

Ottawa Medical Physics Institute (OMPI)

(the Medical Physics Organised Research Unit, Dept. of Physics, Carleton University)

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Editor: Jan P. Seuntjens

(Also on: <http://www.physics.carleton.ca/research/OMPI/>)

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The Ottawa Medical Physics Institute, an Organized Research Unit of Carleton University

The Ottawa Medical Physics Institute of Carleton University has 30 members involved with research and/or teaching in the Ottawa area. To provide a report on activities in the past year, this newsletter (pages 3-22) includes a membership profile including affiliation, current research, funding, and recent publications. The Medical Physics graduate students at Carleton are an important component of the Ottawa Medical Physics Institute. A student section in this newsletter (pages 31-33) lists their research topics and supervisors. The Executive meets about once a month and consists of a Director (Paul Johns), Past-Director (Ian Cameron), Secretary (Jan Seuntjens), Academic Officer (Giles Santyr), and a graduate student representative (Gosia Niedbala). Other members (Pavel Dvorak, Cheng Ng, and Robert DeKemp) attend executive meetings as observers. Pavel Dvorak has also coordinated the seminars for the past two years.

A Note from the Director

Summer is here and it's time to look back at another year of medical physics in Ottawa.

In the 1998-99 academic year OMPI welcomed three new members:

- David Wilkins - is a member of the medical physics staff at the Ottawa Regional Cancer Centre (ORCC). Dr. Wilkins is a graduate of the Carleton Physics program in medical physics. His training also included a postdoc and medical physics residency at the ORCC. His research interests are in radiation therapy and radiobiology.
- George Daskalov - did his early graduate work in nuclear physics in Sofia, Bulgaria and holds a PhD in nuclear engineering from the University of Tennessee. He is currently an Assistant Research Officer in the Ionizing Radiation Standards group at NRC. His interests focus on the radiation physics of brachytherapy. He has been working on applying the multigroup discrete ordinates method, a technique used in nuclear engineering, to photon calculations for brachytherapy.
- Julia Wallace - is a Research Associate in the Carleton Magnetic Resonance Facility. Dr. Wallace is a graduate of the Carleton Physics program in medical physics. Her current research interests are in MR imaging of hyperpolarized Xe and in MR thermometry.

A continued strength of the Carleton graduate program in medical physics is the quality of the courses. This year four half courses were offered: Medical Radiation Physics, which I taught; Radiobiology, by Peter Raaphorst; Physics of Medical Imaging, by Giles Santyr plus Barry McKee and myself, and Radiation Protection, by Elagupillai. Special thanks to Peter Raaphorst, Barry McKee and Elagu for taking the time from their demanding schedules at their own institutions to make these courses available.

Five graduate student theses were completed in 1998-99. Miller MacPherson completed his PhD in July 1998 and is currently a medical physics resident at the ORCC. At the end of that summer Geoff Zhang defended his PhD. He is presently a staff physicist at JDS Fitel in Ottawa. Gosia Niedbala completed her MSc in December and is now a PhD student in our program. Daryoush Sheikh-Bagheri defended his PhD in January 1999 and is employed with the Computer Products section at Theratronics in Kanata. Tanya Hewitt completed her MSc in April and continues to work as a physicist in the Heart Institute PET Centre. She had been there part-time for the last several months of her degree.

The monthly OMPI seminars were well-attended this year. Thank you to all speakers and attendees. This year we also ran a soccer game and barbecue in the fall, a broomball game in the winter, and had a tour of Theratronics in May. We welcome suggestions for future social and/or educational activities.

The Ottawa Life Sciences Council is working hard to promote private sector development in biosciences and medical devices in our region. OMPI has been a corporate member of the Council since 1995 and was pleased to

organize a session of invited speakers at the Ottawa Life Sciences Conference in November 1998. The speakers were David Weber (General Electric, Milwaukee), Aaron Fenster (Robarts Research Institute, London Ontario), Giles Santyr (Carleton), and Peter Raaphorst (ORCC). We plan to continue to use this venue to publicize medical physics in this city.

In the winter and spring of 1999 the OCIP graduate program in Physics was the subject of site visits by three physicists, as part of the periodic OCGS appraisal of programs. Thank you to all the OMPI members and graduate students who participated in this. I have not yet seen the reports, but I believe that the collaborative model upon which our program is built was viewed very positively.

It is the OMPI Executive which holds our organization together and keeps things moving. Jan Seuntjens was elected to the position of Secretary of OMPI in December 1999. Our thanks go to Barry McKee who served as Secretary for the previous two years and who did a superb job. Giles Santyr was acclaimed for a second two-year term as Academic Officer. Gosia Niedbala has replaced Daryoush Sheikh-Bagheri as the student representative. And, after two years as Seminar Organizer, Pavel Dvorak will be giving up that responsibility and a new person will take over in September. Thank you Daryoush for bringing the students' interests forward and thank you Pavel for two good years of OMPI seminars. Thanks go to all current members of the Executive for their drive and commitment to our activities of the next year.

In closing, thank you to all OMPI members and graduate students for your support in 1998-99. With our continued joint efforts we can look forward to another good year.

OMPI Membership Profile including Recent Research

In order that the Newsletter may serve as an annual report to the Dean of Graduate Studies and Research of Carleton University, this section describes briefly the research activities, recent publications, and sources of research funding of the OMPI members. The editor has imposed a standard format.

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Recent Research: Magnetic Resonance Imaging (MRI) is used to study water diffusion in human tissue. In order to better understand, at a basic level, the effects of water diffusion in MRI, the range over which the water molecules diffuse in a given time is measured for a variety of tissues and experimental conditions in human volunteers (completely non-invasively). These results are then interpreted using a combination of analytical models and simulations based on Monte Carlo algorithms. We have also designed and built special gradient coils which allow us to study this process over a much larger range of values than would otherwise be possible.

A second research area that we are involved with is known as functional MRI (fMRI). In fMRI the volunteer is asked to perform a specific task (e.g. finger tapping) and the part of the brain that is used to perform this task is detected. This research is applied to following the recovery of patients who have suffered a recent stroke.

Another research interest is in Hyperpolarized Noble Gas (HNG) MRI. With HNG MRI a special procedure is used to polarize noble gas molecules such that when inhaled by a patient they will produce a signal that can be used to generate an MRI image. This is a very new approach to MRI but it has a lot of potential.

Funding: Co-investigator on NSERC grant to support HNG MRI research. \$200k/y

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Recent Research: Studying the use of highly focussed beams of ultrasound for the reduction or removal of benign and malignant lesions. The process of tissue destruction, consisting of energy deposition, diffusion and tissue response is being studied experimentally, theoretically and by computer modelling. Appropriate lens design and the dosimetry of high intensity ultrasound are also being investigated. Ultrasound tissue lesioning needs accurate temperature measurement as a function of space and time. The most promising technique uses quantitative results from MRI. Work has been started on measuring the point spread function and time dependence of an MRI temperature measuring system.

Publications:

- R.L. Clarke and G.R. ter Haar, "Temperature rise recorded during lesion formation by high-intensity focused ultrasound", *Ultrasound in Med. & Biol.* **23**, 299-306, 1997.

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Recent Research: In the area of clinical electron beam dosimetry the verification process of the new electron beam algorithm implemented in Theraplan Plus is in progress. This algorithm attempts to use a similar approach to dose calculation as has been successfully used for photon beams. One of the explicitly required parameters to describe an electron beam is a Peak Scatter Factor, PSF. Rigorous tests are being performed to evaluate the performance of this algorithm. A special set of carefully machined phantoms with inhomogeneities of various densities embedded in them is used to carry out the verification tests. Measurements and calculations of Electron Peak Scatter Factors as a function of field size and beam energy are in progress. In parallel to this project, an effort of clinical implementation of electron beam calibration at a new reference depth is carried on. Collaboration with the NRC scientists within the OMEGA project is continued. Clinical implementations of new dosimetry devices (MOSFETS and gafchromic films) are carried on in collaboration with the Canadian industry and scientists from the NRC.

Studies of biological equivalence of high dose rate (HDR) and pulse dose rate (PDR) brachytherapy treatments have been started in collaboration with other scientists from ORCC. Irradiations of human glioma cells and normal human fibroblasts will be carried on under several different fractionation regimes. Amount of biological damage to cells will be measured using asymmetric field inversion gel electrophoresis and other modern techniques.

Publications:

- G.X.Ding, J.E. Cygler, "Measurement of electron beam peak scatter factors", *Med.Phys.* **25**, 251-253, 1998
- G.X.Ding, J.E.Cygler, "Measurement of P_{repl} P_{wall} factors in electron beams and in ^{60}Co beam for plane-parallel chambers", *Med.Phys* **25**, 1453-1457, 1998
- G.G. Zhang, D.W. O. Rogers, J.E. Cygler, T.R. Mackie, "Effects of changes in stopping – power ratios with field size on electron beam ROFs", *Med. Phys.* **23**, 1711-1724, 1998
- G.Ding, D.W.O. Rogers, J.Cygler, "Electron Fluence Correction Factors for Conversion of Dose in Plastic to Dose in Water", *Med. Phys.* **24**, 161-176, 1997
- D. Wilkins, X.A.Li, J.Cygler, L.Gerig, "The Effect of Dose Rate Dependence of p-type Silicon Detector on Linac Relative Dosimetry", *Med. Phys.* **24**, 879-881, 1997

- J.Cygler, X.A.Li, G.Ding, E.Lawrence, "Practical Approach to Electron Beam Dosimetry at Extended SSD", *Phys. Med. Biol.* **42**, 1505-14, 1997
- J.Cygler, G.X.Ding, W.Kendal, P.Cross, "Fetal Dose for a Patient Undergoing Mantle Field Irradiation for Hodgkin's Disease", *Med. Dosimetry*, **22**, 135-137, 1997
- N.V. Klassen, L.van der Zwan, J.Cygler, "Gafchromic MD-55 investigated as a precision dosimeter", *Med. Phys.* **24**, 1924-1934, 1997

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Recent Research:

- Semi-analytical approach in heterogeneity correction factor determination within the framework of the scatter-subtraction dosimetry model in brachytherapy.
- Development of multigroup photon cross section libraries for brachytherapy dosimetry calculations.
- Multi-dimensional discrete ordinates modeling of I-125 and Ir-192 brachytherapy sources dosimetry.

Publications:

- G.M. Daskalov, J.F. Williamson, A.S. Kirov, "Analytical Approach to Heterogeneity Correction Factor Calculation for Brachytherapy," *Med. Phys.*, **25**, 722-735 (1998).
- G.M. Daskalov, et al, "Multigroup Discrete Ordinates Photon Transport Calculations of Water Kerma for Brachytherapy Applications", In: *Proceedings of the 1998 ANS Radiation Protection and Shielding Division Topical Conference*, **2**, pp.261-268 (1998).

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Recent Research: Development of three-dimensional attenuation and scatter corrections for positron emission tomography, and automated 3D cardiac image analysis and interpretation. Current efforts are focused on kinetic modelling of ^{82}Rb blood flow and ^{18}F FDG metabolism measurements. New control algorithms will be developed for the ^{82}Rb isotope delivery system, to allow precise control of infusion dose rates as well as total injected dose and volume.

Funding: MRC grant \$55k/y. Evaluating new treatments for heart disease using dynamic PET.

Publications:

- C.C. Watson, D. Newport, M.E. Casey, R.A. deKemp, R.S. Beanlands, "Evaluation of Simulation-Based Scatter Correction for 3-D PET Cardiac Imaging", *IEEE Trans.Nucl.Sci.*, **44**, 90-97, 1997.
- R.S.B. Beanlands, R.A. deKemp, A. Scheffel, C. Nahmias, E.S. Garnett, G. Coates, E.Fallen, "Can N-13-ammonia kinetic modeling define myocardial viability independent of F-18 fluorodeoxyglucose?", *J. Am Coll. Cardiol.*, **29**(3), 537-543, 1997.
- R.A. deKemp and R.S. Beanlands. "Postinjection Attenuation Correction using Singles Transmission on a Positron Tomograph without Interplane Septa", *IEEE Nuclear Science Symposium and Medical Imaging Conference* 1997.

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Recent Research: - Experimental elementary particle physics, weak interactions, development of new detectors and instrumentation for particle physics and applied physics. Present interests are: OPAL experiment at CERN and the development of gas microstrip detectors for digital x-ray imaging for medical and industrial applications and for radiation dosimetry.

Publications:

- M.S. Dixit, J.C. Armitage, J. Dubeau, D.G. Gobbi, P.C. Johns, D. Karlen, and F.G. Oakham, "Development of gas microstrip detectors for digital x-ray imaging and radiation dosimetry", *IEEE Trans. on Instrumentation and Measurement*, **47**, 809-813 (1998)
- D.G. Gobbi, J.C. Armitage, M.S. Dixit, J. Dubeau, P.C. Johns, D. Karlen and F.G. Oakham, "Photon counting radiography with gas microstrip detectors", *Proc. 43rd Ann. Meet. Can. Org. Med. Phys.*, 31-33, 1997, Abs: *Med Phys.* **24**, 1197, 1997.
- R. Sudharsanan, N.H. Karam, A.C. Greenwald, M. Dixit, J. Dubeau, and E.W. Somerville, "Deposition and characterization of CdZnTe thin films for gas microstrip detectors", *IEEE Trans. Nucl. Sci.*, **3**, 665, 1997

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Recent Research: Studies of patient doses from x-ray procedures, computer simulations of x-ray procedures, development of testing and measuring techniques, both in medical and non-medical x-ray applications. Facilities: Three phase and single phase radiographic/fluoroscopic, mammographic, dental and industrial x-ray machines, assorted phantoms, measuring equipment an automatic film processor and an x-ray spectrometer.

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Recent Research: Quantification of the risk to health (cancer, genetic and teratogenic effects) and environmental effects of exposure to low dose and low dose-rate of low and high LET ionising radiation, reduction of uncertainties in risk estimates, design and improvement of radiation practices at work places (hospital, research, power reactor, uranium mine, mill and refinery, radioactive waste disposal facilities) are the areas of main research interest.

