



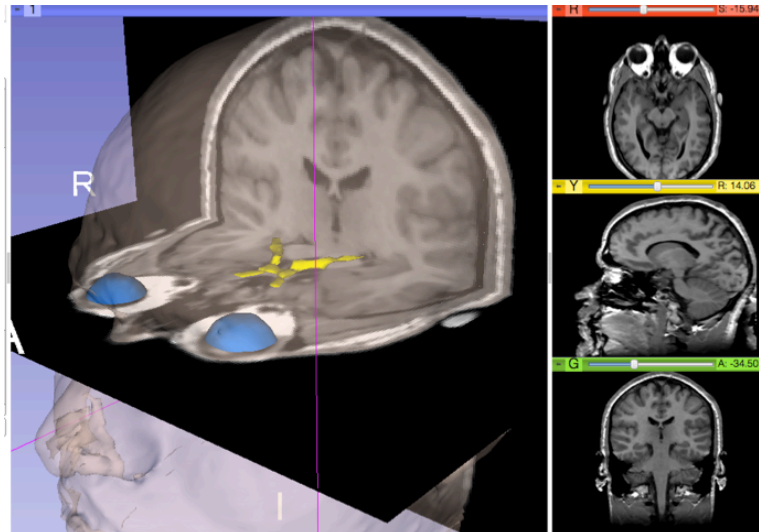
3DSlicer  
Version 4.0

# The 3D Slicer open-source platform for image analysis and 3D visualization

Junichi Tokuda, Ph.D., Nicole Aucoin, M.S. (Presenters)

Sonia Pujol, Ph.D.

Surgical Planning Laboratory,  
Brigham and Women's Hospital, Harvard Medical School



# Part I – From algorithms to tools: the 3D Slicer software for translational research

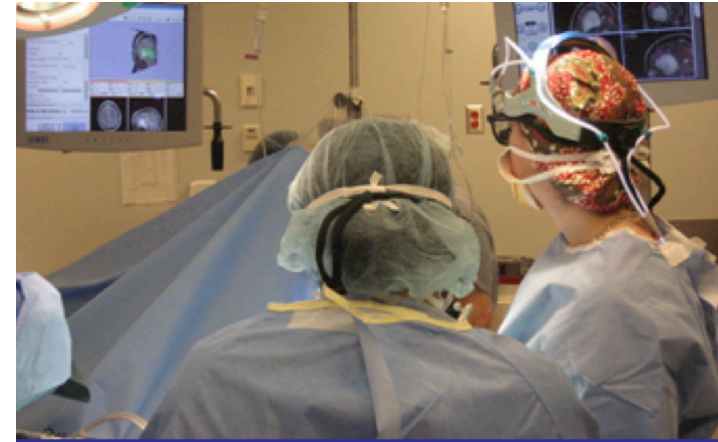


# Translational research

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An **open-source environment**  
for software developers



An **end-user application**  
for clinical investigators  
and scientists

3D Slicer: an open-source platform for  
***translating*** innovative algorithms into  
clinical research applications



# Slicer 16<sup>th</sup> year Anniversary

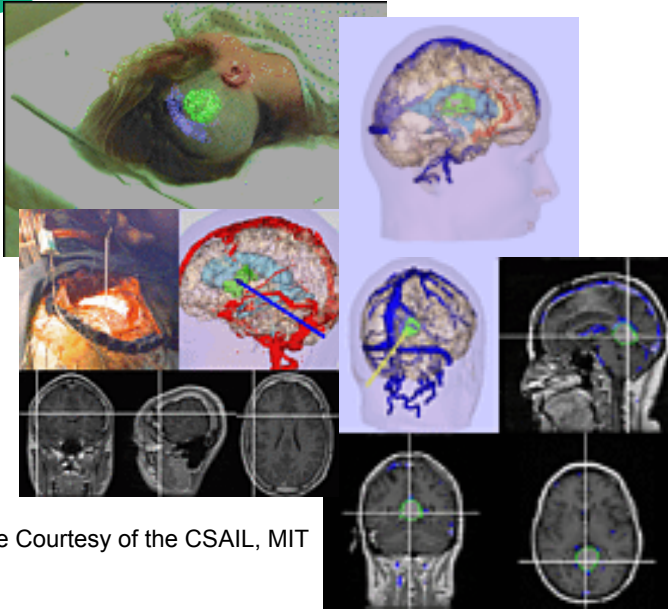


Image Courtesy of the CSAIL, MIT

- 1997: Slicer started as a Master's thesis between the Surgical Planning Lab (Harvard) and the MIT Computer Science and Artificial Intelligence Laboratory (CSAIL)

- 2013: International open-source platform developed through a multi-institution effort

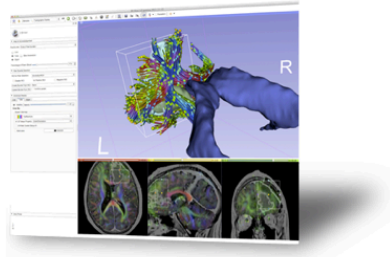
P.I. Prof. Ron Kikinis, BWH, Harvard

Powerful processing.	Streamlined interface.	Extensible platform.

**3D Slicer** version 4 [www.slicer.org](http://www.slicer.org)



# 3D Slicer in practice



## Get Slicer 4.

Slicer 4 is the latest stable version of 3D Slicer, a free, comprehensive software platform for medical image analysis and visualization developed with NIH support.

3D Slicer is distributed under a permissive BSD-style open source license. It has a thriving user and developer community.

### Pre-compiled binaries

	Windows	Mac OS X	Linux
stable release	64 bit 4.1.0 64 bit installer 2012-04-11 r19886 (159.6MB)	4.1.0 64 bit installer 2012-04-11 r19886 (236.9MB)	4.1.0 64 bit archive 2012-04-11 r19886 (251.5MB)
	32 bit 4.1.0 32 bit installer 2012-04-11 r19886 (153.3MB)		
nightly build	64 bit nightly 64 bit installer 2012-04-29 r19953 (160.4MB)	nightly 64 bit installer 2012-04-27 r19951 (237.4MB)	nightly 64 bit archive 2012-04-29 r19953 (252.0MB)
	32 bit nightly 32 bit installer 2012-04-29 r19953 (154.0MB)		

### System requirements

Slicer requires 1GB of RAM absolute minimum, with more highly recommended. Common data sets may require 4GB or more RAM for processing. A fast graphics card or GPU that supports OpenGL is also recommended.

Slicer is built and tested on many hardware and software platforms. 3D Slicer runs on Microsoft Windows XP, Vista, and Windows 7; Mac OS X versions 10.5 (Leopard), 10.6 (Snow Leopard), and 10.7 (Lion); and a variety of Linux distributions.

- Slicer is free
- Slicer is open-source
- Slicer works on Windows, Linux, and Mac
- Slicer is distributed under a BSD-style license agreement with no restriction on use



# Slicer Is Open

- Open Science  
= Open Source  
+ Open Data  
+ Open Community

Madrid 2012



Iowa City, USA 2012

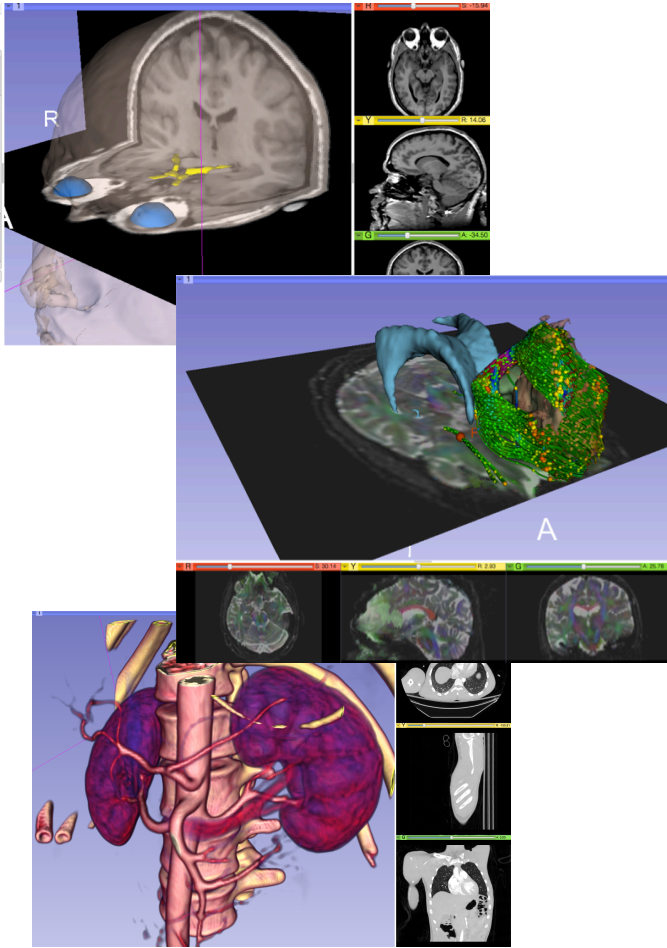


Courtesy R. Kikinis



# Slicer Open Community

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- 80 authorized developers contributing to the source code of Slicer
- Over 700 subscribers on Slicer user and Slicer developer mailing list



# Nov.2011-March.2013 Downloads



## Slicer 4 download statistics

Total matching downloads:  
**62948**

Date range:

forever

Release type:

any

Browser type:

desktop

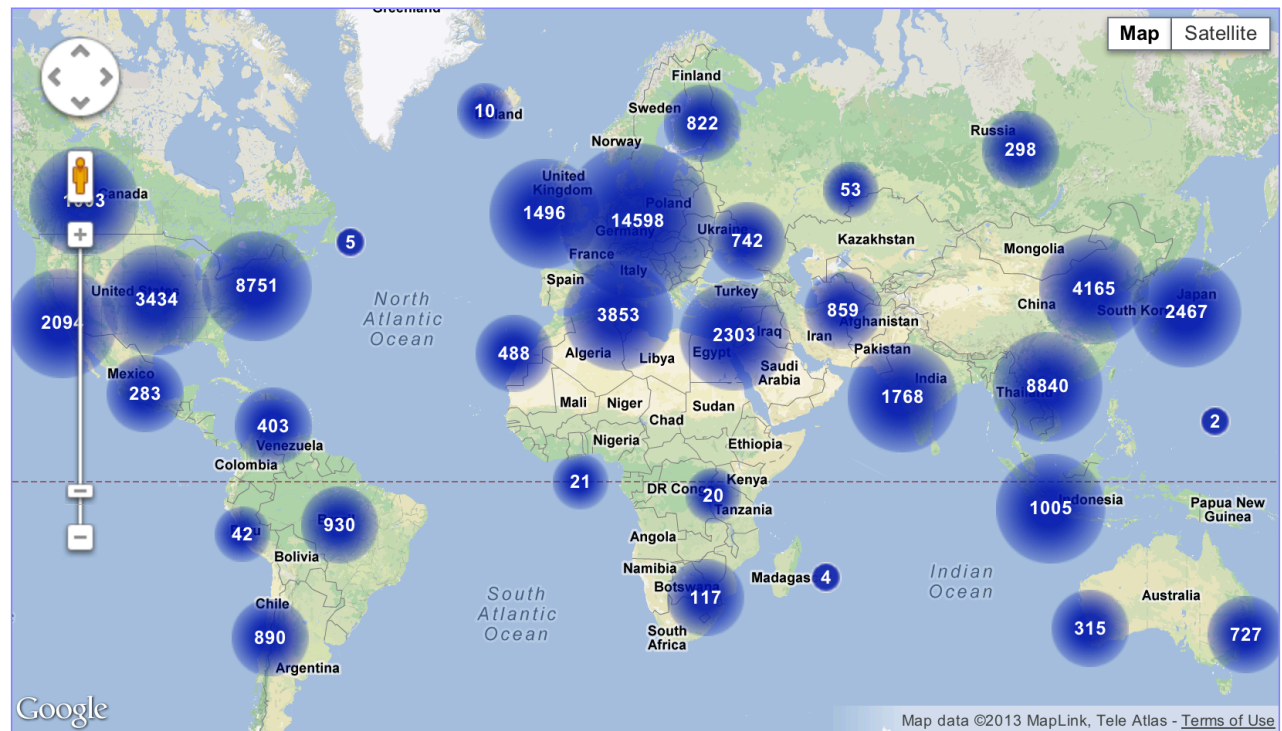
Update

Download location

By Country

By Filename

By Month



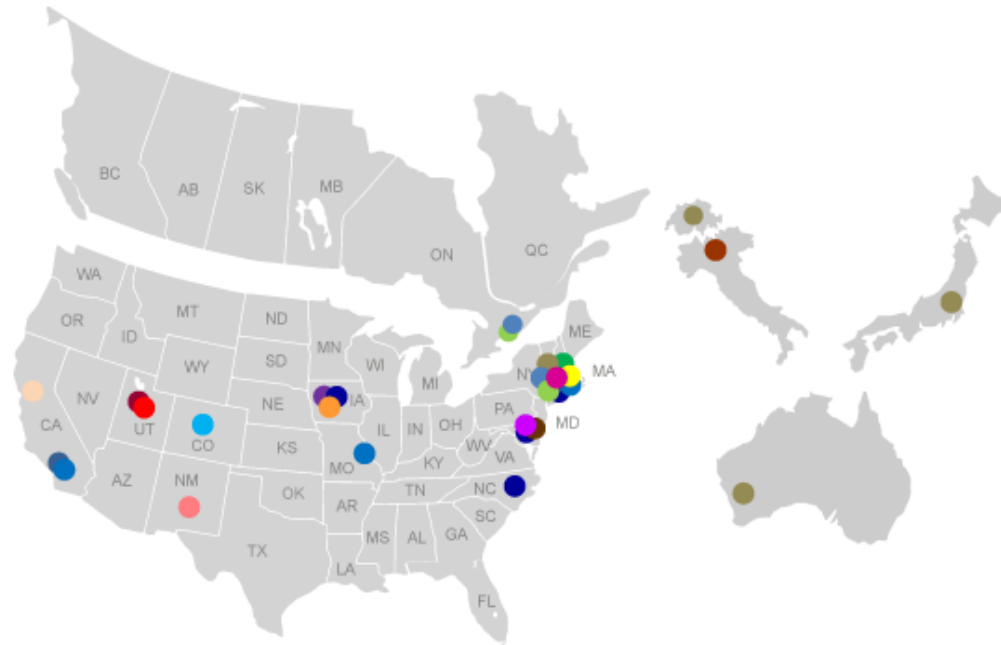




# A Multi-institution Effort



- Autism
- Brain Cancer
- Depression
- Head and Neck Cancer
- Huntington's Disease
- Lupus
- Schizophrenia
- Traumatic Brain Injury
- VCFS
- Neuroimage Analysis
- Lung Disease
- Atrial Fibrillation
- Cardiovascular Disease
- Liver Cancer
- Colon Cancer
- Prostate Cancer
- Orthopedic Injury
- Neuromuscular Dynamics
- Image Informatics



## Active

- R01MH084795
- R01EB005973
- UL1RR025758
- R01MH084795
- U41RR019703
- U54EB005149-05S2
- U54LM006748
- U41RR019703
- NSF CCF-0916526
- U54GM072970
- U24RR025736
- CO-ME, Switzerland
- R01EB008171
- P41RR013218
- U24RR021992
- U01HL089897
- R01EB006733
- U24RR021382
- R01CA124377
- R01NS050568
- U24RR026057
- R01CA131718
- R21EB009900
- AIST, Japan
- R01CA11128
- U54EB005149-05S3
- UWA, Australia
- OCAIRO, Canada

## Completed

- U54EB005149-04S1

- Infrastructure grants fund the platform
- Collaborative projects (e.g. Canada, Japan, Australia, Italy) fund the application packages



# End-user Documentation

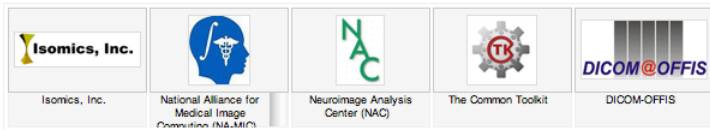
Documentation/4.1/Modules/DICOM

Home < Documentation < 4.1 < Modules < DICOM

## Introduction and Acknowledgements

This work is part of the National Alliance for Medical Image Computing (NA-MIC), funded by the National Institutes of Health through the NIH Roadmap for Medical Research, Grant U54 EB005149. Information on NA-MIC can be obtained from the [NA-MIC website](#).

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Contributor3: Julien Finet, Kitware  
Contributor4: Stephen Aylward, Kitware  
Contributor5: Nicholas Herlaambang, AZE  
Contact: Steve Pieper, [spieper@bwh.harvard.edu](mailto:spieper@bwh.harvard.edu)

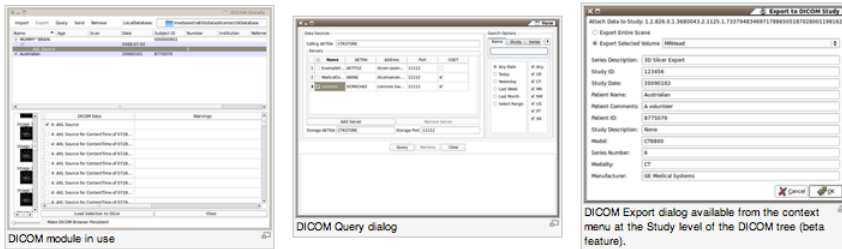


## Module Description

Provides DICOM local database and networking support.

- A new DICOM infrastructure was put in place beginning with Slicer 4.0.
- DICOM data is stored in a local data base, which is based on SQLite.
- DICOM data can be imported from disk into this data base
- DICOM data can be retrieved from a PACS system after proper configuration of Slicer.
- DICOM data can be loaded into Slicer from the local database. A graphical user interface with display of thumbnails is available for data selection.
- Plans for the near future, include support for storing data from slicer into the data base and uploading data from the data base into a PACS system.

## Use Cases



## Tutorials

Links to tutorials that use this module (not yet available)

## Panels

### Parameters:

#### Servers

- Start/Stop Listener:** Control external process that listens for network connections to populate the local database. The listener port is controlled by the setting in the `listener` file.

- Wiki-based web pages accompany every module of Slicer and provide reference documentation of functionality and usage examples.



# Developer Documentation



3DSlicer

search

Google™ Custom Search

GO

navigation

- Slicer Website
- Wiki Home
- Slicer Downloads
- Training
- Documentation
- Users
- Developers
- Help
- FAQ
- Acknowledgements
- Links
- Recent Changes

toolbox

- What links here
- Related changes
- Special pages
- Printable version
- Permanent link

Documentation/4.1/Developers/Tutorials/ModuleWriting

Home < Documentation < 4.1 < Developers < Tutorials < ModuleWriting

CONTENTS [hide]

- 1 Consider also reading
- 2 Initialization
  - 2.1 1) Create the module directory

**Slicer 4.1**  
Slicer is a multi-platform, free and open source software package for visualization and medical image computing

Main Page | Related Pages | Modules | Namespaces | **Classes** | Files | Directories | Examples

Class List | **Class Index** | Class Hierarchy | Class Members

**Class Index**

A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | \_

**A**

- qSlicerAboutDialog
- qSlicerAbstractCoreModule
- qSlicerAbstractModule
- qSlicerAbstractModuleFactoryManager
- qSlicerAbstractModulePanel
- qSlicerAbstractModuleRepresentation
- qSlicerAbstractModuleWidget
- qSlicerActionsDialog
- AffineImageToImageRegistrationMethod (itk)
- AnisotropicSimilarity3DTransform (itk)
- AnisotropicSimilarityLandmarkBasedTransformInitializer (itk)
- vtkAnnotationBidimensionalWidget
- qMRMLAnnotationDisplayNodePropertyWidget
- qMRMLAnnotationDisplayNodePropertyWidget
- vtkAnnotationGlyphSource2D
- qSlicerAnnotationModulePropertyDialog
- qSlicerAnnotationModuleReportDialog
- qSlicerAnnotationModuleSnapShotDialog
- qSlicerAnnotationModuleWidget
- qSlicerAnnotationModuleWidgetsAbstractPlugin
- qSlicerAnnotationModuleWidgetsPlugin
- vtkAnnotationROIRepresentation
- vtkAnnotationROIRepresentation2D
- vtkAnnotationROIWidget
- qMRMLAnnotationROIWidget
- vtkAnnotationROIWidget2D
- qMRMLAnnotationROIWidgetPlugin
- vtkAnnotationRuleRepresentation
- vtkAnnotationRuleRepresentation3D
- vtkAnnotationRuleWidget
- qSlicerAnnotationsID
- qSlicerAnnotationsDOptionsWidget
- qSlicerAnnotationsModule
- qMRMLAnnotationTreeView
- qSlicerApplication
- vtkAtlasCreatorLogic

**B**

- qSlicerBaseQTBasePythonQDecorators
- qSlicerBaseQTGUIPythonQDecorators
- BoundMethodWeakref (saferef)
- BoundNonDescriptorMethodWeakref (saferef)
- BsplineControlPointImageFilter (itk)
- BsplineImageToImageRegistrationMethod (itk)
- vtkBSplineInterpolateImageFunction
- ButtonGroupWidgetWrapper
- TimeSeriesDatabase-CacheBlock (itk)

**C**

- qSlicerConEnginePlugin
- IdentifyIslandsEffect (EditorLib:IdentifyIslandsEffect)
- IdentifyIslandsEffectLogic (EditorLib:IdentifyIslandsEffect)
- IdentifyIslandsEffectOptions (EditorLib:IdentifyIslandsEffect)
- IdentifyIslandsEffectTool (EditorLib:IdentifyIslandsEffect)
- IdentifyIslandsOptions (EditorLib:EditOptions)
- vtkCTDataManager
- vtkCTDataStream
- vtkCTGSTStream
- vtkCTMatrixState
- vtkCTOpenTrackerStream
- vtkCTPAZimRegistration
- vtkImageAccumulateDiscrete
- vtkImageBimodalAnalysis
- vtkImageConnectivity
- vtkImageErode
- vtkImageFillROI
- vtkImageCellTensorComponents
- vtkImageLabelChange
- vtkImageLabelCombine
- vtkImageLabelOutline
- vtkImageLinearReslice
- vtkImageNeighborhoodFilter
- vtkImageRectangularSource
- ImageRegionMomentCalculator (itk)
- ImageRegistrationViewer
- vtkImageResliceMask
- vtkImageSetTensorComponents
- vtkImageSlicePaint
- vtkImageStack
- ImageToImageRegistrationHelper (itk)
- ImageToImageRegistrationMethod (itk)
- ImageToImageRegistrationMethodTestingHelper (itk)
- ImageToVTImageFilter (itk)
- ImplicitRectangleOptions (EditorLib:EditOptions)
- InitialImageToImageRegistrationMethod (itk)
- qSlicerIO
- qSlicerIOManager
- qSlicerIOOptions
- qSlicerIOOptionsWidget
- ipDataUnion
- IslandEffect (EditorLib:IslandEffect)
- IslandEffectLogic (EditorLib:IslandEffect)
- IslandEffectOptions (EditorLib:IslandEffect)
- IslandEffectTool (EditorLib:IslandEffect)
- qMRMLItemDelegate
- vtkTKArcheTypeImageSeriesReader
- vtkTKArcheTypeImageSeriesScalarReader

**D**

- vtkMRMLTransformNode
- vtkMRMLTransformStorageNode
- vtkMRMLUnstructuredGridDisplayNode
- vtkMRMLUnstructuredGridNode
- vtkMRMLUnstructuredGridStorageNode
- vtkMRMLVectorVolumeDisplayNode
- vtkMRMLVectorVolumeNode
- vtkMRMLViewDisplayableManager
- vtkMRMLViewNode
- vtkMRMLVolumeArcheTypeStorageNode
- vtkMRMLVolumeDisplayNode
- vtkMRMLVolumeGlyphSliceDisplayableManager
- vtkMRMLVolumeHeaderlessStorageNode
- vtkMRMLVolumeNode
- vtkMRMLVolumePropertyNode
- vtkMRMLVolumePropertyStorageNode
- vtkMRMLVolumeRenderingDisplayableManager
- vtkMRMLVolumeRenderingDisplayNode
- vtkMRMLVolumeRenderingScenarioNode
- vtkMRMLXYPlotManagerNode
- qSlicerMultiVolumeRenderingModule
- qSlicerMultiVolumeRenderingModuleWidget

