



Exploring Peritumoral White Matter Fibers for Neurosurgical Planning

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Clinical Goal

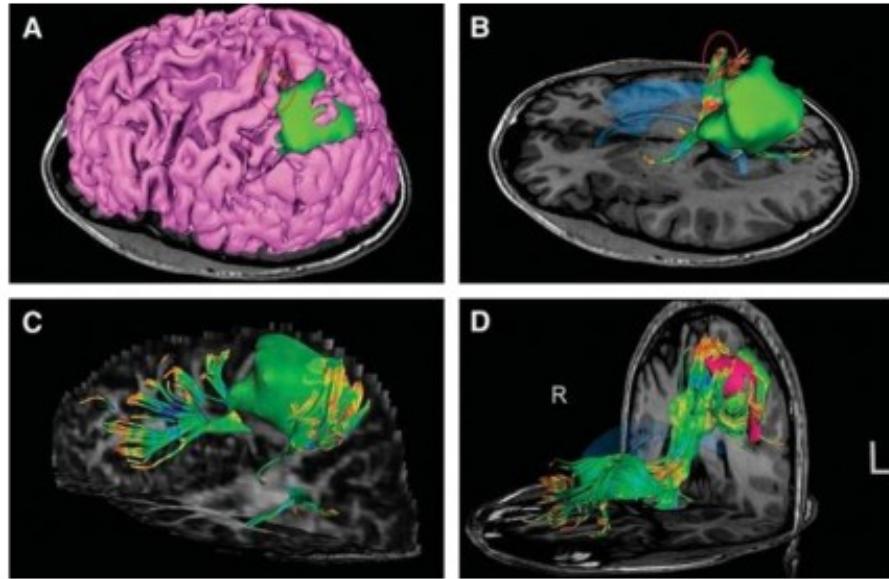
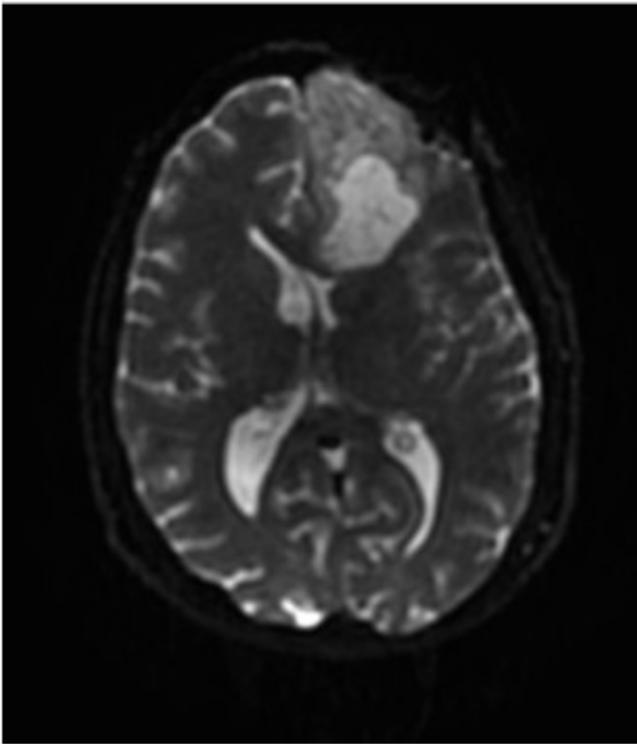


Image Courtesy of Dr. Alexandra Golby, Brigham and Women's Hospital, Boston, MA..

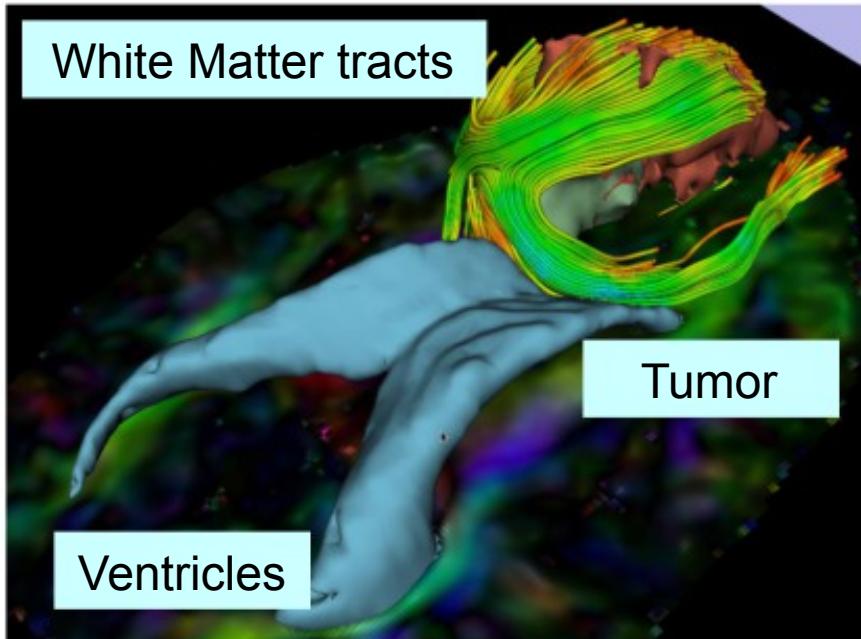
Diffusion Tensor Imaging (DTI) Tractography has the potential to bring valuable spatial information on tumor infiltration and tract displacement for neurosurgical planning of tumor resection.

Clinical Case



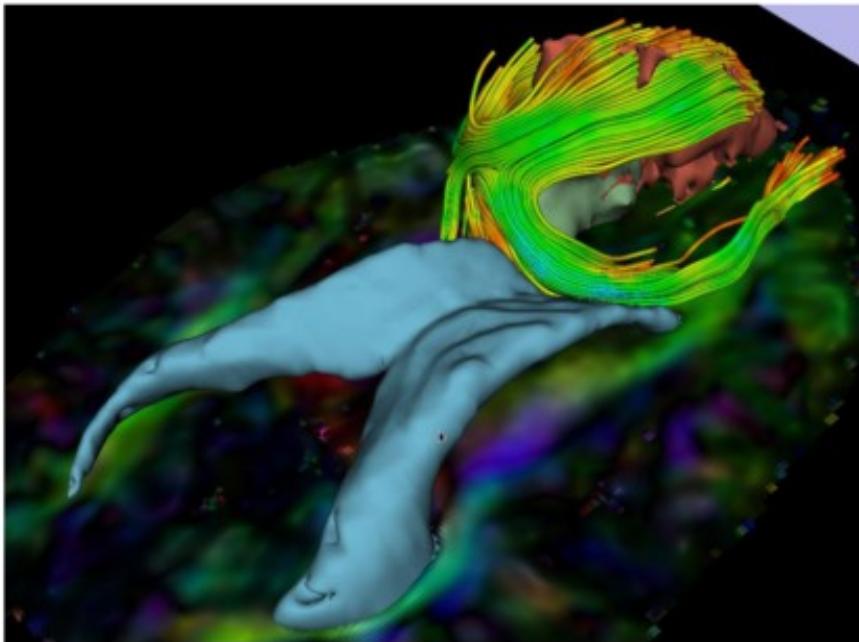
- 35 year-old male diagnosed with **Glioblastoma multiforme (GBM)**
- Diffusion Weighted Imaging (DWI) acquisition for neurosurgical planning

Clinical Goal



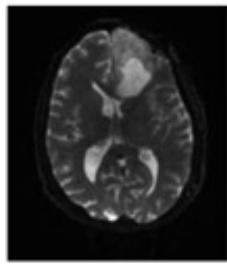
The goal of this tutorial is to explore white matter fibers surrounding a tumor using Diffusion Tensor Imaging (DTI) Tractography.

Image Analysis Pipeline

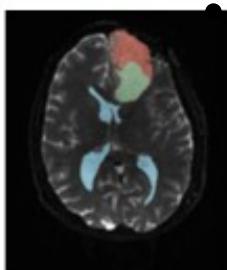


The image analysis pipeline described in this tutorial uses three different algorithms: the “Grow Cut” algorithm for segmentation of the tumor parts, the Marching Cube algorithm for surface modeling, and the single tensor streamline tractography algorithm for tract generation.

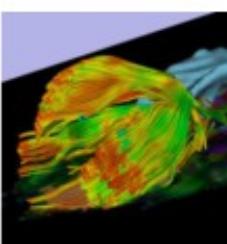
Overview of the analysis pipeline



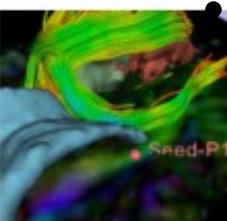
Part 1: Loading & Visualization of Diffusion Data



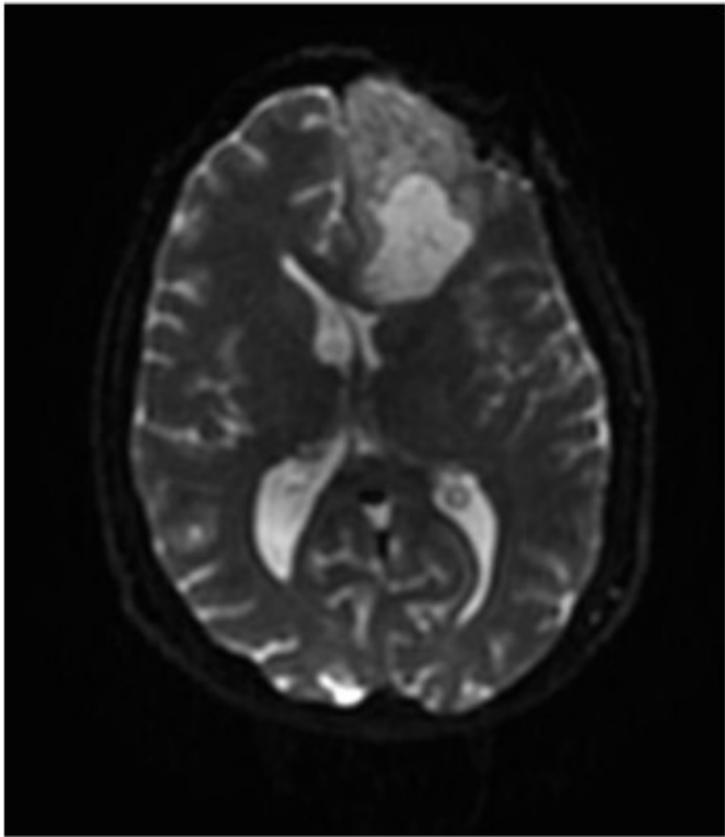
Part 2: Segmentation of the ventricles, and solid and cystic parts of the tumor



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

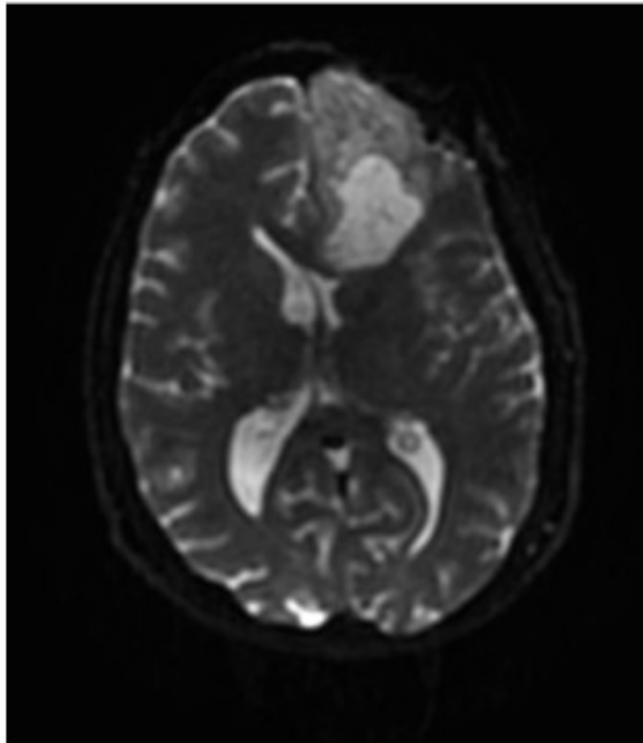


Part 4: Tractography exploration of the ipsilateral and contralateral side



Part 1: Loading and Visualization of Diffusion Data

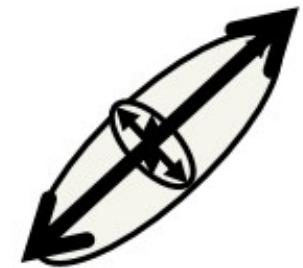
Diffusion Tensor Imaging



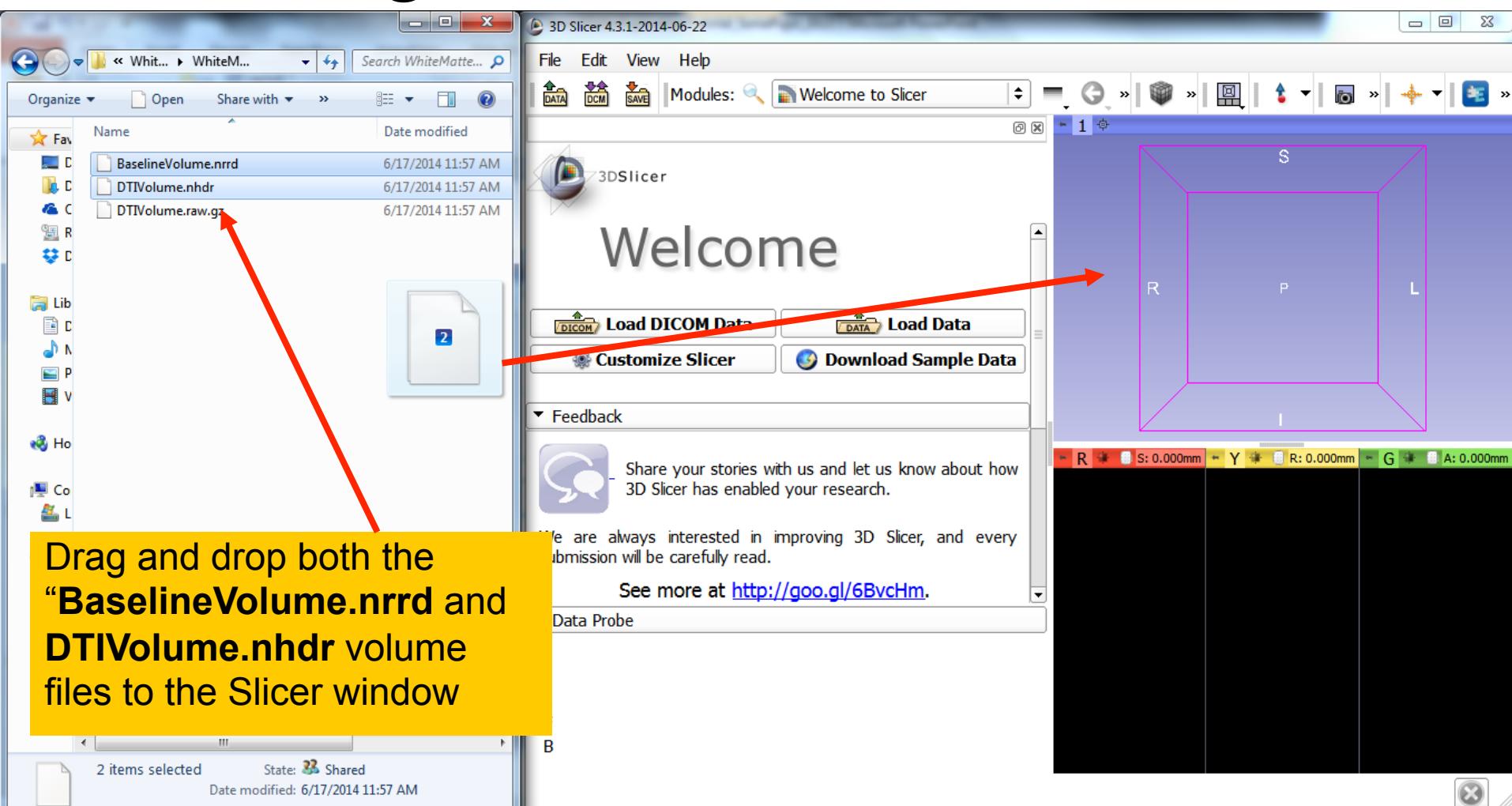
$$S_i = S_0 e^{-b \hat{g}_i^T D \hat{g}_i}$$

(Stejskal and Tanner 1965, Basser 1994)

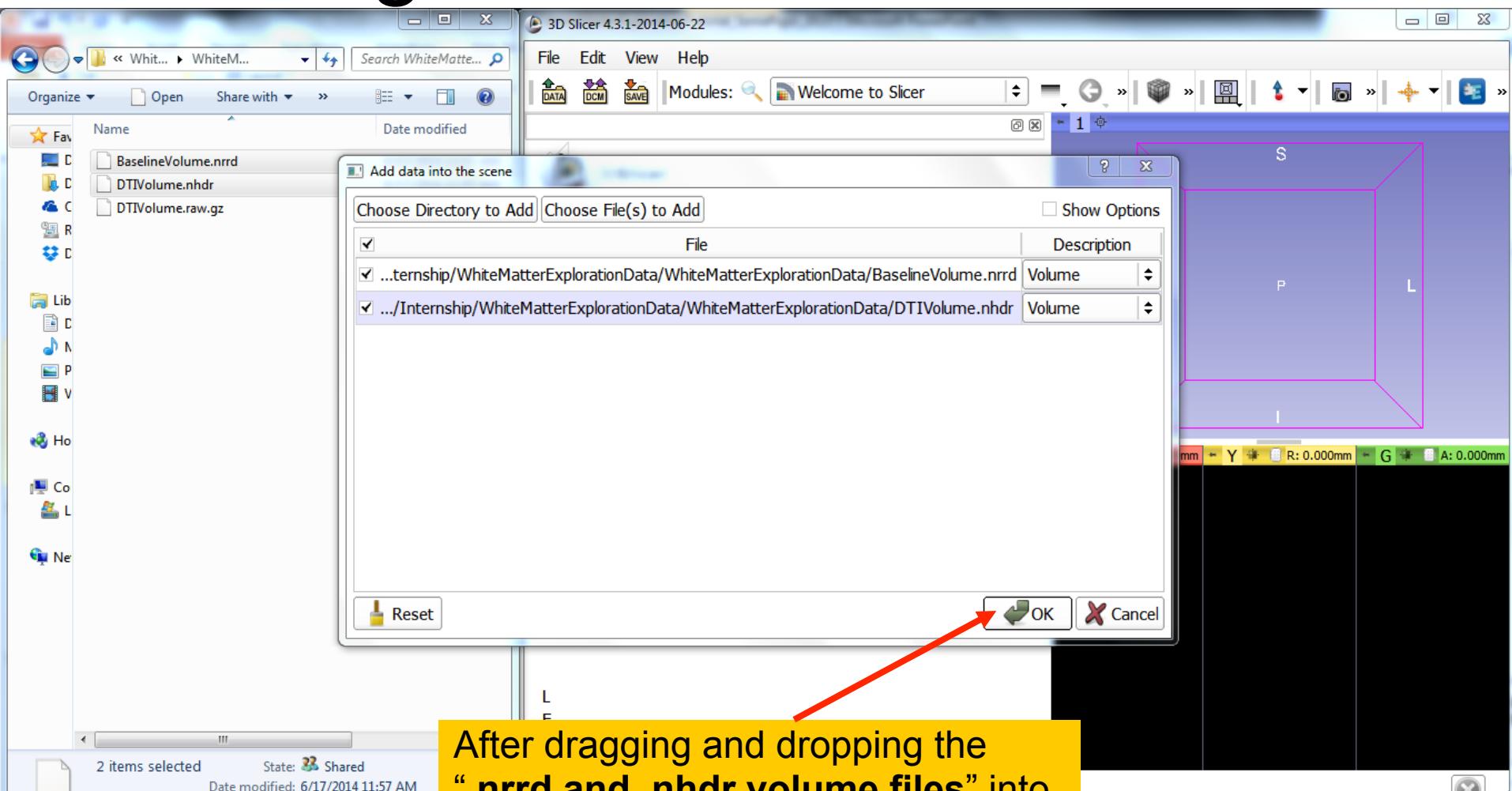
$$\underline{\mathbf{D}} = \begin{bmatrix} D_{xx} & D_{xy} & D_{xz} \\ D_{yx} & D_{yy} & D_{yz} \\ D_{zx} & D_{zy} & D_{zz} \end{bmatrix}$$



Loading DTI and Baseline Data

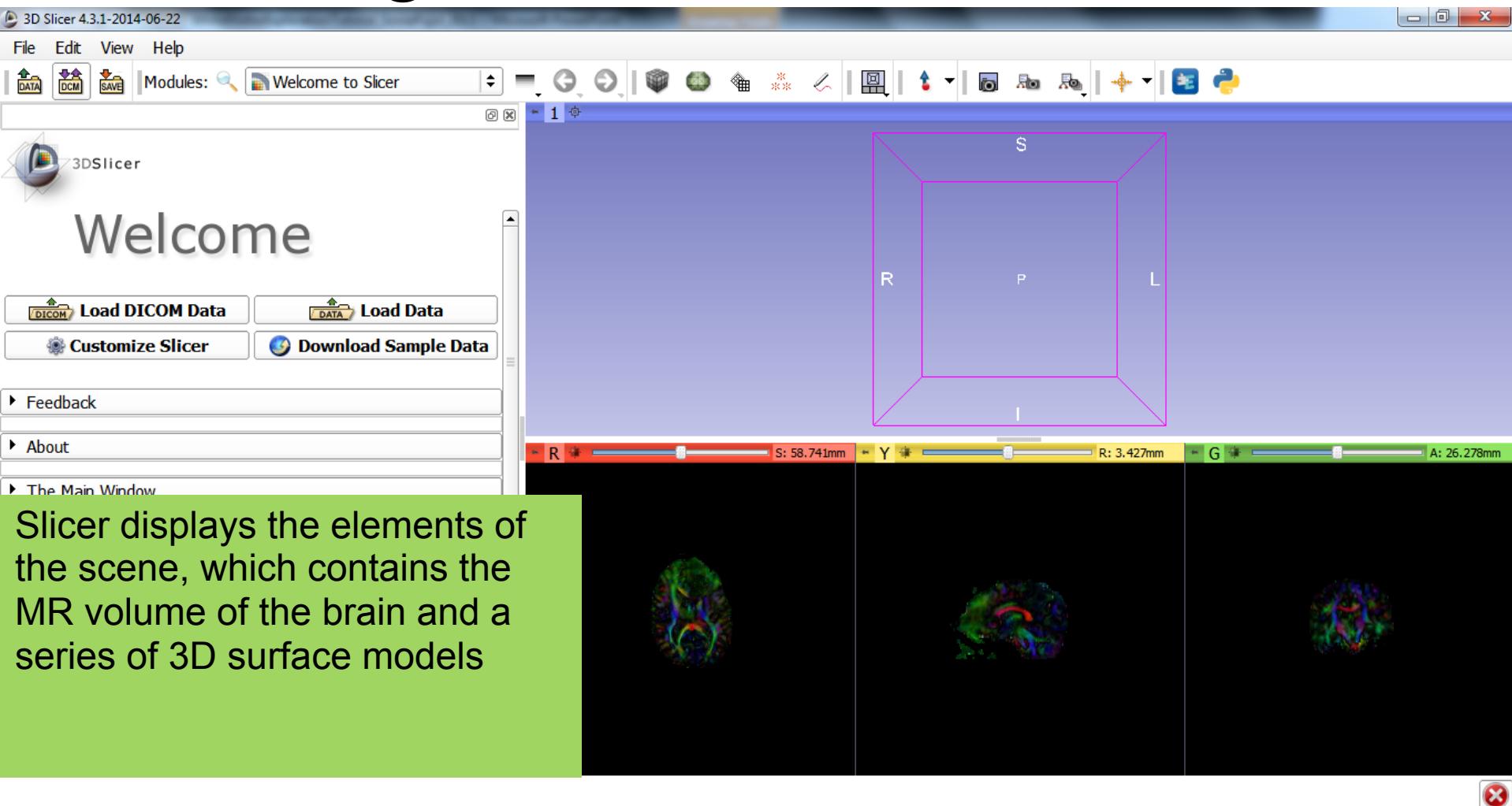


Loading DTI and Baseline Data

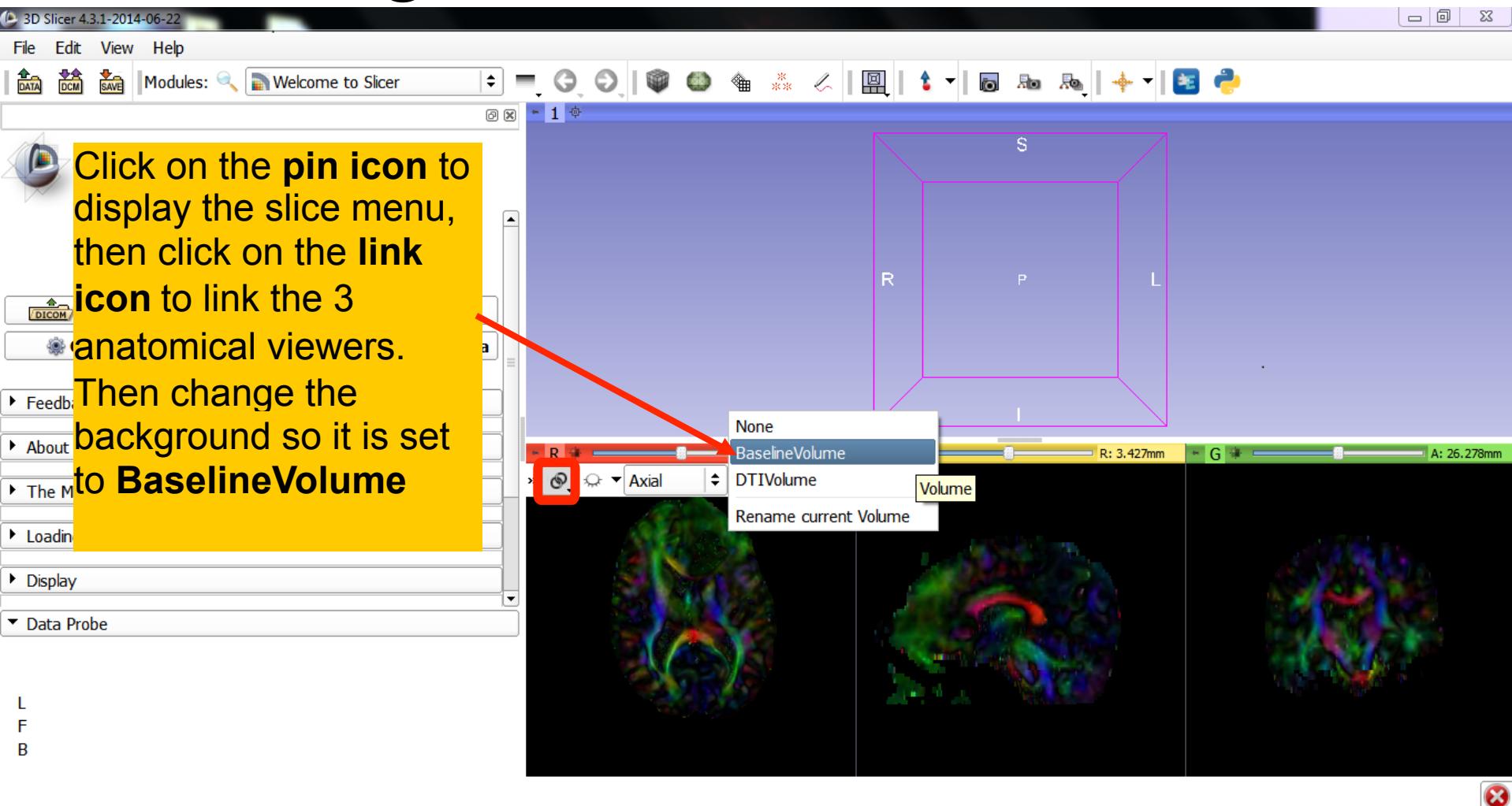


After dragging and dropping the
“**.nrrd and .nhdr volume files**” into
the Slicer window, click on **OK**