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Recent Research: In our present work we are developing a methodology by which one can perform a cost benefit analysis of new technology and proposed changes to patterns of practice in radiation therapy. This tool will provide a rational basis upon which we can:

- Make equipment purchase decisions
- Make patterns of practice decisions
- Determine the optimal distribution of limited resources

Cancer treatment is in many ways similar to the manufacturing industry, whereby raw product is input into a system or process and a product is produced. In cancer treatment the "input" is the patient and the resources of the health care system. These are both funneled into the cancer treatment process and the outcome for the general population is statistical, that is a certain percentage of the patients are cured, the rest are not. For the individual the outcome is binary, either they are cured or they are not. In industry, if a process has a significantly high failure rate, whereby the product does not meet specification, the process is examined and the source of failure is identified and corrected. The various stages of the process are quality assured during manufacturing by statistical sampling. The more stringent the sampling process, the better the quality control on the product. In general this approach is not applied to cancer treatment. That is, when two seemingly identical patients enter the treatment process and one is cured while the other is not, very little is done to examine the process to determine where the failure occurred. The difference is ascribed to "biological variability". Indeed there is biological variability and much of the statistical nature of what is seen clinically can be attributed to it. However, there may also be a large, but unmeasured, variability in the day to day "treatment" process which could also play a significant role.

We are developing a model by which we can examine the entire radiation cancer treatment process, including staging, imaging, prescription, treatment planning and finally treatment delivery. The model treats the radiation therapy process as a linear chain, in that information is collected and passed from one stage of patient care to the next. The output of one stage acts as the input for the next. As a simple example, staging is determined based on the results of many tests including biochemistry, imaging and physical examination. Thus the output of the testing acts as the input for determination of the target volume. This chain continues and culminates in the delivery of treatment. As a result of the temporal and spatial dose actually delivered the patient experiences an outcome (product). Thus, any weakness or error in any part of the chain will contribute to a reduced probability of a favorable outcome. In order to achieve optimal improvement in the system with finite resources the weakest links in the chain must be identified.

The model is coupled to a biological response in order to predict outcome. We have chosen for this model the linear quadratic model with a repair term and Gompertzian growth kinetics and we will use Normal Tissue Complication Probability (NTCP) and Tumor Control Probability (TCP) as our endpoints. Combining all of these elements we hope to develop a model which would help predict the impact of various changes of practice and the introduction of new technologies. Integrating this with estimates on the cost (negative or positive) of the changes one can then make a predictive cost benefit analysis.

Publications:

- Soubra M., Gerig L.H., Szanto J. (1999) "A Study of Linear Accelerator Head Scatter Factors", Submitted *Med. Phys.*, 1999.
- Wilkins D.E., Soubra M., Gerig L.H., Szanto J. "A method of calculating head scatter factors for fields shaped with a Siemens multileaf collimator." *Med Phys* **25**(6) 1075, 1998.
- Wilkins D., Li X.A., Cygler J., Gerig L. "The Effect of Dose Rate Dependence of P-Type Silicon Detectors on Linac Relative Dosimetry." *Med Phys* **24**(6), 879-881, 1997.
- Akyurekli D.U., Gerig L.H., Raaphorst G.P., "Changes in Muscle Blood Flow Distribution During Hyperthermia", *International Journal of Hyperthermia*, **13** (5), 481-496, 1997.

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Recent Research: Studying radiation-induced conformational changes to the human genome in living cells using time-resolved and immunofluorescence spectroscopies. Using electron spin resonance (ESR) bio-dosimetry of human samples or tissue-equivalent surrogate samples. Developing an automated multiwell cell survival assay using a redox dye as a vital stain for quantitative studies of biological response modification and the radioprotective action of antioxidants. Exploring the lymphocyte immunosurveillance system as an early-warning system for radiation, cancer-proneness, cell signalling and adaptation. An immunoassay technique (ELISA) has been set up to measure antioxidant levels in cells, and to examine their role in protecting against radiation, cancer and aging. Applying health physics and radiation protection to risk assessment.

Funding:

AECL core operational and special projects funding.

Publications:

- K.J. Lenton and C.L. Greenstock, "Ability of human plasma to protect against radiation is inversely correlated with age", *Mech. Ageing Develop.* **105**, 256-260, 1998.
- R.B. Richardson, A. Trivedi and C.L. Greenstock, "Dosimetry of organically bound tritium derived from diet", *Atomic Energy Control Board Publication RSP-0068*, AECB Ottawa Canada, 1998.
- D.G. Jarrett, G.C. Norris, R. Mosebar, S.J.P. Livingstone, D.A. Schauer, R. Kehlet and C.L. Greenstock, "Background and overview." *Proceedings of Workshop on "Triage of Irradiated Personnel"*, Armed Forces Radiobiology Research Institute Publication AFFRI 98-2, Bethesda MD, p. 1-5, 1998.
- W.F. Blakely, T.M. Seed, P.G.S. Prasanna, A.J. Carmichael, N.Ramakrishnan, D.A. Schauer and C.L. Greenstock, "Forward-field bioindicators for dose assessment: Possible alternatives." *Proceedings of Workshop on "Triage of Irradiated Personnel"*, AFFRI Publication 98-2, Bethesda MD, p. 21-26, 1998.
- C.L. Greenstock, "Review of potential biomarkers of radiation exposure". *Proceedings of Workshop on "Triage of Irradiated Personnel"*, AFFRI Publication 98-2, Bethesda MD, p. A13-19, 1998.
- K.J. Lenton and C.L. Greenstock, "Antioxidants and biological radiation protection". *Proceedings of the 19th Annual Canadian Nuclear Society Conference*, **1**, 5A, p. 1-7, 1998.
- C.L. Greenstock, "Health effects and radiation protection: A primer". *Proceedings of the Annual Conference of the Canadian Radiation Protection Association*, (abstract), IV, p.1, 1998.
- K.J. Lenton and C.L. Greenstock, "An antioxidant assay using radiation generated free radicals", *Proceedings of the Annual Conference of the Canadian Radiation Protection Association*, (abstract), IV, p.3, 1998
- C.L. Greenstock, "Nuclear energy worker (atomic radiation worker) status". *Atomic Energy of Canada Limited Publication RPM-5.6*, 1998.
- C.L. Greenstock, "Filter/swipe retention following an incident or site emergency". *Atomic Energy of Canada Limited Publication OG-608*, 1998.
- A. Trivedi, T. Duong and C.L. Greenstock, "Distribution, biokinetics and dosimetry of tritiated organics", *Radioprotection* **32**, Suppl. C-1, 365-370, 1997.
- C.L. Greenstock, "Investigation of an I-125 contamination incident in the NRU reactor", *AECL Publication*, UER-NRU-96-04, 1997.
- C.L. Greenstock, "Radiation quantities and units", *AECL Publication*, RPM-5.4, pp.6, 1997
- K.J. Lenton and C.L. Greenstock, "Free radical scavenging and antioxidant kinetics using a fluorescent protein target", *Cahiers de radiobiologie* **4**, 9-12, 1997.
- C.L. Greenstock, "Health effects: Biological response and practical implications", *Proceedings of the 42nd Annual Health Physics Society Conference*, (abstract), H-1, p.1, 1997.

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Recent Research: - Ultrasound waveguide interstitial applicator has been studied in the past for its use in hyperthermia, adjuvant modality of cancer treatment. Currently studies were initiated of use of the applicator array for thermal therapy. The main interest relates to minimally invasive treatment of brain gliomas. In the procedure, two to six applicators in the array are proposed for heating. We investigate temperature pattern in tissue phantoms. FEA modelling of heating effects provides additional information on power required from individual applicators. The modelling enables appropriate planning of applicator location that results in best lesion coverage with minimal heat toxicity.

- In thermal treatment of cancer knowledge of blood flow is considered as an important factor for the treatment success. In FEA modelling described above effective thermal conductivity approach has been used. Recently we started modelling the tissue with discrete blood vessels included in the most sensitive areas. In the modelling vessels shape and size, their location relative to an applicator and blood flow velocity are studied. Proper modelling of heating effects requires information of ultrasound/tissue interaction. We are investigating this effect as well laser generated ultrasound for heating.

Funding: NSERC operating grant \$18k/y.

Publications

- B. J. Jarosz, "3-D Temperature Distribution in Ultrasound Hyperthermia with Interstitial Waveguide Applicator", *Ann. NY Acad. Sci.*, **858**, 47-55, 1998.
- B. J. Jarosz, D. Kaytar, "Ultrasonic Heating with Waveguide Interstitial Applicator Array", *IEEE Trans. Instr. Meas.*, **47**, 703-707, 1998.
- B. J. Jarosz, D. Kaytar, "Ultrasonic Waveguide Applicator Arrays for Interstitial Heating: A Model Study", *IEEE Trans. Ultrason., Ferroelectr., Freq. Contr.*, **45**, 806-814, 1998.
- B. J. Jarosz, "3-D Temperature Distribution in Ultrasound Hyperthermia with Interstitial Waveguide Applicator Arrays", Book of Abstr. Int. Symp. on Heat and Mass Transf. in Biol. and Mech. Eng., June 8-12, 1998, Kusadasi, Turkey, pp. 18-19.
- B. J. Jarosz, "3-D Temperature Distribution in Ultrasound Interstitial Heating with Three Applicator Array", *Proc. IEEE Instr. Meas. Techn. International Conf.*, St. Paul, MN, May 18-21, 1998, pp.858-862.
- B. J. Jarosz, "Feasibility of interstitial thermotherapy with ultrasound waveguide applicator arrays", *SPIE Proc. Surgical Application of Energy*, **3249**, pp. 20-30, 1998.
- B. J. Jarosz, D. Kaytar, "Ultrasonic heating with waveguide interstitial applicator array", *Proc. IEEE Instr. Meas. Techn. International Conf.*, Ottawa, ON, May 19-21, 1997, pp. 1346-1349.

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Recent Research: - Investigating means of obtaining diagnostic information using coherent and incoherent scatter. Although coherent scatter has a small cross section compared with Compton scattering, it is a forward directed process, so that coherently-scattered photons have a high probability of reaching the image receptor. Furthermore, the differential coherent cross section varies with scattering angle and photon energy in a material-specific manner, even for amorphous materials; this is the diffraction signature of the material. This dependence on Z and chemical structure suggests that it can be used to obtain chemical information about tissues. We are in the process of a detailed investigation of scatter imaging to determine its sensitivity, i.e. the radiation dose to the patient required to detect the presence of a volume of tissue of specified dimensions against a background of other tissue.

- Member of collaboration at Carleton investigating the use of gas microstrip detectors for medical x-ray imaging. By operating in photon counting mode, the energy of each photon event can be measured, providing input for applications such as dual-energy radiography.
- Studying iterative reconstruction techniques to reduce artefacts in computed tomography (CT) by accounting for the polyenergetic nature of the x-ray beam as well as scattered x rays.

Funding: NSERC Operating Grant \$15.4k /y
Carleton University GR-5 Funding (Installation of Donated X-Ray Angiography Equipment) \$5k

Publications:

- D.G. Gobbi, M.S. Dixit, J. Dubeau and P.C. Johns, "Photon-counting radiography with the gas microstrip detector", *Phys. Med. Biol.* **44**, 1307-1335 (1999).
- M.S. Dixit, J.C. Armitage, J. Dubeau, D.G. Gobbi, P.C. Johns, D. Karlen, F.G. Oakham, and A.J. Waker, "Development of Gas Microstrip Detectors for Digital X-Ray Imaging and Radiation Dosimetry", *IEEE Trans. Instrumentation and Measurement* **47**, 809-813 (1998).
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- R.J. Leclair and P.C. Johns, "A Semi-Analytic Model to Investigate the Potential Applications of X-Ray Scatter Imaging", *Med. Phys.* **25**, 1008-1020 (1998).
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Recent Research:

- Electron transport theory,
- Monte Carlo techniques,
- Theoretical dosimetry

Publications:

- I. Kawrakow and A.F. Bielajew, "On the representation of electron multiple elastic-scattering distributions for Monte Carlo calculations", *Nuc Inst. & Meth B* **134**, 325-336, (1998)
- M. Fippel, I. Kawrakow and K. Friedrich, "Electron beam dose calculations with VMC and the verification data set of the NCI working group", *Phys. Med. Biol.*, **42**, 501-519, (1997).
- I. Kawrakow, "State-of-the-art Monte Carlo techniques for Radiation Treatment Planning", Invited talk, *World Congress on Med. Phys. and Biomed. Engineering*, Nice, France, 1997.
- I. Kawrakow, "Analysis of the Condensed History technique", Invited talk, *International Conference on Monte Carlo Methods*, Monte Carlo, 1997.

- I. Kawrakow and A.F. Bielajew, "New multiple scattering theory and transport algorithm for electron Monte Carlo simulations", *Proceedings of XII ICCR*, Salt Lake City 155, (1997).

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Recent Research: Involved in the work to establish absorbed dose standards based on water calorimetry. This is being done for high energy photons and Co-60 beams. The temperature rise in the water, caused by the absorbed dose, has a component which is due to chemical changes in the aqueous absorber. This component is simulated by computer and the simulations are tested by measuring the hydrogen peroxide in the irradiated aqueous systems. Recently, a method was developed for using GafChromic MD-55 (a thin film dosimeter) as a transfer dosimeter with an uncertainty of less than 1%. An effect of polarized light on GafChromic MD-55 was discovered and explained.

Publications:

- N.V. Klassen, K.R. Shortt, J.P. Seuntjens, and C.K. Ross, "Fricke dosimetry: The difference between $G(\text{Fe}^{3+})$ for ^{60}Co γ -rays and high-energy x-rays", *Phys. Med. Biol.* **44**, 1609-1624 (1999).
- N. V. Klassen and C. K. Ross. "Water calorimetry: the heat defect", *J. Res. Natl. Inst. Stand. Technol.*, **102**: 63-74, 1997.
- N.V. Klassen, L.van der Zwan, J.Cygler, "Gafchromic MD-55 investigated as a precision dosimeter", *Med. Phys.* **24**: 1924-1934, 1997

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Recent Research: - Radiotherapy using charged particle beams including negative pi-mesons and protons. Development of dosimetry and beam delivery techniques for particle beams.
- Theoretical radiobiology of combined effects of mixtures of radiations of different qualities. Investigation of the general concept of effective dose in radiobiology and in radiotherapy.
- Theoretical studies of interaction of toxic agents. Development of general interpretation and definition of synergism and antagonism for mixtures of toxic agents with different mechanisms of action.

