3D Slicer

Overview

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Right tool for the job

Jalopnik.com

Innovative,
not robust,
usually single developer
supported

www.unusuallocomotion.com

Robust and usable
enough for clinical
evaluation, flexible,
open, portable,
community
supported

www.senkox.com

FDA approved,
company supported,
closed source

Without an application platform

- Each application is developed from ground up
- Completely new software is developed for each problem/procedure/device
- Significant work is needed to integrate new, advanced algorithms

👍 Quick start.

👎 Huge waste of time, money, and effort overall.

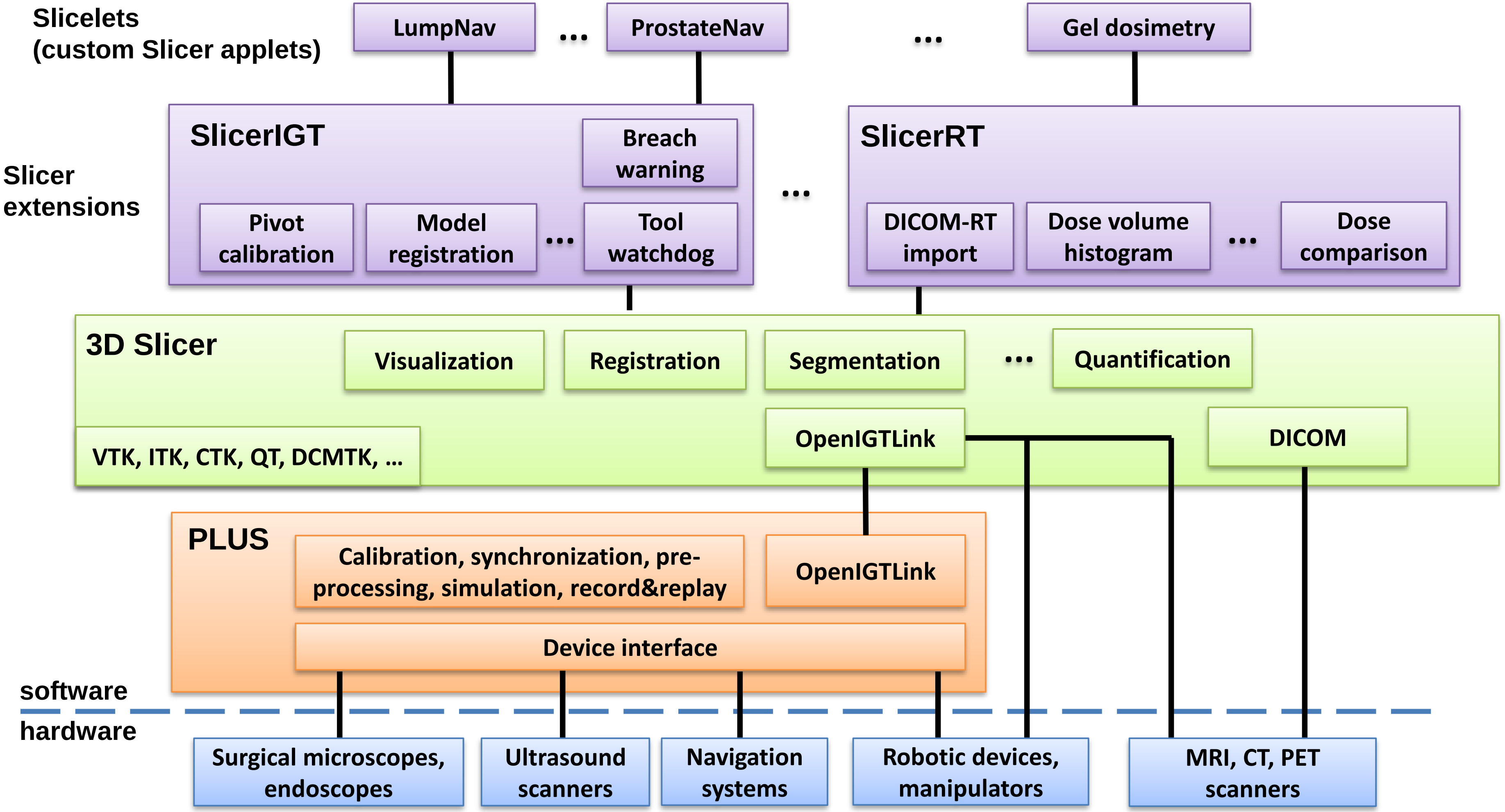
Building on an application platform

- Core functionalities are already implemented
- New software modules can be developed for specific needs
- Many new, advanced algorithms are available
- Well-supported with a large user and developer community

👎 Investment at the beginning: learning.

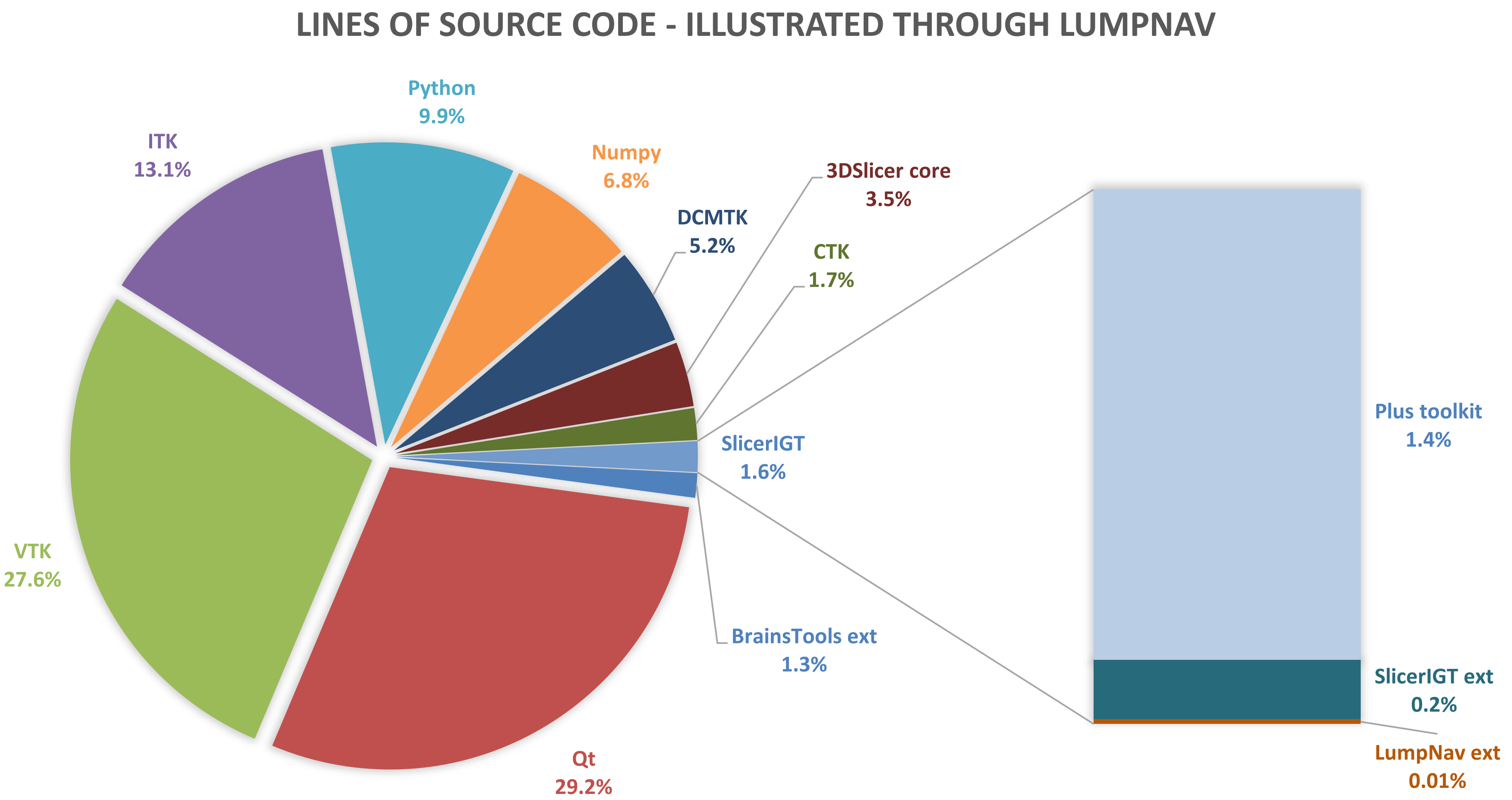
👍 Minimal wasted efforts.

