COMP CCPM
CANADIAN ORGANIZATION OF MEDICAL PHYSICISTS
ORGANISATION CANADIENNE DES PHYSICIENS MEDICAUX

CANADIAN COLLEGE OF PHYSICISTS IN MEDICINE
LE COLLEGE CANADIEN DES PHYSICIENS EN MEDECINE

# *CANADIAN MEDICAL PHYSICS NEWSLETTER / Le BULLETIN CANADIEN de PHYSIQUE MEDICALE*

*Août / August 1994*

***FROM THE EDITOR:***

Well, my term as editor is ending, so this is the last issue of the Newsletter which will come from this office. At about 37 pages this issue is one of the longest in the last three years, so I seem to be going out with a bang. This is an indication both of the times, when our organizations are dealing with a number of important issues, and of the success of the Newsletter. The scope of material in this issue, with submissions from members of the professional committee, various executive members, the AECB, clinical physicists and more, also shows how people have come to appreciate the strength of the Newsletter for disseminating information to the members of COMP and the CCPM. This has led to an increase in the number of submissions to the Newsletter in the last three years. Whereas at the beginning of my tenure as editor I had to rely on a small number of supporters for the articles making up each issue, submissions now come from the whole membership right across the country.

As I look back at the last three years I am compelled to evaluate the success of the Newsletter. I think a pretty decent job has been done. There were ten issues that went out from this office containing a total of nearly 300 pages. I would venture that this was a new record for the Medical Physics Newsletter. And while there were some welcome light articles to give us a laugh, the main content of each issue really did bring us the Canadian medical physics news.

One measure of my success as editor has been the feedback I have received from COMP and College members with each issue. In 1991 I would get compliments after each issue came out; the gist seemed to be that folk were amazed that an issue had even crossed their desk. Now I get calls from subscribers while issues are still in preparation asking me why the newsletter is late yet again. People now expect each issue and are annoyed when it does not cross their desks on time. I can note here that the delays in recent issues are an indication that it really is time for me to leave as editor so that someone with a bit more time, or with better organizational skills, can take over.

When I try to measure my contribution to the success of the Newsletter I have to recognize that, while I was able set things in motion, it was the contributors who truly improved the product. However, I will take the credit for the one particular development of which I am proud: the publication of the abstracts of graduate medical physics students. In the last three years the Newsletter has published the abstracts of 78 theses completed between 1991 and 1993. These reports truly indicated the strength of medical physics in this country. I hope to maintain a hand in this review even

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## *INFORMATION EXCHANGE*

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## *ACMP ANNUAL MEETING 1994 JACKSON HOLE, WYOMING*

One of the objectives of the Professional Affairs Committee is to establish lines of communication with other medical physics organizations/committees with similar interests. The American College of Medical Physics (ACMP) is the only organization (on this continent at least) whose sole purpose is the professional interests of clinical medical physicists. With a membership of 350 "board certified" physicists, they act to promote and support the profession, publish recommendations for standards, roles, staffing levels, etc. In consideration of these joint interests, the ACMP issued an invitation for COMP representatives to attend their Annual Meeting in Jackson, Wyoming, June 15 to 18. Sherry Connors (Chair-elect) and myself (member PAC), accepted their offer of complementary registration.

Our travel plans included a rental car and some marathon driving through scenic plains, hills, and mountains. Excluding the obligatory stop at the duty-free shop and some cross-border shopping, it is a 15 to 16 hour drive from Calgary and an additional 3 hours from Edmonton.

ACMP Annual Meetings are held in conjunction with a scientific symposium having a separate registration. This year, the symposium was a two-day program titled "Computers for the Radiation Oncology Physicist". Unfortunately, our complementary registration did not extend to this symposium and the US$250 fee ($350 on-site) did not fit into our shoe-string budget.

The pace of the ACMP meeting was decidedly more relaxed than the intensive activity at AAPM or COMP meetings. In order to take advantage of the resort setting, sessions end early, with some free time in the afternoons for recreation and socializing.

I was given the opportunity to address the business meeting. I described the Canadian medical physics organizations, including the differences between COMP and CCPM (there is always confusion here), our membership levels, and the objectives of the two organizations (Did you know that they were printed in the Membership Directory?)

The relevance of the ACMP program to Canadian physicists will vary from year to year. This year, sessions focussed on the impact of U.S. health care reforms, the impact of mammography regulatory requirements, updates on licensure and certification activities, and professionalism and ethics.

Medical physicists in the US are already beginning to feel the impact of health care reforms within their system. With the rush to restructure and economize, jobs are being lost and many physicists are becoming nervous. Decisions are being made by administrators who often do not understand the role of physicists in the delivery of health care. There is a real risk that there will be a downgrading of professionals and that responsibilities will be delegated to people with lesser qualifications, in a cascade. Forces to counteract these pressures will be the existence of government regulations, standards of practice, licensure, certification, and the cooperation and vigilance of professional groups. Apathy existing within the profession must be overcome. The advice given was "control your own destiny or someone else will".

Does this have any implication for Canada? Here in Alberta I see similar things happening. I see nurses being fired en masse from hospitals, being replaced by "personal care assistants", ie. people "off the street" trained to do specific tasks. I see the government limiting the number of physicians, and preparing to allow nurses to deliver much of the primary health care that is now delivered by the general practice physician. The perpetual shortage of experienced radiation oncology medical physicists has already forced efficiencies upon us in many locations. Will administrative edicts result in some unacceptable situations?

The session on mammography standards attempted to clarify the alphabet soup of MQSA, ACR-MAP, HCFA. I won't attempt to do that here, but will just pass on some interesting information: - Every US mammography facility must be certified by October, 1994 -At the present time, qualifications of physicists allowed to do mammography inspections is controlled by the ACR, which recognizes certification by the ABR, but not the ABMP. The physics organizations are attempting to rectify this situation. From a Canadian perspective, should (and could) the CCPM seek status with the appropriate US agency to allow Canadian physicists to do mammography inspections across the border?

Sessions on professionalism were very interesting. Farideh Bagne, a medical physicist who went on to get a degree in law, gave a very provocative talk on how medical physicists should think, dress, and act in order to get ahead in the corporate hospital environment that we work in. Then, a panel discussion considered several ethical dilemmas that a practicing medical physicist could encounter. Some of these were relevant to the Canadian experience, some not.

In 1996, the ACMP meeting will be held in Montreal. Unfortunately, this does not facilitate a joint meeting, since we are in Montreal in 1995, and in Vancouver in 1996. However the ACMP program

organizers were interested in inviting some local physicists to speak at their meeting.
One issue discussed was the need for another employment service to complement the AAPM activities. Deficiencies pointed out were that senior people need a more confidential service, while junior people need some guidance to avoid some very bad employment situations. The ACMP might be taking some steps to address these needs in the future.

In the category of interesting literature picked up: A job description and the 1993 Salary Survey results for U.S. dosimetrists. This is a three page document which I would be pleased to share on request.

Was it worthwhile? Yes, we need to strengthen our own professional situation and we need to maintain contacts with similar professional groups to do so.

Karen Breitman FCCPM
Calgary

## *THE AVAILABILITY AND NEED FOR MULTILEAF COLLIMATORS AND PORTAL IMAGING AT CANADIAN RADIOTHERAPY FACILITIES*

The B.C. Cancer Agency has completed the planning for a new radiotherapy facility in Surrey which is presently under construction and due to open in the Spring of 1995. This Clinic is to be equipped with state of the art equipment and 2 of the dual linear accelerators will have both portal imaging (PI) and multileaf collimators (MLC). Yet another facility is needed and plans are underway for a new radiotherapy clinic in Kelowna, B.C.

Since linear accelerators last for many years, some decisions need to be made about the future of radiotherapy techniques. One of the major questions is whether each accelerator needs the expensive new technology, such as MLC and portal imaging. These items are as yet not in routine clinical use in many centers. Therefore, we decided to conduct a survey of Canadian institutions to determine the perceived need for MLC and portal imaging.

Physicists from 17 Canadian radiotherapy facilities, in addition to our own 3 clinics, responded to the survey (Fig. 1), and the data is shown in Table 1. The number of Cobalt units as well as single energy and dual energy linacs per facility are shown.

Institutions #18, 19 and 20 are the two existing B.C. Clinics and the Surrey Clinic. Including those, there are 6 MLC's existing or being installed, and 16 portal imaging systems. Thirty linear accelerators are on order, of those, 13 will have MLC and 20 portal imaging.

1. *How many Cobalt machines do you have?*
2. *How many single energy accelerators do you have in the department? What energies?*
3. *How many dual energy accelerators do you have in the department? What energies?*
4. *How many of your current accelerators have multileaf collimators?*
5. *How many of your current accelerators have portal imaging?*
6. *If you have any accelerators currently on order, which of the above features do they have?*
7. *If you were to order accelerators in the future which of the above features would you want to include? .. and why?*

Figure 1: The B.C. Cancer Agency survey questions.

As for the perceived need, only 3 from the 20 had no need for MLC. One of those gave a reason that this expensive equipment should be investigated at the larger institutions before being put in use at smaller clinics. In addition, 2 other centers were not sure that the expense of MLC's was justified and prefer to wait and see, but need possibility to retrofit accelerators. Only 1 center was not sure of the need for portal imaging and another wanted its use tested at larger centers first before putting into clinical use at smaller centers.

Based on the survey there is clearly a desire to have both MLC and portal imaging available at least on 1 machine. It should probably be 2 machines, since if one is down one can transfer patients without the need to pour a multitude of blocks. Their potential is recognized as well as the work needed to put this technology into full clinical use.

Some of the comments received were that MLC is needed for the development of conformal therapy and portal imaging is extremely useful for head and neck treatment and pediatric cases. Other comments were that PI should be on every linac, no MLC should be used without PI and MLC eliminates some forms of blocks and leads to increased through put of patients.

One institution has already a policy that all new linacs should have PI. However, both technologies will be labour intensive for physicists to implement. Treatment planning with MLC is not yet fully developed. Eventually there will be a savings in blocks and films when MLC replaces blocks and PI films.

It was also pointed out that a policy must be developed on what to do with the large amount of PI data generated and when to take action on positioning shifts.

| *Institution* | *Co-60* | *Standard Linacs* | *Energy (MV)* | *Special Linacs* | *Energy (MV)* | *MLC* | *PI* | *on order* | *MLC* | *PI* | *need MLC* | *need PI* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *1* | 3 | 4 | 2 x 4<br>1 x 6<br>1 x 10 | 1 | 6/18 | 0 | 0 | 1 | 1 | 1 | √ | √ |
| *2* | 1 | 2 | 4 , 6 | 3 | 2x 6/18<br>1 x 25 | 0 | 1 | 3<br>(3 yrs) | 1 | 2 | √ | √ |
| *3* | 2 | 0 | - | 2 | 6/18 | 0 | 1 | 0 | - | - | √ | √ |
| *4* | 1 | 1 | 4 | 1 | 20 | 0 | 0 | 1 | 0 | 1 | √ | √ |
| *5* | 2 | 2 | 6 | 2 | 25 | 0 | 0 | 6 | 3 | 4 | √ | √ |
| *6* | 1 | 1 | 6 | 2 | 6/15<br>6/23 | 0 | 2 | Co-60 | - | - | ? | √ |
| *7* | 1 | 2 | 4 , 6 | 1 | 6/18 | 0 | 0 | 0 | - | - | √ | √ |
| *8* | 4 | 0 | - | 0 | - | - | - | 1 | 1 | 0 | √ | √ |
| *9* | 1 | 3 | 6 | 3 | 2x 6/18<br>1x 6/15 | 1 | 1 | 0 | - | - | √ | √ |
| *10* | 1 | 1 | 6 , 25 | 0 | - | - | - | 1 | 1 | 1 | √ | √ |
| *11* | 1 | 1 | 4 , 18 | 1 | 6/15 | 0 | 0 | 0 | - | - | - | - |
| *12* | 1 | 0 | - | 1 | 6/20 | 0 | 0 | 1 | 1 | 1 | √ | √ |
| *13* | 1 | 1 | 6 | 1 | 6/23 | 0 | 3 | 0 | - | - | - | √ |
| *14* | 3 | 3 | 6 , 20 | 2 | 6/20 | 0 | 0 | 2 | 2 | 2 | ? | ? |
| *15* | 3 | 3 | 2 x 6<br>1 x 18 | 1 | 6/18 | 0 | 0 | 3 | 0 | 2 | - | √ |
| *16* | 2 | 1 | 6 | 2 | 6/15<br>6/10 | 1 | 1 | 0 | - | 1 | √ | √ |
| *17* | 5 | 4 | 2 x 6<br>18 , 25 | 5 | 6/25<br>4x 6/18 | 1 | 3 | 10 | 3 | 5 | √ | √ |
| *18* | 1 | 3 | 4 | 4 | 3x 6/10<br>25 | 1 | 2 | 1 | 0 | 0 | √ | √ |
| *19* | 1 | 1 | 6 | 1 | 10 | 0 | 0 | 0 | - | - | √ | √ |
| *20* | 1 | 1 | 6 | 2 | 6/18 | 2 | 2 | 0 | - | - | √ | √ |

Table 1: The results of the BCCA survey.

Ellen El-Khatib
B.C.C.A.

## *COMP RECEIVES CALGARY AAPM MEETING REVENUE*

I recently received a cheque for the Canadian share of the revenue from the 1992 AAPM Annual Meeting held in Calgary. It was for US $11,352.92, which was based on 2% of the gross receipts. COMP coffers will therefore be richer by $ 15,900.

According to the original agreement which the Local Arrangements Committee made with COMP, 20% of the profit will be held intrust for the benefit of medical physicists in western Canada. I propose to set up a "board" consisting of one department director from each of the western provinces to recommend appropriate use of this portion of the funds.

Karen Breitman
1992 AAPM Local Arrangements Chairman.

