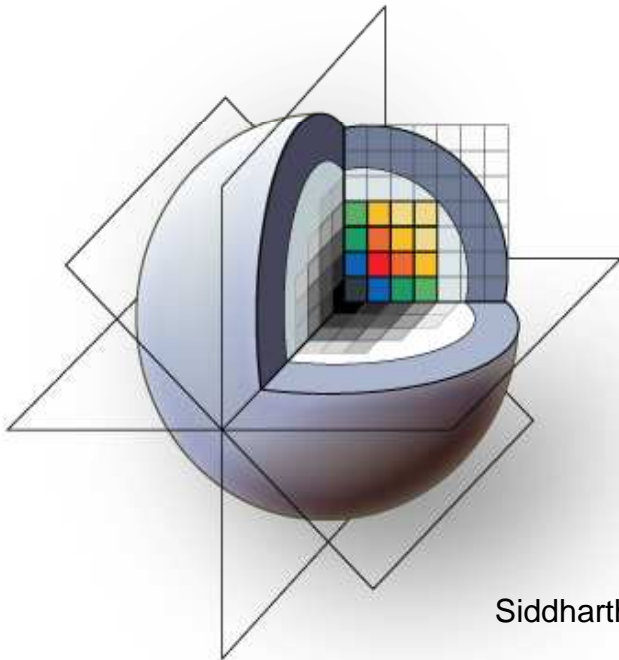




## *Slicer3 Training Compendium*

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# Slicer3 Training Tutorial PERK Station (Percutaneous interventions training suite)



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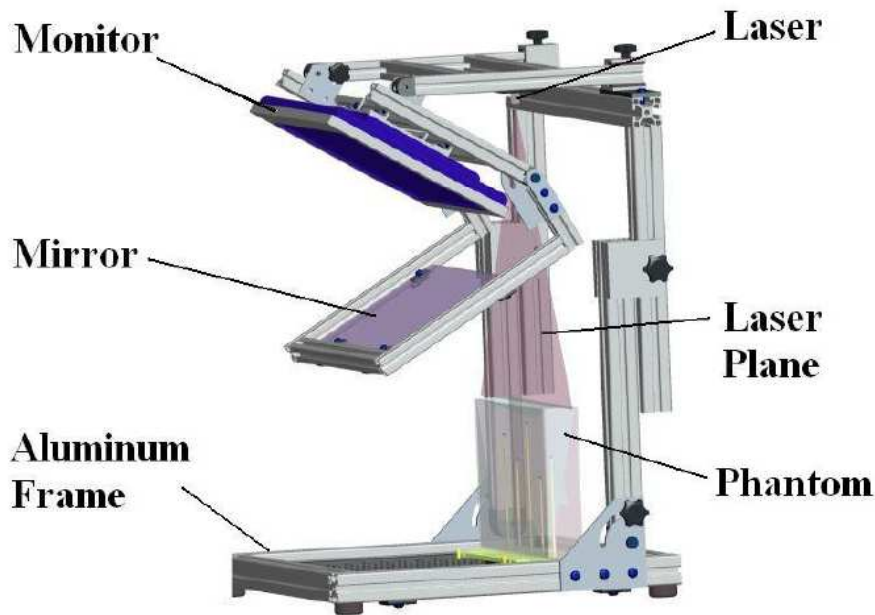
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# Learning Objective

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Following this tutorial, you will be able to use the integrated hardware-software system (PERK Station) for training and evaluating percutaneous surgical interventions.



## PERK Station is a

- Integrated system that combines three assistance techniques for performing percutaneous needle interventions
- Tool that provides feedback to trainee in controlled environment

## In this tutorial, you will learn

- About the perk station components and its hardware
- About the Slicer3 software module that works with hardware
- Workflow of 'image overlay' assistance technique



# *Prerequisites*

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- Perk Station hardware
  - Overview will be described in this presentation
  - Please go through relevant publications [1,2]
  - Reproducible CAD designs, assembly instructions will be available at:

<http://www.na-mic.org/Wiki/index.php/DBP2:JHU:PerkStation>

Further, 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>

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# *Materials*

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Since this module (*Perk Station*) 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 *PerkStationModule* from source code; give the output path of build to be Slicer's `\\lib\\Slicer3\\Modules`.
2. Install Slicer3, copy the *PerkStationModule.dll* file in `\\SLICER_INSTALL_DIR\\lib\\Slicer3\\Modules`



# *Materials*

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

- Build ***PerkStationModule***, source code

<http://svn.na-mic.org/NAMICSandBox/trunk/Queens/PerkStationModule/>

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, *PerkStationModule* shows up in modules drop down list

This is the recommended method of integration

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# Materials

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If one chooses Method 2 of integration, then:

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

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

- Copy the *PerkStationModule.dll* file to  
\\SLICER\_INSTALL\_DIR\\lib\\Slicer3\\Modules

Now, when you run Slicer3, PerkStationModule 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.

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# Materials

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- Tutorial dataset (**<PerkStationTutorialDataset.zip>**)  
<http://www.na-mic.org/Wiki/index.php/DBP2:JHU:PerkStation>
- Unzip the folder
- Will create the directory PerkStationTutorialDataset, with the following files in: Plan.dcm
- This image (Plan.dcm) corresponds to MR acquisition made at the centre-most slice of the spine phantom.

**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.*

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# *Overview*

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1. Perk station motivation
2. Perk station system design
3. Systems overview
4. Workflow
5. Demonstration using SLICER





- 
- 1. Perk station motivation**
  2. Perk station system design
  3. Systems overview
  4. Workflow
  5. Demonstration using SLICER



# *Motivation*

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- Image-guided percutaneous needle interventions
    - Tumor biopsy
    - Neurological pain management
    - Tissue ablations
    - ...
  - Complex: workspace and maneuver limitations
  - Training under senior supervision, slow and subjective
  - Different assistance techniques involved
  - Perk station: a platform that integrates three popular assistance techniques in one system
  - Phantom provides a means for objective assessment across trainees
-



- 
1. Perk station motivation
  - 2. Perk station system design**
  3. Systems overview
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# *Perk station system design*

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- Components
- Structure and dimensions
- Assistance techniques supported
- Phantom



# *Perk station system design*

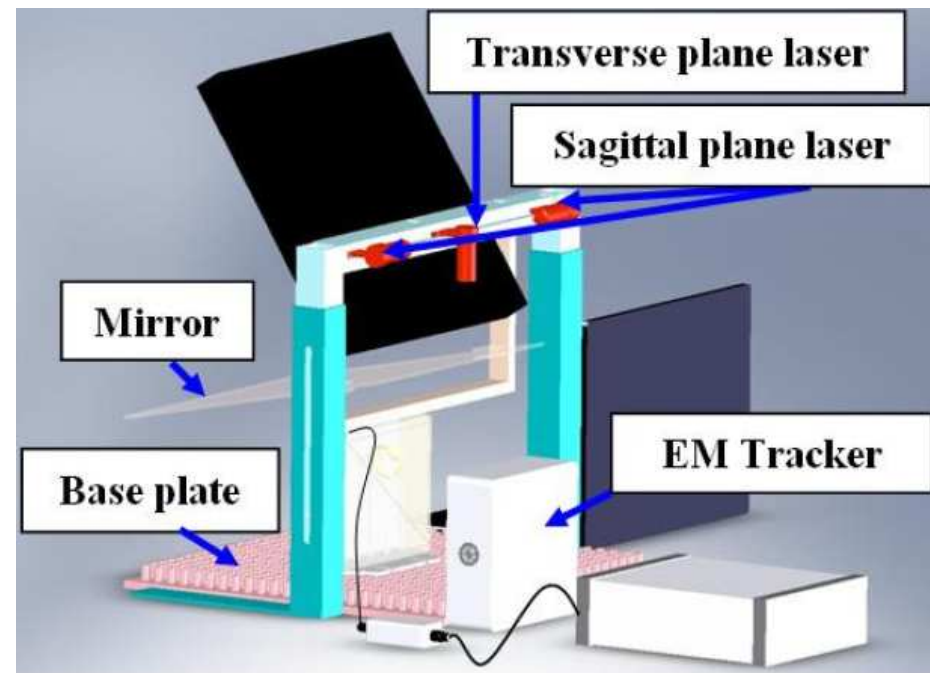
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- **Components**
- Structure and dimensions
- Assistance techniques supported
- Phantom

# *Perk station system design*

## Components

- LCD display
- Semi-transparent mirror
- Two para-sagittal lasers
- Transverse laser
- EM tracker
- Phantom
- Laptop/desktop





# *Perk station system design*

---

- Components
- **Structure and dimensions**
- Assistance techniques supported
- Phantom



