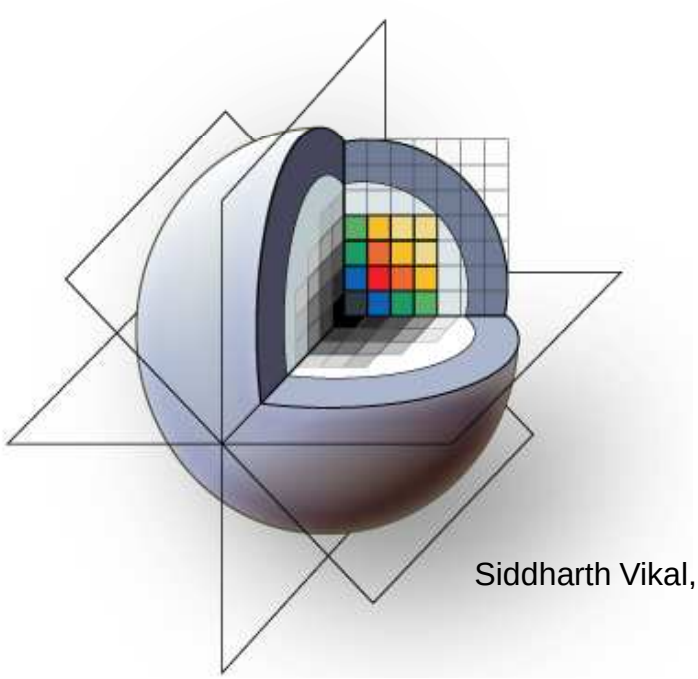
Slicer3 Training Tutorial
Trans-rectal MR-guided prostate biopsy



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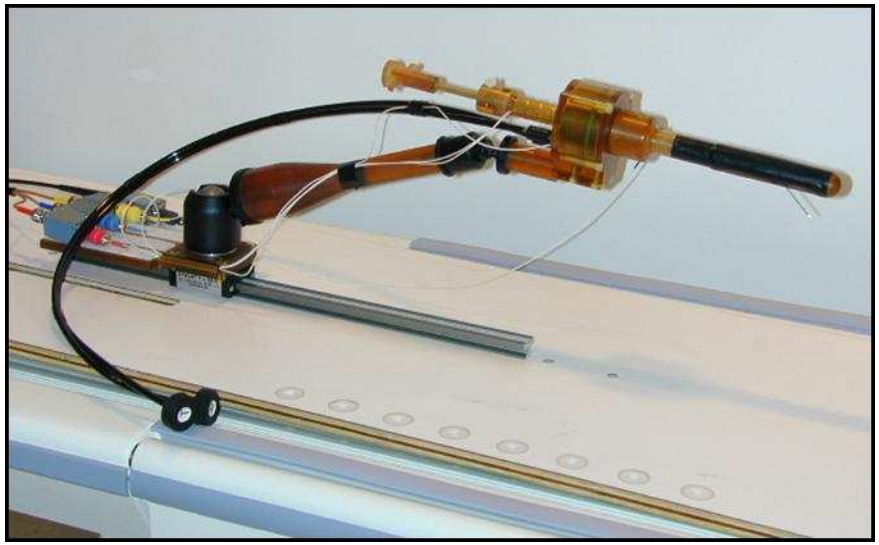
Learning Objective

This tutorial will teach you how to perform MR-guided prostate biopsy using MR-compatible trans-rectal robot with SLICER



Prerequisites

MR-compatible trans-rectal robot: Detailed information can be found here:

[1] Krieger A, Susil RC, Menard C, Coleman JA, Fichtinger G, Atalar E, Whitcomb LL, Design of A Novel MRI Compatible Manipulator for Image Guided Prostate Intervention, IEEE Trans. Biomed. Eng. 2005; 52(2):306-313

[2] Susil RC, Ménard C, Krieger A, Coleman JA, Camphausen K, Choyke P, Ullman K, Smith S, Fichtinger G, Whitcomb LL, Coleman NC, Atalar E, Transrectal Prostate Biopsy and Fiducial Marker Placement in a Standard 1.5T MRI Scanner, J Urol. 2006 Jan;175(1):113-20

Prerequisites

This tutorial assumes that you have already completed the tutorial **Data Loading and Visualization**. Tutorials for **Slicer3** are available at the following location:

- **Slicer3** tutorials
http://www.na-mic.org/Wiki/index.php/Slicer3.2:Training

Materials

Since this module (*Transrectal Prostate Biopsy*) is not part of core modules, but an external loadable module, just the installation of Slicer3 would not show this module in the modules list. There are two possible ways of integrating this module inside Slicer:

1. Build (not install) Slicer3 from source code; build *TRProstateBiopsy* from source code; give the output path of build to be Slicer's \\lib\\Slicer3\\Modules.

2. Install Slicer3, copy the *TRProstateBiopsy*.dll file in *SLICER_INSTALL_DIR*\\lib\\Slicer3\\Modules

Materials

If one chooses Method 1 of integration, then:

- Build **Slicer3** (***Slicer 3.x***), instructions can be found at:

http://www.slicer.org/slicerWiki/index.php/Slicer3:Build_Instructions

- Build ***TRProstateBiopsy*** **module, source code**

http://svn.na-mic.org/NAMICSandBox/trunk/Queens/TRProstateBiopsy/

Set the output path of build to be Slicer's \\lib\\Slicer3\\Modules

Now, when you run Slicer3-real.exe from the release/debug directory, *TRProstateBiopsy* shows up in modules drop down list

This is the recommended method of integration

Materials

If one chooses Method 2 of integration, then:

- Install Slicer3, **Slicer3** download page (***Slicer 3.2***)

http://www.slicer.org/pages/Downloads/

- Copy the *TRProstateBiopsy.dll* file to
  SLICER_INSTALL_DIR \\lib\\Slicer3\\Modules

Now, when you run Slicer3, TransrectalProstateBiopsy shows up in modules drop down list

This is a faster way of integration, however, it assumes that the 'dll' file was built in the same configuration as was Slicer3 when it was installed. This assumption does not hold true often.

Materials

- Tutorial dataset (**<** TRPBTutorialDataset .zip**>**)
- Unzip the folder
- Will create the directories within top level directory (TRPBTutorialDataset): Calibration, Segmentation, Targeting, Verification

Disclaimer: *It is the responsibility of the user of Slicer to comply with both the terms of the license and with the applicable laws, regulations, and rules.*

Overview

1. Clinical background and motivation
2. MRI-compatible robot manipulator
3. Systems overview
4. Workflow
5. Demonstration with SLICER
    1. Robot calibration
    2. Prostate segmentation
    3. Biopsy targeting
    4. Verification

1. **Clinical background and motivation**
2. MRI-compatible robot manipulator
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MRI-guided prostate biopsy: clinical background

- Prostate cancer, most common cancer in men
- Core needle biopsy definitive diagnostic for prostate cancer
- TRUS has been “Gold standard” for guiding biopsy
- MRI/MRS offers high sensitivity for localizing tumor
- Robotic access required inside scanner[1,2]

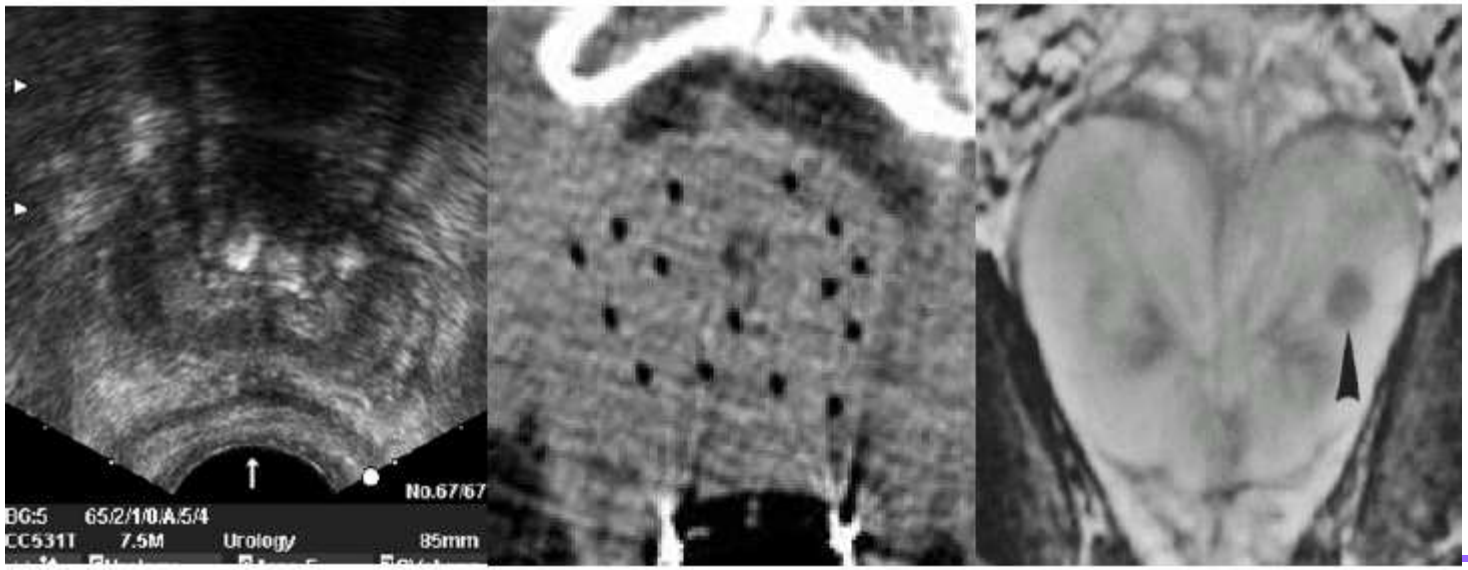

Figure 1.1: Prostate images from ultrasound, CT, and MRI

1. Clinical background and motivation
2. **MRI-compatible robot manipulator**
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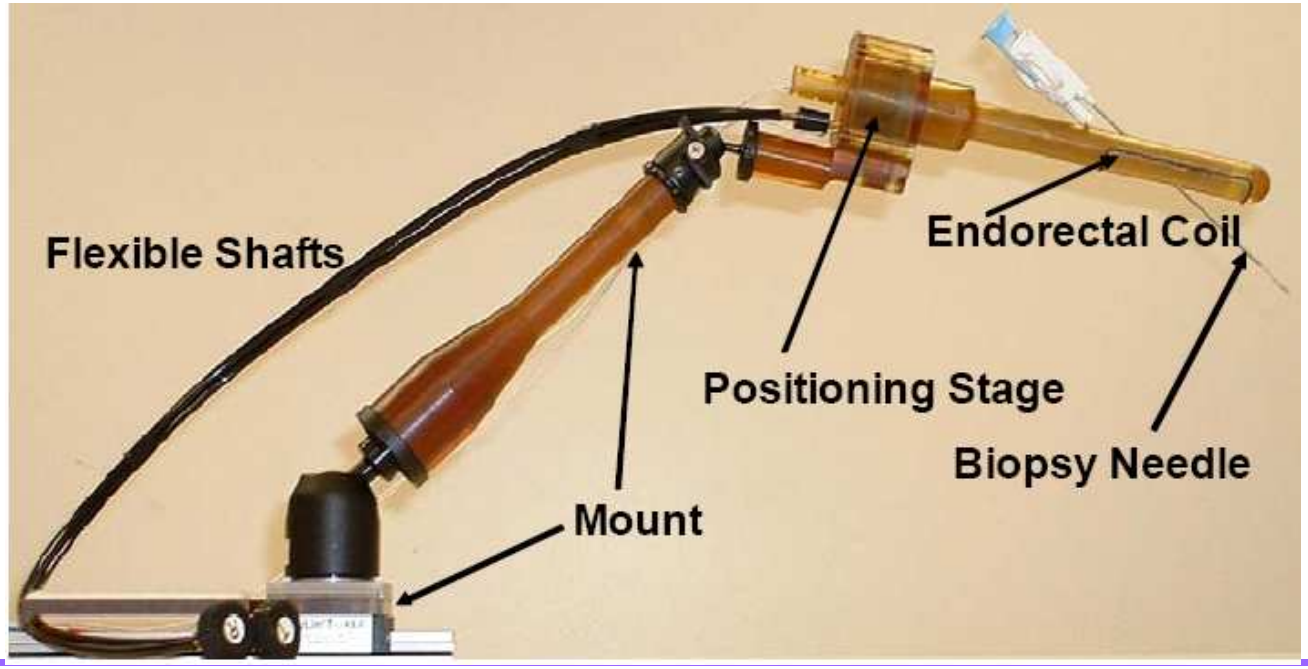
MRI-compatible robot

