COMP OCPM
CANADIAN ORGANIZATION OF MEDICAL PHYSICISTS
ORGANISATION CANADIENNE DES PHYSICIENS MÉDICAUX

CANADIAN COLLEGE OF PHYSICISTS IN MEDICINE
LE COLLÈGE CANADIEN DES PHYSICIENS EN MÉDECINE

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FROM THE EDITOR:

In my first official role as the new Councillor for the Newsletter, I want to extend my appreciation to Albert Fung, who so ably guided the Newsletter for the past two years. Thanks to Albert, I think the Newsletter has taken on a much more important role for COMP/CCPM. I hope to continue the high standards set by Albert and I hope that you, the COMP/CCPM members, will continue to benefit from, and contribute to, the Newsletter.

It is often difficult to think of themes that will unite the variety of articles and announcements that are submitted for any one issue of the Newsletter. However, this issue is an exception. Examining all of the articles, two themes emerge; the scientific success of COMP/CCPM members and our international outlook. Stuart Foster has been awarded the Thomas W. Eadie Medal from the Royal Society of Canada, Brian Rutt has been awarded the Barnett/Ivey/Heart and Stroke Foundation of Ontario Chair at the Robarts Research Institute, Michael Westmore, Ian Cunningham and Aaron Fenster have been awarded the Sylvia Sorkin Greenfield award from the AAPM and Jack Cunningham has been awarded the Award of Merit from the IUPESM. These awards not only recognise the contribution to medical physics by COMP/CCPM members, but also demonstrate that we are increasing the recognition of medical physics as an important discipline. My heartiest congratulations to you all! Furthermore, COMP/CCPM members seem to be travelling internationally more than ever before. In this issue there are reports on the ASTRO meeting in Orlando, Florida; the World Congress on Medical Physics and Biomedical Engineering in Nice, France; the International Congress of Radiation Oncology in Beijing, China; and the 9th International Brachytherapy Conference in Palm Springs, California. Who says that Canadians are introspective!

Talking about meetings, the organisation of the CCPM Symposium and the COMP Annual Meeting, to be held from 18-20 June 1998 in London, Ont., is now taking place. As one of the members of the local arrangements committee, I encourage every COMP/CCPM member to attend. Traditionally, the COMP/CCPM meeting is the highest quality meeting that I attend. There is every reason to expect that the high quality will continue this year.

Also in this issue are some items that will be of interest to radiation therapy physicists. The AECB wants to encourage the development of nation-wide standards for quality assurance in radiation therapy and COMP/CCPM members have been asked to participate in their development. In addition, the CCPM and the CAMRT are collecting information on dosimetry training, with feedback requested from the COMP/CCPM community.

As you can see there have been some changes to the appearance of the Newsletter. Over the next several issues, I will endeavour to make the Newsletter even more readable. A long term goal is to get more content from the Newsletter onto the COMP/CCPM's web site. You will notice that the Newsletter banner carries an (updated) address for the COMP/CCPM web site.

Any feedback, especially positive, is welcome. And if you have any suggestions about how to improve the Newsletter or the COMP/CCPM web site, please let me know. Finally if you have any contributions (scientific successes, interesting graphics or photographs, humorous stories, gossip, information about people on the move, restructuring information, opinions, etc.) do not hesitate to send them this way!

Finally my congratulations to John Schreiner, who has recently been elected (or is that press-ganged?) into the position of Vice-President of the CCPM. I would further like to thank John for his efforts in compiling the abstracts of Canadian Medical Physics Theses for the 1996 calendar year.

Peter Munro

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COMP Chair's Report

Best wishes to all COMP members for a happy and productive 1998. With the passing of New Year's Day our annual cycle moves to the phase of focusing on our summer conference. This year we will meet in London Ontario, home of some of the strongest clinical and research medical physics groups in the country. Highlights of the meeting, being organised under the direction of Aaron Fenster, will include a welcome barbecue on the evening of Wednesday June 17; a CCPM Symposium on Functional Imaging plus a CCPM Workshop on dosimetry during the day Thursday, followed by an evening Poster Reception; the J.R. Cunningham Young Investigators' Symposium and the Banquet on Friday; the CAP Lecture and tours of facilities on Saturday; and a golf tournament on Sunday. Proffered papers will be given in the COMP sessions on Friday and Saturday. We anticipate that the corporate participation in our annual conference will continue to grow. Make plans now to attend what should be the largest COMP/CCPM conference to date.

Turning to other matters, the COMP Executive wishes to make more explicit the conditions for student membership. This membership category is heavily subsidised and is aimed exclusively at students studying towards a university degree. This category is not open to post-doctoral fellows, research associates, or clinical medical physics residents. A clear statement of the eligibility requirement, now added to the membership application and renewal forms, should eliminate confusion and result in fairness to all. For annual renewal of student membership, we are also requiring a signature from someone in authority verifying continuing eligibility. This is common practice in other societies.

On November 21 and 22 the COMP Executive, CCPM Board, and a number of their committees gathered in Ottawa for the annual mid-year business meetings of our two organisations. Efforts are being made to rationalise the endeavours of COMP and CCPM and to collaborate in several areas rather than make parallel efforts. Important changes coming from this are that the Professional Affairs Committee and the Radiation Regulations Committee have both been made shared committees of the COMP and the CCPM. The latter committee will centralise all the efforts previously done by one or the other organisation concerning radiation regulations, including responding to initiatives by the AECB, Health Canada, and provincial agencies such as HARP in Ontario.

We have now exchanged letters with the AECB (reprinted in this issue) concerning their interest in patient safety in radiotherapy. We believe it worthwhile for COMP and the CCPM to proceed towards developing national standards for radiotherapy quality assurance. Ervin Podgorsak has agreed to take responsibility to lead this effort, and will be assisted by Peter O'Brien, Clement Arsenault, and George Sandison. All four of these have recently agreed to serve on the Radiation Regulations Committee.

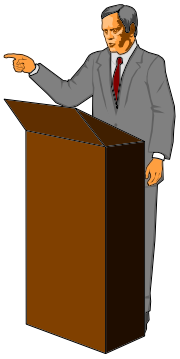
With regard to committee membership, there were additions to two other committees in 1997. Lee Gerig and Ting Lee have joined the Professional Affairs Committee, and Ken Shortt has joined the Awards Committee.

All of our committees have a lot on their plate in the current era. I thank the individuals named above, plus those that continue to serve, for their commitment.

And that brings me to my final topic for this issue, a topic which is always recurring: there is always opportunity to get involved in our national organisation. For example, the Professional Affairs Committee is currently seeking new members, and in 1998 there will be elections for the positions of COMP Secretary and Chair-Elect. No one on our Executive or committees will claim that life there is easy, but serving on committees or on the Executive gives a perspective on Canadian medical physics which has its own rewards. If you have interest in working on the common professional and scientific goals of the Canadian medical physics community please do not hesitate to make yourself known.

Paul Johns

President's Report



The annual mid-winter meeting of the Board of the Canadian College of Physicists in Medicine was held in Ottawa on 21st and 22nd November 1997. As has been our practice over the last few years we met in conjunction with the COMP Executive and the various committees.

The most important item on our Agenda was to rationalise, with COMP, committee structure to avoid duplication, to minimise confusion both within and outside the medical physics community and to enable us to respond rapidly to changes or potential changes in our external environment. Paul Johns and I will prepare a detailed description, with rationale, of the new CCPM/COMP committee structure for the next Newsletter. Here it is sufficient to point out that the Professional Affairs and Radiation Regulations Committees will report to the joint executive of the CCPM/COMP as will the newly formed Finance Committee.

I believe this reconfiguring of our committee structure will be of significant tangible benefit to the Canadian medical physics community and it does address almost all of the organisational difficulties we have encountered in recent years. Watch the next Newsletter for more details.

The specifically College issues which were addressed by the Board were several. John Schreiner most graciously accepted the position of Vice President of the College. This position was vacated by Ron Sloboda in the summer. John will take over from me at an appropriate time during the next year and a half.

The questionnaire generated by the joint CCPM-CAMRT working group on a special credential for dosimetrists should be distributed to all cancer centres in the country in the first half of January. This is a major collaborative effort between two national organisations representing complementary professions. My request is that you consider the issues raised in the questionnaire carefully and that you do take the time to respond.

The issue of the College's role in accrediting mammography physicists was on the Agenda again. There will be a motion presented in London to deal finally with this issue. Prior to that meeting the motion will appear in these pages.

The Board is aware of the ABR's project to review and probably revise its certification process. There are also moves in Europe to achieve a greater measure of uniformity in the various national certification processes. Our own process will have very limited credibility if it is not recognised or at least consistent with certification protocols outside the borders of our country. It has to be a priority of the College to maintain the reciprocity arrangements we currently have and to seek the wider recognition of CCPM certification.

Peter Dunscombe

39th Annual Meeting of ASTRO
Orlando, Florida, October 19-23, 1997

Peter Munro
London Regional Cancer Centre

The 39th annual meeting of the American Society of Therapuetic Radiology and Oncology was held at the Orlando convention centre. Home of Disney World, the Magic Kingdom, and EPCOT, Orlando also boasts one of the largest convention facilities in the United States. Indeed, in 2002, the annual meeting of the Radiological Society of North America will be held in Orlando, the first time in over 15 years that the RSNA will not be held at McCormick Place in Chicago.

Having not been a regular attendee of the ASTRO meeting, I was impressed by some aspects of the meeting. While there are relatively few scientific sessions dealing with physics topics, the opportunities for continuing education are great. Every morning at 7:15 a.m. there are a wide variety of refresher courses covering many aspects of radiation oncology including: 3-D conformal radiation treatments, on-line portal imaging, stereotactic radiosurgery, information systems for radiation oncology departments, breast cancer, prostate cancer, head and neck cancer, and even intra-vascular irradiation for preventing restenosis. The number of topics covered is truly impressive.

While it is difficult to summarise such a large meeting comprehensively, there were a number of topics that were especially interesting to me including radiation and vascular restenosis, Monte Carlo treatment planning, and Outcomes Research.

Radiation and Restenosis

Since its inception almost exactly 20 years ago (in Switzerland), balloon angioplasty has become the preferred treatment to correct blockages of coronary vessels. Approximately 900,000 of these procedures are performed world-wide each year. Unfortunately, a large fraction (between 25-50%) of the vessels treated this way will restenose leading to (perhaps) more invasive by-pass surgery. In the past 4-5 years, much excitement has been created by the observation that radiation can prevent restenosis in many vessels, if it is applied 0-2 days after the balloon angioplasty procedure. This field is still in its infancy, and there are many unanswered questions including: how the radiation should be delivered (intra-vascular versus external beam), whether centring of the radioactive source in a blood vessel is important for success, whether beta or gamma sources should be used for intra-vascular irradiation, whether too low of a radiation dose can stimulate rather than prevent neointimal formation, whether the right coronary artery responds differently to radiation than other coronary vessels, and many other controversies. Perhaps the most important controversy is why can radiation lead to vessel stenosis (e.g., stereotactic radiosurgery) or prevent restenosis?

To understand some of the effects of radiation, one must have some background about the restenosis process. Balloon angioplasty is quite injurious, rupturing the various layers (intima, media, adventitia) of the vessel wall. In response to this injury, various events such as thrombosis, vascular recoil, neointimal hyperplasia, and vascular remodelling can occur, leading to a reduction in the diameter of the vessel. Radiation appears to be effective in preventing the proliferation of the smooth muscle cells (neointimal hyperplasia) and in preventing the process of negative remodelling, where the vessel architecture changes (somewhat like a scar formation). While the exact mechanism of how radiation prevents restenosis is unknown, a fascinating theory was proposed at this meeting by Philip Rubin (the former editor of the Int.J.Radiat. Oncol.Biol.Phys.). He believes that radiation destroys monocyte derived macrophages, the cells that are charged with initiating the wound healing process. Without these cells, Rubin hypothesises that the resulting healing process is not as intense as normal wound healing, so that smooth muscle cells are not stimulated to proliferate and the various processes that lead to negative remodelling do not occur.

There are a large number of technologies that are being investigated to deliver the radiation dose. These include intra-vascular ^{192}Ir gamma sources, intra-vascular Sr/Y beta sources, and radioactive stents. (Stents are metal scaffolding that are sometimes placed in vessels to prevent the vessel from collapsing.) In addition, two very novel approaches were described at this meeting: the "hot arteries" irradiator and the intra-vascular x-ray source. The "hot arteries" irradiator is a catheter, which contains ^{99m}Tc, with nipples along its side. The ^{99m}Tc, which is packaged within liposomes so that it will be lipophilic, is released from the nipples - resulting in a form of unsealed source radiation therapy. Preliminary studies in pigs suggest that 10% of the radiation remains incorporated within the vessel wall 40 minutes after release. The intra-vascular x-ray source, which is being commercialised by Interventional Innovations Corporation, is a miniature x-ray tube that was originally developed at the Lawrence Livermoor National Laboratory. The concept is to miniaturise a stationary anode x-ray tube and have high voltage cables transmit power from an external high voltage power supply to x-ray tube. The x-ray tube must be operated in a pulsed mode of operation to avoid overheating. Thus, the technologies for intra-vascular irradiation range from the familiar (HDR sources) to the (almost) unbelievable.

It is clear from the refresher courses that I attended (there were three 90 minute courses on this topic) that the use of radiation to prevent restenosis is an extremely dynamic field. It appears certain that if this form of treatment becomes adopted widely, that there will be an increased demand for medical physicists to set-up and maintain intra-vascular irradiation programs. For more information about the intra-vascular x-ray tube see: http://www.llnl.gov/PAO/NewsReleases/April96/NR-96-04-02.html For more information about an upcoming conference on radiation and restenosis see: http://www.radiationonline.com.

Monte Carlo Treatment Planning

The Lawrence Livermoor National Laboratory has been instrumental in the development of the Peregrine Monte Carlo code. Initiated in 1992, the Peregrine Monte Carlo code is capable of modelling neutron, proton, photon and electron transport. Keys to the development are: sophisticated programming techniques to produce code that runs efficiently, "turning off" of physical events that have no effect on the final results (e.g., photon only calculations in the beam generation section of the code, definition of the beam definition plane at the isocentre to allow efficient sampling, and high cut-off energies in the patient region), and the development of an "affordable" parallel processor computer that can run the code. Current calculation times are 20 minutes per plan (~ 200 million histories), but the developers are confident that this will decrease to 2 minutes per plan within a year. While there were few details available about the hardware and software, it is clear that the developers are very knowledgeable about the dose computation needs in radiation oncology. They have formed a medical physics advisory council (MEDPAC), whose members include almost all of the big names in treatment planning and conformal radiation therapy (e.g., Rahde Mohan, Rock Mackie, Art Boyer, Michael Goitein, Ken Hogstrom, Jin Purdy, Lynn Verhey, ...). The approach that the Peregrine developers have taken is not to develop a treatment planning system, but to create a dose computation engine that can be attached like a file server to any commercial treatment planning system. The developers have been talking with several treatment planning vendors (ADAC, CMS) and they claim that by this time next year, Monte Carlo calculations on a commercial treatment planning system will be available. Many details need to be worked out and it remains to be seen whether Monte Carlo treatment planning will be available within a year. For more information see: http://www-phys.llnl.gov/peregrine

Outcomes Research

One of the keynote speakers, John Eisenberg, who is the administrator of the Agency of Health Care Policy and Research (which is part of Department of Health and Human Services), presented a lecture entitled "Measuring Outcomes in Radiation Oncology - What's the Difference?". The outcome of medical procedures is an area of increasing importance for both patients and (in the USA) the insurance companies paying for the procedures. The AHCPR has established a program (called the evidence-based practice initiative) to document the variations in medical practise and the variations in outcome throughout the United States. Any organisation or interested party can suggest procedures that should be investigated and the AHCPR contracts research institutions to perform the studies. Currently 12 institutions have received five-year contracts to examine a number of topics including: swallowing problems in the elderly, secondary complications of paralysis, depression, and the use of testosterone for treatment of prostate cancer. One of the more interesting developments is that by the fall of 1998 the AHCPR plans to create a National Guideline Clearinghouse, which will be an Internet-based listing of all of the guidelines for treatment of various medical conditions. Physicians will be able to use these guidelines to help them decide on the appropriateness of various procedures. The long term goal is to make health-care more uniform and "cost-effective". For more information about the Agency for Health Care Policy and Research see http://www.ahcpr.gov/ and for more information about their various programs see: http://www.ahcpr.gov/offices/about.htm.