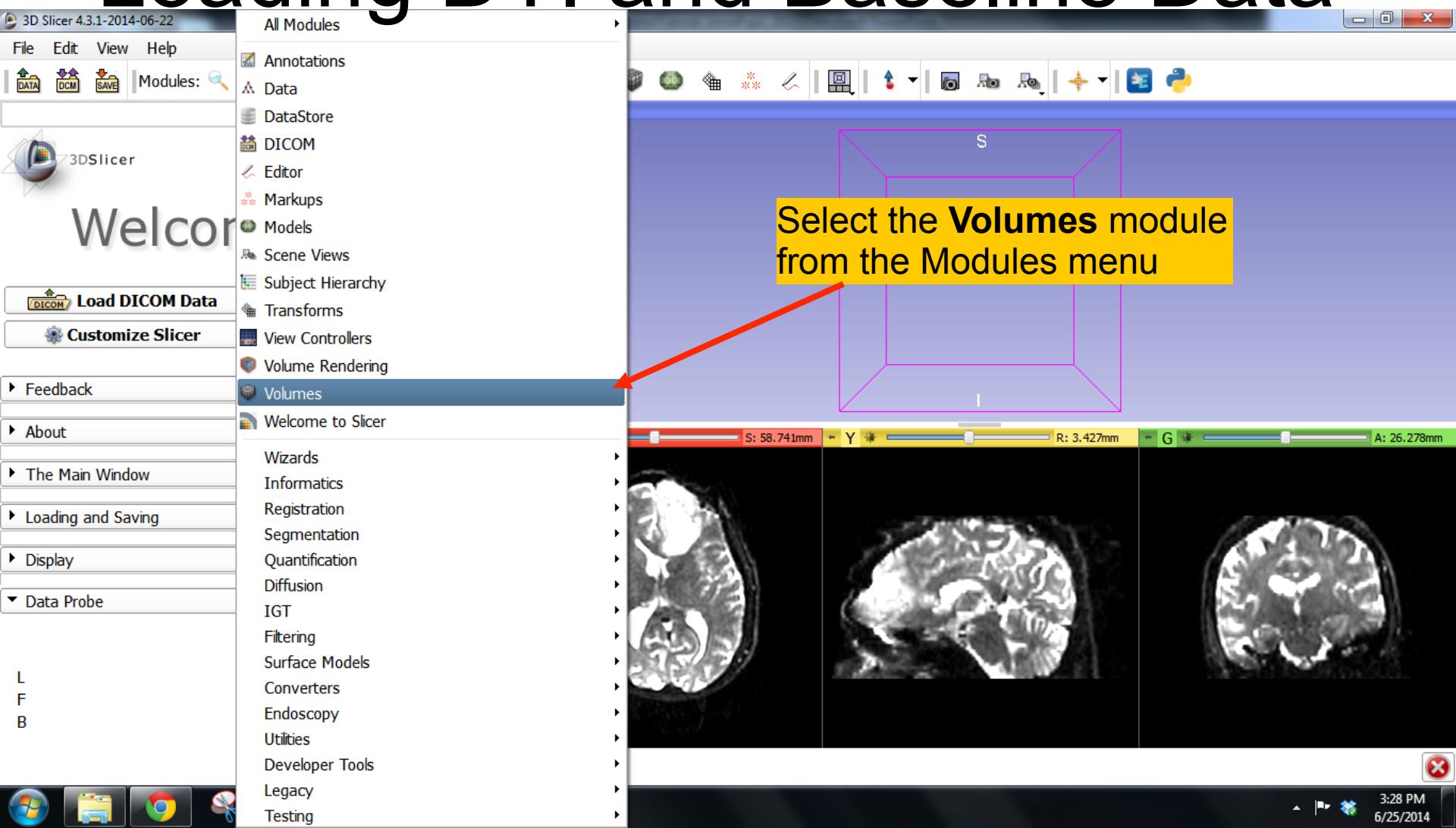
Loading DTI and Baseline Data



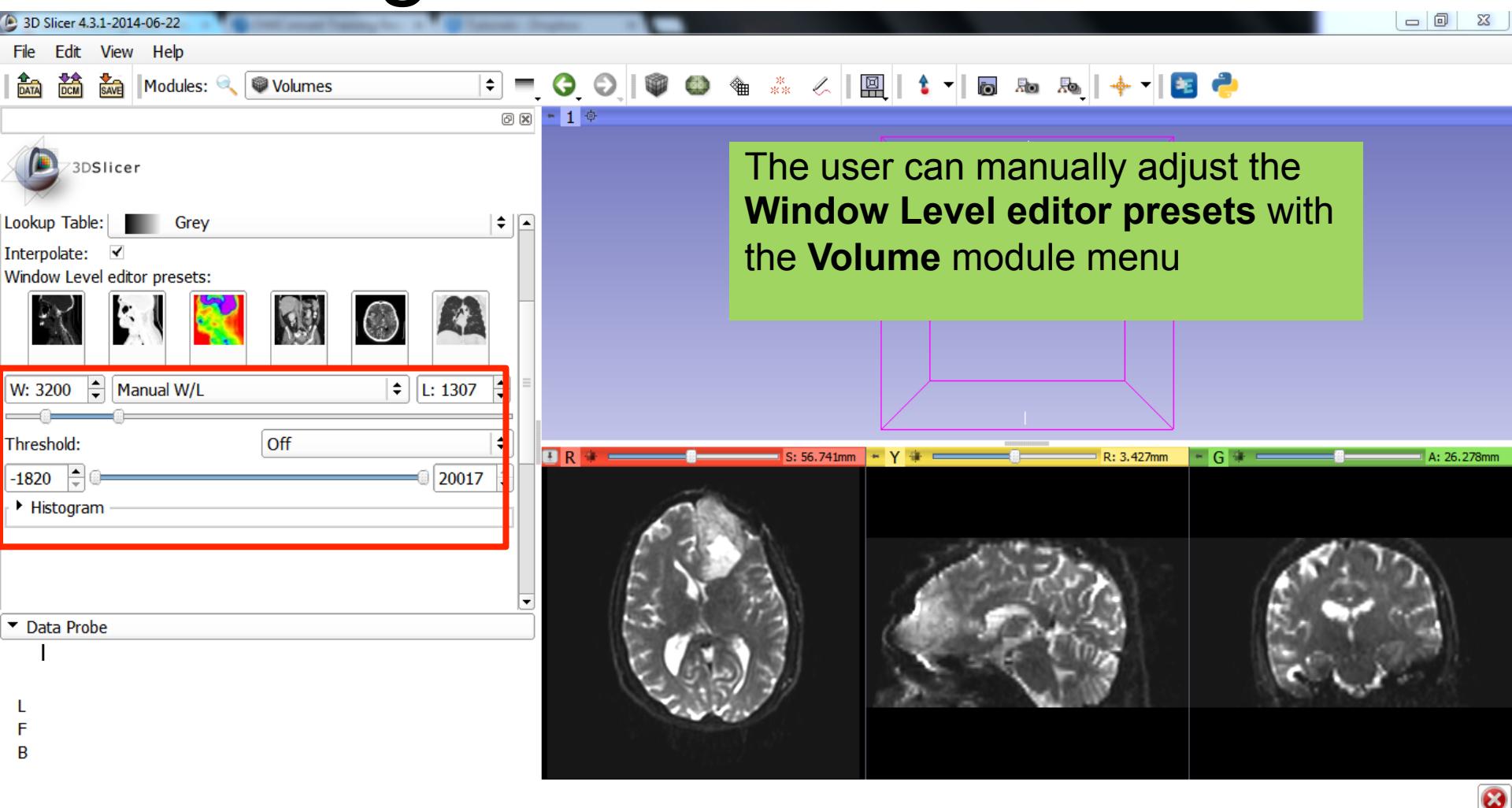
Loading DTI and Baseline Data



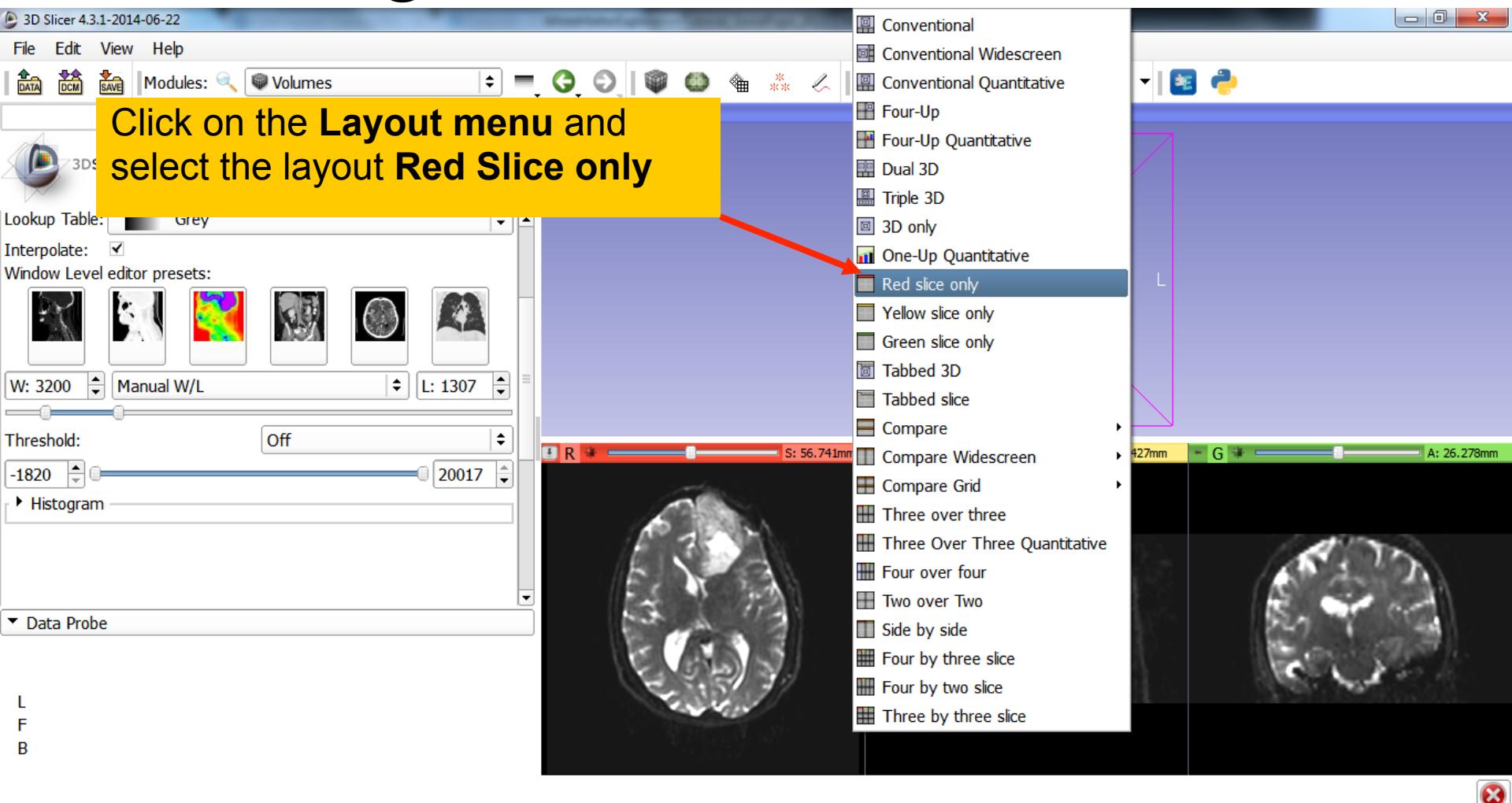
Loading DTI and Baseline Data

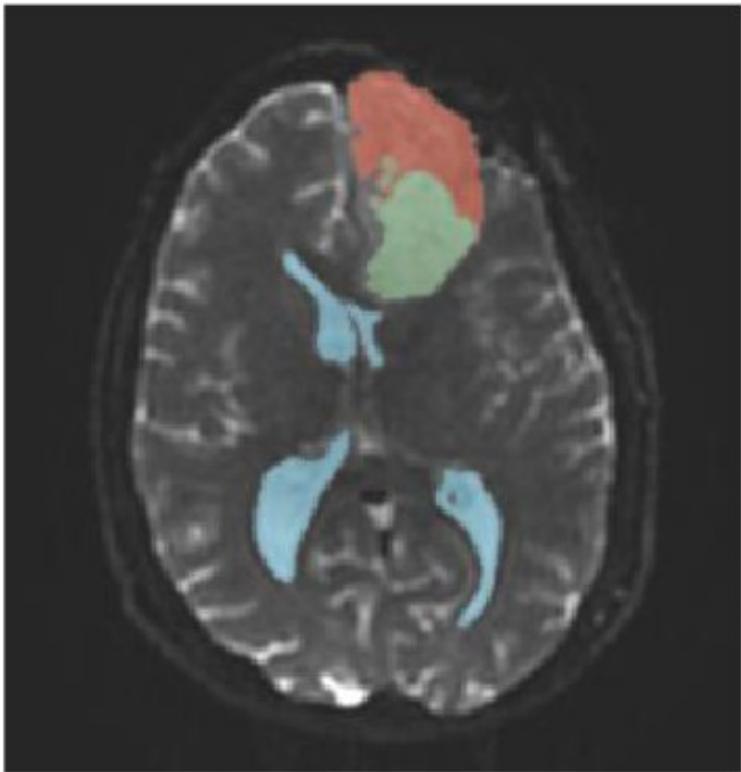


Loading DTI and Baseline Data



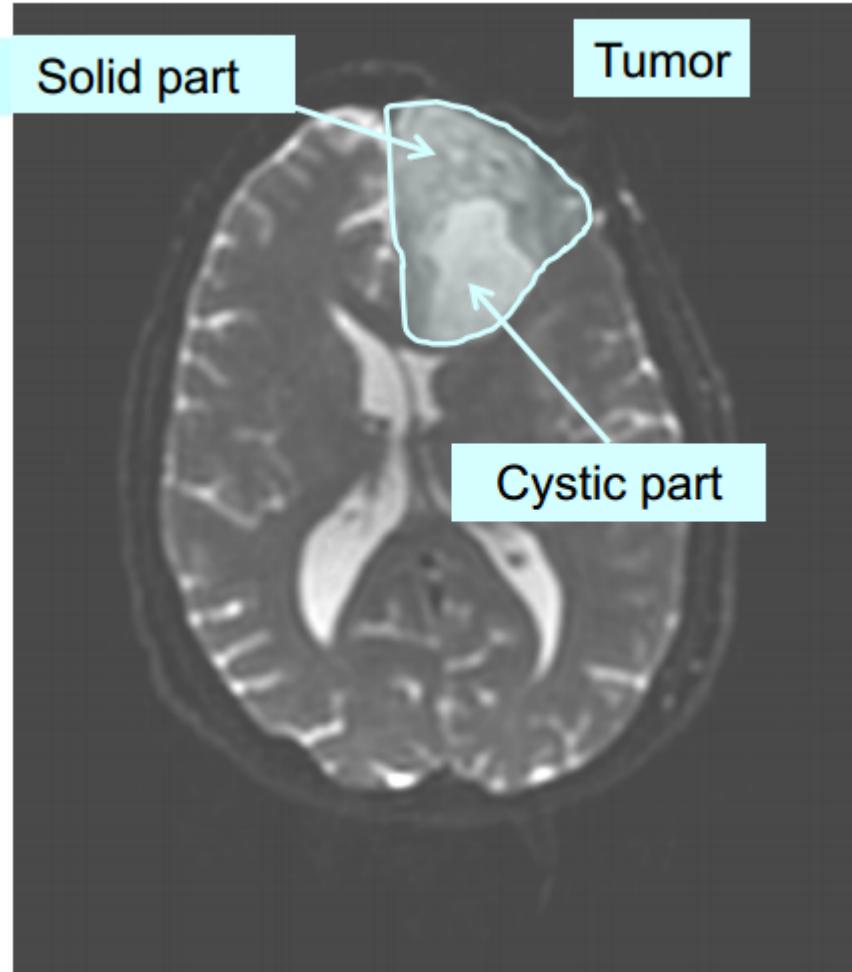
Loading DTI and Baseline Data





Part 1: Segmenting the tumor and ventricles

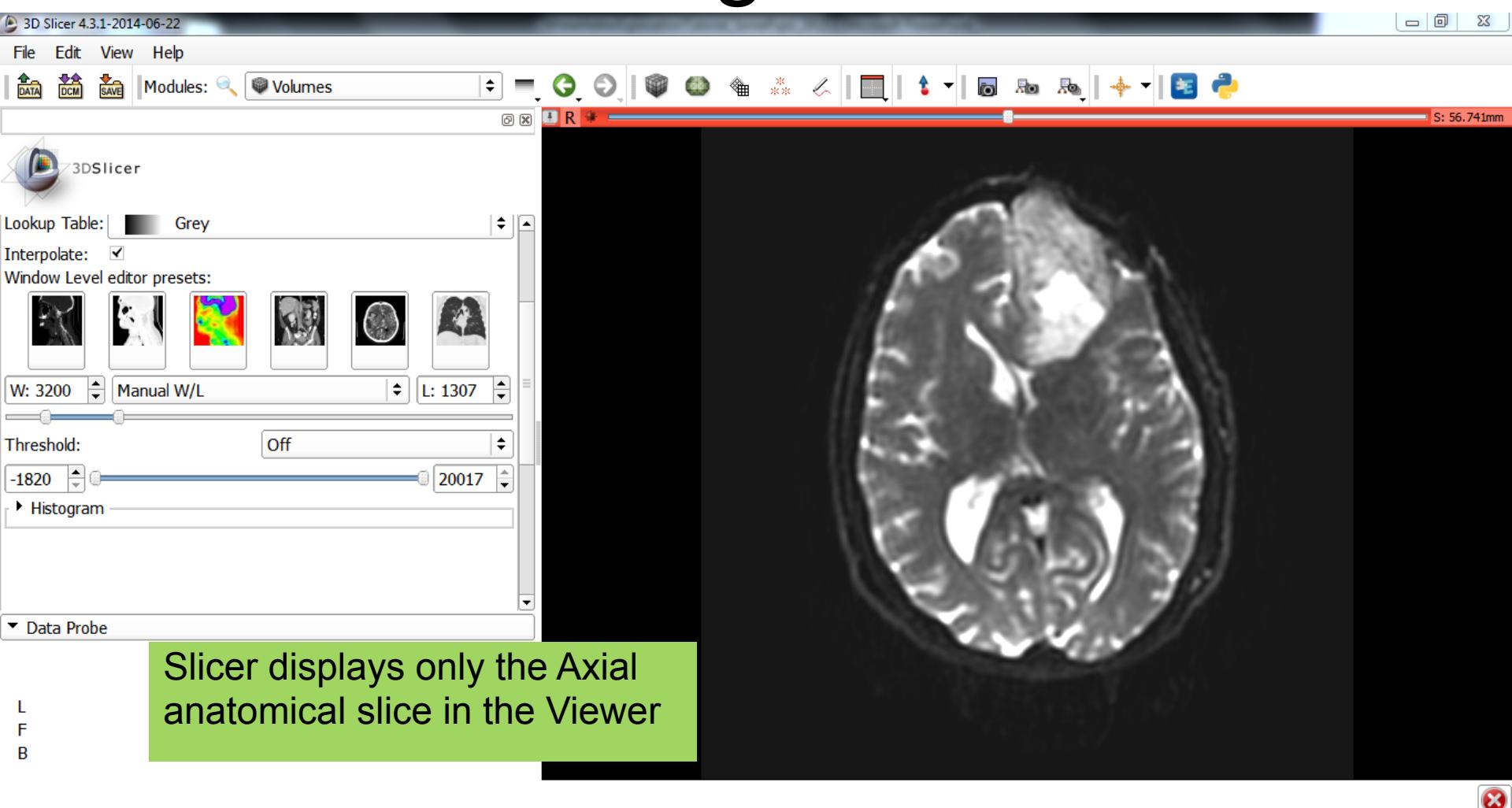
Tumor Segmentation



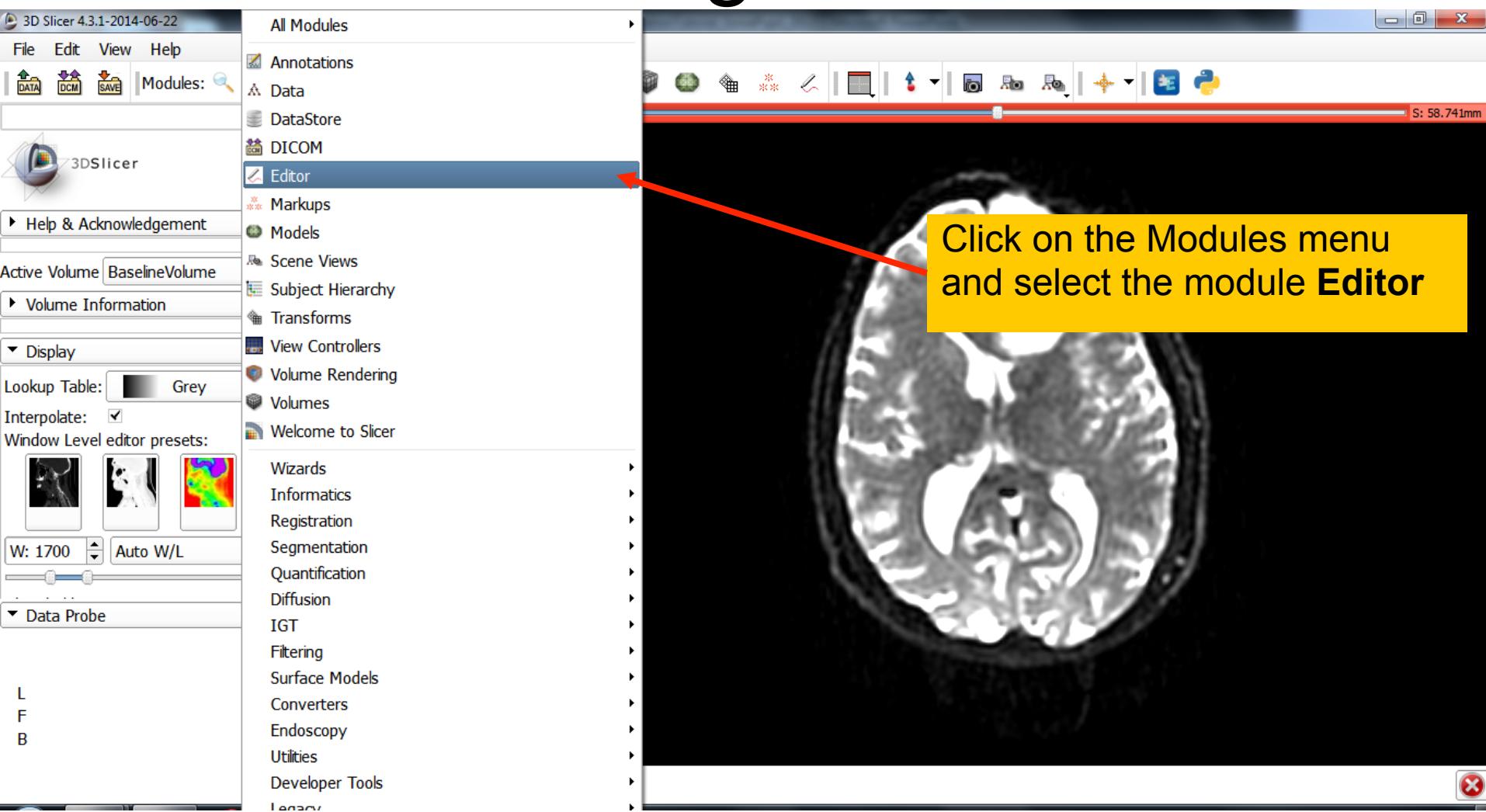
The tumor in this clinical case is composed of two parts: a solid part, and a cystic part.