**E**

- N3BiasFieldScaleCostFunction (itk)
- N3MRIBiasFieldCorrectionImageFilter (itk)
- N3MRIBiasFieldCorrectionImageFilter (itk)
- qMRMLNavigationView
- qMRMLNavigationViewPlugin
- NewOtsuThresholdImageCalculator (itk)
- NewOtsuThresholdImageFilter (itk)
- qMRMLNodeComboBox
- qMRMLNodeComboBoxDelegate
- qMRMLNodeComboBoxMenuDelegate
- qMRMLNodeComboBoxPlugin
- qMRMLNodeFactory
- qMRMLNodeSelectorPlugin
- vtkNRDRReader
- vtkNRDRWriter

**F**

- qSlicerObject
- vtkObservation
- vtkObserverManager
- OptimizedImageToImageRegistrationMethod (itk)
- OtsuStatistics (itk)
- OtsuThreshold (itk)

**G**

- PaintEffect (EditorLib:PaintEffect)
- PaintEffectLogic (EditorLib:PaintEffect)
- PaintEffectOptions (EditorLib:PaintEffect)

Code examples  
and Doxygen  
source code  
API  
documentation




# Slicer Bug Tracker

My View - Mantis

http://www.na-mic.org/Bug/my\_view\_page.php

My View - Mantis



Logged in as: *spujol* (Sonia Pujol - reporter) 2012-04-28 05:35 EDT Project: Slicer4

[Main](#) | [My View](#) | [View Issues](#) | [Report Issue](#) | [Change Log](#) | [Roadmap](#) | [Docs](#) | [My Account](#) | [Logout](#)

Issue #  Jump

**Unassigned [^] (1 - 10 / 29)**

- 0001951 Resample Scalar/Vector/DWI module does not accept DWI input  
Command Line Modules (Modules/CLI) - 2012-04-26 15:09
- 0001938 Volume rendering volume received from OpenIGTLink  
Base Code - 2012-04-24 16:53
- 0001930 Scrolling volume slices past the last slice  
Usability - 2012-04-23 19:23
- 0001929 Texts in 3D are hard to see  
Usability - 2012-04-23 15:36
- 0001918 Color scale  
Usability - 2012-04-18 11:58
- 0001915 Effect of matrix bottom row in Transforms module  
Base Code - 2012-04-18 10:12
- 0001910 Problem with fiducial registration  
Command Line Modules (Modules/CLI) - 2012-04-17 03:11
- 0001899 Saving and reopening .nrrd problem  
Usability - 2012-04-12 12:43
- 0001887 scenenview roundtrip problem with LUT and with VR  
MRML - 2012-04-11 22:56
- 0001888 Ensure Capitalization rule is respected all over Slicer  
GUI - 2012-04-10 10:55

**Reported by Me [^] (1 - 10 / 37)**

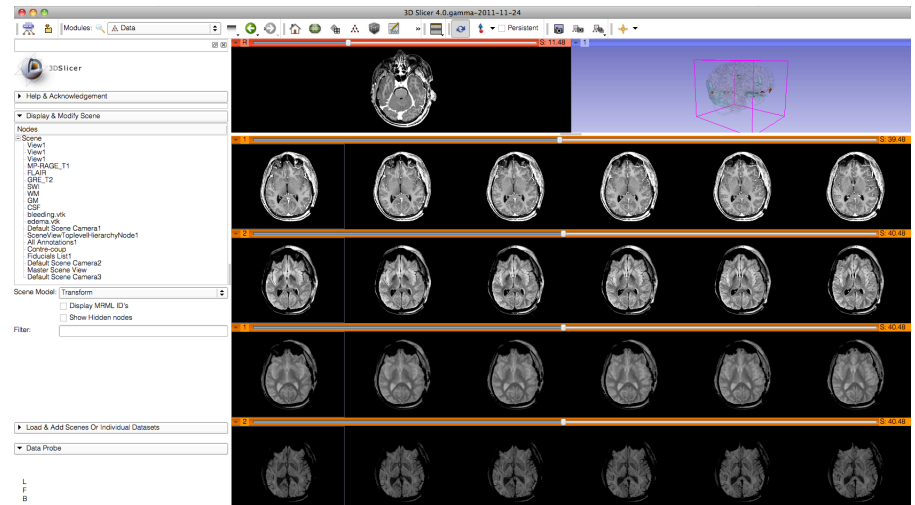
- 0001894 EM Segmenter labelmap opacity  
EMSegmenter - 2012-04-25 20:59
- 0001389 Tract Visibility  
Diffusion - 2012-04-18 10:27
- 0001893 Download of Sample MR head data failed  
Base Code - 2012-04-11 16:33
- 0001845 GUI issue in red slicer viewer mode on Mac  
GUI - 2012-04-11 09:17
- 0001892 Colors Module GUI: LUT label values issue  
Base Code - 2012-04-10 20:29
- 0001873 Saving a scene with a new LUT  
Base Code - 2012-04-10 15:23
- 0001844 Maximum path length - Fiducial seeding  
Diffusion - 2012-04-07 12:23
- 0001867 Restoring a scene view with tract intersection  
Diffusion - 2012-04-07 12:21
- 0001866 Saving Scene: path update issue  
Base Code - 2012-04-06 12:06
- 0001778 Tractography Display module  
Diffusion - 2012-04-06 11:37

**Resolved [^] (1 - 10 / 130)**

- 0001204 Centralize revision/version/name of Slicer  
Packaging - 2012-04-26 18:53
- 0001167 Fix warning related to SlicerFunctionGenerateExtensionDescription  
Building (CMake, Superbuild) - 2012-04-26 17:24
- 0001677 SVN download of loadable extension modules does not work  
Base Code - 2012-04-26 16:51
- 0001747 windows build/run issues as of svn 19350  
Building (CMake, Superbuild) - 2012-04-26 16:06
- 0001863 To avoid \_RegisterApplication / \_CGSDefaultConnection error, create a template of launchd file for dashboard  
Building (CMake, Superbuild) - 2012-04-26 12:38
- 0001940 No version in mac bundle  
Packaging - 2012-04-26 10:31
- 0001645 update of the mouse mode toolbar  
GUI - 2012-04-25 16:22
- 0001593 Untoggle "Place a fiducial" on click  
Annotations - 2012-04-25 16:22
- 0001936 make RAS box axis labels visibility camera dependent  
Usability - 2012-04-24 11:35
- 0001923 {{documentation/{{documentation/version}}/module-category}} doesn't support extra newline spacing in XML  
Documentation - 2012-04-23 13:47

**Recently Modified [^] (1 - 10 / 776)**

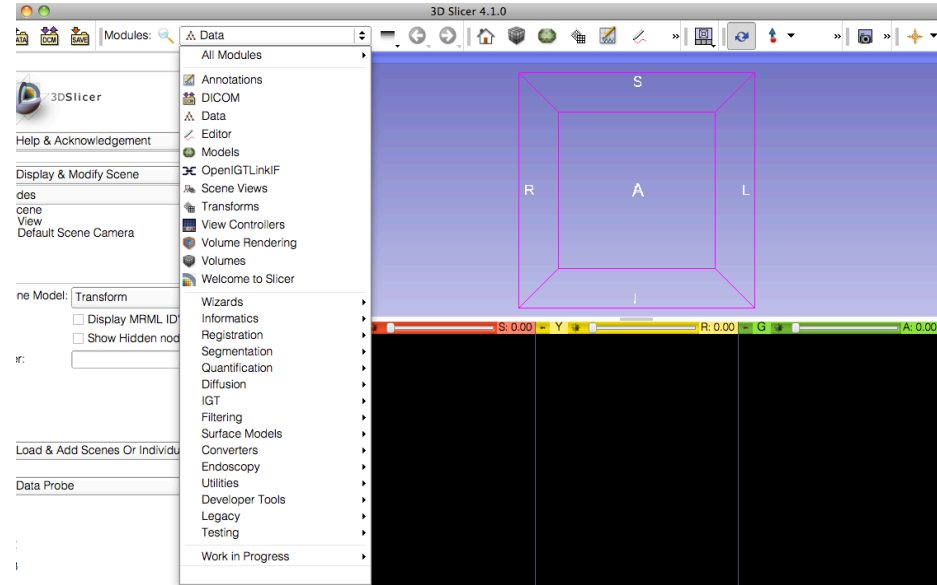
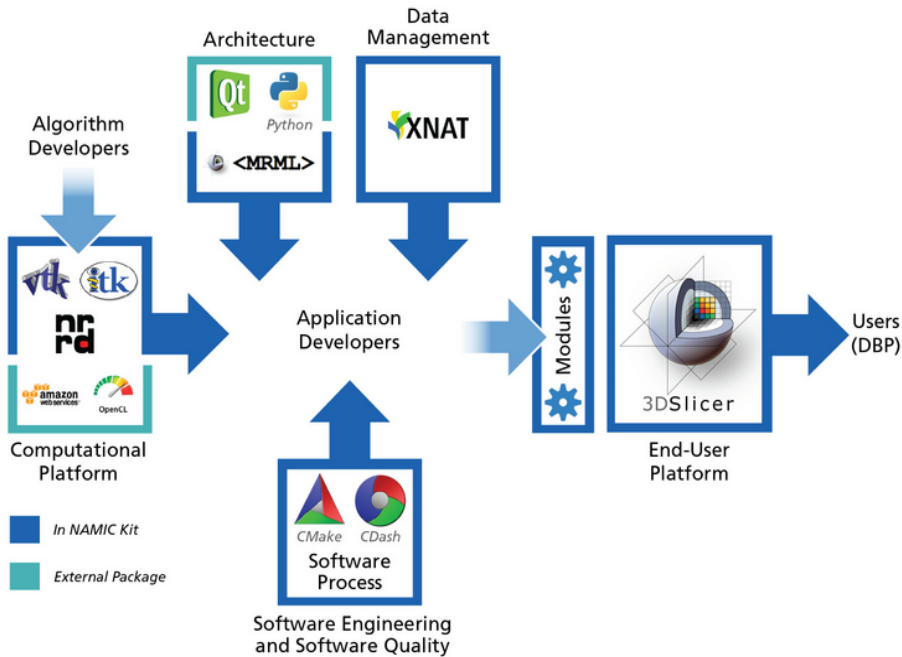
- 0001855 Link errors during CTk build  
Building (CMake, Superbuild) - 2012-04-27 17:03
- 0001868 crash on exit and other issues  
Scripting (Wrapping, Python) - 2012-04-27 17:00
- 0001850 Found PythonLibs: ... get\_filename\_component unknown component optimized  
Building (CMake, Superbuild) - 2012-04-27 16:59
- 0001955 EMSegmenter shows up red in Modules Setting but works fine  
Base Code - 2012-04-27 16:44
- 0001954 drag & drop: option to lock view settings  
GUI - 2012-04-27 10:04
- 0001942 Model to Label Map not working  
Diffusion - 2012-04-27 07:46
- 0001941 Extensions download from SVN repository fails  
Extensions - 2012-04-26 21:52
- 0001952 camera position after loading scene  
GUI - 2012-04-26 20:13
- 0001486 VTK Qt designer plugins are missing  
Packaging - 2012-04-26 19:26
- 0001145 Add Test to make slicer starts  
Base Code - 2012-04-26 19:04



# SLICER FUNCTIONALITIES

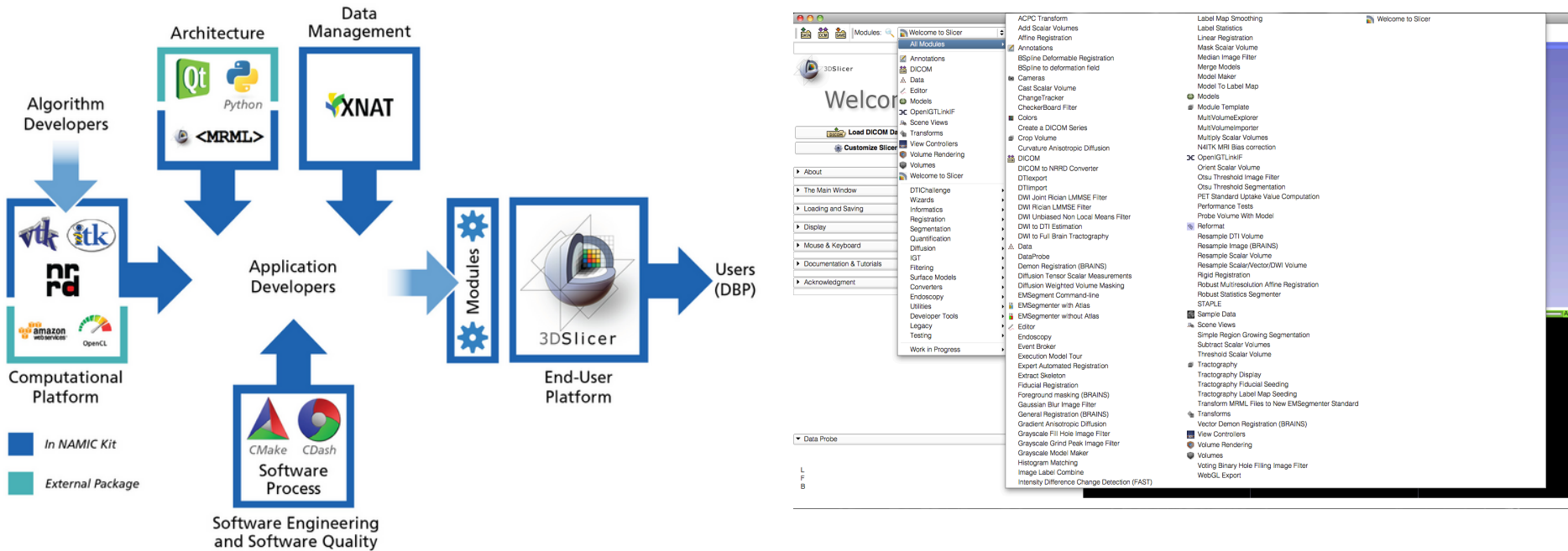


# Core Functionalities





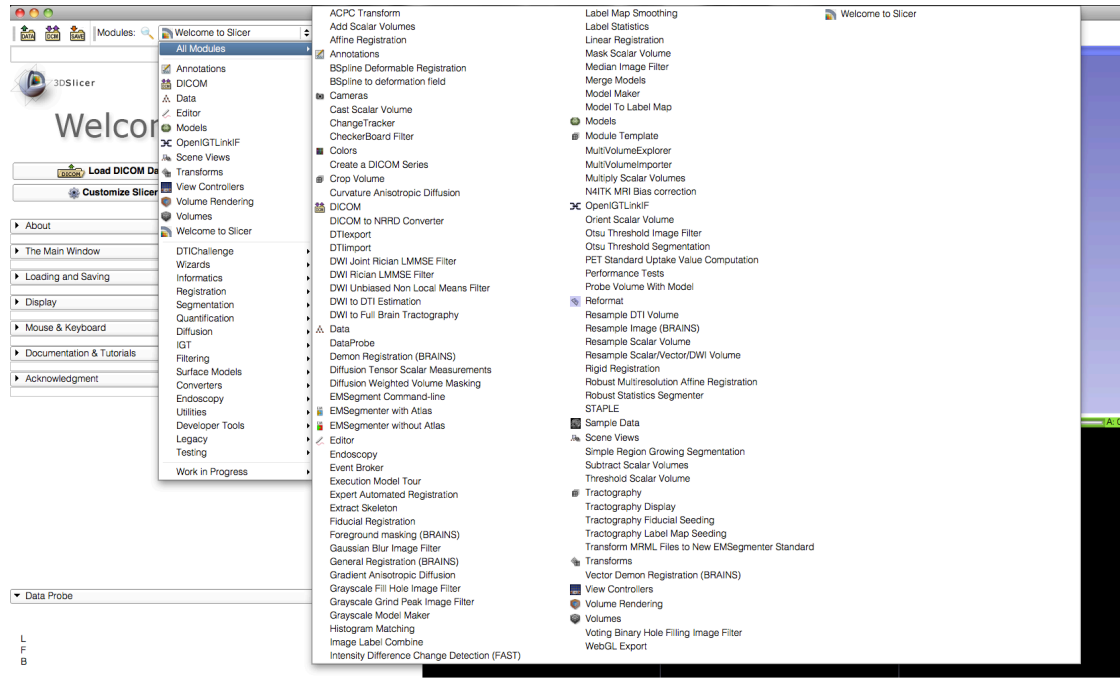
# Core Functionalities



Slicer4 core functionalities include 108 modules, and represent 700,000 lines of code



# Core Functionalities

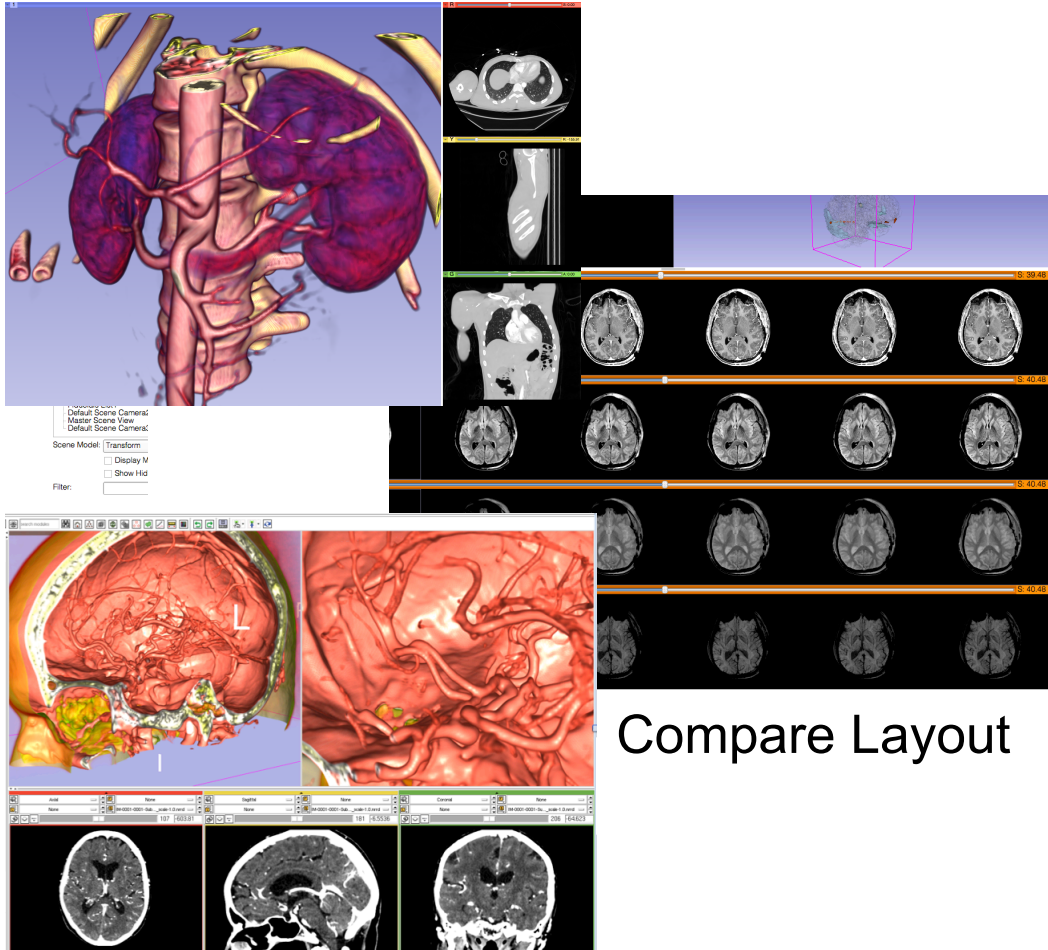


- Visualization
- Segmentation
- Registration
- Reconstruction
- Diffusion
- Image Guided Therapy
- Quantification
- Reporting





# Core Functionalities



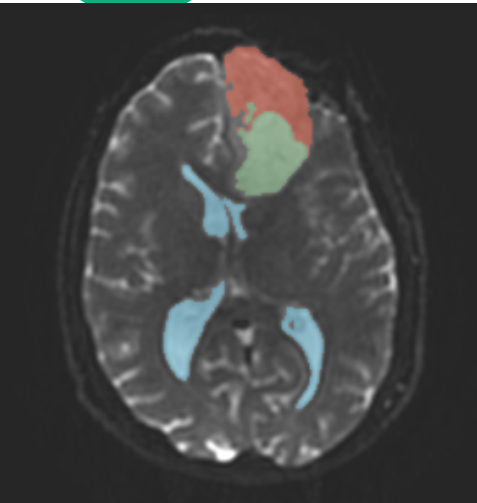
- Visualization
- Segmentation
- Registration
- Reconstruction
- Diffusion
- Image Guided Therapy
- Quantification

Compare Layout

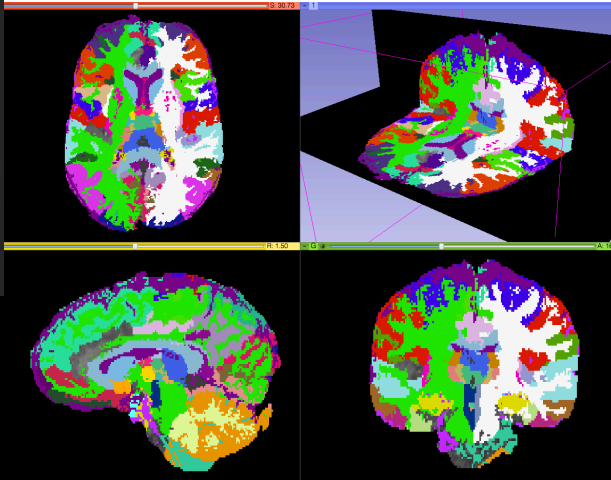
Volume Rendering



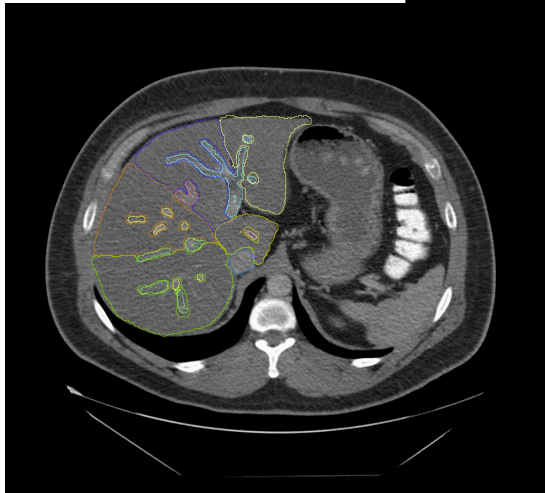
# Core Functionalities



Editor



EMSegmenter

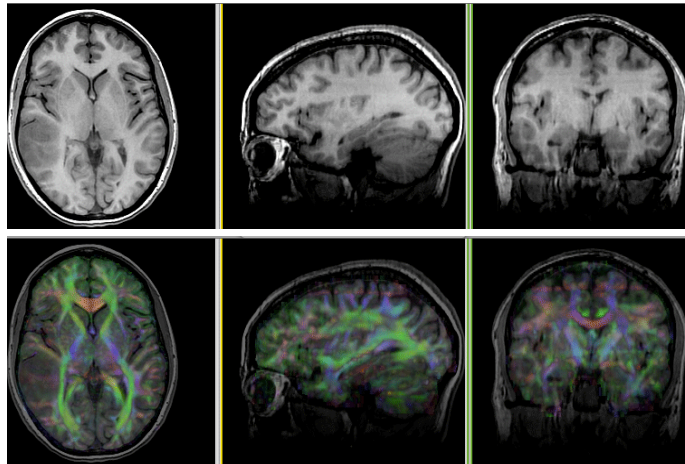
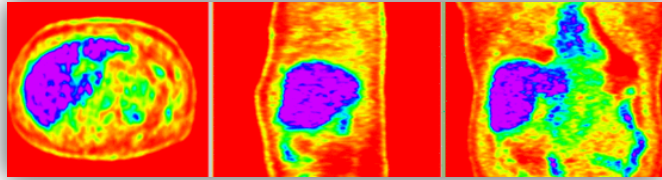


