Mechanically Assisted Trans-Rectal Prostate Biopsy

DBP2: Prostate Interventions, Queen's University and JHU

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Goal for roadmap project

- End-to-end application for MR-guided robotically-assisted trans-rectal prostate biopsy

- Add slicer features relevant to clinical interventional procedures

- Utilize slicer in our diagnostic and therapeutic research programs for prostate cancer

Prostate cancer statistics

- One of every 6 men in the U.S. will be diagnosed
- 230,000 new cases in 2007
- incidence will double by 2025
- ~1 million needle biopsies per year
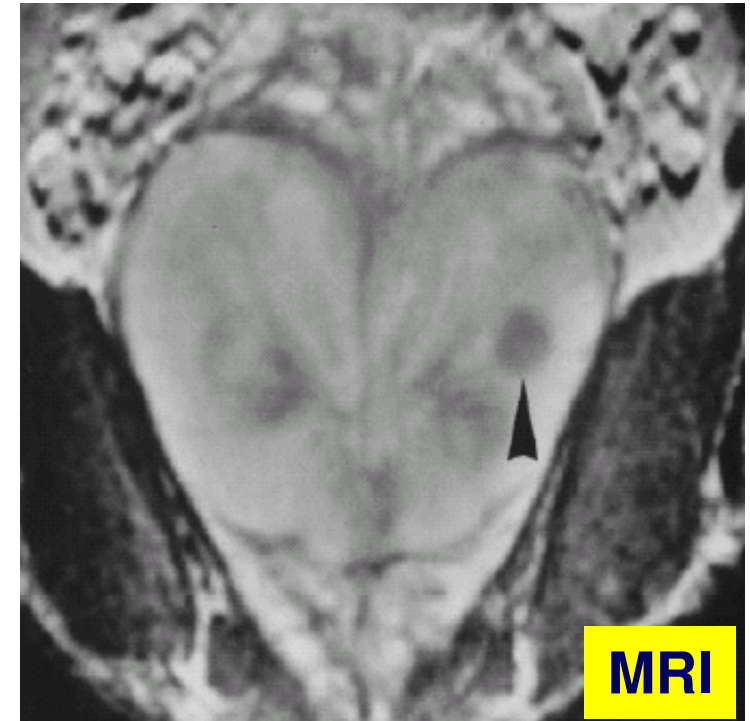- (Add 10% for Canada, and double for Europe)

- ***Ultrasound guided biopsy is cheap, but has poor sensitivity. Cancers as large as a sugar cube are routinely missed***
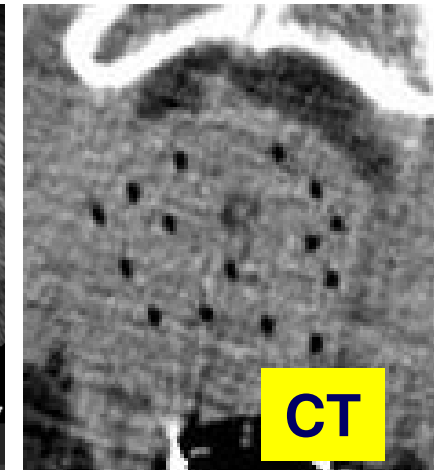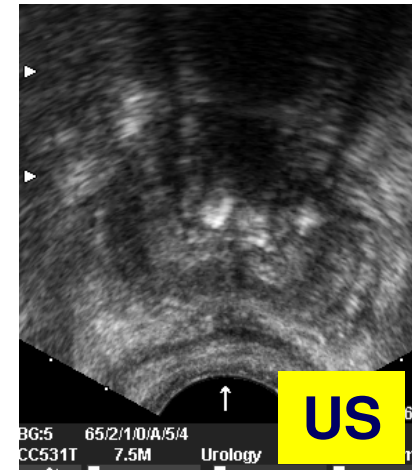
MRI for biopsy guidance

