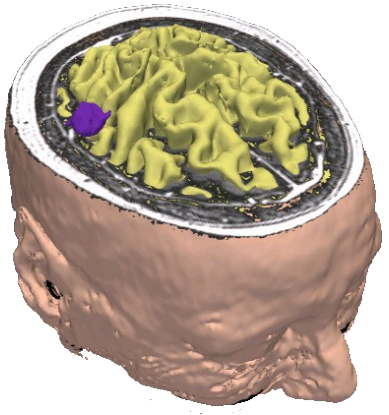
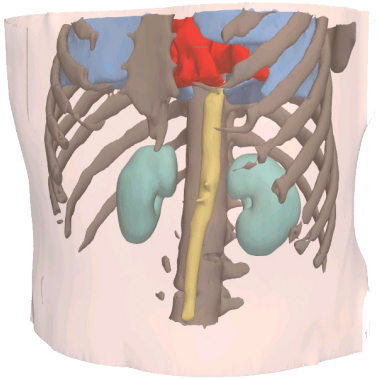
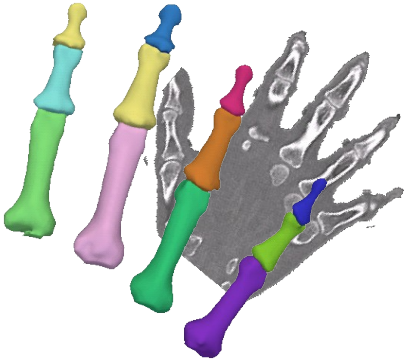
EMSegmenter Tutorial (Advanced Mode)

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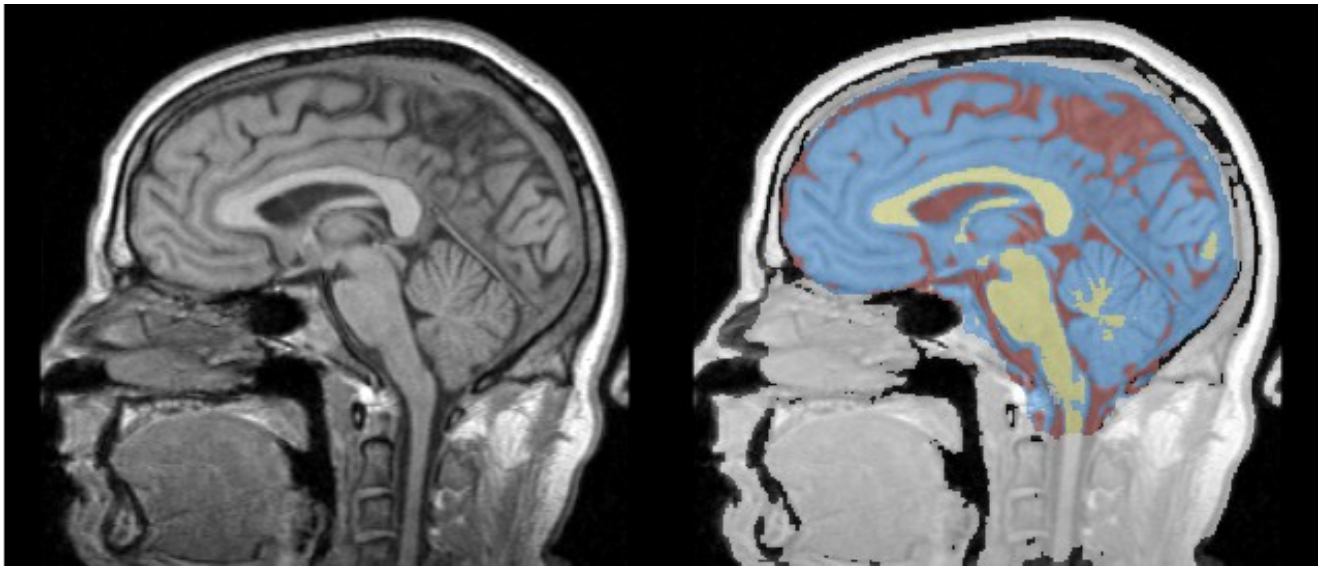
Overview

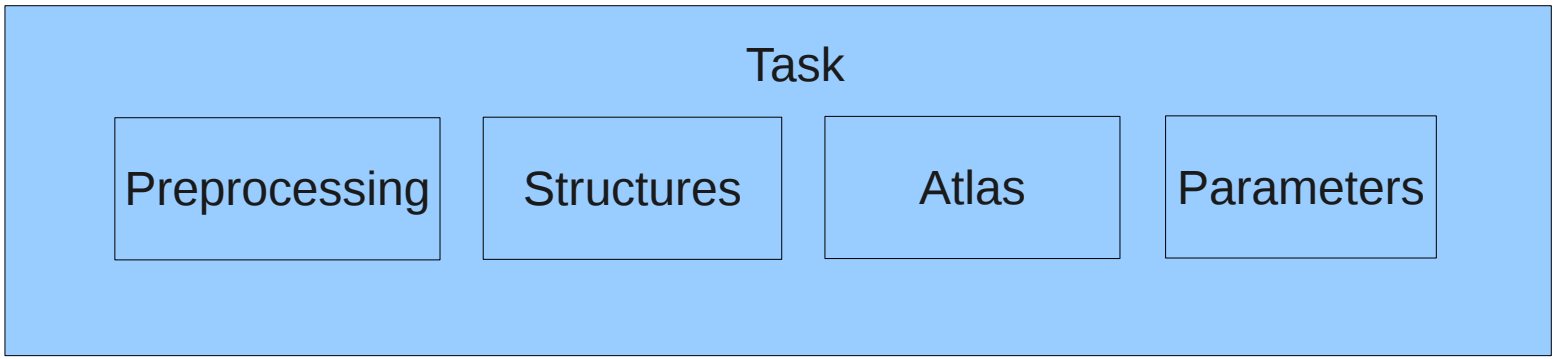
The goal of this tutorial is to apply the EMSegmenter to MRI brain scans. We will segment the clinical T1 scan shown below into grey matter, white matter, and cerebrospinal fluid.

The tutorial is based on Slicer 3.6.2 .

Before  After

Overview

We will segment the MRI scans by specifying a 'Task' for the EMSegmenter. The task captures the setting of the EMSegmenter for generating the automatic segmention of the subject scan. A task specifies the pre-processing of the scan, such as the type of atlas to image registration. It also specifies the structures to be segmented and the atlas specifying the structures. Furthermore, the task specifies the parameters related to the optimization algorithm (EM).



Overview

The tutorial leads you through the steps necessary for creating a new task:

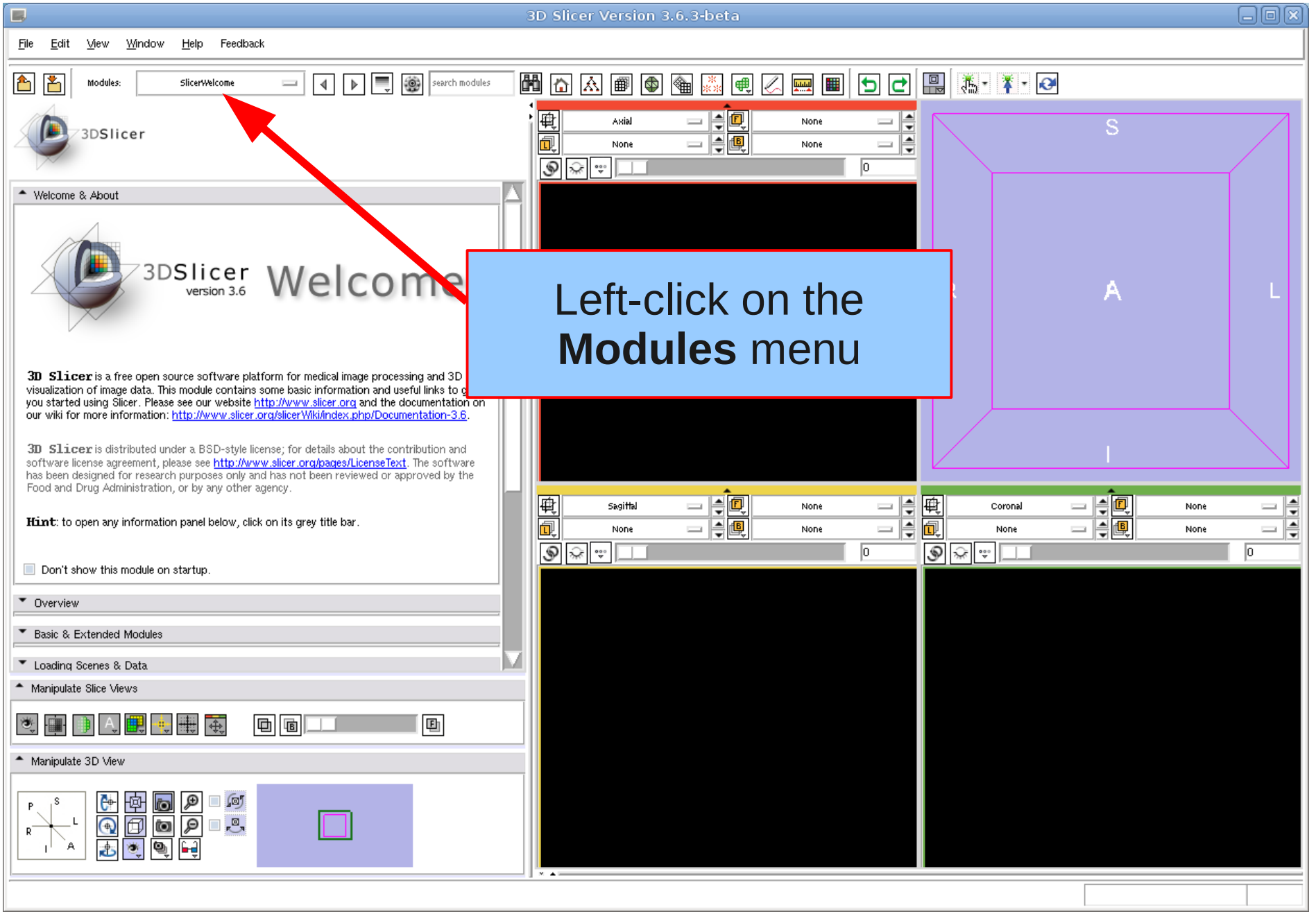
Step 1: Define task name and type of pre-processing
Step 2: Define Input Channel
Step 3: Define the Anatomical Tree
Step 4: Assign an atlas to each node in the tree
Step 5: Defining the Atlas to Image Registration
Step 6: Further Specify pre-processing
Step 7: Specifying the Intensity Distribution
Step 8: Define EM Specific Parameters
Step 9: Specify the Region of Interest and complete the Segmentation

Define Task

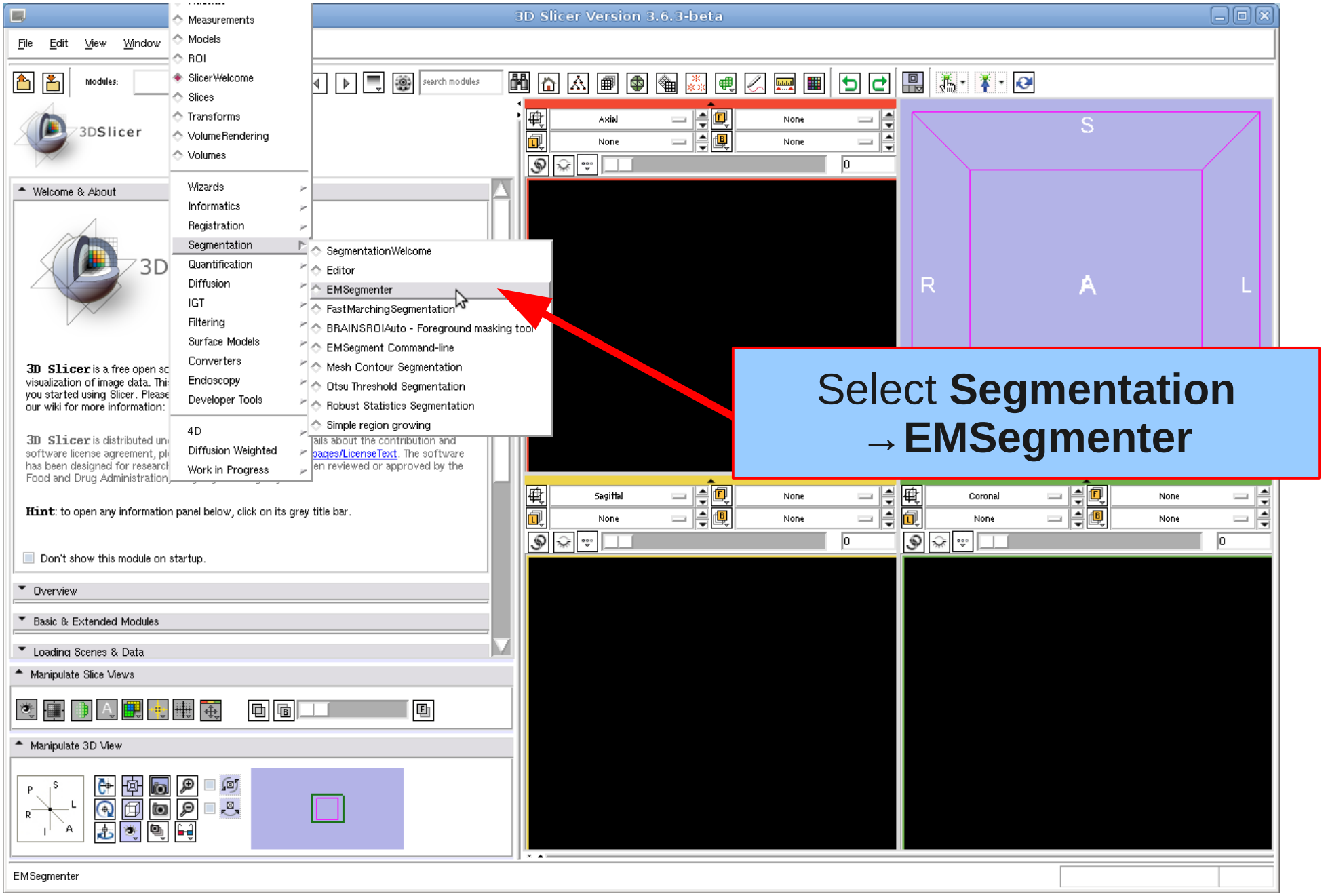
Step 1:
Define task name and type of pre-processing

The name should be a brief description of the segmentation scenario that the task addresses, such as 'T1 Brain Tissue Segmentation'. Each pre-processing type defines a sequence of approaches for modifying the scan before segmenting the scan into the structures of interest. For example, the pre-pocessing “MRI Human Brain” consists of image inhomogeneity correction and atlas registration. For further details please see http://www.slicer.org/slicerWiki/index.php/EMSegmenter-Tasks

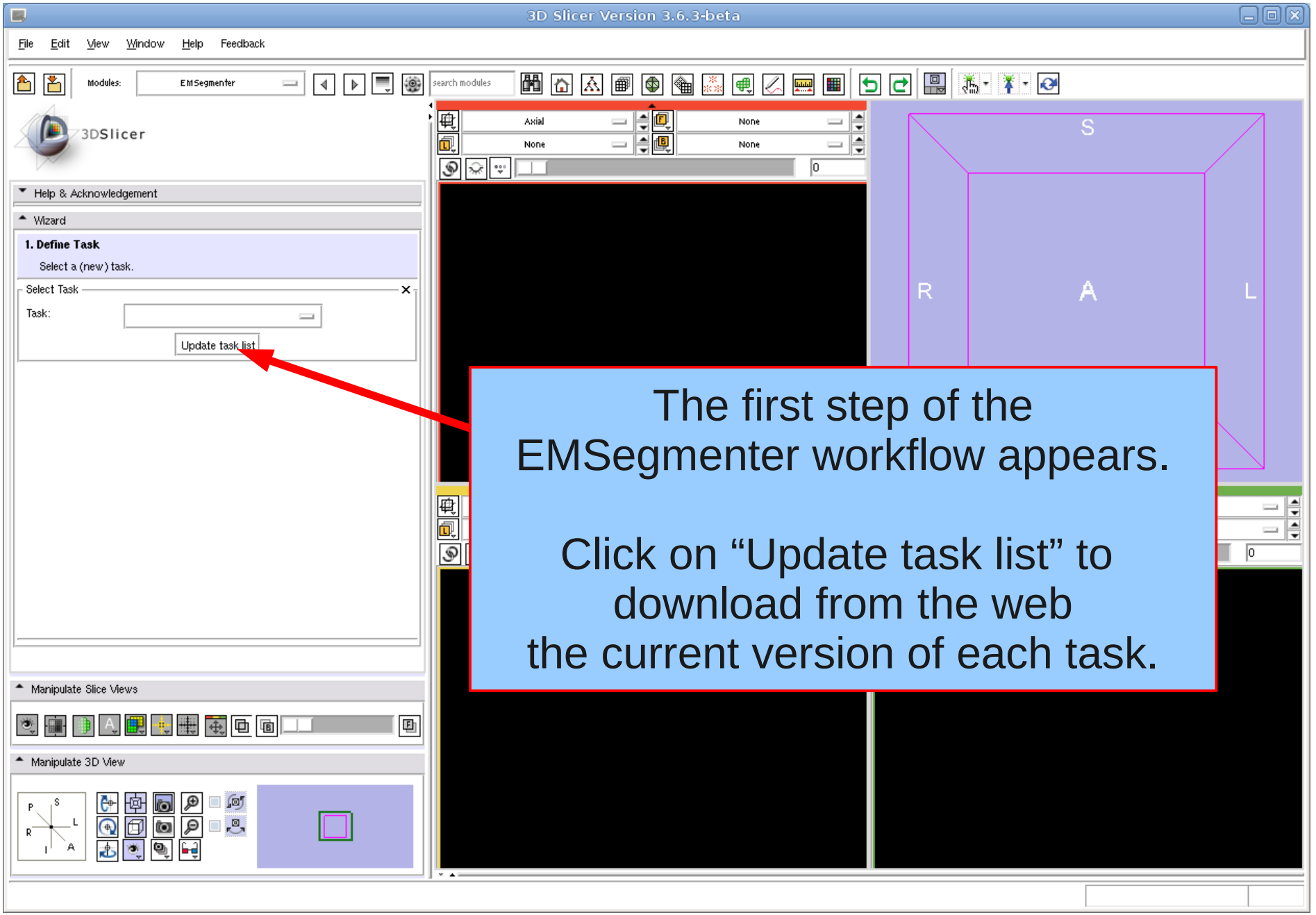
EMSegmenter (Advanced mode)



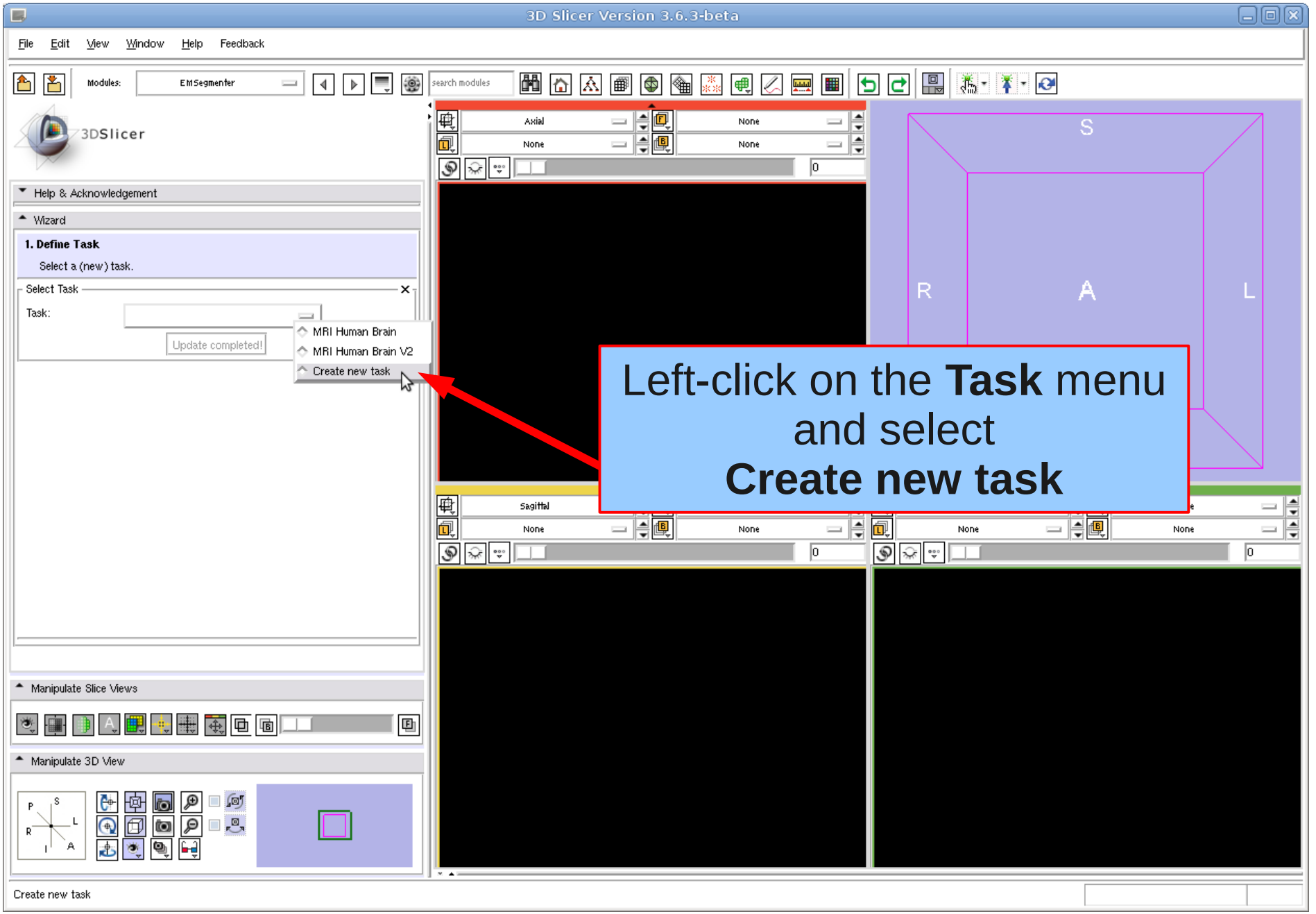
Select EMSegmenter Module



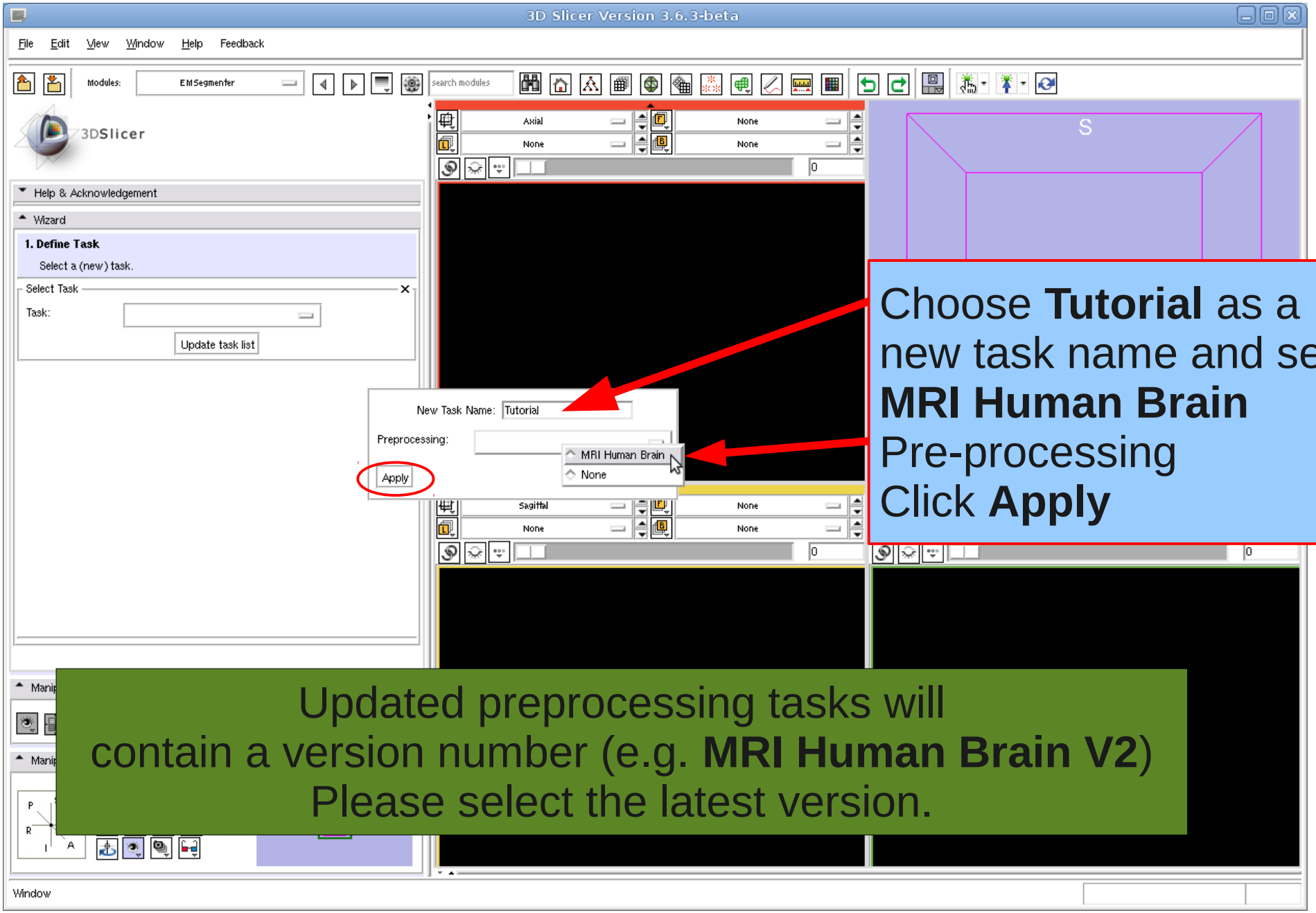
Update Task List



Create New Task



Create New Task



Choose **Tutorial** as a new task name and select **MRI Human Brain** Pre-processing
Click **Apply**

