MPORU NEWSLETTER -- No. 9, June 1997

Medical Physics Organised Research Unit
Physics Department, Carleton University

Editor: Barry McKee (Also on: http://www.physics.carleton.ca/research/MPORU/)

CONTENTS

The MPORU: Members, Executive, and Students

The Medical Physics Organized Research Unit (MPORU) of Carleton University now has 26 members involved with research and/or teaching in the Ottawa area. The major space in this Newsletter (pages 6-23) is a membership profile including affiliation, current research, outside funding, and recent publications.

The Executive of the MPORU consists of a Director (Paul Johns), Past-Director (Ian Cameron), Secretary (Barry McKee), Academic Officer (Bog Jarosz), and a graduate student representative (Miller MacPherson). Members are elected for two year terms. The Executive meets about once a month and other MPORU members (Pavel Dvorak, Cheng Ng, Giles Santyr and Ken Shortt) have attended Executive meetings as observers in the past year. Giles Santyr has also coordinated the MPORU seminars.

Students, who are medical physics graduate students at Carleton, are an important component of the MPORU. A student section in the Newsletter (pages 30-32) lists their research topics and supervisors.

A Note from the Director

It has been another year of progress for the MPORU, with several developments. First of all, at its regular monthly meeting of 19 Sept 1996, the Executive approved a new category of membership: Associate. The idea is to enhance the MPORU by forming greater ties with Ottawa researchers in other fields whose work has application to medical physics or is otherwise related to medical physics. Their presence at our monthly seminars should enrich our activities.

In the 1996-97 academic year we welcomed two new members, both of whom are scientists in the Radiation Biology and Health Physics Branch at AECL Chalk River:

- Richard Richardson - has academic training in medical physics and worked several years in the UK as a hospital physicist before coming to Canada. He has extensive expertise in the health physics of alpha emitters, especially radon. Current interests include the human internal dosimetry of tritium and actinides. Dr. Richardson has been accepted as a Full Member of the MPORU.
- Akhilesh Trivedi - has background in radiation biochemistry and biophysics, radiation molecular biology, and biological dosimetry. His current interests are in the metabolism and dosimetry of internally-deposited radionuclides, especially tritium. Dr. Trivedi has been accepted as an Associate Member of MPORU.

A continued strength of the Carleton graduate program in medical physics is the quality of the courses. In the fall term, three courses were offered: Medical Radiation Physics which I taught, Radiobiology given by Peter Raaphorst, and the Medical Physics Practicum coordinated by Bog Jarosz with modules offered by Ian Cameron, Ken Shortt, Lee Gerig, and Peter Raaphorst. In the winter term there was one course: Medical Radiotherapy Physics given by Joanna Cygler, Ken Shortt, Jan Seuntjens, Iwan Kowrakow, and Lee Gerig. Special thanks to Peter Raaphorst, Ian Cameron, Ken Shortt, Lee Gerig, Joanna Cygler, Jan Seuntjens, and Iwan Kowrakow for taking the time from their demanding schedules at their own institutions to make these courses available.

The monthly MPORU seminars are the lifeblood of our organization and I thank all those who presented in the series and all those who attended this year. In terms of venue, two highlights were the December seminar, held at the National Museum of Science and Technology, at which the Roentgen centennial exhibit was available for viewing, and the final seminar, held at AECL Chalk River, with tours of nuclear physics and of health physics offered. It is often difficult to get away from one's other responsibilities to go to seminars and the efforts of all those who attended in 1996-97 are appreciated. For those members and students who let their attendance drop this year, we look forward to seeing you at the September seminar!

One graduate student thesis was completed in 1996-97. Ruth Brown completed her PhD at the end of August 1996 and is now a post-doc in Jack McLean's radiobiology lab at Health Canada. In the previous year (1995-96), six graduate theses were completed; the drop to only one in the current year is a statistical effect, and we anticipate that up to three thesis defences will be held before the end of 1997 summer. We are also in the process of accepting several new graduate students to commence in September 1997.

At Carleton a new initiative is underway to draw together the various research groups who work in the area of health applications. Besides the MPORU, at Carleton there is an Institute of Neuroscience and programs in biochemistry and biology, and in addition there are efforts in biomedical engineering which may

lead to a new program in the very near future. Not having a medical school or faculty of health sciences, there has not been a natural focus for these groups to interact in the past. A very successful Biomedical Sciences and Engineering Research Afternoon was held 24 April 1997 with brief talks by the various groups and a poster session. The MPORU and the medical physics graduate program were given much exposure during this event. It is anticipated that such a research afternoon will become an annual event and lead to a greater presence and impact at the Ottawa Life Sciences Conference, held every fall.

The Carleton University Capital Campaign fundraising drive was officially kicked off October 1996. One of the projects to be enabled is the funded chair in medical physics. We look forward to momentum strengthening for the Capital Campaign and for this funded chair over the next year.

This summer Bog Jarosz steps down from the position of Academic Officer, having served since the beginning of 1995. Bog has run the MPORU academic program with diligence and enthusiasm and will be missed in this role. In 1997-98 he will be taking a well-deserved sabbatical to concentrate on his research of ultrasound thermal therapy for brain tumours. Giles Santyr, who was Seminar Organizer this year, will take over as Academic Officer. Pavel Dvorak will assume the duties of Seminar Organizer.

The MPORU was formed in 1989, and its "constitution" was the document submitted the summer of that year to Dean of Science Les Copley and subsequently forwarded to and approved by the Faculty of Graduate Studies and Research. This document was reprinted in our first Newsletter, September 1989. For most of you this document is no longer accessible, and therefore it has been reprinted in this edition of the Newsletter, updated according to the amendments over the years. (See section below entitled "MPORU - Rules of Operation"). These amendments include the addition of the position of Past-Director to the Executive, the Associate Member category mentioned above, and some clarifications regarding qualifications for membership.

Thank you to all MPORU members and graduate students for your support in 1996-97. With our continued joint efforts we can look forward to another stimulating year of progress in Ottawa medical physics.

Paul Johns, Director of the MPORU

MPORU - Rules of Operation

Note: This section is based on two sources. The first is the document "Proposal for an Organized Research Unit on Medical Physics (MPORU)" dated 19 July 1989, which was submitted to the then Dean of Science L. Copley, who forwarded it to the Faculty of Graduate Studies and Research. Formal approval by the Faculty of Graduate Studies and Research was obtained in October 1989. The wording has been rephrased from that of a proposal to wording which describes an ongoing organization, and the list of institutions of the members has been brought up to date. Items specific to the initial status of the MPORU in 1989 are not reproduced here. The second source is minutes of subsequent meetings of the MPORU Executive. Over the years since 1989 the following have been approved: position of Past-Director, clarification regarding eligibility for membership, and creation of the Associate Member category.

1. Overview

This document is intended to address the requirements stated in the document "Guidelines for the Formation of Research Collectives (Organized Research Units)". It describes the operation at Carleton of an ORU on Medical Physics, drawing on individuals from organizations within Carleton and external to it. In 1997 these were:

Physics Department, Carleton University,
Atomic Energy Control Board,
Chalk River Laboratories of Atomic Energy of Canada Ltd.,
Radiation Protection Bureau of Health Canada,
Ionising Radiation Standards Group of the Inst. of National Measurement Standards, National Research Council,
Ottawa Civic Hospital,
Ottawa General Hospital,
Ottawa Heart Institute, and
Ottawa Regional Cancer Centre of the Ontario Cancer Treatment & Research Foundation.

The document deals with the objectives of the ORU, its membership criteria, its management structures, and its Annual Report. The impetus for setting up the ORU is given.

2. MPORU Objectives

There is, in the Ottawa area, a significant number of research workers in several of the various fields known as medical physics, specifically in therapy, imaging, radiation biophysics, and radiation standards. Important developments in these areas hold promise for improvements in the diagnosis and understanding of disease and applications of high technology to patient care. It has also become apparent on a national, and perhaps world scale, that a shortage of scientifically trained and clinically skilled physicists is developing. Meetings in the 1980's of area persons led to the formation of a precursor to the MPORU which identified areas of common interest.

The objectives of the MPORU are:

1. To promote basic and applied research in those fields of medical physics in which there is local strength, in conformity with the research objectives of the institutions involved.
2. To advise the Carleton University Physics Department and the Ottawa Carleton Institute for Physics (OCIP) on matters of Medical Physics.
3. To develop collaborative research activity in these fields.
4. To promote graduate studies in medical physics.
5. To facilitate graduate student placement with a supervisor who is a member of the ORU.
6. To develop laboratory facilities for medical physics.
7. To encourage funding from government and from private agencies.
8. To organize seminars, meetings and other forms of communication among the members.

It is the belief of those engaged in research in medical physics that the existence of the MPORU will help substantially in the search for research funding in this field. Funding to support research and graduate students has not been easy to find in competition with other more readily recognized fields in medicine and physics.

3. MPORU Membership

3.1 Full Membership

The membership consists of individual scientists whose activities and expertise will further the objectives of the MPORU. Membership is by invitation of the Executive and is restricted to those active in the Medical Physics field (via research, graduate student supervision, or substantial participation in the teaching of the graduate courses).

[The following clarification was adopted 14 December 1995.] Membership in the MPORU can be granted to anyone with a relevant degree or relevant work experience that can convince the Executive that they are active in Medical Physics research. This can include PDF's, Physics Residents and Trainees or anyone else at a similar level. PDF's, Physics Residents and Trainees etc. who are clinically active in Medical Physics but who are not doing research should not be granted membership. They should, however, be encouraged to attend MPORU seminars.

3.2 Associate Membership [adopted 19 September 1996].

Scientists not eligible for regular Membership may be invited by the Executive to become Associate Members of the MPORU if it is deemed that such membership would further the objectives of the MPORU. They shall be researchers whose work has application to or is otherwise related to medical physics, but they shall not be medical physicists themselves, as determined by a review of their CV by the Executive.

Presentation of a seminar in the regular MPORU series shall be a prerequisite for membership. Following commencement of membership, Associate Members shall be invited but not required to give seminars in the regular MPORU series. They shall be invited but not required to list their research activities relevant to medical physics in the annual Newsletter; their other research activities will not be reported.

Associate Members may not vote nor serve on the Executive of the MPORU.

