



MR Guided Prostate Interventions



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Advantages of MRI

- No ionizing radiation
- High soft-tissue contrast
- High resolution imaging
- True 3D volumetric imaging
- Multi-parametric imaging
 - T1/T2 weighting, Functional, Diffusion, Flow, Temperature, Oxygenation, ...
- Can provide “real-time” imaging capabilities



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Why MRI?

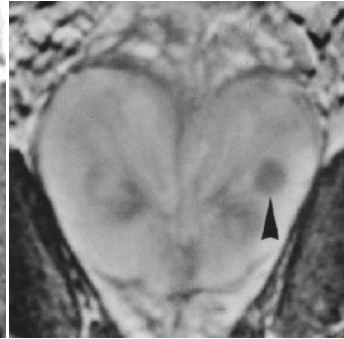
US



CT



MRI



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Close Bore Magnet



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Intra-operative MRI – open magnet in the OR

Operating Room



Black, Jolesz et al., Harvard BWH



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MRI-Guided Laser Ablation

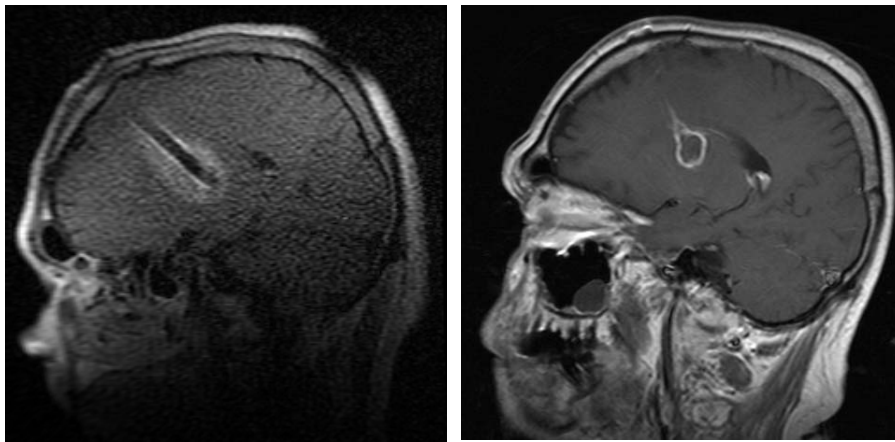


Black, Jolesz et al., Harvard BWH



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MRI-Guided Laser Ablation



Black, Jolesz et al., Harvard BWH



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Transperineal Implants & Biopsy



Tempany et al., Harvard BWH

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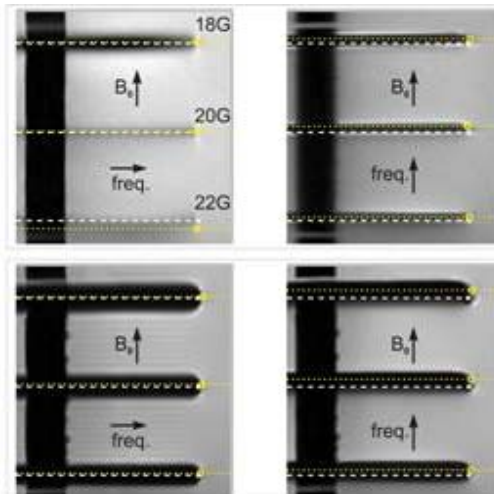
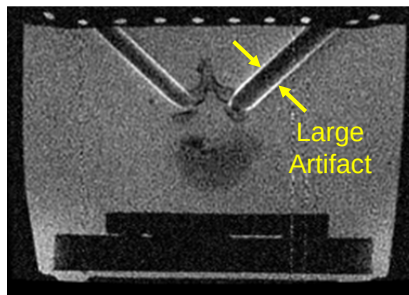
Transperineal HDR & Biopsy



Menard et al., NIH

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Why is MRI so hard?