PROS

- Sensitivity in detecting soft tissue abnormalities

- Excellent visualization of prostate and normal tissues

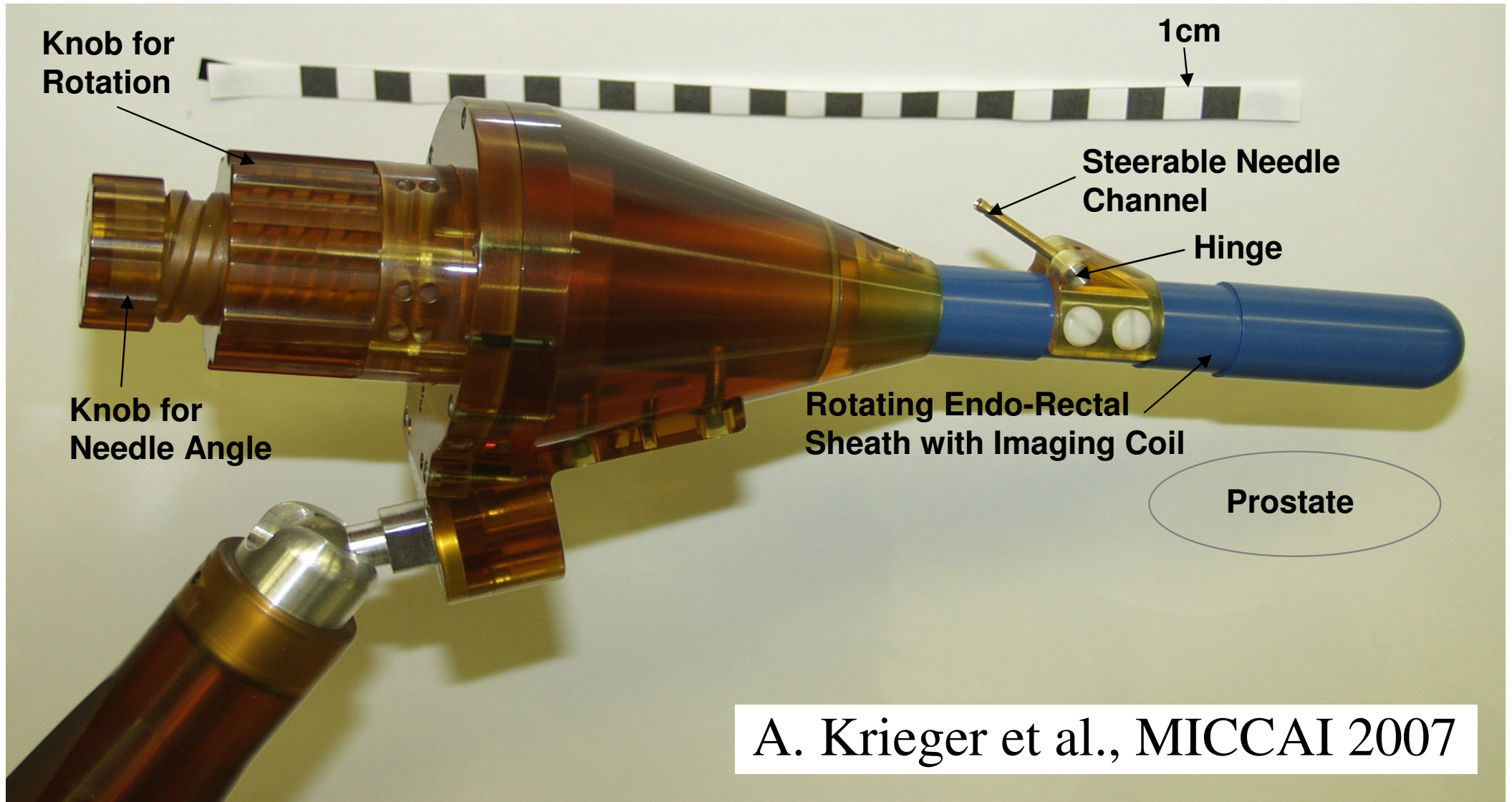- Morphological, functional and molecular imaging

