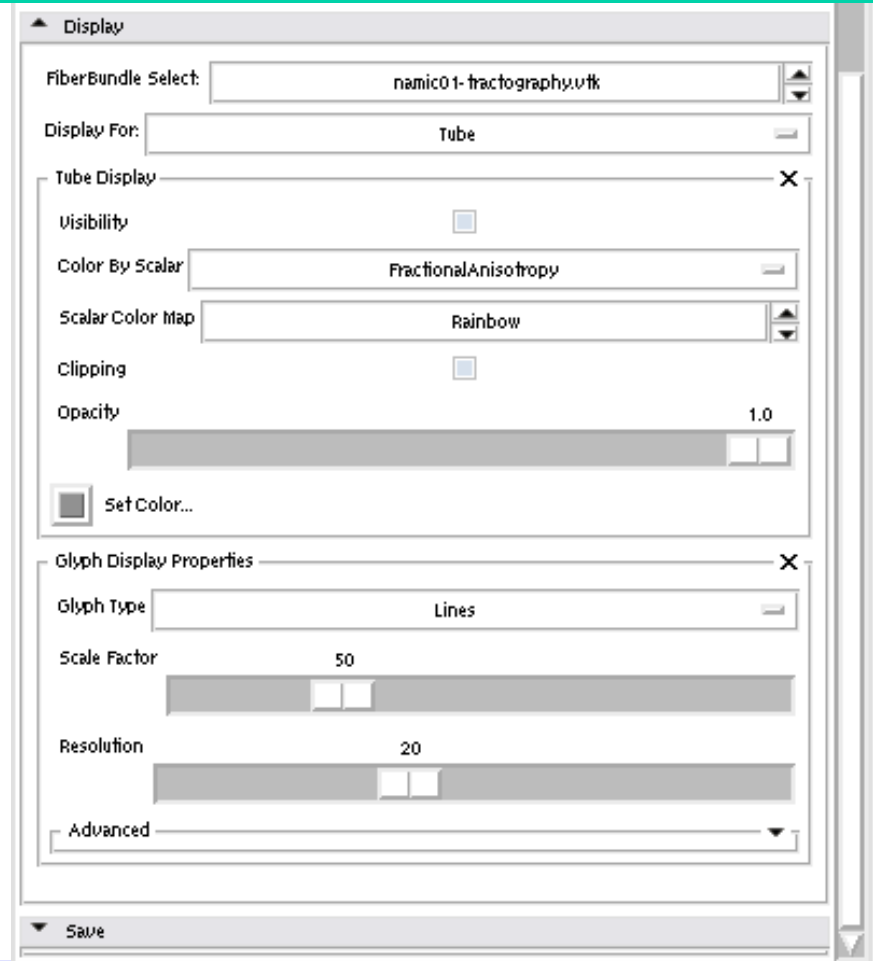
Loading and displaying tracts

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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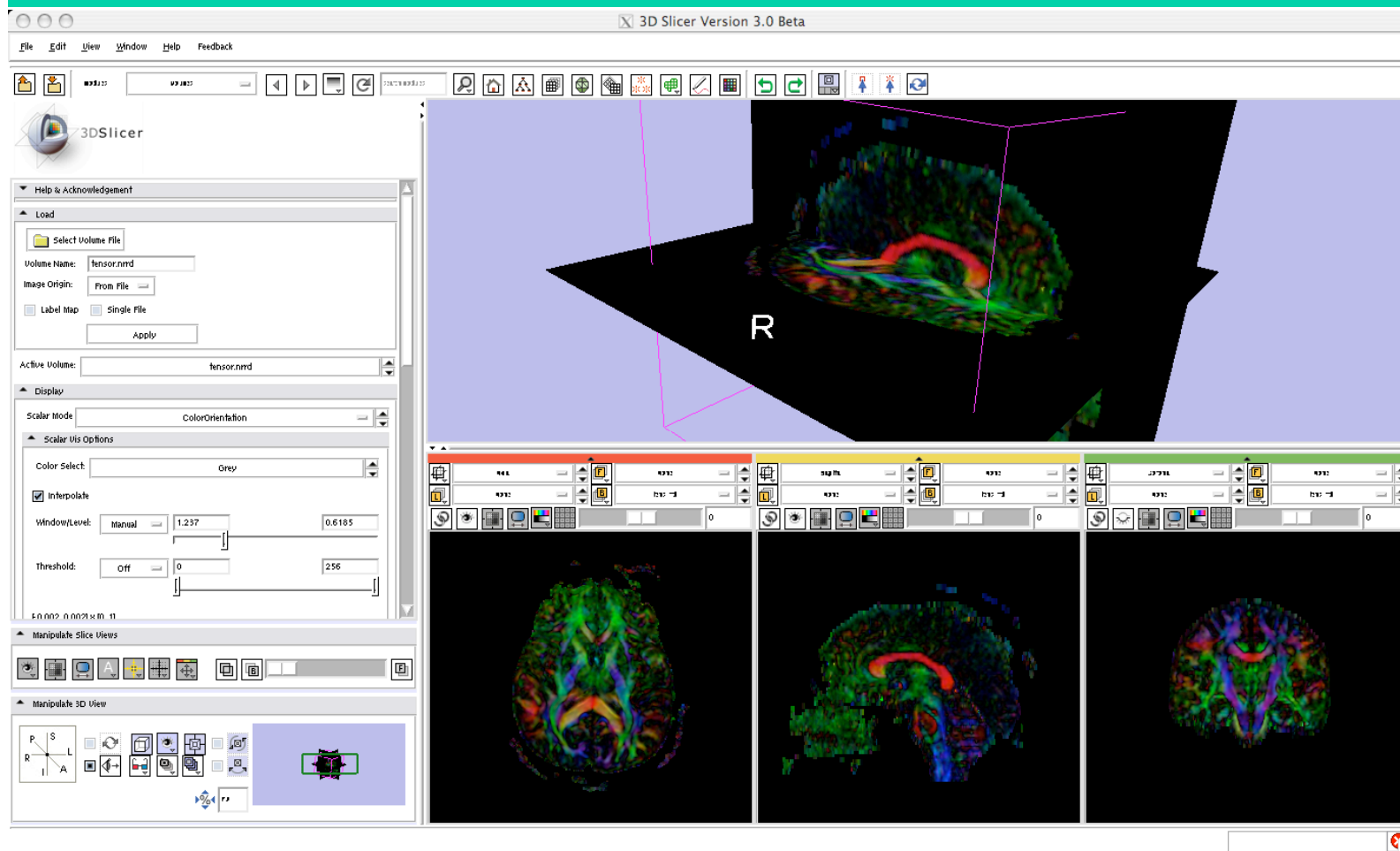**Surgical Planning Laboratory**
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Performing tractography with fiducial seedings

