# 2010

OMPI Seminar Archive

# Justin Sutherland, Brenda Clark

**Date: Thursday, January 21, 2010**
**National Research Council Canada, 1200 Montreal Road | 3:30 p.m.**

**Monte Carlo calculated absorbed-dose energy dependence of EBT and EBT2 film.**
**Justin Sutherland, Carleton University**

**Abstract:** Using EGSnrc user codes we calculated the absorbed-dose energy dependence of GAFCHROMIC EBT and EBT2 film irradiated in photon beams. The absorbed-dose energy dependence was found to be constant in the mega-voltage range but non-uniformities were found in the low energy range. Differences with experimental results in literature for EBT in the kilo-voltage range suggest the possibility of an intrinsic energy dependence.

**Management of Error in Radiation Treatment through Incident Learning**
Brenda Clark, The Ottawa Hospital Cancer Centre

Abstract: This presentation will describe the implementation of an incident learning system in our radiation treatment program and the analysis of more than 1,000 incidents, most of which had little or no clinical impact. This presentation will answer the obvious question “why report, investigate, determine basic cause and identify learning follow-up on so many incidents with little or no impact on patient treatment?” The answers to this question, and there are many, include reference to the inevitability of human error in systems involving human intervention, the best way to prevent mosquitoes spoiling your summer and, more seriously perhaps, the impact of the Incident Learning System in enhancing the culture of safety at the individual health care professional level and at the multidisciplinary team level by addressing quality improvement initiatives collaboratively with transparent accountability.

# Richard B. Richardson

**Date: Thursday, February 25, 2010**
**The University of Ottawa Heart Institute. (40 Ruskin Street), room H2368 3:30 p.m.**

**Ionizing radiation and aging: rejuvenating an old idea**

Richard B. Richardson
Radiation Protection Research and Instrumentation Branch, Atomic Energy of Canada Limited, Chalk River Laboratories

**Abstract:** This talk reviews the contemporary evidence that radiation can accelerate aging, degenerative health effects and mortality. Around the 1960s, the idea that ionizing radiation caused premature aging was dismissed as the radiation-induced health effects appeared to be virtually confined to neoplasms. More recently, radiation has become associated with a much wider spectrum of age-related diseases, including cardiovascular disease; although some diseases of old age, such as diabetes, are notably absent as a radiation risk. On the basis of recent research, is there a stronger case today to be made linking radiation and aging? Comparison is made between the now-known biological mechanisms of aging and those of radiation, including oxidative stress, chromosomal damage, apoptosis, stem cell exhaustion and inflammation. The association between radiation effects and the free-radical theory of aging as the causative hypothesis seems to be more compelling than that between radiation and the nutrient-sensing TOR pathway. Premature aging has been assessed by biomarkers in calorie restriction studies; yet, biomarkers such as telomere erosion and p16INK4a are ambiguous for radiation-induced aging. Some animal studies suggest low dose radiation may even demonstrate hormesis health benefits. Regardless, there is virtually no support for a life span extending hypothesis for A-bomb survivors and other exposed subjects.
The article is posted on the open access, Aging web:
http://www.impactaging.com/papers/v1/n11/pdf/100081.pdf

# Chad Hunter, Laurel Sinclair

**Date: Thursday, March 25, 2010**
**Carleton University, HP5115. 3:30pm.**

**New Effective Dose Estimates for Rubidium-82 Based on Dynamic PET/CT Imaging in humans.**
Chad Hunter (Carleton University & Heart Institute)

**Abstract:**
Objectives: Published radiation dose estimates for Rubidium-82 vary widely, and no comprehensive study in man has yet been conducted. With the increasing use of Rb-82 PET for myocardial perfusion imaging, improved dosimetry information is needed for accurate risk assessment. The purpose of this study was to measure Rb-82 internal organ and effctive doses with PET/CT in humans. Methods: We recruited 26 cardiac patients and 4 normal subjects with no cardiac history. Dynamic 3D PET scans were acquired (GE Discovery RX/VCT) over 10 minutes following IV injection of 10 MBq/kg Rb-82. Images were reconstructed using FORE-OSEM and 8 mm Hann filter. Cardiac scans of the chest were acquired at rest for all 30 subjects, plus one additional scan of the Head, Neck, Abdomen,Pelvis, or Thighs. Mean Rb-82 residence times were determined in 22 source organs using volumes-of-interest (VOI) drawn on the fused PET/CT images. For large organs a small VOI was used to avoidpartial volume losses. For small organs the average activity above 80% threshold was multiplied by the volume at 40% of the peak value within the organ VOI. Target organ doses and the effective dose estimate were calculated using OLINDA/EXM 1.0 according to ICRP 60, and recalculated according to ICRP 103. Results: A total of 283 organs were measured across the 60 scans, with at least 4 samples obtained in each source organ. The average 'adult' effective dose for Rubidium-82 was found to be 0.00074 mSv/MBq using ICRP 60. Using ICRP 103, the male and female effective doses were 0.00074 and 0.00092 mSv/MBq respectively. The highest dose organs were the lungs, kidneys and stomach wall. Conclusion: These dose estimates for Rubidium-82 are the first to be measured directly with PET/CT in humans, and are 4 to 4.5 times lower than previous ICRP 60 values based on a theoretical blood flow model. The new values derived from human studies suggest a typical effective dose of 0.6 mSv per scan with 3D PET. Research Support: DRAXimage, Ontario Research Fund.

**Long Range Detection of Radioactive Threat Material**
Laurel Sinclair (Natural Resources Canada)

**Abstract:**
In both security investigations and incident remediation work, there is a need to precisely define the locations of man-made radioactivity in the environment. Deploying simple gamma and neutron detectors from an airborne platform has proven a valuable method to delineate dispersed radioactivity. However, in some scenarios, a land-based detection system is required. The presence of partial shielding in these cases, and the restriction of the survey platform to roads, necessitates the use of instruments capable of directionality or imaging. To address this need, we are working with a commercial partner on a synthetic aperture gamma array detector. We are also designing and building a rugged and transportable Compton gamma imager. The latest results from these development efforts will be presented.

# Elsayed Ali, Tong Xu

**Date: Thursday, April 22, 2010**
**Health Canada ( 775 Brookfield Road, Ottawa ), room 205B . 3:30pm**

**Unfolding linac photon beam spectra from transmission measurements**
**Elsayed Ali (Carleton University)**

**Abstract:**
In clinical photon beams, the energy distribution (spectrum) of the photons coming out of the treatment head is the ultimate beam quality specifier, from which many dosimetric quantities can be derived. Because direct spectroscopic measurements (including Compton spectrometry) are not suitable for a typical clinical environment or for typical therapeutic dose rates, a variety of indirect methods to measure megavoltage bremsstrahlung spectra have been investigated in the past. One indirect method, which uses transmission measurements, stood out for its simplicity and cost effectiveness. In this method, various thicknesses of an attenuating material are introduced in the beam path, and the measured ion chamber signals are used to unfold the spectrum. Despite the large volume of experimental and computational work on this method, a definitive work on the subject is still lacking. This is partly because of the inherent ill-conditioned nature of the problem, but largely because previous investigations have collectively a) not fully exploited basic radiation physics principles, b) ignored or grossly approximated various dosimetric aspects of the problem, c) limited the investigations to specific situations or beam energies, d) suffered from weak validation and benchmarking and, e) not carried out the measurements and uncertainty budgets so as to unearth all hidden type-B uncertainties. In this talk, I'll present a series of computational and experimental solutions to address the limitations to unfolding linac photon beam spectra from transmission measurements.

**Dynamic dual-energy chest radiography: a potential tool for lung tissue motion monitoring and function study**
Tong Xu (Carleton University )

**Abstract:**
Dual-energy x-ray imaging allows the separation of image signal of soft tissue from bone structures. By removing the anatomic rib background, statistic dual-energy chest x-ray image has the potential of better diagnosis of lung nodules as compared with conventional chest x-ray. With the development of digital flat panel detectors (FPD), Dual-energy x-ray imaging has now become more feasible. The FPD has also enabled another technique: Dynamic chest x-ray imaging, which takes a "movie" of the lung" during a breathing cycle. It may be used to evaluate the lung function for the diagnosis of lung diseases such as emphysema and chronic obstructive pulmonary diseases. In this study, we combined the above techniques and implemented dynamic dual energy chest radiography system. Animal studies were performed to evaluate the feasibility of this technique in lung functional imaging and tumour motion assessment.

# Munira Fardous Nahin, Paul Johns

**Date: Thursday, May 20, 2010**
**Time: 3:30pm, refreshment start at 3:15pm. (BBQ at 5pm)**
**Location: Building M-36, NRC Montreal Rd Campus, Kelvin Room.**

**(Please check in at the front desk)**

**Special events:** Don't forget to register with Malcolm McEwen **(Malcolm.McEwen@nrc-cnrc.gc.ca)** for the BBQ after the seminar.

**(Click here for direction)**

**(Click here for NRC campus map)**

**Reproducibility of Tl-201 for cardiac micro SPECT imaging with a rat model**
Munira Fardous Nahin (Carleton University and Ottawa Heart Institute)

Abstract:
Gated myocardial perfusion single-photon emission computed tomography (SPECT) is a non-invasive and valuable tool for in vivo measurements of cardiac function. In vivo measurements are used to study heart disease in small animals and thereby develop new therapies and new radio-tracers. The left ventricular end diastolic volume (EDV), end systolic volume (ESV), ejection fraction (EF) and perfusion homogeneity (PH) are important measures of heart function which can be determined using SPECT. Longitudinal imaging of a single animal increases the statistical power of studies and reduces unnecessary sacrifice improving our ability to study disease development and evaluate interventions. Understanding measurement variability is essential for evaluating the significance of observed changes. The purpose of our study was to determine the inter- and intra-subject reproducibility of the left ventricular volumes, ejection fraction and perfusion homogeneity with Tl-201 myocardial perfusion SPECT in a rat model.

**Coherently-Scattered X Rays as a Source of Radiological Contrast**
Paul Johns(Carleton University )

Abstract:

In diagnostic radiology, up to 90% of the x-ray quanta approaching the image receptor have been coherently or incoherently scattered. Although it is usually treated as a nuisance to be suppressed, scattered radiation also carries information about the patient. Coherent scatter, which is the basis of x-ray diffraction, can be particularly useful. The underlying physics and basic approaches to scatter imaging will be reviewed. Our research progress on modelling the imaging potential of scattered photons, on projection imaging with scatter, and on measuring the basic cross sections, will be reported.

# Patrick Assouad, Gabriel Sawakuchi

**Date: Thursday, September 30, 2010**
**Time: 3:30pm, refreshment start at 3:15pm.**
**Location: Carleton University, Herzberg building room H4351**

**(Click here for directions)**

**Special events: Soccer game and Beer after the seminars**

**Mid-Infrared Fiber Evanescent Wave Spectroscopy for In-Vivo Diagnostic of Malignant Tissue**
Patrick Assouad (Carleton University)

Abstract:
Fingerprint molecular spectral signatures have traditionally been obtained from tissue through Fourier Transform Infrared (FTIR) spectroscopy requiring biopsies and appropriate sample preparation. Previous work has identified spectral biomarkers for malignant mutations in several types of cancers. Here, the feasibility of acquiring comparable spectral tissue readings in-vivo is investigated through mid-infrared Fiber Evanescent Wave spectroscopy (FEWS). In this approach, a silver halide fiber is used to guide the radiation to a sensing probe placed in contact with the tissue, eliminating the need for sample collection and preparation. Results of a preliminary analysis are presented comparing both techniques using samples of healthy and malignant cervical tissue. A discussion of inherent complications arising from an in-vivo environment is also given.

**LET determination using the optically stimulated luminescence of Al2O3:C**
Gabriel Sawakuchi (Carleton University )

Abstract:
Knowledge of biological radiation dose, which in turns depends on the linear energy transfer (LET), is important for hadron therapy of cancer patients. Currently, no technique exists for measuring the LET in hadron therapy clinical dosimetry on a daily basis; the only quantity reported is the absorbed dose. Development of a technique for measuring LET is an important step because without knowledge of the radiation's LET, it is difficult to determine the biological dose (that is, the LET characterizes the dose that causes a biological effect). Hadron therapy beams, including proton and carbon ion beams, have a higher LET and thus produce a greater biological effect than x-ray or electron beams. Therefore, the relative biological effectiveness (RBE) of hadron therapy beams with respect to cobalt-60 gamma rays can differ from unity and the physical absorbed dose (D) can significantly differ from the biological dose (E = D × RBE). The objective of this talk is to show that the optically stimulated luminescence of Al2O3:C detectors can be used to measure LET of therapeutic proton beams.

# Ernesto Mainegra, Rebecca Thornhill

**Date: Thursday, October 21, 2010**
**Time: 3:30pm, refreshment start at 3:15pm.**
**Location: Health Canada (Brookfield rd.), room RPB 205B, please check-in at the front desk. Parking across the street.**

(Click here for directions)

**Free Air Chamber attenuation corrections for low-energy x-ray beams**
Ernesto Mainegra (NRC/Carleton U)

Abstract:
Free Air Chambers (FAC) are used as the primary standard for the calibration of radiation detectors for x-ray beams at the Ionization Radiation Standards (IRS) group at the NRC. The ability to estimate FAC attenuation correction factors for low energy x-ray beams using EGSnrc is demonstrated. Monte Carlo (MC) calculated attenuation correction factors are compared to experimentally determined values. Two sets of beam qualities are used in the study; a mammography set of x-ray beams with tube potentials from 23 kVp up to 50 kVp filtered with 0.064 mm of Mo, and a softer, Al filtered (0.245 mm Al), set of x-ray beams with tube
potentials ranging from 10 kVp up to 80 kVp. An inconsistency in the experimental “evacuated tube” technique for the determination of the attenuation correction is found to be of the order of 0.2% for the softer Al filtered beams and less than 0.1% for the mammography beams.
Discrepancies between the MC calculated and the experimental values of the attenuation correction for the Al filtered beams can be explained by increasing the contribution from L-shell characteristic x-rays suggesting a need to rescale the L-shell electron impact ionization (EII) cross sections.

**Magnetic Resonance tools for the Evaluation of Cardiovascular Disease & Metabolic Disorders**
Rebecca Thornhill (The Ottawa Hospital)

Abstract:
Cardiovascular disease currently accounts for 30% of all deaths in Canada. Together, ischemic heart disease and acute ischemic stroke result in almost 70 000 deaths in Canada each year, as well as substantial long-term disability.

Magnetic resonance imaging (MRI) is a highly versatile tool, offering a potential ‘one-stop-shop’ for the evaluation of cardiovascular disease. After providing some brief background and MRI terminology, I will discuss how MRI can be used to assess myocardial viability following a heart attack, including evidence gleaned from canine and patient studies of ischemic heart disease.

Secondly, I will provide an example of how MRI can be used for risk stratification in emergency stroke imaging and its potential to predict serious bleeding complications in acute ischemic stroke.

Finally, I will briefly propose how MRI can be used to measure subtle changes in heart function in patients with metabolic disorders such as diabetes. Heart failure is the most common cause of death among diabetics who have suffered a heart attack. In addition to providing clinicians with a sensitive marker of incipient heart failure, MRI strain analysis may offer a non-invasive strategy for delineating incremental benefits from emerging therapies.

# Tyler Dumouchel, Eric Vandervoort

**Date: Thursday, November 18, 2010**
**Location: Ottawa Hospital General Campus, main building 2nd floor Auditorium**

(Click here for directions)

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# Jared Strydhorst, Dmitry Klokov

**Date: Thursday, December 16, 2010**
**Location: University of Ottawa Heart Inistitute. room H-2403**

**(Click here for map)**

**Modeling photon attenuation in the reconstruction of small animal pinhole SPECT images**
Jared Strydhorst (Carleton University & U.O. Heart Institute)

Molecular imaging of small animals is a valuable tool for research of diseases and development of new drugs and therapies. However, the effects being investigated are often very small and achieving sufficient quantitative accuracy to detect them is a challenge. In particular, photon attenuation can result in significant differences between the true tracer concentration and the measured tracer concentration and limit the reproducibility of measurements between animals. In this work, we investigate modelling the photon attenuation as part of the OSEM reconstruction algorithm. Five rats were injected with Tc-99m tetrofosmin and scanned in a nanoSPECT/CT scanner in both CT and SPECT mode. The CT data was used to create an attenuation map which was incorporated into the reconstruction. For the five rats studied, the absolute measured tracer concentration in the uncorrected reconstructions was 30±2% less than in the attenuation corrected images. In the heart, three of the seventeen segments exhibited significant differences in relative perfusion when corrected and uncorrected images were compared, and several adjoining segments exhibited changes that were nearly significant. No significant changes were observed in the overall uniformity of the cardiac perfusion as a result of attenuation correction.

**Radiobiological studies at Chalk River Laboratories: radioadaptive response and DNA repair**
Dmitry Klokov, Chalk River Laboratories, Atomic Energy Canada Limited

Chalk River Laboratories (CRL) of Atomic Energy Canada Limited (AECL) is involved in R&D activities that are related to nuclear industry, including research in the field of radiological protection and radiation biology. Radiological Protection Research and Instrumentation (RPRI) branch consists of three sections: Instrumentation, Biodosimetry and Radiation Biology. The Biodosimetry group conducts both service and research activities related to evaluation of a radiation dose received in a potential nuclear accident or terrorist attack and modeling radionuclide routes in an organism. Research activities within the Biodosimetry section are focused around developing novel and improved methods for biological dosimetry. The Radiation Biology section represents a fundamental wing of the branch and involved in basic studies of mechanisms of biological effects of low dose ionizing radiation of different properties (gamma-, alpha-, beta-) that are related to radiological protection. Low dose of ionizing radiation are known to induce radioadaptive response – increased radioresistance to high radiation dose. In our studies we use mouse models, as well as cultured mammalian cells in vitro to investigate mechanisms of radioadaptive responses. End-points include life span, tumour frequency, cytogenetic damage, DNA damage and repair. Our recent results indicate that reapir of DNA double strand breaks (the most deleterious type of DNA lesions that may trigger carcinogenesis) is not involved in systemic radioadaptive responses (increase of life span and decrease of tumour frequency in low-dose irradiated mice). Future studies will examine biological effects of chronic low dose rate exposure to gamma- vs. beta-radiation (Tritium) in mice in vivo at levels of gene expression, epigenetic changes, DNA damage signalling, cytogenetic damage and sife span. Transgenerational effects will be studied as well. RPRI branch is interested in linkages with academic institutions to invite potential students to conduct masters, PhD, or post-doc studies at CRL in the fields of biodosimetry, radiological protection and radiation biology using its state-of-the-art animal research facility, as well as cell and molecular biology, biochemistry, microscopy facilities.

# 2011

OMPI Seminar Archive

# Lindsay Beaton, Malcolm McEwen

**Date: Thursday, December 16, 2010**
**Time: 3:30pm**
**Location: Carleton University, Herzberg Building, HP4351**

**Biomarkers of Radiation Sensitivity in Human Lymphocytes**
Lindsay Beaton (Carleton Univ.& Health Canada)

Radiotherapy is a treatment modality often used for different types of cancer. The goal of treatment is to deliver a toxic dose of radiation to the tumour while sparing the healthy tissue. Sometimes a patient does not have a normal response to radiation; they might be more radiosensitive than normal, in which case a normal dose would result in increased side effects, or they could be radioresistant, in which case a normal dose could result in poor tumour control. The development of a predictive assay for radiation response would allow patients who are sensitive to radiation to be identified and considered for a reduced dose or even an alternative therapy to radiation. Conversely, those resistant to radiation could be prescribed a higher dose, resulting in improved tumour control.
The primary goal of this project is to examine the in vitro γH2AX response in lymphocytes and lymphocyte subsets from patients who have shown a radiosensitive response to radiation to determine whether the more radiation responsive subsets will provide more specific markers for radiosensitivity. Concurrently, cytogenetic endpoints will also be examined in these patients to provide additional information about the mechanisms of radiosensitivity.

**OMPI - a year in review**

Malcolm McEwen (Director, Ottawa Medical Physics Institute )

The Ottawa medical physics community has one of the most diverse spectra of research and service activities in Canada, and at the heart is the Ottawa Medical Physics Institute (OMPI). Founded in 1989, OMPI provides a forum for presentations and discussion, a networking opportunity for researchers, and a co-ordinating structure for supporting the graduate medical physics program at Carleton University.

This presentation will provide some background on OMPI but the main aim is to celebrate the activities of the organization during the 2009-2010 academic year.

# Jason Belec, Glenn Wells

**Date: Thursday, February 24, 2011**
**Time: 3:30pm**
**Location: Carleton University, Herzberg Building, HP4351**

**Monte Carlo calculation of photon beam treatment dose distributions delivered using Tomotherapy and VMAT**

Jason Belec - The Ottawa Hospital Cancer Centre

The commercial release of volumetric modulated arc therapy techniques using a conventional linear accelerator and the growing number of helical tomotherapy users have triggered renewed interest in dose verification methods, and also in tools for exploring the impact of machine tolerance and patient motion on dose distributions without the need to approximate time-varying parameters such as gantry position, MLC leaf motion, or patient motion. To this end we have developed a Monte Carlo-based calculation method capable of simulating a wide variety of treatment techniques without the need to resort to discretization approximations. The ability to perform complete position-probability-sampled Monte Carlo dose calculations was implemented in the BEAMnrc/DOSXZYnrc user codes of EGSnrc. The method includes full accelerator head simulations of our tomotherapy and Elekta linacs, and a realistic representation of continuous motion via the sampling of a time variable. The functionality of this algorithm was tested via comparisons with both measurements and treatment planning dose distributions for four types of treatment techniques: 3D conformal, step-shoot intensity modulated radiation therapy, helical tomotherapy, and volumetric modulated arc therapy.

**Dedicated Cardiac SPECT: Changing How We Look at the Heart**

Glenn Wells - The University of Ottawa Heart Institute

Cardiac disease remains one of the leading causes of death in Canada and costs Canadians an estimated 22 billion dollars a year. Nuclear medicine imaging with single-photon emission computed tomography (SPECT) plays a key role in the management of heart disease – at the University of Ottawa Heart Institute, we perform more than 6000 cardiac studies every year. Recent developments in SPECT camera technology has the potential to drastically alter both how we do cardiac imaging and also what information we can obtain. The new dedicated cardiac systems provide a significant increase in sensitivity over standard cameras. The greater sensitivity allows a four-fold reduction in scan times or a similar reduction in the amount of injected activity used in our tests. Based on pixelated cadmium-zinc-telluride solid state detectors, the new designs also provide improved energy resolution and reduced deadtime. Finally, unlike traditional systems, the new SPECT cameras do not rotate. These features offer the potential to improve our ability to perform dual-isotope cardiac perfusion studies and open the door to allowing absolute measures of blood flow in the heart with SPECT. I will discuss the new camera technology and highlight some of the work being done at the University of Ottawa Heart Institute to validate its current performance and to investigate the future capabilities of the new design.

# Bryan Muir, Nicolas Ploquin

**Date: Thursday, March 24, 2011**
**Time: 3:30pm**
**Location: NRC – 1200 Montreal Road, North Campus, Building M-36 – Kelvin Room (please check in at the front desk)**

(Click here for directions)

(Click here for NRC campus map)

**Characterization of plane-parallel ion chambers for reference dosimetry of MV photon beams**

Bryan Muir - Carleton University

Calibration of high-energy radiotherapy sources requires that clinical medical physicists follow reference dosimetry protocols (e.g., TG-51 or TRS-398). In the past, reference dosimetry protocols did not allow the use of plane-parallel ionization chambers for calibration of high-energy photon beams because sufficient data were not available. This work aims to determine beam quality conversion factors, kQ, for several plane-parallel ionization chambers to potentially enable the use of these chambers for reference dosimetry of megavoltage photon beams. Eleven different types of plane-parallel chamber were obtained from the major ion chamber manufacturers. Measurements of the absorbed dose to water calibration coefficient were made at the National Research Council of Canada (NRC) for the 60Co irradiator and the Elekta Precise 6, 10 and 25 MV photon beams to obtain kQ. Monte Carlo simulations of these ionization chambers were performed with the egs_chamber user-code for EGSnrc to calculate kQ factors. For characterization of these chambers over the range of clinically relevant energies, measurements of the time required for chamber stabilization, leakage currents, ion recombination and polarity behavior, as well as chamber-to-chamber variations were investigated. In this talk, I will discuss the results of Monte Carlo simulations and measurements performed to date and how they compare.

**Locoregional left breast cancer irradiation: From TomoTherapy to VMAT**

Nicolas Ploquin - The Ottawa Hospital Cancer Centre

Treating left sided locoregional breast cancer has always been a challenge because of the contiguous nodal and breast volumes which have a radically different shape and depth over an extended region of the body. The proximity of critical organs at risks such as the heart and the lung, especially for patients who have undergone a mastectomy, makes the treatment even more challenging. A multitude of techniques is available in radiation therapy to treat this volume. In addition to 3D Conformal Radiation Therapy with a linac, the Ottawa Hospital Cancer Centre has been using TomoTherapy technology since 2005 to treat left sided locoregional breast cancer with Intensity Modulated Radiation Therapy (IMRT). We have recently commissioned a new technique on our Elekta Synergy linac called Volumetric Modulated Intensity Modulated Radiation Therapy (VMAT). This technique delivers rotational IMRT on a regular linac, decreasing the treatment time required for a similar quality dose distribution relative to other IMRT techniques. We have investigated the feasibility of adapting our technique developed on TomoTherapy for treating left sided locoregional breast cancer to VMAT on our Elekta Synergy linac. I will briefly review the various rotational IMRT techniques available, then I will present the main components in the commissioning of VMAT technique and finally I will discuss the challenge of treating left sided locoregional breast cancer with IMRT using TomoTherapy or VMAT techniques.

# Elizabeth Henderson , Michel Lalonde

**Date: Thursday, May 19, 2011**
**Time: 3:30pm**
**Location: The Ottawa Hospital General Campus**

**Note that there is a cyberknife tour before the seminar. Right before 3:30pm, the tour group should meet in front of the fireplace in the new General Campus cancer center building (Radiation Therapy North).**

**Location #1 (3:30pm tour): new General Campus cancer center building**

**If you did not registered for Cyberknife tour, please go directly to the auditorium at 4pm for the semianrs.**

**Location #2 (4pm seminar): Hospital Auditorium, 2nd floor, (Take escalator from main lobby to 2nd floor, Auditorium is behind module G, follow signage)**

**(Click here for direction)**

**(Click here for floor map)**

**Cyberknife in Ottawa**

Elizabeth Henderson - The Ottawa Hospital Cancer Centre

The Ottawa Hospital Cancer Center installed a CyberKnife system, used for high precision, small volume radiation therapy treatments, in August 2010. The CyberKnife system consists of a 6MV LINAC mounted on an industrial robot arm. Image guidance is accomplished using a pair of orthogonal ceiling-mounted X-ray sources and corresponding detectors in the floor. With this combination of features, the CyberKnife system is able to track moving targets, significantly decreasing the volume of normal tissue that receives a high dose of radiation. In this talk, I will discuss the commissioning and quality assurance of the CyberKnife system, and the Ottawa Hospital experience in using the CyberKnife to treat brain, spine, liver and lung tumours.

**Development of SPECT RNA methodologies for quantifying cardiac wall motion**

Michel Lalonde – Carleton University

SPECT radionuclide angiography (RNA) can be used to quantify cardiac wall motion. It has been investigated with phase analysis for its potential at predicting cardiac resynchronization therapy response (CRT), producing modest results. However, the quantitative analysis of wall-motion curves, which is currently qualitative in nature, may hold potential for other applications as well. The development of new SPECT RNA methodologies, in particular, cluster analysis, will help provide increased accuracy and reproducibility for the quantification of cardiac wall motion. This could lead to better prediction of CRT response. In this presentation, I will present an overview of cardiac dyssynchrony and CRT; the results from a second methodology investigated (amplitude analysis) and introduce cluster analysis, and the various steps needed to properly implement it.

# Elsayed Ali, Ruth Wilkins

**Date: Thursday, June 23, 2011**
**Time: 3:30pm (BBQ starts at 5pm, see the note below *)**
**Location: NRC – 1200 Montreal Road, North Campus, Building M-36 – Kelvin Room (please check in at the front desk)**

**(Click here for direction)**
**(Click here for NRC campus map)**

**Unfolding linac photon spectra from simple depth-dose measurements**

Elsayed Ali – Carleton University

The current approach to linac photon beam commissioning is to tune the beam model to match measured beam data. It has been shown in the literature that while this `self-tuning' approach is suitable for many application, it does not guarantee that the beam model is accurate for non-standard conditions - e.g., for dose calculations around tissue heterogeneities. A reliable method to determine the true spectra would lead to a more robust commissioning process and allow for stricter testing of the dose calculation engines in treatment planning systems. In this study, the prospects are explored for a method to unfold spectra of clinical photon beams from simple depth-dose measurements. The method is validated on an NRC research linac whose spectra are independently known. In this talk I will present a description of the method and some validation results.

**New approaches to high through-put biological dosimetry**

Ruth Wilkins – Health Canada

In the event of a large scale radiological/nuclear emergency, biological dosimetry is essential for providing timely assessments of radiation exposure for the general population and to identify first responders who must be restricted from further exposure. The dicentric chromosome assay (DCA) is currently the accepted biodosimetry method for radiation dose assessment, however in a mass casualty scenario this assay is not well suited for providing timely dose estimates due to its time- and expertise-intensive nature. Canada is striving to increase triage-quality biological dosimetry throughput by: 1) increasing the number of trained personnel capable of conducting the DCA and, 2) evaluating alternative approaches to DCA scoring and 3) developing novel, high throughput methods for biological dosimetry. These strategies for increasing throughput for biological dosimetry will be presented.

