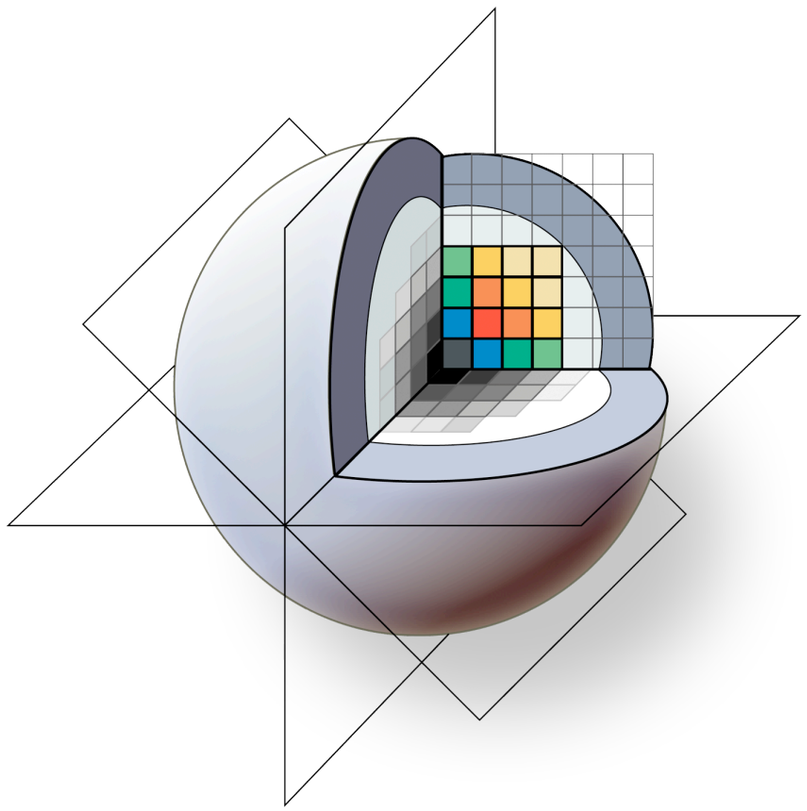


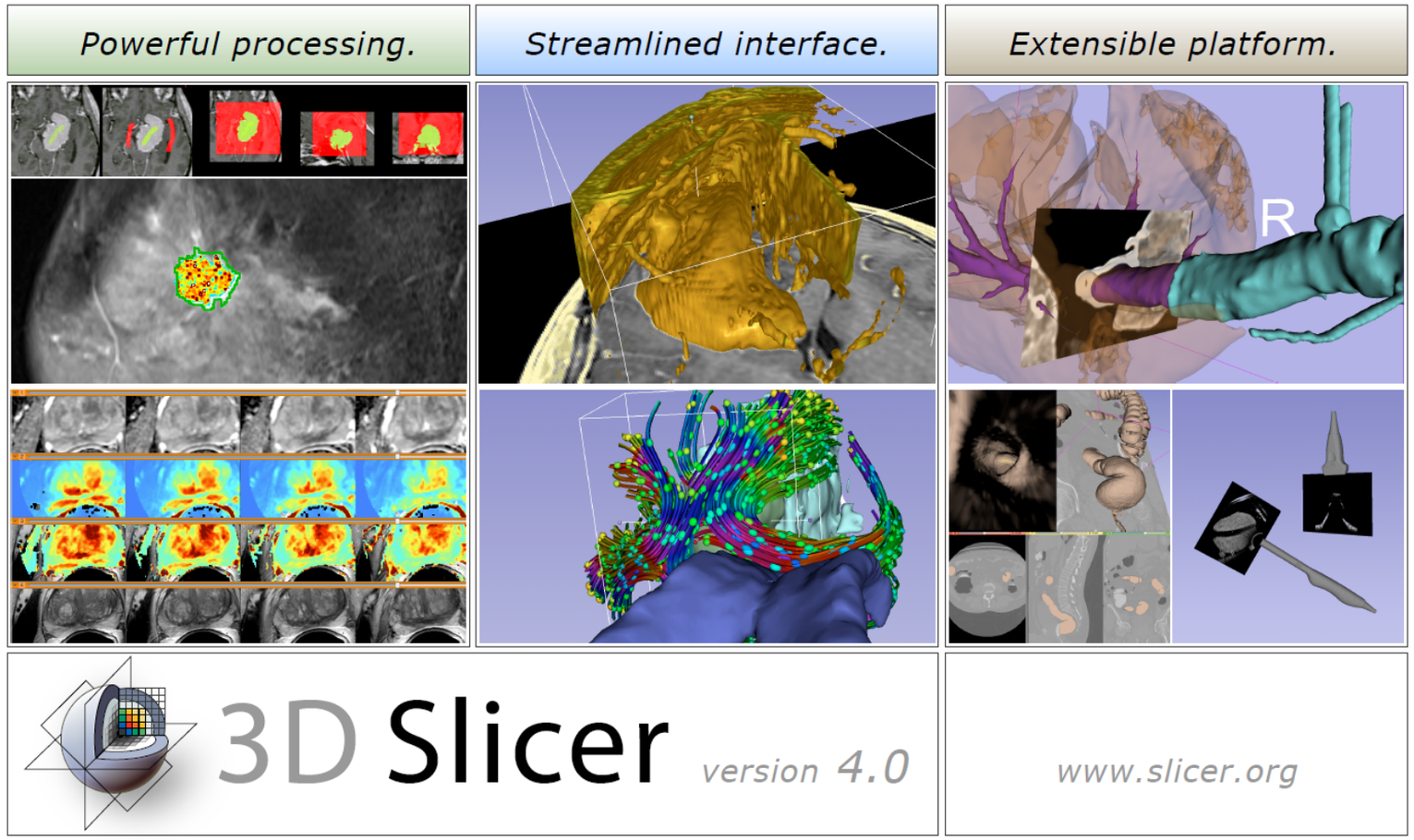
3D Slicer: A Free, Open Source and Extensible Platform For Medical Image Analysis and Visualization

Sonia Pujol, Ph.D., Steve Pieper, Ph.D., Andriy Fedorov, Ph.D., Ron Kikinis, M.D.

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

3D Slicer: An overview

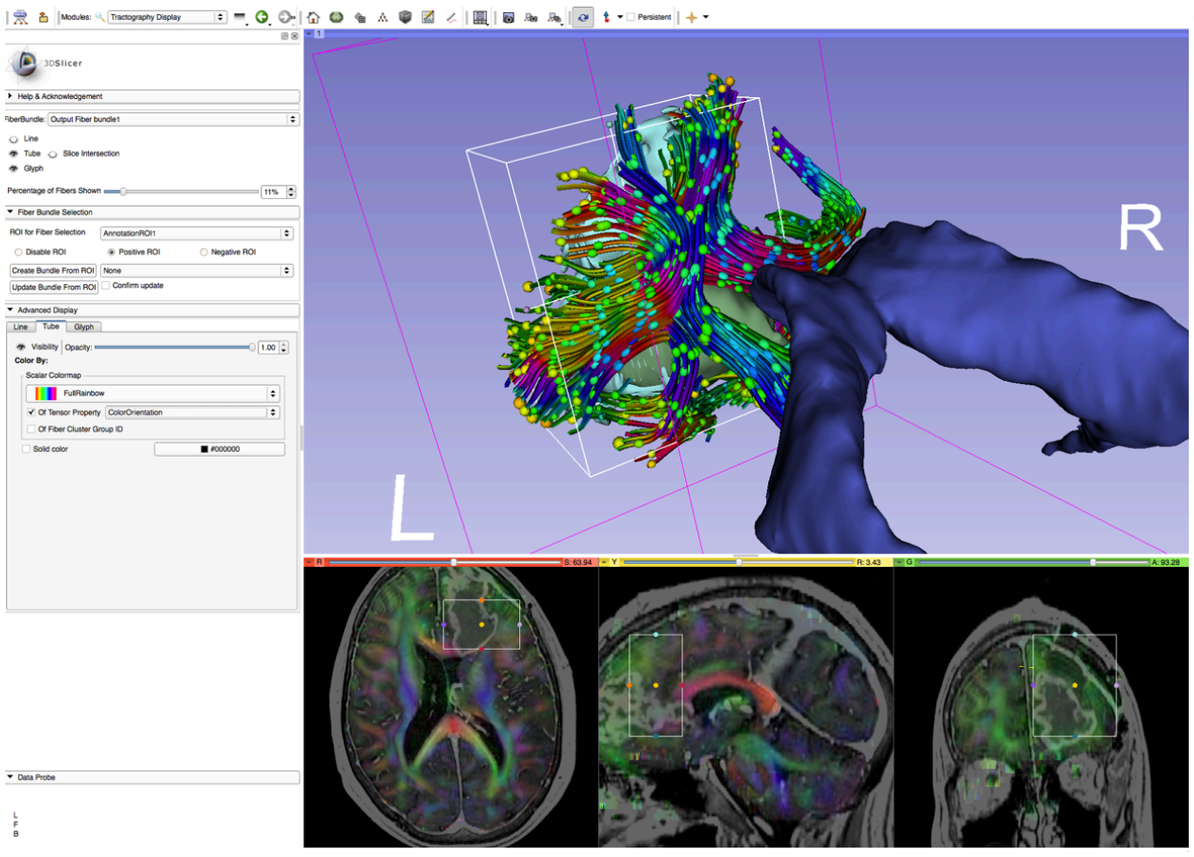
3D Slicer is a multi-platform, free and open source software package for visualization and medical image computing.



www.slicer.org

3D Slicer: An overview

The software platform is community created for the purpose of subject specific medical image analysis and visualization. Slicer includes support for:

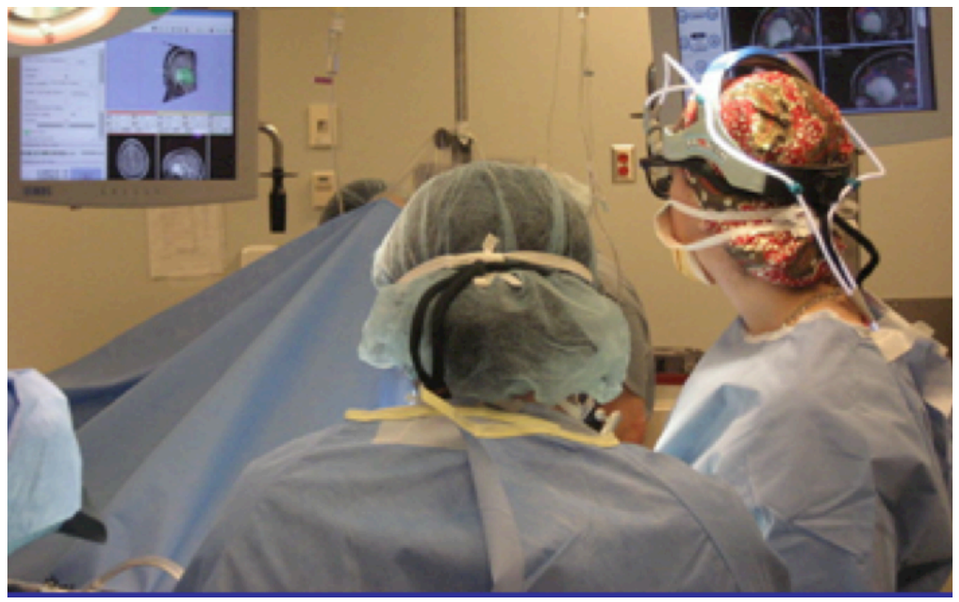


Using an ROI to crop streamlines from a whole brain tractography. The streamlines display color by orientation, the ellipsoids are displaying fractional anisotropy.

- Multi-modality imaging including, MRI, CT, US, nuclear medicine, and microscopy
- Multi-organ from head to toe
- Bidirectional interface for devices and scanners
- Expandable and interfaced to multiple toolkits

Translational research

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

3D Slicer: An overview

Types of users:

Algorithm researchers who work within 3DSlicer's development environment and with associated toolkits)

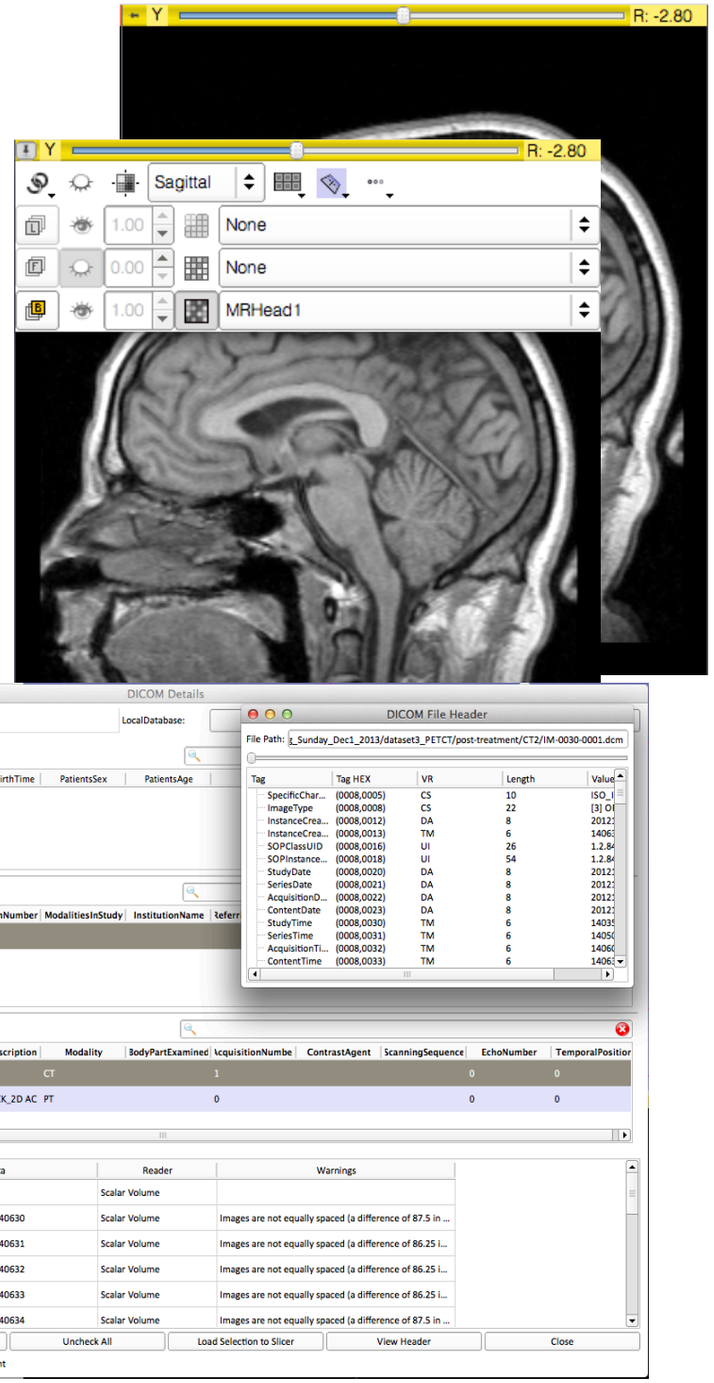
Biomedical engineers (who rely on 3DSlicer's interactive enironment and scripting capabilities)

Application scientists (who use 3DSlicer as a desktop application and turnkey system)

Core use scenarios:

- Longitudinal and multi-channel dataset analysis
- Individual and group analysis
- Real-time control and tracking in the operating theater
- Neurosurgical planning and guidance

3D Slicer: What's different in 4.3?

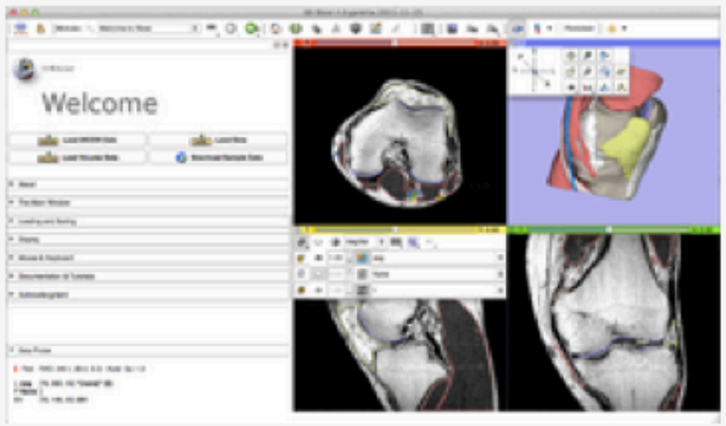


- Qt-based GUI
- Streamlined user- and developer-level interfaces
- Improved DICOM support
- 64-bit support for all platforms

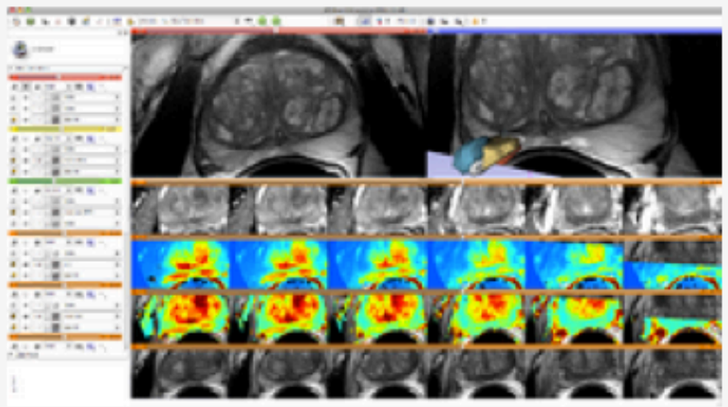
3D Slicer: What has not changed?