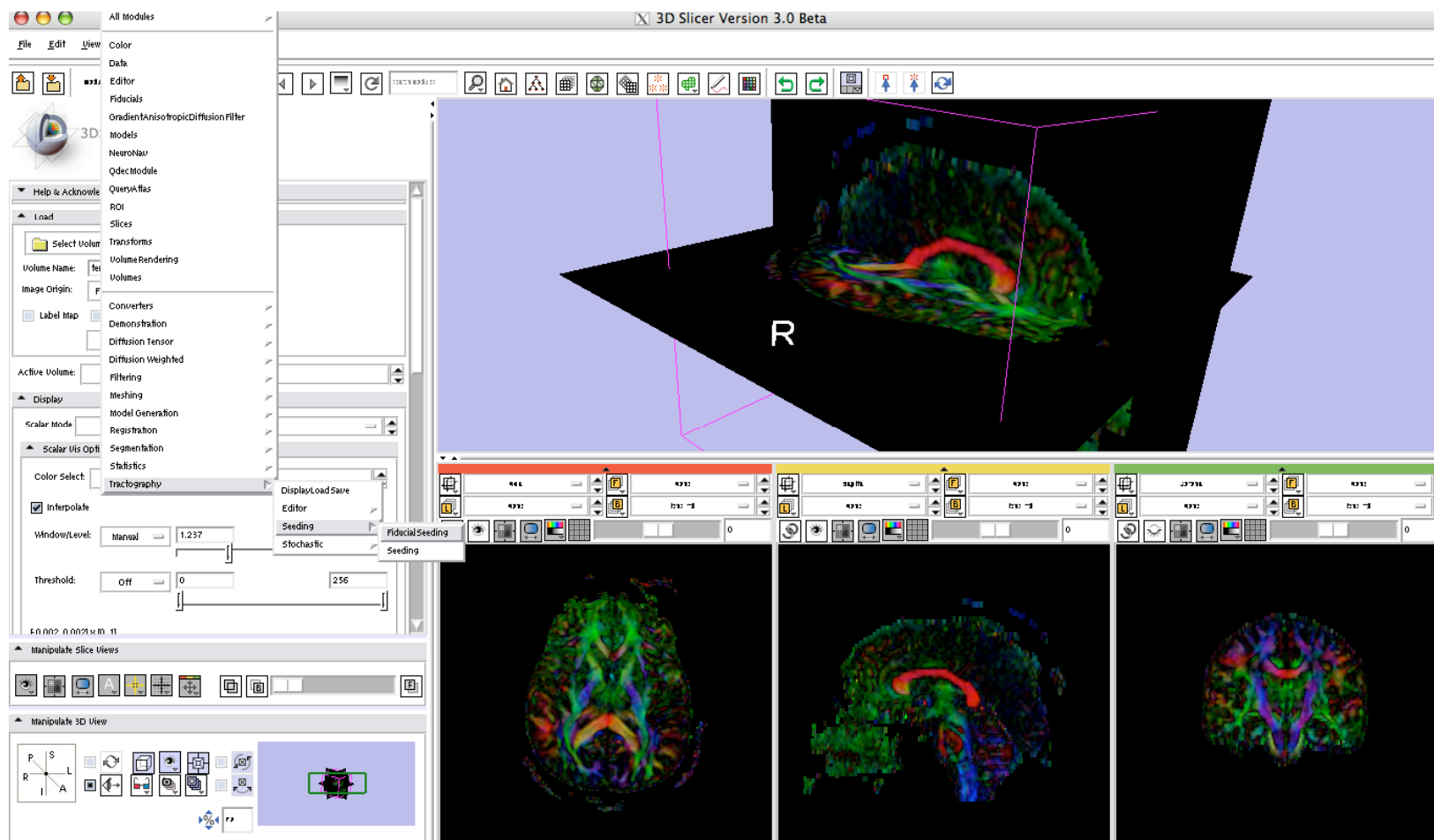1.- Visualize the tensor volume in the most appropriate way to select fiducials