- Remotely actuated manipulator
- Operates inside a conventional high-field MRI scanner (higher SNR) as opposed to open bore scanner
- Employs trans-rectal access to prostate



1. Clinical background and motivation
2. MRI-compatible robot manipulator
3. **Systems overview**
4. Workflow
5. Demonstration with SLICER
    1. Robot calibration
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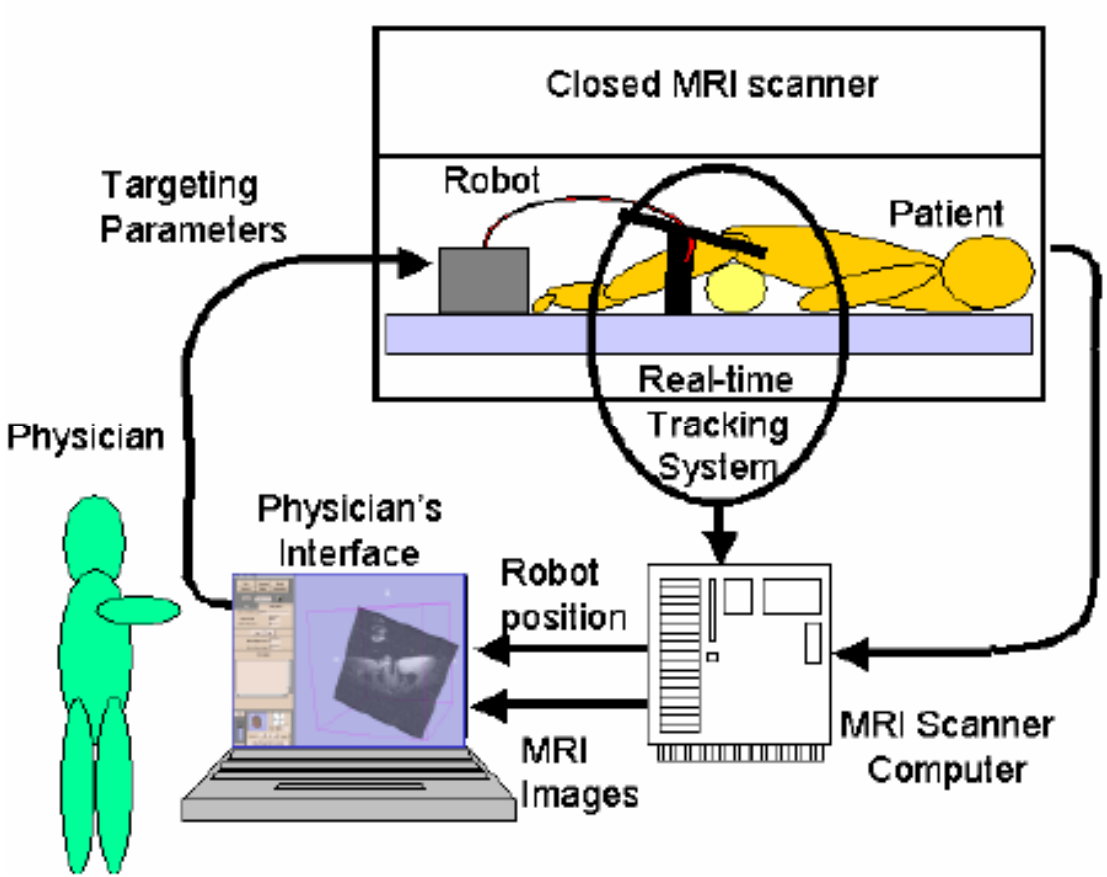
Systems overview



1. Clinical background and motivation
2. MRI-compatible robot manipulator
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4. **Workflow**
5. Demonstration with SLICER
    1. Robot calibration
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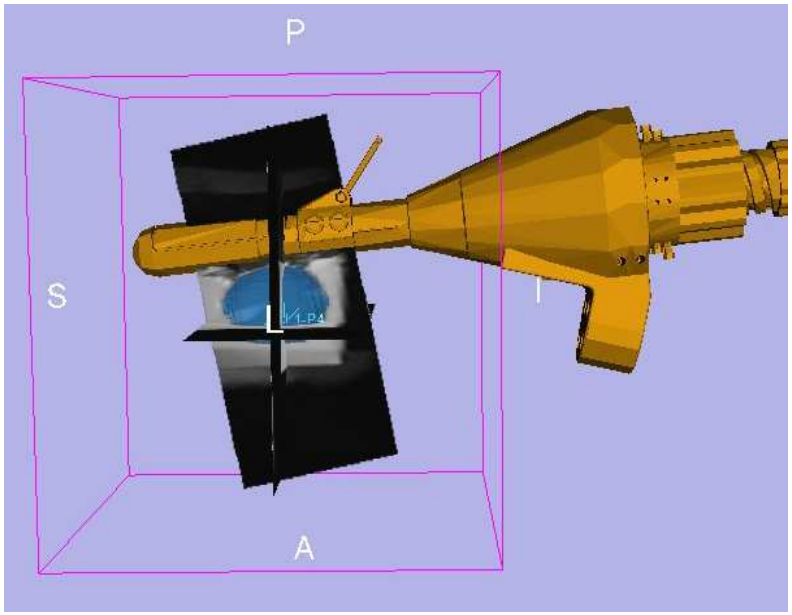
Workflow

1. Acquire a calibration volume, calibrate/register robot to MR coordinate system
2. Acquire targeting volume, pick/mark biopsy(or seed) targets
3. Perform biopsy
4. Acquire validation volume, with needle still in
5. Perform validation analysis

1. Clinical background and motivation
2. MRI-compatible robot manipulator
3. Systems overview
4. Workflow
5. **Demonstration with SLICER**
    1. Robot calibration
    2. Prostate segmentation
    3. Biopsy targeting
    4. Verification

Demonstration with SLICER

1. Robot calibration (registration)
2. Prostate segmentation
3. Biopsy targeting
4. Verification



Transrectal Prostate Biopsy GUI

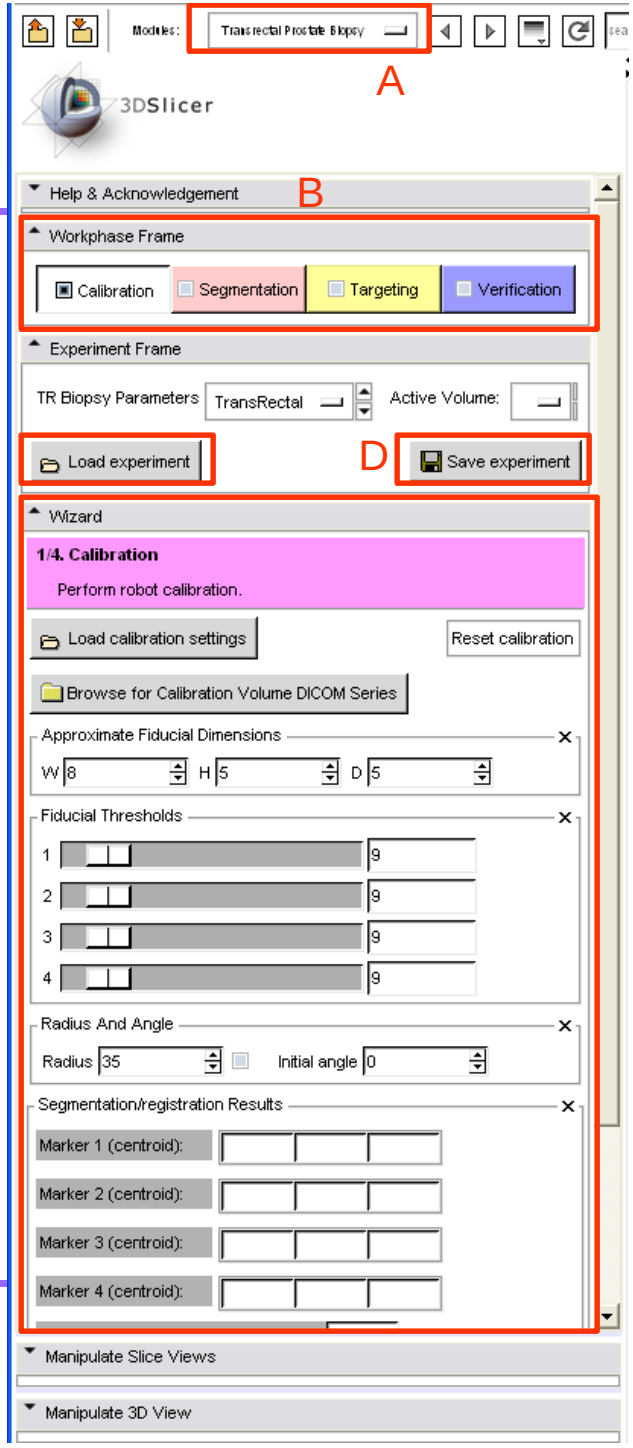
A - Select << Transrectal Prostate Biopsy >> from modules list, GUI loads up with “Experiment” frame and “Wizard workflow GUI” frame

B - Workphase frame depicts which step you are currently in, can also be for navigation a particular step directly

C - “Load experiment” to load any previously saved intervention

D - “Save experiment” to save the experiment

E - Wizard workflow GUI, as an intuitive interface to perform the intervention step-by-step; here, it illustrates the first step of calibration; each step’s wizard GUI is explained in the following slides