CONS

- Expensive, limited availability

- This is gradually changing as clinical efficacy is being proven

MRI

US

CT

Trans-rectal, MR compatible

Knob for Rotation

1cm

Steerable Needle Channel

Hinge

Knob for Needle Angle

Rotating Endo-Rectal Sheath with Imaging Coil

Prostate

A. Krieger et al., MICCAI 2007

Implementation plan

- Interactive Slicer module
  - Workflow wizard à la EMSegment module

- Workflow:
  - Pre-op planning (future)
  - Robot pose calibration
  - Intra-op targeting
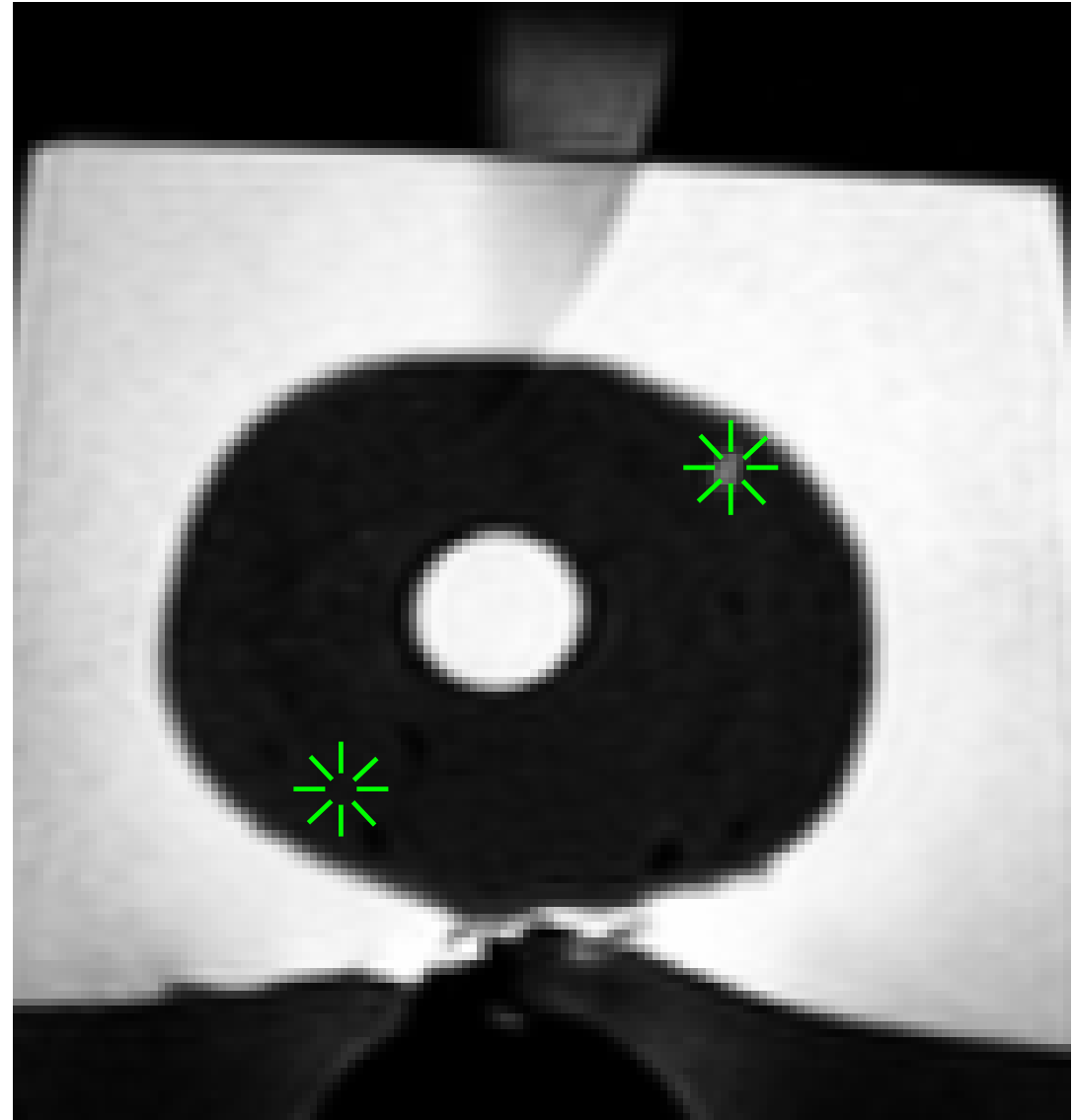 - Post-biopsy verification