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Performing tractography with fiducial seedings

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

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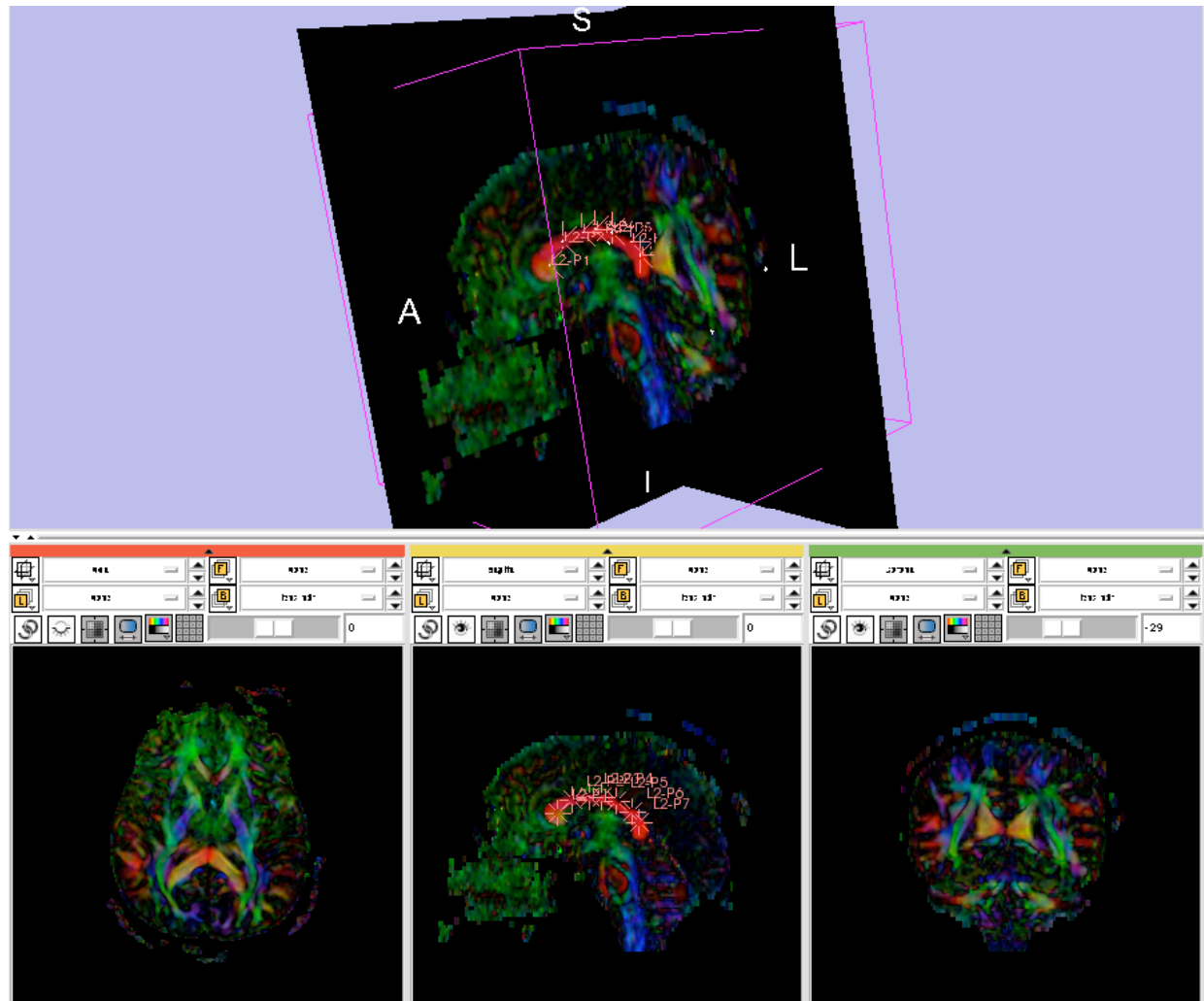http://www.slicer.org