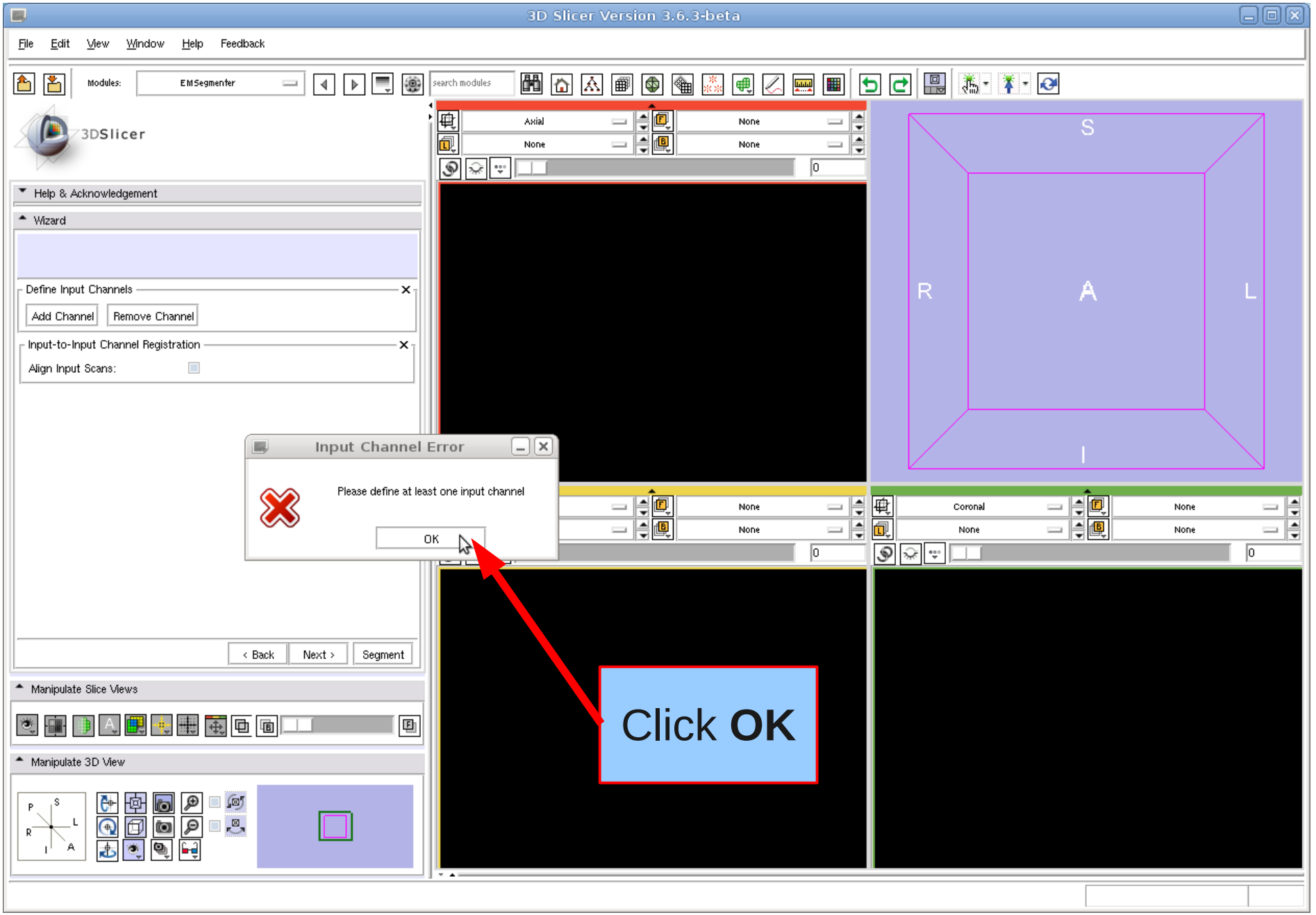
Updated preprocessing tasks will contain a version number (e.g. **MRI Human Brain V2**)
Please select the latest version.

Define Input Channel

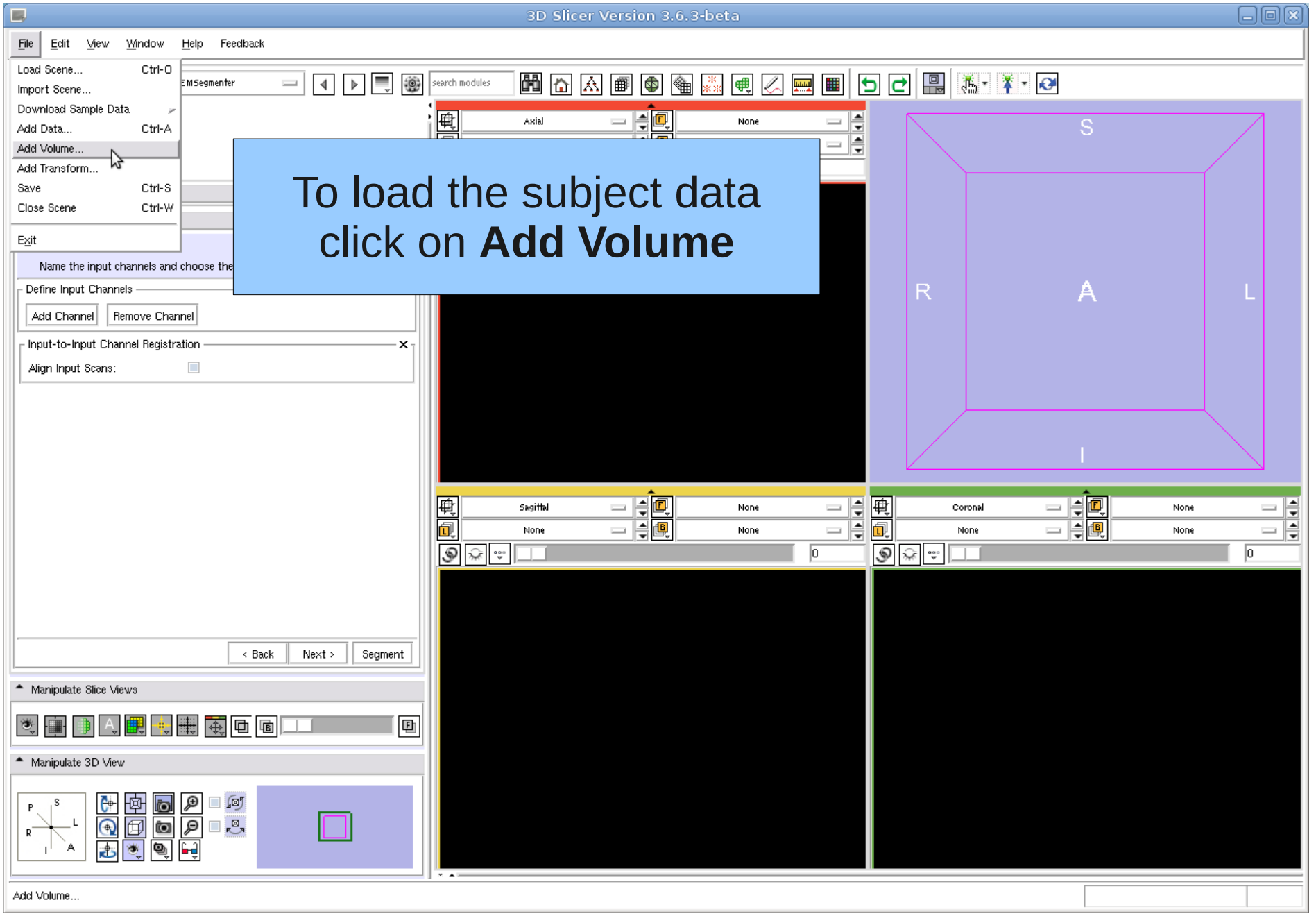
Step 2:
Define Input Channel

The EMSegmenter is equipped for multi-channel segmentations. For this tutorial, we want to perform single channel T1 segmentation. We now specify the task accordingly by loading in a T1 scan and creating a single input channel.

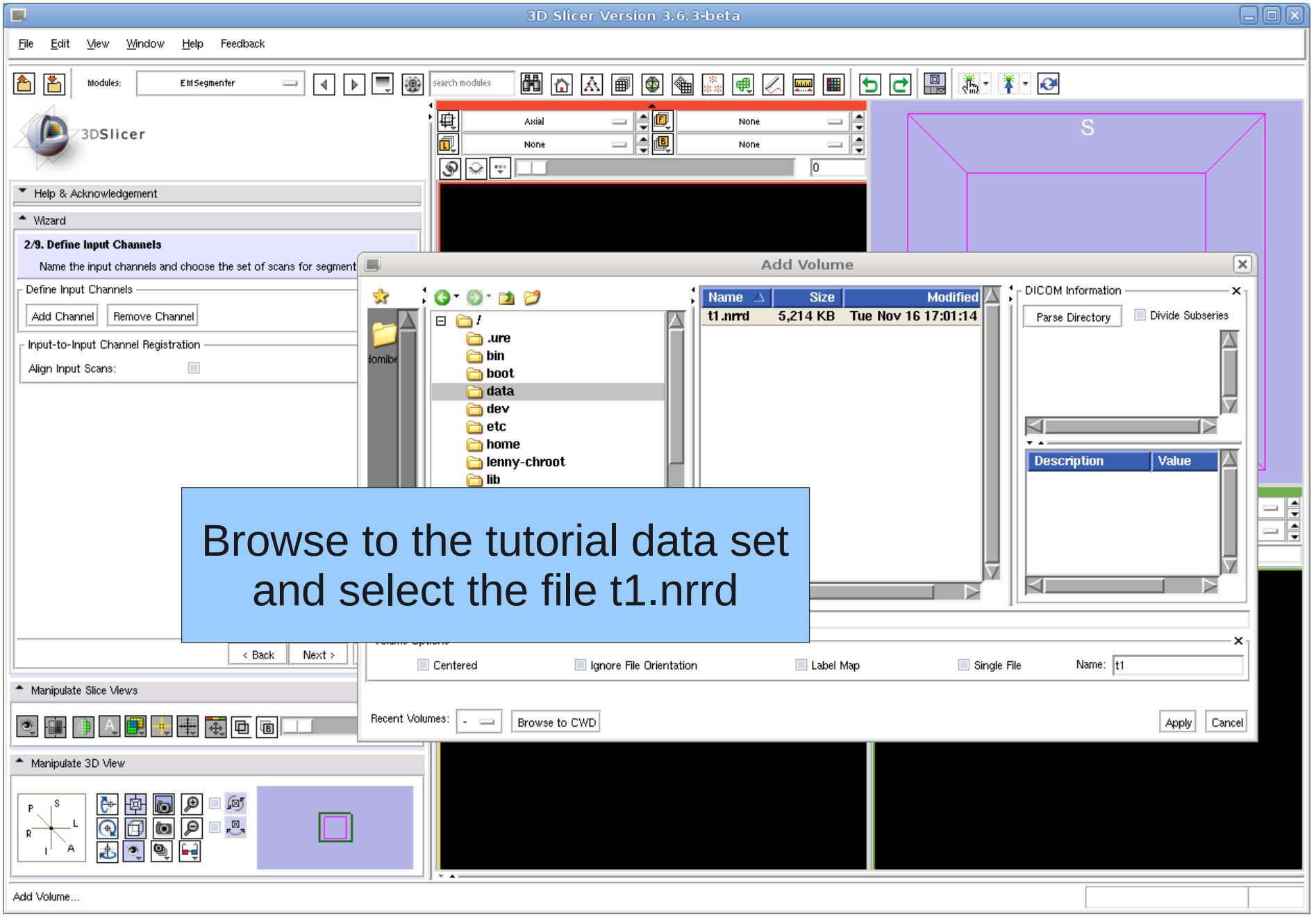
Define Input Channels



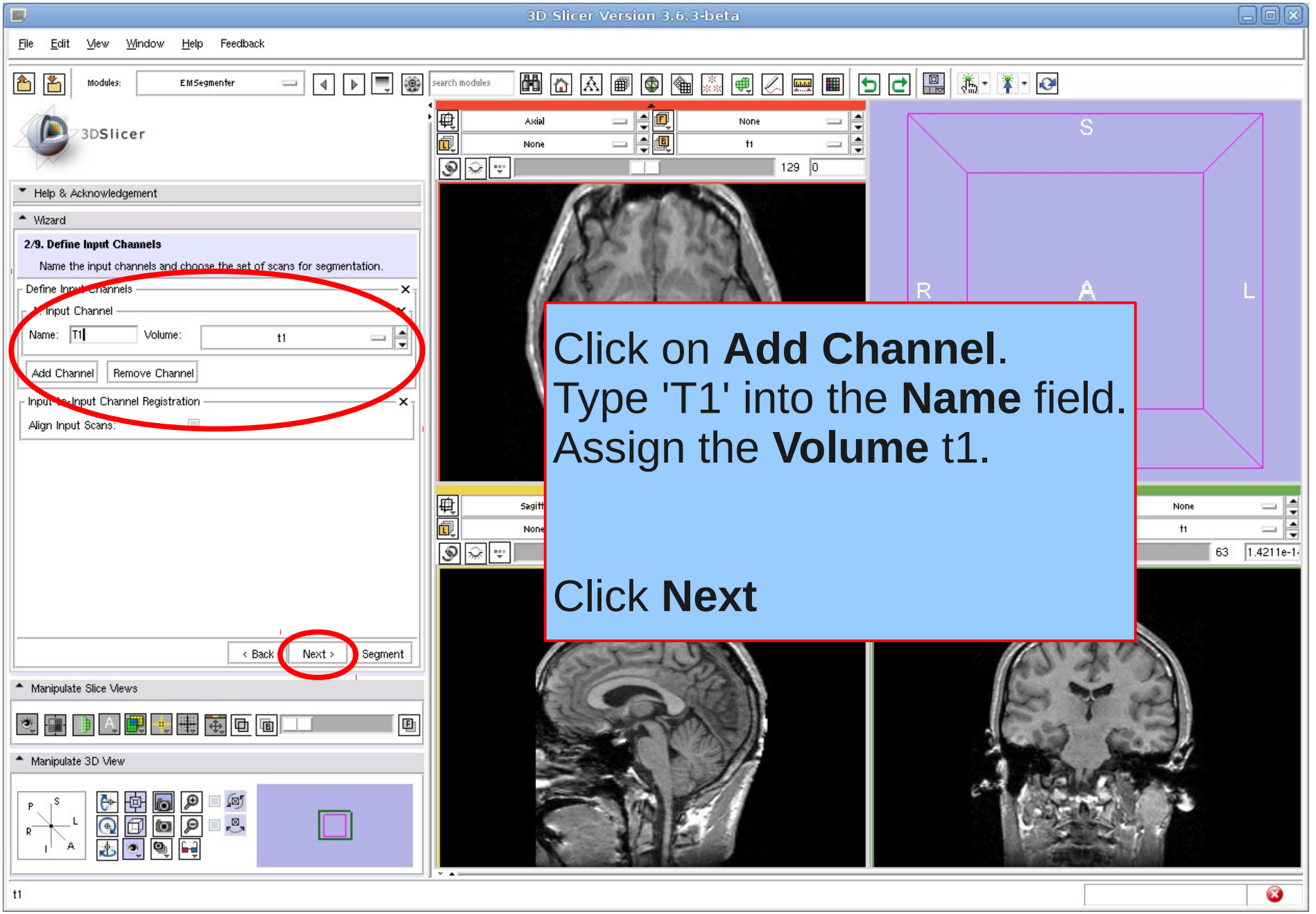
Add Subject Data



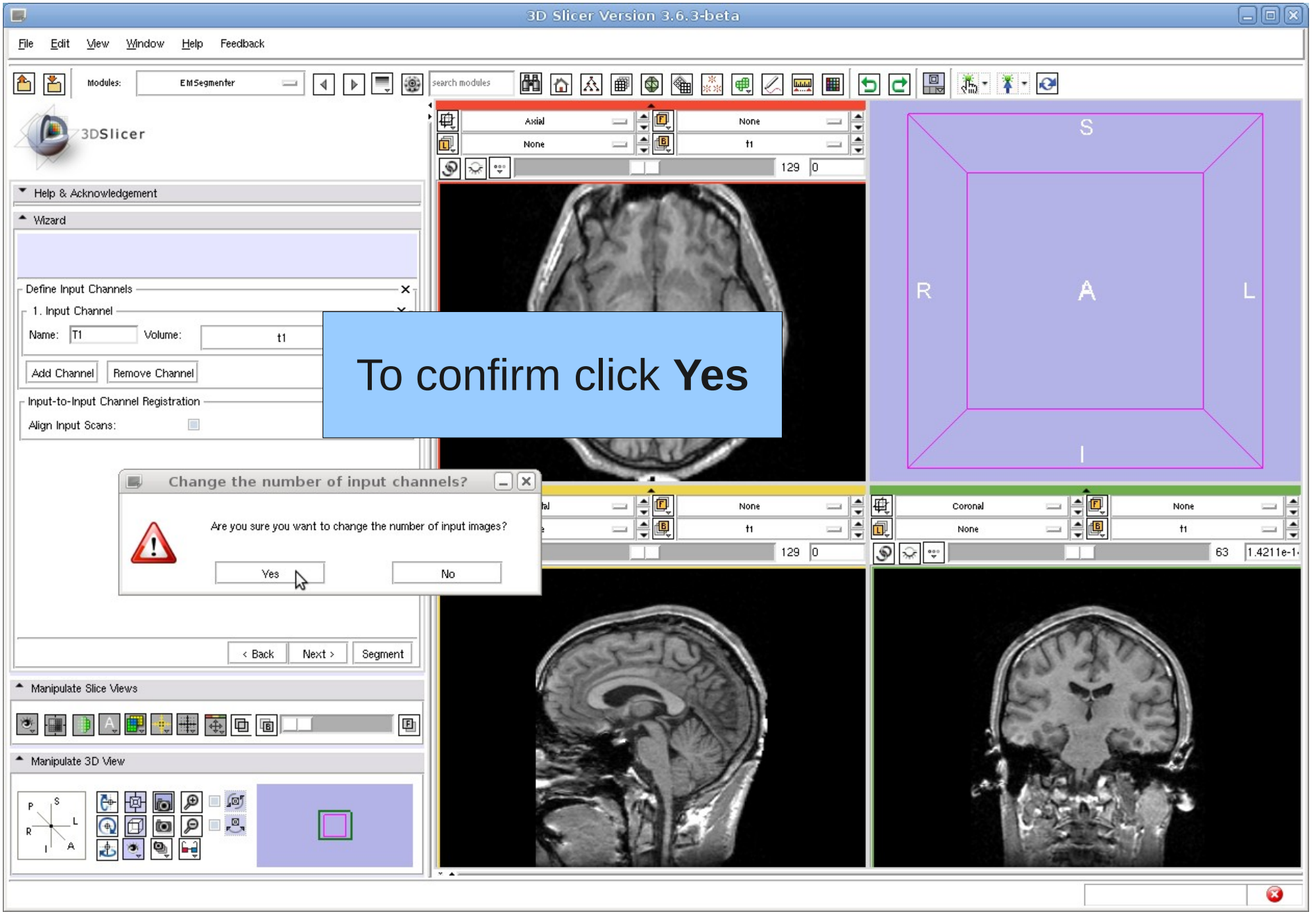
Load Subject Data



Define Input Channel



Define Input Channel

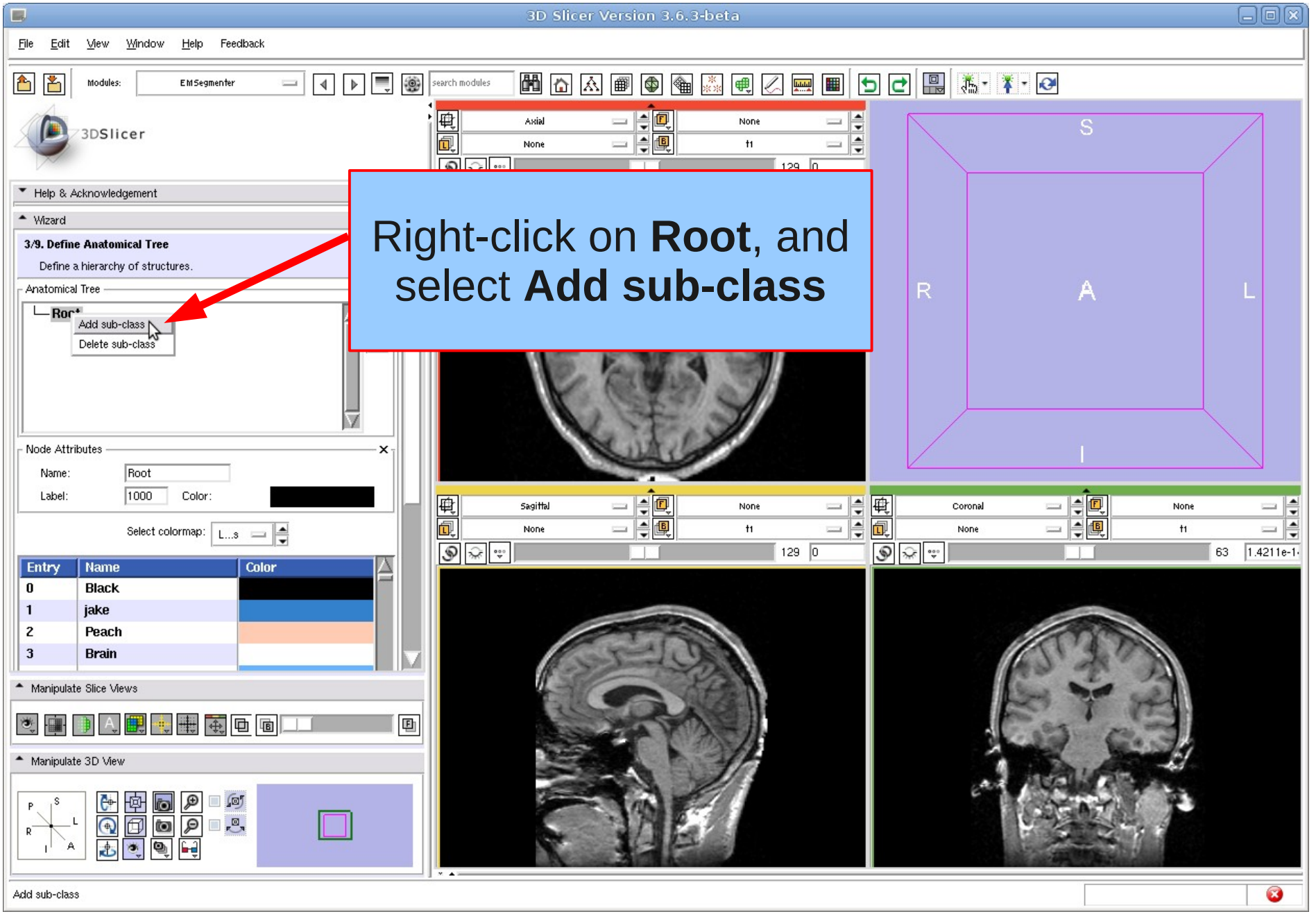


Define Anatomical Tree

Step 3:
Define the Anatomical Tree

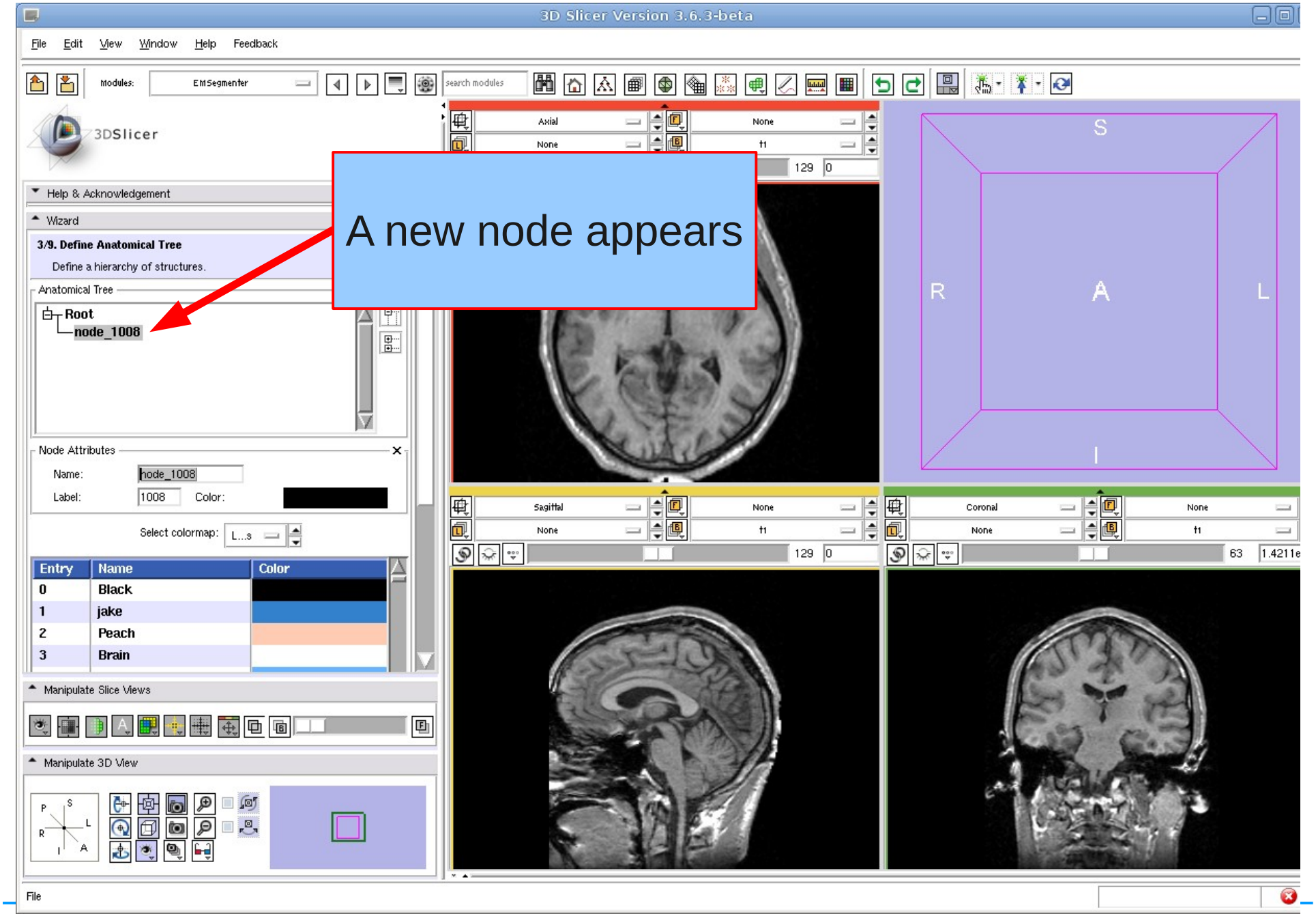
In this step we are defining the anatomical structures we want to segment and store the information in a tree data structure.
Each node represents an anatomical structure.
Additionally, a label and color can be assigned to each node, which are used when generating the segmentation map.