4. MPORU Management Structure

It is understood that the MPORU reports through the Chairman of the Carleton Physics Department to the Dean of the Faculty of Science of Carleton University.

4.1 Executive

The unit elects from its members an Executive consisting of four officers:

1. A Director to oversee and lead the operation of the ORU, guide the relations of MPORU and the institutions from which its members come, coordinate the scientific efforts of the members, and produce the Annual Report.
2. Past-Director [adopted 16 December 1993].
3. A Secretary to record the proceedings of the ORU, coordinate matters of public relations and publicity, to produce a newsletter, and to assist in the organization of MPORU seminars and workshops.
4. An Academic Officer to coordinate graduate student activities with the appropriate university authorities. He also undertakes liaison with the student representative, to ensure that matters of direct concern to the graduate students will be brought to the attention of the Executive, with invitation of the student representative to appropriate meetings.

Officers are elected for a period of two years, renewable, with elections taking place in December of alternate years. As far as possible the terms of the officers are staggered. The Executive and MPORU membership are expected to meet regularly.

4.2 Advisory Board

Because of the commitment of the MPORU to collaborative research and education between the University and local institutions, an Advisory Board was established soon after the formation of the ORU. The principal function of the Board is to review the activities and research and educational activities of the ORU and make recommendations on its future directions.

At its last meeting, the composition of the Board was as follows:

Director of the MPORU,
Director of OCIP,
Dean of Science, Carleton University,
One representative from OCTRF,
One representative from Health Canada,
One representative from NRC,
Dean of Medicine, University of Ottawa.

The Advisory Board is chaired by the Director of the MPORU.

5. Annual Report

The MPORU publishes an annual report, in conformity with the requirements of the University, to publicize its strengths and accomplishments. The report covers research and graduate studies, with descriptions of the activities of its members and the laboratory facilities available, and a listing of publications.

MPORU 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 external sources of research funding of the MPORU members. The editor has attempted to reduce all the contributions to a standard format.

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Recent Research: Using analytic and Monte Carlo methods to improve the foundations of theoretical dosimetry.
- Analytic models of ionisation chambers.
- Theoretical development of multiple scattering theory.
- Development of electron and photon transport physics for fundamental dosimetry and radiotherapy treatment planning.
- Improving Monte Carlo methods in the therapeutic range (10 keV-50 MeV) by modelling the physics more accurately - with most of the emphasis on the EGS (Electron Gamma Shower) Monte Carlo code.
- Development of geometry modelling techniques for accurate Monte Carlo transport.

Funding: Lawrence Livermore National Laboratory electron transport grant, $68 k.

Publications: (http://www.irs.inms.nrc.ca/inms/irs/papers/irs_www/irs_www.html)
- A.F. Bielajew. "EGS4 timing benchmark results: Why Monte Carlo is a viable option for radiotherapy treatment planning", Proc. of the Int. Conference on Mathematics and Computations, Reactor Physics, and Environmental Analyses *(American Nuclear Society Press, La Grange Park, Illinois, USA*), pages 831 - 837, 1995.
- A.F. Bielajew. "HOWFAR and HOWNEAR: Geometry Modelling for Monte Carlo Particle Transport", *National Research Council of Canada Report PIRS-0341*, 1995.
- A.F. Bielajew. "Incorporating the Lawrence Livermore photon interaction data base into the electron-photon Monte Carlo transport code EGS4", Canadian Organization of Medical Physicists Conference Proceedings *(Canadian Organization of Medical Physicists Secretariat, Edmonton, Canada)*, pages 31 - 32, 1995.
- A.F. Bielajew. "A hybrid multiple-scattering theory for electron-transport Monte Carlo calculations", Nucl. Inst. and Meth. *(in press)*, 1995.
- A.F. Bielajew and D.E. Cullen. "Incorporating the Lawrence Livermore photon interaction data base into the electron-photon Monte Carlo transport code EGS4", Proceedings of the International Conference on Mathematics and Computations, Reactor Physics, and Environmental Analyses *(American Nuclear Society Press, La Grange Park, Illinois, USA)*, pages 154 - 161, 1995.
- K.R. Borg and A.F. Bielajew. "QUADPLOT: A programme to plot quadric surfaces", *National Research Council of Canada Report PIRS-0491,* 1995.
- M.J. Corsten and A.F. Bielajew. "Determination of point-source non-uniformity correction factors for cylindrical ion chambers in the vicinity of brachytherapy sources", Canadian Organization of Medical Physicists Conference Proceedings *(Canadian Organization of Medical Physicists Secretariat, Edmonton, Canada)*, pages 119 - 120, 1995.
- B.B. Sorcini, P.Andreo, A.F. Bielajew, S. Hyodynmaa, and A. Brahme. "An improved energy-range relationship for high energy electron beams based on multiple accurate experimental and Monte Carlo data sets", Phys. Med. Biol., 40:135 - 1159, 1995.

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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/yr

Publications:
- L. Gates and I.G. Cameron. "Diffusion Measurements at Very Short Diffusion Times in Human Muscle Using a Double Maxwell Gradient Coil", *Proceedings of the International Society for Magnetic Resonance in Medicine Conference,* Nice, France, 1995.
- L. Gates and I.G. Cameron. "Time Dependence of Water Diffusion in Human White Matter", *Proceedings of the International Society for Magnetic Resonance in Medicine Conference,* Nice, France, 1995.
- L. Gates and I.G. Cameron. "Using MRI to Measure Diffusion of Water in Human White Matter", *Proceedings of the Canadian Organization of Medical Physicists Conference, Montreal*, pp 43-44, 1995.

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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.
- I.H. Rivens, R.L. Clarke, and G.R. ter Haar, "Design of focused ultrasound surgery transducers", *accepted Trans. IEEE - UFC*, 1996.
- R.L. Clarke, "Modification of intensity distributions from large aperture ultrasound sources", *Ultrasound in Med. & Biol.* 21 (3), 353-363, 1995.

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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 imbedded 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. 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.*, in press.

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Recent Research: Development of three-dimensional attenuation and scatter corrections for positron emission tomography, automated 3D cardiac image interpretation, and development of an automated isotope delivery system for the short-lived blood flow tracer Rb-82.

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.A. deKemp, W.F. Jones, C. Nahmias, R.S. Beanlands. "PET Quantitation and Reconstruction: Design and Performance of 3D Single Photon Transmission Measurement on a Positron Tomograph with Continuously Rotating Detectors", In: *Serie Computational Imaging and Vision*, P.Grangeat, J.L.Amans (eds), Kluwer Academic Publishers, 1996.
- R.A. deKemp and C. Nahmias, "Automated Determination of the Myocardial Long Axis in Cardiac Positron Emission Tomography", *Physiol. Meas*., 17: 95-108, 1996.
- R.S. Beanlands, T.D. Ruddy, R.A. deKemp, E. Harmsen, J. Veinot, N.G. Hartman. "The effects of necrosis and low flow reperfusion on the myocardial kinetics of Tc-99m-teboroxime" *J Am.Coll.Cardiol*., 28: 487-494, 1996.

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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 and automatic film processor.

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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: Radiation Therapy is a complex and expensive health care modality. The outcome of the radiation therapy process can be assessed in terms of tumour control, patient survival, normal tissue complication and patient quality of life. In our present research program we are modelling the entire radiation therapy process as a series of independent processes. Each of the processes are represented by a modulation function which degrades the quality of the outcome from some theoretical maximum. Our work is focused on developing a complete model which includes radiation biology, diagnosis and tumour localization, treatment planning, and treatment delivery. The nature of the modulation terms for each step, particularly treatment delivery, is being examined in detail.

Publications:
- Akyurekli D.U., Gerig L.H., Raaphorst G.P., "Changes in Muscle Blood Flow Distribution During Hyperthermia", *International Journal of Hyperthermia*, Accepted, April 1997.
- Li X.A., Soubra M., Szanto J., Gerig L., "Lateral electron equilibrium in measurements of head scatter factors using miniphantoms and brass caps", *Med Phys* 22(7), pp 1167-1170, 1995.
- Akyurekli D.U., Gerig L.H., Raaphorst G.P. "A Tissue Preparation Technique for Microsphere Assays of Blood Flow", *Laboratory Animal Science*, 45, 78, 1995.
- Grimard, L, Szanto, J., Girard, A., Howard, M., Eapen, L., and Gerig, L,"Asymmetric Arc Technique for Posterior Pharyngeal Wall and Retropharyngeal Space Tumors", *Int. Journal of Radiation Oncology Biol. Phys*. 31(3), Feb. 1995.

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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.
- Measuring radiation damage to the lymphocyte immunosurveillance system.
- Monitoring early-warning response to radiation, cancer-proneness, cell signalling and adaptation mechanisms using fluorescent monoclonal antibody binding to specific cell surface receptors.
- An immunoassay technique (ELISA) has been set up to measure antioxidant enzyme levels in cells, and to explore their role in inducible and constitutive radiation protection mechanisms.
- Applying health physics and radiation protection to risk assessment.

Funding:
- CANDU Owners Group (COG), R &D support, $150k
- AECB contract for organically bound tritium dosimetry, $62k
- Faulding(Canada) contract to study catalase action in cancer therapy, $20k
- COG graduate student scholarship support, $10k/year

Publications:
- 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, "Review of potential biomarkers of radiation exposure", *Proc. AFFRI Workshop on Triage of Irradiated Personnel*, DOE Publn., Bethesda MD, 1997 (in press).
- Y. Xu, C.L. Greenstock, A. Trivedi and R.E.J. Mitchel, "Occupational levels of radiation exposure induce surface expression of interleukin-2 receptors in stimulated human peripheral blood lymphocytes", *Radiat. Environ. Biophys*. 35, 89-93, 1996.
- Y. Xu, B. Conway, J.S.G. Montaner, M.V. O'Shaughnessy and C.L. Greenstock, "Effect of low dose gamma radiation on HIV replication in human peripheral blood mononuclear cells", *Photochem. Photobiol.* 64, 238-241, 1996.
- K.J. Lenton and C.L. Greenstock, "Free radical scavenging and antioxidant kinetics using a fluorescent protein target", *Cahiers de Radiobiologie*, 4, 9-12, 1996.
- C.A. Chuaqui, A. Petkau, C.L. Greenstock and C.P. Brown, "Identification and monitoring of non-radiological carcinogens", *Atomic Energy Control Board (AECB) Report; INFO-0594,* Ottawa ON 1-81, 1995.
- C.L. Greenstock and A. Trivedi, "Low- and high-LET radiation dosimetry using surrogate biosamples", *Proc. 4th International Symposium on ESR Dosimetry and Applications* (D.F. Regulla, ed.), Neuherberg Press, Germany, A-197, 1995.
- C.L. Greenstock, A. Trivedi and R.E.J. Mitchel, "Cellular response to stress and risk modulation", *Proc. Amer. Assoc. Cancer Res.*, 36, 182, 1995.
- A. Trivedi and C.L. Greenstock, "Recent developments in biodosimetry", *Atomic Energy Control Board (AECB) Report, INFO-0597*, Ottawa, 1-85, 1995.
- Y.Xu, C.L. Greenstock, M.V. O'Shaughnessy and B. Conway, "The effects of low doses of gamma irradiation on HIV-replication in human peripheral blood mononuclear cells", *Second National Conference on Human Retroviruses and Related Infections*, II, 29, 1995.
- C.L. Greenstock, "From Szechuan to Saskatchewan: A Profile of H.E. Johns and the Cobalt Bomb", In: *A New Kind of Ray: The Radiological Sciences in Canada 1895-1995*, (J.E. Aldrich and B.C. Lentle, eds.) The Canadian Association of Radiologists, Montreal, 247-251 and 428-429, 1995.