- Free Open Source Software
  - Free to use both in academic and commercial projects
- NA-MIC Kit foundation tools and robust software development practices
- Cross-platform portability: Win / Mac / Linux
- Support of user and developer communities

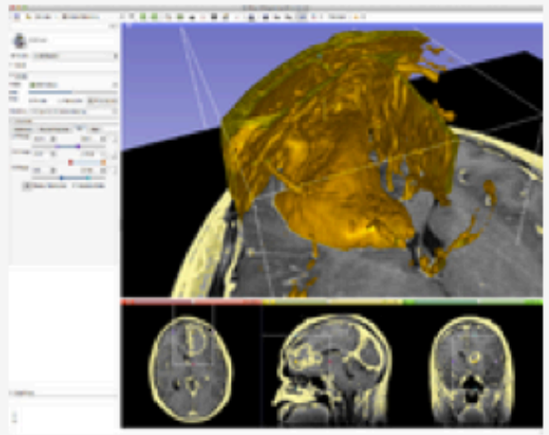
3D Slicer: Version 4 Highlights



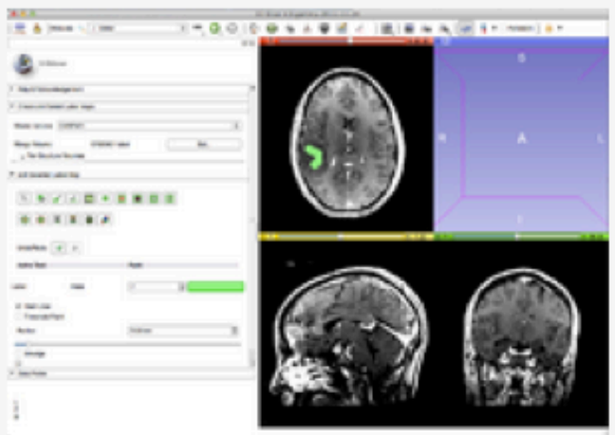
Main GUI



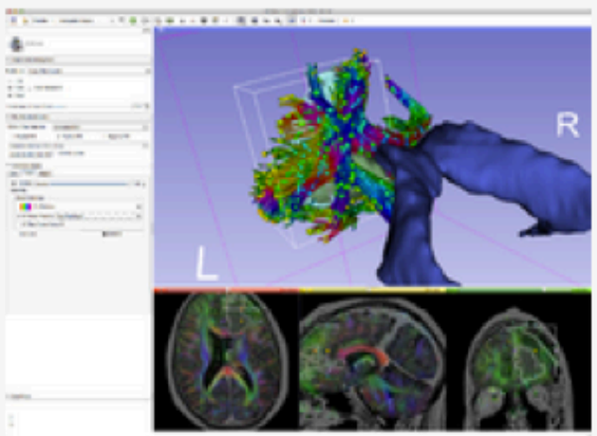
Layouts



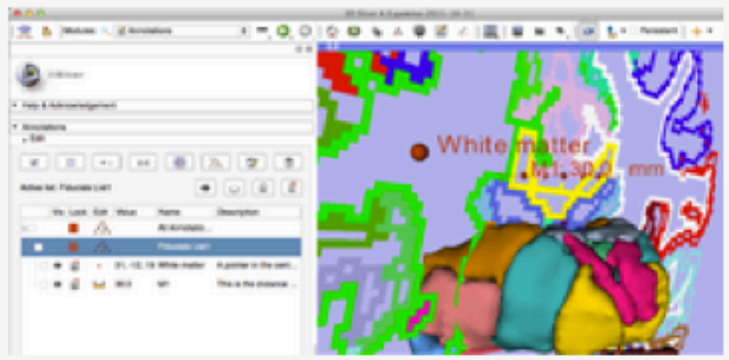
Volume Rendering



Editor

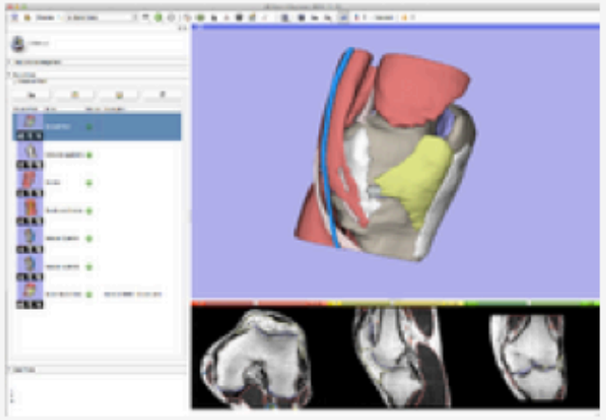


Diffusion: Fiber Display

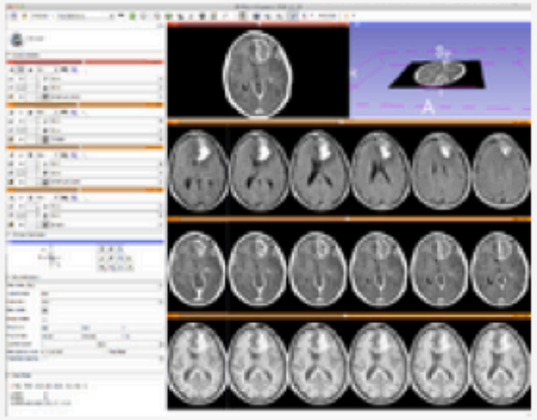


Annotations

3D Slicer: Version 4 Highlights

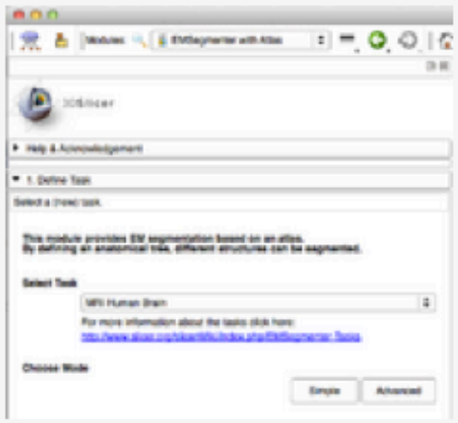


Sceneviews



View controllers

Volume module



EM segmenter

Slicer welcome module

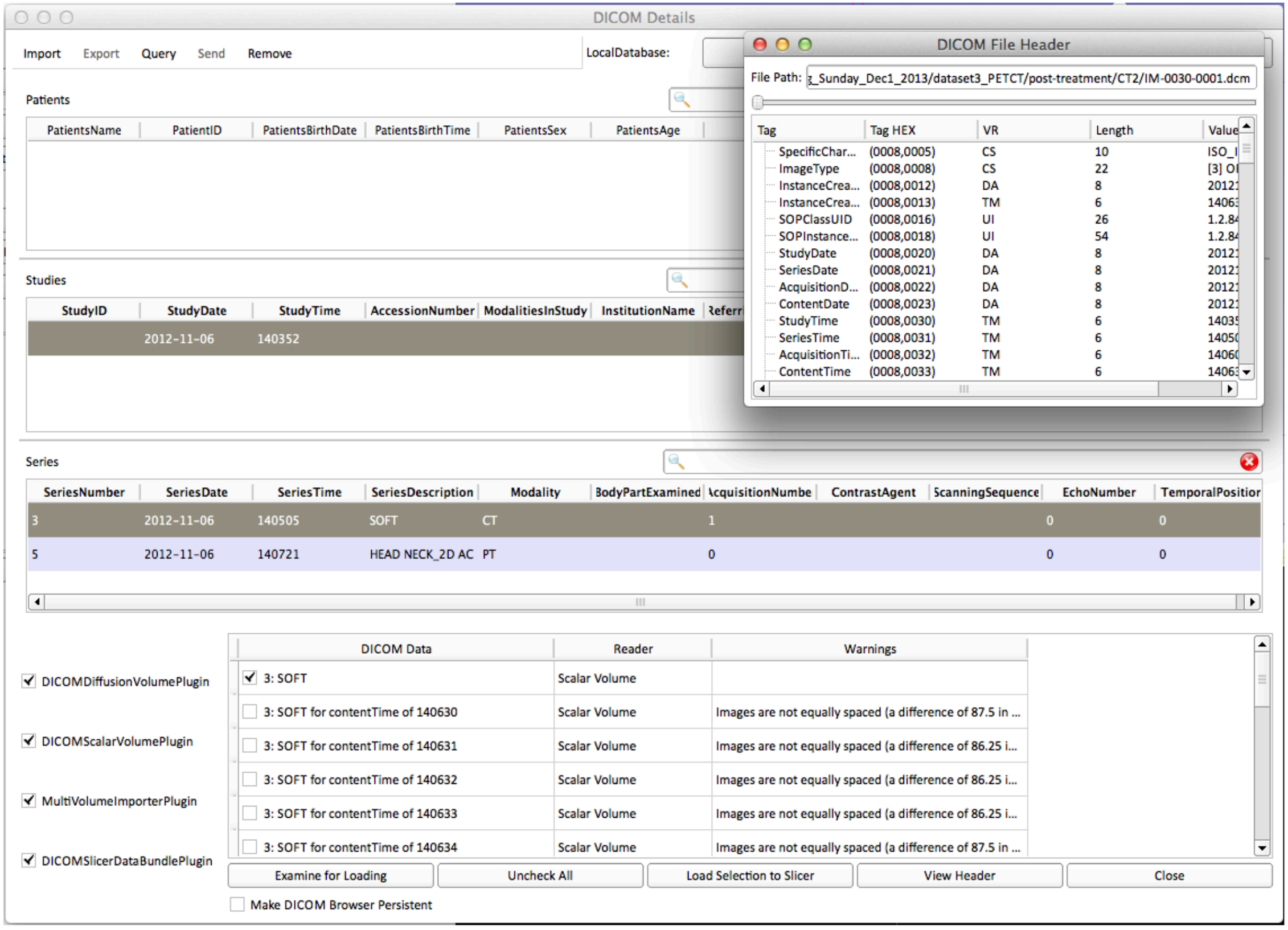
Data probe

3D Slicer: File Formats

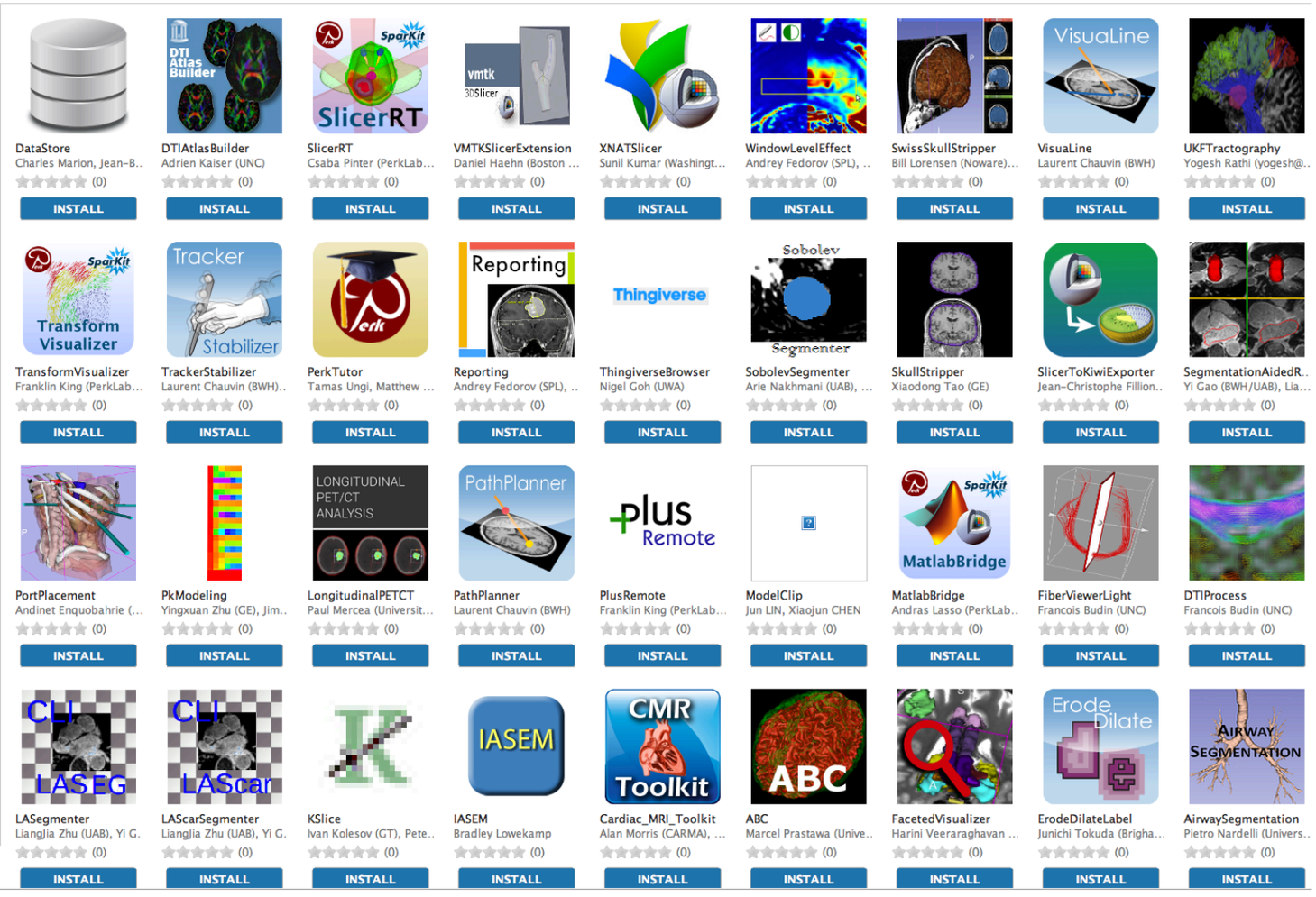
Format	File Name Extensions	Read	Write	
Scenes				
MRML (Medical Reality Markup Language File)	.mrml	yes	yes	MRML file
MRB (Medical Reality Bundle)	.mrb, .zip	yes	yes (.mrb extension only)	MRB is a t including a
Raster Images *this includes 2D and 3D images, and more complicated types such as DWI or DTI*				
DICOM	.dcm ...	yes[1]	no[2]	DICOM, D
NRRD	.nrrd, .nhdr	yes	yes	
MetaImage	.mhd, .mha	yes	yes	
VTK	.vtk	yes	yes	
Analyze	.hdr, .img, .img.gz	yes	yes	
NifTI	.nia, .nii, .nii.gz	yes	yes	
BMP	.bmp	yes	yes	
BioRad	.pic	yes	yes	
Brains2	.mask	yes	yes	
GIPL	.gipl .gipl.gz	yes	yes	
JPEG	.jpg, .jpeg	yes	yes	
LSM	.lsm	yes	yes	
PNG	.png	yes	yes	
Stimulate	.spr	yes	yes	
TIFF	.tif, .tiff	yes	yes	
MGH-NMR	.mgz	yes	yes	
MRC Electron Density	.mrc, .rec	yes	yes	
Models				
VTK Polygonal Data	.vtk	yes	yes	
VTK XML Polygonal Data	.vtp	yes	yes	
STL	.stl	yes	yes	
OBJ	.obj	yes	no	
Others (to be tested)	.g, .byu, .orig, .inflated, .sphere, .white, .smoothwm, .pial	yes	no	
Fiducials				
CSV	.fcsv	yes	yes	
Text	.txt	yes	yes	
Transforms				
Transform	.tfm, .mat	yes	yes	
Text	.txt	yes	yes	
Transfer Functions				
Volume Rendering properties	.vp	yes	yes	
Text	.txt	yes	yes	
Lookup tables				
Text	.txt, .ctbl	yes	yes	
Double Arrays				
CSV	.csv	yes	yes	

Slicer supports multiple images file formats including DICOM

3D Slicer: DICOM Networking



3D Slicer:Extension Manager



3D Slicer supports plug-ins called Slicer extensions available from the Extension Manager

Allows end-users to select extensions useful to them, without having to download the entire extension archive.

Built Nightly with Slicer

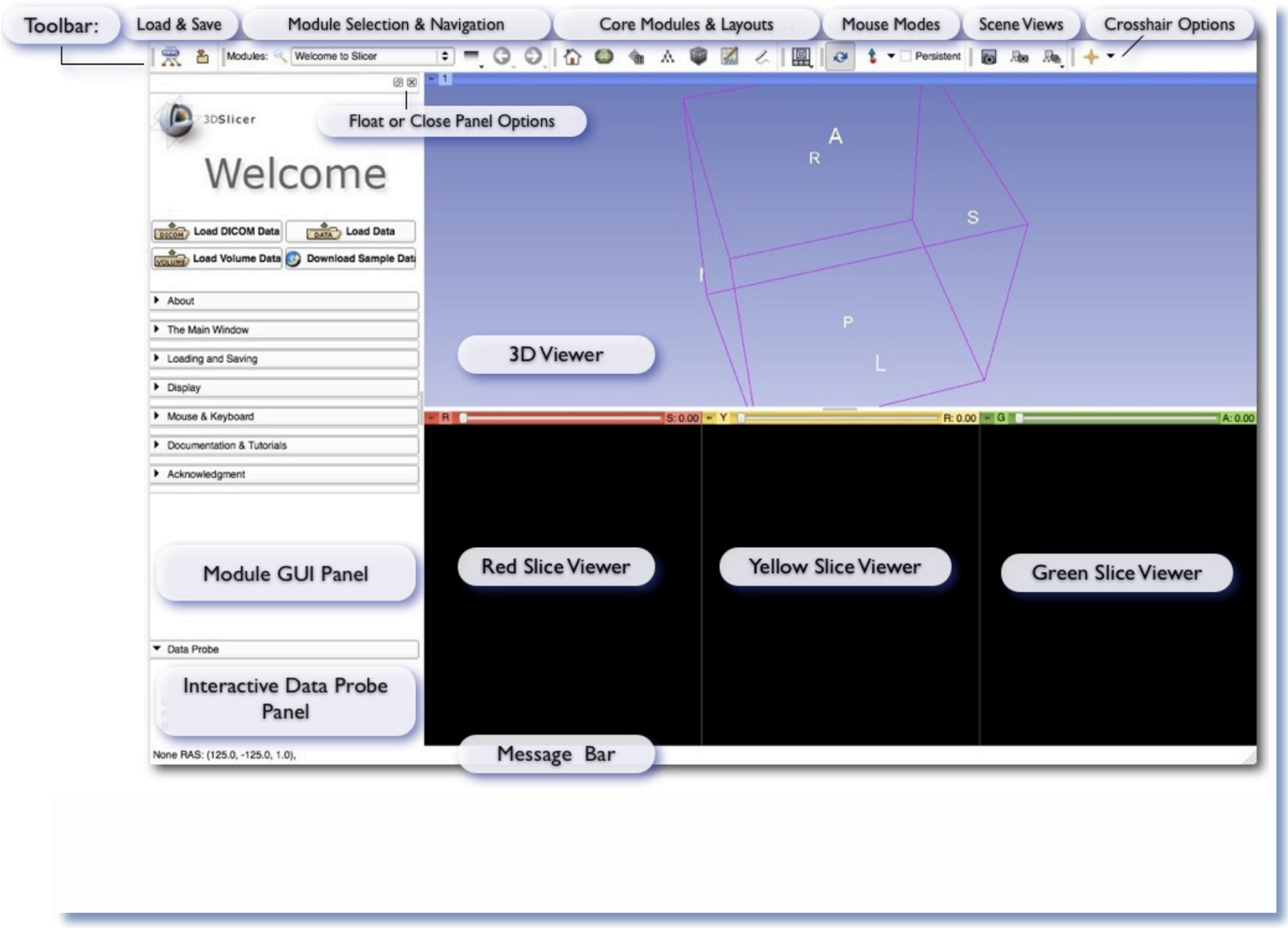
3D Slicer: What extensions afford...