# *Perk station system design*

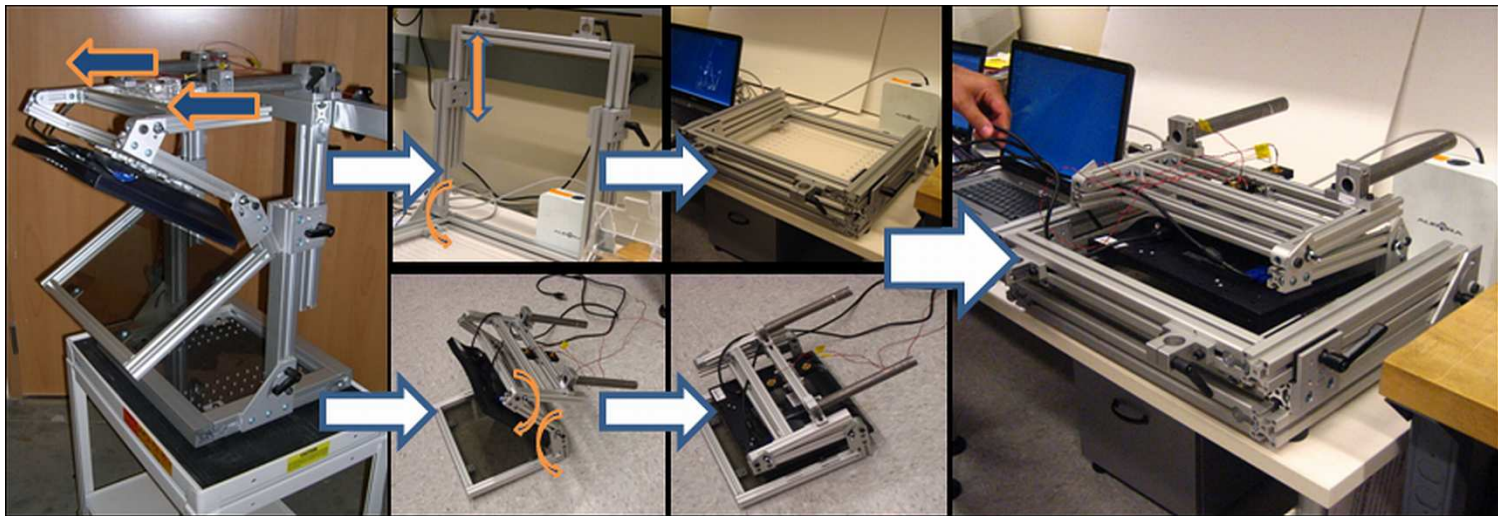
## Structure

- Extruded aluminum frame
- Light weight – 16.5 kg

## Dimensions

- 57 x 55 x 29 cms

## Portability







# *Perk station system design*

---

- Components
- Structure and dimensions
- **Assistance techniques supported**
- Phantom



# *Perk station system design*

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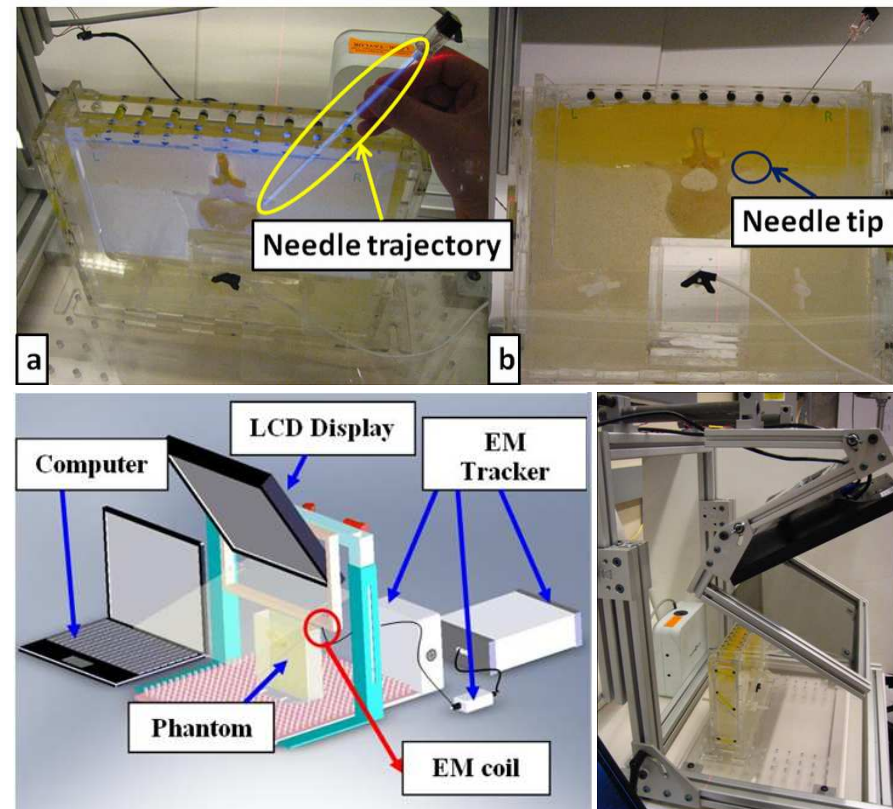
Assistance techniques supported

- Image overlay
- Bi-plane laser guidance
- Freehand needle insertion

# *Perk station system design*

## Image Overlay

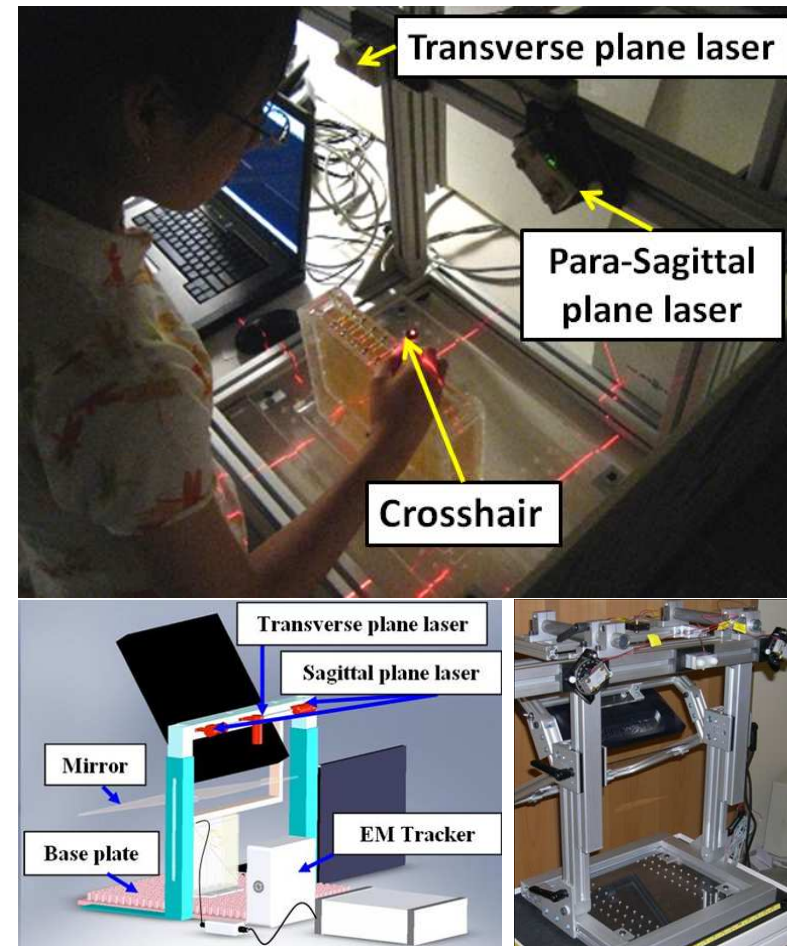
- Image floating inside phantom
- In-situ visualization
- EM tracker can be used for gesture studies



# *Perk station system design*

## Bi-plane laser guide

- Transverse laser + one of two para-sagittal laser
- Needle trajectory marked by the intersection of two planes
- Two para-sagittal planes for bilateral interventions





# *Perk station system design*

---

- Components
- Structure and dimensions
- Assistance techniques supported
- **Phantom**