- C.L. Greenstock and A. Trivedi, "ESR dosimetry using surrogate biosamples", *Health Phys*. 68, Suppl. 1, S23, 1995.
- C.L. Greenstock and S.R. Maves, "Fluorescence lifetime studies of DNA structure in gamma-irradiated lymphocytes", In: *Radiation Research 1895-1995*, Congress Proceedings, Vol. 1(U. Hagen, H. Jung and C. Streffer, eds.), 10th ICRR Society, Wurzburg, Germany, 422, 1995.
- D.P. Heller and C.L. Greenstock, "Fluorescence lifetime analysis of DNA intercalated ethidium bromide and quenching by free dye", *Biophys. Chem*. 50, 305-312, 1995.

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Recent Research: - Ultrasound thermal therapy of deep localized tumours.
Research involves a wide range of animal and phantom investigation of heating with an array of two to six ultrasonic interstitial waveguide applicators for thermal therapy. Interaction of sonic waves with tissues and mode conversion in tissues have been studied. Finite Element Analysis computations of the above processes have been used to evaluate effectiveness of the arrays for heating. The research includes also laser generated ultrasound for heating.

Funding: Carleton University GR5-6 grant $5k/y.

Publications:
- B.J. Jarosz and D. Kaytar, "Ultrasonic heating with waveguide interstitial applicator array", *Proceedings of IEEE Inst. & Measurement Technology Conference*, May, 1997, Ottawa, Canada, pp 1346-1349, 1997.
- B.J. Jarosz, "Feasibility of Ultrasound Hyperthermia with Waveguide Interstitial Applicator", *IEEE Trans. on Biomedical Engineering*, 43,1106-1115, 1996.
- B.J. Jarosz and D. Kaytar, "Hyperthermia Fields Generated by an Array of Interstitial Ultrasonic Waveguide Applicators", *Proceedings, 1995 COMP/CCPM Conference*, Montreal PQ, 37-38, June 1995.

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Recent Research: 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.
- Investigating means of obtaining diagnostic information using coherent 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 coherent 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 some 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.

Funding: NSERC Operating Grant $15k /y

Publications:
- 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", *Proceedings of the IEEE Instrumentation and Measurement Technology Conference*, Ottawa, May 1997 (IEEE #97CH36022) pp.1357-1360, 1997.
- P.C. Johns, J.C. Armitage, D.C. Bouius, M.S. Dixit, J. Dubeau, D.G. Gobbi, D. Karlen, and F.G. Oakham, "Development of Gas Microstrip Detectors for Digital X-Ray Imaging", *Proceedings of 42nd Ann Meeting of the Canadian Organization of Medical Physicists*, 255-256, 1996. [Abstract: *Medical Physics* 23, 809,1996].
- R.J. Leclair and P.C. Johns, "An Investigation of the Use of Scattered Photons in X-Ray Imaging", *Proceedings of 42nd Annual Meeting of the Canadian Organization of Medical Physicists*, 80-81, 1996. [Abstract: *Medical Physics,* **23,** 798-799, 1996].
- M.S. Dixit, J.C. Armitage, D. Bouius, L. Diaconescu, J. Dubeau, M. Grabari, P.C. Johns, D. Karlen, and F.G. Oakham, "Digital X-Ray Imaging Using Gas Microstrip Detectors", *Proceedings of IEEE Medical Imaging Conference*, San Francisco (October 1995).
- P.C. Johns, J.C. Armitage, M.S. Dixit, J. Dubeau, D. Karlen, and F.G. Oakham, "Gas Microstrip Detectors for Digital X-Ray Imaging", *Proceedings of 41st Annual Meeting of the Canadian Organization of Medical Physicists*, 143-144, 1995. [Abstract: *Medical Physics* **22,** 675, 1995].

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Recent Research: Involved in the work to establish absorbed dose standards based on water calorimetry. This is being done for 20 MV 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 and C. K. Ross. "Water calorimetry: the heat defect", *J. Res. Natl. Inst. Stand. Technol*., **102**: 63-74, 1997.
- C. K. Ross and N. V. Klassen, "Water calorimetry for radiation dosimetry", *Phys. Med. Biol*., **41**: 1-29, 1996.
- N. V. Klassen. "Ice near 0 C: radiolysis and absorbed dose calorimetry", *Radiat. Phys. Chem*., **48**: 281-287, 1996.

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Recent Research: Using EGS4 Monte Carlo calculation and experimental measurement to study some clinical dosimetry problems. Orthovoltage x-ray beams are widely used for the treatment of superficial lesions. The effects of extended SSD on orthovoltage x-ray dosimetry are being studied experimentally. We are also interested in the choice of relative dosemeters and improvement of output calibration for these beam qualities. A endorectal irradiation technique is currently being developed on our orthovoltage x-ray unit. Dose optimization is a deterministic approach to treatment planning which offers several advantages over the current

conventional “trial and error” approach. In collaboration with D. Salhani, the algorithms have been developed and tested for brachytherapy with very promising results. Extension of the algorithm to external beams is currently in development.

Funding: ORCC grants for study of: dose optimization, $20k; PSF for megavoltage photon beams, $6k

Publications:
- X.A. Li, D. Salhani and C-M Ma,"Characteristics of orthovoltage x-ray therapy beam at extended SSD for applicators with end plates", *Phys. Med. Biol*. 42 357-370 (1997).
- X.A. Li, C.-M. Ma and D. Salhani, "Relative dosimetry measurement for kilovoltage x-rays", Submitted to *Phys. Med. Biol*. (1997).
- J. Cygler, X.A. Li and E. Lawrence, "Practical approach for electron beams at extended treatment distances", Submitted to *Phys. Med. Biol*. (1997).
- C. -M. Ma, X.A. Li and J. Seuntjens, "Consistency check for kilovoltage x-ray beam dosimetry", *Proceedings of workshop on KV x-ray beam dosimetry for radiotherapy* (Stanford, USA) (1997).
- X.A. Li, D. Salhani, C.M. Ma and O. Agboola, "Dosimetry of a kilovoltage x-ray unit for an endocavitary radiotherapy technique", Submitted to *Medical Physics* 1996.
- D. Wilkins, X.A. Li, J. Cygler and L.Gerig, "The effect of dose rate dependence of silicon diode detectors on linac relative dosimetry", Submitted to *Med. Phys*. 1996.
- X.A. Li, M. Soubra, J. Szanto and L.H. Gerig, "Lateral electron equilibrium in measurements of head scatter factors using miniphantoms and brass caps", *Med. Phys*. 22 1167-1170 (1995).
- X.A. Li and D.W.O. Rogers, "Electron mass scattering powers: Monte Carlo and analytical calculations", *Med. Phys*. 22 531-541 (1995).
- X.A. Li, M. Soubra, J. Szanto and L. Gerig, "The effect of head scatter radiation on the field size dependence of wedge factor", *Med. Phys*. 22, 666 (1995).

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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 wrists, etc., and for research applications in radiopharmaceutical development.
- Modelling and measuring the scatter background in SPECT systems to develop and test improved correction methods.

Funding: NSERC Research Grant $10k/y

Publications:
- 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.
- M.J. Chamberlain, K.Y. Gulenchyn, R.B. Jammal and B.T.A. McKee “Nuclear medicine goes filmless: Experience with a miniPACS,” *Proceedings of SCAR96, Conference on Computer Applications in Radiology*, Denver, June, 1996, 483-484, 1996.
- B.T.A. McKee, M.J. Chamberlain, and R.B. Jammal “The feasibility of 511 keV SPECT imaging: the scattered background,” *J. Nucl. Medicine*, 36, no.5, 174P (abst), 1995.
- B.T.A. McKee, R.B. Jammal and M.J. Chamberlain “The scatter background in high-resolution pinhole SPECT,” *Conference Record of the 1994 IEEE Medical Imaging Conference*, Norfolk, Va, 1498-1501, 1995.

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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 the OCTRF;
- NCIC (Principal Investigator) interaction between X-radiation and topoisomerase poisons, $99k/year;
- 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/year);
- NCIC grant (Co-investigator) cellular radiosensitivity, $70k.