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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)
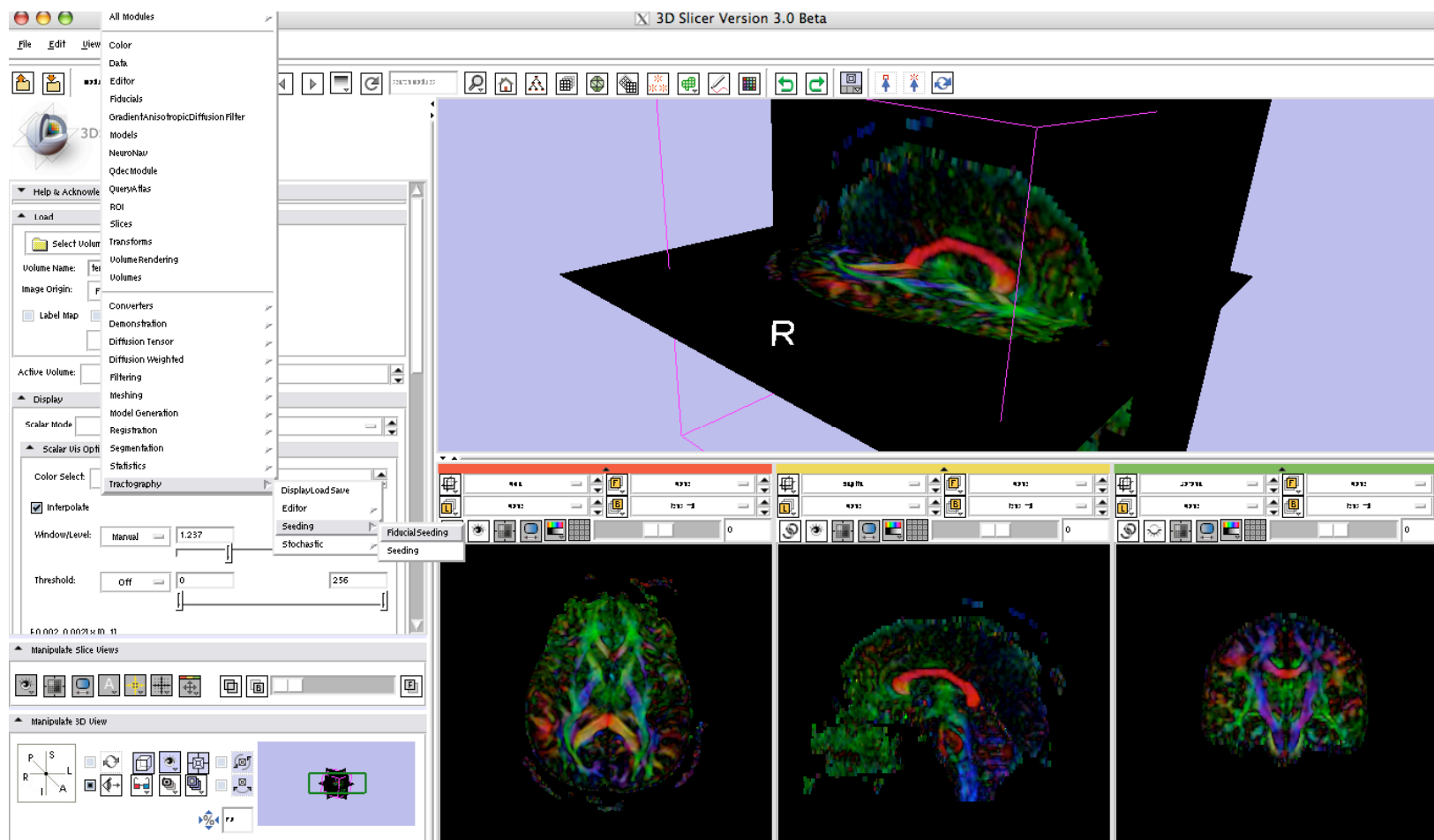
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Performing tractography with fiducial seedings

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

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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.

