Exploring Peritumoral White Matter Fibers for Neurosurgical Planning

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Clinical Goal

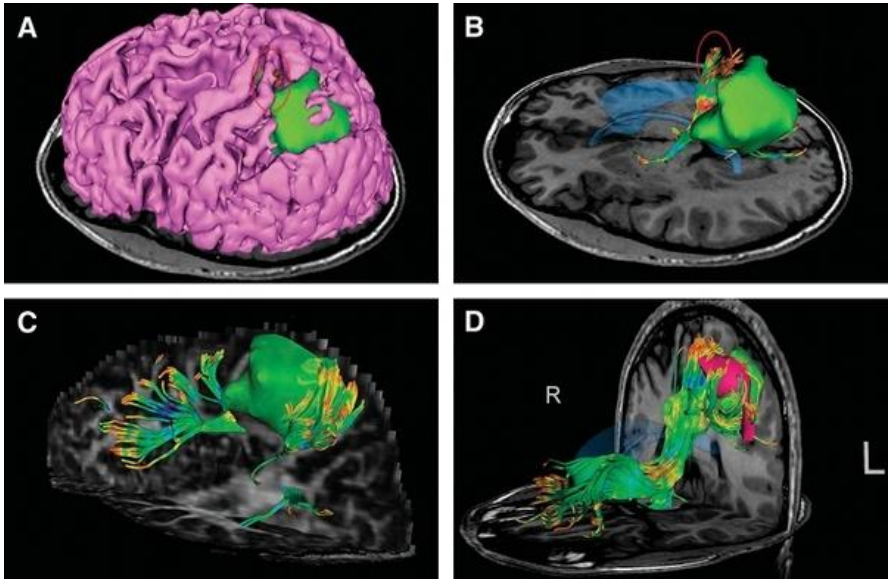
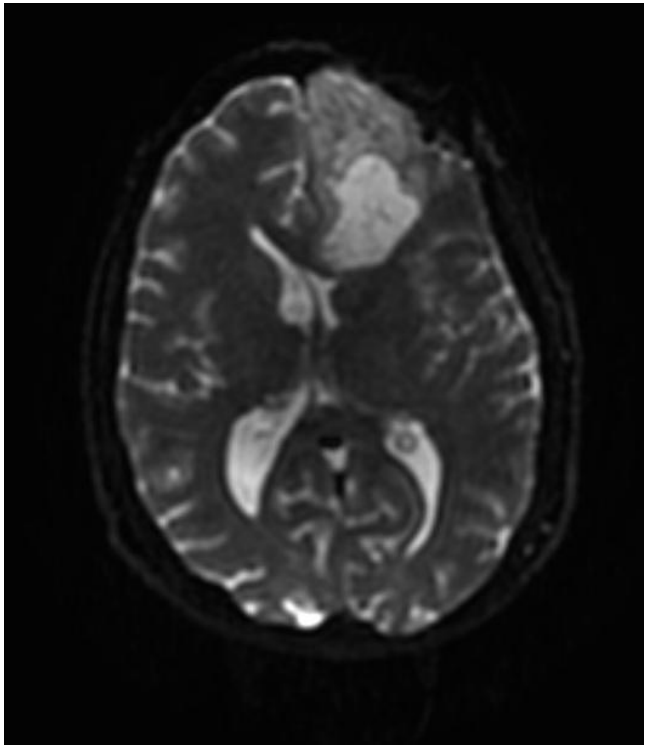


Image Courtesy of Dr. Alexandra Golby, Brigham and Women's Hospital, Boston, MA..

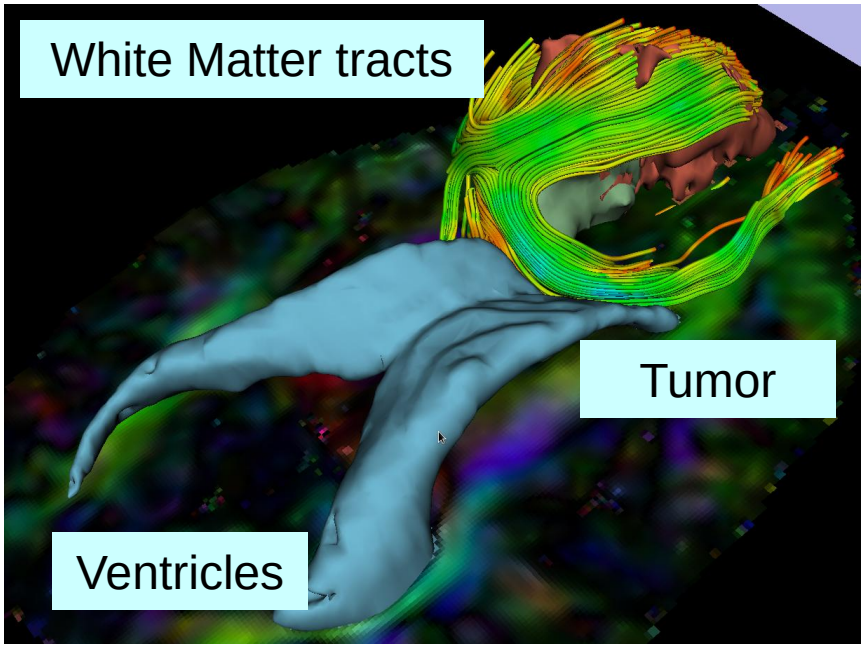
Diffusion Tensor Imaging (DTI) Tractography has the potential to bring valuable spatial information on tumor infiltration and tract displacement for neurosurgical planning of tumor resection.

Clinical Case



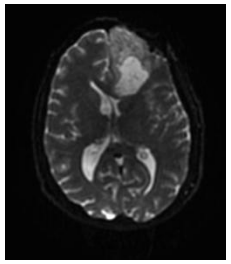
- 35 year-old male diagnosed with Glioblastoma multiforme (GBM)
- Diffusion Weighted Imaging (DWI) acquisition for neurosurgical planning

Clinical Goal

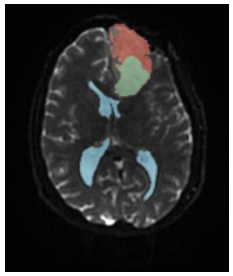


The goal of this tutorial is to explore white matter fibers surrounding a tumor using Diffusion Tensor Imaging (DTI) Tractography.

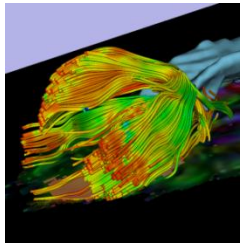
Overview of the analysis pipeline



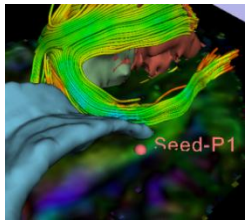
Part 1: Loading &Visualization of Diffusion Data



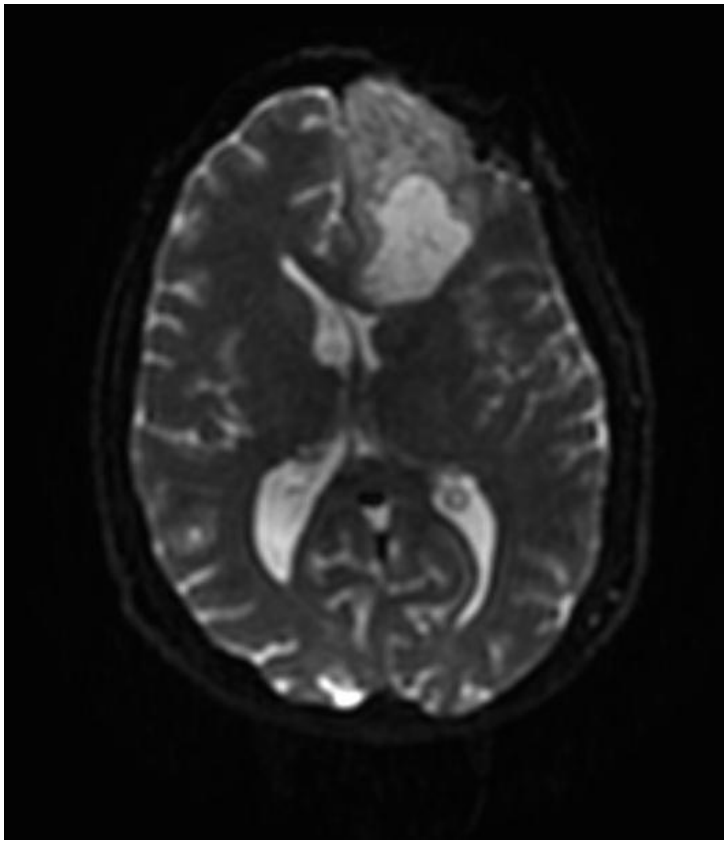
Part 2: Segmentation of the ventricles, and solid and cystic parts of the tumor



Part 3: Tractography reconstruction of the white matter fibers in the peri-tumoral volume

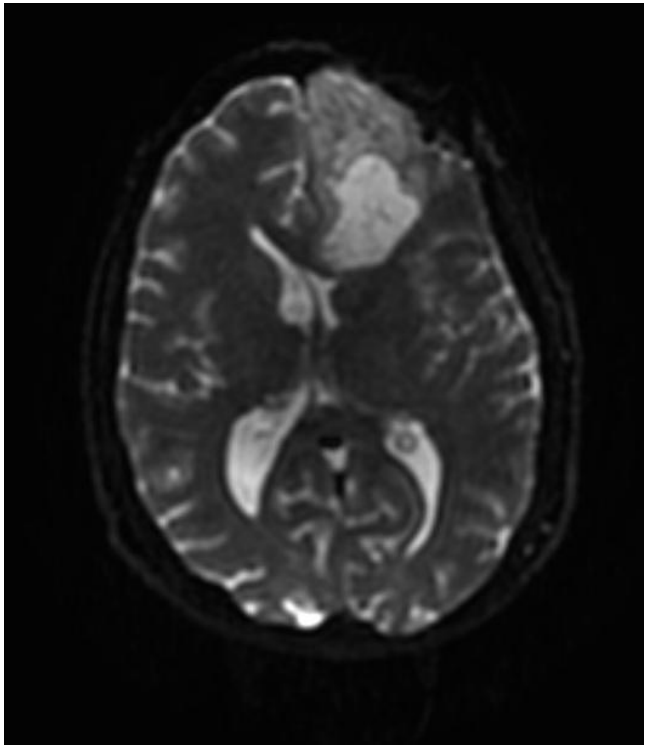


Part 4: Tractography exploration of the ipsilateral and contralateral side



Part 1: Loading and Visualization of Diffusion Data

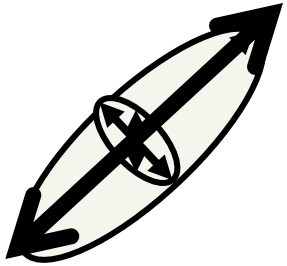
Diffusion Tensor Imaging



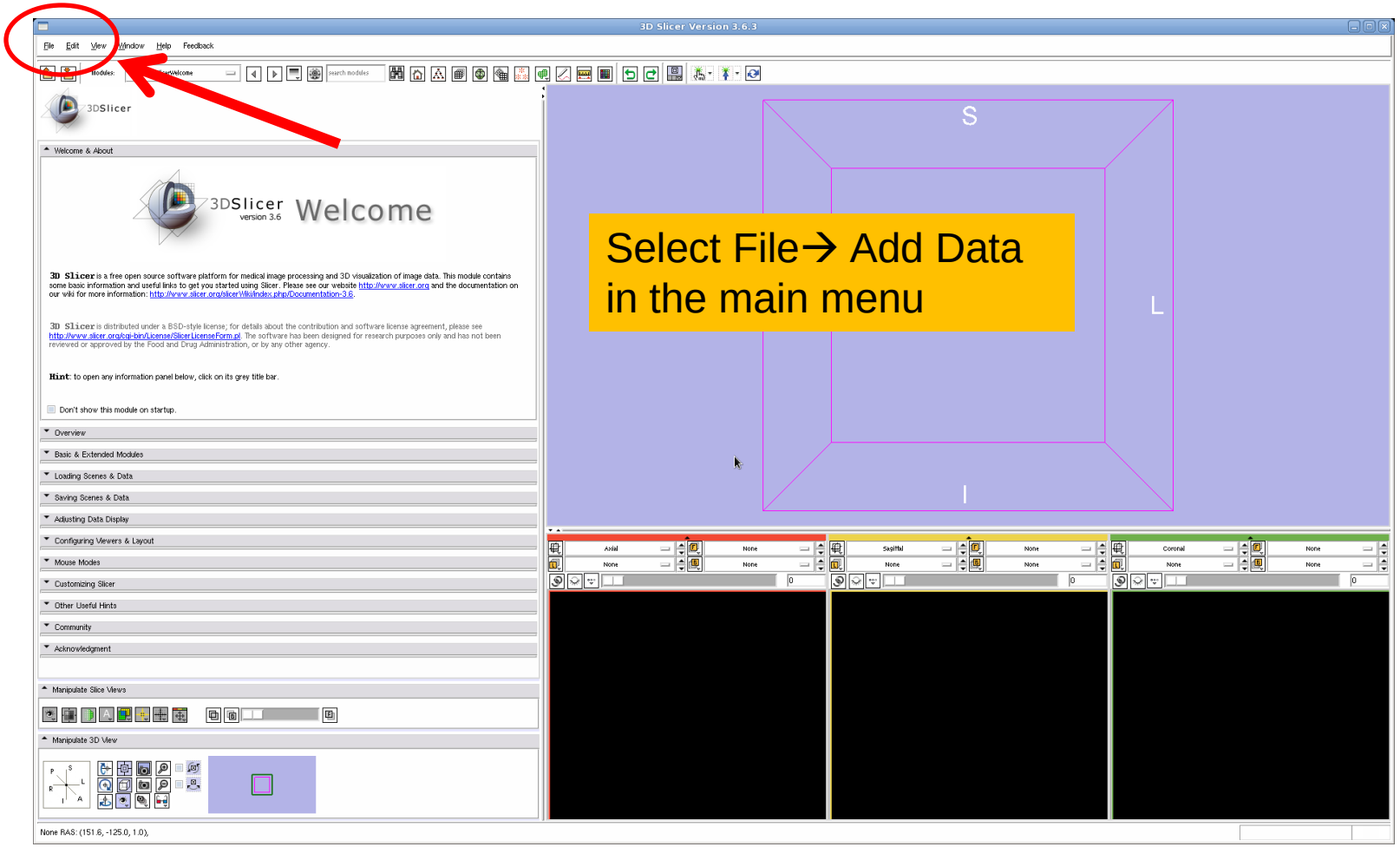
$$S_i = S_0 e^{-b\hat{g}i^T \underline{D} \hat{g}_i}$$

(Stejskal and Tanner 1965, Basser 1994)

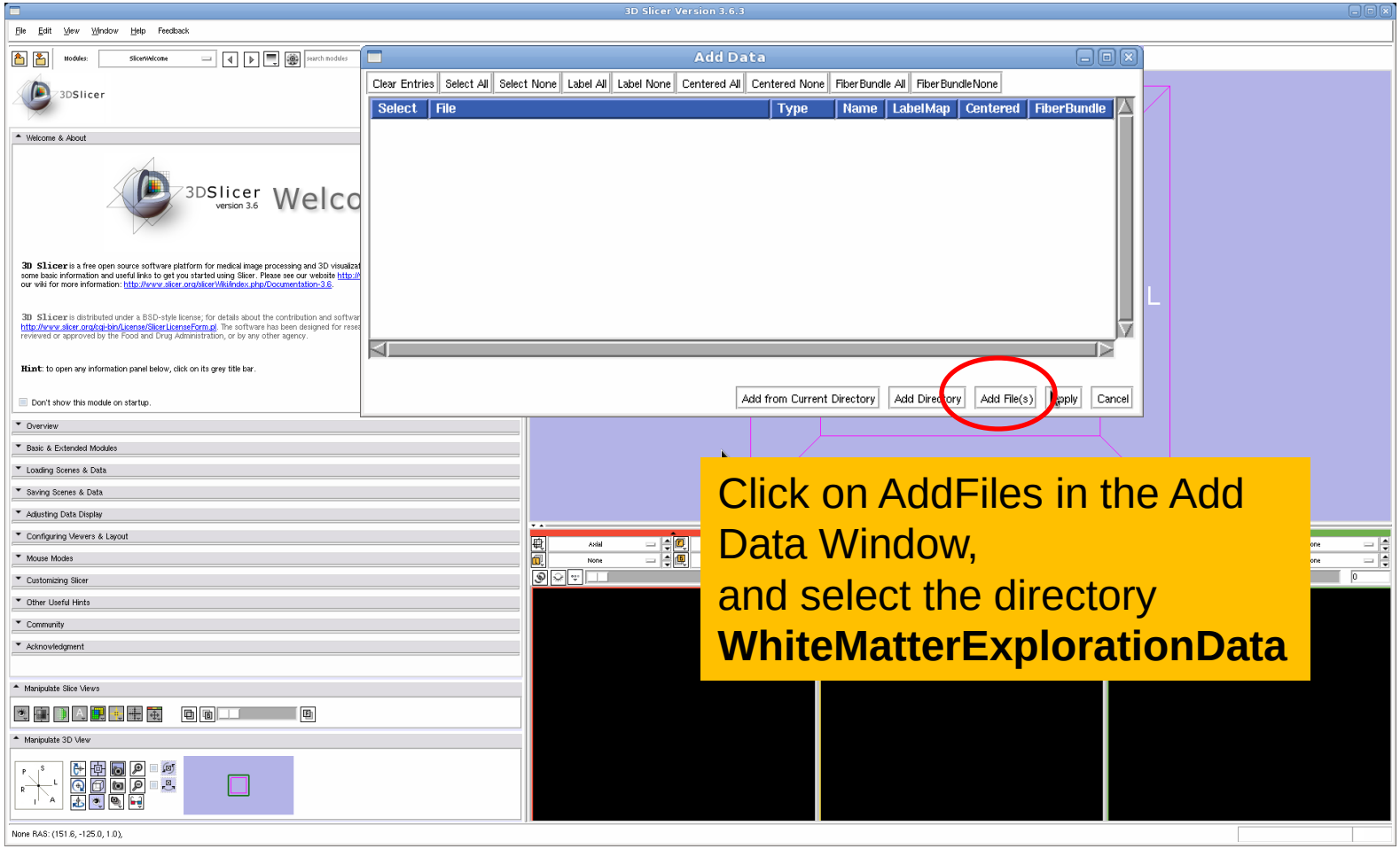
$$\underline{\mathbf{D}} = \begin{bmatrix} D_{xx} & D_{xy} & D_{xz} \\ D_{yx} & D_{yy} & D_{yz} \\ D_{zx} & D_{zy} & D_{zz} \end{bmatrix}$$