Trends

There were some interesting trends in the exhibitors booths. Intensity modulated treatments are becoming a reality, with all accelerator manufacturers offering products for this type of treatment. The use of networks to link all of the sources of information in a radiation oncology department are becoming more common, and importantly, it appears that these networks are improving so that they solve real clinical problems (e.g. transferring patients from one accelerator to another in case of a break-down and facilitating communication between therapists and radiation oncologists). There are also major changes among the accelerator vendors. GE (formerly CGR/MeV) has stopped producing linear accelerators and their European service business has been taken over by Varian. I would not be surprised to see further consolidation among accelerator vendors in the coming years. Finally, while there is no definite news, rumours are flying that most accelerator vendors will announce a new generation of portal imaging systems within the next year based on amorphous silicon technologies. These should offer much improved image quality and larger fields of view compared to existing devices.

International Congress of Radiation Oncology
Beijing, China, June 5-7, 1997

Peter O'Brien
Toronto-Sunnybrook Cancer Centre

This international meeting is held every 3 years and organised by the International Society for Radiation Oncology (Present Chair - Dr. J.C. Horiot (France)). There was a large European presence at the meeting and a relatively small North American contingent. There were 6 or 7 Canadian medical physicists and perhaps a dozen Canadian radiation oncologists in a total of a few thousand participants. The meeting was organised with parallel sessions including a series of Teaching sessions, a series of topical Symposia and proffered papers including a physics series. There was a large poster session completely dominated by Chinese and other Asian contributors. The Symposia and Teaching Sessions dealt with current and controversial topics and the speakers usually were world authorities on the topic. These formed the most interesting part of the meeting. From a physics/technology perspective there was the usual emphasis on modern tools and techniques for precision, conformal radiation treatment. The Conference Lecture was one of the highlights of the meeting, titled "Conformal radiotherapy: biological basis and physical approaches" and delivered impeccably by Dr. Cliff Ling, the Head of Medical Physics at the Memorial-Sloan Kettering Institute in New York and a native of China.

Some of the items that caught my interest were:

1. A session on "special modalities" which highlighted the difficulties in target delineation, noting for example, that prostate defined on MR can be 30% smaller in volume than the same prostate defined by CT.

2. Several sessions on hyperthermia, a modality which does not get much air time in North America, described clinical results in Japan, China, and Europe.

3. An excellent symposium on Fractionation with talks by Bernard Cummings (PMH), Jack Fowler (Belgium) and Jens Overgaard (Denmark). There were considerable differences of opinion in this session with the clinical high ground clearly being taken by the Danish clinical trials group (DAHANCA). They presented results of a careful series of clinical trials culminating in the 7th trial which demonstrates a large tumour control and survival advantage for head and neck patients (supraglottic and pharynx) when overall treatment time is reduced and treatments are given at 6 fractions per week instead of 5.

4. An unexpected variety of Chinese equipment suppliers at the show, including the manufacturers of a rotating multi-source cobalt unit which supposedly combines the best of linac and gammaknife features for stereotactic radiosurgery. There is a curious mixture of very old and very modern technology in China combined with a shortage of trained technical staff. In China, the ratio of radiation oncologists to medical physicists is 17:1 compared to a North American average of 2:1.

The Congress was held in the Beijing International Convention Centre, a complex which includes a hotel, recreation centre and meeting rooms. The exterior impression of all these facilities is impressive but signs of wear were evident in this fairly new complex, built for the Asian Games. The only problem at the presentations was the Audio-Visual equipment which was not up to par.

China is a fascinating place to visit. The airport in Beijing is like a scene from the "Manchurian Candidate" - completely chaotic. Outside, traffic was congested and not orderly - anything goes. We travelled from the airport to the city down a tree-lined expressway with high-rise construction in the distance and a mixture of Mercedes-Benz and foot-powered carts on the side roads. The city is huge and full of contrasts. A beautiful park in the city centre, with lakes dug by hand at the time of Kublai Khan and a series of serene pagodas and temples has rock music blaring from the speakers of a KFC outlet. Milton Woo and I were able to tour, by bicycle, the maze of crowded alleyways around Tianenaman square known as HuTongs after gawking at the huge and somewhat intimidating public buildings surrounding the square itself. Parts of the Great Wall are an easy drive from the city. This is an incredible sight but the entrance roadway is lined with souvenir shops hawking "I Climbed the Great Wall" tee-shirts.

In sharp contrast to Beijing was Singapore, which I visited after the ICRO. This highly controlled city-state is booming, bustling and clean. I visited the Radiation Therapy Department at the Singapore General Hospital. My impression was that this facility is equipment rich but struggling to catch up to a large workload with insufficient staffing. The department has, for example, the X-knife, CADPLAN and modern linear accelerators. This capability is not matched by a sophistication in treatment delivery. Techniques are crude and simple with 60 or more patients being treated on a linac in an 8 hour day. The medical physics department is severely understaffed and medical physicists are poorly paid even by Canadian standards.

Equipment suppliers are understandably salivating at the prospect of supplying Asia with radiation treatment. The number of linear accelerators per person is an indicator of the potential market. In the USA, 1 per 100,000; in

Germany, 1 per 250,000; in China, 1 per 7,500,000 and in India 1 per 30,000,000.

In summary the ICRO provided a good refresher course on current problems in radiation oncology in a stimulating environment and emphasised the diversity in approaches to radiation treatment around the world. Although the North American (more correctly the USA) approach in both Radiation Oncology and Medical Physics is predominant there are strong programs in Europe and emerging ones in the Far East.

1997 World Congress on Medical Physics and Biomedical Engineering Nice, France, September 14-19, 1997

Peter Dunscombe
North Eastern Ontario Regional Cancer Centre

It was nice in Nice.

On registration at this year's meeting of the International Organisation for Medical Physics in Nice, participants received a thick page program booklet and two 600 page tomes of abstracts. It was not at all clear that this much material could be covered, let alone digested, in five and half days. On examination it became clear that the medical radiation physics component was probably not more than about 25% of the whole meeting. Although there were parallel sessions only about 3 of the ten or so at any one time were of direct relevance to physicists in therapeutic or diagnostic radiation medicine. The obvious question then is why meet with the bioengineers? The answer is somehow related to a numbers game and the International Council of Scientific Unions. I don't fully understand all the issues although they were debated and the decision was made to continue with such joint mega meetings. The next one is in Chicago in 2000.

The science in the sessions I attended contained a sprinkling of the usual snoozers (e.g. measuring wedge factors to a milli percent) but there were also some very good and thought provoking presentations. It was particularly valuable to learn about the perspectives and challenges of medical physicists from societies quite different from ours. It's easy to lead a sheltered scientific existence if one only attends North American meetings.

There were three prominent themes for me. Intensity Modulated Radiation Therapy remains a hot topic although it's not clear if it could be demonstrated that the benefit of such complex approaches is economically justified particularly in the sites which make up most of the workload in radiation therapy departments.

The second theme was Q.A. in the broadest sense such as embodied in the ISO 9000 philosophy. The Europeans, in particular, are taking this very seriously. The message here may be let's not forget to do the routine stuff as well as can while we look to future developments.

Lastly is biological modelling. What ultimately matters in radiotherapy is the response of the patient and not how many Gy are dropped at some point. There's a very long way to go to establishing with acceptable certainty the relationship between absorbed dose and its distribution and effect in individual patients but my prediction is that this will assume increasing importance in the years ahead.

You should be convinced by now that the meeting was very busy. **What follows is hearsay.** Nice was a superb location for a meeting. The weather was temperate, the architecture interesting and the ambience delightfully French with an international flavour. The cuisine was exquisite, as expected, and I understand the clothing costs for half the population of sun bathers are modest (is that the right word?). You'll have to read the contributions by others to find out more about the latter. This correspondent was busy at the meeting.

The 9th International Brachytherapy Conference and 3rd National Brachytherapy Conference: "Towards the Millennium" Palm Springs, California 3 - 6 September 1997

Wyndioto (Frank) Chisela
London Regional Cancer Centre

The International Brachytherapy Conference is a Nucletron sponsored conference and Nucletron uses it exclusively for its own promotions. The National Brachytherapy Conference is an HDR brachytherapy nursing workshop and runs in parallel to the main conference. They are held annually in different places. This time, the venue was Indian Village, a golf resort in the desert near Palm Springs, California. The hotel is a five star luxury Hyatt Grand Champions where a bed is (only!) US$180 a night and a suite fetches US $380 during the peak of the business. The dress code for the event was business casual with an emphasise on golf attire. But no one could venture onto the beautifully maintained golf grounds with the 103-106^0 F temperatures and the record high humidity. We quickly discovered why the hotel had a special rate of US$110 a night for us. September in Indian Village, the

business is slow and hotel occupancy rates are at their lowest.

The conference opened with a note of disappointment. A "special guest" decided to accept an invitation to join the Clintons at their summer resort at the last minute and deprived the conference of their keynote speaker. At any rate, the attendance at this conference was an impressive 500+ participants from all over the world. The International Conference had no theme, but National Conference had one: "Brachytherapy Towards the Millennium". There were four days of meetings and the volume of material presented covered almost the entire spectrum of modern brachytherapy. The majority of topics were traditional ones with little incremental knowledge, if anything. A notable addition to the agenda, however, was the new emerging areas of brachytherapy which were accorded separate sessions; "**Intravascular Brachytherapy**", and "**Virtual Brachytherapy**".

Intravascular brachytherapy to prevent restenosis is now in a phase where its efficacy must be established. Immediate clinical results in animal models are overwhelmingly convincing but there is shortage of data in humans and for the few available human studies, long term patency can only be hoped for. A number of feasibility studies are under way at centres that have pioneered this field in Europe and North America. There are many problem areas in this field, including the choice of radioisotope, source delivery techniques, dosimetry, dose prescription and fractionation etc. Clearly, this is a fertile ground for research physicists.

Image-guided brachytherapy or "Virtual brachytherapy" in the conference parlance is finally receiving some attention. The benefits of imaging technology have not been realised in brachytherapy to the extent that it has in external beam therapy. This session was championed by the William Beaumont Hospital group who presented work in progress in the use of US, CT, and MR in brachytherapy planning. John Wong reminded us of the serious deficiency in brachytherapy planning, where important "virtual" planning tools such DVH, TCP, and NTCP can not be used because of lack of geometric definitions of target volumes and critical structures in brachytherapy.

Another prominent session was on prostate brachytherapy, particularly permanent seed implants. Indications, techniques and current clinical results were presented by major players in this area such John Blasko, Martinez, T. Mate, to name just a few. From these talks, one sees the future pointing to more ultrasound guided permanent seed implants as an alternative approach for management of localised prostate cancer.

The remainder of the sessions were devoted to topics covering techniques and clinical results in high dose rate (HDR) and low dose rate (LDR) brachytherapy of head and neck, lung, oesophagus and gynaecological malignancies. This was peppered with a pinch of lonesome presentations on "Intraoperative HDR brachytherapy", a topic that seems to have joined "hyperthermia" in the closet.

The closing sessions included topics on 3D planning for brachytherapy, the kind of tools we should expect for the future in brachytherapy, and of course a Nucletron award presentation to the most outstanding work in any area. Overall, most presentations were excellent. There was an impressive display of poster presentation, around 80 exhibits covering an array of topics in clinical brachytherapy and instrumentation all of high quality as well.

Stuart Foster Receives the Thomas W. Eadie Medal from the Royal Society of Canada

Michael Bronskill
Sunnybrook Health Science Centre

Below is reproduced the text of the announcement given by the Royal Society of Canada while awarding the **Thomas W. Eadie Medal** to **Stuart Foster** on November 21, 1997. This is one of the most prestigious awards ever given to a Canadian medical physicist and recognises the contribution that Stuart Foster has made to science in Canada. The Royal Society of Canada is the senior national body of distinguished Canadian scientists and scholars. Its primary objective is to promote learning and research in the natural and social sciences and in the humanities. **Election to Fellowship in the Society is the highest academic accolade available to scientists and scholars in Canada**. For more information about the Royal Society of Canada or the Thomas W. Eadie Medal see http://www.rsc.ca/.

"Dr. Foster has made major contributions in medical ultrasound imaging. He has researched, invented, and built ultrasound transducers with structural resolution and design features optimized for many individual anatomical sites of potential disease. His ultrasound biomicroscope for imaging of the eye in health and disease provides previously unobtainable visualization of the iris, lens, lateral musculature, and the entire anterior chamber. With this device he also images skin lesions such as melanoma and psoriasis. He designed large conical and annular transducers for breast examinations, which demonstrated both cysts and tumours in this organ. For visualizing the prostate he built rotating, intra-cavitary transducers.

Recently, devising miniature transducers that fit into hypodermic needles and catheters, he has imaged obstructions in coronary arteries and developed methods to assess arterial elasticity from within blood vessels. Stuart Foster's imaging devices are based on his measurements of ultrasound scattering and attenuation in specific tissues. He measured the electromechanical properties of potential piezoelectric materials to optimize the designs; he researched and was guided by the physics of image formation of different transducer configurations; and he designed special ultrasound instruments, like his "macroscope", to facilitate the measurements. A number of his devices are patented, and his ultrasound biomicroscope for eye scanning is commercially available. His application of ultrasound physics, engineering design and tissue characterization is the basis of his major contributions to many aspects of ultrasound imaging in medicine. His work and his collaborations with others created both fundamental new knowledge and new instruments for clinical applications, while his teaching and presentations have disseminated his knowledge world-wide."

Endowed Chair at the Robarts Research Institute Awarded to Brian Rutt

Peter Munro

Brian Rutt has been awarded a $2-million endowed research chair at the Robarts Research Institute. The chair, known as the Barnett/Ivey/Heart and Stroke Foundation of Ontario Chair at the Robarts Research Institute, was established to honour the lifetime achievements of Dr. Henry Barnett, a neurologist who established a world-wide reputation for the assessment and treatment of stroke. Dr. Barnett was also the founding President and Scientific Director of the Robarts Research Institute. The chair was made possible by contributions from Richard M. Ivey, the Richard Ivey Foundation, and the Heart and Stroke Foundation of Ontario.

Brian Rutt will use the chair to continue his efforts to develop MRI techniques that will help identify patients most at risk for stroke. His group is currently developing MR imaging tools to assess, *in vivo*, the likelihood that atherosclerotic plaques will develop stroke-generating emboli. This requires very high spatial and temporal resolution, since the important features occur at the interface between the wall of the plaque and the blood (e.g., wall shear stress, plaque surface irregularities, plaque mechanical strain, plaque composition).

Congratulations Brian! This is a real accomplishment for you and one that all COMP/CCMP members can be proud of.