- Keep the base package "lean and mean"
- Modules have individual identity
  - Per-module web site, svn, downloads, mailing lists, wiki…
- Users can customize their own subset of tools
- Easy to download compatible extensions
  - Analogous to Firefox extensions
  - Integrate extension builds into developer/nightly/release processs
- NITRC Supplement to NA-MIC providing additional infrastructure (Neuroimaging Informatics Tools and Resources Clearinghouse)
  - NITRC can host neuroimaging projects (gforge implementation)

3D Slicer: Integration options

Slicer Libs	• ModuleDescriptionParser • GenerateCLP • vtkITK • MRML	Non-slicer specific support libraries
Slicer Base	• Application logic • Widgets	Common infrastructure for Slicer applications
Built in modules	• Slice viewers • Models • Fiducials • Transforms	Full access to Slicer internals
Loadable modules	• Query Atlas • QDEC • Volume rendering • ChangeTracker • EMSegment	Full access to Slicer internals
Scripted modules	• Editor • Teem Two Tensor Tractography • VMTK	Limited access to Slicer internals
Command line modules	• Registration	Restricted access to Slicer internals
Daemon	• OpenIGTLink • Stochastic Tractography	Access to MRML

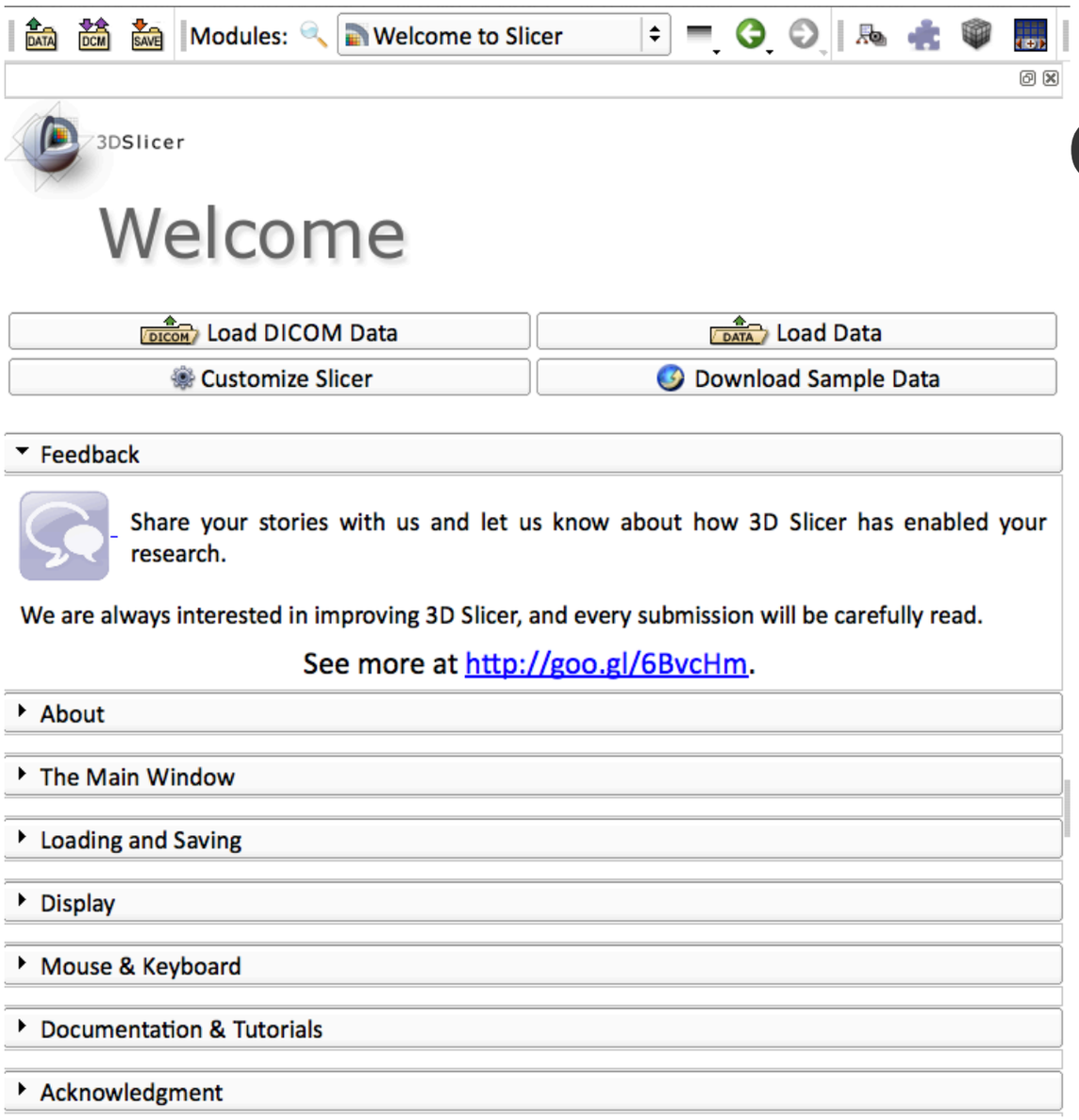
3D Slicer: Application Interface



User-centered design:

- User guidance and feedback incorporated into design process where possible
- Qt-based thin GUI layer
- Presentation layer independent of application logic & state
- Architecture supports scripting (Python) and command-line use

3D Slicer: Quick Start for New Users



Greetings and guidance from

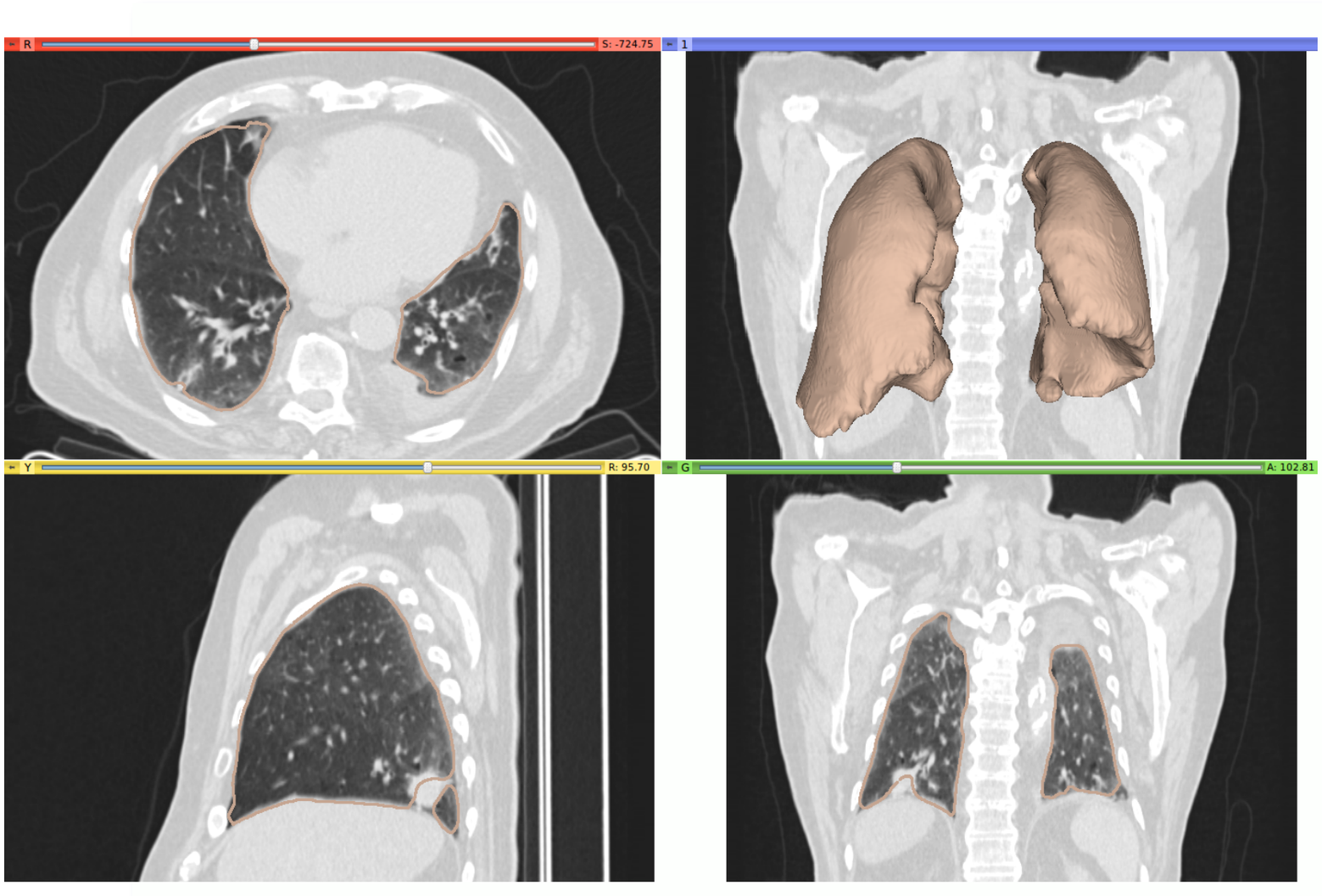
Slicer's Welcome Module

Default start-up module for new users:

- Brief friendly overview of the application interface
- Describes core modules
- Describes basic data loading and saving
- Provides tips for adjusting data display
- Describes how to change layouts
- Points users to more detailed resources
- and more...

3D Slicer: Segmentation Tools

Segmentation is required for defining features of interest in imaging data for quantification and analysis.

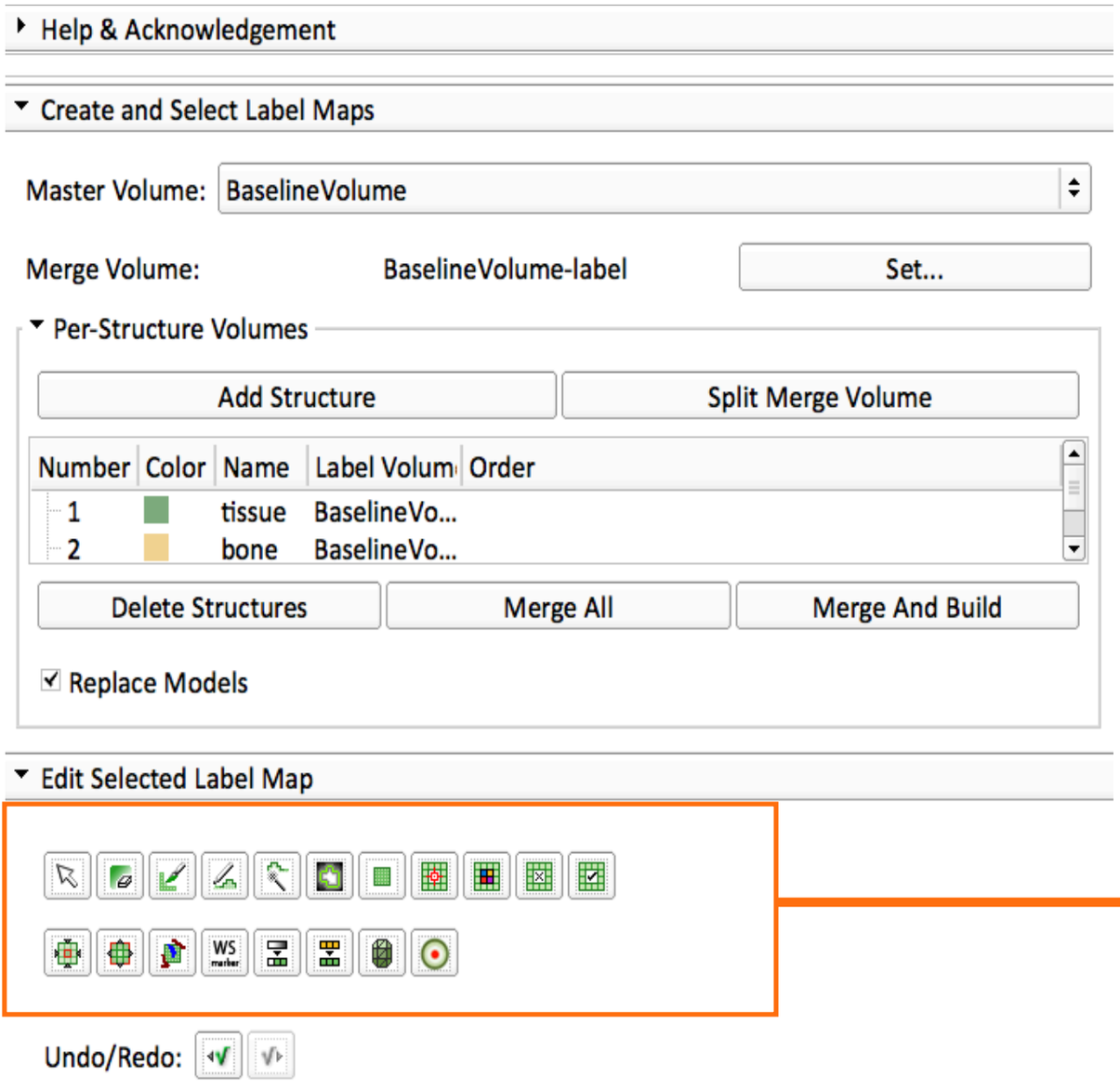


3D Slicer has a variety of interactive and automated segmentation methods:

- Editor Module for manual contouring and editing
- region growing and level sets
- graph cuts with gesture support
- EM-segmentation
- hierarchical brain segmentation for morphological studies