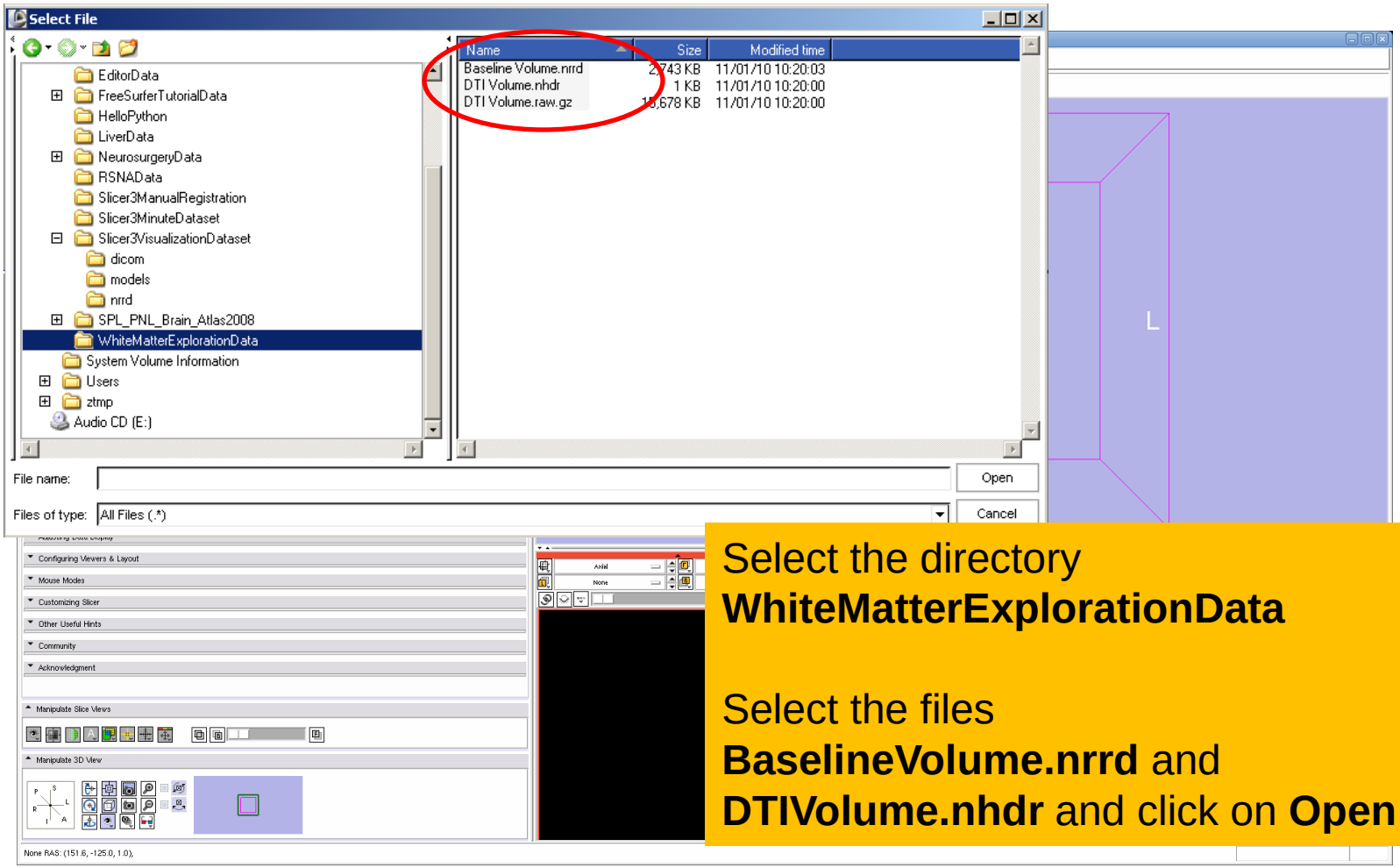
Loading DTI and Baseline Data



Loading DTI and Baseline Data



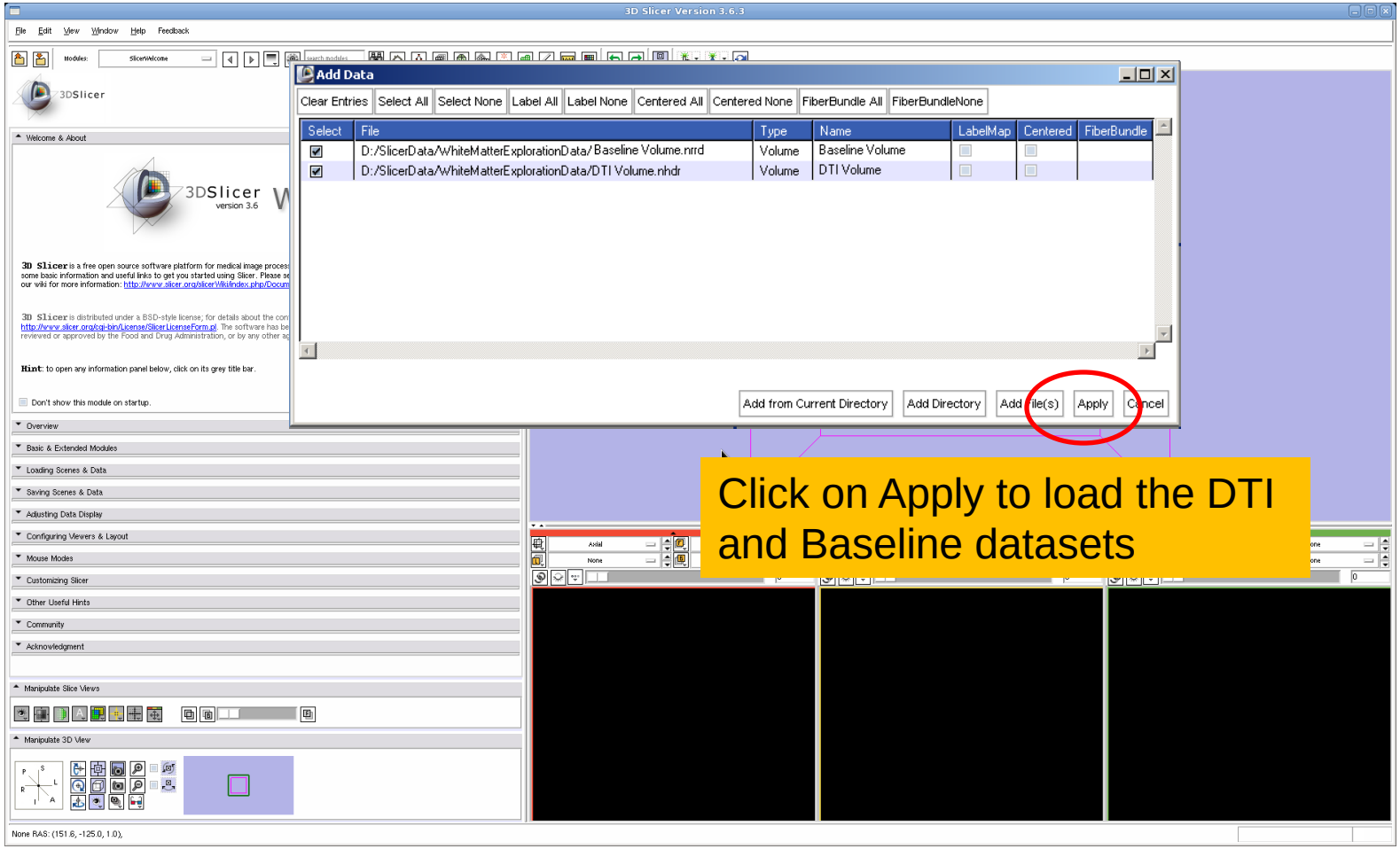
Loading DTI and Baseline Data



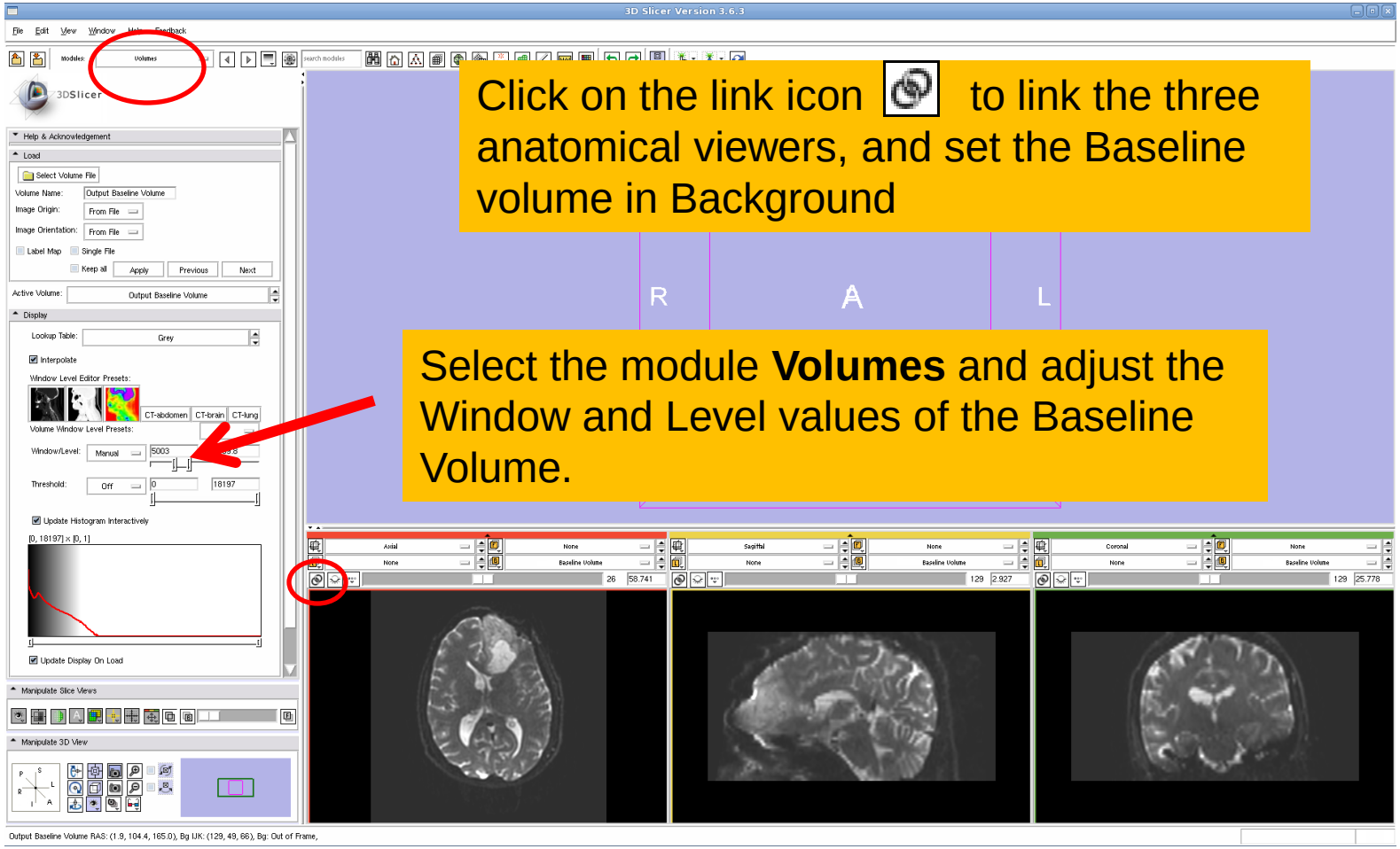
Select the directory **WhiteMatterExplorationData**

Select the files **BaselineVolume.nrrd** and **DTIVolume.nhdr** and click on **Open**