- Visualization
- Segmentation
- Registration
- Reconstruction
- Diffusion
- Image Guided Therapy
- Quantification



# Core Functionalities

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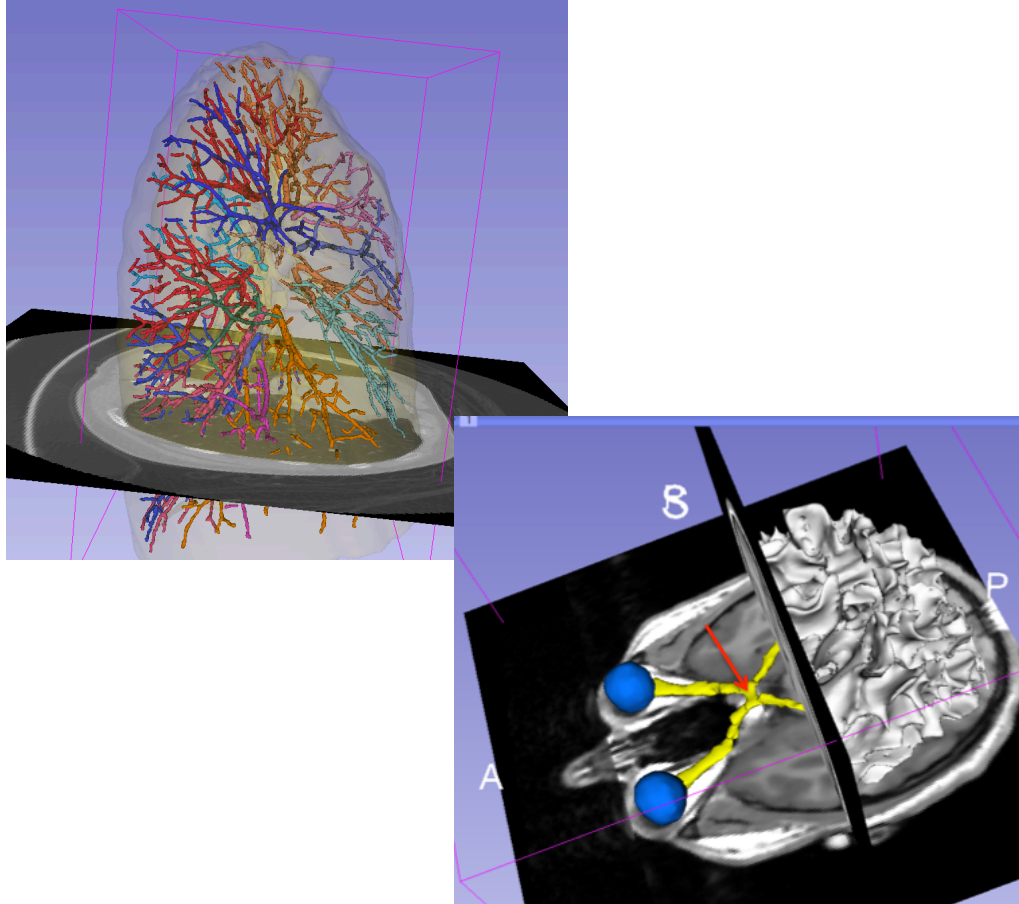


- Visualization
- Segmentation
- **Registration**
- Reconstruction
- Diffusion
- Image Guided Therapy
- Quantification



# Core Functionalities

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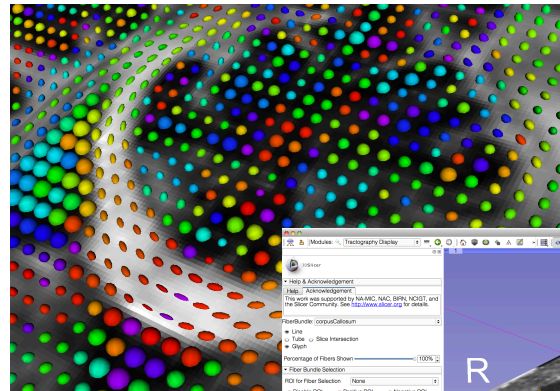


- Visualization
- Segmentation
- Registration
- **Surface Reconstruction**
- Diffusion
- Image Guided Therapy
- Quantification

Model Maker

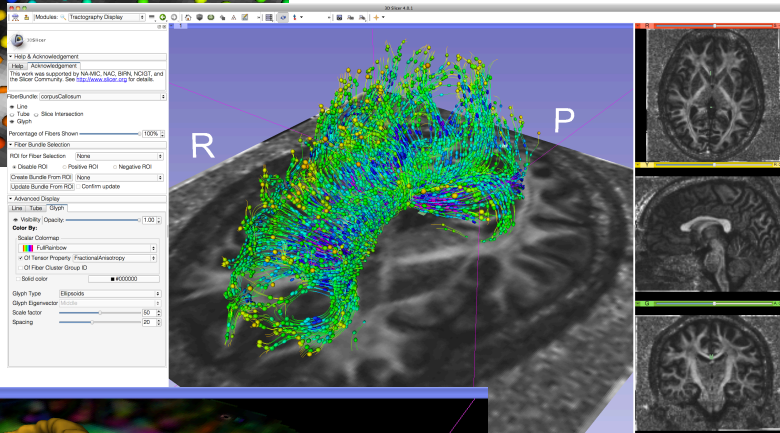


# Core Functionalities

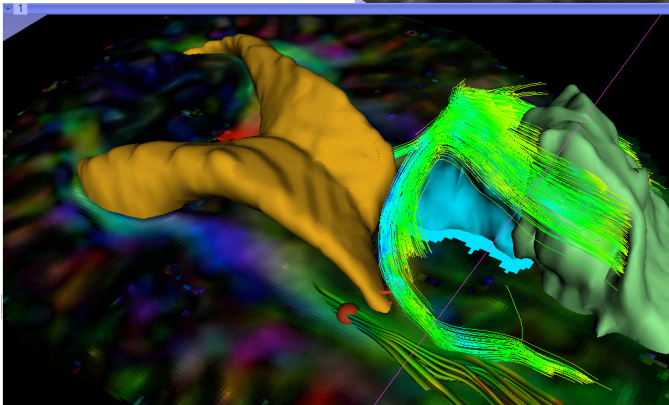


DWI To DTI  
Estimation

Labelmap  
Seeding



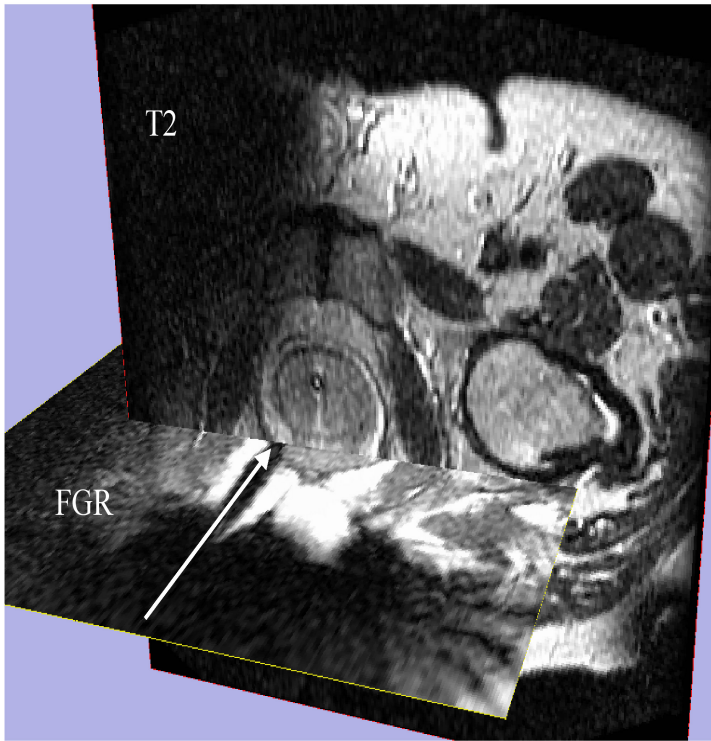
- Visualization
- Segmentation
- Registration
- Reconstruction
- **Diffusion MRI**
- Image Guided Therapy
- Quantification



Interactive  
Seeding



# Core Functionalities



- Visualization
- Segmentation
- Registration
- Reconstruction
- Diffusion
- Filtering
- Image Guided Therapy
- Quantification

Image Courtesy of Steven Haker, PhD and Clare Tempany, MD

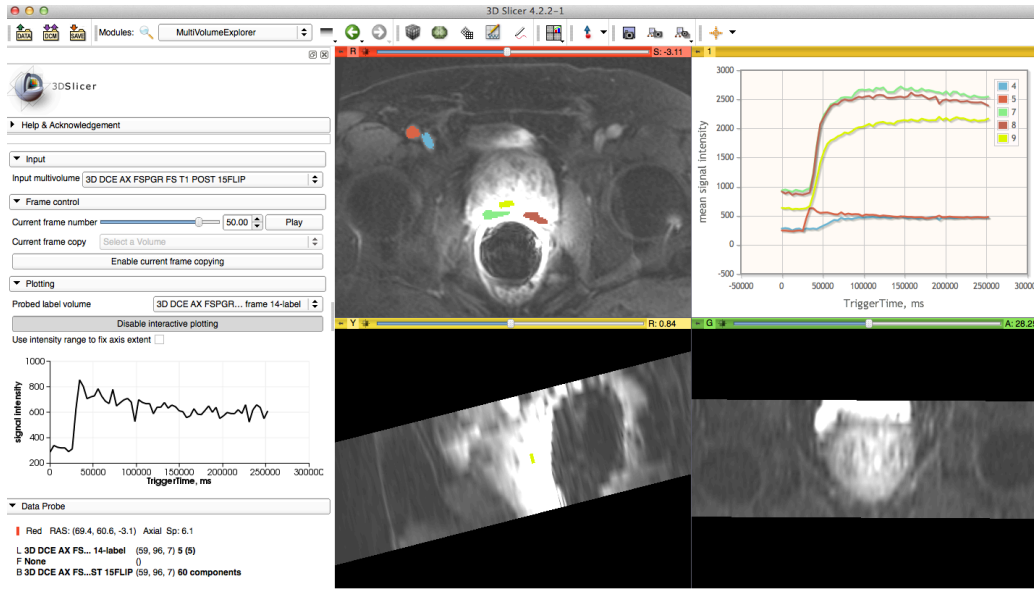
Image-guided therapy for prostate interventions:

- Brachytherapy Planning
- Navigation for Biopsy

Here Junichi feel free to  
replace this image by one of  
your papers



# Core Functionalities



- Visualization
- Segmentation
- Registration
- Reconstruction
- Diffusion
- Filtering
- Image Guided Therapy
- Quantification

Prostate DCE-MRI analysis.

## MutiVolumeExplorer



# Slicer use in clinical research environment

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Improving Patient Care with AMIGO  
Advanced Multimodality Image Guided Operating Suite

- AMIGO, BWH, Boston



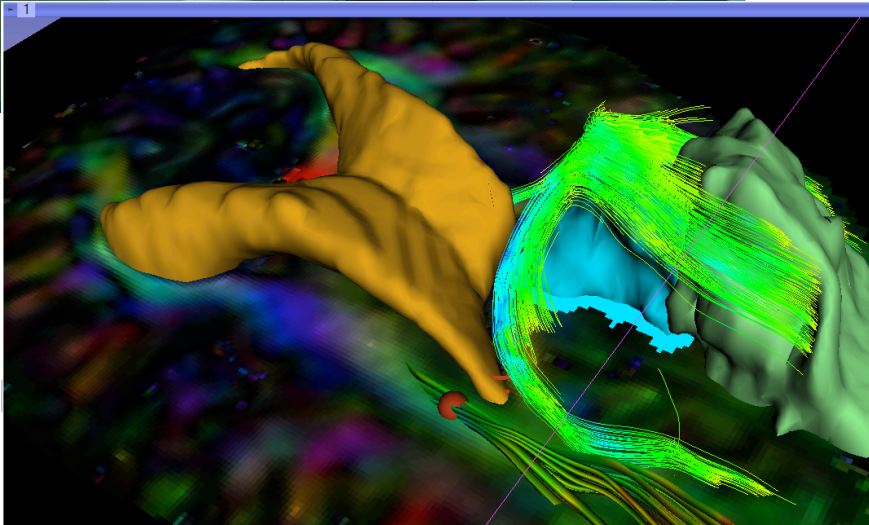


# Neurosurgery applications

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Interactive exploration  
of peritumoral white  
matter anatomy  
neurosurgical planning  
using DTI tractography

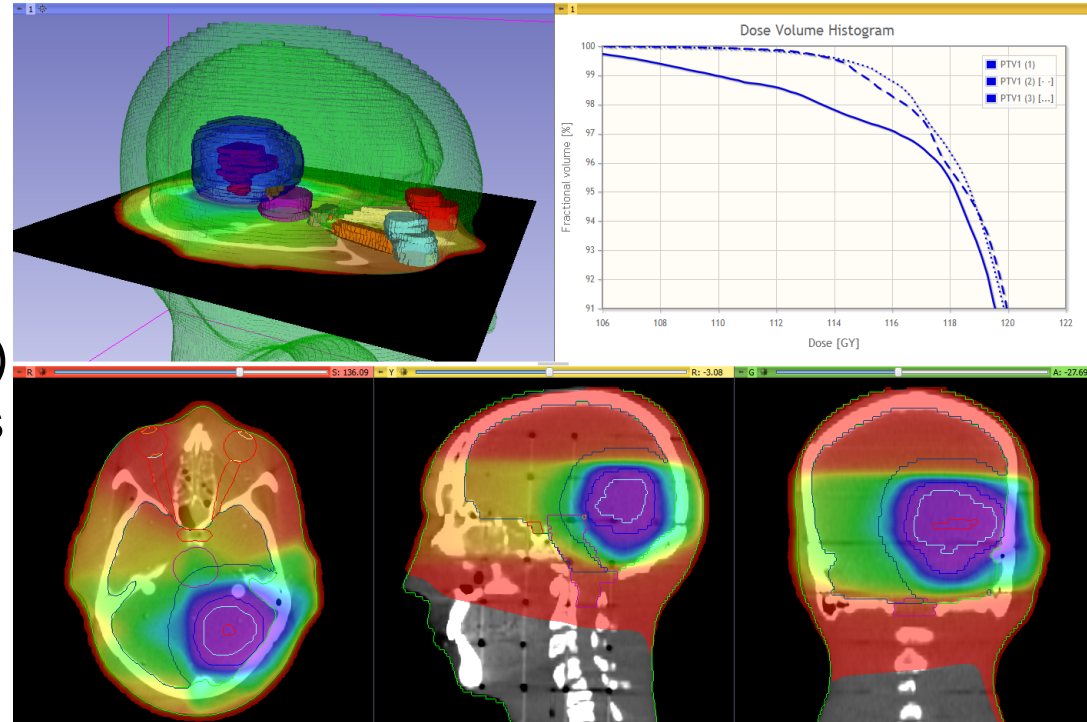




# SlicerRT for radiation therapy

## SlicerRT extension

- DICOM-RT import
- RT-specific analysis:
  - Dose Accumulation
  - Dose Comparison (gamma)
  - Isodose contours / surfaces
  - Contour Comparison
  - Contour Morphology
- Plastimatch
  - BSpline registration
  - Landwarp registration
- Project homepage: <https://www.assembla.com/spaces/slicerrt/>



Slide courtesy  
G.Fichtinger and  
C.Pinter



# 3DSLICER: TRAINING



# Slicer Trainees

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- Clinical investigators
- Senior scientists
- Postdoctoral fellows
- Programmers
- Undergraduate and graduate students
- Staff researchers

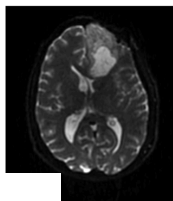


## Exploring Peritumoral White Matter Fibers for Neurosurgical Planning

Sonia Pujol, Ph.D.  
Ron Kikinis, M.D.

Surgical Planning Laboratory  
Harvard University

### Clinical Case



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

### 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

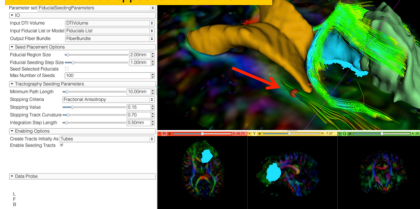


Part 4: Tractography exploration of the ipsilateral and contralateral side

White Matter Exploration for Neurosurgical Planning Sonia Pujol, Ph.D. – Ron Kikinis, M.D. NA-MIC ARR 2012-2014

### Fiducial Seeding

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



White Matter Exploration for Neurosurgical Planning Sonia Pujol, Ph.D. – Ron Kikinis, M.D. NA-MIC ARR 2012-2014

- Clinically driven goal
- Pre-computed anonymized datasets
- Image-analysis pipeline with step-by-step instructions



# Slicer Tutorials: for developers



## Programming in Slicer4

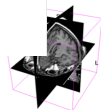
Sonia Pujol, Ph.D.  
Surgical Planning Laboratory,  
Harvard Medical School

Steve Pieper, Ph.D.  
Isomics Inc.

Paul Cézanne, Moulin sur la Couleuvre à Pontosse, 1881, Staatliche Museen zu Berlin, Nationalgalerie

## Course Material

Unzip the HelloPython.zip archive



spgr.nhdr spgr.raw.gz  
(124 SPGR images)



HelloPython.py  
HelloLaplace.py  
HelloSharpen.py

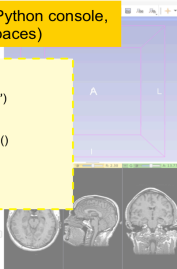
## Course Overview

- Part A: Exploring Slicer via Python
- Part B: Integration of the HelloPython.py program into Slicer4
- Part C: Implementation of the Laplace operator in the HelloPython module
- Part D: Image Sharpening using the Laplace operator

## Manipulating Arrays

Run the following code in the Python console,  
(indent each new line with 2 spaces)

```
Welcome  
def toggle():  
    n = slicer.util.getNode('spgr')  
    a = slicer.util.array('spgr')  
    a[:] = a.max()/2. - a  
    n.GetImageData().Modified()  
    print('Toggled')  
toggle()
```



- Slicer Module development
- Pre-computed exemplar source code
- Programming pipeline with step-by-step instructions



# Slicer Training Workshops

---

Hands-on courses at major international conferences (e.g. RSNA, SfN, SPIE, CARS, etc..)

Invited workshops at international universities (April 2013: Iwate Medical Center, Japan)





# Slicer Project Weeks

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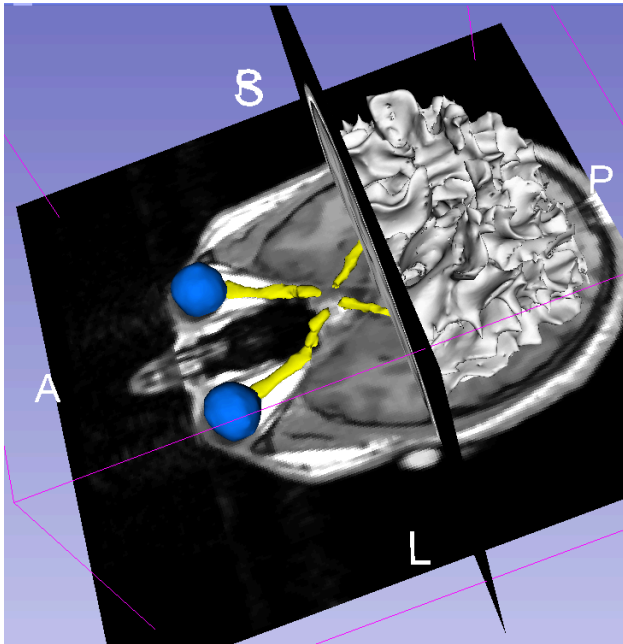


- Bi-annual week of hands-on programming (Winter: Salt Lake City, Summer: MIT)



- Practical exchange of idea and experience
- 17 project weeks since 2005
- Next Project Week: June 17-21, 2013, MIT

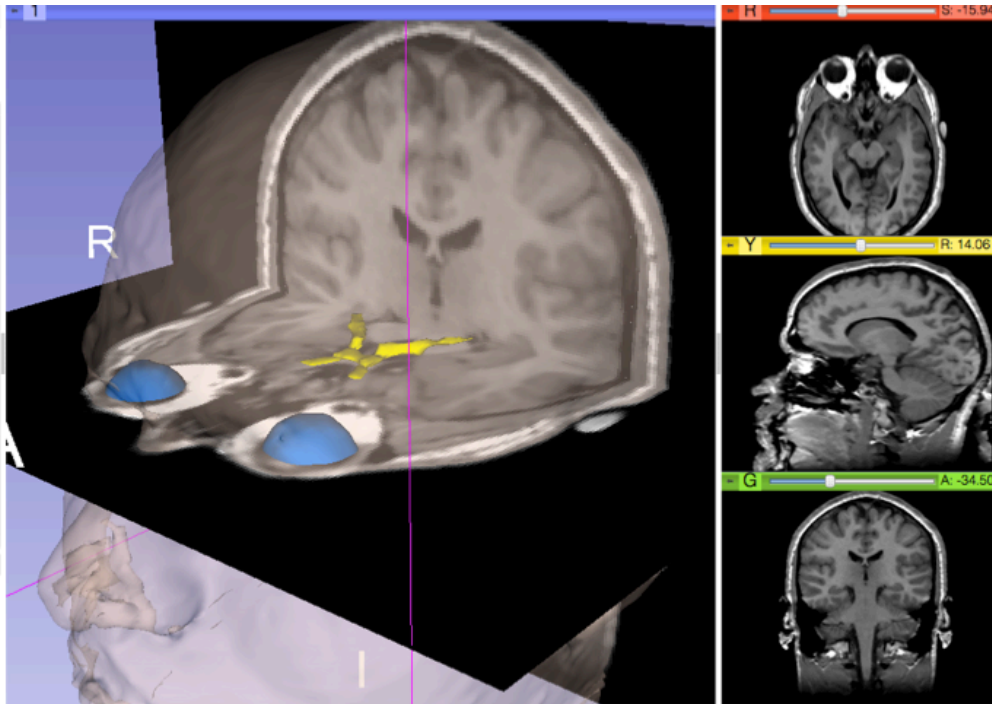




## Part II – Hands-on session: Slicer4 Minute tutorial on data loading and 3D Visualization



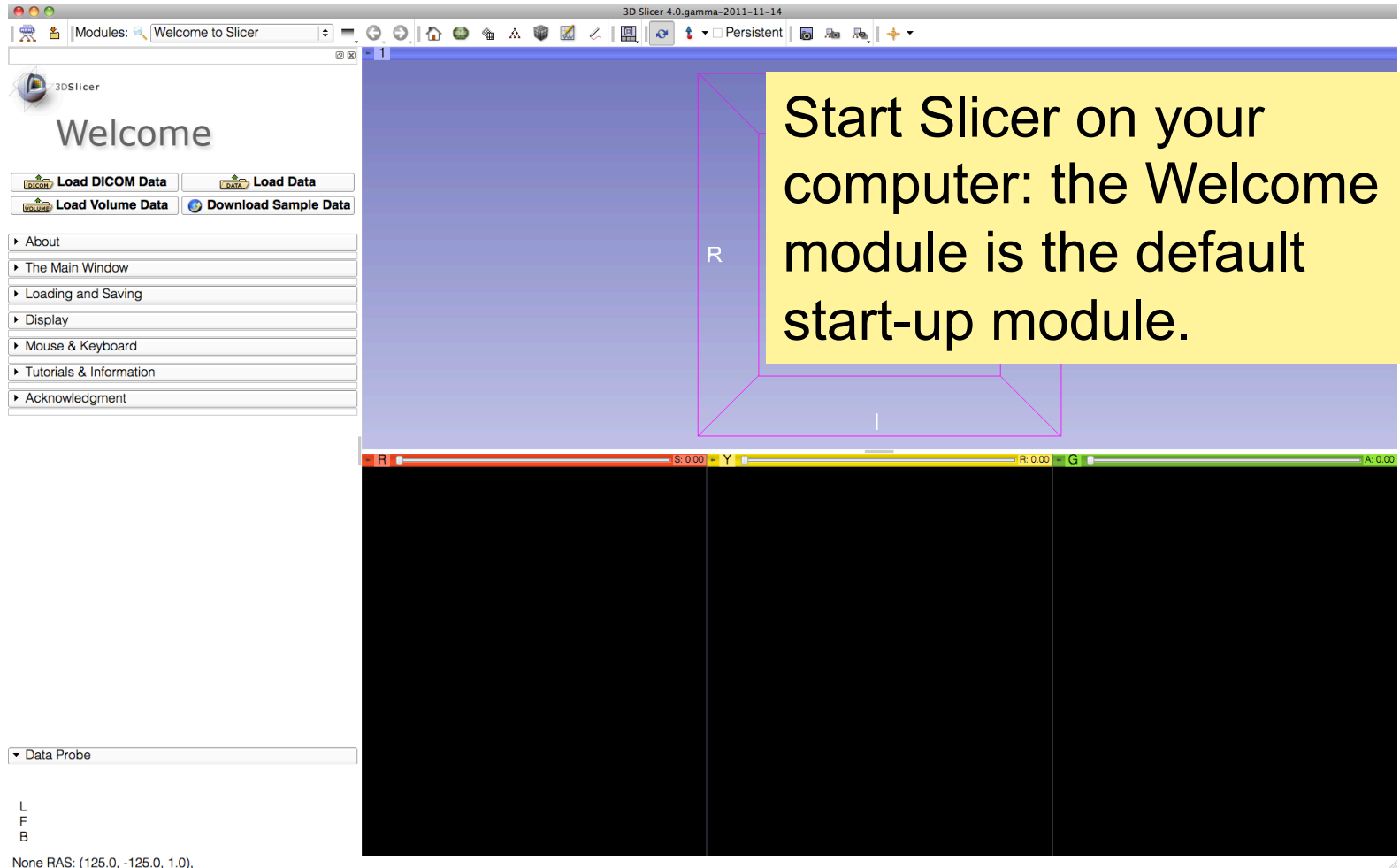
# Slicer4 minute tutorial



This tutorial is an introduction to the 3D visualization capabilities of the Slicer4 software for medical image analysis.

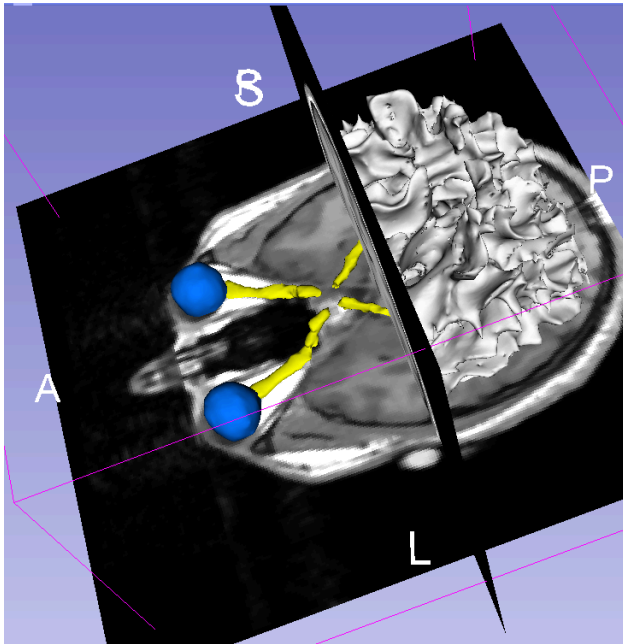


# 3DSlicer version 4





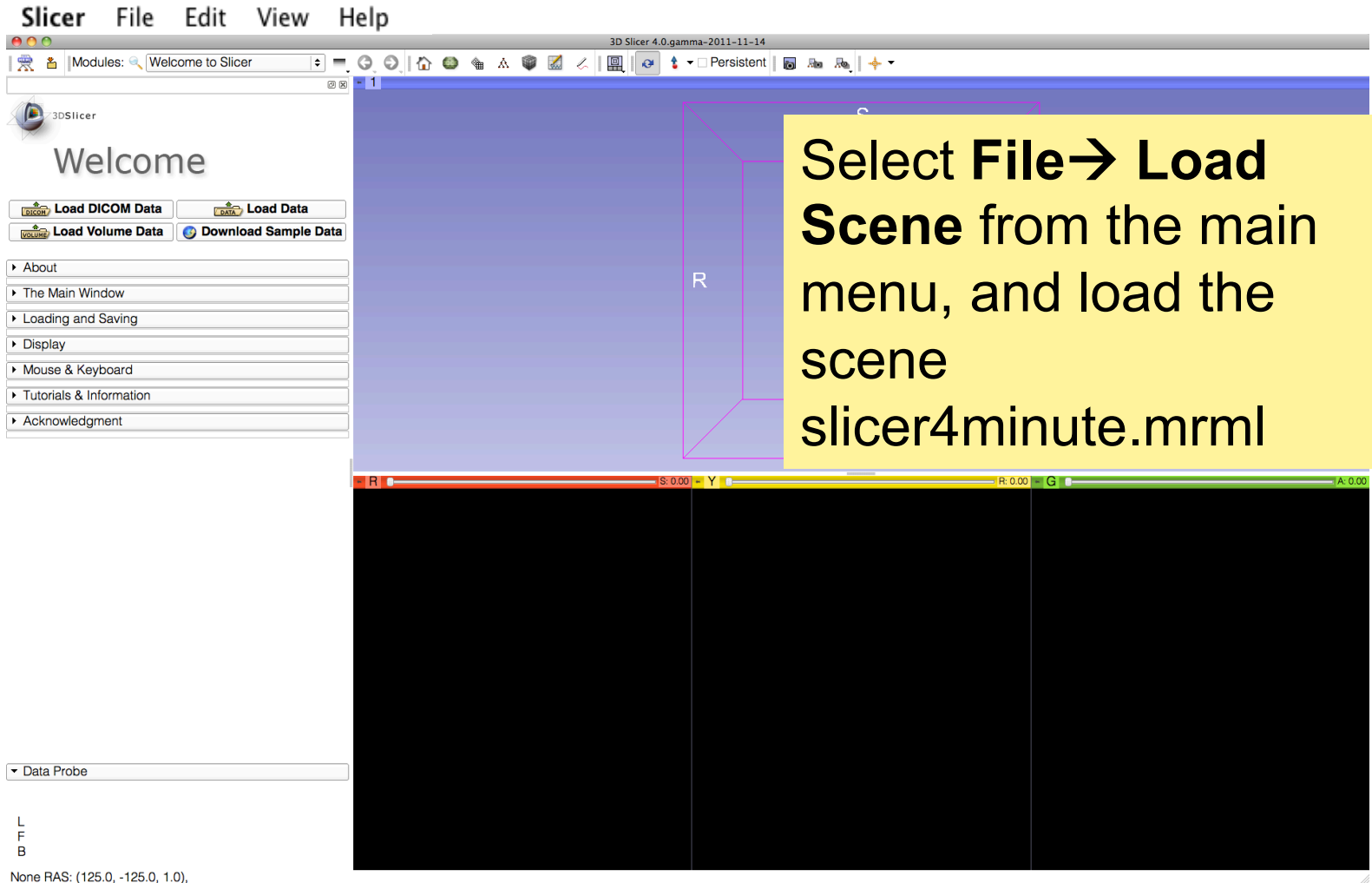
# 3D Slicer Scene



- A Slicer scene is a MRML file which contains the list of elements loaded into Slicer (volumes, models, fiducials...)
- The following example uses a 3D Scene which contains images and 3D surface models of the head from the SPL-PNL Brain Atlas.

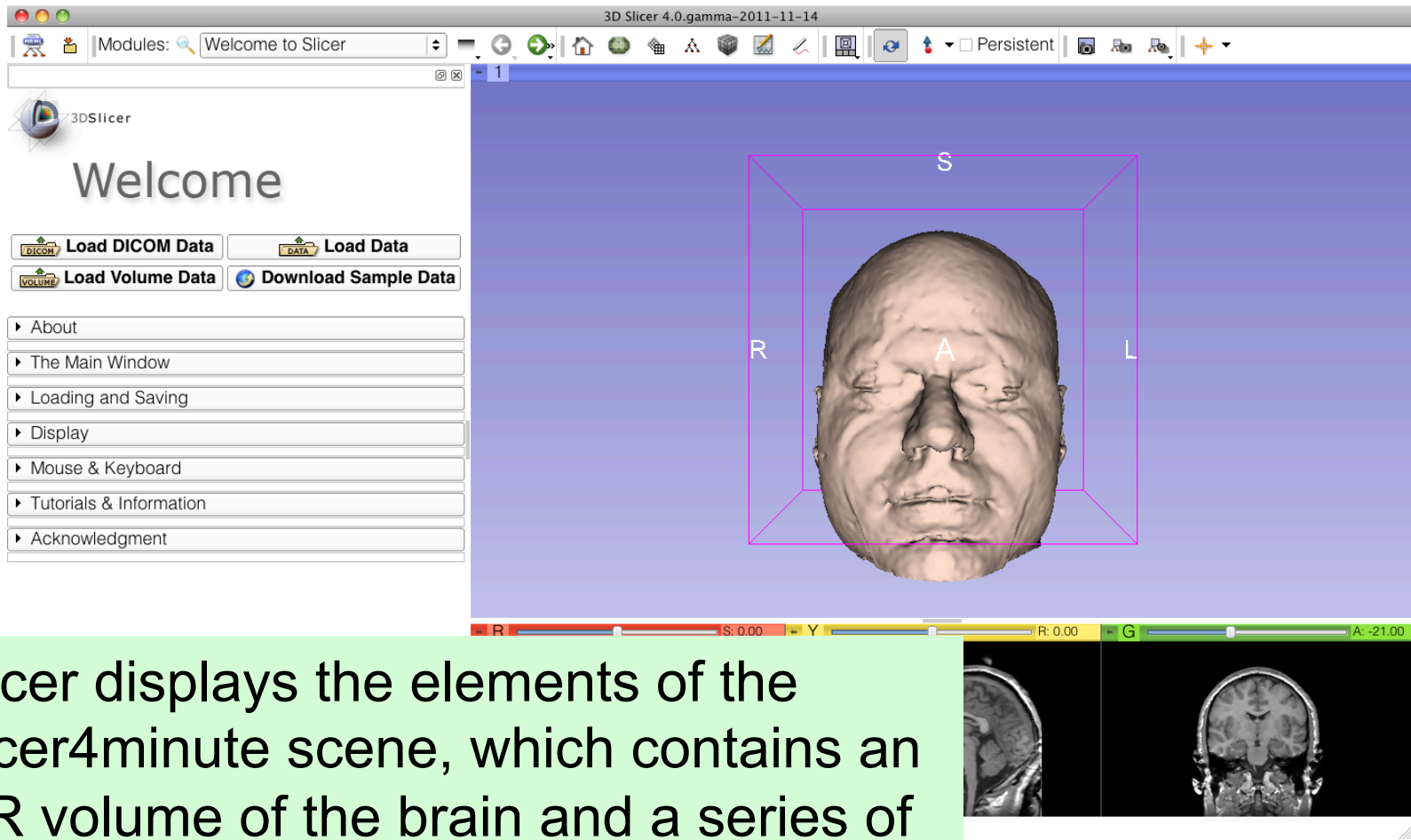


# 3DSlicer version 4





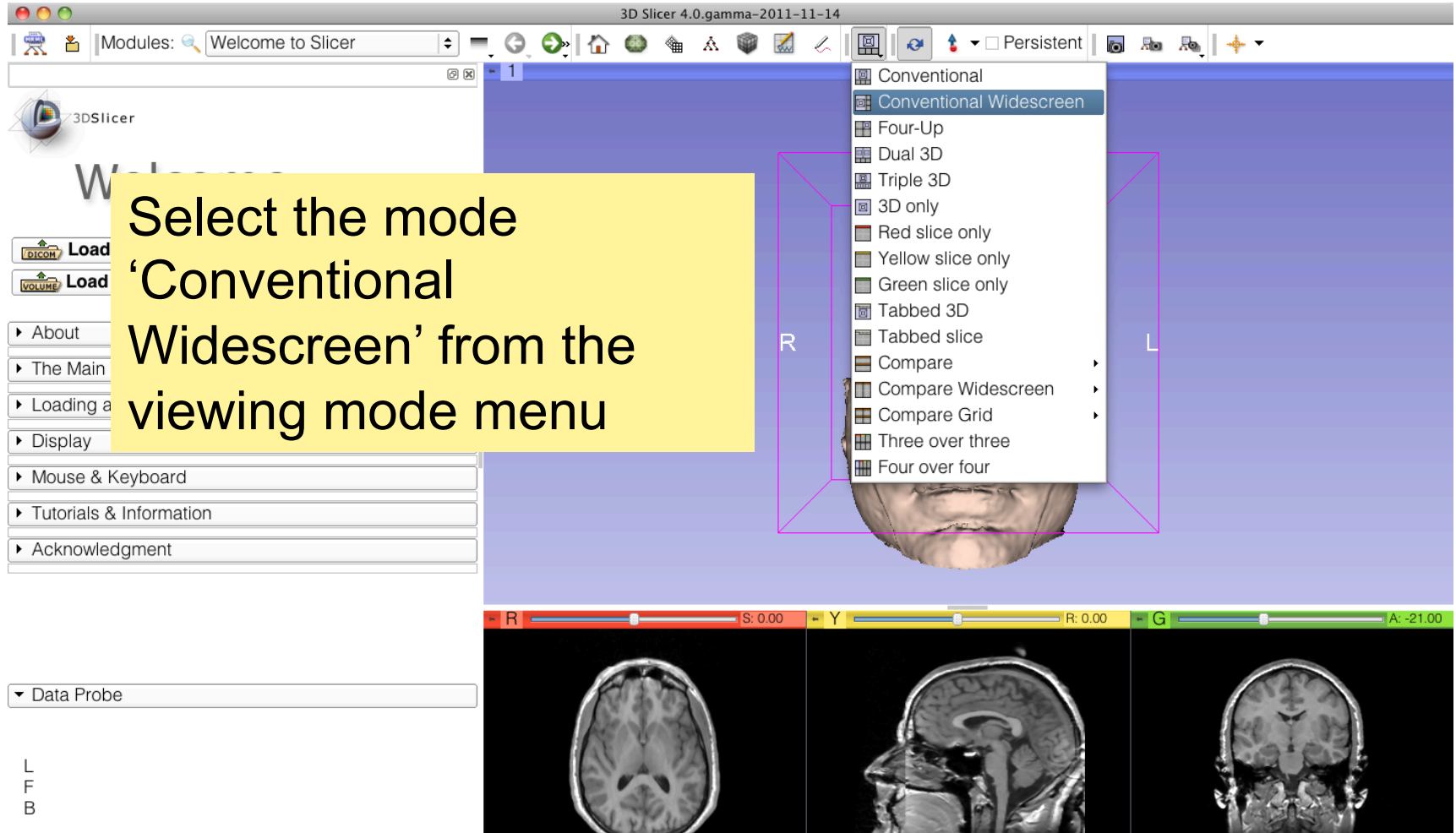
# Slicer4 minute Scene



Slicer displays the elements of the slicer4minute scene, which contains an MR volume of the brain and a series of 3D surface models.

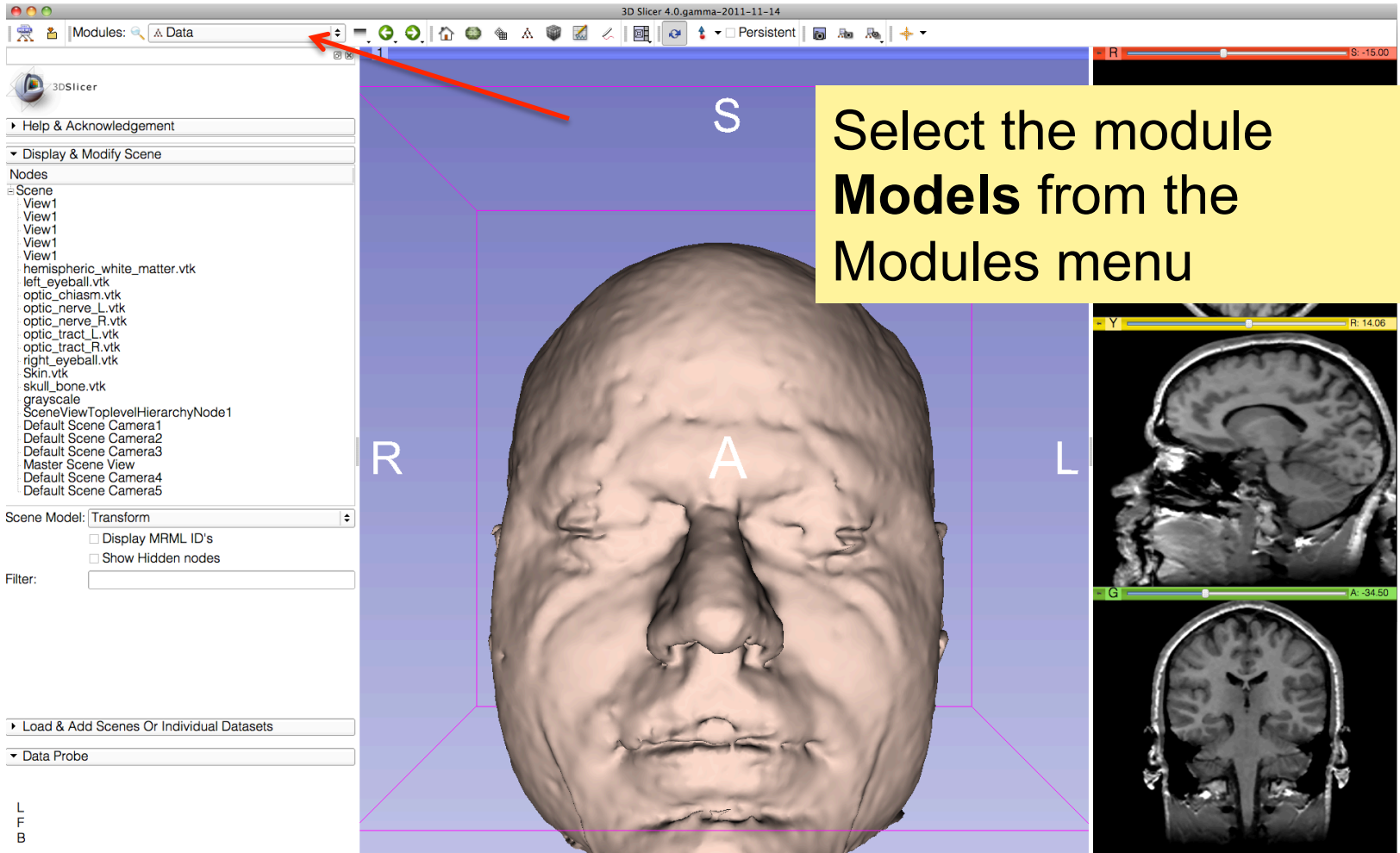


# Slice4 minute scene





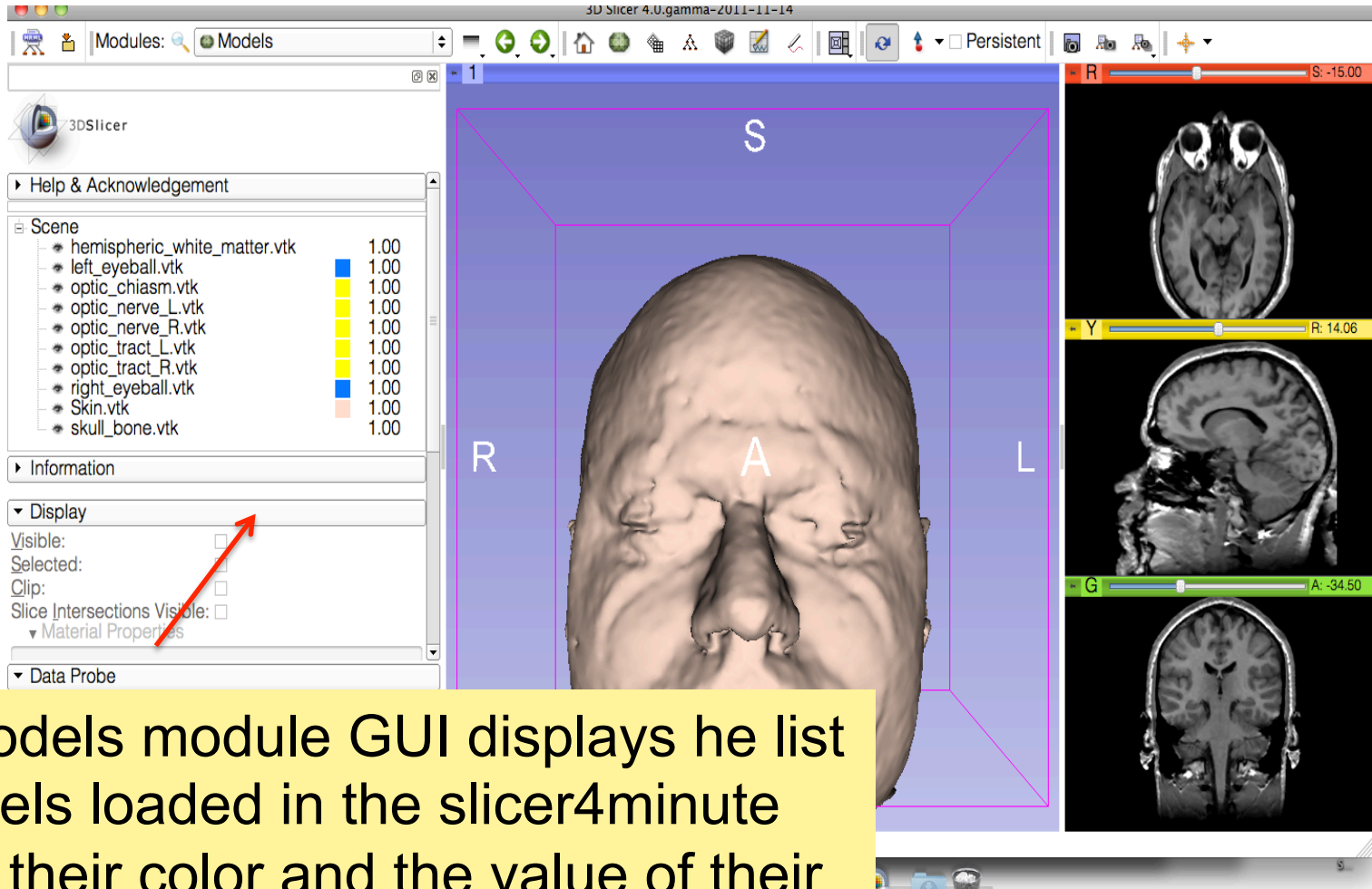
# Slicer4minute Scene







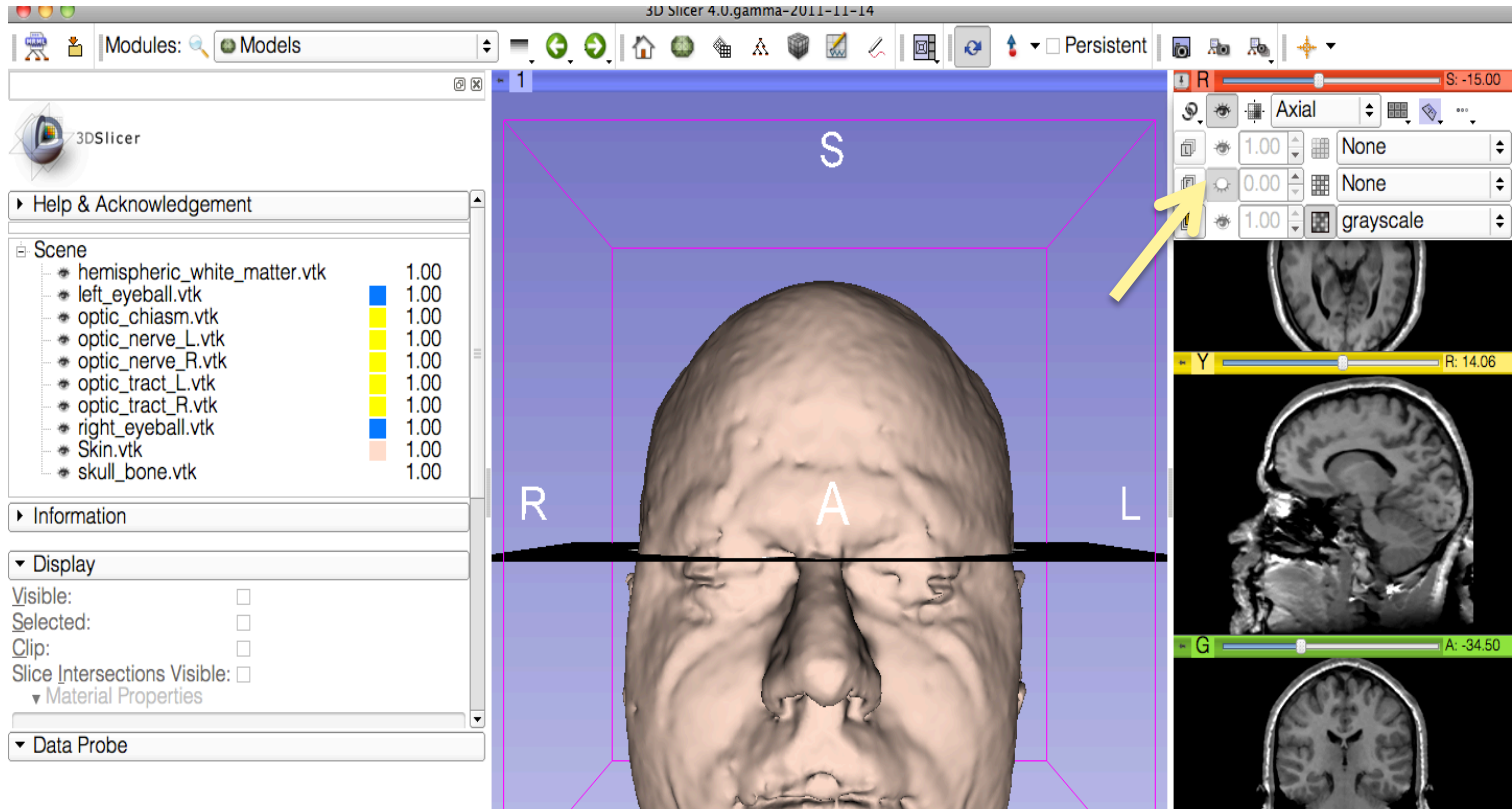
# 3D Visualization



The Models module GUI displays the list of models loaded in the slicer4minute scene, their color and the value of their opacity (between 0.0 and 1.0)



# 3D Visualization



Click on the pin icon on the top left corner of the red slice to display the slice viewer menu.

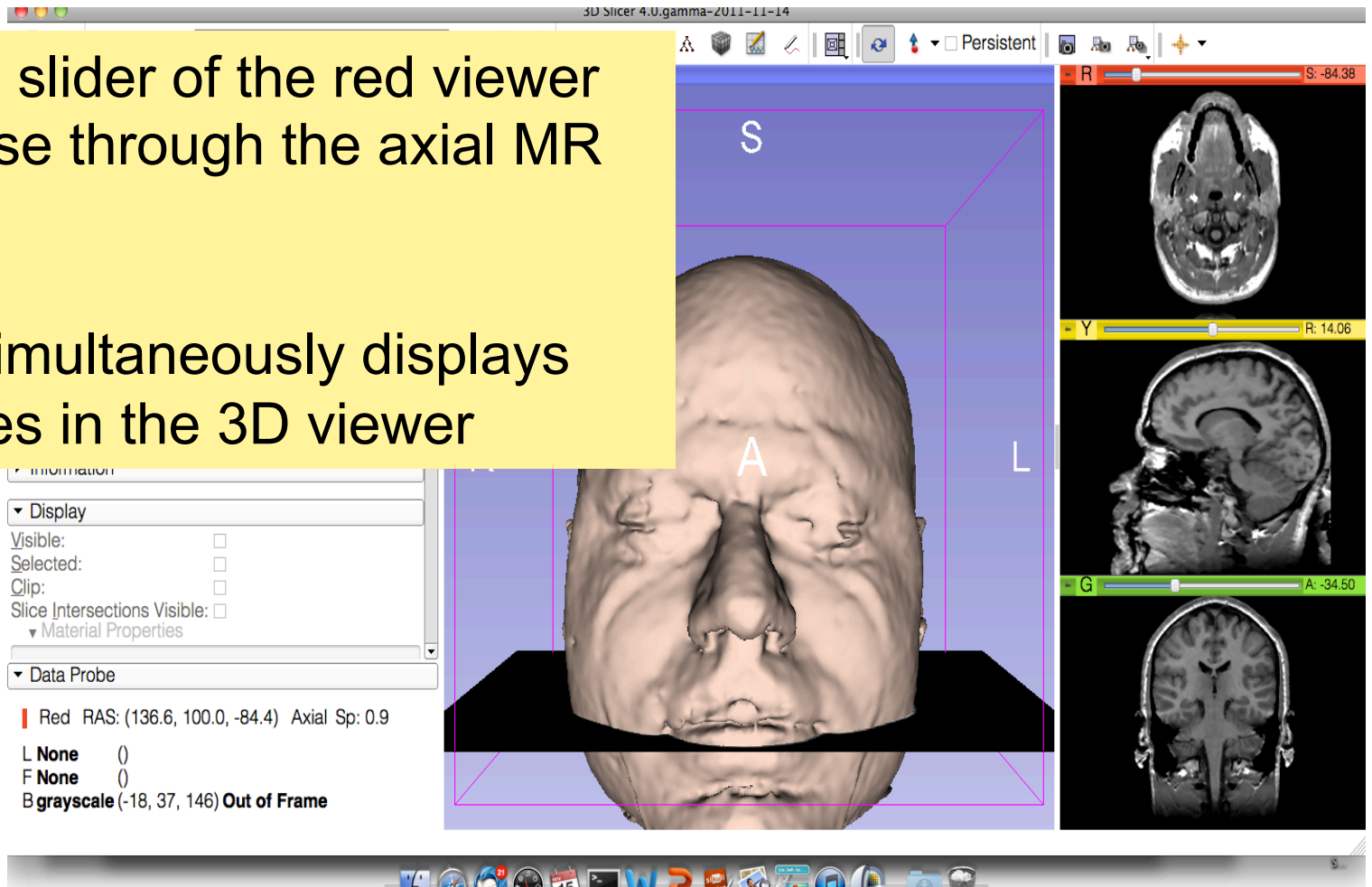
Click on the eye icon to display the axial slice in the 3D Viewer



# 3D Visualization

Use the slider of the red viewer to browse through the axial MR slices.

Slicer simultaneously displays the slices in the 3D viewer





# 3D Visualization

Lower the opacity of the Skin.vtk model in the Display tab

na-2011-11-14

Help & Acknowledgement

Scene

- hemispheric\_white\_matte... 1.00
- left\_eyeball.vtk 1.00
- optic\_chiasm.vtk 1.00
- optic\_nerve\_L.vtk 1.00
- optic\_nerve\_R.vtk 1.00
- optic\_tract\_L.vtk 1.00
- optic\_tract\_R.vtk 1.00
- right\_eyeball.vtk 1.00
- Skin.vtk 0.38**
- skull\_bone.vtk 1.00

Information

Display

Visible:

Selected:

Clip:

Slice Intersections Visib

Material Properties

Color: [Slider]

Opacity: [Slider] 0.38

Ambient: [Slider] 0.00

Data Probe

L  
F  
B

R S L A

R S: -22.03

Y R: 34.69

G A: -25.50

The skull\_bone.vtk model appears through the skin.



# 3D Visualization

Position the mouse in the 3D viewer, click on the left-mouse button to drag and rotate the model. Click on the right-mouse button to zoom in and out

Information

Display

Visible:

Selected:

Clip:

Slice Intersections Visible:

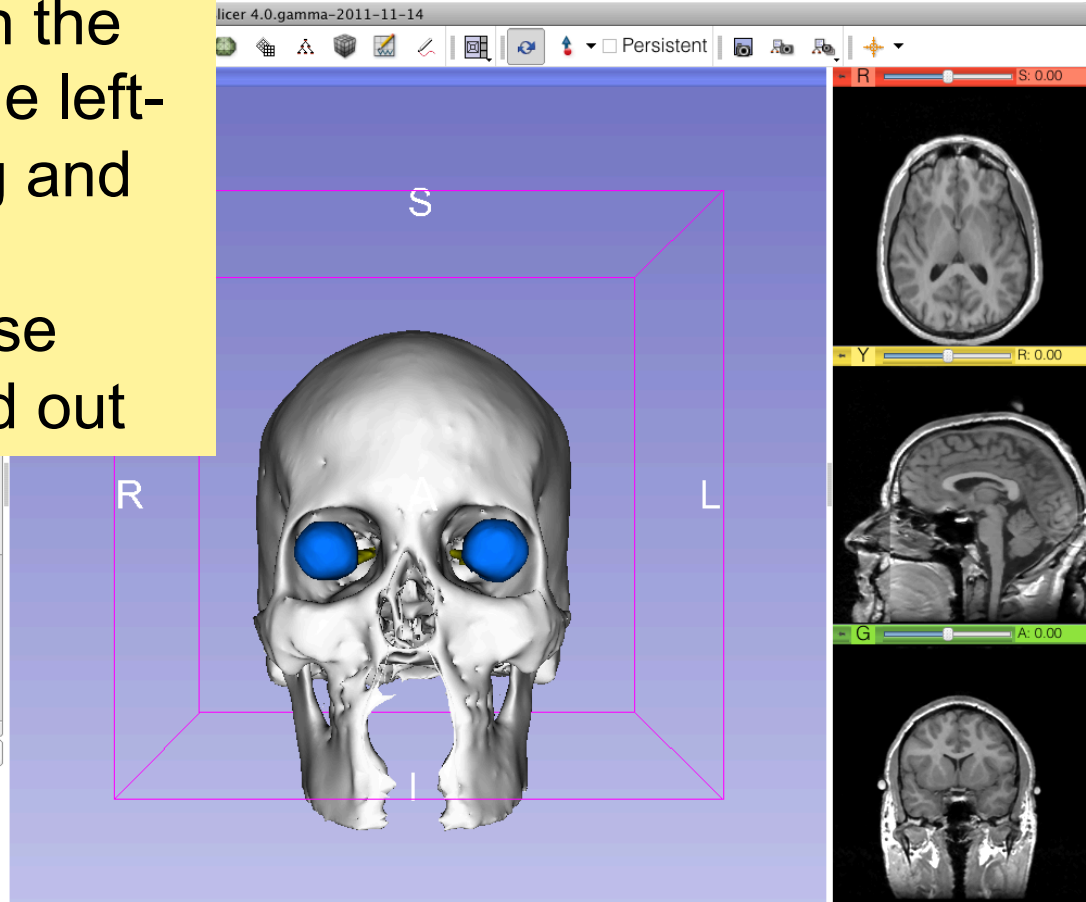
Material Properties

Color:

Opacity:

Ambient:

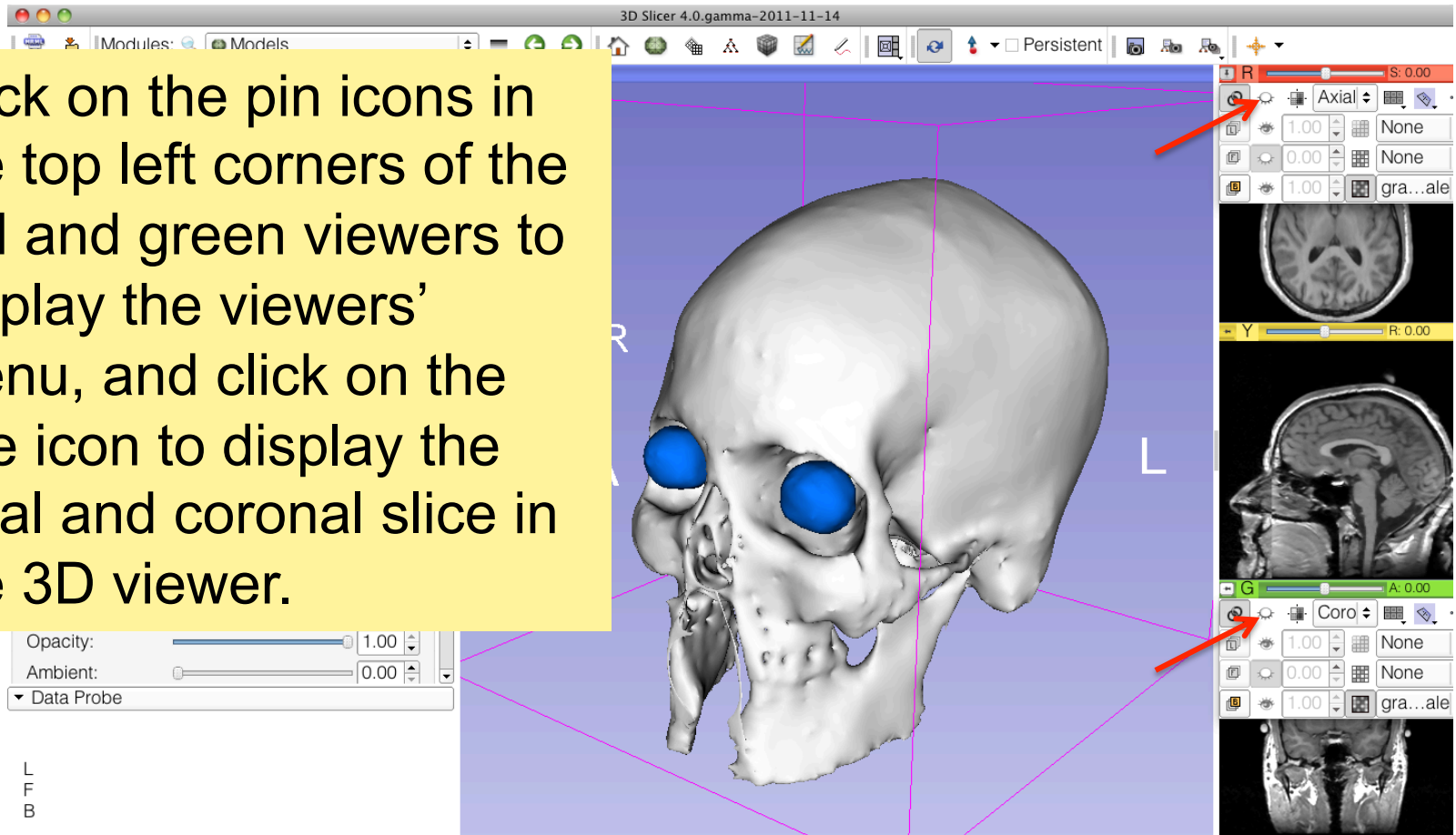
Data Probe





# Anatomical Views

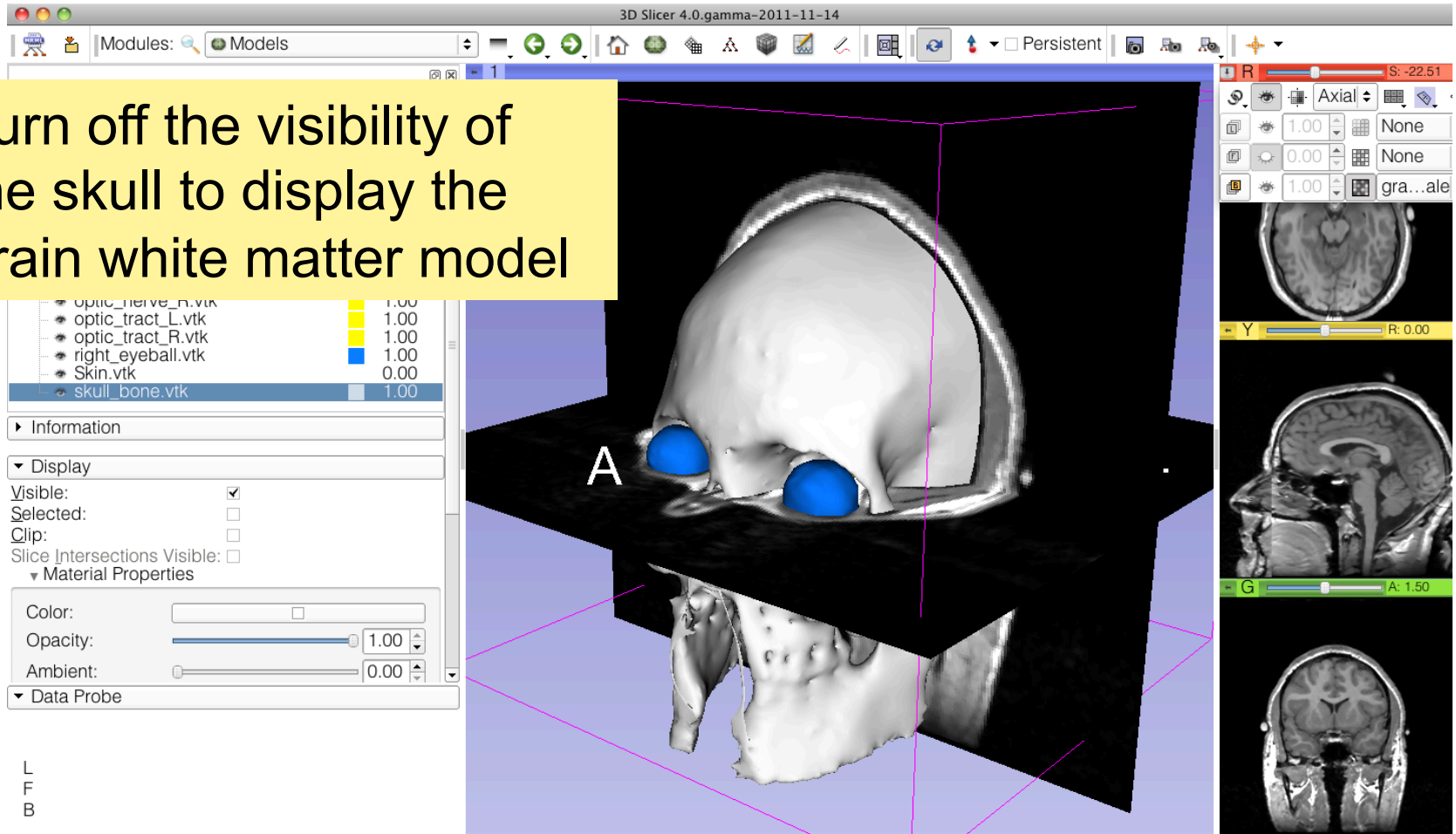
Click on the pin icons in the top left corners of the red and green viewers to display the viewers' menu, and click on the eye icon to display the axial and coronal slice in the 3D viewer.





# 3D Visualization

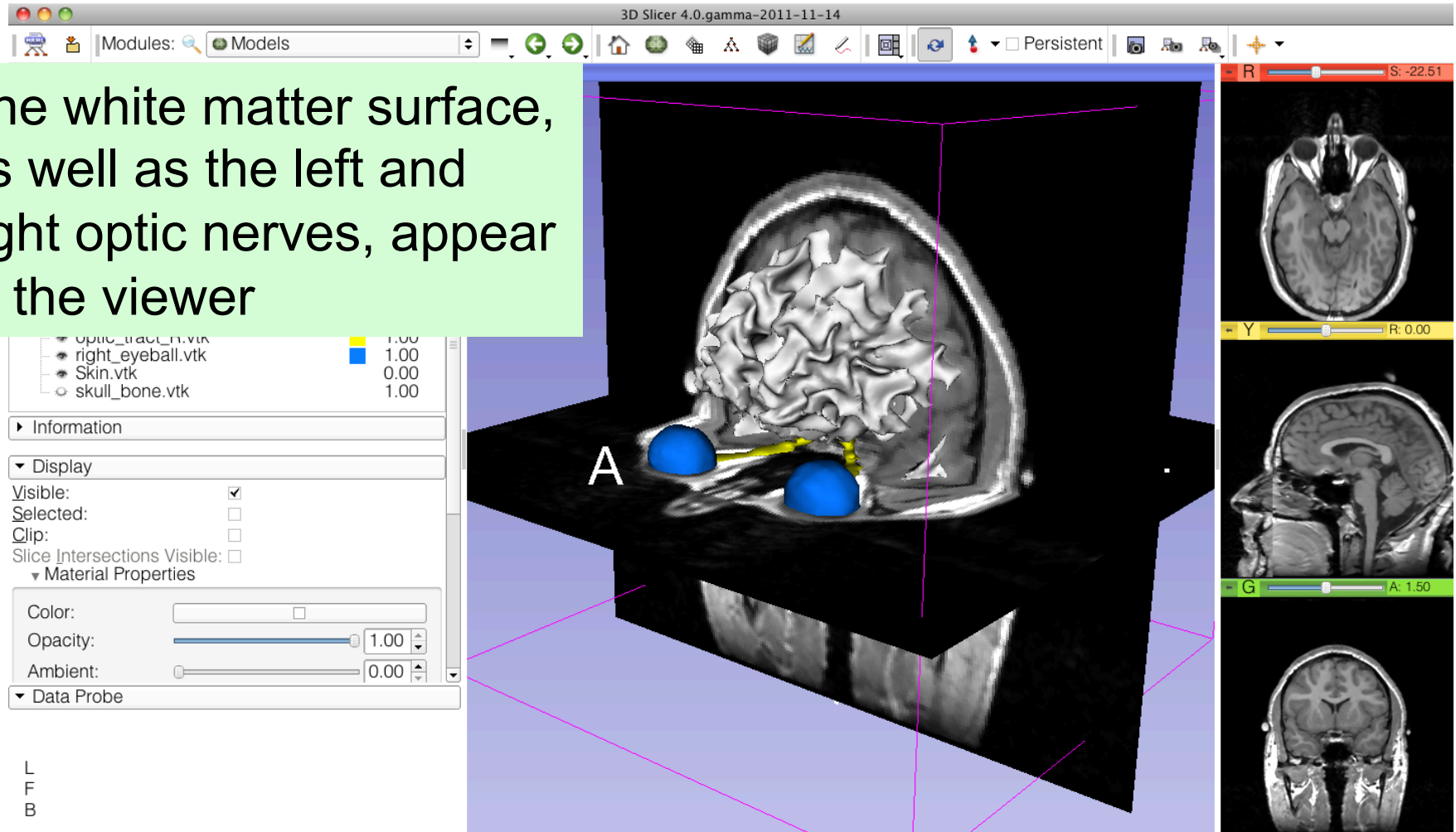
Turn off the visibility of the skull to display the brain white matter model





# 3D Visualization

The white matter surface, as well as the left and right optic nerves, appear in the viewer



L  
F  
B





# 3D Visualization

3D Slicer 4.0.gamma-2011-11-14

Modules: Models

3DSlicer

Help & Acknowledgement

Scene

- hemispheric\_white\_matter.vtk 1.00
- left\_eyeball.vtk 1.00
- optic\_chiasm.vtk 1.00
- optic\_nerve\_L.vtk 1.00
- optic\_nerve\_R.vtk 1.00
- optic\_tract\_L.vtk 1.00
- optic\_tract\_R.vtk 1.00
- right\_eyeball.vtk 1.00
- Skin.vtk 0.00
- skull\_bone.vtk 1.00

Information

Display

Visible:

Selected:

Clip:

Slice Intersections Visible:

Material Properties

Color:

Opacity:

Ambient:

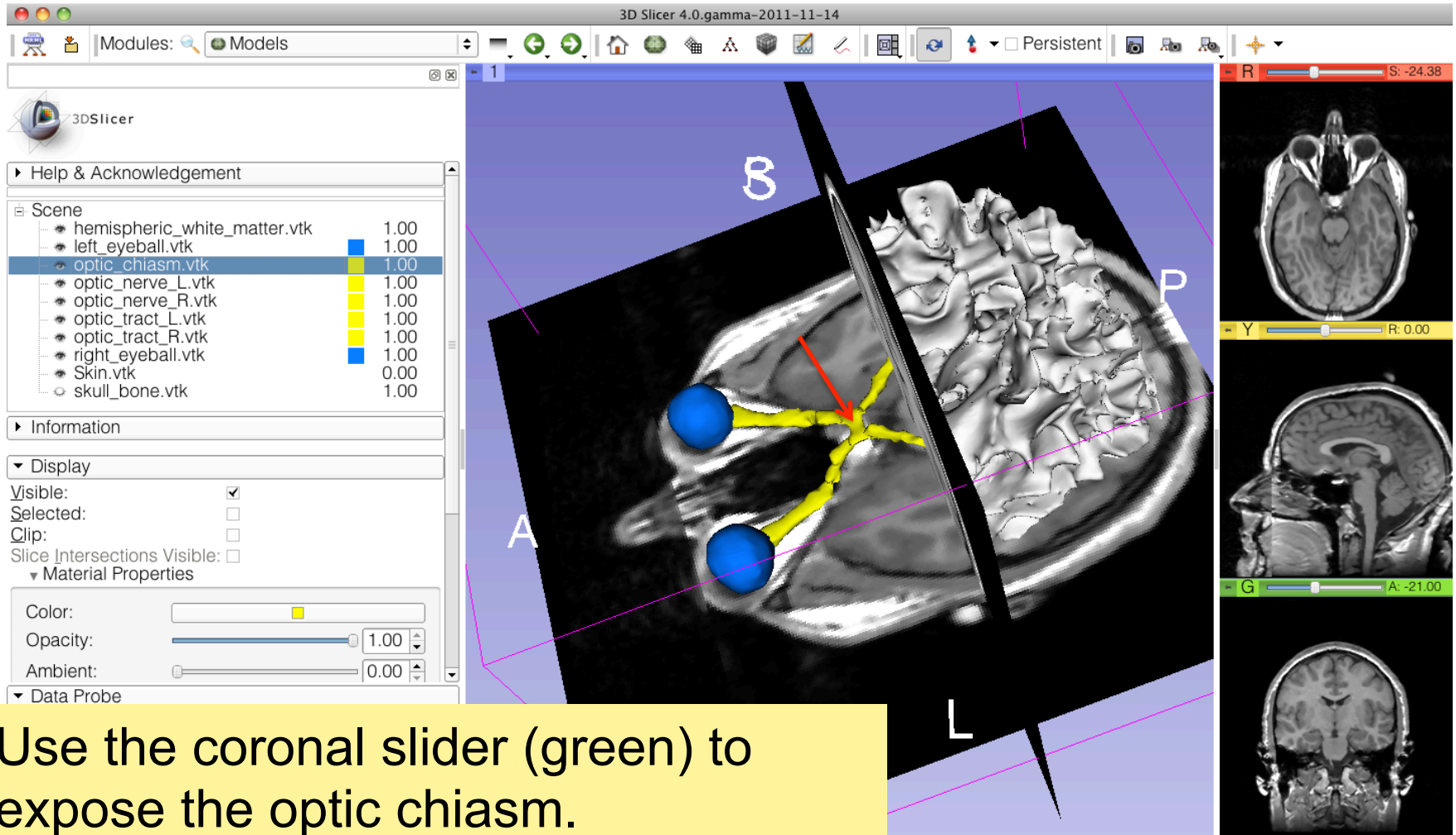
Data Probe

L  
F  
B

**Select the hemispheric\_white\_matter.vtk model, and check Clip in the Display options tab.**

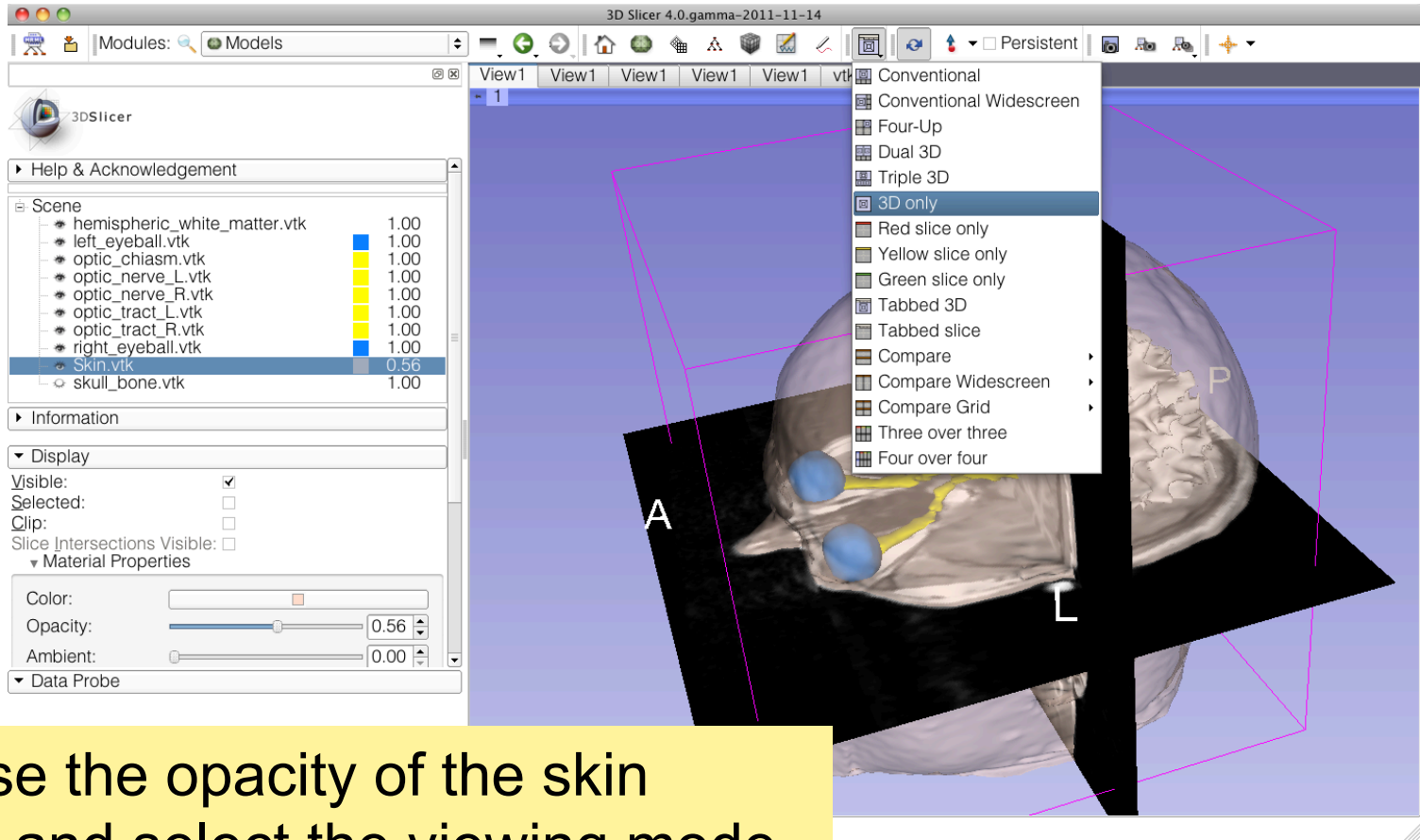


# 3D Visualization





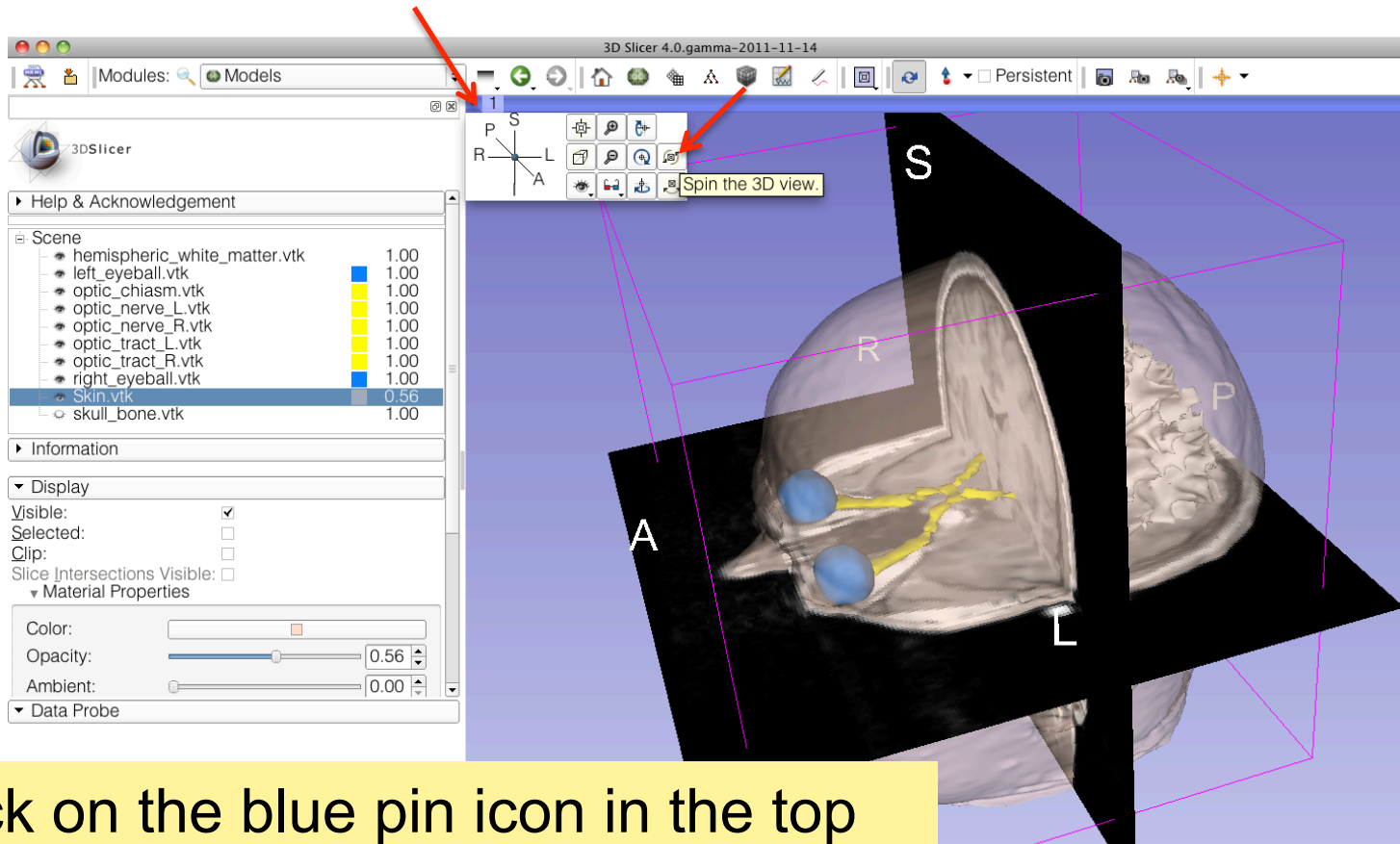
# 3D Visualization



Increase the opacity of the skin model, and select the viewing mode '3D only'



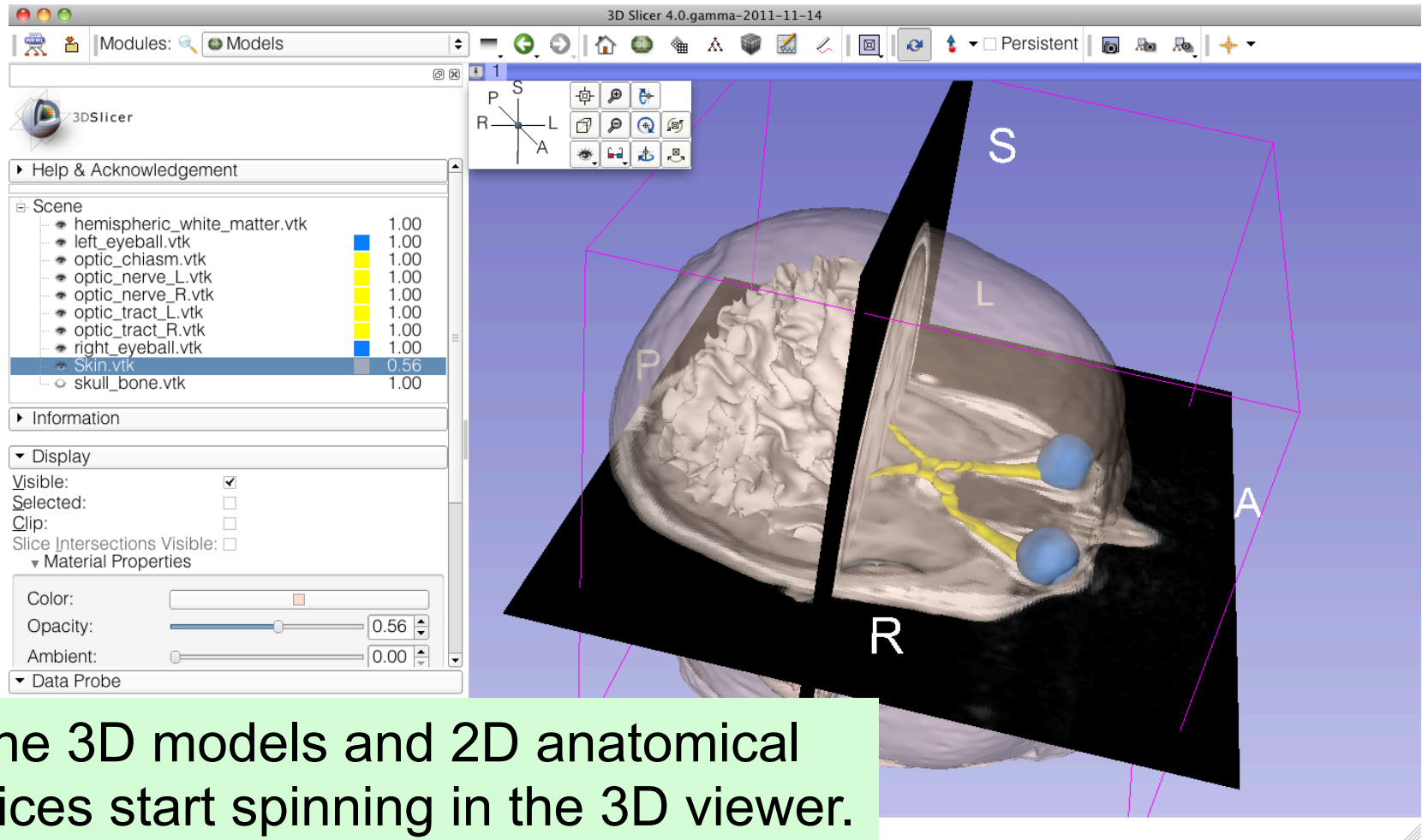
# 3D Visualization



Click on the blue pin icon in the top left corner of the 3D viewer, and click on the Spin icon.



# 3D Visualization

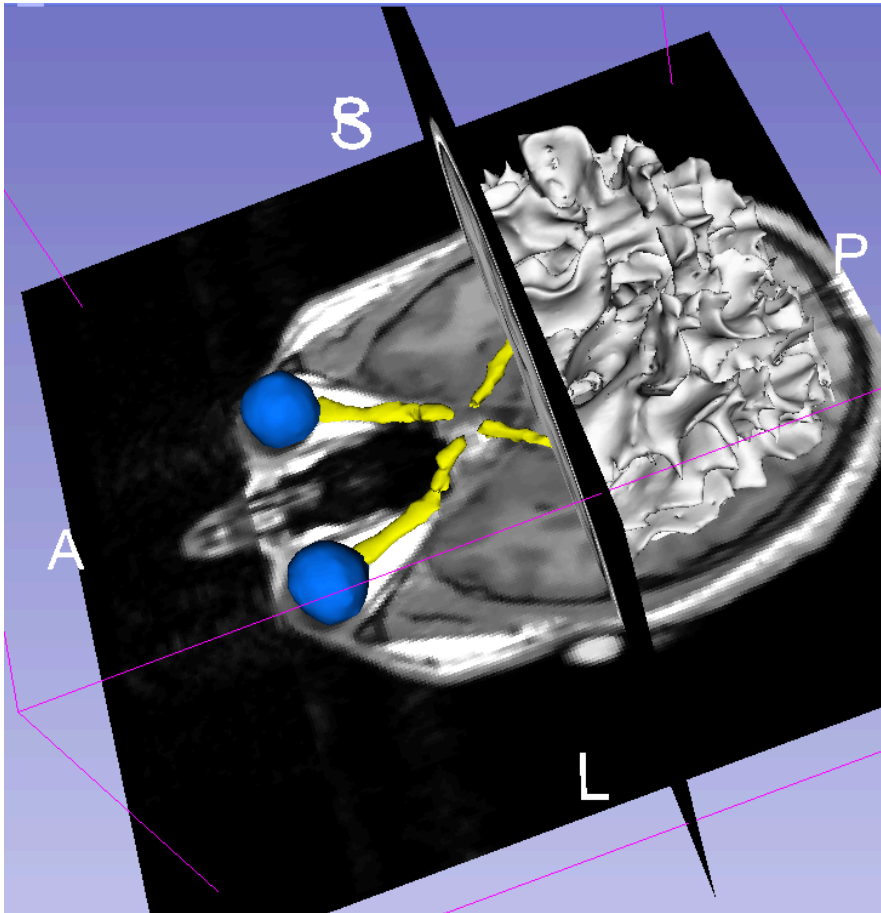


The 3D models and 2D anatomical slices start spinning in the 3D viewer. Click a second time on the spin icon to stop the models from spinning.



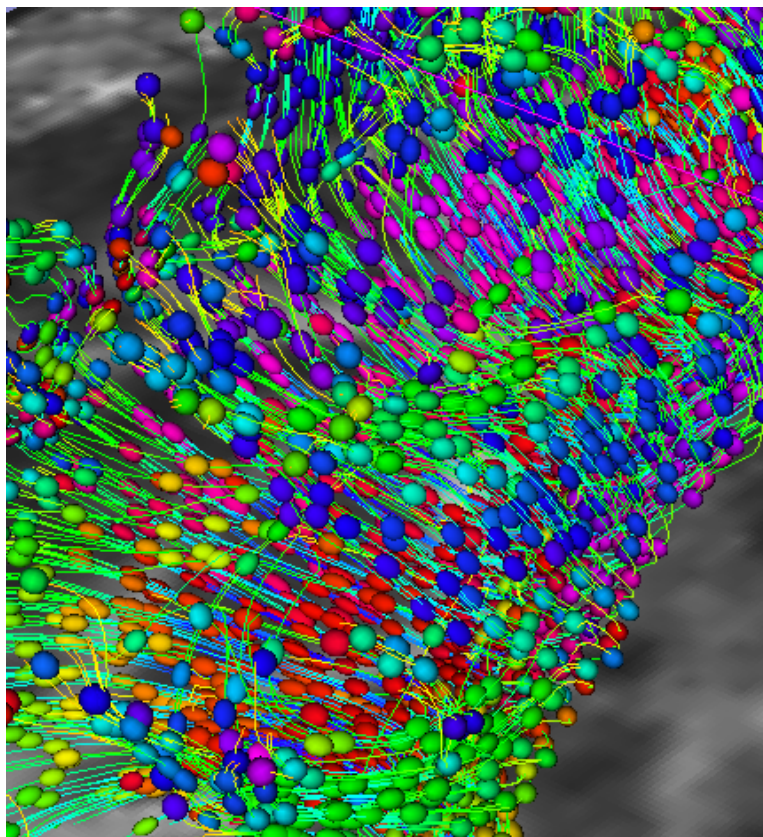
# Slicer4 minute tutorial

---



This tutorial was a short introduction to the 3D visualization capabilities of Slicer.