DiMaio, Fischer, Fichtinger et al., JHU

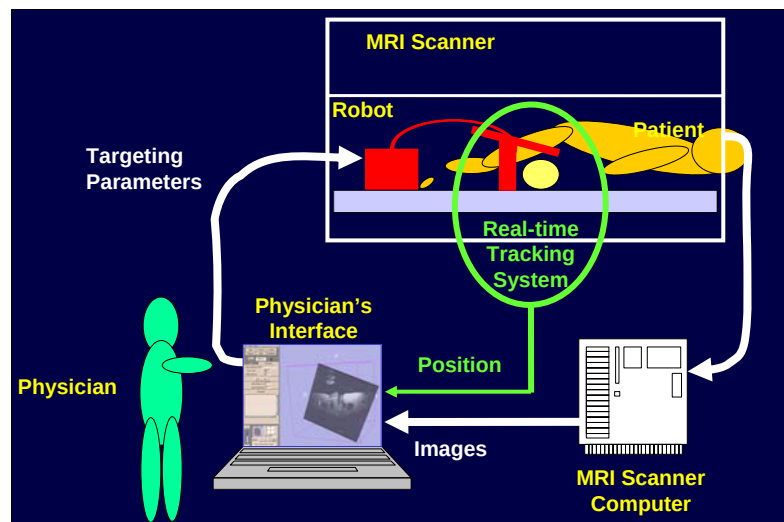
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Why is MRI so hard?



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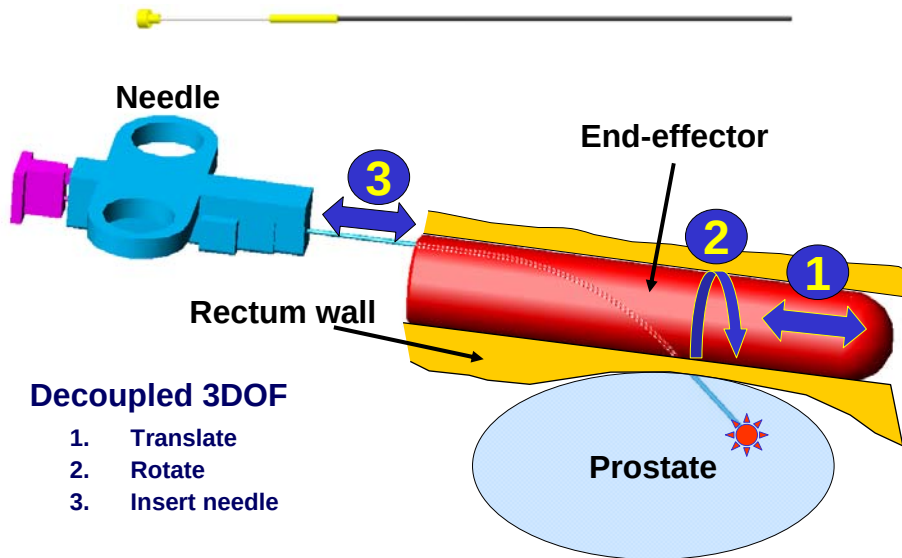
Point & Click System Concept



CREDIT: Krieger, Susil, Ménard, Coleman, Singh, Whitcomb, Atalar, Fichtinger (Johns Hopkins and NIH)

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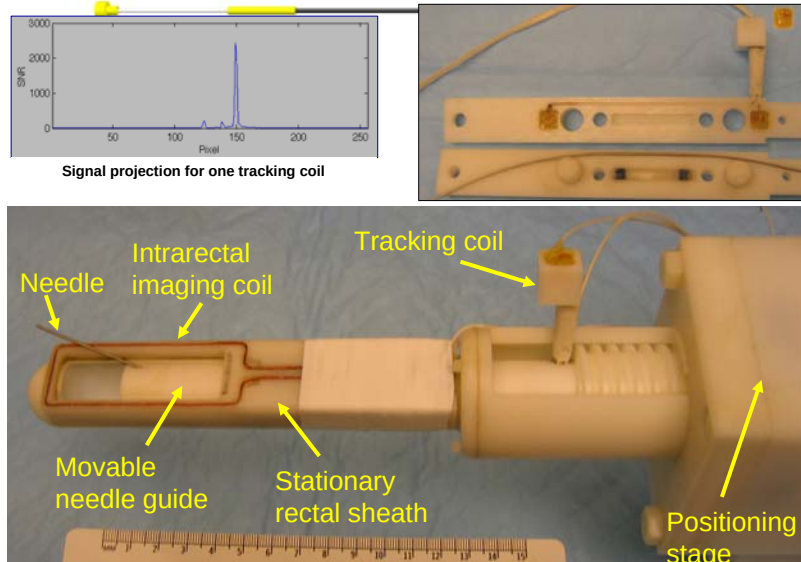
Transrectal Prostate Interventions in 3T MRI