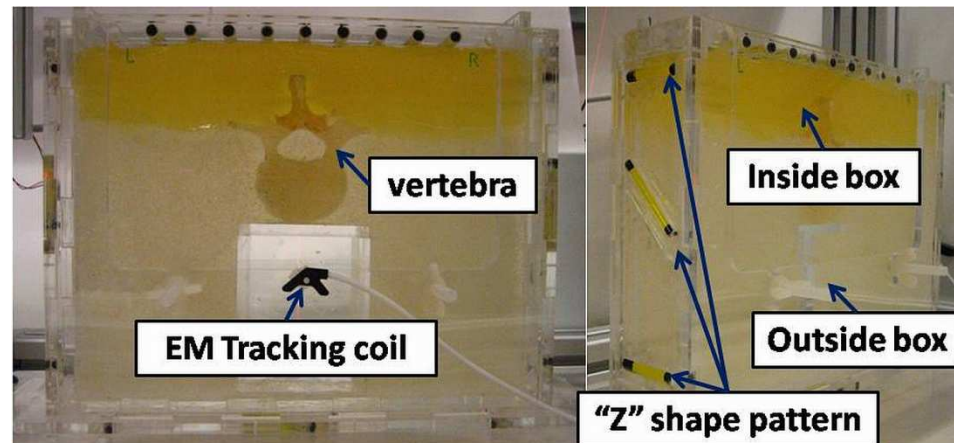


# *Perk station system design*

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## Phantom

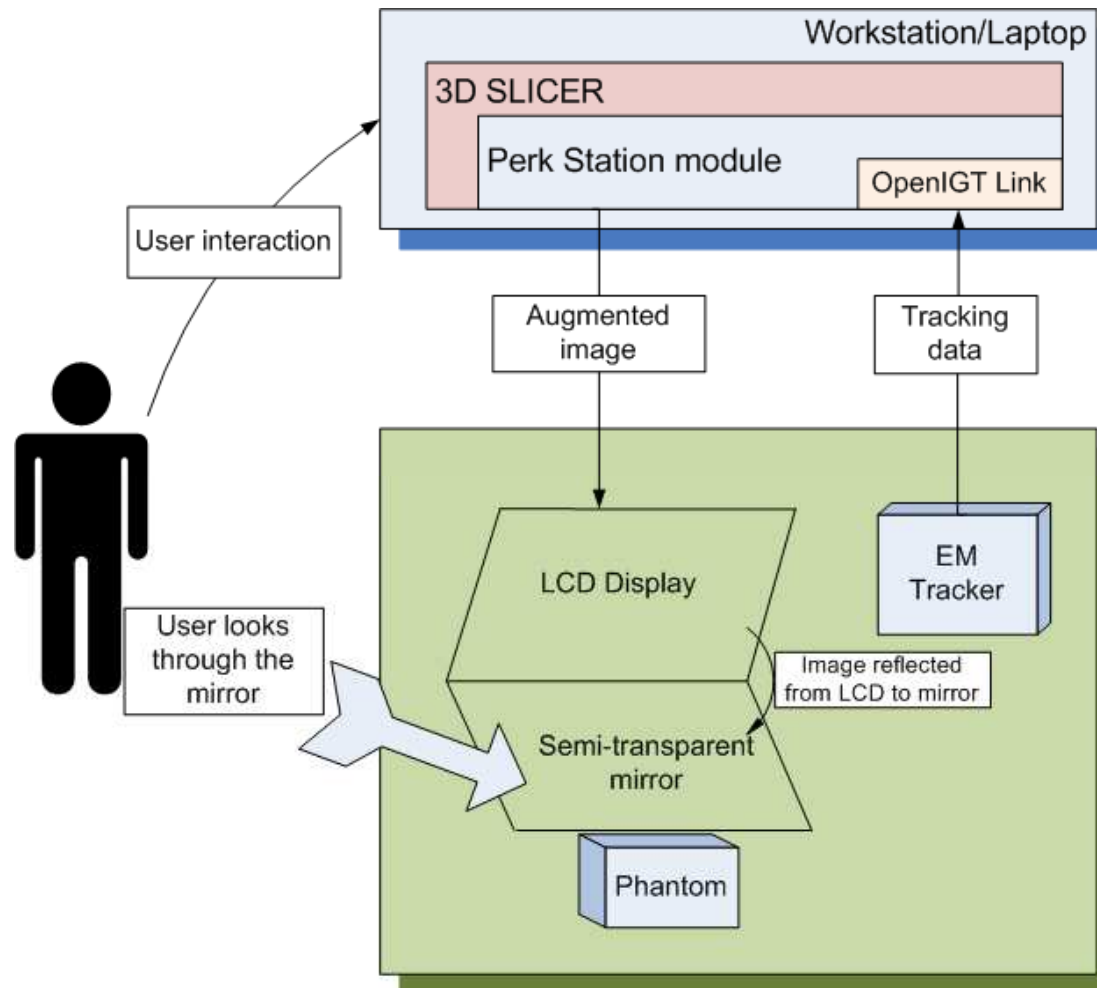
- Human cadaver lumber spine
- Tissue mimicking gel of different stiffness to emulate muscle and fat
- Modular design: gel phantom + external housing
- Z-shape fiducial pattern for registration





- 
1. Perk station motivation
  2. Perk station system design
  - 3. Systems overview**
  4. Workflow
  5. Demonstration using SLICER

# Systems overview







- 
1. Perk station motivation
  2. Perk station system design
  3. Systems overview
  - 4. Workflow**
  5. Demonstration using SLICER



# *Workflow*

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1. (Pre) Acquire the planning image(s) (MR/CT) of phantom; the planes of acquisition are marked by measurement strip on the phantom top
  2. Place phantom on base plate, roughly below the transverse laser source; connect Perk Station display to laptop running 3D SLICER; connect EM tracker (if any) to laptop
  3. Calibrate and register image to phantom
  4. Plan the needle intervention (entry point and target point)
  5. Perform the insertion
  6. Post intervention analysis
-

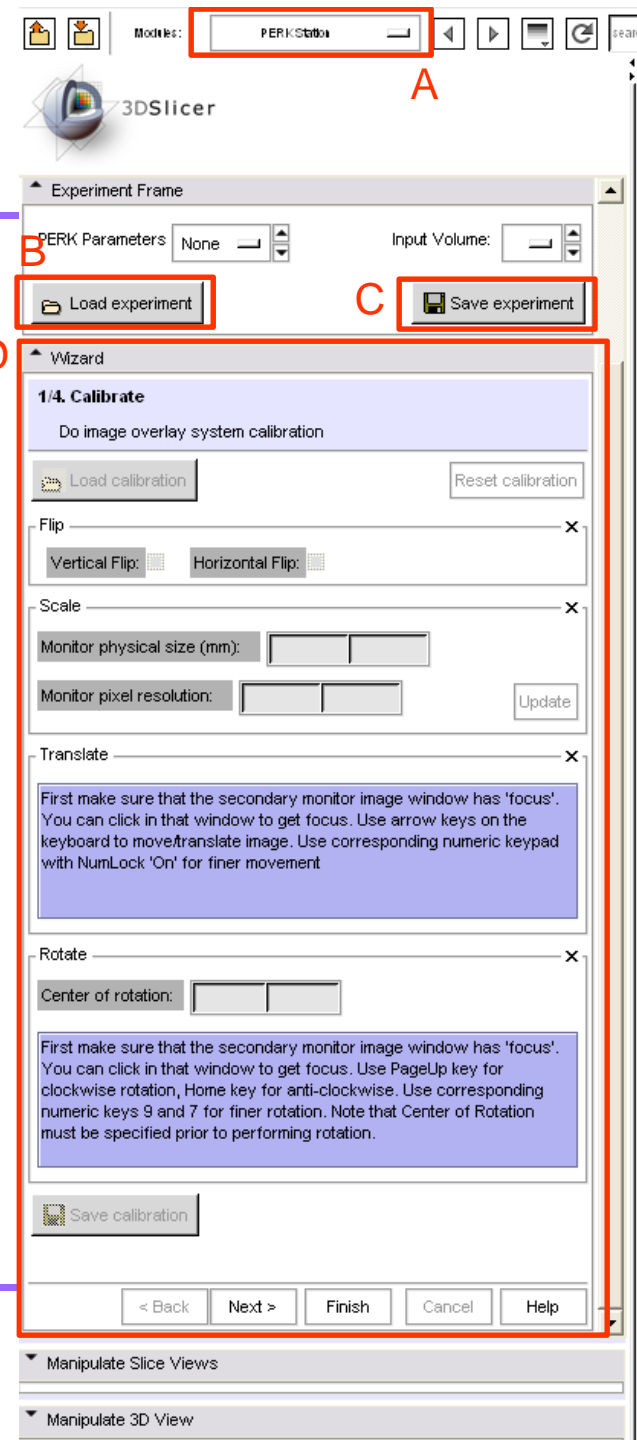


- 
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# Perk Station GUI

- A** - Select << Perk Station >> from modules list, GUI loads up with “Experiment” frame and “Wizard workflow GUI” frame
- B** - “Load experiment” to load any previously saved intervention
- C** - “Save experiment” to save the experiment
- D** - 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





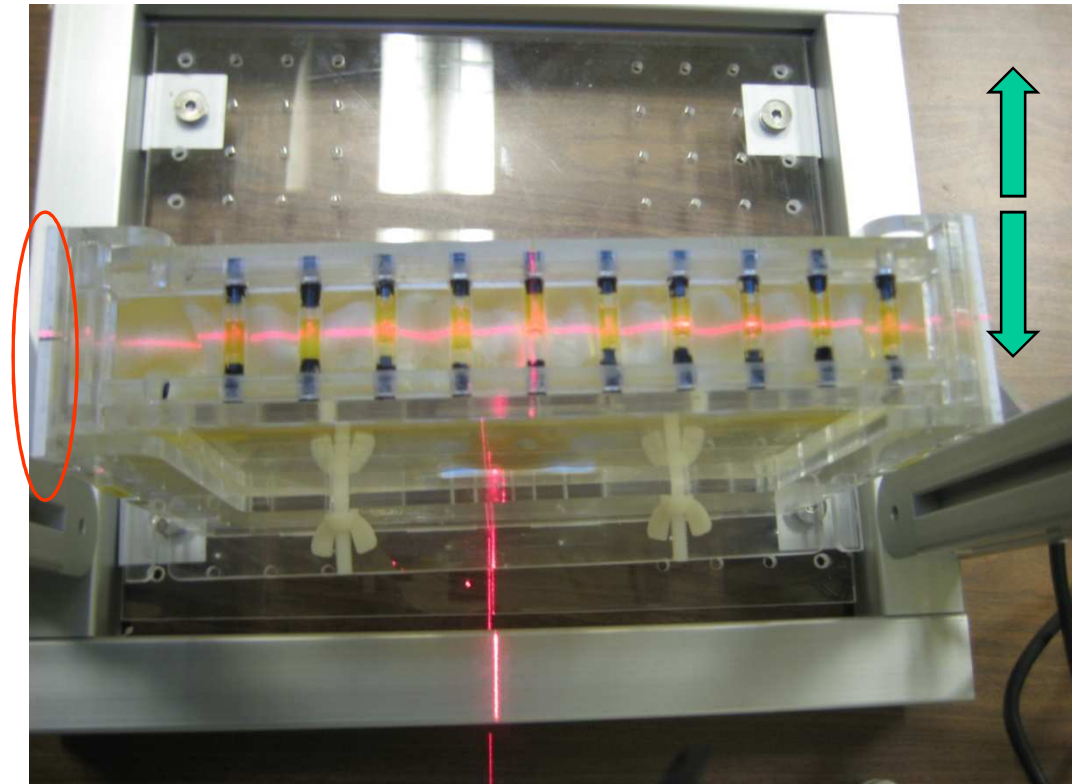
# *Z-plane alignment of phantom*

---

The reading on the measurement strip on the phantom top, correlates to the unique planning image; this correlation is recorded during acquisition