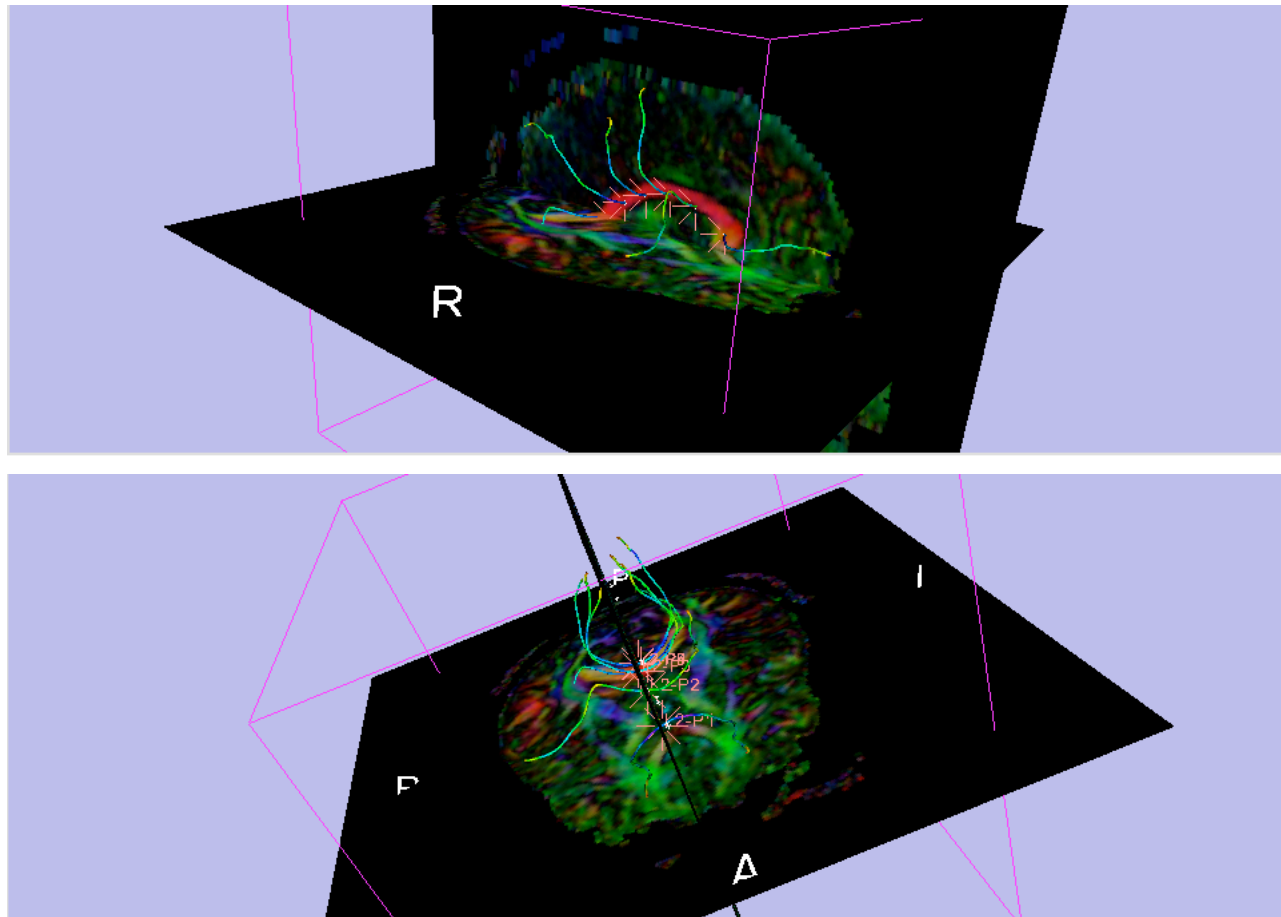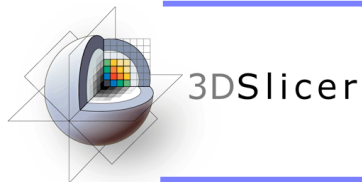**Surgical Planning Laboratory**
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Performing tractography with fiducial seedings

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

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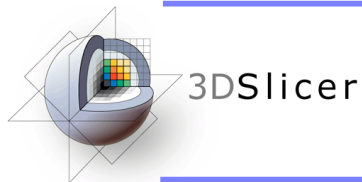http://www.slicer.org