## *INTERLOCK ERROR ON RT250*

At the Cross Cancer Institute we recently discovered a potentially dangerous problem with the filter interlock circuit of our Philips RT250 deep X-ray unit. This problem allowed the beam to be turned on with a filter installed incorrectly. Worse yet is that the beam could be turned on at all energies with this same filter installed in this way. The worst case gave a dose rate double the intended dose rate. Fortunately this was found during QA measurements, and did not affect any patients. This particular unit was installed in 1983, other units may or may not have the same interlock circuitry. A basic description of the problem is as follows:

All the filters used clinically have two pins for interlocking the energy to the appropriate filter. One pin indicates that a filter is installed, the other indicates which energy the filter should be used for. However, there is a special filter for servicing the machine that only has the pin that indicates the filter is installed. With this filter installed the machine can be run at all energies. Our problem appeared when a filter was installed incorrectly, such that only the pin indicating that the filter was installed made contact with its limit switch, the other pin did not make contact. This made the machine believe that the service filter was installed and allowed the beam to be turned on at any energy. Obviously if the filter is not appropriate for the energy selected, the energy spectrum will be different than expected, as will the dose rate for a given mA. This problem could also appear if the filter was installed properly, but the contact on the microswitch that senses the energy is broken. In this case any energy could be used with this filter. In other words the interlocks are designed in such a way that they fail in an unsafe manner. We have now modified the interlock circuit to prevent this from happening in the future. Our solution is to use a switch in the circuit, such that the switch must be closed to use the service filter, and if the switch is open, both pins on the filter must make contact with the appropriate micro-switch.

We would recommend that all RT 250 users test this situation on their machines, and modify the interlocks if the problem occurs. A description of the problem has been submitted to "Medical Devices Alert". If you would like further information (including our modifications)please contact us at the Cross Cancer Institute.

Brad Murray
Medical Physics Dept.
Cross Cancer Institute

## *HDR EMERGENCY CONTAINER*

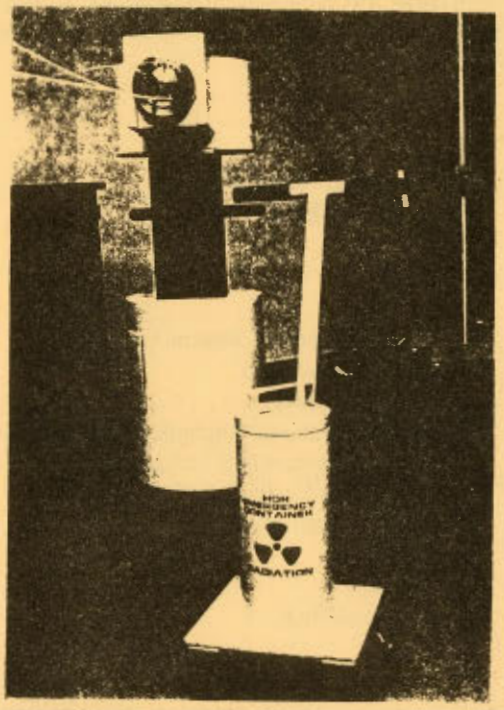
As a safety requirement, an emergency source container must be placed near the HDR remote afterloader for use in the event the 10 Ci Ir-192 source fails to return into the unit's safe. The container must provide adequate shielding against the 10 Ci Ir-192 source and be constructed in such a manner that applicators or catheters can be inserted quickly in an emergency situation. The Nucletron source transport containers are not suitable for this application because of the very small diameter of the bore (0.13 cm).

At the LRCC, we have designed and constructed an appropriate emergency source container with a large opening to allow smooth and quick insertion of catheters and applicators if the source becomes detached from its transfer cable. The container has the following features:

* 3.5 cm lead thickness ( ≈ 4 TVLs of Ir-192)
* 30 cm deep central bore with 7.5 cm diameter
* 85 Kg overall weight
* 4 heavy-duty swivel casters with drive handle

The container requires one week to fabricate in our workshop. For more information you can contact me at the LRCC.

Frank Chisela
LRCC, London ON



## *ROLE AND FUNCTION OF MEDICAL PHYSICISTS IN CANADIAN CANCER THERAPY CENTERS*

## I. INTRODUCTION

Medical Physicists are scientists trained in physics with further studies in radiation physics, radiological sciences, radiobiology, and medical/clinical applications. They are an essential component of the staffing requirements in a Radiation Treatment Program. Acting behind the scenes in many activities, medical physicists are instrumental in ensuring that radiation doses are delivered in an accurate and safe manner. The role of Medical Physicists includes all aspects of radiation dose specification and calibration, treatment planning and preparation, equipment QA and radiation safety. The high technology basis of radiation therapy requires that Medical Physicists play a central role in equipment evaluation and selection, as well as new technology/technique introduction into a radiation treatment program. In addition Medical Physicists play a key role in the education process, such as teaching physics and oncology residents, radiation therapy students and graduate students. This document will define the role and function of a Medical Physicist/program in an academic multimodality cancer therapy program.

## II PRINCIPAL AREAS OF INVOLVEMENT

### A Major

1. Direct Support of Patient Treatment
2. Quality Assurance
3. Radiation Safety
4. Development and Implementation of New Clinical Devices and Techniques
5. Equipment Evaluation, Selection and Commissioning
6. Education
7. Research
8. Administration

### B. Minor

[1]1. Computer Technology and Communications
*2. Imaging Technologies/Techniques related to radiotherapy
3. Liaison with other institutions
4. Facility design (other than radiation protection)
5. Representation on Professional and Regulatory Committees
6. Public Relations

## III. DETAILED DESCRIPTION OF MEDICAL PHYSICIST JOB FUNCTION

Because of the rapidly changing nature of modern technology the role of a Medical Physicist is constantly changing to keep pace with the requirements of the job. The function description will continue to change to meet the challenge of tomorrow. This description only reflects the requirements of today and must be continuously updated.

### A. Areas of Major Involvement

#### 1. Direct Support of Patient Treatment

The Medical Physicist plays a central role in the precise assessment and definition of radiotherapy dose and dose mapping and in technical problem solving in all applications of radiotherapy.

a) Treatment Planning: Supervision of routine treatment planning; Procedures and policies for dose calculations; Specialized treatment planning (eg. complex fields, junctions, new techniques).
b) Consultation with physicians and dosimetrists regarding treatment strategies.
c) Computer generated dose calculations: responsible for understanding the algorithm theory and implementation in order to define the limitations of the dose modeling and to predict situations where accuracies may occur; Responsible for verification of computer generated dose calculations.
d) Treatment measurement: Dosimetric measurement of specialized treatments ie. complex fields, new energies, new treatments, cutouts, boluses, inhomogeneities.

e) Design and development of specialized patient treatment devices, ie. patient immobilization, beam modifying devices and shielding, jigs for shielding, boluses.
f) Brachytherapy: Development of new methods, jigs, and devices to facilitate treatment, dosimetric measurements and calculations; Radiation source processing and calibration.

**2. Quality Assurance**

The Medical Physicist is responsible for the assurance that the prescribed radiotherapy doses are accurately determined and delivered to the prescribed anatomical volumes.

a) Development, administration and evaluation of the technical aspects of the radiation oncology quality assurance program.
b) Absolute dosimetry on all radiotherapy equipment.
c) Measurement and verification of beam characteristics on all radiotherapy equipment.
d) Measurement and verification of all mechanical, laser and light field alignments.
e) Verification of treatment planning systems on an ongoing basis.
f) Optimization of the quality of imaging systems (simulators, other x-ray units, CT units used in radiotherapy)
g) Periodic evaluation of all physics equipment used in support of radiotherapy ie. absolute dosimetry systems, beam scanning dosimetry systems, survey meters, TLD systems.
h) Verification of the accuracy of all elements comprising the chain of transfer of geometrical information from imaging systems to treatment planning systems to treatment machine setup to patient anatomy.
i) Checking of jigs and devices used in radiotherapy, ie. beam modifying devices, patient positioning and immobilization.

**3. Radiation Safety**

The Medical Physicist is responsible for ensuring the radiation safety of staff and patients.

a) Application for and control of all licensing for radiotherapy facilities
b) Supervision of the personnel dosimetry service
c) Monitoring of radiation levels ie. surveys, wipe tests
d) Radiation therapy (radiation protection) facility design, ie. design of bunkers, isotope storage rooms, shielded patient rooms, specialized shields for patient and staff.
e) Teaching radiation safety to all appropriate staff
f) Control of radioactive source inventory including source acquisition and disposal
g) Assessment of radiation incidents and communications regarding these with the appropriate authorities such as the AECB
h) Assurance that all aspects of license compliance are met; Organization of and participation in compliance inspections.

**4. Development and Implementation of New Clinical Devices and Techniques**

The Medical Physicist is responsible for ensuring that techniques used are both valid and state-of-the-art and for research and development of new concepts in medical physics as applied to radiotherapy.

a) Research and development of new techniques and concepts ie. stereotactic radiosurgery, online imaging and verification, new brachytherapy sources.
b) The transfer of new or improved treatment techniques into the radiotherapy program eg. techniques in total body irradiation. This includes development of devices, measurement and QA
c) Introduction of new technologies into the program, including development of policies and procedures. eg. high dose rate brachytherapy, new treatment planning systems, patient treatment verification systems, dynamic therapy.
d) Training of staff in the use of new techniques and technologies

**5. Equipment Evaluation, Selection and Commissioning**

The Medical Physicist is responsible for ensuring that equipment used in the radiation oncology program meets the needs of the program, and that complete and accurate data is measured on the treatment units to enable the prescribed doses to be delivered.

a) Remaining up-to-date on all radiotherapy equipment and technologies
b) Performance specification and comparative assessment of equipment at the time of acquisition or upgrade. Recommendations for the equipment. Technical negotiations with the manufacturers.
c) Decommissioning old equipment
d) Supervision of installation and/or upgrade of equipment
e) Carrying out all acceptance testing of equipment
f) Commissioning equipment for clinical use: This includes the measurement of all relevant parameters and the preparation of tables and other documents required for clinical implementation. It includes searching for unusual or expected behaviors. For treatment equipment it includes the setup of the database in the treatment planning computer algorithm so that computer modeling agrees with the measured values.
g) Participation in training of staff to use equipment.

### 6. Education

Medical Physicists are responsible for teaching Medical Physics and related subjects to students and staff in the health care system.

a) Teaching Radiation Physics and Radiobiology to Medical Residents
b) Teaching and training Medical Physics Residents
c) Teaching of Radiation Therapy Students
d) Teaching university courses
e) Supervision of graduate students
f) Supervision of summer students and undergraduate research courses/projects.
g) Participation in graduate student committees, comprehensive exams and thesis defence
h) Participation in peer review
i) Delivering a Continuing Education program such as seminars and courses to other members of the health care team as well as to other medical physicists
j) Responsibility for a program of personal continuing education to ensure an up-to-date level of expertise and to recognize the evolving nature of the profession

### 7. Research

Research plays an important role in the improvement of cancer control. Medical Physicists have the appropriate educational training to perform research and are extensively involved with research related to cancer control.

a) The supervision and performance of applied and basic research consistent with the mission of the cancer control program
b) Application and competition for peer review research funding
c) Acquisition of industrial research funding
d) Preparation and publication of research funding
e) Participation in review of grant proposals and manuscripts presented for publication
f) Presentation of results at scientific meetings
g) Participating in research seminar series and workshops

### 8. Administration

The Medical Physics Department consists of a multidisciplinary group of professionals who participate in the cancer control program. Good Medical Physics Department administration and participation in Centre administration assure optimum integration and utilization of these resources.

a) Administration in the Department of Medical Physics
b) Participation in Cancer Centre Administration
c) Participation in Corporate Administration where applicable
d) Participation in University Administration where applicable

## B. Areas of Minor Involvement

It should be noted that programs within Cancer Centres can vary extensively and that some of the following may be major activities in some cancer centres.

### 1. Computer Technology and Communication

Computer technology is progressively playing a more central role in cancer control. Medical Physicists have a strong background in computer

training and play important roles in its application to medicine.

a) Keeping up-to-date on latest computer technology and development in software; assisting in selection of systems
b) Performing or assisting in hardware and software installation
c) Developing and modifying algorithms for treatment planning dose calculations
d) Programming for specific requirements
e) Setting communications between computer systems and/or radiotherapy/physics equipment
f) Acting as systems manager for computer systems
g) Training users

### 2. Imaging Technologies/Techniques Related to Radiotherapy

Medical imaging is a key element of the cancer therapy process. Medical Physicists are involved in many aspects of imaging.

a) Assuring that image quality meets standards required. This may be through liaison with host hospital or directly depending on the local arrangements.
b) Participate in bringing in new or improved imaging technologies.
c) Assuring that data communication between imaging technologies and radiotherapy devices is possible and meets program requirements.
d) Maintaining an up-to-date awareness of development and change in imaging technologies.

### 3. Liaison with Other Institutions

The application of physics in medicine requires extensive communication on a multidisciplinary level, which can also involve a wide range of institutions.

a) Liaise with host hospitals regarding imaging technologies used and applied to radiotherapy.
b) Liaise with host hospitals regarding therapy with unencapsulated radioisotopes.
c) Liaise with host hospitals regarding shared and treatment facilities and their licensing.
d) Liaise with universities regarding educational programs.
e) Interact with regulatory agencies, such as AECB, HARP, Health and Welfare regarding regulation and safe practice.

### 4. Facility Design (other than radiation protection)

New facility design requires many considerations such as equipment siting and physical layout, and many other factors that require the participation of a Medical Physicist.

a) Designing Medical Physics Facilities in a Cancer Centre
b) Assisting with design and layout of radiation therapy areas

### 5. Representation on Professional and Regulatory Committees

There are committees at the provincial and federal levels which set policy and procedures for the use and safety of radiative technologies in therapy and there are also international committees which make recommendations in this area. Medical Physicists play an important role in serving on these organizations and committees such as COMP, CCPM, AAPM, AECB, HARP, NCRP, ICRP and ICRU.

### 6. Public Relations

Medical Physicists involvement in the high technology components of cancer therapy provide opportunities to engage in effective public education and public relations. Medical Physicists make presentations to local service clubs, to high schools, and do interviews with the news media.

## IV. SUMMARY

Medical Physicists participate in a wide range of areas within a comprehensive cancer control program. Their expertise assures the quality and safe practice of radiotherapy and allows the continual development and importation of up-to-date technologies consistent with a continuous quality improvement program. In addition, Medical Physicists play a central role in teaching the medical physics and safety aspects of the

radiotherapy technologies used in the practice of radiotherapy and imaging.

Medical Physicists have been responsible for most of the technical advances that have taken place in radiation oncology.

**A statement from the Professional Affairs Committee of the Canadian Organization of Medical Physicists.**

Developed by G.P. Raaphorst and K.E. Breitman. (1994)

***KUDOS***

Congratulations to Dr. David Rogers of the Ionizing Radiation Standards Group of INMS at the NRC who has received the R.S. Landauer Award from the San Francisco Bay area chapters of the AAPM and the Health Physics Society for his distinguished contributions to the field of radiological physics and radiation health protection.