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

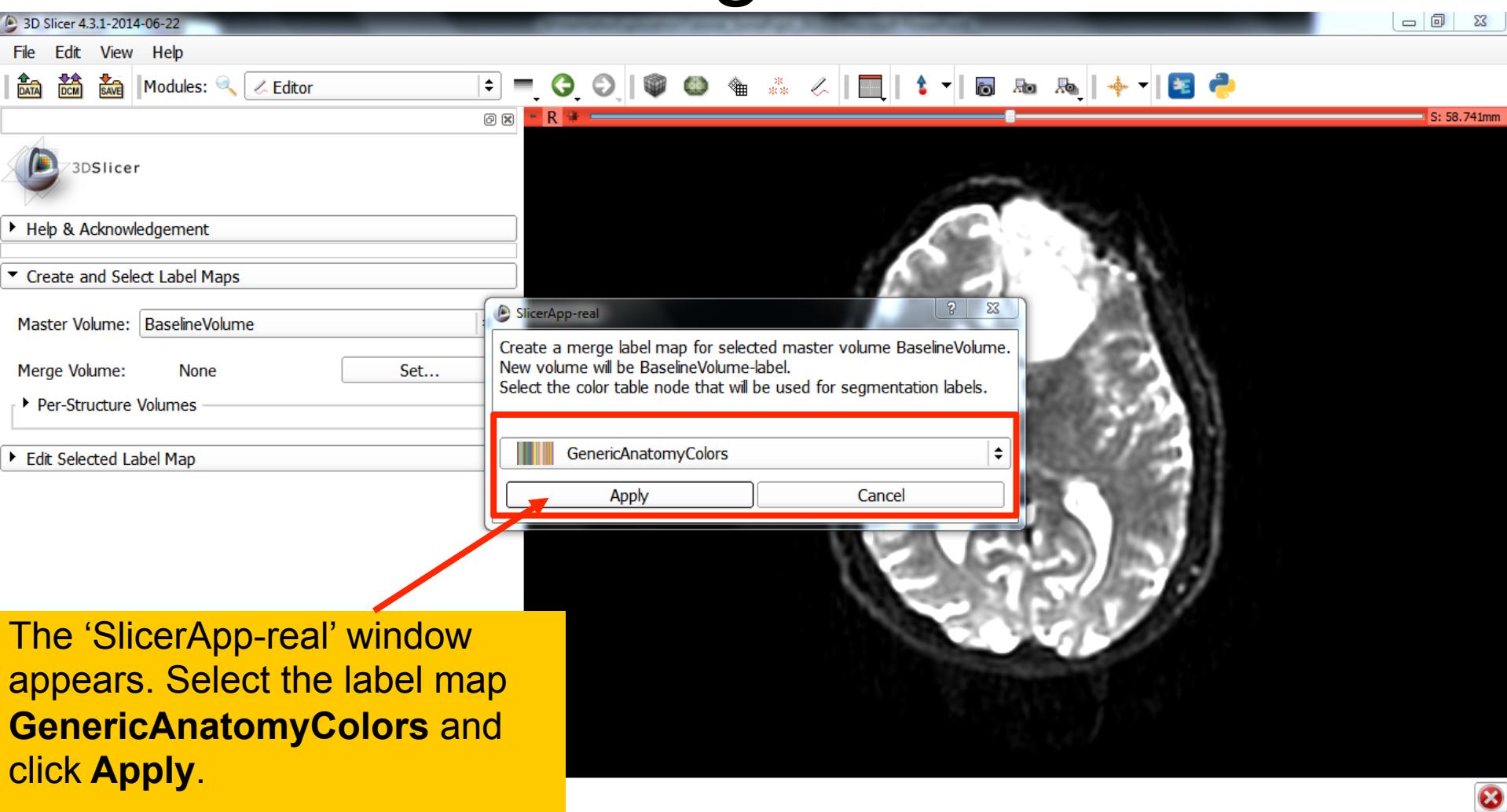
Tumor Segmentation



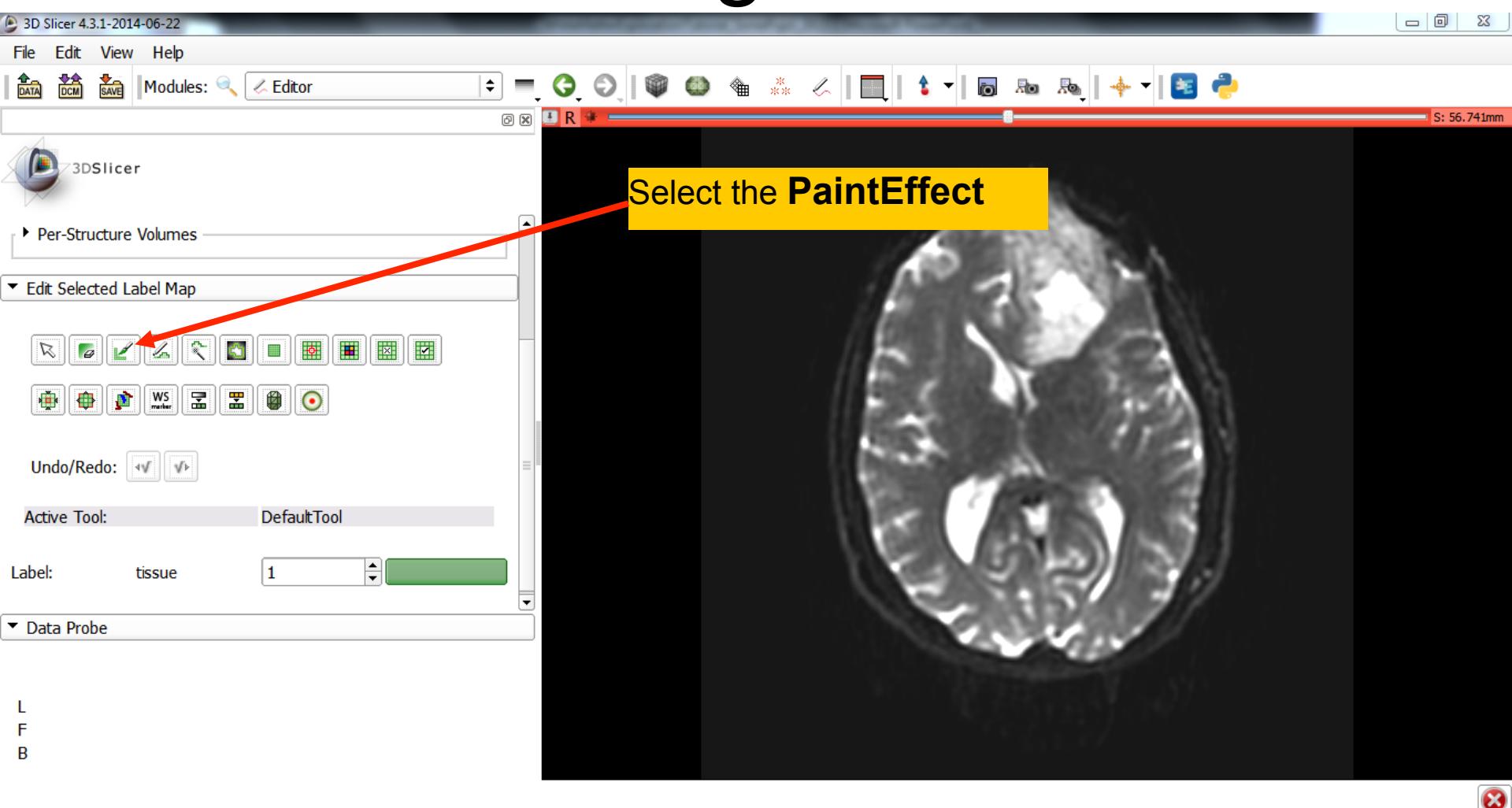
Tumor Segmentation



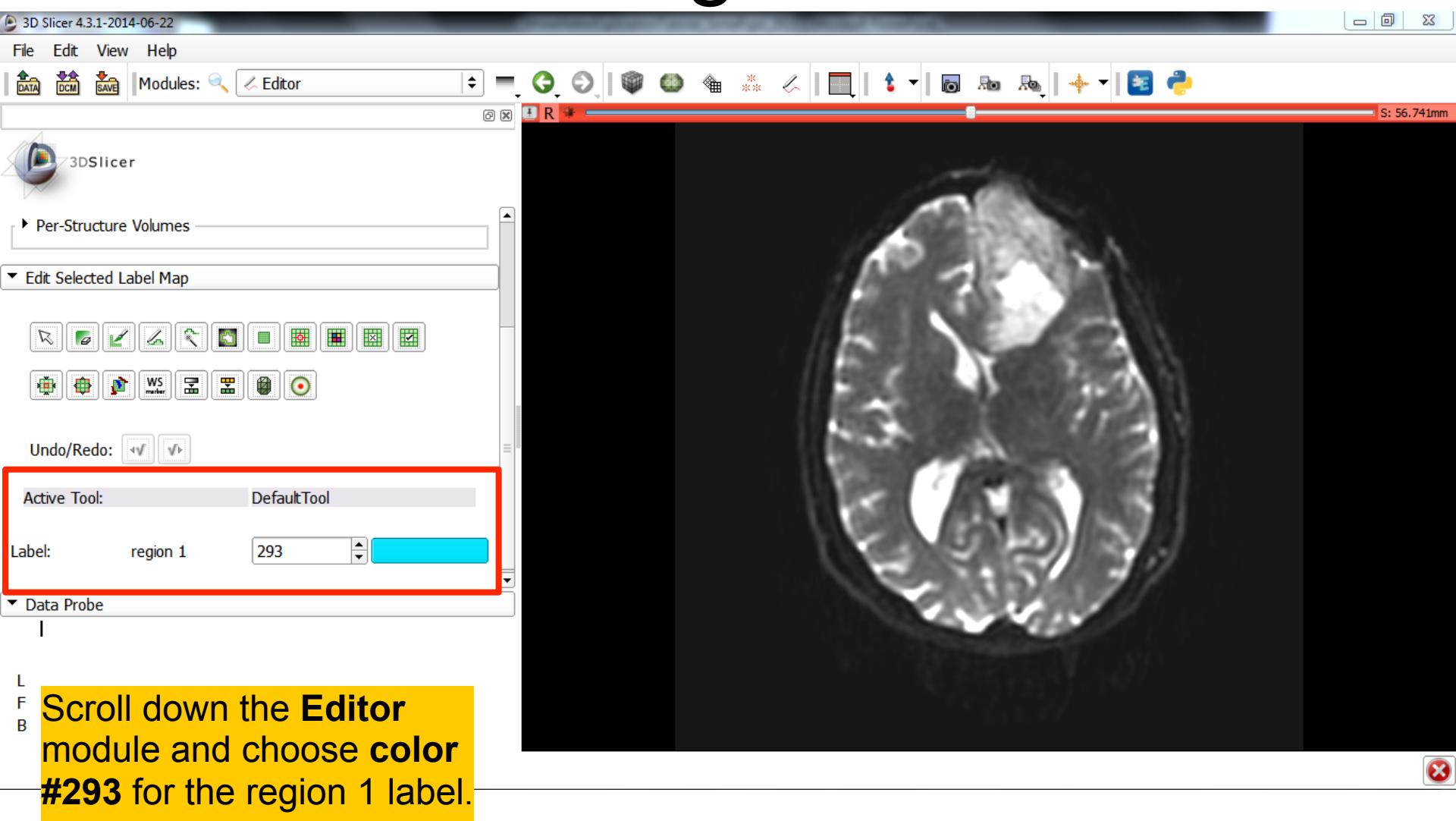
Tumor Segmentation



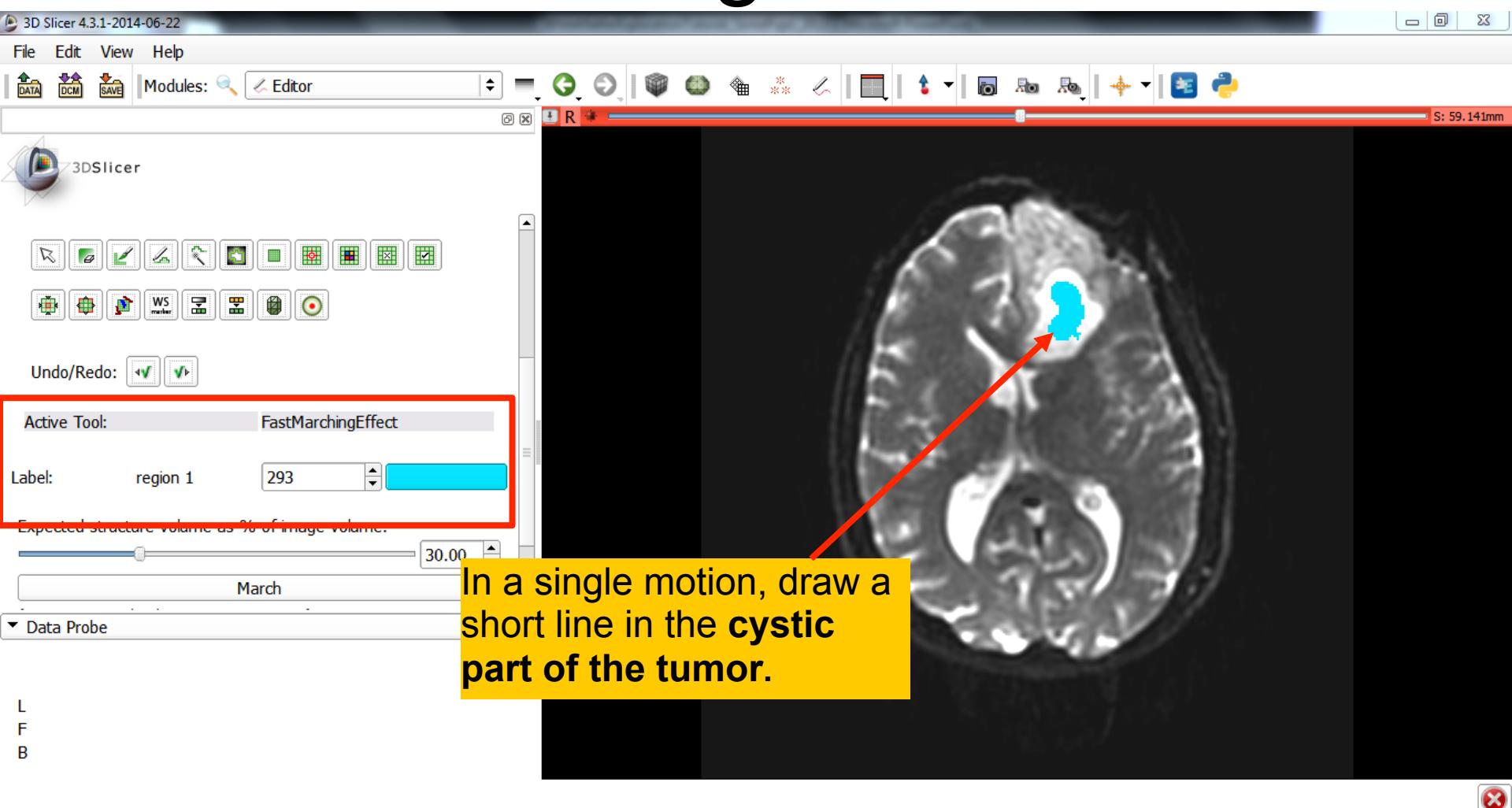
Tumor Segmentation



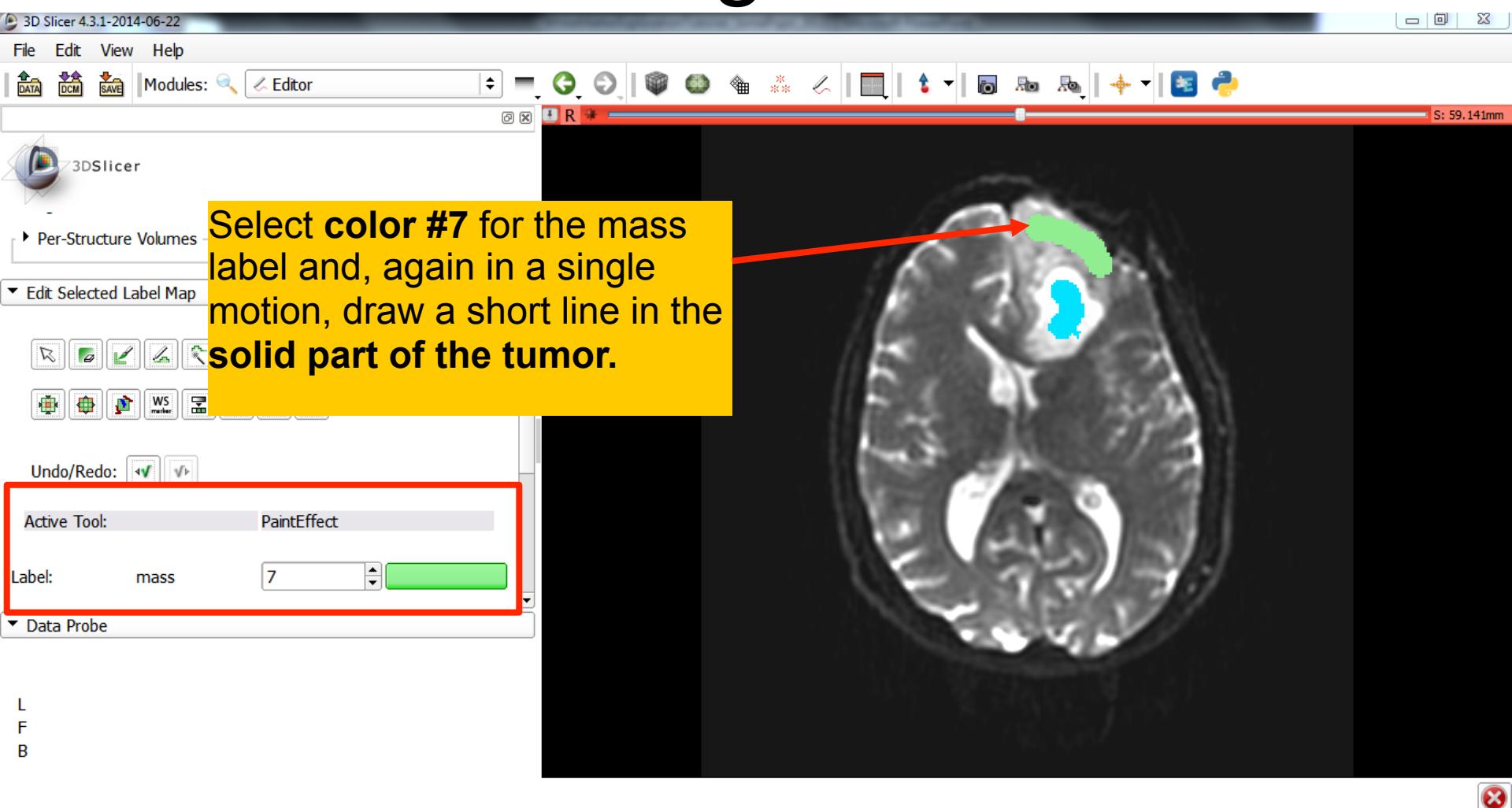
Tumor Segmentation



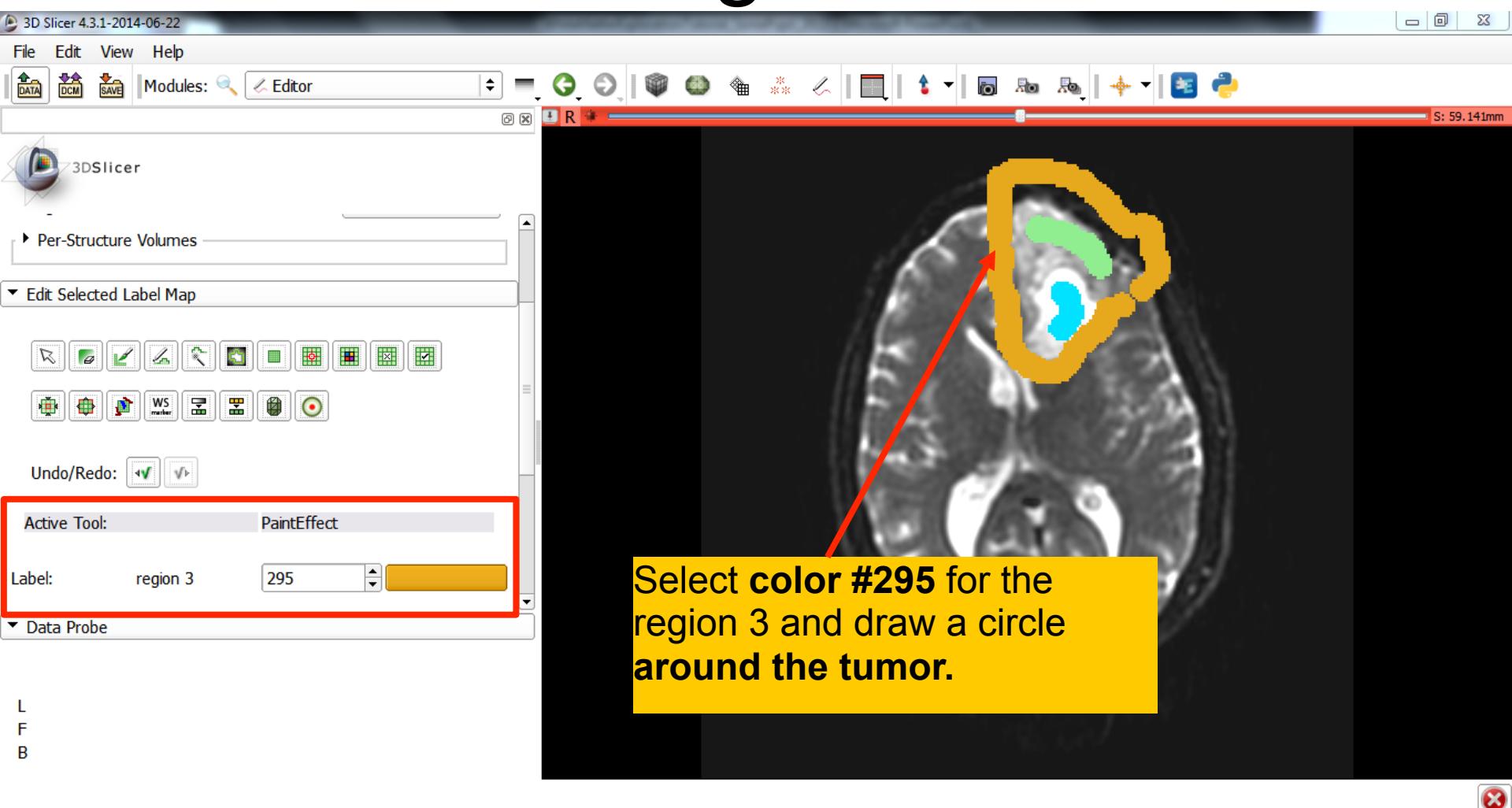
Tumor Segmentation



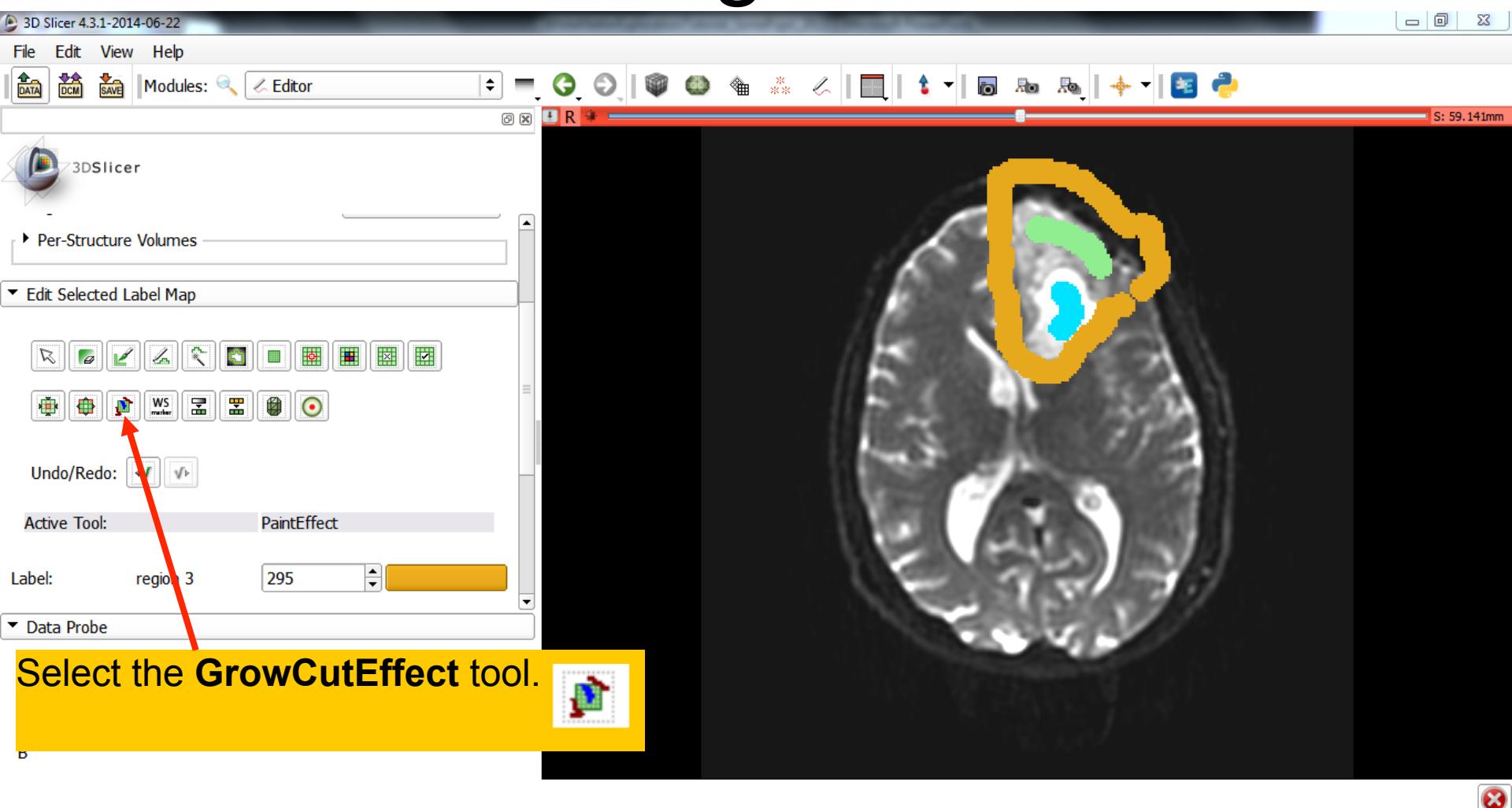
Tumor Segmentation



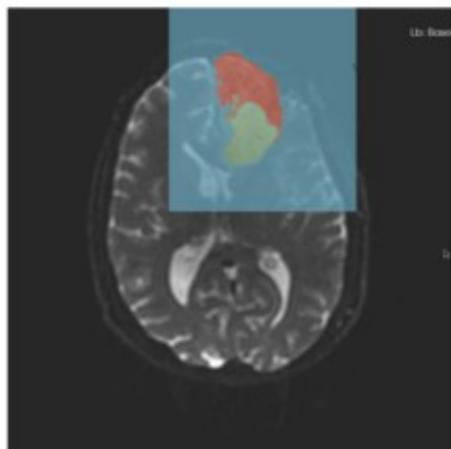
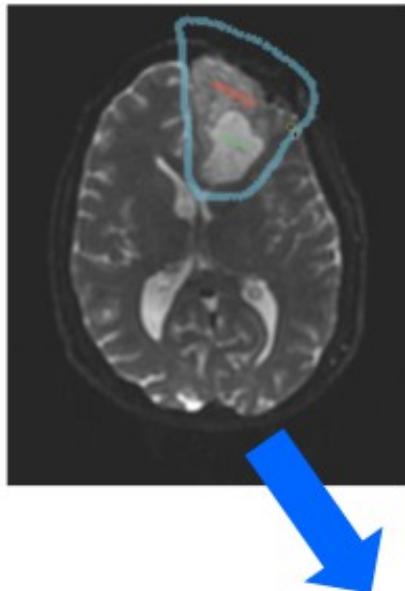
Tumor Segmentation