Robarts Group Awarded the Sylvia Sorkin Greenfield Award from the AAPM

Peter Munro

Michael Westmore, Aaron Fenster and Ian Cunningham were awarded the Sylvia Sorkin Greenfield award from the AAPM for the best paper published in Medical Physics in the 1996 calendar year. Michael Westmore is a graduate student, about to complete his Ph.D., in the Department of Medical Biophysics at the University of Western Ontario, Aaron Fenster is the director of the Imaging Research Laboratories at the Robarts Research Institute, and Ian Cunningham is a senior scientist at the same institution as well as a physicist in the Radiology Department of the London Health Sciences Centre. Their paper, entitled "Angular dependent coherent scatter measured with a diagnostic x-ray image intensifier-based imaging system."[Med. Phys. **23(5):** 723-733 (1996)], describes a technique that may allow tissues to be characterised by their atomic structure. In the time since publication of their award winning paper, the authors have generated coherent scatter CT images, where the contrast between tissues can be adjusted depending upon which coherent scatter dataset is used to reconstruct the images. This new work may prove to be invaluable for the analysis of bone mineral density in patients at risk for osteoporosis.

Reproduced below is the abstract of the award winning paper.

Low-angle scatter of x rays at diagnostic energies is primarily coherent. This coherence gives rise to interference effects resulting in x-ray diffraction patterns that are characteristic of the scattering material. A method is described of imaging these low-angle (0^0-10^0) x-ray diffraction properties of tissue specimens using a diagnostic x-ray beam and image intensifier-based system. The coherent-scatter cross sections of several materials measured this way are presented. It is shown theoretically that the measurements made with this system can be expressed as the mono-energetic cross section "blurred" by the x-ray spectrum using a linear superposition integral. Experimental results using aluminum powder confirm this. Using a 70 kVp x-ray beam filtered with gadolinium to reduce the spectral width, materials such as water, Lucite, and hydroxyapatite all have significantly different diffraction patterns. The cross sections determined from this analysis from the basis of a unique method of characterizing and identifying tissue samples according to their atomic structure rather than x-ray attenuation properties.

Jack Cunningham Receives the Award of Merit from the IUPESM
Nice, France, 13 September, 1997
Peter Munro

Dr. Jack Cunningham was given the Award of Merit from the International Union for Physics and Engineering Sciences in Medicine (IUPESM) during the World Congress on Medical Physics and Biomedical Engineering in Nice, France on 13 September 1997. The Award recognises the lifetime contribution of a medical physicist or a biomedical engineer to the field of medicine. Since Jack only had two weeks notice that he had been chosen as the recipient of the award, he chose to talk about Harold Johns during his acceptance speech, a presentation that he had planned to give in the session entitled "Historical Events in Medical Physics" (see COMP Newsletter Volume 43 Issue 4 page 89). The following are Jack's introductory remarks.

Mr. President, Members of the Organizing Committees and Ladies and Gentlemen: I was notified about two weeks ago that I had been chosen as the recipient of the IUPESM Award. Of course I was delighted by the news and I accepted gladly. I consider that it does not in the least diminish the award to be told that John Laughlin had been chosen first. The rules stipulate that the Awardee should be present and give a speech. Unhappily, John, for medical reasons, was not able to attend, and he requested that the next in line should be chosen. I can assure you that I am very honoured to be chosen second to John Laughlin.

The Awardee is given rather free reign in the subject matter of his speech and it is usual to spend some time reminiscing and to tell the story of his major scientific contribution to his field. It is not easy, on short notice, to talk in an interesting way about oneself, so I am going to talk about someone else: my mentor, my colleague and my friend, Harold Johns. Without him I would not be standing here accepting this award.

AECB and Quality Assurance Standards in Radiation Therapy

Reproduced below are the communications between Bob Irwin of the Directorate of Fuel Cycle and Materials Regulation, Atomic Energy Control Board and Paul Johns (COMP chair) and Peter Dunscombe (president CCPM) about the AECB's initiative to establish nation-wide standards for quality assurance in radiation therapy. COMP/CCPM will have a direct involvement in developing these standards.

Peter Munro

July 17, 1997

Dear Dr. Johns:

Thank you for permitting me to address members of the Canadian Organization of Medical Physicists (COMP) at the beginning of your annual meeting in Charlottetown on July 9. Your meeting schedule was very busy and I appreciate your efforts to accommodate me and I thank those who attended my presentation for their attention and comments. I gathered from COMP members both limited support and strong opposition to any AECB involvement in efforts to establish quality assurance standards pertaining to the safety of patients in radiation therapy. This is perhaps understandable in times when resources are limited.

I should clarify one or two matters that arose in discussion. First, while the AECB's mandate in the patient safety area is not clear, we see a weakness in patient safety where QA practices are not consistent and we are willing to act as a catalyst in the development of national QA standards. Dr. Bishop, the AECB President and a physician, is keen on this matter and we see the medical physicists as a key group in the development of standards. I further expect that any process for the development of standards would have to involve representatives of Health Canada.

Moreover, while the AECB's role is undeniably to regulate, the development and implementation of effective standards may obviate any need for regulation. ACEB staff are routinely involved in standards development activities, and there are numerous examples of standards set by practitioners which we accept and use in licensing, particularly in the area of training and certification of staff.

Almost two years ago, I wrote to COMP about the possibility of the AECB writing regulations governing the safety of patients in radiation therapy. In response, among other things, Dr. G. Dean stressed the importance of

obtaining the input of practising clinical medical physicists. We see the same weakness in QA now that was apparent then, but faced with fewer resources, QA standards may be more appropriate than regulations and we again write to COMP to solicit their involvement. Will you assist – indeed spearhead – the QA standards and development process? If so, I'd be grateful if you would nominate a COMP representative with whom I might liaise regularly to get the process underway and monitor progress.

I will keep you posted about the feedback from CARO and from CAMRT.

Thanks for considering this matter. If you have any suggestions, please do not hesitate to contact me.

Sincerely

Bob Irwin, Head
Medical, Academic & Accelerator Licensing
Materials Regulation Division
Atomic Energy Control Board

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October 23, 1997

Dear Mr. Irwin,

This is in response to your letter of 17 July 1997. The COMP Executive and CCPM Board felt that it was very useful for you to address our membership on July 9 and appreciates the AECB making the effort to obtain feedback in this manner. Indeed, the AECB communicated with COMP and the CCPM as long ago as 1994 about whether there was a need for patient safety regulation in radiotherapy and we commend you for this careful approach.

You are correct that there was a diversity of opinion by our members at the information session in Charlottetown. The main concern, which someone pointed out that evening, is that any paper exercise which decreases time available by the physicist to work on the day-to-day practical problems of patient treatment will decrease the overall efficacy of the treatment centre in controlling and curing cancer. As well, we believe that the direction of approach of the AECB has historically been one of "safety" and preventing "accidents". In the application of ionizing radiation for cancer therapy, accidents of the type that the AECB probably envisions are rare occurrences. A much more useful approach would be to look at the entire treatment program and ensure that it is efficacious for tumour control. For example, if all the doses are out by 10% there is probably not a "safety" problem in the usual sense, but there will certainly be a major impact on tumour control and normal tissue complication rate. We hope that the distinction between an approach focusing on accidents and one on quality assurance (QA) is not lost on the AECB.

As a result of the provincial responsibility of health care, to date there are no national standards for radiotherapy physics QA programs in Canada. The Canadian Organization of Medical Physicists and the Canadian College of Physicists in Medicine are confident that it would be beneficial to patients and efficient in terms of resource utilization in the health care sector if all radiotherapy facilities in Canada worked under common national standards for radiotherapy QA. The standards would have to address both the technical specifications of the work to be done, and the professional qualifications of those doing it. The medical physics profession is the most knowledgeable concerning the technical work, and has in place, through the CCPM, a professional certification process.

Therefore, COMP and the CCPM welcome the opportunity to develop national standards for radiotherapy QA under the auspices of an AECB initiative. We see the AECB, in its position as a federal agency, as providing an opportunity to develop nation-wide standards which will be enabled through its licensing process.

We do require clarification on the future division of responsibilities between the AECB and Health Canada, and between the federal agencies and the provincial health ministries.

At your presentation you noted that the AECB has funds available to support the development of national standards by a professional group such as COMP/CCPM. In today's fiscally-constrained environment this support might well be necessary in order to free up time by clinical medical physicists to work on this project.

On behalf of the COMP and the CCPM, Dr. Ervin Podgorsak will liaise with you on this project. Dr. Podgorsak is a member of the COMP/CCPM Radiation Regulations Committee. We note that if this project develops, additional clinical medical physicists will need to be involved, and AECB fiscal support will become necessary.

We look forward to further communications with you on this matter.

Sincerely

Paul C. Johns & Peter B. Dunscombe
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CANADIAN MEDICAL PHYSICS THESES

1996

The Canadian Medical Physics Newsletter is again pleased to publish a review of medical physics graduate work completed at Canadian Universities. In this issue, work presented in 1996 in 36 different theses is reported. It is especially nice to see a number of theses from institutes which have not previously submitted their work. I thank the authors for their submissions and congratulate them on their research efforts. I trust that this report continues to be a useful resource for other researchers in the community.

There is of course the chance that some work has been omitted in this report. I ask that authors update my files as it may be possible to make this resource available on the Internet in the future if there is sufficient interest. Feedback would be appreciated before that effort is made.

I now invite submissions for fall issue of the Canadian Medical Physics Newsletter in which work completed in 1997 will be reviewed. See the end of this report for details.

L. John Schreiner
Kingston Regional Cancer Centre,
Kingston, ON

University of Alberta, Edmonton, AB

Department of Physics

John R. Kollar

Evaluation and Modification of a Differential SAR Dose Calculation Algorithm.

M.Sc.

"George's RAdiotherapy Treatment desIgn System" (GRATIS), a treatment planning system designed at the University of North Carolina by George Sherouse and his colleagues, offers a flexible and fast algorithm for the calculation of dose in 3D conformal radiotherapy. Its calculation routine is a generalization of the CBEAM algorithm created by John Cunningham, which calculates the dose value at a point in phantom by separately evaluating the components of dose that are due to primary and scattered radiation. The calculation algorithm, although fairly general in design, currently makes a number of simplifying assumptions to reduce calculation time, and the corresponding tradeoff is a potential loss of accuracy.

We have attempted to remove these simplifications and test the limits of accuracy of the algorithm for symmetric and asymmetric collimator configurations. Isodoses have been obtained on GRATIS, on a Varian 2300CD Linac, and on the "Alberta Treatment Planning system" (ATP) so that the performance of GRATIS can be evaluated. A modification to the algorithm has been investigated that involves a redefinition of the "pencils" used in the "scatter integration". This modification makes the integration more consistent with the measured data which is used by the algorithm and increases its accuracy. Limitations of this type of calculation have also been demonstrated for off axis cases where the energy spectrum of the accelerator is significantly different from the central axis spectrum.

Supervisor: B. McClean

University of British Columbia, Vancouver, BC

Department of Physics and Astronomy

Sofia Emilia Chavez

The Concept Of Local Normal Tissue Damage In The Evaluation Of Treatment Planning Parameter Space

M.Sc.

At present, there is still no systematic approach to the radiation treatment planning process which aims to provide maximum dose to all the tumour cells while the surrounding, normal but critical tissues are minimally irradiated. In fact, the process of treatment plan selection is usually simply based on experience from a large number of past trial-and-error cases in individual cancer centers. In this thesis, two new concepts are introduced, that are demonstrated to be useful tools to rationalize a systematic planning process.

1. The concept of local normal tissue damage (LNTD): Using a similar concept to that of “cellular damage” in radiobiological models, a concept of a *localized* “normal tissue damage” is introduced. This simple model is designed to make the best use of current limited clinical estimates of whole organ complication probabilities while providing a coherent framework that will preserve spatial information as well as condense the information into a numerical score for the plan.

2. The concept of parameter space mapping: Treatment parameter mappings will indicate the tissue-specific *effect* of the dose distribution resulting for the given parameter values. Such mappings can provide very useful insights for treatment plan selection. The use of this new tool is demonstrated in studying the values of the fixation point coordinates for the treatment of uveal melanoma at TRIUMF. Important insight is gained about the effects of the values of the fixation point coordinates on the probable success of the treatment. Such mappings help make treatment planning more efficient, objective and systematic which allows for a better exploitation of the full potential of the proton beam.

The above concepts are combined to provide a systematic strategy for treatment planning that will rely on the tissue-specific response to inhomogeneous dose distributions. The LNTD model is used to transform dose distributions into damage maps and then an overall score for that plan can be determined. This score is then used as the information mapped on a fixation point space mapping in order to facilitate selection of a plan. Also, the rationale for the development of multiple-fields is based on the resulting non-linearity of the LNTD(d) curves and hence it is demonstrated that it can be used along with the parameter

space mappings in order to successfully plan such a treatment.

Supervisor: G. Lam

Jacob A. Haider

Dosimetry Studies of Small Fields in Homogeneous and Inhomogenous Media for High Energy Photons
Ph.D.

Dose decreases rapidly for photon field sizes smaller than the range of the laterally scattered electrons. The reduction in dose leads to dose non-uniformity and the degree of dose non-uniformity depends on the shape of the tumor. The dose reduction due to lateral electronic nonequilibrium increases with increasing photon energy. Small tumors are best treated with lower energy photons.

We modified the primary and scatter dose model to include the effect of lateral electronic non-equilibrium. The dose model was verified experimentally for various geometries and is in good agreement with the measurements.

We developed a new cavity theory which includes secondary electron backscattering from the medium into the cavity. The proposed theory gives better agreement with experiments in aluminum, copper and lead for Co-60 gamma rays and 10 MV X-rays than do the Burlin and Kearsley cavity theories. A method for obtaining an ionization chamber correction factor for measuring dose in inhomogeneous media is also given.

There is a significant dose reduction in lung as compared to normal density tissue for small fields. The dose reduction in lung increases with decreasing field size and increasing photon energy. Results of the measurements suggest that a tumor in tissue surrounding lung would have better dose uniformity if the direction of the photon beam is such that the tumor resides in the proximal side of the tumor-lung interface. Tumors in lung and surrounding the lung have better dose uniformity if teated with lower energy photons.

Significant dose reduction was also observed near the air-tissue interface. The dose perturbation increases with increasing air-cavity thickness, decreasing field size and increasig photon energy. Results of the measurements again suggest that a tumor in tissue surrounding air-cavities, such as the bronchial tube, would have better dose uniformity if the direction of the photon beam is such that the tumor resides in the proximal side of the tumor-air interface. And again, lower energy photons provide better dose uniformity for tumors surrounding the air-cavity.

The presence of bone in tissue causes only modest dose perturbation for photon energies between 2 MV and 20 MV X-rays.

Supervisors: G. Lam and L. Skarsgard

Carleton University, Ottawa, ON

Department of Physics

Doru Kaytar

Hyperthermia with Array of Interstitial Ultrasound Applicators

M.Sc.

Radio- and chemotherapy, well established cancer treatment modalities, fail at times to produce the expected healing effects. Hyperthermia, a relatively recent method in cancer therapy, has been used as the other modalities sensitizer. This thesis presents and evaluates an original system to produce localized hyperthermia. The system uses an array of interstitial ultrasound waveguide applicators to deliver ultrasound energy to the volume of interest where this energy is converted into heat. Ultrasound, at frequencies around 1 MHz, is produced by a 12.7 mm diameter piezoelectric disk, generating longitudinal waves. The applicator uses 1.1 mm diameter hypodermic needle as the waveguide of surface modes. The surface modes deposit their energy into the medium from the unclad part of the waveguide. It has been found that the heating efficiency depended in the first place on the waveguide radius that defines the divergence of the radiated beam. Attenuation has been less important, with the effects of absorption within the medium vanishing at radial distances larger than 1 cm. For applicators operated at 30 V rms, cladding of the waveguide has resulted in about 10% decrease of the energy output. With up to four applicators, hyperthermic temperature elevation of about 6ºC has been produced in as large as 240 cm^3 tissue phantoms of high thermal conductivity. Hyperthermia simulations using Finite Element Analysis showed uniform temperature elevations of at least 6ºC in the region enclosed by the array. The average difference between experimental and simulated temperatures at ten locations was 0.0ºC, with a standard deviation of 0.5ºC.