Software stack example



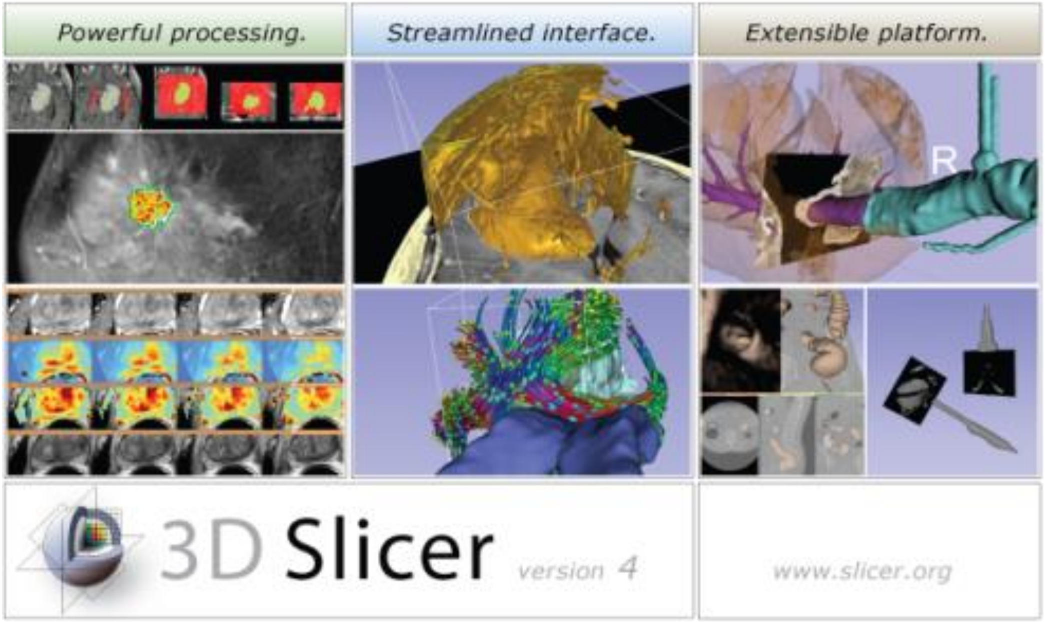
hundreds of devices (imaging, position tracking, various sensors, and manipulators)

Building on a platform



Background for 3D Slicer

- Software application for medical image computing: data import/export, visualization, segmentation, registration, quantification, real-time guidance
- Application framework: customizable, extensible custom modules
- Completely free (BSD)
- Multi-platform



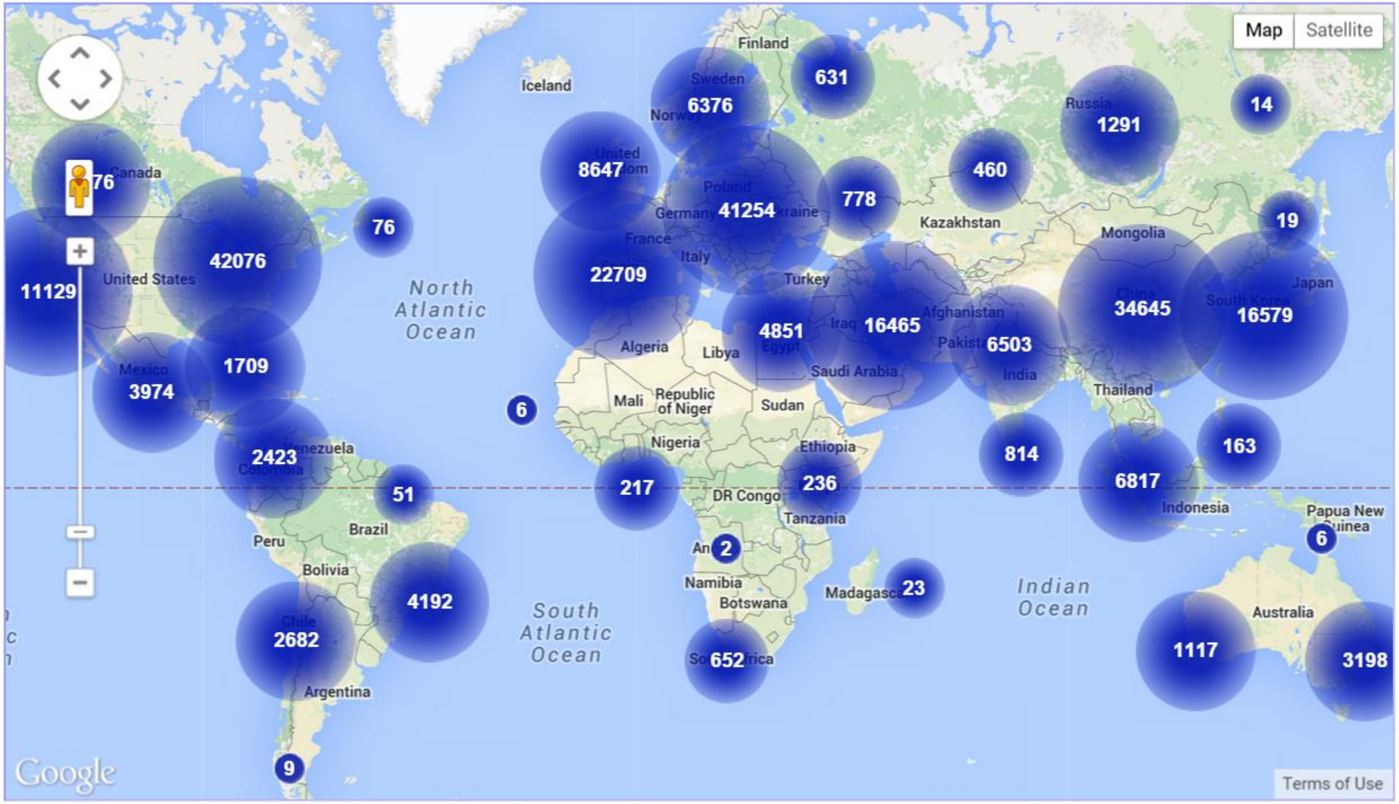
- User and developer support
- Training courses, documentation, tutorials

Fedorov, *et al.* "3D Slicer as an image computing platform for the Quantitative Imaging Network." Magnetic resonance imaging 30.9 (2012): 1323-1341.

Large user community

500 downloads per week in 2012
2000 downloads per week in 2017

250 000+ downloads over the past 4 years:

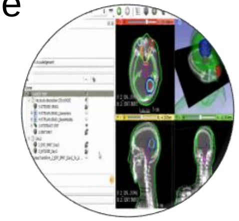


Project week

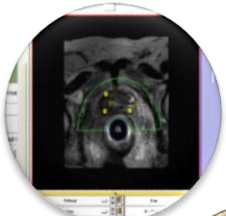
- Twice a year
- Bring your own project, work with experts
- Meetings, training
- Upcoming:
  January 2018, at MIT (Boston, MA)

3D Slicer in clinical use

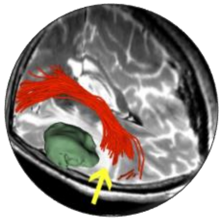
Radiation dose calculations



MRI-guided prostate biopsy

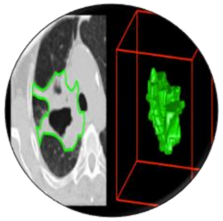


Tracking peritumoral white matter fibers



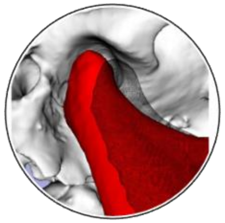
Breast cancer surgery guidance

Diagnosis of Different Tumors in Lung Cancer

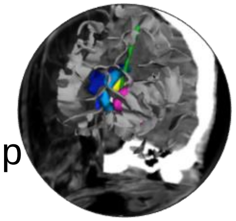


Clinical users drive creation of technology

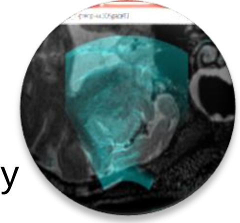
Diagnosis of Osteoarthritis Degeneration