Tumor Segmentation

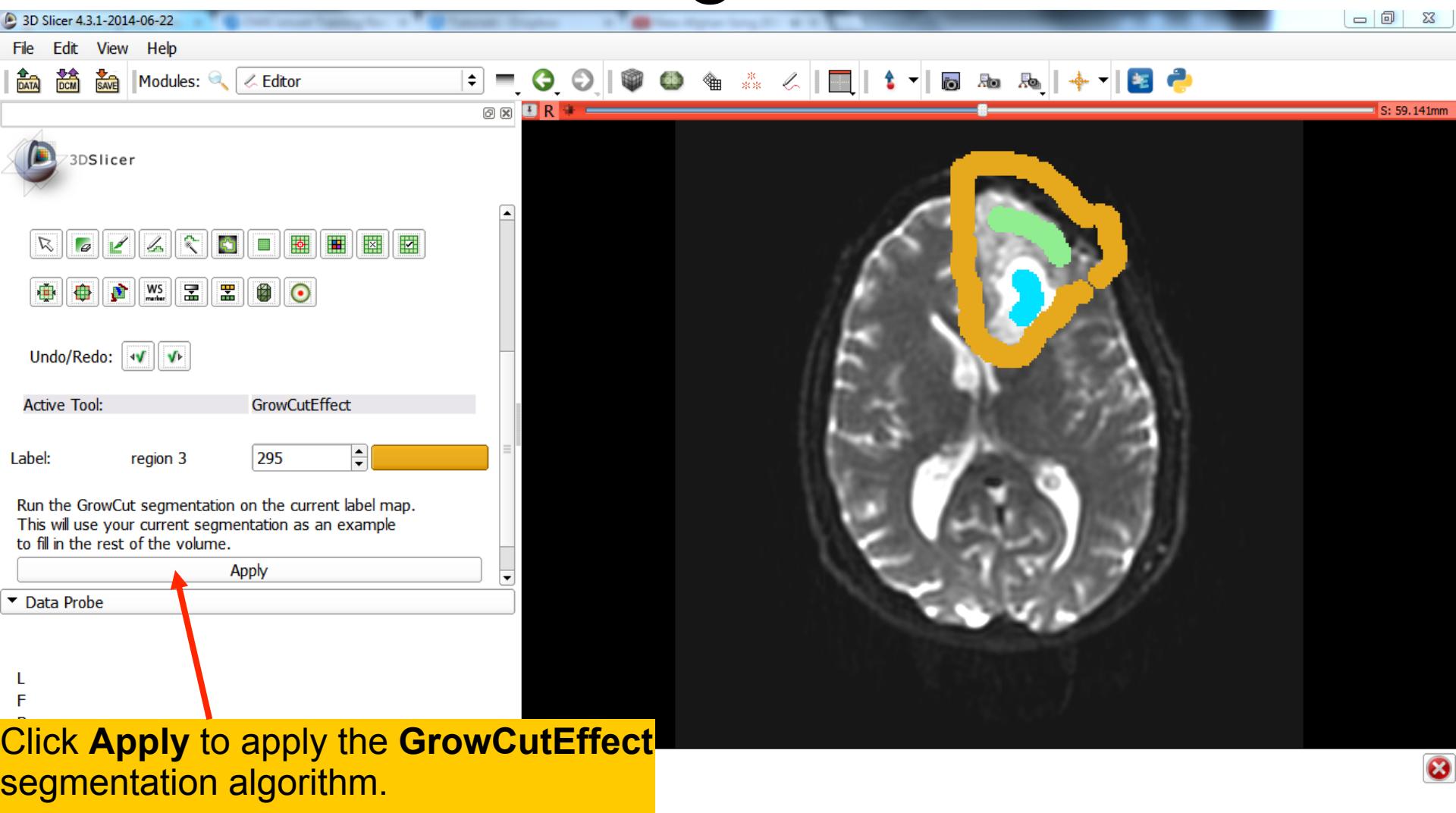


Grow Cut Segmentation

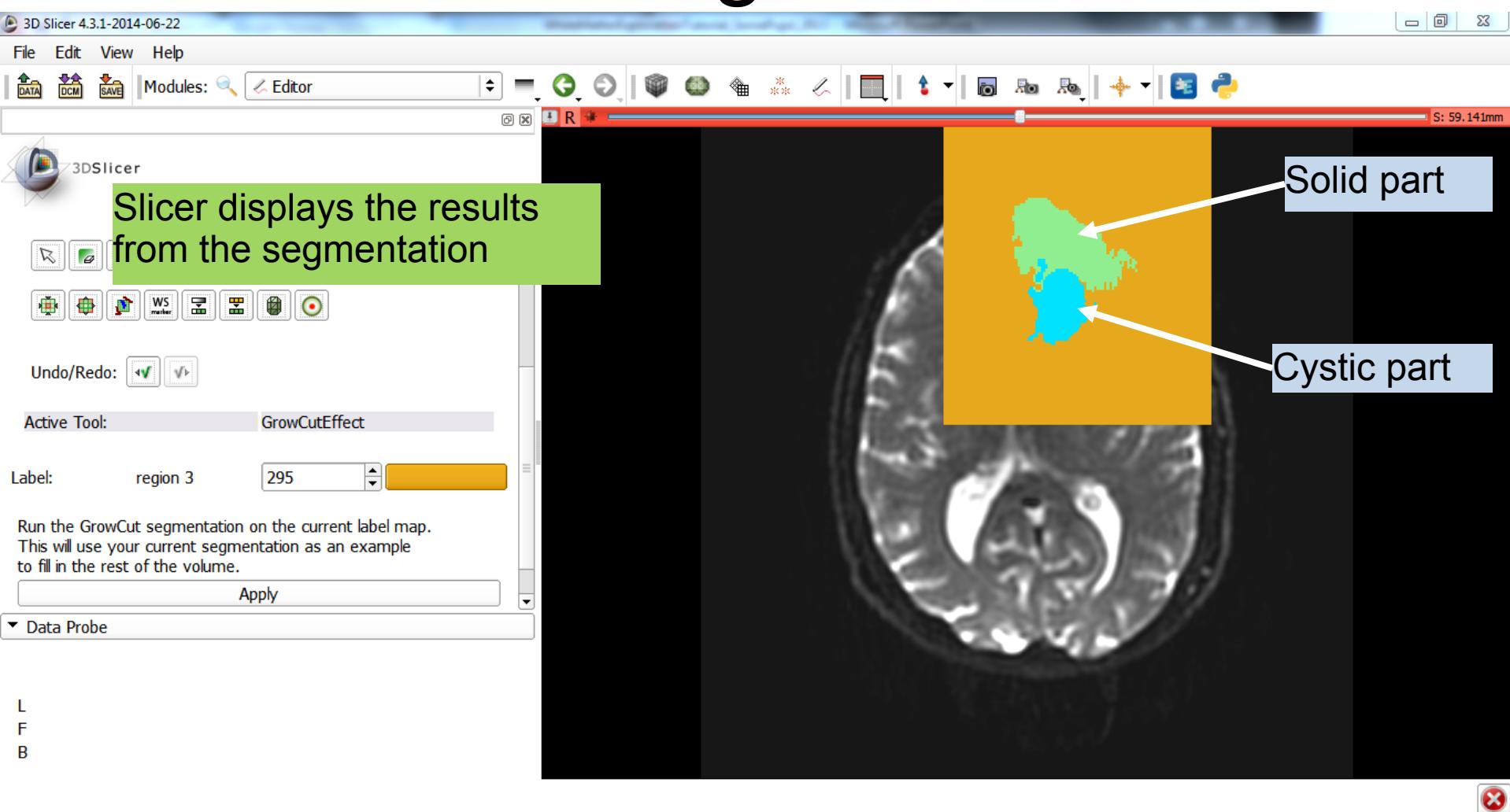


- The Grow Cut Segmentation method is a competitive region growing algorithm using Cellular Automata.
- The algorithm performs multi-label image segmentation using a set of user input scribbles.
- V. Vezhnevets, V. Konouchine. "Grow-Cut" - Interactive Multi-Label N-D Image Segmentation". Proc. Graphicon.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

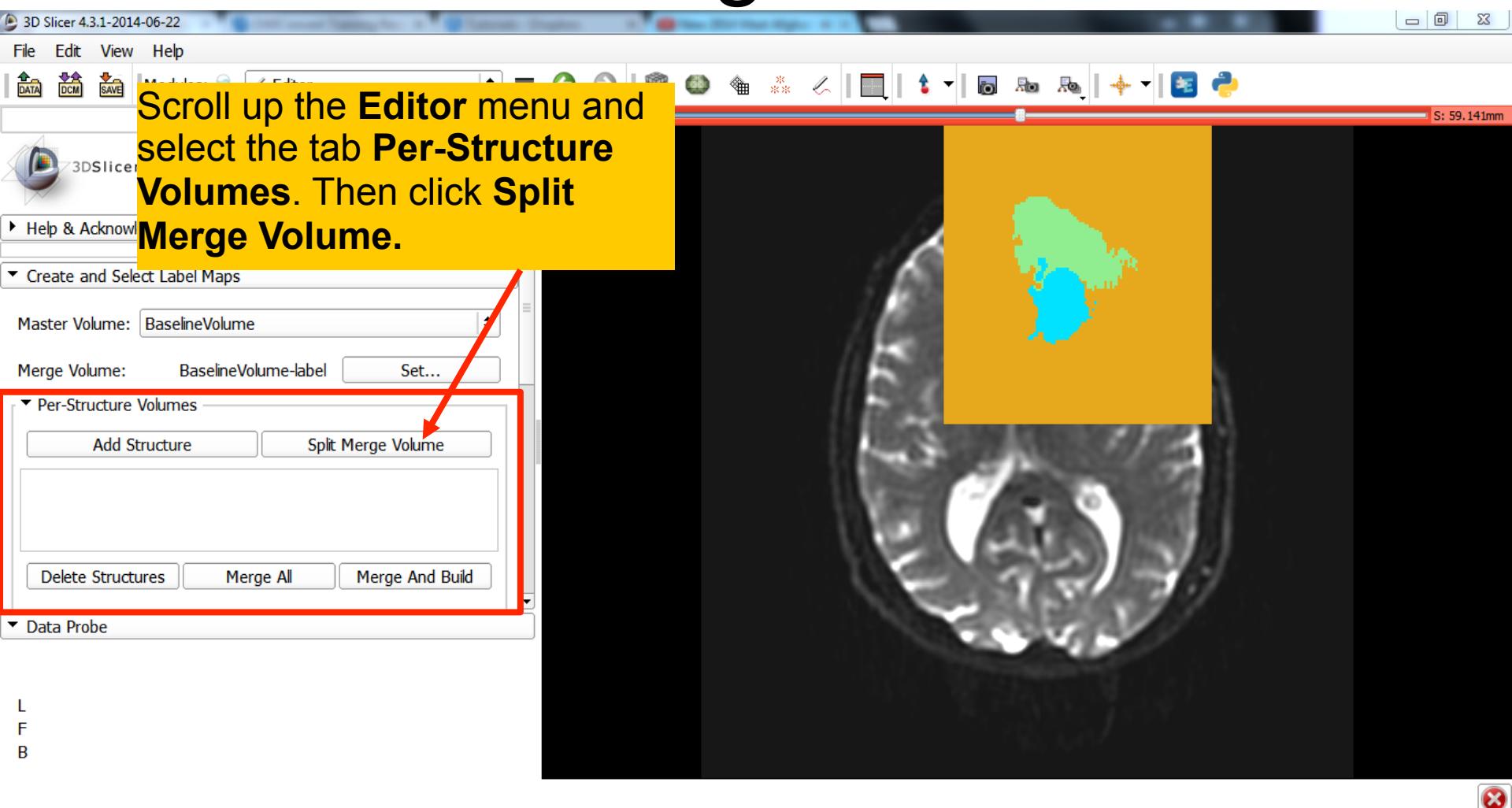
Tumor Segmentation



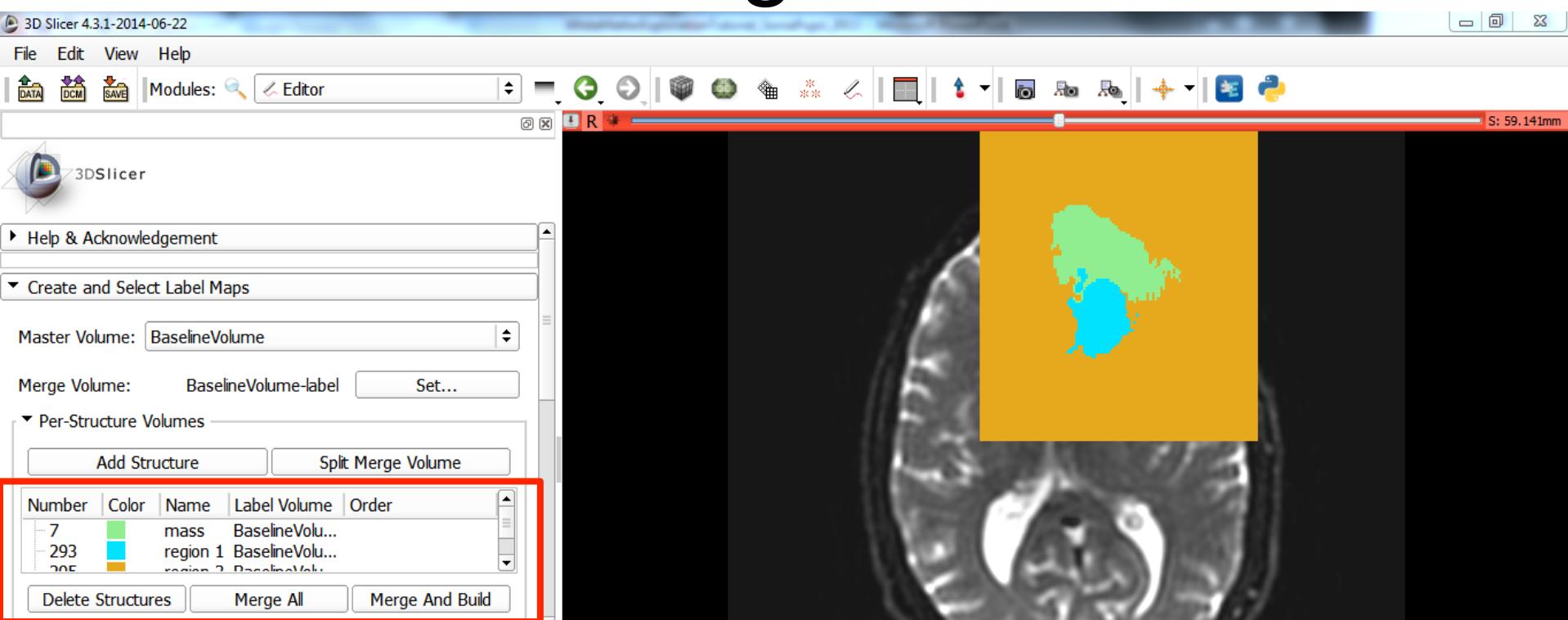
Tumor Segmentation



Tumor Segmentation



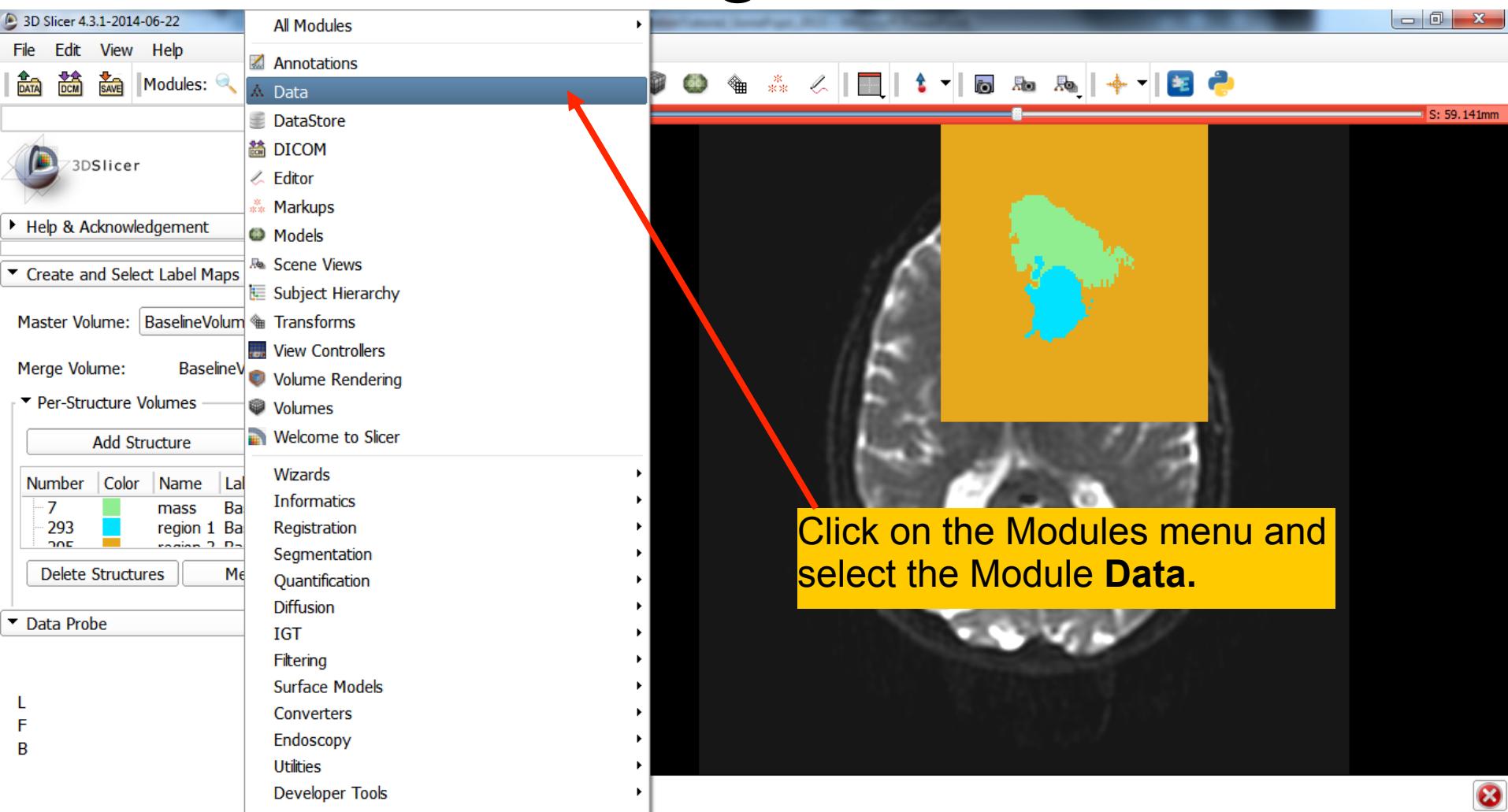
Tumor Segmentation



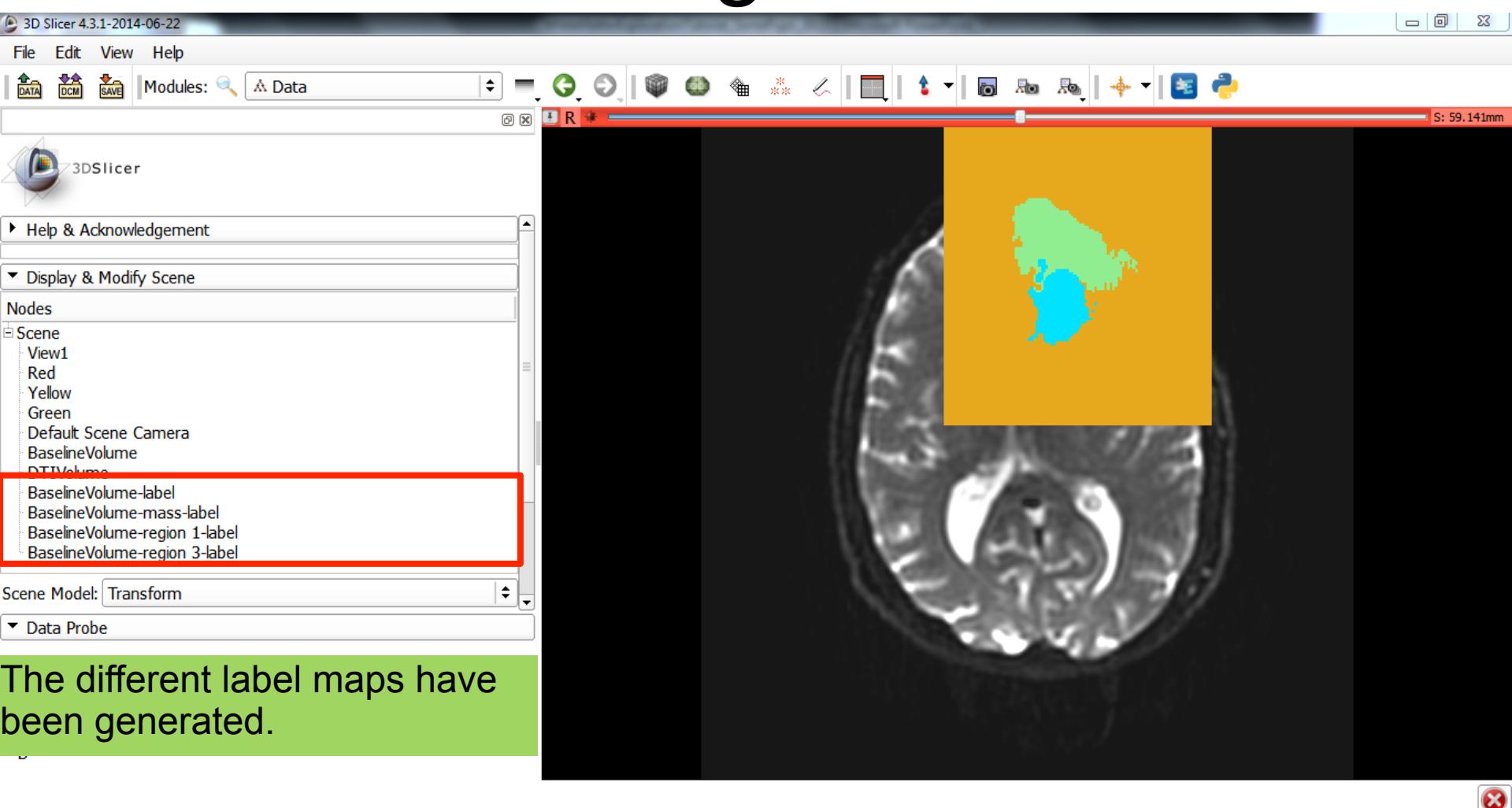
The label map **BaselineVolume-label** has been split into three volumes:

- **BaselineVolume-mass-label**: solid part of the tumor
- **BaselineVolume-region_1-label**: cystic part of the tumor
- **BaselineVolume-region_3-label**: surrounding structures

