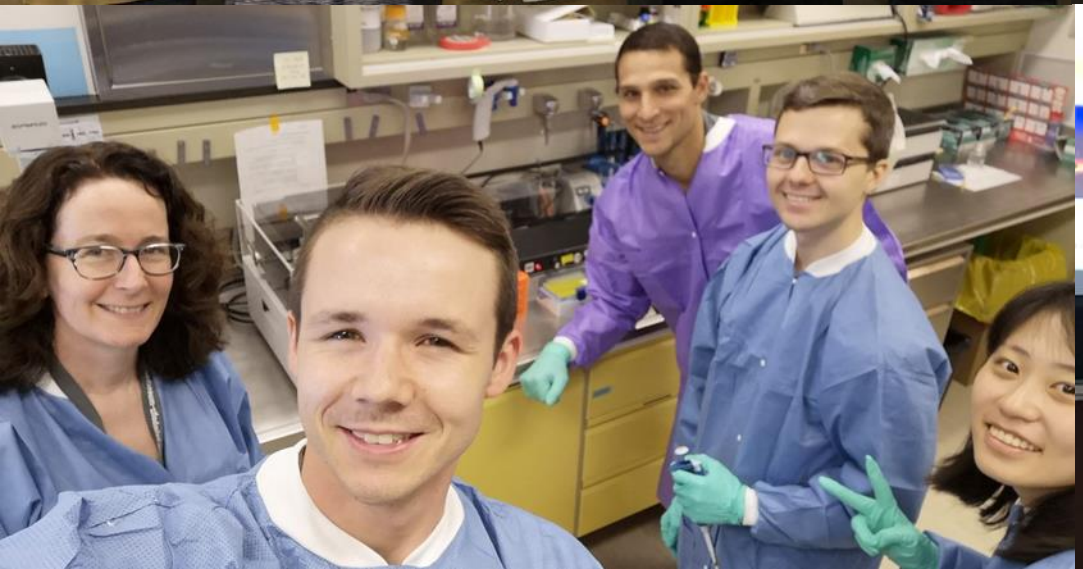
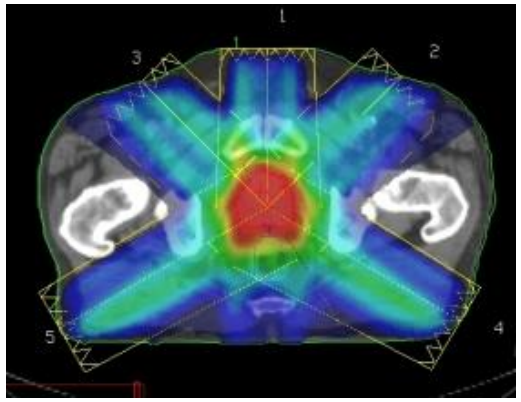
Carleton Medical Physics

@CarletonMedPhys



What is Medical Physics?

- The application of physics to improving the diagnosis and treatment of disease
- Four main specializations:

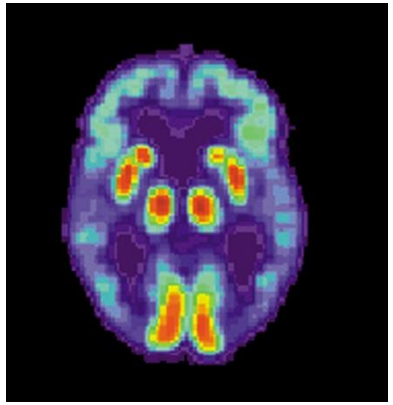


Radiation Therapy

Source: http://northdallasradiationoncology.com/wp-content/uploads/2010/04/Prostate-Planning-Photo.bmp