CREDIT: Krieger, Susil, Ménard, Coleman, Singh, Whitcomb, Atalar, Fichtinger (Johns Hopkins and NIH)

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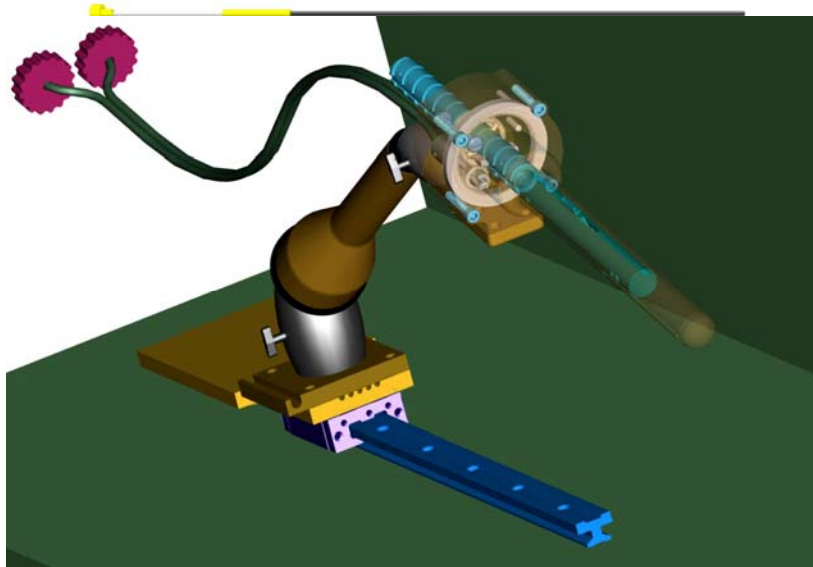
The End-Effector (First Prototype)



CREDIT: Krieger, Susil, Ménard, Coleman, Singh, Whitcomb, Atalar, Fichtinger (Johns Hopkins and NIH)

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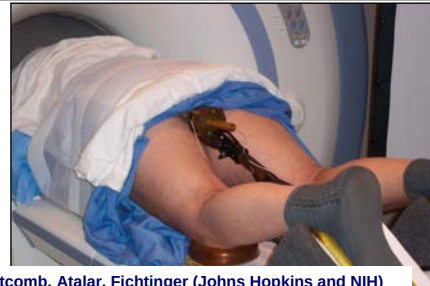
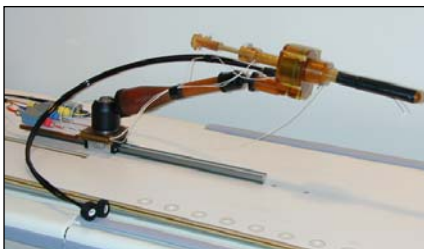
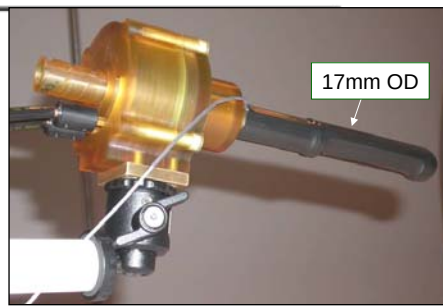
Human Grade Device