3D Slicer: Interactive Editor

Tools for manual segmentation & model building

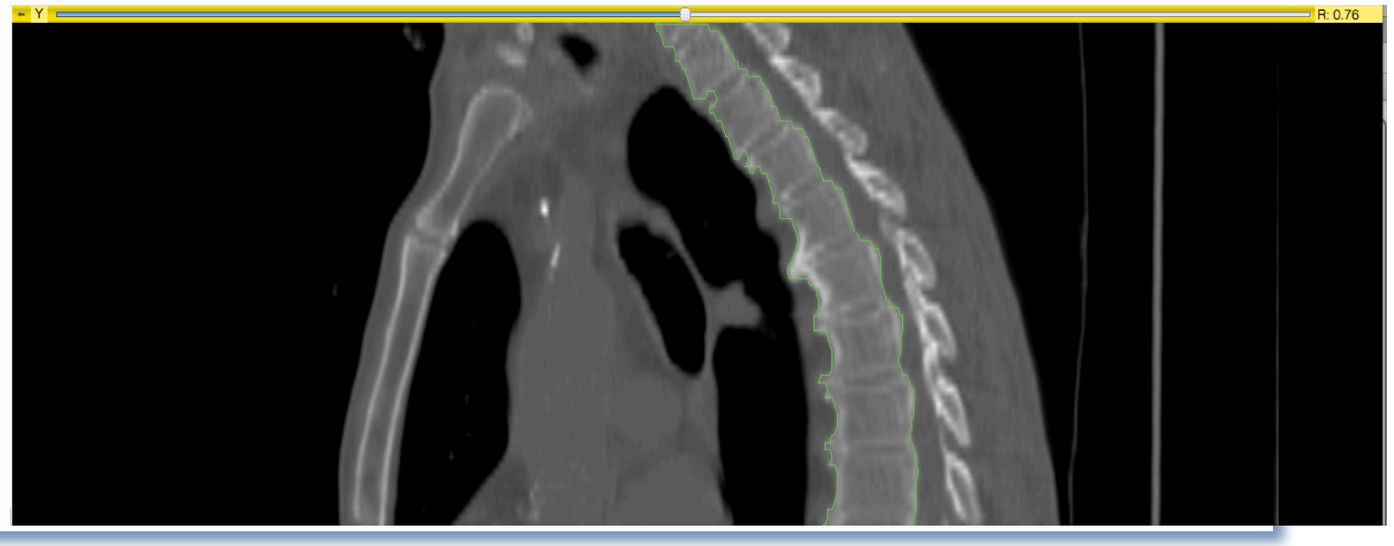


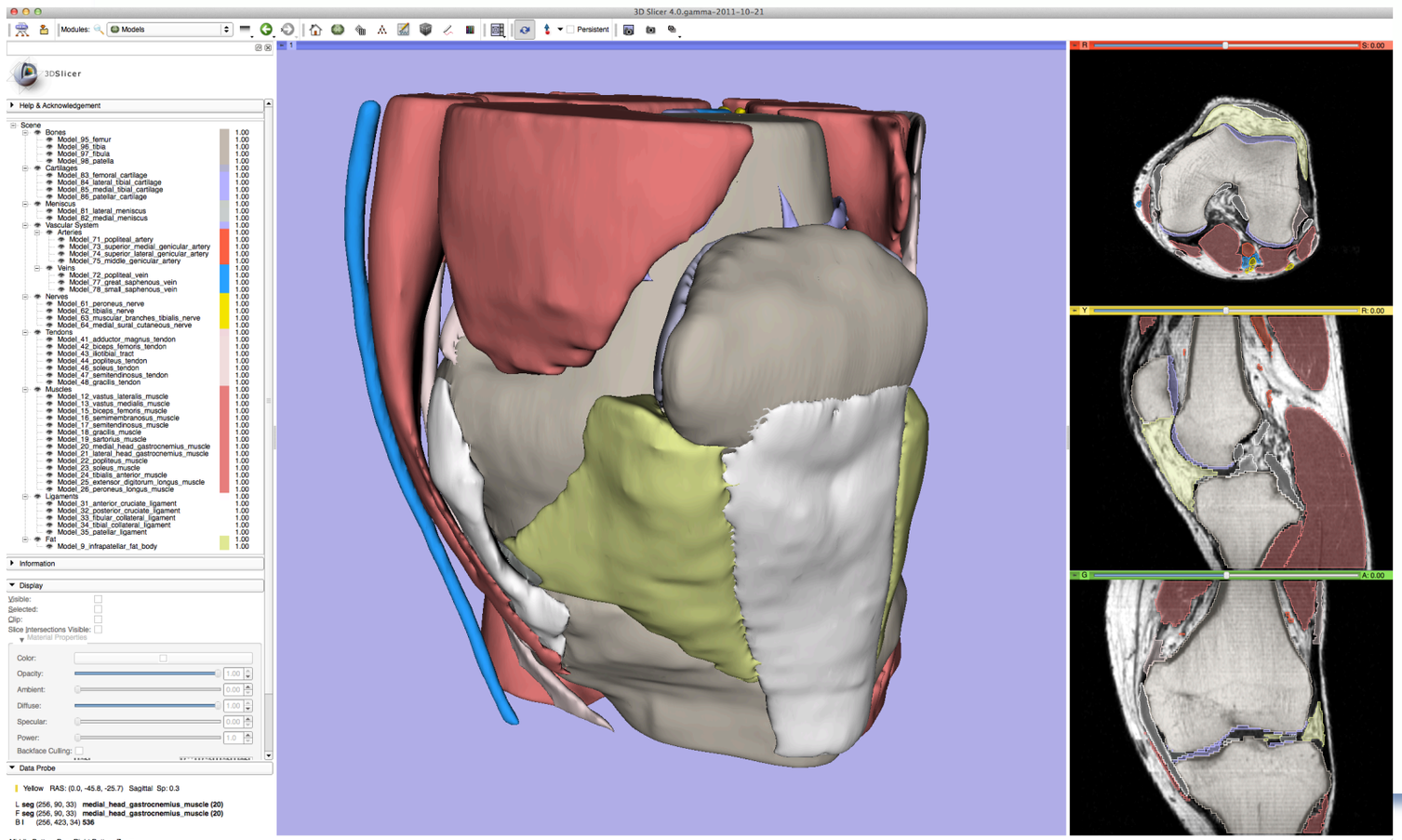
Tools include:

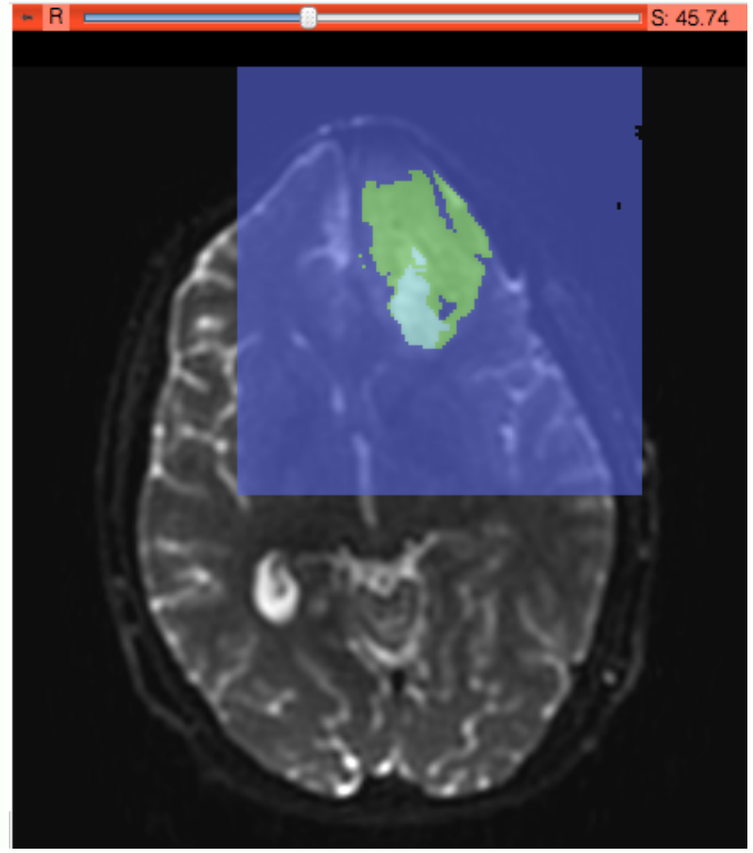
- Paint
- Erase
- Draw
- Rectangle
- Level Tracing
- Change Label
- Identify Islands
- Remove Islands
- Save Island
- Identify Island
- Erode
- Dilate
- Model Maker
- Fast Marching
- GrowCutSegmentation
- WandEffect
- WatershedFromMarkerEffect
- Undo / Redo

3D Slicer: Interactive Editor

Tools for manual and automated segmentation, 3D model building



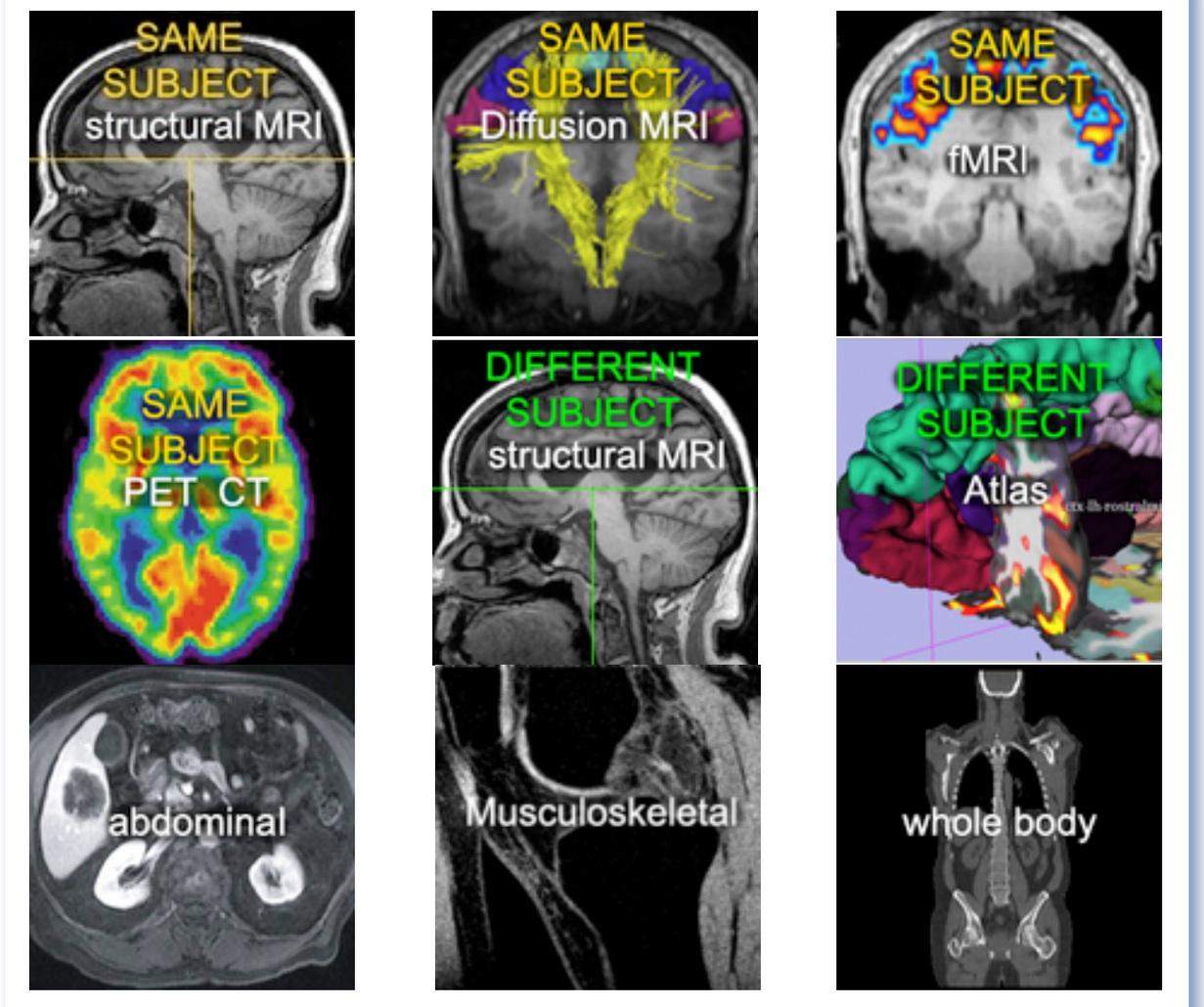




3D Slicer: Registration Tools

Slicer also provides a variety of **registration methods** and **resources** to support versatile applications:

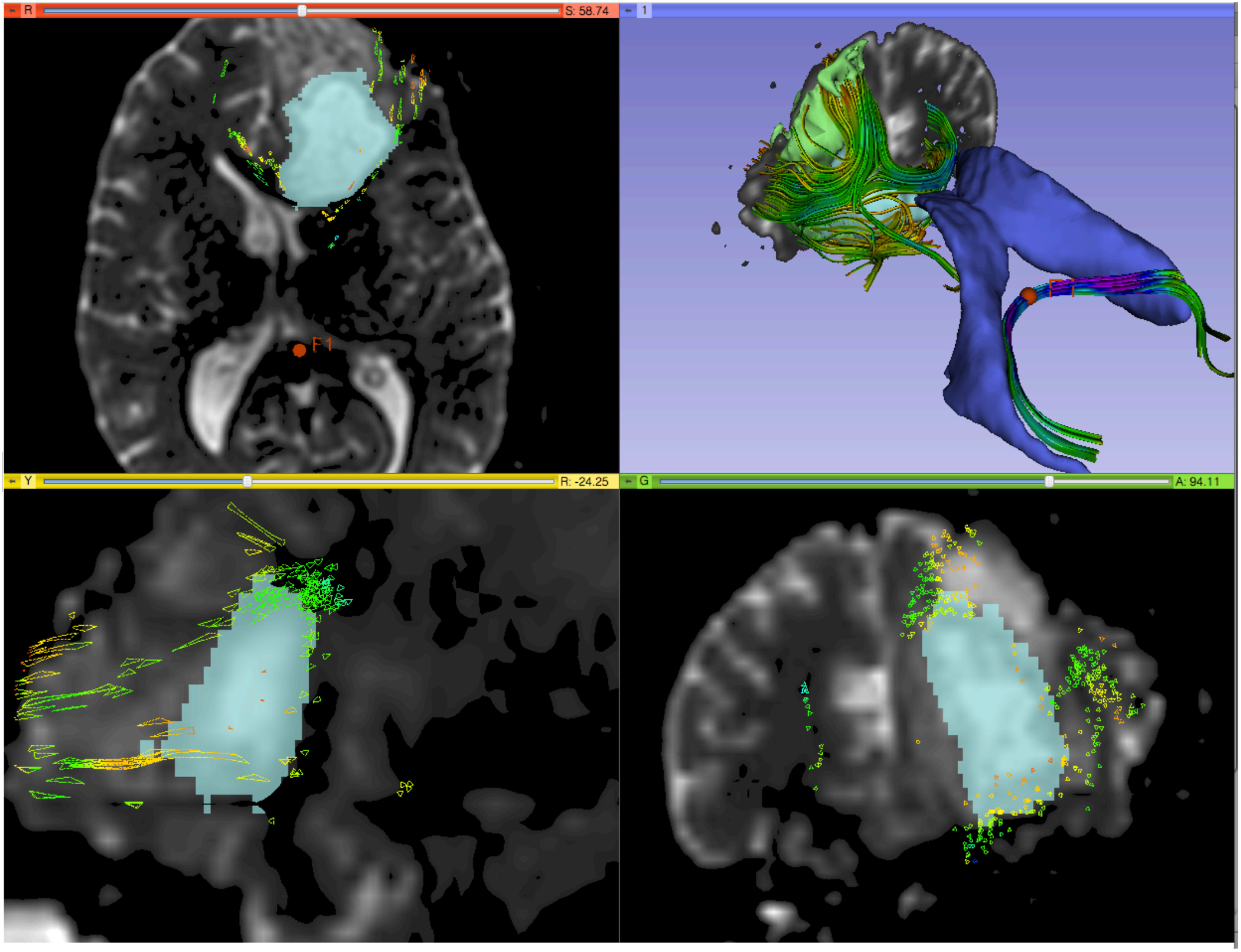
- Deformation models: rigid, affine, non-rigid, fluid
- Algorithm types: fiducial-, surface-, intensity-based
- Image types: scalar, vector, tensor



Resource: find an extensive collection of Slicer registration cases and recipes at:

www.slicer.org/slicerWiki/index.php/Slicer3:Registration

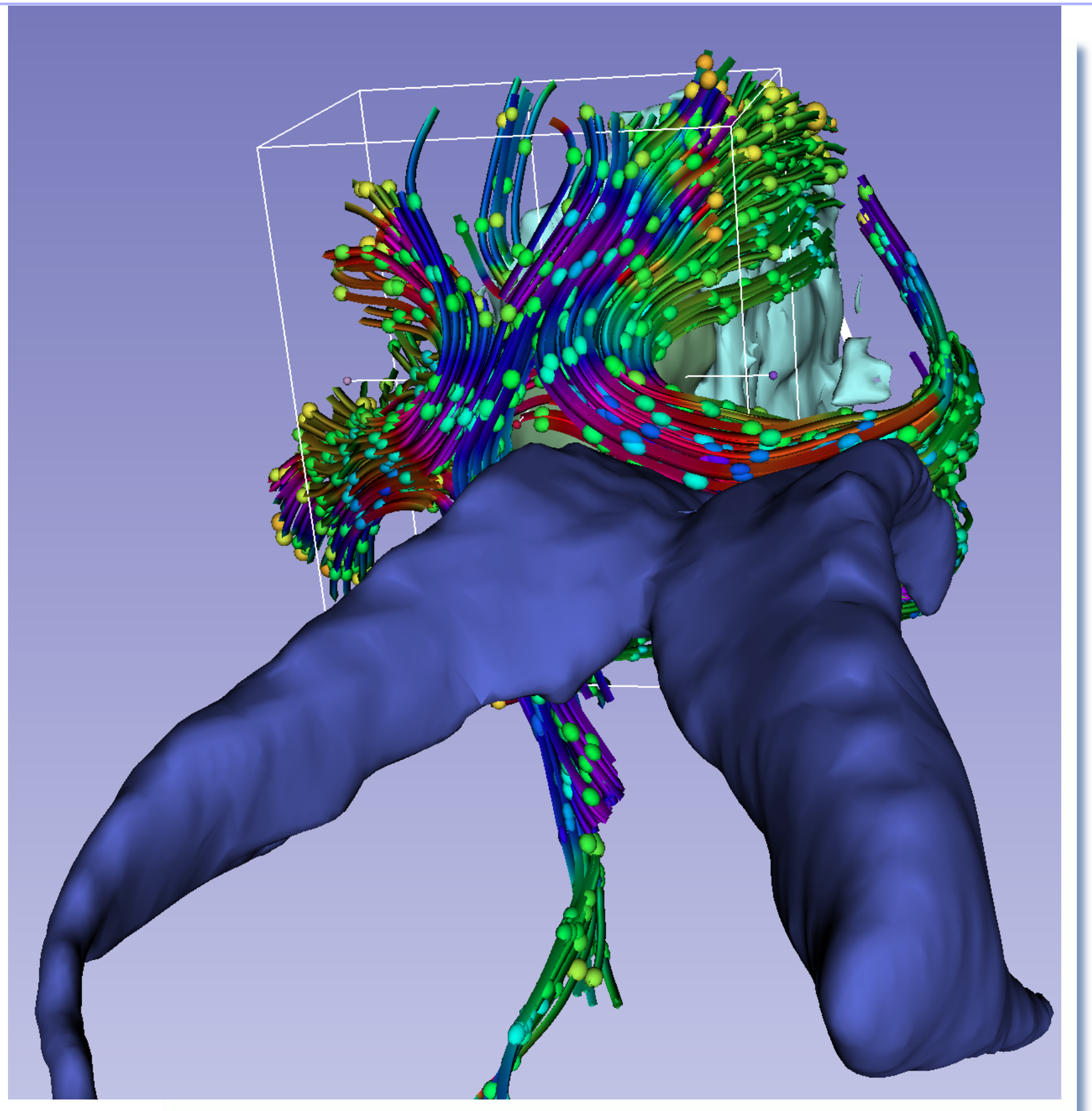
3D Slicer: Tractography Tools



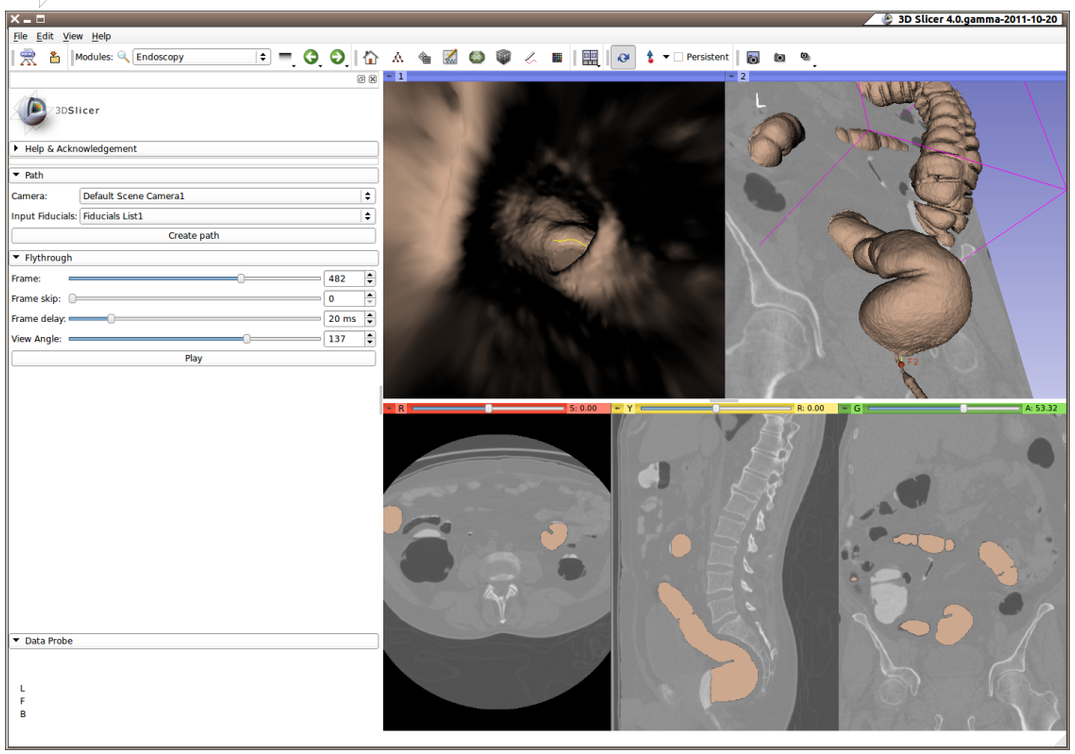
3D Slicer: Tractography Tools

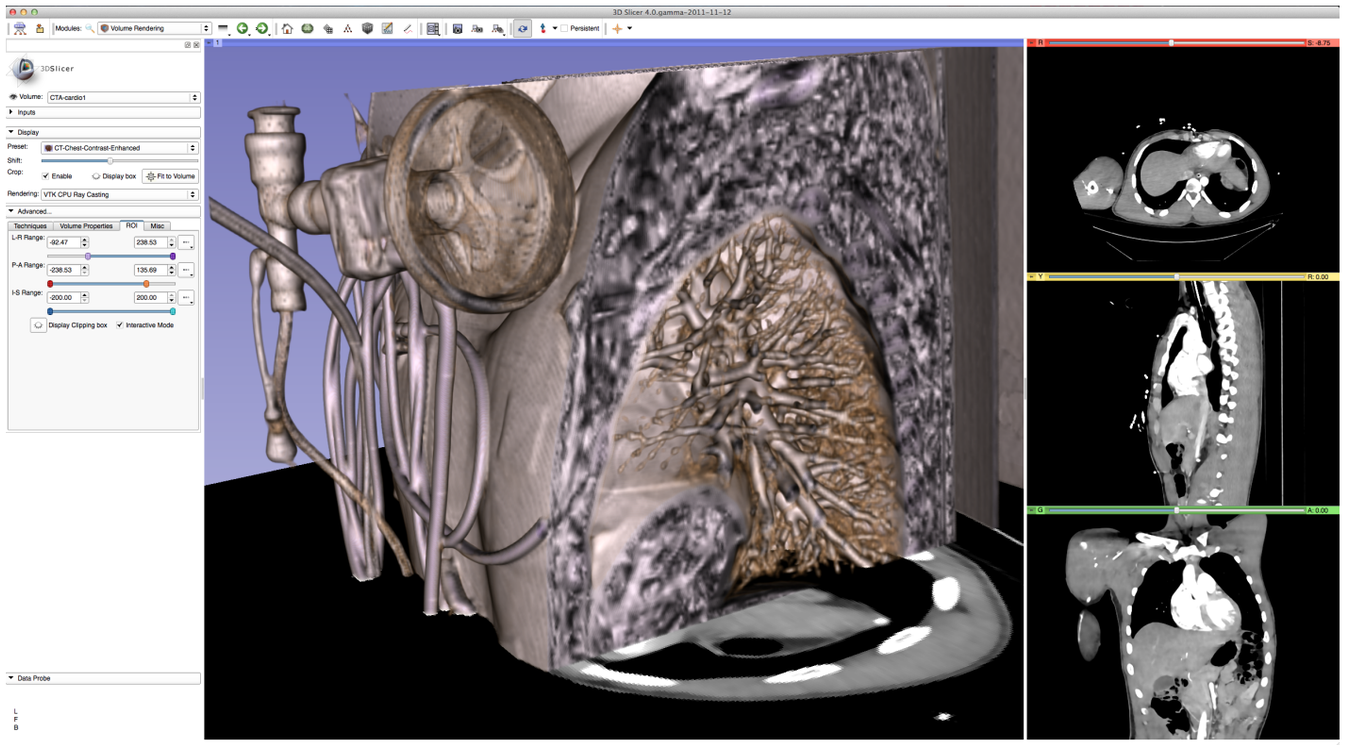
Seeding tracks from:

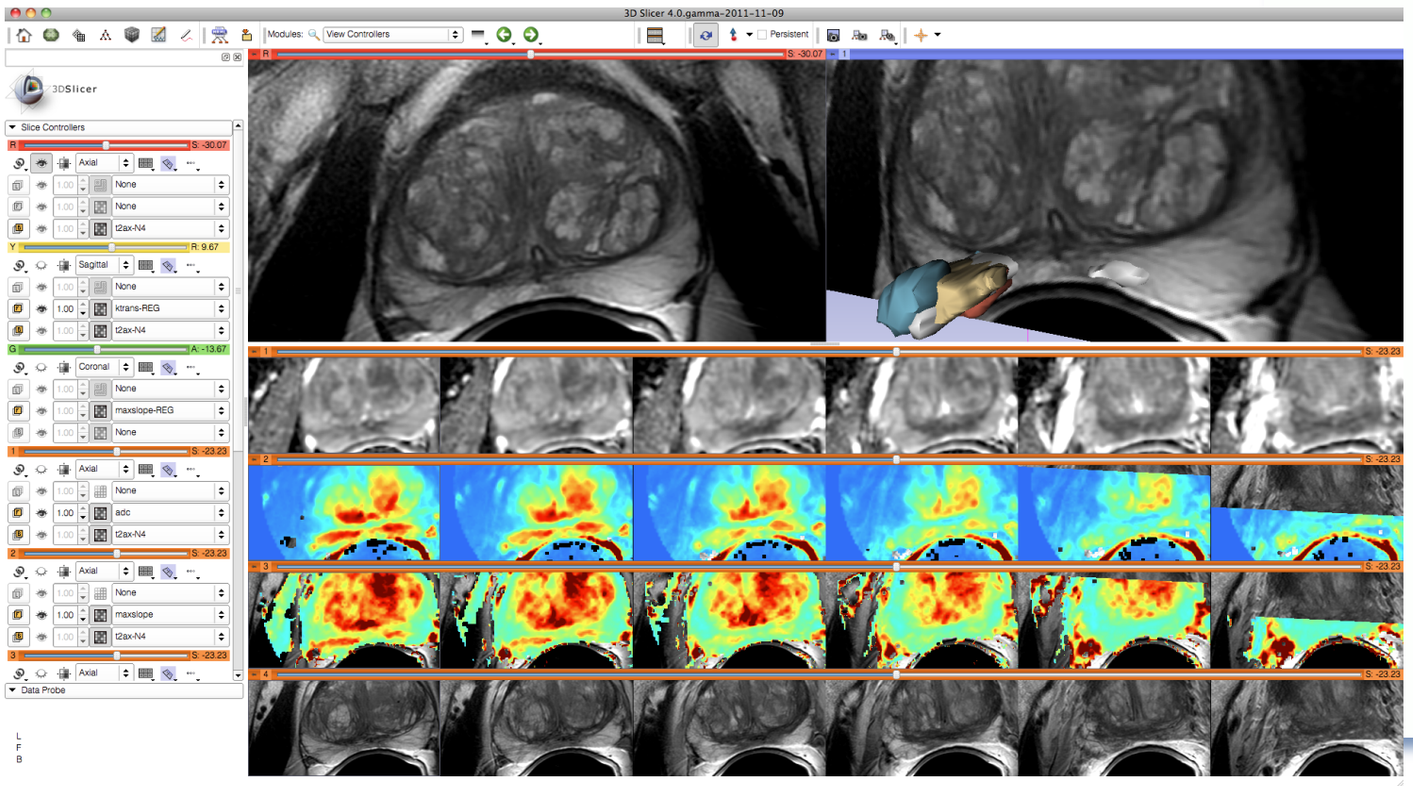
- Labels (segmentations)
- fiducial markers (points) or ROIs – interactive seeding
- 3D models



3D Slicer: Layouts



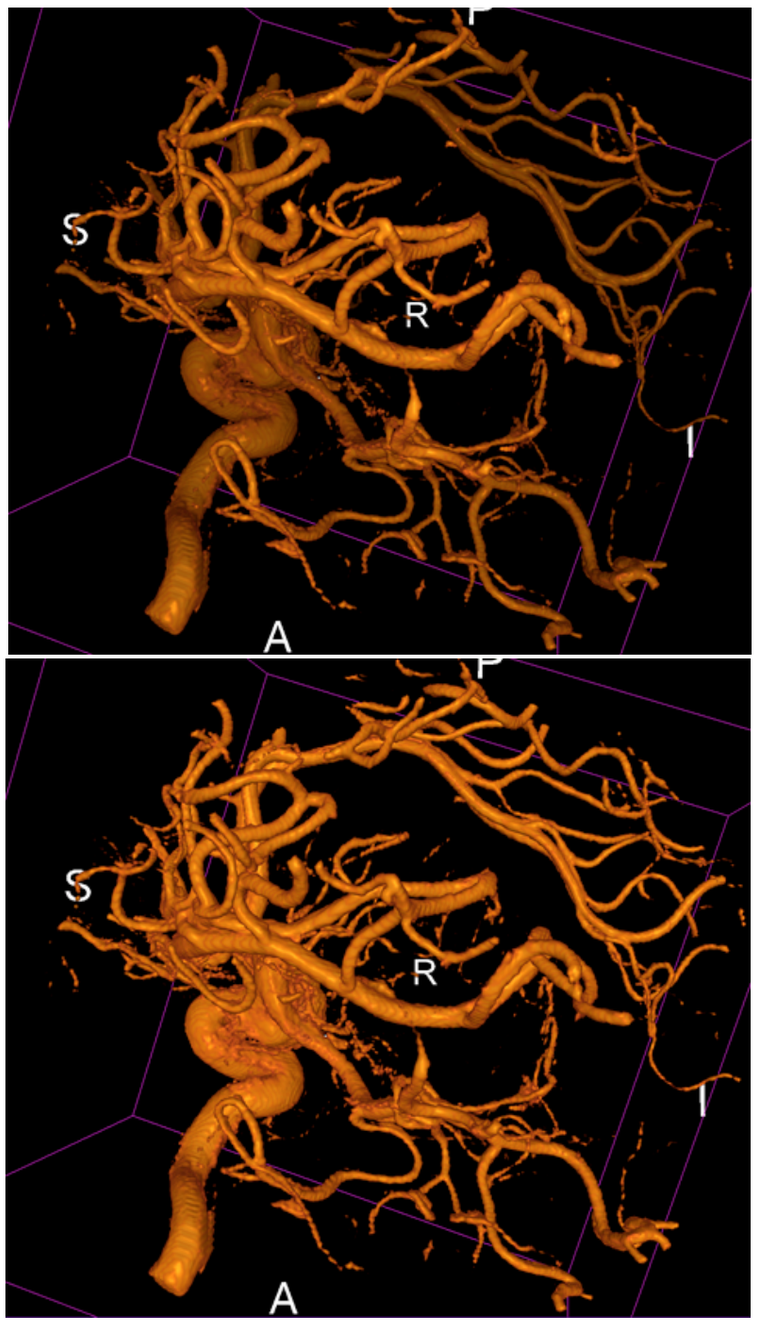




A variety of standard and specialized layouts are available including:

- Lightbox view
- Wide-screen layouts
- Study comparison view
- Dual 3D view
- Large slice viewer
- and others...

3D Slicer: Volume Rendering



Rendering Methods

VTK CPU Ray Casting

- Uses the CPU for volume rendering,
- is parallelized and can take advantage of multi-core capabilities.
- Uses level-of-detail approach where low resolution is rendered while moving, and high resolution is rendered once motion ceases.
- Allows zbuffer compositing with texture map cross sections and non-transparent triangulated surface model.

VTK GPU Ray Casting

- Uses GPU accelerated ray caster.
- Allows z-buffer compositing with non-transparent polygon models only.
- This is currently working on Linux and Win32, but not on Mac

VTK OpenGL 3D Texture Mapping

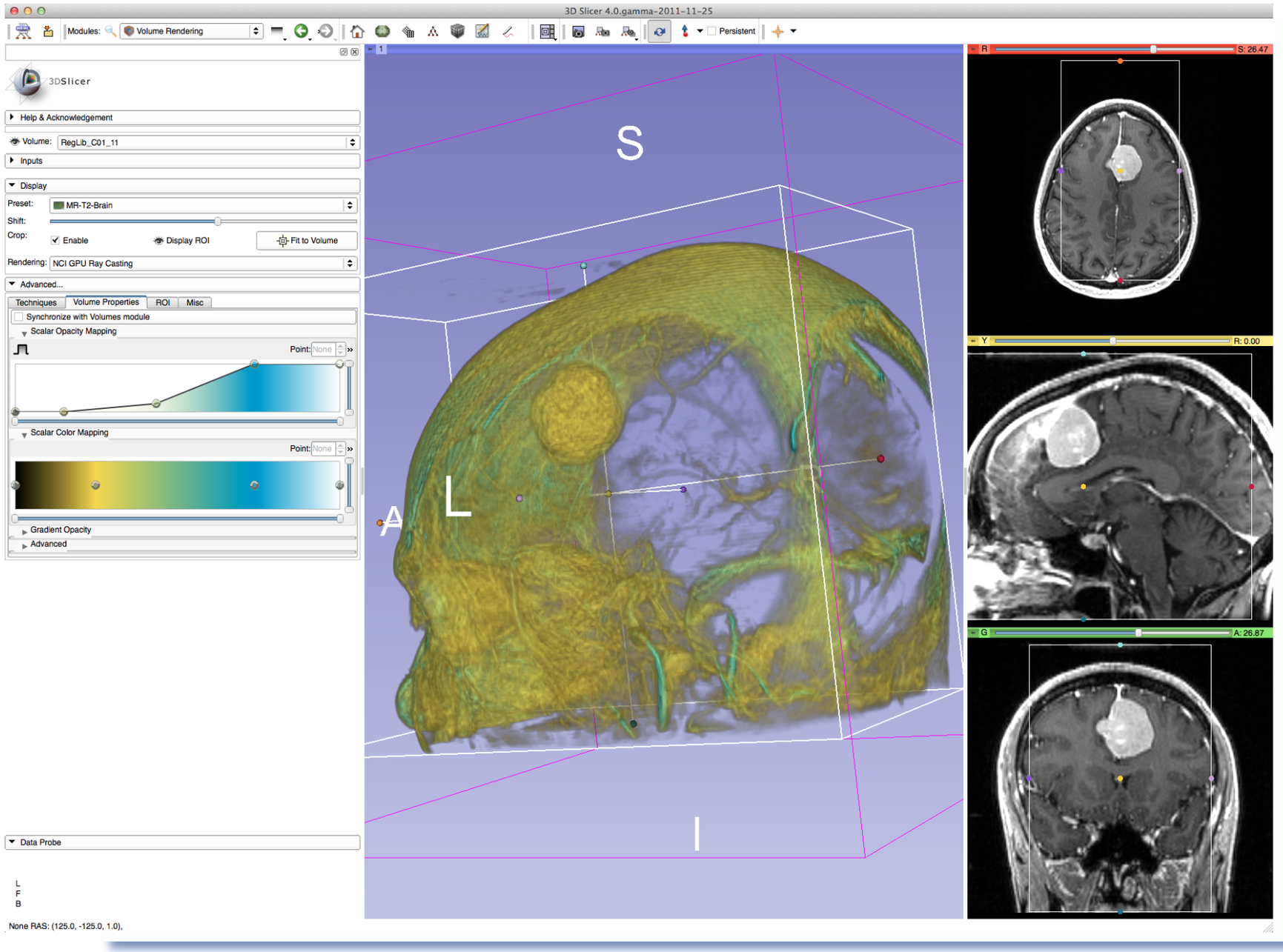
- Uses texture mapping approach to volume rendering
- compared to the two render methods above, it has slightly lower performance and slightly coarser appearance.