Model-Guided Deep Brain Simulation

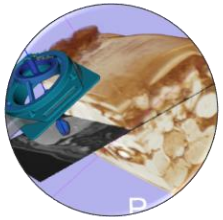


Brain surgery



Quantitative assessment of COPD

Surgical navigation

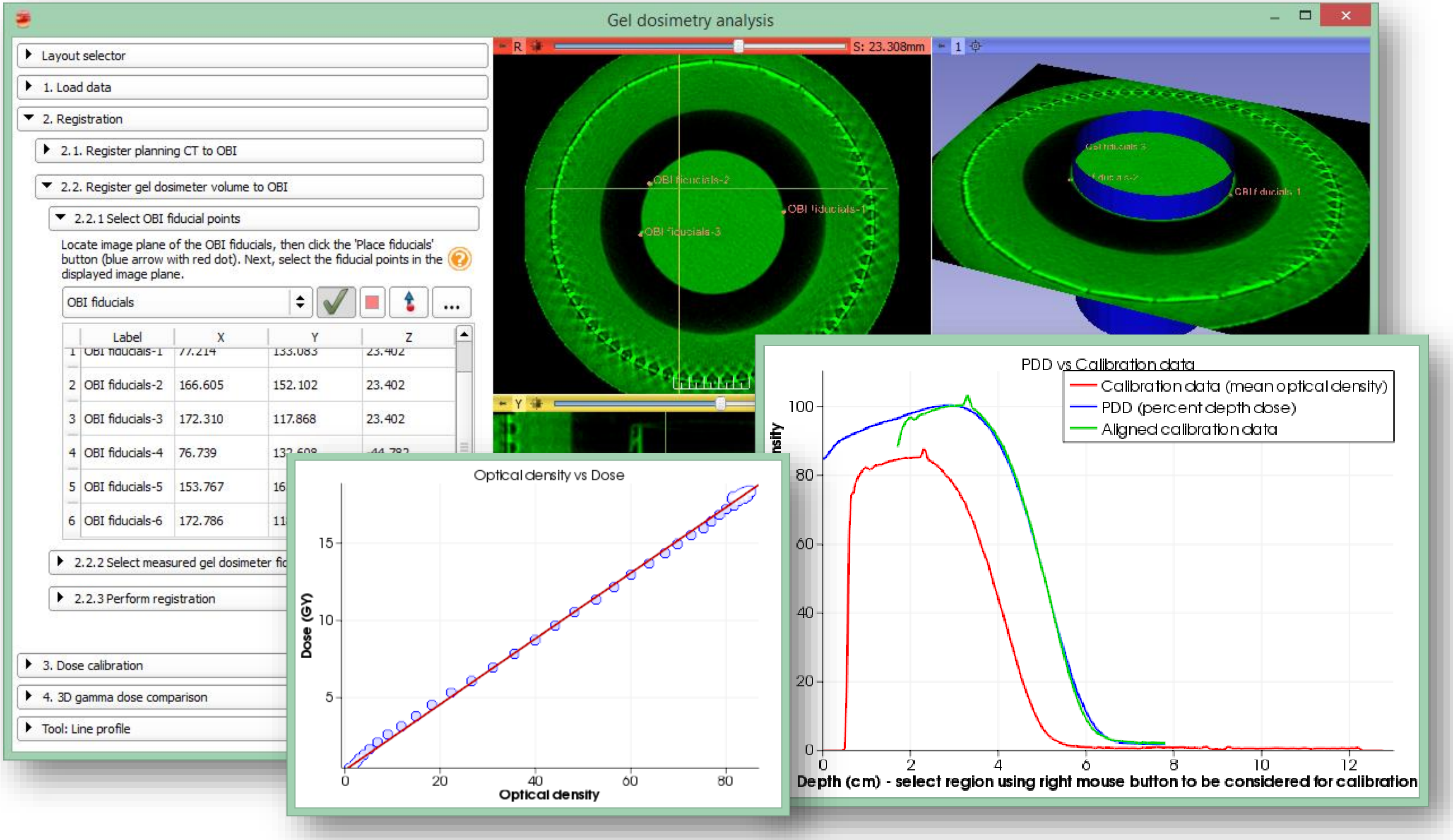


Commercial use

Known commercial activities range from use “as is” to full blown product development:

- Xstrahl (small animal radiation product)
- mebio (radiology product, prostate guidance)
- SonoVol (ultrasound product) (R43CA192482...)
- Novartis (quantitative imaging clinical trials)
- New Frontier (navigation system)
- KUKA (surgical robotics)
- Siemens (diagnostic and interventional research)
- Canon (robotic interventions)
- GE (research and products)
- NDI (trackers for surgical navigation)
- Isomics (research, consulting)
- Kitware (research, consulting)
  - 10+ Slicer based projects in the past two years
  - 5 commercial products being launched

Example: Gel Dosimetry tool



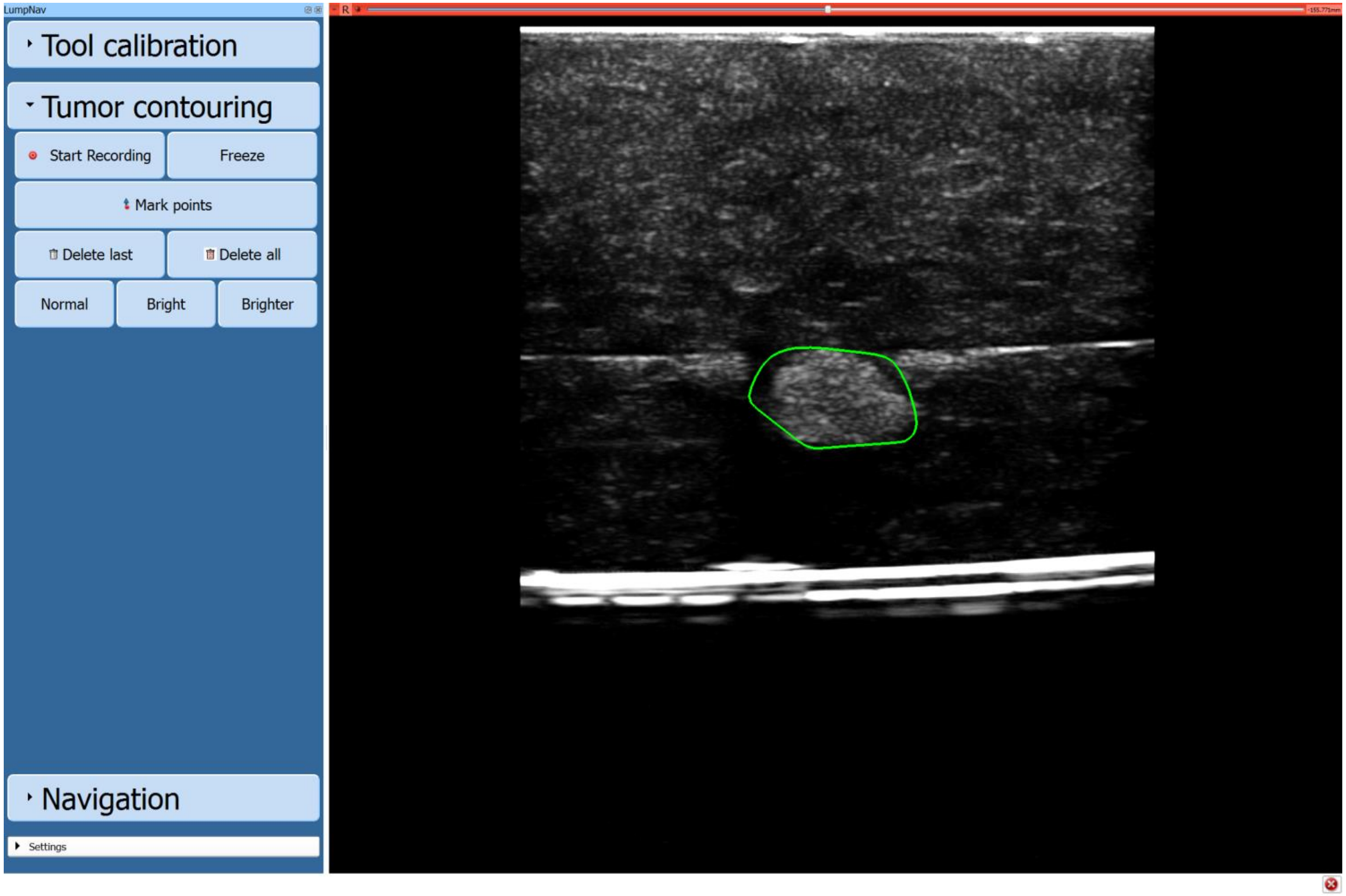
Locate image plane of the OBI fiducials, then click the 'Place fiducials' button (blue arrow with red dot). Next, select the fiducial points in the displayed image plane.