Define Anatomical Tree

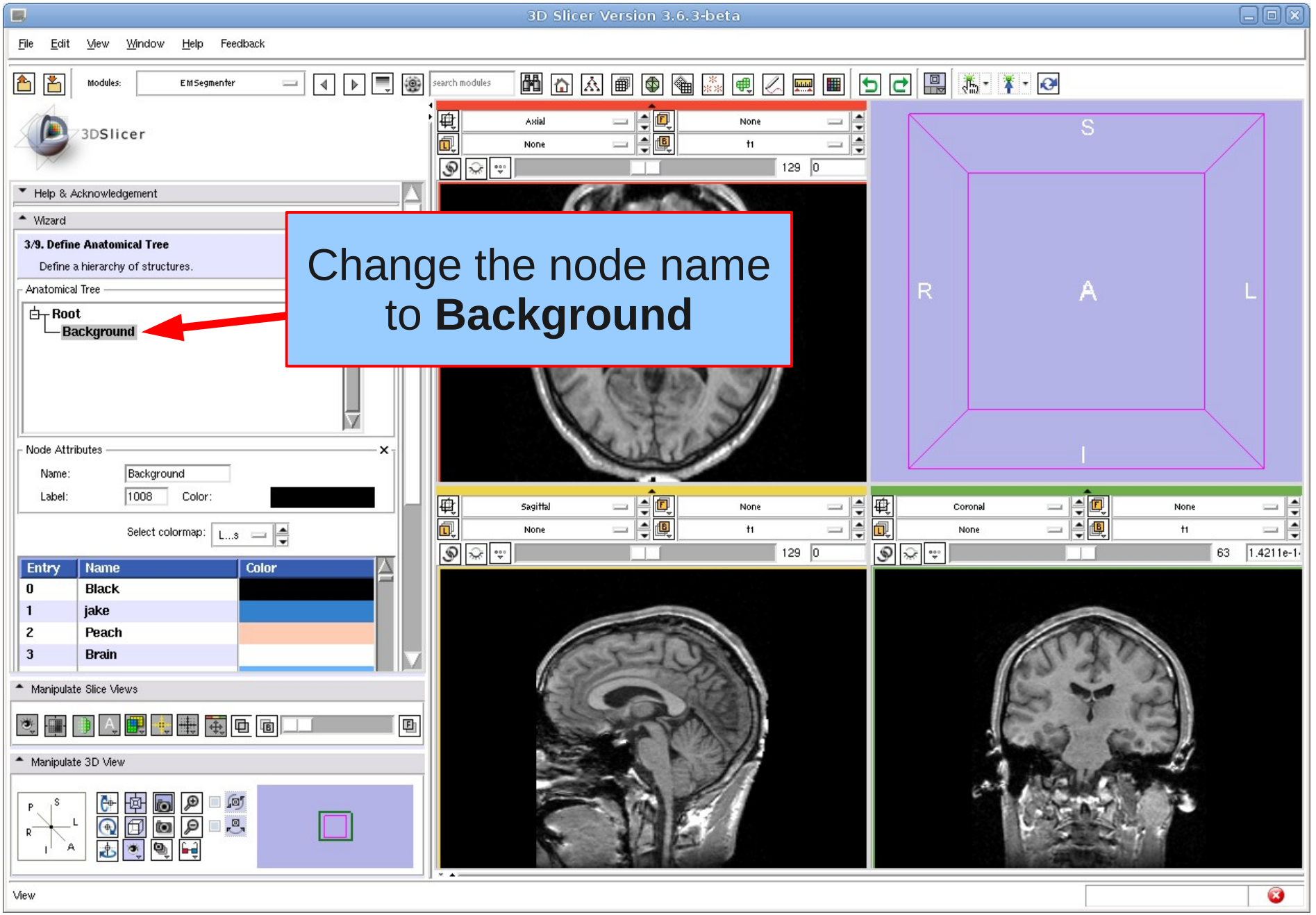


Right-click on **Root**, and select **Add sub-class**

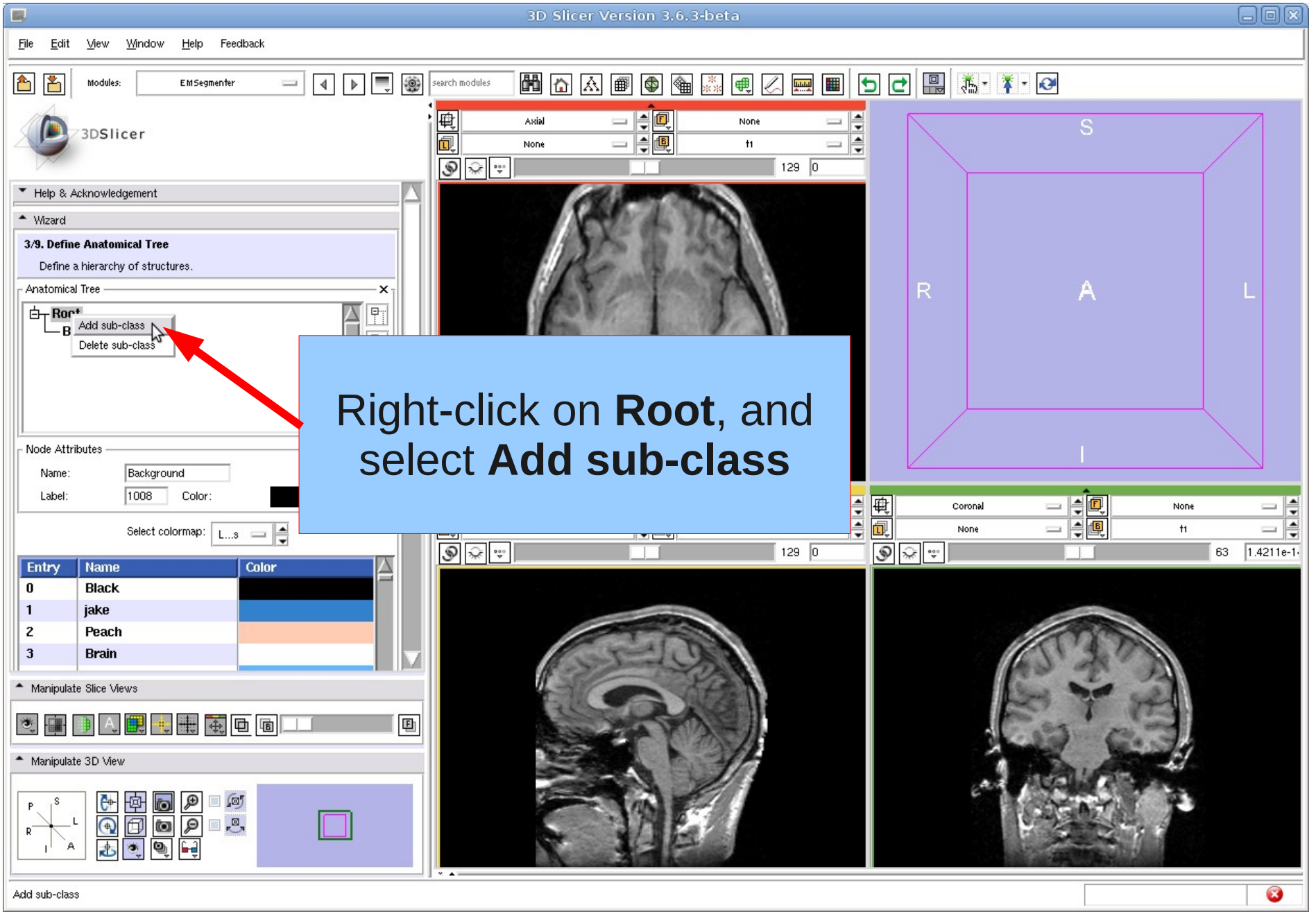
Define Anatomical Tree



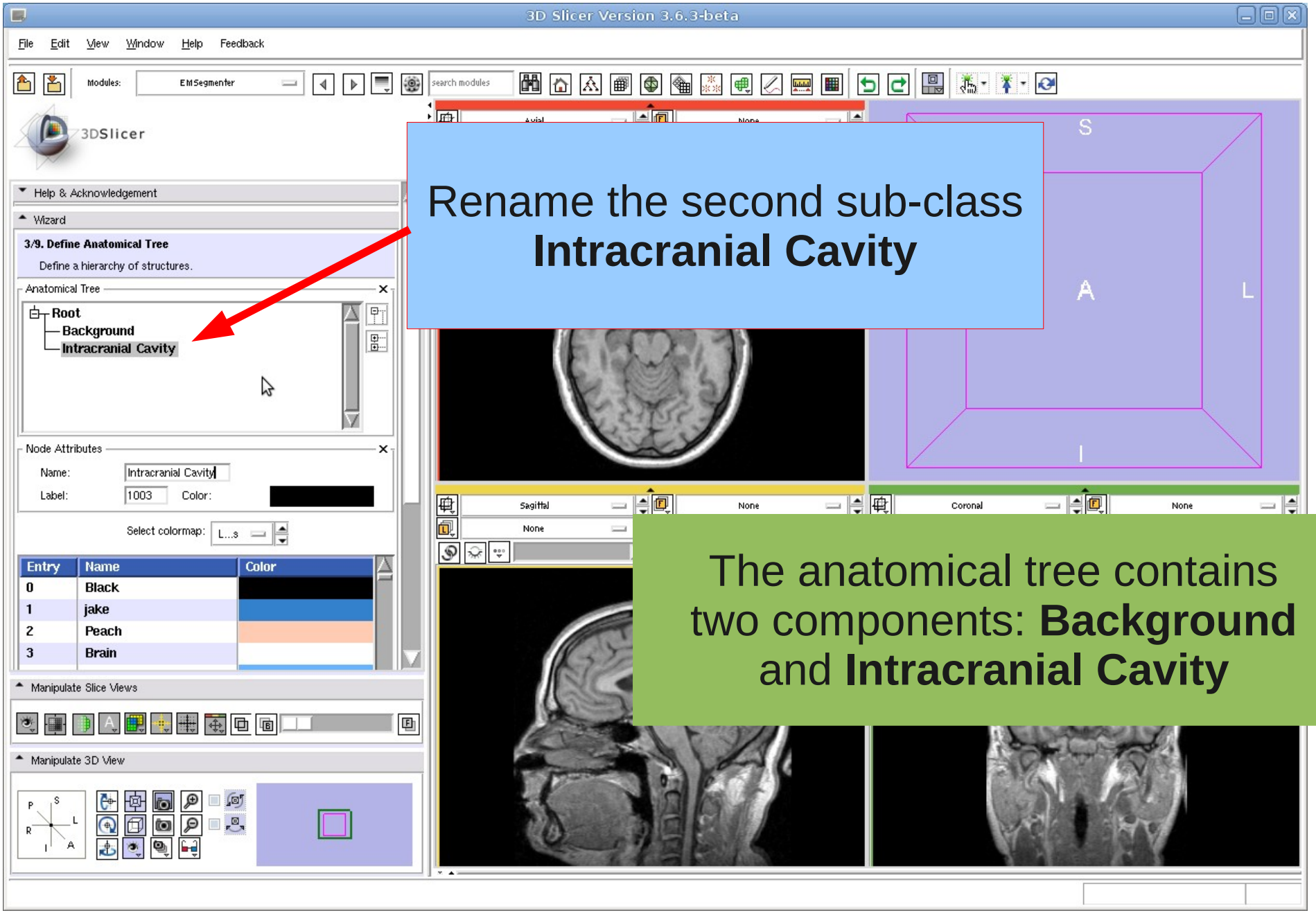
Define Anatomical Tree



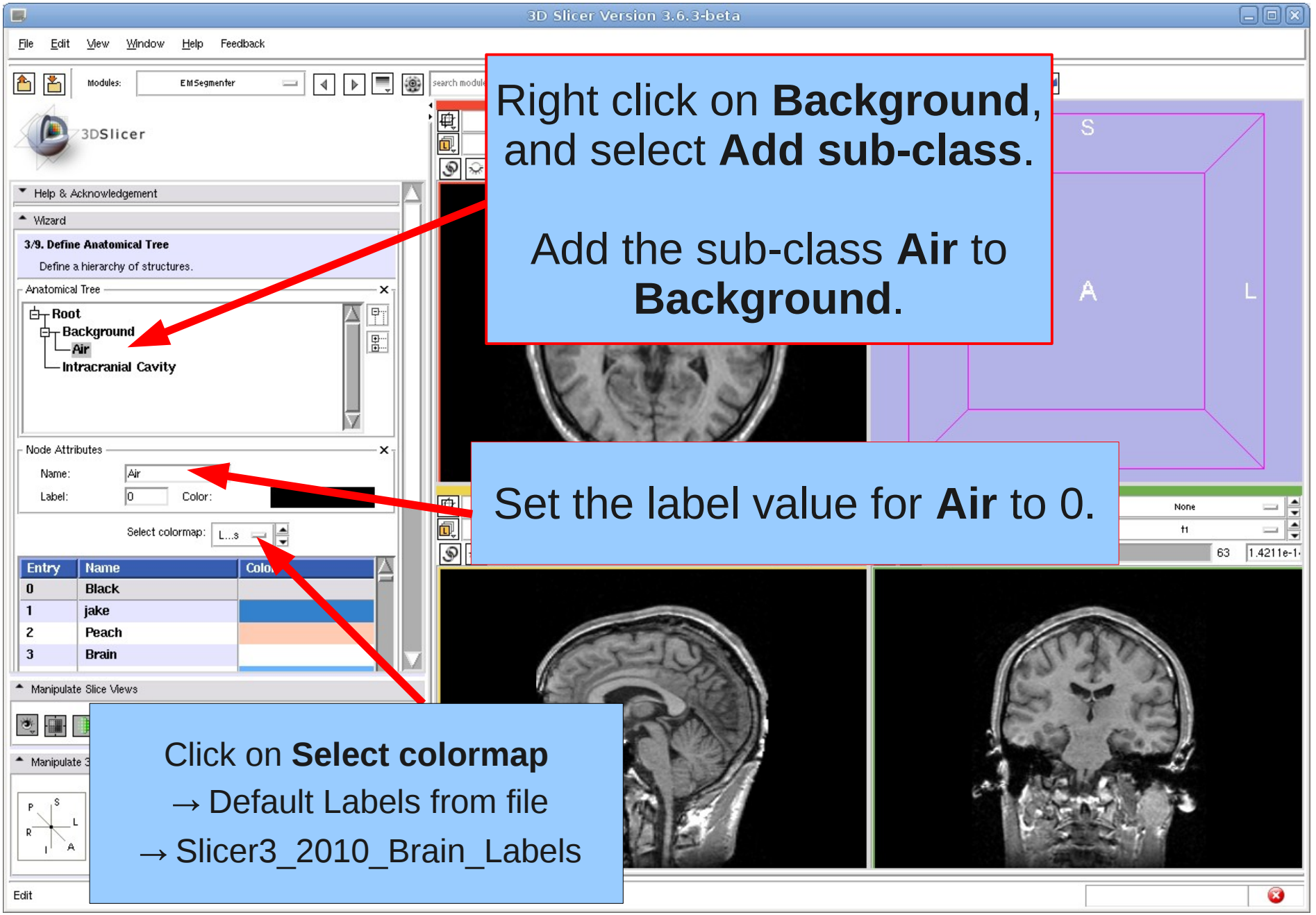
Define Anatomical Tree



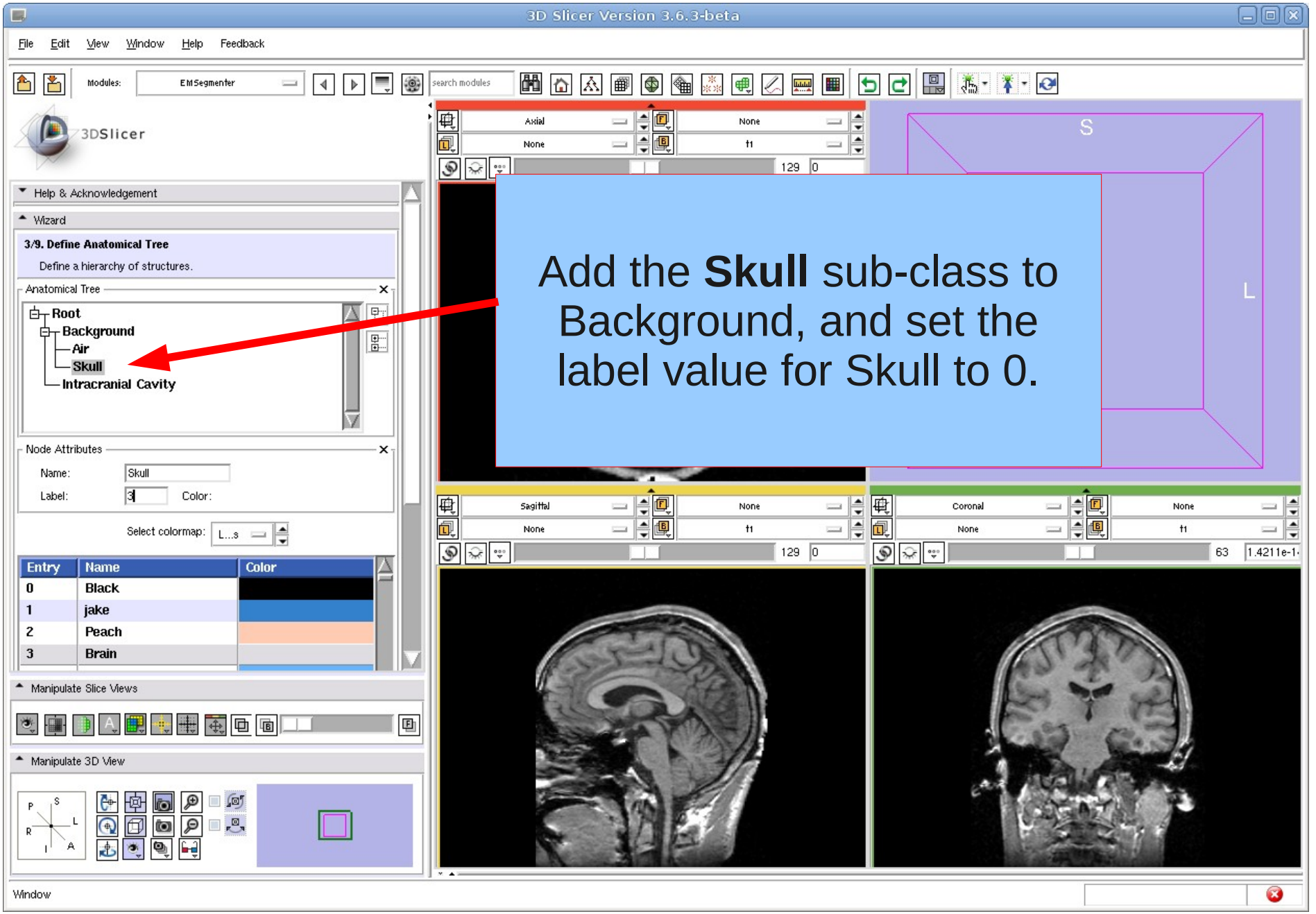
Define Anatomical Tree



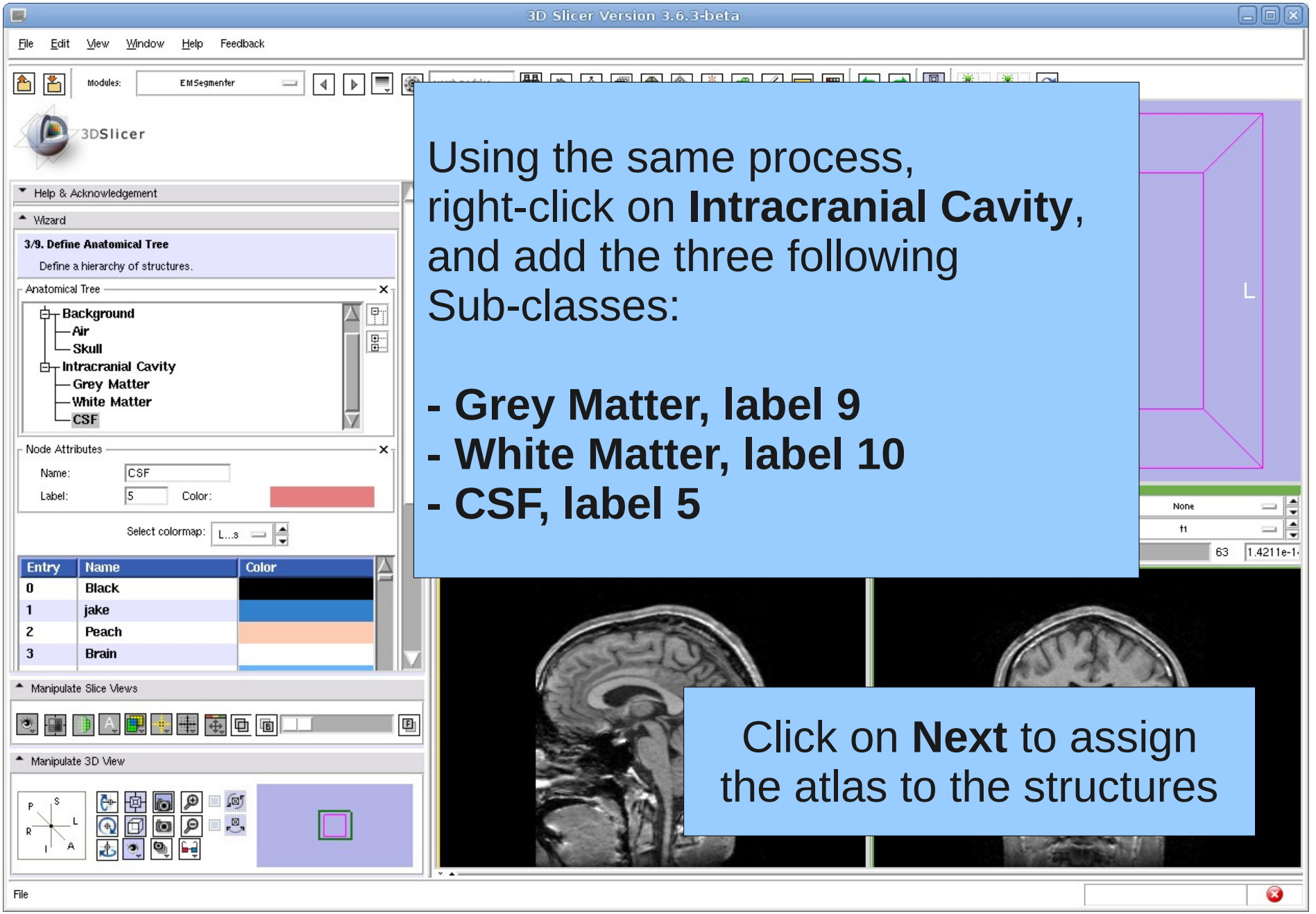
Define Anatomical Tree



Define Anatomical Tree



Define Anatomical Tree



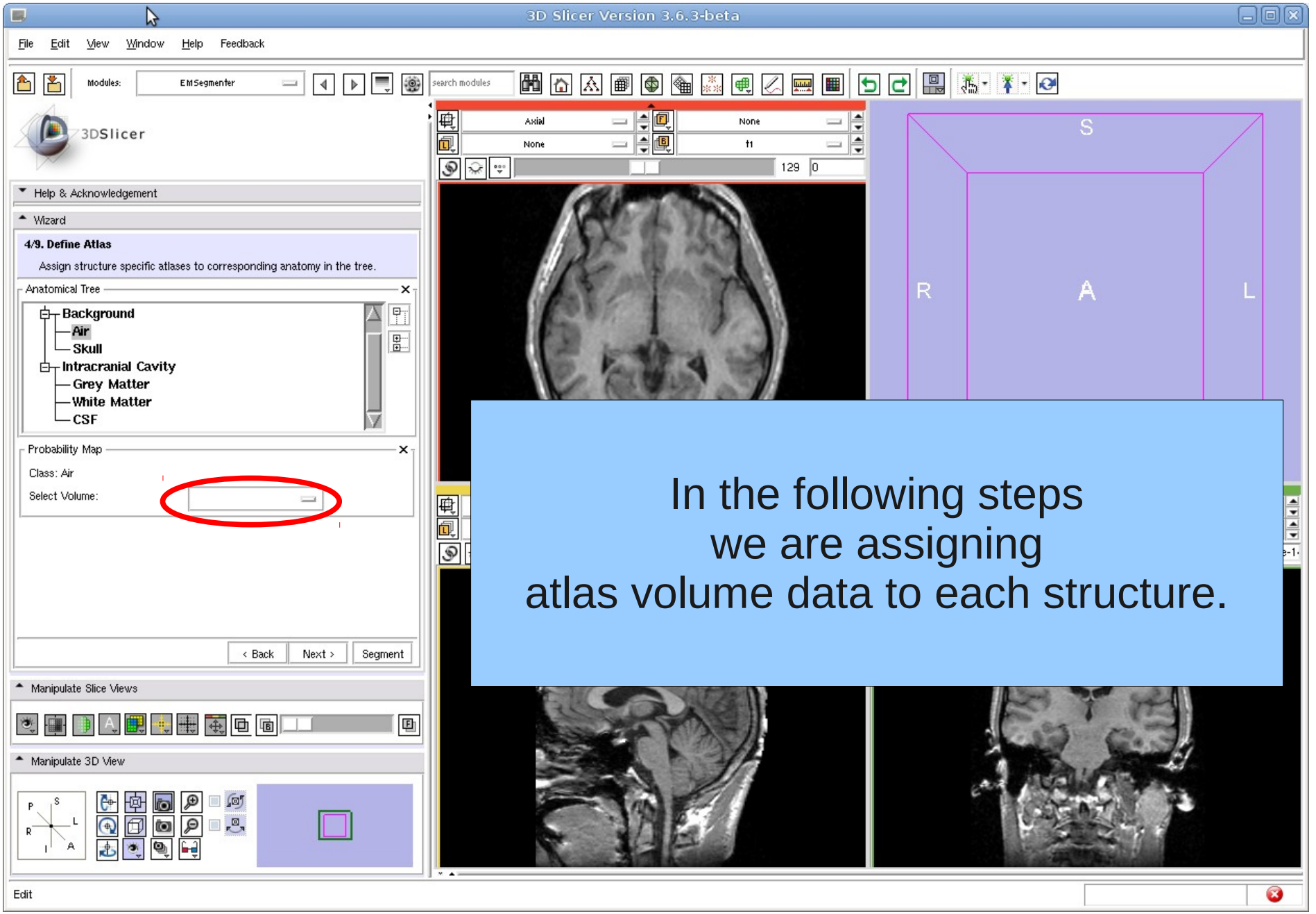
Define Atlas

Step 4:
Assign an atlas to each node in the tree

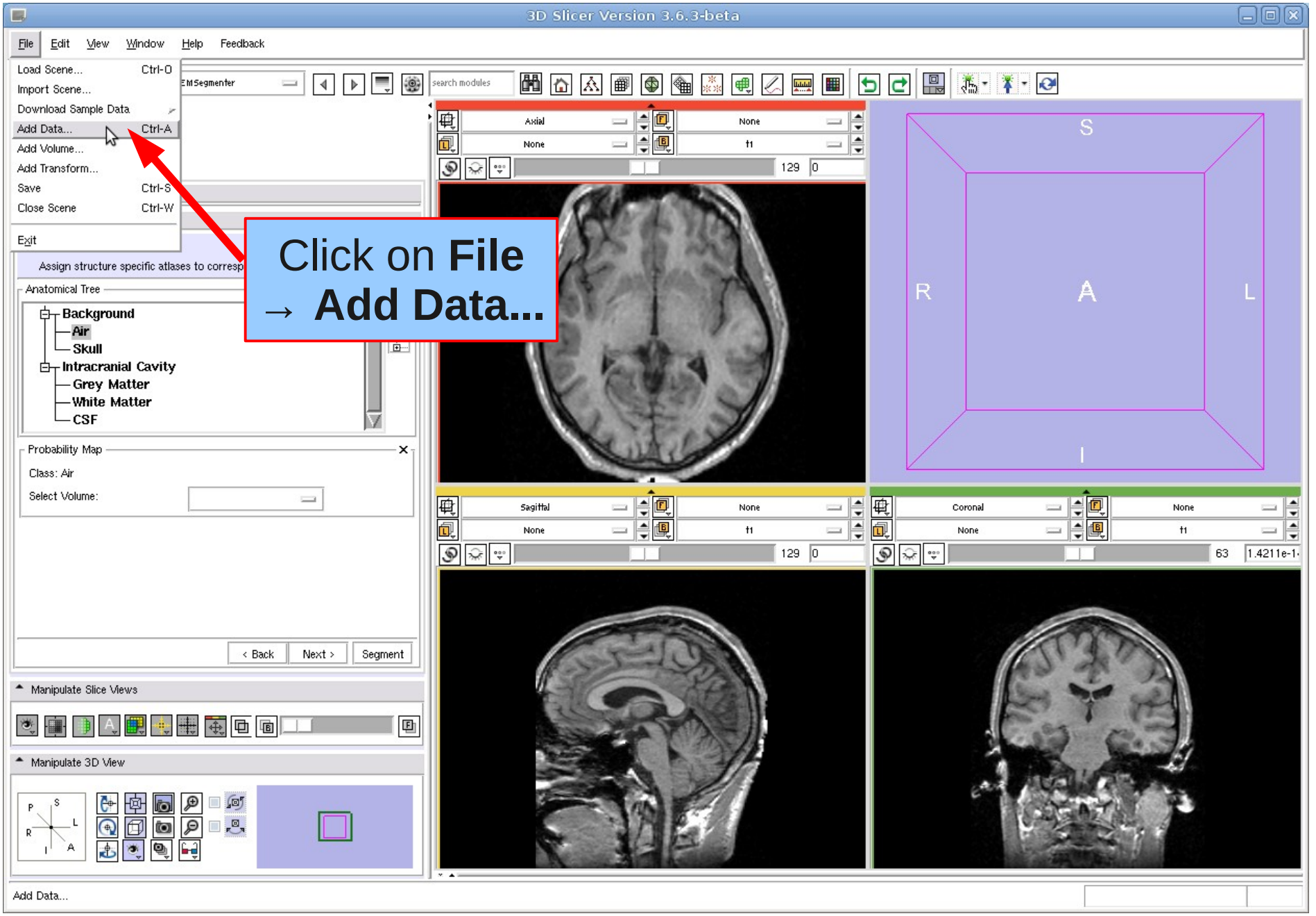
We now further characterize each anatomical structure by specifying the atlas associated with that structure. For the EMSegmenter, the atlas defines the spatial distribution of the structure of interest, which is the frequency the structure appeared at each image location in a given set of scans.

For further information on generating these atlas please read:
L. Zöllei, M. Shenton, W.M. Wells III, K.M. Pohl. “The Impact of Atlas Formation Methods on Atlas-Guided Brain Segmentation, Statistical Registration.” In Pair-wise and Group-wise Alignment and Atlas Formation Workshop at MICCAI 2007: Tenth International Conference on Medical Image Computing and Computer-Assisted Intervention, pp. 39 - 46, 2007.
https://www.rad.upenn.edu/sbia/Kilian.Pohl/publications/zollei-miccai-2007.pdf

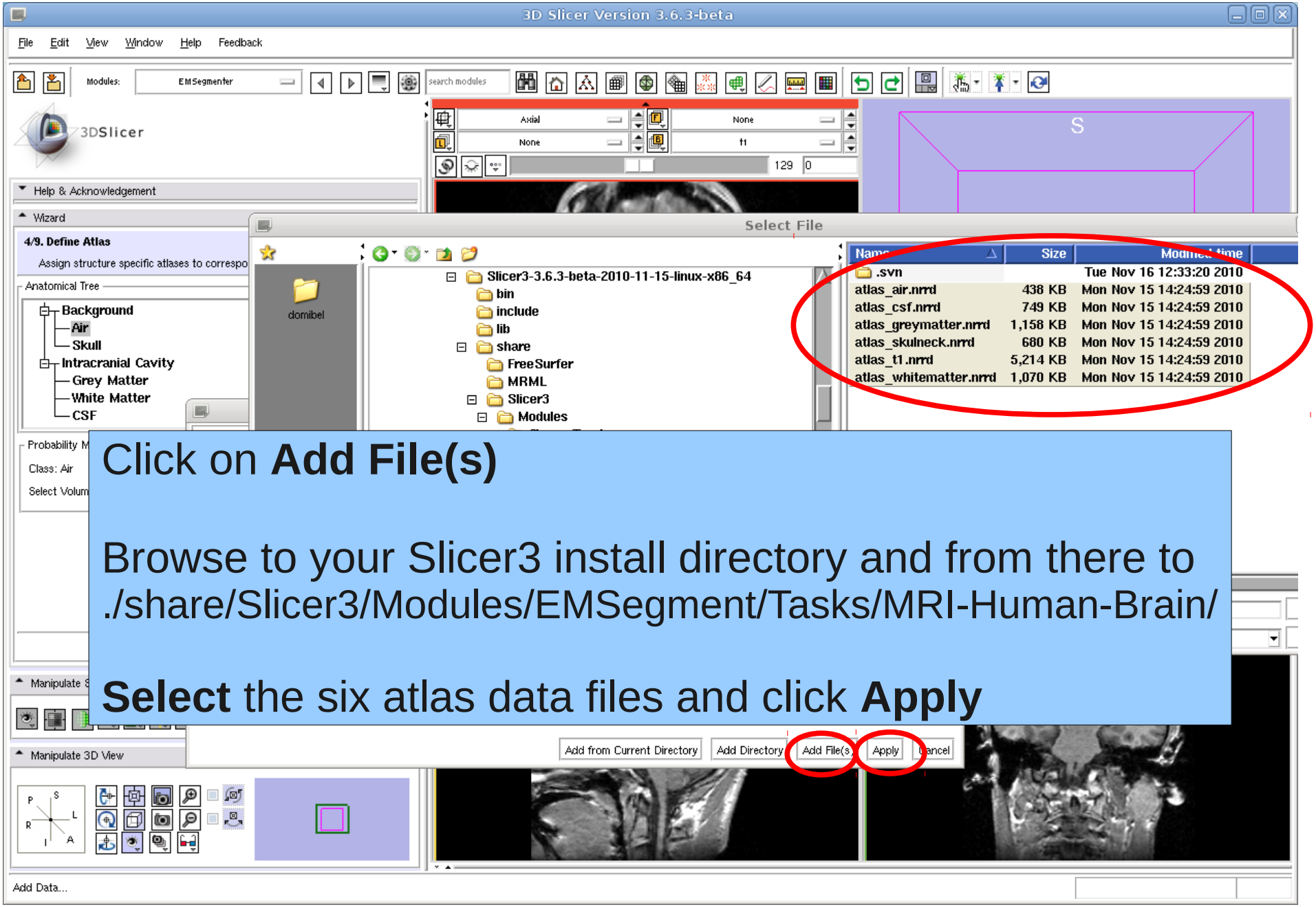
Define Atlas



Load Atlas Data



Load Atlas Data

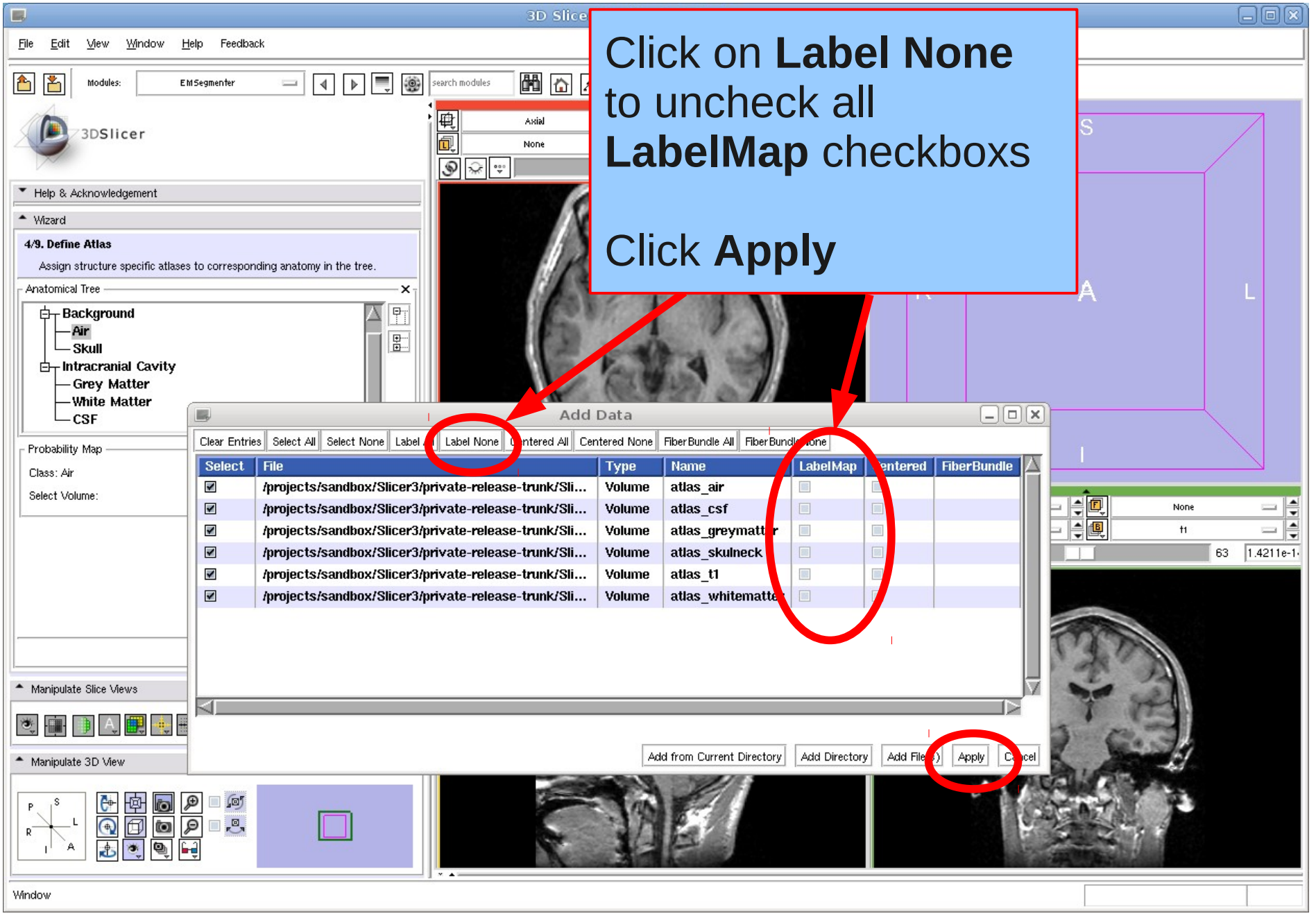


Click on **Add File(s)**

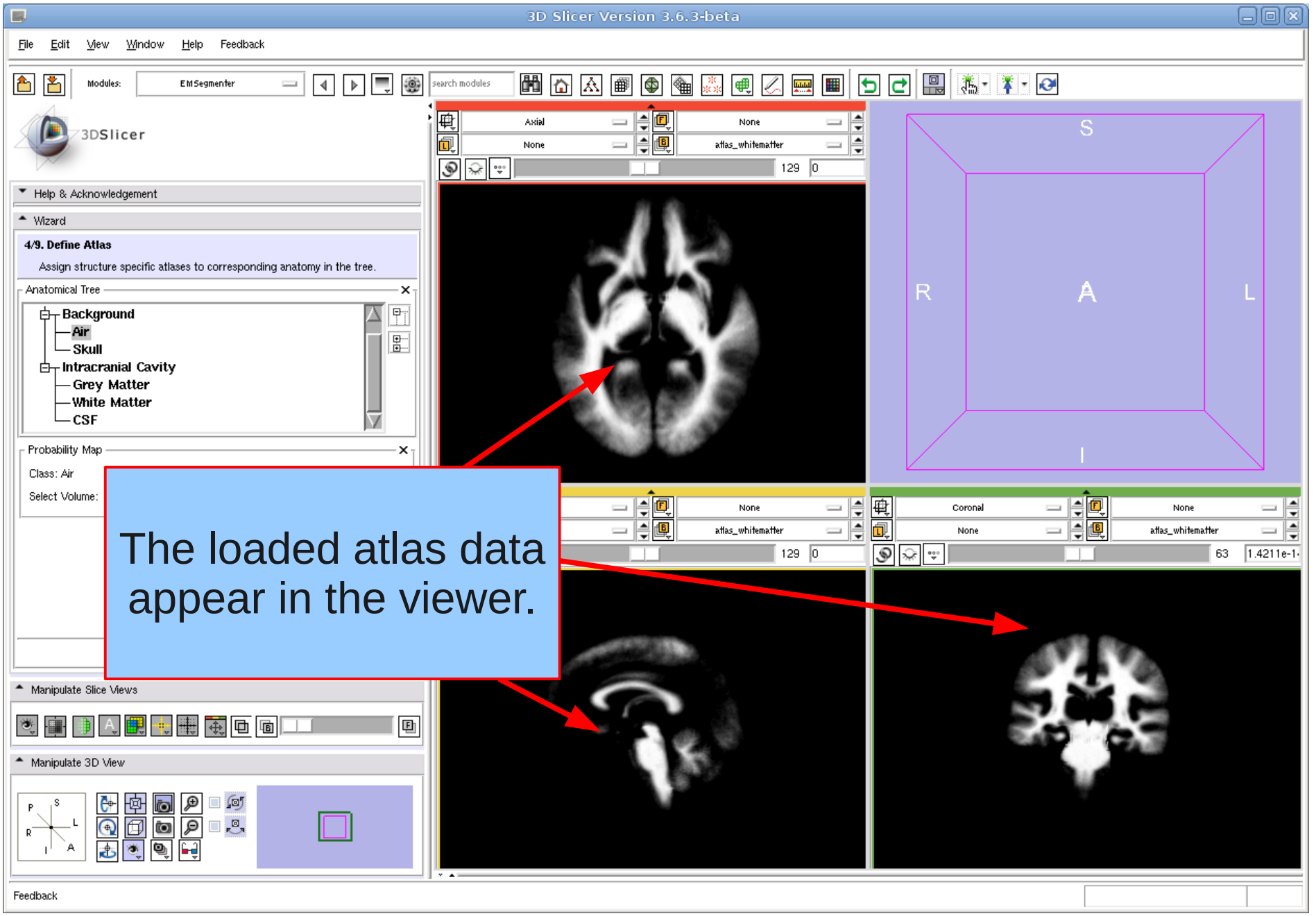
Browse to your Slicer3 install directory and from there to ./share/Slicer3/Modules/EMSegment/Tasks/MRI-Human-Brain/

Select the six atlas data files and click **Apply**

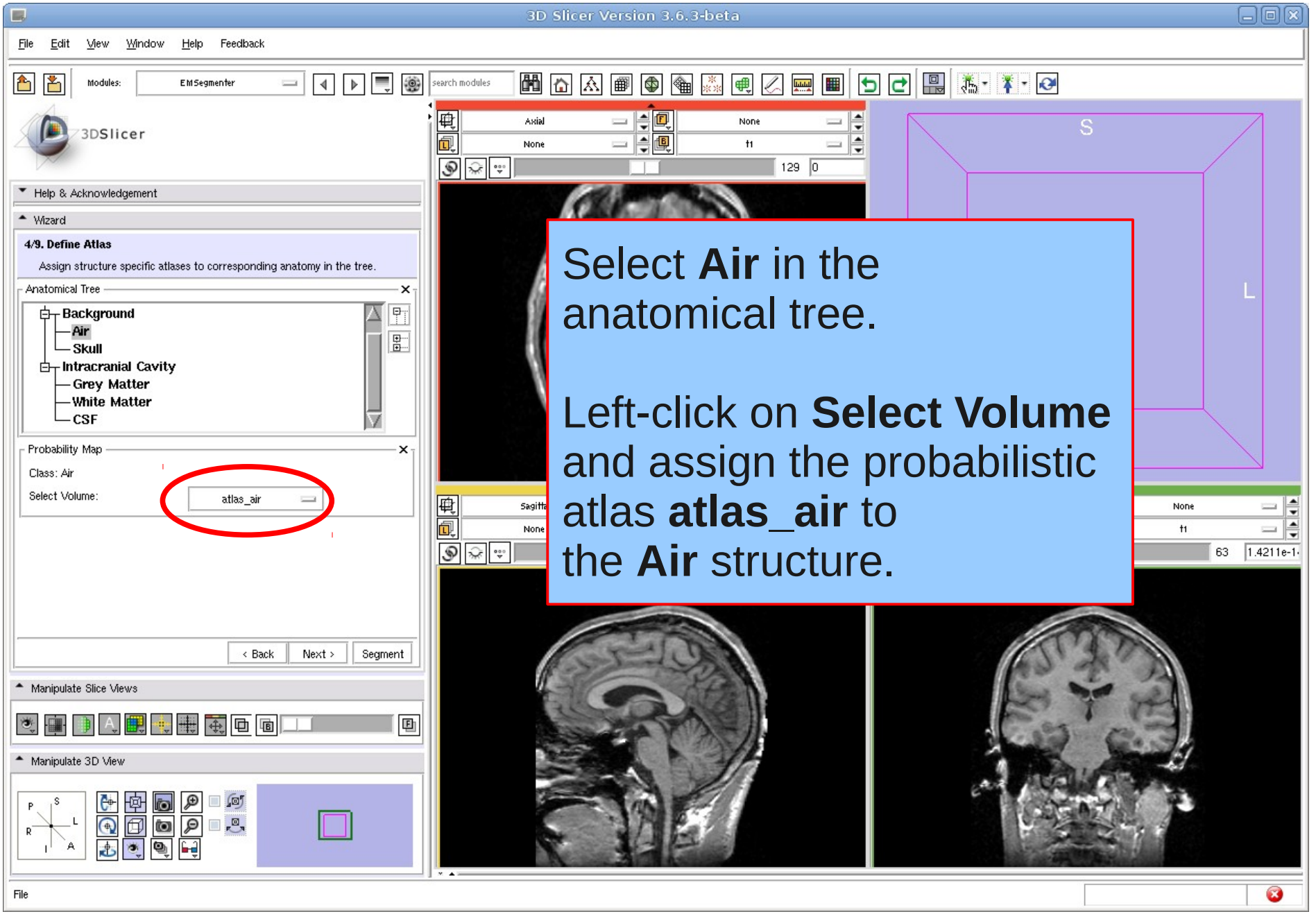
Load Atlas Data



Load Atlas Data



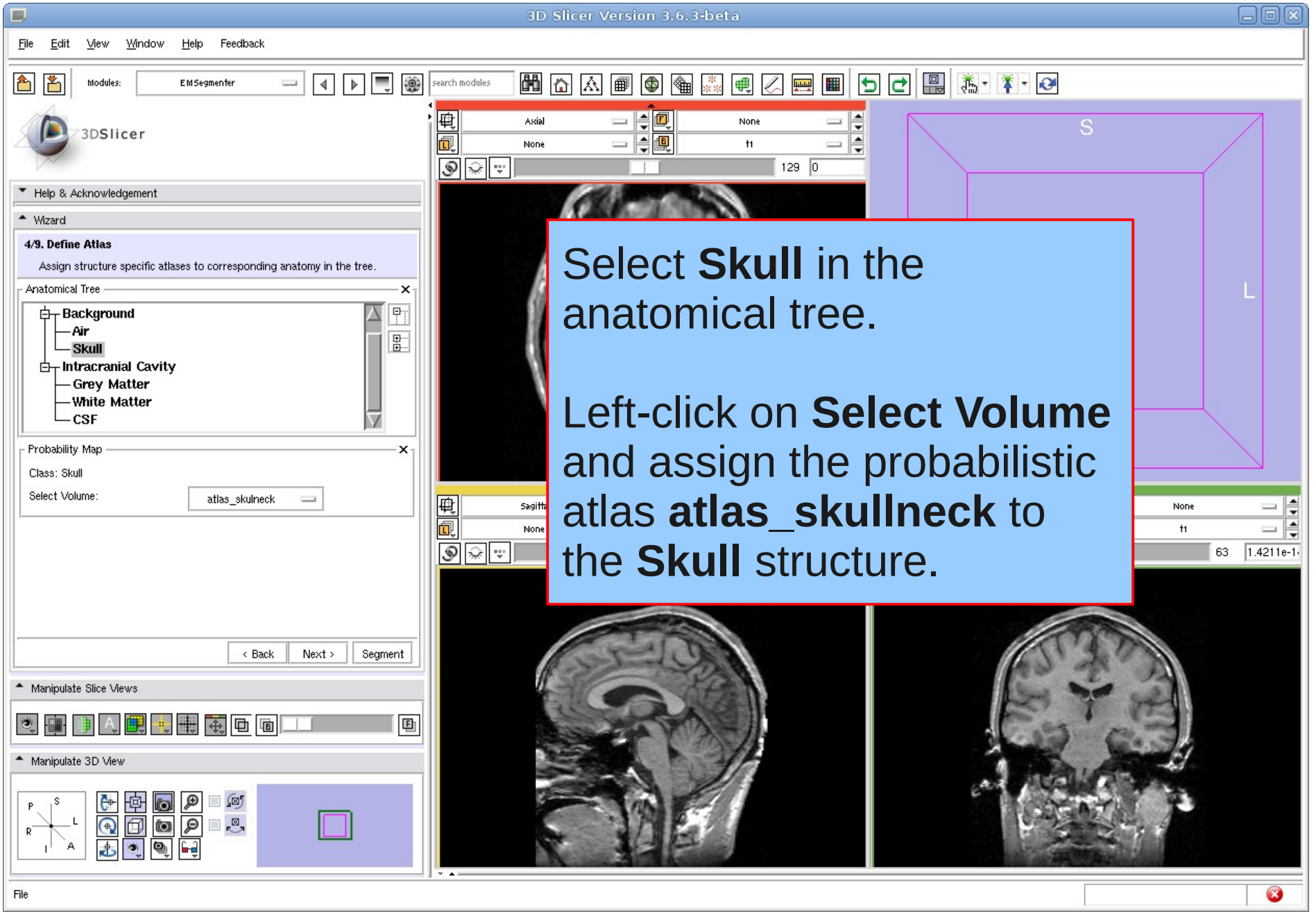
Define Atlas



Select **Air** in the anatomical tree.