Supervisor: B. J. Jarosz

Ruth C. Brown

The Prediction of Patient Radiosensitivity Using the Clonogenic Assay and Asymmetric Field Inversion Gel Electrophoresis

Ph.D.

Radiation therapy is usually administered with the assumption that all patients respond equally to treatment. This is not the case and researchers have been trying to find ways to predict how patients will respond to radiotherapy by predicting both tumour response and normal tissue response. In radiotherapy, however, the dose of radiation that can be delivered to the tumour is limited by the dose that can be tolerated by the normal tissue in the treatment field. Therefore, it is more important to predict normal tissue response in order to deliver the maximum dose possible to the tumour to maximize the probability of tumour control. Previous studies have used surviving fractions after low doses (2 Gy) of radiation, but it is doubtful whether differences in survivals at this low level of cell kill are measurable.

In this thesis, several radiation protocols were examined for predictive value including survival after high doses (6 Gy) at both high (112 cGy/min) and low (0.882 cGy/min) dose rates, fractionated doses (12 Gy in 6 fractions) and when 6 h of repair time is allowed after a single high dose rate irradiation (HDRI). Two pairs of cell lines were studied: a pair of melanoma cell lines, SKMEL3 and HT144, which are radioresistant and radiosensitive respectively and a pair of primary fibroblast cell lines grown from skin samples from humans. The OMB1 cell line was from an apparently normal volunteer and the S11358 cell line was from a patient who had an extremely sensitive reaction to radiation therapy. It was found that, with the clonogenic assay, the radiation protocol which best distinguished between the sensitivities of the two cell lines was fractionation.

The clonogenic assay, however, is too slow to be useful in the clinic and a faster assay is required. The asymmetric field inversion gel electrophoresis (AFIGE) assay which measures DNA double strand breaks was examined as a possible assay. This assay, which can be completed in a few days, was only able to resolve differences in radiation response between the melanoma cell lines after HDRI. It did, however, point out that cell lines have different sensitivities for a variety of reasons and that more than one assay will be needed to predict the radiosensitivity of a patient prior to therapy.

Supervisor: G.P. Raaphorst

Cathy MacGillivray

Diffusion-Weighted MR Imaging of Moving Structures Using a Three Echo Navigator Imaging Technique

M.Sc.

The possibility of acquiring good quality diffusion-weighted MR images of moving structures using a three echo navigator imaging technique was investigated. Simulations were run to demonstrate the detrimental effects of motion in diffusion-weighted images - severe artifacts and gross error in diffusion coefficient quantification. They also showed that, in theory, the effects of such motion (rigid body, translational motion within a plane) can be corrected for in postprocessing using information derived

from two specially encoded navigator echoes. Phantom experiments confirmed the theory - images of moving objects acquired using our three echo technique were markedly improved over those acquired using either a one or two echo approach. In fact, the images were often indistinguishable from those acquired while the object was stationary. Finally, an experiment carried out on a human volunteer confirms that our technique shows great promise for diffusion-weighted in vivo imaging.

Supervisor: I.G. Cameron

Patrick L. Rapley

Semi-Cylindrical Surface Gradient Coils: A Novel Approach to NMR Gradient Coil Design
Ph.D.

A novel NMR gradient coil design has been introduced that provides relatively fast switching, strong gradient fields. The design, called Semi-Cylindrical Surface Gradient Coils (SCSGC), is based on a geometry with the current density confined to the surface of a half cylinder. A new method for the design of gradient coils has been developed as computer software. The numerical optimization algorithm used is a hybrid between the downhill simplex and simulated annealing techniques. The software optimizes gradient coils, and provides all necessary performance specifications.

A three direction SCSGC has been designed and constructed to fit inside of a 40 cm bore, 4.7T NMR system. The coil's performance has been measured and agrees with specifications calculated using the design software. The constructed x, y, and z gradient coils can attain gradient strengths of 6.1, 4.3, and 5.6 G/cm respectively at 150 amperes of current. In all cases, the effective ramp time to these values is less that 140 μs. The gradient field is linear to within 5% (peak to peak) over cuboid volumes of greater than 3 cm x 3 cm x 3 cm while the usable volume for imaging is found to be greater than 6 cm x 6 cm x 10 cm for the x, y, and z directions respectively. The coil is found to be appropriate for Echo Planar Imaging, as well as diffusion studies.

A variation of the SCSGC providing a larger effective imaging volume (at the cost of reduced coil efficiency) has been investigated. The design incorporates movable current loops providing variability in the position of the imaging volume. A gradient coil set based on this modified SCSGC principle has been designed. The result is a gradient coil allowing human whole body access, yet capable of producing gradient fields appropriate for Echo Planar Imaging.

Supervisor: J.K. Saunders

Julia C. Wallace

Characterization of Human Ovarian Cancer by Magnetic Resonance Spectroscopy Using in vitro and ex vivo Models
Ph.D.

This thesis examines the potential role of Magnetic Resonance Spectroscopy (MRS)in diagnosing ovarian cancer and detecting cellular changes that occur following the induction of resistance in cells. Proton (1H) MRS characteristics of four human ovarian cancer cell lines were measured. Two of these cell lines were from untreated ovarian cancer patients and the remaining two cell lines were from cisplatin (a common anti-cancer drug) resistant mutants developed from the two parental cell lines. The drug resistant cells exhibited different metabolite profiles compared to their sensitive parental cell lines. In particular, changes in the level of glutathione, taurine, glutamate and lipids were observed. These changes were consistent with known cellular mechanisms of resistance.

An additional level of complexity in modelling in vivo ovarian cancer was attained by measuring the MR spectra of cells in different growth phases and multicellular spheroids of increasing diameter. Cells in exponential growth phases exhibited significantly different spectra from those in plateau phase. Spectra from small spheroids closely resembled the spectra from exponentially growing cells. Larger spheroids with necrotic centres had elevated lipid spectral intensities.

1H MR spectra of ex vivo normal post-menopausal ovaries and ovarian neoplasms were obtained to provide biochemical information which could be used to discriminate between normal and cancerous tissue. Using linear discriminant analysis (LDA), classification of normal and cancer was accomplished with a sensitivity of 100% and a specificity of 95% and overall accuracy of 98%. In addition, LDA distinguished untreated ovarian cancer from recurrent ovarian cancer with sensitivity 92%, specificity 100% and overall accuracy 97%. With removal of the single "fuzzy" sample, accuracy was increased to 100%. Thus 1H MRS shows promise in characterizing the properties of chemotherapy resistant cells.

With the long term goal of assessing the optimal treatment protocol for resistant cells, a perfusion system was designed and contructed which could maintain viable growing cells for over 72 hours. Cells were embedded in calcium alginate beads and the biological characteristics of these embedded cells were assessed. 31P spectra of drug-sensitive and -resistant ovarian cancer cells were measured to monitor energy and membrane metabolites. The resistant mutants

showed significantly elevated levels of phosphocreatine (PCr) and phosphodiesters (PDE) ($P<0.05$). 31P spectra were also measured on perchloric acid extracts of the same cell lines and, in agreement with the results obtained on perfused cells, elevated levels of PCr and PDE were observed.

This study indicates that MRS can be used to distinguish between classes of ovarian cancer (ex vivo) and can detect differences between drug -sensitive and -resistant cell lines (in vitro). Applications of this knowledge to in vivo measurements could lead to non-invasive diagnosis and monitoring of ovarian cancer.

Supervisor: G.P. Raaphorst

Université Laval, Quebec, QC

Département de génie électrique et génie informatique

Louis-Martin Girouard

Imagerie portale en radiothérapie: Localisation automatique de la prostate

M. Sc.

Étant donné le besoin de positionner le patient de façon précise et reproductible à chaque fraction d'un traitement de radiothérapie, cette étude a permis de développer un algorithme de localisation automatique lors du traitement du cancer de la prostate en utilisant l'imagerie portale électronique. La localisation se fait à deux niveaux, soit la détection d'un marqueur radio-opaque implanté à l'apex prostatique et la détection des structures osseuses de la région pelvienne.

La méthode de détection du marqueur est basée sur la recherche d'un minimum global dans le champ de traitement . Un critère a été ajouté pour améliorer la robustesse de l'algorithme au bruit et aux atténuations des contours osseux. Quant aux contours osseux, la déviation de leurs positions par rapport à une image portale de référence est mesurée par corrélation d'images de contours osseux après avoir rehaussé ces derniers sur les images originales. Les images avaient aussi besoin d'être restorées pour éliminer des artefacts.

La détection du marqueur est réussie dans une proportion de 87% pour 142 images portales cliniques. La mesure de déviation est de ±1,35 mm dans 98% des fois et ±1,04 mm dans 94% des fois dans les directions horizontales et verticales respectivement. Les tests de déviations ont été fait avec 53 images de fantôme.

Knowing the need for accurate and reproducible patient setup, this study enabled the development of an automatic prostate localization algorithm in radiotherapy using electronic portal images, EPIs. It is known that the positioning is important in the tumor control The localization is done at two levels which are the detection of a radiopaque marker implanted at the prostatic apex and bone edge detection in the pelvic region.

The marker detection is based on global minima search in the treatment field. A criteria was found to improve the robustness to the noise and false attenuations such as bone edges. Concerning the bone structures, the position deviation with respects to a reference image is measured by bone edge correlation after an edge enhancement on original EPIs. The EPIs needed also restoration to remove artefacts.

The marker has been detected with 87% of success for a 142 clinical images sample. The deviation measurements

were within ±1,35 mm for 98% of images and within ±1,04 mm for 94% in horizontal and vertical direction respectively. This validation was performed on 53 phantom EPIs.

Superviseurs: X. Maldague, A. Zaccarin, Computer Vision and J. Pouliot, Medical Physics

McMaster University, Hamilton, ON

Department of Physics

George Alexandrakis

Macromolecule Transport in Tumours: Mathematical Modelling and Experimental Studies
M.Sc.

The delivery of immunoreactive macromolecules to tumour cells in solid, heterogeneously perfused tumours is a major problem in the effectiveness of immunotherapy. To help optimize the new experimental treatment method, a published mathematical model of macromolecule transport (Baxter & Jain 1989,1990,1991a) was appraised and verified experimentally. Computational and analytical tools were developed to predict the interstitial plasma fluid pressure and velocity distribution in well perfused spherical tumours. Their published analytical solutions of the formulation were found to have some errors and were corrected in this work. To check the validity of the formulation, a series of animal experiments was performed to quantify the total vascular volume, and plasma fluid extravasation rate in SKOV3ipl human ovarian tumour xenografts in nude mice. The result compared well with the theoretically predicted total plasma fluid extravasation rate. Computer codes were also developed to predict the spatial and temporal distributions of intact IgG and its F(ab')2 and Fab/Fab' fragments in well perfused spherical tumours using the formulation proposed by Baxter & Jain (1989,1990,1991a). The cases of non-binding and binding macromolecules were treated separately. The codes for both the interstitial pressure and macromolecule distributions were written to include a radially variable vessel surface area for transcapillary exchange per unit volume of tumour tissue (S/V). The sensitivity of the overall tumour perfusion to variation of (a) the macromolecule m.w., binding affinity, and metabolism, (b) S/V, tumour radius, and (c)microvascular permeability were investigated. Comparison of the theoretical predictions with available experimental data lead to the realization of a number of shortcomings in the previously proposed formulations. Finally, a computational method for deriving the effective spherically symmetric spatial distributions for the vascular volume density, and S/V from tumour serial sections was developed. This bridges the gap between the actual topology of vascular distributions in tumours and the format of current formulations.

Supervisor: C. S. Kwok

Deidre L. Batchelar

A Multiple-Source Delivery System for Interstitial Laser Photocoagulation

M.Sc.

Interstitial laser photocoagulation (ILP) is a minimally invasive technique for destroying solid, localized tumours thermally by delivering infrared laser energy directly into the targeted volume via percutaneously implanted optical fibres. Using current treatment parameters, each fibre delivers sufficient energy to destroy a volume of one to two cm3, larger lesions may be created by using multiple fibres excited simultaneously. An efficient delivery system has been constructed consisting of several fibres bundled through a single cannula and splayed out through a specially designed tip. This delivery system is simple to use and provides accurate fibre placement.

By linearly superposing single source solutions to the bioheat transfer equation, a mathematical model for coalescent thermal lesions has been developed. It has been determined that large, clinically useful thermal lesions can be created by implanting four sources at the corners of a square. It has been demonstrated, through ex vivo experimentation in bovine liver, that the model correctly predicts the dimensions of the thermal lesions.

Supervisor: D. R. Wyman

Silviu-Marcel Marcu

Beta Dosimetry: The Scaling Method for Beta-ray Dose Distributions
M.Sc.

Radioimmunotherapy consists in the use of beta radioactive labelled monoclonal antibodies as selective carriers of radiation to tumors. Internal spatially distributed sources created at the disease sites would deliver high radiation doses to tumors while the normal tissue would not be exposed to the intense radiation as in conventional forms of cancer treatments.

A rapid and accurate estimation of the spatial dose distribution from nonuniform sources is essential for the optimization of this form of cancer therapy. The method used for such calculations is based on the knowledge of dose distributions around a unit source, quantities referred to as dose kernels. Thus far, the Monte Carlo technique is the most accurate way of the dose kernel determinations. However, for routine dosimetry simpler and less time consuming methods of adequate accuracy may appear more preferable.

The “scaling factor” method is used to determine the depth dose distribution in a medium based on data about the dose distribution in an arbitrary reference medium (e.g. air, water). The transformation of the dose distribution curves from the reference medium to the desired new medium is done using a constant, known as scaling factor or relative dose attenuation, and a closely related renormalization factor imposed by the energy conservation.

This work investigates the accuracy of the scaling factor method using a statistical approach (generalized chi-squared test), focusing on a particular case of potential practical interest, the scaling factor water to bone. The work also investigates a procedure for extending the applicability of the scaling factor method to dosimetry in dissimilar media, as a first step, a planar interface.

Supervisor: W.V. Prestwich

Tamie Lynn Poepping

Application of First Order Unimolecular Rate Kinetics to Interstitial Laser Photocoagulation
M.Sc.

An investigation of the temperature response and corresponding lesion growth resulting from in vivo interstitial laser photocoagulation was performed in order to test the applicability of Arrhenius theory. The irradiations were performed in vivo in rabbit muscle for various exposures at 1.0W using an 806 nm diode laser source coupled to an optical fibre with a pre-charred tip, thereby forcing it to function as a point heat source. Temperature responses were measured using a five-microthermocouple array along a range of radial distances from the point heat source. Each temperature profile was fitted with a curve predicted by the Weinbaum-Jiji bioheat transfer equation. The lesions were resected 48 hours after irradiation and the boundary of thermal damage resulting in necrosis was determined histologically. Numerical integration of the Arrhenius integral using temperature-time data at the lesion boundary produced corresponding activation energy and pre-exponential factor pairs (Ea ,a) consistent with reported values for various other endpoints and tissue types. As well, theoretical predictions of the lesion growth from Arrhenius theory agreed well with experimental results. However, the thermal parameters, which are generally assumed to be constant when solving the bioheat transfer equation, were found to vary with radial distance from the source, presumably due to a dependence on temperature.

Supervisor: D. R. Wyman

Brian William Pogue

Frequency-Domain Optical Spectroscopy and Imaging of Tissue and Tissue- Simulating Media
Ph.D.