Publications:

- K. Nemoto, T. Pickles, A. Minchinton and G. Lam, "The Relative Biological effectiveness of the Modulated Proton Beam at TRIUMF", *Radiation Medicine*, **16**, 43-46 (1998).
- J.A.Haider, L.D. Skarsgard and G.K.Y.Lam, "A General Cavity Theory", *Phys. Med. Biol.* **42**, 491-500 (1997)

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Recent Research: - Developing a high-resolution pinhole SPECT camera that will achieve a resolution of about 4 mm over a limited field of view. Various image reconstruction methods are being explored. Pinhole

tomography should be useful for clinical imaging of the thyroid, and for research applications in radiopharmaceutical development.

- Modelling and measuring the scatter background in SPECT systems to develop and test improved correction methods.

Publications:

- T.A. Hewitt, B.T.A. McKee, and M.J. Chamberlain, "Pinhole SPECT: Towards Clinical Thyroid Tomography", *Proceedings of the 1998 Canadian Organization of Medical Physicists Conference*, London, Ont. , 243-245, 1998.

- T.A. Hewitt, B.T.A. McKee, and M.J. Chamberlain, "Towards clinical pinhole SPECT: Some imaging characteristics", *Proceedings of the 1997 Canadian Organization of Medical Physicists Conference*, 49-51, Charlottetown, July 1997.

- B.T.A. McKee, M.J. Chamberlain and T.A. Hewitt, "A New Direction in Nuclear Medicine Imaging: Pinhole Tomography", *Proceedings of the IEEE Instrumentation and Measurement Technology Conference*, Ottawa, May 1997 (IEEE #97CH36022) pp.1350-1353, 1997.

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Recent Research: The ability of drugs to potentiate the response of human cancer cells to X-radiation and hyperthermia is being investigated. The aim of these experiments is to determine if the inhibition of cellular repair of X-radiation damage or the interaction of the drugs with hyperthermia can lead to selective killing of human tumour relative to normal cells. A selective killing of tumour over normal cells is necessary to treat tumours successfully in the clinic. In particular, two types of drugs, DNA topoisomerase poisons and cisplatin, are being emphasized. Both of these drugs are already in active use clinically; the DNA topoisomerase poisons, in particular, are also being investigated as an adjunct to radiotherapy of cancer. Recent work has also focussed on the role of the tumour suppressor, p53, in the modulation of killing by the topoisomerase poisons.

Funding: Supported as a Career Scientist with CCO.

-NCIC (Principal Investigator) interaction between X-radiation and topoisomerase poisons, \$99k/y;

-ORCC Foundation (Principal Investigator) mechanisms of resistance in human pancreatic tumour cells,\$10k;

-NCIC (Co-investigator)interaction of cisplatin with X-radiation and hyperthermia, \$128k/y;

-NCIC grant (Co-investigator) cellular radiosensitivity, \$70k.

Publications:

- Ng, C.E., Cybulski, S.E., Bussey, A.M., Aubin, R.A. and Raaphorst, G.P. "DNA topoisomerase I content of a pair of human melanoma cell lines with very different radiosensitivities correlates with their in vitro sensitivities to camptothecin." *Anticancer Res.*, **18**: 3119-3126, 1998.

- Raaphorst, G.P., Mao, J.P., and Ng, C.E. "Thermotolerance effects in thermo-radiosensitization in human glioma cells." *Int. J. Hyperthermia*, 14: 85-96, 1998.

- Ng, C.E. "Radiobiology: Mobilizing physics and chemistry for the battle against cancer. Challenge, Life with Cancer", *Magazine of the Ottawa Regional Cancer Centre*, 16-17, Fall/Winter 1998.

- Raaphorst, G.P., Mao, J.P., Yang, D.P. and Ng, C.E. "Comparison of hyperthermia radiosensitization and DNA polymerase inactivation in human normal and melanoma cell lines of different radiosensitivities." *Rad. Oncol. Invest.*, 5: 1-7 1997.

- Wallace J.W., Raaphorst, G.P., Somorjai, R.L., Ng, C.E., Fung, M.K.F., Senterman, M. and Smith, I.C.P. "Classification of ¹H Magnetic Resonance spectra from untreated and recurrent ovarian cancer using linear discriminant analysis." *Mag. Res. in Medicine*, 38: 569-576, 1997.

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Recent Research: Presently there are three main areas of research as follows:

- The study of radiosensitization of human cancer cell to radiation using hyperthermia and drugs. This project includes the study of the response of a wide range of human tumour cells (glioma, ovarian carcinoma, breast cancer, melanoma *etc*) to radiation at different dose rates and the effect of hyperthermia (heating from 40 to 45°) on radiosensitization. In addition the effect of chemotherapy agents in combination with hyperthermia and radiation is also being evaluated. In these studies we are also assessing the mechanisms of radiation resistance and the capacity of cells to repair radiation damage. The experimental results are being modelled in order to developed comprehensive models that can be used to predict radiotherapy outcome. These studies also include design of special radiation apparatus to deliver specific dose rates and require the development of a good understanding of radiation dosimetry.

- Prediction of radiation response. In this study we are evaluating the response of human normal and tumour cells in culture to irradiation. The normal and tumour cells are obtained from patients before undergoing radiation therapy and are assessed for the radiation response and then compared to the response of the patient undergoing radiotherapy. To date we have found a correlation between the *in-vitro* and the patient tissue response. Further studies are ongoing to model these responses and to determine whether the results can be used as a predictor of radiation sensitivity and for customized dose prescription in order to optimize radiotherapy.

- Induction of radiation resistance with low doses of radiation. Our preliminary studies have shown that low dose and low dose rate irradiation can induce radiation resistance in human cells. This can have a major impact on radiation therapy where in some cases radiation is given either in fractions or at low dose rate. In addition such resistance can also have an impact on working in low level radiation fields such as those found in some industries or in outer space. We are currently characterizing this induced resistance in human cells and will develop strategies for its optimization. In addition we are also looking at other means to induce or possibly prevent induction of radiation resistance. These results are being put into models to help predict the radiotherapy response.

Funding:

- NCIC Grant for the study of cellular radiation resistance and methods of sensitization \$101k/y for 3 y
- NCIC Grant for the study of combined treatment of radiation cisplatin and hyperthermia. \$106k/y for 3 y
- Department of Defence funding for the study of induced radiation resistance. \$23k/y.

Publications:

- G.P. Raaphorst, C.E. Ng and B.H. Shahine. "Comparison of radiosensitization by 41°C hyperthermia during low dose rate irradiation and during pulsed simulated low dose rate irradiation in human glioma cells". *Int. J. Radiat. Oncol.* In press 1999.
- J.A. Dolling, D.R. Boreham, D.L. Brown, G.P. Raaphorst and R.E.J. Mitchell. "Cisplatin-modification of DNA repair and ionizing radiation lethality in yeast, *Saccharomyces cerevisiae*." *Mutation Research*. **433** 127-136 (1999).
- G.P. Raaphorst, C.E. Ng and D.P. Yang. "Thermal radiosensitization and repair inhibition in human melanoma cells: A comparison of survival and DNA double strand breaks". *Int. J. Hypertherm.* **15**, 17-27 (1999).
- G.P. Raaphorst, J. Miao and C.E. Ng. "Cisplatin and mild hyperthermia in radiosensitization to low dose rate irradiation in human ovarian carcinoma cells". *AntiCancer Research*. **17**, 3469-3472 (1998).
- C.E. Ng, S.E. Cybulski, A.M. Bussey, R.A. Aubin and G.P. Raaphorst. "DNA topoisomerase I content of a pair of human melanoma cell lines with very different radiosensitivities correlates with their in-vitro sensitivities to camptothecin." *Anticancer Research* **18**, 3119-3126 (1998).

- G.P. Raaphorst, J. Mao, H. Yang, R. Goal, B. Niknafs, F.H. Shirazi, H.M. Yazdi, P. Rippstein and C.E. Ng. "Evaluation of apoptosis in four human tumour cell lines with differing sensitivities to cisplatin". *Anti Cancer Research* **18**, 2945-2952 (1998).
- G.P. Raaphorst, J. Maio, C.E. Ng and D.J. Stewart. "Concomitant treatment with mild hyperthermia cisplatin and low dose rate irradiation in human ovarian cancer cells sensitive and resistant to cisplatin". *Oncology Reports* **5**, 971-977 (1998).
- J.A. Dolling, D.R. Boreham, D.L. Brown, R.E.J. Mitchell and G.P. Raaphorst. "Modulation of radiation-induced strand break repair by cisplatin in mammalian cells". *Int. J. Radiat. Biol.* **74**, 61-69 (1998).
- G.P. Raaphorst, D.E. Wilkins, J. Maio and C.E. Ng. "Evaluation of cross resistance between responses to cisplatin, hyperthermia, and radiation in human glioma cells and eight clones selected for cisplatin resistance". *Int. J. Oncology* In press 1998.
- G. Alsbeih and G.P. Raaphorst. "Feasibility of induction of premature chromosome condensation by calyculin A in 2 fibroblasts and 2 melanoma cell lines of human origin". *Cahiers de Radiobiologie* **7**, 12-23, 1998.
- G. Alsbeih, B. Fertil, J. Boniver, E.P. Malaise and G.P. Raaphorst. "Hypersensitivity to low single doses and split dose recovery: two manifestations of induced resistance that might be related". *Int. J. Radiat. Biol.* Accepted 1998.
- G.P. Raaphorst and S. Boyden. "Adaptive response and its variation in human normal and tumour cells". *Int. J. Radiat. Biol.* In press 1998.
- G.P. Raaphorst, J. Maio and C.E. Ng. "Interactions of mild hyperthermia, cisplatin and split dose irradiation in human ovarian carcinoma cells". *Cancer Chemotherapy and Pharmacology*. In press 1998.
- D.E. Wilkins, C.E. Ng and G.P. Raaphorst. "Cell cycle perturbations in cisplatin sensitive and resistant human ovarian carcinomal cells following treatment with cisplatin and low dose rate irradiation". *Cancer Chemotherapy and Pharmacology*, **40**: 159-166, 1997.
- G. Alsbeih and G.P. Raaphorst. "Radiosensitive human cells at the crossroads: high split-dose recovery and diminished inducible response". *Int. J. Radiat. Biol.*, **72**, 135-137, 1997.
- G.P. Raaphorst, J.P. Mao, D.P. Yang and C.E. Ng. "Comparison of thermotolerance development in three human cell lines". *Endocurietherapy/Hyperthermia Oncology*, **12**, 231-240, 1997.

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Recent Research: - Developing, with Dave Dunford, an internal dosimetry Microsoft WINDOWS-based code, called GENMOD that calculates the radiation dose to the lung and other organs.
- Investigating the subcellular dosimetry for tritium-contaminated intakes in collaboration with research workers at Carleton University and AECL.
- Internal dosimetry of tritium and carbon-14 in diet.
- Leader of the Human Dosimetry project group, of the International Energy Agency's "Cooperative Program on Environmental, Safety and Economic Aspects of Fusion Power"

Research Funding: Dosimetry of organically bound tritium derived from diet. AECB, Canada (1996-Present)

Publications:

- R.B. Richardson and D.W. Dunford. "Incorporation of current ICRP recommendations in the Genmod internal dosimetry code." *Radiat. Protect. Dosim.* **79**; 375-378 (1998)
- R.B. Richardson, A. Trivedi and C.L. Greenstock. "Dosimetry of organically bound tritium derived from diet - Phase 1." Atomic Energy Control Board, Ottawa, Ontario, Canada, AECB report RSP-0068.
- R.B. Richardson and A. Hong. "Microdosimetry of tritiated particulates in alveolar sacs. In: Microdosimetry: An Interdisciplinary Approach.," (Eds. D.T. Goodhead, P. O'Neill, and H.G. Menzel) Cambridge: *The Royal Society of Chemistry*: 297-300 (1997).

- J. Lochard, R.B. Richardson, F. Lange, A.R. Sundararajan, Y. Nomura *et al.* "Safety, Health and Environmental Implications of the Different Fuel Cycles." Key Issue Paper No. 4, Working Group 4 for the "International Symposium on Nuclear Fuel Cycle and Reactor Strategy: Adjusting to New Realities", IAEA, Vienna, 1996 June 2-6, Pub: IAEA, Vienna (1997).

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Recent Research: - Monte Carlo techniques are used to calculate correction factors required for primary radiation standards. Recent examples are the calculation of wall correction factors for ionization chambers used for air kerma standards, and the calculation of the wall effect for Fricke dosimeter vials. These correction factors have a significant impact on several national standards.

- Developing more accurate and easily used clinical dosimetry protocols. In this regard, the effect of beam size and beam quality on ionization chamber calibration factors is being calculated. Also, work is underway on a formalism which will use absorbed dose, rather than exposure, calibration factors.

- Measuring fundamental data using the NRC linear accelerator. A recent project has accurately measured the bremsstrahlung yield from thick targets as a function of energy and angle and compared the results to Monte Carlo calculations. Another project is underway to measure electron stopping powers which play a fundamental role in radiation dosimetry but have never been measured with an accuracy of better than 5 %.

- Working on the OMEGA project. This is a collaboration with Rock Mackie's group at the University of Wisconsin to develop a Monte Carlo based code to calculate the dose in a patient undergoing electron beam radiotherapy. We are developing a general purpose code to model radiation beams from clinical accelerators.

Funding:

- NIH - \$125k/y for 3 y for the project "Improved photon beam and ¹⁹²Ir clinical dosimetry".

Publications:

- D.W.O. Rogers, "A new approach to electron beam reference dosimetry", *Med. Phys.*, **25**, 310-320, 1998.

- G.G. Zhang, D.W.O. Rogers, J.E. Cygler, and T.R. Mackie, "Effects of changes in stopping-power ratios with field size on electron beam ROFs", *Med. Phys.* **25**, 1711-1726, 1998

- G.M. Daskalov, R.S. Baker, R.C. Little, D.W.O. Rogers, and J.F. Williamson, "Multigroup discrete ordinates photon transport calculations of water kerma for brachytherapy applications", in *Proceedings of the 1998 ANS/RP&S Topical Conference*, Nashville, TN (April, 1998).