	Label	X	Y	Z
1	OBI fiducials-1	77.214	133.083	23.402
2	OBI fiducials-2	166.605	152.102	23.402
3	OBI fiducials-3	172.310	117.868	23.402
4	OBI fiducials-4	76.739	132.608	-44.782
5	OBI fiducials-5	153.767	16	
6	OBI fiducials-6	172.786	11	

https://www.slicer.org/slicerWiki/index.php/Documentation/Nightly/Modules/GelDosimetry

Chosen option: “slicelet”

Example: LumpNav (touch optimized)

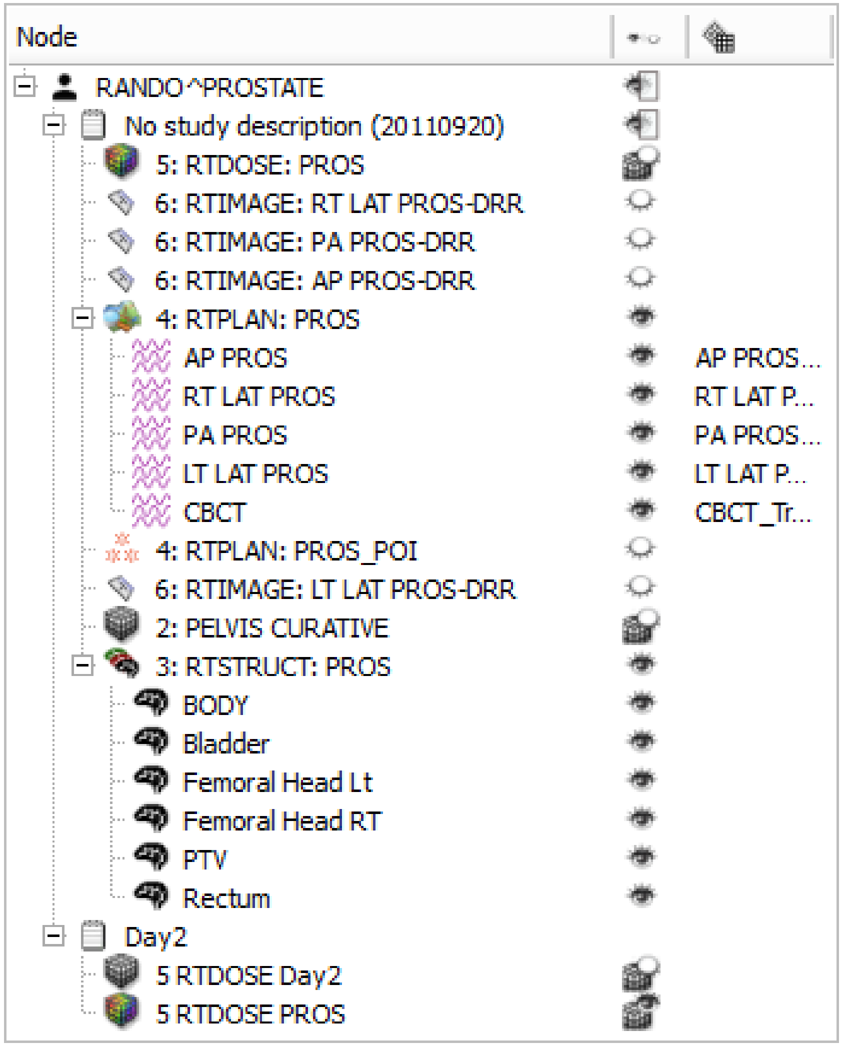


http://www.slicerigt.org/wp/breast-cancer-surgery/

Chosen option: “simplified main window”

Data import/export

- DICOM: 2D/3D/4D volumes, structure sets, dose volumes, etc. (extensible without Slicer core changes)
- Research data formats for volumes, meshes, transforms (NRRD, MetaIO, VTK, HDF, etc.)
- Common non-medical data formats (JPEG, TIFF, etc.)
- Save and complete restore of application state



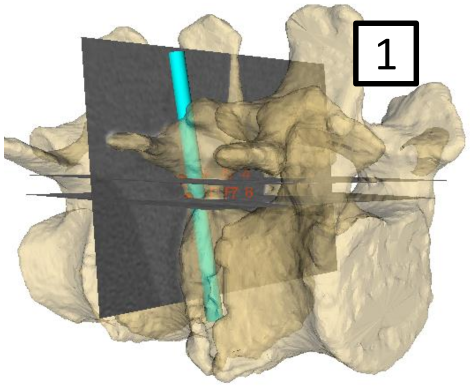
```
Node
RANDO^PROSTATE
  No study description (20110920)
    5: RTDOSE: PROS
    6: RTIMAGE: RT LAT PROS-DRR
    6: RTIMAGE: PA PROS-DRR
    6: RTIMAGE: AP PROS-DRR
    4: RTPLAN: PROS
      AP PROS                         AP PROS...
      RT LAT PROS                     RT LAT P...
      PA PROS                         PA PROS...
      LT LAT PROS                     LT LAT P...
      CBCT                            CBCT_Tr...
    4: RTPLAN: PROS_POI
    6: RTIMAGE: LT LAT PROS-DRR
    2: PELVIS CURATIVE
    3: RTSTRUCT: PROS
      BODY
      Bladder
      Femoral Head Lt
      Femoral Head RT
      PTV
      Rectum
  Day2
    5 RTDOSE Day2
    5 RTDOSE PROS
```

Data handling: the MRML scene

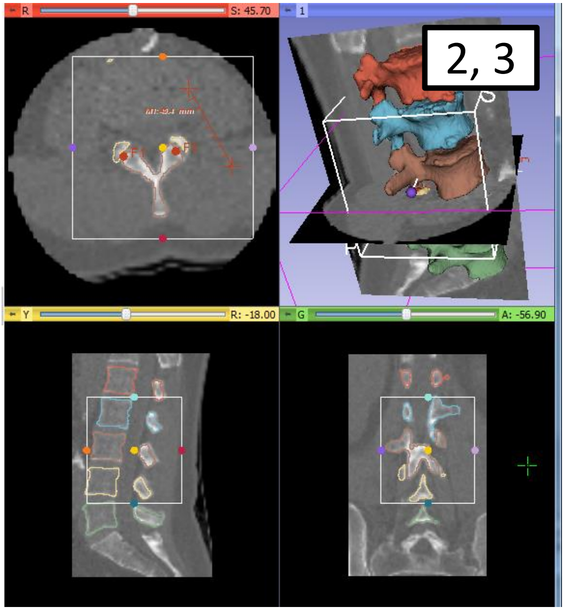
- MRML: Medical Reality Modeling Language
- All objects (volumetric images, surface models, transforms, etc.) are stored in a hierarchical structure of MRML nodes
- Each MRML node has its own list of custom attributes that can be used to specify additional characteristics for the data object
- Enables the modules to have access to the MRML tree, allowing new extensions to leverage existing processing and visualization functions without directly interfering with other modules