Please visit the Slicer4 training compendium for more information on the software  
[www.slicer.org](http://www.slicer.org)

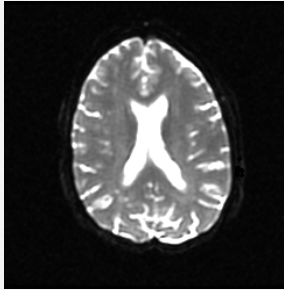


## Part III: 3D Slicer DTI demo

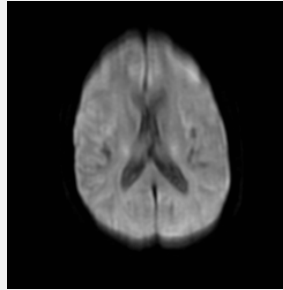


# MR Diffusion Analysis Pipeline

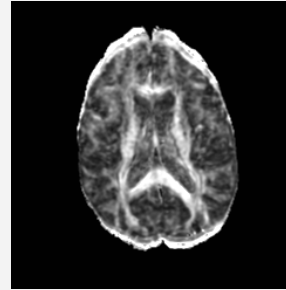
---



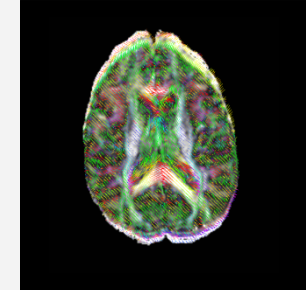
DWI  
Acquisition



Tensor  
Calculation



Scalar  
Maps

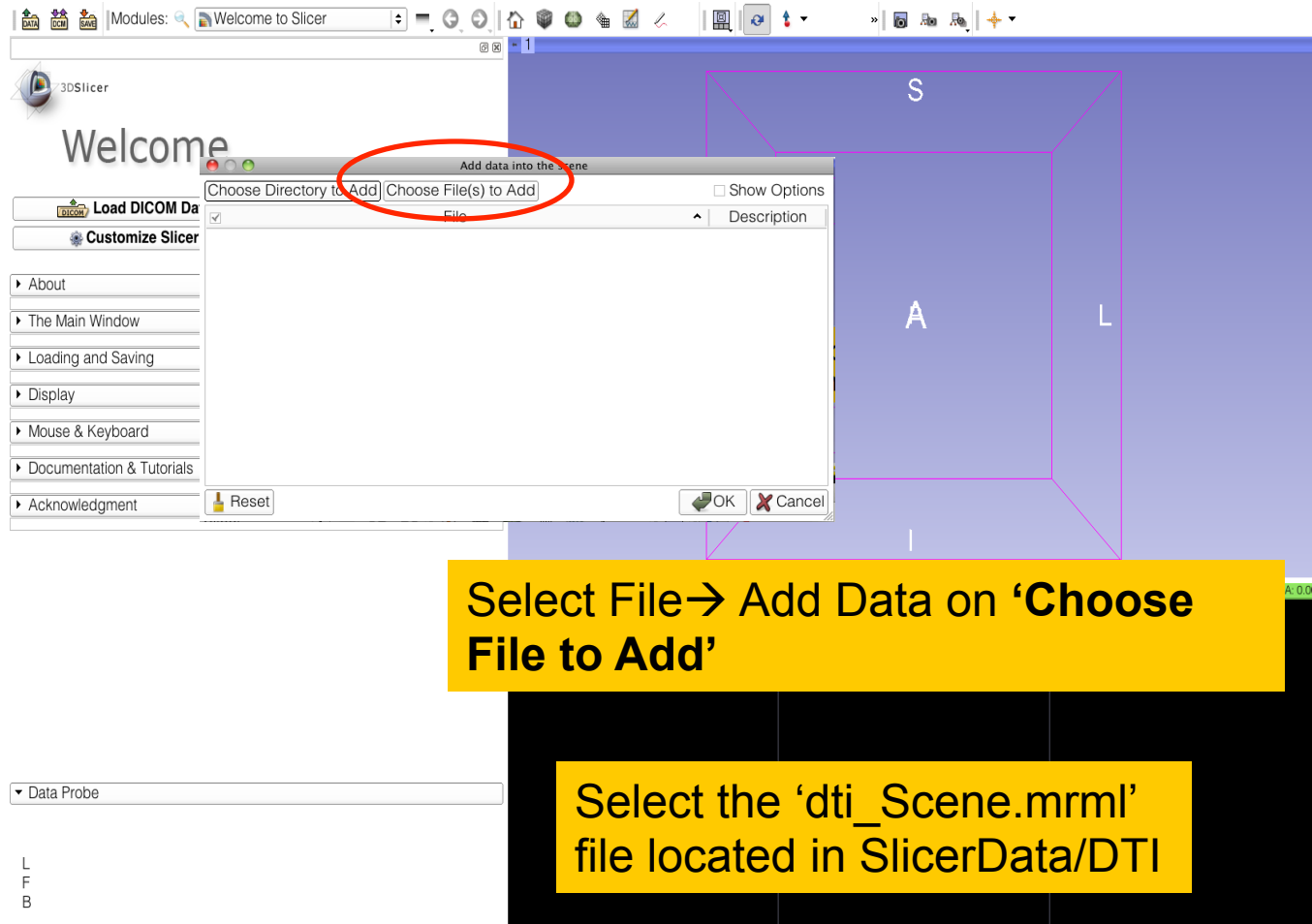


3D  
Visualization



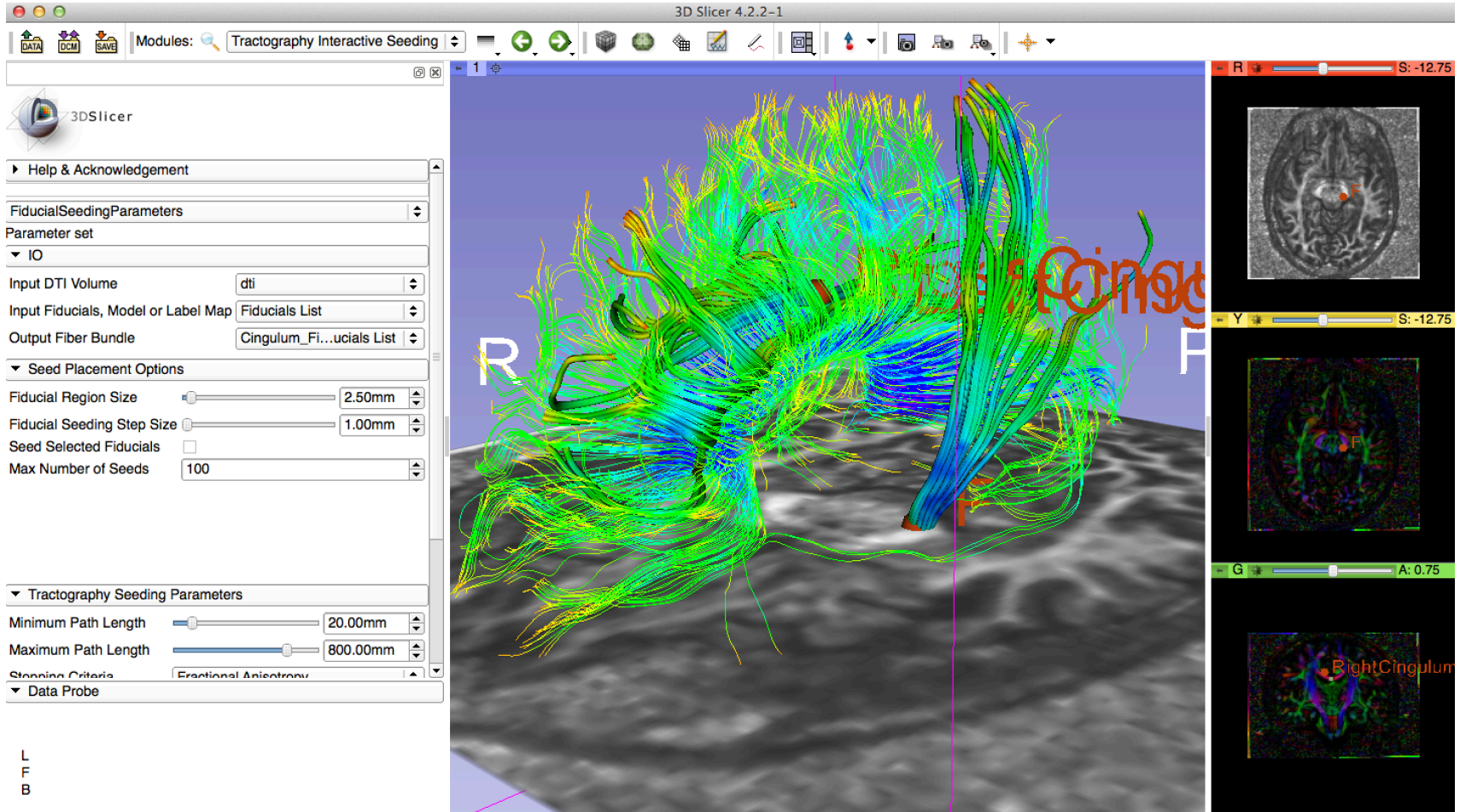


# Loading the DTI Scene



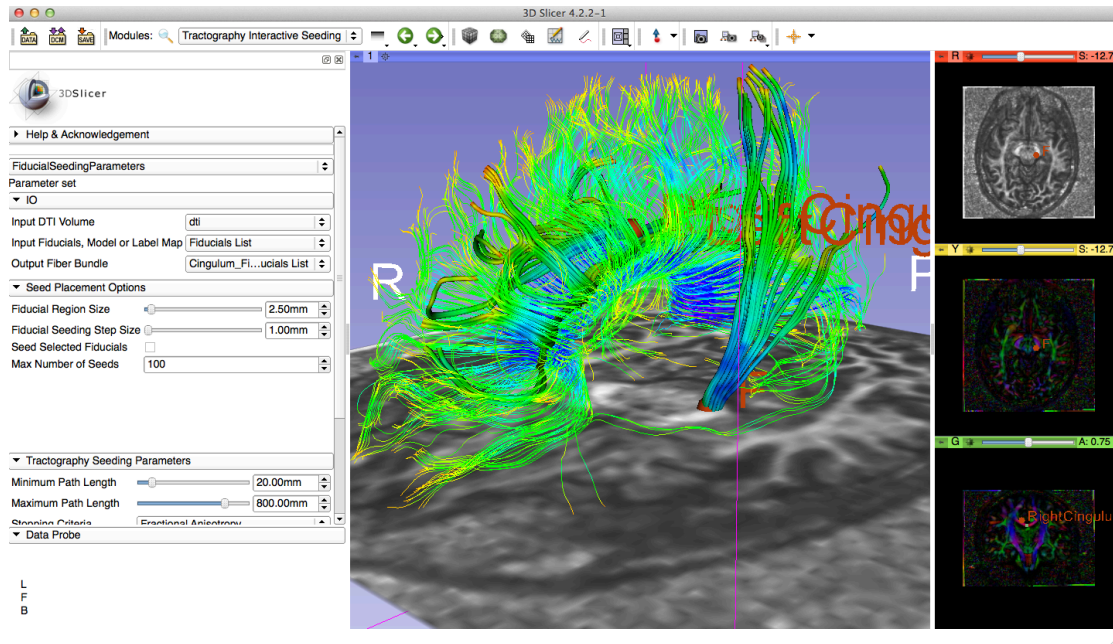


# DTI Scene

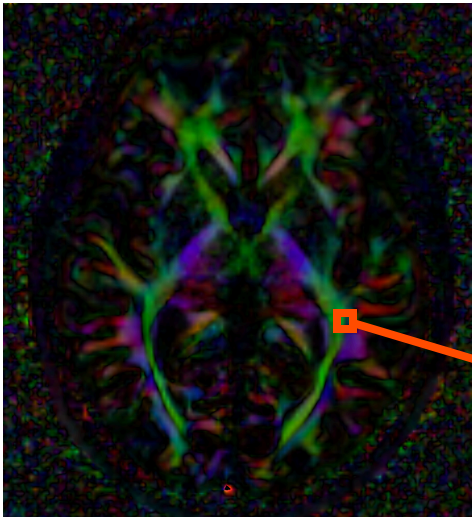




# DTI Scene



The DTI Scene contains a pre-computed DTI volume and corresponding FA map. Slicer displays the tractography reconstructions of part of the corpus callosum, left and right cingulum.



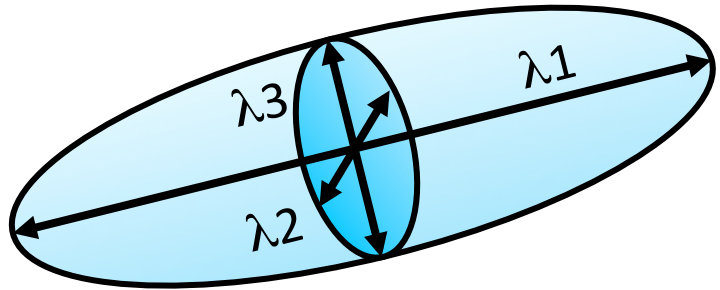
$$S_i = S_0 e^{-b \hat{g}_i^T \underline{D} \hat{g}_i}$$

Stejskal-Tanner equation (1965)

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

The diffusion tensor  $\underline{\mathbf{D}}$  in the voxel (I,J,K) is a 3x3 symmetric matrix.

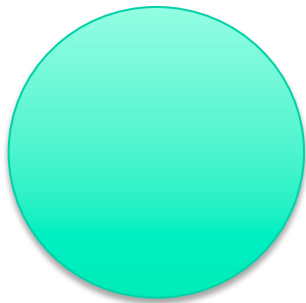
- The diffusion tensor  $\underline{D}$  in the voxel (I,J,K) can be visualized as an ellipsoid, with the eigenvectors indicating the directions of the principal axes, and the square root of the eigenvalues defining the ellipsoidal radii.
- Scalar maps can be derived from the rotationally invariant eigenvalues  $\lambda_1$ ,  $\lambda_2$ ,  $\lambda_3$  to characterize the size and shape of the diffusion tensor.





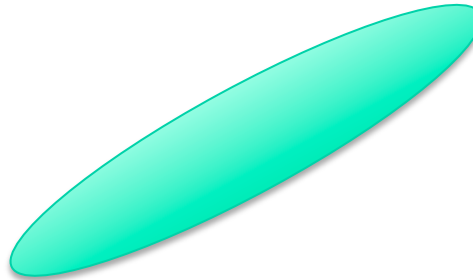
# Diffusion Tensor Shape

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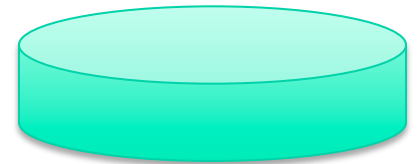
$$\lambda_1 = \lambda_2 = \lambda_3$$

Isotropic media  
(CSF, gray matter)



$$\lambda_1 \gg \lambda_2, \lambda_3$$

Anisotropic media  
(white matter)



$$\lambda_1 \sim \lambda_2 \gg \lambda_3$$

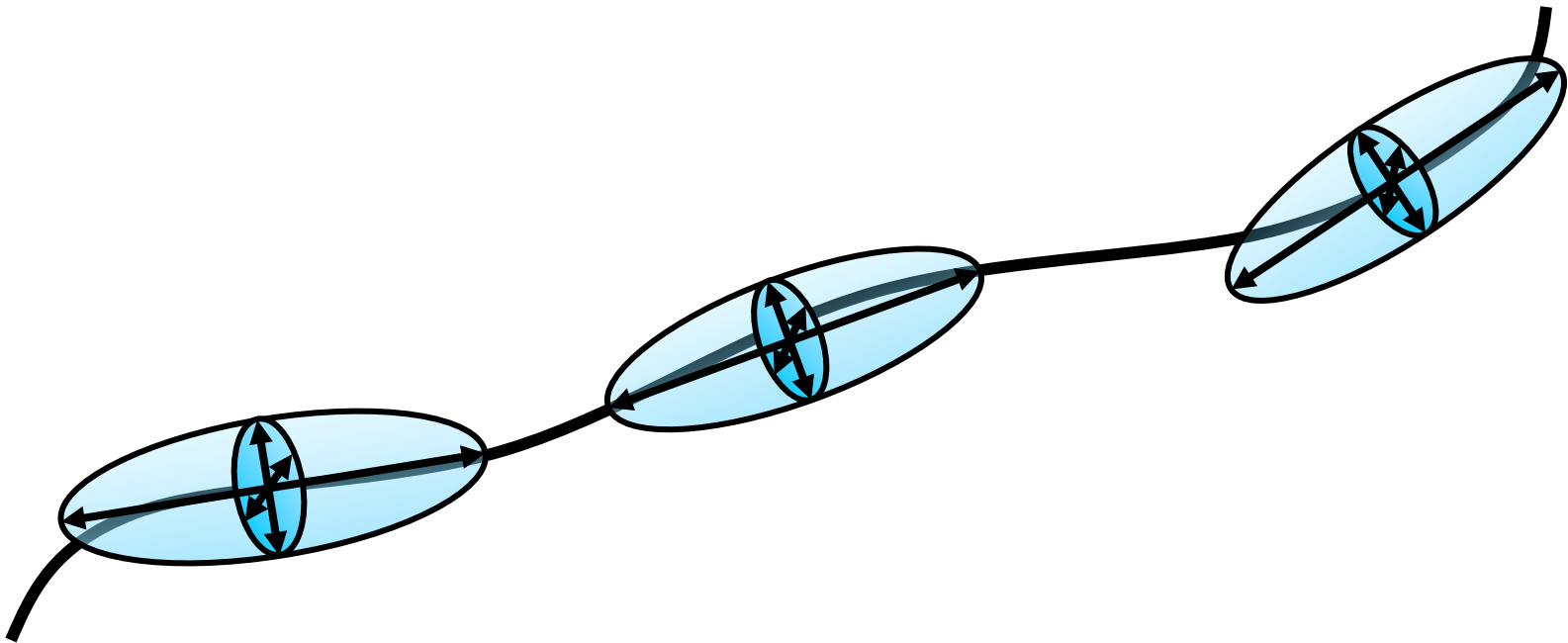
- Tractography can be defined as the virtual reconstruction of the trajectory of water molecules along white matter bundles.
- DTI tracts provide a mathematical representation of the underlying white matter anatomy.
- Each voxel contains hundreds of thousands of axon fibers: size of a voxel  $\sim 1\text{-}5\text{ mm}$ ; diameter of an axon  $\sim 0.1\text{-}10\ \mu\text{m}$   
→ A DTI tract is not equivalent to a real fiber.



# Streamline tractography

---

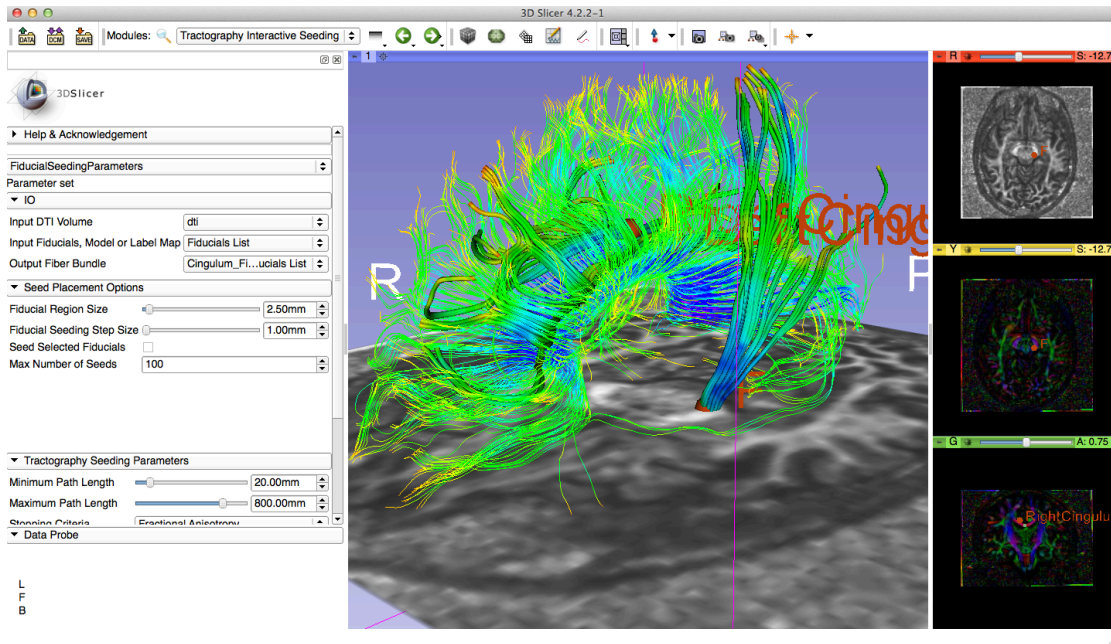
Underlying Assumption: the orientation of the fibers is collinear with the direction of the principal eigenvector







# DTI Scene



In this example, the tractography reconstruction of the corpus callosum has been generated using the **LabelMap Seeding** module;



# LabelMap Seeding Module

3D Slicer 4.2.2-1

Modules: Tractography Label Map Seeding

3DSlicer

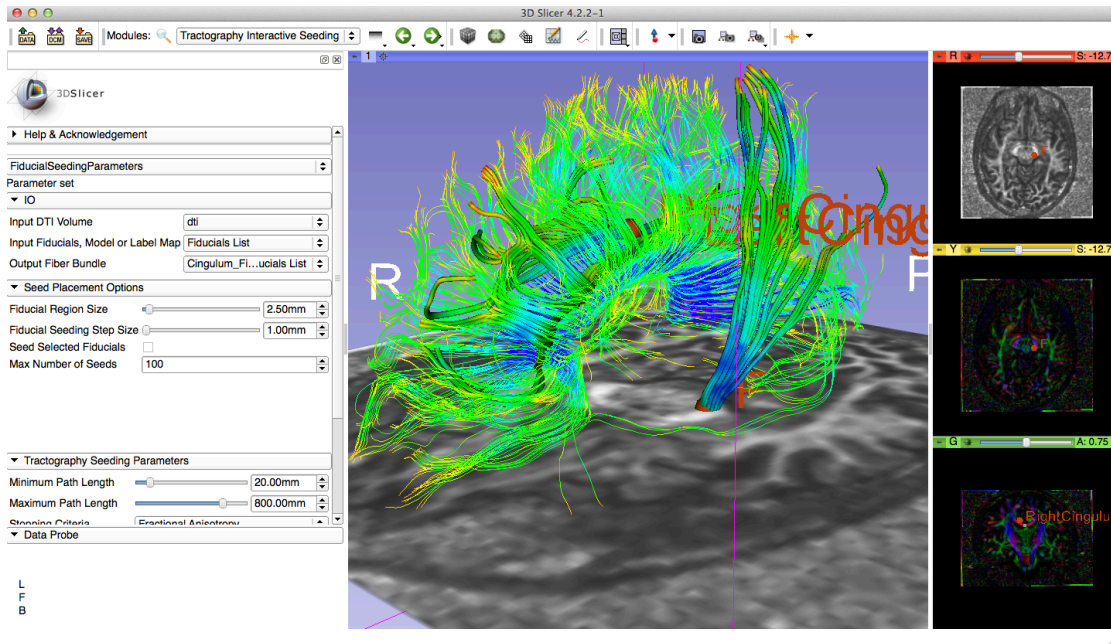
- Help & Acknowledgement
- Tractography Label Map Seeding
  - Parameter set: Tractography Label Map Seeding
  - Status: Idle
  - IO
    - Input DTI Volume: dti
    - Input Label Map: fa-label
    - Output Fiber Bundle: corpusCallosum
  - Seed Placement Options
    - Use Index Space:
    - Seed Spacing: 2.00
    - Random Grid:
    - Linear Measure Start Threshold: 0.3
  - Tractography Seeding Parameters
    - Minimum Path Length: 20.00
    - Maximum Length: 800.00
    - Stopping Criteria:
      - LinearMeasure
      - FractionalAnisotropy
    - Stopping Value: 0.25
  - Data Probe

L  
F  
B

R: -13.99  
Y: R: 2.25  
G: A: -4.99



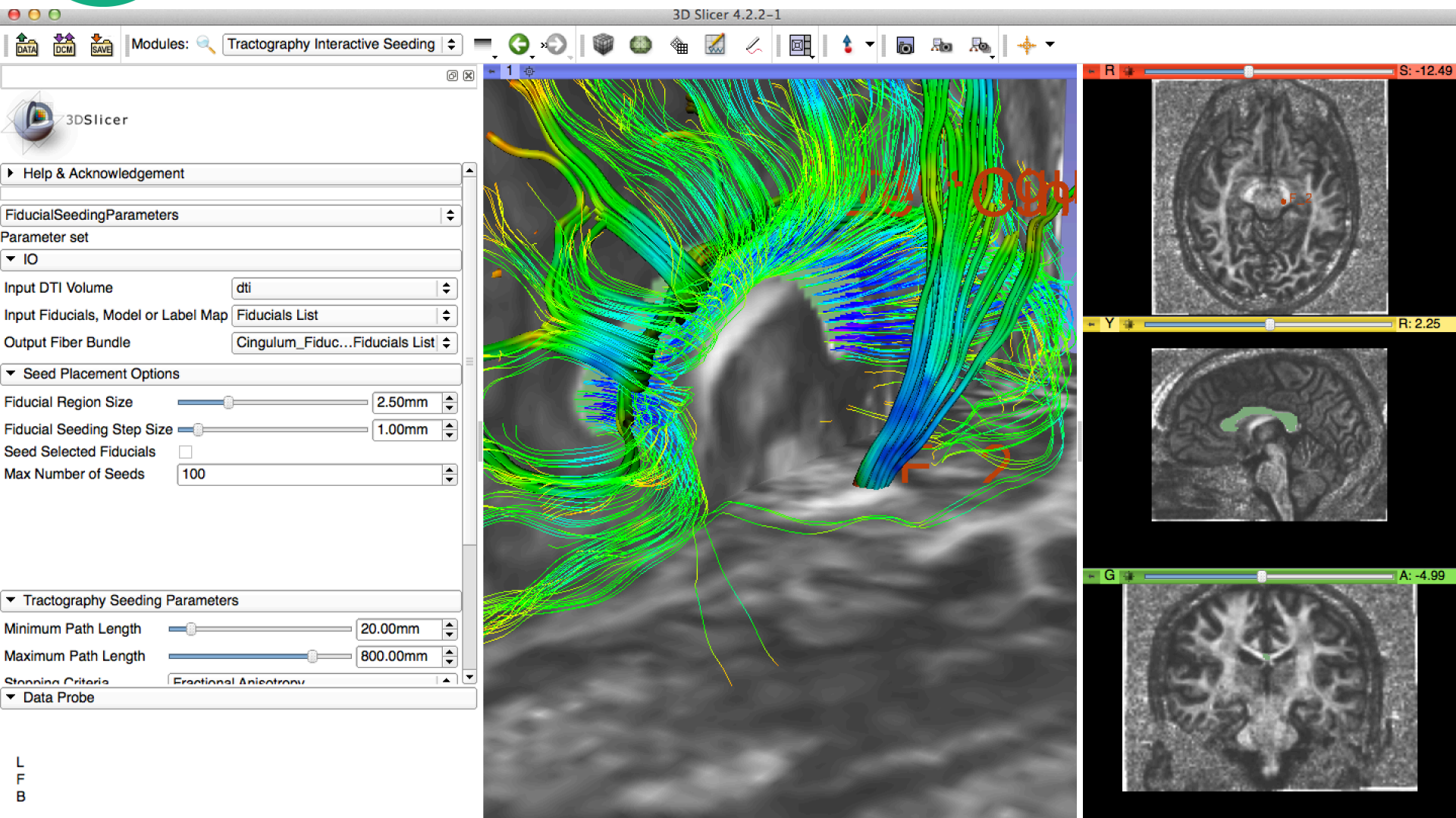
# DTI Scene



In this example, the tractography reconstruction of the the cingulum has been generated using the **Interactive Tractography Seeding** module.