- G.X. Ding, D.W.O. Rogers, J.E. Cygler, and T.R. Mackie, "Electron fluence correction factors used in conversion of dose measured in plastic to dose in water", *Med. Phys.* **24**, 161-176, 1997.

- C.M. Ma, B.A. Faddegon, D.W.O. Rogers, and T.R. Mackie, Accurate characterization of Monte Carlo calculated electron beams for radiotherapy, *Med. Phys.*, **24**, 401-416, 1997.

- D.W.O. Rogers, A.F. Bielajew, N.V. Klassen, C.K. Ross, J.P. Seuntjens, K.R. Shortt, and L. Van der Zwan, "NRC Activities and Publications, 1995-97": Report to CCEMRI(I) Meeting, BIPM, CCEMRI(1)97-29, 1997.

- M. Holmes, T. R. Mackie, D.W. O. Rogers, and G.X. Ding, "Comparison of clinical electron dose distributions between a commercial radiation treatment planning system and EGS4 Monte Carlo", In *Proceedings of the XII'th Conference on the Use of Computers in Radiotherapy* (Medical Physics Publishing) 54-56, 1997.

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Recent Research: - The knowledge of the photon spectrum from medical linear accelerators improves the quality and accuracy of the radiation dosimetry. The spectral shape strongly influences the dose distribution in the patient especially in the presence of heterogeneities, correction factors required for beam calibration, and unit head design. Additionally, the spectrum shape plays a role in dose calculations involving beam modifying devices. Direct measurement of a photon spectrum is not possible in a clinical environment. As a result, approximate methods for estimating these spectra must be considered. In our work, an integral equation formulation for unfolding x-ray spectra from transmission data is being studied. The integral equation to be solved is a Fredholm type of the first kind which is, in general, extremely difficult to solve. Our approach is to transform this to a Fredholm type of the second kind, which is handled much more readily using standard numerical methods such as collocation or Galerkin methods. This approach promises to be challenging and has direct application to other areas of medical physics including the inverse-planning problem.

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Recent Research: - The general goal of our research is to develop new Magnetic Resonance (MR) imaging methods for improved patient care. Our primary clinical focus is breast cancer. Current research activities in our laboratory include: the use of spin locking and magnetization transfer contrast for improving detection of lesions in radiodense breasts, characterization of breast lesions (benign vs. malignant) using rapid imaging of gadolinium-based contrast agents, measurement of tumour blood flow and 3-D image display issues. Clinical studies to evaluate the usefulness of these techniques are in progress. Our clinical collaborators include The Ottawa Hospital, General Site (see: Ian Cameron), the Kingston General Hospital and the Children's Hospital of Eastern Ontario. A relatively recent area of research involves the imaging of hyperpolarized noble gases (HNG), in particular ^{129}Xe and ^3He . As part of an NRC/NSERC Research Partnership, we are investigating the large-scale production, storage, transport and delivery of HNG as well as MR imaging applications for both in vivo imaging of gas and dissolved phases (e.g. blood flow) and non-biological material testing. This collaborative research involves investigators at the NRC Steacie Institute for Molecular Sciences as well as The Ottawa Hospital, General Site.

Funding:

- NIH FIRIST Award from NCI: "Spin locking for magnetic resonance imaging of breast cancer", \$100k/y.
- NRC/NSERC Research Partnership Grant: "Research Partnership in Hyperpolarized Noble Gas (HNG) Technology", \$250k/y.
- Canada Foundation for Innovation (CFI): "Carleton Magnetic Resonance Facility", awarded 10/98, \$200k.
- NSERC Operating Grant: "Magnetic Resonance Imaging of Hyperpolarized Xenon", \$25k/y.
- Canadian Breast Cancer Research Initiative (CBCRI): "Hyperpolarized Xenon MR Imaging of Breast Cancer", \$35k.
- Heart and Stroke Foundation of Canada (Co-Investigator): "Chronic Ischemia of Brain and Retina", awarded 04/99-04/03, \$68k/y.

Publications:

- G.J. Wilson, G.E. Santyr, M.E. Anderson, P.M. DeLuca, "T₁ Relaxation Times of ^{129}Xe in Tissue Homogenates", *Magnetic Resonance in Medicine*, **41**, 933-938 (1999).
- G.O. Cron, G.E. Santyr, F. Kelcz, "Accurate and Rapid Quantitative Dynamic Contrast-Enhanced Breast MR Imaging Using Spoiled Gradient-Recalled Echoes and Bookend T₁ Measurements", (revised: *Magnetic Resonance in Medicine*, March 1999).
- G.O. Cron, G.E. Santyr, F. Kelcz, "Spoiled Gradient-Recalled Echo MR Imaging with Bookend T₁ Measurements for Determination of Gd-DTPA Extraction-Flow Product and Tissue Cell Fraction of Breast Lesions", (submitted to: *Magnetic Resonance in Medicine*, Nov. 1998).

- E.R. Niendorf, T.M. Grist, F.T. Lee Jr., P.C. Brazy, G.E. Santyr, "Rapid *in vivo* Measurement of Single Kidney Extraction Fraction and Glomerular Filtration Rate with MR Imaging", *Radiology* **206**, 791(1998).
- J.E. Bishop, G.E. Santyr, F. Kelcz and D.B. Plewes, "Limitations of the Keyhole technique for Quantitative Dynamic MRI", *J. Magn. Reson. Imag.*, **7**, 716 (1997).
- E.R. Niendorf, T.M. Grist, R. Frayne, P.C. Brazy and G.E. Santyr, "Rapid Measurement of Gd-DTPA Extraction Fraction in a Dialysis System using Echo-Planar Imaging", *Med. Phys.*, **24**, 1907(1997).
- G.J. Wilson, G.E. Santyr, M.E. Anderson and P.M. DeLuca, " T_2 of ^{129}Xe in Rat Tissue Homogenates and Blood at 9.4 T", *Int'l. Society of Magnetic Resonance in Medicine*, Philadelphia 1999 (abstract).
- J.C. Wallace, R.L. Clarke and G.E. Santyr, "MRI Mapping of One-Dimensional Temperature Gradients Across Ex-Vivo Liver Tissue During Rapid and Slow Heating", *Intl. Society of Magnetic Resonance in Medicine*, Philadelphia 1999 (abstract).
- G.O. Cron, J.C. Wallace, T. Fortin, W.D. Stevens, B.A. Pappas, F. Kelcz and G.E. Santyr, "Non-Invasive Measurement of the Arterial Input Function for Quantitative Dynamic Contrast-Enhanced MR Imaging of Cancerous Lesions in the Rat", *Intl. Society of Magnetic Resonance in Medicine*, Philadelphia 1999 (abstract).
- P. Sevigny, G. Santyr, J. Wallace, S. Breeze, S. Lang, A. Cross, I. Moudrakovski, C. Ratcliffe, B. Simard and J. Ripmeester, "A Study of Dissolved Hyperpolarized ^{129}Xe for Injection Delivery", *Canadian Organization of Medical Physicists*, Sherbrooke, 1999 (abstract).
- J.C. Wallace, R.L. Clarke and G.E. Santyr, "MRI Mapping of One-Dimensional Temperature Gradients Across Ex-Vivo Liver Tissue During Rapid and Slow Heating", *Canadian Organization of Medical Physicists*, Sherbrooke, 1999 (abstract).
- G.O. Cron, J.C. Wallace, T. Fortin, W.D. Stevens, B.A. Pappas, F. Kelcz and G.E. Santyr, "Non-Invasive Measurement of the Arterial Input Function for Quantitative Dynamic Contrast-Enhanced MR Imaging of Cancerous Lesions in the Rat", *Canadian Organization of Medical Physicist*, Sherbrooke, 1999 (abstract).
- S. Breeze, J. Ripmeester, C. Ratcliffe, I. Moudrakovski, S. Lang, and G. Santyr, "Surface Coatings for the Storage and Transportation of Hyperpolarized Xenon-129", *82nd CSC Conference and Exhibition*, Toronto, 1999 (abstract).
- G. Santyr, G. Wilson, P. Sevigny, J. Wallace, S. Lang, S. Breeze, M. Anderson, P. DeLuca, J. Ripmeester, "Transverse Relaxation Times of ^{129}Xe in Rat Tissue Homogenates and Blood", *Hyperpolarized Gases in Magnetic Resonance: Biomedical Investigations and Clinical Applications*, Les Houches, 1999 (abstract).
- I. Cameron, G. Santyr, S. Lang, S. Breeze, J. Wallace, P. Sevigny, I. Moudrakovski, B. Simard, J. Ripmeester, "A Centralized Approach to Production and Distribution of Hyperpolarized Xenon", *Hyperpolarized Gases in Magnetic Resonance: Biomedical Investigations and Clinical Applications*, Les Houches, 1999 (abstract).
- P. Sevigny, G. Santyr, J. Wallace, S. Breeze, S. Lang, I. Moudrakovski, C. Ratcliffe, B. Simard and J. Ripmeester, "Optimization of Gradient-Echo Imaging for Hyperpolarized Xenon Gas", *American Physical Society*, Atlanta, 1999 (abstract).
- S. Lang, I. Moudrakovski, C. Ratcliffe, J. Ripmeester, S. Breeze and G. Santyr, "A Flow System for Large-Scale Production of Hyperpolarized Xenon", *MOOT 98 NMR Minisymposium*, Waterloo, 1998 (abstract).
- S. Breeze, I. Moudrakovski, C. Ratcliffe, J. Ripmeester and G. Santyr, "Effect of S/V Ratio on Surface Induced Relaxation of Hyperpolarized ^{129}Xe ", *MOOT 98 NMR Minisymposium*, Waterloo, 1998 (abstract).
- P. Sevigny, G. Santyr, J. Wallace, S. Breeze, S. Lang, J. Xu, I. Moudrakovski, B. Simard and J. Ripmeester, "MRI of Hyperpolarized Xenon", *Int. Isotope Society 6th Canadian Chapter Meeting*, Ottawa 1998 (abstract).
- P. Sevigny, G. Santyr, J. Wallace, S. Breeze, S. Lang, J. Xu, I. Moudrakovski, B. Simard and J. Ripmeester, "MRI of Hyperpolarized Xenon", *Canadian Organization of Medical Physicists*, London, 1998 (abstract).
- J.C. Wallace, W.K. Myint, R.L. Clarke, G.E. Santyr, "Mapping of Temperature Gradients in Liver using MRI and Thermocouple Temperature Measurements", *Can. Org. of Medical Physicists*, London, 1998 (abstract).
- G.O. Cron, G. Santyr, F. Kelcz, "Multislice Adiabatic Saturation Recovery T1 Measurement for quantitative Dynamic Contrast-enhanced Breast MRI", *Can. Organization of Medical Physicists*, London, 1998 (abstract).
- G.O. Cron, G.E. Santyr, F. Kelcz, "Dynamic Contrast-Enhanced Imaging of the Breast with Magnetic Resonance", *-IEEE Instrumentation and Measurement Technology Conference*, Ottawa 1997 (abstract).
- G.O. Cron, G.E. Santyr, F. Kelcz, "Correction of Errors due to Slice Profile Imperfections in Quantitative Dynamic -Contrast-Enhanced Breast MRI", *Intl. Society of Mag. Res. in Medicine*, Vancouver 1997 (abstract).
- G.J. Wilson, G.E. Santyr, M.E. Anderson, P.M. DeLuca, T1 "Relaxation Times of Xe-129 in Tissue Homogenates", *Intl. Society of Magnetic Resonance in Medicine*, Vancouver 1997 (abstract).

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Recent Research: - Successful treatment of tumors using radiotherapy requires accurate knowledge and verification of absorbed dose delivered by the treatment unit. The first step in determination of the dose to the tumor is calibration of the treatment unit in terms of the quantity absorbed dose to water. The IRS group is working on calibration methods to allow the clinical physicist to directly determine absorbed dose to water with unprecedented accuracy. These methods are based on the calibration of ionization chambers, the commonly used instrument in clinical dosimetry, in terms of absorbed dose by comparing them with a water calorimetric technique. Using calorimetry the dose can be determined from first principles by measuring the temperature rise in water caused by radiation. The Canadian standard for absorbed dose to water is now based on the sealed water calorimeter.

- In one part of the work we concentrate on establishing the water calorimetry technique to measure absorbed dose in Co-60 beams, and linear accelerator photon and electron beams. Various high precision measurements and numerical modeling of heat transport in water have improved our understanding and correction factors on the sealed water calorimeter.

- In a second part of the work we use the water calorimeter to measure absorbed dose beam quality dependence correction factors (k_Q) of commonly used cylindrical ionization chambers in high energy photon beams. By studying these correction factors various problems in the procedures currently employed by the clinical physicists can be identified. This part of the project goes hand in hand with Monte Carlo simulations, in order to understand the various effects related to wall correction factors of ion chambers.

- In the framework of the American Association of Medical Physicists' RTC Task Group No 61, we are working on a new dosimetry guide for kV X-rays for clinical physicists and radiobiologists. Various smaller research projects and publications are carried out to optimize the recommendations of the new protocol.

Publications:

- C.-M. Ma and J.P. Seuntjens "Mass-energy absorption coefficient and backscatter factor ratios for kilovoltage x-ray beams". *Phys. Med. Biol.* **44**, 131 – 143, 1999

- J.P. Seuntjens and H. Palmans "Correction factors and performance of a 4°C sealed water calorimeter". *Phys. Med. Biol.* **44**, 627 – 646, 1999

- N.V. Klassen, K.R. Shortt, J.P. Seuntjens, and C.K. Ross, "Fricke dosimetry: The difference between $G(\text{Fe}^{3+})$ for ^{60}Co γ -rays and high-energy x-rays", *Phys. Med. Biol.* **44**, 1609-1624 (1999).