Visualization

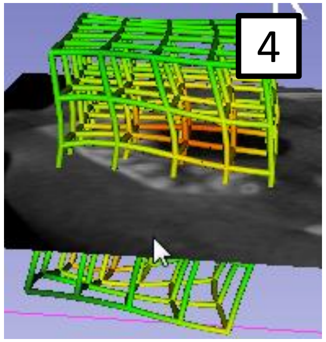
1. 2D (slice) and 3D views, chart views
2. Configurable layout
3. Multi-modality image fusion (foreground, background, label map)
4. Transforms, vector and tensor field visualization
5. Surface and volume rendering
6. Time sequence data



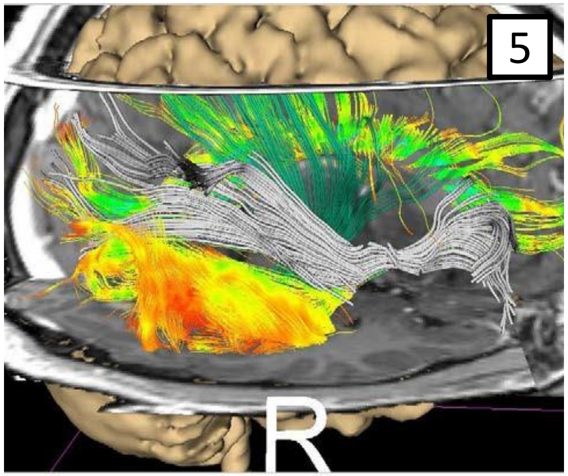
1



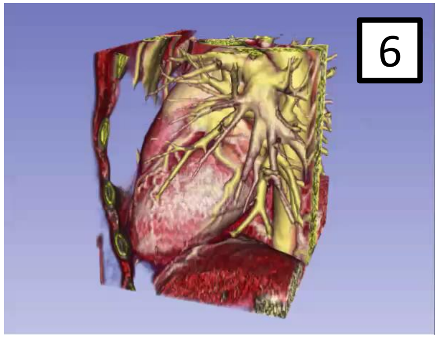
2, 3



4



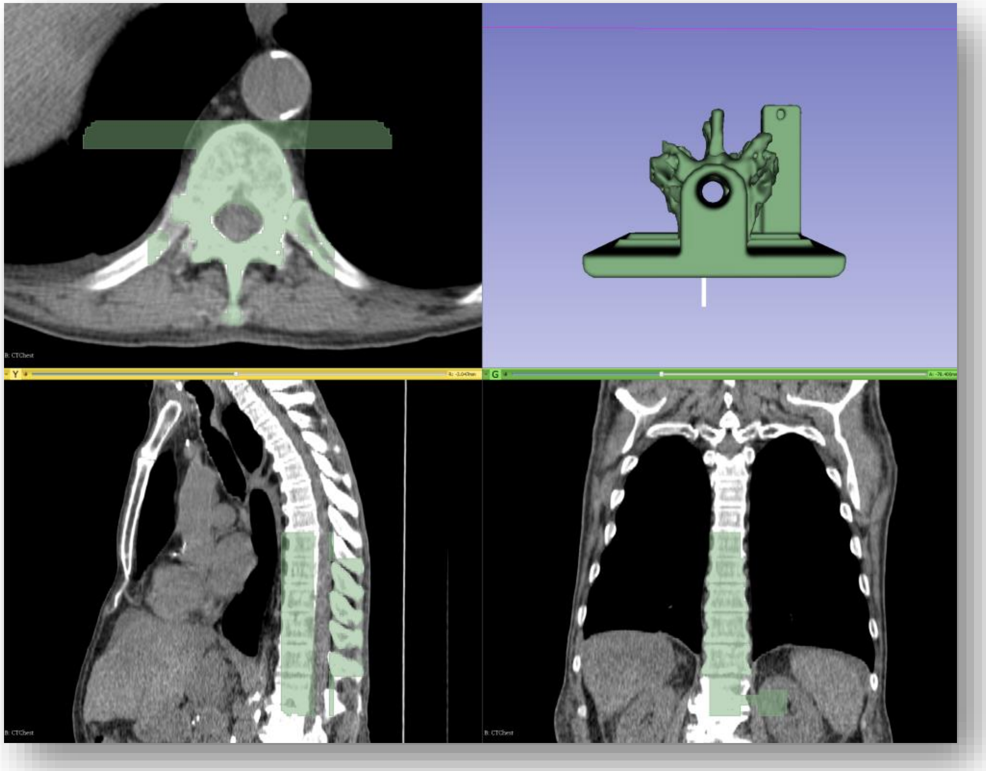
5

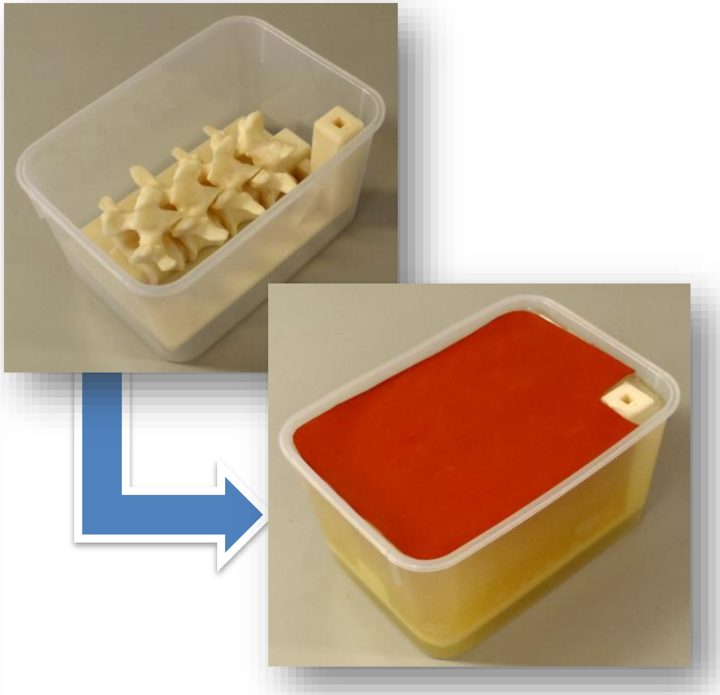


6

Segmentation

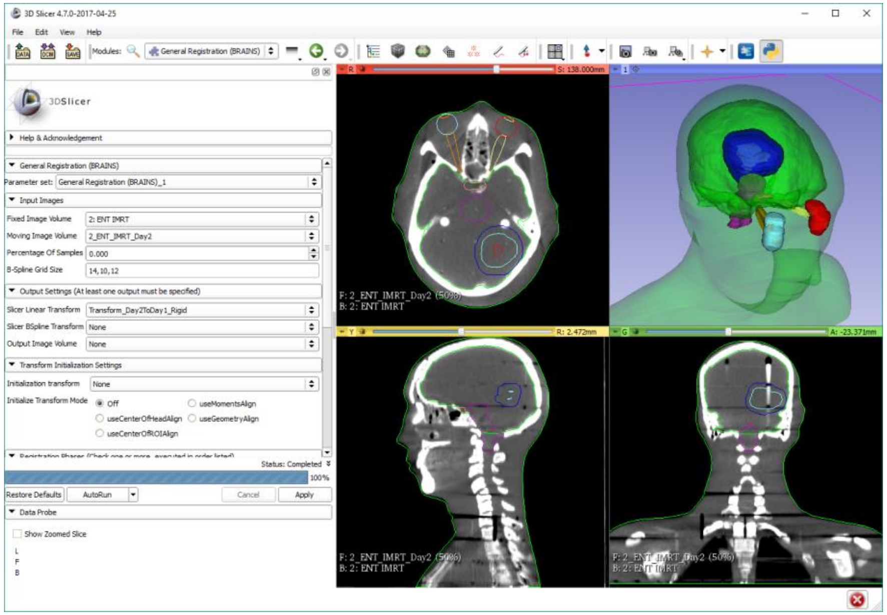
- Manual (paint, draw, scissor, threshold, etc.)
- Semi-automatic (region-growing, fill between slices, etc.)
- Automatic (atlas-based, robust statistics, etc.)





Registration

- Manual: translation, rotation in 3D
- Automatic: rigid, deformable, with various similarity metrics, initialization methods, optimizers, masking, etc.
- Extensions: surface-based registration, Elastix, etc.