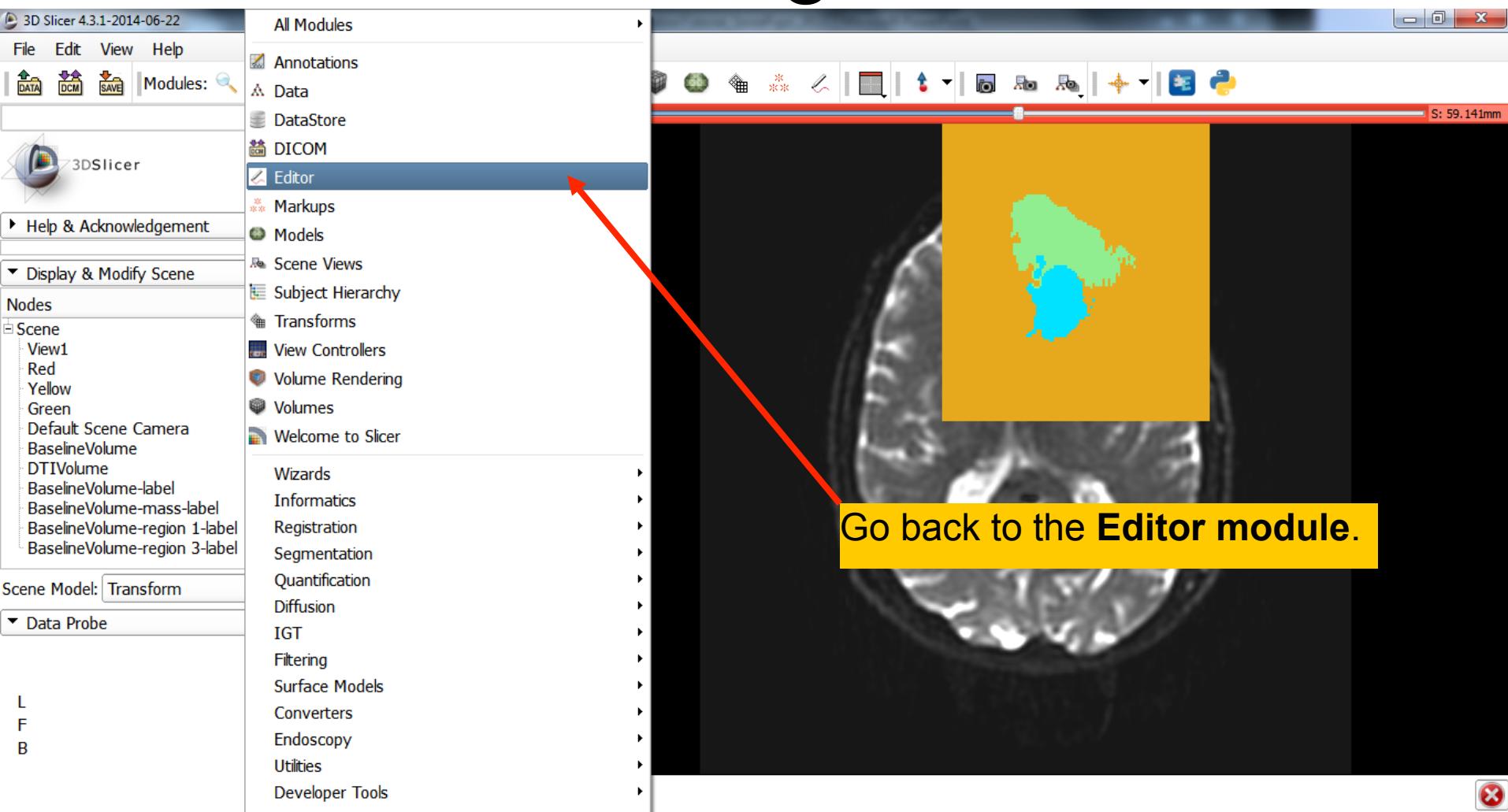
Tumor Segmentation



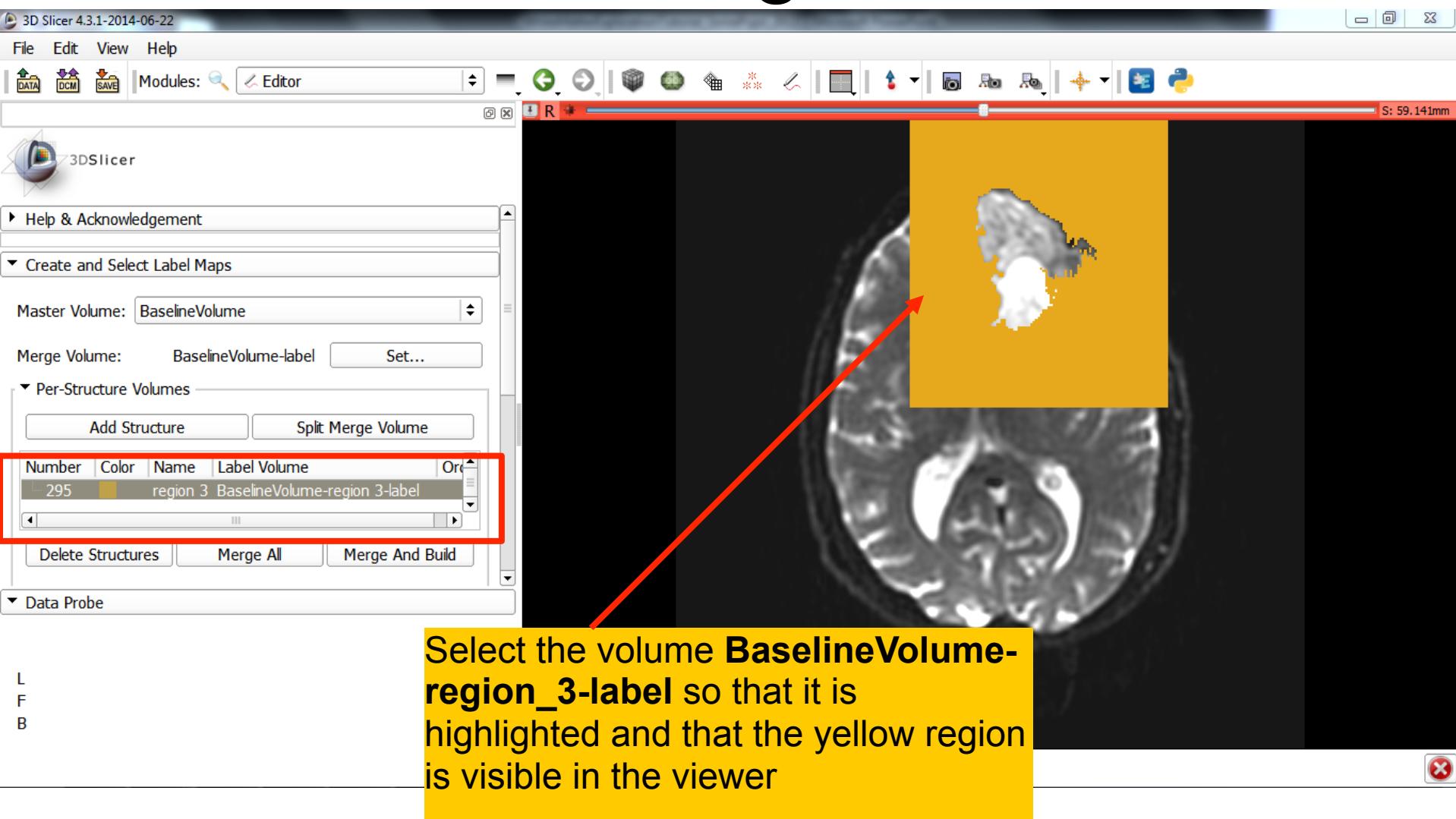
Tumor Segmentation



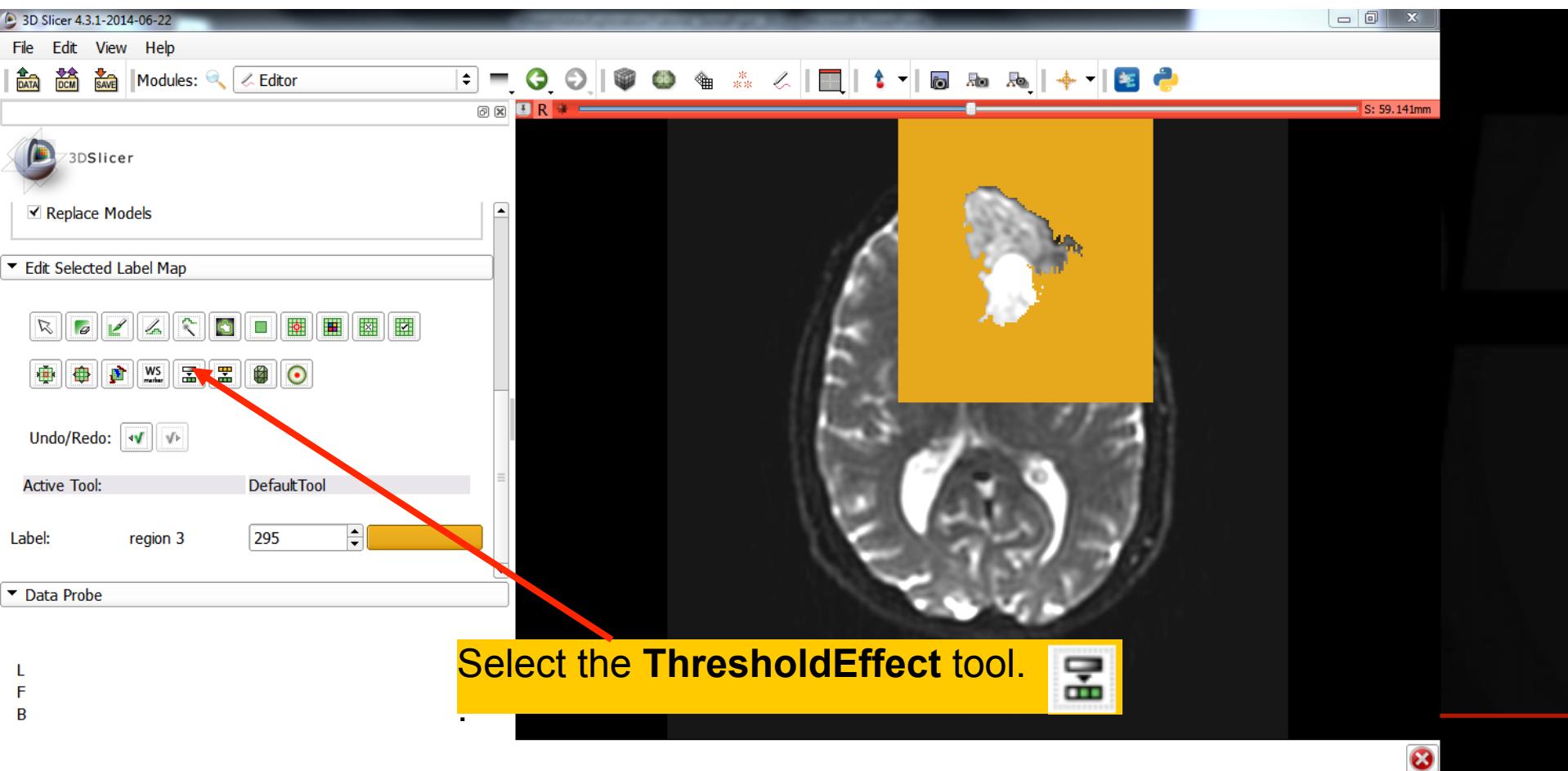
Ventricles Segmentation



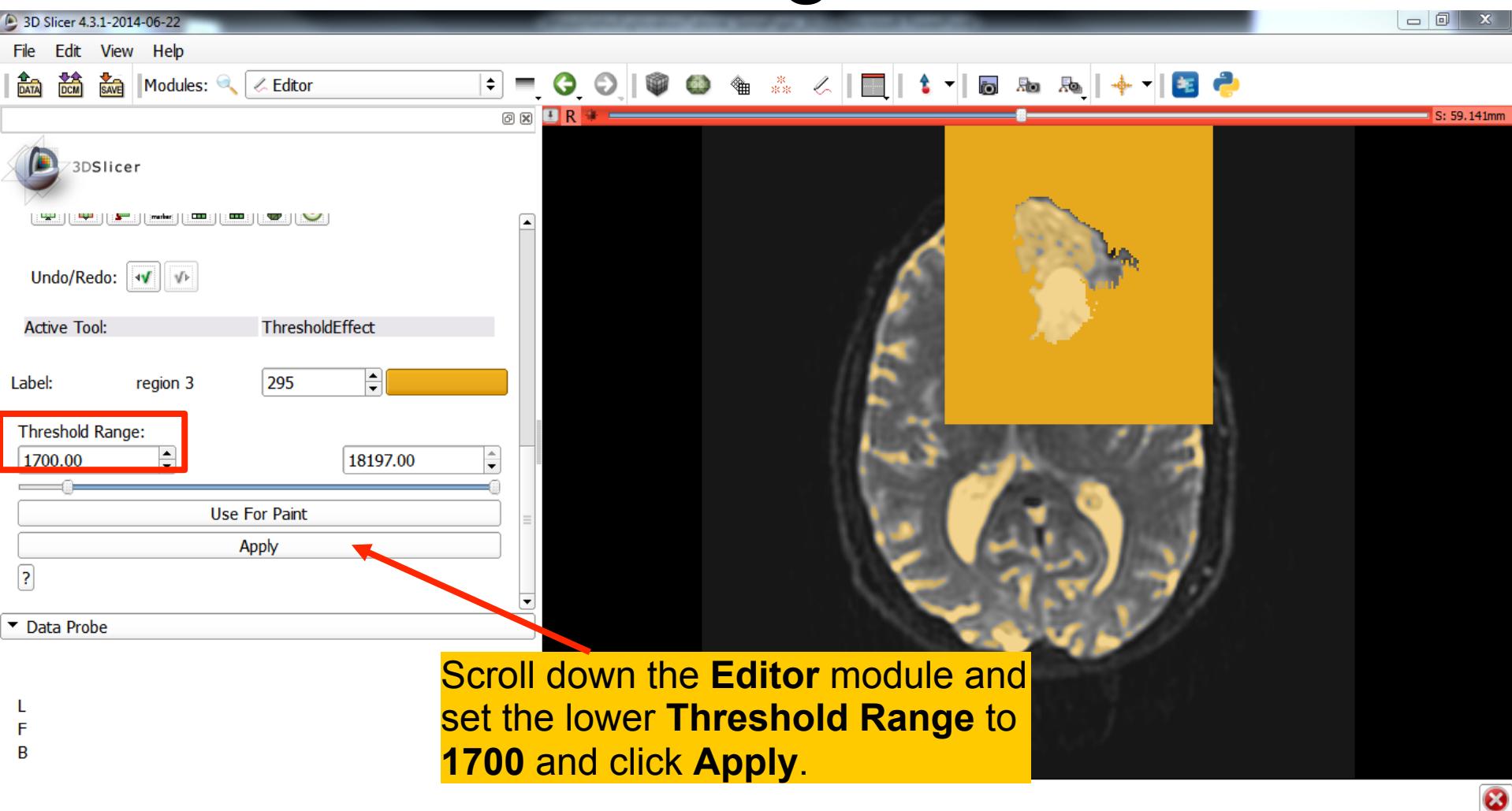
Ventricles Segmentation



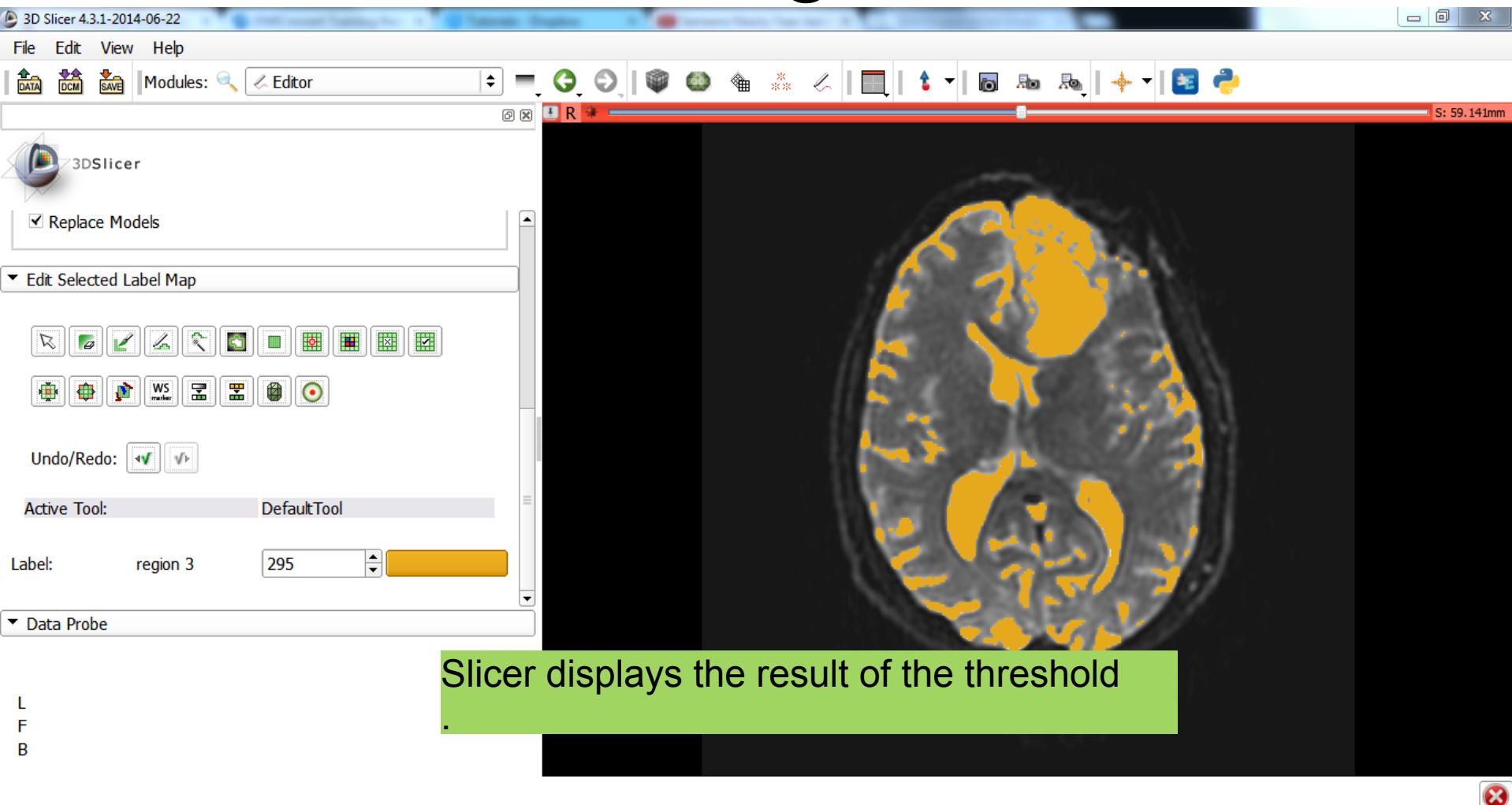
Ventricles Segmentation



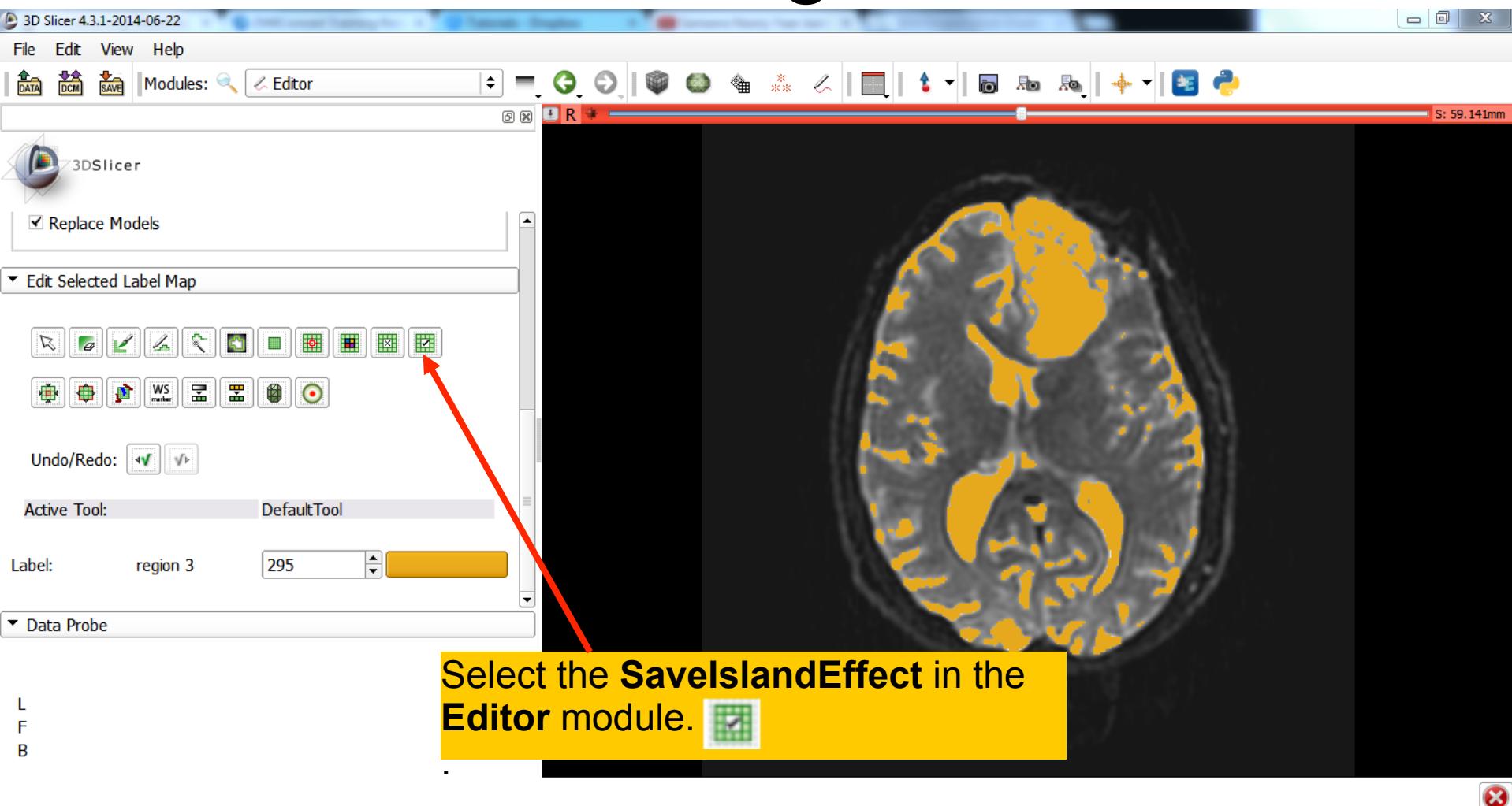
Ventricles Segmentation



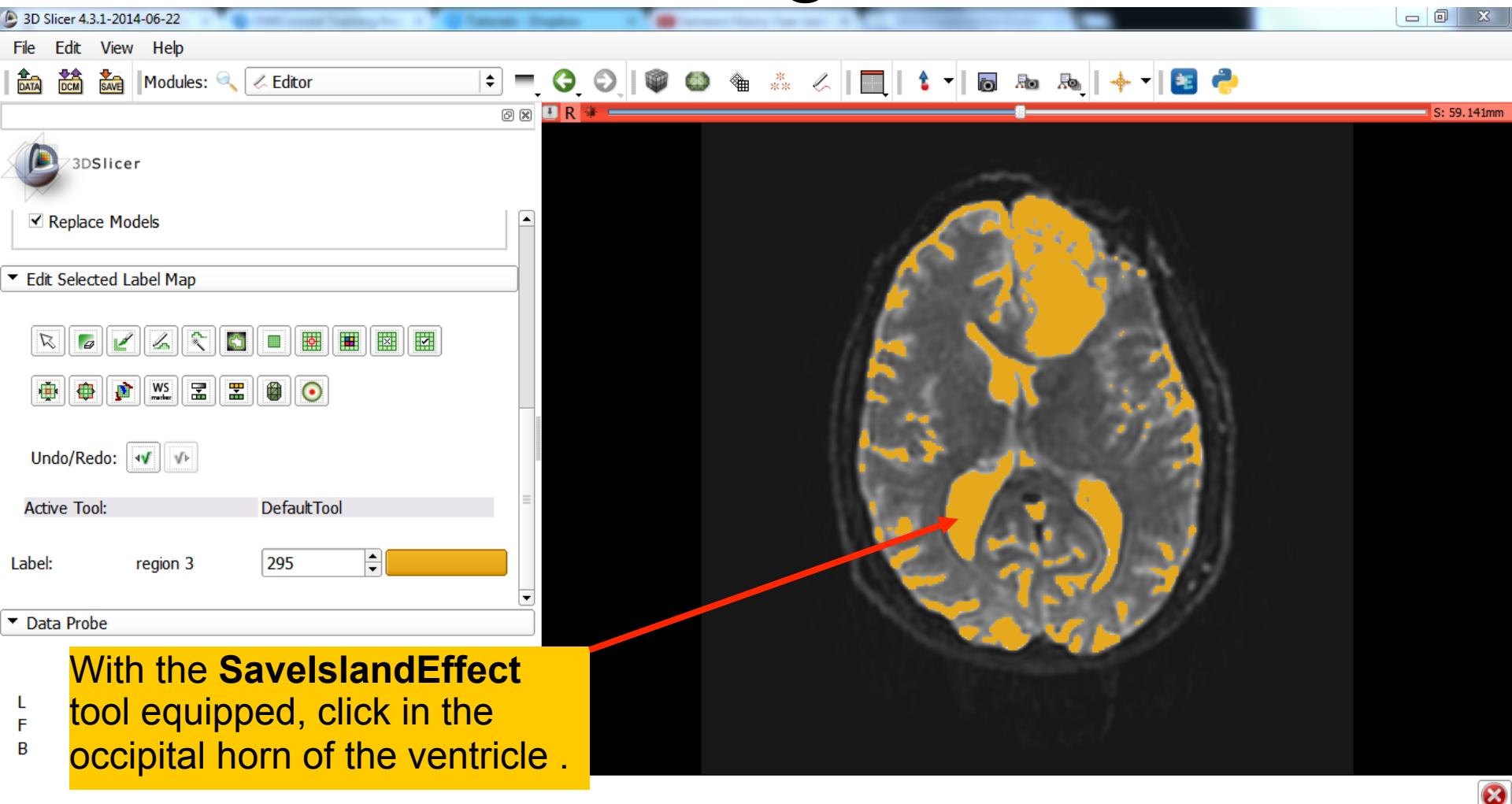
Ventricles Segmentation



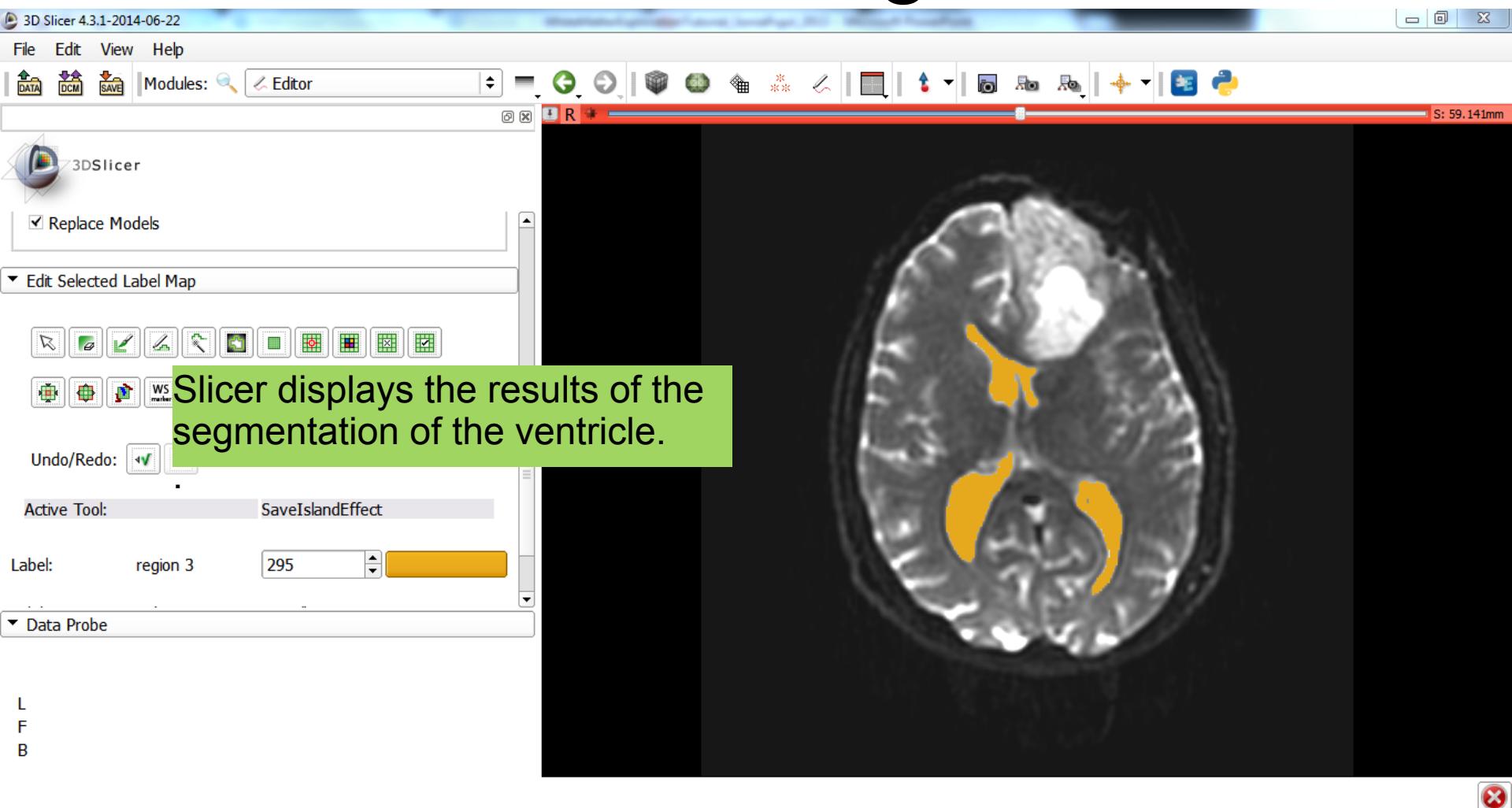
Ventricles Segmentation



