MPORU NEWSLETTER

Medical Physics Organised Research Unit
Physics Department, Carleton University

Editor: Alex F Bielajew* Number 7, June 1995

Contents

1 The MPORU

In the fall of 1989, an Organized Research Unit (ORU) was formed at Carleton University to encourage communication among those working in medical physics within the Ottawa area and to help coordinate the graduate studies program in medical physics at Carleton. The ORU was named the Medical Physics Organized Research Unit, or MPORU, and eight objectives were defined. They were:

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 of Physics 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 MPORU.
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.

*The editor acknowledges Heather Matchett and Carl Ross for their work on the four previous newsletters and providing the means to make the transition as painless as possible.

Membership in the MPORU is by invitation of the Executive. Members are expected to be involved in teaching, research or the supervision of graduate students. The main method for the exchange of information among MPORU members is via the monthly seminar series, in which both graduate students in medical physics and MPORU members make presentations.

1.1 MPORU Executive

The Executive of the MPORU consists of a Director (Ian Cameron), Secretary (Alex Bielajew), Academic Officer (Paul Johns until 94/12/31, Bog Jarosz from 95/01/01), and a graduate student representative (Ruth Brown). Members are elected for two year terms. The Executive meets about once a month and other MPORU members (Bob Clarke, Joanna Cygler (who also coordinates the MPORU seminars), Pavel Dvorak, Barry McKee, Peter Raaphorst (past Director) and Ken Shortt) have attended Executive meetings as observers.

2 A Note from the Director

Another year of successful operation for the MPORU is winding down. The MPORU has grown a lot over the past six years and, as someone suggested to me recently we have probably now reached adolescence and we are fast approaching maturity. The introduction of the Practicum course and the procurement of a new faculty position in the Physics Department at Carleton over the past year are both significant extensions of the graduate programme at Carleton and demonstrate that the programme is continuing to grow. Although we still cannot compare with the big schools such as the Universities of Toronto and McGill we are quickly becoming recognized as one of the better Medical Physics programmes in Canada.

The future of the MPORU and the Ottawa Medical Physics community looks very positive indeed. During the past year we had a very successful seminar series thanks to the efforts of Joanna Cygler, the meeting coordinator, and the various speakers who presented very interesting seminars on a variety of topics. We also had a healthy number of students in the graduate programme. I fully expect these two areas to continue to do well in the future.

In addition to this, however, I foresee a significant number of new MPORU members over the next few years. In addition to increasing our scope and introducing new ideas and energy into the MPORU this should also increase the number of positions we have available for graduate students. There are currently six Medical Physicists that I am aware of that are either coming to Ottawa in the near future or are already here and will soon be in a position to apply for MPORU membership. For example, the Cancer Foundation has recently hired two of our graduates into their residency programme. Congratulations to George Ding and Dave Wilkins. We will also soon have a new Medical Physics professor at Carleton. As you are aware, the Physics Department has recently completed interviewing several candidates for the position. At the time this article was written the final decision as to who would get the position had not yet been made, however, by the time you read this newsletter the candidate will likely have been chosen. Having a third MPORU member on campus should also significantly bolster the graduate programme. Hopefully we won't have to wait too long before a fourth position becomes available!

In addition to the potential new MPORU members mentioned above, Carleton University has also approved funding for a Chair in Medical Physics. Carleton is about to launch a major new fundraising initiative and one of the projects to be supported is a Chair in Medical Physics. This means that the University will attempt to raise funds to support an internationally renowned researcher in Medical Physics to come to Carleton to work for several years. You have been made aware of this before but I thought it was worth reminding you since it should have major ramifications for Medical Physics in Ottawa. Although the official fundraising campaign has not yet been launched, a lot of work is being done behind the scenes.

In the fall of '94 we offered the Practicum Course for the first time with three students participating. Overall the feedback on the course has been quite positive (in spite of a few "growing pains"). I think it was felt generally that the course was very useful and that it is an important course to have in our curriculum. I'd like to thank all of the instructors for volunteering their time and their employers for donating equipment and personnel time. Thanks also to the students for their patience in putting up with our growing pains. A special thanks must also go out to Bog Jarosz for the major role he played in designing, implementing and

coordinating this new course. After some initial discussions by the executive, Bog took the proverbial bull by the horns and made it a reality.

Paul Johns, who held the post of Academic Officer on the MPORU Executive since the MPORU began, stepped down from this position at the end of '94. He has always worked very conscientiously as a member of the executive and has demonstrated a deep concern for the MPORU. Although his input at meetings has been missed, I think it is time that he enjoys a well deserved break. Fortunately, Bog Jarosz, another long time member of the executive, has agreed to take over this important responsibility and is doing a commendable job.

In October of '94 the Ottawa Life Sciences Council hosted a very interesting two day conference which dealt with various aspects of the Life Sciences in the Ottawa area. Participation from the MPORU was outstanding and I'd like to thank all of those who attended, especially those that also presented a poster.