Medical Imaging

Source: Wikimedia commons



Nuclear Medicine

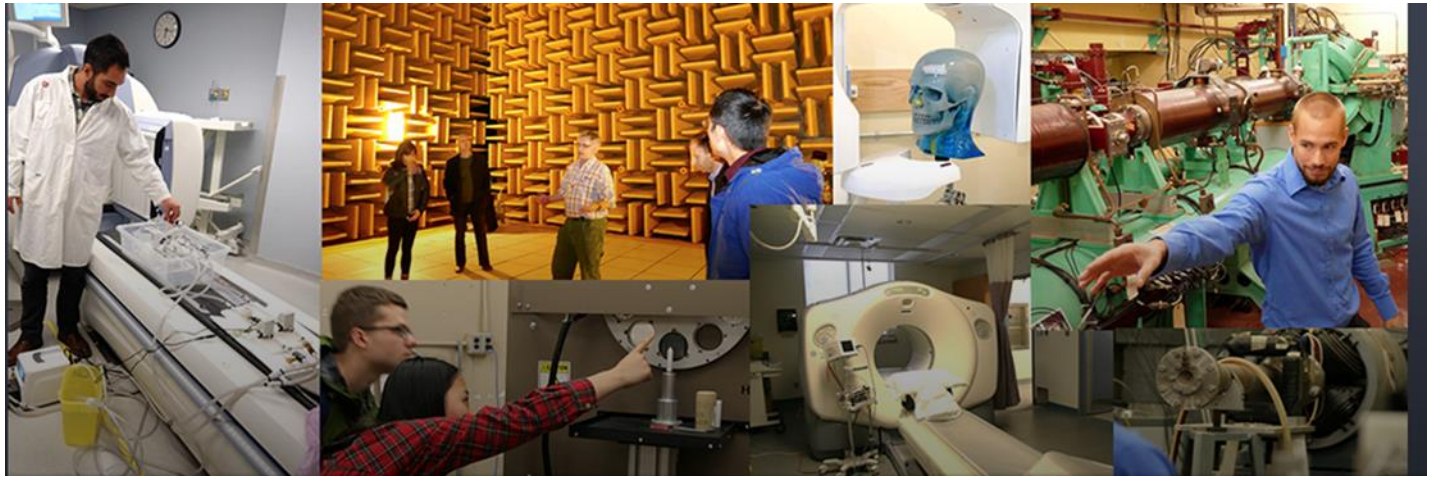
Health Physics

Medical Physics at Carleton University

physics.carleton.ca/ompi

Ottawa Medical Physics Institute

-Carleton Research Centre
-Home for the medical physics grad program
-30th anniversary of OMPI in 2019!



Ottawa Medical Physics Institute

- a Carleton Research Centre that encompasses ~40 medical physicists in the Ottawa area
- members supervise medical physics grad students working on a wide range of research topics
- hosts a monthly seminar series

Carleton UNIVERSITY
Canada's Capital University

Canadian Nuclear Laboratories
Laboratoires Nucléaires Canadiens

The Ottawa Hospital | L'Hôpital d'Ottawa
Inspired by research. Driven by compassion. Inspiré par la recherche. Guidé par la compassion.

Health Canada Santé Canada

Canadian Nuclear Safety Commission Commission canadienne de sûreté nucléaire

Natural Resources Canada Ressources naturelles Canada
Canada

NRC·CNRC

UNIVERSITY OF OTTAWA HEART INSTITUTE
INSTITUT DE CARDIOLOGIE DE L'UNIVERSITÉ D'OTTAWA

Recent thesis titles

- Spencer Manwell PhD – “Patient motion compensation in cardiac PET using radioactive fiducial markers” [Tong Xu, Ran Klein, Rob deKemp]
- Eric Christiansen PhD – “A framework for the robust delivery of respiratory-motion adaptive radiation therapy” [Emily Heath and Tong Xu]
- Alexandra Bourgouin PhD – “Determination of W_{air} value in high energy electron beams” [Malcolm McEwen]
- Nick Majtenyi PhD - "Improved Arterial Input Function For Dynamic Contrast-Enhanced Magnetic Resonance Imaging Using Phase and T1 Measurements" [Ian Cameron]
- Martin Martinov PhD - "Heterogeneous multiscale Monte Carlo models for radiation therapy using gold nanoparticles". [Rowan Thomson]
- Luke McCooeye MSc - "Dynamic model-based dose calculations of permanent implant prostate brachytherapy” [Emily Heath & Rowan Thomson]

Currently available grad student projects

Potential Graduate Study Supervisors

The following OMPI Members have openings in **2021** for M.Sc. or Ph.D. students. Click on their names for details on their research interests.

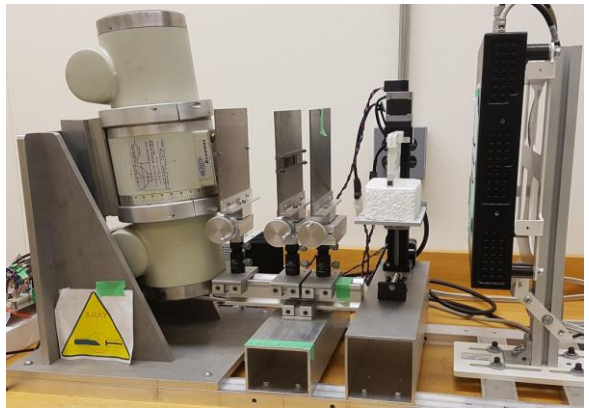
For general information on the medical physics program, contact the **OMPI Assistant Academic Officer**.