Calibration

Calibrate step wizard GUI

Load/save/reset

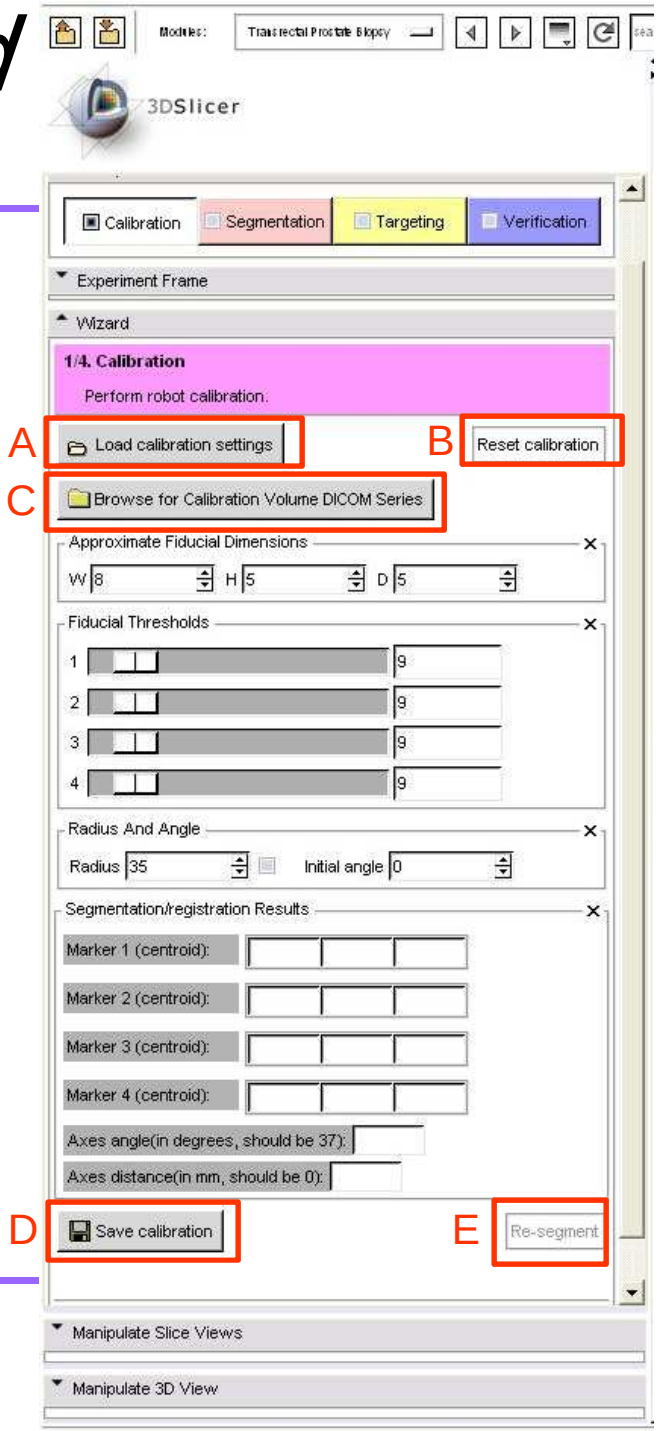
A - Click to load a previous saved calibration

B - Reset calibration completely, new marker guesses

C - Click to load calibration volume dicom series

D - Save the current achieved calibration

E - Re-segment markers with new set of segmentation parameters, not giving new guesses; this button becomes active if calibration has been done at least once



Calibrate step wizard GUI

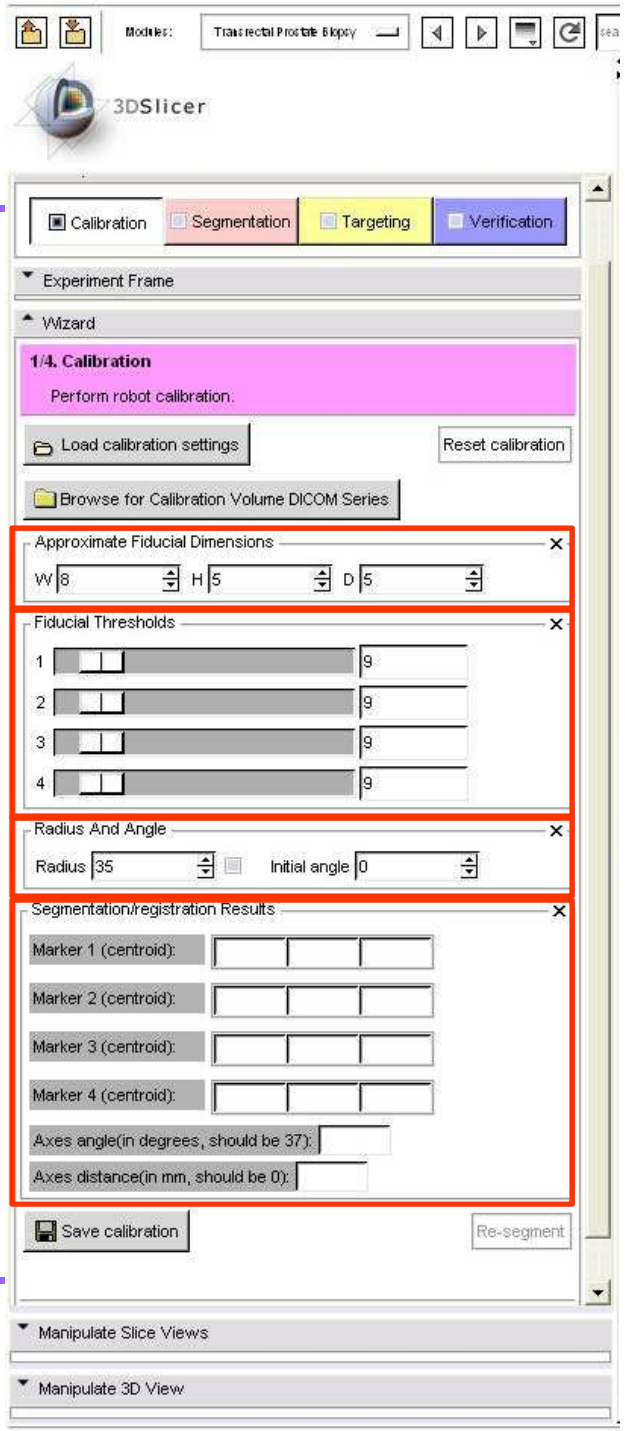
Marker segmentation parameters

A - Approximate fiducial dimensions for morphological filtering

B - Threshold for each of the four markers on robot to aid segmentation

C - Readings on the robot

D - Segmentation/Registration results displayed here



Load calibration dicom series

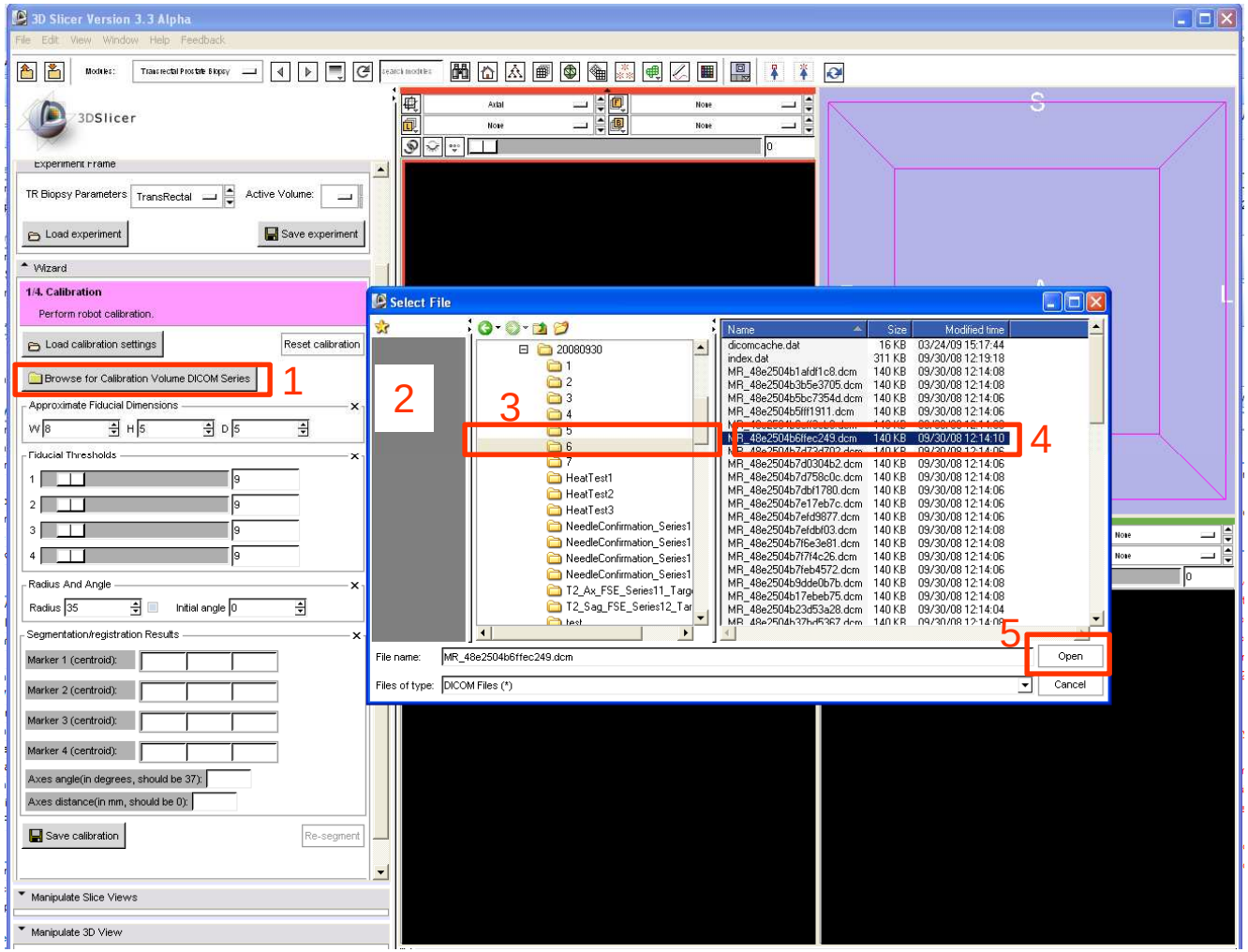
1 - Click “Browse for calibration dicom…”

2 - Dialog box appears

3 - Navigate to desired directory (TRPBTutorialDataset \Calibration\)

4 - Select any one file in the directory

5 - Click “Open”



Calibrate step

1 - Select the parameters

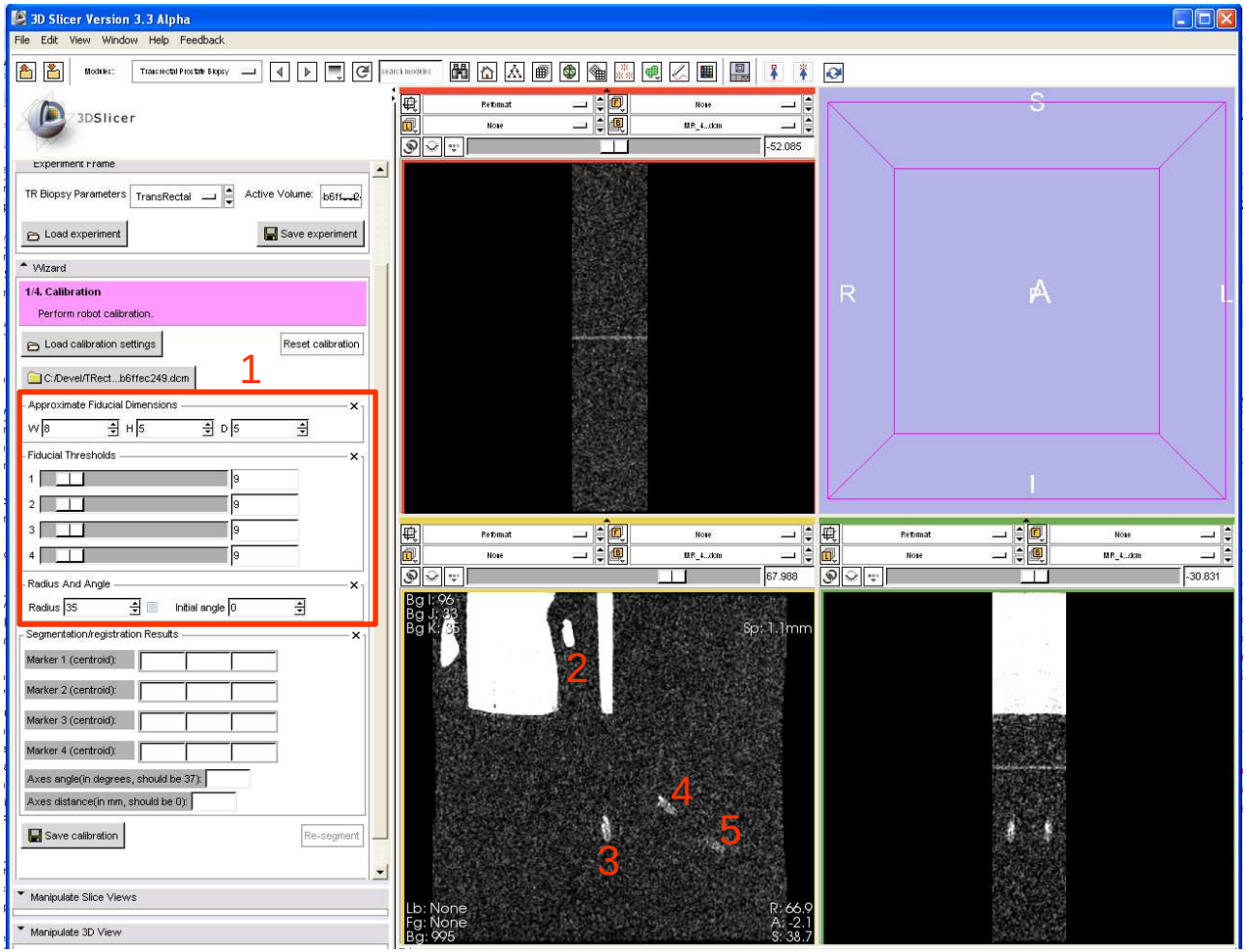
In any of three views, wherever the marker is best visible:

2 - Click first marker roughly at center

3 - Click second marker roughly at center

4 - Click third marker roughly at center

5 - Click fourth marker roughly at center

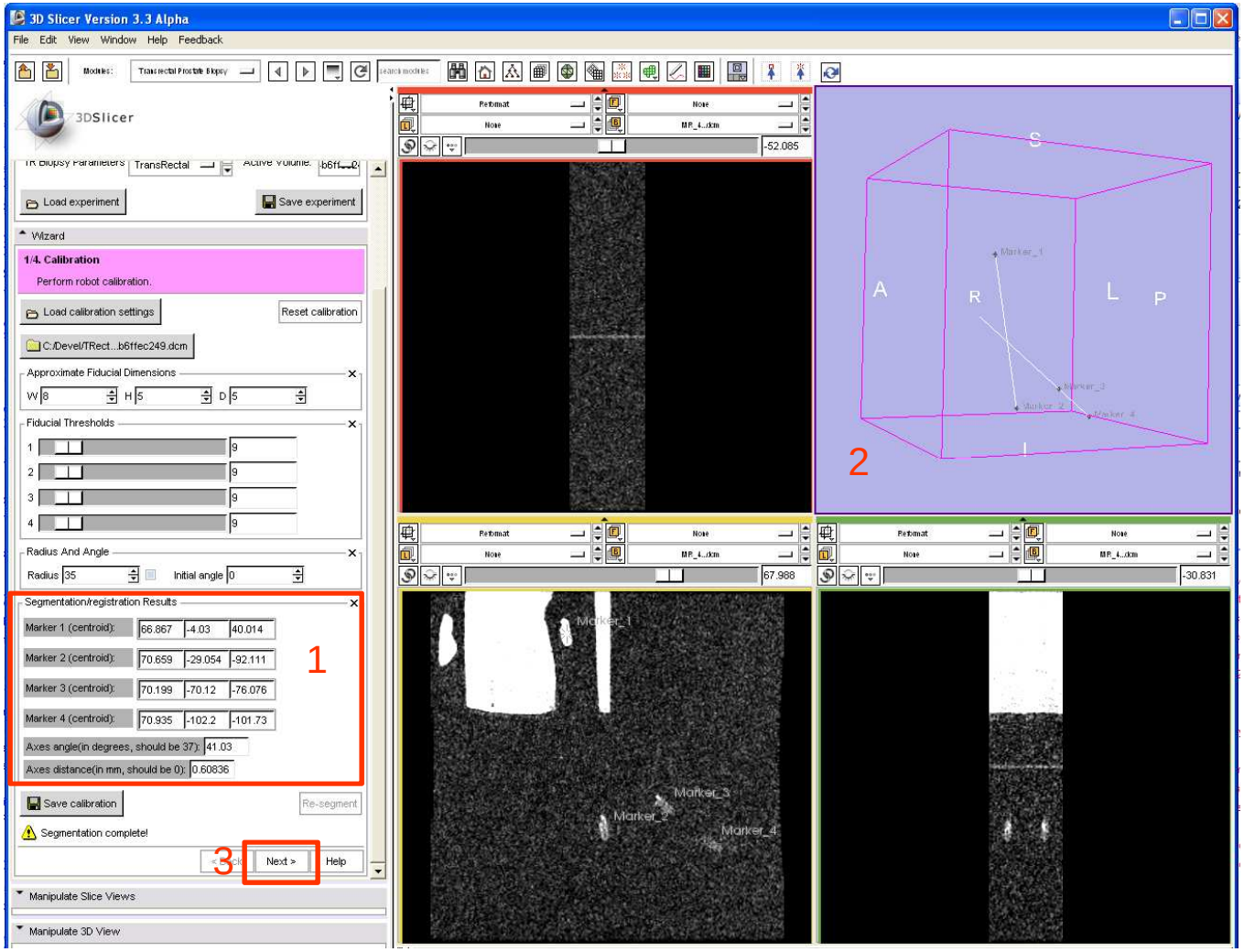


Calibrate step -- results

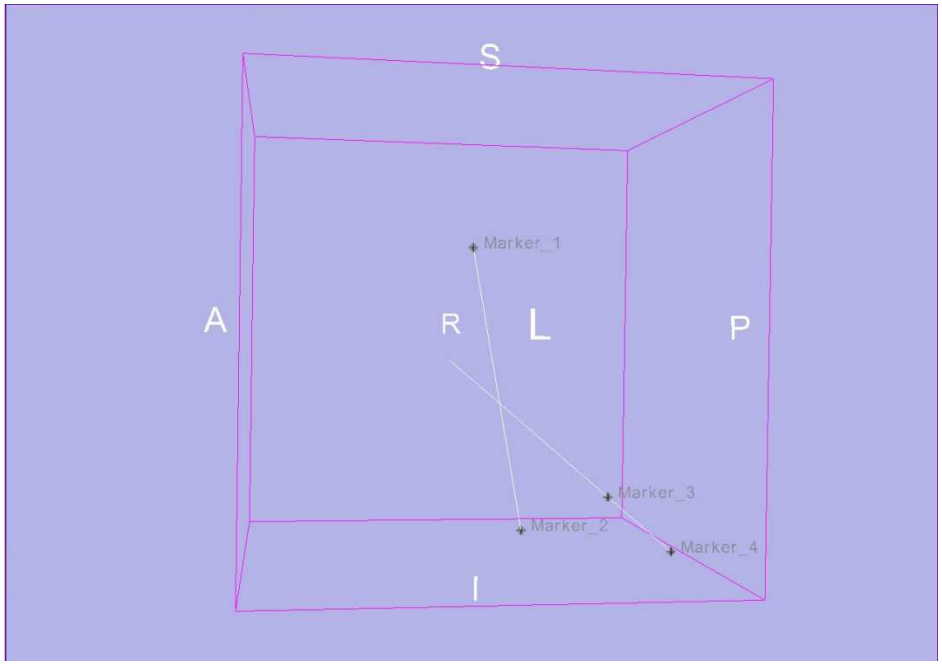
1 - Results displayed

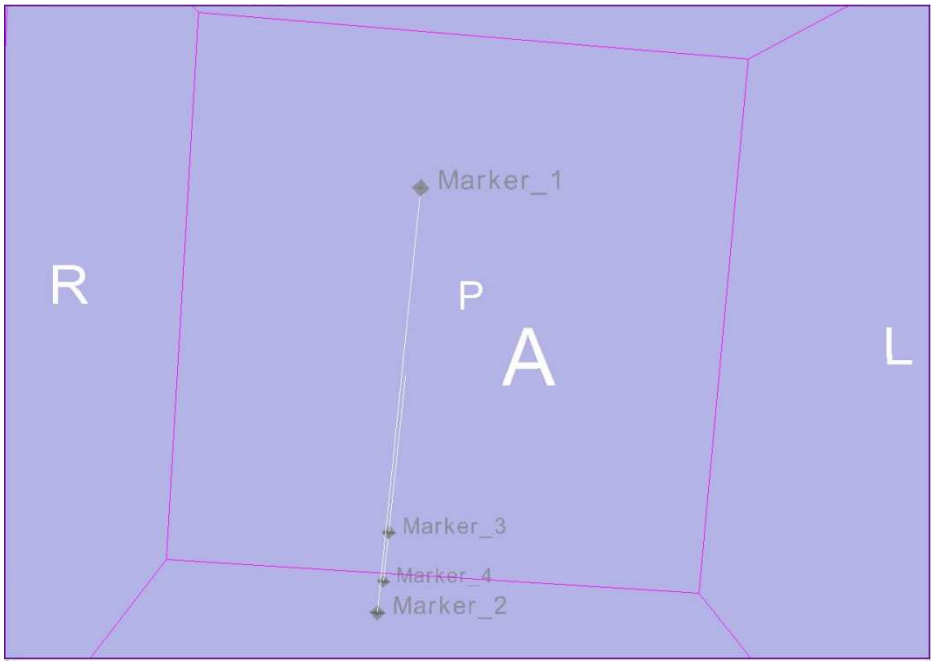
2 - 3D visualization of registration, depicting two axes of robot (probe and needle); gives an idea of coverage

3 - Click “Next” if satisfied with results



Calibrate step -- results

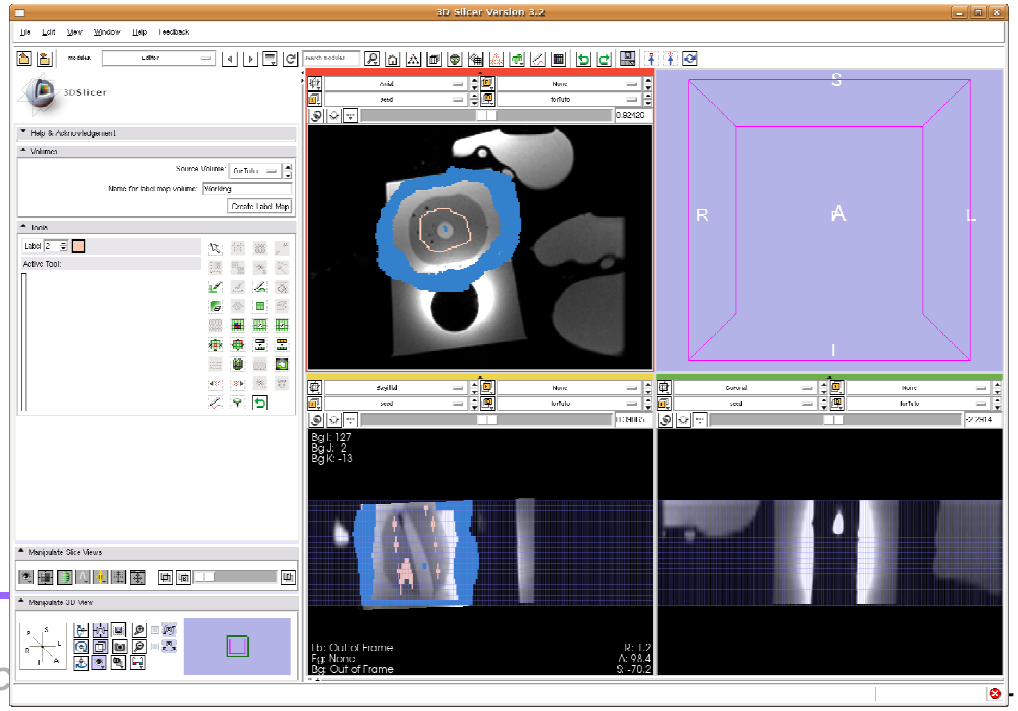




Prostate Segmentation

Generate the seed image

- Use the Slicer3 Editor:
  - Load the volume (TRPBTutorialDataset\ToSegment.nhdr)
  - Label 1: background seed, blue
  - Label 2: object seed, orange