Choose the strip position (in effect, the planning image) you wish to work with

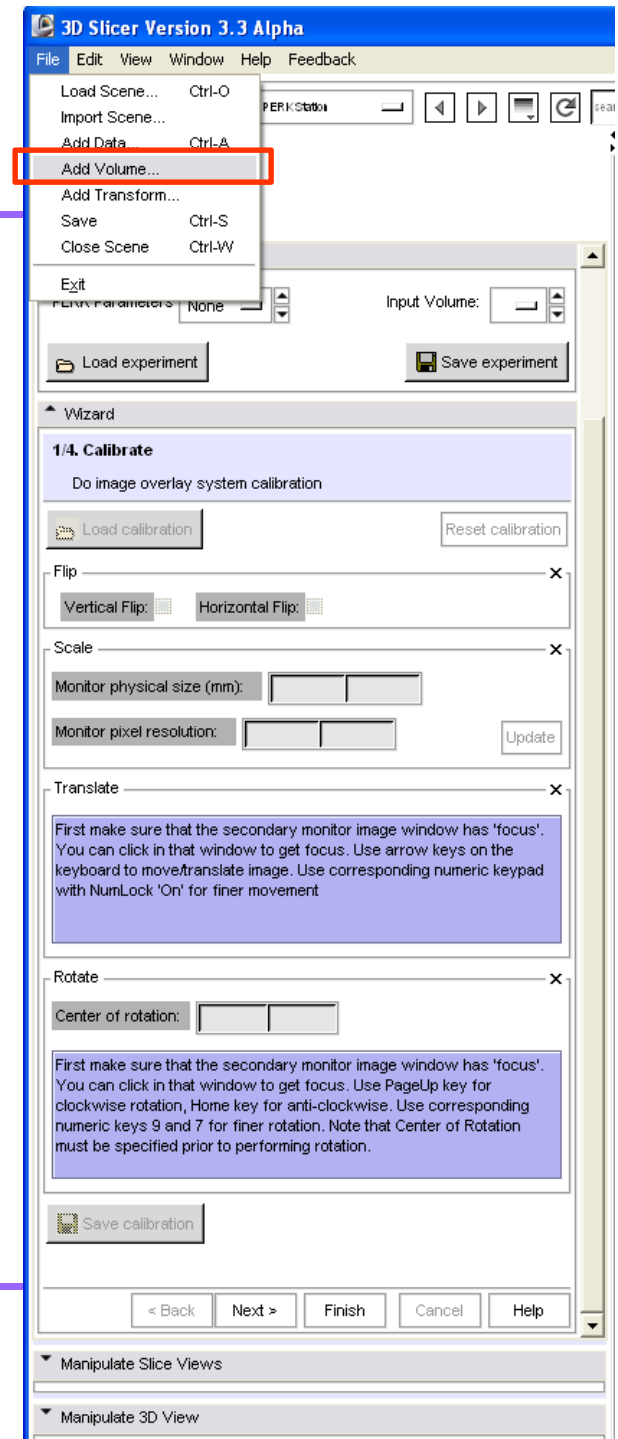
Move the phantom laterally till that measurement strip position gets aligned to the transverse laser plane





# *Load planning image*

Click “Add Volume” from File Menu





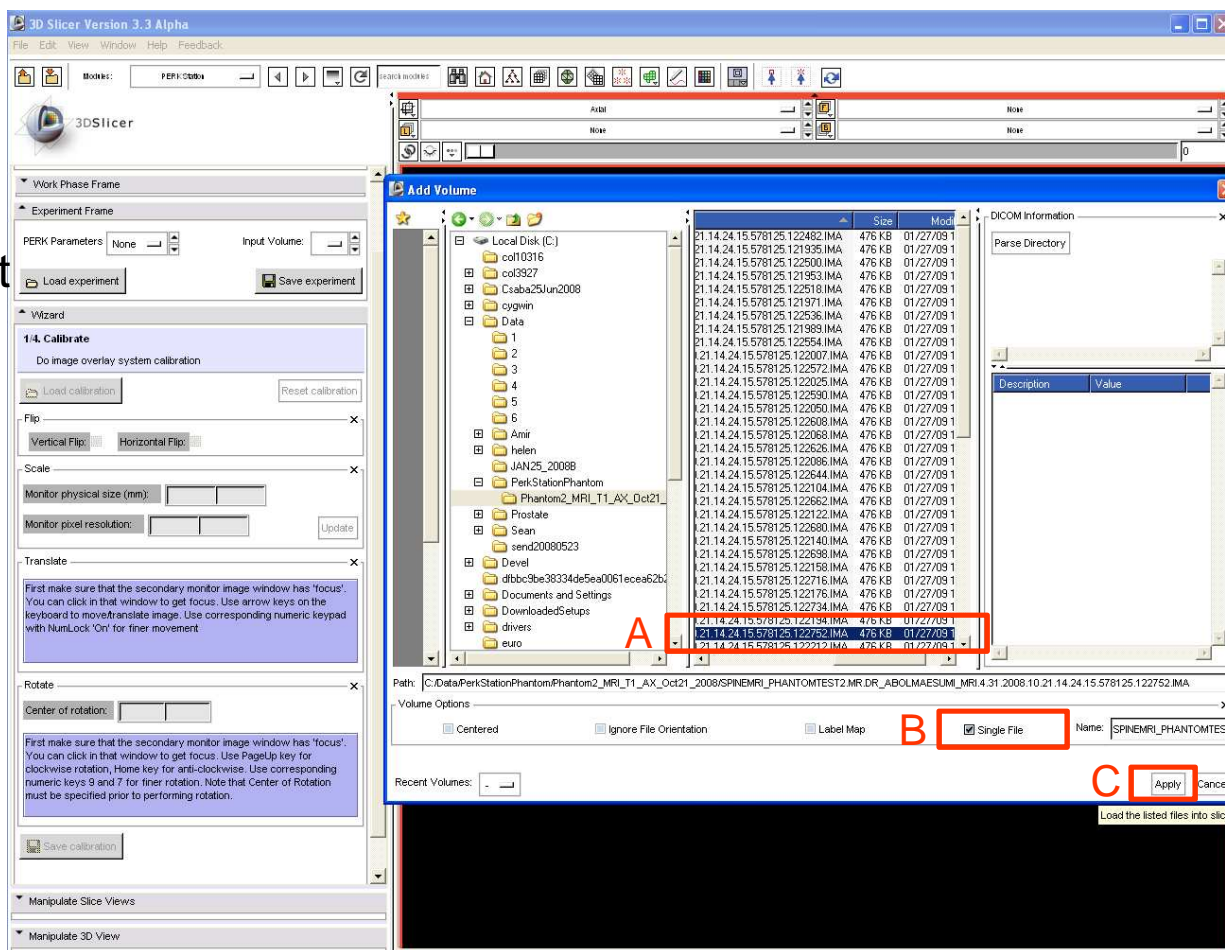
# Load planning image

Dialog box opens

A - Select the image  
(PerkStationTutorialDataset  
\Plan.dcm)