* We will be finishing off this season's seminar series with a BBQ at the NRC. To help in organizing this, we would like to have an idea of how many people are planning to come to the seminar and stay for the food afterwards. Please RSVP to **Claudiu Cojocaru** by June 20 to guarantee your share. We will make every effort to accommodate special dietary needs (e.g. vegetarians) but only if we know in advance.

# Azeez Omotayo, Ian Cameron

**Date: Thursday, September 29, 2011**
**Time: 3:30pm**
**Location: Carleton University - Herzberg Building - Room HP4351**

**(Click here for the map)**

**Characterization of sensitivity changes of nanoDot OSLDs exposed to 6 MV x-ray beams**

Azeez Omotayo – Carleton University

The optically stimulated luminescence (OSL) technique is prominently used in dating, environmental and personnel dosimetries. In personnel dosimetry, the most common OSL dosimeter (OSLD) is aluminum oxide doped with carbon (Al2O3:C). Recently, Al2O3:C OSLDs have been applied in medical physics for audit dosimetry programs and quality control protocols in radiotherapy departments. This work presents an investigation of relevant parameters for accurate use and re-use of commercial Al2O3:C OSLDs. The OSLDs were irradiated at The Ottawa Hospital Cancer Center to 6 MV x-ray beams. Numerical simulations were also performed to explain and provide a better insight on the experimental observations.

Evaluation of Diffusion and Diffusion-like Motion in Human Subjects Using MRI

Ian Cameron – The Ottawa Hospital

Magnetic Resonance Imaging (MRI) can be made sensitive to motions on several length scales. In this talk, I will explain how MRI can be used to detect water molecule displacement caused by diffusion. Furthermore, since the motion of blood in many capillary networks can be treated as a diffusion-like process, tissue blood flow in vascular tissues can be measured using the same diffusion-weighted technique. Results showing the anisotropic nature of water diffusion in the white matter of the brain and tissue blood flow maps for the liver and placenta of healthy human subjects will be presented. All of these measurements are performed completely non-invasively and without the use of contrast agents. Another method for measuring tissue blood flow with MRI, called Dynamic Contrast Enhanced MRI, will also be discussed (if time permits).

# Karl Landheer, Bog Jarosz

**Date: Thursday, October 20, 2011**
**Time: 3:30pm**
**Conference room A&B, Room C2362, 2nd floor, Cancer Centre South**

**(Click here for the map)**

**Coherent Scatter Ring Integration Imaging**

Karl Landheer – Carleton University

Traditional projection X-ray imaging utilizes only the information from the primary photons. Low-angle coherent scatter images can be made simultaneous to the primary images and provide additional information. To speed up acquisition time for coherent scatter projection imaging, we are developing disentangling algorithms for the overlapping scatter patterns generated by multi pencil-beam geometries. We configured a system at the Canadian Light Source synchrotron which utilizes a 33.17 keV monoenergetic pencil beam from a Laue monochromater. The pencil beam then travels through the sample and is absorbed by a tungsten bar. A digital flat panel detector records the scatter patterns from the beams. The sample is scanned through the beams using an automated step-and-shoot setup. The pixel value of the coherent scatter image is generated by integrating the radial profile (scatter intensity versus scattering angle) over an angular range. The angular range integrated over can be adjusted after the data have been acquired to achieve maximum contrast between any two materials of interest. We developed an MLEM-based iterative method to disentangle the scatter patterns. We are also investigating a least-squares method and using simulated data to compare the accuracy of both methods.

Computations of Temperature Patterns in Interstitial Thermal Therapy

Bog Jarosz – Carleton University

In the presentation, several issues pertaining to computations of temperature patterns in cancer thermal therapy will be addressed. Fundamental equations used in the computations will be presented with an analytical solution used in computations of heating pattern for simple geometry. Usefulness of this approach will be evaluated and novel methods will be demonstrated. Use of these methods will be illustrated for the case of brain glioma thermal therapy.

# Benjamin Spencer, Janos Szanto

**Date: Thursday, November 17, 2011**
**Time: 3:30pm - 5:00 pm**
**Room RPB 205B (boardroom), Health Canada, 775 Brookfield Road**

**(Click here for the map)**

**Distortion correction, geometric calibration, and volume reconstruction for an isocentric c-arm x-ray system**

Benjamin Spencer – Carleton University

In order to facilitate cone-beam CT using a mobile x-ray C-Arm, accurate geometric calibration must be carried out. Such calibration requires a precise correction of x-ray image intensifier (II) distortion. Regional distortion correction was performed for the x-ray II using a planar grid phantom. The distortion correction reduced the RMS error of known locations (or points) spanning the II field of view from 1.71 pixels to 0.63 pixels. For each projection, a six-ball calibration phantom was then used to determine the behavior of 9-geometric calibration parameters. These parameters were subsequently used to achieve 3D volume reconstruction. Without the correction of II distortion the geometric calibration parameters showed the addition of incorrect structured behavior while the reconstructed image was observed to have minor visual differences than the reconstruction with distortion correction incorporated.

**CyberKnife: one year later**

Janos Szanto – The Ottawa Hospital Cancer Centre

Ottawa has maintained a stereotactic radiotherapy treatment program for 20 years, during which time the technology has evolved steadily. Today, the Ottawa Hospital delivers stereotactic radiotherapy using a piece of “cutting edge” technology called the CyberKnife. I will present a brief history of Ottawa’s stereotactic radiotherapy program, and review the CyberKnife’s unusual dosimetry, its image guidance system and clinical applications. My talk will focus on physics developments done within our CyberKnife program during its first year of operation: improved dosimetry, fiducial based image registration, commissioning of Monte Carlo dose calculation in the CyberKnife treatment planning system, and development of a patient specific quality assurance technique.

# Matthew Efseaff, Rolf Clackdoyle

**Date: Thursday, December 15, 2011**
**Time: 3:30pm - 5:00 pm**

**East Foustanellas Auditorium - 2nd floor, H2368 - The University of Ottawa Heart Institute, 40 Ruskin Street**

**Repeatability of short term quantitative resting myocardial blood flow measurements using rubidium-82 PET imaging**

Matthew Efseaff – Carleton University

Rubidium-82 PET imaging is seeing an increased workload as a myocardial health indicator due to its portability. However, few studies have been published regarding repeatability. We have a highly automated analysis program that we used to investigate myocardial blood flow (MBF) repeatability. We measured the repeatability of resting MBF in a population of coronary artery disease patients (n = 27) and healthy normal volunteers (n = 9). Repeatability was assessed with correlation and Bland-Altman repeatability coefficients. Factors affecting MBF included male/female differences, patients vs. normal volunteers, and partial volume spillover correction ($p \leq 0.001$). We found that the current clinical method was not the best and that there is a clinical benefit (regarding repeatability) in using iterative reconstruction, shorter scan length, and a spillover correction.

**Reduced Radiation Dose using Software Techniques?**

Rolf Clackdoyle – Université St. Etienne, France

In X-ray CT, radiation dose issues are becoming increasingly significant as technological advances provide more extensive body coverage in shorter scan times. The challenge is to provide equivalent-quality images using reduced x-ray exposures. One of the 'obvious' approaches is to apply recent developments in image reconstruction methods that in principle can provide accurate region of interest (ROI) imaging but without the standard mathematical requirement that the entire slice be irradiated from all directions. In this talk the principles behind one of the ROI methods will be explained, and examples will be shown to illustrate exactly which x-rays are no longer needed. The issue of quantifying radiation dose benefits will be discussed.

# 2012

OMPI Seminar Archive

# Stéphanie Chiasson, Dave Rogers

**Date: Thursday, January 19, 2012**
**Conference room A&B, Room C2362, 2nd floor, Cancer Centre South , The Ottawa Hospital (General)**

**(Click here for the directions)**

**Crosstalk corrections using a triple energy window (TEW) method in dual-isotope cardiac SPECT imaging on a dedicated CdZnTe camera**
Stéphanie Chiasson – Carleton University

Single Photon Emission Computed Tomography (SPECT) is widely used in the field of cardiac imaging to diagnose and manage heart disease. Implementation of dual-isotope imaging in myocardial perfusion studies has many advantages, including improved image alignment and greatly reduced test duration. Dedicated cardiac cameras based on solid-state (CZT) detectors have recently been introduced into the clinic, with improved energy resolution and greater sensitivity. However, an obstacle to simultaneous imaging is the presence of crosstalk between different isotopes. The purpose of our investigations is to assess the accuracy of using a modified Triple-Energy-Window (TEW) cross-talk correction method for Tl-201/Tc-99m-tetrofosmin dual-isotope imaging with a CZT-based dedicated cardiac SPECT camera. We are studying the correction accuracy using single-isotope clinical studies acquired on the camera at the University of Ottawa Heart Institute and will be testing the method on synthetic dual-isotope studies. This talk will focus on the motivation and methodology being employed in the study and will present some of our preliminary results. Successful implementation of simultaneous dual-isotope SPECT imaging would reduce the test duration from more than 4 hours to 30-45min and greatly improve the patient experience for this common diagnostic procedure.

**The value of (W/e)air and its importance to ion chamber dosimetry**
Dave Rogers – Carleton University

In an air-filled ionization chamber, the quantity (W/e)air (J/C) relates the quantity of interest, viz the energy deposited by electrons in the air, to a quantity that can be measured, i.e. the charge released. Ion chambers work well because (W/e)air appears to be constant, independent of energy in photon and electron beams. The world's primary standards of air kerma need the value of (W/e)air which was thought to be known at the 0.18% level. With the development in 2008 of Monte Carlo techniques which could accurately account for the perturbing effect of an ion chamber's cavity on the dose in a medium, it became possible to re-analyze the most important papers for determining W/e and it was found that the value in Co-60 beams needs to be changed by 0.8%. Thus the world's primary standards of air kerma in a Co-60 beam need to change by 0.8% which is substantial considering the currently assigned uncertainty of 0.17%. In a separate comparison of values of kQ values measured at NRC to the Monte Carlo calculated values for 37 different ion chambers used in reference dosimetry of accelerator beams, the extremely close agreement implies that a limit on the possible variation of (W/e)air between Co-60 and 25 MV bremsstrahlung beams is less than 0.36% at the 95 % confidence limit. The conclusion is that Monte Carlo calculations are an essential complement to careful measurements in the pursuit of accurate ion chamber dosimetry.

# Shoaib Khan, Rob deKemp

**Date: Thursday, February 16, 2012**
**Time: 3:30pm - 5:00 pm (special event after the seminars)**
**Location: Carleton University - Herzberg Building - Room HP4351**

**Source Localization using Directional Gamma Ray Spectrometer**
Shoaib Khan – Carleton University

The lost or orphan radioactive sources have recently created a concern for different governmental bodies and institutions ranging from the scientific community to the security agencies. That is why it is becoming very important these days to develop robust techniques to find and localize such sources. A well known technique for approximating the distance to the source performs fitting of the measured counts profile along the road to the known model for count rate as a function of source strength, detection efficiency and the location of the source. In our present work we have experimented a complementary technique using a directional gamma survey spectrometer. The instrument consists of four NaI(Tl) detectors oriented vertically in such a way that the crystals on one side shield the crystals on the other side of this vertical arrangement as could be seen in the work that follows. The relative counts in each crystal as a function of trucks position can be used to calculate the azimuthal angle to the source by forming direction vectors. The survey then returns a field of these direction vectors which maybe fit for their point of intersection to determine the horizontal geographic coordinates of the source position. Multiple truck borne surveys were conducted using this instrument on the days Aug 24 and Aug 25 of 2011 driving past Na-22 and Cs-137 sources with this directional spectrometer instrument being inside the truck at different speeds. The surveys were repeated with the source placed at different distances from the road that truck drove through back and forth. Here we are presenting the results of these measurements. We have shown the calculated azimuthal direction vectors as a function of position along the road and then the result of fitting these vectors to obtain the best uncertainty on the extracted source position.

**Rubidium-82 PET alternative to Tc-99m SPECT for Myocardial perfusion imaging**
Rob deKemp – University of Ottawa Heart Institute

Cardiovascular (CV) disease is the leading cause of death in Canada. Fifty percent of all Tc-99m used in nuclear medicine is for the diagnosis of coronary artery disease (CAD) with SPECT myocardial perfusion imaging (MPI). The reduced supply of Tc-99m requires other tracers to be investigated. Tl-201 SPECT is available but generally accepted to be inferior to Tc-99m. Rubidium (Rb-82), a nonreactor produced tracer, is believed to have superior accuracy compared to Tc-99m and Tl-201 SPECT, with 5-20 times lower radiation dose. In the U.S. Rb-82 generators have been FDA-approved since 1989 and are used increasingly for CAD diagnosis, but are still considered investigational in Canada.
Objectives: To demonstrate that Rb-82 PET MPI is i) an accurate, cost-effective alternative to Tc-99m; ii) superior to Tl-201; iii) can be implemented in multiple Canadian centres for the diagnosis and management of CAD. Short term clinical outcomes of Rb-82 will be evaluated and compared to Tc-99m and Tl-201 SPECT MPI across Canadian imaging centres.
Methods: Rubidium-ARMI is an innovative multidisciplinary, multi-centre imaging research initiative that builds on existing collaborative networks and Canadian industry partnership (DRAXIMAGE). Rubidium PET will be implemented, standardized and validated in 4 overlapping phases over 2 years, at up to 10 Canadian Centres.
Impact: According to the CIHR funding criteria, this project is expected to “lead to clinical trial applications and clinical validation studies which compare novel radiolabeled probes with those in current practice”, and to “bring a new radiopharmaceutical to the clinic” within a short time frame. Increased use of Rb-82 PET MPI has the potential to reduce the demand for Tc-99m by 10-40%, effectively increasing the available supply for other procedures, and improving the standard of care for many Canadians at risk of heart disease.

# Rachel Timmins, Gregory Cron

**Date: Thursday, March 22, 2012**
**Time: 3:30pm - 5:00 pm**
**Location: Room RPB 205B (boardroom), Health Canada, 775 Brookfield Road**

**Cross-talk correction in dual isotope 111-In / 99m-Tc small animal SPECT imaging**
Rachel Timmins – Carleton University

Abstract: Dual-isotope imaging via energy discrimination is a major strength of SPECT imaging but image quality is degraded by cross-talk interference. Cross-talk correction techniques have been developed for clinical SPECT however application to small-animal imaging is not ideal. The reduced subject size & variability in small-animal imaging may allow simpler cross-talk correction methods to provide adequate quantification accuracy. The objective of this study is to evaluate the accuracy of three simple cross-talk correction methods, triple energy window subtraction (TEW) applied in both projection and image space, and convolution subtraction, for use in small-animal 111In/99mTc imaging. We compared the three methods on a simple three syringe phantom to determine the best method and then tested this method across a range of activity concentrations. We then tested the method in-vivo on images of six rats, again over a range of activity concentrations. TEW applied in projection space gave the best reduction of In-111 cross-talk. The concentration of Tc-99m was recovered to within 4+/-1% or less of the true value over the range of concentrations evaluated

**Vascular input functions measured using MRI phase**
Gregory Cron – Ottawa Health Research Institute

Abstract: Quantitative dynamic contrast-enhanced magnetic resonance imaging can be useful for predicting tumor aggressiveness. An important component of this technique is the concentration-vs-time of contrast agent in the blood, a.k.a. the vascular input function (VIF). The VIF can be very difficult to measure and continues to be a subject of intense research in the MRI community. This talk will describe a relatively new method for measuring the VIF which involves acquisition of the MR phase signal.

# Marc Chamberland, Lesley Buckley

**Date: Thursday, April 19, 2012**
**Time: 3:30pm - 5:00 pm**
**Location: Centre Foustanellas Auditorium - 2nd floor - The University of Ottawa Heart Institute, 40 Ruskin Street**

**Performance evaluation of real-time motion tracking using positron emission fiducial markers**
Marc Chamberland – Carleton University

Abstract: Tumor motion due to patient breathing is a factor that limits the accuracy of dose distribution in radiotherapy. I present an experimental evaluation of the performance of PeTrack, a technique that can track internal fiducial markers in real-time for tumor tracking. PeTrack uses position sensitive detectors to record annihilation coincidence gamma rays from fiducial positron emission markers implanted in or around the tumor. It uses an expectation-maximization clustering algorithm to track the position of the markers. A normalized least mean square adaptive filter was used to predict the position of the markers 100 and 200 ms in the future. I evaluated the performance of the tracking and of the prediction by using a dynamic anthropomorphic thorax phantom to generate three-dimensional 3D motion of three fiducial markers. The algorithm was run with four different data sets. In the first run, the motion of the markers was based on a sinusoidal model of respiratory motion. Three additional runs were done with motion based on patient breathing data. In the case of the sinusoidal model, the average 3D root mean square error for all markers was 0.44 mm. For the three runs based on patient breathing data, the precision of the 3D localization was 0.49 mm. At a latency of 100 ms, the average 3D prediction error was 1.3±0.6 mm for the sinusoidal model and for the three patient breathing runs. At a latency of 200 ms, the average 3D prediction errors were 1.7±0.8 mm for the sinusoidal model and 1.4±0.7 mm for the breathing runs.

**Evaluating new techniques to improve adaptive radiotherapy**
Lesley Buckley – The Ottawa Hospital Cancer Centre

Abstract: Treatment planning techniques, combined with improved imaging, allow for the creation and delivery of increasingly complex radiotherapy treatments. One of the limitations of a conventional, forward thinking process is that these precise plans are based almost entirely on the patient anatomy at the time of treatment simulation and do not take into account changes that occur once treatment has begun. The increased use of high quality daily image guidance provides additional information regarding the changes to the tumour volume and the surrounding normal tissues throughout the course of treatment. A challenge of radiation therapy is in determining how best to use this information to adapt the treatment to reflect these changes. This talk will discuss the impact of new technology on the clinical implementation of adaptive radiotherapy. Specifically, the potential of 4-D cone beam CT imaging to assess tumour motion will be described. Also, the use of commercially available image registration software and its role in adaptive planning will be discussed.

# Elizabeth Orton, Raphael Galea

**Date: Thursday, May 17, 2012**
**Time: 3:30 - 5:00 pm – Thursday – May 17, 2012**
**Location: NRC – 1200 Montreal Road, North Campus, Building M-36 – Kelvin Room (please check in at the front desk)**

**Presentations:**

**1. "Interference of abdominal activity in 82-Rb PET myocardial perfusion imaging"**
Elizabeth Orton – Carleton University

Abstract: Positron emission tomography (PET) is considered the gold standard for myocardial perfusion imaging (MPI), defined as generating functional images showing where the blood is flowing into the myocardium by following the distribution of tracers injected into the blood stream. However, even gold standards are not without problems and one such problem encountered in PET MPI, using the two most common perfusion radiotracers (82-Rb and 13-N NH3), is interference due to high levels of tracer uptake in organs close to the heart. Bateman et al. (2006) report that liver and bowel uptake affected interpretation of 10% of Rb-82 PET MPI studies. A review of Rb-82 PET MPI records at UOHI shows that, after mitigation efforts, extra-cardiac interference due to elevated stomach wall uptake is observed at a similar frequency in 'static' images (counter intuitively, 'static' meaning images averaged over both cardiac and respiratory motion). 'Static' images can also be broken down into a cardiac gated series, routinely used to assess heart wall motion and ejection fraction. Observations of cardiac gated images suggest stomach motion over the cardiac cycle is at the sub-voxel level; while the heart contracts away from the stomach, potentially providing a frame where stomach wall to heart separation is sufficient to reliably isolate the stomach activity distribution. Assuming negligible stomach motion between cardiac gates would then allow subtraction of the stomach activity, as defined in the reliable frame, from all others, removing stomach interference in the cardiac gated data. Summation over all cardiac frames would provide a corrected 'static' image. The aim of my research is a reliable method to subtract interfering extra-cardiac signal from 82-Rb PET MPI. This will require stomach wall segmentation, noise reduction and motion assessment. A simplified analytic simulation has been developed to use as a known-truth assessment tool. The simulation matches realistic human anatomy, cardiac and respiratory motion, relative organ activity and image noise. The relationship between stomach wall segmentation and noise reduction will be demonstrated through presentation of initial approaches and results. I will conclude with an outline of future methods for investigation.

**2. "Reduce, reuse and recycle: A green solution to Canada's medical isotope shortage"**
Raphael Galea – National Research Council of Canada

Abstract: Due to the unforeseen maintenance issues at the National Research Universal (NRU) reactor at Chalk River and coincidental shutdowns of other international reactors, a global shortage of medical isotopes (in particular technetium-99m, Tc99m) occurred in 2009. The operation of these research reactors is expensive, their age creates concerns about their continued maintenance and the process results in a large amount of long-lived nuclear waste, whose storage cost has been subsidized by governments. While the NRU has since revived its operations, it is scheduled to cease isotope production in 2016. The Canadian government created the Non-reactor based medical Isotope Supply Program (NISP) to promote research into an alternative methods for producing medical isotopes. The NRC was a member of a collaboration looking into the use of electron linear accelerators (LINAC) to produce molybdenum-99 (Mo99), the parent isotope of Tc99m. This talk will outline NRC's involvement in every step of this process, from the production, chemical processing, recycling and preliminary animal studies to demonstrate the equivalence of LINAC-Tc99m with the existing supply. This process stems from reusing an old idea, reduces the nuclear waste to virtually zero and recycles material to create a green solution to Canada's medical isotope shortage.

# Sarah Cuddy, Patrick Saull and OMPI social

**Date: Thursday, September 27, 2012**
**The first OMPI seminar of the 2012-2013 academic year will be held at Carleton University:**
**Time: 3:30 - 5:00 pm - Thursday - September 27, 2012**

**Location: Carleton University - Herzberg Building - Room HP4351 (map)**

**The seminar will be followed by a social event at MacLaren's Pub located at 301 Elgin st (map)**

**Presentations:**

**High Resolution Detectors for Positron Emission Mammography**

**Sarah Cuddy - Carleton University**

Abstract: Dedicated-breast molecular imaging systems such as positron emission mammography (PEM) have potential to improve the sensitivity of cancer in women with radio-dense breasts and to reduce the false-positive rate of breast screening when used as a diagnostic adjunct. To ensure high signal-to-noise ratio and to minimize the patient dose, scintillation detectors in a PEM system must have high annihilation photon detection efficiency. This efficiency can be increased by accepting annihilation photons from wider incident angles and by using depth-of-interaction (DOI) measurement within a scintillation crystal to minimize parallax blurring. We have developed a dual-ended readout block (DERB) detector that uses asymmetry of signals from photodetectors on either end of a scintillation array to measure DOI and uses Anger Logic with light sharing to identify interacting crystal elements while minimizing the number of photodetectors required. Our design was evaluated using DETECT2000 Monte-Carlo simulation and by characterizing a prototype DERB detector. This presentation will discuss the advantages of the design and the effects of various boundary conditions on the performance of the detector.

**A Compton Gamma Imager for Safety and Security**

**Patrick Saull - National Research Council Canada**

Abstract: A Compton camera is a device that images a gamma-ray field through reconstruction of the positions and energies of incoming photons which undergo both scatter and absorption in its active volume. In 2007, our small collaboration of researchers from McGill, NRCan, and NRC was awarded $1.4 million in federal R&D funds from CRTI to develop a rugged, person-portable Compton imager for safety and security purposes. The design goal was to be able to localize a 10 mCi Cs-137 source at a distance of 40 meters to a few degrees angular resolution, in under a minute. To keep costs low, we have opted for an all-scintillator, layered design. This talk will focus on one of two approaches we are pursuing: a pixel-based detector, comprising two scatter layers of CsI(Tl) cubes read out with thin silicon photomultipliers (SiPMs), and an absorber layer of conventional NaI(Tl)/PMT units stacked into an array. The final prototype saw "first light" this past August. I will summarize its development, from conception, through early prototypes, to final design, discussing in detail the Compton method, the data acquisition, and the reconstruction algorithm.

# Islam El Gamal, David Wilkins

**Date: Thursday, October 18, 2012**
**Time: 3:30 - 5:00 pm – October 18, 2012**

**Location: West Foustanellas Auditorium (H-2366) – 2nd floor – The University of Ottawa Heart Institute, 40 Ruskin Street (map)**

**Presentations:**

**1. "Feasibility study of the determination of absorbed dose to water using a Fricke based system"**

**Islam El Gamal – Carleton University**

Abstract: By measuring the dose to water directly a metrology standard, independent of air kerma, can be developed to make the basis of HDR brachytherapy dosimetry consistent with current dosimetry methods for external radiation beams. The Fricke dosimeter system, a liquid chemical dosimeter, provides a means of measuring the absorbed dose rate to water directly by measuring the radiation-induced change in optical absorption of the Fricke solution. In an attempt to measure the absorbed dose to water directly for a 192Ir HDR brachytherapy source a ring shaped Fricke holder was constructed from PMMA. Benchmark measurements conducted in a 60Co beam yielded a standard uncertainty in the absorption reading of 0.16 %, comparable with previous results in the literature. Measurements of the standard uncertainty of the control (un-irradiated) solution using the holder yielded 0.13 %, indicating good process control and minimal contamination from the holder itself. Irradiations with a 17 GBq source, in a water phantom, gave a standard uncertainty of approximately 0.29 %, indicating that the target uncertainty of less than 1% for the measurement of absorbed dose to water using a Fricke-based primary standard is achievable. This would be comparable with water calorimeter standards currently being developed.

**2. "Radiation Safety Then and Now"**

**David Wilkins – The Ottawa Hospital Cancer Centre**

Abstract: The practice of radiation safety in cancer centers has evolved considerably over the years, from a technical discipline to an organizational approach incorporating elements of quality management with a focus on patient safety. This talk will discuss that evolution and its impact on staff doses, and will describe some recent changes to regulations which have affected the approach to radiation safety in cancer centers.

# Brandon Zanette, Rowan Thomson

**Date: Thursday, November 15, 2012**
**Time: 3:30 - 5:00 pm – November 15, 2012**
**Location: Conference room A&B, Room C2362, 2nd floor, Cancer Centre South, The Ottawa Hospital General Campus**

**Presentations:**

**1. "Validation of the Bookend Method in Dynamic Contrast Enhanced MRI"**

**Brandon Zanette – Carleton University**

Abstract: Dynamic Contrast Enhanced (DCE) MRI is a method used to obtain quantitative, biologically relevant information in a tissue of interest. DCE-MRI involves the use of a contrast agent injection which is tracked in time via a rapid T1-weighted imaging sequence. The contrast agent will cause a signal increase, which is proportional to its concentration in the tissue. One important use of DCE-MRI is the diagnosis and grading of cancer. There is often a distinct difference in parameter values measured with DCE-MRI between tumours and healthy tissue. The technique currently used for DCE measurements is susceptible to experimental error caused by spatial variation of the flip angle. The goals of this project are to gain a better understanding of this effect and to develop techniques to mitigate these errors, thereby improving concentration estimation.

**2. "Monte Carlo simulations on the cellular scale"**

**Rowan Thomson – Carleton University**

Abstract: Monte Carlo simulations are widely applied in radiotherapy for computing dose in macroscopic volumes of interest; however, there is increasing interest in applications at microscopic length scales. This presentation will describe some recent research related to Monte Carlo simulations on cellular length scales. The first part of the presentation will focus on cellular dosimetry for kilovoltage radiation and several cancerous and normal soft tissues. This research investigates how alternative macroscopic dose descriptors track absorbed dose to biologically relevant cellular targets. In the second part I will discuss research aimed at understanding the limitations of widely-used `classical' Monte Carlo simulations of low energy electron transport, and new work towards developing modelling techniques consistent with quantum theory.

# Marielle Lesperance, Costel Flueraru

**Date: Thursday, December 20, 2012**
**Time: 3:30 - 5:00 pm – December 20, 2012**
**Location: Room RPB 205B (boardroom), Health Canada, 775 Brookfield Road (map)**

**Presentations:**

**1.“Model-based dose calculations for ocular brachytherapy”**

Marielle Lesperance – Carleton University

Abstract: Ocular plaque brachytherapy has been shown to be as effective as complete removal of the eye for treatment of uveal melanoma. Despite this, local control is not always achieved and radiation damage to healthy eye structures may occur. In order to properly link treatment outcome with dose delivered, it is necessary to obtain accurate dose distributions. As current treatment planning assumes the patient is water-equivalent, eye geometry and composition are not taken into account. To assess dose sensitivity to these factors, we have created a full eye model with realistic dimensions and composition. This presentation will discuss the effects on dose of ocular media composition for three different radionuclide sources: I-125, Pd-103 and Cs-131. It will also include comparison between the current method of reporting dose to points of interest and dose to volumes of interest.

**2.“Optical imaging modalities for medical application - Optical Tomography”**

Costel Flueraru – National Research Council Canada

Abstract: Medical imaging modalities play a significant role in improving the diagnosis, the clinical management of disease and the understanding of disease pathogenesis. In the first part of this presentation I will review the optical imaging modalities and their relation with the conventional medical imaging techniques. The second part will focus on new developments of optical coherence tomography and its applications in cardiovascular imaging and tissue characterization.

# 2013

OMPI Seminar Archive

# Conor McFadden, Carl Ross and OMPI social event

**Date: Thursday, January 17, 2013**
**Time: 3:30 - 5:00 pm – January 17, 2013**
**Location: West Foustanellas Auditorium (H-2366) – 2nd floor – The University of Ottawa Heart Institute, 40 Ruskin Street.**

In the event that the rideau canal is open for skating, the seminar will be followed by an evening skate from Dow's lake to the Royal Oak at Pretoria bridge for drinks (map). Otherwise, there will be a social gathering at Pub Italia on Preston st (map).