Segmentation step wizard GUI

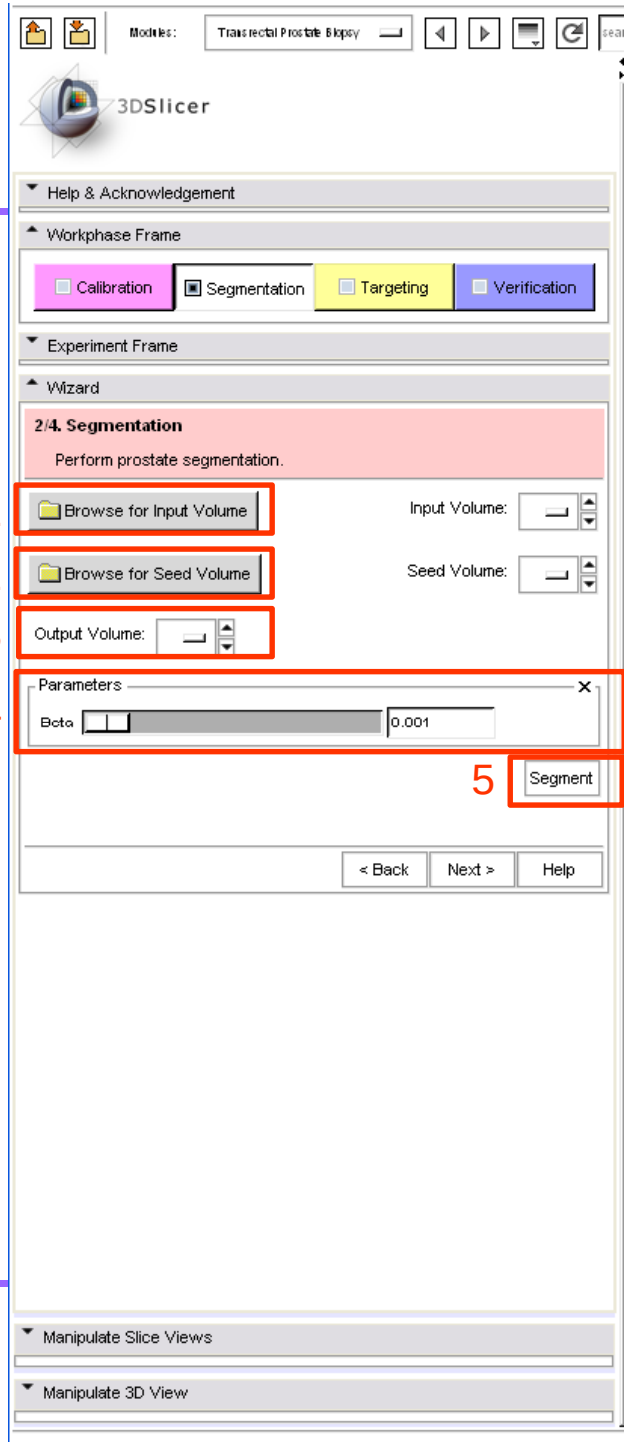
1 - Click to load the input volume (Load from directory: TRPBTutorialDataset\ToSegment.nhdr)

2 - Click to load the seed volume (Use the seed volume generate in previous step or load from directory TRPBTutorialDataset\seed.nhdr)

3 - Set output volume (Set “Create new one”)

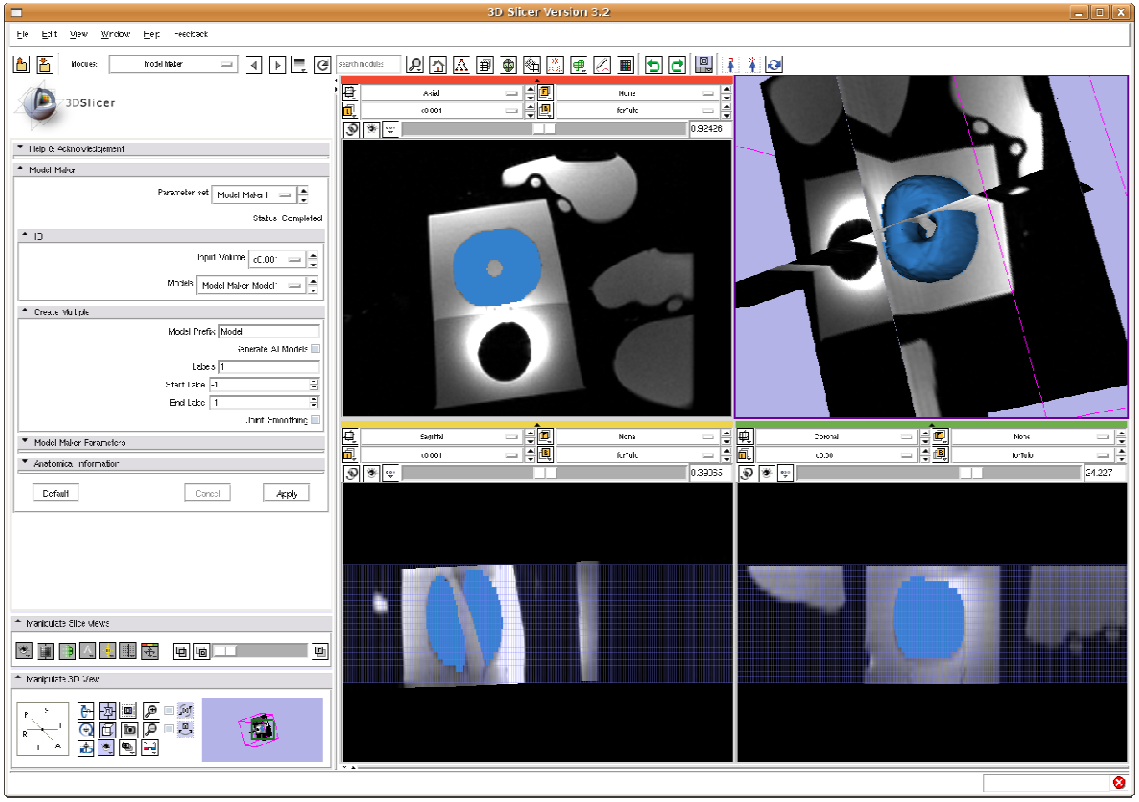
4 - Segmentation parameter “Beta” to 0.001

5 - Press to start the segmentation



Generate model

- Use the Slicer3 Model maker module:
- Use the volume generated from previous step as input



Targeting

Targeting step wizard GUI

A - Click to load the targeting volume dicom series

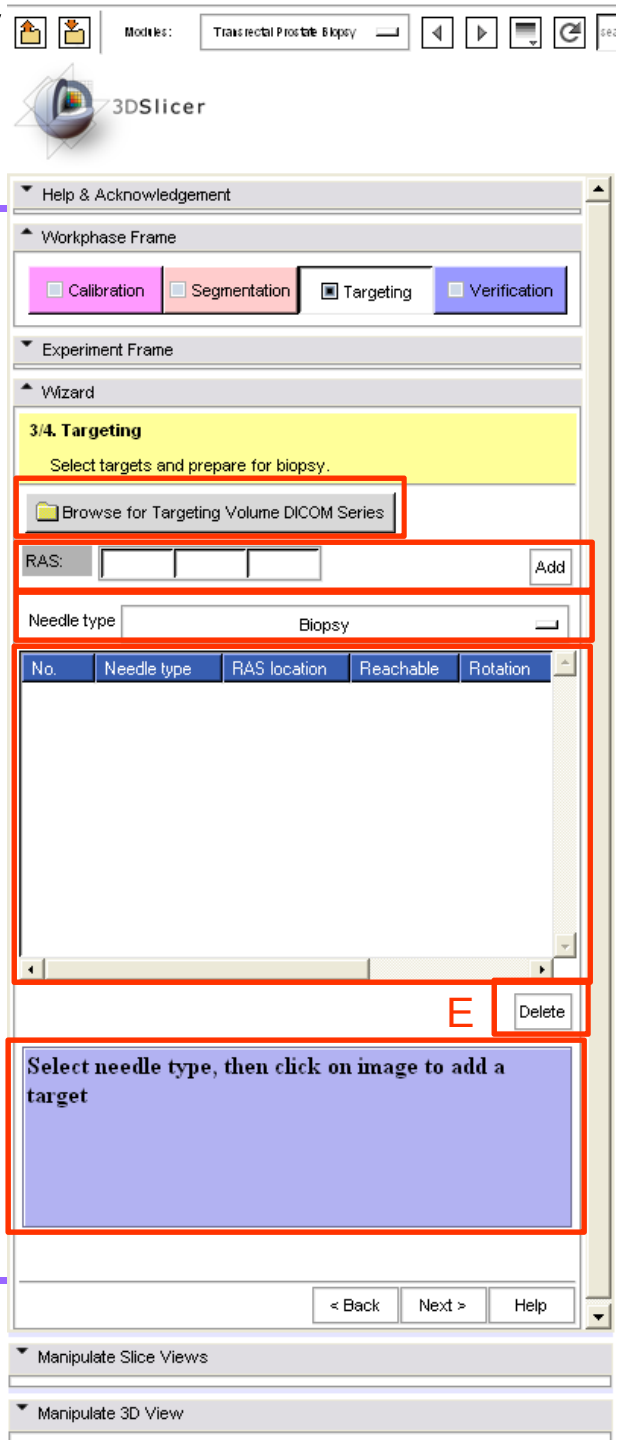
B - Controls to key-in the target RAS coordinates (conventional method is to just click using mouse)

C - Drop-down list to choose from available needle types

D - Multi-column scrollable list, that would display each target, along with all the relevant information about targeting parameters of the robot to reach that target location

E - One can delete a certain target, by first selecting the target from the list and then clicking ‘Delete’