NCI GPU Ray Casting

- This is a GLSL-based ray caster with several experimental mapping techniques.
- No z-buffer compositing with polygon models.
- Good performance and quality.
- No hardware restrictions on this method

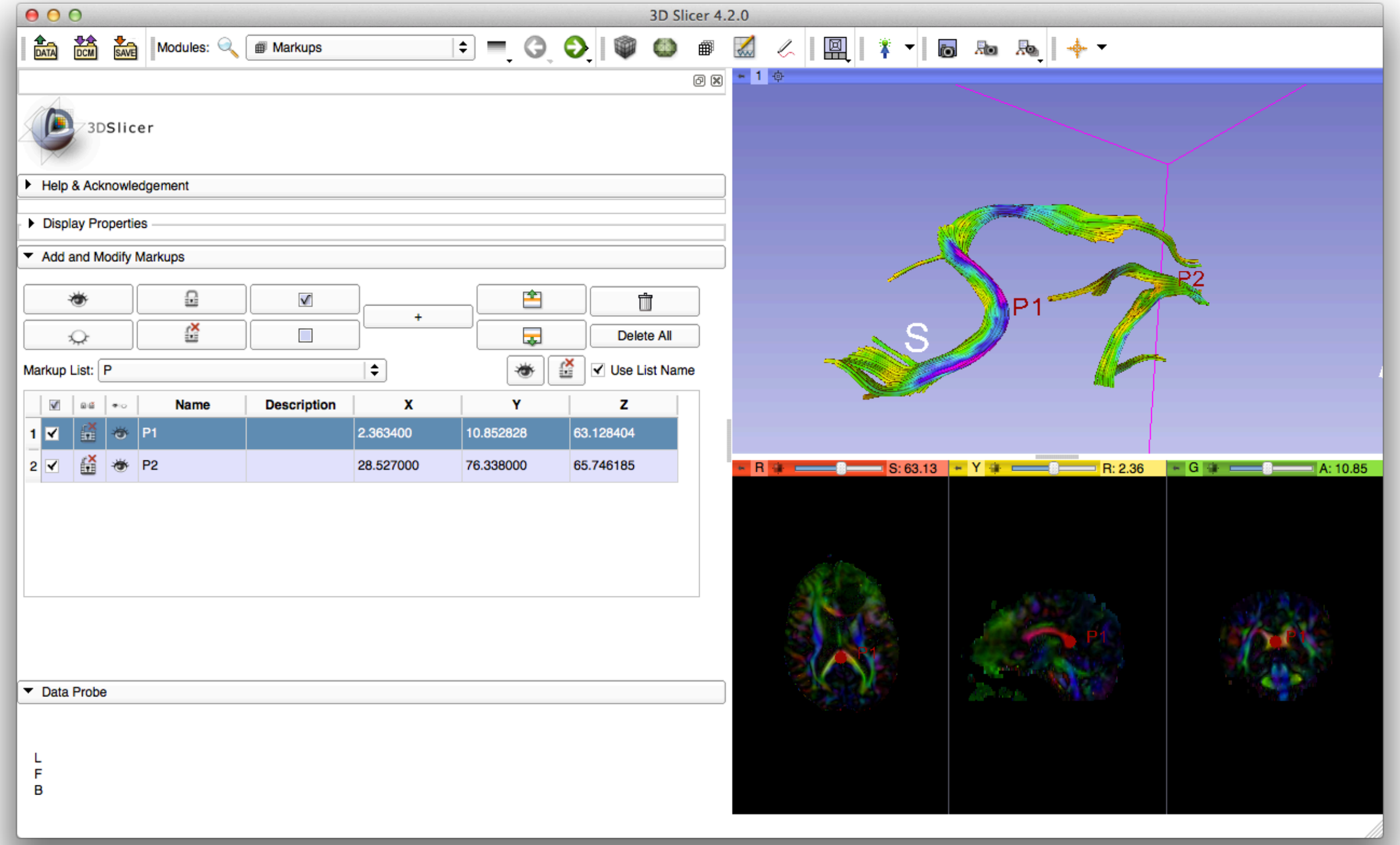
3D Slicer: Volume Rendering

Grayscale and labelmap volumes can be volume rendered, with interactive region of interest definition.



Dedicated GPUs with dedicated GPU memory are recommended for GPU accelerated methods.

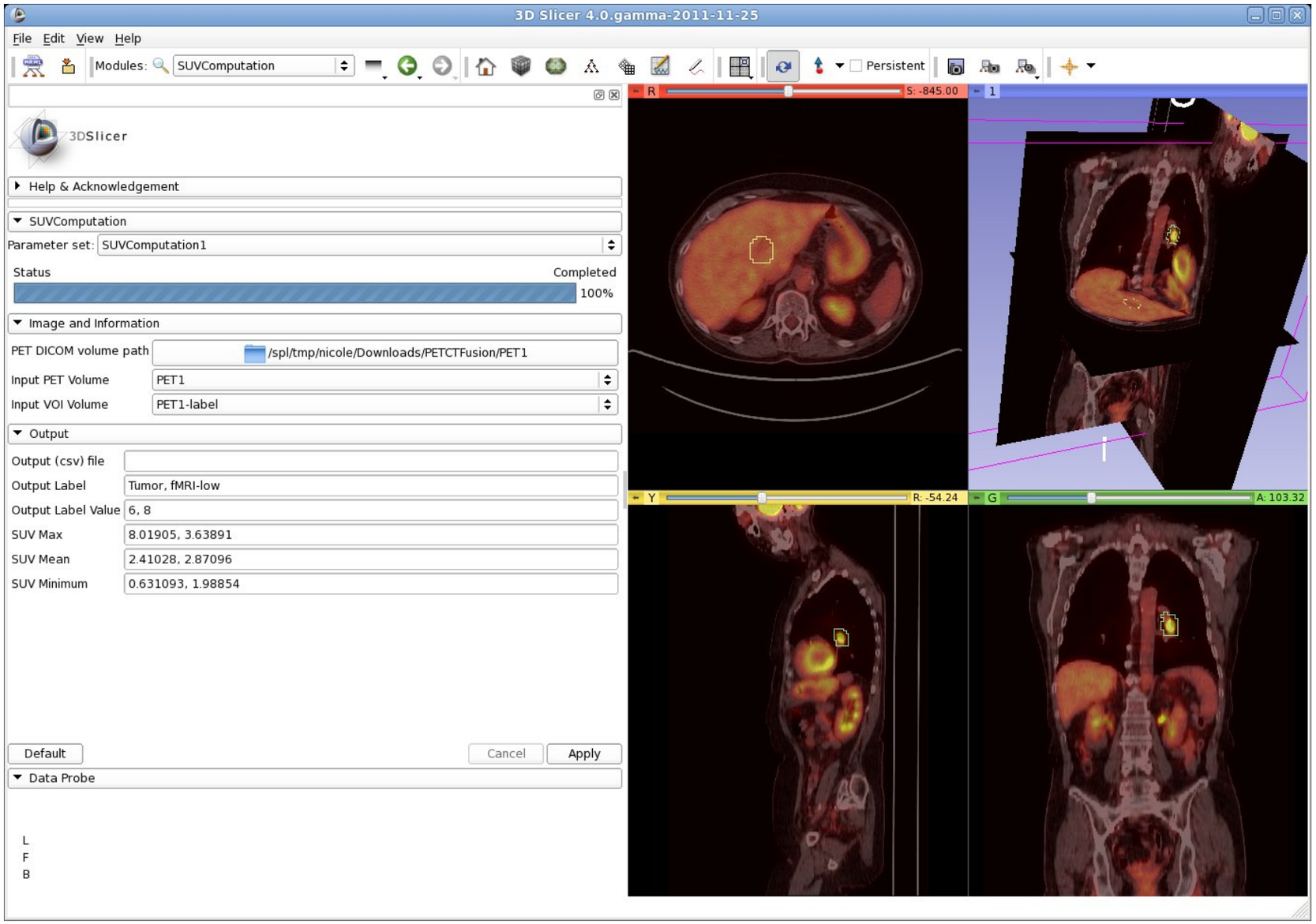
3D Slicer:Markups



3D Slicer: Dice Coefficient

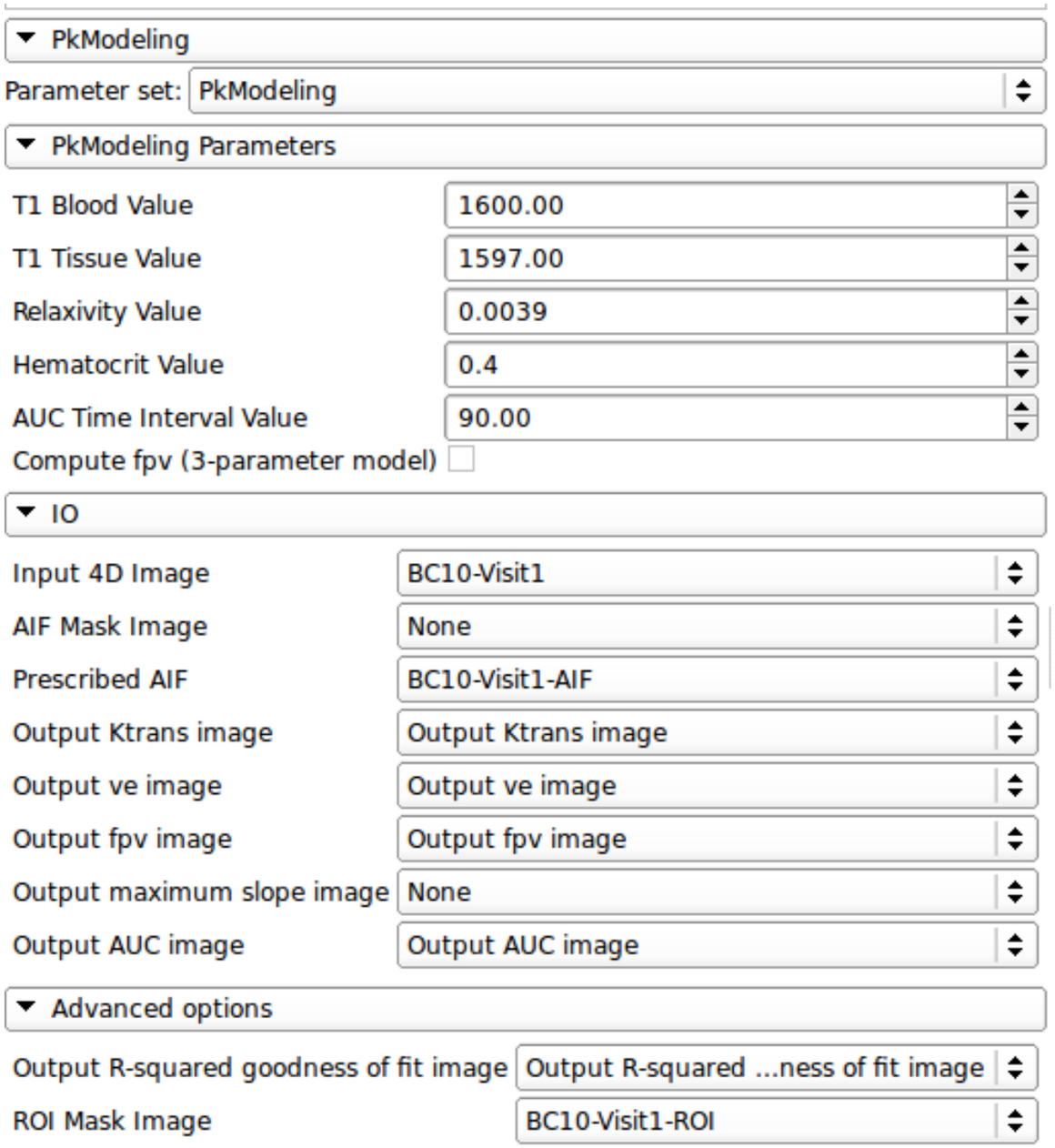
The DiceComputation module computes Dice Similarity Coefficient of overlap to quantitatively compare several **registered** segmented volumes.

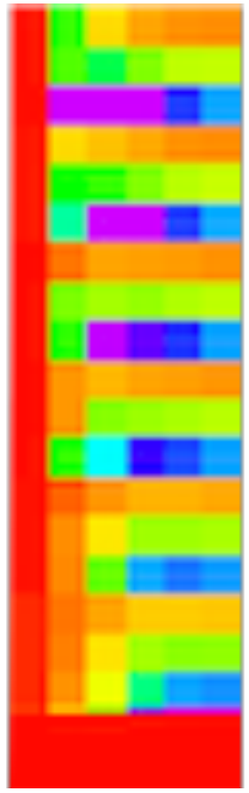
3D Slicer: PET/CT SUV computation



- Combined visualization of structural and colorized functional images
- VOIs defined in Slicer's Editor Module
- extracted DICOM study parameters used in computation
- Computation of Standardized Uptake Value (based on patient body weight) per VOI.

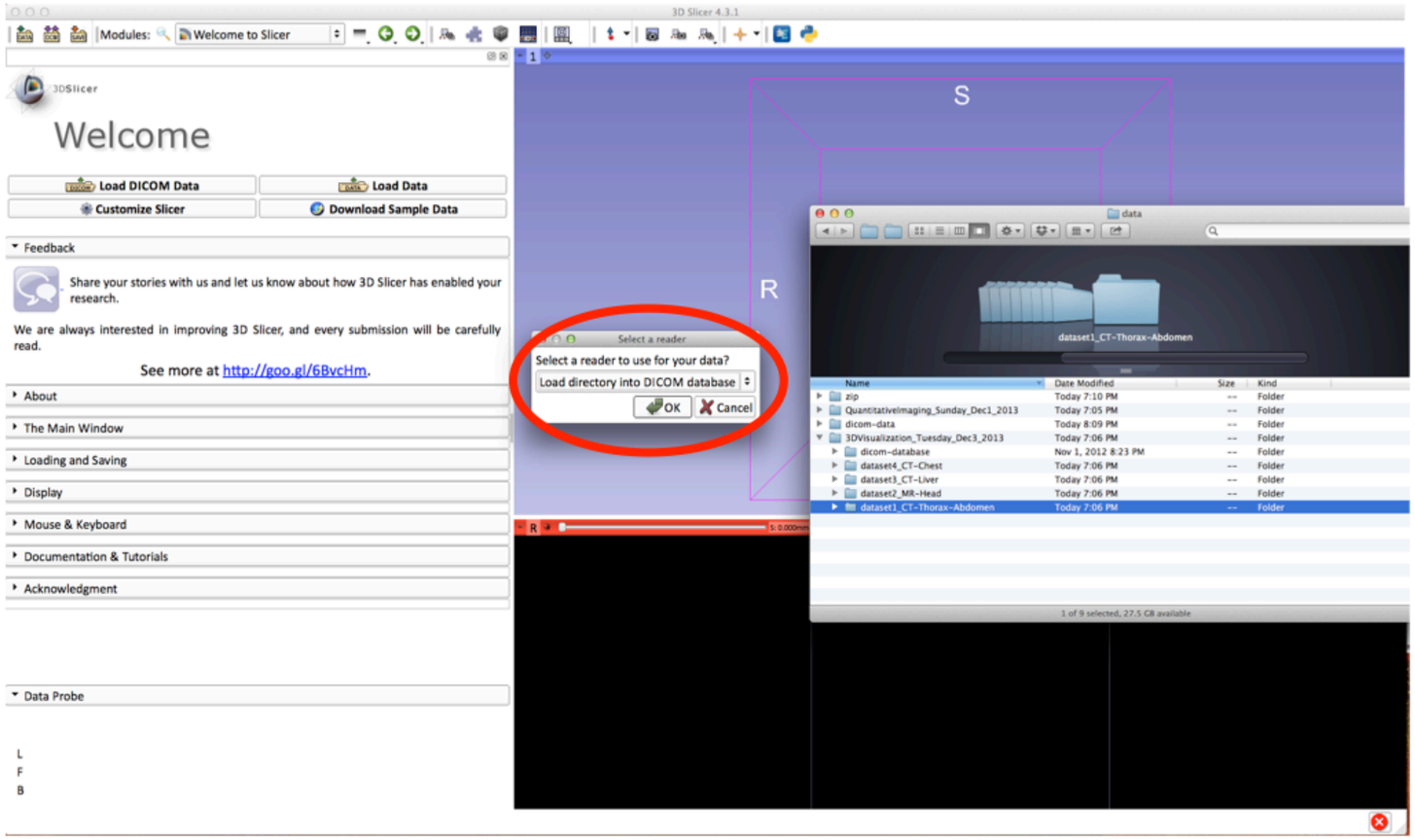
3D Slicer:PkModeling





PkModeling (Pharmacokinetics Modeling) calculates quantitative parameters from Dynamic Contrast Enhanced DCE-MRI images.