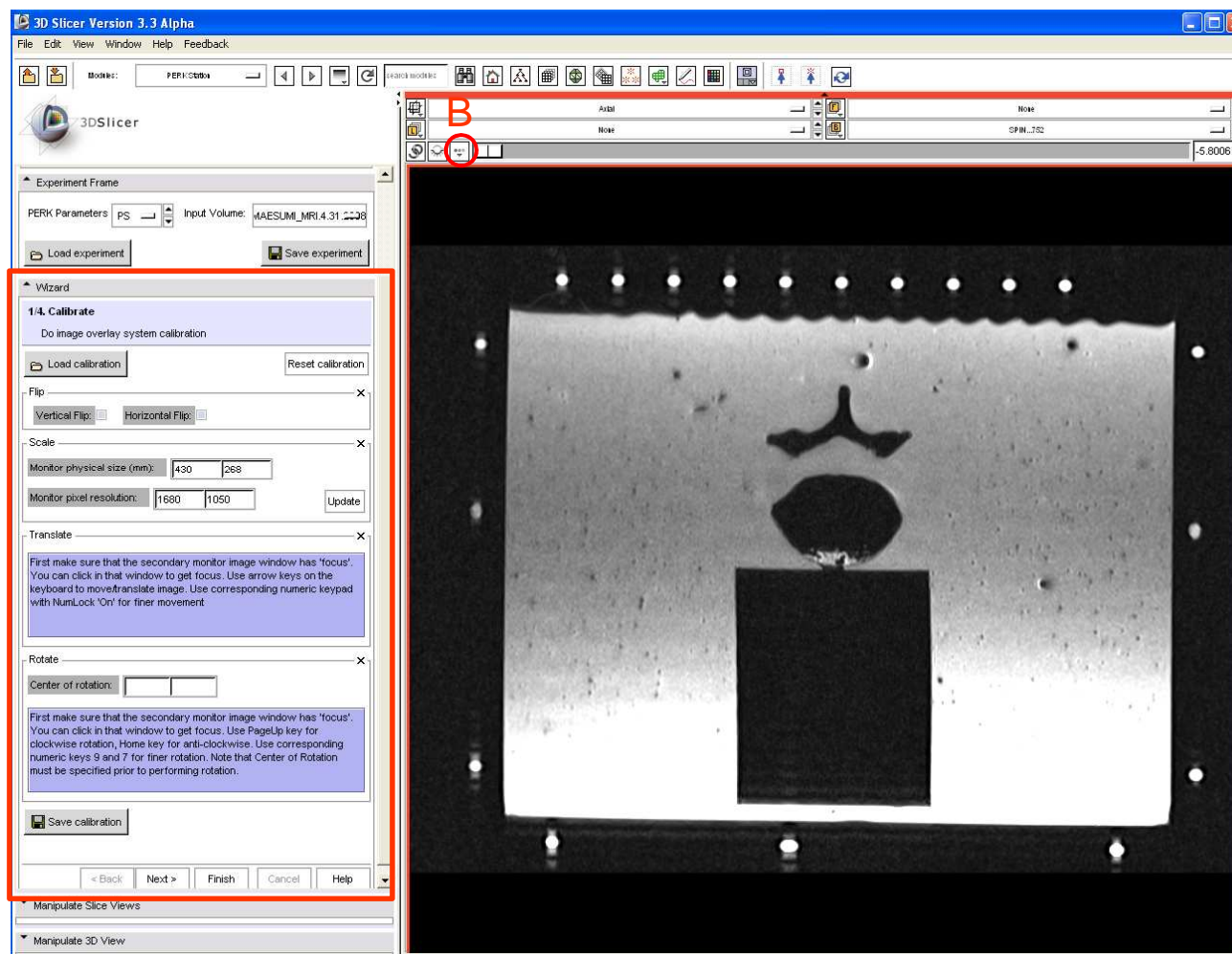
B - Check "Single File"

C - "Apply"



# Load planning image

- A** - Calibrate step GUI controls activated
- B** - Click, select “Fit to window”





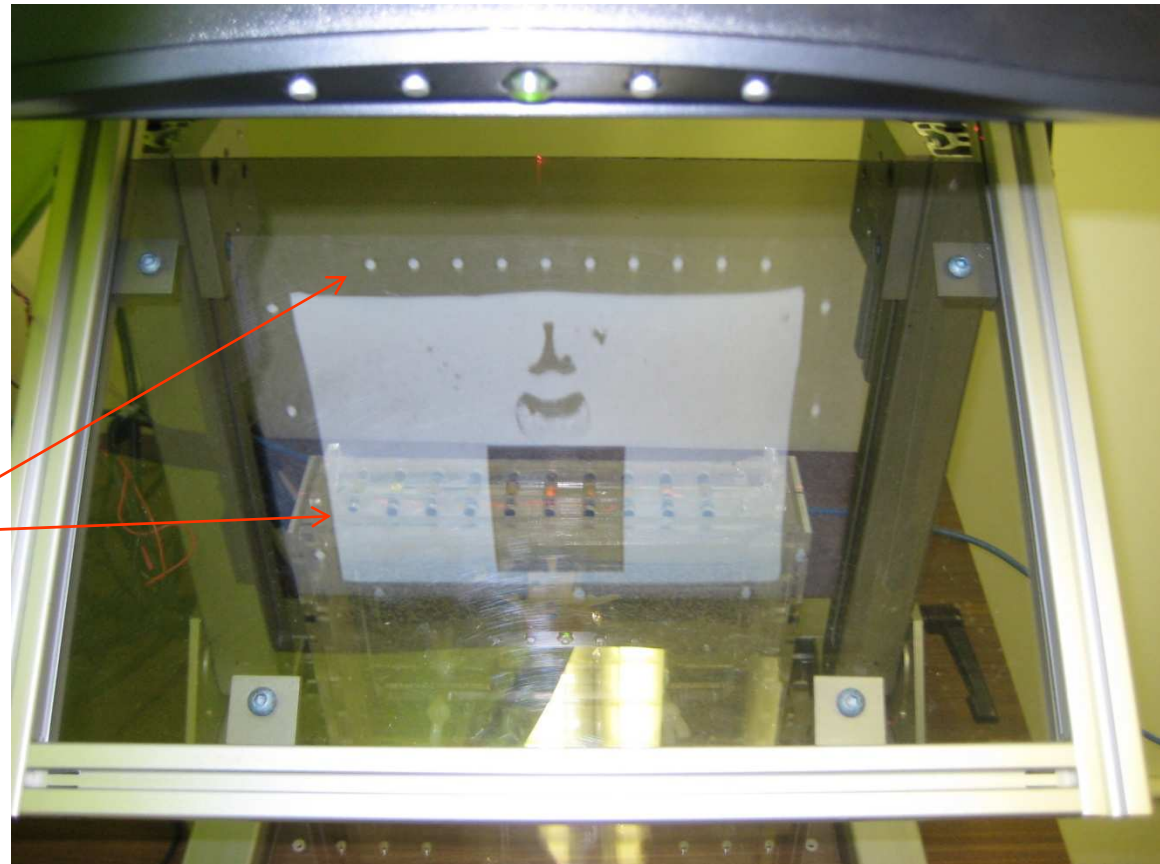


# *Planning image overlaid on Perk Station display*

Image projection plane and transverse laser planes coincide; By aligning the phantom and laser plane at desired measurement strip position, we performed z or out-of-plane registration

Notice the in-plane fiducial misalignments!