F - Message/instruction display area



Load targeting dicom series

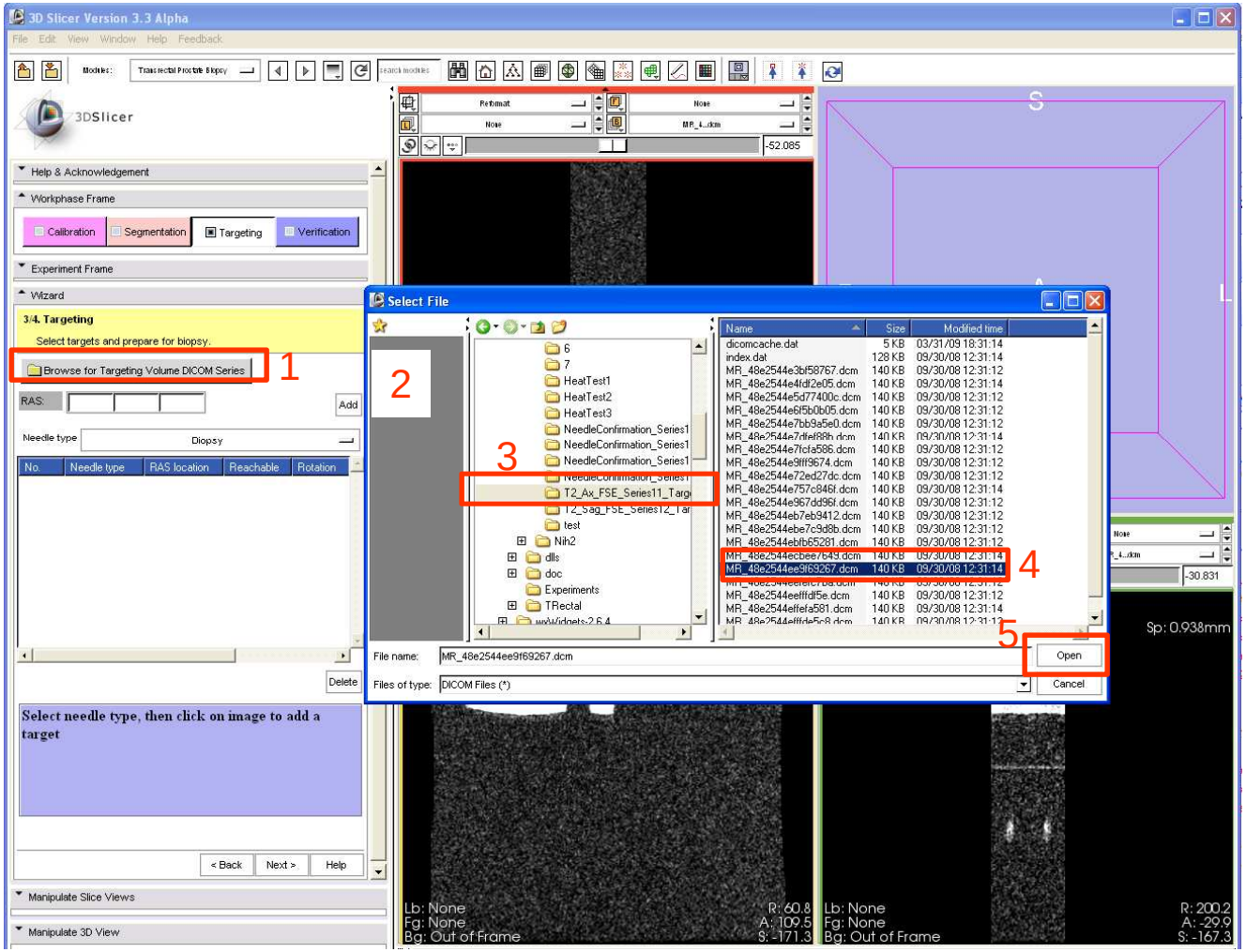
1 - Click “Browse for targeting dicom…”

2 - Dialog box appears

3 - Navigate to desired directory (TRPBTutorialDataset \Targeting\)

4 - Select any one file in the directory

5 - Click “Open”



Pick biopsy targets

1 - Select the needle type from drop-down list

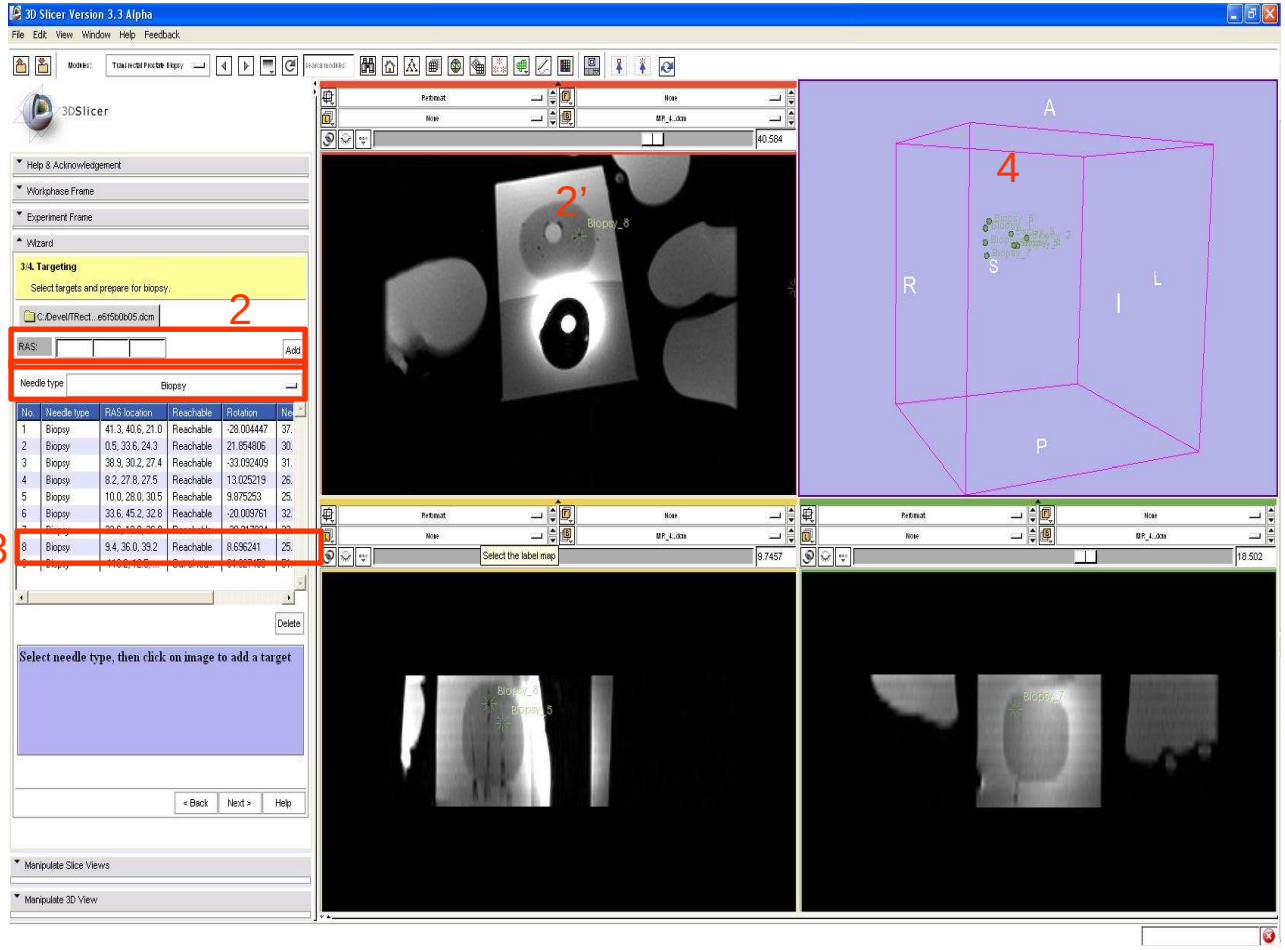
2 - Key-in ‘RAS’ coordinates

or

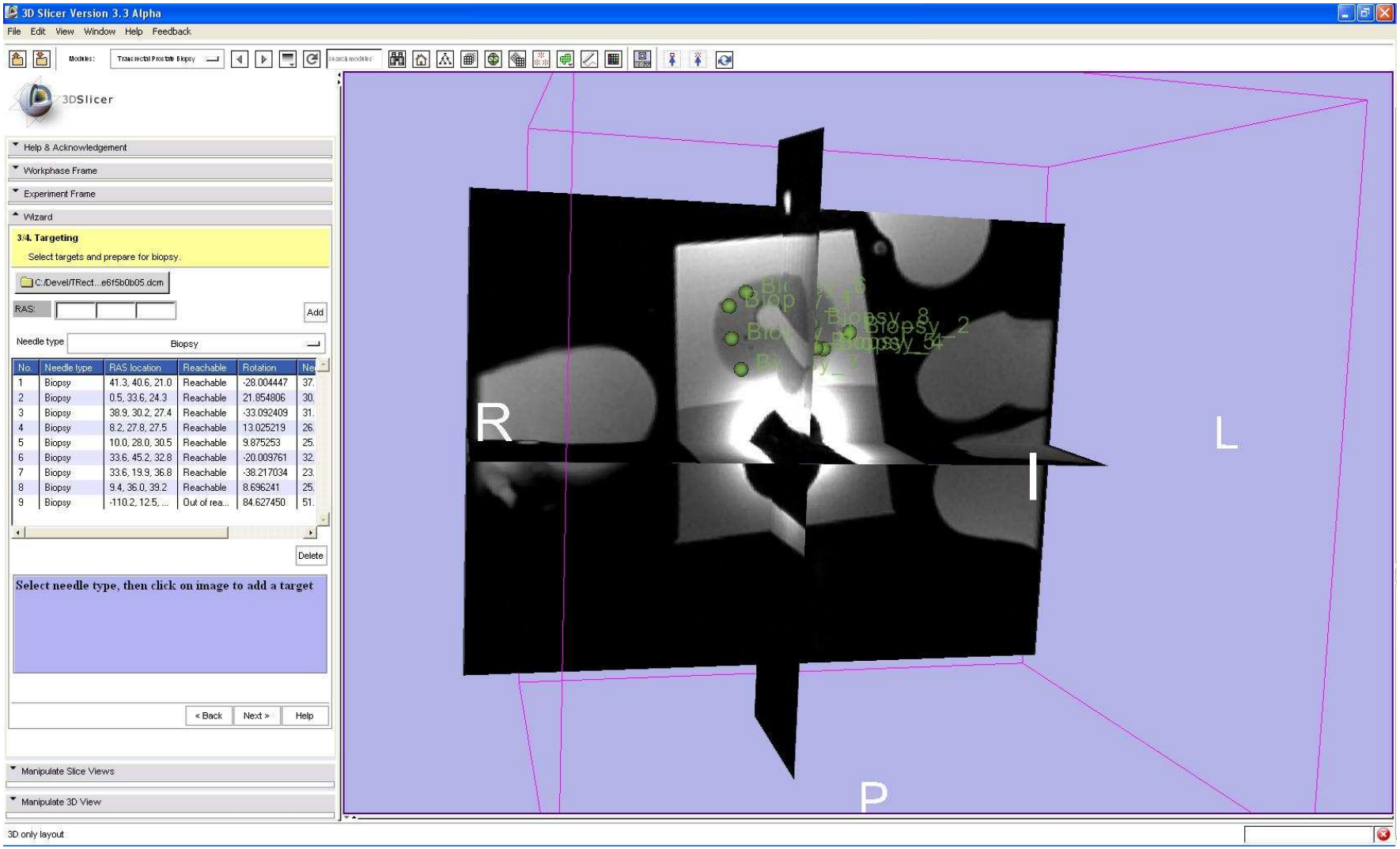
2’ - Navigate to desired slice in any of three views, and pick a target by clicking