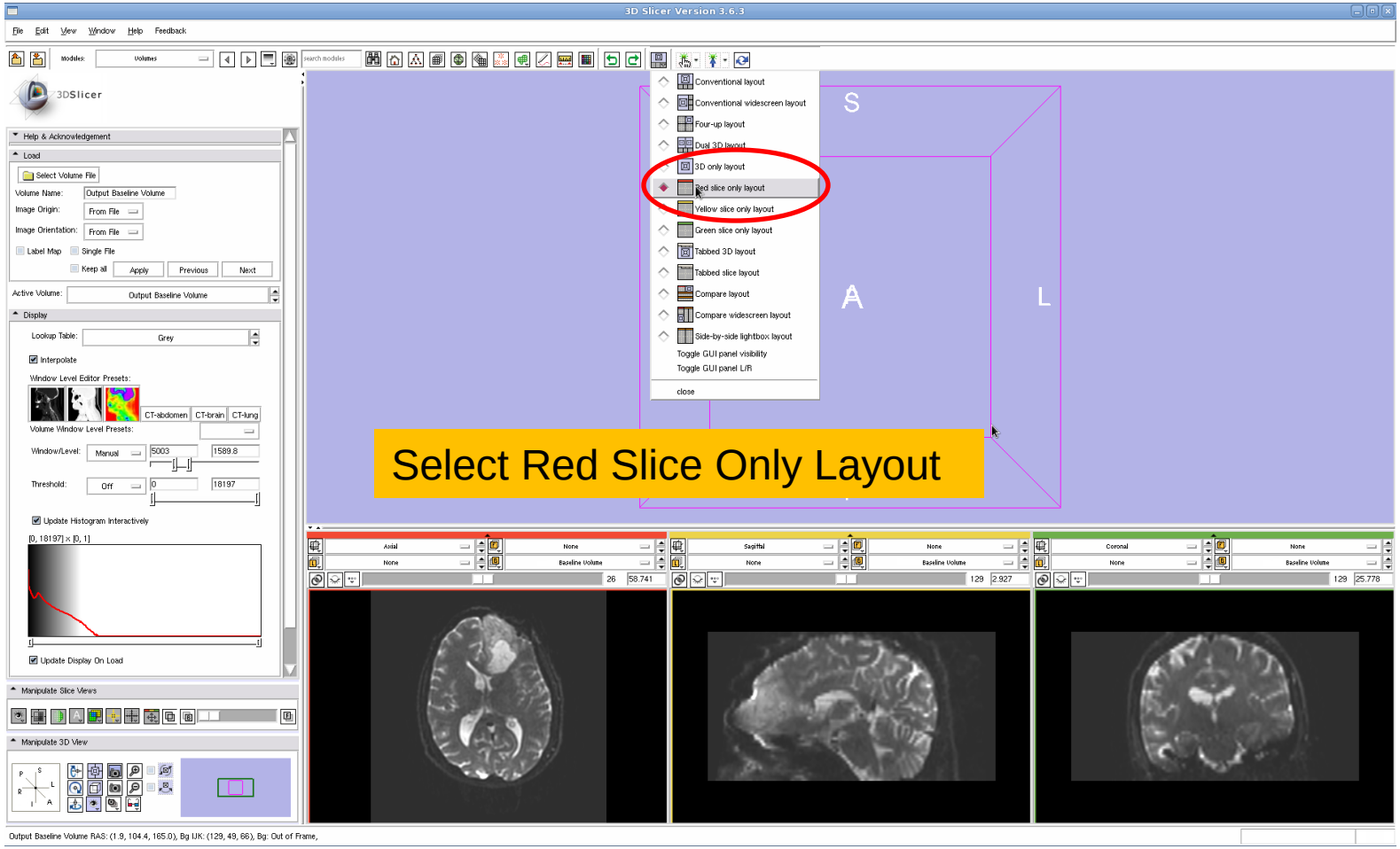
Loading DTI and Baseline Data

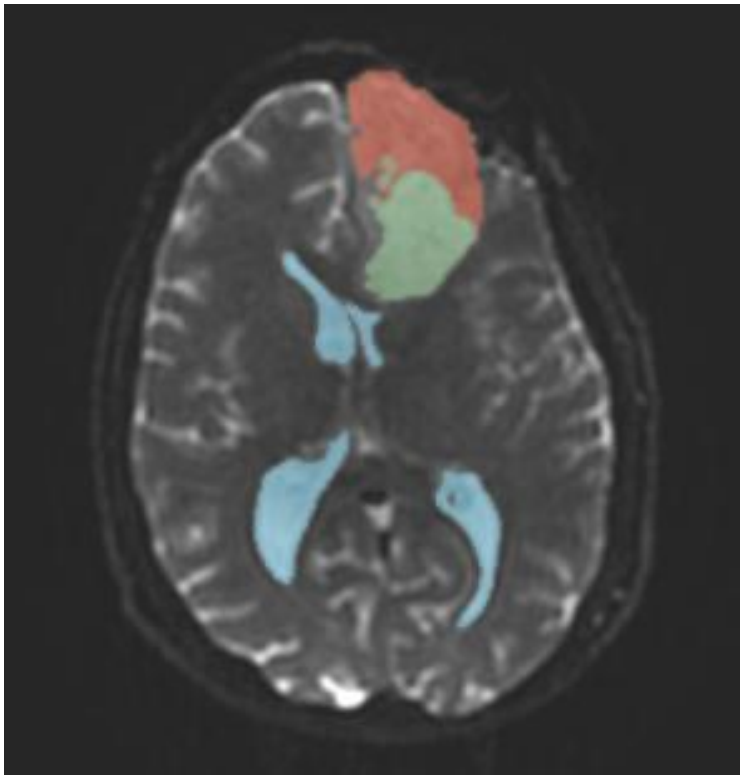


Loading DTI and Baseline Data



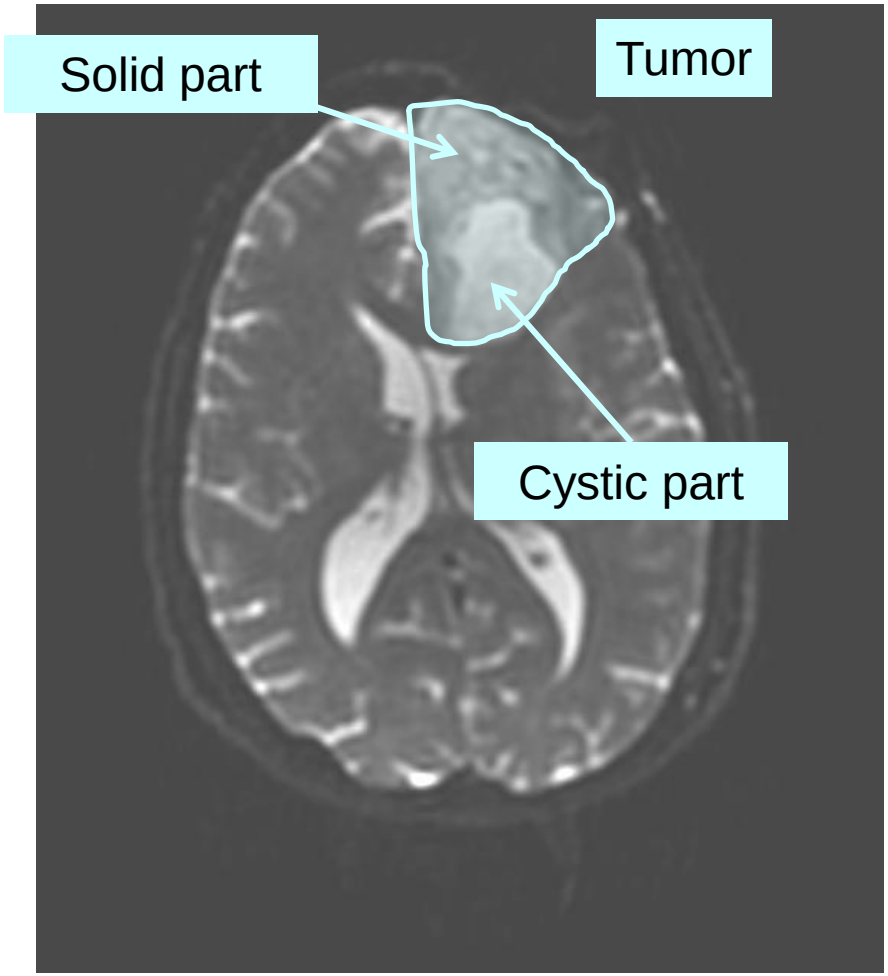
Loading DTI and Baseline Data





Part 1:
Segmenting the tumor and ventricles

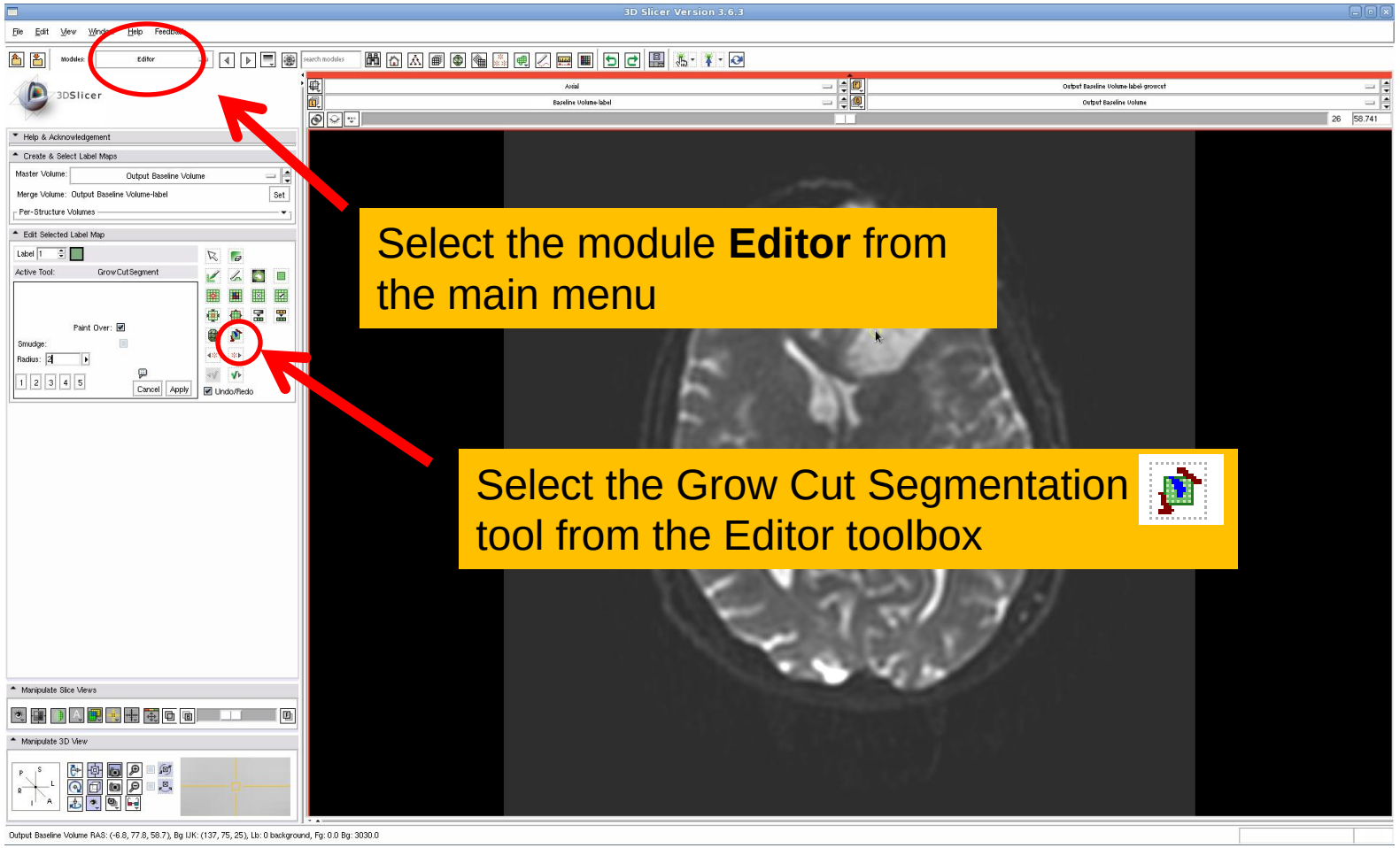
Tumor Segmentation



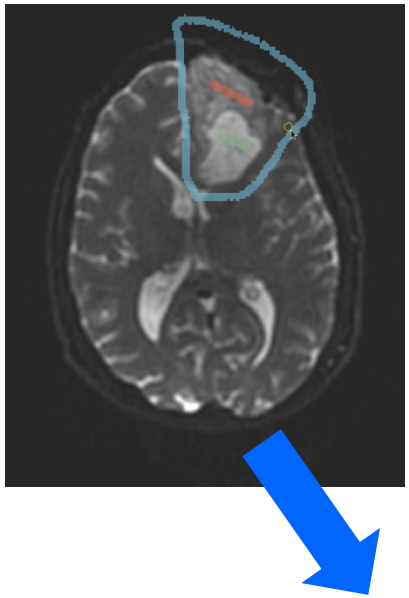
The tumor in this clinical case is composed of two parts: a solid part, and a cystic part.

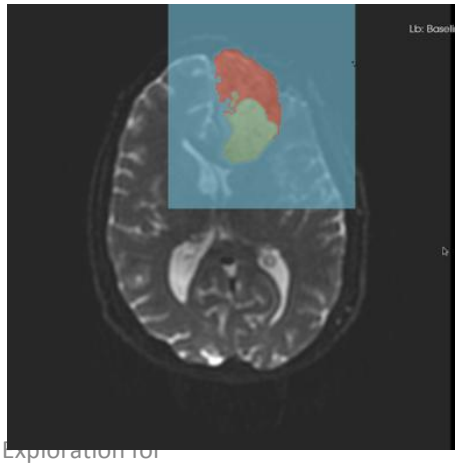
In this section, we'll segment the different parts of the tumor using a Grow Cut Segmentation algorithm.

Tumor Segmentation



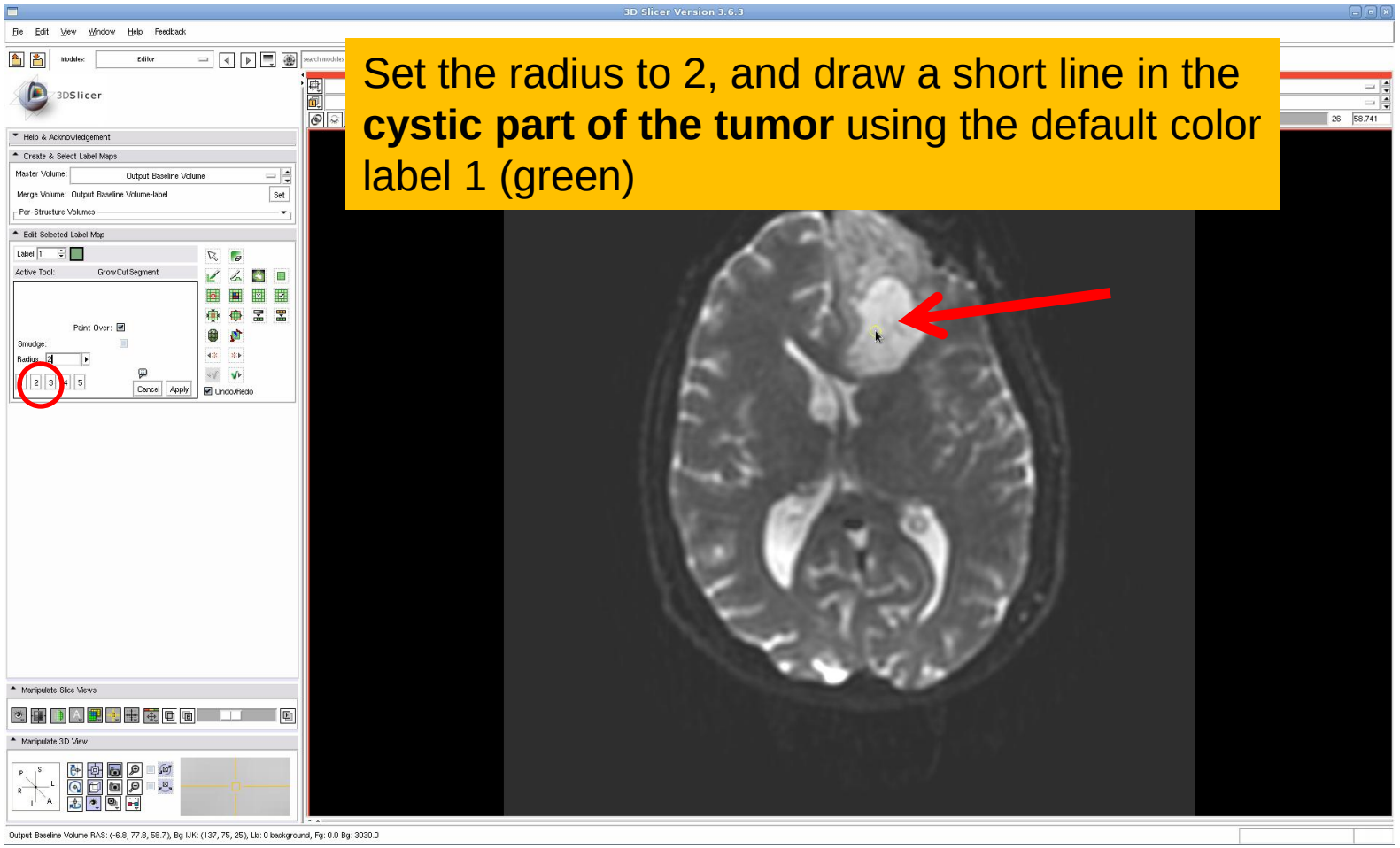
Grow Cut Segmentation





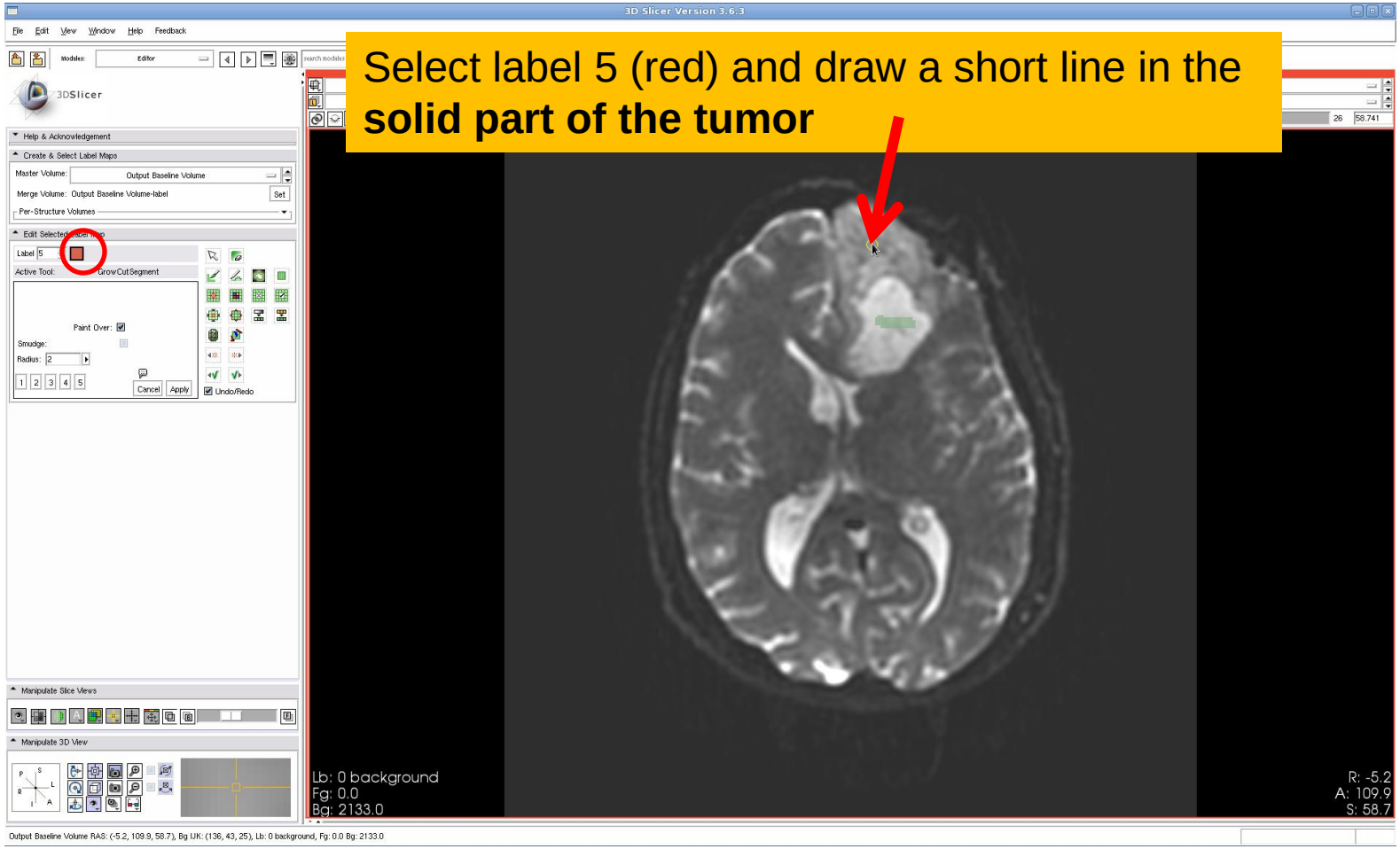
- The **Grow Cut Segmentation method** is a competitive region growing algorithm using Cellular Automata.
- The algorithm performs multi-label image segmentation using a set of user input scribbles.
- V. Vezhnevets, V. Konouchine. "Grow-Cut" - Interactive Multi-Label N-D Image Segmentation". *Proc. Graphicon*. 2005 . pp. 150–156.

Tumor Segmentation

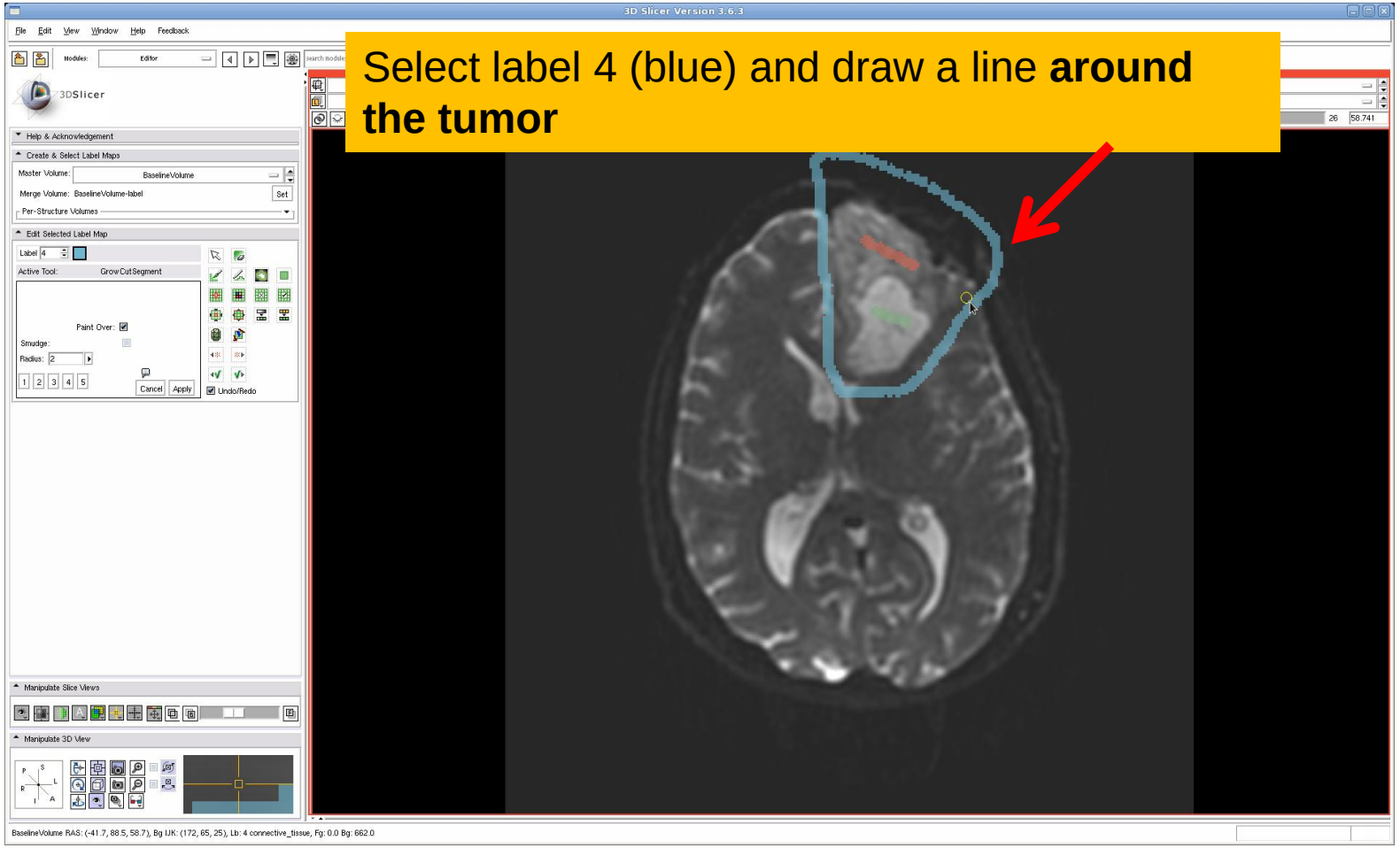


Set the radius to 2, and draw a short line in the **cystic part of the tumor** using the default color label 1 (green)