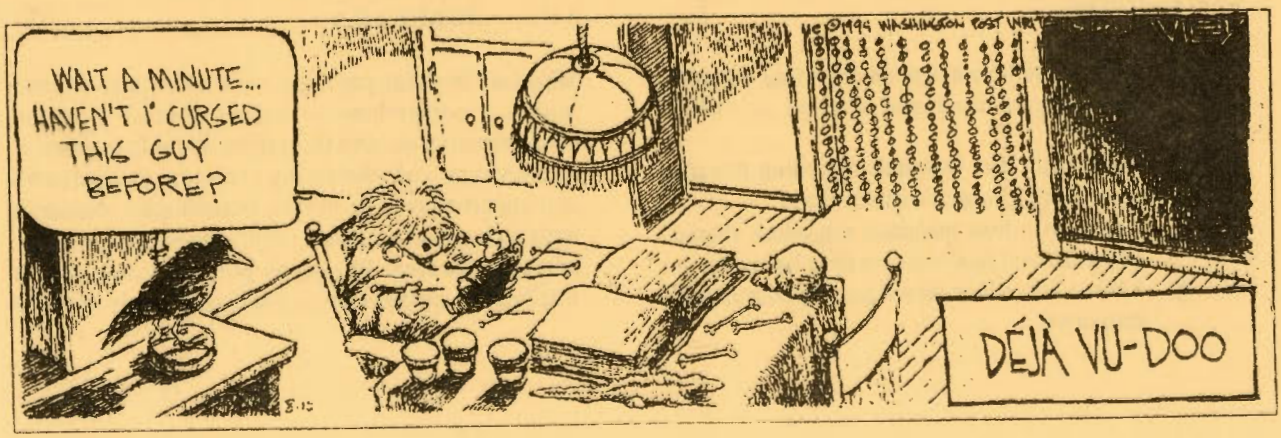
***1996 AAPM Summer School Teletherapy Physics, Present and Future***

Recently at the AAPM Anaheim meeting, the selection of the site for the 1996 AAPM Summer School was awarded to Vancouver, University of British Columbia Campus. Sherry Connors and Matthew Al-Ghazi were successful in securing the bid for the dates June 23 - 27, 1996. The intent is to have the COMP meeting adjacent in time to the summer school, and this will be decided at the Annual General Meeting in Toronto.The AAPM Meeting will be held in Philadelphia 3 weeks later (July 21-25).

Rock Mackie and Jatinder Palta are co-directors for the summer school, which will focus on the newer technologies in Radiotherapy (Multileaf Collimators, Portal Imaging, Dynamic wedge) as well as new developments in Treatment Planning. The course will focus on the implementation (how to) and timing (when).More detailed announcements will be available in MEDICAL PHYSICS.

Although I was unsuccessful in getting a break on the registration fee for Canadians ($550-$650 US) the room and board fees will be reasonable, and travel should be affordable. I am looking forward to a fair proportion of Canadian participation, as there will be Canadian faculty invited and I intend to draw Local Arrangements help from across Canada. (Local Arrangements people have the registration and room and board fees paid by the Summer School). So if you don't mind some hard work, and missing a few lectures, please contact me within the next year.

Sherry Connors



## Newsletter Announcements

**Addresses for Submissions:**
Submissions can be sent to the present editor

**L. John Schreiner**
**Medical Physics Department**
**Montréal General Hospital**
**1650 Avenue Cedar,**
**Montréal, QC.**
**H3G IA4**

**tel: (514) 934-8052**
**fax: (514) 934-8229**

**E-Mail :**
**jschreiner@medphys.mgh.mcgill.ca**

or to the future editor

**Wil van der Putten**
**Department of Medical Physics,**
**Manitoba Cancer Treatment and**
**Research Foundation,**
**100 Olivia Street,**
**Winnipeg, Manitoba**
**R3P 1T4.**

**tel : (204) 787-1256**
**fax : (204) 775-1684**

**E-Mail :**
**wil@mctrf.mb.ca**

**When making Submissions to the Newsletter, please confirm that your submission arrives at our office by phone or FAX.**

**Newsletter Submissions**
**Format for contributions:**

Articles for the Newsletter are best submitted by E-mail or on computer disk. The Newsletter production is on a PC compatible computer so submissions must be on PC compatible disks or on 31/2 inch IBM disks *in text or ASCI* format. MAC submissions can be sent to John Schreiner to be read and forwarded to Wil van der Putten. Please send a hard copy by mail or FAX so that any symbols or special characters can be verified.

Good print quality submissions are also welcome. Newsletter articles should be single column on 8 1/2 by 11 inch paper with suitable margins on all sides. Contributions should be double spaced in a clear font or type (not dot matrix), the font size / pitch should be $\geq 12$ to facilitate scanning and reading with OCR software. Please end your submission with your name and institution. Advertisements should be submitted camera ready for direct reproduction in Newsletter.

**FAX submissions must be supported by original copy and will not be used directly.**

**DEADLINE FOR NEXT ISSUE OF THE COMP NEWSLETTER**

**The next Medical Physics Newsletter will come out in the late fall, early winter. Since the editor's office will most likely be moving during this time submissions should be sent early (mid-October) to help the transition.**

## *AECB AND SAFETY IN RADIATION THERAPY:*

The following article recently appeared in the summer issue of the "AECB Reporter". It requests comments, opinions and information about the need for regulations pertaining to the safety of patients undergoing radiation therapy.

When this article was submitted to the Newsletter, Mr. Irwin stressed that AECB is presently fact-finding. The Boards interest arises because no specific regulation of patient safety in radiation therapy exists in Canada at a time when many other industrialized countries have developed regulations in this area. AECB is also concerned about the number of serious accidents that have befallen radiation therapy patients worldwide over the past decade. The AECB is particularly interested in data and information which would support or refute the premise that further regulation of radiation therapy in Canada is needed. Should regulation be needed, further questions of jurisdiction must be dealt with as well as the scope and level of detail of the legislation.

In submitting this article to the Medical Physics Newsletter, Mr. Irwin is formally requesting responses from medical physicists in Canada. If you have any questions, please contact him at the address given below.

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## *PATIENT SAFETY IN RADIATION THERAPY: AECB REQUESTS INFORMATION AND COMMENTS*

The Atomic Energy Control Board is seeking comments, information, references and recommendations from interested parties on the need for regulations governing the safety of patients in radiation therapy.

Any regulations deemed necessary would pertain to teletherapy with cobalt units, high and low-energy electron accelerators, and manual and remote afterloading brachytherapy. Regulations would address the delivery of radiation therapy, the qualifications of authorized users and radiation safety officers, and machine maintenance, repair and calibration. Also included would be misadministration criteria and the quality assurance activities intended to verify the patient's identity, the target treatment site and the prescribed dose. Radioisotope therapies and diagnostic applications are not being considered at the present time.

The Control Board issues construction approvals and operating licences to Canadian cancer clinics and hospitals for high-energy particle accelerators, and issues radioisotope licences for cobalt teletherapy and brachytherapy treatments. These licences are issued upon the recommendation of Board staff, if the submission complies with the requirements of licensing guides and appropriate international standards.

At present, radiation dose limits contained in the *Atomic Energy Control Regulations*, do not apply to doses of radiation received by patients "in the course of diagnosis or treatment by a qualified medical practitioner". For this reason, only worker and public (no-patient) safety are routinely considered in the AECB's licensing and inspection of these facilities.

In 1985, one patient was injured by a high-energy medical accelerator in Canada. In the United States, two patients were killed by the same type of machine, and in 1990, 14 patients died of overexposures from a linear accelerator in Spain. As a result, several countries have promulgated regulations governing patient safety in radiation therapy.

Board staff recently prepared reports for Board members comparing the regulation of medical accelerators in Canada with other countries, and reviewing quality assurance and patient safety in radiation therapy. Staff learned that beyond the safe design of the machines, the delivery of radiation therapy and quality assurance practices are not subject to regulatory control.

The Control Board is reviewing this issue and may seek to develop a plan of action in cooperation with other federal and provincial bodies. However, more information is required. Any plan or prospective regulations would recognize that radiation therapy is an essential life-saving treatment, and would be based on the views and comments of those potentially affected as well as on an analysis of the risks to patients.

Organizations representing those involved in the planning and delivery of radiation therapy, licenses, and other interested parties are asked to submit their views on the safety of patients in radiation therapy. Information on the criteria for radiation therapy misadministrations, the frequency and severity of accidents in radiation therapy, and the reporting, recording and analysis of such occurrences, is of particular interest to the Control Board.

In addition, many institutions have quality assurance programs in place, but the uniformity and

implementation of such programs vary. Comments on the effectiveness of quality assurance in comparison to regulations, and the impact of regulations are also requested. Written comments should be directed to the address below before September 30, 1994:

Mr. R. Irwin
Radioisotopes and Transportation Division
Atomic Energy Control Board
P.O. Box 1046
Ottawa, Ontario
K1P 5S9

## *CCPM PRESIDENT'S PODIUM*

Brief Notes

1. Some time ago, all Members and Fellows of the CCPM as well as the entire COMP membership should have received the formal registration package for the upcoming CCPM/COMP/CARO Symposium on September 15, 1994 as well as the joint COMP/CCPM Scientific Meeting on September 16-18, 1994 in Toronto. The meeting is a new venture in that we are also meeting with the Royal College of Physicians and Surgeons. Remember that the advance registration deadline is August 19, 1994. After that date the registration fees increase. As I have indicated in previous Newsletters, this should prove to be an interesting meeting from various perspectives. We look forward to your participation in September.

2. At the meeting in Toronto, we will also have an opportunity to hold our Annual General Business Meeting at which time we will be able to give you a status report of all College related activities. Fellowship Exams will again be held in the day or days prior to the Symposium.

3. AECB Requests Information on Patient Safety in Radiation Therapy. As a point of interest for the radiation therapy medical physics community, I have had an informal discussion with Robert Irwin of the AECB and he informs me that the AECB is reviewing the need for regulations governing the safety of patients in radiation therapy. If the scheduling was right, an article with further information might be found in this Canadian Medical Physics Newsletter. For those interested in the type of information the AECB is after, you should consult an article in the most recent AECB Reporter entitled "Patient Safety in Radiation Therapy, AECB requests information and comments". Their deadline for written comments is September 30, 1994. This is an extremely important issue for those of us in radiation therapy departments and, therefore, sound and well thought out advice will be very helpful to the AECB.

4. A much more detailed report will be forthcoming in the next Canadian Medical Physics Newsletter after our Annual Meeting in September.

5. I look forward to seeing you in Toronto in September.

Jake Van Dyk
President, CCPM

## *REPORT OF THE COMP CHAIR*

The past few months have been filled with activity in preparation for the COMP Annual Meeting. Sherry Connors has dealt with the monumental task of assembling the scientific sessions and has organized them into an exciting program. Again, the scientific papers promise to be excellent and cover a wide range of topics in medical physics. For the first time, we will have a Young Investigators' Competition. From the list of titles, I believe that this will be the highlight of the meeting. Also, for the first time, COMP has an Awards Committee. The committee, chaired by Dave Rogers, has already been active and has awarded two Travel Awards for travel to our Annual Meeting in Toronto. The committee will continue to work at the meeting and will be responsible for the Young Investigators' Competition. The other committees have also been active and will report to the membership at our AGM. Clearly, this year's meeting promises to be best ever and I therefore urge everyone to plan to attend. See you in Toronto in September.

Aaron Fenster, Ph.D., F.C.C.P.M.,
Chairman, COMP/OCPM

## *Calendar of Events*

The following schedule of meetings has been gathered from a variety of sources (mainly the Nuc Med mailing list on e-mail). Readers are invited to submit material for inclusion in the calendar.

20-26 August 1994, RIO DE JANEIRO, Brazil
World cong of med phys

13-18 September 1994, TORONTO, ON
COMP/CCPM ann mtg with CARO

23-28 October 1994, SYDNEY, Australia
6th World congress nucl med & biol
Contact: Congress Secretariat, GPO Box 2609, Sydney, NSW 2001, Australia

Nov 14 - 16, 1994
Measurement Seminar at NRC
Contact: David Rogers,
Ionizing Radiation Standards, NRC
e-mail: dave@irs.phy.nrc.ca
fax: 613 952-9865, phone: 613 993-2715

Nov 27-Dec 02, 1994, CHICAGO, IL
Joint mtg AAPM/RSNA
Contact: AAPM Exec Office, 335 East 45th St, NEW YORK, NY 10017

3-7 June 1995, MONTREAL, QC
COMP/CCPM ann mtg

12-15 June 1995, MINNEAPOLIS, MN
42nd Annual SNM
Contact: SNM, 136 Madison Ave, New York, NY 10016-6760

23-27 July , 1995, BOSTON,MA
Joint mtg AAPM/HPS
Contact: AAPM Exec Office, 335 East 45th St, NEW YORK, NY 10017

### *MORE FROM THE EDITOR* (con't from p1)

after my Newsletter editorship ends by becoming a custodian of a data base archiving graduate student work by Canadians. I hope that the community will continue to support me in this venture.

I guess I should also address some of the deficiencies of my tenure as editor for the sake of completeness. The first, of which you are all too aware, was the difficulty in keeping up with deadlines. While, this was not a problem for most of the articles published, it did occasionally present problems for people and centres which were advertising positions or courses that were coming up. I recommend that the next editor be ruthless with deadlines. The wait for promised submissions all too often can turn from one or two days to a week or more. Secondly, while the previous and current secretaries of COMP were invaluable in maintaining the mailing lists of the subscribers to the Newsletter I could have done a better job at getting the Newsletter out to some additional people such as newsletter editors of other medical physics (e.g., the AAPM, IOMP) and related organizations (CBME) and to other interested parties. The next editor should perhaps maintain a separate mailing list from which additional labels can automatically be generated for each issue. Finally, while I was able to maintain a very good contact with the COMP's commercial members the first half of my editorship the ties have weakened this last year. This may be an issue that should be looked at an executive level so that the organization as a whole can strive for better relationships with commercial members.

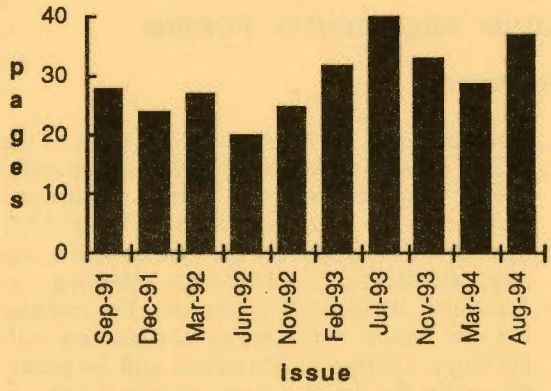


Fig.1: The length of each of the last ten issues of the Newsletter. The increase in content is somewhat obscured by the new compressed layout introduced in 1992.