The goal of this work was to develop and study the use of a diagnostic in vivo tissue spectroscopy system based upon frequency-domain light measurements. Intensity-modulated light which is incident upon a scattering sample creates waves of light intensity which propagate through the medium in a manner which is dependent upon the scattering and absorption characteristics of the tissue. Detection of these waves at a point on the surface of the sample can be used to non-invasively estimate the scattering and absorption coefficients. Recovering these optical interaction parameters requires the use of a suitable model of light propagation in tissue, for which diffusion theory has been shown to work. The technical development of this system and the theoretical modelling are examined in this study. Some physiologically important chromophores can be detected within tissue using the spectral discrimination provided by a wavelength tunable source or detector. The quantification of chromophores can be used in dosimetry for therapeutic laser treatments or for diagnostic laser applications such as measuring hemoglobin oxygen saturation.

In addition to reflectance measurements, diffuse fluorescence can be detected from a scattering medium such as tissue if there is an active fluorescent molecule present. The theoretical modeling for diffuse fluorescence signals was developed and experimentally tested in a tissue-simulating phantom. There was excellent agreement between the theoretical model and the experimental tests with a fluorophore in a scattering emulsion. This work suggests that measurements of fluorescence lifetime or quantum yield can be made on a homogeneous tissue volume by deconvolution of the effects of multiple scattering.

Preliminary work was done on an optical tomography algorithm using measurements of phase and intensity at multiple points on a tissue surface to reconstruct images of the optical properties of the interior. Tomographic imaging is routinely done with x-rays for diagnostic imaging and recent developments suggest that a similar form of imaging can be accomplished with light, albeit with much poorer resolution and contrast. Frequency-domain measurements can provide a method for diffuse optical imaging through relatively thin tissue volumes (i.e. thickness less than approximately 10 cm). The theoretical development of a tomographic imaging system is examined in the final section of this thesis and tested with data from a tissue simulating phantom. The potential medical applications of such a system range from tissue oxygenation imaging to detection of cancerous regions within soft tissue.

Supervisor: M.S. Patterson

William M. Whelan

Dynamic Modelling of Interstitial Laser Photocoagulation in Soft Tissues.
Ph.D.

Interstitial Laser Photocoagulation (ILP) is a minimally invasive cancer treatment technique whereby optical energy from an implanted optical fiber is used to destroy small, solid tumours. In this work, an optical diffusion approximation and heat transfer equations were used to develop dynamic models of interstitial laser heating. Modifications in the thermophysical and optical properties due to tissue coagulation ($T^3$60°C) and vaporization of tissue water ($T^3$100°C) were incorporated into the physical description. In addition, the effect of different blood perfusion approximations on temperature distributions for an in vivo liver model was explored. The calculational results presented indicate the necessity to include dynamic modifications in the tissue biophysical and blood perfusion properties in future parametric investigations of the potential of ILP in various tissues. A quasi-linear model of tissue charring during single fiber ILP was derived. The increase in optical absorption at the fiber tip due to the browning/charring process was modelled as a linear continuous shift in energy deposition from a point optical source to a point heat source. The tissue charring temperature was estimated by placing experimentally measured charring dimensions on calculated temperature profiles. The potential for combining on-line thermometry with dynamic thermal modelling to reconstruct complete tissue temperature distributions during ILP was also investigated. Features of an on-line temperature reconstruction system have been identified and the physical and technical limitations explored.

Supervisor: D.R. Wyman

Siu Ki Yu

Attenuation Correction in Positron Tomography
Ph.D.

Accurate attenuation corrections is a prerequisite for the determination of precise regional radioactivity concentrations in positron tomography. Attenuation correction can be performed using an external source of radiation and two measurements: a blank scan performed with no subject in the tomograph, and a transmission scan performed with the subject in the field of view. The ratio of blank to transmission counts gives the appropriate attenuation correction factor for each line of response. In theory, this provides a perfect correction for photon attenuation, but in practice the technique is limited by noise

due to limited counting statistics and scattered radiation in the measured transmission data.

In the present work, 137Cs is proposed as a suitable radiation source for transmission measurements in 'singles' mode, a technique that substantially increases the statistical accuracy of the transmission data. 137Cs can be used without any recalibration of the tomograph, and the spatial resolution is comparable to that obtained using 68Ge. Since 137Cs emits a monoenergetic gamma ray at 662 keV, and emission data are acquired by detecting annihilation photons of energy 511 keV, a simple extrapolation method is developed to extrapolate the attenuation coefficients measured at 662 keV to 511 keV. To eliminate scatter contamination in the transmission data, a dual-energy-window scatter correction technique is developed whereby correction can be made on-the-fly during data acquisition. Using the developed extrapolation method and dual energy scatter correction method, the linear attenuation coefficients measured in 'singles' mode using 137Cs agree well with the expected values.

To achieve further suppression of noise in the transmission data, a segmented attenuation correction technique is also developed in this work. The technique uses artificial neural networks for processing the count-limited transmission data. The technique has been validated in phantoms and verified in human studies. The results indicate that attenuation coefficients measured in the segmented transmission images are accurate and reproducible. Activity concentrations measured in the reconstructed emission image can also be recovered accurately with this technique. The accuracy of the technique is subject independent and insensitive to scatter contamination in the transmission data. It can predict accurately the value of the attenuation coefficient for any material in the range from air to water. Satisfactory results are obtained if the transmission data contains as few as 400,000 true counts per plane. Thus, accurate attenuation data can be obtained by acquiring a short transmission scan using the 'singles' method, and then processing these data using the artificial neural network technique.

Supervisor: D.R. Wyman

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Medical Physics Unit, Faculty of Medicine

Chantal Audet

NMR-Dose Response Studies of the Gels Used for 3-D Radiaition Dosimetry by Magnetic Resonance Imaging
Ph.D. : Department of Physics

In the past ten years, three dimensional radiation dosimetry techniques based on the dose response of the Nuclear Magnetic Resonance (NMR) spin relaxation of the water protons in gels have been developed. The studies in this work focus on 1) the dose response of the spin-lattice relaxation rate, R1, of the ferrous sulfate-doped gelatin dosimeter and 2) the dose response of the spin-spin relaxation rate, R2, of the BANG (Bis Acrylamide Nitrogen Gelatin) polymer gel dosimeter.

When the ferrous sulfate gelatin dosimeter is irradiated ferrous ions are converted to ferric ions. A model is proposed for the R1-dose response of the dosimeter. The model includes such parameters as the ferric ion yield and the ion relaxivities which measure the ability of the ions to enhance the spin-lattice relaxation of water protons. The effects of gelatin and sulfuric acid concentration on the ferric ion yield and ion relaxivities are studied. The ferric ion relaxivity is shown to vary because of the complexing of the ferric ions resulting from gelatin-induced pH changes or pH changes arising from variations in sulfuric acid concentration. A modified version of the R1-dose response model accounting for ferric ion complexing is presented and tested spectrophotometrically. The results are also examined for possible ways of optimizing the dosimeter.

The BANG dosimeter is based on the radiation-induced polymerization of the Bis and acrylamide monomers in the gelatin. Studies on the reproducibility of the R2-dose response of small volume BANG polymer gel dosimeters show that there are post-irradiation reactions and that sufficient time delays must elapse before the value of R2 stabilizes. A preliminary fast exchange model for the R2-dose response of BANG dosimeters involving the polymer yield and polymer spin-spin relaxivity is presented. Results of the effects of gelatin, Bis and acrylamide concentration, and the NMR measurement temperature on the R2-dose response are presented. The results are used to determine the dosimeter compositions and NMR measurement temperatures providing the best NMR-dose response. Also, the results are interpreted in terms of the polymer yield and relaxivity to better understand the physical and chemical mechanisms governing the R2-dose response of BANG dosimeters.

Depuis les dix dernieres annees, des techniques de radiodosimetrie trois dimensionelles ont ete developees. Les techniques sont basees sur l'effet de la dose sur la relaxation Resonance Magnetique Nucleaire (RMN) des protons d'eau trouves dans les dosimetres de gels radiosensibles. Les etudes presentees regardent 1) la relation dose-effet du taud de relaxation spin-reseau, R1, du dosimetre contenant des ions ferreux et de la gelatine et 2) la relation dose-effet du taud de relaxation spin-spin, R2, du dosimetre polymerique BANG (Bis Acrylamide Nitrogen Gelatin).

Quand le premier dosimetre est irradie les ions ferreux sont convertis en ions ferriques. Un modele representant la relation dose-effet de R1 du dosimetre est propose. Le modele inclu deux parametres d'importance, le rendment d'ion ferrique et les relaxivites qui sont une mesure de l'abilite des ions de promouvoir la relaxation spin-reseau des protons d'eau. Les effets de la concentration de gelatine et d'acide sulferique sur le rendement d'ion ferrique et les relaxivites sont investiges. Il est demontre que la relaxivite de l'ion ferrique est affectee par la formation de complexes des ion ferriques. Cette formation est induit par les changements de pH apportes par la gelatine ou la concentration d'acide sulferique. Une version modifiee du modele prennant compte de la formation des complexes est presentee et verifiee en utilisant des methodes de spectrophotometrie. Les resultats sont aussi examines pour les manieres possible d'ameliorer la relation dose-effet.

Le dosimetre BANG est base sur la polymerization, induite par la radiation, des monomeres de Bis et d'acrylamide qui se trouvent dans la gelatine. Les etudes sur la reproduction des relations dose-effets de R2 pour des dosimetres BANG demontre qu'il y'a des reactions qui procedent apres l'irradiation du dosimetre et qu'il faut attendre un certain temps avant que la valeur de R2 stabilise. Un modele preliminaire pour la relation dose-effet de R2 du dosimetre BANG est presente. Le modele comprend un parametre de rendment de polymere et un de relaxivite spin-spin. Les resultats des effets de les concentrations de gelatine, Bis et acrylamide et de la temperature de la mesure de R2 sur la relation dose-effet de R2 sont presentes. Ils sont utilises pour determiner les compositions du dosimetre BANG et les temperatures de mesures qui produisent les meilleurs relations dose-effect de la relaxation RMN. Les resultats sont aussi interpretes en termes de rendement de polymere et de relaxivite spin-spin pour mieux comprendre les mechanisms physique et chimique gouvernant la relation dose-effet de R2.

Supervisor: L.J. Schreiner

Robert A. Corns

An implementation of the ICRP66 respiratory tract model in internal dosimetry
M.Sc

This treatise examines the ICRP's new respiratory tract model and its implementation into GENMOD, a program that facilitates internal dosimetric calculations for the body. The inclusion of the ICRP66 model into GENMOD improves the radiation dose estimates to the respiratory tract. The accuracy of this implementation was confirmed by validating GENMOD's output against results published in ICRP66.

Supervisors: R.B. Richardson (AECL Chalk River) and E.B. Podgorsak

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François Deblois

Implementation of 3D Photon External Beam Dosimetry in the McGill Planning System
M.Sc.

A clinically-useful treatment planning system for external photon beam radiotherapy must yield fast and accurate calculations of the dose distribution in the patient. The interface of the system should be "user friendly" and designed to minimize user work and errors. Visualization of the patient volume and dose calculation results should provide necessary information without being confusing. A software module meeting these criteria has been implemented within the McGill Treatment Planning System (MPS). The MPS program is written in C code and compiled with CodeWarrior C\C++™ from MetroWerks Inc. The MPS program runs on the Apple Macintosh platform (either 68K or PowerPC series). This new software module permits dose calculation (modified Milan-Bentley method) and viewing of the patient volume in three dimensions. Patient anatomical data is acquired from computer tomography (CT) or magnetic resonance (MRI) images. The accuracy of the dose calculation has been verified through comparison of the calculated results with water tank and film measurements.

Un programme efficace de planification de traitement par irradiation externe avec des photon doit permettre au dosimétriste de calculer de façon rapide et précise la dose dans le volume traité tout en lui offrant une interface agréable et performante tant au niveau de l'entrée des données que pour le visionnement du résultat des calculs et du volume du patient. Les bases d'un tel programme ont été implémentées pour le programme de planification de traitement "McGill Treatment Planning System" (MPS). Le programme MPS est écrit en langage C et compilé avec CodeWarrior C\C++™ de MetroWerks Inc. Il fonctionne sur plate-forme Apple Macintosh, séries 68K et PowerPC. Le système permet de calculer la dose (par méthode de Milan-Bentley modifiée) et de visualiser le volume du patient en trois dimensions. Les données anatomiques du patient sont obtenues par l'entremise a finalement été vérifiée en comparant les résultats calculés avec des mesures prises dans un réservoir d'eau et avec des films.

Supervisor: C. Pla

Tony Falco

MTF, NPS and DQE Analysis of Portal Metal-Plate / Film Detectors
M.Sc.

Previous studies of modulation transfer function (MTF), noise power spectrum (NPS), and detective quantum efficiency (DQE) of metal-plate/film portal detectors have been performed on limited combinations of front and back metal-plates. We report on these parameters for an extensive set of forty-nine front-back metal-plate combinations. The portal detector consists of a double emulsion RP (Kodak localization therapy) film placed between metal-plates: Al, Cu, brass and Pb of thicknesses varying from 0.30 to 4.80 mm. Radiation sources included a Theratron Co-60 unit, and a Varian Clinac-18 linear accelerator delivering a polyenergetic 10 MV X-ray spectrum. In terms of the absolute efficiency of the detectors, the best DQE is obtained with the detector consisting of a 1.75 mm Cu front plate and a 1.62 mm Al back plate for the Clinac-18, and with the detector consisting of a 0.95 mm Cu front plate and a 0/80 mm Cu or a 1.62 mm Al back plate for the Co-60 gamma ray source.
Peu d'études ont été effectuées pour évaluer la fonction de transfert de modulation (MTF), le spectre de puissance du bruit (NPS), et l'efficacité de détection quantique (DQE) pour des détecteurs composés d'un film radiographique situé entre des plaques de métal. Notre détecteur, concu pour l'imagerie médicale à de hautes énergies, consiste en un film RP (Kodak, localization de thérapie) à double émulsion placé entre des plaques de métal de composition variée: Al, Cu, laiton, et Pb variant entre 0.30 mm et 4.80 m d'épaisseurs. Deux sources de photons ont été utilisées pour irradier le détecteur: le cobalt-60 et un spectre de rayons x (10 MV) provenant d'un accélérateur linéaire Varian Clinac-18. Nous avons étudié le MTF, le NPS, et le DQE pour quarante-neuf combinaisons de plaque-avant/plaque-arrière. Nous avons conclu que les détecteurs qui offrent la DQE la plus élevée sont: le détecteur avec plaque avant de Cu d'épaisseur 1.75 mm et de plaque arrière d'Al d'épaisseur 1.62 mm pour le Clinac-18, et le

détecteur avec plaque avant de Cu d'épaisseur 0.95 mm et plaque arrière de Cu ou d'Al d'épaisseurs 0/80 mm et 1.62 mm, respectivement, pour le cobalt-60.

Supervisor: B.G. Fallone

Normand Frenière

Paramètres de Blindage Photonique d'une Salle de Radiothérapie
M. Sc.

Lors de la planification du blindage d'une salle de radiothérapie, la plus grande contrainte est souvent l'espace disponible. Une solutoin réside en l'utilisation du béton à haute densité. Nous avons entrepris une étude pour obtenir les courbes de transmission de la radiation primaire, de fuite et diffusée au travers un béton spécial à haute densité. Nous avons également étudié diverses caractéristiques de la radiation de fuite et diffusée obtenue à partir d'un accélerateur linéaire de 10 MV. Ce mémoire présente les résultats de ces études.

Nous avons mesuré les courbes d'équilibre électronique et vérifié la validité de la loi de l'inverse carré de la distance pour des champs de radiation primaire, de fuite et diffusée dans le but d'établir la configuration appropriée lors de la caractérisation de ces types de radiation. Les résultats montrent que, pour la radiation diffusée d'un humanoïde, peu ou aucune région d'équilibre électronique n'est requise même à faible angle de diffusion.