Imaging

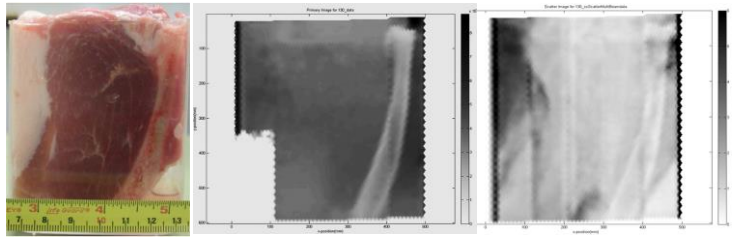
- **Rob deKemp**
  - Cardiac PET-CT blood flow quantification
  - Kinetic modeling for sympathetic innervation tracers
  - Cardiac PET-MR attenuation correction
  - Deep learning for diagnostic image interpretation
- **Paul Johns**
  - x-ray scatter imaging
  - x-ray tube focal spot assessment
- **Gerd Melkus**
  - Development of quantitative Magnetic Resonance Imaging methods to characterize cartilage, bone and muscle
  - Magnetic resonance based attenuation and motion correction for pelvis/hip Positron Emission Tomography (PET-MRI)
- **Sangeeta Murugkar**
  - Development of biofluid Raman spectroscopy and machine learning for early cancer screening
  - Development of micro-dosimetry system based on Raman micro-spectroscopy technique

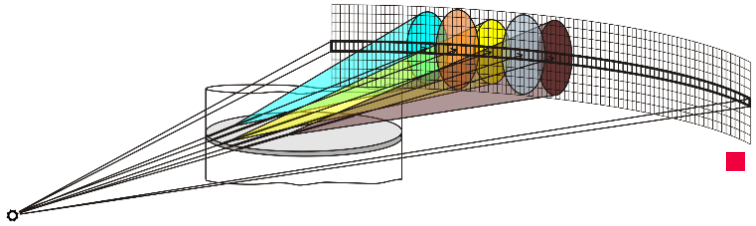
physics.carleton.ca/ompi/graduate-studies/potential-supervisors

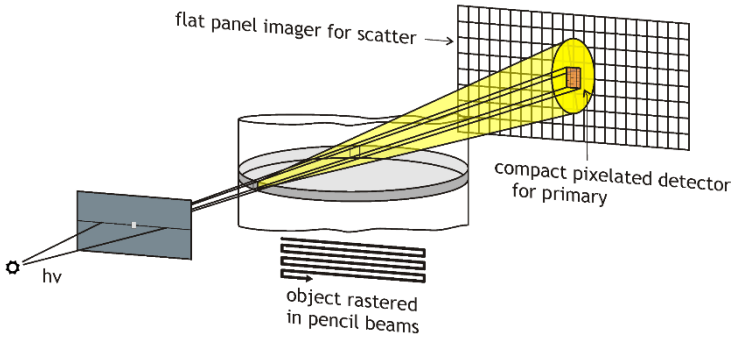
More details about some projects…



Paul Johns - X-Ray Imaging Lab







- Use scattered x rays rather than transmitted x rays
- The dependence of **forward x-ray scatter** on Z (atomic number) and chemical structure makes it very useful in distinguishing tissues within a patient and in applications outside medicine.
  - **development work at Canada's synchrotron (CLS)**
  - **system configured in our x-ray lab in Herzberg**
  - **next: hybrid system with compact detector for primary**
- Other interests:
  - **dual-energy radiography**
  - **x-ray tube focal spot assessment**

- projects are experimental and theoretical/computational

Recent publ: Dydula, Belev, & Johns Rev. Sci. Instr. 90 (2019)
Dydula, Xu, & Johns SPIE 11404 (2020)

LLAMPE

Associate Professor of Physics

Ph.D. (U.Michigan, Ann Arbor)

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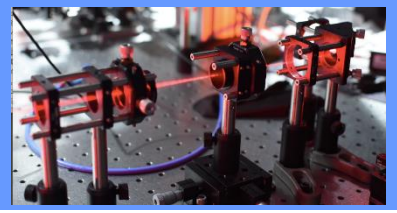
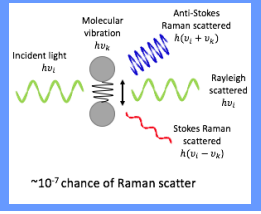
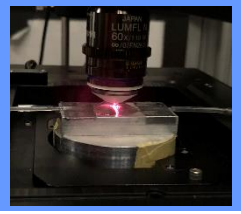
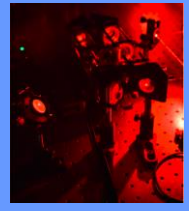
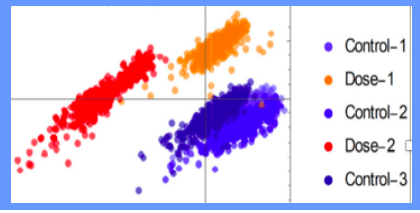