3D Slicer 4.7.0-2017-04-25

Modules: General Registration (BRAINS)

General Registration (BRAINS)

Parameter set: General Registration (BRAINS)_1

Input Images

- Fixed Image Volume: 2: ENT IMRT
- Moving Image Volume: 2_ENT_IMRT_Day2
- Percentage Of Samples: 0.000
- B-Spline Grid Size: 14, 10, 12

Output Settings (At least one output must be specified)

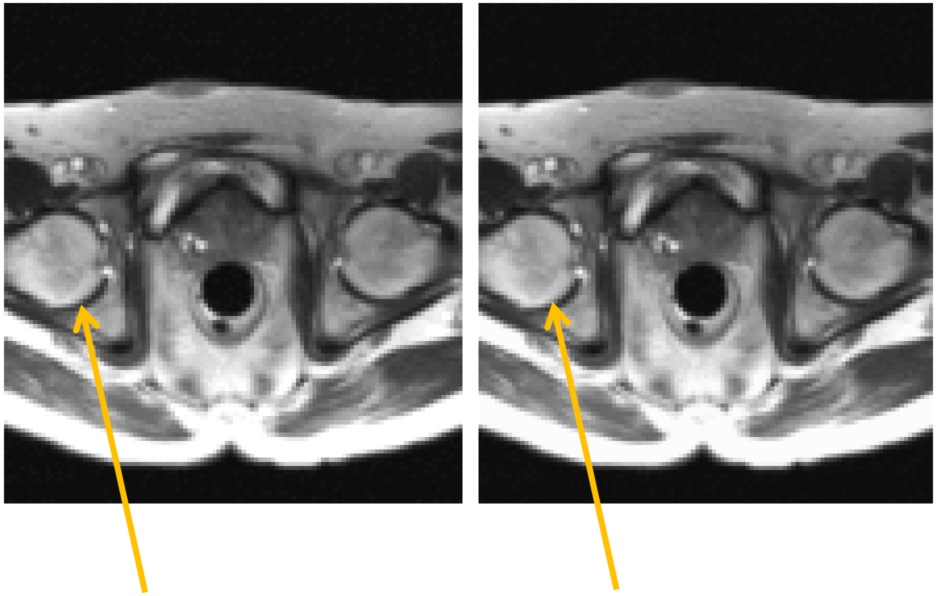
- Slicer Linear Transform: Transform_Day2ToDay1_Rigid
- Slicer BSpline Transform: None
- Output Image Volume: None

Transform Initialization Settings

- Initialization transform: None
- Initialize Transform Mode: ● Off ○ useMomentsAlign ○ useCenterOfHeadAlign ○ useGeometryAlign ○ useCenterOfROIAlign

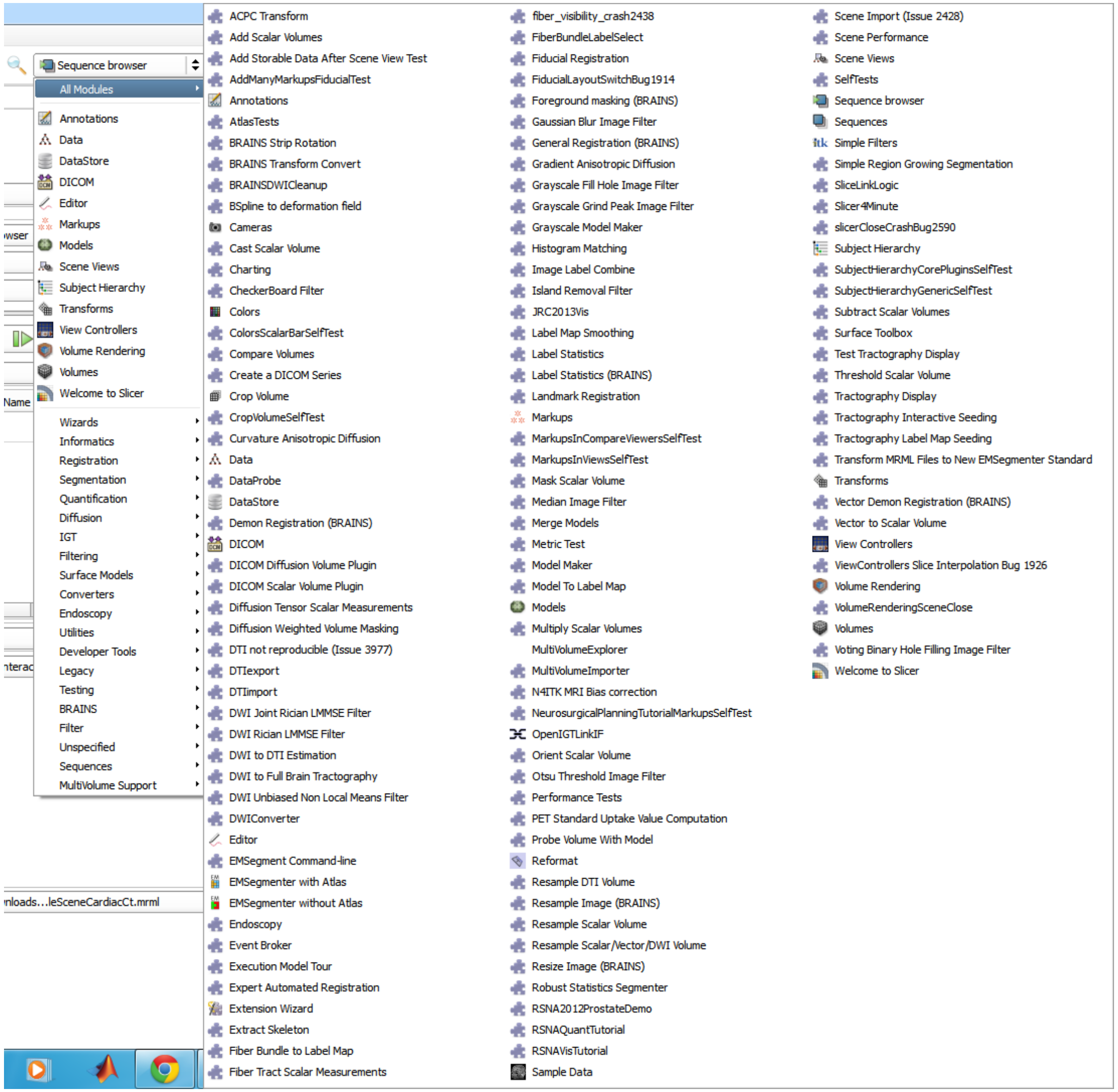
Status: Completed

100%



Many other modules...

- Image filtering (image noise reduction, MRI bias correction, etc.)
- Surface processing
- Diffusion imaging
- Quantification, statistics
- …