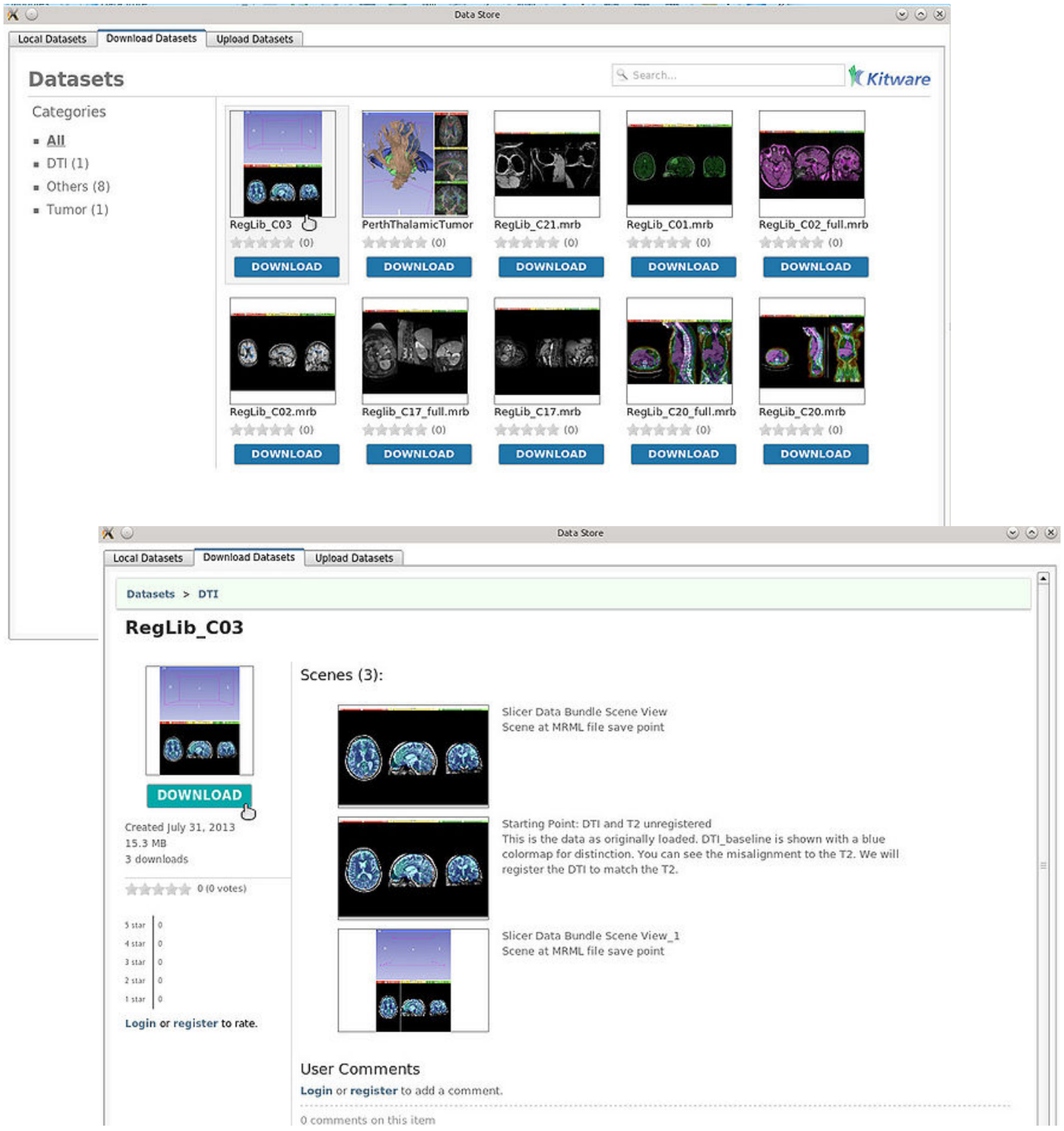
3D Slicer: Drag and Drop



Drag & Drop multiple files (e.g. data, scenes, mrb files etc.) and folders on the application will bring up the Add Data dialogue with the corresponding documents

A Medical Reality Bundle (Mrb) file is an archive file that contains a mrml scene file and all data for loading into Slicer4.

3D Slicer:DataStore



The Data Store extension allows an user to easily upload and download dataset files.

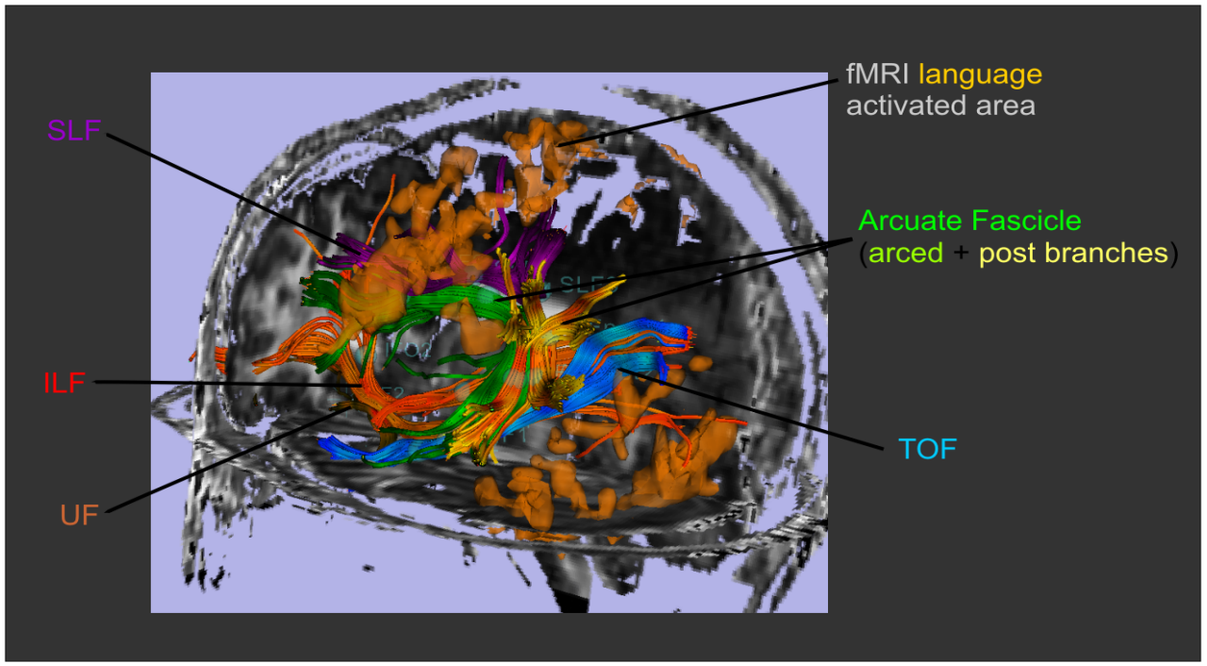
- Browse and search datasets in a remote database
- Download, Review and comment the datasets
- Upload new datasets

3D Slicer: Image-Guided Therapy

3D Slicer has been used in clinical research, with IRB clinical protocols appropriately created and managed.

In image-guided therapy (IGT) research, Slicer is frequently used to construct and visualize collections of MRI data that are available pre- and intra-operatively, and to display the tracked spatial position of surgical instruments.

3D Slicer: Image-Guided Therapy

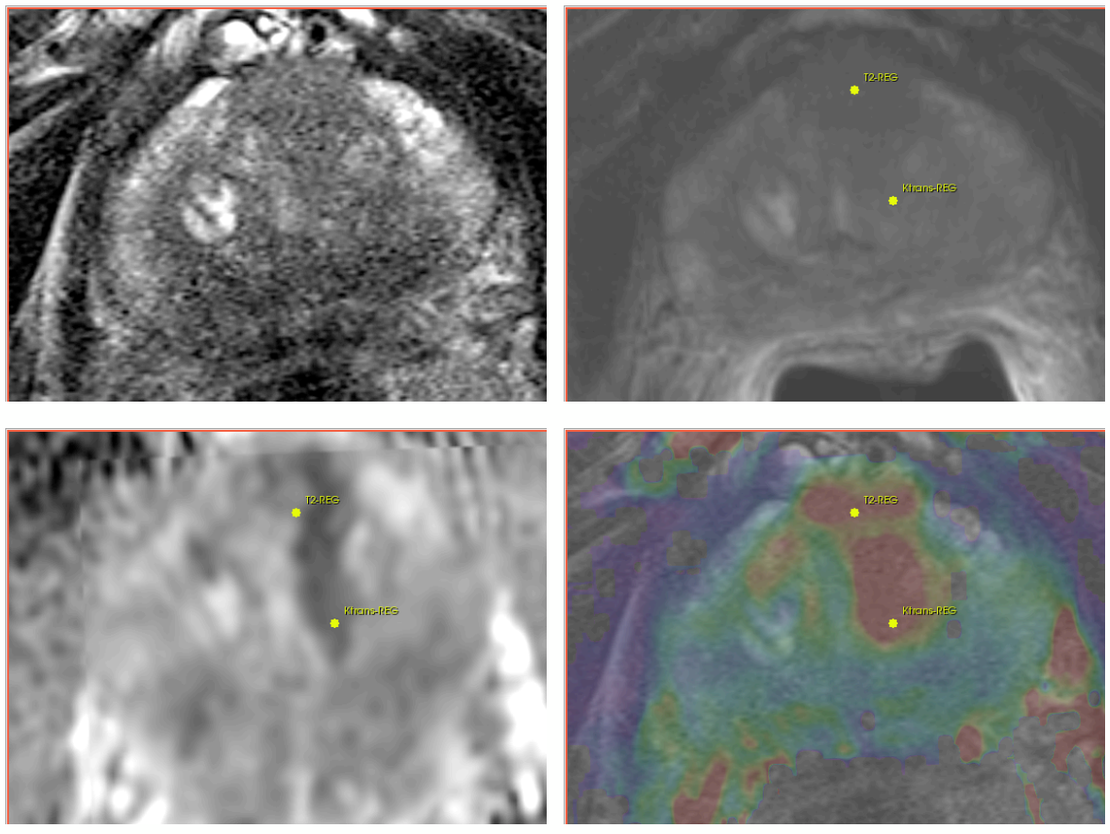


3D Slicer has been used extensively for brain tumor resection planning and guidance during surgery.

Integration of 3D Slicer with the surgical navigation BrainLab system allows **to track surgical instruments in real-time**, and transfer the position to 3D Slicer.

This project is a joint collaboration between BWH, Yale University and BrainLab.

3D Slicer: Image-Guided Therapy



Targeted MRI guided prostate cancer biopsy attempts to improve the biopsy precision while reducing the number of tissue samples that need to be collected.

This is achieved by first using diagnostic multi-parametric MRI to highlight the suspicious areas. The biopsy procedure takes place in the MR bore.

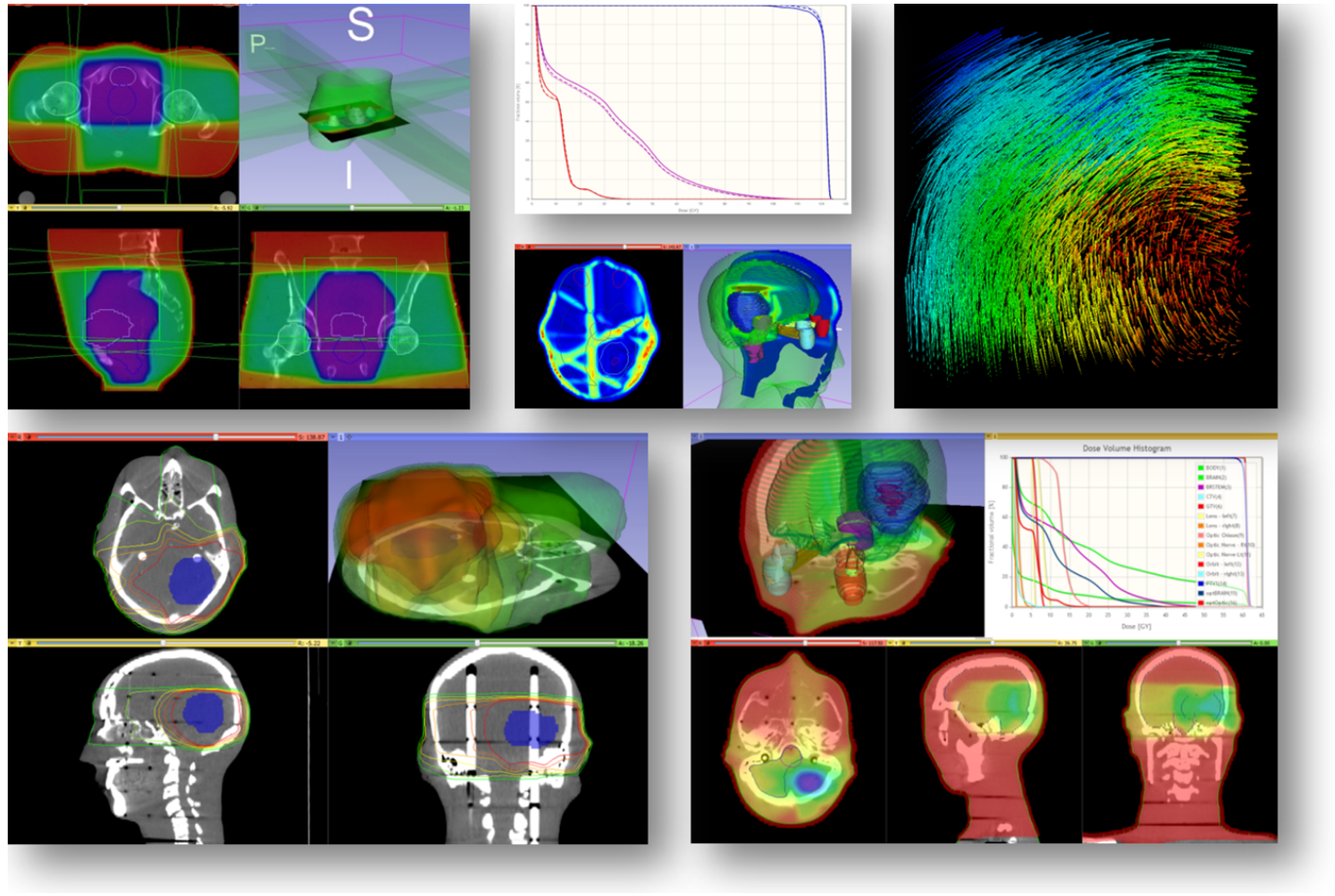
3D Slicer is used for MRI visualization and fusion, target planning, deformable registation, and needle trajectory planning.

Deformable registration is used to fuse the diagnostic image data to the intra-procedural configuration of the gland.

SlicerRT: Radiation Therapy

Features

- DICOM-RT import
- RT-specific analysis:
  Dose Accumulation
  Dose Comparison (gamma)
  Isodose contours / surfaces
  Contour Comparison
  Contour Morphology
- Plastimatch
  BSpline registration
  Landwarp registration

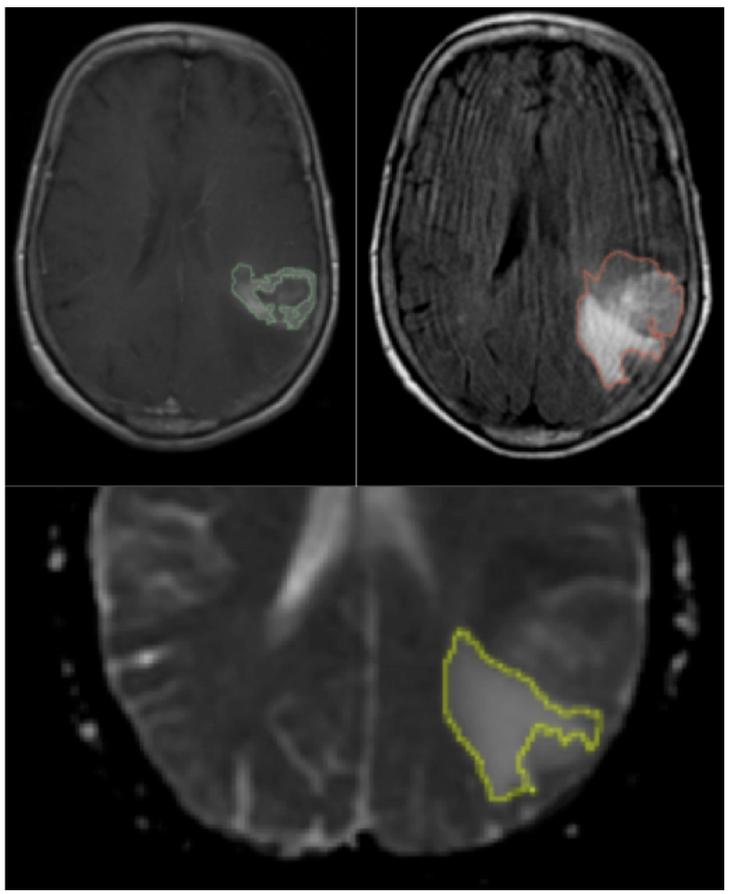


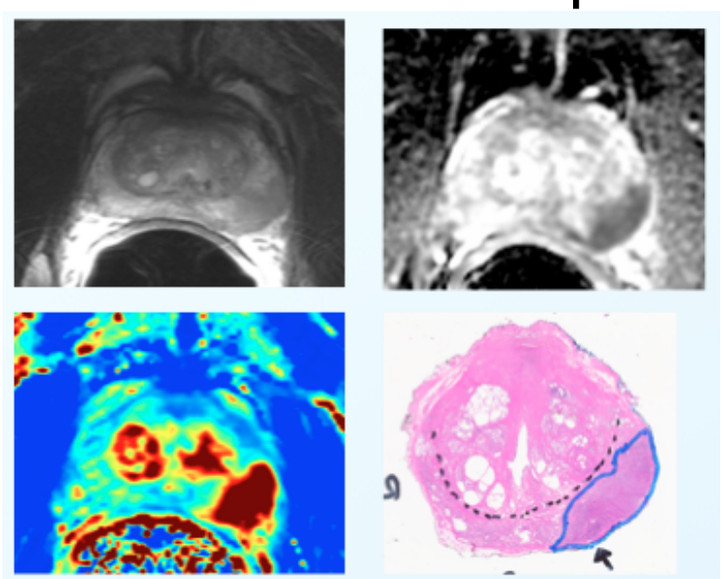
- Overview paper: Csaba Pinter, Andras Lasso, An Wang, David Jaffray, and Gabor Fichtinger, "SlicerRT: Radiation therapy research toolkit for 3D Slicer", Med. Phys. 39 (10), October 2012
- Project homepage: https://www.assembla.com/spaces/slicerrt/
- Contact: Andras Lasso (lasso@cs.queensu.ca)