Publications:
- Ng, C.E., Bussey, A.M. and Raaphorst, G.P. “Reduction of etoposide induced cell killing by hyperthermia can occur without changes in etoposide transport or topoisomerase II activity”. *Int. J. Hyperthermia*,**12**: 551-567, 1996.
- Wilkins, D.E., Ng, C.E. and Raaphorst, G.P. “Cisplatin and low dose rate irradiation in cisplatin resistant and sensitive human glioma cells”. *Int. J. Rad. Oncol. Biol. Phys*., **36**: 105-112, 1996.
- Shahine, B.H., Ng, C.E. and Raaphorst, G.P. “Modelling of continuous low dose rate and accelerated fractionated high dose rate irradiation treatments in a human glioma cell line”. *Int. J. Rad. Biol*., **70**: 555-562, 1996.
- Ng, C.E., Bussey, A.M. and Raaphorst, G.P. “Sequence of treatment is important in the modification of camptothecin induced cell killing by hyperthermia”. *Int. J. Hyperthermia*, **12**: 663-678, 1996.
- Raaphorst, G.P., Yang, H., Wilkins, D.E. and Ng, C.E. “Cisplatin, hyperthermia and radiation treatment in human cisplatin sensitive and resistant glioma cell lines”. *Int. J. Hyperthermia*, **12**: 801-812, 1996.
- 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 ^{1}H Magnetic Resonance spectra from untreated and recurrent ovarian cancer using linear discriminant analysis”. *Mag. Res. in Medicine*, accepted, 1996.
- Ng, C.E., Bussey, A.M., MacDonald, H.M., Heller, D.P. Wilkins, D.E. and Raaphorst, G.P. “Cross sensitivity to X-radiation and type I and II DNA topoisomerase inhibitors in a range of human and rodent cell lines”. *Int. J. Oncol*., **7**: 1179-1184, 1995.
- Raaphorst, G.P., Wang, G. and Ng, C.E. “Radiosensitization by cisplatin treatment in cisplatin resistant and sensitive human ovarian carcinoma cell lines”. *Int. J. Oncol*., **7**: 325-330, 1995.
- Ng, C.E., Yang, D.P., Bussey, A.M. and Raaphorst, G.P. “Cultured Chinese Hamster Ovary cells lack a transferable X-radiation resistance factor”. *Oncol. Reports*, **2**: 439-442, 1995.
- Raaphorst, G.P., Mao, J.P. and Ng, C.E. “Thermotolerance in human glioma cells”. *Int. J. Hyperthermia*, **11**: 523-529, 1995.

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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 deg) 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 develop 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 years.
- NCIC grant for the study of combined treatment of radiation cisplatin and hyperthermia. $106k/y for 3 years.
- Department of defence funding for the study of induced radiation resistance. $23k/y.

Publications:
- G.P. Raaphorst, P. Chabot, S. Doja, D. Wilkins, D. Stewart and C.E. Ng. "Effect of hyperthermia on cisplatin sensitivity in human glioma and ovarian carcinoma cell lines resistant and sensitive to cisplatin treatment". *Int. J. Hypertherm.* 129, 211-222, 1996.
- G.P. Raaphorst, S. Doja, L. Davies, D. Stewart and C.E. Ng. "Comparison of cisplatin-hyperthermia in human ovarian carcinoma and glioma cell lines sensitive and resistant to cisplatin treatment". Cancer Chemother. Pharmacol. 37, 574-580, 1996.
- G.P. Raaphorst, J.P. Mao, D.P. Yang and C.E. Ng. "Thermal-radiosensitization by protracted low temperature hyperthermia in human glioma cells". *J. Therm. Biol*., 21, 239-244, 1996.
- G.P. Raaphorst, G. Wang, D. Stewart and C.E. Ng. "Concomitant Low Dose Rate Irradiation and Cisplatin Treatment in Ovarian Carcinoma Cell Lines Sensitive and Resistant to Cisplatin Treatment". *International Journal of Radiation Biology*, 69: 623-631, 1996.
- C.E. Ng, A.M. Bussey and G.P. Raaphorst. "Reduction of etoposide induced cell killing by hyperthermia can occur without changes in etoposide transport or topoisomerase II activity". *Int. J. Hyperthermia*, 12: 551-567, 1996.
- C.E. Ng, A.M. Bussey and G.P. Raaphorst. "Sequence of treatment is important in the modification of camptothecin induced cell killing by hyperthermia". *Intl. J. Hyperthermia* 12 : 663-678, 1996.

- 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*. In press 1996.
- G.P. Raaphorst, H. Yang, D.E. Wilkins and C.E. Ng. "Cisplatin, hyperthermia and radiation treatment in human cisplatin-sensitive and resistant glioma cell lines". *Int. J. Hyperthermia*. In press 1996.
- R.C. Brown, G.P. Raaphorst, C.E. Danjoux and P. Drouin. "Multi-organ fatal chronic complications following radiation treatment for cancer of the cervix, results of fibroblast assay". *Gynecologic Oncology*, 61:116-121, 1996.
- G.P. Raaphorst, J.P. Mao and C.E. Ng. "A comparison of hyperthermia inhibition of sublethal radiation damage recovery in four human cell lines with different radiosensitivity". *Int. J. of Oncology*, accepted 1996.
- G.P. Raaphorst, J.P. Mao, D.P. Yang and C.E. Ng. "Comparison of hyperthermia radiosensitization and DNA polymerase inactivation in human normal and melanoma cell lines of different radiosensitivities". *International Journal of Radiation Oncology*. In press 1996.
- G.P. Raaphorst, J.P. Mao, D.P. Yang and C.E. Ng. "Comparison of thermotolerance development in three human cell lines". *Oncology Investigations*. In press 1996.
- B.H. Shahine, C.E. Ng and G.P. Raaphorst. "Modelling of continuous low dose rate and accelerated fractionated high dose rate irradiation treatments in a human glioma cell line", *Radiation Research.* In press,1996.
- R.C. Brown, C.E. Ng and G.P. Raaphorst. "Measurement of DNA damage by pulsed field gel electrophoresis following different irradiation protocols". *Proceedings COMP*, 115-120, Vancouver, 1996.
- C.E. Ng, D.P. Yang, A.M. Bussey and G.P. Raaphorst. "Cultured Chinese hamster ovary cells lack a transferable X-radiation resistance factor". *Oncology Reports*, 2, 439 - 442, 1995.
- G.P. Raaphorst, D.P. Yang, A. Bussey and C.E. Ng. "Cell killing, DNA polymerase inactivation and radiosensitization to low dose rate irradiation by mild hyperthermia in four human cell lines". *Int. J. Hyperthermia,* 11:851-854, 1995.
- G.P. Raaphorst, J.P. Mao and C.E. Ng. "Thermotolerance in human glioma cells". *Int. J. Hypertherm.*, 11: 523-529, 1995.
- G.P. Raaphorst, D.P. Yang and C.E. Ng. "Stepdown hyperthermia in human melanoma cell; effects on protracted mild hyperthermia for survival and DNA polymerase inactivation". *Melanoma Res.* 5: 229-234, 1995.
- G.P. Raaphorst, G. Wang and C.E. Ng, "Radiosensitization by cisplatin treatment in cisplatin resistant and sensitive human ovarian carcinoma cell lines". *Int. J. Oncol.* , 7, 325 - 330, 1995.
- G.P. Raaphorst, D.P. Yang, D. Grewaal, D. Stewart, R. Goel, C.E. Ng. "Analysis of mechanisms of cisplatin resistance in three pairs of human tumour cell lines expressing normal and resistant responses to cisplatin". *Oncology Reports*, 2:1037-1043, 1995.
- G.P. Raaphorst, G. Wang, D. Stewart and C.E. Ng. "A Study of Cisplatin-Radiosensitization through Inhibition of Repair of Sublethal Radiation Damage in Ovarian Carcinoma Cells Sensitive and Resistant to Cisplatin". *International Journal of Oncology*, 7: 1373-1378, 1995.

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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:
- A. Trivedi, D. Galeriu, R.B. Richardson and E.S. Lamothe, "Dose Contribution from Metabolised Organically Bound Tritium after Tritiated Water Intakes in Humans", *Bull Radiat. Prot.* 19 (3&4): 1-3, 1996.
- D.J. Gorman, R. Maloney, R.B. Richardson, B. Tracy and D.W. Whillans, "The Management of Carbon-14 in Canadian Nuclear Facilities", *Advisory Committee on Radiological Prot., ACRP-14, AECB INFO-0569 (E)*, 1995.
- A. Trivedi, R.B. Richardson and D. Galeriu., "Dynamics of Tritiated Water and Organically Bound Tritium after an Acute Tritiated Water Intake in Humans", *Fusion Tech*. 28: 982-987, 1995.
- A. Trivedi, R.R. Richardson and D. Galeriu, "Dose from Organically Bound Tritium after an Acute Tritiated Water Intake in Humans", *AECB Project No. 7.155.1, INFO-0598*, 1995.

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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:
- NSERC - graduate student support of $10k/year
- NIH - $130k/year (to Ottawa) for three years for the OMEGA project

Publications:
- A. Booth and D.W.O. Rogers. "PROT: A General Purpose Utility for Calculating Quantities related to Dosimetry Protocols". *Technical Report PIRS-529*, NRC Canada, Ottawa, K1A OR6, 1996.
- D.T. Burns, G.X. Ding, and D.W.O. Rogers. "R_{50} as a beam quality specifier for selecting stopping-power ratios and reference depths for electron dosimetry". *Med. Phys.*, 23: 383-388, 1996.
- G.X. Ding and D.W.O. Rogers. "Energy spectra, angular spread, and dose distributions of electron beams from various accelerators used in radiotherapy". *NRC Report PIRS-439*, 1995.
- G.X. Ding, D.W.O. Rogers and T.R. Mackie. "Calculation of stopping-power ratios using realistic clinical electron beams". *Med. Phys*., 22: 489-501, 1995.
- G.X. Ding, D.W.O. Rogers and T.R. Mackie. "Mean energy, energy-range relationships and depth-scaling factors for clinical electron beams". *Med. Phys*., 23: 361-376, 1996.
- D.W.O. Rogers. "NRC Activities and Publications, 1993-1995", Report to the CCEMRI(I) Meeting, BIPM, April 1995. *BIPM document CCEMRI(I)/*95-35, 1995.
- D.W.O. Rogers. "Re-evaluation of (W/e) and $(W/e)s_{gr,air}$", Report to the CCEMRI(I) Meeting, BIPM, April 1995. *BIPM document CCEMRI(I)*/95-34, 1995.
- D.W.O. Rogers."Ionizing Radiation Dosimetry and Medical Physics", *Phys. in Canada*, 51(#4):178-181, 1995.