- T.W.M. Grimbergen, A.H.L. Aalbers, J. Van Dam, B.J. Mijnheer, J. Seuntjens, H. Thierens, F.W. Wittkamper and J. Zoetelief "The NCS code of practice for dosimetry of low and medium energy x-rays." *Proceedings of the kV X-Ray Workshop*, eds C.-M. Ma and J.P. Seuntjens p 55 – 68, 1999

- C.M. Ma, X.A. Li, and J.P. Seuntjens Consistency study on kV dosimetry, *Proceedings of the kV X-Ray Workshop*, Stanford University, eds C.-M. Ma and J.P. Seuntjens p 69 – 88, 1999

- C.-M. Ma, X.A. Li, J.P. Seuntjens "Study of dosimetry consistency for kilovoltage x-ray beams". *Med. Phys.* **25**, 2376-2384, 1998

- C.-M. Ma and J.P. Seuntjens "Correction factors for water-proofing sleeves in kilovoltage x-ray beams". *Med. Phys.* **24**, 1507-1513, 1997

- J.P. Seuntjens, C.K. Ross, N.V. Klassen, and K.R. Shortt, "A status report on the NRC sealed water calorimeter," *Technical Report PIRS-584*, NRC Canada, Ottawa, K1A-0R6, 1999.

- J. Borg, J.P. Seuntjens, and D.W.O. Rogers "Monte Carlo calculations of fluence spectra in air for several ^{192}Ir Source configurations", *Proc. 1998 COMP Annual Meeting*, London, Ontario, p 177-179

- C.L. Yang, D.W.O. Rogers, and J.P. Seuntjens, "Calculation of photon beam quality specifiers", *Proceedings of the COMP Annual Meeting*, London, Ontario p 186 – 188, 1998

- T.W.M. Grimbergen, A.H.L. Aalbers, J. Van Dam, B.J. Mijnheer, J. Seuntjens, H. Thierens, F.W. Wittkamper and J. Zoetelief (1997) Dosimetry of low and medium energy x-rays. A code of practice for use in radiotherapy and radiobiology, NCS Report 10, Netherlands Commission on Radiation Dosimetry

Ken Shortt

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National Research Council of Canada
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Recent Research: The National Research Council declared a new standard of absorbed dose to water in July, 1998. A series of comparisons of the dosimetric standards of NRC with the corresponding standards of the US, France, Switzerland and the BIPM was carried out in the fall of 1998.

Collaborative research with Giles Santyr and Julia Wallace of Carleton University in the field of gel dosimetry is progressing nicely.

The energy dependence of G, the yield of ferric ions produced by irradiating Fricke chemical dosimetry solution has been studied and a paper in press.

The relative value of the absorbed dose calibration factor for a variety of commercially produced transfer ionization chambers, called k_Q , is also under investigation at several linac energies. A paper on this is in preparation.

Radiation detector development with industrial collaborators is continuing as are experiments in radiation protection using TLDs.

Publications:

- N.V. Klassen, K.R. Shortt, J.P. Seuntjens, and C.K. Ross, "Fricke dosimetry: The difference between $G(\text{Fe}^{3+})$ for ^{60}Co γ -rays and high-energy x-rays", *Phys. Med. Biol.* **44**, 1609-1624 (1999).
- N.G. Tarr, G.F. MacKay, K. Shortt and I Thomson. "A floating gate MOSFET dosimeter requiring no external bias supply." *IEEE Trans Nuc. Sci.* 45: 1470 – 1474, 1998
- K.R. Shortt, C.K. Ross and I. Janovsky. "The response of LiF TLDs to Cs-137 and Co-60 gamma rays". *Rad. Prot. Dosim.* 69, 257-266, 1997.

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Recent Research:

- 3-D external beam, brachytherapy and stereotactic radiosurgery dose calculation algorithms
- Radiation treatment planning optimization methods
- Dynamic radiotherapy techniques and their implementation in 3-D radiation treatment planning systems

Publications:

- J. Sun, D. Sheikh-Bagheri and G. Doswell, "Modeling Primary Fluence Distribution of High Energy Photon Beams in the Theraplan Plus Treatment Planning System", *Proceedings of COMP Annual Conference*, Sherbrooke, Quebec, 44-46, 1999.
- J. Sun, U. Orhun and J.R. Cunningham, "Improvement of Dose Calculation Accuracy Under Small Block for High-energy Photon Beam by Using an Effective Block Transmission Factor", *Proceedings of COMP Annual Conference*, London, Ontario, 52-54, 1998.
- J. Sun, C. Plume-Angers, U. Orhun and J.R. Cunningham, "A Semi-orthogonal Brachytherapy Source Reconstruction Algorithm Implemented in Theraplan Plus Treatment Planning System", *Proceedings of COMP Annual Conference* (1997), Charlottetown, PEI, 179-181, 1997.

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Recent Research: - Design and Dosimetry of a Fractionated Stereotactic Radiotherapy System.

At the Ottawa Regional Cancer Centre we have developed a unique system for the delivery of fractionated stereotactic radiotherapy. Patients are immobilized in a very accurate, stable, reproducible, non-invasive, relocatable stereotactic frame which is based on a custom made Cobalt-Chrome bite-block that locks into the undercuts of the teeth. The patient motion is measured by our optically based patient position monitoring system and found to be within ± 1 mm.

The dosimetry of small, high energy X-ray beams has been investigated both experimentally and by Monte-Carlo calculations. Some difficulty arises from the lack of lateral electronic equilibrium and the detectors' relatively large sizes.

Akhilesh Trivedi (Associate Member)

Radiation Biology and Health Physics Branch, Atomic Energy of Canada Limited
Chalk River, Ontario, K0J 1J0
(613) 584 3311 x 4764 (voice), (613) 584 1689 (fax), trivedia@aecl.ca (e-mail)

Recent Research

- (i) Health effects and dosimetry of tritium and ^{14}C -related compounds.
- (ii) Development of physiologically based metabolic models for dose assessment
- (iii) Radioecological dosimetry and ecological risk assessment.
- (iv) Development of advanced bioassay techniques for monitoring ultra low-levels of radionuclides in biological samples.
- (v) Biomarkers for the biological dosimetry.
- (vi) Radiobiology of low-dose low dose-rate exposures and risk prediction.
- (vii) Cellular and molecular biological effects of exposure to environmental factors.
- (viii) Risk of tumorigenesis and carcinogenesis in living systems.
- (ix) Membrane biogenesis and bioenergetics

Funding:

- CANDU Owners group (COG) contract for advanced bioassay development program, \$70 k;
- Atomic Energy Control Board (AECB) contract for OBT-in-diet dosimetry, \$65 k;
- AECL R&D support for tritium and carbon-14 dosimetry, \$110 k.

Publications:

- W. J. Workman, A. Trivedi and R. J. Cornett "Tritium concentrations inside the home of occupationally exposed workers: dosimetric implications". *Health Phys.* **75**, 55-58, 1998.
- A. Trivedi and R.E.J. Mitchel "How relevant to radiation protection is the adaptive response mechanism?" *In: Proceedings of Canadian Nuclear Society* (Jenkins, D.A., ed.), CNS, Toronto, 1998.
- R.B. Richardson, A. Trivedi and C.L. Greenstock "Dosimetry of organically bound tritium derived from diet phase 1" RSP-0068, Atomic Energy Control Board, Ottawa, Ontario, Canada, 1998.
- T. Kotzer, A. Trivedi, G. Waito and W. Workman "Ultra low-level measurement of organically bound tritium in bioassay samples" (1999) AECL-11956/COG-98-131-I, Chalk River, Ontario, Canada, 1999.
- A. Trivedi "Do physiological factors affect organically bound tritium dose?" *Radiation Prot. Environ.* (in press)
- F. Cucinotta, J.W. Wilson, R.E.J. Mitchel and A. Trivedi "Multistage carcinogenesis models and cosmic ray exposures" *Adv. Space Res.* (in press).

- A. Trivedi "Is dosimetry for dietary organically bound tritium adequate?" *Radiation Prot. Environ.* (in press)
- A. Trivedi and T. Duong "Characterization of tritium exposures by measuring tritiated metabolites in urine" *J. Radioanaly. Nucl. Chem.* (in press)
- A. Trivedi, T. Duong and J. Leon "A rapid fecal bioassay method for Pu/Am." *J. Radioanaly. Nucl. Chem.* (in press)
- A. Trivedi, D. Galeriu and E.S. Lamothe "Dose contribution from metabolised organically bound tritium after chronic tritiated water intakes in human" *Health Phys.* (in press)
- A. Trivedi and N.E. Gentner "Assessment and measurement endpoints for radioecological impacts." *Proceedings of 2nd International Symposium on Ionizing Radiation: Environmental Protection Approaches for Nuclear Facilities*, Ottawa, May 10-14, 1999
- F. Cucinotta, J.W. Wilson, R.E.J. Mitchel and A. Trivedi, "Multistage carcinogenesis models and cosmic-ray exposures." *Adv. Space Res.* (in press) 1998.
- A. Trivedi, T. Duong and C.L. Greenstock, "Distribution, biokinetics and dosimetry of tritiated organics." *Radioprotection* **32**, 365-370, 1997.
- A. Trivedi, D. Galeriu and R.B. Richardson, "Dose contribution from metabolised organically bound tritium after acute tritiated water intakes in human." *Health Phys.* **73** 1-8, 1997.
- A. Trivedi, D.P. Morrison and N.E. Gentner, "Relative biological effectiveness of organically bound tritium." *Health Phys.* **73**, 397-398, 1997.
- T. Duong and A. Trivedi, "Evaluation of storage conditions for tritiated thymidine as reference organically bound tritium in urine." *J. Radioanaly. Nucl. Chem.* **226**, 229-231, 1997.
- A. Trivedi, R. J. Cornett, D. Galeriu, W. Workman and R.M. Brown, "Daily tritium intakes by people living near a heavy water reactor research facility: Dosimetric significance. AECL 11648/COG96-333, Chalk River, Ontario, Canada, 1997.

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Recent Research: - The application of microdosimetric methods and counters in radiation protection mixed field dosimetry and monitoring with particular emphasis on the radiation environment within CANDU power plants. The development of low pressure tissue equivalent proportional counters with enhanced sensitivity and collaborative work on the dosimetric properties of Gas Microstrip Detectors developed at Carleton University and the Centre for Research in Particle Physics at Carleton. The development of experimental methods based on laser desorption and time-of-flight mass spectrometry for the study of radiation damage to DNA as part of a program of microdosimetry at the molecular level for studying fundamental aspects of radiation quality.

Publications:

- V.V. Moiseenko, R.N. Hamm, A.J. Waker and W.V. Prestwich "Modelling "DNA damage induced by different energy photons and tritium beta-particles". *Int. J. Radiat. Biol.* **74** (5), 533-550, 1998 [Also AECL-12006]
- V.V. Moiseenko, R.N. Hamm, A.J. Waker and W.V. Prestwich "The cellular environment in computer simulations of radiation induced damage to DNA." *Radiat. Environ. Biophys.* **37**, 167-172, 1998 [Also AECL-11971]
- M.S. Dixit, J.C. Armitage, J. Dubeau, D.G. Gobbi, P.C. Johns, D. Karlen, F.G. Oakham and A.J. Waker "Development of gas microstrip detectors for digital X-ray imaging and radiation dosimetry." *IEEE Trans. on Instr. and Measurement* **47** (3), 809-813, 1998
- A. Pejovic-Milic, F.E. McNeill, W.V. Prestwich, A.J. Waker and D.R. Chettle, "Development Of An Accelerator Based Determination Of Aluminium Burden In Peripheral Bone By Neutron Activation Analysis", *Appl. Radiat. Isot.* **49**, 717-719, 1998
- V. Moiseenko, A.J. Waker and W.V. Prestwich, "Modelling Early Physical And Chemical Events For DNA Damage Induced By Photons And Tritium Beta Particles", *AECL-11850*, COG-97-374-I, 1998

- V. Moiseenko, A.J. Waker and W.V. Prestwich, "Energy Deposition Patterns For Tritium And Different Energy Photons - A Comparison Study", *Health Phys.* **71**, p388, 1997.
- J.C. Nunes, W.G. Cross and A.J. Waker, "Feasibility Of Creating CANDU-Like Neutron Fields In An Existing Irradiation Facility" *Radiat. Prot. Dosim.* **72**, 11-20, 1997.
- M.A. Huels, J. Khoury, B. Gueraud, B. Boudaiffa, P.C. Dougal, D. Hunting, L. Sanche and A.J. Waker, "A Novel Apparatus For Low Energy Electron (0-5000 eV) Irradiation Of Lyophilized DNA In An Ultra-Clean UHV Environment", *Microdosimetry - An interdisciplinary approach*. (Ed. Goodhead, O'Neil and Menzel) The Royal Society of Chemistry, p89-92, 1997.
- M.A. Huels, J. Khoury, B. Gueraud, B. Boudaiffa, P.C. Dougal, D. Hunting, L. Sanche and A.J. Waker, "Experimental Microdosimetry With Microstrip Gas Counters" *Microdosimetry - An interdisciplinary approach*. (Ed. Goodhead, O'Neil and Menzel) The Royal Society of Chemistry, p383-386, 1997.
- C. R. Hirning and A.J. Waker, "Needs And Performance Requirements For Neutron Monitoring In The Nuclear Power Industry", *Radiat. Prot. Dosim.* **70**, 67-72, 1997.
- A.J. Waker, K. Szornel and J. Nunes, "TEPC Performance In The CANDU Workplace", *Radiat. Prot. Dosim.* **70**, 197-202, 1997.

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Recent Research: - Our group is developing MR imaging methods to detect and diagnose disease and to contribute to the treatment of diseases. - We are investigating the accuracy of MR thermometry for monitoring tissue temperatures during focused-ultrasound thermal therapies. - We are also evaluating BANG dosimetry gels for equipment calibrations and for 3D visualization of prescribed radiation treatments. - In addition, we are investigating the use of both established and novel contrast agents for the early diagnosis of breast cancer.