As I have stated in each of my previous reports, the Newsletter production in the Medical Physics Department of the Montreal General Hospital has been a team effort. I will not name names, because invariably I will offend someone I forget, but a number of people gave valuable assistance at each stage of production from setup (with transcription, and occasional translation, of submissions), to printing, to collating and mailing. I thank them for their assistance and reassure them that they no longer have to dive for cover every time they see me coming down the hall.

John Schreiner
McGill University

### *Physics of Mammography Course*

A course in the Physics of Mammography will be held in Toronto at the Sunnybrook Health Science Centre on Sunday Sept. 18 and Monday Sept 19, following the annual meeting of the COMP and CCPM. It will sponsored by the CCPM to assist those preparing for certification as an accredited Mammographic Physicist.

Registration will be limited to 20 and the course will be contingent on adequate enrollment. The fee will be $175. which will cover coffee breaks and two lunches. The course will cover : Basic physics of imaging, Radiologic aspects of Breast Disease, Film and Processing, Mammographic Equipment, Quality Control CAR/ACR phantom analysis and Image Qualtiy Troubleshooting.

Send applications to

Cindy Thomason, Clinical Physics, Princess Margaret Hospital, 500 Sherbourne St. Toronto ON M4X 1K9

Cindy can also be reached at

Cindy Thomason Thomason@clinphys.pmh.toronto.on.ca

### *New Job Search Service*

Since its inception, the Canadian Medical Physics Newsletter has accepted advertisements from organizations seeking personnel. At the COMP annual general meeting last year it was suggested that some similar service be extended to individuals seeking employment.

This service is now being offered. A small advertisement can be placed in the Newsletter for a fee of $20 for COMP members and $25 for non-members (prepaid cheque or money order made out to COMP). The advertisement should include the person's name, address and phone number, and a 50 word (maximum) paragraph in point form giving information which may help employers decide if a reply is justified. For example, one might wish to specify degrees hux-ci n'ont pas améliorés la performance des systèmes.

## *HAROLD JOHNS TRAVEL AWARD*

The Board of the Canadian College of Physicists in Medicine is pleased to honour the Founding President of the College by means of the Harold John's Travel Award for Young Investigators. This award, which is in the amount of $1,000.00, is made to a College member under the age of 35 who has been a member for not more than two years. The award is intended to assist the individual to extend his or her knowledge by travelling to another centre or institution with the intent of gaining further experience in his or her chosen field, or, alternately, to embark on a new field of endeavor in medical physics.

Further information can be obtained from:

## *BOURSE de VOYAGE HAROLD JOHNS*

Le Conseil du Collège Canadien des Physiciens en Médecine est heureux d'honorer son président fondateur en offrant aux jeunes chercheurs la bourse Harold Johns. Cette bourse, d'une valeur de $1000,00, est éligible aux membres du Collège agés de moins de 35 ans et qui sont membres depuis deux ans ou moins. La bourse a pour but d'aider le récipiendaire à parfaire ses connaissances dans son domaine ou à démarrer dans un nouveau champ d'activités reliées à la physique médicale, en lui permettant de voyager vers un autre centre specialisé.

Les demandes seront addressées à:

The Registrar / Le Registraire
CCPM
c/o NSCC
5820 University Ave
Halifax, NS
B3H 1V7

The deadline for the next award is February 3, 1995

La date limite pour les demandes du prochain concours est le 3me Fevrier 1995.

Past recipients:

Récipiendaire anterieur:

| | |
|---|---|
| 1990 | Dr. L. John Schreiner, Montreal |
| 1991 | Ms. Moira Lumley, Kingston |
| 1992 | Dr. Donald Robinson, Edmonton |
| 1993 | Dr. Yunping Zhu, Toronto |
| 1994 | TBA at the Toronto meeting |

Members of the COMP/OCMP and/or the CCPM can make a donation to the fund by volunteering to increase their 1994 membership dues.

Les membres du COMP/OCPM et\ou du CCPM peuvent faire un don à la cotisation de 1994 un montant additionel de leur choix.

***Canadian College of Physicists in Medicine*** | ***Le Collège Canadien des Physiciens en Médecine***

## *CCPM Examination Schedule*

The application and exam schedule for 1994 is:

| Membership Exam: | | Fellowship Exam: | |
|---|---|---|---|
| Apply by: | January 10, 1995 | Apply by: | March 24, 1995* |
| Exam date: | March 25th 1995 | Exam date: | June 2, 1995 |

*Note: Those writing the membership exam on March 25, 1995 should confirm their Fellowship application and pay the fee within one week of receiving the membership exam results.*

### COMP/OCMP Corporate Membership

The Canadian Organization of Medical Physics would like to acknowledge the support given in the past year by our corporate members :

***Keithley***

***Oldelft***

***Theratronics***

***Varian***

We hope to continue our association with these and new corporate members in this new year. To encourage this affiliation we are implementing new benefits for our corporate members.
Details are available from the COMP office.

### Medical Physics E-mail Server List

A Canadian based electronic mailing list of medical physicists has been established in London through the efforts of Trevor Cradduck.

***To Subscribe:***
In order to be included on the list please send an e-mail message to:

cradduck@uwo.ca

and in the Subject: line put the words "subscribe canada-l" (that is an ell for List, not a one). The rest of the message can be left blank (it will be ignored anyway!).
Do not send your message to the burster directly as you will just be telling everyone you want to subscribe but you will not end up on the list.

***To Use:***
To distribute an e-mail message over the burster send your message to

**canada-l@irus.rri.uwo.ca**

Note that *all* subscribers will get messages sent to this address.

If you have any comments about the use of the list, or to what use it should be put, please send these in a separate message (with a different Subject:!).
Thank you for your cooperation.

# The Kingston Regional Cancer Center

is currently seeking to recruit a

## Chief Medical Physicist

Applications are invited for the position of Chief Medical Physicist at the Kingston Regional Cancer Centre. The Centre is one of eight regional cancer centres operated by the Ontario Cancer Treatment Foundation and is located at the Kingston General Hospital, on the campus of Queen's University.

Approximately 2,000 new cancer patients are registered annually at the Centre. The Radiotherapy Department operates two linear accelerators, a cobalt unit, an orthovoltage x-ray unit and remote afterloading equipment. A two bunker expansion project was completed in February 1994. A Varian 2100C/D accelerator has been installed in one of the bunkers, and a second identical unit will be installed in October 1994. The Medical Physics Department supports training programs in Medical Physics, Radiation Oncology, and Radiation Therapy.

In addition to supervision of the Medical physics Department, the Chief Medical Physicist will be encouraged and supported in research and development activities in basic and/or applied radiation physics or radiation biology. There are opportunities for research collaboration with the active photodynamic therapy research group at the Centre, and with the Physics Department at Queen's University. Further opportunities for research collaboration exist with the strong clinical Radiation Oncology Program in the Centre, and the Radiation Oncology Research Unit.

The successful candidate for this position will be a fully trained Medial Physicist, with a minimum of five years experience in clinical radiation therapy physics, and demonstrated leadership and administrative abilities. Preference will be given to candidates with a Ph.D. and/or demonstrated success in research. Membership and/or fellowship in the Canadian College of Medical Physics or equivalent is required. An academic appointment at Queen's University will be arranged commensurate with qualifications.

In accordance with Canadian Immigration requirements, priority will be given to Canadian citizens and permanent residents of Canada. Applications are invited from all qualified candidates. Please submit a curriculum vitae and the names of three professional referees to:

Andrew Padmos, BA, MD, FRCPC
Director and Chief Executive Officer
Kingston Regional Cancer Centre
25 King Street West
Kingston, Ontario K7L 5P9
FAX: (613) 544-4967

Hamilton
Kingston
London
Ottawa
Sudbury
Thunder Bay
Toronto
Windsor

THE ONTARIO CANCER TREATMENT AND RESEARCH FOUNDATION

# PHYSICIEN MÉDICAL

## Centre d'oncologie de Moncton
## Moncton, New Brunswick (CANADA)

Le Centre d'oncologie de Moncton, traitant environ 800 patients par année, est présentement à la recherche d'un physicien médical spécialisé en radiothérapie. Les responsabilités du candidat seront entre autres, la dosimétrie, la curiethérapie, l'assurance de qualité et l'acquisition de données physiques pour la planification de traitement.

Le candidat choisi devra posséder un doctorat en physique médicale ou dans un domaine connexe, et au moins deux ans d'expérience clinique en radiothérapie. Etre Membre du Collège canadien des physiciens en médecine serait un atout. Il serait aussi avantageux de posséder de l'expérience en curiethérapie à haut débit. Puisque la clientèle du Centre d'oncologie de Moncton est bilingue, le candidat devra être en mesure de bien pouvoir maîtriser les deux langues officielles, soit le français et l'anglais.

Le département de physique médicale est responsable pour 2 accélérateurs linéaires Siemens, 2 systèmes d'imagerie de contrôle, un simulateur, un appareil d'orthovoltage, un ordinateur de planification de traitement et deux appareils de curiethérapie à chargement différé (un à haut débit, l'autre à débit faible). Le département de physique médicale possède aussi d'excellents ateliers mécanique et électronique.

Selon les règlements de l'immigration canadienne, la priorité sera accordée aux candidats ayant la citoyenneté canadienne ou un statut de résident permanent. Ce poste est ouvert également aux hommes et aux femmes.

Les personnes intéressées doivent faire parvenir leur résumé et le nom de trois références à:

Pierre L. Sirois
Directeur des ressources humaines
Hôpital Dr Georges-L. Dumont
330, rue Archibald
MONCTON NB
E1C 2Z3
Tél: (506)862-4250
Fax: (506)862-4256

Numéro de référence: 94-003

# RADIATION THERAPY PHYSICIST

## Moncton Oncology Centre
## Moncton, New Brunswick (CANADA)

The Moncton Oncology Centre has an immediate opening for a Radiation Therapy Physicist. Responsabilities will include clinical treatment planning, brachytherapy, quality assurance and physics measurements.

Preference will be given to candidates who have a Ph.D. in Medical Physics or a related field and at least two years clinical experience in radiation therapy physics. Membership of, or eligibility for membership of, the Canadian College of Physicists in Medicine or equivalent certification is desirable. Experience in high dose rate brachytherapy would be an advantage for the position. Excellent communications skills (both in English and French) are required to ensure effective work in clinical environments.

The Moncton Oncology Centre treats approximately 800 patients per year. Present facilities in the Department of Medical Physics include 2 Siemens linear accelerators with an additional bunker for future expansion, 2 on-line portal imaging systems, 1 simulator, 1 kilovoltage X-ray unit, 1 treatment planning computer as well as HDR and LDR remote afterloading brachytherapy systems with their own treatment planning computer. Excellent mechanical and electronic services are available in the Department of Medical Physics.

In accordance with Canada Employment and Immigration requirements, preference will be given to Canadian citizens and landed immigrants.

The Moncton Oncology Centre is an Equal Opportunity Employer.

For immediate consideration please submit a detailed resumé and the names of three references to:

Pierre L. Sirois
Director of Human Resources
Dr. Georges-L. Dumont Regional Hospital
330, Archibald Street
MONCTON NB
E1C 2Z3
Tel: (506)862-4250
Fax: (506)862-4256

Competition # 94-003

## *Windsor Regional Cancer Centre*

## *HEAD, CLINICAL PHYSICS - RADIATION ONCOLOGY and MEDICAL PHYSICIST*

Applications are invited for the position of Head of the Physics Department and for one medical physicist in the Windsor Regional Cancer Centre. The WRCC is a member of the Ontario Cancer Treatment and Research Foundation which includes 8 cancer centres across the province. It provides cancer care for approximately 300,000 residents of Essex County in southwestern Ontario, with an annual new caseload of over 900 radiotherapy patients. Its location affords convenient collaborative opportunities with the University of Windsor and Wayne State University.

The Windsor Regional Cancer Centre provides a full range of radiotherapy services. Facilities include a Phillips 100 KV unit, Theratronics T1000 Cobalt Unit, Phillips 25 MV dual energy unit, Toshiba LX40A simulator, LDR and HDR Selectron units, mouldroom and an electronics workshop. New linear accelerators will be installed within the next 5 years. The HDR brachytherapy suite contains a dedicated Picker simulator and is equipped to support patients undergoing endoscopic procedures. There is much interest in HDR brachytherapy research and development. The centre is designated as γ-site for the development of the Nucletron Plato treatment Planning System.

Candidates for Head should have either M.Sc. or Ph.D. degrees and a minimum of 10 years experience in clinical physics. The successful candidate will play an important role in education and research development at the centre, and will lead a team of two other physicists, a dosimetrist, electronics technologist and an instrument maker. The successful candidate for Medical Physicist will play an integral role in this team, should have either M.Sc. or Ph.D. degrees and work experience in clinical physics, and be eligible for membership in the Canadian College of Physicists in Medicine.

The Ontario Treatment and Research Foundation is an Equal Opportunity Employer, but is directed by the Canadian Immigration to state that "preference will be given to Canadian citizens and permanent residents of Canada".

Interested candidates may submit their curriculum vitae and names of three references before September 15, 1994, in confidence, to:

Dr. C. Springer
Head, Physicist Selection Committee
Windsor Regional Cancer Centre
2220 Kildare Road, Windsor, Ontario N8W 2X3

# *CANADIAN MEDICAL PHYSICS THESES*

## *1993*

The Canadian Medical Physics Newsletter is pleased to publish the following review of medical physics graduate work completed at Canadian Universities in 1993. Thirty one authors have submitted their work for this report. I thank them for their submissions and congratulate them on their research efforts. I trust that this resource will be useful to other researchers in the community.

This year we have extended the scope of the review by adding submissions from Canadian students who studied outside of the country. The criteria for acceptance were that the work lead to a degree, that the student was a Canadian citizen and that the student maintained student membership in COMP while studying.

I now invite submissions for next year. The newsletter will publish a report of theses completed in 1994 in the spring/summer 1995 issue.

John Schreiner
McGill University
Montréal, QC

*Carleton University, Ottawa, ON*
*Department of Physics*

Dennis P. Heller

**Radiobiological aspects of cellular recovery following high and low dose-rate irradiation with/without mild hyperthermia in a human glioma cell model**
PhD

Despite current treatment modalities the prognosis for patients with malignant glioma is poor. The intrinsic radioresistance of these tumours is thought to play a major role in the failure of radiotherapy. A major component of intrinsic radioresistance is the cellular recovery from radiation damage.
One primary reason for the success of combined hyperthermia and radiation is thought to be the ability of hyperthermia to overcome radioresistance by inhibiting the cellular recovery of radiation damage. Recent clinical trials of simultaneous low dose-rate irradiation (LDRI) and mild (<42oC) hyperthermia have shown great promise.
In this thesis, cell survival and recovery following radiation damage were measured under a variety of conditions in human glioma cells. Recovery during LDRI was examined in a non-proliferating cell population. Recovery was investigated following high dose-rate irradiation (HDRI) in proliferating and non-proliferating cell populations under various environmental and physiological conditions. The kinetic nature of this recovery was also measured. Lastly, the inhibition of recovery by mild hyperthermia was investigated.
A range in cell survival and recovery levels was observed in proliferating and non-proliferating cells by pre- and post-irradiation manipulation of the growth medium. The degree of metabolic and proliferative quiescence affected by a change in pH was significant in determining the immediate and delayed plating survival levels, and the amount of recovery observed, with pre- and post-irradiation manipulation of the growth medium, respectively.
Recovery post-HDRI followed mono-exponential kinetics. The recovery half-time increased as a function of dose implying that the recovery processes were saturated (T1/2 from 0.9 to 3.5 h for dose of 3.0 to 9.0 Gy). This increase was similar to the increase in the amount of recovery observed as a function of dose. At an iso-recovery level the rate of recovery was similar in proliferating and non-proliferating cells.
Cellular recovery from radiation damage was measured during LDRI and following HDRI. While the recovery in either case was maximal under the same conditions (non-proliferating cells, low pH, low metabolic activity), under alternate conditions the recovery was different.

A large degree of thermoradiosensitization was seen with concurrent 41oC heating and LDRI (TER of 1.5 to 2.1 at 1% survival level). Less sensitization was seen at 39 and 40°C. This study indicates that mild hyperthermia may be an effective inhibitor of cellular recovery which occurs during LDRI and following HDRI, only if applied while the recovery processes are taking place. This has implications in clinical trials in which hyperthermia is administered before or after irradiation, especially when only mild hyperthermic temperatures are achieved. It also supports the role of simultaneous mild hyperthermia as an effective way to improve brachytherapy.

Supervisor: G. Peter Raaphorst

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E. Lawrence

**The Variables Controlling the Intensity and Purity of Fluorescence X Rays**
M.Sc.

There are several potential applications and benefits associated with using monoenergetic x-ray beams. These beams can be approximated by fluorescence x-ray beams.
A conventional W-anode x-ray tube was used to irradiate seven pure elemental foils: Zr, Ag, Sn, La, Ho, W, and Pb. The purity and intensity of the resulting fluorescence radiation produced from the Sn and Pb foils was studied as a function of: kVp, primary beam filter thickness, fluorescence beam filter thickness, fluorescence foil thickness, detector angle, and foil angle, using a high purity Ge spectrometer.
In order of decreasing importance, the variables controlling the intensity of the fluorescence x-rays produced are: fluorescence beam filter thickness, kVp, fluorescence foil thickness, primary beam filter thickness, foil angle, and detector angle. Purity is most sensitive to: fluorescence beam filter thickness, and kVp (if close to the K-edge of the foil). The other variables had a much smaller effect on purity.

Supervisor: Paul Johns

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David E. Wilkins

**Radiobiological and magnetic resonance studies of combined radiation and cisplatin therapy in the 9l rat brain tumour model**
Ph.D.

The prognosis for adult patients with primary malignant brain tumours is poor. Radiation therapy is a standard adjuvant to surgery in the treatment of these patients, but is rarely curative. The extreme radioresistance of primary malignant brain tumours is due in part to their enhanced capacity for repair of potentially lethal radiation damage. The chemotherapeutic agent cisplatin has been shown to inhibit repair of radiation damage. Therefore combined cisplatin and radiation therapy could be a key to enhanced therapeutic gain in the treatment of primary malignant brain tumours.
In this project, the 9L rat brain tumour model was used to investigate combined radiation and cisplatin treatments. In vitro experiments showed the 9L cell line to be highly radioresistant and, like human malignant brain tumour cells, to have a high capacity for repair of potentially lethal radiation damage. These cells were found to be moderately resistant to the cytotoxic effects of cisplatin. In vitro exposure to cisplatin at clinically relevant concentrations caused inhibition of potentially lethal damage repair, with the amount of inhibition depending on cisplatin dose and treatment sequence.
Magnetic resonance imaging (MRI) was used to monitor the effects of combined radiation and cisplatin treatments of implanted intracranial 9L tumours in rats. A new technique for implanting experimental tumours was developed which resulted in more uniform tumour growth, and methods for radiation and cisplatin treatment of experimental intracranial tumours were developed and evaluated. Non-invasive measurements of tumour size using MRI were found to correlate well with measurements made from histological sections. Intraperitoneal administration of gadolinium contrast agent immediately before T1-weighted MRI was shown to be the most accurate and reliable method for MRI measurement of intracranial tumour size.
The capability of MRI to provide early indications of radiation injury to normal brain tissue was evaluated in the rat, and MRI changes were found to occur on average 130 days following partial brain irradiation. Combined radiation and cisplatin treatment of intracranial 9L tumours did not result in tumour regression observable by MRI, despite histopathological evidence of increased tumour necrosis compared with radiation or cisplatin treatments alone.

Supervisor: G. Peter Raaphorst

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***Dalhousie University, Halifax, NS***
*Department of Physics*

Grant S. MacNevin,

**Reconstruction of the 25 MeV Bremsstrahlung Spectrum from a Therac-25 Medical Linear Accelerator**
MSc

Direct measurement of the photon energy spectrum from a linear accelerator is difficult. The finite counting rate of presently available scintillation spectrometers inhibits such detectors from counting the high number of photons in high energy x-ray beams. The goal of this study was to reconstruct the photon energy spectrum of a 25 MeV medical linear accelerator from transmission measurements.
A modified probability density function with two adjustable parameters was selected as a model for the photon energy spectrum. The density function was selected based on a chi-square fit to a simple Monte Carlo simulation of the spectrum. The function was used to fit transmission data measured for various field sizes. Polystyrene sheets were used as the absorbing material. Values for the fitted parameter set were thus obtained for each field size.
The spectra thus obtained were similar to that from the Monte Carlo simulation. The half-value layer thicknesses in lead and water calculated with the model function were within 4% of the measured half-value layer thicknesses.

Supervisor: M. Hale

***McMaster University, Hamilton, ON***
*Department of Physics*

Ricky Khaloo

**An Evaluation of Hydrogen as a Tissue Equivalent Proportional Counter (TEPC) Counting Gas in Radiation Protection Microdosimetry**
M.Sc.

Tissue Equivalent Proportional Counters (TEPCs) filled with conventional tissue equivalent gases have a significantly low neutron dose equivalent response in the neutron energy region between 5 and about 200 keV. Theoretical modelling in monoenergetic neutron fields has suggested that using pure hydrogen as a microdosimetric counting gas would improve the dose equivalent response in this region. Average neutron dose equivalent response calculations have been done for selected realistic broad energy neutron fields and are found to generally support this suggestion.
Gas gain investigations performed with conventional tissue equivalent gases and hydrogen indicate that hydrogen has a very limited region, up to a reduced electric field of about 250 V $cm^{-1}$ $torr^{-1}$, where it can be of use as a proportional counter gas. Conventional tissue equivalent gases can be used up to about 2000 V $cm^{-1}$ $torr^{-1}$. Microdosimetric measurements performed with hydrogen as a counting gas demonstrate that it is unsuitable for obtaining easily interpreted event size spectra primarily because of its non tissue equivalent nature.

Supervisors: A.J. Waker and D.R. Chettle

***University of Manitoba***
*Department of Medical Physics*

Christine W. Yu

**An investigation of a computer model of the effect of patient localization uncertainties on radiotherapy dose distributions**
M.Sc.
The efficacy of ionizing radiation depends strongly upon the precision with which the dose is delivered to the prescribed biological tumour volume (BTV). However substantial localization errors are known to occur during radiotherapy treatments. These uncertainties should be taken into account when radiation treatment is planned.
Two existing approaches to evaluating the effects of patient localization uncertainties are described. They are shown to be either time-consuming or unable to provide dose distributions with sufficient accuracy.
A new automatic computer technique is developed to calculate the absorbed dose distribution in a non-stationary patient. The dose calculation algorithm of this technique is based on the scatter-air ratio model. It derives the non-stationary dose distribution from the stationary dose distribution through convolution and inverse square law modification. It is found that in the prostate and abdominal treatment regions this dose calculation algorithm satisfies presently recommended dose calculation accuracy requirements and takes only 1 or 2 seconds to generate a single-beam dose distribution for a non-stationary patient. It is more reliable and clinically applicable than the previous two techniques.
Results from studying a plan for a case of cancer of the prostate indicate that random localization uncertainties (RLUs) have the potential of creating large but shallow underdose volumes in the BTV region, which may result in a decrease of tumour control probability. It was noticed that three factors determine the size as well as the depth of the

additional underdose volume caused by the RLUs. They are the extent of the RLUs, the field margin size, and the isocentre dose value. Two alternative strategies were found to be effective in eliminating the additional underdose volume, namely raising the isocentre dose and increasing the field margin. It was observed that when conformal therapy is applied, raising the isocentre dose is probably preferable to increasing the field margin if the tumour overdose is not of great concern. It was also found that in the studied case random localization uncertainties have insignificant impacts on the surrounding sensitive organs.
Supervisor: David Viggars

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***McGill University, Montréal, QC***
*Medical Physics Unit, Faculty of Medicine*

Paule Charland

**Stereoscopic Visualization of Medical Images**
M.Sc.

This thesis presents some guidelines for the implementation of a stereoscopic medical image display for neurosurgery planning.
A survey of different 3-D image visualization techniques and aspects of field-sequential stereoscopic display serves as an introduction which is followed by a comparison of algorithms for solving the homogeneous transformation matrix describing the relationship between points seen in the 2-D DSA (Digital Subtraction Angiography) image and the corresponding points in the 3-D volume.
The latter part of this thesis describes the results of various experiments concerning the perceptual issues relevant to the presentation of DSA images on a field-sequential stereoscopic display. The analysis of the results indicates that the positioning of a 3-D cursor in the stereoscopic display by an observer remains relatively accurate under different constraints. It is shown that some parameters can help improving the 3-D perception on the stereoscopic display (cursor's shape and color, depth cue on the cursor, image processing and viewing position).

Ce memoire presente des lignes directrices pour un affichage stereoscopique d'images medicales pour guider la neurochirurgie.
L'ouvrage debute par un survol des differentes techniques de visualisation d'images en 3-D et de plusieurs aspects relies aux ordinateurs stereoscopiques a temps multiplexe. Vient ensuite une comparaison d'algorithmes en vue de solutionner la matrice de transformation homogene decrivant la relation entre les points 2-D d'une image d'ANS (angiographie numerisee soustraite) et les points correspondants dans le volume 3-D.
Le reste du document est constitue de la presentation des resultats de diverses experiences sur les issues perceptuelles pour presenter des images d'ANS sur un ordinateur stereoscopique a temps multiplexe. Il en ressort que le positionnement par un observateur d'un curseur 3-D sur ce type d'affichage reste relativement precis sous diverses contraintes. Certains parametres peuvent jouer sur l'amelioration des conditions de visionnement en stereoscopie (forme et couleur du curseur, indice de profondeur sur le curseur, traitements de l'image et position d'observation).

Supervisor: Terry Peters

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Roch Comeau

**The design and implementation of a three dimensional computerized treatment planning system.**
M. Sc.

An efficient and productive radiation treatment planning (RTP) system must make use of both appropriate visualization techniques and good user interface design. The suitability of several visualization techniques have been examined in the context of 3-D radiation treatment planning. These techniques include wire frame, surface rendering, volume rendering and a subset of volume rendering: reformatiing of data. A rudimentary computerized RTP system was written using th most appropriate visualization techniques examined earlier. These techniques were used to display the anatomical data acquired from computed tomography (CT) scanners, the beam position within the anatomy, and finally, the dose distribution resulting from the entered plan. The program was written in ANSI C and runs on a Silicon Graphics Personal Iris UNIX workstation. The system makes use of effective user interface tools and efficient code which results in an efficient and interactive system. The accuracy of the system is verified by comparing dose profiles obtained with film dosimetry and from the computer calculations.

Un système de planification de traitment par radiation doit se servir de techniques de visualisation appropriées et d'une interface à l'utilisateur efficace. Plusieurs techniques de visualisation graphiques ont été examinées dans le contexte d'un system de planification de traitement par radiation. Ces techniques incluent les modèles "fils de fer", le rendement de surface, le rendement de volume, et la restructuration des données. Un système rudimentaire de planification de traitement par radiation a été conçu en se servant des techniques que nous avons trouvées des plus appropriées. Ces techniques sont utilisées pour visualiser l'anatomie dérivée d'un Tomogramme

Axial, la position du champ de traitement dans l'anatomie, et la distribution de dose qui résulte d'un traitement. Le logiciel a été écrit en "ANSI C" sous le système d'exploitation UNIX et fonctionne sur un ordinateur "Personal Iris" de Silicon Graphics. Ce système se sert auusi d'un interface à l'utilisateur qui est efficasse et intuitive. La précision du système est vérifé en faisant la comparaison de profils de dose derivés de films et de profils obtenus du logiciel.

Supervisor: B. Gino Fallone

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Pierre Courteau

**Electron arc therapy dose calculation using the angle-β concept.**

M.Sc.

A computer program was developed during the course of this work to calculate electron arc dose distributions with the angle b concept. The angle b uniquely describes the dependence of radial percentage depth doses in electron arc therapy on the nominal field width, isocenter depth, and virtual source-axis distance. The b concept can be used in clinical situations to determine the field width when the isocenter depth and the required radial percentage depth dose are known. This thesis presents an overview of the physical properties of electron arc therapy and describes in detail the angle b pseudo-arc techniques used at McGill. A description of the algorithms used in the computer program is given and the b technique is compared to measurements and other calculation methods.

Un programme d'ordinateur a été conçu pour calculer les distributions de dose pour des traitements rotationels avec électrons en utilisant le concept de l'angle b. L'angle b décrit la dépendence du rendement radial de dose en profondeur de façon unique avec la largeur du champ de radiation (w), la profondeur de l'isocentre (d), et la distance source virtuelle à isocentre (f). Cet angle peut ètre utilisé dans des situations cliniques pour déterminer w lorsque d et le rendement de dose en profondeur sont connus. Ce travail présente premièrement une revue des propriétés physiques de la thérapie rotationelle avec électrons et ensuite le concept de l'angle b utilisé à McGill est décrit en détail. Les algorithmes utilisées dans le logiciel de calcul de dose sont aussi présentées et finalement le technique de thérapie avec l'angle b est comparée avec des mesures et une autre methode de calcul.

Supervisor: Conrado Pla

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Christopher J. Henri

**Three-dimensional reconstruction of cerebral vasculature**

Ph.D. (Department of Biomedical Engineering)

This thesis examines the few-view reconstruction problem as it applies to imaging cerebral vasculature using digital subtraction angiography. A fully automated reconstruction algorithm is developed that circumvents the traditional `correspondence problem' using only notions of consistency and connectivity. Here it is assumed that the object is a connected structure and that its centre-lines have been identified in 3 or more images. The first of three steps in the procedure involves generating a connected structure that represents the multiplicity of solutions that are consistent with any two (different) projections of the vascular tree. The second step assigns to each branch in this structure a measure of consistency based on its agreement with a third (or additional) view of the object. The problem then becomes one of propagating this information, via connectivity relationships and other consistency checks, throughout the above structure to distinguish between the branches comprising the imaged structure and the accompanying artifacts.

This thesis also addresses the issue of how different imaging geometries affect the outcome of the reconstructed data. Here it is suggested that it may be possible to favourably affect the reconstruction by selecting certain projections based on what is known after two or more views.

Simulations using mathematical models of varying complexity and experiments based on actual image data are used to validate the methods described here and demonstrate that it is possible to achieve adequate reconstructions with as few as three distinct views.

Le propos de cette thèse est l'étude de la reconstruction du système vasculaire cérébral à partir d'un nombre limité d'images angiographiques numérisées (de 3 ou plus) obtenues sous des angles différents, en vue d'automatiser cette reconstruction. Ce problème que l'on rencontre également dans l'analyse de scènes tri-dimensionelles et dans la vision par ordinateur, est abordé par le biais de l'application des concepts de contraintes de connectivité et de cohérence pour la résolution des ambiguités géométriques, et révèle les limitations inhérentes au processus de reconstruction.

Après l'identification du squelette des vaisseaux contenus dans les images bi-dimen-sionnelles, on procède en trois étapes: Premièrement, la reconstruction de la structure connectée tri-dimensionnelle représentant l'ensemble des solutions pouvant correspondre à toute paire de projections de l'arbre vasculaire. Deuxièmement, l'identification et l'élimination des artéfacts identifiés par l'introduction

de projections supplémentaires. Finalement, des relations de connectivité sont appliquées pour identifier les branches vasculaires réelles et éliminer les branches erronées.
Il est également question dans cette thèse de l'impact de la géométrie du système d'imagerie sur les résultats obtenus après reconstruction des données brutes. Il apparaît possible d'affecter de façon favorable le processus de reconstruction en sélectionnant certaines projections compte-tenu des résultats obtenus après deux vues ou plus.
Nous présentons des résultats de simulations faites sur des modèles mathématiques de niveaux de complexité variables, ainsi que des résultats d'application à des données cliniques. Ces expériences ont permis la validation des diverses étapes de la méthode, et ont démontré que le système vasculaire peut être reconstruit de facon adéquate à partir d'un minimum de trois projections.

Supervisor: Terry Peters

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Kavita Murthy
**A study of the effects of detector width and depth of resolution in Positron Emission Tomography**
M.Sc.

As scintillation crystals used in Positron Emission Tomography (PET) cameras are made smaller to improve resolution, there is a loss of resolution at the edges of the field of view (FOV). This loss can be eliminated by the determination of the depth of interaction of photons within each crystal. A 4 mm black band around a 30 x 10 x 3 mm Bismuth Germanate (BGO) crystal painted at 10 mm along its length divides the crystal into two regions of equiprobable interaction. By collecting scintillation light from the front side of such a detector, it is possible to differentiate between photon interactions in front of and behind the band. The effectiveness of the technique for single and multiple detector blocks was studied.
More than half the annihilation photons incident upon the BGO crystals are Compton scattered before being absorbed photoelectrically in the crystal. The effect of scatter upon the aperture function (AF) of five 25 x 10 mm BGO crystals with widths increasing from 1 mm to 3 mm in steps of 0.5 mm was studied. The AF dependence upon the crystal depth was also investigated.

Lorsque les cristaux à scintillation utilisés en tomographie par émission de positons sont coupés plus minces dans le but d'améliorer la résolution spatiale, il y a une perte de résolution en périphérie du champs de vue. On peut réduire cette perte de résolution en mesurant la profondeur d'interaction de chaque photon dans le cristal. Une bande noire large de 4 mm peinturée autour d'un cristal de 30 x 10 x 3 mm de germanite de bismuth (BGO) à 10 mm de sa face avant divise le cristal en deux régions d'interaction égales. En mesurant la lumière émise avant la bande noire, on peut distinguer la région d'interaction. L'efficacité de cette technique fut étudiée pour des cristaux simples et pour des ensembles de cristaux.
Plus de la moitié des photons de 511 keV subissent un diffusion Compton avant d'être absorbés par une interaction photo-électrique. L'effet du rayonnement diffusé sur la fonction d'ouverture fut étudié pour cinq cristaux de BGO de 25 x 10 mm ayant des largeurs de 1.0, 1.5, 2.0, 2.5 et 3.0 mm. La dépendance de la fonction d'ouverture avec la profondeur des cristaux fut également étudiée.

Supervisor: Chris Thompson

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Horacio Patrocinio
**Evaluation of backscatter factors for diagnostic x-ray beams**
M.Sc.

This thesis proposes models for the calculation of upper and lower limiting values to the backscatter factor (BSF) that can be used to evaluate measured and modelled BSF values. The upper limit to the BSF is obtained from a Monte Carlo simulation of an infinite parallel beam incident on a semi-infinite phantom in which the dose contribution from all orders of photon scatter is considered. The lower limit is calculated using an analytical photon transport model which considers only the primary dose and the scatter dose from photons that have undergone a single scattering interaction in the phantom. A parametrization of the limiting values in terms of photon energy and irradiation field size is presented and comparisons are made with BSF's from the literature. To further illustrate the utility of the limiting BSF's, comparisons are also made with current TLD-measured BSF's and Monte Carlo simulations of the BSF.

L'auteur propose des modèles pour le calcul de limites supérieures et inférieures aux facteurs de rétrodifussion, qui peuvent servir à l'évaluation de facteurs de rétrodifussion mésurés ou calculculés. La limite supérieure est obtenue à partir d'un calcul avec la méthode Monte Carlo qui tient compte de la dose provenant de tous les niveaux de diffusion pour un faisceau infini et parallèl. La limite inférieure est basée sur un modèle tenant compte des photons n'ayant subi qu'une seule diffusion dans le fantôme où le calcul de dose se fait à l'aide d'intégrations sur les trajectoires empruntées par les rayons X. Des

équations paramétriques pour les limites aux facteurs de rétrodifussion sont présentes en fonction de l'énergie du faisceaux et de la grandeur du champ d'irradiation. Avec ces equations, des comparaisons entre les limites aux facteurs de rétrodifussion et des valeurs obtenues dans la litérature sont éffectuées. Les limites aux facteurs de rétrodifussion sont aussi comparées avec des mesures utilisant des dosimètres thermoluminescents et avec des simulations Monte Carlo éffectuées pour cette thèse.

Supervisor: L. John Schreiner

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Yani Picard

**Improving the precision and accuracy of Monte Carlo simulations in Positron Emission Tomography**

M.Sc.

PETSIM, a Monte Carlo simulation program of Positron Emission Tomography (PET) systems, was improved in terms of accuracy and efficiency. First, the accuracy, the speed and the ease of use of PETSIM were improved by using tabulated values of the Compton scattering and photoelectric absorption partial interaction attenuation coefficients for all common biological, collimator and detector materials. These were generated from chemical formula, or physical composition, and density of the absorbing medium.

Furthermore, simulations of PET systems waste considerable time generating events which will never be detected. For events in which the original photons are usually directed towards the detectors, the efficiency of the simulations was improved by giving the photons additional chances of being detected. For simulation programs which cascade the simulation process into source, collimation, and detection phases such as PETSIM, the additional detections resulted in an improvement in the simulation precision without requiring larger files of events from th source/phantom phase of the simulation. This also reduced the simulation time since fewer positron annihilations were needed to achieve a given statistical precision. This was shown to be a use improvement over conventional Monte Carlo simulationsof PET systems.

PETSIM, un programme de simulation Monte Carlo des systèmes de Tomographie par Emission de Positrons (TEP), a été amélioré au point de vue précision et efficacité. Premièrement, la précision, la rapidité et la facilité d'utilisation de PETSIM a été améliorées grâce à l'utilisation de valeurs tabulées des coefficients partiels d'atténuation des interactions Compton et photo-électriques pour tous les matériaux biologiques et ceux des collimateurs et des détecteurs communément rencontrés en TEP. Ceux-ci ont été générés a partir de leur formule chimique ou de leur composition physique et de leur densité.

De plus, les simulations de TEP perdent énormément de temps à générer des événements qui ne seront jamais détectés. Pour les événements dont les photons sont généralement orientés vers les détecteurs, l'efficacité d'une simulation complète a été améliorée en donnant aux photons de nouvelles chances d'être détectés. Pour les programmes de simulations qui effectuent la simulation en phases, soit la simulation de la source, des collimateurs et des détecteurs, les détections additionnelles améliore la précision des simulation sans nécessité de fichiers d'événements de plus grande dimension de la part de la phase source de la simulation. Ceci a permis de réduire aussi le temps de simulation puisque moins d'annihilations de positrons sont nécessaires pour obtenir une précision statistique donnée. Ceci s'avère une amélioration utile des simulateurs Monte Carlo conventionnels.

Supervisor: Chris Thompson

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Katharina E. Sixel

**Measurements and Monte-Carlo simulations of x-ray beams in radiosurgery.**

Ph.D. (Dept. of Physics)

Radiosurgery is characterized by high radiation doses, delivered via small diameter radiation beams in a single session, placing stringent requirements on the numerical and spatial accuracy of dose delivery to the target volume within the brain. In this thesis, physical and clinical aspects of radiosurgery are discussed, including a method for the production of cylindrical dose distributions with rectangular beams using cylindrical dynamic rotation.

The measurements of radiosurgical x-ray beam parameters are presented. Monte Carlo simulations determine that a measured increase in depth of dose maximum with increasing field size is a result of primary dose deposition in phantom for small diameter beams.

An analytical representation based on a curve-fitting process is developed to parametrize radiosurgical x-ray beam percentage depth doses as a function of depth in phantom, field diameter and beam energy using bi-exponential and polynomial functions.

Measurements of dose in the build-up region of x-ray beams ranging from $1\times1$ cm$^2$ to $30\times30$ cm$^2$ show that the depth of dose maximum increases rapidly with increasing field size at small fields, reaches a maximum around $5\times5$ cm$^2$ and then gradually decreases with increasing field size for large fields. Monte Carlo simulations attribute the effect observed at large fields to the scatter contamination of the primary beam from the linac head. This scatter contamination is measured by a half-block technique

and further experiments show that it consists of electrons originating in the flattening filter of the linac.

La radiochirurgie est caractérisée par des doses élevées de radiation, administrées par des faisceaux de faibles diamètres, lors d'une session unique. Cela nécessite une administration au volume-cible á l'intérieur du cerveau d'une dose rigoureusement exacte numériquement et spatialement. Dans cette thèse, les aspects physiques et cliniques de la radiochirurgie sont discutés, y compris une méthode de production de distributions de doses cylindriques avec des faisceaux rectangulaires en utilisant une rotation dynamique cylindrique.
Nous présentons les mesures des paramètres du faisceau de rayons X de radiochirurgie. Des simulations de Monte Carlo sont utilisées pour démontrer que l'augmentation mesurée de la profondeur de dose maximale avec l'agrandissement du champ résulte d'une déposition de dose primaire dans le fantôme pour des faisceaux de radiochirurgie de faibles diamètres.
Nous développons une représentatin basée sur un procédé d'ajustement analytique pour obtenir les paramètres du rendement en profondeur du faisceau de photons de radiochirurgie en fonction de la profondeur dans le fantôme, du diamètre du champ et de l'énergie du faisceau suivant des fonctions bi-exponentielles et polynomiales.
Les mesures de doses dans la région entre la surface d'entrée et le point de dose maximale pour des faisceaux de rayons X allant de 1×1 $cm^2$ à 30×30 $cm^2$ montrent que pour une énergie donné, la profondeur de la dose maximale augmente rapidement avec l'augmentation de la grandeur du champ pour les petits champs, atteint un maximum autour de 5×5 $cm^2$ puis décroit graduellement avec l'agrandissement des champs pour les grands champs. Les simulation de Monte Carlo montrent que pour les grands champs, l'effet provient de la contamination du faisceau primaire par la diffusion du faisceau dans la tête de l'accélérateur. La technique du demi-bloc permet de mesurer cette contamination de diffusion et des expériences subséquentes montrent qu'elle est composée d'electrons provenant du filtre égalisateur de l'accélérateur.

Supervisor: Ervin B. Podgorsak

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Manouchehr S. Vafaee
**Evaluation and implementation of an automatic blood sampling system for positron emission tomographic studies.**
M.Sc.

Quantification of physiological functions with positron emission tomography requires knowledge of the arterial radioactivity concentration. Automated blood sampling systems increase the accuracy of this measurement, particularly for short-lived tracers such as oxygen-15, by reducing the sampling interval to a fraction of a second. They, however, require correction for tracer delay between the arterial puncture site and the external radiation detector (external delay), and for the tracer bolus distortion in the sampling catheter (external dispersion).
We have evaulated and implemented the "Scanditronix" automated blood sampling system and measured its external delay and dispersion. PET studies of cerebral blood flow and oxygen metabolism using simultaneous manual and automated blood sampling were analyzed and compared. We show that the results obtained with automated blood sampling are more reliable than those based on manual sampling. We also present suggestions to further improve the reliability of quantitative PET studies based on automated blood sampling.

La quantification de fonctions physiologiques à l'aide de la tomographie par émission de positons nécessite la concentration radioisotopique artérielle. Des systèmes d'échantillonnage automatique sont particulièrement utiles pour des marqueurs radioactifs à courte demi-vie tel l'oxygène-15. Ils permettent de réduire l'intervalle d'échantillonnage à moins d'une seconde. Cependant, ces systèmes demandent des corrections pour le délai du marqueur entre le site de la ponction artérielle et le détecteur de radiation (délai externe) ainsi que pour la distorsion du bolus dans le cathéter d'échantillonnage (distorsion externe).
Nous avons mesuré de délai et la distorsion externe du système d'échantillonnage automatique "Scanditronix". Nous avons comparé des études de débit sanguin et de métabolisme d'oxygène cérébraux utilisant simultanément l'échantillonnage manuel et l'échantillonnage automatique. Nous démontrons que les résultats basés sur l'échantillonnage automatique sont plus fiables. Enfin, nous suggérons certaines améliorations pouvant augmenter encore la fiabilité des mesures quantitatives de tomographie par émission de positons à l'aide de l'échantillonnage automatique.

Supervisor: Ernst Meyer

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Hui Wang
**Automatic image segmentation and correlation in radiotherapy verification**
M.Sc. (Dept. of Physics)

Two active topics in radiation therapy treatment verification, portal image segmentation and correlation, are addressed, and a robust algorithm for automatic segmentation of portal images and portal image registration with respect to a reference image is developed. Morphological techniques have been

intensively applied in all stages of the segmentation part of this algorithm, from edge detection to feature extraction. An important issue, edge enhancement, is discussed particularly in detail. The performance of the morphological edge detection technique on portal images is compared with that of local gradient operators and optimal edge detectors, while the advantage of the morphological edge detection and segmentation techniques is justified. The treatment field mask is proposed as the landmark for portal-simulator image correlation achieved by matching inertia moments of landmarks. The effect of two different landmarks, the treatment field mask and the treatment field contour, is examined with this correlation method, and the superiority of using the treatment field mask is shown.

Deux sujets d'importance pour la vérification de traitements en radiothérapie, la segmentation et la corrélation des images portaux, sont adressés. En plus, un algorithme robuste qui segmente automatiquement des images portaux et qui enregistre une image par rapport à une image de référence est dévelopé. Des techniques morphologiques ont été appliquées intensivement à tour les niveaux de la section de segmentation dans l'algorithme, incluant la détection de bords jusqu'à l'extraction de traits. L'amélioration de bordures, un sujet d'importance, est souligné. La performance de la technique morphologique de la détection de bordures sur des images portaux est comparée à celle des opérateurs de gradients locausx et des détecteurs de bordures tout en justifiant l'avantage de la technique morphologique et celle de segmentation. Le masque du champ de traitement est utilisé comme point de repére pour la corrélation des images sijulateurs et portaux qui est accomplie en mettant ensemble les moments d'inertie des points de repère. L'effet d'utiliser le masque de champ de traitement ou le contour du champ de traitement comme point de repère pour cette méthode de corrélation est examiné, et la supériorité obtenu en utillisant le masque est démontrée.

Supervisor: B. Gino Fallone

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*Université de Montréal,*
*Montréal, QC. Institut de génie biomédical*

Yves Archambault

**Réalisation, par méthode Monte Carlo, et validation d'un simulateur pour la médecine nucléaire**

M.Sc.A.

Dans le but de valider une approche *voxels* pour la représentation des objets lors de simulations Monte Carlo en médecine nucléaire, deux simulateurs ont été développés. L'un utilise des *voxels* pour représenter les objets et l'autre utilise plutôt des expressions analytiques. Les simulateurs tiennent compte des effets d'atténuation et de diffusion de la radiation.
Le simulateur utilisant le modèle analytique a été validé en comparant ses résultats avec ceux d'un simulateur du Conseil National de Recherche du Canada et avec des résultats expérimentaux. Le simulateur basé sur le modèle analytique a ensuite servi de point de comparaison pour la validation du simulateur utilisant les *voxels*. La comparaison a été réalisée en simulant une source $^{99}Tc^{m}$ placée à différents endroits dans un cylindre d'eau de 21 cm de diamètre et de 20 cm de haut puis au centre de cylindres d'eau de différents diamètres. Les spectres énergétiques obtenus avec le modèle analytique puis avec six dimensions de *voxels* ont été comparés à l'aide de trois paramètres: l'écart maximal, le rapport des aires et la fraction de diffusé dans une fenêtre énergétique de 20% à 140 keV.
Les résultats de cette comparaison ont démontré la validité du modèle proposé. Ils ont aussi permis de suggérer une norme pour la dimension maximale des *voxels* à utiliser pour des sources de $^{99}Tc^{m}$ dans l'eau. Des *voxels* de 2,5 mm d'arrête permettent de représenter adéquatement des objets aussi petits qu'un cylindre de 2,625 cm de diamètre. Avec cette dimension de *voxels*, le spectre énergétique d'une source de $^{99}Tc^{m}$ est identique à celui obtenus avec le modèle analytique à 2% près.

In order to validate a voxels based Monte Carlo approach in Nuclear Medicine, two simulators, representing volumes analytically and with voxels, were developed. The simulators include attenuation and diffusion effects.
The simulator using the analytical model for volume representation was validated both with a Monte Carlo simulator from the National Research Council of Canada and with experimental data. It was then used as a reference in the validation of the simulator using

voxels to represent volumes. To achieve the comparison between the two models of volume representation, $^{99}Tc^{m}$ line sources were simulated at different positions in a water cylinder (21 cm diam. and 20 cm height) and at the centre of water cylinders of different diameters. The energy spectra obtained with the simulator using the analytical model and with six different voxel sizes were compared using three parameters: maximum error, total signal ratio and scatter fraction in a 20% energy window centred at 140 keV.
The results from this comparison showed the validity of the model that has been proposed. An upper limit in voxel size was also suggested for the simulation of $^{99}Tc^{m}$ sources in water. 2,5 mm voxels represented well enough objects as small as a 2,625 cm diameter cylinder to fit the energy spectrum of the analytical model to within 2% for sources at any position in that cylinder.

Superviseurs: Robert A. Leblanc et Robert Ouellet

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Etienne Roussin

**Analyse de l'impact de diverses méthodes de traitement d'image sur la quantification des radiotraceurs en médecine nucléaire**
M.Sc.A.

Bien que la tomographie par émission de photon unique contrôlée par ordinateur (SPECT) soit maintenant une procédure clinique courante en médecine nucléaire, le problème de l'atténuation des photons persiste toujours lorsque la distribution des coefficients d'atténuation du milieu étudié n'est pas homogène. De plus, la détection de photons diffusés est reconnue comme étant une des sources majeures de l'imprécision des images obtenues en SPECT. La quantification absolue de la concentration de radioactivité d'un milieu passe obligatoirement par la correction de ces processus de dégradation de l'image. Une connaissance précise de la distribution des coefficients d'atténuation du milieu et de la distribution spatiale des photons diffusés devrait donc permettre d'obtenir une amélioration de la quantification de la concentration d'un radio-isotope.
Dans ce travail, une étude comparative des performances quantitatives de deux méthodes de compensation d'atténuation utilisant une carte de la distribution spatiale des coefficients d'atténuation obtenue par tomodensitométrie a été effectuée. La première méthode corrige l'effet de l'atténuation après la reconstruction en calculant l'atténuation moyenne subie par chaque pixel, alors que dans la deuxième méthode, de nouvelles projections corrigées sont générées en utilisant la coupe transverse non-corrigée. De plus, la comparaison des performances de deux méthodes de correction de la diffusion a aussi été réalisée. La distribution des photons diffusés est représentée par une fonction mono-exponentielle dans la première technique alors que dans la seconde estime cette distribution à l'aide d'une acquisition effectuée dans une fenêtre énergétique secondaire.
Les coupes transverses corrigées de trois cylindres de concentration et de taille différentes placés à l'intérieur d'un autre cylindre rempli d'une concentration de base ont été comparées avec les coupes transverses correspondantes qui ont été générées de façon analytique et qui représentent les cas sans la présence des phénomènes d'atténuation et de diffusion. Les effets de la variation du ratio des concentrations, de la taille de la source et de l'amplitude du bruit statistique ont été étudiés.
Les coupes transverses d'une source linéaire introduite à différentes positions dans un mannequin d'acrylique plein ont été utilisées pour établir la comparaison entre les deux méthodes de compensation de la diffusion. Elles ont été comparées avec les images de la même source placée aux positions correspondantes dans l'air.
Nos résultats ont démontré que les deux méthodes de compensation de l'atténuation permettent d'obtenir une quantification plus précise. Cependant, lorsque le ratio des concentrations augmente, les deux méthodes ne réussissent pas à compenser de manière adéquate pour l'atténuation. De plus, l'application des deux méthodes de compensation de la diffusion améliore le contraste et la résolution spatiale. Par contre, les deux méthodes éprouvent des difficultés lorsque la source est de petite taille.

Superviseurs: Robert A. Leblanc et Robert Ouellet

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***University of Toronto***
*Department of Medical Biophysics*

Jeffrey William Byng

**Quantitative Analysis of Mammographic Densities**
M.Sc.

Quantitative classification of mammographic parenchyma can provide one of the strongest estimates for the risk of developing breast cancer. Existing quantitative classification schemes, however, are limited by coarse category scales and subjectivity which can lead to sizeable inter- and intra- observer

variations. Two approaches to provide more quantitative and reliable characterizations of digitized film-screen mammograms were investigated. The first, employed interactive thresholding to measure the proportion of radiographic density in the mammogram. This technique although interactive is very reliable (intra-class correlation coefficient between observes typically R > 0.9) and provides a quantitative measure which is well correlated, R > 0.91 (Spearman coefficient), with subjective classifications of radiographic density by radiologists. A direct automatic quantitative classification of mammographic parenchyma, was investigated through a third order moment about the mean of the histogram of pixel values in the breast image. When calculated as the average of local measurements, this automatic measure is well correlated with the classification of density by radiologists, R = -0.88 (Spearman coefficient).

Supervisor: Martin Yaffe

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Steven Francis de Boer

**Investigation of Scintillator and Fibre Light In plastic Scintillation Dosimetry**
M.Sc.

Plastic scintillation dosimetry is a new and promising method of measuring dose in radiation therapy beam. In this dosimetry system the light signal produced in the miniature scintillator is transmitted to a photomultiplier tube via fibre optic cables. This system offers many advantages over conventional dosimetry methods. However an undesired, radiation-induced light signal is produced in the optical fibres. Investigation of this new dosimetry system focuses on methods to increase the scintillator to fibre light ratio. Examination of the Cerenkov light produced in the fibre light has led to the development of equations that describe the collection of this light as a function of the fibre orientation within the electron beam for different fibres and different electron beam angular distributions. The focus of this investigation has determined that an increase in the scintillator to fibre light ratio of a factor of 2.1 is achievable by scintillator light shifting and optical filtering of the fibre light signal. An additional factor of 7.1 is expected by theoretical analysis of the addition of coatings to the surface of the scintillator.

Supervisor: J.Alan Rawlinson

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Rebecca Fahrig

**Optimization of Spectral Shape for Digital Mammography**
M.Sc.

It has been proposed that breast cancer detection can be improved through the use of digital mammography. We hypothesize that the choice of proper spectral shape can lead to significant improvements in image signal-to-noise (SNR) for a given dose. To test this hypothesis, an energy transport model incorporating recently measured breast tissue attenuation coefficients and exposure to dose conversion values was developed to describe the image acquisition process. The model has been verified experimentally. The applied kV and filter for Mo and W target x-ray sources has been optimized with respect to SNR and absorbed dose. For detectors based on a $Gd_2O_2S$ scintillating screen, a 40% improvement in SNR can be achieved, for a practical imaging time, if the optimum filter-kVp combinations are chosen. Maximum SNR for both infiltrating ductal carcinoma and calcifications is provided by a single filter-kVp combination. The model can now be used to compare and improve upon novel detector designs.

Supervisor: Martin Yaffe

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Ronald John Lalonde

**Field conjugate acoustic lenses for ultrasound hyperthermia**
Ph.D.

The treatment of deep seated tumours in hyperthermia is limited by the ability to focus heating energy into a specific target volume. We have created a method of designing acoustic lenses for generating complex, 3-dimensional ultrasound focus patterns using a single (focused or unfocused) ultrasound source. The lenses minic the focusing abilities of a 2-dimensional ultrasound phased array. Heating experiments in homogeneous and inhomogeneous perfused phantoms have confirmed the ability of these lenses to heat in perfused tissue. Three-dimensional temperature distributions produced by these lenses in homogeneous phantoms closely match predictions of a transient 3-dimensional finite difference thermal model.

Combining lenses with variable frequency transducers allows electronic scanning and scaling of the ultrasound focus patterns. The variation of focus pattern with frequency can be predicted from Fresnel diffraction equations, and these predictions have been confirmed experimentally.

We have also developed a method of optimizing the ultrasound focus distribution based on termperature constraints in target field. The method assumes a

"worse case" scenario of high, uniform tissue perfusion acting as a heat sink in the bio-heat equation. The optimization method may be performed for any 3-dimensional volume, and for steady state or transient heating. Transient, high temperature treatments have the advantage that they greatly reduce temperature variations in hyperthermia caused by non-uniform tissue perfusion.

Supervisor: J. Hunt

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Bruno Madore

**Motion Artifacts in Fast Spin-Echo MRI**
M.Sc.

Magnetic resonance imaging (MRI) has now become a routinely used diagnostic imaging modality. However, the relatively long time required for the acquisition of an image makes MRI vulnerable to motion problems.
The use of fast pulse sequences has partly solved the motion problem. Fast spin-echo (FSE) is a pulse sequence which may give images of diagnostic quality, in a time shorter than a breathold, eliminating respiratory artifacts. But motion is a problem even in FSE imaging since motions of relatively high frequency, like the heartbeat, still generate artifacts.
In the present work, the ghosting process in FSE imaging is analyzed. The point spread function (PSF) of a moving point was calculated for FSE imaging. Experimental data have been acquired by imaging a moving liquid sphere of diameter 1.5 mm, and the agreement with the calculated PSF is shown to be excellent. It has been found that motion artifacts in FSE arise from the convolution of two distinct band patterns, one of which may dominate the convolution giving its own spacing to the overall result. For other acquisition parameters, the convolution gives rise to an intricate pattern, which may appear to lack overall structure.
The equation for the PSF of a moving point and the knowledge of the ghosting process in FSE imaging should help us to apply existing motion correction methods to FSE imaging, or to find new ways of approaching the motion problem in FSE imaging.

Supervisor: Mark Henkelman

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Andrew D. A. Maidment

**Scanned-Slot Digital Mammography**
Ph.D.

The propagation of signal and noise is examined in x-ray detectors for digital mammography. The detectors consist of a phosphor screen optically coupled to a charge-coupled device (CCD) image array. The following have been investigated: 1) a method by which optical coupling efficiency can be measured and modelled, with emphasis on the angular emission and transmission of light; 2) the noise and signal handling requirements (i.e. dynamic range of the detector for specific imaging tasks; 3) the effect of the coupling efficiency on a) zero spatial-frequency detective quantum efficiency (DQE) and b) spatial-frequency-dependent DQE. It is important to ensure that the dominant noise source in the recorded image is due to x-ray quantum fluctuations. This consideration affects the choice of every component in the imaging system. It was found that a detector suitable for digital mammography requires a dynamic range of 3000. Using this detector, 12 bits of data per pixel should be recorded. Although conventional zero spatial-frequency DQE analysis indicates that x-ray quantum-noise-limited images can be obtained with a coupling efficiency on the order of 1 electron ($e^-$) per x-ray, spatial frequency dependent analysis showed that on the order of 10 $e^-$/x-ray are required to achieve this condition at high spatial-frequencies. These results were used to design a scanned-slot digital mammography detector in which a phosphor screen was coupled to a time-delay integration CCD image array with a 2:1 demagnifying fibre-optic taper. The scanned-slot format provides dose-efficient scatter reduction and rapid scan times (3 to 8 seconds per image). In an analysis of the first prototype, described herein, a coupling efficiency of 6.1 $e^-$/x-ray was measured. With planned improvements, this value should increase 5-fold. In experiments, it was found that the limiting resolution was 9.5 line pairs per mm, and that DQE(f) = 0.29 at 0 $mm^{-1}$. Phantom images demonstrate that the digital system possesses contrast sensitivity and latitude which exceeds those of film screen systems.

Supervisor: Martin Yaffe

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Sandra Joan Stapleton

**Investigation of Factors Affecting Quantitative Analysis of 99mTc-HMPAO SPECT Images**
M.Sc.

Quantitative techniques of evaluating $^{99m}$Tc-HMPAO SPECT images have the potential to provide objective, sensitive, and reproducible methods of measuring blood flow deficits, and measuring the change in deficits in patient images taken weeks or months apart. Two important factors limiting our ability to obtain useful information from the images are: 1) improper spatial orientation of the patient data set, and 2) the non-linear uptake of HMPAO across the blood-brain barrier. Applying corrections for these factors improves both the reliability of observer assessments of deficits, and the degree of correlation between count values and underlying blood flow

levels. Since normal variations in blood flow have not been quantified, an observer-defined threshold is often used to classify quantitative measurements of blood flow deficits as significant or not. The threshold value is observer-dependent; however observer variability is reduced when a suitable colour intensity mapping scale (rather than a grey scale) is used to display the images.

Supervisor: Martin Yaffe

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Wei Zhao

**A Flat Panel Detector for Digital Radiology Using Self-Scanned Readout of X-Ray Photoconductor: Fundamental Study of Feasibility**
M.Sc.

We are proposing a new concept for making a large area, flat-panel detector for digital radiology. It employs an x-ray sensitive photoconductor to convert incident x-radiation to a charge image which is then electronically read out with a large area integrated circuit. The large area integrated circuit is called an active matrix and it consists of a two dimensional array of thin film transistors. The image readout of the detector can be performed in real-time (30 frames per second) and thus can potentially be applied in both radiography and fluoroscopy. The potential advantages of the flat panel detector for digital radiography include: instantaneous digital radiographs without operator intervention; compact size approaching that of a screen-film cassette thus compatible with the existing x-ray equipment; better detective quantum efficiency than phosphor screen based systems. Its advantages over the x-ray image intensifier (XRII) / video systems for fluoroscopy include: compactness; no geometric image distortion; better image contrast resolution. The feasibility of the detector for digital radiology was investigated based on the properties of one type of photoconductor (amorphous selenium) and active matrix (cadmium selenide). The results showed that it can potentially satisfy the detector design requirements for radiography (e.g. chest radiography and mammography). For fluoroscopy, the images can be obtained in real-time but the detector is not quantum noise limited below the mean exposure rate typically used in fluoroscopy. Thus the focus of our future work is to overcome the practical difficulties in making the detector feasible for radiography and investigate methods for improving the x-ray sensitivity and noise performance of the detector for its application in fluoroscopy.

Supervisor: John Rowlands

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*University of Western Ontario,*
*London, ON, Department of Medical Biophysics*

Maria Drangova

**Computed tomography scanner for dynamic vascular imaging in vitro convocation date**
Ph.D.

A dynamic computed-tomography (CT) scanner has been developed for imaging objects undergoing periodic motion. The scanner has high spatial resolution and sufficiently high temporal resolution to produce quantitative tomographic images of objects, such as excised arterial samples perfused under physiological pressure conditions.

The dynamic CT scanner is comprised of a modified x-ray image intensifier (XRII) coupled to a 1024-element linear photo-diode-array detector. The XRII was modified to allow continuous electro-optical magnification of the field-of-view, thereby increasing the system's limiting resolution. High-resolution gated projection radiographs of a single slice are acquired at the rate of 60 Hz, as the object undergoes periodic motion. If the moving object is rotated through 180°, and projections are obtained at many view angles, tomographic images at different phases of the object's motion cycle can be reconstructed. Performance evaluation of the scanner showed that tomographic images can be obtained with resolution as high as 3.2 $mm^{-1}$, with only a 9% decrease in the resolution limit for objects moving at 1 cm $s^{-1}$. Quantitative measurements of attenuation coefficient are obtained with an accuracy of $\pm 0.02$ $cm^{-1}$, and the accuracy in geometrical measurements of perimeter is $\pm 0.3$ mm.

To evaluate the application of the system for imaging of intact excised vascular specimens under simulated physiological conditions, a computer-controlled flow simulator was built and used in the measurement of dynamic arterial distensibility. The flow simulator can reproduce physiological flow waveforms (including waveforms with reverse components) with a precision of $\pm 0.1$ ml $s^{-1}$.

Existing techniques for the measurement of the static and dynamic elastic properties of excised vessels were adapted to take advantage of the additional data from the CT images and were used to demonstrate the utility of the CT scanner for applications in vascular research. Using these techniques, the local static and dynamic circumferential modulus of elasticity can be measured in intact arterial samples. Since the imaging

technique is non-destructive, the mechanical properties of these vessels can be correlated directly with the composition of the vascular wall. This new system, together with the described techniques, offers a unique opportunity for studying dynamic events in vitro.

supervisor: Aaron Fenster

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Daryoush Sheikh-Bagheri.
**Verification imaging for High-Dose Rate Brachytherapy.**
M.Sc.

In High Dose Rate (HDR) brachytherapy, no method currently exists to check at the start or during the treatment that the 192Ir source has been positioned, as prescribed, with respect to the patient's anatomy. One way to monitor the position of the source inside the patient is to use x-ray fluoroscopy. The problem with this approach is that photons emitted by the treatment source (192Ir, 65-885 keV) interact with the x-ray image intensifier (XRII) of the fluoroscopy system, producing extraneous x-ray quantum noise and degrading image quality. We have used the Monte Carlo method (EGS4) to simulate the interactions of 192Ir photons with the patient and the x-ray detector of an XRII. The goal is to understand what factors influence the amount of energy absorbed in the phosphor of the XRII, from 192Ir photons. We have also calculated the quantum noise added by the 192Ir photons to the image, taking account of the absorbed energy distribution in the CsI phosphor. Our results show that 192Ir photons scattered within the patient are mainly responsible for degradation of the image quality. The scattered 192Ir photons are distributed in the energy range (15-200 keV) which is markedly lower than the average energy of the primaries (360 keV) and therefore interact more efficiently with the detector. The energy absorbed by the XRII from scattered 192Ir photons is 5 to 55 times greater than that from the primary 192Ir photons (with a 10 cm air gap between the patient and XRII). Our experiments show that the amount of the extraneous signal produced in the XRII by the 192Ir source, becomes appreciably larger when the 192Ir source is positioned inside the patient. For a 10 cm air gap the signal-to-noise ratio (SNR) can decrease by factors ranging between 2 - 10, depending on the position of the 192Ir source inside a 30 cm thick water phantom. In typical clinical situations, a focused grid (Pb, 12:1, 40 lines/cm) can increase the SNR by about a factor of two. Furthermore, the SNR rapidly increases with increasing air gap, such that a 20 cm air gap can be as effective as a 12:1 air interspaced grid. Our results suggest that use of an appropriate diagnostic x-ray fluence, air gap and grid can make the fluoroscopic verification of source position in HDR brachytherapy feasible. This can improve the quality assurance of such cancer treatments.

Supervisor: Peter Munro

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Michael Steckner
**Computing the Modulation Transfer Function of MR Imagers**
Ph.D.

The quality of images produced by imaging devices of all types can be analyzed and quantified by a variety of metrics. Resolution is an important metric for all imaging devices because if the resolution characteristics do not meet the minimum requirements of an application, the resultant image may be unsuitable and possibly misleading. One resolution metric, called the Modulation Transfer Function (MTF), describes the ratio of input to output signal magnitude as a function of spatial frequency. Application of the MTF is limited to systems whose output scales linearly with input (linearity) and produces the same output image regardless of object position (shift invariance). Although a variety of experimental MTF analysis techniques have been developed for a range of imaging devices, no suitable technique has been developed for a linear, shift invariant (within sub-regions) medical imaging modality called Magnetic Resonance Imaging (MRI). Magnetic Resonance Imaging is the three dimensional imaging modality of choice for detecting various soft tissue pathologies in the head, spinal cord and other anatomical regions of the human body. Unfortunately, most MR images are produced by the magnitude Fourier Transform (FT) reconstruction algorithm, a non-linear method which is not amenable to previously developed MTF analysis techniques. A new MTF analysis method, presented here, and developed specifically for MRI, eliminates the errors caused by the magnitude operator in the reconstruction algorithm by using the complex image formed just prior to the magnitude operator and modifying the MTF theory accordingly. Tests with experimentally produced MRI data have confirmed the feasibility of the new technique by producing accurate MTF's which agree with theoretically predicted resolution characteristics.

supervisor: Dick Drost

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W.T. Ivan Yeung

**Contrast Enhanced CT Measurement of Blood-Brain Permeability in Human Brain Tumors**

Ph.D.

A contrast enhanced CT method was developed for measuring the blood-brain permeability (K) and cerebral plasma volume (Vp) in human brain tumors in-vivo. In patient studies, Isovue 300 (iopamidol) was injected intravenously at a dosage of 1 ml/kg patient body weight. It was followed by serial head scanning of the tumor and arterial blood sampling to measure the contrast concentration in tumor and arterial plasma respectively. The leakage of iopamidol into the brain through the blood-brain barrier was modelled as an exchange process between two compartments, namely, the intravascular plasma space and the tissue interstitial space. using this compartmental model and concentration measurements in tissue and blood plasma, quantitative estimates of K and Vp were obtained with non-linear regression.

In a preliminary study of 12 patients, the average K and Vp in brain tumors were found to be 0.0273+/- 0.0060 ml/min/g and 0.068+/- 0.11 ml/g respectively. These values were found to be significantly higher than those in the contralateral "normal" hemisphere ($p<0.05$).

To increase the efficiency of the CT method in a clinical environment, an absorptiometry method was developed to measure contrast concentration in blood automatically. This method was based on the principle of single photon absorptiometry and was found to measure the arterial contrast concentration with a 5% uncertainty in patient studies.

Error analysis on the K estimate by the CT method was studied with sensitivity functions, computer simulations and covariance matrix formalism. The CT method was found to determine K in brain tumor with negligible bias and 5% uncertainty. In contrast, it determined K in normal brain with 14% bias and 73% uncertainty.

The CT method was used to study the effect of steroids on K in 10 patients. Each patient was studied twice: before and after 7 days of dexamethansone treatment of 16 mg/day orally. The results showed that K and Vp in brain tumor decreased by 32% ($p<0.01$) and 10% ($p<0.09$) respectively after dexamethasone treatment. Functional images which map these parameters were also found to be more sensitive in detecting changes in K than ordinary contrast enhanced CT images.

Supervisor: Ting Y. Lee

***Degrees outside of Canada,***

Matthew B. Podgorsak

**Radiation Parameters of High Dose Rate Iridium-192 Sources**

Ph.D., Dept of Medical Physics
University of Wisconsin

A lack of physical data for high dose rate (HDR) Ir-192 sources has necessitated the current practice of using basic radiation parameters measured with low dose rate (LDR) Ir-192 seeds and ribbons in HDR Ir-192 dosimetry calculations. A rigorous examination of the radiation properties of several HDR Ir-192 sources has shown that this extension of physical data from LDR to HDR Ir-192 may be inaccurate. For example, analysis of the photon energy spectrum measured for an HDR Ir-192 source gave a value of $(29.02 \pm 0.26) \times 10^{-18}$ Gy $m^2 Bq^{-1} s^{-1}$ ($0.441 \pm 0.004$ R $m^2 Ci^{-1} h^{-1}$) for the air kerma rate constant, significantly lower than the value now used by most HDR Ir-192 planning systems (30.66 Gy $m^2$ $Bq^{-1} s^{-1}$). Furthermore, the mean half-life for decay calculated from an analysis of decay curves measured for five clinically-used HDR Ir-192 sources was found to be $73.820 \pm 0.009$ days, in good agreement with the value determined by NIST (73.83 days), but different from the value of 74.0 days currently used in most treatment planning systems. Polynomial expressions modeling dose build-up in water and the air kerma-rate anisotropy due to source self-attenuation and oblique filtration through source encapsulation were derived from measurements made with several HDR Ir-192 sources. These expressions give correction factors different from those calculated by the models presently used in HDR Ir-192 treatment planning systems. The results of this work show that dosimetry errors of up to 0.3%, 6%, and 2% may occur when using the currently-accepted values of the half-life for decay and air kerma-rate constant coupled with the expression modeling the dose buildup effect, respectively. Use of the parameter values measured in this work may result in a reduction in the overall dose uncertainty for HDR Ir-192 implants.

Supervisor: Bhudatt R. Paliwal

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Thank you for your cooperation.

Dr. L. John **Schreiner**
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"Give me a hand here, boys! It's young Schreiner ! ... Dang fool tried to ride into the sunset!"