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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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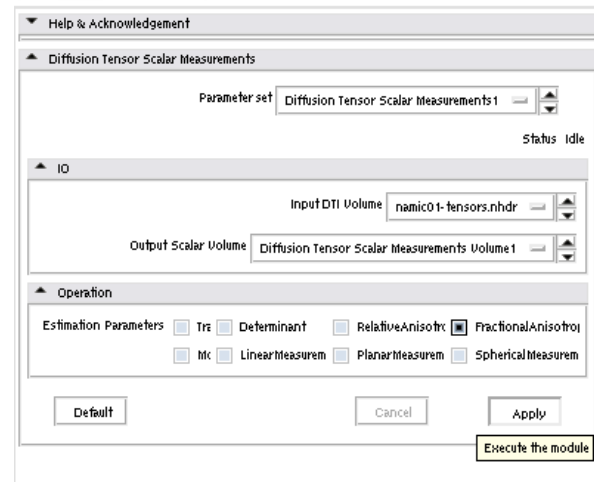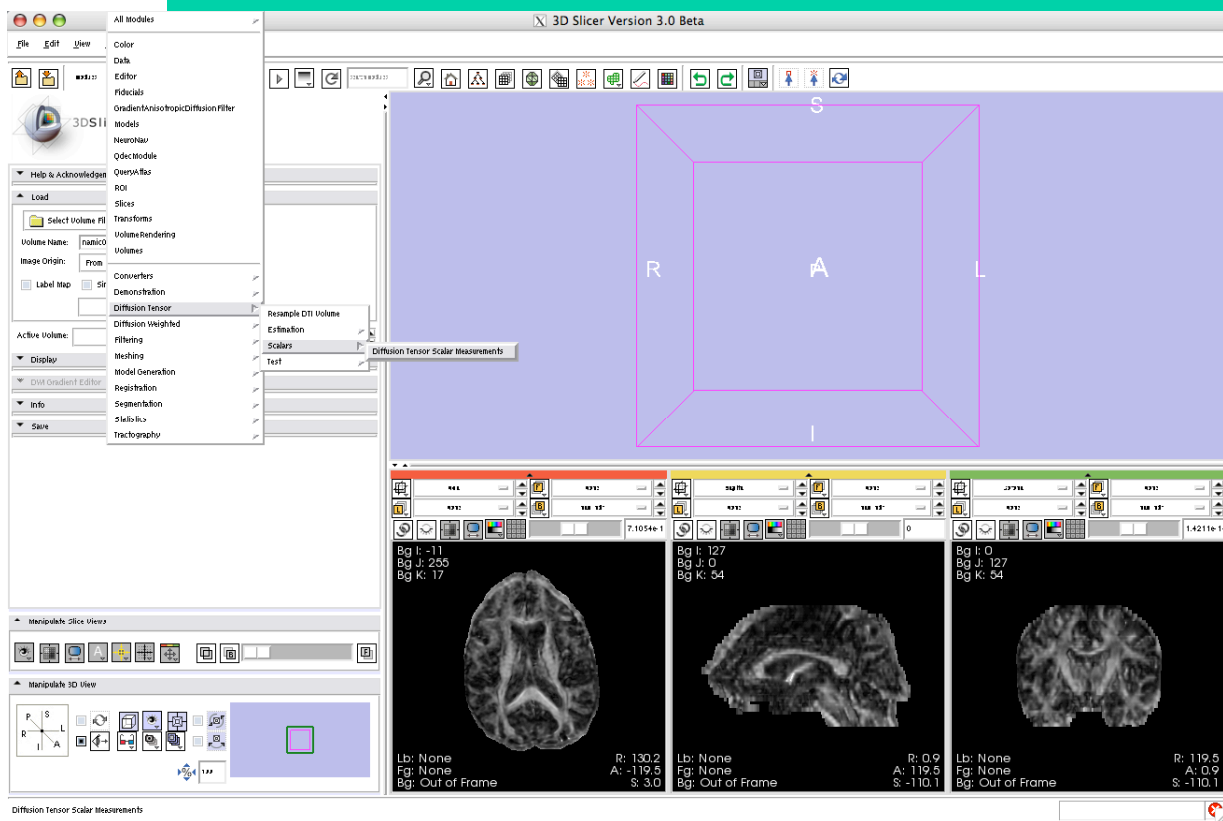
Performing tractography with ROI seeding

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

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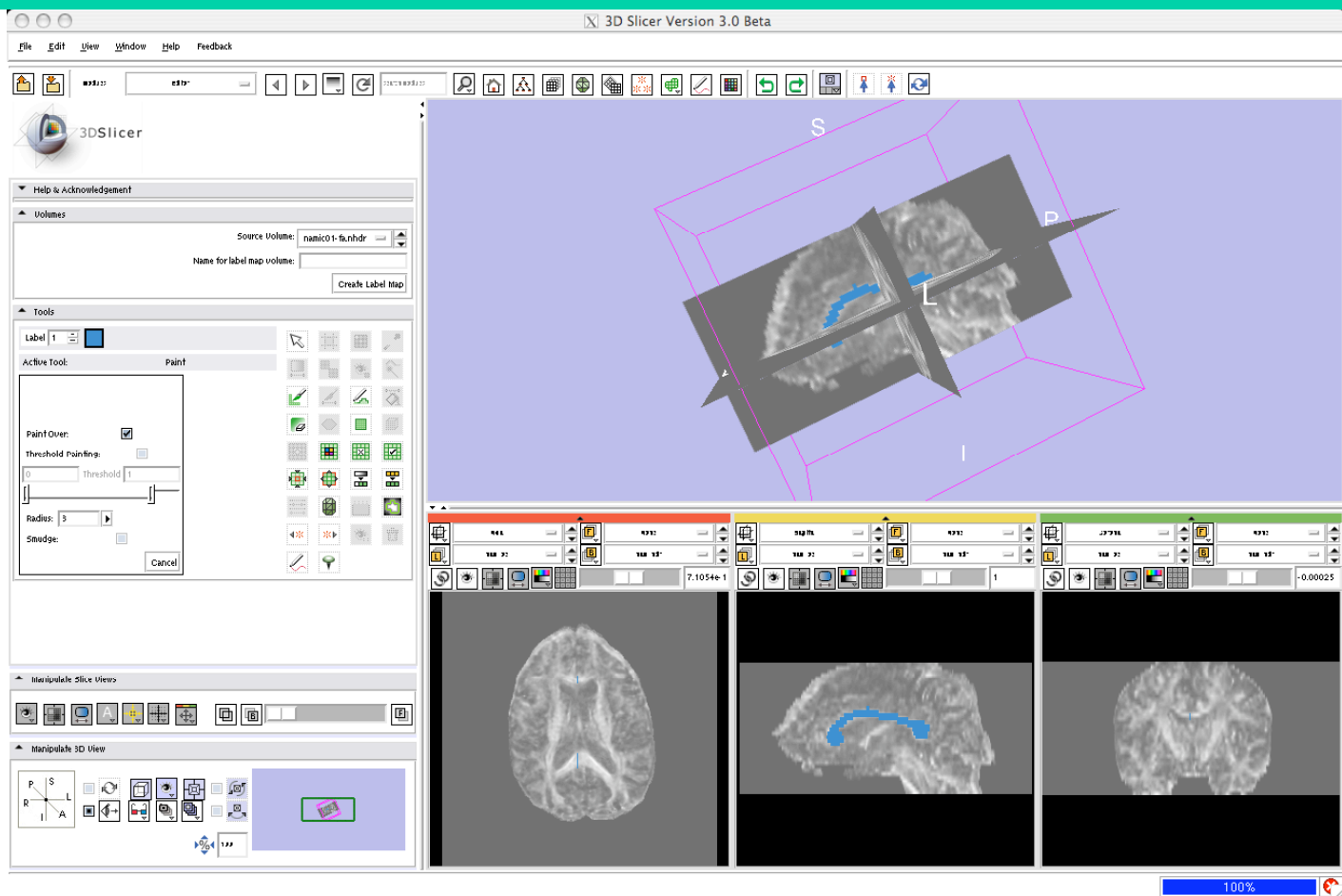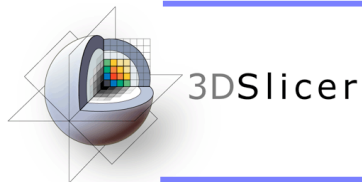
Performing tractography with ROI seeding