- D.W.O. Rogers. "Fundamentals of Dosimetry Based on Absorbed-Dose Standards". In J.R. Palta and T.R. Mackie, editors, *Teletherapy Physics, Present and Future*. 1996.
- D.W.O. Rogers, B.A. Faddegon, G.X. Ding, C.M. Ma, J.Wei, and T.R. Mackie. "BEAM: A Monte Carlo code to simulate radiotherapy treatment units". *Med. Phys*., 22:503-524, 1995.
- D.W.O. Rogers, C.M. Ma, G.X. Ding, and B.Walters. "BEAM Users Manual". *NRC Report PIRS 509a*, 1995.
- D.Sheikh-Bagheri, D.W.O.Rogers."BEAM Example: A 16 MV photon beam" *NRC Report PIRS-509i*, 1995.
- B.Walters and D.W.O. Rogers. "BEAM Example: Depth-Dose in a Phantom, *NRC Report PIRS-509j*, 1995.
- B.Walters and D.W.O. Rogers. "QA for the BEAM System; Component Modules, Variance Reduction Options and Source Routines". *NRC Report PIRS-509k*, 1995.

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Recent Research: The amount of ionizing radiation absorbed by a material generally is specified by the quantity absorbed dose. For purposes of radiation therapy, it is the absorbed dose to tissue which is of most interest. As a first step in determining the dose to tissue, the dose to water is established in some well-defined geometry. Field instruments used to determine the dose to water must be calibrated in terms of some reference standard, and one of the objectives of our group is to develop and maintain standards and calibration services for the absorbed dose to water. Our standard for the absorbed dose to water is based on water calorimetry, in which the energy deposited by the radiation field is determined by measuring the temperature rise in irradiated water. Our intention is to have a single standard which can be used for all photon beams from ^{60}Co gamma-rays to 30 MV x-rays.

A quantity of considerable importance to radiation physics and medical physics is the electron stopping power. Stopping power data in use today is based mainly on calculations. In order to test the calculated values, we are measuring electron stopping powers in the energy range from 5 to 40 MeV for various materials. The technique uses a large NaI detector to measure the electron spectrum after the electron beam has passed through an absorber of known thickness. By comparing the measured spectrum to that calculated using Monte Carlo techniques we can extract the stopping power. Preliminary results indicate that the uncertainty on the measured stopping power should be about 0.5 %.

Publications:
- K. R. Shortt, C. K. Ross and I. Janovsky, "The Response of LiF TLDs to ^{137}Cs and ^{60}Co gamma Rays", *Radiat. Prot. Dosim.* 69, 257-266, 1997.
- N. V. Klassen and C. K. Ross, "Water Calorimetry: The Heat Defect", *J. Res. Natl. Inst. Stand. Technol*. 102, 63-74, 1997.
- Y. Nogami and C.K. Ross. "Scattering from a nonsymmetric potential in one-dimension as a coupled channel problem". *Am. J. Phys*, 64, 923-928, 1996.
- C.K. Ross and N.V. Klassen. "Water calorimetry for radiation dosimetry", *Phys. Med. Biol*., 41:1 - 29, 1996.
- C.K. Ross and M.S. MacPherson. "Comments on 'A new method to determine ratios of electron stopping powers to an improved accuracy'," *Phys. Med. Biol*., 41, 785-788, 1996.

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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.

Publications:

- X.A. Li, D. Salhani, C. Ma, "Characteristics of Orthovoltage X-ray Therapy Beams at extended SSD for applicators with end plates", *Phys. Med. Biol*., 42, 357-370, 1997.
- J. Crook, Y. Raymond, D. Salhani, H.Yang, B. Esche, "Prostate Motion during Standard Radiotherapy as assessed by Fiducial Markers", *Radiation and Oncology*, 37, 35-42, 1995.

Giles Santyr

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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, image display and development of an MR-based breast biopsy system. Clinical studies to evaluate the usefulness of these techniques are in progress. Other areas of interest include: in vivo measurement of kidney glomerular filtration rate (in collaboration with the University of Wisconsin), basic physics of MR image contrast, development of MR phantom materials and imaging of hyperpolarized gases (i.e. ^{129}Xe and ^{3}He) for biomedical applications and non-biological material testing.

Funding:

- NIH FIRST Award from NCI: "Spin locking for magnetic resonance imaging of breast cancer", $100k/yr.
- NRC/NSERC Research Partnership Grant: "Research Partnership in Hyperpolarized Noble Gas (HNG) Technology", $250k/yr.

Publications:

- Santyr G.E., Kelcz F. and E. Schneider, "Pulsed Magnetization Transfer Contrast for MR imaging with application to breast", *J. Magn. Reson. Imag*., 6, 203 (1996).
- Niendorf E.R., G.E. Santyr, P.C. Brazy and T.M. Grist, "Measurement of Gd-DTPA Dialysis Clearance Rates Using a Look-Locker Imaging Technique", *Magnetic Reson. Med* 36, 571 (1996).
- Kelcz F., G.E. Santyr, G.O. Cron and S.J. Mongin, "Application of a Quantitative Model to Differentiate Benign from Malignant Breast Lesions Detected by Gd-enhanced MRI", *J. Magn. Reson. Imag*., 6, 743 (1996).
- Bishop J.E., G.E. Santyr, F. Kelcz and D.B. Plewes, "Limitations of the Keyhole technique for quantitative Dynamic MRI", (accepted for publication in *Magnetic Reson. Med*., 03/97).
- Niendorf E.R., G.E. Santyr, R. Frayne, P.C. Brazy and T.M. Grist, "Measurement of Gd-DTPA Filtration Fraction in a Dialysis Filter System using an EPI Lock-Locker Technique", (accepted to *Med. Physics*, 10/96).
- Santyr G.E. and R.V. Mulkern, "Magnetization transfer in MR imaging: A report from the relaxometry and biophysics committee of the SMRI", *J. Magn. Reson. Imag*. 5, 121 (1995).

- Kelcz F. and G.E. Santyr, "Gd-enhanced Breast MRI", in *Critical Reviews of Diagnostic Imaging* 36(4), 287-338, CRC press, Inc. Boca Raton, FL (1995).
- Fairbanks E.J., Santyr G.E. and J.A. Sorenson, "One-shot measurement of spin-lattice relaxation times in the off-resonance rotating frame using MR imaging, with application to breast", *J.Magn.Reson. B*, 106, 279 (1995).
- Niendorf E.R., G.E. Santyr, R. Frayne, T.M. Grist, "Measurement of Gd-DTPA Filtration Fraction in a Dialysis Filter using an EPI Look-Locker Technique", *International Society of Magnetic Resonance in Medicine*, New York 1996 (abstract).
- Kelcz F., G.E. Santyr, K. Groh, G.O. Cron, "Reduced Sensitivity of Gd-enhanced MRI for Cancer Manifest Soley by Mammographic Microcalcifications", *International Society of Magnetic Resonance in Medicine*, New York 1996 (abstract).
- Wilson G.J., G.E. Santyr, M.E. Anderson, P.M. DeLuca, "T1 Relaxation Times of Xe-129 in Tissue Homogenates". Workshop on *Perspectives of MR Imaging using Polarized Gases*, Les Houches, France 1996.
- Cron G.O., G.E. Santyr, F. Kelcz, "Dynamic Contrast-Enhanced Imaging of the Breast with Magnetic Resonance", *Ottawa Life Sciences National Conference*, Ottawa 1996 (abstract).
- Cron G.O., G.E. Santyr, F. Kelcz, "Dynamic Contrast-Enhanced Imaging of the Breast with Magnetic Resonance", -*IEEE Instrumentation and Measurement Technology Conference*, Ottawa 1997 (abstract).
- Cron G.O., G.E. Santyr, F. Kelcz, "Correction of Errors due to Slice Profile Imperfections in Quantitative Dynamic -Contrast-Enhanced Breast MRI", *Intl. Society of Magnetic Resonance in Medicine*, Vancouver 1997.
- Wilson G.J., 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).
- Kelcz F., G.E. Santyr, G.O. Cron, "An Algorithm for incorporating breast MRI into clinical practice", AUR Meeting, San Diego 1995 (abstract).
- Santyr G.E., G. Wilson, F. Kelcz, "Breast Tissue Characterization Using a Lorentzian/Gaussian Model of Magnetization Transfer", *Society of Magnetic Resonance*, Nice 1995 (abstract).
- Kelcz F., G.E. Santyr, G.O. Cron, "Incorporation of Washin and Washout Criteria for Improvement of Specificity in Dynamic Gadolinium-enhanced MRI of Breast Lesions", *Society of Magnetic Resonance*, Nice 1995 (abstract).
- Bishop J.E., G.E. Santyr, F. Kelcz, D.B. Plewes, "Accuracy of Keyhole Data Acquisition in Quantitative Analysis of Dynamic Contrast-Enhanced Breast MRI", *Society of Magnetic Resonance*, Nice 1995 (abstract).

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Recent Research: In NIH funded project we are measuring absorbed dose beam quality dependence correction factors (k_Q) of commonly used cylindrical ionization chambers in high energy photon beams. Using the newly available high precision Monte Carlo electron transport algorithms developed by I. Kawrakow and A. Bielajew, special attention is given to problems in our current understanding of wall correction factors (P_{wall}) for photon dosimetry.

Our second project, to which currently a deal of effort is being devoted, deals with the commissioning of the sealed water calorimeter in high energy photon beams. If successful, the Canadian absorbed dose standard will be based on this system.

Using the recently developed new electron transport algorithms we are studying correction factors to use a cavity ionization chamber as air kerma standard for HDR ^{192}Ir brachytherapy sources.
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.

Publications:

- 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, 1997.

- J.P. Seuntjens, L.Van der Zwan, and C.M. Ma, "Type dependent Correction factors for Cylindrical chambers for In-phantom dosimetry in Medium Energy X-ray Beams," *kV X-Ray Workshop*, Stanford University, 1997.
- C.M. Ma, X.A. Li, and J.P. Seuntjens, "Consistency study on kV dosimetry," *Report at the kV X-Ray Workshop*, Stanford University, 1997.
- H. Palmans, J. Seuntjens, F. Verhaegen, J-M Denis, S. Vynckier and H. Thierens, "Water Calorimetry and Ionisation Chamber Dosimetry in a 85 MeV Clinical Proton Beam," *Med. Phys*. **23**, 643- 650, 1996.
- J. Seuntjens and F. Verhaegen, "Dependence of overall correction factor of a cylindrical ionization chamber on field size and depth in medium energy X-ray beams," *Med. Phys*. **23** 1789 - 1796, 1996.
- C.M. Ma and J.P. Seuntjens, "Correction factors for water-proofing sleeves in kilovoltage x-ray beams," *Med. Phys*. (submitted), 1996.
- H. Palmans, J. Seuntjens, F. Verhaegen, J-M Denis, S. Vynckier and H. Thierens, "A study of Ion Chamber Response Compared with Water Calorimetry in a Clinical 85 MeV Proton Beam", *Radioth. and Oncol*. **37** (Suppl. 1) (Abstract), S44, 1995.
- F. Verhaegen and J. Seuntjens, "Monte Carlo study of electron spectra and backscatter dose in the vicinity of media interfaces for monoenergetic photons of 50 - 1250 keV," *Radiat. Res*. **143**, 334-342, 1995.