3 - Target and its targeting parameters populated in the list

4 - Target shows up in the 3D view



Pick biopsy targets

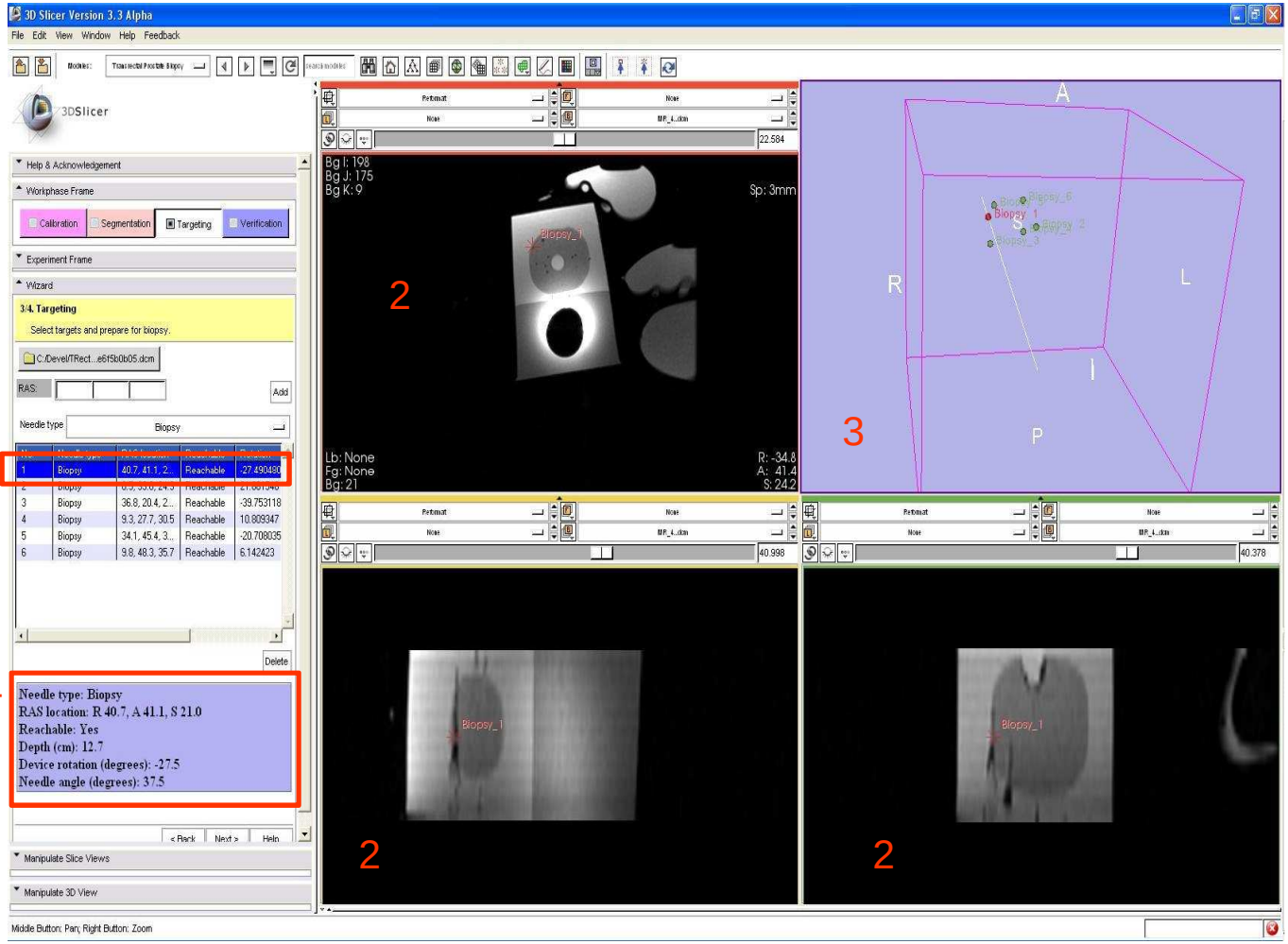


Select a specific target, and perform biopsy with robot

1 - Scroll, and select from the list, the target which you want to biopsy

2 - The target is marked red and is brought to view in all three orthogonal views

3 - In 3D view, target selected and the 3D needle trajectory visualized (very useful feedback for clinician)

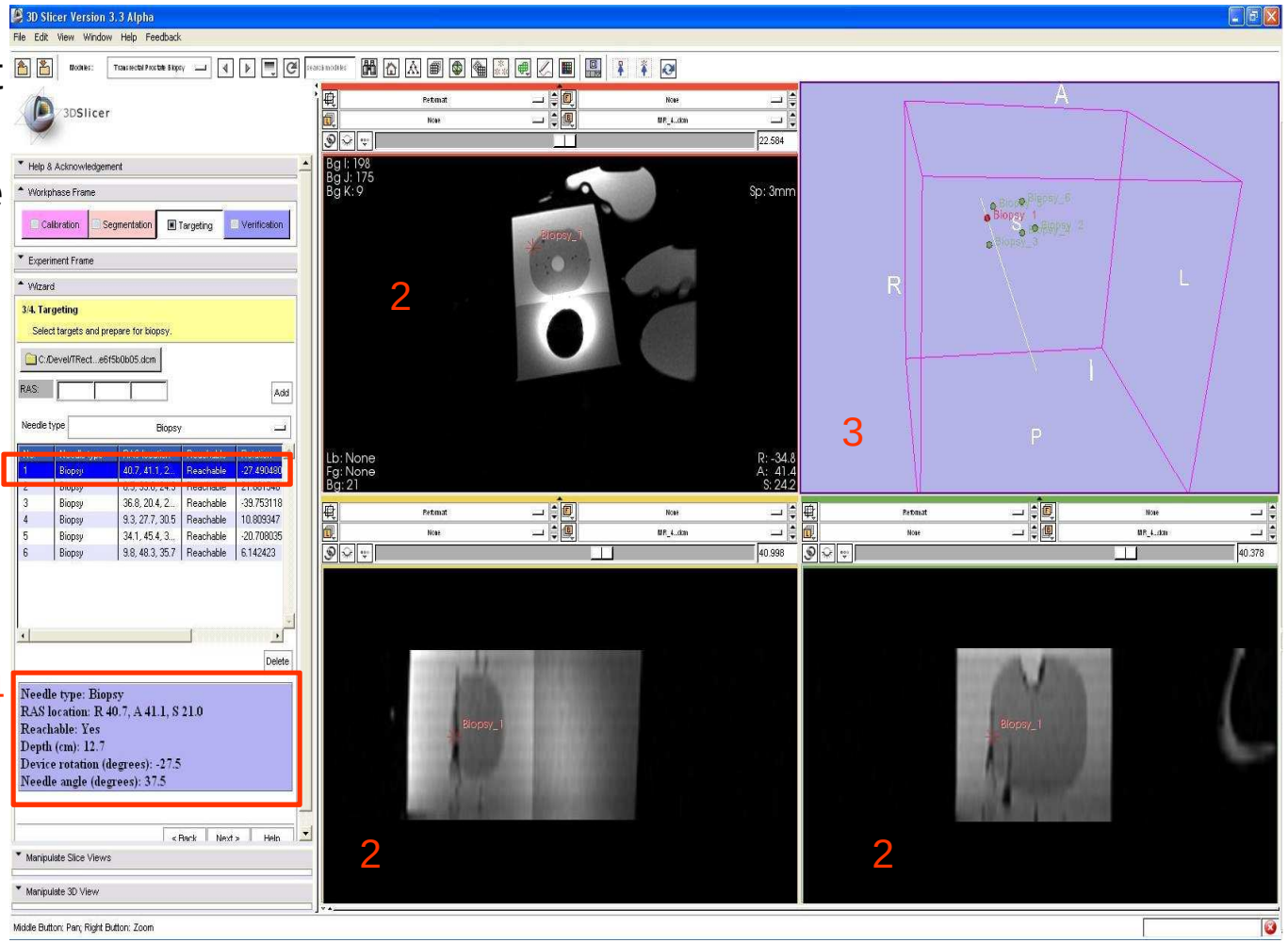


Select a specific target, and perform biopsy with robot

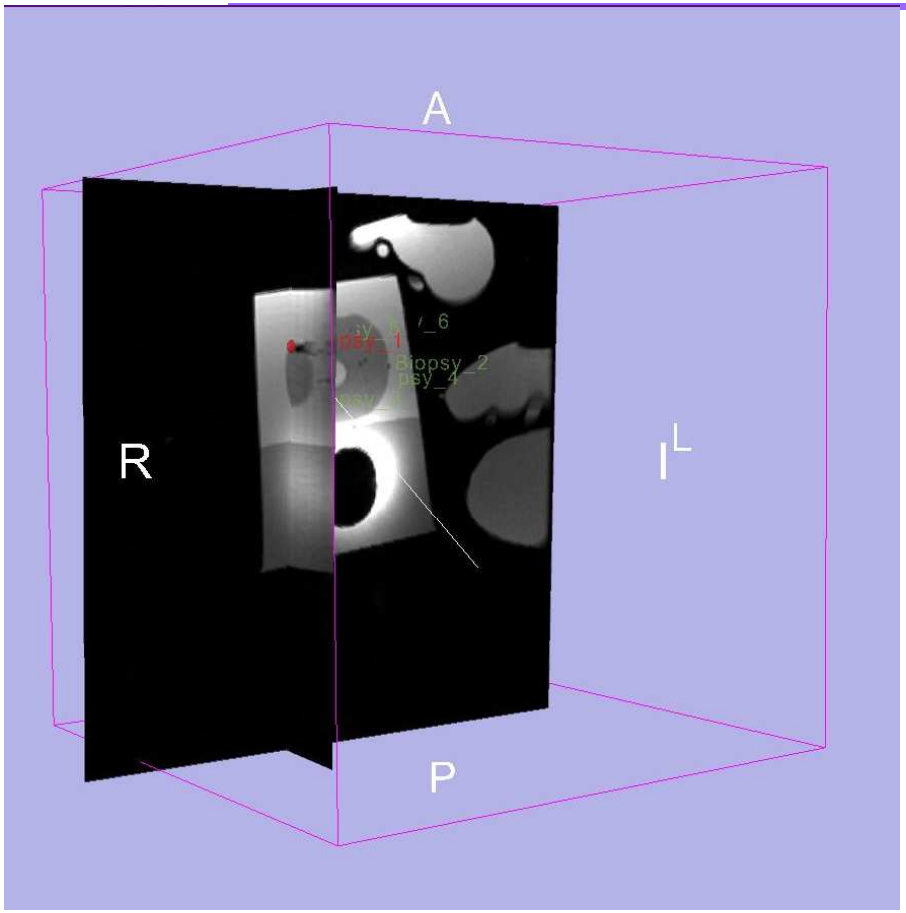
4 - Targeting parameters for robot displayed

5 - On the robot, set the device rotation, and needle angle values to as computed and displayed for that specific target; fire the needle to perform the biopsy!

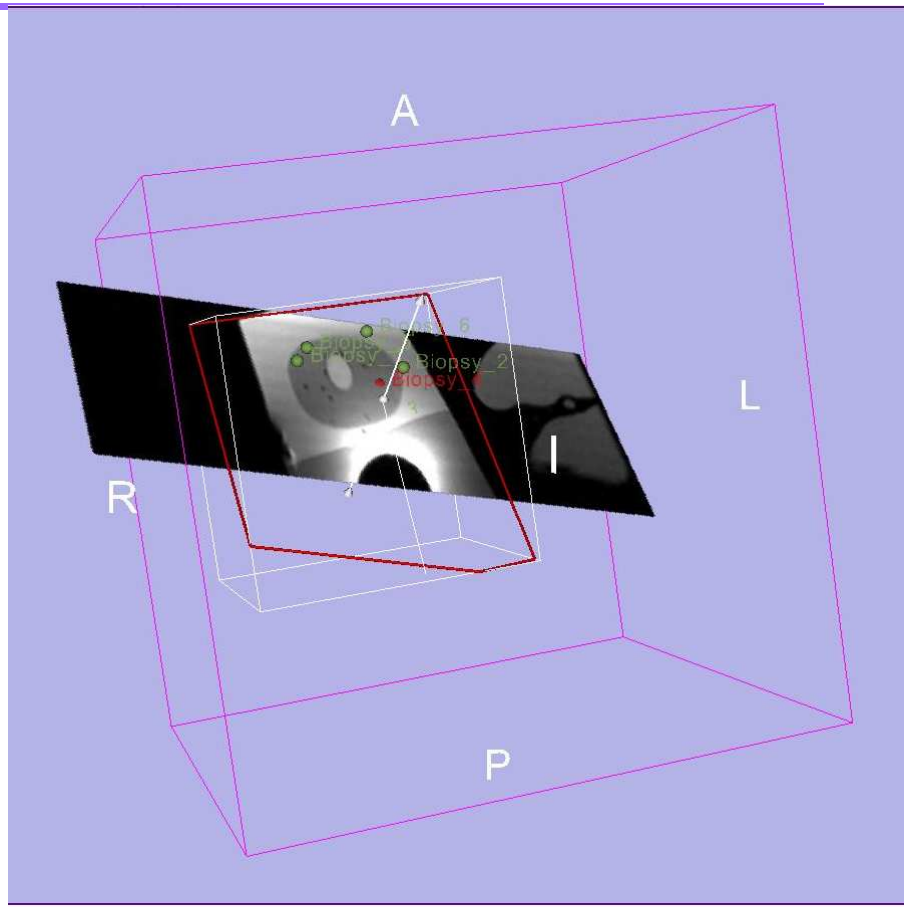
PS: Robot is not software actuated, one has to manually set the parameters and perform biopsy