Space constraints constraints often present the greatest challenge in determining the lay-out of specific radiotherapy installations. To fulfill these constraints high density concrete is often employed in construction. We have undertaken a study to establish the transmission of primary, leakage and scatter radiation through a particular type of high density concrete. In the course of this study various characteristics of leakage and scatter radiation from a 10 MV linac hae also been investigated. The result of these studies are reported in this thesis.

To establish the correct chamber configuration required for the characterization o the transmission factors for primary, leakage and scatter radiation and to determine the scatter-to-incidence dose ratio a, we have measured the build-up curves and verified the validity of the inverse square law for these different radiations. The build-up data for the radiation scattered from a humanoid phantom at different angles from the primary axis have shown that even at low scatter angles little to no build-up is required for scatter radiation measurements.

Supervisors: L.J. Schreiner/E.B. Podgorsak

Richard Hoge

Fast Acquisition Strategies for Functional Magnetic Resonance Brain Imaging
M.Sc.

This thesis presents two techniques for enhancing the volume coverage and temporal resolution of functional magnetic resonance brain imaging on conventional clinical scanners, namely echo-shifting and retrospective temporal resolution selection (RTRS). The techniques are compared with conventional 2D gradient echo imaging on the bases of speed and sensitivity to functional changes, and the necessary theory is reviewed to develop physical models explaining the different properties observed.

Acquisition, reconstruction, and analysis software packages for functional brain mapping are presented and demonstrated with visual stimulation. The echo-shifted sequence permitted acquisition of 3D maps of brain activity which could be better correlated with local anatomy than 2D maps, and the RTRS method provided physiological response curves with greatly increased temporal resolution.

Cette thèse décrit deux méthodes rapide d'imagerie fonctionelle du cerveau par résonance magnétique dans deux et trois dimensions avec une systeme conventionnelle, soit, le déplacement d'écho, et la sélection rétrospective de la résolution temporelle. Les techniques sont comparées avec une séquence conventionelle à écho de gradient du point de vue de la sensibilité aux changements fonctionnels et à la rapidité d'acquisition, et une révision de la théorie nécessaire pour développer des modèls physiques pour expliquer les différences de performance entre les méthodes est presentée.

Des logiciels pour l'acquisition, la reconstruction, et l'analyse des donnés sont aussi presentés et demonstrés avec des donnés acquises durante la stimulation visuelle. Les techniques d'imagerie à haute vitesse ont permis l'acquisition d'image en 3D de l'activité cérébrale qui était impossibles à réaliser avec des méthodes conventionnels. Des enregistrements de la réponse physiologique avec une résolution temporelle élevée ont aussi été faits.

Supervisor: G.B. Pike

Bernard J.Lachance

A new penumbra generator for matching of electron fields
M.Sc.

We describe the geometric and dosimetric characteristics of a device developed to modify the penumbra of an electron beam and thereby improve the dose uni- formity in the overlap region when fields are abutted. The device is a Lipowitz metal block placed on top of the electron applicator's insertion plate and positioned to stop part of the electron beam. The air-scattered electrons beyond the block increase the penumbra width from about 1.4 to 2.7-3.4 cm. The modified penumbra is broad and almost linear at all depths for the 9 MeV and 12 MeV elecron beams used in this study. Film dosimetry was used to obtain beam profiles and isodose distributions. Without the penumbra generator, lateral setup errors of 2 to 3 mm may introduce dose variations of up to 20% in the junction region. Similar setup errors cause less than 5% dose variations when the penumbra generator is used to match the fields.

Supervisors: R. Pouliot (Quebec) and E.B. Podgorsak

Anas Orfali

Verification of a 3-D External photon beam treatment planning system
M.Sc.

Treatment planning is recognized as a fundamental step in clinical radiotherapy. The increased availability and complexity of three dimensional (3D) computerized treatment planning systems necessitates a full verification protocol to be completed prior to the implementation of the treatment planning system in routine use. We have designed and performed a detailed experimental verification program aimed at evaluating each individual dosimetric aspect of our 3D computerized treatment planning system (Varian CADPLAN, version 2.62). The verification tests ranged in complexity from the most basic standard geometry to a simulation of a full treatment case. Results from each individual testing geometry are presented, and an overall evaluation is discussed. We have concluded that our 3D treatment planning system is acceptable for clinical use.

Supervisor: E.B. Podgorsak

Laura Pisani

Incorporation of Stereoscopic Video into Image-Guided Neurosurgy
M.Sc.

This thesis describes a technique to establish live feedback to the image-guided neurosurgery environment, in the form of stereoscopic video scenes from the operating room. The video scenes are superimposed on images presently available in image-guided neurosurgery. The effect of displaying these superimposed images stereoscopically is that the viewer's natural, binocular vision appears to penetrate the patient's head, and to reveal internal anatomy.

Brief histories of conventional stereotactic, and frameless image-guided neurosurgery are provided. Relevant capabilities and limitations of the neurosurgical environment into which video is introduced are described, as well as the development and description of the pertinent video technology. Next, the mathematics of projection imaging, and principles of stereoscopic imaging are discussed. The role of stereoscopic video in the operating room is reviewed, and a technique for merging magnetic resonance images (MRI) and video stereoscopic-pairs is presented. The performance of the developed system is evaluated using a phantom and human subjects.

Cette thèse décrit une technique qui fournit au système de neurochirurgie guidée par images électroniques, un feed-back continuel, sous la forme de deux scènes vidéos en stéreo de la chambre d'opération. On supèrpose les scènes vidéos sur des images qu'on emploie présentement dans le système de neurochirurgies guidée par images électroniques. La superposition de ces deux genres d'images en stéreo donne l'effet que, la vision binoculaire naturelle de l'observateur pénétre la tête du patient et expose la structure anatomique intèrne.

On présente un bref recit de l'histoire de la neurochirurgie guidée par images électroniques, stéreotactique et sans cadre. On décrit les capacitées et limitations du système neurochirurgical, dans lequel on introduit les scènes vidéo pértinente. Ensuite, on discute la formulation mathématique de l'imagerie en projection et les principes de stéreoscopie. On met en question le rôle des scènes vidéos en stéreo dans la chambre d'opération, et on présente une technique de fusioner des images de résonance magnétique (IRM) avec des scènes vidéos en stéreo. On mesure la performance du système dévelopé sur des données artificiélles et humaines.

Supervisor: T.M. Peters

Vlado Robar

Characteristic angle-beta concept in electron arc therapy
M.Sc.

Electron arc therapy is the treatment of choice for tumours involving large curved surfaces. At the Montreal General Hospital a unique approach to the electron arc therapy was developed in 1986 and has been used clinically ever since. The approach is based on the concept of the characteristic angle beta.

We measured radial percentage depth doses in a polystyrene cylindrical phantom irradiated with electron arc beams having angles beta in the range from 5^o to 100^o, for 9 MeV, 12 MeV, 15 MeV, and 18 MeV electron beam energies. We showed that the characteristic angle-β concept can be extended to the beams with nominal energy of 18 MeV. The validity of the empirical relationship, relating the doses in two beams with different energies, was confirmed. A linear relationship between the angle β and the depth of dose maximum, the depth of the 85% depth dose, and the depth of the 50% depth dose, was established. The surface dose dependence on the angle β was also determined and the bremsstrahlung contamination in the electron arc therapy studied.

L'électronthérapie en arc est le traitement de choix pour les larges tumeurs de surface courbée. À l'Hôpital Général de Montréal une approche unique au traitement en arc, fondée sur le concept de l'angle caractéristique, a été dévéloppé en 1986 et est utilisée depuis ce temps.

Nous avons mesuré les rendements en profondeur radiaux dans un phantom cylindrique de polystyrène, lorsqu'irradié par des faisceaux d'électrons en arc, ayant des angles β des 5^o à 100^o. Les énergies des faisceaux d'électrons utilisées sont celles disponibles à partir d'un accélérateur linéaire Clinac-18 (9 MeV, 12 MeV, 15 MeV et 18 MeV). Nous avons démontré que le concept de l'angle charactéristique peut être étendu aux faisceaux d'énergie nominale de 18 MeV. Nous avons confirmé la relation empirique reliant la dose obtenue à partir d'un faisceau d'énergie quelconque, à celle d'un autre faisceau d'énergie différente. Nous avons trouvé des relations linéaires entre l'angle β et la profondeur de dose maximale, ainsi que celle du rendement en profondeur de 85% et celle de 50%. La dépendance de la dose en surface avec l'angle β fut determinée. Finalement, nous avons étudié la contamination en rayonnement de freinage inhérente à l'électronthérapie.

Supervisors: E.B. Podgorsak, M. Olivares

Hui Wang

Development of a Portal Imager and of Tools for Radiation Treatment Verification

Ph.D., Department of Physics

A prototype electrostatic imager has been developed for megavoltage portal imaging in radiation therapy. The imager utilizes amorphous selenium (a-Se) with a front metal plate as the image receptor and a high resolution voltmeter probe for image readout. Imaging characteristics of a-Se have been investigated theoretically through Monte Carlo simulations, and experimentally by measuring radiation discharging curves and phantom tests. The results of this study have shown that the prototype imager has high sensitivity, good spatial resolution and low noise level. Our study also reveals the potential of electrostatic imaging with metal/a-Se in megavoltage imaging. Two computer algorithms have also been developed for automatic segmentation and contrast-enhancement of digital portal images, and for radiation field shape verification. Based on a priori knowledge of the properties of portal images, the segmentation and contrast-enhancement algorithm employs multiple criteria and dynamic reasoing to achieve optimal segmentation of individual images, and has been proved to be accurate, robust and fast. The algorithm for radiation field shape verification is an adaptation of the chamfer matching technique to a specific application: matching closed contours. By incorporating geometric features of the radiation field and using a simple minimization method which is more specific to this task, the algorithm appears to be able to improve the matching results of the standard method.

Un nouveau détecteur électrostatique a été çonu pour l'imagerie numérique de vérification lors de la radiothérapie effectué avec des faisceaux de photons à haute tension placée derrière une feuille de métal. Une fois irradiée, la lecture de la tension locale sur la plaque de sélénium se fait par moyen d'une sonde de haute résolution. Les propriétés radiologiques du sélénium amorphe ont été examiné théoriquement à l'aide de simulations Monté Carlo, et expérimentellement en mesurant les courbes de déchange et en effectuant des tests avec des fantômes. Nous avons constaté que notre détecteur est très sensible, peu contaminé par le bruit, et possède une bonne résolution spatiale. Ceci témoigne du grand potentiel de l'imagerie électrostatique avec le métal/sélénium amorphe pour la vérification en radiothérapie. Un premier algorithme informatique a été développé pour la segmentation automatique et le rehaussement du contraste des images. Un deuxième algorithme a été développé pour la vérification de la forme des champs de radiation. En se basant sur les propriétés a priori des images numériques de vérification, le premier algorithme utilise des critères multiples et le raisonnement dynamique pour arriver à une segmentation optimale de l'image, rapidement et surement. Le deuxième algorithme adapte le procédé du "chamfer mathing" au problème de l'ajustement de contours fermés. En incorporant les traits géométriques du champs de radiation et en utilisant une méthode de minimisation appropiée, cet algorithme paraît être plus performante que l'algorithme conventionnelle.

Supervisor: B.G. Fallone

University of Toronto, Toronto, ON

Department of Medical Biophysics

Ariff Kassam

Fourier Registration of Three-Dimensional Brain MR Images: Exploiting the Axis of Rotation

M. Sc.

Magnetic resonance imaging (MRI) applications that require the analysis of serially acquired images are prone to errors associated with patient movement and/or repositioning between images. Such applications include contrast-enhanced imaging, staging of disease, monitoring response to treatment, and functional MRI (fMRI). A partial solution to this problem is to register the images before analysis. The registration algorithm must be three-dimensional (3-D) and have sub-voxel accuracy. A novel algorithm was developed to register 3-D digital images where the motion between images can be modeled as a rigid-body. The most interesting feature of the algorithm is its ability to reduce a general 3-D rotation to a simple planar rotation by finding the axis of rotation. The algorithm, which is a non-trivial extension of existing two-dimensional (2-D) Fourier registration algorithms, has been tested on 30 artificially misaligned MR images of a phantom and four segmented brain images. The algorithm successfully registered every image. For the phantom images, the registration error for a voxel 10 cm from the origin was at most 2.8 mm and had a mean of 1.2 mm and standard deviation of 0.7 mm (1.2, 0.5, and 0.3 voxels respectively). The results indicate that the algorithm is accurate, reliable and fast. The rigid-body model requires the brain to be segmented from MR images of the head prior to registration.

Supervisor:

Chris Macgowan

Phase-Encode Reordering to Minimize Errors Caused by Motion in MRI

M.Sc

A new method is presented for suppressing the effects of motion in magnetic resonance (MR) images by reordering the acquisition of k space. Existing reordering methods fail to prevent image blurring. This method applies specifically to translation along the phase-encoding direction, which is the dimension encoded using only the phase of the signal. In such cases, it reduces both ghosting and blurring. The method is intended for anatomic sites in which substantial translational motion occurs along the phase-encoding direction, such as the cranial-caudal motion of the liver and kidneys. The theory behind the reordering method is described and validated experimentally by imaging a moving phantom.

Supervisor: Michael L. Wood

Pia Rieppo

An Amorphous Selenium X-Ray Light Valve for Diagnostic Radiography

M.Sc.

This thesis proposes a novel x-ray imaging system which incorporates x-ray absorption, image formation and amplification stages within a simple, flat panel structure. The system, called the X-ray Light Valve (XLV), is based on two key components physically coupled in a sandwich structure: a solid state electrostatic x-ray detector; and an electro-optic light modulator. X-ray absorption in the photoconductive detector controls the optical state of the electro-optic modulator via the creation of charge carriers, which induce spatial and temporal variations in the electric potential of the modulator. The XLV image may be viewed directly or it may be combined with an optical detector and analogue-to-digital converter for digital radiography. The feasibility of adapting the XLV to clinical radiography is examined with a theoretical model based on the properties of an amorphous selenium detector and a twisted nematic liquid crystal cell. It is shown that the XLV, in theory, can satisfy or exceed the imaging requirements of medical radiographic systems. In addition, it is shown that the XLV differs markedly from existing x-ray imaging systems, most of which are based on phosphor screen technologies. As the primary detector is electrostatic, there is essentially no blurring in the charge image formation and it is expected that the XLV will have high resolution. Moreover, as image formation is based on light modulation rather than light creation, the XLV effectively acts as a light amplifier thus overcoming signal-to-noise ratio limitations related to a coupling secondary quantum sink. Furthermore, the operation of the XLV has a unique time dependence which may be used to extend the dynamic range of the system and which adds imaging versatility, allowing a number of imaging tasks to be carried out with a single device. The concept of using a light valve in x-ray imaging is also investigated experimentally with prototype XLVs.

Supervisor: J. Rowlands.

John M. Sabol

A Scan-Rotate Geometry for Efficient Equalization Mammography
Ph. D.

Mammographic screening is acknowledged as the best method for the reduction of breast cancer mortality. However, breasts containing a significant fraction of dense, fibroglandular tissue produce a range of exposure which exceeds the dynamic range of conventional mammography. Equalization radiography involves the modulation of the incident x-ray exposure distribution to compensate for variations in x-ray transmission within the patient, ensuring optimal contrast throughout the image. It has been shown that equalization radiography offers the potential for dose-efficient, improved lesion detection in the dense breast. However, current equalization geometries are not practical due to tube loading and scan duration inefficiencies. I propose a scan-rotate geometry for equalization radiography (rotary scanning equalization radiography, RSER) in which the image receptor is exposed by repeated scans of a modulated fan beam, oriented at a variety of angles with respect to the patient. The superposition of exposure from appropriately modulated, rotated fans beams will produce an entrance exposure distribution that will efficiently equalize the film exposure.