**"Performing radiation measurements at the sub-micrometer scale"**
Conor McFadden – Carleton University

Abstract: Currently, there is no technique capable of measuring radiation quantities directly with sub-micrometer spatial resolution. Moreover, quantities describing events of energy deposition by ionizing radiation are not well defined on the sub-micrometer scale. Sub-micrometer resolution radiation measurements are important to understand the effects of ionizing radiation in cells and the effectiveness of different types of radiation in causing biological damage. The purpose of this work is to develop a technique capable of: a) measuring energy deposition events with sub-micrometer spatial resolution; and b) co-localizing these events with images of cell nuclei. A custom confocal laser scanning microscope (CLSM) was developed at Carleton which is capable of resolving ionization events in the volume of an Al2O3:C,Mg fluorescent nuclear track detector (FNTD). The spatial resolution of the FNTD technique is at the sub-micrometer scale, which is sufficient for performing radiation measurements at the level of the cell nucleus. This talk will outline the development of the CLSM, as well as our current efforts towards characterization of FNTDs for measuring radiation quantities in clinical radiation beams.

**"Making Medical Isotopes – Present Status and Future Prospects"**
Carl Ross – National Research Council Canada

Abstract: The isotope crisis of 2009 drew attention to the fact that the global supply of Tc-99m was reliant upon a few aging research reactors. The crisis prompted a review of supply options and a wide range of possibilities have been suggested. Only a few of these are technologically and economically practical and major efforts are underway to have workable solutions by the time NRU stops making medical isotopes in 2016. There are two options being explored to establish a domestic supply for Canada. One approach uses proton cyclotrons to produce Tc-99m directly while the second uses electron linacs to produce Mo-99 which decays to Tc-99m. Technology, economics and politics will all impact on how nuclear pharmacies deliver Tc-99m after 2016. I will review the pros and cons of various approaches and discuss why the electron linac option is the most promising.

# Amir Pourmoghaddas and Balazs Nyiri

**Date: Thursday, February 28, 2013**
**Time: 3:30 - 5:00 pm - February 28, 2013**
**Location: Carleton University - Herzberg Building - Room HP4351**

**"Quantitative imaging for a dedicated cardiac SPECT camera"**
Amir Pourmoghaddas - Carleton University

Abstract: Blood flow imaging of the heart is a very useful tool in the diagnosis of heart disease. The best way for measuring blood flow is by using a positron emission tomography (PET) camera. PET can measure absolute blood flow, that is, exactly how much blood flow is present rather than just a relative measure of whether some parts of the heart have more or less than others. Absolute measurements more accurately diagnose extensive multivessel coronary artery disease. Another popular way to picture blood flow is with single photon emission computed tomography (SPECT). SPECT is a less expensive technology and there are many more of SPECT cameras available than PET cameras, but SPECT has traditionally measured only relative blood flow. A recent revolution in SPECT camera design has greatly improved image quality and opened the door to measuring absolute blood flow. However, in order to increase the accuracy of the camera to allow for quantitative measurements, factors such as attenuation and scatter need to be taken into account. This presentation will describe some of the research done in order to evaluate the performance of scatter and attenuation correction techniques on a dedicated cardiac SPECT camera. Quantitative accuracy may also vary depending on the number of iterations when using iterative reconstruction algorithms. Consistency of activity measurement as a function of MLEM iterations will also be discussed.

**"Three self-referencing methods for the measurement of beam spot position"**
Balazs Nyiri - The Ottawa Hospital Regional Cancer

Abstract: High-energy electrons, striking a bremsstrahlung target in the treatment head of a linear accelerator, produce the photons used in cancer therapy. The position and distribution of the electrons (beam spot) on the target is controlled by the Linac's beam steering circuitry and influences many clinically relevant treatment and imaging properties. Three quantitative methods of measuring electron beam spot position with respect to the collimator axis of rotation are discussed.

# Bryan Muir and Trevor Stocki

**Date: Thursday, March 21, 2013**
**Time: 3:30 - 5:00 pm - March 21, 2013**
**Location: Conference room A&B, Room C2362, 2nd floor, Cancer Centre South, General Campus, 501 Smyth Road**

**"Measurements and Monte Carlo simulations for reference dosimetry of electron beams"**

Bryan Muir – Carleton University

Abstract: Clinical medical physicists follow protocols, such as the AAPM's TG-51, to calibrate high-energy radiation therapy sources. A working group of the AAPM is currently engaged in updating the TG-51 protocol for high-energy reference dosimetry. This work investigates current recommendations for electron beam reference dosimetry using measurements and Monte Carlo simulations of ion chamber response. Depth-ionization measurements with parallel-plate and cylindrical ion chamber types are performed at NRC in clinical electron beams with energies ranging from 4 to 18 MeV. Variable results are observed in terms of the short- and long-term stability of ratios of chamber readings to reference ion chambers. Monte Carlo simulations of the absorbed dose to the gas in an ion chamber and the absorbed dose to water are performed as a function of depth using the EGSnrc egs_chamber user-code. A variety of realistic clinical accelerator models as well as less realistic electron beam sources are used to study the dependence of dosimetric data on the incident source model. Using these simulations, beam quality conversion factors and gradient effects are investigated for several different cylindrical and parallel-plate chamber types.

**"Environmental Transfer Modelling to Determine Radiation Dose to Humans"**

Trevor Stocki – Health Canada

Abstract: In January 2009, the IAEA EMRAS II (Environmental Modelling for Radiation Safety II) program was launched. The goal of the program is to develop, compare and test models for the assessment of radiological impacts to the public and the environment due to radionuclides being released or already existing in the environment; help countries build and harmonize their capabilities; and to model the movement of radionuclides in the environment. Within EMRAS II, nine working groups are active; this presentation will focus on the activities of Working Group 1: Reference Methodologies for Controlling Discharges of Routine Releases. Within this working group environmental transfer and dose assessment models are tested under different scenarios by participating countries and the results are compared. This process allows each participating country to identify characteristics of their models in order to refine their methods of estimating the impact of radionuclide releases into the environment. The goal of this working group is to identify reference methodologies for the assessment of exposures to the public due to routine discharges of radionuclides to the terrestrial and aquatic environments. In the framework of this working group, several different models are being applied to estimate the transfer of radionuclides in the environment for various scenarios. In the first phase of the project, the group has been working on a scenario where a nuclear power reactor with a coastal location routinely (continuously) discharges 60Co, 85Kr, 131I, and 137Cs to the atmosphere and 60Co, 137Cs, and 90Sr to the marine environment. In this scenario many of the parameters and characteristics of the representative group were given to the modellers and cannot be altered by the users. Various models have been used by the different participants in this inter-comparison (PC-CREAM, CROM, IMPACT, CLRP POSEIDON, and others). The first scenario is to enable a comparison of the radionuclide transport and dose modelling. These scenarios will facilitate the development of reference methodologies for controlled discharges. A review of the Canadian standard on how to perform these calculations will also be reviewed during this presentation.

# Chad Hunter and Ran Klein

**Date: Thursday, April 18, 2013**
**Time: 3:30 - 5:00 pm - April 18, 2013**
**Location: Room RPB 205B (boardroom), Health Canada, 775 Brookfield Road**

**1. "Patient body motion affects myocardial blood flow quantification with rubidium-82 PET imaging"**
Chad Hunter – Carleton University

Abstract: Patient motion >0.7 cm occurs in >24% of rubidium-82 (Rb-82) dynamic PET scans, and is known to cause attenuation correction (AC) artifacts, but the effects on myocardial blood flow (MBF) quantification are less clear. This study aimed to quantify inaccuracies in MBF, induced by patient body motion. Simulations were performed using patient-derived activity distribution and time-activity curves (TAC) of Rb-82 PET, and a digital NCAT phantom. A simulation without motion was used as a reference standard. Translational motion in three dimensions (±1 and ±2 cm) was simulated (n=12), consisting of an instantaneous shift in the body location at a shift-time (30, 60, 120, 240 s). Noise-free images were reconstructed using filtered back-projection. Dynamic images were reconstructed with and without AC artifacts. Blood flow quantification was performed using the 1-tissue-compartment model, including blood spillover and partial-volume corrections as implemented in the FlowQuant (UOHI) software program. Errors were greatest for shifts at 120s, CTAC misalignment artifacts alone accounted for 5 to 13% error in MBF measurements. CTAC artifacts occurring after the shift-time resulted in 30% greater MBF error compared to those before the shift point. Dynamic body motion alone with regional partial-volume recovery correction (RC) resulted in MBF errors as high as 230%, indicating that inconsistency in the dynamic TAC data is the dominant source of MBF inaccuracy. Regional partial-volume recovery correction (RC) resulted in 80% increase in variability and 20% increase in the maximum MBF error compared to a global-average RC, indicating that regional partial-volume correction methods are also sensitive to body motion. Patient body motion of 1 to 2 cm can result in >200% error in MBF due to inconsistent myocardial TAC data, suggesting that post-reconstruction image-based motion correction may correct for the majority of body motion-induced bias in MBF measurements.

**2. "Myocardial blood flow quantification - 82Rb PET is the just the beginning"**
Ran Klein – University of Ottawa Heart Institute

Abstract: Our work on quantification of myocardial blood flow using rubidium-82 (82Rb) positron emission tomography (PET) is poised to provide precise clinical information for effective patient management, while substantially reducing the cost of these exams, and radiation exposure. The lessons we learnt and the technology we developed is now being translated to new imaging modalities and applications. This talk will introduce our cutting edge 82Rb PET technology and will highlight ongoing research which exploits this technology.

# Dal Granville, Richard Richardson and OMPI BBQ social

**Date: Thursday, May 16, 2013**
**Time: 3:30 - 5:00 pm - May 16, 2013**
**Location: NRC – 1200 Montreal Road, North Campus**

We will be finishing off this season's seminar series with a BBQ at the NRC. To help in organizing this, we would like to have an idea of how many people are planning to come to the seminar and stay for the food afterwards. **Please reply by May 13 to guarantee your share - Claudiu.Cojocaru@nrc-cnrc.gc.ca.** We will make every effort to accommodate special dietary needs (e.g. vegetarians) but only if we know in advance.

Presentations:

**1. "Measurement of average LET of proton therapy beams using optically stimulated luminescence detectors"**

Dal Granville – Carleton University

Abstract: The biological response of tissue irradiated with heavy charged particle beams depends on both the absorbed dose in the tissue and the linear energy transfer (LET) of the beam. While absorbed dose is routinely measured using a variety of detectors, there is no device available for the routine measurement and verification of LET. This work aims to further develop the optically stimulated luminescence (OSL) technique, which is already well established for absorbed dose measurements, to allow for routine measurements of LET in heavy charged particle beams, specifically proton beams. This presentation will focus on the LET dependence of Al2O3:C OSL detectors, and a proof-of-concept experiment that demonstrates the feasibility of using these detectors for LET measurements of radiotherapy proton beams.

**2. "Are Alpha- and Beta-Emitting Bone-Seeking Radionuclides Effective Treatments against Leukemia Stem Cells and Bone Metastases?"**

Richard Richardson – Atomic Energy of Canada Limited (AECL)

Abstract: Studies are in progress with clinicians/scientists at Ottawa Hospital that are examining the fundamental effects of ionizing radiation on marrow stem cells, the source of common forms of leukemia and bone cancer. I will also describe the results of a Monte Carlo simulation with scientists at Purdue University, USA, which initially indicated that the radiation dosimetry of bone metastases with bone-seeking radium-223 was effective and non-toxic, but not so when later allowance was made for the diffusion of radon-119.

# Nelson Miksys, Richard Wassenaar and OMPI social event

**Date: Thursday, September 26, 2013**
**Time: 3:30 - 5 pm**
**Location: Room HP4351, Herzberg Building, Carleton University**
**Nelson Miksys and Richard Wassenaar**

Presentations:

**1. "Patient-specific Monte Carlo dosimetry for permanent implant brachytherapy"**
Nelson Miksys – Carleton University

Abstract: Dose distributions for permanent implant brachytherapy can be more accurately calculated with Monte Carlo (MC) simulations than with the widely-used TG-43 water-based approach because tissue heterogenieties and inter-seed attenuation effects are considered. However, challenges remain in the application of MC in brachytherapy, e.g., the mitigation of streaking artifacts (due to brachytherapy sources) in CT images and the ambiguous assignment of tissues and densities when deriving patient-specific MC phantoms from CT images. This work addresses these challenges, presents results on patient-specific artifact-corrected CT- based MC dosimetry for prostate and breast brachytherapy, and paves the way for clinical application of patient-specific MC dosimetry.

**2."Device Design and Security of Radioactive Sealed Sources"**
Richard Wassenaar – Best Theratronics

Abstract: Radioactive sealed sources are common worldwide, filling a wide variety of roles, including medical usage. Due to the activity of these sources, the potential for harm to the general public is high, should the sources fall into the wrong hands and be used maliciously. Due this potential threat, there has been increased attention, at the international level, related to the security of such sources. In fact, the CNSC has recently issued new regulatory document pertaining to the security of Category 1 and 2 (high risk) sealed sources. Within this framework, manufacturers plan an important role in ensure devices are designed to meet security requirements. Best Theratronics has been actively working with various regulatory and government organizations to redesign their radiation devices with the goal of greater security in mind. In this talk, the results of that work, including the challenges faced by manufacturers and end-users, will be discussed.

The talks are followed by a social gathering at McLauren's Pub: 301 Elgin Street Ottawa, ON K2P 2N9 (map)

Time: 6-11 pm.

# Matt Rodrigues and Dan La Russa

**Date: Thursday, October 24, 2013**
**Time: 3:30 pm**
**Location: Room RPB 205B (boardroom), Health Canada, 775 Brookfield Road**

**1. "An automated high-throughput method of the cytokinesis block micronucleus (CBMN) assay for dose estimation in radiation biodosimetry"**
Matthew Rodrigues - Carleton University

Abstract: The cytokinesis-block micronucleus (CBMN) assay is employed in biological dosimetry as a method for determining the dose of radiation to an exposed individual from the frequency of micronuclei (MN) in binucleated lymphocyte cells. The assay is typically performed using manual microscopy but it would be advantageous to automate the method to allow for increased throughput. With the development of new technologies such as the ImageStreamX, an imaging flow cytometer, it is now possible to adapt the CBMN assay to an automated imaging cytometry method. The ImageStreamX has adequate sensitivity to quantify radiation doses to within ~0.5 Gy while adding the increased throughput of traditional flow cytometry. The protocol and analysis which adapts the CBMN assay for use on the ImageStreamX will be presented as well as recent results which indicate that binucleated cells (BNCs) and MN can be identified, imaged and enumerated automatically using the ImageStreamX, allowing for dose estimation.

**2. "Quality and safety initiatives in radiation therapy at the Ottawa Hospital Cancer Centre"**
Daniel La Russa - The Ottawa Hospital Cancer Centre

Abstract: This presentation will review some of the recent updates to the quality management of the Radiation Medicine Program at The Ottawa Hospital Cancer Centre (TOHCC). Emphasis will be put on the use of Failure Mode and Effect Analysis (FMEA) and the use of Statistical Process Control (SPC) in the context of a modern radiation therapy treatment process. Examples of the use of these techniques at TOHCC will be presented along with a overview of some device-centric quality control tests of our IMRT/VMAT treatment processes. A project underway to develop free, open source software for quality control of radiation therapy treatment plans will also be described.

# Frank Marshall and Tong Xu

**Date: Thursday, November 21, 2013**
**Time: 3:30 pm**
**Location: Conference room A&B, Room C2362, 2nd floor, Cancer Centre South , The Ottawa Hospital (General Campus)**

**1. "Reconstruction of a Distributed Radioactive Source with a Directional Spectrometer"**

Frank Marshall - Carleton University

Abstract: The Emergency Response Group at Natural Resources Canada is responsible for developing innovative techniques of reconstruction for localizing and mapping radioactive sources. In one area of research, the group is has been in joint collaboration with Defense Research and Development Canada (DRDC) to determine novel techniques for mapping radioactive distributed sources (RDDs). Over the past two years, Medicine Hat in Suffield, Alberta has provided the testing grounds for several experiments, in which lanthanum-140 sources were detonated. In these experiments, a directional spectrometer was used to record the spatial variation of the source intensity. It consists of four, tightly-packed, NaI detectors. It was mounted on a truck and driven around the source distribution. From this survey, the limited data of points along the truck path leave much information to be extracted regarding the true source distribution. This talk will review some of the methods that are employed to approximate the local intensity in the vicinity of the trucks path. In particular, there will be a review of the method used to determine a factor that converts the measured signal into an intensity measurement for the case of the detector overlying an infinite disc source. This method makes use of a curve of counts versus disc radius, which is called the detector footprint. Results of EGSnrc simulations will be presented for this calculation, as will results of detector parameter simulations.

**2. "A GPU implementation of EGSnrc"**

Tong Xu - Carleton University

Abstract: As an effort to enable accurate and fast Monte Carlo simulation for potential clinical use, the physics core of the well accepted Monte Carlo simulation package, EGSnrc, was implemented on the parallel computing platform based on GPU, Graphics Process Units. With hundreds of processors integrated in one cost effective board, GPU has recently shown great potential on high performance computing, including Monte Carlo simulations. An introduction to the concept of GPU computing will be given. The simulation structure of EGSnrc was changed to achieve better performance on GPU. Through the simulation of PDDs and dose profiles, the newly developed GPU based system was benchmarked and validated against the original EGSnrc.

# Martin Martinov, Peter Raaphorst

**Date: Thursday, December 19, 2013**
**Time: 3:30 pm**
**Location: Foustanellas Auditorium (room H-2367), second floor, The University of Ottawa Heart Institute. 40 Ruskin st, Ottawa, On K1Y 4W7**

**1. "Recent developments with BrachyDose"**
Martin Martinov - Carleton University

Abstract: This presentation will review the work done for and with BrachyDose in CLRP recently. It will look over a Graphical User Interface (GUI) made for the upcoming distribution of BrachyDose. The GUI has the same functionality as most of the other EGSnrc user-code GUIs wih some additional features. It will give an overview of a graphical reimplimentation of StatDose with additional functionality as well. Then it will cover an analysis of several different eye plaque models used in ocular melanoma treatments, building on the work done creating an eye model in CLRP this previous year.

**2. "The Physics and Quality Control of Clinical Bone Mineral Density Programs"**
Peter Raaphorst - Carleton University

Abstract: A serious problem in the aging process is the loss of bone minerals resulting in osteoporosis. This causes the bones to become weak a brittle and susceptible to fracture and breaking. Spinal and hip fractures can lead to severe debilitation and to death in the elderly. The rate of bone mineral loss varies between genders and amongst individuals. Early detection of bone mineral loss can lead to intervention and the delay of osteoporosis. Differential x-ray absorptiometry (DXA) can be used to detect bone mineral loss. This is a quantitative x-ray procedure that requires a high level of precision. In order to achieve this precision a quality control process has been developed to allow detection of bone mineral loss in the spine and the hip with precision as low as 0.5%. The physics and quality control of DXA will be described and examples of serious errors that were incurred when a QC program is not followed will be presented.

# 2014

OMPI Seminar Archive

# Elizabeth Orton, Sangeeta Murugkar and winter special event

**Date: Thursday, January 23, 2014**
**Time: 3:30 - 5 pm**
**Location: Room RPB 205B (boardroom), Health Canada, 775 Brookfield Road**
**Elizabeth Orton and Sangeeta Murugkar**

Presentations:

**1. "Automated detection of extra-cardiac interference in Rubidium-82 PET myocardial perfusion imaging"**
Elizabeth Orton - Carleton University

Abstract: In nuclear cardiology, myocardial perfusion imaging, MPI, is used to reflect the heart muscle's regional blood supply and it is widely applied for diagnosis and risk stratification of coronary artery disease. MPI studies produced with PET and the radio-labeled cardiac perfusion tracer rubidium-82 chloride, Rb-82, frequently show tracer uptake not only in the myocardium but also in the stomach wall and spleen. When the proximity of these structures to the myocardium is combined with local cardiac and respiratory motion and the spatial resolution of the imaging modality, the result can be an unknown amount of extra-cardiac signal contributing to the area of the image designated as myocardium. An estimated 10% of Rb-82 PET MPI studies suffer from extra-cardiac interference that impacts clinical image interpretation. An algorithm for quickly and consistently detecting extra-cardiac interference in Rb-82 PET MPI will be presented, along with validation of the algorithm against 100 expert-read studies, and finally, algorithm-based prevalence results from 2560 Rb-82 PET MPI studies from the 2011 - 2012 University of Ottawa Heart Institute database.

**2. "Optical Molecular Imaging in Biomedicine"**
Sangeeta Murugkar - Carleton University

Abstract: Optical molecular imaging (OMI) couples optical imaging with different methods of enhancing chemical contrast at the molecular level. It promises to revolutionize the field of medicine due to its comparatively lower cost, high sensitivity and resolution combined with minimal toxicity. The development and applications of a label-free OMI technique based on coherent anti-Stokes Raman scattering (CARS) will be discussed in this talk. I will describe the design and implementation of the first fiber-optic miniaturized multimodal CARS microscope for the in vivo study of spinal cord disorders in small animals. I will share my vision of label-free OMI based on this technology for early disease detection in the clinic.

The talks are followed by an evening skate on the Rideau canal, ending with a social gathering at the Royal Oak at pretoria bridge (map). Please RSVP to Elizabeth Orton (Eorton [at] ottawaheart [dot] ca) if you'll be joining us for skating and/or meeting us at the pub.

# Simin Razavi, Jason Belec and winter special event

**Date: Thursday, February 27, 2014**
**Time: 3:30-5pm**
**Location: Carleton University - Herzberg Building - Room HP4351**

**1. "Distortion and efficiency studies of Positron emission tracking system (Pe-track)"**
Simin Razavi - Carleton University

Abstract: Following the steps for the development of positron emission based 3D tracking (PeTrack), the co-registration of PeTrack with an x-ray C-arm imaging system showed an uncounted systematic error. Identification of the source of systematic error is essential in order to correct it. One of the possible sources of error could be the spatial distortion of tracking. Several simulations have been done using a Monte Carlo Software (Gate) to investigate the detection efficiency and the spatial distortion. We tracked the raster scanning of a positron source in different detector planes within the field of view. The results show that the distortion at the edge of the planes is increasing when the distance of the planes get farther from the iso-centre of the modules. Meanwhile an experiment has been done tracking a positron source in the real time, using an X-Y plotter to provide the scanning motion. The results from simulation and experiment were compared.

**2. "Modeling continuous motion in radiation therapy using Monte Carlo techniques: from breathing interplay effect to tomotherapy leaf latency"**
Jason Belec - The Ottawa Hospital Cancer Centre

Abstract: Recent advances in external photon beam radiation therapy techniques include increase in the number of degrees of freedom and continuous change of several machine parameters during treatment delivery (field shape, dose rate, tumor tracking, etc.). In this talk, we will give three clinical examples where the use of Monte Carlo techniques was useful to model continuous motion and overcome limitation of commercial clinical systems. The examples are: 1) total marrow irradiation treated with helical tomotherapy, 2) Head and neck treatments treated with helical tomotherapy and 3) stereotactic ablative lung treatments treated with volumetric modulated arc therapy.

The talks are followed by an evening skate on the Rideau canal, ending with a social gathering at GuadalaHarry's at Dow's Pavillion (map). Please RSVP to Elizabeth Orton (Eorton [at] ottawaheart [dot] ca) if you'll be joining us for skating and/or meeting us at the pub.

# Hong Shen, Gerd Melkus

**Date: Thursday, March 20, 2014**
**Time: 3:30 - 5:00 pm**
**Location: West Foustanellas Auditorium (H-2366) - 2-nd floor - The University of Ottawa Heart Institute, 40 Ruskin Street**

**1. "The NRC Wide-Angle Free-Air Chamber"**
Hong Shen - Carleton University/NRC

Abstract: NRC is setting up a national primary standard to calibrate radioactive seeds for low dose-rate brachytherapy. A commercial wide-angle free air chamber (WAFAC), based on the design pioneered by NIST, was introduced recently for measurement of air kerma strength of the seeds. In order to test the performance of the chamber, it was set up in a low-energy X-ray beam (effective energy of 31 keV) where the air kerma rate has been established using the existing NRC air kerma standard. Excellent agreement of the air kerma rate obtained with the WAFAC using the same aperture opening as the primary standard free-air chamber (FAC) validates the proper functioning of this new instrument. Measurements were also carried out for a range of WAFAC apertures, including the 80 mm aperture used for seed measurements. The results show the importance of including air scatter corrections for large aperture openings. Preliminary measurements with 125I seeds give results that are consistent with the stated seed activity. Work is ongoing to establish the correction factors and uncertainty estimates.

**2. "Development and application of biochemical MRI methods for Musculoskeletal Research"**
Gerd Melkus - The Ottawa Hospital

Abstract: Osteoarthritis and lower back pain are two major diseases which are linked to the degeneration of cartilage and adjacent tissues such as subchondral bone. Non-invasive imaging techniques can help understand articular cartilage and cartilage repair tissue. Recent developments in the field of Magnetic Resonance Imaging (MRI) can be used to characterize these tissues not only morphologically, but also biochemically. In this presentation, the concepts of quantitative MRI methods (gagCEST, T1rho and Diffusion Tensor Imaging) will be discussed. Moreover, pre-clinical and clinical applications will be shown where biochemical MRI can be used to visualize non-invasively the composition of cartilage and adjacent tissues.

# Paul Prior and Lindsay Beaton

**Date: Thursday, April 17, 2014**
**Time: 3:30-5pm**
**Location: Conference room A&B, Room C2363, 2nd floor, Cancer Centre South, The Ottawa Hospital - General Campus, 501 Smyth Road**

**1. "An iterative triple energy window approach for cross talk correction in dual isotope Tc99m & In111 small animal SPECT"**
Paul Prior - Carleton University

Abstract: Dual isotope SPECT allows simultaneous measurement of two different tracers in vivo. With In111 (emission energies of 171keV and 245keV) and Tc99m (140keV), quantification of Tc99m is degraded by cross talk from the In111 photons that scatter and are detected at an energy corresponding to Tc99m. The Triple Energy Window (TEW) uses counts recorded in two narrow windows surrounding the Tc99m primary window to estimate scatter. Iterative TEW corrects for the bias introduced into the TEW estimate resulting from un-scattered counts detected in the scatter windows. The contamination in the scatter windows is iteratively estimated and subtracted as a fraction of the scatter-corrected primary window counts. The iterative TEW approach was validated with a small-animal SPECT/CT camera using a 2.5mL plastic container holding thoroughly mixed Tc99m/In111 activity fractions of 0.15, 0.28, 0.52, 0.99, 2.47 and 6.90. Dose calibrator measurements were the gold standard. Uncorrected for scatter, the Tc99m activity was over-estimated by as much as 80%. Unmodified TEW underestimated the Tc99m activity by 13%. With iterative TEW corrections applied in projection space, the Tc99m activity was estimated within 5% of truth across all activity fractions above 0.15. This is an improvement over the non-iterative TEW, which could not sufficiently correct for scatter in the 0.15 and 0.28 phantoms.

**2. "Astronaut Biodosimetry"**
Lindsay Beaton - Health Canada

Abstract: Radiation induces damage to DNA which can be measured using cytogenetic endpoints to determine the level of exposure of an individual based on biological markers. This method is termed biodosimetry and is essential for triage in the case of a large scale radiological/nuclear emergency. Cytogenetic endpoints are also routinely used in other research projects, such as the identification of individual radiation sensitivity biomarkers, as well as the cytogenetic analysis of blood samples from astronauts. The biodosimetry of these astronaut samples provides an in vivo measurement of the biological damage from space radiation. This talk will focus on the biodosimetry methods used by Health Canada with a focus on the analysis of Canadian and European astronaut lymphocytes prior to- and post-flight, and will include some of our recent results.

# Victor Malkov, Randle Taylor, IRS tour and annual OMPI BBQ

**Date: Thursday, May 22, 2014**
**Time: 3:30 - 5:00 pm**
**Location: NRC - 1200 Montreal Road, North Campus, Building M-36 - Kelvin Room (please check in at the front desk)**

**1. "Implementing charged particle transport in electric and magnetic fields in EGSnrc"**
Victor Malkov - Carleton University

Abstract: The development of coupled MRI-radiotherapy technologies for IGRT necessitates the ability to perform Monte-Carlo calculations which take magnetic fields into account. This allows for better understanding of dose perturbations induced by these fields, including in-phantom effects and the electron return effect, apparent at air-phantom interfaces. An algorithm that takes advantage of the EGSnrc charged particle transport to improve efficiency has been implemented, and a boundary crossing method is proposed to deal with general geometries when using the EM field package. Preliminary calculations, including simple slab geometries and ion chambers with constant magnetic fields, are performed to verify functionality and applicability of the code. These calculations show that even under low field conditions the change in exit surface dose is not negligible, and warrants further study.

**2. "Filling the gaps in commercial clinical software"**
Randle Taylor - The Ottawa Hospital Cancer Centre

Abstract: At The Ottawa Hospital Cancer Centre (TOHCC) the Medical Physics group is currently using and actively developing a number of in house software applications for clinical use. Our in-house software touches on a wide range of clinical areas including our machine quality control program, treatment planning quality control, staff management, incident learning and radiation safety. Bespoke software allows our clinic to fill the gaps in commercial software offerings and create tools that fit well withing our existing clinical workflows and best practices. However, the development of custom software is not without risk and often raises concerns about software quality and ongoing support & maintenance. In this talk I'll present some of the software we've developed and discuss some of the ways we've mitigated the inherent risks of in-house software.

**3. Tour and BBQ:**

We will be finishing off this season's seminar series with a BBQ at the NRC. To help in organizing this, we would like to have an idea of how many people are planning to come to the seminar and stay for the food afterwards. Please reply by May 19 to guarantee your share : Bryan.Muir [at] nrc-cnrc.gc.ca. We will make every effort to accommodate special dietary needs (e.g. vegetarians) but only if we know in advance.

For interested students there will be a tour of the Ionizing Radiation Standards Group facilities starting at 2:00pm. Please register with Bryan at: Bryan.Muir [at] nrc-cnrc.gc.ca.

# Khalid Gameil, Emily Heath and OMPI social

**Date: Thursday, September 25, 2014**
**Time: 3:30-5 pm**
**Location: Carleton University - Herzberg Building - Room HP4351**

**1. "Data acquisition for NRC's Ionization Chambers for Radionuclide Standards"**
Khalid Gameil - Carleton University/NRC

Abstract: The Radionuclide Lab, at the National Research Council (NRC), uses ionization chambers (IC) to measure the activity of predominantly gamma-emitting isotopes. This study presents data acquired by the combinations of the two ionization chambers (Vinten or TPA) with their respected electrometers (Keithley 6517A or 6517B). This study allows for confirmation on historical data acquired with these chambers as well as give insight to the accuracy of the current process of measuring an isotope's activity. A new data acquisition (DAQ) application was created, called IC_DAQ, to communicate with the electrometers and analyze the data to output the activity in Mega-Becquerels (MBq). In addition, new methods for activity determination were incorporated into the DAQ. The DAQ was validated for multiple isotopes with known activities. Graphs of activities for each combination of isotope, ionization chamber, and electrometer were made to investigate any differences. Dose calibrators are IC's found in every Nuclear Pharmacy and Nuclear Medicine department in every hospital in Canada. The NRC can use its IC and DAQ system to calibrate and check these dose calibrators as a service. This service has been offered in the past and is currently being relaunched. A trial of this process was done at the NRC's Radionuclide Lab.

**2. "Modeling and compensating for effects of respiratory motion in lung radiotherapy"**
Emily Heath - Carleton University

Abstract: Tumour motion due to respiration poses a challenge to radiation therapy that, if unaccounted for, can lead to a suboptimal treatment. A varisssety of planning and delivery methods have been proposed to compensate for respiratory motion during radiation therapy. One approach that is currently under development is 4D radiotherapy, where individual patient respiratory motion parameters are incorporated into the plan optimization. These "4D" plans have been shown to be more conformal than conventional planning approaches, however, the added complexity of the approach means that these plans are highly sensitive to uncertainties in the patient motion model. This talk will discuss some methods to quantify these motion uncertainties and minimize their impact on the delivered dose.

The talks are followed by a social gathering at Georgetown Pub: 1179A Bank Street (map)
from 5:30pm onward. Hope to see you there.

# Leila Lukhumaidze and Miller MacPherson

**Date: Thursday, October 23, 2014**
**Time: 3:30-5 pm**
**Location: Room RPB 205 (boardroom), Health Canada, 775 Brookfield Road**
**Leila Lukhumaidze and Miller MacPherson**

**1. "Electron Impact Ionization in EGSnrc"**

Leila Lukhumaidze - Carleton University

Abstract: Monte Carlo simulations play an important role in diagnostic medical imaging, as it is relatively easy to calculate some quantities that are difficult to measure experimentally, such as x-ray doses to the breast and x-ray scatter. The x-ray spectra need to be validated. Usually the validation of Monte Carlo calculation codes is performed by doing a simulation which reproduces an actual experiment and comparing the results to the experimental data. We calculate 5-25 keV x-ray spectra emitted from different target materials using the general-purpose EGSnrc BEAM code with two different Electron Impact Ionization cross sections, one developed by Ivan Kawrakow and another developed by Salvat and referred as Penelope cross section. They are compared to the existing experimental data and a preference for the Penelope cross section is found.

**2. "The global need for radiation therapy"**

Miller MacPherson - The Ottawa Hospital Cancer Centre

Abstract: In the developing world, cancer now kills more people than HIV, malaria, and tuberculosis combined. By 2035, 70% of all cancers will occur in low and middle income countries (LMICs). Strong efforts are underway on prevention and screening to mitigate this trend, but investments in treatment infrastructure are also needed as not all cancers can be prevented. It has been established that more than half of all cancer patients should have radiation therapy at some point during the course of their care. Unfortunately, the burden of cancer is rising fastest in jurisdictions that have little or no access to radiation therapy. This talk will describe the global cancer landscape, recent efforts to address the gap at local levels, and focus on a Canadian-led initiative to elevate the need for radiation therapy to the global health policy arena.

# Marc Chamberland and Paul Johns

**Date: Thursday, November 20, 2014**
**Time: 3:30 - 5:00 pm**
**Location: Hospital Auditorium, 2nd floor, General Campus (escalator from main lobby to 2nd floor, follow signage)**

Presentations:

**1. "List-mode motion tracking and correction for positron emission tomography imaging using low-activity fiducial markers"**
**Marc Chamberland - Carleton University**

Abstract: Positron emission tomography (PET) imaging suffers from artifacts caused by patient body motion. We propose a method of tracking three-dimensional (3D) patient body motion during dynamic PET imaging by placing low-activity positron-emitting markers on a patient and using a tracking algorithm to extract the 3D motion information from the raw list-mode PET data. This information can then be used to perform motion correction on the raw list-mode data. Monte Carlo techniques were used to simulate a 92.5-kBq Na-22 marker moving sinusoidally in 3D. The simulated events were combined with list-mode data from patients undergoing cardiac PET imaging in order to test the algorithm. In experimental studies, three external Na-22 markers were placed on a dynamic torso phantom with an initial activity of approximately 680 MBq of Rb-82 in its cardiac insert. We tracked the motion of those markers while simulating breathing motion and patient drift with the phantom. Results show that the tracking can achieve submillimetre precision and accuracy. In addition, the motion information was used to correct the raw list-mode data. Reconstructed images showed no perceivable translational motion compared to the original non-motion-corrected images. We conclude that this technique can potentially replace the need for additional and expensive respiratory-motion/triggering systems used for respiratory-gated or motion-free PET image reconstruction.

**2. "X-ray scatter imaging: Cross sections, collimation, and signal extraction"**
**Paul Johns - Carleton University**

Abstract: In diagnostic radiology, scattered photons comprise up to 90% of the radiation downstream of the patient and can provide useful information above and beyond that provided by the transmitted primary x rays. Our development work on x-ray scatter imaging will be described. First, since coherent scatter cross sections are too complicated to calculate, we have measured them for some normal tissues and phantom materials using an energy-dispersive system. Second, step-and-shoot scatter imaging using multiple pencil beams has been demonstrated using 33.2 keV x rays at the Canadian Light Source synchrotron. Collimation design options range from scanning a single pencil beam in tandem with a pixelated scatter detector over the patient, which is prohibitively slow but which captures all scatter information unambiguously, to multibeam geometries which speed acquisition but are reliant on pattern untangling algorithms since the diffraction ring patterns overlap. These innovations in radiography are applicable both in medicine and in industrial nondestructive testing, security imaging, and other areas.

# Sarah Cuddy and Elsayed Ali

**Date: Thursday, December 18, 2014**
**Time: 3:30-5 pm**
**Location: Multimedia room H2373 - 2nd floor - The University of Ottawa Heart Institute, 40 Ruskin Street**

**1. "Characterizing the effect of position dependent Poission-like noise in multi-pinhole cardiac SPECT"**
Sarah Cuddy-Walsh - Carleton University
Abstract: A dedicated-cardiac single photon emission computed tomography (SPECT) camera using multiple pinholes with solid-state cadmium zinc telluride (CZT) detectors provides 2 × better energy resolution, > 4 × increase in camera sensitivity (allowing lower dose or shorter imaging time), and ~2.4 × better spatial resolution than traditional parallel-hole camera designs. The limited angle sampling of the fixed position design in the new camera however leads to a number of unique artifacts with unknown impact on image quality. Our work investigates the extent of these artifacts and how they might impact patient outcomes clinically. Two artifact effects will be discussed. First, the effect of variable pinhole sensitivity across the field of view (FOV) is shown to lead to a position dependent uncertainty in the reconstructed relative radiotracer uptake. Second, we will discuss the effect of having projection views from a limited number of angles on the reconstructed image resolution. Specifically we will look at the change in the resolution at different positions inside the FOV and with different object orientations. Conclusions from evaluating both effects may be used to aid in the interpretation of reconstructed images clinically and to make recommendations for future camera designs.

**2. "Rotational artifacts in on-board cone-beam computed tomography"**
Elsayed Ali - The Ottawa Hospital Cancer Centre
Abstract: Modern clinical linear accelerators are equipped with on-board x-ray imaging systems. These imaging systems are mainly used to acquire cone-beam computed tomography (CBCT) scans of the patient on the treatment table. The CBCT images help in reproducing the same patient position that was used to create the treatment plan. CBCT images can also, in principle, be used for dose calculations in adaptive planning. While an on-board imaging system is a valuable tool on the linac, it can introduce its own systematic errors in the radiation therapy process. This talk is about a systematic error in the Elekta on-board CBCT imaging systems in the form of a rotational artifact.

# 2015

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# Raanan Marants and Laurel Sinclair

**Date: Thursday, January 29, 2015**
**Time: 3:30 - 5:00 pm**
**Location: Room RPB 205 (boardroom), Health Canada, 775 Brookfield Road**

Presentations:

**1. "Dose and Position Quality Assurance using the RADPOS System for 4D Radiotherapy with CyberKnife"**
**Raanan Marants - Carleton University**

Abstract: Radiotherapy treatment becomes more difficult in cases where patient motion, such as breathing, causes movement of the treatment target or organs-at-risk. The CyberKnife radiosurgery system offers an excellent solution in the form of real-time tumor motion tracking through its Synchrony respiratory motion tracking system. Such a complex dose delivery system needs independent performance verification to assure safe patient treatments, which can potentially be accomplished with the RADPOS 4D dosimetry system. RADPOS consists of a microMOSFET dosimeter combined with an electromagnetic positioning sensor, enabling it to perform real-time dose and position measurements simultaneously. RADPOS is used as an independent QA tool to verify the CyberKnife system's motion tracking and delivered dose. RADPOS motion measurements are compared with internal metal fiducials and external LED optical markers log files. Dose measurements are compared with GAFCHROMIC film and treatment planning calculations

**2. "Surface contamination concentration measurements from aerial radiometric survey"**
**Laurel Sinclair - Natural Resources Canada**

Abstract: Natural Resources Canada has responsibility for emergency response mobile radiometric mapping in the event of a radiological or nuclear incident, whether accidental or malicious in nature. We fly aerial gamma-ray surveys, and extrapolate to isotope-specific concentrations on the surface of the ground, using an assumption that the radiation is infinite in extent and uniform. This approach can accurately determine the total amount of radioactivity, and specify the locations of high and low concentration. However, it suffers from the problem that it produces a result which is averaged over a large area. This is an issue which is particularly acute for emergency response where a highly localized hot spot could be misrepresented as a broad deposit which is relatively weak. We have developed a method to deconvolve the aerial radiometric map for spatial smearing. In this way we can recover some of the sharpness of the features on the ground, and get a more accurate measure of the strength of localized hot spots. In this talk, recent measurements of surface concentrations will be presented, using both synthetic and real-world data.

# Dal Granville and Dal Granville

**Date: Thursday, February 26, 2015**
**Time: 3:30 - 5:00 pm**
**Location: Carleton University - Herzberg Building - Room HP4351**

Presentations:

**1. “LET measurements in therapeutic proton beams”**
**Dal Granville - Carleton University**
Abstract: The biological response resulting from proton radiotherapy depends on both the absorbed dose in the irradiated tissue and the linear energy transfer (LET) of the beam. While absorbed dose is readily measured using a variety of detectors, there is no device available for the routine measurement and verification of LET. This work aims to further develop the optically stimulated luminescence (OSL) technique to allow for routine measurements of LET in therapeutic proton beams. This presentation will focus on the LET dependence of OSL detectors, and detail the progress made in using them to verify LET in proton therapy treatment plans.

**2. “Investigating the anomalous response of the NE2575 ionization chamber, and ideal chamber shapes”**
**Frédéric Tessier - National Research Council Canada**
Abstract: In 1993, upon acquiring a Cs-137 irradiator, physicists in Ionizing Radiation Standards at the NRC noticed that measurements with a large volume 600cc ionization chamber model NE2575 showed an unexpected deviation from the inverse square law, with a discrepancy of up to 4% at 8 meters from the source. Although this anomaly was confirmed experimentally and was well documented, a definitive explanation remained elusive. Twenty years later, we revisit this problem using EGSnrc Monte Carlo simulations to discern the contribution of each chamber component to the anomaly. We show that the observed deviation arises mostly from long photon attenuation paths inside the chamber cylindrical side wall. We propose an empirical correction to address the issue in practice, but also uncover an optimal chamber angle at which the expected behaviour is recovered. Finally, we expand the question and consider the ideal shape of an ionization chamber to minimize deviations from the inverse square law.

# Eric Christiansen and Dmitry Klokov

**Date: Thursday, March 26, 2015**
**Time: 3:30 - 5:00 pm**
**Location: Hospital Auditorium, 2nd floor, General Campus (escalator from main lobby to 2nd floor, follow signage)**

Presentations:

**1. "Clinical field ionization chamber correction factors for the CyberKnife radiosurgery system"**
**Eric Christiansen - McGill University**

Abstract: A proposed dosimetry formalism for small and non-standard fields involves the determination of ionization chamber correction factors to convert the dose measured in a clinical plan to the dose associated with either a static machine-specific reference (MSR) field, and/or a plan-class specific reference (PCSR) composite field being as close as possible to a class of clinical plans of interest. The aim of this work is to determine detector correction factors for a number of representative Cyberknife treatments, for two microchambers and a commercial plastic scintillator. First, a linac head model was created in BEAMnrc by matching percentage depth dose curves and output factors measured using an A16 microchamber with Monte Carlo calculations performed in egs_chamber to explicitly model detector response. Using this model, intermediate correction factors related to the non-water components of each detector were calculated for the microchambers and the plastic scintillator in fourteen different composite fields inside a solid water phantom. Seven of these fields used a 5 mm diameter collimator; the remaining fields employed a 7.5 mm collimator but were otherwise identical to the first seven. It was determined that large and variable CFs are required for microchambers in small composite fields primarily due to density and volume effects. Corrections are reduced but not eliminated for a plastic scintillator in the same fields.

**2. "Effects of low dose gamma-radiation on cellular aging"**
**Dmitry Klokov - Canadian Nuclear Laboratories**

Abstract: The use of ionizing radiation for diagnostic imaging in medicine has increased tremendously over the past three decades, mostly due to rise of the computed tomography technology. Debates continue whether such increased exposures to low doses of ionizing radiation (LDR) may lead to detrimental health effects, such as cancer, later in life. Cellular aging or senescence, a state of irreversible cell cycle arrest, is a means by which damaged cells are prevented from becoming precancerous cells. However, it has recently been linked to cancer due to proinflammatory signalling elicited by senescent cells which promotes cancer growth. We, therefore, sought to examine whether LDR can affect cellular aging/senescence, which in turn may affect cancer risk. Primary cultures of normal human diploid fibroblasts were exposed to 10, 100 mGy or left untreated at a young age and were maintained under normal growth conditions for 70 days in which 100% of cells normally reach the state of senescence. Different end-points were measured in the course of aging the cell cultures related to: a) senescence markers; b) gene expression; c) cell proliferation; d) microRNA expression. Our results showed that accumulation of senescent cells with time was delayed in LDR-exposed cultures. This was accompanied by an increased rate of proliferation and changes in the expression of genes involved in various cellular pathways, such as DNA repair, cell cycle, DNA damage signaling and epigenetic gene expression regulation. Profiling of 1008 most abundantly expressed microRNA genes revealed a significant number of changes in LDR-exposed vs. control cells. Our results suggest that LDR is capable of suppressing the rate of cellular aging in vitro and that the mechanisms of such effect include gene expression changes mediated by epigenetic microRNA pathways. It is important to validate these results using in vivo mouse models and such studies are currently underway at Canadian Nuclear Laboratories. Extended to the in vivo conditions, these data may be used for evaluating potential health risks in patients exposed to LDR in the medical setting, as well as to nuclear industry professionals or public exposed to LDR as a result of nuclear accidents.

# Patty Oliver and Eric Vandervoort

**Date: Thursday, April 23, 2015**
**Time: 3:30 - 5:00 pm**
**Location: West Foustanellas Auditorium (H-2366) – 2-nd floor – The University of Ottawa Heart Institute, 40 Ruskin Street**

Presentations:

**1. "A study of macroscopic and microscopic dose descriptors for kilovoltage cellular dosimetry using Monte Carlo simulations and cavity theory"**
**Patty Oliver – Carleton University**

Abstract: Monte Carlo (MC) simulations and cavity theory are used to investigate cellular dosimetry for kilovoltage photon sources. Multicellular models of normal and cancerous tissues are developed using data from a literature review; MC simulations are employed to compute doses to cellular targets for a variety of cell morphologies as well as doses to bulk tissues and water. Simulation geometries involve cell clusters, single cells, and single nuclear cavities embedded in various healthy and cancerous bulk tissue phantoms. Cell and nucleus radii range from 5 to 10 microns and 2 to 9 microns, respectively. Variations in cell dose with simulation geometry are most pronounced for lower energy sources: the nuclear dose in a multicell model differs from the dose to a cavity of nuclear medium in an otherwise homogeneous bulk tissue phantom by more than 7% at 20 keV. Bulk tissue and water cavity doses differ from cellular doses by up to 16% so that neither water nor bulk tissue is an appropriate surrogate for subcellular targets in radiation dosimetry. MC results are compared to cavity theory predictions; large and small cavity theories qualitatively predict nuclear doses for energies below and above 50 keV, respectively. Various intermediate cavity theory methods are reviewed. The influence of microscopic inhomogeneities in the surrounding environment on the nuclear dose and the importance of the nucleus as a target for radiation-induced cell death emphasizes the potential importance of cellular dosimetry for understanding radiation effects.

**2. "Sources of uncertainty in composite field delivery for the Cyberknife radiosurgery system"**
**Eric Vandervoort – The Ottawa Hospital Cancer Centre**

Abstract: In recent years, stereotactic ablative radiosurgery (SABR) has moved from using rigid frames fixed to a patient's skull to the use of non-invasive frameless techniques requiring in-room image guidance. The Cyberknife, consisting of a compact linear accelerator mounted to an industrial robotic arm, is one such SABR system which has been in use at the Ottawa hospital since 2010. This system delivers highly conformal radiation dose by employing many (typically > 100) small aperture (5 to 60 mm in diameter) radiation fields from many different non-coplanar directions. The central axes of these beams may share a common point of intersection (isocentric) and provide highly-conformal spherically-shaped radiation dose distributions similar to those delivered using arc therapy with cones on a conventional LINAC. The vast bulk of Cyberknife treatments, however, treat arbitrary shaped tumours using hundreds of non-isocentric beams with their central axes directed at points on the exterior surface of a target. The Cyberknife robotic radiosurgery system also employs a complex motion prediction algorithm to compensate for respiratory motion in extracranial treatments. Measurement and simulated results for single detectors and film in a phantom geometry for these isocentric and non-isocentric composite fields will be discussed. The initial calibration of the robot treatment positions, static field commissioning, and the tests employed to monitor and maintain delivery accuracy will be described with a focus on the differences between the Cyberknife and conventional gantry mounted LINAC systems, along with sources of error and opportunities for further investigation.

# OMPI Seminar and annual BBQ: Nima Sherafati and Rebecca Thornhill

**Date: Thursday, May 28, 2015**
**Time: 3:30 - 5:00 pm**
**Location: NRC – 1200 Montreal Road, North Campus, Building M-36 – Kelvin Room (please check in at the front desk)**

Presentations:

**1. "Kilo-Voltage X-ray Tube Correction Factors for In-water Measurement"**

**Nima Sherafati – Carleton University**

Abstract: For x-ray tube potentials larger than 100 kV, the AAPM TG-61 protocol for 40-300 kV x-ray beam dosimetry in radiotherapy recommends an in-water measurement which is based on ionization chambers calibrated in air in terms of air kerma. We studied the variation of the overall correction factor (PQch) and its components (known as corrections for the change in the chamber response due to the change in the spectrum distribution in phantom compared to that used for the calibration in air (kQ), displacement of water by the ionization chamber (Pdis) and displacement of water by the stem (Pstem)) as well as the correction for a waterproofing sleeve (Psheath) with depth and field size for 6 different beam qualities in the orthovoltage x-ray range (100 kV < tube potential < 300 kV).

**2. "Searching for hidden patterns in cancer and cardiovascular images"**

**Rebecca Thornhill – The Ottawa Hospital**

Abstract: Conventionally, radiologists produce diagnoses on the basis of a combination of their training, experience, and individual judgment. Radiologists perceive image patterns and associate or infer a diagnosis consistent with those patterns. However, there will be an inevitable degree of variability in image interpretation as long as it relies primarily on human visual perception. Pattern analysis can provide a quantitative vocabulary for the otherwise subjective characteristics of lesions. Tools for automated pattern recognition can provide objective information to support clinical decision-making and may serve to reduce variability. To date we have applied quantitative shape and texture pattern analysis to a number of cancer and cardiovascular imaging applications. Several of these will be discussed, with particular focus on how pattern analysis can supplement conventional radiologic interpretation. Finally, these applications will also provide opportunities to discuss some of the pitfalls and challenges presented by these techniques.

* We will be finishing off this season's seminar series with a BBQ at the NRC.
To help in organizing this, we would like to have an idea of how many people are planning to come to the seminar and stay for the food afterwards.
Please contact Bryan.Muir@nrc-cnrc.gc.ca by May 25 to guarantee your share.
We will make every effort to accommodate special dietary needs (e.g. vegetarians) but only if we know in advance.

# OMPI and Social Event: Jaswinder Taank and Malcolm McEwen

**Date: Thursday, September 17, 2015**
**Time: 3:30-5:00 pm - Refreshments start at 3:15 pm.**
**Location: Carleton University, Herzberg Building, Room HP4351**

Presentations:

**1. "Examining the influence of humidity on Farmer chamber performance"**

**By Jaswinder Taank - McMaster University and National Research Council Canada**

Abstract: The average energy required to produce an ion pair in an ion chamber (W) is mostly dependent on the gas, the temperature/pressure of the gas, and the type/energy of the radiation. The humidity of the gas also plays a role, albeit a much smaller one. Its influence appears to be flat for typical room humidities and therefore, it often gets ignored in most scientific labs. However, its influence is much more pronounced near relative humidities of 0 and 100% . ICRU 31, the most comprehensive document on the topic, reports an influence of up to ± 0.3%, but it relies on old data generated from the 60s and 70s. Obtaining a more accurate understanding of this behaviour is important for standards labs in particular, because we require uncertainties of about the same order. In this project, we explore the influence of humidity on various farmer chambers using a weak Sr-90 beta source. We also show our most recent measurements from a Co-60 gamma source.

**2. World-Wide Radiation Metrology: The BIPM, the CIPM MRA, SIM and NRC**

**By Malcolm McEwen - National Research Council Canada**

Abstract: Since the Metre Convention was signed in 1875 there has been steady progress to ensure the consistency of measurements from one country to another. The Bureau International des Poids et Mesures (BIPM) co-ordinates comparison exercises that demonstrate the equivalency of measurement standards from one national laboratory to another with the aim of simplifying international commerce and eliminating cross-border regulatory barriers.
This presentation will describe how the international realization of the SI is managed under the Mutual Recognition Arrangement of the CIPM and show how NRC, as Canada's National Measurement Institute, plays a major role in world-wide radiation metrology. In addition to the explanation of the many acronyms in this field, the presentation will present the results of recent international comparisons of Canadian measurement standards.

**Social event details**

For the first OMPI social event of the season, we are going to head over to Maclarens (301 Elgin Street) to play some pool. It is a short drive from Carleton University, and we will try to arrange rides for those who need it. If you are interested in participating or making suggestions regarding OMPI socials in the future, please fill out this short form (http://goo.gl/forms/LfwOFuVHlH). Your RSVP via the form would be greatly appreciated.

# OMPI Seminar: Chad Hunter, Dmitry Klokov and Yi Wang

**Date: Thursday, October 22, 2015**
**Time: 3:30-5:00 pm - Thursday 22 October 2015. Refreshments start at 3:15 pm.**
**Location: Room RPB 205 (boardroom), Health Canada, 775 Brookfield Road Carleton University.**

Presentations:

**1. Motion correction in Positron Emission Tomography (PET) imaging**

**By Chad Hunter, Carleton University and The University of Ottawa Heart Institute.**

Abstract: Patient motion is a common problem during dynamic PET scans for quantification of myocardial blood flow (MBF). Computer simulation studies indicate that errors in MBF can approach 500 % for scans with severe patient motion. Motion correction algorithms should be effective in identifying mid- and late-time-frame motion, and motion in the left/right direction, since these cases produce the largest errors in MBF, particularly for high resolution PET imaging. A post reconstruction image-based method, and a pre reconstruction projection-based method for detecting and correcting patient motion was developed and evaluated.

**2. Rejuvenating effect of low dose gamma-radiation on blood immunological parameters: Evidence for mice vs. human**

**By Dmitry Klokov and Yi Wang, Canadian Nuclear Laboratories.**

Abstract: Our previous results indicated that low dose gamma-radiation may delay the onset of cellular senescence/aging in an in vitro model of normal human fibroblasts. We extended this result into an in vivo mouse study wherein we examined various immunological and DNA damage and repair parameters in C57Bl6/J mice. We compared responses to 10 mGy of gamma-radiation in 2-months old (young) with those in 26-months old (aged) mice. We found that responses in aged mice were in general more pronounced. An aged related shift in levels of blood cytokines (16 cytokines screened) was observed in non-exposed mouse groups. Strikingly, 2 weeks after 10 mGy dose, levels of 6 cytokines in aged mice were reversed back to the levels observed in young non-irradiated control mice. This rejuvenating effect of low dose gamma-radiation on immunological blood cytokine levels required further verification using functional immunological assays in mice, as well as in human patients undergoing low dose diagnostic irradiations.

# OMPI Seminar: Amir Pourmoghaddas and Ruth Wilkins

**Date: Thursday, November 19, 2015**
**Time: 3:30-5:00 pm. Refreshments start at 3:15 pm.**
**Location: The Ottawa Hospital Auditorium, second floor, General Campus**

Webstream has been arranged for this month's presentation. If you want to watch it from your computer, the webcast link is: http://webcast.otn.ca/mywebcast?id=49875450

Presentations:

**1. Analytically-based photon scatter modeling for a dedicated cardiac SPECT camera**

**By Amir Pourmoghaddas, Carleton University and The University of Ottawa Heart Institute.**

Abstract: Photon scatter is one of the main effects contributing to the degradation of image quality and to quantitative inaccuracy in Cardiac SPECT imaging. One possible way to calculate photon scatter is to model the photon propagation from emission until the photon is lost or detected by the camera, such as in Monte Carlo approaches. Monte Carlo calculations have the advantage of being capable of producing extremely accurate and precise results, but have a large computational burden. In this talk, I will present a technique based on the analytic photon distribution (APD) method for calculating the photon distribution in SPECT projections, as measured with our dedicated pinhole cardiac SPECT camera. This technique uses an estimate of the source distribution and a map of the attenuating medium and is capable of producing scatter calculations in times that have the potential for integration in the clinic. Validation of the technique using phantom experiments will also be presented.

**2. The Canadian Biodosimetry Network**

**By Ruth Wilkins, Health Canada**

Abstract: Health Canada is the lead of the Canadian Biodosimetry Network which provides biologically based dose assessments for potentially exposed individuals during a large scale event involving radiological or nuclear material. During such an event, biodosimetry is essential for providing timely assessments of radiation exposure for the general population and to identify first responders who must be restricted from further exposure.

The dicentric chromosome assay (DCA) is currently the accepted biodosimetry method for radiation dose assessment; however in a mass casualty scenario this assay is not well suited for providing timely dose estimates due to its time- and expertise-intensive nature. Health Canada has been working to increase triage-quality biological dosimetry throughput by networking both within Canada and internationally. For such networks to function, it is essential to perform proficiency testing to ensure each laboratorys ability to produce high quality dose assessments.

A series of these inter-comparisons will be described. In addition, much effort has been devoted to developing novel, high throughput methods for biological dosimetry. An overview of recent progress in these methods will be presented.

# OMPI Seminar: Sara Kashi and Glenn Wells

**Date: Thursday, December 10, 2015**
**Time: 3:30-5:00 pm. Refreshments start at 3:15 pm.**
**Location: Centre Foustanellas Auditorium, Second Floor, The University of Ottawa Heart Institute, 40 Ruskin Street.**

Presentations:

**1. 4D Monte Carlo simulations for verification of delivered dose to a moving anatomy**

**By Sara Kashi, The Ottawa Hospital Cancer Centre and Carleton University**

Abstract: One of the main concerns during radiotherapy treatment of lung cancer is the impact of respiratory motion on the dose delivered to the target. Different approaches have been used to estimate the dose delivered to a patient while accounting for such motions. In this talk, I will present a 4D Monte Carlo simulation method that uses measurements of a patient's respiratory motion pattern to calculate the dose delivered to a continuously moving anatomy during static or VMAT beam deliveries. A Monte Carlo model of the Elekta Agility linac has been used for dose calculations with this method. Validation of this method using measurements on a respiratory motion phantom will be presented as well.

**2. The pros and cons of pinhole SPECT**

**By Glenn Wells, The University of Ottawa Heart Institute**

Abstract: Single-photon emission computed tomography (SPECT) is an imaging modality that is commonly used in the management of cardiac disease. Standard SPECT cameras use parallel-hole collimators, but recently cardiac SPECT cameras with pinhole collimators (and multiple detectors) have been introduced into the clinic. Compared to standard cameras, the multi-pinhole design offers advantages in both sensitivity and resolution which allows decreased acquisition times and reduced patient radiation exposure. The multi-pinhole camera design can also be stationary (i.e. non-rotating) which greatly increases temporal resolution and opens the door to dynamic SPECT imaging. However, a complication of the pinhole collimators is that they produce variable resolution, magnification, and sensitivity across the field of view (FOV) of the camera. The greater complexity of the imaging geometry places a higher demand on the accuracy of the system model used for image reconstruction and methods do not presently exist to measure the camera configuration and
ensure image quality. In this presentation, I will discuss some of the pros and cons of using pinhole collimator cameras for cardiac SPECT and some of the work we have been doing to investigate and characterize these cameras.

# 2016

OMPI Seminar Archive

# OMPI Seminar: Mehan Haidari and Rolf Clackdoyle

**Date: Thursday, January 21, 2016**
**Time: 3:30-5:00 pm - Thursday 21 January 2016. Refreshments start at 3:15 pm.**
**Location: Room RPB 205 (boardroom), Health Canada, 775 Brookfield Road.**

Program:

**1. Retrospective dosimetric Monte Carlo study for permanent implant prostate brachytherapy at the Ottawa Hospital Cancer Centre**

**By Mehan Haidari, Carleton University.**

Abstract: Current clinical dose calculation methods for low dose-rate (LDR) prostate brachytherapy are performed following the protocols defined by the AAPM Task Group report no. 43 (TG43) formalism. Under the TG-43 formalism, absorbed dose is calculated in a homogeneous water phantom, ignoring the effects of tissue heterogeneities. Additionally, dose contributions from each radionuclide are considered independently, ignoring interseed attenuation and scattering effects. Using Monte Carlo (MC) techniques, these limitations inherent to TG-43 are overcome. This talk will investigate the MC technique used to calculate dose distributions for a cohort of patients that received LDR prostate brachytherapy at the Ottawa Hospital Cancer Center. Furthermore, some work done in linking patient outcomes with these more accurate dose calculation models will be discussed.

**2. Data consistency conditions and their relevance to medical imaging**

**By Rolf Clackdoyle, Hubert Curien Laboratory in France, and Physics Deartment at Carleton University**

Abstract: X-ray Computed Tomography (CT), Positron Emission Tomography (PET), and Single Photon Emission Computed Tomography (SPECT) scanners gather “projections” at different orientations around the patient, and these projections are assembled by the reconstruction algorithm to form a three-dimensional image of the corresponding physical parameter (electron density, positron-emitting isotope, gamma-emitting isotope respectively).

These projections gather largely independent information, which is why so many of them are measured. However, there is a small amount of redundancy (or overlap of information) between projections. This redundancy can be described precisely using mathematical equations referred to as data consistency conditions (DCC). The DCC can be used to remove undesired systematic effects (such as patient motion, to name one of many examples) from the measurements before image reconstruction. Very recently there has been progress in identifying DCC for fanbeam and conebeam imaging geometries which are particularly suitable for CT. One such example of new fanbeam DCC will be presented with a toy problem to illustrate the approach and efficacy in removing systematic effects, even in the presence of (zero-mean) noisy data.

# OMPI Seminar: Nelson Miksys and Ian Cameron and Social Event

**Date: Thursday, February 25, 2016**
**Time: 3:30-5:00 pm. Refreshments start at 3:15 pm.**

**Location: Herzberg Building Room 4351, Carleton University.**

Program:

**1. Patient-specific Monte Carlo dose calculations for Pd-103 permanent implant breast brachytherapy**

**By Nelson Miksys, Carleton University.**

Abstract: This talk will summarize a recent investigation of patient-specific Monte Carlo dose calculations for patients who received Pd-103 permanent implant breast brachytherapy at The Ottawa Hospital Cancer Centre. One purpose of this work is to compare retrospectively calculated dose distributions between the clinical AAPM TG-43 water-based approach and the Monte Carlo method which models patient-specific anatomy. DVH-metrics evaluated in the PTV and the skin can differ by up to 27% and 48% respectively between TG-43 and Monte Carlo, which may help inform a future reassessment of prescription dose and OAR dose limits. A second purpose of this investigation is to explore the sensitivity on Monte Carlo dose calculations from the necessary modelling choices required to derive virtual patient-specific models. The observed sensitivities motivate the development of clear consensus modelling guidelines to build upon the limited recommendations provided in AAPM TG-186. Towards this goal, we present modelling choice suggestions based on our experiences with patient-specific Monte Carlo dose calculations of breast brachytherapy.

**2. Using MRI to assess microvascular blood flow**

**By Ian Cameron, The Ottawa Hospital, and Physics Deartment at Carleton University**

Abstract: Detailed knowledge of microvascular flow can be very useful for the assessment of certain pathologies. We have been working with a radiologist at The Ottawa Hospital for the past several years to develop better ways of measuring microvascular parameters for gliomas using MRI. There are several MRI techniques that are sensitive to microvascular flow. The more established methods track contrast agent as it flows through the tissue; other approaches do not require the injection of a contrast agent. In the first part of my talk I will briefly introduce these different methods, giving relative merits and shortcomings of each. The focus of the talk will then shift to a discussion of Diffusion Weight Imaging and how it could potentially be used to obtain information about slow blood flow in tissues. While it is known that these measurements are sensitive to slow flow, it is not known how the parameters obtained with this approach relate to the parameters from the other MRI approaches. The goal of the research project is to investigate this relationship.

**3. Social event announcement from Liz:**

Calling all Ottawa physicists (and friends!),

Although the weather is still making the availability of canal skating a prediction with large associated uncertainty, Id like to invite you all to come out for a Winter OMPI Social following the next seminar. Should the canal be open, athletic enthusiasts are invited to join me for a skate from Carleton down to Pretoria, followed by drinks and food at the Royal Oak at Pretoria.

For those of us who are not interested in freezing their toes off, I will make the reservation at the Royal Oak early enough that you can proceed straight there from the seminar. Please feel free to bring friends,

significant others, they typically do an excellent job of balancing the physics-over-beer conversation with all the other things the rest of the world is interested in.

**When? Thurs Feb 25th, 5:45pm onwards**
**Where? Royal Oak Pretoria, (website gives address as Canal 221 Echo Drive)**
**What to do? Please RSVP to me eortontoh.on.ca so I can estimate the reservation size**

I have an extra pair of size 8 mens (~ size 9 womens) hockey skates in case anyone needs to borrow them.

Looking forward to seeing you!

# OMPI Seminar: Hamid Moradi and Richard Richardson

**Date: Thursday, March 24, 2016**
**Time: 3:30-5:00 pm - Thursday 24 March 2016. Refreshments start at 3:15 pm.**
**Location: The Ottawa Hospital Auditorium, 2nd floor, main hospital, 501 Smyth Road**

Program:

**Webcast link: http://webcast.otn.ca/mywebcast?id=53907227**

Presentations:

**1. Characterization of radioresistance in human ovarian cancer cells**

By Hamid Moradi, Carleton University

Abstract: “The development of a radiosensitivity predictive assay is an attractive goal in radiation Oncology. Since there is a high degree of inter-patient variability in the inherent sensitivity or resistance to therapy, it is crucial to have the ability to identify molecular markers that correlate with sensitivity or resistance to radiation treatment. We have applied Raman micro-spectroscopy (RMS) in vitro to discriminate between the ovarian carcinoma cell lines A2780s (parental wild type) and A2780cp (cisplatin cross radio-resistant variant). These two cell lines represent a good model of tumor tissues of similar origin but with different intrinsic chemo- and radio-sensitivities. Moreover, their radiobiological behavior has been extensively studied and their survival curves under different irradiation schemes are known. The Raman spectra collected from individual cells undergo initial preprocessing (background subtraction, normalization and noise reduction) to yield true Raman spectra representative of the cells. The mean of these spectra are analyzed with Principal Component Analysis (PCA) followed by Linear Discriminant Analysis (LDA) to yield a strong separation between the cell lines. The objective of this ongoing work is to characterize the spectral differences between the two cell types in order to determine the underlying biochemical basis for this separation. The multivariate classification model constructed using such Raman spectra of ovarian cancer cells could potentially be utilized for early prediction of tumor response.”

**2. Talk on 2016 paper by Richard Richardson and Mary-Ellen Harper, University of Ottawa: “Mitochondrial stress controls the radiosensitivity of the oxygen effect: Implications for radiotherapy”**

By Richard Richardson, Canadian Nuclear Laboratories, Chalk River

Abstract: It has been more than 60 years since the discovery of the oxygen effect that empirically demonstrates the direct association

between cell radiosensitivity and oxygen tension, important parameters in radiotherapy. Yet the mechanisms underlying this principal tenet of radiobiology are poorly understood. Better understanding of the oxygen effect may explain difficulty in eliminating hypoxic tumor cells, a major cause of regrowth after therapy. Our analysis utilizes the Howard-Flanders and Alper formula, which describes the relationship of radiosensitivity with oxygen tension. Here, we assign and qualitatively assess the relative contributions of two important mechanisms. The first mechanism involves the emission of reactive oxygen species from the mitochondrial electron transport chain, which increases with oxygen tension. The second mechanism is related to an energy and repair deficit, which increases with hypoxia. Following a radiation exposure, the uncoupling of the oxidative phosphorylation system (proton leak) in mitochondria lowers the emission of reactive oxygen species which has implications for fractionated radiotherapy, particularly of hypoxic tumors. Our analysis shows that, in oxygenated tumor and normal cells, mitochondria, rather than the nucleus, are the primary loci of radiotherapy effects, especially for low linear energy transfer radiation. Therefore, the oxygen effect can be explained by radiation-induced effects in mitochondria that generate reactive oxygen species, which in turn indirectly target nuclear DNA.

# OMPI: Martin Martinov and Claudiu Cojocaru

**Date: Thursday, April 21, 2016**
**Time: 3:30-5:00 pm. Refreshments start at 3:15 pm.**
**Location: Centre Foustanellas Auditorium, Second Floor, The University of Ottawa Heart Institute, 40 Ruskin Street.**

Webcast possibility is being explored. Will update in the next announcement.]

Student speaker

**Title: Applications of EGSnrc Monte Carlo simulations on subcellular length scales**
**Speaker: Martin Martinov, PhD student at Carleton University**
**Supervisor: Professor Rowan Thomson**

Abstract: Increasingly, studies are using Monte Carlo (MC) simulations to investigate the effects of radiation on cellular and subcellular length scales. These studies aim to improve our understanding of microdosimetry and biological effects for existing treatments, as well as to contribute to the development of novel treatment techniques such as the use of gold nanoparticles as radiosensitizers. Due to the challenges and uncertainties of traditional MC simulations at subcellular scales, there is considerable variation in the use of simulation parameters, MC codes and modelling approaches. This work investigates MC simulations on subcellular length scales in a variety of contexts, working towards the development of a more robust, comprehensive, and efficient framework for microscopic simulations."

Member speaker

**Title: Water calorimetry as a primary standard for absorbed dose to water**
**Speaker: Claudiu Cojocaru, PhD, National Research Council Canada**

Abstract: In order to investigate the stability of a water calorimetry system as a primary standard for absorbed dose to water, measurements were performed in Co-60 and high energy linac photon beams over a span of several years. Over this period, four sealed and three unsealed water vessels saturated with various gases were used to measure absorbed dose to water. These experiments showed that the water calorimeter system is stable for both the sealed and unsealed water vessels.

between cell radiosensitivity and oxygen tension, important parameters in radiotherapy. Yet the mechanisms underlying this principal tenet of radiobiology are poorly understood. Better understanding of the oxygen effect may explain difficulty in eliminating hypoxic tumor cells, a major cause of regrowth after therapy. Our analysis utilizes the Howard-Flanders and Alper formula, which describes the relationship of radiosensitivity with oxygen tension. Here, we assign and qualitatively assess the relative contributions of two important mechanisms. The first mechanism involves the emission of reactive oxygen species from the mitochondrial electron transport chain, which increases with oxygen tension. The second mechanism is related to an energy and repair deficit, which increases with hypoxia. Following a radiation exposure, the uncoupling of the oxidative phosphorylation system (proton leak) in mitochondria lowers the emission of reactive oxygen species which has implications for fractionated radiotherapy, particularly of hypoxic tumors. Our analysis shows that, in oxygenated tumor and normal cells, mitochondria, rather than the nucleus, are the primary loci of radiotherapy effects, especially for low linear energy transfer radiation. Therefore, the oxygen effect can be explained by radiation-induced effects in mitochondria that generate reactive oxygen species, which in turn indirectly target nuclear DNA.

# OMPI Seminar and BBQ: Nick Majtenyi and Boguslaw Jarosz

**Date: Thursday, May 19, 2016**
**Time: 3:30-5:00 pm - Thursday 19 May 2016. Refreshments start at 3:15 pm.**
**Location: NRC - 1200 Montreal Road, Building M-36 - Kelvin Room (please check in at the front desk).**

Program:

**1) Comparing input function measurements in DCE-MRI using phase and MOLLI**
**Nick Majtenyi, PhD student at Carleton University**
Supervisor: Professor Ian Cameron

Abstract: Dynamic contrast-enhanced (DCE)-MRI is a quantitative imaging technique to obtain tissue hemodynamic information (e.g. tumours). Despite widespread clinical application of DCE-MRI, the technique suffers from a lack of standardization and accuracy, especially with respect to the concentration-versus-time of gadolinium (Gd) contrast agent in feeding arteries (the input function, IF). MR phase has a linear quantitative relationship with Gd concentration ([Gd]), making it ideal for measuring the first-pass of the IF, but is not considered accurate in the steady-state washout. Modified Look-Locker Inversion Recovery (MOLLI) is a fast and accurate method to measure T1 and has been validated to quantify typical [Gd] ranges experienced in the washout of the IF. This work compares two different methods to compute the IF used for DCE-MRI: (1) conventional phase-versus-time and (2) phase-versus-time combined with pre- and post-DCE MOLLI T1 measurements.

**2) Ultrasound thermal therapy of cancer: Models and phantom measurements for brain**
**Boguslaw Jarosz, Emeritus Professor, Carleton University**

Abstract: This talk presents issues regarding ultrasound thermal therapy of cancer. A design of an interstitial waveguide applicator will be presented and its physical characterization in a water phantom will be described. Results of measurements imply that for use in thermal therapy an array of applicators must be considered and such an array will be considered for treatment of brain tumours. First, FEA computations of blood flow effects on temperature pattern will be shown. This will be followed by details of a design of blood vessels incorporating phantom with its physical characterization. Heating patterns in the phantom will conclude the presentation.

**3) End of season BBQ**

Please don’t forget to RSVP Bryan (Bryan.Muir(at)nrc-cnrc.gc.ca) if you will be attending the BBQ after the seminar (along with any dietary restrictions). Deadline for RSVP is May 16th.

# OMPI Seminar and Social: Victor Malkov and Greg Cron

**Date: Thursday, September 22, 2016**
**Time: 3:30 - 5:00 pm. Refreshments start at 3:15 pm.**
**Location: Herzberg Building Room 4351, Carleton University.**

Presentations:

**1. "Magnetic fields in EGSnrc - validation and applications"**

By Victor Malkov, PhD student at Carleton University, Supervisor: David W. O. Rogers

Abstract:
Development of synergistic MRI-radiation therapy machines requires magnetic field capable Monte Carlo codes. We have implemented an efficient and accurate code to perform charged particle transport in magnetic fields in EGSnrc. Verification with the Fano cavity theorem demonstrates excellent agreement between our calculations and theory while also highlighting sensitivities in the magnetic field Fano cavity
testing procedure. The code is used to evaluate the effects of the magnetic field on ion chamber response and lung dose near heterogeneous structures.

**2. "The University of Ottawa seven Tesla small animal MRI: cerebral and renal perfusion"**

By Greg Cron, PhD, Imaging physicist at The Ottawa Hospital

Abstract:
Dynamic contrast-enhanced (DCE) magnetic resonance imaging (MRI) involves rapid, repeated MRI imaging during intravenous infusion of a contrast agent. These data are combined to make a "movie" of contrast agent delivery to tissues of interest. The movie can be analyzed to obtain blood flow characteristics of the tissue, which can help diagnose pathologies. Development of DCE-MRI protocols is non-trivial, however, especially for small animals. This talk will discuss the first two successful implementations of DCE-MRI on UofO's 7T animal MRI scanner. The first research project looked at how eating a junk food diet affects stroke recovery in rats. The second ongoing project is investigating the effect of aspirin on hypertensive mice and rats.

**Social event:**
Coordinated by the OMPI graduate student representative, Martin Martinov

This year's first OMPI social will be held at McLaren's on Elgin. A night of drinks and billiards to kick off

# OMPI Seminar and tour of NRC facilities: Alexandra Bourgouin and Bryan Muir

**Date: Thursday, October 20, 2016**
**Time: 3:30 - 5:00 pm. Refreshments start at 3:15 pm.**
**Location: NRC - 1200 Montreal Road, Building M-36 - Kelvin Room (please check in at the front desk).**

TOUR: There will be a tour of NRC facilities right after the seminars, starting around 5 pm. NRC staff would like to know the number of people interested in the tour in order to organize the logistics. If you're interested please email **Dr. Malcolm McEwen (Malcolm.McEwen@nrc-cnrc.gc.ca)**.

Presentations:

**1) "Ion chamber dose measurements - problems with the temperature-pressure correction factor"**
**By Alexandra Bourgouin, PhD student, Carleton University and NRC**
Supervisor: Malcolm McEwen

Abstract:
Purpose: To investigate the behavior of ionization chambers over a wide pressure range. Methods: Three cylindrical and two parallel-plate designs of ion chamber were investigated. The ion chambers were placed in vessel where the pressure was varied from atmospheric (101 kPa) down to 5 kPa. Measurements were made using Co-60 and high-energy electron beams. The pressure was measured to better than 0.1% and multiple data sets were obtained for each chamber at both polarities to investigate pressure cycling and dependency on the sign of the charge collected.

Results: For all types of chamber, the ionization current, corrected using the standard PTP, showed a similar behaviour. Deviations from the standard theory were generally small for Co-60 but very significant for electron beams, up to 20 % below P = 10 kPa. The effect was found to be always larger when collecting negative charge, suggesting a dependence on free-electron collection. The most likely source of such electrons is low-energy electrons emitted from the electrodes. This signal would be independent of air pressure within the chamber cavity. The data was analyzed to extract this signal and it was found to be a non-negligible component of the ionization current at atmospheric pressure. In the case of the parallel plate chambers, the effect was approximately 0.25 %. For the cylindrical chambers the effect was larger - up to 1.2 % - and dependent on the chamber type, which would be consistent with electron emission from different wall materials. For the electron beams, the correction factor was dependent on the electron energy and approximately double that observed in Co-60.

Conclusion: Measurements have indicated significant deviations of the standard pressure correction that are consistent with electron emission from chamber electrodes. This has implications for both primary standard and reference ion chamber-based dosimetry.

**2) "Progress toward updating the TG-51 protocol for electron beam reference dosimetry"**
By Bryan Muir, PhD
National Research Council Canada

Abstract:
The addendum to the TG-51 protocol for photon dosimetry was published in 2014 and included refinements to the original protocol. The revision for electron beam dosimetry will require more extensive changes. In this talk, I will discuss progress toward updating the protocol for electron beam dosimetry including: (i) updated Monte Carlo calculations of electron beam quality conversion factors, (ii) gradient corrections and optimal shifts for accurate electron beam dosimetry, (iii) the use of cylindrical chambers in electron beams, and (iv) electron beam primary standard water calorimetry to obtain measured beam quality conversion factors at the National Research Council.

# Special event: Dr. Peter Raaphorst COMP Gold Medal Celebration and Spencer Manwell

**Date: Thursday, November 17, 2016**
**Location: The Ottawa Hospital - 501 Smyth Road, Royal Room (very close to the entrance of the cafeteria).**
**Time: The student talk will be from 3:30 to 4:00 pm as per usual. The event for Dr. Raaphorst will start at 4:00 pm.**

This month we are replacing the member speaker with a special event to celebrate Dr. Peter Raaphorst's COMP Gold Medal Award. The afternoon is catered with light refreshments starting at 3:15.

Program:

**1) "Toward patient motion compensation in PET imaging studies using PeTrack"**

By Spencer Manwell, PhD student, Carleton University

Supervisors: Tong Xu, Rob deKemp, Ran Klein

Abstract: The presence of patient motion can introduce PET image artifacts, such as overestimation of the size of tissues of interest and underestimation of tracer uptake. Artifacts such as these can adversely impact a clinician's ability to diagnose or stage disease. Various approaches exist that seek to address these problems by compensating or correcting the motion of the patient during an imaging procedure. One approach, PeTrack (positron emission tracking), will be the focus of this talk. A review of the PeTrack algorithm, recent evaluations of its performance and prospective investigations into its uses will be discussed.

**2) Dr. Peter Raaphorst celebration:**

The event starts at 4:00 pm. The first 30 mins are short reflections on Dr. Raaphortst's career and accomplishments, including remarks from Dr. Raaphorst himself. The rest of the afternoon is not structured so that people get a chance to mingle and talk with Peter.

# OMPI Seminar: Chris Dydula and Dave Rogers and tour of Health Canada, Radiation Protection facilites

**Date: Thursday, December 15, 2016**
**Times: 2:00 - 3:00 - Tour of Health Canada facilites, 3:30 - 5:00 pm - Refreshments start at 3:15 pm.**
**Location: Room RPB 205 (boardroom), Health Canada, 775 Brookfield Road, Ottawa. Please check in at the front desk.**

The tour of Health Canada facilities requires sign up. Please RSVP Lindsay Beaton (lindsay.beaton@hc-sc.gc.ca).

Presentations:

**1) "Prototyping an x-ray scatter projection imaging system at the Canadian Light Source"**
**By Chris Dydula, PhD student, Carleton Universit**y
Supervisor: Dr. Paul Johns

Abstract: A major challenge in traditional x-ray projection imaging, which utilizes only information from primary photons, is obtaining adequate soft-tissue contrast. We are developing a high soft-tissue contrast x-ray projection imaging technique at the Canadian Light Source synchrotron based on the detection of low-angle scattered photons. In order to acquire scatter images in reasonable times, we have configured a system with multiplexed 3 mm2 rectangular pencil beams at 33.2 keV and with samples moving continuously at 1 cm/s during the scan. A consequence of faster acquisition is an increase in the complexity of the scatter data, requiring additional corrections when reconstructing images.

**2) "Using Monte Carlo to improve reference dosimetry for low dose rate brachytherapy"**
**By Dave W. O. Rogers, PhD, Carleton University**

Abstract: TLD dosimetry with LiF has been widely used to establish dosimetry parameters for use in brachytherapy, most notably dose rate constants. However almost all of the literature is based on calibrations and factors from the 1980s and/or ignores the fact that the signal per unit dose to the LiF varies substantially with photon energy and/or ignores the fact that the dose to LiF per unit dose to water depends on the details of the seed and shape of the detector. This talk is about using Monte Carlo techniques to overcome these problems and to provide a reanalysis of measured dose rate constants for 24 different seeds. This improves the agreement between the calculated and measured values to within about 1% on average as opposed to the previous disagreement of 5% on average.

# 2017

OMPI Seminar Archive

# OMPI Seminar: Stephen Deering and Ernesto Mainegra-Hing

**Date: Thursday, January 19, 2017**
**Time: 3:30 - 5:00 pm - Thursday 19 January 2017. Refreshments start at 3:15 pm.**
**Location: East Foustenallas Auditorium (H2368), Second Floor, The University of Ottawa Heart Institute, 40 Ruskin Street.**

**1) Calculating Dose Distributions with EGS Brachy - A new EGSnrc user code**

By Stephen Deering, MSc student, Carleton University, Supervisor: Dr. Rowan Thomson

Abstract: egs_brachy is a new, efficient Monte Carlo user code which has been developed in order to enable more accurate brachytherapy dose calculations for both research and clinical applications. This talk will present some preliminary research done using egs_brachy, in the form of dose calculations for ocular and breast brachytherapy. For ocular brachytherapy, depth dose curves were calculated and benchmarked for a large range of photon and beta-emitting eye plaques, which are widely used in the treatment of intraocular tumors. Then, the ability of egs_brachy to provide a comprehensive look at model-based dose calculations for permanent seed implant breast brachytherapy will be discussed. These two topics show a small sample of the possible uses for egs_brachy and provide good examples to introduce both the user code and its ability to improve on current model-based dose calculations.

**2) Accuracy of electron transport in the presence of magnetic fields with EGSnrc**

By Ernesto Mainegra-Hing, PhD, National Research Council Canada

Abstract: Since the 2016 release, EGSnrc, a well-known toolkit for the Monte Carlo simulation of electron, positron and photon transport, allows the inclusion of the effect of electromagnetic fields on the transport of charged particles. EGSnrc's main strength resides in its ability to transport charged particles accurately and efficiently thanks to its charged particle transport algorithm and exact multiple scattering theory. The approach used to model the transport of charged particles in the presence of a magnetic field is described, and its accuracy tested by means of a modified Fano test, valid under very specific conditions. Fano tests are carried out for an ion chamber and a slab geometry of varying density showing that accurate results can only be obtained when restricting charged particles to take very small condensed-history steps. The impact on simulation time is discussed as well as the possibility of increasing calculation efficiency using variance reduction techniques.

# OMPI Seminar: Ming Lui and Pat Saull

**Date: Thursday, February 16, 2017**
**Time: 3:30 - 5:00 pm. Refreshments start at 3:15 pm.**
**Location: Carleton University, 1125 Colonel By Drive, Herzberg Building, Room 4351.**

Agenda:

**1) Student speaker: "Accuracy of the CyberKnife Synchrony respiratory tracking system for liver cancer"**

**By Ming Liu, PhD student, Carleton University**

Supervisors: Drs. Eric Vandervoort and Joanna Cygler.

Abstract: Organ motion management during radiotherapy treatment is the biggest challenge for accurate dose delivery to the tumor. The CyberKnife® Robotic Radiosurgery System tracks real-time respiratory motion and automatically corrects for changes in the tumor position. The Synchrony respiratory motion compensation system used by CyberKnife estimates tumor motion based on the positions of internally implanted fiducials and external motion from LED markers located on the exterior of the patient. For each treatment, the CyberKnife system generates log-files that include estimates of its own tracking accuracy, based on the difference between predicted and internal fiducial position measurements acquired every 1 to 2 minutes. Today, I will present a retrospective analysis of the log-files for 40 liver patients treated on the CyberKnife at TOHCC. I will also show a software tool I created that allows for off-line analysis of patient breathing traces recorded in treatment log-files.

**2) Member speaker: "Compton gamma imaging"**

**By Pat Saull, PhD, National Research Council Canada**

Abstract: I present recent results on the development of Compton gamma imagers for safety and security, an effort lead by NRC in collaboration with researchers and end users from NRCan, DRDC, CBSA, the RCMP, and DND. Starting off with EGSnrc simulations of a pinhole camera imaging gamma rays of varying energy, I briefly discuss the coded-aperture approach before showing how well the Compton method works using experimental data from a 262-channel, all-scintillator, lab-based Compton imager. The design and fabrication of a 40-channel portable imager read out entirely with silicon photomultipliers is reviewed and the results obtained with it during recent field exercises shown. Our first pass at a commercial imager is introduced. Finally, because Compton imagers are also spectrometers, a method is outlined for calibrating an imager in terms of air-kerma rate at different energies using calibrated liquid sources combined with EGSnrc simulations. There may be a movie, but maybe not.

**3) Social Event: Message from the graduate student representative Martin Martinov:**

Due to the relatively hot temperatures of this winter, skating down the canal does not seem as viable an option this year as it was in previous years. Worry not though, as you can drink your warm winter woes away at Patty's Pub, located at 1186 Bank Street. It is only a 5 minute drive,

15 minute bus ride or even a 30 minute walk (if you are so inclined) from Carleton. It is a great opportunity to socialize with other OMPI members whom you normally see only once a month. I hope to see you there!

# OMPI Seminar: Ericka Venturina and Janos Szanto

**Date: Thursday, March 23, 2017**
**Time: Refreshments start at 3:15 pm. Seminar 3:30 - 5:00 pm**
**Location: NRC - 1200 Montreal Road, Building M-36 - Kelvin Room (please check in at the front desk).**

**1) "Modern implementation of dynamic conformal arc therapy"**

**By Ericka Venturina, MSc student, Carleton University, Supervisor: Elsayed Ali.**

Abstract: Dynamic Conformal Arc Therapy (DCAT) is an external beam radiation therapy modality that conforms the beam to the tumor while the linac head is rotating around the patient. The classical version of DCAT allows for only a single dose rate and no modulation. A modern implementation of DCAT features dose rate variation and modulation around the periphery of the target. These additional degrees of freedom make this modern implementation of DCAT closer to that of Volumetric Modulated Arc Therapy (VMAT) – a modality known for its ability to conform the radiation dose to the target and to carve it away from nearby healthy tissues. In this talk, I will present the methods and results of my characterization of this modern implementation of DCAT.

Based on this characterization, I will present the potential niches of DCAT in the current radiation therapy landscape in terms of planning efficiency, conformality, and robustness against machine and patient uncertainties.

**2) "Clinical innovations of stereotactic radiotherapy in Ottawa"**

**By Janos Szanto, PhD, The Ottawa Hospital cancer Centre**

Abstract: One of the first LINAC-based stereotactic radiotherapy in 1991 was established in Ottawa. Shortly after, we developed a patient position monitoring system (PPMS) - a world first. Our successful stereotactic radiotherapy clinical program has been functional for more than 17 years. CyberKnife entered a new era in 2010. Since then, we have had numerous clinical innovations: specialized imaging for trigeminal neuralgia or arteriovenous malformation (AVM); new fiducial application was evolved for liver lesions, prostate cancer treatments, etc; we also established a new patient-specific quality assurance program.

# OMPI Seminar: Eric Christiansen and Lesley Buckley

**Date: Thursday, April 20, 2017**
**Time:3:30 - 5:00 pm, Refreshments start at 3:15 pm.**
**Location: Room RPB 205 (boardroom), Health Canada, 775 Brookfield Road, Ottawa. Please check in at the front desk.**

Agenda:

**1) "Implementation of VMAT in matRad, an open source treatment planning toolkit"**

**By Eric Christiansen, PhD student, Carleton University**

Supervisor: Dr. Emily Heath

Abstract: Purpose: To implement and evaluate single-arc volumetric modulated arc therapy (VMAT) plan optimization within matRad, an open-source treatment planning system. Materials and Methods: The three-step approach to VMAT optimization was followed: fluence map optimization (FMO) followed by arc sequencing, then direct aperture optimization (DAO). FMO was performed at control points (CPs) spaced every 28°, with the optimal fluence maps sequenced in a sliding window fashion. Resulting apertures were spread to CPs neighbouring those initialized by FMO. These apertures were refined during the DAO step, with machine delivery constraints included in the optimization. Sequencing parameters were optimized using conformal index and delivery time as two preliminary benchmarks. Following this, three representative cases were planned: a C-shaped target surrounding a critical structure, a prostate target, and a head-and-neck target (both of the latter included lymph nodes). Dose volume metrics in the target and organs at risk (OARs) were calculated and compared to local clinical guidelines. Results: All clinical OAR constraints were met for the three investigated plans. Dose in each target exhibited varying degrees of homogeneity, with the C-shaped target, prostate, and head and neck having variations of 3.7%, 7.6%, and 9.2% between D95% and D5%. Delivery time ranged from 2.2-2.6 min; optimization time ranged from 9-12 min. Conclusions: matRad is now capable of optimizing high-quality VMAT plans that have reasonably short treatment times. VMAT optimization has been implemented as an extended module, which will be released in an upcoming update of matRad.

**2) "Imaging dose in radiation therapy: a sad tale of neglect"**

**By Lesley Buckley, PhD, The Ottawa Hospital Cancer Centre**

Abstract: Increased use of imaging in radiation therapy has impacted many aspects of treatment: including targeting, patient positioning and dose fractionation. Many new treatment techniques rely heavily on the information provided by improved imaging at the time of both simulation and treatment. The radiation dose from imaging is small when compared to the therapeutic dose and is therefore seldom taken into account when computing the total patient dose. This talk will discuss the various sources of imaging dose for a patient undergoing radiation therapy and will quantify this dose for a variety of cases. Methods to reduce this dose will be discussed, including clinical protocols as well as software driven dose reduction techniques.

# OMPI Seminar: Particia Oliver and Graeme Wardlaw and Year-end BBQ

**Date: Thursday, May 25, 2017**
**Time: 3:30 - 5:00 pm - Thursday 25 May 2017. Refreshments start at 3:15 pm. BBQ starting at 5 pm.**
**Location:NRC - 1200 Montreal Road, Building M-36 - Kelvin Room (please check in at the front desk).**
Agenda:

Program:

**1) Investigating energy deposition in glandular tissues for mammography using multiscale Monte Carlo simulations**

**By Particia Oliver, PhD student, Carleton University**

Supervisor: Dr. Rowan Thomson

Abstract: Multiscale models of compressed breasts are developed, and a mammographic exam is simulated using Monte Carlo. These multiscale models combine varying levels of detail on different lengthscales: cell populations consisting of >1000 mammary epithelial cells and ~200 adipocytes are embedded throughout the breast tissue. We compute specific energy (energy imparted per unit mass) in mammary epithelial cell nuclei, and doses to corresponding macroscopic (~mm) voxels containing glandular issue for a 30 kVp Mo/Mo spectrum.

Mammography glandular voxel doses underestimate mean specific energies to epithelial cell nuclei by ~25%, with considerable variations (~82% relative to the mean for a glandular voxel dose of 4 mGy) in specific energy throughout corresponding cell populations, in addition to considerable dose variations (between 1 and 18 mGy) throughout the breast. Energy deposition within mammary epithelial cell nuclei is sensitive to microscopic model details including cellular elemental composition and nucleus size. Results may be relevant for radiation-induced cancer risk evaluation in mammography.

**2) Computed Tomography (CT) Diagnostic Reference Levels (DRLs): Context, Canada, and Caveats**

**By Graeme Wardlaw, PhD, Health Canada**

Abstract: The concept of the Diagnostic Reference Level (DRL) has existed for some time – dating back to publication of ICRP reports 60 and 73 in 1991 and 1996. With increased attention on radiation safety in recent years, especially in relatively higher dose procedures such as computed tomography (CT), DRLs have become widely developed and promoted as a means to help manage patient exposures while avoiding restrictive limits on imaging practice. A brief introduction to the DRL concept and proposed DRLs obtained from the recent National CT Survey will be presented, along with a summary of some important DRL limitations.

**3) End of yeart BBQ**

If you plan on attending the BBQ please RSVP to Byran Muir (Bryan.Muir@nrc-cnrc.gc.ca) so that NRC folks get an idea of how much food to prepare.

# OMPI Seminar: Sara Kashi, Dal Granville, Malcolm McEwen

**Date: Thursday, September 21, 2017**
**Time: 3:30-5:00 pm (Refreshements start at 3:15)**
**Location: Herzberg Building Room 4351, Carleton University.**

**Note: Seminar will be followed by annual social event: TBD**

Agenda:

**1. "Experimental verification of 4D Monte Carlo simulations of dose delivery to a deforming anatomy"**

**by Sara Kashi, Supervisors: Emily Heath and Joanna Cygler.**

Abstract: One of the main concerns during radiotherapy treatment of lung cancer is the impact of respiratory motion on the dose delivered to the target. Different approaches have been used to estimate the dose delivered to a patient while accounting for such motions. In this talk I will present our 4D Monte Carlo simulation method that uses measurements of a patient's respiratory motion pattern to calculate the dose delivered to a deformable phantom during static or VMAT beam deliveries.

The phantom is designed in a way to emulate the radiological and motion properties of the lung. A Monte Carlo model of the Elekta Infinity linac has been used for dose calculations with this method. Validation of this method using measurements on a respiratory motion phantom will be presented as well.

**2. "Machine learning applications in patient-specific quality assurance"**

**by Dal Granville, Supervisors: Justin Sutherland and Dan La Russa**

Abstract: Patient-specific quality assurance (QA) measurements are routinely performed prior to the delivery of intensity modulated radiotherapy treatments to verify accuracy in dose calculation and plan delivery. In this work, we applied machine learning techniques to our database of ~2000 patient-specific QA measurements to examine the impacts of treatment plan complexity and linac performance on patient-specific QA results. The goals of this work were to isolate problematic plan features from problematic linac issues and to pre-emptively identify treatment plans that are likely to fail QA. Such techniques allow clinical physicists to better identify corrective actions when failures occur, and have the potential to reduce the considerable resources dedicated to the patient-specific QA process.

**3. "OMPI: state of the union"**

**by Malcolm McEwen, PhD**

Abstract: As OMPI looks towards its 30th Anniversary we have a lot to be proud of. This celebratory presentation will provide an overview of OMPI: where it came from, who is involved and what makes it special. In a sentence, OMPI is a self-governing volunteer network that is the foundational element to building a world-class medical physics educational program in Ottawa that capitalizes on expertise distributed over several clinical, government, and academic centres. The presentation will expand on this and attendees will be energized by the content, finding it hard not to plunge headlong into volunteering with OMPI in any way they can.

**4. Social Event**

Details: Nick Majtenyi has made a reservation at Patty's Pub near Carleton (1186 Bank Street) for a group gathering after the seminar.

# OMPI seminar: Sarah Cuddy-Walsh and Dave Wilkins

**Date: Thursday, October 19, 2017**
**Time: 3:30 - 5:00 pm (Refreshments start at 3:15 pm)**
**Location: East Foustenallas Auditorium (H2368), Second Floor, The University of Ottawa Heart Institute, 40 Ruskin Street.**

Presentations:

**1. "Standardizing Image Quality: A weight-based dosing method for dedicated cardiac SPECT"**

**by Sarah Cuddy-Walsh PhD Candidate (Supervisor: Glenn Wells)**

Abstract: Given the same injected activity (330MBq) and acquisition time (5 min), large patients (102 kg) will have more SPECT image noise (6.7%) due to attenuation effects than petite patients (70 kg, 4.8%). Current guidelines for SPECT imaging recommend tailoring the administered activity to patient habitus, however robust methods to do so are lacking. We have developed a weight-based formula to calculate patient specific radiotracer activity requirements to standardize the magnitude of image noise present in all images. Use of this formula improves the standardization of image quality, holding the image noise constant with 4.8% and 5.0% noise for 70 and 102 kg patients given 332 MBq and 483 MBq respectively.

**2. "Medical Physics for World Benefit (MPWB): A sustainable development initiative to improve global access to radiotherapy"**

**by Dave Wilkins, PhD**

Abstract: It is estimated that 12.5 million cancer patients will need radiation therapy in 2035, but the world's capacity to deliver this treatment is inadequate, especially in low and middle income countries. This talk will discuss the challenges in meeting this need and some recent efforts to overcome these challenges, and the development of a nascent charitable organization, Medical Physics for World Benefit (MPWB), which is dedicated to providing support for medical physicists in low and middle income countries.

# OMPI Seminar: Kevin Britton and Jennifer Renaud

**Date: Thursday, November 23, 2017**
**Time: 3:30 - 5:00 pm. Refreshments start at 3:15 pm.**
**Location: Room RPB 205 (boardroom), Health Canada, 775 Brookfield Road, Ottawa. Please check in at the front desk.**

Agenda:

**1) "A radium series multimedia model as a tool in health physics"**

**By Kevin Britton, MSc student in Earth Sciences, University of Ottawa**

Supervisor: Dr. Trevor Stocki

Abstract: Health Canada is responsible for collecting and utilizing information to protect Canadians from health risks associated with radionuclides in food and the environment. Improved modelling of radionuclides enables better human dose assessments. The present study is to develop the easy to use and adaptable Hg Environmental Ratios Multimedia Ecosystem Sources (HERMES) model to estimate concentrations of radium-226, lead-210 and polonium-210 in waterways that may be elevated by location and / or human activity. This sub-series is prevalent at significant concentrations in air, soil, water and organisms. The series comprises about 30% of ingestion doses to humans, and more significant overall doses to many populations and species. Lead-210 and polonium-210 are more difficult to measure than other radionuclides in potential human food sources. The model can inform sampling design optimization where media and biota data are difficult to collect or not available.

**2) "Canadian technology for rubidium-82 PET: perfusion imaging and blood flow quantification"**

**By Jennifer Renaud, Msc, University of Ottawa Heart Institute**

Abstract:Cardiovascular disease remains the leading cause of death worldwide. Traditionally, relative perfusion imaging with SPECT has been the most commonly used technique for the diagnosis and prognosis of coronary artery disease. However, the reduced supply of Tc-99m has motivated the investigation of alternative methods. PET imaging with rubidium-82 is gaining more widespread use due to its superior diagnostic accuracy and its availability without the need for an onsite cyclotron. The Canadian-developed technology for delivery of rubidium-82 to patients and its utility in PET perfusion imaging and blood flow quantification will be the focus of this presentation.

# OMPI Seminar: Zack Parsons and Rob deKemp

**Date: Thursday, December 14, 2017**
**Time: 3:30 - 5:00 pm - Refreshments start at 3:15 pm.**
**Location: Boardroom H-2403, Second Floor, The University of Ottawa Heart Institute, 40 Ruskin Street.**

Presentations:

**1. Monte Carlo calculation of doses for eye plaque brachytherapy.**

**By: Zack Parsons, MSc student.**

Supervisor: Rowan Thomson.

Abstract: egs_brachy is a new Monte Carlo user code developed by members of the CLRP research group for fast brachytherapy dose calculations. This talk presents recent results obtained with egs_brachy that focus on eye plaque brachytherapy, a treatment widely utilized for ocular melanomas. The use of egs_brachy allows for the development of techniques for a more accurate model based approach to the calculation of dose as opposed to the more generally used TG-43 approximations. The results to be presented include the comparison of dose to previous data for both photon eye plaques and beta-emitting Ru/Rh-106 eye plaques for benchmarking purposes, and the implementation of the new EGSnrc egs_radionuclide source for use with beta-emitting plaques. Future work leading to the simulation of the non-uniformity in beta plaque dose distributions will also be discussed.

**2. Title: PET Molecular Imaging of (Para-)Sympathetic Innervation of the Heart: Understanding the (Yin-) Yang Control of Cardiac Function.**

**By: Rob deKemp, PhD.**

Abstract: The autonomic nervous system regulates heart function through a balance of sympathetic (fight-or-flight) and para-sympathetic (rest-and-digest) control signals. Non-invasive imaging of so-called ‘cardiac innervation’ can be performed using radio-labeled tracers, which are generally analogs of the respective neurotransmitters, nor-epinephrine and acetyl-choline. The two most commonly used tracers (I-123-mIBG and C-11 mHED) have been developed for SPECT and PET imaging of the sympathetic nervous system (SNS) in patients with poor cardiac pump function, i.e. those in various stages of heart failure. Imaging and analysis methods vary from planar measurements of relative heart-to-mediastinum ratios, to dynamic volumetric measurements for quantification of receptor or transporter density and activity. Pre-clinical and clinical applications of PET SNS imaging will be shown in diabetes, heart failure, sleep apnea, coronary artery disease and atrial fibrillation.

# 2018

OMPI Seminar Archive

# OMPI Seminar: Elizabeth Orton and Elizabeth Henderson + Tour of GammaPod

**Date: Thursday, January 18, 2018**

**Tour**

**Time: 2:15**
**Location: Main enterance to The Ottawa Hospital, By the escalators and the Second Cup**

Presentation: The Ottawa Hospital Cancer Centre has recently acquired a GammaPOD unit by Xcision for specific types of breast cancer treatments. It is the only one of its kind in Canada. Dr. Eric Vandervoort is the lead physicist for GammaPOD, and he graciously agreed to give a tour of the GammaPOD suite to those interested before the OMPI seminar this Thursday. No reservation Required.

**Seminar**

**Time: 3:30-5:00 pm. Refreshments start at 3:15 pm.**
**Location: The Ottawa Hospital Auditorium, 2nd floor, main hospital, 501 Smyth Road**

Presentations:
**1. "Towards accurate bowel dosimetry in radiation therapy"**
**By Elizabeth Orton, PhD, Physics resident, The Ottawa Hospital Cancer Centre. (Supervisor: Elsayed Ali)**

Abstract: The bowel is an important organ-at-risk during radiation therapy of many pelvic and spinal disease sites. Accurate knowledge of the radiation dose to the bowel is important for correlating bowel dose with early (nausea, vomiting, diarrhea ) and late (obstruction, ulceration) toxicities, for bowel sparing during treatment planning, and for determining if prophylactic medication is necessary to proactively reduce the effects of early toxicity (as these medications themselves have unwanted side effects). The literature on this topic is extremely limited, and clinicians currently operate on the basis of their own experience. In the first part of this talk, the barriers to accurate bowel dosimetry will be identified. These barriers include lack of practical "ground truth" and associated uncertainty for the bowel (inconsistent bowel definitions, inter- and intra-observer contouring variability, etc), bowel mobility during fractionated radiation therapy, bowel visibility on daily cone beam CT images, deformable-image registration challenges in the abdominal area, and issues with dose accumulation for the bowel. The second part of the talk will report on the development of practical guidelines for bowel contouring definitions and evaluation of the associated inter- and intra-observer variability on treatment planning CT and on cone beam CT.

**2. "Training clinical medical physicists at The Ottawa Hospital Cancer Centre"**
**By Elizabeth Henderson, PhD FCCPM**

Abstract: The Ottawa Hospital (TOH) has a long history of training medical physicists for careers as clinical radiation oncology physicists. In this talk, I'll present the evolution of our training program, connections (past and future) between OMPI and the TOH radiation oncology physics residency program, and give an overview of our current program. I'll also discuss the contributions that physics residents make to both the clinical work and the research and development work at TOH. Finally, I'll share what I've learned from recent recruitments, and give some tips for graduate students considering residency programs.

# OMPI Seminar and Social Outing: Iymad Mansour and Balazs Nyiri

**Date: Thursday, February 15, 2018**
**Time: 3:30 - 5:00 pm - Refreshments start at 3:15 pm.**
**Location: Herzberg Building Room 4351, Carleton University.**

Presentations:

**1) "Development of a mailed audit protocol for Canada using Alanine dosimeters"**
**by Iymad Mansour, MSc student, National Research Council and Carleton University**

Supervisor: Dr. Malcolm McEwen

Abstract: The National Research Council of Canada (NRC) is currently in the process of developing a mailed audit system using alanine dosimeters. The intention is to offer an on-demand dosimetry service that would provide an independent check on the dose measurements of each Canadian cancer center and thus ensure consistency of treatment across the country. The focus of this talk will be on the development of a clinically applicable alanine dosimetry protocol. Alanine, which was originally developed for dosimetry at the kGy level, has a series of hurdles when considering clinically applicable dosimetry caused by both the readout procedure as well as pellet handling conditions. To achieve a mailed dosimetry service with the targeted sub 1% uncertainty a robust protocol must be developed in order to mitigate these sources of error.

**2) "Investigations towards Raman Spectroscopy based blood dosimetry"**
**by Dr. Balazs Nyiri**

The Ottawa Hospital Cancer Centre

Abstract: Raman spectroscopy has recently gained interest for providing biochemical information using a label-free, non-invasive approach. It is non-destructive and applicable on all sample types with minimal sample volume requirement and has successfully been applied in recent years, among others, in biological, medical, and food industry applications. It also offers portability for the real-time assessment of biochemical changes, a feature most welcome in clinical and in-field applications.

Here, we present work towards the development of a novel approach to identify Raman spectral features in blood that are modified by radiation exposure. Whole blood, lysed blood and isolated white blood cells were used for initial assessment. A workflow from sample handling to analysis was established. A pilot study was conducted using freshly drawn blood from 8 healthy donors. The blood was ex-vivo irradiated at doses ranging from 0-5 Gy. Three hours post-irradiation, the samples were frozen to lyse cellular contents. Each sample was analyzed on a commercial portable Raman spectrometer system. The initial results are promising and show convincing evidence of discrimination between blood samples of different radiation doses using multivariate statistical analysis methods. However, further work is needed to optimize spectrum quality and measurement efficiency. For this purpose, we are currently investigating the possibility of developing a "flow-cell" attachment to the portable Raman system. With this we hope to minimize sample degradation thereby improving spectrum quality, also increase reproducibility, and data collection efficiency.
Social event details (a message from Nick Majtenyi)

With a recent change in the weather predicted for Thursday the canal is CLOSED overnight on Wednesday for maintenance, and may not be open Thursday for skating. Instead, let's all meet up for beer closer to Carleton at The Senate Tavern on Bank (1159 Bank Street, near the intersection of Belmont & Bank) following the seminar! It has its own stop off the #7 bus or about a 20 minute walk away. Please feel free to bring friends, significant others, or anyone you'd like for this great opportunity to socialize with other OMPI members!

I hope to see everyone there!

# OMPI Seminar: Harry Allen and Raphael Galea

**Date: Thursday, March 22, 2018**
**Time: 3:30 - 5:00 pm - Refreshments start at 3:15 pm.**
**Location: Room RPB 205 (boardroom), Health Canada, 775 Brookfield Road, Ottawa. Please check in at the front desk.**

Presentations:

**1) "Towards classification of cells by dose using Raman spectroscopy"**
**by Harry Allen, MSc student, Carleton University,**

Supervisor: Dr. Sangeeta Murugkar

Abstract: Recent studies investigating the effects of ionizing radiation (IR) on the lens of the eye indicate dose-related lens opacification occurs at much lower doses (<2 Gy) than indicated in past radiation protection guidelines.

Research efforts are thus now being directed towards identifying early predictors of lens degeneration resulting in cataractogenesis. In particular, Health Canada is interested in the possibility of developing quick, non-invasive methods for performing in vivo radiation dosimetry. This talk will focus on the study conducted by the Carleton Biophotonics Research Group, in cooperation with Health Canada, investigating the effects of IR on human lens epithelial (HLE) cells exposed to doses ranging from 0.01 Gy to 5 Gy using Raman micro-spectroscopy. Raman spectroscopy is a non-invasive method of generating a molecular fingerprint of a sample from the spectrum of inelastically scattered light it produces when illuminated with a laser.

Statistically significant differences were found between the mean spectra of each dose relative to control (0 Gy). Using linear discriminant analysis (LDA) in conjunction with principal component analysis (PCA), it was found possible to discriminate between the Raman spectra of a given dose and control to an accuracy of > 74% for doses ranging from 0.25 for 5 Gy. Leave-one-out cross-validation (LOOCV) was used to determine accuracy. Full multi-class classification is still a work in progress, as will be explained during the talk.

**2) "Absolute activity standards"**
**by Dr. Raphael Galea, National Research Council Canada**

Abstract: There is a great deal of familiarity with ionizing radiation standards in the medical field. Standards for dosimetry and radioactivity are used in radiology and nuclear medicine. The production of certified reference materials (CRMs) in radioactivity can be compared to chemical metrology in that they essentially quantify the amount of material in an artifact. The essential difference is in the inherent shelf life of the CRM which is defined by the isotopes half-life. This presentation will focus on some methods of absolute activity determination. Applications of the standards and research in the measurement of radioactivity will also be presented as examples of the dissemination of the radionuclide metrology in medical applications and in nuclear security.

# OMPI Seminar: Martin Martinov and Zoltan Nagy

**Date: Thursday, April 19, 2018**
**Time: 3:30 - 5:00 pm - Refreshments start at 3:15 pm.**
**Location: The Ottawa Hospital Auditorium, 2nd floor, main hospital, 501 Smyth Road**

This session will be available for off-site viewing via the following webcast link (firefox or Chrome): https://meeting.ottawahospital.on.ca/invited.sf?id=24912&secret=4fe4528a-1163-4105-b783-4b4e6b8d6fbf

Presentations:

1) “Pushing the limits of EGSnrc: Computing microscopic dose metrics on a macroscopic scale using multiscale modeling”

by Martin Martinov, PhD student, Carleton University

Supervisor: Dr. Rowan Thomson

Abstract: Monte Carlo (MC) simulations of radiation transport to investigate microscopic dose metrics are being used with increasing regularity. Expanding such detailed models to tumour-sized volumes often proves to be beyond the computational limit of most codes. This work presents the multiscale model, in conjunction with the already fast EGSnrc, as an accurate and efficient method of extracting microscopic dose metrics on a macroscopic scale. EGSnrc’s radiation transport algorithms are first verified at short length scales with other Monte Carlo codes typically used in the field. The multiscale model is then demonstrated with simulations of different gold nanoparticle therapy scenarios.

2) “In-vivo cortical parcellation with Diffusion MRI: concept and implementation challenges”

by Dr. Zoltan Nagy, Institute for Biomedical Engineering, University of Zurich, Switzerland.

Abstract: In-vivo histology is an effort to characterise tissue non-invasively and based on multi-modal imaging data. Specifically, I focus on fingerprinting cortical grey matter of the brain, based on information we can extract form diffusion MRI data. I will present the proof-of-principle, explain the aspects of MRI acquisitions that hinder these efforts and describe magnetic field monitoring technology that helps eliminate or alleviate these technical limitations. The talk will finish with some future outlook toward planned and possible experiments.

# OMPI Seminar: Mathew Efseaff and Ran Klein

**Date: Thursday, May 24, 2018**
**Time: 3:30 - 5:00 pm, Refreshments start at 3:15 pm.**
**Location: NRC - 1200 Montreal Road, Building M-36 - Kelvin Room (please check in at the front desk).**

As usual, the end-of-season BBQ will start after the seminars, ~5 pm. If you plan on attending the BBQ please RSVP to Byran Muir so that the NRC folks get an idea of how much food to prepare. Deadline for RSVP is May 21st. Also if you have any dietary restrictions, please let Bryan know.

Presentations:

**1) Evaluating the accuracy of a general cavity theory**

**by Matthew Efseaff, PhD student, Carleton University**

Supervisors: Dr. Miller MacPherson and Dr. Dan La Russa

Abstract: In radiation dosimetry protocols, the primary objective is to derive the absorbed dose in an irradiated medium, Dmed, from the dose to a detector placed in that medium, Ddet. The relationship between Dmed and Ddet is determined from cavity theory, whose formulation has traditionally depended on the nature of the radiation source, detector, and geometry (including field size, material combinations, etc). In this presentation, a general cavity theory will be introduced that has potential applications over a wide range of incident energies and detector types, making it a suitable candidate for the growing landscape of radiation devices not encompassed by existing dosimetry protocols, or to augment protocols currently in use. The approach to evaluating the accuracy of this general cavity theory using Monte Carlo methods (EGSnrc) will be presented along with preliminary results.

**2) Squeezing medical insight out of photons**

**by Ran Klein, PhD Elec Eng, The Ottawa Hospital, Nuclear Medicine Department.**

Abstract: The quality of medical exams and the quality of their interpretation can limit the precision of the indications derived from these exams and hence limit appropriate patient care. A holistic approach towards quality is essential for optimal patient care and is the primary responsibility of medical physicists. This presentation will highlight potential sources of error in nuclear medicine tests and describe some of the approaches being applied at The Ottawa Hospital to improve quality at all stages of the medical procedure. Past, current and future research projects relating to quality in the Nuclear Medicine Department will be described.

# OMPI Seminar: Rowan Thomson and Nick Majtenyi

**Date: Thursday, September 20, 2018**
**Time: 3:30 - 5:00 pm, Refreshments start at 3:15 pm.**
**Location: Herzberg Building Room 4351, Carleton University.**

Presentations:

**1) Quantitative measurement of brain perfusion parameters using intravoxel incoherent motion**

**by Nick Majtenyi, PhD Candidate, Carleton University**

Supervisor: Professor Ian Cameron

Abstract: Clinically-useful quantitative parameters can be obtained from MR perfusion imaging based on signal intensity changes following the injection of a gadolinium-based contrast agent (GBCA). One conventional perfusion technique, dynamic contrast-enhanced (DCE)-MRI, can be unreliable in its measurement methodology. Intravoxel incoherent motion (IVIM) is an MR-based diffusion-weighted imaging technique that differentiates diffusion and perfusion properties of tissue without the use of a GBCA. The IVIM acquisition and data processing techniques are currently not standardized, and its comparison to conventional perfusion parameters has been under-investigated. In this work, we investigate the origin of the IVIM signal and test several different data-fitting methods. Additionally, we compare the results of the perfusion parameters to those obtained from DCE-MRI in human patients with gliomas.

**2) Taking Monte Carlo to new lows**

**by Rowan Thomson, PhD, Carleton University**

Abstract: Monte Carlo (MC) simulations are applied in diverse contexts in medical physics to model radiation interactions and energy deposition. Traditionally, Monte Carlo simulations in medical physics focused on mm to cm length scales, often in the context of cancer radiation therapy. However, recent work is extending the range of widely-used MC codes to subcellular length scales. While there are many exciting prospects for these MC simulations, from advancing knowledge of the biological effects of radiation to the development of new treatment techniques, there are also challenges. This presentation will focus on research connecting macroscopic and microscopic MC simulations, and challenges encountered in applying MC techniques on subcellular levels.

# OMPI Seminar: Rolf Clackdoyle and Nathan Murtha

**Date: Thursday, October 18, 2018**
**Time: 3:30 - 5:00 pm, Refreshments start at 3:15 pm.**
**Location: Room RPB 205 (boardroom), Health Canada, 775 Brookfield Road, Ottawa. Please check in at the front desk.**

Presentations:

**1) "Tomographic Imaging of a Source in a Restricted Area Using Compton Gamma Imaging"**

**by Nathan Murtha, PhD Candidate, Carleton University**

Supervisors: Laurel Sinclair (Natural Resources Canada) and Patrick Saull (National Research Council)

Abstract: Compton gamma imaging uses the kinematics of Compton scattering to constrain the reconstructed origin of a detected gamma ray to somewhere on a conical surface. Two-dimensional projections of these conical surfaces then form rings, the intersections of which may be used to form contours delineating where in the field-of-view the source is likely to lie. Reconstruction of the shape of a distributed source in an area restricted to entry is a particularly challenging problem which may be resolved by observing the source from multiple points of view. In March 2018, an L-shaped extended source of La-140 measuring 120 m by 20 m on one arm and 60 m by 10 m on the other arm was laid out at an experimental proving ground in Suffield, AB. This L-shaped distribution was contained in a 500 m by 500 m exclusion zone, restricting the proximity within which measurements were possible. Data were accumulated at seven positions around the exclusion zone. Using a simple back-projection method, we demonstrate preliminary results of a tomographic reconstruction of the activity distribution inside the exclusion zone.

**2) "Radar and Scatter Imaging: Dual Image Reconstruction Problems"**

**by Rolf Clackdoyle, L'Université Grenoble Alpes**

Abstract: In synthetic aperture radar (SAR) a nominal image reconstruction problem arises. The idea is that an airplane flying a straight line along (say) the x-axis receives radar signals that are averages over circles (of various radii) centered on the x-axis. The "tomographic" reconstruction problem is to map out the radar signal at each point on the ground, based on these "circular" ray sums. This problem has been well-studied and has all the same mathematical features as the usual tomographic reconstruction problem that we are familiar with in medical imaging – there is a back-projection step which alone gives a blurred image, and pre-back-projection filtering – yielding the well-known Filtered Back-Projection (FBP) algorithm. Previous work has been presented (OMPI) that describes a system for imaging scattered radiation – a collection of overlapping "radial profiles" is obtained where each radial profile can (potentially) provide diagnostic information about a point of the sample that was irradiated with a primary beam of x-rays. In the hypothetical situation where a large collection of overlapping radial functions are acquired, all with their centers along a straight line, we see some similarity with the SAR problem, except that in this case, the unknown quantities are the individual radial functions. In this presentation, it will be shown

# OMPI Seminar: Susan Al-Abboodi and Yani Picard

**Date: Thursday, November 15, 2018**
**Time: 3:30 - 5:00 pm - Refreshments start at 3:15 pm.**
**Location: The Ottawa Hospital Auditorium, 2nd floor, main hospital, 501 Smyth Road**

Presentations:

**1) "Patient-specific respiratory motion models for 4D Monte Carlo simulations of radiation therapy"**

**by Susan Al-Abboodi (PhD Candidate), Carleton University**

Supervisors: Emily Heath (Carleton University), Joanna Cygler (University of Ottawa)

Abstract: Errors during radiotherapy treatment delivery can arise from different sources. Errors in the patient set-up and the beam delivery are possible. Also, the shapes and positions of the treatment targets and surrounding tissues may vary from day-to-day and even during the treatment. For example, motion of the organs in the thoracic and abdominal region due to respiratory motion can cause clinically significant targeting errors. All these errors lead to a deviation ofthe delivered radiation dose from the original planned dose. Therefore, methods to determine the delivered patient dose are needed in order to verify that the correct dose is delivered to the patient as calculated by the treatment planning system. This information could also be used to adapt the treatment plan to compensate for delivery errors.

The objective of this research project is to develop patient-specific respiratory motion models from measurements acquired during radiotherapy delivery. These models will be used for 4D Monte Carlo simulations to reconstruct the delivered dose to the patient. In this initial work, principal component analysis was used to generate a parametric model to correlate the patient surface motion with the internal motion. This PCA method was tested using a numerical phantom, 4D XCAT, which simulates respiratory motion. Both the phase and amplitude of the surface motion were used as inputs to the PCA model. Preliminary results show the external surface motion amplitude can provide a more accurate prediction of the internal motion than using the phase of the surrogate motion.

**2) "Regulating accelerators in Canada"**

**by Yani Picard, PhD, Canadian Nuclear Safety Commission**

Abstract: This presentation is an overview of how CNSC regulates accelerators in Canada, from medical linacs and cyclotrons to the newly announced proton therapy facility.

# OMPI Seminar: Luke McCooeye and Costel Flueraru

**Date: Thursday, December 13, 2018**
**Time: 3:30 - 5:00 pm, Refreshments start at 3:15 pm.**
**Location: University of Ottawa Heart Institute, 40 Ruskin St., East Foustanelas auditorium (H2368)**

Presentations:

**1) "Monte Carlo dose calculations considering edema in permanent implant prostate brachytherapy"**

**by Luke McCooeye, Carleton University (Supervisors: Rowan Thomson, and Emily Heath)**

abstract: The implantation procedure for permanent implant prostate brachytherapy (PIPB) treatments can cause an edema response and the resulting swelling increases prostate volume and displaces seeds, disrupting the treatment plan and causing reduced dose to the target. The dynamic nature of the edema necessitates a 4D approach to accurately account for delivered dose. A framework is presented that, beginning with a post-implant CT image, allows for full-tissue MC (egs_brachy) simulations to calculate dose delivered at discrete stages of edema resolution and ultimately accumulate these doses into a single dose representative of the total dose delivered to an organ considering edema. Results indicate the dosimetric effect of edema in PIPB is sensitive to both patient specific geometries and the characteristics of the edema. For a subset of patients the dose reduction due to edema is significant for assessing implant quality which is associated with treatment outcomes.

**2) "Can Optical Coherence Tomography be used to monitor radiation therapy?"**

**by Costel Flueraru, National Research Council (NRC)**

abstract: Optical Coherence Tomography is an imaging modality that provides high-resolution cross-sectional imaging using a minimally invasive approach. In the first part of my talk, I will be explaining how the Optical Coherence Tomography works. I will guide you through a few development stages of this imaging modality and share some successes and failures. In the second part of my presentation, I will show you how OCT can be used to monitor changes in the tumor vasculature during the radiotherapy. It is not a direct monitoring of the tumor but it is a relevant modality for monitoring the effect of radiation therapy. I hope to convince you that the answer to my title is affirmative.

# 2019

OMPI Seminar Archive

# OMPI Seminar: Ghada Aldosary and Reid Townson, and social outing

**Date: Thursday, January 17, 2019**
**Time: 3:30 - 5:00 pm, Refreshments start at 3:15 pm.**
**Location: Carleton University, Herzberg 4351**

Presentations:

**1) Evaluation of MRI image geometric inaccuracy for MRI based treatment planning on GammaPod**

**by Ghada Aldosary, Carleton University**

Supervisor(s): Eric Vandervoort and Claire Foottit

Abstract: The GammaPod™ (Xcision Medical Systems, USA) is an ablative radiation therapy (RT) device dedicated for breast cancer. It relies on computed tomography (CT) images for the RT planning process. Due to its superior soft tissue contrast, better visualization of target structures within the breast can be achieved with magnetic resonance imaging (MRI). However, MRI suffers from geometric inaccuracy—which may lead to unacceptable errors for these precise treatments.

In this talk, our method for quantifying geometric inaccuracy on both CT (helical and C-Arm systems) and MRI based treatment planning images will be presented. Results from an in-house 3D printed phantom, as well as a commercial stereotactic radiosurgery quality assurance phantom will be compared. In preparation for MRI-based treatment planning on GammaPod, the application of these preliminary results will then be presented.

**2) Modeling radionuclides with EGSnrc: the dirty details of nuclear data**

**by Reid Townson, National Research Council (NRC)**

Abstract: A radionuclide source model was recently added to the EGSnrc code for Monte Carlo radiation transport. On the surface, this is a useful tool for users to quickly insert complex radionuclide source emissions into their simulations. Delving deeper, I will outline how the model depends on the nuclear data, how decay-by-decay emissions are produced, and the difficult choices that must be made when designing a model based on experimental results.

**Social Outing:**

For those interested, Spencer Manwell (SpencerManwell@cmail.carleton.ca) has also booked a table at Patty's Pub afterwards for some Mid-Winter cheer!

Address: 1186 Bank St, Ottawa, ON K1S 0W6

https://www.google.com/maps/place/Patty's+Pub/@45.3919038,-75.6817347,15z/data=!4m5!3m4!1s0x0:0x40d294be7e1d3ee2!8m2!3d45.3919038!4d-75.6817347

**Driving from Carleton: (5 min)**

Take University Dr. to Bronson Ave.
Continue straight onto Sunnyside Ave.
Turn right onto Bank St.
Patty's Pub is on the right, at intersection of Ossington Ave. and Bank St..
Transit from Carleton: (15 min)

Walk to stop at Sunnyside Ave. and Carraway Pvt,
Take 7 St. Laurent until the stop at Grove Ave. and Bank St..
Walking: (20 min)

Exit Carleton campus by the Raven's Nest
Cross Bronson Ave. and continue into Brewer Park
Follow the trails toward Ossington Ave. and continue on to Bank St.

Please RSVP to Spencer, if you're interested in going to Patty's Pub. If you'd also like to partake in an evening skate, please let Spencer know when you RSVP for pub and we can organise a group for those interested (canal conditions permitting of course).

# OMPI Seminar: Ghada Aldosary and Reid Townson, and social outing

**Date: Thursday, January 31, 2019**
**Time: 15:30**
**Location: Herzberg building, room HP4351**

**Prof. John Kildea**
**Opal - Empowered Patients, Informed Research**
**McGill University**

Abstract: Opal (opalmedapps.com) is a person-centered patient portal smartphone app that was built at and has been released to cancer patients at the McGill University Health Centre in Montreal. Opal was designed with two goals in mind: (1) to empower patients, and (2) to inform research.

Opal empowers cancer patients with access to their electronic medical records (appointment schedules, lab results, clinical notes, etc) and automatically-personalized educational material tailored to their disease and phase of treatment. For example, it can automatically advise a patient on how to prepare for an upcoming appointment, provide a map of where to go, and facilitate appointment check-in and call-in so that the patient does not need to wait in the waiting room. It can also display the radiotherapy treatment planning process and let patients follow the progress of their treatment plans.

As a research tool, Opal is designed to collect patient-reported outcomes. It is also designed to operate in a multi-institutional context so that patients can communicate with and access all of their data from multiple hospitals at once. With their multi-institution data in hand, consenting patients can donate them to research studies, facilitating patient-powered multi-institutional data linkage for real-world evidence research.

This presentation will describe the history of the Opal project, the technology behind it, the stakeholder co-design process that was used to build it, and the research projects that are now forming around it.

# OMPI Seminar: Tong Xu and James Renaud

**Date: Thursday, February 28, 2019**
**Time: 3:30 - 5:00 pm, Refreshments start at 3:15 pm.**
**Location: National Research Council, Kelvin Room (M36)**

Presentations:

**1) Calorimetry-based clinical reference dosimetry of a 1.5T MRI-linac in water and solid phantoms using Aerrow**

**By: James Renaud, PostDoctoral Candidate, National Research Council (NRC)**

Supervisor(s): Bryan Muir and Malcolm McEwen.

Abstract: Calorimeters are used as primary standards for absorbed dose measurements in ionizing radiation. Due to the complexity of the systems, and the time required to obtain measurements, they have remained in the standards laboratory and are rarely seen in end-user situations, such as cancer centres. However, calorimetry offers some significant advantages over secondary dosimeter systems and a clinical implementation of a calorimeter would provide new measurement capabilities for the medical physicist.

In this talk, an introduction to Aerrow, a probe-format graphite calorimeter, is provided along with a detailing of its use to perform clinical reference dosimetry in the high-energy photon beam of a 1.5T MRI-linac. Response perturbations due to the presence of the magnetic field, as well as detector orientation dependence – in both water and solid phantoms – are investigated.

**2) “A generalized MLC simulation method designed for GPU”**

**By Tong Xu, Carleton University and NRC**

Graphics Process Units (GPU) are very attractive for parallel computing thanks to their low cost per processing core and the ability of integrating thousands of cores in one desktop computer. This talk will start with a brief introduction of a GPU implementation of EGSnrc (GEGS) and some basic benchmarking against EGSnrc. Then a framework for multi-leaf-collimator (MLC) simulation designed for GPU will be introduced. This new framework is designed to minimize the code divergence in GPU. It also allows the simulation of MLCs of arbitrary shapes, which makes it possible to be adopted for MLC from different manufacturers. Some examples of simulated MLC fields will be presented.

# OMPI Seminar: Richard Wassenaar and Alexandra Bourgouin

**Date: Thursday, March 21, 2019**
**Time: 3:30 - 5:00 pm, Refreshments start at 3:15 pm.**
**Location: Health Canada, Radiation Protection Building, 775 Brookfield Road, Room 205B**

**Prof. John Kildea**
**Opal - Empowered Patients, Informed Research**
**McGill University**

Presentations:

**1) Determination of W(air) in high-energy electron beams**

**by Alexandra Bourgouin, PhD Candidate, Carleton University, Department of Physics**

Supervisor: Malcolm McEwan

Abstract: The mean energy required to create ion pair in air, W(air), is considered to be energy independent above 10 keV. However, an extreme interpretation of the available data would allow a variation of up to 2% in the clinical energy range. To investigate this, a graphite ionization chamber and calorimeter with the same geometry and sensitive volume were irradiated with high energy electron beams to yield a value for W(air). Although the experiment yielded a value consistent with the ICRU #90 value, it highlighted the problems of using graphite detectors, particularly related to density variations. To obtain additional experimental data in high-energy electron beams to determine W(air), a pure aluminium detector has been designed, built and is now being commissioned.

**2) Development of Occupational Dosimetry Metrics for a Source Manufacturer**

**by Richard Wassenaar, PhD, Nordion (Canada)**

Abstract: Nordion is a manufacturer and world-wide distributor of radioisotope sources. Open sources of radioisotopes are received from various reactors. The radioisotopes are processed and manufactured into sources destined for health care facilities and industrial irradiators. Given the high-activity, high-radiation risk nature of the work, Nordion has implemented a robust occupational radiation dosimetry program for its workers. In this talk, I will present some of the work Nordion is doing to further develop metrics for dosimetry analysis to improve evaluation of personnel doses. I will discuss the analysis of data undertaken as a result of the recent revision regarding the lens of the eye doses and present an interesting case study that was found during the analysis. In addition, I will present my work relating to automated statistical analysis of personnel's dosimetry measurements.

# OMPI Seminar: Dan LaRussa and Christopher Dydula

**Date: Thursday, April 18, 2019**
**Time: 3:45- 5:15 pm, Refreshments start at 3:30 pm. Please notice the 15 minute delay in start.**
**Location: The Ottawa Hospital, 501 Smyth Road., Auditorium (Room M2919, 2nd floor)**

Presentations:

**1) "Fast synchrotron-based x-ray scatter projection imaging: Image acquisition, formation, and quality assessment"**

**by Christopher Dydula, PhD Candidate, Carleton University, Department of Physics**

Supervisor: Paul Johns

Abstract: X-ray scatter imaging utilizes material-dependent scatter signatures to provide information missed by conventional transmission imaging and improve contrast. It has applications in medicine, security, and non-destructive testing. One challenge to its dissemination has been the time needed to acquire image data. We have implemented a prototype x-ray scatter projection imaging system at the Canadian Light Source synchrotron, and have reduced acquisition times from ~1 h to ~2 min. In this talk I will present scatter data acquisition schemes, the steps required to turn the data into images, and assess image quality degradation in the faster compared to the slower schemes.

**2) "Advanced visualization of medical images and models using virtual reality"**

**by Daniel LaRussa, PhD, The Ottawa Hospital**

Abstract: A new era of virtual and augmented reality technology is enabling a new, booming landscape of innovative medical applications. In this presentation, a comprehensive framework for navigating this new creative space will be introduced, with an emphasis placed on visualizing and manipulating medical images and models in a perspective 3D environment. Various concepts associated with this framework will be illustrated using examples of medical virtual reality applications under development by realizeLAB at The Ottawa Hospital (TOH) and University of Ottawa. New opportunities for personalized care, cross-discipline clinical collaboration and communication, and integration with radiology and radiotherapy programs will also be highlighted

# OMPI Seminar: Eric Christiansen and Trevor Stocki and Year End BBQ

**Date: Thursday, May 23, 2019**
**Time: 3:30 - 5:00 pm, Refreshments start at 3:15 pm. BBQ to follow (see below).**
**Location: National Research Council, 1200 Montreal Road (at Blair Road), Kelvin Room (M36)**

Presentations:

**1) 4D-VMAT plan optimization: Robustness against variations in breathing pattern**
**Eric Christiansen, Carleton University, Department of Physics**

Supervisors: Emily Heath & Tong Xu

Abstract: Volumetric modulated arc therapy (VMAT) is a radiation therapy technique that can deliver dose distributions which conform tightly around the tumour, and as such have become a standard radiotherapy treatment for many cancer sites. To accomplish this high degree of conformity, a multi-leaf collimator (MLC) inside the treatment machine is used to modulate the intensity of the radiation beam while it is rotated around the patient. Internal organ motion during radiotherapy, such as the movement of the lungs due to breathing, can distort these highly conformal treatments, leading to a blurred dose distribution. This deviation from the planned dose may result in an increased dose to healthy tissues and/or a decreased dose to the tumour, thereby compromising treatment outcomes. A variety of approaches have been developed to address tumour motion during radiation therapy, but the ideal solution would be to adapt the radiation beam delivery in real-time to follow the tumour motion. PeTrack is a tracking system developed at Carleton University that can accurately measure tumour motion using positron-emitting markers implanted directly into the tumour. A 4D-VMAT treatment optimization algorithm will be presented, which coupled with PeTrack or other real-time tracking system, could be used to deliver a conformal therapy to mobile tumours. In contrast to some 4D-VMAT approaches, dose is computed along all specific tumour trajectories. Further, the algorithm uses a patient-specific probabilistic model of the breathing pattern to compute the expectation value and variance of the dose integrated over all possible trajectories. The optimization is based on a combination of a quadratic objective function and a variance term, which is included so that the final plan is robust to changes in the expected patient breathing pattern.

**2) “Radioecology of Small Modular Reactors (SMRs): Can sunken subs help us?”**
**Trevor Stocki, Health Canada**

Abstract: A number of countries are doing research into developing Small Modular nuclear Reactors (SMR) for electrical power generation. These types of reactors could be used to power remote locations, heavy industry applications, and on-grid applications. This nothing new, from 1968 to 1975, the Americans used a “SMR” in the Panama Canal Zone for electricity. This was a floating nuclear power station, named the MH-1A. More recently the Russians have put two nuclear reactors on a barge and plan to send it to a remote Arctic community to replace diesel power generation. Canada also has a road map for SMRs. Health Canada is required to review environmental assessments, so Health Canada is interested in the radio-ecological consequences of SMRs in terms of radiation dose received by humans. A possible first step in understanding SMRs is to understand the radioecology of the nuclear submarines that have been sunk in the Kara Sea and surrounding area. The question posed is can this help shine any light on the issue for SMRs? The submarine, K-27 will be discussed.

**BBQ:**

If you haven’t already done so, please RSVP to OMPI year-end BBQ using the following link: https://forms.gle/XHwvyahHVo8f9FyE7

The team at NRC will be shopping to order based on RSVPs, so please confirm your attendance and meal preference as soon as possible to avoid missing out on the fun!

# Special lecture: Broadband Photon Tomography

**Date: Wednesday, June 19, 2019**
**Time: 11:00-12:00**
**Location: University of Ottawa Heart Institute, 40 Ruskin St., Centre Foustenellas Auditorium**

Title: Broadband Photon Tomography: High Performance Integrated 4x4D PET, SPECT, Optical & X ray Tomography

Presenter: Prof. dr. Freek J. Beekman, Delft University of Technology, Department of Radiation Science and Technology

Abstract: In this presentation a highly adaptive and versatile nuclear, optical and structural imaging platform will be explained along with many scientific applications contributed by hundreds of world wide users. Finally, the results of translating our nuclear imaging technologies into <3 mm resolution clinical SPECT will be presented.

# Special Event: The Elements (part of OMPI30)

**Date: Thursday, September 19, 2019**
**Time: 15:30-17:00, Refreshments start at 3:15**
**Location: Carleton University, Herzberg Laboratories, Room 4351**

Program:

**1) Lecture: The Periodic Table: How the elements are discovered and named.**

**By: Juris Meija (NRC)**

Abstract: The Periodic Table of Chemical elements has been called one of the greatest icons of our culture. At 150 years old, it still continues to inspire artists, adorns virtually every science class in the world (even Bill Gates has one in his office), and leaves still enough room for scientists to explore the properties of super-heavy elements. Is there a single definite Periodic Table or does it matter? What can it predict, how did we get to the 118 elements we know today, and who gets to name the elements?

**2) Activity: What is the best/most important element for Medical Physics?**

**By: Malcom McEwen and attendees**

OMPI members will make a bid to have their element recognized as the most significant to Medical Physics.

Abstract: The current periodic table contains 118 elements and it can be argued that medical physics makes use of most of them (at least up to Z=98). However, there are clearly certain elements that are more important and more associated with medical physics than others. In this presentation we will be reviewing the periodic table and identifying the important elements/isotopes that have aided the development of medical physics and are at the forefront of diagnosis and treatment of disease (Note we are not talking about “basic infrastructure” elements such as Fe, Al or Si or “essential-for-life” elements such as C, O and H).

As an added twist, this is not a one-way presentation, attendees are invited to make their case for their favourite element. The format is 2 minutes, with an option of a single Powerpoint slide. (Warning to the verbose - these constraints will be rigidly imposed!) It’s first-come, first-served, so don’t wait for the day of the seminar to propose your element, duplicates will not be allowed. Once we’ve completed this exhaustive review the audience will vote to determine THE medical physics element! There will be a prize for the winning presenter as well!

3) Event is followed by social gathering at Mike’s Pub including a quiz.

# Special Event: The Elements (part of OMPI30)Special Event: The Great (Medical Physics) Debate (part of OMPI30)

**Date: Thursday, October 17, 2019**
**Time: 16:00-17:00**
**Location: University of Ottawa Heart Institute, 40 Ruskin St., Centre Foustenellas Auditorium (Room 2367)**

Program:

This is the second of three special, monthly events being held in September, October, and November of this season as we celebrate 30 years of OMPI - regular seminar schedule will resume on 28 November 2019.

Two teams will debate a subject in medical physics to be chosen by the membership. The audience will vote for the winners by applause. Debate Resolution:

<table>
<tr><td colspan="2">Debate Resolution:<br><br>The increased use of Artificial Intelligence (AI) and Machine Learning (ML) in medical science poses undue risk to patient outcomes.</td></tr>
<tr><td>Debaters in favour of resolution:<br><br>David Wilkins - Experienced Medical Physicist, Boat maker, and now happily retired.<br><br>Nathan Murtha - PhD graduate student, Medical Physics, Carleton University</td><td>Debaters opposed to resolution:<br><br>Graeme Wardlaw - Medical Physicist, Health Canada Iymad Mansour - PhD graduate student, Medical Physics, Carleton University</td></tr>
<tr><td colspan="2">Moderator:<br><br>Malcolm McEwan - National Research Council (NRC)</td></tr>
</table>

For more information on special events, please visit OMPI30 webpage:
**https://science.carleton.ca/ompi30/**

# Special Event: Symposium and Dinner celebrating OMPI30

**Date: Thursday, November 7, 2019**
**Time: 13:00-21:00**
**Location: Carleton university, Residence Commons 270/272/274 followed by Baker's Grill**

Program:

The focal event of OMPI30 celebrates 30 Years of Collaboration and Innovation in Medical Physics through half-day symposium and celebratory dinner.

Program at a glance:

| Time | Activity | Location |
|---|---|---|
| 13:00 | Poster viewing and networking | Residence Commons |
| 13:30 | Opening remarks | Residence Commons |
| 14:00 | Presentatiaons and panel discussion | Residence Commons |
| 17:00 | Reception and dinner at Baker's Grill (by registration) | Baker's Grill |

**For full information, please visit https://science.carleton.ca/cu-events/ompi30-symposium/ and...**

## Don't forget to register here

# OMPI Seminar: Ming Liu and Sangeeta Murugkar

**Date: Thursday, November 28, 2019**
**Time: 15:30, refreshements 15:15**
**Location: Health Canada, Radiation Protection Building, 775 Brookfield Road, Room 205B**

**Presentations:**

**1) Patient-specific PTV margins for liver SBRT with an early-warning system for margin adaptation**

**by Ming Liu (PhD Candidate)**

Supervisors: Joanna Cygler and Eric Vandervoort

Abstract: In radiation therapy, the planning target volume (PTV) covers the gross tumor volume (GTV), and the PTV-GTV margin compensates for the tumor motion as well as some other uncertainties during treatment. We aim to reduce the PTV margin to avoid high dose in healthy tissue surrounding the tumor. Therefore, we propose an adaptive PTV margin strategy incorporating a volumetric tracking error assessment after each fraction of robotic stereotactic body radiation therapy (SBRT) liver treatment. Based on a mock treatment before planning, support vector classification (SVC) is used in the classification of different translational motion-tracking residual errors for patients. We are developing tools based on both volumetric and dosimetric assessments for liver treatments using CyberKnife, to implement patient specific PTV margins prior to planning.

**2) Developing optical techniques to measure treatment response**

**by Sangeeta Murugkar, PhD (Carleton University)**

Abstract: Raman spectroscopy is a non-invasive, label-free optical technique that is based on the inelastic scattering of light by vibrating molecules. We have successfully applied this single-point measurement technique, in conjunction with multivariate statistical analysis methods for the label-free classification of living cells and tissue based on their chemical composition. This talk will describe our recent work to develop a Raman spectroscopy-based technique to measure the response of blood undergoing oxidative stress. In addition, it will include a discussion of our new, lab-built multimodal nonlinear optical microscope that is expected to shed light on fundamental mechanisms of cellular response. We are using this label-free imaging platform to quantify changes in the metabolic activity of live blood cells exposed to different external stimuli.

# 2020

OMPI Seminar Archive

# OMPI Seminar: Spencer Manwell and Richard Richardson and Winter Social

**Date: Thursday, January 23, 2020**
**Time: 15:30**
**Location: Carleton university**

**Presentations:**

**1) The phantom with the blurry heart: Motion correction in cardiac PET/CT**

**by Spencer Manwell, PhD Candidate**

Supervisors: Tong Xu, Ran Klein, Rob deKemp

Abstract: In positron emission tomography (PET) studies acquisition times can range from 10 to 60 minutes. As one may imagine, demanding that a patient remains perfectly still during this time is often unreasonable. The effect of patient motion during imaging is two-fold: image blur leads to loss of the image contrast for regions with radiotracer uptake; and spatial mis-registration between the PET emission data and the transmission data used for attenuation correction (AC) which can lead to AC artifacts. Generally, these effects are not so significant that they impact clinical decision making or diagnosis, but moderate to severe motion is certainly not uncommon and has the potential to reduce overall diagnostic accuracy. In this talk I'll describe a framework for motion correction that is based on tracking the motion of a small radioactive marker placed on patients during cardiac PET perfusion studies using the PET scanner itself. This approach was designed to address both the motion-induced artifacts described above, as well as obviate the need for external motion tracking hardware, e.g. optical cameras. In particular, this talk will focus on a recent experiment where we imaged an anthropomorphic torso phantom that allowed us to simulated cardiac PET studies and test our motion correction algorithm. I'll review our findings of the case of the phantom with the blurry heart and finish with a description of where our research is headed.

**2) Radon Non-Lung Cancer Health Effects and the Search for Radon Biomarkers in the Blood of Canadian Residents**

**by Richard Richardson, PhD (Atomic Energy of Canada Limited)**

Abstract: The following questions are addressed:

- What are the concerns about radon exposures in Canadian homes?
- Does inhaled radon affect tissues beyond the lung?
- Does systemic radon cause leukaemia, non-cancer diseases and aging?
- Are stem cells in hypoxic niches vulnerable to high LET radon exposures ('oxygen effect')?
- Has radon the potential to accelerate aging?
- What radon biomarkers in the blood of Canadian residents will CNL test for and what are the confounding factors?

3) The 2020 Winter social will be held at Mike's Place. For this year a round of pub trivia, spanning general knowledge outside of medical physics, is planned. Those interested should contact **lymadMansour@cmail.carleton.ca**

# OMPI Seminar: Keren Mayorov and Emily Heath [to be rescheduled]

**Date: Thursday, February 27, 2020**
**Time: 15:30**
**Location: The Ottawa Hospital, General Campus, 501 Smyth Ave, Main Auditorium**

**NOTICE: This event has been cancelled due to inclement weather. These talks will be rescheduled for later in the term.**

Presentations:

**1) Postmastectomy radiation therapy for patients with tissue expanders**

**by Keren Mayorov (MSc Candidate)**

supervisor: Elsayed Ali

Abstract: An increasing number of women choose to undergo breast reconstruction after mastectomy, with a rising trend towards implant-based reconstruction. A common technique involves the insertion of a temporary tissue expander at the time of mastectomy to stretch and prepare the overlaying skin for a permanent implant. The tissue expander contains a metal port that is accessed with an external magnet and used for gradual saline injections. Some of these patients receive radiation treatment with the metal port in the radiation field. Perturbations in the dose distribution occur if the presence of the high-density metal port is not accurately modelled in the treatment planning calculation, or if its' location at the time of treatment is different from its location in the simulation scan. In this study I investigated the magnitude and the dosimetric effect of the inter-fractional positional variations of the metal port in different treatment techniques, and compared their robustness in treatment delivery.

**2) Robust Optimization for Mixed-Beam Radiotherapy**

**by Emily Heath, PhD (Carleton University)**

Abstract: Mixed-beam radiotherapy (MBRT) is an emerging external beam radiotherapy technique that uses intensity-modulated beams of different radiation types. MBRT using photon and electron beams has been shown to be dosimetrically superior to conventional photon IMRT in cases where part of the tumour is close to the skin. Considerable progress has been made towards enabling clinical implementation of MBRT. A remaining challenge is that conventional treatment margins to account for patient setup uncertainties may not be valid. Robust optimization is an alternative planning approach where uncertainties in the radiotherapy delivery are modelled in the treatment plan optimization. Treatment plans which compensate for the modeled uncertainties can be automatically generated. In this talk I will describe the implementation of a robust optimization process for MBRT followed by results of experimental validation of the delivery of these plans. A comparison of conventional PTV-based plans and robust plans will be presented.

