The past, present and future of radiation treatment of cancers in the liver: a physicist's perspective

Eugene Wong
Associate Professor
Dept. Physics & Astronomy, University of Western Ontario

Date: Tuesday, September 11, 2012

Time: 3:30PM-4:30PM

Location: HP4351

Abstract:

Radiotherapy has evolved rapidly in the past twenty years. Previous toxic whole liver treatments with radiation doses that at best relieve cancer symptoms are now targeted to the tumours only, guided by imaging and triggering of radiation delivery based on patient's respiration. We can now escalate dose to levels impossible before, only limited by surrounding normal tissues. Along with earlier diagnoses and better follow up, liver metastases from colorectal diseases, for instance, are diagnosed earlier, with smaller tumors, and often solitary. This state of limited metastases is now known as oligometastasis, and long term cure is possible with aggressive treatments. Risks of complications for these patients are estimated by a model of liver normal tissue complication probability (NTCP) based on the treatment plans and information from prior clinical trials. Since tumours are of different sizes and locations with respect to the liver, patients received different prescriptions. We will show in this talk how we took advantage of the different dose prescriptions to extract tumour control probability (TCP) for liver metastases and compared it to that of primary liver cancers. Such dose-response curve will be used as a population-based prediction of treatment outcome. To explore patient-specific dose prescription, we began investigating into liver tumour blood flow imaging, with the hypothesis that low blood flow imply hypoxia, conferring radiation resistance. The theory and practice of such liver blood flow imaging will be reviewed. Last but not least, coming full circle, we have recently begun reviewing toxicities from treating this group of patients with an eye to validate or update the existing NTCP model parameters used in the clinic.

The Discovery and Resolution of the Pioneer Anomaly

Viktor T. Toth

Date: Tuesday, September 18, 2012

Time: 3:30PM-4:30PM

Location: HP4351

Abstract:
For the past decade, Viktor Toth played a pivotal role in the research, led by NASA's Jet Propulsion Laboratory, of the anomalous acceleration of the 40-year old Pioneer 10 and 11 spacecraft and the possible breakdown of Einstein's laws of gravity at great distances from the Sun. His presentation begins with a brief historical overview of these remarkable space missions, including original plans to use the trajectory of these spacecraft to detect gravitational anomalies in the outer solar system and the discovery of a constant anomalous acceleration. He discusses the significance of the possibility of using man-made instruments in the solar system to detect deviations from standard gravity theory. Alas, the recent, most detailed study of the anomaly points to a mundane cause, heat emitted by the spacecraft and the resulting recoil force. This confirms Einstein's predictions in the solar system at a level of accuracy that is not likely to be achieved again for decades. The chapter of the Pioneer Anomaly thus seems to be drawing to a close, though some questions remain.

A new generation of radiation dose detectors tailored for radiation treatment monitoring

Louis Archambault

Medical Physicist/Adjunct Professor
CHUQ/Laval University

Date: Tuesday, October 2, 2012

Time: 3:30PM-4:30PM

Location: HP4351

Abstract:

Radiation treatments have considerably evolved in recent years. Today, radiotherapy employs complex dose distributions that are highly modulated in three dimensions. Furthermore, treatments can now be delivered dynamically by varying an array of parameters simultaneously such as the beam orientation, the dose rate and the shape of the beam aperture. In this context, traditional radiation dose detectors have increasing difficulties to accurately track radiation dose delivery. We are therefore motivated to develop new instruments specifically designed to monitor modern radiation treatments. Based on our past experience with plastic scintillation dose detector, we are investigating two novel detector concepts that would exhibits high spatial and temporal resolution as well as high measurement precision and accuracy.

By using multiple-scintillating elements emitting different wavelength spectra and a novel mathematical formalism akin the one used in hyperspectral imaging we have shown a way to optically encode spatial information within the scintillation signal thus allowing us to build a miniature detector array for real-time dose measurement capable of making readings at multiple locations simultaneously. In a second investigation, we have shown the feasibility of performing a tomographic acquisition of the scintillation signal produced within a large volume of scintillating material. With such a device, it is possible to reconstruct a complete, three-dimensional dose distribution after a single irradiation with a spatial resolution of the order of the millimeter.

While further work is required to bring these new instruments in the clinic, our work have shown their strong potential for answering the needs of modern radiation treatments. The use of these detectors will improve our confidence that complex, highly conformal treatments can be delivered accurately without risk to patients.