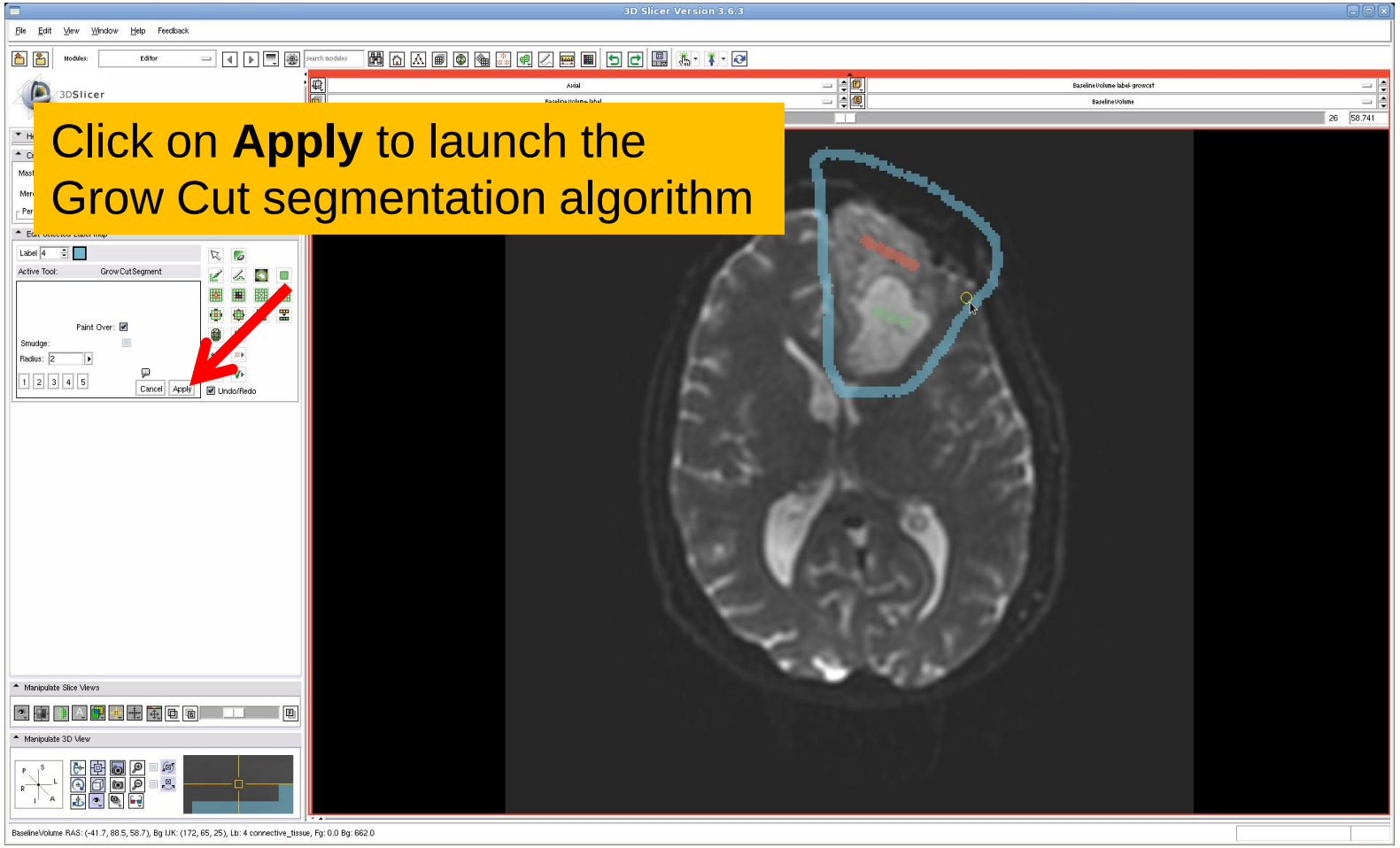
Tumor Segmentation



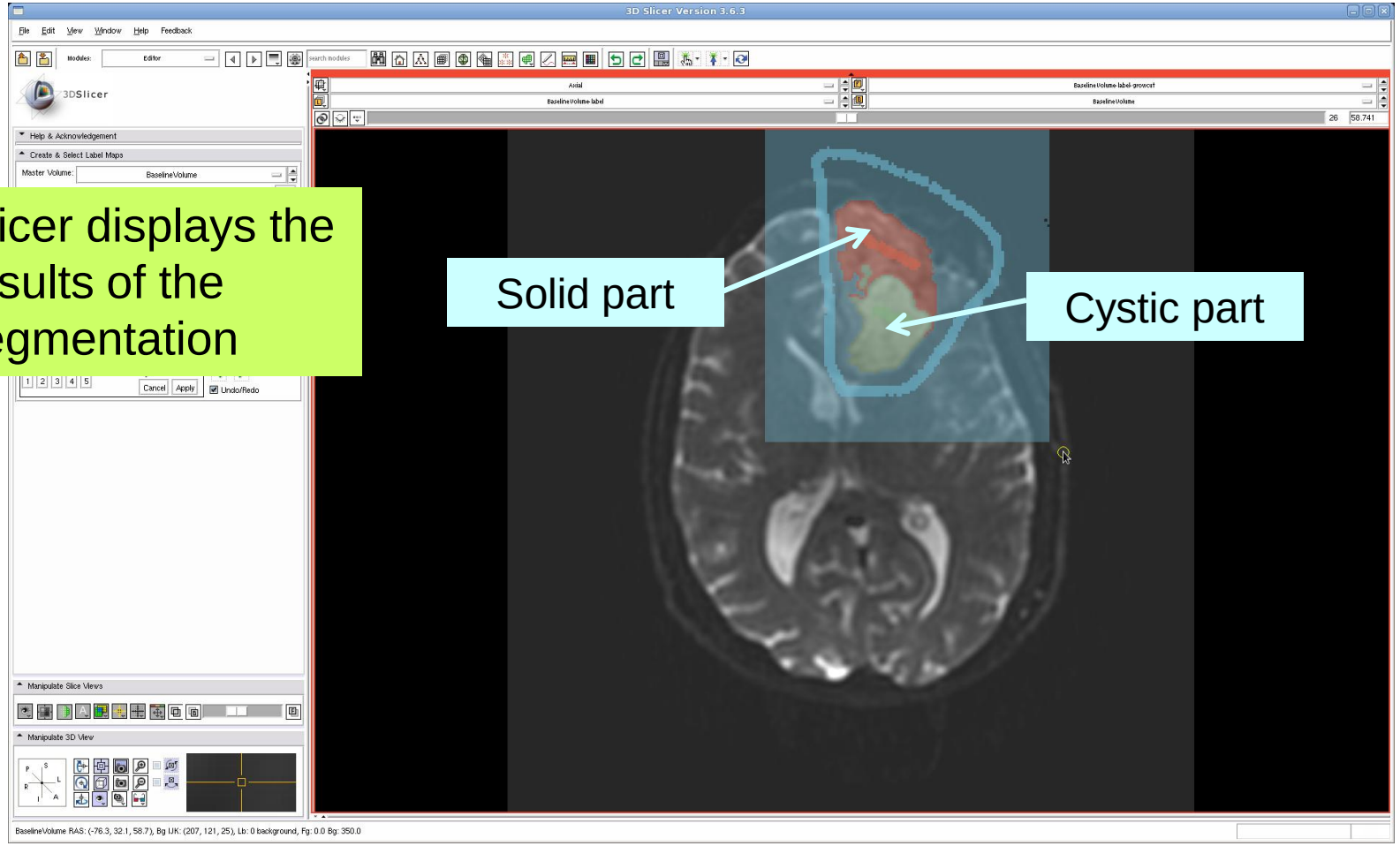
Tumor Segmentation



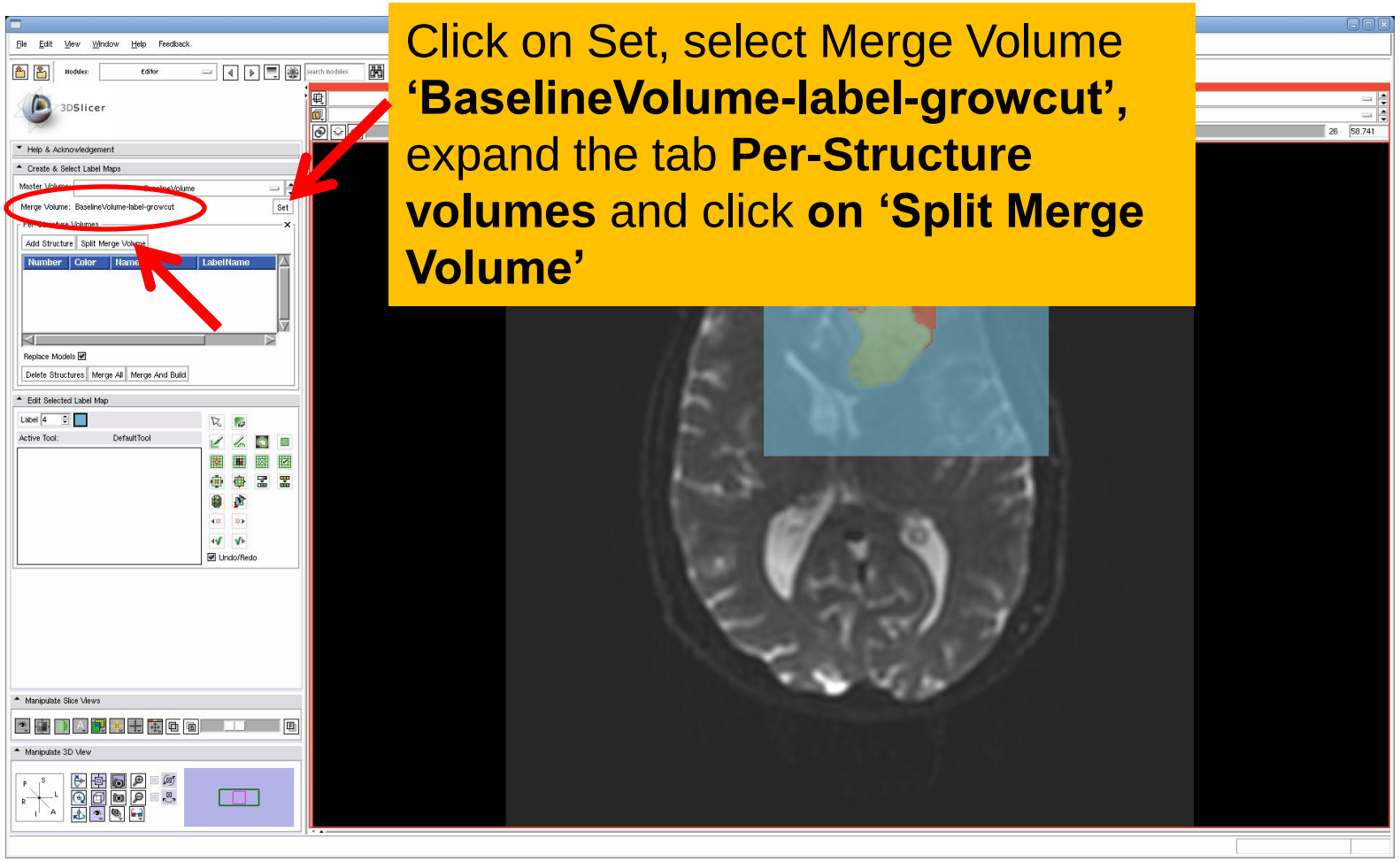
Tumor Segmentation



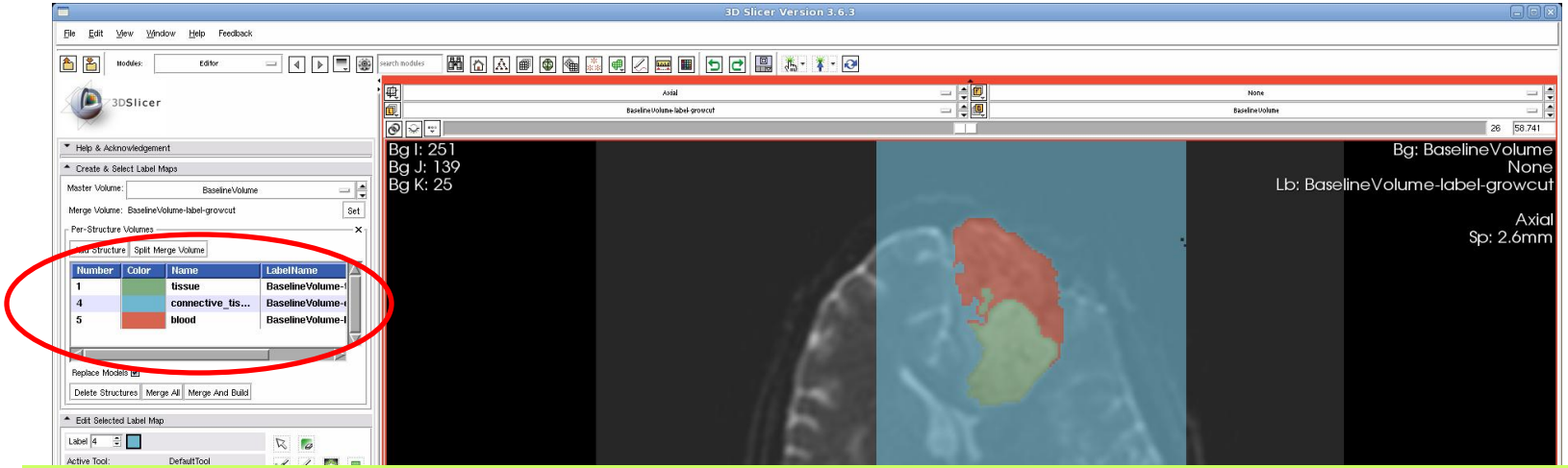
Tumor Segmentation



Tumor Segmentation



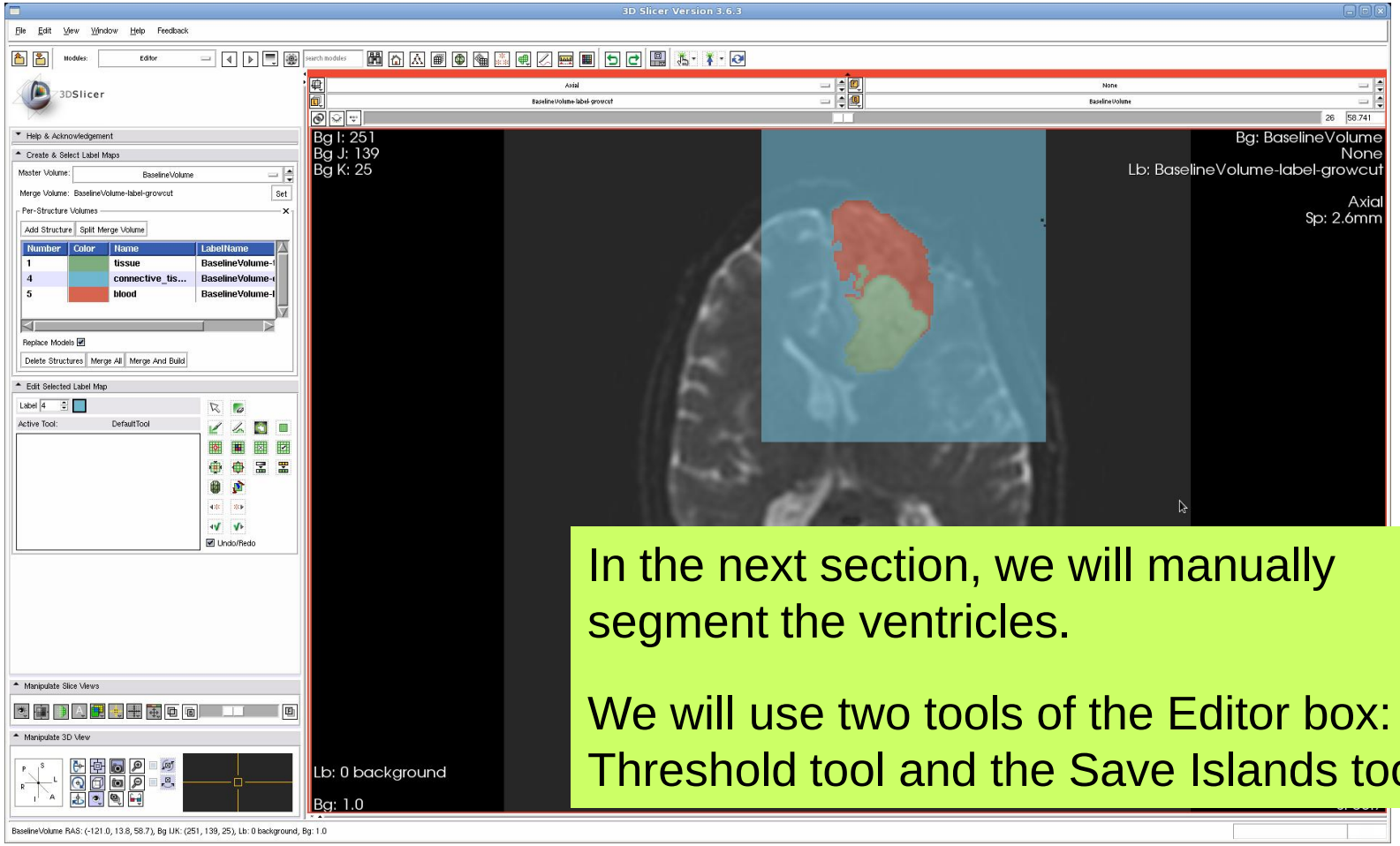
Tumor Segmentation



The label map **BaselineVolume-label-growcut** has been split into three volumes:

-**BaselineVolume-tissue-label** (label1): cystic part of the tumor
-**BaselineVolume-connective_tissue-label** (label 4): ventricles
-**BaselineVolume-blood-label** (label 5): solid part of the tumor