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

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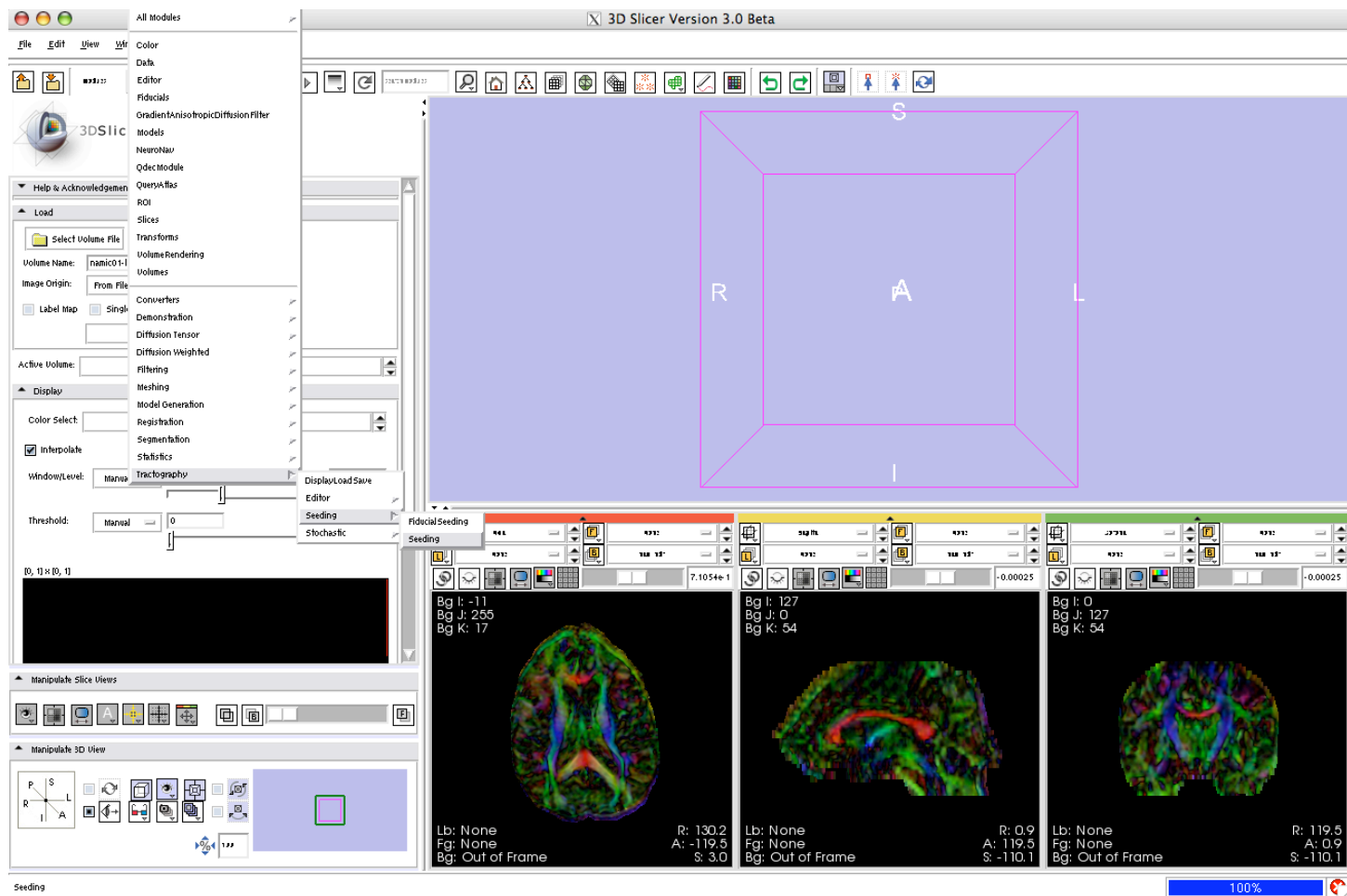
Performing tractography with ROI seeding