Need for in-plane registration





---

*Calibrate,  
register image  
to phantom*



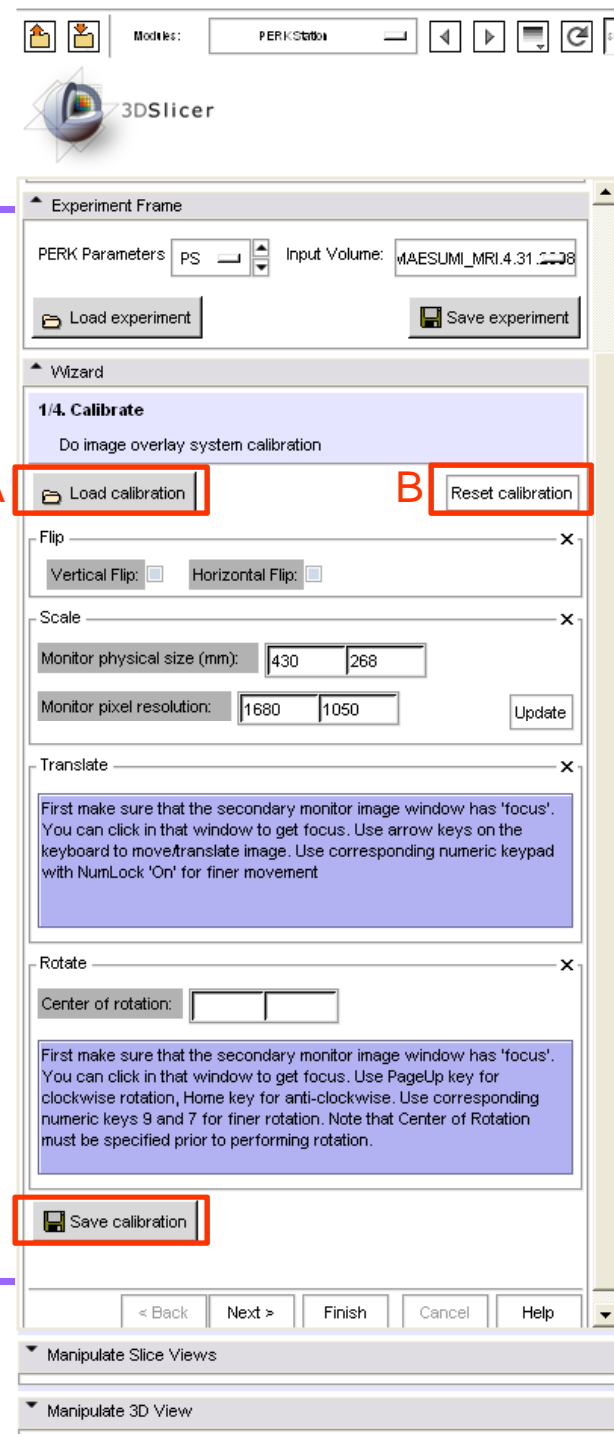
# Calibration step GUI

Load/save/reset

A - Click to load a previous saved calibration

B - Reset calibration, if something goes wrong

C - Save the current achieved calibration

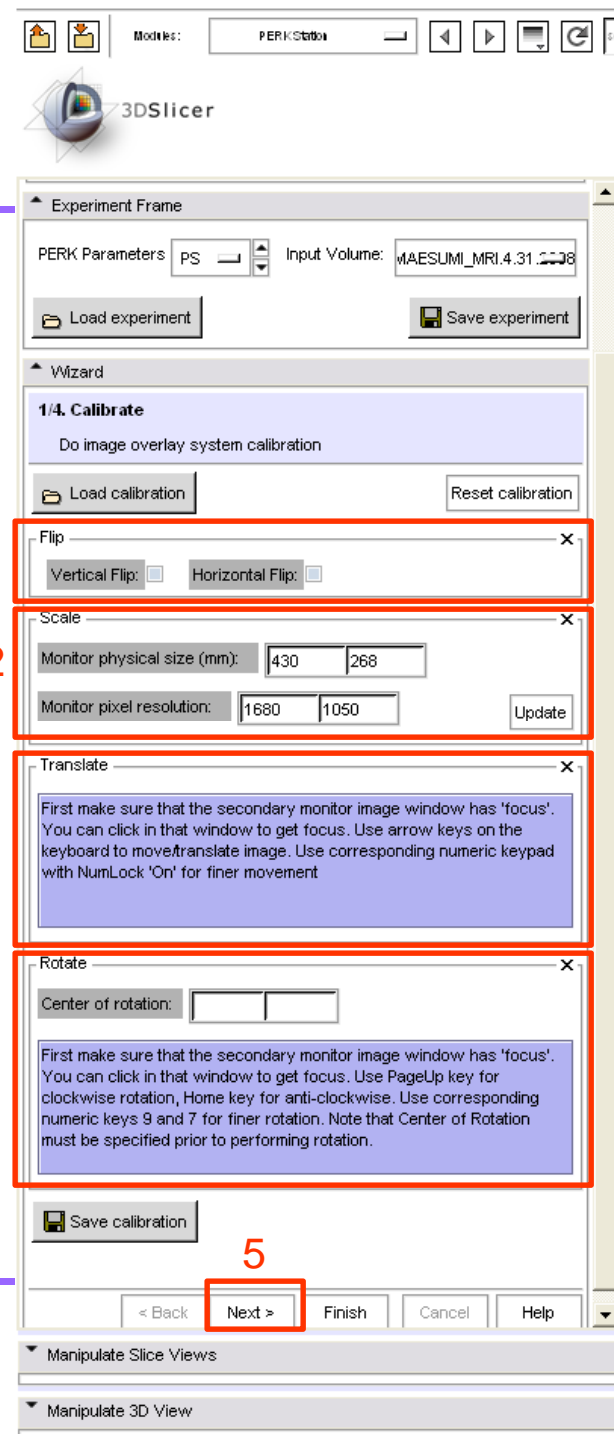




# Calibration steps

## Components of Calibration:

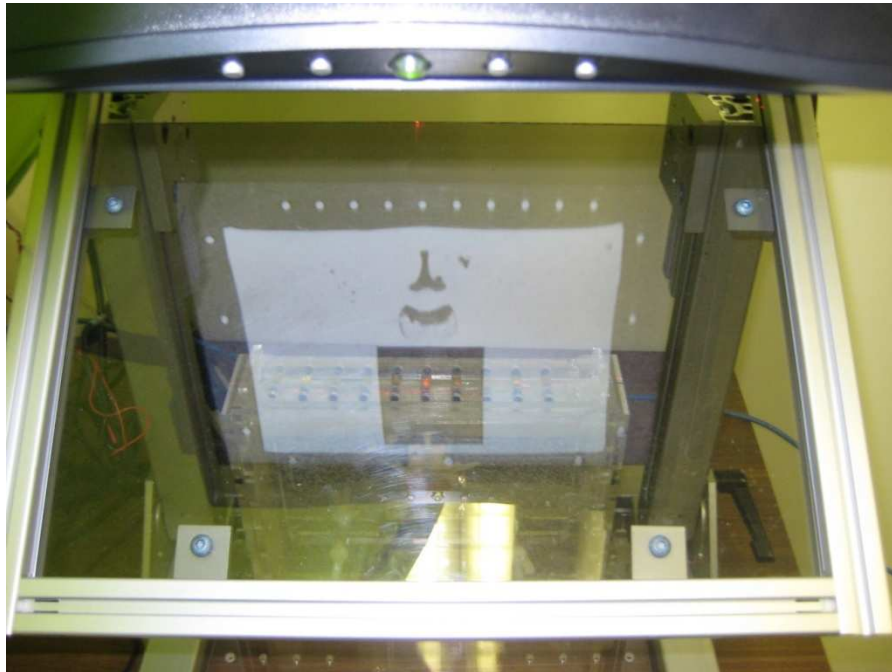
- 1 - Flip: To ensure that “right” on phantom appears, “right” on the image overlaid; depending on Perk Station LCD display arrangement, one may need a vertical or a horizontal flip
- 2 - Scale: To ensure that the image size as displayed corresponds to its physical size in millimeters; It automatically detects and displays Perk Station LCD physical size, pixel resolution, however, this must be verified and corrected if needed
- 3 - Translate: Best in-plane translational alignment of fiducials as seen on image, and as seen through semi-transparent mirror; Instructions on how to do it: Use keyboard arrow keys
- 4 - Rotate: Correct in-plane rotational misalignment; Use the best aligned fiducial as center of rotation (by clicking); then use keyboard keys for rotation
- 5 - Press ‘Next’ when done



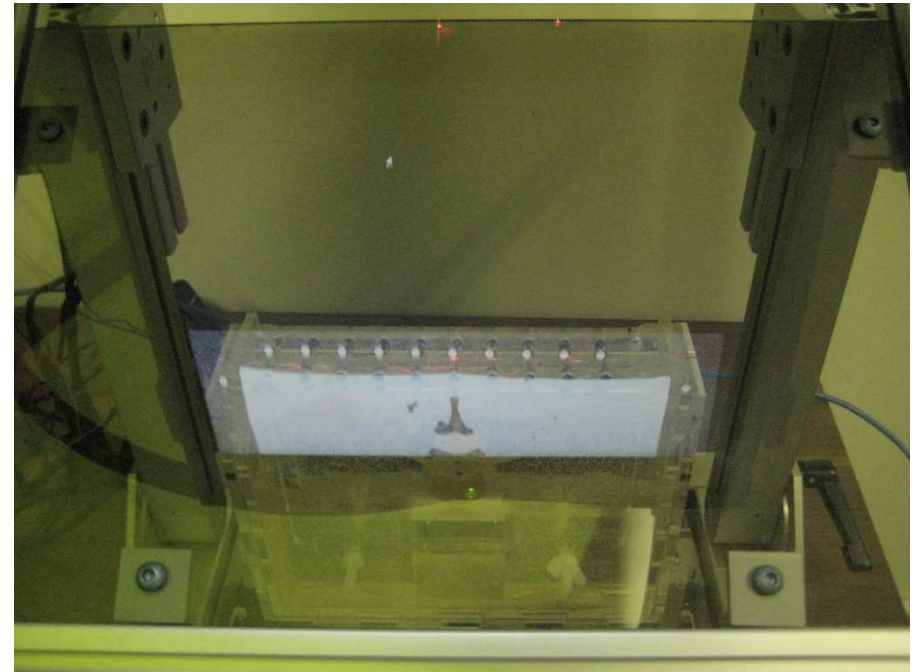
# *Calibrate: after alignment*

---

Before



After



PS: The calibration takes place only on Perk Station monitor, the image on laptop inside Slicer remains unaffected and stationary. This is helpful for next step

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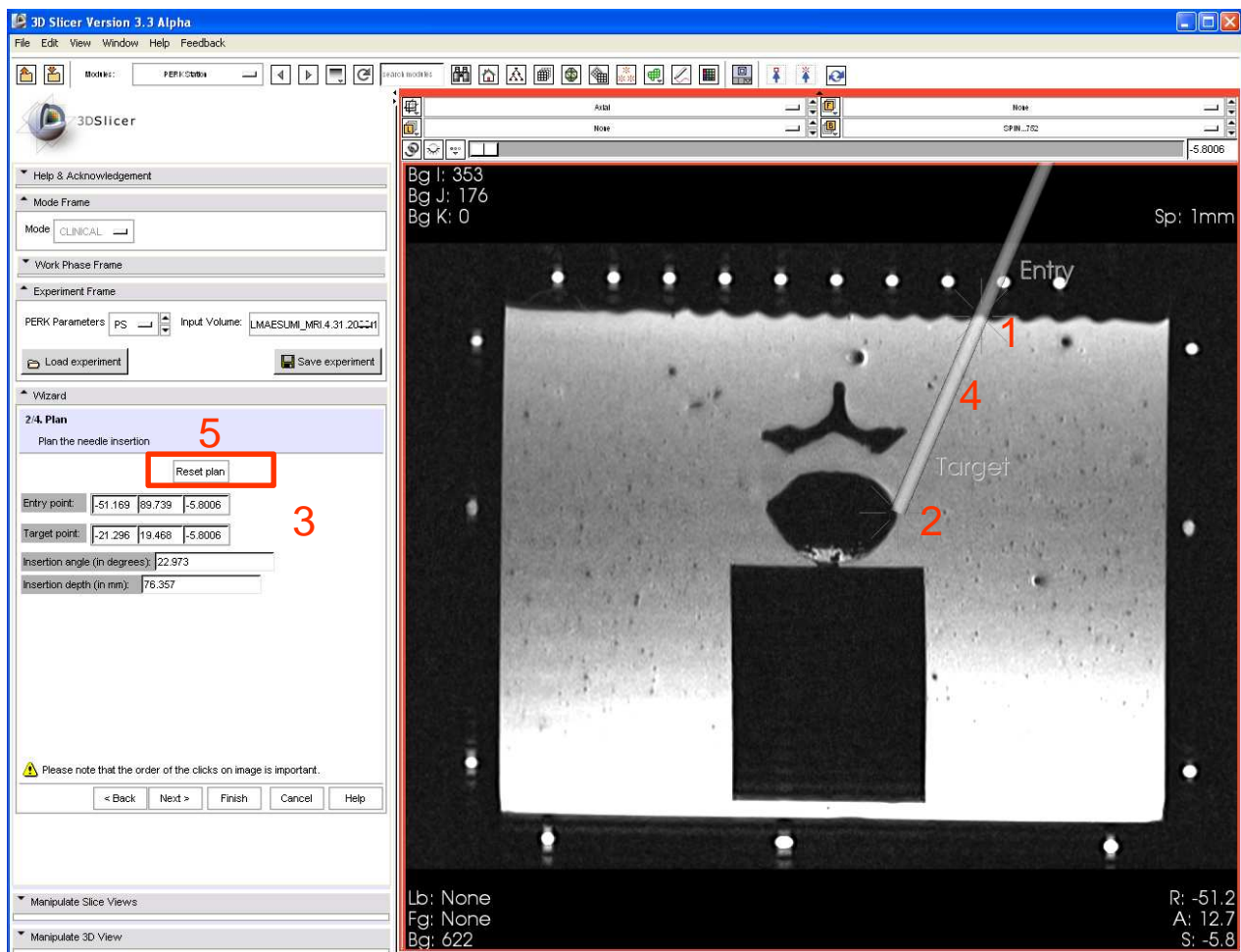
---

# *Plan*



# Plan step

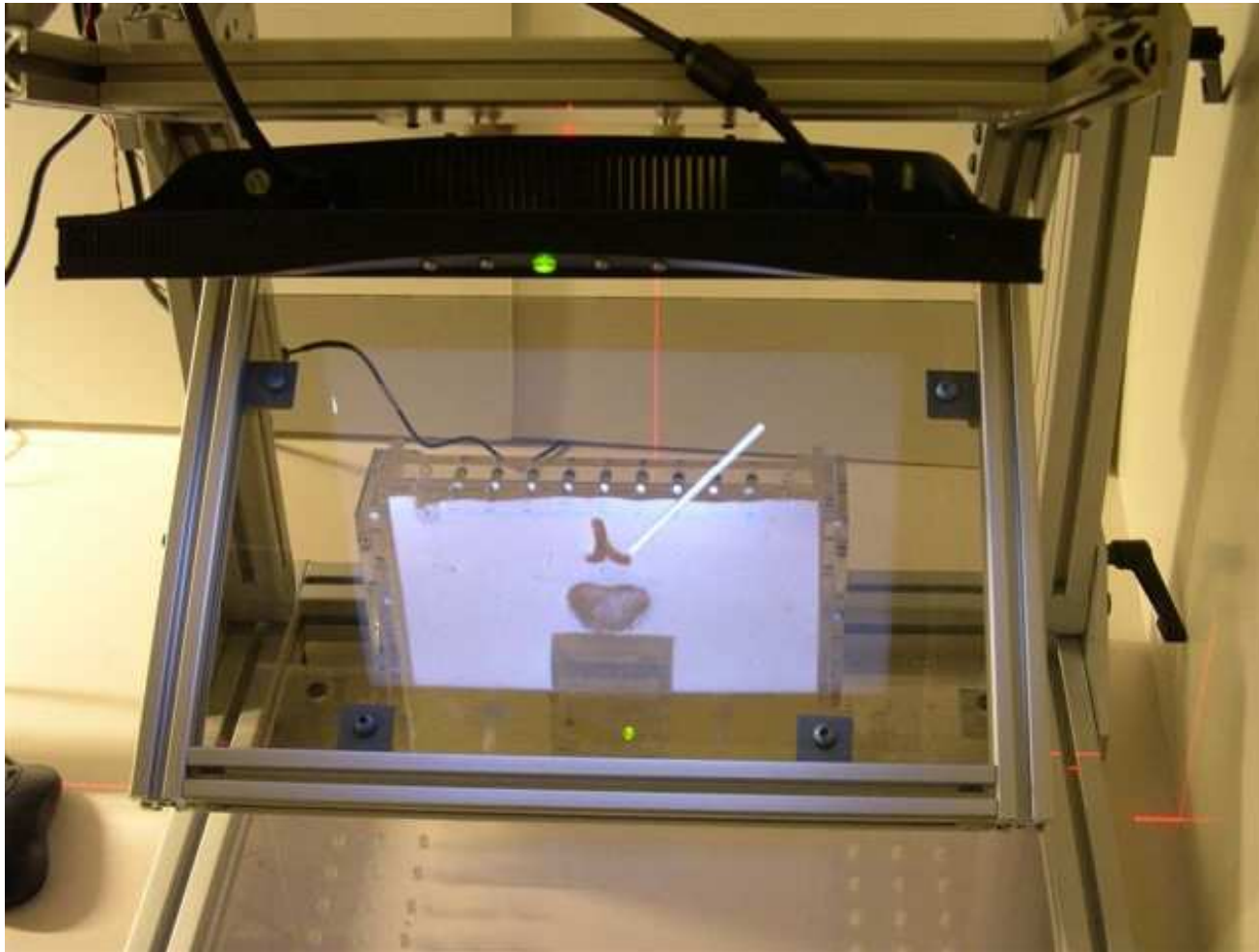
- 1 - Click to select 'Entry' point
- 2 - Click to select 'Target' point
- 3 - RAS coordinates, insertion depth, insertion angle populated
- 4 - Needle trajectory appears overlaid
- 5 - Reset if necessary