Left-click on **Select Volume** and assign the probabilistic atlas **atlas_air** to the **Air** structure.

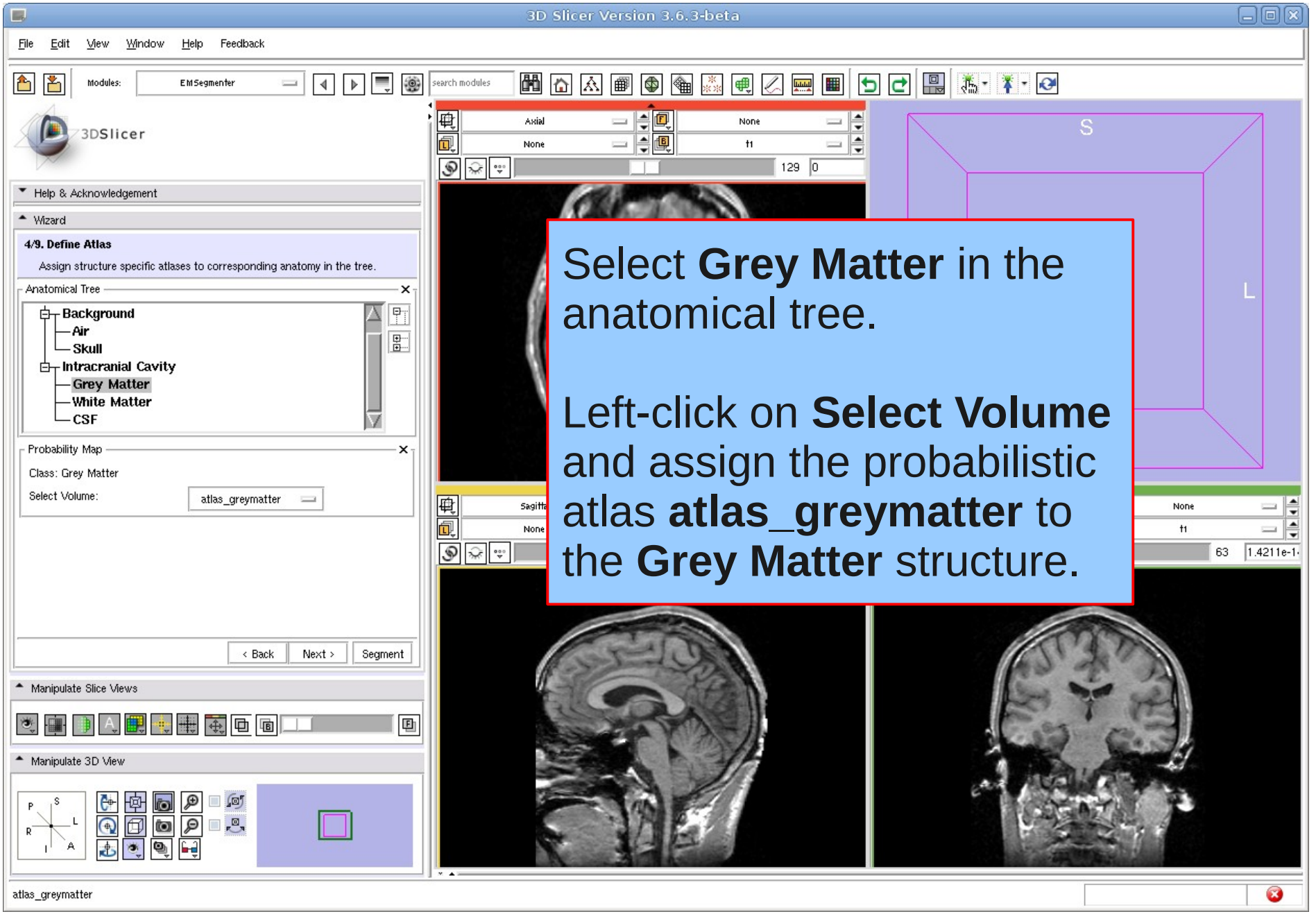
Define Atlas



Select **Skull** in the anatomical tree.

Left-click on **Select Volume** and assign the probabilistic atlas **atlas_skullneck** to the **Skull** structure.

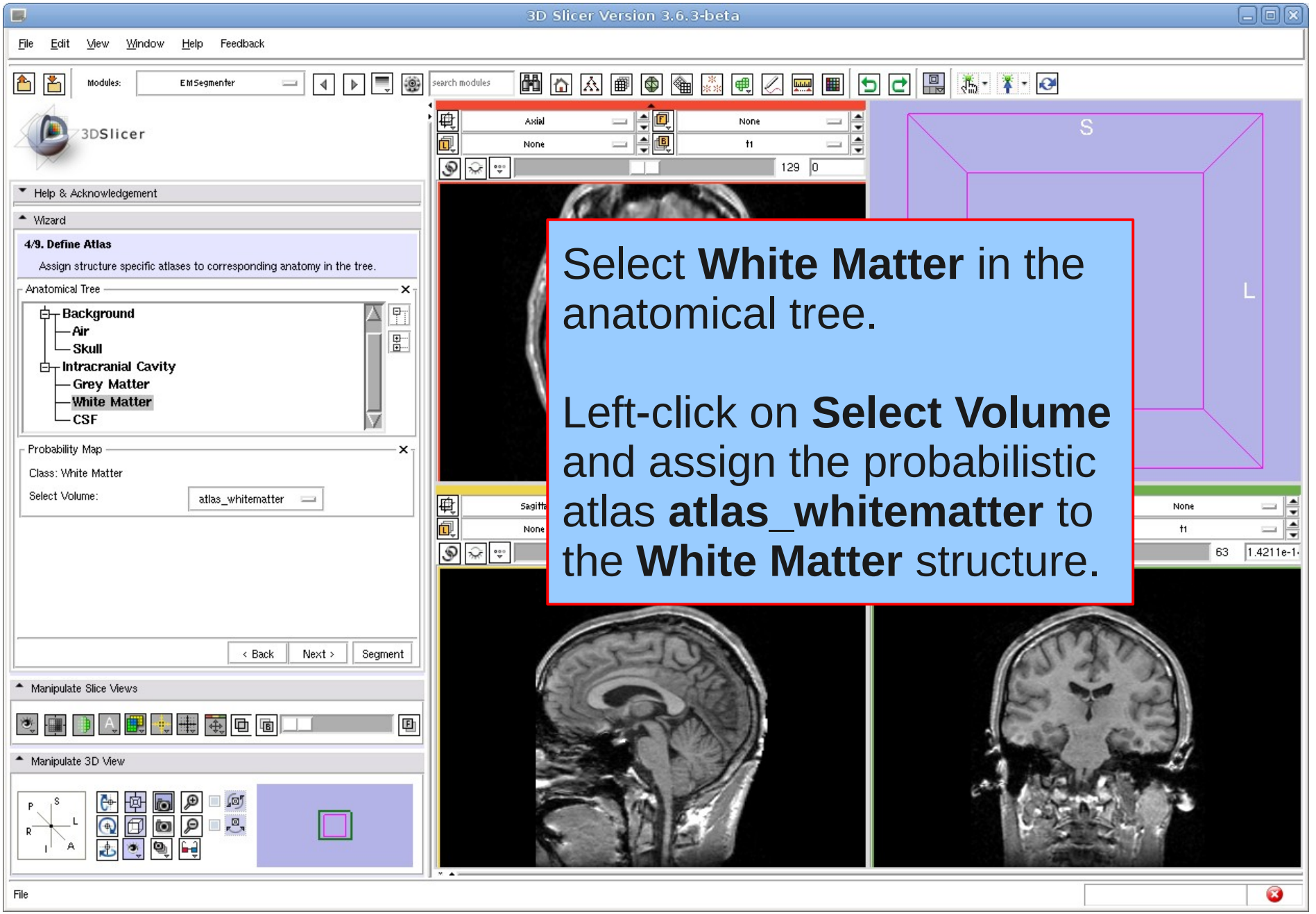
Define Atlas



Select **Grey Matter** in the anatomical tree.

Left-click on **Select Volume** and assign the probabilistic atlas **atlas_greymatter** to the **Grey Matter** structure.

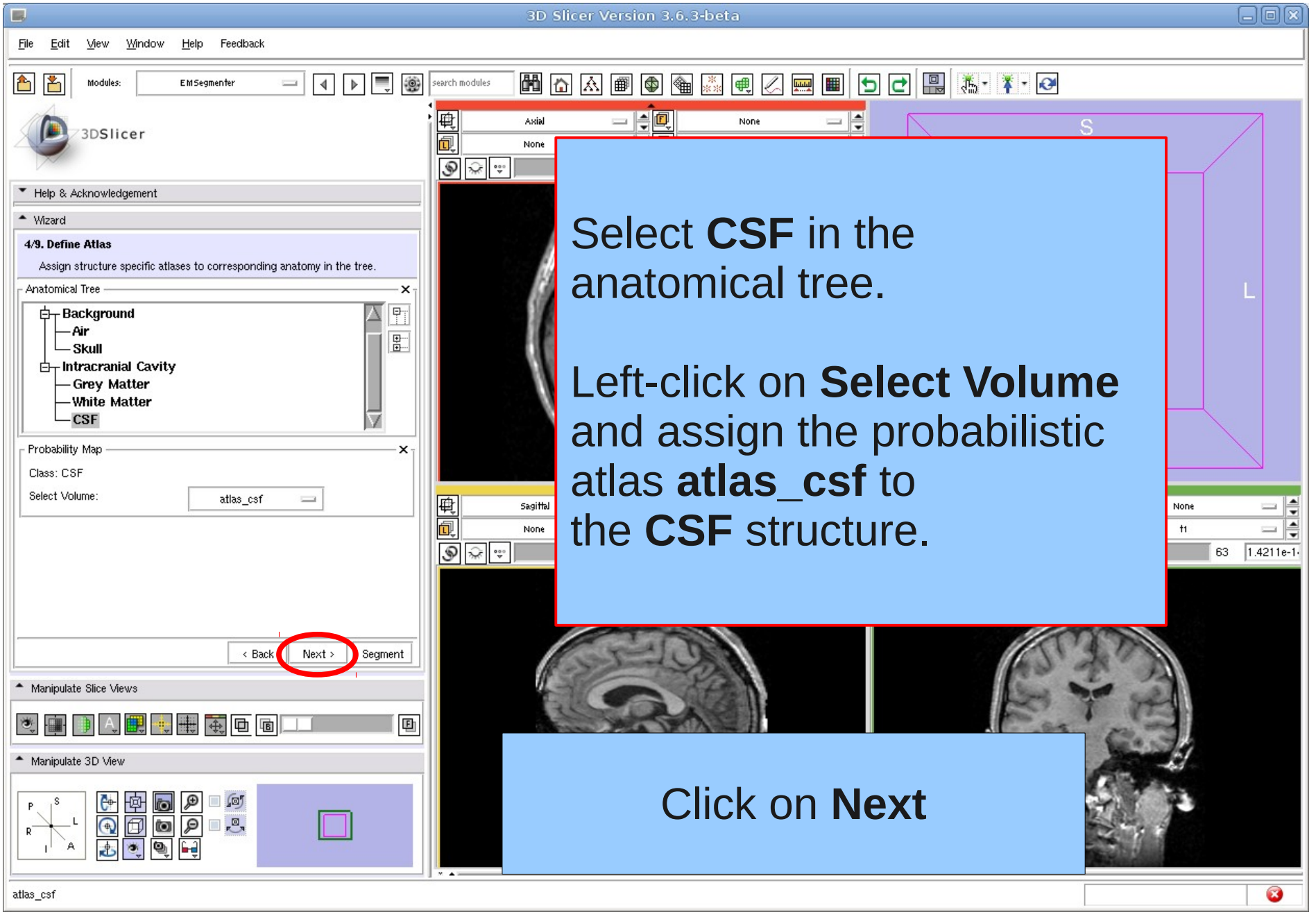
Define Atlas



Select **White Matter** in the anatomical tree.

Left-click on **Select Volume** and assign the probabilistic atlas **atlas_whitematter** to the **White Matter** structure.

Define Atlas



Select **CSF** in the anatomical tree.

Left-click on **Select Volume** and assign the probabilistic atlas **atlas_csf** to the **CSF** structure.

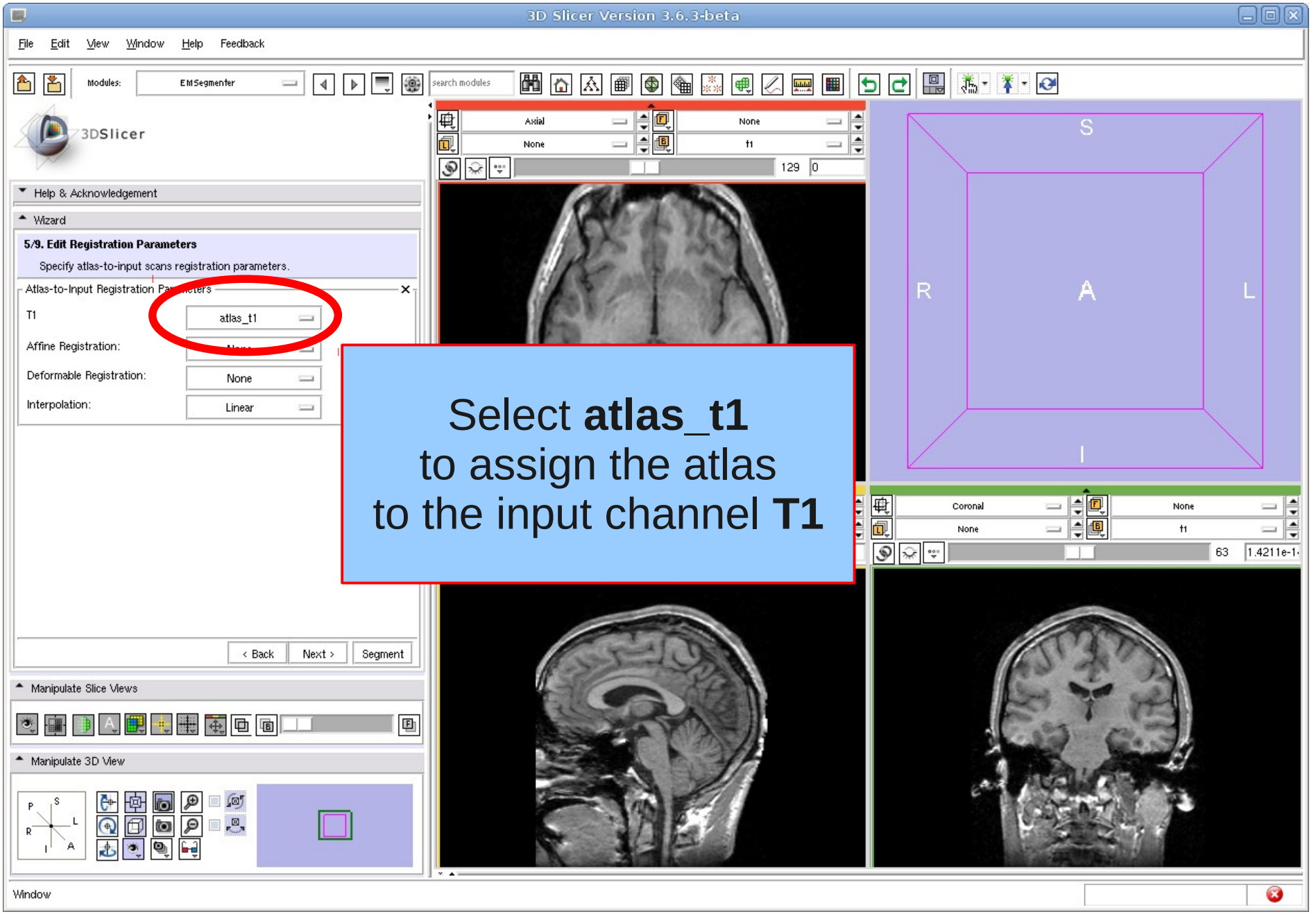
Click on **Next**

Edit Registration Parameters

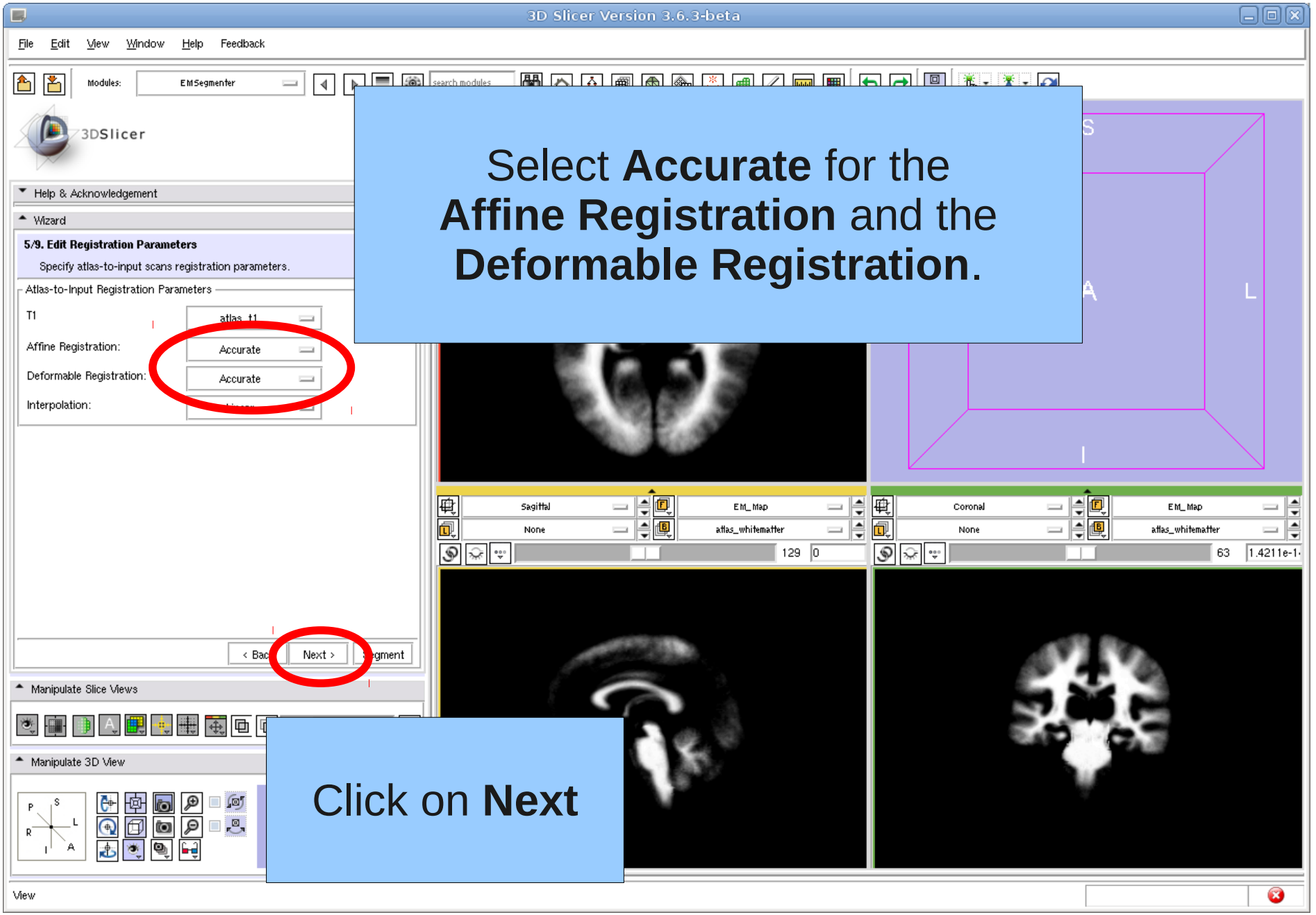
Step 5:
Defining the Atlas to Image Registration

In general, the currently defined atlas has to be aligned to the subject scan. To do so, we define in this step the template, which in this case is a T1 scan, that the atlas is currently aligned to as well as the type of registration we would like to perform

Edit Registration Parameters



Edit Registration Parameters



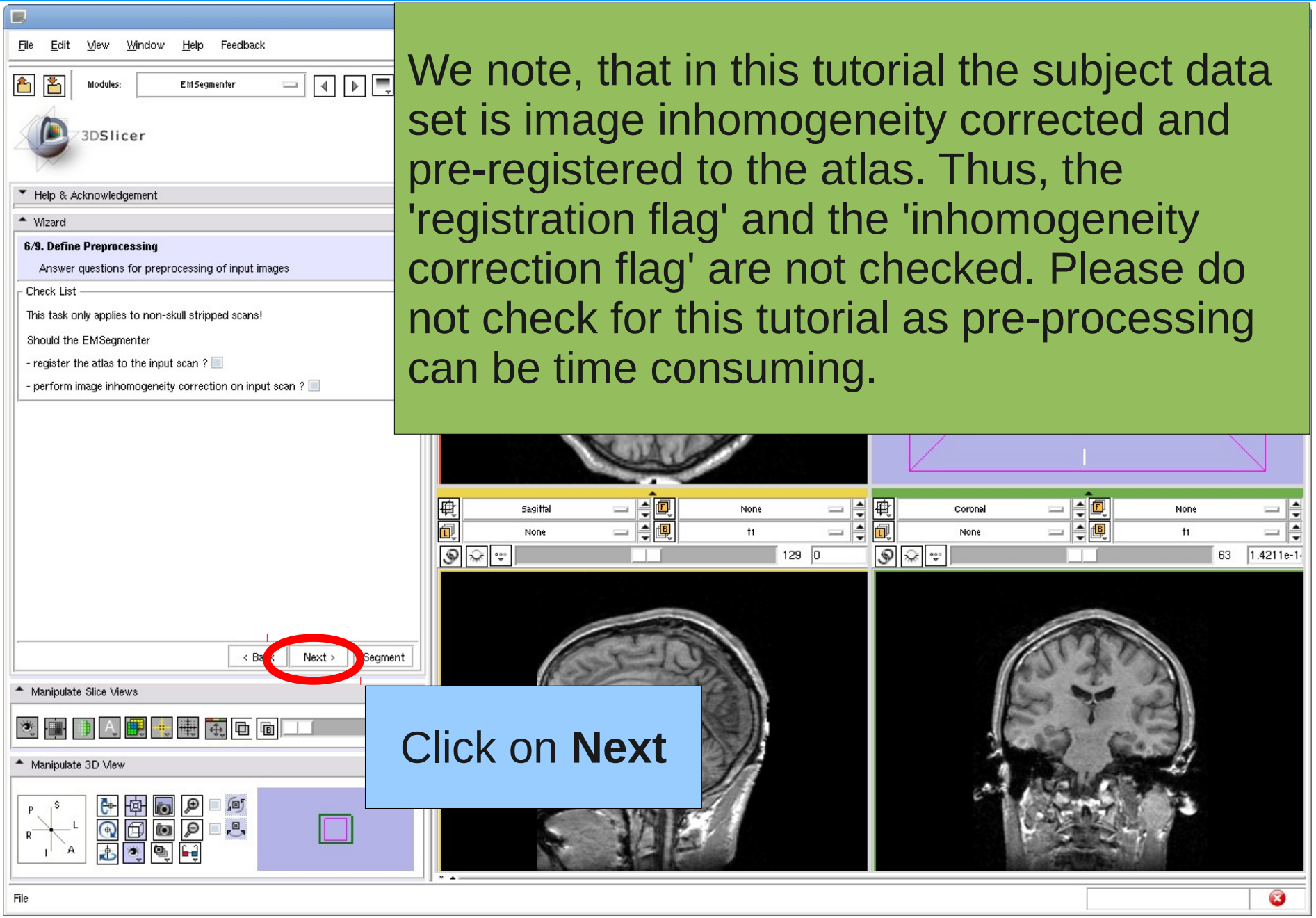
Define Preprocessing

Step 6:
Further Specify Preprocessing

In the first step, we defined the type of preprocessing we wanted to perform. We now further specify the pre-processing by answering a set of questions further specifying the type of data we attend to segment. For example, in this tutorial we assume that the subject scan is already aligned to the atlas so that we skip the atlas to image registration during preprocessing.