Two-minute colloquia followed by soccer game

Date: Tuesday, October 9, 2012

Time: 3:30PM-4:30PM

Location: HP4351 and field behind Nesbitt

Abstract:
This is a special colloquium given by faculty members, research scientists, research associates and adjunct professors from the Physics Department. Each one will give a two-minute talk to introduce their research fields.

Graduate and undergraduate students are especially invited!

Undergraduate students: this is a good opportunity for you to know the faces and research fields of honours project and/or summer research potential supervisors. Thus, undergrad students are strongly encouraged to attend it.

We will have coffee/tea and cookies from 3:00 pm to 3:25 pm in "room 2461" (the lunch lounge). Please, come at 3:00 pm to chat with others and have a rest from your desk.

After the colloquium we will have the annual soccer game (Undergrad versus Professors/RAs/staff/grad students) at 4:45 pm in the field behind the Nesbitt. Bring your soccer gear!

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.

The turbulent birth of planets

Dr. Wladimir Lyra
NASA Carl Sagan Fellow
Jet Propulsion Laboratory, California Institute of Technology

Date: Tuesday, October 23, 2012
Time: 3:30PM-4:30PM
Location: HP4351

Abstract:

During the first million years of evolution, nascent planetary systems are embedded in dense disk-shaped clouds of gas. These circumstellar disks are home to a myriad of hydrodynamical and magnetohydrodynamical processes, which bring about turbulence and the emergence of viscous-like behaviour, enabling accretion of gas onto the protostar. Meanwhile, micron-size interstellar dust grains embedded in the disk are growing through coagulation onto pebbles and rocks. Turbulence has a positive effect on these small solids, concentrating them into transient pressure maxima for long enough to achieve gravitational collapse into km-sized bodies, forming the first planetesimals. Giant storm systems in the disk, similar to Jupiter's Great Red Spot may exist in the resistive quiescent zone of the disk. These are even more prone to collecting solid material, producing the first terrestrial planets and cores of giant planets. Once the planets are formed, N-body interactions, migration through the disk, and jitter from the turbulent gas define the system's final architecture. Concurrently, high energy photons from the central star slowly evaporate the gas, eventually leaving behind a disk of dust and debris. These debris disks tend to show a variety of non-trivial structures attributed to planetary perturbations and utilized to constrain the properties of the unseen exoplanets. In this talk I will review the state of the art and recent advances in the field of planet formation, and provide an alternative explanation for some of the structure seen in debris disks around young stars.

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.

Galactoseismology: Evidence, Origin, and Implications for Vertical Waves in the Galactic Disk

Larry Widrow
Professor
Department of Physics, Queen's University

Date: Tuesday, November 20, 2012
Time: 3:30PM-4:30PM
Location: HP4351

Abstract:

I will present evidence for a North-South asymmetry in the distribution of stars near the Sun based on an analysis of data from the Sloan Digital Sky Survey. The North-South asymmetry has the appearance of vertical waves and may be due to the passage of a satellite galaxy or dark matter subhalo through the disk of the Milky Way. I will also describe recent observations of the outskirts of the Milky Way and Andromeda galaxies where we see enormous stellar streams and arcs. These stellar debris fields may provide important clues as to the formation of galaxies and the distribution of dark matter.

Twenty-first Century Lattice Gauge Theory: Consequences of the QCD Lagrangian

Andreas Kronfeld

Scientist
Fermi Lab

Date: Tuesday, December 4, 2012

Time: 3:30PM- 4:30PM

Location: HP4351

Abstract:

Quantum chromodynamics (QCD) is the modern theory of the strong nuclear force. For many years, many of its amazing properties were believed to be true, but had not yet been demonstrated. In this colloquium, I survey several results from lattice gauge theory, which start with the basic equations of QCD and then, via large-scale computing, establish these features. We now know, for example, how QCD generates almost all the mass of everyday objects. This, and the other topics covered, are quantitatively impressive and qualitatively important to particle physics, nuclear physics, and astrophysics.

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)

Abstract:

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.

Medical Physics Seminar

Dr. Emily Heath

Assistant Professor
Department of Physics, Ryerson University

Date: Tuesday, January 15, 2013

Time: 3:30pm

Location: HP4351

Abstract:

Modeling and compensating for geometrical and biological tumour variability in Radiation Therapy

Modern radiation therapy uses multiple high energy x-ray beams to destroy cancer cells while minimizing irradiation of surrounding healthy tissues. Radiation therapy is employed in more than 50% of cancer treatments, however, for certain sites the effectiveness of the treatment is limited by uncertainties in the tumour geometry and biology.