# OMPI Seminar: Odai Salman and Emily Heath [to be rescheduled]

**Date: Thursday, March 26, 2020**
**Time: 3:30 - 5:00 pm, Refreshments start at 3:15 pm.**
**Location: The Ottawa Hospital, General Campus, 501 Smyth Ave, Main Auditorium**

**Cancelled due to COVID-19 social distancing**

Presentations:

**1) TBD**

**by Odai Salman, PhD Candidate, Carleton University, Department of Systems and Computer Engineering**

Supervisor: Ran Klein

Abstract: TBD

**2) TBD**

**by Emily Heath, PhD, Carleton Univesity, Department of Physics**

Abstract: TBD

# OMPI Seminar: Byron Wilson and Gerd Melkus

**Date: Thursday, April 30, 2020**
**Time: 15:30**
**Location: This is a virtual seminar via this Microsoft Teams link (you do not need to install software and can access using most modern smart devices).**

**Presentations:**

**1) My Experience in a Medical Physics Residency and Technologies that I'm Somewhat Knowledgeable About**

**by Byron Wilson (Medical Physics Resident, Ottawa Regional Cancer Centre, The Ottawa Hospital)**

Abstract: Are you interested in doing a residency? This talk is going to be an amalgamation of the various things that I have learned during my residency and the projects that I have been able to do. Some of the projects discussed will be my work on automated contouring, MRI QC, and Cyberknife patient specific QC. I will try to tie everything together with philosophical ramblings about early career medical physics pedagogy, and the role that research plays in clinical physics.

**2) Biochemical and functional imaging of the hip in patients with cam-type FAI**

**by Gerd Melkus, PhD (Department of Radiology, The Ottawa Hospital)**

Abstract: Cam morphology of the hip femoral head-neck junction can lead to osseous conflict with the acetabular rim and may predispose to femoroacetabular impingement (FAI). The impingement damages the cartilage, which can lead to the development of osteoarthritis. However, the timing of changes to the bone and cartilage is unclear, as arthritic changes existed in adults regardless of symptomatology. A biomarker is required that is more specific and sensitive to changes in periarticular tissues, especially in the very early stages of degeneration. Non-invasive imaging methods, such as MRI or PET are promising tools to research and investigate FAI longitudinally and clinically and have the potential to serve as biomarkers. In this presentation, MRI T1ρ mapping for biochemical sensitive imaging of cartilage and PET techniques in functional bone imaging for FAI will be reviewed and discussed.

# OMPI Seminar: Keren Mayorov, Julia Wallace and Miller MacPherson

**Date: Thursday, May 21, 2020**
**Time: 15:30**
**Location: Virtual Teams meeting**

**Presentations:**

**1) Postmastectomy radiation therapy for patients with tissue expanders**

**by Keren Mayorov (Student)**

Supervisor: Elsayed Ali, The Ottawa Hospital Cancer Centre.

Abstract: An increasing number of women choose to undergo breast reconstruction after mastectomy, with a rising trend towards implant-based reconstruction. A common technique involves the insertion of a temporary tissue expander at the time of mastectomy to stretch and prepare the overlaying skin for a permanent implant. The tissue expander contains a metal port that is accessed with an external magnet and used for gradual saline injections. Some of these patients receive radiation treatment with the metal port in the radiation field. Perturbations in the dose distribution occur if the presence of the high-density metal port is not accurately modelled in the treatment planning calculation, or if its location at the time of treatment is different from its location in the simulation scan. In this study I investigated the magnitude and the dosimetric effect of the inter-fractional positional variations of the metal port in different treatment techniques, and compared their robustness in treatment delivery.

**2) Experiential learning in an undergraduate physics course: Practical dosimetry skill development at NRC's Ionizing Standards Lab**

**by Julia Wallace, PhD (Institute of Environmental and Interdisciplinary Science and Department of Physics, Carleton university)**

Abstract: As one component of a third year modern physics course, my students undertook a half-day field trip to NRC's Ionizing Standards Lab. The purpose of this exercise was for students to gain hands-on practical experience in a work environment. The activity was divided into a mini-lecture, measurements of background radiation (inside and outside the building), a tour of the Compton Gamma Imaging Lab and finally a round-up discussion about jobs related to this field. I will describe how this activity enhanced my course and share some of my students' reflections.

**3) Update from The Ottawa Hospital Cancer Centre: Covid-19 Impact**

**by Miller MacPherson, PhD (Ottawa Regional Cancer Centre)**

# OMPI Seminar and Social: Iymad Mansour and Emily Heath

**Date: Thursday, September 17, 2020**
**Time: 15:30**
**Location: This is a virtual seminar via this Zoom Meeting.**

**Presentations:**

**1) Haralick analysis in microdosimetry: characterization of energy deposition in cellular targets**

**by Iymad Mansour**

Supervised by Rowan Thompson, Phd (NRC)

Abstract: Microdosimetry accounts for the stochastic nature of the energy deposition processes in microscopic structures, considering spatial and temporal aspects. Macroscopic quantities such as dose and dose rates are averages that disregard the inherent fluctuations thereby providing limited information on energy deposition on cellular length scales. The focus of this talk will be on the application of Haralick analysis to microdosimetry, towards advanced analyses of energy deposition on microscopic length scales. Haralick analysis, which was historically developed for image analysis and classification, can analyze the texture within an image. Applying this technique to energy distributions computed using Monte Carlo simulations in micron scale geometries demonstrates the potential of the technique.

**2) Robust Optimization for Mixed-beam radiotherapy**

**by Emily Heath, PhD (Department of Physics, Carleton University)**

Abstract: Mixed-beam radiotherapy (MBRT) uses combinations of intensity modulated electron and photon beams in order to treat tumours that have both a superficial and deep component. Planning studies have shown the MBRT plans can achieve a superior plan quality compared to conventional radiotherapy techniques for certain treatment sites. Recent developments in planning and delivery of MBRT have brought this technique closer to clinical implementation, however, it has been shown that conventional PTV margins may not be effective at compensating for setup errors in MBRT. A promising alternative to margins is the use of robust optimization techniques where the dosimetric effects of setup errors are modeled in the plan optimization.

This talk will give an overview of the motivation for, and recent developments in, mixed-beam radiotherapy. I will describe the application of robust optimization to a novel treatment planning framework for MBRT and the subsequent experimental validation of the first delivery of a robust MBRT plan. Preliminary results from a planning study comparing robust optimized MBRT plans with margin-based MBRT plans will be presented.

**3) SOCIAL EVENT**

Join us for the first OMPI virtual social event ever (we think)!

“OMPI-is-never-trivial Pursuit”!

Grab a beverage and a snack after the seminar and be ready for 6 rounds of fiendishly easy quiz questions. Show that you know more than your specialized subject of medical physics and be crowned OMPI Polymath 2020!

There will be prizes (real, physical prizes!) and hopefully a lot of fun too.

Logistics for those who need to know all the details beforehand:

1. Quiz will start around 15 minutes after the seminar finishes – time for a visit to the bathroom/kitchen/ LCBO (if you are very fast)/your favourite fast-food establishment and/or place your delivery order.

2. Google is not your friend – stay away from search engines for the duration of the quiz

3. Have fun!

# OMPI Seminar: Matthew Efseaff and Paul Johns

**Date: Thursday, October 15, 2020**
**Time: 15:30**
**Location: This is a virtual seminar via this Zoom Meeting.**

**Presentations:**

**1) Evaluating the accuracy of a new general cavity theory**

**by Matthew Efseaff (PhD Candidate)**

Supervised by Miller McPherson, PhD and Dan La Russa, PhD (The Ottawa Hospital)

Abstract: Cavity theory provides the foundation of modern radiation dosimetry protocols. However, the cavity theory formalisms in conventional use are confined to a narrow range of incident beam energies and detector configurations. This is partly due to the limiting assumption that the detector cavity minimally perturbs the charged particle fluence in the surrounding medium. This presentation will explore a novel cavity theory that is formulated to explicitly account for the perturbing effect of the cavity, thereby affording it the potential to be generally applicable over a broader range of physical conditions. Of particular interest is the performance over the range of incident beam energies and detector configurations where traditional cavity theory formalisms are known to be inaccurate. This was explored computationally using the EGSnrc Monte Carlo (MC) code to first calculate the dose to the cavity of an idealized plane-parallel ion chamber, free-in-air, exposed to a range of mono-energetic incident photon beams. Calculations were performed for various combinations of incident beam energies, chamber wall materials, cavity sizes, and threshold energies for creating and tracking charged particles to form a set of benchmark calculations. Using a consistent set of interaction cross-sections, stopping powers, scattering powers, and transport parameters the EGSnrc code was also used to calculate cavity theory formalism parameters, including the charged particle spectra and chamber-dependent charged particle energy deposition functions. Cavity doses predicted by the general cavity theory formalism agree well with full MC simulations. For example, the cavity theory calculations performed with the lowest particle transport energy threshold (1 keV) for a 300 keV photon beam incident on an aluminum chamber are within 0.3% of full EGSnrc calculation. At an incident energy of 1.25 MeV combined with a chamber made with copper walls, the maximum deviation with full Monte Carlo calculations decreases to within 0.13%. The accuracy of the formalism in this energy range suggests it can underscore dosimetry protocols applied to orthovoltage units and other kV x-ray irradiators, as well as to those applied in the MV energy range. It also suggests that detectors constructed with non-air-equivalent materials can be used without introducing large correction factors to offset the associated charged particle fluence perturbations.

**2) X-ray coherent scatter imaging**

**by Paul Johns, PhD (Department of Physics, Carleton University)**

Abstract: Conventional x-ray projection and CT images are based on measurement of the radiation transmitted through the object without interaction. Much information is also carried by the radiation scattered out of the object, by either Compton or coherent scattering. The latter is the basis of x-ray diffraction analysis and so is particularly sensitive to material composition. Scatter imaging researchers are prototyping systems with increased image contrast for medicine, nondestructive testing, and security inspection. Using an array of multiple pencil beams, we have demonstrated step-and-shoot and continuous motion scatter imaging using 33.2 keV synchrotron x rays and more recently using a polychromatic spectrum from a conventional rotating anode source. The current status and next steps will be described.

# OMPI Special Event to mark International Day of Medical Physics 2020

**Date: Thursday, November 5, 2020**
**Time: 3:30pm**
**Location: https://zoom.us/j/97033650367?pwd=T3FLckMxTGlDeUZYb2VUaCtmUkFJQT09**
**Meeting ID: 970 3365 0367**
**Passcode: ompi**

**International Day of Medical Physics special OMPI Event - S4**

In 2019 COMP introduced S3 at the Annual Scientific Meeting – "Science Spoken Succinctly". In 2020 OMPI is going one better with S4 – "Science Spoken Succinctly by Seniors"!

The premise of S3 is that the presenters (competitors) have to present their research in an accessible way in 3 minutes with no visual aids except a single slide. S3 was targeted at graduate students and residents but we are flipping things around and those doing the presenting will be senior researchers - our own OMPI members. We ask our graduate students to be ready with their elevator pitch at a moment's notice. For IDMP 2020 we thought it would be a bit of fun to see if established researchers can also present their work in a succinct manner that is understandable by all.

Starting at 3:30pm on the 5th, you will see and hear the best of OMPI present their research in a way they are probably not comfortable with. It will not only be a test of our members, it will give an overview of all that is going on within the OMPI community in less than 90 minutes!

The session will be moderated by two of our senior graduate students, Nathan Murtha and Iymad Mansour, and they will make sure everyone sticks to time and follows the rules. You, the audience, will be able to submit questions, as we want to test our researchers' ability to not only present clearly, but not waffle their way through an answer!

The best presenters in OMPI – our graduate students – will be the judges but there may be a category of "fan favourite" (stay tuned for further details from Iymad and Nathan). And if there are judges, then there will be prizes!

# OMPI Seminar: Meaghen Shiha and Laurel Sinclair

**Date: Thursday, November 19, 2020**
**Time: 15:30**
**Location: This is a virtual seminar via this Zoom Meeting.**

**Presentations:**

**1) 4D Monte Carlo based patient dose reconstruction incorporating surface motion measurements**

**by Meaghen Shiha (M.Sc. Candidate)**

Supervised by Joanna E. Cygler, The Ottawa Hospital Cancer Centre and Emily Heath, Dept. of Physics, Carleton University

Abstract: In radiation therapy it is of great importance to deliver a planned amount of radiation to the tumor while sparing the healthy tissue. This can be made difficult in the case of lung cancer where there may be significant motion due to respiration. This motion, which can vary throughout the course of treatment, may cause deviations in the delivered dose distribution possibly leading to the under-treatment of the tumor and the unintentional irradiation of healthy tissue. Methods to reconstruct the delivered dose, accounting for respiratory motion, can be used to verify correct delivery of the prescribed dose and to inform development of methods to compensate for respiratory motion effects. The 4Ddefdosxyznrc dose reconstruction tool has been previously verified in a phantom to calculate the dose delivered to a moving and deforming anatomy. This tool incorporates machine log files and patient surface motion measurements recorded during treatment. The framework for the application of this tool to patient dose reconstructions will be described and preliminary results will be presented.

**2) Spatial Deconvolution in Mapping of Radioactivity: The forty-minute version**

**by Laurel Sinclair, PhD (Natural Resources Canada)**

Abstract: Natural Resources Canada is responsible for mobile survey and mapping in case of a radiological or nuclear emergency. Researchers support that function developing calibration methods and improvements to operational procedures, and introducing novel instrumentation and advances in algorithms and data processing. We present an overview of the impact to nuclear emergency response operations of these innovations broadly. We then get into the details of a very current analysis using data from a direction-capable gamma spectrometer (ARDUO) which is mounted on an unmanned aerial vehicle. The capability of ARDUO to point toward radioactivity can be exploited to improve spatial precision of radioactivity maps, and also to extrapolate the map into areas which have not been traversed during the survey. This is the forty-minute version of the thee-minute presentation of the same title which was given at the International Day of Medical Physics special OMPI Event two weeks ago.

# OMPI Seminar: Islam El Gamal and Rebecca Thornhill

**Date: Thursday, December 17, 2020**
**Time: 15:30**
**Location: This is a virtual seminar via this Zoom Meeting.**

**Presentations:**

**1) Developing a Metrology Standard for Synchrotron Produced X-ray Beams**

**by Islam El Gamal (PhD Candidate)**

Supervised by Malcolm McEwen, PhD (NRC)

Abstract: Synchrotrons produce beams of collimated and high flux X-ray photons with dose rates several orders of magnitude greater than conventional X-ray tubes. The potential to produce micro-meter sized pencil beams with the appropriate collimation makes them a valuable research tool and a potential unique therapeutic delivery modality. As with any radiation source, accurate dosimetry is essential and, to date, most measurements have relied on ion chambers calibrated for use with conventional X-ray tubes, resulting in a lack of direct traceability to a primary standard at the beam quality and dose rate of interest. To realize the full potential of synchrotron radiation sources as medical physics tools, a metrology-quality dosimetry standard is being developed. Preliminary experiments to characterize the monochromatic synchrotron beams at the Canadian Light Source will be discussed along with associated measurement challenges. A new calorimeter design to address these challenges will be presented.

**2) Adventures in Ottawa Radiomics**

**by Rebecca Thornhill, PhD (Department of Radiology, The Ottawa Hospital)**

Abstract: Conventionally, imaging clinicians produce diagnoses on the basis of a combination of their training, experience, and individual judgment. Radiologists perceive image patterns and associate or infer a diagnosis consistent with those patterns. However, there will be an inevitable degree of variability in image interpretation as long as it relies primarily on human visual perception. Radiomics can provide a quantitative vocabulary for the otherwise subjective characteristics of lesions. This presentation will summarize how we have applied radiomics and machine learning to a number of relevant medical imaging applications in Ottawa. There will be a special focus on CT imaging of renal masses, as this example application will provide opportunities to discuss some of the pitfalls and challenges we have faced in radiomics and our strategies for for improving interpretability and acceptance among clinicians.

# 2021

OMPI Seminar Archive

# OMPI Seminar: Odai Salman and Ruth Wilkins and Social

**Date: Thursday, February 4, 2021**
**Time: 15:30**
**Location: This is a virtual seminar via this Zoom Meeting.**

**Presentations:**

**1) Development of an Integrated System for Automatic Tumor Detection for PET-CT Images**

**by Odai Salman (PhD Candidate, Systems and Computer Engineering Department, Carleton University)**

Supervised by Ran Klein, PhD (The Ottawa Hospital) and Andy Adler, PhD, Carleton University

Abstract: The key to improving outcomes in cancer treatment is accurate early diagnosis. Hybrid imaging of 18F-lablelled-fluorodeoxyglucose (FDG) using hybrid positron emission tomography (PET) and x-ray computed tomography (CT) is highly sensitive to detecting and characterizing many types of cancers and is gaining increasing clinical use. Human interpretation of these images is difficult due to large data volume and large number of possible clinical findings. Artificial intelligence for cancer detection and interpretation may assist human observers in producing more accurate clinical interpretations. However, having an effective and reliable tumor detection and segmentation system is a major challenge because of the wide variations in the clinical environments and tumors shapes and sizes. In this work, we introduce a tumor detection system that starts by identifying anatomical regions of interest then use these for organ segmentation and finally, use precise organ regions for tumor segmentation. The work also includes identification of associated limitations and possible solutions. The presented work was taken from a thesis work, mainly covering CT modality.

**2) New strategies for understanding the health effects of low dose radiation**

**by Ruth Wilkins, PhD (Health Canada)**

Abstract: One of the biggest questions in radiation protection is: What is the risk at low doses?. In order to determine increased risk at doses below 100 mSv, huge epidemiology data sets are required which do not exist. There is, however, a massive amount of radiobiological research data that addresses this question. What is needed, is a framework to consolidate all of this data such that mechanistic pathways from exposure to adverse outcome could be elucidated. The Adverse Outcome Pathway (AOP) framework is a collaborative tool that maps out measured key events at all levels of biological organization leading to an adverse outcome. The framework has origins in the field of chemical toxicity but is now gaining interest within the radiation research community. Furthermore, much of the recent radiobiological data available examines the gene and protein expression of systems after exposure to radiation. These large data sets are challenging to analyse but recent work has been conducted at Health Canada on applying Benchmark Dose Modelling (BMD) to this data. This modelling identifies the point of departure from background levels of a response to determine whether thresholds of effect exist. Both BMD modelling and the AOP framework will be discussed with respect to their application to low dose radiation effects.

3) Social event

The 2021 Winter social will be a virtual games night. For this year, we will be playing Jackbox games. Jackbox has a series of virtual games designed for any individual to be able to play without any prior experience. Come out, bring your favorite drink, and enjoy a friendly round of competition with the community.

# OMPI Social

**Date: Wednesday, February 17, 2021**

By popular demand, there will be a second OMPI social held this month: round two of Jackbox games. The social will be held after the OMPI professionalism workshop which will on February 17th, and start at 5 pm. Expect it to last about 60-90 minutes, see below for zoom invitation.

If you've never had the opportunity to play Jackbox, it is a set of online games which a group of people can play together. It's about creativity rather than knowledge (although knowing stuff can help!) and it really is about taking part rather than winning. Any internet enabled device will allow you to participate. This is a chance for everyone to enjoy a beverage, engage in some healthy competition and catch up with the community. Look forward to seeing you there!

# OMPI Seminar: Ghada Aldosary and Reggie Taylor

**Date: Thursday, February 25, 2021**
**Time: 15:30**
**Location: This is a virtual seminar via this Zoom Meeting.**

**Presentations:**

**1) The reliability of surgical clips for defining breast radiotherapy treatment targets following oncoplastic surgery**

**by Ghada Aldosary (PhD Candidate)**

Supervised by Eric Vandervoort, PhD and Dr. Clare Foottit (The Ottawa Hospital)

Abstract: Breast cancer patients usually receive radiotherapy (RT) after surgery, during which surgical clips are placed to demarcate the excised tumour's location. Radiation oncologists (RO's) rely on these clips as an aid for defining the tumor bed on a patient's computed tomography (CT) image. In the past few years, oncoplastic breast surgery (OBS) has gained popularity among surgeons as a technique that offers efficacious breast cancer treatment with improved cosmetic results. In this talk, I will introduce OBS, and show how surgical clips are used to define breast tumor beds (TBs). I will also show how we used realistic breast phantoms to simulate different OBS surgeries. In the presented work, each phantom was CT imaged at different phases of surgery in order to record pre- and post-OBS closure surgical clip displacements, as well as to extract the true TB (TBTrue). Two experienced radiation oncologists (ROs) were then asked to contour TBs on CTs by relying on surgical clips as per standard clinical protocol. Their original contours, as well as those expanded using 5-15 mm margins, were then compared to TBTrue. It was determined that post-OBS surgical clips are often significantly displaced beyond the original tumor's location. Results also showed that while inter- and intra-RO TB contours were consistent, they both systematically differed from TBTrue. Using expansion margins did not improve contour congruence and caused significant over-contouring of "healthy tissue". Based on our data, we conclude that following OBS, surgical clips alone are not reliable for defining TBs, and that accurate TB delineation is challenging. Finally, we will also share potential options for providing efficacious treatments for post-OBS patients.

**2) Advanced magnetic resonance spectroscopy techniques for studying glutamate, GABA, and glycine in the human brain**

**by Reggie Taylor, PhD (Royal Ottawa)**

Abstract: Magnetic Resonance Spectroscopy (MRS) is a valuable tool for non-invasively examining metabolite concentrations in the brain. While basic MRS techniques have proven to be useful for measuring many neuronal metabolites, there are certain metabolites that they are often unable to measure reliably. Three such metabolites that are of interest in neuropsychiatry are gamma aminobutyric acid (GABA), glycine and glutamate. GABA is an inhibitory neurotransmitter that is of growing interest in many neuropsychiatric disorders. It is difficult to quantify because it experiences strong spectral overlap with other metabolites. Using a spectral-editing technique called MEGA-PRESS, it is now possible to get reliable measurements. Glycine, an agonist to the NR2 subunit of the N-methyl-D-aspartate (NMDA) receptor, could provide critical missing information in psychiatric disorders like schizophrenia. It is difficult to quantify with MRS due to its low concentration and spectral overlap. TE-averaging is a technique that is being developed locally to measure it. Glutamate can be measured with routine MRS sequences, but it experiences strong spectral overlap with its metabolic precursor, glutamine, and can be difficult to quantify separately. TE-averaging may also help separate them. This presentation will give a background on MRS and outline studies currently being carried out at The Royal that are interested in these three metabolites.

# OMPI Seminar: Liz Fletcher, and Special Event Panel Discussion - Med phys and 1 y of covid19

**Date: Thursday, March 18, 2021**
**Time: 15:30**
**Location: This is a virtual seminar via this Zoom Meeting.**

**Presentations:**

**1) Multiscale modelling of gold nanoparticle enhanced radiation therapy**

**by Liz Fletcher (PhD Candidate)**

Supervised by Rowan Thomson, PhD (Carleton Physics)

Abstract: Although radiotherapy is an effective cancer treatment, there are limitations in its ability to deliver dose to cancerous tissue while sparing healthy tissue. Because of this, novel radiotherapy treatments are continually being developed in order to enhance the dose to cancerous cells while decreasing the dose to healthy cells. One such novel therapy involves the use of gold nanoparticles (GNPs), which are incorporated into cancerous cells in order to enhance energy deposition close to the particles (within nano- to micrometers of the GNPs). This technique is known as gold nanoparticle dose-enhanced radiotherapy (GNPT). In order to understand the biological effects of this treatment, an understanding of the pattern of energy deposition in the cells is needed, so it is necessary to have a MC framework that can accurately and efficiently model large populations of realistic cells. In this talk I will introduce the MC framework I have built in EGSnrc to model realistic cell populations both with and without GNPs. I will also present the preliminary results of my studies on the effects of GNPT at the cellular level as a function of GNP concentration, beam energy, and absorbed dose.

**2) Panel Discussion - Med phys and 1 y of covid19**

Panelists: Claire Foottit (The Ottawa Hospital Cancer Centre), Raphael Galea (NRC Ionizing Radiation Standards), Ming Liu (PhD alumnus), Julia Wallace (Carleton Univ., Assoc. Dean of Science), Graeme Wardlaw (Can. Nucl. Safety Comm., formerly at Health Canada)

Moderator: Malcolm McEwen (NRC Ionizing Radiation Standards, OMPI Director)

This special event marks the one-year anniversary of the Ontario announcement that emptied buildings and had people scrambling to set up offices in basements, bedrooms and any space they could find. Since then we've learnt a lot of new terms and acronyms - N95, Zoom, WFH, positivity rates, virtual classrooms - and developed new skills (and likely lost some others). We've faced up to the challenge of being remote from our colleagues while at the same time being very local to our fridges. We've gone cold turkey on international travel but discovered the pleasure of walking round our neighbourhoods. We've scoured streaming sites every evening for new content and, of course, said "Can you hear me" or "You're muted" way more times that we can count!
But, what about medical physics? 12 months on, we are going to hear from a panel of OMPI members about their experiences of working (or not working) through the pandemic. Our panelists will provide their perspectives on how their activities - research, teaching, learning, clinical service delivery, manufacturing and client support - have been impacted and how they have adapted, both personally and in their organizations. The aim is to learn from others and understand how our experience fits into the wider community.

We also want to hear from the wider OMPI membership, so come with your questions, comments, life hacks, etc and be prepared to share.

Note - we are NOT planning a follow-up in 2022...

# OMPI Seminar: Mehan Haidari and Eric Vandervoort

**Date: Thursday, April 15, 2021**
**Time: 15:30**
**Location: This is a virtual seminar via this Zoom Meeting.**

**Presentations:**

**1) Towards Rapid Palliative Conformal Radiation Therapy: Synthetic CT Generation**

**by Mehan Haidari (PhD Candidate)**

Supervised by Dr. Elsayed Ali, The Ottawa Hospital Cancer Centre

Abstract: The standard clinical process of scan-plan-treat in external beam photon treatment has each of those 3 steps performed separately over a period of 1-2 weeks. This process may be cumbersome to a subset of patients who require radiation treatment for palliation, or for emergency intervention. Past and current approaches to expedite this process compromise on conformality of the treatment, and/or have been resource intensive, which makes them not scalable. We propose a solution to automate this process to reduce resource utilization without compromising treatment quality. This talk will provide an overview of the proposed solution and will then focus on the first step: the generation of synthetic high-quality CT images for targeting and treatment planning.

**2) Maintaining quality for ablative radiotherapy using multiple treatment modalities**

**by Eric Vandervoort, PhD (The Ottawa Hospital)**

Abstract: Many large radiation oncology departments now have different stereotactic ablative radiotherapy (SABR) treatment techniques available. Patients need to be directed to the appropriate modality weighing technical considerations and competing demands on resources. This could lead to variations in treatment quality if processes deviate across treatment platforms. In our center, the primary SABR modality is the CyberKnife radiosurgery system. Demand has increased as more and more evidence has been published demonstrating the efficacy of SABR treatments. We have needed to increase capacity across our radiation oncology program for different types of ablative treatments and anticipate where increased demand will be in the future. To provide the same quality of care to all patients, the equivalency of treatment on the alternative treatment modality (usually conventional gantry mounted linear accelerator) must be demonstrated. Some of the factors investigated include intra-fraction motion, plan quality across modalities, and dose delivery accuracy. A framework is proposed to ensure that an appropriate SABR technique has been selected which is based on evidence from our own patient population and radiation therapy system performance evaluations. Disease sites to be discussed include brain, spine, liver and prostate cancer.

# OMPI Seminar: Sara Gholampourkashi and Frederic Tessier

**Date: Thursday, May 27, 2021**
**Time: 15:30**
**Location: This is a virtual seminar via this Zoom Meeting.**

**Presentations:**

**1) Clinical implementation of a fully automated evaluation tool for 4DCT quality control**

**by Sara Gholampourkashi, PhD (Medical Physics Resident, The Ottawa Hospital Cancer Centre)**

Supervisor: Dr. Lesley Buckley, The Ottawa Hospital Cancer Centre

Abstract: 4DCT imaging is a routine clinical imaging protocol in radiotherapy clinics, used for thorax and upper abdominal scans. The 4D images are used to generate an average scan, used for target delineation, organ at risk identification and treatment planning. As such, Routine quality assurance of the 4DCT imaging should be included as part of the CT QC program. These tests evaluate image quality parameters of a moving target including mean and standard deviation of CT numbers, spatial integrity (dimension and location) and spatial resolution. The operational impact of such extra tests would be the additional workload and user-dependent results due to manual analysis in a clinic. Our automated analysis tool, using a simple respiratory motion phantom, has enabled us to offset some of the operational impact by speeding up the process the additional advantage of improving reproducibility of the analysis between test cycles and operators.

**2) Towards key comparisons of Monte Carlo simulations: 1. Registry of detector models for dosimetry calculations**

**by Frederic Tessier, PhD (NRC)**

Abstract:

Radiation dosimetry, in a way, is the poor child of metrology: while other SI units seek bragging rights through high precision primary standards (up to 16 decimal digits in the case of the second!), radiation dose measurements are typically reported with 3 digits of precision at best (why is that?). Monte Carlo simulations over the past few decades have afforded insight into radiation physics at or beyond this level of precision, by considering small changes between otherwise identical simulations. However, I have observed over time that disagreements in simulations results between different research groups—even different people in the same group!—are the norm rather than the exception, somewhat surprisingly. The reality is that there is still some degree of “art” today in running Monte Carlo simulations, with any of the general-purpose radiation transport software available: different modelling choices, and dull mistakes, lead to significant discrepancies. At best these lead to erroneous data and conclusions, and at worse discredit the Monte Carlo approach altogether (or the other way around, depending on your own proclivities). To resolve this absurd situation, I propose a standard metrological approach: key comparisons that go much beyond the historical “comparison between codes”, towards public computational models, shared validation data and routine testing within a continuous integration perspective. Not only would such a framework improve the quality, validity and credibility of simulation work, it would also serve as a rigorous vetting environment for future development of all radiation transport software toolkits.