5.- Select the parameters, and click Apply

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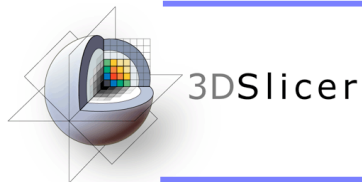
Performing tractography with ROI seeding

The obtained tracts will appear in the 3D view.

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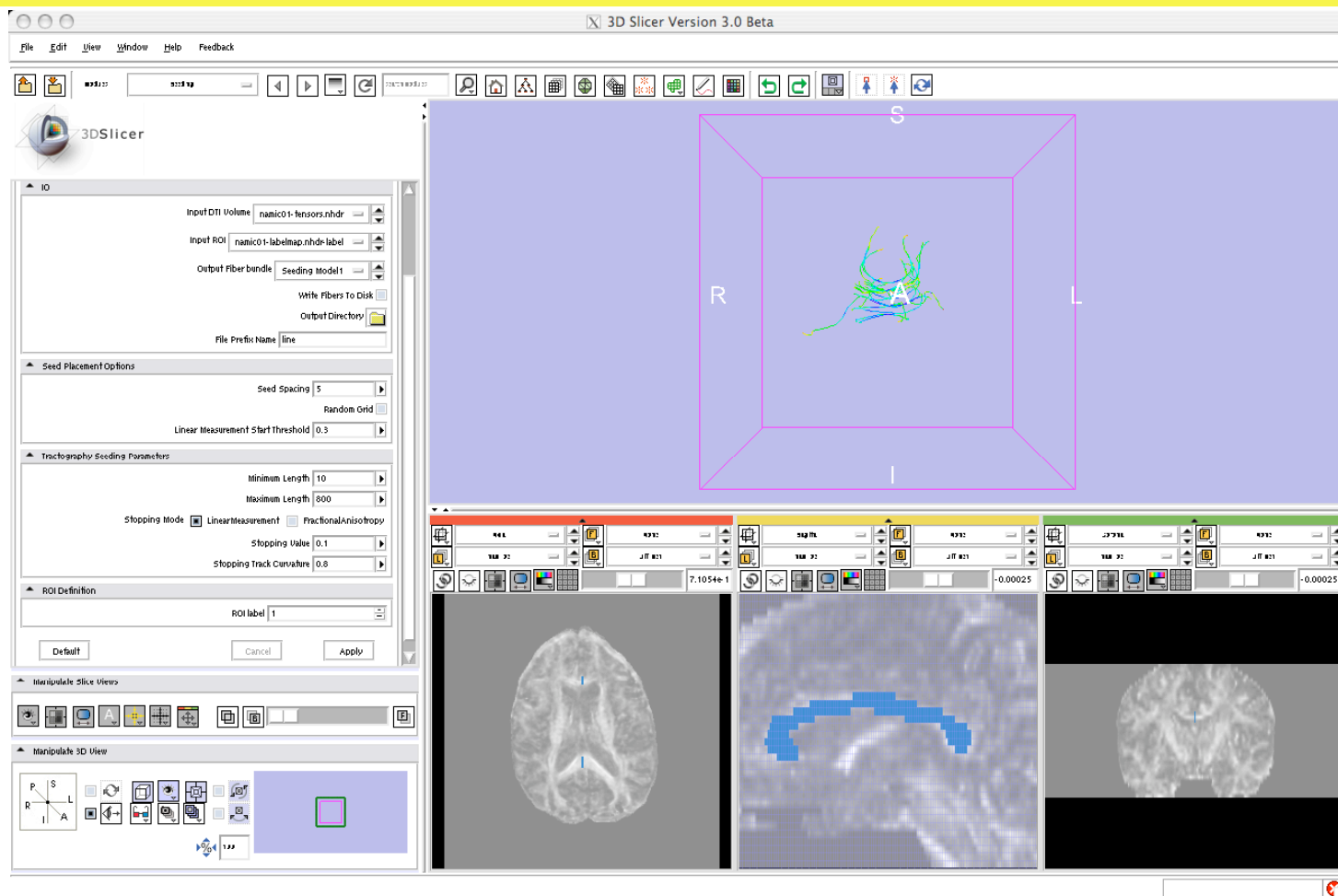
Performing tractography with ROI seeding

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

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