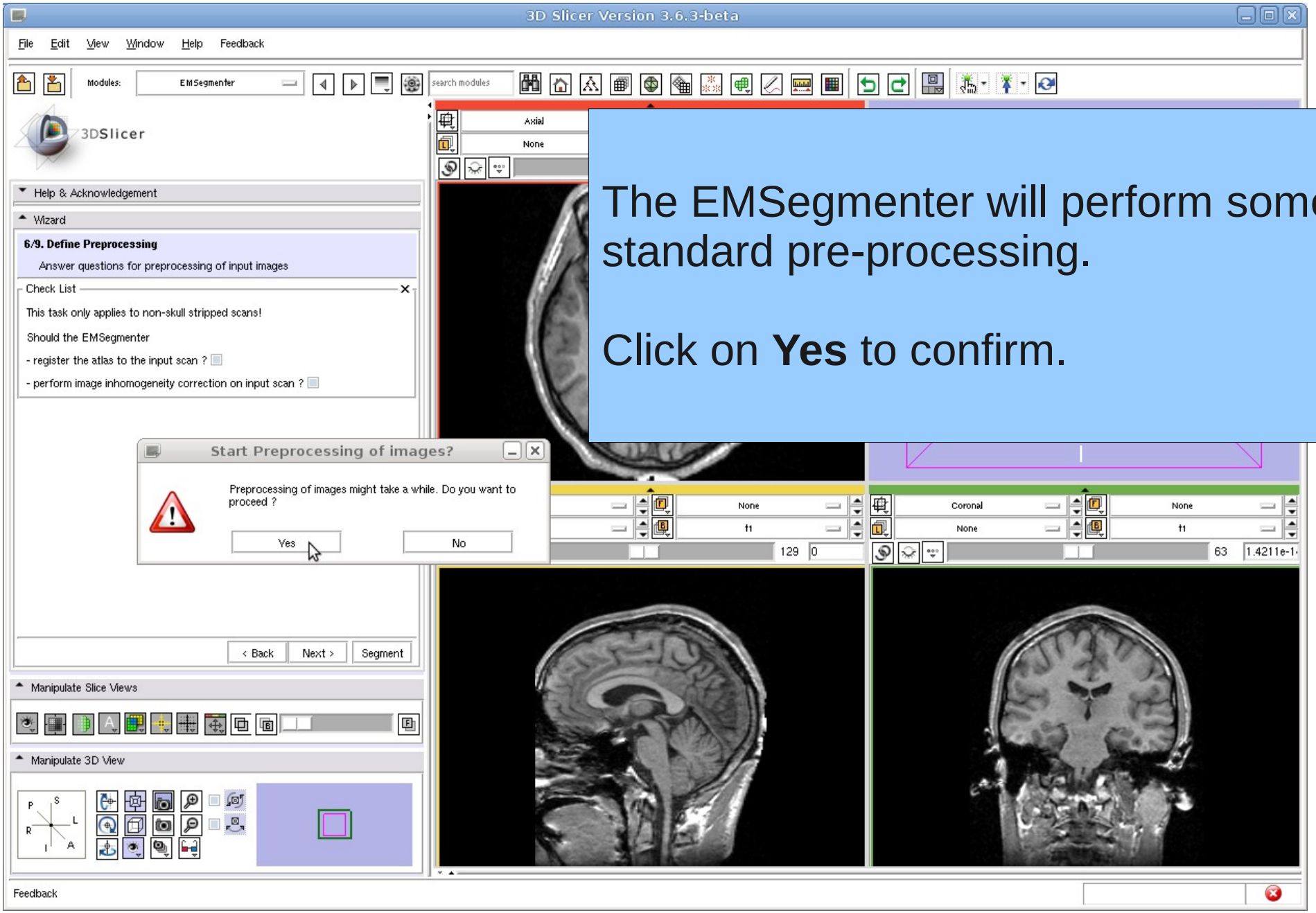
Define Preprocessing

We note, that in this tutorial the subject data set is image inhomogeneity corrected and pre-registered to the atlas. Thus, the 'registration flag' and the 'inhomogeneity correction flag' are not checked. Please do not check for this tutorial as pre-processing can be time consuming.



Click on **Next**

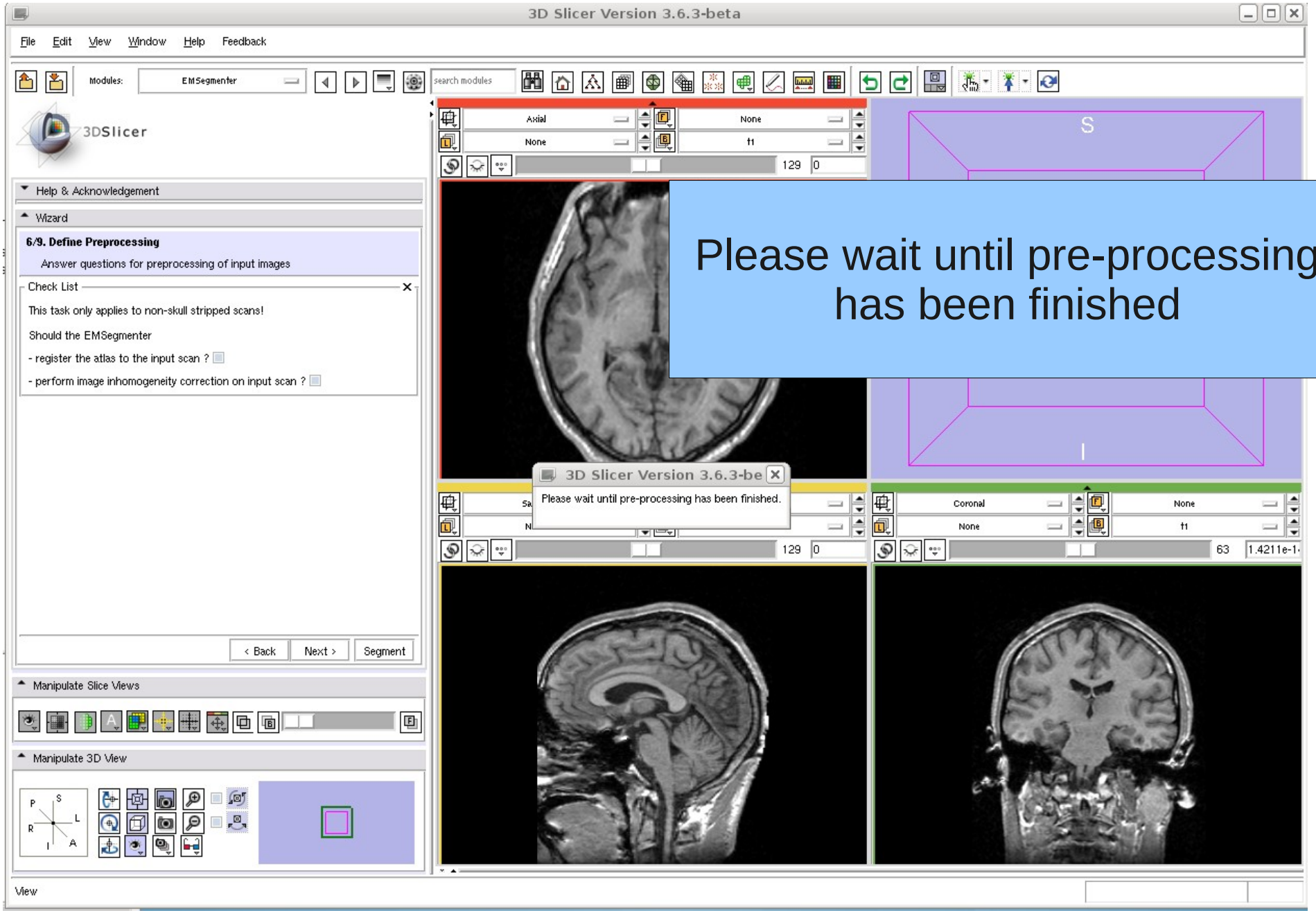
Define Preprocessing



The EMSegmenter will perform some standard pre-processing.

Click on **Yes** to confirm.

Define Preprocessing



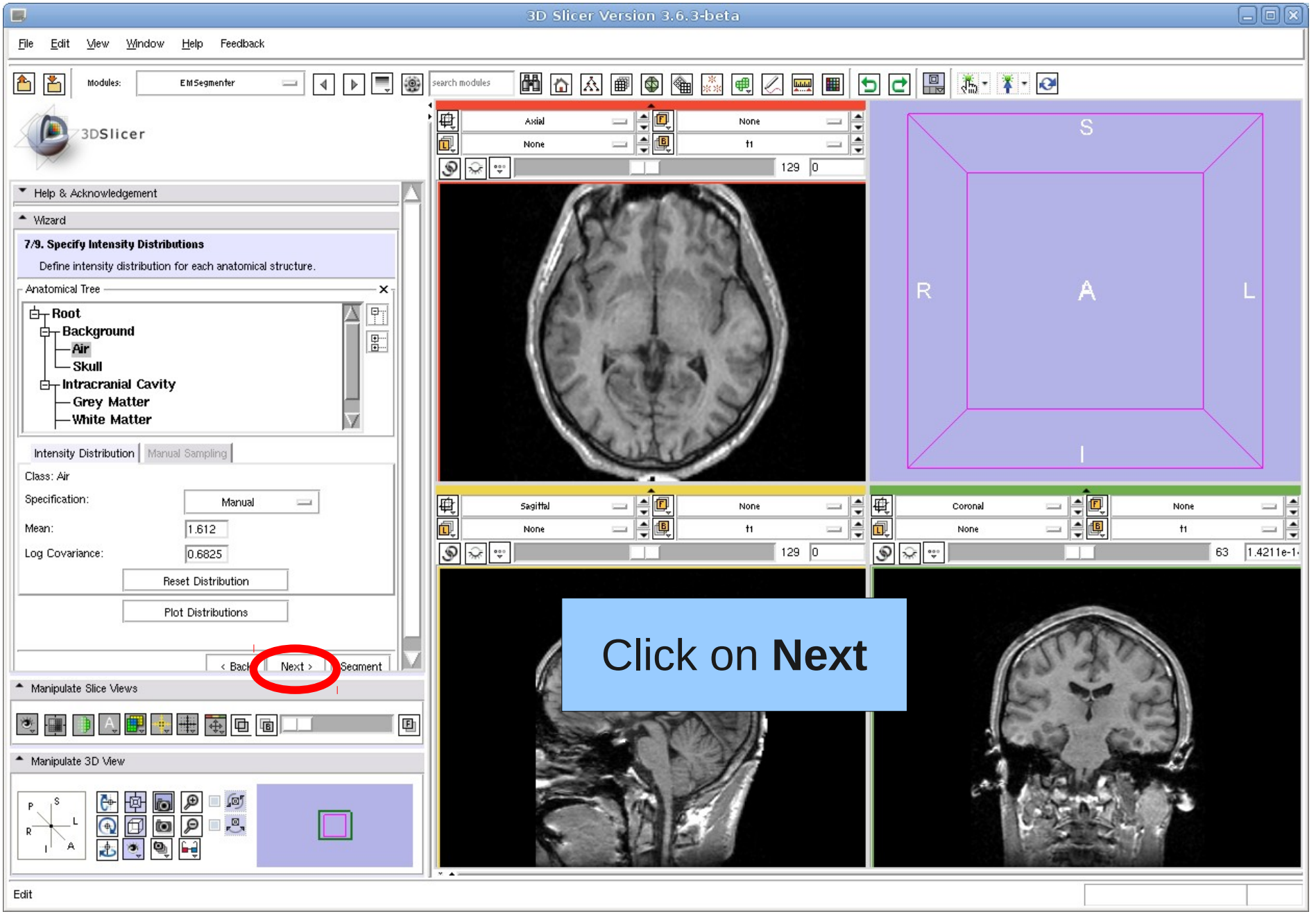
Specify Intensity Distribution

Step 7:
Specifying the Intensity Distribution

In this step, users further specify each anatomical structure by defining the intensity distribution that is typical for the structure in the input scan.

In this tutorial the step can be skipped as the intensity distributions have been calculated during the pre-processing.

Specify Intensity Distribution



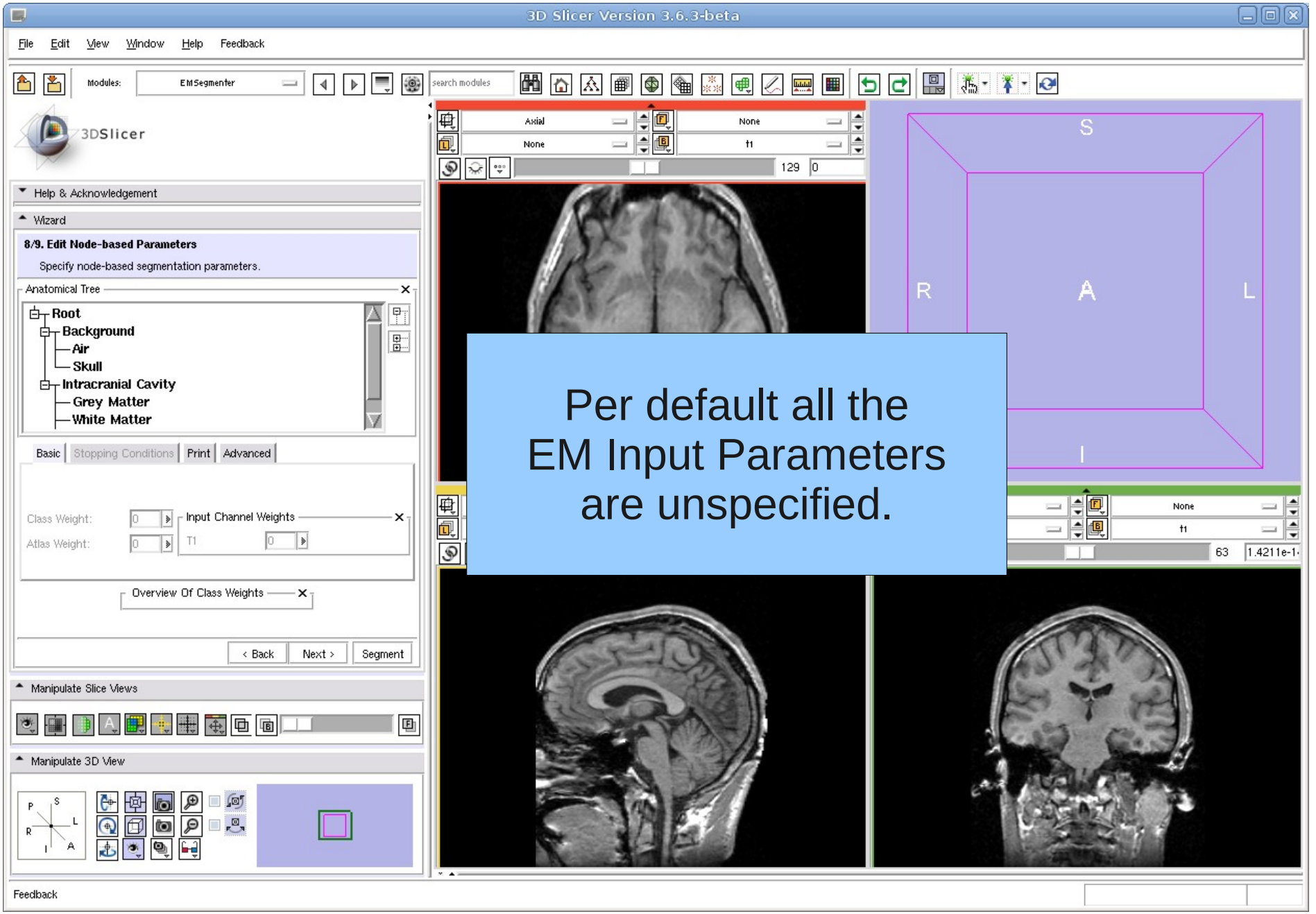
Edit Node-based Parameters

Step 8:
Define EM Specific Parameters

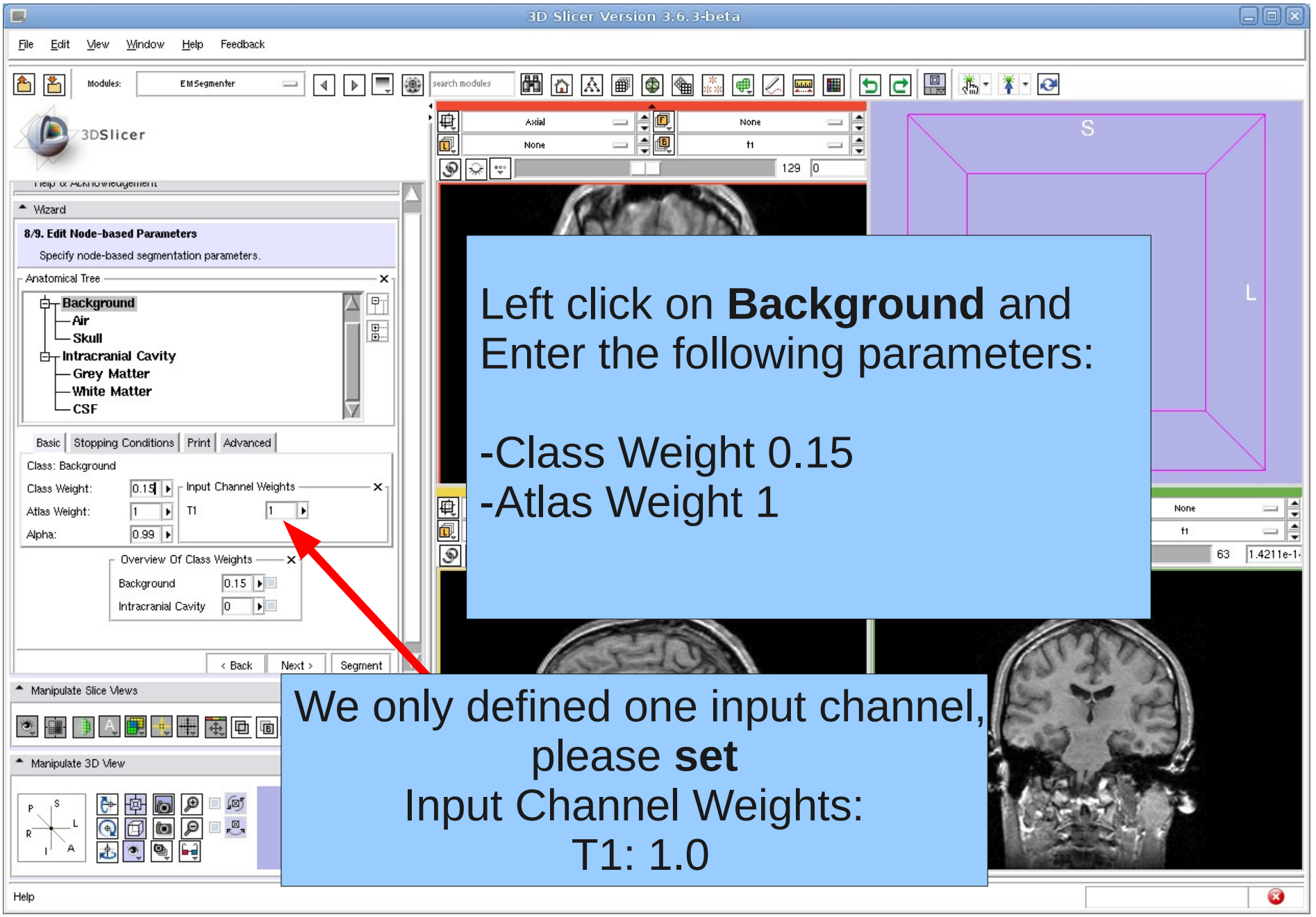
The EMSegmenter segments the input scans of Step 1 into the structure of interest of Step 2 by using an optimization algorithm called the Expectation Maximization Algorithm. This algorithm has specific parameters that influence the segmentation. In this tutorial we will specify:

- **class weights**, which define the relative importance of structure over other structure. This is useful if a structure is too dominant in the automatic segmentation. By lowering the weight, the structure will be less present in the corresponding automatic segmentation.
- **atlas weight**, which define the importance of the atlas (of Step 3) over the image data defined in Step 1. One might want to lower the weight if the intensity distributions clearly define each structure to be segmented.
- **Input Channel weight**, which defines the importance between the different input channels for the structure of interest. Since we only defined one input channel, this parameter should simply be set to 1.
- **Alpha**, which defines the smoothness of the segmentation. The alpha value has to be between 0 and 1. An alpha value of 1 produces fairly smooth segmentations while an alpha value of 0 generally results in noisy segmentations.