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Recent Research:
The National Research Council is preparing to declare a new standard of absorbed dose to water based on measurements using water calorimetry. The energy dependence of G, the yield of ferric ions produced by irradiating Fricke chemical dosimetry solution, is being studied. The relative value of the absorbed dose calibration factor for a variety of commercially produced transfer ionization chambers, called Kq, is also under investigation at several linac energies. Radiation detector development with industrial collaborators is continuing as are experiments in radiation protection using TLDs.

Publications:
- 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.
- C.J. Peters, N.G. Tarr, K.R. Shortt, I. Thomson and G.F. McKay. "A floating gate MOSFET gamma detector". *Can. J. Phys*. 74(suppl.), 685-688, 1996.

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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.

Publications:
- Szanto, J., Gerig, L.H., Malone S., Girard, A, Ragnitz, H.W., El-Hakim S., "A System for Fractionated Stereotactic Radiotherapy", Radiotherapy and Oncology, 40 (Suppl. 1): S186, 1996.
- Li, X.A., Soubra, A., Szanto, J., and Gerig, L.H., "Lateral Electron Equilibrium in Measurements of Head Scatter Factors using Miniphantoms and Brass Caps", Med. Phys. 22(7): 1167-1170, 1995.

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Recent Research:
- Tritium and ^{14}C-related health physics and radiation protection programs
- Metabolism and dosimetry of internally deposited radionuclides
- Development of advanced bioassay techniques for internally deposited radionuclides
- Development of physiologically based metabolic models for dosimetry
- Retrospective dosimetry using the electron spin resonance spectrophotometry
- Biomarkers for the biodosimetry and risk prediction
- Cellular and molecular biological effects of exposure to environmental factors
- Risk of tumorigenesis and carcinogenesis in living systems
- 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:
- A. Trivedi, T. Duong and C.L. Greenstock, "Distribution, biokinetics and dosimetry of tritiated organics". *Radioprotection*, 32, 365-370, 1997.
- 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, D. Galeriu and R.B. Richardson, "Dose contribution from metabolised organically bound tritium after acute tritiated water intakes in human". *Health Physics* (in press)
- A. Trivedi, D.P. Morrison and N.E. Gentner, "Relative biological effectiveness of organically bound tritium". *Health Physics* (in press)
- W. J. Workman, A. Trivedi and R. J. Cornett, Tritium concentrations in indoor air of the home of an occupationally exposed worker. *Health Physics* (in press)
- T. Duong and A. Trivedi, "Evaluation of storage conditions for tritiated thymidine as reference organically bound tritium in urine". *Radioanaly. Nucl. Chem*. (in press)
- Yindong, Xu, C.L. Greenstock, A. Trivedi and R.E.J. Mitchel, "Occupational levls of radiation exposure induce interleukin-2 receptor expression in stimulated human peripheral blood lymphocyte". *Radiat. Environ. Biophys.* 35, 89-93, 1996.
- A. Trivedi, D. Galeriu, R.B. Richardson and E.S. Lamothe, "Dose contribution from organically bound tritium after tritiated water intakes". *Bull. Radiat. Prot*. 19, 1-3, 1996.
- A. Trivedi, R.E.J. Mitchel, Y. Xu and C.L. Greenstock, "Interleukin-2 receptors as biomarkers for occupational levels of radiation exposure and cancer risk prediction". In: *Proceedings of International Cancer Congress,* New Delhi, India (Rao, R.S. *et al*, eds.), Monduzzi Editore, Italy, pp. 2719-2724, 1995.
- A. Trivedi, "Percutaneous absorption of tritiated pump oil in hairless rats". *Health Phys*. 69 (1995) 1-8.
- A. Trivedi and C.L. Greenstock, "Trends in biodosimetry". In: *Biological Concepts in Radiotherapy* (Singh, B.B., Bhattacharjee, D., eds.), Narosa Publishing, New Delhi, India, pp. 62-71, 1995.
- A. Trivedi, R.B. Richardson and D. Galeriu, "Dynamics of tritiated water and organically bound tritium following an acute intake of tritiated water". *Fusion Tech.* 28, 982-987, 1995.

Tony Waker

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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 the study fundamental aspects of radiation quality.

Publications:
- C. R. Hirning and A.J. Waker, "Needs And Performance Requirements For Neutron Monitoring In The Nuclear Power Industry", *Radiat. Prot. Dosim*. 70, No 1-4, 67-72, 1997.
- A.J. Waker, K. Szornel and J. Nunes, "TEPC Performance In The CANDU Workplace", *Radiat. Prot. Dosim.* 70, No 1-4, 197-202, 1997.
- J. C.Nunes, A. J. Waker and A. Arneja, "Neutron Spectrometry and Dosimetry In Specific Locations at Two Candu Power Plants", *Radiat. Prot. Dosim*. 63, No2, 87-104, 1996.
- J.C. Nunes, A.J. Waker and M. Lieskovský, "Neutron Fields Inside Containment of a CANDU-600 PHWR Power Plant", *Health Phys*. 71, No 2, 235-247, 1996.
- K. Szornel and A.J. Waker, "Rem 500 Neutron Monitor Evaluation", *COG-96-262*, RC-1659, 1996.
- V. Moiseenko, A.J. Waker and W.V. Prestwich, "Energy Deposition Patterns From Tritium And Different Energy Photons - A Comparative Study". *COG-96-281-I*, RC-1670, 1996.
- J. C. Nunes and A. J. Waker, "Multisphere Spectrometry and Analysis of TEPC and Remmeter Results Around a Heavy Water Moderated Reactor", *Radiat. Prot. Dosim*., 4, 279-284, 1995.
- R. Khaloo and A.J. Waker, "An Evaluation of Hydrogen As a TEPC Counting Gas in Radiation Protection Microdosimetry", *Radiat. Prot. Dosim*. 58, 3, 1995
- A. Arneja and A. J. Waker, "Wide-Range Neutron Dose Determination with CR-39", *Radiat. Prot. Dosim*. 58, 3, 201-204, 1995.
- A. J. Waker and C. D. Sauer, "Properties of an Air-Flow Ionization Chamber for the Measurement of Beta Contamination", *Radiat. Prot. Dosim*. 61, 1-3, 73-76, 1995.
- P. Kliauga, A. J. Waker and J. Barthe, "Design of Tissue-Equivalent Proportional Counters", *Radiat. Prot. Dosim*. 61, 4, 297-308, 1995.
- A. J. Waker, "Principles of Experimental Microdosimetry", *Radiat. Prot. Dosim*. 61, 4, 297-308, 1995.

Curricula Vitae of New Members

Richard Richardson

EDUCATION

1992	Ph.D., Physics, University of Bristol
1987	Radiation Protection Adviser HPA Certification
1978	M.Sc., Medical Physics, University of Aberdeen
1973	Certificate in Education, University of Southampton
1971	B.Sc., Physics with Astronomy, University of London, UK

PROFESSIONAL EXPERIENCE

1993-Present	Research Scientist, Radiation Biology and Health Physics Branch, AECL Chalk River, Ontario
1992-93	Senior Lecturer, (part-time) College of Health, University of South West of England, Bristol
1991-92	Research Associate, Department of Physics, University of Bristol
1988-90	Senior Grade Physicist, Department of Physics, University of Bristol
1983-88	Senior Grade Physicist, Frenchay Hospital, Bristol
1980-83	Basic Grade Physicist, Frenchay Hospital, Bristol
1979-80	Basic Grade Physicist, Bristol Royal Infirmary, Bristol
1973-77	Secondary School Science Teacher, Ralph Allen School, Bath, UK

PROFESSIONAL AFFILIATIONS

- European Late Effects Project Group - elected "Corresponding Member" of EULEP (1992-present)
- Canadian Radiation Protection Association (1993-present)
- Advisory Committee on Radiological Protection - member of ACRP WG-8 on Regulation of Carbon-14 in Effluents (1993-present)
- Member of AECB Working Group on Internal Dosimetry (1993-present)
- International Energy Agency (IEA) - cooperative Program on Aspects of Fusion Power, Leader: Human Dosimetry (1993-present)
- Health Physics Society Member (1994-present)
- International Atomic Energy Agency (IAEA), Vienna - member Working Group "Symposium on Nuclear Fuel Cycle and Reactor Strategy. Adjusting to New Realities"

CURRENT RESEARCH INTERESTS

- 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.
- Other current interests include the 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".

SAMPLE PUBLICATIONS

- D.J. Gorman, R. Maloney, R.B. Richardson, B. Tracy and D.W. Whillans, “The Management of Carbon-14 in Canadian Nuclear Facilities”, *Advisory Com. on Radiological Prot, ACRP-14, AECB INFO-0569(E)*, 1995.
- R.B. Richardson, “Model of ^{210}Pb and ^{210}Po Placental Transfer to Fetal Bone”, *Radiat. Prot. Dosim*. 54: 139-144, 1994.
- R.B. Richardson,“Transfer of Radiobismuth to the Fetus in Guinea Pigs”, *Radiol. Prot. Dosim*. 41, 169-172, 1992.
- R.B. Richardson, J.P. Eatough, and D.L. Henshaw, “Dose to Red Bone Marrow from Natural Radon and Thoron Exposure”, *Br. J. Radiol*. 64, 608-624, 1991.

Akhilesh Trivedi (Associate Member)

EDUCATION
1983 Ph.D. (Life Sciences) Jawaharlal Nehru University, New Delhi, India.
1978 M.Sc. (Life Sciences) Jawaharlal Nehru University, New Delhi, India.

RESEARCH AND PROFESSIONAL EXPERIENCE
1987-present Scientist, Radiation Biology and Health Physics Branch, Atomic Energy of Canada Limited, Chalk River Laboratories, Chalk River, Ontario, Canada.
1983-1987 Research Associate, Department of Biochemistry, University of Western Ontario, London, Ontario, Canada.