Respiratory motion is known to be a large source of geometrical uncertainty in radiation therapy of lung tumours. The dominant effect of respiratory motion is a reduction of the radiation dose delivered to the tumour, however, for dynamic radiotherapy techniques the delivered radiation dose can be complex and difficult to predict. The availability of advanced 4D (temporal) imaging and plan optimization techniques has enabled to development of treatments which compensate for an individual patient's respiratory motion.

Furthermore, the biological properties of tumour cells may be non-uniform. The biological damage inflicted by ionizing radiation is determined by the individual tumour cell radiation sensitivity which can be influenced by multiple factors including the oxygenation status of cells. Certain tumour sites are known to exhibit hypoxic regions which are resistant to radiation.

This talk will present methods to predict the radiation dose delivered in the presence of geometrical and biological uncertainty. A simulation tool which models the interplay between the radiation beam modulation and patient respiratory motion to reconstruct the dose delivered by dynamic radiotherapy techniques will be presented. The development of robust 4D treatment planning techniques to compensate for respiratory motion will be discussed. Finally, a treatment planning approach which delivers a spatially varying radiation dose to overcome tumour hypoxia in head and neck cancer will be presented.

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 Al_2O_3: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.

Medical Physics Seminar

Dr. Magdalena Bazalova
Research Instructor
Stanford School of Medicine

Date: Tuesday, January 22, 2013

Time: 3:30pm

Location: HP 4351

Abstract:

Radiation Therapy for the Poor and the Rich

External beam radiation therapy, commonly used to treat deep-seated tumors, is typically delivered with high-energy (megavoltage) photon beams. We have explored the feasibility of unconventional radiation sources to overcome two current issues of radiotherapy - the high cost of radiotherapy machines and the long (i.e. 4-45 min) treatment times resulting in difficulties to treat moving targets, such as lung tumors.

Specifically, we have investigated the use of 1) low-energy (kilovoltage) photon beams to decrease the cost of radiotherapy machines by a factor of 10 and the use of 2) very high-energy electron (VHEE) beams to significantly decrease the treatment times in order to deliver an entire fraction of radiation within a single breath hold.

We have performed a series of Monte Carlo simulations, experimental measurements, and treatment planning studies for both types of the unconventional radiation therapy sources. We have concluded that more cost-effective kilovoltage photon beam radiotherapy of deep-seated tumors is feasible and we have confirmed that VHEE radiotherapy can be delivered within a few seconds.

Medical Physics Seminar

Dr. Rajat Ghosh
Post Doctoral Researcher
University of Pensylvania

Date: Tuesday, January 29, 2013

Time: 3:30pm

Location: HP4351

Abstract:

Application of Singlet States to hyperpolarized imaging

Hyperpolarized hetero-nuclei provide a sensitive probe to assess a variety of disease models, image chemical reactions *in-vivo* in real time, as well as measure regional function *in-vivo* by increasing nuclear spin polarization by a factor of 10^6 over the equilibrium Boltzmann polarization. It may enable imaging of pulmonary nodules, heart and lung perfusion, lung physiology, and circulatory blockages. Provided sensitivity is increased, it may enable early detection of cancer, and guide patient therapy by determining an individual's metabolic response to specific cancer drugs. However the diagnostic potential of hyperpolarized magnetic resonance spectroscopy is handicapped by relatively short nuclear spin polarization lifetimes. In order to achieve application in a clinical setting, this limitation must be overcome. Increasing the polarization lifetime would result in higher resolution real-time MRI images of chemical reactions and chemical uptake *in-vivo*, and the ability to probe physiological and chemical processes on a significantly longer time scale. This talk will focus on the development of techniques to increase the nuclear spin lifetime using singlet states. Nuclear singlet states of doubly ^{13}C- or ^{15}N-labelled molecules can be constructed and maintained for a timescale much longer than the ordinary relaxation time T_1. Such a state can be exploited for the transport of hyperpolarized nuclear spin order and the enhanced observation of cell metabolism, as well as lung physiology. Characterization of the relaxation mechanisms of singlet states, methods to populate singlet states from longitudinal polarization as well as hyperpolarization of gases by dynamic nuclear polarization will be discussed. In particular applications of these techniques to nitrous oxide will be detailed.