In this thesis, it is shown that less than half of the area of a dense breast is imaged conventionally with high contrast. The RSER geometry is described and its imaging characteristics are shown theoretically to be similar to current equalization geometries. Furthermore, RSER is resistant to exposure artefacts in typical mammographic imaging tasks. Numerical simulations which compared the imaging performance of RSER, current equalization geometries and conventional mammography show that RSER produces images with the same degree of equalization as current equalization geometries, with minimal tube loading, and only four scanning angles. Finally, an experimental prototype RSER system is described and characterized. Experimental images confirm the theoretical and numerical predictions. High contrast, artefact-free images of anthropomorphic breast phantoms can be obtained with minimal scan times and tube loading. The prototype system increases the fraction of the breast imaged with high contrast from 46 %to 80%.

These results indicate that RSER is an efficient, simple, and practical means of overcoming the latitude limitations of film screen mammography, and improving the detection of breast cancer.

Supervisor: D.B. Plewes

University of Victoria, Victoria, BC

Department Electrical and Computer Engineering

Gregory A. Gallant

Experimental Validation of Dose Distributions Predicted by a Treatment Planning System for Complex Models
M. Sc.

The trend towards dose escalation in radiation therapy creates the need for non-coplanar beam arrangements to help minimize healthy tissue morbidity in the proximity of treatment volumes. Treatment planning software packages are able to generate external beam non-coplanar isodose distributions, but this aspect of the software available in the Vancouver Island Cancer Centre has not been experimentally verified.

Kodak XV film was used to measure the relative dose within various tissue equivalent phantoms for comparison with the distributions predicted by the G.E. Target treatment planning software. The results confirm that Target is able to predict the isodose distribution for coplanar and non-coplanar beams incident on patient equivalent phantoms containing relatively large, semi-infinite inhomogeneities well enough to warrant its implementation into routine clinical use. However, we have found that Target may not be able to adequately predict dose distributions around smaller inhomogeneous inclusions. Further work will be required to investigate this potential problem.

Supervisors: J. Scrimger and M. Stuchly

University of Western Ontario, London, ON

Department of Medical Biophysics

Jean-Pierre Bissonnette

Optimization of portal imaging systems
Ph.D.

Many portal imaging devices have been developed to verify the geometric accuracy of radiation therapy treatments. Portal imaging devices are used to take images of the patient during radiation therapy treatments. These images are used to detect patient positioning errors which may jeopardize the outcome of conventional and high-precision radiotherapy treatments. Unfortunately, the quality of portal images obtained with such devices is disappointing, resulting in sparse clinical use of these devices.

Researchers have been substituting various imaging components on these portal imaging systems in the hopes of optimizing portal image quality. This empirical approach has led to some successes. However, choosing imaging system components on the basis of one desirable parameter while ignoring the impact of the change of overall system performance wastes time, money, and effort. Clearly, a more efficient approach is required.

This thesis presents approaches for the optimization of both the design and use of portal imaging devices. These approaches require understanding of the fundamental physics of portal imaging, such as the size and shape of the x-ray sources of medical linear accelerators and the interaction of x rays within typical portal imaging detectors. The *use* of existing portal imaging systems (i.e., portal films and video-based systems) has been optimized by finding the radiographic magnification which provides the best image quality for a particular system/linear accelerator combination. It has been found that, for portal films, radiographic magnification is undesirable. On the other hand, a radiographic magnification of 1.5-1.7 is optimal for video-based systems. Therefore, the image quality from an existing imaging system can be improved without changing the system design. The *design* of portal imaging systems has been optimized using a theoretical approach known as quantum accounting diagram (QAD) theory. Using this theory, a detailed analysis of a video-based portal imaging system has permitted the theoretical derivation of the detective quantum efficiency (DQE) of the imaging system. The analysis has shown that the video-based portal imaging system suffers from severe secondary quantum sinks for non-zero spatial frequencies, resulting from sub-optimal system design. Furthermore, the theoretical DQE's have been compared with experimental measurements - the first experimental verification of the QAD theory. The QAD theory has been expanded to include the physical parameters involved with the human visual system and allow the computation of indices of perceived image quality. This approach enables the optimization of imaging devices using a single figure of merit, and has been used to optimize the phosphor screen thickness used by two different designs of portal imaging systems. We have demonstrated that the QAD approach allows us to predict the change in overall system performance for any modification in the imaging system. In future, we believe that this tool will be vital to the development and optimization of improved portal imaging systems for radiation therapy.

Plusieurs chercheurs ont développé des appareils radiographiques pour vérifier la précision géométrique des traitements de radiothérapie. Lors d'un traitement, les images de vérification acquises avec ces appareils (i.e., images portales) servent à détecter les erreurs de mise en place du patient. Ces erreurs peuvent compromettre les chances de succès des traitements de radiothérapie. Malheureusement, ces appareils demeurent peu utilisés cliniquement à cause de la mauvaise qualité des images obtenues avec ces appareils.

Pour améliorer la qualité des images portales, plusieurs chercheurs ont comparé plusieurs alternatives aux composantes formant les appareils actuels. Cette approche empirique a mené à certains succès. Toutefois, on a gaspillé beaucoup de temps, d'argent et d'efforts parce qu'on remplace une composante, sur la base d'une caractéristique désirable, sans égards à l'impact de ces changements sur la performance globale du système d'imagerie.

Cette thèse présente des approches pour l'optimisation de l'usage et de la conception d'appareils d'imagerie portale. Ces approches tiennent compte des limites physiques inhérentes à la formation d'images avec des rayons x à haute énergie, incluant la forme et la taille des sources de rayons x émis par les accélérateurs linéaires médicaux ainsi que l'interaction de ces rayons x avec les détecteurs utilisés habituellement par ces appareils d'imagerie. L'analyse de l'agrandissement radiographique optimal a permis d'améliorer la qualité des images produites par les systèmes existants (i.e., film en contact avec plaques de métal et système basé sur une caméra vidéo). L'agrandissement radiographique est indésirable pour le film portal alors qu'un facteur d'agrandissement entre 1,5 et 1,7 est optimal pour les systèmes vidéo. Donc, on peut améliorer la qualité des images portales obtenues avec un système existant sans en changer la conception. On a optimisé la *conception* des appareils d'imagerie portale en appliquant une approche théorique dite des 'Diagrammes de Propagation Quantique' (DPQ). Cette théorie a permis l'analyse détaillée d'un

appareil d'imagerie portal basé sur une caméra vidéo, de même que la dérivation théorique de l'Efficacité de Détection Quantique (EDQ) de cet appareil. Cette analyse a démontré une perte considérable d'information due à une conception inadéquate du système. De plus, on a comparé l'EDQ théorique à celle obtenue expérimentalement, présentant du même coup la première vérification de la théorie des DPQ. On a développé cette théorie afin d'inclure les paramètres physiques du système visuel humain et le calcul d'indices de perception de qualité d'image. On a utilisé cette approche, qui permet l'optimisation de systèmes d'imagerie à l'aide d'un seul paramètre, afin d'optimiser l'épaisseur des écrans phosphorescents utilisés par deux systèmes d'imagerie portale de conceptions différentes. Nous avons démontré que l'analyse DPQ permet de prédire l'effet, sur la qualité d'image, de toute modification apportée à un appareil d'imagerie. Nous croyons que les outils présentés dans cette thèse seront d'une grande utilité pour développer et l'optimiser les systèmes d'imagerie portale futurs.

Supervisor: P. Munro

Jeff Lawrence

Measurement of Lumenal Geometry Using Conventional Angiography and Volumetric Computer Tomography
M.Sc.

A technique for performing quantitative measurements from conventional film angiograms was developed. This technique, which overcomes the problem of trying to interpret three-dimensional geometry from a two-dimensional image, yielded a good assessment of the true artrerial geometry. The angiographic technique used a hollow, triangular calibrating wedge to calibrate contrast agent thickness to angiographic optical density. Contrast agent was injected into the wedge and an excised arterial specimen, both contained in a 14 cm water bath, simultaneously. A radiograph of this wedge-artery grouping was taken and digitized for computer image processing. To correlate the angiographic findings, an experimental volumetric CT system was used to create three dimensional CT images of the same arteries. A region growing method was then applied to the the CT images to extract the lumen. Measurements were performed on cylindrical calibration tubes, excised porcine thoracic aortas, and excised human aorta-iliac bifurcations to determine the accuracy and limitations of the angiographic method. Cross-sectional areas along the arteries and thickness profiles were used to compare geometry measurements from the CT and angiography techniques. It was found that cylindrical tubing of known size produced errors under 4% in area, and that the porcine specimens produced RMS differences ranging from about 2.5 mm^2 to 4.5 mm^2 (or about 1.6% to 3.4%). The human arterial specimens presented more problems, citing an RMS difference of about 10 mm^2 to 37 mm^2, or about 5% to 29%, but methods for overcoming this were presented. This new system, together with the described techniques, offers a unique tool to perform accurate geometrical measurements from conventional film angiograms.

John McLellan

Improving Dose Calculations in Electron-Beam Radiation Therapy
Ph.D.

The finite range of electrons in tissue makes electron beams a useful radiation treatment modality for many tumour sites. However, the simplistic methods of dose calculation in current clinical use lack sufficient accuracy in many situations of clinical importance. This thesis rests on the premise that a more accurate dose calculation method must incorporate all the major physical processes which shape the dose distribution.

The thesis unites the important transport processes of electron energy loss and angular scattering in a single mathematical model known as the compound Poisson process (CPP). CPP-based calculations of energy-loss spectra for 10, 20 and 30 MeV electrons incident on graphite and aluminum absorbers agreed within 1% with Monte Carlo simulations for electrons travelling path lengths less than 0.5 g/cm^2. Similarly, calculations of angular distributions agreed with Monte Carlo simulations within 2% for 5 and 10 MeV electrons traversing water slabs up to 0.5 cm thick.

The evolution and Monte Carlo methods of dose calculation can both incorporate the CPP model into a complete transport calculation. An analysis of the convergence of the two methods reveals that: (i) the number of histories in a Monte Carlo simulation is analogous to the number of discrete bins in the evolution method, (ii) the convergence of the evolution method depends on the dimensionality of the problem while the convergence of the Monte Carlo method does not, and (iii) for the full six dimensional transport problem, the ratio of the error in the evolution method to that in the Monte Carlo method is proportional to $N^{1/6}$ where N is the number of histories or bins.

Since the convergence of the evolution method improves with fewer dimensions, an approximate "dimensionally-reduced" evolution method is pro-posed. Preliminary calculations of dose distributions in a homogeneous water phantom achieved reasonable agreement with Monte Carlo simulations for incident 10 and 20 MeV electron beams. The least accurate result underestimated the dose by 5% at the

depth of dose maximum and overestimated the width of the 10% isodose line by 8 mm. These early results indicate that the dimensionally-reduced evolution method merits further investigation.

Supervisor: J. Battista

J. Ross Mitchell

Visualization and Analysis of Multiple Sclerosis Lesions in MR Images
PhD

Quantifying changes in the number and extent of lesions in MR images has been used to indicate disease activity in Multiple Sclerosis. However, quantification is arduous and subject to variability. These factors increase the duration and cost of clinical trials which rely on quantitative measurements to assess therapeutic effect. A computerised system was developed to assist MS lesion quantification in MR exams. Both manual and assisted quantification were compared using repeated measurements of lesions in MR exams of a phantom and MS patient. Results indicate that assisted quantification reduced inter-operator variability by 1/2, and reduced intra-operator variability by 1/3. Repeated measurements were also used to determine the impact on operator variability of: a) lesion quant-ification in high-field (1.5T) versus mid-field (0.5T) exams; and, b) an anisotropic diffusion filter which reduces image noise without blurring or moving edges. Results indicate that signal-to-noise ratios are higher, and operator variability is lower, in anisotropically filtered and in 0.5T exams. Finally, a new technique was developed to provide lesion composition information from MR exam intensities. Analysis of serial exams of 3 MS patients revealed changes in the intensity spectra within lesions, even when their volume remained constant. Together, assisted lesion quantification and analysis may provide additional insight into disease activity, and improve the sensitivity of clinical trials of new therapies.

Supervisor: A. Fenster

We now invite submissions for the fall issue of the Newsletter which will publish a report of theses completed in 1997. Please check the April issue of the Newsletter to see if your work is on file.

All submissions should be sent as computer ready submissions (e-mail or 3 1/2 in floppy disks in both ASCI and word processor format; please specify programme used). FAXed or written submissions of abstracts can not be entered completely into the report, although information on the author, title, etc. will be reported. Hard copy to confirm special symbols or fonts is appreciated, especially for submissions in French.

The submissions should be sent to:

L. John Schreiner, Ph.D.
Chief, Medical Physics Department
Kingston Regional Cancer Centre
25 King St West
Kingston, ON
K7L 5P9

e-mail to: jschreiner@cancercare.on.ca

Canadian College of Physicists in Medicine Examination Schedule 1998

Membership Examination:

Applications due: 19 January 1998
Examination date: 4 April 1998

Fellowship Examination:

Applications due: 24 April 1998
Examination date: 16 or 17 June 1998
London, Ontario

Note: Fellowship applicants writing the membership examination should confirm their fellowship application and pay the fee within one week of receiving the membership examination results.

For further information, application kits, and membership examination study guides, contact the Registrar, Dr. Alistair Baillie, at:

Dr. Alistair Baillie
The Registrar/ Le Registraire, CCPM
c/o Cancer Centre for the Southern Interior
399 Royal Avenue
Kelowna, BC, V1Y 5L3

Proceedings of Past COMP/CCPM Conferences Available

There are a few copies of the 1996 COMP/CCPM Conference in Vancouver and of the 1997 COMP/CCPM Conference in Charlottetown available. The 1996 Proceedings have cerlox bindings and are being offered free of charge to COMP or CCPM members. The 1997 Proceedings have the regular binding and are for sale at a cost of $30 each. To obtain a copy, please contact:

Brighid McGarry
COMP Secretariat, Edmonton
Tel: (403)479-1110
Fax: (403)474-5894
E-mail: bmcgarry@compusmart.ab.ca

COMP OCPM
CANADIAN ORGANIZATION OF MEDICAL PHYSICISTS
ORGANISATION CANADIENNE DES PHYSICIENS MÉDICAUX

CALL FOR NOMINATIONS/ APPEL POUR MISES EN CANDIDATURE

Nominations for Chair-Elect/
Candidature comme vice prèsident

And/et

Nominations for Secretary/
Candidature comme Secrétaire

Nominations must be received by March 1, 1998/
Date limite de mise en candidature: 1er mars 1998.

Nominations must be signed by two sponsoring members and by the nominee who by his/her signature agree to accept the nomination/ La mise en candidature doit être signée par deux membres actifs et par le candidat.

Please send nominations to:/
Envoyez vos mises en candidature à:

Lee H. Gerig
COMP Past Chair
Head Clinical Physics
Ottawa Regional Cancer Centre
501 Smyth Rd
Ottawa, ON. K1H 8L6
Tel: (613) 737-7700 x6736
Fax: (613) 247-3507
Email: gerig@physics.carleton.ca

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 Johns Travel Award for Young Investigators. This award, which is in the amount of $1500, is made to a College member under the age of 35 who became a member within the previous three 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 endeavour 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 $1500, est éligible aux membres du Collège agés de moins de 35 ans at qui sont membres depuis moins de trois an. 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 spécialisé.