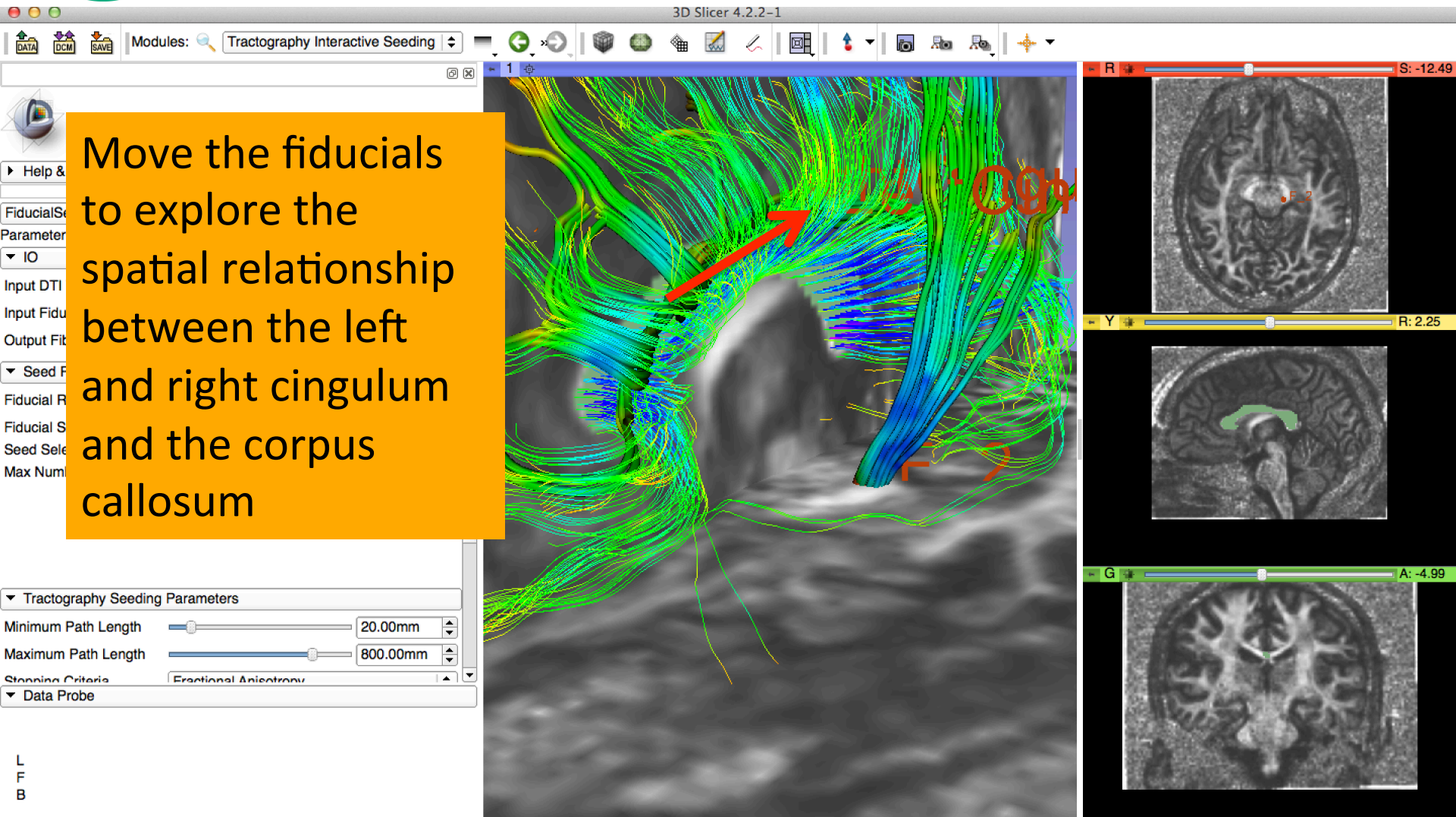
# Interactive Tractography Seeding





# Interactive Tractography Seeding

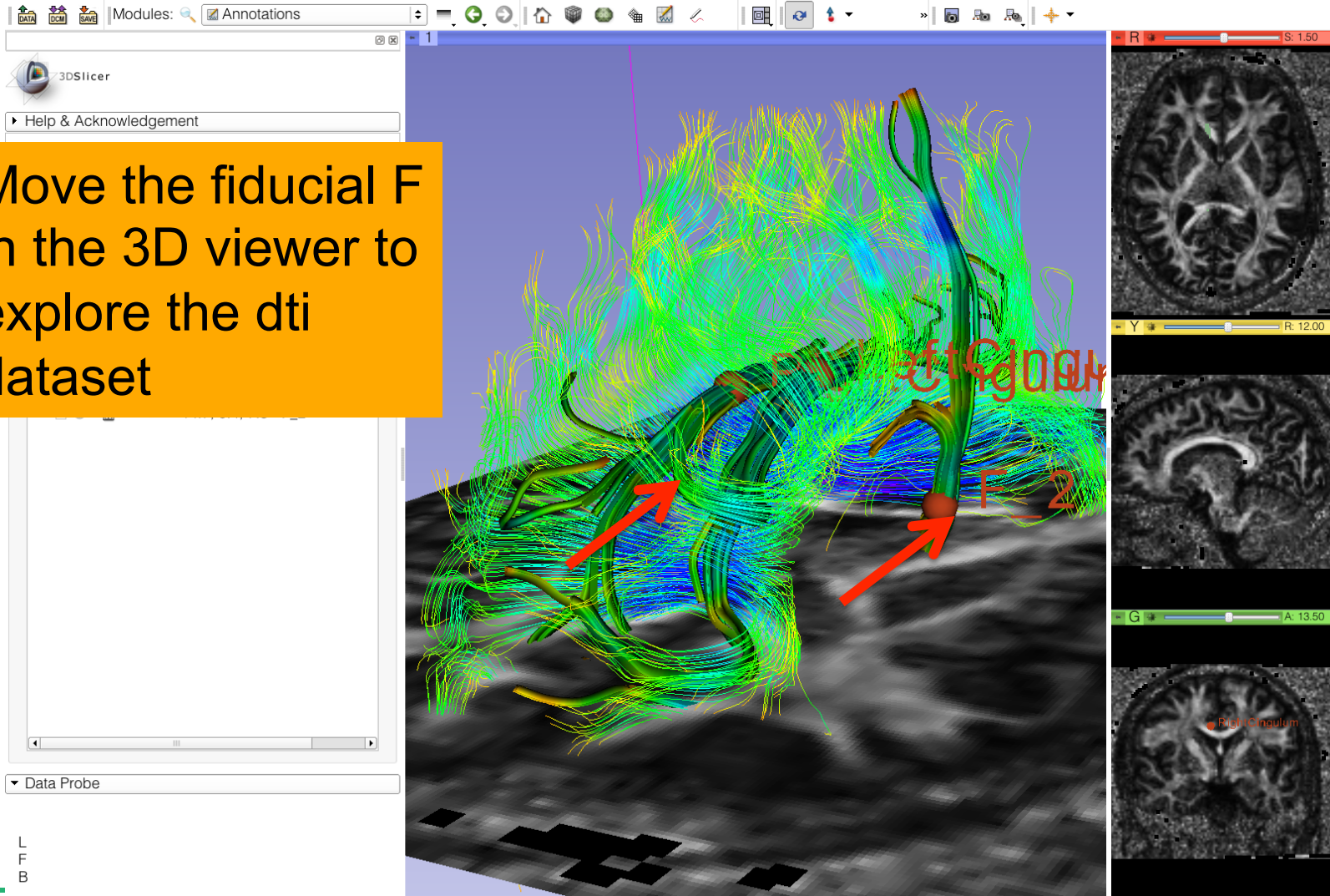
Move the fiducials to explore the spatial relationship between the left and right cingulum and the corpus callosum





# Fiducial Seeding

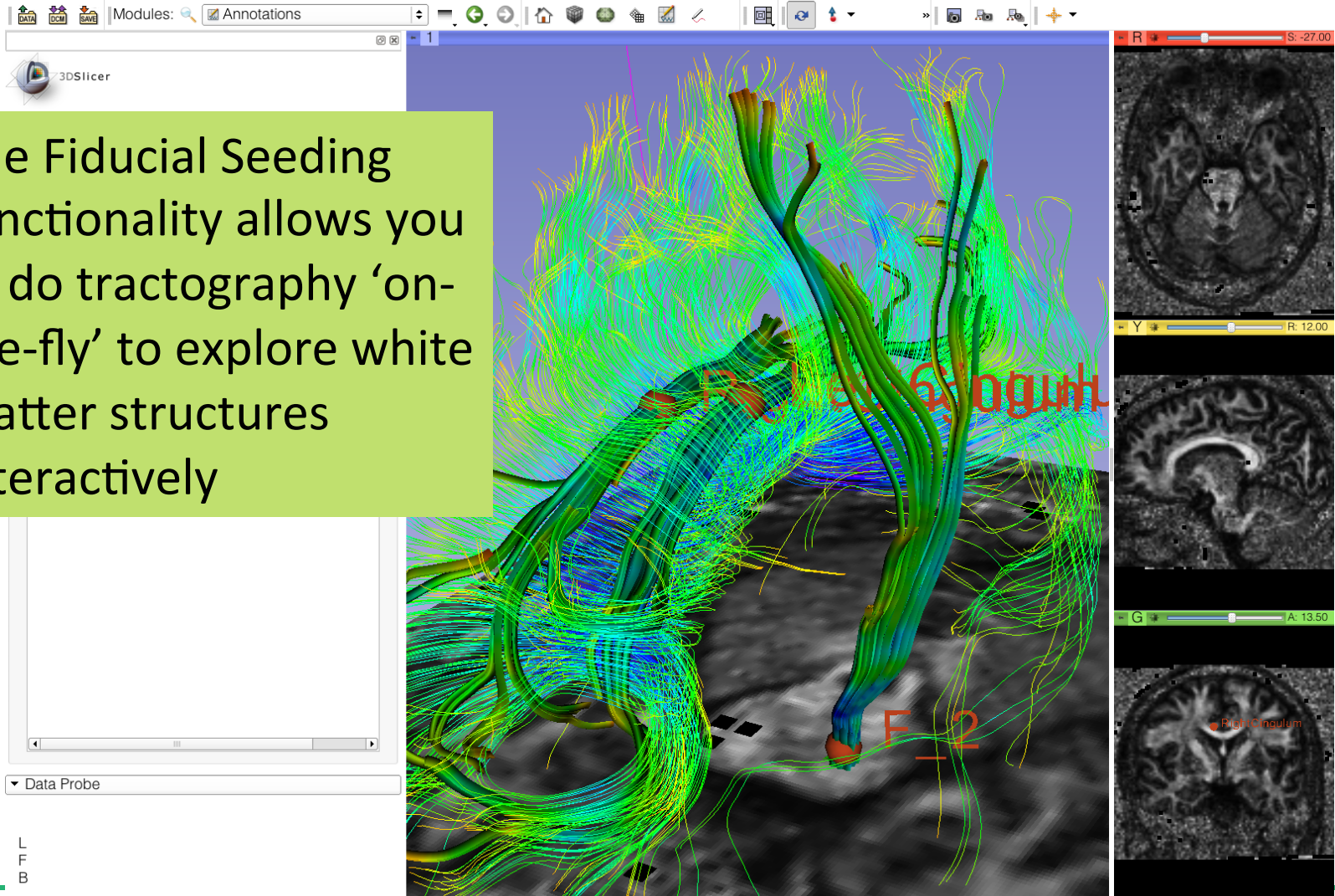
Move the fiducial F in the 3D viewer to explore the dti dataset





# Tractography 'on-the-fly'

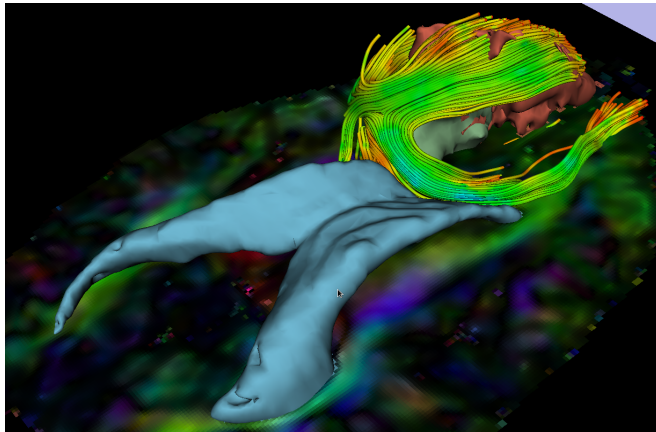
The Fiducial Seeding functionality allows you to do tractography 'on-the-fly' to explore white matter structures interactively





# Going Further

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- DTI tractography can be used to guide resection of tumor located in eloquent areas
- However, validation of DTI findings in clinical settings has yet to be established





# MICCAI DTI Challenge

- International collaborative effort on the validation of DTI tractography for neurosurgical planning
- Standardized comparison of tractography methods on patient data
- Working group of DTI Experts, Practising neurosurgeons, tractography algorithms developers and neuroradiologists
- <http://dti-challenge.org>

14<sup>th</sup> International Conference on Medical Image Computing and Computer Assisted Intervention

18-22 September  
**MICCAI 2011**  
Toronto CANADA



**DTI Tractography for Neurosurgical Planning: A Grand Challenge**



MICCAI 2011 Workshop  
Sunday September 18, 9am-6pm  
Westin Harbour Castle  
Toronto, Canada

Workshop Faculty

Soma Pujol, PhD, Surgical Planning Laboratory, Harvard Medical School  
Raz Kikinis, MD, Surgical Planning Laboratory, Harvard Medical School  
Alexandra Golby, MD, Brigham and Women's Hospital, Harvard Medical School  
Guido Bello, PhD, The Scientific Computing and Imaging Institute, University of Utah  
Martin Styner, PhD, NeuroImage Research and Analysis Laboratory, University of North Carolina  
William Wells, PhD, Surgical Planning Laboratory, Harvard Medical School  
Carl-Fredrik Westin, PhD, Laboratory of Mathematics in Imaging, Harvard Medical School  
Sylvain Goutard, MSc, The Scientific Computing and Imaging Institute, University of Utah

National Alliance for Medical Image Computing  
[http://www.na-mic.org/workshops/Workshop\\_DTITractography\\_Challenge\\_MICCAI\\_2011](http://www.na-mic.org/workshops/Workshop_DTITractography_Challenge_MICCAI_2011)

MICCAI 2012 DTI Tractography Challenge  
Second Edition

INTRODUCTION THE CHALLENGE FACULTY KEYNOTE SPEAKER DATA REGISTRATION CONTACT

Welcome to the 2nd edition of the MICCAI DTI Tractography Challenge. The workshop will be held on Monday October 1st, 2012 as part of the 15th International Conference on Medical Image Computing and Computer Assisted Intervention (MICCAI 2012).



The 15<sup>th</sup> International Conference on Medical Image Computing and Computer Assisted Intervention  
1-5 October 2012 - Acropolis Convention Center - Nice, France





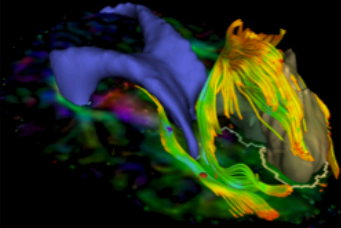
# Third edition: Sept 22, 2013, Nagoya, Japan

MICCAI 2013 DTI Challenge [Introduction](#) [Datasets](#) [Faculty](#) [Program](#) [Submission](#) [Contact](#)

## MICCAI 2013 DTI Tractography Challenge

Sunday September 22, 2013, Nagoya, Japan

[Learn more »](#)



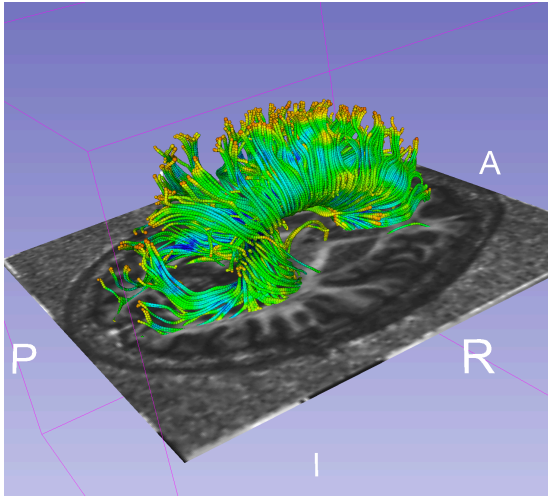
DTI Tractography Challenge on Peritumoral White Matter Anatomy for Neurosurgical Decision-Making



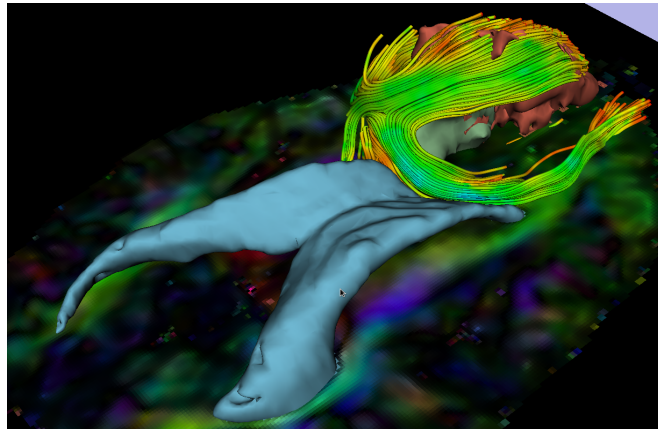


# DTI training tutorials in Slicer4:

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- Diffusion MR Imaging tutorial
- Exploring White Matter peritumoral fibers for exploration for neurosurgical planning
- Tutorials and datasets available at [www.slicer.org](http://www.slicer.org)





# Acknowledgments

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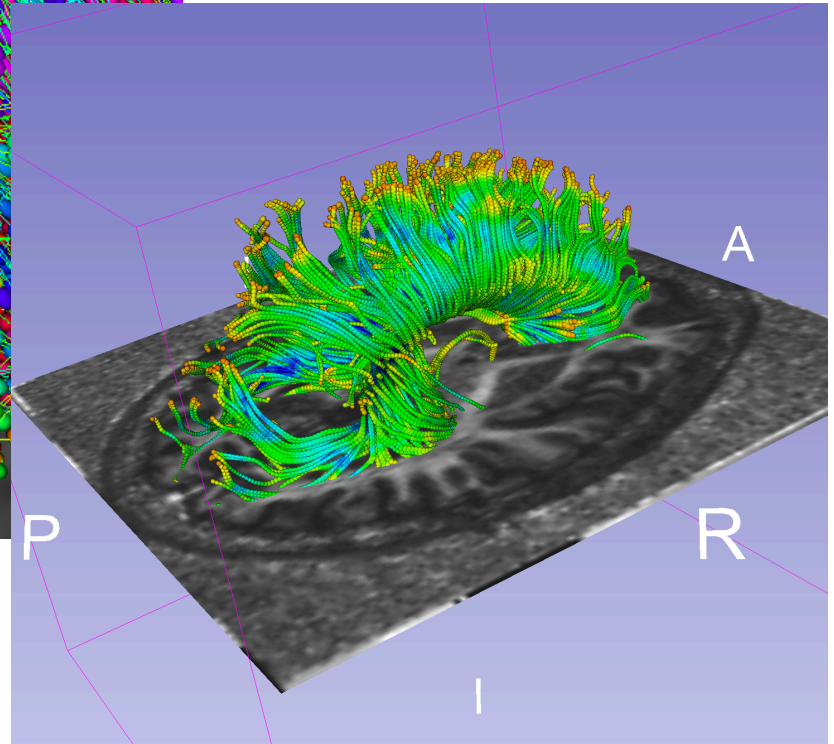
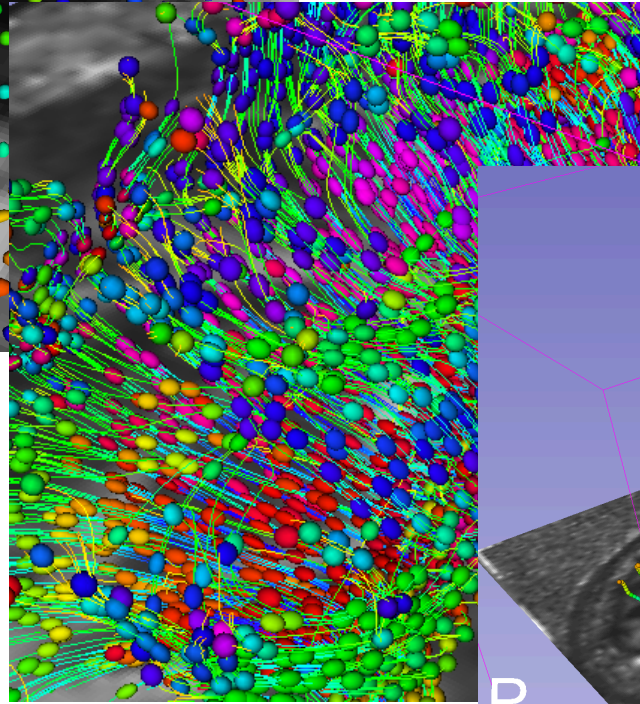
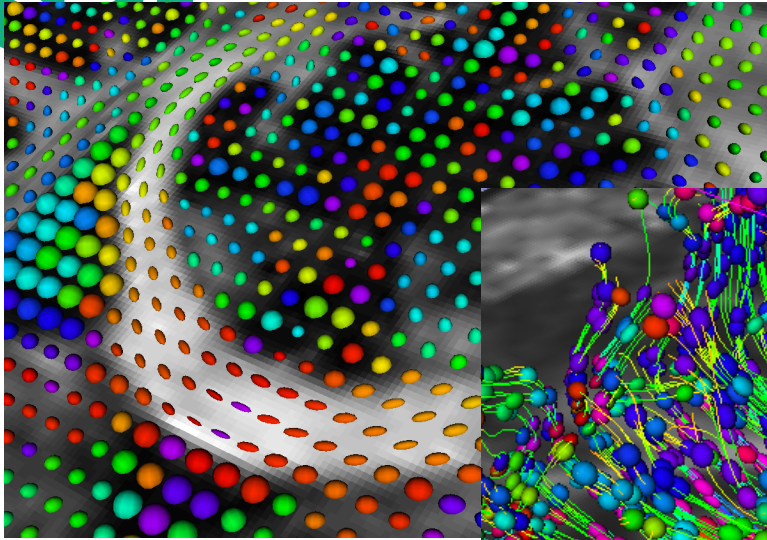
NIH P41RR013218



# Slicer Community

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- [www.slicer.org](http://www.slicer.org)
- Mailing lists:  
[slicer-user@bwh.harvard.edu](mailto:slicer-user@bwh.harvard.edu)  
[slicer-devel@bwh.harvard.edu](mailto:slicer-devel@bwh.harvard.edu)



Contact:  
[spujol@bwh.harvard.edu](mailto:spujol@bwh.harvard.edu)



# Conclusion

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- Slicer is an open-source research platform for the rapid development of biomedical image analysis tools.
- Slicer community is open with contributors from all over the world
- Slicer is a versatile platform for translational research and subject specific analysis of biomedical image data





# Acknowledgments

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