



Memorial Sloan Kettering  
Cancer Center

# Physics Opportunities in MR Imaging Research

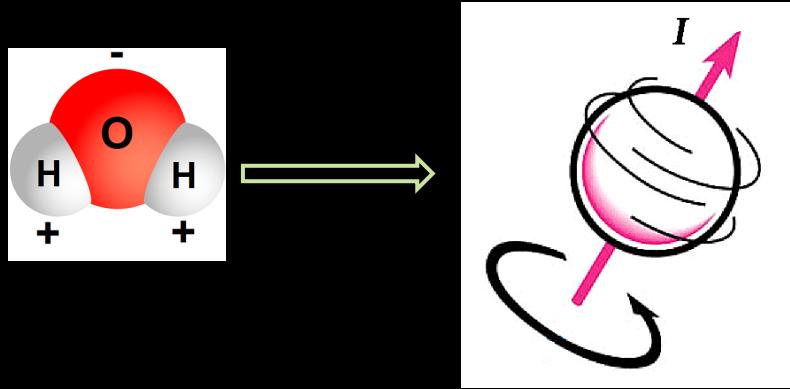
**Yale Physics Professional Development Organization**

**September 20, 2017**

**Kristen L. Zakian, Ph.D.**

**Associate Attending Physicist**

# Physics PhDs excel in MRI research



*It's all about spin (angular momentum)*





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# Postdoctoral Research Fellowships

- Abundant
- Will require biology/medical study in area of interest
- The more facets of MR Physics you learn, the better
- Project focus will influence career path

>> active areas of research

# MR Research

preclinical

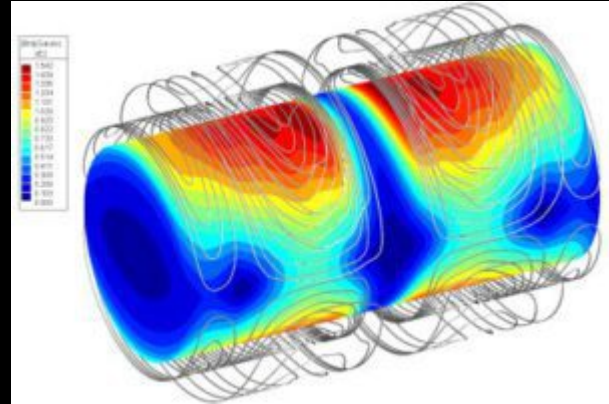
clinical



# Hardware



RF coils

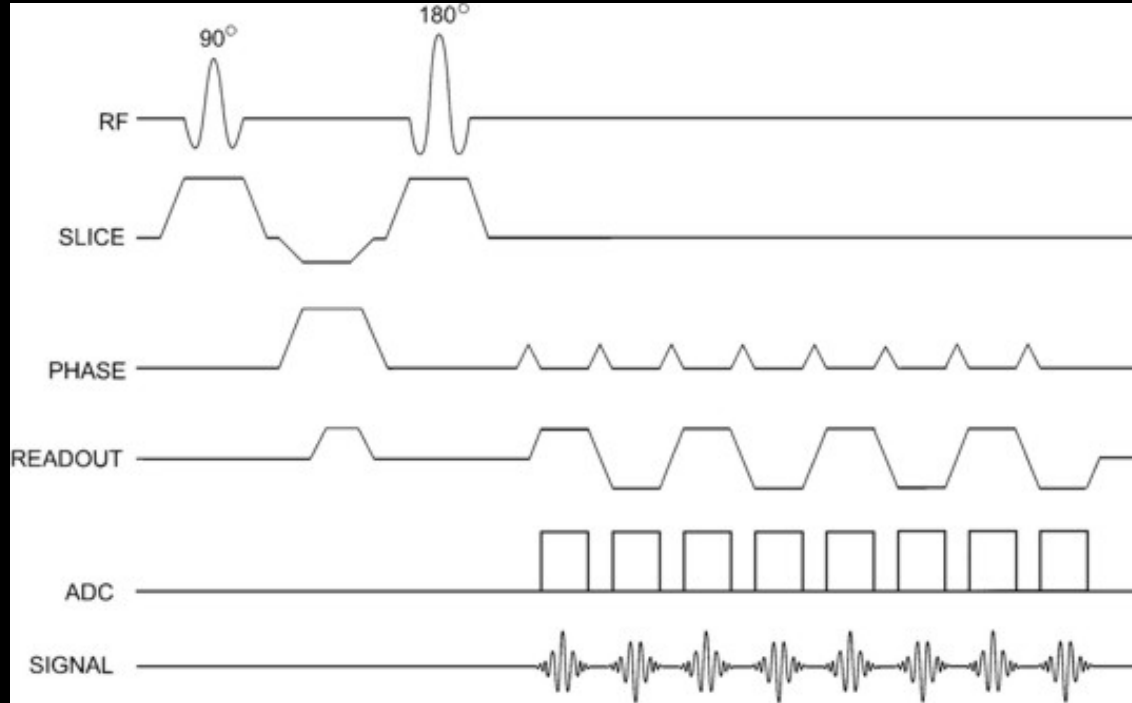


Gradient coils

Mainly preclinical and high-field human



# Acquisition Software: pulse programming

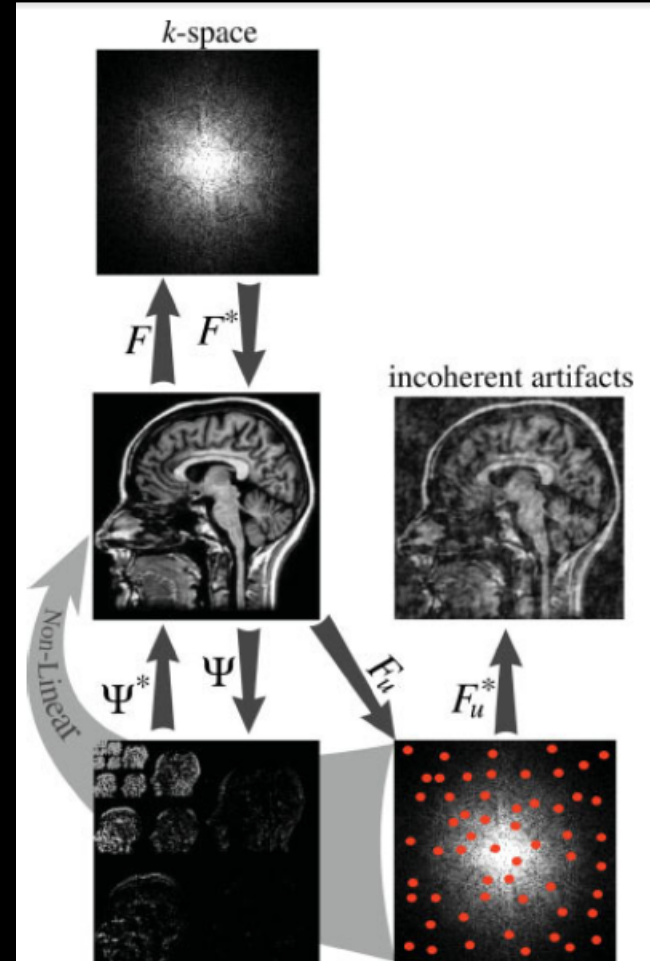


Preclinical and Clinical



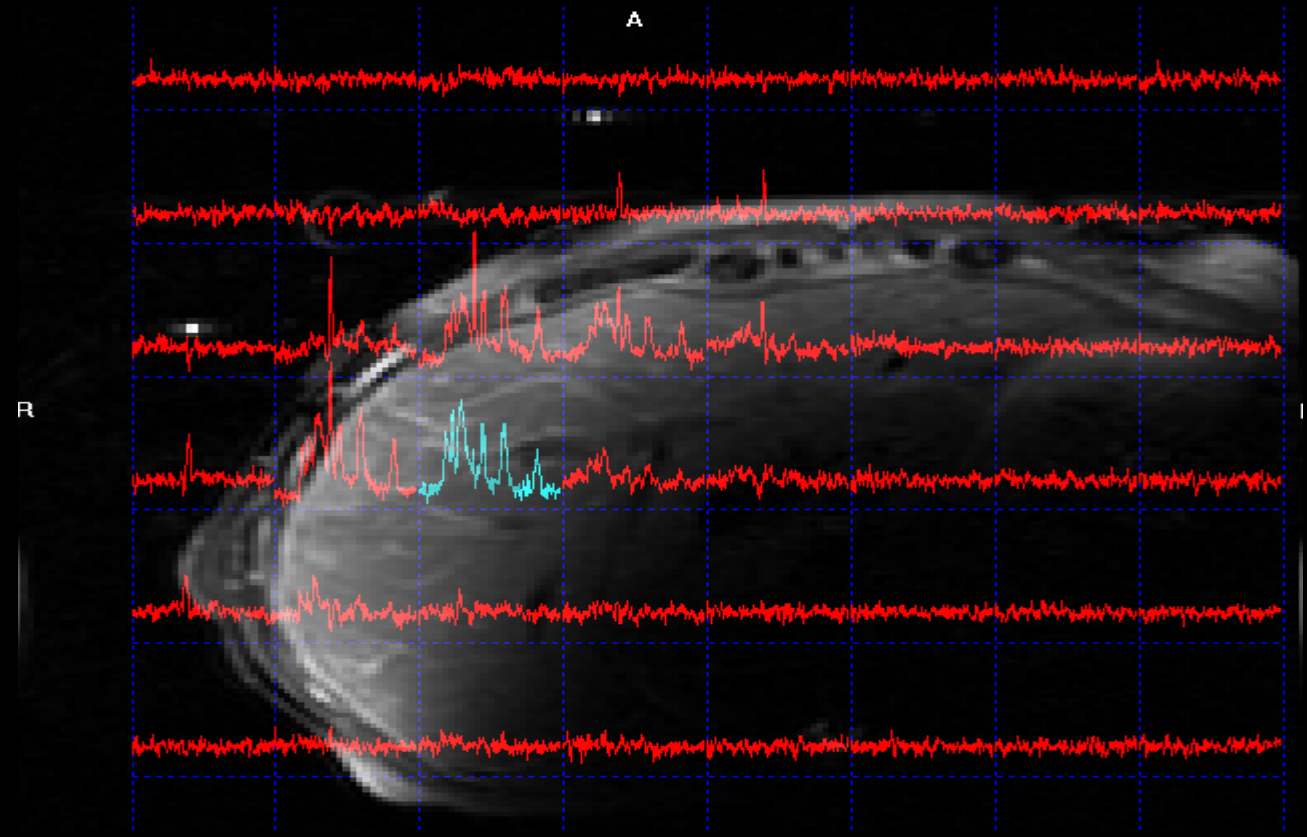
# Reconstruction Software Data Analysis and Modeling

*Lustig, et. al. Sparse MRI: The Application of Compressed Sensing for Rapid MR Imaging  
Magnetic Resonance in Medicine 58:1182–1195 (2007)*



# $^{31}\text{P}$ magnetic resonance spectroscopic imaging: human liver

*In vitro* and *in vivo*  
MR spectroscopy





# MR in Radiation Therapy



- Precision treatment planning: MR Simulator
- Real-time imaging and treatment (MR Linac)



# Career Paths:

- Clinical MRI has matured
- Grant funding is scarce
- Old model doesn't always work

Postdoc → faculty

- Certifications may give an edge



# Certifications/ Formal Recognition—

- ACR/AAPM Diagnostic board certification (includes all diagnostic imaging modalities)
- ACR MRI Physics Accreditation
- MR Safety Expert (MRSE) –new
- ACR Quality Assurance: not formalized but expertise in demand (scanner must be ACR certified for billing purposes)

*Residency may provide an edge*



# Thanks for your attention!



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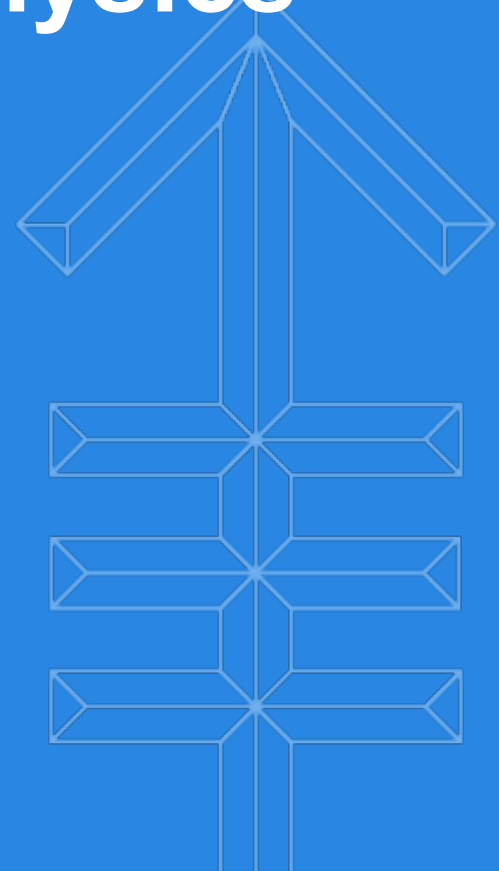


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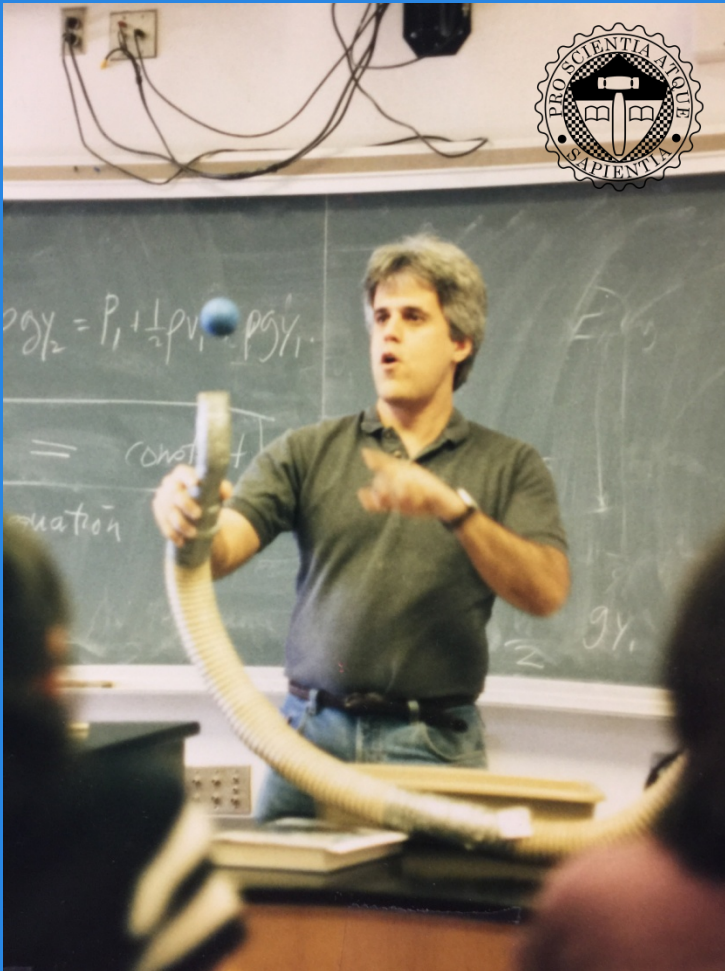
# Therapeutic Medical Physics

Jim Mechalakos  
Memorial Sloan-Kettering Cancer Center

September 20, 2017, Yale University



# 1994-1998



1994 PhD Columbia-  
High Energy Physics

1994-1998  
Teaching- Stuyvesant,  
CUNY

1997- took the MCAT

1998- answered an ad  
on AIP website from  
MSK

1998- postdoc research

CT guided radiotherapy of the prostate



Courtesy Michael  
Lovelock 6/20/2000



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# 2000- Clinical training

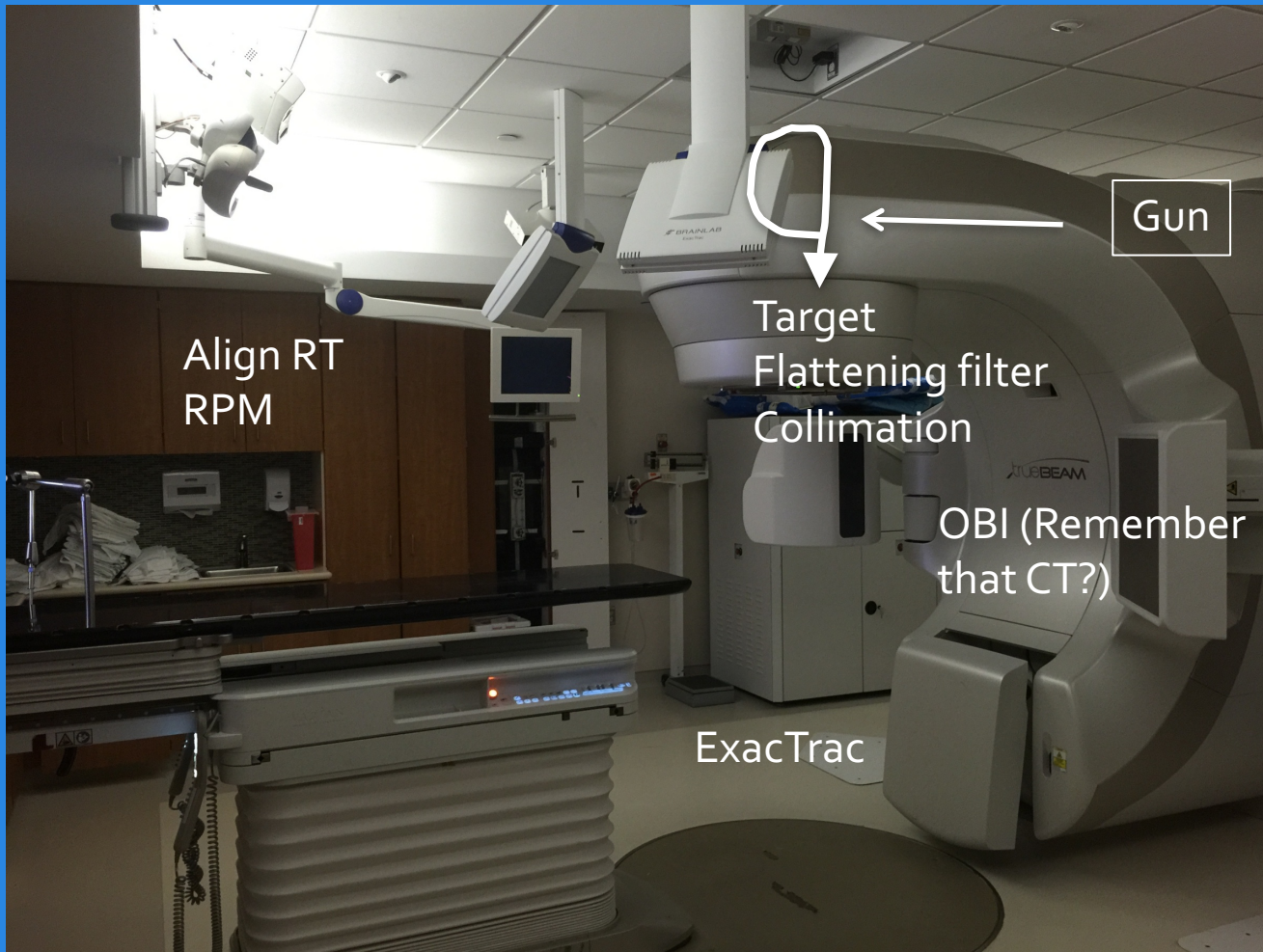
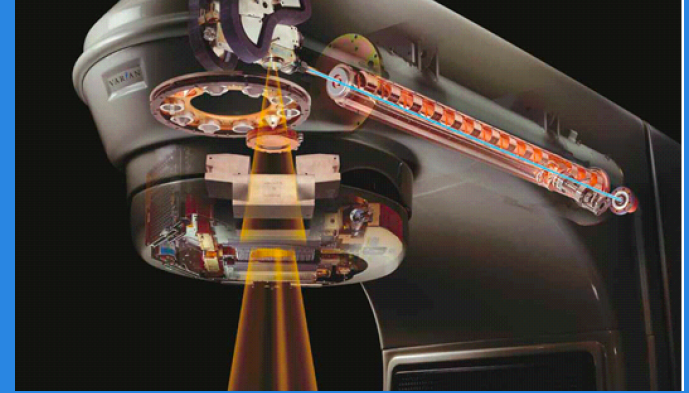
- Most medical physics careers have a clinical component
- Required to safely practice clinical medical physics, also required for licensure and certification
- Rotations
  - Radiation safety
  - Dosimetry/calibration
  - Treatment Planning
  - Brachytherapy



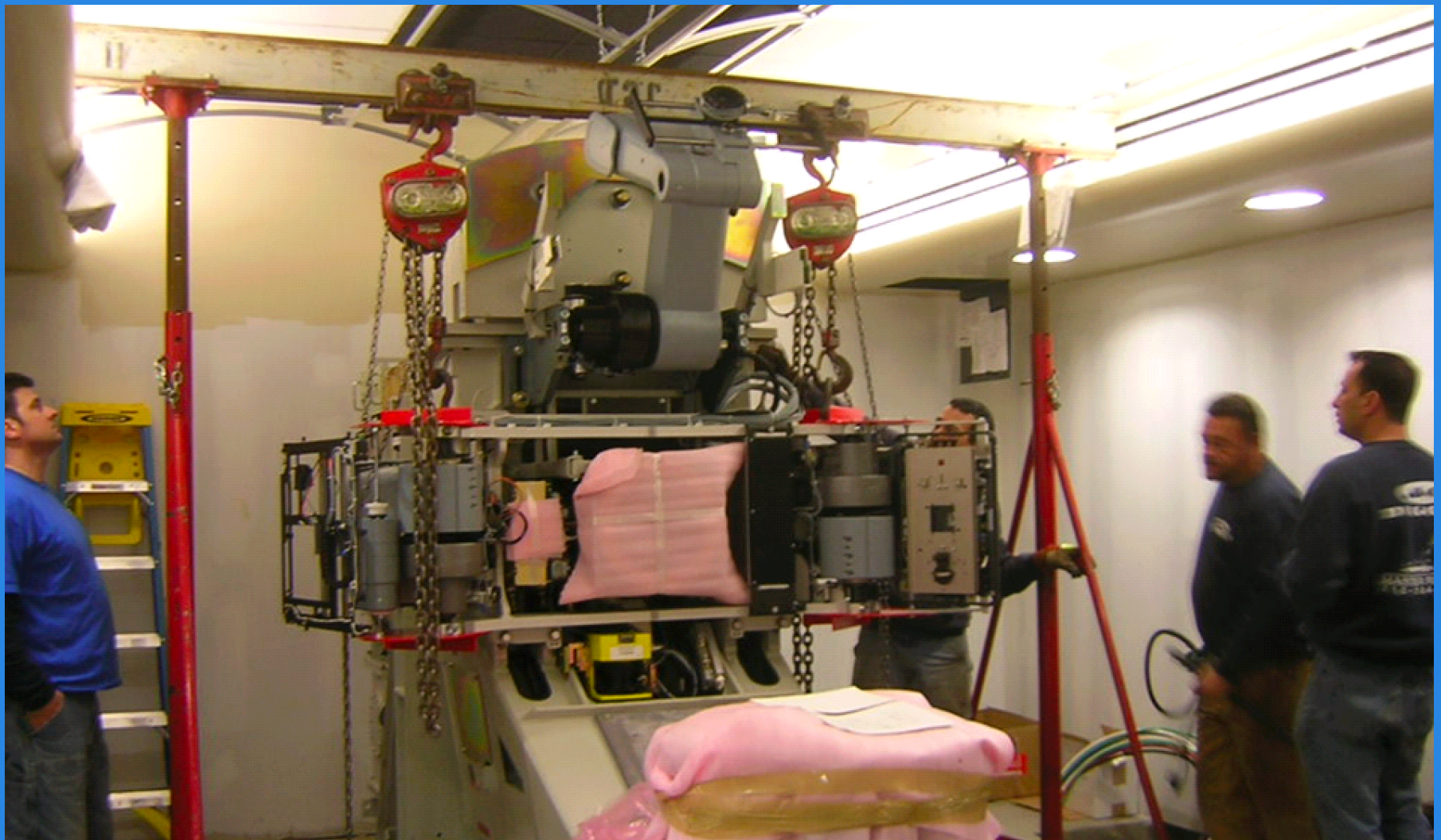


# Calibration and dosimetry

Machine QA  
Patient specific measurements



# Linac Installation



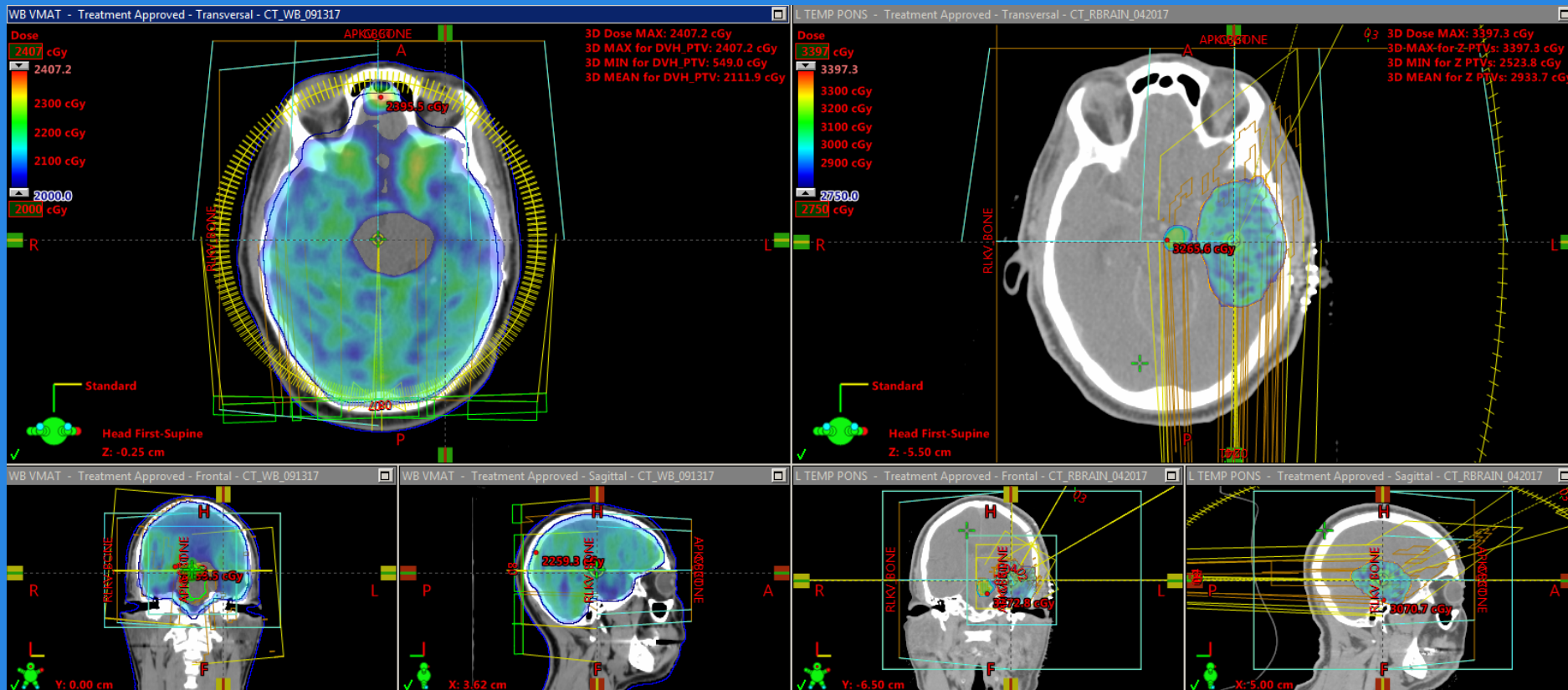
# Radiation safety

Shielding design, room surveys, patient education...



# Treatment Planning

Designing of treatment plans for external beam therapy  
Analysis of previous treatment  
CT, MR, PET imaging



Retreatment to the brain- rigidly fused previous treatment to compare irradiated areas



# Brachytherapy

Implantation of radioactive sources (HDR, LDR)



LDR (low dose rate)

Radiation oncologist Michael Zelefsky delivers brachytherapy — the placement of radioactive seeds into the prostate gland — with the assistance of an intraoperative CT unit called the O-Arm, which gives real-time snapshots of the prostate.

# 2001-today

- 2001- Joined MSKCC regional faculty in Dover-Denville, NJ
  - Full range of clinical work + research in organ motion and machine workload
- 2003- returned to Main Campus in Treatment Planning group as an Assistant Attending Physicist
  - Clinical Treatment Planning
  - Research in Head and Neck cancer, IGRT
- 2009- Became section head of Treatment Planning

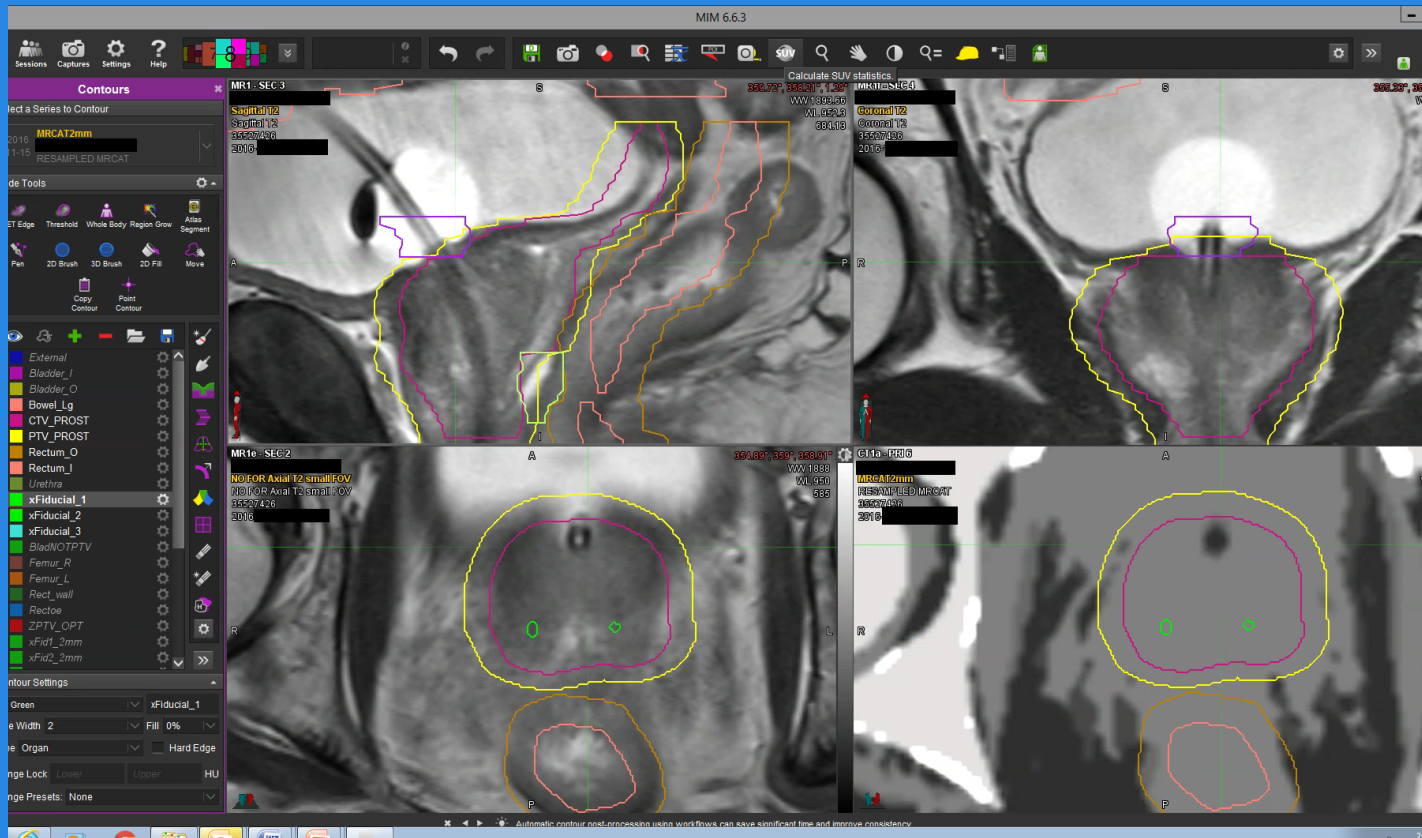


# 2001 until today

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# Research- Development – bringing new ideas into the clinic



Direct collaboration with MR physicists

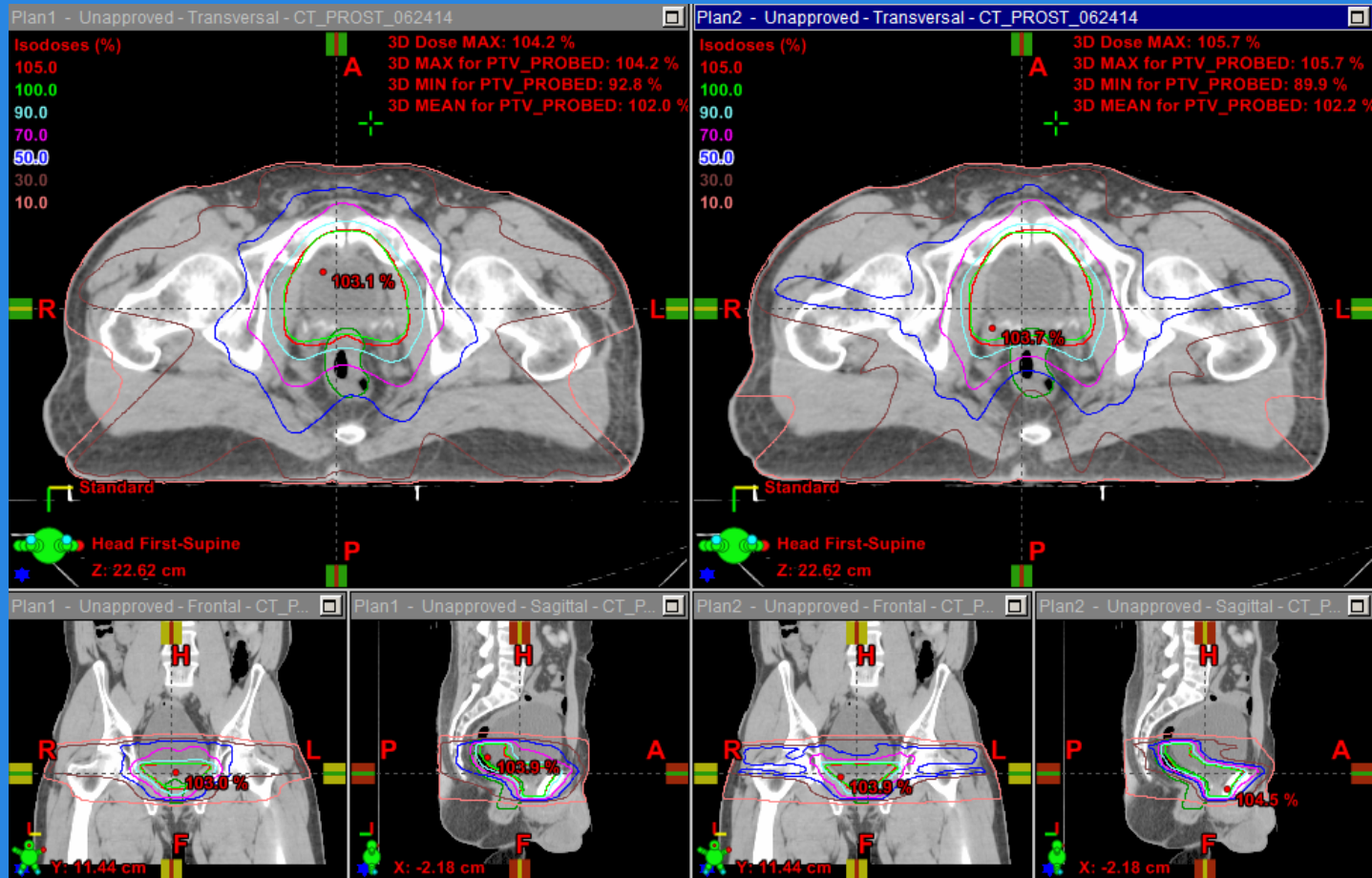
Creation of pseudo-CT's from MR scans for dose calculations



# ECHO- Expedited Constrained Hierarchical Optimization

Planner's Plan

ECHO Plan



A form of automated treatment planning that delivers superior intensity modulated plans.

# Software development- Automated Plan Check Tool- scripted QA

EclipsePlanCheck Version 13.2.1.0 Patient Id: [REDACTED] Name: [REDACTED] Course: [REDACTED] Plan: PROSTATE User: mechalaj

Select Body Site:  Default  Calc  VMAT Cranial  iPlan SRS

1 Reported Items for Manual Review 2 Naming Conventions and Demographics 3 Beams, optimization, and calculation 4 QA/Approvals/Aria

Item	St	Results	Notes
<input checked="" type="checkbox"/> Report Plan UID		Plan UID: 1.2.246.352.71.5.181627416654.2379412.20161206154014	
<input checked="" type="checkbox"/> Report gating status		Gating is set to "OFF" for clinical plan "PROSTATE"	

**Stage 2: Naming Conventions and Demographics**

Item	St	Results	Notes
<input checked="" type="checkbox"/> Naming Convention: Clinical Course		Automatic Checks passed	
<input checked="" type="checkbox"/> Verify non-clinical courses are completed		Automatic Checks passed	
<input checked="" type="checkbox"/> Check for invalid characters		Automatic Checks passed	

**Stage 3: Beams, optimization, and calculation**

Item	St	Results	Notes
<input checked="" type="checkbox"/> Report CT Overrides			
<input checked="" type="checkbox"/> Ensure Bolus HU=0		Automatic Checks passed	
<input checked="" type="checkbox"/> Appropriately used support structure		Automatic Checks passed	
<input checked="" type="checkbox"/> Report Isocenter (x,y,z)		Isocenter 1 ( 0.00, 0.00, 0.00 ) Automatic Checks passed	
<input checked="" type="checkbox"/> FFF beams used when appropriate.		Automatic Checks passed	
<input checked="" type="checkbox"/> Plan naming and VMAT normalization		Automatic Checks passed	
<input checked="" type="checkbox"/> Appropriate number control points		Automatic Checks passed	
<input checked="" type="checkbox"/> Correct LMC algorithm		Automatic Checks passed	
<input checked="" type="checkbox"/> LostMU x MaxMU for IMRT		Automatic Checks passed	
<input checked="" type="checkbox"/> Report VMAT duty cycle		Plan PROSTATE: Duty Cycle = 3.04	
<input checked="" type="checkbox"/> Verify calculation model and options		Automatic Checks passed	
<input checked="" type="checkbox"/> Alert unusual warnings		Automatic Checks passed	
<input checked="" type="checkbox"/> Bolus linked to fields		Automatic Checks passed	

**Stage 4: QA/Approvals/Aria**

Item	St	Results	Notes
<input checked="" type="checkbox"/> Confirm plan status		Reviewed by [REDACTED] 51 PM	
<input checked="" type="checkbox"/> Verify appropriate review approval		Plan Approved by oht on [REDACTED] 1:14 AM	
<input checked="" type="checkbox"/> Verify appropriate plan approval		Plan was approved by an unauthorized user [REDACTED] 11:14 AM	
<input checked="" type="checkbox"/> Show plan current status		Current Status: Plan Approved by [REDACTED] 11:14 AM	

- Mundane tasks that can be done by a computer are scripted.
- Ensures robust QA
- Allows for a higher level review of the plan

Courtesy S. Berry

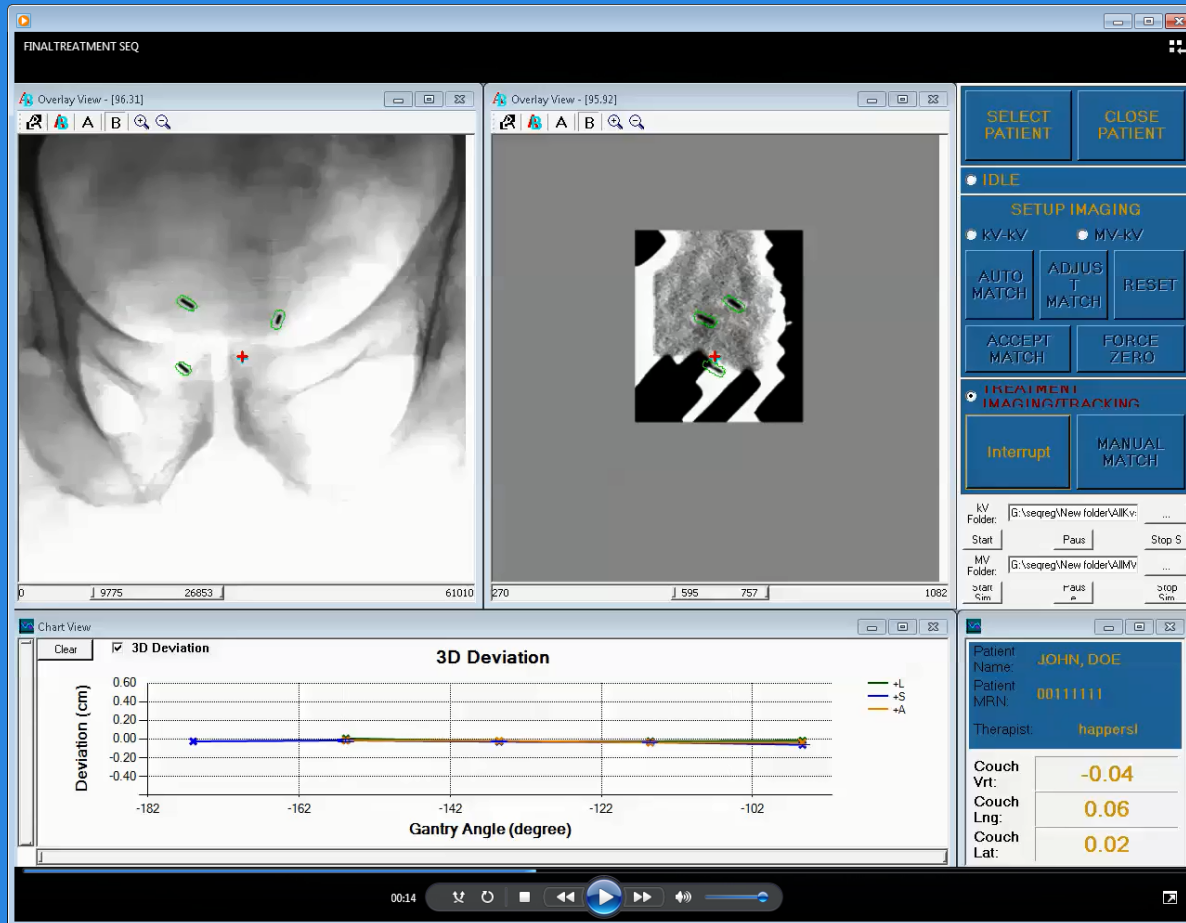
Sim → Contour → Optimize → QA → Treat



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# MV/kV imaging

Simultaneous MV and kV imaging during treatment with real time marker detection and shift determination



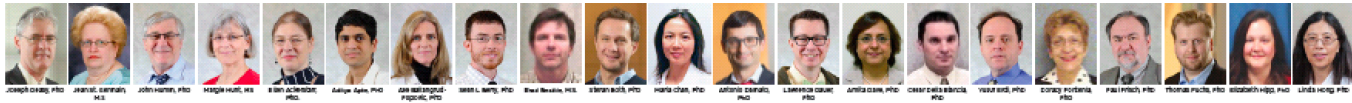
# Professional pathway in clinical medical physics

- CAMPEP accredited medical physics degree or certificate
- CAMPEP accredited residency
  - 2 years of clinical rotations
  - PhD's can do 2+2 (2 research/2 clinical)
- ABR certification
  - Part 1- general
  - Part 2- clinical medical physics
  - Part 3- oral exam
- Licensure



# DEPARTMENT OF MEDICAL PHYSICS

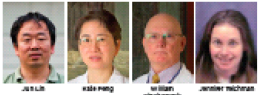
## FACULTY



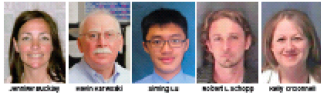
### DOSIMETRY QA



### BASKING RIDGE



### COMMACK



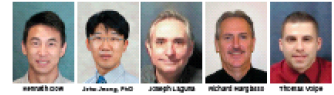
### MONMOUTH



### ROCKVILLE CENTRE



### WESTCHESTER



### LABORATORY STAFF



### BRACHYTHERAPY PHYSICS



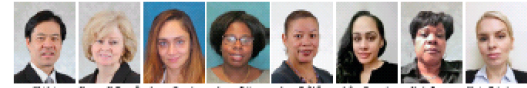
### PHYSICS COMPUTING



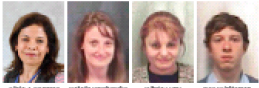
### PREDICTIVE INFORMATICS



### DEPARTMENTAL ADMINISTRATION



### MRI QA AND SPECTROSCOPY



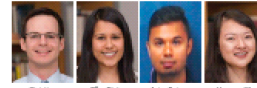
### IMAGING QA PHYSICS



### MOLECULAR IMAGING PHYSICS



### RSA



### EDITOR/WRITER



### EMERITUS FACULTY



### BIOMEDICAL ENGINEERING AND PHYSICS



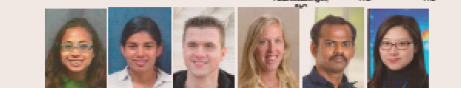
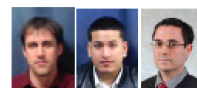
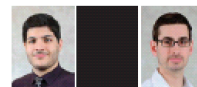
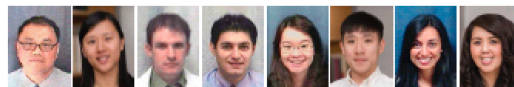
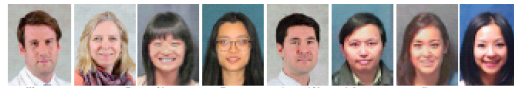
### CLINICAL PHYSICS — EXTERNAL BEAM TREATMENT PLANNING



### MEDICAL HEALTH PHYSICS



### RESIDENTS AND FELLOWS

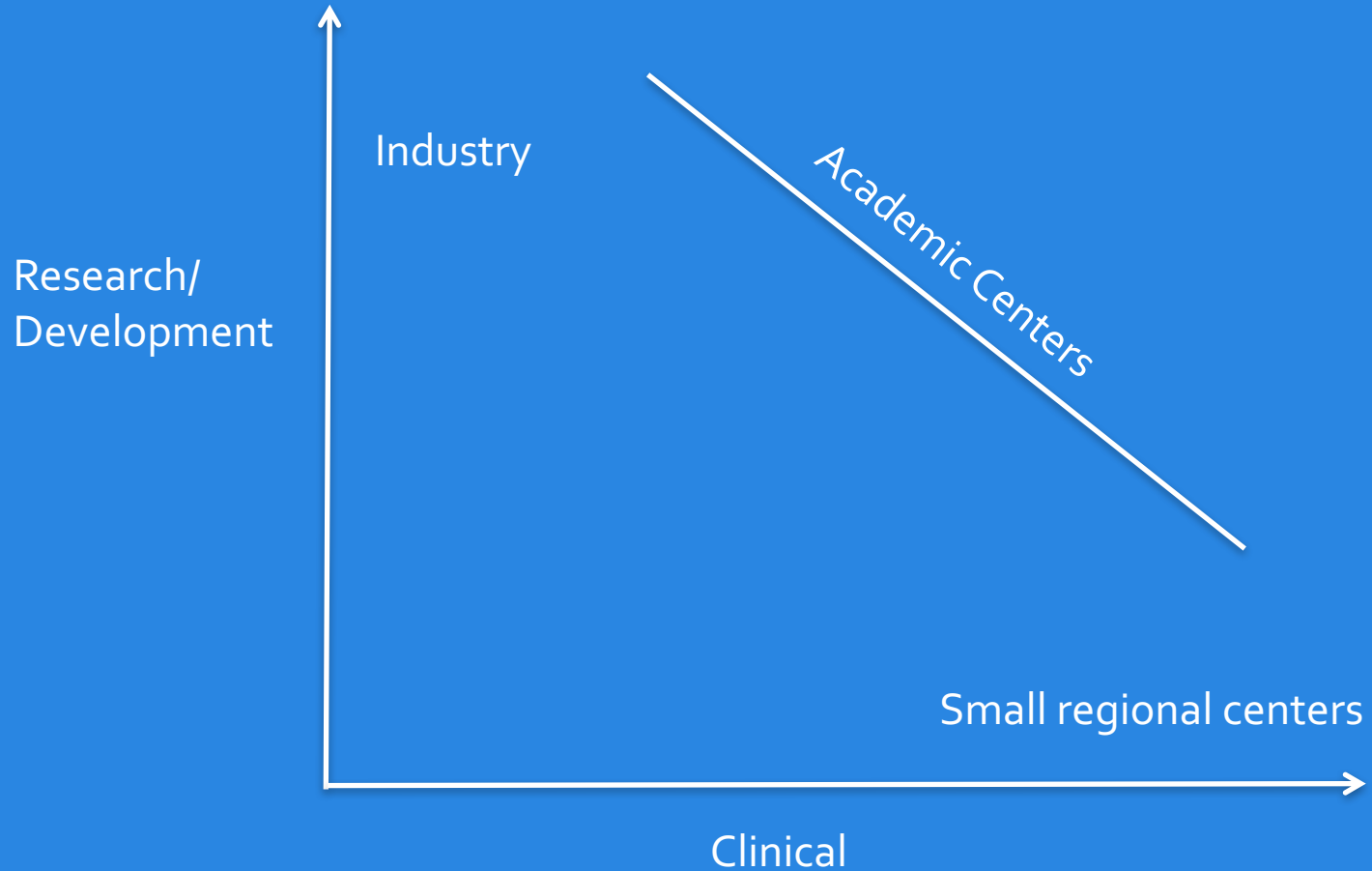


## Residents



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# Types of careers



# *Panel on Medical Physics at Yale*

*Ross Boltyanskiy*

*2017.09.20*

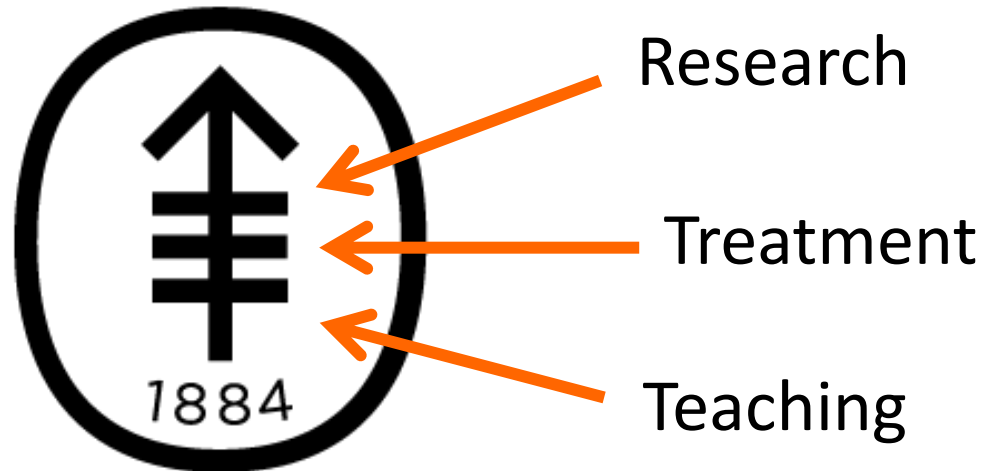


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# *Panel on Medical Physics at Yale*

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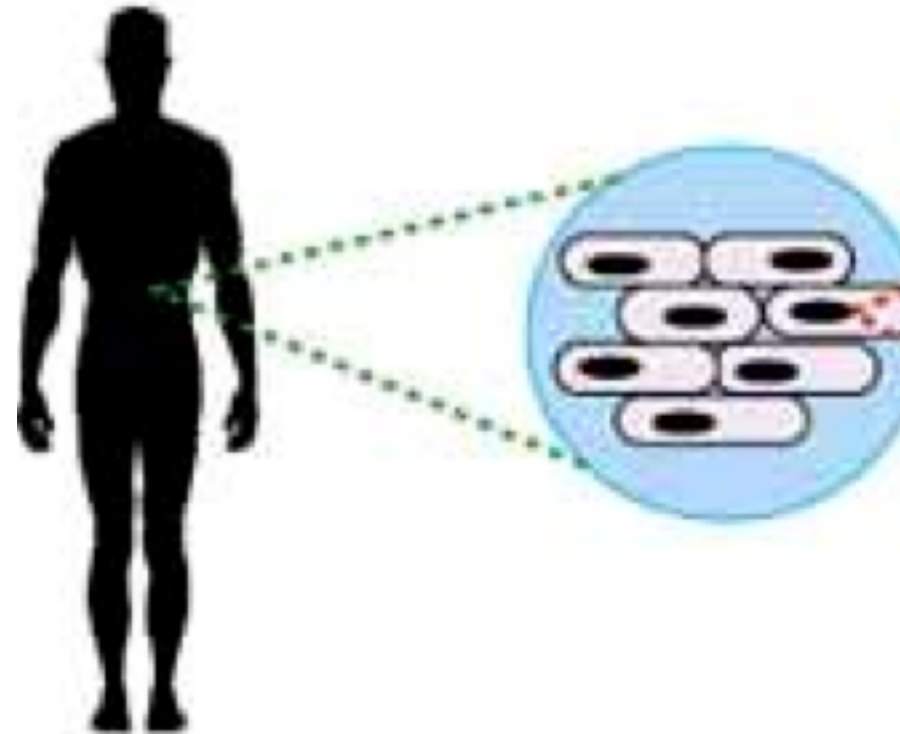
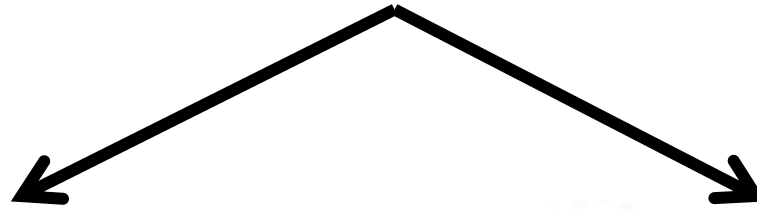


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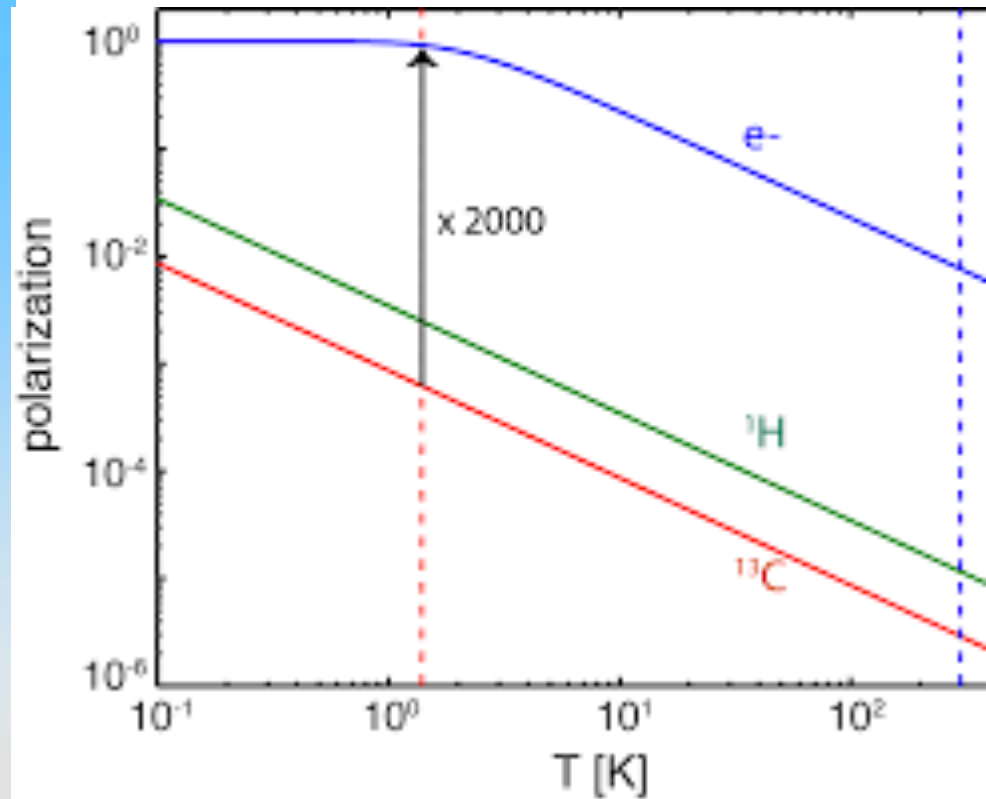
# *What am I doing at MSK?*

**Advancing MRI technology towards better diagnostic accuracy and higher resolution**



# Identifying high grade tumors based on metabolic activity

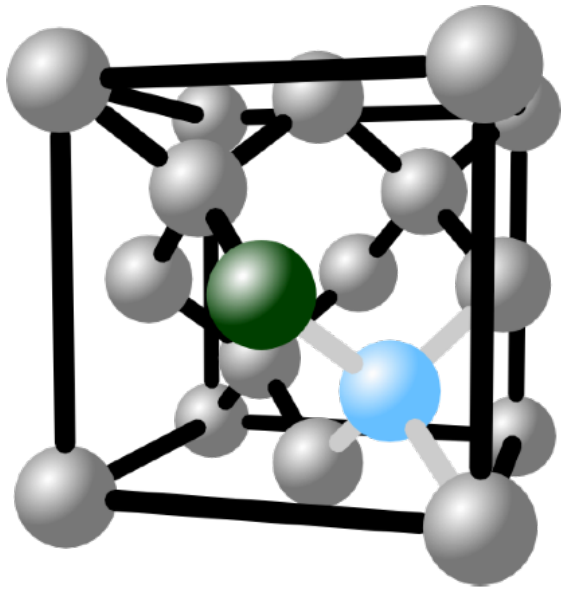
## Hyperpolarized pyruvate and lactate imaging in the human brain



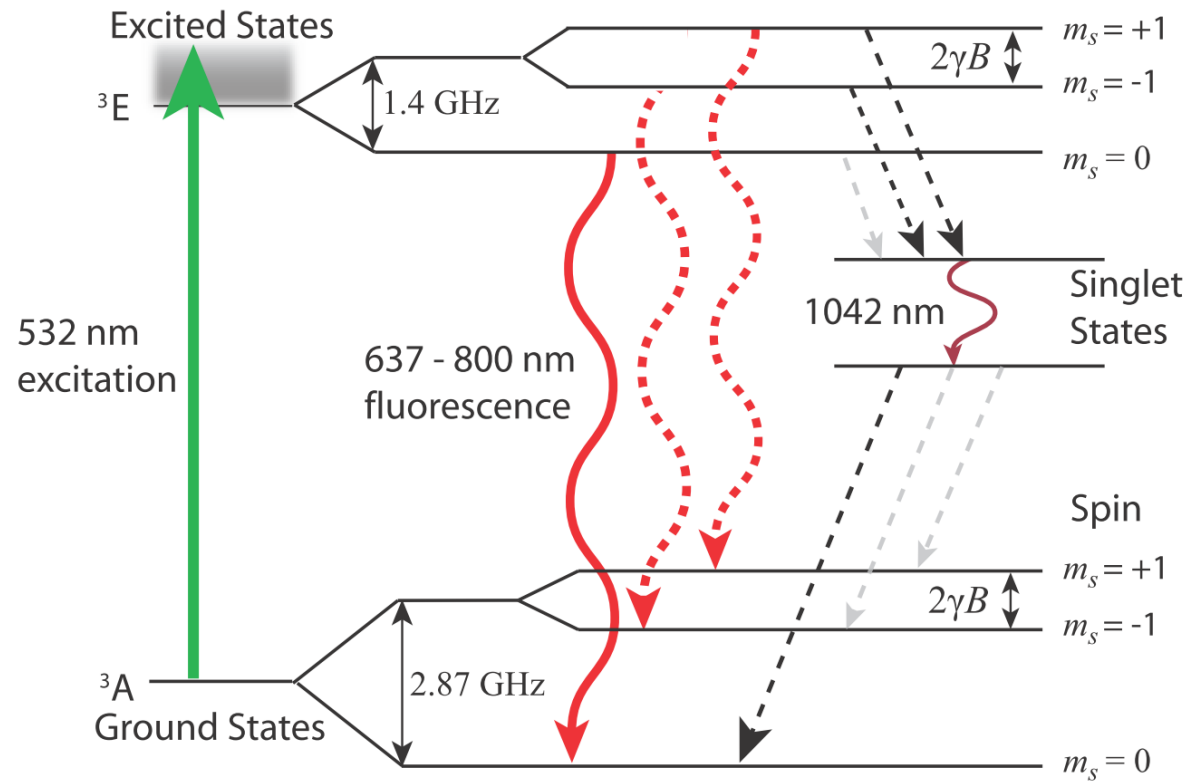
# Developing technology for ultra sensitive magnetic detection

## Convenient quantum optical properties

### Defect in a diamond

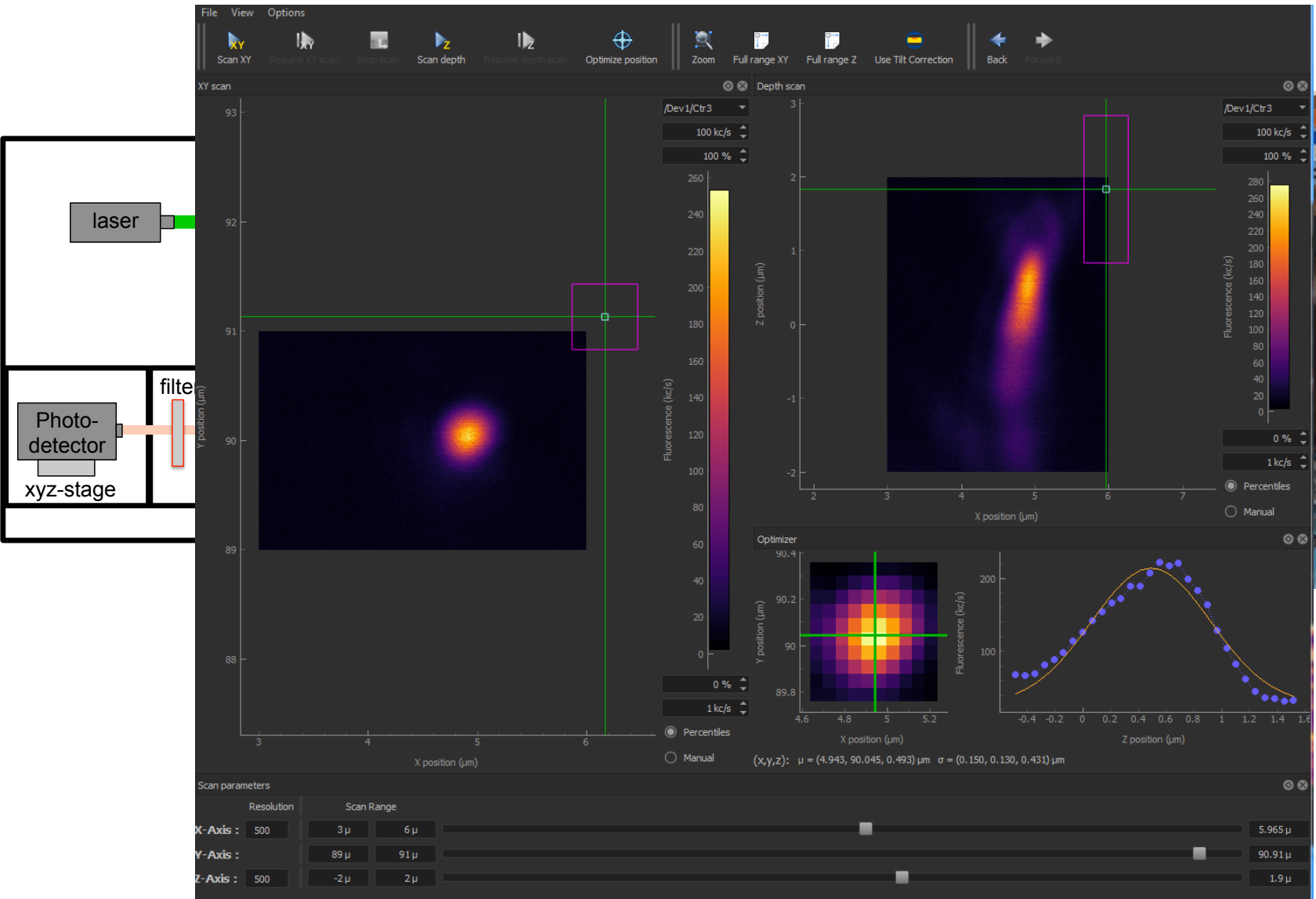


Kay Daniel Jahnke, Dissertation, 2012



Rainer Siegfried Pfeiffer, Dissertation, 2012

# Developing technology for ultra sensitive magnetic detection



# *Benefits & challenges of working at MSK and transitioning to a new (biomedical) field*

## **Challenges**

(1) For physicists and engineers the resources are more limited.

(2) Talks, conversations, collaborations more narrowly focused.

(3) Could be difficult to “break into” a new scientific community.

## **Benefits**

(1) Amazing resources aligned with the agenda of the institute

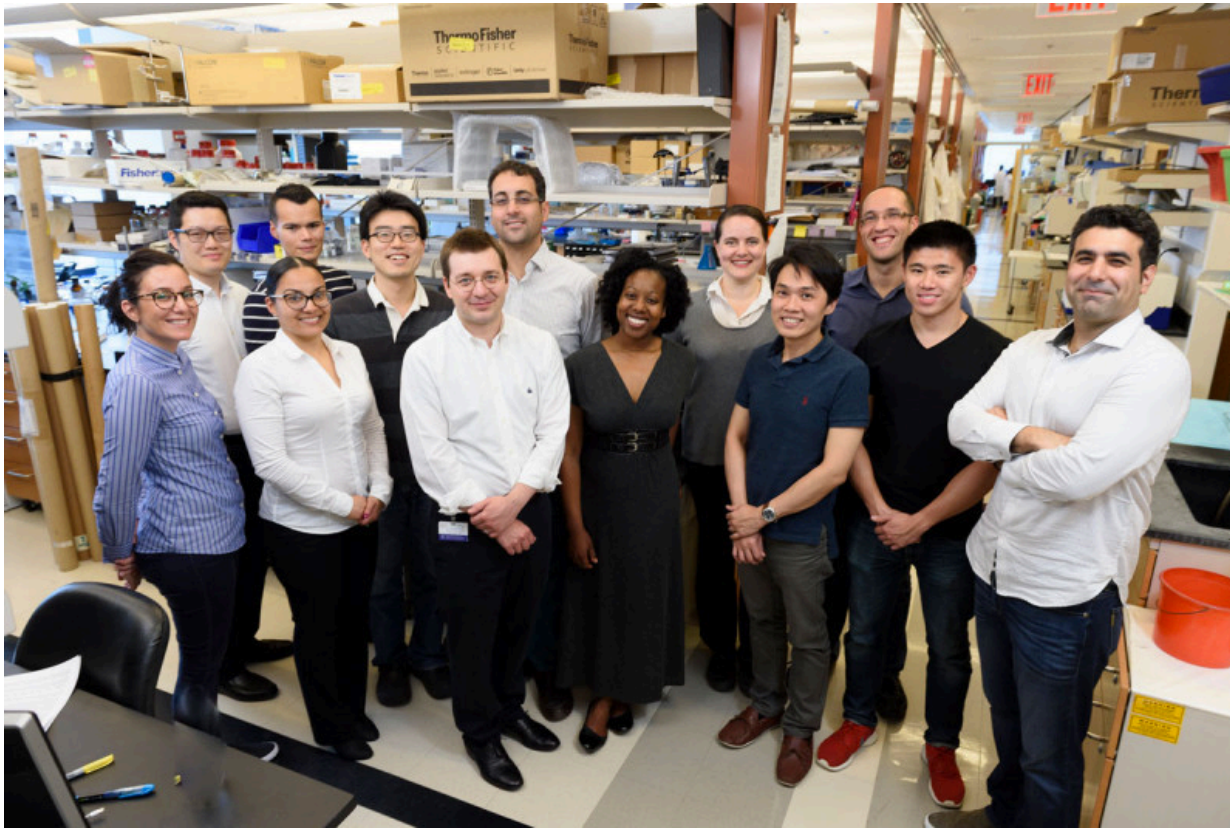
(2) Postdoc / Research staff time is valued tremendously

(3) Flexibility is similar to academia at least on the postdoc level

(4) Incredible opportunities to expand knowledge base

# *Questions and Following up*

**Ross Boltyanskiy**  
**rossbolt@gmail.com**



**Thank you!**