A special thanks should be expressed to you, the members of the MPORU and the students in the Medical Physics programme, since without your support we could not function effectively. I am looking forward to an exciting future for the MPORU. If you have any comments or suggestions regarding what the MPORU has been doing in the recent past or where it should be headed in the future please don't hesitate to contact me or anyone else on the executive. We would love to get your input and we will try our best to incorporate your suggestions into our agenda for the future. I hope we can count on your continuing support!

Ian Cameron, Director of the MPORU

3 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 sources of 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 modeling the physics more accurately—with most of the emphasis on the EGS (Electron Gamma Shower) Monte Carlo code. • Development of geometry modeling techniques for accurate Monte Carlo transport.

Publications:

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- A.F. Bielajew, "EGS4 timing benchmark results: Why Monte Carlo is a viable option for radiotherapy treatment planning," In "Proceedings of the International Conference on Mathematics and Computations, Reactor Physics, and Environmental Analyses" (American Nuclear Society Press, La Grange Park, Illinois, U.S.A.) 831 – 837 (1995).
- A.F. Bielajew, "HOWFAR and HOWNEAR: Geometry Modeling for Monte Carlo Particle Transport," National Research Council of Canada Report PIRS-0341 (1995).
- K.R. Borg and A.F. Bielajew, "QUADPLOT: A programme to plot quadric surfaces," National Research Council of Canada Report PIRS-0491 (1995).

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- J.L. Karr and A.F. Bielajew, "A 1-D cubic spline routine for fitting electron elastic cross sections," National Research Council of Canada Report PIRS-0366 (1993).
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Recent Research: Magnetic Resonance Imaging (MRI) is used to study water diffusion in brain and muscle tissue as well as perfusion of blood in capillary beds. 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). This quantity is strongly dependent on the nature of the cell that the water is in. 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 is possible with the gradient coils provided with a clinical imager. • We have recently also begun studies to determine if diffusion and/or perfusion weighted imaging can be performed in the abdomen where physiological motions due to breathing and peristalsis (i.e. digestion) could overwhelm the minute motions associated with diffusion. Initial attempts at overcoming this problem appear to be quite promising! As a practical application of this we hope to be able to measure the slow perfusion of blood in the placenta as a monitor of intrauterine growth retardation. This may help physicians decide whether or not to induce labour prematurely when a fetus is unusually small.
Funding: NSERC operating grant, $15,000/year.

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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 modeling. Appropriate lens design and the dosimetry of high intensity ultrasound are also being investigated.
Publications:
- M.G. Vaughan, G.R. ter Haar, R.L. Clarke and J.W. Hopewell (1994) "Minimally Invasive Cancer Surgery Using Focused Ultrasound: a Preclinical, Normal Tissue Study," Br. J. Radiol. **67** 267–274.

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Recent Research: The response of human malignant cell lines to ionizing radiation at various dose rates has been studied under oxic and anoxic conditions. • The mechanism of radiation induced cell death has been investigated as a function of dose and oxygen for rat thymocytes. Apoptosis appears to be the main

mechanism of cell death in the range of low to medium doses. For higher radiation doses thymocytes die via necrosis. This study has been carried on in close collaboration with the NRC scientists from Physics and Biology Divisions and the pathologist from the Ottawa Civic Hospital. • Clinical verification of a new dosimetry system based on Dual Bias Dual MOSFET detectors is on-going. Further work is needed to implement such a detector in routine clinical use. A collaboration with Canadian industry is ongoing on this subject. • A project on dosimetry of clinical electron beams is carried on in collaboration with the NRC scientists within the Omega project. New treatment technique with a high-Z mesh surface dose modifier has been implemented. Monte Carlo calculations for realistic clinical beams are used to optimize electron beam modifiers. • High dose-rate brachytherapy is also being evaluated and a clinical program is ongoing.

Publications:

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X-Ray 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.

Non-Ionizing Radiation Research: Interactions of RF fields with human body and possible association between electromagnetic fields and cancer; sound power from noisy machinery and biological effects of aircraft noise; interactions of ultrasound with human body; biological effects of solar radiation.

Facilities: RF anechoic chamber (13 m x 7 m x 6 m), with test equipment and signal generators from 5 Hz to 22 GHz; acoustic anechoic chamber (13 m x 9 m x 8 m) and laboratory, equipped to test and generate acoustic noise (includes aircraft noise simulation) and ultrasound; electro-optics laboratories with 25 W argon laser, 900 mW dye laser, 11 W excimer laser, incoherent light sources, cultured cells UV exposure laboratory, measuring equipment.

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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: The Patient Position Monitoring System is being developed as a tool for the computer-controlled radiation therapy program. The design criteria are that this system will provide an independent means of measuring patient position in real time. Position can be reported in either absolute or relative terms and will provide both rotational in three planes and translational motions updating every five seconds. This is a joint project spearheaded by the ORCC and being done in conjunction with the National Research Council and Siemens Medical Laboratories. • There is a well-defined need for the development and implementation of a stereotactic radiation surgery and radiation therapy program at the ORCC. The principal difference between radiation surgery and radiation therapy is that radiation surgery delivers a very high dose in a single fraction whereas radiation therapy has all the same requirements except the dose must be delivered in a fractionated manner. The program includes the development of special radiation therapy cones to provide a very well-defined, well collimated x-ray beam, patient immobilization devices specifically for the radiation therapy component, localization devices which can be correlated to the patient immobilization devices and treatment planning and dosimetry for the verification of dose distributions. It is hoped that the stereotactic radiation therapy program will be implemented fully by May of 1993, although preliminary patient work has been done as early as November of 1992.

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Recent Research: Studying radiation-induced conformational changes in the human genome using time-resolved and immunofluorescence spectroscopy. Using ESR bio-dosimetry of human samples or tissue-equivalent surrogate materials. Measuring radiation damage to the lymphocyte immunosurveillance system. Fluorescent monoclonal antibody binding to specific cell surface receptors is used to monitor an early-warning response to radiation, cancer proneness, cell signalling and adaptation mechanisms. An immunoassay technique (ELISA) has been set up to measure antioxidant levels in cells, and to explore their role in inducible and constitutive radiation protection mechanisms.
Funding: Candu Owners Group, R&D support, 150K • Accelerator Business Unit, Impela dosimetry grant, 15K • Atomic Energy Control Board, biolog. dosimetry grant, 22K • AECL Research H.O., isotope operation/study grant, 10K
Publications:
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- "Cellular response to stress and risk," Proceedings, 86th Annual Meeting of the American Association for Cancer Research, Toronto, March 1995, (with A. Trivedi and R.E.J. Mitchel).
- "The effects of low doses of gamma radiation on HIV-replication in human peripheral blood mononuclear cells," Proceedings, Second National Conference on Human Retroviruses and Related Infections, Washington, D.C., January 1995, (with Y. Xu, M.V. O'Shaughnessy and B. Conway).
- "From Szechuan to Saskatchewan: A profile of H.E. Johns and the cobalt bomb," in B.C. Lentle, J.E. Aldrich and D.Melanson (eds.) "A New Kind of Ray: The Radiological Sciences in Canada 1895–1995. The Canadian Association of Radiologists, Montreal, 1995.

- "Fluorescence lifetime analysis of DNA intercalated ethidium bromide and quenching by free dye," Biophys. Chem. **46** (1994), (with D.P. Heller).
- "Biological and biophysical techniques to assess radiation exposure: a perspective," Prog. Biophys. Molec. Biol. **61** (1994), (with A. Trivedi).
- "Interleukin-2 receptors as biomarkers for occupational levels of radiation exposure and cancer risk prediction," Proceedings, 16th International Cancer Congress, New Delhi, India, October 1994, (with A. Trivedi, R.E.J. Mitchel and Y. Xu).
- "Is there a common stress modulating system for transient cellular response to radiation," Proceedings, International Symposium on Gene Regulation and Cellular Response to Radiation, Kyoto, Japan, November 1994, (with A. Trivedi and R.E.J. Mitchel).
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- "Use of sugars and hair samples for ESR emergency dosimetry," Appl. Radiat. Isot. **44**(1993), (with A. Trivedi).
- "The use of sugar pellets in ESR dosimetry," Radiat. Prot. Dosim. **46**(1993), (with A. Tchen and A. Trivedi).
- "An investigation of silicone-sucrose pellets: A new development in ESR dosimetry," in G. Keenleyside (ed.) Atomic Energy of Canada Limited. Ottawa: CANDU Owners Group, 1993, (with A. Tchen, I. Bonnot and A. Trivedi).
- "Effect of altered membrane sterol content on yeast cell viability and bioenergetics at elevated temperatures," Proceedings, 16th Specialized Symposium on Yeast, Arnhem, The Netherlands, July 1993 (with A. Trivedi, R.E.J. Mitchel, D.J. Fantin and E.A Tustanoff).

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Recent Research: Therapeutic applications of ultrasound for hyperthermia of deeply localized tumours. Current research concentrates on wide range of animal and phantom tests of the array of original interstitial ultrasonic waveguide hyperthermia applicators. Of paramount importance is understanding of interaction of sonic waves with tissue and mode conversion in tissues, projects that have been currently studied. The array has been intended for therapy of brain tumours, an undertaking started in collaboration with the Ottawa Civic Hospital, Department of Neurosurgery. FEA simulations of ultrasound hyperthermia using the array has been also initiated. Also, laser generated ultrasound for hyperthermia has been of interest.