Calibration of Robot Pose

- Load thin-slab calibration image

- Semi-automatic identification of 4 robot fiducials

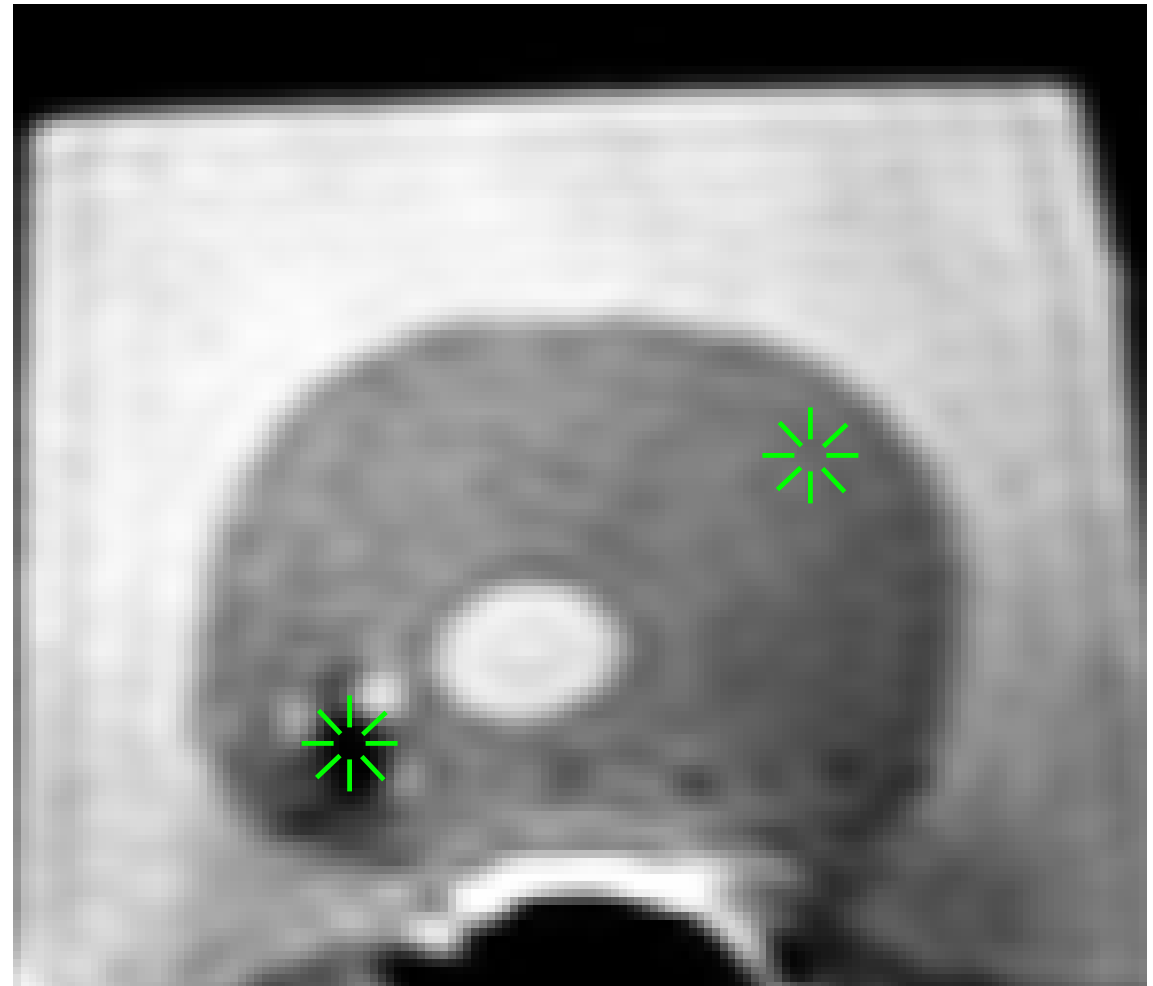- Compute robot pose in scanner coords
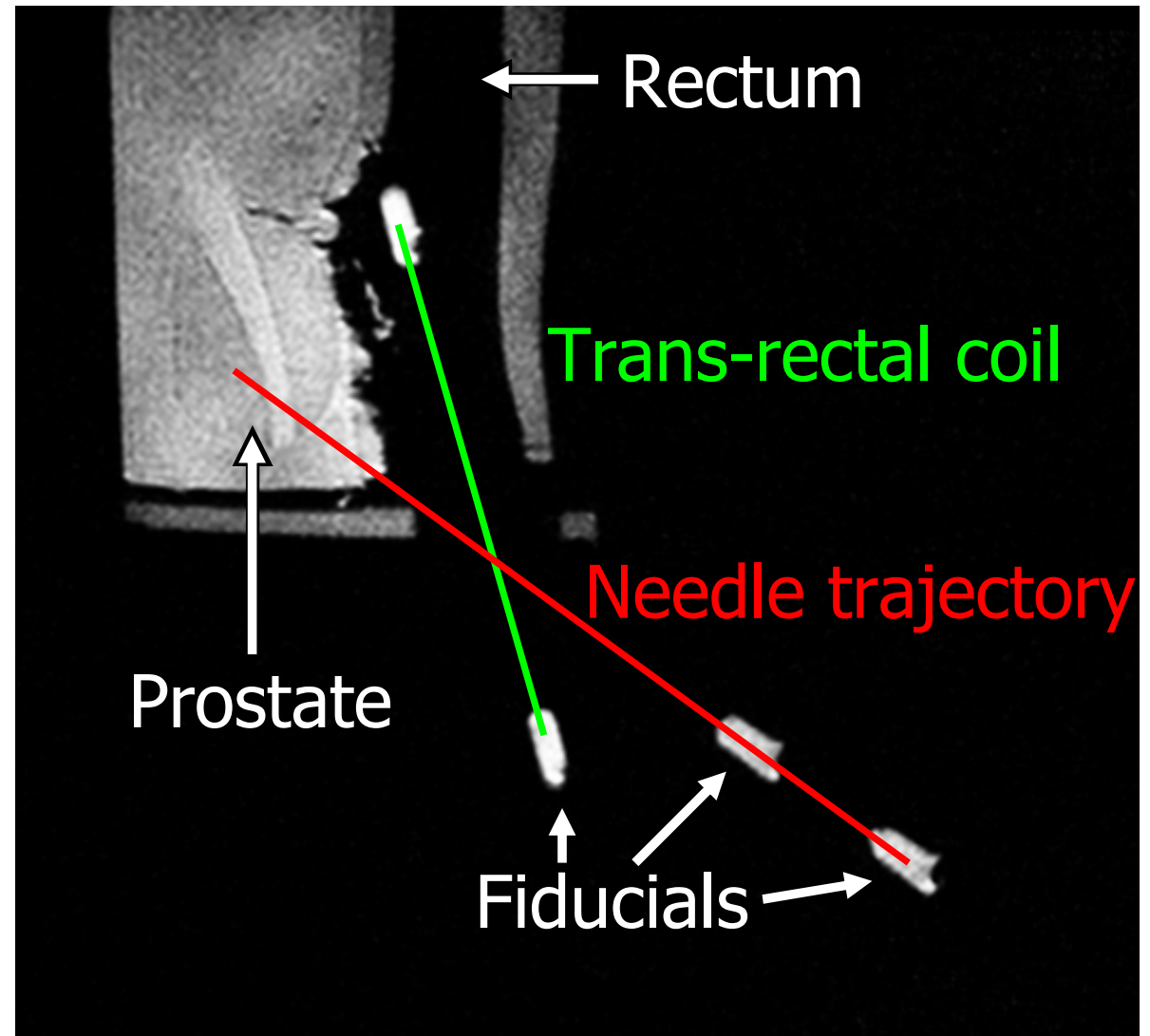
Targeting biopsy sites

- Load targeting image

- Identify targets with Slicer fids

- Compute robot rotation, needle trajectory, needle depth

- Physician adjusts robot manually and takes biopsy

Verification after biopsy

- Scan after each biopsy (slice or thin slab)

- Compare needle void with planned target

Registration needs

- MR to MR registration
  - Currently, targets are manually placed on intra-op scan based on the pre-op plan
  - Better: pre-op to intra-op registration
  - Must be deformable registration
    - Prone vs. supine, robot in rectum

- MR to US highly desired for future
  - Compare MR to current TRUS procedures

Robot communication needs

- This is a "manual" robot
  - Positioned by hand, no motors
  - Robot joints have encoders, readouts must be displayed to the operator
  - Slicer IGT demon can be used

- Motorized version is forthcoming!

Display needs

- Dual-display required
  - #1: display by scanner console
  - #2: in-room for interventionalist

- In-room display properties:
  - Full-screen of one Slicer view
  - No interaction, just display

Data-handling needs

- Read DICOM oblique orientations
  - Needed for intervention in general
  - Use Slicer's IJK to RAS

- RAS to LPS conversion
  - Planning, targeting is always LPS
  - Scanner consoles are LPS

"Frame of Reference"

- Each procedure can involve several "frames of reference" (FORs)
    - i.e. motion occurs: calibration repeated
    - Need FOR identifier tags for data sets and fiducial lists
    - Data sets with different FORs must not be allowed to be overlaid or compared: <u>very real risk to the patient</u>

Feature Summary

- From NA-MIC
  - Workflow GUI infrastructure
  - Oriented images set from DICOM header
  - Registration

- From Queens/JHU
  - End-to-end application
  - Secondary full-screen display
  - Prostate-specific registration

- Shared
  - Multiple Frame-of-Reference in Slicer