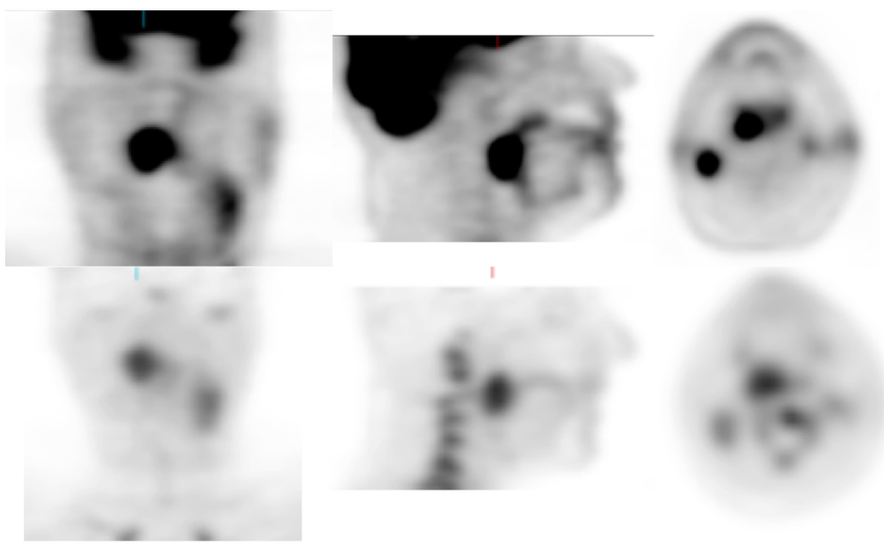
3D Slicer and QIN

http://qiicr.org U01 CA180918

- Quantitative Image Informatics for Cancer Research (QIICR)
- Support the needs of the active project in NCI Quantitative Imaging Network (QIN):
  - processing workflows, data and tool sharing
  - brain cancer (MGH)
  - head and neck cancer (U. of Iowa)
  - prostate cancer (BWH)
- Investigate the use of DICOM for results sharing
  - longitudinal and multi-modality analysis
  - segmentation and registration results
  - structured reporting and custom templates

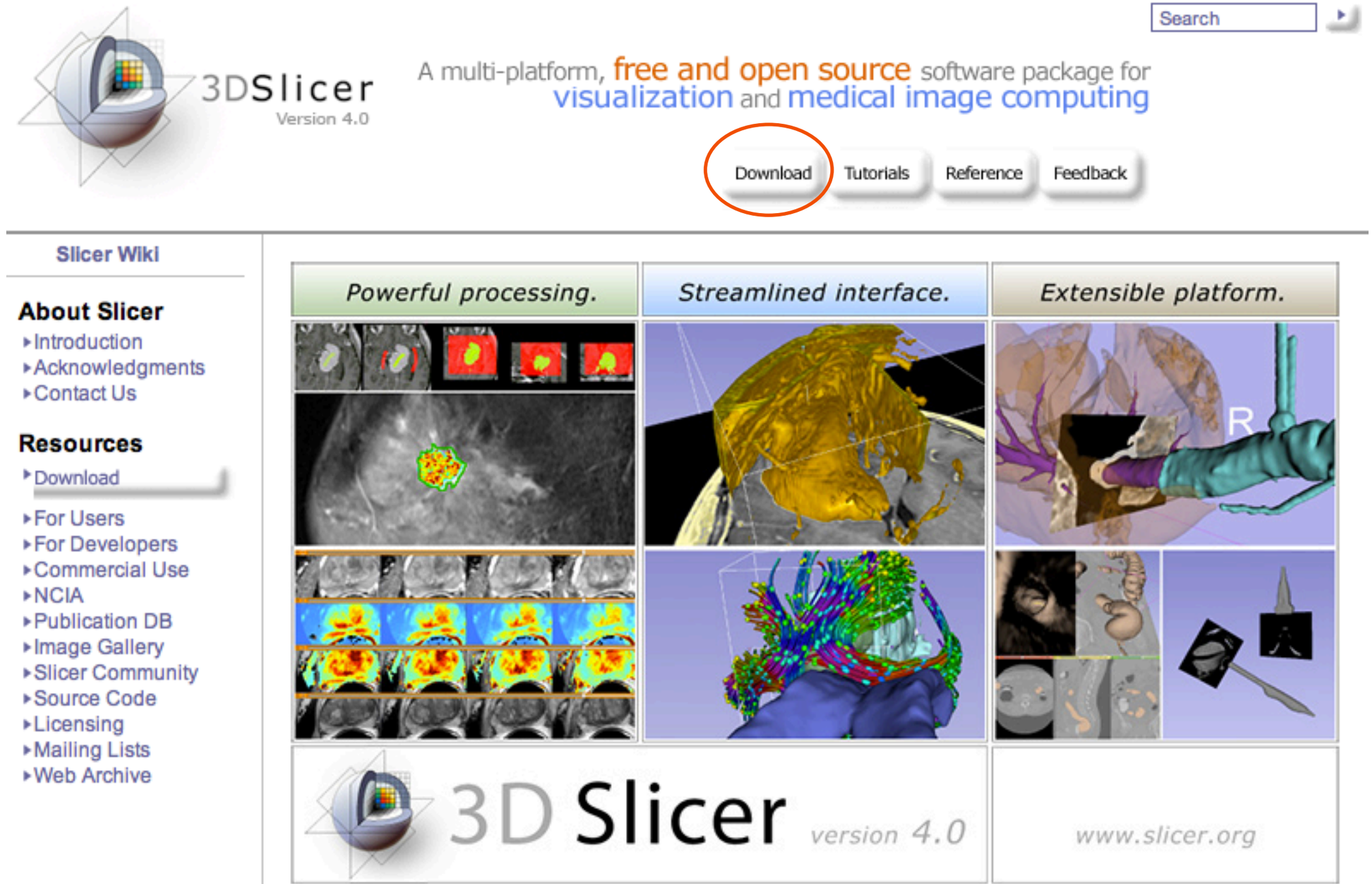






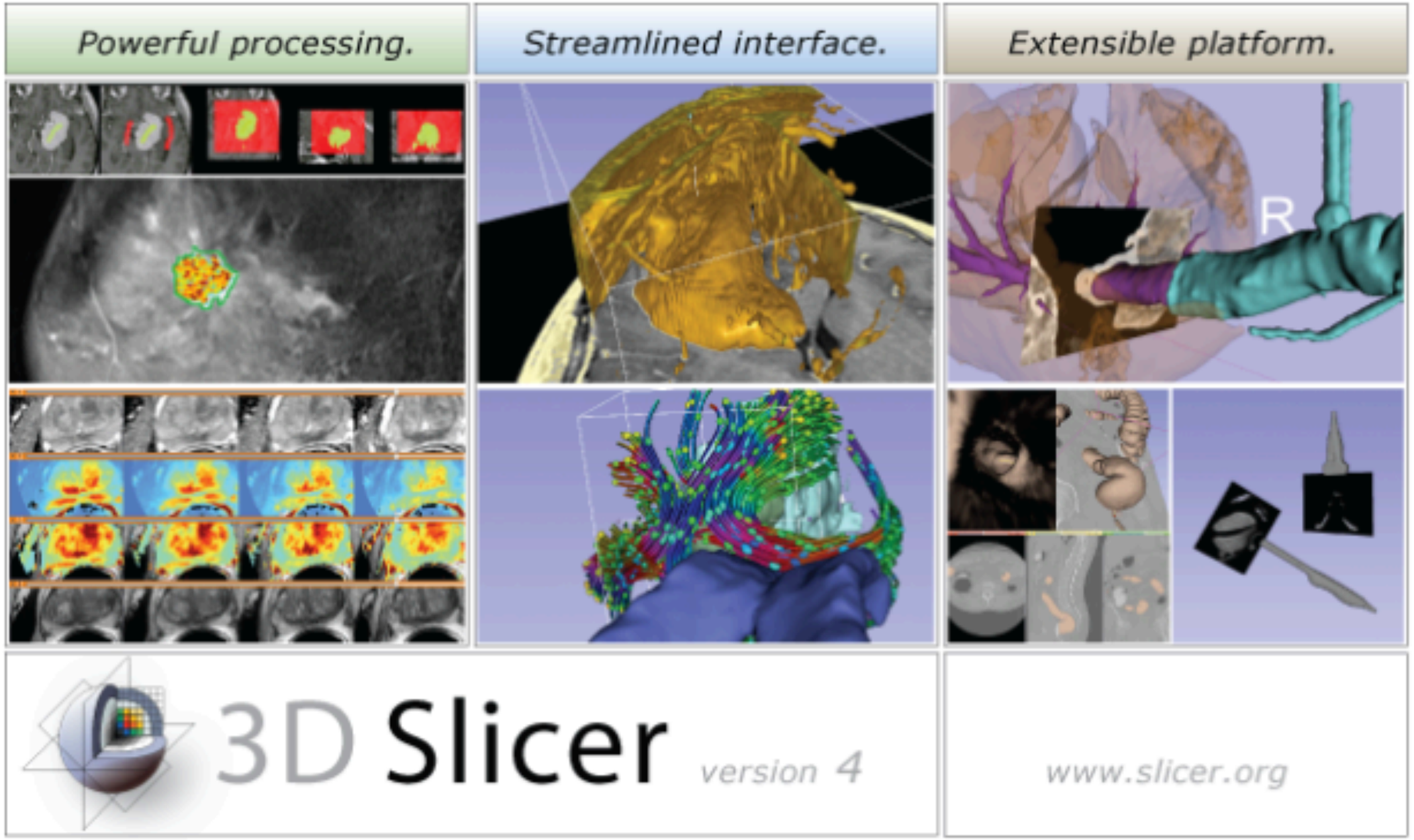
3D Slicer: Get the software

http://www.slicer.org



3D Slicer: Find Tutorials & More

http://www.slicer.org



3D Slicer: Attend a workshop

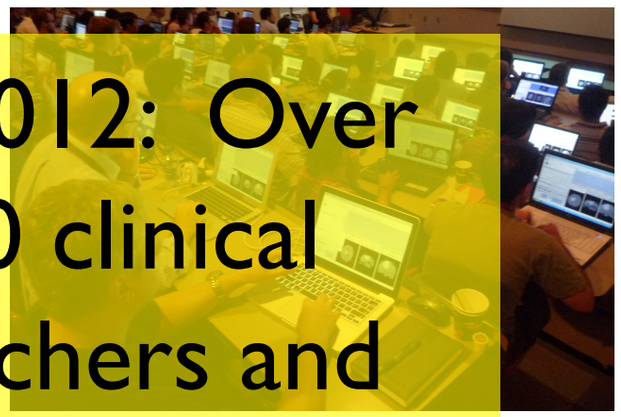
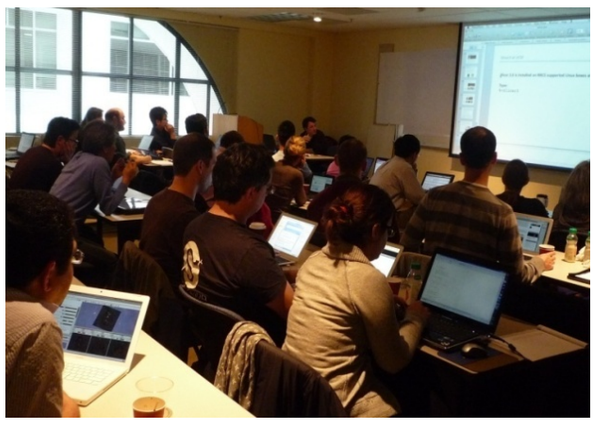
http://wiki.na-mic.org/Wiki/index.php/Training:Slicer
http://wiki.na-mic.org/Wiki/index.php/Events

1. HST.583 Life Cycle of Medical Imaging Lab, Harvard-MIT Division of Health Science and Technology (Sept.10)
2. MICCAI DTI Tractography Challenge, Nice, France, (Oct.1st)
3. 3D Visualization of DICOM images for Radiology Applications, Hands-on course, RSNA 2012, Chicago (Nov.28)
4. Quantitative Medical Imaging for Research and Practice, Hands-on course, RSNA 2013, Chicago, (Nov.25)
5. 3D Slicer Booth, Quantitative Imaging Reading Room, RSNA 2012, Chicago (Nov.25-30)
6. HST.583 Diffusion Tensor Imaging Lab, Harvard-MIT Division of Health Science and Technology (Dec.3)
7. 3D Slicer Hands-on workshop, Psychiatry Neuroimaging Lab, Boston, MA (Dec.10)
8. DTI Hands-on course, SPIE 2013, San Diego, Ca (Feb.5)
9. 3D Slicer demos, IMAGINE session, European Congress of Radiology, ECR 2013, Vienna, Austria (March 7-11)
10. Imaging in Neuroscience hands-on course, Harvard Catalyst 3D Slicer hands-on workshop, Tokyo, Japan (April 9)
11. 3D Slicer hands-on workshop, Iwate, Japan (April 10)
12. 3D Slicer invited lecture, AAPM New England Chapter Summer meeting, Portsmouth, NH (May 31)
13. 3D Slicer Hands-on workshop, BWH, Boston, (June 14)
14. Image-Guided Therapy Workshop, CARS 2013, Heidelberg, Germany (June 30)
15. BRAINSCamp hands-on workshop, Iowa City (August 1st)
16. MICCAI 2013 DTI Tractography Challenge, Nagoya, Japan
    MICCAI 2013 CTK Programming Tutorial, Nagoya, Japan
17. 3D Slicer Neurosurgery workshop, PLA General Hospital, Beijing, China (Sept.29)
18. 3D Visualization of DICOM images for Radiology Applications, Hands-on course, RSNA 2013, Chicago (Dec.1)
19. 3D Slicer Booth, Quantitative Imaging Reading Room, RSNA 2013, Chicago (Dec.1-6)
20. Quantitative Medical Imaging for Research and Practice, Hands-on course, RSNA 2013, Chicago, (Dec.3)\

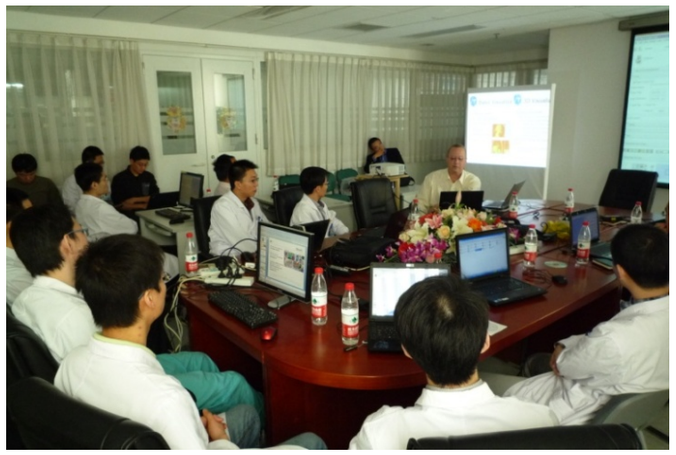
3D Slicer: Attend a workshop





2005-2012: Over 2,000 clinical researchers and scientists trained




http://wiki.na-mic.org/Wiki/index.php/Training:Slicer
http://wiki.na-mic.org/Wiki/index.php/Events

Slicer Hands-on courses at RSNA 2013

3DVisualization of DICOM images for Radiological Applications.
Tuesday. Dec.3, 12:30 pm -2 pm (SCD401)

Sonia Pujol, Ph.D.,
Surgical Planning Laboratory, Harvard Medical School, Brigham & Women's Hospital, Boston MA.

Ron Kikinis, M.D.
Surgical Planning Laboratory, Harvard Medical School, Brigham & Women's Hospital, Boston MA.

Kitt Shaffer, M.D. Ph.D., Boston University School of Medicine, Boston Medical Center, Boston, MA.

Quantitative Medical Imaging for Clinical Research and Practice.
Sunday. Dec. 1, 11:00 am – 12:30 pm (SCD401)

Sonia Pujol, Ph.D., Department of Radiology, Brigham & Women's Hospital,
Boston MA.

Katarzyna J. Macura MD, PhD, The Johns Hopkins Medical Institutions,
Baltimore, MD.

Ron Kikinis, M.D.
Surgical Planning Laboratory, Harvard Medical School, Brigham & Women's Hospital, Boston MA.

3D Slicer: Information for Developers

www.slicer.org/pages/DeveloperOrientation

Slicer 3.x (Current development version)	
Slicer Developer Documentation	Development Project Homepage, Execution Model Documentation and Building a Slicer 3 Module GUI
Build Instructions	Slicer 3 Build Instructions
Coding Considerations	Slicer 3 Coding Style and Slicer 3 Interface Design
SVN Source Code Repository Browsing	View VC
API	Slicer 3 Doxygen Source Documentation,
Slicer 3 SVN Repository and SVN Instructions	svn Repository and Introduction to Slicer 3 svn
Dashboard	Slicer 3 Dashboard
Bug Tracker	Slicer 3 Bug Tracker
Visual Blog	Visual Blog
Developer Discussion	Developer's Mailing List
Module Execution Documentation	Execution Model and Adapting Slicer to Large Scale Experiments

3D Slicer: Acknowledgements

Major Sponsors & Contributors

National Institutes of Health

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National Cancer Institute

Telemedicine & Advanced Technology Research Center of the US Army

Georgia Institute of Technology

New Energy and Industrial Technology Development Organization, Japan

Neuroimaging Analysis Center

Center for Integration of Medicine and Innovative Technology

National Alliance for Medical Image Computing

National Center for Image Guided Therapy

Biomedical Informatics Research Network

GE Global Research

Neuroinformatics Tools and Resources Clearinghouse

Surgical Planning Laboratory

Laboratory of Mathematics in Imaging

Massachusetts Institute of Technology

Johns Hopkins University CISST

Isomics, Inc.

Kitware, Inc.

The Martinos Center Massachusetts General Hospital

Harvard NeuroDiscovery Center

Psychiatric Neuroimaging Laboratory

Scientific Computing and Imaging Institute

The Harvard Clinical and Translational Science Center

Surgical Navigation and Robotics Laboratory

3D Slicer User Community

3D Slicer Developer Community