Special Medical Physics Seminar

Dr. Randall Stafford

Research Associate
University of Pennsylvania

Date: Tuesday, February 12, 2013

Time: 3:30pm

Location: HP4351

Abstract:

Non-Contrast Enhanced Vascular Assessment with MRI

Magnetic Resonance Imaging (MRI) is a medical imaging modality that allows for in vivo imaging that does not involve ionizing radiation. Different magnetic properties in tissue can be manipulated

with MRI to uncover valuable clinical information, such as blood flow, anatomical features and tissue function. Vascular MRI is used to assist diagnosis and treatment planning in a broad range of pathologies, including atherosclerotic diseases, tumor angiogenesis and dementia. Recent findings have linked patients with compromised renal function with developing nephrogenic systemic fibrosis following exposure to certain gadolinium-based vascular MRI contrast agents. Thus, emphasis has been placed on development of non-contrast enhanced (NCE) techniques. In addition to increased patient safety and reduced healthcare costs, NCE MRI techniques are not limited by the dynamic passage of a transient contrast bolus and are well-suited for longitudinal studies. This talk will discuss two NCE vascular MRI techniques: MR angiography (MRA) and arterial spin labeling (ASL); and illustrate their relevant clinical applications. NCE MRA is ideal for patients with systemic atherosclerotic diseases who are at risk of renal insufficiency in the presence of renal artery stenosis. In ASL, magnetically labeled arterial blood is used as an endogenous tracer for absolute quantitative perfusion measurements. ASL has applications in cerebral blood flow quantification, functional MRI and to assess tumor response to radiotherapy and chemotherapy.

Special OCIP Seminar

Dr. John Behr
Research Scientist
TRIUMF

Date: Tuesday, February 26, 2013

Time: 3:30pm

Location: HP4351

Abstract:

Atom traps, beta decay, and wrong-handed neutrinos

Electroweak unification offers a beautiful model for the weak interaction in terms of exchange of heavy partners of the photon, though precise enough low-energy experiments can still test its features and search for additional physics. At TRIUMF, we use laser trapping and cooling techniques to study beta-decaying isotopes. The pressure of laser light traps the radioactive atoms in a 1 mm-sized cloud. The nucleus produced in the decay has very low kinetic energy, and would stop in ten atomic layers of material. But it freely escapes the trap, and we can measure its momentum. When we do this in coincidence with the emitted electron, we can deduce the (otherwise invisible) neutrino momentum. Recently we completed an experimental upgrade, and measured

electron and recoil decay asymmetries with respect to the nuclear spin of 37K, a decay similar in many ways to that of the neutron. The asymmetries are sensitive to the chirality of the emitted electron and neutrino, and our eventual goal it to provide a rigorous test of the Standard Model feature that the emitted neutrino is always left-handed.

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

Abstract:

"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.

Special Medical Physics Seminar

Dr. Emilie Soisson

Assistant Professor
McGill University

Date: Thursday, March 7, 2013

Time: 3:30pm

Location: HP4351

Abstract:

Ten Years of Experience with Tomotherapy

Twenty years ago, Rock Mackie at the University of Wisconsin published a paper detailing a novel treatment delivery system that seamlessly combined two new concepts in radiation therapy: image guidance and intensity modulated radiotherapy. Soon thereafter, a spin-off company, TomoTherapy Inc., was founded in Madison, WI, just down the street from the University. A prototype was developed and in 2002, clinical implementation of this new treatment delivery system began at UW. This talk will review the process of designing a research program around a new technology and the use of clinical research to drive product development in industry as it applies to Tomotherapy. Specific emphasis will be placed on developments between 2003 and 2013 and specifically, on the use of Tomotherapy as a "stereotactic" delivery system.

Special Medical Physics Seminar

Dr. Sangeeta Murugkar

Senior Scientist
University of Ottawa

Date: Thursday, March 14, 2013

Time: 2:30pm

Location: HP4351

Abstract:

Optical Molecular Imaging in Biomedicine

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.

CAP Lecture

Dr. Martin Laforest

Senior Manager
Institute for Quantum Computing, University of Waterloo

Date: Tuesday, March 19, 2013

Time: 3:30pm

Location: HP4351

Abstract:

Quantum Information Science and Technology: When Tiny Things Do Big Things

Two landmark theories that emerged in the 20th century forever changed our world: quantum mechanics and information theory. The first altered our perception of reality; the second enabled the information age of today. Quantum Information Science and Technology bridge these theories — by probing deep questions about information and reality, and by developing the transformative technologies of tomorrow. This talk will overview the basic concepts of Quantum Information Science and Technology and its applications to computing, communication and sensing. The current state of its physical realization using nuclear and electronic spins, photons, superconductor and semiconductors will also be explored.

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

Abstract:

“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.