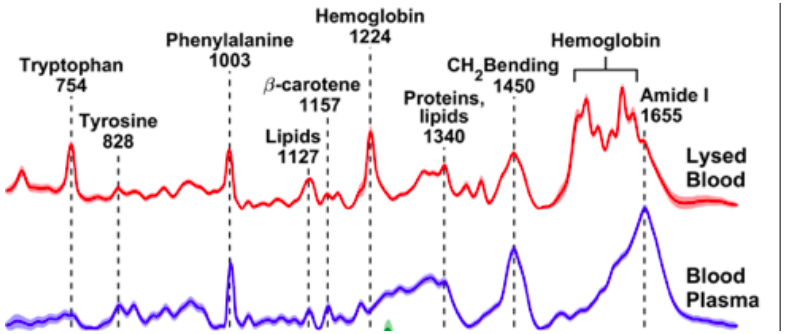
Laboratory for Laser Assisted Medical Physics and Engineering

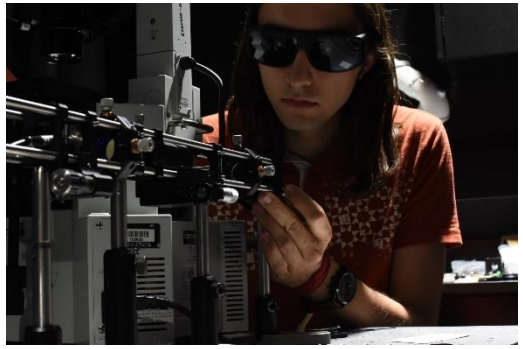
I) Raman spectroscopy: Using near-infrared laser interaction with vibrating molecules to get a "**chemical fingerprint**" of the material

Project: **Liquid Biopsy**

Develop Raman spectroscopy technique & analyze using machine learning methods

Application: Early detection of cancer and recurrence (ovarian/brain)





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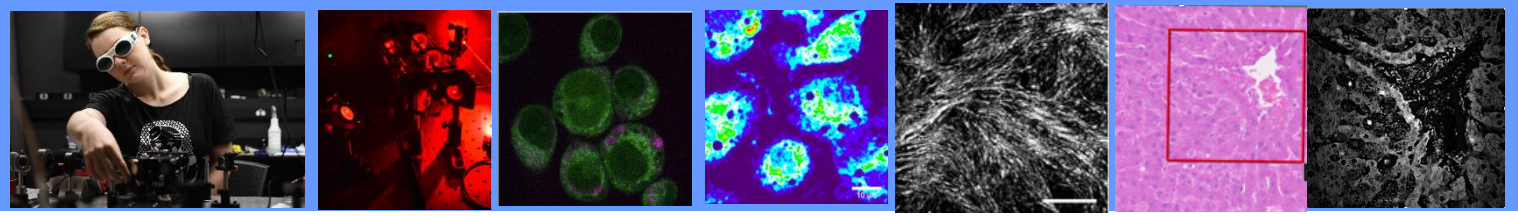


Laboratory for Laser Assisted Medical Physics and Engineering

Associate Professor of Physics

Ph.D. (U.Michigan, Ann Arbor)

sangeeta.murugkar@carleton.ca

biophotonics-lab.physics.carleton.ca/~smurugkar/

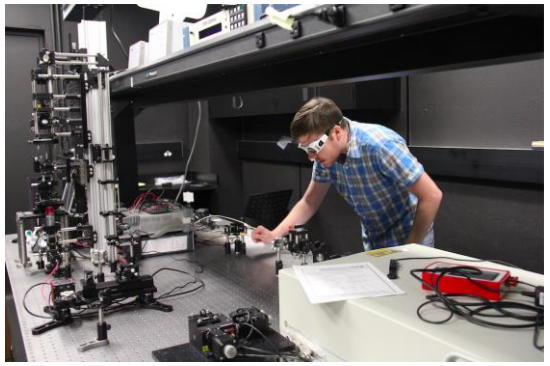
II) Nonlinear Optical Imaging: Using near-infrared **femtosecond pulse** lasers to generate molecular images without using external contrast agents