RESEARCH & DEVELOPMENT INTERESTS
- Tritium and ^{14}C-related health physics and radiation protection programs
- Metabolism and dosimetry of internally deposited radionuclides
- Development of advanced bioassay techniques for internally deposited radionuclides
- Development of physiologically based metabolic models for dosimetry
- Retrospective dosimetry using the electron spin resonance spectrophotometry
- Biomarkers for the biodosimetry and risk prediction
- Cellular and molecular biological effects of exposure to environmental factors
- Risk of tumorigenesis and carcinogenesis in living systems
- Membrane biogenesis and bioenergetics

PROFESSIONAL AFFILIATIONS
Health Physics (Plenary Member) 1989-onward.
Radiation Research Society (Full Member) 1988-onward.
Indian Society for Radiation Biology (Life Member) 1991-onward.
Medical Physics Organized Research Unit (MPORU), Carleton University (Associate member) 1996-onward.
Canadian Radiation Protection Association (Plenary Member) 1989-1993.
North American Hyperthermia Group (Full Member) 1988-1990.

HONOURS AND AWARDS
- District, State and National Merit Scholarships (1967-78).
- Junior, Senior and PostDoc Fellowships of the Council of Scientific and Industrial Research, India (1978-83).
- Atomic Energy of Canada Limited Research Fellowship (1987).
- Young Investigator's Fellowship from the International Radiation Protection Association (IRPA) (1995).

SAMPLE PUBLICATIONS
- A. Trivedi, T. Duong and C.L. Greenstock, "Distribution, biokinetics and dosimetry of tritiated organics". *Radioprotection* 32, 365-370, 1997.
- A. Trivedi, D. Galeriu, R.B. Richardson and E.S. Lamothe, "Dose contribution from organically bound tritium after tritiated water intakes". *Bull. Radiat. Prot*. 19, 1-3, 1996.
- A. Trivedi, R.E.J. Mitchel, Y. Xu and C.L. Greenstock, "Interleukin-2 receptors as biomarkers for occupational levels of radiation exposure and cancer risk prediction". In: *Proceedings of International Cancer Congress*, New Delhi, India (Rao, R.S., *et al*, eds.), Monduzzi Editore, Italy, pp. 2719-2724, 1995.
- A. Trivedi, "Percutaneous absorption of tritiated pump oil in hairless rats". *Health Phys*. 69, 1-8, 1995.
- A. Trivedi and C.L. Greenstock, "Trends in biodosimetry". In: *Biological Concepts in Radiotherapy* (Singh, B.B., Bhattacharjee, D., eds.), Narosa Publishing, New Delhi, India, pp. 62-71, 1995.
- A. Trivedi, R.B. Richardson and D. Galeriu, "Dynamics of tritiated water and organically bound tritium following an acute intake of tritiated water". *Fusion Tech*. 28, 982-987, 1995.

Seminars

MPORU Seminars

One of the main vehicles of the MPORU 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/MPORU.

Following is a list of MPORU seminars held in 1996-97. The second speaker listed is a graduate student.

September 19 at Carleton University

A. Trivedi	AECL	*Tritium intakes and metabolism: dosimetric significance*
G. Cron	Wisconsin	*Dynamic contrast-enhanced MR imaging of the breast*

October 17 at The National Research Council of Canada

R. Richardson	AECL	*Alpha-emitters and leukemia*
S. Boyden	Carleton	*Evidence of induced radioresistance from survival curves*

November 21 at the Ottawa Regional Cancer Centre, Civic Division

R. Clarke	Carleton	*Minimally invasive surgery using focused ultrasound: physics, status and prospects*
M. MacPherson	Carleton	*Measured electron stopping powers for elemental absorbers*

December 12 at the National Museum of Science and Technology

N. Klassen	NRC	*An investigation of GafChromic dosimetry media MD-55*
L. Gates	Carleton	*Using MRI to study water diffusion within human white matter*

January 23 at the Ottawa General Hospital

D. Rogers	NRC	*The TG-51 dosimetry protocol for external beam radiotherapy*
R. Leclair	Carleton	*A semi-analytic model to investigate the potential applications of X-ray scatter imaging*

February 20 at the Radiation Protection Bureau, Health Canada

P. Dvorak	Health Canada	*Using common computer software to evaluate factors affecting contrast and patient dose in medical X-ray imaging*
G. Zhang	Carleton	*Monte Carlo calculated electron beam applicator gap factors*

March 27 at Carleton University

K. Shortt	NRC	*The Canadian primary standard of absorbed dose to water: its history and present status*
D. Sheikh-Bagheri	Carleton	*Improving the efficiency of photon beam simulations of medical linear accelerators using the bremsstrahlung cross section*

May 1 at AECL (Chalk River)

B. Jarosz	Carleton	*Ultrasound applicators for cancer thermal therapy*
G. Niedbala	Carleton	*Continuous and fractionated irradiation of human ovarian carcinoma cells*
T. Waker	AECL	*Radiation damage to DNA - local and wider perspectives*

Carleton University Physics Department Seminars

Carleton University Physics Department runs a regular seminar series 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 physics were held in 1996-97:

June 17 - Dr Hongyue Yu, Stony Brook: *Studies in NQR Spectroscopy*.
September 30, OCIP Seminar - Dr. V. Elaguppillai, AECB: *Chernobyl Nuclear Accident: What Really Happened at Chernobyl on that Fateful Night of April 25, 1986; Health Consequences 10 Years Later*.

October 17 - Dr Paula Gareau, Guelph: *The Use of MRI to Study Toxic Liver Injury*.
November 4 - Dr. Benoit Simard, NRC: *Nuclear Hyperpolarization of Rare Gases: Fundamentals and Applications*
November 13, Graduate Student Fall Seminar Afternoon - David Gobbi, Carleton: *X-Ray Imaging with High-Pressure Gas Microstrip Detectors*
- Kevin Lenton, Carleton: *Free Radical Scavengers and Antioxidants in Radiation Protection*.
November 25 - Dr. Richard Cobbold, Toronto: *Doppler Ultrasound, Some Insights from a Historical Perspective*
December 2 - Dr. Jacques Dubeau, Carleton: *Health Physics Applications of Microstrip Gas Counters*
December 13, OCIP Christmas Symposium - Giles Santyr, Carleton: *The Carleton Magnetic Resonance Facility: Current Progress and Future Direction*
January 27 - Dr. Keith St. Lawrence, Western: *The Measurement of Cerebral Blood Flow using Magnetic Resonance Spectroscopy and the tracer Deuterium Oxide.*
February 3 - APS Seminar: Dr. Janet Sisterson, Harvard: *Proton and Ion Therapy in 1996: The world wide experience*
February 17 - Dr. Bruno Madore, Toronto: *Reduced Data Requirements for Phase-Contrast MR Angiography*
February 19 - Dr. Thomas J. Ruth, UBC/TRIUMF: *From disease prediction to therapy: Positron Emission Tomography in movement disorders.*
May 9 - Dr. Jidong Xu, Stuttgart: *Gas Phase Magnetic Resonance*
May 14, Graduate Student Spring Seminar Afternoon - Mazen Soubra, Carleton: *Linac Head Scatter Factors for Asymmetric Radiation Fields*
- Geoff Zhang, Carleton*: Monte Carlo Calculation of Electron Beam Output Factors*
May 22 - Dr. George Giakos, Akron: *Hybrid Detection Trends in Medical Imaging*

Other Seminars of Interest to the MPORU

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 MPORU. The ones which have been brought to our attention are noted below:
June 12 1996, at Carleton University - Dr Evangelia Micheli-Tzanakou, Rutgers University: *Vision in Machines and Biological Systems*.
June 13 1996, at the Ottawa Civic Hospital - Dr Peter Waight, formerly WHO: *Chernobyl: Confounding Factors in Assessing Health Consequences*.
July 18 1996, at NRC IRS/INMS - Dr Alan Nahum, Royal Marsden Hospital: *Modelling Tumour Control Probability in Radiation Therapy*.
May 29 1997, at Carleton - Mr. Mark Sunderland, BioMedical Industry Group: *Appropriate Technologies in Health Care.*
June 23 1997, at NRC IRS/INMS - Dr George Starkschall, M.D. Anderson Cancer Center: *What is 3-D Radiation Treatment Planning?*

Special Visits to Museum of Science and Technology and AECL Chalk River

A meeting of the MPORU (December 12, '96) was held at the National Museum of Science and Technology, providing an opportunity to view the regular exhibits as well as the special Roentgen Centenary exhibit entitled: *The Inside Story: 100 Years of X Rays*. This exhibit, in Ottawa for a limited engagement, celebrated the 100th anniversary of the discovery of X rays by Roentgen in 1895. It recounts the history of X rays high-lighting the importance of their discovery and their applications, and underlining the contribution of numerous Canadian scientists to the development of X-ray technology. Those who attended the exhibit had a chance to see many rare artifacts from the past and present illustrating the evolution of science and medicine in Canada. Following the exhibit viewing, presentations were made by Norman Klassen and Larry Gates. Special thanks to Randall Brooks, curator, for the kind invitation to attend this special exhibit and use the Museum facilities.

On May 1, 1997, the MPORU membership made a special visit to the AECL labs at Chalk River. Fourteen members and students from the Ottawa area joined several of the members at Chalk River in a day of tours and scientific presentations. Two tours were organized in the morning: one of the reactor facility and the other of the radiobiology laboratories. After lunch, presentations were made by: Gosia Niedbala, Boguslaw Jarosz, and Tony Waker (see seminar section for more details). An informative and enjoyable day was had by all. Special thanks to Tony Waker for local arrangements. Thanks also to the Carleton Physics Department for assistance with transportation costs.

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 MSc typically requires six half-courses in addition to the thesis; the PhD requires four. For the fall 1998 term, the normal MSc course requirement will be 5 half-courses. PhD students who lack any of the relevant courses (or their equivalents) required for the MSc must complete them in their PhD. MSc students may be permitted to take up to two fourth-year half-courses and credit them towards the degree. PhD students can credit only graduate courses.