CREDIT: Krieger, Susil, Ménard, Coleman, Singh, Whitcomb, Atalar, Fichtinger (Johns Hopkins and NIH)

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Human-Grade Device



CREDIT: Krieger, Susil, Ménard, Coleman, Singh, Whitcomb, Atalar, Fichtinger (Johns Hopkins and NIH)

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Robot in Clinical Trials

- From concept to 2 trials in 22 month
- ~50 biopsies & marker seed placements
- No severe adverse events
- Supports 4 clinical trials as validation tool

MOVIE



Example



CREDIT: Krieger, Susil, Ménard, Coleman, Singh, Whitcomb, Atalar, Fichtinger (Johns Hopkins and NIH)
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Liquid Injection monitoring

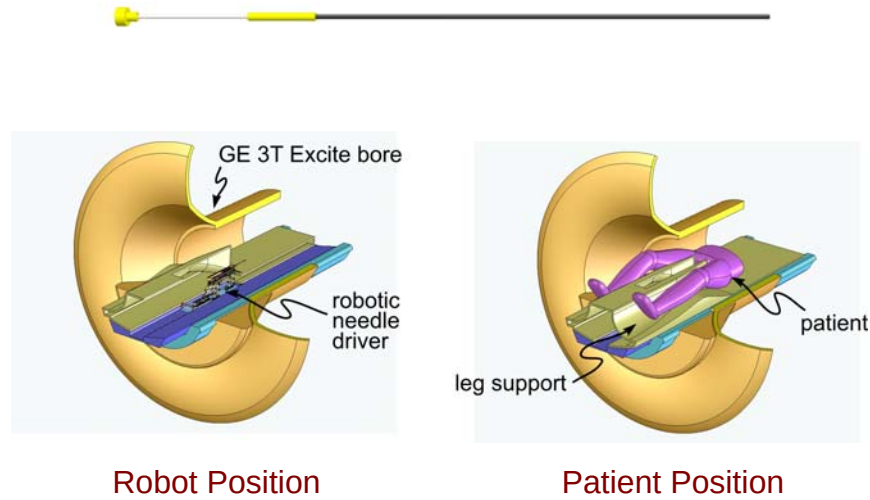
canine studies

GOOD BAD



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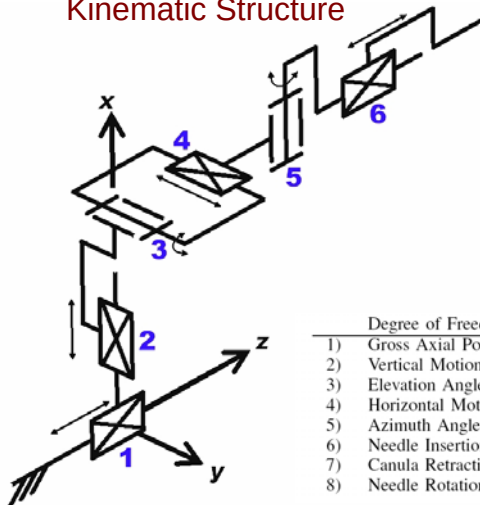
Transperineal Brachytherapy / Biopsy



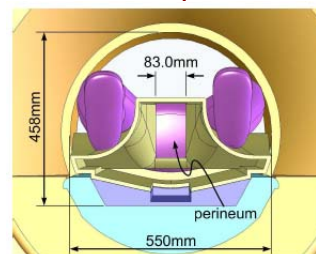
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Mechanical Design

Kinematic Structure



Workspace

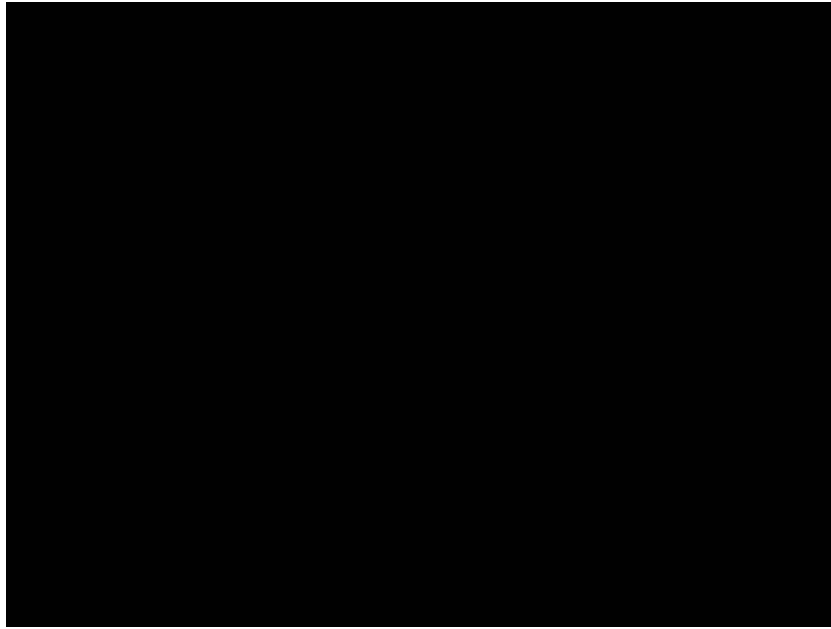


Degree of Freedom	Motion	Requirements
1) Gross Axial Position	1m	Manual with repeatable stop
2) Vertical Motion	0-100mm	Precise servo control
3) Elevation Angle	$+15^\circ, -0^\circ$	Precise servo control
4) Horizontal Motion	$\pm 50\text{mm}$	Precise servo control
5) Azimuth Angle	$\pm 15^\circ$	Precise servo control
6) Needle Insertion	120mm	Cooperative or Automated
7) Canula Retraction	60mm	Cooperative or Automated
8) Needle Rotation	360°	Manual or Automated

Fischer GS, Iordachita I, Csoma C, Tokuda J, Mewes PW, Tempny CM, Hata N, Fichtinger G, Pneumatically Operated MRI-Compatible Needle Placement Robot for Prostate Interventions, International Conference on Robotics and Automation - ICRA 2008, Pasadena, CA, May 2008 (accepted)