Funding

Co-investigator on Canadian Breast Cancer Research Initiative grant. \$35k

Publications

- Wallace, J.C., Clarke, R.L. and Santyr, G.E., "MRI Mapping of One-dimensional Temperature Gradients Across Ex-vivo Liver Tissue During Rapid and Slow Heating", *Conference Proceeding, ISMRM 7th Annual Conference, Philadelphia, PA, May, 1999* (abstract)
- Cron, G.O., Wallace, J.C., Fortin, T., et al., "Non-invasive Measurement of the Arterial Input Function for Quantitative Dynamic Contrast-Enhanced MR Imaging of Cancerous Lesions in the Rat", *Conference Proceeding, ISMRM 7th Annual Conference, Philadelphia, PA, May, 1999* (abstract)
- Sevigny, P., Santyr, G., Wallace, J.C., et al., "Optimization of Gradient-Echo Imaging for Hyperpolarized ¹²⁹Xe Gas", *Proceeding of the American Physical Society*, March 1999, Atlanta, GP01 (abstract)
- Wallace, J.C., Raaphorst, G.P., Somorjai, R.L., Ng, C.E., Fung Kee Fung, M., Senterman, M. and Smith, I.C.P., "Classification of ¹H MR Spectra of Biopsies from Untreated and Recurrent Ovarian Cancer Using Linear Discriminant Analysis", *Mag. Res. Med.*, **38**, 1997

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Recent Research: -Radiation therapy is normally delivered in discrete fractions over a period of weeks, partly to allow for repair of radiation damage to normal tissue. The rates of repair of tumour and normal cells are rarely known for a particular patient, but radiobiological data from cultured cells can provide estimated values.

During extended fractionated treatments, the effects of tumour proliferation can, in some cases, become important to the overall treatment outcome. Computer models, based on the linear quadratic model of cell survival and the Gompertzian-Exponential model of tumour proliferation, have been formulated to provide a tool for evaluating the effectiveness of particular fractionation schemes. These models are being used to evaluate novel fractionation schemes such as hyperfractionation and pulsed dose rate brachytherapy, as well as to evaluate the effects of unplanned treatment interruptions on treatment outcome for rapidly proliferating tumours.

- Other areas of research include cellular evaluation of the biological equivalence of high dose rate, pulsed dose rate and low dose rate brachytherapy, and evaluation of the clinical utility of various radiation detection devices.

Publications:

- D.E. Wilkins, X.A. Li, J. Cygler, L. Gerig. The effect of dose rate dependence of p-type silicon detectors on linac relative dosimetry. *Med. Phys.* **24**, 879-881, 1997.

- D.E. Wilkins, C.E. Ng, G.P. Raaphorst. Cell cycle perturbations in cisplatin-sensitive and resistant human ovarian carcinoma cells following treatment with cisplatin and low dose rate irradiation. *Cancer Chemoth. Pharmacol.* **40**, 159-166, 1997.

- D.E. Wilkins, C.E. Ng, G.P. Raaphorst. Cisplatin and low dose rate irradiation in cisplatin resistant and sensitive human glioma cells. *Int. J. Radiation Oncology Biol. Phys.* **36**, 105-111, 1996.

Curricula Vitae of New Members

George Daskalov

EDUCATION

1996 Ph.D in Nuclear Engineering, University of Tennessee, Knoxville, TN
 1994 Ph.D. in Nuclear Physics, Bulgarian Academy of Sciences, Sofia, Bulgaria
 1977-1982 B.Sc. & M.Sc. in Physics, Sofia University, Sofia, Bulgaria

PROFESSIONAL EXPERIENCE

1997-present Assistant Research Officer, IRS/INMS, NRC of Canada, Ottawa, Ontario
 1996-1997 Researcher, Mallinckrodt Institute of Radiology, Washington University Medical School, St. Louis, MO
 1992-1995 Research assistant, University of Tennessee, Knoxville, TN.
 1990-1992 Research Fellow, Institute for Nuclear Research and Nuclear Energy, Sofia, Bulgaria
 1984-1990 Researcher, Institute for Nuclear Research and Nuclear Energy, Sofia, Bulgaria

RESEARCH AND DEVELOPMENT INTERESTS

Development and implementation of analytical and numerical methods for solving the radiation transport equations. Applications to three-dimensional conformal treatment planning for clinical radiation cancer treatment.

PROFESSIONAL AFFILIATIONS

Member American Association of Physicists in Medicine

SAMPLE PUBLICATIONS

- G.M. Daskalov, J.F. Williamson, E. Loffler, "Monte Carlo-Aided Dosimetry of a New High Dose-Rate Brachytherapy Source," *Med. Phys.*, **25**, 2200-2208 (1998).

- K. Ilieva, T. Apostolov, S. Belousov, S. Antonov, T. Petrova, G.M. Daskalov, "Neutron fluence estimations on WWER-440 reactor vessel," *Deterministic methods seminar and TORT workshop*. Oak Ridge, TN (United States). 4-6 Feb 1992.

- G.M.Daskalov, M.V. Kazarnovskii, E.Ya. Pariev, "Analytical calculation of secondary nucleons double-differential distributions in interactions of intermediate energies nucleons with nuclei," *Bulg. Journal of Physics*, **17**, 169-179, 1990.
- T. Apostolov, G.M. Daskalov, *et al.*, In: *Proceedings of the 4th Int. Symposium on Environmental Degradation of Materials in Nuclear Power Systems-Water Reactors*, **2**, pp.76-78, August 6-10, 1989.
- G.M. Daskalov, M.V. Kazarnovskii, E. Ya. Pariev *Journal of Nuclear Physics* **52**, 62 (1990).

Julia Wallace

EDUCATION

- 1996 Ph.D., Physics, Carleton University, Ottawa, ON, Canada
- 1985 M.Sc., Biophysics, University of British Columbia, Vancouver, BC, Canada
- 1983 B.Sc., Math and Physics, University of New Brunswick, Fredericton, NB, Canada

PROFESSIONAL EXPERIENCE

- 1997 – present Research Associate, Physics Department, Carleton University
- 1988 – 96 Researcher, Institute for Biodiagnostics, National Research Council
- 1986 – 88 Research Scientist, Department of Physics, University of British Columbia

RESEARCH AND DEVELOPMENT INTERESTS

Our group is developing MR imaging methods to detect and diagnose disease and to contribute to the treatment of diseases. In particular, we are investigating MR thermometry for monitoring minimally invasive thermal therapies, BANG dosimetry gels for 3D visualization of prescribed radiation treatments and the use of novel MR contrast agents for the early detection and diagnosis of breast cancer.

PROFESSIONAL AFFILIATIONS

- International Society for Magnetic Resonance in Medicine (ISMRM)
- Canadian Organization of Medical Physicists (COMP)

SAMPLE PUBLICATIONS

- Wallace, J.C., Clarke, R.L. and Santyr, G.E., "MRI Mapping of One-dimensional Temperature Gradients Across Ex-vivo Liver Tissue During Rapid and Slow Heating", *Conference Proceeding, ISMRM 7th Annual Conference*, Philadelphia, PA, May, 1999
- Cron, G.O., Wallace, J.C., Fortin, T., *et al.*, "Non-invasive Measurement of the Arterial Input Function for Quantitative Dynamic Contrast-Enhanced MR Imaging of Cancerous Lesions in the Rat", *Conference Proceeding, ISMRM 7th Annual Conference*, Philadelphia, PA, May, 1999
- Sevigny, P., Santyr, G., Wallace, J.C., *et al.*, "Optimization of Gradient-Echo Imaging for Hyperpolarized ¹²⁹Xe Gas", *Proceeding of the American Physical Society*, March 1999, Atlanta, GP01
- Wallace, J.C., Raaphorst, G.P., Somorjai, R.L., Ng, C.E., Fung Kee Fung, M., Senterman, M. and Smith, I.C.P., "Classification of ¹H MR Spectra of Biopsies from Untreated and Recurrent Ovarian Cancer Using Linear Discriminant Analysis", *Mag. Res. Med.*, **38**, 1997
- Wallace, J.C., Kitchen, D., Raaphorst, G.P., Somorjai, R.L., Ng, C.E., Fung Kee Fung, M., Senterman, M. and Smith, I.C.P., "Classification of Proton MR Spectra From Untreated and Recurrent Ovarian Cancer Using Linear Discriminant Analysis", *Proceeding of the 3rd Annual ISMRM Meeting*, Nice, 1995
- Wallace, J. C., Raaphorst, G. P., Fung Kee Fung, M., Smith, I. C. P., Saunders, J. K. and Ng, C. E., "Differences Between Treatment Sensitive and Resistant Human Ovarian Cancer Cells Observed By Proton Magnetic Resonance Spectroscopy", *Rad. Res. Soc. 42nd Annual Meeting*, 1994
- Wallace, J.C., MacKay, A.L., Sasaki, K. and Taylor, I.E.P., Proton Nuclear Magnetic Resonance Study of the Physical Changes of the Growing Plant Cell Wall, *Planta*, **190**, 227, 1993
- Lareau, S., Keon, W. K., Wallace, J.C., Whitehead, K., Mainwood, G.W. and Deslauriers, R., Cardiac Hyperthermia: "³¹P and ¹H Spectroscopic Study of the Effect of Buffer on Human Heart Atrial Appendage", *C. J. of Phys. And Pharm.*, **69**, 1726, 1991

Dave Wilkins

EDUCATION

1993 PhD, Medical Physics, Carleton University
 1986 MSc(A), Medical Physics, McGill University
 1979 BSc(Honours, Physics), Queen's University

PROFESSIONAL EXPERIENCE

1997-present Medical Physicist, Ottawa Regional Cancer Centre
 1995-97 Medical Physics Resident, Ottawa Regional Cancer Centre
 1993-95 Postdoctoral Fellow, Medical Biophysics Lab, Ottawa Regional Cancer Centre

PROFESSIONAL CERTIFICATIONS AND AFFILIATIONS

Member of the Canadian College of Physicists in Medicine
 Peer Review 'A', Cancer Care Ontario
 American Association of Physicists in Medicine, Member
 Canadian Organisation of Medical Physicists, Member
 Radiation Research Society, Member

CURRENT RESEARCH INTERESTS

- Radiobiological modeling of tumour and normal tissue response to radiation therapy
- Computer modeling of tumour progression
- Evaluation of the clinical utility of various radiation detectors

SAMPLE PUBLICATIONS

- D.E. Wilkins, X.A. Li, J. Cygler, L. Gerig. "The effect of dose rate dependence of p-type silicon detectors on linac relative dosimetry." *Med. Phys.* **24**, 879-881, 1997.
- D.E. Wilkins, C.E. Ng, G.P. Raaphorst. "Cell cycle perturbations in cisplatin-sensitive and resistant human ovarian carcinoma cells following treatment with cisplatin and low dose rate irradiation." *Cancer Chemoth. Pharmacol.* **40**, 159-166, 1997.
- D.E. Wilkins, C.E. Ng, G.P. Raaphorst. "Cisplatin and low dose rate irradiation in cisplatin resistant and sensitive human glioma cells." *Int. J. Radiation Oncology Biol. Phys.* **36**, 105-111, 1996.
- D.E. Wilkins, G.P. Raaphorst, J.K. Saunders, G.R. Sutherland, I.C.P. Smith. "Correlation between Gd-enhanced MR imaging and histopathology in treated and untreated 9L rat brain tumors." *Magnetic Resonance Imaging* **13**(1), 89-96, 1994.
- D.E. Wilkins, D.P Heller, G.P. Raaphorst. "Inhibition of potentially lethal damage recovery by cisplatin in a brain tumor cell line." *Anticancer Research* **13**(6), 2137-2142, 1993.

Seminars

OMPI Seminars

One of the main vehicles of the OMPI for developing and maintaining contact is through a seminar series in which all the members and the graduate students in medical physics are required to make a presentation. Seminars are scheduled monthly, and for the last several years have been held at 3:30 p.m. on Thursdays. The seminar location is rotated among the major centres involved in medical physics. Seminar information is posted on the web at <http://www.physics.carleton.ca/research/OMPI>.

Following is a list of OMPI seminars held in 1998-99. The second speaker listed is a graduate student.

Thursday, September 17, 1998 at Carleton University

Barry McKee (Ottawa Hospital)	<i>Beyond "picture archiving" in nuclear medicine</i>
Malgorzata Niedbala (Carleton U.)	<i>Effect of pulsed dose rate on three cell lines with and without hyperthermia</i>

Thursday, October 15, 1998 at ORCC (General Division)

David Wilkins (ORCC)	<i>Models of fractionation and tumour progression in radiotherapy</i>
Daryoush Sheikh-Bagheri (Carleton U.)	<i>Monte Carlo simulation of photon beams from medical linear accelerators: optimization, benchmark, and application</i>

Thursday, November 19, 1998 at Theratronics

George Daskalov (NRC)	<i>Dosimetric modelling of the Microselectron high dose rate Ir-192 source by the multigroup discrete ordinates method</i>
Pascale Sevigny (Carleton U.)	<i>Magnetic resonance (MR) imaging of hyperpolarized xenon gas</i>

Thursday, December 10, 1998 at the Ottawa Life Sciences Technology Park

Richard Richardson (AECL)	<i>The measurement and theoretical estimate of the radiation dose from radon and other alpha emitters</i>
Robert Leclair (Carleton U.)	<i>Information content accessible with x-ray scatter imaging</i>

Thursday, January 21, 1999 at the National Research Council

Elagu V. Elaguppillai (ICLDRR)	<i>Activities of the International Centre for Low Dose Radiation Research, University of Ottawa</i>
Tanya Hewitt (Carleton U.)	<i>Characterization of a half circle pinhole tomograph for emission tomography</i>

Thursday, February 18, 1999 at Carleton University

Lee Gerig (ORCC)	<i>A study of linear accelerator head scatter factors</i>
Kenji Myint (Carleton U.)	<i>Cisplatin radiosensitization in radiotherapy</i>

Thursday, March 11, 1999 at the Ottawa Hospital - Civic Campus

Janos Szanto (ORCC)	<i>Stereotactic radiotherapy</i>
Mei Li (Carleton U.)	<i>Introduction to the China Institute for Radiation Protection</i>

Thursday, April 15, 1999 at the Radiation Protection Bureau, Health Canada

Julia Wallace (Carleton U.)	<i>MRI thermometry of tissue during heating</i>
Yvan Gauthier (Carleton U.)	<i>Measurement of water diffusion in the brain using NMR: phantom study and Monte-Carlo simulations</i>