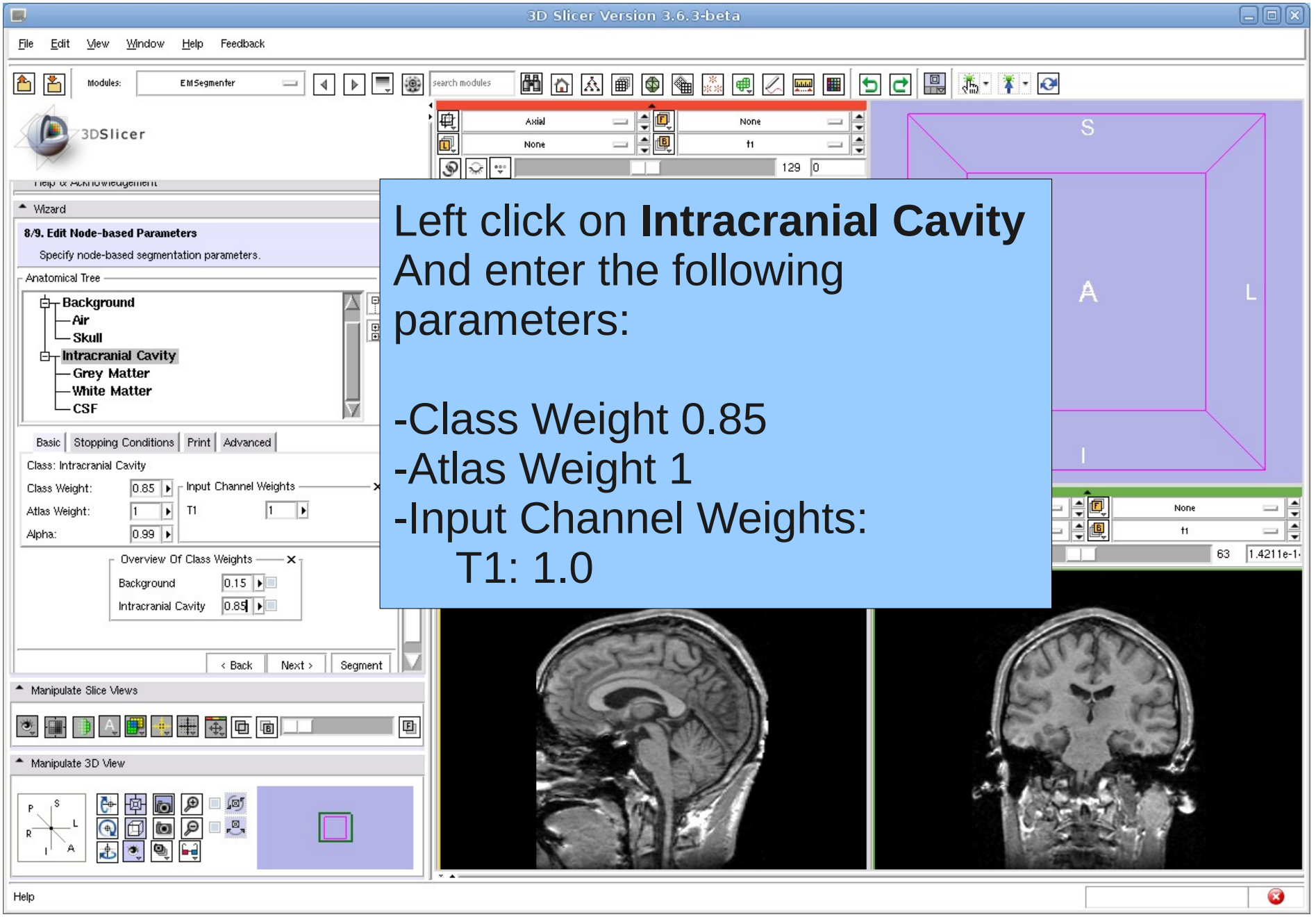
Edit Node-based Parameters



Edit Node-based Parameters



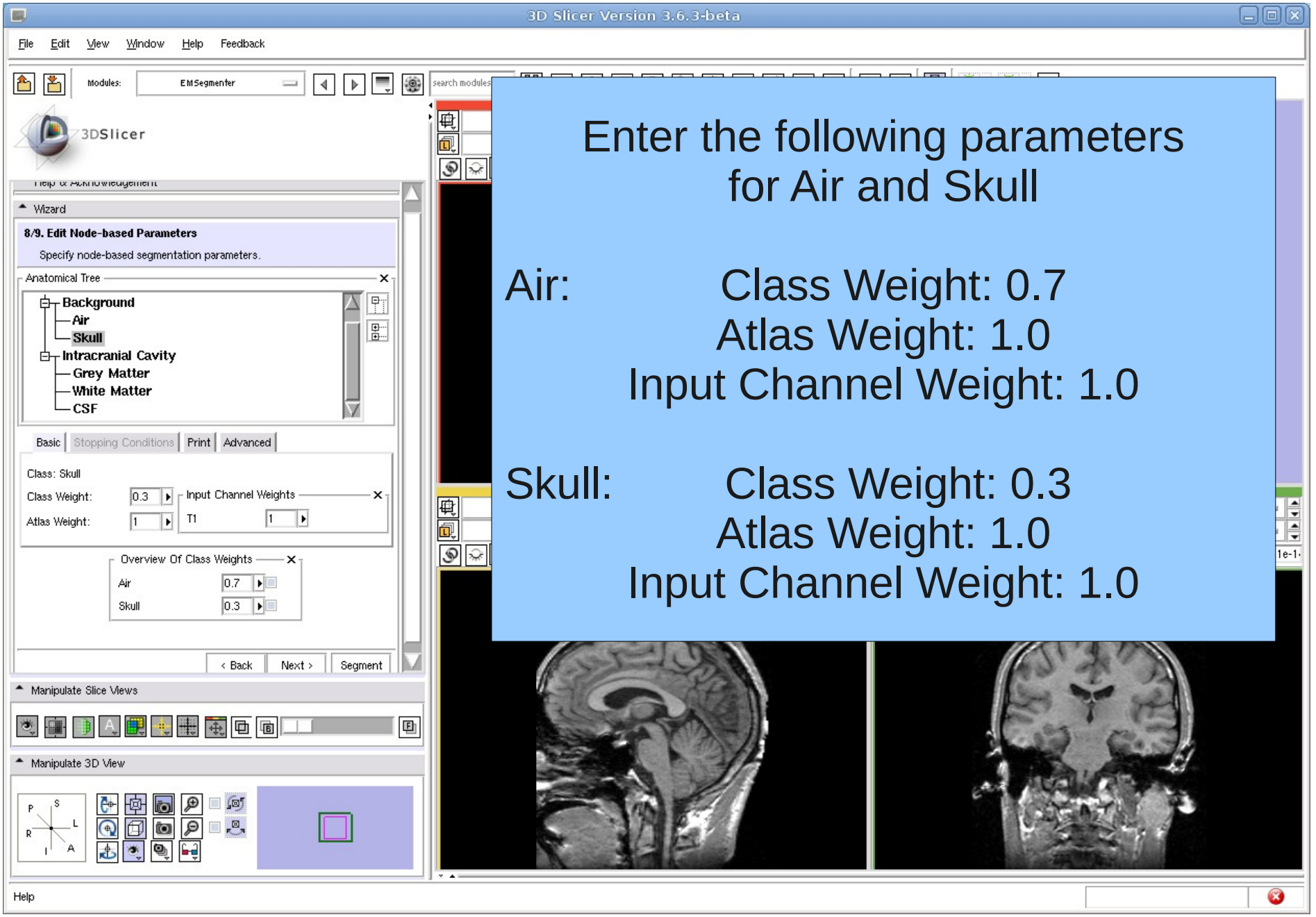
Edit Node-based Parameters



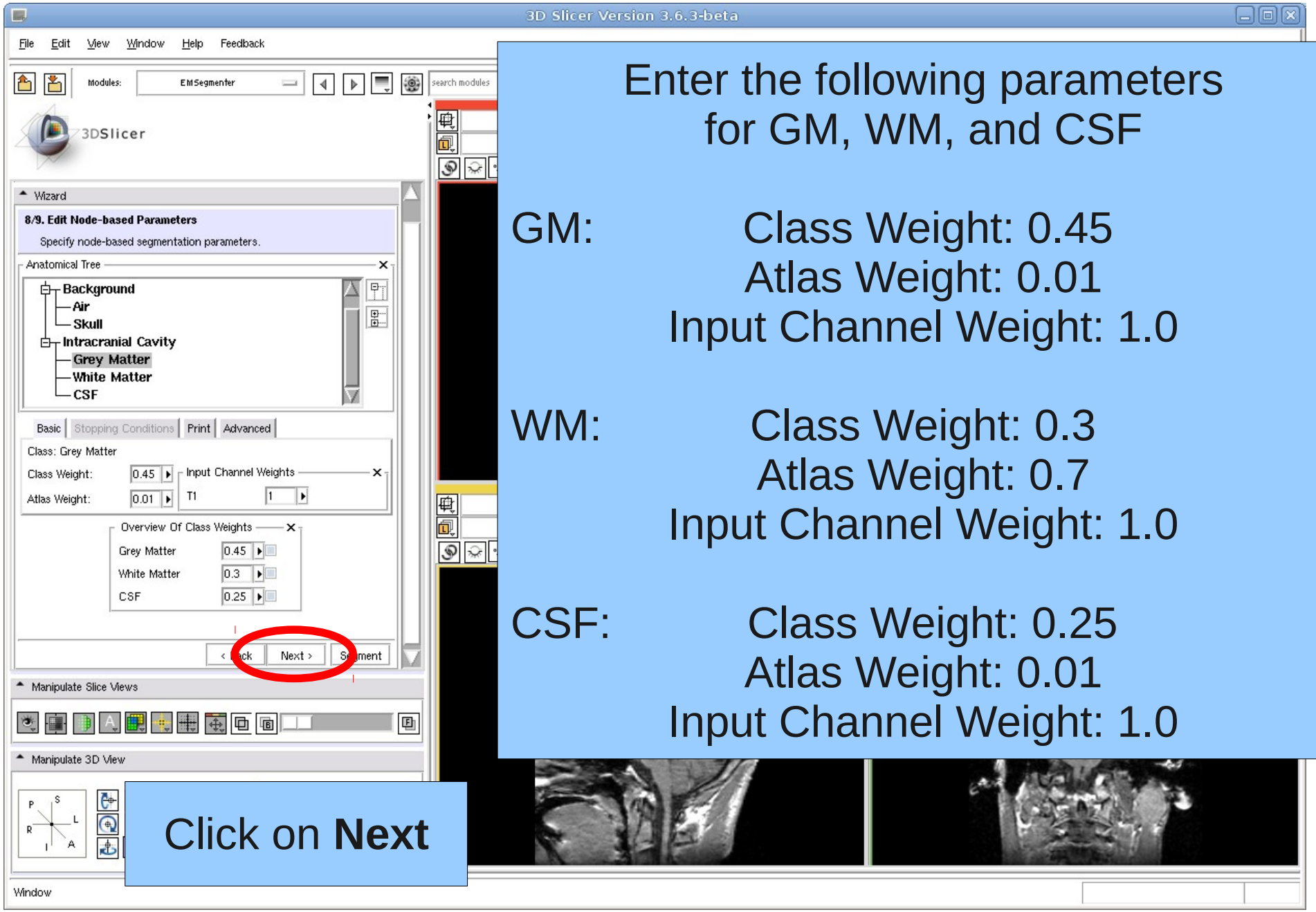
Left click on **Intracranial Cavity**
And enter the following parameters:

-Class Weight 0.85
-Atlas Weight 1
-Input Channel Weights:
T1: 1.0

Edit Node-based Parameters



Edit Node-based Parameters



Enter the following parameters for GM, WM, and CSF

GM: Class Weight: 0.45
Atlas Weight: 0.01
Input Channel Weight: 1.0

WM: Class Weight: 0.3
Atlas Weight: 0.7
Input Channel Weight: 1.0

CSF: Class Weight: 0.25
Atlas Weight: 0.01
Input Channel Weight: 1.0

Click on **Next**

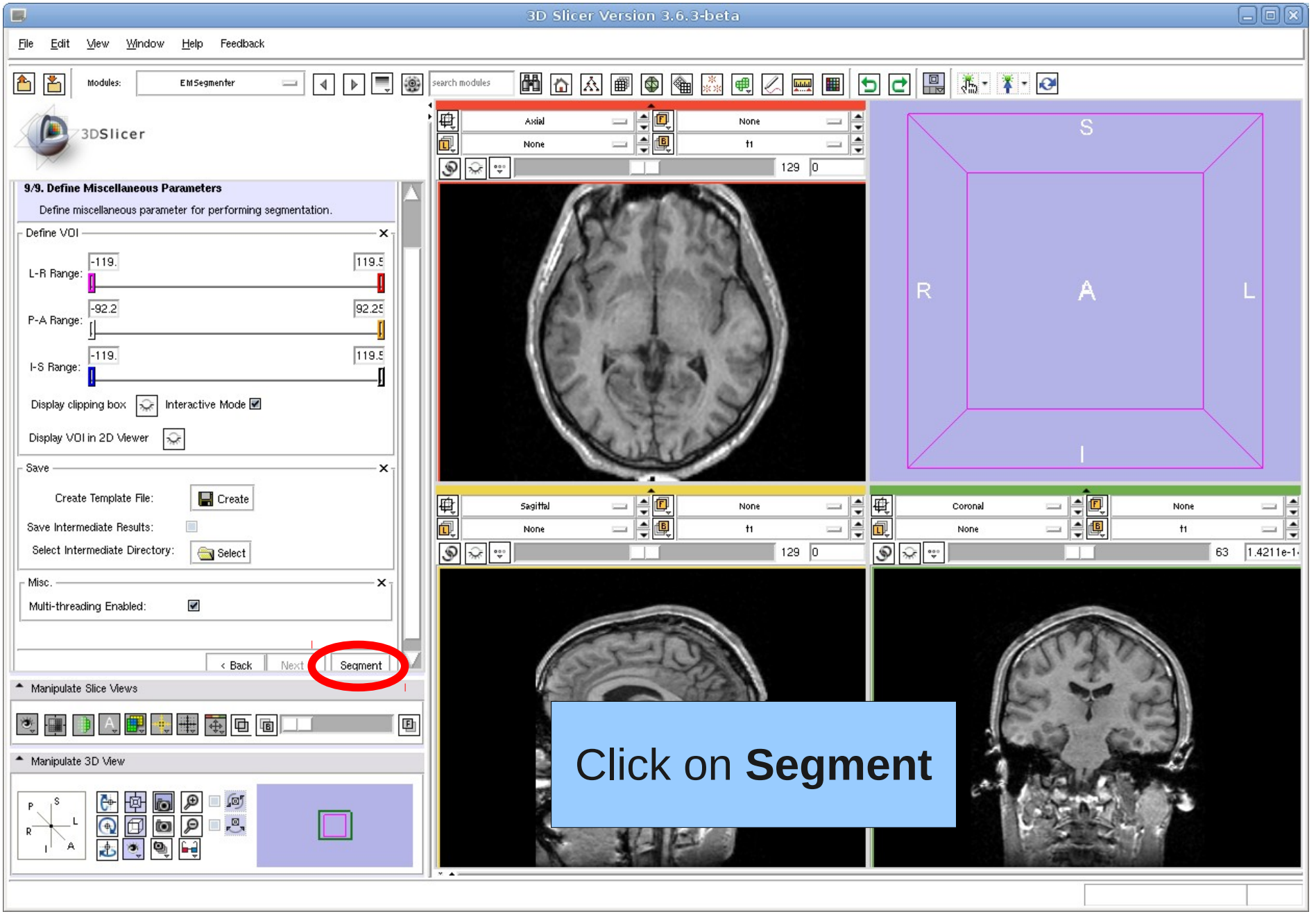
Run Segmentation

Step 9:
Specify the Region of Interest and complete the Segmentation

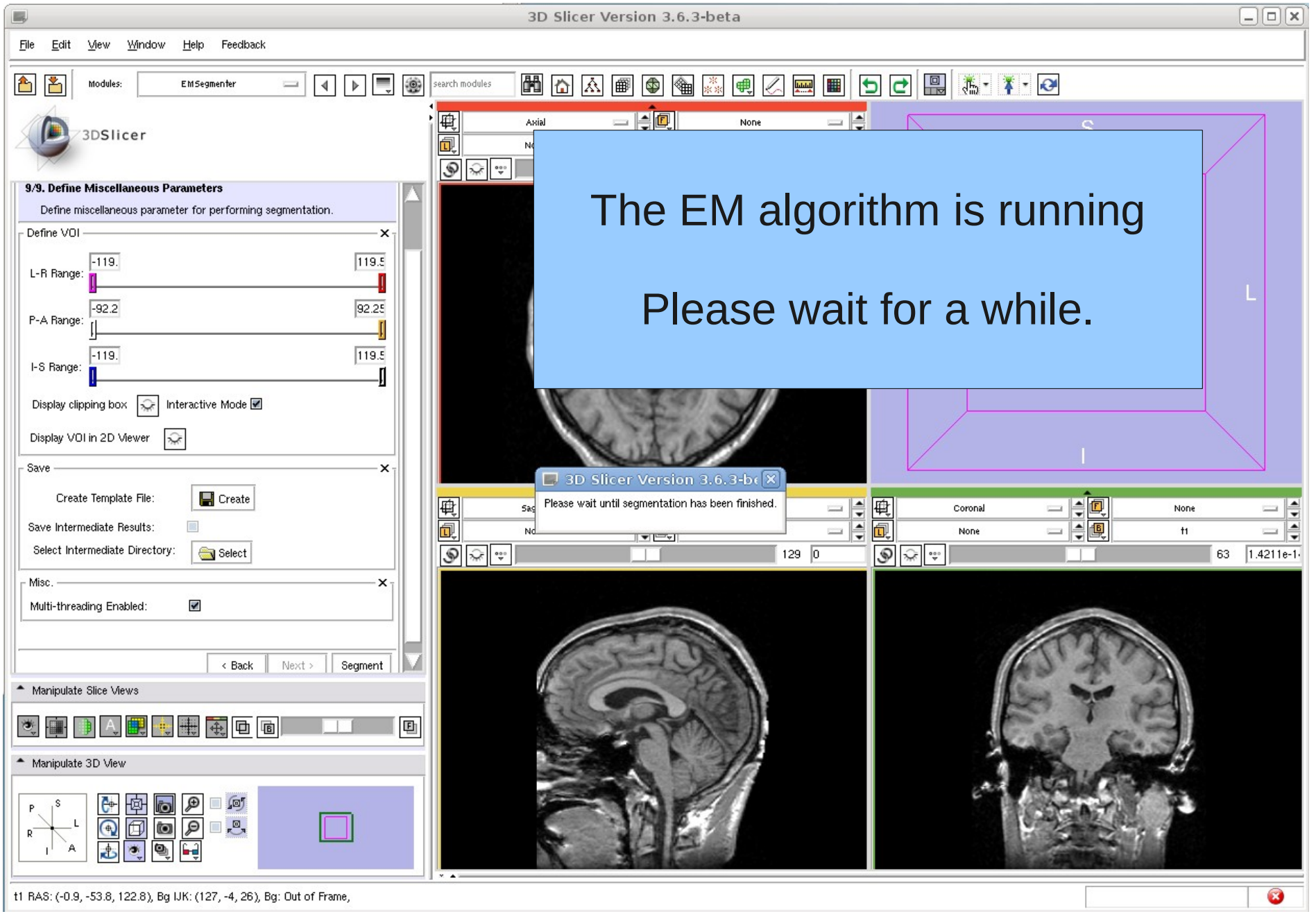
This is the last step of the EMSegmenter wizard.

The Volume Of Interested (VOI) can be specified, and one can start the EM algorithm, which will segment the input channels by taking all the information entered in the previous steps into account .

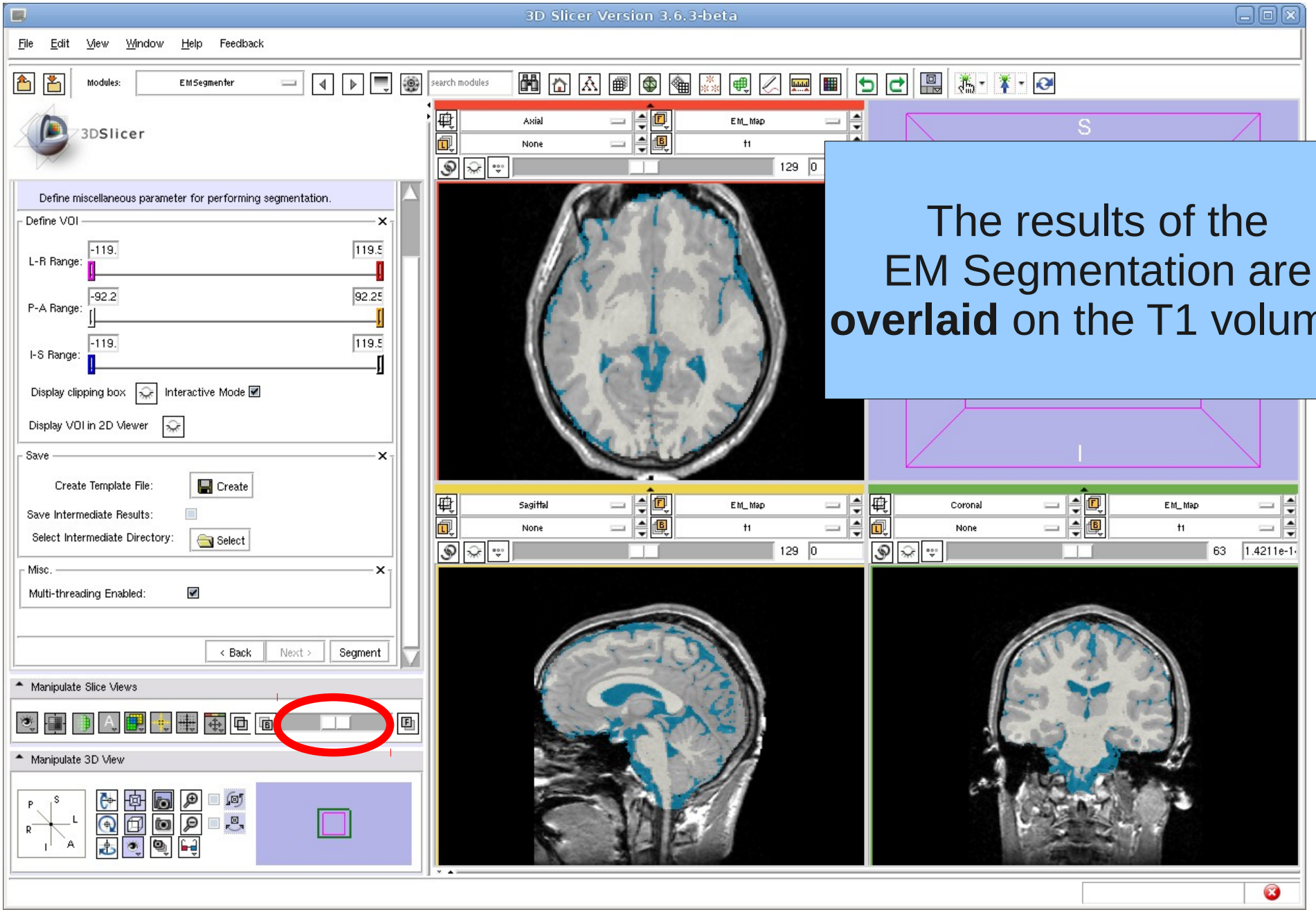
Run Segmentation



Run Segmentation



Results: Run Segmentation

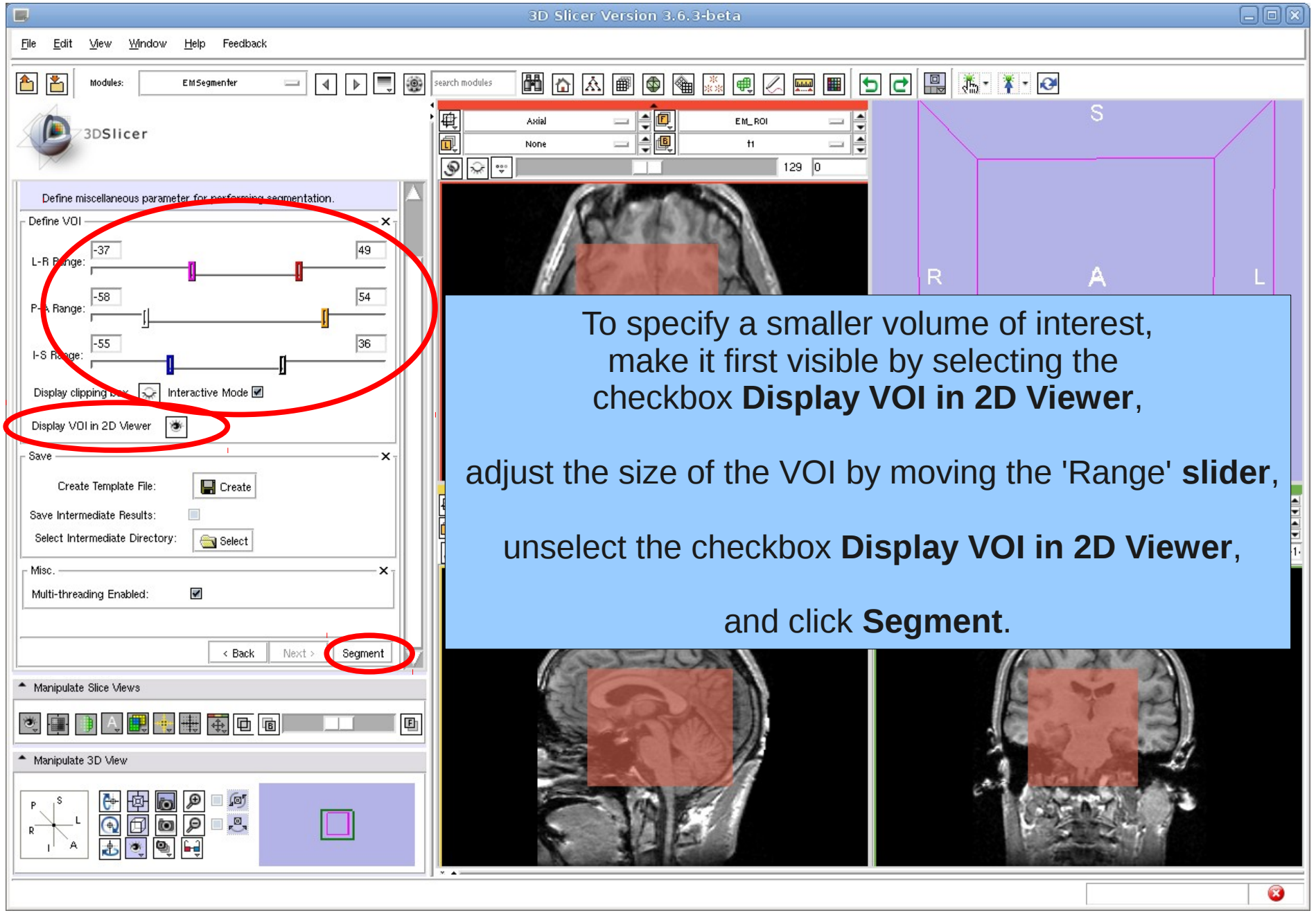


The results of the EM Segmentation are **overlaid** on the T1 volume.

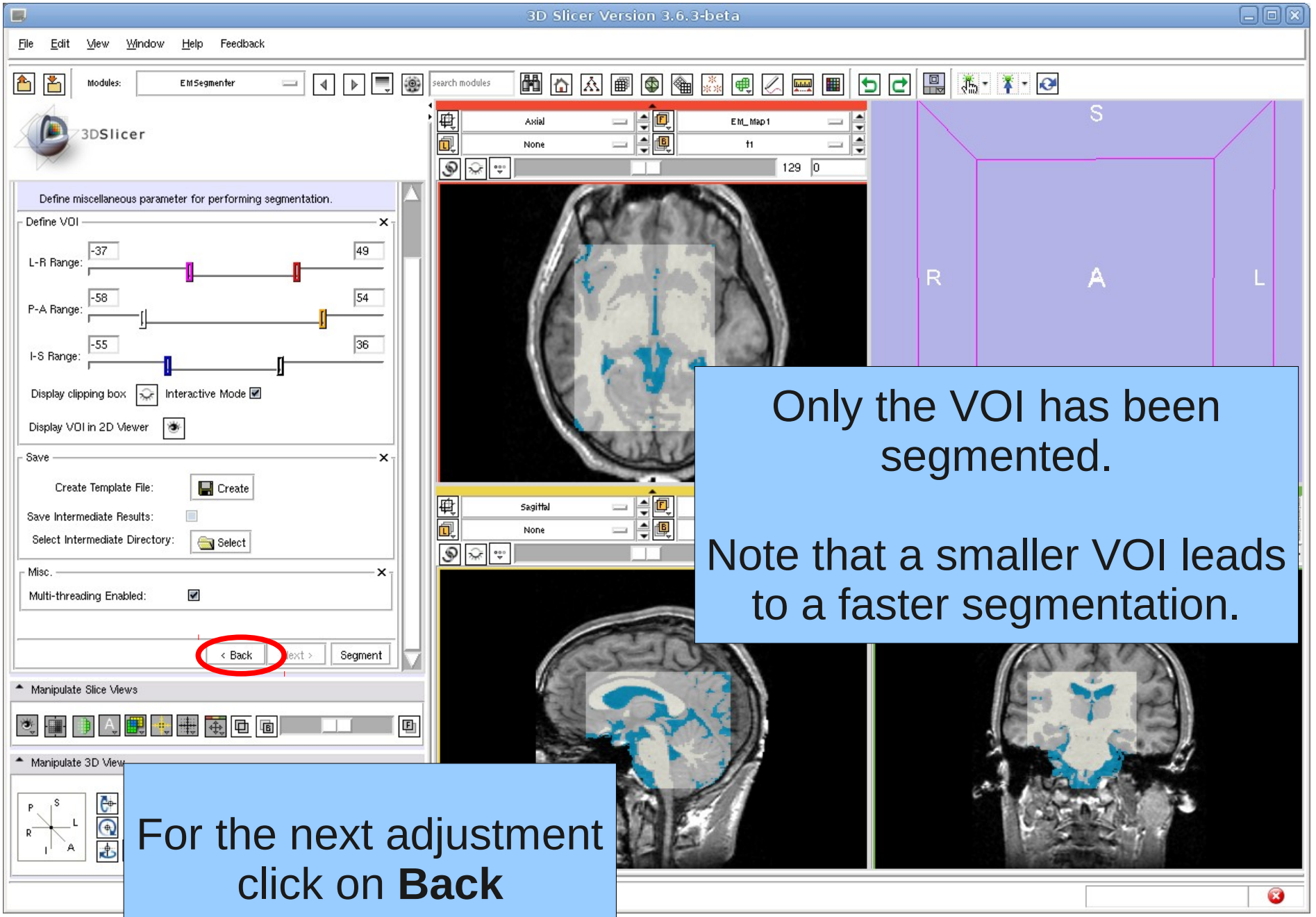
Consecutive adjustment

As previously mentioned, one might want to adjust the parameters of Step 8 in order to improve the segmentation. We now adjust three parameters and show the impact on the segmentation The following slides illustrate
-how to specify a volume of interest and
-how to adjust segmentation parameters
the refine the segmentation result.