Project: **Optical Biopsy**

Develop ultrafast imaging technique and analysis using machine learning methods

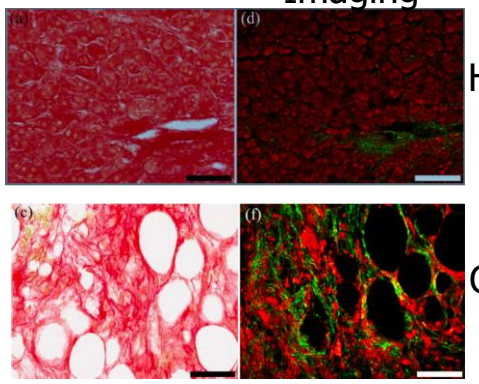
Application: Rapid non-invasive detection of cancer margin

Bench-top



Pathology

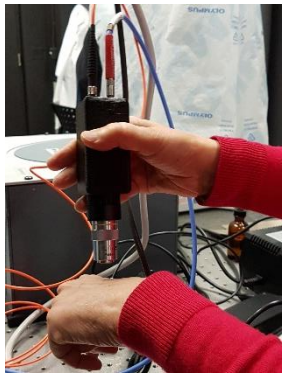
Nonlinear Optical Imaging



Healthy

Cancer

Hand-held

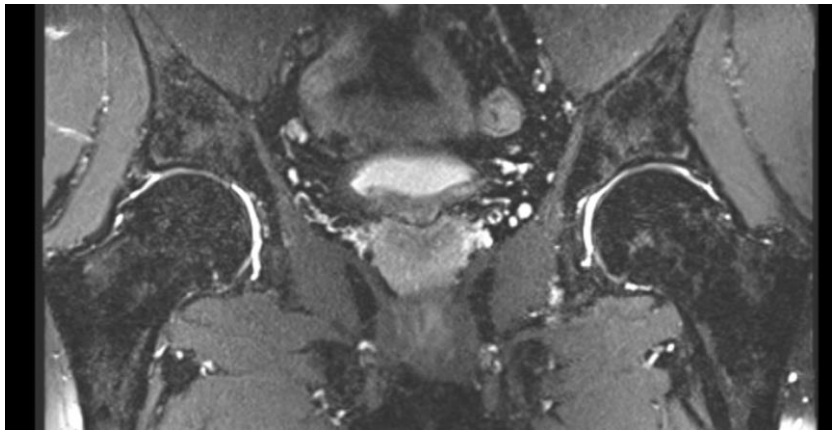


PET-MRI for Osteoarthritis (OA) Research

Background: Osteoarthritis (OA) Research

→Osteoarthritis affects Cartilage and Bones

→PET-MRI is an excellent tool for investigation of Bone (PET) and Cartilage (MRI)

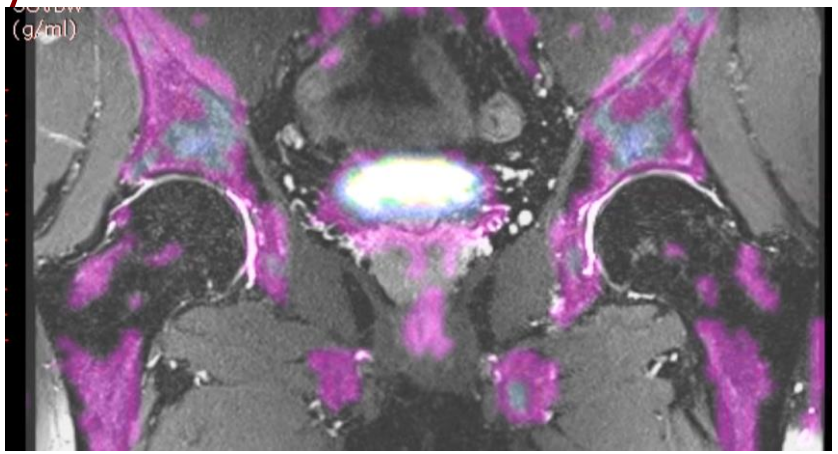


MRI for cartilage evaluation

Goals/ Outcomes:

→Understanding the OA process *in vivo* (patients)

→Establish a Biomarker/Predictor for early OA and changes to Therapy



^{19}F NaF PET of the hip bone as overlay

PhD position: Improving PET-MRI techniques for OA research

We are working on:

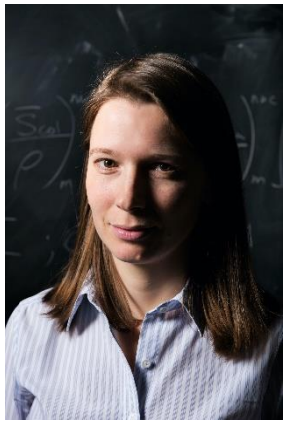
- Improving the Attenuation Map for PET based on MRI
- Reducing the scan time for dynamic PET acquisitions
- Accelerating MRI cartilage imaging

Contact: Dr. Gerd Melkus, Email: **gmelkus@toh.ca**

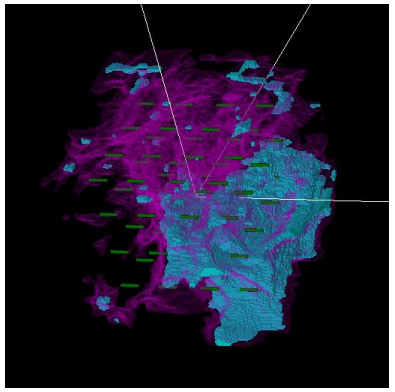
Dr. Tong Xu - Motion Compensation for PET/MRI

Project goal: Integrate positron emission motion tracking (PeTrack) with a PET/MRI scanner to provide patient motion compensation and improve imaging quality.

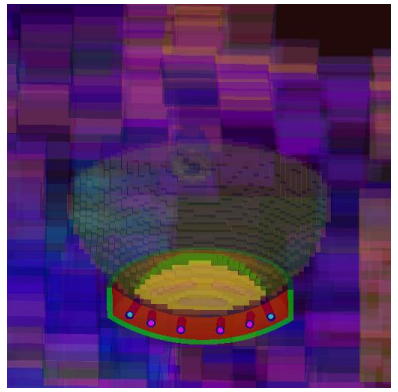
Prof. Rowan Thomson: Brachytherapy projects



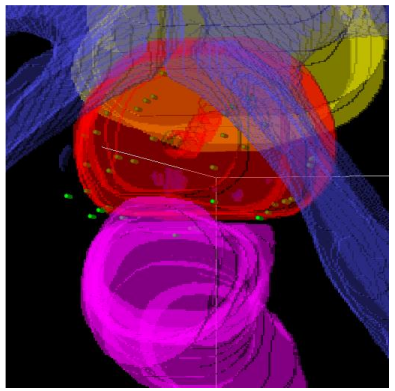
- Ongoing development and applications of egs_brachy, a fast and comprehensive Monte Carlo code for brachytherapy.
- Initiating cross-Canada collaboration (CIHR Project Grant) on breast and prostate brachytherapy treatments.
- Use egs_brachy for treatment evaluation, radiobiological modelling. Implement egs_brachy for treatment planning.



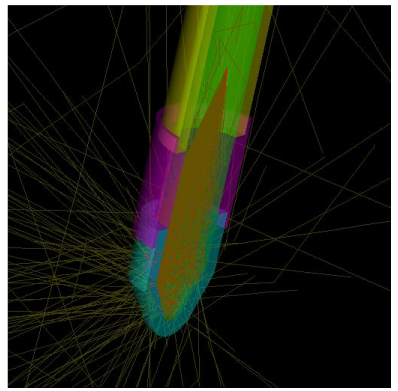
^{103}Pd breast implant



^{125}I eye plaque



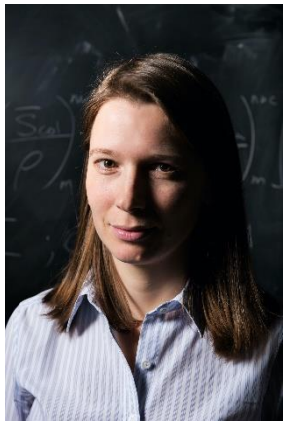
^{125}I prostate implant



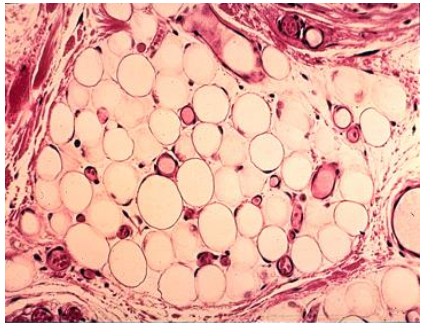
Electronic brachytherapy

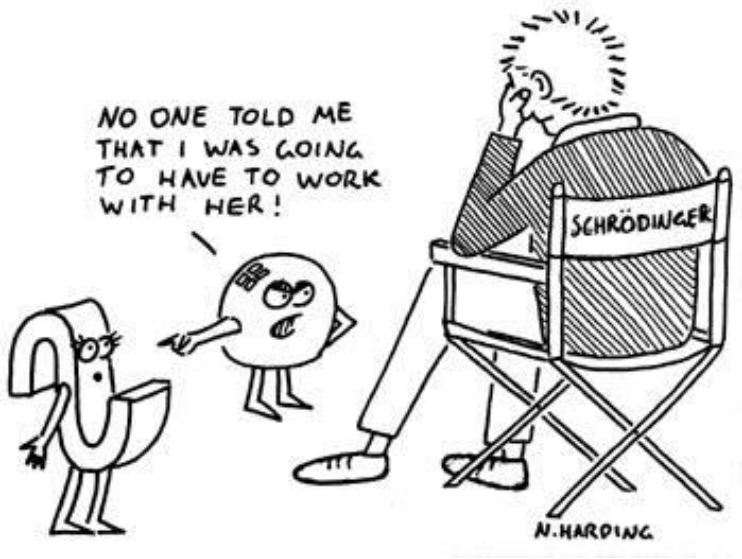
Rowan.Thomson@Carleton.ca

Prof. Rowan Thomson: Cellular dosimetry projects



- Radiation interactions and energy deposition on cellular level
- Connections with experimental measurements of biological response
- Radiation therapy using nanodevices
- Fundamental limits of Monte Carlo simulations at short length scales (interactions of radiation with DNA) – electrons as waves

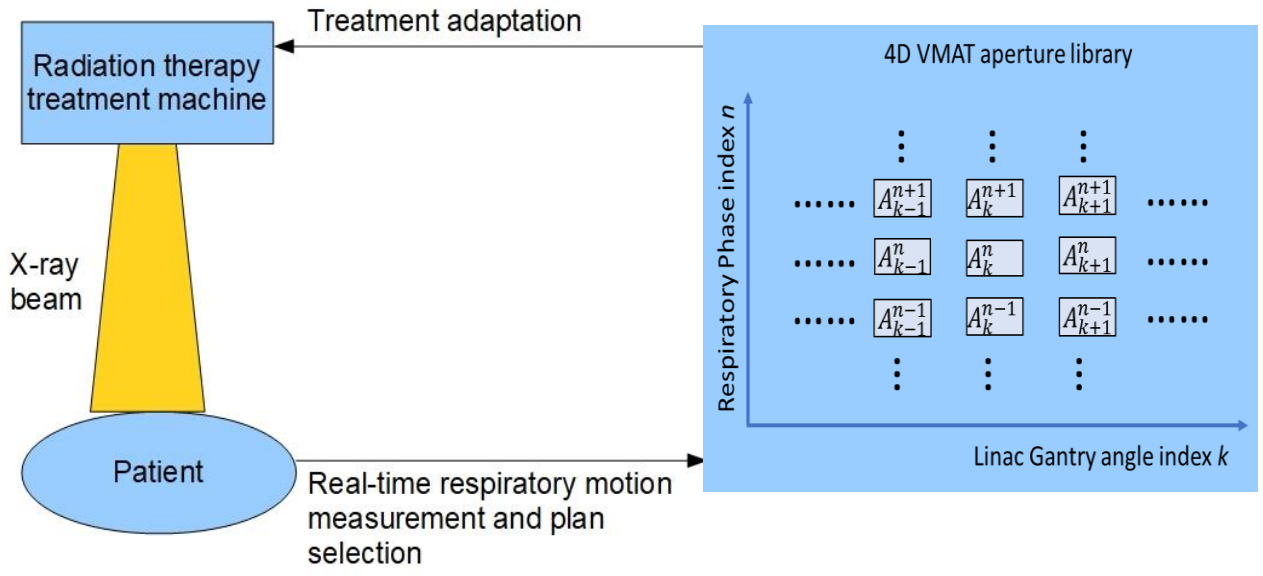




Rowan.Thomson@Carleton.ca

Experimental verification of 4D VMAT delivery (Dr. Emily Heath and Dr. Tong Xu)

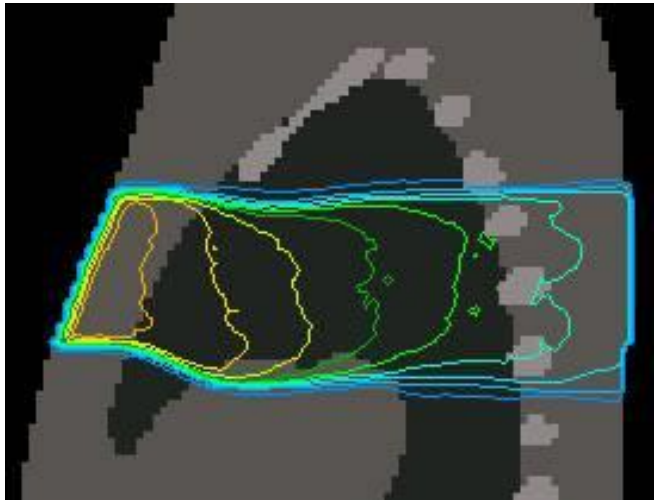
Project goal: Integrate, evaluate, and improve a previously developed motion-adapted delivery approach using PeTrack system on a research Linac at NRC. To improve delivery accuracy of radiotherapy

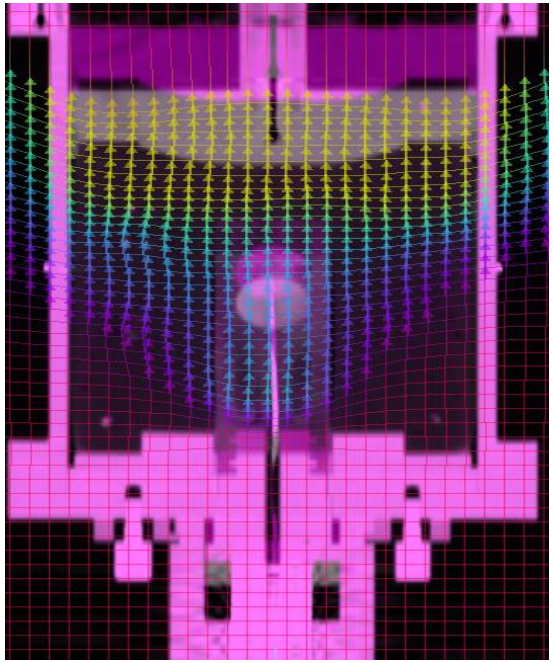


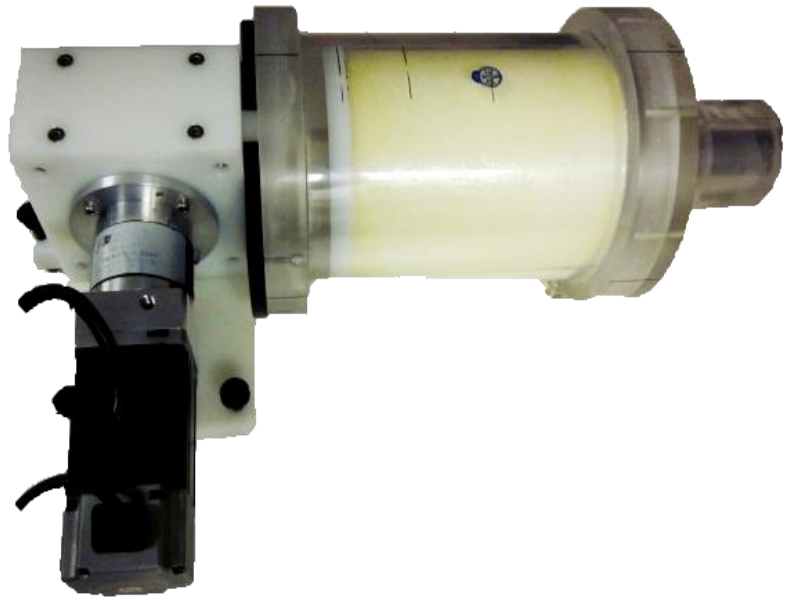
PeTrack system
Installed at NRC

Dr. Emily Heath - 4D patient dose reconstruction

- Develop patient-specific 3D motion models from surface motion measurements and imaging during radiotherapy treatments
- Modeling impact of respiratory motion on different types of radiotherapy treatments (Cyberknife)







Degree programs

1) MSc in Medical Physics

2) Combined MSc in Medical Physics and Data Science

3) PhD in Medical Physics (CAMPEP-accredited)

4) MASc and PhD in Biomedical Engineering (see www.ocibme.ca)

CAMPEP www.campep.org
Commission on Accreditation of Medical Physics Education Programs, Inc.

Course requirements

1) MSc
   - 5 half-term courses
   - MSc thesis

2) PhD
   - At least 4 half-term courses (requires completion of all 6 CAMPEP-required courses)
   - PhD thesis

Graduate courses in Medical Physics

- Computational Physics
- Medical Radiation Physics
- Physics of Medical Imaging
- Medical Radiotherapy Physics
- Radiobiology
- Radiation Protection
- Medical Physics Practical Measurements
- Anatomy and Physiology for Medical Physicists

https://physics.carleton.ca/ompi/graduate-studies/medical-physics-courses

Info for students

- Grad: physics.carleton.ca/ompi/graduate-studies
  - How to apply
  - Financial aid
  - Medical physics courses
  - Potential supervisors
  - Careers in medical physics
  - Medical physics alumni
  - Program statistics

Questions?

email: ompi_aao@physics.carleton.ca