Carleton University Physics Department Seminars

Carleton University Physics Department runs a regular seminar series usually on Monday afternoons (with overflow to other days of the week) at 3:30 p.m. in the Herzberg Building. Information on upcoming seminars is posted on the web. (<http://www.physics.carleton.ca/seminars>). The following seminars of interest to medical physicists were held in 1998-99:

October 5, 1998

C.-M. (Charlie) Ma, (Stanford University School of Medicine): "Monte Carlo treatment planning for intensity-modulated radiotherapy (IMRT)"

<u>November 2, 1998</u>	M.K. Sundaresan (Carleton): “ <i>Development of a Computerised System for Serological Tests in Blood Banks</i> ”
<u>November 9, 1998</u>	Leszek Ropelewski (CERN): “ <i>GEM Gas Electron Multiplier: Recent Developments</i> ”
<u>November 16, 1998</u>	Aaron Fenster (Robarts Research Institute, London, Ontario): “ <i>Basic Principles and Applications of 3-D Ultrasound Imaging</i> ”
<u>Friday December 18, 1998</u>	OCIP Christmas Symposium – Bog Jarosz (Carleton University): “ <i>Ultrasound interstitial applicators for cancer thermal therapy</i> ”; Madhu Dixit (Centre for Research in Particle Physics): “ <i>Recent Developments in Gas Avalanche Microdetectors</i> ”
<u>January 18, 1999</u>	Robert Clarke (Carleton): “ <i>High Intensity Focused Ultrasound Surgery – a progress report</i> ”
<u>February 1, 1999</u>	Alan E. Nahum (Institute of Cancer Research & Royal Marsden NHS Trust, UK): “ <i>Tumour Control Probability Modelling and the ΔTCP Concept</i> ”
<u>February 22, 1999</u>	Tony Waker (AECL): “ <i>Microdosimetric Aspects of Low Dose Radiation Exposure and Risk</i> ”
<u>March 8, 1999</u>	Dave Rogers (NRCC): “ <i>Improving cancer care by simulating the transport of ionizing radiation</i> ”
<u>April 19, 1999</u>	Richard Richardson (AECL) “ <i>Sizing of Alpha-Emitting Particles on Personnel Air Samplers Using CR-39 Autoradiography</i> ”

OCIP Graduate Student Seminars

Student seminars organized by the Ottawa-Carleton institute of Physics. The titles mentioned below only represent the medical physics related student seminars.

November 27, 1998, Fall Seminars

- Narine Kizilian, Carleton U.: “*Predicting Radiosensitivity using the Comet Assay*”

June 3, 1999 - Spring Seminars

- Pascale Sevigny, Carleton U.: “*Magnetic Resonance Imaging of Hyperpolarized Xenon in the Dissolved Phase*”
- Yvan Gauthier, Carleton U.: “*Measurement of water diffusion in the brain using NMR: phantom study and Monte-Carlo simulations*”

Other Seminars of Interest to the OMPI

In addition to the seminars listed in the above sections, there are a variety of other seminars in the Ottawa area which are of interest to the OMPI. The ones which have been brought to our attention over the last year are noted below:

- Nigel E.A. Crompton, (Paul Scherrer Institute, Switzerland) gave a seminar at the ORCC on Thursday, September 10, 1998. Title: “*Radiotherapy patients displaying increased toxicity have altered apoptotic profiles*”
- Albert R. Cross, (MRI Centre, University of New Brunswick) gave a seminar at the NRC Steacie Institute for Molecular Sciences on Monday, December 7, 1998. Title: “*Maximizing Magnetic Resonance Imaging Parameters – Two different examples*”
- Keith U. Ingold (NRC, Canada) gave the Gerhard Herzberg Lecture at Carleton University on Thursday March 11, 1999. Title: “*Free Radicals, Antioxidants, and Human Health*”
- Monique Frize (Carleton University / University of Ottawa) gave a lecture in the framework of the IEEE EMBS Ottawa Chapter Series at Carleton University on June 15, 1999. Title: “*Information Technologies applied to Medicine: Current and Future Trends*”

IRS informal Seminar Series. These seminars usually deal with radiation physics and dosimetry, Monte Carlo calculations, instrumentation and electronics, but can occasionally be about more broad topics. The speakers are members of the IRS group (National Research Council) as well as external visitors. The usual time is 10:30 unless otherwise indicated. Seminar organizer: Blake Walters.

<u>Date</u>	<u>Speaker</u>	<u>Title</u>
Nov 17 '98	Carl Ross	"Energy variation of W" (3:00 pm)
Nov 24. '98	George Daskalov	"Multigroup discrete ordinates in photon transport: A comparison of calculations in 2-D cylindrical geometries" (3:00 pm)
Dec 8 '98	Jette Borg	"Cavity theory - does it really break down?"
Jan 6 '99	Ken Shortt	"Comparison of Co60 standards"
Feb 4 '99	Jan Seuntjens	"Absorbed dose beam quality correction factors" (3:00 pm)
Feb 9 '99	Jakob Helt-Hansen (Risø)	"Portable silicon telescope spectrometer for measuring β dose in a mixed β - γ field"
Feb 16 '99	Dave Rogers	"Update on AAPM TG51 related calculations and quantities"
Mar 24 '99	Claus Yang	"Ion recombination in chambers in continuous radiation"
Mar 30 '99	Blake Walters	"Preview of NPL simulations"
Apr 13 '99	Dallas Santry	"Recent calibrations of radionuclides at NRC"
Apr 27 '99	Weihua Zhang	"Accurate γ -ray spectrometry for low-level activity measurements"
May 4 '99	Bob Grasty (GAMMA-BOB Inc)	"Reducing statistical noise in γ spectra"
May 11 '99	Iwan Kawrakow	"General cavity theory"
June 3 '99	Joakim Medin	"The NRC-OFMET water calorimetry project"
June 7 '99	Norman Klassen	"Madly off in all directions"
June 8 '99	Leo Heistek	"Like a bridge over troubled circuits" (12:00 pm)

Medical Physics Graduate Courses

The Carleton medical physics program has three specializations: imaging, therapy and biophysics. Shown below is the menu of courses for each. Required course numbers are printed in **underlined bold font**; the others are recommended.

Depending on the thesis weighting, the Ph.D. typically requires four half-courses in addition to the thesis. The normal M.Sc. course requirement is 5 half-courses in addition to the thesis. Ph.D. students who lack any of the relevant courses (or their equivalents) required for the M.Sc. must complete them in their Ph.D. M.Sc. students may be permitted to take up to two fourth-year half-courses and credit them towards the degree. Ph.D. students can credit only graduate courses.

When a student has covered material in a prior program, such as an M.Sc. in medical physics elsewhere, then the equivalent courses at Carleton are of course not required. The courses to be taken by a given student will be decided on in consultation with the student and the supervisor.

Listed for each course is the course number, the campus where taught and the course name. Carleton courses are numbered with the prefix "75" indicating Physics, followed by a 400-series number if fourth year, or either a 500- or 600- series number for graduate courses.

Specialization in Imaging

<u>Fall Term</u>	<u>75.523</u>	Carleton	Medical Radiation Physics
	<u>75.423</u>	Carleton	Physical Applications of Fourier Analysis ¹
	75.527	Carleton	Radiobiology
	75.529	Carleton	Medical Physics Practicum
<u>Winter Term</u>	<u>75.524</u>	Carleton	Physics of Medical Imaging
	75.526	Carleton	Medical Radiotherapy Physics
	75.528	Carleton	Radiation Protection
<u>Fall & Winter (both terms)</u>	ANA 7301	Ottawa HSC ²	Anatomy
	PHS 5210	Ottawa HSC ²	Physiology
<u>Fall or Winter</u>	<u>75.5xx/6xx</u>	Carleton or Ottawa	Half-course outside of medical physics ³

Specialization in Therapy

<u>Fall Term</u>	<u>75.523</u>	Carleton	Medical Radiation Physics
	75.527	Carleton	Radiobiology
	75.529	Carleton	Medical Physics Practicum
<u>Winter Term</u>	75.524	Carleton	Physics of Medical Imaging
	<u>75.526</u>	Carleton	Medical Radiotherapy Physics
	75.528	Carleton	Radiation Protection
<u>Fall & Winter</u> (both terms)	ANA 7301	Ottawa HSC ²	Anatomy
	PHS 5210	Ottawa HSC ²	Physiology
<u>Fall or Winter</u>	<u>75.5xx/6xx</u>	Carleton or Ottawa	Half-course outside of medical physics ³

Specialization in Biophysics

<u>Fall Term</u>	<u>75.523</u>	Carleton	Medical Radiation Physics
	<u>75.527</u>	Carleton	Radiobiology ⁴
	75.529	Carleton	Medical Physics Practicum
<u>Winter Term</u>	75.524	Carleton	Physics of Medical Imaging
	75.526	Carleton	Medical Radiotherapy Physics
	75.528	Carleton	Radiation Protection
<u>Fall & Winter</u> (both terms)	<u>ANA 7301</u>	Ottawa HSC ²	Anatomy ⁴
	<u>PHS 5210</u>	Ottawa HSC ²	Physiology ⁴
<u>Fall or Winter</u>	<u>75.5xx/6xx</u>	Carleton or Ottawa	Half-course outside of medical physics ³

¹ Prerequisite to 75.524; additional to degree if PhD

² HSC = Health Sciences Centre, Smyth Road

³ Subject to approval. Permission may be given for 75.4xx if MSc

⁴ In the Biophysics specialization, one of Radiobiology, Anatomy or Physiology must be taken.

Course Descriptions

75.523F--- Medical Radiation Physics (½ course, Fall) Basic interaction of electromagnetic radiation with matter. Sources: x ray, accelerators, nuclear. Charged particle interaction mechanisms, stopping powers, kerma, dose. Introduction to dosimetry. Units, measurements, dosimetry devices.

Reference: H.E. Johns and J.R. Cunningham, *The Physics of Radiology*, 4th ed., 1983.

Lecturer: P.C. Johns

75.524W--- Physics of Medical Imaging (½ course, Winter) Outline of the principles of transmission x-ray imaging, computerized tomography, nuclear medicine, magnetic resonance imaging, and ultrasound. Physical descriptors of image quality, including contrast, resolution, signal-to-noise ratio, and modulation transfer function are covered and an introduction is given to image processing.

Prerequisites: Medical Radiation Physics or equivalent and knowledge of Fourier optics at the senior undergraduate level.

Reference: H.H. Barrett & W. Swindell, *Radiological Imaging*, 1981

Lecturers: G. E. Santyr (coordinator), P.C. Johns, and B.T.A. McKee.

75.526W--- Medical Radiotherapy Physics (½ course, Winter) Terminology and related physics concepts. Bragg-Gray, Spencer-Attix cavity theories, Fano's Theorem. Dosimetry protocols, dose distribution calculations. Radiotherapy devices, hyperthermia.

Prerequisite: Medical Radiation Physics or equivalent.

References: F.H. Attix, *Introduction to Radiological Physics and Radiation Dosimetry*, 1986.

H.E. Johns and J.R. Cunningham, *The Physics of Radiology*, 4th ed., 1983.

Lecturers: J. Cygler (Coordinator), J. Seuntjens, K.R. Shortt, I. Kawrakow, and L.H. Gerig.

75.527F--- Radiobiology (½ course, Fall) Introduction to basic physics and chemistry of radiation interactions, free radicals, oxidation and reduction, G values. Subcellular and cellular effects: killing, repair, sensitization, protection. Measurement methods. Survival curve models. Tissue effects, genetic and carcinogenic effects, mutations, hazards. Cancer therapy. Radiation protection considerations.

Prerequisite: Medical Radiation Physics or equivalent must have been taken, or be taken concurrently.

Reference: E.J. Hall, *Radiobiology for the Radiologist*, 4th ed., 1994.

Lecturer: G.P. Raaphorst

75.528W---Radiation Protection (½ course, Winter) Biophysics of radiation hazards, dosimetry and instrumentation. Monitoring of sources, planning of facilities, waste management, radiation safety, public protection. Regulatory agencies.

Prerequisite: Medical Radiation Physics or equivalent.

Reference: Herman Cember, *Introduction to Health Physics*, 3rd ed., 1996.

Lecturer: V. Elaguppillai

75.529F---Medical Physics Practicum (½ course, Fall) This course provides hands-on experience with current clinical medical imaging and cancer therapy equipment, and dosimetry and biophysics instrumentation. Experimental projects on medical imaging, radiotherapy, dosimetry, and biophysics, conducted at local clinics and NRC laboratories in Ottawa.

Prerequisites: Medical Radiation Physics or equivalent, plus, as appropriate to the majority of projects undertaken, one of Physics of Medical Imaging, Medical Radiotherapy Physics, or Radiobiology or other biophysics course.

Coordinator: B. J. Jarosz

The following life science courses are available at the University of Ottawa and are appropriate to medical physics graduate students:

ANA 7301---Anatomy for Medical Physics Graduate Students (½ course, extends through Fall and Winter) A basic course in anatomy for medical physics students utilizing the systemic approach to emphasize practical and clinical aspects of the gross structure of the human body. The course consists of lectures, laboratory demonstrations with dissected materials and a series of audio-visual presentations involving imaging techniques.

PHS 5210---Mammalian Physiology (full course, extends through Fall and Winter) A comprehensive study of mammalian physiology with an emphasis on regulating mechanisms. The course includes the biophysical basis of excitable tissues and the physiology of the central nervous system, blood and cardiovascular system, respiratory system, endocrine system, G.I. tract and renal physiology. It is assumed that students have a basic knowledge of chemistry, physics and biology.

In addition, the following physics half courses are particularly relevant:

75.502---Computational Physics (½ course, Winter) Computational methods used in physics research. Introduction to the UNIX operating system. Numerical methods for problems in linear algebra, interpolation, integration, root finding, minimization, and differential equations. Monte Carlo methods for simulation of random processes. Statistical methods for parameter estimation and hypothesis tests. Chaotic dynamics.

Prerequisite: An ability to program in FORTRAN, C, or C++ and permission of the Department.