Medical Physics Seminar

Victor Yang

Associate Professor
Ryerson University

Date: Tuesday, March 26, 2013

Time: 3:30pm

Location: HP4351

Abstract:

Artificial Muscle Actuated Smart Catheter

Intracranial vascular lesions can benefit from minimally invasive treatment techniques utilizing flexible catheters. Catheters that can actively change its bending curvature may have advantages over traditional medical catheters and guidewires with fixed shapes. We will review the feasibility of using laser micromachined artificial muscle as actuation method for such "smart" catheters, and discuss the performance characterization as well as it's potential enhancement for medical applications.

Special Medical Physics Seminar

Dr. Devika Chithrani
Assistant Professor
Physics Department, Ryerson University
Date: Tuesday, April 16, 2013
Time: 3 pm
Location: HP4351
Abstract:

Gold-based Nanostructures for Improved Cancer Therapeutics

The field of nanotechnology is currently undergoing explosive development on many fronts. The technology is expected to generate innovations and play a critical role in cancer therapeutics. Among other nanoparticle (NP) systems, there has been tremendous progress made in the use of spherical gold NPs (GNPs) in cancer therapeutics. In treating cancer, radiation therapy and chemotherapy remain the most widely used treatment options. These nanostructures further provide strategies for improving loading, targeting, and controlling the release of drugs to minimize the side effects of highly toxic anticancer drugs used in chemotherapy. Our recent results shows enhancement of cell death during radiation therapy when GNPs are targeted to nucleus. In addition, we have seen enhanced therapeutic effects when GNPs are used as anticancer drug carriers. Hence, gold nanostructures provide a versatile platform to integrate many therapeutic options leading to effective combinational therapy in the fight against cancer. A multifunctional platform based on gold nanostructures with targeting ligands, therapeutic molecules, and imaging contrast agents will hold the possibility of promising directions in cancer research.

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
Abstract:

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 - ^{82}Rb 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 (^{82}Rb) 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.

Special Medical Physics Seminar

Dr. T. Rock Mackie

Professor
University of Wisconsin

Date: Tuesday, April 23, 2013
Time: 3:30pm
Location: HP4351

Abstract:

Title: Medical Isotope Production with a Sub-Critical Assembly

As a response to the shortage in Mo-99 supply following a long shutdown of Chalk River's NRU reactor and the failure of the Maple reactors to be licensed, the US Department of Energy launched a program for a US domestic supply of medical isotopes without the use of highly enriched uranium. This talk reports on the progress of one of those programs. The plan is to use a gas-target tritium target bombarded by a deuteron beam to sustain fission in an aqueous sub-critical solution. This will result in efficient fission-produced medical isotopes using a fraction of the uranium needed for a reactor. The basic design and operation, including safety systems, will be discussed.

Special Theory Seminar

Dr. Brooks Thomas
Research Associate
University of Hawaii

Date: Wednesday, May 1, 2013
Time: 3:30pm
Location: HP4351

Abstract:

Dynamical Dark Matter: A New Framework for Dark-Matter Physics

Dynamical dark matter (DDM) is a new framework for dark-matter physics in which the requirement of stability is replaced by a balancing between lifetimes and cosmological abundances across a vast ensemble of individual dark-matter components whose collective behavior transcends that normally associated with traditional dark-matter candidates. This absence of stability implies that quantities such as the total dark-matter relic abundance and the dark-matter equation-of-state parameter experience non-trivial time-dependencies beyond those associated with the expansion of the universe. In this talk, I provide an overview of the DDM framework and provide examples of theoretical contexts in which DDM ensembles naturally arise. I also discuss the phenomenological implications of DDM scenarios and, in particular, how DDM ensembles can potentially be

differentiated from traditional dark-matter candidates at the next generation of direct-detection experiments and at the LHC.

Particle Physics Seminar

Dr. Christos Anastopoulos
Physics Research Fellow
CERN

Date: Thursday, May 2, 2013

Time: 3:30pm

Location: HP3230

Abstract:

The Higgs boson discovery and the measurement of its properties using the H->4l Channel

On the 4th of July 2012, the ATLAS and CMS experiments announced the observation of a new narrow resonance at a mass of ~125. The new boson was observed primarly in the H->4l and H->γγ final states. Studies of the properties of this particle are now in full force with the aim to identify the particle as the long sought Higgs boson of the Higgs mechanism. The discovery of the Higgs boson as well as the measurements of its properties using the "golden channel" H->4l are presented.

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

Abstract:

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 [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.

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.