When a student has covered material in a prior program, such as an MSc 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

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

Specialization in Therapy

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

Specialization in Biophysics

Fall Term	**75.523**	Carleton	Medical Radiation Physics
	75.527	Carleton	Radiobiology[4]
	75.529	Carleton	Medical Physics Practicum
Winter Term	75.524	Carleton	Physics of Medical Imaging
	75.526	Carleton	Medical Radiotherapy Physics
	75.528	Carleton	Radiation Protection
Fall & Winter	**ANA 7301**	Ottawa HSC[2]	Anatomy[4]
(both terms)	**PHS 5210**	Ottawa HSC[2]	Physiology[4]
Fall or Winter	**75.5xx/6xx**	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

75.523 – 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

75.524 – 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: 75.523 or equivalent and 75.423 or equivalent.
Reference: S. Webb, editor, *The Physics of Medical Imaging*, 1988.
Lecturers: G. E. Santyr and P.C. Johns.

75.526 – 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: 75.523 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, J. Seuntjens, K.R. Shortt, I. Kawrakow, and L.H. Gerig.

75.527 – 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: 75.523 or equivalent must have been taken, or be taken concurrently.
Reference: E.J. Hall, *Radiobiology for the Radiologist*, 3rd ed., 1988.
Lecturer: G.P. Raaphorst

75.528 – 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: 75.523 or equivalent.
Reference: Herman Cember, *Introduction to Health Physics*, 3rd ed., 1996.
Lecturer: V. Elaguppillai

75.529 – Medical Physics Practicum (½ course, Fall) This course provides hands-on experience with current clinical medical imaging and cancer therapy equipment, and with biophysics instrumentation. The student is expected to complete a small number of practical experimental projects during the term on topics such as magnetic resonance imaging, computed tomographic scanning, radiotherapy dosimetry, hyperthermia, biophysics, and radiation protection. The projects will be conducted at hospitals, cancer treatment facilities, and NRC laboratories in Ottawa.
Prerequisites: 75.523 or equivalent. Also, as appropriate to the majority of projects undertaken, one of 75.524, 75.526, or 75.527 or other biophysics course, or permission of the Department.
Coordinator: B. J. Jarosz

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.

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.
Precludes additional credit for Physics 75.424
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 A half-course in an area of physics outside of medical physics is required. Appropriate possibilities include nuclear, theoretical, quantum, particle, solid-state and computational physics. Selection is subject to the approval of the Academic Officer.

Bog Jarosz, Academic Officer, MPORU

Students

Medical Physics Programme Graduate Students

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

Ph.D. Students

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Starting date: 9/91, Supervisor: Raaphorst, Specialization: Biophysics
Thesis topic: Biophysics of radiation damage and repair

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737-8476 (voice) 737-8611 (fax) larry@physics.carleton.ca (e-mail)
Starting date: 9/91, Supervisor: Cameron, Specialization: Imaging
Thesis topic: MRI measurement of water diffusion

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

Lenton, Kevin
Radiation Biology and Health Physics Branch, AECL Research
Chalk River Laboratories. Chalk River, Ontario K0J 1J0
(613)584-3311x3523 (voice) (613)584-1713 (fax) lenton@physics.carleton.ca (e-mail)
Starting date: 9/92, Supervisor: Greenstock, Specialization: Biophysics
Thesis topic: Studies of radiosensitivity at cellular level

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993-2197 (voice) 952-9865 (fax) mmacpher@irs.phy.nrc.ca (e-mail)
Starting date: 2/93, Supervisor: Ross, Specialization: Therapy
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
Thesis topic: OMEGA (online Monte Carlo radiotherapy planning)

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Starting date: 9/88, Supervisor: Gerig, Specialization: Therapy (part-time)
Thesis topic: Asymmetric linac fields for radiotherapy

Zhang, Geoffery
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Starting date: 10/93, Supervisor: Rogers, Specialization: Therapy
Thesis topic: OMEGA (online Monte Carlo radiotherapy planning)

M.Sc. Students

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Starting date: 9/95, Supervisor: Raaphorst, Specialization: Biophysics
Thesis topic: Biophysics of radiation damage and repair

Gobbi, David
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520-2600x1854 (voice) 520-4061 (fax) dgobbi@physics.carleton.ca (e-mail)
Starting date: 9/95, Supervisor: Johns/Dixit, Specialization: Imaging
Thesis topic: Gas Microstrip Detector

Hewitt, Tanya
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763-4000x3352 (voice) 761-4041 (fax) thewitt@physics.carleton.ca (e-mail)
Starting date: 9/96, Supervisor: McKee, Specialization: Imaging
Thesis topic: Pinhole SPECT

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737-7700x6942 (voice) 247-3507 (fax) niedbala@physics.carleton.ca (e-mail
Starting date: 9/96, Supervisor: Raaphorst, Specialization: Biophysics
Thesis topic: Biophysics of radiation damage and repair

Graduate Student Thesis Completed in '96-97

Student	Degree	Thesis Title
Brown, Ruth	PhD	"The Prediction of Patient Radiosensitivity using the Clonogenic Assay and Asymmetric Field Inversion Electrophoresis" Thesis Supervisor: Peter Raaphorst. Thesis Examination Date: August 30, 1996.

Undergraduate Honours Physics Project Completed in '96-97

Student	Course	Project Title
Barker, Jennifer	75.497	"Ultrasound thermal therapy with interstitial waveguide applicators: simulations and experiments." Supervisor: Bog Jarosz

Visiting Student in '96-97

Student	Home University	Project Title
Decossas, Sébastien	Université Joseph Fourier Grenoble, France	"Development of an experimental method for collecting biological x-ray diffraction patterns" Supervisor: Paul Johns

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

Kudos

- Ottawa medical physicists play a leading role in the Canadian Organization of Medical Physicists (COMP). At the 1996 conference in Vancouver, Peter Raaphorst was elected Councillor for Professional Affairs. Paul Johns is the 96-98 Chair of COMP, and Lee Gerig is Past-Chair.
- A Carleton PhD Student, Miller MacPherson, placed first in the COMP Young Investigators Symposium at the 1996 conference.

Carleton Biomedical Sciences and Engineering Research Afternoon

On Thursday 24 April 1997, all researchers at Carleton whose work involves health applications were invited to participate in the first Carleton Biomedical Sciences and Engineering Research Afternoon. Approximately 85 faculty, students, administrators, and external collaborators were in attendance. The purpose of the afternoon was to showcase the exciting biomedical research going on at Carleton, and to help the various groups doing health-related research build communication links with each other.

Following introductory remarks by Prof. John ApSimon, VP External and Research, presentations were made in each of: Medical Physics, Neuroscience, Biomedical Engineering, and Biology/Biochemistry. In each area, a brief overview was given of the program, followed by two or three brief research presentations. The sessions were chaired by Prof. Peter Watson, Dean of Science, and Prof. Malcolm Bibby, Dean of Engineering. The speakers were: Paul Johns (Physics), Boguslaw Jarosz (Physics), Jack Kelly (Psychology), Bruce Pappas (Psychology), Donald Russell (Mechanical & Aerospace Engineering), Monique Frize (Systems & Computer Engineering), John Gaydos (Mechanical & Aerospace Engineering), Iain Lambert (Biology), and Ken Storey (Biochemistry). In addition to the oral presentations, a total of 23 posters was shown. A compilation of the poster titles and authors plus the abstracts of the oral presentations was distributed to all attendees.

Since Carleton does not have a medical school or health sciences faculty, there has not been a readily identified focal point for researchers working on health problems to come together and share their work. It is hoped that the Biomedical Sciences and Engineering Research Afternoon will become an annual event.

The Research Afternoon was organized by Jim Cheetham, Paul Johns, and Don Russell. Judging by the turnout on April 24 which was well above expectations, biomedical research at Carleton has a bright future.

Based on this success, the next project will be to enhance the Carleton presence at the annual Ottawa Life Sciences Conference.

MPORU Contribution at IEEE IMTC/97

Ottawa hosted an international meeting of the IEEE Instrumentation and Measurement Society at the Chateau Laurier on May 19-21, 1997. Organizing committee of the conference was made up of researchers from several local research institutions (NRC, Université du Quebec, Carleton University, University of Ottawa, and others). One of the MPORU members, B.J. Jarosz was asked to serve as Arrangement Chairman at the conference. There were over 300 registered participants from five continents. The scientific part of the meeting was in the form of oral and poster presentations of original research.

About 460 papers were submitted and of those 396 were accepted for presentation. Oral presentations were divided into thirty six sessions, with four of the sessions running in parallel during the three days. Each session featured typically five presentations. There were also three poster sessions and a special time was allotted to them.

Three of the sessions, two oral and a poster, were of particular interest to the MPORU community. Those were 'Imaging Systems' organized and chaired by Dr. G. Giakos, University of Akron, OH, USA, 'Medical Instrumentation' organized and chaired by Dr. B.J. Jarosz, and 'Medical Instrumentation - Poster Session'. Of the five invited presentations at the 'Medical Instrumentation', four had involvement of MPORU members and two were presented by members. The talks were (in the sequence of conference presentation, the presenter appears first in the list):

- B. J. Jarosz, Doru Kaytar, "Ultrasonic heating with waveguide interstitial applicator array".
- B.T.A.McKee, M.J.Chamberlain, T.Hewitt, "A new direction in nuclear medicine imaging: pinhole tomography"
- G.O.Cron, G. Santyr, F. Kelcz, "Dynamic contrast-enhanced imaging of the breast with Magnetic Resonance".
- M.S. Dixit, J.C. Armitage, J. Dubeau, D.G. Gobbi, P.C. Johns, D. Karlen, F.G. Oakham, A.J. Waker, "Development of gas microstrip detectors for digital X-ray imaging and radiation dosimetry".

Overall post-conference impression of the attendees as well as the Society Executive was very good; there were many congratulations from very many people. Congratulations to our colleagues who have worked hard that the conference be a success!

MPORU E-mail Bursters

E-mail sent to the following addresses is broadcast to all users on the respective lists by the e-mail burster at Carleton:

E-mail address	**Target recipients**
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mporu_students@physics.carleton.ca	Students in the Carleton Physics medical physics graduate program
mporu_seminars@physics.carleton.ca	All who receive MPORU seminar announcements
mporu_exec@physics.carleton.ca	Members of the MPORU Executive

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[1] Associate Member

[2] University of Wisconsin at Madison student of Giles Santyr now located at Carleton