Lecturer: D. Karlen

75.423---Physical Applications of Fourier Analysis (½ course, Fall) Laplace transform and its application to electrical circuits. Fourier transform, convolution. Sampling theorem. Applications to imaging: descriptors of spatial resolution, filtering. Correlation, noise power. Discrete Fourier transform, FFT. Filtering of noisy signals. Image reconstruction in computed tomography and magnetic resonance. Integral transforms and their application to boundary-value problems.

Prerequisite: Physics 75.387; or permission.

Reference: R.N. Bracewell, *The Fourier Transform and its Applications*, Revised 2nd ed., 1986.

Lecturer: P.C. Johns

Half-course outside of medical physics Also required is a graduate physics course outside of medical physics. Appropriate possibilities include nuclear, theoretical, quantum, particle, and solid-state physics. Selection is subject to the approval of the Academic Officer.

Giles Santyr, Academic Officer, OMPI

Students

Medical Physics Programme Graduate Students

Note: "Starting date" is the date first taking courses or commenced lab work, not registration date.

Ph.D. Students

- Cron,
Greg Physics Department, Carleton University
1125 Colonel By Drive, Ottawa K1S 5B6
520-2600x1073 (voice) 520-4061 (fax) gcron@physics.carleton.ca (e-mail)
Starting date: 9/95, Supervisor: Santyr, Specialization: Imaging
Thesis topic: Quantitative dynamic MRI of the breast
[Registered at U. of Wisconsin at Madison]
- Leclair,
Robert Physics Department, Carleton University
1125 Colonel By Drive, Ottawa K1S 5B6
520-2600x1854 (voice) 520-4061 (fax) robert@physics.carleton.ca (e-mail)
Starting date: 9/94, Supervisor: Johns, Specialization: Imaging
Thesis topic: X-ray imaging using scattered radiation
- Niedbala,
Malgorzata Ottawa Regional Cancer Centre, Department of Medical Physics
501 Smyth Road, Ottawa, K1H 8L6
737-7700x6942 (voice) 247-3507 (fax) niedbala@physics.carleton.ca (e-mail)
Starting date: 1/99 [following completion of M.Sc. with G.P. Raaphorst]
Supervisor: Raaphorst, Specialization: Biophysics
Thesis topic: Biophysics of radiation damage and repair
- MacPherson,
Miller Ionizing Radiation Standards, Institute for National Measurement Standards
National Research Council of Canada, Ottawa K1A 0R6
993-2197 (voice) 952-9865 (fax) mmacpher@irs.phy.nrc.ca (e-mail)
Starting date: 2/93, Supervisor: Ross, Specialization: Therapy
Date of Ph.D. defence: July 20, 1998
Thesis topic: Measurement of electron stopping powers
- Sheikh-Bagheri,
Daryoush Ionizing Radiation Standards, Institute for National Measurement Standards
National Research Council of Canada, Ottawa K1A 0R6
993-2197 (voice) 952-9865 (fax) dbagheri@irs.phy.nrc.ca (e-mail)
Starting date: 9/93, Supervisor: Rogers, Specialization: Therapy
Date of Ph.D. defence: January 8, 1999
Thesis topic: OMEGA (online Monte Carlo radiotherapy planning)
- Zhang,
Geoffery Ionizing Radiation Standards, Institute for National Measurement Standards
National Research Council of Canada, Ottawa K1A 0R6
993-2197 (voice) 952-9865 (fax) gzhang@irs.phy.nrc.ca (e-mail)
Starting date: 10/93, Supervisor: Rogers, Specialization: Therapy
Date of Ph.D. defence: September 3, 1998
Thesis topic: OMEGA (online Monte Carlo radiotherapy planning)

M.Sc. Students

- Gauthier,
Yvan MRI Unit, Department of Radiology, Ottawa Hospital, General Site
501 Smyth Road, Ottawa K1H 8L6.
737-8476 (voice) 737-8611 (fax) ygauthie@physics.carleton.ca (e-mail)
Starting date: 1/98, Supervisor: Cameron, Specialization: Imaging
Thesis topic: MRI measurement of water diffusion.

- Hewitt, Tanya
 Division of Nuclear Medicine, Ottawa Hospital - Civic Site
 1053 Carling Ave, Ottawa K1Y 4K7
 798-5555x3352 (voice) 761-4041 (fax) thewitt@physics.carleton.ca (e-mail)
 Starting date: 9/96, Supervisor: McKee, Specialization: Imaging
 Date of M.Sc. defence: April 28, 1999
 Thesis topic: Pinhole SPECT
- Kizilian, Narine
 Radiation Protection Bureau, Health Canada
 Radiobiology Section, 775 Brookfield Road, Ottawa, K1A 1C1.
 954-9584 (voice) 941-1734 (fax) Narine_Kizilian@hc-sc.gc.ca (e-mail)
 Starting date: 9/97, Supervisor: Raaphorst, Specialization: Biophysics
 Thesis topic: Radiosensitivity by measuring Apoptosis using the Comet assay
- McDonald, Mark
 Physics Department, Carleton University
 1125 Colonel By Drive, Ottawa K1S 5B6
 520-2600x1855 (voice) 520-4061 (fax) mcdonald@physics.carleton.ca (e-mail)
 Starting date: 9/98, Supervisor: Santyr, Specialization: Imaging
 Thesis topic: Low field MRI at hyperpolarized Xenon
- Li, Mei
 Physics Department, Carleton University
 1125 Colonel By Drive, Ottawa K1S 5B6
 520-2600x1854 (voice) 520-4061 (fax) mli@physics.carleton.ca (e-mail)
 Starting date: 9/98, Supervisor: Johns and Dixit, Specialization: Imaging
 Thesis topic: Gas electron multipliers detectors for x-ray imaging
- Myint, Kenji
 Ottawa Regional Cancer Centre, Department of Medical Physics
 501 Smyth Road, Ottawa, K1H 8L6
 737-7700x6942 (voice) 247-3507 (fax) kmyint@physics.carleton.ca (e-mail)
 Starting date: 9/98, Supervisor: Raaphorst, Specialization: Biophysics
 Thesis topic: Cisplatin Radiosensitization in Radiotherapy
- Owen, Daron
 Ottawa Regional Cancer Centre, Department of Medical Physics
 501 Smyth Road, Ottawa, K1H 8L6
 737-7700x6942 (voice) 247-3507 (fax) down@physics.carleton.ca (e-mail)
 Starting date: 9/97, Supervisor: Ng, Specialization: Biophysics
 Thesis topic: Effects of low dose rate radiation with chemotherapeutic drug.
- Sevigny, Pascale
 Physics Department, Carleton University
 1125 Colonel By Drive, Ottawa K1S 5B6
 520-2600x4307 (voice) 520-4061 (fax) psevigny@physics.carleton.ca (e-mail)
 Starting date: 9/97, Supervisor: Santyr, Specialization: Imaging
 Thesis topic: MR imaging using hyperpolarized xenon
- Smith, Debbi
 Ottawa Regional Cancer Centre, Department of Medical Physics
 501 Smyth Road, Ottawa, K1H 8L6
 737-7700x6942 (voice) 247-3507 (fax) dsmith@physics.carleton.ca (e-mail)
 Starting date: 9/97, Supervisor: Raaphorst, Specialization: Biophysics
 Thesis topic: Pulsed Dose Rate Brachytherapy

Graduate Student Theses Completed in '98-99

<u>Student</u>	<u>Degree</u>	<u>Thesis Title</u>
Hewitt, Tanya	M.Sc.	"Pinhole Single Photon Emission Computed Tomography" Thesis Supervisor: B. McKee. Examination Date: April 28, 1999.

Niedbala, Malgorzata	M.Sc	<i>“A Comparison of Pulsed Dose Rate to Low Dose Rate Irradiations with / without Mild Hyperthermia using Three Human Cell Lines”</i> Thesis Supervisor: P. Raaphorst. Examination Date: December 10, 1998.
MacPherson, Miller	Ph.D.	<i>“Accurate Measurement of the Collision Stopping Powers for 5 to 30 MeV Electrons”</i> Thesis Supervisor: C. Ross. Examination Date: July 20, 1998.
Sheikh-Bagheri, Daryoush	Ph.D.	<i>“Monte Carlo study of Photon Beams from Medical Linear Accelerators: Optimization, Benchmark and Spectra”</i> Thesis Supervisor: D. Rogers. Examination Date: January 8, 1999.
Zhang, Geoff	Ph.D.	<i>“Monte Carlo Investigation of Electron Beam Relative Output Factors”</i> Thesis Supervisor: D Rogers. Examination Date: September 3, 1998.

Undergraduate Honours Physics Project Completed in '98-99

<u>Student</u>	<u>Course</u>	<u>Project Title</u>
Charles, Kevin	75.499	<i>“A temperature controller for measurement of transverse relaxation times in BANG dosimeter gels”</i> Supervisor: Giles Santyr.

Past Student Graduates

Below are listed the current positions held by graduates from the Carleton Physics program in Medical Physics.

BSS Rao	MSc	1970	
Holo Devnani	MSc	1971	
Alan Mortimer	MSc	1974	Scientist, Canadian Space Agency
Donald Richardson	MSc	1975	
Mike White	MSc	1977	Ontario Hydro
Michael Ebifegha	MSc	1980	
Kulvir Kapoor	PhD	1981	Ontario Hydro
Hripsime Shahbazian	MSc	1984	
Bruce Faddegon	PhD	1990	Radiotherapy physicist, Toronto-Sunnybrook Regional Cancer Centre
Elias Zakhour	MSc	1991	Was Physics assistant, Ottawa Regional Cancer Centre. Position unknown.
Reza Dokht	MSc	1991	sessional instructor in medical physics, Tehran
Julia Older	MSc	1991	(BSc, 1989) Physics assistant, Ottawa Regional Cancer Centre
Andrew Weber	MSc	1991	(BSc, 1988) telecommunications industry
David Wilkins	PhD	1993	Radiotherapy physicist, Ottawa Regional Cancer Centre
Ted Lawrence	MSc	1993	Radiotherapy physicist, Sydney, N.S.
Dennis Heller	PhD	1993	Faculty of Medicine, Univ. of Cincinnati
George Ding	PhD	1995	Radiotherapy physicist, Vancouver
Doru Kaytar	MSc	1995	software industry
Dennis Akyürekli	PhD	1995	(MSc, 1988, BSc, 1985) Radiotherapy physicist, Kingston Regional Cancer Centre
Bilal Shahine	MSc	1995	PhD student at Univ. British Columbia
Ria Corsten	MSc	1995	Radiotherapy physicist, St. John's, Nfld.
Julia Wallace	PhD	1996	Research Associate with Prof. Giles Santyr (CMRF)
Patrick Rapley	PhD	1996	Radiotherapy physicist, Kelowna, B.C.
Cathy MacGillivray	MSc	1996	Trainee in clinical medical physics, Winnipeg
Ruth Brown	PhD	1996	Post-doc in biophysics, Health Canada
Larry Gates	PhD	1997	Post-doc in clinical mri, Halifax

David Gobbi	MSc	1997	PhD student at Univ. Western Ontario
Mazen Soubra	PhD	1997	Radiotherapy physicist, upstate New York
Kevin Lenton	PhD	1998	Post-doc in biophysics at Univ. Sherbrooke
Sheri Boyden	MSc	1998	MD student at McMaster University
Miller MacPherson	PhD	1998	Radiotherapy Physicist, Ottawa Regional Cancer Center
Geoff Zhang	PhD	1998	Physicist at JDS Fitel in Ottawa
Malgorzata Niedbala	MSc	1998	Currently a Ph.D. student in our program
D. Sheikh-Bagheri	PhD	1999	Medical Physicist at Theratronics
Tanya Hewitt	MSc	1999	Research Assistant at the Ottawa Heart Institute

Scientific Societies of Relevance to Medical Physics

The following scientific societies are of interest to students and scientists in medical physics. For further information contact the individuals listed:

AAPM	American Association of Physicists in Medicine	Paul Johns, Dave Rogers
CAP	Canadian Association of Physicists	Bob Clarke, Paul Johns, Dave Rogers
COMP	Canadian Organization of Medical Physicists	Paul Johns, Lee Gerig, Ken Shortt
CRPA	Canadian Radiation Protection Association	Clive Greenstock, Dave Rogers
EMBS	Engineering in Medicine and Biology Society of the IEEE	Bog Jarosz
HPS	Health Physics Society	Dave Rogers, Clive Greenstock
IRPS	International Radiation Physics Society	Paul Johns
RRS	Radiation Research Society	Peter Raaphorst, Clive Greenstock
ISMRM	International Society for Magnetic Resonance in Medicine	Ian Cameron, Giles Santyr
CNS	Canadian Nuclear Society	Clive Greenstock

OMPI Social Activities over the last year

Over the last year, in connection with the seminars, our institute has started to organize a limited number of social activities. The purpose is more informal get-togethers between members as well as students in connection with the professional and student seminars. A social activity usually consists of an outdoor sports or non-sports activity followed by dinner at a local restaurant or a BBQ. Over the last year the social activities included a soccer game, broomball and a visit to Theratronics in Kanata. Below are some nice memories from the broomball event.



Above: A key player from one of the teams in static "action" ...



Left: Enthusiastic team getting ready for the game.



Right: Well deserved recovery at a local restaurant.

Kudos

- OMPI member Clive Greenstock was appointed to the Editorial Board of the HPS journal Health Physics in January, 1998.
- OMPI student Gosia Niedbala is the proud chairperson of the new Carleton GASP – Graduate Association of Students in Physics, an organization to support graduate students at Carleton University. Support is provided in many ways, e.g. do comprehensive exam simulations, organize social events, etc.
- OMPI can be proud that several of its members were runners up for the Sylvia Fedoruk Prize for best Canadian paper in 1998 within the field of medical physics:
 - Dave Rogers with “*A new approach to electron-beam reference dosimetry*” Med. Phys. **25**, 310-320, 1998
 - Robert Leclair and Paul Johns with “*A semi-analytical model to investigate the potential applications of x-ray scatter imaging*” Med. Phys. **25**, 1008-1020, 1998
- OMPI member Jan Seuntjens and former OMPI member Chang-Ming (Charlie) Ma won a COMP poster award at the 1999 annual meeting in Sherbrooke, QC (June 16-19, 1999).

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