Publications:

- B.J. Jarosz, Martin Werner (1994) "Effects of Tissue Microstructure on Ultrasonic Heating with Interstitial Applicator", Proceedings, 16'th Annual International Conference of the IEEE Engineering in Medicine and Biology Society, Baltimore MD, USA.
- B.J. Jarosz, Martin Werner (1994) "Role of Microstructure in Ultrasonic Hyperthermia by Interstitial Applicator", CCPM/COMP Ann. Sci. Meet., Toronto, Canada.
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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 the factors controlling the spectral purity and intensity of monoenergetic x-rays produced via secondary fluorescence. • 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 beginning 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, especially mammography. By operating in photon counting mode, these detectors could achieve significantly higher DQE than do screen-film systems.
Funding: NSERC Operating Grant $15,000/y
Publications:

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Recent Research: Involved with work to establish absorbed dose standards based on water calorimetry. One initiative is to extend the work done at 20 MV to 60Co. Another is to compare experimentally determined H2O2 yields in water irradiated in the calorimeter under normal operating conditions to the yields predicted by computer simulation and the temperature rise measured in irradiated water.
Publications:

- J. Cygler, N.V. Klassen, C.K. Ross, T.J. Bichay and G.P. Raaphorst, "The Survival of Aerobic and Anoxic

Human Glioma and Melanoma Cells after Irradiation at Ultrahigh and Clinical Dose Rates," Rad. Res. **140** 79 – 84 (1994).
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- N.V. Klassen, C.K. Ross and K.R. Shortt, "Water calorimetry: Model and experiment," Proc. of NPL Water Calorimetry Workshop (1994).
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Recent Research: Using Monte Carlo techniques to improve our understanding of cavity theory and dosimeter response for radiotherapy dosimetry. • Using the EGS4 Monte Carlo code system to calculate correction factors for Fricke dosimeters and ionization chambers in medium-energy x-ray beams and in high-energy photon and electron beams. • Working on the OMEGA project. This is a collaboration between the NRCC and the University of Wisconsin to develop a Monte Carlo code to calculate dose distributions in a patient irradiated by a high-energy electron beam.

Publications:
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Recent Research: Developing a high-resolution pinhole SPECT camera that will achieve a resolution of about 3 mm over a limited field of view. This will be useful for clinical imaging of wrists, etc., and for research applications in radiopharmaceutical development. • Modeling and measuring the scatter background in SPECT systems to develop and test improved correction methods. This takes advantage of recent experience in developing scatter correction methods for 3D PET imaging.
Publications:

- B.T.A. McKee, L.G. Hiltz and P.J. Harvey (1994) "Signal-to-noise ratios for attenuation correction in PET imaging," IEEE Trans. Med. Imaging, **MI-13**, 711–715.
- B.T.A. McKee and L.G. Hiltz (1994) "Attenuation correction for three-dimensional PET using uncollimated flood-source transmission measurements," Phys. Med. Biol. **39**, 2043–2058.
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Recent Research: Studying the way the environment in the immediate vicinity of the cell surface affects what happens to the cell. Ultrasound is known to increase the transport of messenger ions across the cell membrane. Also, the space environment decreases the immune response of cells in suspension. This may be due to reduced convection, leading to reduced surface interaction. Work is underway to study cell surface binding and transport across membranes in simulated micro gravity. Studies are also planned to determine how ultrasound changes the properties of cell membranes thereby affecting wound healing.

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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 tumor relative to normal cells. A selective killing of tumor over normal cells is necessary to treat tumors successfully in the clinic. In particular, we are emphasizing two types of drugs, DNA topoisomerase poisons and cisplatin. Both of these drugs are already in active use clinically; the DNA topoisomerase poisons in particular, are also in widespread use in cancer chemotherapy.
Funding: Supported as a Career Scientist with the Ontario Cancer Foundation • Co-investigator on NCIC grant for the study of cellular radiosensitivity, three years ($53,000/year).
Publications:
- Ng, C.E., A.M. Bussey and G.P. Raaphorst (1994) Inhibition of potentially lethal and sublethal damage repair by camptothecin and etoposide in human melanoma cell lines. Int. J. Rad. Biol., **66** 49–57. Raaphorst, G.P., A.M. Bussey, D.P. Heller and C.E. Ng (1994) Comparison of thermoradiosensitization in two human melanoma cell lines and one fibroblast cell line by concurrent mild hyperthermia and low dose rate irradiation. Rad. Res., **137** 338–345.
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Recent Research: In vitro studies of the role of repair in the radiation resistance of various human tumour cell lines are underway. Hyperthermia is used to cause radiosensitivity and to inhibit repair. Low dose rate measurements are underway, and they show large increases in survival as the dose rate is lowered. The effects of hyperthermia at low dose rates is being evaluated. These data show a large enhancement of radiation sensitivity, which is primarily caused by the presence of hyperthermia during irradiation, blocking systems which repair radiation damage. The response of human glioma cells to very high dose rates is also being studied. • The effect of radiation resistance is also being evaluated. Cell lines expressing radiation sensitivity as well as radiation resistance are being tested for characteristics of this resistance such as increased repair of radiation damage and methods are being investigated to overcome this resistance such as combinations of hyperthermia drugs combined with radiation. In addition, mechanisms of resistance are also being explored and survival curve models are being developed to predict and assess resistance. • The evaluation of patients' radiation sensitivity before treatment is also being investigated. The determination of genetic variation of radiation response can lead to better prescription of dose to individual patients depending on their relative radiation sensitivity. • Hyperthermia in animal model and in the clinic is also being evaluated. To date we have treated 35 patients and have shown that hyperthermia in combination with radiation can provide benefit in superficial tumours. This clinical trial has been completed. In addition, we are evaluating the effect of hyperthermia on blood flow in pigs. The data show that hyperthermia can effect blood flow in muscles, brain and kidney. These data are being analyzed and will contribute to developing a hyperthermia model which can be used in treatment planning in a prediction of thermal dose. • Magnetic resonance spectroscopy is being used to study 1H and 31P in human ovarian carcinoma and rat glioma cells both in vitro and in

vivo. It is shown that there are differences in the 1H spectra between cells expressing a normal response and a resistant response to chemotherapeutic agents. Results also show that the stress of cancer therapeutic agents causes changes in the high energy phosphorous metabolites within cells. The effects of hyperthermia, radiation and chemical agents are also being studied. • Various aspects of external beam radiotherapy are being studied. This includes the development and implementation of asymmetric arc therapy; the development of a radiosurgery program; the development of a patient position monitor; the evaluation of therapy using asymmetric collimator jaws; the development of dynamic wedges; the development of algorithms for fitting treatment unit data, and the inverse problem is being studied.

Funding: NCIC grant for the study of cellular radiosensitivity, three years - $101,000/year • NCIC grant for the study of cisplatin in combination with low dose rate irradiation, three years - $95,000/year • NIH Grant, Study of hyperthermic and low dose rate irradiation, three years- $128,000/year • Industrial funding for development of patient positioning monitor system, five years $500,000 • ORCC capital and operating fund - $16,000 • $16,000/year MRC graduate fellowship • $16,000/year, NSERC graduate fellowship.

Publications:

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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

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- G.X. Ding and D.W.O. Rogers, "Monte Carlo simulation of NPL linac and calculation of dose distributions and water/air stopping-power ratios," National Research Council of Canada Report PIRS 0399 (1993).
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- C.-M. Ma, D.W.O. Rogers, K.R. Shortt, C.K. Ross, A.E. Nahum and A.F. Bielajew, "Wall correction and absorbed dose conversion factors for Fricke dosimetry: Monte Carlo calculations and measurements," Med. Phys. **20** 283 – 292 (1993).
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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 γ-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:

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- J. Cygler, N.V. Klassen, C.K. Ross, T.J. Bichay and G.P. Raaphorst, "The Survival of Aerobic and Anoxic Human Glioma and Melanoma Cells after Irradiation at Ultrahigh and Clinical Dose Rates," Rad. Res. **140** 79 – 84 (1994).
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Recent Research: Involved with the establishment of a primary standard of absorbed dose to water for high energy x-rays. The approach is to use a water-filled calorimeter whose heat defect can be calculated or measured to calibrate a Fricke chemical dosimeter solution. The calibrated solution is placed in small glass vials to determine the dose at a point. The Canadian dose standard has been compared to those of other countries using transfer ionization chambers. A number of perturbations, such as those caused by vial walls and water proofing sleeves are under investigation. The x-ray energy range is being extended to go from 60Co to 25 MV.
Publications:
- N.V. Klassen, C.K. Ross and K.R. Shortt, "Water calorimetry: Model and experiment," Proc. of NPL Water Calorimetry Workshop (1994).
- G. Mackay, N. Whyte, K. Shortt, I. Thomson, C.K. Steeves and A. Egan, "Performance of a new direct-reading extremity dosimeter," Health Phys. Suppl. S37 (1994).
- C.K. Ross, K.R. Shortt, D.W.O. Rogers and F. Delaunay, "A Test of TPR_{10}^{20} as a Beam Quality Specifier for High-Energy Photon Beams," IAEA–SM–330/10, in Proceedings of Symposium on Measurement Assurance in Dosimetry, (IAEA, Vienna) 309 – 321 (1994).
- D.W.O. Rogers, C.K. Ross, K.R. Shortt, N.V. Klassen and A.F. Bielajew, "Towards a Dosimetry System Based on Absorbed-Dose Standards," IAEA–SM–330/9 in Proc. of Symp. on Meas. Assurance in Dosimetry, (IAEA, Vienna) 565 – 580 (1994).
- C.K. Ross, K.R. Shortt, N.V. Klassen and D.W.O. Rogers, "The development of an absorbed dose to water standard and calibration service at NRC," Phys. Med. Biol. **39a** (abstract) 792 (1994).
- C.K. Ross, N.V. Klassen and K.R. Shortt, "The development of a standard based on water calorimetry for absorbed dose to water," Proc. of NPL Water Calorimetry Workshop (1994).
- A. Wu, A. Maitz, K. Shortt, G. Mackay, I. Thomson, M. Johnson, J. Washick, L. Lunsford and S. Kalnicki, "Performance of a new dosimeter system with MOSFET sensor for radiosurgery applications," Med. Phys. **21**(abs) 968 (1994).
- C.-M. Ma, D.W.O. Rogers, K.R. Shortt, C.K. Ross, A.E. Nahum and A.F. Bielajew, "Wall correction and absorbed dose conversion factors for Fricke dosimetry: Monte Carlo calculations and measurements," Med. Phys. **20** 283 – 292 (1993).
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- K.R. Shortt, "Report of a comparison of dosimetric measurement standards of the NRC and the NIST," CCEMRI(1)/93–29 (1993).

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Recent Research: The application of microdosimetry and neutron spectrometry 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 for neutron monitoring, and the study of air-ions with respect to instrumentation for tritium-in-air monitoring. Molecular microdosimetry and the experimental determination of radiation damage in biomolecules.
Funding: Candu Owners Group
Publications:
- A. Arneja and A.J. Waker (1995) "Wide-range neutron dose determination with CR-39," Rad. Prot. Dosim. **58**, No. 3, 201–204.
- R. Khaloo and A.J. Waker (1995) "An evaluation of hydrogen as a TEPC counting gas in radiation protection microdosimetry," Rad. Prot. Dosim. **58** No. 3.
- A.J. Waker (1994) "Microdosimetric Radiation Field Characterization and Dosimetry in a Heavy Water Moderated Reactor Environment," Rad. Prot. Dosim. **52** No. 1/4 415–418.

- R.A. Surette and A.J. Waker (1994) "Workplace monitoring of swipes and air filters for Fe-55," IEEE Trans. Nucl. Sci. **41** 4.
- A.J. Waker (1994) "Biomolecular Ionics," AECL report COG-94-60.

4 Seminars

4.1 MPORU Seminars

One of the main vehicles of the MPORU for developing and maintaining contacts 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 this year were held at 3:30 p.m. on Thursdays. The seminar location was rotated among the major centres involved in medical physics.

The following is a list of MPORU seminars held in 1994-95. The first speaker listed is a graduate student.

September 22 at Carleton University

Dennis Akyurekli	Carleton	*The effects of hyperthermia on normal porcine tissue blood flow*
Paul Johns	Carleton	*X-ray imaging research at Carleton: CT and monoenergetic radiation*

October 20 at Health Canada

Maria Corsten	Carleton	*Point source non-uniformity correction factor,* $A_{\rm pn}$
V Elaguppillai	AECB	*The dose-response relationship: Is it linear without or with a threshold?*

November 10 at the National Research Council

George Ding	Carleton	e^-*-beam spectra from various accelerators used in radiotherapy*
Carl Ross	NRC	*Improved dosimetry for radiation therapy*

December 15 at the Ottawa Regional Cancer Clinic, Civic Division

Larry Gates	Carleton	*Using MRI to measure diffusion of water in human tissue*
Barry McKee	Civic	*The scatter background in emission imaging*

January 19 at the Ottawa Regional Cancer Clinic, General Division

Bilal Shahine	Carleton	*Hyperthermia in fractionated radiotherapy*
Lee Gerig	ORCC	*Conformal Radiotherapy*

February 16 at the Ottawa Regional Cancer Clinic, Civic Division

Mazen Soubra	ORCC	*Head scatter factor contributors in asymmetric photon beams*
Peter Raaphorst	ORCC	*Is prediction of radiotherapy response mythology or methodology?*

March 23 at the National Research Council

Pierre Laporte	Carleton	*Estimates of aggregate equivalent doses in a clinic*
Tony Waker	AECL	*Towards the measurement of molecular lesion spectra*

April 20 at Carleton University

Cathy MacGillivray	Carleton	*On the use of diffusion-weighting in abdominal MRI*
Alex Bielajew	NRC	*Geometry modelling in Monte Carlo calculations*

4.2 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.html). The following seminars of interest to medical physics were held in 1994-95:

September 26, 1994

Jeff Bamber, Royal Marsden Hospital, Surrey, UK
Ultrasound Image Speckle

October 12, 1994

Jean Barthe, Department of Application and Metrology of Ionizing Radiation, CEA Saclay
Radiation Physics Research at IPSN and DAMRI

November 7, 1994
Dwayne Miller, University of Rochester
Energetics and Dynamics of Deterministic Protein Motion: New Insights into Molecular Cooperativity
December 2, 1994—Fall Graduate Seminar Afternoon
Ruth Brown
Predicting Radiosensitivity of Normal Cells from the Radiation Response of Human Fibroblasts in vitro
Bilal Shihane
Combined Fractionated Irradiation and Hyperthermia Treatment of Brain Tumour Cells
December 5, 1994
Brian Wilson, Ontario Cancer Institute, Toronto
Optical Spectroscopy In-vivo: A Biophysical Perspective
December 19, 1994
OCIP Christmas Symposium—Alex F Bielajew, IRS/NRC
Advances in electron transport theory
January 5, 1995
Peter Munro, University of Western Ontario/London Regional Cancer Centre, London Ontario
Imaging Research at the London Regional Cancer Centre
March 16, 1995
Giles Santyr, University of Wisconsin, Madison
Recent Advances in Magnetic Resonance Imaging of the Breast
April 3, 1995
Charlie Ma, NRC Ottawa
Application of Monte Carlo Techniques in Radiotherapy Dosimetry
April 6, 1995
Jamal Charara, St.Francois d'Assise Hospital/Laval University
Hemodynamics and Endothelial Cell Behaviour
April 10, 1995
Louis Lemieux, National Hospital for Neurology and Neurosurgery, London, UK
Multi-Modality Brain Imaging and Electrophysiological Modeling
May 16, 1994—Winter Graduate Seminar Afternoon
Ria Corsten
Point-Source Non-Uniformity Correction Factors for Use in Exposure Measurements

4.3 Other Seminars of Interest to the MPORU

In addition to the seminars listed in the above Sections there are occasionally 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 8, 1994 at the University of Ottawa (IEEE EMBS)
Micheal Zelin, i-STAT Corporation
Miniaturization of Point-of-Care Medical Devices
November 17, 1994 at the HMCS By-Town Wardroom (IEEE EMBS)
J. R. Cunningham, Consultant, Theratronics Corporation
3-D Treatment Planning: What Is It?
December 8, 1994 at Carleton University (IEEE EMBS)
Peder Pederson, Worcester Polytechnic Institute, Worcester MA
Medical Applications of Ultrasound Doppler Measurements
January 18, 1995 at the National Research Council (Ionizing Radiation Standards)
John Schreiner, Montreal General Hospital, McGill University, Montreal, Quebec
Imaging Dose Distributions with MRI
February 9, 1995 at Health Canada (Health Canada, Radiation Protection Bureau)
Frantisek Spurny, Czech Academy of Science, Prague
Aircrew Exposure to Cosmic Radiation

February 22, 1995 at the National Research Council (Ionizing Radiation Standards)
Dave Rogers, Ionizing Radiation Standards, National Research Council
The Work of the Ionizing Radiation Standards Group
March 9, 1995 at Carleton University (IEEE EMBS)
John ApSimon, Carleton University
The Ottawa Life Science Council

Ionizing Radiation Standards Journal Club

Starting in September and continuing until about June, the IRS group at NRC sponsors a "journal club" presentation by one of the staff or visitors. These occur typically at two week intervals. Staff and visitors usually use this opportunity to talk about their latest work although journal article critiques are encouraged as well. The '95–'96 schedule will be posted to the MPORU mailing list as soon as it is available. The schedule changes quite frequently and anyone wishing to attend the meetings should contact Alex Bielajew for last minute updates. The visitors who made presentations during the '94–'95 season were:

N Takata, Electrotechnical Laboratory, Japan, Oct 7, 1994
Recombination in ionization chambers
Jean Barthe, DAMRI, France, Oct 11, 1994
Radiation Physics Research at IPSN and DAMRI
Jette Borg, RISØ, Denmark, Mar 28, 1995
Spectra and dose measurement for C-14—a low-energy beta-source

5 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. 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 (1/2 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 (1/2 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: H.H. Barrett and W. Swindell, *Radiological Imaging*, 1981.
Lecturers: P.C. Johns, B.T.A. McKee and I.G. Cameron.

75.526—Medical Radiotherapy Physics (1/2 course, Winter) Terminology and related physics concepts. Bragg-Gray, Spencer-Attix cavity theories, Fano's Theorem. Dosimetry protocols, dose distribution calculations. Radiotherapy devices, brachytherapy, 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, D.W.O. Rogers, K.R. Shortt and L.H. Gerig.

75.527—Radiobiology (1/2 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 must be taken concurrently.
Reference: E.J. Hall, *Radiobiology for the Radiologist*, 3rd ed., 1988.
Lecturer: G.P. Raaphorst

75.528—Radiation Protection (1/2 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.
Lecturer: V. Elaguppillai

75.529—Medical Physics Practicum (1/2 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 (1/2 course, extends through Fall + 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 + 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 (1/2 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.

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.

Bog Jarosz, Academic Officer, MPORU

6 Students

6.1 Medical Physics Programme Graduate Students

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

6.1.1 Ph.D. Students

Akyurekli, Dennis
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501 Smyth Road, Ottawa K1H 8L6
737-6743 (voice) 737-6745 (fax) dennis@physics.carleton.ca (e-mail)
Starting date: 1/89, Supervisor: Gerig, Specialization: Therapy/Biophysics, PhD
Thesis topic: Physiology of blood flow during hyperthermia

Brown, Ruth
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Civic Division, 190 Melrose Avenue, Ottawa K1Y 4K7
725-6210 (voice) 725-6320 (fax) ruth@physics.carleton.ca (e-mail)
Starting date: 9/91, Supervisor: Raaphorst, Specialization: Biophysics, PhD
Thesis topic: Biophysics of radiation damage and repair

Ding, George
Ionizing Radiation Standards, Institute for National Measurement Standards
National Research Council of Canada, Ottawa K1A 0R6
993-2197 (voice) 952-9865 (fax) gding@irs.phy.nrc.ca (e-mail)
Starting date: 9/91 (Transferred from U. Manitoba), Supervisor: Rogers
Specialization: Therapy, PhD
Thesis topic: OMEGA (online Monte Carlo radiotherapy planning)

Gates, Larry
MRI Unit, Department of Radiology, Ottawa General Hospital
501 Smyth Road, Ottawa K1H 8L6
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Starting date: 9/91, Supervisor: Cameron, Specialization: Imaging, PhD
Thesis topic: MRI measurement of water diffusion

Leclair, Robert
Physics Department, Carleton University
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788-2600x1854 (voice) 788-4061 (fax) robert@physics.carleton.ca (e-mail)
Starting date: 9/94, Supervisor: Johns, Specialization: Imaging, PhD
Thesis topic: X-ray imaging using scattered radiation

Lenton, Kevin
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584-3311x3523 (voice) 584-1713 (fax) lenton@physics.carleton.ca (e-mail)
Starting date: 9/92, Supervisor: Greenstock, Specialization: Biophysics, PhD
Thesis topic: Studies of radiosensitivity at cellular level

MacPherson, Miller
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Starting date: 2/93, Supervisor: Ross, Specialization: Therapy, PhD
Thesis topic: Measurement of electron stopping powers

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Starting date: 9/89, Supervisor: Saunders, Specialization: Imaging, PhD
Thesis topic: Imaging MR coil design, pulse sequences for ovarian cancer

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Starting date: 9/93, Supervisor: Rogers, Specialization: Therapy, PhD
Thesis topic: OMEGA (online Monte Carlo radiotherapy planning)

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

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Starting date: 9/89, Supervisor: Raaphorst, Specialization: Biophysics/Imaging, PhD
Thesis topic: Biophysics of tumour cellular & tissue response via MRS

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Thesis topic: OMEGA (online Monte Carlo radiotherapy planning)

6.1.2 M.Sc. Students

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Thesis topic: Theory of ion chamber response to brachytherapy sources

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Starting date: 9/92, Supervisor: Jarosz, Specialization: Therapy, MSc
Thesis topic: Ultrasonic interstitial hyperthermia array applicator for brain tumours

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Starting date: 9/93, Supervisor: Szanto/Gerig, Specialization: Therapy, MSc
Thesis topic: Dosimetry for radiotherapy field dynamic wedging

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Starting date: 9/93, Supervisor: Cameron, Specialization: Imaging, MSc
Thesis topic: Diffusion-weighted MRI

Shahine, Bilal — Ottawa Regional Cancer Centre, Department of Medical Physics
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Starting date: 9/93, Supervisor: Raaphorst, Specialization: Biophysics, MSc (part-time)
Thesis topic: Biophysics of radiation damage and repair

6.2 Graduate Student Theses Completed in '94–95

Student's Name	Degree	Thesis Title
George Ding	PhD	"An Investigation of Radiotherapy Beams using Monte Carlo Techniques" Supervisor: Dave Rogers, Thesis Examination Date: 95/05/10
Doru Kaytar	MSc	"Hyperthermia generated with an array of interstitial ultrasound waveguide applicators", Supervisor: Boguslaw Jarosz, Thesis Examination Date: 95/04/28

6.3 Honours Fourth-year Undergraduate Physics Projects Completed in '94–95

Student's Name	Course	Project Title
Vineeti Nigam	75.499	"Validity of temperature detection with a miniature thermistor embodied in an interstitial applicator", Supervisor: Boguslaw Jarosz

7 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 shown:

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: Alex Bielajew
RRS Radiation Research Society: Peter Raaphorst
SMR Society of Magnetic Resonance: Ian Cameron

8 Kudos

- Dennis Akyurekli and Ruth Brown received Travel Awards to the 10^{th} International Congress of Radiation Research in Wurzburg, Germany in August 1995.
- Ruth Brown, Kevin Lenton and Bilal Shahine received Travel Awards to the 43^{rd} Radiation Research Conference in San Jose in April 1995.
- George Ding was awarded third place in the Young Investigators Symposium at the September 1994 Canadian Organization of Medical Physics annual meeting in Toronto for a presentation entitled "Electron beam spectra from different accelerators in radiotherapy" which was co-authored with Dave Rogers and Rock Mackie (University of Madison, Wisconsin).
- Larry Gates received a student stipend to attend the 2^{nd} meeting of the society of Magnetic Resonance in San Francisco, USA in August, 1994.
- Kevin Lenton was awarded the a Candu Owner's Group Scholarship for 1994–95.
- Daryoush Sheikh-Bagheri received the 3^{rd} prize at the 3^{rd} annual Carleton University Faculty of Science student poster competition on March 17, 1995.

- Alex Bielajew and Dave Rogers were awarded the National Research Council's Outstanding Achievement Award in October 1994 for contributions made to Monte Carlo development and its application to dosimetry.
- Joanna Cygler and Janos Szanto became Fellows of the CCPM in 1994.
- Lee Gerig was elected president of Canadian Organization of Medical Physics in 1994 and will assume the post at the annual meeting in Montreal, June 1995.

9 Member and Student Directory

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