# *Needle trajectory overlaid in-situ on Perk Station*

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*Insert*

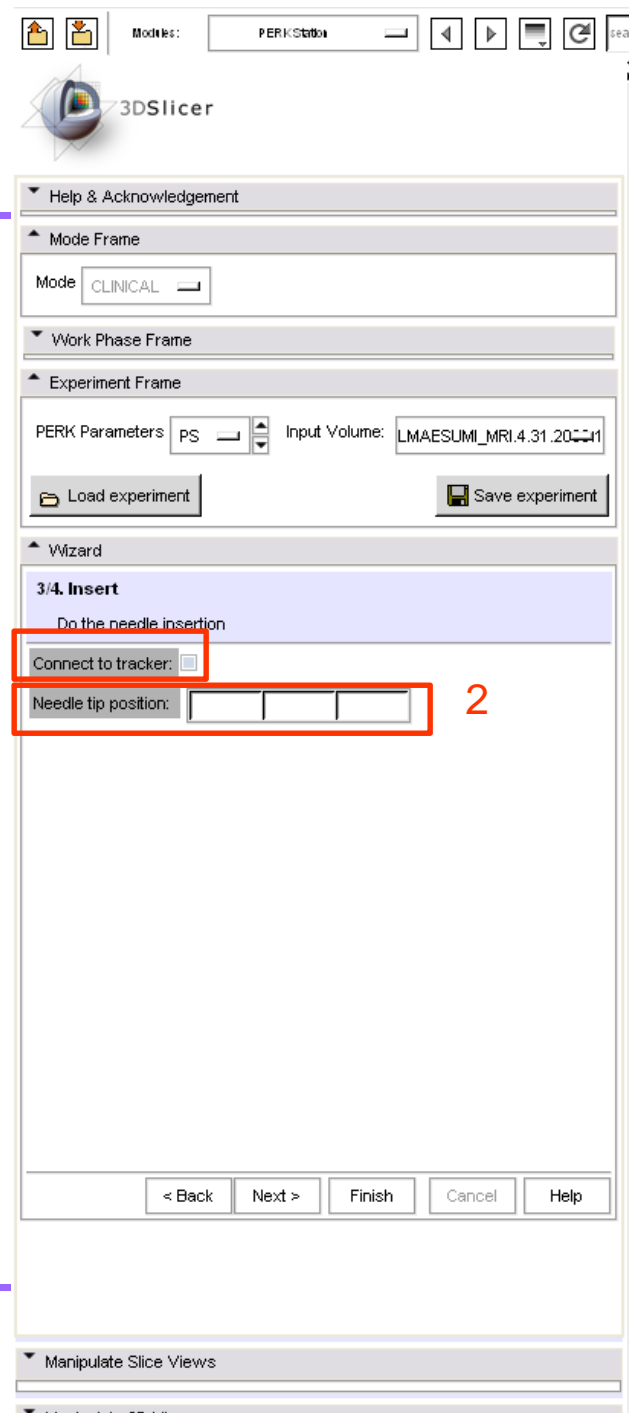


# Insert step

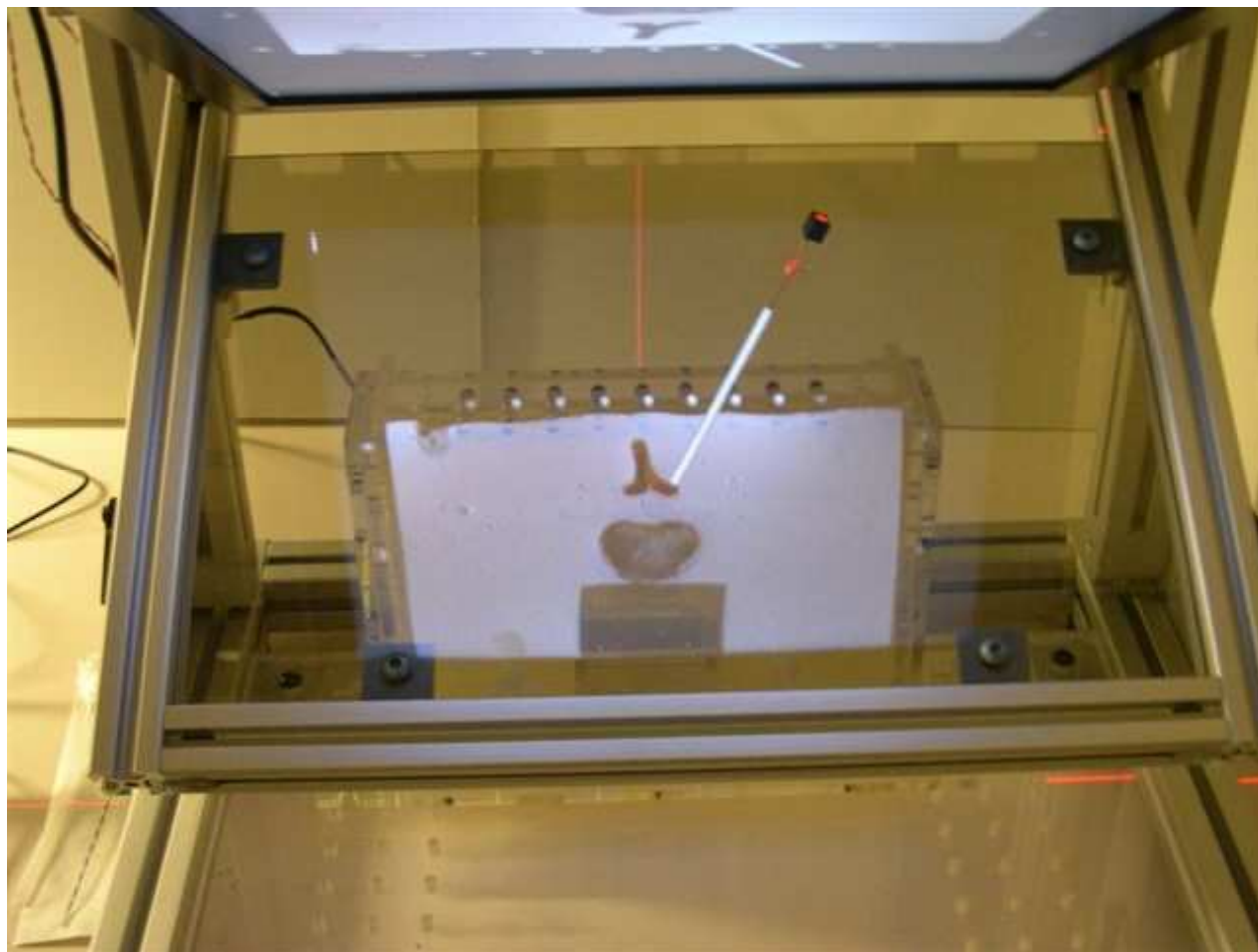
Only if the EM tracker is connected!!

- 1 - Select this to connect to tracker and start receiving tracking data
  - 2 - Needle tip position is updated real time, as well the needle trajectory is also overlaid in 3D in real-time in different color alongside planned trajectory
- \*This functionality is still under implementation

PS: This step requires prior offline step of registration of a specific needle between EM coordinate space, phantom space, and MRI/CT image coordinate space. This procedure is described in [ref]



# *Needle inserted*





---

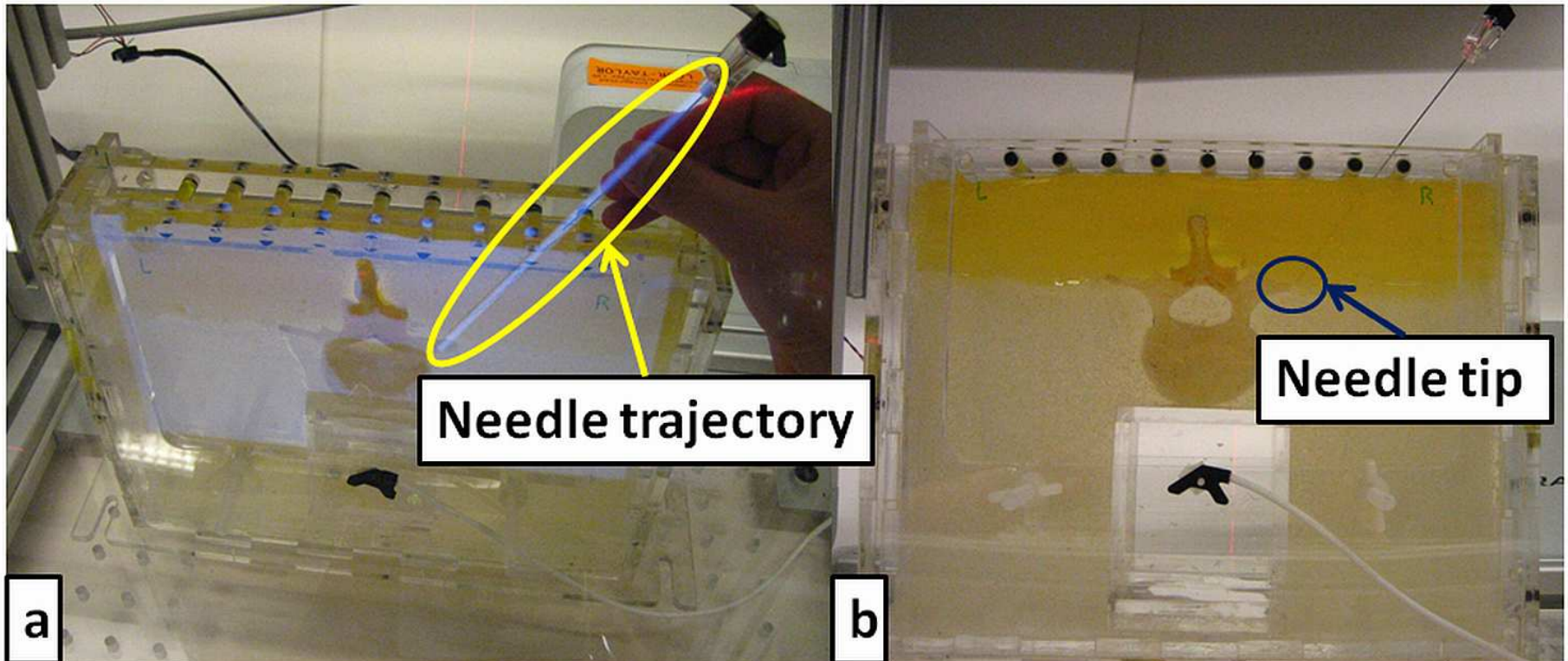
# *Validation*



# *Validation*

---

- With EM tracker : Since the needle position and orientation is sensed and known, the errors can be computed right-away
  
- Without EM Tracker
  - 1 - Image the phantom with needle inserted
  
  - 2 - Load the validation image
  
  - 3 - Click on actual entry and needle end points





# *Post-intervention analysis*

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- If the needle is being tracked by EM tracker, then the whole insertion attempt can be recorded, and data can be used for gesture and performance analysis
- This is still work in progress [4]



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# *Outreach activities*





# *Outreach activities, teaching tool*

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- Perk Station has debuted as undergrad course teaching aid, and has received a huge response!
- Besides, it is being used for outreach tool to attract young minds to science.





# *Conclusion*

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- A training and performance evaluation system in needle-based surgical guidance applications is introduced and presented
- Intuitive graphical user interface to interact with the data
- Open-source environment



## *Reference, more information*

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- [1] P. U-Thainual, G. Fischer, I. Iordachita, S. Vikal, G. Fichtinger, The Perk Station: systems design for percutaneous intervention training suite, IEEE International Conference on Robotics and Biomimetics (ROBIO 2008), February 21-25, 2009, Bangkok, Thailand
  
  - [2] P. U-Thainual, I. Iordachita, G. Fichtinger, The Perk Station: Design of a percutaneous intervention training suite, 20<sup>th</sup> International Conference of the Society for Medical Innovation and Technology (SMIT), Vienna, Austria, August 28-31, 2008. Electronic proceedings, ISBN 3-902087-25-0, pp. 148-153
  
  - [3] Narges Ahmidi, Paweena U-Thainual, Siddharth Vikal, Parvin Mousavi, Iulian Iordachita, Gabor Fichtinger, A System for Performance Analysis of Surgeon Dexterity in Percutaneous Needle-based Interventions, 7th Imaging Symposium of the Imaging Network of Ontario, 2008
-



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1 R01 CA118371-01A2



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