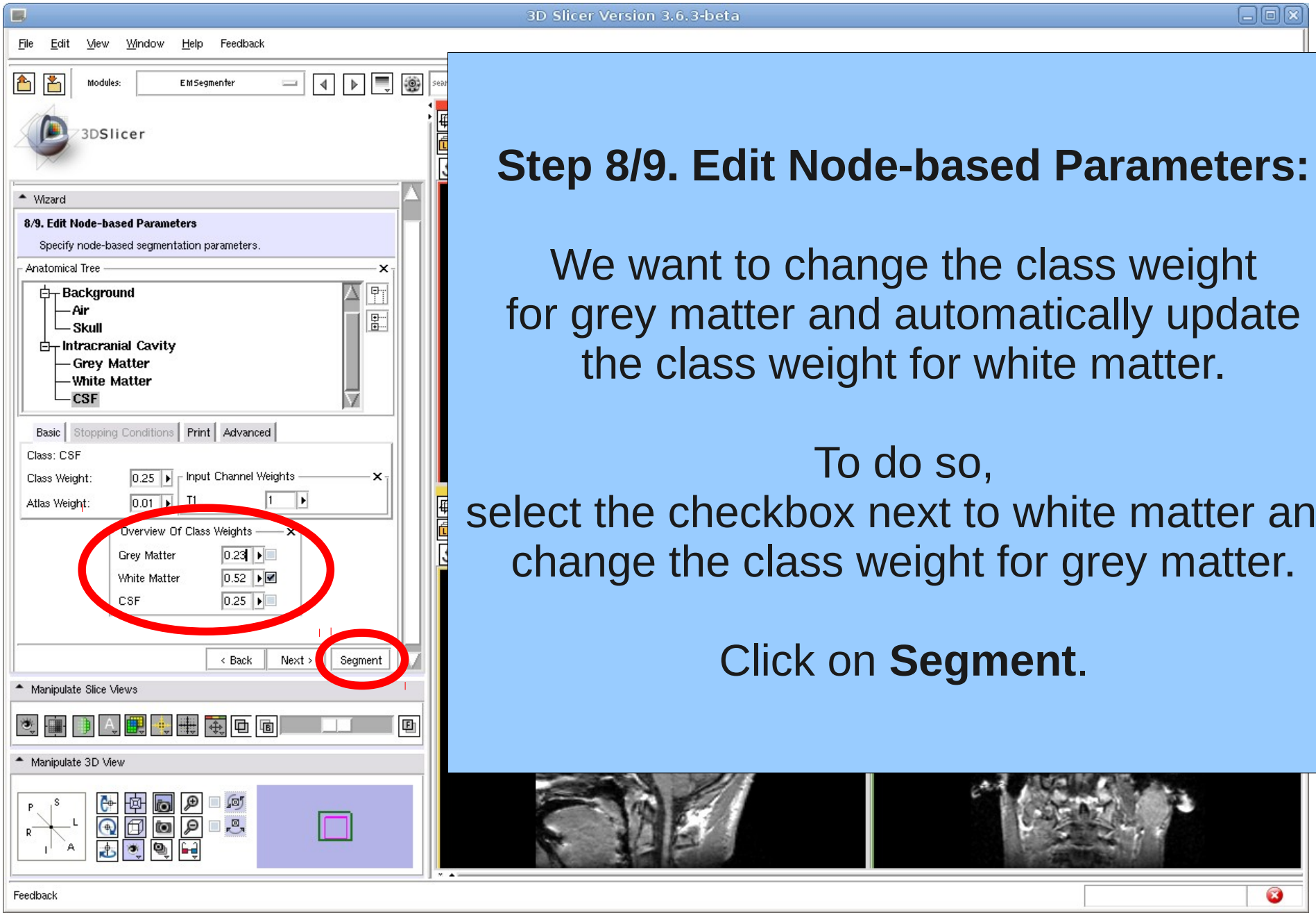
Volume Of Interest (VOI)



Result: Volume Of Interest (VOI)



Adjusting Parameters



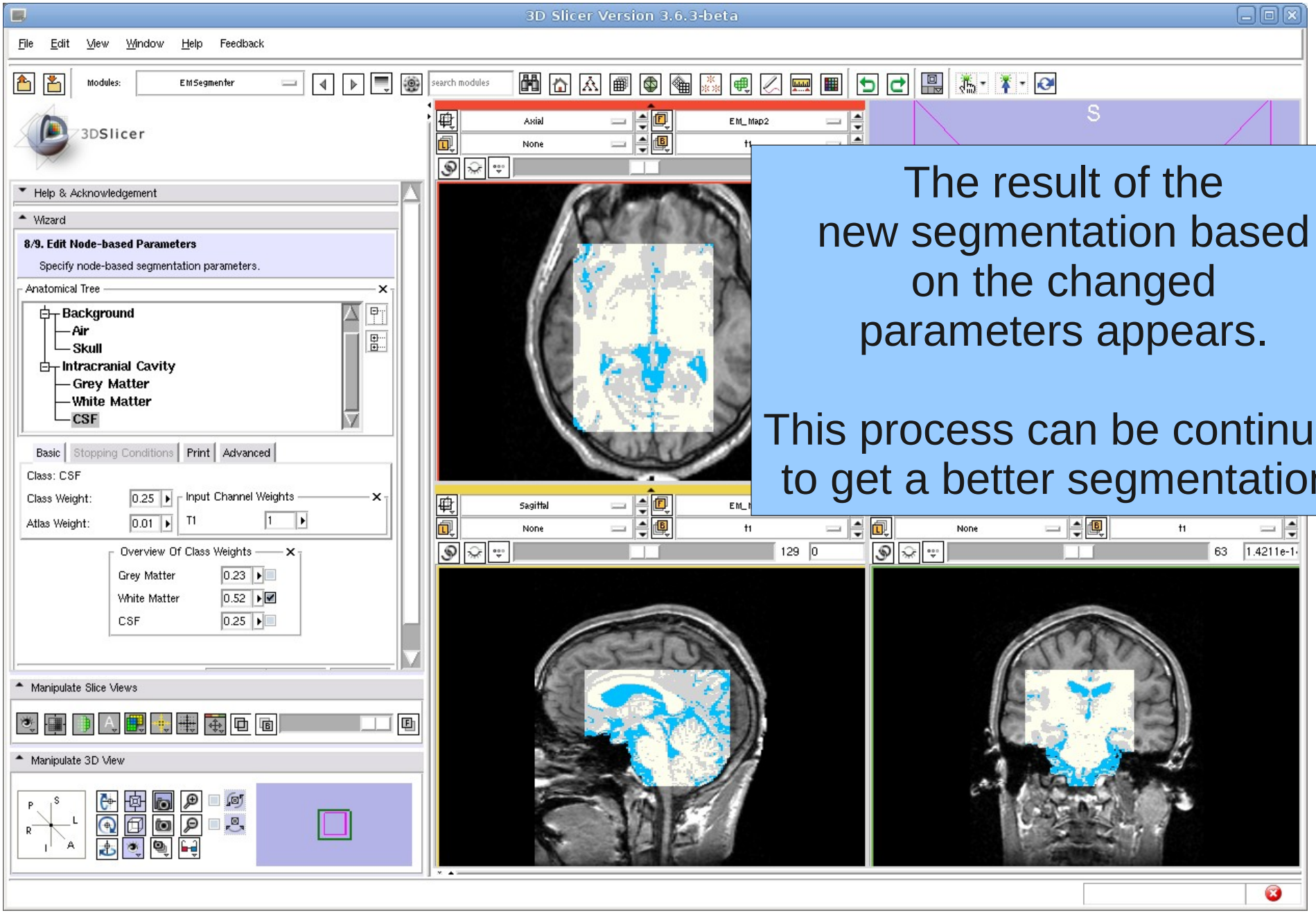
Step 8/9. Edit Node-based Parameters:

We want to change the class weight for grey matter and automatically update the class weight for white matter.

To do so, select the checkbox next to white matter and change the class weight for grey matter.

Click on **Segment**.

Result: Adjusting Parameters

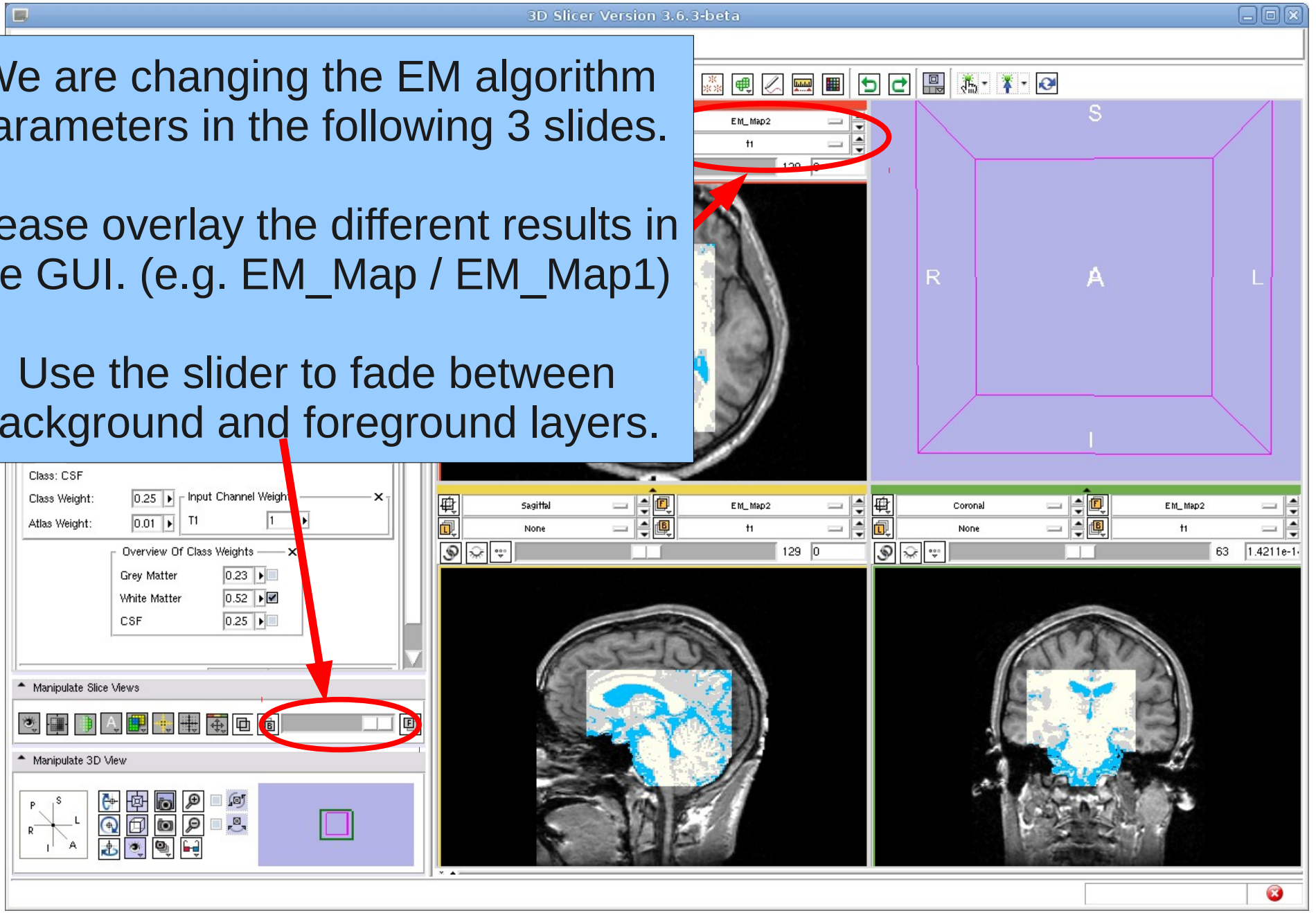


Compare Results

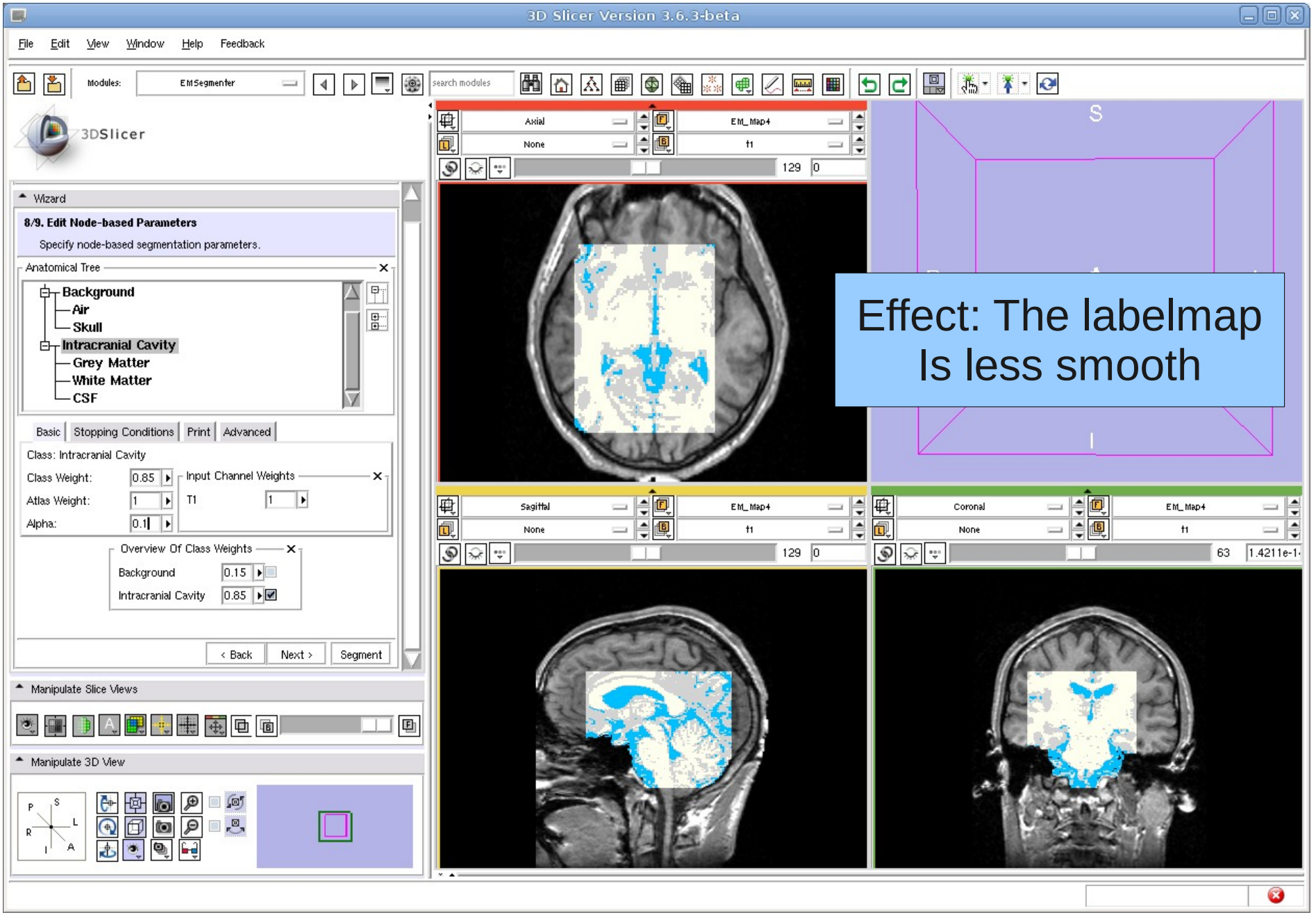
We are changing the EM algorithm parameters in the following 3 slides.

Please overlay the different results in the GUI. (e.g. EM_Map / EM_Map1)

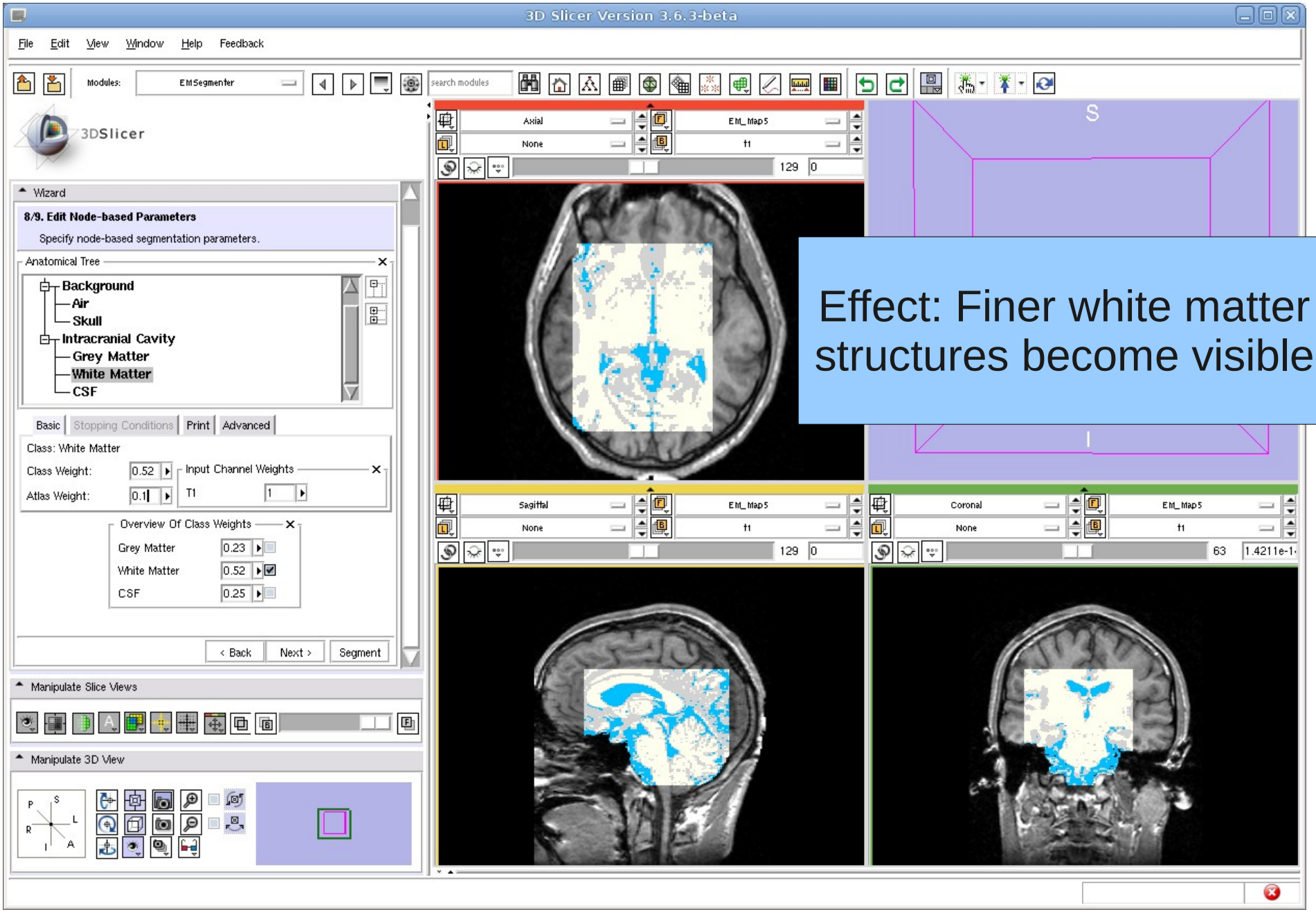
Use the slider to fade between background and foreground layers.



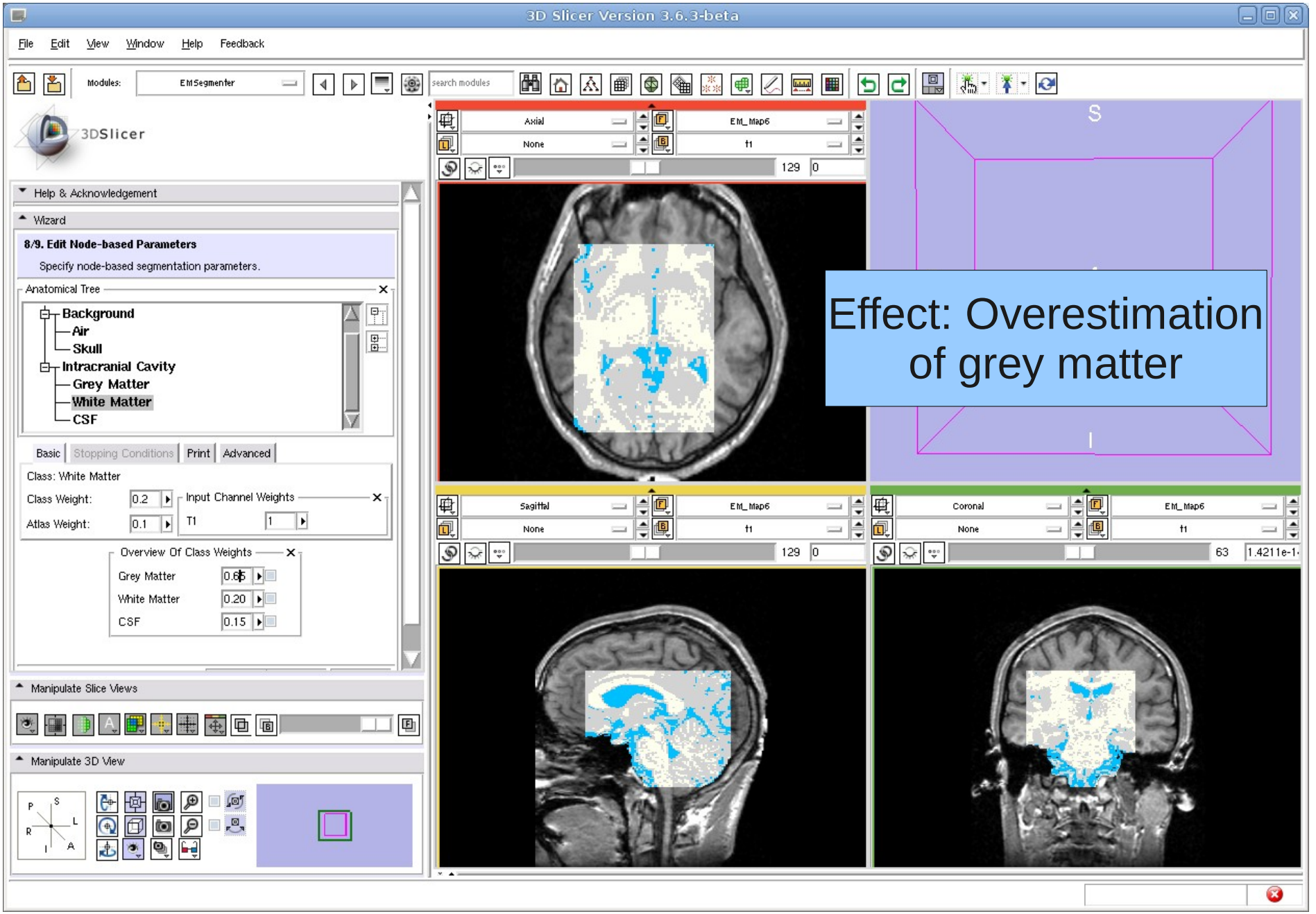
Low ICC alpha value



Low white matter atlas weight



High grey matter class weight



Further Info & Acknowledgments

EMSegmenter Wiki Page:

http://www.slicer.org/slicerWiki/index.php/EMSegmenter-Overview

The EMSegmenter technology behind was reported in:

K.M. Pohl et. A hierarchical algorithm for MR brain image parcellation. IEEE Transactions on Medical Imaging, 26(9), pp 1201-1212, 2007.

We thank the following institutions for their support: