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)

http://mri-q.com/what-is-spin.html
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

Mainly preclinical and high-field human RF coils Gradient coils
Acquisition Software: pulse programming

Preclinical and Clinical

http://bitc.bme.emory.edu/seq_dia.html
Reconstruction Software
Data Analysis and Modeling

Lustig, et. al. Sparse MRI: The Application of Compressed Sensing for Rapid MR Imaging
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!
Therapeutic Medical Physics

Jim Mechakalos
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
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
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)

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.

https://www.mskcc.org/blog/treating-prostate-missile-delivery-high-dose-radiation
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

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

Courtesy L. Hong
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
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
Types of careers

- Clinical
- Research/Development

Industry

Academic Centers

Small regional centers

Clinical
Panel on Medical Physics at Yale

Ross Boltyanskiy
2017.09.20

Memorial Sloan Kettering Cancer Center
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


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

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<tr>
<th>Challenges</th>
<th>Benefits</th>
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<td>(1) For physicists and engineers the resources are more limited.</td>
<td>(1) Amazing resources aligned with the agenda of the institute</td>
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<td>(2) Talks, conversations, collaborations more narrowly focused.</td>
<td>(2) Postdoc / Research staff time is valued tremendously</td>
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<td>(3) Could be difficult to “break into” a new scientific community.</td>
<td>(3) Flexibility is similar to academia at least on the postdoc level</td>
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<td>(4) Incredible opportunities to expand knowledge base</td>
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Questions and Following up

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Thank you!