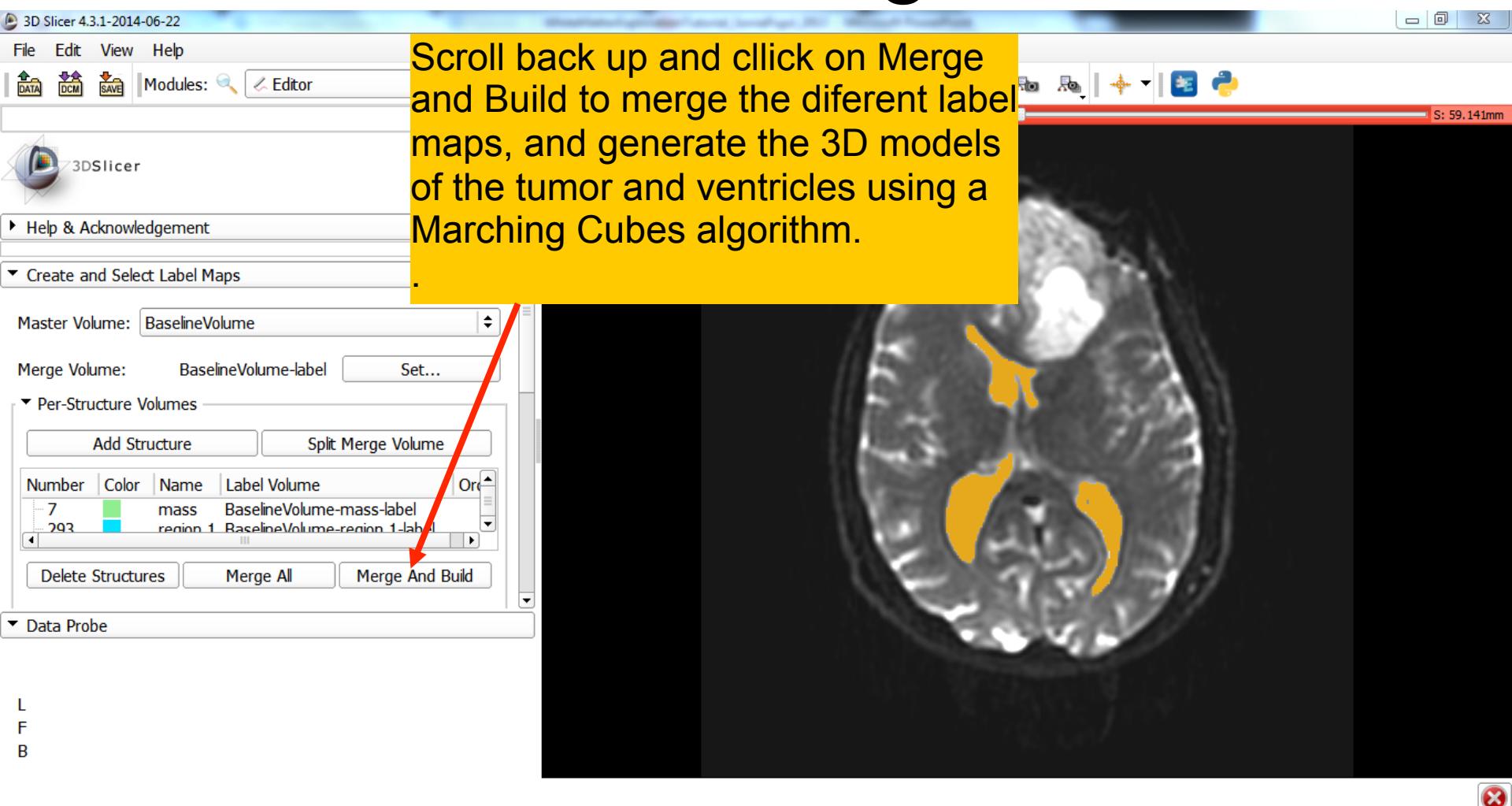
Ventricles Segmentation



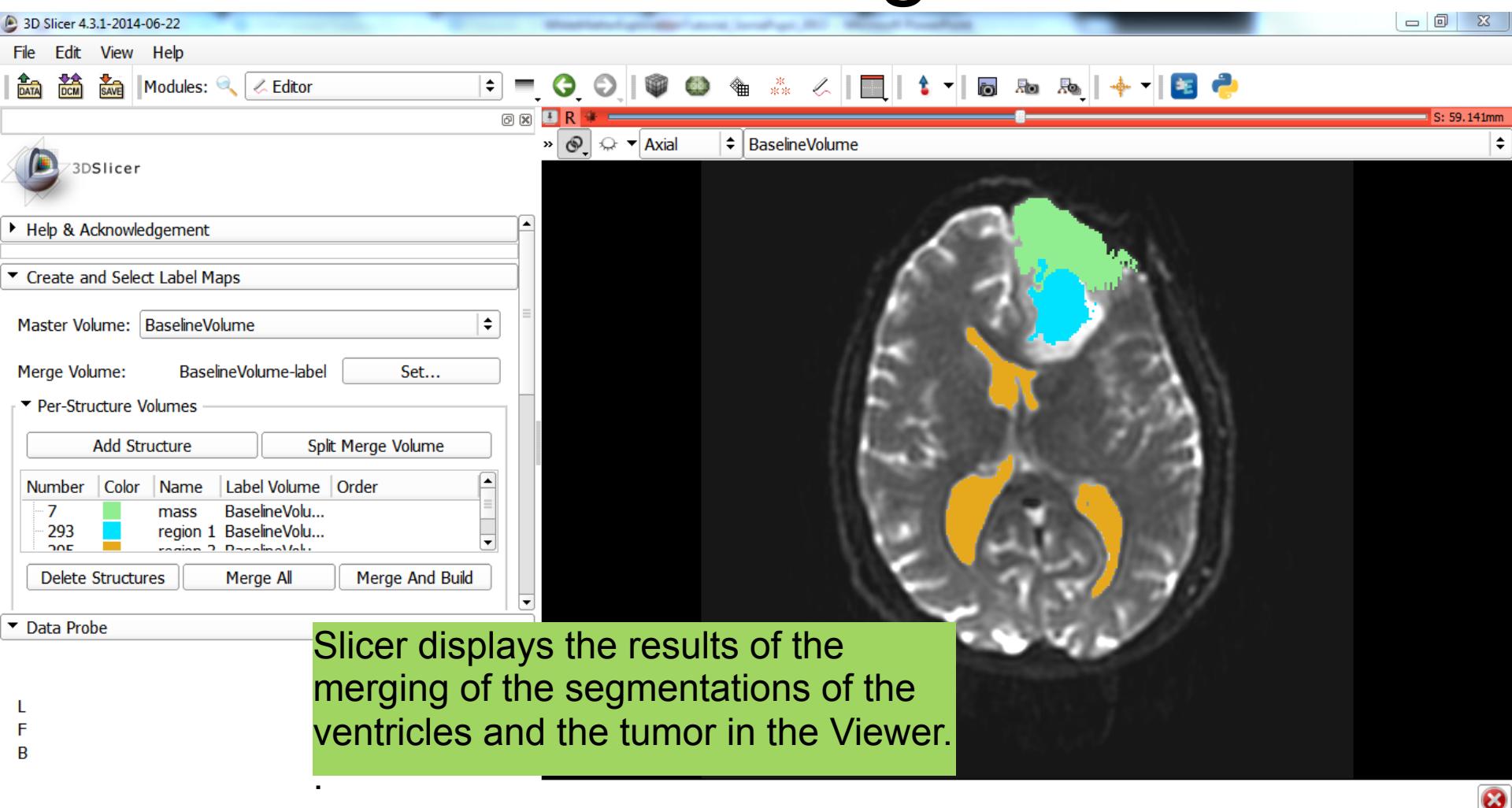
Final Result of Segmentation



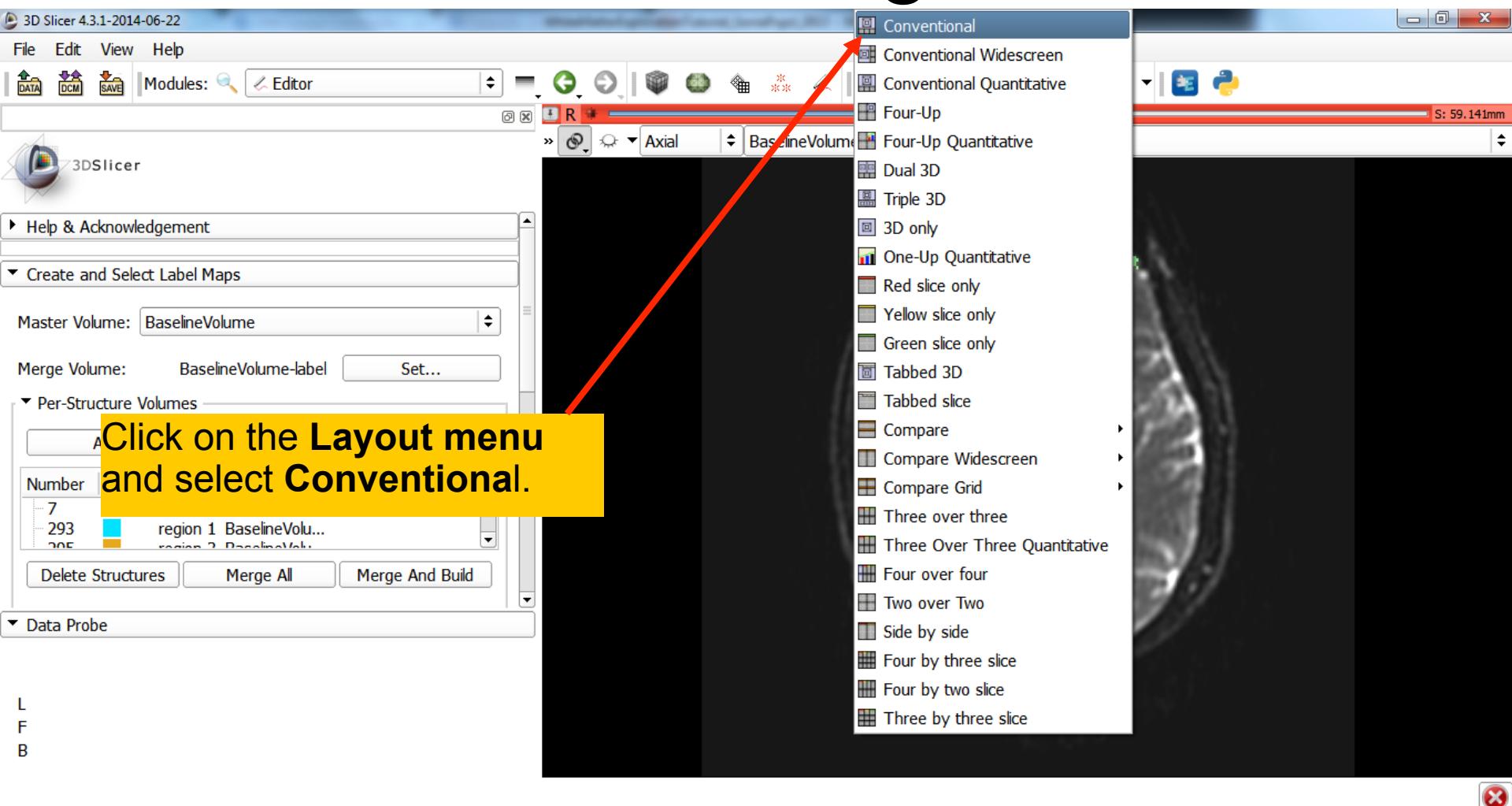
Final Result of Segmentation



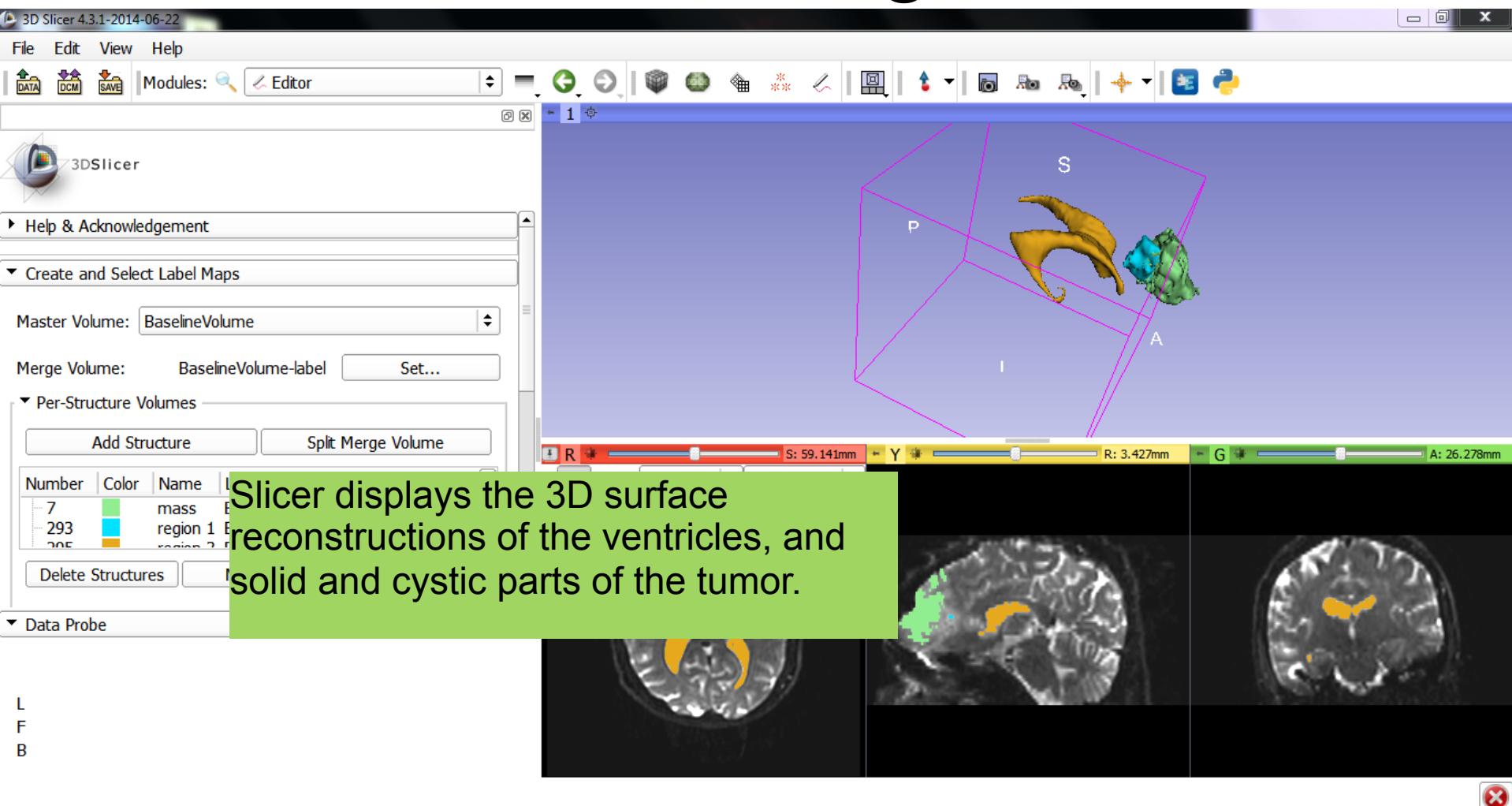
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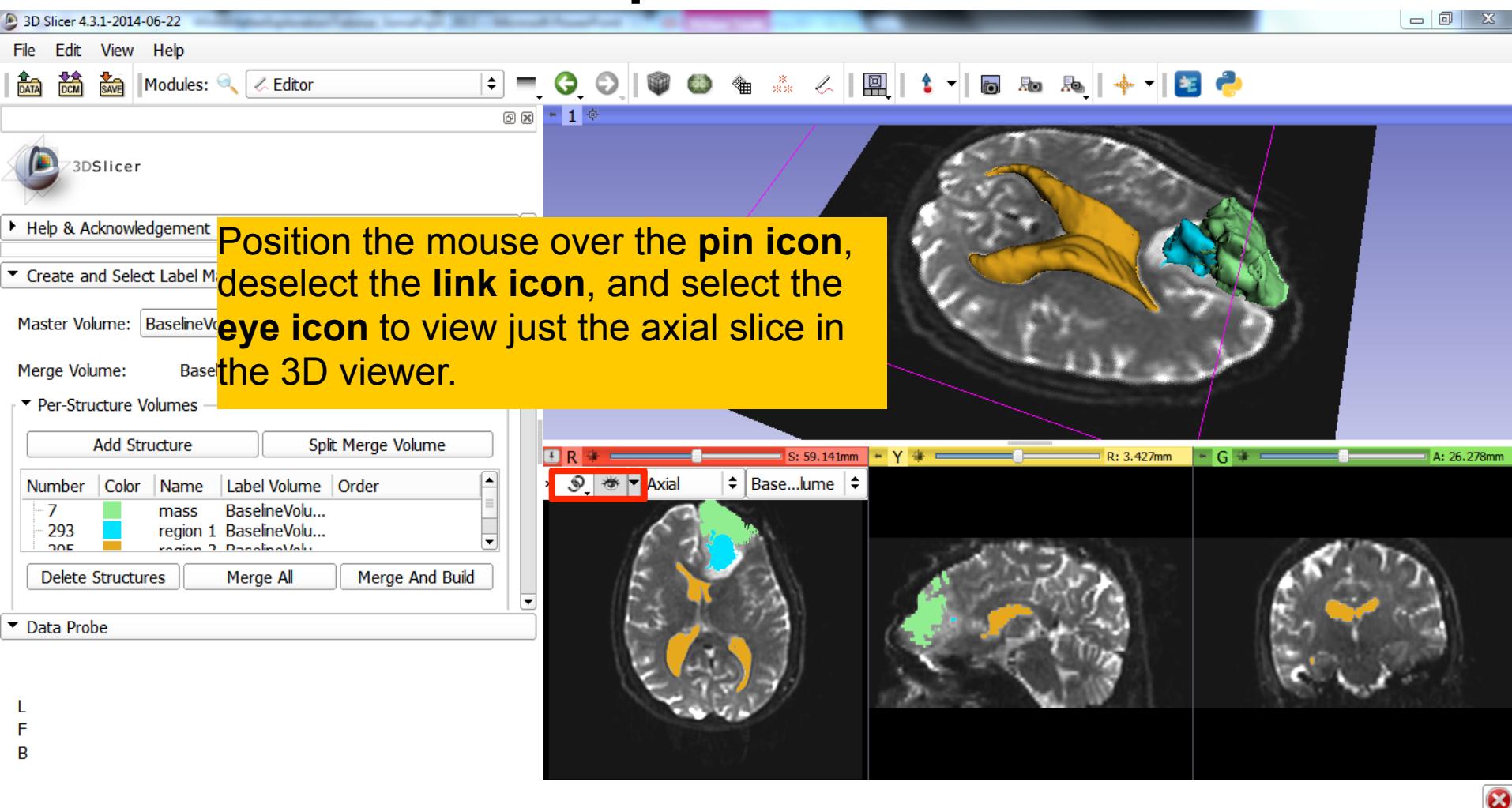
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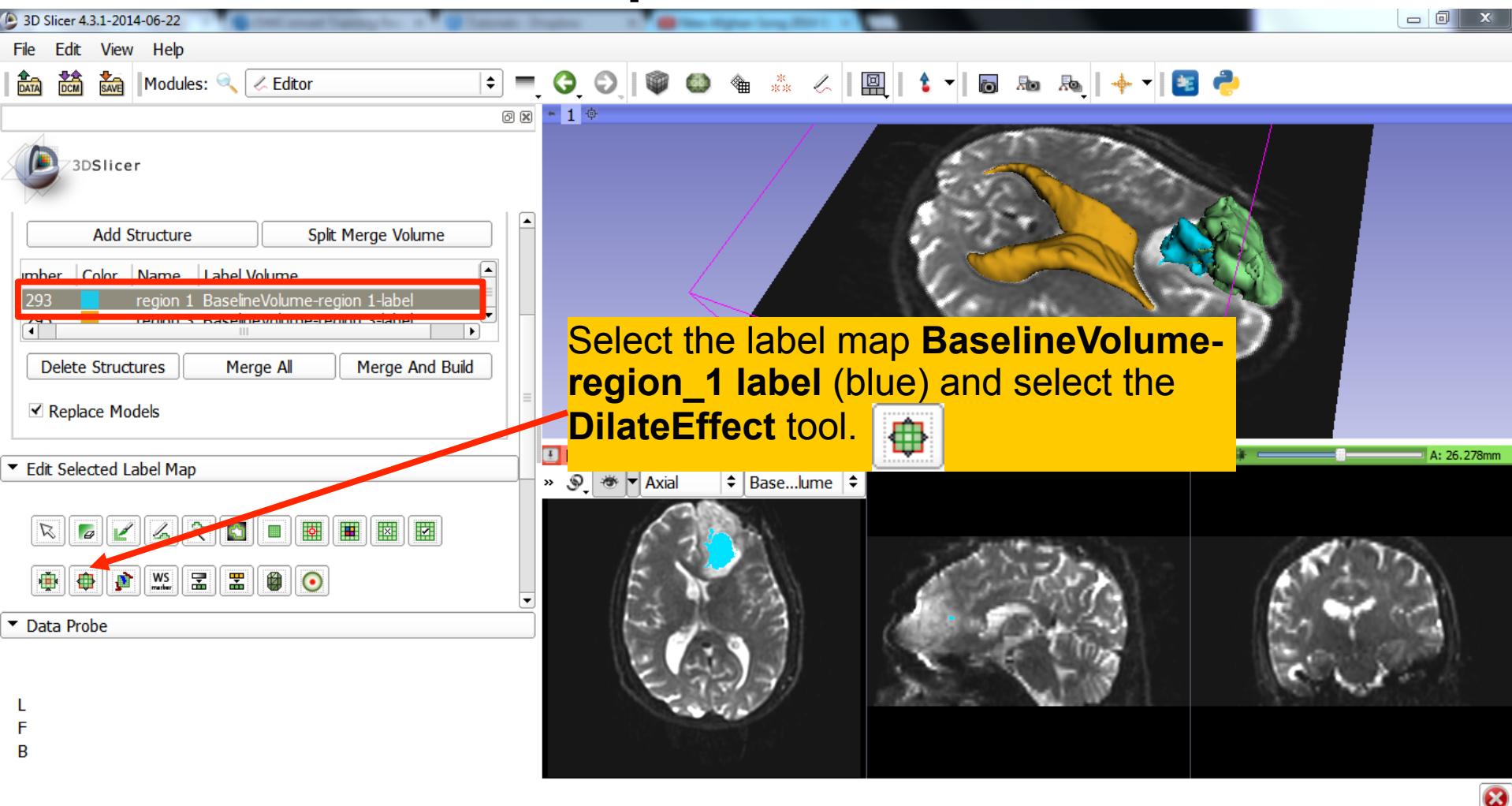
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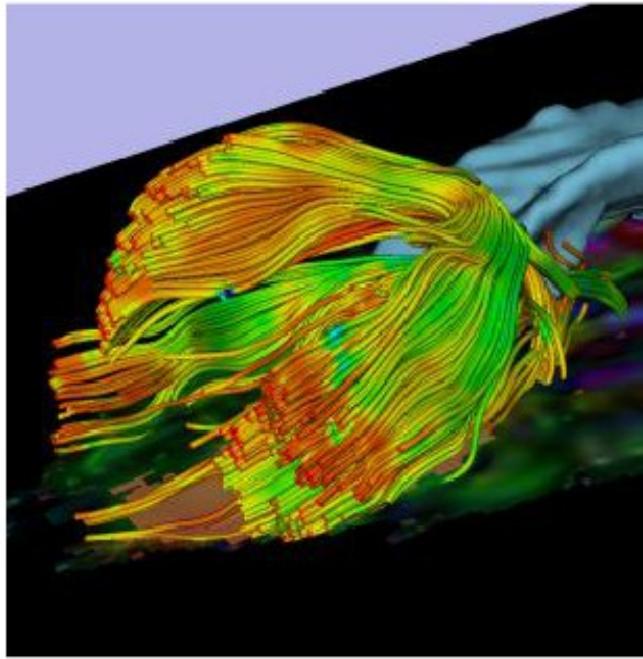


Definition of peri-tumoral volume



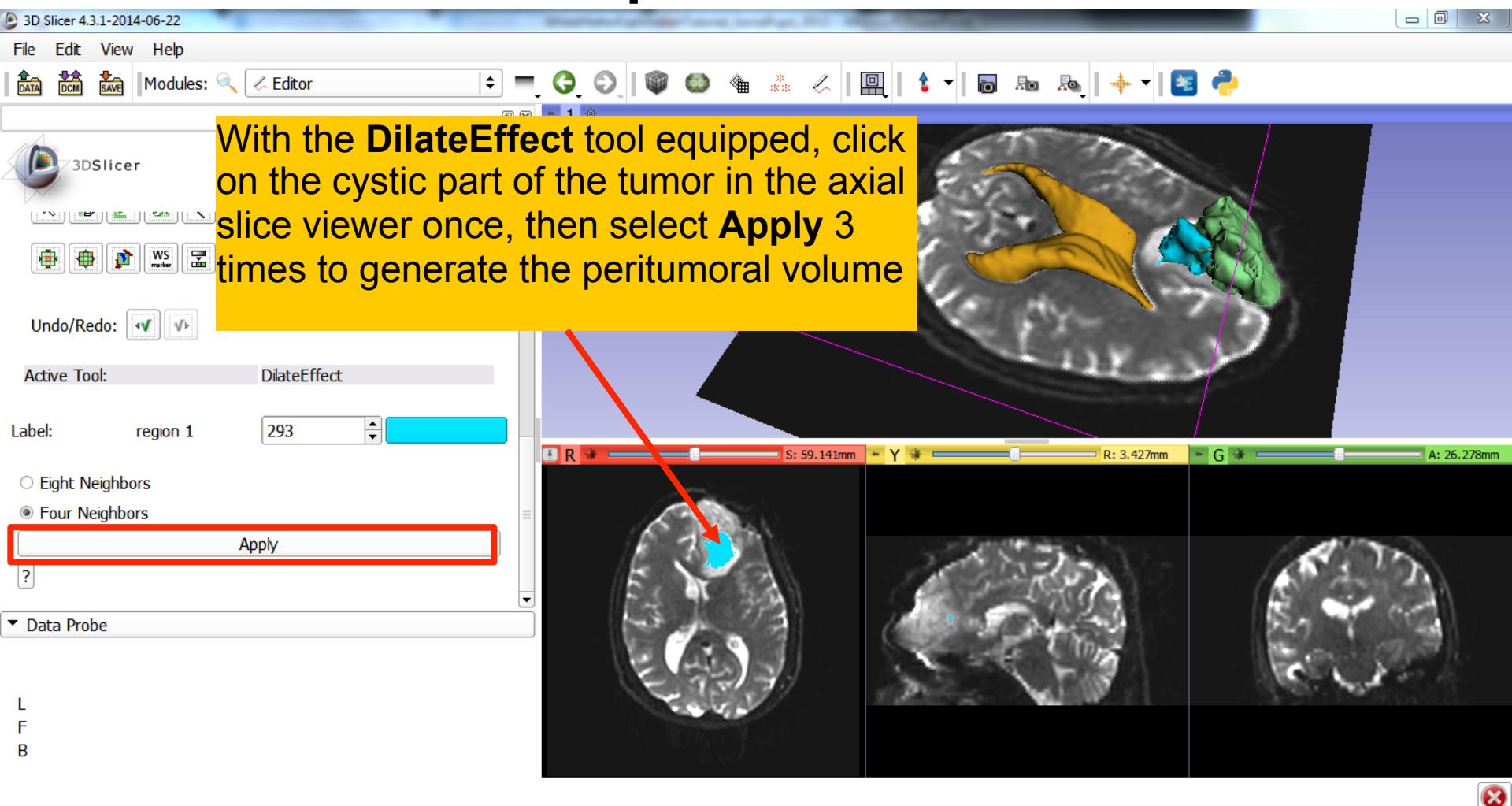
Definition of peri-tumoral volume



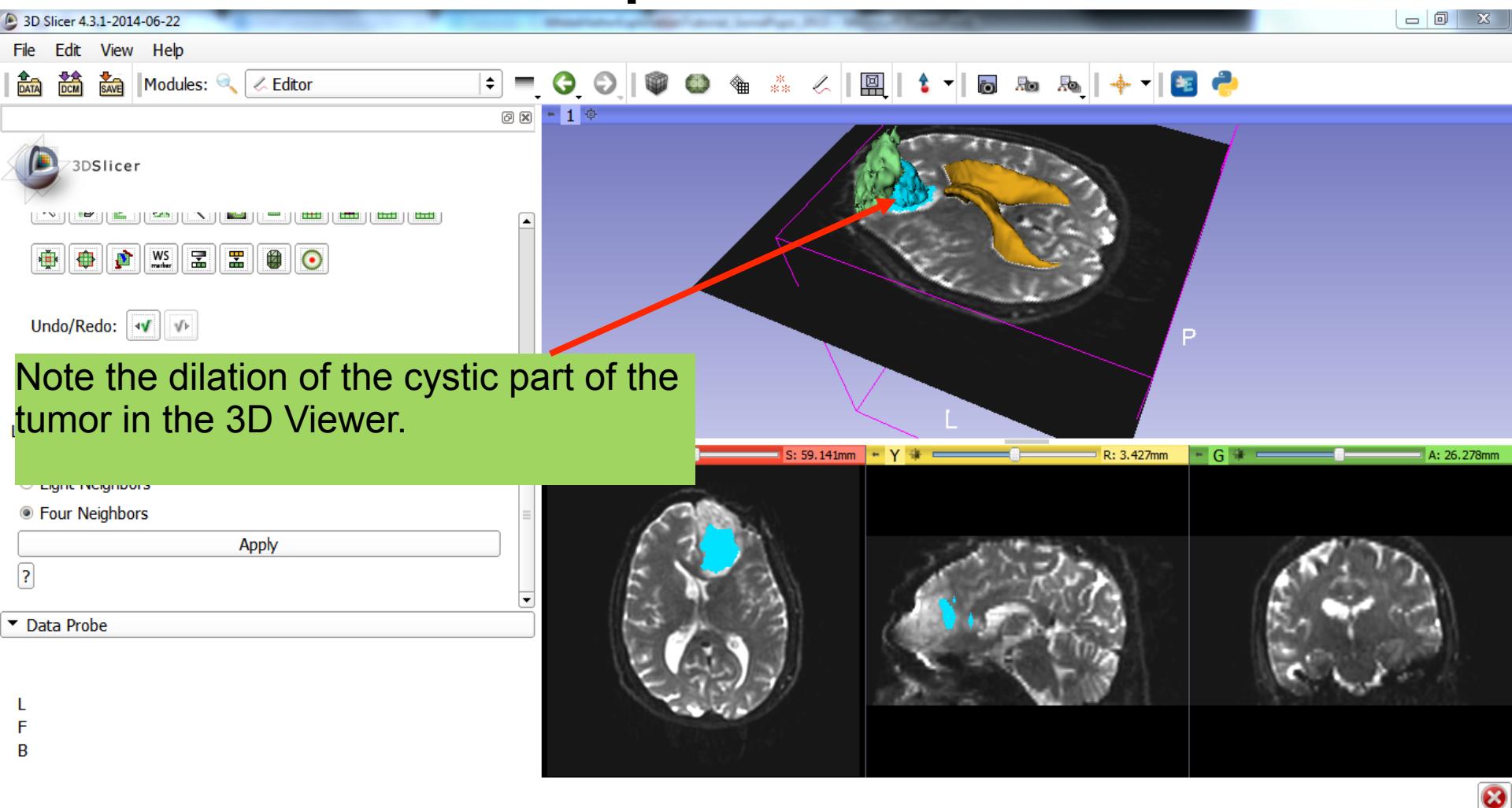


Part 2: Tractography exploration of peri- tumoral white matter fibers

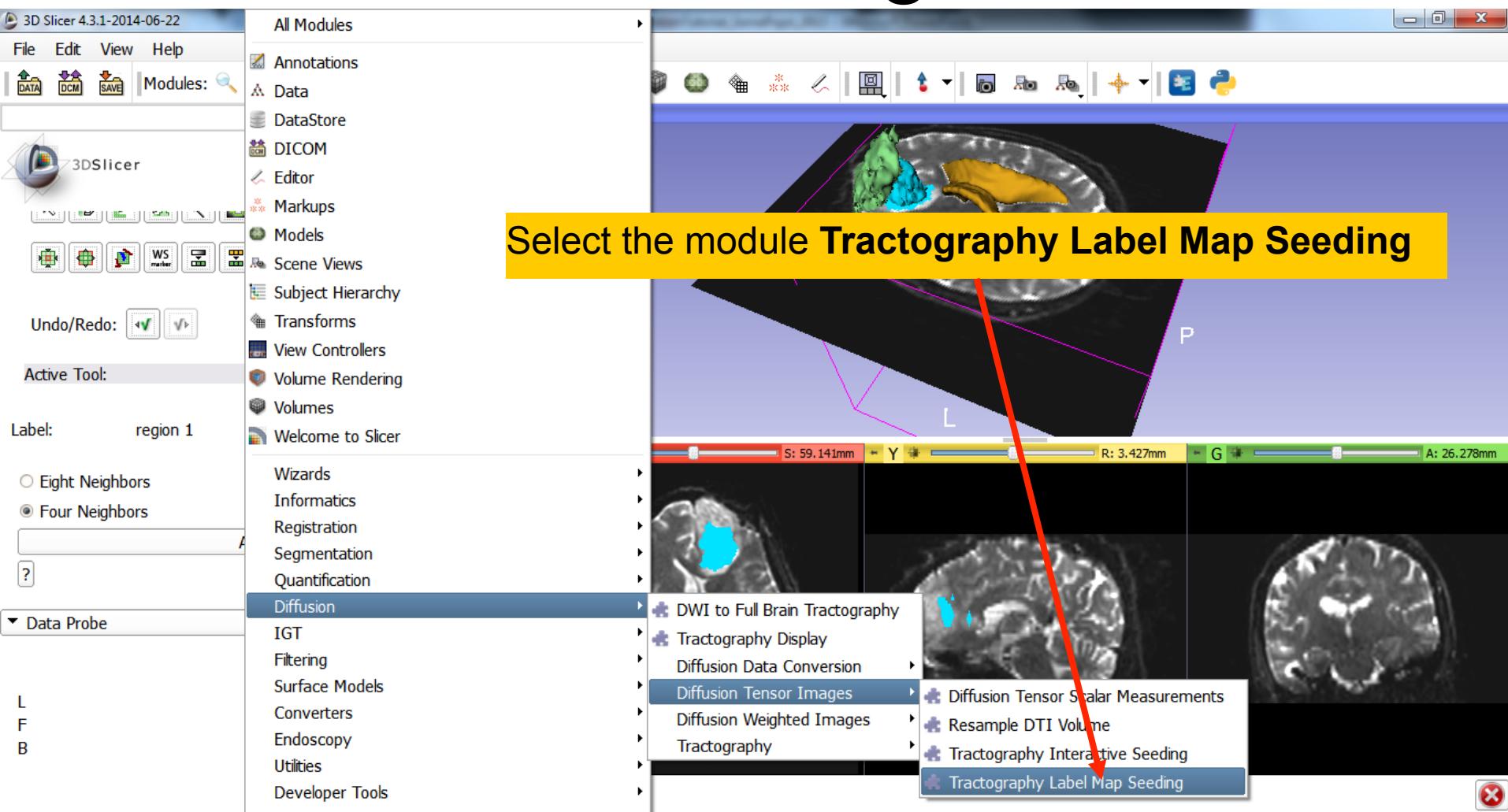
Definition of peri-tumoral volume



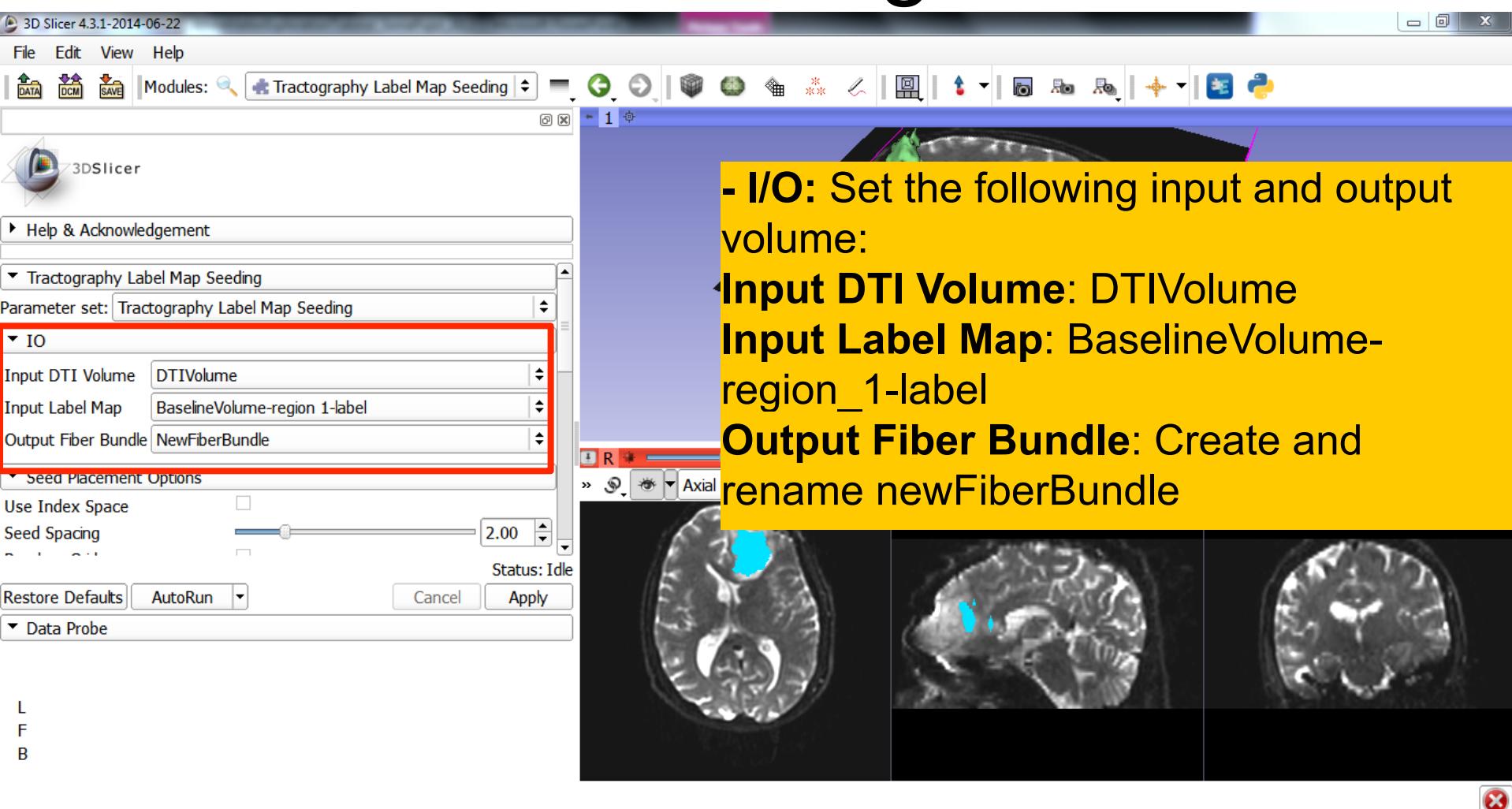
Definition of peritumoral volume



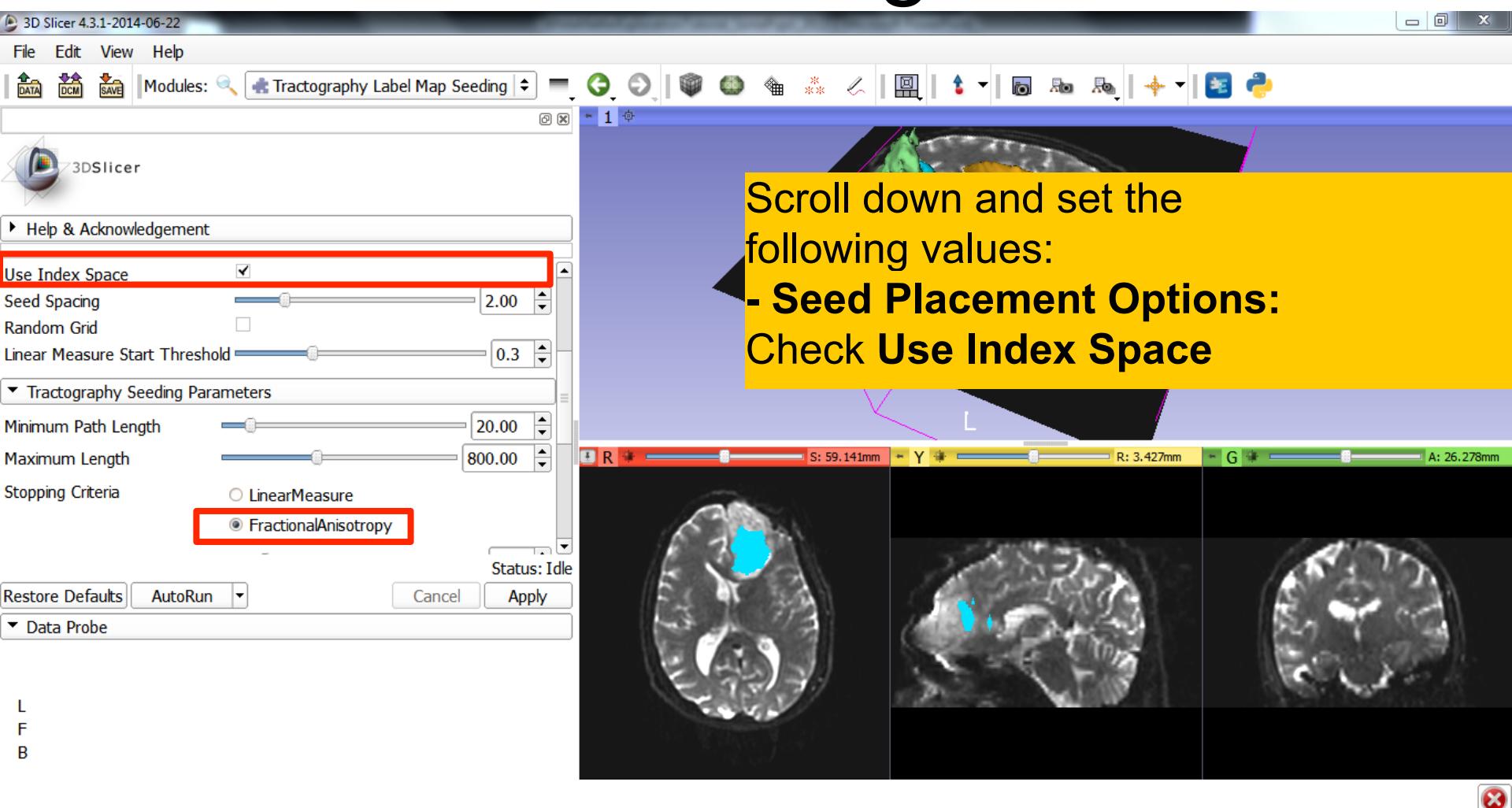
Final Result of Segmentation



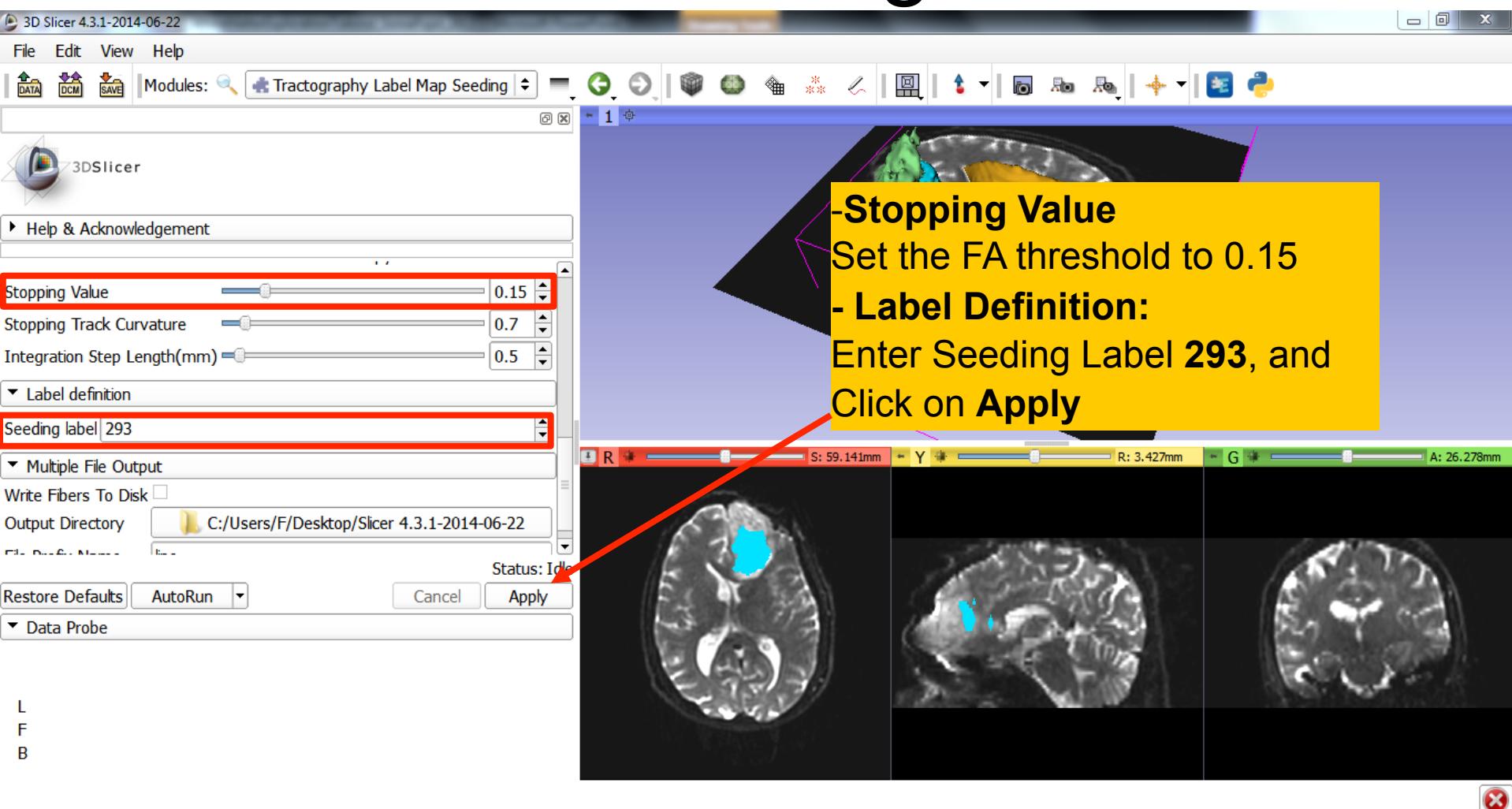
Final Result of Segmentation



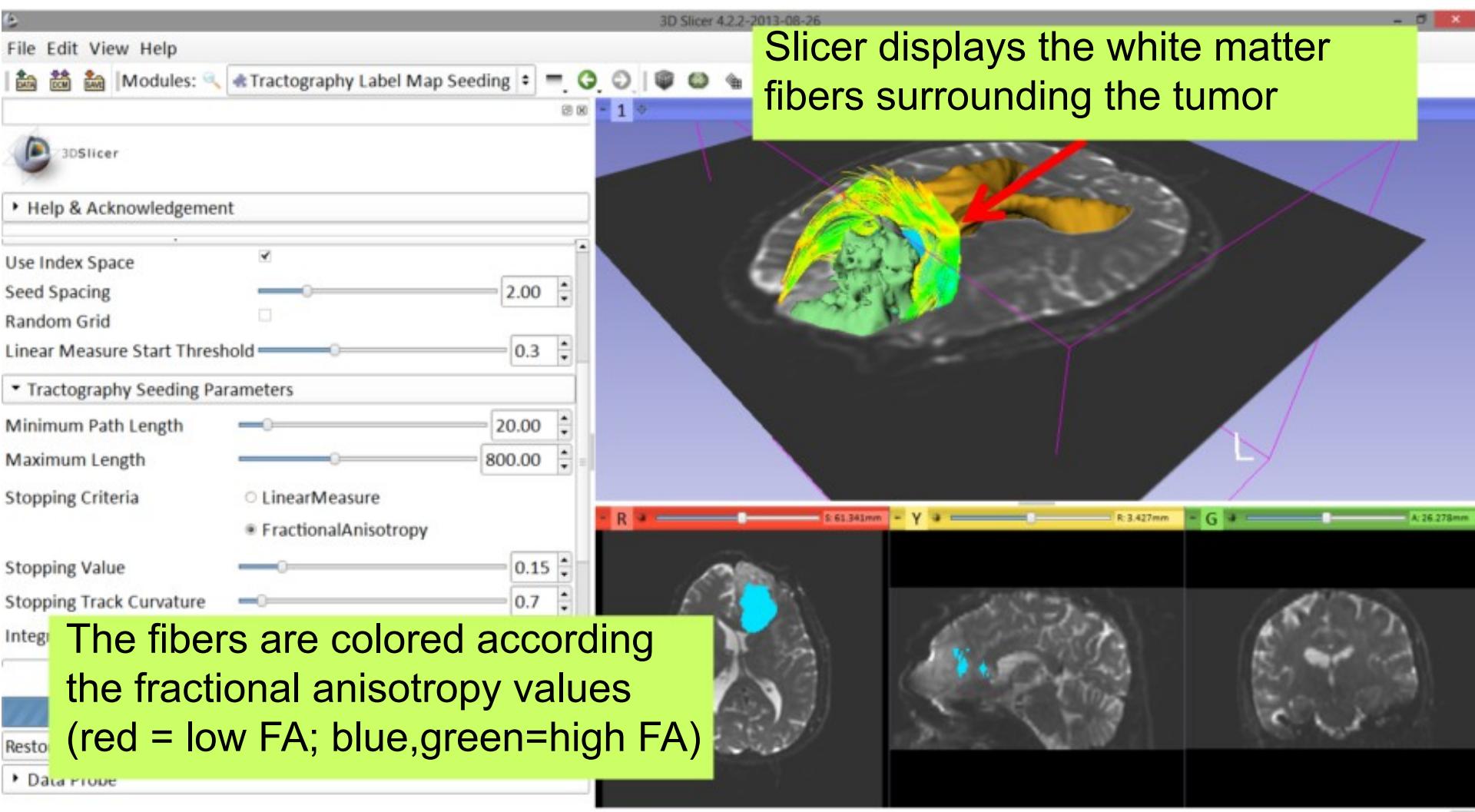
Final Result of Segmentation

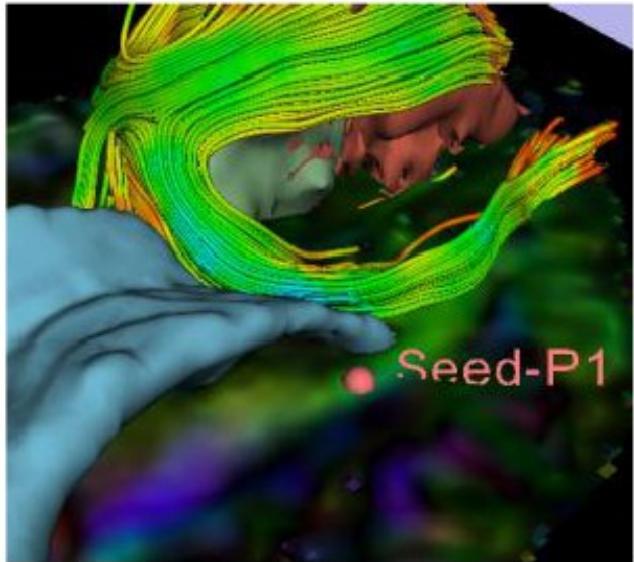


Final Result of Segmentation



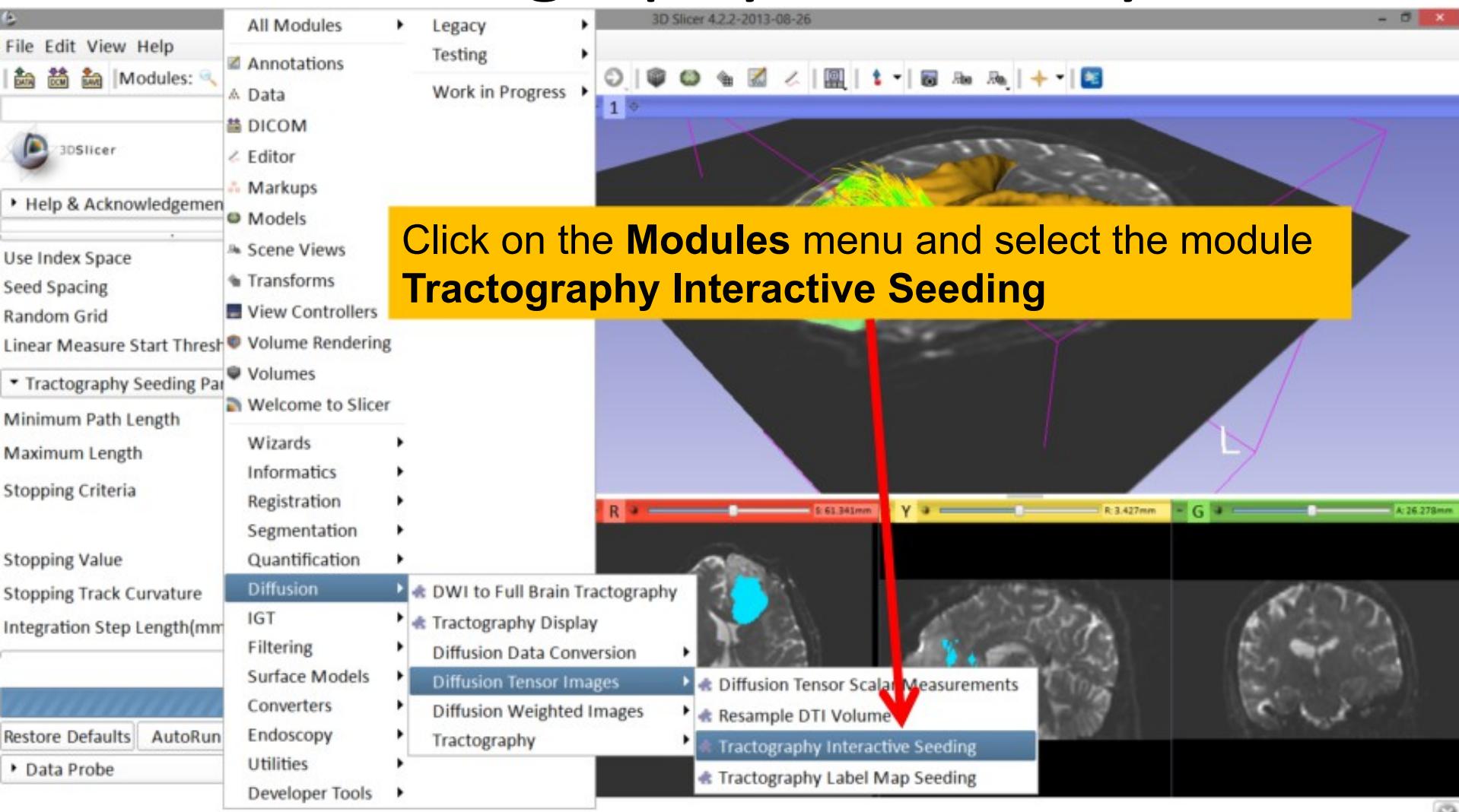
Final Result of Segmentation



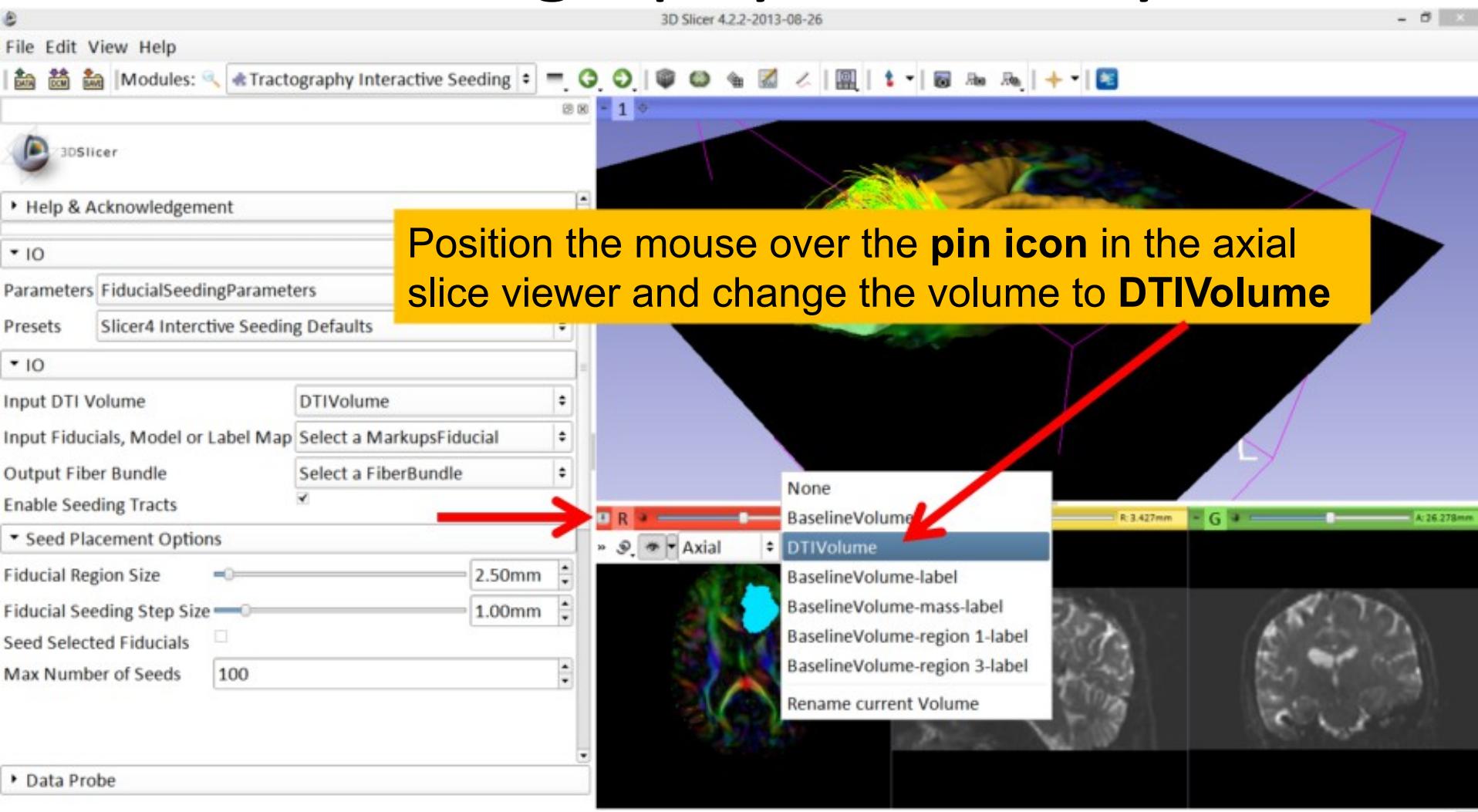


Part 4: Tractography exploration of the ipsilateral and contralateral side