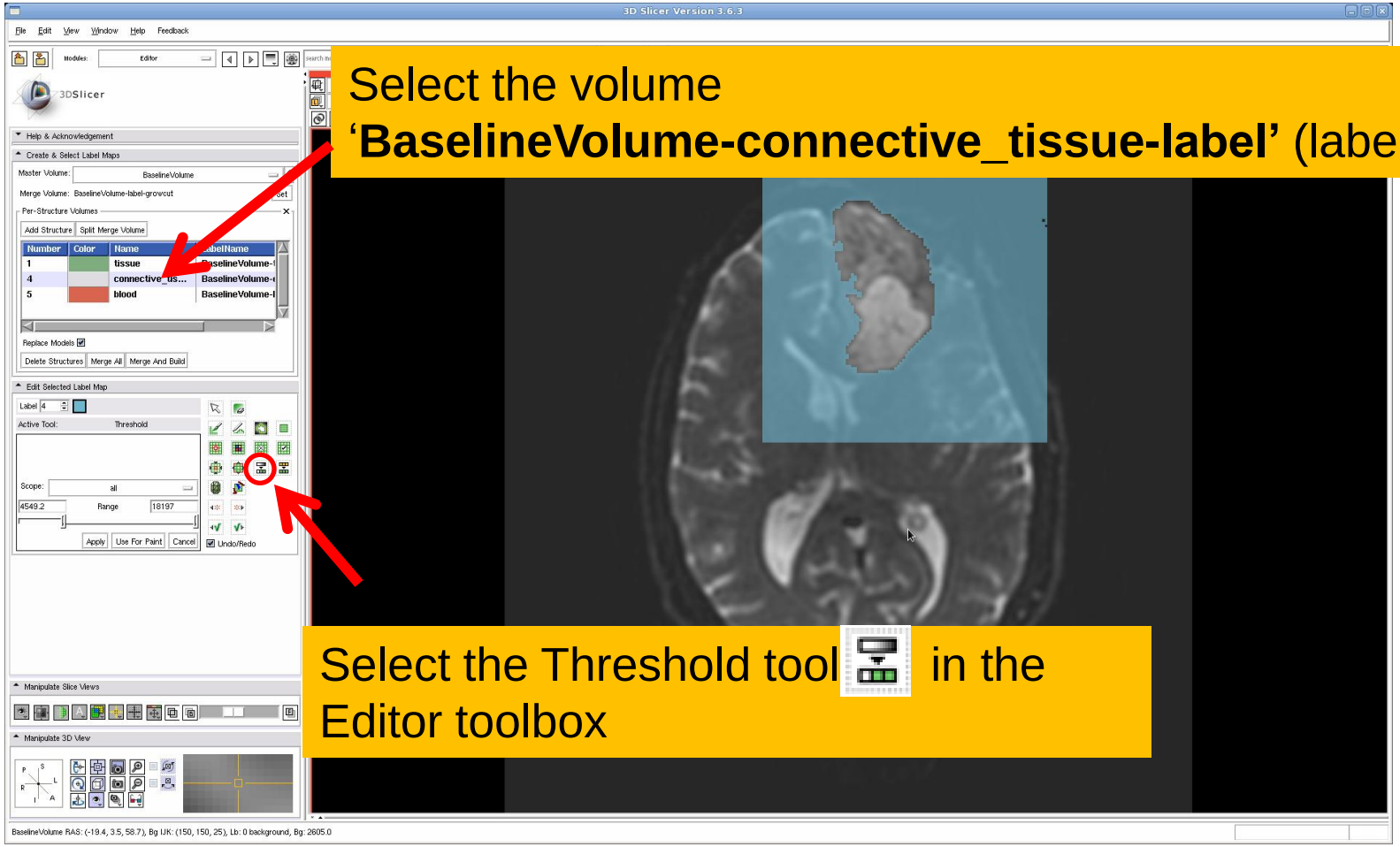
Ventricles Segmentation



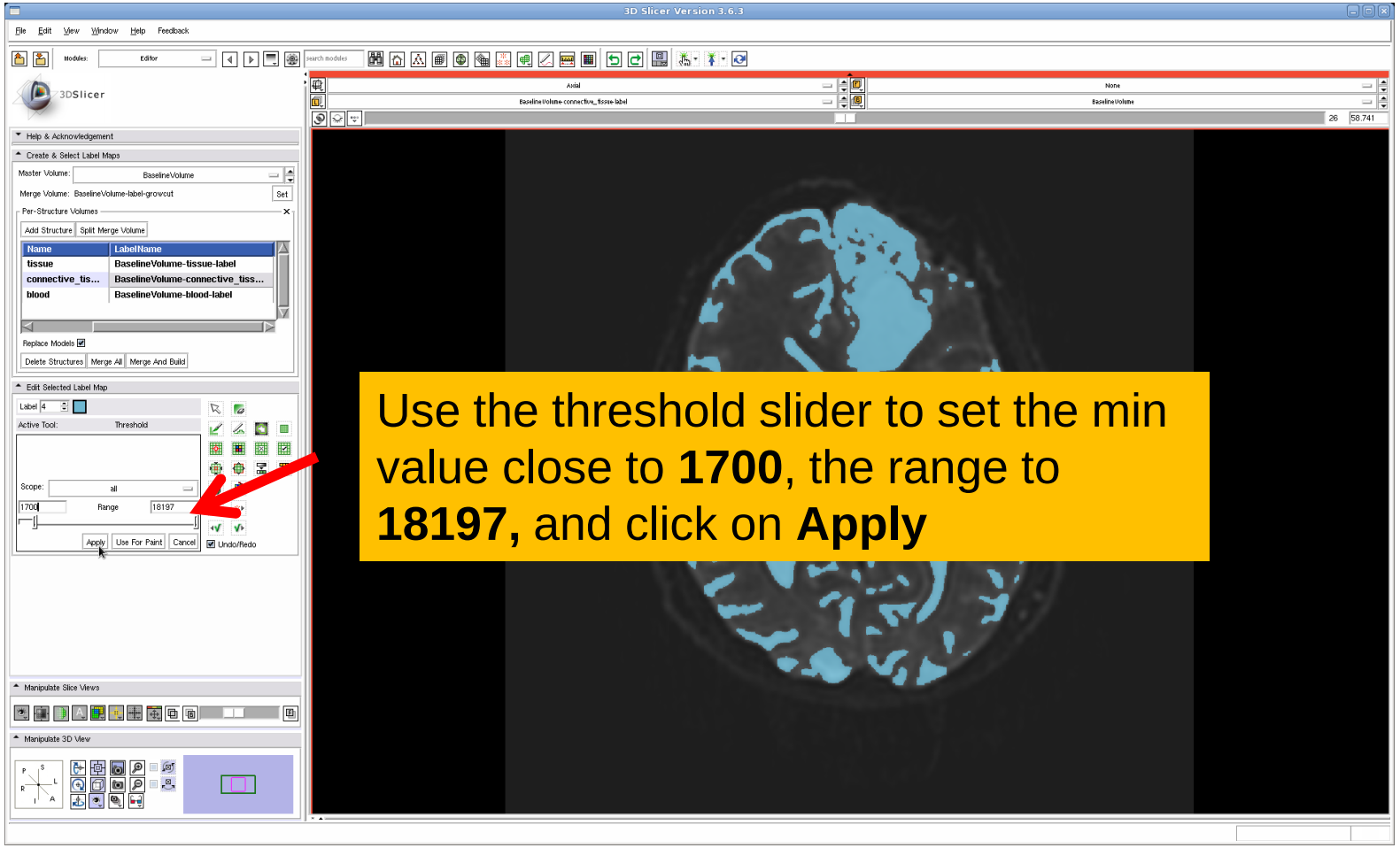
In the next section, we will manually segment the ventricles.

We will use two tools of the Editor box: the Threshold tool and the Save Islands tool.

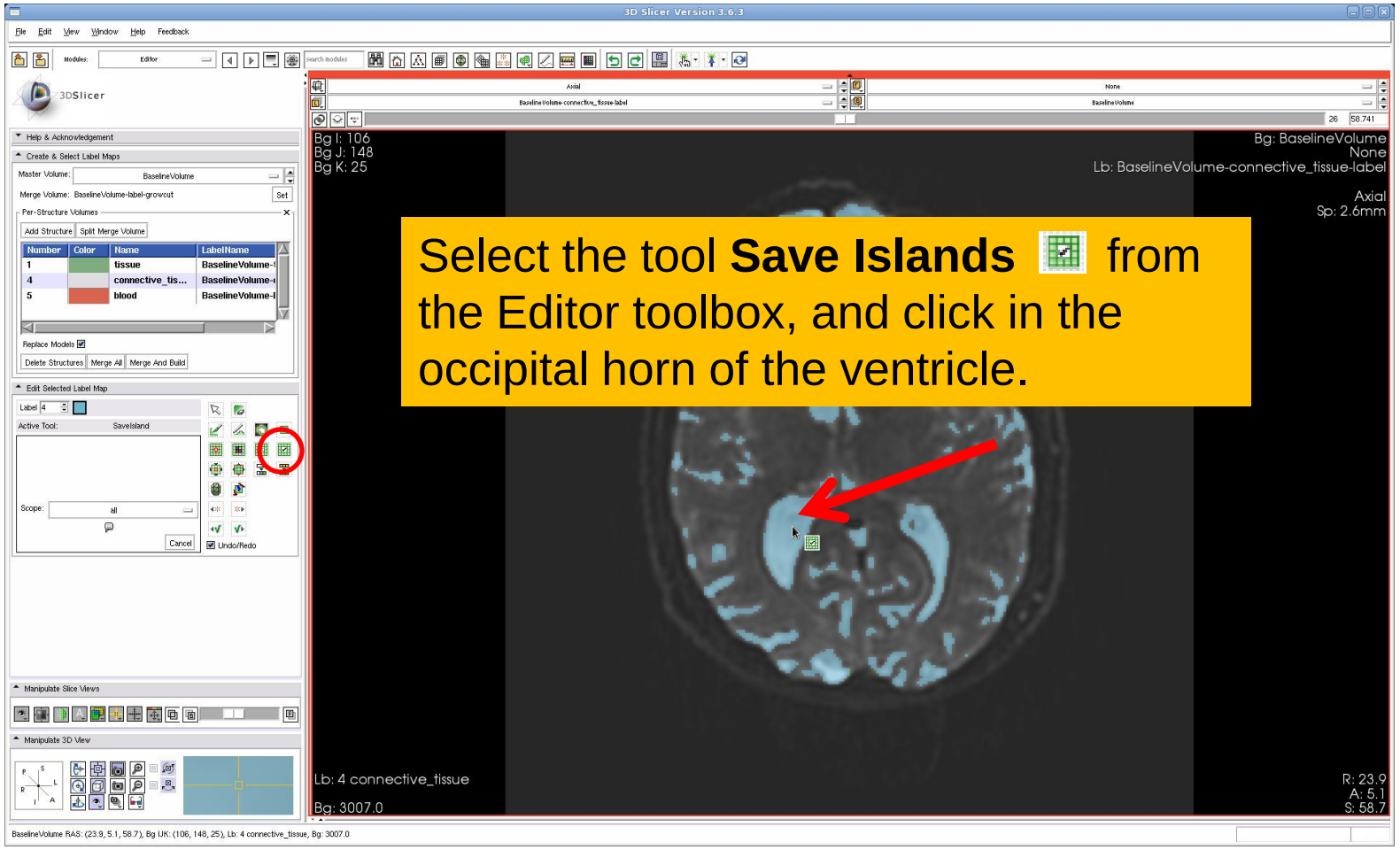
Ventricles Segmentation



Ventricles Segmentation



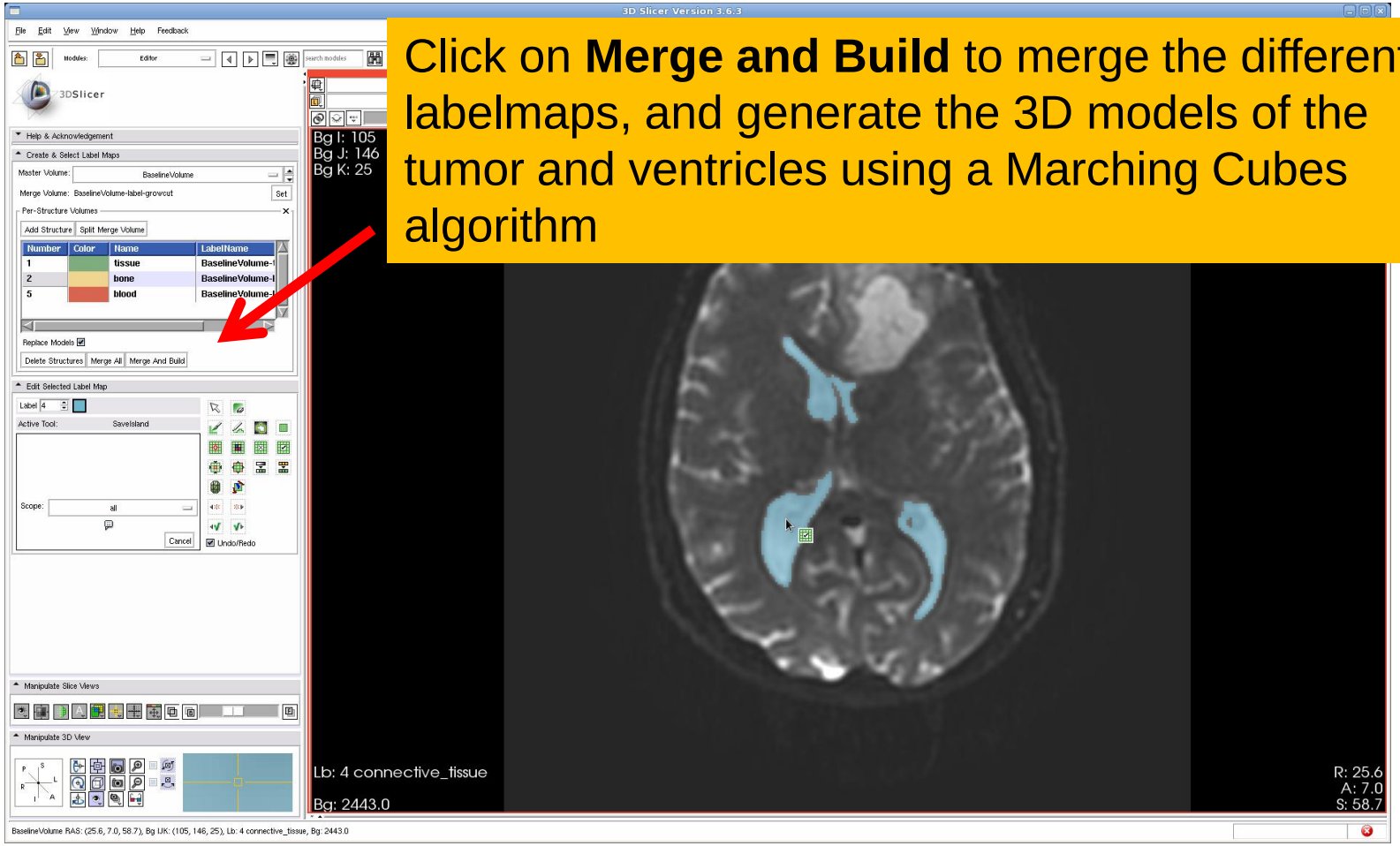
Ventricles Segmentation



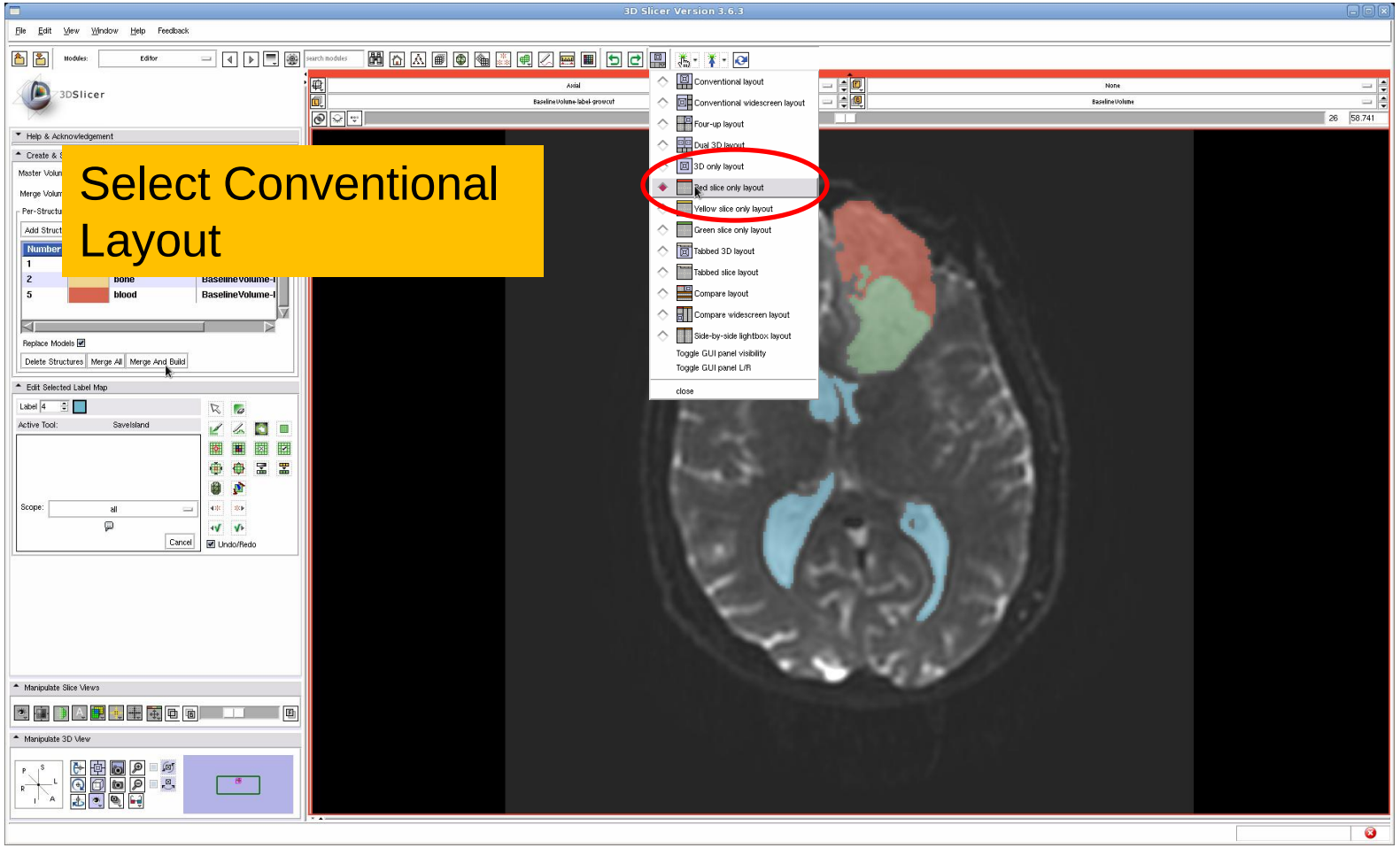
Final Result of the Segmentation

Slicer displays the result of the segmentation of the ventricles.

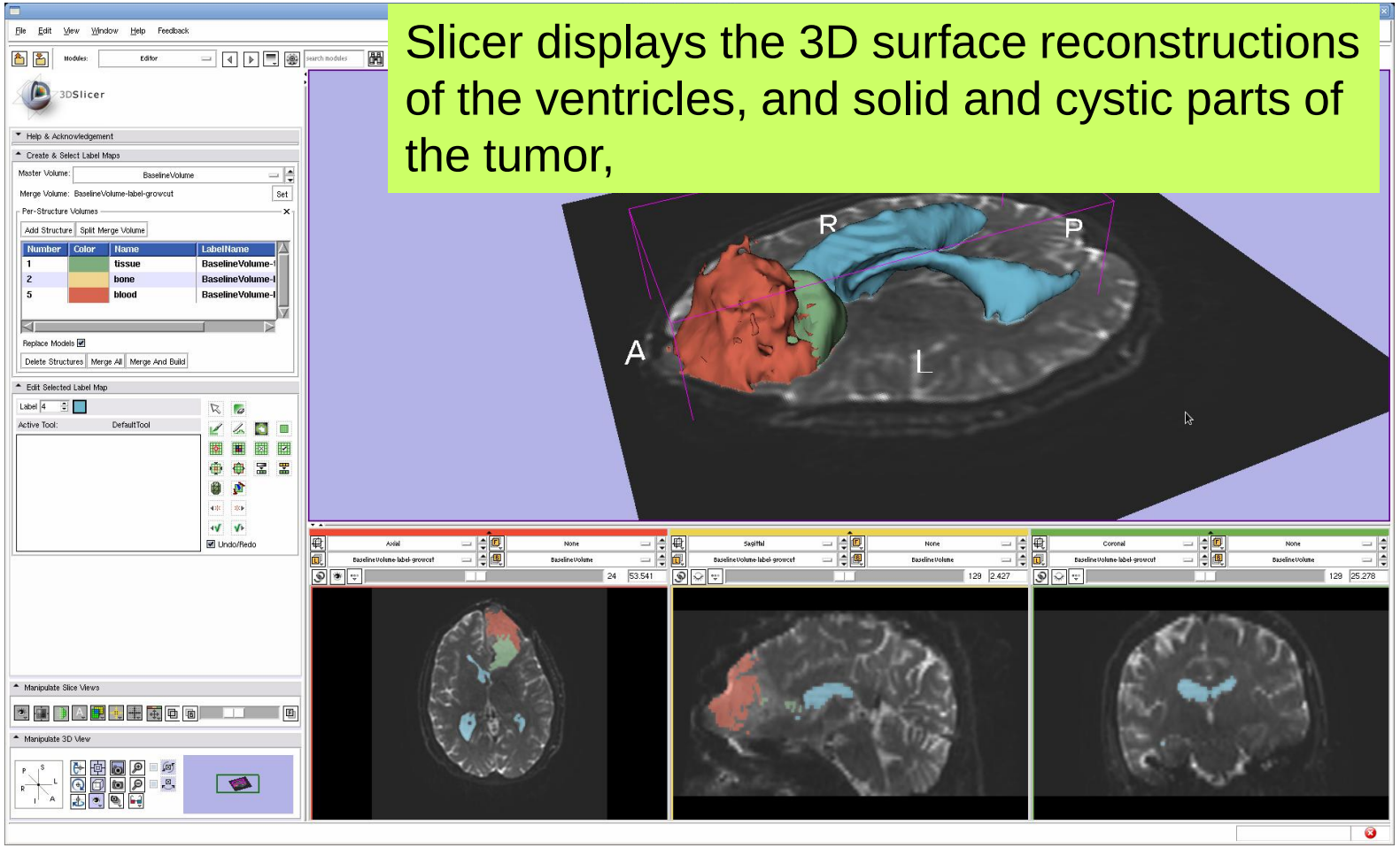
Final Result of the Segmentation

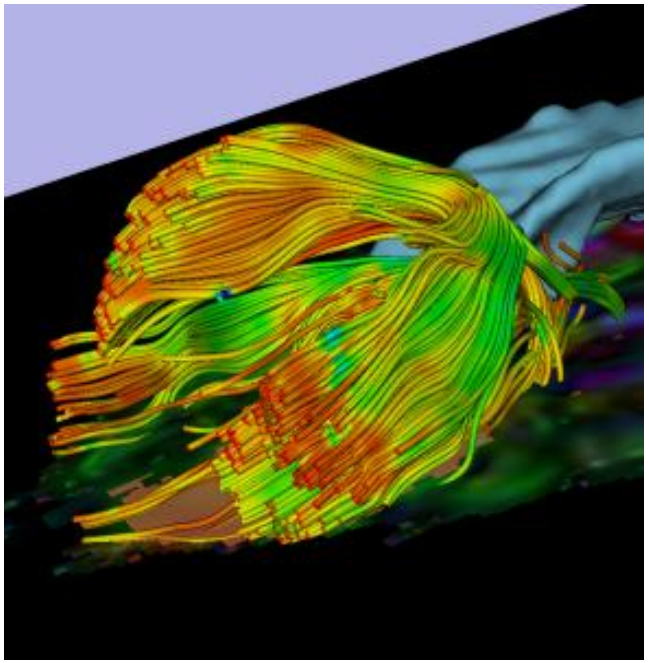


Final Result of the Segmentation



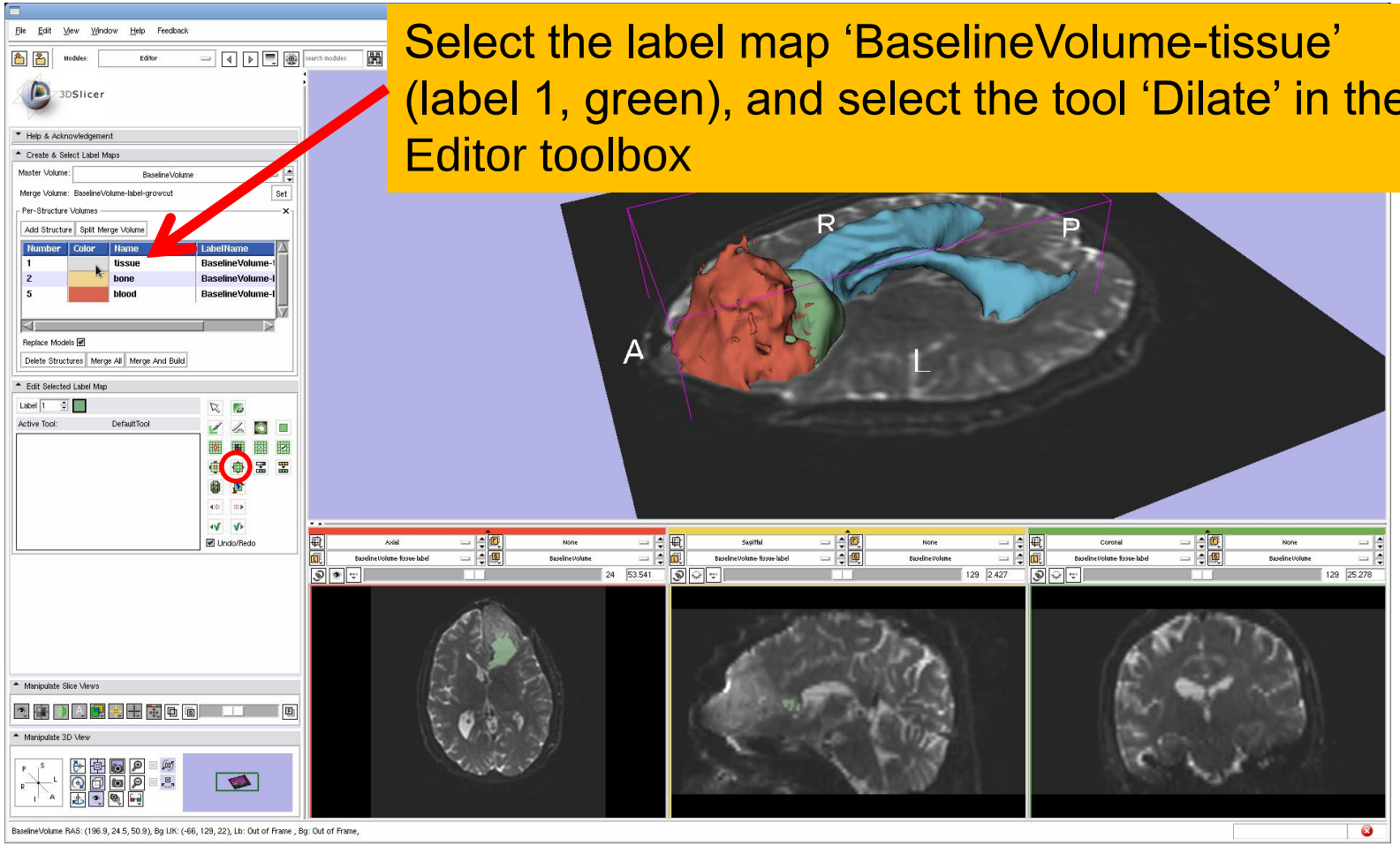
Final Result of the Segmentation



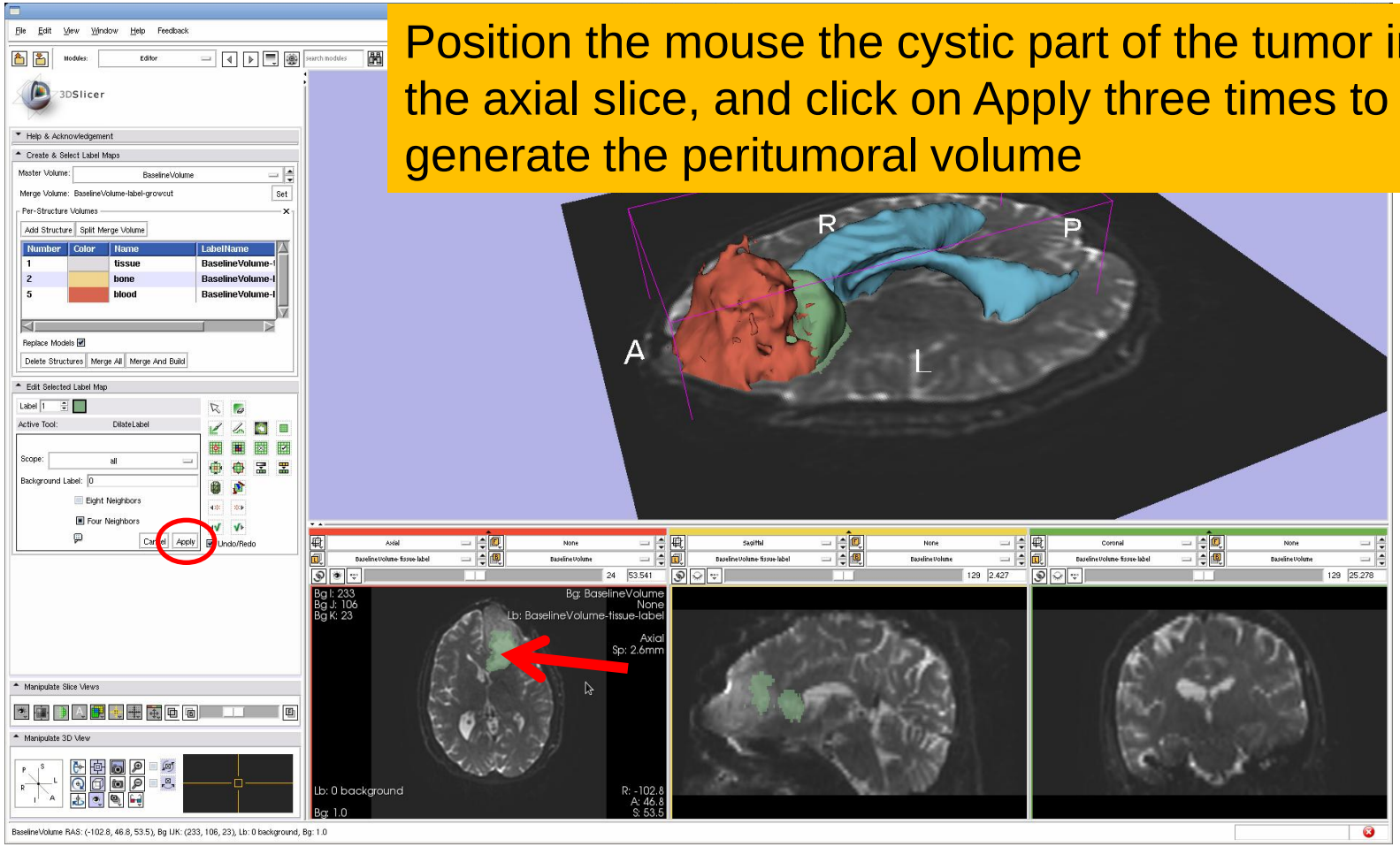


Part 2: Tractography exploration of peri-tumoral white matter fibers

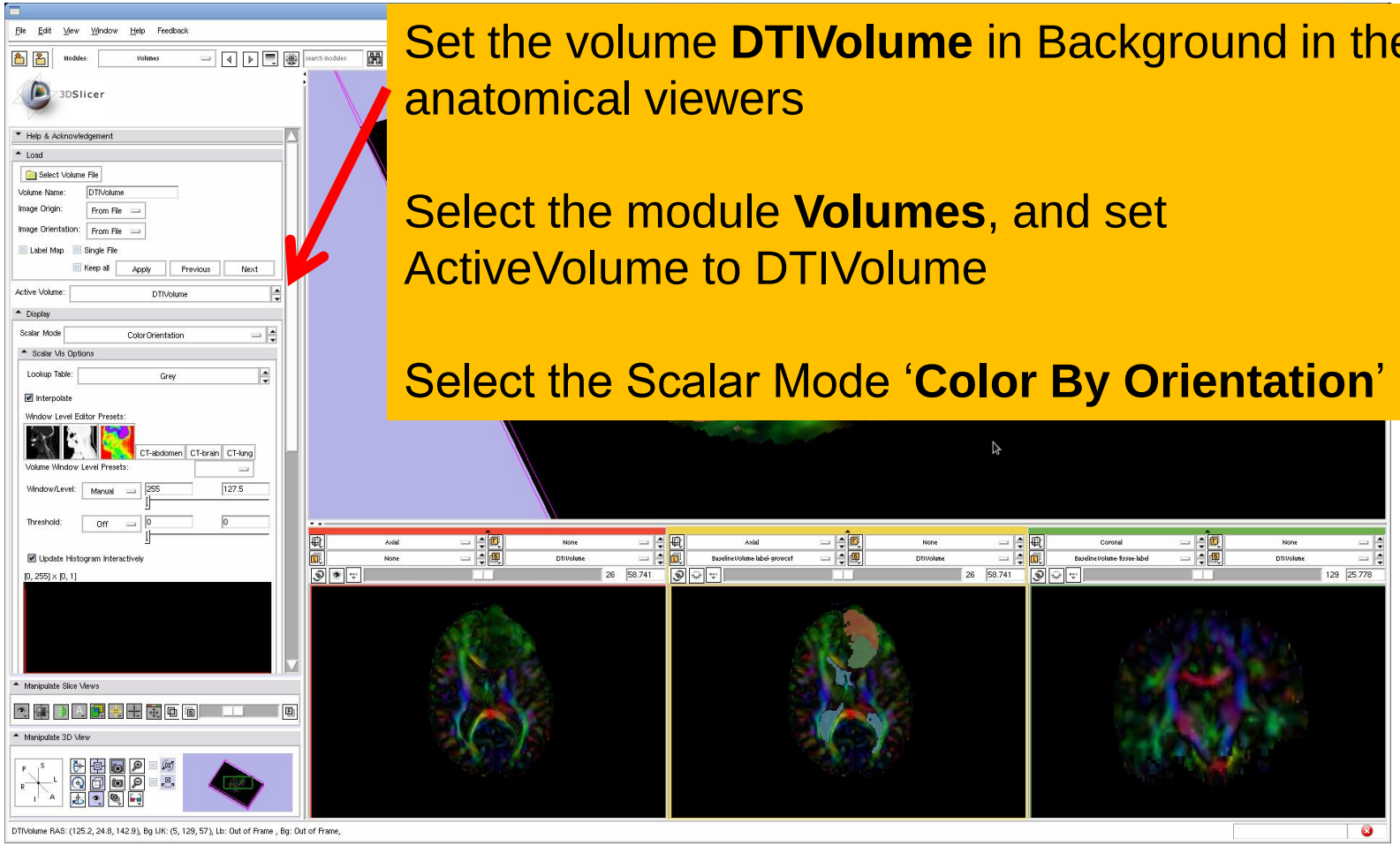
Definition of the peri-tumoral volume



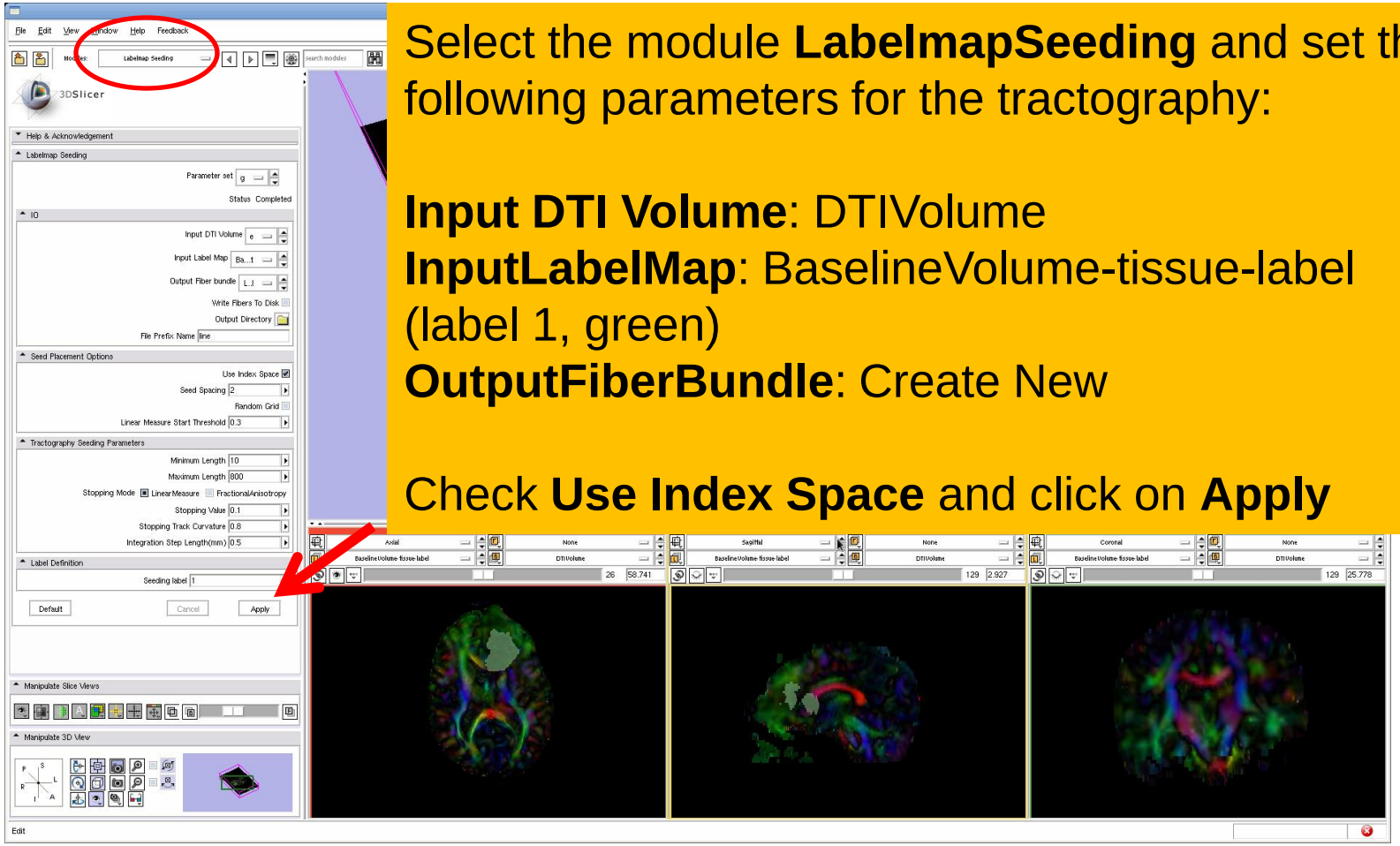
Definition of the peri-tumoral volume



Visualization of the DTI Volume



Tractography Parameters

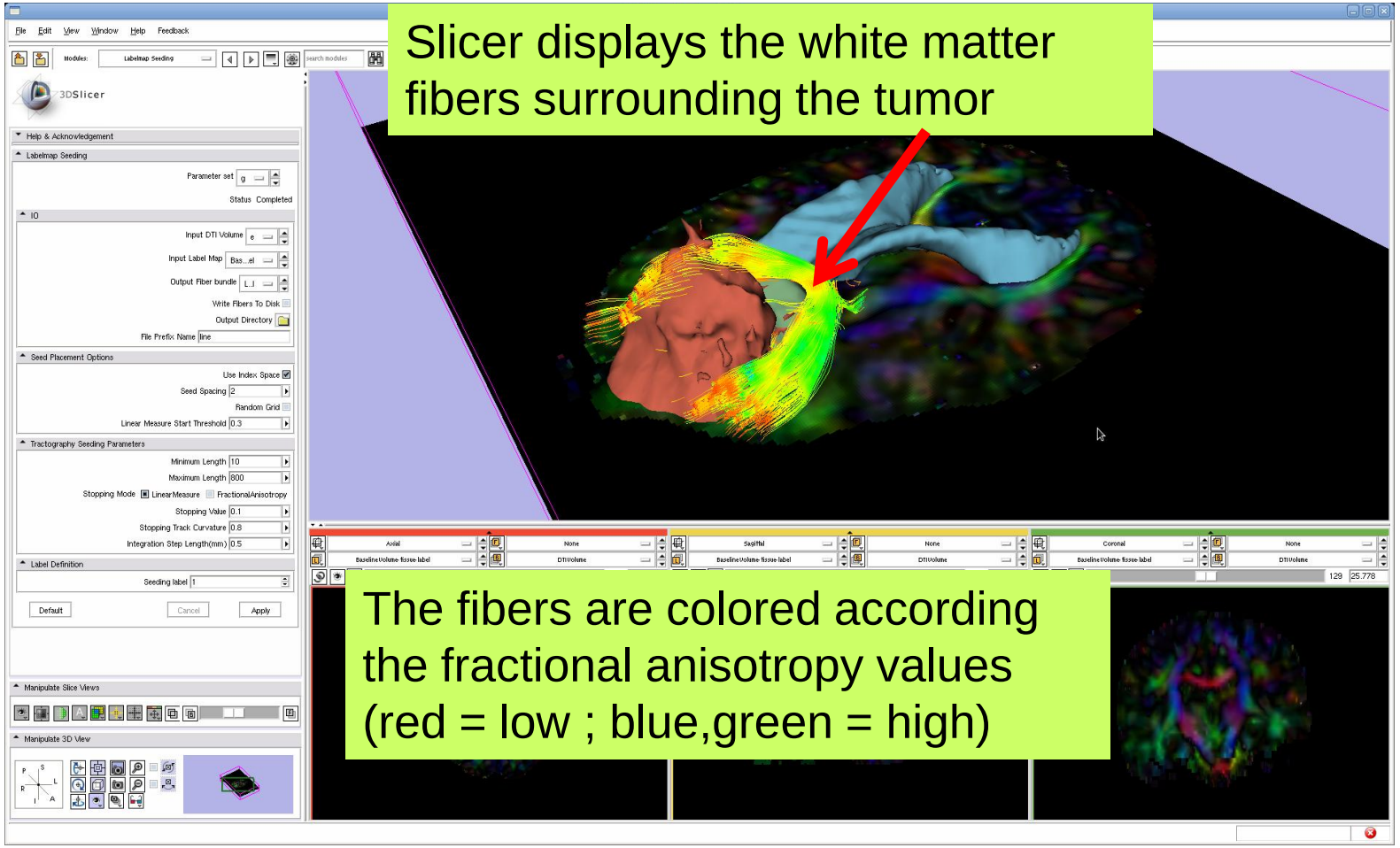


Select the module **LabelmapSeeding** and set the following parameters for the tractography:

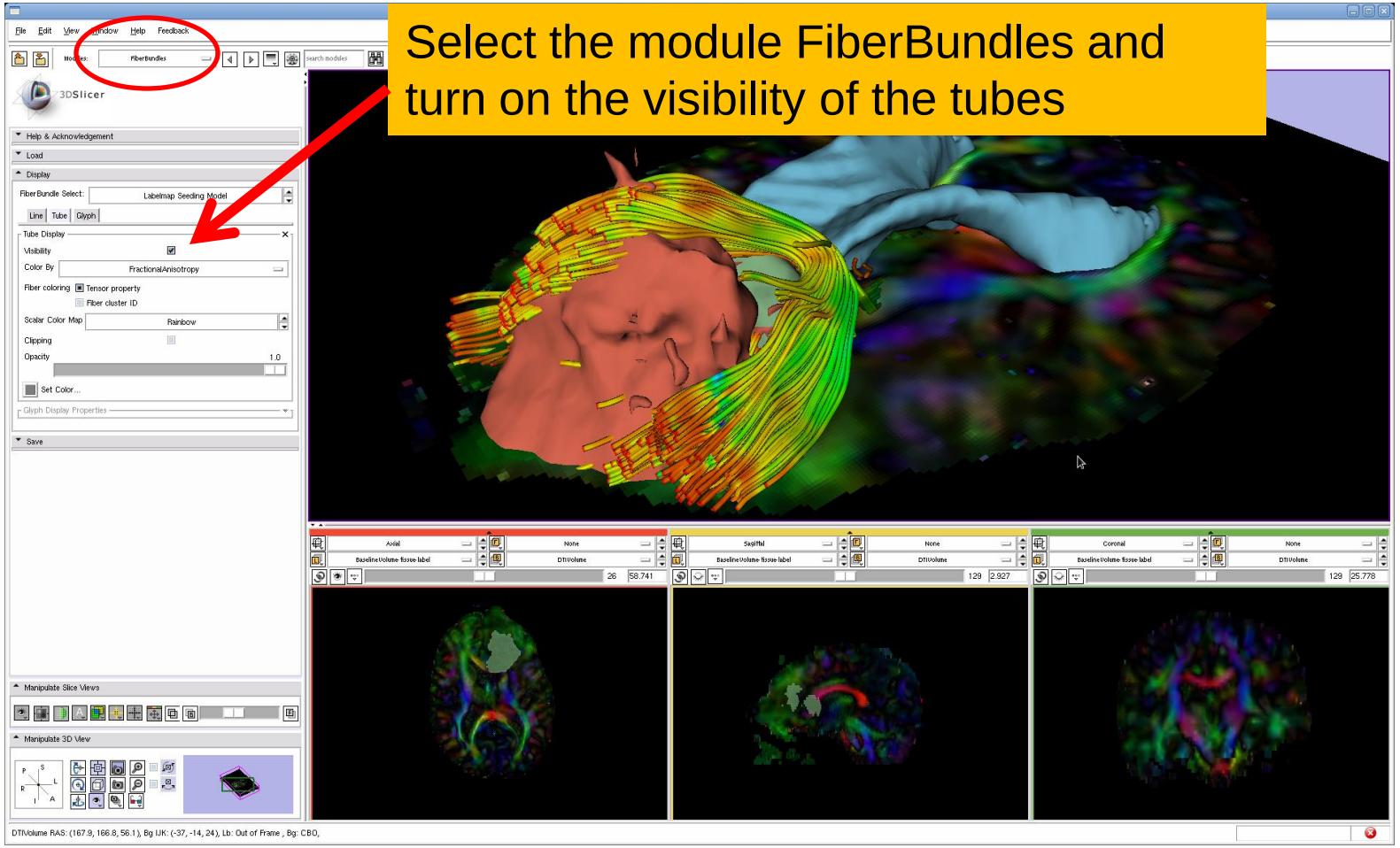
Input DTI Volume: DTIVolume
InputLabelMap: BaselineVolume-tissue-label (label 1, green)
OutputFiberBundle: Create New

Check **Use Index Space** and click on **Apply**

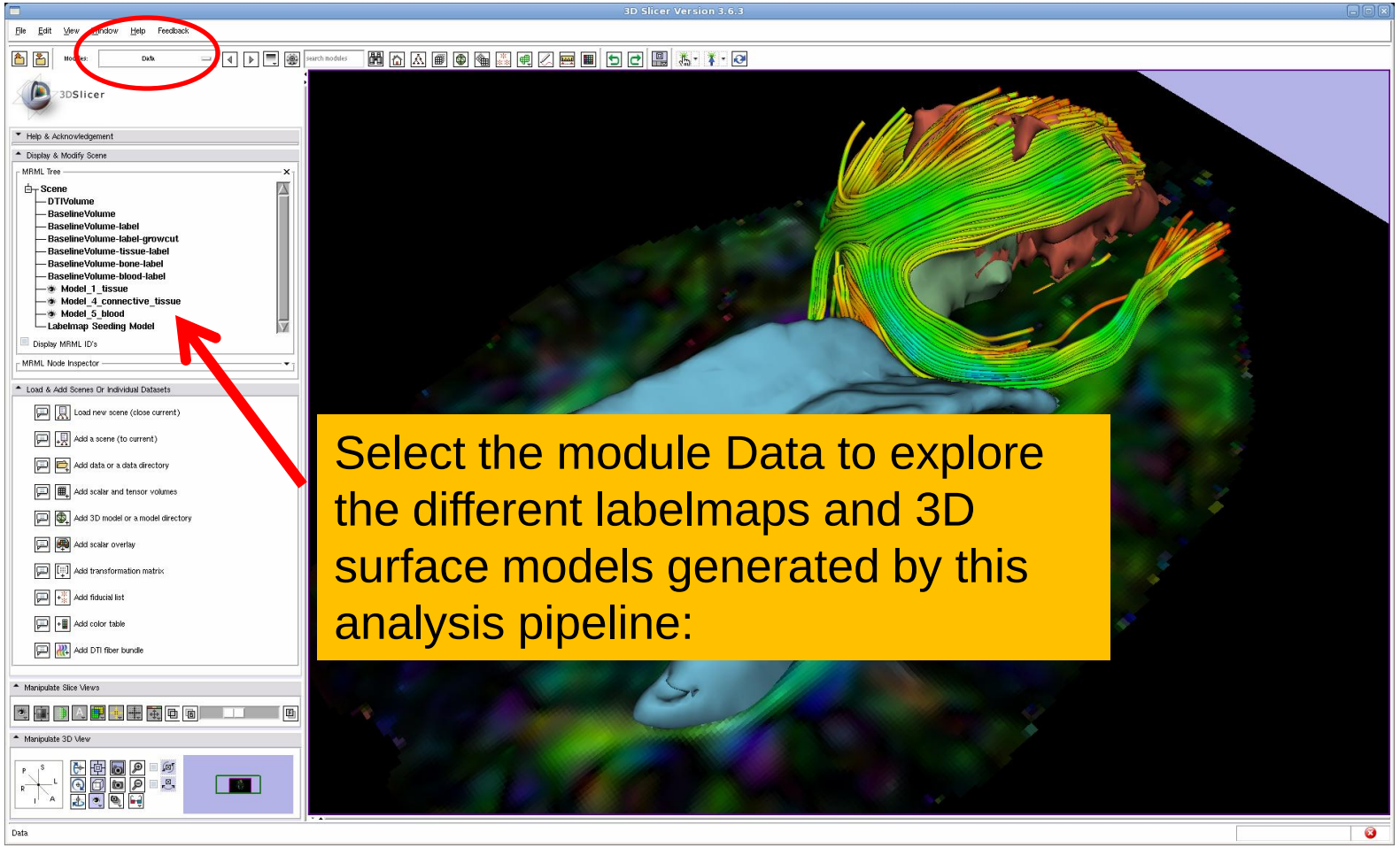
Tractography Results

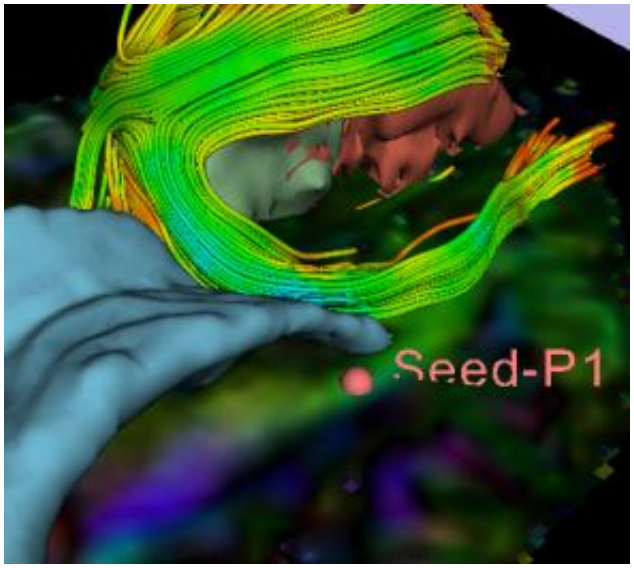


Tractography Results



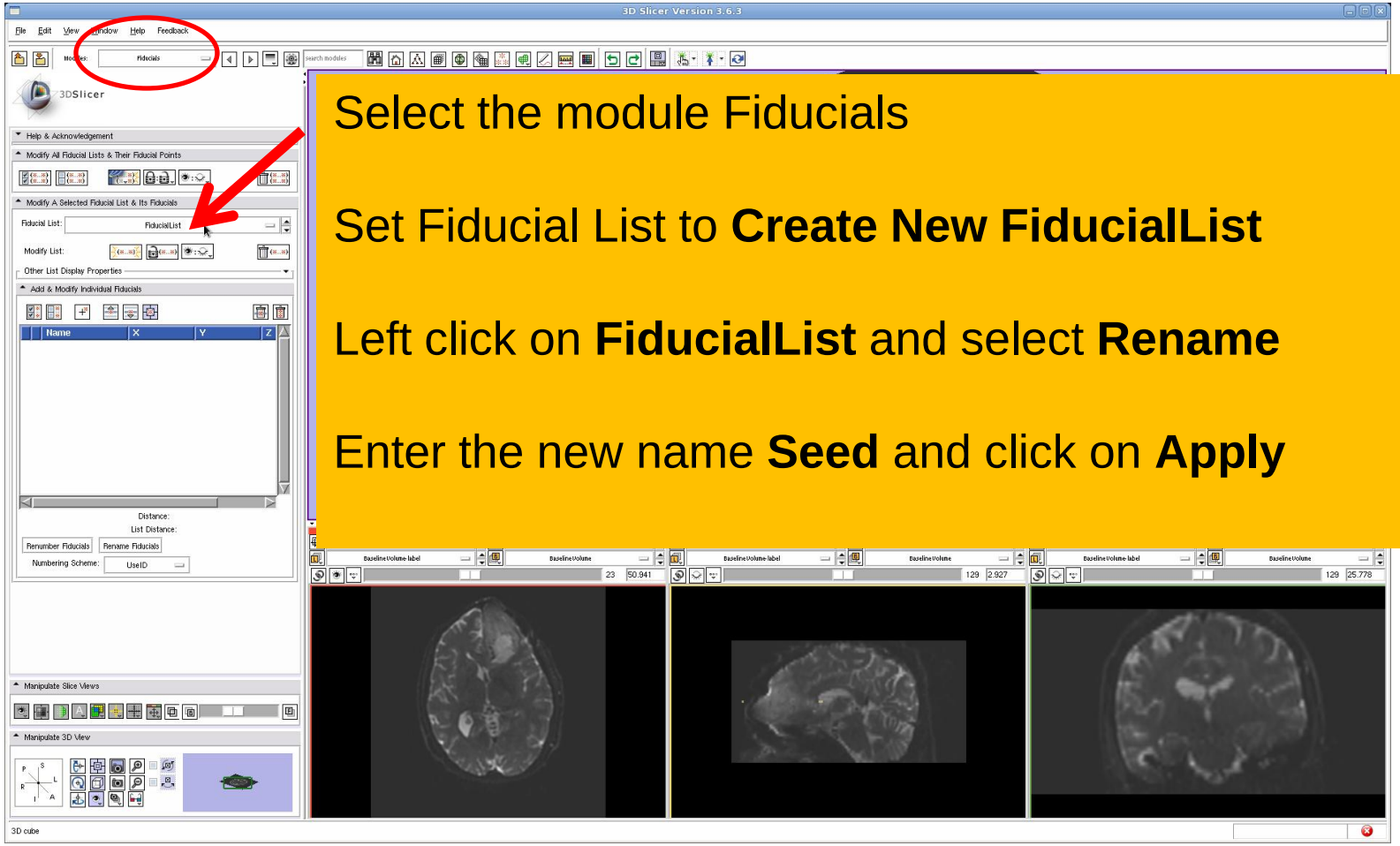
Tractography Results





Part 4: Tractography exploration of the ipsilateral and contralateral side

Tractography on-the-fly



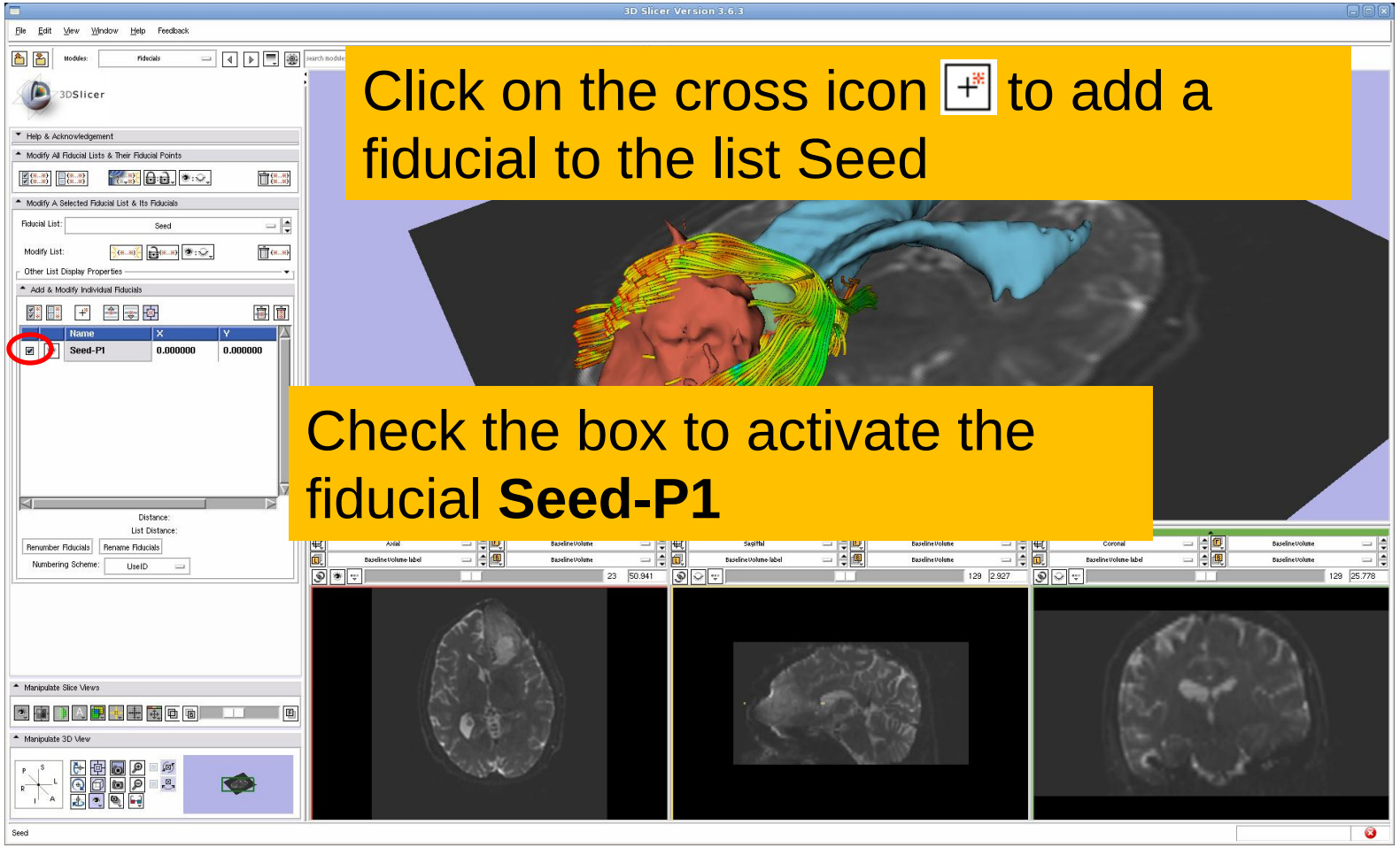
Select the module Fiducials

Set Fiducial List to **Create New FiducialList**

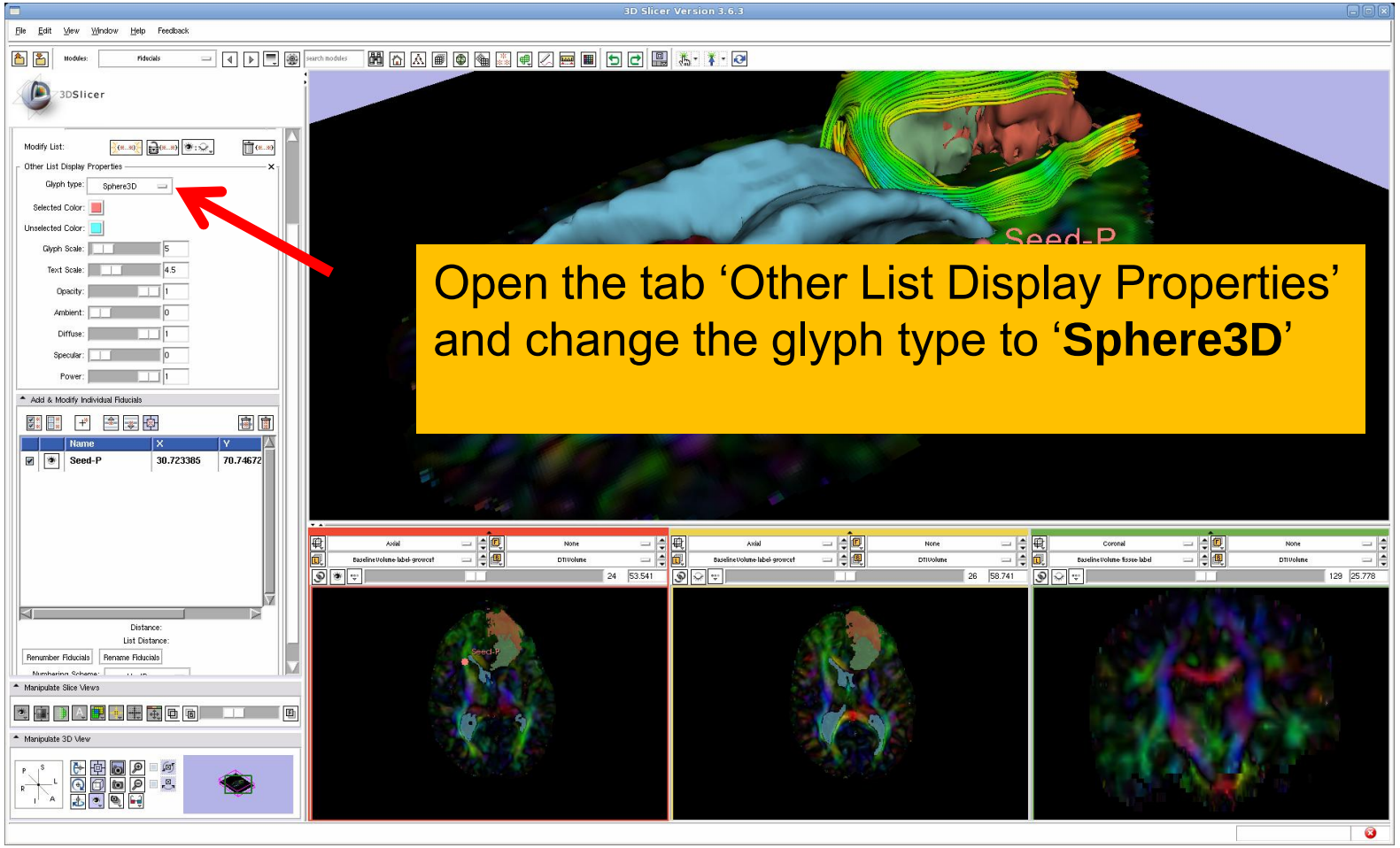
Left click on **FiducialList** and select **Rename**

Enter the new name **Seed** and click on **Apply**

Tractography on-the-fly

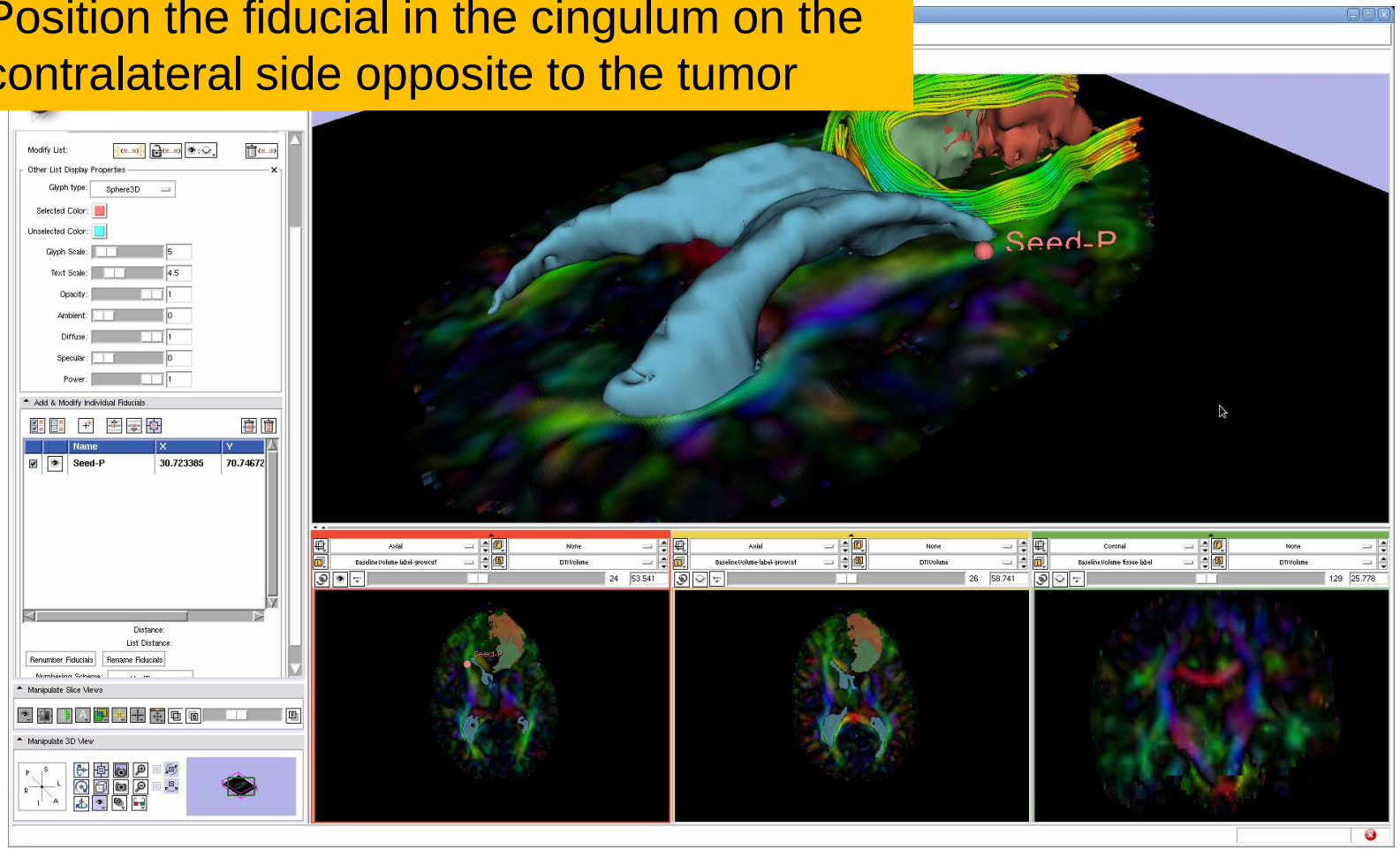


Fiducial Seeding

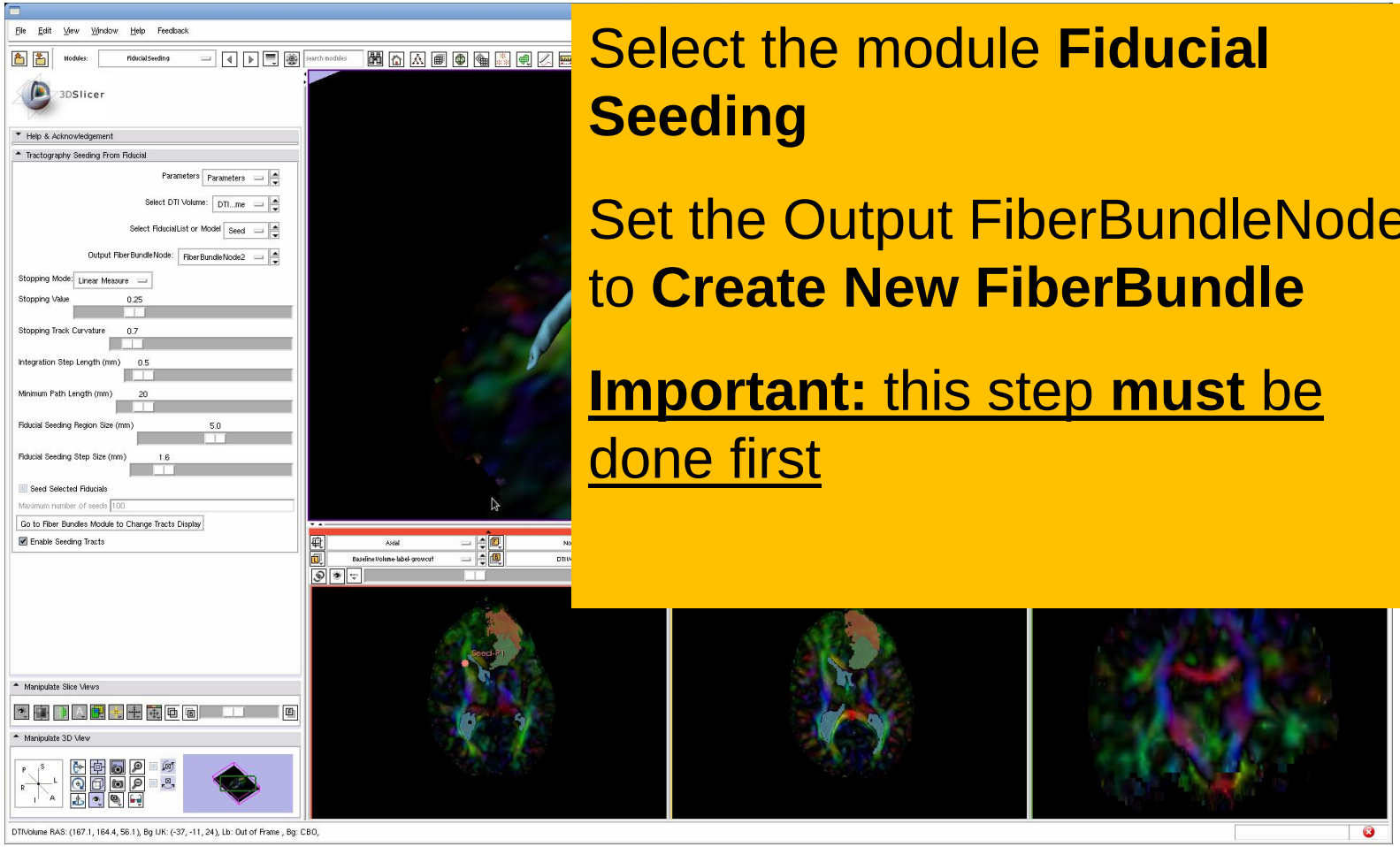


Fiducial Seeding

Position the fiducial in the cingulum on the contralateral side opposite to the tumor



Tractography on-the-fly

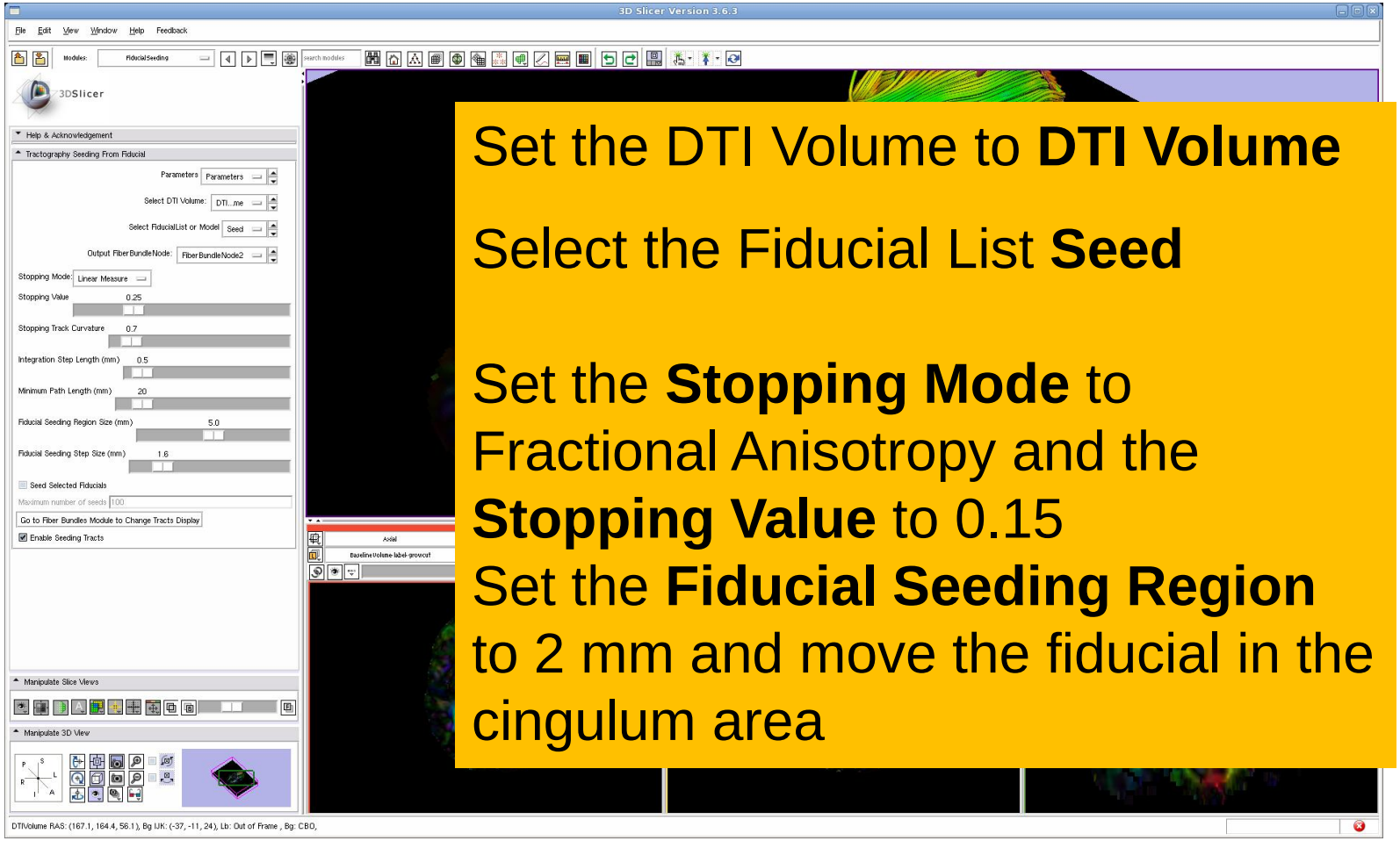


Select the module **Fiducial Seeding**

Set the Output FiberBundleNode to **Create New FiberBundle**

Important: this step **must** be done first

Tractography on-the-fly



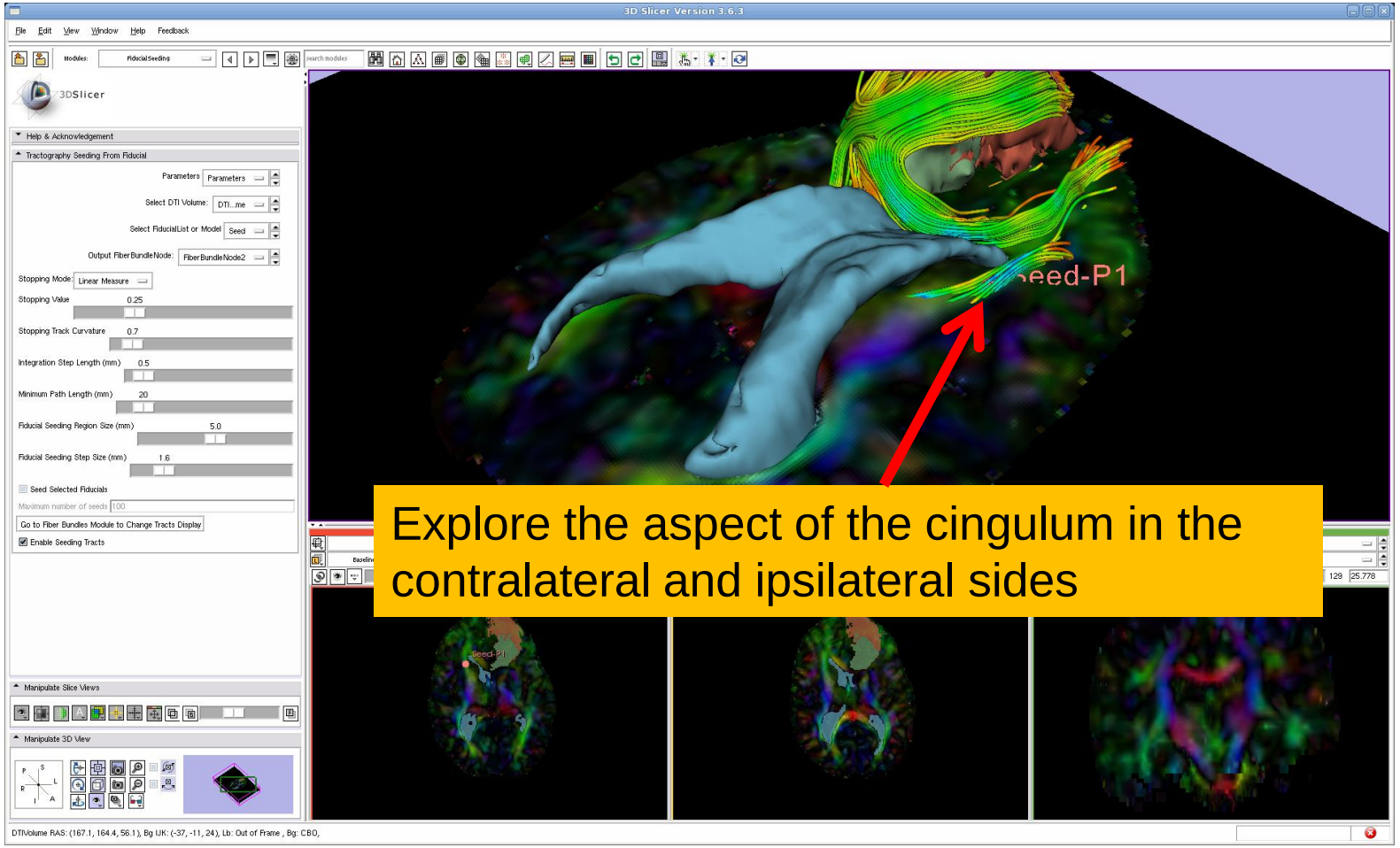
Set the DTI Volume to **DTI Volume**

Select the Fiducial List **Seed**

Set the **Stopping Mode** to Fractional Anisotropy and the **Stopping Value** to 0.15

Set the **Fiducial Seeding Region** to 2 mm and move the fiducial in the cingulum area

Tractography on-the-fly



Conclusion

- Fully integrated pipeline for semi-automated tumor segmentation and white matter tract reconstruction
- 3D interactive exploration of the white matter tracts surrounding a tumor (peri-tumoral tracts) for neurosurgical planning

Neurosurgical Planning Workshop,

September 18, 2011 - Toronto

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Events: DTI Tractography Challenge MICCAI 2011

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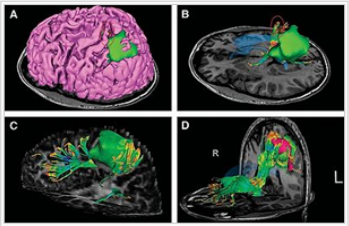
14th International Conference on Medical Image Computing and Computer Assisted Intervention

DTI Tractography for Neurosurgical Planning: A Grand Challenge

Welcome to the 'DTI Tractography for Neurosurgical Planning: A Grand Challenge' workshop. The goal of this initiative is to compare Diffusion Tensor Imaging Tractography algorithms for reconstructing white matter bundles for pre-surgical planning. The workshop is part of the 14th International Conference on Medical Image Computing and Computer Assisted Intervention MICCAI 2011, to be held from 18th to 22th September 2011 in Toronto, Canada.

Overview

Diffusion Tensor Imaging (DTI) tractography has a unique potential for neurosurgical planning since it provides a window on the complex organization of white matter pathways *in-vivo*. During the past decade, the MICCAI community has been a major contributor to the development and refinement of a wide variety of advanced tractography techniques. Still the transfer of these cutting-edge algorithms to clinical routine is hindered by the difficulties of validating tractography results. The DTI Tractography Challenge workshop will give participants the opportunity to evaluate the performances of their tractography algorithms in a neurosurgical context. Participants will gain insights on the currently available gold-standard for evaluating tractography results in the Operating Room, in the absence of ground truth.



Neurosurgical case with left frontoparietal tumor. Neurosurgery 2011 Feb; 68(2):496-505. Image courtesy of Dr. Alexandra Golby.

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