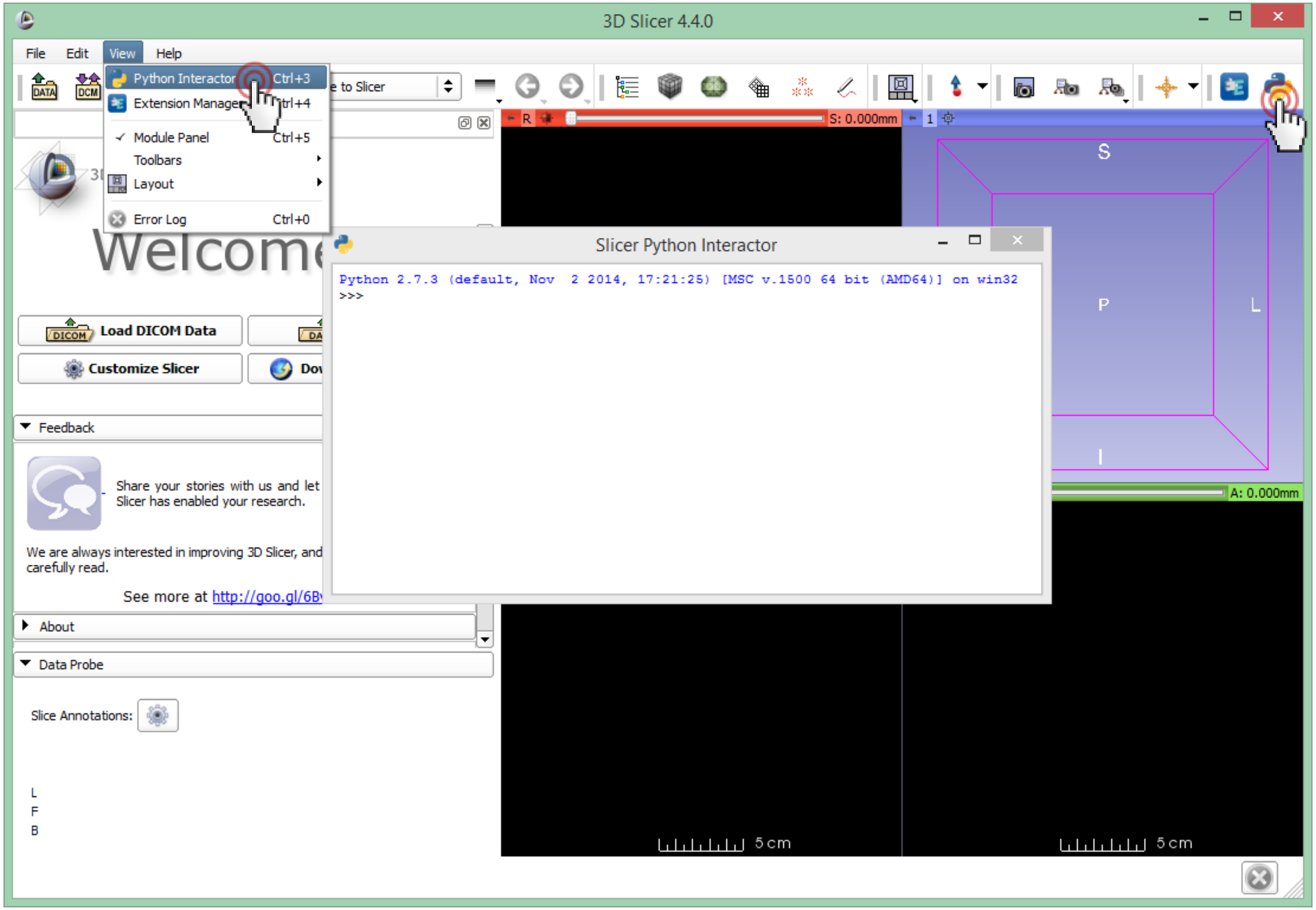


Python in Slicer

The Python console of Slicer4 gives access to

- Scene objects (MRML)
- Modules (core and extensions)
- Data arrays (volumes, models)
- GUI elements (Qt) that can be encapsulated in a module
- Processing Libraries
    - numpy
    - VTK
    - ITK (SimpleITK)
    - CTK

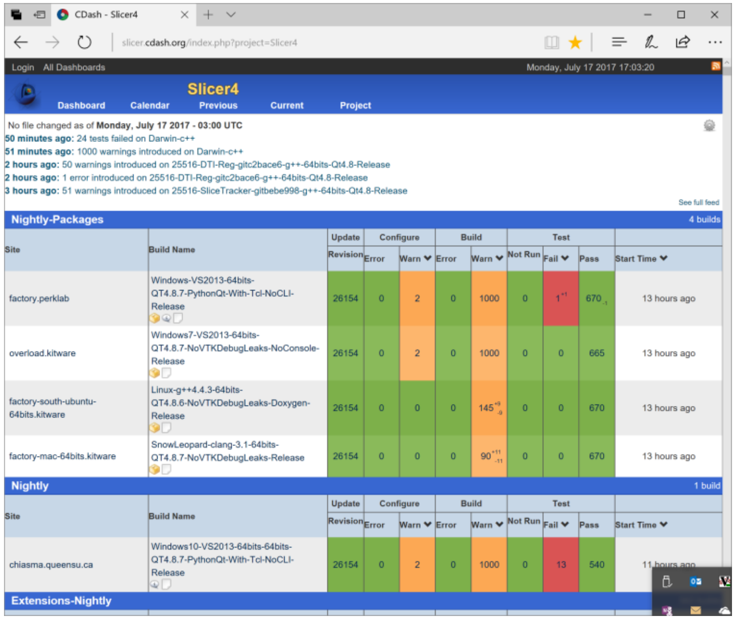
Python console in Slicer



```
Python 2.7.3 (default, Nov  2 2014, 17:21:25) [MSC v.1500 64 bit (AMD64)] on win32
>>>
```

Automatic regression testing

- Automatic tests ensure detecting regression errors
- Results published on [web-based dashboard]
- Types
  - Generic tests: automatically generated
  - Logic tests: ests a custom module's behavior, processing results
  - Python self-tests
    - Comprehensive test, including user interface, logic, data storage
    - Details: http://wiki.slicer.org/slicerWiki/index.php/Documentation/Nightly/Developers/Tutorials/SelfTestModule



Monday, July 17 2017 17:03:20

No file changed as of **Monday, July 17 2017 - 03:00 UTC**
50 minutes ago: 24 tests failed on Darwin-c++
51 minutes ago: 1000 warnings introduced on Darwin-c++
2 hours ago: 50 warnings introduced on 25516-DTI-Reg-gitc2bace6-g++-64bits-Qt4.8-Release
2 hours ago: 1 error introduced on 25516-DTI-Reg-gitc2bace6-g++-64bits-Qt4.8-Release
3 hours ago: 51 warnings introduced on 25516-SliceTracker-gitbebe998-g++-64bits-Qt4.8-Release

Nightly-Packages 4 builds

		Update	Configure		Build		Test			
Site	Build Name	Revision	Error	Warn	Error	Warn	Not Run	Fail	Pass	Start Time
factory.perklab	Windows-VS2013-64bits-QT4.8.7-PythonQt-With-Tcl-NoCLI-Release	26154	0	2	0	1000	0	1^{+1}	670_{-1}	13 hours ago
overload.kitware	Windows7-VS2013-64bits-QT4.8.7-NoVTKDebugLeaks-NoConsole-Release	26154	0	2	0	1000	0	0	665	13 hours ago
factory-south-ubuntu-64bits.kitware	Linux-g++4.4.3-64bits-QT4.8.6-NoVTKDebugLeaks-Doxygen-Release	26154	0	0	0	145^{+9}_{-9}	0	0	670	13 hours ago
factory-mac-64bits.kitware	SnowLeopard-clang-3.1-64bits-QT4.8.7-NoVTKDebugLeaks-Release	26154	0	0	0	90^{+11}_{-11}	0	0	670	13 hours ago

Nightly 1 build

		Update	Configure		Build		Test			
Site	Build Name	Revision	Error	Warn	Error	Warn	Not Run	Fail	Pass	Start Time
chiasma.queensu.ca	Windows10-VS2013-64bits-64bits-QT4.8.7-PythonQt-With-Tcl-NoCLI-Release	26154	0	2	0	1000	0	13	540	11 hours ago