Visualization capabilities



Turn slice visibility ‘on’ for better visualization of target within anatomy



Use Slicer’s re-format widget to re-slice in arbitrary orientation e.g. along plane of needle trajectory

Verification

Verification step wizard GUI

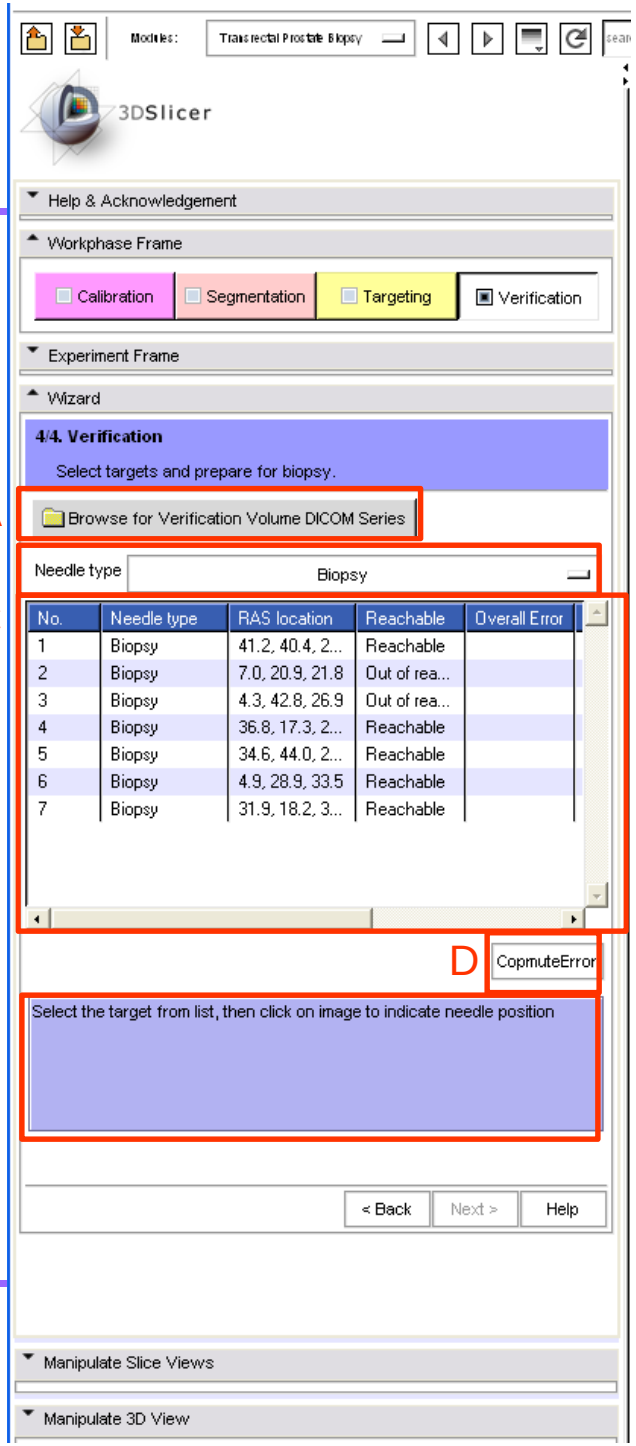
A - Click to load the verification volume dicom series

B - Drop-down list to choose from available needle types

C - Multi-column scrollable list, that would display each target, along with the error calculations if the target was validated

D - Click ‘Compute Error’ to initiate verification process

E - Message/instruction display area



Load verification dicom series

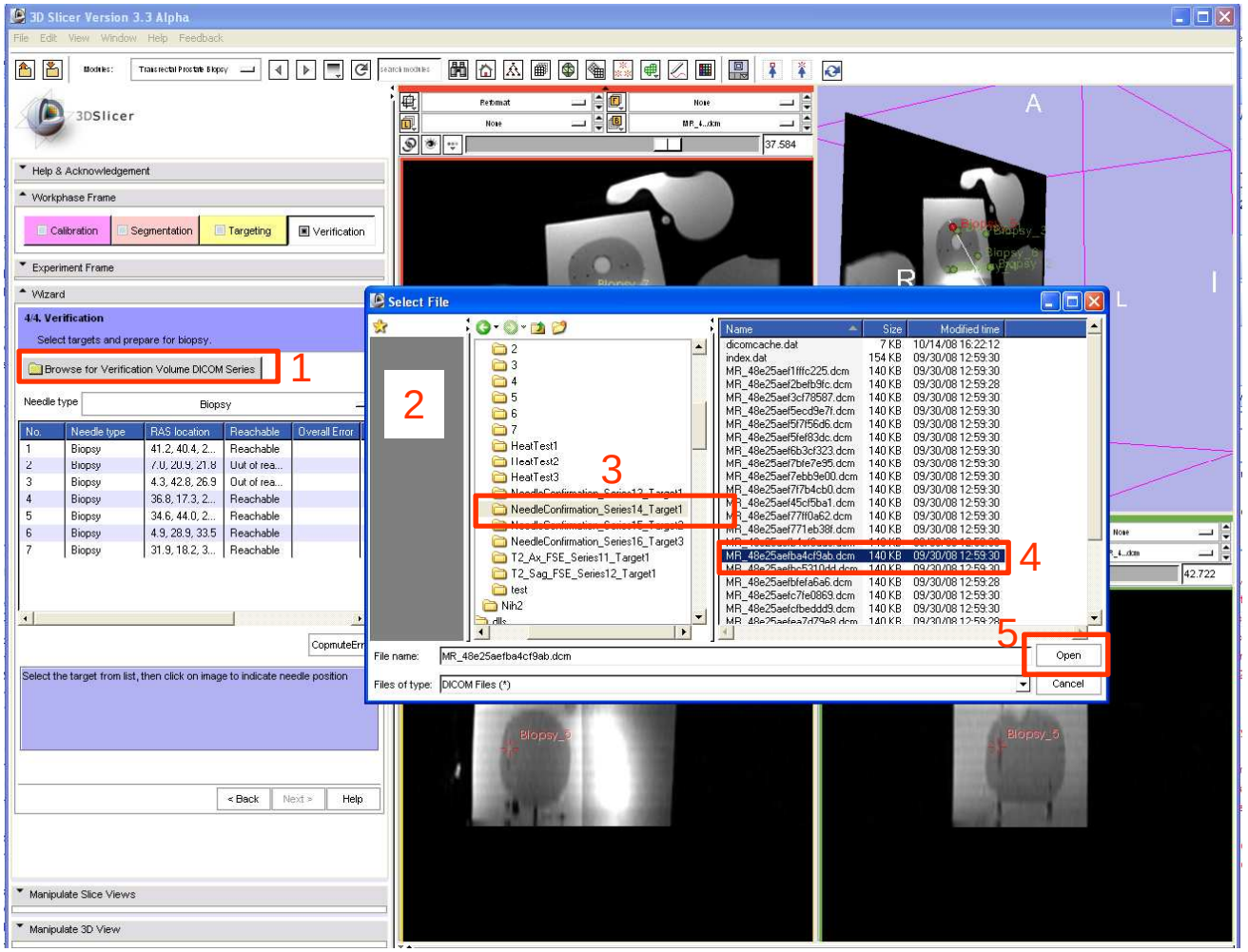
1 - Click “Browse for targeting dicom…”

2 - Dialog box appears

3 - Navigate to desired directory (TRPBTutorialDataset \Verification\)

4 - Select any one file in the directory

5 - Click “Open”



Verify a target

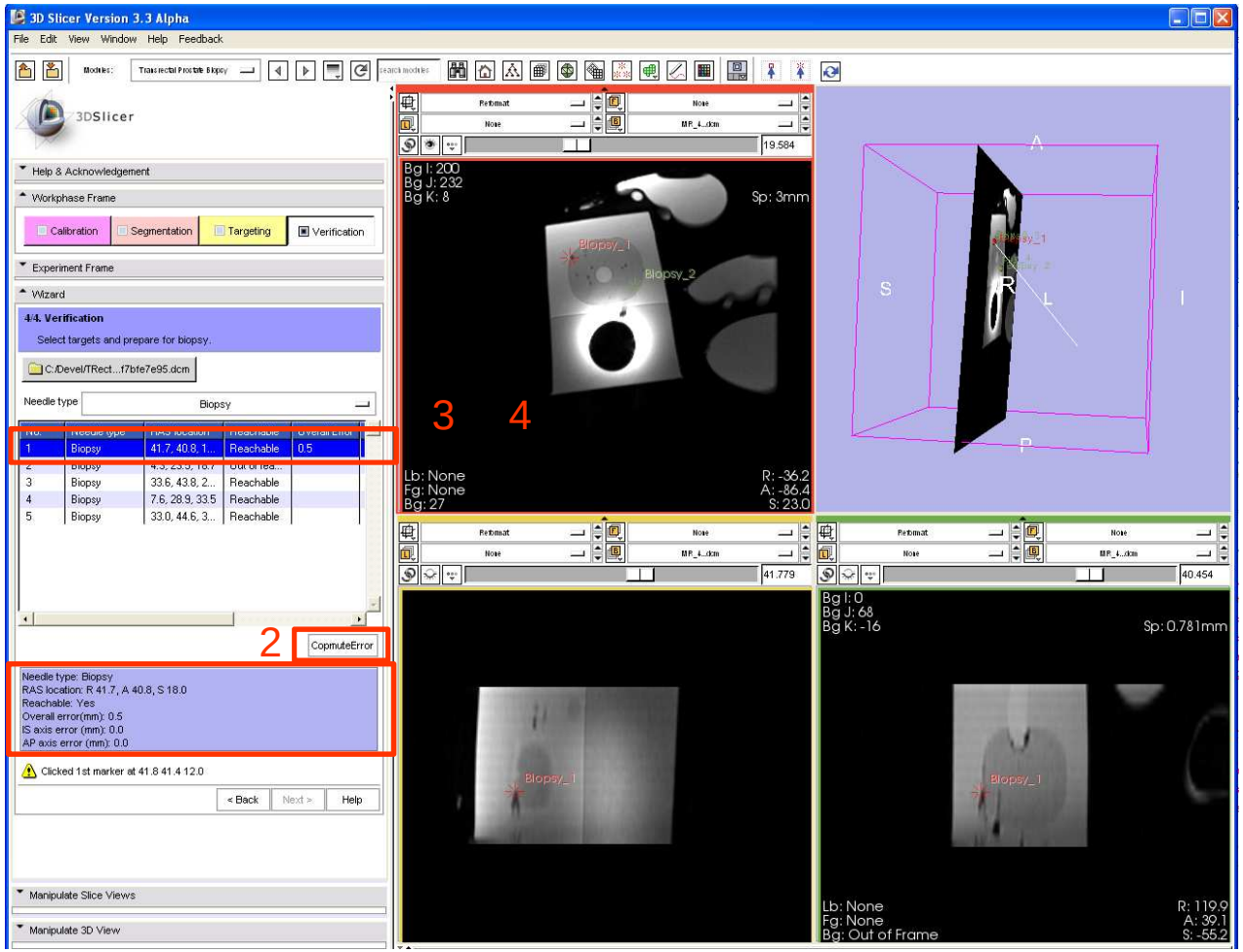
1 - Select the target from the list to validate

2 - Click ‘Compute Error’

3 - Click to give needle end

4 - Click to give the other end of needle

5 - Needle placement error calculated and displayed



Conclusion

- End-to-end application for performing a MR-guided prostate intervention using SLICER is presented
- Intuitive graphical user interface to interact with the data
- The NAMIC kit's open-source environment allows clinicians and researchers to share data and solutions to common problems

Acknowledgements

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