

MPORU NEWSLETTER

Medical Physics Organized Research Unit
Physics Department, Carleton University

Editor: Carl Ross

Number 3, June 1991

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1. A Note from the Director

The second year of the Medical Physics Organized Research Unit has been a very successful one indeed. During this year we achieved a growing membership and an ever increasing size of the medical physics community in Ottawa. Such growth brings with it new challenges in organization and responsibility at all levels of the MPORU. During this year the academic activities of the MPORU have been very strong and one of the highest priorities of the MPORU remains to strengthen its component at the university level.

In this regard, at Carleton University the addition of one medical physics position to the Physics Department remains one of the highest priorities and hopefully will be achieved in the following year. The number of vacancies for medical physicists in universities, hospitals, cancer centres and industries indicates the importance of training the future generation of medical physicists to fill this sector of society. The MPORU is strongly committed to fulfilling this goal and in its last two years of operation the graduate student enrolment has always exceeded 10 and larger numbers of graduate students are applying for participation in this program.

Many milestones have been reached during this last year, some of which are noted below:

1. In the fall of 1990, the first Ph.D. student graduated from the program and shortly thereafter, early in the new year, the first M.Sc. student graduated from the program.
2. Several new grants were received by members of the program, amongst which were 2 NIH grants and 2 NCI grants. These grants support research and graduate students.
3. Several graduate students received scholarships from MRC and OGS.
4. The MPORU Advisory Board met and strongly supported the goals of the MPORU and indicated their support for the development of another academic position at Carleton University to balance out the program and provide critical mass.
5. Three members of the MPORU Advisory Board volunteered to support guest speakers to present to the program and increase profile and activity within the MPORU.
6. Another very active year of seminars from members and graduate students was completed.
7. A new course on radiobiology was added to the academic curriculum of the program.
8. Several new members joined the program broadening the scope of research expertise and graduate student supervisorship.

More details of the accomplishments of the MPORU are described in the newsletter. These accomplishments and the rapid growth of the medical physics program in Ottawa give a sense of excitement and challenge. The first challenges have already been met in that the program has borne fruit in graduating the first graduate students. The road ahead seems clear.

The need for medical physics in modern society is a clear road sign that the MPORU is on the right track in emphasizing the training of graduate students in medical physics. This field offers many exciting opportunities to work in various sectors of society for the new graduates. In addition, it stimulates research on a wide variety of topics relating to human health and other areas. Our greatest challenge now is to cement securely the medical physics program within the

university, establishing a firm academic base in which all interested medical physicists from the community research centres, hospitals and industry can participate. I have no doubt that this can be achieved with the overwhelming support for this program at the university as well as in other institutions. As a team the program has moved forward and will continue to do so, leading the way to a future of exciting medical research involving graduate student training and graduation.

I wish to thank all the participants who have worked hard to make the program such a great success and lets continue to do so in the years to come.

Peter Raaphorst
Director, MPORU

2. MPORU Executive and Advisory Board

The executive of the MPORU consists of a Director (Peter Raaphorst), Secretary (David Rogers; Carl Ross replaced Dave as Secretary in December 1990); Academic Officer (Paul Johns) and a graduate student representative (Dennis Heller). Members are elected for two year terms. The executive meets about once a month and has observers from other groups (John Saunders, Gary Kramer and Bog Jarosz). The MPORU seminars were organized by Bog Jarosz.

Members of the Advisory Board are listed below:

Dr. L. Copley
Dean of Science
Carleton University
Colonel By Drive
Ottawa, Ont. K1S 5B6

Dr. W.K. Evans
CEO Ottawa Regional Cancer Center
and VP, OCFRF
190 Melrose Avenue
Ottawa, Ont. K1Y 4K7

Dr. B. Hird, Director OCIP
Physics Department, Faculty of Science
University of Ottawa
34 George Glinski Street
Ottawa, Ont. K1N 6N5

Dr. E.G. Letourneau, Director
Bureau of Radiation and Medical Devices
Health and Welfare
775 Brookfield Road
Ottawa, Ont. K1A 1C1

Dr. G. Peter Raaphorst, Head
Medical Physics Department
Ottawa Regional Cancer Centre
190 Melrose Avenue
Ottawa, Ont. K1Y 4K7

Dr. J.F. Seeley
Dean of Medicine
University of Ottawa
Health Sciences Building
451 Smyth Road
Ottawa, Ont. K1H 8M5

Dr. Ian Smith, Director-General
Division of Biological Sciences
National Research Council
Building M-54
Montreal Road
Ottawa, Ont. K1A 0R6

3. Seminar Series

3.1 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 asked to make a presentation.

Seminars take place at 3:30 p.m. on Thursdays. Coffee, juice and delicacies are available in the seminar room prior to the meeting.

The following is a list of MPORU seminars held in 1990-91. With the exception of September 13, the first speaker listed for each day is a graduate student.

Date	Speaker	Title
September 13	MPORU Executive	MPORU State of the Union
	Stephen Bly (Health & Welfare)	The Effects of Non-Linear Propagation on Ultrasonic Heating of the Fetus
October 18	Elias Zakhour (Carleton University)	Determination of Thermal Dose and Blood Perfusion Rate from Clinical Data
	P. Dvorak and G.R. Symonds (Health and Welfare)	Computation of Organ Dose and Computer Simulation of X-Ray Absorption
November 15	Reza Dokht (Carleton University)	Focusing Ultrasound with Zone Lenses
	Ken Shortt (National Research Council)	A Comparison of Absorbed Dose Standards for High Energy X-Rays
December 13	Andrew Weber (Carleton University)	Methods of Measuring Total Renal Blood Flow in Swine
	Clive Greenstock (Atomic Energy of Canada Ltd. Chalk River)	Biophysical Indicators at Low Radiation Doses
January 17	Julia Older (Carleton University)	Analysis of CT Scanner Artifacts
	Carl Ross (National Research Council)	The Near-Earth Ionizing Radiation Fields
February 14	Julia Wallace (Carleton University)	Proton NMR Study of Normal and Osteoporotic Bone Samples
	Ian Smith (National Research Council)	Detection and Characterization of Cancer in Humans by Magnetic Resonance

March 21	Pat Rapley (Carleton University)	An Introduction to Selective Pulse Design for NMR Imaging and Spectroscopy
	Norman Klassen (National Research Council)	The Chemistry of Water Calorimetry
April 18	David Wilkins (Carleton University)	Radiation and Cisplatin Response in the 9L Rat Brain Tumor Model
	Joanna Cygler (Ottawa Regional Cancer Centre)	Effects of Gold and Silver Backing on the Dose Rate around an ^{125}I Seed

3.2 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 room 252 of the Herzberg Building. The following seminars of interest to medical physics were held in 1990-91:

September 20	Ralph Nelson, Stanford Linear Accelerator Centre - "EM Cascade Showers and the EGS4 Computer Code".
October 22	Peter Ottensmeyer, Dept. of Medical Biophysics, University of Toronto - "Electron Energy Loss Microscopy in Biophysics".
November 19	Bruce Faddegon, Carleton University & Institute for National Measurement Standards, NRC - "Bremsstrahlung from 10 to 30 MeV Electrons Incident on Thick Targets".
December 3	Andrew Coward, Northern Telecom - "Pattern Extraction and Brain Modelling".
December 18	OCIP Christmas Symposium - Gary Slater, Dept. of Physics, University of Ottawa - "Reptation and DNA Stories for Christmas".
January 14	Lee Gerig, Ottawa Regional Cancer Centre - "The Spatial Resolution of Type T and K Thermocouple Thermometers for Hyperthermia".
February 21	Rick Murphy, AECL Chalk River - "Computed Tomography Applications at Chalk River".
March 18	Jim Lepock, Dept. of Physics, University of Waterloo - "Protein Unfolding and Relevance to Cellular Damage During Hyperthermia".
March 25	Ian Cameron, Ottawa General Hospital - "Localized In Vivo ^1H Magnetic Resonance Spectroscopy at the Ottawa General Hospital".
April 8	John Stevens, Playfair VI Lab, Toronto - "Volume Investigation - New Tool for the Three Dimensional Analysis, Reconstruction and Display of Two Dimensional Biological Data Sets".

Fall Graduate Student Seminar Day, November 23, 1990

Dennis Heller - "Low Dose Rate Studies In Vitro".

Winter Graduate Student Seminar Day, May 1, 1991

Julia Older - "Correction of CT Beam Hardening"

Reza Dokht - "Focussing Ultrasound With a Zone Lens".

4. Membership Directory of the MPORU

Name	Telephone (Fax)	e-mail	Address
Alex Bielajew	993-2715 (952-9865)	BLIF at NRCVM01	Ionizing Radiation Standards Institute for National Measurement Standards National Research Council Ottawa K1A 0R6
Stephen Bly	954-0308 (954-2486)		Acoustics Unit, Room 66 Health Protection Building Tunney's Pasture Ottawa
Ian Cameron	737-8635 (737-8470)		MRI Unit Department of Radiology Ottawa General Hospital 501 Smyth Road Ottawa K1H 8L6
Robert Clarke	788-4377 (788-4061)		Physics Department Carleton University Colonel By Drive Ottawa K1S 5B6
Joanna Cygler	725-6267 (725-6320)		Ottawa Regional Cancer Centre Department of Medical Physics Civic Division 190 Melrose Avenue Ottawa K1Y 4K7
Pavel Dvorak	954-0319 (952-7767)		X-Ray Section, Room 257A Health Protection Building Tunney's Pasture Ottawa K1A 0L2

Bruce Faddegon	993-2715 (952-9865)		Ionizing Radiation Standards Institute for National Measurement Standards National Research Council Ottawa K1A 0R6
Lee Gerig	737-6736 (737-6745)		Ottawa Regional Cancer Centre General Division 501 Smyth Road Ottawa K1H 8L6
Clive Greenstock	584-3311 Ext. 6053 (584-4024)	05011 at AECLRC	Radiation Biology Branch A.E.C.L. Research Chalk River, Ontario K0J 1J0
Boguslaw Jarosz	788-2600 Ext. 4318 (788-4061)	BOG@ PHYSICS. CARLETON.CA	Physics Department, Room 350A Carleton University Colonel By Drive Ottawa K1S 5B6
Paul Johns	788-2600 Ext. 4317 (788-4061)	JOHNS@ PHYSICS. CARLETON.CA	Physics Department, Room 420 Carleton University Colonel By Drive Ottawa K1S-5B6
Norman Klassen	993-2715 (952-9865)	KLASSEN at NRCVM01	Ionizing Radiation Standards Institute for National Measurement Standards National Research Council Ottawa K1A 0R6
Gary Kramer	954-6668 (957-1089)		Bureau of Radiation and Medical Devices 775 Brookfield Road Ottawa K1A 1C1
Deirdre Morison	957-7910 (954-2468)		Department of National Health & Welfare Room 137, Environmental Health Centre Tunney's Pasture Ottawa K1A 0L2
Alan Mortimer	990-0801		Space Science Division Canadian Space Agency 100 Sussex Drive Ottawa K1A 0R6
Peter Raaphorst	725-6228 (725-6320)		Ottawa Regional Cancer Centre Civic Division 190 Melrose Avenue Ottawa K1Y 4K7

Dave Rogers	993-2715 (952-9865)	IRS @ NRCVM01	Ionizing Radiation Standards Institute for National Measurement Standards National Research Council Ottawa K1A 0R6
Carl Ross	993-9352 (952-9865)		Ionizing Radiation Standards Institute for National Measurement Standards National Research Council Ottawa K1A 0R6
Douglas Salhani	737-7700 (737-6745)		Ottawa Regional Cancer Centre General Division 501 Smyth Road Ottawa K1H 8L6
John Saunders	993-8582 (954-7368)		Institute for Biological Sciences Building M-40 National Research Council Ottawa K1A 0R6
Janos Szanto	737-7700 (737-6745)		Ottawa Regional Cancer Centre General Division 501 Smyth Road Ottawa K1H 8L6
Ken Shortt	993-2715 (952-9865)	IRS @ NRCVM01	Ionizing Radiation Standards Institute for National Measurement Standards National Research Council Ottawa K1A 0R6
Ian Smith	990-0884 (952-0583)		Institute for Biological Sciences Room B161A - M-54 National Research Council Ottawa K1A 0R6

5. Medical Physics Graduate Courses

The Carleton medical physics program has 3 specializations: imaging, therapy, and biophysics. Shown below is a menu of courses for each. Required courses are marked →; the others are recommended.

Depending on the thesis weighting, the MSc typically requires 6 half-courses in addition to the thesis; the PhD requires 4. 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 2 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

<u>Fall Term</u>	→ 75.523 (Carleton) → 75.427 (Carleton)	Medical Radiation Physics Modern Optics (prerequisite to 75.524; additional to degree if PhD)
<u>Winter Term</u>	→ 75.524 (Carleton) 75.526 (Carleton)	Physics of Medical Imaging Medical Radiotherapy Physics
<u>Fall or Winter</u>	One of: 75.591 (Carleton) or ANA 7301 (Ottawa HSC) or PHS 5210 (Ottawa HSC) → 75.5xx/6xx (Carleton or Ottawa) 75.591/691 (Carleton or Ottawa)	Radiobiology Anatomy Physiology Appropriate physics half-course outside of medical physics (permission may be given for 75.4xx if MSc) Directed Studies

SPECIALIZATION IN THERAPY

<u>Fall Term</u>	→ 75.523 (Carleton)	Medical Radiation Physics
<u>Winter Term</u>	75.524 (Carleton) → 75.526 (Carleton)	Physics of Medical Imaging Medical Radiotherapy Physics
<u>Fall or Winter</u>	One of: 75.591 (Carleton) or ANA 7301 (Ottawa HSC) or PHS 5210 (Ottawa HSC) → 75.5xx/6xx (Carleton or Ottawa) 75.591/691 (Carleton or Ottawa)	Radiobiology Anatomy Physiology Appropriate physics half-course outside of medical physics (permission may be given for 75.4xx if MSc) Directed Studies

SPECIALIZATION IN BIOPHYSICS

<u>Fall Term</u>	→ 75.523 (Carleton)	Medical Radiation Physics
<u>Winter Term</u>	75.524 (Carleton) 75.526 (Carleton)	Physics of Medical Imaging Medical Radiotherapy Physics

<u>Fall or Winter</u>	→ One of: 75.591 (Carleton)	Radiobiology
	or ANA 7301 (Ottawa HSC)	Anatomy
	or PHS 5210 (Ottawa HSC)	Physiology
	→ 75.5xx/6xx (Carleton or Ottawa)	Appropriate physics half-course outside of medical physics (permission may be given for 75.4xx if MSc)
	75.591/691 (Carleton or Ottawa)	Directed Studies

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 & 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 75.427 or equivalent.
Reference: H.H. Barrett & W. Swindell, *Radiological Imaging*, 1981.
Lecturers: P.C. Johns, J. Saunders

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, hyperthermia.

Prerequisite: 75.523 or equivalent.
References: F.H. Attix, *Introduction to Radiological Physics and Radiation Dosimetry*, 1986.
H.E. Johns & J.R. Cunningham, *The Physics of Radiology*, 4th ed., 1983.
Lecturers: J. Cygler, D.W.O. Rogers, K.R. Shortt, L.H. Gerig

Radiobiology (1/2 course, Fall)(to be listed in calendar as 75.527 in 1992/93) - Introduction to basic physics and chemistry of radiation interactions, free radicals, oxidation and reduction, G values. Subcellular effects, cellular effects, endpoints, 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

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.

75.427 - Modern Optics (1/2 course, Fall) - Diffraction theory, coherence, Fourier optics, spatial filtering; holography and its applications; laser theory: stimulated emission, cavity optics, modes; gain and bandwidth; design and characteristics of atomic and molecular gas lasers.

[This is a Fourth-Year half-course which covers material prerequisite to the Physics of Medical Imaging graduate course].

Reference: J.W. Goodman, *Introduction to Fourier Optics*, 1968.

Lecturer: M.K. Sundaresan

Appropriate physics 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.

75.591/691 - Directed Studies - Detailed study of a medical physics topic may be offered as Directed Studies. This provides a means of covering topics other than those described above, and in the last 2 years has been a vehicle for introducing new graduate courses.

Note that the intent of the course requirements is to impart a solid grounding in medical physics overall, with detailed subjects in the student's own research area being learned as part of the MSc or PhD project. Therefore, depending on the other courses taken and the thesis project, a Directed Studies course in the area of the student's own research may be deemed to be an additional course beyond those required towards the degree if otherwise the student would be left with too narrow a focus.

Paul Johns
Academic Officer, MPORU

6. Students

6.1 Graduate Students Enrolled in the Medical Physics Program

<u>STUDENT</u>	<u>DATE STARTED*</u>	<u>SUPERVISOR</u>	<u>SPECIALIZATION</u>	<u>THESIS TOPIC</u>
<u>PhD Students</u>				
Wilkins, David	Sept 1986	Raaphorst	Biophysics/ Imaging	MRI and MRS of brain tumors
Heller, Dennis	Sept 1988	Raaphorst	Biophysics	Radiobiology of low dose rate irradiation
Soubra, Mazen	Sept 1988 (P.T.**)	Gerig	Therapy	Combined hyperthermia & brachytherapy

Akyurekli, Dennis	Jan 1989	Gerig	Therapy/ Biophysics	Physiology of blood flow during hyperthermia
Rapley, Patrick	Sept 1989	Saunders	Imaging	MR spectroscopy coil design, pulse sequences
Wallace, Julia	Sept 1989	Raaphorst	Biophysics/ Imaging	Biophysics of tumor cellular & tissue response via MRS

MSc Students

Dokht, Reza	May 1987 (P.T.** to 1989)	Clarke	Imaging	Lens for ultrasound therapy
Weber, Andrew	Sept 1988	Gerig	Therapy	Instrumentation for in vivo measurement of blood flow
Older, Julia	Sept 1989	Johns	Imaging	Algorithms for CT reconstruction with minimal artifacts
Lawrence, Ted	Sept 1990	Johns	Imaging	Fluorescence x ray production for diagnostic radiology

* - date first started taking courses, not the official date of first registration

** - P.T. = Part Time

6.2 Theses and Projects Completed in 1990/91

GRADUATE STUDENT THESES

Bruce Faddegon	PhD	Thesis Title:	Bremsstrahlung of 10 to 30 MeV Electrons Incident on Thick Targets
		Supervisor:	Dave Rogers
		Thesis Examination:	21 September 1990
Elias Zakhour	MSc	Thesis Title:	Thermal Dose and Blood Perfusion Rate from Clinical Data
		Supervisor:	Peter Raaphorst
		Thesis Examination:	11 January 1991

HONOURS FOURTH-YEAR UNDERGRADUATE PHYSICS PROJECTS

Richard Beauregard	75.499	Project Title:	An Extension to the Theory of Dual- Energy Radiology
		Supervisor:	Paul Johns

Tak Wong	75.499	Project Title:	Effects of Inhomogeneity on Focussing Effectiveness of Ultrasound Beams
		Supervisor:	Bog Jarosz
Bertrand Theriault	75.497	Project Title:	Production of a Thyroid Tissue Equivalent Material
		Supervisor:	Gary Kramer

7. Scientific Societies of Relevance to Medical Physics

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

COMP - Canadian Organization of Medical Physicists, Paul Johns, Ken Shortt.

CAP - Canadian Association of Physicists, Dave Rogers, Bob Clarke, Paul Johns.

SMRI - Society for Magnetic Resonance Imaging, John Saunders.

CRPA - Canadian Radiation Protection Association, Gary Kramer, Dave Rogers.

AAPM - American Association of Physicists in Medicine, Dave Rogers, Paul Johns.

HPS - Health Physics Society (US), Dave Rogers.

RRS - Radiation Research Society, Peter Raaphorst.

8. Recent Research by MPORU Members

In order that the Newsletter may serve as an annual report to the Dean of Graduate Studies and Research of Carleton University, a Section has been added this year which 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.

Alex Bielajew

Research: Improving Monte Carlo methods in the therapeutic range (10 keV-50 MeV) by modelling the physics more accurately. Most emphasis is on the EGS (electron gamma shower) Monte Carlo code. Using analytic and Monte Carlo methods to improve the foundations of theoretical dosimetry.

Publications:

Rogers, D.W.O. and Bielajew, A.F. 1990 *Wall attenuation and scatter corrections for ion chambers: measurements versus calculations*, Phys. Med. Biol. **35** 1065-1078.

A.F. Bielajew 1990 *On the technique of extrapolation to obtain wall correction factors for ion chambers irradiated by photon beams*, Med. Phys. **17** 583-587.

A.F. Bielajew, 1990 *Correction factors for thick-walled ionisation chambers in point-source photon beams*, Phys. Med. Biol. **35** 501-516.

A.F. Bielajew, 1990 *An analytic theory of the point-source non-uniformity correction factor for thick-walled ionisation chambers in photon beams*, Phys. Med. Biol. **35** 517-538.

Funding: Supported as a member of NRC staff.

Ian Cameron

Research: Using magnetic resonance imaging (MRI) to measure blood perfusion, and for in vivo magnetic resonance spectrometry (MRS). The perfusion measurements have concentrated on placental blood perfusion as a monitor of intrauterine growth retardation. The work may also lead to techniques for measuring organ perfusion and slow blood flow in arteriovenous malformations.

The MRS studies give hydrogen and phosphorus spectra in volumes as small as 2 x 2 x 2 cm. These spectra give information on the pH, energy metabolism and chemical composition of the tissues being studied. Fluorine spectra have also been obtained and will be used to study fluorinated chemotherapy drugs.

Publications:

I.G. Cameron and J.A. Ripmeester 1991 *¹⁹F Spin-Lattice Relaxation in the Clathrate Hydrates of SF₆ and SeF₆*, Submitted to J. Chem. Phys.

L.J. Schreiner, I.G. Cameron, L. Miljkovic, M.M. Pintar, N. Funduk and D.W. Kydon 1991 *Proton NMR Spin Grouping and Exchange in Dentin*, Biophys. J., **59**.

W.T. Sobol, I.G. Cameron and M.M. Pintar 1991 *A Zeeman Level Crossing Study of the Symmetry of the Potential Hindering the Torsion Oscillator CH₃*, Chem. Phys. **151**.

W.T. Sobol, I.G. Cameron and M.M. Pintar 1990, *Rotating Frame NMR Relaxation in the Dipolar Spin Glass RB_{1-x}(NH₄)_xH₂AsO₄*, J. Magn. Reson. **88** 501-510.

I.G. Cameron, P. Handa and T.H.W. Baker 1990, *Compressive Strength and Creep Behavior of Hydrate Consolidated Sand*, Can. Geotech. J. **27** 255-258.

Funding: Supported as a staff member of the Ottawa General Hospital.

Robert Clarke

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.

Bruce Faddegon

Research: Successfully defended PhD thesis on 10 to 30 MV bremsstrahlung from thick targets. Now working with Alex Bielajew and Dave Rogers on an international collaboration: "The OMEGA Project". This project will realize a long sought goal of applying the Monte Carlo techniques embodied in EGS4 to treatment planning for electron beams in radiation therapy.

Publications:

B.A. Faddegon, C.K. Ross and D.W.O. Rogers 1990 *Angular Distributions of Bremsstrahlung from 15 MeV Electrons Incident on Thick Targets of Be, Al and Pb*, Submitted to Med. Phys.

B.A. Faddegon, C.K. Ross and D.W.O. Rogers 1990 *Forward-Directed Bremsstrahlung of 10-30 MeV Electrons Incident on Thick Targets of Al and Pb*, Med. Phys. 17(5) 773.

B.A. Faddegon (1990) *Pile-up Corrections in Pulsed-Beam Spectroscopy*, Nucl. Instr. Meth. B51, 431.

B.A. Faddegon, Len Van der Zwan, D.W.O. Rogers and C.K. Ross 1991 *Precision Response-Function Estimation, Energy Calibration, and Unfolding of Spectra Measured With a Large NaI Detector*, Nucl. Instr. Meth. A301 138.

Funding: Supported as a member of NRC staff.

Clive Greenstock

Research: Studying conformational changes in the cellular genome as a result of exposure to stress, such as ionizing radiation, chemical carcinogens and chemotherapeutic agents. A fluorescent probe, ethidium bromide, which intercalates into the DNA, is used to measure the changes. The technique can be used for radiosensitivity- and cancer-screening, as well as studying repair-deficient, radiosensitive mammalian cells.

Using electron spin resonance (ESR) spectrometry to study paramagnetic species trapped in irradiated sugars and bio-organic substances. The ESR signals are dose dependent and can be used for dosimetric purposes to quantitate emergency exposures, monitor radioactive contamination and measure accumulated absorbed dose.

Measuring changes or abnormalities in cell membranes using the cell's immunosurveillance system. Fluorescent monoclonal antibodies which bind to specific cell surface receptor antigens are used to detect radiation damage to human blood lymphocytes. A loss of binding due to an absorbed dose as low as 0.01 Gy can be observed.

Publications:

C.L. Greenstock and N.E. Gentner 1990 *A Review of Potential Health Hazards Associated with Occupational Exposure to Beryllium*, Canadian Fusion Fuels Technology Program (CFFTP) Report.

D.P. Heller and C.L. Greenstock 1990 *Fluorescence Lifetime Analysis: A Detailed Review and Optimization of Instrument Operations and Data Analysis*, Atomic Energy of Canada Limited (AECL), Report No. AECL-10127.

Funding:	Canadian Fusion Fuels Technology Program	25K
	Candu Owners Group (ESR dosimetry)	150K
	Natural Sciences & Engineering Research Council (summer student awards)	3K

Boguslaw J. Jarosz

Research: Therapeutic application of ultrasound in hyperthermia of deeply localized tumors. Current research concentrates on improvements to already developed interstitial hyperthermia applicator. A non-invasive hyperthermia system currently studied would enable simultaneous ultrasonic imaging of the treated volume. Another project of substantial potential involves the development of a multi-applicator interstitial hyperthermia system for therapy of brain tumors. The latter involves research of laser generated ultrasound.

Publications:

B.J. Jarosz and R.L. Clarke 1991, *Interstitial Ultrasonic Hyperthermia Applicator*, submitted to Physics in Medicine and Biology.

B.J. Jarosz 1991, *Ultrasonic surface modes generated by laser pulses on duraluminium*, Ultrasonics, 29, 53.

B.J. Jarosz 1990, *Rate of heating in tissue in vitro by interstitial ultrasound*, Proc. 12th Ann. Int. Conf. IEEE Eng. Med. Biol. Soc., Vol. 12, 274.

B.J. Jarosz 1989, *Ultrasonic interstitial heating in phantoms*, Proc. 11th Ann. Int. Conf. IEEE Eng. Med. Biol. Soc., Vol. 11, 1451.

Funding: Supported as a member of Carleton University staff.

Paul Johns

Research: Studying 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.

Analysing the effect of system noise and scattered radiation in dual energy x-ray imaging. The results are being applied to mammography.

Analysing the radiation dose received during the diagnosis and follow up phases of patients receiving percutaneous transluminal coronary angioplasty. Fifteen hundred patients treated at the Ottawa Heart Institute are involved in the study.

Studying the possibility of using CT for planning screw placement and use of bone cement during spinal surgery. CT was used to measure equivalent K_2HPO_4 concentration in bone, and a supralinear relationship was found between bone tensile strength and the K_2HPO_4 concentration.

Publications:

S.G. Gilbert, P.C. Johns, D.C. Chow and R.C. Black, *Relation of Vertebral Bone Screw Axial Pullout Strength to Quantitative CT Trabecular Bone Mineral Content*, submitted for publication.

Funding: NSERC Operating Grant, awarded for three years (April 1989-1992) \$20,000/year.

Norman Klassen

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 ^{60}Co . The other is to examine the radiation chemistry of water in order to resolve anomalies between the experimentally determined H_2O_2 yields, the yields predicted by computer simulation and the temperature use measured in irradiated water.

Participating in a study of cell death by apoptosis in rat thymocytes, initiated by radiation. Particular emphasis will be placed on initial radiation damage. End points being used are cell shrinkage, staining and electron microscopy of membrane separation.

Publications:

N.V. Klassen and C.K. Röss 1991 *Absorbed Dose Calorimetry using Various Aqueous solutions*, Radiat. Phys. Chem., 38, 95-104.

Funding: Supported as a member of NRC staff.

Alan Mortimer

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.

Publications:

A.J. Mortimer and M. Dyson *The Effect of Ultrasound on the Transport of Calcium in 3T3*

Fibroblasts in Vitro, J. Ultrasound in Med.

A.J. Mortimer *The Method for the Measurement of Calcium Transport in Micro gravity using Sounding Rocket*.

Funding: Supported as a member of NRC staff.

Peter Raaphorst, Lee Gerig, Joanna Cygler, Janos Szanto and Douglas Salhani

Research: Studying hyperthermia with a view to using it alone or in combination with other modalities for the treatment of cancer. Twenty patients have been treated with a combination of microwave hyperthermia and radiotherapy and the results indicate that hyperthermia can induce improved response over radiation alone. Various methods are being used to study the role of blood flow in the removal of heat during clinical hyperthermia. A probe is being developed which will incorporate both a hyperthermia applicator and a brachytherapy source. Thermocouple arrays used for measuring temperature distributions induced by hyperthermia are being evaluated. Thermometry data are being used to calculate the thermal dose delivered to tissue, and to analyse how blood flow changes in response to hyperthermia.

In vitro studies of the role of repair in the radiation resistance of various human tumor 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 will also be evaluated. The response of human glioma cells to very high dose rates is being studied.

Magnetic resonance spectroscopy is being used to study ^{31}P in rat glioma cells both in vitro and in vivo. Results 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 will be studied.

A solid state (MOSFET) detector is being evaluated as a clinical dosimeter. Various aspects of external beam radiotherapy are being studied. This includes the evaluation of methods for calculating the dose for irregularly shaped fields; 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; and the development of algorithms for fitting treatment unit data.

Publications

E.I. Azzam, J.A. Vadasz and G.P. Raaphorst 1990, *Thermal sensitivity and radiosensitization in Chinese Hamster V79 cells exposed to 2-aminopurine or 6-thioguanine*. Rad. Res. in press.

J. Cygler, D.W.O. Rogers, M. Soubra and J. Szanto 1990, *Effect of gold backing on the dose rate around Iodine-125 seed*, Med. Phys. 17 172.

S.B. Field and G.P. Raaphorst 1990, *Thermal Dose*, In *An introduction to practical aspects of clinical hyperthermia*. S.B. Field and J.W. Hand eds., London, England: Taylor and Francis, p. 69.

J. Keddy-Grant, S. Garnis-Jones, J. Adam, C. Danjoux, L. Gerig, A. Ginsburg, R. Mitchell and G.P. Raaphorst 1990, *Complications of microwave hyperthermia treatment in psoriasis*, J. American Academy of Derm. 22 651.

D. Ko, G.P. Raaphorst, M.M. Feeley, C.E. Danjoux, J. Maroun and W.K. Evans 1990, *The in vitro effects of lonidamine combined with cisplatin in human small cell lung cancer lines*, Anti Cancer Res. in press.

G.P. Raaphorst, M.M. Feeley, C.E. Danjoux, V. Da Silva and L.H. Gerig 1990, *Hyperthermia enhancement of radiation response and inhibition of recovery from radiation damage in human glioma cells*, Int. J. Hyperthermia in press.

G.P. Raaphorst, M.M. Feeley, L. Martin, C.E. Danjoux, J. Maroun, A.J. de Sanctis and D. Ko 1990, *The enhancement of sensitivity of hyperthermia by lonidamine in human cancer cells*, Int. J. Hyperthermia in press.

G.P. Raaphorst, E.I. Azzam, M.M. Feeley and M.D. Sargent 1990, *Inhibitors of repair of potentially lethal damage and DNA polymerases also influence recovery of potentially neoplastic transforming damage in C3H-10T1/2 cells*, Radiat. Res. 123 49.

G.P. Raaphorst, M.M. Feeley, C.E. Danjoux, L. Martin, J. Maroun and A.J. de Sanctis 1990, *The effect of lonidamine on radiation and thermal responses of human and rodent cell lines*, Int. J. Radiat. Oncol. in press.

G.P. Raaphorst 1990, *Fundamental aspects of Hyperthermic biology*, In *An introduction to practical aspects of clinical hyperthermia*. S.B. Field and J.W. Hand eds., London, England: Taylor and Francis, p. 10.

G.P. Raaphorst, M.M. Feeley, D.P. Heller, C.E. Danjoux, L. Martin, J.A. Maroun and A.J. Sanctis 1990, *Lonidamine can enhance the cytotoxic effect of cisplatin in human tumour cells and rodent cells*, Anti Cancer Res. 10 923.

G.P. Raaphorst and M.M. Feeley 1990, *Comparison of hyperthermia and radiation PLD*, Radiat. Res. 121 107.

G.P. Raaphorst, D. Ko, M.M. Feeley, C.E. Danjoux, J. Maroun and W.K. Evans 1990, *The effect of lonidamine alone and in combination with cisplatin on in vitro growth and viability of lung squamous cell carcinoma cell lines*, Anti Cancer Res. in press.

D. Wilkins, G.P. Raaphorst, I.C.P. Smith, G. Sutherland and J.K. Saunders 1990, *Magnetic resonance imaging of radiation injury in rat brain*, Proc. Soc. Magnetic Res. in Med.

Funding: NCIC grant for the study of cellular radiosensitivity, three years - \$53,000/year.

NCIC grant for the study of hyperthermia on perfusion in animals, three years - \$43,000/year.

NIH Grant, Study of hyperthermic and low dose rate irradiation, three years - \$128,000/year.

ORCC capital and operating fund:

\$16,000/year, MRC graduate fellowship

\$16,000/year, NSERC graduate fellowship

Dave Rogers

Research: Using Monte Carlo techniques 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.

Publications:

D.W.O. Rogers and A.F. Bielajew 1990 *Monte Carlo techniques of electron and photon transport for radiation dosimetry* in 'The Dosimetry of Ionizing Radiation', Vol III, eds. K.R. Kase, B.E. Bjarngard and F.H. Attix, Academic Press 427-539.

J. Cygler, D.W.O. Rogers, M. Soubra and J. Szanto 1990, *Effect of gold backing on the dose rate around Iodine-125 seed*, Med. Phys. **17** 172.

B.A. Faddegon, C.K. Ross and D.W.O. Rogers 1990 *Forward-Directed Bremsstrahlung of 10-30 MeV Electrons Incident on Thick Targets of Al and Pb*, Med. Phys. **17**(5) 773.

B.A. Faddegon, Len Van der Zwan, D.W.O. Rogers and C.K. Ross 1991 *Precision Response-Function Estimation, Energy Calibration, and Unfolding of Spectra Measured With a Large NaI Detector*, Nucl. Instr. Meth. **A301** 138.

Rogers, D.W.O. and Bielajew, A.F. 1990 *Wall attenuation and scatter corrections for ion chambers: measurements versus calculations*, Phys. Med. Biol. **35** 1065-1078.

H. Hirayama, W.R. Nelson and D.W.O. Rogers (1990) *How to Use EGS4 (in Japanese)*, KEK (Japanese National Laboratory for High Energy Physics) Internal Report 89-15, Tokyo.

D.W.O. Rogers 1990, *Monte Carlo Calculation of the Response of Parallel-Plate Chambers in ⁶⁰Co beams*, NRC Report PIRS-0259.

Funding NRC - ongoing operations and capital funds

NSERC - graduate student support of \$12.5 k/year

NIH - \$100k/year (to Ottawa) for three years for the OMEGA project.

Carl Ross

Research: Involved with the project to use water calorimetry to establish absorbed dose standards for high energy photon beams. A comparison of our preliminary 20 MV standard with the PTB (Germany) has been completed. The standards agree to better than 1%, although a number of corrections are still under investigation. Have also participated in the work to measure high energy bremsstrahlung spectra using a large NaI detector.

Publications:

N.V. Klassen and C.K. Ross 1991 *Absorbed Dose Calorimetry using Various Aqueous solutions*, Radiat. Phys. Chem., in press.

B.A. Faddegon, C.K. Ross and D.W.O. Rogers 1990 *Angular Distributions of Bremsstrahlung from 15 MeV Electrons Incident on Thick Targets of Be, Al and Pb*, Submitted to Med. Phys.

B.A. Faddegon, C.K. Ross and D.W.O. Rogers 1990 *Forward-Directed Bremsstrahlung of 10-30 MeV Electrons Incident on Thick Targets of Al and Pb*, Med. Phys. **17**(5) 773.

B.A. Faddegon, Len Van der Zwan, D.W.O. Rogers and C.K. Ross 1991 *Precision Response-Function Estimation, Energy Calibration, and Unfolding of Spectra Measured With a Large NaI Detector*, Nucl. Instr. Meth. **A301** 138.

Funding: Supported as a member of NRC staff.

Ken Shortt

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.

Funding: Supported as a member of NRC staff.

9. CVs of New MPORU Members

This year we welcome four new members into the MPORU: Ian Cameron, Bruce Faddegon, Doug Salhani and Janos Szanto. Highlights from their CVs are given below. The CVs of established members may be found in previous Newsletters.

Ian G. Cameron

Mailing Address: MRI Unit, Department of Radiology
Ottawa General Hospital
501 Smyth Road, Ottawa, Ontario K1H 8L6

(613) 737-8635

Current Position: MRI Physicist at Ottawa General Hospital

Previous Positions:

1989 Division of Biological Sciences, NRC
1986-1989 Division of Chemistry, NRC

Education:

1981-1986 Ph.D., Physics, University of Waterloo, Supervisor: M.M. Pintar
1978-1981 M.Sc., physics, University of Waterloo, Supervisor: M.M. Pintar
1974-1978 B.Sc., physics, and mathematics, University of P.E.I.

Research Interests:

- (1) The measurement of blood perfusion in capillaries, organs (e.g. placenta) and arteriovenous malformations using MRI.
- (2) Technique development for ^1H , ^{13}C , ^{19}F and ^{31}P in vivo Magnetic Resonance Spectroscopy (MRS).
- (3) The use of MRI and MRS in tumor evaluation and treatment assessment.

Sample Publications:

L.J. Schreiner, I.G. Cameron, L.Miljkovic, M.M. Pintar, N. Funduk and D.W. Kydon. *Proton NMR Spin Grouping and Exchange in Dentin*, Biophys. J., Vol. 59 (1991).

W.T. Sobol, I.G. Cameron, W.R. Inch and M.M. Pintar. *Modelling of Proton Spin Relaxation in Muscle Tissue Using Nuclear Magnetic Resonance Spin Grouping and Exchange Analyses*, Biophys. J. 50, 181-191 (1986).

J.A. Ripmeester, C.I. Ratcliffe and I.G. Cameron. *Molecular Motion in Solid p-nitrophenol Inclusion Compounds of Cyclomalto-hexose and -heptose (α - and β -Cyclodextrins): NMR and dielectric studies*, Carbohydrate Res. 192, 69 (1989).

W.T. Sobol, I.G. Cameron and M.M. Pintar. *Rotating Frame NMR Relaxation in the Dipolar Spin Glass $\text{Rb}_{1-x}(\text{NH}_4)_x\text{H}_2\text{AsO}_4$* , J. Magn. Reson. 88, 501-510 (1990).

W.T. Sobol, K.R. Sridharan, I.G. Cameron and M.M. Pintar. *Tunnelling Spectroscopy by Nuclear Magnetic Resonance: Analysis of Tunnelling in Solid Pentamethylbenzene*, Z. Naturforsch 40a, 1075-1084 (1985).

Bruce A. Faddegon

Mailing Address: Institute for National Measurement Standards
National Research Council of Canada
Building M-35, Montreal Road, Ottawa, Ontario K1A 0R6
Telephone 613-992-2197/FAX 613-952-9865

Current Position: Associate Research Officer

Previous Positions:

1987-1988 Consultant of Health Physics, Ontario Hydro
1984-1986 Medical Physicist, Ottawa Regional Cancer Centre
1982-1984 Sessional lecturer and laboratory instructor, University of Victoria
1977-1980 Geophysicist, Amoco Canada Petroleum Company

Education:

1990 Ph.D., Physics, Carleton University
1983 M.Sc., Physics, University of British Columbia
1977 B.Sc., Physics, University of Victoria

Scholarships, Awards and Honours:

July 1989 AAPM Young Investigators Symposium, 2nd prize
1988-1990 Ontario Graduate scholarships for Ph.D. studies
1986-1987 Ontario Cancer Foundation fellowship for Ph.D. studies
1980-1982 NSERC post-graduate scholarship for M.Sc. studies

Sample Publications:

Bruce A. Faddegon, C.K. Ross and D.W.O. Rogers, *Angular Distributions of Bremsstrahlung from 15 MeV Electrons Incident on Thick Targets of Be, Al and Pb*. Med. Phys., in press.

Bruce A. Faddegon, Len van der Zwan, D.W.O. Rogers and C.K. Ross, *Precision Response-Function Estimation, Energy Calibration and Unfolding of Spectra Measured With a Large NaI Detector*, Nucl. Inst. Meth., A301, 138 (1991).

Bruce A. Faddegon, C.K. Ross and D.W.O. Rogers, *Forward-Directed Bremsstrahlung of 10-30 MeV Electrons Incident on Thick Targets of Al and Pb*, Med. Phys. 17(5), 773 (1990).

Bruce A. Faddegon, *Pile-up Corrections in Pulsed-Beam Spectroscopy*, Nucl. Inst. Meth., B51, 431 (1990).

B.A. Faddegon and P.M. Pfalzner, *Computer Aided Design and Verification of Megavoltage Tissue Compensators for Oblique Beams*, Med. Phys. 15(5), 757 (1988).

B. Palcic, B. Faddegon and L.D. Skarsgrad, *The Effect of Misonidazole as a Hypoxic Radiosensitizer at Low Dose*, Rad. Research 100(2) 340 (1984).

B. Palcic, B. Faddegon, B. Jaggi and L.D. Skarsgrad, *The Automated Low Dose Assay System for Survival Measurements of Mammalian Cells In Vitro*, J. of Tissue Culture Methods 8(3) 103 (1988).

Douglas Salhani

Mailing Address: Medical Physicist
Ontario Cancer Treatment & Research Foundation
Ottawa Regional Cancer Centre
501 Smyth Road, Ottawa, Ontario

Education: B.Sc., University of Western Ontario, London, Ontario
M.Sc., University of Western Ontario, London, Ontario
Ph.D., University of Western Ontario, London, Ontario

Recent Publications:

D.S. Salhani, J. Szanto and L.H. Gerig, *Functional Representation of Dosimetric Data Involving Implicit and Explicit Methods*, in preparation.

Recent Presentations:

J. Szanto, L.H. Gerig, A. Girard, D. Salhani, *An Approach to Small Beam Radiotherapy Dosimetry*, 12th Clinical Cancer Research Conference, Geneva Park, Lake Couchiching, April 1990.

A. Kania, J. Szanto, D. Salhani, L.H. Gerig, *Clinical Application of Asymmetric Arcs*, 26th Clinical Conference, Sudbury, November 1990.

Janos Szanto

Mailing Address: Medical Physicist
Ontario Cancer Treatment & Research Foundation
Ottawa Regional Cancer Centre
501 Smyth Road, Ottawa, Ontario

Associate Professor
Department of Radiology
University of Ottawa

Education: M.Sc., Roland Eotvos University, Budapest, Hungary
Ph.D., University of Technology, Budapest, Hungary

Recent Publications:

J. Cygler, D.W.O. Rogers, J. Szanto and M. Soubra, *Effect of Gold and Silver Backings on the Dose Around an ¹²⁵I Seed*, J. Med. Phys., 17(2) 172-178 (1990).

Recent Presentations:

L.H. Gerig, C.E. Danjoux, G.P. Raaphorst and J. Szanto, *Hyperthermia Dosimetry*, World Congress on Medical Physics and Biomedical Engineering, San Antonio, Texas, August 1988.

A. Girard, J. Szanto, L. Avruch, M. Soubra and P. Genest, *A Practical Method of MRI Treatment Planning*, 5th European Conference on Clinical Oncology, London, England, September 1989.

J. Szanto, L.H. Gerig, A. Girard and D. Salhani, *An Approach to Small Beam Radiotherapy Dosimetry*, 12th Clinical Cancer Research Conference, Geneva Park, Lake Couchiching, April 1990.

L.H. Gerig, J. Szanto and G.P. Raaphorst, *The Characteristics of Thermometric Spatial Response Functions*, 12th Clinical Cancer Research Conference, Geneva Park, Lake Couchiching, April 1990.

A. Kania, J. Szanto, D. Salhani, L.H. Gerig, *Clinical Application of Asymmetric Arcs*, 26th Clinical Conference, Sudbury, November 1990.