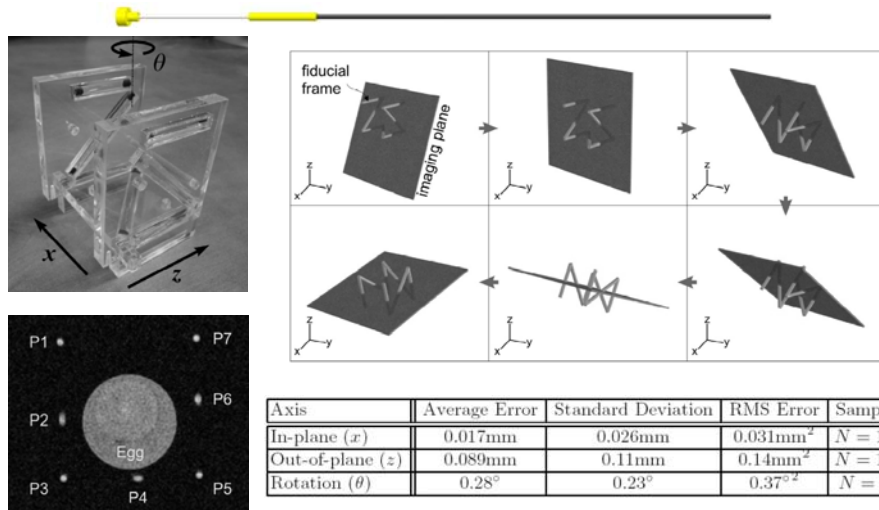


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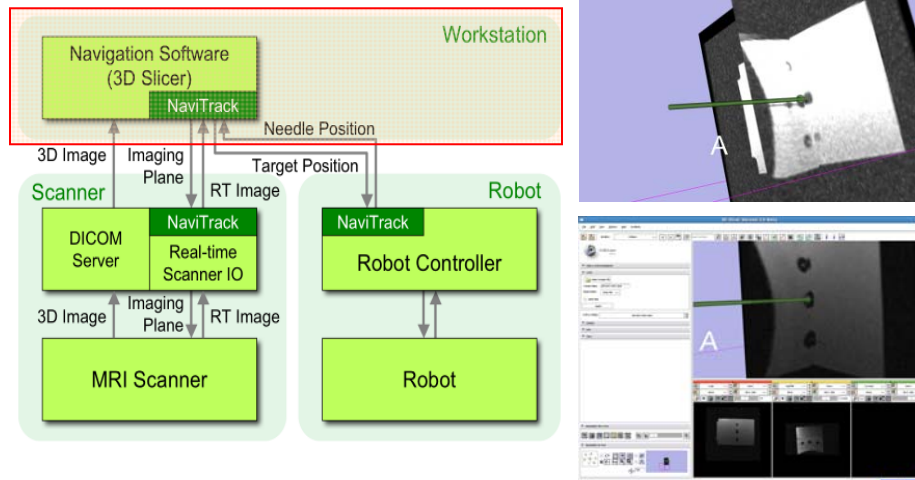
Fischer GS, et al., MRI-Compatible Pneumatic Robot for Transperineal Prostate Needle Placement, IEEE / ASME Transactions on Mechatronics – Focused section on MRI Compatible Mechatronic Systems, June 2008
Johns Hopkins University, Engineering Research Center for Computer Integrated Surgical Systems and Technology

Registration of Robot to MRI



DiMaio S, Samset E, Fischer GS, Iordachita I, Fichtinger G, Jolesz F, Tempany C, Dynamic MRI Scan Plane Control for Passive Tracking of Instruments and Devices, 10th International Conference on Medical Image Computing and Computer-Assisted Intervention - MICCAI 2007, Brisbane, Australia, LNCS, Vol 4792, pp 50-58, Springer, November 2007

Software Interface



Mewes PW, Tokuda J, DiMaio SP, Fischer GS, Csoma C, Gobbi DG, Tempny CM, Fichtinger G, Hata N, An Integrated MRI and Robot Control Software for an MRI-compatible Robot in Prostate Intervention, International Conference on Robotics and Automation - ICRA 2008, Pasadena, CA, May 2008 (accepted)

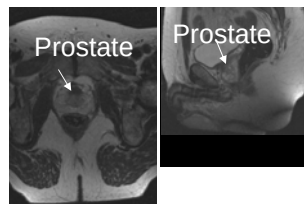


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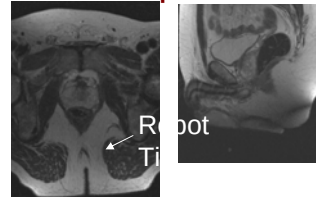
Patient workflow & MRI compatibility



No Robot

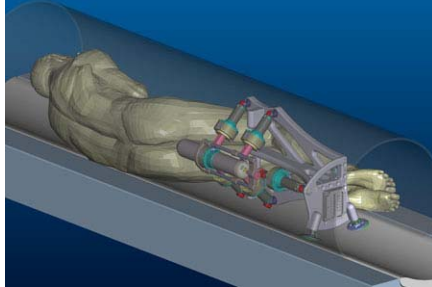


Robot Operational



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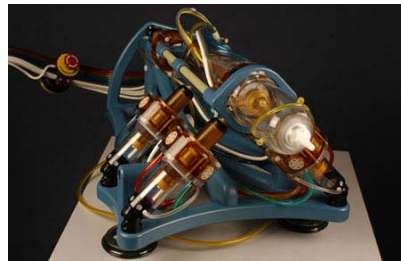
Other work at Johns Hopkins



[Movie1](#)

[Movie2](#)

[Movie3](#)



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Innomedic Robot



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Innomedic CAD/CAM workflow

set up on bed



image



plan



move robot



insert needle manually



confirm in image



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New wide & short bore magnets coming...



Field strength 1.5T – 3T
Bore diameter ~ 75 cm
Isocenter depth ~125 cm



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