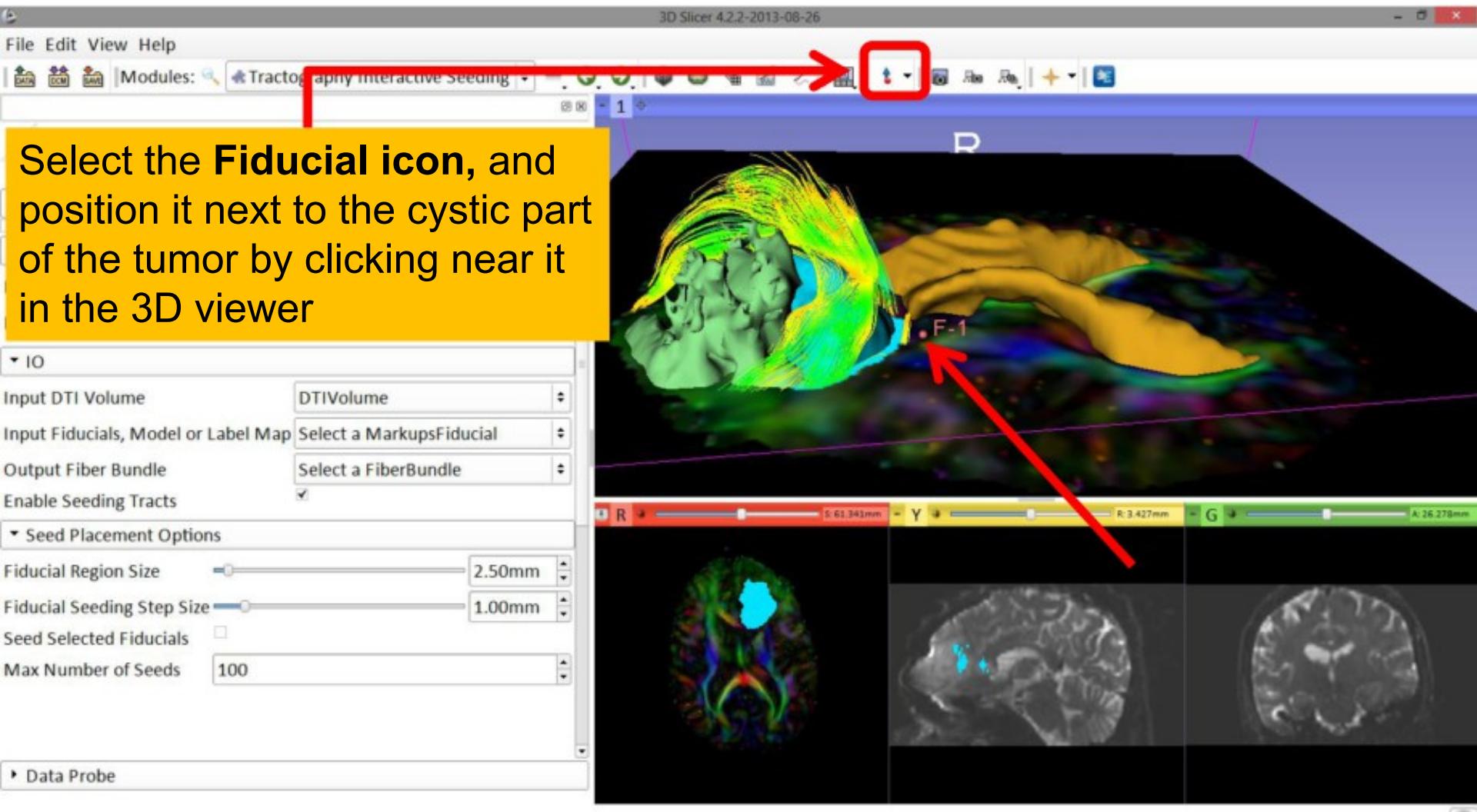
Tractography on-the-fly



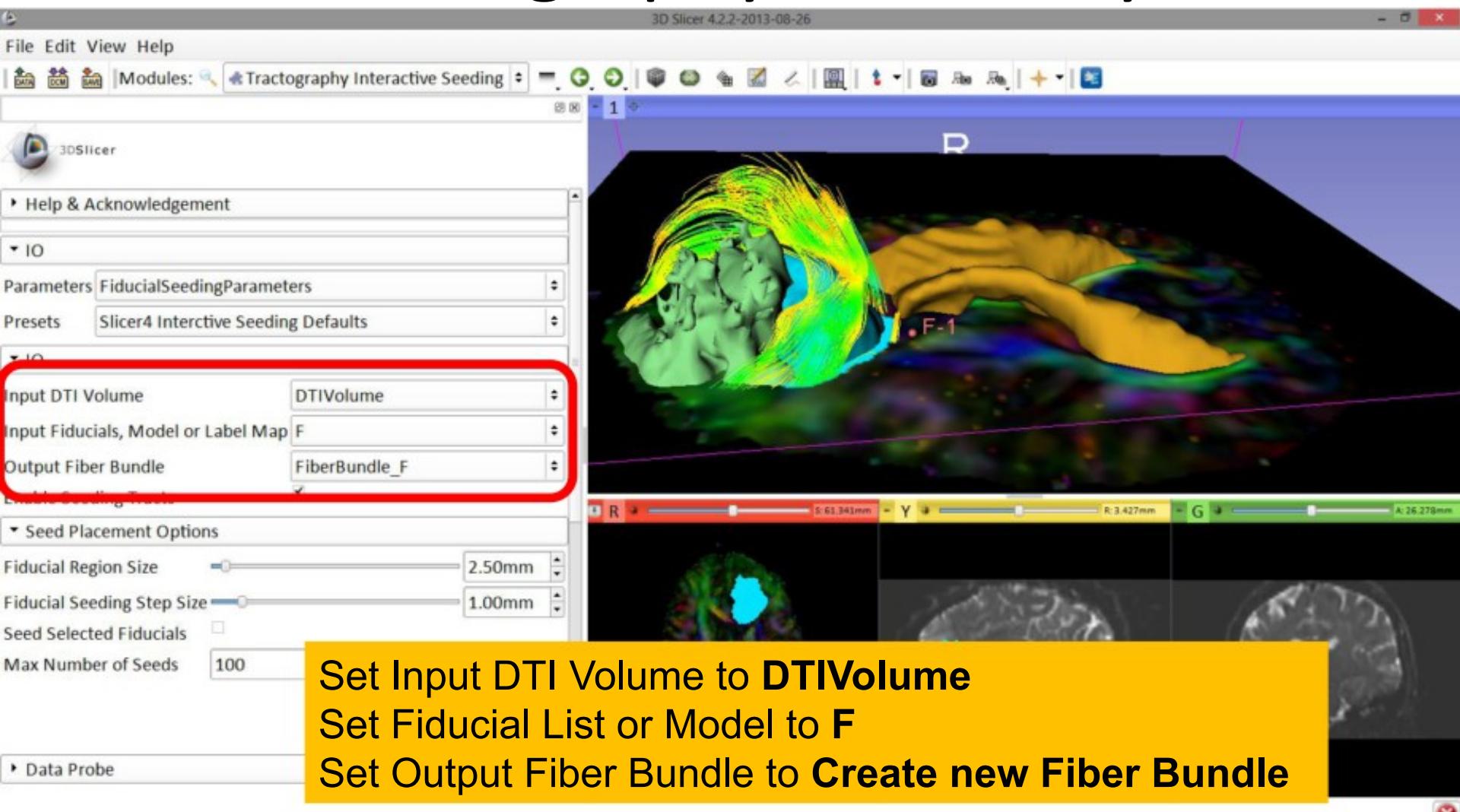
Tractography on-the-fly



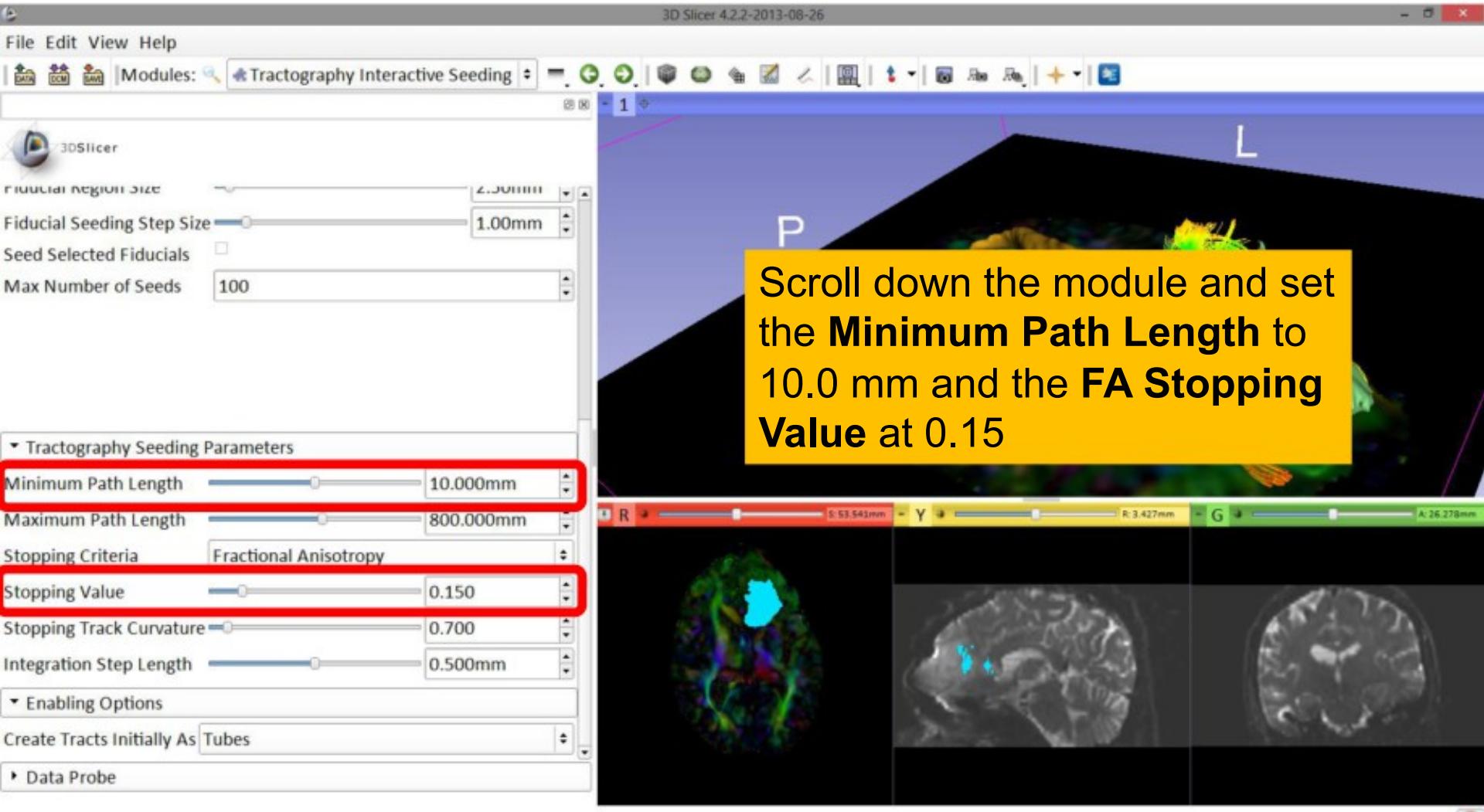
Tractography on-the-fly



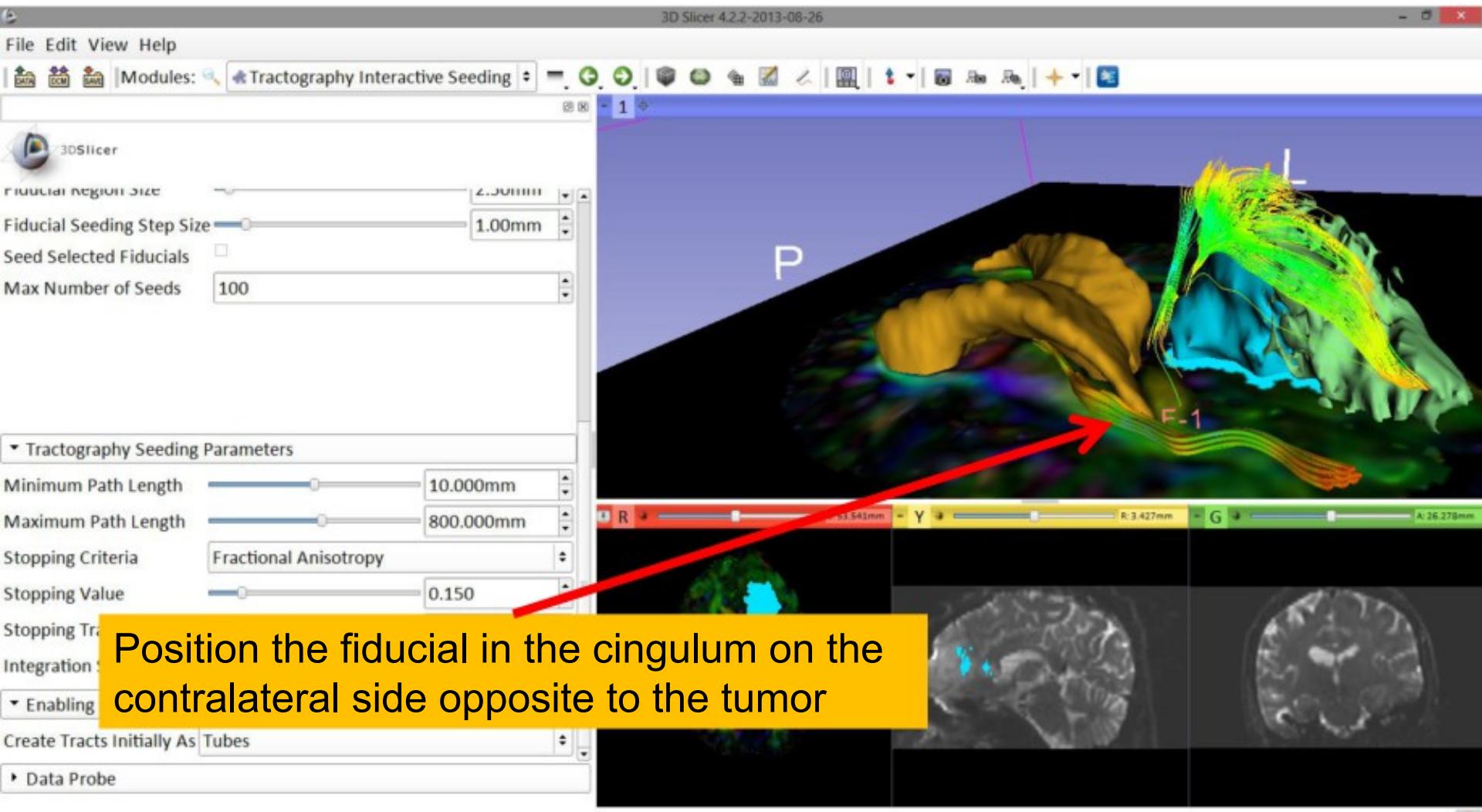
Tractography on-the-fly



Tractography on-the-fly

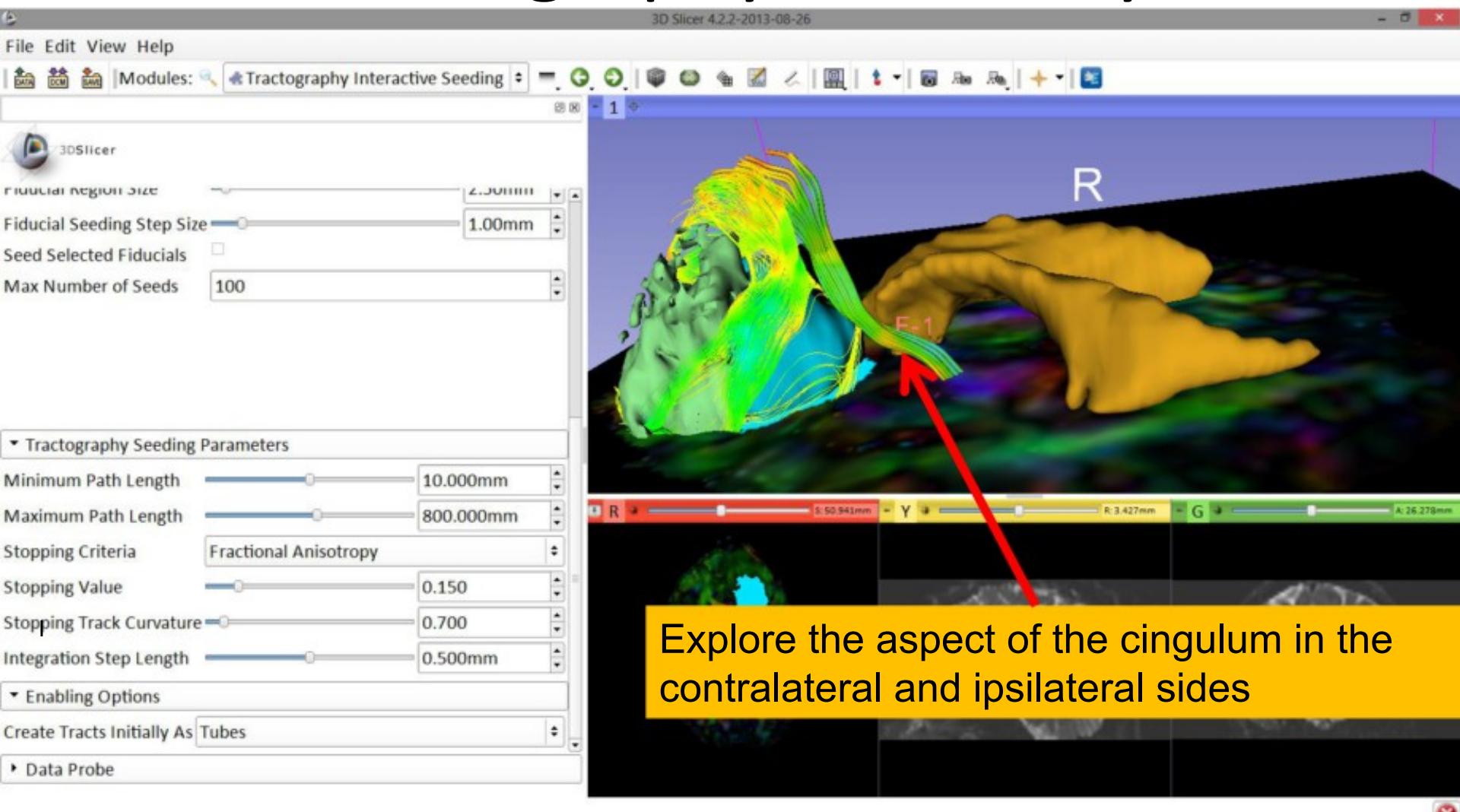


Fiducial Seeding



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

Tractography on-the-fly



Conclusion

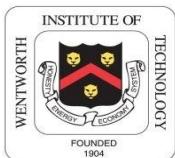
- Fully integrated pipeline for semi-automated tumor segmentation and white matter tract reconstruction
- 3D interactive exploration of the white matter tracts surrounding a tumor (peritumoral tracts) for neurosurgical planning

Acknowledgments

- National Alliance for Medical Image Computing (NA-MIC)
NIH U54EB005149



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