Les demandes seront addressées à:

The Registrar / Le Registraire
CCPM
c/o Cancer Centre for the Southern Interior
399 Royal Avenue
Kelowna, BC, V1Y 5L3

The deadline for applications for the next award is **April 1, 1998**. The award will be announced at the 1998 CCPM Annual General Meeting in London.

La date limite pour les demandes du prochain concours est le **1er avril 1998**. Le récipiendaire de la bourse sera annoncé à la rencontre annuelle de 1998 du CCPM à London

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 Dr. Brendan McClean, Edmonton
1995 Dr. George Mawko, Halifax
1996 M. Alain Gauvin, Montreal
1997 Dr. Katherina Sixel, Toronto

Members of the COMP/OCPM and/or the CCPM can make a donation to fund by volunteering to increase their 1998 membership dues.

Les membres du COMP/OCPM et\ou du CCPM peuvent faire un don à la cotisation de 1998 un montant additionel de leur choix.

CANADIAN COLLEGE OF PHYSICISTS IN MEDICINE

LE COLLÈGE CANADIEN DES PHYSICIENS EN MÉDECINE

Joint CCPM/CAMRT Initiative

On a Speciality Certificate in Dosimetry

About two years ago, the Canadian College of Physicists in Medicine (CCPM) and the Canadian Association of Medical Radiation Technologists (CAMRT) identified a potential need for a special credential in Dosimetry/Treatment Planning for the radiotherapeutic treatment of cancer. A joint Working Group was established to explore this issue and, after extensive preliminary discussions, both the CCPM and the CAMRT are now seeking input from the broader Canadian radiation treatment community.

The Working Group has developed a questionnaire that will be distributed to Department Heads or equivalent individuals at all Canadian cancer centres. Department Heads are asked to make the questionnaire available to all their staff.

COMP/CCPM members involved with radiotherapy are asked to take the time to consider the issues raised in the questionnaire and to respond with your opinions by the deadline indicated in the questionnaire. If we are to move forward on this unique initiative we need to know what you think.

Once the results are received and have been analysed, a report will be published in this newsletter.

Thank you to those who take time to assist the joint Working Group. Please ensure that completed surveys are returned to one of the individuals below:

Peter Dunscombe, President
Canadian College of Physicists in Medicine
11328 – 88 Street
Edmonton, AB
T5B 3P8

or

Sheila Boutcher, President
Canadian Association of Medical Radiation Technologists
601 – 294 Albert Street
Ottawa, ON
K1P 6E6

1998 Sylvia Fedoruk Prize in Medical Physics

The Saskatchewan Cancer Foundation is pleased to sponsor a competition for the 1998 Sylvia Fedoruk Prize in Medical Physics. This award is offered annually to honour the distinguished career of Sylvia Fedoruk, former Lieutenant-Governor of Saskatchewan and previously physicist at the Saskatoon Cancer Centre.

The prize will comprise a cash award of five hundred dollars ($500), an engraved plaque and travel expenses to enable the winner to attend the annual meeting of the Canadian Organization of Medical Physicists (COMP) and the Canadian College of Physicists in Medicine (CCPM) which will be held June 18-20, 1998 in London, Ontario.

The 1998 Prize will be awarded for the best paper on a subject falling within the field of medical physics, relating to work carried out wholly or mainly within a Canadian institution and published during the 1997 calendar year. The selection will be made by a panel of judges appointed by COMP.

Papers published in *Physics in Medicine and Biology* and *Medical Physics* which conform to the conditions of the preceding paragraph will automatically be entered in the competition and no further action by the author(s) is required. All other papers must be submitted individually. Four (4) copies of each paper being entered must be sent to:

The Executive Director
Saskatchewan Cancer Foundation
2631 28th Avenue, Suite 400
Regina, SK, S4S 6X3
Tel: (306) 585-1831
Fax: (306) 584-2733

Each paper must be clearly marked: “Entry for 1998 Sylvia Fedoruk Prize” and must reach the Saskatchewan Cancer Foundation no later than **Monday February 16, 1998**.

The award winners from the last four years were:

C. J. Henri and T. M. Peters, “Three-Dimensional Reconstruction of Vascular Trees. Theory and Methodology”, *Medical Physics* **23**, 197-204 (1996).

W. Zhao and J. A. Rowlands, “X-ray Imaging using Amorphous Selenium: Feasibility of a Flat Panel Self-Scanned Detector for Digital Radiology”, *Medical Physics* **22**, 1595-1604 (1995).

R. M. Henkelman, G. J. Stanisz, J. K. Kim, and M. J. Bronskill, "Anisotropy of NMR Properties of Tissues", *Magnetic Resonance in Medicine* **32**, 592-601 (1994).

J. M. Sabol, I. C. Soutar, and D. B. Plewes, "Mammographic Scanning Equalization Radiography", *Medical Physics* **20**, 1505-1515 (1993).

New Members ...

The following are members who newly joined COMP during Oct.-Dec. 1997:

(F) Dr. Ram Ramani Physicist: Toronto Sunnybrook Cancer Centre

Membership classes: F: full; A: associate; S: student; C: corporate.

(Please inform the Newsletter Editor if your name is left out.)

Information Exchange

The Canadian Medical Physics Newsletter accepts advertisements from organisations and individuals. Send good copy and purchase order number to Editor, COMP Newsletter. Billing will be performed by the Treasurer of COMP. Make cheques payable to Canadian Organization of Medical Physicists.

It is presumed that advertisers are in full compliance with applicable equal opportunities laws and, unless otherwise stated in the advertisement, wish to receive applications from qualified persons regardless of race, age, national origin, religion, sex or physical handicap.

On the Move

The following physicists have joined the new cancer centre in Kelowna:

Cancer Centre for the Southern Interior
399 Royal Avenue
Kelowna, BC, V1Y 5L3

Alistair Baillie (Clinical Practise Leader)
Phone: (250) 712-3914
e-mail: abaillie@bccancer.bc.ca

Cynthia Araujo (formerly from Vancouver)
Phone: (250) 712-3916
e-mail: caraujo@bccancer.bc.ca

Darcy Mason (formerly from Toronto-Sunnybrook)
Phone: (250) 712-3917
e-mail: dmason@bccancer.bc.ca

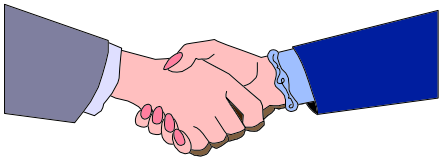
Rasika Rajapakshe (formerly from Vancouver)
Phone: (250) 712-3915
e-mail: rrajapak@bccancer.bc.ca

Patrick Rapley (formerly from Thunder Bay)
Phone: (250) 712-3918
e-mail: prapley@bccancer.bc.ca

John Grant has become the first physicist to join the new Sydney cancer centre. His address after 5th Jan 1998 will be:

John Grant
Medical Physics
Nova Scotia Cancer Centre Cape Breton
Healthcare Complex
l482 George Street
Sydney, Nova Scotia B1P2E9
Tel (902) 473-6020

Note that the phone number is that of the Halifax clinic. John will be in Halifax until early March.



Corporate Membership

COMP would like to acknowledge the support given by our corporate members:

ADAC

CNMC

Elekta

Frank Barker

G. E. Medical

Hilferdine

Keithley

Landauer

MED-TEC

Multidata

Nucletron

Picker

PTW

Sandstrom

Siemens

Theratronics

Varian

Wellhofer

X-Ray Imaging

We hope to continue our association with these and new corporate members.

Calendar 1998

February 21-26, 1998
SPIE Medical Imaging 1998
Town and Country Hotel, San Diego CA
[SPIE (360) 676-3290; e-mail spie@spie.org]

March 8-10, 1998
Advances in Cardiovascular Radiation Therapy II
Renaissance Washington, DC Hotel
[http://www.radiationonline.com]

March 26-28, 1998
Wescan '98
Regina, Saskatchewan
[Peter Dickof, pdickof@scf.sk.ca, (306) 766-2285]

April 18-24, 1998
International Society of Magnetic Resonance in Medicine
Sydney Convention & Exhibition Centre, Sydney, Australia

June 7-11, 1998
Society of Nuclear Medicine
Toronto Convention Centre, Toronto, ON

June 7-10, 1998
Canadian Association of Radiologists
Westin Hotel, Halifax, Nova Scotia

June 18-20, 1998
44th Annual COMP/CCPM Annual Meeting
London, Ontario
[Mrs. Brighid McGarry (COMP Secretariat),
Tel: (403)479-1110, Fax: (403) 474-5894,
bmcgarry@compusmart.ab.ca]

August 9-13, 1998
40th Annual AAPM Annual Meeting
San Antonio, Texas
[Lisa Rose Sullivan, Tel: (301)209-3387]

October 25-28, 1998
40th Annual ASTRO Meeting
Phoenix, Arizona
[Mrs. B. Rapp, ASTRO, 1891 Preston White Drive,
Reston, VA, 22091 (703)648-8900, Fax (703)648-9176]

October 29-31, 1998
EPI98: 5th International Workshop on Portal Imaging
Pheonix, Arizona
[(410) 269-6801; http://www.ea.net/epi98/]

Nov 29-Dec 1, 1998
Radiological Society of North America
McCormick Place, Chicago, IL,
[www.rsna.org]

INSTRUCTIONS ON NEWSLETTER CONTRIBUTIONS

Articles for the Newsletter are best submitted as a file attached to E-mail. Submissions must be in ASCII, or Word 6.0 format. If you use another word processor please contact the editor before submitting an article so arrangements can be made. Please send a hard copy by fax so that any symbols or special characters can be verified.

Good print quality submissions are also welcome. Newsletter articles should be on 8-1/2 by 11 inch paper with one-inch margins on all sides. Contributions should in a clear font or type (default for the Newsletter is 10 point Times New Roman). Please end your submission with your name and institution. Advertisements should be submitted camera ready for direct reproduction in Newsletter or in Word 6.0 format. Fax submissions must be supported by original copy and will not be used directly. Please send contributions to:

Peter Munro, Ph.D., MCCPM
London Regional Cancer Centre
790 Commissioners Rd. E.
London, Ontario, N6A 4L6
Tel: (519)685-8600 x3317
Fax: (519)685-8658
pmunro@lrcc.on.ca

Deadline of submissions for the next issue of the Newsletter is 1st March 1998.

Medical Physics E-mail and WWW Services

The canada-l mailing list is now being managed by Majordomo. Send messages to:

canada-l@irus.rri.uwo.ca

If you want to subscribe or unsubscribe, you can send mail to <Majordomo@irus.rri.uwo.ca> with the following command in the BODY of your e-mail message:

subscribe canada-l you@your.email.address
unbscribe canada-l you@your.email.address

For more information, you can send mail to <Majordomo@irus.rri.uwo.ca> with the following command in the body of your e-mail message:

help
end

This will give you a list of all the commands you have access to. If you have any other questions or concerns please send e-mail to canada-l-owner@irus.rri.uwo.ca , and someone will get back to you.

Frank Sargent
fsargent@irus.rri.uwo.ca
System Manager, Robarts Research Institute

COMP/CCPM Web Site

In addition to the Canada-l burster, CCPM and COMP now maintain a www site that can be accessed via

http://www.bic.mni.mcgill.ca/ccpm

It contains descriptive pages on CCPM and COMP, and will be expanded as time goes on to include membership and examination forms, as well as conference announcements.

Suggestions for improvement of the pages are welcomed and these should be forwarded to Terry Peters in London, (tpeters@irus.rri.uwo.ca) or Peter Munro in London (pmunro@lrcc.on.ca).

1998 CAP Congress

The University of Waterloo is pleased to host
the 53rd Annual Congress of the Canadian Association of Physicists
from June 14-17, 1998
in Waterloo, Ontario.

- The Call for Abstracts and Registration Form will be available on-line and in the January/February issue of “Physics in Canada”
- Advanced registration deadline is 1 May 1998.
- For more information, please visit “sponsored events” in the CAP website at www.cap.ca

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TENURE-TRACK ASSISTANT OR ASSOCIATE PROFESSOR

DEPARTMENT OF PHYSICS & ASTRONOMY
McMASTER UNIVERSITY

The Department of Physics & Astronomy invites applications for a tenure-track appointment at the Assistant or Associate Professor level.

The successful candidate will have a PhD in a field which will enrich and enhance our existing strengths in one or more of the following fields: astrophysics, condensed matter physics, **medical physics,** nuclear physics, and theory. She or he will be responsible for creation and leadership of a strong research group involving graduate students, and to the extent possible, undergraduate students. They must also have a strong academic record, show exceptional promise for independent research and be committed to graduate and undergraduate physics instruction.

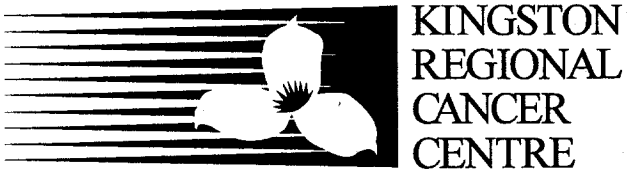
The position will commence **July 1, 1998**. Salary will depend on qualifications and experience.

Applications including curriculum vitae and the names of three referees, should be submitted by **February 15, 1998** to:

The Chair
Department of Physics & Astronomy
McMaster University
1280 Main Street West,
Hamilton, Ontario L8S 4M1.

E-mail and FAX applications will not be accepted.

In accordance with Canadian immigration requirements, this advertisement is directed to Canadian citizens and permanent residents. McMaster University is committed to employment equity and encourages applications from all qualified candidates, including aboriginal peoples, persons with disabilities, members of visible minorities and women.



MEDICAL PHYSICIST
RADIATION ONCOLOGY PROGRAMME
KINGSTON REGIONAL CANCER CENTRE, KINGSTON, ONTARIO
CANCER CARE ONTARIO

Applications are invited for the position of Medical Physicist at the Kingston Regional Cancer Centre. The Centre is one of eight regional cancer centres operated by Cancer Care Ontario and is located at the Kingston General Hospital, on the campus of Queen's University. Cancer Care Ontario through its regional centres and partnerships, provides a province wide system of cancer Care.

Approximately 2,000 new cancer patients are registered annually at the Centre. The Radiation Oncology Programme operates two Varian Clinac 2100C/D and one Clinac 600C linear accelerators, a cobalt unit, an orthovoltage x-ray unit, and LDR remote afterloading equipment, and is acquiring a Theraplan 3D treatment planning system. Members of the Medical Physics Department supervise medical physics graduate students in the Department of Physics at Queens University, and support training programmes in Radiation Oncology and Radiation Therapy.

The successful candidate will be expected to participate in all clinical, educational and research activities of the Medical Physics Department. Clinical activities include acceptance testing and commissioning of new equipment, calibrations, dosimetry data base maintenance, quality assurance, and treatment planning support. All medical physicists are expected to be active leaders in the development of technical improvements in the radiation planning and treatment program.

Candidates for this position must be fully trained Medical Physicists, with a postgraduate degree (Ph.D. preferred) and a minimum of one year of post-training experience in clinical radiation therapy physics. Membership in the Canadian College of Physicists in Medicine or equivalent is preferred. Applicants must have good evidence of research and/or development activity with credentials and experience which could lead to an academic appointment in the Physics Department at Queen's University. Experience with 3D planning, Monte Carlo computer simulation and expertise in networking and administering computer systems would be an asset.

Priority will be given to Canadian citizens and permanent residents of Canada, in accordance with Canadian Immigration requirements. Applications are invited from all qualified candidates. Please submit a curriculum vitae and the names of three professional referees by the 31st January 1998 to:

John Schreiner, Ph.D., FCCPM
Head, Medical Physics
Kingston Regional Cancer Centre
25 King Street West
Kingston, Ontario, K7L 5P9
FAX: (613) 544-9708
E-mail: jschreiner@cancercare.on.ca