Extensions-Nightly

Modular architecture

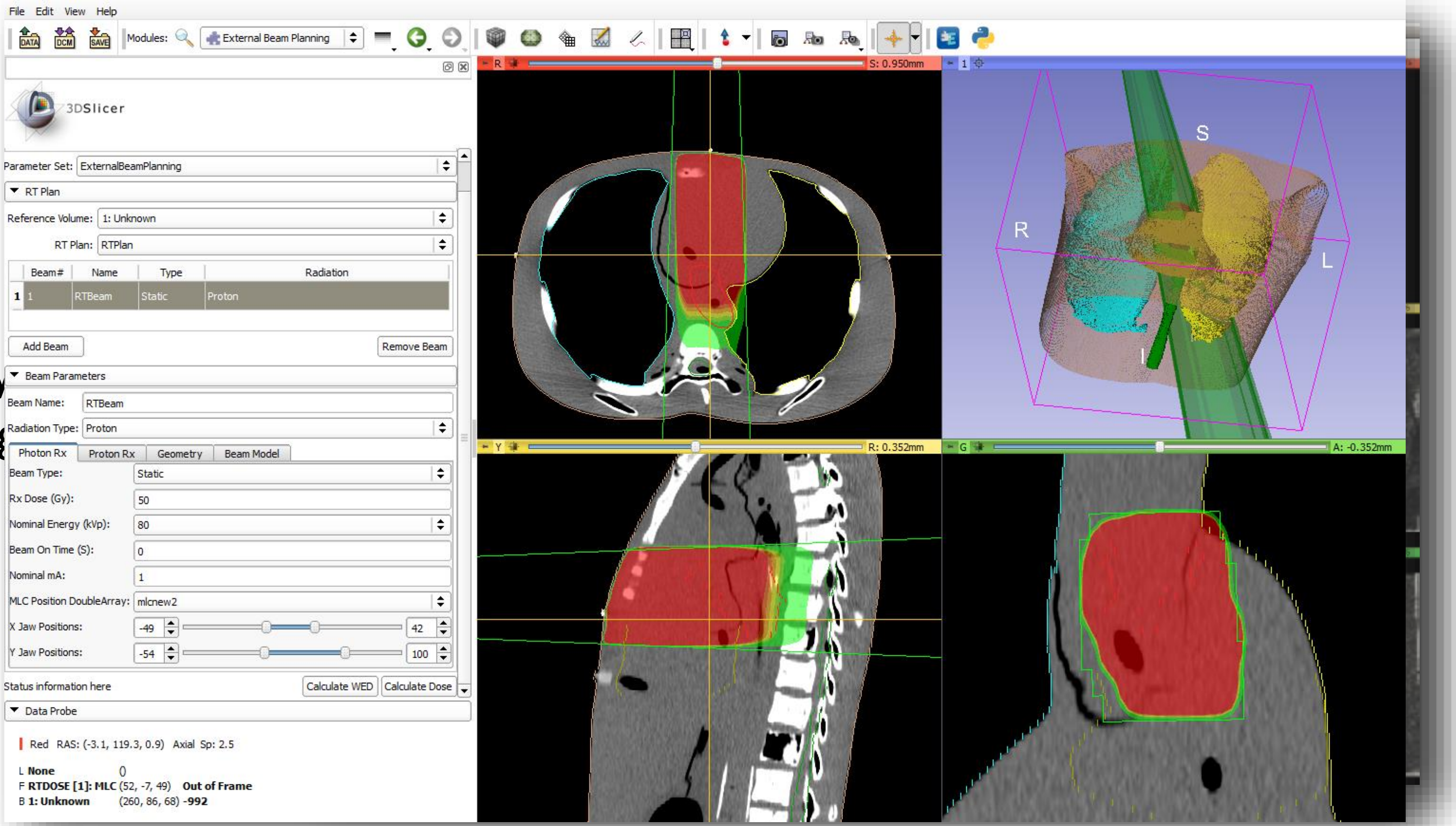
Three types of modules:

- Scripted modules – written in python
- Command-line modules (CLI) – use ITK
- Loadable (interactive) modules – written in C++

e.g. Tractography labelmap seeding

e.g. External beam planning

Image courtesy: Sonia Pujol



Modules: External Beam Planning

Parameter Set: ExternalBeamPlanning

RT Plan

Reference Volume: 1: Unknown

RT Plan: RTPlan

	Beam#	Name	Type	Radiation
1	1	RTBeam	Static	Proton

Add Beam   Remove Beam

Beam Parameters

Beam Name: RTBeam

Radiation Type: Proton

Photon Rx | Proton Rx | Geometry | Beam Model

Beam Type: Static

Rx Dose (Gy): 50

Nominal Energy (kVp): 80

Beam On Time (S): 0

Nominal mA: 1

MLC Position DoubleArray: mlcnew2

X Jaw Positions: -49   42

Y Jaw Positions: -54   100

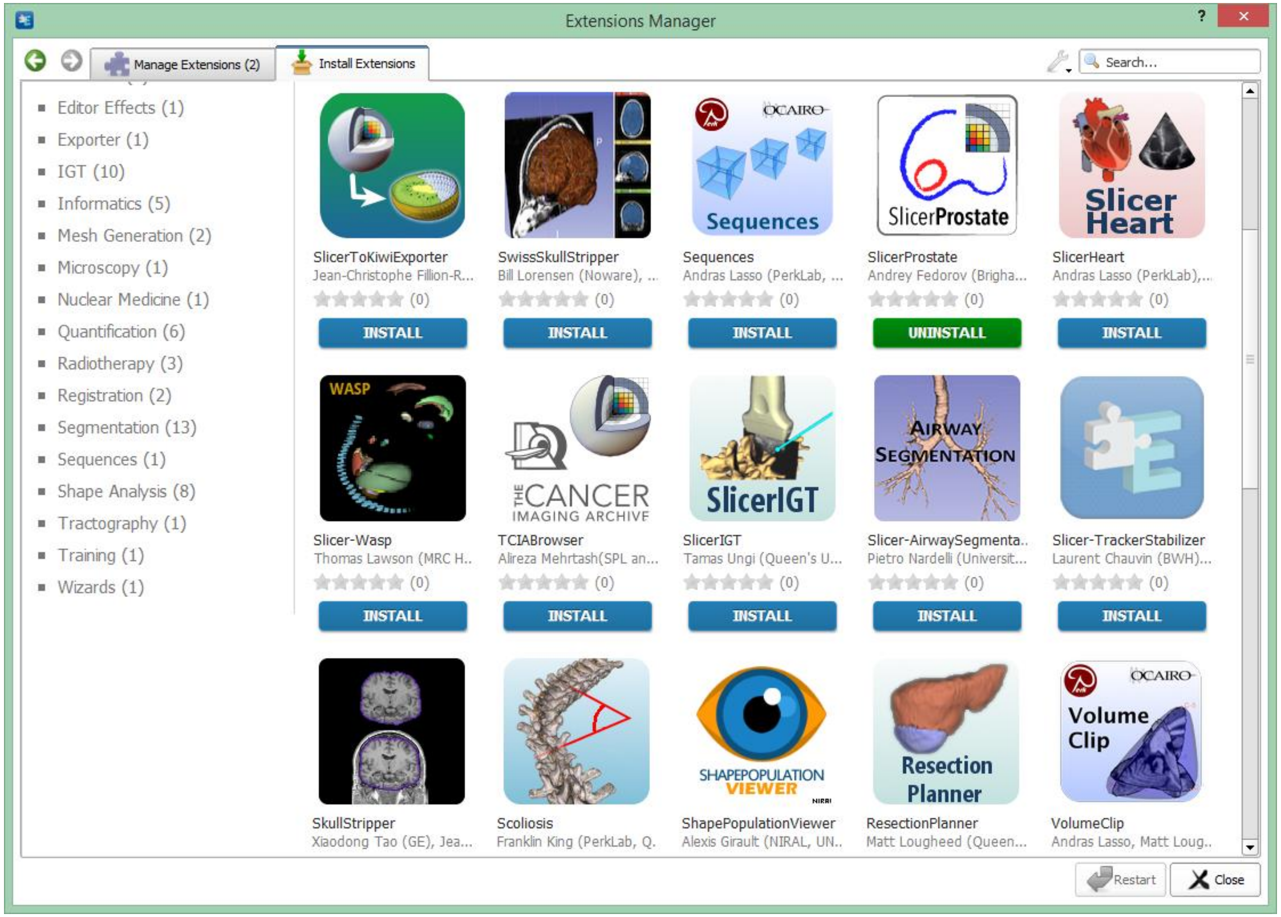
Status information here   Calculate WED   Calculate Dose

Data Probe

Red RAS: (-3.1, 119.3, 0.9) Axial Sp: 2.5

```
L None              0
F RTDOSE [1]: MLC (52, -7, 49)   Out of Frame
B 1: Unknown       (260, 86, 68) -992
```

Slicer is extensible



Slicer Extension Manager offers the possibility to the user to download and install additional Slicer modules by a few clicks

Share your tools

- In the spirit of the open-source paradigm, it is encouraged to share your tools
- The shared extensions
  - appear in the Extension Manager
  - are nightly tested on the Slicer Factory platforms
- How to share?
  - Fork ExtensionIndex from GitHub and upload your extension description (.s4ext) file https://github.com/Slicer/ExtensionsIndex
  - Ask the core team to integrate (send a “pull request”)

http://discourse.slicer.org

@lassoan